US Army Corps
of Engineers
Los Angeles District

SANTA ANA RIVER BASIN, CALIFORNIA

Santa Ana River

Design Memorandum No. 1

PHASE II GDM ON THE SANTA ANA RIVER MAINSTEM including Santiago Creek

VOLUME 3
LOWER SANTA ANA RIVER
APPENDIXES

August 1988

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This appendix provides a description for the project area, the geology, faulting, seismicity, groundwater conditions; describes the geotechnical explorations and testing performed; presents the existing foundation conditions and parameters used in the project design.

A GEOTECHNICAL

LOWER SANTA ANA RIVER
PHASE II GENERAL DESIGN MEMORANDUM
APPENDIX A

GEOTECHNICAL APPENDIX

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

AUGUST 1988

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I. INTRODUCTION

Purpose and Scope

1-01 Geotechnical investigations were conducted to determine and evaluate the topography, geology, and groundwater and foundation conditions of the Lower Santa Ana River. This appendix provides a description of the project area; the geology, faulting and seismicity; groundwater conditions; describes the geotechnical explorations and testing performed; presents the existing foundation conditions; and parameters used in the project design. Recommendations are given for foundation treatment, embankment design, subdrainage systems, disposal site compatibility, and construction applications.

Location

1-02 The channelization measures for the Lower Santa Ana River discussed in this report extend approximately 23 miles through the northwestern portion of Orange County, California. The project begins at Weir Canyon Road and ends at the Pacific Ocean between Huntington and Newport Beaches. Localized improvements are also proposed within Santa Ana Canyon, immediately below Prado Dam. The proposed project is shown on plate 1. All Lower Santa Ana River stationing within this report is based upon the Phase I GDM alignment, as shown in table A. The Santa Ana Canyon stationing will not be adjusted.

Description of Existing Condition

1-03 Channelization of the Lower Santa Ana River, from Weir Canyon Road to the Pacific Ocean, currently consists of several types. Typical channel sections are described in the following paragraphs. The reaches are defined by the existing geometry and structures. A tabulation of designed and existing conditions along the Lower Santa Ana River is shown in table 1. Typical existing cross-sections from the original construction drawings are shown on plate 2.

Table A. Lower Santa Ana River.

Phase I-Phase II Stationing
Equation Table

Landmark	Phase I Station (as used in this appendix)	Phase II Station
Weir Canyon Road	1202+00	1207+10
Imperial Highway	1057+50	1055+50
Lakeview Avenue	975+50	983+48
Riverside Freeway	918+50	926+28
Santa Fe Railroad	890+00	897+80
Lincoln Avenue	813+50	821+50
Ball Road	742+00	749+30
Katella Avenue	701+00	708+92
Orange Freeway	675+00	682+45
Santa Ana Freeway	617+50	625+40
Garden Grove Freeway	595+00	603+17
Santiago Creek	558+50	566+00
17th Street	513+50	521+30
Edinger Avenue	385+00	392+80
Harbor Boulevard	342+00	349+90
San Diego Freeway	254+34	262+20
Adams Avenue	163+71	171+32
Fairview Channel	145+00	150+32
Hamilton-Victoria	82+16	90+40
Pacific Coast Highway	9+47	17+20

WEIR CANYON ROAD TO KATELLA AVENUE

1-04 From Weir Canyon Road downstream to a point about 1100 feet south of Katella Avenue, a distance of 9.5 miles, the existing channel is trapezoidal in cross section with a soft bottom invert and stone revetted side slopes of 1V on 2H, extending to a depth of 9 feet below invert. It has a base width ranging from 300 feet at the upstream end to 320 feet near Katella Avenue, and levee heights ranging from 12 to 14 feet. Below Imperial Highway, to Katella Avenue, a series of water retention basins exist which parallel the river outside the right levee. The water elevation in these basins is controlled by weirs and is retained at an elevation approximately level with that of the adjacent river invert. Within this reach there is one invert stabilizer and eight drop structures.

KATELLA AVENUE TO GARDEN GROVE FREEWAY

1-05 Downstream from Katella Avenue to the Garden Grove Freeway, a channel reach of 2.1 miles, the earth-bottom trapezoidal channel has a base width varying between 240 to 270 feet, a levee height ranging from 12 to 16 feet, and side slopes changing from 1V on 1.5H to 1V on 3H. The upper 500 feet of channel with the steeper side slopes has concrete slope protection, and the remaining reach of this channel has flatter stone-revetted slopes, extending to a depth of 9 feet below invert. Within this reach of channel, two drop structures, approximately one mile apart, were constructed by the Orange County Flood Control District. There are also two invert stabilizers.

GARDEN GROVE FREEWAY TO 17TH STREET

1-06 For a distance of 1.5 miles, from south of the Garden Grove Freeway to the vicinity of north of 17th Street, the river has only limited improvement. About half of the banks are protected by pipe and wire fence, and the remaining banks within the River View Golf Course are stabilized by turf. One drop structure has been constructed at the southern end of this reach.

17TH STREET TO ADAMS AVENUE

1-07 From approximately 1200 feet upstream of 17th Street to about 3000 feet downsteam of Adams Avenue, a reach of 7.4 miles, the channel is well entrenched with a soft bottom, trapezoidal cross section, and levee heights ranging from 13 to 17 feet. The side slopes, varying from 1V on 1.5H to 1V on 2H, are protected with reinforced concrete, which extends 8 feet below invert. The base width of the channel varies significantly within this reach, ranging from 180 to 230 feet. Since 1980, seven invert stabilizers have been constructed within this reach.

ADAMS AVENUE TO PACIFIC OCEAN

1-08 Downstream from Adams Avenue for a distance of 1.8 miles, the base width of the soft-bottom trapezoidal channel varies from 230 to 160 feet. The channel height varies from approximately 16 to 18 feet. The side slopes of the channel are 1V on 1.5H and are protected with reinforced concrete, which extends to 4 feet below invert. A riprap toe protection continues to a depth of 7 feet below invert.

1-09 From the above reach to the Pacific Coast Highway, the distance is 0.6 miles. The channel base width is 160 feet except at the downstream 0.2 miles where the width changes to 180 feet and the soft-bottom channel changes in cross section from trapezoidal to rectangular. The wall height for both types of channel sections is approximately 16 feet. The vertical channel walls are constructed with reinforced concrete. The invert is concrete paved.

1-10 The outlet of the Santa Ana River is located south of the Pacific Coast Highway in Huntington Beach where the river enters the Pacific Ocean. The outlet consists of a transition section, from rectangular to trapezoidal, with a stone jetty containment. The 700-feet long channel reach has a soft bottom invert with a base width that increases from 180 to 316 feet, as the Greenville-Banning and Huntington Beach channels converge with the Santa Ana River at the mouth.

SANTA ANA CANYON

1-11 This portion of the Santa Ana River is located just below Prado Dam in an area that has limited development and minor floodproof improvements, by locals, scattered throughout this reach. The entrenched river meanders through the 9-mile long canyon with a base width ranging from 250 feet at the drop structure to approximately 100 feet in the Green River Golf Course area. At the drop structure, there is an approximately 8 feet change in elevation of the river with the surrounding terrain being typical of flood plain areas. At the Green River Golf Course, the river flows under the Santa Fe railroad bridge and continues on through the golf course in a well defined path flowing under several foot and golf cart bridges. The surrounding floodplain area (golf course) is a well kept grass with many mature trees and shrubs.

Description of Proposed Improvements

1-12 The Lower Santa Ana River improvements vary according to the parameters of hydraulic capacity, right-of-way constraints, and geotechnical conditions. For the purpose of geotechnical analyses, seven reaches of the river have been identified as having distinguishing characteristics. The proposed project is described in the following subparagraphs in terms of the unique geometric conditions of each particular reach. See plate 3 for proposed typical cross sections of each reach. The geotechnical conditions within these reaches will be discussed in subsequent paragraphs. A summary of the future flow conditions, including the design flow of 30,000 cfs, is presented below:

All River Plan - Future Flow Conditions

Q - cfs	2000	5000	10,000	20,000	30,000
Days Exceeding Q in 100 years	3490	1512	655	201	10

WEIR CANYON ROAD TO IMPERIAL HIGHWAY, (REACH 1; Main Report-Sta. 1207+10 to 1055+50; This Appendix-Sta. 1202+00 to 1057+50).

1-13 Along this 3-mile reach the existing cross-section of channel will be utilized to the extent practical. Two new drop structures will be constructed between Weir Canyon Road and Imperial Highway to supplement the existing one, with four stabilizers added between the drop structures. Material between invert structures will be removed and the result will be that the invert level will be about 5 feet lower. The new levee crest will be about the same or up to 4 feet higher than the existing, depending on the location. The levee slopes will be revetted with grouted stone.

1-14 As the levee height is increased on the south side of the river upstream from Imperial Highway, the levees will be built upward and outward into the existing river channel. The close proximity of the Riverside Freeway on the south side makes it impractical to encroach into the freeway right-of-way. In order to obtain a usable channel base width of between 290 and 300 feet it will be necessary to rebuild about 2-1/2 miles of the existing north levee. The channel centerline would be shifted about 20 feet northward. A transition will bring the channel back to the existing centerline just upstream of the Imperial Highway bridge.

IMPERIAL HIGHWAY TO KATELLA AVENUE, (REACH 2; Main Report-Sta. 1055+50 to 708+92; This Appendix-Sta. 1057+50 to 701+00).

1-15 Improvements in this 7-mile reach will consist of upgrading the existing trapezoidal earth-bottom channel. To provide greater channel capacity, levee heights will generally remain at the existing height, but will be raised up to 3 feet, depending on location with respect to drop structures. Typically, the channel side slopes will be revetted with grouted stone. Approximately 1 mile of channel slopes, however, will be covered with riprap. The rock toe revetment will be extended to a lower elevation. The seven existing drop structures will be hydraulically redesigned. Twelve new invert stabilizers will be located within this reach. The spreading basins adjacent to the flood control channel will remain. At bridge crossings, a minor amount of work will be necessary; for example, access ramps above and below the bridges will be provided or restored as necessary. Ramp work will be designed by the County.

KATELLA AVENUE TO SANTIAGO CREEK, (REACH 3; Main Report-Sta. 708+92 to 566+00; This Appendix-Sta. 701+00 to 558+50).

1-16 In the 3-mile reach of river from south of Katella Avenue downstream to the Garden Grove Freeway, the channel will be trapezoidal with a soft bottom. The existing channel base width narrows from about 320 feet upstream of Katella Avenue to 270 feet downstream. Rather than widen the channel, the levee crest levels will be raised about 3 to 5 feet. The channel will continue with about a 270-foot base width and an average 16-foot depth, to the confluence with Santiago Creek. The revetment will be strengthened by the uses of approximately 1 mile of grouted stone slope protection, and a generally larger riprap size. There are three new drop structures and five new stabilizers in this reach.

SANTIAGO CREEK TO 17TH STREET, (REACH 4; Main Report-Sta. 556+00 to 521+30; This Appendix-Sta. 558+50 to 513+50).

1-17 At the Santiago Creek confluence, the east revetment will bend around to the north bank of the creek and stop about 200 feet upstream. On the west side of the river, a grouted stone slope will continue to a transition into a concrete channel about 700 feet upstream from 17th Street. A grouted stone drop structure will be constructed immediately upstream from the Santiago Creek confluence.

17TH STREET TO FAIRVIEW CHANNEL, (REACH 5; Main Report-Sta. 521+30 to 150+32; This Appendix-Sta. 513+50 to 145+00).

1-18 This 7-mile reach of channel currently has concrete side slopes extending about 8 feet below the existing soft bottom invert. To gain more capacity, the recommended plan calls for conversion to a paved, hard bottom channel.

1-19 In the reach from 17th Street down to about the San Diego Freeway, the top width of channel would be about the same as the existing top width, in the range of 242 to 250 feet. The slopes and invert would be paved. The channel will be about 18 feet deep.

1-20 South of Edinger Avenue, the river is no longer deeply entrenched. The levees rise to about 12 feet above the natural ground line, with the river bottom only about 3 feet below the ground line. The river bottom will be lowered an average of about 5 feet in order to increase channel capacity.

1-21 In the reach from the San Diego Freeway down to the Fairview channel, the top (and base) width of channel would be about the same as the existing top width, but within this reach the channel would be converted to a rectangular, hard-bottom channel.

1-22 Near Adams Avenue, the channel gradient flattens from 9 feet per mile to about 3 feet per mile. At this point the concrete channel will widen from 250 to 365 feet, and the wall heights will increase from about 18 to 21 feet to accommodate the slower flow. To avoid additional right-of-way requirements along the east side of the Greenville-Banning channel near Adams Avenue, the Santa Ana and Greenville-Banning channels will be located very close to one another. Thirty feet of clearance will be maintained between the two channels to provide for an elevated access road. Ramps constructed along the reach will provide access into the concrete channel. At several bridges, tunnel underpasses will be constructed to retain grade-separated crossings. Several bridges will be rebuilt or modified. All bridge, tunnel and ramp improvements will be designed by the County.

FAIRVIEW CHANNEL TO HAMILTON-VICTORIA STREET, (REACH 6; Main Report-Sta. 150+32 to 90+40; This Appendix-Sta. 145+00 to 82+16).

1-23 The Santa Ana River will transition and widen to 450 feet in the area adjacent to the Greenville-Banning channel confluence with the Fairview channel. The main channel will transition from concrete to soft bottom with revetted slopes. A soft bottom (approximately 8 feet lower than the existing) is required in this tidal zone of the Santa Ana River for environmental reasons. The Greenville-Banning channel will parallel the Santa Ana River as a concrete bottom channel.

HAMILTON AVENUE-VICTORIA STREET TO THE PACIFIC OCEAN, (REACH 7); Main Report-Sta. 90+40 to End; This Appendix-Sta. 82+16 to End).

1-24 The Santa Ana River and Greenville-Banning channels will be merged into one common soft bottom channel just below the Hamilton Avenue-Victoria Street Bridge. The Santa Ana River and Greenville-Banning combined channel will be about 22 feet deep and 480 feet wide. The channel bottom will be lowered to 10 feet. The revetted channel slopes will continue to within 500 feet of the ocean; at that point, the channel walls will transition to stone jetties that extend to the low tide line.

SANTA ANA CANYON

1-25 The Corps of Engineers will construct localized improvements in the canyon reach, to supplement existing improvements by others. The proposed Corps improvement at the existing drop structure (below Hwy. 71) will consist of extending a 23 foot deep steel sheet pile wall on both sides. The sheet piles will extend 45 degrees back from ends of the drop structure, for a length of 100 feet, to prevent eddy current erosion.

1-26 The proposed Corps improvement at the Green River Golf Course area will consist of a levee along the south side of the river to protect an existing mobile home park. The upstream portion of the levee will tie into the existing Santa Fe bridge abutment and the dowstream end will tie into the Riverside Freeway (State Highway 91). The levee will be approximately 4 feet higher than the existing ground surface and the riprap slope protection will extends downward at a 1V on 2H slope approximately 40 feet to provide protection below the river's thalweg.

MATERIAL DISPOSAL

1-27 During construction of the river channel, an estimated 4.5 million cubic yards of material will be excavated from the channel bed. Some of the required excavation will be used for channel improvement. The excess material, which naturally would be deposited in the ocean by floodflows, may be placed on neighboring beaches between Anaheim Bay and Newport Bay if it is deemed suitable for such use. Additional inland disposal sites have been identified, by utilizing existing landfill operation and depleted gravel mining sites. The inland disposal sites are discussed in the environmental appendix.

II. GEOLOGY

Topography

2-01 The Lower Santa Ana River project is situated within the southeastern (Orange County) part of the Los Angeles basin (see fig. 1), a broad alluviated lowland plain on the coast of southern California at the north end of the Peninsular Ranges province. The physiographic basin is bounded on the east and southeast by the Santa Ana Mountains and San Joaquin Hills and on the northwest and north by the Santa Monica Mountains and the Elysian, Reppetto, Puente and Chino Hills of the Transverse Ranges province. Elevations in the rolling hills to mountainous terrain that rim the coastal plain range from 200 feet to more than 5000 feet above sea level.

2-02 The Santa Ana River has its headwaters in the San Bernardino Mountains and flows across the Upper Santa Ana Valley to Prado Dam. Downstream from Prado Dam, the Santa Ana River flows through the relatively narrow steep-sided Santa Ana Canyon for a distance of approximately 9 miles. The north side of the canyon is bounded by the rolling topography of the Chino Hills (also known as the eastern Puente Hills). On the south side, the more rugged, higher, and more geologically diverse Santa Ana Mountains bound the canyon. Downstream from Santa Ana Canyon, the river flows across the Los Angeles basin, also referred to as the central plain in figure 2. The river flows through a coastal lowland known as the Santa Ana Gap before entering the Pacific Ocean. The gap is an alluvial valley about 2-1/2 miles wide, bounded on either side by highland areas known as the Huntington Beach and Newport Mesas. The mesas range in elevation from about 50 to 85 feet higher than adjoining areas in the gap.

Regional Geology

2-03 The Los Angeles basin is underlain by a northwest trending structural depression (see fig. 2), parts of which have been the site of discontinuous deposition since late Cretaceous time and of continuous subsidence and deposition since late Tertiary time (Yerkes and others, 1965). The Precambrian to Cretaceous age igneous and metamorphic basement rocks are overlain, in the deepest part of the basin, by approximately 30,000 feet of chiefly marine sediments ranging in age from Cretaceous to Holocene (Recent). Locally around the margins of the basin, particularly in the Santa Ana Mountains, these sediments have been stripped away by erosion to reveal the complex assemblage of basement rocks. A geologic map of the project area is shown on plate 4.

2-04 The Los Angeles basin in late Tertiary time extended well beyond its present day margins. However, tectonic forces subsequently produced several smaller depositional basins including the San Fernando, San Gabriel and Upper Santa Ana inland valleys. The rapidly rising mountains bordering the basin as well as changes in the sea level began to affect the cycle of erosion and deposition. As a result, up to several thousand feet of alluvial sediments derived from the surrounding highland areas were deposited in the ever deepening basins during the Pleistocene; a process which continues even today.

2-05 Near the mouth of the Santa Ana River, at the Santa Ana Gap, the geologic conditions are further complicated by deformation and uplift along the Newport-Inglewood structural zone. As a result of this deformation, early Pleistocene formations are exposed in mesas on either side of the river. The gap itself was created near the end of the Pleistocene when a major decline in sea level occurred. The ancestral Santa Ana River, in response to this changing base level, eroded a valley, the Santa Ana Gap, about 200 feet deep across the elevated coastal plain. After the last of the ice age glaciers melted and the sea level began to rise, the river began to aggrade, depositing coarse alluvium (the Talbert aquifer). As the rate of sea level rise slowed, the sediments became finer grained. These relatively impervious silts, clays, and organic deposits effectively confined the very permeable sands and gravels below. Generally speaking, these finer grained deposits are present from the Pacific Ocean to just below the confluence of the Santa Ana River and Santiago Creek. As a result, the Los Angeles basin in Orange County is hydrologically divided into two main subbasins (see fig. 3), the Santa Ana Forebay, which occurs generally north of the Santa Ana Freeway and is characterized by unconfined groundwater and the Santa Ana Pressure Area, which lies south of the freeway and is characterized by confined groundwater (California Department of Water Resources, 1959).

Local Geology

GENERAL

2-06 The Los Angeles basin contains a thick succession of Late Cretaceous through Pleistocene marine and nonmarine clastic sedimentary rocks and interbedded volcanic rocks of middle Miocene age. This assemblage overlies rocks of the Jurassic to Late Creteceous-age basement complex. Regional stratigraphic studies infer that, in the central part of the basin, the lower parts of this succession are thinned or missing beneath younger rocks; the Pliocene and Quaternary strata are as much as four times as thick as in the Santa Ana Mountains; and the entire depositional sequence attains a maximum thickness of about 30,000 feet (Yerkes and others, 1965). The basement complex includes the Bedford Canyon Formation, the Santiago Peak Volcanics, and intrusive plutonic rocks of the southern California batholith.

COASTAL PLAIN

2-07 The lowest sedimentary rocks overlying the basement complex consist of up to approximately 10,000 feet of predominantly sandstone and conglomerate of Late Cretaceous to early Miocene age. These rocks are overlain by up to several thousand feet of middle and upper Miocene marine sandstones, siltstones, and conglomerates assigned to the Topanga and Puente Formations. Locally, thick sequences of Miocene age intrusive and extrusive igneous rocks occur in several parts of the basin. Rocks of Miocene age are overlain by about 2000 feet of lithologically similar marine sediments of the early Pliocene lower member of the Fernando Formation. The upper member of the Fernando Formation, locally called the Pico Formation, follows in stratigraphic sequence, and consists of up to 5000 feet of Late Pliocene age marine sediments, similar in composition to those of the lower member. Pleistocene marine and nonmarine deposits range in thickness from about 200 to 2500 feet. They are divided into the San Pedro Formation of early Pleistocene age, unnamed middle Pleistocene deposits, and the La Habra Formation of Late Pleistocene age. In the Santa Ana Gap, the entire upper Pleistocene section, which ranges in thickness from 0 to 400 feet, has been designated the Lakewood Formation by the California Department of Water Resources (1961). Sediments of Holocene (Recent) age consist of alluvial and littoral deposits of clay, silt, sand, gravel, and peat. In the Santa Ana Gap, the Recent unit has been divided into upper and lower zones. Fine sand, silt, and clay of low permeability form the upper zone above the permeable coarse sands and gravels of the lower zone. These deposits range in thickness from 0 to a maximum of 180 feet in the Santa Ana Gap.

SANTA ANA CANYON

2-08 The Santa Ana Canyon is approximately 9 miles long and only 0.3 miles wide at the narrowest place, just below Prado Dam. The Quaternary alluvial fill in the canyon has a nearly uniform thickness of from 80 feet near the upper end to 100 feet in the lower part. The alluvial deposits are coarsest at depth, where boulders from 1 to 2 feet in diameter are present. The deposits are predominantly sandy near the surface. The bedrock floor beneath the streambed alluvium is deeper above the head of the canyon and below its mouth. Remnants of alluvial material deposited by the Santa Ana River at elevations now above the active stream channel are present as terraces on both sides of Santa Ana Canyon. Bedrock exposures in the mountains and hills which border the canyon consist generally of marine and nonmarine sandstones, siltstones, and conglomerates of Late Cretaceous to Pleistocene age. Rocks of the older basement complex, consisting of Santiago Peak Volcanics and related intrusive rocks, outcrop near the upper end of the canyon in the Santa Ana Mountains.

GEOLOGIC STRUCTURE

2-09 The depth to the basement surface along the Santa Ana River is influenced by several northwest-trending structural features, the major ones being a doubly plunging synclinal trough underlying the central part of the basin and an anticlinal feature known as the Anaheim nose (see fig. 2). Depths to basement rock range from about 14,000 to 16,000 feet below sea level in the Santa Ana Gap area, rising gently to an average subsea depth of 9500 feet in the axial part of the Anaheim nose. The northeast flank of the anticline slopes down to an average subsea depth of about 12,000 feet in the lower portion of the Santa Ana Canyon area. Depths to basement rock are much shallower in the upper reaches of the canyon, where they have been complicated by faulting.

Faulting

GENERAL

2-10 The Lower Santa Ana River, like most locations in southern California, is surrounded by active or historically active faults capable of generating earthquakes which could cause seismic shaking along the river. The most significant of these faults are listed in table 2 along with the magnitudes of maximum probable and maximum credible earthquakes, and postulated maximum horizontal accelerations in rock attenuated to the nearest limits of the project. The maximum credible earthquake (MCE), as defined by the U.S. Army Corps of Engineers (1983b), is the earthquake(s) associated with specific seismotectonic structures, source areas, or provinces that would cause the most severe vibratory ground motion or foundation dislocation capable of being produced at the site under the currently known tectonic framework. It is determined by judgement based on all known regional and local geological and seismological data. The maximum probable earthquake (MPE), however, is the earthquake that by probabilistic determination of recurrence could occur during the design life of the project. The major structural features within a 100-mile radius of the project area are shown on plate 5. The Lower Santa Ana River improvements between Prado Dam and the Pacific Ocean are in close proximity to or actually cross three main separate zones of faulting (see pl. 4), which are discussed in the following paragraphs.

WHITTIER FAULT ZONE

2-11 At the upstream end, the Whittier fault zone lies approximately 1 mile north and 0.5 miles south of the Weir Canyon Road and Green River Golf Course improvements, respectively. The Whittier fault zone, which consists of northwest trending sub-parallel branching and en echelon faults, extends from Whittier Narrows in Los Angeles County to Santa Ana

Canyon, a distance of about 25 miles, where it merges with the Elsinore fault zone, and continues through the Peninsular Ranges to the Gulf of California. As stated previously, lateral and vertical movement along the Whittier fault, since the late Tertiary, is at least partially responsible for the formation of the Chino Hills. Recent fault investigations along the trace of the fault have uncovered offsets in Holocene age alluvium (Dames and Moore, 1980). In addition, both micro and macro seismicity in the area suggest that the Whittier fault is active (Dames and Moore, 1980).

2-12 North of the Whittier fault zone lie two subsidiary west-trending faults, the Scully Hill and the Aliso Canyon faults (see pl. 4). The projected trace of the Scully Hill fault crosses the alluvial fill of the Santa Ana Canyon about 1200 feet north of the proposed Green River Golf Course improvements while the inferred trace of the Aliso Canyon fault is just below Prado Dam and less than 100 feet south of the Prado Dam outlet channel drop structure. These faults may be associated with either the Whittier or Elsinore fault zones, but they do not appear to be direct extensions or splays of either (Woodward-Clyde Consultants, 1980). The activity of these two faults is not known but apparently unfaulted Quaternary-age terrace deposits have been mapped across the Scully Hill fault in the Horseshoe Bend area of Santa Ana Canyon (Durham and Yerkes, 1964).

EL MODENO-PERALTA HILLS FAULTS

2-13 Approximately 7 miles downstream of Weir Canyon Road, near Lincoln Avenue, the river crosses a poorly defined zone of possible concealed faulting, which might be a projection of either the Peralta Hills or El Modeno faults. The Peralta Hills fault, an east-trending, north-dipping thrust fault, has a mapped surface trace of more than 5 miles along the southern side of the Peralta Hills. The El Modeno fault is a northwest-trending, steeply-dipping normal fault which extends along the southwestern flank of the Santa Ana Mountains. The fault trace segments lie separated by short expanses of alluvial materials but may in fact be connected into a continuous and discrete feature (Ryan and others, 1982). There is some evidence suggesting that both the El Modeno and Peralta Hills faults may displace Holocene (Recent) alluvium (Morton and others, 1976; Bryant and Fife, 1982; Ryan and others, 1982), including a possible groundwater barrier as evidenced by a significant differential in static water levels between key wells downstream from well no. 4S/9W-6P01 and upstream from well no. 4S/9W-8C01 (see pl. 6). The trace of the northern portion of the El Modeno fault has not been precisely located. Its trend may lie parallel to that of the Peralta Hills as shown on plate 4, or the fault, as Bryant and Fife (1982) suggest, may be truncated by or pass beneath the Peralta Hills fault.

NEWPORT-INGLEWOOD FAULT ZONE

2-14 The Newport-Inglewood fault zone, which extends from possibly Baja California to at least Santa Monica in Los Angeles County (a distance of approximately 150 miles), is the predominant structural/tectonic feature to cross the Santa Ana River. The zone is approximately 4 miles wide near the mouth of the river (Santa Ana Gap). It is characterized by northwest trending parallel faults and folds. Within the Gap (downstream of the San Diego Freeway), three primary branch faults within the Newport-Inglewood fault zone have been mapped (see pl. 4). These branches are referred to as the South Branch fault, the North Branch fault, and the Bolsa-Fairview fault. The location and extent of the numerous individual faults in the gap area are predominantly defined in the subsurface from oil well data and groundwater barriers in the older basin sediments. Geologic evidence of surface faulting within the fault zone is minimal. Guptill and Heath (1981) reported that possible evidence of surface faulting on the North Branch of the Newport-Inglewood fault zone at Newport Mesa may be associated with the 1933 Long Beach earthquake. A study by Woodward-Clyde Consultants (1984) demonstrated that near-surface faulting on the Newport-Inglewood North Branch fault at Huntington Beach Mesa may be late Pleistocene or possibly Holocene in age. No evidence of surface faulting on these branches has been documented within the Santa Ana Gap. Despite the fact that there is little or no indication of direct shearing or displacement in the main body of the Recent sediments extending across the fault zone, the zone is seismically active as evidenced by the 1933 Long Beach earthquake, as well as subsequent macroseismic activity (Barrows, 1974).

Seismicity

HISTORIC SEISMICITY

2-15 The Lower Santa Ana River is located in Zone 4 of the Seismic Zone Map of the Contiguous States (U.S. Army Corps of Engineers, 1983a), an area of high seismic potential. The California Institute of Technology's seismologic data base for southern California, Nevada, and Arizona indicates a total of 592 earthquakes with Richter magnitudes equal to or greater than 4.0 have occurred within a 100-mile radius of the project area between February 1932 and January 1987. A plot of their epicenter locations, including magnitude 6.0 or greater events since 1900, are shown on plate 5. The most significant earthquakes (Richter magnitudes of 6.0 or greater) to occur within a 100-mile radius of the project area and their likely fault sources are listed in table 3. Earthquakes which could cause shaking along the river range from a major event on the San Andreas fault zone (approximately 30 miles northeast of the project area at its closest extent) to shaking and possible ground rupture from a near-field event on the Newport-Inglewood fault zone at the lower end of the project. The California Institute of Technology's 55-year computer record lists 165 earthquakes as having occurred within a 25-mile radius of the project area. The majority (150) of the events had Richter magnitudes between 4.0 and 4.9. Fourteen earthquakes had assigned magnitudes between 5.0 and 5.9, while the 1933 Long Beach event, with a Richter magnitude of 6.3 was the largest instrumentally recorded event in the area. However, the rate of seismicity has not been uniform throughout this period. Approximately 90 percent of these shocks occurred during the first 10 years of the record. Much of this seismicity can be attributed to the 1933 Long Beach earthquake and aftershock sequence. Between January 1962 and January 1987, only six events, none with a magnitude greater than 4.5, occurred locally. The October 1, 1987 Whittier Narrows earthquake, with a Richter magnitude of 5.9 and an epicenter location a minimum of 19 miles northwest of the Santa Ana River, was the largest instrumentally recorded earthquake to occur near the project area since the 1933 Long Beach event.

FAULT ZONE SEISMIC PARAMETERS

2-16 The historical record, although brief, indicates that potentially damaging earthquakes have occurred, and, given the developed pattern of seismic activity, would be expected to occur during the design life of the project. Using the attenuation curves for horizontal accelerations in rock developed by Schnabel and Seed (1973) and Greensfelder (1974), a maximum credible earthquake of Richter magnitude 7.0 generated on the Newport-Inglewood fault zone near the mouth of the Santa Ana River would produce a maximum rock acceleration of approximately 0.7 g at that location. However, a maximum probable earthquake with a Richter magnitude of 6.0 would result in a lower maximum rock acceleration of slightly less than 0.6 g at the epicenter location. Similar rock accelerations could be produced at the upstream end of the project by a local maximum credible or maximum probable event on the Whittier-Elsinore fault system. Horizontal bedrock accelerations resulting from the recent (1987) Whittier Narrows earthquake were recorded by instrumentation at three Corps of Engineers' dams near the project area. Peak accelerations of 0.16 g and 0.22 g were recorded by the respective left abutment accelerometers at Brea Dam, located 5 miles northwest of the Santa Ana River and 14 miles southeast of the earthquake epicenter, and at Carbon Canyon Dam, located 9 miles north of the river and 17 miles southeast of the epicenter. A peak acceleration of 0.07 g was recorded at the left abutment of the more distant Prado Dam (28 miles from the earthquake epicenter). The magnitude 5.9 earthquake produced an estimated maximum rock acceleration of less than 0.15 g along the middle portion of reach 2 of the channel. However, no damage to any existing structures along the Lower Santa Ana River was reported.

2-17 Considerable uncertainty exists as to the tectonic significance of the Peralta Hills and El Modeno faults. Both faults may be capable of producing large-magnitude earthquakes (probably in the Richter magnitude 5.5 to 6.0 range). However, the Peralta Hills fault could represent only a surficial flexural-slip reverse fault which is related to the regional tectonics but is incapable of generating a large magnitude earthquake.

2-18 Despite the possibility of a magnitude 8-plus event on the San Andreas fault, attenuation of ground motions would produce a maximum acceleration in rock of only 0.25 g at the upstream limit of the project. A relationship between maximum accelerations on rock and on various soil conditions was developed by Seed and others (1976). Given a maximum acceleration in rock of 0.2 g, the maximum ground accelerations developed on various alluvial deposits would range from approximately 0.15 to 0.2 g. However, for a higher rock acceleration of 0.5 g, acceleration values for soil would be more variable, ranging from approximately 0.25 to 0.45 g. In most cases, except when maximum accelerations in rock fall below 0.1 g, the highest values for alluvium are in stiff soil conditions.

2-19 Lamar, Merifield and Proctor (1973) have estimated point recurrence intervals for both the southern segment of the San Andreas fault system and the Whittier-Elsinore fault system. For magnitude 6 and 7 events on the Whittier-Elsinore system, recurrence intervals of 300 and 2000 years, respectively, have been estimated. In contrast, a magnitude 8 earthquake on the San Andreas fault has a much shorter recurrence interval, estimated to be about 200 years. Little information is available on recurrence intervals for the Newport-Inglewood fault zone. Woodward-Clyde Consultants (1983) estimated a return period of approximately 200 years for a large earthquake (magnitude 7.0).

POTENTIAL SEISMIC HAZARDS

2-20 In the historic past, the 1933 Long Beach earthquake with a Richter magnitude of 6.3 probably caused the greatest shaking along the Lower Santa Ana River (see pl. 4 for epicenter location). The Long Beach earthquake resulted in numerous surface expressions other than ground rupture. These included surface cracking due to lurching and settling, landslides and/or rockfalls, changes in water table elevations in wells and structural damage due to liquefaction, settling, or lurching. Disruption of the ground surface, not necessarily along known faults, will probably occur during any future event of the magnitude and duration of the Long Beach earthquake (Barrows, 1974). Cracking of the ground might cause damage to the project during any large magnitude shocks. In addition, elevation changes resulting from possible earthquake induced subsidence and uplift may also occur.

2-21 Rapid tectonic subsidence and/or uplift in the project area would most likely be associated with a major seismic event (magnitude greater than 6) on the Newport-Inglewood or Whittier-Elsinore fault zones. Elevation changes resulting from events with magnitudes less than 6 would be more localized and probably not measurable (Morton and others, 1976). Leveling surveys bracketing the Long Beach earthquake showed possible earthquake induced subsidence of as much as 0.4 feet and apparent uplift of as much as 0.6 feet in portions of the southern coastal plain area (Morton and others, 1976).

Groundwater

BASIN DESCRIPTION

2-22 The Lower Santa Ana River lies within the Orange County groundwater basin (see fig. 3) which includes the Santa Ana Gap area. The water-bearing sediments in the basin consist of Quaternary and some late Tertiary alluvial deposits. In general, at least three distinct bodies of groundwater have been identified in the project area (Poland and others, 1956). They are: (1) a "semiperched" or shallow zone of water of variable chemical quality that occurs in the upper part of the Recent alluvium; (2) a zone of fresh groundwater or deeper zone that occurs in the lower part of the Recent alluvium as well as in Pleistocene and older units, and (3) a body of saline groundwater that underlies the fresh-water body and occurs in sediments of Tertiary age. The most important aquifer in the Recent alluvial deposits are the Talbert sands and gravels which extend from the lower end of Santa Ana Canyon to the Pacific Ocean. The Talbert aquifer has an average thickness of approximately 70 feet, and generally occurs above elevation -200 feet below sea level. The most important source of groundwater in the Pleistocene age sediments, underlying the Recent alluvium is the Main aquifer within the San Pedro Formation. This aquifer generally occurs at elevations between -500 and -200 feet below sea level and also tends to be continuous across the basin.

2-23 The groundwater basin is replenished naturally and artificially in the area generally north of the Santa Ana Freeway. To the south, groundwater occurs under artesian pressure in aquifers which are interbedded with sediments of low permeability. Thus percolation of surface waters to the aquifers in the pressure area is greatly restricted. The upper "semiperched" zone is essentially unconfined, and, according to Robbins (1986), regionally extensive rather than being composed of isolated discontinuous lenses. An evaluation of various types of groundwater data, including gradient directions, elevation of water levels, and water quality suggests an interrelation (i.e., hydraulic continuity) between the upper shallow zone and the deeper aquifers in the forebay area. The shallow zone generally occurs above a depth of 50 feet in the Recent deposits.

2-24 The Newport-Inglewood fault zone forms a more or less effective barrier to groundwater movement to and from the Pacific Ocean in sediments underlying the Recent deposits in the Santa Ana Gap area. These formations have been tilted and extensively faulted so that barriers to hydrologic continuity have been created and the saline ocean water cannot directly intrude them. Groundwater, however, appears to move in an unrestricted manner within the Recent sediments across the fault zone.

GROUNDWATER LEVELS

2-25 Groundwater information for the Lower Santa Ana River was obtained from Orange County Water District (OCWD) groundwater contour maps (OCWD, 1987), state water well records compiled by the California Department of Water Resources, and Robbins (1986). A November 1986 groundwater contour map of the Orange County groundwater basin is shown in figure 4. Water well data available for the project were used to develop piezometric groundwater profiles along the river which are shown on plate 6. The highest and lowest recorded groundwater elevations are depicted for key wells in the vicinity of the river. In addition, three generalized water level profiles, two derived from OCWD November 1984 and November 1986 groundwater contour maps and one derived from a November 1984 shallow groundwater contour map by Robbins (1986) are shown. The upper 1984 profile represents the approximate level of the shallow zone while the lower 1984 profile and the 1986 profile are composites of water levels from the various deeper fresh water aquifers. In general, water levels along the Lower Santa Ana River tend to undergo monthly and seasonal fluctuations, primarily in response to the seasonal and cyclic unbalance between groundwater replenishment and draft. Examination of individual state well records indicates that water table elevations have varied considerably since the 1920's. Net changes range from as little as 10 feet to more than 150 feet. Recent though limited well data available for the project reach between Adams Avenue and Lincoln Avenue indicate that in 1985 seasonal variations in groundwater levels of between 4 and 15 feet occurred. In general, the highest water levels were measured during the winter and spring (February and May) while the lowest water levels were recorded in the summer and fall (August and November).

2-26 Upstream of the Santa Fe Railroad bridge, and in Santa Ana Canyon, the water table is fairly shallow because of the relatively thin alluvial cover. In the upper reaches of Santa Ana Canyon, between the Green River Golf Course and the Prado Dam drop structure, groundwater is generally present at an average depth of 20 feet outside the channel thalweg. A water table elevation of 435 feet was established for the Prado Dam outlet channel drop structure area as a result of field investigations by the Corps of Engineers in 1987. Water well data available for that reach of the canyon downstream of Prado Dam covering the proposed Green River Golf Course channel improvements indicate that the groundwater table in 1966-68 ranged from elevation 435 feet approximately 2 miles upstream from the golf course to elevation 417 feet near the golf course. Water levels were at their highest (5 to 6 feet above current levels) in this reach during 1939-40, prior to construction of Prado Dam, and only minor fluctuations, up to a maximum of about 15 feet, have been recorded since then. In the vicinity of Weir Canyon Road, the groundwater was at depths ranging from 15 to 18 feet (elevation 312 feet) in August 1982. In 1984, water levels recorded in wells just upstream of Weir Canyon Road near the Savi Ranch levee, showed similar depths to groundwater but with an average groundwater table elevation of 320 feet. In November 1986, water levels ranged from approximately 20 feet (elevation 240 feet) near Imperial Highway to approximately 35 feet (elevation 200 feet) near the Riverside Freeway.

2-27 As the river emerges from the canyon onto the coastal plain and the depth to bedrock increases, water levels in the deep aquifers decline sharply, to depths exceeding 100 feet. Plate 6 indicates a maximum depth to groundwater in November 1986 of about 135 feet (elevation +60 feet) near well 4S/10W-7M01 (upstream of Lincoln Avenue). This rather anomalous steep gradient may indicate the existence of a possible fault related groundwater barrier (see paragraph 2-13). Downstream of Lincoln Avenue, water levels, despite some extreme fluctuations due to local recharge conditions (see November 1984 deeper zone groundwater profile), become progressively shallower towards the ocean as the ground surface elevation decreases. Near the coast, the water table elevation tends to be at or near sea level (see pl. 6), fluctuating with the amount of natural and artificial recharge and pumping. This lower reach is also affected by the Newport-Inglewood fault zone. Between 1977 and 1985, there has been an overall rise in deeper groundwater levels throughout most of the basin, ranging from 10 feet in state well 6S/10W-5B03, between Adams Avenue and the San Diego Freeway, to 30 feet in well 4S/10W-25F01, near Orangewood Avenue. Information on water level trends in the shallow zone is not available but if the upper zone does mimic the deeper groundwater flow regime as Robbins (1986) suggests, then similar upward trends might be expected although the magnitude of such changes would probably be much less.

2-28 The "semiperched" shallow zone, as depicted on plate 6, generally occurs above a depth of 50 feet, and also becomes progressively shallower towards the ocean. Downstream of 17th Street, water levels in this upper zone are typically within 25 feet of the existing channel ground surface. A comparison of the differences in elevation between the shallow zone and deeper zone water levels by Robbins (1986) reveals that elevation differences on the order of 40 to 60 feet are common for most of the basin while in the northern portion of the basin (near Santa Ana Canyon) and near the coast, differences are minor and the two zones in a sense merge together. The Orange County Water District (1981) monitored the semiperched groundwater zone as part of their Green Acres Project study. Three observation wells, located near the river channel between 5th Street and the San Diego Freeway, encountered water at depths ranging from 27 feet (approximate elevation, 48 feet) in the upstream well to 9 feet (approximate elevation, 11 feet) in the downstream well.

2-29 Water levels encountered during subsurface explorations by the Corps of Engineers, along the Lower Santa Ana River alignment (see pls. 8 through 26), generally do not reflect the regional groundwater conditions previously described but instead are indicative of a localized zone of influent seepage (a mounded condition) which exists because of perennial low flows in the channel. However, downstream of the San Diego Freeway where groundwater levels are fairly shallow, there is good correlation between the depths to water in subsurface borings and the local groundwater conditions.

CONSTRUCTION CONSIDERATIONS

2-30 A review of published groundwater information available for the Lower Santa Ana River project indicates that the regional groundwater table will probably be encountered during construction in at least two reaches of the channel: (1) upstream from Lakeview Avenue (sta. 975+50) and (2) downstream from the San Diego Freeway (sta. 254+34). However, the localized mound of subsurface water, generally present at depths between 1 and 5 feet in the active river channel, will be encountered throughout the construction reach. Both shallow groundwater and mounded subsurface water would require implementation of a dewatering scheme prior to construction. Diversion and control of the perennial surface flows in the river channel will also need to be addressed during construction. In addition, tidal variations within the lower reach of the project downstream of Adams Avenue (sta. 163+71) will create additional dewatering requirements. Groundwater conditions within the project area will continue to be monitored in the future to detect any possible changes which might affect channel design or construction.

SEA WATER INTRUSION

2-31 The Talbert and older Pleistocene aquifers are very productive and have yielded great quantities of water since the early 1900's. By 1930, the pumping of groundwater had lowered pressure levels in the shallow aquifers to below sea level and sea water intrusion began. See plate 7 for a piezometric profile of the Talbert aquifer in 1963. Since the Talbert aquifer was in continuity with the ocean it was the first to experience the effects. By 1960, the intrusion had also begun to affect certain water bearing zones below the Talbert aquifer.

2-32 The problem of sea water intrusion in the Santa Ana Gap and methods to prevent it were studied in detail by the California Department of Water Resources (1966). One of the suggested plans to control intrusion was to create an injection ridge along Ellis Avenue. This plan was later implemented by construction of the Talbert Barrier Project, which maintains a seaward hydraulic gradient in the underlying aquifers by the injection of potable water under pressure. The barrier project, which consists of a water supply, a distribution pipeline, a series of closely spaced injection wells, extraction wells, and numerous monitoring wells, was completed in 1975 and water was first injected in 1976. This plan has been successful in reversing the gradient and halting the intrusion of saline water. Plate 7 shows a recent piezometric profile and contour map of the gap. As a part of the injection program, the Orange County Water District monitors a series of wells, see plate 7, on a weekly, monthly, and biannual basis. In addition to the piezometric levels in the aquifer, various water quality parameters are measured and the results published in a Talbert Barrier Performance Report.

2-33 In 1979, ten shallow soil borings were drilled by the Corps of Engineers with a hollow stem auger between Hamilton Avenue and the Pacific Coast Highway along the existing Santa Ana River channel. The generalized information from these borings in addition to data from previously drilled observation wells and shallow soils investigations conducted along the Santa Ana River channel by various geotechnical firms are presented in cross-section on plate 7. The top of the Talbert aquifer is positively identified in the deeper observation wells at an elevation between -40 and -70 feet below sea level. Downstream from well M-10 the top of the aquifer is not positively known. However, it may daylight at sea level near the Pacific Coast Highway. Regardless, excavations for a soft bottom channel in this reach would not affect the quality of the groundwater because the Talbert aquifer is already in hydrologic continuity with the ocean and the injection program upstream maintains a positive gradient which would not allow landward movement of degraded water.

Subsidence

2-34 Only minimal land subsidence has been reported in the immediate vicinity of the Lower Santa Ana River even though significant amounts of both oil and water have been extracted from the subsurface. Morton and Miller (1976) indicate that the only measureable subsidence (up to 0.15 feet) occurred along the river south of Warner Avenue between the leveling surveys of 1964-65 and 1968-69-70. However, a maximum of 5 feet of subsidence due primarily to petroleum withdrawal has been estimated for the period 1920 to 1972 in the vicinity of Huntington Beach (Morton and Miller, 1976). Very localized subsidence due to possible soil consolidation or oxidation of peat layers caused by lower groundwater levels has also been reported to have occurred in scattered inland areas from Sunset to Newport Beaches (Leighton-Yen and Associates, 1974). Subsidence due to petroleum withdrawal has been stabilized by water injection and little additional effect due to soil consolidation or peat oxidation is expected.

III. INVESTIGATION

General

3-01 Information on conditions of the foundation, levee, invert, and sources of borrow along the approximately 23 miles of river alignment has been collected from several sources. Previous investigations conducted for the County of Orange by various geotechnical firms supplement recent investigations by the Corps of Engineers. The investigation techniques included hollow stem and bucket auger borings, and backhoe trenching. Both disturbed bulk samples and undisturbed tube samples were obtained for testing. All test site excavations were logged. The logs of the Corps of Engineers' investigations are presented on sheets immediately following each plan of investigation plate. The logs of investigation conducted for the County of Orange are presented on sheets following the Corps of Engineers' logs and the appropriate plan of investigation plate. See plates 8 through 27 for the plans, profiles, and logs of the investigation. The investigation methods and sites are discussed in subsequent paragraphs, in relation to the location and structural feature of the proposed improvements. The individual locations of test sites may be utilized for the assessment of more than one feature and, in those cases, those sites are mentioned several times.

Existing Levees and Foundation

PREVIOUS INVESTIGATION

3-02 The existing levee system along the Lower Santa Ana River has been the subject of many subsurface investigations. The specific investigations are referenced in tables 4 and 5. The logs of the levee investigations by others (for the County of Orange) are reproductions from the original reports and are shown on plates 8 through 26.

RECENT FIELD INVESTIGATIONS

3-03 A levee foundation and embankment investigation was conducted by the Corps of Engineers, over a period of several years. In 1979, 10 hollow stem auger holes were drilled between Hamilton-Victoria Street and the Pacific Ocean, as part of Phase I of this study. Between 1982 and 1985, the investigation was continued with additional hollow stem and bucket auger holes drilled between Weir Canyon Road and the Pacific Ocean. A complete listing of the investigation, including locations, depths and equipment types, is shown in table 6.

3-04 Generally, the borings were started on the levee crest and were extended down into the foundation materials. Occasionally, borings were made on the landside of the levee where access was a problem, or where a new levee alignment was being considered. The materials encountered were visually logged. Disturbed samples of the materials were obtained from each boring at intervals of 3 feet, or less if the material changed. Representative, undisturbed drive samples were obtained of the finer grained and cohesive materials.

3-05 Standard penetration testing was conducted in each boring in accordance with ASTM D 1586, at approximately 3-foot intervals.

3-06 The logs of investigations by the Corps of Engineers are presented on plates 8 through 27.

Drop Structures and Stabilizers

PREVIOUS INVESTIGATION

3-07 The foundation investigations conducted for the County of Orange, for the existing drop structures and stabilizers are included within this report as a source of general information on foundation conditions. The specific investigations are referenced in table 4.

RECENT FIELD INVESTIGATION

3-08 Bucket auger and backhoe were used to sample the representative materials for the proposed drop structures and stabilizers.

3-09 The foundation materials encountered were visually logged. Disturbed samples were obtained for laboratory testing of each material type, at depth intervals of 3 feet or less. Standard penetration testing was conducted in each boring, at approximately 3 foot intervals.

Invert

PREVIOUS INVESTIGATION

3-09 There are several invert investigations, conducted by other agencies that were considered in preparing this report. The previously conducted levee investigations, which contain information on foundation conditions adjacent to an invert location, were also used to supplement the Corps of Engineers' investigation of the invert materials.

RECENT FIELD INVESTIGATION

3-10 The primary means of obtaining representative information about the invert materials was a series of backhoe trenches excavated between 1979 and 1985. Each trench went approximately to the depth of the proposed invert. In addition to the backhoe trenches, several bucket auger holes were also drilled within the invert. The location and depth of each exploratory hole along the invert are included in table 6.

3-11 Disturbed representative samples of the invert materials were obtained from each trench or hole at intervals of 3 feet, or less if the material changed. Densities were determined by standard penetration testing at approximately 3 foot intervals within the borings.

Borrow

3-12 The source of borrow for the project will be both the required invert excavation and existing levees in the reaches which are to be realigned and reconstructed. As a result, the sources of borrow were investigated as part of the previously discussed levee, foundation and invert investigations.

Revetment

3-13 The design stone revetment along the lower Santa Ana River varies in gradation and in thickness as indicated on both plate 2 and table 1. Most of the existing riprap placed prior to 1970 was designed for a 400-pound maximum stone size (W50 of approximately 120-pound) based upon the Corps criteria set forth in EB 52-15, "Slope Protection". Subsequently placed riprap was designed for a 750-pound maximum (W50 of approximately 200-pound) stone, which was designed using EM 1110-2-1601, "Hydraulic Design of Flood Control Channels". The 400-pound stone was specified to be placed in an 18 inch thick layer, and the 750-pound stone in a 24-inch thick layer. The levee revetment was inspected by Geotechnical Branch personnel in 1983 and 1987, and the stone visible at the ocean jetties was inspected in 1986. Results of the inspections are discussed in section V.

Santa Ana Canyon

3-14 Subsurface investigations of foundation material for both the drop structure (TH 87-1, 2 and 3) and the Green River Golf Course area (TH 87-4, 5 and 6) were conducted in April 1987, and July 1987, respectively. A 24-inch bucket auger was used in obtaining disturbed samples. Densities were determined by Standard penetration testing (SPT) at approximately 5-foot intervals during the first 20 feet of exploration. Location of the borings and logs are shown on plate 27. Depths of the borings ranged from 23 to 43 feet at the drop structure site, and 40 to 49 feet at the golf course site.

Disposal Beach

3-15 Approximately 15 miles of beach, adjacent to the mouth of the river, were evaluated as possible disposal sites for the required invert excavation materials from the lower Santa Ana River. Twenty-four transects, or lines, perpendicular to the proposed disposal beach were surface sampled at every 6-foot change in elevation from +12 to -30 feet MLLW. The sampling was done in October 1982. The sample locations are shown on plate 28.

IV. LABORATORY TESTING

General

4-01 Laboratory testing of all the materials sampled during geotechnical investigation were conducted to determine mechanical analysis, Atterberg limits, and moisture content. The samples were classified in accordance with the Unified Soil Classification System. The logs of the Corps test sites are shown on the investigation plates 8 through 27. Tests of remolded and undisturbed samples were conducted by the South Pacific Division (SPD) Laboratory to determine shear strengths, permeabilities, compaction properties and consolidation characteristics. The tests were performed in accordance with Engineering Manual EM 1110-2-1906, "Laboratory Soils Testing," dated 30 November 1970. The soil test results are contained in attachment 1. Summaries of the testing are shown in tables 7 and 8.

4-02 The statistical summaries of the mechanical analyses are presented in table 9. The summaries are for each reach of the river, for the sites of the proposed drop structures, and for the proposed invert borrow areas. Composite summaries are typically for the materials in a potential borrow area materials and frequency summaries are generally for the materials that are to remain in place.

Levee Material

4-04 Representative disturbed samples from the levee embankments were tested to determine gradations, Atterberg limits, and moisture contents. Samples of the typical material types were compacted by both ASTM methods D 698 and D 1557, for maximum density and optimum moisture determinations. Representative material types were then remolded for R-type triaxial and direct shear strength tests at densities typical of the existing or proposed embankment conditions.

Foundation Material

4-04 The foundation samples were tested to determine gradations, Atterberg limits, and moisture contents. Disturbed samples of typical material types were compacted in accordance with both ASTM D 698 and D 1557 in order to determine maximum density and optimum moisture content. Remolded materials were subjected to R-type triaxial strength testing at densities typical of the existing conditions. Undisturbed samples were subjected to unconfined strength testing, R-type triaxial strength testing, and consolidation and permeability testing.

Invert Materials

4-05 Disturbed samples, representative of the invert materials, were tested to determine gradations, Atterberg limits and moisture content. Typical materials were compacted by both methods ASTM D 698 and D 1557 in order to determine maximum density and optimum moisture characteristics. Representative samples were remolded to typical in situ densities in order to determine R-type triaxial strengths and permeabilities.

Revetment

4-06 Recent quality compliance testing has been conducted on existing quarry sources in the project area. In addition, samples of the existing levee riprap material were collected for quality compliance testing. Stone samples from both the quarries and river levees were subjected to the following tests: petrographic and x-ray diffraction analysis, specific gravity and absorption, wetting and drying, Los Angeles abrasion and magnesium sulfate soundness. The results of petrographic analyses and research of historic records were used to determine possible quarry sources for the levee riprap. See table 10 for the compliance test results.

Disposal Beach

4-07 The materials from the proposed disposal beach were tested by performing a mechanical analysis on each disturbed sample. The composite average of all samples along each particular range sampling line was then computed to determine the representative gradation of that section of beach. The composite averages of all sampled range lines are shown in table 11.

V. GEOTECHNICAL CONDITIONS

Weir Canyon Road to Imperial Highway, (Reach 1)

5-01 The materials in the streambed foundation and in the existing levees in reach 1 are predominantly well-graded, noncohesive sands with significant but varying amounts of silt and gravel. Up to 20 percent cobbles to 6 inches in diameter are present in many areas that were explored, along with occasional boulders up to 2 feet in diameter. Atterberg limits tests conducted on the samples from this reach indicate that clayey fines are relatively uncommon. However, layers of sandy silt up to 6 feet thick were found at three locations, though generally below the proposed invert elevations. Groundwater was encountered under the right levee adjacent to Yorba Regional Park at depths ranging from 15 to 18 feet in four test holes. Natural moisture contents above the water table were mostly between 2 and 8 percent in the sandy materials and between 19 and 40 percent in the silty layers. The sand and silty sand materials are generally medium dense to dense as indicated by SPT blow counts in the range from 11 to 40. However, loose layers with blow counts less than 10 were commonly encountered during the exploration.

5-02 The active streambed materials in the invert are poorly-graded, noncohesive sands with virtually no fines and up to 40 percent gravel. Occasionally, cobbles and boulders up to 15 inches in diameter were encountered. Groundwater was encountered at depths of 5 feet or less. Densities were estimated to range from loose to medium dense, based on visual observations and ease of excavation.

5-03 Based on water level data from the exploration program, the ground-water table appears to maintain a gentle downstream gradient, from elevation 293 feet just downstream from Weir Canyon Road, to elevation 267 feet just upstream from Imperial Highway. This would result in groundwater being at elevations ranging from 0 to 10 feet below the proposed channel invert. The gradient for the 1986 groundwater (deeper zone) profile shown on plate 6 is much steeper for this same reach. The water table drops from elevation 293 feet near well 3S/8W-30R01 to elevation 248 feet near well 4S/9W-2B03. Water levels within this reach of the project are probably influenced to varying extents by low flows within the channel and by irrigation and seepage from small ponds at the park, and therefore, would be expected to undergo seasonal or yearly fluctuations.

5-04 An inspection of the existing river levees between Weir Canyon Road and Imperial Highway determined that the existing stone revetment generally does not meet the original size and thickness requirements as discussed in paragraph 3-13. The rock also tends to be of unsuitable quality. Various lithologies are represented in the levee riprap. However, the predominant rock type, as classified petrographically, is a gray, moderately hard to hard, slightly to moderately weathered, porphyritic meta-andesite. Individual pieces contain numerous rust stained surfaces and incipient fractures. These fractures, which are generally open but occasionally filled with quartz or calcite, are present in random orientations. It was estimated that up to 70 percent of the volcanic rocks contain these fractures, which can part very easily under only light to moderate hammer blows, and occasionally hand pressure. Numerous individual pieces were observed to be breaking down along these planar discontinuities which may explain the apparent undersized nature of the riprap. Only minor amounts (probably 1 percent) of soft, decomposed to highly weathered rock were noted. Minor rock types identified by field or laboratory methods include a mottled white and black, slightly weathered, hard, fine to coarse grained granodiorite; a pink and gray, hard, slightly weathered micropegmatitic granite; and a tan to gray, moderately hard, slightly to moderately weathered, fine to coarse grained arkosic sandstone. These rock types, in contrast to the meta-andesite, are generally sound, with only minor breakdown and decomposition noted. The levee riprap is typically subangular to angular in shape. Only the sandstone tends to exhibit more pronounced subrounded edges. North of the Imperial Highway bridge, an overlay of fresher, larger, more durable andesite rock was apparently placed. The rock in reach 1 is generally poorly graded and ranges in size from 2 to 8 inches, with a random maximum rock size of from 1 to 2 feet. Significant breakdown in localized areas on the grade has resulted in patches of 1- to 2-inch diameter rock. It appears that the stone revetment was probably obtained from local sources in the Corona-Riverside area. The meta-andesite rock appears to be diagnostic of material from the Harlow Quarry near Corona while the Riverside quarries may be possible sources for the granodiorite. The granite may have been obtained from the Magnolia Quarry near Corona. The sandstone is not indicative of a known quarry source but might represent material obtained from the local streambed.

Imperial Highway to Katella Avenue, (Reach 2)

5-05 In reach 2, the materials along the left bank, invert and right bank are significantly different. The differences are due to the various methods utilizied to place the materials in their present position.

5-06 The left bank is largely composed of natural alluvial deposits laid down over a period of time when the river channel meandered through the area. Its stratifications, therefore, include a variety of materials ranging from clays to sandy gravels, distributed somewhat randomly with depth. The majority of the materials are noncohesive sands with varying amounts of silt and gravel. Both well-graded and poorly-graded layers are common, as are cobbles in the 3 to 6 inches range. Occasionally, larger boulder size rocks were encountered. Fine grained clays, silts, and clayey or silty sands occur at various depths in layers up to 11 feet thick throughout the reach. Subsurface water, primarily the result of a mounded condition due to low flows in the channel, was encountered at depths ranging from 16 to 29 feet in about half of the test holes. Subsurface water was not observed in other test holes drilled to depths ranging from 35 to 40 feet in this reach. The natural water contents above the water levels ranged from 1 to 19 percent in the granular materials, and from 6 to 34 percent in the fine-grained clays and silts. Most of the materials are medium dense to dense, as characterized by SPT blow counts in the range from 11 to 50. However, significant numbers of loose layers are indicated by blow counts between 4 and 10, mostly in relatively clean sandy materials with few fines. The widely varying densities of these naturally occuring alluvial materials reflect the depositional environment and energy level present at the time of their formation. Because the historic floodplain in this area is relatively wide and level, layers of soft or loose materials are assumed to extend over significant areas instead of occuring in isolated pockets. Stability analysis (described later) of critical levee sections reflects the occurence of these weak layers in the foundation and levees.

5-07 The right bank of the river in this reach is a combination of natural alluvial deposits and a built-up levee section which separates the main channel from a parallel series of groundwater recharge basins. Nearly all of the materials in the upper portions of the right bank and levee are noncohesive sands with varying amounts of silt and gravel. Cobbles up to 4 inches are common, along with occasional larger cobbles and boulders. Clayey and silty materials, in layers 3 to 11 feet thick, are commonly encountered, but only from depths of 15 to 30 feet below the top of the levee. However, just downstream from Imperial Highway, a layer of hard sandy clay is located at a depth of 9 feet below the top of the levee. Blow counts in the range from 13 to 60 indicate that the most of the materials along the right bank are medium dense to very dense. Relatively few low SPT blow counts indicating loose material were recorded, and these were nearly all in noncohesive sands below a depth of 20 feet. The foregoing gradation and density data verify that the upper portions of the right levee are predominately compacted fill materials, likely obtained from streambed excavation, and the lower sections are composed of both compacted fill and natural alluvial materials. Subsurface water, primarily related to low flows in the channel, was encountered in 12 of the 20 test holes drilled in this reach, at depths ranging from 15 to 22 feet below the top of the levee.

The test holes in which subsurface water was not observed were drilled to depths of 34 to 43 feet. The water levels under the right levee would be expected to vary seasonally in general response to the presence and depth of water in the adjacent groundwater recharge basin. Natural water contents above the water levels were found to range from 3 to 16 percent in the sandy materials and from 13 to 37 percent in the silty and clayey materials.

5-08 The active streambed materials are predominately clean, noncohesive poorly-graded sands and gravelly sands, with occasional thin layers of silty sand or fine-grained silt or clay. Relatively few cobbles and boulders were encountered during exploration. Subsurface water was at a depth of 1.5 to 14 feet below the surface in three of the test holes in the streambed, and was not observed in five other test holes drilled to depths from 7 to 17 feet. The unconsolidated invert materials are very loose near the surface and medium dense below the active streambed depth, with SPT blow counts ranging from 3 to 16.

5-09 A comparison of water level data from the published literature and the field exploration program indicates that within the reach one mile downstream from Imperial Highway, water levels observed in the test holes and test trenches probably reflect the regional groundwater table. Downstream from that reach, subsurface water levels are probably indicative of a more localized perched water table associated with a mounded condition due to low flows in the active channel and the adjacent groundwater recharge basins. Composite water levels in the deeper zone of fresh water aquifers drop very rapidly in this lower reach (see pl. 6), to depths well below the proposed channel invert. Information on the shallow semi-perched zone within this reach of the project was not available but water levels in this zone would probably also be below the influence of construction activities. Subsurface water was encountered during the field exploration program at elevations ranging from 2 feet above to 15 feet below the proposed channel invert.

5-10 An inspection of the existing river levees between Imperial Highway and Katella Avenue determined that the condition of the stone revetment is similar to that in reach 1 because of breakdown along fracture planes in the volcanic rock. Two major rock types were noted during the field inspection, the volcanic andesite characteristic of reach 1 and a dark gray, fine to medium grained, moderately hard to hard, slightly to moderately weathered, undifferentiated granitic rock. The petrographic analyses distinguished two volcanic and three granitic rock types. The volcanic lithologies were composed of the meta-andesite and an associated meta-dacite. The granitic rocks consisted of diorite, granodiorite and gabbro/meta-gabbro. The amount of incipient fracturing observed in the volcanic rock varied from approximately 50 percent near Lakeview Avenue and the Riverside Freeway, to 60 to 70 percent downstream near Ball Road. Less fracturing and rust staining, but more decomposition was noted in the granitic rocks. The amount of soft, highly weathered to decomposed rock ranged from less than 5 to 15 percent. The rock is predominantly subangular to angular in shape, although localized decomposition has resulted in more subrounded rock surfaces. Rock sizes at the different sampling sites were more variable.

Larger well graded rock (generally ranging from 3 to 12 inches) was common near Lakeview Avenue and Glassell Street. Poorly graded rock near the Riverside Freeway and Ball Road generally ranged from 2 to 8 inches in diameter, while poorly graded rock, usually between 2 and 6 inches in diameter (with scattered areas of 1- to 2-inch rock) was noted near Lincoln Avenue. A random maximum rock size of 2 feet was common throughout reach 2 except near Lincoln Avenue, where a random maximum size of only 8 to 10 inches was observed. Local quarries in the Corona-Riverside area again appear to be the most likely sources for the stone revetment. The volcanic rocks were probably obtained from the Harlow Quarry while the Corona Pacific Quarry and the Riverside quarries may have supplied the granitic rock types.

Katella Avenue to Santiago Creek, (Reach 3)

5-11 The condition of the foundation and levee materials in reach 3 are controlled by the existing fine-grained materials more so than in the upstream reaches. Silts, clays, and silty and clayey sands are the predominant materials throughout the reach, although significant quantities of relatively clean sands were encountered in test holes drilled through the left levee between Katella Avenue and the Santa Ana Freeway. Very few cobbles were encountered. Subsurface water was measured at depths from 12 to 28 feet in seven of the test holes. No subsurface water was observed in the other twelve test holes, which were drilled to depths ranging from 25 to 36 feet. Natural moisture contents above the water levels ranged from 1 to 17 percent in relatively clean sands, and from 3 to 39 percent in the fine-grained material. Most of the sandy materials are medium dense to dense, with SPT blow counts in the range from 11 to 50. Occasionally, loose layers with blow counts less than 10 were encountered in the levee foundations. Silts and clays are generally of a medium to stiff consistency, with SPT blow counts in the range from 5 to 15.

5-12 The surficial materials in the active streambed, to a depth of 3 feet, are poorly-graded, noncohesive sands with less than 2 percent gravel or fines. The foundation materials below this unconsolidated layer range from sand and silty sand in the upstream half of the reach to silt at the lower end. Cobbles, up to 4 inches, were only rarely encountered. Subsurface water was encountered at the top of the silt layer just downstream from the Santa Ana Freeway, but not elsewhere in the invert. Densities were estimated to range from very loose near the surface to medium dense with depth, based on visual observations and ease of excavation.

5-13 Subsurface water encountered during the field exploration program is generally the result of a mounded condition due to low flows in the channel. The groundwater profiles for the shallow semi-perched zone and the deeper fresh water aquifers, as shown on plate 6, are well below the proposed invert of the channel. Subsurface water levels would be at elevations ranging from 6 feet above to 15 feet below the proposed channel invert.

5-14 An inspection of the existing river levees between Katella Avenue and Garden Grove Boulevard revealed that the stone revetment, in contrast to the upstream reaches, is generally in good condition and therefore would be suitable for reuse in project construction. Two major rock types were noted during the field inspection, the volcanic andesite characteristic of Reaches 1 and 2, and a medium to dark gray, hard, fresh to slightly weathered, fine to coarse grained granitic rock, resembling a quartz diorite. The volcanic rock is the dominant type between Katella Avenue and Orangewood Avenue, while the granitic rock predominates downstream of Orangewood Avenue. Petrographic analyses again confirmed the presence of the meta-andesite and a variety of granitic rocks, including diorite, monzodiorite and granodiorite. The volcanic rock is of better quality than that described previously, with only about 30 to 50 percent of the individual rocks containing incipient fractures. Only localized pockets of highly weathered to decomposed material (probably less than one percent of the total rock mass) were observed. The granitic rock is generally sound and durable. The individual rocks tend to be subangular to angular in shape and very little rust stained, cracked or decomposed rocks were present. A slight increase in weathering was observed near the Garden Grove Freeway. The granitic rock is mostly well graded, 4 to 12 inches in size, with random maximum sizes of between 2 and 3 feet. The granitic rock tends to be larger and more durable than the volcanic rock. The volcanic rock is generally poorly graded and ranges in size from 2 to 10 inches, reaching a random maximum diameter of from 2 to 3 feet. The stone revetment was most likely obtained from the same sources mentioned for Reach 2.

Santiago Creek to 17th Street, (Reach 4)

5-15 The foundation materials in this reach are predominantly silts, clays, and silty and clayey sands, with cleaner sandy materials derived from the streambed in the built up levee sections. Relatively little gravel and pratically no cobbles were encountered during the investigation. Subsurface water was present at depths ranging from 15 to 26 feet in four test holes in the upstream half of the reach, and was not observed in the three test holes which were drilled to 30 feet in the downstream half. Natural moisture contents above the water levels ranged from 2 to 13 percent in the relatively clean sands, and from 12 to 37 percent in the finer-grained materials. The density of the sandy materials are mostly medium dense to dense, with occasional layers of loose material, as determined from SPT blow counts ranging from 5 to 38. The clayey and silty materials generally had blow counts in the range from 5 to 15, indicating medium stiff to stiff consistencies.

5-16 As in the upstream reaches, the surficial streambed materials in reach 4 are relatively clean, poorly-graded, noncohesive sands to an average depth of about 3 feet. These are underlain by moderately consolidated alluvial deposits varying from clays to sands. Subsurface water was not encountered in the relatively shallow exploration conducted in the invert of reach 4.

5-17 Subsurface water encountered during the field exploration program is generally the result of a mounded condition due to low flows in the channel. The groundwater profiles for the shallow and deeper zones, as shown on plate 6, would be below the influence of any construction activities. Subsurface water levels would be at elevations ranging from 5 to 20 feet below the proposed invert of the channel.

5-18 The existing slope protection, inspected in 1983 and found to be of acceptable quality, has since been removed from the right bank of the river downstream of the Santiago Creek and Santa Ana River confluence.

Seventeenth St. To Fairview Channel, (Reach 5)

5-19 The foundation conditions in this reach include the condition of the active streambed as well as deeper materials. The active streambed materials, located at or near the surface of the existing streambed, are mostly silty sands with occasional gravel and cobbles to 12 inches. Moisture contents of the streambed materials ranged between 25 to 30 percent and indicate that the materials are saturated. These materials will be excavated to the proposed invert elevation. The foundation materials at the proposed invert elevation are predominantly loose to medium dense sands and silty sands with 1- to 3-foot thick lenses of medium stiff to stiff sandy silts and sandy clays. The plasticity of the clay lenses increases between Harbor Boulevard and the Fairview Channel. Typical SPT blow counts in the sands and silty sands ranged from 9 to 20 blows per foot, and in the silts and clays from 5 to 15 blows per foot. Water well data indicate that upstream of the San Diego Freeway, current (1986) maximum groundwater depths increase from 20 to 90 feet below the proposed invert elevation. However, the shallow semiperched zone is only 5 feet below the proposed channel invert elevation near the San Diego Freeway, increasing to 20 feet below the invert elevation near Seventeenth Street. Subsurface water, the result of a mounded condition due to low flows in the channel, was encountered during exploration. Between the San Diego Freeway and the Fairview Channel, groundwater was observed at an elevation as high as 5 feet above the proposed channel invert. Although groundwater levels in the areas surrounding the channel alignment may vary by more than 10 feet seasonally, perennial low flows in the channel keep the proposed invert area wet year round.

5-20 The channel embankment materials are primarily sands and silty sands with occasional 2- to 3-foot thick clay and silty lenses to the invert elevation. Between Seventeenth Street and Harbor Boulevard, the materials are loose to medium dense, and between Harbor Boulevard and the Fairview Channel, the materials are primarily medium dense. Moisture contents encountered typically range from 5 to 15 percent.

5-21 Materials from the required excavation for the proposed improvements are generally active streambed material, as described above. The gradations of materials to be excavated are summarized statistically for various reaches in table 9.

5-22 Slope protection within this reach of the channel consists of 6 inches of reinforced concrete or 4 to 8 inches of reinforced concrete on 3 inches asphaltic concrete.

Fairview Channel to Hamilton-Victoria Street, (Reach 6)

5-23 The foundation materials in this reach, not including the active streambed materials, are primarily silts and clays but a significant amount (about 30 to 40 percent) of the soils are silty sands. Much of the fine grained material is highly plastic with plasticity indices of 35 to 40. These silts and clays are typically stiff to very stiff with SPT blow counts ranging between 10 and 30. Clay layers encountered were up to 15 feet thick and extend well below the proposed invert elevation. The silty sands are typically medium dense to dense with SPT blow counts between 20 and 40. Subsurface water, primarily groundwater, was encountered at depths ranging from 15 to 20 feet from the top of the levees (from 10 feet below to 5 feet above the proposed invert) throughout the reach. Thus, foundation materials in the reach are typically saturated. The materials remain wet in this reach year-round due to flow in the channel and the tidal surges from the mouth of the river.

5-24 Embankment materials in this reach are primarily silty sands but high proportions of clay and silt are present. Clays in the embankment are generally not highly plastic and are found in layers up to 5 feet thick. Embankment materials are medium dense and typical moisture contents range from 10 to 25 percent.

5-25 The active streambed materials in this reach are generally very fine grained. Silt and clay were the most frequently encountered material, but there are also some small lenses of silty sand and sand. Particles larger than 3/8 inches were not found. Within the existing channel, groundwater was encountered at depths from about 1 to 20 feet below the existing invert elevation; that is, from about 10 feet below to 5 feet above the proposed invert elevation.

5-26 Slope protection in this reach of the channel consists of 6 inches of reinforced concrete.

Hamilton-Victoria Street to Pacific Ocean, (Reach 7)

5-27 Foundation materials in this reach are generally silty sands and poorly graded sands. These materials are medium dense to very dense with SPT blow counts typically between 20 and 60. Groundwater remains high in this reach year-round due to flow in the channel and to tidal surges from the mouth of the river. As a result, moisture contents in the foundation are at or near saturation levels.

5-28 The embankments within this reach are composed primarily of silty sands, however, significant lenses of silt and/or clay up to 5 feet thick were encountered. The materials are medium dense to loose, and moisture contents vary over a wide range, typically between 10 to 30 percent.

5-29 Materials at or below the proposed invert elevation are mostly sands and silty sands. Occasional silt layers up to 2 feet thick were found primarily at the proposed invert elevation. Particles larger than 3/4 inches are not encountered and materials are generally saturated.

5-30 An inspection of the stone jetties at the mouth of the Santa Ana River in Huntington Beach determined that the 1/2 to 3-ton capstone is generally in good condition even after a maximum 30-year service record. The majority of the rock is fresh to only slightly weathered, with less than one percent breakdown noted. The dominant rock type present appears to be a medium to dark-gray, fresh to slightly weathered porphyritic andesite. The fresher, dark gray rock is located mostly in an approximate 300-foot section on the east jetty which was restored under a Corps contract in 1970. Minor amounts (approximately 10 percent) of a light gray to medium gray, slightly to moderately weathered porphyritic andesite and a light gray, coarse grained granodiorite are also present. The lighter colored andesite is characterized by numerous healed to rust stained incipient fractures and surface coatings of hematite and limonite. Most of the rock breakdown noted appeared to have occurred along these fractures. Most of the rock placed on the jetties probably came from the Harlow Quarry, south of Corona.

Santa Ana Canyon

5-31 The foundation material at the drop structure consists of most sandy silts and clays, silty and clayey sands with some layers of poorly graded sands and gravels to 3 inches. Moisture contents range from 3 to 12 percent in the coarser materials, and from 28 to 46 percent in the finer materials. Some cobbles are encountered below 20 feet. Standard penetration testing (SPT) indicates that materials in TH 87-1, located on the south side of the drop structure, are loose with blow counts ranging from 3 to 9. The other two holes (i.e. TH 87-2 and 3), on the north side, indicates an increase in density naving blow counts ranging from 11 to 40. Groundwater was encountered approximately 20 feet below the ground surface.

5-32 At the Green River Golf Course area, foundation materials are generally coarser than those found at the drop structure. They are composed of poorly graded sands, and silty sands with some layers of poorly graded gravel and sandy silts. Drilling in this area required drilling fluid within the first 5 feet. SPT data taken within material above 15 feet indicate that it is loose with blow counts below 15. Below this zone, the material increases in density, which was reflected by an increase in drilling effort. Penetration tests in these zones were not done due to the gravel and cobbles. Groundwater was encountered approximately 20 feet below the ground surface.

VI. ANALYSES

Levee Analysis

DESIGN VALUES

6-01 Representative design values have been selected for the foundation, levee and other construction materials. The selected design values are based on the results of detailed laboratory testing conducted on disturbed samples of representative materials from the foundation, levee, and invert; and on previous tests on similar materials from other projects; and on extensive construction experience with alluvial and streambed materials in the general vicinity of the project. Because the exploration revealed a wide variety of material types, and numerous loose or soft layers in the foundation and levees, laboratory tests were conducted on the various materials compacted to both 80 and 90 percent of maximum density as determined by ASTM test method 1557. The 80 percent compaction values were chosen to simulate the loose layers of in situ materials, and the 90 percent values were chosen to approximate the firmer in situ foundation and levee materials, and to represent the expected densities in the compacted levee embankment materials. The moisture-density relationships established by compaction studies and in situ foundation tests were used to determine the dry and moist unit weights. The saturated unit weights were determined by calculating the volume of voids at 80 and 90 percent of maximum density and assuming those voids were filled with water. The shear strength and cohesion values selected are interpretation of consolidated undrained triaxial compression test data, with pore pressure measurements used to determine consolidated drained values (R-type test). Conservative permeability values for calculating seepage through the levees were chosen from test results on similar materials. The adopted design values for the various materials in the foundation and levee are shown in the following table.

SEEPAGE

6-02 The proposed levees were analyzed for potential through seepage on the landside slopes. The seepage analysis addresses both the concerns of quantity of flow and of the factor of safety against piping.

TABLE B

Lower Santa Ana River
The Adopted Foundation And
Levee Design Parameters.

DESIGN PARAMETER / SOIL TYPE	MAXIMUM DRY UNIT WEIGHT γ_d (PCF)	OPTIMUM MOISTURE CONTENT W.C. (%)	R STRENGTHS				S STRENGTHS				UNIT WEIGHT LOOSE (80% COMPACTION)			UNIT WEIGHT DENSE (90% COMPACTION)		
			LOOSE (80% COMPACTION)		DENSE (90% COMPACTION)		LOOSE (80% COMPACTION)		DENSE (90% COMPACTION)							
			FRICTION ANGLE ϕ (DEGREES)	COHESION C (PSF)	FRICTION ANGLE ϕ (DEGREES)	COHESION C (PSF)	FRICTION ANGLE ϕ (DEGREES)	COHESION C (PSF)	FRICTION ANGLE ϕ (DEGREES)	COHESION C (PSF)	AVERAGE DRY UNIT WEIGHT γ_d (PCF)	MOIST UNIT WEIGHT γ_M (PCF)	SATURATED UNIT WEIGHT γ_{SAT} (PCF)	AVERAGE DRY UNIT WEIGHT γ_d (PCF)	MOIST UNIT WEIGHT γ_M (PCF)	SATURATED UNIT WEIGHT γ_{SAT} (PCF)
CLAY	121	11	15	600	23	600	24	200	30	200	99	109	124	111	123	132
SILT	117	12	20	200	25	400	26	80	32	100	94	104	122	105	117	129
SILTY GRAVELLY SAND	130	8	28	0	35	0	32	0	37	0	104	112	128	117	127	136
SAND	118	13	27	0	33	0	31	0	36	0	94	106	122	106	120	129
SILTY SAND	119	12	24	200	30	300	28	0	34	0	95	107	123	107	121	130
SAND/ SILTY SAND	123	11	26	0	32	0	30	0	35	0	98	109	124	111	122	131
CLAYEY SAND	130	8	22	400	27	400	26	100	32	100	104	113	128	117	127	136

6-03 Variables that significantly affect the seepage analysis are the levee height (including decreases in invert elevation), the slope of the levee faces, the ground level behind the levee, the elevation of impervious layers, and the water level. The levee side slopes were set to be 1V on 2H, the top width was set at not less than 15 feet to allow for construction and maintenance equipment access, and the water surface was established at the maximum flood elevation, with 3 additional feet of freeboard determining the levee height. The transient flow condition was determined for the design flow period of just more than 4 days, although the maximum design water level would actually exist for less than 2 days.

6-04 A permeability for the embankment and foundation materials of 10 ft/day was selected as a value representative of the lower quartile gradations, from the frequency studies of samples. The seepage exit points were estimated for the different levee heights typical of those conditions found in the project area, and were then compared to the ground heights behind the levees. All of the areas in which the ground height behind the levees is above the exit point were eliminated from further analysis as they would not develop seepage problems. There are percolation ponds on the backside of the right side of the levee in reach 2. For the purpose of the seepage analysis, the ponds were assumed to contain water to their weir elevations during floodflows. This assumption allows areas where the exit point is lower than the weir elevation to be eliminated as a seepage problem area due to the fact that the water on the backside of the levee would counteract the seepage forces.

6-05 The remaining levee areas were then analyzed to determine the extent of any seepage that might occur. The sections analyzed within each reach included those with the greater typical heights on both sides of the levee. The critical seepage sections within reaches 1 through 4 were developed as a 15-foot high levee on an impervious base. The maximum seepage quantity for the brief period of maximum design flow was calculated to be less than 20 cubic feet per day per lineal foot of levee, with a factor of safety against piping of about 2. The critical seepage sections within reaches 6 and 7 were develoed as a 22-foot high levee with groundwater at the invert elevation. The maximum seepage quantity within this area was calculated to be about 30 cubic feet per day per lineal foot, with a factor of safety against piping of about 2. The factors of safety against piping are considered conservative since they are based upon steady state conditions rather than the transient seepage condition, as discussed in subparagraph 6-03. The quantity of seepage is not considered a concern other than a consideration for the hydraulic design of side drainage. Rainfall behind the levees, for any storm large and long enough to develop seepage through the levees, would be added to the calculated seepage quantities, and the resulting quantities would be contained by the side drainage system. Local sections of levee that are affected by the design seepage conditions are listed in the following table:

Table C. Levee Areas Possibly Affected by Seepage.

Station	Reach	Levee	Comments
830+00*	2	Right	---
740+00*	2	Right	---
710+00*	2	Right	---
640+00*	3	Left	---
610+00*	3	Right	Left & right levees contained within higher existing banks.
150+00 to 0+00	6/7	Right	Private property on backside of right levee.

* Seepage within sections 1,000 feet in length unless noted otherwise.

SLOPE STABILITY

6-06 This analysis of the slope stability is based on the recommended plan. The stability of the levee slopes (including the trapezoidal portion of reach 5) was initially analyzed for the existing soil conditions, and additionally analyzed for new construction conditions where the proposed alignment would require placing new material.

6-07 Cross-sections representing typical and composite soil conditions were developed for both the left and right levees. Typical cross-sections generally represent the most common soil conditions encountered during the field investigation and composite cross-sections generally represent weak materials (such as loose sand, low strength silt and clay) and locally higher levees. Material types and properties used in the analysis were determined from field investigations and laboratory test results. The cross-sections have a top width of not less than 15 feet, and 1V on 2H side slopes. They are analyzed for end of onstruction, critical flood stage, sudden drawdown, steady seepage, and earthquake slope stability cases as required by EM 1110-2-1913. See plates 29 through 38 for representative cross-sections, including the failure arcs and a table of the safety factors obtained.

General conditions of the existing or new embankments and foundations are identified for each of the required slope stability cases. These conditions form the basis for the slope stability analysis, and are discussed in the following paragraphs:

- End of Construction. Slope stability for the case of end of construction takes into consideration any build up of pore pressure in impervious soils during the construction period. A major portion of the proposed levee construction will utilize existing levees, and, therefore, the end of construction condition would not be applicable. There will be some relocation and construction which would generally utilize free-draining materials and, therefore, consolidated-drained, S, shear strengths have been used for the end of construction analysis. For areas in reaches 3 through 7, construction of new levees may utilize a less pervious material. Although the less pervious materials are expected to drain faster than construction proceeds, consolidated-undrained, R, shear strengths have been conservatively used for the analysis.

  The end of construction condition was analyzed for reaches 1, 3, 5, 6, 7 and the Canyon for newly constructed embankments and Reach 4 for new material placed on existing embankments. The analyses indicate factors of safety above the minimum required.

- Critical Flood Stage. This case analyzes the riverside slope during prolonged flood stages in which the levee embankments may become saturated and develop a condition of steady seepage. Shear strengths for the less pervious soils were defined by a strength envelope midway between the R and S test envelopes for high normal stresses, and with the S strength envelope for low normal stresses. For free-draining materials, the slopes were analyzed with the S strength envelope. Most of the existing materials in the levees and the proposed borrow materials, are free-draining and the S strength envelope was used in the analyses. However, some of the existing materials in the lower reaches, 3 through 7, are not free-draining and the combined R and S strength envelope, as discussed above, was used for the critical flood stage analyses.

  Each of the levee cross-sections was analyzed with the water level at the design flood stage. All factors of safety for these analyses were above the required minimum factor of safety of 1.4.

- Sudden Drawdown. In general, the sudden drawdown analyses are based on the conservative assumption that the embankments are saturated and remain saturated during drawdown when the water surface is lowered instantaneously from maximum design flood stage to the minimum stage at the invert. Where the above conservative assumption resulted in factors of safety less than required, a more realistic condition was assumed and analyzed.

This condition took into account the fact that the time required for the flood waters to recede is estimated to be at least 3 days, and that, for most of the levees, the existing materials and the proposed borrow materials are free-draining. These conditions allow drainage of the slope face to proceed concurrently with the lowering of the flood waters. However, in areas of Reaches 3 and 7, some of the existing materials are not free-draining and the general assumption that pore pressure does not dissipate would be the more representative approach. For free-draining materials the S shear strengths was used and for less pervious materials the minimum of the R and S shear strength envelopes was used in the sudden drawdown analysis.

Each of the levee cross-sections analyzed for sudden drawdown met or exceeded the required factor of safety of 1.0.

- Steady Seepage. The condition of steady seepage occurs when water levels remain at the flood stage long enough to develop a steady state phreatic surface through the limited sections of levee not paved or grouted. Hydrographs for the Santa Ana River indicate that the maximum flood waters will be of a duration just long enough to develop the condition of steady seepage with the more pervious levee materials. The stability analyses for the case of steady seepage were performed for the landside slopes. For less pervious materials, a shear strength envelope which uses S strengths for low normal stresses and an envelope midway between the R and S test envelope for higher normal stresses were used. The S strength envelope was used for free-draining materials. Even though conservative values were chosen for analyzing the steady seepage condition, the full phreatic surface would only develop for storms of the magnitude of 100-year or greater.

  All the cross-sections developed a factor of safety equal to or greater than the minimum required 1.4 for steady seepage without earthquake. The acceptable factors of safety, even for the more shallow stability arcs (3- to 5-feet deep) within cohesionless embankment materials, indicate that sloughing of the slopes due to the short term steady seepage will not be a concern.

- Earthquake. The slope stability cases of end of construction, critical flood stage, and steady seepage were analyzed with earthquake forces. The representative design coefficient of 0.15 g for the earthquake case was selected in accordance with EM 1110-2-1902, after a combined seismic and flood risk analysis determined that the use of maximum probable accelerations to preclude the release of only occasional floodflows (as quantified below), was not required.

  (a) The calculated combined risk associated with a 0.2 g local surface acceleration produced by an earthquake on the San Andreas fault, is less than 0.0007 during a period of design flow.

(b) The calculated combined risk associated with a 0.45 g near field surface acceleration produced by either an earthquake on the Whittier-Elsinore fault zone at the upper end of the project or the Newport-Inglewood fault zone at the lower end of the project, is only about 0.0001 during a period of design flow.

In all cases analyzed, the levee cross-sections met or exceeded the minimum required factor of safety of 1.0.

SLOPE PROTECTION

6-08 Revetment stone is required on the unpaved riverside levee slopes. Hydraulic design (see Main Report-Vol. 3) determined the maximum riprap thickness required for the levees will vary considerably as indicated in table D. In areas near drop structures and places of higher velocities, maximum riprap thickness will be as much as 60 inches, with grouted stone proposed as an alternative where riprap thicknesses are excessive. Riprap placed under water would have a 50 percent thicker layer. Grouted stone revetment is proposed to be placed as a 15-inch layer, as a possible alternative to the riprap, throughout the project.

6-09 In order to prevent erosion and loss of fines through the voids in the riprap stone revetment, some type of filter will be required. Two types of filter material were evaluated so that the most economical could be used. The two types are filter stone and filter cloth.

6-10 The stone and filter requirements were designed in accordance with EM 1110-2-1913 and ETL 1110-2-120.

Table D. Riprap/Filter Thickness.

Riprap Thickness (D50)	Riprap Thickness (Dry)	Riprap Thickness (Wet)	Filter Thickness (Dry)	Filter Thickness (Wet)
8"	12"	18"	6"	9"
10"	15"	24"	6"	9"
12"	18"	27"	6"	9"
14"	21"	33"	6"	9"
15"	24"	36"	9"	12"
24"	36"	54"		
33"	48"	72"		

Drop Structure and Stabilizer Analysis

6-11 In order to maintain the invert grade line, drop structures and invert stabilizers are proposed within the soft bottom reaches of the project. Typical cross sections of the structures are shown in figures 5 and 6.

DESIGN VALUES

6-12 Based on the foundation conditions at the proposed invert structure improvements, the following values are selected for design:

Table E. Invert Structure - Design Values.

Moist unit weight, (pcf)	120
Saturated unit weight, (pcf)	130
Angle of internal friction, (deg)	34
Active earth pressure coef.	0.28
Moist equiv. earth fluid, (pcf)	34
Saturated equiv. earth fluid, (pcf)	80
Passive earth pressure coef.	3.5
Moist equiv. earth fluid, (pcf)	420
Saturated equiv. earth fluid, (pcf)	300
At-rest earth pressure coef.	0.45
Saturated equiv. earth fluid, (pcf)	93
Allowable bearing pressure, (psf)	3000
Permeability,(fpd)	50
Coefficient of sliding friction	0.40

UNDERSEEPAGE

6-13 A drain blanket will be required beneath the proposed drop structures in order to preclude the effects of uplift and piping due to underseepage. Two water surface conditions were considered for this analysis; one for a saturated invert, and another considering full flow conditions. The permeabilities of the foundation materials were based upon the D_{10} of the foundation materials. The uplift forces for both conditions indicated that the saturated invert condition is more critical, and thus is the basis for design. The drain blanket was designed in accordance with ETL 1110-2-236.

STONE PROTECTION

6-14 The hydraulic design has established that the stone requirements for the drop structures, will include derrick stone at the leading and trailing invert areas. The invert stabilizers will be constructed of grouted cobblestone, and will require derrick stone at the trailing invert areas. The gradation requirements for the required stone have been designed in accordance with ETL 1110-2-120, and the filter requirements are in accordance with EM 1110-2-1913.

BEARING

6-15 The existing foundation materials encountered beneath the proposed drop structures will provide a bearing capacity of 3000 psf. Settlement is expected to be negligible for the invert structures, since the additional load due to the improvements is not an appreciable increase from the existing overburden.

LATERAL PRESSURES

6-16 The lateral pressures acting on the breast walls have been determined, assuming that all backfill will be from local required excavation. It has been assumed that drop structure breast wall backfill will remain saturated, and that the driven steel sheetpile wall backfill within the Canyon will drain.

SLIDING

6-17 The coefficient of friction between the base of drop structure slab and the foundation material is assumed to be 2/3 the angle of internal friction of the foundation material.

Concrete Trapezoidal and Rectangular Channel Analysis

DESIGN VALUES

6-18 The soils design values selected for the proposed concrete channel are based on conservative interpretations of the field and laboratory test results. Consideration was given to design values selected for similar material on major projects constructed by the Los Angeles District Corps of Engineers. Permeability of the foundation materials is based on tests performed at 80 and 90 percent of maximum density (ASTM D 1557) on samples representative of lower quartile gradations from frequency studies of all foundation samples taken. The following values are selected for the rectangular channel and for the trapezoidal channel design:

Table F. Concrete Channel Design Values.

Foundations	
Allowable Bearing Pressure, (psf)	1500
Permeability, (fpd)	5
Backfill	
Dry Unit Weight, (pcf)	100
Moist Unit Weight, (pcf)	108
Angle of Internal Friction, (deg)	28
Cohesion, (psf)	0
Active Earth Pressure coef.	0.36
Equivalent Earth Fluid Weight, (pcf)	40

SUBDRAIN

6-19 A subdrainage system will be required between 17th Street and Fairview Channel in the Santa Ana River Channel, and in the Greenville-Banning Channel between the San Diego Freeway and Hamilton-Victoria Avenue. A subdrainage system is necessary to control hydrostatic uplift forces under the channel invert and low flow area, due to high groundwater levels or a perched water condition. The subdrain system was designed in accordance with ETL 1110-2-236 and the Los Angeles District Report on Manhole Subdrain System, July 1957. The design was based on channel dimensions given as amended in the Phase II GDM hydraulic design, and an estimated minimum channel invert thickness of 10 inches. A design hydrostatic head of 10 feet above the top of the subdrain collector pipes was used and subdrain pipes were assumed to flow a maximum of 80 percent full. The effect of adjacent subdrains in both the main and Greenville-Banning channels was considered in the subdrain design. Where possible, consistent pipe sizes were maintained along the channel while discharge distances were varied. The design (as discussed in paragraph 7-35) was verified by the construction of full channel flow nets.

LEVEE SLOPE STABILITY

6-20 From Seventeenth Street to about the San Diego Freeway, the channel will be a trapezoidal concrete lined channel. Existing levees will be utilized to some degree. Levee heights, however, will not be increased. The stability of the existing levee materials along the proposed trapezoidal channel reach was checked in accordance with EM 1110-2-1902, as presented in paragraph 6-06.

BEARING

6-21 The bearing capacity of the foundation soils was determined in accordance with EM 1110-2-1903, accounting for both shear and settlement considerations. The allowable foundation bearing pressure of 1500 psf is based on a maximum allowable settlement of 1-inch considering each of the material types encountered in the rectangular channel reach.

LATERAL FORCES

6-22 The lateral earth forces acting on the rectangular wall were determined in accordance with EM 1110-2-2502. The forces were selected assuming that wall deflections will be sufficient to reduce wall pressures to the active state. An active earth pressure coefficient (Ka) of 0.36 and equivalent earth fluid weight (EEF) of 40 pcf are given in paragraph 6-18 with other pertinent design values. These values are based on a cohesionless silty sand (SM) backfill compacted to 90 percent of maximum density (ASTM D 1557).

Disposal Beach Compatibility Analysis

6-23 The analysis of compatibility is based upon the gradations of representative materials obtained from both the disposal (beach) and the borrow (required invert excavation) sites. The gradations of the sampled range lines along the proposed disposal beach have been grouped into composite blends representing similar materials within adjoining sections of beach. The same type of grouping was done for the materials that are to be removed down to the proposed invert within functional construction reaches. The groupings were made so that increased flexibility would be obtained in utilizing all available required invert excavation for the replenishment of adjacent beaches.

COMPATIBILITY CRITERIA

6-24 The criterion for beach fill materials is set within the Code of Federal Regulations, Title 40, Part 230. Specifically, within Section 230.4-1.b.1, the code states that beach restoration materials are to be composed predominately of sand, gravel or shells with particle sizes compatible with the material on disposal beaches.

6-25 The Los Angeles District Corps of Engineers has established quantitative guidelines for the compatibility of beach and borrow materials. The guidelines say that in order to determine compatibility, the grain size distribution curves for the disposal beach samples will be plotted. These curves define an envelope within which all the existing beach material will fall. For the borrow material to be considered compatible, the composite curves for the borrow should fall within the envelope of curves for the disposal beach with the following exceptions. The coarse grained portion of the composite curves may fall outside of the envelope if not restricted by esthetic considerations.

The fine grained portion may also fall outside of the envelope, however, the percentage of silt and clay (percent passing the No. 200 sieve) shall not exceed that of the finest beach sample by more than 10 percentage points.

DISPOSAL BEACH

6-26 Composite gradations for each particular range line were determined using every sample along each range line. The range line gradations are shown in table 11. Range line gradations for similar sections of beach were then compiled, and the average and upper quartile composite and upper limit gradations of the combined areas were plotted. See figure 7 for representative beach gradation envelopes.

INVERT MATERIAL

6-27 All invert areas of required excavation were sampled. The gradation of each sample was obtained and compared with the gradations of adjoining reaches of invert. A composite gradation summary was then developed for functional areas of similar materials, within each reach where excavation is required. See table 9 for representative composite gradations of the invert material to be removed.

COMPATIBILITY

6-28 The Los Angeles District guideline was used to determine grain size compatibility. The average and upper quartile composite and upper limit gradations of one combined section of disposal beach were plotted. The composite average gradation of each representative reach of excavated invert was then plotted on the same figure. Invert materials judged to be generally suitable for beach replenishment are those functional composite groupings that contain up to 10 percentage points more fines than the upper quartile gradation of a section of disposal beach. See figure 7 for the gradation comparisons.

VII. DESIGN APPLICATIONS AND CONSTRUCTION CONSIDERATIONS

Project Dewatering

GENERAL

7-01 The construction of all levee embankments, invert structures, hard-bottom channel sections will be accomplished free of standing water.

7-02 Dewatering could be accomplished by some combination of drainage ditches, dikes, cofferdams, wellpoints, and pumps or other techniques proposed by the contractor. Each of these methods will be discussed in the following paragraphs. This report also presents a suggested scheme for estimating the dewatering for each typical reach or section.

7-03 The groundwater conditions along the project alignment have been discussed, herein, before. The groundwater basin is illustrated in figures 3 and 4, and groundwater profiles along the project alignment are shown on plate 6.

Diversion

7-04 Surface flow is expected to be continuous along the Lower Santa Ana River, during construction. Generally, water could be diverted to the inactive side of the channel, by means of dikes and drainage ditches. The dikes will be of sufficient height to preclude overtopping, and of sufficient sectional width to eliminate piping. It is recognized that the dike section(s) will be pushed-up and continuously maintained by the contractor, as an area is worked. Any drainage ditch construction, or excavation of dike fill that goes deeper than the final invert elevation will be backfilled and compacted. Overexcavation in reaches of the proposed hard-bottom sections will also be backfilled with compacted fill material.

Groundwater

7-05 Subsurface water may generally be removed by pumping the gravity flow from a sump system, since the foundation materials for this project are typically sand or silty sand. The pumping rates for the preconstruction dewatering of each proposed improvement, will be discussed in the following paragraphs. The rates are discussed as an aid to estimating construction costs. Excessive flows in the cleaner sand foundation materials may be controlled with sheet pile cutoff walls. Seepage into any excavation may be removed by pumping from a sump trench. Based on a 15-foot wide excavation 12 feet deep, a required pumping rate of about 150 gpm per 100 feet of excavation can be expected. A sheet pile cutoff around the excavation could be used to reduce the seepage rate. A cutoff to a depth of 10 feet below the bottom of the excavation would reduce the required pumping rate to about 70 gpm per 100 feet of excavation.

Cofferdams

7-06 Tidal variations within the lower reach of the Santa Ana River will create additional dewatering requirements. The tide is expected to rise as high as +8 feet MLLW (+10 feet NGVD), meaning that tidal surface flows could effect construction as far inland as Adams Avenue. Cofferdams may be used to control the upstream movement of the tides.

Levee Construction

NEW CONSTRUCTION

7-07 New construction will consist of building new levees to the alignment and elevations required by the hydraulic design where existing levees cannot be modified or do not currently exist. Paragraph 7-12 discusses the proposed levee modifications, including widening or raising existing levees as described in paragraphs 1-13 through 1-24. Closely related construction in the channel, including stabilizers and drop structures and channel excavation, are discussed in the following paragraphs 7-22 through 7-40.

Geometry

7-08 The new levees would be constructed with 1V on 2H side slopes and a top width of not less than 15 feet. Typical dimensions and cross sections are shown on plates 29 to 37.

Foundation Treatment

7-09 The foundation areas for new levee construction would be cleared and grubbed to expose the foundation soils, and proof-rolled to at least 90 percent of maximum density (ASTM 1557) to provide a firm foundation for the compacted fill materials and to reduce underseepage and settlement. Control of surface water in the channel can be accomplished with diversion levees to direct the flows to the opposite side of the channel, however dewatering may still be required in some areas to allow excavation and construction of the levee toe. Dewatering could be accomplished with a system of well points or a collection ditch with sump pumps. Temporary excavation slopes for the toe construction would be no steeper than 4V on 3H, and in areas of relatively loose noncohesive granular soils, may need to be flatter. The required excavation for toe construction will preclude the need for the excavation of a separate inspection trench. Unsuitable foundation soils such as soft clays, loose sands or open-graded gravel or cobble layers would be removed and recompacted or replaced with compacted levee fill materials.

Sources of Material

7-10 The new levees will be constructed with materials from the required channel invert excavation. Hydraulic design of the channel requires the lowering of the existing invert elevation at various locations. The two locations within reasonable haul distances that could provide suitable materials from the required excavation are in reach 1, above Imperial Highway, and just downstream of reach 4 between Seventeenth Street and Edinger Avenue. The materials available in the upper borrow area are primarily sands with relatively small amounts of silt and gravel, as described in paragraphs 5-01 through 5-10. The materials available in the lower borrow area are finer grained, primarily silty and clayey sands with occasional gravels and cobbles, as described in paragraphs 5-19 through 5-22. The balance factors for materials from either borrow site would be approximately 0.85 when excavated, hauled, placed, and compacted with conventional construction techniques. The relatively pervious granular materials from the upper borrow area are preferred due to their ease of handling and free-draining characteristics. Excess pore pressures and marginal slope stability under sudden drawdown conditions would be largely eliminated if these materials are used to construct the new levee sections. Finer-grained, slower-draining materials from the lower borrow area would reduce the hauling distance and costs for the levees in reaches 3 and 4, but would probably increase the potential for slope distress during the life of the project. A discussion of the stone and filter materials to be used on the levees is presented in paragraphs 7-17 through 7-21.

Construction Requirements

7-11 Conventional heavy construction equipment would be suitable for construction of the levees. Excavation of the borrow materials from the channel invert could be accomplished with self-propelled scrapers if the haul distance is reasonably close, or with rubber-tired loaders and hauled in off-road trucks if haul distances are longer. After clearing, grubbing and proof-rolling the foundation, borrow materials from the channel invert excavation would be placed and spread in lifts no thicker than one foot. Cobbles and boulders larger than 3/4 of the lift thickness would be removed on grade before compaction. Processing of the excavated materials to remove the oversize particles would not be required due to the relatively small amount of stone in the borrowed areas. Moisture content of the fill materials would be adjusted to near optimum by adding water on grade if too dry, or by scarifying and aerating if too wet. The conditioned fill material would then be compacted to at least 90 percent of maximum density as determined by ASTM D 1557 by rolling with a rubber-tired or other type roller suited to the materials being compacted. Field density tests (ASTM 1556) would be conducted in sufficient numbers to assure that the required compaction is accomplished. Slope protection requirements are discussed in paragraphs 7-17 through 7-21.

RECONSTRUCTION

7-12 The existing levees would be modified in some locations by increasing the height of the levee or by a realignment of the centerline.

Geometry

7-13 The modified levees would be constructed with 1V on 2H side slopes and a top width of not less than 15 feet, the same as the new levee sections. Typical sections showing the variations and extent of levee modification are shown on plates 29 through 36.

Foundation Treatment

7-14 Where new fill material is to be placed over existing levees, the levee will be prepared as a suitable foundation by removing any pavement on the crest and any slope protection or vegetation on the side slopes. Sloped surfaces steeper than 1V on 4H will be flattened or stepped so that the compaction equipment will bear fully, and proof-rolled to at least 90 percent of maximum density as determined by ASTM test method D 1557. New foundation areas will be cleared grubbed, proof-rolled, and scarified before the first lift is placed. As with the new levee construction, dewatering may be required in some areas where the riverside slope of the existing levee is to be modified.

Sources of Material

7-15 Borrow materials for modification of the existing levees will be obtained from the same channel excavation sources as for the new levee construction. Free draining granular materials will be available within all the construction reaches of the project.

Construction Requirements

7-16 Reconstruction of the existing levees can be accomplished with conventional heavy construction equipment following the same procedures described for new levee construction, except that the existing slope protection would be removed and stockpiled if adequate for reuse.

SLOPE PROTECTION

Stone Sources

7-17 Slope protection materials for the Lower Santa Ana River project would be available from two sources, nearby commercial rock quarries and portions of the existing river levees. Local quarries which have produced suitable stone within the past 5 years for Corps of Engineers' construction projects are listed in table G. All these sources are within 30 miles of either the upstream limits (Santa Ana Canyon) or downstream limits (Pacific Ocean) of stone placement for the project. The Corona group of quarries (Corona-Pacific, Harlow and 3M) would be the closest sources to the upper reaches of the project. Stone could also be obtained from the more distant Atkinson, Declezville and Stringfellow operations in the Jurupa Mountains near Riverside. The Slover Mountain Quarry near Colton and the Fish Canyon Quarry near Azusa would also be potential sources of stone. The closest source to the downstream limits of the project is the Pebbly Beach (Connolly-Pacific) Quarry on Santa Catalina Island.

Table G. Rock Quarry Locations.

Quarry	Nearest City	Minimum Distance to Site (mi)
Atkinson	Riverside	18
Corona-Pacific	Corona	9
Declezville	South Fontana	18
Fish Canyon	Azusa	22
Harlow	Corona	11
Pebbly Beach	Avalon (Santa Catalina Is.)	30
Slover Mountain	Colton	24
Stringfellow	Riverside	18
3M	Corona	10

During construction, suitable stone may also be reclaimed from portions of the existing levees (see paragraph 5-14). Reach 3 from Katella Avenue to Santiago Creek would provide stone suitable for reuse as slope protection. Armor stone currently in place on the existing jetties could be utilized in the jetty reconstruction.

Stone Quality

7-18 Results of recent quality compliance tests conducted by SPD laboratory on stone samples from the quarries listed in table G and from the existing levees are summarized in table 10. In addition, the most recent Corps of Engineers project associated with each quarry source is shown. Although the quarries listed in table 10 have provided suitable stone for Corps projects in the past, restrictions were placed on recent usage of stone from the Harlow Quarry near Corona. Stone from this source was accepted for use only as grouted stone in the Warm Creek-Santa Ana River Confluence project because of the breakdown which occurred during the June 1985 wetting and drying test. Despite high abrasion losses shown for the Pebbly Beach and Declezville quarries, and a sulfate soundness loss much greater than the specified limit of 10 percent for the Pebbly Beach source, stone from both quarries has previously been accepted for use on Corps projects based on proven satisfactory service records. Stone from Declezville was placed in the San Pedro Breakwater, completed in 1912, and has shown no appreciable deterioration since that time. Stone from Pebbly Beach, despite its heterogeneous character, has given good service in the Long Beach and Middle Breakwaters, beginning in the mid-1930's.

7-19 Results of quality compliance tests conducted in February 1988 on samples of the existing levee riprap indicate an overall improvement in rock quality between reaches 1 and 3 (see table 10). However, the test results do not accurately reflect the deteriorating physical condition of the volcanic andesite rock in reaches 1 and 2. Although the rock types common to each reach passed the wetting and drying tests, the andesite, which is diagnostic of Harlow Quarry, has demonstrated an unsatisfactory service record because of its tendency to breakdown along incipient fractures. This fact in itself would make the riprap on the existing levees between Weir Canyon Road and Katella Avenue unsuitable for reuse as slope protection and might preclude or restrict the use of stone from Harlow Quarry on the project.

Stone Assessment

7-20 More than one source may be required to supply the estimated 500,000 plus cubic yards of riprap required for the Lower Santa Ana River project. Suitable stone may be available form additional quarries in the Riverside-Corona area or from other locations, but information on these potential sources is not included in table 10 due to lack of either recent test data or service records on Corps projects. Although the majority of the sources have produced acceptable stone in the past, it cannot be assumed that they will continue to do so. Therefore, any stone source considered for use as slope protection will require further field inspection and evaluation, and may require additional quality compliance testing prior to stone placement.

Revetment

7-21 Stone revetment meeting the gradation requirements as analyzed in paragraph 6-08 can be placed with conventional methods from either the top or bottom of the levee. Care must be taken during placement to prevent segregation and unnecessary displacement of the underlying filter or bedding layers. Riprap stone gradations, for each dry thickness presented in the hydraulic design, are as follows:

Table H. Riprap Gradations.

Riprap - 12" thickness

Approximate Weight of Individual Pieces (lbs)	Percent Passing (by weight)
86	100
35	65-100
26	50-70
17	15-50
5	0-15

Riprap - 15" thickness

Approximate Weight of Individual Pieces (lbs)	Percent Passing (by weight)
169	100
67	65-100
50	50-70
34	15-50
11	0-15

Riprap - 18" thickness

Approximate Weight of Individual Pieces (lbs)	Percent Passing (by weight)
292	100
117	65-100
86	50-70
58	15-50
18	0-15

Riprap - 21" thickness

Approximate Weight of Individual Pieces (lbs)	Percent Passing (by weight)
463	100
185	65-100
137	50-70
93	15-50
29	0-15

Riprap - 24" thickness

Approximate Weight of Individual Pieces (lbs)	Percent Passing (by weight)
691	100
276	65-100
205	50-70
138	15-50
43	0-15

Riprap - 36" thickness

Approximate Weight of Individual Pieces (lbs)	Percent Passing (by weight)
2333	100
933	65-100
691	50-70
467	15-50
146	0-15

Riprap - 48" thickness

Approximate Weight of Individual Pieces (lbs)	Percent Passing (by weight)
5520	100
2200	65-100
1647	50-70
1111	15-50
350	0-15

Filter Stone

7-22 Layers of filter stone can be placed with conventional construction methods. Recommendations for filter stone are as follows:

1. The layer thickness of filter stone will be in accordance with the table presented in subparagraph 6-08.

2. Filter fabric is an alternative to filter stone in areas where dewatering is a concern, since placing filter stone under water could cause segregation. If filter stone is placed under water, a 50 percent thicker layer should be used.

3. Filter fabric will be used in the higher energy revetment sections downstream of Pacific Coast Highway in order to eliminate both segregation concerns and multiple layer costs.

4. The filter stone gradation of the 12-, 15-, 18-, 21- and 24-inch thick riprap stone follows:

Table I. Filter Stone Gradation.

Sieve Size	Percent Finer (by weight)
3 inch	100
1-1/2 inch	65-100
1 inch	50-85
1/2 inch	15-50
No. 4	0-15

7-23 Filter fabric will have an equivalent opening size (EOS) of 70 and should be nonwoven to prevent tearing. A 15 percent increase in slope area should be considered in estimating filter fabric requirements, to consider the effects of lapping and bunching. Filter fabric would need to be anchored at the top and the bottom, and protected from puncture with an overlying layer of crushed rock. The top and bottom can be anchored in narrow trenches at the top and bottom of the levee by placing the edge of the fabric in the trench and backfilling with soil. A 6-inch thick (9-inch when placed in wet) layer of crushed rock or sandy streambed materials on top of the fabric would cushion the fabric from the impact of larger stones during the placement of the revetment. Steambed materials would be placed with a controlled drop height not to exceed 12-inches, and would *not* be used as bedding in higher energy areas (i.e., when dry riprap thicknesses exceed 24-inches). Splicing segments of filter together in the field would be in accordance with the manufacturer's recommendations.

Grouted Stone

7-24 Stone to be grouted can be placed with the same methods and equipment used to place stone revetment. No filter layer would be required beneath the grouted stone. If groundwater is present near the surface, dewatering of the toe excavation may be necessary to carry out the grouting operation. For estimating purposes, the volume of grout may be expected to be about 30 percent of the calculated volume of the grouted stone layer. For a 15-inch layer of grouted stone, the stone would be well graded and vary in size from 3 to 12-inches in diameter.

Drop Structure and Stabilizer Construction

REQUIRED EXCAVATION

7-25 The proposed invert structures will be founded on the native invert materials. The invert will be excavated to an average depth of about 5 feet for invert stabilizer construction, and 10 feet for the construction of the drop structures. Temporary slopes will not be steeper than 4V on 3H.

7-26 The excavation will be kept free of standing water during construction. Any surface flows will be diverted around the construction area by means of temporary dikes. Seepage into the excavation will be removed by means of pumping from sumps. The pumping rate to dewater the drop structure excavations is conservatively estimated to be not more than 200 gpm, based upon an open excavation of half the channel width. Dewatering rates for the invert stabilizer excavations would be less than half of that for the drop structures.

FOUNDATION PREPARATION AND BACKFILL

7-27 The foundation subgrade surface will be trimmed and proof-rolled to a smooth and uniform grade prior to any structural improvement.

7-28 The backfill and fill materials will be selected from the required excavation. Materials with greater than 20 percent fines should not be used as backfill for the breast walls. The backfill will be placed in 1-foot lifts and will be compacted to not less than 90 percent of maximum density as determined by ASTM method D 1557. Fill materials will be placed on surfaces that have been cleared and scarified to a depth of 6 inches. Sloped ground surfaces steeper than one vertical to 4 horizontal will be flattened or stepped so that the compaction equipment will bear fully on the fill layer. The fill will be compacted to not less than 95 percent of maximum density.

GEOMETRY

Invert Structure Stone

7-29 The invert structure stone will be placed to the dimensions shown in figures 5 and 6. The stone will be graded as presented in following table. Grouted stone will be placed in a uniform mass in order to eliminate double decking or layering of the stone.

Table J. Invert Structure Stone Gradations.

Gravel Drain(1-1/2 inch crushed rock)

Sieve Size	Percent finer (by weight)
1-1/2 inch	100
1 inch	90-100
3/4 inch	55-90
3/8 inch	8-20
No. 4	0-5

Bedding Stone

Weight of individual Pieces (Pounds)	Percent Finer (by weight)
85	100
35	65-100
15	15-50
5	0-15

Derrick Stone

7-30 The derrick stone will be approximately 36 inches in diameter, will extend 30 feet upstream and downstream of the structure. On the downstream portion, the stone will slope downward at a 1V on 2H slope. The thickness of the derrick stone will be 5 feet with 2 feet of bedding stone, a layer of filter fabric, and 6 inches of bedding sand (raked, native material, 3-inch material) beneath the derrick stone layer.

Grouted Stone

7-31 The grouted cobblestone will be reasonably well graded between 3 and 12 inches.

Drain Blanket

7-32 The gravel drain material and 6-inch collector drain pipe will be placed to the dimensions shown in figure 5. Additionally, 3-inch weep holes, 10-foot on center, will drain the breast wall backfill. The gravel drain material will be graded as presented in the previous table. Segregation and contamination of the drain materials will be avoided. The gravel drain material will lie over a filter fabric and 6 inches of native invert materials which have been raked of +3-inch material. The grouted stone drop structure will have 3-inch diameter horizontal weepholes spaced at 10 feet on center and will be placed one foot above the elevation of the end sill. Each weephole will be backed with a one cubic foot gravel drain pocket completely bound by filter fabric. The interface between the gravel pocket and the grouted stone will be separated by a 12-inch by 12-inch section of galvanized wire mesh (1/4 inch openings). The gravel drain material will be 1-1/2-inch crushed rock as shown in table J.

Levee Facing

7-33 To preclude the possibility of piping around the invert structures, the grouted stone levee facing should extend not less than 5 feet below the deepest portion of grouted facing stone of the invert stabilizers, or 10 feet below the bottom of the base slab of the drop structure.

SANTA ANA CANYON SHEETPILE

7-34 At the drop structure, improvements will consist of extending the steel sheetpile wall 23 feet deep on both sides of the river down to an elevation of 435 feet. Materials in this drop structure area should not be a problem for standard sheetpile driving procedures.

Concrete Channel Construction

CHANNEL EXCAVATION

7-35 From Seventeenth Street to Fairview Channel, the proposed concrete channel will be founded on native soil and will be constructed by open cut. The invert will be excavated up to a depth of 5 feet below the existing streambed surface. Invert materials are generally medium dense poorly graded sands and silty sands. In addition to the invert excavation, it will be necessary to cut into some existing levees for construction of the channel walls and new levee slopes. Temporary slopes will not be steeper than 4V on 3H.

7-36 The excavation will be kept free of standing water during construction. Surface flows will be diverted around the active construction area by means of temporary earth dikes, and seepage into the excavation will be controlled by means of pumping from sumps. Based on an open excavation of half the channel width and 5 feet deep, the pumping rate required to dewater the excavation is about 100 gpm per 100 feet of channel.

FOUNDATION PREPARATION

7-37 In areas where the proposed channel invert is below the existing streambed, the subgrade will be excavated to the design grade, approximately 1 foot below the bottom of invert slab elevation, then trimmed to a uniform grade. The subgrade will then be proofrolled to 95 percent of maximum density (ASTM D 1557) so that no stone protrudes more than 3 inches above grade. Any soft or yielding materials encountered would be removed, backfilled with select material, and recompacted to 95 percent of maximum density (ASTM D 1557). Where the proposed channel invert is above the existing streambed, fill material from the required excavation will be placed on the existing grade in compacted lifts no thicker than 12 inches. Lifts will be built up to the design grade elevation and will be compacted to at least 95 percent of maximum density (ASTM D 1557). To prevent hydrostatic uplift of the fill and paved invert, fill material placed beneath the invert will contain not more than 15 percent fines.

SUBDRAIN CONSTRUCTION

7-38 The subdrainage system in the Santa Ana River Channel will be constructed in three configurations, and a fourth configuration will be constructed in the Greenville-Banning Channel. Each configuration will include a 6-inch gravel drain layer placed between a 6-inch thick layer of filter sand and the concrete channel invert. The subdrainage system for the downstream end of the rectangular channel will consist of an 8-inch diameter collector (perforated) pipe placed longitudinally behind either channel wall and two 6-inch diameter collector pipes placed longitudinally under each half of the invert slab at 50 foot spacings, starting from the channel wall collector. A final or third 6-inch diameter collector pipe will be placed adjacent to either side of the low flow channel, inset 60 feet from the previous invert collector. The system for the upstream (narrower) portion of the rectangular channel will be the same but with one less collector pipe and constant 50 feet spacing. The subdrainage system for the trapezoidal channel will consist of three 6-inch diameter collector pipes placed longitudinally under each side of the invert slab. The first collector will be under the outer edge of the invert, the second will be inset 30 feet, and the final pipe will be inset 40 additional feet. The drain and filter materials will extend up, beneath the channel slope paving, 5 feet above the invert. The subdrainage system for the Greenville-Banning Channel will consist of one 10-inch diameter collector pipe behind either side of the channel just above the base of the channel walls.

7-39 The collector pipes under the invert slab will empty into 10-inch diameter nonperforated discharge pipes. The nonperforated pipes will be spaced at 300 feet for the lower portion of the rectangular channel, 400 feet for the upper portion of the rectangular channel, and 600 feet for the trapezoidal channel. The collector pipes behind the rectangular channel L-walls will discharge directly through a flap gate in the channel wall. Flap gates in the channel walls will be spaced at 500 feet for the lower portion of the rectangular channel, and 600 feet for the upper portion of the rectangular channel. Flap gates in the Greenville-Banning channel walls will be spaced at 300 feet for the rectangular channel and 600 feet for the trapezoidal channel.

7-40 The design configuration plates for the subdrain systems are presented within the Main Report-Vol. 3.

7-41 The filter and gravel drain materials will be graded between the standard limits specified below:

Table K. Subdrain Stone Gradations.

Filter Material (Washed Concrete Sand)

Sieve Size	Percent Finer (by weight)
3/8 inch	100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

Gravel Drain (1-1/2 inch crushed rock)

1-1/2 inch	100
1 inch	90-100
3/4 inch	55-90
3.8 inch	8-20
No. 4	0-5

Care will be taken to avoid contamination or segregation of the sand filter and gravel drain materials during placement. Precautions, such as use of light equipment, will be employed to ensure uncontaminated layers of the required thickness.

EMBANKMENT CONSTRUCTION

7-42 The existing left and right levees of the Santa Ana River Channel that will be paved as a trapezoidal section may be either cut back or built out, depending on the location, in order to create the new channel alignment. Conventional heavy construction equipment will be suitable for excavation of existing levees and construction of new levee fills. Fill materials will come from the required levee and invert excavation. Excavation of the borrow materials may be accomplished with self-propelled scrapers for short haul distances or with rubber-tired loaders and hauled in trucks for long haul distances. Levee fill will be placed in compacted lifts no thicker than 12 inches. Fill will contain no particles greater than 9 inches and will be compacted to 90 percent of maximum density (ASTM D 1557). Where new fill material is placed over existing levees, the levee will be prepared as a suitable foundation by removing any pavement or vegetation and flattening or stepping slopes steeper than 1V on 4H so that compaction equipment will bear fully on the compacted layer.

BACKFILL

7-43 Structural backfill behind the rectangular channel L-walls will consist of select material from the required excavation. Backfill materials will consist of sands and silty sands containing no particles larger than 3/4 of the compaction lift thickness and no more than 10 percent passing the #200 sieve. Backfill will be placed in 12-inch thick loose lifts and compacted to not less than 90 percent of maximum density (ASTM D 1557) and within 2 percent of optimum moisture content. Compaction of backfill material will be accomplished by means which do not overstress the L-wall. Mechanical hand tampers may be employed, but heavy equipment will not be permitted within 3 feet of the wall.

ACCEPTABLE INVERT EXCAVATION

7-44 The acceptable invert materials for beaches are shown in the figure 7 series of compatibility envelopes, as described in paragraph 6-28. Acceptable materials have been identified only to the depth of the proposed invert. All composite areas of required invert excavation (see table 9) are useable for beach placement. Because invert materials are subject to change during periods of significant channel flow, the suitability of any required excavation designated for placement on the beach should be monitored during construction. Acceptable materials are identified only by grain size in this appendix.

PLACEMENT

7-45 The method of placing renourishment materials on a beach is a critical factor in retaining the materials. Specific methods of placement and geometry will be presented in the Coastal Design Appendix.

VIII. CONCRETE MATERIALS

GENERAL

8-01 This section discusses the availability and suitability of concrete materials. Prior to the preparation of plans and specifications, a detailed concrete materials investigation will be prepared for the concrete structures. The scope of the investigation will be in accordance with the requirements of EM 1110-2-2000, Standard Practice for Concrete, dated 5 September 1985.

Aggregate Sources

GENERAL

8-02 The following paragraphs summarize the potential sources of concrete materials available for the project. The material sources listed are representative of those currently used by the local producers. Plate 39 shows the locations of aggregate, cement, and pozzolan sources. Detailed investigations, which evaluate the quality of the aggregates from those sources are in progress. Additional sources will be investigated and the complete analysis of the results will be presented in the Feature Design Memorandum addressing major items of concrete construction.

