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GEOLOGIC ASPECTS OF TUNNELING IN THE LOS ANGELES AREA*

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INTRODUCTION

In July 1975 the U.S. Department of Transportation commissioned a study of geologic and hydrologic aspects of downtown Los Angeles and adjacent areas as they would affect tunneling for subways. The objective is to collect, evaluate, and integrate available information as an initial basis for more detailed feasibility, alinement, and design studies. Although a considerable volume of relevant surface and shallow subsurface data was obtained from public and private files, much of it originally was collected for other purposes, most is unpublished, and none has been integrated into a three-dimensional study for the purpose at hand. Thus, the report is not intended to be site-specific, as the required quantity and quality of data are not available. Instead, the report describes the general range, types, and distribution of tunneling conditions represented, and locates and describes the geologic-hydrologic factors that bear on route selection, more detailed geotechnical investigations, and excavation techniques.

The methods and limitations of the report are described and compared to a geologic investigation designed for the purpose of planning tunnels. The report then presents a brief summary of the geologic setting of the area, maps and sections that show surficial and shallow subsurface geology in units that characterize inferred tunneling conditions, the approximate position of the water table as of November 1974, the known or inferred distribution of faults and other potential hazards to tunneling, the location and content of wells and borings used as control points, and the location and magnitude of instrumentally recorded earthquakes through 1976. Finally, significant gaps in data are discussed.

A geologic investigation designed for planning tunnels would 1) assess the regional tectonic-geologic setting where relevant, such as in areas of seismic activity and active faults, review the general lithology and structure of the local area, and summarize case histories of existing tunnels; and 2) include field studies designed to assess alternative routes and plan for more detailed drill-hole investigations appropriate to the terrain, specific alinements, and ground-water conditions. The objective of such site-specific studies would be to determine 1) the engineering properties of the materials to be excavated--what methods of excavation would be most efficient and what difficulties or hazards should be anticipated, and 2) how the materials will behave after excavation.

METHODS AND LIMITATIONS

The present report is a compilation of data initially collected by others largely for other purposes. Surficial geology (sht. 1) was adapted chiefly from Lamar (1970, pl. 1), supplemented by the studies of Hoots (1931), Jennings and Strand (1969), Thomas, Landry, and Turney (1961), and Byer (1968). Each of these investigations was made for purposes other than mapping and describing geotechnical properties relevant to tunneling. Similarly, the wells and boreholes mapped, were, with the exception of the shallow borings along Freeways and the "Wilshire Corridor" (section A-D, sht. 4), drilled for purposes other than obtaining geotechnical properties of materials at depth.

Such relevant detailed data as mineral type, grain-size range, distribution and relative density, percentage, type and size of rock fragments, permeability and porosity, type and degree of cementation, type, orientation, and distribution of joints, width and attitude of faults and type of material within the fault zone, details of weathering, details of rock structure, hardness, unusual water conditions, and many others, commonly are not collected systematically during general-purpose geologic investigations of the sort upon which this report is based. Consequently, the inferred correlation between geologic aspects and tunneling conditions is based chiefly on generalized lithologic descriptions of the units where exposed to weathering, plus topical studies by Terzaghi (1950), Brandt, Stone, Smith, Willis, and Pastuhof (1970), Proctor (1971, 1973), Peck, Hendron, and Mohraz (1972), and Heuer (1974, 1977).

Precision

The topographic contours of the base maps generally are accurate to one-half contour interval; the contour interval is 20 ft for the Hollywood and Los Angeles quadrangles (the area south of lat 34°07'30") and 40 ft for the Burbank and Pasadena quadrangles (north of lat 34°07'30"). On these base maps the true relative horizontal location of features originally observed by others cannot be more precise than about 100 ft.

The water-table and bedrock contour maps were derived by interpolation between irregularly-spaced, locally sparse wells and borings. Because of errors in location of the wells, plus irreducible errors in vertical control, the true location in space of a point on a given contour cannot be more precise than about 150 ft horizontally and 25 ft vertically. The sections were derived by projection from the mapped data; therefore the precision of location of features on the sections is dependent on that of the maps, as well as on imprecise control for vertical projection.

GEOLOGIC-TECTONIC SETTING

The structural setting of the map area (fig. 1) includes parts of several structural blocks that make up the Los Angeles basin area and is traversed by elements (York Boulevard, Elysian Park, and Hollywood faults, sht. 1-A) of major zones of faults that in general form the south boundary of the western Transverse Ranges (for example, the south boundary of the Santa Monica and San Gabriel Mountains). (See Lamar, 1970, 1975; Yerkes and others, 1974, for additional details).

Unlike most of the structural features of coastal California, which trend northwest-southeast, those of the Transverse Ranges, such as the Santa Monica Mountains, all trend east-west. The continuing earthquakes, faulting and mountain-building activity in the western Transverse Ranges are believed to reflect the influence of relative motions along the San Andreas fault. Because of the configuration of the San Andreas in this part of California, the relative motion of the crustal blocks adjoining the fault results in strong north-south compressive stresses over a broad area of southern California, including the western Transverse Ranges. The compression is reflected in the Southern California uplift (Castle and others, 1976) and relieved in part by movement on the faults concentrated near the south boundary of the western Transverse Ranges. Some of these faults are seismically active (fig. 2). The 1971 San Fernando earthquake (magnitude 6½) occurred on one element of the zone; the 1973 Point Mugu earthquake (M 6.0) occurred on a western continuation of the zone that includes the Hollywood fault; and elements of the boundary zone coincide with the south limit of the Southern California uplift. Geologic evidence at all scales indicates that faulting and related tectonic deformation have been continuing in this part of southern California for several million years; there is no reason to expect significant changes in the rate or mode of deformation.

The oldest bedrock units of the map area (sht. 1) consist of deeply-weathered, generally soft and crumbly

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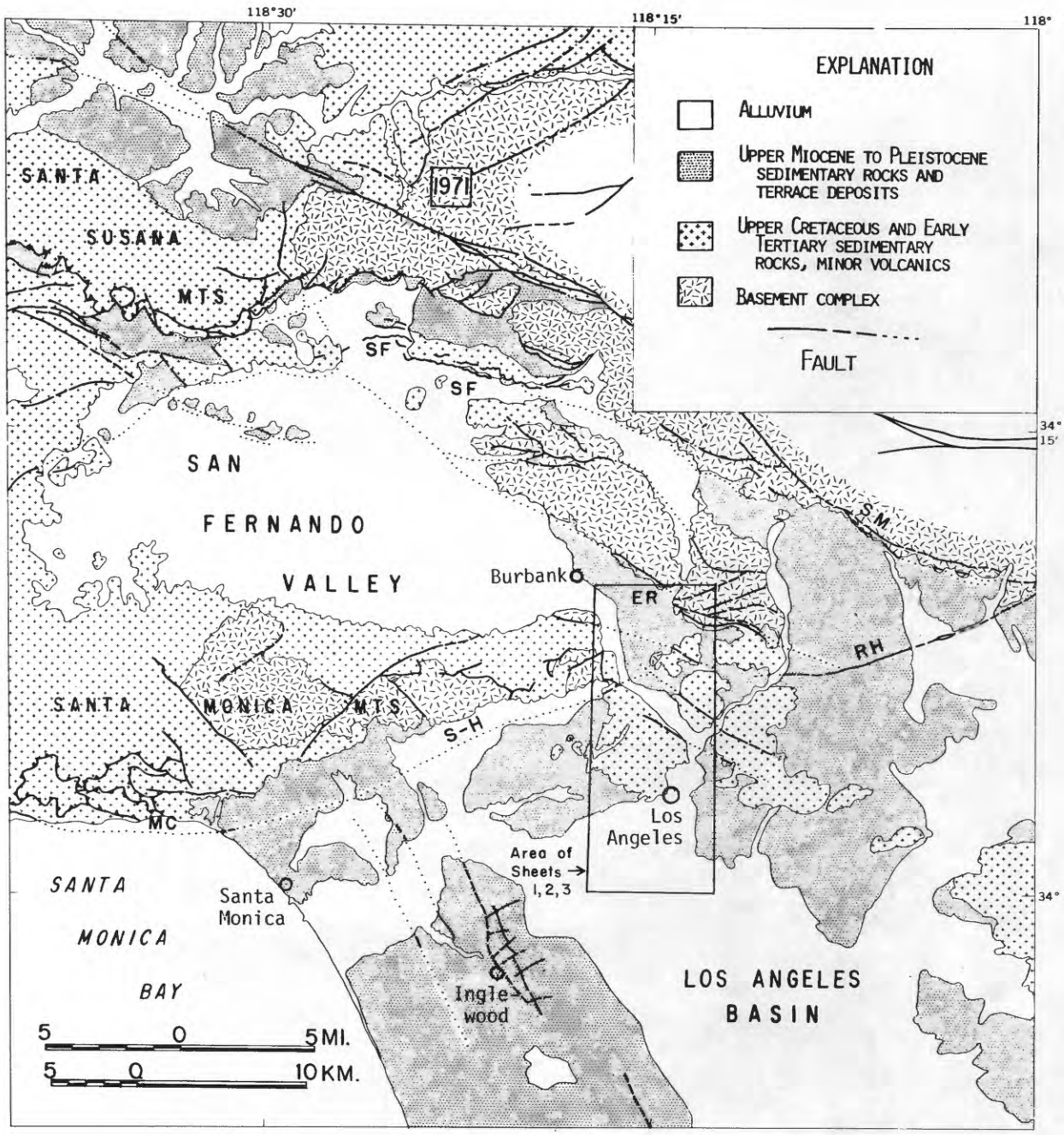

Figure 1. Generalized geologic map of the Los Angeles region showing major Quaternary faults in or near the western Transverse Ranges and area of sheets 1, 2, and 3. Identified faults are elements of the south boundary zone of the western Transverse Ranges; ER, Eagle Rock; MC, Malibu Coast; RH, Raymond Hill; SF, San Fernando; S-H, Santa Monica-Hollywood; SM, Sierra Madre. Faults are dashed where approximately located, dotted where inferred or concealed. 1971, epicenter of the 1971 San Fernando earthquake.

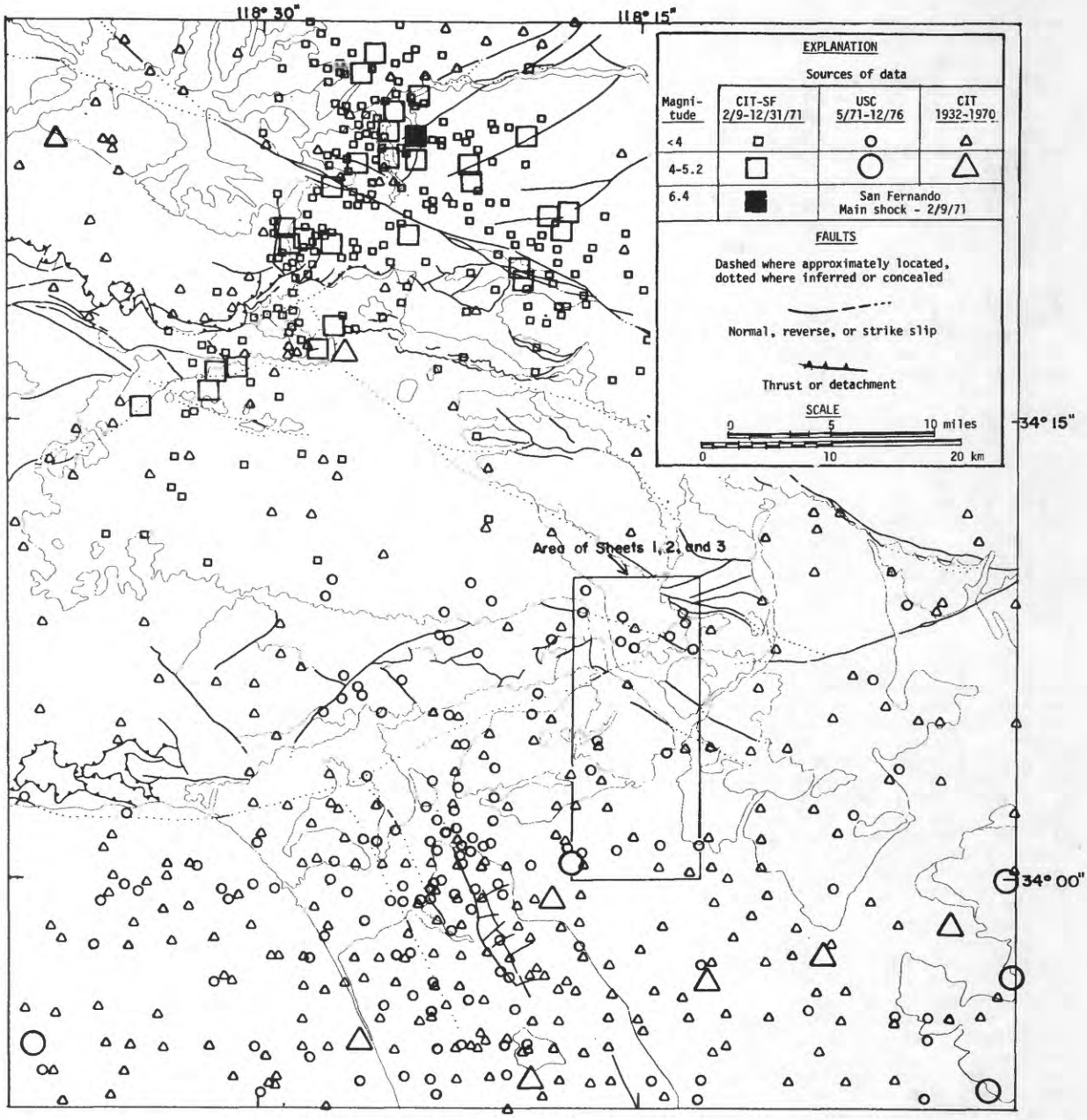

Figure 2.--Map showing instrumentally-located earthquake epicenters in the Los Angeles area for various periods since 1932. CIT-SF, California Institute of Technology, special investigation, San Fernando earthquake (Whitcomb and others, 1973; Allen and others, 1975); USC, University of Southern California (Teng, 1977); CIT, California Institute of Technology (Hileman and others, 1973).

dioritic rocks of the basement complex, which are exposed in the north part of the map area. The basement rocks are faulted against younger sedimentary rocks (Topanga, Puente, and Fernando Formations of Lamar, 1970), which vary in thickness and lithology from fault block to fault block and within a given fault block. The sedimentary rocks, including the youngest bedrock units exposed, are tightly folded along generally east-trending axes (see Lamar, 1970, pl. 1 for details).

Uplifted and dissected, slightly consolidated alluvial terrace deposits are present in the south part of the area both west and east of the Los Angeles River (sht. 1-B). Deposits of late Pleistocene age are known to be folded and faulted in nearby areas of the basin.

Dissected, slightly consolidated old alluvium generally covers lowland areas east and west of the Los Angeles River and is inferred to be buried beneath alluvium of the river where it locally contains many boulders (section E-F, sht. 4). These deposits are inferred to be cut at depth by a strand of the Hollywood fault on the basis of ground water evidence (section E-F, sht. 4); immediately east of the map area deposits of late Quaternary age are offset at the ground surrace along the Raymond Hill fault (fig. 1; Wentworth and others, 1970).

Unconsolidated to slightly consolidated bouldery gravel, sand, and silt make up the alluvial deposits of the rivers and flood plains. These deposits are not known to be faulted at the ground surface and at depth they cannot be differentiated from buried old alluvium on the basis of available evidence. However, the abundant evidence of geologically young deformation, such as faulted water-bearing deposits (section E-F, sht. 4), indicates that such effects as impounded water should be anticipated along the trends of all the more extensive faults where tunneling in alluvium near or below the water table.

TUNNELING CONDITIONS

Important geologic factors that bear on the type of tunnel boring machine (TBM) to be used, rates of advance, and hence cost of tunneling are 1) the type and uniformity of ground to be excavated, especially whether it is mixed face or bouldery; and 2) whether the tunnel is above or below the water table. (See Brandt and others, 1970, p. F-24; Peck and others, 1972, p. 261-262; Schmidt, 1974). Full-face rotary-head boring machines may have difficulty coping with boulders; although openface hoe-excavator or "digger"-type machines have been designed to handle boulders up to 2 ft or so in diameter (the width of the conveyor belt), the unsupported face may fail, especially if in saturated ground (see app., Metropolitan Water Dist. San Fernando tunnel).

The tunneling characteristics of soils may change drastically with their position relative to the water table. Cohesive clay soils are stable when the ratio of shear strength to overburden pressure is great enough, a characteristic that generally will be independent of water table. Non-cohesive clay-poor sediment below water table is usually flowing ground and must be dewatered or stabilized by other means; above water table, it may be running or slow raveling. A deposit with high permeability such as well-graded coarse-grained sand may be the source of large inflows of water below water table. Some materials, such as saturated silt, have a very low compressive strength below the water table, leading to sloughing, caving, and overbreak problems.

The earth materials at tunnel depths in the map area range from very firm or firm dry soft rock, generally well suited for tunnel boring machines, to possibly running or flowing ground where unconsolidated or slightly consolidated surficial deposits are locally below the water table. Hard rock conditions may exist locally north of the Hollywood and Eagle Rock faults.

The maps (shts. 1, 2) summarize available data relevant to tunneling conditions; sheet 1 shows the surface distribution of relatively unconsolidated deposits and bedrock units, faults, approximate depth to ground-water, distribution of near-surface petroleum deposits, and instrumentally recorded earthquake epicenters (fig. 2). Sheet 2 shows the surface distribution of exposed bedrock and the approximate depth to bedrock[1/] (or thickness of relatively unconsolidated deposits) in areas where it is buried.

Sheet 3 shows the locations of about 885 wells and borings for which adequate locations and lithologic logs could be obtained; the locations are keyed by number to a register of basic data (operator, elevation, total depth, generalized sequence of geologic units) extracted from the logs (table 1).

The sections (shts. 4, 5) integrate the available data at tunneling depths along representative alinements: generalized geologic structure, approximate location of the water table in 1974, general tunneling conditions as inferred from geologic data, and known difficult or potentially hazardous tunneling conditions. The tunneling conditions indicated on the sections are inferred from the map distribution and general lithology of the geologic units, their position relative to the water table, and the topical discussions of Terzaghi (1950), Brandt, Stone, Smith Willis, and Pastuhof (1970), Proctor (1971), and Heuer (1974); suitably detailed data on the subsurface geometry of the various rock-soil units and their geotechnical properties are not presently available. Table 2 defines the terms used for tunneling conditions.

Tunnel advance rates

Representative tunnel advance rates for materials above 250 ft subsurface in the Los Angeles area have been estimated by Heuer (1977). The estimates are for a fully-shielded tunneling machine and include installation of segmented precast concrete tunnel lining; the estimates apply to either "digger"-type or rotating face machines.

Alluvial deposits above water table: 100 ft per (24-hr work) day.

Alluvial materials below water table: 40 ft per day; includes time for drilling horizontal drains ahead of the tunnel face.

Oil-saturated materials: 40 ft per day, averaged over 1000 ft of tunnel; but determination of specific conditions requires exploratory borings along selected route.

Fault zones in sedimentary rocks: 20 ft per day. Assumes need for "feeler" holes, problems with face stability, high water inflow, and some shutdown for ventilation of gas.

Consolidated sedimentary rocks: 80 ft per day, independent of specific rock type and ground water level.

Geotechnical properties

Measured geotechnical properties generally are lacking except in the area traversed by section A-D (shts. 1, 4), where in situ penetration tests were made on surficial deposits and the younger bedrock units; the tests were made in 1962, at 5-ft vertical intervals in 47 shallow borings distributed over a distance of 4.5 mi, during exploration of the "Wilshire Corridor" of a proposed rapid transit system. Pentration counts were taken with a 2-inch split-spoon sampler driven by a 140-lb hammer dropped 30 inches. Data from the logs of the borings (Kaiser Engineers, 1962), grouped by geologic unit and Unified Soil Classification, are plotted against depth in Figure 3. Most of the data are from depths

[1/] The buried bedrock surface mapped on sheet 2 is inferred to be the boundary between consolidated sedimentary rocks of the Fernando Formation or older units and overlying relatively unconsolidated materials of the San Pedro Formation and younger units.

of 60 ft or less and thus do not apply directly to materials at greater depths.

The penetration data show that competence of the materials generally increases with depth. Penetration data for sands can be associated qualtitatively with relative density and those for clays with consistency and unconfined compressive strength (table 3). If the measured counts are representative of the alluvial deposits in this area, with extrapolated blow counts greater than 40 per foot (at a subsurface depth of 50 ft), they can be characterized as at least slightly consolidated and dense to very dense. Similarly, the shallow shale and siltstone bedrock materials in this area may be characterized as very stiff to hard in consistency.

Bouldery ground

Bouldery ground apparently is common down to at least 200 ft subsurface along the Los Angeles River north of the Pasadena Freeway (section E-F), as well as in the river deposits in the Union Station area (section C-D). Bouldery ground also should be expected in unconsolidated deposits in the south quarter of the area (south half of sht. 1-B). Approximately the upper 250 ft of deposits in this area contains the Recent alluvium and Lakewood Formations of Thomas, Landry, and Turney (1961): Recent alluvium contains cobbles to 5 in. in diameter as well as "boulder gravel" (Thomas and others, 1961, p. 56-62). The logs of several shallow borings (to 50 ft subsurface) in this area cite gravel with cobbles as large as 8 in. in diameter.

Relatively unconsolidated deposits in the area between Glendale and the Los Angeles River (north half of sht. 1-B) are thicker than about 200 ft and are expected to contain numerous cobbles and boulders. Similarly, unconsolidated deposits in the area east of the Los Angeles River and between the San Bernardino and Santa Ana Freeways, although somewhat thinner (thickness not well known) are expected to contain boulders and cobbles.

Case history

A relevent case history has been reported by Heuer (1976, Case B, p. 281-282). A tunnel 22 ft in diameter was being excavated by a fully shielded backhoe-type "digger" machine through alluvial and alluvial fan deposits at the south margin of the westernmost San Gabriel Mountains about 15 mi northwest of the map area. Very rapid tunneling progress was made through the relatively dry, unconsolidated but locally cemented clayey silt, sand, and gravel where above the water table. Pumping tests prior to excavation indicated an "average permeability of 10^{-2} to 10^{-3} cm/sec" for these materials. In a section bounded by faults which acted as natural dams, the water table was about 40 ft above the tunnel, which had about 135 ft of cover. An attempt was made to advance the tunnel through this section without prior dewatering, but difficulty was had with flowing ground and caving of the face, where water flows of several hundred gallons per minute were reported. On several occasions complete collapse of the face occurred with inflows of several thousand gallons of water and soil in a few seconds. The ground overhead caved upward and ahead of the machine to the "bottom of a harder silty layer" (as quoted by Heuer) at or near the natural water table about 95 ft below the gound surface. During one of several such runs the cavity propagated upward through dry ground to the surface and formed a hole 10-15 ft in diameter. The water problem eventually was controlled by dewatering the ground just ahead of the machine with numerous 3- to 4-inch diameter holes drilled horizontally about 200 feet ahead of the tunnel face.

Ground water

The present map area is within the Los Angeles Forebay Area of the Central Basin Pressure Area of Thomas, Landry, and Turney (1961, pl. 2), which comprises much of the lowland plain traversed by the Los Angeles River. The forebay area is chiefly one of free groundwater rather than one containing confined aquifers, as in much of the area to the south. A number of aquifers and intervening aquicludes have been identified and mapped below a depth of 60 feet subsurface. The degree of saturation of aquifers below the water table probably varies with degree of hydraulic continuity across intervening aquicludes; all of the deeper aquifers are shown to be truncated--and thus in hydraulic continuity with--the lower of two young aquifers in the area where Whittier Boulevard intersects the Los Angeles River (Thomas and others, 1961, section K-K', pl 6E).