BLUE DIAMOND MATERIALS

8-03 This producer of concrete aggregate is located on an alluvial sand and gravel deposit along the Santiago Creek in Irvine, CA. Blue Diamond has been at this location for 12 years and expects to be in production there for a minimum of 8 more. The plant produces 1-1/2" aggregate, 3/8" pea gravel, and washed concrete sand. Additionally, the plant produces 3/4", 1/2", and 3/8" crushed rock as well as some boulders of up to three foot diameter. The plant has an annual output of approximately one million tons and is located 28 miles from the Santa Ana River at both Prado Dam and its juncture with Pacific Coast Highway.

FOSTER SAND AND GRAVEL

8-04 Foster Sand and Gravel is located along Temescal Wash near Corona, California, and consists of an alluvial sand deposit. Foster has been at this location since 1972 and expects to be in production there for a minimum of 25 more years. The plant produces chiefly sand for fine aggregate although about 15 percent of its output consists of 1 inch aggregate and 3/8 inch pea gravel. The plant has an annual output of approximately one million tons and is located 15 miles from the Santa Ana River at Prado Dam and 45 miles from the river at Pacific Coast Highway. Located in the immediate vicinity of Foster are several other producers of sand for use in concrete including R.J. Noble, Chandler, Concrete Products Inc., and C.L. Pharris.

OWL ROCK

8-05 The Owl Rock Plant in Rialto has been located along Lytle Creek since 1955 and expects to be in production there for a minimum of 80 more years. The site consists of an alluvial deposit and produces 1-1/2 inch and 1 inch aggregate, 3/8 inch pea gravel, and washed concrete sand. The plant has an annual output of almost two million tons and is located 30 miles from the Santa Ana River at Prado Dam and 60 miles from the river at Pacific Coast Highway. While this source is not located in the immediate vicinity of the project area it is included here because it supplies aggregate to many ready mix firms which are in the project area.

TRANSIT MIXED CONCRETE

8-06 Transit Mixed Concrete mines a deposit along the San Gabriel River in Azusa, CA which is alluvial in nature. Transit Mixed has been at this location for over 40 years and expects to be in production there for a minimum of 15 more years. The plant produces 1-1/2 inch and 1 inch aggregate, 3/8 inch pea gravel, and washed concrete sand and has an annual output of over three million tons. It is located 25 miles from the Santa Ana River at Prado Dam and approximately 45 miles from the river at Pacific Coast Highway. Located in the immediate vicinity of Transit Mixed are several other aggregate producers including Blue Diamond Materials and Cal Mat.

Cementitious Materials

CEMENT SOURCES

8-07 There are a relatively wide variety of cement producers in and near the Los Angeles Basin which are capable of supplying cement certified by the Corps of Engineers ongoing cement certification program. Among these plants are the California Portland Cement Company plant at Colton, the Kaiser Cement Company plant at Lucerne Valley, the

Southwestern Cement Company plant at Victorville, and the Riverside Cement Company plant at Riverside. All of these plants are in the state of Califorina. The following paragraphs summarize the types of cements which these plants produce. Table L supplies prices of various cements from the sources specified, and Table M contains cost data on the shipping of cement.

8-08 The California Portland Cement Company plant at Colton, located approximately 25 miles north of Prado Dam and 55 miles north of the Santa Ana River's juncture with the Pacific Coast Highway, produces Type II and III cements conforming to the requirements of ASTM C-150.

8-09 The Kaiser Cement Company plant in the Lucerne Valley, located approximately 89 miles north of Prado Dam and 119 miles north of the Santa Ana River's juncture with the Pacific Coast Highway, produces Type II cement conforming to the requirements of ASTM C-150. This plant also produces a blended cement conforming to the requirements of ASTM C-595, Type IP.

8-10 The Riverside Cement Company plant at Riverside, California, located approximately 17 miles west of Prado Dam and 47 miles northeast of the Santa Ana River's juncture with the Pacific Coast Highway, produces Type II cement conforming to the requirements of ASTM C-150.

8-11 The Southwest Cement Company plant at Victorville, California, located approximately 66 miles north of Prado Dam and 96 miles north of the Santa Ana River's juncture with the Pacific Coast Highway, produces Type II and V cements conforming to the requirements of ASTM C-150.

Table L. Cement Prices in Dollars Per Ton.
(FOB Plant, December 1987)

Cement Plant and Location	Cement Type IP	II	III	V
California Portland, Colton	-	73.00	78.00	-
Kaiser, Lucerne Valley	74.30	60.00	-	-
Southwestern, Victorville	-	64.00	-	80.30
Riverside Cement, Riverside	-	63.00	-	-

Table M. Cement Shipping Prices in Dollars Per Ton. (December 1987)

Distance (Miles)	Cost	Distance (Miles)	Cost	Distance (Miles)	Cost
3-5	3.142	30-35	4.480	70-80	7.828
5-10	3.296	35-40	5.200	80-90	8.446
10-15	3.450	40-45	5.922	90-100	9.012
15-20	3.760	45-50	6.386	100-110	9.682
20-25	3.966	50-60	6.902	110-120	10.300
25-30	4.224	60-70	7.314	120-130	11.072

POZZOLAN SOURCE

8-12 ETL 1110-1-127, dated 17 August 1984 requires the Federal Government to allow the use of flyash in concrete construction except in those cases where it's use can be proven to be undesirable. The local practice of the ready-mix concrete industry is to use flyashes as pozzolanic admixtures in concrete. The reasons for this is the reduction of heat of hydration, reduction in cost due to the price of flyashes in comparison to the price of cement, increased workability at lower water contents, and the reduction in the alkali-aggregate reaction. The practice of local agencies is to specify Type F flyash generally conforming to the requirements of ASTM C-618. The Corps of Engineers has recently started a program to evaluate the quality and uniformity of flyashes and has set up a certification plan, for flyashes, similar to the one used for cements. Materials conforming to these requirements are produced at the plants shown on plate 39.

8-13 The closest local producer, the Western Ash Company, supplies flyash, conforming to the requirements of ASTM C-618, Type F, from a plant at Page, Arizona, approximately 555 miles northeast of Prado Dam and 585 miles northwest of the juncture of the Santa Ana River and Pacific Coast Highway.

Admixtures

8-14 A wide variety of admixtures are regularly used by ready-mix concrete suppliers in southern California. These include all of the following: air entraining agents, accelerators, retarders, water reducers and high range water reducers. The relatively common methods anticipated for construction of the strutures described above should not require any specialty admixtures other than those recommended in the section: Recommendations.

Water

8-15 Water of sufficient quantity and suitable quality for the production of concrete will be available from local municipal water systems.

Curing Compounds

8-16 A wide variety of curing compounds are available for use from the aggregate suppliers to the local ready-mix concrete industry. Curing compounds will be specified in accordance with project requirements and ASTM C-309.

Transit Mixed Concrete

8-17 Commercial ready mixed concrete plants are located within competitive hauling distances of all sections of the Santa Ana River downstream of Prado Dam. As of December, 1987 the approximate cost of a cubic yard of concrete in the project area is $60.

Recommendations

AGGREGATES

8-18 Aggregates suitable for the production of concrete are produced at the sources previously discussed. These sources are capable of supplying sufficient amounts of aggregates to meet the needs of this project. All aggregates used shall conform to the requirements of ASTM C 33. Coarse aggregate gradations should be 1-1/2 x 3/4, 1 x No. 4 as described in CALTRANS specifications, or should be size No. 467, No. 57, or No. 67 as described in ASTM C 33, as required by the design/engineer. All aggregate used shall conform to the requirements of ACI 350 and ASTM C 33 with the following limitations.

a. Soft particles: 2.0 percent.

b. Chert as a soft impurity (defined in Table 3 of ASTM C 33): 1.0 percent.

c. Total of soft particles and chert as a soft impurity: 2.0 percent.

d. Flat and elongated particles (long dimension more than 5 times short dimension): 15 percent.

e. Maximum aggregate size shall not exceed 1-1/2 inches, except where structural or other considerations require a difference.

CEMENTS

8-19 The following cements and requirements will be specified.

a. Cement would be Type II, low alkali (0.6 percent maximum), conforming to the requirements of ASTM C-150.

b. Blended cements would conform to the requirements of ASTM C-595, Type IP.

c. For applications in which high early strengths would be desired due to construction scheduling, ASTM C-150, Type III cement would be acceptable.

POZZOLANS

8-20 The only pozzolanic materials generally in use locally are type F flyashes conforming to the requirements of ASTM C-618. Specifications will call for flyashes conforming to the requirements of ASTM C-618, Type F, with the loss in ignition limited to 6 percent.

ADMIXTURES

8-21 Construction of the structures described above involve relatively simple construction procedures. The necessity for sophisticated admixtures is not anticipated. However, calcium chloride wil not be permitted to be added for reinforced concrete because of the deleterious effect it may create by accelerating the corrosion of the reinforcing steel and concrete (ACI 201). The following types of admixtures will be specified in all construction.

Air Entraining Admixtures

8-22 If air-entrained admixtures are used, they would conform to the requirements of ASTM C-260.

Accelerating Admixtures

8-23 Accelerating admixtures will conform to the requirements of ASTM C-494, Type C, except that no calcium chloride will be allowed in reinforced concrete.

Retarding Admixtures

8-24 Retarding admixtures will conform to the requirements of ASTM C-494, Type B or D.

Water Reducing Admixtures

8-25 Water reducing admixtures will conform to the requirements of ASTM C-494, Type A or D.

MIX PROPORTIONING

8-26 All materials used should be so proportioned as to produce a well graded mixture of high density and maximum workability, with a specified 28-day compressive strength of 3500 psi (ACI 350), except where special structural or other considerations require concrete of greater strength. The water-cement ratio should be limited to .45 maximum (ACI 211), thus producing a very dense and low permeable concrete. Slump in the range of 1 to 3 inches is recommended for workability.

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A GEOTECHNICAL

TABLES

TABLE 1

LOWER SANTA ANA RIVER: WEIR CANYON ROAD TO PACIFIC OCEAN

REACH STATION FROM	TO	LANDMARK (STATION)	****** EXISTING CHANNEL CONDITIONS ****** ORANGE COUNTY DRAWING NUMBER	CHANNEL BASE WIDTH (ft.)	LEVEE BERM WIDTH (ft.)	LEVEE HEIGHT (ft.)	INSIDE SIDE SLOPE (H:1V)	OUTSIDE SIDE SLOPE (H:1V)	HEIGHT OF UNPRTECTD TOP OF LEVEE (ft.)	SLOPE PROTEC-TION	TYPE AND DEPTH OF TOE PROT-ECTION
REACH 1											
1220+00	1207+63		E01-701-8	varies		12-22					
1207+63	1204+75		E01-701-8 & E01-101-26	varies	30	13-22	2	2	1	4' facing stone w/ 8" filter	11' facing stn + 3' drrck stn
1204+75	1198+08	WEIR CYN. RD. (1202+00) M.W.D. OUTLET (1200+50)	E01-701-8 & E01-101-4-A& E01-101-26	340-320	20,30	13-21	2	2	1,2	2-4' facing stone w/ 6-8" filter	6-11' fcg stn + 3' drrck stn
1198+08	1197+60	DROP STRUCTURE (1198+07)		320	20	22-14			0	8" R.C.	conc invert
1197+60	1196+07		E01-701-8 & E01-101-4-A	315	20	18.2-22			2	18-36" grtd fcg stone w/ 6" filter	
1196+07	1174+00			varies	20	18-18.5			2	18" fcg stn w/ 6" fltr	6' facing stone + 3' derrick stone
1174+00	1148+50		E01-701-8 &	290	20,21	17.5-18			0,2		
1148+50	1129+50		E01-501-1-A&	290-295	20,21	14.5-17.5					11-13' fcg stn + 3' drrck stn
1129+50	1128+70	STABILIZER (1129+40)	E01-101-4-A		20,21	14.5,15.5				24,18" facing stone w/ 6in filter	grtd stone invert
1128+70	1110+00			295	20,21	14.5-17					11-13' fcg stn + 3' drrck stn
1110+00	1074+70		E01-501-1-A& E01-101-4-A	300	20,21	12-14			0,2		6' facing stone + 3' derrick stone
1074+70	1056+00	IMPERIAL HWY. (1057+50)	E01-501-1-A	300	21	12	2	2	0	24" fcg stn w/ 6" fltr	

TABLE 1 (cont.)

REACH STATION FROM	TO	LANDMARK (STATION)	ORANGE COUNTY DRAWING NUMBER	CHANNEL BASE WIDTH (ft.)	LEVEE BERM WIDTH (ft.)	LEVEE HEIGHT (ft.)	INSIDE SIDE SLOPE (H:1V)	OUTSIDE SIDE SLOPE (H:1V)	HEIGHT OF UNPRTECTD TOP OF LEVEE (ft.)	SLOPE PROTEC-TION	TYPE AND DEPTH OF TOE PROT-ECTION
			****** EXISTING CHANNEL CONDITIONS ******								
REACH 2 - UPPER											
1056+00	1049+92		E01-101-10-A	300	21,24	15.2	2		1	24" facing stone w/ 6,16" fltr	6' facing stone + 3' derrick stone
1049+92	1032+20			300-320	21,24	13.7-15.2		2	1		
1032+20	1022+98			320	24	13.0-13.7		0,2	1	24" facing stone w/ 16" filter	
1022+98	1022+58	DROP STRUCTURE (1022+98)			24	17.9-13.0			0		
1022+58	976+30		E01-101-10-A		24 min	14.1-17.9			1		
976+30	970+00	LAKEVIEW AVE. (975+50) DROP STRUCTURE (970+00)	E01-101-9-A		21 min	13.5-14.1			1		
970+00	969+60					18.5-13.5			0		
969+60	907+00	RIVERSIDE FWY. (918+50) TUSTIN AVE. (910+50) DROP STRUCTURE (907+00)				13.5-18.5		0,2	1	18" facing stone w/ 6" filter	
907+00	906+63					19.4-13.5		2	0		
906+63	902+00		E01-101-9-A			16.4-19.4			1		
902+00	884+00	S.P.R.R. (890+00)				14.7-16.4			1		
REACH 2 - LOWER											
884+00	883+59	DROP STRUCTURE (884+00)	E01-101-9-A & E01-101-12-A			18.7-14.7			3 in	24" fcg stn w/ 16" fltr & 18" fcg stn w/ 6" fltr	
883+59	859+00				21 min	16.7-18.7		2	1		
859+00	841+71	GLASSEL ST. (858+00)	E01-101-5-A& E01-101-12-A		20 min	15.3-17		0,2	1		
841+71	836+50	CARBON CYN. DIV. CH. (841+00)	E01-101-6-A & E01-101-5-A			14.9-15.3			1		
836+50	836+03	DROP STRUCTURE (836+50)				23.9-14.9			0		
836+03	803+50	LINCOLN AVE (813+50)				14.9-23.9			1 - 5		
803+50	803+03	DROP STRUCTURE (803+50)				23.8-14.9			0	18" facing stone w/ 6" filter	
803+03	737+50	BALL RD. (742+00)			20 min	15.1-25			1 min		
737+50	737+03	DROP STRUCTURE (737+50)	E01-101-6-A & E01-101-5-A		21 min	24-15.1			0		
737+03	703+14	S.P.R.R. (725+50)			21 min	15.3-24		0,2	1 - 10		6' facing stone + 3' derrick stone
703+14	702+14		E01-101-6-A	320	21 min	16.7-15.3	2	2	1		
702+14	701+94		E01-101-3-A	240-250	26	15	1.5 - 2			8" reinf. concrete	9' reinf. concrete + 3' derrick stone
701+94	701+20			250	26	15	1.5				
701+20	698+92	KATELLA AVE. (701+00)		250	26	16					

TABLE 1 (cont.)

REACH STATION FROM	REACH STATION TO	LANDMARK (STATION)	ORANGE COUNTY DRAWING NUMBER	CHANNEL BASE WIDTH (ft.)	LEVEE BERM WIDTH (ft.)	LEVEE HEIGHT (ft.)	INSIDE SIDE SLOPE (H:1V)	OUTSIDE SIDE SLOPE (H:1V)	HEIGHT OF UNPRTECTD TOP OF LEVEE (ft.)	SLOPE PROTEC-TION	TYPE AND DEPTH OF TOE PROT-ECTION
			****** EXISTING CHANNEL CONDITIONS ******								
REACH 3											
698+92	697+83			250	26	13-16	1.5				
697+83	697+08		E01-101-3-A	250	26	13	2 - 1.5	2	1	8" reinf. concrete	9' reinf. concrete + 3' derrick stone
697+08	682+00	CHANNEL (693+48) A.T.& S.F.R.R. (685+50)	E01-101-22	250-260	20 min	12-13.4	2	0	0		
682+00	681+48	DROP STRUCTURE (682+00)	E01-101-22	260	20 min	20.5-12			0		
681+48	679+00		E01-101-3-A	260	20 min	15-20.5			0		
679+00	664+75	ORANGE FWY. (675+00)		260	15 min	13			1		
664+75	662+75			260-270	15 min	13			1		
662+75	659+50	ORANGEWOOD AVE. (661+00)		270	15 min	13			1		
659+50	657+50		E01-101-3-A	270-260	15 min	13		0	1	18" facing stone w/ 6-8" filter	6' facing stone + 3' derrick stone
657+00	656+00		E01-101-22	210	20 min	12.5-12		2	0		
656+00	637+50			210-240	20 min.	12.5	2		0		
637+50	637+00			240-260	20 min	12.5	3 - 2		0		
637+00	636+43	DROP SRUCTURE (637+00)		260	20 min	20-12.5	3		0		
636+43	628+95	CHAPMAN AVE. (630+80)	E01-101-22	260-210	20 min	15.2-20		2	1 - 0		
628+95	622+06		E01-101-3-A	260	15 min	13		0	1		
622+06	617+50	BITTERBUSH CANAL (621+00) SANTA ANA FWY. (617+50)	E01-701-2A		20 min	12	3	2	4		4' facing stone
617+50	593+35	S.P.R.R. (616+50) GARDEN GROVE FWY. (595+00)	E01-101-22		20 min.	12.5	2,3	0	0		6' facing stone + 3' derrick stone
593+35	592+84	DROP STRUCTURE (593+35)			20 min	19.6-12.5	2	0	0		
592+84	590+63		E01-101-22		20 min	15.6-19.6	2	0	0		
590+63	557+25	Golf Course GARDEN GROVE BLVD. (575+00) STABILIZER (574+00) SANTIAGO CK. CONFL. (558+50)			20	12	3	2	12	none	none
REACH 4											
557+25	551+00		E08-701-1 & E01-701-2-A		20	12.5-13	3	2	2 - 4	18" rock	4' rock
551+00	526+00		E08-701-1	260	20	13-12.5	w. side: natural, e. side: 3	w side: natural e side: 2	e. side: 2 - 4	w. side: none, e. side: 18" rock	w. side: none, e. side 4' rock
[illegible]	522+00		[illegible]	250-220	19	13.4	2	0	3.7-0	4-8" reinf. [illegible]	8' reinforced [illegible]

TABLE 1 (cont.)

REACH STATION FROM	TO	LANDMARK (STATION)	ORANGE COUNTY DRAWING NUMBER	CHANNEL BASE WIDTH (ft.)	LEVEE BERM WIDTH (ft.)	LEVEE HEIGHT (ft.)	INSIDE SIDE SLOPE (H:1V)	OUTSIDE SIDE SLOPE (H:1V)	HEIGHT OF UNPRTECTD TOP OF LEVEE (ft.)	SLOPE PROTEC-TION	TYPE AND DEPTH OF TOE PROT-ECTION
			****** EXISTING CHANNEL CONDITIONS ******								
REACH 5 - UPPER											
509+00	425+00	FAIRVIEW ST. (501+00) STABILIZER (498+00) S.P.R.R. (481+00) STABILIZER (474+00) FIFTH ST. (466+00) BOLSA AVE. (452+00) STABILIZER (448+50)	E01-101-18 E01-101-18	220	20 min.	13.4		2	3.7		8' reinforced concrete
425+00	398+00	MCFADDEN AVE. (421+50) STABILIZER (419+00)	E01-101-18 & E01-101-13-A	220		13.4					
398+00	393+00			220-180		14.5-13.4				4-8" reinf. conc. on 3" a.c.	8' reinforced concrete
393+00	356+64	EDINGER AVE. (385+00) STABILIZER (382+50)		180		14.5					
356+64	354+60			180		15-14.5			3.7		
354+60	261+00	HARBOR BLVD. (342+00) WARNER AVE (334+00) STABILIZER (329+30) SLATER AVE (311+00) TALBERT AVE (282+00) STABILIZER (275+00)		180		15	2		0 - 3.7		6-8' reinforced concrete
REACH 5 - LOWER											
261+00	260+00		E01-101-18 & E01-101-13-A	180-190		17-15	1.5 - 2		3.7-1		
260+00	235+00	SAN DIEGO FWY. (254+32)	E01-101-15-A	190		17	1.5		1	6" reinforced concrete	4' concrete + 7' rip-rap
235+00	219+00			190					1		
219+00	215+00		E01-101-15-A	190	20 min.				1		
215+00	214+00		E01-101-19-A	190-230	20				0		
214+00	170+54		E01-101-19-A	230	20						
170+54	158+10	ADAMS AVE. (163+71)	E01-701-7	230	20			2			
158+10	153+00		E01-101-19-A	230	20,25			1.75,2			
153+00	133+71	FAIRVIEW CHANNEL (143+00)	E01-101-19-A	230	20,25	17	1.5	1.75,2	0	6" reinforced concrete	4' concrete + 7' rip-rap

TABLE 1 (cont.)

REACH STATION FROM	TO	LANDMARK (STATION)	ORANGE COUNTY DRAWING NUMBER	CHANNEL BASE WIDTH (ft.)	LEVEE BERM WIDTH (ft.)	LEVEE HEIGHT (ft.)	INSIDE SIDE SLOPE (H:1V)	OUTSIDE SIDE SLOPE (H:1V)	HEIGHT OF UNPRTECTD TOP OF LEVEE (ft.)	SLOPE PROTEC-TION	TYPE AND DEPTH OF TOE PROT-ECTION
			****** EXISTING CHANNEL CONDITIONS ******								
REACH 6											
133+71	132+71		E01-101-21	230	20,25	18-17	1.5	1.75,2	0	6" reinforced concrete	4' concrete + 7' rip-rap
132+71	91+40			230		18					
91+40	88+40			230-220							
REACH 7											
88+40	43+00	HAMILTON AVE. (82+16)		220	20,25						4' + 3' rip-rap
43+00	41+00			220-195	20-45						
41+00	30+00			195	45-25						
30+00	23+18			195	25	18	1.5			6" reinforced concrete	concreted stone invert
23+18	20+00		E01-101-21	195-160	25-20	16-18	2 - 1.5	1.75,2			
20+00	14+50		E01-701-1-A	160-180	20	18-16	0 - 2	2		8-18" R.C.	
14+50	9+35	PACIFIC COAST HWY. (9+47)		180-176	20-25	16-18	0	1,2		10-18" R.C.	concrete invert
9+35	7+00			176-204	12-0	16	2 - 0	1.5,1		4-6' rock & 8-18" R.C.	
7+00	00+00		E01-701-1-A	204-316	12-0	16	2,1.5	1.75,1	0	4-6' rock	6-7.5' stn

Table 2. Lower Santa Ana River.

Major Significant Faults

Fault	Fault Length (mi)	Min. Dist. to Site (mi)	Epicenter Magnitude MCE[a]	MPE[b]	Max. Rock[c] Accel. (g) MCE	MPE
San Andreas	630	32	8.5	8.25	0.25	0.25
Newport-Inglewood	35+	0	7.0	6.0	0.70	0.60
Whittier-Elsinore	145	1	7.5	6.5	0.73	0.65
San Jacinto	145	27	7.5	7.2	0.20	0.18
Sierra Madre	60+	18	7.0	6.0	0.25	0.15
Palos Verdes	40	11	7.0	5.5	0.35	0.15

a. MCE: Maximum Credible Earthquake, from Leeds (1979).
b. MPE: Maximum Probable Earthquake, from Leeds (1979).
c. Data in columns from Schnabel and Seed (1973) and Greensfelder (1974).

Table 3. Lower Santa Ana River.

Significant Earthquakes (Richter Magnitude 6+) Since 1900[a]

Date	Probable Causative Fault	Richter Magnitude	Min. Dist. to site (mi)
9/20/1907	San Andreas (?)	6.0	42
5/15/1910	Elsinore (?)	6.0	21
10/23/1916	?	6.0	96
4/21/1918	San Jacinto	6.8	41
7/23/1923	San Jacinto	6.3	33
3/11/1933	Newport-Inglewood	6.3	1
3/25/1937	San Jacinto	6.0	90
12/4/1948	Mission Creek	6.5	77
2/9/1971	San Fernando (Sierra Madre)	6.4	51

a. From Yerkes (1985) and Real and others (1978).

Table 4. Lower Santa Ana River.

Channel Foundation Investigation Reports

Title	Prepared By	Date	Location Symbol	Station reach
Geotechnical Evaluation of Proposed Improvements of Santa Ana River Channel	Woodward-Clyde Consultants	1/6/78	WC78	20-133
Geotechnical Investigation Santa Ana River Channel Improvements	Woodward-Clyde Consultants	1/17/77	WC77	50-190
Dike Stability Investigation Santa Ana River	Woodward-McNeill & Associates	6/15/73	WM73	220-470
Soils Investigation, Santa Ana Interceptor Sewer	Geolabs-California, Inc.	7/27/71	GC71	225-702
Soil Investigation, Santa Ana River Drop Structures	Moore & Taber	5/31/78	MT78	558-701
Santa Ana River Study	Moore & Taber	3/19/64	MT64	605-1053
Foundation Investigation, Santa Ana River Structures	Moore & Taber	4/3/68	MT68	638-686
Foundation Investigation, Santa Ana River Levee	W.A. Wahler & Associates	7/24/69	WA69	708-854
Buttress Stabilization of Burris Sand Pit	Foundation Engineering Co., Inc.	4/15/75	FE75	730-820
Stability Investigation, Santa Ana River Levee	Moore & Taber	5/13/66	MT66	737-796
Preliminary Site Evaluation, Santa Ana River Spreading Basin Development	Woodward-McNeill & Associates	8/2/74	WM74	768-975
Soil Investigation, Santa Ana River Channel	Moore & Taber	10/29/70	MT70	846-1057
Soil Investigation, Santa Ana River Interceptor Sewer	Southern California Testing Laboratory	5/12/75	SCT75	910-1058

Table 4. (Continued)

Title	Prepared By	Date	Location Symbol	Station Reach
Soil Investigation, Santa Ana River Interceptor Sewer	Southern California Testing Laboratory	9/10/75	SC75	1112-1216
Geotechnical Investigation Santa Ana River Drop Structure Weir Canyon Road	Moore & Taber	3/12/80	MT80	1171-1196
Foundation Investigation & Analysis, Santa Ana River	Geolabs-California, Inc.	5/24/72	GC72	1171-1215

Table 5. Lower Santa Ana River.

Bridge Foundation Investigation Reports

Title	Prepared By	Date	Location Symbol	Station
Foundation Investigation, Hamilton-Victoria Bridge Across Santa Ana River	Orange County	3/31/76	OC76	82
Foundation Investigation, Adams Ave. Bridge Across Santa Ana River	Orange County	6/5/68	OC68	164
Foundation Investigation, Slater-Segestrom Bridge Across Santa Ana River	Orange County	12/9/71	OC71	311
Foundation Investigation McFadden Ave. Bridge Across Santa Ana River	Orange County	12/15/75	OC75	421
Foundation Investigation, Seventeenth Street Bridge Across Santa Ana River	Orange County	8/20/75	OC75	513
Soils Logs for Garden Grove Blvd. Bridge Across Santa Ana River	Orange County	10/71	OC71	575
Foundation Investigation Weir Canyon Rd. Bridge Across Santa Ana River	Moore & Taber	8/26/82	MT82	1202

TABLE 6

LOWER SANTA ANA RIVER SUMMARY OF EXPLORATIONS

STATION	LOG NUMBER	DEPTH (ft.)	EQUIPMNT	DATE	WATER DEPTH (ft.)	LOG PLATE	SAMPLES
REACH I							
1207+00R	0801	25.0	B.A.	10-31-84		8	F
1171+50R	0805	27.0	B.A.	10-26-84		8	L,F
1171+00L	0806	30.0	B.A.	11-19-84		8	L,F
1171+00C	0871	15.0	B.H.	11-19-84	5.0	8	I
1148+00R	0901	40.5	B.A.	11-19-84	18.0	9	L,F
1148+00L	0902	40.0	B.A.	11-16-84		9	L,F
1130+50R	0903	30.0	B.A.	10-29-84	15.0	9	L,F
1129+00L	0904	26.0	B.A.	11-14-84		9	L,F
1115+00R	0905	25.0	B.A.	11-20-84	18.0	9	L,F
1097+00R	0906	40.0	B.A.	10-31-84	16.5	9	L,F
1097+00L	0907	40.0	B.A.	11-14-84		9	L,F
1080+00R	1001	30.0	B.A.	11-01-84		10	L,F
1080+00L	1002	30.5	B.A.	11-13-84		10	L,F
1080+00C	1071	11.5	B.H.	11-19-84	4.5	10	I
1062+00C	1072	13.0	B.H.	11-20-84	5.0	10	I
1063+40R	1003	30.0	B.A.	10-29-84	16.0	10	L,F
1062+00L	1004	30.0	B.A.	11-13-84		10	L,F
REACH II UPPER							
1046+00C	1073	15.0	B.H.	11-20-84		10	I
1064+00R	1005	30.0	B.A.	11-12-84	17.5	10	L,F
1046+00L	1006	30.0	B.A.	11-12-84		10	L,F
1023+00R	1101	40.0	B.A.	10-30-84	21.0	11	L,F
1023+00L	1102	39.0	B.A.	11-12-84		11	L,F
1007+00C	1108	8.6	B.A.	11-15-84		11	I
1007+00R	1103	35.0	B.A.	11-02-84		11	L,F
1007+00L	1104	35.0	B.A.	11-09-84		11	L,F
985+00C	1109	7.0	B.A.	11-15-84		11	I
985+00R	1105	35.0	B.A.	11-15-84	18.0	11	L,F
985+00L	1106	35.0	B.A.	11-07-84		11	L,F
970+00L	1107	39.0	B.A.	11-09-84		11	L,F
960+00R	1201	30.0	B.A.	11-20-84		12	L,F
950+00R	1202	35.0	B.A.	11-05-84		12	L,F
950+00L	1203	35.0	B.A.	11-08-84		12	L,F
940+00L	1204	27.0	B.A.	11-08-84	22.0	12	L,F
930+00L	1206	34.0	B.A.	11-07-84		12	L,F
920+00R	1207	30.0	B.A.	11-23-84	22.5	12	L,F
910+00L	1208	35.0	B.A.	11-14-84	16.5	12	L,F
900+00R	1301	33.0	B.A.	11-08-84	17.4	13	L,F
895+00L	1302	35.0	B.A.	11-14-84	16.5	13	L,F
885+00R	1303	35.0	B.A.	11-08-84	20.0	13	L,F

BA=BUCKET AUGER BH=BACKHOE FA=FLIGHT AUGER

L=LEVEE F=FOUNDATION I=INVERT

TABLE 6 (Cont.)

LOWER SANTA ANA RIVER SUMMARY OF EXPLORATIONS

STATION	LOG NUMBER	DEPTH (ft.)	EQUIPMNT	DATE	WATER DEPTH (ft.)	LOG PLATE	SAMPLES
REACH II							
LOWER							
875+00R	1304	38.5	B.A.	11-09-83	19.5	13	L,F
875+00C	1309	21.0	B.A.	12-12-84	18.0	13	I
875+00L	1305	45.0	B.A.	11-16-83	17.0	13	L,F
865+00L	1306	35.0	B.A.	11-17-83	17.0	13	L,F
854+00C	1372	17.0	B.H.	11-23-84		13	I
854+00L	1307	24.0	B.A.	11-10-83	21.0	13	L,F
854+00R	1308	40.0	B.A.	11-17-83	21.0	13	L,F
840+00R	1401	35.0	B.A.	11-23-83		14	L,F
830+00L	1402	36.0	B.A.	12-19-84		14	L,F
820+00R	1403	40.0	B.A.	11-23-83		14	L,F
820+00L	1404	34.0	B.A.	11-19-83		14	L,F
810+00R	1405	31.0	B.A.	11-25-83		14	L,F
800+00L	1406	40.0	B.A.	11-21-83		14	L,F
789+00C	1472	15.0	B.H.	11-23-84		14	I
789+00R	1407	43.0	B.A.	11-28-83		14	L,F
789+00L	1408	40.0	B.A.	11-22-83	29.0	14	L,F
780+00L	1501	34.5	B.A.	11-30-84		15	L,F
771+00R	1502	40.0	B.A.	11-28-83	20.0	15	L,F
771+00L	1503	40.0	B.A.	11-29-84		15	L,F
760+00R	1504	35.0	B.A.	11-30-84		15	L,F
753+00C	1572	15.0	B.H.	11-27-84	3.5	15	I
753+00R	1505	40.0	B.A.	12-04-84		15	L,F
753+00L	1506	40.0	B.A.	11-06-84		15	L,F
740+00L	1507	30.0	B.A.	11-27-84		15	L,F
730+00L	1508	36.0	B.A.	11-27-84		15	L,F
719+00C	1573	12.5	B.H.	11-27-84		15	I
719+00R	1509	40.0	B.A.	11-05-84		15	L,F
719+00L	1510	40.0	B.A.	11-26-84		15	L,F
710+00L	1601	25.0	B.A.	12-04-84		16	L,F

BA=BUCKET AUGER BH=BACKHOE FA=FLIGHT AUGER

L=LEVEE F=FOUNDATION I=INVERT

TABLE 6 (Cont.)

LOWER SANTA ANA RIVER SUMMARY OF EXPLORATIONS

STATION	LOG NUMBER	DEPTH (ft.)	EQUIPMNT	DATE	WATER DEPTH (ft.)	LOG PLATE	SAMPLES
REACH III							
699+00C	1671	15.0	B.H.	11-29-84		16	I
699+00R	1602	18.0	B.A.	08-17-83		16	L
699+00L	1603	25.5	B.A.	08-17-83		16	L,F
690+00L	1604	26.0	B.A.	08-16-83	18.0	16	L,F
680+00L	1605	36.0	B.A.	08-12-83		16	L,F
665+00L	1606	30.0	B.A.	08-11-83	14.0	16	L,F
657+00R	1607	36.0	B.A.	12-11-84		16	L,F
657+00L	1608	30.0	B.A.	08-10-83		16	L,F
657+00C	1672	15.0	B.H.	11-26-84	1.0	16	I
644+00L	1701	30.0	B.A.	08-10-83		17	L,F
636+00L	1702	40.0	B.A.	08-08-83	21.0	17	L,F
622+00L	1703	31.0	B.A.	08-08-83	19.0	17	L,F
615+50R	1704	30.0	B.A.	08-11-83	29.5	17	L,F
615+00C	1771	15.0	B.H.	11-29-84		17	I
614+00L	1705	30.0	B.A.	08-05-83		17	L,F
601+50L	1706	27.0	B.A.	08-04-83	24.0	17	L,F
590+00L	1707	35.0	B.A.	08-04-83	12.0	17	L,F
574+00L	1801	23.0	B.A.	08-03-83		18	F
572+00R	1802	31.5	B.A.	08-01-83	27.0	18	L,F
561+00R	1803	30.0	B.A.	08-01-83		18	L,F
561+00L	1804	20.0	B.A.	08-02-83	16.0	18	L,F
559+00L	TH79-1 S	30.0	B.A.	10-01-79	27.5	18	F
553+00R	1807	30.0	B.A.	07-29-83	24.0	18	L,F
548+50L	1805	27.5	B.A.	08-02-83	20.0	18	F
540+00R	1806	30.0	B.A.	07-28-83	26.0	18	L,F
535+00L	1811	26.0	B.A.	08-02-83		18	F
531+00R	1808	30.0	B.A.	07-28-83		18	L,F

BA=BUCKET AUGER BH=BACKHOE FA=FLIGHT AUGER

L=LEVEE F=FOUNDATION I=INVERT

TABLE 6 (Cont.)

LOWER SANTA ANA RIVER SUMMARY OF EXPLORATIONS

STATION	LOG NUMBER	DEPTH (ft.)	EQUIPMNT	DATE	WATER DEPTH (ft.)	LOG PLATE	SAMPLES
REACH IV							
524+50R	1809	30.0	B.A.	07-28-83		18	L,F
522+50L	1810	29.0	B.A.	07-27-83		18	L,F
518+00C	TT79-22	10.0	B.H.	07-13-79		19	I
518+00C	1981	5.0	B.H.	11-26-84		19	I
REACH V						19	
UPPER						19	
508+80L	1902	30.0	B.A.	07-26-83	17.5	19	L,F
497+00C	TT79-21	1.0	B.H.	07-13-79		19	I
495+00L	1903	31.0	B.A.	07-26-83	17.0	19	L,F
485+00L	1904	29.0	B.A.	07-22-83	23.0	19	L,F
477+50C	TT79-20	1.0	B.H.	07-13-79		19	I
477+00C	1982	10.0	B.H.	12-04-84		19	I
474+00L	1906	31.5	B.A.	07-22-83	28.5	19	L,F
474+00R	1905	30.0	B.A.	12-14-84		19	L,F
468+00L	1907	31.5	B.A.	07-20-83	24.0	19	L,F
460+00L	1908	31.5	B.A.	07-19-83		19	L,F
458+00C	TT79-19	1.0	B.H.	07-12-79		19	I
449+00L	2001	31.5	B.A.	07-18-83		20	L,F
440+00L	2002	31.5	B.A.	07-18-83	22.0	20	L,F
437+50C	TT79-18	1.0	B.H.	07-12-79		20	I
437+50C	2081	10.0	B.H.	12-04-84		20	I
430+00L	2003	29.0	B.A.	07-07-83		20	L,F
420+00R	2004	31.5	B.A.	07-19-83		20	L,F
419+00L	2005	28.0	B.A.	07-07-83		20	L,F
418+00C	TT79-17	1.0	B.H.	07-12-79		20	I
410+00L	2006	28.0	B.A.	07-06-83		20	L,F
400+00L	2007	30.0	B.A.	07-01-83		20	L,F
395+00C	TT79-16	2.5	B.H.	07-11-79		20	I
395+00C	2082	4.0	B.H.	12-14-84		20	I
390+00L	2008	34.0	B.A.	06-30-83		20	L,F
380+00L	2101	31.0	B.A.	06-24-83		21	L,F
375+50C	TT79-15	1.0	B.H.	07-11-79		21	I
370+00R	2102	26.5	B.A.	06-23-83		21	L,F
370+00L	2103	31.0	B.A.	06-27-83		21	L,F
360+00L	2104	31.0	B.A.	06-28-83		21	L,F
358+00C	TT79-14	2.0	B.H.	07-10-79		21	I

BA=BUCKET AUGER   BH=BACKHOE   FA=FLIGHT AUGER

L=LEVEE   F=FOUNDATION   I=INVERT

TABLE 6 (Cont.)

LOWER SANTA ANA RIVER SUMMARY OF EXPLORATIONS

STATION	LOG NUMBER	DEPTH (ft.)	EQUIPMNT	DATE	WATER DEPTH (ft.)	LOG PLATE	SAMPLES
REACH V							
LOWER							
350+00L	2105	31.0	B.A.	06-29-83		21	L,F
338+00L	2106	31.0	B.A.	06-29-83		21	L,F
337+50C	TT79-13	3.0	B.H.	07-10-79		21	I
330+00L	2107	30.0	B.A.	12-13-83		21	L,F
320+00R	2201	30.0	B.A.	12-22-83		22	L,F
320+00L	2202	30.0	B.A.	12-17-84		22	L,F
317+00C	TT79-12	3.5	B.H.	07-10-79		22	I
310+00L	2203	30.0	B.A.	12-14-84		22	L,F
300+00L	2204	31.5	B.A.	06-20-83		22	L,F
299+00C	TT79-11	4.0	B.H.	07-10-79		22	I
290+00L	2205	30.0	B.A.	06-16-83	20.0	22	L,F
280+00L	2206	30.0	B.A.	06-15-83	21.0	22	L,F
276+00C	TT79-10	4.0	B.H.	07-10-79		22	I
276+00C	2282	3.0	B.H.	12-11-84		22	I
270+00R	2207	28.5	B.A.	06-22-83		22	L,F
270+00L	2208	30.0	B.A.	06-15-83	20.0	22	L,F
260+00L	2209	31.0	B.A.	06-14-83		22	L,F
257+00C	TT79-9	10.0	B.H.	07-10-79		23	I
246+00R	2342	30.0	F.A.	03-23-83	16.5	23	L,F
238+00L	2301	21.0	B.A.	12-06-84		23	F
237+00C	TT79-8	10.0	B.H.	07-09-79		23	I
236+00R	2344	30.0	F.A.	03-23-83	19.0	23	L,F
227+50L	2303	9.5	B.A.	03-10-83	6.5	23	F
226+00R	2346	30.0	F.A.	03-22-83	15.0	23	L,F
222+00L	2305	10.5	B.A.	03-10-83	7.5	23	F
217+00L	2307	29.0	B.A.	03-07-83	23.0	23	L,F
216+00C	TT79-7	10.0	B.H.	07-09-79		23	I
216+00R	2348	30.0	F.A.	03-22-83	14.0	23	L,F
211+00L	2309	11.5	B.A.	03-07-83	6.5	23	F
206+00R	2340	30.0	F.A.	03-22-83	19.0	23	L,F
200+00L	2311	27.0	B.A.	02-28-83	24.0	23	L,F
199+00C	TT79-6	10.0	B.H.	07-09-79		23	I
196+00R	2332	30.0	F.A.	03-18-83		23	L,F
190+00L	2401	29.0	B.A.	02-28-83	23.0	24	L,F
185+00R	2432	30.0	F.A.	03-16-83	18.0	24	L,F
182+30L	2403	10.0	B.A.	03-07-83	5.5	24	F
179+78L	2404	30.0	B.A.	02-25-83		24	L,F
177+50C	TT79-5	10.0	B.H.	07-06-79		24	I
175+00R	2435	30.0	F.A.	03-16-83		24	L,F
170+00L	2406	26.0	B.A.	02-25-83	22.5	24	L,F
157+00L	2407	21.0	B.A.	03-08-83		24	L,F
152+00R	2438	30.0	F.A.	03-16-83	19.5	24	L,F
147+00L	2409	23.5	B.A.	03-08-83	18.5	24	L,F

BA=BUCKET AUGER BH=BACKHOE FA=FLIGHT AUGER

L=LEVEE F=FOUNDATION I=INVERT

TABLE 6 (Cont.)

LOWER SANTA ANA RIVER SUMMARY OF EXPLORATIONS

STATION	LOG NUMBER	DEPTH (ft.)	EQUIPMNT	DATE	WATER DEPTH (ft.)	LOG PLATE	SAMPLES
REACH VI							
142+50R	2440	45.0	F.A.	03-23-83	19.0	24	L,F
140+00C	TT79-4	10.0	B.H.	07-06-79		24	I
138+50R	2433	45.0	F.A.	03-25-83	16.5	24	L,F
130+00L	2531	45.0	F.A.	03-31-83	25.0	25	L,F
125+00L	2532	35.0	F.A.	03-31-83	13.0	25	F
120+00R	2533	45.0	F.A.	03-25-83	18.0	25	L,F
117+50C	TT79-3	10.0	B.H.	07-06-79		25	I
117+50C	TT79-2	4.0	B.H.	07-05-79		25	I
115+00L	2534	35.0	F.A.	04-01-83	15.0	25	F
111+00L	2535	45.0	F.A.	03-10-83	21.0	25	L,F
110+00R	2536	45.0	F.A.	03-25-83	22.0	25	L,F
105+00L	2537	44.0	F.A.	03-30-83	26.0	25	L,F
100+00R	2538	45.0	F.A.	03-28-83	28.0	25	L,F
98+00C	2581	10.0	B.H.	12-11-84		25	I
98+00C	TT79-1	10.0	B.H.	07-05-79		25	I
95+00L	2539	35.0	F.A.	04-01-83	15.0	25	F
90+50L	2541	40.5	F.A.	03-29-83	20.0	25	L,F
90+00R	2540	45.0	F.A.	03-28-83	25.0	25	L,F
86+00L	2542	35.0	F.A.	03-29-83	20.0	25	F
81+00L	TH79-10	40.5	F.A.	08-07-79	14.5	25	F
REACH VII							
76+72R	2543	50.0	F.A.	04-07-83	24.0	25	L,F
70+50L	2546	50.5	F.A.	04-08-83	11.0	25	F
67+50R	TH79-9	28.0	F.A.	08-02-79	20.0	25	F
67+50L	TH79-8	39.0	F.A.	08-02-79	9.0	25	F
60+00R	2638	45.0	F.A.	04-07-83	17.5	26	L,F
57+50L	TH79-7	39.0	F.A.	08-06-79	14.0	26	F
54+25L	2631	45.0	F.A.	04-12-83	11.0	26	L,F
50+00C	2681	10.0	B.H.	12-13-84		26	I
48+00R	2632	45.0	F.A.	04-06-83	17.0	26	L,F
47+00L	TH79-6	39.0	F.A.	08-07-79	13.0	26	F
38+50L	TH79-5	38.0	F.A.	08-02-79	20.0	26	L,F
37+25L	2633	45.0	F.A.	04-11-83	10.9	26	F
30+00R	2634	45.0	F.A.	04-04-83	20.0	26	L,F
27+50L	TH79-4	39.0	F.A.	08-06-79	18.5	26	F
17+50L	TH79-3	39.0	F.A.	08-08-79	10.6	26	F
17+00R	2635	45.0	F.A.	04-04-83	15.0	26	L,F
13+00R	TH79-2	39.5	F.A.	08-01-79	10.5	26	F
12+00L	2636	45.0	F.A.	04-11-83	10.0	26	F
10+00R	2637	45.0	F.A.	04-05-83	11.0	26	F
6+00L	TH79-1	39.0	F.A.	08-01-79	12.0	26	F

BA=BUCKET AUGER   BH=BACKHOE   FA=FLIGHT AUGER

L=LEVEE   F=FOUNDATION   I=INVERT

TABLE 7
LOWER SANTA ANA RIVER
SPD SOIL TEST RESULT SUMMARY

Station	Hole No.	Div. Serial No.	Report Date	Depth From	Depth To	Class	Mech. Analy. % finer sand #4	Mech. Analy. % finer fine #200	LL	PI	Densities Field dry PCF	Densities Field % Moist	Densities Compaction mth	Densities Compaction dry PCF	Densities max % Moist	% max den. test	Shear Strength samp	Shear Strength U.U. C tsf	Shear Strength U.D. 0 deg	Shear Strength U.D. C tsf	Shear Strength C.D. 0 deg	Shear Strength C.D. C tsf	Con-solidation Cc	Permeability ft/day
1207+00	801	91509	12-85	6.0	9.0	SM	86	24	23	3														
1207+00	"	91510	12-85	15.0	18.0	CL	96	67	41	17			Mo.	123.0	10.7	90	3-R		17	0.6	35	0.0		
1207+00	"	91511	12-85	24.0	25.0	SM	76	16		NP			Mo.	130.0	8.3	80	3-R		11	0.0	25	0.0		
1171+50	805	91512	12-85	3.0	9.0	SP	92	4		NP			Mo.	118.0	12.5	90	3-R		30	0.0	38	0.0		
1171+00	806	91513	12-85	21.0	24.0	SM	97	28		NP			Mo.	119.3	12.2	80	3-R		13	0.0	36	0.0		
1148+00	902	91043	12-85	33.0	37.0	CL	100	76	47	24	88.4	32.3					3-U		14	0.3	32	0.1		
1129+00	903	91514	12-85	3.0	6.0	SP	88	4		NP														
1129+00	"	91515	12-85	18.0	20.0	SP-SM	98	5		NP														
1129+00	"	91516	12-85	21.0	25.0	SP-SM	73	6		NP														
1080+00	1001	91517	12-85	12.0	15.0	SP	82	3		NP														
1080+00	"	91518	12-85	26.0	30.0	CL	86	56	42	20			Mo.	124.0	10.4	80	3-R		16	0.0	29	0.0		
1062+00	1004	91519	12-85	27.0	30.0	SW-SM	93	12		NP			Mo.	122.8	10.5	90	3-R		37	0.2	37	0.0		
1007+00	1103	91520	12-85	20.0	24.0	SP	92	4		NP														
1007+00	"	91521	12-85	27.0	30.0	SW	84	2		NP														
1007+00	"	91522	12-85	33.0	35.0	SP	95	7		NP														
0985+00	1106	91523	12-85	33.0	35.0	SC	85	28	34	12														
0950+00	1203	91524	12-85	21.0	24.0	SW-SM	68	6		NP														
0929+00	1206	91525	12-85	25.0	27.0	SC	93	37	28	10			Mo.	130.3	8.2	80	3-R		12	0.1	30	0.0		
0771+00	1503	91044	12-85	36.0	38.0	CL	100	82	34	19	117.3	10.8					1-U	3.2$						
0771+00	"	91045	12-85	38.0	40.0	CL	100	81	31	14	97.3	17												
0760+00	1504	91526	12-85	27.0	29.0	SM	99	21		NP														
0753+00	1506	91527	1-86	24.0	27.0	SM	99	28		NP			St.	117.2	12.0									2.1-15
0753+00	"	91528	12-85	40.0		CL	100	82	35	11			Mo.	114.8	11.5	80	3-R		14	0.3	33	0.0		
0740+00	1507	91529	12-85	24.0	27.0	CL	100	77	33	10			Mo.	123.5	11.5									
0719+00	1510	91046	12-85	15.0	18.0	CL-ML	100	23	21	4														
0719+00	"	91047	12-85	38.0	40.0	CL	100	80	33	18	114.4	16.6					1-U	0.7$						
0719+00	1509	91530	12-85	27.0	30.0	SM	97	22		NP			Mo.	119.4	9.3	90	3-R		25	1.8	36	0.0		
0710+00	1601	91531	1-86	21.0	22.0	SW-SM	97	7		NP			St.	113.2	12.4									15-180
0699+00	1602	91532	1-86	18.0	21.0	SP	99	3		NP			St.	107.1	15.3									25-150
0657+00	1607	91048	12-85	18.0		ML	100	58		NP	96.8	24.5					3-U		23	0.0	36	0.0		
0657+00	"	91049	12-85	30.0		CL	100	90	38	14	105.0	23												
0522+50	1811	91050	12-85	11.5		CL	100	86	36	15	100.9	21.3					1-U	1.0$						
0522+50	"	91051	12-85	15.0		CH	100	93	56	33	99.0	25.4											0.25	
0522+50	"	91052	12-85	20.0		CL	100	82	37	14	101.9	24												
0474+00	1905	91533	12-85	27.0	30.0	CL	100	79	30	9														
0310+00	2203	91534	1-86	27.0	30.0	ML	100	56	25	3			St.	111.5	13.5									.45-.6
0236+00	2301	82536	9-83	3.0	4.5	SP-SM	100	12		NP			St.	102.5	15.5									
0236+00	"	91053	12-85	10.0		SM	100	23		NP	92.1	26.3					3-U		28	1.0	35	0.0		
0236+00	"	91054	12-85	15.0		CL	100	75	43	26	91.5	28.3					1-U	0.4$						
0236+00	"	91055	12-85	20.0		CL	100	78	37	19	92.3	29.1											0.26	
0222+00	2305	82537	9-83	6.5	8.5	SP-SM	100	10		NP			St.	101.5	17.7									
0217+00	2307	82538	9-83	9.0	11.0	SM	99	32	19	1			St.	115.6	12.0	90	3-R		25	1.0	34	0.0		
0217+00	"	82539	9-83	14.0	16.0	SM	97	21	20	2			St.	119.4	11.0	90	3-R		27	1.2	32	0.0		
0217+00	"	82540	9-83	20.0	21.0	SM	99	22		NP			St.	115.0	11.7									
0217+00	"	82541	9-83	27.0	28.0	ML	100	56		NP			St.	101.5	18.2									
0200+00	2311	82542	9-83	4.0	6.5	SM	97	14		NP			St.	118.3	11.3									
0200+00	"	82543	9-83	6.5	9.5	SM	98	36		NP			St.	115.7	13.0									
0200+00	"	82544	9-83	20.0	22.5	SM	100	43		NP			St.	110.3	14.3									

TABLE 7 (continued)
LOWER SANTA ANA RIVER
SPD SOIL TEST RESULT SUMMARY

Station	Hole No.	Div. Serial No.	Report Date	Depth From	Depth To	Class	Mech. Analy. % finer sand #4	Mech. Analy. % finer fine #200	LL	PI	Densities Field dry PCF	Densities Field % Moist	Densities Compaction mth	Densities Compaction dry PCF	Densities Compaction max % Moist	% max den. test	Shear Strength samp	Shear Strength U.U. C tsf	Shear Strength U.D. 0 deg	Shear Strength U.D. C tsf	Shear Strength C.D. 0 deg	Shear Strength C.D. C tsf	Con-solidatio Cc	Permeability ft/day
0190+00	2401	82545	9-83	0.0	3.0	SM	99	30	21	2			St.	118.5	10.7									
0190+00	"	82546	9-83	-	-	SM	100	33	20	2			St.	116.6	12.0	90	3-R		25	1.0	34	0.0		
0177+50	2405	82547	9-83	6.5	13.0	SM	100	23		NP			St.	108.0	14.5									
0157+00	2407	82548	9-83	3.0	4.5	SC-SM	99	49	25	7			St.	118.0	12.5									
0157+00	"	82549	9-83	5.0	7.5	SM	99	17	18	1			St.	114.7	11.3	90	3-R		27	1.2	32	0.0		
0157+00	"	82550	9-83	20.5	21.0	SW-SM	98	9		NP			St.	111.5	13.3									
0157+00	2408	82551	9-83	4.5	5.0	SM	98	28		NP			St.	109.6	13.5									
0147+00	2409	82552	9-83	20.0	21.0	CL	100	72	40	20			St.	108.0	18.0									
0130+00	2501	82825	9-83			CH	100	99	76	43	81.4	39.6												
0130+00	"	82826	9-83			ML	100	77	32	7	93.9	29.7												
0125+00	2502	82827	9-83			CH	100	99	80	45	78.7	42.9												
0125+00	"	82828	9-83			SM	100	29		NP	97.6	26.3												
0120+00	2533	82829	9-83	13.5	16.5	CH	100	99	73	40	82.1	37.1												
0120+00	"	82830	9-83	18.5	21.5	CH	100	100	91	54	80.7	40.1												
0120+00	"	82831	9-83	21.5	24.5	ML	100	89	41	14	86.4	35												
0120+00	"	82832	9-83	24.5	27.5	SM	100	14		NP	93.7	26.7												
0120+00	"	82833	9-83	29.0	31.5	SP-SM	100	11		NP	103.1	14.8												
0117+00	T-79-2	71825	1-80	6.0	7.0	SP-SM	97	7		NP			St.	108.1	0.3		3-R				41*	0.0		
0115+00	2534	91056	12-85	12.0		CH	100	92	69	43	78.5	39.3					3-U		16	0.2	28	0.0		
0115+00	"	91057	12-85	15.0		ML	100	99	33	2	91.1	31.7					3-U	2.0						
0115+00	"	91058	12-85	20.0		SM	100	30		NP	103.2	21.4												
0098+00	T-79-1	71824	1-80	7.0	10.0	CL	100	96	44	19			St.	103.3	20.0	95	3-R				29*	0.0		
0082+00	79-10	71832	1-80	16.0	-	ML	100	55		NP	92.9	30.4					2-U		29	1.2	32	0.0	0.14	0.015
0070+50	2546	91062	12-85	4.5		CL	100	87	49	24	84.3	32.7					1-U	0.6$						
0070+50	"	91063	12-85	12.0		SM	100	30		NP	90.1	19.8											0.11	
0067+00	79-8	71822	1-80	0.0	5.0	CL	100	77	35	13			St.	103.3	19.5	95	3-R				35*	0.0		
0067+00	79-8	71823	1-80	9.0	15.0	SM	100	44	23	2			St.	110.5	14.5	94	3-R				38*	0.0		
0067+00	79-9	71830	1-80	15.0	-	ML	100	51		NP	95.9	28.1					2-U		25	1.0	35	0.0	0.13	0.005
0067+00	"	71831	1-80	30.0	-	ML	100	95	33	6	93.4	30.2					1-U		29	1.2	32	0.0	0.14	0.015
0060+00	2638	82836	9-83			MH	100	98	63	30	78.9	38.5												
0060+00	"	82837	9-83			SM	100	42	29	2	86.7	33.5												
0048+00	2632	82834	9-83	17.0	19.5	CH	100	52	59	35	83.9	34.1					1-U	0.4						
0047+00	79-6	71828	1-80	0.0	4.0	ML	100	93	43	15			St.	99.3	20.8	95	3-R		21	0.4	34	0.0		
0047+00	"	71829	1-80	5.0	10.0	CH	100	98	53	25			St.	99.2	21.6	95	3-R		18	0.1	28	0.1		
0030+00	2634	82835	9-83	20.0		MH	100	97	61	29	71.1	49.7					2-U	0.4						
0017+00	79-3	71826	1-80	1.0	4.0	CL	100	71	46	21			St.	106.1	20.5	95	3-R		19	0.3	28	0.2		
0017+00	"	71827	1-80	6.0	9.0	SC	100	23	28	11			St.	113.7	13.8	94	3-R				37*	0.0		
0012+00	2636	91059	12-85	13.0		SP-SM	100	11		NP	97.3	23.8											0.06	
0012+00	"	91060	12-85	16.0		SP-SM	100	7		NP														

NOTES:
R - Remolded sample
U - Undisturbed sample
* - Direct shear test
$ - Unconfined Compression Test
T - Test trench
Permeabilities range from 80% to 95% of max. density

TABLE 8

LOWER SANTA ANA RIVER
COMPACTION TEST RESULT SUMMARY
(ASTM D 1557)

Station	Hole No.	Report Date	Depth From	Depth To	Class	Mech. Analy. % finer sand #4	Mech. Analy. % finer fine #200	LL	PI	Compaction PCF	% Moist
910+00	1208	3-26-84	13.0	15.0	SW-SM	90	8		NP	117.2	9.7
900+00	1301	3-19-84	10.0	12.5	SP-SM	89	6		NP	119.5	10.5
895+00	1302	4-9-84	29.0	35.0	SC	100	31	61	28	120.8	11.8
885+00	1303	3-15-84	9.0	18.0	SM	88	12		NP	127.0	7.5
875+00	1304	4-5-84	3.0	15.0	SP-SM	87	7		NP	116.9	11.0
875+00	1304	4-12-84	28.0	34.0	CL	100	69	35	18	121.9	12.3
875+00	1304	4-12-84	35.5		SM	66	20		NP	135.7	7.8
875+00	1305	4-26-84	13.0		SP-SM	99	6		NP	111.8	14.1
875+00	1305	4-29-84	27.0		CH	100	88	72	30	97.1	19.1
875+00	1305	4-12-84	36.0		ML	100	63		NP	130.3	8.9
820+00	1403	3-29-84	22.0		CL	100	76	34	17	125.2	10.2
820+00	1404	4-5-84	25.5		SC	64	22	30	10	133.5	7.0
800+00	1406	4-5-84	38.0	40.0	CL	100	85	33	10	118.5	11.6
789+00	1407	4-12-84	30.0	41.5	SC	100	29	23	6	121.0	12.0
719+00	1510	2-17-84	14.5	18.0	SM	100	19		NP	132.0	5.0
719+00	1510	2-17-84	2.0	9.0	SP-SM	93	8		NP	115.1	7.7
710+00	1601	2-17-84	15.0	24.0	SP	96	3		NP	104.4	10.7
699+00	1602	1-18-83	0.0	12.0	SC	75	23	21	8	134.8	5.7
690+00	1604	2-17-84	1.0	12.0	SP	94	4		NP	106.7	4.6
680+00	1605		24.0	29.0	GW-GM	55	10		NP	134.0	7.3
646+00	1701		12.0	21.0	SM	95	12		NP	120.5	4.5
646+00	1701		21.0	30.0	CL	100	70	49	25	117.0	13.5
622+00	1703	3-29-84	3.0	12.0	SP	95	4		NP	111.1	13.8
614+00	1705		15.0	24.0	CL	100	86	37	17	115.0	14.2
601+50	1706		17.0	27.0	CL	100	78	42	20	114.0	15.5
590+00	1707	1-5-84	1.0	15.0	CL	100	61	27	10	119.3	12.1
590+00	1707		24.0	32.0	CL	100	86	36	14	114.2	12.9
561+00	1803	3-29-84	13.5	14.0	CL	100	75	44	22	117.0	12.6
561+00	1804	3-19-84	8.0	13.0	CL	100	73	34	13	119.3	11.5
561+00	1804	3-19-84	16.0	18.0	SM	100	37		NP	119.0	11.0
548+50	1805		12.0	18.0	CL	100	76	36	15	119.0	13.5
460+00	1808		3.0	15.0	SW	89	4		NP	104.2	3.3
522+50	1810	1-12-84	2.5	6.0	SM	97	23		NP	116.5	6.8
508+80	1902	1-12-84	4.0	7.0	SM	99	14		NP	110.0	12.2
474+00	1906	3-26-84	9.0	18.0	SW	98	5		NP	111.2	12.5
474+00	1906	4-5-84	22.0	30.0	CL	100	80	33	10	119.3	11.0
468+00	1907	3-19-84	6.0	12.0	SM	100	32		NP	119.0	12.0
468+00	1907		18.0	25.0	SW	95	4		NP	110.0	7.0
460+00	1908	1-12-84	3.0	12.0	SM	100	13		NP	115.0	10.0
460+00	1908		24.0	30.0	ML	100	94	37	12	107.0	19.0
420+00	2004	3-26-84	0.0		SM	97	12		NP	119.8	9.0
420+00	2004		16.0	18.0	CH	100	54	53	28	118.0	11.5
390+00	2008	1-8-84	0.0	15.0	SM	99	13		NP	111.5	12.9
390+00	2008	3-29-84	26.0		ML	100	82	36	10	112.7	13.2
390+00	2008	3-26-84	33.0		ML	100	66			117.5	12.2
370+00	2101	4-9-84	26.5		SM	100	23		NP	123.9	7.9
350+00	2105	4-9-84	28.0	29.0	CL	100	54	30	13	125.8	9.2
350+00	2105	3-26-84	25.0	28.0	SM	98	43		NP	121.8	11.2
330+00	2107	3-26-84	0.0	3.0	SW-SM	94	9		NP	118.2	10.4
310+00	2203	3-26-84	12.0	15.0	SM	96	20		NP	123.2	9.2
270+00	2207	4-9-84	25.0	28.0	CL	100	59	44	22	117.9	9.9
260+00	2209	1-11-84	9.0		SM	99	47		NP	112.8	8.0
260+00	2209	1-23-84	13.0		SW-SC	100	10	43	20	120.8	11.8
260+00	2209	1-18-84	29.0		CH	100	87	60	34	110.0	17.0

TABLE 9

LOWER SANTA ANA RIVER
SUMMARY GRADATION AT RIVER

LOWER SANTA ANA RIVER		MECHANICAL ANALYSIS (PERCENT FINER) SIEVE SIZE										GRAIN SIZE IN MILLIMETERS			
		3.0	1.5	3/4	3/8	#4	#10	#16	#40	#100	#200	D10	D50	D85	D15
REACH-1															
Right Embankment	UL	100	100	99	97	94	90	82	55	33	25	0.00	0.36	1.52	0.00
Composite Summary	UQ	100	98	94	89	87	81	72	35	17	13	0.02	0.73	3.90	0.11
	AVG	99	94	90	86	82	75	66	36	17	11	0.06	0.77	8.18	0.13
	LQ	100	92	88	83	78	71	61	29	11	7	0.13	0.92	13.51	0.21
	LL	95	89	81	77	72	66	57	27	6	3	0.20	1.01	28.50	0.26
Right Embankment	UL	100	100	100	100	99	97	95	89	80	71	0.00	0.00	0.30	0.00
Frequency Summary	UQ	100	100	98	96	92	86	77	45	20	11	0.07	0.54	1.91	0.11
	AVG	99	94	90	86	82	75	66	36	17	11				
	LQ	100	93	85	81	75	67	57	26	7	4	0.19	1.02	19.05	0.26
	LL	84	45	42	38	34	31	27	9	2	1	0.46	42.98	77.18	0.68
Left Embankment	UL	100	100	100	100	100	98	96	86	62	42	0.00	0.10	0.41	0.00
Frequency Summary	UQ	100	100	97	94	90	85	75	42	21	12	0.06	0.61	2.00	0.10
	AVG	99	95	90	86	79	74	66	36	15	10				
	LQ	100	92	85	81	73	68	60	28	9	5	0.16	0.95	19.05	0.23
	LL	81	81	69	65	8	7	5	4	3	1	4.93	8.27	76.20	5.35
Foundation	UL	100	100	100	100	100	98	97	90	90	81	0.00	0.00	0.11	0.00
Frequency Summary	UQ	100	100	98	96	92	86	75	42	25	16	0.00	0.61	1.93	0.07
	AVG	99	94	89	83	77	68	59	33	19	15				
	LQ	100	93	86	77	68	57	43	17	6	4	0.25	1.60	17.99	0.37
	LL	67	45	42	37	31	23	16	4	1	1	0.31	46.76		1.13
Invert	UL	100	100	100	99	98	95	86	76	68	37	0.00	0.00	0.39	0.00
Frequency Summary	UQ	100	100	95	89	80	71	55	18	3	2	0.28	1.09	7.41	0.37
	AVG	96	92	88	82	75	63	49	14	3	2				
	LQ	94	89	85	74	69	59	42	8	1	0	0.47	1.57	19.05	0.58
	LL	70	64	63	61	58	42	27	4	0	0	0.62	3.38		0.79

NOTE

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TABLE 9

LOWER SANTA ANA RIVER
SUMMARY GRADATION AT RIVER

		MECHANICAL ANALYSIS (PERCENT FINER) SIEVE SIZE										GRAIN SIZE IN MILLIMETERS			
LOWER SANTA ANA RIVER		3.0	1.5	3/4	3/8	#4	#10	#16	#40	#100	#200	D10	D50	D85	D15
REACH-2															
(ABOVE STA.880)															
Embankment	UL	100	100	100	100	100	100	99	96	89	84	0.00	0.00	0.09	0.00
Frequency Summary	UQ	100	100	99	98	95	91	84	56	26	16	0.00	0.37	1.31	0.07
	AVG	100	99	96	93	90	85	78	48	23	14				
	LQ	100	100	95	92	88	82	74	38	14	8	0.10	0.68	3.38	0.16
	LL	79	65	60	57	53	44	38	11	4	2	0.38	3.84	92.53	0.53
Embankment	UL	100	100	98	97	95	92	86	62	44	34	0.00	0.24	1.15	0.00
Composite Summary	UQ	100	100	98	95	92	86	80	54	27	15	0.00	0.38	1.89	0.07
	AVG	100	99	96	93	90	85	78	48	23	14	0.04	0.47	2.14	0.09
	LQ	100	97	94	91	87	83	75	44	17	11	0.05	0.57	3.30	0.13
	LL	96	95	93	89	83	77	67	34	11	6	0.14	0.80	6.41	0.20
Foundation	UL	100	100	100	100	100	100	99	96	88	75	0.00	0.00	0.13	0.00
Frequency Summary	UQ	100	100	100	98	96	91	85	51	23	15	0.00	0.41	1.19	0.07
	AVG	99	97	94	90	86	79	71	41	22	16				
	LQ	100	96	92	87	82	69	58	25	8	4	0.18	1.00	7.62	0.26
	LL	74	65	51	40	31	23	17	8	1	0	0.59	18.18		1.02
Invert	UL	100	100	98	91	79	62	43	19	7	4	0.22	1.49	7.14	0.33
Frequency Summary	UQ	100	100	95	85	72	54	41	17	4	3	0.27	1.75	9.53	0.38
	AVG	94	91	82	74	64	50	38	12	3	2				
	LQ	100	81	71	63	55	46	38	9	2	1	0.45	3.23	76.20	0.58
	LL	74	69	62	54	47	39	30	8	1	0	0.49	6.80		0.67

NOTE

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TABLE 9

LOWER SANTA ANA RIVER
SUMMARY GRADATION AT RIVER

LOWER SANTA ANA RIVER		MECHANICAL ANALYSIS (PERCENT FINER) SIEVE SIZE										GRAIN SIZE IN MILLIMETERS			
		3.0	1.5	3/4	3/8	#4	#10	#16	#40	#100	#200	D10	D50	D85	D15
REACH-2 (BELOW STA.880)															
Embankment Frequency Summary	UL	100	100	100	100	100	100	99	96	89	71	0.00	0.00	0.13	0.00
	UQ	100	100	100	99	97	93	85	52	19	12	0.05	0.40	1.19	0.11
	AVG	100	99	97	95	92	87	78	46	19	12				
	LQ	100	100	97	94	90	84	73	37	9	4	0.16	0.70	2.46	0.21
	LL	80	75	69	63	49	40	32	6	0	0	0.54	5.10		0.69
Embankment Composite Summary	UL	100	100	100	100	99	96	90	63	43	34	0.00	0.25	1.04	0.00
	UQ	100	100	99	98	96	91	83	51	20	13	0.04	0.41	1.42	0.09
	AVG	100	99	97	95	92	87	78	46	19	12	0.05	0.52	1.83	0.11
	LQ	100	99	95	92	88	83	74	37	10	5	0.14	0.69	3.15	0.20
	LL	98	92	89	82	73	64	50	13	1	0	0.35	1.19	13.61	0.46
Foundation Frequency Summary	UL	100	100	100	100	100	100	100	99	96	92	0.00	0.00	0.00	0.00
	UQ	100	100	100	100	99	97	93	73	48	31	0.00	0.17	0.88	0.00
	AVG	100	98	95	91	87	83	76	51	29	22				
	LQ	100	98	95	91	85	76	66	31	8	4	0.17	0.84	4.76	0.23
	LL	76	70	56	44	33	26	22	8	1	0	0.53	14.29		0.81
Invert Frequency Summary	UL	100	100	100	100	100	99	97	90	85	84	0.00	0.00	0.15	0.00
	UQ	100	100	100	99	97	92	82	37	12	5	0.13	0.64	1.43	0.18
	AVG	100	98	95	92	87	81	72	35	13	8				
	LQ	100	97	91	89	84	76	64	21	2	1	0.26	0.94	5.71	0.33
	LL	87	80	75	60	48	42	33	6	0	0	0.53	5.55	65.31	0.68

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TABLE 9

LOWER SANTA ANA RIVER
SUMMARY GRADATION AT RIVER

LOWER SANTA ANA RIVER		3.0	1.5	3/4	3/8	#4	#10	#16	#40	#100	#200	D10	D50	D85	D15
		MECHANICAL ANALYSIS (PERCENT FINER) SIEVE SIZE										GRAIN SIZE IN MILLIMETERS			
REACH-3															
Embankment Frequency Summary	UL	100	100	100	100	100	100	100	99	93	90	0.00	0.00	0.00	0.00
	UQ	100	100	100	100	99	98	91	74	42	31	0.00	0.22	0.92	0.00
	AVG	100	99	99	98	96	93	77	58	29	21				
	LQ	100	100	99	98	96	91	67	41	9	4	0.16	0.69	1.80	0.20
	LL	99	78	66	62	54	43	35	19	1	0	0.28	3.76	50.80	0.36
Embankment Composite Summary	UL	100	100	100	100	100	97	94	92	77	64	0.00	0.00	0.30	0.00
	UQ	100	100	100	99	98	96	87	62	25	18	0.00	0.33	1.14	0.04
	AVG	100	99	99	98	96	93	77	58	29	21	0.00	0.35	1.61	0.01
	LQ	100	99	99	98	96	92	71	47	13	8	0.10	0.53	1.73	0.16
	LL	100	95	91	89	85	78	62	32	1	0	0.23	0.88	4.62	0.27
Foundation Frequency Summary	UL	100	100	100	100	100	100	100	100	99	99	0.00	0.15	0.15	0.00
	UQ	100	100	100	100	100	99	98	98	91	80	0.00	0.00	0.11	0.00
	AVG	100	99	98	97	95	93	88	79	62	51				
	LQ	100	100	100	94	98	95	81	58	29	12	0.07	0.35	1.42	0.09
	LL	95	82	64	48	35	26	20	14	1	0	0.34	10.72	46.89	0.55
Invert Frequency Summary	UL	100	100	100	100	100	99	99	98	96	94	0.00	0.00	0.00	0.00
	UQ	100	100	100	100	100	98	97	87	68	51	0.00	0.07	0.39	0.00
	AVG	99	99	98	97	96	92	87	56	33	27				
	LQ	100	100	99	97	95	88	81	30	3	2	0.22	0.72	1.65	0.27
	LL	95	92	89	79	69	55	40	6	0	0	0.51	1.73	15.24	0.62

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TABLE 9

LOWER SANTA ANA RIVER
SUMMARY GRADATION AT RIVER

LOWER SANTA ANA RIVER		MECHANICAL ANALYSIS (PERCENT FINER) SIEVE SIZE										GRAIN SIZE IN MILLIMETERS			
		3.0	1.5	3/4	3/8	#4	#10	#16	#40	#100	#200	D10	D50	D85	D15
REACH-4															
Embankment	UL	100	100	100	100	100	100	100	99	93	90	0.00	0.00	0.00	0.00
Frequency Summary	UQ	100	100	100	100	100	100	99	96	78	58	0.00	0.04	0.25	0.00
	AVG	100	100	99	98	97	95	93	79	49	34				
	LQ	100	100	100	99	98	95	91	66	23	10	0.07	0.32	1.01	0.10
	LL	100	94	88	81	70	53	42	20	6	3	0.23	1.78	14.97	0.32
Embankment	UL	100	100	100	100	100	100	100	98	87	68	0.00	0.00	0.14	0.00
Composite Summary	UQ	100	100	100	99	99	97	94	83	55	39	0.00	0.12	0.54	0.00
	AVG	100	100	99	98	97	95	93	79	49	34	0.00	0.16	0.74	0.00
	LQ	100	100	99	98	96	94	91	73	31	21	0.00	0.27	0.93	0.04
	LL	100	99	96	93	90	86	79	52	21	8	0.09	0.40	1.88	0.12
Foundation	UL	100	100	100	100	100	100	100	100	99	99	0.00	0.15	0.15	0.00
Frequency Summary	UQ	100	100	100	100	100	100	100	98	92	82	0.00	0.00	0.10	0.00
	AVG	100	100	100	100	100	98	98	94	80	68				
	LQ	100	100	100	100	100	98	98	93	73	57	0.00	0.04	0.31	0.00
	LL	100	91	91	83	71	63	56	41	19	10	0.07	0.88	11.91	0.12
Invert	UL	100	100	100	100	100	100	99	96	76	43	0.00	0.09	0.27	0.00
Frequency Summary	UQ	100	100	100	100	100	94	92	62	14	9	0.09	0.35	1.01	0.15
	AVG	100	100	100	99	98	94	91	67	25	15				
	LQ	100	100	100	100	100	94	92	62	12	9	0.10	0.35	1.01	0.17
	LL	100	100	98	95	92	87	80	51	12	4	0.13	0.41	1.77	0.17

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LOWER SANTA ANA RIVER
SUMMARY GRADATION AT RIVER

LOWER SANTA ANA RIVER		MECHANICAL ANALYSIS (PERCENT FINER) SIEVE SIZE 3.0	1.5	3/4	3/8	#4	#10	#16	#40	#100	#200	GRAIN SIZE IN MILLIMETERS D10	D50	D85	D15
REACH-5															
(ABOVE STA.350)															
Embankment	UL	100	100	100	100	100	99	98	93	60	36	0.00	0.12	0.36	0.00
Composite Summary	UQ	100	100	100	99	99	97	94	75	39	21	0.00	0.23	0.81	0.05
	AVG	100	100	99	99	98	95	90	70	34	18	0.00	0.27	1.00	0.06
	LQ	100	100	99	98	97	94	89	67	27	14	0.05	0.31	1.05	0.08
	LL	100	99	98	96	94	91	69	47	16	7	0.10	0.51	1.79	0.14
Foundation	UL	100	100	100	100	100	100	100	100	100	100	0.00	0.15	0.15	0.00
Frequency Summary	UQ	100	100	100	100	100	100	99	97	87	71	0.00	0.00	0.14	0.00
	AVG	100	100	99	99	98	96	93	77	50	38				
	LQ	100	100	100	100	99	97	92	57	14	7	0.11	0.38	1.04	0.16
	LL	100	80	64	63	41	40	37	14	1	0	0.34	6.71	47.63	0.45
Invert	UL	100	100	100	100	100	99	98	96	89	81	0.00	0.00	0.11	0.00
Frequency Summary	UQ	100	100	100	100	99	98	98	96	89	81	0.00	0.00	0.11	0.00
	AVG	100	100	99	98	95	89	84	57	35	31				
	LQ	100	100	99	98	95	82	70	33	2	1	0.22	0.77	2.64	0.26
	LL	100	96	87	73	64	56	50	14	1	0	0.34	1.19	17.69	0.44
REACH-5															
(BELOW STA.350)															
Embankment	UL	100	100	100	100	100	100	99	93	69	44	0.00	0.09	0.33	0.00
Composite Summary	UQ	100	100	100	100	99	98	97	85	52	30	0.00	0.14	0.45	0.00
	AVG	100	100	100	99	99	97	95	76	41	24	0.00	0.22	0.79	0.04
	LQ	100	100	99	99	98	96	91	61	25	13	0.06	0.34	1.04	0.09
	LL	100	99	97	95	89	71	53	17	1	1	0.30	1.13	4.15	0.39
Foundation	UL	100	100	100	100	100	100	100	100	99	96	0.00	0.00	0.00	0.00
Frequency Summary	UQ	100	100	100	100	100	100	100	98	89	66	0.00	0.02	0.14	0.00
	AVG	100	100	100	100	99	99	98	88	63	44				
	LQ	100	100	100	100	100	99	98	88	42	16	0.00	0.20	0.40	0.07
	LL	100	93	89	83	79	71	53	17	1	1	0.30	1.13	12.70	0.39
Invert	UL	100	100	100	100	100	100	100	99	95	93	0.00	0.00	0.00	0.00
Frequency Summary	UQ	100	100	100	100	100	100	99	92	48	16	0.00	0.16	0.38	0.07
	AVG	100	100	99	98	97	94	90	66	28	15				
	LQ	100	100	99	97	94	89	81	43	7	2	0.17	0.56	1.60	0.21
	LL	100	93	91	90	88	71	53	17	1	1	0.30	1.13	4.27	0.39

NOTE

UL = UPPER LIMITS
UQ = UPPER QUARTILE
AVG = MEAN (AVERAGE)
LQ = LOWER QUARTILE
LL = LOWER LIMITS

TABLE 9

LOWER SANTA ANA RIVER
SUMMARY GRADATION AT RIVER

LOWER SANTA ANA RIVER		MECHANICAL ANALYSIS (PERCENT FINER) SIEVE SIZE										GRAIN SIZE IN MILLIMETERS			
		3.0	1.5	3/4	3/8	#4	#10	#16	#40	#100	#200	D10	D50	D85	D15
REACH-6															
Embankment	UL	100	100	100	100	100	100	100	98	95	84	0.00	0.00	0.08	0.00
Composite Summary	UQ	100	100	100	100	100	100	99	94	75	62	0.00	0.01	0.29	0.00
	AVG	100	100	100	100	100	99	99	90	63	44	0.00	0.10	0.37	0.00
	LQ	100	100	100	100	100	99	98	87	59	40	0.00	0.11	0.40	0.00
	LL	100	100	100	100	99	99	97	83	46	26	0.00	0.18	0.55	0.04
Foundation	UL	100	100	100	100	100	100	100	100	99	99	0.00	0.15	0.15	0.00
Frequency Summary	UQ	100	100	100	100	100	100	100	99	95	83	0.00	0.00	0.09	0.00
	AVG	100	100	100	100	100	98	97	95	74	51				
	LQ	100	100	100	100	100	99	98	95	65	16	0.00	0.13	0.33	0.07
	LL	100	100	100	95	87	78	73	58	6	1	0.17	0.38	4.15	0.20
REACH-7															
Embankment	UL	100	100	100	100	100	100	100	100	97	88	0.00	0.00	0.05	0.00
Composite Summary	UQ	100	100	100	100	100	100	99	98	80	55	0.00	0.06	0.22	0.00
	AVG	100	100	100	99	99	98	97	89	61	42	0.00	0.11	0.38	0.00
	LQ	100	100	100	99	98	97	95	89	44	22	0.00	0.19	0.40	0.05
	LL	100	100	99	98	97	94	92	62	4	1	0.18	0.36	1.02	0.20
Foundation	UL	100	100	100	100	100	100	100	100	99	98	0.00	0.00	0.00	0.00
Frequency Summary	UQ	100	100	100	100	100	100	100	98	63	10	0.07	0.13	0.32	0.08
	AVG	100	100	100	100	99	97	95	83	37	12				
	LQ	100	100	100	100	99	97	93	78	16	3	0.11	0.30	0.78	0.14
	LL	100	100	97	91	83	77	67	24	3	1	0.24	0.89	5.95	0.30

NOTE

UL = UPPER LIMITS
UQ = UPPER QUARTILE
AVG = MEAN (AVERAGE)
LQ = LOWER QUARTILE
LL = LOWER LIMITS

TABLE 9

LOWER SANTA ANA RIVER
SUMMARY GRADATION AT RIVER

LOWER SANTA ANA RIVER		MECHANICAL ANALYSIS (PERCENT FINER) SIEVE SIZE										GRAIN SIZE IN MILLIMETERS			
		3.0	1.5	3/4	3/8	#4	#10	#16	#40	#100	#200	D10	D50	D85	D15
DROP STRUCTURE FOUNDATION FREQUENCY SUMMARIES															
STA.875+40	UL	100	100	100	100	100	99	97	92	83	81	0.00	0.00	0.21	0.00
	UQ	100	100	99	98	97	90	81	45	21	15	0.00	0.53	1.55	0.07
	AVG	99	97	94	90	86	79	70	42	22	16				
	LQ	100	96	94	90	85	74	65	29	12	7	0.12	0.87	4.76	0.20
	LL	87	80	75	60	48	42	33	13	1	0	0.35	5.55	65.31	0.50
STA .1023+50	UL	100	100	100	100	100	99	98	92	88	75	0.00	0.00	0.13	0.00
	UQ	100	100	100	100	99	98	95	86	67	55	0.00	0.04	0.41	0.00
	AVG	99	94	90	87	84	81	75	55	38	30				
	LQ	100	94	77	71	63	57	50	25	9	6	0.17	1.19	28.01	0.25
	LL	84	65	51	40	31	23	17	9	5	3	0.52	18.18	78.21	1.00
STA. 1098+50	UL	100	100	100	99	98	95	92	84	82	81	0.00	0.00	0.52	0.00
	UQ	100	100	99	96	92	84	76	27	13	10	0.07	0.78	2.35	0.19
	AVG	99	94	89	83	72	64	54	28	18	15				
	LQ	100	94	86	81	67	54	41	16	5	3	0.27	1.75	17.15	0.40
	LL	90	55	43	37	8	7	5	4	3	2	5.09	30.16	70.76	5.91
STA. 1148+60	UL	100	100	98	97	96	92	87	68	44	39	0.00	0.22	1.11	0.00
	UQ	100	100	97	93	85	80	65	32	20	6	0.10	0.84	4.76	0.12
	AVG	97	93	88	82	74	64	52	25	12	9				
	LQ	100	93	88	78	67	57	34	14	5	3	0.30	1.75	16.19	0.46
	LL	67	59	50	44	40	34	26	6	2	1	0.57	19.05		0.77

NOTE

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TABLE 9

LOWER SANTA ANA RIVER
SUMMARY GRADATION AT RIVER

LOWER SANTA ANA RIVER		MECHANICAL ANALYSIS (PERCENT FINER) SIEVE SIZE										GRAIN SIZE IN MILLIMETERS			
		3.0	1.5	3/4	3/8	#4	#10	#16	#40	#100	#200	D10	D50	D85	D15
INVERT BORROW COMPOSITE SUMMARIES															
STA. 1207 TO 1075	UL	100	100	99	95	90	78	57	18	4	3	0.27	1.05	3.61	0.36
5FT.DEPTH	UQ	100	99	95	88	81	70	55	17	3	2	0.28	1.08	7.51	0.38
	AVG	100	97	92	84	74	60	43	11	3	1	0.38	1.52	10.65	0.51
	LQ	100	93	88	77	68	55	41	8	1	1	0.47	1.70	16.79	0.59
	LL	87	80	73	70	66	51	38	6	1	0	0.52	1.94	65.31	0.64
STA. 509 TO 398	UL	100	100	100	100	100	100	99	98	82	61	0.00	0.04	0.20	0.00
7FT.DEPTH	UQ	100	100	100	100	98	94	86	52	12	9	0.11	0.41	1.17	0.17
	AVG	100	100	99	98	95	89	84	60	35	26	0.00	0.31	1.34	0.00
	LQ	100	99	98	92	88	82	74	29	2	1	0.23	0.77	3.20	0.28
	LL	100	96	87	73	64	56	50	14	1	0	0.34	1.19	17.69	0.44
STA. 393 TO 356	UL	100	100	100	100	100	99	95	38	2	1	0.21	0.53	1.05	0.25
5FT.DEPTH	UQ	100	100	100	100	99	98	93	37	1	1	0.21	0.60	1.08	0.25
	AVG	100	100	100	99	98	95	89	37	2	0	0.21	0.61	1.13	0.25
	LQ	100	100	100	99	97	95	89	34	1	0	0.22	0.64	1.13	0.26
	LL	100	100	100	99	97	93	87	33	1	0	0.23	0.66	1.16	0.27
STA. 354 TO 261	UL	100	100	100	99	96	92	88	60	26	15	0.00	0.34	1.10	0.07
7FT.DEPTH	UQ	100	100	99	98	95	92	87	56	14	6	0.11	0.38	1.15	0.15
	AVG	100	99	98	97	94	89	81	44	11	6	0.13	0.54	1.58	0.18
	LQ	100	99	97	96	94	89	78	34	6	3	0.18	0.71	1.72	0.23
	LL	100	97	96	95	91	80	67	27	5	2	0.22	0.86	3.25	0.28
STA.219 TO 215	UL	100	100	99	99	99	98	96	86	60	40	0.00	0.11	0.41	0.00
13FT.DEPTH	UQ	100	100	99	98	97	96	95	85	59	40	0.00	0.11	0.45	0.00
	AVG	100	99	97	96	95	94	93	83	59	39	0.00	0.12	0.60	0.00
	LQ	100	99	97	95	94	93	92	82	58	38	0.00	0.12	0.66	0.00
	LL	100	99	96	94	92	92	90	80	57	37	0.00	0.12	0.78	0.00
STA. 132 TO 91	UL	100	100	100	100	100	100	99	92	69	55	0.00	0.05	0.34	0.00
8FT.DEPTH	UQ	100	100	100	100	100	100	99	90	61	50	0.00	0.07	0.37	0.00
	AVG	100	100	100	100	100	99	98	86	53	44	0.00	0.13	0.41	0.00
	LQ	100	100	100	100	99	99	97	81	41	37	0.00	0.21	0.62	0.00
	LL	100	100	100	100	99	97	95	79	8	2	0.16	0.31	0.69	0.17
STA. 77 TO 13	UL	100	100	100	100	100	100	100	100	100	99	0.00	0.00	0.00	0.00
10FT.DEPTH	UQ	100	100	100	100	100	100	100	100	90	74	0.00	0.02	0.13	0.00
	AVG	100	100	100	100	100	100	99	96	74	57	0.01	0.06	0.23	0.02
	LQ	100	100	100	100	100	100	98	93	57	35	0.03	0.13	0.27	0.04
	LL	100	100	100	100	99	97	95	89	46	13	0.07	0.16	0.03	0.08

NOTE

UL = UPPER LIMITS
UQ = UPPER QUARTILE
AVG = MEAN (AVERAGE)
LQ = LOWER QUARTILE
LL = LOWER LIMITS

Table 10. Lower Santa Ana River. Potential Stone Sources - Quality Compliance Test Results.

Stone Source	Rock Type	Specific Gravity Bulk (SSD)	Specific Gravity Apparent	Absorption (%)	Sulfate Soundness (% loss)	Abrasion (% loss)	Date[1] Tested	Remarks[2]
Commercial Quarries								
Atkinson	Monzonite/ Monzodiorite	2.76	2.77	0.1	2.0	25.2	6/85	Sepulveda Basin
Corona-Pacific	Tonalite	2.67	2.68	0.3	0.5	14.1	4/88	San Pedro Breakwater
Declezville	Granodiorite	2.77	2.79	0.3	2.3	46.5	11/83	Morro Bay North and South Breakwaters.
Fish Canyon	Granite	2.74	2.76	0.4	1.5[3]	16.9	11/86	Redondo Beach (King Harbor) North Breakwater
Harlow	Andesite	2.66	2.66	0.2	1.6	14.3	6/85	Warm Creek-Santa Ana River Confluence
Pebbly Beach	Meta-Cgl.	2.67	2.71	0.8	34.8	43.4	10/86	Port San Luis
	Graywacke	2.64	2.65	0.4	4.7	15.3	10/86	Breakwater, San Pedro
	Meta-Volcanic	2.66	2.68	0.7	7.7	20.7	10/86	& Middle Breakwaters
Slover Mtn.	Marble	2.72	2.73	0.2	1.0	38.0	11/83	Morro Bay North
	Metasediment	2.90	2.92	0.3	1.2	27.2	11/83	Breakwater
Stringfellow	Granite	2.66	2.67	0.2	0.4	18.3	6/85	San Pedro Breakwater
3M	Andesite	2.69	2.70	0.4	0.5	10.0	9/83	Dana Point Breakwater

Table 10. (Continued)

Stone Source	Rock Type	Specific Gravity Bulk (SSD)	Specific Gravity Apparent	Absorption (%)	Sulfate Soundness (% loss)	Abrasion (% loss)	Date[1] Tested
Existing Levees							
Reach 1	Granite/ Granodiorite	2.68	2.69	0.2	2.6	31.3	2/88
	Meta-Andesite	2.61	2.64	0.7			
	Sandstone	2.53	2.55	0.6			
Reach 2	Diorite	2.75	2.76	0.2	2.0	20.8	2/88
	Granodiorite	2.69	2.70	0.2			
	Gabbro/Meta-Gabbro	2.78	2.79	0.3			
	Meta-Dacite	2.67	2.68	0.1			
	Meta-Andesite	2.63	2.63	0.1			
Reach 3	Diorite	2.73	2.73	0.1	0.6	15.3	2/88
	Monzodiorite	2.72	2.72	0.1			
	Granodiorite	2.59	2.59	0.2			
	Meta-Andesite	2.73	2.74	0.3			

1. Only the most recent test results are shown for each stone source.

2. Rock from Harlow Quarry was only suitable for use as grouted stone on the Warm Creek-Santa Ana River Confluence project due to 50 percent failure during the wetting and drying test. The Declezville and Pebbly Beach Quarries have provided suitable rock for Corps of Engineers projects based on service records.

3. April 1982 test.

Table 11. Lower Santa Ana River.

Composite Gradation of Proposed Disposal Beach

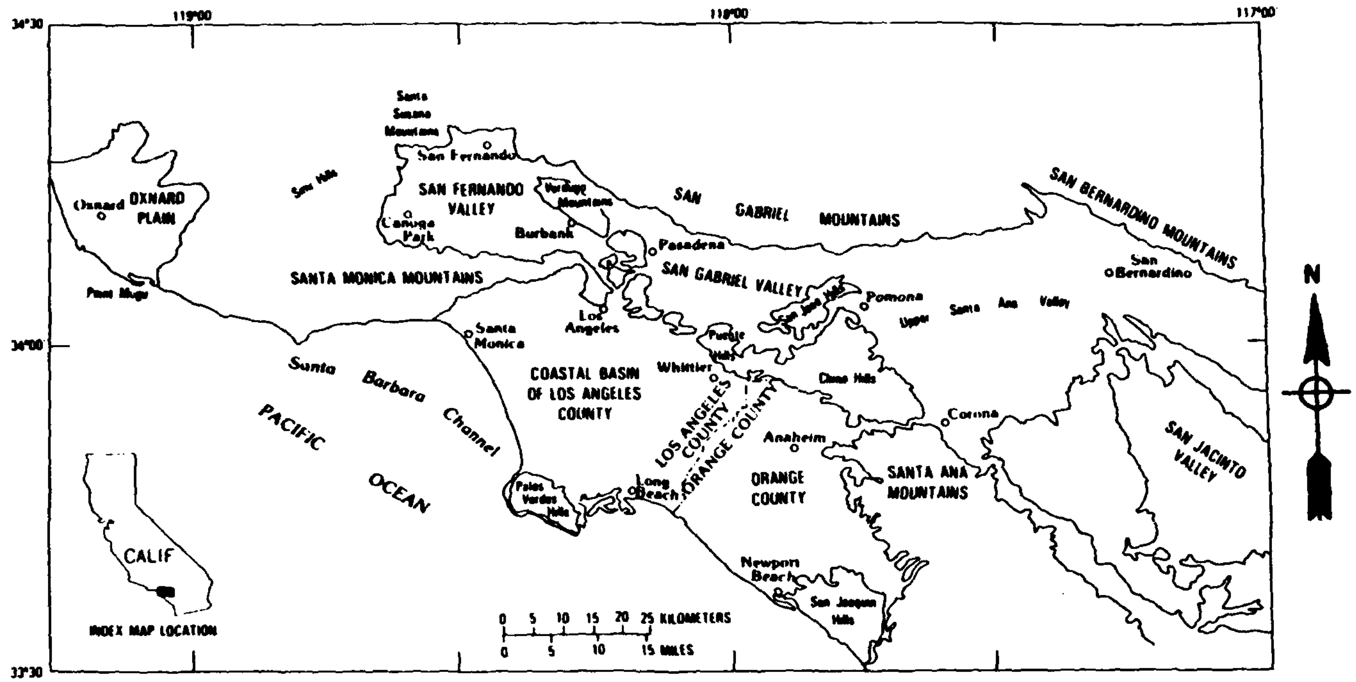
Range Station	Percent Finer - Passing Sieve Number 4	7	10	14	18	25	35	45	60	80	100	120	170	200
107+84	97	93	92	90	87	84	79	72	62	56	54	48	28	19
117+83	100	100	100	100	99	97	89	77	65	59	58	50	29	15
127+84	100	100	100	95	94	90	83	73	62	58	57	48	25	12
137+84	100	99	99	98	95	91	79	66	51	42	40	35	22	9
147+84	100	100	100	100	99	97	91	81	68	57	53	46	28	11
157+84	100	100	100	99	98	97	90	81	70	61	60	55	33	15
167+85	100	100	100	100	99	97	91	81	66	58	56	50	32	16
177+86	100	100	100	99	98	96	90	82	68	58	54	48	30	14
187+84	100	100	100	99	96	89	75	61	45	31	27	20	10	3
197+87	100	99	98	96	93	88	80	68	56	50	47	39	19	9
207+87	100	100	100	98	97	95	88	77	59	42	36	30	17	7
217+87	100	100	100	99	98	95	89	79	65	55	49	38	19	8
227+87	100	98	98	96	94	90	83	73	61	52	49	40	21	10
237+87	100	100	100	99	97	93	85	75	69	58	54	44	22	11
247+87	100	100	99	98	95	90	78	65	54	44	40	30	15	7
267+88	100	100	100	100	99	95	83	65	48	40	38	31	15	8
307+88	100	100	100	99	98	95	84	66	45	36	33	23	10	6
367+85	100	100	100	99	99	97	89	75	63	47	39	28	14	8

Table 11. (Continued)

Range Station	Percent Finer - Passing Sieve Number 4	7	10	14	18	25	35	45	60	80	100	120	170	200
477+12	100	100	99	99	97	94	85	74	67	60	57	47	30	18
547+84	100	100	100	100	99	98	93	86	78	64	58	45	30	18
649+31	100	100	100	100	100	98	94	86	72	54	51	43	37	29
750+94	100	100	100	100	100	100	100	96	86	70	59	44	24	17
840+44	100	100	100	98	96	89	79	68	58	56	42	15	10	9
899+53	100	100	100	99	98	94	85	71	54	41	37	24	8	6

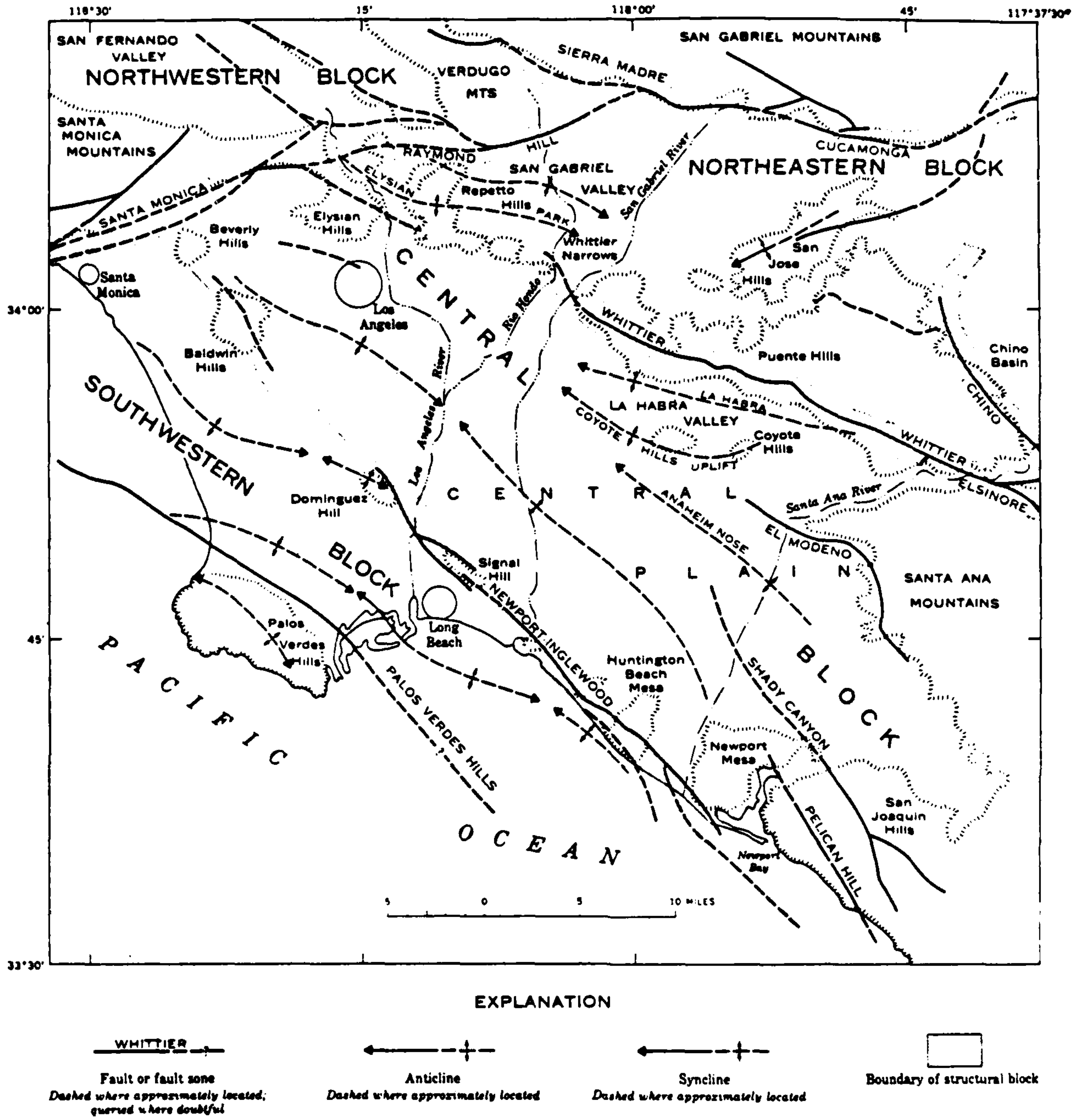
A GEOTECHNICAL

FIGURES



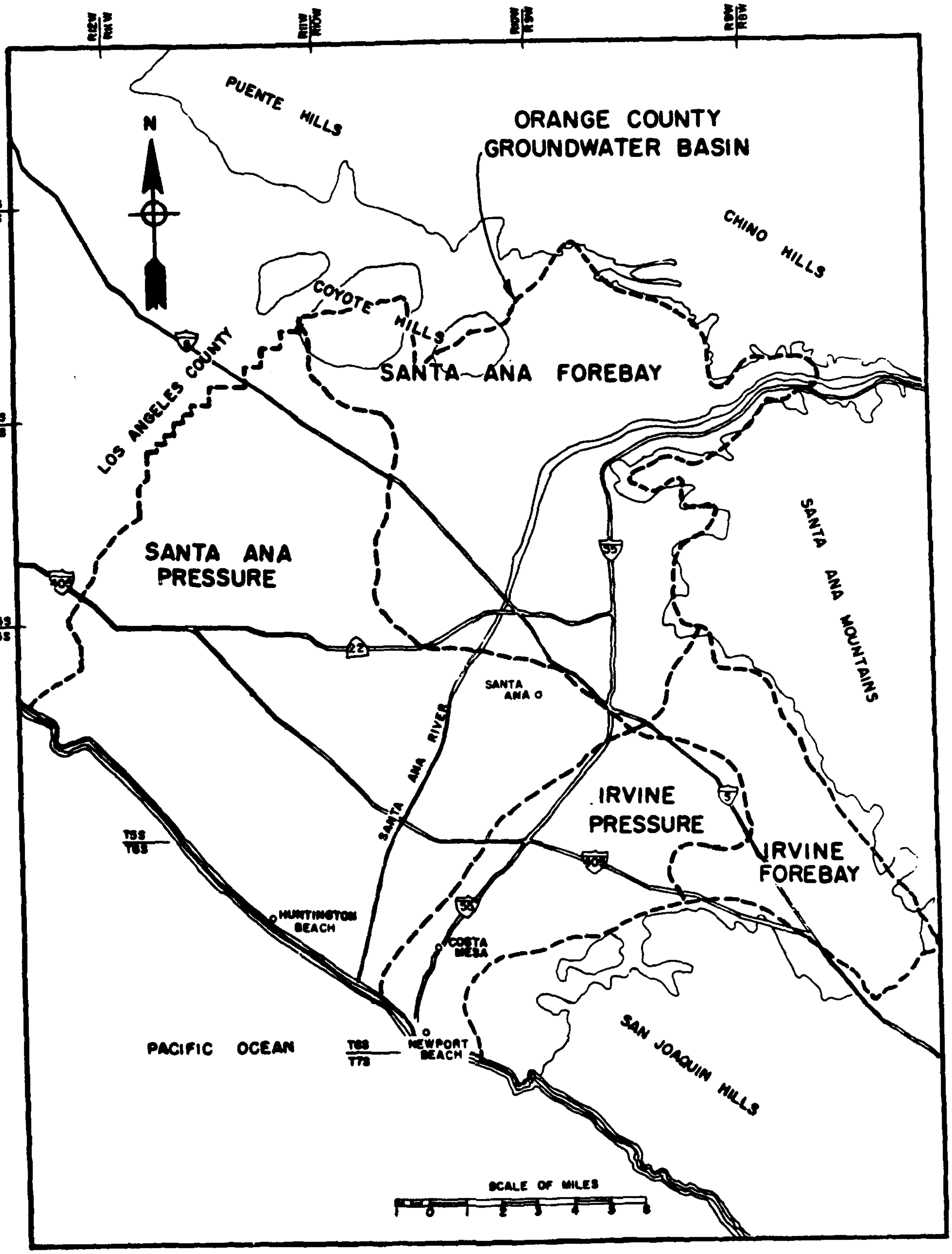
INDEX MAP OF THE LOS ANGELES REGION SHOWING MAJOR ALLUVIAL BASINS (FROM TINSLEY AND FUMAL, 1985)

FIGURE 1-A



GENERAL PHYSIOGRAPHY AND STRUCTURAL FEATURES OF THE LOS ANGELES BASIN (YERKES AND OTHERS, 1965)

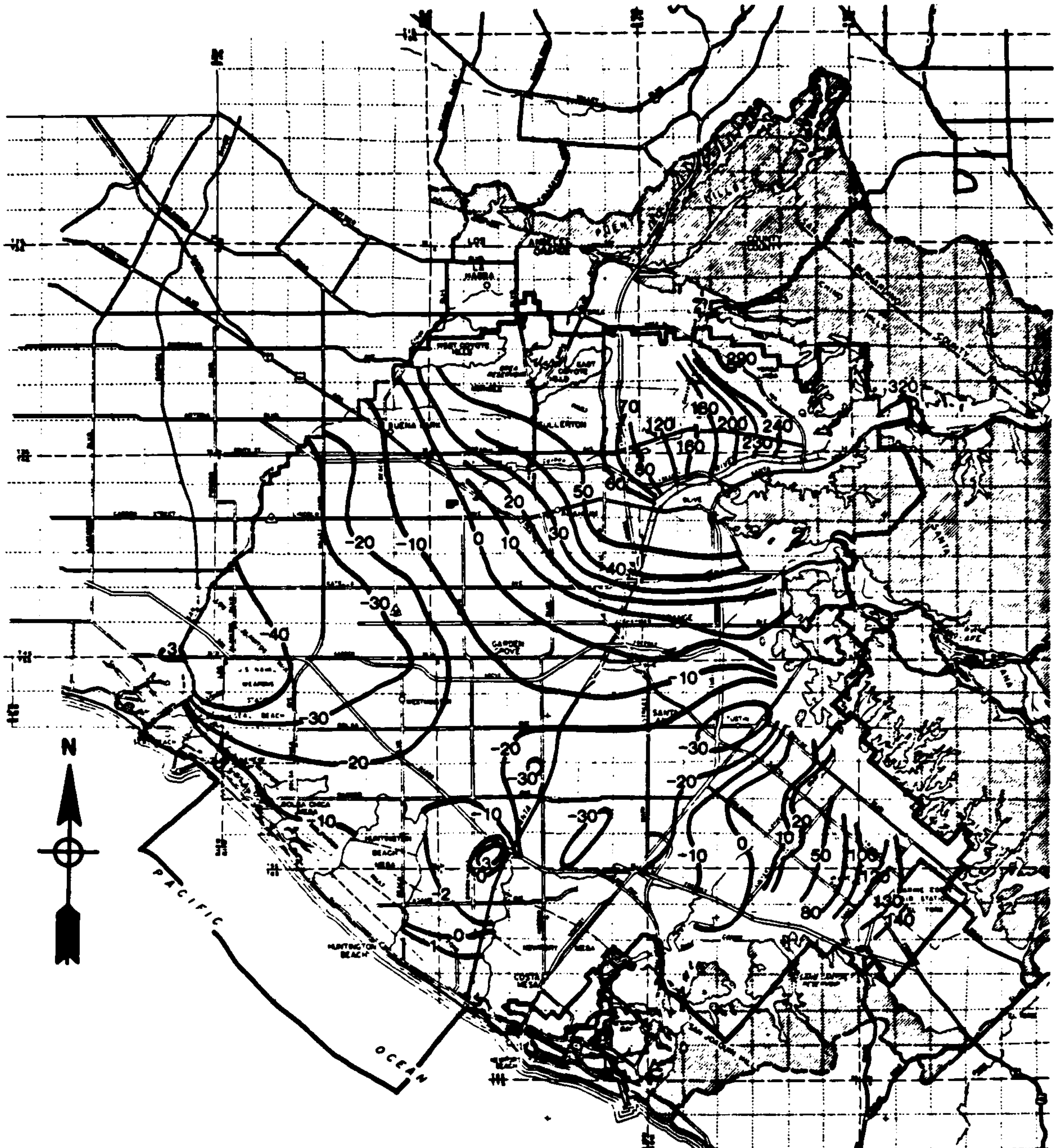
FIGURE 2-A



ORANGE COUNTY GROUNDWATER BASIN

F3.1

FIGURE 3-A



ORANGE COUNTY GROUNDWATER BASIN - GROUNDWATER CONTOUR MAP, NOVEMBER 1, 1986 (FROM OCWD, 1987)

FIGURE 4-A

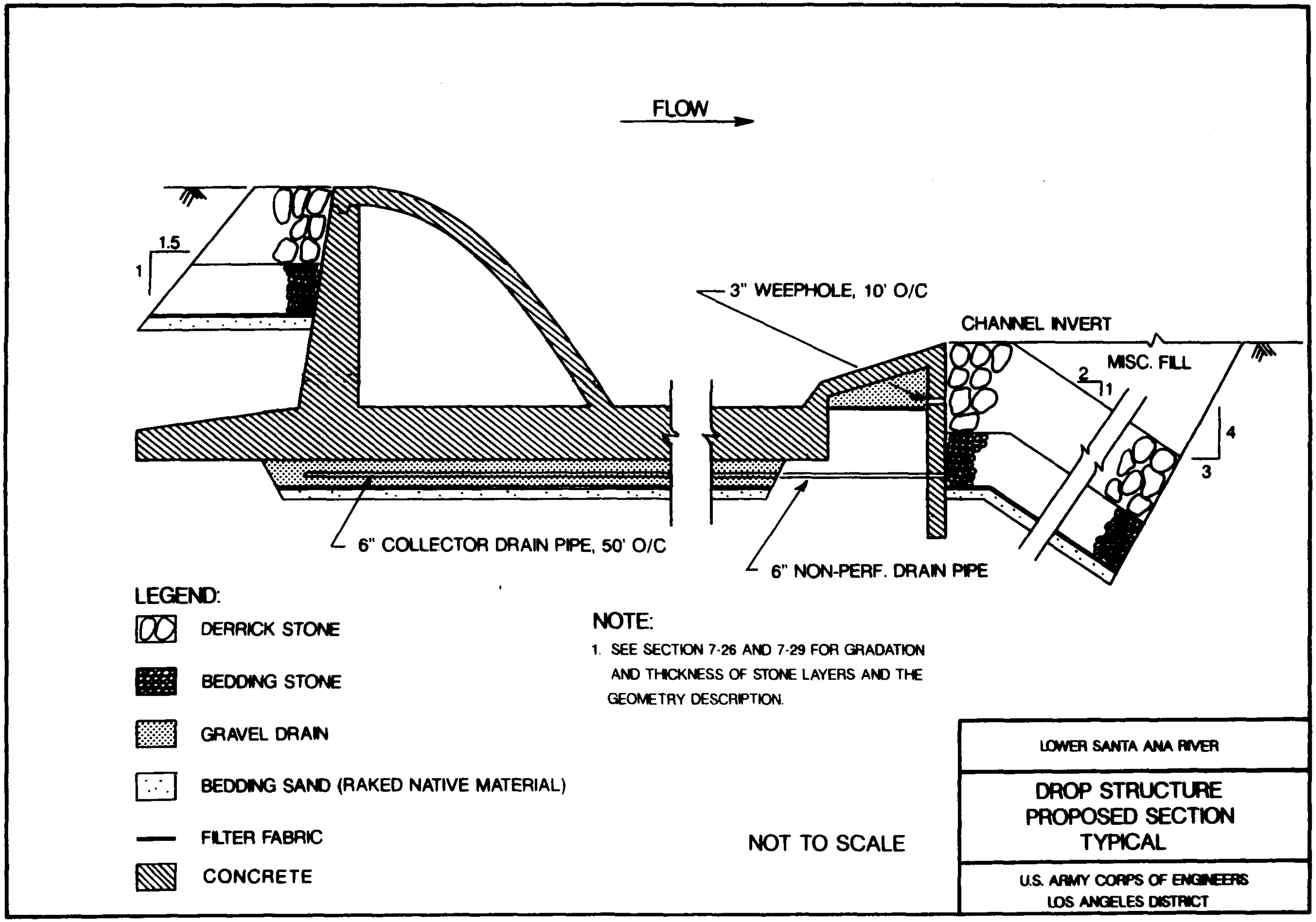
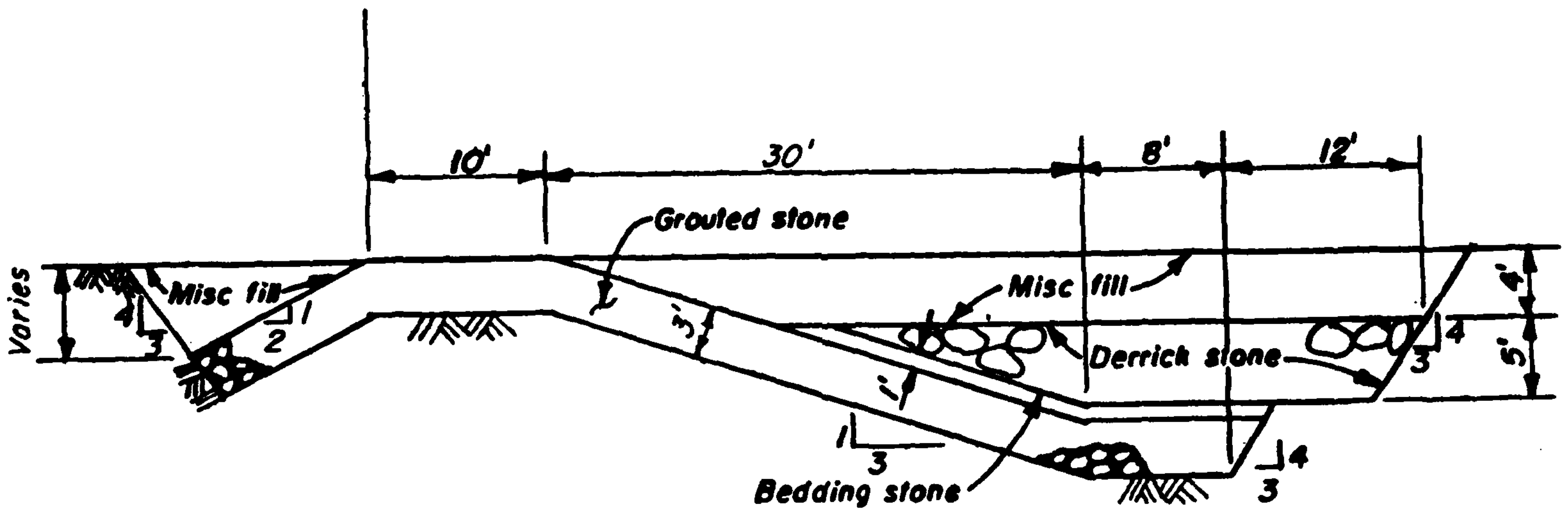

FLOW
1.5
1
3" WEEPHOLE, 10' O/C
CHANNEL INVERT
MISC. FILL
2
1
4
3
6" COLLECTOR DRAIN PIPE, 50' O/C
6" NON-PERF. DRAIN PIPE
LEGEND:
DERRICK STONE
BEDDING STONE
GRAVEL DRAIN
BEDDING SAND (RAKED NATIVE MATERIAL)
FILTER FABRIC
CONCRETE
NOTE:
1. SEE SECTION 7-26 AND 7-29 FOR GRADATION AND THICKNESS OF STONE LAYERS AND THE GEOMETRY DESCRIPTION.
NOT TO SCALE
LOWER SANTA ANA RIVER
DROP STRUCTURE
PROPOSED SECTION
TYPICAL
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

FIGURE 5-A



NOT TO SCALE

LOWER SANTA ANA RIVER

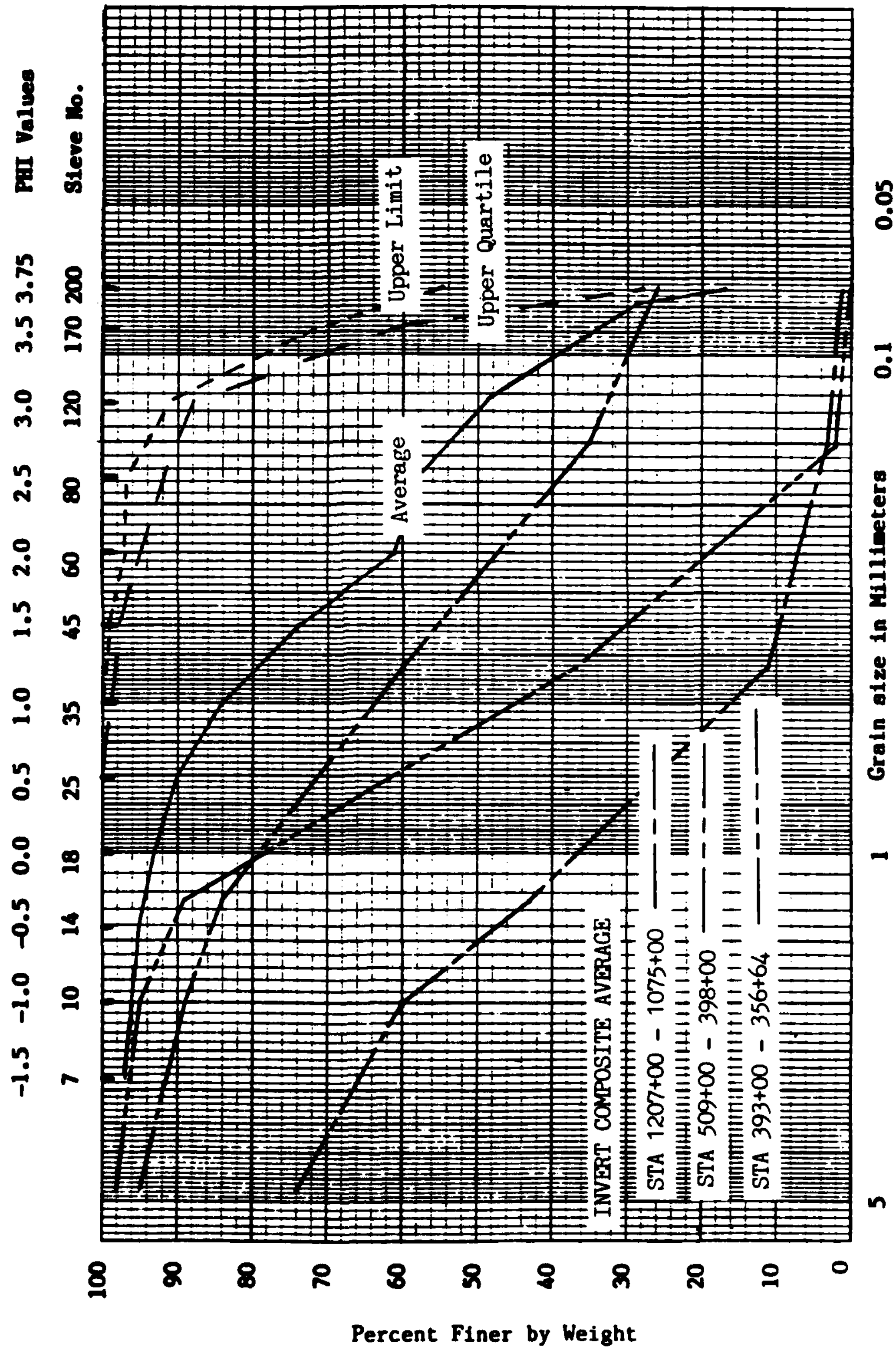
INVERT STABILIZER
PROPOSED SECTION
TYPICAL

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

FIGURE 6-A

LOWER SANTA ANA RIVER
BEACH COMPATIBILITY
COMPOSITE BEACH GRADATIONS

STA 107+84 - 117+83



F7.1

FIGURE 7-A

Lower Santa Ana River

Beach Compatibility

Composite Beach Gradations

STA 107+84 - 117+83

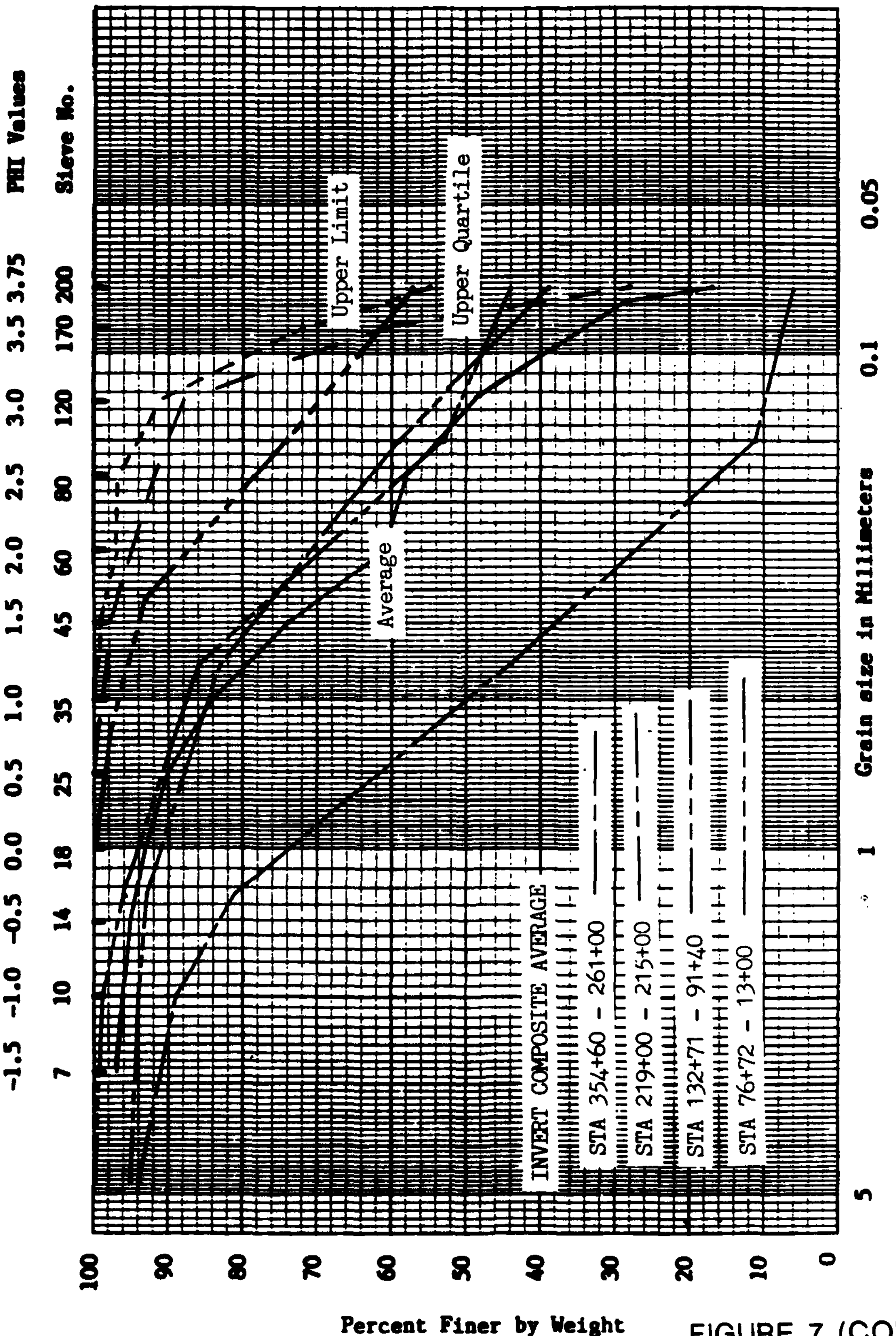


FIGURE 7 (CONT.)

LOWER SANTA ANA RIVER
BEACH COMPATIBILITY
COMPOSITE BEACH GRADATIONS

STA 127+84 - 177+86

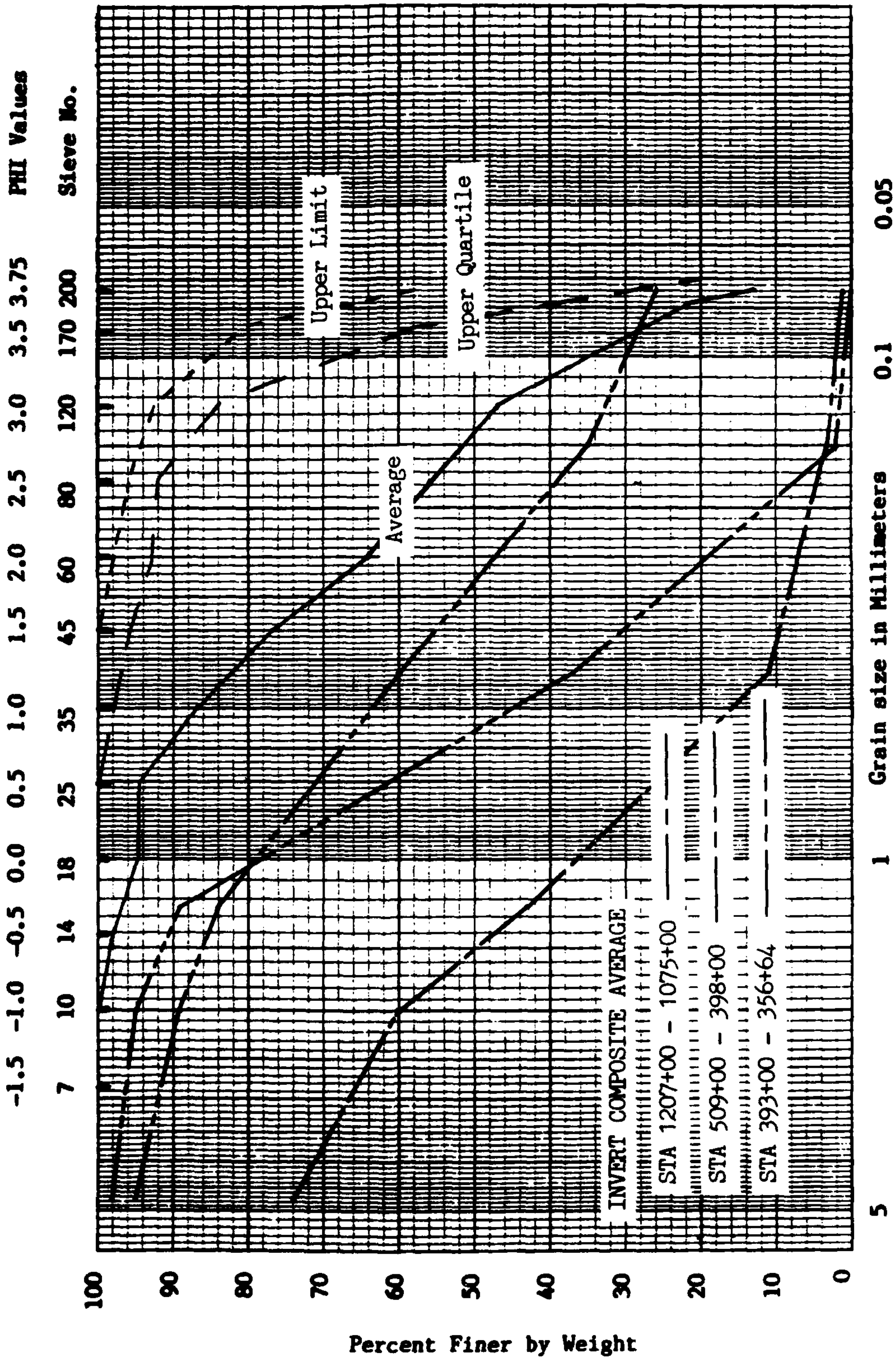


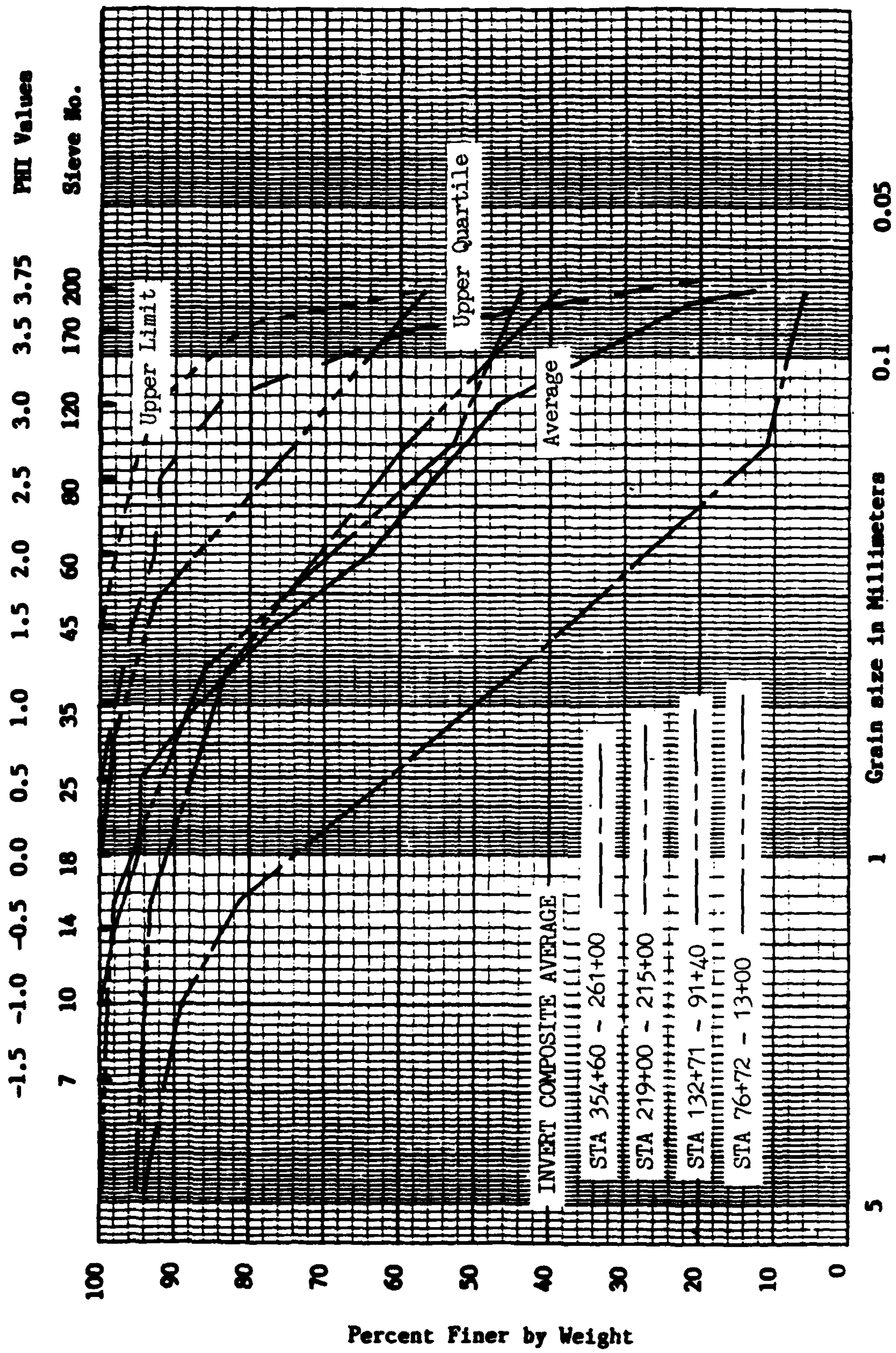
FIGURE 7 (CONT.)

Lower Santa Ana River

Beach Compatibility

Composite Beach Gradations

STA 127+84 - 177+86



F7.4

FIGURE 7 (CONT.)

LOWER SANTA ANA RIVER
BEACH COMPATIBILITY
COMPOSITE BEACH GRADATIONS
STA 187+84 - 367+85

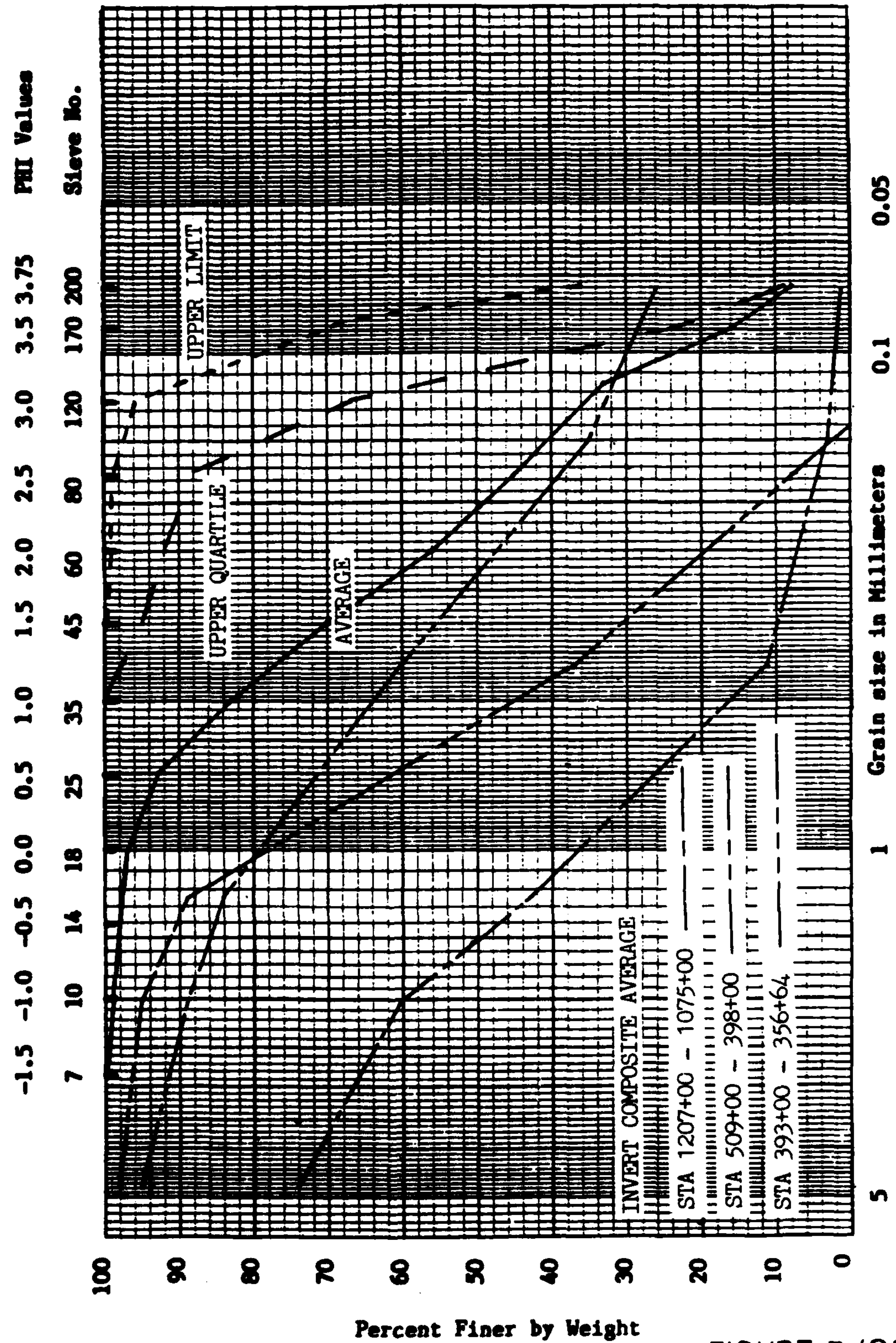
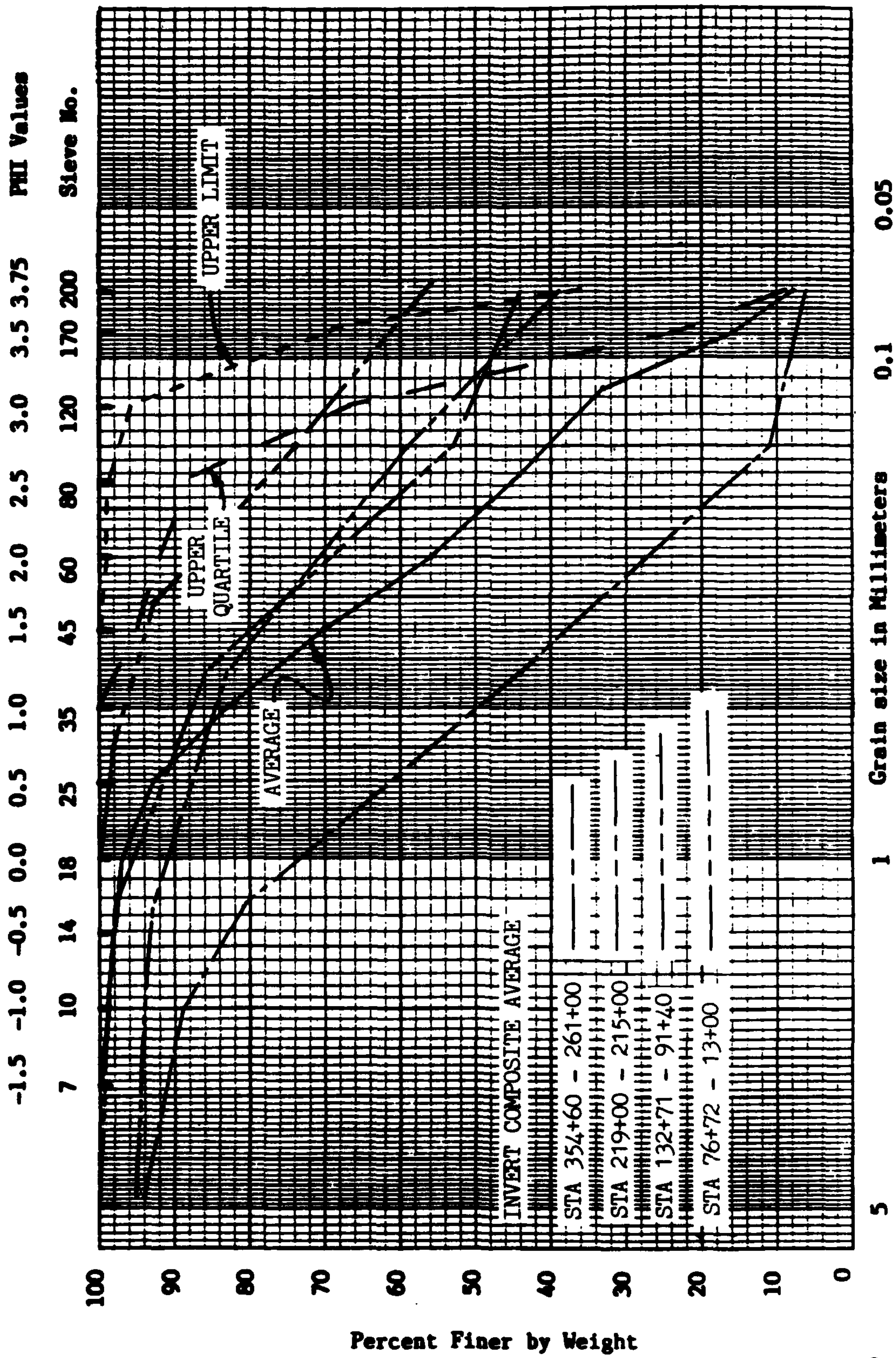


FIGURE 7 (CONT.)

Lower Santa Ana River
Beach Compatibility
Composite Beach Gradations

STA 187+84 - 367+85

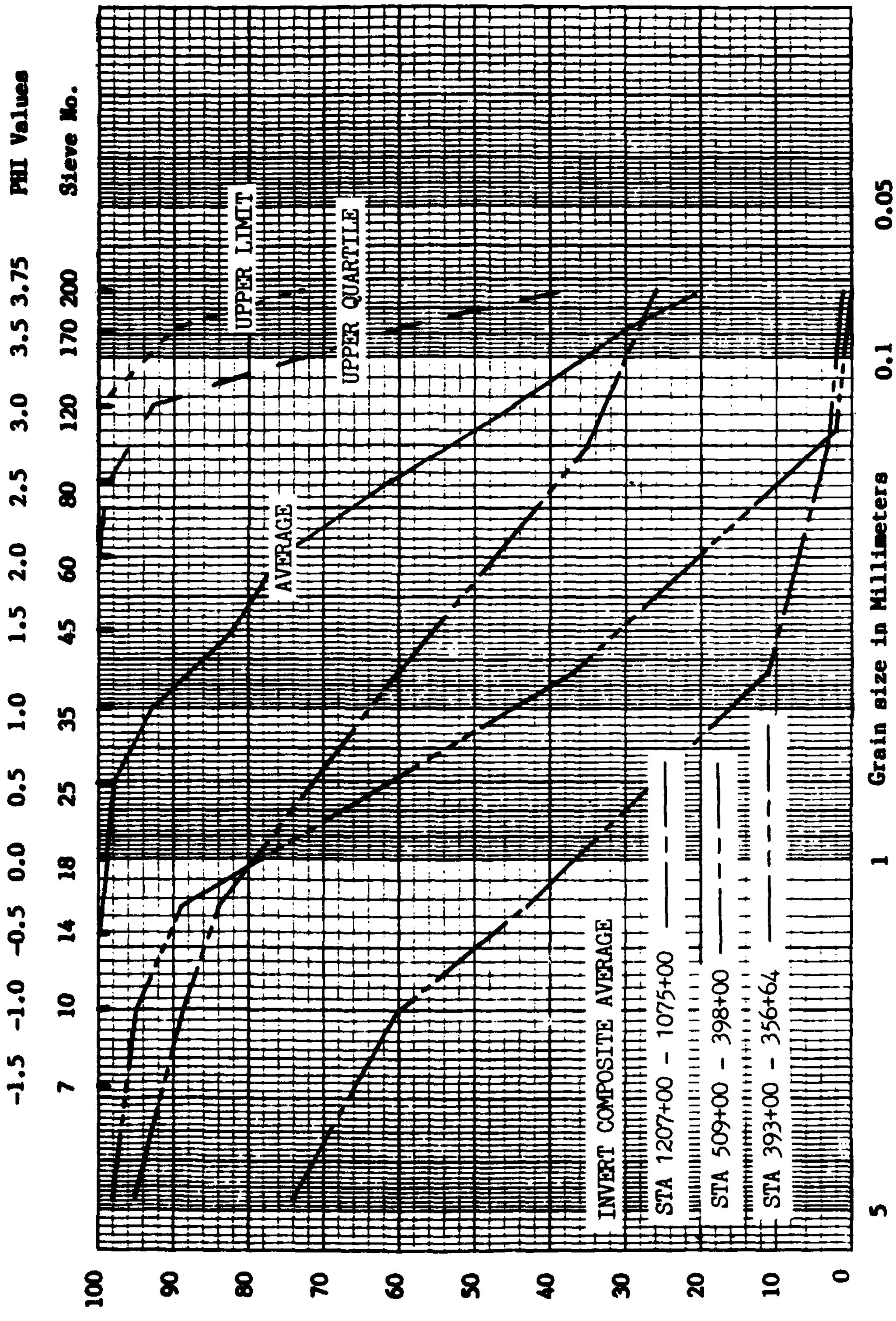


F7.6

FIGURE 7 (CONT.)

LOWER SANTA ANA RIVER
BEACH COMPATIBILITY
COMPOSITE BEACH GRADATIONS

STA 477+12 - 750+94



F7.7

FIGURE 7 (CONT.)

Lower Santa Ana River

Beach Compatibility

Composite Beach Gradations

STA 477+12 - 750+94

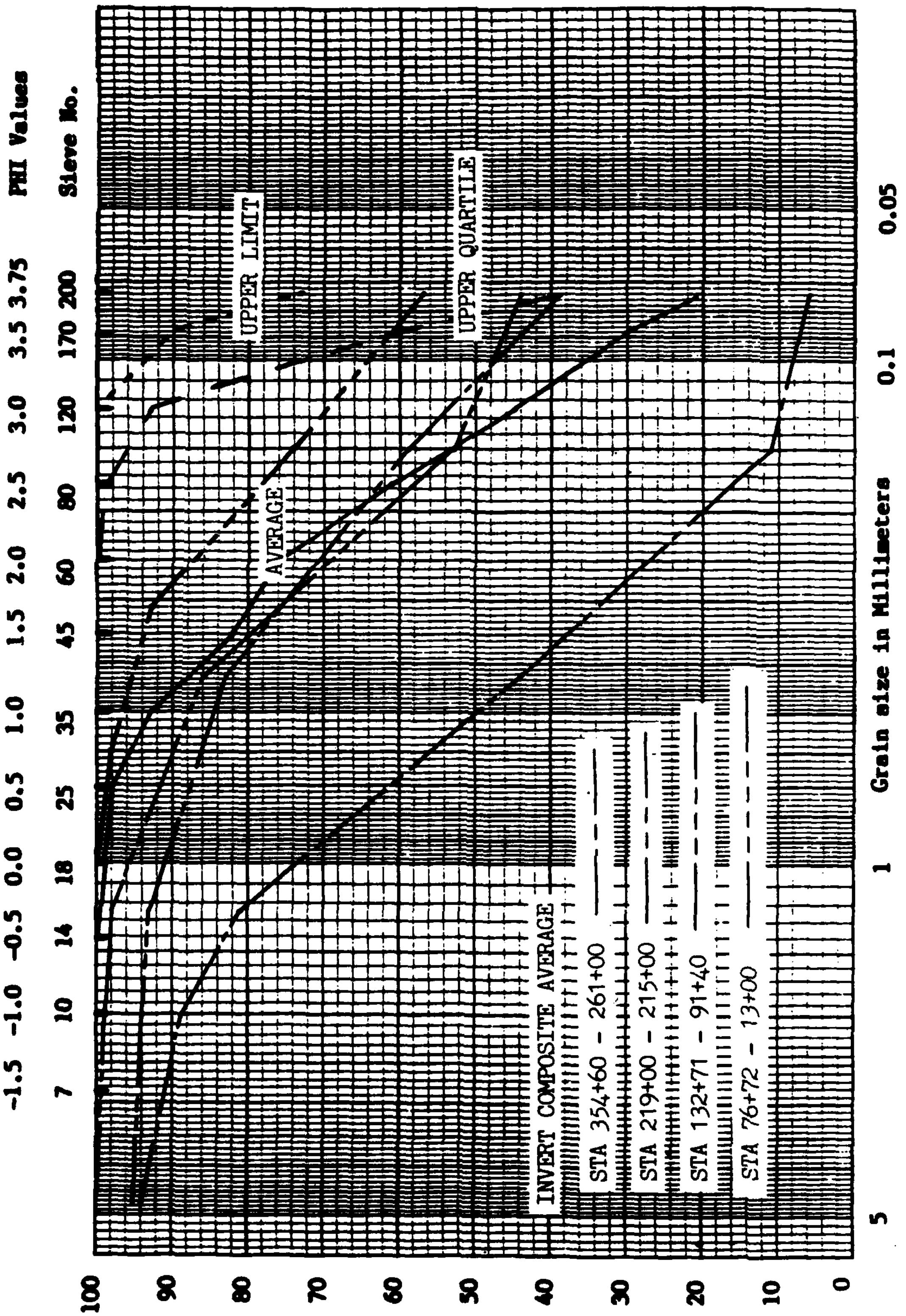


FIGURE 7 (CONT.)

LOWER SANTA ANA RIVER
BEACH COMPATIBILITY
COMPOSITE BEACH GRADATIONS

STA 840+44 - 899+53

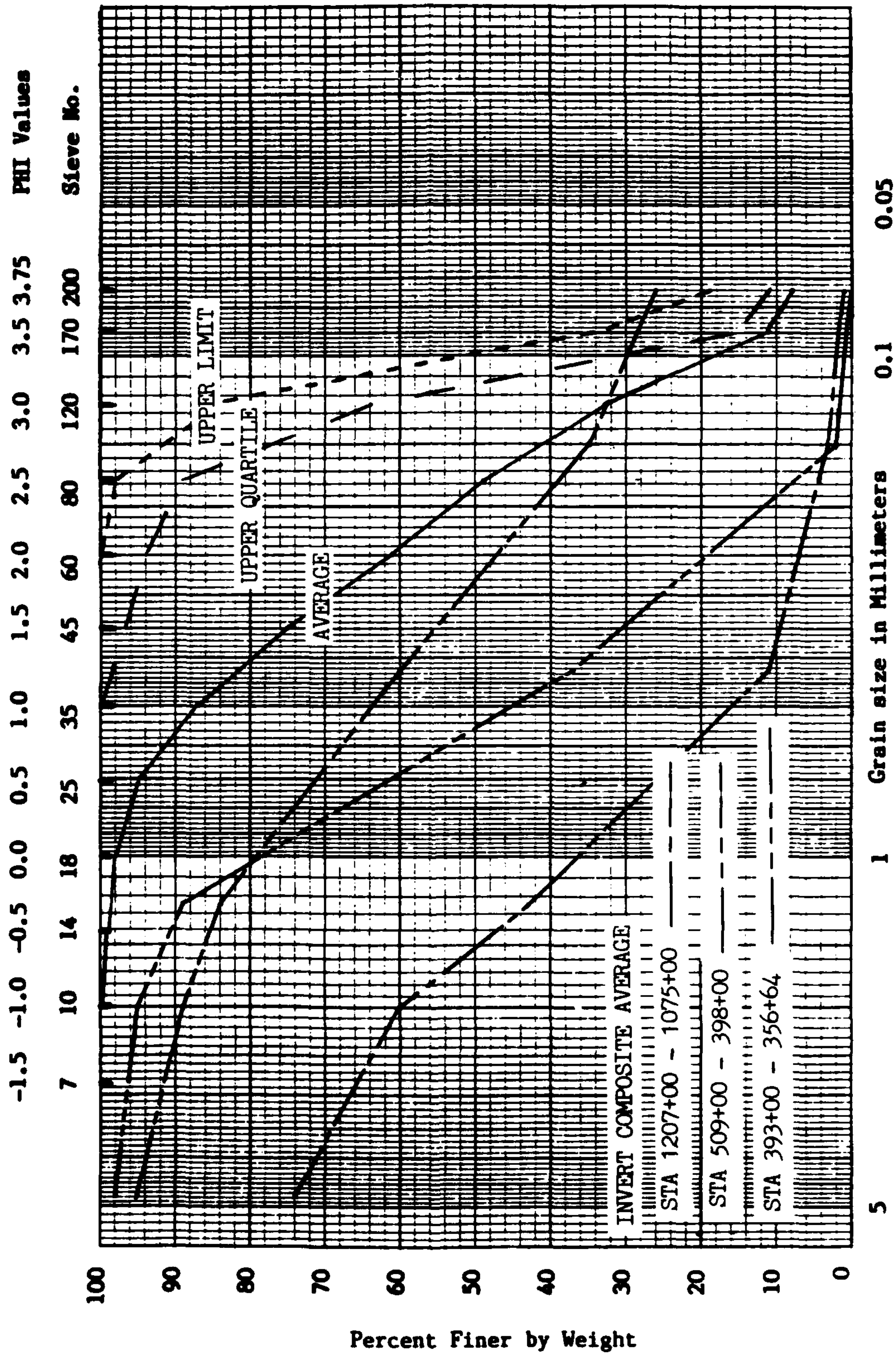
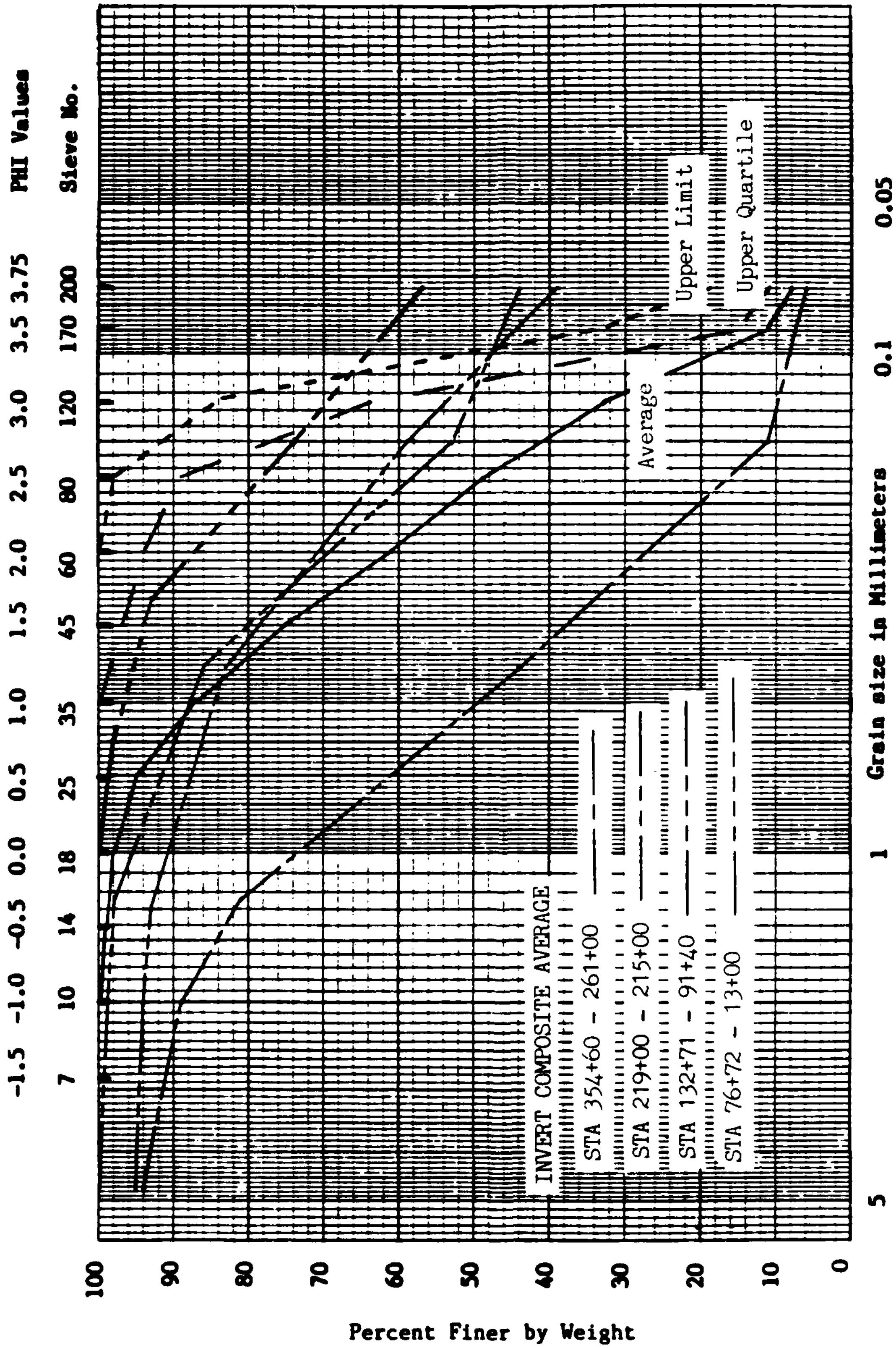


FIGURE 7 (CONT.)

Lower Santa Ana River
Beach Compatibility
Composite Beach Gradations

STA 840+44 - 899+53



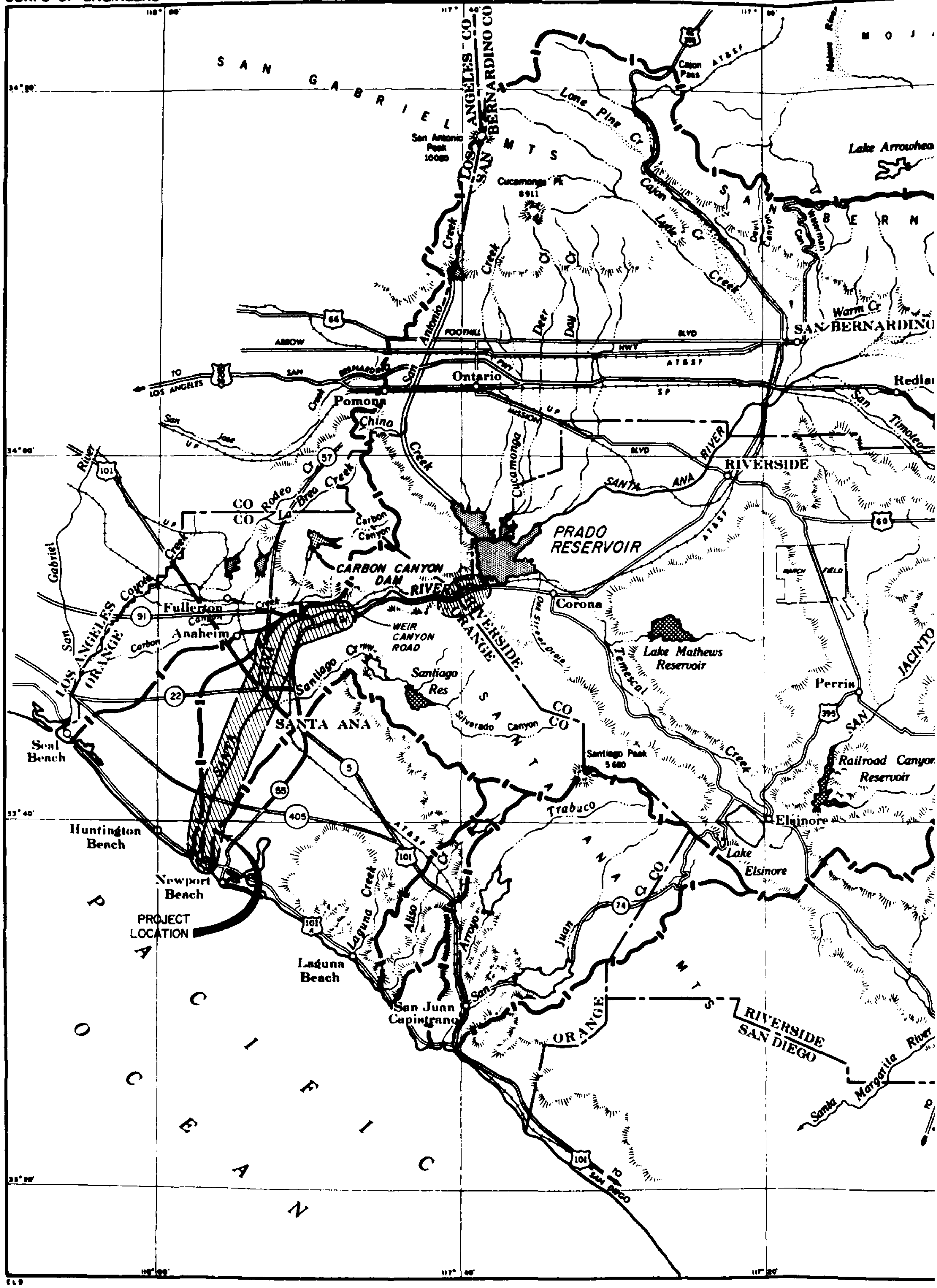
F7.10

FIGURE 7 (CONT.)

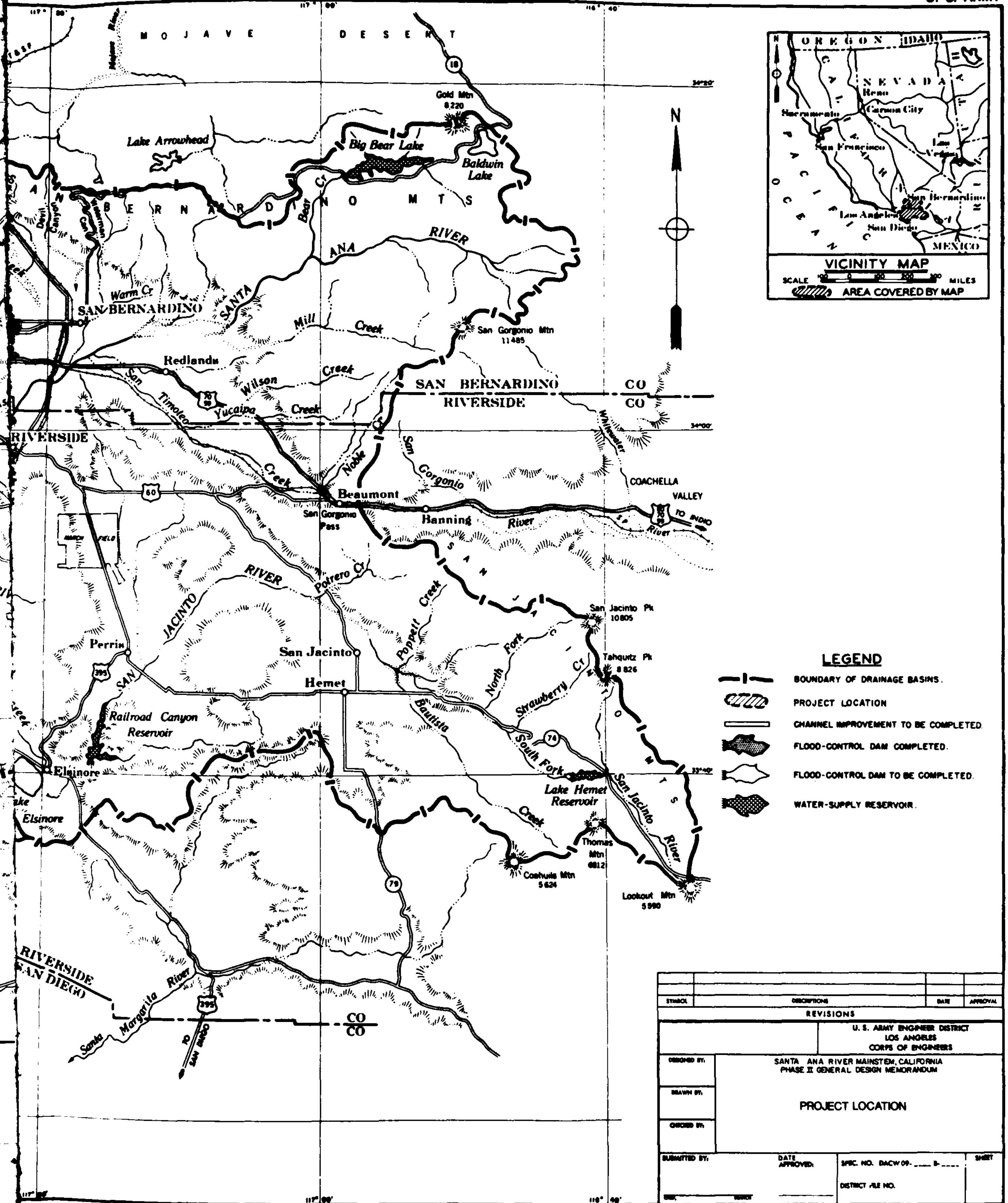
A GEOTECHNICAL

PLATES

CORPS OF ENGINEERS



U. S. ARMY



SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

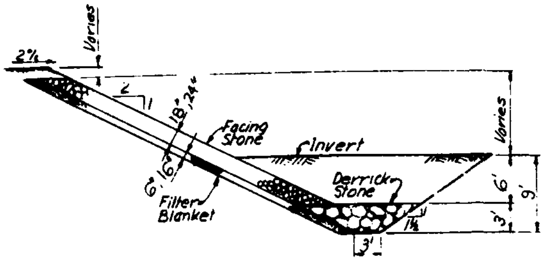
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PROJECT LOCATION

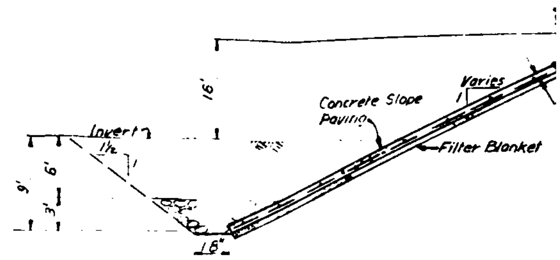
SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

DISTRICT FILE NO.

PLATE 1



WEIR CANYON ROAD TO KATELLA AVENUE
NOT TO SCALE



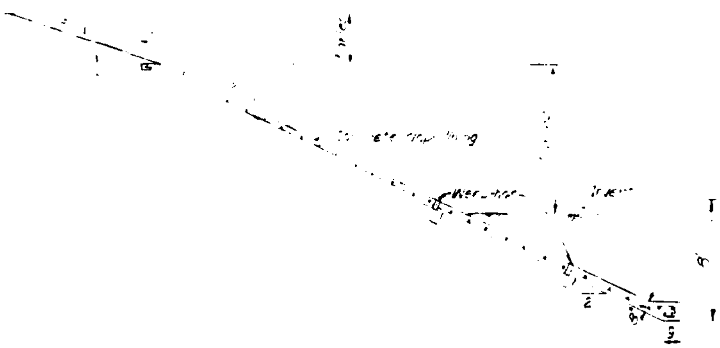
KATELLA AVENUE TO GARDEN GROVE FREEWAY
STA 702 TO STA 697
NOT TO SCALE

LIMITED EXISTING IMPROVEMENT

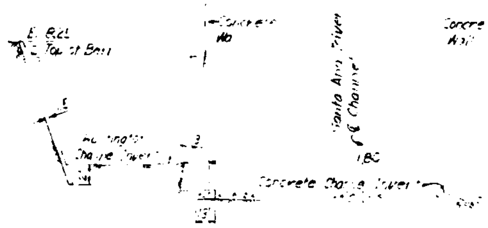
- PIPE AND WIRE FENCING.
- TURF STABILIZED EMBANKMENTS.

GARDEN GROVE FREEWAY TO 17TH STREET

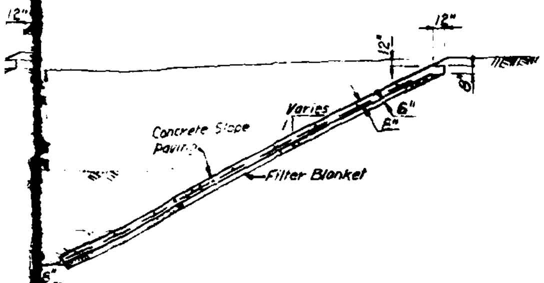
ADAMS AVENUE TO PACIFIC OC
STA. 164 TO STA. 20
NOT TO SCALE



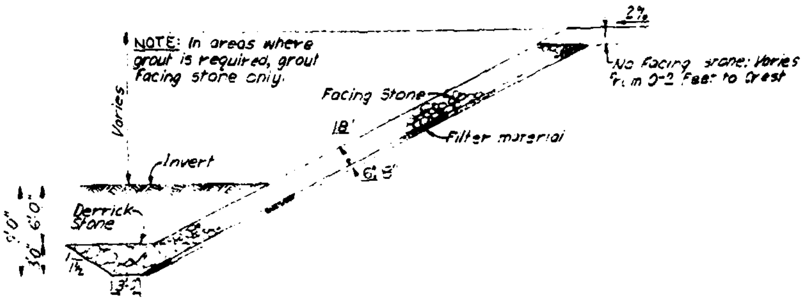
17TH STREET TO ADAMS AVENUE
NOT TO SCALE



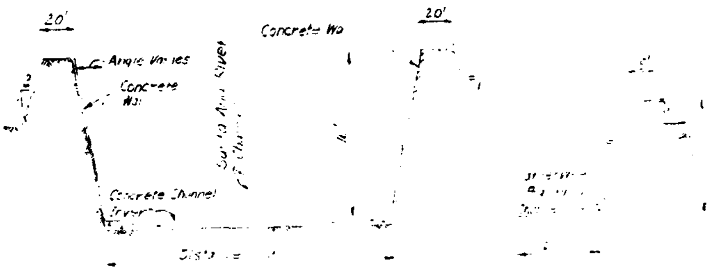
ADAMS AVENUE TO PACIFIC OC
STA. 14 TO STA. 7
NOT TO SCALE



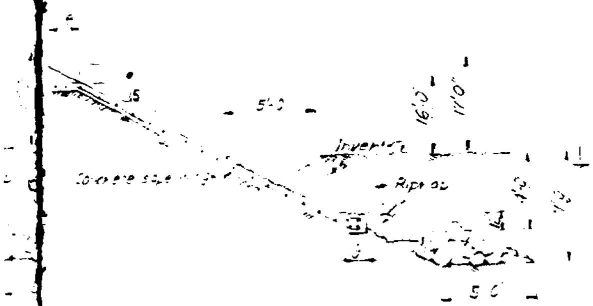
AVENUE TO GARDEN GROVE FREEWAY
STA 702 TO STA 697
NOT TO SCALE



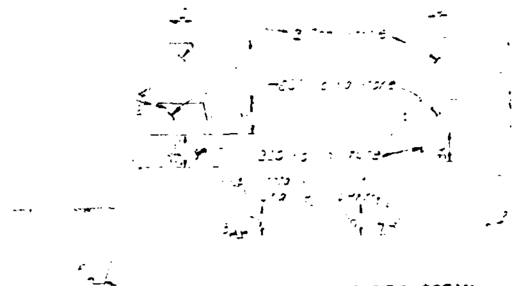
KATELLA AVENUE TO GARDEN GROVE FREEWAY
NOT TO SCALE



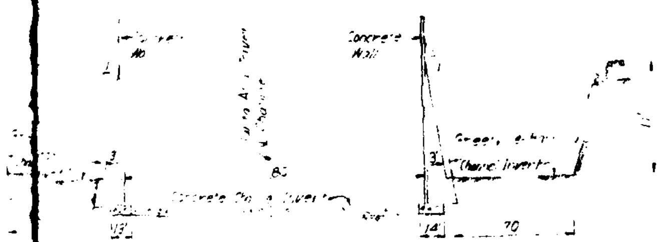
ADAMS AVENUE TO PACIFIC OCEAN
STA. 20 TO STA 14
NOT TO SCALE



ADAMS AVENUE TO PACIFIC OCEAN
STA 164 TO STA 20
NOT TO SCALE



ADAMS AVENUE TO PACIFIC OCEAN
STA. 7 TO END
NOT TO SCALE



ADAMS AVENUE TO PACIFIC OCEAN
STA 14 TO STA 7
NOT TO SCALE

NOTE:
SEE TABLE 1 FOR SPECIFIC EXISTING CONDITION INFORMATION.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

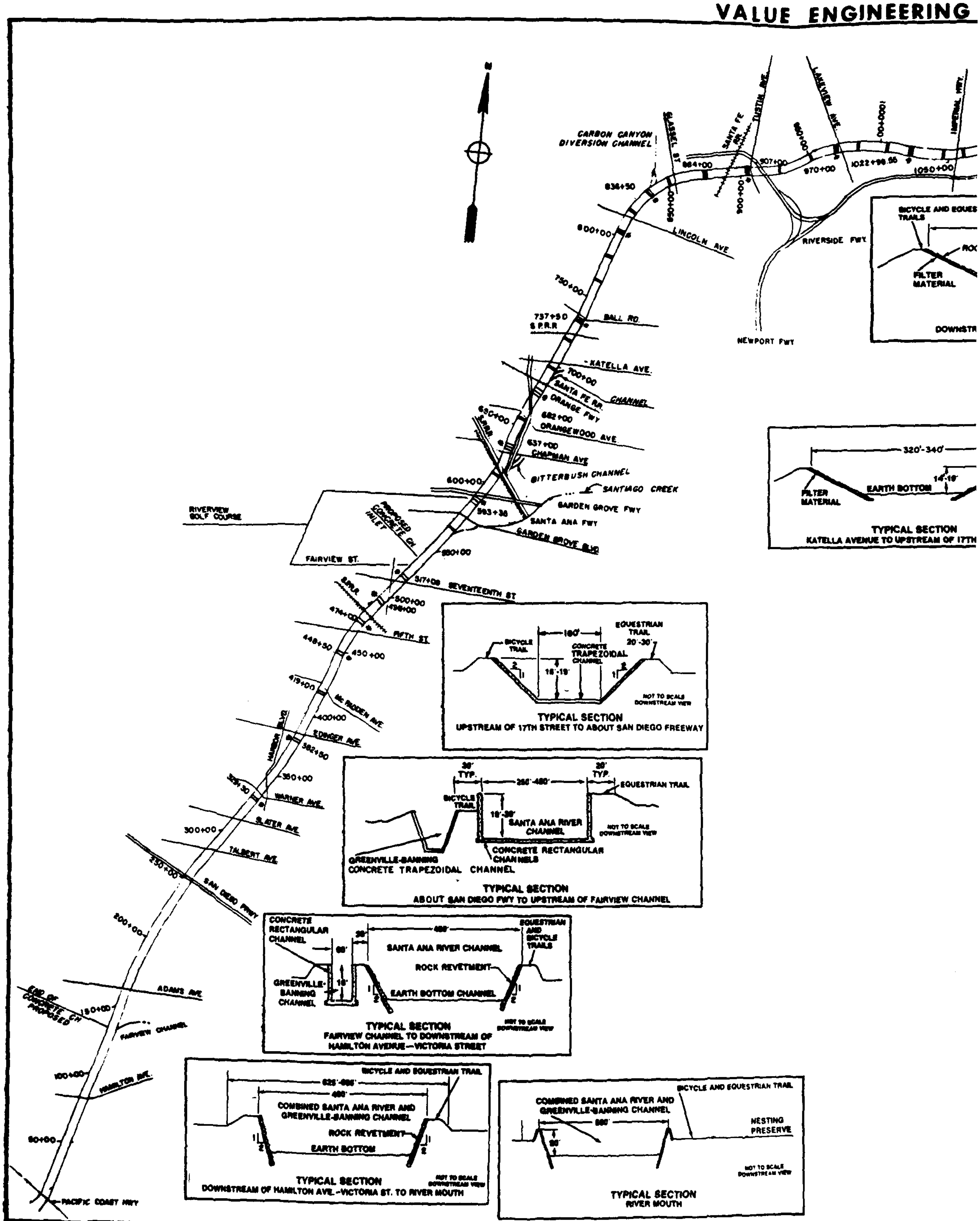
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

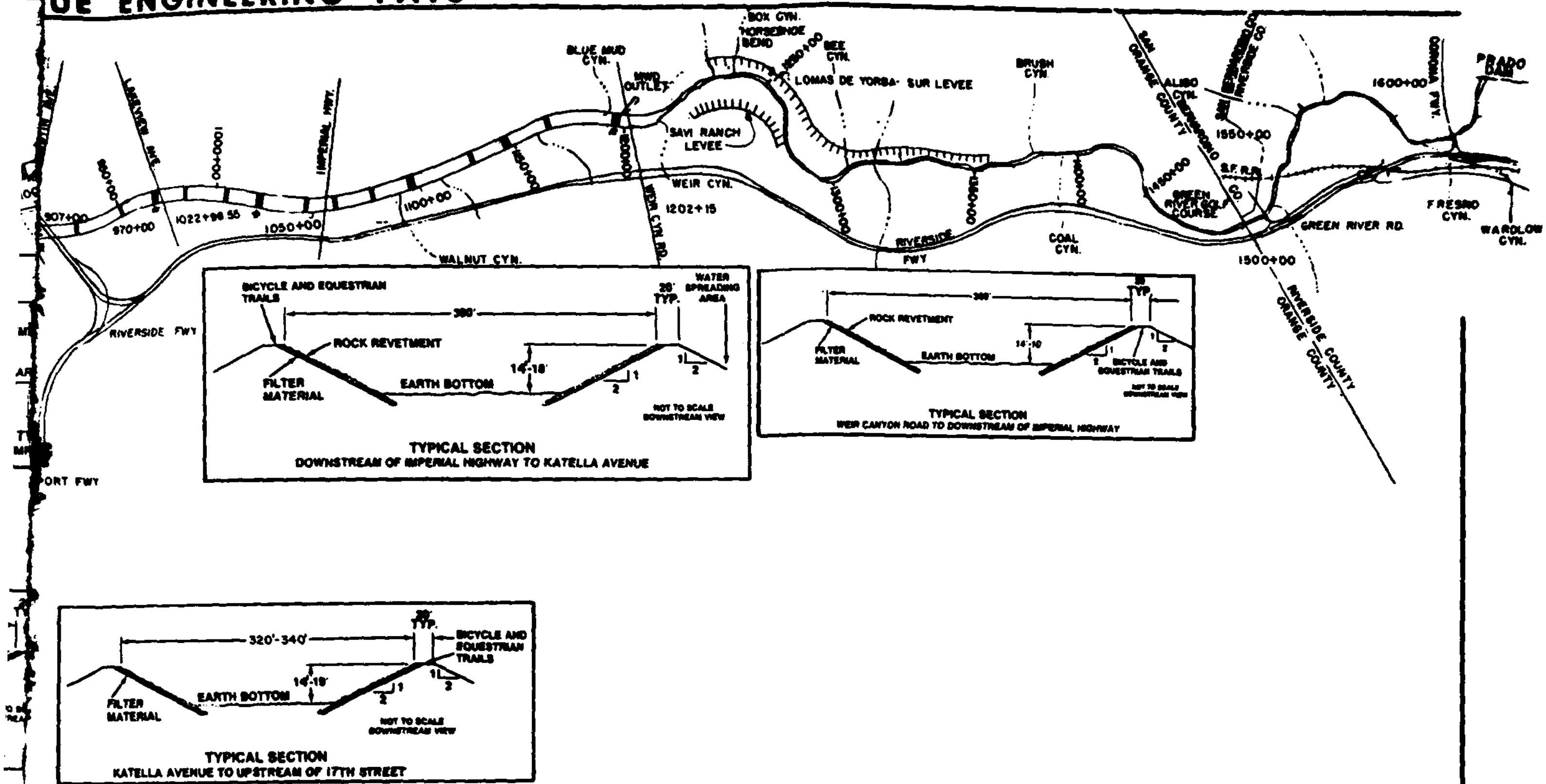
EXISTING CONDITION
TYPICAL DETAILS

DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09- ____ - ____
SHEET
DISTRICT FILE NO.

PLATE 2


CARBON CANYON DIVERSION CHANNEL
GLASSEL ST
SANTA FE RR
TUSTIN AVE
LAKEVIEW AVE
IMPERIAL HWY
834+50
864+00
907+00
970+00
1022+96.55
1050+00
800+00
LINCOLN AVE
RIVERSIDE FWY
NEWPORT FWY
750+00
737+50 S.P.R.R
BALL RD.
KATELLA AVE.
700+00
SANTA FE RR.
CHANNEL
ORANGE FWY
682+00
ORANGEWOOD AVE
650+00
637+00
CHAPMAN AVE
BITTERBUSH CHANNEL
600+00
SANTIAGO CREEK
GARDEN GROVE FWY
563+38
SANTA ANA FWY
GARDEN GROVE BLVD
RIVERVIEW GOLF COURSE
PROPOSED CONCRETE CH. INLET
FAIRVIEW ST.
550+00
517+00 SEVENTEENTH ST
S.P.R.R.
500+00
496+00
474+00
FIFTH ST
448+50
450+00
419+00
McFADDEN AVE
400+00
HARBOR BLVD
EDINGER AVE
382+50
350+00
WARNER AVE
SLATER AVE
300+00
TALBERT AVE
250+00
SAN DIEGO FWY
200+00
ADAMS AVE
END OF CONCRETE CH PROPOSED
150+00
FAIRVIEW CHANNEL
100+00
HAMILTON AVE.
50+00
PACIFIC COAST HWY
BICYCLE AND EQUESTRIAN TRAILS
FILTER MATERIAL
DOWNSTR
320'-340'
FILTER MATERIAL
EARTH BOTTOM
14'-19'
TYPICAL SECTION
KATELLA AVENUE TO UPSTREAM OF 17TH
BICYCLE TRAIL
180'
EQUESTRIAN TRAIL 20'-30'
CONCRETE TRAPEZOIDAL CHANNEL
16'-19'
NOT TO SCALE DOWNSTREAM VIEW
TYPICAL SECTION
UPSTREAM OF 17TH STREET TO ABOUT SAN DIEGO FREEWAY
30' TYP.
30' TYP.
EQUESTRIAN TRAIL
BICYCLE TRAIL
18'-30'
SANTA ANA RIVER CHANNEL
NOT TO SCALE DOWNSTREAM VIEW
CONCRETE RECTANGULAR CHANNELS
GREENVILLE-BANNING CONCRETE TRAPEZOIDAL CHANNEL
TYPICAL SECTION
ABOUT SAN DIEGO FWY TO UPSTREAM OF FAIRVIEW CHANNEL
CONCRETE RECTANGULAR CHANNEL
480'
SANTA ANA RIVER CHANNEL
EQUESTRIAN AND BICYCLE TRAILS
ROCK REVETMENT
GREENVILLE-BANNING CHANNEL
EARTH BOTTOM CHANNEL
TYPICAL SECTION
FAIRVIEW CHANNEL TO DOWNSTREAM OF HAMILTON AVENUE—VICTORIA STREET
NOT TO SCALE DOWNSTREAM VIEW
BICYCLE AND EQUESTRIAN TRAIL
COMBINED SANTA ANA RIVER AND GREENVILLE-BANNING CHANNEL
ROCK REVETMENT
EARTH BOTTOM
TYPICAL SECTION
DOWNSTREAM OF HAMILTON AVE.-VICTORIA ST. TO RIVER MOUTH
NOT TO SCALE DOWNSTREAM VIEW
BICYCLE AND EQUESTRIAN TRAIL
COMBINED SANTA ANA RIVER AND GREENVILLE-BANNING CHANNEL
NESTING PRESERVE
NOT TO SCALE DOWNSTREAM VIEW
TYPICAL SECTION
RIVER MOUTH

UE ENGINEERING PAYS



LEGEND

STABILIZER ■ EXISTING
DROP STRUCTURE ■ EXISTING
EXISTING LEVEE (SLOPING TOWARD RIVER)
TRIBUTARY

APPROXIMATE PLAN SCALE
0 5000 10000 FT

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

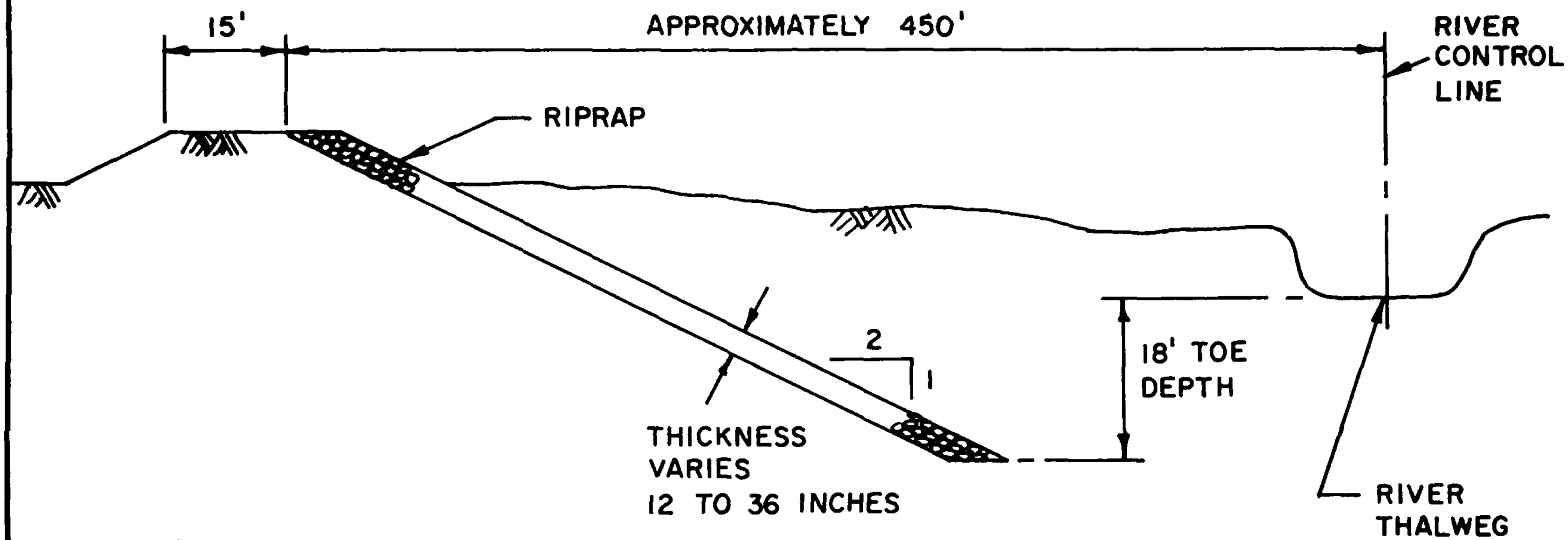
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PROPOSED IMPROVEMENTS
TYPICAL DETAILS

SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW 09- ___ B- ___
DISTRICT FILE NO.
SHEET

SAFETY PAYS

PLATE 3



TYPICAL SECTION

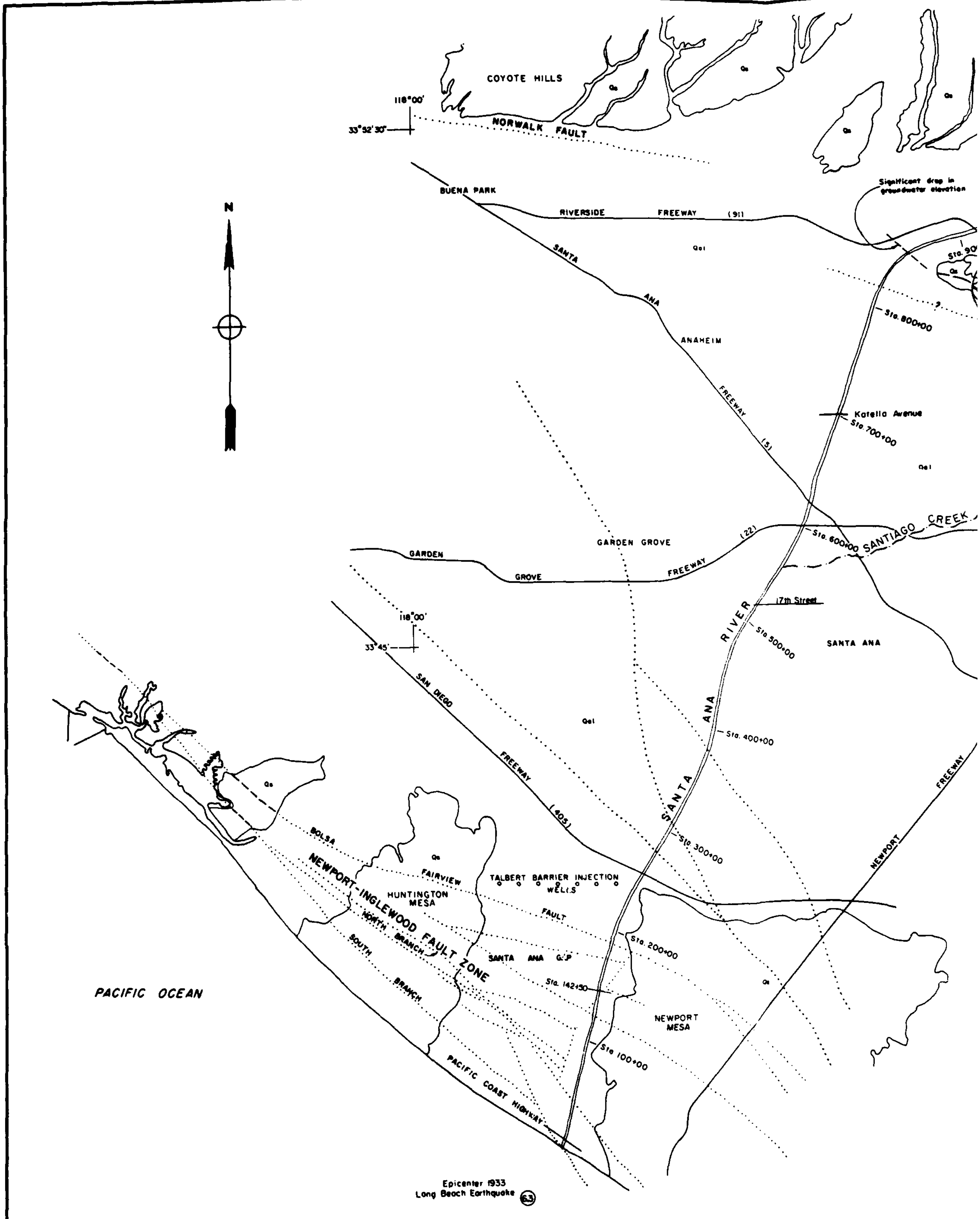
NOT TO SCALE

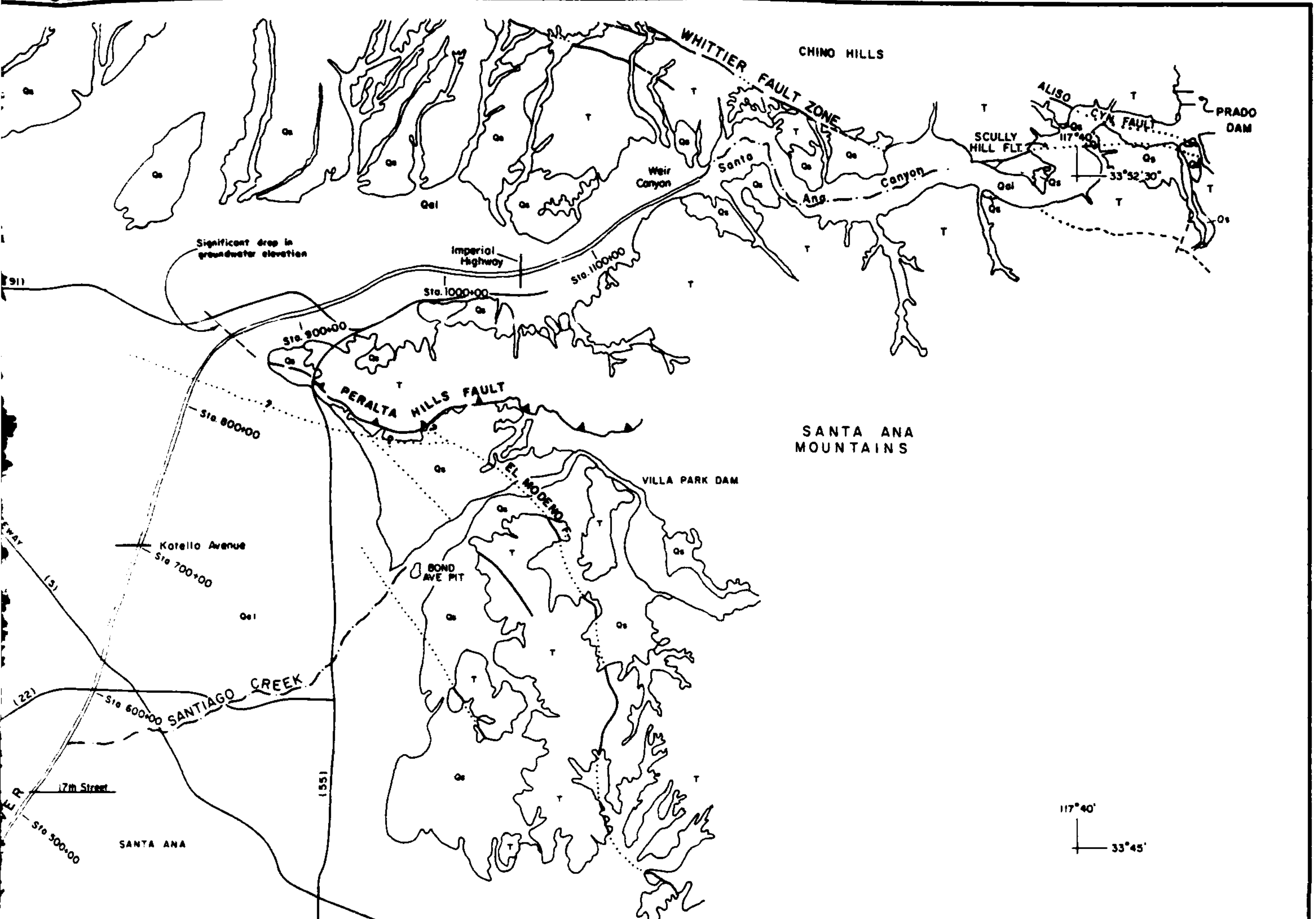
GREEN RIVER GOLF COURSE

LOWER SANTA ANA RIVER

PROPOSED IMPROVEMENT
SANTA ANA CANYON

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT


COYOTE HILLS
118°00'
33°52'30"
NORWALK FAULT
Significant drop in groundwater elevation
BUENA PARK
RIVERSIDE FREEWAY (91)
SANTA ANA
ANAHEIM
FREEWAY (5)
N
Sta. 800+00
Katella Avenue
Sta. 700+00
GARDEN GROVE
GARDEN GROVE FREEWAY (22)
Sta. 600+00
SANTIAGO CREEK
17th Street
118°00'
33°45'
SANTA ANA RIVER
Sta. 500+00
SANTA ANA
SAN DIEGO FREEWAY (405)
Sta. 400+00
Sta. 300+00
NEWPORT FREEWAY
BOLSA
FAIRVIEW
TALBERT BARRIER INJECTION WELLS
HUNTINGTON MESA
FAULT
NEWPORT-INGLEWOOD FAULT ZONE
NORTH BRANCH
SOUTH BRANCH
SANTA ANA GAP
Sta. 200+00
Sta. 142+50
NEWPORT MESA
Sta. 100+00
PACIFIC OCEAN
PACIFIC COAST HIGHWAY
Epicenter 1933
Long Beach Earthquake
63



LEGEND

T	Tertiary and pre-tertiary formations
Qs	Pleistocene sediments
Qal	Recent alluvium
	Fault, dashed where approximately located, dotted where inferred or concealed
	Thrust fault

NOTES

1. Base map and geology after Morton and Miller (1981), Schoellhamer and others (1981), and Durham and Yerkes (1964).
2. Location of Peralta Hills Fault from Bryant and Fife (1982).

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

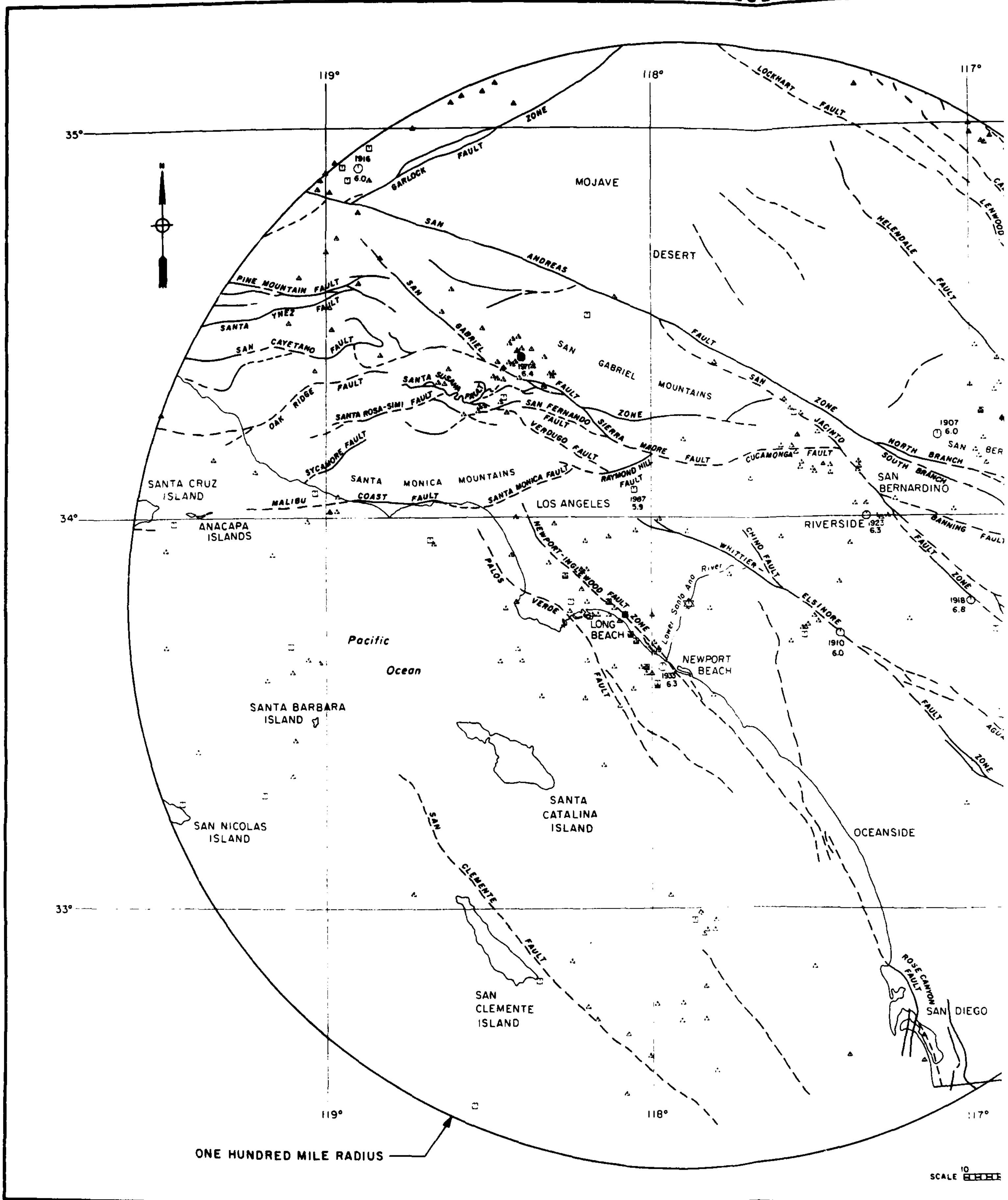
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

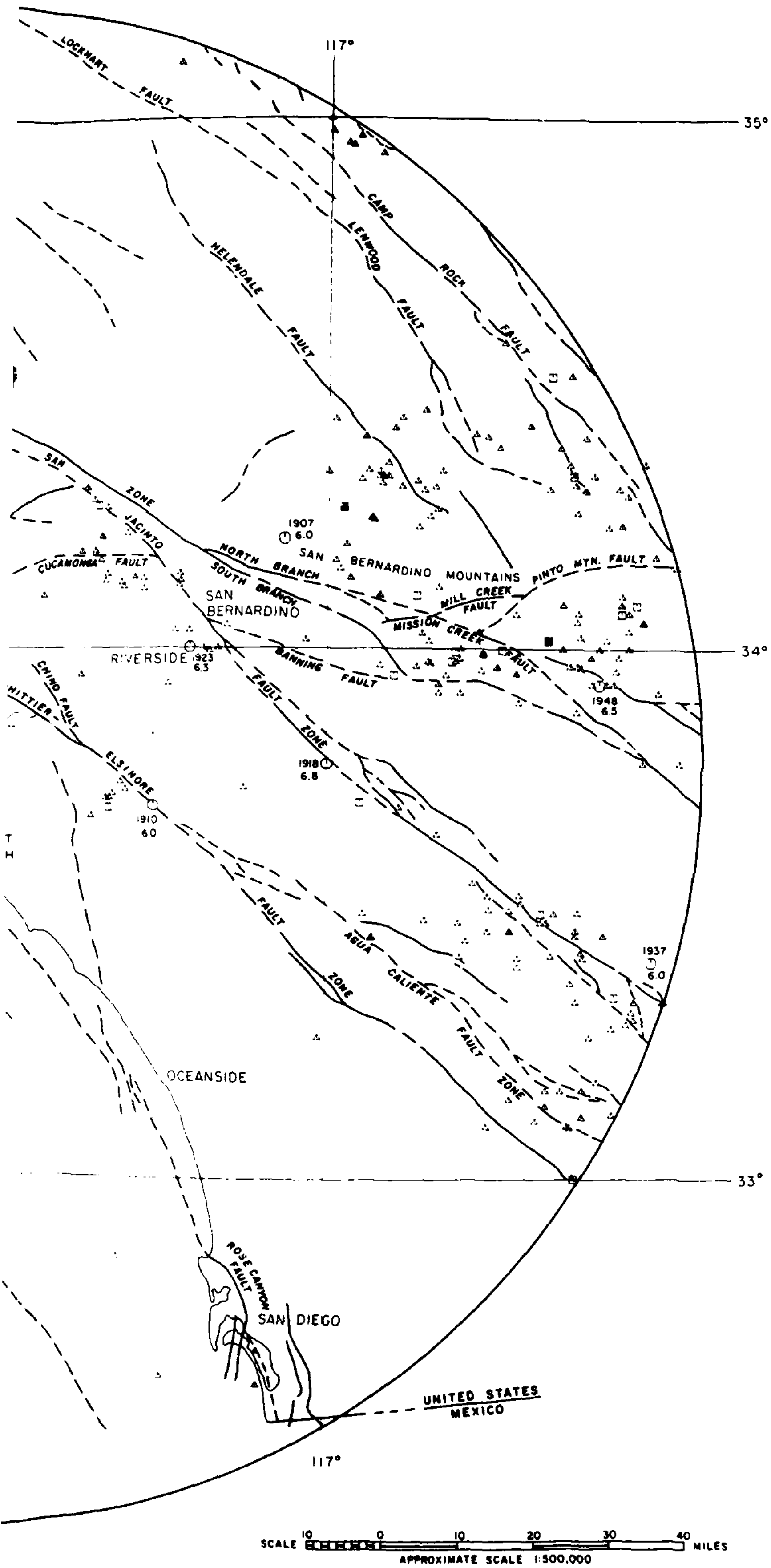
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

GENERAL SITE GEOLOGY
PLAN

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET
DISTRICT FILE NO.



119°
118°
117°
35°
34°
33°
N
MOJAVE
DESERT
SAN ANDREAS FAULT ZONE
GARLOCK FAULT
ZONE
LOCKHART FAULT
HELENDALE FAULT
LENWOOD
1916 6.0
PINE MOUNTAIN FAULT
SANTA YNEZ FAULT
SAN CAYETANO FAULT
SAN GABRIEL
SAN GABRIEL MOUNTAINS
SAN GABRIEL FAULT
OAK RIDGE FAULT
SANTA SUSANA FAULT
1971 6.4
SANTA ROSA-SIMI FAULT
SAN FERNANDO FAULT
VERDUGO FAULT
SIERRA MADRE FAULT ZONE
CUCAMONGA FAULT
SAN JACINTO FAULT ZONE
NORTH BRANCH
SOUTH BRANCH
1907 6.0
SAN BERNARDINO
SYCAMORE FAULT
SANTA MONICA MOUNTAINS
SANTA MONICA FAULT
RAYMOND HILL FAULT
1987 5.9
MALIBU COAST FAULT
SANTA CRUZ ISLAND
ANACAPA ISLANDS
LOS ANGELES
RIVERSIDE
1923 6.3
BANNING FAULT
NEWPORT-INGLEWOOD FAULT ZONE
PALOS VERDE
CHINO FAULT
WHITTIER
ELSINORE FAULT ZONE
Lower Santa Ana River
1918 6.8
1910 6.0
LONG BEACH
NEWPORT BEACH
1933 6.3
Pacific Ocean
FAULT
SANTA BARBARA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE FAULT
OCEANSIDE
SAN CLEMENTE ISLAND
ROSE CANYON FAULT
SAN DIEGO
ONE HUNDRED MILE RADIUS
SCALE
10



LEGEND

- △ EARTHQUAKE WITH MAGNITUDE 4.0 THRU 4.99
- ⊡ EARTHQUAKE WITH MAGNITUDE 5.0 THRU 5.99
- ⊙ EARTHQUAKE WITH MAGNITUDE 6.0 THRU 6.99
- ✡ LOCATION OF PROJECT AREA
- TRACE OF FAULT DASHED WHERE INFERRED OR CONCEALED

NOTES:

1. Richter scale magnitudes are a measure of the energy released at the focus (center of the earthquake) as determined by the amplitudes produced on a seismogram.
2. The epicenter is the point on the earth's surface directly above the focus.
3. Earthquake epicenters plotted are from 1932 to 1987, unless earlier dates are shown.
4. Base map modified from state of California (South Half) 1:500,000 topographic map, United States Geological Survey, 1981.
5. Locations of faults are approximate. Data derived from various California Division of Mines and Geology and United States Geological Survey publications.
6. Earthquake epicenter locations are from California Institute of Technology's seismologic data base for Southern California, Nevada, and Arizona; from Toppozada and others (1981), and from Toppozada and Parke (1982).

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
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CHECKED BY:

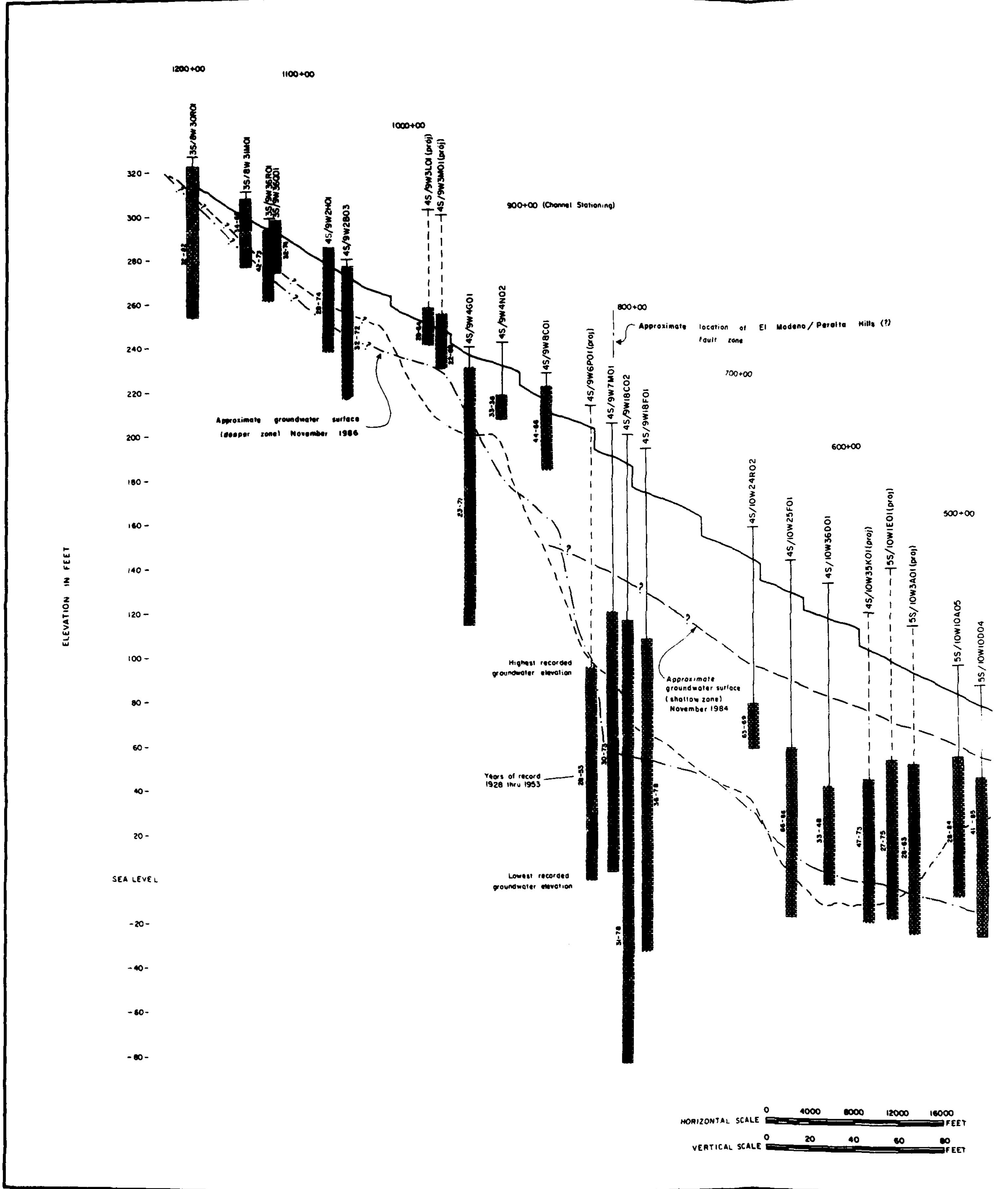
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

EARTHQUAKE EPICENTER AND
FAULT LOCATION MAP

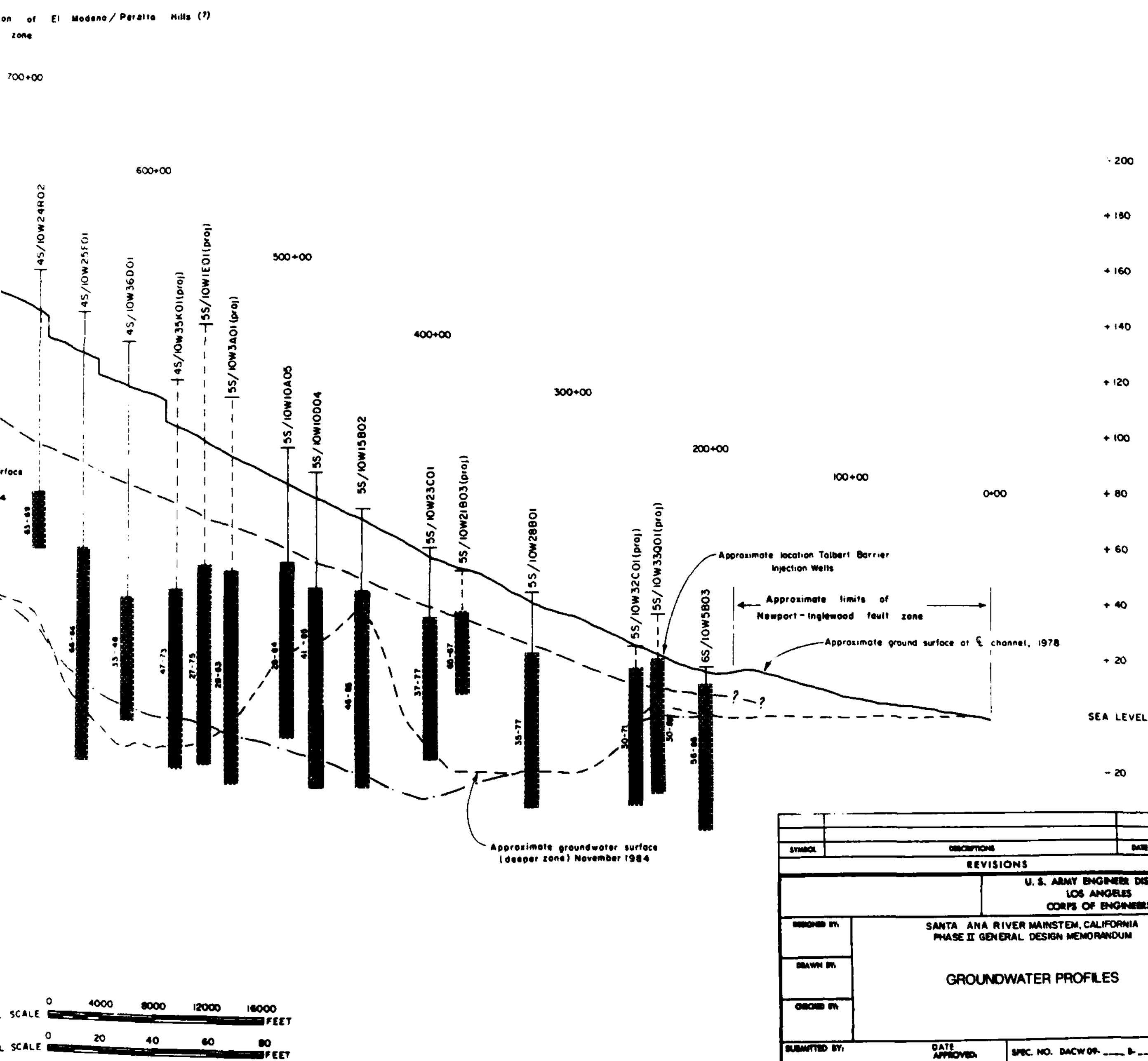
SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-___ B-____ SHEET

DISTRICT FILE NO.

PLATE 5


1200+00
1100+00
1000+00
900+00 (Channel Stationing)
800+00
700+00
600+00
500+00
3S/8W 30R01
3S/8W 31M01
3S/9W 36R01
3S/9W 36Q01
4S/9W2H01
4S/9W2B03
4S/9W3L01 (proj)
4S/9W3M01 (proj)
4S/9W4G01
4S/9W4N02
4S/9W8C01
4S/9W6P01 (proj)
4S/9W7M01
4S/9W18C02
4S/9W18F01
4S/10W24R02
4S/10W25F01
4S/10W36D01
4S/10W35K01 (proj)
5S/10W1E01 (proj)
5S/10W3A01 (proj)
5S/10W10A05
5S/10W10D04
Approximate location of El Modeno / Peralta Hills (?) Fault zone
Approximate groundwater surface (deeper zone) November 1986
Approximate groundwater surface (shallow zone) November 1984
Highest recorded groundwater elevation
Years of record 1928 thru 1953
Lowest recorded groundwater elevation
ELEVATION IN FEET
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
SEA LEVEL
-20
-40
-60
-80
HORIZONTAL SCALE 0 4000 8000 12000 16000 FEET
VERTICAL SCALE 0 20 40 60 80 FEET

ALUE ENGINEERING PAYS



SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

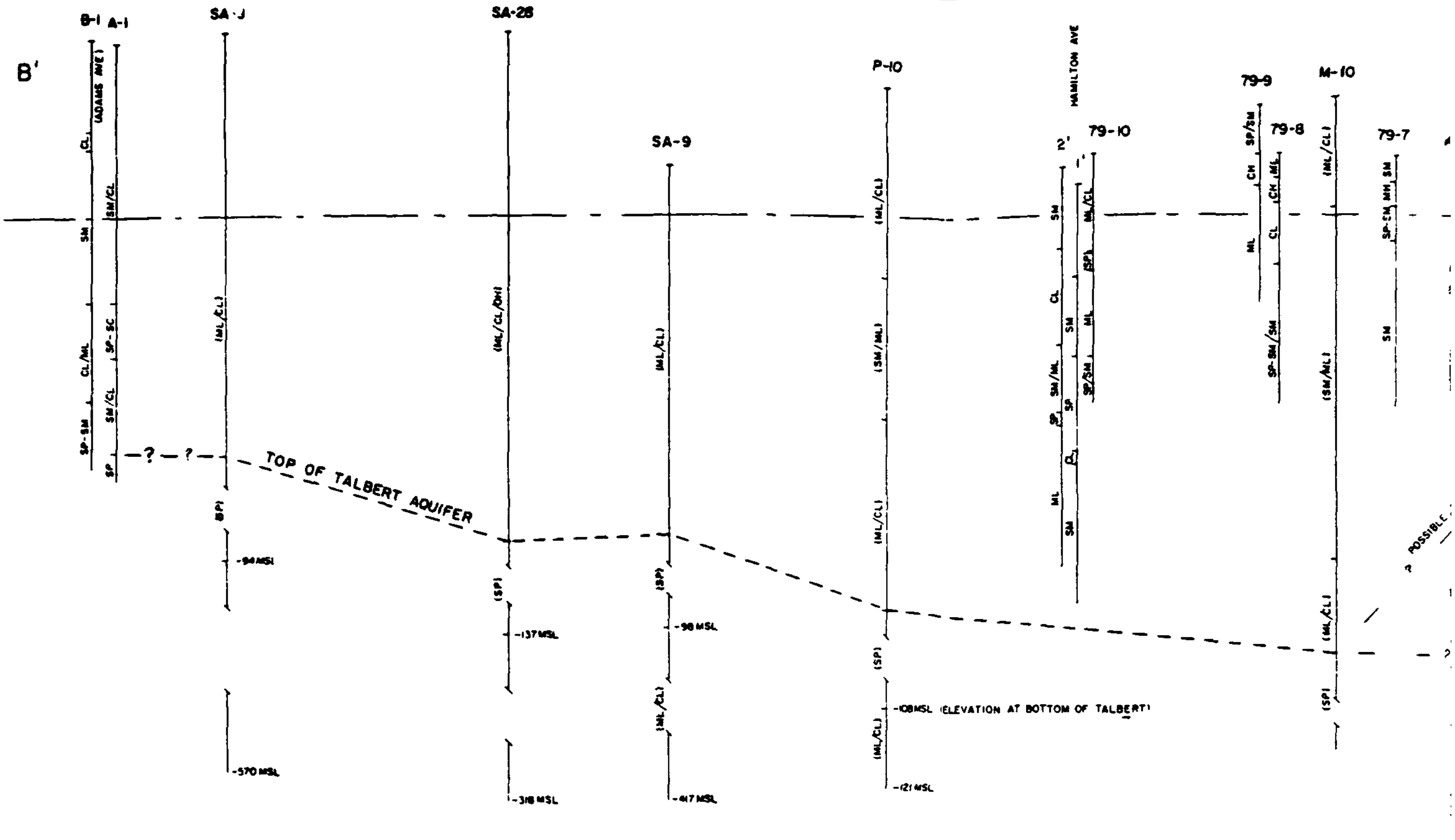
GROUNDWATER PROFILES

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-___ B-___ | SHEET

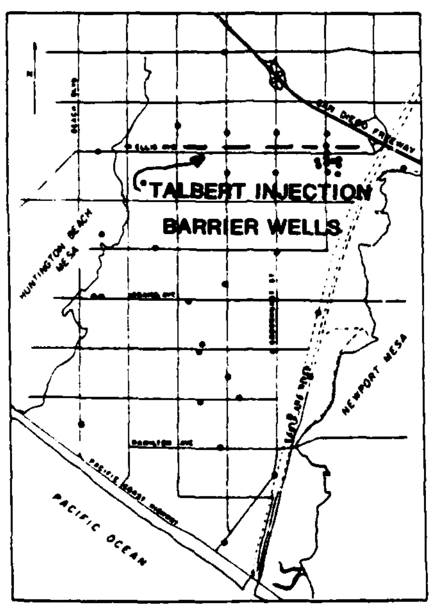
DISTRICT FILE NO.

PLATE 6

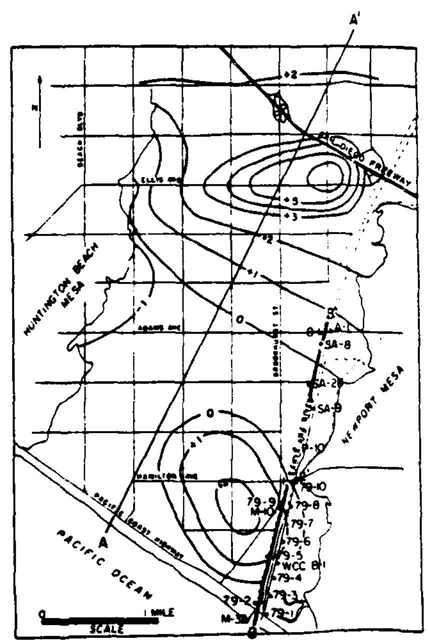
SAFETY PAYS



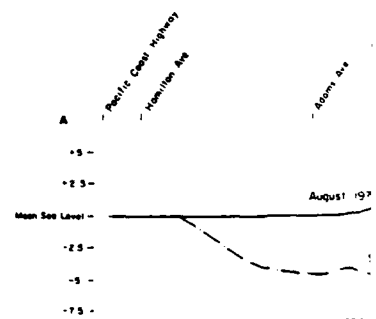
SECTION B-B'



GROUNDWATER MONITORING LOCATIONS



TALBERT AQUIFER WATER LEVEL
AUGUST 1979
LOCATION OF WELLS AND BORINGS



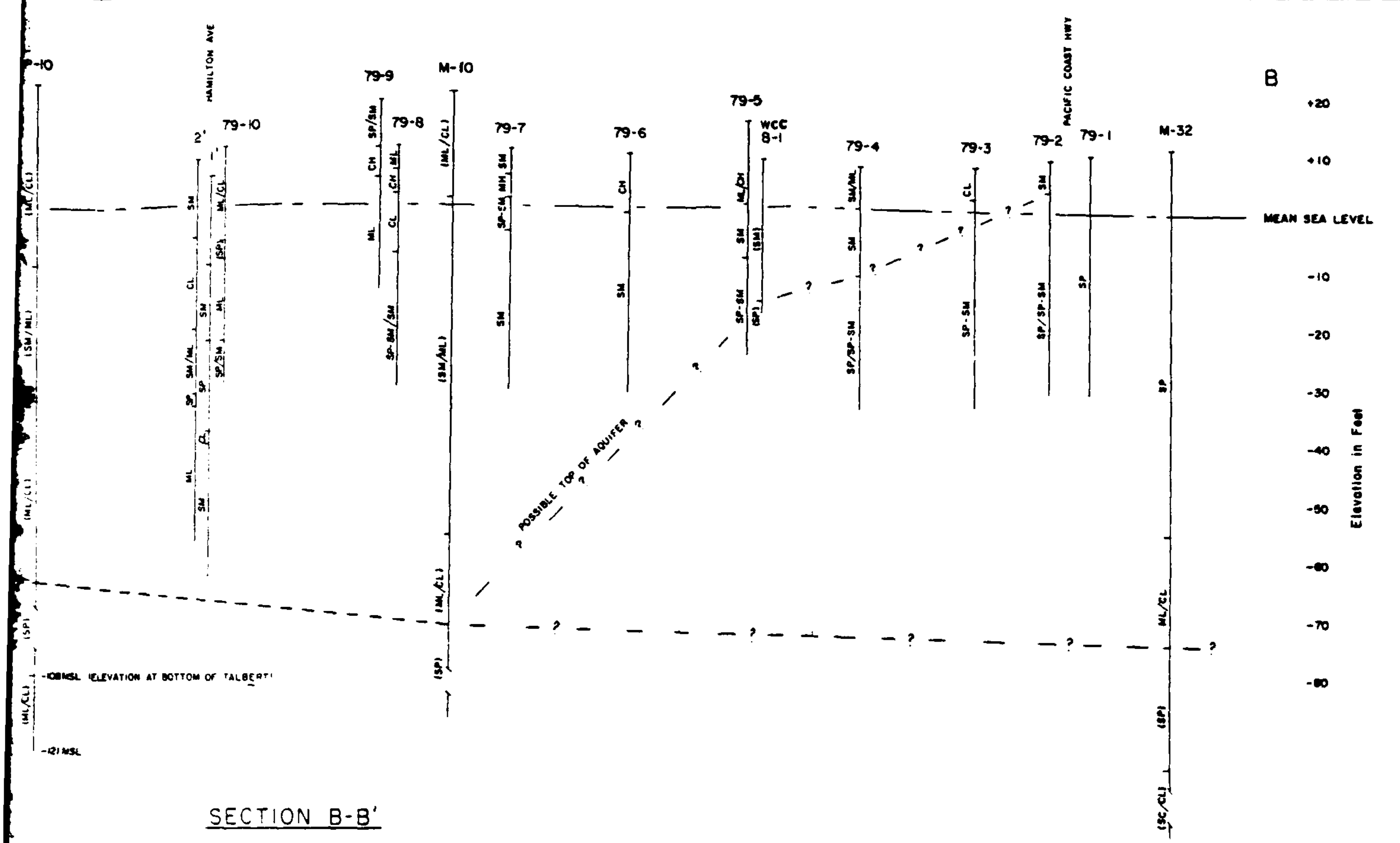
pre-construction profil

PIEZOMETRIC P
TALBERT AQ
A-A'

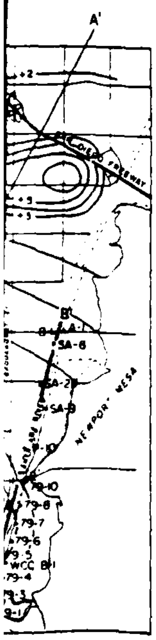
NOTE:

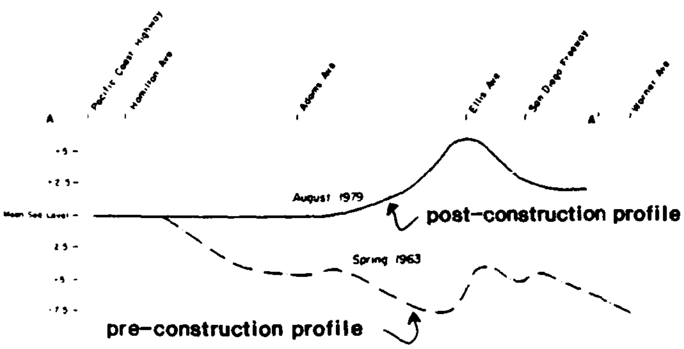
The Talbert Barrier Project, c

sea water intrusion from ex



SECTION B-B'





PIEZOMETRIC PROFILES
TALBERT AQUIFER
A-A'

NOTE:

The Talbert Barrier Project, constructed in 1975, prevents sea water intrusion from extending past Ellis Avenue.

NOTES

1. Soils borings 79-1 thru 79-10 by U.S. Army Corps of Engineers, 1979.
2. Soils boring WCC B-1 by Woodward Clyde Consultants.
3. Exploratory wells W-30, P-10, SA-9, SA-2B and SA-8 were drilled for the California State Department of Water Resources.
4. Well W-32 was logged by Glenn A. Brown and Associates, 1971.
5. Soils borings 1', 2', A-1 and B-1 were engineering investigations for bridge crossings at Hamilton and Adams Avenues.
6. Soils are classified by the Unified Soils Classification System.
. Where soils symbols are in parentheses, (SP), the classification is based upon a visual description and not laboratory analysis.
4. Symbols separated by a slash, SW/ML, indicate interbedded soils or a composite description.
9. Groundwater contours and monitoring locations provided by the Orange County Water District.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

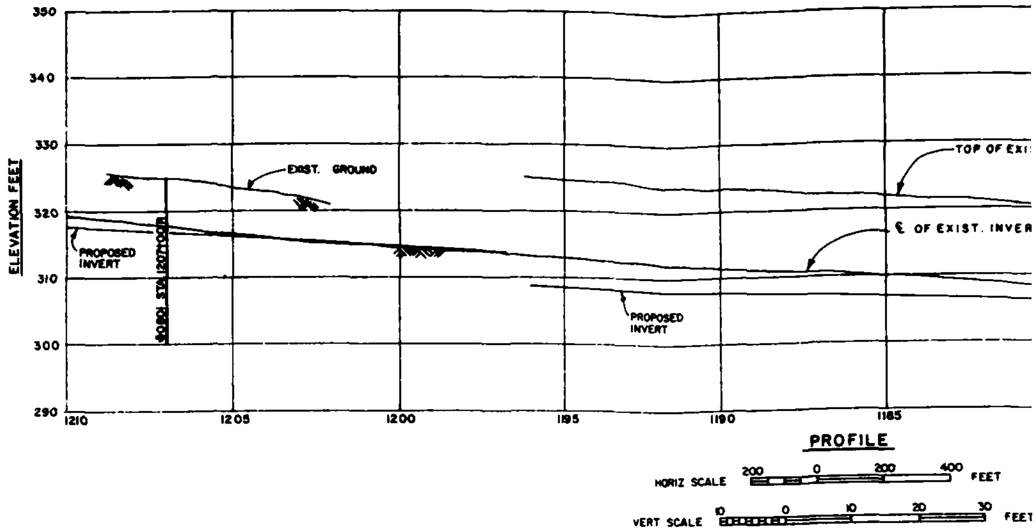
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER
SEAWATER INTRUSION

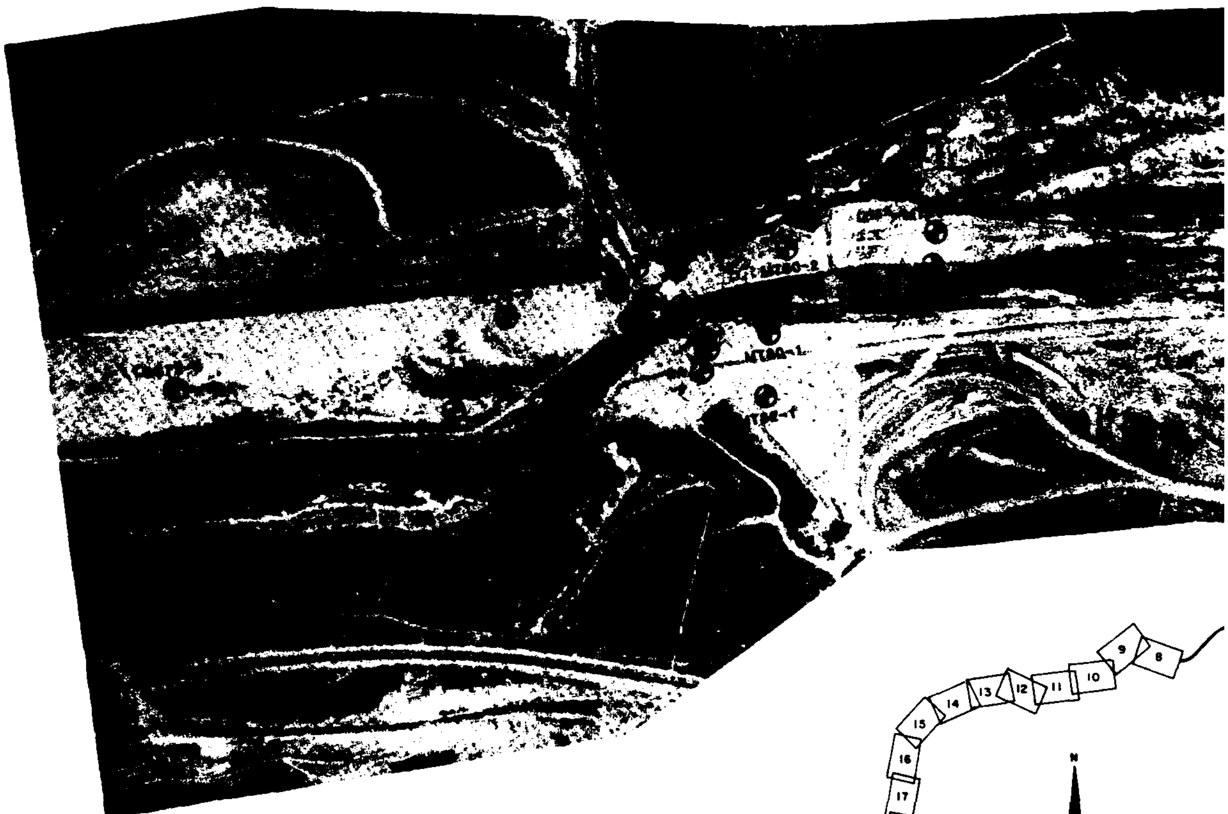
SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-___ B-____ SHEET

DISTRICT FILE NO.

VALUE ENGINEERING F

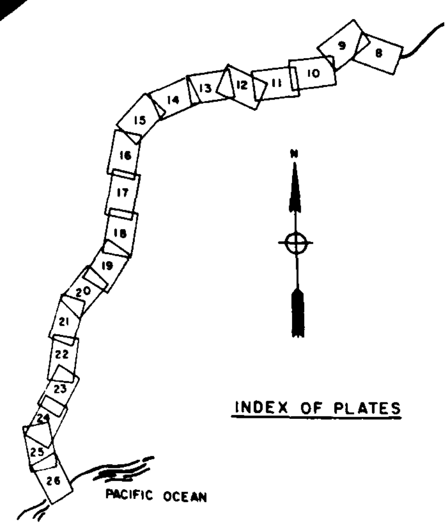


PROFILE

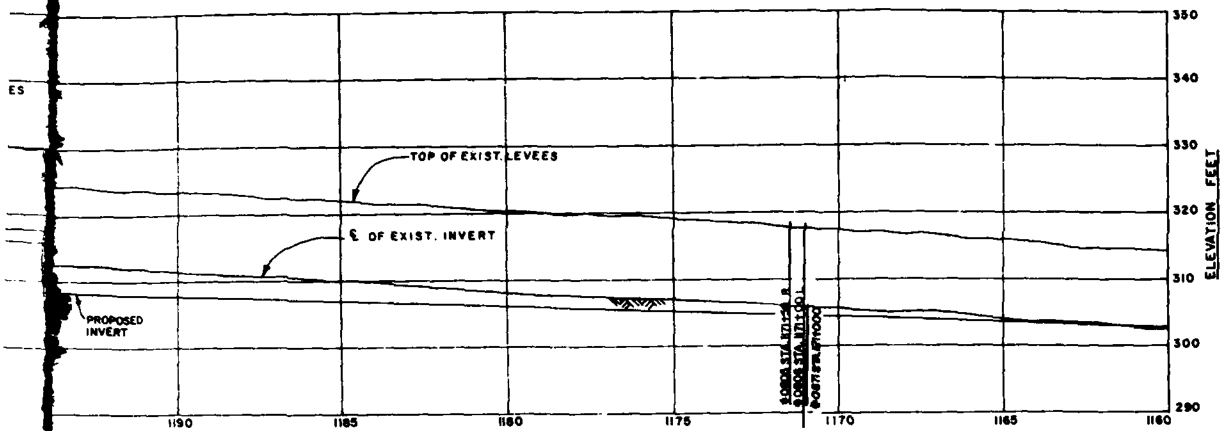


LEGEND

TH84-0801 ●	CORPS OF ENGINEERS TEST HOLE, YEAR AND NUMBER.
TT84-0871 ■	CORPS OF ENGINEERS TEST TRENCH, YEAR AND NUMBER.
GC72-8	TEST SITE BY OTHERS, YEAR AND NUMBER.



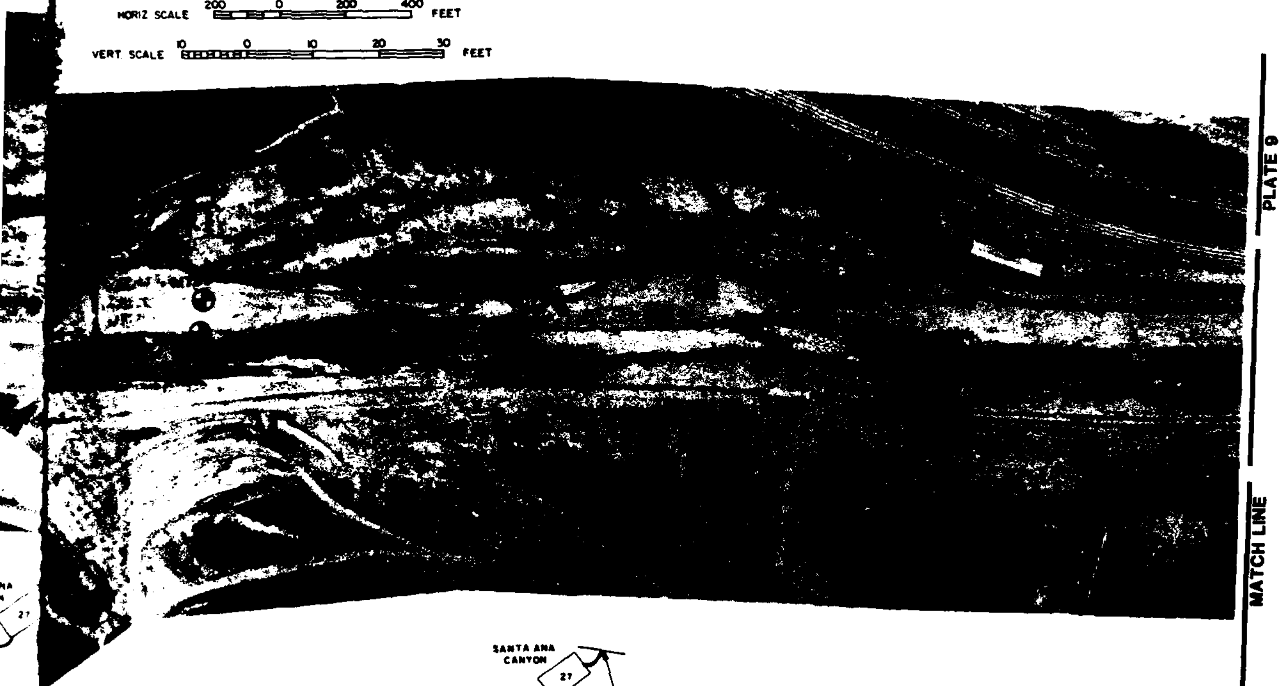
INDEX OF PLATES

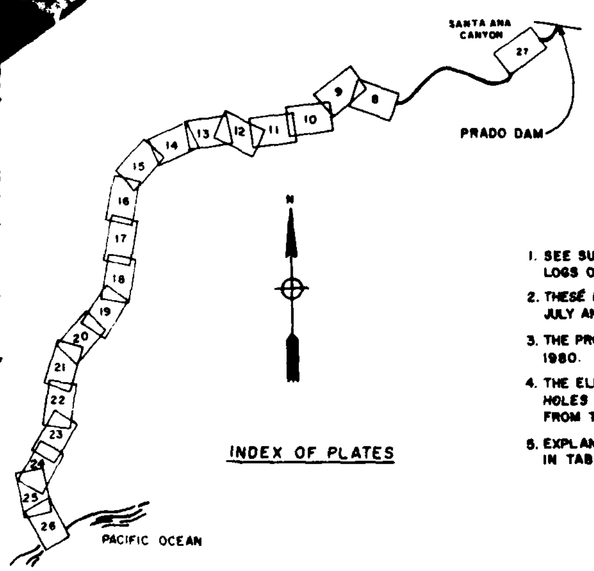


PROFILE

HORIZ SCALE 200 0 200 400 FEET

VERT SCALE 10 0 10 20 30 FEET





INDEX OF PLATES

GENERAL NOTES:

1. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATION
2. THESE REPRESENTATIVE PHOTOGRAPHS WERE TAKEN IN JULY AND AUGUST 1982.
3. THE PROFILE ELEVATIONS WERE DETERMINED IN SEPTEMBER 1980.
4. THE ELEVATIONS FOR THE CORPS OF ENGINEERS TEST HOLES AND TEST TRENCHES HAVE BEEN DETERMINED FROM THE 1980 PROFILE ELEVATIONS.
5. EXPLANATION FOR TEST SITES BY OTHERS ARE FOUND IN TABLES 4 AND 5.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE

STA.1210+00 TO STA.1160+00

SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09- ___ B-___
DISTRICT FILE NO.
SHEET

PLATE 8

TH84-0801

TH84-0801 STA 1207+00 R EL. 325±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP	2			95	3	15	SAND: WHITE, LOOSE TO MEDIUM DENSE, FINE GRAINED SAND.
3.0	SW				70	2	12	GRAVELLY SAND: SAME AS ABOVE WITH A FEW GRAVEL AND COBBLES TO 5 INCHES.
6.0	SP				95	4	11	SAND: MEDIUM BROWN, LOOSE TO MEDIUM DENSE, OCCASIONAL CLUMPS OF CLAYEY MATERIAL.
9.0	SM			NP	99	24	7	SILTY SAND: MEDIUM DARK BROWN, LOOSE, MEDIUM TO FINE GRAINED SAND.
12.0	SW				73	4	10	GRAVELLY SAND: MEDIUM BROWN, MULITCOLORED, LOOSE TO MEDIUM DENSE, MEDIUM TO COARSE GRAINED SAND, 10 PERCENT COBBLES TO 6 INCHES.
15.0	ML	40	41	15	99	70		SANDY SILT: DARK GREY-GREENISH, MEDIUM DENSE, NO GRAVEL, MODERATE PLASTICITY.
			38	7	100	67		SAME: WITH FREQUENT VEINS OF BRIGHT BROWN SILTY SAND THROUGHOUT.
21.0	SM		29	6	86	13	7	SILTY SAND: DARK GREY-GREENISH, MEDIUM DENSE, MODERATE PLASTICITY.
				NP	74	21	30	SILTY GRAVELLY SAND: DARK GREY-BROWN, MULTICOLORED, MEDIUM GRAINED SAND, FEW GRAVEL.
25.5								

TH84-0806

TH84-0806 STA 1171+00 L EL. 318±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	6		NP	73	21		SILTY GRAVELLY SAND: DARK BROWN, MOIST, LOOS DENSE, SOME COHESION, GRAVEL TO 1", COARSE GR SOME COBBLES.
3.0	SW/SM	4		NP	80	9	18	GRAVELLY SAND/ SILTY GRAVELLY SAND: BROWN, M GRAINED SAND, GRAVEL TO 1-1/2 INCHES, SOME CO
6.0	SP/SM			NP	66	5	31	SAME: GRAVEL TO 2 INCHES, 17 INCH BOULDER AT
9.0	SW/SM	4		NP	78	9	26	
12.0			40	7	95	41		SILTY SAND: BROWN, MOIST, FINE GRAINED SAND, COHESIVE.
			35	10	39	42	9	
	SM			NP	95	17		SAME: LIGHT GREY-BROWN, DAMP, DENSE TO VERY CEMENTED, FINE GRAINED SAND, ROCK AT 18'.
				NP	99	14	30R	REFUSAL AT 22.0 FEET DUE TO ROCK.
							R	REFUSAL AT 24.5 FEET DUE TO ROCK.
				NP	95	14	R	REFUSAL AT 27.0 FEET DUE TO ROCK.
30.0								

TH84-0805

TH84-0805 STA 1171+50 R EL. 318±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	GM			NP	52	13	30R	SILTY SANDY GRAVEL: DARK BROWN, MOIST, GRAVEL TO 3". REFUSAL AT 1.0' DUE TO ROCK.
3.0	SP/SM			NP	90	9	22	SAND/SILTY SAND: DARK BROWN, MOIST, FINE GRAINED SAND.
6.0	SW/SM			NP	92	5	23	SAME: VERY MOIST, FINE GRAINED SAND, GRAVEL TO 3/4".
9.0	SP/SM			NP	90	5	19	
12.0	SW				77	3	9	GRAVELLY SAND: DARK BROWN, VERY MOIST, COARSE GRAINED SAND, GRAVEL TO 3/4 INCHES, FEW COBBLES TO 9 INCHES, USED MUD FROM 15 FEET TO 30 FEET.
15.0	GP				34	1	15	SANDY GRAVEL: DARK BROWN, VERY MOIST, COARSE GRAINED SAND, COBBLES TO 6 INCHES, BOULDERS TO 14 INCHES.
					37	2		
21.0	SM			NP	96	35		SILTY SAND: DARK GREY, VERY MOIST, FINE SAND.
23.5	SW/SM			NP	75	6		GRAVELLY SAND/SILTY GRAVELLY SAND: DARK BROWN, VERY MOIST COARSE GRAINED SAND, GRAVEL TO 3/4 INCHES.
30.0								

TT84-0871

INVERT

TT84-0871 STA [illegible]71+00 [illegible] EL. 306±

DEPTH	LOG	MC	LL	PI	[illegible]	-200	N	[illegible]PTION
					[illegible]	[illegible]		SAND: TAN-BROWN, VERY [illegible] TURE, LOO
					3[illegible]	2		GRAVELLY SAND: GREY-BROWN, SOME MOISTURE, 6".
W 5.0	SP				51	1		SAME: GREY, GRAVEL TO 4 INCHES.
					92	1		SAND: SAME, COBBLES TO 10".
					97	2		GRAVELLY SAND: MULTICOLORED, SATURATED, C 15" BOULDER AT 14'
15.0					58	1		

TH84-0806

1+00 L — EL. 318±

-4	-200	N	DESCRIPTION
73	21		SILTY GRAVELLY SAND: DARK BROWN, MOIST, LOOSE TO MEDIUM DENSE, SOME COHESION, GRAVEL TO 1", COARSE GRAINED SAND, SOME COBBLES.
80	9	18	GRAVELLY SAND/ SILTY GRAVELLY SAND: BROWN, MOIST, COARSE GRAINED SAND, GRAVEL TO 1-1/2 INCHES, SOME COBBLES.
66	5	31	SAME: GRAVEL TO 2 INCHES, 17 INCH BOULDER AT 9 FEET.
78	9	25	
95	41		SILTY SAND: BROWN, MOIST, FINE GRAINED SAND, SLIGHTLY COHESIVE.
38	42	9	
95	17		SAME: LIGHT GREY-BROWN, DAMP, DENSE TO VERY DENSE, WELL CEMENTED, FINE GRAINED SAND, ROCK AT 18'.
99	14	30P	REFUSAL AT 2?.? FEET DUE TO ROCK.
		?	REFUSAL AT 24.5 FEET DUE TO ROCK.
95	14	?	REFUSAL AT ??.0 FEET DUE TO ROCK.

TT84-0871

?1+00 C — EL. 30?±

-4	-200	N	DESCRIPTION
3?	2		SAND: TAN-BROWN, VERY LITTLE MOISTURE, LOOSE.
30	2		GRAVELLY SAND: GREY-BROWN, SOME MOISTURE, SOME COBBLES 6".
51	2		SAME: GREY, GRAVEL TO 4 INCHES.
92	1		
			SAND: SAME, COBBLES TO 10".
37	2		
58	1		GRAVELLY SAND: MULTICOLORED, SATURATED, COBBLES TO 10", 15" BOULDER AT 14'

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS (More than half of material is larger than no. 200 sieve size.)	GRAVELS (More than half of coarse fraction is larger than no. 4 sieve size.)	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than half of coarse fraction is smaller than no. 4 sieve size.)	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS (More than half of material is smaller than no. 200 sieve size.)	SILTS AND CLAYS	Low liquid limit.	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts, with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays.
			OL	Organic silts and organic silty clays of low plasticity.
		High liquid limit.	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity.
			OH	Organic clays of medium to high plasticity, organic silts.
Highly organic soils			Pt	Peat and other highly organic soils.