Depth to ground water south of the Santa Monica Freeway is unknown except in the Vernon area, where it was approximately 200 ft in November 1974. Interpolation of sparse data on regional-scale maps of the Los Angeles County Flood Control District indicates that depth to the November 1973 water table in the southwest part of the map was approximately 150 ft or greater (Los Angeles County Flood Control District, 1975, p. 281).

The depth and configuration of the water table in areas of exposed sedimentary rock are unknown in detail, but it often is at 10 to 50 ft below topographic lows (Heuer, 1977). The depth to the base of fresh water in the Los Angeles City oil field is given as 150 ft (Calif. Div. Oil and Gas, 1974). No injection or local water disposal is carried on (Calif. Div. Oil and Gas, 1975, p.137, 149).

It is reported that during construction of the Pacific Electric subway tunnel (just south of Fourth Street, Sht. 2-B) in the mid-1920's, ground-water flowed into the tunnel at rates of about 17 gal per min; the abandoned, extant portions of the tunnel (west of Figueroa and east of Hope) are still pumped regularly to control ground-water flows (data from A. Dennis, Engineer of the Street Opening and Widening Division, Bureau of Engineering City of Los Angeles, written commun., Oct. 4, 1976). Heuer (1977) states that tunnel-face flows of a few tens of gal per min may be expected from the cleaner, coarser-grained sandstone beds and that much of the rock is expected to be only damp to dripping in tunnel. Proctor (1977, written commun.) states that some tunneling experience in rock in and near downtown indicates that water inflows generally do not cause hazardous (caving) conditions, probably because of a greater degree of consolidation and cementation.

A tunnel at a depth 50 ft subsurface generally along the Harbor Freeway and Flower Street would be dry (section G-H, sht. 5), whereas one at that depth along Seventh Street would be below a 1962 perched water table west of the Harbor Freeway (section A-B), and one generally northward along the Los Angeles River would be below the November 1974 water table from about First Street to about 1 mi south of the Glendale Freeway (section E-F). Elsewhere in the map area the majority of tunnels at 50 ft subsurface would be dry on the basis of available data.

The elevation of the water table varies seasonally with recharge and demand as well as with depth of the aquifer being pumped; water levels generally are higher in the spring and lower in the fall. Recognized increases in elevation of the water table between November 1974 and April 1975 were:

- In the northwest part of the map area near the Santa Monica Mountains; 10 to 28 ft;
- In the vicinity of Glendale, 3 ft;
- In shallow wells in the vicinity of the Glendale Freeway, 3 to 11 ft;
- Just north of the Santa Monica Freeway, east of the Harbor Freeway, 10 ft;
- In the vicinity of Vernon: deep wells, 6 ft; wells less than 400 ft deep, no change.

The ground-water data now available constitute only a first approximation, and are not adequate to determine possible areas of perched water (see west end of section A-B, sht. 4), the degree of saturation of the materials below the water table, or to delineate the precise position of the water table or its seasonal fluctuation along any given alinement. Such data could be obtained only from appropriately spaced and perforated observation wells,

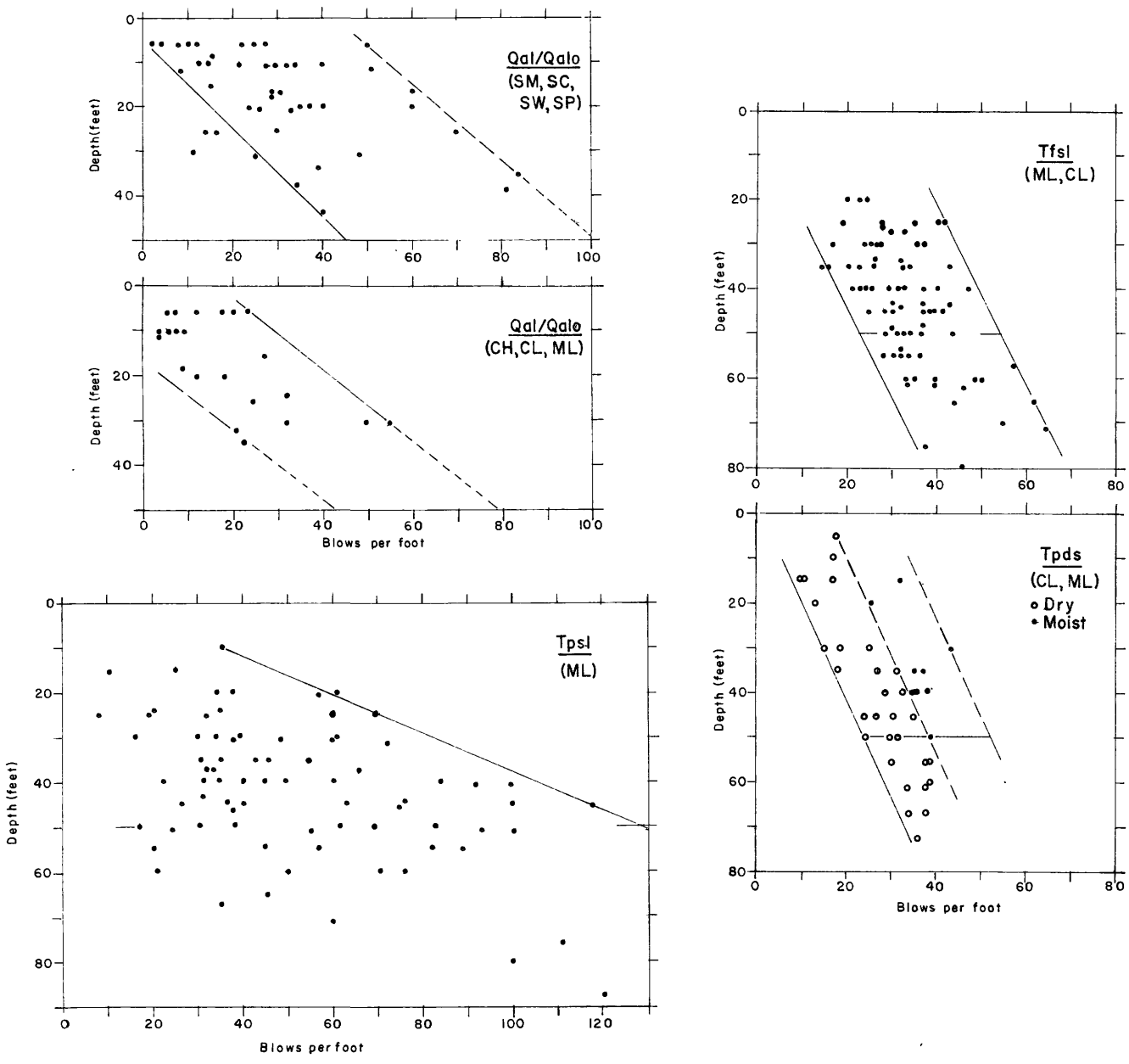

Figure 3.--Penetration test data from shallow borings (WC 75-WC 122, Kaiser Engineers, 1962) along section A-D (sheet 4), grouped by geologic unit and Unified Soil Classification. Blow counts taken with 2-inch split-spoon sampler, 140-lb. weight, dropped 30 inches. Qal/Qalo, alluvium; Tfsl, siltstone, Fernando Formation of Lamar (1970); Puente Formation of Lamar (1970): Tpds, diatomaceous shale and siltstone; Tpsl, siltstone and very fine-grained sandstone. Counts in gravel excluded; appreciable count differences in moist or wet vs. dry samples apparent only in Unit Tpds.

monitored at appropriate intervals.

Faults

Transportation routes in the Los Angeles area cannot avoid crossing potentially active faults, such as the Santa Monica-Hollywood-Raymond Hill, York Boulevard, or Eagle Rock (shts. 1, 2, 4, and 5). In bedrock the mapped fault traces generally constitute zones of crushed or slickensided rock that may be several tens of feet wide and extend downward, commonly at steep angles, beyond tunnel depths. In slightly consolidated or unconsolidated materials, the effects of faulting are more diffuse; instead of forming discrete ruptures that cut the rock materials, the fabric of grains and fragments is deformed by rearrangement. In both cases, faults are expected to form barriers or possibly conduits along which impounded ground water may enter a tunnel bore near or below the water table.

The Santa Monica, Hollywood, and Raymond Hill faults are classified as potentially active (no recognized historic activity, but may move again in the near future) on the basis of their tectonic setting and relations to young geologic deposits (see Greensfelder, 1974; Wiggins and others, 1974, p. IV-19 to IV-21). These faults and the associated Elysian Park and York Boulevard faults are inferred to cut buried surficial deposits at tunneling depths. In addition, the Santa Monica-Hollywood-Raymond Hill zone is considered capable of generating on earthquake as large as magnitude 7.5 (Greensfelder, 1974). Since near-surface displacement and surface rupture may be associated with earthquakes of magnitude 5 or larger on most California faults, such displacements, probably with a large component of vertical separation, may occur on one or more of those faults in the event of such an earthquake.

Petroleum

Local accumulations of petroleum (petroleum gas, free oil, asphalt or tar) and a few of hydrogen sulfide were found in shallow borings (generally above 50 ft subsurface) at several places between Seventh Street near the Hollywood Freeway and west of Harbor Freeway, in the downtown area, along the Los Angeles River north of the San Bernardino Freeway (section D-E), and around the intersection of the San Bernardino and Golden Freeways (sht. 1-B). The Los Angeles City oilfield extends east-west across the map area north of section A-D and west of the Los Angeles River. The oilfield is characterized by shallow accumulations of petroleum, surface seeps, and more than 1250 wells, only 54 of which were active in 1974 (sht. 5; Calif. Div. Oil and Gas (1975, p. 78). Most of the wells were drilled during or before 1900, were not surveyed or otherwise accurately located, and the ground surface has since been developed for other uses. Consequently, no accurate record exists of the location of all the wells drilled, although Crowder (1961, pl. 2; this report, sht. 5) has mapped 1116 of them at a scale of 1:7,200.

Oil has been produced from very shallow depths in the field; early production was from hand-dug pits and surface seeps (Crowder, 1961, p. 68). The earliest drilled wells produced from depths as shallow as 140 ft. Structure sections of the field show that shallow petroliferous strata extend continuously along the length of the field from east to west and dip southward at about 30°, being exposed near and along the north boundary of the field and extending to depths of 500 to 1,000 ft subsurface along the south boundary (sht. 5). Gas and seeping oil were encountered in 1976 during excavation of a shallow storm drain through the field (see app., Los Angeles County Flood Control District).

Subsidence

The map includes parts of 3 areas of relatively small scale but areally extensive differential subsidence. A northwest-trending elliptical subsidence bowl extends into the southwest part of the map from its center about 2 mi south. The 1968/69-71 rate of subsidence at the center of the bowl was about 0.1 ft per yr with respect to Tidal 8, and at the south center of the map, the rate was about 0.066 ft per yr (Castle and others, 1975, fig. 5). Total subsidence at the center during 1926-64 was 1.64 ft, for an average of about 0.04 ft per year.

A second area of differential subsidence averages about 3.5 mi in diameter and centers near the axis of the Los Angeles City oilfield where it crosses the Los Angeles River. The rate of differential subsidence at the center of this area during 1968/69-71 with respect to Tidal 8 was about 0.066 ft per yr (Castle and others, 1975, fig. 5).

The third area centers near Burbank, about 1 mi northwest of the map, but extends into the northwest corner of the map. A survey mark in the northwest corner subsided about 0.5 ft with respect to Tidal 8 during 1925-64; the 1968/69-71 rate was about 0.033 ft per yr (Castle and others, 1975, fig. 5).

GAPS IN DATA

Comparison of the data available for this study with those required for a specific investigation for tunneling reveals important gaps in both quality and quantity of essential data. These gaps are summarized below:

Ground water

Because of their significance to tunneling conditions, the precise depth to the water table, the distribution of ground water below the water table, and the distribution of perched water should be known with great reliability. Perched water must be differentiated from the permanent water table because the effects of perched water on tunneling are adverse and temporary.

If tunnel depths greater than 150 ft subsurface are considered for the area south of the Santa Monica Freeway, it may be necessary to determine the distribution of ground water within the several aquifers and aquicludes reported for that area (Thomas and others, 1961, sections A-A', K-K', pls. 6A, 6E). Similar considerations apply to the Glendale area in the northeast part of the map.

Bouldery ground

As indicated by the records of numerous wells and boreholes, boulders to 3 ft in diameter or more and cobbles to 10 in. in diameter are wisespread but not uniformly distributed either geographically or with depth, in most surficial deposits in the area. Instead, irregularly-shaped lenses of large and small boulders and cobbles characterize the surficial deposits in and near present and past flood plains of the Los Angeles River and its tributaries. The size and number of boulders presumably decrease downstream with decrease in carrying capacity of floods, but this has not been demonstrated in any quantitative way for the present case.

The presence of boulders and cobbles is cited in table 1 where given in original sources. However, it is reasonable to assume that in most cases, boulders were cited only when they posed an obstacle to the tool, and their absence therefore cannot be assumed where not noted, especially in surficial deposits in and near the Los Angeles River. To obtain reliable, quantitative data on the distribution and size of boulders along a given alinement, in order to estimate the efficienty and costs of different tunneling methods, the record presented here must be supplemented with many additional suitably located and logged exploratory borings, especially where surficial deposits are to be traversed.

Petroleum

Shallow accumulations of petroleum - gas, asphalt tar, or free oil are potential safety hazards and are locally common (sht. 1, table 1). As now known,

these accumulations occur in both bedrock and surficial deposits in an east-west band or zone about 1½ mi wide and generally north of Wilshire Boulevard on the west and San Bernardino Freeway on the east. This is the general area where south-dipping petroliferous bedrock strata are transgressed by younger materials. Shallow petroliferous strata are also fairly continuous and widespread in the Los Angeles City oilfield area (sht. 5); local shallow accumulations of petroleum deposits should be expected throughout the area of the field, as well as elsewhere in the zone.

Buried faults

Faults in bedrock constitute generally steep zones, as much as a few tens of feet wide, of brecciated or sheared rock, and thus are zones of relatively weak materials; in relatively unconsolidated deposits, fault zones may constitute barriers along which ground water may concentrate and enter a tunnel near or below the water table. The faults shown as buried by relatively unconsolidated deposits (sht. 1) are based on projections of exposures in bedrock and sparse well control. The interpretation that some faults cut buried older parts of those deposits - instead of being buried by them (sht. 4) is based on the general tectonic regime of the area, an inferred ground water cascade along one of the faults, and geologically young activity. Because of lack of control, the precise location of the faults and their vertical extent in the buried deposits is unknown. Reliable location and characterization of the mapped faults, and delineation of others not presently mapped, depend chiefly on detailed correlation between suitably located exploratory boreholes, drilled or cored to bedrock, and logged by suitable methods (for a discussion of geophysical techniques of logging boreholes, see Alsup, 1974).

Bedrock

Only the most generalized lithologic and structural properties of exposed bedrock are known. Significant engineering properties, such as permeability, deformability, strength, mineral composition, range in size and distribution of rock fragments and mineral grains, type and degree of cementation, details of weathering and structure, and type and distribution of fluids, are known in only a general way (such as for two existing tunnels in the downtown area--see app)., and for weathered materials only, or not at all. Precise data must be obtained from suitably spaced and logged exploratory borings along specified alinements.

Depth to the buried bedrock surface is known reasonably well only along the Los Angeles River (sht. 2A) and north of the Santa Monica Freeway (sht. 2B). Relevant data are completely lacking for much of the Glendale area, the area east of the river between the Pasadena and San Bernardino Freeways, and a particularly critical area just east of Alameda Street north and south of section C-D, where both bedrock and the water table presumably are shallow. Although a number of bedrock-depth points are inferred for the area south of the Santa Monica Freeway, the bedrock surface there apparently is locally quite irregular and many more points are required to approximate its general configuration.

Tunneling conditions

The tunneling conditions (sht. 4, table 3) were inferred from very generalized descriptions of the geologic units as based on their surface exposures. Knowledge of relevant geotechnical and structural properties such as accurate geometric configuration of the various stratal units in the subsurface, their permeability (dewatering characteristics), cohesion, shear strength, range in size and distribution of mineral grains and rock fragments, type and degree of cementation, distribution and attitude of joints and distribution of saturated zones below the water table, are almost totally unknown in uniformly useful detail. Tunneling conditions may vary significantly with each of these properties; the precise range and type of conditions along a specific alinement cannot be predicted from present knowledge, but can be determined only by systematic investigation and sampling designed for the purpose.

Subsidence

As presently known, subsidence probably would not pose a problem to construction of tunnels in the map area. If it is determined that differential subsidence of the ground surface at average rates up to about 0.1 ft per year over a distance of about 3 mi and inferred compaction of aquifers at and below tunnel depths are of consequence, the present-day extent and rates of the three areas of differential subsidence should be determined. As pumpage of fluids continues, at least in the northwest and southwest of these areas, it is reasonable to assume that differential subsidence and attendant shallow compaction may also.

Liquefaction potential

Liquefaction of clay-poor granular sediments has produced severely damaging surface and near-surface ground failures such as those that occurred in Sylmar during the 1971 San Fernando earthquake (Thompson, 1971; Youd, 1971).

On an empirical basis the highest potential for liquefaction is present where water-saturated clay-poor granular sediments with relative densities less than 65 percent are present within about 50 ft of the ground surface. In a San Francisco Bay investigation, relative densities of 65 percent or less were found to correlate with penetration resistances of 20 or fewer blows per ft (Youd and others, 1975, fig. 49, p. A-71). Although it is not known that this combination of conditions is present in the map area, it is reasonable to assume that it may be present locally along the Los Angeles River where the water table is shallow (section D-E, sht. 4). Exploratory borings made in such areas therefore should include tests for these criteria.

SUMMARY AND CONCLUSIONS

A 55-square-mile rectangular area underlain by relatively unconsolidated deposits or soft rock, extending northward from Vernon Avenue through the downtown business district of Los Angeles to Glendale and the Ventura Freeway and traversed by the Los Angeles River, has been analyzed for the density, suitability, and quality of existing geologic-hydrologic data requisite for initial studies of routing and designing tunnels for a rapid-transit system. Surface geologic data, hydrologic records, and logs of about 885 wells and shallow borings have been collected, interpreted, and the results incorporated into maps and representative geotechnical sections that portray inferred, generalized tunneling conditions to depths of 100-300 ft subsurface. Even so, the distribution and quality of available data are inadequate for site-specific alinement, design, and cost analyses.

Abundant evidence illustrates the types and general distribution of tunneling conditions that exist in the map area. The downtown area and much of that to the south is underlain at tunnel depths by slightly consolidated sand and gravel or siltstone-shale that should provide chiefly dry, firm tunneling conditions. Rates of excavation in these materials for fully shielded TBM are estimated at 80-100 ft per (24-hr work) day. Much of the surficial deposits and bedrock in the latitude of the Los Angeles City oilfield contain petroleum such as gas, tar, or free oil at tunnel depths; strong ventilation has been used to avoid problems in such areas (see app.). TBM rates are estimated at 40 ft per day for these conditions.

Much of the alluvium north of downtown contains boulders, and, where tunneled below the water table, may flow and form cavities that could propagate upward to the surface if precautions such as prior dewatering are

not exercised. TBM rates in saturated alluvium are estimated at 40 ft per day. The 1974 water table was within 25 feet of the surface along parts of the Los Angeles River north of the San Bernardino Freeway (section C-E sht. 4). To avoid saturated alluvium in this segment, a tunnel profile would have to be deepened to more than 50 feet subsurface; depths of 200 feet or more would be required along the river between the Pasadena Freeway and Glendale Boulevard. The area north of downtown Los Angeles is traversed by several faults that may form barriers that locally impound groundwater; some of these faults also may be subject to movement. TBM rates in this terrain are estimated at 20 ft per day.

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Table 1A. Wells and shallow borings shown on sheet 3A (North Sheet)

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2700 A	PC	foundation	380±	21	0-10: Qalo 10-20: bedrock	shale	Shale moderately cemented.
2700 B	Hosp.	foundation	387	25	0-12: Qalo 12-25: bedrock	shale	Shale decomposed and weathered.
2700 C	Hosp.	foundation	385	40	0-6: af 6-11: Qalo 11-40: bedrock	silt-stone	Siltstone decomposed and weathered. 32: Water seepage, 7/22/62.
2701 A	PC	foundation	320±	25	0-21: Qalo 21-25: bedrock	shale	Shale with thin sandstone layers. 21: Water seepage, 2/19/70.
2710 B	DWP	water	377±	107	0-23: Qalo 23-107: bedrock	granite	Granite decomposed. 3-23: Hard pan
2710 C	DWP	water	376±	114	0-114: Qalo		
2710 D	DWP	water	362±	81	0-81: Qalo		
2710 F	PC	foundation	330±	45	0-19: af 19-43: Qalo 43-45: bedrock	shale	Shale very hard. 0-19: Raveling. 30: Water level, 8/17/67.
2710 G	PC	foundation	370±	90	0-41: Qalo 41-90: bedrock	shale	70-75, 80-73: Moderately cemented. 20: Water level, 8/4/70.
2710 H	Hosp.	foundation	393±	35	0-28: Qalo 28-35:bedrock	shale	Shale weathered.
2710 J	Hosp.	foundation	388±	40	0-13: af 13-30: Qalo 30-40: bedrock	shale	Shale weathered. 30: Water level, 7/22/62.
2710 K	Hosp.	foundation	377	24	0-20: Qalo 20-24: bedrock	shale	Shale weathered and fractured.
2710 L	Hosp.	foundation	384	36	0-4: af 4-32: Qalo 32-36: bedrock	shale	Shale weathered. 30: Water level, 7/22/62.
2710 M	Hosp.	foundation	384	35	0-19: Qalo 19-35: bedrock	shale	Shale weathered. 34: Water level, 7/22/62.
2711 A	LACFCD	storm drain	321±	28	0-28: Qalo		
2711 B	LACFCD	storm drain	310±	20	0-20: Qalo		
2711 C	LACFCD	storm drain	299±	15	0-15: af, Qalo		
2711 D	LACFCD	storm drain	293±	33	0-33: Qalo		14: Water seepage, 10/7/69.
2711 E	LACFCD	storm drain	299±	33	0-7: Qalo 7-33: bedrock	silt-stone	Siltstone very dense at base. 8: Water seepage, 12/9/69.
2721 A	LACFCD	storm drain	355±	22	0-22: Qalo		12: Water encountered, 4/25/68.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2721 B	LACFCD	storm drain	344±	18	0-18: bedrock	sandstone & siltstone	
2730 A	LACFCD	storm drain	395±	22	0-22: Qalo		7: Water encountered, 4/23/68.
2730 B	LACFCD	storm drain	418±	7	0-7: bedrock	sandstone	Boring terminated due to hardness of sandstone.
2730 C	LACFCD	storm drain	456±	13	0-13: bedrock	sandstone	
2731 A	PC	foundation	570	101	0-6: Qalo 6-101: bedrock	sandstone & shale	Sandstone and shale interbedded with an average dip and strike of 41°-S35°W.
2731 C	LACFCD	storm drain	458±	22	0-2: Qalo 2-22: bedrock	sandstone & siltstone	Sandstone and siltstone weathered. 12: Water encountered, 4/23/68.
2731 G	LACFCD	storm drain	478±	26	0-26: Qalo		9: Water encountered, 4/23/68.
2731 H	LACFCD	storm drain	370±	21	0-21: Qalo		9: Water encountered, 4/23/68.
2740 A	LACFCD	storm drain	536	11	0-5: af 5-11: Qal		
2741 A	PC	foundation	472	22	0-4: af 4-10: Qal/Qalo 10-22: bedrock	sandstone	Sandstone with shale lenses.
2741 B	LACFCD	storm drain	479	15	0-15: af		
2741 C	LACFCD	storm drain	455	17	0-6: af 6-17: Qal		16: Water encountered, 4/4/72.
2741 F	LACFCD	storm drain	503	13	0-13: af		
2750 A	Caltrans	foundation	368	44	0-43: Qal 43-44: bedrock	sandstone	Sandstone very dense.
2750 B	Caltrans	foundation	369	45	0-41: Qal 41-45: bedrock	sandstone	37-41: Qal dense. 16: Ground water surface, 6/17/58.
2750 C	SBOC	Park 1	425	2300	0-600: no log 600-2300: bedrock		
2750 D	Caltrans	foundation	354	13	0-10: Qal 10-13: bedrock	sandstone	Sandstone very dense.
2750 E	Caltrans	foundation	356	30	0-14: Qal 14-30: bedrock	sandstone, siltstone & shale	0-4: Some cobbles. Interbedded sandstone, siltstone, and shale.
2750 F	Caltrans	foundation	354	50	0-27: Qal 27-50: bedrock	sandstone, siltstone & shale	Interbedded sandstone, siltstone, and shale. Bedrock with odor of H_2S.
2750 G	Caltrans	foundation	346	36	0-33: Qal 33-36: bedrock	sandstone	Sandstone very dense. 30: Caving.
2750 H	Caltrans	foundation	350	23	0-11: Qal 11-23: bedrock	sandstone & shale	