NOTES:

1. Boundary Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example, GW-GC, well-graded gravel-sand mixture with clay binder.
2. All sieve sizes on this chart are U. S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus no. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart, and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. The Soil Classification System is based on the American Society for Testing and Materials (ASTM).
   a. (ASTM) D2487 Standard Test Method for Classification of Soils for Engineering Purposes.
   b. (ASTM) D2488 Standard Recommended Practice for Description of Soils (Visual Manual Procedure).
5. This Classification System is applicable to Corps of Engineers Logs Only

LEGEND:

TH84-0801	TEST HOLE, YEAR AND NUMBER
TT84-0871	TEST TRENCH, YEAR AND NUMBER
MC	FIELD MOISTURE CONTENT IN PERCENT OF DRY WEIGHT.
LL	LIQUID LIMIT.
PI	PLASTICITY INDEX (LIQUID LIMIT — PLASTIC LIMIT).
—4	PERCENT OF MATERIAL BY WEIGHT RETAINED ON NO. 4 SIEVE.
—200	PERCENT OF MATERIAL BY WEIGHT PASSING NO. 200 SIEVE.
N	NUMBER OF BLOWS BY A 140 POUND HAMMER FREE FALLING 30 INCHES REQUIRED TO DRIVE A STANDARD OPEN END SAMPLER SPOON ONE FOOT.
▼	OBSERVED WATER LEVEL

NOTES.

1. SEE PLATE 8 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
3. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL OR "EXISTING GROUND" ON BACK SIDE OF THE LEVEE
4. THE ELEVATIONS FOR THE CORPS OF ENGINEERS LOGS HAVE BEEN DETERMINED FROM THE 1980 PROFILE ELEVATIONS (±1 FOOT)
5. THE OBSERVED WATER LEVELS INDICATED ON THE LOGS ARE AS RECORED AT THE TIME OF EXPLORATION THESE WATER LEVELS MAY VARY CONSIDERABLY WITH TIME, ACCORDING TO UPSTREAM RELEASES RAINFALL OR OTHER FACTORS

SCALE: 1 IN.=3 FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

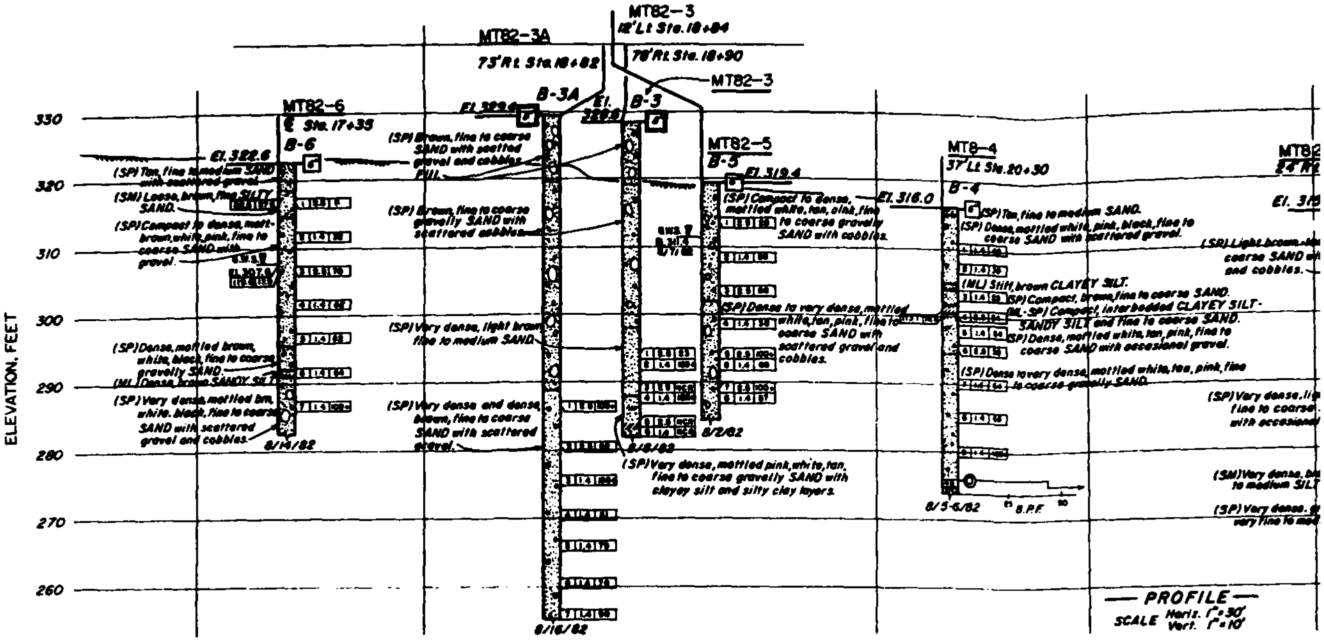
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.1207+00 TO STA.1171+00

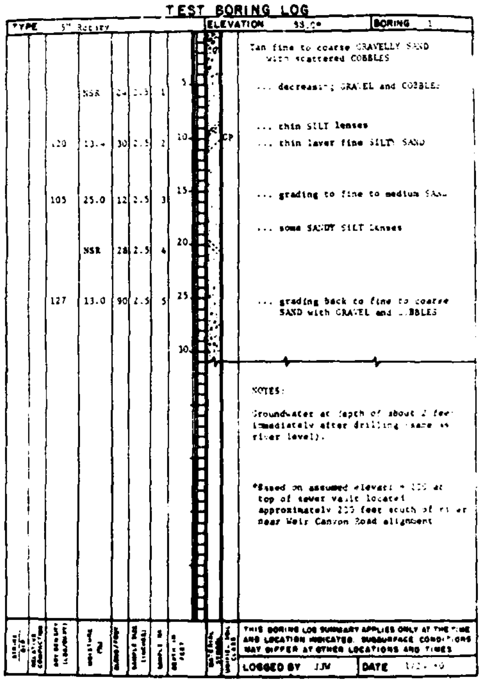
SUBMITTED BY: — DATE APPROVED: — SPEC. NO. DACW09-____ B-____ — SHEET
DISTRICT FILE NO.

PLATE 8A



MT80-1

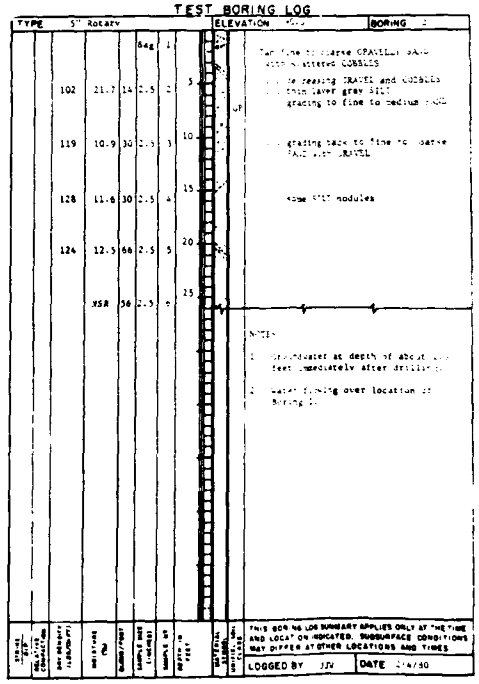
TEST BORING LOG



Job No. 179-97 - March 12, 1980

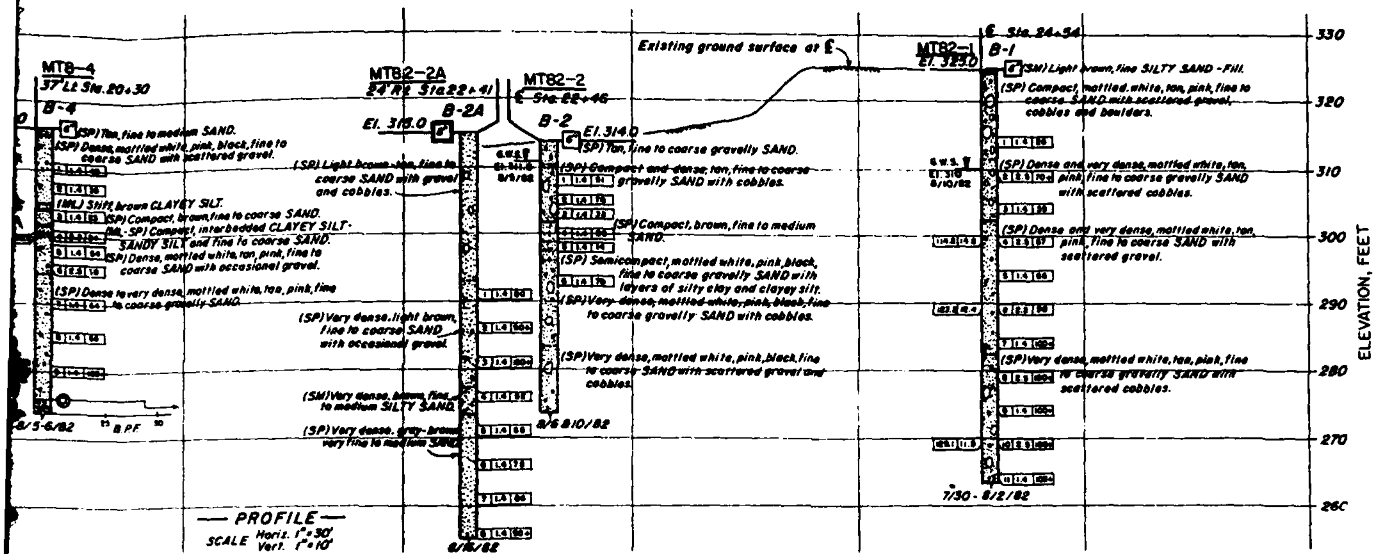
MT80-2

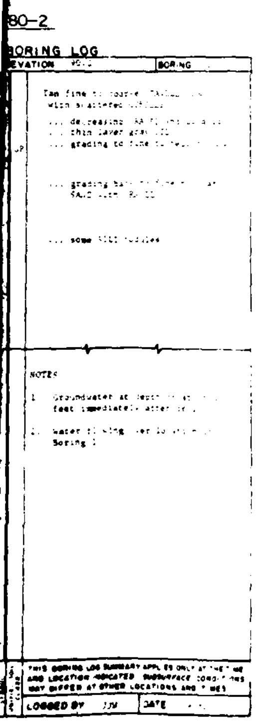
TEST BORING LOG

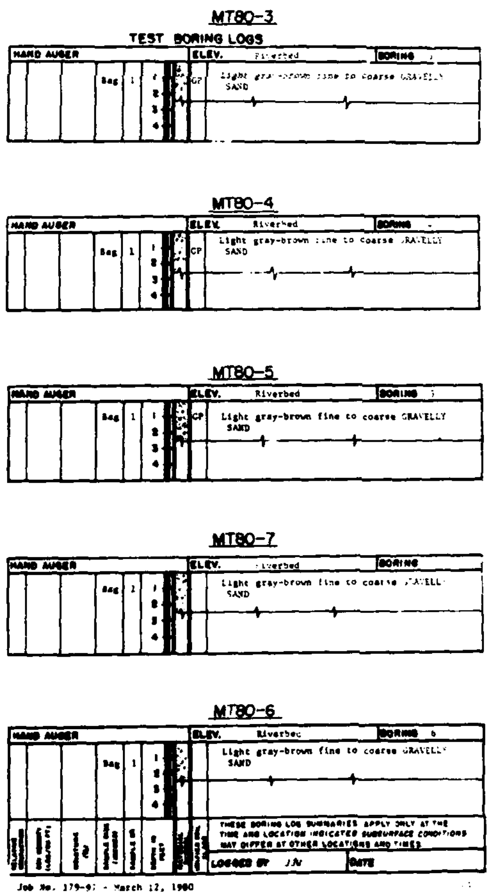


Job No. 179-97 - March 12, 1980

VALUE ENGINEERING PAYS







NOTES:

1. SEE PLATE 8 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

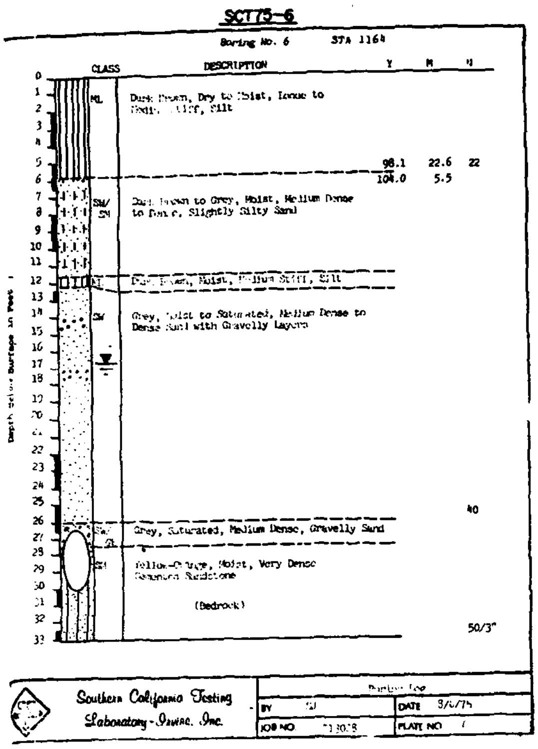
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

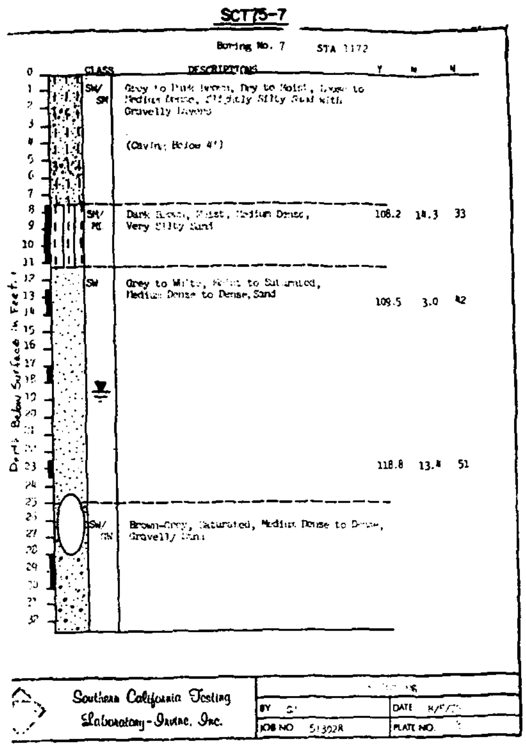
LOGS OF INVESTIGATION
BY OTHERS
STA.1220+00 TO STA.1160+00

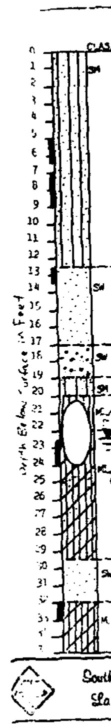
SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-__-B-____ | SHEET
DISTRICT FILE NO.

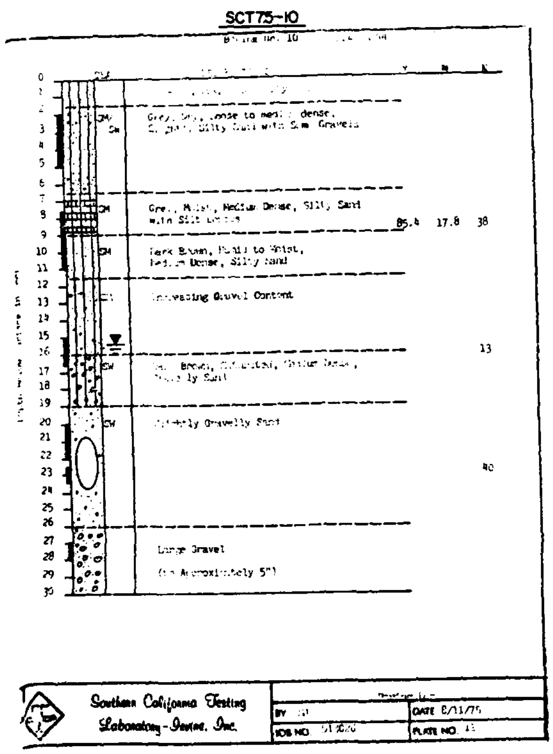
PLATE 88

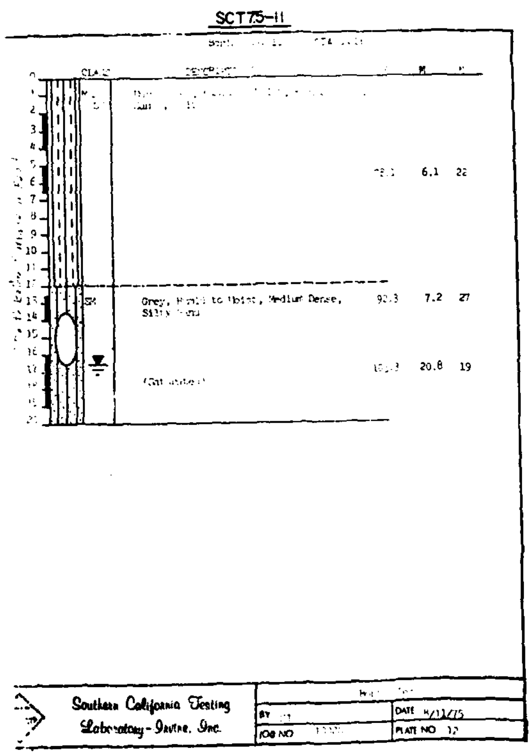
SAFETY PAYS


SCT75-6
Boring No. 6 STA 1164
CLASS DESCRIPTION Y M N
Depth Below Surface in Feet
ML
98.1 22.6 22
104.0 5.5
SM/SW
Dark Brown to Grey, Moist, Medium Dense to Dense, Slightly Silty Sand
SW
Grey, Moist to Saturated, Medium Dense to Dense Sand with Gravelly Layers
40
Grey, Saturated, Medium Dense, Gravelly Sand
Yellow-Orange, Moist, Very Dense
(Bedrock)
50/3"
Southern California Testing Laboratory-Irvine, Inc.
BY DATE JOB NO PLATE NO

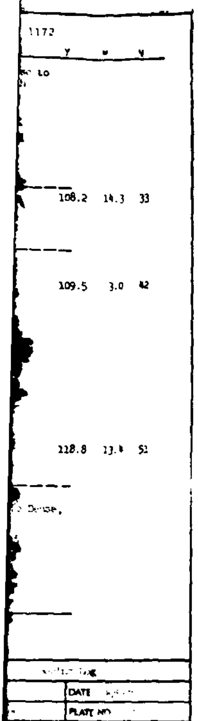

SCT75-7
Boring No. 7 STA 1172
CLASS DESCRIPTIONS Y M N
Depth Below Surface in Feet
SW/SM
Gravelly Layers
(Caving Below 4')
SM/ML
Dark Brown, Moist, Medium Dense, Very Silty Sand
108.2 14.3 33
SW
Grey to White, Moist to Saturated, Medium Dense to Dense, Sand
109.5 3.0 42
118.8 13.4 51
Brown-Grey, Saturated, Medium Dense to Dense, Gravelly Sand
Southern California Testing Laboratory-Irvine, Inc.
BY DATE JOB NO 513028 PLATE NO.

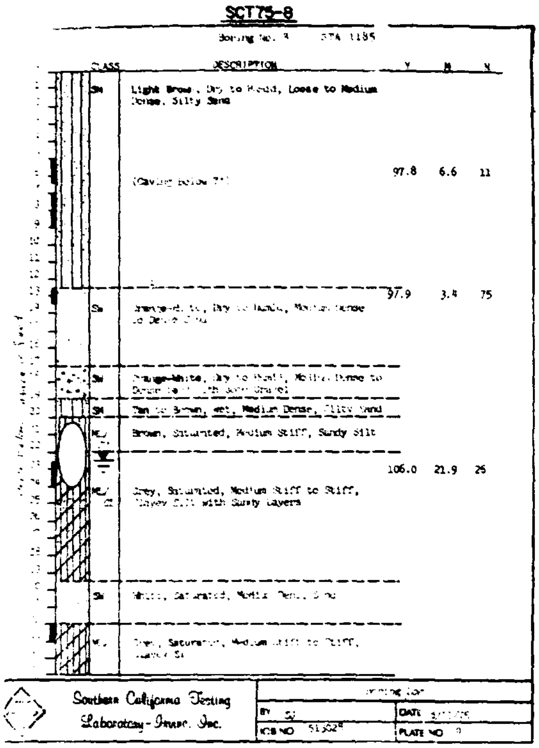

CLASS
Depth Below Surface in Feet
SM
SW
Southern
Labo

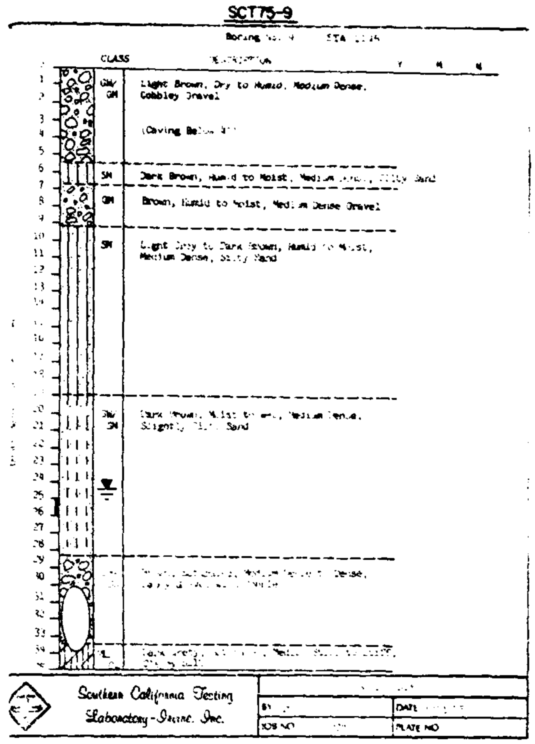

SCT75-10
Boring No. 10
Y M N
SM/SW
SM
Grey, Moist, Medium Dense, Silty Sand
85.4 17.8 38
SM
Increasing Gravel Content
13
SW
Slightly Gravelly Sand
40
Large Gravel
Southern California Testing Laboratory-Irvine, Inc.
BY DATE 8/11/75 JOB NO PLATE NO

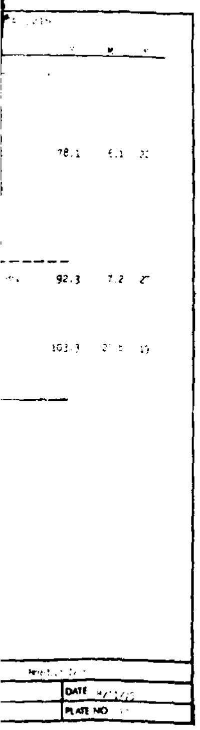

SCT75-11
CLASS DESCRIPTION M N
6.1 22
SM
Grey, Moist to Moist, Medium Dense, Silty Sand
92.3 7.2 27
20.8 19
Southern California Testing Laboratory-Irvine, Inc.
BY DATE 8/11/75 JOB NO PLATE NO

VALUE ENGINEERING PAYS









NOTES

1. SEE PLATE 8 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS
STA.1220+00 TO STA.1160+00

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-___ B-____ | SHEET
DISTRICT FILE NO.

PLATE 8C

SAFETY PAYS

GC72-1

GEOLABS, INC.

BORING LOG

STATION NO. 1171 + 25
BORING No. 1
DRIVING Wt. 300 lbs.
SURFACE ELEVATION 307.0
DROP 24 inches
W.O. 318-80

DEPTH FEET	CORE ○	BAG □	PENE. RESIST. BLOWS/FOOT	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION %	DIRECT SHEAR STRENGTH PARAMETERS φ	c	CLASSIFICATION (% Sand, % Silt, % Clay)
0									Brown SILTY SAND, SM, dry loose. Grades to SAND, SP, coarse grained, occasional layers of gravel and cobbles, medium dense. Saturated from 1 foot.
	①		16	123.0	10.5				
5									
	②		13	SPT*	14.9				
10									
	③		35	LOST	SAMPLE				
15									
	④		5	SPT	44.9				
									Gray ORGANIC CLAY, OH, soft to medium stiff, saturated.
20									
	⑤		80/10"	133.0	7.0				Gray SAND, SP, with lots of gravel, occasional thin layers of CLAY, OL, dense to very dense, saturated.
25									
	⑥		40	SPT	14.9				
30									
	⑦		80/...	LOST	SAMPLE				SAND

GC72-2

GEOLABS, INC.

BORING LOG

STATION NO. 1173 + 30
BORING No. 2
DRIVING Wt. 300 lbs.
SURFACE ELEVATION 312.0
DROP 24 inches
W.O. 318-80

DEPTH FEET	CORE ○	BAG □	PENE. RESIST. BLOWS/FOOT	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION %	DIRECT SHEAR STRENGTH PARAMETERS φ	c	CLASSIFICATION (% Sand, % Silt, % Clay)
0									Tan SAND, SP, coarse grained with lots of gravel, dry and loose at the surface, moist and medium dense.
5	①		22	SPT	7.5				
10	②		21	LOST	SAMPLE				Thin lense of ORGANIC CLAY, OH, at 10 feet.
15	③		45	131.0	9.3				Grades to GRAVELLY SAND, SP, saturated and dense.
20	④		7	SPT					Gray ORGANIC CLAY, OH, medium stiff, saturated.
									Gray GRAVELLY SAND, SP, saturated.
25	⑤		25	LOST	SAMPLE				Gray CLAYEY FINE SAND, ML, organics, medium dense, saturated.
									Gray coarse SAND, SP, with gravel.
									Gray SAND SILT, ML, trace of organics, medium dense, saturated. (37, 47, 16)
30	⑥		49	90.0	32.9				SANDY SILT Tan, gravelly SAND, SP, dense, saturated. Dark gray CLAYEY FINE SAND, ML, trace of organics, saturated.
35									Tan SAND, SP, coarse grained, trace of gravel, dense, saturated.
	⑧		40	SPT					

GC72-3

GEOLABS, INC.

BORING LOG

STATION NO. 1181 + 40
BORING No. 3
DRIVING Wt. 300 lbs.
SURFACE ELEVATION 313.0
DROP 24 inches
W.O. 318-80

DEPTH FEET	CORE ○	BAG □	PENE. RESIST. BLOWS/FOOT	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION %	DIRECT SHEAR STRENGTH PARAMETERS φ	c	CLASSIFICATION (% Sand, % Silt, % Clay)
0									Tan SAND, SP, fine grained at surface grades to coarse below 1 foot, medium dense, moist, trace of gravel. Grades to GRAVELLY SAND.
	①		16	122.0	7.0				
5									
	②		17	SPT	NO SAMPLE				Occasional cobbles. Grades to dense.
10									
	③		24	116.0	20.5				
15									
	④		81	SPT	11.1				Thin lense of fine SAND, SP, slightly silty at 19 feet.
20									
	⑤		58	SPT	9.3				
									Brown SILTY SAND, SM, dense, saturat...
25									Brown gravelly SAND, SP, very dense, saturated.
	⑥		46	SPT	8.7				
30									Gravelly SAND Hard rock, very difficult to penetrat...

GC72-6

GEOLABS, INC.

BORING LOG

STATION NO. 1205 + 70
BORING No. 6
DRIVING Wt. 300 lbs.
SURFACE ELEVATION 326.0
DROP 24 inches
W.O. 318-80

DEPTH FEET	CORE ○	BAG □	PENE. RESIST. BLOWS/FOOT	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION %	DIRECT SHEAR STRENGTH PARAMETERS φ	c	CLASSIFICATION (% Sand, % Silt, % Clay)
0									Tan SILTY SAND, SM, loose, dry.
	①		19	124.0	6.4				Tan SAND, SP, coarse grained with gravel, clean, medium dense, moist.
5									
	②		10	95.5	17.0				
10									
	③		60	SPT	7.0				Tan gravelly SAND, SP, very dense, moist.
15									Thin layer of brown SILTY CLAY, CL, soft, wet. (6")
	④		37	125.5	9.3				
20									Gray ORGANIC CLAYEY SILT, OL, saturated, soft.
	⑤		34	108.5	21.2				Tan SAND, SP, medium grained, trace of gravel, very dense, wet.
25									
	⑥		59	SPT	18.3				
30									Tan, coarse SAND, SP, with appreciable amount of gravel, saturated, very dense.
	⑦		45	122.5	13.6				
35									
	⑧		50	SPT	8.7				

GC72-7

GEOLABS, INC.

BORING LOG

STATION NO. 1206 + 90
BORING No. 7
DRIVING Wt. 300 lbs.
SURFACE ELEVATION 324.0
DROP 24 inches
W.O. 318-80

DEPTH FEET	CORE ○	BAG □	PENE. RESIST. BLOWS/FOOT	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION %	DIRECT SHEAR STRENGTH PARAMETERS φ	c	CLASSIFICATION (% Sand, % Silt, % Clay)
0									Fill, tan SAND, SP, coarse, moist, loose.
5	①		9	SPT	1.0				
									Tan SAND, SP, with gravel, medium dense, moist.
10	②		20	96.0	20.5				Grades to saturated and dense below 5 feet.
15	③		32	SPT	13.0				
20	④		40	134.0	5.0				
25	⑤		48	SPT	4.0				
30	⑥		28	116.0	18.3				Layer of SILTY CLAY, CL, stiff (4"). Grades to very dense SAND with appreciable amount of gravel.
35	⑦		Refusal	SPT					Very hard strata, unable to penetrate.

GC72-8

GEOLABS, INC.

BORING LOG

STATION NO. 1214 + 75
BORING No. 8
DRIVING Wt. 300 lbs.
SURFACE ELEVATION 325.5
DROP 24 inches
W.O. 318-[illegible]

DEPTH FEET	CORE ○	BAG □	PENE. RESIST. BLOWS/FOOT	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION %	DIRECT SHEAR STRENGTH PARAMETERS φ	c	CLASSIFICATION (% Sand, % Silt, % Clay)
0									Tan, gravelly SAND, SP, dry at surf... to one foot, moist and medium de... below one foot.
5	◯		25	125.5	14.9				Saturated.
10	◯		24	119.0	18.3				
15	◯		Refusal (Hit cobble)		13.6				Lenses of SILTY SAND, SM, and gray ORGANIC CLAY, OL, saturated.
									Gray SANDY GRAVEL, GP, dense to very dense, very difficult to penetrat... saturated.
20	◯		37	SPT	10.5				
25									
	◯		95	SPT	25.0				Black SILTSTONE.
30									Black SILTSTONE, moist hard, with SAND, SAND, SP, interbed.
	◯		50/3"	SPT	17.6				

GC72-3

GEOLABS, INC.

BORING LOG

[illegible] NO. 1181 + 40
[illegible] No. 3
DRIVING Wt. 300 lbs.
[illegible]E ELEVATION 313.0
DROP 24 inches
WO. 318-80

CORE ○	BAG □	PENE. RESIST. BLOWS/FOOT	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION %	DIRECT SHEAR STRENGTH PARAMETERS φ	c	CLASSIFICATION (% Sand, % Silt, % Clay)
								Tan SAND, SP, fine grained at surface grades to coarse below 1 foot, medium dense, moist, trace of gravel. Grades to GRAVELLY SAND.
1		16	122.0	7.0				
2		17	SPT	NO SAMPLE				Occasional cobbles. Grades to dense.
3		24	116.0	20.5				
4		31	SPT	[illegible]				Thin lense of fine SAND, SP, slightly silty at 19 feet.
5		38	SPT	[illegible]				
								Brown SILTY SAND, SM, dense, saturated.
								Brown gravelly SAND, SP, very dense, saturated.
6		[illegible]	SPT	[illegible]				
								Gravelly SAND
								Hard rock, very difficult to penetrate

GC72-4

GEOLABS, INC.

BORING LOG

STATION NO. 1193 + 00
BORING No. 4
DRIVING Wt. 300 lbs.
SURFACE ELEVATION 316.0
DROP 24 inches
WO. 318-80

DEPTH FEET	CORE ○	BAG □	PENE. RESIST. BLOWS/FOOT	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION %	DIRECT SHEAR STRENGTH PARAMETERS φ	c	CLASSIFICATION (% Sand, % Silt, % Clay)
0									Fill, brown SAND, SP, trace of gravel, moist below 3 inches, loose.
5	1		6	116.0	7.0				
10	2		17	106.0	4.7				Brown SAND, SP, fine grained, clean, medium dense, moist.
15	3		15	SPT	4.2				Tan, gravelly SAND, SP, medium dense, moist.
									Brown SAND, SP, medium dense to dense, saturated.
20	4		43	LOST	SAMPLE				
25	5		15	123.0	13.0				
									Rust brown SILTY FINE SAND, ML, medium dense, saturated.
30	6		56	SPT					Sand
35	7		100/11"	LOST	SAMPLE				
									Brown SILTY CLAY, very stiff, moist.
	8		90	11.1	116.0				Gray CLAYEY SANDSTONE, hard, moist.
									Black SILTSTONE, hard, moist.
	9		50/4"	SPT	22.2				

GC72-5

GEOLABS, INC.

BORING LOG

STATION NO. 1199 + 60
BORING No. 5
DRIVING Wt. 300 lbs.
SURFACE ELEVATION 324.0
DROP 24 inches
WO. 318-80

DEPTH FEET	CORE ○	BAG □	PENE. RESIST. BLOWS/FOOT	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION %	DIRECT SHEAR STRENGTH PARAMETERS φ	c	CLASSIFICATION (% Sand, % Silt, % Clay)
0									Tan SAND, SP, dense to very dense, dry and loose at surface, occasional layers of dense gravel, sometimes cobbles. Sand is clean, coarse grained, increasing in moisture at depth.
5	1		17	127.5	4.2				
10	2		31	SPT	4.2				
15	3		21/5"	116.5	16.6				
20	4		55	131.0	5.8				
25	5		52	SPT	15.3				
30	6		48	124.0	13.0				SAND
35	7		50/6"	SPT	11.0				
40	8		37/10"	131.0	8.1				

GC72-8

GEOLABS, INC.

BORING LOG

[illegible]ION NO. [illegible]
[illegible] No. 8
DRIVING Wt. 300 lbs.
[illegible]ACE ELEVATION [illegible]
DROP 24 inches
WO. 318-80

CORE ○	BAG □	PENE. RESIST. BLOWS/FOOT	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION %	DIRECT SHEAR STRENGTH PARAMETERS φ	c	CLASSIFICATION (% Sand, % Silt, % Clay)
								Tan, gravelly SAND, SP, dry at surface to one foot, moist and medium dense below one foot.
[illegible]		25	123.[illegible]	[illegible]				Saturated.
[illegible]		24	[illegible]	[illegible]				
[illegible]		Refusal [illegible]		[illegible]				Lenses of SILTY SAND, SM, and gray ORGANIC CLAY, OL, saturated.
								Gray SANDY GRAVEL, GP, dense to very dense, very difficult to penetrate, saturated.
[illegible]		[illegible]	SPT	[illegible]				
[illegible]		95	SPT	[illegible]				Black SILTSTONE.
								Black SILTSTONE, moist hard, with SAND, SAND, SP, interbed.
[illegible]		50/3"	SPT	[illegible]				

NOTES:

1. SEE PLATE 8 FOR TEST SITE LOCATIONS.
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3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

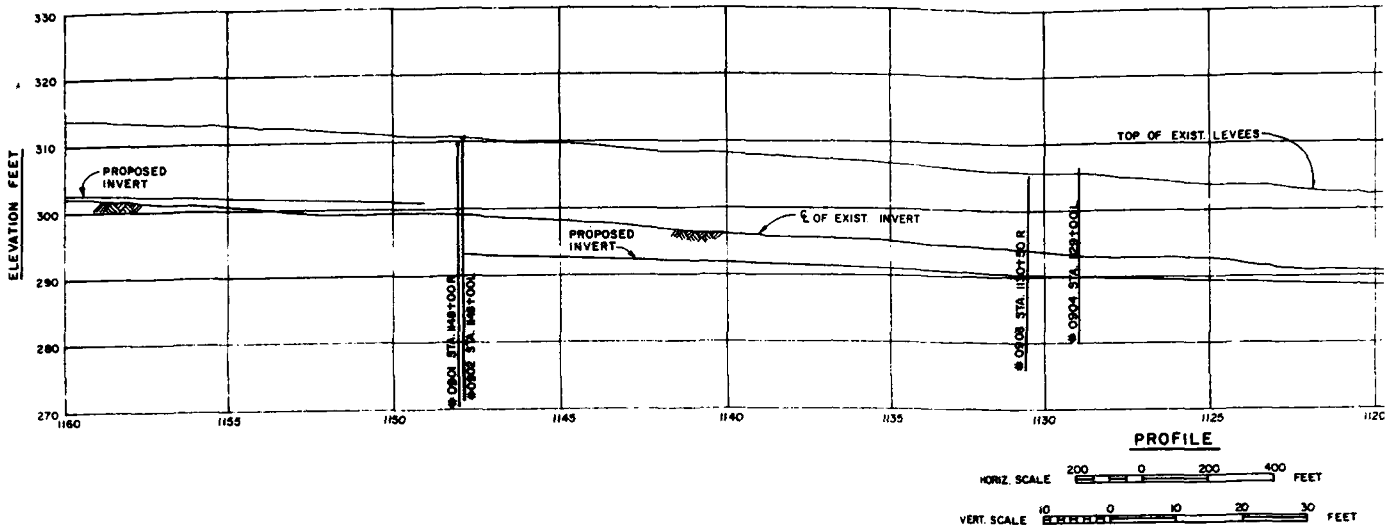
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS
STA.1220+00 TO STA.1160+00

SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-____-B-____
DISTRICT FILE NO.
SHEET


ELEVATION FEET
330
320
310
300
290
280
270
PROPOSED INVERT
TOP OF EXIST. LEVEES
℄ OF EXIST. INVERT
PROPOSED INVERT
1160
1155
1150
1145
1140
1135
1130
1125
1120
PROFILE
HORIZ. SCALE 200 0 200 400 FEET
VERT. SCALE 10 0 10 20 30 FEET

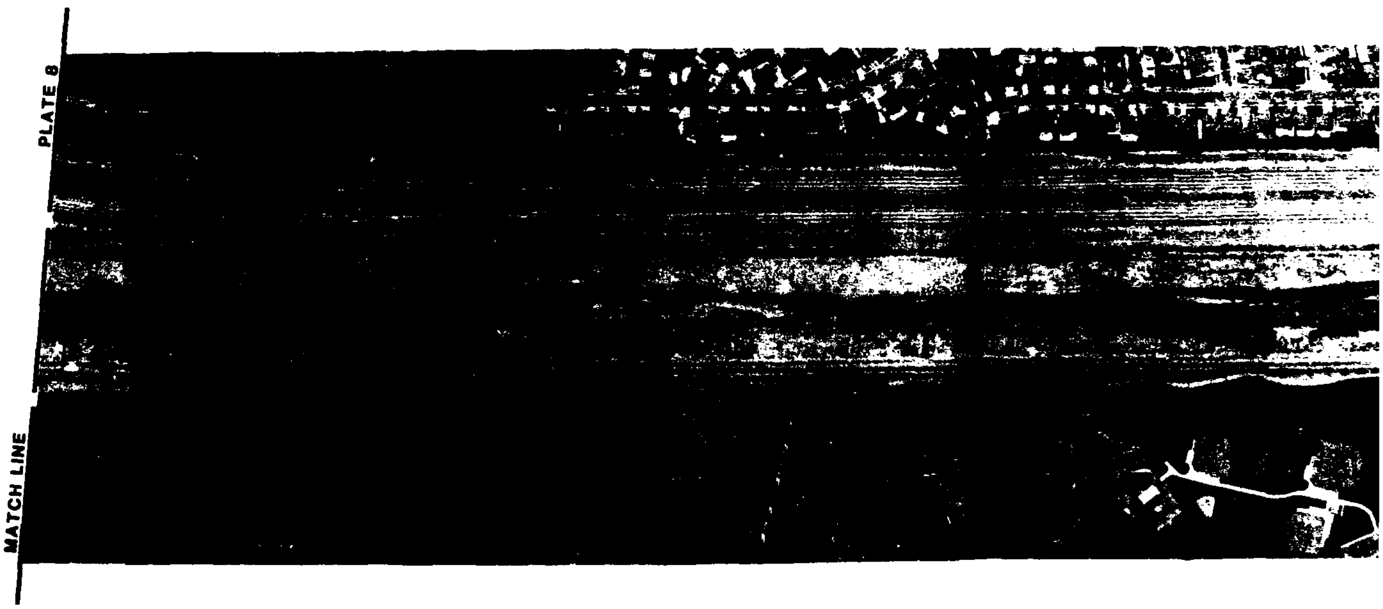
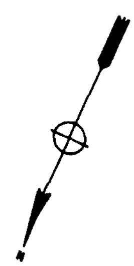
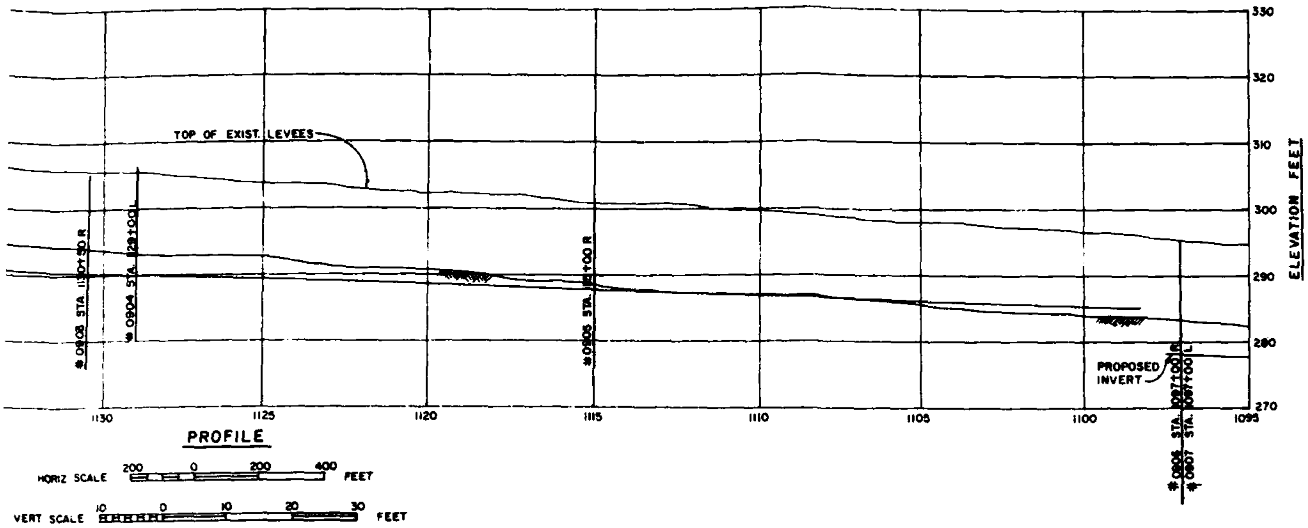


PLATE 8
MATCH LINE





NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE

STA. 1160+00 TO STA. 1095+00

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW 09-___ B-___ | SHEET
DISTRICT FILE NO.

PLATE 9

TH84- 0901

TH84-0901 STA 1148+00 R EL. 311±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, MOIST, FINE TO COARSE GRAINED SAND, GRAVEL TO 3 INCHES, 5 PERCENT COBBLES TO 6 INCHES.
	SW/SM	2		NP	67	5		
		2		NP	75	6	38	
5.0								
	SW	3			81	4	37	GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 3 INCHES.
[illegible]								
	SP/SM			NP	96	5	22	SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND, GRAVEL TO 1-1/2 INCHES.
12.0								
	SW				74	4	19	GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 2 INCHES, SOME COBBLES.
[illegible]								
	SP				97	3	23	SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 2 INCHES, SOME COBBLES, USING MUD AT 13 FEET, WATER AT 13 FEET.
18.0								
	SP/SM			NP	55	5	16	GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 2 INCHES, SOME COBBLES.
[illegible]								
								GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 2 INCHES, SOME COBBLES.
	SP			NP	66	4		
							89	SAME: REFUSAL AT 25.0' DUE TO COARSE GRAVEL.
[illegible]								
	SM		32	5	72	18	17	SILTY GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAEL TO 2 INCHES, SOME CLUMPS OF SILT, DARK GREY, MOIST, COHESIVE.
[illegible]								
	SP				67	3	21	GRAVELLY SAND: MULTICOLORED, MOIST, TO WET, COARSE GRAINED SAND, SOME FINE SILTY SAND, GRAVEL TO 2 INCHES, SOME COBBLES.
33.0								
	SW				77	3	37	
[illegible]								
	GP				40	2	39	SANDY GRAVEL: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 2 INCHES, REFUSAL AT 36.5 DUE TO ROCK.
[illegible]								
	SP				59	3		GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 2 INCHES.
40.5								

TH84 - 0902

TH84-0902 STA 1148+00 L EL. 311±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, 3 INCHES, 30 PERCENT COBBLES TO 9 INCHES.
	SW/SM			NP	60	12		
								SAME: FINE TO COARSE GRAINED SAND GRAVEL SOME COBBLES, MUD USED AT 6 FEET DUE TO CA
6.0								
							10	GRAVELLY SAND: MULTICOLORED, MOIST, LOOSE SAND, GRAVEL TO 2 INCHES, LARGE BOULDER AT
	SP				79	3		
							11	
12.0								
							20	GRAVELLY SAND: MULTICOLORED, MOIST, COARS GRAVEL TO 3 ICHES, 20 PERCENT COBBLES TO 6 METAL OBJECT AT 15 FEET AND 13 FEET.
	SW				79	4		
[illegible]								
	SW/SM			NP	88	6		SAND/SILTY SAND: MULTICOLORED, MOIST, COA SAND, GRAVEL TO 3 INCHES, 20 PERCENT COBBL
[illegible]								
	SW				76	4	11	GRAVELLY SAND: MULTICOLORED MOIST, COARSE GRAVEL TO 3 INCHES, 20 PERCENT COBBLES TO 6 INCHES.
[illegible]								
	SM		45	17	95	21	33	SILTY SAND: GREEN-BROWN, MOIST, FINE TO SAND, COHESIVE, GRAVEL TO 1 INCH.
[illegible]								
							35	GRAVELLY SAND: MULTICOLORED, MOIST, COA GRAVEL TO 1-1/2 INCHES.
	SP				99	1		SAME: SMALL POCKETS OF SILTY SAND.
							30	
[illegible]								
								GRAVELLY SILTY SAND: DARK GREY, MOIST, GRAINED SAND, COHESIVE.
	SM		32	3	95	39	37	
				NP	39	15		SILTY SAND: GREEN TO BROWN, MOIST TO WET GRAINED SAND.
[illegible]								
	SP				97	3	79	SAND: LIGHT GREEN, MOIST TO WET, FINE GR. OCASSIONAL GRAVEL.
40.0								

LUE ENGINEERING PAYS

TH84-0902

STA 1148+00 L — EL. 311±

PI	-4	-200	N	DESCRIPTION
NP	[illegible]	[illegible]		GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, DRY, GRAVEL TO 3 INCHES, 30 PERCENT COBBLES TO 9 INCHES.
				SAME: FINE TO COARSE GRAINED SAND GRAVEL TO 3 INCHES, SOME COBBLES, MUD USED AT 6 FEET DUE TO CAVING.
	[illegible]	[illegible]	[illegible]	GRAVELLY SAND: MULTICOLORED, MOIST, LOOSE, COARSE GRAINED SAND, GRAVEL TO 2 INCHES, LARGE BOULDER AT 12 FEET.
			11	
			[illegible]	GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 3 INCHES, 20 PERCENT COBBLES TO 5 INCHES, LARGE METAL OBJECT AT 15 FEET AND 13 FEET.
NP	[illegible]			SAND/SILTY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 3 INCHES, 20 PERCENT COBBLES TO 5 INCHES.
	[illegible]		[illegible]	GRAVELLY SAND: MULTICOLORED MOIST, COARSE GRAINED SAND, GRAVEL TO 3 INCHES, 20 PERCENT COBBLES COBBLES TO 5 INCHES.
				SILTY SAND: GREEN-BROWN, MOIST, FINE TO COARSE GRAINED SAND, COHESIVE, GRAVEL TO 1 INCH.
			[illegible]	GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO [illegible] INCHES.
				SAME: SMALL POCKETS OF SILTY SAND.
				GRAVELLY SILTY SAND: DARK GREY, MOIST TO WET, FINE GRAINED SAND, COHESIVE.
NP				SILTY SAND: GREEN TO BROWN, MOIST TO WET, FINE TO COARSE GRAINED SAND.
				SAND: LIGHT GREEN, MOIST TO WET, FINE GRAINED SAND, OCCASIONAL GRAVEL.

TH84-0903

TH84-0903 — STA 1130+50 R — EL. 306±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
3.0	GM			NP	50	27	50R	SILTY SANDY GRAVEL: MEDIUM BROWN, MOIST, GRAVEL REFUSAL AT 1.0 FEET DUE TO VERY DENSE MATERIAL.
6.0	SP-SM			NP	87	8	25	SAND/SILTY SAND: MEDIUM BROWN, MOIST, MEDIUM DENSE, FEW GRAVEL.
12.0	SW	5			90	4	26 11	GRAVELLY SAND: LIGHT BROWN WITH MULTICOLORED MINERALS, MOIST, MEDIUM DENSE TO LOOSE, COARSE GRAINED SAND, SOME GRAVEL.
15.0	SM	3		NP	85	16	11	SILTY SAND: LIGHT BROWN, DAMP, MEDIUM DENSE TO LOOSE, COARSE GRAINED SAND, LARGE CLUMPS OF DARK BROWN CLAYS, WATER AT 15 FEET.
[illegible]	SW/SM	18		NP	[illegible]	5	8	GRAVELLY SAND/SILTY GRAVELLY SAND: LIGHT BROWN TO GREY, COARSE GRAINED SAND, FEW COBBLES, SOME PLASTICITY.
[illegible]	SP				90	[illegible]	[illegible]	SAND: MULTICOLORED GRAINS (WHITE, TAN, ORANGE), COARSE GRAINED SAND, BROKE LARGE BOULDER. SAME: MANY SUBANGULAR COBBLES TO 5 INCHES, MIGHT BE DUE TO BROKEN BOULDER ABOVE.
[illegible]	SW				[illegible]			GRAVELLY SAND: MULTICOLORED GRAINS, WHITE, TAN, ORANGE COARSE GRAINED SAND.
	SW/SM			NP	[illegible]	[illegible]	50R	GRAVELLY SAND/SILTY GRAVELLY SAND: BROWNISH GREY, COARSE GRAINED SAND, CLINGS TOGETHER IN LARGE CLUMPS, REFUSAL AT 25.0 FEET.
[illegible]				NP	[illegible]	[illegible]		SAND/SILTY SAND: MULTICOLORED GRAINS, FINE GRAINED SAND DENSE, HIT CLAY LENSES AT 29.5 FEET.

NOTES

1. SEE PLATE 9 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SCALE 1 IN = 3 FT

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA. 1148+00 TO STA. 1130+50

SUBMITTED BY: — DATE APPROVED: — SPEC. NO. DACW09- ____ B- ____ — SHEET
DISTRICT FILE NO.

SAFETY PAYS

TH84-0904

TH84-0904 STA 1129+00 L EL. 306±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SC	5	26	5	71	19		SILTY GRAVELLY SAND/CLAYEY GRAVELLY SAND: BROWN, MOIST, LOOSE, SOME FINE GRAINED SAND, SOME COBBLES TO 4-1/2".
3.0								
	SW/SM	3		NP	100	12	16	SAND/SILTY SAND: BROWN, MOIST, SOME COBBLES 4-1/2".
6.0								
	SP/SM	3		NP	79	6	12R	GRAVELLY SNAD/SILTY GRAVELLY SAND: COARSE GRAINED SAND, SOME COBBLES TO 5-1/2" REFUSAL AT 7.0' DUE TO ROCK.
9.0								
	SP				90	4	15	SAND: MULTICOLORED, MOIST, FINE TO COARSE GRAINED SAND, SOME COBBLES TO 6", MUD ADDED AT 12' DUE TO CAVING.
12.0								
	SP/SM			NP	99	5	14	SAND/SILTY SAND: LIGHT GREY, MOIST TO WET, FINE GRAINED SAND.
15.0								
							9	GRAVELLY SAND: MULTICOLORED, MOIST TO WET, FINE TO COARSE GRAINED SAND, SOME COBBLES TO 6".
	ML			NP	83	3		
							7	
21.0								
	SW/SM			NP	76	5	10	GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED, MOIST TO WET, COARSE GRAINED SAND, SOME COBBLES.
24.0								
	SP/SM			NP	66	6		SAME: MULTICOLORED, MOIST TO WET, COARSE GRAINED SAND, 25 PERCENT COBBLES, 10 PERCENT BOULDERS, LARGE BOULDER AT 26.5'.
26.5								

TH84-0905

TH84-0905 STA 1115+00 R EL. 301±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM	3		NP	75	3		GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, MOIST, COARSE GRAINED SAND, 5 PERCENT COBBLES TO 5 INCHES.
3.0								
	SP	3			79	2	18	GRAVELLY SAND: BROWN, MOIST, COARSE GRAINED SAND, 5 PERCENT COBBLES TO 5 INCHES.
6.0								
	SP/SM			NP	36	7	20	SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND.
9.0								
	SM		34	3	39	42	9	SILTY SAND: DARK GREY, MOIST, COHESIVE, FINE GRAINED SAND, LARGE CLUMPS.
12.0								
							9	SAND: MULTICOLORED, COARSE GRAINED SAND, SOME FINE GRAINED SAND, GRAVEL TO 1/2 INCHES.
	SP				33	2		
							15	SAME: MOIST TO WET, WATER AT 18 FEET, USING MUD AT 13'.
# 18.0								
					51	1		GRAVELLY SAND: MULTICOLORED, COARSE GRAINED SAND, SOME COBBLES TO 5 INCHES.
21.0								
	SP/SM			NP	74	9	17	GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED, WET, COARSE GRAINED SAND, SOME COBBLES TO 5 INCHES, SOME CLUMPS OF DARK GREY SILTY SAND, COHESIVE.
25.5							38	

TH84-0906

TH84-0906 STA 1097+00 R EL.

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESC
							56	GRAVELLY SAND/SILTY GRAVE FINE-MEDIUM GRAINED SAND.
	SW/SM	3		NP	75	9		
							29	
6.0								
							31	SILTY GRAVELLY SAND: ME GRAINED SAND, GRAVEL TO 2 8 FEET.
	SM	4		NP	74	24		
9.0								
							32	GRAVELLY SAND/SILTY GRAV MEDIUM DENSE, FINE TO ME COBBLES TO 6 INCHES, PRB
	SP/SM			NP	57	10		
12.0								
							31	GRAVELLY SAND: LIGHT BR SAND, GRAVEL TO 1 INCH.
	SM	4			77	3		
15.0								
W16.5							23	GRAVELLY SAND: WHITE TO GRAINED SAND, GRAVEL AND 16.5' DEPTH.
					77	2		
								SAND: MULTICOLORED, CO 2 FEET BOULDER AT 18 FEE
	SP				94	3		
25.0								
	SW/SM			NP	74	10		GRAVELLY SAND/SILTY GRAV COLORED, COARSE GRAINED
27.0								
							31	SANDY GRAVEL/SILTY SAND MULTICOLORED, MEDIUM TO OCCASIONAL COBBLES.
	SP/GM			NP	41	7		
30.0								
							7	GRAVELLY SAND/SILTY GRAV COLORED, COARSE GRAINED NO SPT AT 33.5 FEET DUE
	SW/SM			NP	70	7		
36.0				NP	77	9		
							21	SILTY SAND: DARK TO ME SAND, COARSE CLEAN SAND CLUMPS THROUGHOUT.
	SM			NP	92	16		
39.0								
	SW/GM			NP	31	5		SANDY GRAVEL/SILTY SAND COLORED, MEDIUM TO VERY 30-40 PERCENT COBBLES
41.5								

[illegible]

NOTES

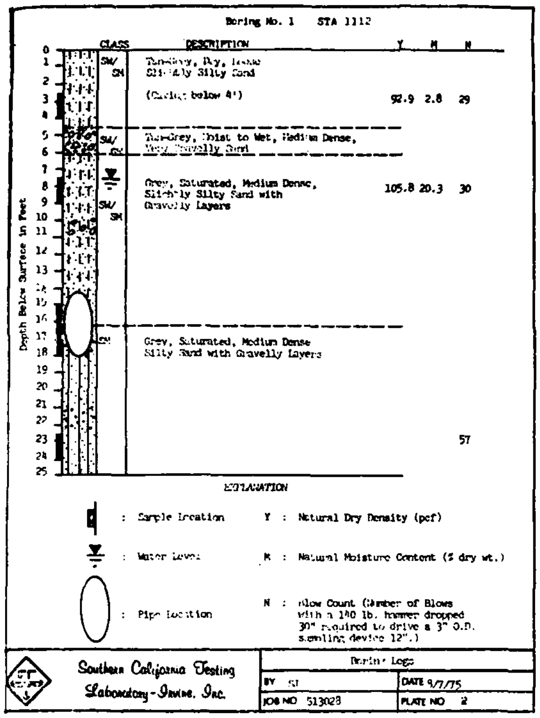
[illegible]

LOGS OF INVESTIGATIONS

CORPS OF ENGINEERS

STA [illegible] TO STA [illegible]

SC75-1



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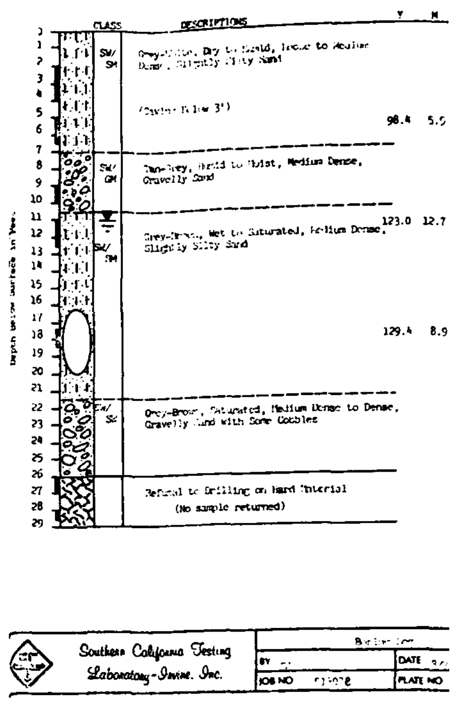
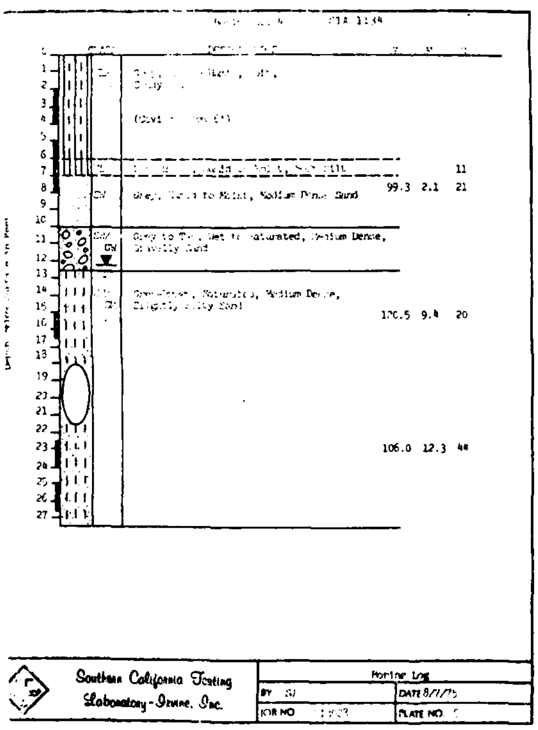
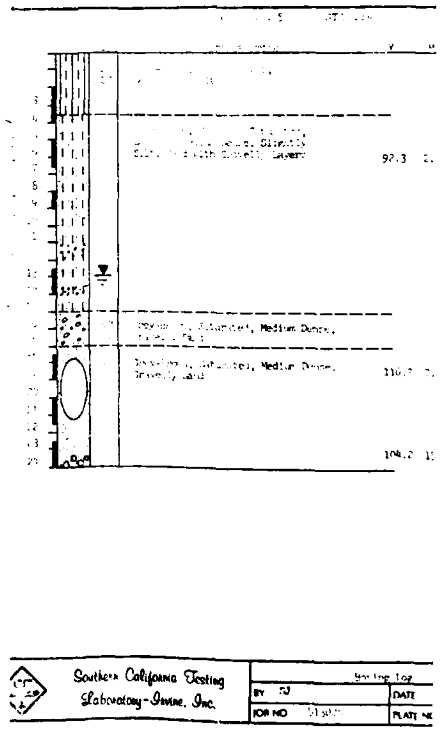


SC75-4



SC75-5



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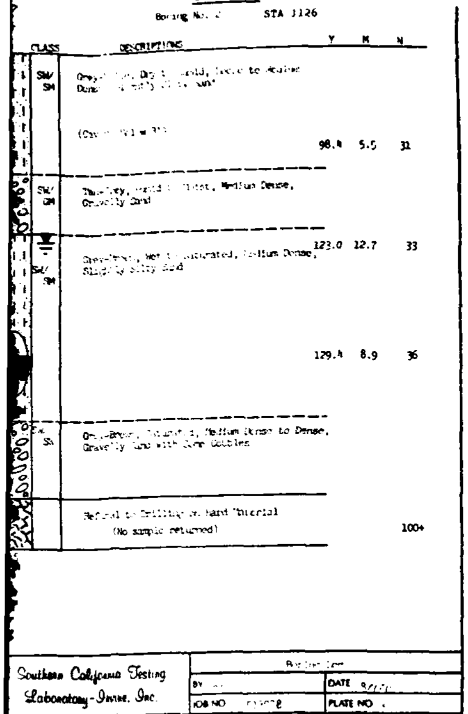
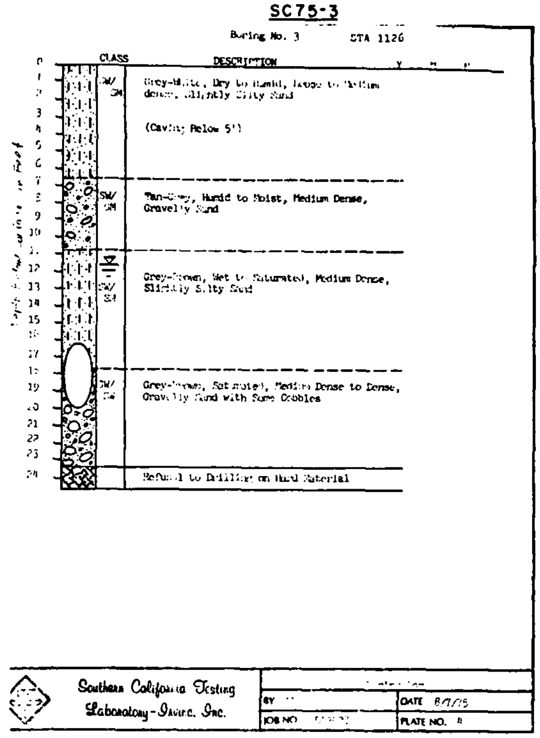


SC75-3



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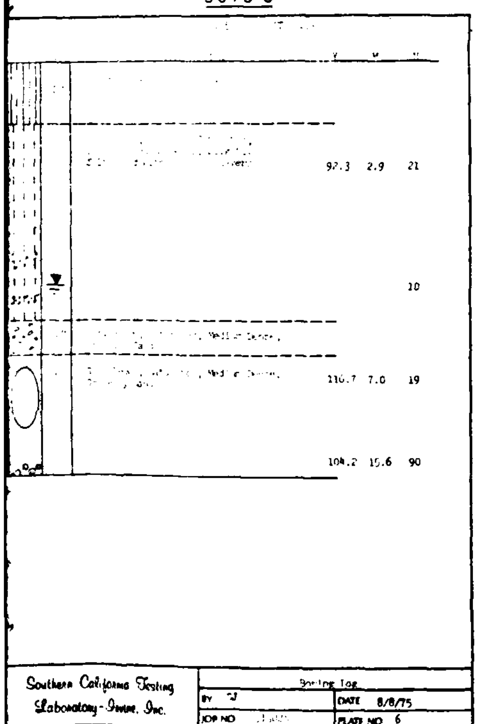


NOTES:

1. SEE PLATE 9 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

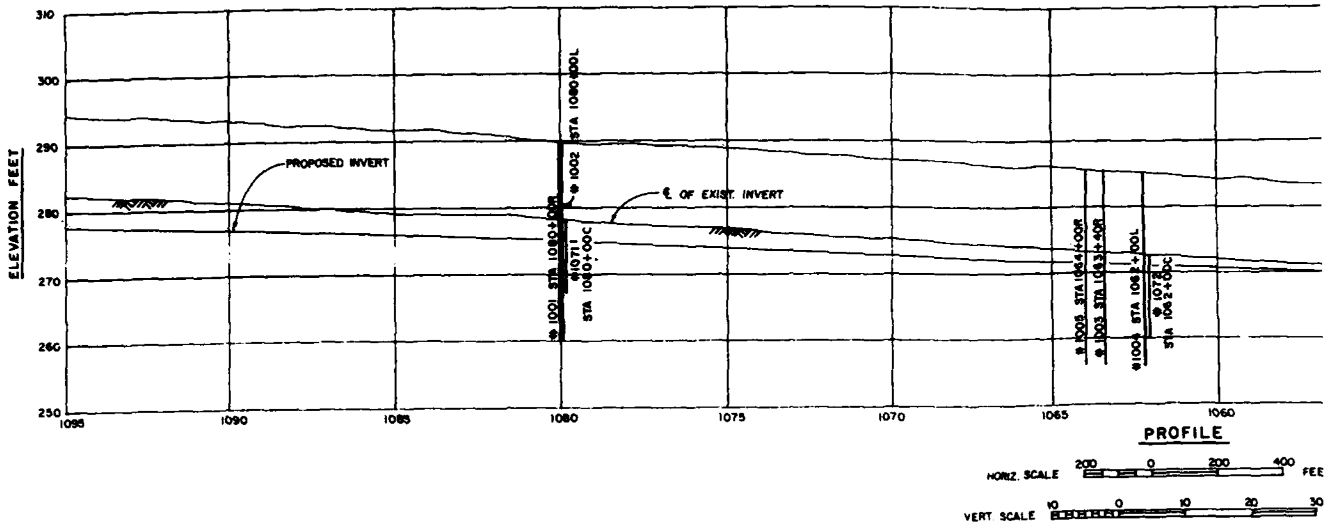
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS
STA. 1160+00 TO STA. 1095+00

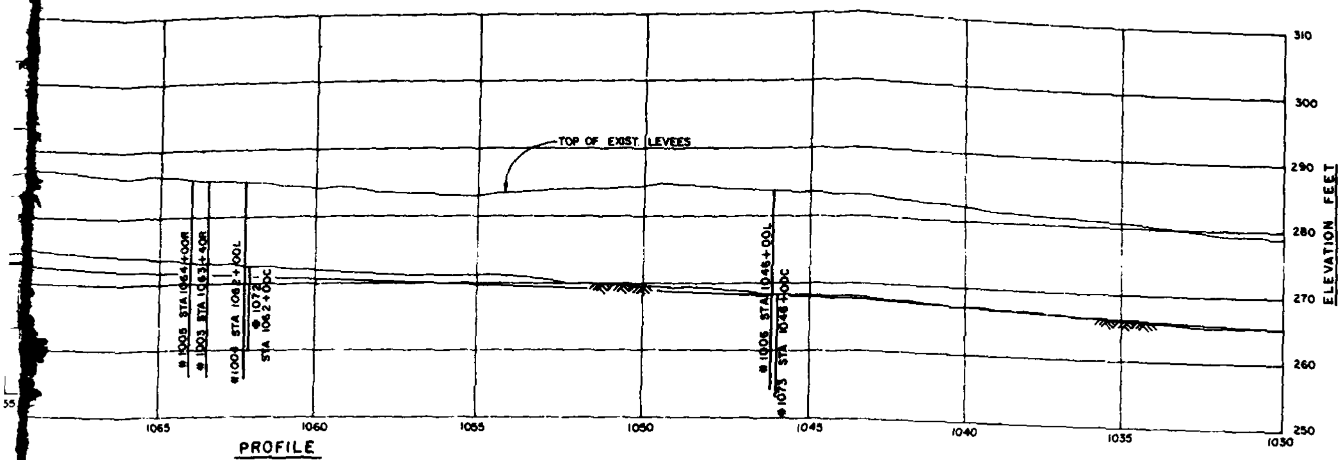
SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-___ -B-____ | SHEET
CHIEF, | BRANCH | DISTRICT FILE NO.

PLATE 9C

VALUE ENGINEERING



SAFETY PAY



PROFILE

HORIZ. SCALE 200 0 200 400 FEET

VERT. SCALE 10 0 10 20 30 FEET

NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

PLAN AND PROFILE

CHECKED BY:

STA.1095+00 TO STA.1030+00

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-____ B-____ | S. SET

DISTRICT FILE NO.

TH84-1001

TH84-1001 STA 1080+00 R EL. 290±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								GRAVELLY SAND/SILTY GRAVELLY SAND: LIGHT BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, GRAVEL TO 2 INCHES.
		2		NP	71	7		
								SAME: MEDIUM BROWN, FINE TO COARSE GRAINED SAND, FEW COBBLES TO 6 INCHES, NO SPT AT 3.5 FEET DUE TO ROCK.
	SW/SM			NP	72	7		
								SAND/SILTY SAND: SAME AS ABOVE, NO SPT AT 6.5 FEET DUE TO ROCK.
9.0		3		NP	88	8		
							24	GRAVELLY SAND: MULTICOLORED, WHITE, MOIST, FINE TO MEDIUM GRAINED SAND.
	SW	2			83	4		
							26	
15.0					79	3		
15.5	SC		36	14	78	49		GRAVELLY CLAYEY SAND: MEDIUM BROWN, MEDIUM DENSE, MEDIUM GRAINED SAND, SLIGHT TO MODERATE PLASTICITY.
17.0	SP				46	3		SANDY GRAVEL: MULTICOLORED SAND GRAINS, COARSE GRAINED SAND, COBBLES TO 8 INCHES, 12" x 8" BOULDER, NO SPT AT 15.5 FEET DUE TO ROCK.
	SW/SM			NP	77	[illegible]		GRAVELLY SAND/SILTY GRAVELLY SAND: MEDIUM BROWN TO MULTI-COLORED, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 1", COBBLES TO 9 INCHES, AT 23.5 FEET TO 24 FEET.
							37	
24.0				NP	68	9		
26.0	SP				56	3		GRAVELLY SAND: MULTICOLORED, MEDIUM TO COARSE GRAINED SAND COBBLES TO 4 INCHES, NO SPT AT 24.5 FEET.
								SANDY SILT: DARK BROWN TO DARK GREY, STIFF, SOME MEDIUM GRAINED SAND.
							14	
	ML	29	45	18	93	57		
31.5							18	

TT84-1071

INVERT

TT84-1071 STA 1080+00 C EL. 278±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SW				65	4		GRAVELLY SAND: BROWN, DAMP, MEDIUM DENS 2 INCHES, OCCASIONAL COBBLES TO 12 INCHE GRAINED SAND.
W4.5					71	0		SAME: BROWN, WET, MEDIUM DENSE, FEW CO COARSE SAND, GRAVEL TO 3 INCHES.
	SP							SAME: BROWN, SATURATED, LOOSE TO MEDIU COARSE GRAINED SAND, GRAVEL TO 2 INCHES, COBBLES, WATER AT 4.5 FEET.
					80	0		
					77	0		SAME: BROWN, SATURATED, MEDIUM DENSE, C COBBLES TO 12 INCHES, CAVING AT 11.5 FE
11.5					69	1		

TH84-1004

TH84-1004 STA 1062+00 L EL. 285±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
3.0	SM	4		NP	75	17		SILTY GRAVELLY SAND: LIGHT TO DARK BROWN, MOIST, FINE GRAINED SAND, GRAVEL TO 3 INCHES, SOME COBBLES TO 5 INCHES.
6.0	SW/SM	2		NP	95	5	16	SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE TO COARSE GRAINED SAND, GRAVEL TO 1-1/2 INCHES, SOME COBBLES TO 5 INCHES.
								GRAVELLY SAND/SILTY GRAVELLY SAND: LIGHT BROWN, MOIST, FINE TO COARSE GRAIN SAND, GRAVEL TO 1-1/2 INCHES SOME COBBLES TO 8 INCHES, USING MUD AT 12 FEET DUE TO CAVING.
	SP/SM			NP	75	5		
12.0							15	
							26	SAME: MULTICOLORED, MOIST, FINE TO COARSE GRAINED SAND, GRAVEL TO 2-1/2 INCHES, SOME COBBLES.
	SW/SM			NP	79	5		
18.0							39	
21.0	GP				45	2		SANDY GRAVEL: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 2-1/2 INCHES, SOME COBBLES TO 3 INCHES, NO SPT AT 19.5 FEET.
24.0	SW/SM			NP	97	10	33	SAND/SILTY SAND: LIGHT BROWN, MOIST, SOME COARSE GRAINED SAND BUT MOSTLY FINE GRAINED SAND, FEW GRAVEL.
								CLAYEY SAND: LIGHT BROWN, MOIST, VERY STIFF TO HARD, COARSE TO FINE GRAINED SAND, OCCASIONAL GRAVEL, FEW CLUMPS OF LIGHT TO DARK GREY SILT: WET, STIFF, COHESIVE.
	SC		50	22	95	41		
30.0			42	20	93	40		

TH84-1003

TH84-1003 STA 1063+40 R EL. 285±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
3.0	SW	3			80	4	32	GRAVELLY SAND: LIGHT BROWN, WITH SOME ICLES, MOIST, GRAVEL, FINE TO COARSE GR
							9	SILTY SAND: MEDIUM BROWN TO BLACK, MOI DENSE, SOME PLASTICITY, MEDIUM GRAINED
	SM	[illegible]		NP	[illegible]	20		
9.0							18	
							24	GRAVELLY SAND: MULTICOLORED, COARSE GR GRAVEL TO 2-1/2 INCHES, FEW CLAYEY CLUM
					73	2		
							13	
W 16.0								SAND: MEDIUM TO FINE GRAINED SAND.
	SP				94	4		
							50	
					91	4	41	SAME: MEDIUM TO COARSE GRAINED SAND.
24.0								
25.5	GC		27	3	63	29		CLAYEY SANDY GRAVEL: MULTICOLORED, COA SMALL POCKETS OF CLAY.
27.0	SM			NP	89	13		SILTY SAND: MULTICOLORED, COARSE GRAIN 2-1/2 INCHES.
	GP				31	1	27	SANDY GRAVEL: MULTICOLORED, COARSE GRA TO 6 INCHES.
30.0								

TT84-1071

STA 1060+00 C — EL. 278±

MC	LL	PI	-4	-200	N	DESCRIPTION
			65	4		GRAVELLY SAND: BROWN, DAMP, MEDIUM DENSE, GRAVEL TO 2 INCHES, OCCASIONAL COBBLES TO 12 INCHES, FINE TO COARSE GRAINED SAND.
			71	0		SAME: BROWN, WET, MEDIUM DENSE, FEW COBBLES, MEDIUM TO COARSE SAND, GRAVEL TO 3 INCHES.
			80	0		SAME: BROWN, SATURATED, LOOSE TO MEDIUM DENSE, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 2 INCHES, OCCASIONAL COBBLES, WATER AT 4.5 FEET.
			77	0		SAME: BROWN, SATURATED, MEDIUM DENSE, COARSE GRAINED SAND, COBBLES TO 17 INCHES, CAVING AT 11.5 FEET.
			69	1		

TH84-1002

TH84-1002 — STA 1080+00 L — EL. 290±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM			NP	89	6		SAND/SILTY SAND: LIGHT BROWN, MOIST, LOOSE, COARSE TO FINE GRAINED SAND, GRAVEL TO 1-1/2 INCHES.
3.0								
							10	SAME: FINE GRAINED SAND, FEW GRAVEL TO 1 INCHES.
		2		NP	97	7		
	SP/SM						28	
				NP	80	5		GRAVELLY SAND/SILTY GRAVELLY SAND: SAME, FINE TO COARSE GRAINED SAND, GRAVEL TO 2 INCHES, SOME COBBLES TO 6".
12.0								
							19	SAND/SILTY SAND: DARK BROWN, MOIST TO WET, COARSE GRAINED SAND, GRAVEL TO 2-1/2 INCHES, BEGAN USING MUD AT 15 FEET DUE TO CAVING.
				NP	86	5		
	SW/SM						20	
18.0								
							39	GRAVELLY SAND: DARK BROWN, MOIST TO WET, COARSE GRAINED SAND, GRAVEL TO 2-1/2 INCHES.
	SP				71	4		
							4	
24.0								
	SM		29	6	95	22	20	SILTY SAND: GREY, MEDIUM DENSE, MEDIUM TO COARSE GRAINED SAND, CLAYEY CLUMPS.
27.0								
	SP/SM			NP	95	5	35	SAND/SILTY SAND: GREY, DENSE, MEDIUM TO COARSE GRAINED SAND, LARGER CLAYEY CLUMPS.
				NP	73	10		GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, SOME CLAYEY CLUMPS, GRAVEL TO 3/4".
30.5								

TH84-1003

STA 1063+40 R — EL. 295±

MC	LL	PI	-4	-200	N	DESCRIPTION
1			80	4	32	GRAVELLY SAND: LIGHT BROWN, WITH SOME MULTICOLORED PARTICLES, MOIST, GRAVEL, FINE TO COARSE GRAINED SAND.
					3	SILTY SAND: MEDIUM BROWN TO BLACK, MOIST, LOOSE TO MEDIUM DENSE, SOME PLASTICITY, MEDIUM GRAINED SAND.
[illegible]		NP	95	[illegible]		
					11	
					24	GRAVELLY SAND: MULTICOLORED, COARSE GRAINED SAND, FEW GRAVEL TO [illegible] INCHES, FEW CLAYEY CLUMPS.
			73	2		
					13	
			74	4		SAME: MEDIUM TO FINE GRAINED SAND.
					50	
			91	4	41	SAME: MEDIUM TO COARSE GRAINED SAND.
	27	3	63	29		CLAYEY SANDY GRAVEL: MULTICOLORED, COARSE GRAINED, SOME SMALL POCKETS OF CLAY.
		NP	89	13		SILTY SAND: MULTICOLORED, COARSE GRAINED SAND, GRAVEL TO 2-1/2 INCHES.
			31	1	27	SANDY GRAVEL: MULTICOLORED, COARSE GRAINED SAND, COBBLES TO 6 INCHES.

NOTES

1 SEE PLATE 10 FOR LOCATION OF TEST HOLES AND TEST TRENCHES

2 SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM

3 SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED

4 ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SCALE 1 IN = 3 FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATONS
CORPS OF ENGINEERS

STA. 1080+00 TO STA. 1062+00

SUBMITTED BY: DATE APPROVED:

SPEC. NO. DACW09-____-B-____

DISTRICT FILE NO

SHEET

PLATE 10 A

TT84-1072

INVERT

TT84-1072 STA 1062+00 C EL. 272±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
					90	1		SAND: LIGHT BROWN, DRY, MEDIUM TO COARSE GRAINED SAND, LOOSE.
					78	0		GRAVELLY SAND: BROWN, DAMP, MEDIUM DENSE TO DENSE.
W5.0	SP							
					74	0		SAME: SATURATED, 10 PERCENT COBBLES TO 6", WATER AT 5.0'.
					76	0		SAME: MEDIUM TO COARSE GRAINED SAND, 10 PERCENT COBBLES AT 12 INCHES, BOULDERS AT 13 FEET, POSSIBLE TOE STONES.
13.0					77	0		

TH84-1005

TH84-1005 STA 1046+00 R EL. 284±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM	3		NP	92	7		SAND/SILTY SAND: MEDIUM BROWN, MOIS MEDIUM GRAINED SAND, FEW GRAVEL TO 3,
3.0								
							49	SILTY SAND: DARK GREY, MOIST, DENSE 1-1/2 INCHES, SLIGHT PLASTICITY, REF
	SM	9		NP	91	20		
							26R	
		5		NP	92	15		
9.0								
	CL	19	26	16	97	71	39	SANDY CLAY: DARK GREY, MEDIUM BROWN IN ZONES), MOIST, HARD, MODERATE PLA
12.0								
	SW/SM	5		NP	97	11	29	SAND/SILTY SAND: LIGHT TO MEDIUM BR DENSE, FINE TO MEDIUM GRAINED SAND.
15.0								
	SM			NP	98	25	13	SILTY SAND: GREY TO BROWN, MEDIUM D SAND, WATER AT 17.5 FEET.
W17.5 18.0								
	SW/SM			NP	79	7	11	GRAVELLY SAND/SILTY GRAVELLY SAND: COLORED, LOOSE, COARSE GRAINED SAND 2 INCHES.
21.0								
	SM		35	9	34	25	9	GRAVELLY SILTY SAND: GREYISH BROWN, LOOSE, MEDIUM TO COARSE GRAINED MULT
24.0								
							14R	GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED SAND, DENSE, MEDIUM TO FEW COBBLES, SOME LARGE SILTY CLUMPS
	SW/SM			NP	31	10		
							36	
				NP	31	5		
30.0								

TH84-1006

TH84-1006 STA 1046+00 L EL. 294±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SC		35	11	94	22		CLAYEY SAND: BROWN, MOIST, LOOSE, FEW GRAVEL, FINE GRAINED SAND.
3.0								
	SW/SM	9		NP	90	7		SAND/SILTY SAND: BROWN, MOIST, DENSE, GRAVEL TO 3 INCHES, FINE GRAINED SAND.
6.0							48	
	SW/SC	7	23	5	69	15		SILTY GRAVELLY SAND/CLAYEY GRAVELLY SAND: LIGHT TO DARK GREY, MOIST, DENSE, GRAVEL TO 3 INCHES, COBBLES TO 9 INCHES REFUSAL AT 9.5 FEET DUE TO ROCKS.
9.0							13R	
								SAND: MULTICOLORED, MOIST, FEW GRAVEL, FINE GRAINED SAND, SOME COBBLES.
	SP	3			31	1		
							35	GRAVELLY SAND: SAME AS ABOVE, GRAVEL TO 2 INCHES, SOME COBBLES TO 6 INCHES.
					31	3		
15.0							10	
	SW				69	3		SAME: MULTICOLORED, MOIST, LOOSE, COARSE GRAINED SAND, GRAVEL TO 2 INCHES, 10 PERCENT COBBLES.
18.0							6	
	SP				62	4		SAME: 20 PERCENT COBBLES TO 10 INCHES, NO SPT AT 20.5'.
21.0								
	SP/SW			NP	56	5		GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 2 INCHES, COBBLES TO 10 INCHES.
24.0								
	SW/SM			NP	79	5	31	
27.0								
							36	GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 2 INCHES, COBBLES TO 10 INCHES.
	SW				72	4		
31.5								

TT84-1073

INVERT

TT84-1073 STA 1046+00 C EL. 268±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
					68	0		GRAVELLY SAND: MULTICOLORED, DRY, LO GRAINED SAND, GRAVEL TO 3 INCHES, 5 P
								SAND: MULTICOLORED, MOIST TO WET, FI GRAVEL TO 1 INCH.
W5.0								
	SP				74	1		GRAVELLY SAND: SAME AS ABOVE, 15 PER 8 INCHES, WATER AT 5.0 FEET.
					69	2		SAME: COBBLES TO 10 INCHES.
14.0								
	ML		33	1	99	69		SANDY SILT: GREY, MOIST TO WET, COM SAND.
15.0								

TH84-1005

STA 1046+00 R

EL. 284±

LL	PI	-4	-200	N	DESCRIPTION
	NP	97	7		SAND/SILTY SAND: MEDIUM BROWN, MOIST, DENSE, FINE TO MEDIUM GRAINED SAND, FEW GRAVEL TO 3/4 INCHES.
				49	SILTY SAND: DARK GREY, MOIST, DENSE, FEW GRAVEL TO 1-1/2 INCHES, SLIGHT PLASTICITY, REFUSAL AT 7.0 FEET.
	NP	91	20		
				26P	
	NP	92	15		
25	16	97	71	39	SANDY CLAY: DARK GREY, MEDIUM BROWN, (2 DISTINCT COLORS IN ZONES), MOIST, HARD, MODERATE PLASTICITY.
	NP	97	11	29	SAND/SILTY SAND: LIGHT TO MEDIUM BROWN OR TAN, MEDIUM DENSE, FINE TO MEDIUM GRAINED SAND.
	NP	98	25	13	SILTY SAND: GREY TO BROWN, MEDIUM DENSE, FINE GRAINED SAND, WATER AT 17.5 FEET.
	NP	79	[illegible]	11	GRAVELLY SAND/SILTY GRAVELLY SAND: MEDIUM BROWN-MULTICOLORED, LOOSE, COARSE GRAINED SAND AND GRAVEL TO [illegible] INCHES.
35	9	34	25	[illegible]	GRAVELLY SILTY SAND: GREYISH BROWN, MODERATE PLASTICITY, LOOSE, MEDIUM TO COARSE GRAINED MULTICOLORED SAND.
				74P	GRAVELLY SAND/SILTY GRAVELLY SAND: GREYISH BROWN SILT, MULTICOLORED SAND, DENSE, MEDIUM TO COARSE GRAINED SAND, FEW COBBLES, SOME LARGE SILTY CLUMPS, REFUSAL AT 25.0'
	NP	81	13		
				36	
	NP	91	5		

TT84-1073

STA 1046+00 C

EL. 268±

LL	PI	-4	-200	N	DESCRIPTION
		68	2		GRAVELLY SAND: MULTICOLORED, DRY, LOOSE, FINE TO COARSE GRAINED SAND, GRAVEL TO 3 INCHES, 5 PERCENT COBBLES.
					SAND: MULTICOLORED, MOIST TO WET, FINE GRAINED SAND, GRAVEL TO 1 INCH.
		79	1		GRAVELLY SAND: SAME AS ABOVE, 15 PERCENT COBBLES AT [illegible] INCHES, WATER AT 5.0 FEET.
		59	2		SAME: COBBLES TO 10 INCHES.
[illegible]	[illegible]	99	63		SANDY SILT: GREY, MOIST TO WET, COHESIVE, FINE GRAINED SAND

NOTES

1. SEE PLATE 10 FOR LOCATION OF TEST HOLES AND TEST TRENCHES.
2. SEE PLATE 8 A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SCALE: 1 IN=3FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

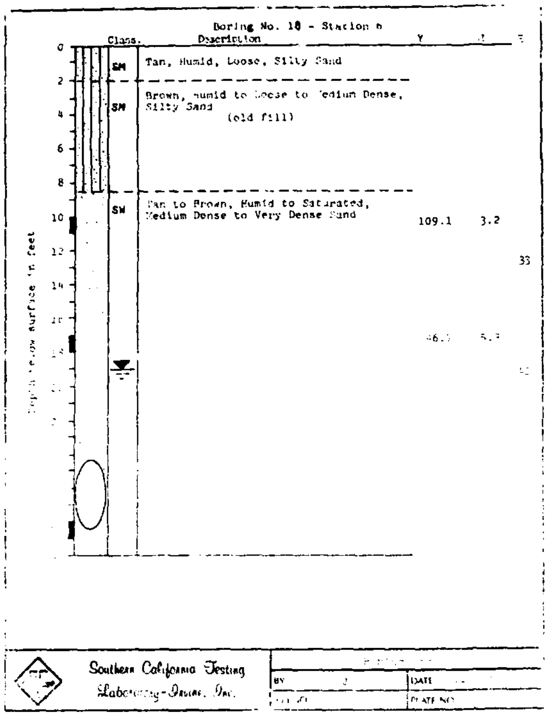
STA.1062+00 TO STA.1046+00

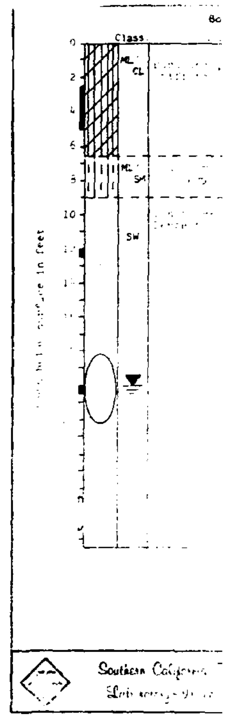
SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW 09- ____ B- ____ SHEET

DISTRICT FILE NO.

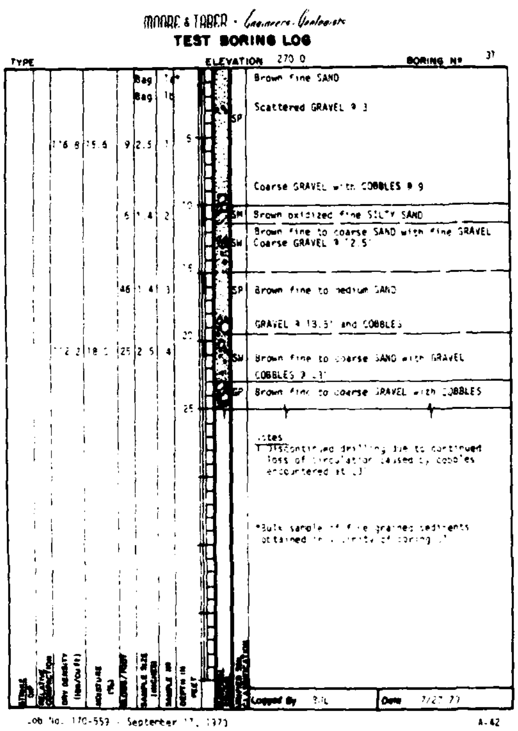
CHIEF, BRANCH

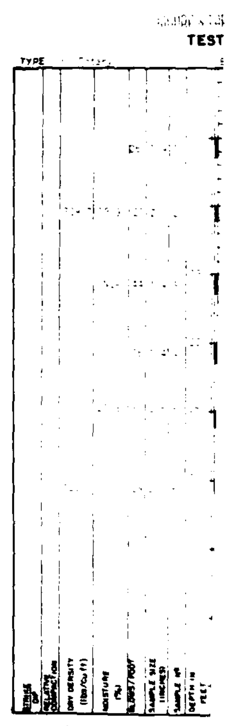
SCT75-18



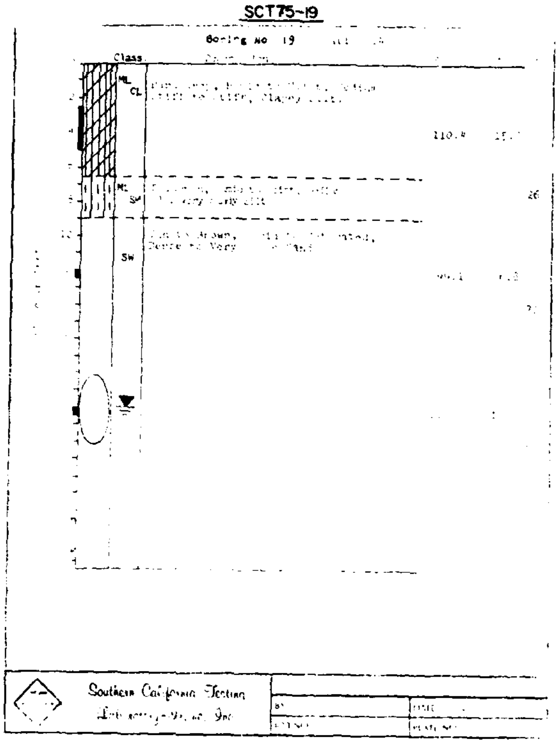


MT70-31

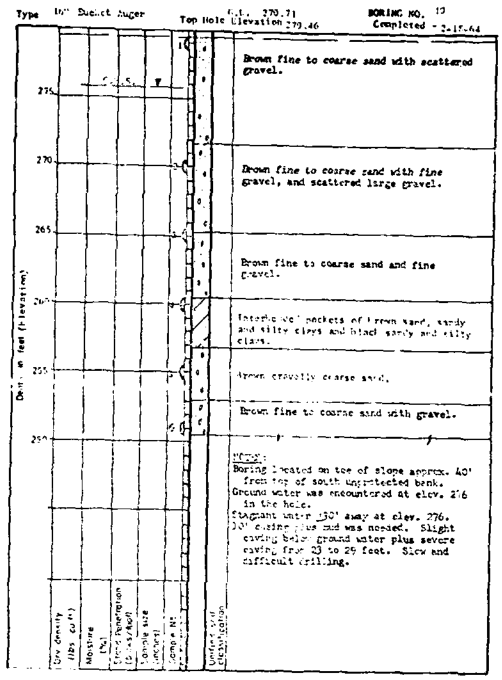




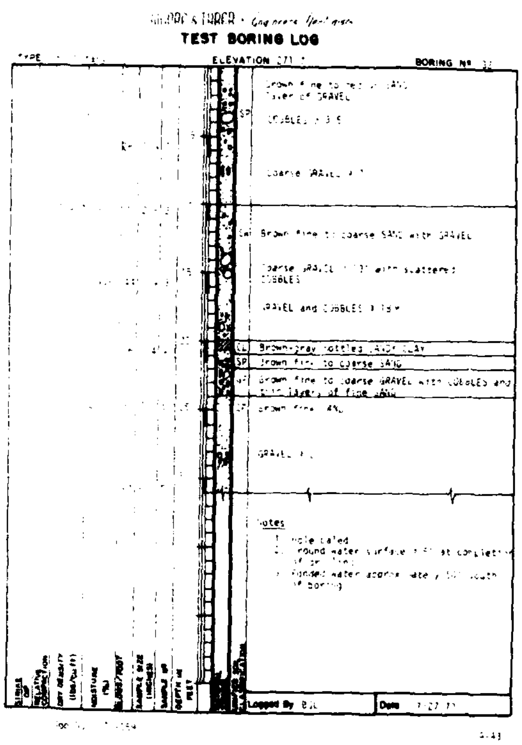
SCT75-19



MT64-19



MT70-32



NOTES:

1. SEE PLATE 10 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

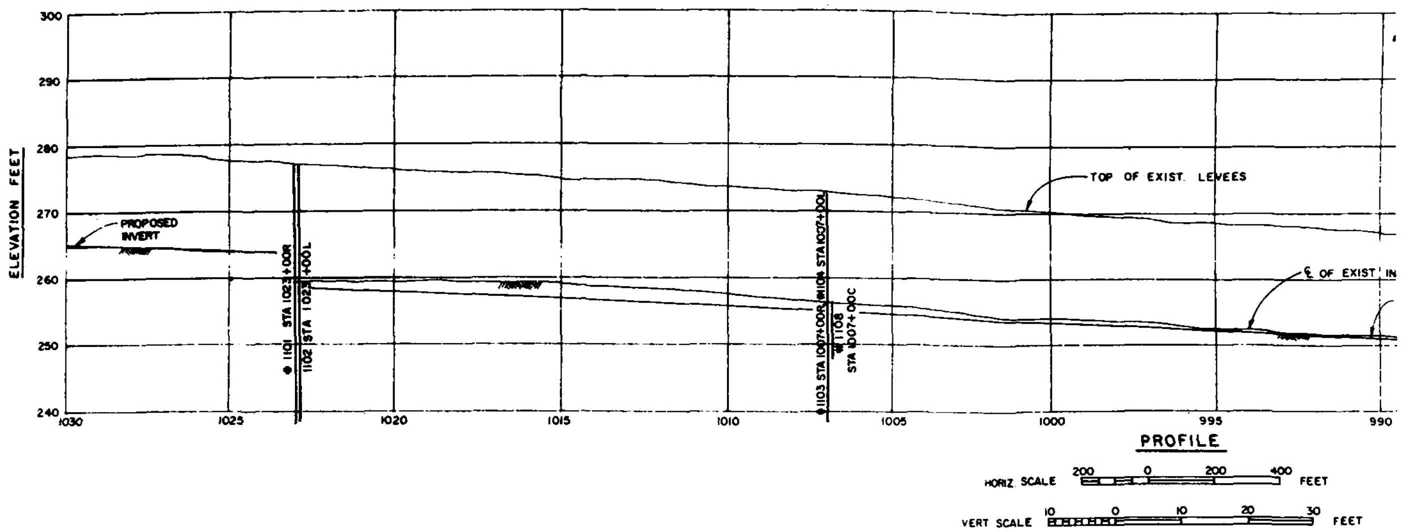
LOGS OF INVESTIGATION
BY OTHERS

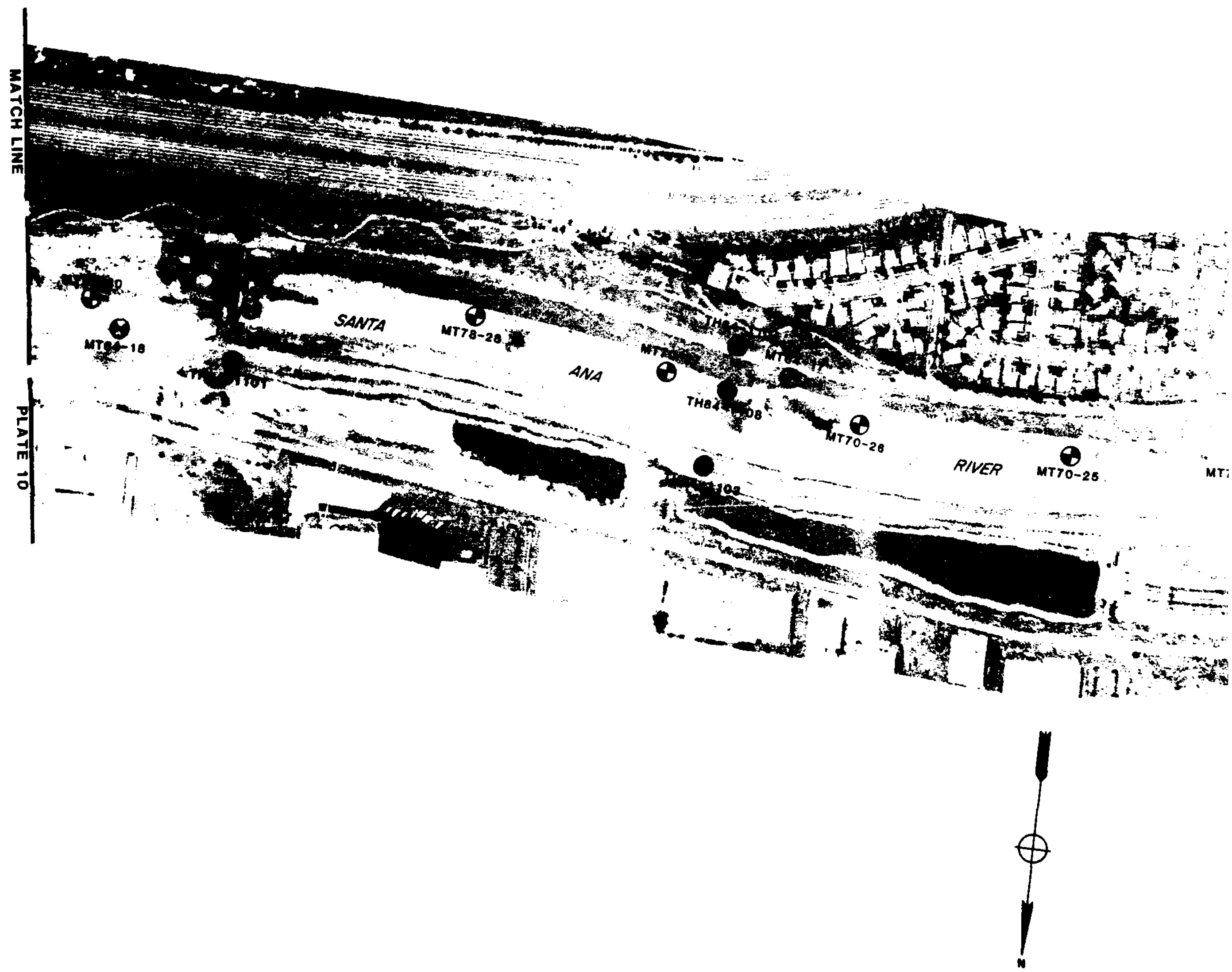
STA.1095+00 TO STA.1030+00

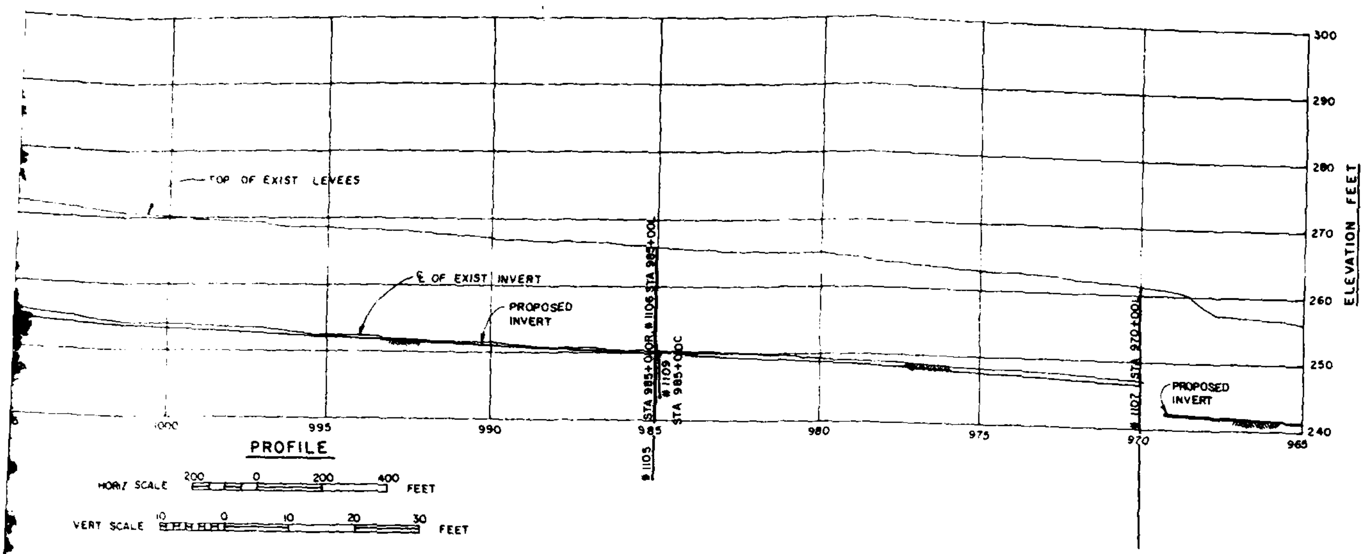
SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

DISTRICT FILE NO.

PLATE 10C


ELEVATION FEET
PROPOSED INVERT
TOP OF EXIST. LEVEES
PROFILE
HORIZ SCALE
VERT SCALE
FEET


MATCH LINE
PLATE 10
SANTA
ANA
RIVER
MT78-28
MT70-26
MT70-25



NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE

STA. 1030+00 TO STA. 965+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____-B-____ SHEET

DISTRICT FILE NO.

PLATE

TH84-1101

TH84-1101 STA 1023+00 R EL. 277±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SILTY SAND: BROWN TO DARK BROWN, MEDIUM TO FINE GRAINED SAND, SOME CLAYEY CLUMPS, OCCASIONAL GRAVEL TO 1 INCH. 30 BLOWS FOR 6 INCHES FROM 1.0 FEET TO 1.5 FEET
		5		NP	90	16		
							22	
							33	SAME: DARK GREYISH GREEN, MOIST, FINE GRAINED SAND, SOME CLAYEY CLUMPS.
	SM							
		12		NP	94	72		
							13	
							35	
14.5								GRAVELLY SAND: LIGHT BROWN AND MULTICOLORED, MOIST, FINE GRAINED SAND, OCCASIONAL GRAVEL AND COBBLES TO 4 INCHES. REFUSAL AT 16 FEET DUE TO A COBBLE.
							15R	
	SP				53	3		
							34	
21.0								SAND/SILTY SAND. GREY AND MULTICOLORED, COARSE GRAINED SAND.
	SP/SM			NP	97	6		
							58	
27.0								
							30R	
	SW-SM			NP	99	6		
30.0							58	SANDY SILT. BROWN TO REDDISH BROWN, NO GRAVEL, VERY STIFF TO HARD, SOME COHESION.
	ML		33	5	99	74		
							45	
35.0								SILTY SAND. BROWN TO REDDISH BROWN, MEDIUM DENSE.
	SM	20		NP	100	26	27	
39.0								SANDY GRAVEL. BROWN AND MULTICOLORED, COARSE GRAINED SAND, COBBLES TO 5 INCHES.
	GW				31	4	27R	
40.5								

TH84-1102

TH84-1102 STA 1023+00 L

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	GP/GM			NP	53	8		[illegible]
3.0							[illegible]	[illegible]
		11		NP	90	13		
	SM						[illegible]	[illegible]
				NP	[illegible]	[illegible]	[illegible]	[illegible]
		11		NP	98	[illegible]		
12.0							[illegible]	[illegible]
	SP/SM			NP	97	5		
							[illegible]	
18.0								[illegible]
	SP				92	4	[illegible]	
21.0								[illegible]
	SM	19	35	[illegible]	97	57		
24.0								[illegible]
	CL		25	[illegible]	94	55		
			32	14	99	68		
30.0								[illegible]
	ML		[illegible]	[illegible]	99	75		
33.0								[illegible]
	SM		[illegible]	[illegible]	59	[illegible]		
35.0								[illegible]
	SP/SM			NP	53	3		
39.0								

TH84-1102

STA 1023+00 L — EL. 277±

LL	PI	-4	-200	N	DESCRIPTION
	NP	53	8		SANDY GRAVEL/SILTY SANDY GRAVEL: BROWN, MOIST, GRAVEL TO 2-1/2 INCHES, FINE GRAINED SAND, FEW COBBLES.
				23	SILTY SAND: DARK BROWN, MOIST, GRAVEL TO 1-1/2 INCHES, FINE GRAINED SAND, SOME GRAVEL.
	NP	90	13		
				37	SAME: BROWN.
	NP	96	15		
				29	SAME: DARK GREY.
	NP	98	31		
				25	SAND/SILTY SAND: LIGHT BROWN, MOIST, SOME CLUMPS OF STIFF SANDY SILT, WATER AT 18 FEET, ADDING MUD AT 18 FEET.
	NP	97	5		
				42	
		92	4	16	GRAVELLY SAND: BROWN, MOIST, FINE GRAINED SAND, GRAVEL TO 2-1/2 INCHES, COBBLES TO 5 INCHES.
35	9	97	52	[illegible]	SILTY SAND: REDDISH DARK BROWN, MOIST, COHESIVE, REFUSAL AT 21.5 FEET DUE TO ROCK.
				[illegible]	SANDY CLAY: REDDISH DARK BROWN, MOIST, COHESIVE.
29	9	98	55		
				[illegible]	
32	14	99	58		
46	15	99	75		CLAYEY SANDY SILT: REDDISH DARK BROWN, MOIST, COHESIVE.
				[illegible]	
22	3	59	13		SILTY GRAVELLY SAND: REDDISH BROWN, MOIST, SOME COHESION, GRAVEL TO 3 INCHES, COBBLES TO 8 INCHES.
				8	
	NP	53	[illegible]		GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED, MOIST, GRAVEL TO 3 INCHES, COBBLES TO 3 INCHES. REFUSAL AT 35.0' DUE TO ROCK.

TH84-1103

TH84-1103 — STA 1007+00 R — EL. 273±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN TO DARK BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, FEW GRAVEL TO 1-1/2 INCHES.
	SW/SM	4		NP	83	9		
				NP	88	7	24R	SAND/SILTY SAND: SAME AS ABOVE, BLACK STREAKS THROUGHOUT, REFUSAL AT 4.0 FEET.
6.0								
	SM	10		NP	93	25	37	SILTY SAND: DARK GREY TO BLACK, MOIST, DENSE, SLIGHT PLASTICITY, FINE TO MEDIUM GRAINED SAND.
10.0							19R	
	SW/SM	5		NP	90	6		SAND/SILTY SAND: BROWN, MEDIUM TO COARSE GRAINED SAND, FEW GRAVEL TO 3/4 INCHES, REFUSAL AT 10.0 FEET.
12.0								
	SP				59	2	21	GRAVELLY SAND: BROWN, DAMP, DENSE, GRAVEL TO 1-1/2", FINE TO MEDIUM GRAINED SAND, REFUSAL AT 13.0 FEET.
14.5								
	SP/SM	4		NP	68	5	44	GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 2 INCHES, LARGE BROWN, CLAYEY CLUMPS AT 17 FEET.
18.0								
							22	GRAVELLY SAND: MULTICOLORED AND BROWN, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 2 INCHES.
		5			83	4		
	SP							SAND: BROWN AND GREY, DENSE, MEDIUM GRAINED SAND.
							42	
					89	3		
								SAME: GREY AND MULTICOLORED, DENSE, FINE TO MEDIUM GRAINED SAND.
25.0					98	3	29R	
	SW/SM			NP	82	5		GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED, COARSE GRAINED SAND, GRAVEL TO 2 INCHES, REFUSAL AT 25.0 FEET.
27.0								
	SP				91	4	8	SAND: MULTICOLORED, COARSE GRAINED SAND, GRAVEL TO 2 INCHES, REFUSAL AT 27.5 DUE TO ROCK.
31.5							17	
	SP/SM	31		NP	86	5		SAND/SILTY SAND: BROWN, MEDIUM TO COARSE GRAINED SAND, DENSE.
33.0							22	
	SW/SM			NP	94	9		SAND/SILTY SAND: MULTICOLORED, FEW GRAVEL TO 1 INCH.
35.0								

NOTES

1. SEE PLATE 11 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM.
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SCALE: 1 IN = 3 FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA. 1023+00 TO STA. 1007+00

SUBMITTED BY: — DATE APPROVED: — SPEC. NO. DACW09-____-B-____ — SHEET

DISTRICT FILE NO.

TH84-1108

INVERT

TH84-1108 STA 1007+00 C EL. 256±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
3.0	SP				66	3	5	GRAVELLY SAND: LIGHT BROWN, LO SAND, GRAVEL TO 2 INCHES, SOME C OF HOLE.
6.0	SP				47	1	17	SANDY GRAVEL: MULTICOLORED, MO SAND, GRAVEL TO 2-1/? INCHES, S
8.5	SP				55	4	2R	GRAVELLY SAND: MULTICOLORED, M COBBLES, REFUSAL AT 8.5 FEET DU

TH84-1105

TH84-1105 STA 985+00 R EL. 266±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
3.0	SM	4		NP	87	15		SILTY SAND: BROWN, DRY TO MOIST, LOOSE TO MEDIUM DENSE, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 3 INCHES, FEW COBBLES.
6.0	SW/SM			NP	92	8	229	SAND/SILTY SAND: BROWN, MOIST, MEDIUM TO COARSE GRAINED SAND, FEW GRAVEL TO 3 INCH, FEW COBBLES, REFUSAL AT 4.0 FEET.
9.0	SM			NP	91	15	42	SILTY SAND: GREENISH BROWN, MOIST, DENSE, MEDIUM TO COARSE GRAINED SAND, LENSES OF DARK GREY SILT, COHESIVE.
12.0	SP				37	2	42	SAND: LIGHT BROWN, MOIST, MEDIUM TO COARSE GRAINED SAND, FEW COBBLES.
15.0	SW/SP			NP	77	12	24	GRAVELLY SAND/SILTY GRAVELLY SAND: LIGHT BROWN, MOIST, MEDIUM DEN[illegible] MEDIUM TO CAORSE GRAINED SAND.
16.0	SM		54	19	79	34	32	SILTY SAND: DARK GREY, MOIST, ORGANIC SMELL, COHESIVE.
18.0	SP				95	4		SAND: GREY TO BROWN, WET, FINE TO MEDIUM GRAINED SAND, WATER AT 18.0 FEET.
21.0	SW				89	3	21	GRAVELLY SAND: MULTICOLORED, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 1 INCH, ADDED MUD AT 18 FEET.
24.0	SM		30	6	97	40	7	SILTY SAND: GREENISH BROWN, FINE TO MEDIUM GRAINED SAND, SMALL POCKETS OF SILT, SOPF COHESION.
30.0	SW			NP	94	4	26 32	SAND: MULTICOLORED, MEDIUM TO COARSE GRAINED SAND, OCCASIONAL GRAVEL TO 1 INCH.
35.0	SP				68	4	15 9	GRAVELLY SAND: MULTICOLORED, COARSE GRAINED SAND, GRAVEL TO 3 INCHES, FEW COBBLES TO 5 INCHES.

TH84-1109

INVERT

TH84-1109 STA 985+00 C EL. 251±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP				79	0		GRAVELLY SAND: LIGHT BROWN, DRY TO COARSE GRAINED SAND, GRAVEL TO 2 INC START OF HOLE.
7.0					72 / 60	2 / 1	16	SAME: MULTICOLORED, MOIST TO WET CO GRAVEL TO 3 INCHES, SOME COBBLES, FA

NOTES

TH84-1104

TH84-1104 STA 1007+00 L EL. 273±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	GC		32	11	55	13		CLAYEY SANDY GRAVEL: TAN, DRY TO MOIST, LOOSE, ANGULAR TO SUBROUNDED GRAVEL TO 3 INCHES, FINE GRAINED SAND, 5 PERCENT COBBLES TO 4 INCHES.
3.0								
	SP/SM				94	10	21	SAND/SILTY SAND: TAN, MOIST, MEDIUM DENSE, ROUNDED TO SUBROUNDED GRAVEL.
6.0								
	SC		35	12	94	29	28	CLAYEY SAND: BLACK, ORGANIC SMELL, MEDIUM DENSE, NO COHESION, COARSE GRAINED SAND, FEW ANGULAR TO ROUNDED GRAVEL TO 3 INCHES.
9.0								
	SM	28	22	1	89	17	31	SILTY SAND: BLACK, ORGANIC SMELL, MEDIUM DENSE TO DENSE, NO COHESION, COARSE GRAIND SAND, SOME ANGULAR TO ROUNDED GRAVEL TO 3 INCHES, REFUSAL AT 13.0 FEET.
13.0							23R	
					39	5		SAND/SILTY SAND: TAN, FINE GRAINED SAND, SUBANGULAR TO ROUNDED GRAVEL TO 2-1/2 INCHES.
	SW/SM				34	5	29	GRAVELLY SAND/SILTY GRAVELLY SAND: SAME AS ABOVE.
					92	7		NO SPT AT 18.5 FEET DUE TO ROCK.
20.0								
	SM				100	37		SILTY SAND: BROWN-GREY, WET, SOME COHESION, FINE GRAINED SAND A POCKET OF DARK, GREY SILT, COHESIVE, WATER AT 21.0 FEET, ADDED REVERT.
W21.0							22	
	ML		49	16	100	64		SANDY SILT: BROWN, WET, MEDIUM DENSE, SOME COBBLES, COARSE GRAINED SAND.
23.0								
	SW/SM				59	7		GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, COARSE GRAINED SAND, ROUNDED TO SUBROUNDED GRAVEL TO 3 INCHES, ROUNDED COBBLES TO 6 INCHES, NO SPT AT 24.5 FEET.
27.0								
	SM		30	4	100	25	16	SILTY SAND: GREYISH BROWN, COHESIVE CLUMPS, FINE GRAINED SAND, OCCASIONAL ANGULAR TO SUBANGULAR GRAVEL TO 2-1/2".
30.0								
	SW/SM				33	3		SAND/SILTY SAND: LIGHT BROWN, SOME COHESION, OCCASIONAL ROUNDED TO SUBROUNDED GRAVEL TO 1 INCH.
32.0							21	
	ML		31	6	100	72		SANDY SILT: BROWN, SOME COHESION, OCCASIONAL ROUNDED GRAVEL TO 1 INCH, OCCASIONAL COBBLES TO 4 INCHES.
35.0							23	

TH84-1108

STA 1007+00 C EL. 256±

MC	LL	PI	-4	-200	N	DESCRIPTION
			66	3	5	GRAVELLY SAND: LIGHT BROWN, LOOSE, FINE TO MEDIUM GRAINED SAND, GRAVEL TO 2 INCHES, SOME COBBLES, USING MUD AT START OF HOLE.
			47	1	17	SANDY GRAVEL: MULTICOLORED, MOIST TO WET, COARSE GRAINED SAND, GRAVEL TO 2-1/2 INCHES, SOME COBBLES.
			55	4	2R	GRAVELLY SAND: MULTICOLORED, MOIST TO WET, SOME LARGE COBBLES, REFUSAL AT 8.5 FEET DUE TO LARGE BOULDER.

TH84-1109

STA 985+00 C EL. 251±

LL	PI	-4	-200	N	DESCRIPTION
		79	0		GRAVELLY SAND: LIGHT BROWN, DRY TO MOIST, VERY LOOSE, COARSE GRAINED SAND, GRAVEL TO 2 INCHES, USING MUD AT START OF HOLE.
		72	2	16	SAME: MULTICOLORED, MOIST TO WET COARSE GRAINED SAND, GRAVEL TO 3 INCHES, SOME COBBLES, FACING STONE AT 7.0 FT.
		50	1		

SCALE: 1 IN = 3 FT
5 0 5 10

NOTES:

1. SEE PLATE 11 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: DRAWN BY: CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.1007+00 TO STA.985+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-___-___ SHEET
DISTRICT FILE NO.

PLATE 11B

TH84 - 1106

TH84-1106 STA 985+00 L EL. 266±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM			NP	90	8		SAND/SILTY SAND: TAN, LOOSE TO MEDIUM DENSE, FINE GRAINED SAND, FEW ROUNDED TO SUBROUNDED GRAVEL, FEW ANGULAR COBBLES TO 4 INCHES.
3.0								
	SM	7		NP	98	17	15	SILTY SAND: TAN, MOIST, FINE GRAINED SAND.
6.0								
	SP				92	3	12	SAND: TAN, MOIST, MEDIUM DENSE, COARSE GRAINED SAND, FEW ROUNDED GRAVEL TO 1/2 INCH, OCCASTIONAL ANGULAR TO SUBANGULAR COBBLES TO 6 INCHES.
9.0								
	SP/SM	3		NP	89	5	18	SAND/SILTY SAND: TAN, MOIST, COARSE GRAINED SAND, FEW ROUNDED GRAVEL TO 1/2 INCHES, 5 PERCENT ANGULAR TO SUBANGULAR COBBLES TO 6 INCHES.
12.0								
	SW	2			77	4	26	GRAVELLY SAND: TAN, MOIST, COARSE GRAINED SAND, ROUNDED GRAVEL, 5 PERCENT ANGULAR TO SUBANGULAR COBBLES TO 6 INCHES.
15.0								
	SW/SM	3		NP	86	2	29	SAND/SILTY SAND: TAN, MOIST, COARSE GRAINED SAND, ROUNDED GRAVEL, 5 PERCENT ANGLAR, TO SUBANGULAR COBBLES, WATER AT 18.0 FEET, ADD REVERT AT 18.0 FEET.
W18.0								
	SP				98	2	23	SAND: COARSE GRAINED SAND, GRAVEL TO 3 INCHES, COBBLES TO 5 INCHES, CAVING AT 19.0 FEET.
21.0								
	SW/SM			NP	93	7		SAND/SILTY SAND: COARSE GRAINED SAND, ANGULAR TO SUBROUNDED GRAVEL TO 3 INCHES, FEW ANGULAR TO SUBANGULAR COBBLES TO 3 INCHES.
24.0								
					61	1	11	GRAVELLY SAND: TAN, MEDIUM DENSE, COARSE GRAINED SAND, ANGULAR TO SUBROUNDED GRAVEL.
	SP							
					96	3	10	SAND: TAN, COARSE GRAINED SAND, FINE GRAINED GRAVEL TO 1/2 INCH, POCKETS OF BROWNISH GREEN SILT AT 29.0 FEET, SOME COHESION
30.0								
	SM			NP	92	20	7	GRAVELLY SILTY SAND: TAN, COARSE GRAINED SAND, POCKETS OF BROWNISH GREEN SILT.
33.0								
	SW/SM			NP	33	9	7	GRAVELLY SAND/SILTY GRAVELLY SAND: COARSE GRAINED SAND, SUBROUNDED TO ANGULAR GRAVEL TO 2 INCHES, POCKETS (CLUMPS) OF SILT BINDING SAND TOGETHER, SOME COHESION.
35.0								

NOTES

VALUE ENGINEERING PAYS

TH84-1107

[illegible]

SCALE [illegible]

NOTES:

1. SEE PLATE [illegible] FOR LOCATION OF TEST HOLES AND TEST TRENCHES.
2. SEE PLATE [illegible] FOR LEGEND AND CLASSIFICATION SYSTEM.
3. SEE TABLE [illegible] FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS IN WAY IN THE CHANNEL AND EXISTING GROUND ON BACK SIDE OF LEVEE.

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.985+00 TO STA.970+00

SAFETY PAYS

WM74-8

LOG OF BORING 8

DATE OF BORING 13 June 74 WATER DEPTH — — DATE MEASURED —— SAMPLES Pitcher and Calif. Mod.

TYPE OF DRILL RIG Falling 1500; Rotary wash HOLE DIAMETER 4 7/8in. WEIGHT OF HAMMER 140lbs. FALLING 30in.

SURFACE ELEVATION: 263'

Depth, ft.	Samples	Blows/Foot	Ground Water	Description	Unc. Comp. Strength, ksf	Moisture Content, %	Dry Density pcf	Other Tests
				Fill: Loose, dry, brown SILTY SAND (SM)				
				Fill: Medium dense, damp, brown CLAYEY SAND (SC)				
10				Very dense, tan SAND (SP-SM) occasional GRAVEL				
	1, 2	>50				10	108	SA
20				Dense to very dense, tan SAND (SP) micaceous				
	3, 4	>50		Lense of stiff, brown CLAYEY SILT (ML)		29	95	SA
30								
	5, 6	>50				18	107	SA
40				Some GRAVEL				
	7, 8	>50		Very dense, brown SILTY SAND (SM) micaceous		31	92	SA
50	9, 10	>50		Very dense, tan SAND (SP-SM)		19	105	SA
				Bottom of boring 55 feet				

MT70-21

MOORE & TABER · Engineers Geologists

TEST BORING LOG

TYPE 6" Rotary ELEVATION 252.2 BORING No 21

USCS	Description
SP	Light brown fine to medium SAND
GW	Brown fine to coarse SANDY GRAVEL with scattered COBBLES
	Brown fine to medium SAND with some coarse SAND and fine GRAVEL
SP	Brown fine SAND with [illegible] and some fine GRAVEL
SP	Brown fine to medium SAND with scattered coarse SAND and fine to coarse GRAVEL
	COBBLES
SP	Brown [illegible] fine SAND
	GRAVEL

Column headings: Strike Dip; Relative Compaction; Dry Density (lbs/cu ft); Moisture (%); Blows/Foot; Sample Size (inches); Sample No; Depth in Feet; Material Symbol; Unified Soil Classification

Logged By | Date

MT70-24

MOORE & TABER · Engineers Geologists

TEST BORING LOG

TYPE [illegible] ELEVATION 25[illegible] BORING No 24

USCS	Description
SP	Light brown fine to coarse SAND
ML	Dark gray-brown SANDY SILT
SP	Brown fine to medium SAND with scattered coarse GRAVEL
SC	Brown fine CLAYEY SAND
SP	Light brown fine to coarse SAND with GRAVEL
	COBBLES
SP	Brown fine SAND
	Some coarse SAND and fine [illegible]
ML	Dark [illegible] SANDY SILT
CL	Brown [illegible] CLAY with scattered GRAVEL
SP	Brown fine to medium SAND
	Some coarse [illegible] with fine to coarse GRAVEL

Notes:
[illegible]
2. Ground water surface [illegible] feet [illegible]
3. Hole cased to [illegible] feet

Column headings: Strike Dip; Relative Compaction; Dry Density (lbs/cu ft); Moisture (%); Blows/Foot; Sample Size (inches); Sample No; Depth in Feet; Material Symbol; Unified Soil Classification

Logged By [illegible] | Date [illegible]

MT70-25

MOORE & TABER · Engineers Geologists

TEST BORING LOG

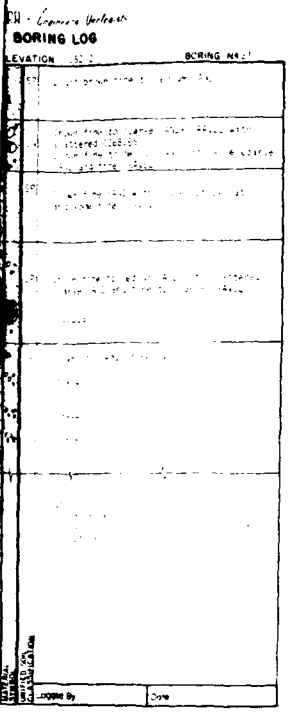
TYPE [illegible] ELEVATION [illegible] BORING No [illegible]

[illegible]

Column headings: Strike Dip; Relative Compaction; Dry Density (lbs/cu ft); Moisture (%); Blows/Foot; Sample Size (inches); Sample No; Depth in Feet; Material Symbol; Unified Soil Classification

Logged By | Date

MT 70-21



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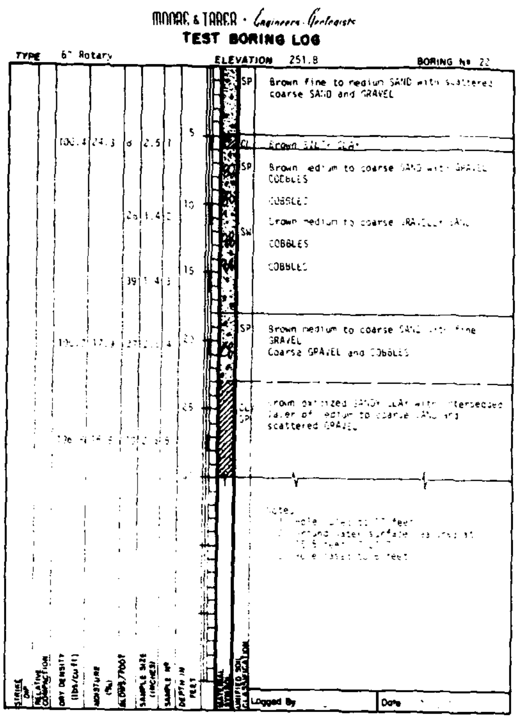

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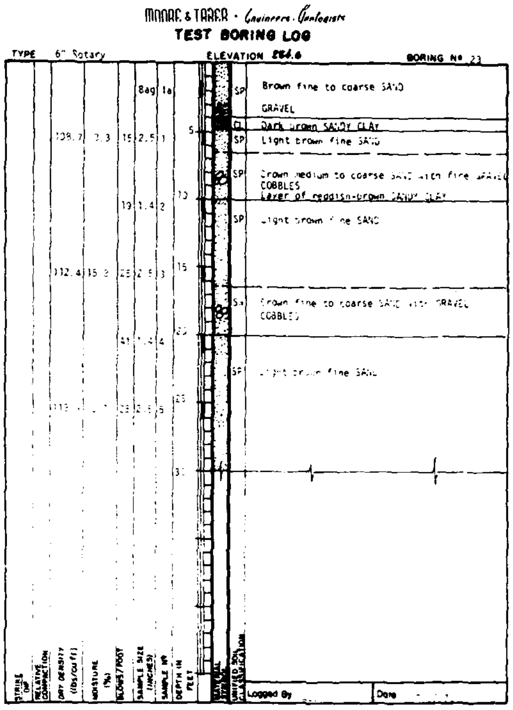

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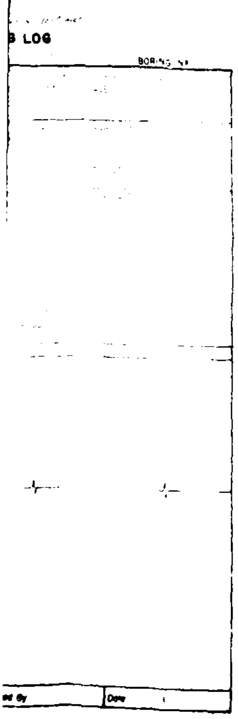

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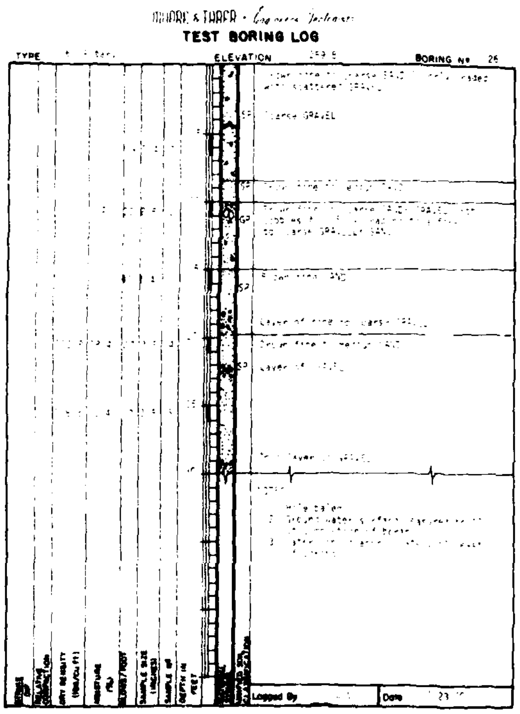


NOTES:

1. SEE PLATE 11 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

LOGS OF INVESTIGATION
BY OTHERS

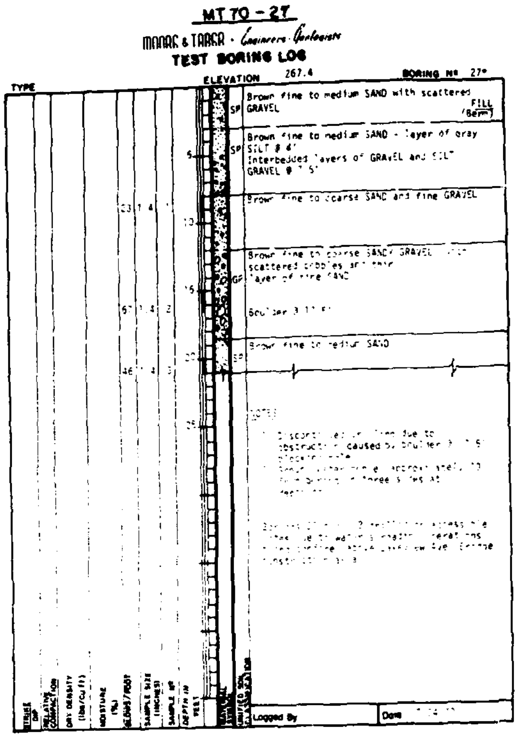
CHECKED BY:

STA.1030+00 TO STA.965+00

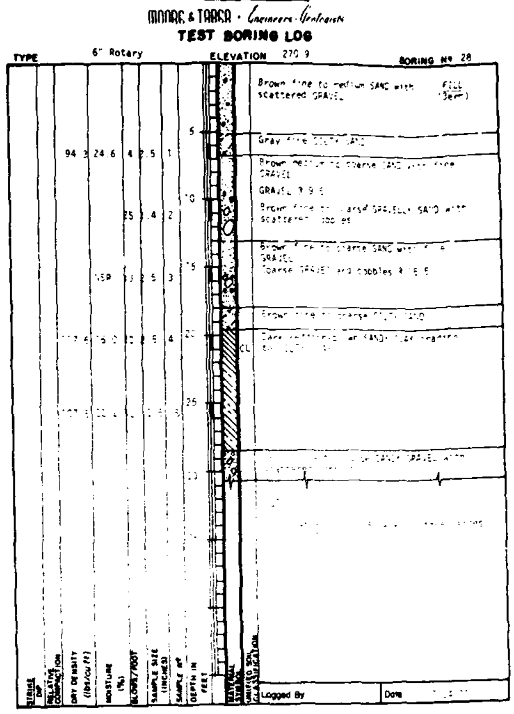
SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-____ B-____ | SHEET

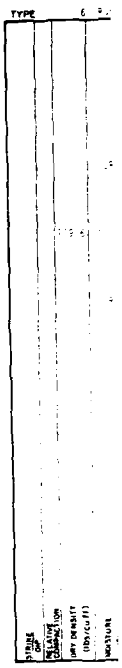
DISTRICT FILE NO.

MT 70 - 27



MT 70 - 28





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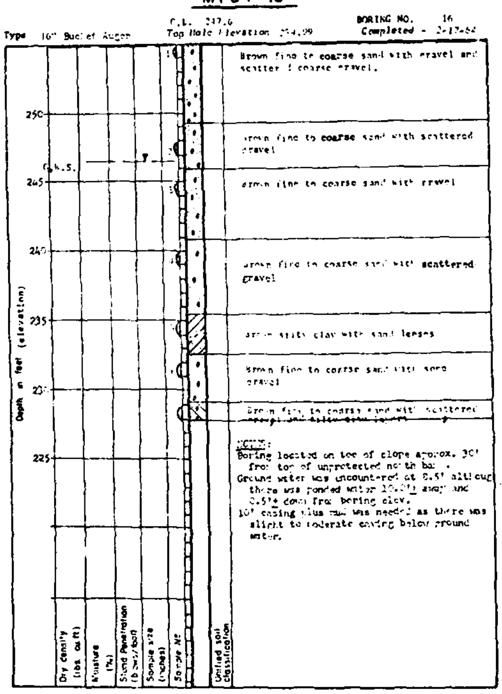

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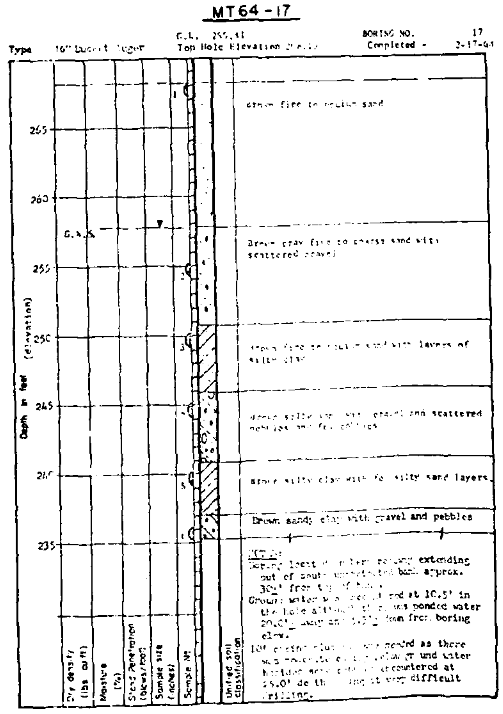
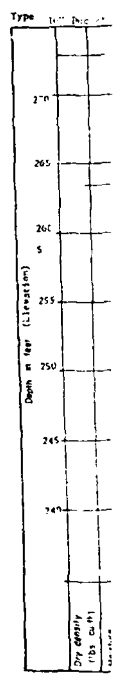
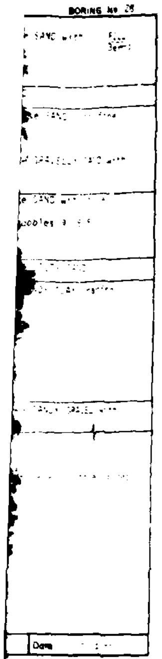
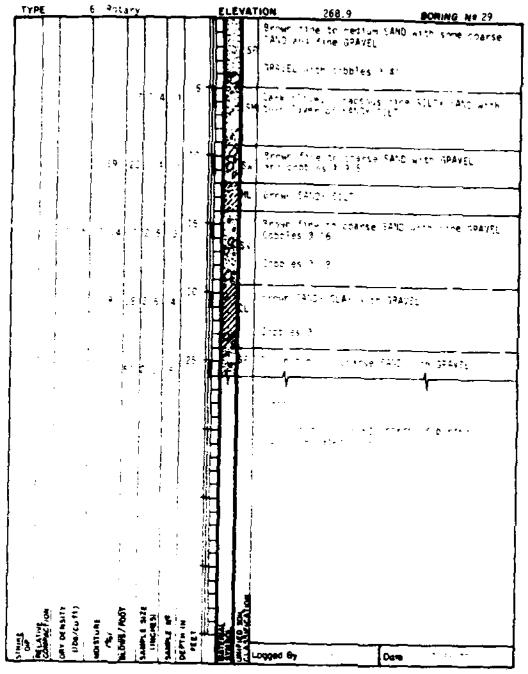
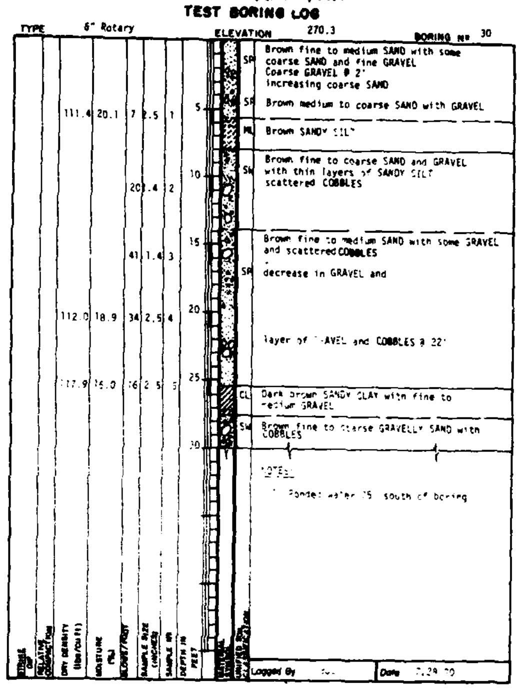
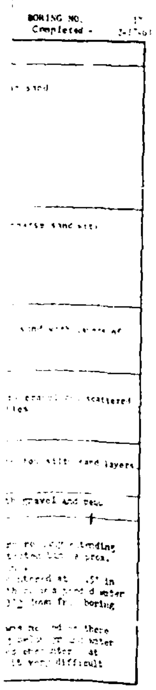


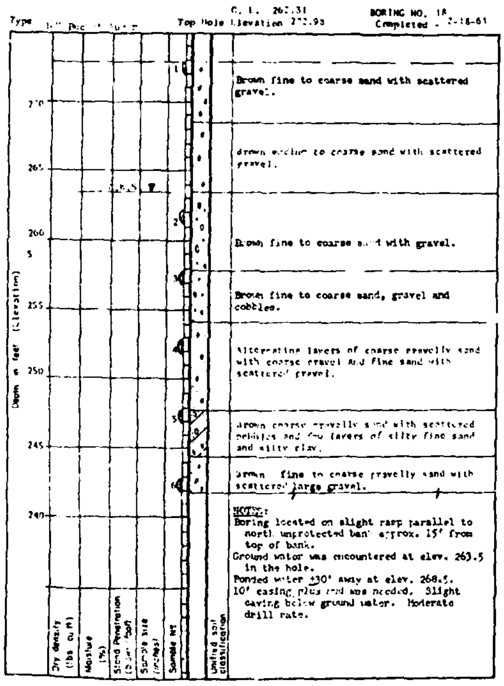












NOTES:

1. SEE PLATE 11 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

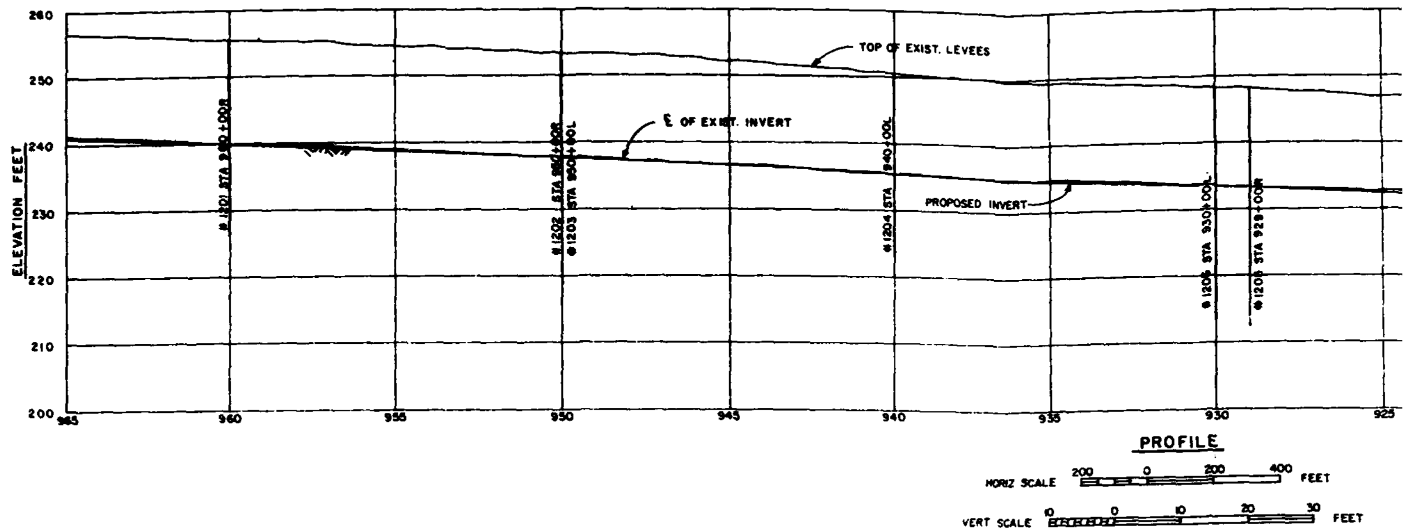
LOGS OF INVESTIGATION
BY OTHERS

CHECKED BY:

STA. 1030+00 TO STA. 965+00

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW 09-____ B-____ | SHEET

DISTRICT FILE NO.


260
250
240
230
220
210
200
ELEVATION FEET
TOP OF EXIST. LEVEES
℄ OF EXIST. INVERT
PROPOSED INVERT
#1201 STA 960+00R
#1202 STA 950+00R
#1203 STA 950+00L
#1204 STA 940+00L
#1205 STA 930+00L
#1206 STA 928+00R
965
960
955
950
945
940
935
930
925
HORIZ SCALE 200 0 200 400 FEET
VERT SCALE 10 0 10 20 30 FEET

PROFILE

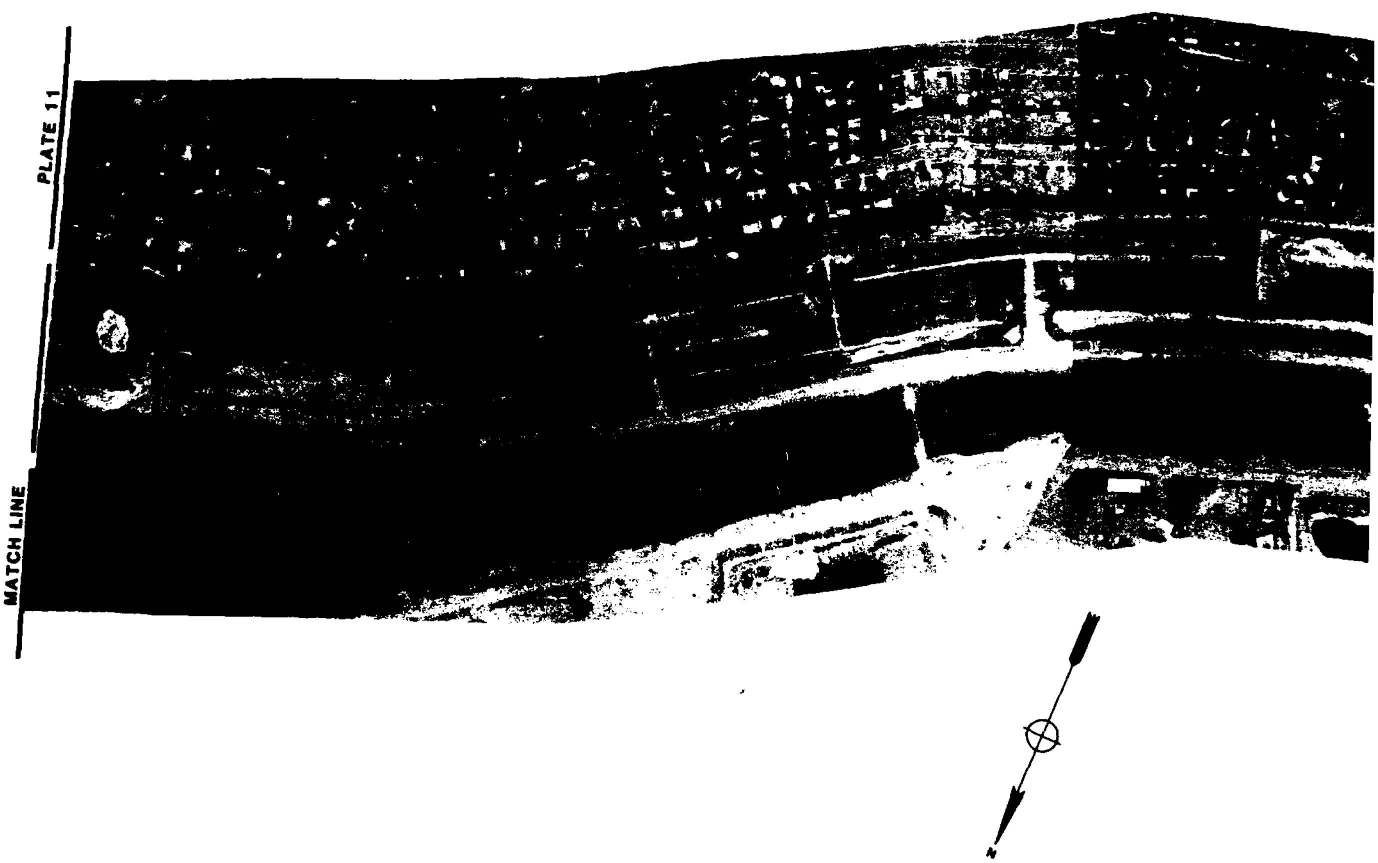
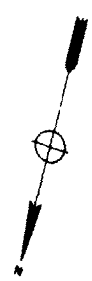


PLATE 11
MATCH LINE
N

VALUE ENGINEERING PAYS



NOTES:
1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE
STA.965+00 TO STA.905+00

DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW 09- ___ B- ___
DISTRICT FILE NO.
SHEET
PLATE 12

SAFETY PAYS

TH84 — 1201

TH84-1201 STA 960+00 R EL. 256±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM			NP	90	8		SAND/SILTY SAND: BROWN, LOOSE, FINE GRAINED SAND, FEW GRAVEL TO 1 INCH.
3.0								
	SP/SM			NP	94	5	4R	SAME: WITH CLUMPS OF BROWN, MOIST, COHESIVE SILTY SAND, REFUSAL AT 4.0 FEET.
6.0								
	SM	9		NP	98	20	18R	SILTY SAND: GREY, MOIST, FINE GRAINED SAND, REFUSAL AT 7.0 FEET.
9.0								
	SW/SM			NP	92	10		SAND/SILTY SAND: GREY, MOIST, FINE GRAINED SAND, FEW GRAVEL TO 1-1/2 INCHES.
12.0								
							40	SILTY SAND: GREY, MOIST, FINE GRAINED SAND, CLUMPS OF CLAYEY MATERIAL, ADDED MUD AT 18.0 FEET, REFUSAL AT 16.0'.
	SM			NP	98	73		
							27R	
18.0								
W 19.5							17R	GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED, SATURATED, COARSE GRAINED SAND, GRAVEL TO 3 INCHES, REFUSAL AT 19.0 FEET, WATER AT 19.5 FEET.
				NP	65	7		
							16	
	SW/SM							
							11	SAND/SILTY SAND: BROWN-MULTICOLORED SATURATED, FINE TO COARSE GRAINED SAND, FEW GRAVEL TO 2 INCHES.
				NP	90	5		
29.0								
	ML		34	7	93	72		SANDY SILT: BROWN, WET, COHESIVE, FINE GRAINED SAND, OCCASIONAL GRAVEL.
30.0								

TH84 — 1202

TH84-1202 STA 950+00 R EL. 254±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SAND/SILTY SAND: BROWN, MOIST, GRAVEL TO REFUSAL AT 3.5 FEET DUE TO ROCK.
		4		NP	86	9		
							21R	
	SW/SM							
		9		NP	94	12	R	SAME: GREY, SLIGHT COHESION, ORGANIC SME TO 1/2 INCH, REFUSAL AT 9.5 FEET.
				NP	90	10		SAME: BROWN, FINE GRAINED GRAVEL.
12.0								
	SM	9		NP	80	15	R	SILTY SAND: GREY, MOIST, SLIGHT COHESION, REFUSAL AT 12.5 FEET.
15.0								
	SP/SM			NP	64	5		GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN ROUNDED TO SUBANGULAR GRAVEL, COBBLES TO
18.0								
	SW/SM			NP	86	10	7R	SAND/SILTY SAND: BROWN, MOIST, ROUNDED TO GRAVEL, COBBLES TO 9 INCHES, POCKETS OF S AT 18.5 FEET DUE TO LARGE COBBLES.
21.0 W 21.5								
							R	GRAVELLY SAND: COARSE GRAINED GRAVEL, SU ROUNDED GRAVEL AND COBBLES, WATER AT 21.5 REVERT AT 21.5 FEET, REFUSAL AT 21.5 FEET
	SW				75	4		
24.0								
	SP				91	4	R	SAND: BROWN, ROUNDED TO SUBROUNDED, COAR GRAVEL TO 1 INCH, REFUSAL AT 25.? FEET.
27.0								
	SW/SM			NP	97	9	6	SAND/SILTY SAND: BROWN, LOOSE, SLIGHT CO GRAINED SAND.
30.0								
	SM/SC		22	5	86	15		SILTY SAND/CLAYEY SAND: BROWN, INCREASE GRAINED SAND, REFUSAL AT 30.5 FEET.
33.0								
	SP				88	2	R	SAND: BROWN-MULTICOLORED, DENSE, REF
35.0								
	SW/SM			NP	93	6		SAND/SILTY SAND: BROWN-MULTICOLORED ANGULAR SAND.
36.0								

TH84 — 1204

TH84-1204 STA 940+00 L EL. 251±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM			NP	98	12		SAND/SILTY SAND: TAN, DRY TO MOIST, LOOSE, FINE GRAINED SAND.
3.0								
							12	SILTY SAND: TAN, MOIST, MEDIUM DENSE, FINE GRAINED SAND, OCCASIONAL ROUNDED TO SUBROUNDED GRAVEL TO 1/2 INCH.
	SM	5		NP	98	13		
6.0				NP	95	38		SAME: DARK BROWN, MOIST, COHESIVE.
							6	SAND/SILTY SAND: BROWN, SLIGHT COHESION, FEW SUBROUNDED GRAVEL TO 3/4 INCHES.
		8		NP	93	11		
							9	SAME: MOIST, FEW GRAVEL TO 2 INCHES, SOME ROOTS, SOME COBBLES AT 10.0 FEET.
	SW/SM							
				NP	93	11		
							7	SAME: ROOTS AND BARBED WIRE AT 14.5 FEET.
14.5								
15.0	SM			NP	95	20		SILTY SAND: BROWN, MOIST, SOME COHESION, COARSE GRAINED SAND.
	SW/SM	8		NP	90	12	3R	SAND/SILTY SAND: BROWN, MOIST, FEW GRAVEL TO 2 INCHES, COBBLES TO 6 INCHES, REFUSAL AT 16.0 FEET DUE TO ROCK.
19.0								
			25	6	99	35		SILTY SAND/CLAYEY SAND: BROWN, MOIST, OCCASIONAL GRAVEL TO 2-1/2", COBBLES TO 6".
W 22.0								SAME: LARGE BOULDERS, DIFFICULT DRILLING, WATER AT 22.0'.
	SM/SC							
			26	5	97	49		SAME: DARK BROWN, SLIGHT COHESION, FINE GRAINED SAND, 1-1/2' BOULDER AT 27.0'.
27.0								

NOTES

1 SEE PLATE TRENCHES
2 SEE PLATE
3 SEE TABLE TYPE OF E
4 ALL TEST THE LEVEE IN THE CHA LEVEE

VALUE ENGINEERING PAYS

TH84—1202

STA 950+00 R — EL. 254±

MC	LL	PI	-4	-200	N	DESCRIPTION
4		NP	86	9	21R	SAND/SILTY SAND: BROWN, MOIST, GRAVEL TO 3 INCHES, REFUSAL AT 3.5 FEET DUE TO ROCK.
3		NP	94	12	R	SAME: GREY, SLIGHT COHESION, ORGANIC SMELL, FEW GRAVELS TO 1/2 INCH, REFUSAL AT 9.5 FEET.
		NP	90	10		SAME: BROWN, FINE GRAINED GRAVEL.
[illegible]		NP	80	15	R	SILTY SAND: GREY, MOIST, SLIGHT COHESION, ORGANIC SMELL, REFUSAL AT 12.5 FEET.
		NP	64	5		GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, MOIST, SUBROUNDED TO SUBANGULAR GRAVEL, COBBLES TO 5 INCHES.
		NP	86	10	7R	SAND/SILTY SAND: BROWN, MOIST, ROUNDED TO SUBROUNDED GRAVEL, COBBLES TO 3 INCHES, POCKETS OF GREY SILT, REFUSAL AT 18.5 FEET DUE TO LARGE COBBLES.
			75	4	R	GRAVELLY SAND: COARSE GRAINED GRAVEL, SUBROUNDED TO ROUNDED GRAVEL AND COBBLES, WATER AT 21.5 FEET, ADDING REVERT AT 21.5 FEET, REFUSAL AT 21.5 FEET DUE TO ROCK.
			91	4	R	SAND: BROWN, ROUNDED TO SUBROUNDED, COARSE GRAINED GRAVEL TO 1 INCH, REFUSAL AT 25.0 FEET.
		NP	97	9	5	SAND/SILTY SAND: BROWN, LOOSE, SLIGHT COHESION, FINE GRAINED SAND.
	22	5	86	15		SILTY SAND/CLAYEY SAND: BROWN, INCREASE IN COHESION, FINE GRAINED SAND, REFUSAL AT 30.5 FEET.
			88	2	R	SAND: BROWN-MULTICOLORED, DENSE, REFUSAL AT 33.5 FEET.
		NP	93	5		SAND/SILTY SAND: BROWN-MULTICOLORED, SUBROUNDED TO SUBANGULAR SAND.

TH84—1203

TH84-1203 — STA 950+00 L — EL. 253±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM			NP	97	14		SILTY SAND: MOIST, LOOSE, FINE GRAINED SAND, ROUNDED FINE GRAINED GRAVEL TO 1/2 INCHES, 1 INCH POCKETS OF FINER MATERIAL.
				NP	99	31	14	
5.0								
	CL		41	16	100	84		SANDY CLAY: BROWN, MOIST, SOFT TO STIFF, COHESIVE.
6.0								
	SW/SM		4	NP	98	11	5	SAND/SILTY SAND: LIGHT TAN, MOIST, OCCASIONAL ROUNDED GRAVEL TO 3/4 INCHES, CAVING AT 8.0 FEET.
9.0								
	SP/SM			NP	86	10	10	SAME: BROWN, COARSE GRAINED SAND, FEW GRAVEL TO 3 INCHES, SOME POCKETS OF SILT, ADDED MUD AT 9.0 FEET DUE TO CAVING.
12.0								
	SP				68	3	17	GRAVELLY SAND: BROWN, COARSE GRAINED SAND, GRAVEL TO 3 INCHES.
15.0								
	SM				74	4	14	
18.0								
							22R	GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 3 INCHES, REFUSAL DUE TO ROCK.
	SW/SM			NP	79	3		
				NP	72	3	14	SAME. COBBLES TO 6 INCHES.
24.0								
	SP				63	12	13	GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 3 INCHES.
25.0								
	SP/SM			NP	95	2		SAND/SILTY SAND: BROWN, MOIST, MEDIUM DENSE TO LOOSE, SLIGHT COHESION, GRAVEL TO 1-1/2 INCH.
27.0								
								GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 3 INCHES.
	SP				84	1		
32.0								
	SM						22	SILTY SAND: DARK BROWN, SLIGHT COHESION, FINE GRAINED SAND, ROUNDED GRAVEL TO 1 INCH, COBBLES TO 1 FEET, ROUNDED BOULDERS TO 1-1/2'.
35.0								

SCALE: 1 IN = 5 FT

5 0 5 10

NOTES

1. SEE PLATE 12 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

TH84-1205

TH84-1205 STA 929+00 R EL. 248±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM	6		NP	86	10		SAND/SILTY SAND: BROWN, MOIST, LOOSE, GRAVEL TO 1 INCH.
3.0							30	SILTY SAND: BROWN, MOIST, FEW GRAVEL TO 2 INCHES, SOME CLUMPS OF SILT.
	SM			NP	92	19	30	SAME: GREY, SLIGHT COHESION, OCCASIONAL GRAVEL TO 1 INCH.
				NP	92	19	30	
12.0							30	SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE TO COARSE GRAINED SAND, GRAVEL TO 1 INCH.
	SW/SM	5		NP	92	3	30	SAME: WATER AT 18 FEET, USING MUD AT 18.0 FEET.
18.0	SM			NP	33	15		SILTY SAND: GREY TO BROWN, MOIST, SLIGHT COHESION, FINE TO COARSE GRAINED SAND, GRAVEL TO 1-1/2 INCHES.
21.0	SW/SM			NP	91	7	25R	SAND/SILTY SAND: MULTICOLORED, WET, FINE TO COARSE SAND, FEW GRAVEL TO 1-1/2 INCHES, 5 PERCENT COBBLES TO 4 INCHES.
24.0							40	GRAVELLY SAND: MULTICOLORED, WET, COARSE GRAINED SAND, GRAVEL TO 2 INCHES, 10 PERCENT COBBLES TO 5 INCHES.
	SP				73	2		
							3	
30.0							19	
	SW				73	5		
							15	
[illegible]								

VALUE ENGINEERING PAYS

TH84-1206

TH84-1206 STA 930+00 L EL. 248±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								GRAVELLY CLAYEY SAND: DARK BROWN, MOIST, COARSE GRAINED SAND, ROUNDED TO SUBROUNDED GRAVEL TO 2-1/2 INCHES, ROUNDED COBBLES TO 6 INCHES, REVETMENT STONE TO 12 INCHES AT 2 FEET, 3 INCH SILTY/CLAYEY COHESIVE CLUMPS.
			27	10	85	24		
							29	CLAYEY SAND: SAME AS ABOVE.
	SC	11	25	11	86	40		
							26	GRAVELLY CLAYEY SAND: SAME AS ABOVE, MEDIUM DENSE, ROUNDED GRAVEL TO 1 INCH, COBBLES TO 1 FOOT, DIFFICULT DRILLING.
		11	26	10	79	28		
							16	
11.0								
								SILTY SAND/CLAYEY SAND: DARK GREY, MOIST, MEDIUM DENSE, SLIGHT COHESION, COARSE GRAINED SAND, FEW ROUNDED TO SUB-ROUNDED GRAVEL, COBBLES TO 5 INCHES, ORGANIC SMELL, STEEL CABLE AT 13.0 FEET.
	SM/SC		27	7	94	42		
								SAME: FEW GRAVEL TO 3 INCHES, COBBLES TO 9 INCHES, ORGANIC SMELL.
19.0								
							22	GRAVELLY CLAYEY SAND: GREY, MOIST, MED. DENSE, COHESIVE, ORGANIC SMELL, ROUNDED GRAVEL, NO COBBLES.
	SC		29	8	83	37		
							20	
			33	13	32	32		SAME: DARK BROWN, ROUNDED TO SUBROUNDED GRAVEL, 3 INCH SILTY/CLAYEY CLUMPS.
25.5								
								GRAVELLY SILTY SAND: GREY, MOIST, MEDIUM DENSE, SLIGHT COHESION, ORGANIC SMELL, COARSE GRAINED SAND, ROUNDED TO SUBROUNDED GRAVEL TO 1 INCH, 5 PERCENT COBBLES.
	SM		29	2	34	32		
							29	
29.0								
								CLAYEY SAND: GREY SAND, POCKETS OF BROWN COHESIVE CLAYEY CLUMPS, FEW GRAVEL TO 1/2 INCH, 5 PERCENT COBBLES TO 5" DIFFICULT DRILLING DUE TO BOULDERS.
							15	
	SC		27	9	93	35		
34.0								

SCALE: 1 IN = 3 FT

NOTES

1. SEE PLATE 12 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.930+00 TO STA.929+00

TH84-1207

TH84-1207 STA 920+00 R EL. 246±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, MOIST, FINE TO COARSE GRAINED SAND, GRAVEL TO 1-1/2 INCH.
		4		NP	85	9		
								SAND/SILTY SAND: SAME, SOME COBBLES.
	SW/SM							
				NP	88	11		
							25R	SAME: REFUSAL AT 7.0 FEET DUE TO BOULDER.
9.0								
								SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND, FEW GRAVEL TO 1 INCH.
	SP				94	4		
12.0								
	SM			NP	95	19		SILTY SAND: GREY, MOIST, SLIGHT COHESION, FINE GRAINED SAND.
15.0								
							16R	SAND/SILTY SAND: GREY, MOIST, FINE GRAINED SAND, SOME COBBLES, REFUSAL AT 16.0 FEET.
				NP	92	9		
								SAME: MOIST TO WET, FINE TO COARSE GRAINED SAND, FEW GRAVEL TO 1 INCH.
							36	
	SW/SM	9		NP	97	7		
W 22.5							23R	SAME: REFUSAL AT 22.0 FEET, WATER AT 22.5 FOOT, USING MUD AT 22.5 FEET.
24.0								
							9	GRAVELLY SAND: MULTICOLORED, WET, LOOSE TO MEDIUM DENSE, COARSE GRAINED SAND, GRAVEL TO 3 INCHES, 5 PERCENT COBBLES.
	SP				64	3		
							18	
					60	2		
30.0								

TH84-120

DEPTH

S

3.0

6.0

11.5

W 16.5

35.0

VALUE ENGINEERING PAYS

TH83-1208

TH84-1208 STA 910+00 L EL. 243±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM			NP	86	12	23	SAND/SILTY SAND: BROWN, MEDIUM DENSE, COARSE GRAINED SAND, COBBLES TO 12 INCHES.
3.0							24R	
								SANDY SILTY: TAN-BROWN, MOIST, LOOSE, FINE GRAINED SAND.
	ML			NP	98	57	9	
6.0								
								SILTY SAND: TAN-BROWN, MOIST, LOOSE, MEDIUM GRAINED SAND.
							18	
	SM			NP	98	16		
								SAME: MEDIUM DENSE.
11.5							19	
								SAND/SILTY SAND: TAN-BROWN, MOIST, MEDIUM GRAINED SAND.
								SAME: WET, MEDIUM TO COARSE GRAINED SAND.
				NP	95	10	25	
W 16.5								GRAVELLY SAND/SILTY GRAVELLY SAND: GREY, WET, MEDIUM DENSE, COARSE GRAINED SAND ADDED REVERT AT 16.5 FEET.
				NP	85	6	14	
	SW/SM							
							12	
								SAND/SILTY SAND: GREY, WET, MEDIUM DENSE, COARSE GRAINED SAND.
							17	
				NP	99	11	12	
32.0							21	
								SILTY SAND: GRAY, WET, MEDIUM DENSE, MEDIUM TO COARSE GRAINED SAND.
							15	
	SM			NP	99	14		
35.0								

SCALE 1 IN=3FT

5 0 5 10

NOTES

1. SEE PLATE 12 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS

CORPS OF ENGINEERS

STA.920+00 TO STA.910+00

WM74-5

LOG OF BORING 5

DATE OF BORING 4 June 74 WATER DEPTH 32' DATE MEASURED 19 June74 SAMPLES Pitcher and Calif. Mod.
TYPE OF DRILL RIG Budha, rotary wash HOLE DIAMETER 4 7/8in. WEIGHT OF HAMMER 140lbs. FALLING 30in.

SURFACE ELEVATION: ≈ 265'

DEPTH, FT.	SAMPLES	BLOWS/FOOT	GROUND WATER	DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
				Fill: Loose, dry, brown SILTY SAND (SM)				
				Fill: Loose to medium dense, damp, brown GRAVELLY SAND (SW-SM)				
10								
				Medium dense, damp to wet, brown SAND (SW-SM) with GRAVEL				
20								
	1	>50		Very dense, damp to wet, tan SAND (SP-SM) with GRAVEL		12	120	SA
30			▽					
	2			Very stiff-hard, reddish-brown SILTY CLAY (CL)				
40	3	50		Very dense, reddish-brown SILTY SAND (SP-SM) with GRAVEL		16	113	
				Bottom of boring 44 feet				

WM74-6

DATE OF BORING 5 June 74 WATER DEPTH 22' DATE MEASURED 19 June74 SA
TYPE OF DRILL RIG Budha, Rotary wash HOLE DIAMETER 4 7/8in. WEIGHT OF HA

SURFACE ELEVATION ≈ 250'

DEPTH, FT.	SAMPLES	BLOWS/FOOT	GROUND WATER	DESCRIPTION
				Fill: Loose, dry, brown SILTY SAND (SM)
				Fill: Loose, dry, brown SILTY SAND (SW-SM) with GRAVEL
10				CLAYEY
	1	>50		Dense to very dense, damp, tan SANDY GRAVEL (GW-GM) to GRAVELLY SAND (SW-SM)
20	2	NR	▽	
	3			Dense, tan SAND (SP)
	4	44		
30				Very dense with GRAVEL
40				Bottom of boring 38 feet

WM74-9

LOG OF BORING 9

DATE OF BORING 13 June 74 WATER DEPTH 22' DATE MEASURED 19 Jun 74 SAMPLES None
TYPE OF DRILL RIG Falling 1500: Rotary wash HOLE DIAMETER 4 7/8in. WEIGHT OF HAMMER N/A FALLING N/A

SURFACE ELEVATION: 250'

DEPTH, FT.	SAMPLES	BLOWS/FOOT	GROUND WATER	DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
				Fill: Loose, dry, brown SILTY SAND (SM)				
				Fill: Loose, dry, brown GRAVELLY SAND (SW-SM) with layers containing COBBLES				
10								
				Medium dense to dense, brown GRAVELLY SAND (SW-SM)				
20								
				Intermittent COBBLES				
30								
40								
50				Bottom of boring 50 feet				

MT70-10

[illegible] & TABER - Engineers Geologists

TEST BORING LOG

TYPE [illegible] ELEVATION 226.3 BORING No

UNIFIED SOIL CLASSIFICATION	DESCRIPTION
SP	Loose brown fine to coarse SAND [illegible] scattered GRAVEL
ML	Very soft dark gray [illegible]
SP	Loose to semi-compact brown [illegible] coarse SAND
SP	Semi-compact brown fine SAND
SC	Brown fine CLAYEY SAND
SP	Brown fine SAND
CL	Black [illegible]
SC	Brown fine CLAYEY SAND
SP	Brown [illegible] to coarse [illegible]
SC	Red-brown fine [illegible]
CL	Black [illegible]
SP	Brown fine to coarse [illegible] GRAVEL
GP	Brown fine to coarse [illegible]

[illegible]tes
[illegible]

Column headings: [illegible] DIP, RELATIVE COMPACTION, DRY DENSITY (lbs/cu ft), MOISTURE (%), BLOWS/FOOT, SAMPLE SIZE (INCHES), SAMPLE No, DEPTH IN FEET, [illegible], UNIFIED SOIL CLASSIFICATION

Logged By [illegible] Date [illegible]

VALUE ENGINEERING PAYS

WM74-6

LOG OF BORING 6

5 June 74 WATER DEPTH 22' DATE MEASURED 19 June74 SAMPLES Pitcher and Calif. Mod.
Bucha, Rotary wash HOLE DIAMETER 4 7/8in. WEIGHT OF HAMMER 140lbs FALLING 30in.

Elevation: ≈ 250'

DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
Fill: Loose, dry, brown SILTY SAND (SM)				
Fill: Loose, dry, brown SILTY SAND (SW-SM) with GRAVEL				
CLAYEY				
Dense to very dense, damp, tan SANDY GRAVEL (GW-GM) to GRAVELLY SAND SAND (SW-SM)		11	125	SA
Dense, tan SAND (SP)		13	117	SA
Very dense with GRAVEL				
Bottom of boring 38 feet				

WM74-7

LOG OF BORING 7

DATE OF BORING 12 June 74 WATER DEPTH ----- DATE MEASURED ----- SAMPLES Pitcher and Calif. Mod.
TYPE OF DRILL RIG Failing 1500; Rotary wash HOLE DIAMETER 4 3/4in. WEIGHT OF HAMMER 140lbs. FALLING 30in.

SURFACE ELEVATION: 253'

DEPTH, FT.	SAMPLES	BLOWS / FOOT	GROUND WATER	DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
				Fill: Loose, dry, brown SILTY SAND (SM) with COBBLES				
				Fill: Medium dense, damp tan SAND (SP)				
				← COBBLES				
10	1			Medium dense, moist, dark brown CLAYEY SAND (SW-SC) with GRAVEL				
	2	30		Dense to very dense, tan SAND (SP-SM) with GRAVEL		7	112	SA
20	3							
	4	>50				12	103	SA
30	5							
	6	>50				10	124	SA
				← COBBLES				
40	7	RR						
	8	>50				12	114	SA
50	9			Very dense, tan SAND (SP) with GRAVEL				
	10	>50						
	11	>50				17	109	SA
60	12			Thin layer of brown SANDY CLAY (CL)				
				Bottom of boring 62½ feet				

MT70-10

MOORE & TABER · Engineers Geologists

TEST BORING LOG

ELEVATION BORING No 10

Logged By Date

MT70-11

MOORE & TABER · Engineers Geologists

TEST BORING LOG

TYPE Rotary ELEVATION 226.4 BORING No 11

Brown fine to coarse SAND with GRAVEL

Brown micaceous SANDY SILT

Brown fine to coarse SAND with GRAVEL

Increase in GRAVEL

Brown fine to coarse GRAVELLY SAND with COBBLES

Brown fine to coarse SAND, GRAVEL and COBBLES

Increase in COBBLES

Brown fine to coarse SAND, GRAVEL with COBBLES

Increase in COBBLES

Logged By Date

NOTES:

1. SEE PLATE 12 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY: DATE SHEET

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION BY OTHERS

STA.965+00 TO STA.905+00

MT70-12

MOORE & TABER - Engineers - Geologists

TEST BORING LOG

TYPE 6" Rotary ELEVATION 228.6 BORING No 12

Blows/Foot	Sample Size (Inches)	Sample No	Depth in Feet	Unified Soil Classification	Description
				SP	Loose tan fine to coarse SAND
	Bag	1a			
					thin gravel layer
10	1.4	1	5	SM	Loose, brown-gray layered fine SILTY SAND
				SW	Semi-compact brown fine to coarse SAND with fine to coarse GRAVEL
41	1.4	2	10	SP	Dense tan fine to medium SAND
			15	SP/SM	Compact, brown fine to coarse SAND and fine GRAVEL with thin layers of brown fine SILTY SAND
				SM	Brown fine SILTY SAND
			20	SW/GW	Dense, brown fine to coarse SAND and fine to coarse GRAVEL
71	1.4	4		SW	Very dense tan fine to coarse SAND layer of COBBLES

Notes:
Discontinued drilling due to heavy concentration of cobbles

Strike Dip | Relative Compaction | Dry Density (lbs/cu ft) | Moisture (%) | Blows/Foot | Sample Size (Inches) | Sample No | Depth in Feet | Material Symbol | Unified Soil Classification | Logged By | Date

MT70-13

MOORE & TABER - Engineers - Geologists

TEST BORING LOG

TYPE 6" Rotary ELEVATION 230.8 BORING No 13

Blows/Foot	Sample Size (Inches)	Sample No	Depth in Feet	Unified Soil Classification	Description
				SW	Semi-compact tan fine to coarse SAND
					fine gravel
13	1.4	1	5	SP	Semi-compact tan-gray fine to medium SAND
				GP	Coarse GRAVEL
35	1.4			SP	Compact, tan fine to medium SAND
22	1.4	3	15	CL/ML	Brown-red brown SANDY CLAY and SILT
			20	SP	Very dense, brown fine to coarse SAND with coarse GRAVEL and small COBBLES of slightly weathered GRANITE and other hard rocks
128	1.4	4			
133			25		[illegible]
					[illegible]
					[illegible]
					[illegible]
74	1.4	6		GW/SW	Very dense fine to coarse SAND and fine GRAVEL ... COBBLES
					[illegible]
	1.4				

Strike Dip | Relative Compaction | Dry Density (lbs/cu ft) | Moisture (%) | Blows/Foot | Sample Size (Inches) | Sample No | Depth in Feet | Material Symbol | Unified Soil Classification | Logged By | Date

TYPE 6" Rotary

MOORE

MT70-16

MOORE & TABER - Engineers - Geologists

TEST BORING LOG

TYPE 6" Rotary ELEVATION 234.3 BORING No 16

SP Brown fine to medium SAND with some coarse SAND and scattered fine to coarse GRAVEL

Brown fine to medium SANDY GRAVEL

SP Brown fine SAND

[illegible]

Strike Dip | Relative Compaction | Dry Density (lbs/cu ft) | Moisture (%) | Blows/Foot | Sample Size (Inches) | Sample No | Depth in Feet | Material Symbol | Unified Soil Classification | Logged By | Date

MT70-17

MOORE & TABER - Engineers - Geologists

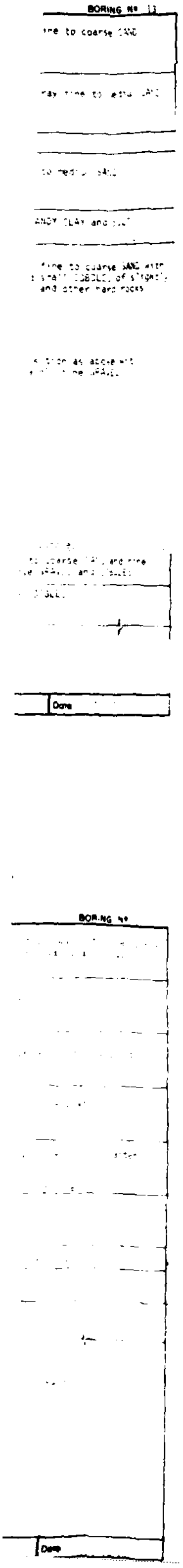
TEST BORING LOG

TYPE 6" Rotary ELEVATION BORING No

[illegible]

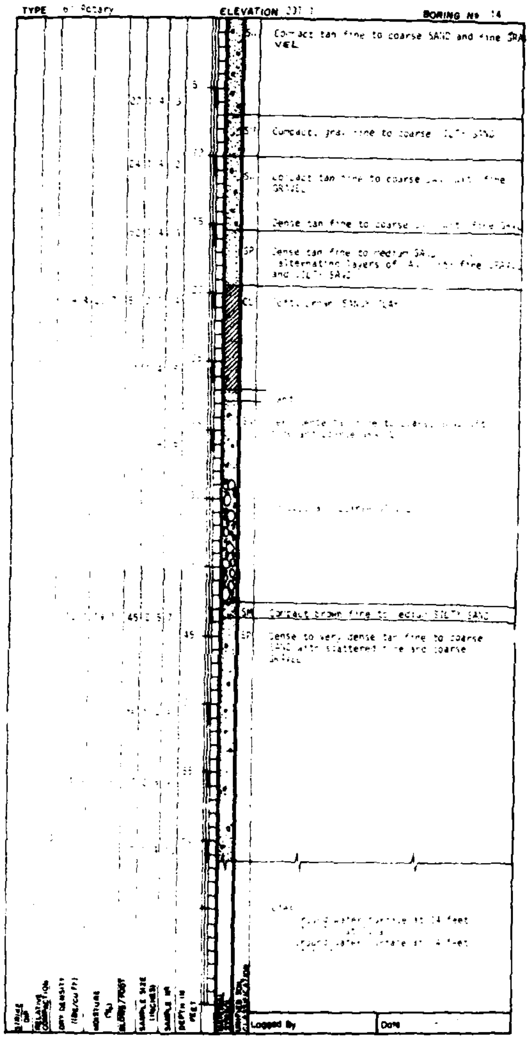
Strike Dip | Relative Compaction | Dry Density (lbs/cu ft) | Moisture (%) | Blows/Foot | Sample Size (Inches) | Sample No | Depth in Feet | Material Symbol | Unified Soil Classification | Logged By | Date

ALUE ENGINEERING PAYS



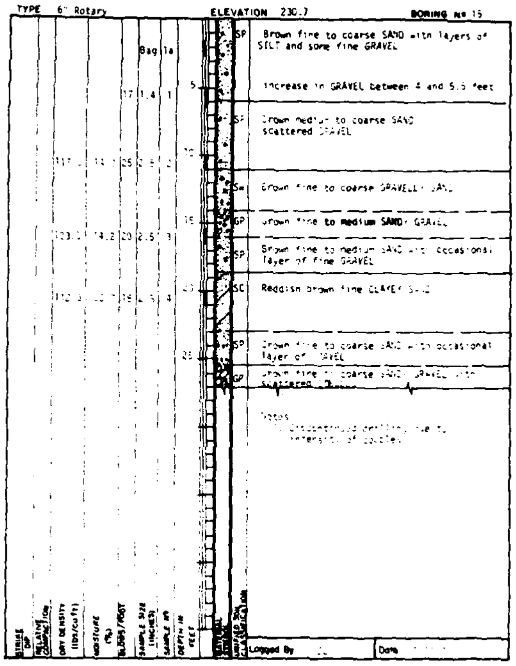
MT70-14

MOORE & TABER · Engineers · Geologists
TEST BORING LOG



MT70-15

MOORE & TABER · Engineers · Geologists
TEST BORING LOG



NOTES:

1. SEE PLATE 12 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE.

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

LOGS OF INVESTIGATION
BY OTHERS

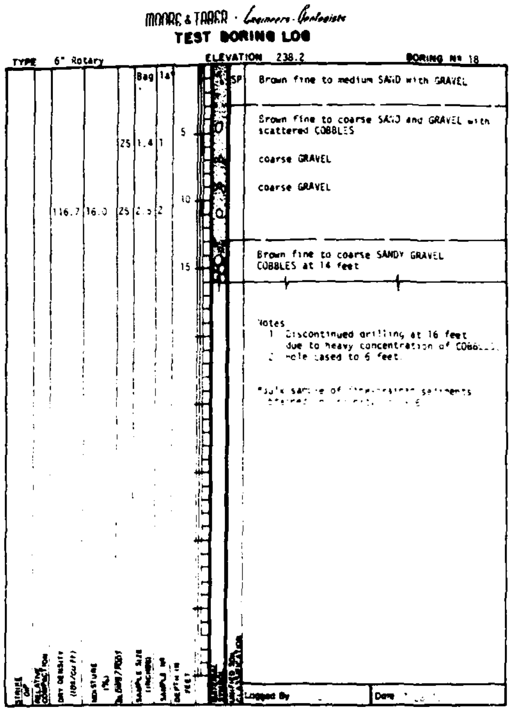
CHECKED BY:

STA.965+00 TO STA.905+00

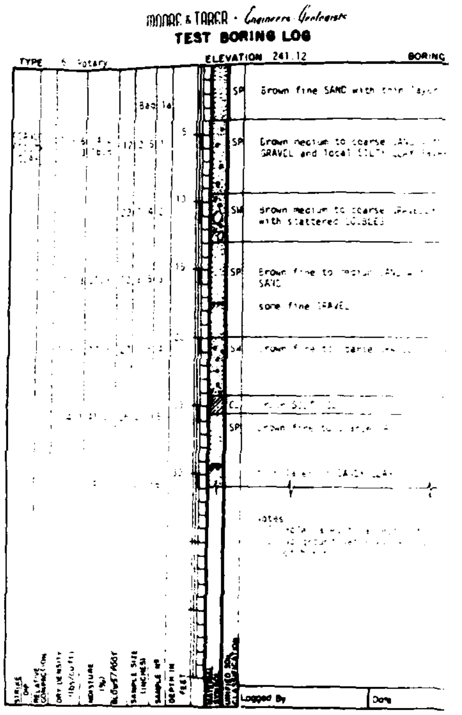
SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-____ B-____ | SHEET

VALUE ENGINEERING PA

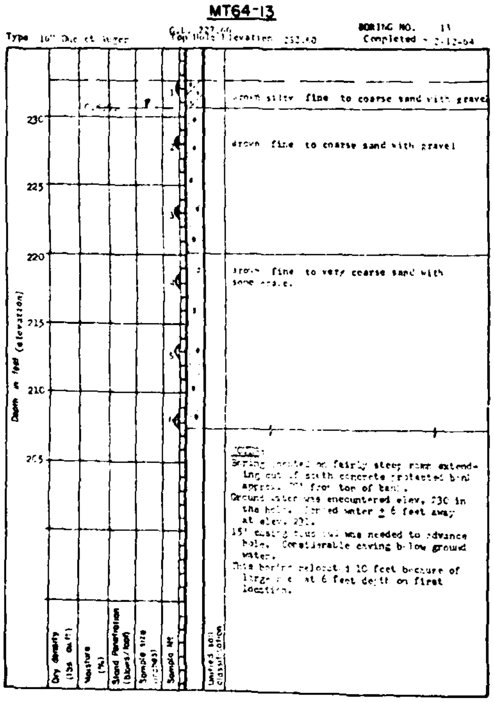
MT70-18



MT70-19



MT64-13



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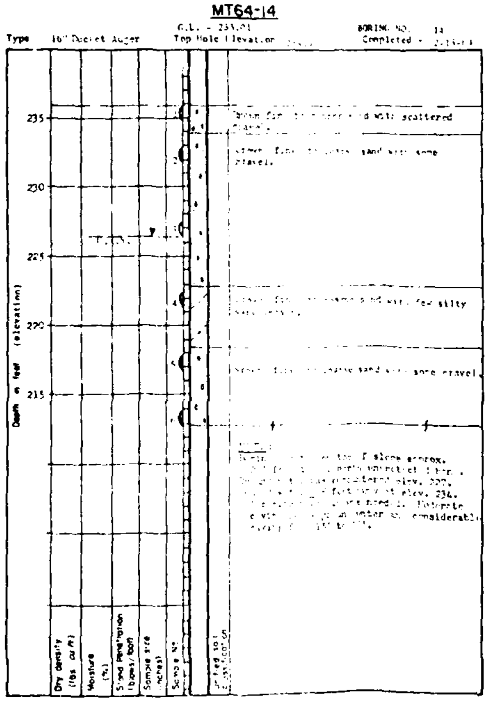
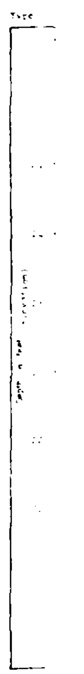
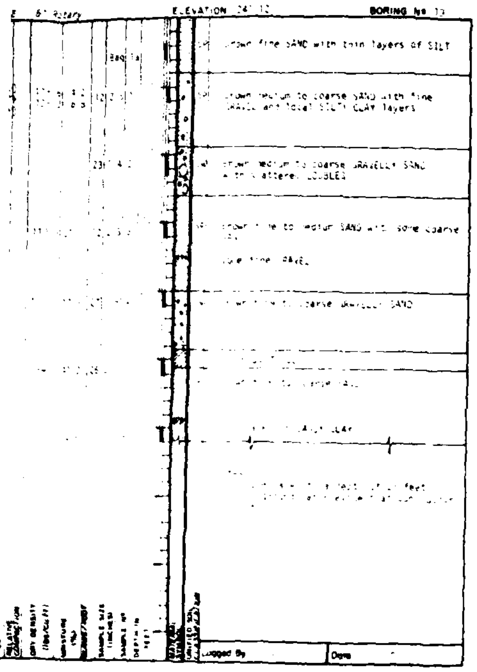




LUE ENGINEERING PAYS

MT70-19



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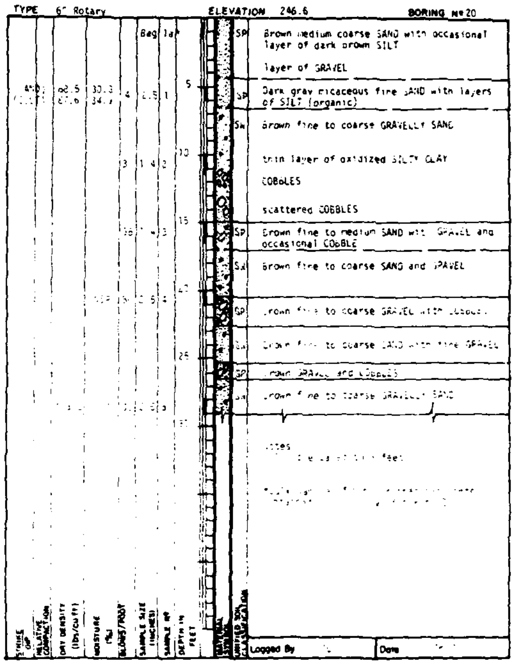

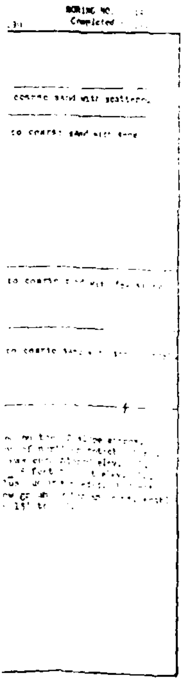

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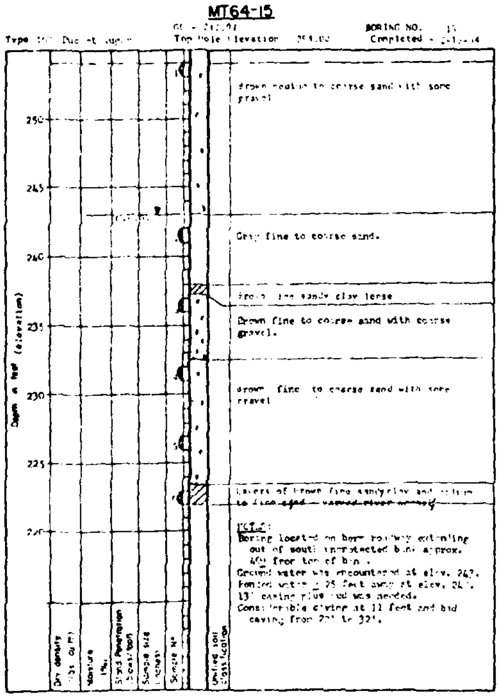

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SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

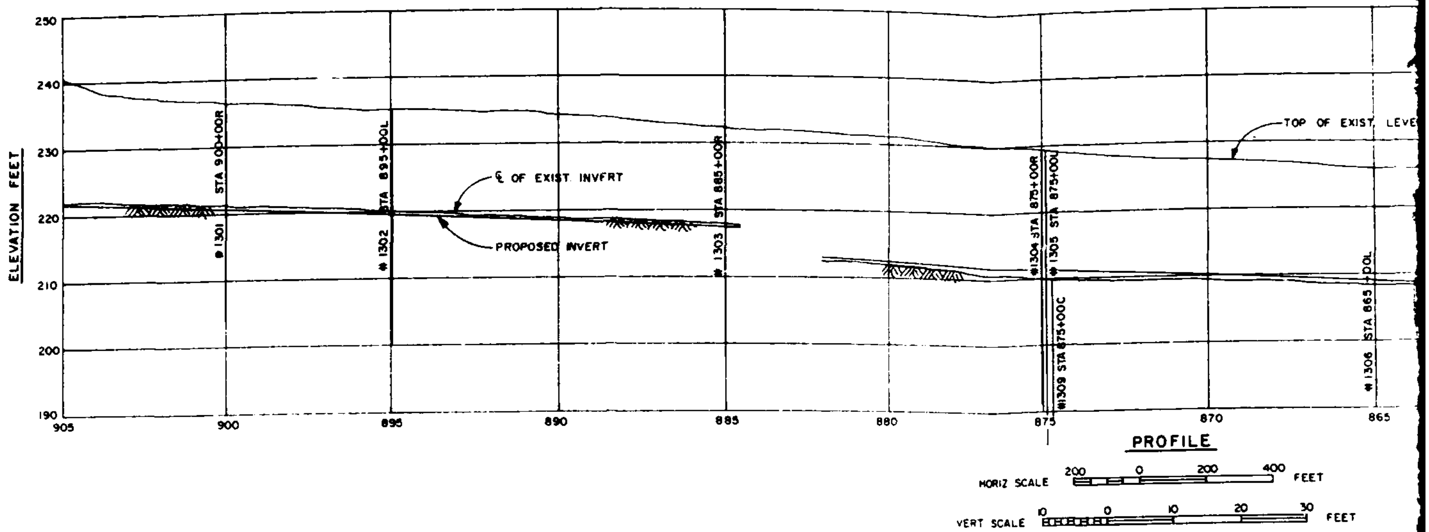
DESIGNED BY:
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:
LOGS OF INVESTIGATION
BY OTHERS

CHECKED BY:
STA.965+00 TO STA.905+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____-B-____ SHEET

VALUE ENGINEERING PAY

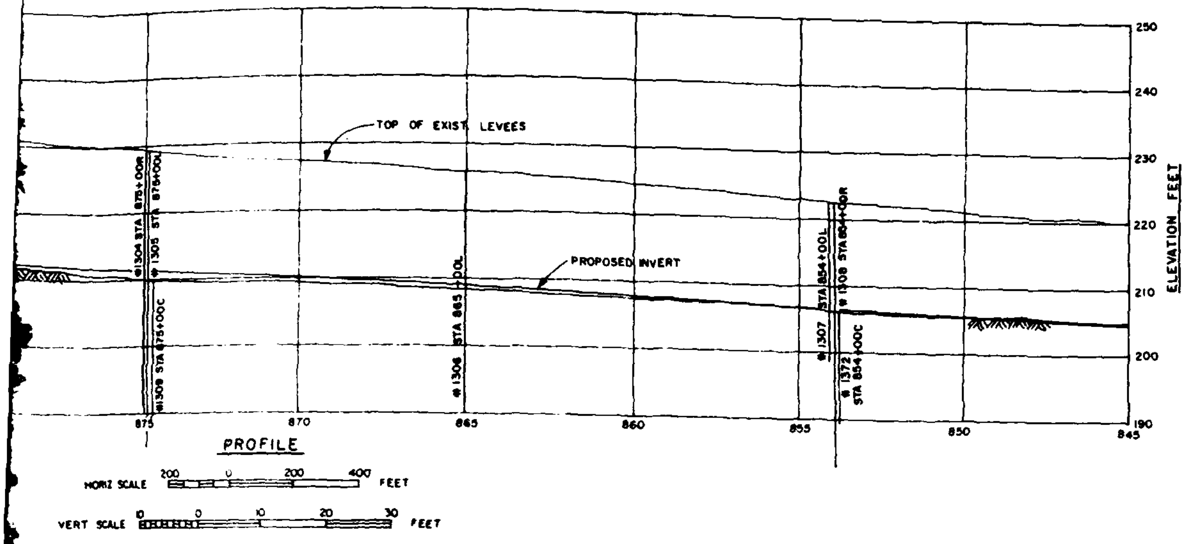


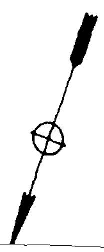
NOTES:

1. SE

2. SE
S

VALUE ENGINEERING PAYS





DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
REVISIONS			

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:	SANTA ANA RIVER MAINSTEM, CALIFORNIA PHASE II GENERAL DESIGN MEMORANDUM
DRAWN BY:	PLAN AND PROFILE
CHECKED BY:	STA.905+00 TO STA.845+00

NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

TH84-1301

TH84-1301 STA 900+00 R EL. 237±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
				NP	90	7		SAND/SILTY SAND: BROWN, MOIST, FEW GRAVEL TO 3/4 INCHES, 3 INCH AC AT SURFACE.
	SW/SM			NP	90	12	R	SAME: DARK BROWN, COARSE GRAINED SAND, FEW GRAVEL TO 1/2 INCH, REFUSAL AT 2.0 FEET.
								SAME: FEW GRAVEL TO 1-1/2 INCHES, REFUSAL AT 5.0 FEET.
				NP	90	10		
6.0							R	
	SM			NP	93	14		SILTY SAND: DARK BROWN, MOIST, COARSE GRAINED SAND, FEW GRAVEL TO 1/2 INCH, REFUSAL AT 8.5 FEET DUE TO ROCK.
				NP	83	16	29R	SILTY GRAVELLY SAND: DARK BROWN AND GREY, MOIST, GRAVEL TO 1 INCH.
10.5								SILTY SAND: GREY, MOIST, COARSE GRAINED, SAND, FEW GRAVEL 1-1/2 INCHES.
12.0	SW/SM			NP	88	16		SAND/SILTY SAND: GREY, MOIST, COARSE GRAINED SAND, GRAVEL TO 1-1/2 INCHES.
								SILTY SAND: GREY, MOIST, DENSE, COARSE GRAINED SAND, FEW GRAVEL TO 1/2 INCH, REFUSAL AT 14.5 FEET.
				NP	92	15	29R	SAME: WATER AT 17.5 FEET, ADDING MUD AT 17.5 FEET.
	SM							
W 17.4				NP	91	14	36	
				NP	91	13		
21.0							5	
	SW/SM			NP	92	9		GRAVELLY SAND/SILTY GRAVELLY SAND: TAN, COARSE GRAINED SAND, GRAVEL TO 2 INCHES.
24.0							20	
	SM			NP	95	14		SILTY SAND: BROWN-TAN, SLIGHT COHESION, FEW GRAVEL TO 2 INCHES.
27.0							10	
	SP/SM			NP	90	12		SAND/SILTY SAND: LIGHT TAN, SLIGHT COHESION, COARSE GRAINED SAND, FEW GRAVEL TO 1/2 INCH.
30.0							19	
	SW/SM			NP	97	11		SAME: FEW GRAVEL TO 3 INCHES, FEW COBBLES TO 4 INCHES, NO SPT AT 33.0 FEET DUE TO COBBLES.
33.0								

TH84-1302

TH84-1302 STA 895+00 L EL. 23

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPT
							39	SAND/SILTY SAND: BROWN, MOI SAND, REFUSAL AT 2.5 FEET.
		6		NP	86	6	19R	
								SAME: TAN-BROWN.
		3		NP	97	11		
								SAME: MEDIUM DENSE.
		4					R	
	SP/SM							
		4		NP	96	5	22	
W 16.5		[illegible]					17	SAME: WET, WATER AT 15.5 FE
								SAME: LOOSE.
				NP	93	12	8	
21.0								
22.0	SW-SM			NP	85	9		GRAVELLY SAND/SILTY GRAVELLY COBBLES.
				NP	99	25		SILTY SAND: TAN-BROWN, WET, COBBLES, REFUSAL AT 23.0 FEE
		26		NP	89	33	R	REFUSAL AT 26.0 FEET TO ROC
								SAME: GREEN, FINE GRAINED
		27		NP	100	28		
	SM	28		NP	100	25	R	SAME: GREEN W/ LENS OF PINK
								SAME: GREEN, FINE TO COARS
							50P	
		[illegible]		NP	100	39		
35.0								

VALUE ENGINEERING PAYS

TH84-1302

STA 895+00 L — EL. 236±

MC	LL	PI	-4	-200	N	DESCRIPTION
					39	SAND/SILTY SAND: BROWN, MOIST, DENSE, COARSE GRAINED SAND, REFUSAL AT 2.5 FEET.
5		NP	86	6	19R	
						SAME TAN-BROWN.
3		NP	97	11		
						SAME MEDIUM DENSE.
4					9	
4		NP	96	5	22	
3					17	
						SAME WET, WATER AT 15.5 FEET, ADDING REVERT AT 15.5.
						SAME LOOSE
		NP	93	12	3	
		NP	85	9		GRAVELLY SAND/SILTY GRAVELLY SAND: SAME AS ABOVE, FEW COBBLES.
		NP	99	25		SILTY SAND: TAN-BROWN, WET, COARSE GRAINED SAND, FEW COBBLES. REFUSAL AT 23.0 FEET DUE TO ROCKS.
25		NP	89	33	9	REFUSAL AT 25.0 FEET TO ROCKS.
						SAME GREEN, FINE GRAINED SAND.
27		NP	100	28		
28		NP	100	25	9	SAME GREEN W/ LENS OF PINK, VERY DENSE, REFUSAL AT 29.0'.
						SAME GREEN, FINE TO COARSE GRAINED, REFUSAL AT 32.5 FT.
					50P	
35		NP	100	39		

TH84-1303

TH84-1303 — STA 885+00 R — EL. 233±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP/SM			NP	88	5		SAND/SILTY SAND: TAN-BROWN, DRY, COBBLES TO 6 INCHES. REFUSAL AT 0.5 FEET DUE TO ROCKS.
1.5							R	
	SW/SM			NP	91	10		SAME: DARK BROWN, DENSE, REFUSAL AT 2.5' DUE TO GRAVEL.
3.0							30R	
								SILTY SAND: DARK BROWN, DRY, DENSE.
				NP	91	13		
							34	
	SM							SAME: GREY, FEW GRAVEL TO 3 INCHES, FEW COBBLES.
								SAME: FEW GRAVEL TO 3", COBBLES TO 6", REFUSAL AT 8.0 FEET DUE TO GRAVEL.
				NP	93	13	R	
		8		NP	90	16		
12.0							R	
								SAND/SILTY SAND: GREY, MOIST, DENSE, REFUSAL AT 14.0 FEET DUE TO GRAVEL.
	SW/SM	7		NP	91	11		
15.0							R	
	SP/SM	8		NP	34	6	R	REFUSAL AT 17.0 FEET DUE TO GRAVEL.
								GRAVELLY SAND/SILTY GRAVELLY SAND. SAME AS ABOVE, TAN-GREY, WATER AT 19.5 FEET.
19.5		10		NP	62	7		
W 20.0	SW/SM	21		NP	73	10		
								CLAYEY GRAVELLY SAND: BROWN-TAN, WET, NO SPT AT 20.0 FEET DUE TO COBBLES.
	SC	31	27	11	66	20		SAME: TAN.
							6	CLAYEY SAND: TAN-BROWN, LOOSE.
			43	29	34	45		
26.0								
	ML			NP	97	3		SANDY SILT: GREY-TAN, COARSE GRAINED SAND.
28.0							20	
	SP				95	3		SAND: GREY-TAN, COARSE GRAINED SAND.
30.0							19	
								SAND/SILTY SAND: GREY-TAN, MEDIUM DENSE, COARSE GRAINED SAND.
	SW/SM			NP	92	5		
33.0							19	
	SP/SM		34	16	89	12		
35.0								

SCALE: 1 IN=3FT

5 0 5 10

NOTES:

1. SEE PLATE 13 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS

CORPS OF ENGINEERS

STA.900+00 TO STA.885+00

SUBMITTED BY: — DATE APPROVED: — SPEC. NO. DACW09- ____ - ____ — SHEET

VALUE ENGINEERING I

TH84 — 1304

TH84-1304 STA 875+00 R EL. 230±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SAND/SILTY SAND: BROWN, MOIST, COBBLES TO 12 INCHES.
		5		NP	96	10	R	
								SAME: DENSE, COBBLES TO 6", REFUSAL AT 2.5' DUE TO GRAVEL.
	SW/SM	3/4		NP	91	9	60R	
								SAME: DENSE, COBBLES TO 4", REFUSAL AT 5.5' DUE TO GRAVEL.
6.0							43R	
								GRAVELLY SAND/SILTY GRAVELLY SAND: SAME, REFUSAL AT 8.5" DUE TO ROCK.
		4					19R	
	SP/SM			NP	80	7		
								SAME: MOIST, GRAVEL TO 3/4", REFUSAL AT 11.0' DUE TO ROCK.
		5						
12.0							R	
								SAME: GRAVEL TO 2", REFUSAL AT 14.5' DUE TO ROCK.
		5					32R	
		—		NP	85	8		
								SAME: MOIST, GRAVEL TO 1", SOME CONCRETE DEBRIS TO 4", REFUSAL AT 17.5' DUE TO ROCK.
		9						
	SW/SM						36R	
		11						SAND/SILTY SAND: SAME, MOIST TO WET.
W 19.5		19		NP	98	9		SAME: LIGHT BROWN, WET, WATER AT 19.5'.
							22	SAME: TAN-BROWN, COARSE GRAINED SAND.
							23	
				NP	90	8		
27.0							20	
28.0	SW	22			87	2		SAND: REDDISH TAN, COARSE GRAINED SAND.
	CL	22	38	16	100	69	24	SANDY CLAY: REDDISH TAN, STIFF.
31.0								
	SM	25	23	2	74	37	R	GRAVELLY SILTY SAND: REDDISH TAN, MEDIUM DENSE, REFUSAL AT 32.0' DUE TO ROCKS.
35.5				NP	71	24		SILTY GRAVELLY SAND: SAME, NO SPT AT 35.0' DUE TO ROCKS.
								GRAVELLY SAND/SILTY GRAVELLY SAND: REDDISH TAN, WET, BOULDERS TO 16" AT 38.5', NO SPT AT 38.0' DUE TO ROCKS.
	SW-SM			NP	55	9		
39.5								

TH84 — 1309

TH84-1309 STA 875+00 C EL. 210±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
W 1.5							6	GRAVELLY SAND: LIGHT BROWN, MOIST TO WET COARSE GRAINED SAND, GRAVEL TO 1/2", WATE
					73	1		
	SP						3	
								SAND: MULTICOLORED, WET, LOOSE, COARSE GR GRAVEL TO 3 INCHES.
					95	4		
9.0								
							16	SANDY GRAVEL: BROWN, WET, MEDIUM DENSE, SAND.
	GP				48	4		
							16	
15.0								
	GM/GC		27	7	58	23	18	SILTY SANDY GRAVEL/CLAYEY SANDY GRAVEL: WET, COARSE GRAINED SAND, GRAVEL TO 3 INC TO 5 INCHES, SOME CLUMPS OF CLAYEY SILT, 15.0 FEET.
18.0								
	SP/SM	3			95	5	15	SAND/SILTY SAND: DARK BROWN, WET, MEDIUM COHESION, FINE GRAINED SAND, FEW GRAVEL T
21.0								

VALUE ENGINEERING PAYS

TH84 — 1309

STA 875+00 C   EL. 210±

LL	PI	-4	-200	N	DESCRIPTION
				6	GRAVELLY SAND: LIGHT BROWN, MOIST TO WET, LOOSE, FINE TO COARSE GRAINED SAND, GRAVEL TO 1/2", WATER AT 1.5 FEET.
		73	1		
				3	
					SAND: MULTICOLORED, WET, LOOSE, COARSE GRAINED SAND, FEW GRAVEL TO 3 INCHES.
		35	4		
				15	SANDY GRAVEL: BROWN, WET, MEDIUM DENSE, FINE GRAINED SAND.
		48	4		
				16	
				18	SILTY SANDY GRAVEL/CLAYEY SANDY GRAVEL: MULTICOLORED, WET, COARSE GRAINED SAND, GRAVEL TO 3 INCHES, SOME COBBLES TO 5 INCHES, SOME CLUMPS OF CLAYEY SILT, REFUSAL AT 15.0 FEET.
	7	58	23		
				15	SAND/SILTY SAND: DARK BROWN, WET, MEDIUM DENSE, SOME COHESION, FINE GRAINED SAND, FEW GRAVEL TO 3 INCHES.
		95	5		

TH83 — 1305

TH83-1305   STA 875+00 L   EL. 229±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
							33	SAND/SILTY SAND: BROWN, DENSE, COARSE GRAINED SAND.
				NP	92	8		
							29R	SAME: COBBLES TO 4", REFUSAL AT 2.5'.
	SW/SM							
							49	
				NP	93	9		
9.0							15	
11.0	MH		51	22	99	70		SANDY SILT: BROWN, MOIST, COHESIVE, COARSE GRAINED SAND.
							29	SAND/SILTY SAND: TAN-BROWN, MOIST, MEDIUM GRAINED SAND.
								SAME: COARSE GRAINED SAND.
				NP	99	8	32	
W 17.0								SAME: WET, WATER AT 17.0'.
							72	
	SW/SM							
								SAME: BROWN-TAN, COBBLES TO 5", NO SPT AT 20.0' DUE TO ROCKS.
				NP	87	7		SAME: COBBLES TO 8", NO SPT AT 23.0 DUE TO ROCKS.
								SAME: COBBLES TO 12 INCHES.
26.0			75	39	97	81	27	SANDY SILT: GREEN, MOIST, SLIGHT COHESION, FINE GRAINED SAND.
	MH							SAME: GREEN WITH RUST COLOR.
30.0			75	39	97	91	26	
								SILTY SAND: GREEN, WET, COARSE GRAINED SAND, 1 INCH LENS MUSTARD COLORED SILT.
				NP	94	15	R	SAME: NO LENS OF SILT, REFUSAL AT 31.0'.
	SM						R	REFUSAL AT 35.0'.
								SAME: FINE TO COARSE GRAINED SAND, FEW GRAVEL, REFUSAL AT AT 38.0.
				NP	97	13	R	
42.0							R	REFUSAL AT 41.2'.
45.0	SW/SM			NP	98	3	R	SAND/SILTY SAND: GREEN-RUST, WET, FINE TO COARSE GRAINED SAND, FEW GRAVEL, REFUSAL AT 44.2'.

SCALE 1 IN=3 FT
5 0 5 10

NOTES:

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SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA. 875+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____   SHEET

TH83-1306

TH83-1306 STA 865+00 L EL. 226±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		6		NP	95	7		SAND/SILTY SAND: BROWN, MOIST, COARSE GRAINED SAND, COBBLES TO 9", BOULDER TO 24", NO SPT AT 0.5' DUE TO ROCKS.
							24	SAME: MEDIUM DENSE, COBBLES TO 6 INCHES.
		5		NP	91	6		
							20	
							R	SAME: ORGANIC AND INORGANIC DEBRIS AT 9.0, STEEL WIRE AND CABLE, REFUSAL AT 8.0.
	SW/SM							
		15		NP	91	10		
				NP	95	7		NO SPT AT 11.0 FEET DUE TO ROCKS.
								SAME: ADDING WATER AT 15.0 FEET DUE TO CAVING.
15.0							35	
∇17.0	SP/SM							SAME: TAN-BROWN, WET, COARSE GRAINED, FEW GRAVEL, NO SPT AT 17.0 FEET DUE TO ROCKS, WATER AT 17.0 FEET.
18.0				NP	95	6		
								SANDY SILT/SANDY CLAY: TAN-BROWN, WET, HARD, COHESIVE, FINE GRAINED SAND.
	CL/ML		29	7	100	65	55	
22.0								
24.0	ML		49	21	100	92	45	SANDY SILT: TAN-BROWN, WET, HARD, COHESIVE, FEW FINE GRAINED SAND.
								SANDY CLAY: TAN-BROWN, WET, HARD, COHESIVE, FINE GRAINED SAND.
27.0	CL		35	14	100	81	41	
								SILTY SANDY GRAVEL: BROWN, WET, FINE TO COARSE GRAINED SAND, COBBLES TO 4 INCHES.
	GM			NP	53	13	36	
33.0								NO SPT AT 32.0' DUE TO ROCKS.
	SP/GM			NP	33	6		SANDY GRAVEL/SILTY SANDY GRAVEL: BROWN, WET, COARSE GRAINED SAND, COBBLES TO 5 INCHES.
35.0								

TH83-1307

TH83-1307 STA 854+00 L EL. 223±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.5	SW/SM	4			36	8	R	SAND/SILTY SAND: BROWN, DENSE, 5% COBBLES, REFUSAL AT 0.5' DUE TO ROCKS.
3.0	SP	5			49	3	R	SANDY GRAVEL: BROWN, VERY DENSE, 5% COBBLES TO 4", REFUSAL AT 2.0' DUE TO ROCKS.
								SAND/SILTY SAND: GREY, MOIST, VERY DENSE, COARSE GRAINED SAND, REFUSAL AT 5.0'.
		7			92	11	R	
								SAME: TAN-GREY, MOIST TO DRY, DENSE, 5% COBBLES TO 4", REFUSAL AT 9.5'.
		6			92	9	46*	
								SAME: TAN-BROWN, MOIST, VERY DENSE, REFUSAL AT 11.5'.
	SW/SM							
		7			91	11	51*	
		5			95	9	26*	REFUSAL AT 14.5' DUE TO ROCKS.
		7			91	8	26*	REFUSAL AT 17.5' DUE TO ROCKS.
19.5					90	9		SAME: GRAY, MOIST, COARSE GRAINED SAND.
∇21.0							12*	SILTY SAND: BROWN, WET, COARSE, GRAINED SAND, REFUSAL AT 20.5', WATER AT 21.0.
22.5	SM				87	25		
	SW				93	4	9	GRAVELLY SAND: BROWN, WET, COARSE GRAINED SAND, REFUSAL AT 25.0 DUE TO LARGE ROCK.
25.0								

TH83-1308

TH83-1308 STA 854+00 R EL. 223±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
							33	GRAVELLY SAND/SILTY GRAVELLY SAND: COARSE GRAINED SAND, 5 PERCENT COB REFUSAL AT 2.5 FEET DUE TO ROCKS.
	SW/SM	8/5		NP	80	5		
3.0							9R	
								SAME: TAN-BROWN, FINE GRAINED SAN
	SP	4		NP	84	7		
6.0							22	
								SAND: TAN-BROWN, MOIST, MEDIUM DE SAND.
	SP	4			96	2		
8.5							24	
								SILTY SAND: TAN-BROWN, MOIST, WET GRAINED SAND, WIRE DEBRIS AT 9.0 F
		7		NP	92	15	15	
								SAME: DARK BROWN, MOIST, MEDIUM GRAINED SAND.
	SM							
		27		NP	99	35	28	
18.0								
								SANDY GRAVEL/SILTY SANDY GRAVEL: GRAINED SAND.
	GP/GM	6		NP	52	5		
20.5 / W 21.0							15	
								GRAVELLY SAND: BROWN, WET, COARS TO 4 INCHES, NO SPT AT 23.0 FEET 21.0 FEET, ADDING REVERT AT 21.0
	SP				69	7		
27.0								NO SPT AT 26.0 FEET DUE TO ROCKS.
								SANDY GRAVEL: BROWN, WET, COARSE TO 8 INCHES, NO SPT AT 29.0 FEET
	GP				49	4		NO SPT AT 32.0 FEET DUE TO ROCKS.
36.0								NO SPT AT 35.0 DUE TO ROCK.
	GW				43	3		NO SPT AT 39.0 DUE TO ROCK.
40.0								

ALUE ENGINEERING PAYS

TH83-1308

STA 854+00 R

EL. 223±

MC	LL	PI	-4	-200	N	DESCRIPTION
[illegible]		NP	80	5	33	GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, MOIST, DENSE, COARSE GRAINED SAND, 5 PERCENT COBBLES TO 4 INCHES, REFUSAL AT 2.5 FEET DUE TO ROCKS.
					9R	
[illegible]		NP	94	7		SAME: TAN-BROWN, FINE GRAINED SAND, MEDIUM DENSE.
					22	
[illegible]			96	2		SAND: TAN-BROWN, MOIST, MEDIUM DENSE, COARSE GRAINED SAND.
					24	
		NP	92	15	15	SILTY SAND: TAN-BROWN, MOIST, MEDIUM DENSE, COARSE GRAINED SAND, WIRE DEBRIS AT 9.0 FEET.
[illegible]		NP	99	35	29	SAME: DARK BROWN, MOIST, MEDIUM DENSE, COHESIVE, FINE GRAINED SAND.
6		NP	57	5		SANDY GRAVEL/SILTY SANDY GRAVEL: TAN-BROWN, WET, COARSE GRAINED SAND.
					15	
			69	7		GRAVELLY SAND: BROWN, WET, COARSE GRAINED SAND, COBBLES TO 4 INCHES, NO SPT AT 23.0 FEET DUE TO ROCKS, WATER AT 21.0 FEET, ADDING REVERT AT 21.0 FEET.
						NO SPT AT 26.0 FEET DUE TO ROCKS.
			49	4		SANDY GRAVEL: BROWN, WET, COARSE GRAINED SAND, COBBLES TO 8 INCHES, NO SPT AT 29.0 FEET DUE TO ROCKS. NO SPT AT 32.0 FEET DUE TO ROCKS.
						NO SPT AT 35.0 DUE TO ROCK.
			43	3		NO SPT AT 38.0 DUE TO ROCK.

TT84-1372

INVERT

TT84-1372 STA 854+00 C EL. 206±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP				89	1		SAND: MULTICOLORED, LOOSE, COARSE GRAINED SAND, FEW GRAVEL GRAVEL TO 1/2 INCHES.
3.0								
	SM			NP	97	14		SILTY SAND: LIGHT BROWN, MOIST, LOOSE, FINE TO COARSE GRAINED SAND.
6.0								
	SW/SM			NP	85	5		GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED, MOIST TO WET, LOOSE, COARSE GRAINED SAND, GRAVEL TO 1-1/2 INCHES.
13.0								
14.0	SP/SM			NP	98	6		SAND/SILTY SAND: SAME, LIGHT GREY, SLIGHT COHESION, FINE GRAINED SAND.
	SW/SM			NP	74	5		GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED, MOIST TO WET, LOOSE, COARSE GRAINED SAND, GRAVEL TO 1-1/2 INCHES.
17.0								

SCALE: 1 IN=3 FT

5 0 5 10

NOTES

1. SEE PLATE 13 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM.
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

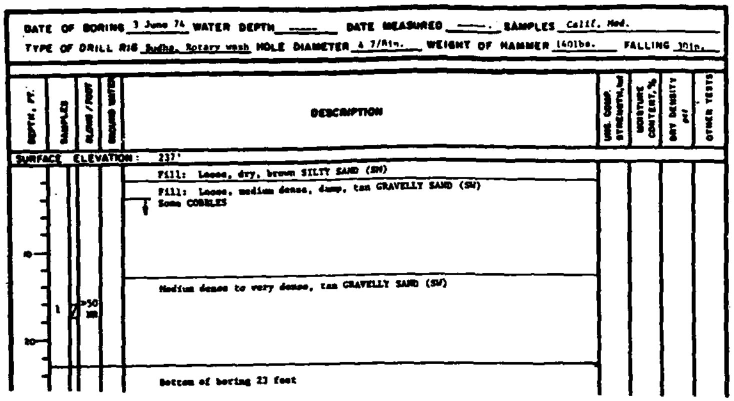
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

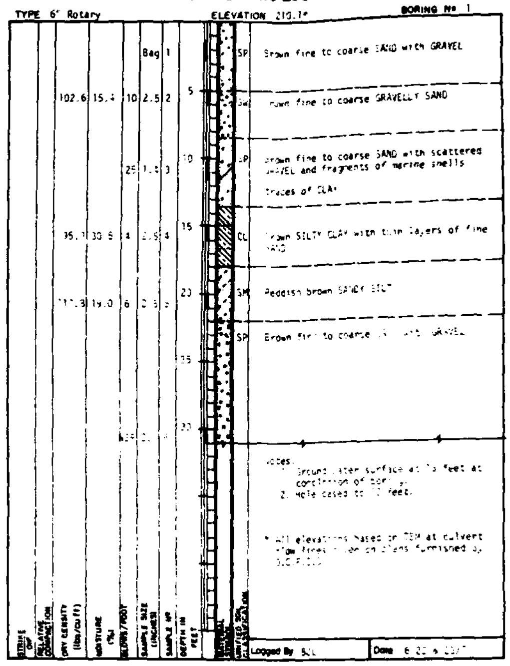
STA.865+00 TO STA.865+00

WM74-4

LOG OF BORING 4



MT70-1



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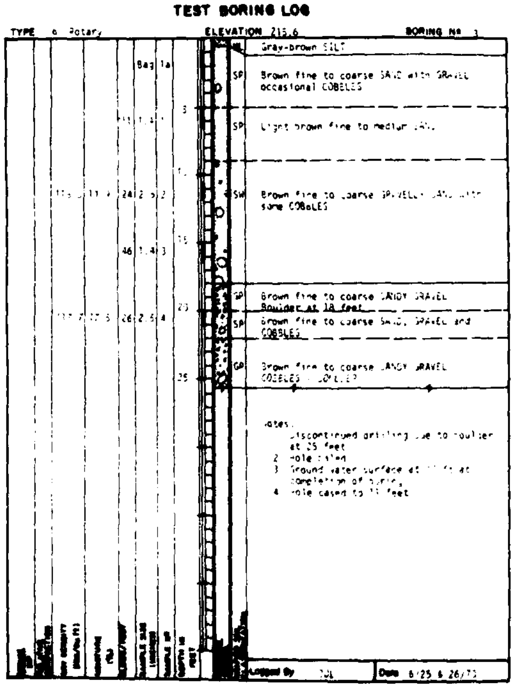

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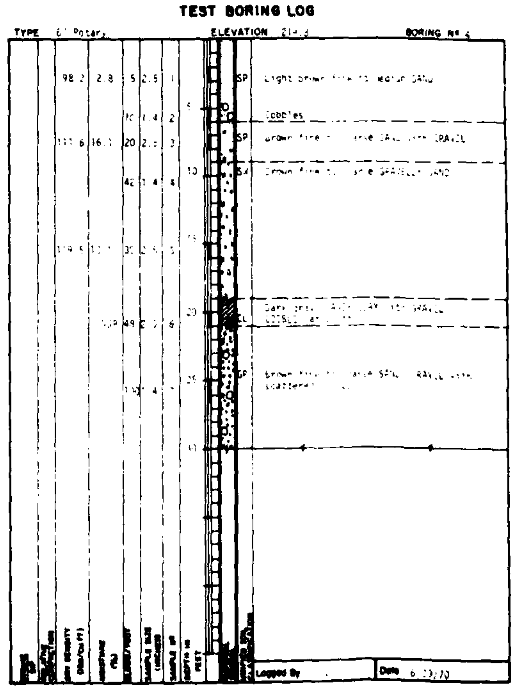
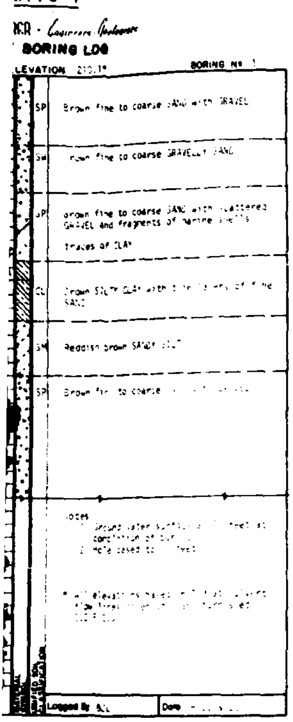
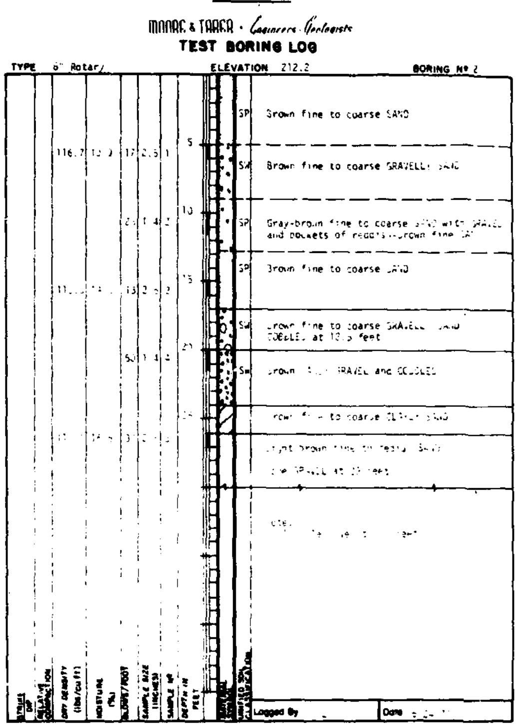


ALUE ENGINEERING PAYS

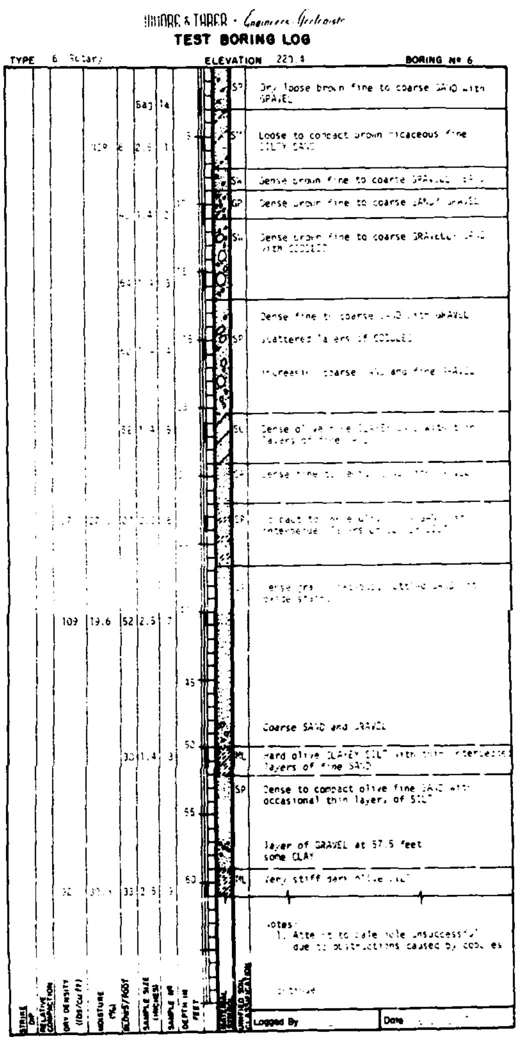
MT70-1

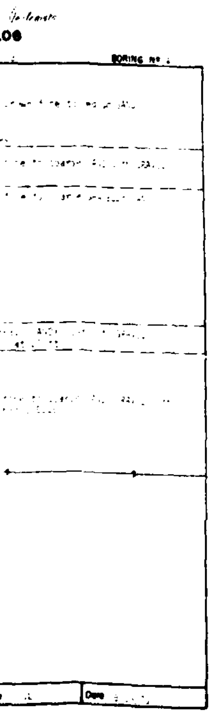


MT70-2

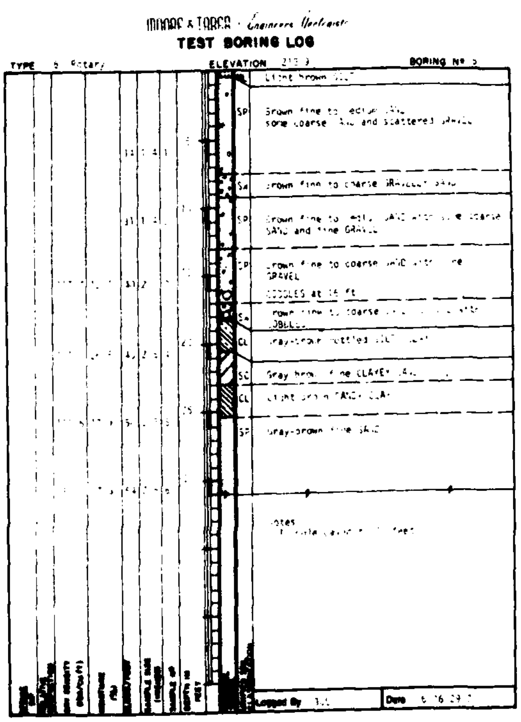


MT70-6





MT70-5



NOTES:

1. SEE PLATE 13 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS
STA.905+00 TO STA.845+00

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-____ B-____ | SHEET

MT70-6A

MOORE & TABER · Engineers · Geologists
TEST BORING LOG

TYPE 6" Rotary — ELEVATION 220.6 — BORING No 6A

Depth	Blows/Foot	Sample Size	Sample No.	Unified Soil Classification	Description
				SP	Loose to semi-compact brown fine to medium SAND with some coarse SAND and scattered fine GRAVEL
					coarse GRAVEL at 4.5 feet
5	37	1.4	1	SW	Dense brown fine to coarse SAND with fine GRAVEL
10	+100	1.4	2	GP	Very dense brown fine to coarse SANDY GRAVEL with BOULDER at 10 feet, COBBLES at 11 and 12.5 feet
15	76	1.4	3	SW	Very dense to dense olive, oxidized fine to coarse SAND with GRAVEL and trace of CLAY binder
20	[illegible]	2.5	4		
25	[illegible]		5		Stiff to very stiff brown mottled CLAYEY SILT with pockets of fine SAND
					[illegible]

Strike / Dip — Relative Compaction — Dry Density (lbs/cu ft) — Moisture (%) — Blows/Foot — Sample Size (inches) — Sample No — Depth in Feet — Natural Symbol — Unified Soil Classification

Logged By [illegible] — Date [illegible]

MT70-7

MOORE & TABER · Engineers · Geologists
TEST BORING LOG

TYPE 6" Rotary — ELEVATION 220.9 — BORING No 7

Depth	Dry Density	Moisture	Blows/Foot	Sample Size	Sample No.	Unified Soil Classification	Description
						SP	Very loose to loose brown fine to coarse SAND with scattered GRAVEL
5		NSR	7	2.5	1		Predominantly medium to coarse SAND and fine GRAVEL
							coarse GRAVEL
10			44	1.4	2	SW	Dense to [illegible] brown fine to coarse SAND with fine GRAVEL
							thin layer of coarse GRAVEL
15	105	17.2	24	2.5	3		
20			[illegible]			SP	[illegible] brown fine SAND with interbedded layers of SANDY CLAY
25						CL	[illegible]

[illegible]

Strike / Dip — Relative Compaction — Dry Density (lbs/cu ft) — Moisture (%) — Blows/Foot — Sample Size (inches) — Sample No — Depth in Feet — Natural Symbol — Unified Soil Classification

Logged By — Date

TYPE 6" Rotary

Strike / Dip — Relative Compaction — Dry Density (lbs/cu ft) — Moisture (%) — Blows/Foot — Sample Size

WA69-1

DRILL RIG: Rotary Wash	HOLE ELEVATION: 207.2	LOGGED BY: C. C.
GROUNDWATER DEPTH [illegible]: See Notes	HOLE DIAMETER: 6 Inch	DATE DRILLED: 6/3/69

Description and Remarks	Color	Moisture	Consist	Soil Type	Depth	Penetration Resistance
Fine SAND with 6 inch SILT layer	Tan	Wet	Loose	SP		
			M Dense		5	
CLAY lenses	Gy					
Sandy GRAVEL	Gy	Wet	V Dense	GP	10	
with variable size cobbles throughout						100+
6 inch lens of SAND w/large cobbles					15	
Fine to Coarse SAND	Gy Brn	Wet	V Dense	SP		100+
Sandy GRAVEL with some cobbles	Gy Brn	Wet	V Dense	GP	20	100+
BOTTOM OF HOLE AT 24 FEET					25	

NOTES:
1) Caving of Boring walls curtailed with use of extra thick drillers' mud.
2) Hole not bailed to determine groundwater level.
3) Hole terminated due to severe drilling conditions, causing slow progress. Many cobbles and some boulders.

W.A. Wahler & Associates — Santa Ana River Levee, Orange County, California — Soil Exploration Drill Hole Log — Hole No. 1

MT64-11

Type [illegible] — G. L. 206.71 — Top Hole Elevation 206.16 — BORING NO. [illegible] — Completed - [illegible]

Elevation	Sample No.	Description
205	1	Brown silty sand with layers of sandy clay and clayey sand.
	2	Reddish-brown fine to coarse sand with sandy clay lenses and scattered gravel.
200		
	3	Brown sandy clay.
195		
	4	Reddish-brown fine to coarse sand.
190	5	Gray medium to fine sand.
	6	Brown medium to fine sand.

NOTES:
Boring located on fairly steep ramp coming off south bank approx. 25 feet from top of bank.
Ground water was encountered at elevation 187 although there was running water ± 30 feet away at elevation 20[illegible].
Fast to moderate drill rate with no significant cave.

Depth in feet (Elevation)

Dry density (lbs cu ft) — Moisture (%) — [illegible] — Sample size (inches) — Sample No. — Unified Soil Classification

ALUE ENGINEERING PAYS

MT70-8

MOORE & TABER · Engineers-Geologists

TEST BORING LOG

TYPE 6" Rotary ELEVATION 223.7 BORING No 8

Depth (feet)	Unified Soil Classification	Description
	SP	Brown medium to coarse SAND
	ML	Dark gray to brown SILT
5	SP	Brown medium to coarse SAND with GRAVEL with thin layers of fine SAND
	CL	Gray-brown SANDY CLAY with scattered GRAVEL
15	SP	Brown fine to coarse SAND with fine GRAVEL coarse GRAVEL between 15.5 and 16.5 feet
20		Coarse GRAVEL
	SW	Brown fine to coarse GRAVELLY SAND with scattered COBBLES
		Predominantly COBBLES between 26 and 27 ft.
	SP	Brown fine to coarse SAND, coarse GRAVEL and COBBLES at 28 feet

Notes:

Logged By Date

MT70-9

MOORE & TABER · Engineers-Geologists

TEST BORING LOG

TYPE 6" Rotary ELEVATION 224.8 BORING No 9

Depth (feet)	Unified Soil Classification	Description
	SP	Loose brown medium to coarse SAND with fine GRAVEL; thin layers of SILT
10	SP	Brown fine to coarse SAND with interbedded layers of CLAYEY SAND; occasional thin layer of GRAVEL
	SM	Brown fine to coarse GRAVELLY SILT
15	SP	Brown fine to medium SAND
20	SM	Tan very fine SILTY SAND
	SP	Gray-brown fine SAND with SANDSTONE fragment
30	ML	Brown SANDY SILT

Notes:

Logged By Date

MT64-11

Boring No. 11 Completed

Description
Brown ... with layers of sandy clay and gravel
Reddish-brown fine to coarse sand with sandy clay lenses and scattered gravel.
Brown sandy clay.
Reddish-brown fine to coarse sand.
Gray medium to fine sand.
Brown medium to fine sand.

NOTE:
Boring located on fairly steep ramp coming off south bank approx. 25 feet from top of bank.
Ground water was encountered at elevation 18? although there was running water ± 30 feet away at elevation 204.
Fast to moderate drill rate with no significant cave.

MT64-12

Type 6" Bucket Auger

G. L. 218.50 Top Hole Elevation 223.0

Boring No. 12 Completed 2-11-64

Depth in Feet (Elevation)	Sample	Description
220	1	Brown gravelly silty sand with some coarse gravel.
215	2	Brown silty sand and gravel with few silty clay lenses.
	3	Brown clean fine to coarse sand with some gravel.
210		Same as above with few pebbles.
205	5	Brown sandy clay.
	6	Brown fine to coarse sand with coarse gravel.
200	7	
195		

NOTE:
Boring located on gentle ramp coming off north unprotected bank approx. 300 feet from top of bank.
No ground water was encountered in the hole although there was running water ± 30 feet away and ± 3 feet below boring elevation.
Fast drilling rate with no cave problems.

Column headings: Dry density (lbs cu ft); Moisture (%); Stand. Penetration (blows/foot); Sample size (inches); Sample No.; Unified soil classification

NOTES:

1. SEE PLATE 13 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

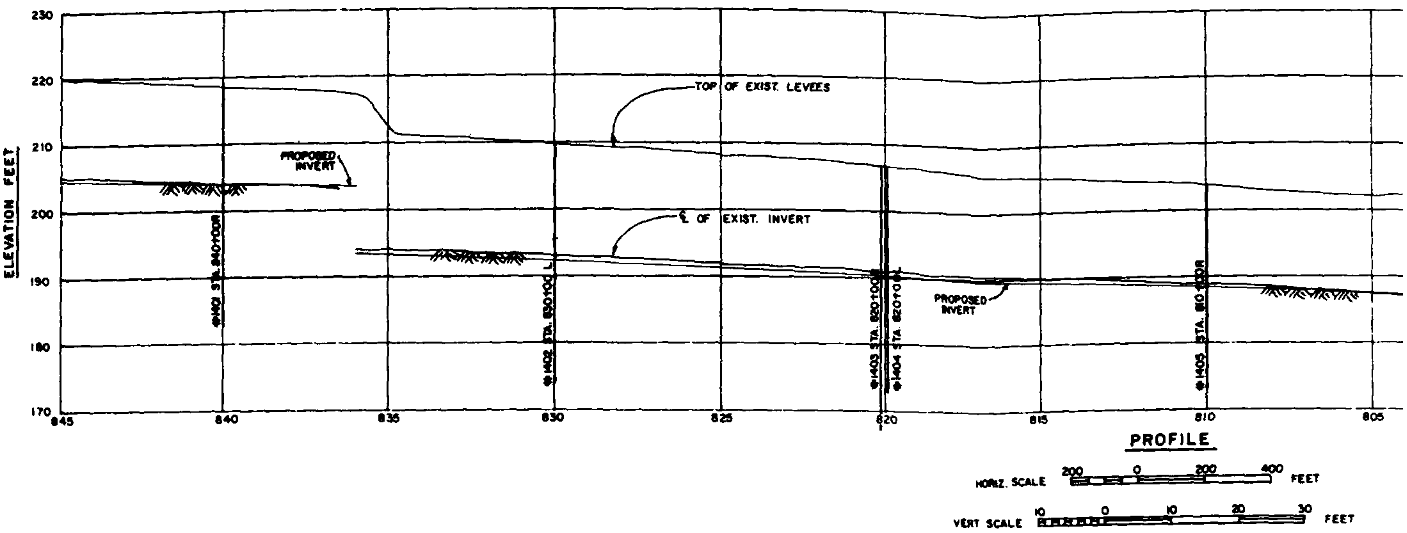
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

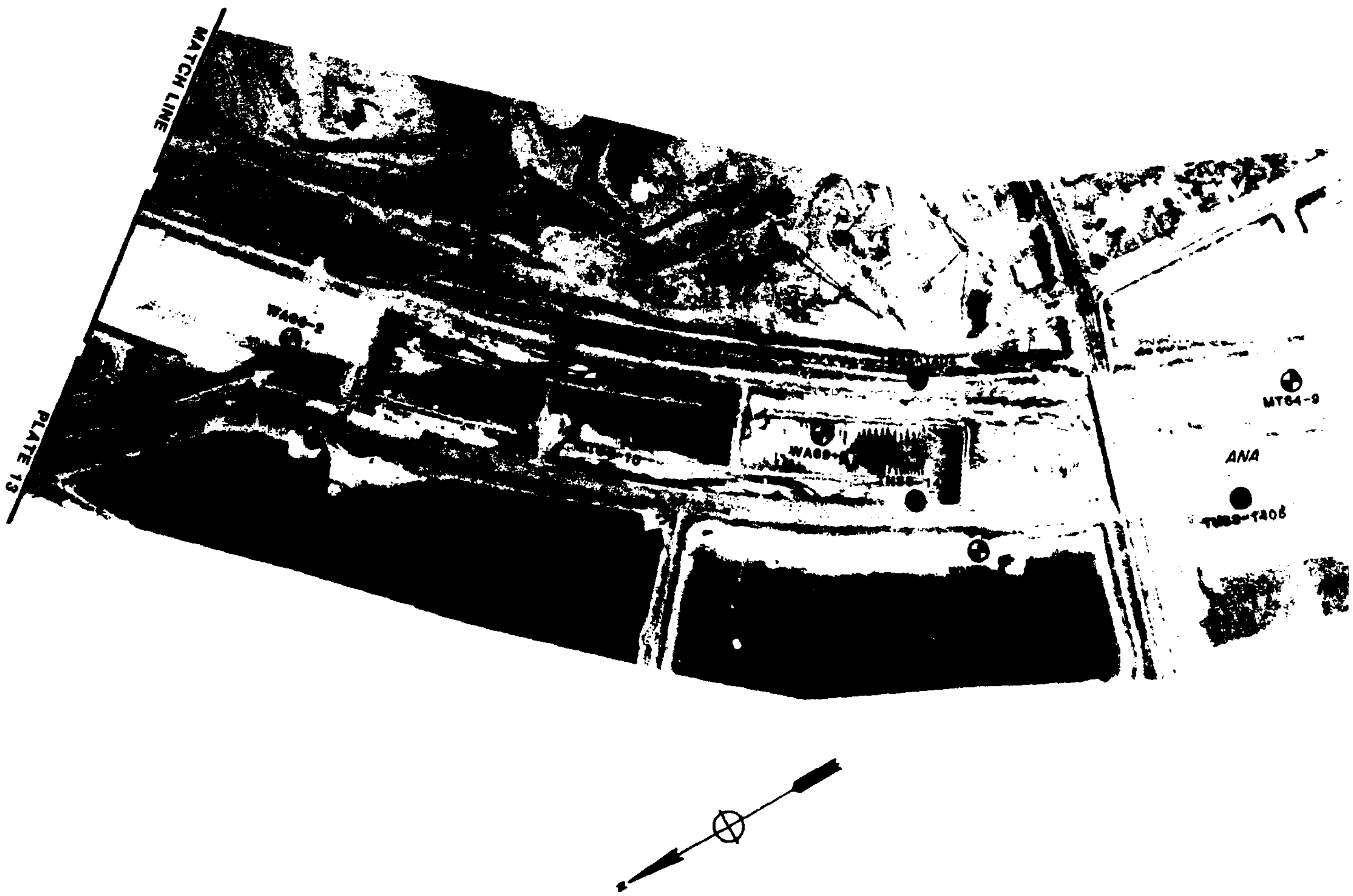
DESIGNED BY:
DRAWN BY:
CHECKED BY:

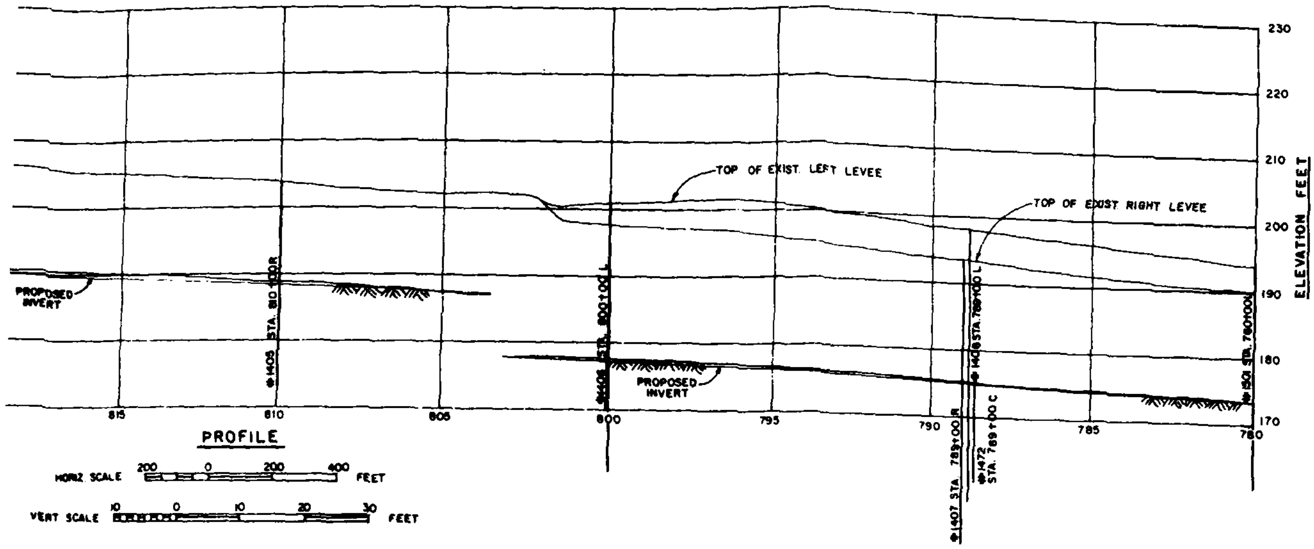
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

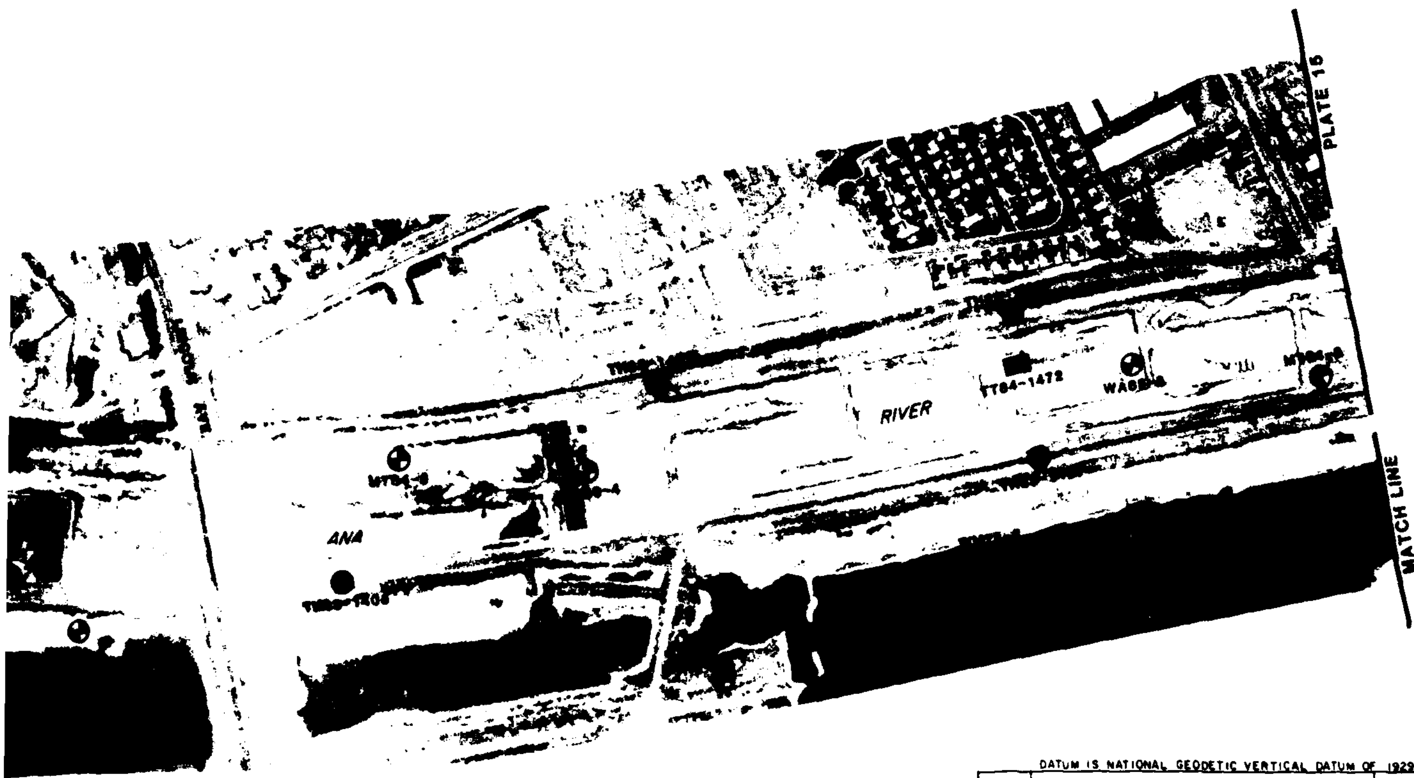
LOGS OF INVESTIGATION
BY OTHERS
STA.905+00 TO STA.845+00

VALUE ENGINEERING PAY









NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE

STA.845+00 TO STA.780+00

SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-____ B-____
DISTRICT FILE NO.
SHEET

TH 83-1401

TH83-1401 STA 840+00 R EL. 219±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	7		NP	81	18		SILTY GRAVELLY SAND: BROWN, MOIST, DENSE, MEDIUM GRAINED SAND, REFUSAL AT 2.5 FEET.
2.5							23R	
		3						SAND/SILTY SAND: BROWN-TAN, MOIST, MEDIUM GRAINED SAND, FEW GRAVEL, REFUSAL AT 6.5 FEET DUE TO ROCKS.
	SP/SM	5		NP	92	7		
							21R	
7.0								SILTY SANDY GRAVEL/CLAYEY SANDY GRAVEL: GREY-TAN, DENSE, COBBLES TO 6", NO SPT AT 8.0' DUE TO ROCKS.
8.5	GM/GC	9	23	6	57	16		
		6		NP	80	10		GRAVELLY SAND/SILTY GRAVELLY SAND: GREY-TAN, DENSE, COBBLES TO 6 INCHES, NO SPT AT 11.0 FEET DUE TO ROCKS.
								SAME: TAN-GREYISH BROWN, MOIST, MEDIUM GRAINED SAND, FEW GRAVEL.
	SW/SM	6		NP	78	7		
		5		NP	90	8	R	SAME: MEDIUM DENSE, REFUSAL AT 17.0 FEET DUE TO ROCKS.
21.0							24	
	SM			NP	89	14		SILTY SAND. GREY, MOIST, ORGANIC SMELL.
23.0								
		6		NP	87	7	40	SAND/SILTY SAND: TAN-BRN, MOIST, MED. TO COARSE GRND. SND.
								SAME: MEDIUM DENSE TO DENSE.
	SW/SM	7						
		8		NP	89	8	30	SAME: DENSE
30.0							47	
								SAND/SILTY SAND: TAN-BROWN, MOIST, MEDIUM TO COARSE GRAINED SAND.
	SP/SM	8		NP	98	6	46	
35.0								

TH 84-1402

TH84-1402 STA 830+00 L EL. 210±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM	12		NP	94	12		SAND/SILTY SAND: LIGHT BROWN, M[illegible] SOME CLUMPS OF COHESIVE CLAYEY S[illegible]
3.0								
							40	SAND: LIGHT BROWN, MOIST, FINE [illegible] FEW GRAVEL.
		3			94	3		
							28	
							8	SAME: FEW GRAVEL TO 1/2 INCH
	SP	4			93	3		
							26	
							39	SAME: FEW GRAVEL TO 1 INCH.
		5			95	2		
							12	
						88	2		
21.0								
	ML/CL	5	23	6	99	65	27	SANDY SILT/SANDY CLAY: DARK BR[illegible] COHESIVE, FINE GRAINED SAND.
24.0								
	GP/GM			NP	33	5	R	SANDY GRAVEL/SILTY SANDY GRAVEL [illegible] TO MEDIUM DENSE, FINE TO COARSE [illegible] 3 INCHES, COBBLES TO 5 INCHES, [illegible] COARSE GRAVEL, NO SPT AT 27.5 FE[illegible]
[illegible]								
	GP				36	4		SANDY GRAVEL: DARK BROWN, MOI[illegible] FINE TO COARSE GRAINED SAND [illegible] TO 5 INCHES, NO SPT AT 29.5 FEE[illegible]
33.0								
	SP/SM			NP	57	7		GRAVELLY SAND/SILTY GRAVELLY SAN[illegible] LOOSE TO MEDIUM DENSE, FINE TO C[illegible] TO 3 INCHES, COBBLES TO 5 INCHE[illegible]
35.0								

VALUE ENGINEERING PAYS

TH 84-1402

[illegible] STA 830+00 L EL. 210±

LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
SW/SM	12		NP	[illegible]	12		SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND, SOME CLUMPS OF COHESIVE CLAYEY SILT.
						40	SAND: LIGHT BROWN, MOIST, FINE TO COARSE GRAINED SAND, FEW GRAVEL.
	3			[illegible]	3		
						29	
						3	SAME: FEW GRAVEL TO 1/2 INCH.
	4			[illegible]	3		
						25	
						39	SAME: FEW GRAVEL TO 1 INCH.
	3			[illegible]	[illegible]		
				[illegible]	[illegible]	12	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	SANDY SILT/SANDY CLAY: DARK BROWN, MOIST, VERY STIFF, COHESIVE, FINE GRAINED SAND.
SP/GM			NP	[illegible]		3	SANDY GRAVEL/SILTY SANDY GRAVEL: DARK BROWN, MOIST, LOOSE TO MEDIUM DENSE, FINE TO COARSE GRAINED SAND, GRAVEL TO 3 INCHES, COBBLES TO 5 INCHES, REFUSAL AT 24.5 FEET DUE TO COARSE GRAVEL, NO SPT AT 27.5 FEET DUE TO ROCKS.
[illegible]				[illegible]	[illegible]		SANDY GRAVEL: DARK BROWN, MOIST, LOOSE TO MEDIUM DENSE, FINE TO COARSE GRAINED SAND, GRAVEL TO 3 INCHES, COBBLES TO 5 INCHES, NO SPT AT 29.5 FEET DUE TO COBBLES.
[illegible]			NP				GRAVELLY SAND/SILTY GRAVELLY SAND: DARK BROWN, MOIST, LOOSE TO MEDIUM DENSE, FINE TO COARSE GRAINED SAND, GRAVEL TO 3 INCHES, COBBLES TO 5 INCHES.