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2760 A	Pacific Fruit Express Co.	foundation	330	121	0-106: Qal 106-121: bedrock	sandstone & shale	Sandstone with shale at base.
2760 B	DWP	water	333±	108	0-108: Qal/Qalo		80-108: Boulders.
2760 C	DWP	water	328	68	0-68: Qal/Qalo		20: Ground water, 1974.
2760 F	Ice plant	foundation	328	121	0-105: Qal/Qalo 105-121: bedrock	shale	85-105: Some cobbles to 5 inches.
2760 G	DWP	water	335	164	0-130: Qal/Qalo 130-164: bedrock	sandstone & shale	30-40, 85-102, 120-130: Boulders. 10° dip in bedrock.
2761 A	Caltrans	foundation	337	60	0-60: Qal/Qalo		32: Ground water surface, 3/25/58.
2771 A	Caltrans	foundation	325	70	0-64: Qal/Qalo 64-70: bedrock	shale	Shale very dense. 43: Ground water encountered, 12/31/57
2771 C	DWP	water	325	112	0-103: Qal/Qalo 103-112: bedrock	shale	36-59: Boulders.
2771 G	DWP	water	300±	85	0-82: Qal/Qalo 82-85: bedrock		
2771 H	DWP	water	345±	66	0-66: Qal/Qalo	?	
2771 I	DWP	water	353±	114	0-81: Qal/Qalo 81-114: bedrock	Sandstone & siltstone	12-16: Boulders.
2771 J	DWP	water	315±	89	0-86: Qal/Qalo 86-89: bedrock	sandstone	40-52: Boulders.
2771 S	DWP	water	355±	82	0-66: Qal/Qalo 66-82: bedrock	?	18-54: Boulders. "Soft shale sandstone."
2781 A	DWP	water	363±	62	0-50: Qal/Qalo 50-62: bedrock	shale	4-40: Boulders.
2781 D	DWP	water	367	84	0-38: Qal/Qalo 38-84: bedrock	shale & sandstone	Shale and sandstone interbedded.
3903 M	DWP	water	470±	606	0-606: Qal/Qalo		39-256: Boulders. 103: Water encountered, 7/1/53.
3903 N	DWP	water	486	619	0-619 Qal/Qalo		549-592: Sulfur.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
3904 A	DWP	water	464±	431	0-431: Qal/Qalo		82-125, 224-246, 310-320: Boulders. 44: Water encountered, 11/13/31.
3908 A	LACFCD	storm drain	702	10	0-10: Qalo		No water.
3913 A	DWP	water	470±	500	0-500: Qalo		
3913 B	DWP	water	470±	597	0-597: Qalo		90-105: Cemented gravel.
3913 C	DWP	water	470	499	0-499: Qalo		
3913 F	DWP	water	465±	504	0-495: Qal/Qalo 495-504: bedrock	conglomerate	
3913 H	DWP	water	479	551	0-571: Qal/Qalo		5-306: Boulders.
3914 A	DWP	water	460	436	0-420: Qal/Qalo 420-436: bedrock	conglomerate	42-127, 204-241, 308-362: Boulders. H_2S odor in bedrock. Conglomerate weathered.
3914 B	DWP	water	465±	606	0-606: Qal/Qalo		31-61, 104-131, 224-230: Boulders.
3914 C	DWP	water	465±	534	0-534: Qal/Qalo		40-402: Boulders.
3914 D	Caltrans	foundation	456	60	0-60: Qal/Qalo		
3914 E	DWP	water	436	276	0-273: Qal/Qalo 273-276: bedrock	granite	Granite decomposed.
3914 F	DWP	water	444	362	0-359: Qal/Qalo 359-362: bedrock	granite	Granite decomposed.
3914 H	DWP	water	440	320	0-312: Qal/Qalo 312-320: bedrock	granite	Granite decomposed.
3914 J	DWP	water	442	380	0-377: Qal/Qalo 377-380: bedrock	granite	Granite decomposed.
3914 K	DWP	water	448	296	0-290: Qal/Qalo 290-296: bedrock	granite	Granite decomposed.
3914 L	DWP	water	456	338	0-332: Qal/Qalo 332-338: bedrock	granite	Granite decomposed. 220-236, 295-328: Boulders.
3914 M	DWP	water	458	357	0-357: Qal/Qalo		202-230: Some boulders.
3914 N	DWP	water	405±	504	0-504: Qal/Qalo		123-306: Boulders.
3914 P	Caltrans	foundation	458	80	0-80: Qal/Qalo		47-80: Cobbles and scattered boulders.
3914 Q	DWP	water	460	294	0-291: Qal/Qalo 291-294: bedrock	granite	

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
3914 S	DWP	water	445±	330	0-330: Qal/Qalo		198-217: Boulders. 275-293: Some boulders.
3914 T	DWP	water	465±	313	0-294: Qal/Qalo	granite	17-125, 203-225, 290-294: Boulders.
3915 A	DWP	water	402	151	0-133: Qal/Qalo 133-151: bedrock	conglomerate & sandstone?	22-73: Boulders. 133-151: "Hill Formation."
3915 B	PC	foundation	481	16	0-7: af 7-10: Qalo 10-16: bedrock	granite	Granite decomposed.
3918 A	WSP 139	well #222	555±	48	0-48: Qalo		
3918 B	LACFCD	storm drain	642	16	0-16: Qalo		
3919 B	LACFCD	storm drain	473	12	0-7: Qalo 7-12: bedrock	siltstone	Siltstone with thin interbeds of sandstone. 0-7: Qalo (gypsum).
3919 C	LACFCD	storm drain	442	20	0-10: Qalo 10-20: bedrock	siltstone	Siltstone interbedded with sandstone. 10: Water encountered, 6/28/72.
3919 D	LACFCD	storm drain	431	12	0-12: bedrock	siltstone	7-12: Siltstone with interbedded sandstone, highly weathered.
3924 A	DWP	water	439	308	0-305: Qal/Qalo 305-308: bedrock	granite	Granite decomposed.
3924 B	DWP	water	435	335	0-334: Qal/Qalo 334-335: bedrock	granite	Granite decomposed.
3924 C	DWP	water	437	371	0-370: Qal/Qalo 370-371: bedrock?	granite?	"Gravel decomposed."
3924 E	DWP	water	441	182	0-180: Qal/Qalo 180-182: bedrock	granite	Granite decomposed. 12-108: Some boulders.
3924 F	DWP	water	440±	177	0-175: Qal/Qalo 175-177: bedrock	granite	Granite decomposed.
3924 H	DWP	water	462±	200	0-200: Qalo		
3924 J	DWP	water	435	192	0-186: Qal/Qalo 186-192: bedrock	granite	Granite decomposed.
3924 K	DWP	water	430±	209	0-206: Qal/Qalo 206-209: bedrock	granite	Granite decomposed.
3924 L	DWP	water	430±	239	0-236: Qal/Qalo 236-239: bedrock	granite	Granite decomposed.
3924 M	DWP	water	429	257	0-255: Qal/Qalo 255-257: bedrock	granite	Granite decomposed.
3924 N	DWP	water	400±	424	0-424: Qal/Qalo		20-310: "Some rocks."
3924 P	DWP	water	445	296	0-255: Qal/Qalo 255-296: bedrock	granite	199-223: Some boulders. Granite hard.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
3924 Q	DWP	water	440	335	0-282: Qal/Qalo 282-335: bedrock?	granite?	Granite decomposed with "sand and shale at base."
3924 R	DWP	water	460±	400	0-400: Qal/Qalo		
3924 T	DWP	water	440±	?	0-192: Qal/Qalo 192-? bedrock	granite	Granite decomposed.
3925 A	DWP	water	429	128	0-118: Qal/Qalo 118-128: bedrock	granite	Granite decomposed.
3925 B	DWP	water	429	93	0-84: Qal/Qalo 84-93: bedrock	granite	Granite decomposed.
3925 C	DWP	water	425±	130	0-124: Qal/Qalo 124-130: bedrock	granite	Granite decomposed. Bedrock harder at base.
3925 D	DWP	water	429	134	0-130: Qal/Qalo 130-134: bedrock	granite	Granite decomposed.
3925 E	DWP	water	430	153	0-143: Qal/Qalo 143-153: bedrock	shale	
3925 H	DWP	water	430±	172	0-172: Qal/Qalo		42-62, 82-94, 158-166: Boulders.
3925 J	DWP	water	430	195	0-181: Qal/Qalo 181-195: bedrock	granite	Granite decomposed. 26-56, 65-123, 137-141, 154-181: Boulders.
3925 K	DWP	water	425±	241	0-229: Qal/Qalo 229-241: bedrock	granite	Granite decomposed. 104-110, 156-181, 197-219: Boulders.
3925 L	DWP	water	420±	143	0-140: Qal/Qalo 140-143: bedrock	granite	Granite decomposed.
3925 M	DWP	water	421±	155	0-149: Qal/Qalo 149-155: bedrock	granite	Granite decomposed.
3925 N	DWP	water	422±	101	0-101: Qal/Qalo		0-15: Some boulders.
3925 R	DWP	water	424±	86	0-86: Qal/Qalo		
3925 S	DWP	water	425	85	0-76: Qal/Qalo 76-85: bedrock	granite	Granite decomposed.
3925 T	DWP	water	426	75	0-57: Qal/Qalo 57-75: bedrock	granite	Granite decomposed.
3925 U	DWP	water	427	81	0-54: Qal/Qalo 54-60: bedrock	shale?	54-60: "Shale." 60-78: "Decomposed granite." 78-81: "Shale."
3925 W	DWP	water	425	101	0-83: Qal/Qalo 83-101: bedrock	granite	Granite decomposed.
3926 A	DWP	water	409	182	0-182: Qal/Qalo 182+: bedrock	shale	30-43: Boulders. 48-101: Some boulders. 110-182: Boulders.
3926 B	DWP	water	412	173	0-173: Qal/Qalo		30-49: Cobbles. 122-173: Boulders.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
3926 C	DWP	water	405	169	0-168: Qal/Qalo		28-53: Cobbles. 138-168: Boulders.
3926 P	DWP	water	406±	101	0-90: Qal/Qalo 90-101: bedrock	shale	0-90: Cemented gravel.
3926 R	DWP	water	407±	141	0-140: Qal/Qalo 140-141: bedrock	shale	
3926 S	DWP	water	409±	150	0-148: Qal/Qalo 148-150: bedrock	shale	
3926 T	DWP	water	414±	180	0-180: Qal/Qalo		0-30: Cemented gravel. 60-90: Cemented sand.
3926 U	DWP	water	415±	170	0-170: Qal/Qalo		0-30: Cemented gravel.
3926 V	DWP	water	414±	197	0-197: Qal/Qalo		144-186: Cemented gravel.
3926 W	DWP	water	413±	170	0-170: Qal/Qalo		0-30: Cemented gravel. 54-90: Cemented sand. 110-120: Cemented gravel. 120-170: Cemented boulders.
3927 A	DWP	water	408±	40	0-40: Qal/Qalo		
3927 B	Caltrans	foundation	394	29	0-27: Qal/Qalo 27-29: bedrock	granite	Granite decomposed.
3927 C	Caltrans	foundation	395	32	0-32: Qal/Qalo		
3927 D	Caltrans	foundation	394	29	0-27: Qal/Qalo 27-29: bedrock	shale	Shale very hard.
3927 E	Caltrans	foundation	400	38	0-27: Qal/Qalo 27-28: bedrock	shale & siltstone	
3927 F	Caltrans	foundation	401	26	0-19: Qal/Qalo 19-26: bedrock	shale	Shale hard. 0-4: Some cobbles.
3927 G	Caltrans	foundation	401	27	0-15: Qal/Qalo 15-27: bedrock	shale & siltstone	Shale & siltstone siliceous. 13-15: Some cobbles.
3927 H	Caltrans	foundation	396	32	0-31: Qal/Qalo 31-32: bedrock	shale	Shale very hard.
3929 A	Wm.Sullivan	Well #1	418±	2410	0-157: Qalo 157: bedrock?	?	
3929 B	PC	foundation	475	30	0-22: Qalo 22-30: bedrock	siltstone	Siltstone jointed.
3934 A	DWP	water	520±	284	0-284: Qalo		281-284: Gravel cemented.
3934 B	DWP	water	520±	385	0-345: Qalo 365-385: bedrock	sandstone	345-365: Fault zone, gouge & breccia with sheared sands & clays. Sandstone "Topanga Fm."
3935 A	Caltrans	foundation	464	49	0-48: Qalo 48-49: bedrock	granite	Granite decomposed. No water.

Map. No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet
3935 B	Caltrans	foundation	463	44	0-37: Qalo 37-43: bedrock?	granite	Granite decomposed with sand. 43-44: "Very dense sand."
3935 C	DWP	water	473±	275	0-275: Qalo		No water. 28-50: "Rocks." 114-128, 140-152: Boulders. 152-196: Some cobbles.
3936 A	So. Calif. Gas Co.	water	431	330	0-330: Qalo		30-90, 150-195: Boulders.
3936 B	DWP	water	450±	150	0-150: Qalo		265-292: Some boulders.
3937 A	Caltrans	foundation	400	30	0-19: Qalo 19-30: bedrock	shale	2-11: Some cobbles.
3937 G	DWP	water	420	143	0-128: Qalo 128-143: bedrock	shale	9-34: Cobbles to 4 inches.
3938 A	Caltrans	foundation	393	30	0-18: Qal/Qalo 18-30: bedrock	sandstone	
3938 B	DWP	water	380±	46	0-32: Qal/Qalo 32-46: bedrock	shale	32-36: Limestone. 36-46: Shale.
3938 C	Caltrans	foundation	391	60	0-51: Qal/Qalo 51-60: bedrock	shale	30: Ground water surface, 9/22/58. 42-51: Cobbles.
3938 D	Caltrans	foundation	383	35	0-33: Qal/Qalo 33-35: bedrock	siltstone	33-35: Siltstone dense. 20: Ground water surface, 2/25/55.
3938 E	Caltrans	foundation	384	43	0-40: Qal/Qalo 40-43: bedrock	siltstone	40-43: Siltstone dense. 20: Ground water surface, 2/24/55.
3938 F	Caltrans	foundation	401	29	0-27: Qal/Qalo 27-29: bedrock	shale	27-29: Shale very hard.
3938 G	Caltrans	foundation	401	30	0-29: Qal/Qalo 29-30: bedrock	shale	29-30: Shale very hard.
3944 A	DWP	water	542	428	0-428: Qalo		14-51: Some boulders.
3945 A	DWP	water	540±	200	0-200: Qalo		181-197: Gravel cemented.
3945 B	DWP	water	538±	362	0-345: Qalo 345-362: bedrock	conglomerate	
3946 A	LACFCD	storm drain	483	40	0-33: Qalo 33-40: bedrock?	shale	33-40: "Shale and sandy loam."
3947 A	DWP	water	439±	180	0-179: Qalo 179-180: bedrock	shale & sandstone	Shale and sandstone interbedded.
3947 B	DWP	water	438±	162	0-160: Qalo 160-162: bedrock	granite	
3947 C	DWP	water	435±	176	0-168: Qalo 168-176: bedrock	sandstone & shale	
3947 D	DWP	water	438±	160	0-152: Qalo 152-160: bedrock	granite	152-160: Granite decomposed and hard at base.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
3947 E	DWP	water	441±	150	0-142: Qalo 142-150: bedrock	granite	142-150: Granite decomposed.
3947 F	DWP	water	442±	173	0-167: Qalo 167-178: bedrock	granite	167-176: "Shale & rotten granite."
3947 H	DWP	water	430±	241	0-228: Qalo 228-241: bedrock	shale	228-241: Shale hard. 30-33, 194-202: Boulders.
3947 J	DWP	water	439±	463	0-188: Qalo 188-463: bedrock	shale	188-463: Shale very hard.
3948 A	DWP	water	406	260	0-225: Qalo 225-260: bedrock	sandstone, siltstone, & shale	164-225: Some cobbles and boulders. 257: Interbedded sandstone, siltstone, shale, numerous faults, fractures, gouge.
3948 B	DWP	water	395±	360	0-280: Qalo 280-350: bedrock	sandstone, siltstone, and shale	338, 345: "Fault gouge, with bedrock fragments".
3948 C	DWP	water	361	256	0-238: Qal/Qalo 238-256: bedrock	shale	21-238: Boulders to 14 inches.
3948 D	DWP	water	416	217	0-170: Qalo 170-217: bedrock	sandstone and shale	170-217: Abundant fractures and minor faults. 183: Bituminous remains. 153-170: Some cobbles.
3948 H	DWP	water	373±	128	0-128: Qal/Qalo		75-105: Some boulders.
3949 A	DWP	water	343±	190	0-186: Qal/Qalo 186-190: bedrock	shale	
3949 B	DWP	water	340±	205	0-205: Qal/Qalo 205+: bedrock	shale	
3949 C	DWP	water	345±	137	0-131: Qal/Qalo 131-137: bedrock	sandstone & shale	
3949 D	Caltrans	foundation	381	52	0-52: Qal/Qalo		No water.
3949 E	Caltrans	foundation	367	50	0-45: Qal/Qalo 45-50: bedrock	sandstone	Sandstone very dense.
3949 F	PC	foundation	425±	57	0-13: af 13-51: Qalo 51-57: bedrock	sandstone	No caving. 12: Water seepage, 10/26/70.
3953 A	LACFCD	storm drain	715	13	0-13: Qalo		
3953 B	LACFCD	storm drain	759	13	0-3: Qalo 3-13: bedrock	granite	Granite decomposed.
3954 A	DWP	water	602±	534	0-534: Qalo		258-286: Some boulders.
3954 B	Caltrans	foundation	619	50	0-25: Qalo 25-50: bedrock	granite	Granite decomposed. No water.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
3954 D	Caltrans	foundation	640	25	0-25: Qalo		21-25: Boulders. No water.
3954 E	Caltrans	foundation	638	23	0-21: Qalo 21-23: bedrock	granite	Granite decomposed. No water.
3958 A	DWP	water	365±	96	0-96: Qal/Qalo		
3958 C	DWP	water	394±	202	0-202: Qalo		
3958 G	DWP	water	378±	155	0-136: Qal/Qalo 136-155: bedrock	shale	52: Water encountered, 4/18/55.
3958 H	DWP	water	378±	268	0-257: Qalo 257-268: bedrock	shale & sandstone	60-240: Some boulders. 60: Water encountered, 7/17/58.
3958 J	DWP	water	381±	239	0-222: Qalo 222-239: bedrock	shale	42-222: Boulders. 60: Water encountered, 5/13/58.
3958 K	DWP	water	510±	567	0-170: Qalo 170-567: bedrock	shale	Shale with sandstone and chert interbeds. 146-160: Cobbles to 8 inches.
3959 A	DWP	water	381±	98	0-98: Qal/Qalo		
3959 B	Caltrans	foundation	366	51	0-51: Qal/Qalo		
3959 C	DWP	water	355±	365	0-21: af 21-209?: Qal/Qalo 209?-365: bedrock	shale	21-209: Boulders. 209-330: "Clay or shale." 330-360: "Shale hard."
3959 D	DWP	water	350	213	0-132: Qal/Qalo 132-213: bedrock	shale & siltstone	Bedrock dips 16°-33°. 30: Water table, 7/18/57.
3959 E	DWP	water	362±	245	0-3: af 3-236: Qal/Qalo 236-245: bedrock	shale	19-236: Boulders. 56: Water table, 10/10/57.
3959 F	Caltrans	foundation	363	65	0-65: Qal/Qalo		
3959 G	Caltrans	foundation	361	51	0-48: Qal/Qalo 48-51: bedrock?	?	Bedrock: "consolidated sand and clay."
3959 H	Caltrans	foundation	360	35	0-24: Qal/Qalo 24-35: bedrock	siltstone	24-35: Siltstone dense.
3959 J	Caltrans	foundation	369	23	0-19: Qal/Qalo 19-23: bedrock	sandstone	25: Ground water surface, 10/2/58.
3963 A	Caltrans	foundation	756	33	0-33: Qalo		No water.
3964 A	Caltrans	foundation	628	57	0-57: Qalo		No water.
3964 B	Caltrans	foundation	621	47	0-47: Qalo		15-30: Cobbles and very dense. No water.
3964 C	Caltrans	foundation	638	30	0-20: Qalo 20-30: bedrock	granite	Granite decomposed. No water.
3964 D	LACFCD	storm drain	650	36	0-5: af 5-36: bedrock	granite	Granite badly decomposed.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
3964 E	LACFCD	storm drain	665	17	0-17: bedrock	granite	0-17: Granite badly decomposed. 15: Fracture zones serpentinized?
3964 F	LACFCD	storm drain	667	52	0-6 af 6-52: bedrock	granite	Granite badly decomposed.
3965 A	Caltrans	foundation	628	79	0-79: Qalo		No water.
3965 B	DWP	water	593±	20	0-20: Qalo		0-5: Some cobbles to 4 inches.
3968 A	Caltrans	foundation	424	40	0-40: Qalo		No water.
3968 B	PC	foundation	402	35	0-2: af 2-35: Qalo		26: Water level, 3/14/66.
3968 C	LACFCD	storm drain	430	22	0-22: Qalo		
3969 A	LACFCD	storm drain	429	26	0-4 af 4-26: Qalo		No caving. 6: Water encountered, 1/11/67.
3969 B	PC	foundation	406	25	0-2: af 2-22: Qalo 22-25: bedrock	sandstone	No caving. 4: Water encountered, 1/11/67.
3969 C	LACFCD	storm drain	406	25	0-2: af 2-22: Qalo 22-25: bedrock	sandstone	No caving. 4: Water encountered, 1/11/67. Same log filed for 3969 B & C.
3974 A	PC	foundation	700±	16	0-12: Qalo 12-16: bedrock	granite	12-16: Granite decomposed.
3974 B	PC	foundation	680±	38	0-10: Qalo 10-38: bedrock	granite	10-38: Granite decomposed. No caving. 2: Water seepage, 11/18/68.
3974 C	PC	foundation	682	35	0-33: Qalo 33-35: bedrock	granite	33-35: Granite decomposed.
3974 D	PC	foundation	678±	40	0-2: af 2-40: Qalo		39: Water level, 11/2/66.
3975 A	Caltrans	foundation	740	115	0-115: bedrock	granite	0-115: Granite decomposed. No water.
3975 B	Caltrans	foundation	705	81	0-5: Qalo 5-81: bedrock	granite	5-81: Granite moderately decomposed. No water.
3975 C	Caltrans	foundation	656	66	0-66: Qalo		No water.
3975 D	Caltrans	foundation	658	70	0-70: Qalo		No water
3975 E	Caltrans	foundation	681	51	0-51: Qalo		Dense at base of Qalo. No water.
3975 F	Caltrans	foundation	641	62	0-62: Qalo		No water.
3975 G	Caltrans	foundation	643	52	0-52: Qalo		Very dense at base of Qalo. No water.
3975 H	PC	foundation	573	55	0-55: Qalo		No caving. 34: Slight water seepage, 8/18/70.
3975 J	PC	foundation	582	51	0-37: Qalo 37-51: bedrock	granite	37-51: Granite decomposed. 21: Water seepage, 8/19/70.