TH 83 1404

TH83-1404 STA 820+00 R EL. 207±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.5	SM	10		NP	89	14	37	SILTY SAND: BROWN, MOIST, DENSE, FINE TO COARSE GRAINED SAND, FEW GRAVELS, FIRST 6 INCHES ORGANICS.
3.0	SP/SM			NP	93	6	22	SAND/SILTY SAND: TAN-BROWN, MOIST, MEDIUM DENSE, FINE TO MEDIUM GRAINED SAND, FEW GRAVEL.
	SP	8			90	3	19	SAND: TAN-BROWN, MOIST, MEDIUM DENSE, MEDIUM TO COARSE GRAINED SAND, FEW GRAVEL.
		6			95	3		
9.0							22	
	SP/SM	6		NP	83	5		SAND/SILTY SAND: TAN-BROWN, MOIST, MEDIUM DENSE, MEDIUM TO COARSE GRAINED SAND.
12.0							18	
13.5	SP	6			69	2		GRAVELLY SAND: BROWN, MOIST, MEDIUM DENSE, COARSE GRAINED SAND, FEW COBBLES TO 4 INCHES.
15.0	SW/SM	6		NP	72	5		GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, MOIST, LOOSE, COARSE GRAINED SAND, FEW COBBLES TO 4 INCHES.
		20	25	5	99	59		SANDY SILT/SANDY CLAY: TAN-BROWN, MOIST, MEDIUM STIFF, COHESIVE, FINE GRAINED SAND, FEW GRAVEL, ADDING MUD AT 15.0 FEET.
	ML/CL	24	25	5	90	53		
		24	24	6	97	55		SAME: REDDISH BROWN.
21.0							7	
	CL		24	8	99	63		SANDY CLAY: REDDISH BROWN, MOIST, VERY STIFF, COHESIVE, FINE GRAINED SAND, OCCASIONAL GRAVEL.
24.0							42	
25.5	SC	16	27	8	100	43		CLAYEY SAND: REDDISH BROWN, MOIST, COHESIVE.
	GM/GC		26	7	50	15		SILTY SANDY GRAVEL/CLAYEY SANDY GRAVEL: REDDISH BROWN, MOIST, COHESIVE.
27.0							14	
	GM	16		NP	55	27		SILTY SANDY GRAVEL: REDDISH BROWN, MOIST, COHESIVE, FINE GRAINED SAND.
		12		NP	59	20	R	SAME: MEDIUM TO COARSE GRAINED SAND, COBBLES TO 4 INCHES. REFUSAL AT 29.0 FEET.
31.0								
	GW/GM			NP	47	6	R	SANDY GRAVEL/SILTY SANDY GRAVEL: REDDISH BROWN, WET, FINE TO COARSE GRAINED SAND, OCCASIONAL COBBLES, REFUSAL AT 32.0 FEET.
34.0								

SCALE 1 IN = 3 FT

5 0 5 10

NOTES

1. SEE PLATE 14 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA 840+00 TO STA 820+00

TH83-1403

TH83-1403 STA 820+00 L EL. 207±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	8		NP	59	17		SILTY GRAVELLY SAND: BROWN, MOIST, TOP 1.5 FEET, ASPHALT MIXED IN SOIL.
2.0								
	SP/SM	3		NP	91	6	50R	SAND/SILTY SAND: TAN-BROWN, MOIST, DENSE, MEDIUM GRAINED SAND, FEW GRAVEL, REFUSAL AT 2.5 FEET.
		3		NP	93	6	20R	SAME: REFUSAL AT 5.5 FEET DUE TO ROCKS.
8.0								
	SM	3		NP	88	13	19R	SILTY SAND: TAN-BROWN, MOIST, DENSE, REFUSAL AT 8.0 FEET DUE TO ROCKS.
12.0								
	SP/SM	3		NP	92	5	39	SAND/SILTY SAND: TAN-BROWN, MOIST, DENSE.
		6		NP	91	7		
18.0							46	
	SW/SM	19		NP	91	8		
21.0							5	
22.0	SP/SM			NP	99	8		SAME: BROWN, FINE TO MEDIUM GRAINED SAND.
	ML/CL	19	23	5	100	70		SANDY SILT/SANDY CLAY: REDDISH BROWN, MOIST, LOOSE SLIGHT COHESION.
24.0							11	
	CL	17	33	17	100	71	15	SANDY CLAY: REDDISH BROWN, MOIST, FIRM, SLIGHT COHESION.
		19	29	10	100	77		
29.0								
	GC	5	26	9	53	22		CLAYEY SANDY GRAVEL: REDDISH-BROWN, MOIST, SLIGHT COHESION, COBBLES TO 6 INCHES, NO SPT AT 29.0 FEET DUE TO ROCKS.
32.0								
	GP/GM	6		NP	43	5		SANDY GRAVEL/SILTY SANDY GRAVEL: BROWN, MOIST, MEDIUM TO COARSE GRAINED SAND, COBBLES TO 6 INCHES.
36.0								
	SP/SM	5		NP	61	7		GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, MOIST, MEDIUM TO COARSE GRAINED SAND, COBBLES TO 6 INCHES.
40.0								

TH83-1405

TH83-1405 STA 810+00 R EL. 204±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTIO
1.5	SP	9			96	4		SAND: GREY, MOIST, FEW GRAVEL
2.0	CL	13	29	14	100	59		SANDY CLAY: REDDISH BROWN, MOI
3.0	SW/SM	9		NP	94	11	23R	SAND/SILTY SAND: GREYISH TAN-B BLES TO 4 INCHES, REFUSAL AT 2.
	SM	9	20	4	72	18		SILTY GRAVELLY SAND: BROWN, MO GRAINED SAND, FEW GRAVEL.
5.5							44	
7.0	SP/SM	4		NP	93	5		SAND/SILTY SAND: BROWN, MOIST, GRAINED SAND, FEW GRAVEL.
		9		NP	91	16	16R	SILTY SAND: BROWN, MOIST, SLIG GRAINED SAND, FEW GRAVEL, REFUS
	SM	12		NP	81	20		GRAVELLY SILTY SAND: SAME, DAR ODOR.
		10		NP	92	7	16R	SILTY SAND: SAME, BROWN, REFUS
13.0								
14.0	SW/SM	6		NP	96	8		SAND/SILTY SAND: TAN-BROWN, D
W 15.0							27R	SILTY SAND: TAN-BROWN, DAMP, GRAVEL, REFUSAL AT 14.5 FEET,
	SM	8		NP	97	33		
17.0								
18.0	SW/SM	12		NP	95	9	23	SAND/SILTY SAND: GREY, MOIST,
		15						CLAYEY GRAVEL: REDDISH BROWN, MEDIUM DENSE.
	GC	17	32	13	57	45	23	
22.0								
23.0	SC	5	23	8	69	22		GRAVELLY CLAYEY SAND: REDDISH MEDIUM GRAINED SAND.
	GP/GM	5		NP	43	9		SANDY GRAVEL/SILTY SANDY GRAVE FINE TO MEDIUM GRAINED SAND, R ROCKS.
27.0							20R	
		7						SILTY SAND: REDDISH BROWN, MO SAND, FEW COBBLES TO 6 INCHES, GRAVEL.
	SM	6		NP	100	14		SAME: MOIST TO WET, CAVING AT
32.0								

VALUE ENGINEERING PAYS

TH83-1405

STA 810+00 R — EL. 204±

MC	LL	PI	-4	-200	N	DESCRIPTION
						SAND: GREY, MOIST, FEW GRAVEL ASPHALT MIXED WITH SAMPLE.
9			96	9		
13	29	14	100	59		SANDY CLAY: REDDISH BROWN, MOIST, OCCASTIONAL GRAVEL.
9		NP	94	11	23R	SAND/SILTY SAND: GREYISH TAN-BROWN, MOIST, DENSE, 5% COBBLES TO 4 INCHES, REFUSAL AT 2.5 FEET.
9	20	4	72	18		SILTY GRAVELLY SAND: BROWN, MOIST, DENSE, FINE TO MEDIUM GRAINED SAND, FEW GRAVEL.
					44	
4		NP	93	5		SAND/SILTY SAND: BROWN, MOIST, DENSE, FINE TO MEDIUM GRAINED SAND, FEW GRAVEL.
9		NP	91	16		SILTY SAND: BROWN, MOIST, SLIGHT COHESION, FINE TO MEDIUM GRAINED SAND, FEW GRAVEL, REFUSAL AT 8.5' DUE TO ROCKS.
					16R	
12		NP	81	20		GRAVELLY SILTY SAND: SAME, DARK GREY TO GREY, ORGANIC ODOR.
10		NP	92	7	15R	SILTY SAND: SAME, BROWN, REFUSAL AT 11.5 FEET.
6		NP	96	8		SAND/SILTY SAND: TAN-BROWN, DAMP, MEDIUM DENSE.
					27R	SILTY SAND: TAN-BROWN, DAMP, MEDIUM DENSE, OCCASIONAL GRAVEL, REFUSAL AT 14.5 FEET, WATER AT 15.0 FEET.
8		NP	97	33		
12		NP	95	3	23	SAND/SILTY SAND: GREY, MOIST, FINE TO MED. GRAINED SAND.
15						CLAYEY GRAVEL: REDDISH BROWN, MOIST, SLIGHT COHESION, MEDIUM DENSE.
17	32	13	57	45		
					23	
5	23	8	69	22		GRAVELLY CLAYEY SAND: REDDISH BROWN, MOIST, FINE TO MEDIUM GRAINED SAND.
5		NP	43	9		SANDY GRAVEL/SILTY SANDY GRAVEL. REDDISH BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, REFUSAL AT 26.5 FEET DUE TO ROCKS.
					20R	
7						SILTY SAND: REDDISH BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, FEW COBBLES TO 6 INCHES, NO SPT AT 29 FEET DUE TO GRAVEL.
		NP	[illegible]	[illegible]		
6						SAME: MOIST TO WET, CAVING AT 32.0 FEET.

TH83-1406

TH83-1406 — STA 800+00 L — EL. 201±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.5	SW	3		NP	91	2	23	SAND: BROWN, MOIST, MEDIUM TO DENSE, FINE TO MEDIUM GRAINED SAND.
		3		NP	98	6	16	SAND/SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, FEW GRAVEL.
							18	
		4		NP	97	5	22	
	SW/SM							
		5		NP	97	6	14	
		5		NP	98	5	12	
								SAME: TAN, MEDIUM TO COARSE GRAINED SAND, CAVING AT 18.0 FEET, ADDING REVERT AT 18.0 FEET.
		4		NP	97	5		
18.0							17	
	SP				93	4		SAND: TAN, MOIST, MEDIUM TO COARSE GRAINED SAND.
21.0							18	
								SILTY SAND: BROWN, MOIST, MEDIUM GRAINED SAND.
	SM	19		NP	100	41	36	
		17		NP	99	31		
27.0							35	
28.5	SW/SM			NP	100	9		SAND/SILTY SAND: BROWN, WET, MED. TO COARSE GRAINED SAND.
		25	39	15	100	42	25	CLAYEY SAND: BROWN, WET, COHESIVE, FINE TO MEDIUM GRAINED SAND.
	SC							
			15	39	100	49		
33.0							32	
	SP/SM			NP	100	9		SAND/SILTY SAND: BROWN-TAN, WET, MEDIUM TO COARSE GRAINED SAND.
35.0								
	ML			NP	100	60		SILT: BROWN, WET, STIFF, MEDIUM GRAINED SAND.
37.0								
	CL	25	36	16	100	92		CLAY: REDDISH BROWN, MOIST, FINE GRAINED SAND.
40.0							12	

SCALE 1 IN = 5 FT

5 0 5 10

NOTES

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2. SEE PLATE 6A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.820+00 TO STA.800+00

TH83 – 1407

TH83-1407 STA 789+00 R EL. 193±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM	5/6		NP	79	9		SAND/SILTY SAND: BROWN, MOIST, MEDIUM GRAINED SAND, OCCASIONAL GRAVEL, ASPHALT TO 2.5 FEET, REFUSAL AT 2.5 FEET DUE TO ROCKS.
3.0								
	SM	9		NP	99	18		SILTY SAND: BROWN, MOIST, DENSE, FINE TO MEDIUM GRAINED SAND.
6.0							60	
								SAND/SILTY SAND: BROWN, MOIST, VERY DENSE, FINE TO MEDIUM GRAINED SAND.
		7					56	
								SAME: OCCASIONAL GRAVEL, FEW COBBLES TO 4 INCHES, NO SPT AT 11.0 FEET DUE TO ROCKS.
	SW/SM	6		NP	95	13		
								SAME: WIRE DEBRIS, NO SPT AT 14.0 FEET DUE TO ROCKS.
		6						
								SAME: MEDIUM GRAINED SAND.
		7						
18.0							41	
	SP	16			99	2		SAND: BROWN-TAN, MOIST TO WET, DENSE, MEDIUM TO COARSE GRAINED SAND, OCCASIONAL GRAVEL, FEW COBBLES TO 4 INCHES.
							32	
22.0								
	SP/SM	13		NP	98	5	39	SAND/SILTY SAND: BROWN-TAN, MOIST TO WET, DENSE, MEDIUM TO COARSE GRAINED SAND, OCCASIONAL GRAVEL.
24.5								
	SP				95	2		SAND: GREY, WET, DENSE, COARSE GRAINED SAND.
27.0							44	
	SM	32		NP	100	34		SILTY SAND: BROWN, WET, SLIGHT COHESION, MEDIUM TO COARSE GRAINED SAND.
30.0							17	
								CLAY: BROWN, WET, STIFF, FINE TO MED. GRAINED SAND.
		37/32	41	15	100	85	17	
	CL						13	
								SANDY CLAY: SAME AS ABOVE, REDDISH BROWN.
		18	28	12	100	77	21	
41.5								
	SP							GRAVELLY SAND: REDDISH BROWN, WET, 30 PERCENT GRAVEL.
43.0								

TT84-1472

TT84-1472 STA 789+00 C EL. 175±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SAND: MULTICOLORED, MOIST, LOOSE, FE
	SP				97	0		
6.0								
	ML			NP	98	50		SANDY SILT: LIGHT GREY, MOIST FINE (
7.0								
								GRAVELLY SAND: MULTICOLORED, MOIST, 1 INCH, SOME SILT.
	SP				84	2		
					94	3		SAND: SAME AS ABOVE, FEW GRAVEL TO ?
W 14.0								
15.0	MH		63	30	100	84		SANDY SILT: DARK BROWN, WET.

TT84-1472

STA 789+00 C EL. 175±

C	LL	PI	-4	-200	N	DESCRIPTION
						SAND: MULTICOLORED, MOIST, LOOSE, FEW GRAVEL TO 2 INCHES.
			97	0		
		NP	98	50		SANDY SILT: LIGHT GREY, MOIST FINE GRAINED.
						GRAVELLY SAND: MULTICOLORED, MOIST, LOOSE, FEW GRAVEL TO 1 INCH, SOME SILT.
			84	2		
						SAND SAME AS ABOVE, FEW GRAVEL TO 3", WATER AT 14.0'.
			94	3		
	63	30	100	84		SANDY SILT. DARK BROWN, WET.

TH83-1408

TH83-1408 STA 789+00 L EL. 198±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.5	SP	5			97	4	24	SAND: BROWN, MOIST, MED. GRAINED SAND, OCCASIONAL GRAVEL.
3.0	SM	3		NP	100	21	16	SILTY SAND: BROWN-GREY, MOIST, MEDIUM GRAINED SAND.
	SP	4			99	3		SAND: BROWN-GREY, MOIST, MEDIUM GRAINED SAND, NO SPT AT 5.0 FEET DUE TO 8 INCH COBBLE.
7.5		18			99	2		SAME: DARK BROWN, FINE TO MEDIUM GRAINED SAND.
		5					25	SAND/SILTY SAND: BROWN-GREY, MEDIUM GRAINED SAND.
	SP/SM	6		NP	99	7		SAME: FINE TO MEDIUM GRAINED SAND.
12.0							16	
	SP	4			98	3		SAND: BROWN-GREY, MOIST, FINE TO MEDIUM GRAINED SAND.
15.0							12	
								SANDY SILT: BROWN, MOIST, STIFF, FINE TO MEDIUM GRAINED SAND.
	ML	12 / 26		NP	100	52	17	
21.0							23	
	SM	6		NP	99	14		SILTY SAND: BROWN, MOIST, MEDIUM GRAINED SAND.
23.0								
		4					32	SAND: BROWN, MOIST, MEDIUM GRAINED SAND.
					99	2		
	SP	4 / 18					25	SAME: WET, WATER AT 29.0 FEET.
W 29.0								
							21	SAME: COARSE GRAINED SAND.
32.0								
							18	SANDY CLAY: REDDISH-BROWN, MOIST, VERY STIFF TO HARD, FINE GRAINED SAND.
		44	25	9	99	63		
	CL						36	
							40	
40.0								

SCALE 1 IN=5FT

NOTES

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2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
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4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS

CORPS OF ENGINEERS

STA.789+00

FE75-6

LOG OF TEST HOLE

TH-6

MC	DD	4	200	DESCRIPTION
1		95	10	SAND- Brown, fine to coarse, damp, med. dense to dense,
7	103	100	5	
4				
5		95	5	Some gravel to 1"
4		100	5	
5				

12'

Excavated [illegible] 24 75

FE75-10

LOG OF TEST HOLE

TH-10

0' – 1' – 4½' – 6' – 10'

MC	DD	4	200	DESCRIPTION
				SILTY SAND- Brown, damp disturbed.
5	115	100	10	SAND- Brown, damp, dense, buried cable at 3'. caving.
24	109	100	50	SILTY SAND- Brn, v/moist, soft/med.
				SAND- Brown, moist/wet, med. dense, Severe caving.

Excavated 3-4-75

FE75-9

TH-9

0' – 1' – 11'

MC	DD	4	200	DESCRIPTION
				SILTY SAND- Loose, damp, disturbed brown.
5	112	100	10	SAND- Brown, damp, fine to coarse, dense. Discontinuous silty layers water seeps at 3'.
7	108	100	5	Caving.
				more moist w/ depth
8	97	100	15	

Excavated 3-4-75

WM74-2

DATE OF BORING [illegible] May 74 WATER DEPTH 10' DATE MEA[...]
TYPE OF DRILL RIG [illegible], Rotary wash HOLE DIAMETER 6 7/8[...]

DEPTH, FT	SAMPLES	BLOWS/FOOT	GROUND WATER	DESCRIPTION
SURFACE ELEVATION: 19_'				
				Fill: Loose, dry, brown GRAVELLY SAND (SW[...]
				Mostly tan, coarse-grained SAND (SW)
				Thin lense of brown CLAY
10			▽	Fill: Loose, tan, SAND (SP) occasional G[...]
	1	NR		
	2	10		Loose, tan GRAVEL
	3			Soft-medium stiff, gray SILTY CLAY (CL)
	4	50		Loose, gray SILTY SAND (SM)
20				Dense to very dense, tan SAND (SP-SM) wit[...]
	5	49		
				Medium dense
	6	27		
	7	37		
30	8	10		Medium stiff, gray SILTY CLAY (CL)
	9			Medium dense, gray CLAYEY SAND (SC)
	10			
40				With GRAVEL
				Dense, brown GRAVELLY SAND (SP-SC)
				Dense, brown GRAVELLY SAND (SP-SM)
50				
				Bottom of boring 52 feet

WA69-2

DRILL RIG: Rotary Wash | HOLE ELEVATION: 201.7 | LOGGED BY: C.C.
GROUNDWATER DEPTH: See Notes | HOLE DIAMETER: 6 Inch | DATE DRILLED: 6/4/69

Description and Remarks	Color	Moisture	Consist	Soil Type	Depth
Medium to Coarse SAND	Brown	Wet	Loose / M Dense	SP	
with layers of Gravel throughout			Dense		5
			V Dense		10
					15
with occasional small cobbles					20
					25
nest of cobbles					
					30
					35
					40
nest of cobbles					
Sandy GRAVEL with cobbles throughout	Gy Brn	Wet	V Dense	GP	45
					50

NOTES:
1) Caving of boring walls curtailed with use of extra thick drillers' mud.
2) Hole not bailed to determine groundwater level.
3) Hole terminated due to severe drilling conditions, causing slow progress. Many cobbles and some boulders.

W.A. WAHLER & ASSOCIATES — Santa Ana River Levee, Orange County, California — SOIL EXPLORATION DRILL HOLE LOG — Project No. 0340 — Date 6/16/69 — Sheet 1 of 1 — HOLE NO. 2

WA69-3

DRILL RIG: Rotary Wash | HOLE ELEVATION: [illegible] | LOGGED BY: C.C. & W.W.
GROUNDWATER DEPTH: See Notes | HOLE DIAMETER: 6 Inch | DATE DRILLED: 6/[illegible]/69

Description and Remarks	Color	Moisture	Consist	Soil Type	Depth	Penetration Resistance
Gravelly SAND	Lt Brn	Wet	M Dense	GP		
	Brown	Moist to Wet			5	
SILT	Gy Brn	Moist to Wet	Firm	ML	10	
Sandy SILT	Rd Brn	Wet	M Dense	ML	15	
Sandy GRAVEL	Gy Brn	Wet	Dense-V Dense	SP	20	100+
with some cobbles						
with cobbles throughout					25	
					30	100+
BOTTOM OF HOLE AT 31.5 FEET					35	

NOTES:
1) Caving of boring walls curtailed with use of extra thick drillers' mud.
2) Hole not bailed to determine groundwater level.
3) Hole terminated due to severe drilling conditions, causing slow progress. Many cobbles and some boulders.

W.A. WAHLER & ASSOCIATES — Santa Ana River Levee, Orange County, California — SOIL EXPLORATION DRILL HOLE LOG — Project No. 0340 — Date 6/16/69 — Sheet 1 of 1 — HOLE NO. 3

VALUE ENGINEERING PAYS

WM74-2

LOG OF BORING 2

DATE OF BORING 30-31May74 WATER DEPTH 10' DATE MEASURED 3 June 74 SAMPLES Pitcher and Calif. Mod.
TYPE OF DRILL RIG Budha, Rotary wash HOLE DIAMETER 4 7/8in. WEIGHT OF HAMMER 140lbs. FALLING 30in.

SURFACE ELEVATION: 193'

DEPTH, FT	SAMPLES	BLOWS / FOOT	GROUND WATER	DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
				Fill: Loose, dry, brown GRAVELLY SAND (SW)				
				Mostly tan, coarse-grained SAND (SW)				
				Thin lense of brown CLAY				
10			▽	Fill: Loose, tan, SAND (SP) occasional GRAVEL				
	1	NR						
	2	10		Loose, tan GRAVEL		41	80	
	3			Soft-medium stiff, gray SILTY CLAY (CL)				
	4	50		Loose, gray SILTY SAND (SM)				
20				Dense to very dense, tan SAND (SP-SM) with GRAVEL				
	5	49						
				Medium dense				
	6	27				8	106	
	7	37				17	114	
30						38	85	
	8	10		Medium stiff, gray SILTY CLAY (CL)				
	9			Medium dense, gray CLAYEY SAND (SC)				
	10							
40				With GRAVEL				
				Dense, brown GRAVELLY SAND (SP-SC)				
				Dense, brown GRAVELLY SAND (SP-SM)				
50								
				Bottom of boring 52 feet				

WM74-3

LOG OF BORING 3

DATE OF BORING 1 June 74 WATER DEPTH 20.5' DATE MEASURED 19 June74 SAMPLES Pitcher and Calif. Mod.
TYPE OF DRILL RIG Budha, Rotary wash HOLE DIAMETER 4 7/8in. WEIGHT OF HAMMER 140lbs. FALLING 30in.

SURFACE ELEVATION: ≈ 218'

DEPTH, FT	SAMPLES	BLOWS / FOOT	GROUND WATER	DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
				Fill: Loose, dry, brown SILTY SAND (SM)				
				Fill: Loose to medium dense, damp, brown CLAYEY SAND (SC) some GRAVEL				
				Medium dense, brown SILTY SAND (SW-SM) with GRAVEL				
10								
	1			COBBLES				
20			▽					
	2	NR						
	3	47		Dense to very dense		9	127	SA
30								
				Bottom of boring 32½ feet				

WA 69-4

DRILL RIG Rotary Wash	HOLE ELEVATION 187.4	LOGGED BY C.C. & D.P.
GROUNDWATER DEPTH See Notes	HOLE DIAMETER 6 Inch	DATE DRILLED 6/5/69

SOIL DESCRIPTION

DESCRIPTION AND REMARKS	COLOR	MOISTURE	CONSIST	SOIL TYPE	DEPTH	SAMPLES: SPLIT SPOON	PENETRATION RESISTANCE
Fine to Medium (Clean) SAND	Gy Brn	Wet	Loose M Dense	SP			
Silty CLAY	Rd Brn	Damp to Moist	Stiff	CL	5	⊏⊐	
					10	⊏⊐	
Gravelly SAND	Dk Gy	Wet	Dense	SP			
Sandy GRAVEL with cobbles	Grey	Wet	V Dense	GP	15	⊏⊐	100+
Silty CLAY	Rd Brn	Wet	Stiff V Stiff	CL	20	⊏⊐	
Silty SAND and Sandy GRAVEL with cobbles and some boulders	Lt Tan	Wet	Dense- V Dense	SM GP	25	⊏⊐	
					30		

BOTTOM OF HOLE AT 30 FEET

NOTES:
1) Caving of boring walls curtailed with use of extra thick driller's mud.
2) Hole not bailed to determine groundwater level.
3) Hole terminated due to severe drilling conditions, causing slow progress. Many cobbles and some boulders.

SOIL EXPLORATION HOLE

NOTES:

1. SEE PLATE 14 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION BY OTHERS

STA.845+00 TO STA.780+00

WA69-5

DRILL RIG	Rotary Wash	HOLE ELEVATION	101.6	LOGGED BY	D.C.P.
GROUNDWATER DEPTH (BELOW GROUND SURFACE)	16 Feet	HOLE DIAMETER	6 Inch	DATE DRILLED	6/9/69

SOIL DESCRIPTION: DESCRIPTION AND REMARKS	COLOR	MOISTURE	CONSIST.	SOIL TYPE	DEPTH	PENETRATION RESISTANCE
Fine Silty SAND	Lt Gy	Moist	Loose M Dense	SM	0–8	
SAND	Lt Gy	Wet	Dense	SP	8–15	
Fine Silty SAND G.W.S. 6/10/69 With Clay Lenses	Brn	▼	Dense	SM	15–29	
CLAY	Rd Brn	Wet	V Stiff	CL	29–32	
Clayey GRAVEL	Rd Brn	Wet	V Dense	GP	32–35	
Gravely SAND with few cobbles	Grey	Wet	V Dense	SP	35–40	
Sandy GRAVEL with large cobbles and few boulders	Grey	Wet	V Dense	GP	40–41	100+

BOTTOM OF HOLE AT 41 FEET

NOTES:
1) Caving of boring walls curtailed with use of extra thick drillers' mud.
2) Hole not bailed to determine groundwater level.
3) Hole terminated due to severe drilling conditions, causing slow progress. Many cobbles and some boulders.

W.A. WAHLER & ASSOCIATES — Santa Ana River Levee, Orange County, California — SOIL EXPLORATION DRILL HOLE LOG — Project No. [illegible] — Date 6/16/69 — Sheet No. 1 of 1 — HOLE NO. 5

MT66-1

TEST BORING LOG

TYPE 18" Bucket — ELEVATION [illegible] — BORING No. 1

- Mottled [illegible] well graded SAND with scattered gravel
- CL Gray-brown SILTY CLAY
- Reddish-brown with sandy silt lenses and scattered gravel
- SM Mottled brown fine to medium SILTY [illegible] [illegible] fine gravel
- SC Reddish-brown CLAYEY SAND
- Mottled brown SILTY [illegible]

Notes: 1. [illegible] 2. Water not encountered 3. Hole backfilled

MT66-3

TEST BORING LOG

BORING No. 3

[illegible]

MT66-3 (cont'd)

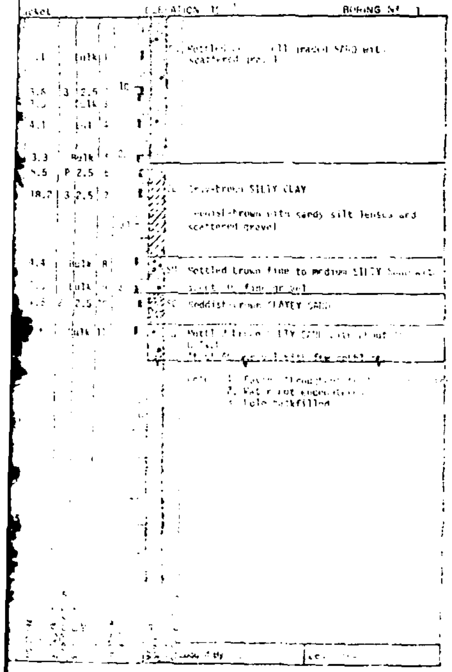
TEST BORING LOG

[illegible]

VALUE ENGINEERING PAYS

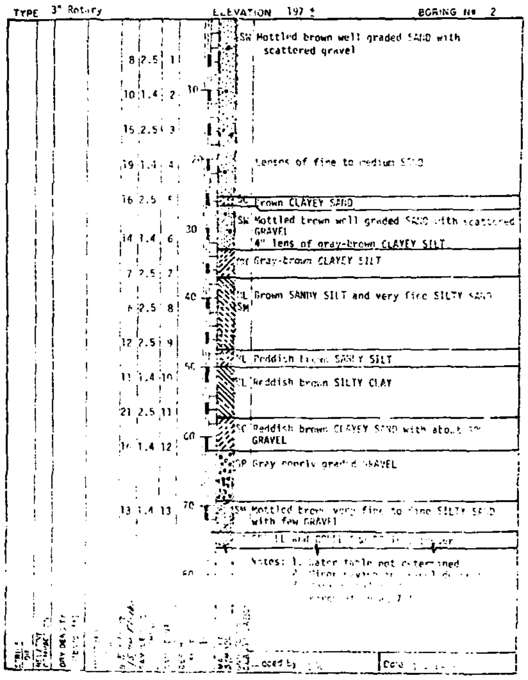
MT66-1

TEST BORING LOG



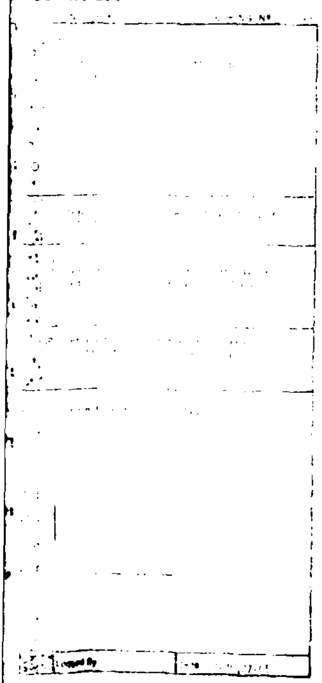
MT66-2

TEST BORING LOG



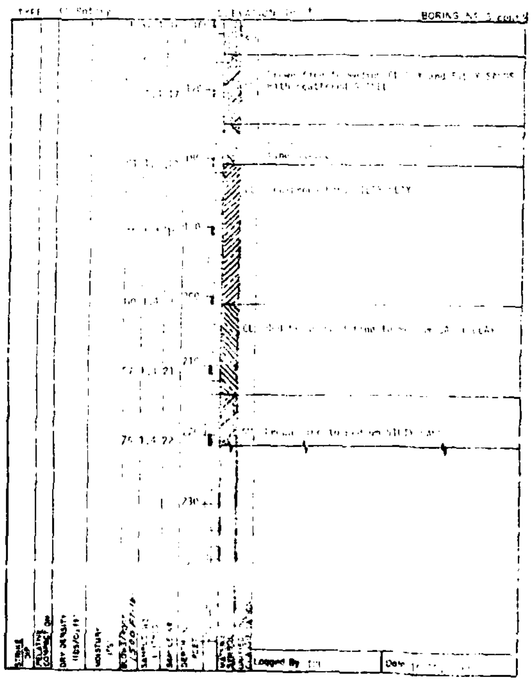
66-3 (cont'd)

T BORING LOG



MT66-3(cont'd)

TEST BORING LOG



NOTES:

1. SEE PLATE 14 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS
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SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

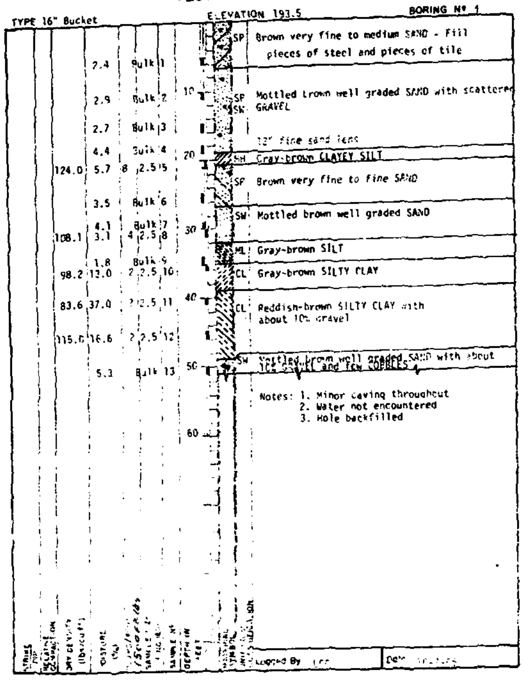
LOGS OF INVESTIGATION

BY OTHERS

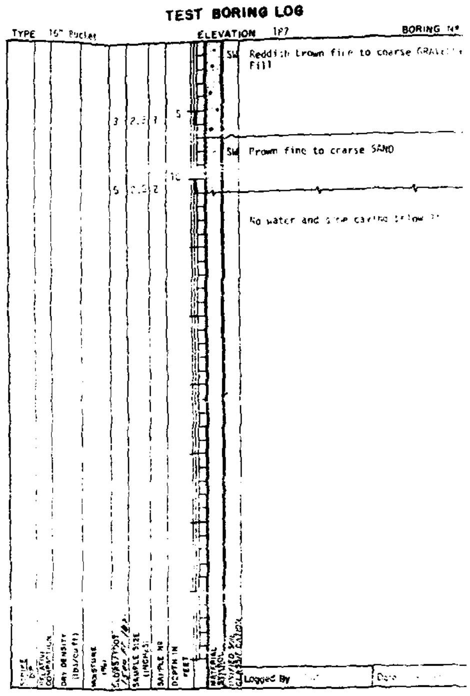
STA.845+00 TO STA.780+00

SUBMITTED BY: | DATE APPROVED | SPEC. NO. DACW09-____ B-____ | SHEET

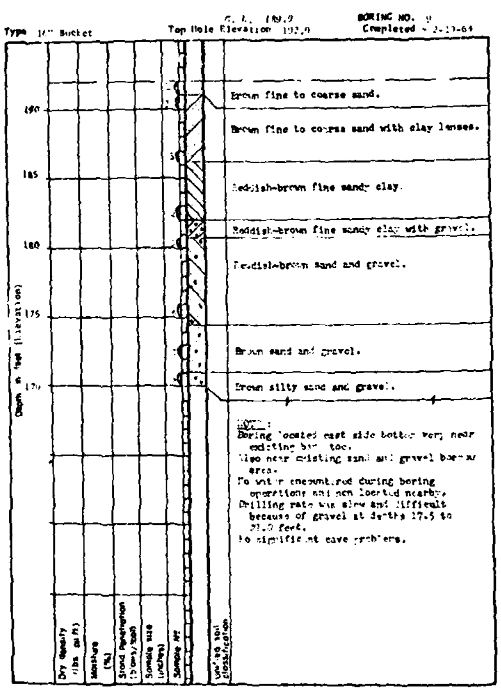
MT66-4



MT66-17



MT64-9



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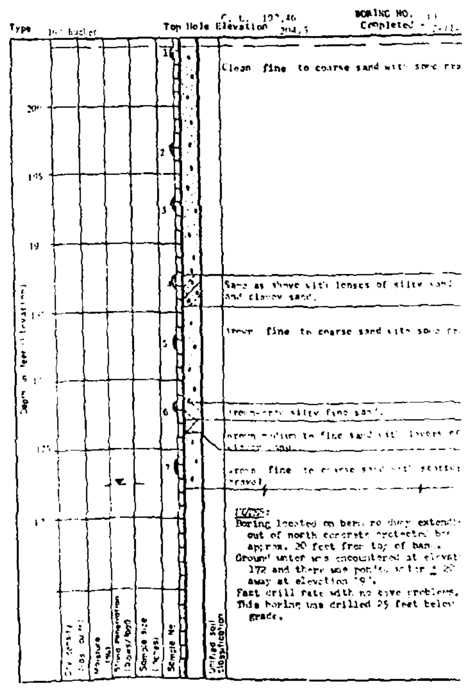
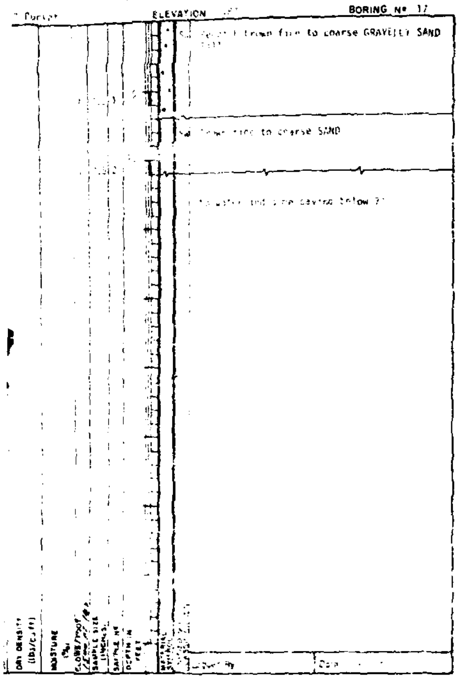


VALUE ENGINEERING PAYS

MT66-17

TEST BORING LOG



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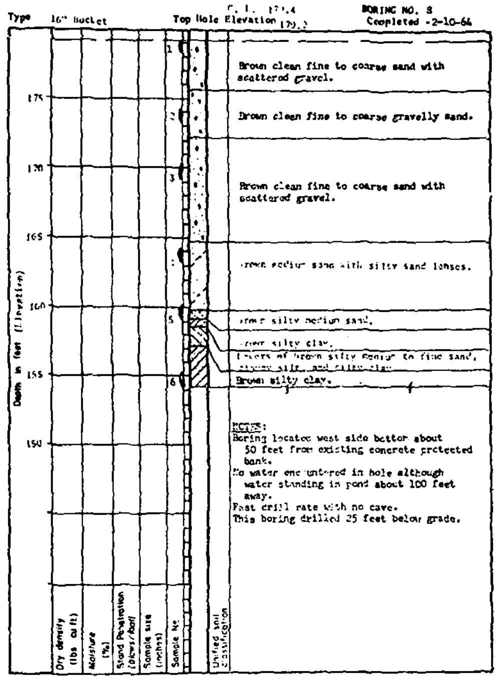
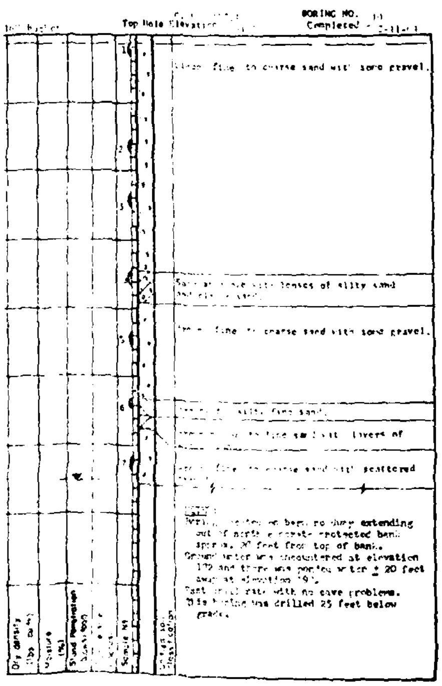


MT64-10



NOTES:

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2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
REVISIONS			

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

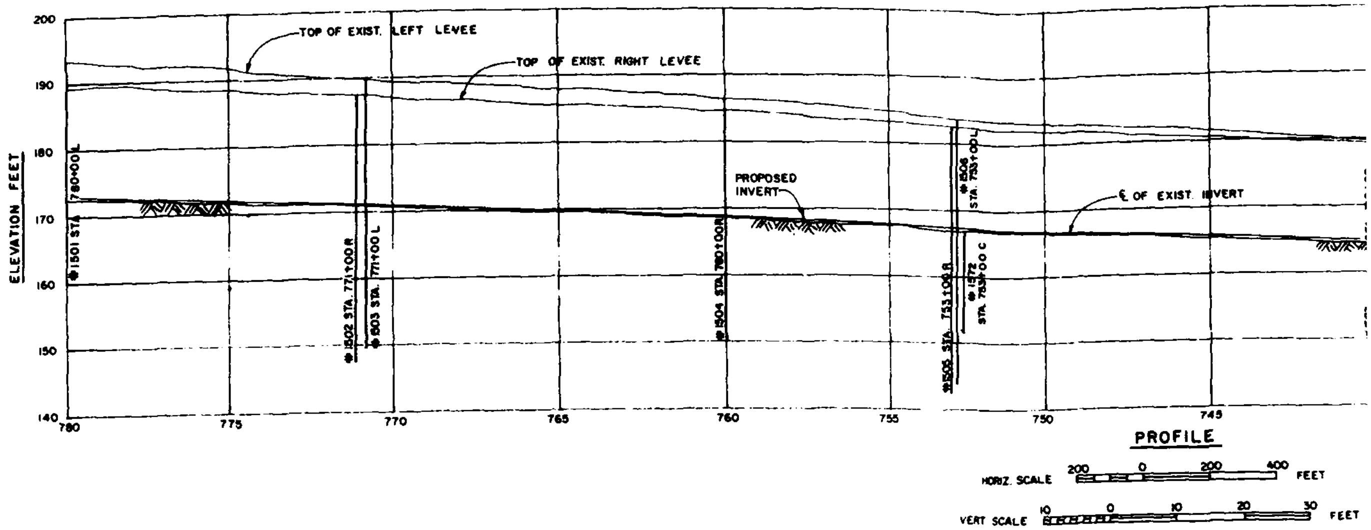
DESIGNED BY:
DRAWN BY:
CHECKED BY:

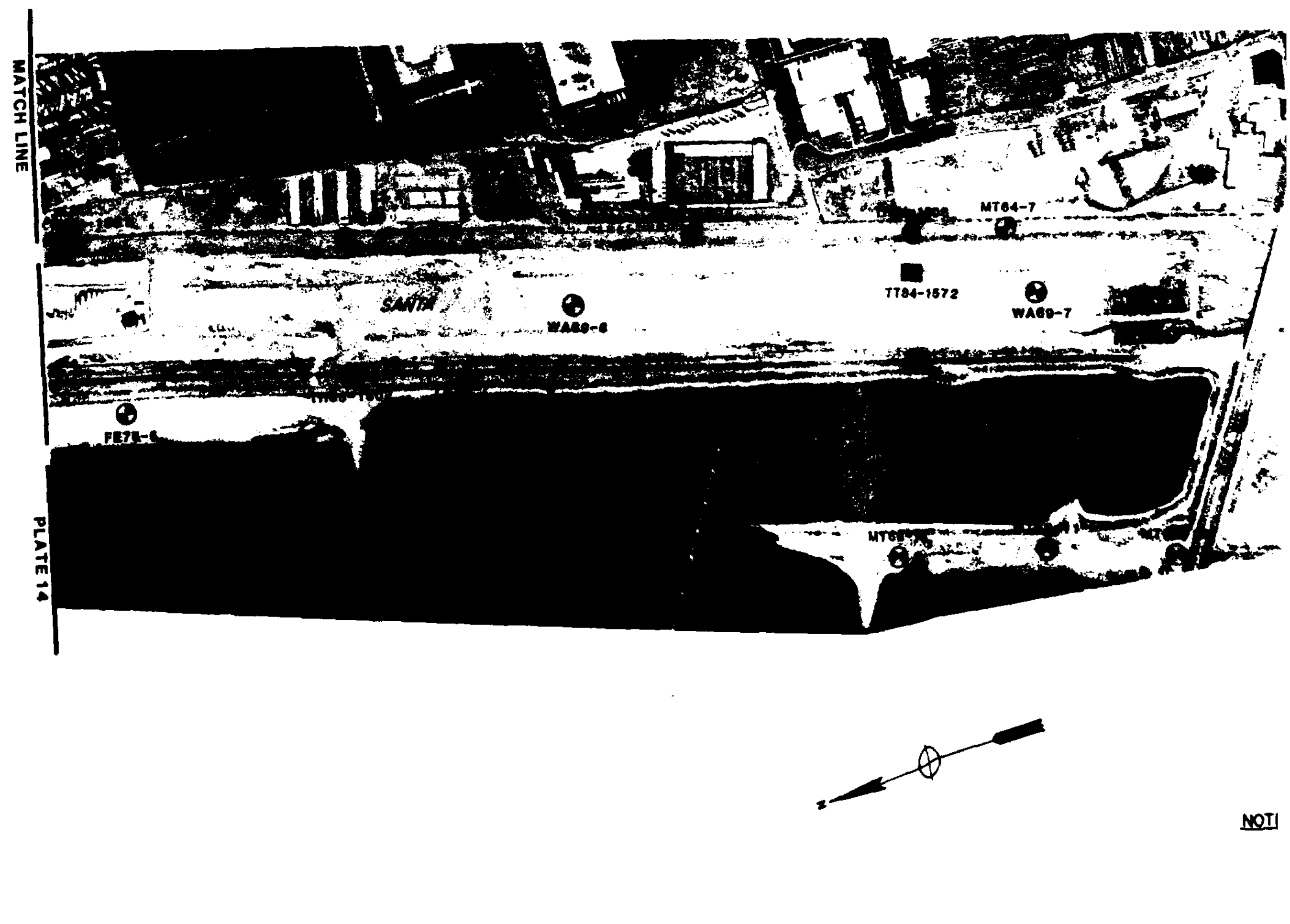
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS
STA.845+00 TO STA.780+00

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-__-B-____ | SHEET

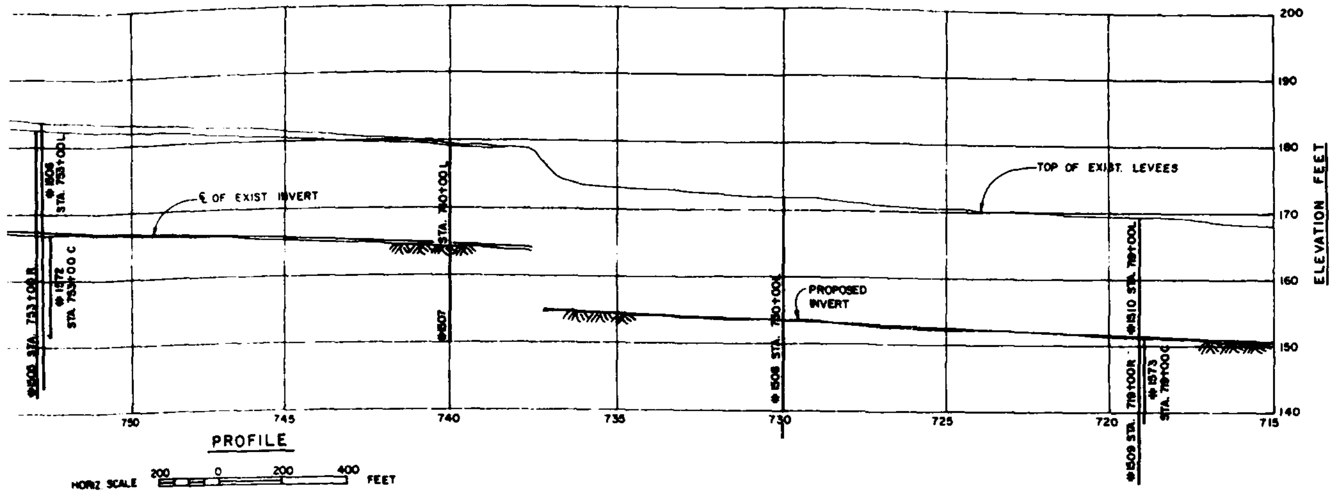
VALUE ENGINEERING P

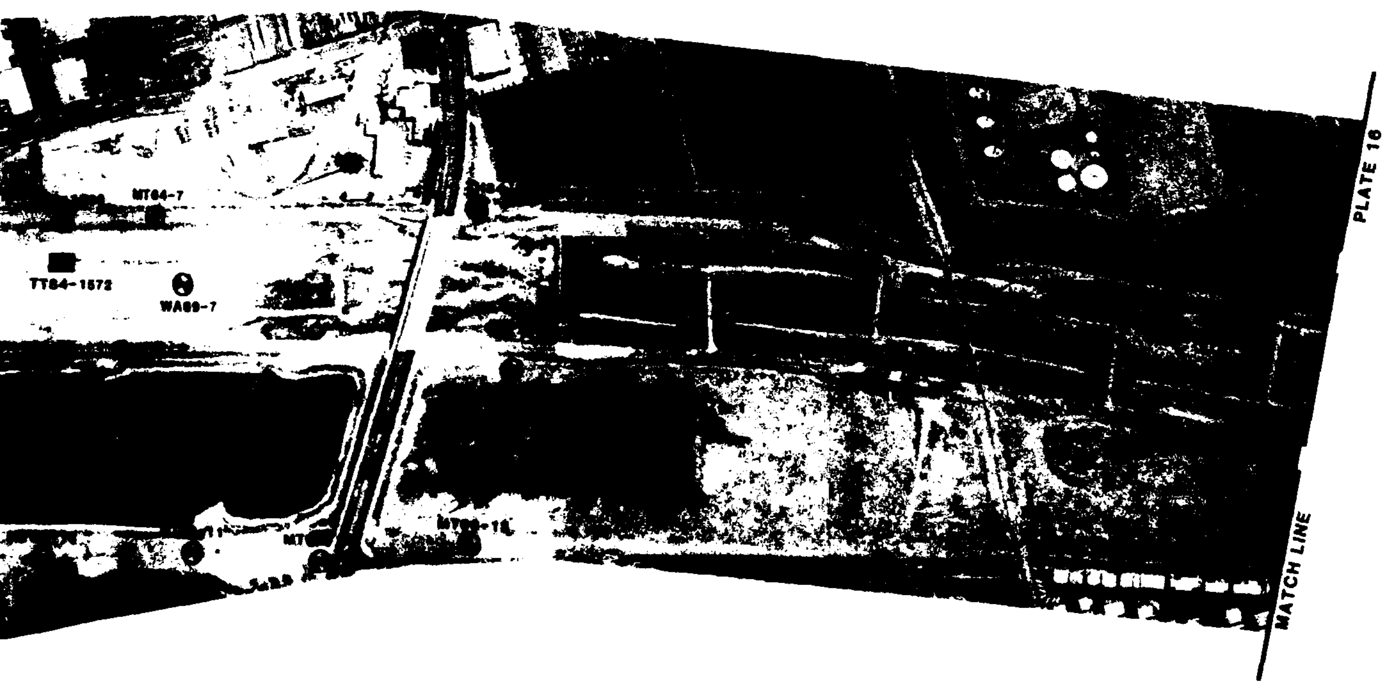




NOT

VALUE ENGINEERING PAYS





DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE

STA.780+00 TO STA.715+00

DESIGNED BY: | DRAWN BY: | CHECKED BY: | SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-___ B-___ | SHEET | DISTRICT FILE NO.

NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

VALUE ENGINEERING PA

TH 84-1501

TH84-1501 STA 780+00 L EL. 194±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP/SM			NP	91	9		SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND, GRAVELS TO 1 INCH.
3.0								
					93	3	19	SAND: TAN, MOIST, FINE TO MEDIUM GRAINED SAND, SOME GRAVEL TO 3/4 INCHES, ROUNDED, MEDIUM DENSITY, CLEAN.
					97	3	12	
		4			98	3	11	SAME: TAN, MOIST, FINE GRAINED SAND, SOME STREAKS OF BLACK (ORGANIC).
	SP	3			88	3	11	SAME: LIGHT BROWN-MULTICOLORED, COARSE GRAINED SAND.
		3			77	1	7	GRAVELLY SAND: SAME AS ABOVE, GRAVEL TO 2-1/2 INCHES.
		3			94	3	16	SAND: TAN, COARSE GRAINED SAND, GRAVEL TO 2-1/2 INCHES.
					98	4	29	SAME: TAN, MEDIUM DENSITY, FEW GRAVEL.
26.0							30	
	SP/SP			NP	98	9		SAND/SILTY SAND: MEDIUM BROWN WITH MULTICOLORED GRAINS, COARSE GRAINED SAND, SOME COHESION.
27.0								
	SP				97	4	33	SAND: MEDIUM BROWN WITH MULTICOLORED GRAINS, COARSE GRAINED SAND.
30.0								
	SP/SM			NP	98	5	14	SAND/SILTY SAND: LIGHT BROWN, MOIST TO WET, FINE TO COARSE GRAINED SAND, SOME GRAVEL.
34.5							19	

TH 83-1502

TH84-1502 STA 771+00 R EL. 188±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		6		NP	98	10		SAND/SILTY SAND: BROWN, MOIST, DENSE, F GRAINED SAND, FEW GRAVEL, ASPHALT SURFAC
		5					56	
		6		NP	97	10	54	
	SW/SM	7						
							55	
								SAME. BROWN-GREY, NO PENTROMETER TEST D STEEL FOUND IN HOLE.
		7		NP	97	12	R	
		6						
14.5							37	
								SAND: BROWN, MOIST, MEDIUM GRAINED SAND
	SP	6		NP	98	4	25	
		7						SAME: GREY-BROWN, WET.
W 20.0								
							22	SANDY/SILTY SAND: BROWN, WET, COARSE GR
	SP/SM	25		NP	93	5		
24.0							13	
	SM	28		NP	92	23		SILTY SAND: BROWN, WET, FINE TO COARSE
27.0							27	
	SW/SM	24		NP	100	7		SAND/SILTY SAND: SAME AS ABOVE.
28.5								
							23	SANDY CLAY: BROWN, WET.
		31	46	22	100	70		
	[illegible]							
							15	SAME: REDDISH-BROWN, WET SOME GRAVE
		32	49	23	89	73		
		27	30	12	94	56		GRAVELLY SANDY CLAY: REDDISH-BROWN, WE
36.[illegible]							23	
								CLAYEY GRAVELLY SAND: REDDISH-BROWN
	[illegible]	32	17	30	60	18		
							23	
40.[illegible]								

VALUE ENGINEERING PAYS

TH 83-1502

STA 771+00 R

EL. 188±

MC	LL	PI	-4	-200	N	DESCRIPTION
						SAND/SILTY SAND: BROWN, MOIST, DENSE, FINE TO MEDIUM GRAINED SAND, FEW GRAVEL, ASPHALT SURFACE.
5		NP	98	10		
5					56	
5		NP	[illegible]	[illegible]	[illegible]	
7						
					[illegible]	
						SAME: BROWN-GREY. NO PENTROMETER TEST DUE TO DEBRIS AND STEEL FOUND IN HOLE.
[illegible]		NP	9[illegible]	[illegible]	[illegible]	
6						
					[illegible]	
						SAND: BROWN, MOIST, MEDIUM GRAINED SAND, FEW GRAVEL.
6		NP	[illegible]	4	[illegible]	
						SAME: GREY-BROWN, WET
					[illegible]	SANDY SILTY SAND: BROWN, WET, COARSE GRAINED SAND.
[illegible]		NP	[illegible]	[illegible]		
					[illegible]	
						SILTY SAND: BROWN, WET, FINE TO COARSE GRAINED SAND.
[illegible]		NP	[illegible]	[illegible]		
					[illegible]	
[illegible]		NP	[illegible]			SANDY SILTY SAND: SAME AS ABOVE.
						SANDY CLAY: BROWN, WET.
					[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]			
						SAME: REDDISH-BROWN, WET, SOME GRAVEL.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		SANDY CLAY: REDDISH-BROWN, WET.
					[illegible]	
						SANDY GRAVEL SAND: REDDISH-BROWN, WET.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
					[illegible]	

TH 84 1503

TH84-1503 STA 771+00 L

EL. 190±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	ML	14	29	3	100	53		SANDY SILT: LIGHT BROWN, MOIST, FINE GRAINED SAND, FEW GRAVEL, SOME COHESION.
3.0								
				NP	97	20	16	SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND, FEW GRAVEL TO 2 INCHES IN SIZE.
							10	SAME: BROWN, MOIST FINE GRAINED SAND, CLUMPS OF COHESIVE DARK BROWN MATERIAL.
	SM	7		NP	97	29		
							20	
12.0								
							15	SAND: BROWN, MOIST, FINE TO COARSE GRAINED SAND, SOME GRAVEL TO 1 INCH IN SIZE.
		3			96	4		
							17	
		3			97	4	34	SAME: BROWN, MOIST, LOOSE, COARSE GRAINED SAND, GRAVEL TO 2-1/2 INCHES IN SIZE.
					95	4	30	SAME: MULTICOLORED, MOIST, LOOSE, FINE TO COARSE GRAINED SAND, GRAVEL TO 2 INCHES IN SIZE. BEGAN ADDING DRILLING MUD TO REDUCE CAVING.
	SP							
							42	
					[illegible]	[illegible]	[illegible]	SAME: LIGHT BROWN, MOIST, FINE GRAINED SAND, SOME GRAVEL TO 1-1/2 INCH IN SIZE. PENETROMETER TEST ENDED WITH 1 INCH TO GO.
					[illegible]	4	[illegible]	
							[illegible]	
35.0								
								SANDY CLAY: DARK BROWN, MOIST TO WET, STIFF, COHESIVE, SOME GRAVEL TO 1 INCH IN SIZE
							[illegible]	
	[illegible]		[illegible]	[illegible]	100	[illegible]		
40.0								

SCALE 1 IN=5 FT

5 0 5 10

NOTES

1 SEE PLATE 15 FOR LOCATION OF TEST HOLES AND TEST TRENCHES

2 SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM

3 SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED

4 ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.780+00 TO STA.771+00

TH84-1504

TH84-1504 STA 760+00 R EL. 187±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SAND/SILTY SAND: BROWN, MOIST, LOOSE, FINE TO MEDIUM GRAINED SAND, FEW GRAVEL TO 3 INCHES.
	SP/SM	3		NP	94	5		
							15	
6.0								
					91	3	13	SAND: SAME AS ABOVE, LESS FINES, GRAVEL TO 2 INCHES.
	SP						10	SAME: BROWN, MOIST, FINE GRAINED SAND, GRAVEL TO 2-1/2".
		4			97	3	13	SAME: LIGHT BROWN, MOIST, CLEAN, FINE GRAINED SAND, FEW GRAVEL TO 1 INCH.
15.0								
							18	SAND/SILTY SAND: GREY-BROWN, FINE TO COARSE GRAINED SAND, GRAVEL TO 2 INCHES, SOME COHESION.
				NP	87	12		
							12	
	SP/SM							
							30R	PENETROMETER HIT ROCK.
23.5				NP	100	34		
							8	SILTY SAND: MEDIUM TO DARK BROWN, MOIST TO WET, LOOSE, COHESIVE, FINE GRAINED SAND.
	SM			NP	100	36		
				NP	99	25		
29.0							28	
	SP/SM			NP	99	8		SAND/SILTY SAND. LIGHT BROWN-MULTICOLORED, FINE TO COARSE GRAINED SAND, SOME SILT.
							23	
33.0								
	SP				100	3		SAND: SAME AS ABOVE.
35.0							30	

TH84-1505

TH84-1505 STA 753+00 R EL.

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESC
		4		NP	96	6		SAND/SILTY SAND: LIGHT GRAVEL TO 3/4 INCHES IN
							30R	
		?		NP	95	12	30R	SAME: GREY, MOIST, FINE IN SIZE.
	SW/SM							
							R	PENETROMETER HIT ROCK.
				NP	91	9	30R	
		?		NP	95	9	R	SAME: GREY, MOIST, FINE IN SIZE, COBBLES TO 4 IN LARGE ROCK.
18.0								
	SP/SM	-		NP	96	5	30R	SAME: BROWN, MOIST, FIN
21.0								
	SM		27	?	99	[illegible]	15	SILTY SAND: GREY, MOIST COHESIVE.
24.0								
					96	4	26	SAND: BROWN, MOIST TO SAND.
					98	4	23	SAME: MULTICOLORED.
	SP						22	
					98	4	20	
					98	4	20	
40.0							34	

TT84-1572

INVERT

TT84-1572 STA 753+00 C EL. 167±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
					96	3		SAND: MULTICOLORED, MOIST, FINE GRAINED SAND, 3 INCH LAYER OF CLAYEY SILT.
W 3.5	SP							GRAVELLY SAND: MULTICOLORED, MOIST, FEW GRAVEL TO 1 INCH.
					70	1		
					96	2		SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, FEW GRAVEL TO 3 INCH.
9.0								
10.0	SM			NP	100	29		SILTY SAND: DARK BROWN, MOIST, SOME COHESION.
	SW/SM			NP	84	5		GRAVELLY SAND/SILTY GRAVELLY SAND: MULTICOLORED, MOIST TO WET, FINE TO MEDIUM GRAINED SAND, FEW GRAVEL TO 7 INCHES.
15.0								

PA

LUE ENGINEERING PAYS

F. FINE · ND. GRA · AND, GRA ZE. PEN · SAND. · FINE GR · TO COAR

TH84-1505

STA 753+00 R — EL. 183±

LL	PI	-4	-200	N	DESCRIPTION
	NP	96	[illegible]		SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND, GRAVEL TO 3/4 INCHES IN SIZE.
				30R	
	NP	[illegible]	12	30R	SAME: GREY, MOIST, FINE GRAINED SAND, GRAVEL TO 3 INCHES IN SIZE.
				0	PENETROMETER HIT ROCK.
	NP	[illegible]	[illegible]	30R	
	NP	[illegible]	[illegible]	[illegible]	SAME: GREY, MOIST, FINE GRAINED SAND, GRAVEL TO 3 INCHES, IN SIZE, COBBLES TO 4 INCHES IN SIZE, PENETROMETER HIT LARGE ROCK.
	NP	[illegible]	5	30R	SAME: BROWN, MOIST, FINE GRAINED SAND.
[illegible]	2	[illegible]	[illegible]	[illegible]	SILTY SAND: GREY, MOIST TO WET, FINE GRAINED SAND, COHESIVE.
		[illegible]	[illegible]	[illegible]	SAND: BROWN, MOIST TO WET, FINE TO COARSE GRAINED SAND.
		[illegible]	[illegible]	[illegible]	SAME: MULTICOLORED.
				[illegible]	
		[illegible]	[illegible]	[illegible]	
		[illegible]	[illegible]	[illegible]	
				[illegible]	

TH84-1506

TH84-1506 — STA 753+00 L — EL. 184±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP	1			74	4	36	GRAVELLY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND, 5 PERCENT COBBLES, GRAVELS SUB-ANGULAR TO ANGULAR (1-1/2" MAX.).
3.0								
	SP/SM	4		NP	98	5	19	SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND, FEW GRAVEL.
6.0								
	SP				98	4	18	SAND: SAME AS ABOVE.
9.0								
	SW/SM			NP	98	8	16	SAND/SILTY SAND: SAME AS ABOVE.
12.0								
		3			99	3	16	SAND: SAME AS ABOVE.
					97	4	18	SAME: LIGHT BROWN, MOIST, COARSE GRAINED SAND, SUB-ROUNDED GRAVEL TO 1/2 INCHES.
	SP							
							16	
22.0							16	
	CL	25	41	16	100	67		SANDY CLAY: DARK BROWN, MOIST TO WET, NO GRAVELS, FINE GRAINED SAND, STIFF CONSISTENCY.
24.0								
							27	SAND/SILTY SAND: DARK BROWN, MOIST TO WET, FINE GRAINED SAND, MEDIUM DENSITY.
	SW/SM			NP	100	9		
27.0								
	SM	2		NP	93	23	22	SILTY SAND: TAN, MOIST, COARSE GRAINED SAND, SUB-ANGULAR TO SUB-ROUNDED GRAVEL (1/2 INCH MAX.), MEDIUM DENSITY.
30.0								
							40	SAND: TAN, MOIST, FINE GRAINED SAND, 5 PERCENT GRAVEL TO 1/2 INCH, DENSE.
					100	4		
	SP							
					99	3	37	
36.0								
							12	SANDY SILT: DARK BROWN, MOIST TO WET, FINE GRAINED SAND SOME GRAVEL, COHESIVE.
	ML	34	43	14	95	81		
40.5		33	41	12	100	85	5	

SCALE 1 IN=3 FT

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.760+00 TO STA.753+00

NOTES

1. SEE PLATE 15 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM.
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF

VALUE ENGINEERING

TH84 — 1507

TH84-1507 STA 740+00 L EL. 180±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		3		NP	82	8		GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, MOIST, FINE TO COARSE GRAINED SAND, GRAVEL TO 2 INCHES IN SIZE, SOME SILT.
				NP	92	8	30R	SAND/SILTY SAND: SAME AS ABOVE.
							30R	
	SW/SM	5		NP	95	7	50	
							35	
							52	SAME: GRAVEL TO 3 INCHES, SOME COBBLES TO 4-1/2 INCHES.
				NP	87	9		
				NP	97	7	20	
21.0								
		27	33	9	100	74	5	SANDY SILT: BROWN, MOIST TO WET, COHESIVE, FINE GRAINED SAND, STIFF.
	ML							
			37	9	100	80	19	
27.0								
	SM	19		NP	100	23		SILTY SAND: BROWN, MOIST TO WET, FINE GRAINED SAND, SOME COHESION.
30.0								

TH84 — 1508

TH84-1508 STA 730+00 L EL. 172±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		6			95	3		SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND, SOME GRAVEL TO 1/2 INCH IN SIZE, SOME SILT.
	SP							
		8					17	
6.0								
	SW/SM			NP	99	7	16	SAND/SILTY SAND: MULTICOLORED, MOIST, FINE TO COARSE GRAINED SAND, GRAVEL TO 2 INCHES, SOME SILT.
9.0								
				NP	98	5	25	SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND, SOME GRAVEL TO 1-1/2 INCH IN SIZE, SOME SILT.
	SP/SM							
							19	
15.0								
	SM			NP	86	13	17	SILTY SAND: MULTICOLORED, MOIST, FINE TO COARSE GRAINED SAND, GRAVEL TO 2 INCHES IN SIZE, SOME SILT.
18.0								
					71	2	22*	GRAVELLY SAND: MULTICOLORED, MOIST, MEDIUM DENSE, COARSE GRAINED SAND, SOME SILT.
	SP							
					90	4	34	SAND: SAME AS ABOVE.
24.0								
	SM				98	29		SILTY SAND: BROWN, MOIST, COHESIVE, FINE TO COARSE GRAINED SAND, MEDIUM DENSE, GRAVEL TO 3/4 INCHES IN SIZE.
27.0								
					99	4	31	SAND: LIGHT BROWN, MOIST TO WET, FINE TO COARSE GRAINED SAND, GRAVEL TO 1/2 INCH IN SIZE, SOME SILT.
	SP						15	
					99	3		

TH84 — 1509

TH84-1509 STA 719+00 R EL. 169

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPT
	SP/SM			NP	95	7		SAND/SILTY SAND: LIGHT BROWN ROUNDED TO ROUNDED GRAVEL TO
3.0								
	SW/SM			NP	89	7		SAND/SILTY SAND: SAME AS ABO DENSE.
6.0								
				NP	96	16		SILTY SAND: SAME AS ABOVE, M
	SM			NP	93	22		SAME: GREY, MOIST, COHESIVE,
				NP	95	18		SAME: GREY, MOIST, SOME SUB
18.0								
	SP/SM			NP	81	5		GRAVELLY SAND/SILTY GRAVELLY ROUNDED GRAVEL TO 1 INCH, DE
21.0								
	ML		41	14	96	52		SANDY SILT: DARK BROWN, MOI
24.0								
	ML/CL		29	7	100	51		SANDY SILT/SANDY CLAY: BROW GRAINED SAND.
27.0								
	SM			NP	96	13		SILTY SAND: LIGHT BROWN, MO
30.0								
	SP/SM			NP	99	5		SAND/SILTY SAND: SAME AS AB
33.0								
								SAND/SILTY SAND: SAME AS AB
	SW/SM			NP	97	6		
40.0								

TT84 — 1573

INVERT

TT84-1573 STA 719+00 C EL.

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESC
					90	1		SAND: MULTICOLORED, FINE
								SAME: MOIST, COARSE GRAI
	SP				93	1		
								SAME: FEW GRAVEL TO 3 IN
					97	1		
11.0								
	CH		[illegible]	23	100	69		SANDY CLAY: GREYISH BRO
12.5								
	SP				95	0		SAND: MULTICOLORED, MOI SAND, FEW GRAVEL TO 1 IN
13.0								

ALUE ENGINEERING PAYS

TH84 — 1509

STA 719+00 R — EL. 169±

LL	PI	-4	-200	N	DESCRIPTION
	NP	95	7		SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE SAND, SOME SUB-ROUNDED TO ROUNDED GRAVEL TO 1 INCH.
	NP	89	7		SAND/SILTY SAND: SAME AS ABOVE, GRAVEL TO 2 INCHES, VERY DENSE.
	NP	96	16		SILTY SAND: SAME AS ABOVE, MOIST.
	NP	93	22		SAME GREY, MOIST, COHESIVE, SOME ORGANICS, DENSE.
	NP	95	18		SAME GREY, MOIST, SOME SUBROUNDED GRAVEL TO 1 INCH.
	NP	91	5		GRAVELLY SAND/SILTY GRAVELLY SAND: LIGHT BROWN, MOIST, ROUNDED GRAVEL TO 1 INCH, DENSE, FINE GRAINED SAND.
[illegible]	14	95	62		SANDY SILT DARK BROWN, MOIST, COHESIVE, FEW GRAVEL.
29	7	100	51		SANDY SILT/SANDY CLAY: BROWN, MOIST, COHESIVE, FINE GRAINED SAND.
	NP	96	13		SILTY SAND: LIGHT BROWN, MOIST, LOOSE, FINE GRAINED SAND.
	NP	99	3		SAND/SILTY SAND SAME AS ABOVE.
	NP	97	[illegible]		SAND/SILTY SAND: SAME AS ABOVE.

TH84 — 1510

TH84-1510 — STA 719+00 L — EL. 169±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		3			87	2		SAND: LIGHT BROWN, MOIST, LOOSE, FINE GRAINED SAND, GRAVEL TO 1 INCH.
					96	4	30	SAME: CLUMPS OF DARK BROWN, COHESIVE MATERIAL.
	SP				87	3	4R	SAME: FINE TO COARSE GRAINED SAND, GRAVEL TO 2 INCHES, PENETROMETER HIT ROCK.
							30	
12.0	ML			NP	100	71	30	SANDY SILT: BROWN, MOIST, FIRM, FINE GRAINED SAND.
15.0	SM	16	24	3	100	42	5	SILTY SAND: DRK BROWN, MOIST, COHESIVE, FINE GRAINED SAND.
18.0					97	3		SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND, FEW GRAVEL TO 1/2 INCH.
	SP						26	
					99	2	23	SAME: BROWN.
27.0				NP	97	5	13	SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE TO COARSE GRAINED SAND, FEW GRAVEL TO 1/2 INCH.
	SP/SM						23	
				NP	97	5	37	
36.0	ML		21	1	99	60	5	SANDY SILT: DARK BROWN-GREY, MOIST, FINE GRAINED SAND, COHESIVE, SOFT.
38.0	CL	17	30	17	99	72		SANDY CLAY: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND.
40.0								

VERT

TT 84 — 1573

STA 713+00 C — EL. 151±

[illegible]	LL	PI	-4	-200	N	DESCRIPTION
			90	[illegible]		SAND MULTICOLORED, FINE TO MEDIUM GRAINED.
			93	[illegible]		SAME MOIST, COARSE GRAINED SAND, FEW GRAVEL TO 1 INCH.
			97	[illegible]		SAME FEW GRAVEL TO 3 INCH, FEW COBBLES TO 5 INCH.
	51	23	100	69		SANDY CLAY: GREYISH BROWN, MOIST, COHESIVE.
			95	[illegible]		SAND: MULTICOLORED, MOIST TO WET, VERY COARSE GRAINED SAND, FEW GRAVEL TO 1 INCH.

NOTES:

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2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM.
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4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SCALE 1 IN = 3 FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY.

DRAWN BY.

CHECKED BY.

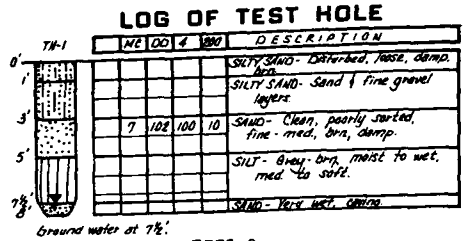
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

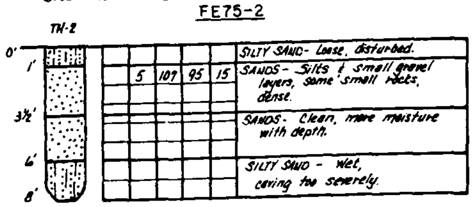
STA.740+00 TO STA.719+00

FE75-1

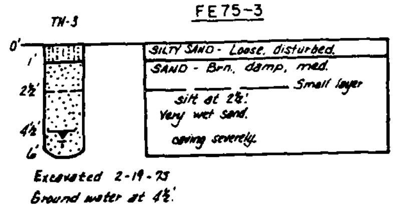
LOG OF TEST HOLE



FE75-2

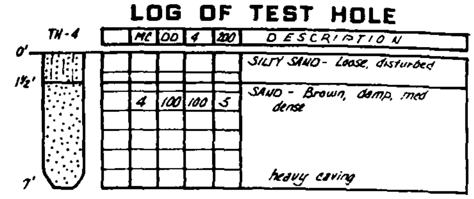


FE75-3

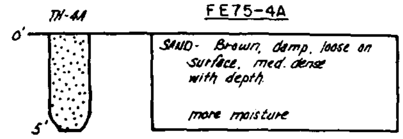


FE75-4

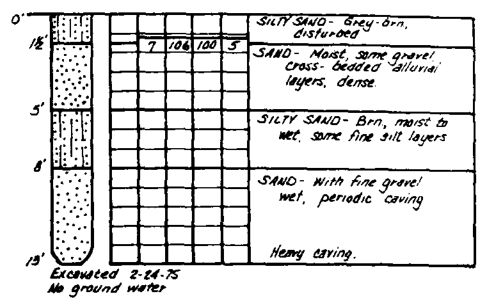
LOG OF TEST HOLE



FE75-4A

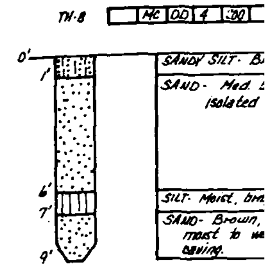


FE75-5



FE75-

LOG OF



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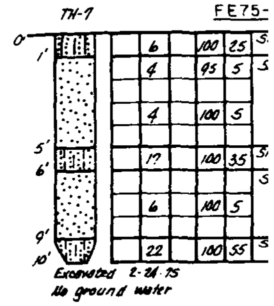
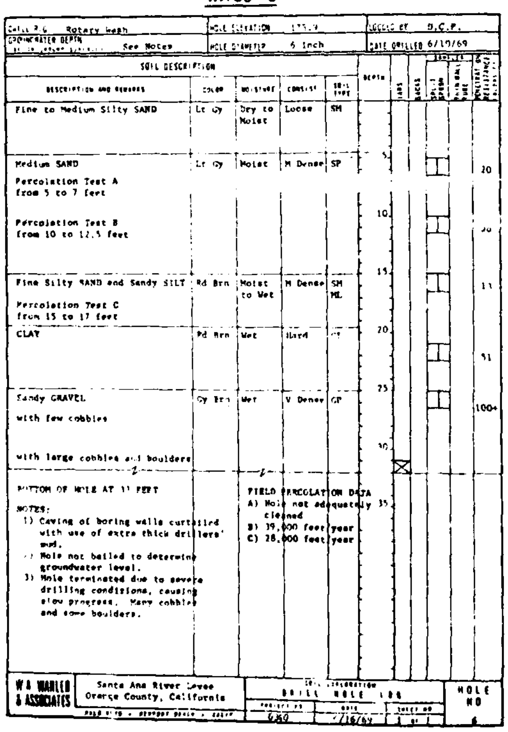


WA69-6



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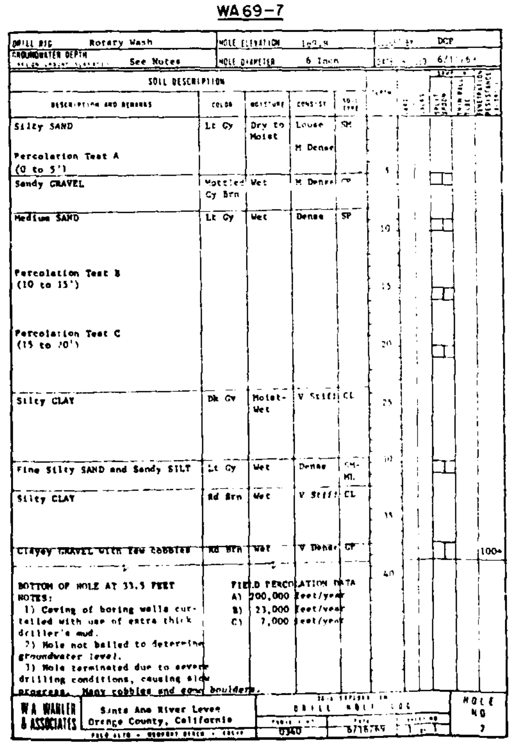
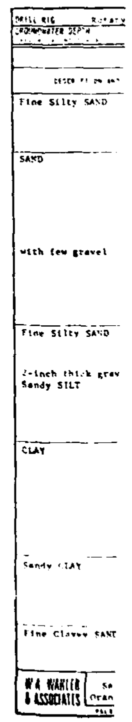




NOTES:

1. SEE PLATE 15
2. SEE TABLES
FROM WHICH TH
AND EXPLANATIO
3. LOGS BY OTHE

LUE ENGINEERING PAYS

FE75-8

LOG OF TEST HOLE

TH-8 | MC | DD | 4 | 300 | DESCRIPTION

Depth	Description
0'–1'	SANDY SILT- Brown, damp, soft.
1'–6'	SAND- Med. brn, damp, isolated caving.
6'–7'	SILT- Moist, brn, soft.
7'–9'	SAND- Brown, fine to coarse, moist to wet. caving.

FE75-7

TH-7

Depth		MC	DD		Description
0'		6	100	25	SILTY SAND- Brn, fine to med, disturbed
		4	95	5	SAND- Brown, fine to coarse 1" max size, damp.
		4	100	5	Some caving.
5'		17	100	35	SILTY SAND- Brn, moist. fine to med.
6'		6	100	5	SAND- Brown, fine to coarse, damp.
9'–10'		22	100	55	SANDY SILT- Brn, v. wet, med. soft

Excavated 2-24-75
No ground water

WM74-1

LOG OF BORING 1

DATE OF BORING 29&30 May 74 WATER DEPTH 36' DATE MEASURED 3 Jun.73 SAMPLES Pitcher and Calif. Mod
TYPE OF DRILL RIG Budha, Rotary Wash HOLE DIAMETER 4 7/8 in. WEIGHT OF HAMMER 140lbs. FALLING 30in.

SURFACE ELEVATION: 155'

Depth, ft.	Samples	Blows / Foot	Ground Water	Description	Unc. Comp. Strength, ksf	Moisture Content, %	Dry Density pcf	Other Tests
				Fill: Loose, dry, brown, fine-to coarse-grained SAND(SW) some fine-medium GRAVEL				
	1	15		Fill: Medium dense, damp, tan fine-to medium-grained SAND (SP), micaceous		6	96	SA
	2		SW					
10								
				Thin lenses of dark brown SILTY CLAY (CL)				
	3	21	SW	Medium dense, damp, gray fine-to medium-grained GRAVEL (GP)		19	108	SA
	4			Medium dense, damp to moist, tan fine-to medium-grained SAND (SP)				
20				Then lenses of brown-green SILTY CLAY (CL)				
				Medium stiff, wet, brown CLAY (CL)				
	5							
	6	8		Loose-medium dense, wet, brown SANDY SILT (ML) to SILTY SAND (SM)		27	95	MA
30				GRAVELLY				
				Dense, wet, tan GRAVELLY SAND (SW) to SANDY GRAVEL (GW-GM)				
	7	NR	▽					
40								
50								
60								
				Bottom of boring 67feet				

WA 69-8

Drill Rig Rotary Wash | Hole Elevation 162.5 | Logged by D.C.P.
Groundwater Depth See Notes | Hole Diameter 6 Inch | Date Drilled 6/11-12/69

Description and Remarks	Color	Moisture	Consist	Soil Type	Depth	Penetration Resistance
Fine Silty SAND	Grey	Dry	Loose	SM		
			M Dense		5	
SAND		Wet	M Dense			
					10	
with few gravel					15	17
					20	
Fine Silty SAND	Grey	Wet	M Dense	SM		
2-inch thick gravel layer Sandy SILT	Rd Brn	Wet	Stiff	ML	25	
					30	
CLAY	Rd Brn	Wet	V Stiff	CL		
					35	21
					40	
Sandy CLAY	Rd Brn	Moist	Stiff	CL		11
					45	
Fine Clayey SAND	Rd Brn	Wet	M Dense	SC		10
					50	

W.A. WAHLER & ASSOCIATES | Santa Ana River Levee, Orange County, California | Soil Exploration Drill Hole Log | Project No 0340 | Date 5/16/69 | Hole No 8

WA69-8 (cont'd)

Drill Rig Rotary Wash | Hole Elevation | Logged by D.C.P.
Groundwater Depth See Notes | Hole Diameter 6 Inch | Date Drilled 6/11-12/69

Description and Remarks	Color	Moisture	Consist	Soil Type	Depth	Penetration Resistance
Sandy CLAY	Rd brn	Wet	V Stiff	CL	55	
					60	22
BOTTOM OF HOLE AT 59.5 FEET						
NOTES: 1) Caving of boring walls curtailed with use of extra thick drillers' mud. 2) Hole not bailed to determine groundwater level. 3) Hole terminated due to severe drilling conditions, causing slow progress. Many cobbles and some boulders.					65	

W.A. WAHLER & ASSOCIATES | Santa Ana River Levee, Orange County, California | Soil Exploration Drill Hole Log | Project No 0340 | Sheet 2 of 2 | Hole No 8

NOTES:

1. SEE PLATE 15 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: | SANTA ANA RIVER MAINSTEM, CALIFORNIA PHASE II GENERAL DESIGN MEMORANDUM
DRAWN BY: | LOGS OF INVESTIGATION BY OTHERS
CHECKED BY: | STA.780+00 TO STA.715+00
SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-____-B-____ | SHEET

VALUE ENGINEERING

WA69-9

DRILL RIG: Rotary Wash	HOLE ELEVATION 158.0	LOGGED BY D.C.P.
GROUNDWATER DEPTH (below ground surface): See Notes	HOLE DIAMETER 6 Inch	DATE DRILLED 6/11-12/69

Description and Remarks	Color	Moisture	Consist.	Soil Type	Depth	Penetration Resistance
Fine Silty SAND	Lt Gy	Damp	Loose	SM		
			M Dense		5	
					10	
					15	
Medium SAND	Lt Gy	Wet	M Dense	SP		
					20	
Fine Silty SAND	Grey	Wet	V Dense	SM		100+
					25	50
CLAY	Rd Brn	Wet	V Stiff	CL		
					30	100+
Clayey GRAVEL with cobbles throughout	Rd Brn	Wet	V Dense	GP		
					35	
					40	
Fine Clayey SAND with Gravel throughout	Rd Brn	Wet	Dense	SC		45
					45	
BOTTOM OF HOLE AT 45 FEET						

NOTES:
1) Caving of boring walls curtailed with use of extra thick drillers' mud.
2) Hole not bailed to determine groundwater level.
3) Hole terminated due to severe drilling conditions, causing slow progress. Many cobbles and some boulders.

NOTES: Shown Above

W.A. WAHLER & ASSOCIATES — Santa Ana River Levee, Orange County, California — Palo Alto • Newport Beach • Calif.
SOIL EXPLORATION DRILL HOLE LOG — Permit No. 0340 — Date 6/16/69 — Sheet 1 of 1 — HOLE NO. 9

MT66-5

TEST BORING LOG

16" Bucket — ELEVATION 191 ± — BORING Nº 5

Dry Density (lbs/cu ft)	Moisture (%)	Blows/Ft	Sample Size (inches)	Sample Nº	Depth in Feet	Unified Soil Classification	Description
	4.7		Bulk	1		SM	Brown SILTY SAND
102.3	1.7	3	2.5	2	10	SP	Mottled brown fine to medium SAND with scattered GRAVEL
	2.2		Bulk	3			
	2.0		Bulk	4			
97.6	10.4	3	2.5	5		SP	Brown fine SAND
	7.2		Bulk	6	30	SP	Mottled brown very fine to fine SAND 6" SILT layer
97.6	24.8	2	2.5	7		ML	Gray-brown CLAYEY SILT
	14.3		Bulk	8	40	SM	Mottled brown well graded SAND
110.6	19.4	3	2.5	9		SM	Brown SILTY SAND
						CL	Reddish brown SILTY CLAY
	11.9		Bulk	10	50	SP	Reddish-brown very fine SAND about 1' GRAVEL

Notes: 1. Minor caving throughout
2. Water not encountered
3. Hole backfilled

Logged By — Date

MT66-6

TEST BORING LOG

6" Rotary — ELEVATION 192.5 — BORING

Dry Density (lbs/cu ft)	Moisture (%)	Blows/Foot (150 lb. 18")	Sample Size (inches)	Sample Nº	Depth in Feet	Unified Soil Classification	Description
						SM	Fill - Brown SAND and GRAVEL with
						SM	Brown fine to coarse SAND with scattered fine GRAVEL
		8	1.4	1	10		
		29	1.4	2	20		
		10	1.4	3	30	SP	Brown loose fine to medium SAND
						CL	Brown stiff fine SANDY CLAY
	14.5	27	1.4	4	40	SM	Brown fine to medium SILTY SAND with scattered fine GRAVEL
						SM	Red-brown dense fine to coarse SAND
		64	1.4	5	50		
		53	1.4	6	60	CL	Red-brown stiff fine SANDY CLAY
						GM	Red-brown dense to very dense fine to coarse GRAVELLY SAND
	6.6	87	1.4	7	70		
					80	CL SM	Red-brown fine stiff SANDY CLAY of fine to medium SILTY SAND

continued

Logged By RAP — Date 11-2,

MT66-8

TEST BORING LOG

MT66-9

TEST BORING LOG

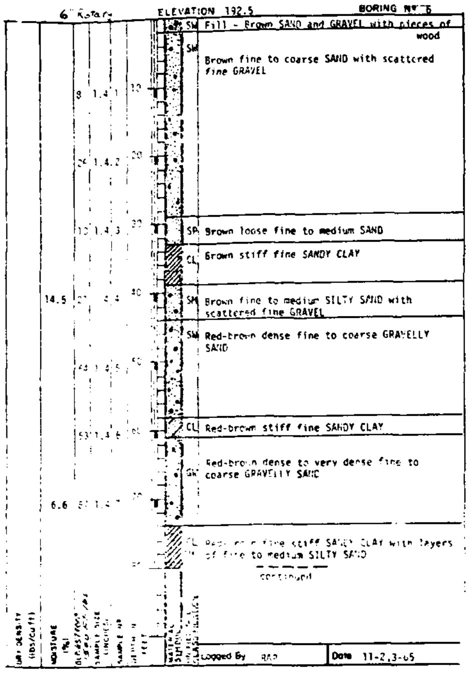
MT66-9 (cont'd)

TEST BORING LOG

VALUE ENGINEERING PAYS

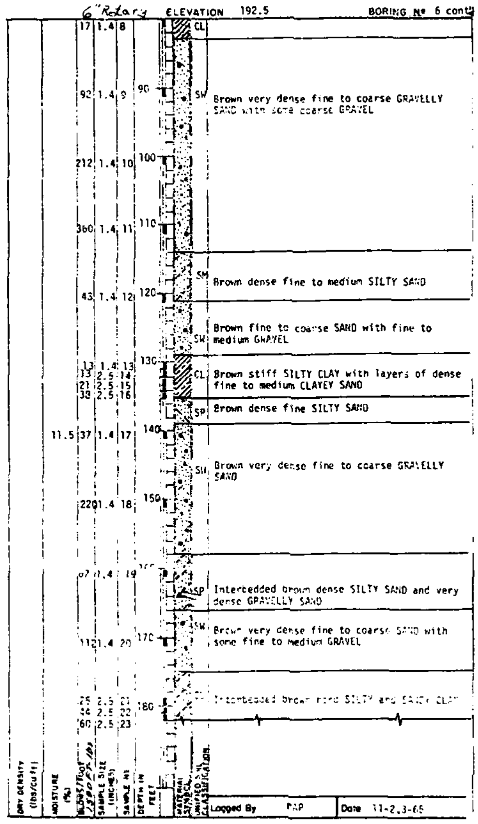
MT66-6

TEST BORING LOG



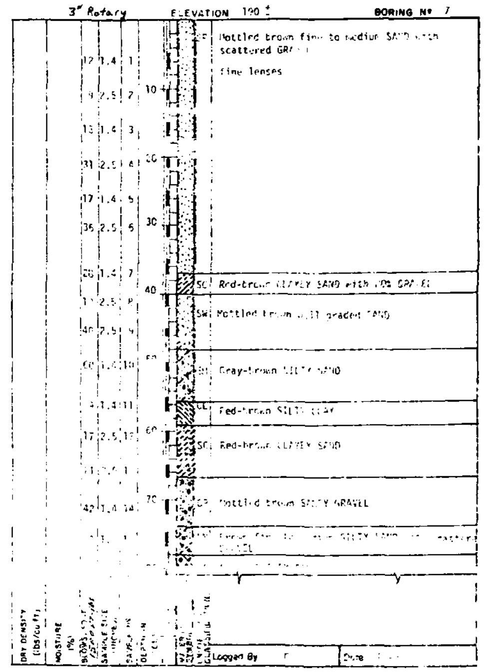
MT66-6 (cont'd)

TEST BORING LOG



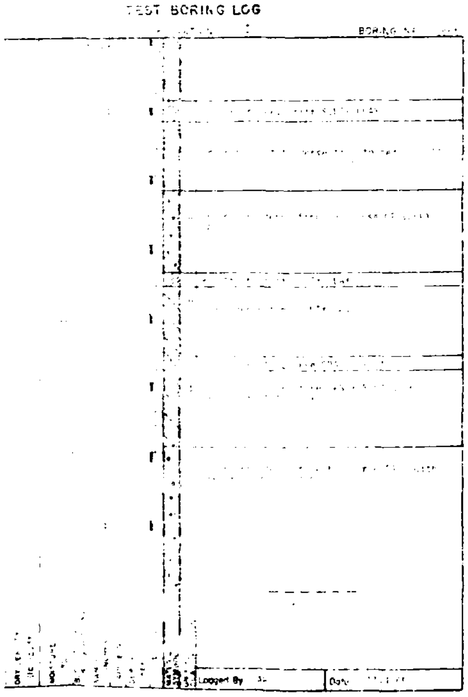
MT66-7

TEST BORING LOG



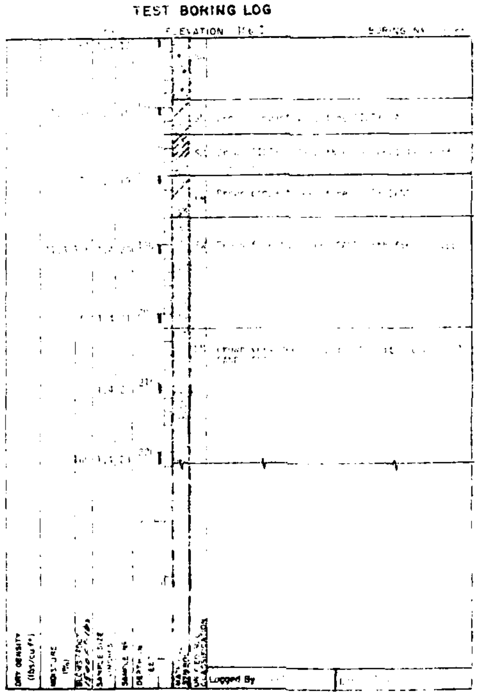
MT66-9 (cont'd)

TEST BORING LOG



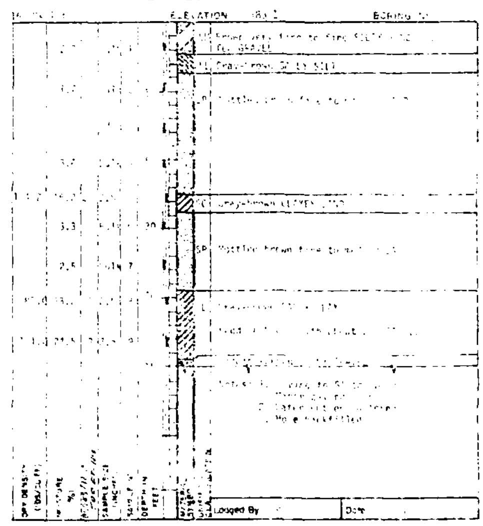
MT66-9 (cont'd)

TEST BORING LOG



MT66-10

TEST BORING LOG



NOTES:

1. SEE PLATE 15 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

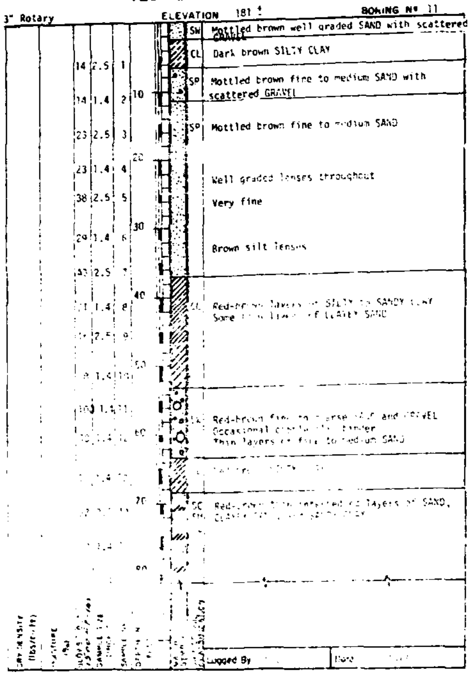
LOGS OF INVESTIGATION BY OTHERS

STA.780+00 TO STA.715+00

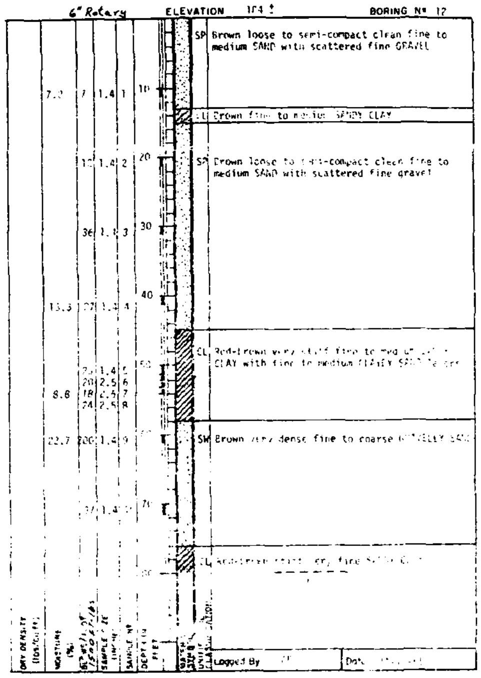
SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-___ B-____ | SHEET

VALUE ENGINEERING PAY

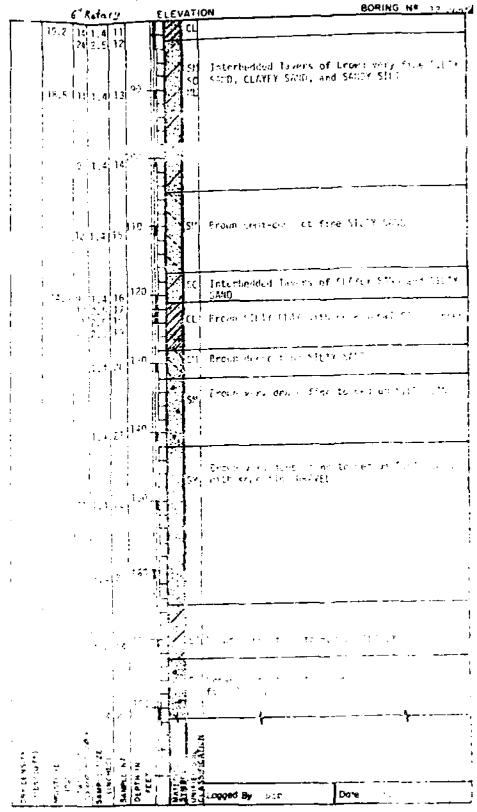
MT66-11
TEST BORING LOG



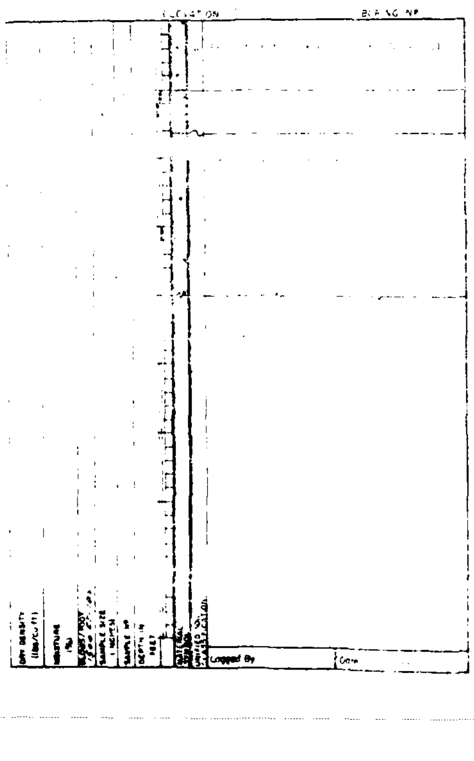
MT66-12
TEST BORING LOG



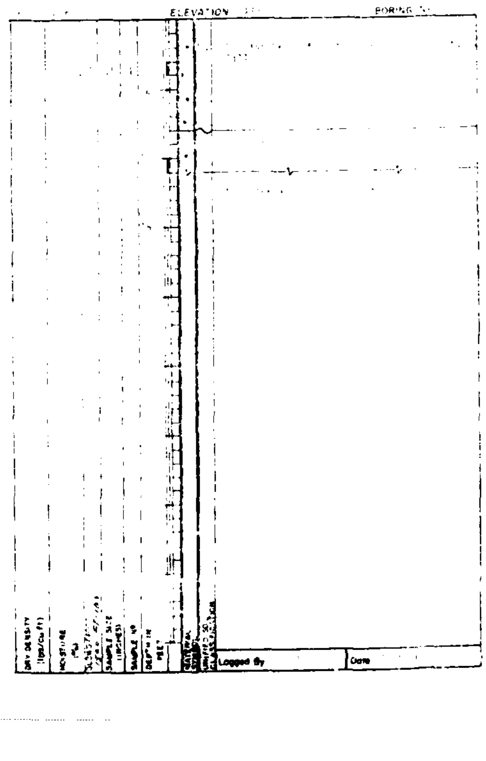
MT66-12 (cont'd)
TEST BORING LOG



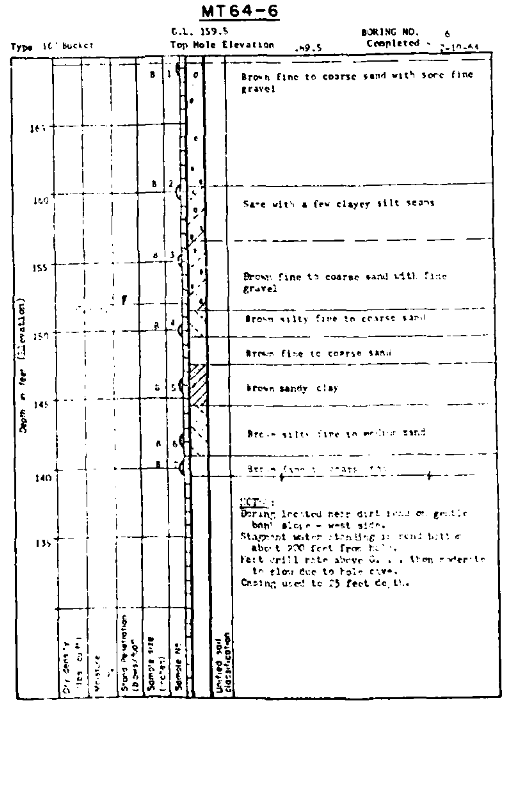
MT66-15
TEST BORING LOG



MT66-16
TEST BORING LOG

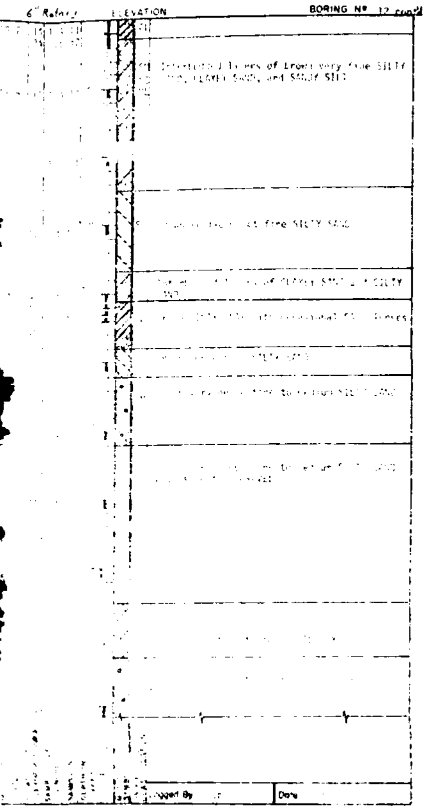


MT64-6

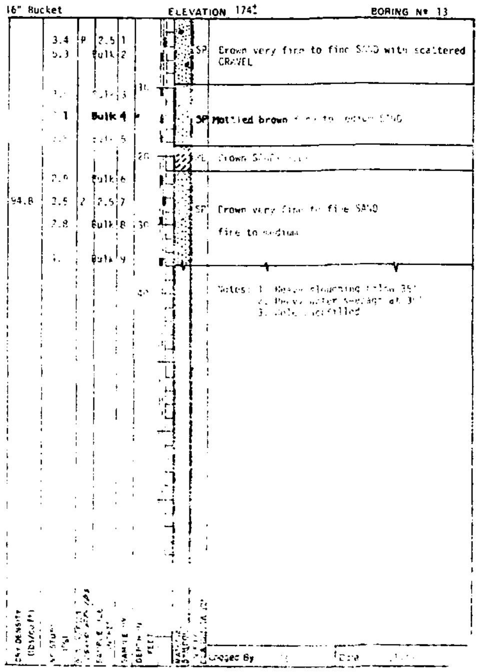


...LUE ENGINEERING PAYS

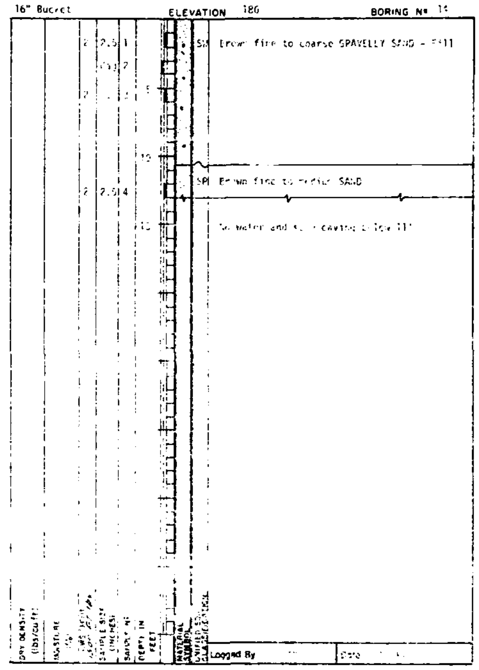
MT66-12 (cont'd)
TEST BORING LOG



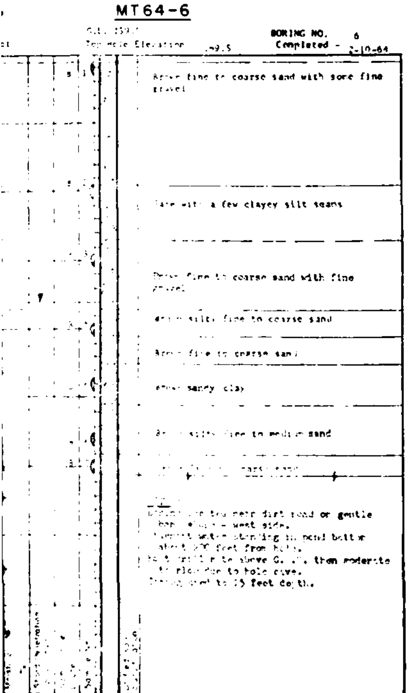
MT66-13
TEST BORING LOG



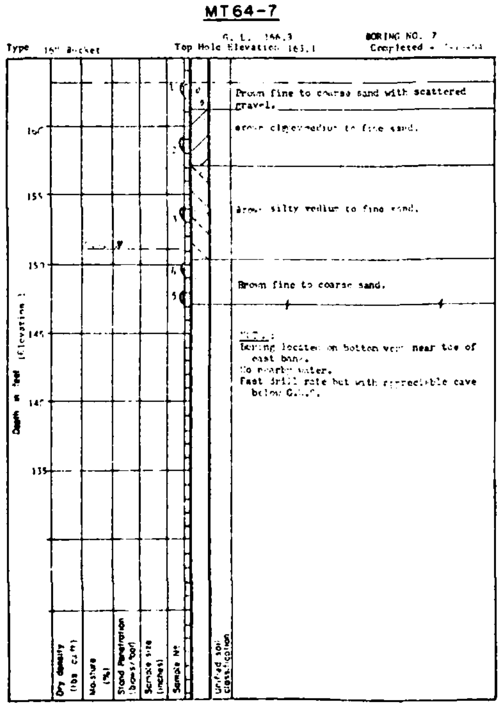
MT66-14
TEST BORING LOG



MT64-6



MT64-7



NOTES:

1. SEE PLATE 15 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

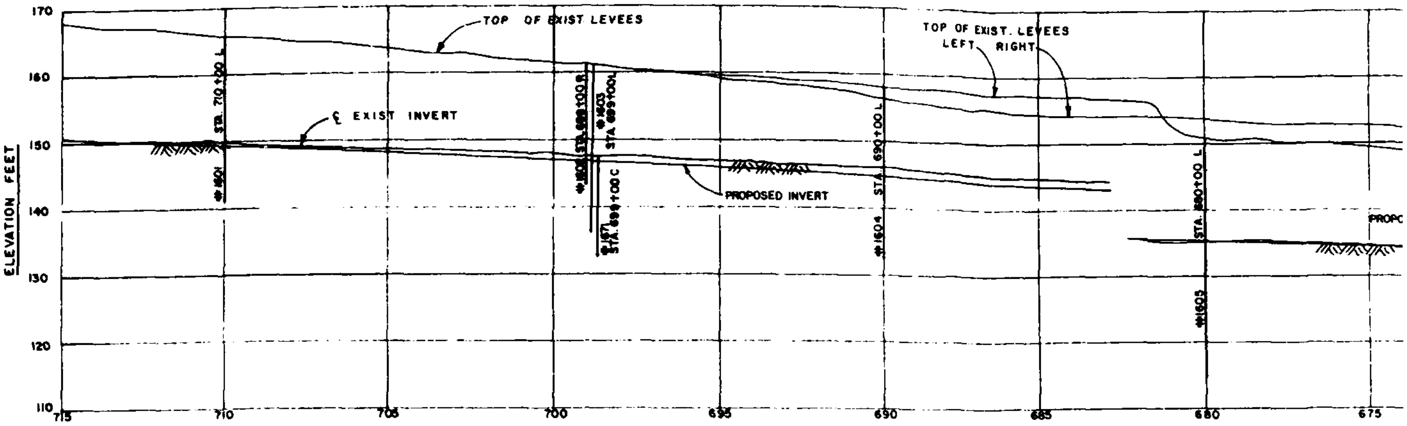
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS

STA.715+00 TO STA.650+00

SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-____ B-____
SHEET

VALUE ENGINEERING PAY

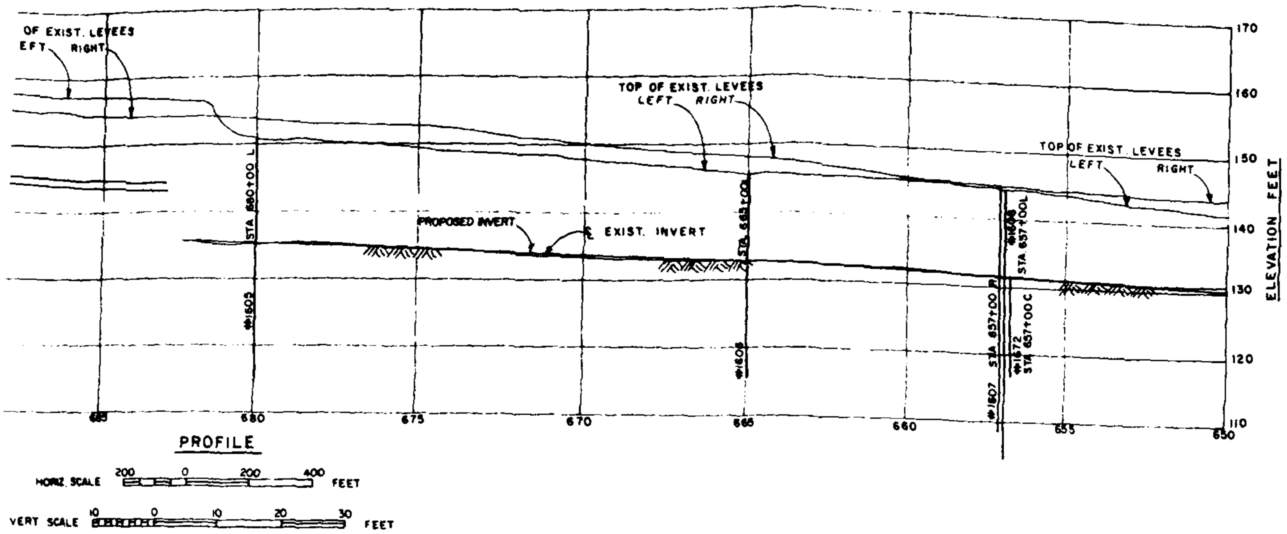


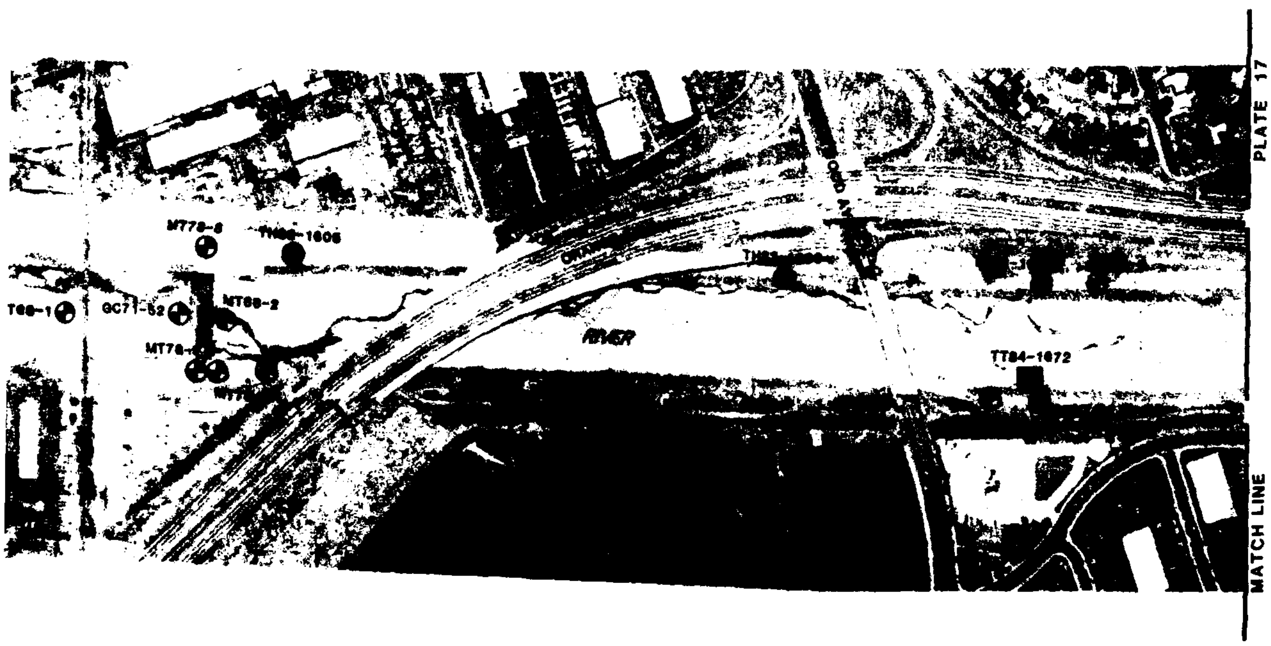
PROFILE

HORIZ. SCALE 200 0 200 400 FEET

VERT SCALE 10 0 10 20 30 FEET

'ALUE ENGINEERING PAYS





NOTES:

1. SEE PLATE 6 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

PLAN AND PROFILE

CHECKED BY:

STA.715+00 TO STA.650+00

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW 09-___ B-___ | SHEET

VALUE ENGINEERING PA

TH84-1601

TH84-1601 STA 710+00 L EL. 166±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SAND: BROWN, MOIST, FINE GRAINED SAND, COBBLES TO 6 INCH, SOME SILT.
	SP	5			89	4		
							50	
6.0								
							60	GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, MOIST, FINE TO COARSE GRAINED SAND, COBBLES TO 7 INCH, SOME SILT.
	SW/SM	5		NP	82	3		
							60	
12.0								
					94	4	24	SAND: BROWN, MOIST, FINE TO COARSE GRAINED SAND, COBBLES TO 7 INCH, SOME SILT.
	SP	4			92	4	11	
							23	
21.0								SAND/SILTY SAND: BROWN, MOIST, FINE TO COARSE GRAINED SAND, COBBLES TO 7 INCH, SOME SILT.
22.0	SW/SM			NP	98	6	21	SAND: LIGHT BROWN, MOIST, FINE TO COARSE GRAINED SAND.
	SP				99	3		
25.0							23	

TH83-1603

TH83-1603 STA 699+00 L EL. 161±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	5		NP	96	21		SILTY SAND: BROWN, MOIST, GRAVEL TO 1 INCH.
		10	19	2	99	31		SAME: SLIGHTLY COHESIVE, GRAVEL TO 3/4 INCHE
3.0							19	
	SM/SC	14	27	[illegible]	96	50	18	SILTY SAND/CLAYEY SAND: BROWN, MOIST, SLIGH GRAVEL TO 3/4 INCHES.
5.0								
	SC	12	28	13	99	18		CLAYEY SAND: BROWN-RED, MOIST.
7.0							28	
	SM	6	16	[illegible]	98	18		SILTY SAND: BROWN, MOIST, MEDIUM TO COARSE G GRAVEL TO 1-1/2 INCH.
9.0								
	SM/SC	12	23	6	94	35	20	SILTY SAND/CLAYEY SAND: BROWN, MOIST, SLIGHT GRAVEL TO 3/8 INCH.
12.0								
	SM	5		NP	95	13	18	SILTY SAND: LIGHT BROWN TO GREY, MOIST, GRA
15.0								
	SP/SM	4		NP	97	6	8	SAND/SILTY SAND: LIGHT BRN. GREY, MOIST, GRA
18.0								
	SP	3			95	4	8	SAND: LIGHT GREY, FEW GRAVEL TO 1-1/2 INCH.
21.0	SW/SM	17		NP	94	9		SAND/SILTY SAND: LIGHT GREY, SATURATED, FEW 1-1/2 INCHES.
22.0								
	SM		21	[illegible]	99	39		SILTY SAND: LIGHT BROWN, SATURATED, FINE GRA
24.0								
	ML	21	25	2	100	60		SANDY SILT: LIGHT BROWN, SATURATED, FINE GRA
25.5							31	

TT84-1671

INVERT

TT84-1671 STA 699+00 [illegible] EL. 148±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
					99	1		SAND: MULTICOLORED, MEDIUM GRAINED SAND.
	SP							
					[illegible]	[illegible]		GRAVELLY SAND: MULTICOLORED, MOIST, COARSE GRAINED SAND, GRAVEL TO 2 INCH.
5.0								
								SILTY SAND: DARK BROWN, MOIST, SOME COHESION, FINE GRAINED SAND.
	SM			NP	99	25		
10.0								
	SP				99	2		SAND: MULTICOLORED, MOIST, FINE GRAINED.
12.0								
	SM			NP	[illegible]	[illegible]		SILTY SAND: LIGHT BROWN, MOIST, COHESIVE, FINE GRAINED SAND.
15.0								

TH83-1604

TH83-1604 STA 590+00 L EL. 158±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SP	2			94	4		SAND: GREY, MEDIUM GRAINED SAND, FEW GRAVE
	SW/SM	4		NP	97	8	50	SAND/SILTY SAND: GREY-LIGHT BROWN, MOIST, [illegible] SAND, GRAVEL TO 3/4 INCH.
3.0								
	SP	4			97	4	40	SAND: GREY-LIGHT BROWN, MOIST, MEDIUM GRAINE GRAVEL TO 3/4 INCHES.
6.0								
	SP/SM	4		NP	96	4	13	SAND/SILTY SAND: GREY-LIGHT BROWN, MOIST, ME GRAINED SAND, GRAVEL TO 3/4 INCHES.
9.0								
		5			95	4	19	SAND: GREY-LIGHT BROWN, MOIST, MEDIUM TO [illegible] SAND, GRAVEL TO 3/4 INCHES.
							23	
	SP	[illegible]			97	3		
							24	
		4			98	4		
¥ 18.0		13			98	3		SAME: SATURATED
		[illegible]			99	3	32	
21.0								
	SP/SM	[illegible]		NP	97	5	22	SAND/SILTY SAND: GRAY, SATURATED, MEDIUM TO GRAINED SAND, GRAVEL TO 3/4 INCHES.
24.0								
	SP	19			99	3		SAND: GREY, SATURATED, MEDIUM TO COARSE GRA GRAVEL TO 3/4 INCHES.
26.0								

VALUE ENGINEERING PAYS

TH83-1603

STA 699+00 L — EL. 161±

MC	LL	PI	-4	-200	N	DESCRIPTION
5		NP	96	21		SILTY SAND: BROWN, MOIST, GRAVEL TO 1 INCH.
13	19	2	99	31	19	SAME: SLIGHTLY COHESIVE, GRAVEL TO 3/4 INCHES.
14	27	7	[illegible]	[illegible]	19	SILTY SAND/CLAYEY SAND: BROWN, MOIST, SLIGHT COHESIVE GRAVEL TO 3/4 INCHES.
12	29	13	[illegible]	[illegible]		CLAYEY SAND: BROWN-RED, MOIST.
[illegible]	16	1	[illegible]	[illegible]	[illegible]	SILTY SAND: BROWN, MOIST, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 1-1/2 INCH.
12	23	6	[illegible]	[illegible]	[illegible]	SILTY SAND/CLAYEY SAND: BROWN, MOIST, SLIGHTLY COHESIVE, GRAVEL TO 3/8 INCH.
5		NP	[illegible]	[illegible]	[illegible]	SILTY SAND: LIGHT BROWN TO GREY, MOIST, GRAVEL TO 3/8".
4		NP	[illegible]	[illegible]	[illegible]	SAND/SILTY SAND: LIGHT BRN, GREY, MOIST, GRAVEL TO 3/8".
[illegible]			[illegible]	[illegible]		SAND: LIGHT GREY, FEW GRAVEL TO 1-1/2 INCH.
[illegible]		NP	[illegible]	[illegible]		SAND/SILTY SAND: LIGHT GREY, SATURATED, FEW GRAVEL TO [illegible] INCHES.
	[illegible]	[illegible]	[illegible]	[illegible]		SILTY SAND: LIGHT BROWN, SATURATED, FINE GRAINED SAND.
[illegible]	26	2	[illegible]	[illegible]	[illegible]	SANDY SILT: LIGHT BROWN, SATURATED, FINE GRAINED SAND.