Map No.	Operator[1/]	Designation or purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
3977 B	LACFCD	storm drain	481	26	0-26: Qalo		
3977 C	LACFCD	storm drain	474	27	0-27: Qalo		19: Water seepage, 11/2/72.
3977 D	LACFCD	storm drain	461	36	0-29: Qalo 29-36: bedrock	sandstone & siltstone	0-29: "Putrid" odor in top half. 29-36: Siltstone with inter-bedded sandstone.
3977 E	LACFCD	storm drain	465	20	0-9: af 9-20: Qalo		
3977 F	LACFCD	storm drain	452	29	0-15: Qalo 15-29: bedrock	shale & sandstone	Shale with sandstone interbeds. 8: Water encountered, 11/1/72.
3977 G	PC	foundation	460	26	0-7: Qalo 7-26: bedrock	shale	7-26: Shale fractured and with thin sandstone beds.
3977 H	PC	foundation	453	21	0-21: Qalo		Below 18: Caving. 18: Water seepage, 2/3/69.
3977 I	DWP	water	480±	70	0-45: Qalo 45-70+: bedrock?	conglomerate & shale	45-70: "Conglomerate." 70-70+: Shale.
3977 J	Calwin Oil Co.	Well #1	480±	6138	0-40: Qalo 40-6138: bedrock	shale, sandstone, & conglomerate	
3977 K	LACFCD	storm drain	440	19	0-2: af 2-5: Qalo 5-19: bedrock	shale & siltstone	5-7: Siliceous shale with 30° dip. 7-19: siltstone with minor siliceous shale.
3978 B	LACFCD	storm drain	579	17	0-2: af 2-17: bedrock	shale & sandstone	2-6: Shale with sandstone lenses.
3978 C	LACFCD	storm drain	560	20	0-7: af 7-16: Qalo 16-20: bedrock	shale & sandstone	16-20: Shale with sandstone interbeds. No caving. 11: Water seepage, 1/14/67.
3979 A	LACFCD	storm drain	534	20	0-17: Qalo 17-20: bedrock	sandstone	17-20: Sandstone with clay lenses. 9: Water encountered, 1/12/67
3979 B	LACFCD	storm drain	510	22	0-22: Qalo		11: Water seepage, 1/14/67. Below 11: Sloughing.
3979 C	LACFCD	storm drain	589	8	0-8: bedrock	siltstone & shale	0-8: Siltstone and shale laminated.
3979 D	LACFCD	storm drain	508	14	0-2: Qalo 2-14: bedrock	siltstone	2-14: Siltstone with minor sandstone lenses.
3979 E	LACFCD	storm drain	495	19	0-7: af 7-18: Qalo 18-19: bedrock	sandstone	
3979 F	LACFCD	storm drain	466	25	0-25: Qalo		16: Water seepage, 1/12/67.
3979 G	LACFCD	storm drain	448	25	0-25: Qalo		13: Water encountered, 1/12/67.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
3986 A	DWP	water	528±	91	0-85: Qalo 85-91: bedrock	granite	85-91: Granite "rotten."
3986 B	DWP	water	530±	151	0-150: Qalo 150-151: bedrock	?	
3986 C	DWP	water	582±	144	0-144: Qalo		
3986 E	DWP	water	528±	102	0-96: Qalo 96-102: bedrock	granite	96-100: Granite decomposed.
3987 A	DWP	water	480±	214	0-74: Qalo 74-214: bedrock?	shale	74-170: "Sand and shale." 170-214: Hard shale.
3987 B	DWP	water	480±	214	0-74: Qalo 74-214: bedrock?	shale	74-170: "Sand and shale." 170-214: Hard shale. Same log filed for 3987 A & B.
3987 C	DWP	water	482±	253	0-164: Qalo 164-205: bedrock?	granite	164-205: Granite decomposed. 205-253: "Cemented sand."
3987 D	LACFCD	storm drain	486	34	0-34: Qalo		12-18: H_2S odor 13: Water seepage, 11/3/72.
3987 F	DWP	water	483±	278	0-278: Qalo		124-129: Boulders.

[1]
ARCO: Atlantic Richfield Company
BOGCO: Burmak Oil and Gas Company
Caltrans: California Department of Transportation
CE: U.S. Army Corps of Engineers
DWP: Los Angeles City Department Water and Power
DWR: California Department Water Resources
Hosp: Hospital
LACFCD: Los Angeles County Flood Control District
LACIB: Los Angeles City public building
LACOB: Los Angeles County public building
MTA: Metropolitan Transit Authority (of 1962)
NPC: Neaves Petroleum Company
PC: Private consultant or contractor
SBOC: Seaboard Oil Company
SOCAL: Standard Oil Company of California
TEXACO: Texaco, Incorporated
VOCO: Ventura Oil Company
WS: William Sullivan
WSP 139: U.S. Geological Survey Water Supply Paper 139

[2]
af: Artificial fill and colluvium
Qal: Alluvium
Qalo: Old alluvium
Qsp: San Pedro Formation (Thomas and others, 1961)

Table 1B. Wells and shallow borings shown on sheet 3B (South Sheet)

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2702 A	PC	foundation	312±	20	0-8: af 8-20: bedrock	shale	1-7: Some cemented lumps. No caving. No water.
2703 A	PC	foundation	245±	40	0-16: af 16-40: bedrock	shale	Shale weathered and laminated. 37-38: Highly cemented layer. No caving. 37: Water seepage, 8/14/59.
2703 B	PC	foundation	249	48	0-35: af 35-48: bedrock	shale	Shale weathered with hard lenses. 38-39: Firm layer. 0-25: "Caving badly."
2703 C	PC	foundation	242	26	0-20: af 20-26: bedrock	shale	Shale firm. No caving. No water.
2703 D	PC	foundation	240	46	0-22: af 22-37: Qalo 37-46: bedrock	shale	Shale weathered. 42-43: Hard layer. No caving. 27: Slight water seepage, 8/12/59.
2703 E	PC	foundation	248	40	0-27: af 27-40: bedrock	shale	Shale weathered. Above 7: Moderate raveling. 29: Water seepage, 7/16/64.
2703 F	PC	foundation	246	50	0-27: af 27-45: Qal/Qalo 45-50: bedrock	shale	Shale weathered and bedded. Water seepage present, 8/3/67.
2703 G	PC	foundation	244±	49	0-45: af 45-49: Qal/Qalo		Patchy raveling in af. 25: Water seepage, 8/14/63.
2703 H	PC	foundation	241	50	0-38: af 38-47: Qal/Qalo 47-50: bedrock	shale	Shale weathered. No caving. 32: Perched(?) water, 2/24/60.
2703 J	PC	foundation	249±	55	0-17: af 17-27: Qal/Qalo 27-55: bedrock	shale	Shale highly weathered, jointed, fractured, and bedded. No caving. 30: Water seepage, 4/9/63.
2703 K	PC	foundation	249±	49	0-26: Qalo 26-49: bedrock	shale	Shale highly weathered, jointed, fractured, and bedded. 24-25: Sloughing. 25: Water seepage, 4/9/63.
2703 L	MTA	WC-75	255	49	0-35: Qalo 35-49: bedrock	siltstone	Bedrock dips to 20°. 10-15: Perched(?) water, 2/20/62.
2703 M	PC	foundation	250±	49	0-29: Qalo 29-49: bedrock	shale	Shale stratified and weathered grading to unweathered. 35,42: Hard cemented layers. 18-22: Caving...no data after 29 feet. 19-29: Water seepage, 1/9/59.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2703 N	PC	foundation	245	58	0-33: af 33-54: Qalo 54-58: bedrock	shale	Shale weathered and bedded. 55: Cemented layers. Below 29: Heavy sloughing. 29,32: Water seepage, 3/3/70.
2704 A	PC	foundation	226	26	0-8: af 8-19: Qal/Qalo 19-26: bedrock	shale	Shale weathered and bedded. 10-12: Caving. 10: Water seepage, 6/28/63.
2707 A	PC	foundation	174	16	0-4: af 4-16: Qal/Qalo		4-16: Few cobbles to 10 inches. Below 6: Raveling. No water.
2709 A	PC	foundation	162±	40	0-7: af 7-40: Qal/Qalo		9-14: Caving. No water.
2711 F	LACFCD	storm drain	295±	32	0-8: Qalo 8-32: bedrock	shale & siltstone	
2711 G	LACFCD	storm drain	297±	34	0-34: bedrock	shale & siltstone	0-10: Shale. 10-34: Siltstone.
2711 H	PC	foundation	294	35	0-2: af 2-19: Qalo 19-35: bedrock	shale	Shale interbedded with thin layers of siltstone. 19-25: Shale highly weathered. No caving. 23: Water seepage, 10/22/74.
2711 J	PC	foundation	291	16	0-3: af 3-15: Qalo 15-16: bedrock	shale	Shale weathered and fractured. 11-15: Caving. 11: Water encountered, 5/30/75.
2712 A	PC	foundation	268	45	0-11: af 11-27: Qalo 27-45: bedrock	siltstone	22-45: Petroleum odor. Water seepage present, 4/6/72.
2712 B	PC	foundation	280±	61	0-57: af 57-61: bedrock	shale	54: Patches of oil-bearing sand. 40-41: "Caving badly." 40: Water seepage, 1957.
2712 C	PC	foundation	270±	49	0-40: af 40-49: bedrock	shale	Shale slightly fractured and thinly bedded. No caving. 30-40: Slight water seepage, 8/21/63.
2712 D	PC	foundation	270±	52	0-43: af 43-46: Qalo 46-53: bedrock	shale	Shale laminated. 40-43: Squeezing-in. 41: Water seepage, 4/28/58.
2712 E	LACFCD	storm drain	310±	35	0-35: bedrock	shale & siltstone	Shale and siltstone interbedded.
2712 F	LACFCD	storm drain	280±	29	0-4: af 4-29: bedrock	sandstone, siltstone, & shale	Sandstone, siltstone, and shale interbedded.
2712 G	LACFCD	storm drain	269±	27	0-16: Qalo 16-27: bedrock	sandstone & siltstone	Sandstone and siltstone interbedded. 21-27: Petroleum odor.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2712 H	LACFCD	storm drain	275±	12	0-7: Qalo 7-12: bedrock	sandstone	
2712 I	LACFCD	storm drain	290±	21	0-10: af 10-21: bedrock	siltstone & sandstone	15-21: Petroleum odor and feel. No caving. 13: Water encountered, 1/27/70.
2712 J	LACFCD	storm drain	290±	56	0-5: af 5-56: bedrock	sandstone & siltstone	Sandstone and siltstone interlayered. 17-56: Petroleum. No caving. 11: Water seepage, 5/5/70.
2712 K	LACFCD	storm drain	286±	28	0-10: af 10-28: bedrock	siltstone	
2712 L	LACFCD	storm drain	286±	25	0-7: af 7-21: bedrock	shale & siltstone	7-21: Shale. 21-25: Siltstone.
2712 M	Caltrans	foundation	298	36	0-12: af 12-36: Qalo		26: Water encountered, 1/13/49.
2712 N	LACFCD	storm drain	280±	32	0-32: Qalo		
2712 P	PC	foundation	320	34	0-27: af 27-34: bedrock	shale	Shale bedded. No caving or water.
2712 Q	PC	foundation	340±	50	0-6: af 6-50: bedrock	siltstone	Siltstone weathered, fractured, and bedded, with sandstone layers, and with seams of gypsum. 41: Oil traces. No caving or water.
2712 R	LACFCD	storm drain	289±	30	0-30: af		
2712 S	PC	foundation	361±	49	0-6: af 6-49: bedrock	siltstone	Siltstone fractured with layers of sandstone and seams of gypsum. 44: Oil traces. No caving or water.
2713 A	PC	foundation	265±	27	0-24: af 24-27: bedrock	sandstone	Sandstone weathered and slightly cemented. No caving. Slight seepage present, 6/6/62.
2713 B	DWP	water	263±	270	0-270: Qalo		240-270: Oil.
2713 C	DWP	water	310±	500	0-500: bedrock	granite	385-400: Oil. 400-425: Oil, gas.
2713 D	LACFCD	storm drain	263±	35	0-17: Qalo 17-35: bedrock	siltstone, shale, & sandstone	17-27: Siltstone. 27-33: Shale with oily texture. 33-35: Sandstone.
2713 E	LACFCD	storm drain	285±	41	0-13: af 13-41: bedrock	siltstone & shale	13-17: Siltstone. 17-41: Shale.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2713 F	LACFCD	storm drain	260±	35	0-18: Qalo 18-35: bedrock	shale & siltstone	18-32: Shale. 32-35 : Siltstone.
2713 G	PC	foundation	264	30	0-6: af 6-8: Qalo 8-30: bedrock	shale	Shale weathered and bedded. No caving. 22: Slight water seepage, 1/28/63.
2713 H	LACFCD	storm drain	253±	40	0-4: af 4-21: Qal/Qalo 21-40: bedrock	siltstone	
2713 I	PC	foundation	277	50	0-18: af 18-35: Qalo 35-50: bedrock	shale	Shale highly weathered with thin beds of sandstone. Below 20: Heavy caving and squeezing. 21,25: Slight water seepage, 3/26/69.
2713 J	PC	foundation	260	62	0-2: af 2-7: Qalo 7-62: bedrock	shale	7-32: Shale highly weathered and fractured with thin sandstone beds. 32-62: Shale less weathered. 2-7: Some cobbles to 8 inches. No caving. 27: Water seepage, 10/11/68.
2713 K	LACFCD	storm drain	254±	30	0-18: af 18-30: bedrock	siltstone	
2713 L	LACFCD	storm drain	262±	31	0-9: af? 9-14: Qal/Qalo 14-31: bedrock	sandstone & siltstone	Sandstone and siltstone interbedded.
2713 M	PC	foundation	247±	26	0-4: Qal/Qalo 4-26: bedrock	shale	Shale weathered. 17: Shale highly fractured. No caving. 16: Slight water seepage, 7/5/61.
2713 N	LACFCD	storm drain	247±	34	0-14: Qal/Qalo 14-34: bedrock	sandstone & siltstone	14-18: Sandstone. 18-34: Siltstone.
2713 P	LACFCD	storm drain	258±	45	0-3: Qalo 3-45: bedrock	siltstone	3-10: Tar abundant. 10-45: Tar interbedded.
2713 Q	PC	foundation	280±	50	0-2: af 2-17: Qalo 17-50: bedrock	shale	Shale laminated. 2-17: Asphalt saturated. 25: Asphaltic sand. 23,44,50: Oil seepage. No caving or water.
2713 R	PC	foundation	256	27	0-9: af 9-17: Qalo 17-27: bedrock	shale	Shale fractured with interbedded lenses of siltstone. 9-17: Asphalt prolific. 20: Asphalt streaks. No caving or water.
2713 S	PC	foundation	253	36	0-14: Qalo 14-36: bedrock	shale	Shale slightly fractured and jointed, thinly bedded, and with sandstone lenses. No caving. 16: Very slight water seepage, 1/24/64

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2713 T	PC	foundation	258	49	0-7: af 7-26: Qalo 26-49: bedrock	shale	Shale thinly bedded, slightly fractured and jointed. 26-49: Occasional oil seams. 3-8: Caving. No water.
2713 U	PC	foundation	261	40	0-33: Qalo 33-40: bedrock	shale	14-16, 29: Highly cemented. 16-20: Asphaltic sand saturated with oil. 33-40: Asphaltic sand laminations. No caving. 15: Slight water seepage, 2/13/58.
2713 V	PC	foundation	261	60	0-31: Qalo 31-60: bedrock	shale	13, 17: Very oily. 19-31: Odorous.
2713 W	MTA	WC-78	245	42	0-25: Qal/Qalo 25-42: bedrock	siltstone	Siltstone bedded. 17: Water encountered, 3/14/62.
2713 X	PC	foundation	262	50	0-4: af 4-23: Qalo 23-50: bedrock	shale	No caving. 29: Moderate water seepage, 1956.
2713 Y	PC	foundation	262	50	0-3: af 3-30: Qalo 30-50: bedrock	shale	Shale weathered, fractured, bedded. 35: Tar streaks. 38-41: Hard cemented layer. Water present, 6/20/71.
2713 Z	MTA	WC-76	258	61	0-28: Qal/Qalo 28-61: bedrock	siltstone	Siltstone with 20° dip. 50-61: Strong H_2S odor. 14: Water encountered, 3/13/62.
2713 AA	MTA	WC-77	260	57	0-30: Qalo 30-57: bedrock	siltstone	Siltstone with 25° dip. 17-30: Petroliferous odor. 30-40: Asphaltic sand. Below 15: Water encountered, 3/13/62.
2713 BB	PC	foundation	255	32	0-3: af 3-27: Qalo 27-32: bedrock	shale	No caving. 17, 25: Water seepage, 4/29/67.
2713 DD	PC	foundation	264	42	0-2: af 2-31: Qalo 31-42: bedrock	shale	Shale weathered and interbedded with sandstone. 24-29: Caving...no data after 29 feet. 24: Water encountered, 10/13/71.
2713 EE	PC	foundation	264±	49	0-1: af 1-27: Qalo 27-49: bedrock	shale	Shale laminated. No caving. 26: Slight water seepage, 1957. 37: Heavy water seepage, 1957.
2713 FF	PC	foundation	265±	48	0-1: af 1-23: Qalo 23-48: bedrock	shale	Shale laminated. No caving. 31, 40: Slight water seepage, 1957.

Map No.	Operator	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2713 GG	PC	foundation	266	21	0-2: af 2-19: Qalo 19-21: bedrock	shale	No caving or water.
2713 HH	PC	foundation	267	32	0-1: af 1-29: Qalo 29-32: bedrock	shale	Shale weathered. 23-29: Heavy caving. 25: Water seepage, 4/14/59.
2713 II	PC	foundation	270	35	0-23: Qalo 23-35: bedrock	shale	Shale weathered. 21-23: Moderate caving. 28: Water seepage, 4/14/59.
2713 JJ	PC	foundation	272	31	0-26: Qalo 26-31: bedrock	shale	Shale well-bedded. 0-26: Slight caving. 25: Water seepage, 1/22/63.
2713 KK	PC	foundation	258	65	0-2: af 2-27: Qalo 27-65: bedrock	shale	No caving. 27: Water seepage, 5/28/72.
2713 LL	PC	foundation	243	49	0-15: af 15-27: Qalo 27-49: bedrock	shale	0-16: Raveling. 27: Water seepage, 5/29/72.
2713 MM	PC	foundation	248	34	0-1: af 1-14: Qalo 14-34: bedrock	shale	Shale with sandstone lenses. 4-14: Slight sloughing. 4, 14: Water seepage, 9/14/66.
2713 NN	PC	foundation	260	39	0-6: af 6-19: Qalo 19-39: bedrock	shale	Shale fractured and laminated. No caving. 26: Water seepage, 5/26/65.
2713 PP	PC	foundation	249	48	0-10: af 10-31: Qalo 31-48: bedrock	shale	Shale weathered. 43-48: Highly cemented. 25-31: Caving. 28-31: Water seepage, 2/12/69.
2713 QQ	PC	foundation	244	45	0-4: af 4-30: Qalo 30-45: bedrock	shale	Shale with sandstone lenses. 45: Cemented. 24-30: Sloughing. 24: Water seepage, 9/25/68.
2713 RR	PC	foundation	250	49	0-7: af 7-20: Qalo 20-49: bedrock	shale	Shale weathered. 49: Highly cemented. No caving. 28: Slight water seepage, 10/25/68.
2713 SS	PC	foundation	246	32	0-8: af 8-10: Qalo 10-32: bedrock	shale	Shale with sandstone lenses. No caving or water.
2713 TT	PC	foundation	263	38	0-23: Qalo 23-38: bedrock	shale	Shale weathered, jointed, thickly bedded, and with gypsum lenses. No caving. 23, 32: Slight water seepage, 11/19/69.

Map No.	Operator	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2713 UU	PC	foundation	244	41	0-12: af 12-19: Qalo 19-41: bedrock	shale	Shale weathered with sandstone lenses. 41: Highly cemented. No caving. 23: Slight water seepage, 10/26/68.
2713 XX	MTA	WC-79	259	55	0-22: Qalo 22-55: bedrock	siltstone	5-45: Petroliferous. No water.
2713 YY	PC	foundation	260±	60	0-4: af 4-35: Qalo 35-60: bedrock	shale	Shale weathered and laminated. Below 20: Heavy caving. 21: Water seepage, 1/17/61.
2714 A	MTA	WC-80	266	67	0-15: Qalo 15-67: bedrock	siltstone	Siltstone with a vertical dip.
2714 B	LACFCD	storm drain	257±	43	0-5: af 5-12: Qalo 12-43: bedrock	siltstone	5-7: Tar saturated.
2714 C	PC	foundation	244±	33	0-1: af 1-11: Qalo 11-33: bedrock	shale	0-30: Shale weathered. 30-33: Shale very firm. No caving. 22: Moderate water seepage, 5/2/60.
2714 D	LACFCD	storm drain	271±	41	0-3: af 3-27: Qalo 27-41: bedrock	siltstone & sandstone	Siltsone and sandstone interbedded.
2714 E	MTA	WC-81	278	67	0-17: Qalo 17-67: bedrock	siltstone	
2714 F	LACFCD	storm drain	237±	36	0-36: Qal/Qalo		2-18: Petroleum odor.
2714 G	PC	foundation	260±	50	0-50: Qalo		No caving or water.
2715 A	SOCAL	Roseberry CH 1	243±	2200	0-155: Qalo 155-2200: bedrock	shale, siltstone, & other	155-2000: Shale and siltstone.
2716 A	ARCO	West Adams CH 1	198±	1900	0-215: Qal/Qalo/Qsp 215-1900: bedrock	shale	
2717 A	SOCAL	Dana CH 2	190±	2100	0-255: Qal/Qalo 255-675: Qsp? 675-2100: bedrock	siltstone & shale	
2718 A	DWP	water	185±	152	0-152: Qal/Qalo		
2718 B	PC	foundation	182±	76	0-76: Qal/Qalo		16-36: 5% cobbles to 8 inches with a few boulders. 7-36, 65-76: Caving. 53: Very slight water seepage, 12/14/64.
2718 C	LACOB	foundation	178±	26	0-26: Qal/Qalo		15-26: Cobbles to 8 inches.
2718 D	LACOB	foundation	178±	25	0-25: Qal/Qalo		16-25: Some cobbles to 8 inches.
2719 A	DWP	water	161±	98	0-98: Qal/Qalo		
2719 B	DWP	water	175±	60	0-60: Qal/Qalo		

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2719 C	Caltrans	foundation	159±	100	0-100: Qal/Qalo		No water.
2721 C	LACFCD	storm drain	334	27	0-8: Qalo 8-27 : bedrock	shale	Shale weathered. 12: Water encountered, 4/29/68.
2721 D	LACFCD	storm drain	328±	34	0-34: bedrock	sandstone, siltstone, & shale	0-20: Sandstone 20-28: Siltstone and shale. 28-34: Sandstone.
2721 E	LACFCD	storm drain	310±	23	0-23: Qalo		
2721 F	LACFCD	storm drain	366	16	0-16: bedrock	sandstone	
2722 A	LACFCD	storm drain	289±	14	0-14: af		
2722 B	PC	foundation	288±	16	0-12: af 12-16: bedrock	shale	Shale weathered. No caving or water.
2722 C	LACFCD	storm drain	297	8	0-8: bedrock	sandstone & siltstone	Sandstone and siltstone interbedded.
2722 D	LACFCD	storm drain	324	15	0-13: af 13-15: bedrock	siltstone	
2722 E	LACFCD	storm drain	349	7	0-5: af 5-7: bedrock	siltstone & shale	Siltstone and shale interbedded.
2722 F	LACFCD	storm drain	360	24	0-2: af 2-24: bedrock	sandstone, siltstone, & shale	Sandstone, siltstone, and shale interbedded.
2722 G	PC	foundation	302±	20	0-18: af 18-20: bedrock	shale	Shale weathered. No caving. 15: Water seepage, 8/29/63.
2722 H	PC	foundation	361±	20	0-9: af 9-20: bedrock	shale	Shale thinly laminated. No caving or water.
2722 I	DWP	water	380±	640	0-640: bedrock	sandstone or siltstone	440-480: Oil. 50: Water encountered, 1902.
2722 J	PC	foundation	361	30	0-3: af 3-30: bedrock	shale	Shale with sandy lenses fractured and bedded with an average strike and dip of 9°, 180°. No caving or water.
2723 A	PC	foundation	313	36	0-15: af 15-36: bedrock	shale	Shale weathered. No caving. 19: Water encountered, 9/20/66.
2723 B	PC	foundation	309	31	0-31: af		No caving. 15: Water seepage, 1955.
2723 C	LACFCD	storm drain	327±	24	0-24: af		18-24: Asphaltic material.
2723 D	LACFCD	storm drain	389±	24	0-24: Qalo		
2723 E	PC	foundation	329	26	0-16: af 16-26: bedrock	shale	Shale jointed and moderately cemented. No caving or water.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2723 F	LACFCD	storm drain	290±	19	0-7: af 7-19: Qalo		13-19: Petroleum seepage.
2723 G	LACFCD	storm drain	290±	24	0-15: af 15-24: bedrock	siltstone ?	8-24: Petroleum odor.
2723 H	LACFCD	storm drain	345±	30	0-30: af		
2723 I	LACFCD	storm drain	272±	26	0-15: Qalo 15-26: bedrock	sandstone & siltstone	Sandstone and siltstone interbedded.
2723 J	PC	foundation	303±	32	0-2: af 2-32: bedrock	sandstone & shale	Sandstone with interbeds of shale with a strike and dip of N86°W, 12°S. No caving. 25: Water seepage, 11/22/61.
2723 K	LACFCD	storm drain	300±	39	0-26: af 26-29: Qalo 29-39: bedrock	sandstone & siltstone	26-29: Methane odor.
2723 L	LACFCD	storm drain	300±	26	0-17: af 17-26: Qalo		
2723 M	LACFCD	storm drain	265±	30	0-18: Qal/Qalo 18-30: bedrock?	sandstone & siltstone	Sandstone and siltstone interbedded.
2723 N	PC	foundation	355	100	0-6: af 6-100: bedrock		Shale bedded and slightly fractured. 52, 66, 97: Petroleum odors. 48-52, 68: Cemented layers. 46: Water seepage, 4/27/68.
2723 P	PC	foundation	352	55	0-15: af 15-55: bedrock	sandstone & shale	Sandstone with shale interbeds. 31: Petroleum odor. No caving or water.
2723 Q	PC	foundation	357	96	0-15: af 15-96: bedrock	shale	39: Gaseous odor. 89: Oil streaks. 68, 72, 83: Cemented layers. No caving. 25: Water seepage, 10/18/73.
2723 R	PC	foundation	365	65	0-7: af 7-65: bedrock	shale	36: Cemented sandstone layer. No caving. 27-36: Water seepage, 10/20/73.
2723 S	PC	foundation	408	76	0-3: af 3-76: bedrock	shale	Shale weathered and fractured. 22-24, 32-35, 43-45: jointed and hard cemented layers. No caving. 32: Slight water seepage, 3/18/63.
2723 T	PC	foundation	363	35	0-1: af 1-35: bedrock	shale	Shale fractured with sandstone interbeds with strike and dip of 175°, 49°. 18: Cemented layer. No caving. 28: Water seepage, 7/11/69.
2723 U	LACOB	foundation	280±	21	0-12: Qalo 12-21: bedrock	siltstone	8-12: Asphaltic stain. 12-14, 17-20: Asphalt.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2723 V	LACOB	foundation	290±	35	0-10: Qalo 10-35: bedrock	siltstone	8-35: Asphalt stains.
2723 W	LACOB	foundation	289	30	0-30: Qalo		
2723 X	LACOB	foundation	300±	31	0-13: Qalo 13-31: bedrock	siltstone	
2723 Y	PC	foundation	326±	26	0-13: af 13-26: bedrock	shale	Shale thinly bedded, slightly weathered and fractured. 21: Cemented layer. No caving. 26: Water seepage, 10/30/64.
2724 A	PC	foundation	256	30	0-7: af 7-23: Qalo 23-30: bedrock	shale	3-7: Caving. 1: Water seepage, 12/10/70.
2724 B	MTA	WC-82	273	66	0-11: Qalo 11-66: bedrock	siltstone	11-13: Siltstone dips 25°. 30-66: Siltstone dips 60°. No water.
2724 C	MTA	WC-83	266	51	0-15: Qal/Qalo 15-51: bedrock	siltstone	38: Water encountered, 1/29/62.
2724 D	MTA	WC-84	260	46	0-10: Qal/Qalo 10-46: bedrock	siltstone	Siltstone dips 5°. 16-19, 30-42: H_2S. No water.
2724 E	MTA	WC-85	263	52	0-10: Qal/Qalo 10-52: bedrock	siltstone	Siltstone dips 60°. 15-16: H_2S. 16: Water encountered, 2/5/62.
2724 K	MTA	WC-86	277	61	0-5: Qalo 5-61: bedrock	claystone & siltstone	5-25: Claystone. 25-61: Siltstone.
2724 L	MTA	WC-87	290	67	0-15: Qalo 15-67: bedrock	claystone & siltstone	
2724 M	MTA	WC-88	301	76	0-22: Qalo 22-76: bedrock	siltstone	22-70: Siltstone weathered. 50-55: H_2S.
2724 N	MTA	WC-89	302±	71	0-23: Qalo 23-71: bedrock	siltstone	
2724 F	PC	foundation	277	26	0-1: af 1-26: bedrock	shale	No caving. 14, 17, 18: Slight water seepage, 10/2/64.
2724 G	PC	foundation	281	50	0-4: af 4-18: Qalo 18-50: bedrock	shale	Shale with sandstone lenses. No caving. 15: Water seepage, 1/11/65.
2724 H	PC	foundation	277	41	0-6: af 6-23: Qalo 23-41: bedrock	shale	Shale with sandstone lenses. No caving. 11: Water encountered, 1/9/65.
2724 I	PC	foundation	310	37	0-2: Qalo 2-37: bedrock	shale	Shale weathered. No caving. 8: Water seepage, 8/24/59.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2724 J	PC	foundation	310±	?	0-14: ? 14-?: bedrock	?	Data from plot plan. No log available.
2724 P	LACIB	foundation	258	16	0-1: af 1-16: Qalo		
2724 Q	PC	foundation	267±	35	0-2: af 2-35: Qalo		No caving or water.
2724 R	PC	foundation	274	31	0-31: Qalo		No caving or water.
2725 A	PC	foundation	258	40	0-2: af 2-40: Qalo		No caving or water.
2725 B	PC	foundation	255±	60	0-1: af 1-60: Qalo		50-60: Cobbles to 7 inches. No caving or water.
2725 C	PC	foundation	248±	41	0-41: Qal/Qalo		22-39: Raveling. No water.
2725 D	PC	foundation	248±	40	0-40: Qalo		
2726 A	ARCO	West Adams CH 2	215±	3100	0-365: Qal/Qalo/Qsp 365-3100: bedrock	shale & siltstone	365-2335: Shale 2335-2610: Siltstone 2610-3100: Siltstone and shale interbedded.
2726 B	SOCAL	Expos.Park-St.James CH 1	216±	2500	0-260: Qal/Qalo 260-340: Qsp 340-2500: bedrock	siltstone & shale	
2727 A	DWP	water	200±	390	0-390: Qal/Qalo		40-48: Boulders.
2727 B	LACOB	foundation	202	100	0-100: Qal/Qalo		11-42: Cobbles.
2727 C	SOCAL	Garey Comm. 1	208±	2000	0-630: Qal/Qalo/Qsp 630-2000: bedrock	siltstone & shale	
2727 R	DWP	water	190	390	0-390: Qal/Qal/Qsp?		
2728 A	DWP	water	198±	350	0-350: Qal/Qalo		
2729 B	DWP	water	175±	171	0-171: Qal/Qalo		
2731 B	ARCO	Silverlake Comm. A-1	378±	8045	0-8045: bedrock	sandstone	
2731 D	LACFCD	storm drain	382	18	0-18: af		
2731 F	PC	foundation	399	20	0-20: Qal/Qalo		
2732 B	PC	foundation	432	33	0-1: af 1-33: bedrock	shale	Shale fractured with some sandstone layers. No caving or water.
2732 C	PC	foundation	389	55	0-4: af 4-33: Qal/Qalo 33-55: bedrock	sandstone	Sandstone slightly weathered with lenses of shale. 52: Oily. No caving. 16: Water seepage, 4/5/63.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2732 D	PC	foundation	392	46	0-19: af 19-46: bedrock	sandstone	Sandstone weathered. 25: Cemented lenses. 42: Oily. No caving. 18: Heavy seepage, 12/4/64.
2732 E	PC	foundation	389	45	0-23: af 23-45: bedrock	sandstone	Sandstone weathered with layers of shale. 35: Oily. No caving. 16: Heavy seepage, 12/4/64.
2732 F	Caltrans	foundation	382	27	0-27: af		23: Ground water surface, 1948.
2732 G	Caltrans	foundation	380	40	0-37: af/Qal? 37-40: bedrock	siltstone	19: Ground water surface, 1948.
2732 H	Caltrans	foundation	380	27	0-27: af		15: Ground water surface, 1948.
2732 I	PC	foundation	373±	30	0-30: af		No caving. 25: Water seepage, 4/17/64.
2732 J	PC	foundation	372±	26	0-1: af 1-26: bedrock	sandstone & shale	Sandstone and shale interbedded, weathered, and jointed. No caving or water.
2733 A	LACFCD	storm drain	357±	14	0-14: af		
2733 B	LACFCD	storm drain	344±	22	0-22: af		
2733 C	LACFCD	storm drain	340±	38	0-38: af		
2733 D	LACFCD	storm drain	338±	30	0-30: af		
2733 E	LACFCD	storm drain	360±	55	0-11: af 11-55: bedrock	sandstone & siltstone	Sandstone and siltstone interbedded
2733 F	PC	foundation	374	35	0-10: af 10-35: bedrock	shale & sandstone	Bedrock badly weathered. 10-17: Shale massive. 17-35: Sandstone with badly weathered shale layers every 5 feet. No caving or water.
2733 G	PC	foundation	380±	40	0-28: af 28-40: bedrock	shale & sandstone	28-30: Shale laminated. 30-40: Sandstone. No caving. 31: Slight water seepage, 7/25/61.
2733 I	PC	foundation	419	25	0-6: af 6-25: bedrock	shale	16: Cemented lenses. No caving or water.
2733 J	PC	foundation	418±	24	0-9: af 9-24: bedrock	shale	Shale weathered, bedded, and with some gypsum. No caving. 16: Water seepage, 4/12/76.
2733 K	PC	foundation	416±	24	0-14: af 14-24: bedrock	shale	Shale weathered and bedded. No caving. 14: Water seepage, 4/12/76.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2733 L	PC	foundation	410±	39	0-25: af 25-39: bedrock	shale	Shale weathered. No caving. 10: Slight water seepage, 1955.
2733 M	PC	foundation	400	47	0-25: af 25-47: bedrock	shale	Shale weathered. 10: Cobbles to 6 inches. 15, 21-25, 33, 37, 46: Oil. 3-5: Slight caving. 26: Moderate water seepage, 7/3/62.
2733 N	PC	foundation	392	51	0-43: af 43-51: bedrock	shale	Shale weathered. 8-40: Severe caving. 30: Water encountered, 6/26/67.
2733 P	PC	foundation	360±	33	0-30: af 30-33: bedrock	shale	No caving. 26: Water seepage, 7/57.
2733 Q	PC	foundation	263±	26	0-1: af 1-26: bedrock	shale	Shale weathered, fractured, and thinly laminated. 10, 12, 26: Gypsum layers. No caving or water.
2733 R	PC	foundation	362±	72	0-30: af 30-43: Qalo 43-72: bedrock	shale	Shale laminated. 58: "Strong odor" 61: Cemented layer. No caving. 26: Water seepage, 7/31/63.
2733 S	PC	foundation	360±	50	0-36: af 36-41: Qalo 41-50: bedrock	shale	No caving. 35-41: Slight water seepage, 3/5/58
2734 A	PC	foundation	425±	25	0-7: af 7-25: bedrock	shale	Shale laminated. No caving or water.
2734 B	PC	foundation	414±	30	0-23: af 23-30: bedrock	shale	Shale with streaks of sandstone. No caving or water.
2734 C	PC	foundation	390±	38	0-38: bedrock	shale	Shale thin-bedded, slightly weathered, fractured, and jointed. No caving or water.
2734 D	PC	foundation	337	61	0-3: af 3-61: bedrock	shale	Shale weathered and massive. No caving. 17, 21: Water seepage, 5/7/69.
2734 E	PC	foundation	339	40	0-1: af 1-4: Qalo 4-40: bedrock	shale	Shale weathered. No caving. 23: Water seepage, 10/28/69.
2734 F	PC	foundation	318	40	0-16: Qalo 16-40: bedrock	shale	Shale weathered. No caving or water.
2734 G	MTA	WC-90	300	63	0-23: Qalo 23-63: bedrock	siltstone	24: Water encountered, 2/15/62.
2734 H	PC	foundation	309±	44	0-23: Qalo 23-44: bedrock	shale	Shale weathered. No caving. 30: Slight water seepage, 8/15/63.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2734 I	HOSP	foundation	342	50	0-50: bedrock	shale	Shale massive. 10: Gaseous odor. No caving.
2734 J	HOSP	foundation	342	43	0-7: Qalo 7-43: bedrock	shale	Shale massive. 20: Strong gaseous odor.
2734 K	HOSP	foundation	347	69	0-69: bedrock	shale	Shale massive. 11: Gaseous odor. No caving.
2734 L	HOSP	foundation	355	60	0-60: bedrock	shale	No caving.
2734 M	HOSP	foundation	371	50	0-50: bedrock	shale	3-26: Shale with many cemented layers. Raveling in cemented layers.
2734 N	HOSP	foundation	345	40	0-40: bedrock	shale	Shale massive. 9: "Odorous layer". 22: Slight raveling.
2734 P	HOSP	foundation	345	40	0-3: af 3-40: bedrock	shale	No caving.
2734 Q	HOSP	foundation	345	40	0-40: bedrock	shale	No caving.
2734 R	PC	foundation	335	49	0-20: af 20-49: bedrock	shale	Shale massive, fractured, weathered and with cemented lenses. 34-36: Highly cemented layer. No caving. 32, 35: Water seepage, 9/13/69.
2734 S	PC	foundation	380±	49	0-1: af 1-49: bedrock	shale	Shale massive. No caving or water.
2734 T	PC	foundation	329±	41	0-5: af 5-30: Qalo 30-41: bedrock	shale	Shale fractured. 40: Cemented layer. 21-30: Raveling. 40: Slight water seepage, 10/19/68.
2734 U	MTA	WC-91	298	53	0-26: Qalo 26-53: bedrock	siltstone	
2734 V	PC	foundation	326	50	0-3: af 3-34: Qalo 34-50: bedrock	shale	Shale massive, fractured, weathered. Occasional 8-inch cobble at base of Qalo. No caving or water.
2734 W	PC	foundation	303	44	0-13: af 13-31: Qalo 31-44: bedrock	shale	Shale weathered. No caving. 23: Water seepage, 12/11/68.
2734 X	MTA	WC-92	300	45	0-26: Qalo 26-45: bedrock	siltstone	
2734 Y	MTA	WC-93	303	50	0-26: Qalo 26-50: bedrock	siltstone	

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2734 Z	PC	foundation	350±	61	0-3: af 3-61: bedrock	shale (siltstone)	42-44: Highly cemented layer. No caving. 37: Slight water seepage, 5/20/72.
2734 AA	MTA	WC-94	306	63	0-30: Qalo 30-63: bedrock	siltstone	56: Bedrock hard.
2734 BB	Caltrans	foundation	307	58	0-26: Qalo 26-58: bedrock	siltstone & shale	26-42: Siltstone. 42-58: Shale. No water.
2734 CC	Caltrans	foundation	306	47	0-32: Qalo 32-47: bedrock	siltstone & shale	32-43: Siltstone. 43-47: Shale. No water.
2734 DD	Caltrans	foundation	303	43	0-30: Qalo 30-43: bedrock	siltstone & shale	30-41: Siltstone. 41-43: Shale. No water.
2734 EE	Caltrans	foundation	304	42	0-25: Qalo 25-42: bedrock	siltstone & shale	25-39: Siltstone. 39-42: Shale. No water.
2734 FF	MTA	WC-95	295±	70	0-44: Qalo 44-70: bedrock	siltstone	55-60: Petroliferous. 61-66: Hard shale layer in siltstone.
2734 GG	Caltrans	foundation	325	60	0-60: bedrock	shale	13-60: Shale firm. 23: Ground water surface, 9/25/49.
2734 HH	Caltrans	foundation	336	69	0-69: bedrock	shale	Shale grades from stiff to hard with depth. 31: Ground water surface, 9/25/49.
2735 A	Caltrans	foundation	263	109	0-109: Qal/Qalo		No water.
2735 B	PC	foundation	280±	76	0-20: af 20-60: Qal/Qalo 60-76: bedrock	shale	35-39: Few cobbles to 8 inches. 36-49: Slight caving and raveling. No water.
2735 C	LACIB	foundation	252±	34	0-4: af 4-34: Qal/Qalo		13-33: 20% cobbles to 14 inches.
2735 D	SOCAL	SMJ CH 1	274	5117	0-132?: Qal/Qalo 132-5117: bedrock	shale, siltstone, & other	132-2050: Shale and siltstone.
2735 E	SOCAL	Salvation Army CH 1	242±	6225	0-145: Qalo 145-6225: bedrock	siltstone, shale, & sandstone	800-2250: Siltstone and sandstone. 2250-2615: Siltstone and sandstone. 2615-2850: Shale.
2735 F	SOCAL	Std.-Occidental-Albany CH 1	232	5400	0-170: Qal/Qalo 170-220: Qsp? 220-5400: bedrock	shale & sandstone	220-4425: Shale. 4425-5400: Sandstone and shale.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2736 A	LACIB	foundation	242	62	0-4: af 4-62: Qal/Qalo		8-25: Cobbles to 8 inches.
2736 B	SOCAL	Broadway Comm. CH 1	236±	6220	0-165: Qal/Qalo 165-225: Qsp? 225-6220: bedrock	siltstone, shale, & sandstone	225-2245: Siltstone and shale. 2245-2850: Shale with interbedded sandstone.
2736 C	SOCAL	LA Unit Venice Comm. 1	233±	4200	0-258: Qal/Qsp 258-1100: bedrock	shale	
2736 D	PC	foundation	227±	35	0-35: Qal/Qalo		4-35: Cobbles to 10 inches. Below 3: Raveling. No water.
2736 E	LACOB	foundation	217	85	0-5: af 5-85: Qal/Qalo		5-42: 10% cobbles. 69-85: Few cobbles. No water.
2737 A	DWP	water	219±	820	0-496?: Qal/Qalo 496?-820: bedrock?		496-820: "Sticky blue clay".
2737 B	DWP	water	210±	275	0-275: Qal/Qalo		
2741 D	LACFCD	storm drain	424	15	0-15: Qalo		
2741 E	LACFCD	storm drain	440	17	0-17: Qalo		
2743 A	LACFCD	storm drain	436	25	0-13: af 13-25: bedrock	sandstone	
2743 B	PC	foundation	440±	3	0-2: af 2-3: bedrock	sandstone	Sandstone slightly weathered. No caving or water.
2743 C	DWP	water	340±	517	0-72: Qalo 72-517: bedrock	shale	71-72: Oil sand. 72-517: Oil and gas saturated.
2744 A	Caltrans	foundation	316	60	0-19: Qt 19-60: bedrock	siltstone & shale	22-33: "Very stiff to hard". 33-60: Siltstone and shale thin-bedded. 11: Ground water surface, 6/15/70.
2744 B	Caltrans	foundation	317	45	0-28: Qal/Qalo 28-45: bedrock	siltstone & shale	14: Ground water surface, 6/11/70.
2744 C	Caltrans	foundation	342	33	0-33: bedrock	shale	26-33: Shale with sandstone interbeds.
2744 D	Caltrans	foundation	350	63	0-20: af 20-63: bedrock	sandstone, shale, & siltstone	20-25: Sandstone with shale interbeds. 25-63: Siltstone and shale.
2744 E	PC	foundation	383	56	0-24: af 24-27: Qt 27-56: bedrock	shale	Shale with sandstone lenses. No caving or water.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2744 F	PC	foundation	383	49	0-12 af 12-15: Qt 15-49: bedrock	shale	Shale with strike and dip of 190°, 25° and with sandstone lenses. No caving or water.
2744 G	PC	foundation	401	82	0-82: bedrock	shale	Shale with average strike and dip of 60°, 180° and with thin sandstone interbeds. No caving or water.
2744 H	Caltrans	foundation	374	73	0-73: bedrock	shale	
2744 I	Caltrans	foundation	350	65	0-65: bedrock	shale	
2744 J	Caltrans	foundation	334	55	0-3: af 3-55: Qalo		
2744 K	LACIB	foundation	336	99	0-99: bedrock	shale	48-61: Conglomeritic layers.
2744 L	LACIB	foundation	332	97	0-97: bedrock	shale	4-8, 55-59,72-80: Conglomerate layers.
2744 M	Caltrans	foundation	339	50	0-50: bedrock	shale & siltstone	0-43: Shale. 43-50: Siltstone. 21: Water encountered, 9/26/49.
2744 N	Caltrans	foundation	341	50	0-50: bedrock	shale	No water.
2744 P	LACIB	foundation	383	66	0-66: bedrock	sandstone & shale	Bedrock with average strike and dip of 182°, 39°. 0-29: Sandstone with shale layers. 29-59: Shale with sandstone layers. 59-66: Shale.
2744 Q	LACIB	foundation	387	65	0-65: bedrock	shale & sandstone	Bedrock with average strike and dip of 178°, 45°. 0-40: Shale with sandstone interbeds. 40-65: Sandstone with shale interbeds.
2744 R	LACIB	foundation	374	100	0-100: bedrock	shale	Shale with average strike and dip of 177°, 47° and with sandstone lenses.
2744 S	LACIB	foundation	377	101	0-8: af 8-101: bedrock	shale	8-88: Shale fractured and bedded. 88-101: Shale massive. No caving. 88:Slight water seepage, 10/24/66.
2744 T	LACIB	foundation	312	101	0-6: af 6-24: Qt 24-101: bedrock	shale	Shale with sandstone lenses. 17: Petroleum odor.
2744 U	LACIB	foundation	310	51	0-3: af 3-12: Qt 12-51: bedrock	shale	Shale with average strike and dip of 190°, 50° and with sandstone lenses.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2744 V	Caltrans	foundation	311	40	0-30: Qal/Qalo 30-40: bedrock	siltstone & shale	51: Ground water surface, 6/12/70.
2744 W	Caltrans	foundation	339	67	0-24: Qalo 24-67: bedrock	siltstone & shale	24-44: Siltstone. 44-67: Shale. 34: Ground water surface, 3/12/70.
2744 X	LACIB	foundation	311	60	0-13: af 13-29: Qal/Qalo 29-60: bedrock	shale & limestone	22-29: Petroleum odor. 29-31: Shale bedded, fractured, and weathered. 31-58: Shale massive. 58-60: Limestone. No caving.
2744 Y	LACIB	foundation	307	65	0-13: af 13-21: Qal/Qalo 21-65: bedrock	shale	17: Strong petroleum odor. Limestone chunks at base of shale.
2744 Z	PC	foundation	333	94	0-7: af 7-11: Qalo 11-94: bedrock	shale	Shale weathered and fractured. 11-35: Shale bedded. 35-94: Shale with indistinct bedding. 21: Petroleum odor. No caving. 34: Slight water seepage, 3/17/75.
2744 AA	LACIB	foundation	324	61	0-11: af 11-36: Qal/Qalo 36/61: bedrock	shale	Shale with sandstone lenses. 34: Strong petroleum odor.
2744 BB	LACIB	foundation	343	55	0-55: bedrock	shale	Shale with average strike and dip of 190°, 65° and with sandstone lenses. 28: Strong petroleum odor.
2744 CC	PC	foundation	380	85	0-24: af 24-85: bedrock	shale	24-62: Shale bedded and highly fractured. 62-85: Shale massive. No caving or water.
2744 DD	PC	foundation	310	28	0-5: af 5-25: Qal/Qalo 25-28: bedrock	shale	8: Salt streaks. 17: Petroleum odor. No caving. 22, 24: Water seepage, 9/1/65.
2744 EE	PC	foundation	313	80	0-23: af 23-26: Qt 26-80: bedrock	shale	26-40: Shale jointed and weathered 40-80: Shale thickly bedded. No caving. 26: Slight water seepage, 9/17/70.
2744 FF	PC	foundation	312	80	0-20: af 20-36: Qal/Qalo 30-80: bedrock	shale	Shale thickly bedded. 52, 66-69: Cemented layers. 31-36: Sloughing. 31, 35: Water seepage, 9/18/70.
2744 GG	LACIB	foundation	312	117	0-27: af 27-37: Qal/Qalo 37-117: bedrock	shale	Shale with limestone layers.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2744 HH	PC	foundation	304	27	0-2: af 2-15: Qt 15-27: bedrock	shale	Shale fractured and bedded. 2-8: Petroleum odor. 6: Salt streaks. No caving. 15, 21: Slight water seepage, 9/1/65.
2744 II	LACIB	foundation	311	162	0-15: af 15-162: bedrock	shale	Shale highly weathered and fractured. 21, 42: "Odorous." No caving. 26, 66: Water seepage, 2/27/71.
2744 JJ	PC	foundation	308	25	0-8: af 8-25: bedrock	shale	Shale slightly fractured and thickly bedded. No caving or water.
2744 KK	PC	foundation	292	25	0-2: af 2-20: Qal/Qalo 20-25: bedrock	shale	Shale slightly fractured. 7: Petroleum odor. No caving. 8, 14: Water encountered, 9/2/65.
2744 LL	LACIB	foundation	366	172	0-38: af 38-172: bedrock	shale	Shale with limy layers. 19: 18 inch boulder.
2744 MM	PC	foundation	310	78	0-29: af 29-39: Qal/Qalo 39-78: bedrock	shale	39-41: Shale jointed and weathered. 41-78: Shale thickly bedded. No caving. 32, 36, 39: Water seepage, 9/18/70
2744 NN	LACIB	foundation	305	105	0-21: af 21-23: Qal/Qalo 23-105: bedrock	shale	
2744 PP	LACIB	foundation	368	176	0-176: bedrock	shale	Shale with average strike and dip of 215°, 30° and with limy layers.
2744 QQ	LACIB	foundation	370	183	0-183: bedrock	shale	Shale with strike and dip of 200°, 20° and with limy layers.
2744 RR	PC	foundation	291	40	0-6: af 6-21: Qal/Qalo 21-40: bedrock	shale	Shale thickly bedded. 11: Petrleum odor. 18-21: Slight sloughing. 18: Water encountered, 2/14/68.
2744 SS	PC	foundation	291	30	0-13: af 13-23: Qal/Qalo 23-30: bedrock	shale	Shale thickly bedded. 3-6: Cobbles to 6 inches. No caving. 18: Water seepage, 12/30/64.
2744 TT	PC	foundation	290	49	0-9: af 9-20: Qal/Qalo 20-49: bedrock	shale	Shale thickly bedded. 9-17: Petroleum odor. 14-17: Slight sloughing. 14: Water encountered, 2/15/68.
2744 UU	LACIB	foundation	306	77	0-16: Qalo 16-77: bedrock	shale	23, 38-42, 56, 63: Conglomerate layers in shale. Qalo with cobbles at base.
2744 VV	LACIB	foundation	333	99	0-13: af 13-18: Qalo 18-99: bedrock	shale	