TH83-1602

TH83-1602 — STA 699+00 R — EL. 161±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SC						50	CLAYEY GRAVELLY SAND: DARK BROWN-RED, MOIST, COBBLES TO 12 INCHES.
							37	SAME: GRAVEL TO 2-INCH, SLIGHTLY COHESIVE.
9.0							18	
	CL						9	SANDY CLAY: DARK BROWN-RED, MOIST, COHESIVE, SOME GRAVEL TO 3-INCH, CAVING AT 14 FEET.
15.0							9	
	SC							CLAYEY SAND: SAME AS ABOVE.
16.0								
	SP/SM							SAND: GREY, MOIST, GRAVEL TO 1-INCH.
18.0							8	

TH83-1604

STA 690+00 L — EL. 158±

MC	LL	PI	-4	-200	N	DESCRIPTION
[illegible]			[illegible]	[illegible]		SAND: GREY, MEDIUM GRAINED SAND, FEW GRAVEL TO 2".
[illegible]		NP	[illegible]	[illegible]		SAND/SILTY SAND: GREY-LIGHT BROWN, MOIST, MEDIUM GRAINED SAND, GRAVEL TO 3/4 INCH.
[illegible]			[illegible]		[illegible]	SAND: GREY-LIGHT BROWN, MOIST, MEDIUM GRAINED SAND, GRAVEL TO 3/4 INCHES.
[illegible]		NP	[illegible]	[illegible]	[illegible]	SAND/SILTY SAND: GREY-LIGHT BROWN, MOIST, MEDIUM TO [illegible] GRAINED SAND, GRAVEL TO 3/4 INCHES.
[illegible]			[illegible]	[illegible]		SAND: GREY-LIGHT BROWN, MOIST, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 3/4 INCHES.
[illegible]			[illegible]	[illegible]		
[illegible]			[illegible]	[illegible]		
[illegible]			[illegible]	[illegible]	[illegible]	SAND: [illegible] SATURATED.
24		NP	[illegible]	[illegible]	[illegible]	SAND/SILTY SAND: GRAY, SATURATED, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 3/4 INCHES.
13			[illegible]	[illegible]		SAND: GREY, SATURATED, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 3/4 INCHES.

NOTES

1. SEE PLATE 16 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SCALE 1 IN = 5 FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.710+00 TO STA.690+00

TH83-1605

TH83-1605 STA 680+00 L EL. 151±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SC	3	29	10	93	31	50	CLAYEY SAND: BROWN, MOIST, GRAVEL TO 3", COBBLES TO 6".
	SM/SC	4	26	6	99	15		SILTY SAND/CLAYEY SAND: GREY, MOIST, GRAVEL TO 1 INCH.
2.5							43	
	SC	7	29	10	99	27		CLAYEY SAND: BRN, MOIST, SLIGHTLY COHESIVE FINE GRAINED.
4.0		3		NP	98	8		SAND/SILTY SAND: BROWN, MOIST, MEDIUM GRAINED SAND GRAVELS TO 1/2 INCH.
	SP/SM	3		NP	99	6		
6.0							41	
		1			97	3		SAME: MEDIUM TO COARSE GRAINED GRAVELS UP TO 3/4 INCHES, FEW FINES.
		2			97	3		
	SP	2			97	2	8	
							21	
		5			100	4		SAME: LIGHT BROWN, MOIST, FINE TO MEDIUM GRAINED.
		3			99	4		SAME: BROWN, MEDIUM TO COARSE GRAINED.
14.5							11	
	SC	8	27	8	100	22		CLAYEY SAND: BRN, FINE TO MEDIUM GRAINED, MOIST SLIGHTLY COHESIVE.
16.5								
	CL	18	26	8	100	52	22	SANDY CLAY: BROWN, COHESIVE, MOIST.
19.0								
	SP/SM	4		NP	100	6		SAND/SILTY SAND: CLEAN, MOIST.
21.0							24	
	SC	16	37	17	77	47		CLAYEY SAND: BROWN, MOIST, PLASTIC GRAVELS TO 3 INCHES, COBBLES TO 5 INCHES.
24.0							12	
	GC	12	27	9	60	26		CLAYEY SANDY GRAVEL: SAME AS ABOVE.
26.5							46	
	GW/GM	7	23	6	48	10		SILTY SANDY GRAVEL: BRN, MOIST, MEDIUM TO COARSE GRAINED, GRAVELS TO 3 INCHES, COBBLES TO 6 INCHES.
30.0								
	GW/GC	6	27	10	35	6		CLAYEY SANDY GRAVEL. BROWN, MOIST, MEDIUM TO COARSE GRAINED, COBBLES TO 7 INCHES.
33.0								
	GP/GC	5	24	8	49	9		SAME.
36.0								

BOULDER AT BOTTOM (36 FEET)

TH84-1672

TI84-1572 STA 657+00 C EL. 131±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
W 1.0	SP				100	2		SAND: LIGHT BRN-MULTICOLORED, MOIST TO WET, FINE GRAINED.
3.0								
				NP	35	5		SAND/SILTY SAND: MULTICOLORED, WET, COARSE GRAINED, FEW GRAVEL TO 1 INCH.
	SP/SM							
				NP	31	5		SAME: FEW GRAVEL TO 2 INCH.
10.0								
	SP				89	3		SAND: MULTICOLORED, WET, COARSE GRAINED, FEW COBBLES TO 4 INCH.
15.0								

TH83-1606

TH83-1606 STA 665+00 L EL. 145±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SC	6	34	18	86	23		CLAYEY SAND: BRN, MOIST, NO COHES-
		9	30	12	90	13	29	SAME: MEDIUM DENSITY GRAVEL TO 1 I
2.0								
		3		NP	97	5	48	SAND/SILTY SAND: COARSE GRAINED, D LIGHT GREY-BROWN, GRAVEL TO 1 INCH.
		2		NP	95	5		
	SP/SM						15	
		3		NP	96	8		
							10	
		3		NP	98	5		
10.0								
10.5	ML	27	30	4	100	72		SANDY SILT: BROWN, MOIST, SLIGHTLY
11.0	SP-SM	6		NP	99	12		SAND/SILTY SAND: BROWN, MOIST, NO
	ML	32	30	7	100	70		SANDY SILT: BROWN, MOIST, COHESIVE
12.0							16	
		7			99	4		SAND: BROWN, MOIST, MEDIUM TO COAR
W 14.0	SP							
		14			99	4		SAME: LIGHT BROWN, WET, NO COHESIO
16.0								
		23		NP	99	9		SAND/SILTY SAND: LIGHT BROWN, SATU MEDIUM TO COARSE-GRAINED.
	SP/SM						6	
		21		NP	98	7		
20.0								
		24	24	3	100	50	7	SILTY SAND: DARK GREY BROWN, SATUR
	SM							
		23	24	3	100	47		
24.0							5	
	ML	34	31	7	99	80		SANDY SILT. BROWN, SATURATED, COHE
26.0								
		31	37	16	94	80		SANDY CLAY: BROWN, SATURATED, COHE
	CL							
		25	31	11	98	64		
30.0								

TH83-1608

TH83-1508 STA 657+00 L EL. 145±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SW/SM	3		NP	88	8		SND/SLT SND: BRN, MOIST, COARSE SM
2.0	SC	5	30	10	97	15	50	CLAYEY SAND: BROWN, MOIST, MEDIUM
							39	
		3		NP	98	6		SILTY SAND: BROWN, MOIST, MEDIUM
	SP/SM							
		4		NP	99	5		SAME: GRAVEL TO 1/2".
6.0							17	
7.0	SP	3			97	2		SAND: LIGHT BROWN, MOIST, COARSE
		19	37	11	100	65		SANDY CLAY: BROWN (GREYISH), MOIS
	CL	16	29	11	100	50	8	
		16	32	14	99	59		SAME: REDDISH BROWN, SLIGHT COHE
12.0							13	
	SM/SC	12	24	6	100	45		SILTY/SAND/CLAYEY SAND: REDDISH COHESIVE.
14.0								
		17		NP	100	45		SILTY SAND: GREYISH BROWN, MOIST GRAINED SAND IN IT.
	SM	7		NP	100	13		SAME: NO COHESION, FINE TO MEDI
							20	
		6		NP	100	20		
21.0							11	
	ML	27	23	[illegible]	100	59		SANDY SILT: REDDISH BROWN, MOIS
22.5								
	SM	18		NP	100	29	9	SILTY SAND: REDDISH BROWN, MOIS
25.0								
	ML	24	31	4	100	82		SANDY SILT: REDDISH BROWN, MOIS
27.5							7	
	[illegible]	[illegible]	[illegible]	10	100	[illegible]		SANDY CLAY: REDDISH BROWN, MOIS

TH83-1606

STA 665+00 L — EL. 145±

LL	PI	-4	-200	N	DESCRIPTION
34 / 30	18 / 12	86 / 90	23 / 14	29	CLAYEY SAND: BRN, MOIST, NO COHES. GRVL TO 3", COBBLES 6". SAME: MEDIUM DENSITY GRAVEL TO 1 INCH.
	NP	97	5	48	SAND/SILTY SAND: COARSE GRAINED, DENSE, CLEAN, MOIST, LIGHT GREY-BROWN. GRAVEL TO 1 INCH.
	NP	95	5	15	
	NP	96	8		
	NP	98	5	10	
30	4	100	72		SANDY SILT: BROWN, MOIST, SLIGHTLY COHESIVE.
	NP	99	12		SAND/SILTY SAND: BROWN, MOIST, NO COHESION.
30	7	100	70	16	SANDY SILT: BROWN, MOIST, COHESIVE.
		99	4		SAND: BROWN, MOIST, MEDIUM TO COARSE GRAINED.
		99	4		SAME: LIGHT BROWN, WET, NO COHESION.
	NP	99	3	6	SAND/SILTY SAND: LIGHT BROWN, SATURATED, NO COHESION MEDIUM TO COARSE-GRAINED.
	NP	98	7		
24	3	100	50	[illegible]	SILTY SAND: DARK GREY BROWN, SATURATED, COHESIVE.
24	3	100	47	5	
31	7	99	33		SANDY SILT: BROWN, SATURATED, COHESIVE, GRAVEL TO 1/2".
37	15	94	80		SANDY CLAY: BROWN, SATURATED, COHESIVE, GRAVEL TO 1/2".
31	11	98	64		

TH84-1607

TH84-1607 — STA 657+00 R — EL. 145±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		4			93	4		SAND: BROWN, MOIST, LOOSE, FINE GRAINED SAND, FEW COBBLES TO 5 INCH.
	SP				99	3	13	
							12	
9.0								
	SM	31	29	6	100	36	7	SILTY SAND: LIGHT BROWN, MOIST TO WET, LOOSE, FINE TO COARSE GRAINED SAND, SOME SILT.
							19	
15.0								
	CL		34	13	100	71	3	SANDY CLAY: BROWN, MOIST, STIFF, COHESIVE, SOME FINE GRAINED SAND AND SILT.
18.0								SANDY SILT: BROWN, MOIST, STIFF, COHESIVE, SOME FINE GRAINED SAND AND SILT.
			30	2	100	52		
							11	
	ML		29	6	100	65	11	SAME: DARK BROWN, SOME COHESION.
			34	10	100	74	9	
33.0								
	SP	9			94	1	13	GRAVELLY SAND: DARK BROWN, MOIST, FINE GRAINED SAND.
36.0								

TH83- 608

STA 657+00 L — EL. 145±

LL	PI	-4	-200	N	DESCRIPTION
	NP	88	3		SAND/SILT SND. BRN, MOIST, COARSE SND, GRV TO 3" COB. TO 5".
33	10	87	15	57	CLAYEY SAND. BROWN, MOIST, MEDIUM SAND, GRAVEL TO 1".
	NP	98	6	39	SILTY SAND: BROWN, MOIST, MEDIUM GRAINED, GRAVEL TO 1"
	NP	99	[illegible]		SAME: GRAVEL TO 1/2".
		97	2	17	SAND: LIGHT BROWN, MOIST, COARSE GRAINED GRAVELS TO 1/2"
37	11	100	65		SANDY CLAY: BROWN (GREYISH), MOIST.
29	12	100	57	4	
32	14	99	59		SAME: REDDISH BROWN, SLIGHT COHESIVE.
24	6	100	45	17	SILTY SAND/CLAYEY SAND: REDDISH BRN, MOIST, SLIGHTLY COHESIVE
	NP	100	45		SILTY SAND: GREYISH BROWN, MOIST, SLIGHTLY COHESIVE, FINE GRAINED SAND [illegible]
	NP	100	13	[illegible]	SAME: NO COHESION, FINE TO MEDIUM GRAINED.
	NP	100	[illegible]		
23	5	100	53	[illegible]	SANDY SILT: REDDISH BROWN, MOIST, SOME COHESION.
	NP	100	29	4	SILTY SAND: REDDISH BROWN, MOIST, SLIGHTY COHESIVE.
31	8	100	82	7	SANDY SILT: REDDISH BROWN, MOIST, SLIGHTLY COHESIVE.
30	10	100	94		SANDY CLAY: REDDISH BROWN, MOIST, SLIGHTLY COHESIVE.

NOTES

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3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SCALE 1 IN=3FT

0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

LOGS OF INVESTIGATIONS

CORPS OF ENGINEERS

CHECKED BY:

STA.680+00 TO STA.657+00

SUBMITTED BY: — DATE APPROVED: — SPEC. NO. DACW09-____ B-____ — SHEET

MT78-8

MOORE & TABER CONSULTING ENGINEERS AND GEOLOGISTS

TEST BORING LOG

TYPE 16" Bucket Auger | ELEVATION 160.5 | BORING 8

Brown fine to medium SILTY SAND with GRAVEL & COBBLES - Fill
... SILT nodules
... decreased GRAVEL & COBBLES
... increased SILT

SM ... decreased SILT

... increased GRAVEL and COBBLES

SP Tan fine to medium SAND

SM Gray-brown fine SILTY SAND
... changing to light brown color, less SILT
... thin layer fine to medium SAND

Approx. Invert Elevation

ML Gray-brown CLAYEY SILT

SM Reddish-brown SILTY SAND with CLAY & GRAVEL

SP Red-brown GRAVELLY SAND with scattered COBBLES

NOTES

1. No caving.
2. No groundwater encountered.
3. Backfilled dry.

THIS BORING LOG SUMMARY APPLIES ONLY AT THE TIME AND LOCATION INDICATED. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND TIMES

LOGGED BY | DATE

MT78-9

MOORE & TABER CONSULTING ENGINEERS AND GEOLOGISTS

TEST BORING LOG

TYPE 16" Bucket Auger | ELEVATION | BORING 9

SM Brown fine to medium SILTY SAND with GRAVEL and COBBLES - Fill

... increased COBBLES

NOTES

THIS BORING LOG SUMMARY APPLIES ONLY AT THE TIME AND LOCATION INDICATED. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND TIMES

LOGGED BY | DATE

MOORE

Approx. Invert Elevation

GC71-51

BORING No. 51 STATION W.O. 22-164 DRILL DATE
SURFACE ELEVATION DRIVING WEIGHT

WATER | DEPTH FEET | GRAPHIC SYMBOL | DESCRIPTION | GROUP SYMBOL U.S.C.S. | PENE. RESIST. BLOWS/FOOT | CORE | BAG | DRY DENSITY pcf | MOISTURE CONTENT % | RELATIVE COMPACTION

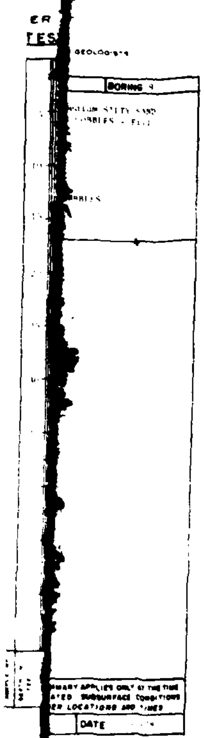
SM, SP, ML, SP

GC71-52

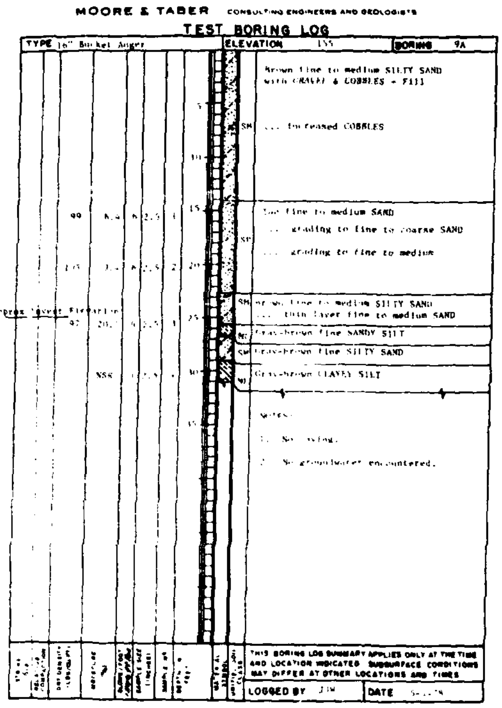
BORING No. 52 STATION W.O. 22-164 DRILL DATE
SURFACE ELEVATION DRIVING WEIGHT

WATER | DEPTH FEET | GRAPHIC SYMBOL | DESCRIPTION | GROUP SYMBOL U.S.C.S. | PENE. RESIST. BLOWS/FOOT | CORE | BAG | DRY DENSITY pcf | MOISTURE CONTENT % | RELATIVE COMPACTION

VALUE ENGINEERING PAYS



MT 78-9A



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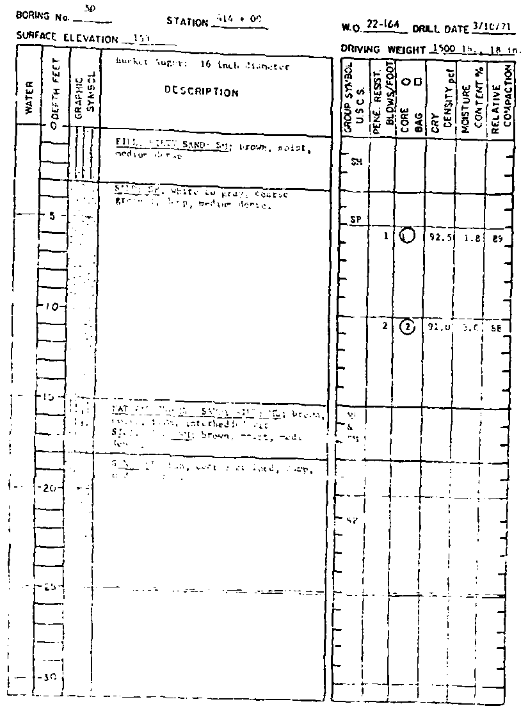
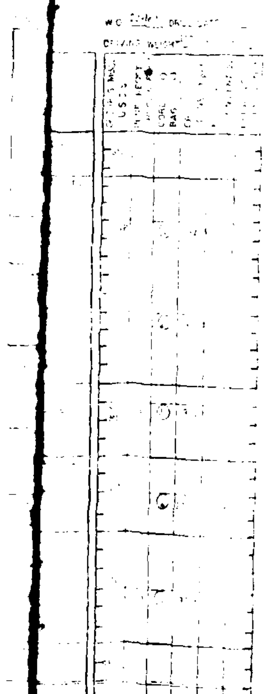
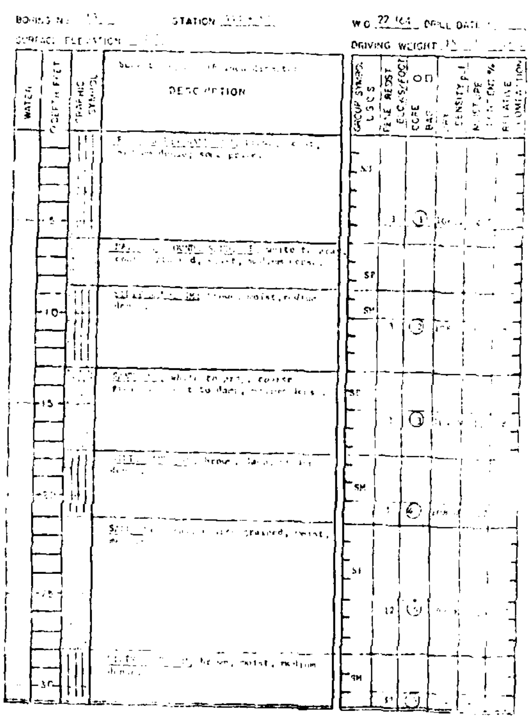




GC71-53



NOTES

1. SEE PLATE 16 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS
STA.715+00 TO STA.650+00

SUBMITTED BY: DATE SHEET

GC 71-54

BORING No. 54 STATION 453 + 76 W.O. 22-164 DRILL DATE 3/9/71

SURFACE ELEVATION 162 DRIVING WEIGHT 750 lb. 18 i / 1500 lb., 18 in

Bucket Auger: 16 inch diameter.

DEPTH FEET	DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE ○ BAG □	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION
0–5	FILL: CLAYEY SAND: SC; brown, moist, medium dense; some gravel.	SC	2	①	105.5	3.6	91
5–11	NATURAL GROUND: SAND: SP; white to gray, medium grained, moist, dense.	SP	2	②	107.5	4.8	93
11–15	SANDY SILT: ML; SILTY CLAY: CL; interbedded, moist, firm.	ML & CL	2	③	104.0	2.9	89
15–30	SAND: SP; white to gray, medium grained, moist, medium dense.	SP	3	④	101.8	[illegible]	88
			10	⑤	100.[illegible]	2.5	5[illegible]
			10*	⑥	[illegible]	3.4	86

WA69-10

DRILL RIG Rotary Wash HOLE ELEVATION 151.[illegible] [illegible] D.C.P.

GROUNDWATER DEPTH See Notes HOLE DIAMETER 6 In [illegible] 6/1?/69

SOIL DESCRIPTION

DESCRIPTION AND REMARKS	COLOR	MOISTURE	CONSIST	SOIL TYPE	
Fine Silty SAND	Lt Gy	Damp	Loose / M Dense	SM	
Fine SAND	Lt Gy	Wet	Dense	SP	32
with few Gravel	Dk Gy		V Dense		59
					50
Gravel layers	Lt Gy				15
Sandy CLAY	Rd Brn	Wet	V Stiff	CL	32
Clayey GRAVEL	Rd Brn	Wet	V Dense	GC	
Sandy CLAY	Rd Brn	Wet	Stiff	CL	16

BOTTOM OF HOLE AT 36.5 FEET

NOTES:

1) Caving [illegible] walls controlled with use of [illegible] drillers' mud.
2) Hole not bailed to determine groundwater level.
3) Hole terminated due to severe drilling conditions, [illegible] ing [illegible]. Many [illegible].

[illegible] & ASSOCIATES

MT64-3

Type 16" bucket G.L. 131.4 Top Hole Elevation 135.0 BORING NO. 3 Completed - 2-6-61

Elevation	Description
135	Brown fine to coarse sand and fine gravel
	Brown clayey silt
130–128	Brown fine sandy silt
125–120	Brown silty fine sand with a few thin silt seams
120	Brown clayey silt
	Brown fine sandy silt with silty sand seams
115–112	Red-brown silty clay

NOTES:
Boring located east side bottom about 60 feet from bank.
No nearby water in river.
Fairly fast drill rate with no appreciable cave.

Dry density (lbs cu ft) | Moisture (%) | Stand Penetration (blows/foot) | Sample size (inches) | Sample No. | Unified soil classification

Depth in feet

MT64-4

Type 16" Bucket G.L. 141.3 Top Hole Elevation 150.0 BORING NO. 4 Completed - 2-6-61

Elevation	Description
150–137	Brown fine to coarse sand and fine gravel with numerous thin seams of silty fine sand
135	Brown fine to coarse [illegible]
	Brown clayey silt
	Brown fine to [illegible]
	Brown fine sandy s[illegible]
	Brown silty fine sa[illegible]
125	Brown clayey silt
	Red-brown silty cl[illegible]
	Brown to gray fine sa[illegible] silt

NOTES:
Boring located [illegible] about 10 feet west of existing [illegible] stake.
No [illegible] water.
Fast drill rate with [illegible] appreciable hole cave.

Dry density (lbs cu ft) | Moisture (%) | Stand Penetration (blows/foot) | Sample size (inches) | Sample No. | Unified soil classification

Depth in feet

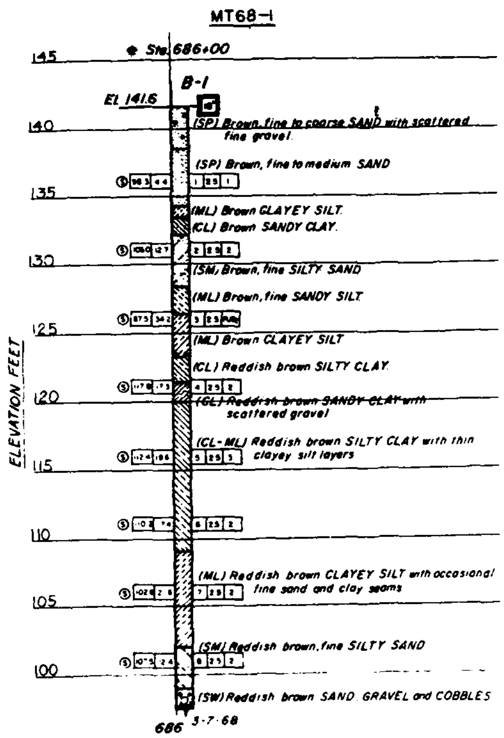
Type 16" Buck[et]

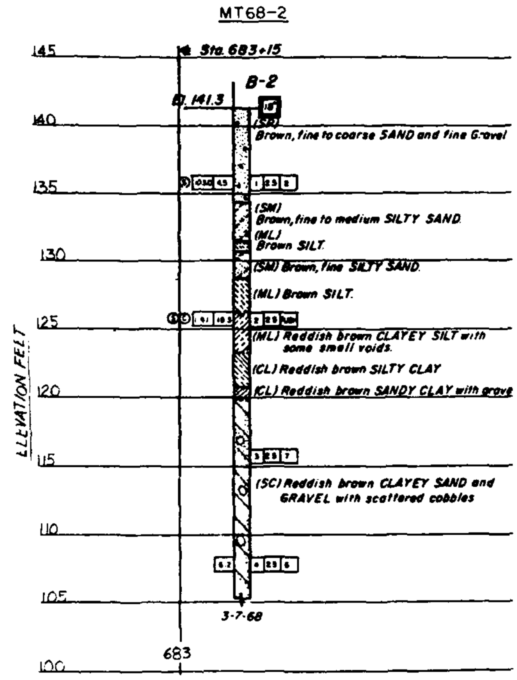
155
150
145
14[illegible]
13[illegible]
12[illegible]

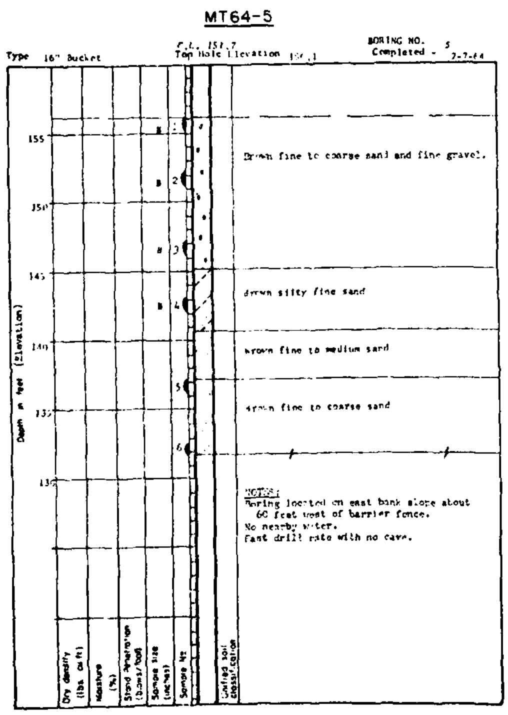
Depth in feet (Elevation)

Dry density (lbs cu ft)

VALUE ENGINEERING PAYS







NOTES:

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3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

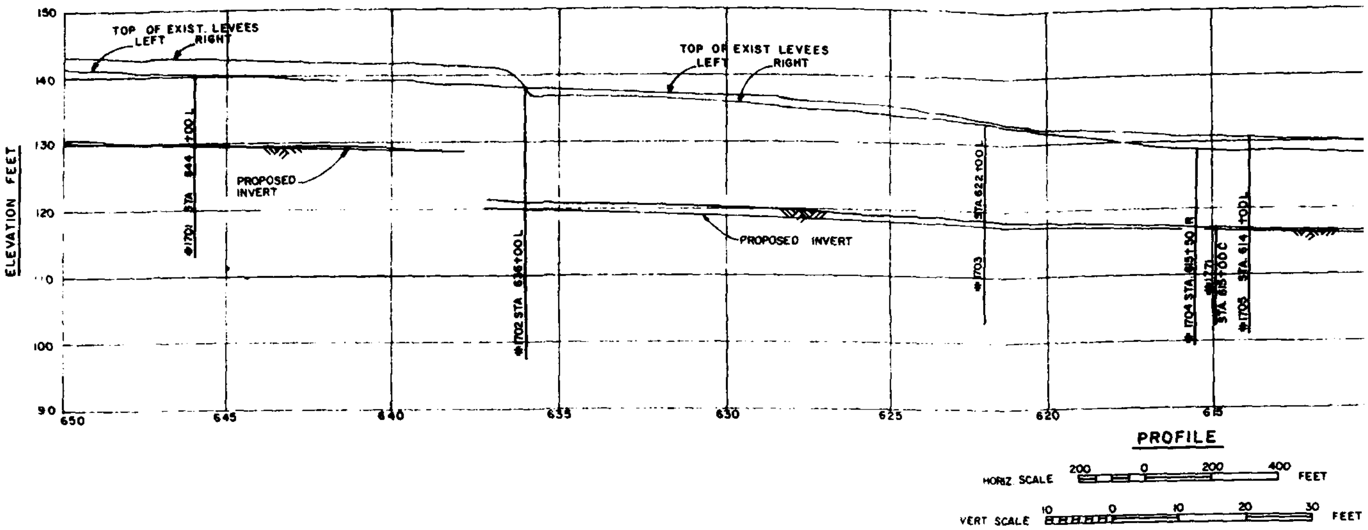
DESIGNED BY:
DRAWN BY:
CHECKED BY:

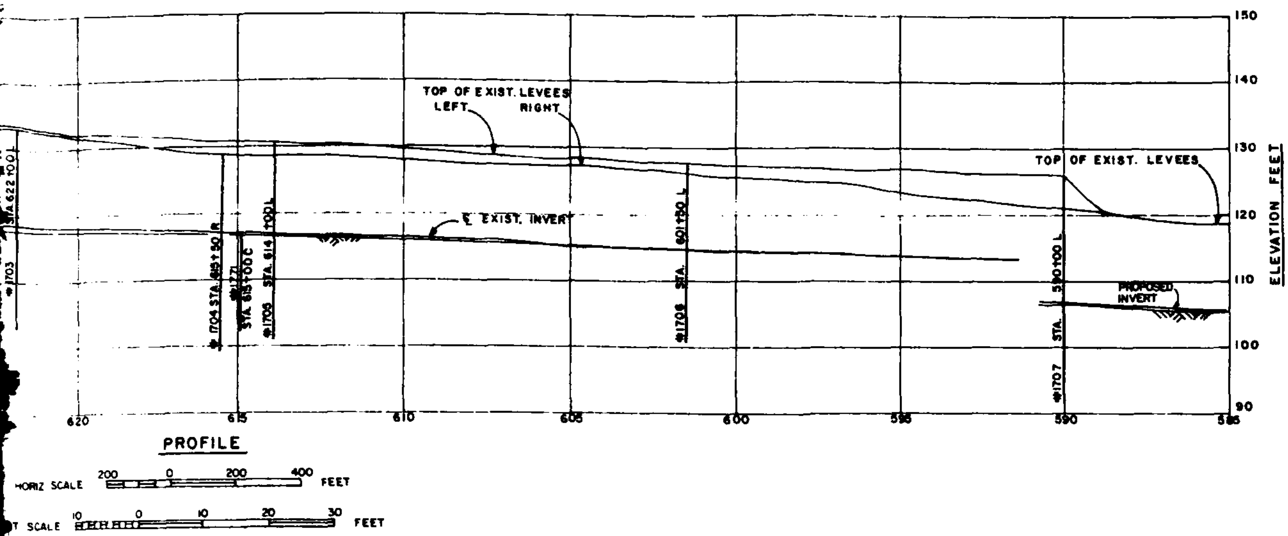
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

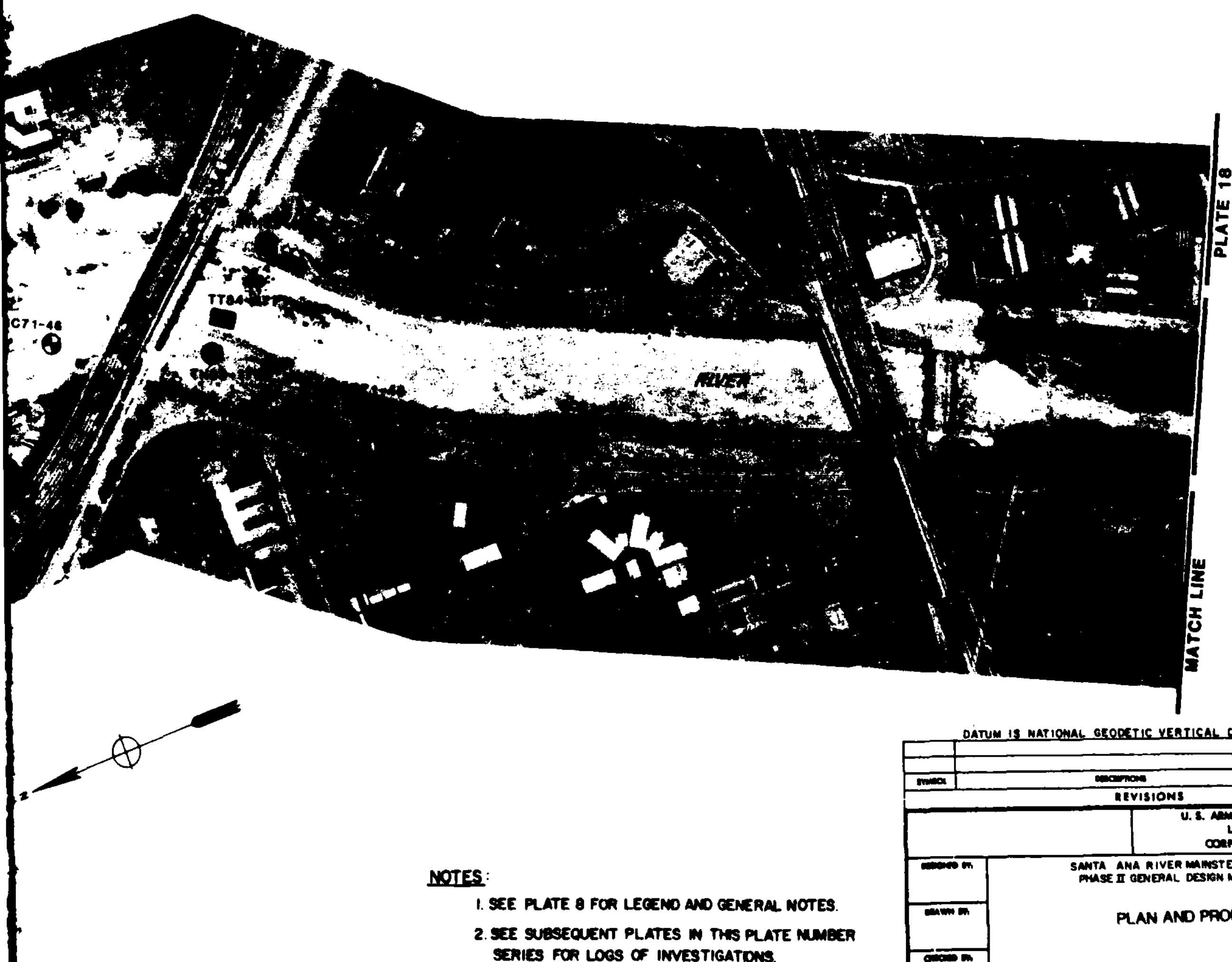
LOGS OF INVESTIGATION
BY OTHERS

STA.715+00 TO STA.650+00

VALUE ENGINEERING P







DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE

STA.650+00 TO STA.585+00

NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

VALUE ENGINEERING P

TH83-1701

TH83-1701 STA 644+00 L EL. 140±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.5	SM/SC	5	24	7	97	20		SILTY SAND/CLAYEY SAND: BROWN, WET, MEDIUM TO COARSE GRAINED, GRAVEL 1-3 INCHES, COBBLES TO 4 INCHES.
	SC	5	26	8	93	19		CLAYEY SAND: BROWN, WET MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 1-3 INCHES, COBBLES 4 INCHES.
5.0								
	SP/SM	5		NP	94	5		SAND/SILTY SAND: BROWN, MOIST, COARSE GRAINED, GRAVELS TO 2 INCHES.
		6		NP	90	6		
9.0							15	
10.5	ML	23	58	28	100	58		SANDY SILT: GREYISH BROWN, MOIST, COHESIVE.
12.0	SP/SM	6		NP	99	7	13	SAND/SILTY SAND: LIGHT BRN COARSE GRAINED, GRAVELS TO 1".
	SP	8			90	4		SAND: LIGHT BROWN, COARSE GRAINED, GRAVEL TO 1 INCH.
		5			100	3	24	
16.0								
18.0	SP/SM	4		NP	98	5	15	SAND/SILTY SAND: BRN, MOIST, COARSE GRAINED, GRVL TO 1".
20.0	SP	4			99	4		SAND: BROWN, MOIST, COARSE GRAINED GRAVEL TO 1 INCH.
21.5	SC	11	40	21	34	22	6	GRAVELLY CLAYEY SAND: BRN, MOIST, MED TO COARSE GRAINED. GRAVEL TO 1/2 INCH, COBBLES TO 3 INCHES.
24.0	CL	23	31	12	98	52	7	SANDY CLAY: BROWN, MOIST, MED. GRAINED. GRAVEL TO 1".
25.5	ML	39	43	15	100	99		CLAYEY SILT: REDDISH BROWN, MOIST, COHESIVE.
28.0	CH	32	58	31	100	98	8	CLAY: REDDISH BROWN, MOIST, COHESIVE.
30.0	CL	23	34	13	100	74		SANDY CLAY: REDDISH BROWN, MOIST, COHESIVE.

TH83-1704

TH83-1704 STA 615+50 R EL. 129±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		~~3~~	~~29~~	~~10~~	~~92~~	~~31~~		CLAYEY SAND: BROWN, MOIST, WELL GRADED FROM FINE TO COARSE GRAVEL TO 3 INCHES.
2.0		11	29	11	95	24		SAME: MEDIUM GRAINED GRAVEL TO 7 INCHES.
	SP/SM	4		NP	97	10	26	SAND/SILTY SAND: BRN, MOIST, MED. TO COARSE GRAINED SAND, NO COHESION.
		3		NP	98	6	25	SAME: LIGHT BROWN, NO COHESION, CLEAN GRAVEL TO 1/2".
7.0							24	
	SP	2		NP	99	6		SAND: LIGHT BROWN, MOIST, CLEAN, MED. TO COARSE GRAINED, NO COHESION, GRAVEL TO 1/2 INCHES.
10.0		2		NP	100	2		
11.0	SM	11		NP	10	23		SILTY SAND: BROWN, MOIST, FINE, NO COHESION.
	SP/SM	4		NP	79	5		SAND/SILTY SAND: MOIST, LIGHT BROWN, MED. TO COARSE GRAINED, NO COHESION.
15.0		4		NP	99	5	14	
	CL	21	32	13	92	56	5	SANDY CLAY: BROWN, MOIST, MEDIUM TO COARSE GRAINED SAND.
18.0		33	47	20	99	92		SAME. SOME COHESION.
20.0	CH	34	51	25	100	98	7	CLAY. BROWN, MOIST.
22.5	ML	30	23	3	100	71	10	SANDY SILT. GREY, MOIST, FINE GRAINED. SOME COHESION, SOME PLASTICTY.
		26	35	14	100	90		CLAY: DARK GREY, BROWN, MOIST, COHESIVE.
	CL	27	38	17	100	78	6	SANDY CLAY: SAME AS ABOVE.
W 29.5 30.0		27	41	19	100	72	10	

TH83-1702

TH83-1702 STA 636+00 L EL. 138±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTI
	SC	~~4~~	~~30~~	~~11~~	~~85~~	~~29~~		GRAVELLY CLAYEY SAND: BROWN, COBBLES TO 4 INCHES.
2.0		2	25	8	93	14	50	CLAYEY SAND: GREYISH BROWN, M
4.5	SP/SM	2		NP	99	5	26	SAND/SILTY SAND: GREY, MOIST, GRAVEL TO 1/2 INCHES.
6.5	SW/SM	2		NP	98	5	10	SAME: MEDIUM TO COARSE GRAINE
		3		NP	99	4		
	SP/SM	2		NP	98	5	13	
		3		NP	99	6		
14.0		~~3~~		~~NP~~	~~99~~	~~5~~	13	
16.0	SP	3			99	4	16	SAND: GREY, MOIST, MED. TO C 1/4 INCH.
18.0	ML	27	31	5	99	90		SANDY SILT: BROWN, WET, SOME
19.0	CH	37	54	28	100	94		CLAY: BROWN, WET, COHESIVE.
W 21.0 21.5	CL	21	44	18	100	96		SILTY CLAY: BROWN, WET, COHE
23.0	ML	29	27	2	100	70		SANDY SILT: BROWN, WET, SOME
	SM	29	24	1	100	61		SILTY SAND: BROWN, WET, SOME
26.5		30	24	2	100	66		
28.5	SC	35	34	10	100	81		CLAYEY SAND: BROWN, WET, SOM
		35	35	12	98	78		SANDY CLAY. BROWN, WET, SOME
	CL	25	36	14	90	69		
36.0		31	32	10	100	72		
38.0	ML	31	33	9	100	77		SANDY SILT: BROWN, WET, SOM
40.0	SM/SC	21	23	5	99	28		SILTY SAND/CLAYEY SAND: BRO MEDIUM TO COARSE GRAINE

INVERT

TT84-1771

TT84-1771 STA 615+00 C

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESC
	.				93	0		SAND: MULTICOLORED, MOIST GRAVEL TO 1 INCH.
3.0								
	ML		46	13	100	34		SILT: DARK BROWN, MO
			35	9	100	69		SANDY SILT: DARK BROWN
15.0			24	1	99	51		

TH83-1702

STA 636+00 L — EL. 138±

LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
SC	4 / 2	30 / 25	11 / 8	85 / 93	29 / 14	50	GRAVELLY CLAYEY SAND: BROWN, MOIST GRAVEL TO 3 INCH, COBBLES TO 4 INCHES. CLAYEY SAND: GREYISH BROWN, MOIST, GRAVEL TO 1 INCH.
SP/SM	2		NP	99	5	26	SAND/SILTY SAND: GREY, MOIST, MED. TO FINE GRAINED. GRAVEL TO 1/2 INCHES.
SW/SM	2		NP	98	5	10	SAME: MEDIUM TO COARSE GRAINED.
	3		NP	99	4		
SP/SM	2		NP	98	5	13	
	3		NP	99	6		
	3		NP	99	5	13	
SP	3			99	4		SAND: GREY, MOIST, MED. TO COARSED GRAINED. GRAVEL TO 1/4 INCH.
ML	27	[illegible]	[illegible]	99	90	16	SANDY SILT: BROWN, WET, SOME COHESION.
CH	37	54	28	100	94		CLAY: BROWN, WET, COHESIVE.
CL	21	44	13	100	96		SILTY CLAY: BROWN, WET, COHESIVE.
ML	29	27	2	[illegible]	70		SANDY SILT: BROWN, WET, SOME COHESION.
	29	24	[illegible]	100	61		SILTY SAND: BROWN, WET, SOME COHESION.
SM	30	24	[illegible]	100	66		
SC	35	34	[illegible]	100	81		CLAYEY SAND: BROWN, WET, SOME COHESION.
	35	[illegible]	[illegible]	98	73		SANDY CLAY: BROWN, WET, SOME COHESION.
CL	25	36	[illegible]	[illegible]	69		
	31	[illegible]	[illegible]	[illegible]	72		
ML	31	[illegible]	[illegible]	100	77		SANDY SILT: BROWN, WET, SOME COHESION.
[illegible]	20	[illegible]	[illegible]	99	28		SILTY SAND/CLAYEY SAND: BROWN, SATURATED, NO COHESION, MEDIUM TO COARSE GRAINED SAND.

TT84-1771

EL. 117±

LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
[illegible]				[illegible]			SAND: MULTICOLORED, MOIST, MEDIUM GRAINED SAND, FEW GRAVEL TO 1 INCH.
							[illegible]: DARK BROWN, MOIST.
ML				[illegible]	[illegible]		
				[illegible]	59		SANDY SILT: DARK BROWN TO GREY, MOIST TO WET, COHESIVE.
				99	51		

TH83-1703

TH83-1703 — STA 622+00 L — EL. 132±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SM/SC	4	26	7	98	14		SILTY SAND/CLAYEY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, GRAVEL 2 INCHES.
	SC	4	26	8	99	20		CLAYEY SAND: BROWN, MOIST, FINE TO MEDIUM SAND, GRAVEL TO 3 INCHES.
		9	27	8	99	27		
4.0		3			99	3	18	SAND: GREY, MEDIUM GRAINED SAND, GRAVEL TO 3/4".
		4			100	3		
	SP	3			99	2	11	SAME: COARSE GRAINED.
		3			99	2		
		3			99	7	14	
12.0	CL	23 / 35	34 / 42	14 / 18	100 / 100	68 / 89		SANDY CLAY: BROWN, MOIST, FINE GRAINED. CLAY: BROWN, MOIST.
14.0	SM	23		NP	100	20		SILTY SAND: BROWN, MOIST, FINE GRAINED.
15.0	MH	22	58	27	100	90	13	SANDY CLAYEY SILT: BROWN, MOIST.
18.0 / W 19.0	ML	36	47	21	100	92		CLAYEY SILT: BROWN, MOIST.
20.0	SC	33	28	10	100	45		CLAYEY SAND: SAME AS ABOVE.
21.0	CL	34	34	12	100	79		SILTY CLAY: YELLOWISH BROWN, WET.
		36	34	12	100	74		
23.5	SC	21	23	6	99	25	19	CLAYEY SAND: DARK BROWN, WET, MEDIUM TO FINE GRAINED.
24.5	SP/SM	23		NP	100	12	40	SAND/SILTY SAND: SAME AS ABOVE.
28.0	CL	27	37	18	100	64		SANDY CLAY: DARK BROWN, WET.
29.5	SC	9	28	9	81	36	22	GRAVELLY CLAYEY SAND: BROWN, WET, GRAVEL TO 1 INCH.
31.0								

NOTES

1. SEE PLATE 17 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SCALE: 1 IN = 3 FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS
STA.644+00 TO STA.615+00

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-____-B-____ | SHEET

TH83-1705

TH83-1705 STA 614+00 L EL. 131±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		8.0	32	13	96	94		CLAYEY SAND: DARK BROWN, MOIST, FINE TO MEDIUM SAND, FEW GRAVEL TO 2 INCHES.
	SC	90	31	12	94	45		SAME: GRAVEL TO 1 INCH, COHESIVE.
3.0							16	
	CL	11	32	11	99	52		SANDY CLAY: DARK BROWN, MOIST, COHESIVE, GRAVEL TO 1".
4.0							20	
	SW/SM	3		NP	99	10		SAND/SILTY SAND: GREY, MOIST, MEDIUM TO COARSE GRAIN.
5.0								
	CL	19	37	12	99	66		SANDY/SILTY CLAY: DARK BROWN, MOIST, COHESIVE, FINE GRAINED SAND.
7.0							14	
	SW/SM	3		NP	99	12		SAND/SILTY SAND: BROWN, MOIST, MEDIUM TO COARSE GRAINED SAND.
9.0								
		17	37	11	100	80	12	SANDY CLAY: LIGHT BROWN, MOIST, COHESIVE, FINE GRAINED.
		18	36	16	100	74	11	
		28	32	10	100	76	12	SAME: LIGHT YELLOW BROWN.
		20	30	9	100	71		
	CL	33	31	15	100	91	5	CLAY: LIGHT BROWN, MOIST.
		32	36	14	100	94	15	
		23	32	11	100	79		
							8	
		23	33	11	100	72		
29.[illegible]								
30.[illegible]	SM	10		NP	100	15		SILTY SAND: DARK BROWN, MOIST, FINE TO MEDIUM SAND.

TH83-1706

TH83-1706 STA 601+50 L EL. 127±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SC	5	28	10	84	35		GRAVELLY CLAYEY SAND: BRN, MOIST, SOME (
		8	30	11	71	32		CLAYEY SAND: BROWN, MOIST, GRAVEL TO 3
3.0							21	
	SP/SM	3		NP	98	6	22	SAND/SILTY SAND: GREY, MOIST, MEDIUM GR
5.0								
	GW/GM		25	1	54	11		SANDY GRAVEL/SILTY SANDY GRAVEL: BLACK- COBBLES TO 6", ORGANIC SMELL.
7.0								
	SM		23	2	79	13	11	SILTY GRAVELL SAND: BLACK-DARK BROWN, S COBBLES TO 6 INCHES.
8.0								
		3		NP	99	11		SAND/SILTY SAND: DARK GREY, MOIST, MEDI
							22	
	SP/SM	1		NP	95	6		SAME: GREY, COARSE GRAINED. MAXIMUM 1/2
							6	
		4	25	7	97	11		SAME: GREY, MOIST, COARSE GRAINED.
14.5								
		[illegible]	34	16	99	51		SANDY CLAY: BROWN, FINE GRAINED, SLIGHT
		[illegible]	34	14	98	71		CLAY: BROWN, FINE GRAINED, COHESIVE.
	CL	[illegible]	35	14	98	83		SAME: LIGHT BROWN, MOIST.
		28	35	13	97	87		
19.0								
	ML	34	39	12	100	96		CLAYEY SILT: LIGHT BROWN, MOIST, COHES
20.5								
		[illegible]	[illegible]	9	100	69		SANDY CLAY: LIGHT YELLOW-BROWN, WET,
							8	
W 24.0	CL							
		[illegible]	34	23	100	73	7	
26.5								

NOTES

1

2

3

4

LUE ENGINEERING PAYS

TH83-1706

STA 501+[illegible] L — EL. 127±

PI	-4	-200	N	DESCRIPTION
[illegible]	[illegible]	[illegible]		GRAVELLY CLAYEY SAND: BRN, MOIST, SOME GRAVEL TO 2".
[illegible]	[illegible]	[illegible]	21	CLAYEY SAND: BROWN, MOIST, GRAVEL TO 3 INCHES.
NP	[illegible]	[illegible]	[illegible]	SAND/SILTY SAND: GREY, MOIST, MEDIUM GRAINED.
[illegible]	[illegible]	[illegible]		SANDY GRAVEL/SILTY SANDY GRAVEL: BLACK-DARK BROWN, COBBLES TO 6", ORGANIC SMELL.
[illegible]	[illegible]	[illegible]	[illegible]	SILTY GRAVELL SAND: BLACK-DARK BROWN, SOME ORGANICS, COBBLES TO 5 INCHES.
NP	[illegible]	[illegible]		SAND/SILTY SAND: DARK GREY, MOIST, MEDIUM GRAIN.
NP	[illegible]	[illegible]		SAME GREY, COARSE GRAINED, MAXIMUM 1/2 INCHES.
[illegible]	[illegible]	[illegible]		SAME GREY, MOIST, COARSE GRAINED.
[illegible]	[illegible]	[illegible]		SANDY CLAY BROWN, FINE GRAINED, SLIGHT COHESION.
[illegible]	[illegible]	[illegible]		CLAY BROWN, FINE GRAINED, COHESIVE. SAME LIGHT BROWN, MOIST.
12	[illegible]	[illegible]		CLAYEY SILT LIGHT BROWN, MOIST, COHESIVE.
[illegible]	[illegible]	[illegible]	[illegible]	SANDY CLAY LIGHT YELLOW-BROWN, WET, COHESIVE.
[illegible]	[illegible]	[illegible]		

TH83-1707

TH83-1707 — STA 590+00 L — EL. 125±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.5	SM	1		NP	95	16		SILTY SAND: GREY, DRY, COARSE GRAINED SAND, NON-COHESIVE, SOME GRAVEL AND ORGANIC MATERIAL.
		18	33	14	99	75	14	SANDY CLAY: BROWN-GREY, MOIST, MEDIUM GRAINED SAND, SLIGHTLY COHESIVE.
		13	26	8	100	55		
	CL	26	45	20	96	88	9	CLAY: BROWN, MOIST, COHESIVE.
		24	30	10	100	67	7	SANDY CLAY: BROWN-GREY, MOIST, COHESIVE.
W 12.0								
13.0	SM	26		NP	100	23		SILTY SAND: BROWN, WET, NON-COHESIVE.
14.5	CL	35	42	17	100	90	5	CLAY: GRAY, WET, COHESIVE.
15.5	SM	24		NP	100	33		SILTY SAND: BRN, NON-COHESIVE, FINE TO MED. GRAINED SAND.
17.5	CL	16 / 17	25 / 26	8 / 8	100 / 100	51 / 54	21	SANDY CLAY: BROWN-GREY, WET, FINE TO MEDIUM GRAINED SAND.
19.5	SP/SM			NP	100	12	17	SAND/SILTY SAND: GREY, WET, NON-COHESIVE.
22.0	SM			NP	100	19		SILTY SAND GREY, WET, COARSE GRAINED SAND.
24.0	ML		35	4	100	96	9	SILT. GREY, WET, SLIGHTLY PLASTIC.
			35	15	100	84	9	SANDY CLAY. BROWN, SLIGHTLY COHESIVE. CLAY. GREY, COHESIVE.
			36	15	100	85		
	CL		35	12	100	97	13	
32.0			35	10	100	79		SANDY CLAY GREY, MOIST, SLIGHTLY COHESIVE.
34.0	SM/SC		28	7	100	16		SILTY SAND/CLAYEY SAND: GREY, MOIST, COHESIVE.
35.0	ML			NP	100	66		SANDY SILT. GREY, MOIST, FINE TO MEDIUM GRAINED SAND.

SCALE 1 IN=3 FT

5 0 5 10

NOTES

1. SEE PLATE 17 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

LOGS OF INVESTIGATIONS

CORPS OF ENGINEERS

CHECKED BY:

STA.614+00 TO STA.590+00

SUBMITTED BY: — DATE APPROVED: — SPEC. NO. DACW09-____-B-____ — SHEET

VALUE ENGINEERING PA

MT78-1

MOORE & TABER CONSULTING ENGINEERS AND GEOLOGISTS

TEST BORING LOG

TYPE 16" Bucket Auger — ELEVATION 140.0 — BORING 1

Dry density	Moisture %	Blows/foot	Sample size	Sample no.	Depth (feet)	Unified class	Description
						SP	Brown fine to medium SAND with some GRAVEL
101	1.8	4	2.5	1	5		. . . scattered COBBLES
99	8.7	5	2.5	2	10	SM	Brown fine SILTY SAND
100	2.8	3	2.5	3	15	SP	Light brown fine to medium SAND . . . scattered GRAVEL . . . thin layer coarse SAND and GRAVEL
						ML	Green-brown SILT with some SAND
84	36.8	8	2.5	4	20	ML	Reddish-brown CLAYEY SILT . . . more CLAY . . . less CLAY
88	31.6	1	2.5	5	25	ML	Gray-green fine SANDY SILT . . . some CLAY
					30		

Approximate Drop Structure Invert

NOTES:

1) Heavy caving below 26 feet
2) Groundwater at 26 feet immediately after drilling.

THIS BORING LOG SUMMARY APPLIES ONLY AT THE TIME AND LOCATION INDICATED. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND TIMES.

LOGGED BY JJW — DATE 4-2/78

MT78-2

MOORE & TABER CONSULTING ENGINEERS AND GEOLOGISTS

TEST BORING LOG

TYPE 16" Bucket Auger — ELEVATION [illegible] — BORING 2

Light brown fine to medium SAND with some scattered coarse SAND

Light brown fine to medium SAND

. . . fine SAND and GRAVEL

. . . medium SAND

. . . fine SAND and GRAVEL

. . . with oxidation

THIS BORING LOG SUMMARY APPLIES ONLY AT THE TIME AND LOCATION INDICATED. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND TIMES.

LOGGED BY [illegible] — DATE [illegible]

MOORE & TAB

MT78-7

MOORE & TABER CONSULTING ENGINEERS AND GEOLOGISTS

TEST BORING LOG

TYPE — ELEVATION — BORING

THIS BORING LOG SUMMARY APPLIES ONLY AT THE TIME AND LOCATION INDICATED. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND TIMES.

LOGGED BY JJW — DATE 4-28-78

GC71-43

BORING NO. 43 — STATION — DRILL DATE — SURFACE ELEVATION

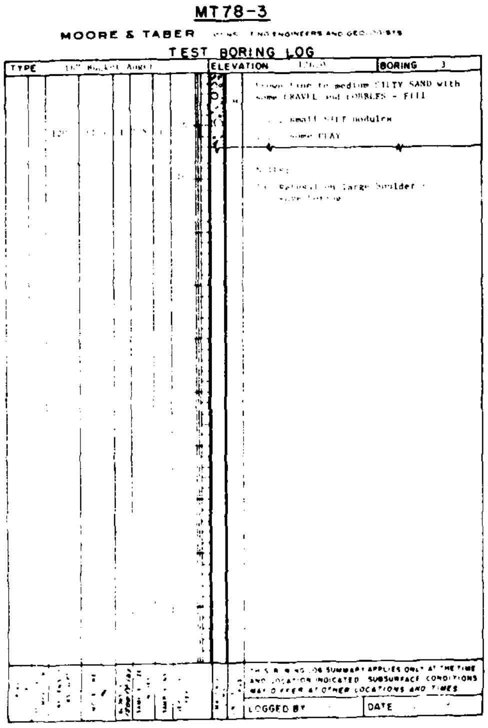
WATER — DEPTH-FEET — GRAPHIC SYMBOL — DESCRIPTION

5, 10, 15, 20, 25, 30

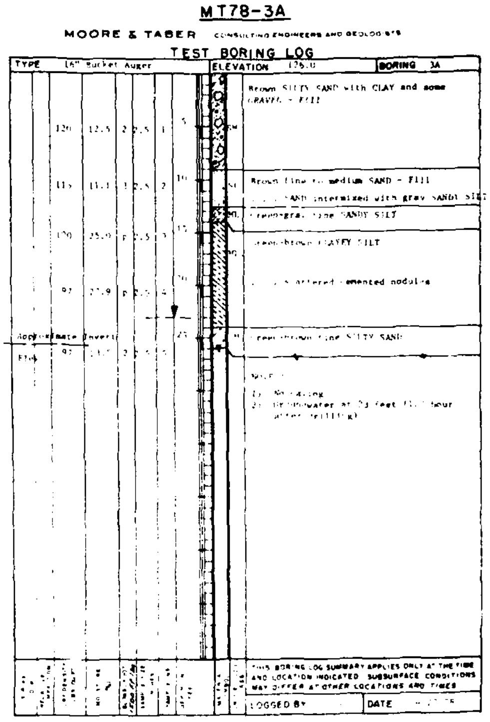
BORING NO. — WATER — DEPTH-FEET

VALUE ENGINEERING PAYS

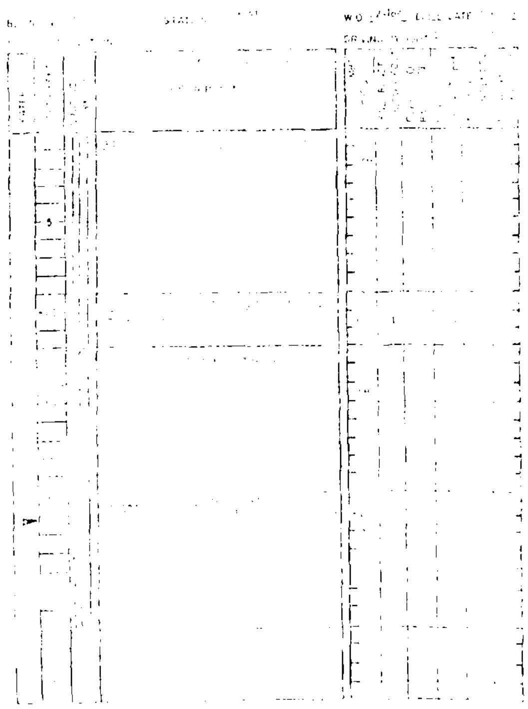
MT78-3



MT78-3A



GC71-44



NOTES

1. SEE PLATE 17 FOR TEST SITE LOCATIONS
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS

STA.650+00 TO STA.585+00

SUBMITTED BY: | DATE APPROVED | SPEC NO. DACW09- | SHEET

GC71-45

BORING No. 45 STATION 365 + 49 W.O. 22-164 DRILL DATE 3/10/71

SURFACE ELEVATION 134 DRIVING WEIGHT 1500 lb., 18 in.

Bucket Auger. 16 inch diameter.

Depth Feet	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core / Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	FILL: SILTY SAND: SM, brown, moist, medium dense.	SM					
	SAND: SP, brown, coarse grained, moist, medium dense.	SP					
5	SILTY SAND: SM; brown, moist, medium dense.	SM					
10	NATURAL [illegible] SANDY SILT: ML, brown, wet, firm.	ML	[illegible]	(1)	101.2	[illegible]	[illegible]
	SILTY SAND: SM, brown, moist, medium dense.	SM					
20	SANDY SILT: ML, brown, moist, firm.	ML	[illegible]	(2)	[illegible]	[illegible]	[illegible]
	[illegible] brown, moist, medium dense.	SM					

GC71-46

BORING No. 46 STATION 375 + 65 W.O. 22-164 DRILL DATE [illegible]

SURFACE ELEVATION 137 DRIVING WEIGHT 1500 lb., 18 in.

Bucket Auger: 16 inch diameter.

Depth Feet	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core / Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	FILL: SILTY SAND: SM; brown, moist, medium dense.	[illegible]					
5	SANDY SILT: ML, brown, moist, f[illegible]	[illegible]					
	SILTY SAND: SM, [illegible] dense.	[illegible]	[illegible]	(1)	[illegible]	[illegible]	[illegible]
15	NATURAL [illegible] SANDY SILT: ML; brown, wet, firm.						
	SILTY SAND: SM; brown, [illegible] medium dense.	[illegible]	[illegible]	(2)	[illegible]	[illegible]	[illegible]
	SANDY [illegible]						
25	[illegible]						

GC71-49

W.O. 22-164 DRIVING WEIGHT 1500 lb., 18 in.

DESCRIPTION

[illegible]

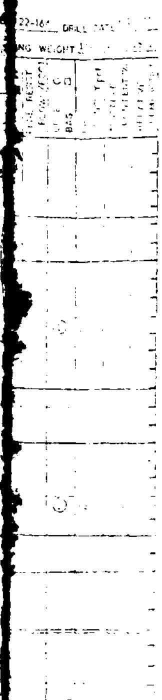
MT64-1

Type [illegible] Top Hole Elevation 114.2

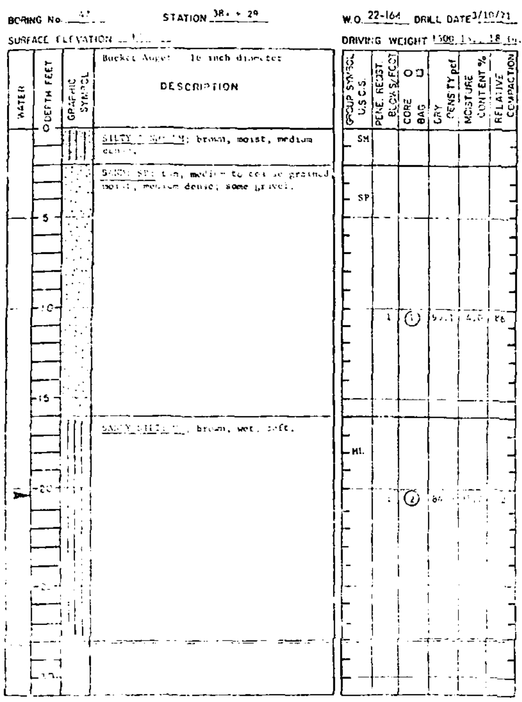
[illegible]

PA

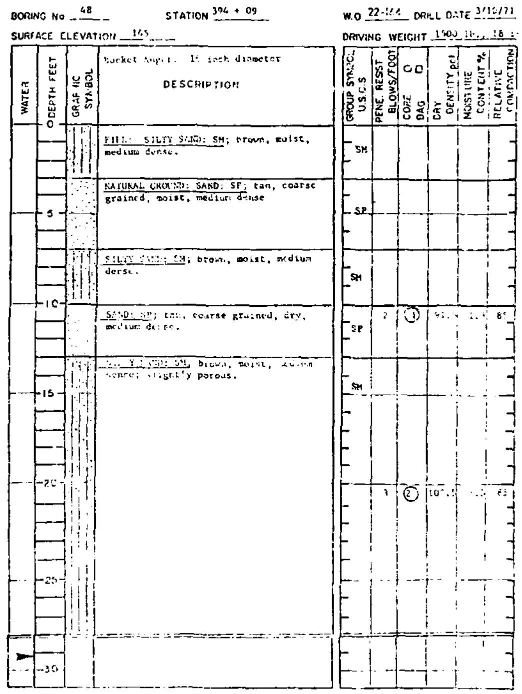
VALUE ENGINEERING PAYS

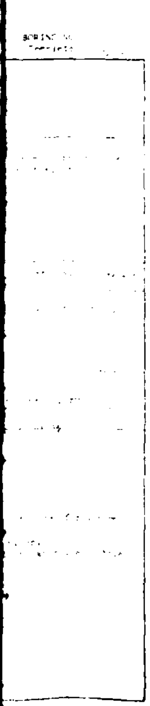


GC71-47

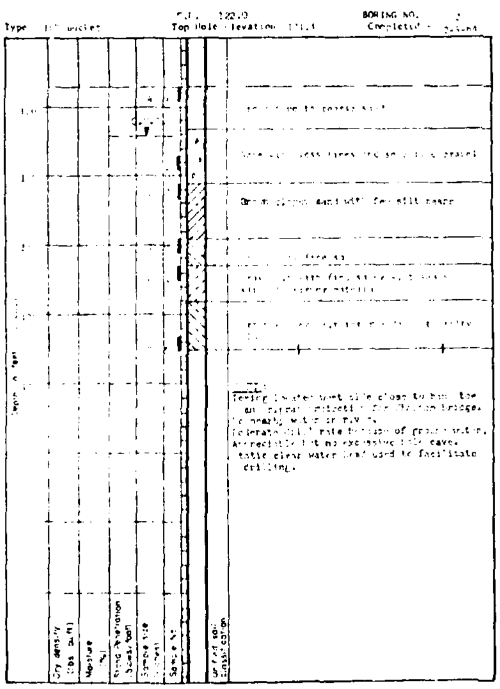


GC71-48





MT64-2



NOTES:

1. SEE PLATE 17 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

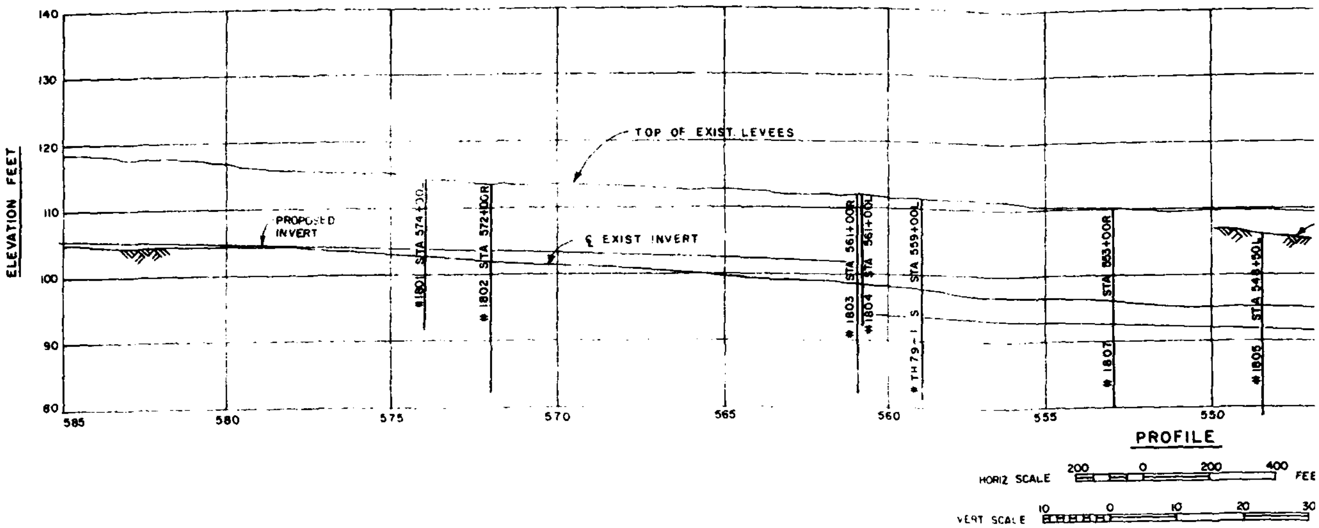
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

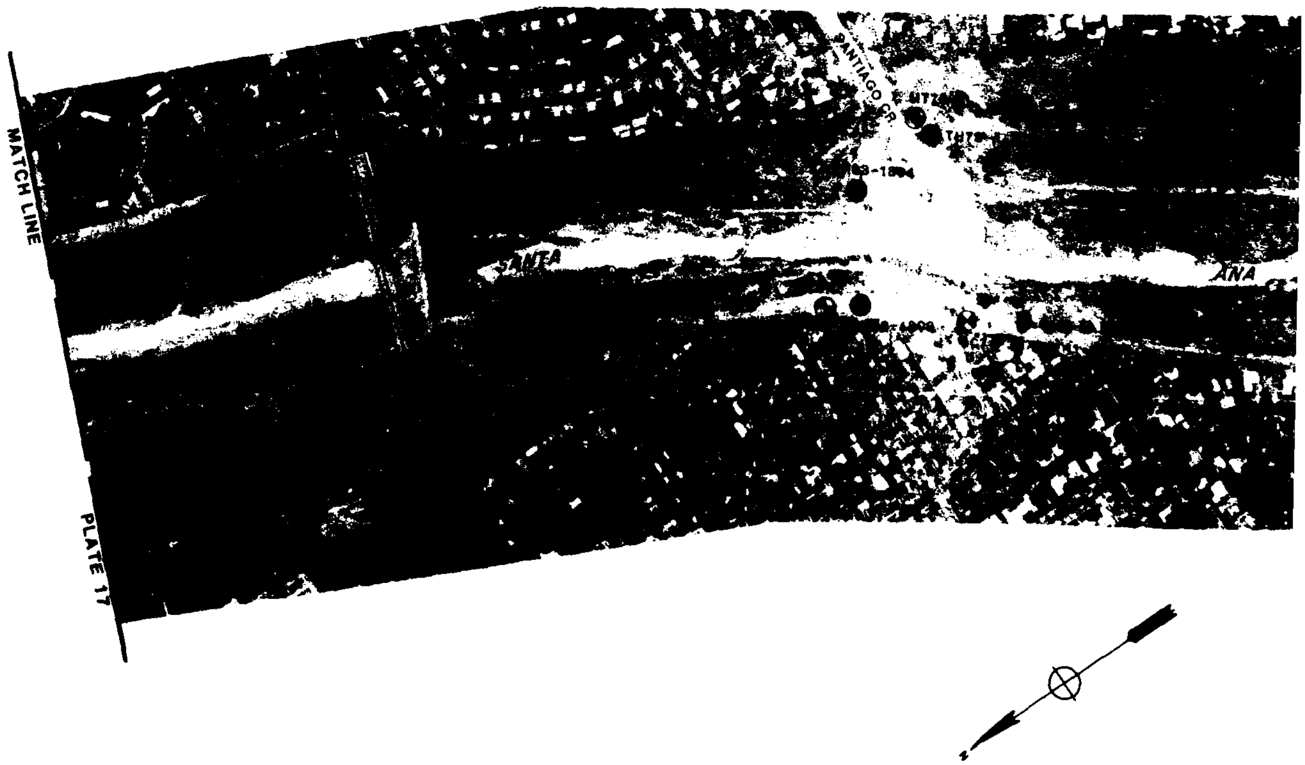
LOGS OF INVESTIGATION
BY OTHERS

STA.650+00 TO STA.585+00

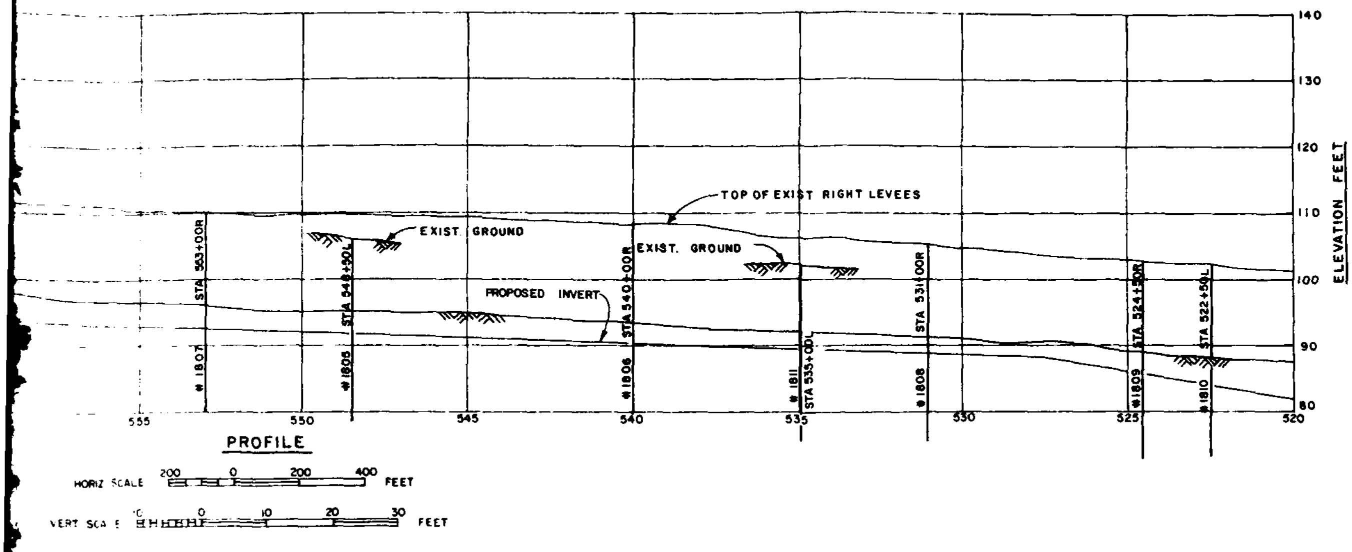
VALUE ENGINEERING



PROFILE



VALUE ENGINEERING PAYS



DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE

STA.585+00 TO STA.520+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____-B-____ SHEET

NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

TH83-1807

TH83-1807 STA 553+00 R EL. 102±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP/SM	2		NP	100	8		SAND/SILTY SAND: TAN, DRY, FINE GRAINED SAND.
3.0							8	
								SILTY SAND: TAN, SLIGHTLY DAMP, FINE-GRAINED SAND.
	SM	2		NP	100	19	7	
		13		NP	100	34		SAME: LIGHT BROWN, FINE GRAINED.
7.0	SP/SM	3		NP	99	5		SAND/SILTY SAND: LIGHT TAN, DAMP, MEDIUM GRAINED SAND.
8.0	SP	3			93	3		GRAVELLY SAND: MOIST, MEDIUM TO COARSE GRAINED, GRAVEL TO 3 INCHES.
10.0	ML	21		NP	100	60		SANDY SILT: DARK BROWN, MOIST, COHESIVE.
11.0	SM	22		NP	100	47		SILTY SAND: DARK BROWN, MOIST, SLIGHTLY COHESIVE.
12.5	CL	22	35	13	100	67		SANDY CLAY: DARK BROWN, MOIST, COHESIVE.
14.0	SC	17	32	12	100	49		CLAYEY SAND: BROWN, SLIGHTLY COHESIVE.
15.5	SM	12		NP	100	24		SILTY SAND: BROWN, MOIST, MEDIUM GRAINED.
16.5		26	43	20	100	78		SANDY CLAY: DARK GREY, MOIST, COHESIVE.
		30	36	13	100	93		CLAY: LIGHT BROWN, WET, SOFTER.
	CL	25	37	15	100	83		SANDY CLAY: GRAY-BROWN, LESS PLASTIC.
W 24.0								
		27	42	17	100	88		CLAY: SAME AS ABOVE.
28.0	SM	23		NP	100	17		SILTY SAND: GREY, WET, FINE-GRAINED, NON-COHESIVE.
30.0								

TH83-1802

TH83-1802 STA 572+00 R EL. 114±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM	4		NP	71	11		GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, MOIST, FIN TO MEDIUM GRAINED SAND.
3.5							17	
	SP/SM	3		NP	98	9	8	SAND/SILTY SAND: BROWN, MOIST, MEDIUM GRAINED SAND.
6.0	ML	16	32	8	100	65		SANDY SILT: BRN, MOIST, FINE GRAINED SND, SLIGHT COHE
7.0	SM	6		NP	100	20	8	SILTY SAND: LIGHT BROWN, MOIST, SLIGHT COHESION.
9.0	SP/SM	4		NP	100	6		SAND/SILTY SAND: LIGHT BROWN-TAN, MEDIUM GRAINED.
10.5							9	
		17	28	9	100	58		SANDY CLAY: BROWN, MOIST, SLIGHT COHESION.
		20	40	23	100	82		SAME: DARK BROWN.
	CL							
		16	28	13	100	52		SAME: GREY-BROWN.
		18	30	11	100	51		SAME: BROWN.
		25	49	24	100	88		CLAY: BROWN, MOIST, COHESIVE.
21.0							11	
	SW/SC	14	22	5	100	42		SILTY SAND/CLAYEY SAND: BROWN, MOIST, FINE GRAINED S
24.0		24	30	8	100	76		SANDY CLAY: BROWN, MOIST, COHESIVE.
	CL	27	30	14	100	76	8	
W 27.0								
28.0							26	
	SM/SC	15	23	6	100	41		SILTY SAND/CLAYEY SAND: BROWN, MOIST, FINE GRAINED S
30.0	SP/SM	15		NP	100	10		SAND/SILTY SAND: BROWN, MOIST, MEDIUM GRAINED SAND.
31.5							21	

TH79-1 S

TH79-1 S STA 559+00 L EL. 117±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SILTY GRAVELLY SAND: BROWN, MEDIUM DENSE, SOME PEA-SIZE GRAVEL.
		3		NP	75	13	8	
	SM						24	
								SILTY SAND: BROWN, MOIST, LOOSE, CHUNKS OF CLAY, ANGULAR GRAVEL TO 1 INCH, COHESION.
		12		NP	92	30	7	
9.0								
							14	SAND/SILTY SAND: LIGHT BROWN, MOIST, MEDIUM-DENSE, ANGULAR GRAVEL TO 1 INCH, NO COHESION.
	SP/SM	5		NP	94	7		
13.5							18	
	CL	21	39	21	100	73	27	SANDY CLAY: BROWN, MOIST, VERY STIFF, GRAVEL TO 1 INCH, COHESION.
16.5								
							20	SILTY SAND: TAN, MOIST, MEDIUM DENSE, GRAVEL TO 1/2 INCH, COHESION.
	SM	17		17	100	40		
21.0							18	
								SANDY CLAY: DARK BROWN, MOIST, STIFF, ROUNDED GRAVEL TO 1 INCH MAXIMUM (5 PERCENT), COHESION.
	CL	21	32	14	100	92		
							9	
25.5								
								SANDY CLAY/SANDY SILT: GREY BROWN, WET, COHESION.
	CL/ML	22	25	5	100	53	17	
W 27.5								
28.5	SM	23		NP	100	36		SILTY SAND: GREY BROWN, WET, COHESION.
30.0								

TH83-1803

TH83-1803 STA 561+00 R EL. 112±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	5		NP	73	21		GRAVELLY SILTY SAND: BROWN, MOIST.
1.5	SP/SM	3		NP	100	8		SAND/SILTY SAND: TAN, DRY, MEDIUM GRAINED SAND.
2.5		15		NP	100	56	16	
	ML	14		NP	100	55		SANDY SILT: BROWN, MOIST, COHESIVE, FINE GRAINED S
4.0							9	
	SP	[illegible]			95	3		SAND: LIGHT BROWN, MOIST, NON-COHESIVE, MEDIUM GRA SAND.
6.5								
	SP/SM	4	23		100	10	3	SAND/SILTY SAND: GRAY, MOIST, NON-COHESIVE, FINE G SAND.
9.0	SP	2			95	4		SAND: GRAY, MOIST, NON-COHESIVE, MEDIUM GRAINED SA
10.5							9	
		22	43	[illegible]	[illegible]	79		SANDY CLAY: BROWN-GREY, MOIST, COHESIVE.
		23	43	[illegible]		86	22	CLAY: DARK BROWN.
	CL	21	44	24	100	85		SAME: BROWN.
							17	
		19	33	14	100	74		SANDY CLAY: BROWN.
		29	44	21	100	90		CLAY: BROWN-GREY.
18.5		23	51	35	100	[illegible]	14	SANDY CLAY: YELLOW-BROWN, MOIST.
	CH	32	51	26	[illegible]	96		
21.0								
	CL	22	33	17	100	[illegible]	11	SANDY CLAY: DARK BROWN, MOIST, SLIGHTLY PLASTIC
24.0	SM	21		NP	100	36	11	SILTY SAND: BROWN, MOIST, SLIGHTLY COHESIVE.
25.0	CL	29	44	29	100	94		CLAY: BROWN, MOIST, COHESIVE, SLIGHTLY PLASTIC.
27.0	ML	29	44	13	100	90		SILT: BROWN, MOIST, COHESIVE, SLIGHTLY PLASTIC.
28.0	ML/CL	24	28	7	100	92		SANDY SILT/SANDY CLAY: BROWN, MOIST, COHESIVE.
29.0	CL	30	44	25	100	90		CLAY: BROWN-GREY, MOIST, COHESIVE, PLASTIC.
30.0								

VALUE ENGINEERING PAYS

TH83-1802

EL. 114±

-200	N	DESCRIPTION
11	17	GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND.
9	8	SAND/SILTY SAND: BROWN, MOIST, MEDIUM GRAINED SAND.
65		SANDY SILT: BRN, MOIST, FINE GRAINED SND, SLIGHT COHESION.
20	8	SILTY SAND: LIGHT BROWN, MOIST, SLIGHT COHESION.
6	9	SAND/SILTY SAND: LIGHT BROWN-TAN, MEDIUM GRAINED.
58		SANDY CLAY: BROWN, MOIST, SLIGHT COHESION.
32		SAME: DARK BROWN.
52		SAME: GREY-BROWN.
51		SAME: BROWN.
98		CLAY: BROWN, MOIST, COHESIVE.
42	11	SILTY SAND/CLAYEY SAND: BROWN, MOIST, FINE GRAINED SAND.
76		SANDY CLAY: BROWN, MOIST, COHESIVE.
76	8	
41	26	SILTY SAND/CLAYEY SAND: BROWN, MOIST, FINE GRAINED SAND.
10	21	SAND/SILTY SAND: BROWN, MOIST, MEDIUM GRAINED SAND.

TH83-1803

EL. [illegible]

-4	-200	N	DESCRIPTION
[illegible]	21		SAND [illegible] SAND: BROWN, MOIST.
[illegible]	[illegible]		SAND/SILTY SAND: TAN, DRY, MEDIUM GRAINED SAND.
[illegible]	55	1[illegible]	
[illegible]	55		SANDY SILT: BROWN, MOIST, COHESIVE, FINE GRAINED SAND.
	[illegible]	9	SAND: LIGHT BROWN, MOIST, NON-COHESIVE, MEDIUM GRAINED SAND.
[illegible]	[illegible]	[illegible]	SAND/SILTY SAND: GRAY, MOIST, NON-COHESIVE, FINE GRAINED SAND.
[illegible]	4	[illegible]	SAND: GRAY, [illegible], NON-COHESIVE, MEDIUM GRAINED SAND.
[illegible]	79		SANDY CLAY: BROWN-GREY, MOIST, COHESIVE.
	86	22	CLAY: DARK BROWN.
[illegible]	85	17	SAME: BROWN.
[illegible]	74		SANDY CLAY: BROWN.
[illegible]	90		CLAY: BROWN-GREY.
[illegible]	55	1[illegible]	SANDY CLAY: [illegible], MOIST.
[illegible]	96		
[illegible]	77	11	SANDY CLAY: DARK BROWN, MOIST, SLIGHTLY PLASTIC.
[illegible]	95	11	SILTY SAND: BROWN, MOIST, SLIGHTLY COHESIVE.
[illegible]	94		CLAY: BROWN, MOIST, COHESIVE, SLIGHTLY PLASTIC.
[illegible]	96		SILT: BROWN, MOIST, COHESIVE, SLIGHTLY PLASTIC.
[illegible]	[illegible]		SANDY SILT/SANDY CLAY: BROWN, MOIST, COHESIVE.
[illegible]	90		CLAY: BROWN-GREY, MOIST, COHESIVE, PLASTIC.

TH83-1801

TH83-1801 STA 574+00 L EL. 114±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	2		NP	90	17		SILTY SAND: GREY, DRY, SOME ORGANIC MATERIAL, GRAVEL TO 3 INCHES, COARSE GRAINED SAND.
2.5							18	
	SC	9	28	9	100	42	11	CLAYEY SAND: BROWN, MOIST, NON-COHESIVE, FINE GRAINED SAND.
		16	29	9	100	42		
6.0								
	MH	29	63	13	100	84		SANDY SILT: BROWN, MOIST, COHESIVE.
10.0								
	ML/CL	20	25	5	100	72		SANDY SILT/SANDY CLAY: BROWN, MOIST, NON-COHESIVE.
12.0	CL	23	33	11	100	67		SANDY CLAY: BROWN, MOIST, SLIGHTLY COHESIVE.
13.0	SM	23		NP	100	29		SILTY SAND: BROWN-GREY, MOIST, NON-COHESIVE.
15.0		31	33	8	100	62		SANDY SILT: BROWN, MOIST, COHESIVE.
		26	33	8	100	52		SAME: BROWN-GREY.
	ML	38	33	8	100	62		SAME: GREY.
		29	39	11	100	96		SILT: BROWN-GREY.
23.0								

TH83-1804

TH83-1804 STA 561+00 L EL. 112±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SC	8	32	10	98	40		CLAYEY SAND: LIGHT BROWN, DAMP, FINE GRAINED SAND. ROOTS AND GLASS FIRST 5 INCHES.
		13	41	21	100	65	18	SANDY CLAY: BROWN, MOIST, SLIGHTLY COHESIVE, FINE GRAINED.
	CL	21	38	17	100	77	11	SAME: DARK BROWN AND LIGHT BROWN LENS.
4.5								
	MH	32	55	25	100	90		SILT: BROWN, MOIST, SLIGHTLY COHESIVE.
7.0		15	30	5	100	77		SNDY SILT: LGT BRN, MOIST, FINE GRAINED SND, SLIGHTLY COH.
	ML	19		NP	100	70		SAME: BROWN.
10.0	[illegible]	26	30	9	100	70		SANDY CLAY: BROWN-GREY, COHESIVE, FINE GRAINED SAND.
11.0								SILTY SAND: BROWN, MOIST, NON-COHESIVE.
	SM	16		NP	100	38	16	
14.5	CL	30	30	10	100	83		SANDY CLAY: BROWN, MOIST, COHESIVE.
W 16.0	SM	25	25	4	100	37		SILTY SAND: GREY, WET, COHESIVE.
19.0	ML	38	35	10	100	72		SANDY SILT: BROWN-GREY, SLIGHTLY COHESIVE.
20.0								

SCALE 1 IN = 3 FT

5 0 5 10

NOTES.

1. SEE PLATE 18 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT"

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS

CORPS OF ENGINEERS

STA.574+00 TO STA.553+00

SUBMITTED BY DATE SHEET

VALUE ENGINEERING F

TH83-1805

TH83-1805 STA 548+50 L EL. 106±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	ML/CL	14	29	7	100	54		SANDY SILT/SANDY CLAY: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, ORGANIC MATERIAL.
							8	
4.0							8	
	CH	24	54	30	100	83		SANDY CLAY: DARK BROWN, MOIST, SLIGHTLY PLASTIC.
6.0								
		22	48	24	100	79		SANDY CLAY: DARK BROWN, MOIST, SLIGHTLY PLASTIC.
		13	48	24	100	70		SAME: LIGHT BROWN, MOIST, FINE GRAINED SAND.
		12	31	12	100	73		
							12	
		18	45	26	100	85		CLAY: GREY-BROWN, MOIST, SLIGHTLY COHESIVE.
	CL							SANDY CLAY: GREY-BROWN, MOIST, SLIGHTLY COHESIVE.
							21	
		17	37	19	100	76		
							13	
		23	32	10	100	69		
		24	32	9	100	65		
19.5							9	
W 20.0	SC	17	25	8	100	48		CLAYEY SAND: BROWN-GREY, MOIST, COHESIVE.
21.0	SM	17		NP	93	14		SILTY SAND: BROWN, WET, SOME GRAVEL 1 INCH.
22.0							10	
22.5	SP/SM	15		NP	71	11		GRAV SND/SLTY GRV SND: GRAY, WET, GRAVEL 2" MAX. DIAMETER.
	ML	28		NP	100	50		SANDY SILT: BROWN, WET, SLIGHTLY COHESIVE, MEDIUM GRAINED SAND.
24.0								
25.0	SP/SM	22	29	2	93	11	19	SAND/SILTY SAND: BROWN, WET, MEDIUM GRAINED SAND.
	SM	21		NP	100	34		SILTY SAND: DARK GREY, WET, FINE GRAINED SAND.
		22		NP	100	40		SAME: BROWN.
27.5								

TH83-1806

TH83-1806 STA 540+00 R EL. 108±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	4		NP	98	14		SILTY SAND: LIGHT BROWN, MOIST, NON-CO
3.5							38	
	ML	22	41	14	100	69	12	SANDY SILT: BROWN, MOIST, SLIGHTLY COH
6.0								
7.0	SM	8		NP	99	31		SILTY SAND: LIGHT BROWN, MOIST, NON-CO
							8	
	CL	21	36	16	100	70		SANDY CLAY: BROWN-RUST, MOIST, COHESIV
9.5								
10.5	SM	4		NP	97	17	31	SILTY SAND: BROWN, FINE GRAINED SAND.
11.5	SP/SM	2		NP	70	5		GRAVELLY SAND/SILTY GRAVELLY SAND: LIG GRAINED SAND.
13.0	CL	27	40	22	100	61		SANDY CLAY: DARK BROWN, MOIST, SLIGHTL COHESIVE.
							9	
	SM	8		NP	99	23		SILTY SAND: DARK BROWN, MOIST, SLIGHTL COHESIVE.
14.5		7		NP	94	13		
15.5	CL	23	34	12	100	87		CLAY: DARK BROWN, MOIST, COHESIVE.
17.0	ML	24	46	12	100	86		SILTY: DARK BROWN, MOIST, COHESIVE.
		24	44	23	100	77		SANDY CLAY: DARK BROWN-GREY, MOIST, C
	CL						12	
		24	43	20	100	79		
22.0								
	SM	19		NP	100	48		SILTY SAND: BROWN-GREY, WET, SLIGHTLY
24.0								
							9	SILT: DARK BROWN, WET, COHESIVE.
W 26.0	MH	33	69	21	100	99		
28.0								
	CL	29	42	19	100	78		SANDY CLAY: DARK GREY-BROWN, WET, COH
30.0								

NOTES

1

2

3

4

VALUE ENGINEERING PAYS

TH83-1806

STA 540+00 R — EL. 108±

LL	PI	-4	-200	N	DESCRIPTION
	NP	98	14	38	SILTY SAND: LIGHT BROWN, MOIST, NON-COHESIVE.
41	14	100	69	12	SANDY SILT: BROWN, MOIST, SLIGHTLY COHESIVE.
	NP	99	31		SILTY SAND: LIGHT BROWN, MOIST, NON-COHESIVE.
36	16	100	70	8	SANDY CLAY: BROWN-RUST, MOIST, COHESIVE.
	NP	97	17	31	SILTY SAND: BROWN, FINE GRAINED SAND.
	NP	70	5		GRAVELLY SAND/SILTY GRAVELLY SAND: LIGHT BROWN, COARSE GRAINED SAND.
40	22	100	61	9	SANDY CLAY: DARK BROWN, MOIST, SLIGHTLY COHESIVE TO NON-COHESIVE.
	NP	99	23		SILTY SAND: DARK BROWN, MOIST, SLIGHTLY COHESIVE TO NON-COHESIVE.
	NP	94	15		
34	12	100	87		CLAY: DARK BROWN, MOIST, COHESIVE.
46	12	100	36		SILTY: DARK BROWN, MOIST, COHESIVE.
44	23	100	77		SANDY CLAY: DARK BROWN-GREY, MOIST, COHESIVE.
43	20	100	79	12	
	NP	100	48		SILTY SAND: BROWN-GREY, WET, SLIGHTLY COHESIVE.
69	21	100	39	9	SILT: DARK BROWN, WET, COHESIVE.
42	15	100	79		SANDY CLAY: DARK GREY-BROWN, WET, COHESIVE, PLASTIC.

TH83-1811

TH83-1811 — STA 535+00 L — EL. 102±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SM	8		NP	100	26		SILTY SAND: BROWN, MOIST, NON-COHESIVE, MEDIUM GRAINED SAND, ORGANIC MATERIAL.
	SP/SM	6		NP	100	10	16	SAND/SILTY SAND: GREY, MOIST, MEDIUM GRAINED SAND, NON-COHESIVE.
4.0							24	
		4			90	3		SAND: GRAY, MOIST, COARSE GRAINED SAND.
	SP						18	SAME: GRAVEL 1/2 INCHES DIAMETER.
		4			100	4		
10.0							29	
		19	48	27	100	84		SANDY CLAY: BROWN, MOIST, SLIGHTLY COHESIVE.
								SAME: GREY-BROWN, COHESIVE.
		27					12	
W 15.5								
		25						SAME: DARK BROWN.
	CL	26						SAME: BROWN.
							13	
		25	32	9	100	55		
		32	42	18	100	30		SAME: DARK BROWN, WET.
							7	CLAY: DARK GREY, WET, COHESIVE.
		32	34	17	100	88		
26.0		33	39	17	100	88	10	

SCALE: 1 IN = 3 FT

5 0 5 10

NOTES

1. SEE PLATE 18 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
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SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.548+50 TO STA.535+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____-B-____ SHEET

DISTRICT FILE NO.

VALUE ENGINEERING

TH83-1808

TH83-1808 STA 531+00 R EL. 105±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		3			98	4	18	SAND: TAN, DRY TO MOIST, MEDIUM GRAINED SAND, NON-COHESIVE.
		3			98	4	5	SAME: MOIST.
6.0 / 5.5	SM	10		NP	100	35		SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND.
	SP	8			99	4	7	SAND: TAN, MOIST, FINE TO MED. GRAINED SAND, NON-COHESIVE.
9.0								
	SC	20	46	25	100	50	17	CLAYEY SAND: DARK BROWN, MOIST, FIRM.
10.5								
	SM	5		NP	100	19		SILTY SAND: GREY, MOIST, SLIGHTLY COHESIVE.
13.0							10	
14.0	CL	14	31	15	100	53		SANDY CLAY: DARK BROWN, MOIST, SOME COHESION.
	SM/SC	14 / 11	24	7	100	42		SILTY SAND/CLAYEY SAND: DARK BROWN, MOIST, SOME COHESION.
								SAME: BROWN, WET.
16.5							9	
		25	41	24	100	91		SANDY CLAY: BROWN, WET, PLASTIC ORGANIC MATERIAL.
	CL	25					11	SAME: GREY-DARK BROWN.
		25						
22.0								
							9	SANDY SILT: BROWN-GREY, WET, PLASTIC.
	ML	23	55	4	100	56		
							9	
27.0								
	CL	27	29	14	100	57		SANDY CLAY: BLUE-GREY, WET, PLASTIC.
29.2	SM	21		NP	100	38		SILTY SAND: GREY, WET, PLASTIC.
30.0								

TH83-1809

TH83-1809 STA 524+50 R EL. 103±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		5		NP	95	23	38	SILTY SAND: BROWN, MOIST, COBBLES T
	SM	9		NP	100	25		SAME: FINE GRAINED SAND.
							13	
		8		NP	100	26		SAME: LIGHT BROWN.
6.5 / 7.0	SP/SM			NP	100	6		SAND/SILTY SAND: LIGHT BROWN, MOIST
							9	
8.0	SM	13		NP	100	33		SILTY SAND: DARK BROWN, MOIST, SOME
	ML	32	48	19	100	72		SANDY SILT: DARK BROWN, MOIST, COHE
10.5							8	
		12	26	3	100	40		CLAYEY SAND: DARK BROWN, MOIST, COH
	SC							
		17					10	
15.5 / 15.0	ML	34	42	16	100	75		SANDY SILT: GREY-BROWN, MOIST, COHE
	SM/SC	23	27	6	100	33	9	SILTY SAND/CLAYEY SAND: DARK BROWN.
17.0								
	ML/CL	28	27	6	110	78		SANDY SILT/SANDY CLAY: DARK GREY, W
18.5								
							8	SANDY CLAY: BROWN, WET, SLIGHTLY PL
		26	32	15	100	78		
							8	
		27	45	25	100	72		SAME: DARK GREY, WET, PLASTIC.
	CL							
		30					10	
		37						
30.0								

LUE ENGINEERING PAYS

TH83-1809

STA 524+50 R — EL. 103±

PI	-4	-200	N	DESCRIPTION
NP	95	23	38	SILTY SAND: BROWN, MOIST, COBBLES TO 4 INCHES.
NP	100	25	13	SAME: FINE GRAINED SAND.
NP	100	26		SAME: LIGHT BROWN.
NP	100	5	9	SANDY/SILTY SAND: LIGHT BROWN, MOIST, COARSE GRAINED SAND.
NP	100	33		SILTY SAND: DARK BROWN, MOIST, SOME COHESION.
19	100	72	9	SANDY SILT: DARK BROWN, MOIST, COHESION.
3	100	40	[illegible]	CLAYEY SAND: DARK BROWN, MOIST, COHESIVE.
16	100	75		SANDY SILT: GREY-BROWN, MOIST, COHESIVE.
6	100	33	9	SILTY SAND/CLAYEY SAND: DARK BROWN, WET, COHESIVE.
6	110	79		SANDY SILT/SANDY CLAY: DARK GREY, WET, PLASTIC.
15	100	78	8	SANDY CLAY: BROWN, WET, SLIGHTLY PLASTIC.
25	100	72	9	SAME: DARK GREY, WET, PLASTIC.
			[illegible]	

TH83-1810

TH83-1810 — STA 522+50 L — EL. 102±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
				NP	96	23		SILTY SAND: BROWN, SLIGHTLY MOIST.
				NP	99	16		SAME: LIGHT BROWN, NON-COHESION.
	SM	5		NP	95	22	6	SAME: BROKEN A/C AND CONCRETE, MOIST.
		5		NP	96	17	10	SAME: GRAVEL TO 2 INCHES.
8.0								
	CL	29	38	20	100	86		CLAY: DARK BROWN-GREY, MOIST, COHESIVE.
10.0							8	
11.0	SM	22		NP	100	43		SILTY SAND: DARK BROWN, MOIST, COHESIVE.
		20		NP	100	51		SANDY SILT: DARK GREY, MOIST, COHESIVE.
		19						SAME: DARK BROWN.
	ML	23	32	5	100	72		SAME: DARK GREY.
		31	47	13	100	78		
21.0								
		31	45	24	100	76		SANDY CLAY: GRAY, WET.
	CL	34						
29.0								

SCALE 1 IN=3 FT

5 0 5 10

NOTES

1. SEE PLATE 18 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
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SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

CHECKED BY:

STA.531+00 TO STA.522+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____-B-____ SHEET

MT78-4

MOORE & TABER CONSULTING ENGINEERS AND GEOLOGISTS

TEST BORING LOG

TYPE 16" Bucket Auger | ELEVATION 113.0 | BORING 4

Dry density	Moisture	Blows/foot	Sample size	Sample no.	Depth (feet)	USCS	Description
96	11.1	1	2.5	1	5	SM	Brown fine SILTY SAND . . . SILT lenses
	N.R.	1	2.5	2	10	SP	Light brown fine to medium SAND
						ML	Dark brown SANDY SILT with CLAY
110	17.5	3	2.5	3	15	MH	Gray-green CLAYEY SILT with oxidation streaks . . . less CLAY - some fine SAND
101	24.1	1	2.5	4	20		. . . changing to reddish color . . . SAND seams . . . more CLAY . . . less CLAY
98	26.3	2	2.5	5	25	SM	Green-brown fine SILTY SAND
						ML	Green-brown fine SANDY SILT
9[illegible]	31.8	1	2.5	6	30	ML	Green-brown CLAYEY SILT

Approximate Invert Elevation 98

NOTES:
1) No caving
2) Groundwater at 23 feet 17 hours after drilling.

THIS BORING LOG SUMMARY APPLIES ONLY AT THE TIME AND LOCATION INDICATED. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND TIMES.

LOGGED BY [illegible] DATE [illegible]

MT78-5

MOORE & TABER CONSULTING ENGINEERS AND GEOLOGISTS

TEST BORING LOG

TYPE 16" Bucket Auger | ELEVATION [illegible] | BORING 5

Dry density	Moisture	Blows/foot	Sample size	Sample no.	Depth (feet)	USCS	Description
						SM	Brown fine to medium SILTY SAND with GRAVEL and COBBLES - Fill . . . large concrete fragments . . . decomposed wood - tar
88	27.2	[illegible]	2.5	1	5	SM	Light brown fine SILTY SAND
						ML	Brown [illegible]
						SM	Gray-brown fine SILTY SAND
92	22.0	2	2.5 Bag	2 3	10	ML	[illegible] SANDY SILT with CLAY
103	24.5	4	2.5 Bag	4 5	15	[illegible]	[illegible] CLAY
96	28.5	[illegible]	2.5	6	20	ML	[illegible] SILT [illegible] fine SAND
103	[illegible]	[illegible]	2.5	[illegible]	25	ML	[illegible] with CLAY

Approx. Invert Elevation

[illegible] at 24.5'

THIS BORING LOG SUMMARY APPLIES ONLY AT THE TIME AND LOCATION INDICATED. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND TIMES.

LOGGED BY [illegible] DATE [illegible]

GC71-37

BORING No. 37 STATION 253 + 91 W.O. 22 164 DRILL DATE [illegible]

SURFACE ELEVATION [illegible] DRIVING WEIGHT 1500 lb. [illegible]

Bucket Auger, 16 inch diameter

Depth feet	Description	Group symbol USCS	Pene. resist. blows/foot	Core / Bag	Dry density pcf	Moisture content %	Relative compaction
0	[illegible] SM, brown, moist, [illegible]	SM					
	[illegible] SP, tan, moist, medium dense.	SP					
5	[illegible] SM, brown, moist, [illegible]	SM	[illegible]	1	107	[illegible]	[illegible]
	[illegible] ML, brown, moist, firm	ML					
10	[illegible] SM, brown, moist, medium dense.	SM					
15			1	2	[illegible]	[illegible]	[illegible]
	SANDY SILT, ML, brown, moist, firm.	ML					
20	SILTY SAND, SM, brown, moist, medium dense.	SM					
25							
30							

BORING No. 38 STAT[illegible]

SURFACE ELEVATION [illegible]

Depth feet	Description
5	[illegible]
10	[illegible]
15	[illegible]
20	
25	
30	

VALUE ENGINEERING PAYS

MT78-6

MOORE & TABER CONSULTING ENGINEERS AND GEOLOGISTS

TEST BORING LOG

TYPE 16" Bucket Auger — ELEVATION — BORING 6

Depth	Description
	Fine to medium SAND
	Brown CLAYEY SILT; some fine SAND; less CLAY; changing to reddish-brown color; more CLAY; changing to greenish-brown color; less CLAY
	SANDY SILT WITH CLAY

Appr. Water Elevation

NOTES:

THIS BORING LOG SUMMARY APPLIES ONLY AT THE TIME AND LOCATION INDICATED. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND TIMES

LOGGED BY — DATE —

GC71-36

BORING No. 36 STATION 276 + 18 W.O. 22-164 DRILL DATE 3/11/71

SURFACE ELEVATION 101 DRIVING WEIGHT 150 lb., 18 in.

Bucket auger: 16 inch diameter

Depth (ft)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core / Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	SILTY SAND: SM; brown, moist, medium dense.	SM					
	SAND: SP; tan, moist, medium dense.						
5		SP	1	(1)	107.0	2.6	92
10			2	(2)	-	-	
	SILTY SAND: SM; brown, moist, medium dense.	SM					
15	SANDY SILT: ML; brown, moist, firm.	ML					
	SILTY SAND: SM; brown, moist, medium dense.	SM					
20							
25							
30							

GC71-38

BORING No. 38 STATION — W.O. 22-164 DRILL DATE —

SURFACE ELEVATION — DRIVING WEIGHT — 18 in.

Depth (ft)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core / Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	SILTY SAND: SM; tan to ..., medium dense.	SM					
	SAND: SP; tan to gray, medium grained, moist, medium dense.	SP					
10	[illegible]	SM					
	SAND: SP; tan to gray, medium grained, moist, medium dense.	SP	1	(1)			
15	SANDY CLAY: CL; brown, moist, firm to stiff.	CL					
25			2	(2)	86.5	21.9	78
30							

NOTES:

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2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

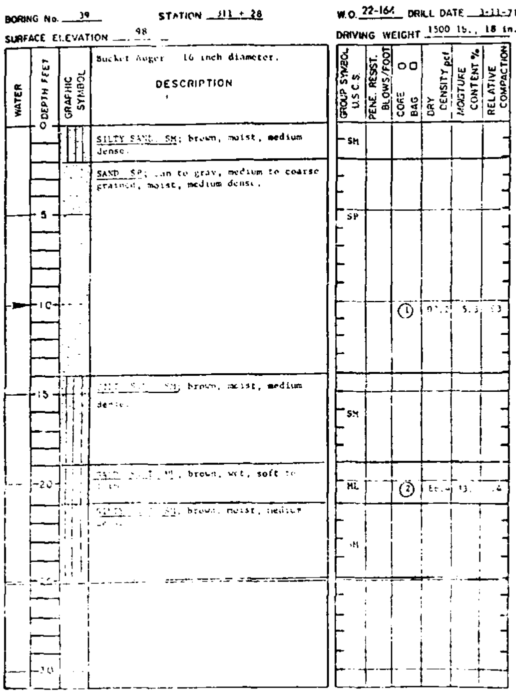
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION BY OTHERS

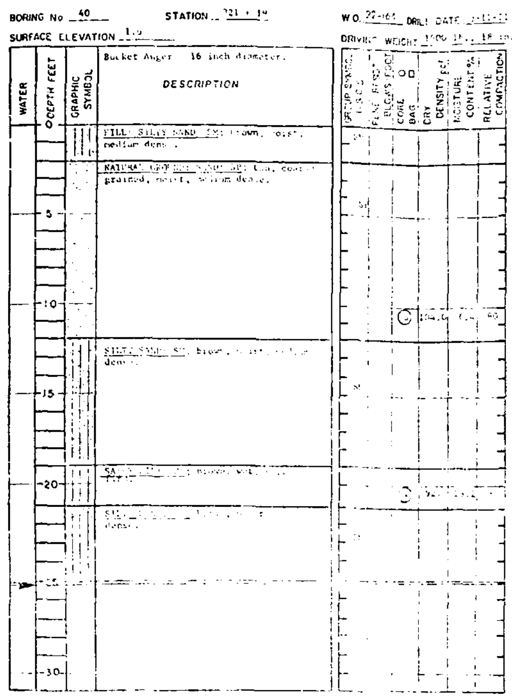
STA.585+00 TO STA.520+00

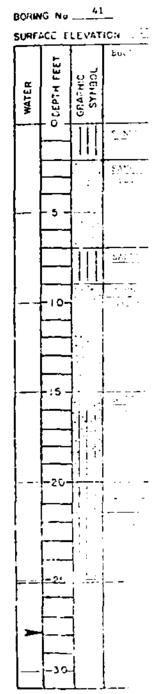
SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW 09-___-B-____ SHEET

GC71-39

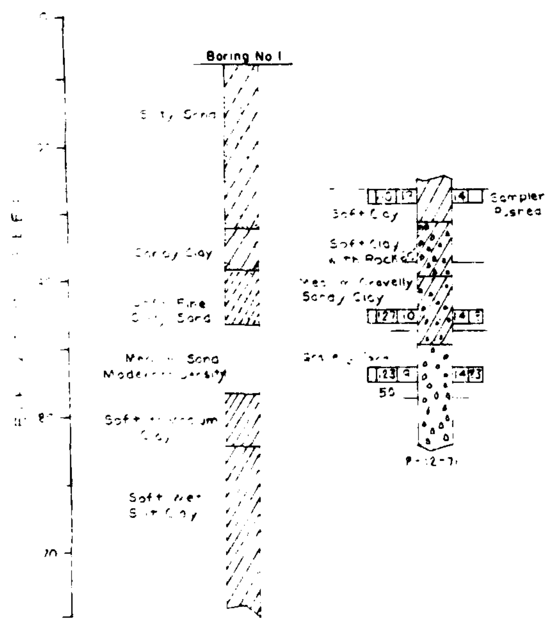


GC71-40

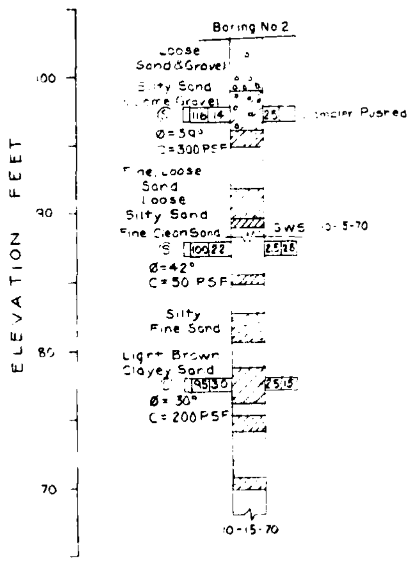


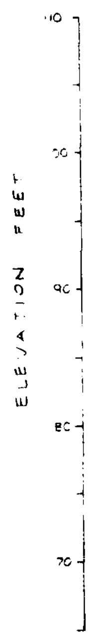


OC 71-1

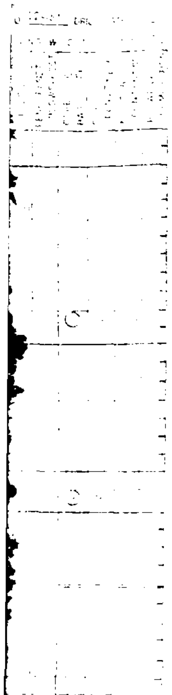


OC 71-2





VALUE ENGINEERING PAYS



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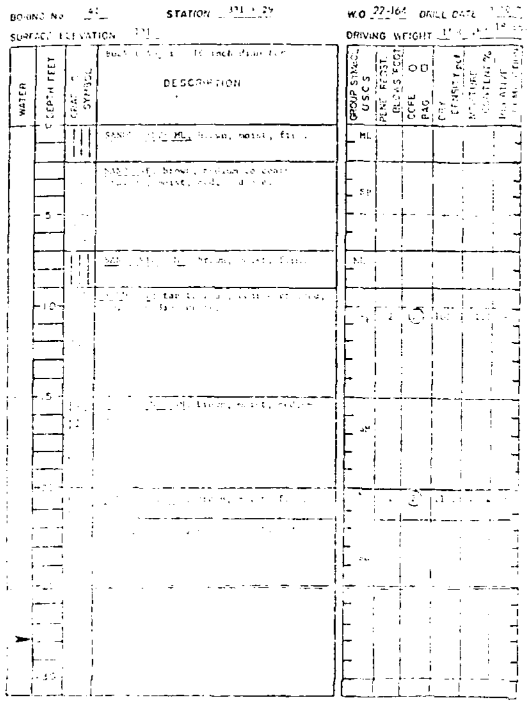
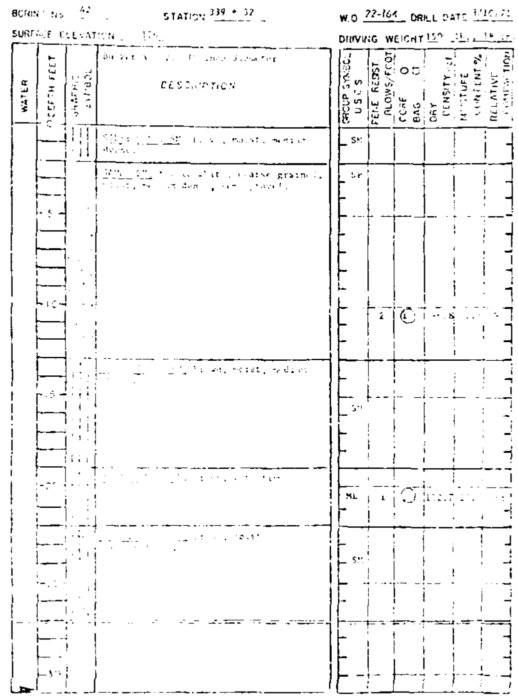
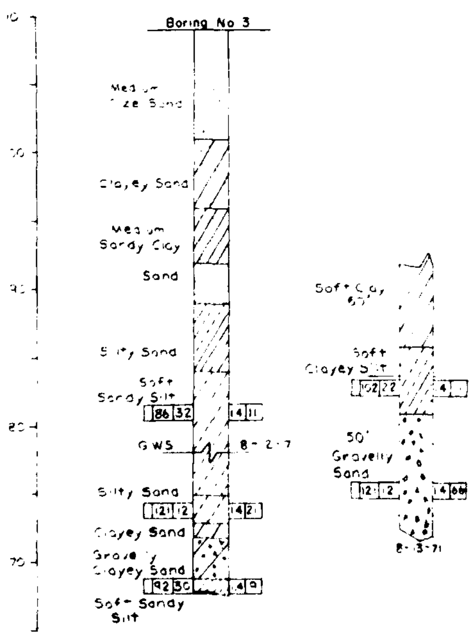


GC71-42



OC71-3



NOTES

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3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

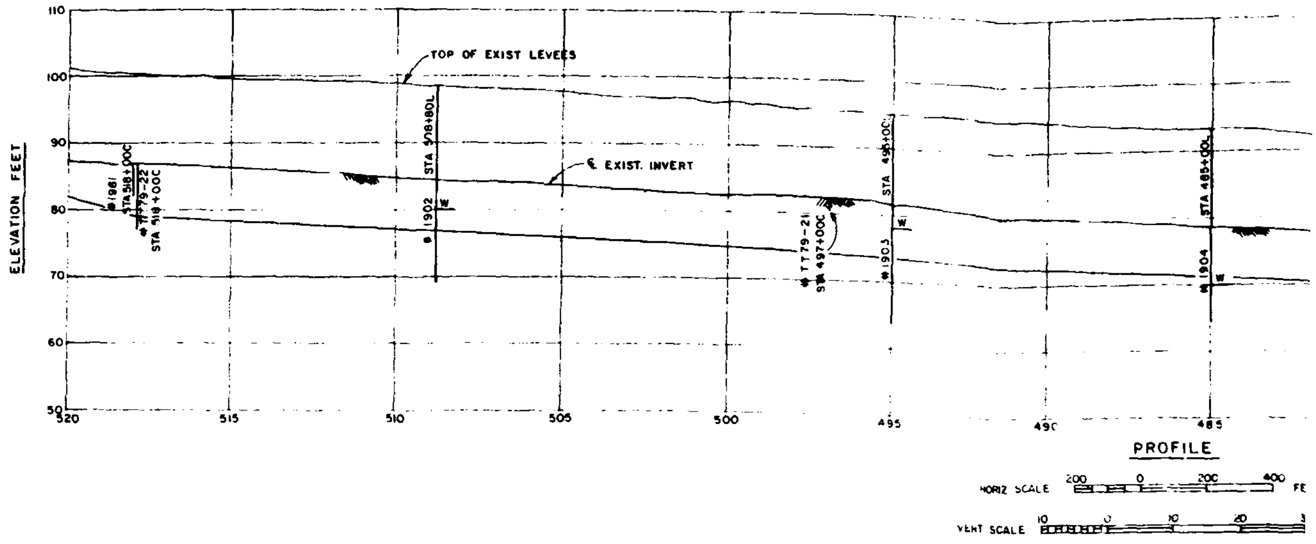
DESIGNED BY
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

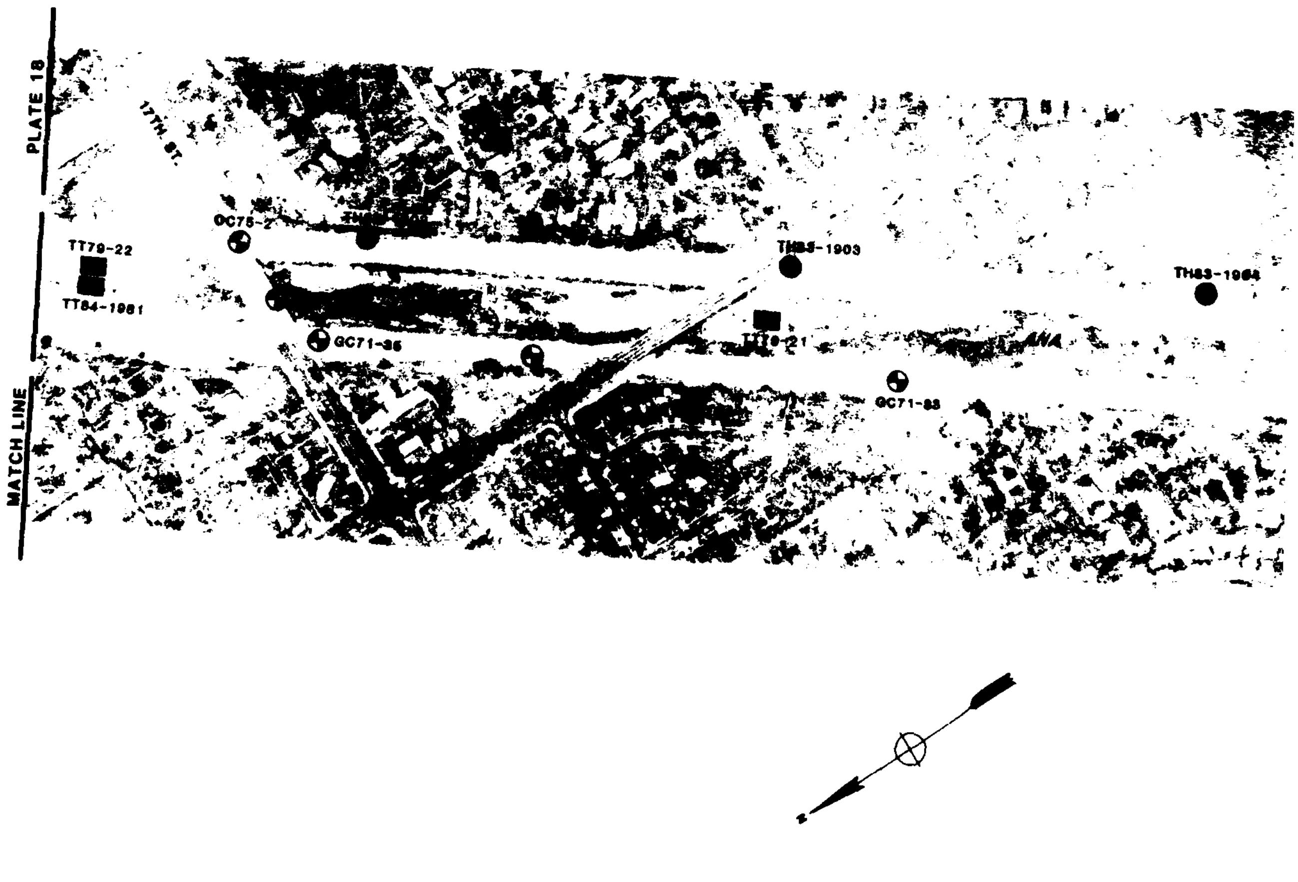
DRAWN BY
LOGS OF INVESTIGATION
BY OTHERS

CHECKED BY
STA.585+00 TO STA.520+00

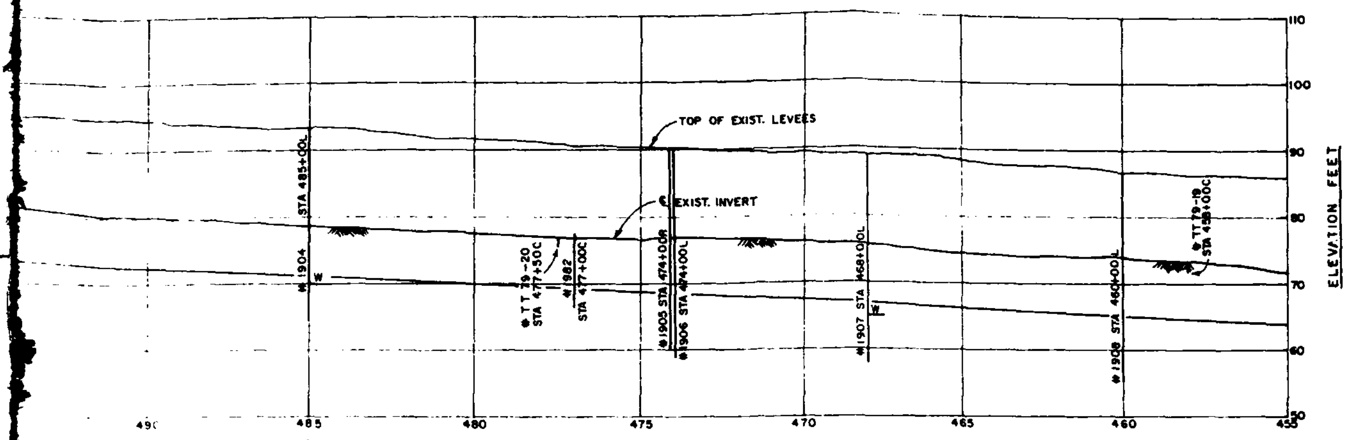
SUBMITTED BY: DATE SHEET

VALUE ENGINEERING





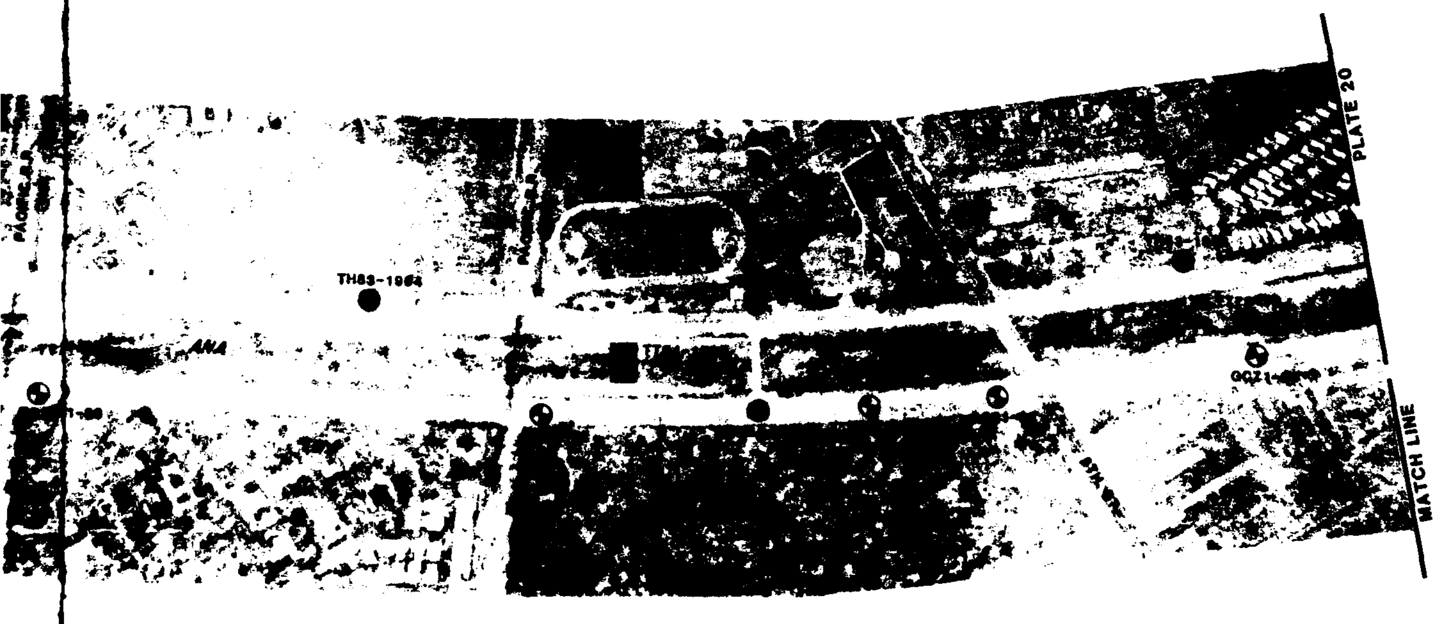
VALUE ENGINEERING PAYS



PROFILE

HORIZ SCALE 200 0 200 400 FEET

VERT SCALE 10 0 10 20 30 FEET



NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

PLAN AND PROFILE

CHECKED BY:

STA.520+00 TO STA.455+00

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-____-B-____ | SHEET

INVERT

TT84-1981

TT84-1981 STA 518+00 C EL. 87±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP/SM			NP	100	9		SAND/SILTY SAND: LIGHT BROWN, MOIST TO WET, FINE GRAINED SAND.
3.0	SM		36	3	100	43		SILTY SAND: GREY BLACK, MOIST TO WET, FINE GRAINED SAND, SOME ORGANIC MATERIAL.
4.0	SP				92	4		SAND: LT BRN-GREY, MOIST TO WET, FINE TO MED. GRAINED SAND SOME GRAVEL 1/8-3 INCHES, SOME COBBLES TO 8 INCHES.
5.0								

INVERT

TT79-22

TT79-22 STA 518+00 C EL. 87

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIP
	SP	4			59	3		GRAVELLY SAND: GREY, MOIST, OCCASIONAL BOULDERS TO 24-IN
2.0		32	44	22	100	86		SANDY CLAY: BROWN, WET, COH
	CL	26	31	13	100	57		
		27	31	12	100	58		SAME: BROWN, WET, COHESIVE.
10.0								

TH83-1903

TH83-1903 STA 495+00 L EL. 95±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	3		NP	91	23		SILTY SAND: LIGHT BROWN, MOIST, GRAVEL TO 2", 1/8 INCH COBBLE.
2.6							32	
	SW/SM	3		NP	96	17		SAND/SILTY SAND: LIGHT BROWN, MOIST, GRAVEL TO 1 INCH.
5.0		7		NP	99	28		SILTY SAND. LIGHT BROWN, MOIST, SOME GRAVEL TO 1 INCH.
		7		NP	100	31		SAME: GREY, FINE GRAINED SAND.
	SM	7		NP	98	13		SAME: LIGHT BROWN, MOIST.
		9		NP	99	25	20	SAME: BROWN-RUST. FINE TO MEDIUM GRAINED SAND.
10.0								
11.0	SC	23	42	13	100	44		CLAYEY SAND: GREY, MOIST.
	SM	4		NP	97	25		SILTY SAND: BROWN, MOIST.
12.5				NP	99	5	10	SAND/SILTY SAND: GREY, MOIST, FINE TO MEDIUM GRAINED.
	SP/SM							SAME: COARSER GRAIN, SOME GRAVEL, RUST STAIN TO 2 INCHES.
		3		NP	97	5		
16.0							19	
17.0	SP	4			99	4		SAND: GREY, MOIST, COARSE GRAINED SAND, SOME GRAVEL.
18.0								
	SP/SM	14		NP	99	6	13	SAND/SILTY SAND: GREY-BROWN, WET, MEDIUM GRAINED SAND.
20.0								
	SC	26	33	15	67	37		CLAYEY GRAVELLY SAND: GREY, WET, COHESIVE.
22.0							8	
	SW/SC		33	17	91	9		SAND/CLAYEY SAND: GREY, NON-COHESIVE, GRAVEL TO 3 INCHES.
25.5							4	
	ML	32	45	19	99	65		SANDY SILT: DARK GREY, COHESIVE, NO GRAVEL.
28.0	SP/SM			NP	98	6	16	SAND/SILTY SAND: GREY-BROWN, FINE GRAINED SAND, NON-COHESIVE.
29.0	CL	28	45	25	100	59		SANDY CLAY: GREY, COHESIVE.
31.0								

TH83-1904

TH83-1304 STA [illegible] EL. 93±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		2		NP	[illegible]	8		SAND/SILTY SAND: LIGHT GREY, MOIST GRAVEL TO 1-1/2 INCHES, COBBLES TO
	SW/SM	3		NP	[illegible]	3		
		2		NP	[illegible]	8		SAME: LIGHT BROWN, GRAVEL TO 3 INC
		4		NP	[illegible]	11		
4.5							30	
	SM	2		NP	[illegible]	17		SILTY SAND: DARK BROWN, MOIST, FIN GRAINED SAND, GRAVEL TO 3/4 INCHES.
6.0								
		9	33	[illegible]	[illegible]	42	27	SAND/SILTY SAND: BROWN, MOIST, [illegible] SAND.
	SM							
		[illegible]	33		[illegible]	42		SAME: SOME ORGANIC MATERIAL.
10.5							10	
	SP/SM	4		NP	[illegible]	3		SAND/SILTY SAND: LIGHT BROWN, MOIS[illegible] ORGANIC MATERIAL, GRAVEL 3/4 INCHES
12.0								
	SP	5			[illegible]	2	16	SAND: BROWN-GREY-RUST, MOIST, MED[illegible] SAND.
13.5								
	SP/SM	5		NP	[illegible]	7		SAND/SILTY SAND: LIGHT BROWN, MOIS[illegible] TO 2 INCHES.
16.0							13	
	SC	24	[illegible]	[illegible]	[illegible]	20		CLAYEY SAND: BROWN, MOIST, SOME
18.0								
	CL	28	[illegible]	[illegible]	[illegible]	69	5	SANDY SILT: DARK BROWN, MOIST,
20.0								
		25	44	[illegible]	[illegible]	59		SANDY CLAY, DARK BROWN,
[illegible]	CL	37	44	[illegible]	[illegible]	30		CLAY: WET.
25.0								
	ML	30		NP	[illegible]	74		SANDY SILT: DARK BROWN, WET, COH
28.0	CL	31	[illegible]	[illegible]	[illegible]	[illegible]		SANDY CLAY: DARK BROWN, WET, COHE
29.0								

VALUE ENGINEERING PAYS

TT79-22

STA 513+00 C — EL. 87±

MC	LL	PI	-4	-200	N	DESCRIPTION
			59	3		GRAVELLY SAND: GREY, MOIST, ORGANIC ODOR, VEGETATION, OCCASIONAL BOULDERS TO 24-INCH.
	44	22	100	56		SANDY CLAY. BROWN, WET, COHESIVE.
	31	13	100	57		
	31	12	100	58		SAME: BROWN, WET, COHESIVE, GROUNDWATER ENCOUNTERED.