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2744 WW	LACIB	foundation	318	134	0-3: af 3-134: bedrock	shale	Shale with intermittant conglomerate layers.
2744 XX	LACIB	foundation	332	93	0-17: af 17-23: Qalo 23-93: bedrock	shale	Shale with intermittant conglomerate layers.
2744 YY	PC	foundation	303	80	0-50: af 50-80: bedrock	shale	Shale thickly bedded. No caving or water.
2744 ZZ	PC	foundation	313	50	0-2: af 2-5: Qalo 5-50: bedrock	shale (siltstone)	5-32: Bedrock weathered. 32-50: Bedrock unweathered. No caving. 25: Slight water seepage, 9/15/75.
2744 AAA	PC	foundation	303	80	0-8: af 8-12: Qal/Qalo 12-80: bedrock	shale	12-34: Shale weathered and jointed 34-80: Shale thickly bedded. 19-34: Patches of oil. No caving or water.
2744 BBB	PC	foundation	292	100	0-14: af 14-22: Qal/Qalo 22-100: bedrock	shale	22-28: Shale weathered and jointed 28-100: Shale thickly bedded. 37, 71, 81: Cemented layers 2' thick. 21-23: Raveling. 21: Water seepage, 12/12/68.
2744 CCC	PC	foundation	289	81	0-8: af 8-24: Qal/Qalo 24-81: bedrock	shale	24-32: Shale weathered and jointed. 32-81: Shale thickly bedded. 14: Petroleum odor. 22-24: Raveling. 22-24: Water seepage, 12/11/68.
2744 DDD	LACIB	foundation	297	81	0-2: af 2-31: Qal/Qalo 31-81: bedrock	shale	Shale with minor sandstone interlayers.
2744 EEE	LACIB	foundation	299	81	0-22: Qal/Qalo 22-81: bedrock	shale	Shale with minor sandstone layers.
2744 FFF	LACIB	foundation	301	101	0-2: af 2-13: Qal/Qalo 13-101: bedrock	shale	Shale with minor sandstone layers.
2744 GGG	PC	foundation	330	40	0-2: af 2-4: Qalo 4-40: bedrock	shale	Shale weathered, fractured, and thickly bedded. 24: Gaseous odor. 28, 35, 36: Cemented layers. No caving or water.
2744 HHH	PC	foundation	309	80	0-5: af 5-10: Qalo 10-80: bedrock	shale	Shale massive. 20: Strong gaseous odor. 21-23, 31, 34: Cemented layers.
2744 III	PC	foundation	318±	5	0-3: af 3-5: bedrock	siltstone	4: Gaseous odor. No caving or water.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2744 JJJ	PC	foundation	296±	20	0-4: af 4-20: bedrock	siltstone, sandstone, shale, & limestone	4-10: Siltstone. 10-12: Sandstone. 12-14: Shale. 14-15, 18: Limestone. 15-20: Sandstone. No caving or water.
2744 KKK	PC	foundation	325	40	0-10: af 10-12: Qalo 12-40: bedrock	shale	Shale weathered, fractured, and thickly bedded. 19: Gaseous odor. 0-10: Raveling. No water.
2744 LLL	PC	foundation	293	80	0-8: Qalo 8-80: bedrock	shale & sandstone	8-10: Shale highly weathered. 10-37: Sandstone highly weathered. 37-80: Shale massive. 30-39: Sloughing. 30-39: Slight water seepage, 5/28/72.
2744 MMM	PC	foundation	283	58	0-3: af 3-18: Qal/Qalo 18-58: bedrock	shale	Shale with thin sandstone beds. 14-28: Some cobbles to 10 inches. No caving. 25: Water seepage, 8/8/70.
2744 NNN	PC	foundation	279	59	0-12: af 12-16: Qal/Qalo 16-59: bedrock	shale	Shale massive. 12-16: 15% cobbles. 16: Petroleum odor. 32, 51: Hard layer. No caving or water.
2744 PPP	PC	foundation	284	20	0-8: af 8-20: Qal/Qalo		8-11: Petroleum odor. No caving or water.
2744 QQQ	PC	foundation	293	60	0-17: Qal/Qalo 17-60: bedrock	shale	No caving. 29: Slight water seepage, 1957.
2744 RRR	LACIB	foundation	286	77	0-4: af 4-19: Qalo 19-77: bedrock	shale	Shale very hard at base.
2744 SSS	LACIB	foundation	297	81	0-1: af 1-31: Qal/Qalo 31-81: bedrock	shale	Shale with occasional sandstone layers up to 2' thick. 27-31: Caving. 27: Severe water seepage, 12/15/67.
2744 TTT	PC	foundation	393	71	0-2: af 2-13: Qt 18-71: bedrock	shale	Shale thickly bedded, fractured, and with a strike and dip of 275°, 53°. No caving or water.
2745 A	LACIB	foundation	279	52	0-3: af 3-15: Qal/Qalo 15-52: bedrock	shale	10-15: Cobbles.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2745 B	LACIB	foundation	275	100	0-2: af 2-25: Qal/Qalo 25-100: bedrock	shale	12-25: 5%-10% cobbles. 12-26: Raveling. 25-26, 52-55: Slight water seepage, 5/8/65.
2745 C	LACIB	foundation	274	100	0-9: af 9-22: Qal/Qalo 22-100: bedrock	shale	11-22: Cobbles and a few boulders. 11-22: Raveling. 22: Slight water seepage, 5/8/65.
2745 D	LACIB	foundation	250	19	0-8: af 8-11: Qal/Qalo 11-19: bedrock	shale	
2745 E	PC	foundation	275	80	0-14: af 14-18: Qal/Qalo 18-80: bedrock	shale	18-38: Shale weathered and jointed. 38-80: Shale thickly bedded. 49, 79-80: Cemented layers. 14-18: Cobbles to 8 inches. 15-18: Raveling. 47, 79: Water seepage, 1/23/70.
2745 F	PC	foundation	271	55	0-32: Qal/Qalo 32-55: bedrock	shale	32-33: Shale weathered and jointed. 33-55: Shale thickly bedded. 15-32: 10%-15% cobbles to 8 inches. 27-32: Heavy caving. 29: Water seepage, 1/23/70.
2745 G	MTA	WC-96	278	59	0-57: Qal/Qalo 57-59: bedrock	siltstone	
2745 H	LACFCD	storm drain	268	82	0-2: af 2-57: Qal/Qalo 57-82: bedrock	shale	13-31: 10% cobbles to 10 inches with occasional boulders to 20 inches.
2745 I	LACIB	foundation	268	82	0-2: af 2-58: Qal/Qalo 58-82: bedrock	shale	12-31: 10% cobbles with occasional boulders. 13-31: Raveling. 55: Water seepage, 11/23/69.
2745 J	MTA	WC-97	270	56	0-42: Qal/Qalo 42-56: bedrock	shale	
2745 K	LACIB	foundation	266	80	0-2: af 2-71: Qal/Qalo 71-80: bedrock	shale	12-29: 10% cobbles and some boulders to 18 inches.
2745 L	PC	foundation	273	71	0-2: af 2-30: Qal/Qalo 30-71: bedrock	shale (siltstone)	13-22: 5%-10% cobbles to 8 inches. 22-28: 10-20% cobbles to 12 inches. 27: Strong petroleum odor. 38: Occasional patches of natural tar. 40, 42-46, 53-55, 57-65: Cemented lenses. Bedrock highly weathered. 18-30: Raveling. 30: Slight water seepage, 10/10/70.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2745 M	PC	foundation	274	75	0-7: af 7-32: Qal/Qalo 32-75: bedrock	shale (siltstone)	22-30: Cobbles to 10 inches. 41 Strong petroleum odor. 52, 62: Cemented layer. 22-30: Heavy raveling. 30: Slight seepage, 10/11/70.
2745 N	LACIB	foundation	271	62	0-48: Qal/Qalo 48-62: bedrock	shale	12-23 : Cobbles to 8 inches.
2745 P	LACIB	foundation	272	72	0-8: af 8-48: Qal/Qalo 48-72: bedrock	shale	
2745 Q	LACIB	foundation	268	79	0-12: af 12-72: Qal/Qalo 72-79: bedrock	shale	12-33: Cobbles.
2745 R	MTA	WC-98	266	49	0-49: Qal/Qalo		
2745 S	LACIB	foundation	267	70	0-13: af 13-69: Qal/Qalo		13-20: Cobbles and boulders. 24-40: Occasional cobbles.
2745 T	MTA	WC-99	265	45	0-45: Qal/Qalo		
2745 U	MTA	WC-100	262	51	0-51: Qal/Qalo		
2774 V	LACIB	foundation	260	72	0-72: Qal/Qalo		10-24: Scattered cobbles. 18-20: Concentrated cobbles. 22-34: Strong petroleum odor.
2745 W	PC	foundation	259	60	0-60: Qal/Qalo		13-16: Some cobbles. 16-27: Large amount of cobbles to 12 inches. 13-26: Caving. No water.
2745 X	MTA	WC-103	266	63	0-63: Qal/Qalo		
2745 Y	MTA	WC-102	262	62	0-62: Qal/Qalo		
2745 Z	MTA	WC-401	261	66	0-66: Qal/Qalo		0-30: Cobbles to 12 inches. 37-66: Cobbles to 10 inches. No water.
2745 AA	DWP	water	258±	292	0-137: Qal/Qalo 137-292: bedrock?	?	Bedrock: "blue clay". 46-50, 80-91: Cemented layers.
2745 BB	MTA	WC-101	261	56	0-56: Qal/Qalo		
2745 CC	PC	foundation	254±	50	0-2: af 2-50: Qal/Qalo		8-10: Cobbles to 6 inches. 10-42: Cobbles to 8 inches. Below 10: Raveling. 37: Water seepage, 2/21/65.
2745 DD	PC	foundation	254±	35	0-12: af 12-35: Qal/Qalo		4-12: 10% cobbles. 12-25: 20% cobbles. 33-35: Few cobbles. 0-24: Caving. No water.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2745 EE	LACIB	foundation	259	70	0-2: af 2-70: Qal/Qalo		6-33: 15% cobbles to 12 inches. 41-55: Few cobbles. 24: Petroleum odor.
2746 A	DWP	water	242±	499	0-230: Qal/Qalo 230-499: bedrock?	?	Bedrock correlated with that of 2736 B. 8-25, 95-100, 173-176: Boulders. 454-458: Oil sand.
2746 B	SOCAL	Wall CH 2	237	5685	0-152: Qal/Qalo 152-245: Qsp 245-5685: bedrock	shale & other	245-2000: Shale.
2746 C	SOCAL	Venice Comm. CH 1	226±	6485	0-470: Qal/Qalo/Qsp 470-6485: bedrock	siltstone, shale, & other	470-2100: Siltstone and shale.
2747 A	DWP	water	225±	462	0-462: Qal/Qalo		
2747 B	DWP	water	228±	320	0-320: Qal/Qalo		
2747 C	SOCAL	Wall CH 1	224	6764	0-450: Qal/Qalo/Qsp 450-6764: bedrock	siltstone & other	450-2150: Siltstone.
2747 D	SOCAL	Menlo CH 1	217	4500	0-395: Qal/Qalo/Qsp 395-4500: bedrock	shale, sandstone, & other	395-1075: Sandstone and shale. 1075-2200: Shale.
2748 A	DWP	water	204±	170	0-170: Qal/Qalo		
2751 A	PC	foundation	475±	60	0-53: Qal/Qalo 53-60: bedrock	sandstone	
2752 A	LACFCD	storm drain	442	20	0-18: Qal/Qalo 18-20: bedrock	shale	
2752 B	LACFCD	storm drain	432	20	0-20: Qal/Qalo		
2752 C	LACFCD	storm drain	432	16	0-9: af 9-16: bedrock	siltstone & sandstone	9-14: Siltstone. 14-16: Sandstone.
2753 A	LACFCD	storm drain	416	16	0-13: af 13-16: bedrock	siltstone	
2753 B	LACFCD	storm drain	399	20	0-2: af 2-20: bedrock	sandstone & siltstone	Sandstone and siltstone interbedded.
2753 C	PC	foundation	442	40	0-28: af 28-40: bedrock	sandstone & siltstone	28-33: Sandstone with 5-inch cobbles. 33-40: Siltstone. 37: Cemented layer. No caving or water.
2753 D	PC	foundation	428	40	0-28: af 28-40: bedrock	siltstone	Siltstone with some sandstone interbeds. 6-12: Gaseous odor. 26-28: Cobbles to 8 inches. 38: Cemented layer. No caving or water.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2753 E	PC	foundation	419	35	0-15: af 15-35: bedrock	siltstone & sandstone	Siltstone and sandstone interbedded. 14: Cobbles. No caving. 4-8: Slight water seepage, 4/11/66.
2753 F	LACFCD	foundation	375	16	0-12: af 12-16: bedrock	siltstone	4-12: H_2S odor.
2753 G	PC	foundation	381	20	0-15: af 15-20: bedrock	sandstone	Sandstone weathered. No caving or water.
2753 H	PC	foundation	338	30	0-9: af 9-30: bedrock	shale	Shale slightly fractured. 8-12: Petroleum odor. 22: Cemented layer. No caving. 15-17: Slight water seepage, 7/2/68.
2753 I	PC	foundation	347	30	0-1: af 1-30: bedrock	shale	Shale slightly fractured with average strike and dip of 192°, 31°. No caving. 15: Water seepage, 7/2/68.
2753 J	PC	foundation	350	36	0-15: af 15-36: bedrock	shale	Shale slightly fractured. No caving. 28: Water seepage, 7/1/66.
2754 A	PC	foundation	386	41	0-1: af 1-41: bedrock	shale	Shale bedded and highly weathered. No caving or water.
2754 B	PC	foundation	380	39	0-2: af 2-40: bedrock	shale	Shale weathered and with lenses of sandstone. 24: Oily odor. No caving. 33: Slight water seepage, 12/24/62.
2754 C	PC	foundation	385	36	0-24: af 24-36: bedrock	shale	Shale bedded and weathered. 12-25: Caving upon removal of casing. No water.
2754 D	LACOB	foundation	401	66	0-2: af 2-66: bedrock	shale	
2754 E	LACOB	foundation	391	61	0-16: Qal/Qalo 16-61: bedrock	shale	
2754 F	PC	foundation	393	44	0-32: af 32-44: bedrock	shale	Shale bedded and weathered. 17-32: Caving upon removal of casing. No water.
2754 G	LACOB	foundation	384	59	0-59: bedrock	siltstone	
2754 H	LACOB	foundation	394	76	0-1: Qt 1-76: bedrock	siltstone	

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2754 I	LACOB	foundation	380	80	0-2: Qt 2-80: bedrock	sandstone & shale	Sandstone and shale interbedded. 22: Gas odor.
2754 J	LACOB	foundation	377	60	0-60: bedrock	sandstone & shale	Sandstone and shale interbedded.
2754 K	LACOB	foundation	404	98	0-4: af 4-98: bedrock	shale	
2754 L	PC	foundation	390	36	0-36: bedrock	shale	Shale weathered. No caving or water.
2754 M	PC	foundation	400	46	0-36: af 36-46: bedrock	shale	Shale bedded, weathered, and interbedded with sandstone. 21-36: Caving upon removal of casing. No water.
2754 N	LACOB	foundation	405	65	0-65: bedrock	shale	Shale with sandstone laminations.
2754 P	LACOB	foundation	404	51	0-51: bedrock	shale	Shale with sandstone interbeds.
2754 Q	LACOB	foundation	399	45	0-11: af 11-22: Qal/Qalo 22-45: bedrock	shale	
2754 R	LACOB	foundation	407	51	0-51: bedrock	shale	Shale with sandstone lenses.
2754 S	LACOB	foundation	403	75	0-59: af 59-65: Qal/Qalo 65-75: bedrock	shale	25-28: Cobbles. 35-50: Brick.
2754 T	LACOB	foundation	403	66	0-35: af 35-42: Qal/Qalo 42-66: bedrock	shale	Shale with sandstone interbeds. 52: Petroleum odor.
2754 U	LACOB	foundation	401	36	0-22: af 22-31: Qal/Qalo 31-36: bedrock	shale	
2754 V	LACOB	foundation	413	105	0-6: af 6-105: bedrock	shale	Shale with average strike and dip of 270°, 45°.
2754 W	LACOB	foundation	382	76	0-34: af 34-76: bedrock	shale	
2754 X	LACOB	foundation	375	70	0-60: bedrock	siltstone & shale	Siltstone and shale interbedded. 9: Gas odor.
2754 Y	LACOB	foundation	383	62	0-30: af 30-62: bedrock	siltstone & sandstone	
2754 Z	LACOB	foundation	360	60	0-60: bedrock	sandstone & shale	Sandstone and shale interbedded.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2754 AA	LACOB	foundation	359	60	0-27: Qal/Qalo 27-60: bedrock	siltstone & claystone	
2754 BB	MTA	WC-111	329	84	0-5: af 5-84: bedrock	siltstone	Siltstone dips 60°.
2754 CC	LACOB	foundation	331	61	0-2: af 2-61: bedrock	shale & sandstone	Shale and sandstone interbedded with average strike and dip of N85°W, 55°S.
2754 DD	LACOB	foundation	361	60	0-9: af 9-60: bedrock	shale	Shale with strike and dip of 270°, 60°.
2754 EE	LACOB	foundation	401	99	0-10: af 10-12: Qal/Qalo 12-99: bedrock	shale	Shale with average strike and dip of ENE, 48°.
2754 FF	LACOB	foundation	399	120	0-1: af 1-120: bedrock	shale	Shale with sandstone interbeds.
2754 GG	LACOB	foundation	371	45	0-33: af 33-45: bedrock	shale	
2754 HH	LACOB	foundation	416	131	0-20: Qal/Qalo 20-131: bedrock	shale	Shale with sandstone lenses. 4-12: Cobbles and boulders.
2754 II	LACOB	foundation	315	21	0-6: af 6-21: bedrock	siltstone	
2754 JJ	MTA	WC-110	337	106	0-12: af 12-106: bedrock	siltstone & claystone	Bedrock dips to 90°.
2754 KK	LACOB	foundation	316	70	0-5: af 5-70: bedrock	shale	Shale with sandstone lenses.
2754 LL	LACOB	foundation	317	31	0-8: af 8-31: bedrock	shale	
2754 MM	LACOB	foundation	334	75	0-1: af 1-75: bedrock	shale	
2754 NN	LACOB	foundation	315	55	0-8: af 8-55: bedrock	shale	
2754 PP	LACOB	foundation	326	40	0-22: af 22-40: bedrock	siltstone	
2754 QQ	MTA	WC-109	320	66	0-11: af 11-66: bedrock	claystone & siltstone	30-66: Claystone. 30-66: Siltstone. No water.
2754 RR	LACOB	foundation	309	38	0-31: Qal/Qalo 31-38: bedrock	shale	22-31: Cobbles to 10 inches.
2754 SS	PC	foundation	286	85	0-10: af 10-12: Qal/Qalo 12-85: bedrock	shale	Shale with indistinct bedding. 10-12: Cobbles. 6-11: Raveling. 12, 77: Slight water seepage, 6/29/69.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2754 TT	LACOB	foundation	325	65	0-10: Qal/Qalo 10-65: bedrock	shale	
2754 UU	PC	foundation	325	37	0-37: af		9-37: Caving upon removal of casing. No water.
2754 VV	LACOB	foundation	408	106	0-10: af 10-106: bedrock	sandstone, shale, & siltstone	10-23: Cobbles, sandstone, and shale. 23-25: Siltstone. 25-58: Sandstone and shale. 58-106: Shale.
2754 WW	PC	foundation	395	55	0-16: Qal/Qalo 16-55: bedrock	shale	Shale thickly bedded and fractured. 9-16: Some cobbles to 8 inches. 12-15: Raveling and sloughing. 13: Water seepage, 8/21/68.
2754 XX	PC	foundation	302	59	0-32: af 32-59: bedrock	shale	Shale thinly laminated.
2754 YY	MTA	WC-108	295	44	0-25: Qal/Qalo 25-44: bedrock	siltstone	
2754 ZZ	PC	foundation	304	50	0-38: af 38-50: bedrock	shale	Shale slightly fractured. 22-27: Few cobbles to 8 inches. 33-38: 12% cobbles to 8 inches. 32-38: Caving. 36-38: Water seepage, 4/19/69.
2754 AAA	PC	foundation	299	55	0-31: af 31-55: bedrock	shale	Shale weathered and fractured. 26-31: 15% cobbles. 3-4: Raveling. 30: Slight water seepage, 11/17/69.
2754 BBB	MTA	WC-107	287	52	0-20: Qal/Qalo 20-52: bedrock	siltstone	No water.
2754 CCC	MTA	WC-106	283	61	0-19: Qal/Qalo 19-61: bedrock	siltstone	No water.
2754 DDD	PC	foundation	288	34	0-11: af 11-17: Qal/Qalo 17-34: bedrock	shale	11-17: Few cobbles.
2754 EEE	PC	foundation	289	73	0-11: af 11-19: Qal/Qalo 19-73: bedrock	shale	Shale thickly bedded. 11-19: Cobbles to 6 inches. 73: Cemented layer. 5-11: Caving. 11-19: Raveling. No water.
2754 FFF	PC	foundation	286	82	0-12: af 12-15: Qal/Qalo 15-82: bedrock	shale	15-20: Shale weathered and jointed 20-82: Shale thickly bedded. 31, 41: Cemented layers. 43-45: Limestone layer. 12-14: Slight raveling. 14: Very slight water seepage, 10/24/69. 12-15: Few cobbles.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2754 GGG	PC	foundation	284	65	0-6: af 6-20: Qal/Qalo 20-65: bedrock	shale	0-20: 10% cobbles. No caving. 20: Water seepage, 5/7/67.
2754 HHH	PC	foundation	280	60	0-3: af 3-35: Qal/Qalo 35-60: bedrock	shale	Shale bedded. 4-35: Raveling. 32-35: Slight water seepage, 7/4/69.
2754 III	PC	foundation	281	65	0-11: af 11-15: Qal/Qalo 15-65: bedrock	shale	11-16: Caving and raveling. 15: Slight water seepage, 5/7/67.
2754 JJJ	PC	foundation	275	58	0-2: af 2-29: Qal/Qalo 29-58: bedrock	shale	6-8: 10% cobbles. 19-29: Few cobbles. 50, 55: Cemented layer. 6-7, 26-28: Caving and raveling. 28: Water seepage, 5/6/67.
2754 KKK	PC	foundation	270	65	0-11: af 11-26: Qal/Qalo 26-65: bedrock	siltstone	Siltstone massive. 14-26: Cobbles. 13-18, 20-26: Raveling. 26: Water seepage, 4/9/74.
2754 LLL	PC	foundation	268	43	0-6: af 6-24: Qal/Qalo 24-43: bedrock	siltstone	Siltstone fractured and massive. 6-13: Cobbles. 6-12, 13-23: Caving. 24: Water seepage, 7/9/65.
2754 MMM	PC	foundation	280	40	0-4: af 4-17: Qal/Qalo 17-40: bedrock	shale	Shale weathered. 11-17: 10% cobbles and a few boulders. 4-16: Caving. 15: Slight water seepage, 11/16/69
2754 NNN	MTA	WC-105	278	75	0-16: Qal/Qalo 16-75: bedrock	siltstone	Below 42: Bedrock hard. 62: Layer of hard shale.
2754 SSS	LACOB	foundation	417	115	0-5: Qalo 5-115: bedrock	shale & sandstone	Shale and sandstone interbedded with average strike and dip of ENE, 45°. 0-5: Some cobbles.
2754 TTT	LACOB	foundation	370	67	0-26: af 26-67: bedrock	shale	Shale weathered.
2755 A	MTA	WC-104	272	82	0-42: Qal/Qalo 42-82: bedrock	siltstone & claystone	42-82: Siltstone. Below 70: Claystone.
2755 B	PC	foundation	266	40	0-2: af 2-33: Qal/Qalo 33-40: bedrock	siltstone	Siltstone massive. 12-30: 15% cobbles. 30-33: 25% cobbles and 10% boulders. 10-33: Raveling. 28: Water seepage, 7/10/65.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2755 C	LACIB	foundation	270±	50	0-50: Qal/Qalo		0-9: Cobbles to 10 inches.
2755 D	PC	foundation	272±	38	0-20: Qal/Qalo 20-38: bedrock	sandstone & shale	15-20: Cobbles to 8 inches. 20-31: Sandstone. 31-38: Shale. 11-20: Raveling. 18-20: Water seepage, 1/23/66.
2755 E	PC	foundation	266±	50	0-4: af 4-50: Qal/Qalo		7-25: Scattered cobbles to 15 inches. 38: Petroleum odor. 0-39: Raveling. 39: Water seepage, 11/20/60.
2755 F	PC	foundation	262	40	0-10: af 10-40: Qal/Qalo		10-40: 15% cobbles and a few boulders. 29: Petroleum odor. 0-10: Caving. 10-32: Moderate raveling. 32: Water seepage, 8/20/66.
2755 G	SOCAL	Grayhound CH 1	254	6240	0-160: Qal/Qalo 160-6240: bedrock	siltstone, shale, & other	160-1400: Siltstone and shale.
2756 A	DWP	water	247±	300	0-157: Qal/Qalo 157-300: bedrock	shale	31-63, 91-105, 109-119: Boulders.
2756 B	DWP	water	247±	300	0-157: Qal/Qalo 157-300: bedrock	shale	33-65, 95-103: Boulders.
2756 C	DWP	water	246±	300	0-156: Qal/Qalo 156-300: bedrock	shale	39-71, 101-109: Boulders.
2756 D	DWP	water	240±	300	0-181: Qal/Qalo 181-300: bedrock	shale	41-77, 85-181: Boulders.
2756 E	DWP	water	240±	300	0-183: Qal/Qalo 183-300: bedrock	shale	41-73, 87-115: Boulders.
2756 J	DWP	water	242±	350	0-185: Qal/Qalo 185-350: bedrock	shale	23-71, 104-117: Boulders.
2756 K	DWP	water	244±	309	0-140: Qal 140-150: Qalo? 150-309: bedrock	shale	23-71, 104-117: Boulders. 140-150: Red horizon.
2756 L	DWP	water	233±	300	0-177: Qal/Qalo 177-300: bedrock	shale	7-56, 84-100: Boulders.
2756 M	DWP	water	244±	454	0-166: Qal/Qalo 166-454: bedrock	shale	38-128: Boulders.
2757 A	DWP	water	223±	510	0-510: Qal/Qalo		160-188: Boulders.
2759 A	DWP	water	201±	209	0-209: Qal/Qalo		
2762 A	Caltrans	foundation	404	71	0-58: Qal/Qalo 58-71: bedrock	shale	17-33: Carbonate pockets and seams. 25: Ground water surface, 5/31/61.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2763 A	Caltrans	foundation	358	71	0-59: Qal/Qalo 59-71: bedrock?	sandstone	0-21: Carbonate seams. 59-71: Oil sand.
2763 B	Caltrans	foundation	340	100	0-41: Qal/Qalo 41-100: bedrock?	siltstone & shale	Siltstone and shale interbedded. 30: Oil. 52: Petroliferous odor. 68-100: Saturated oil sand. 48: Water seepage, 3/17/61.
2763 C	Caltrans	foundation	341	62	0-37: Qal/Qalo 37-62: bedrock?	sandstone	3-17: Carbonate seams. 37-62:Dense sandstone.
2763 D	Caltrans	foundation	348	50	0-38: Qal/Qalo 38-50: bedrock	sandstone	No water.
2763 E	Caltrans	foundation	330	51	0-48: Qal/Qalo 48-51: bedrock		48-51: Petroliferous. No water.
2763 F	PC	foundation	321	35	0-3: af 3-35: Qal/Qalo		26-26: Cobbles to 8 inches. 32-35: Cobbles to 6 inches. Below 20: Caving. No water.
2763 G	LACOB	foundation	288	75	0-3: af 3-75: Qal/Qalo		18-22: Cobbles to 8 inches.
2764 A	MTA	WC-112	307	83	0-31: Qal/Qalo 31-83: bedrock	siltstone & shale	Bedrock dips 50°-60°.
2764 B	MTA	WC-113	296	66	0-26: Qal/Qalo 26-66: bedrock	shale & siltstone	Bedrock dips 45°.
2764 C	MTA	WC-114	278	54	0-54: Qal/Qalo		0-20: Boulders.
2764 D	MTA	WC-115	275	52	0-46: Qal/Qalo		
2764 E	MTA	WC-116	271	66	0-66: Qal/Qalo		26-35: Boulders.
2764 F	MTA	WC-117	281	67	0-66: Qal/Qalo 66-67: bedrock	siltstone	38-48: Boulders.
2764 G	MTA	WC-118	282	68	0-50: Qal/Qalo 50-68: bedrock	siltstone	
2764 H	LACOB	foundation	289	150	0-12: af 12-97: Qal/Qalo 97-150: bedrock	shale	17-97: Cobbles. 36: Water level, 7/11/74.
2764 I	LACOB	foundation	284	75	0-68: Qal/Qalo 68-75: bedrock	shale	17-68: Cobbles, boulders. 45: "Odorous." 31: Water level, 6/28/74.
2764 J	PC	foundation	284±	21	0-2: af 2-21: Qal/Qalo		05: Gaseous odor. 3-16: Caving. No water.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2764 K	PC	foundation	290±	75	0-10: af 10-30: Qal/Qalo 30-75: bedrock	shale	10-30: Occasional cobbles. 30-75: Shale laminated. 05-09: Minor caving. 29: Slight water seepage, 3/30/59.
2764 L	PC	foundation	282	65	0-17: af 17-30: Qal/Qalo 30-65: bedrock	shale	64-65: Very hard layer. 7-12: Heavy caving. 16-18: Slight caving. 26: Heavy seepage, 3/16/59.
2764 M	PC	foundation	278	60	0-10: af 10-47: Qal/Qalo 47-60: bedrock	shale	5-18: Heavy caving. 41-46: Moderate caving. 40-46: Water seepage, 3/19/59.
2764 N	PC	foundation	276	70	0-5: af 5-55: Qal/Qalo 55-70: bedrock	shale	Shale laminated. 68-70: Very hard layer. 42-54: Heavy caving. 42: Heavy water seepage, 3/30/69.
2764 P	PC	foundation	276	75	0-7: af 7-38: Qal/Qalo 38-75: bedrock	shale	No caving or water.
2764 Q	PC	foundation	273	75	0-3: af 3-47: Qal/Qalo 47-75: bedrock		3-47: Occasional cobbles throughout. 30-41: Many cobbles. 42-43: Slight caving. 42-47: Moderate seepage, 3/26/59.
2764 R	Caltrans	foundation	279	20	0-11: af 11-20: Qal/Qalo		11-19: Oily. 19-20: Cobbles.
2765 A	TEXACO	Texaco-UPRR Unit 1-1	255	7010	0-125: Qal/Qalo 125-1850: bedrock	shale	
2765 B	SOCAL	Garey 2	268	6886			
2765 B	SOCAL	Garey 2	268	6886	0-<88: Qal/Qalo <88-1800: bedrock	shale	
2765 D	DWP	water	259±	340	0-145?: Qal/Qalo 145?-340: bedrock	?	10-60: boulders
2765 E	ARCO	L.A. River Fee 1	254±	4618	30-75: Qal 75-145: Qalo 145-1300: bedrock	siltstone & shale	
2765 F	PC	foundation	267	36	0-29: Qal/Qalo 29-36: bedrock	shale	21-23: Few boulders to 16 inches. 16-26: Caving. 29: Water seepage, 3/6/64.
2766 A	DWP	water	240±	300	0-185: Qal/Qalo 185-300: bedrock	shale	43-73, 89-121: Boulders.
2766 B	DWP	water	240±	300	0-187: Qal/Qalo 187-300: bedrock	shale	41-71, 93-117: Boulders.
2766 C	DWP	water	240±	300	0-188: Qal/Qalo 188-300: bedrock	shale	42-73, 95-119: Boulders.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2766 D	DWP	water	240±	300	0-189: Qal/Qalo 189-300: bedrock	shale	45-75, 75-114: Boulders.
2766 E	BOGCO	Signal-Std. Exley EH 1	250±	1005	0-115: Qal/Qalo 115-195: Qsp 195-1005: bedrock	siltstone	
2766 F	SOCAL	Southern Pacific 57-1	243±	8976	0-160: Qal/Qalo/Qsp? 160-8976: bedrock	siltstone, shale, & other	160-1900: Siltstone and shale.
2767 A	DWP	water	225±	448	0-448: Qal/Qalo		
2767 B	DWP	water	228±	317	0-317: Qal/Qalo		45-74: Boulders.
2768 A	SOCAL	Blue Diamond 1	223	8930	0-315: Qal/Qalo 315-815: Qsp 815-8930: bedrock	shale, siltstone, & other	815-2700: Shale and siltstone.
2769 A	DWP	water	205±	874	0-874: Qal/Qalo/Qsp		18-90: Boulders.
2769 E	DWP	water	199±	918	0-918: Qal/Qalo/Qsp		
2769 G	DWP	water	195±	1330	0-1330: Qal/Qalo/Qsp		
2769 H	DWP	water	199±	1200	0-1200: Qal/Qalo/Qsp		
2769 L	DWP	water	199±	1343	0-1343: Qal/Qalo/Qsp		
2771 B	Caltrans	foundation	325	70	0-32: af 32-70: Qal/Qalo		
2771 D	Caltrans	foundation	334	85	0-53: af 53-86: Qal/Qalo		
2771 K	DWP	water	330±	142	0-111: Qal/Qalo 111-142: bedrock	sandstone & shale	53-111: Boulders. 111-130: Sandstone. 130-142: Sandstone & shale.
2771 M	DWP	water	300	41+	0-41: Qal/Qalo 41+: bedrock	shale	
2771 N	DWP	water	310±	60	0-50: Qal/Qalo 50-60: bedrock	shale	
2771 P	DWP	water	330±	104	0-104: Qal/Qalo		
2771 Q	DWP	water	345±	71	0-71: Qal/Qalo		
2771 T	DWP	water	338±	58	0-48: Qal/Qalo? 48-58: bedrock?	sandstone?	
2772 A	DWP	water	340±	118	0-80: Qal/Qalo 80-118: bedrock	shale	38-50, 59-74: Boulders.
2772 B-1	DWP	water	286	78	0-33: Qal/Qalo? 33-48: bedrock	sandstone & shale	33-56: Sandstone. 56-78: Shale.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2772 B-2	DWP	water	284	78	0-30: Qal/Qalo 30-78: bedrock	shale & sandstone	0-30: Boulders. 30-60: Shale. 60-66: Sandstone. 66-78: Shale.
2772 C	PC	foundation	320±	45	0-25: af 25-45: Qal/Qalo		0-25: 20% cobbles and a 14-inch boulder. 25-45: Cobbles. 34: Petroleum odor. 4-45: Caving. 43: Water seepage, 7/23/66.
2772 D	DWP	water	322	111	0-105: Qal/Qalo 105-111: bedrock	shale	3-16: Cobbles. 105-106: Shale. 106-111: Sandstone.
2772 E	DWP	water	321	55	0-20: af 20-35: Qal/Qalo 35-55: bedrock	shale & sandstone	31: Water encountered, 1/10/58.
2772 F	CE	channel improvement	259	30±			No log; derived from structure maps.
2772 G	CE	channel improvement	285±	42±			No log; derived from structure maps.
2772 H	CE	channel improvement	282±	24			No log, derived from structure maps.
2772 I	CE	channel improvement	286	30	0-26: Qal/Qalo 26-30: bedrock	shale	08-26: Boulders.
2772 J	CE	channel improvement	280±	30±			No log; derived from structure maps.
2772 K	CE	channel improvement	279±	40±			No log; derived from structure maps.
2772 L	CE	channel improvement	287	37	0-30: Qal/Qalo 20-37: bedrock	shale	
2772 M	CE	channel improvement	282	39	0-39: Qal/Qalo		
2772 N	DWR	water	307±	125	0-75: Qal/Qalo 75-125: bedrock	?	
2772 P	TEXACO	So. Pacific CH 1	340	5750	0-335: Qal/Qalo 335-5750: bedrock	sandstone, shale, & other	335-2550: Sandstone and shale.
2772 Q	VOCO	Freight Depot 1	320±	1898	0-<200: Qal/Qalo <200: bedrock	?	
2773 A	DWP	water	295±	340	0-235: Qal/Qalo 235-340: bedrock	shale	
2773 B	DWP	water	295±	495	0-57: Qal/Qalo 57-495: bedrock	shale	43-57: Boulders.
2773 C	DWP	water	295±	82	0-82: Qal/Qalo		
2773 D	CE	channel improvement	272±	61	0-61: Qal/Qalo		20-30: Oil and some gas. 33-60: Oil.
2773 E	CE	channel improvement	280	42	0-42: Qal/Qalo		21-42: Oil.
2773 F	CE	channel improvement	279	38	0-38: Qal/Qalo		36-38: Oil.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2773 G	CE	channel improvement	278	56	0-48: Qal/Qalo 48-56: bedrock	shale	
2773 H	CE	channel improvement	281	43	0-27: Qal/Qalo 27-43: bedrock	shale & siltstone	0-27: Oil.
2773 I	CE	channel improvement	280	46	0-43: Qal/Qalo 46: bedrock	shale	23-46: Oil streaks.
2773 J	CE	channel improvement	275	31	0-25: Qal/Qalo 25-31: bedrock	shale	
2773 K	CE	channel improvement	265	40	0-40: Qal/Qalo		
2773 L	DWR	water	282±	40	0-40±: Qal/Qalo		
2773 M	PC	foundation	304	38	0-4: af 4-38: Qal/Qalo		11-16: 5% cobbles to 12 inches. 18-27: Occasional cobbles. 30-34: Strong oily odor and occasional cobbles. 35-38: 5% cobbles to 10 inches. 4-6, 19-38: Caving. 37: Water seepage, 1/24/64.
2774 A	SOCAL	Miller CH 1	388	4535	0-130?: Qal/Qalo 130?-4535: bedrock	shale, siltstone, sandstone, & other	130?-1835: Shale with siltstone. 1835-2165: Siltstone. 2165-2638: Siltstone with sandstone. 2638-2800: Sandstone.
2774 B	CE	channel improvement	262	40	0-40: Qal/Qalo		
2774 C	DWP	water	277±	131	0-131: Qal/Qalo		32-44, 66-67, 97-104: Boulders.
2774 D	CE	channel improvement	254	31	0-29: Qal/Qalo 29-31 bedrock	shale	
2774 E	CE	channel improvement	254	32	0-17: Qal/Qalo 17-32: bedrock	shale	17-32: Shale soft.
2774 F	DWP	water	279	100	0-88: Qal/Qalo 88-100: bedrock	shale	
2774 G	CE	channel improvement	258	36	0-25: Qal/Qalo 25-36: bedrock	siltstone	Siltstone soft.
2774 H	CE	channel improvement	253	26	0-19: Qal/Qalo 19-26: bedrock	shale	Shale medium soft.
2774 I	MTA	WC-121	273±	70	0-42: Qal/Qalo 42-70: bedrock	siltstone	Petroliferous odor at bottom of bedrock. 60° dips in bedrock.
2774 J	PC	foundation	191	15	0-3: fill 3-14: Qal/Qalo 14-15: bedrock	shale	3-14: Some cobbles. 3-14: Heavy caving. No water.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2774 K	MTA	WC-120	279	71	0-50: Qal/Qalo 50-71: bedrock	siltstone	36-46: Boulders. 25° dips in bedrock. 30: Water encountered, 3/62.
2774 L	DWR	water	282±	100	0-90: Qal/Qalo 90-100: bedrock	siltstone?	
2774 M	MTA	WC-119	280	72	0-50: Qal/Qalo 50-72: bedrock	siltstone	30-31: Petroliferous odor, oil sand. 50-72: Loose sandstone at bottom. 41-45: Cobbles.
2774 N	CE	channel improvement	257	56	0-45: Qal/Qalo 45-56: bedrock	shale	33-45: Asphalt. 45-56: Shale, medium soft with trace of oil.
2774 P	CE	channel improvement	252	37	0-37: Qal/Qalo		4-17: Small amount of heavy oil. 24-37: Impregnated with oil.
2774 Q	CE	channel improvement	253	25	0-19: Qal/Qalo 19-25: bedrock	shale	16-19: Oil.
2774 R	CE	channel improvement	254	43	0-37: Qal/Qalo 37-43: bedrock	shale	6-37: Heavy oil.
2774 S	Caltrans	foundation	246	60	0-60: Qal/Qalo		3-4, 12, 35-40: Oil layers. 48-60: Cobbles with "sticky" oil. 31: H_2S odor. 12: Ground water surface, 3/8/55.
2774 T	Caltrans	foundation	278	38	0-11: af 11-48: Qal/Qalo		31-33: Oily. 33-38: Some cobbles.
2774 U	CE	channel improvement	246	50	0-50: Qal/Qalo		
2774 V	Caltrans	foundation	284	46	0-29: af 29-44: Qal/Qalo 44-46: bedrock	shale	No water.
2774 W	Caltrans	foundation	283	50	0-40: af/Qal/Qalo 40-50: bedrock	shale	No water.
2774 X	Caltrans	foundation	298	67	0-14: af 14-44: Qal/Qalo 44-67: bedrock	shale	
2774 Y	Caltrans	foundation	292	27	0-27: Qal/Qalo		21-27: Heavy oil. 0-27: Cobbles.
2774 Z	Caltrans	foundation	276	6	0-5: Qal/Qalo 5-6: bedrock	shale	
2774 AA	MTA	WC-122	317	73	0-26: Qal/Qalo 26-73: bedrock	siltstone	55-60° dips in bedrock.
2774 BB	MTS	WC-123	319	70	0-25: Qal/Qalo 25-70: bedrock	siltstone	26, 36-40: Petroliferous odor. 55: Oil. 50° dips in bedrock.
2775 A	SOCAL	Department of Recreation and Parks CH 2	260	6054	0-167: Qal/Qalo/Qsp? 167-6054: bedrock	shale, siltstone, & other	167-1500: Shale and siltstone.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2776 A	DWP	water	250±	225	0-11: af 11-82: Qal/Qalo 82-225: bedrock	?	11-82: Boulders. Bedrock: "blue clay."
2776 B	DWP	water	245±	100	0-50: Qal/Qalo 50-100: bedrock	?	Bedrock: "blue clay."
2776 C	ARCO	LA River Comm. 1-1	241±	2924	0-107: Qal/Qalo 107-2924: bedrock	shale, sandstone, siltstone, & other	107-770: Shale. 770-1350: Sandstone and siltstone.
2777 J	DWP	water	250±	672	0-672: Qal/Qalo/Qsp?		105-112, 128-175, 210-286: Cemented.
2777 K	DWP	water	240±	686	0-686: Qal/Qalo/Qsp?		205-212: Boulders.
2777 L	DWR	water	227	400	0-400: Qal/Qalo/Qsp?		
2777 M	DWP	water	250±	710	0-710: Qal/Qalo/Qsp?		"Shale" interlayers mentioned.
2778 J	DWP	water	219±	1200	0-48: af 48-1200: Qal/Qalo/Qsp		
2779 A&B	DWP	water	198±	1250	0-1250: Qal/Qalo/Qsp		
2779 C	DWP	water	200±	201	0-201: Qal/Qalo		
2779 D	DWR	water	203±	1115	0-1060: Qal/Qalo/Qsp 1060-1115: bedrock	siltstone & shale	
2779 M	DWP	water	202±	1075	0-1075: Qal/Qalo/Qsp		
2779 Y	DWP	water	204±	1100	0-1100: Qal/Qalo/Qsp		
2779 Z	DWP	water	198±	1246	0-1246: Qal/Qalo/Qsp		
2781 B	DWP	water	345±	105	0-105: Qalo 81-105: bedrock	shale	
2782 A	PC	foundation	345±	40	0-40: Qal/Qalo		No water.
2783 A	LACOB	foundation	323	100	0-100: Qalo		21: Water encountered, 4/16/74.
2783 B	DWP	foundation	305±	76	0-76: Qal/Qalo		
2783 C	LACOB	foundation	329	50	0-9: af 9-50: Qalo		20-22: Cobbles to 6 inches.
2784 A	LACOB	foundation	323	59	0-17: af 17-59: Qalo		
2784 B	LACOB	foundation	308	48	0-8: af 8-37: Qalo 37-49: bedrock	siltstone	23-26: Cobbles. 26-34: Few cobbles. 27: Water encountered, 8/20/75.
2784 C	Caltrans	foundation	302	50	0-50: Qal/Qalo		37-50: Petroliferous. 13: Ground water surface, 12/14/56.
2784 D	Caltrans	foundation	294	45	0-40: Qal/Qalo 40-46: bedrock	shale	Shale firm. 11-20: Oil sand. 28-45: Petroliferous. 6: Ground water surface, 1/31/57.

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2784 E	Caltrans	foundation	294	39	0-32: Qal/Qalo 32-39: bedrock	shale	Shale very dense. 5-25: Petroliferous.
2784 F	Caltrans	foundation	310	45	0-45: Qal/Qalo		29-45: Oil saturated.
2784 G	Caltrans	foundation	324	49	0-49: Qal/Qalo		22: Ground water surface, 11/9/56.
2784 H	Caltrans	foundation	311	40	0-17: Qal/Qalo 17-40: bedrock	siltstone	Siltstone dense. 11: Ground water surface, 11/9/56.
2784 I	Caltrans	foundation	332	55	0-27: Qal/Qalo 27-55: bedrock?	?	Bedrock: "dense blue-black organic silt with thin sandy and gravelly layers".
2784 J	Caltrans	foundation	300	50	0-35: Qal/Qalo 35-50: bedrock?	?	Bedrock: "Compact to dense blue silty coarse sand and gravel." 35-40: Oil saturated sand. 46: Ground water surface, 12/21/56.
2784 K	Caltrans	foundation	323	60	0-60: Qal/Qalo		55-60: Oil bearing.
2784 L	Caltrans	foundation	339	60	0-60: Qal/Qalo		42-60: Petroleum, hydrocarbon odor. 40: Ground water surface, 1/10/57.
2784 M	Caltrans	foundation	334	69	0-69: Qt		46-69: Petroliferous. 23: Ground water surface, 1/7/57.
2784 N	SOCAL	Seventh Day Adventist Church CH 1	340±	6398	0-<100: Qt <100-6398: bedrock	?	
2784 P	PC	foundation	366	12	0-1: af 1-4: Qt 4-12: bedrock	sandstone & shale	1-4: 10% cobbles and cemented. 4-6: Sandstone. 6-12: Shale. No caving or water.
2784 Q	PC	foundation	349	47	0-3: af 3-45: Qt 45-47: bedrock	shale	Shale cemented. 30: Cemented layer. 23-24: Sloughing. 23: Water seepage, 6/11/65.
2784 R	PC	foundation	345	40	0-39: Qt 39-40: bedrock	shale	31: Cemented layers. 22-23: Sloughing. 22: Water seepage, 6/11/65.
2784 S	PC	foundation	338	40	0-37: Qt 37-40: bedrock	shale	No caving or water.
2784 T	PC	foundation	342	40	0-34: Qt 34-40: bedrock	shale	No caving. 13: Water seepage, 6/11/65.
2784 U	Caltrans	foundation	302	45	0-27: Qal/Qalo 27-45: bedrock?	?	Bedrock: "dense blue silt and oil-stained black fine sand."
2784 V	Caltrans	foundation	321	80	0-80: Qalo		63-80: Cobble layers.
2784 W	MTA	WC-124	290	31	0-25: Qalo 25-31: bedrock	siltstone	Siltstone dips 35°-60°.
2785 A	LACFCD	storm drain	333	16	0-16: Qt		

Map No.	Operator[1/]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2/] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2785 B	PC	foundation	352	40	0-40: bedrock	shale	No caving or water.
2785 C	PC	foundation	342	35	0-25: Qt 25-35: bedrock	shale	Shale weathered. No caving. 26: Slight water seepage, 8/23/71.
2785 D	PC	foundation	344	36	0-4: af 4-36: bedrock	shale	No caving. 34: Slight water seepage, 8/24/71.
2785 E	ARCO	Industrial Comm. 1-1	310	3351	0-<100: Qalo <100-3351: bedrock	siltstone & shale	
2786 A	PC	foundation	317	95	0-95: Qalo		18-20: 5% cobbles. 45-50: 10% cobbles. No caving. 61: Slight water seepage, 12/19/55.
2786 B	PC	foundation	286	39	0-7: af 7-12: Qalo 12-39: bedrock	shale	Shale weathered and fractured. 7-12: Cobbles. No caving. 22: Slight water seepage, 7/5/67.
2786 C	PC	foundation	274	10	0-2: af 2-3: Qal/Qalo 3-10: bedrock	shale	Shale weathered and fractured. No caving or water.
2787 A	DWP	water	241±	765	0-765: Qalo/Qsp		
2787 B	DWP	water	264±	511	0-465: Qalo/Qsp? 465-511: bedrock	shale	
2788 A	DWP	water	199±	401	0-401: Qal/Qalo/Qsp?		
2788 B	NPC	Vernon 1	205±	6517	0-950?: Qal/Qalo/Qsp 950?-6517: bedrock	siltstone, shale, & other	950?-2550: Siltstone and shale.
2788 E	DWP	water	209±	497	0-497: Qal/Qalo/Qsp?		
2788 G	DWP	water	203±	602	0-602: Qal/Qalo/Qsp?		
2788 J	DWP	water	203±	2445	0-1270?: Qal/Qalo/Qsp 1270?-2445: bedrock	?	
2789 A	DWP	water	190±	489	0-489: Qal/Qalo/Qsp?		
2789 H	DWP	water	192±	572	0-572: Qal/Qalo/Qsp?		
2789 I	DWP	water	210±	926	0-926: Qal/Qalo/Qsp		
2789 J	DWP	water	199±	1010	0-1010: Qal/Qalo/Qsp		
2793 A	LACOB	foundation	321	71	0-58: Qal/Qalo 58-71: bedrock	sandstone, siltstone, & shale	Sandstone, siltstone, and shale interbedded. 23: Water seepage, 4/8/74.
2794 A	PC	foundation	330±	16	0-13: af/Qalo 13-18: bedrock	claystone & sandstone	No caving or water.

Map No.	Operator[1]	Designation or Purpose	Elev. (feet)	Total Depth (feet)	Geology[2] (depths in feet)	Bedrock Type	Remarks (depths in feet)
2795 A	LACFCD	foundation	335	21	0-21: Qt		No caving or water.
2796 A	PC	foundation	285	28	0-17: af 17-22: Qal/Qalo 22-28: bedrock	shale	Shale weathered and fractured. 4-9: Raveling. No water.
2796 B	PC	foundation	284	39	0-22: af 22-28: Qal/Qalo 28-39: bedrock	shale & siltstone	28-36: Shale weathered and fractured. 36-39: Siltstone weathered and fractured. No caving or water.
2796 C	PC	foundation	265	18	0-10: af 10-13: Qal/Qalo 13-18: bedrock	shale	Shale weathered and fractured. 10-13: Raveling. 13: Water seepage, 7/5/67.
2798 J	DWP	water	185±	811	0-811: Qal/Qalo/Qsp		

[1] ARCO: Atlantic Richfield Company
BOGCO: Burmak Oil and Gas Company
Caltrans: California Department of Transportation
CE: U.S. Army Corps of Engineers
DWP: Los Angeles City Department Water and Power
DWR: California Department Water Resources
Hosp: Hospital
LACFCD: Los Angeles County Flood Control District
LACIB: Los Angeles City public building
LACOB: Los Angeles County public building
MTA: Metropolitan Transit Authority (of 1962)
NPC: Neaves Petroleum Company
PC: Private consultant or contractor
SBOC: Seaboard Oil Company
SOCAL: Standard Oil Company of California
TEXACO: Texaco, Incorporated
VOCO: Ventura Oil Company
WS: William Sullivan
WSP 139: U.S. Geological Survey Water Supply Paper 193

[2] af: Artificial fill and colluvium
Qal: Alluvium
Qalo: Old alluvium
Qsp: San Pedro Formation (Thomas and others, 1961)

TABLE 2. COMBINED TERZAGHI ROCK AND SOFT-GROUND TUNNEL CONDITIONS

(After Proctor, 1971; condition 10 from Brandt and others, 1970)

1 - Hard and intact.
2 - Hard stratified or schistose.
3 - Massive, moderately jointed; *very firm ground.*
4 - Moderately blocky and seamy; *firm ground, may ravel when below water table.*
5 - Very blocky and seamy (closely jointed); *may ravel when below water table.*
6 - Crushed but chemically intact rock or unconsolidated sand; *may run or flow below water table.*
7 - Squeezing rock, moderate depth.
8 - Squeezing rock, great depth.
9 - Swelling rock.
10 - Bouldery ground.

Notes: In practice, there are no sharp boundaries between these categories, and a range of several numbers may best describe some conditions.

Definitions of terms

Blocky and seamy rock--(Rock Condition Nos. 4 and 5). Refers to almost intact rock in which separated blocks or fragments are imperfectly interlocked. Tunnel walls usually require support. "Seamy" is a tunnel man's term and may be described as: irregular schistose layers in crystalline rock: shale or clay layers commonly interbedded in sandstone or limestone, and also any rock with numerous clay-filled joints and fractures. More specifically: *Moderately blocky and seamy*--joints or bedding plane partings are two to six feet apart. Overbreak is generally small. Walls do not require lateral support. Ribs may be set on two- to four-foot centers, if extensive lagging is used. Rock "stands moderately well." *Very blocky and seamy (closely jointed)*--extensively jointed and fractured rock (partings at one-inch to two-foot intervals), or poorly cemented strata; overbreak common. Joints are open or weakly cemented, and several joint sets are obvious. Includes fractured rock, but not crushed or brecciated as in a shear zone. Rock "stands poorly." Groundwater may be very troublesome. Spiling may be required for driving stability, and the walls of the tunnel must be lagged.

Bouldery ground--(Rock Condition No. 10). Applies in some degree to most surficial deposits in Los Angeles area, specifically to alluvium, old alluvium, and terrace deposits. Probably the most severe tunneling condition represented because of difficulty in handling large numbers of boulders without severely reducing the rate of advance; blasting or hand-mining ahead of machine possibly necessary (Brandt and others, 1970, p. 12, 47, 57).

Crushed but chemically intact rock or unconsolidated sand--(Rock Condition No. 6). Brecciated (shattered) fault zone material, often containing fault gouge. If most of the crushed fragments are the size of sand grains, or the material is unconsolidated or weakly cemented sand, these materials below the water table may become running or flowing ground. Side pressures become significant. In normally unlined tunnels, lining is usually required where Rock Condition No. 6 is encountered.

Firm ground--(Rock Condition Nos. 3 and 4). Firm ground refers to consolidated sediments or soft sedimentary rock in which the tunnel heading can be advanced without any, or with only minimal, roof support, and the permanent lining can be constructed before the ground begins to move or ravel. Firm ground is the ideal boring machine material. Below the water table firm ground may become running or flowing ground. Firm ground results from cementation, consolidation, or compaction of sediment. Material has a dull sound when struck with a hammer. Typical representatives of firm ground are cohesive sand and loess above the water table, and various clays with low plasticity, such as kaolin and marl (calcareous clay).

Flowing ground--(Rock Condition No. 6). Flowing ground moves like a viscous liquid. It occurs only below the water table in a saturated material, particularly under artesian pressure. In contrast to running ground, it can invade the tunnel not only through the roof, sides, and face, but also up from the floor. If the flow is not stopped, it will continue until the tunnel is filled. A sudden rush of flowing ground into a tunnel is known as a "blow" or a "boil." Dewatered flowing ground usually becones firm ground.

Hard and intact rock--(Rock Condition No. 1). Massive rock containing no significant joints; when fractured by blasting, it breaks across sound rock, as in tombstone-quality granite. Rock rings when struck with hammer. Bit wear is high. Tunnel supports are not required. Spalling and popping may occur. ("Soft intact" rock is more aptly termed firm ground).

Hard stratified or schistose rock--(Rock Condition No. 2). Consists of indurated or cemented layers or strata. Slaty cleavage belongs in this category. However, stratified or schistose rock can range from complete resistance to no resistance against separation along bedding or foliation planes, and thus includes all rock conditions except No. 1. Stratified rock may have abundant bedding-plane slickensides unrelated to faults. Joint planes commonly occur normal to the bedding or schistosity. If the strata are more than six feet thick, the rock may be termed massive and belong in Rock Condition No. 3.

Jointed rock--contains fractures or cracks. True jointing exhibits more or less systematic orientation of inherent cracks in a rock mass; fractured rock consists of broken rock in which randomly oriented cracks result either from blasting or faulting.

Massive rock--(Rock Condition No. 3). Rock is nearly intact; joints and hair cracks are at spacings of six feet or greater. Large cracks and other rock defects may be naturally cemented to yield a massive rock. Bedding planes are not significant. If overbreak occurs, it is usually a result of poor blasting techniques rather than rock condition. Support ribs may be set on six-foot centers with very little or no lagging, or light roof bolting. Rock "stands well."

Popping rock (rock burst)--a rock condition involving the spontaneous and violent detachment of rock slabs. It is caused by sudden stress release in the rock. Occurs commonly in hard intact rock to moderately jointed rock at great depth.

Raveling ground--(Rock Condition No. 5). Poorly consolidated or cemented materials that can stand up for several minutes to several hours at a fresh cut, but then start to slough, slake, or scale off. Slightly cohesive sand is assigned to this category. Raveling ground may become running or flowing ground below the water table.

Running ground--(Rock Condition No. 6). Material of no cohesion, such as clean sand or gravel, is referred to as running ground regardless of whether it is located above or below the water table. Stand-up time is nearly zero. Tunneling usually is uneconomical below the water table without prior dewatering or grouting. Running ground above the water table will stabilize on a slope of 30 to 40 degrees; the grain size, shape, driving force of water pressures, and moisture content govern the angle of repose. Breastboards or other means of securing the heading are required for advance.

Squeezing rock--(Rock Conditions Nos. 7 and 8). Slow movement of rock into the tunnel without perceptible volume increase. All tunnels in soft clay experience squeeze. The difference between Terzaghi category 7, moderate depth, and 8, great depth, is arbitrary depending on rock types and conditions in a given tunnel; assume 1,000 feet of cover as the dividing line between moderate and great depth. Rock pressure expressed by squeeze can occur in a tunnel in three ways, including (1) *chemically induced squeeze.* (2) *Mechanical squeeze (gravity):* This occurs where rock is adversely jointed or fractured and loosened by overblasting, or where a shallow or weakly consolidated overburden inhibits development of a normal ground-arch above the crown. Gravity then can act on the blocks of rock to load and deform the support system. If ribs are the main type of support, back-packing and wedging behind ribs--to maintain interlocking of rock fragments--are essential in preventing or retarding this type of squeeze. (3) *Tectonic squeeze ("mountain pressure"):* Latent stresses within a rock mass, which usually increase with depth of cover. The tunnel provides a cavity for relief of stresses, and the rock often deforms plastically. Some minerals also expand elastically when confining pressure is relieved. Pressures as high as 20 tons per square foot have been recorded.

Stand-up time--the time that elapses between the exposure of an area at the roof of a tunnel and the beginning of noticeable movements of the ground above this area. For example, the stand-up time of raveling ground may be several minutes, or long enough to install temporary supports, but the stand-up time of flowing ground is zero. Tunnel size is an important factor.

Swelling rock--(Rock Condition No. 9). Expands in volume upon exposure to water. (Swelling is a particular type of squeezing ground.) Excavation may require blasting or the rock may be soft enough to require shield methods. Usually limited to those rocks that contain minerals with an expanding-lattice molecular structure: examples are montmorillonite clay (commonly volcanic ash altered to bentonitic tuff), and serpentinite; sedimentary formations containing anhydrite may hydrate to gypsum with great pressures and volume increase. True swelling in clays is totally reversible only with complete dehydration. Invert struts, circular ribs, or yielding ribs are required for support in swelling ground.

TABLE 3.--STANDARD PENETRATION TEST[1/]

Relative Density of sand		Strength of Clay		
Penetration resistance, N (blows/ft)	Relative density	Penetration resistance, N (blows/ft)	Unconfined compressive strength (tons/ft^2)	Consistency
0-4	Very loose	<2	<0.25	Very soft
4-10	Loose	2-4	0.25-0.50	Soft
10-30	Medium	4-8	0.50-1.00	Medium
30-50	Dense	8-15	1.00-2.00	Stiff
>50	Very dense	15-30	2.00-4.00	Very stiff
		>30	>4.00	Hard

[1/] Terzaghi and Peck, 1967, p. 341,347.

Appendix 1.--Recently-excavated Los Angeles-area tunnels

[Data provided by R. J. Proctor, 1977]

Owner and Tunnel Name	Location	Length	Diameter	Material, Geologic unit	Year begun, method, comments
Los Angeles County Flood Control Dist. Storm Drain #1102 (2 short segments: Hoover St., Sacatella)	Los Angeles (downtown)	0.6 mi	17 ft	Sandstone, shale, Puente Fm.	1975. Gradall in a shield. Prior dewatering required by specs. Gas and seeping oil encountered in Los Angeles City oil field, but controlled by strong ventilation.
Metropolitan Water Dist. Tonner 1 and 2	Near Yorba Linda, Orange Co.	3.4 mi	11 ft	Sandstone and shale, Puente Fm.	1972. Mainly rotary-head mole. Delay in Tonner No. 1 due to hard sandstone, but rate in longer Tonner No. 2 avg. 60 ft/day; several days of over 100 ft/day.
Los Angeles, County Flood Control Dist. Storm Drain #1105	Redondo Beach, Torrance	2 mi	13 ft, 7 ft	Dune sand, damp	1972. Air spade, rubber-tired mucker. Sand stood well during installation of steel ribs.
Metropolitan Water Dist. San Fernando	Sylmar area	5.5 mi	22 ft	Sandstone, siltstone, boulders; Saugus Fm., alluvium	1969. Digger-type mole. Dry old alluvium stood well; wet old alluvium caved, required dewatering from within tunnel. Progress up to 277 ft/day (world record), including precast segment supports. Mole handled boulders in old alluvium and Saugus.
Pacific Telephone Co., Olive Street	Los Angeles (downtown)	750 ft	7 ft	Siltstone, Puente Fm.	1969. Rotary-head mole. Siltstone damp; no problems encountered.
Metropolitan Water Dist. Balboa Outlet	Sylmar	0.7 mi	16 ft	Sandstone, siltstone; Saugus Fm., Sunshine Ranch Fm.	1968. Rotary-head mole; conditions mostly dry to dripping; rates up to 111 ft/day, but avg. 30 ft/day, due in part to short tunnel length and adjustments to new mole.

Appendix 1.--Recently-excavated Los Angeles-area tunnels--cont.

Owner and Tunnel Name	Location	Length	Diameter	Material, Geologic unit	Year begun, method, comments
Metropolitan Water Dist. Sepulveda	Encino area	1.4 mi	12 ft	Sandstone, shale, Puente Fm.	1968. Drill and blast; wet, firm sedimentary rock. No unusual conditions.
Metropolitan Water Dist. Castaic 1 and 2	Castaic	3.5 mi	26 ft	Siltstone, sandstone, boulders; Castaic Fm., Saugus Fm.	1967. Digger-type mole handled large boulders in Saugus Fm. with no significant problems. Avg. rate in Castaic No. 2 was 112 ft/day best rate 202 ft/day (4100 cu. yds. excavated muck in 24 hrs). Precast concrete segment supports used.
Metropolitan Water Dist. Newhall	Newhall-Sylmar	3.3 mi	26 ft	Sandstone, siltstone, mudstone; Saugus Fm., Pico Fm., Towsley Fm.	1966. Rotary-head mole from S. portal, oscillating "windshield-wiper" mole from N. portal. Long segment in wet sandstone with boulders of Saugus was dewatered with surface wells; gas and seeping oil handled with strong ventilation.
Metropolitan Water Dist. Glendora	Glendora	6.2 mi	19 ft	Shale with bentonite, Puente Fm.; Sand and cobbles, alluvium	1966. Drill and blast. Dry shale no problem; wet shale with bentonite swelled, requiring installation of jump-set steel rib supports, causing minor delays. Avg. rate of excavation 22 ft/day.

☆ U.S. Government Printing Office: 1977—240-961/95