TH83-1902

TH83-1902 STA 508+80 L — EL. 98±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM	3		NP	91	12	5	SAND/SILTY SAND: LIGHT BROWN, MOIST, NON-COHESIVE, SOME COBBLES 4 INCHES.
3.0		2		NP	96	7		SAME: MEDIUM GRAINED SAND, GRAVEL TO 1 INCH.
4.0	ML	17		NP	100	53		SANDY SILTY: DARK BROWN, MOIST, SOME COHESIVE.
		9		NP	96	37	7	SILTY SAND: BROWN, MOIST, FINE GRAINED SAND.
	SM	4		NP	99	14	8	SAME: LIGHT BROWN-GREY, NON-COHESIVE.
10.0	SP/SM			NP	99	7		SAND/SILTY SAND: LIGHT BROWN-GREY, NON-COHESIVE.
13.0 / 13.5	ML	25	34	10	98	51	10	SANDY SILT: DARK BROWN, MOIST, COHESIVE.
15.0	SW/SM	15		NP	99	12		SAND/SILTY SAND: BROWN, WET, SOME COHESION.
16.0	SC	21	24	19	100	39		CLAYEY SAND: DARK GREY-BROWN, WET, COHESIVE.
W 17.5	SM	18		NP	100	32	11	SILTY SAND: DARK BROWN, WET, COHESIVE.
18.5		29		NP	100	76		SANDY SILT: BROWN, WET, COHESIVE, PLASTIC.
	ML	30		NP	100	76	3	
23.0	CL	30	35	13	100	75	3	SANDY CLAY: BROWN-RUST, WET, COHESIVE, PLASTIC.
26.0		28		NP	100	76		SANDY SILT: BROWN-RUST, WET, COHESIVE, PLASTIC.
	ML	34		NP	100	76		
30.0								

TH83-1904

STA 485+00 L — EL. 93±

PI	-4	-200	N	DESCRIPTION
NP	94	3		SAND/[illegible] SAND: LIGHT GREY, MOIST, MEDIUM GRAINED SAND, [illegible] COBBLES TO 5 INCHES.
NP	94	2		
NP	94	3		
NP	97	11	12	SAME: LIGHT BROWN, GRAVEL TO 3 INCHES.
NP	98	17		[illegible] SAND: DARK BROWN, MOIST, FINE TO MEDIUM GRAINED GRAINED SAND, GRAVEL TO 3/4 INCHES.
[illegible]	100	42	[illegible]	SAND/SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND.
[illegible]	100	42	1[illegible]	SAME: SOME ORGANIC MATERIAL.
NP	97	3		SAND/SILTY SAND: LIGHT BROWN, MOIST, MEDIUM GRAINED SAND, ORGANIC MATERIAL, GRAVEL 3/4 INCHES.
	95	7	16	SAND: BROWN-GREY-RUST, MOIST, MEDIUM TO COARSE GRAINED SAND.
NP	100	7	13	SAND/SILTY SAND: LIGHT BROWN, MOIST, NON-COHESIVE, GRAVEL TO [illegible] INCHES.
[illegible]	100	20		CLAYEY SAND: BROWN, MOIST, SOME COHESION, COBBLES 1-4".
[illegible]	100	69	[illegible]	SANDY SILT: DARK BROWN, MOIST, COHESIVE.
[illegible]	100	59		SANDY CLAY: DARK BROWN, MOIST, COHESIVE.
21	100	70		CLAY: WET.
NP	100	74		SANDY SILT: DARK BROWN, WET, COHESIVE.
12	100	75		SANDY CLAY: DARK BROWN, WET, COHESIVE.

INVERT — TT79-21

TT79-21 STA 497+50 C — EL. 82±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SP	1			61	1		GRAVELLY SAND: GREY, VEGETATION, GRAVEL TO 2". GROUND-WATER ENCOUNTERED.

SCALE: 1 IN=3 FT

3 0 5 10

NOTES

1. SEE PLATE 19 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 64 FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY.
DRAWN BY.
CHECKED BY.

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.518+00 TO STA.485+00

VALUE ENGINEERIN

TT79-20

INVERT

TT79-20 STA 477+50 C EL. 77±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SP	5			81	0		SAND: GREY, GRAVEL TO 1-INCH, GROUNDWATER ENCOUNTERED.

TT84-1982

INVERT

TT84-1982 STA 477+00 C EL.

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCR
	SM			NP	100	38		SILTY SAND: LIGHT GREY, COHESIVE.
3.0								
	ML		40	11	100	80		SANDY SILT: DARK BROWN,
5.0								
	CL		43	19	99	89		CLAY: DARK BROWN, MOIST.
7.0								
	CH		57	27	100	97		CLAY: DARK BROWN-GREY, COHESIVE.
10.0								

A

VALUE ENGINEERING PAYS

TT84-1982

STA [illegible] EL. 77±

[illegible]	PI	-4	-200	N	DESCRIPTION
	NP	[illegible]	[illegible]		SILTY SAND: LIGHT GREY, MOIST, FINE GRAINED SAND, COHESIVE.
[illegible]	[illegible]	[illegible]	[illegible]		SANDY SILT: DARK BROWN, MOIST, COHESIVE.
[illegible]	[illegible]	[illegible]	[illegible]		CLAY: DARK BROWN, MOIST, COHESIVE, ORGANIC MATERIAL.
[illegible]	[illegible]	[illegible]	[illegible]		CLAY: DARK BROWN-GREY, MOIST, SOME GRAVEL TO 1/2 INCHES, COHESIVE.

TH84-1905

TH84-1905 STA 474+00 R EL. 90±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP/SM	4		NP	96	6		SAND/SILTY SAND: BROWN, MOIST, LOOSE, FINE GRAINED SAND, SOME GRAVEL.
3.0								
	SM	6		NP	98	21	30	SILTY SAND: BROWN, MOIST, FINE GRAINED SAND, SOME GRAVEL.
6.0								
							17	SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND, SOME GRAVEL.
	SP/SM	5		NP	99	5		
							11	
12.0								
	ML	30	44	15	100	65	17	SANDY SILT: DARK BROWN, MOIST-WET, COHESIVE, STIFF, FINE GRAINED SAND.
15.0								
							8	SILTY SAND: BROWN, MOIST-WET, COHESIVE, FINE GRAINED SAND.
	SM			NP	99	26		
							17	
21.0								
		34	[illegible]	5	99	73	11	SANDY SILT: DARK GREEN, MOIST-WET, COHESIVE, STIFF, FINE GRAINED SAND.
	ML	34	[illegible]	7	99	71	14	SAME: DARK BROWN.
			34	9	99	73	7	
30.0								

SCALE: 1 IN.=3 FT

5 0 5 10

NOTES:

1 SEE PLATE 19 FOR LOCATION OF TEST HOLES AND TEST TRENCHES.
2 SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM.
3 SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4 ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.477+00 TO STA.474+00

SUBMITTED BY: DATE: SPEC. NO. DACW09- SHEET

TH83-1906

TH83-1906 STA 474+00 L

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SM	3		NP	92	14		SILTY SAND: LIGHT BROWN, MOIST, FINE TO MEDIUM GRAINED SAND GRAVEL TO 1-1/2 INCHES.
2.5	SP/SM	6		NP	98	12	29	SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, GRAVEL TO 3/8 INCHES.
		6		NP	99	13		SILTY SAND: LIGHT BRN, MOIST, FINE TO MED. GRAINED SAND.
	SM	6		NP	100	14	25	
6.0		11	23	1	100	40		SAME: DARK BROWN, MOIST, FINE GRAINED SAND.
7.5	ML	16	29	1	100	61	7	SANDY SILT: DARK BROWN, MOIST, FINE GRAINED SAND, (GLASS IN SPT).
9.0	SM	5		NP	100	15		SILTY SAND: BROWN-GREY, MOIST, FINE TO MED., GRAINED SAND.
10.5	SP	2			98	4	16	SAND: GREY-LIGHT BROWN, DAMP, MEDIUM GRAINED SAND GRAVEL TO 3/4 INCHES.
12.0	SP/SM	2		NP	99	6		SAND/SILTY SAND: GREY-LIGHT BROWN, DAMP, MEDIUM GRAINED SAND, GRAVEL TO 3/8 INCHES.
13.5	SP	3			99	4	21	SAND: GREY-LIGHT BROWN, DAMP, MEDIUM GRAINED SAND, GRAVEL 3/4 INCHES.
15.0	GP	3		NP	41	3		SANDY GRAVEL: GREY-LIGHT BROWN, DAMP, MEDIUM GRAINED SAND, GRAVEL TO 3/4 INCHES.
16.5	SP/SM	6		NP	100	9	21	SAND/SILTY SAND: GREY-DARK BROWN, MOIST, MEDIUM GRAINED SAND.
18.0	SM	8		NP	100	15		SILTY SAND: LIGHT BRN, MOIST, FINE TO MEDIUM GRAINED SAND.
19.5	SP	4			100	4		SAND: GREY, DAMP, MEDIUM GRAINED SAND.
	SM/SC	22	28	5	100	42		SILTY SAND/CLAYEY SAND: RUST-BROWN, WET COHESIVE, MEDIUM GRAINED SAND.
22.5		23	27	6	100	27	7	SAME: DARK GREY.
24.0	ML/CL	30	28	6	100	66		SANDY SILT/SANDY CLAY: GREY-BROWN, WET, COHESIVE, FINE GRAINED SAND.
25.5	ML	28		NP	100	79	6	SANDY SILT: DARK BROWN-GREY, WET, COHESIVE.
27.0	CL	31	45	24	100	79		SANDY CLAY: DARK BROWN-GREY, WET, COHESIVE.
W 28.5	ML	39		NP	100	70	7	SANDY SILT: DARK BROWN-GREY, WET, COHESIVE.
	CL	30	38	16	100	80		SANDY CLAY: DARK BROWN-GREY, WET COHESIVE.
31.5		29	31	14	100	80	8	

TH83-1907

TH83-1907 STA 468+00 L EL. 89±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	~~3~~ 5		NP	~~100~~ 100	~~13~~ 14		SILTY SAND: LIGHT BROWN, MOIST, F SAND, GRAVEL TO 2-1/2 INCHES. SAME: COBBLES TO 6 INCHES.
3.0		9		NP	100	17		
4.5	SP	2			100	4		SAND: BROWN-LIGHT GREY, MOIST, ME
		10		NP	99	[illegible]		SILTY SAND: DARK BRN-GREY-RUST, M
	SM	11		NP	100	38		SAME: SAND LENS, ORGANIC MATERIAL
9.0		16		NP	92	49		
		13		NP	100	17		SAND/SILTY SAND: DARK BROWN-GREY- TO MEDIUM GRAINED SAND.
	SP/SM	2		NP	100	5		SAME: GREY, MOIST, MEDIUM GRAINE
		4		NP	100	7		SAME: SOME ORGANIC MATERIAL, SAN
15.0		2		NP	92	5		SAME: FEW GRAVEL TO 3/8 INCHES.
	SP	2			92	3		SAND: GREY, MOIST, MEDIUM GRAINE 3/4 INCHES.
18.0		2			100	4		
	SW/SM	6		NP	94	6		SAND/SILTY SAND: GREY, MOIST, MED
21.0		5		NP	33	8		SAME: DARK GREY, COARSE GRAINED
22.5	SP	4			93	4		SAND: DRK GREY, MOIST, COARSE GRA
W 24.0	SP/SM	[illegible]		NP	98	12		SAND/SILTY SAND: DARK GREY, WET, GRAVEL TO 3/8 INCHES.
25.5	SP	19			96	3		SAND: DARK GREY, WET, COARSE GRA
	[illegible]	[illegible]	33	1?	100	79		SANDY CLAY: BROWN, WET, COHESIVE
28.5		2?	37	12	100	61		
	[illegible]	[illegible]	53	29	100	71		SANDY CLAY: BROWN, WET, COHESIVE
31.5		3?	52	25	100	88		CLAY: GREY-BROWN, WET COHESIVE.

TH83-1908

TH83-1908 STA 460+00 L EL. 87±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		4		NP	91	7		SAND/SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, COBBLES TO 4 INCHES.
	SP/SM	~~4~~ 5		~~NP~~ NP	~~36~~ 96	~~5~~ 6	43	SAME: LIGHT BROWN, MEDIUM TO COARSE GRAINED SAND, GRAVEL 1 INCHES.
4.5		6		NP	99	7	18	SAME: BROWN-GREY, MOIST, MEDIUM TO FINE GRAINED SAND.
6.0	ML	24	30	6	100	64		SANDY SILT: BROWN, MOIST, FINE GRAINED SAND.
		15		NP	100	13	8	SILTY SAND: BRN-GREY, MOIST, FINE TO MEDIUM GRAINED SAND.
	SM	3		NP	100	18		SAME: LIGHT BROWN.
[illegible]		9		NP	100	18	14	
		3		NP	100	11		SAND/SILTY SAND: LIGHT BROWN-LIGHT GREY, MOIST, MEDIUM GRAINED SAND.
	SP/SM	5		NP	100	5	12	SAME: MEDIUM TO COARSE GRAINED SAND.
[illegible]		4		NP	100	6		
[illegible]	SP	4			83	4	10	GRAVELLY SAND: LIGHT BROWN, MOIST, COARSE GRAINED SAND, GRAVEL TO 1 INCH.
	SM	23		NP	100	18		SILTY SAND: DARK BROWN, WET, SLIGHTLY COHESIVE.
[illegible]							9	
[illegible]	CL	14	44	20	100	90		SANDY CLAY: LIGHT BROWN-GREY, WET, COHESIVE.
		33	38	12	100	80	5	SANDY SILT: LIGHT BROWN-GREY, WET, COHESIVE.
		31	25	1	100	53		SAME: GREY, WET, SLIGHTLY COHESIVE.
	ML	28 / 33					5	SAME: DARK BROWN, WET, COHESIVE.
		[illegible]	35	10	100	82	5	
31.5		38 / 29					7	

VALUE ENGINEERING PAYS

TH83-1907

STA 468+00 [illegible] EL. 89±

LL	PI	-4	-200	N	DESCRIPTION
	NP	100	13		SILTY SAND: LIGHT BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, GRAVEL TO 2-1/2 INCHES.
	NP	100	14		SAME: COBBLES TO 6 INCHES.
	NP	100	[illegible]		
		100	4		SAND: BROWN-LIGHT GREY, MOIST, MEDIUM GRAINED SAND.
	NP	99	[illegible]		SILTY SAND: DARK BRN-GREY-RUST, MOIST, FINE GRAINED SAND.
	NP	100	33		SAME: SAND LENS, ORGANIC MATERIAL.
	NP	97	49		
	NP	[illegible]	[illegible]		SAND/SILTY SAND: DARK BROWN-GREY-RUST, SAND LENS, FINE TO MEDIUM GRAINED SAND.
	NP	100	5		SAME: GREY, MOIST, MEDIUM GRAINED SAND.
	NP	100	[illegible]		SAME: SOME ORGANIC MATERIAL, SAND LENS 1/2 INCHES.
	NP	92	[illegible]		SAME: FEW GRAVEL TO 3/8 INCHES.
		92	[illegible]		SAND: GREY, MOIST, MEDIUM GRAINED SAND, FEW GRAVEL TO 3/4 INCHES.
		[illegible]	4		
	NP	[illegible]	[illegible]		SAND/SILTY SAND: GREY, MOIST, MED. TO COARSE GRAINED SAND.
	NP	[illegible]	3		SAME: DARK GREY, COARSE GRAINED SAND, GRAVEL TO 3/8".
		[illegible]	[illegible]		SAND: DRK GREY, MOIST, COARSE GRAINED SAND GRAVEL TO 3/8".
	NP	[illegible]	[illegible]		SAND/SILTY SAND: DARK GREY, WET, COARSE GRAINED SAND, GRAVEL TO 3/8 INCHES.
		[illegible]	[illegible]		SAND: DARK GREY, WET, COARSE GRAINED SAND.
[illegible]	[illegible]	[illegible]	[illegible]		SANDY CLAY: BROWN, WET, COHESIVE.
[illegible]	12	[illegible]	[illegible]		
[illegible]	22	[illegible]	[illegible]		SANDY CLAY: BROWN, WET, COHESIVE.
[illegible]	25	[illegible]	[illegible]		CLAY: GREY-BROWN, WET COHESIVE.

TT79-19

INVERT

TT79-19 STA 458+00 C

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SP	6			93	7		SAND: GREY, MOIST, VEGETATION, OCCASIONAL GRAVEL TO 3/4", GROUNDWATER ENCOUNTERED.

NOTES

1. SEE PLATE 19 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SCALE: 1 IN = 3 FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

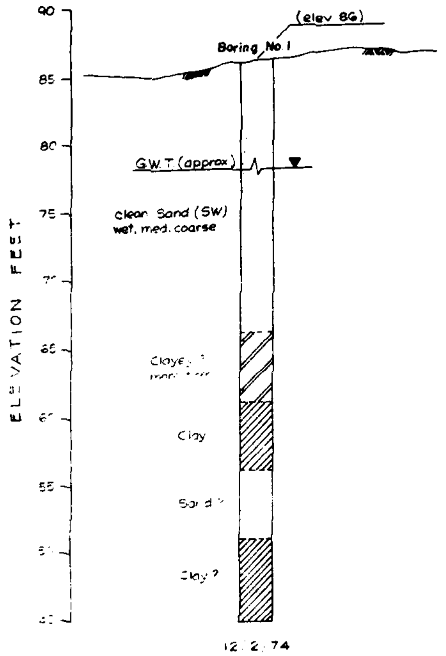
LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

CHECKED BY:

STA.474+00 TO STA.458+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW 09-____ B-____ SHEET

OC75-1



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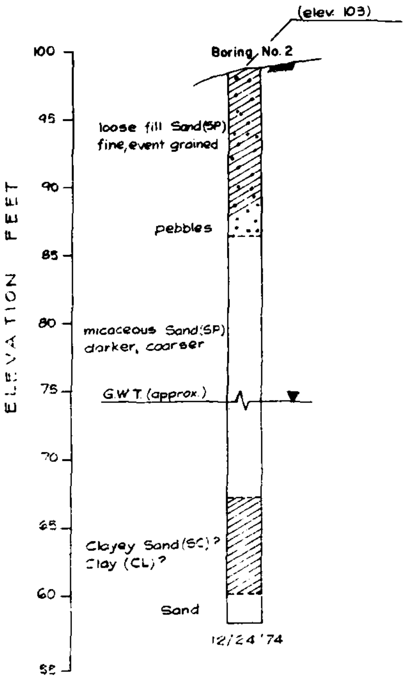
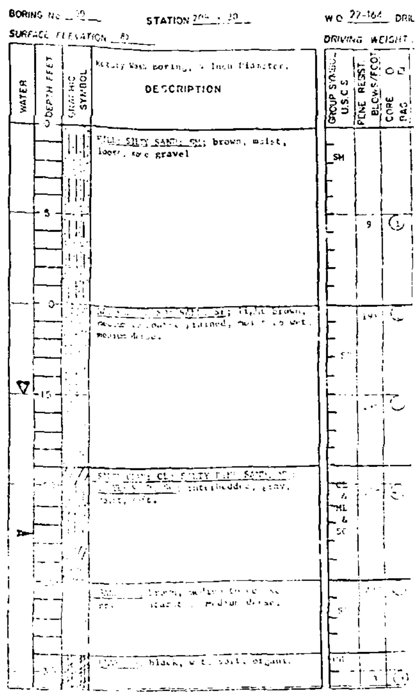


GC71-30



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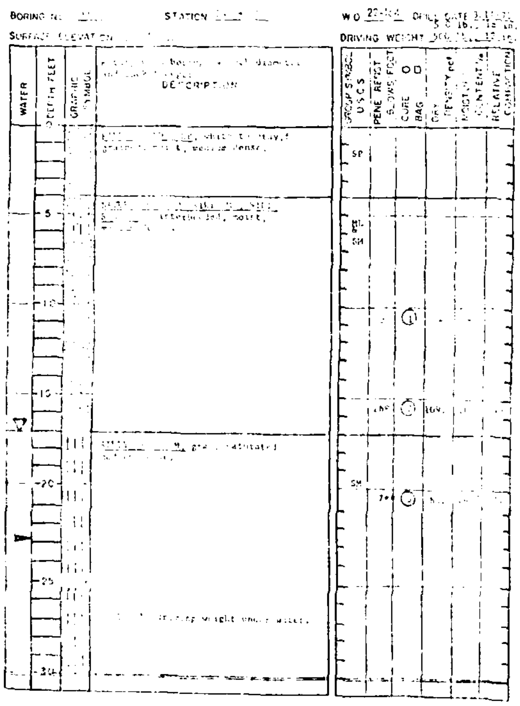

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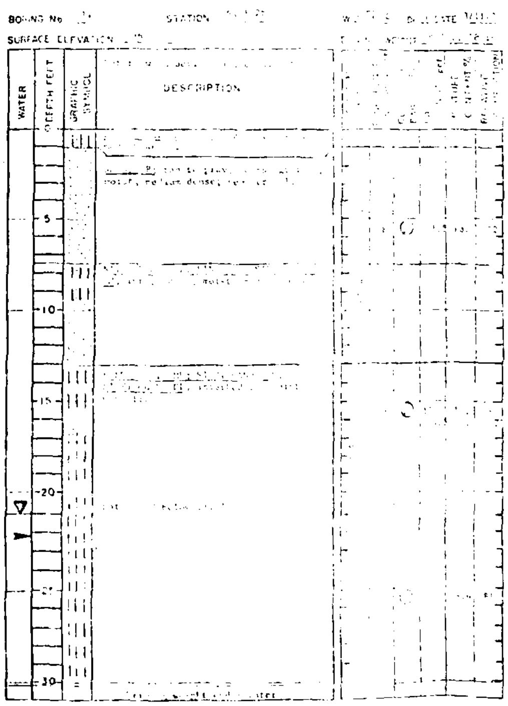
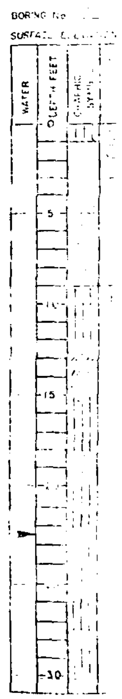




VALUE ENGINEERING PAYS

GC 71-30

W.O. 22-164 DRILL DATE 3/11/71
DRIVING WEIGHT 500 lb., 20 in.

Depth (ft)	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core/Bag	Dry Density pcf	Moisture Content %	Relative Compaction
	SM					
~5		9	①	92.3	15.6	73

GC 71-31

BORING No. 31 STATION 218 + 61
SURFACE ELEVATION 91
W.O. 22-164 DRILL DATE 3/12/71
DRIVING WEIGHT 500 lb., 18 in.

Rotary wash boring; 4 inch diameter

Depth (ft)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core/Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	FILL: SILTY SAND: SM; tan, moist, medium dense.	SM					
1	SAND: SP; white to gray, medium grained, moist, medium dense; some gravel						
5		SP	15	①	104.0	5.9	92
15			15	②	96.2	20.	
16	NATURAL GROUND: SILTY SAND: SM; brown, moist, medium dense; saturated below 17.0'						
20		SM					
25			16	○			

GC 71-32

BORING No. 32 STATION 233 + 65
SURFACE ELEVATION 92
W.O. 22-164 DRILL DATE 3/12/71
DRIVING WEIGHT 500 lb., 18 in.

Rotary wash boring; 4 inch diameter

Depth (ft)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core/Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	FILL: SILTY SAND: SM; brown, moist, medium dense.	SM					
1	SAND: SP; tan to gray, medium grained, moist, medium dense; some gravel.	SP					
5			11	①	96.8	15.0	84
12	NATURAL GROUND: SILTY SAND: SM; tan to gray, moist, medium dense.	SM					
15			6	②	106		
17	Saturated at 17.0'						
18	SILTY CLAY: CL; ..., wet, firm	CL					
20	SILTY SAND: SM; gray, saturated, medium dense						
25		SM	9	③			

GC 71-35

BORING No. STATION W.O. DRILL DATE
SURFACE ELEVATION DRIVING WEIGHT

DESCRIPTION

WM73-5

LOG OF BORING 5

DATE OF BORING 24 May 1973 WATER DEPTH 14' DATE MEASURED 24 May 1973
TYPE OF DRILL RIG Cont. Flight Auger HOLE DIAMETER 6"
WEIGHT OF HAMMER 140 lbs. FALLING 30" SAMPLES 2" Modified California

Depth, ft	Samples	Blows/Foot	Ground Water	Description	Unc Comp Strength, ksf	Moisture Content, %	Dry Density pcf	Other Tests
				SURFACE ELEVATION:				
	1	33		Dense, damp, light brown fine to medium-grained SAND (SP) with trace of SILT		8	102	
				Fine to coarse-grained				
				Loose to medium dense				
5	2	9				12	88	
				Medium dense, very fine-grained SAND				
10	3	13		Medium dense, moist light brown fine-grained SAND (SP)				[illegible]
15	4	11	▽	Fine to coarse-grained		36	86	[illegible]
20	5	16						
25		10		Bottom of boring at 25½ ft.				

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS

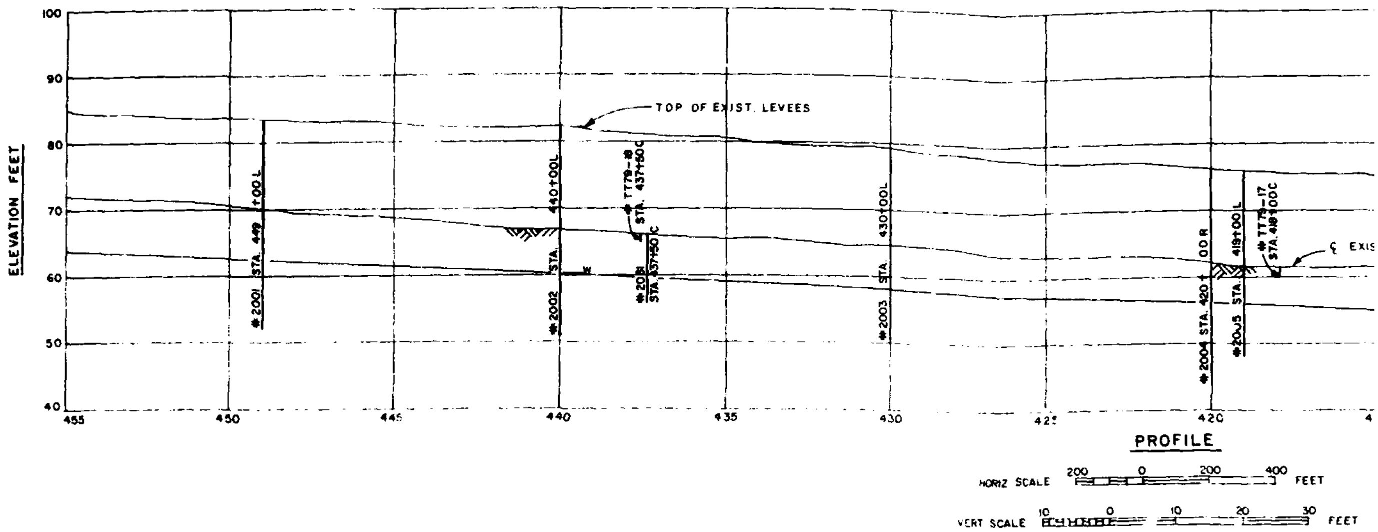
STA.520+00 TO STA.455+00

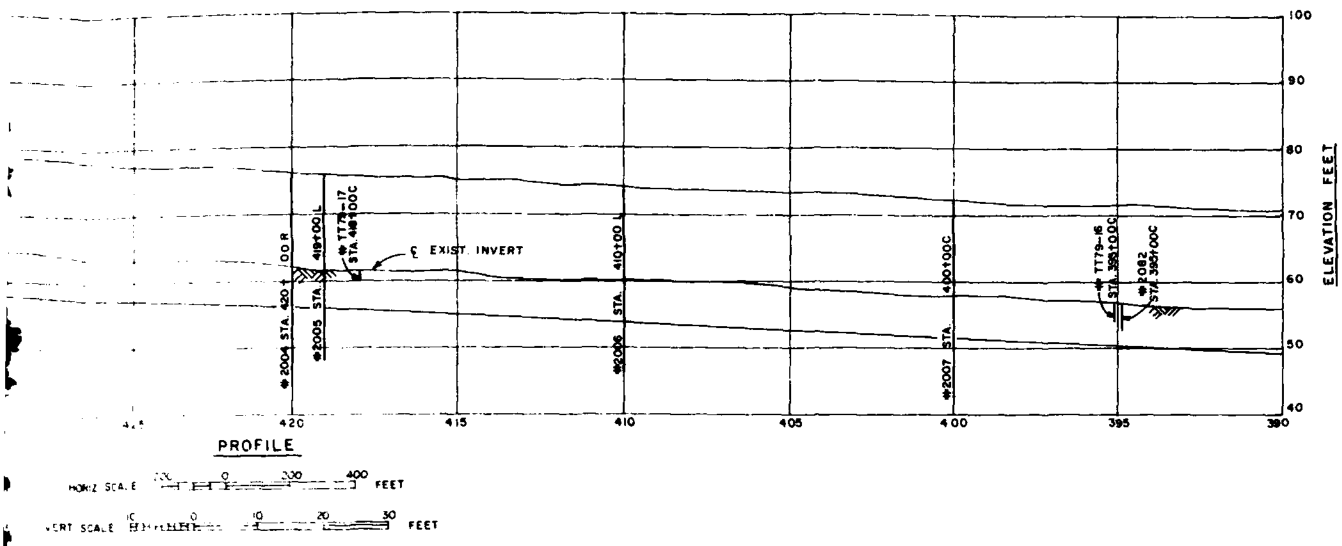
DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

NOTES:

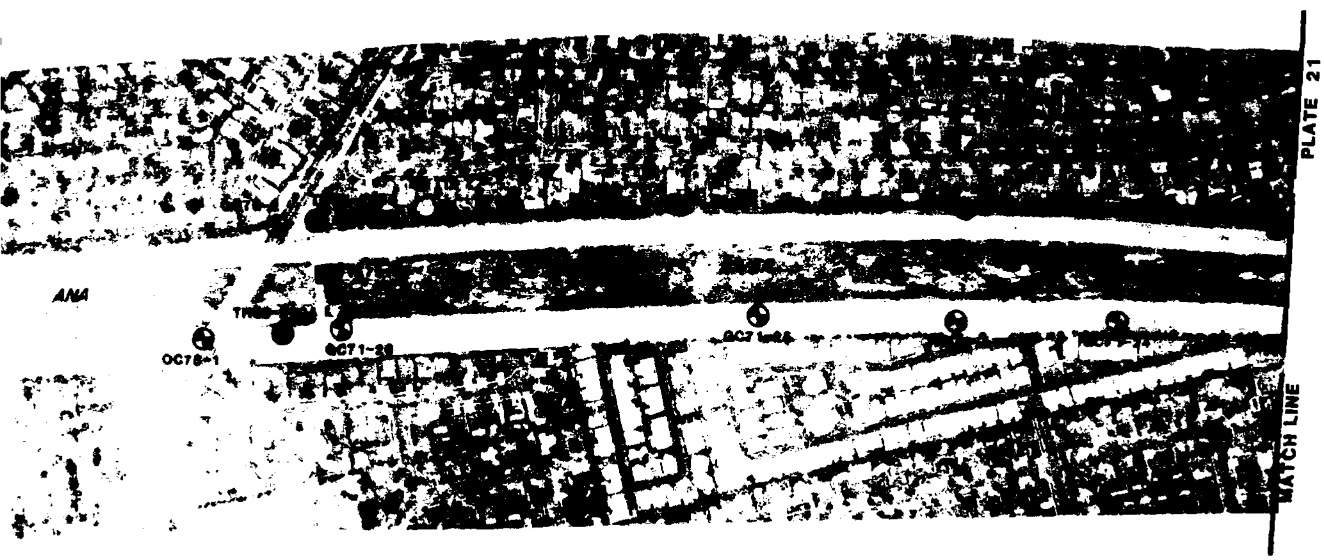
1. SEE PLATE 19 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO

VALUE ENGINEERING P





PROFILE



NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE

STA.455+00 TO STA.390+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

DISTRICT FILE NO.

TH 83-2001

TH83-2001 STA 449+00 L EL. 83±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SW/SM	3		NP	94	100		SAND/SILTY SAND: BROWN, MOIST, MEDIUM TO FINE GRAINED SAND, GRAVEL TO 3/4 INCHES.
	SM	6		NP	98	15	34	SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, GRAVEL TO 3/4 INCHES.
3.5		7		NP	97	20		
4.5	SP/SM	6		NP	96	6	39	SAND/SILTY SAND: BROWN, MOIST, COARSE GRAINED SAND, GRAVEL TO 1-1/2 INCHES.
6.0	SW/SM	3		NP	92	6		SAND/SILTY SAND: BROWN, MOIST, COARSE GRAINED SAND, GRAVEL TO 3/8 INCHES.
7.5	SP	4			95	4	35	SAND: BROWN, MOIST, COARSE GRAINED SAND.
9.0	SW/SM	4		NP	97	10		SAND/SILTY SAND: BROWN, MOIST, COARSE GRAINED SAND, GRAVEL TO 3/8 INCHES.
	SP/SM	4		NP	96	7	8	SAND/SILTY SAND: LIGHT BROWN, MOIST, COARSE GRAINED SAND, GRAVEL TO 1 INCH.
12.0		6		NP	99	10		
		3			96	4		SAND: LIGHT BROWN, MOIST, COARSE GRAINED SAND, GRAVEL TO 1 INCH.
		2			99	4		
	SP	2			96	7	11	
		9			99	4		SAME: WET, GRAVEL TO 1-1/2 INCHES.
19.5					95	4	8	SAME: BROWN, GRAVEL TO 3/8 INCHES.
	SM	5	22	1	99	25		SILTY SAND: BROWN, WET, COARSE GRAINED SAND.
22.5		22	28	5	100	43	6	
24.0	ML/CL	26	29	7	98	62		SANDY SILT/ SANDY CLAY: DARK GREY, WET, COHESIVE.
		27	29	9	100	57	6	SANDY CLAY: DARK GREY, WET, COHESIVE.
	CL	28	36	15	100	80		
		35	38	17	99	78	9	
30.0		30	34	13	100	73		SAME: DARK BROWN.
							5	

TH 83-2002

TH83-2002 STA 440+00 L EL. 82±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		10		NP	100	35		SILTY SAND: BROWN, MOIST, NON-COHESIVE.
		16					16	
		11						
		16		NP	100	37	4	
	SM	12						
		20		NP	100	49	7	
		11		NP	100	28		SAME: LIGHT BROWN.
10.5		12					8	
12.0	CL	4	29	9	100	59		SANDY CLAY: BROWN, MOIST, FINE TO MEDI[illegible]
13.5	SP	2			100	2	14	SAND: LIGHT BROWN, MEDIUM TO COARSE GR[illegible]
	SP/SM	4		NP	100	8		SAND/SILTY SAND: LIGHT BROWN, MOIST, F[illegible] GRAINED SAND.
16.5		6		NP	97	10	14	SAME: LIGHT BROWN-GREY.
		17			100	2		SAND: LIGHT BROWN-GREY, WET, MEDIUM [illegible] SAND.
	SP						19	
21.0		20						
W 22.0		32		NP	100	8		SAND/SILTY SAND: LIGHT BROWN-GREY, WE[illegible] GRAINED SAND
	SP/SM							
25.0		19 / 23						
		34	29	[illegible]	100	69		SANDY CLAY: BROWN, WET, COHESIVE
		26						
	CL	28						SAME: DARK BROWN.
		33						
31.5		30						

TH 83-2003

TH83-2003 STA 430+00 L EL. 79±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SM	5		NP	100	15		SILTY SAND: LIGHT BROWN, MOIST, FINE TO MEDIUM GRAINED SAND.
	SP/SM	5		NP	97	8	11	SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, GRAVEL TO 3/4 INCHES.
3.0		4		NP	95	5		
4.5	SP	3			95	2	10	SAND: LIGHT BROWN, MOIST, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 1 INCH.
	SP/SM	4		NP	93	6		SAND/SILTY SAND: LIGHT BROWN, MOIST, MEDIUM GRAINED SAND, GRAVEL TO 3 INCHES.
7.0		5		NP	93	11		
7.5	SM	5		NP	100	25		SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND.
9.0	SM/SC	9	25	6	100	47		SILTY SAND/CLAYEY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND.
10.5	SM	2		NP	100	26	15	SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND.
		1		NP	98	7		SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND.
		1		NP	100	8		SAME: GREY, MOIST.
	SP/SM	3		NP	98	7		SAME: DARK GREY.
		6		NP	98	5		SAME: GREY, FINE TO MEDIUM GRAINED SAND.
18.0		3		NP	100	8		
		8		NP	100	14		SILTY SAND: GREY, MOIST, FINE TO MEDIUM GRAINED SAND.
	SM	12		NP	100	15		SAME: DARK GREY.
21.0		16 / 23		NP / NP	100 / 100	16 / 39	10	SAME: DARK BROWN, WET.
24.0	CH	35	53	28	100	95		CLAY: DARK GREY, WET, COHESIVE, PLASTIC, SOFT.
	SM	28		NP	100	49	5	SILTY SAND: DARK GREY, WET, SOFT.
27.0		25		NP	100	33		SAME: FINE GRAINED SAND.
	ML	35		NP	100	52		SANDY SILT: DARK GREY, WET, FINE GRAINED SAND.
28.5		38	37	12	100	79	12	SAME: COHESIVE.
29.0	SM	6		NP	100	17		SILTY SAND: DARK GREY, WET, FINE TO MED. GRAINED SAND.

TT 84-81

INVERT
TT84-2081 STA [illegible] C [illegible]

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM			NP	35	17		SAND/SILTY SAND: [illegible] GRAVEL TO [illegible] INCH.
3.0								
								SANDY CLAY: [illegible]
	CL		44	23	[illegible]	91		
10.0								

VALUE ENGINEERING PAYS

TH 83-2002

STA 440+00 L — EL. 82±

LL	PI	-4	-200	N	DESCRIPTION
	NP	100	35		SILTY SAND: BROWN, MOIST, NON-COHESIVE, FINE GRAINED SAND.
				16	
	NP	100	37	4	
	NP	100	49	7	
	NP	100	[illegible]		SAME: LIGHT BROWN.
				8	
29	3	100	[illegible]		SANDY CLAY: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND.
		100	[illegible]	[illegible]	SAND: LIGHT BROWN, MEDIUM TO COARSE GRAINED SAND.
	NP	[illegible]	[illegible]		SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE TO MEDIUM GRAINED SAND.
	NP	[illegible]	[illegible]	[illegible]	SAME: LIGHT BROWN-GREY.
		[illegible]	[illegible]		SAND: LIGHT BROWN-GREY, WET, MEDIUM TO COARSE GRAINED SAND.
				[illegible]	
	NP	[illegible]	[illegible]		SAND/SILTY SAND: LIGHT BROWN-GREY, WET, MEDIUM TO COARSE GRAINED SAND.
[illegible]	[illegible]	[illegible]	[illegible]		SANDY CLAY: BROWN, WET, COHESIVE.
					SAME: DARK BROWN.

TH 83-2004

TH83-2004 — STA 420+00 R — EL. 75±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SW/SM	4		NP	98	12	38	SAND/SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND.
	SM	4		NP	94	13		SILTY SAND: BROWN, MOIST, MEDIUM GRAINED SAND.
		7		NP	98	13		
		5	21	1	81	15	40	SILTY GRAVELLY SAND: GRAVEL TO 1 INCH.
6.0		6		NP	94	14		SILTY SAND: DARK BROWN.
7.5	SP/SM	7		NP	97	6	41	SAND/SILTY SAND: BROWN-GREY, MOIST, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 3/8 INCHES.
	SP	3			94	3		SAND: GREY, MOIST, COARSE GRAINED SAND, GRAVEL TO 3/8".
10.0		4			94	2		
	SM	10	21	1	99	28		SILTY SAND: DARK BROWN, MOIST, FINE GRAINED SAND.
12.0		16	22	2	100	34		
	SP	3			97	4	14	SAND: GREY, MOIST, MEDIUM TO COARSE GRAINED SAND.
15.0		4			97	3		
16.5	SM	20		NP	99	14	10	SILTY SAND: BROWN-GREY, MOIST, NON-COHESIVE, FINE TO MEDIUM GRAINED SAND, LAYERED SAND.
18.0	SC	15	31	9	98	25		CLAYEY SAND: DARK GREY-BROWN, MOIST, FINE TO MEDIUM GRAINED SAND.
	SP/SM	19		NP	100	11	17	SAND/SILTY SAND: GREY, WET, MEDIUM GRAINED SAND.
21.0		17		NP	100	9		
	ML/CL	27	26	6	100	41	6	SANDY SILT/SANDY CLAY: DARK GREY, WET, COHESIVE.
24.0		27	25	6	100	52		
25.0	CL	31	37	13	100	65		SANDY SILT: DARK GREY, WET, COHESIVE.
	ML	26	25	1	100	65	13	SANDY SILT: DARK GREY, WET, FINE TO MEDIUM GRAINED SAND, NON-COHESIVE.
27.0		26	27	1	99	54		
28.5	SM	23		NP	100	24	18	SILTY SAND: GREY, WET, FINE TO MEDIUM GRAINED SAND.
	CL	37	40	17	99	24		SANDY CLAY: DARK GREY, WET, COHESIVE.
31.5		32	36	12	100	92	7	SAME: BLACK, WET, COHESIVE.

TT 84-81

[illegible] — EL. 66±

[illegible]	-4	[illegible]	N	DESCRIPTION
NP	85			SAND/SILTY SAND: DARK BROWN, WET, MEDIUM TO COARSE SAND, GRAVEL TO 1 INCH.
[illegible]	39	[illegible]		SANDY CLAY: DARK BROWN, WET, COHESIVE.

TT 79-18

INVERT
TT79-18 — STA 437+53 C — EL. 66±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SP	6			97	1		SAND: GREY, MOIST, VEGETATION. GROUNDWATER ENCOUNTERED.

SCALE: 1 IN = 5 FT
5 0 5 10

NOTES:

1. SEE PLATE 20 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.449+00 TO STA.420+00

DATE SHEET

TH83-2005

TH83-2005 STA 419+00 L EL. 76±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SM	2		NP	96	13	9	SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, GRAVEL TO 1-1/2 INCHES.
3.0	SP	1 / 1			90 / 96	3 / 4		SAND: GREY, MOIST, MEDIUM GRAINED SAND, GRAVEL 3/4".
	SP/SM	1		NP	96	5	8	SAND/SILTY SAND: GREY, MOIST, MEDIUM GRAINED SAND, GRAVEL TO 3/4 INCHES.
6.5		1		NP	99	9		SAME: MOIST.
7.5	SM	3		NP	100	19	12	SILTY SAND: GREY, MOIST, MEDIUM GRAINED SAND.
9.5	SP/SM	2		NP	100	5		SAND/SILTY SAND: GREY, MOIST, MEDIUM GRAINED SAND.
10.5	SP	1			97	2	17	SAND: GREY, MOIST, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 3/8 INCHES.
12.0	SP/SM	3		NP	99	7		SAND/SILTY SAND: GREY, MOIST, MEDIUM GRAINED SAND.
13.5	SP	1			100	2	14	SAND: GREY, MOIST, MEDIUM GRAINED SAND.
15.0	SP/SM	22		NP	100	8		SAND/SILTY SAND: GREY, MOIST, MEDIUM GRAINED SAND.
		3		NP	100	100		SILT: GREY, MOIST, MEDIUM GRAINED SAND.
16.5	ML	28	41	14	99	57	14	SANDY SILT: BROWN, WET, PLASTIC.
18.0	SP/SM	11		NP	100	9		SAND/SILTY SAND: BROWN-RED, WET, MEDIUM TO COARSE GRAINED SAND.
19.5	SP	3			100	4	76	SAND: GREY, WET, MEDIUM TO COARSE GRAINED SAND.
21.0	SP/SM	19		NP	100	5		SAND/SILTY SAND: GREY, WET, MEDIUM TO COARSE GRAINED SAND.
22.5	SP	11			100	3	19	SAND: GREY, WET, MEDIUM TO COARSE GRAINED SAND.
24.0	SP/SM	23		NP	100	3		SAND/SILTY SAND: GREY, WET, MEDIUM TO COARSE GRAINED SAND.
	CL	18	34	15	100	65	3	SANDY CLAY: DARK BROWN, WET, PLASTIC.
26.5		25	37	17	100	60		
28.0	SM	23		NP	100	15	29	SILTY SAND: DARK GREY, WET, FINE TO MEDIUM GRAINED SAND.

TH83-2006

TH83-2006 STA 410+00 L EL. 74±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SP	1			99	4		SAND: LIGHT BROWN, MOIST.
2.0	SM	10		NP	97	21	14	SILTY SAND: LIGHT BROWN, MOIST, MEDIUM GRAINED SAND.
2.5	SC	14	31	21	100	47		CLAYEY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND.
	SM	13		NP	36	16		SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND.
4.5		10		NP	99	33	20	SAME: LIGHT BROWN, MOIST, MEDIUM GRAINED SAND.
5.5	ML	1		NP	100	74		SILT: LIGHT BROWN, MOIST, MEDIUM GRAINED.
6.0	SM			NP	100	33		SILTY SAND: LIGHT BROWN, MOIST, MEDIUM GRAINED SAND.
	SP/SM	4		NP	99	9	12	SAND/SILTY SAND: LIGHT BROWN, MOIST, MEDIUM GRAINED SAND.
9.0		3		NP	99	12		
10.5	SP	1			36	4	29	SAND: LIGHT BROWN, MOIST, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 3/8 INCHES.
		2		NP	99	9		SAND/SILTY SAND: LIGHT BROWN, MOIST, MEDIUM TO COARSE GRAINED.
	SP/SM	7		NP	99	5	20	
15.0		21		NP	95	5		
17.0	SP	7			95	4	25	SAND: LIGHT BROWN, MOIST, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 1/2 INCHES.
		13		NP	99	7		SAND/SILTY SAND. LIGHT BROWN, MOIST, MEDIUM TO COARSE GRAINED.
	SP/SM	10		NP	99	5	30	
		23		NP	99	6		
22.5		20		NP	99	9	15	SAME: SAND TO 1/4 INCHES.
	SM	25		NP	98	46		SILTY SAND: GREY, MOIST, FINE TO MEDIUM GRAINED SAND.
24.5		23		NP	97	35		SAME: LIGHT BROWN-GREY.
25.0	SP/SM	20		NP	97	10		SAND/SILTY SAND: LT BRN-GREY, MOIST, FINE TO MED GRAINED SND.
25.5	SM	17		NP	100	28	10	SILTY SAND: LIGHT BROWN-GREY, MOIST FINE GRAINED SAND.
27.0	SC	22	28	19	100	41		CLAYEY SAND: BROWNISH-GREY, MOIST, FINE GRAINED SAND, SLIGHTLY COHESIVE.
27.5	SM	22	21	2	100	45		SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND.
28.0	SP/SM	17		NP	100	7	28	SAND/SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED SAND.

TH83-2007

TH83-2007 STA 400+00 L

DEPTH	LOG	MC	LL	PI	-4	-200	N	
2.0	SW/SM	3		NP	99	10	25	SAND/SILTY SAND: LI
		7		NP	99	29		SILTY SAND: BROWN,
4.5	SM	7		NP	99	30	15	
5.5	ML	9	24	3	100	56		SANDY SILT: BROWN,
6.5	CL	12	25	3	100	72		SANDY CLAY: BROWN,
7.0	SM	3		NP	98	21		SILTY SAND: GREY,
8.5	SP/SM	10		NP	99	12	13	SANDY/SILTY SAND:
	SM	2		NP	99	13		SILTY SAND: GREY,
11.5		15		NP	99	23	14	
		3		NP	99	9	17	SAND/SILTY SAND
		2		NP	99	7		
	SP/SM	[illegible]		NP	99	5	17	
		3		NP	100	9		
19.0		23		NP	99	5	15	
20.5	SM	[illegible]		NP	98	18		SILTY SAND: GREY,
		21		NP	99	8	7	SAND/SILTY SAND: GR SAND.
	SP/SM	23		NP	99	9		
24.0		19		NP	99	5		
	SP	15			98	1	7	SAND: GREY, MOIST,
		25			99	3		SAME: FINE TO MEDI
25.5		25			100	3		
28.0	SP/SM	25		NP	99	6	27	SAND/SILTY SAND: GR
29.5	SP	24			100	4		SAND: GREY, MOIST,
30.0	ML	32	30	2	100	99		SILT: GREY, MOIST,
							14	

TH84-2082

INVERT

TT84-2082 STA 395+20 C EL. 5

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRI
3.0	SP				97	1		SAND: MULTICOLOR, MOIST, M GRAVEL TO 1 INCH, VERY LOOS
4.0	SM			NP	99	25		SILTY SAND: DARK BROWN, MO SAND, WITH FEW GRAVEL, DENS

TT79-16

INVERT

TT79 16 STA 395+00 C EL. 5

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRI
2.5	SP	4			95	1		SAND: GREY, MOIST, OCCASIO TATION. GROUNDWATER ENCOUN

VALUE ENGINEERING PAYS

TH83-2007

STA 400+00 L EL. 73±

MC	LL	PI	-4	-200	N	DESCRIPTION
3		NP	99	10		SAND/SILTY SAND: LIGHT GREY, MOIST, MEDIUM GRAINED SAND.
7		NP	99	[illegible]	25	SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND.
7		NP	99	[illegible]		
3	24	3	100	56	15	SANDY SILT: BROWN, MOIST, FINE GRAINED SAND.
12	28	3	100	72		SANDY CLAY: BROWN, MOIST, FINE GRAINED SAND.
3		NP	99	21	13	SILTY SAND. GREY, MEDIUM GRAINED SAND.
10		NP	[illegible]	[illegible]		SANDY/SILTY SAND: GREY, MOIST, MEDIUM GRAINED SAND.
[illegible]		NP	[illegible]	13		SILTY SAND. GREY, MOIST, MEDIUM GRAINED SAND.
15		NP	[illegible]	23	14	
[illegible]		NP	99	[illegible]	17	SAND/SILTY SAND GREY, MOIST, MEDIUM GRAINED SAND.
[illegible]		NP	[illegible]	[illegible]		
[illegible]		NP	[illegible]	[illegible]	12	
3		NP	100	[illegible]		
23		NP	[illegible]	[illegible]	15	
3		NP	99	13		SILTY SAND. GREY, MOIST, MEDIUM GRAINED SAND.
[illegible]		NP	[illegible]	[illegible]	3	SAND/SILTY SAND: GREY, MOIST, MEDIUM TO COARSE GRAINED SAND.
[illegible]		NP	[illegible]	6		
[illegible]		NP	[illegible]	5		
19			36	1		SAND: GREY, MOIST, COARSE GRAINED SAND.
25			59	3	[illegible]	
26			13	3		SAME: FINE TO MEDIUM GRAINED SAND.
35		NP	[illegible]	5	27	SAND/SILTY SAND: GREY, MOIST, MEDIUM GRAINED SAND.
24			100	4		SAND: GREY, MOIST, MEDIUM GRAINED SAND.
35	31	3	100	90		SILT: GREY, MOIST, FINE GRAINED SAND.
					14	

TH-2008

TH83-2008 STA 390+00 L EL. 71±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
2.0	SM	7		NP	98	14	7	SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND, GRAVEL TO 3/8 INCHES.
3.5	SP/SM	1		NP	98	6		SAND/SILTY SAND: LIGHT BROWN, MOIST, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 1 INCH.
4.5	SW/SM	2		NP	98	7	37	
6.0	SM	4	50	20	96	13		SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND.
7.5	SP/SM	3		NP	100	9	9	SAND/SILTY SAND: BROWN, MOIST, FINE GRAINED SAND.
3.5	SM	4		NP	100	17		SILTY SAND: BROWN, MOIST, FINE GRAINED SAND.
	SP/SM	2		NP	100	10		SAND/SILTY SAND: BROWN, MOIST, FINE GRAINED SAND.
11.5		2		NP	98	6		SAME: LIGHT GREY, MEDIUM GRAINED SAND.
13.0	SP	1			98	3		SAND: LIGHT GREY, MOIST, MEDIUM GRAINED SAND.
14.5	SP/SM	3		NP	94	6		SAND/SILTY SAND: LIGHT GREY, MOIST, MEDIUM TO COARSE GRAINED SAND.
		8		NP	100	15	18	SILTY SAND: LIGHT GREY, MOIST, MEDIUM GRAINED SAND.
		24		NP	100	28		SAME: DARK GREY, WET.
	SM	18	51	22	100	45	6	
		26	41	12	100	31		
		22		NP	100	18	9	
23.5		27		NP	100	45		
		31	32	8	100	81	9	SANDY SILT: DARK-LIGHT GREY, WET, COHESIVE.
		30	[illegible]	10	100	85		
		39		NP	100	99	9	SAME: DARK GREY.
	ML	37		NP	100	84		
		32		NP	100	91	16	
				NP	100	100		
34.0		29		NP	100	54		

TH84-2082

STA 395+00 C EL. 57±

PI	-4	-200	N	DESCRIPTION
	37			SAND: MULTICOLOR, MOIST, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 1 INCH, VERY LOOSE.
NP	99	25		SILTY SAND: DARK BROWN, MOIST, FINE TO COARSE GRAINED SAND, WITH FEW GRAVEL, DENSE.

TT79-17

INVERT

TT79-17 STA 418+00 C EL. 67±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SP	6			98	1		SAND: GREY, MOIST, VEGETATION.

TT79-16

STA 395+00 C EL. 57±

PI	-4	-200	N	DESCRIPTION
	95	1		SAND: GREY, MOIST, OCCASIONAL GRAVEL TO 3/4-INCH, VEGETATION. GROUNDWATER ENCOUNTERED AT 7.5 FEET

NOTES:

1. SEE PLATE 20 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 6A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SCALE 1 IN=3FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY.

DRAWN BY.

CHECKED BY.

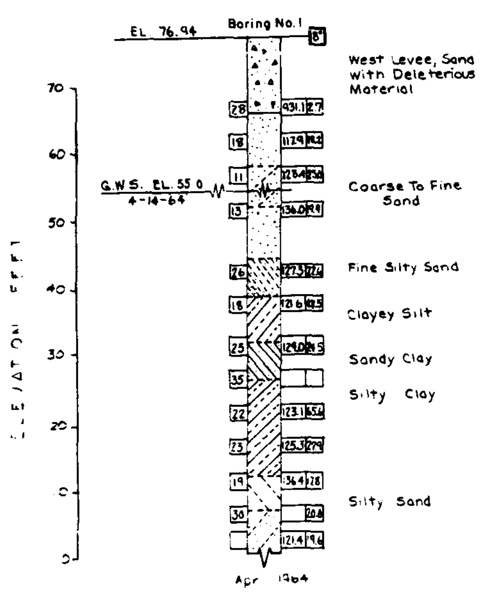
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.419+00 TO STA.390+00

VALUE ENGINEERING

OC75-1



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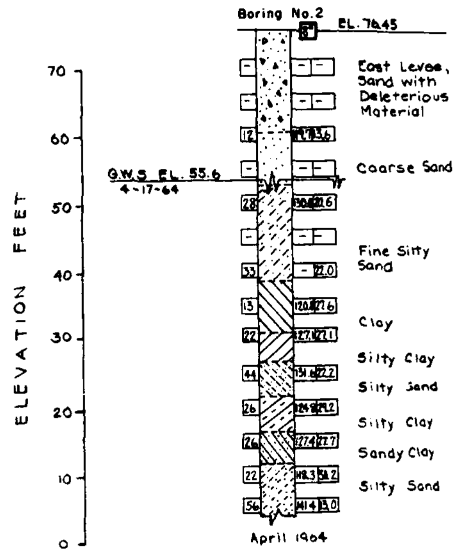
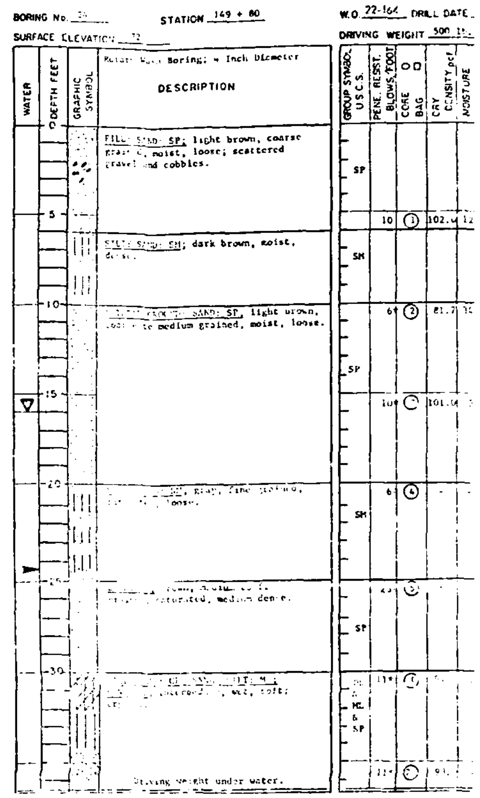


GC71-24



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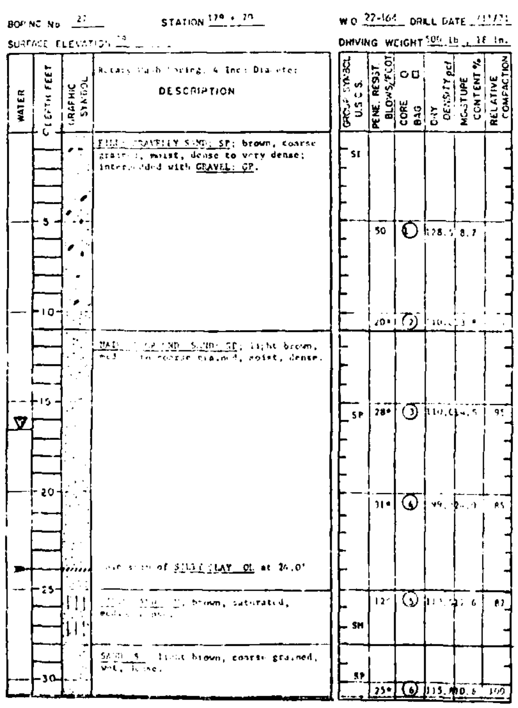
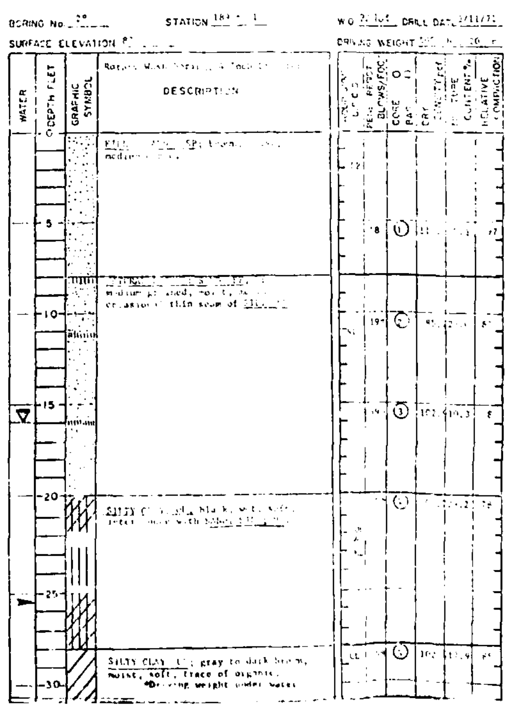
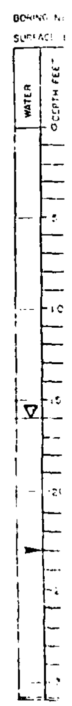


GC71-28





VALUE ENGINEERING PAYS

GC71-24

Boring No. 24 — STATION 149 + 80 — W.O. 22-164 — DRILL DATE 3/10/71
SURFACE ELEVATION 72 — DRIVING WEIGHT 500 lb., 18 in.

Rotary Wash Boring; 4 Inch Diameter

DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE / BAG	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION
FILL: SAND: SP; light brown, coarse grained, moist, loose; scattered gravel and cobbles.	SP	10	(1)	102.0	12.9	88
SILTY SAND: SM; dark brown, moist, dense.	SM	6	(2)	81.7	34.5	71
[illegible] light brown, coarse to medium grained, moist, loose.	SP	10	(3)	101.0	3.7	87
[illegible]	SM	6	(4)	-	-	
[illegible]	SP	25	(5)	-	-	
[illegible]	ML & SP	14	(6)	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	(7)	91.[illegible]	[illegible]	[illegible]

GC71-25

BORING No. 26 — STATION 169 + 61 — W.O. 22-164 — DRILL DATE 3/10/71
SURFACE ELEVATION 76 — DRIVING WEIGHT 500 lb., 20 in.

Rotary Wash Boring; 4 Inch Diameter.

DEPTH FEET	DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE / BAG	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION
0	FILL: SILTY SAND: SM; brown, moist, loose; trace of gravel.	SM					
5	NATURAL GROUND: SAND: SP; brown, medium to coarse grained, moist, loose to medium dense; occasional thin seam of SILT: ML.	SP	19	(1)	105.5	5.0	91
10	SILTY FINE SAND: ML; brown, damp, medium dense.	ML	9	(2)	108.5	5.3	86
15	SAND: SP; light brown, coarse grained, moist, medium dense.	SP	22	(3)	103.5	7.5	89
20	SILTY CLAY: OL; SAND: SP; SILTY SAND: SM; interbedded, wet to saturated, soft; organic.	OL & SP & SM	27	(4)	102.0	20.7	87
25			10	(5)	-	-	
30			[illegible]	(6)	106.5	20.6	84

GC71-27

BORING No. 25 — STATION 159 + 72 — W.O. 22-164 — DRILL DATE 3/10/71
SURFACE ELEVATION 74 — DRIVING WEIGHT 500 lb., 20 in.

Rotary Wash Boring, 4 Inch Diameter.

DEPTH FEET	DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE / BAG	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION
0	FILL: SILTY SAND: SM; brown, moist, loose.	SM					
5	NATURAL GROUND: SAND: SP; gray, medium grained, moist, medium dense.	SP	12	(1)	[illegible]	4.3	86
10	Pocket of GRAVEL: GP at 12.0'.		15	(2)	10[illegible].3	[illegible]	69
15			18	(3)	9[illegible]	[illegible]	81
20	SILTY SAND: SM; brown, medium grained, moist, medium dense.	SM	24	(4)	-	-	
25	SAND: SP; brown, medium grained, moist, medium dense	SP	26	(5)	92.1	29.[illegible]	[illegible]
30	SILTY SAND: SM; dark brown to gray, saturated, loose to medium dense.	SM	10	(6)	10[illegible]	22.4	[illegible]
35	SILTY CLAY: OL; black, moist, stiff; [illegible]	OL	12	(7)	[illegible]	29.[illegible]	[illegible]

GC71-28

W.O. [illegible] — DRILL DATE [illegible]
DRIVING WEIGHT [illegible]

DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE / BAG
[illegible]	[illegible]	18	(1)
[illegible]		15	(2)
[illegible]		15	(3)
[illegible]	ML & ML		
[illegible]	GL	14	(4)

GC71-29

BORING No. 22 — STATION [illegible] — W.O. 22-164 — DRILL DATE [illegible]
SURFACE ELEVATION [illegible] — DRIVING WEIGHT [illegible]

[illegible] Wash Boring, 4 Inch Diameter.

DEPTH FEET	DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE / BAG	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION
0	FILL: SILTY SAND: SM; brown, moist, loose. Cobbles at 2.0'	SM					
5	NATURAL GROUND: SAND: SP; brown, medium grained, moist, medium dense.	SP	45	(1)	10[illegible]	10.8	[illegible]
10	SILTY SAND: SM; brown, moist, medium dense; trace of organic.	SM	15*	(2)	10[illegible]	[illegible]	[illegible]
15	SAND: SP; light brown, medium to coarse grained, wet, dense.	SP	24*	(3)	10[illegible]	2[illegible].4	[illegible]
20	Pockets of GRAVEL: GP at 20.0' and 24.0'		10*		-	-	
25			2[illegible]*	(4)	105	18.[illegible]	
30			28*	(5)	10[illegible]	20.[illegible]	

*Driving weight under water

WM73-4

LOG OF BORING 4

DATE OF BORING 24 May 1973 — WATER DEPTH 15' — DATE MEASURED 24 May 1973
TYPE OF DRILL RIG Cont. Flight Auger — HOLE DIAMETER 6"
WEIGHT OF HAMMER 140 lbs. — FALLING 30" — SAMPLES 2" Modified California

DEPTH, FT	SAMPLES	BLOWS/FOOT	GROUND WATER	DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
				SURFACE ELEVATION:				
	1	54		Dense, moist, orange-brown fine to coarse-grained SAND (SP) with GRAVEL and COBBLES		5	108	
				Dark brown				
				Medium dense, with trace of CLAY and organic material				
5	2	15				8	94	
				Medium dense, moist, light brown-orange fine-grained SAND (SP)				
				Becoming wet, with SILT lenses (SP-SM)				
10	3	20		Caving		23	93	
15	4	22	∇	Fine to coarse-grained (SW)		24	100	
20	5	16						
25		14		Bottom of boring at 25½ ft.				

NOTES:

1. SEE PLATE 20 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SUBMITTED BY:

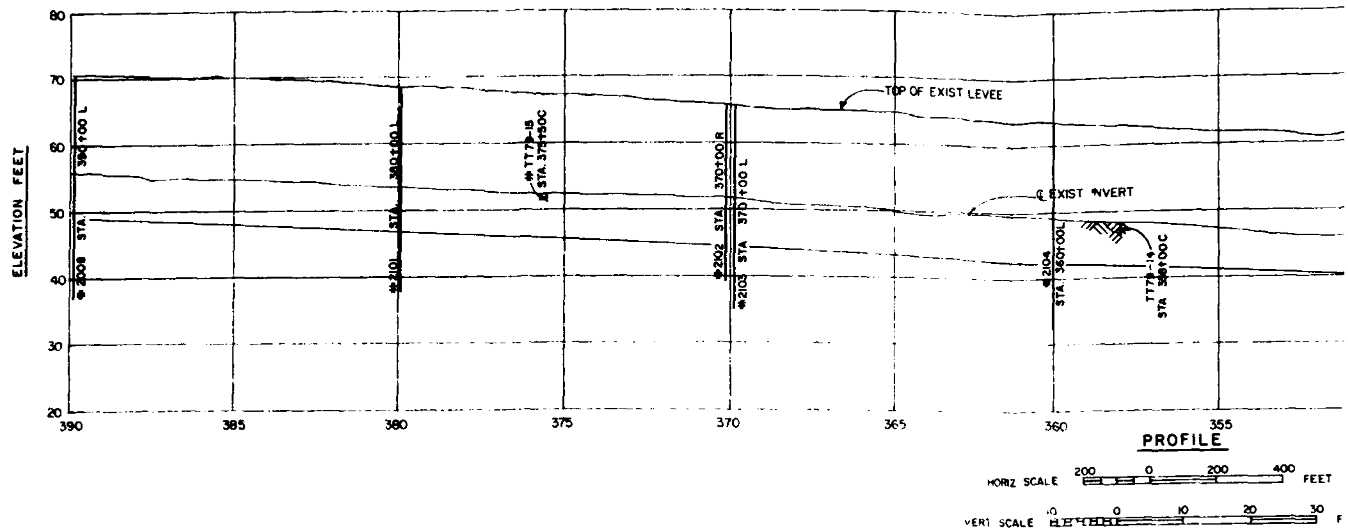
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS

STA.455+00 TO STA.390+00

DATE APPROVED: — SPEC. NO. DACW09-____-B-____ — SHEET

VALUE ENGINEERING



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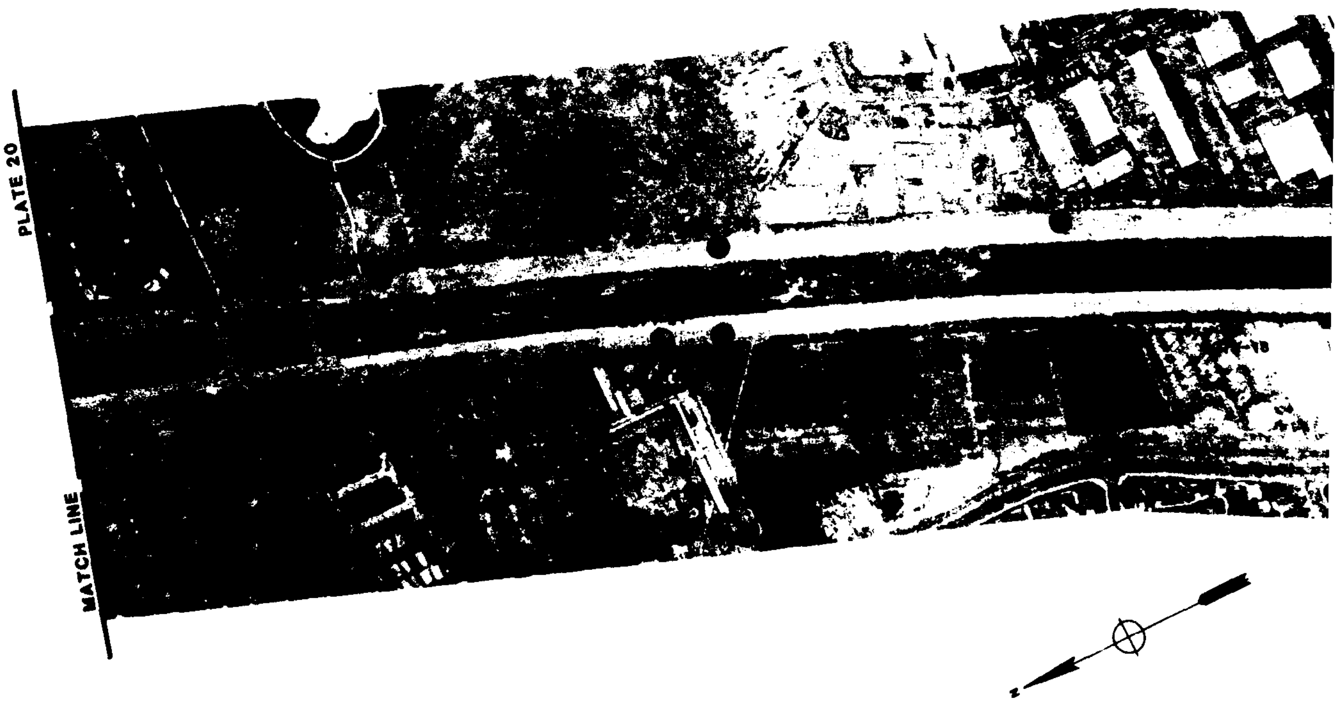
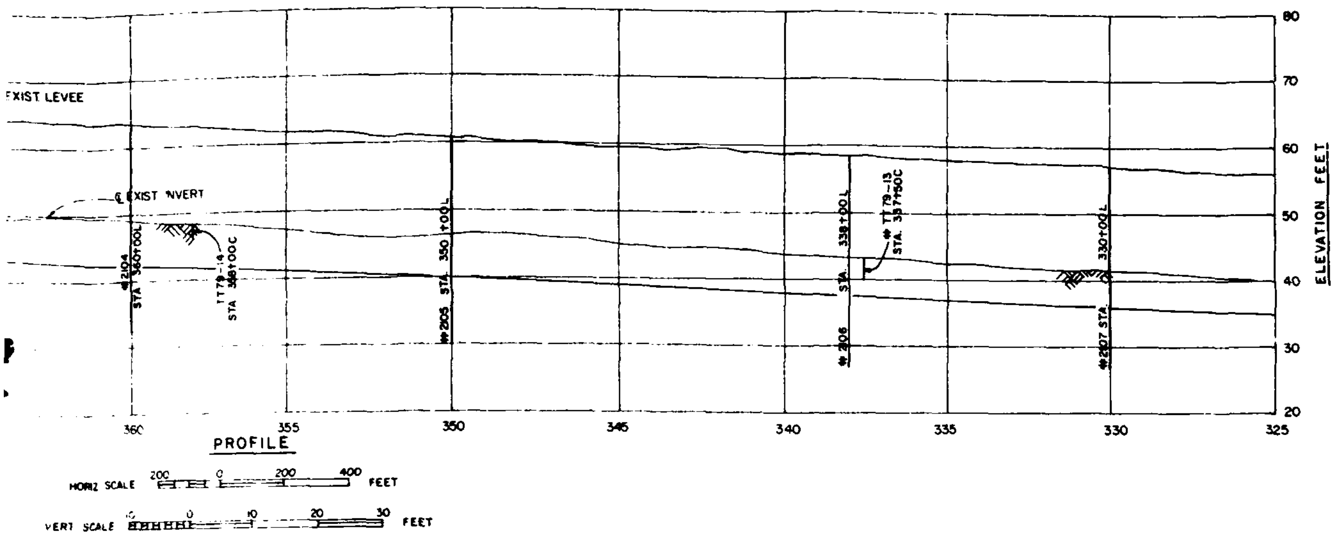
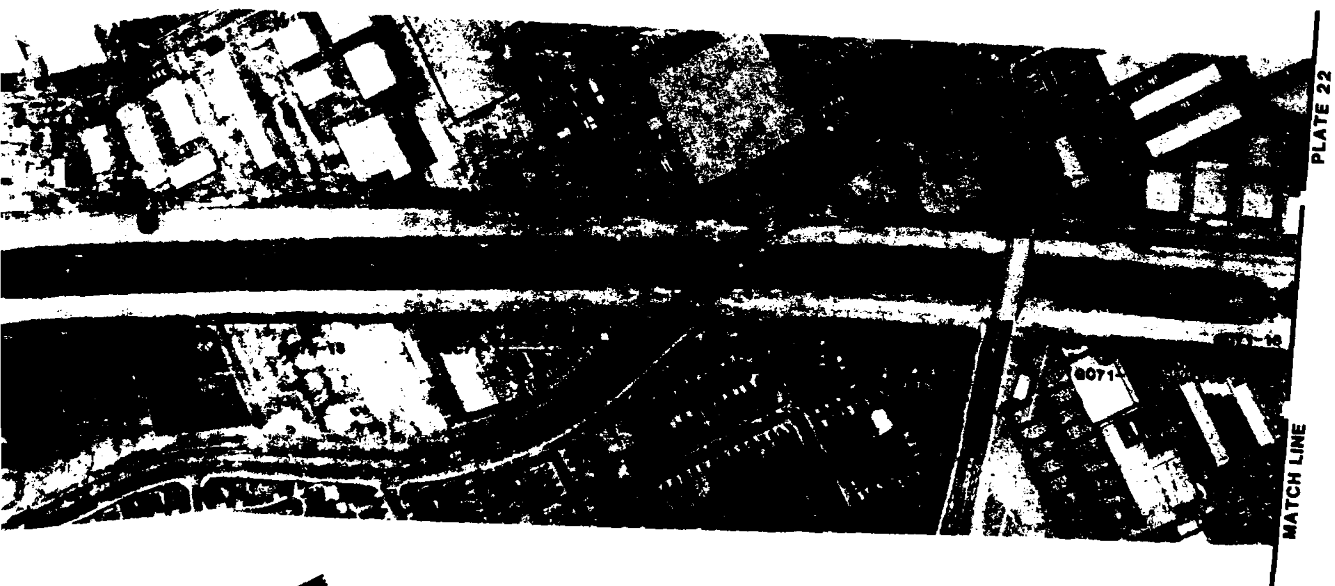


VALUE ENGINEERING PAYS





DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE

STA.390+00 TO STA.325+00

DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-___-B-____
SHEET
DISTRICT FILE NO.

NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

TH 83-2101

TH83-2101 STA 380+00 L EL. 68±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.5	SW/SM	4		NP	94	7	25	SAND/SILTY SAND: BROWN, MOIST, GRAVEL TO 3/8 INCHES, FINE TO MEDIUM GRAINED SAND. 1 INCH LAYER OF MED. GRAINED SAND.
	SM	4		NP	94	13		SILTY SAND: SAME AS ABOVE.
4.0		10		NP	100	17	16	
5.5	SP	2			95	3		SAND: GREY, MOIST, MEDIUM GRAINED SAND.
7.0	SP/SM	7		NP	100	10	9	SAND/SILTY SAND: SAME AS ABOVE.
9.0	CL	33	44	22	100	88		CLAY: BROWN, MOIST, FINE GRAIN SAND.
9.5	ML	32		NP	100	29		SANDY SILT: SAME AS ABOVE.
10.0	SM	15		NP	100	30		SILTY SAND: BROWN AND GREY, WET, MEDIUM GRAIN SAND.
11.5	ML	27		NP	100	55		SANDY SILT: BROWN, WET, FINE TO MEDIUM GRAINED SAND.
	SM	23		NP	100	22	10	SILTY SAND: BROWN AND GREY, WET, MEDIUM GRAIN SAND.
14.5		15		NP	98	16		
	ML	31	38	10	100	75	9	SANDY SILT: GREY, WET, FINE GRAIN SAND, IRON OXIDE.
18.5		43	45	15	100	95		SILT: LIGHT GREY, WET.
20.5	SM	18		NP	100	27	10	SILTY SAND: GREY, WET, FINE GRAIN SAND.
22.5	SP/SM	10		NP	100	10	19	SAND/SILTY SAND: GREY, WET, MEDIUM GRAINED.
		17		NP	100	31		SILTY SAND: BROWN, WET, MEDIUM TO FINE GRAINED.
	SM	23		NP	100	44		SAME: LIGHT GREY, FINE GRAINED.
26.5		19		NP	100	33		SAME. BROWN, MEDIUM TO FINE GRAINED.
29.0	SP/SM	23		NP	100	16	17	SAND/SILTY SAND: GREY, WET, MEDIUM TO COARSE GRAINED SAND.
31.0	SW/SM	24		NP	100	12	19	

TH 83-2102

TH83-2102 STA 370+00 R EL. 66±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTI
		5		NP	96	18		SILTY SAND: BROWN, MOIST, FIN TO 3/4 INCHES.
		10		NP	96	39		
	SM	6		NP	98	24	25	
		3		NP	98	18		
7.5		3		NP	96	13		
9.5	SP/SM	3		NP	97	9		SAND/SILTY SAND: LIGHT BROWN,
							10	SILTY SAND: LIGHT BROWN, MOIS
		4		NP	100	14		
		7		NP	100	29	9	SAME: BROWN, MOIST, FINE TO M
	SM	19		NP	100	49	9	
19.0		16		NP	99	29		SAME: BROWN, WET, MEDIUM GRAI
20.0	CL	32	41	16	99	71		SANDY CLAY: DARK GREY, WET.
		9		NP	99	13		SILTY SAND: GREY, WET, MEDIUM
23.5	SM	29		NP	100	14	10	
26.5	ML	24	24	[illegible]	100	56	6	SANDY SILT: DARK BROWN, WET, COHESIVE.

TT 79-15

INVERT
TT79-15 STA 375+50 C EL. 52±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SP	8			100	1		SAND: GREY, MOIST, VEGETATION. GROUNDWATER AT 1-FOOT.

TH 83-2104

TH83-2104 STA 360+00 L EL. 67±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTI
	SW/SM	3		NP	92	7	25	SAND/SILTY SAND: BROWN-GREY, MEDIUM TO FINE GRAINED SAND.
4.0		4		NP	94	9		
5.5	SP/SM	3		NP	97	6	34	SAND/SILTY SAND: BROWN, MOIST
7.0	SW/SM	5		NP	98	9		SAND/SILTY SAND: SAME AS ABOV
8.5	SP/SM	5		NP	97	7	22	SAND/SILTY SAND: SAME AS ABOV
	SM	3		NP	99	18		SILTY SAND: BROWN, MOIST, FI
11.5		13		NP	99	43	8	SAME: BROWN, MOIST, MEDIUM T
13.0	SP	[illegible]			94	3		SAND: GREY, MOIST, MEDIUM TO TO 3/8 INCHES.
14.5	SP/SM	[illegible]		NP	97	5	10	SANDY/SILTY SAND: SAME AS AB
	SP	3			83	2		GRAVELLY SAND: SAME AS ABOVE
17.5					62	4	13	
	SP/SM	20		NP	92	7	15	SAND/SILTY SAND: GREY-LIGHT B GRAVEL TO 3/8 INCHES.
24.0		18		NP	100	6	2	
26.5	CL	30	32	9	100	53		SANDY CLAY: DARK GREY-BROWN
		35		NP	99	72		SANDY SILT: GREY, FINE GRAI
	ML	31		NP	100	57	13	
31.0		27		NP	100	71	13	

LUE ENGINEERING PAYS

TH 83-2102

STA 370+00 R — EL. 66±

MC	LL	PI	-4	-200	N	DESCRIPTION
5		NP	96	18		SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED, GRAVEL TO 3/4 INCHES.
[illegible]		NP	96	79		
6		NP	95	24	25	
3		NP	98	18		
3		NP	96	13		
5		NP	[illegible]	[illegible]		SAND/SILTY SAND: LIGHT BROWN, MOIST, MEDIUM GRAINED.
					10	SILTY SAND: LIGHT BROWN, MOIST, MEDIUM GRAINED.
4		NP	100	14		
7		NP	100	39	9	SAME: BROWN, MOIST, FINE TO MEDIUM GRAINED.
19		NP	100	49		
					9	
16		NP	[illegible]	[illegible]		SAME: BROWN, WET, MEDIUM GRAINED.
32	37	[illegible]	[illegible]	[illegible]		SANDY CLAY: DARK GREY, WET.
3		NP	[illegible]	[illegible]		SILTY SAND: GREY, WET, MEDIUM TO COARSE GRAINED.
[illegible]		NP	[illegible]	[illegible]	[illegible]	
24	29	[illegible]	100	[illegible]	6	SANDY SILT: DARK BROWN, WET, FINE TO MEDIUM GRAINED, COHESIVE.

TH 83 2103

TH83-2103 — STA 370+00 L — EL. 66±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP/SM	4		NP	98	8		SAND/SILTY SAND: BROWN, MOIST, NON-COHESIVE, FEW GRAVEL TO 3/8 INCHES.
4.0		4		NP	99	8		SAME: BROWN AND GREY, MEDIUM TO COARSE GRAINED SAND.
5.5	ML	19		NP	93	62		SANDY SILT: BROWN, MOIST, MEDIUM TO FINE GRAINED SAND.
	SM	14		NP	100	26	5	SILTY SAND: BROWN, MOIST, MEDIUM TO FINE GRAINED SAND.
		11		NP	98	31		
10.0		19					7	
	SP/SM	5		NP	99	11		SAND/SILTY SAND: GREY TO LIGHT BRN, MOIST, MED. GRAINED.
		3						SAME: GREY.
14.5		5		NP	100	5		
15.5	SM	5		NP	100	14		SILTY SAND: BROWN, MOIST, MEDIUM TO FINE GRAIN.
16.0	ML	26	25	2	100	58		SANDY SILT: DARK BROWN, MOIST, FINE GRAINED.
	SM	17		NP	100	46		SILTY SAND: BROWN, WET, COHESIVE, FINE GRAINED.
19.0		28					20	
	ML	19		NP	95	57		SANDY SILT: GREY, WET, MEDIUM TO COARSE GRAINED SAND.
		22						
23.5		24						SAME: DARK GREY, COHESIVE.
	SM	28		NP	95	19		SILTY SAND: DARK GREY, WET, NON-COHESIVE, MEDIUM TO FINE GRAINED.
		24						
		24						SAME: MEDIUM GRAINED SAND.
31.0		25						

TH 83-2104

STA 360+[illegible] — EL. 67±

MC	[illegible]	[illegible]	[illegible]	-200	N	DESCRIPTION
3		NP	[illegible]	[illegible]	25	SAND/SILTY SAND: BROWN-GREY, MOIST, FEW GRAVEL TO 3/4", MEDIUM TO FINE GRAINED SAND.
4		NP	94	3		
					34	
3		NP	[illegible]	5		SAND/SILTY SAND: BROWN, MOIST, MEDIUM GRAINED SAND.
5		NP	[illegible]	3		SAND/SILTY SAND: SAME AS ABOVE.
					27	
5		NP	[illegible]	7		SAND/SILTY SAND: SAME AS ABOVE.
3		NP	[illegible]	18		SILTY SAND: BROWN, MOIST, FINE GRAINED SAND.
					8	
18		NP	[illegible]	[illegible]		SAME: BROWN, MOIST, MEDIUM TO FINE GRAINED SAND.
4			84	[illegible]		SAND: GREY, MOIST, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 3/8 INCHES.
					10	
5		NP	37	5		SANDY/SILTY SAND: SAME AS ABOVE, GRAVEL TO 1-1/2 INCHES.
3			[illegible]	[illegible]		GRAVELLY SAND: SAME AS ABOVE.
					13	
			[illegible]	4		
20		NP	92	7	15	SAND/SILTY SAND: GREY-LIGHT BROWN, MOIST, MEDIUM TO COARSE GRAVEL TO 3/8 INCHES.
18		NP	100	6		
					2	
30	32	[illegible]	100	[illegible]		SANDY CLAY: DARK GREY-BROWN, WET.
35		NP	99	77		SANDY SILT: GREY, FINE GRAINED SAND, SLIGHTLY COHESIVE.
31		NP	100	57	13	
27		NP	100	71		

NOTES:

1. SEE PLATE 21 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SCALE 1 IN=3FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.380+00 TO ST. 360+00

TT79-14

INVERT

TT79-14 STA 353+00 C EL. 48±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP	4			98	0		SAND: GREY, MOIST.
2.0					96	0		SAME: GREY, MOIST. GROUNDWATER ENCOUNTERED AT 2-FEET.

TT79-13

INVERT

TT79-13 STA 337+50 C EL. 44±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP	2			96	1		SAND: GREY, MOIST.
2.0	SW/SM			NP	93	11		SAND/SILTY SAND: GREY, MOIST. GROUNDWATER ENCOUNTERED.
3.0								

TH83-2105

TH83-2105 STA 350+00 L EL. 61±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP	1			100	4	25	SAND: BROWN, MOIST, MEDIUM GRAINED SAN
1.5		3		NP	100	9		SANDY/SILTY SAND: SAME AS ABOVE.
	SP/SM	4		NP	100	6		SAME: FEW GRAVEL TO 1-1/2 INCHES.
		2		NP	100	5		SAME: FEW GRAVEL TO ¾ INCHES.
5.5	SW/SM	4		NP	100	9		SAND/SILTY SAND: SAME AS ABOVE.
7.0							12	
	SP	6		NP	100	15		SILTY SAND: BROWN, MOIST, FINE TO MED
9.5	SP/SM	4		NP	100			SAND/SILTY SAND: SAME AS ABOVE.
10.5		5		NP	100	13		SILTY SAND: BROWN-GREY, MOIST, FINE GRA
	SM	12		NP	100	15		
12.0							6	
		2		NP	100	2		SAND/SILTY SAND: BRN-GREY, WET, MED
		4		NP	97			SAME: GRAVEL TO 1 INCH.
		11		NP	97		11	
	SP/SM	14		NP	93			
		12		NP	93		11	
		20		NP	100			
		20		NP	100	8		
21.5 / 22.0	SP	23			100	5	9	SAND: GREY, WET, MEDIUM GRAINED SAND
	SP/SM	20		NP	100			SAND/SILTY SAND: SAME AS ABOVE.
		23		NP	100		5	SAME: GREY, WET, MEDIUM TO COARSE
25.0	ML	39	44	16	100	90		SILT: DARK GREY, FINE GRAINED SAND
26.0	SC	25	33	12	100	41	6	CLAYEY SAND: SAME AS ABOVE.
27.5	SM	27		NP	100	49		SILTY SAND: SAME AS ABOVE.
29.0 / 29.5	CL	25	31	11	100	52		SANDY CLAY: BROWN, WET, FINE GRAINED
	SM	21		NP	90	17		SILTY SAND: GREY, WET, MEDIUM GRAINED
31.0							20	

TH84-2107

TH84-2107 STA [illegible] EL. 57±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	7		NP	93	15		SILTY SAND: BROWN, MOIST, LOOSE, FINE GRAVEL TO 1/2 INCHES. SOME CLUMPS
3.0								
	SW/SM	3		NP	95		14	SAND/SILTY SAND: SAME AS ABOVE
							4	
9.0								
	SP				99	4	4	SAND: BROWN, MOIST, LOOSE, FINE GRAINED COHESION.
							11	
15.0								
	CH				100	51	19	SANDY CLAY: DARK BROWN, MOIST, COHESIVE SAND, STIFF.
18.0								
	ML			NP	100	75	6	SANDY SILT: GREY, MOIST, COHESIVE, FINE STIFF.
24.0								
	SM			NP	100	45		SILTY SAND: GREY, MOIST, COHESIVE, FINE STIFF.
				NP	100	46		

ALUE ENGINEERING PAYS

TH83-2105

STA 350+00 : EL. 61±

LL	PI	-4	-200	N	DESCRIPTION
		[illegible]	4		SAND: BROWN, MOIST, MEDIUM GRAINED SAND.
	NP	[illegible]			SANDY/SILTY SAND: SAME AS ABOVE.
	NP				SAME: FEW GRAVEL TO 1-1/2 INCHES.
	NP				SAME: FEW GRAVEL TO 3 INCHES.
	NP				SAND/SILTY SAND: SAME AS ABOVE.
	NP				SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAIN SAND.
	NP				SAND/SILTY SAND: SAME AS ABOVE.
	NP				SILTY SAND: BROWN-GREY, MOIST, FINE GRAINED SAND.
	NP				SAND/SILTY SAND: BRN-GREY, WET, MED TO COARSE GRAINED SAND.
	NP				SAME: GRAVEL TO 1 INCH.
	NP				SAND: GREY, WET, MEDIUM GRAINED SAND.
	NP				SAND/SILTY SAND: SAME AS ABOVE.
	NP				SAME: GREY, WET, MEDIUM TO COARSE GRAINED SAND.
					SILTY SAND: DARK GREY, FINE GRAINED SAND.
					SILTY SAND: SAME AS ABOVE.
	NP				SILTY SAND: SAME AS ABOVE.
					SANDY SILT: BROWN, WET, FINE GRAINED SAND.
	NP				SILTY SAND: GREY, WET, MEDIUM GRAINED SAND, GRAVEL TO 1"[illegible]

TH83-2106

TH83-2106 STA 338+00 L EL. 59±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
2.5	SM	10 / 5		NP	97	18	18	SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED SAND. GRAVEL TO 1-1/2 INCHES.
5.5	SP/SM	2 / 4		NP	99	8	11	SAND/SILTY SAND: GREY-BROWN, MOIST, MEDIUM GRAINED SAND.
	SM	5		NP	99	13	4	SILTY SAND: GREY-BRN, MOIST, FINE TO MEDIUM GRAINED SAND, GRAVEL TO 3/4 INCHES.
8.5		10		NP	98	18		SAME: BROWN, WET, FINE TO MEDIUM GRAINED SAND.
12.0	SP/SM	3 / 4		NP	99	10	7	SAND/SILTY SAND: LIGHT BROWN, WET, MEDIUM GRAINED SAND.
13.5	SM/SC	24	26	6	98	72	5	SILTY SAND/CLAYEY SAND: BROWN, WET, FINE TO MEDIUM GRAINED SAND.
16.0	ML	36	33	2	100	97		SILTY: BROWN, WET, COHESIVE.
17.5	SM	21		NP	98	18	8	SILTY SAND: BROWN, WET, MEDIUM GRAINED SAND.
	ML	34 / 33		NP	100	61	5	SANDY SILT: DARK GREY, FINE GRAINED SAND, SOME COHESION. SAME: DARK GREY, COHESIVE.
		[illegible]		NP	100	63		SAME: LIGHT GREY, SLIGHTLY COHESIVE, FINE GRAINED SAND.
24.5		33 / 38	38	11	100	81	2	SAME: LIGHT GREY, WET, COHESIVE.
	SP	22		NP	100	[illegible]	11	SILTY SAND: GREY-BROWN, WET, MEDIUM GRAINED SAND.
31.0		19 / 20 / 22		NP	100	18	[illegible] / 11	

TH84-2107

EL. 57±

DESCRIPTION

SILTY SAND: BROWN, MOIST, LOOSE, FINE GRAINED SAND, FEW [illegible] INCHES, SOME CLUMPS OF COHESIVE SILT.

SAND/SILTY SAND: SAME AS ABOVE.

SAND: BROWN, MOIST, LOOSE, FINE GRAINED SAND, SOME [illegible]

SANDY CLAY: DARK BROWN, MOIST, COHESIVE, FINE GRAINED SAND, STIFF.

SANDY SILT: GREY, MOIST, COHESIVE, FINE GRAINED SAND.

SILTY SAND: GREY, MOIST, COHESIVE, FINE GRAINED SAND, STIFF.

NOTES

1. SEE PLATE 21 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 84 FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SCALE 1 IN=5 FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: | DRAWN BY: | CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF FNGINEERS

STA.358+00 TO STA.330+00

SUBMITTED BY: DATE SHEET

GC71-13

BORING No. 13 STATION 76 + 37 W.O 22-164 DRILL DATE 3/5/71

SURFACE ELEVATION 41 DRIVING WEIGHT 140 lb. 30 in.

Rotary wash boring; 4 inch diameter and 16 inch bucket auger

Depth (ft)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core / Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	SILTY SAND, SM; brown, medium to coarse grained, moist, medium dense.	SM					
3.5	SANDY SILT, ML; gray, moist, firm.	ML					
4.5	SILTY SAND, SM; gray, fine to medium grained, saturated, loose to medium dense.	SM	P*	①	-	-	
9.5	SANDY [illegible], CL; brown, wet, soft, [illegible] brown [illegible]	CL & SM	[illegible]	②	-	37.5	
14.5	SILTY SAND, SM; brown [illegible]	SM	11	③	-	-	
19.5	[illegible] gray, saturated, soft [illegible]	[illegible]	6	④	-	32.5	
24.5	[illegible]		[illegible]	⑤			

GC71-14

BORING No. 14 STATION 81 + 78 W.O 22-164 DRILL DATE 3/9/71

SURFACE ELEVATION 32 DRIVING WEIGHT 140 lb. 30 in.

Rotary wash boring; 4 inch diameter

Depth (ft)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core / Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	FILL SAND; SP; medium to coarse grained, moist, loose; clean.	SP		①			
5			7	②	-	-	
10			[illegible]	③	-	-	
15	NATURAL GROUND: CLAYEY FINE SAND; ML; SILTY CLAY, CL; SILTY FINE SAND; ML; interbedded [illegible] medium dense.			④	-	-	
20			[illegible]	⑤	-	-	
25			[illegible]	⑥	-	[illegible]	

[illegible] (continued)

BORING No. 15 [illegible] SURFACE ELEVATION 37 [illegible]

GC71-16

BORING No. 16 STATION 93 + 8[illegible] W.O 22-164 DRILL DATE 3/8/71

SURFACE ELEVATION [illegible] DRIVING WEIGHT 140 lb. 30 in.

Depth (ft)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core / Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	[illegible] brown, [illegible] pieces of wood	CL					
2	[illegible] wet, [illegible] trace of gravel	SP	13	①	-	-	
			11	②	-	-	
9.5	[illegible] wet, [illegible]	[illegible] & SM	[illegible]	③	-	[illegible]	
15	[illegible] medium grained, [illegible]	SP	14	④	-	-	
			6	⑤	-	29.[illegible]	
22	[illegible] wet, soft	[illegible]					
26	[illegible] brown [illegible] organic	[illegible]	[illegible]	⑥			

GC71-17

BORING No. [illegible] STATION [illegible] W.O [illegible] DRILL DATE [illegible]

SURFACE ELEVATION [illegible] DRIVING WEIGHT [illegible] 30 in.

Depth (ft)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core / Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	[illegible] SILTY SAND [illegible] and pieces of wood						
1.5	NATURAL GROUND: [illegible] brown [illegible]						
	Pocket of gravel at 5.0'						
10	[illegible]	[illegible]		[illegible]	99	[illegible]	[illegible]
15	[illegible] brown, [illegible]	SP		[illegible]	[illegible]	[illegible]	85
20	[illegible] with SILTY CLAY [illegible]		[illegible]	①			
25	[illegible] medium dense			②			
	[illegible] weight under water						

BORING No. [illegible] SURFACE ELEVATION [illegible]

ALUE ENGINEERING PAYS

GC71-14 (Cont'd)

BORING No. 14 cont. STATION 81 + 78 W.O. 22-164 DRILL DATE 3/9/71

SURFACE ELEVATION 57 DRIVING WEIGHT 140 lb. 30 in.

WATER	DEPTH FEET	GRAPHIC SYMBOL	DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE ○ BAG □	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION
	30		SAND; SP; brown medium grained, dense, grades to gray and brown SILTY FINE SAND; SP; gray and SANDY SILT; ML, moist medium dense.	SP	35	7	-	-	
	35		SILTY FINE SAND; SP; gray, wet, dense; grading to SANDY SILT, ML, brown, moist, firm.	SP ML	18	8	-	-	
	40								

GC71-15

BORING No. 15 STATION 87 + 34 W.O. 22-164 DRILL DATE 3/8/71

SURFACE ELEVATION 62 DRIVING WEIGHT 140 lb. 30 in.

Rotary wash boring; 4 inch diameter

WATER	DEPTH FEET	GRAPHIC SYMBOL	DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE ○ BAG □	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION
▽	0		SAND, SP; brown, fine to medium grained, wet, loose; thin seam of SILTY CLAY; CL; brown, wet, medium stiff at 2.0	SP	6	1	-	-	
	5		SAND; SP; SILT; ML; SILTY CLAY, CL; interbedded, wet, soft.	SP & ML & CL	4	2	-	37.0	
	10		SAND, SP; gray, fine to medium grained, wet, loose.	SP	4	3	-	-	
	15		SILTY SAND, SM; gray brown, fine to medium grained, wet, loose to medium dense; Thin seams of CLAYEY SILT; ML; brown, wet, firm.	SM	10	4	-	-	
	20				11	5	-	25	
	25		SILTY CLAY, CL; gray, moist, medium stiff; interbedded with CLAYEY FINE SAND, ML, wet, loose.	CL & ML	8	6	-	20	
	30								

GC71-19

BORING No. 19 STATION 111 + 25 W.O. 22-164 DRILL DATE [illegible]

SURFACE ELEVATION [illegible] DRIVING WEIGHT [illegible]

Rotary wash boring; 4 inch diameter

WATER	DEPTH FEET	GRAPHIC SYMBOL	DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE ○ BAG □	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION
	0		FILL: SILTY SAND, SM, dark brown, moist, loose to dense; some pieces of concrete.	SM					
▽	5				25	1			
			SANDY SILT [illegible], gray, wet, soft	ML					
	10		SAND, SP, light brown, medium grained, saturated, medium dense to dense	SP	19	2			
	15				16	3			
	20		Thin layers of SILTY SAND, SM, brown, wet, medium dense at 21.0 ft		19	4			
	25				29	5	90.0		
			Driving weight under water						
	30								

NOTES:

1. SEE PLATE 21 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
REVISIONS			

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS

STA.390+00 TO STA.325+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09- ___ - B- ___ SHEET

GC71-18

BORING No. 18 STATION 105 + 92 W.O. 22-164 DRILL DATE 3/?/71

SURFACE ELEVATION 63 DRIVING WEIGHT 1500 lbs, 18 in

Rotary wash boring; 4 inch diameter

35' E ¢ sewer

Depth (feet)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core/Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	FILL: SAND; SP; brown, medium grained, moist, medium dense.	SP					
5			9	(1)	101.[illegible]	23.[illegible]	87
10			6	(2)	1[illegible].5	5.6	[illegible]
12	[illegible] SAND, [illegible] light to dark gray, wet, loose to medium dense.						
15		SP	13*	(3)	-	-	
20			10*	(4)	89.8	22.8	[illegible]
25			[illegible]	(5)	96.[illegible]	23.5	[illegible]
29	* 750 lbs driving weight						
30	continued on next sheet						

GC71-18 (CONT'D)

BORING No. 18 - cont. STATION 105 + 92 W.O. 22-164 DRILL DATE 3/9/71

SURFACE ELEVATION 63 DRIVING WEIGHT 1500 lb. 18 in.

Depth (feet)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core/Bag	Dry Density pcf	Moisture Content %	Relative Compaction
30	SAND, SP; light to dark gray, wet, loose to medium dense.	SP	18*	(6)	97.[illegible]	21.7	[illegible]
35	* 750 lbs. driving weight		30	(7)	[illegible]	[illegible]	[illegible]

GC71-22

BORING No. 22 STATION 129 + 26 W.O. 22-164 DRILL DATE 1/8/71

SURFACE ELEVATION [illegible] DRIVING WEIGHT [illegible] lbs, 18 in.

Depth (feet)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core/Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	[illegible] SP; brown, [illegible] medium, [illegible], moist, loose	SP					
2	Thin [illegible]						
5			6	(1)	[illegible]	[illegible]	82
10	[illegible] SP; [illegible] fine [illegible] loose to med [illegible]	SP	5	(2)	[illegible]	[illegible]	[illegible]
15			16*	(3)	[illegible]	[illegible]	[illegible]
20		SP	17*	(4)	[illegible]	[illegible]	[illegible]
25			17*	(5)	[illegible]	[illegible]	[illegible]
30			31*	(6)	[illegible]	9	90

GC71-23

BORING No. 23 STATION 129 + [illegible] W.O. [illegible] DRILL DATE [illegible]

SURFACE ELEVATION [illegible] DRIVING WEIGHT [illegible]

Depth (feet)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core/Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	[illegible]						
10	[illegible]						
15	[illegible]						
20	[illegible]						
25	[illegible], light brown, [illegible] to coarse grained, saturated, medium dense to dense.					[illegible]	[illegible]
30	continued on next sheet						

VALUE ENGINEERING PAYS

GC71-20

BORING No. 20 STATION 117 + 80 W.O. 22-164 DRILL DATE 3/5/71

SURFACE ELEVATION 54 DRIVING WEIGHT 500 lb., 20 in.

Rotary Wash Boring, 4 Inch Diameter

DEPTH FEET	DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE ○ BAG □	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION
0	SANDY CLAY; CL; dark brown, moist, soft	CL					
5	SILTY CLAY; CL, gray to black, moist, soft.	CL	2	(1)	81.8	36.0	70
10	SAND; SP, light brown, coarse grained, saturated, medium dense.	SP	17*	(2)	102.0	22.6	[illegible]
			14*	(3)	[illegible]	[illegible]	
20	[illegible], moist, medium dense to dense. Thin layer of SILTY CLAY; CL at 23.5'	SM	13*	(4)	95.[illegible]	[illegible]	
25			36*	(5)	[illegible]	[illegible]	
30	*Driving weight under water						

GC71-21

BORING No. 21 STATION 123 + 28 W.O. 22-164 DRILL DATE 3/8/71

SURFACE ELEVATION 55.5 DRIVING WEIGHT 140 lb. 20 in.

Rotary Wash Boring; 4 Inch Diameter

DEPTH FEET	DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE ○ BAG □	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION
0	SAND; SP; brown, fine to medium grained, moist, loose, occasional thin seam of CLAYEY SILT; ML.	SP	7	(1)	-	26.6	
5	Wet at 5.0'		3	(2)	-	-	
10	SAND; SP; brown, medium to coarse grained, wet, medium dense.	SP	12	(3)	-	-	
15	SANDY SILT; ML; brown, wet.	ML	2	(4)	-	-	
20	SAND; SP; brown, medium grained, wet, medium dense.	SP	16	(5)	-	-	
		SP & SM					
25	SAND; SP; SILTY SAND, SM; SILTY CLAY; CL interbedded, wet, soft.	& CL	5	(6)	-	34.2	
30							

GC71-23 (CONT'D)

BORING No. [illegible] STATION [illegible] W.O. 22-164 DRILL DATE [illegible]

SURFACE ELEVATION [illegible] DRIVING WEIGHT [illegible]

DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE ○ BAG □	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION
[illegible]	SP	[illegible]	[illegible]	[illegible]	[illegible]	
		46	(7)	[illegible]	[illegible]	
Driving weight under water.						

NOTES:

1. SEE PLATE 21 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

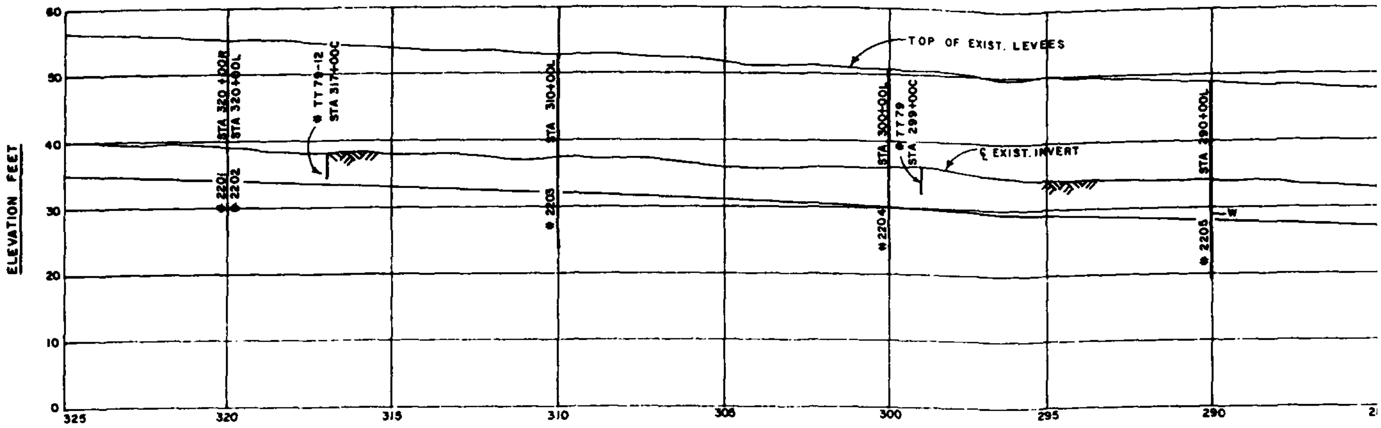
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS

STA.390+00 TO STA.325+00

DESIGNED BY: DRAWN BY: CHECKED BY: SUBMITTED BY: DATE SHEET

VALUE ENGINEERING P



PROFILE

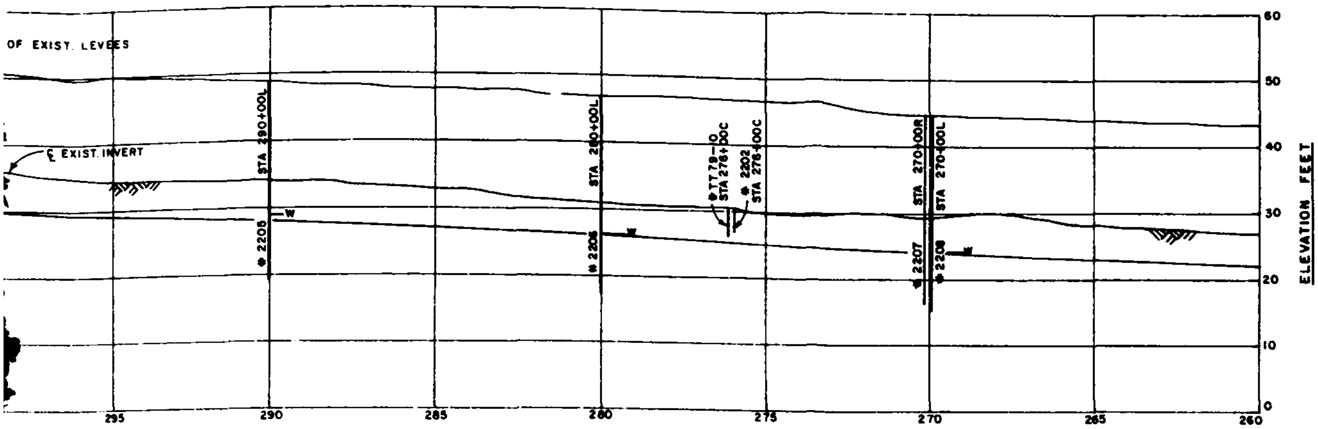
HORIZ. SCALE 200 0 200 400 FEET

VERT. SCALE 10 0 10 20 30 FEET

PLATE 21

MATCH LINE

VALUE ENGINEERING PAYS



PROFILE

HORIZ. SCALE 200 0 200 400 FEET

VERT. SCALE 10 0 10 20 30 FEET

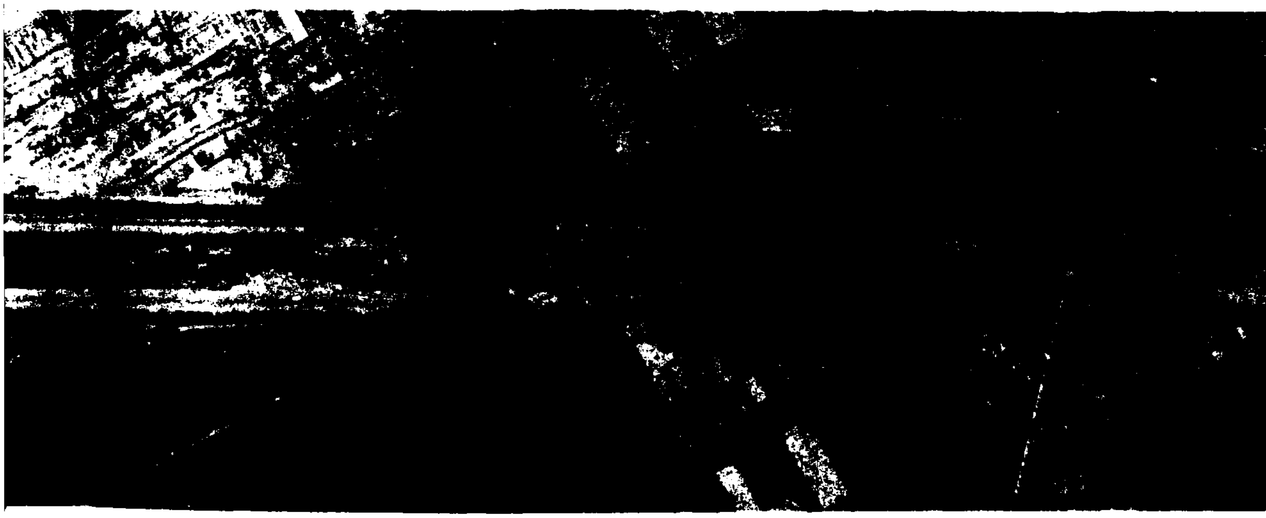


PLATE 23

MATCH LINE

NOTES:

1. SEE PLATE 6 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE

STA.325+00 TO STA.260+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

TH83-2201

TH83-2201 STA 320+00 R EL. 56±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM	5		NP	82	9		GRAVELLY SAND/SILTY GRAVELLY SAND: LIGHT BROWN, MOIST, NO COHESION, MEDIUM GRAINED SAND.
3.0							27	
	SP/SM	1		NP	95	6		SAND/SILTY SAND: SAME AS ABOVE.
5.0	SM	6		NP	100	15		SILTY SAND: LIGHT BROWN, MOIST, NO COHESION, MED. TO FINE GRAINED SAND.
6.0	CH	28	51	25	100	87		CLAY: BROWN, MOIST, SOME COHESION.
7.0								SILTY SAND: BROWN, MOIST, NO COHESION, OCCASIONAL GRAVEL TO 1-1/2 INCHES. BEGAN ADDING DRILLING MUD DUE TO CAVING.
	SM	9		NP	95	21		
10.5	MH	37	55	24	100	92		SILT: BROWN, COHESIVE.
11.5		15		NP	94	19		SILTY SAND: LIGHT BROWN, NO COHESION, MEDIUM GRAIN SAND.
	SM	15		NP	100	29		SAME: SAME AS ABOVE WITH FINE GRAIN SAND.
		21		NP	100	14		SAME: BROWN, WET, MEDIUM GRAIN SAND.
18.0	ML	38	45	15	100	64		SANDY SILT: BROWN, WET, FINE TO MEDIUM GRAIN SAND.
20.0	CL	29	35	11	100	55		SANDY CLAY: DARK GREY, WET, FINE TO MEDIUM GRAIN SAND.
22.0	SC	30	43	13	100	42		CLAYEY SAND: DARK GREY, WET, FINE GRAIN SAND.
23.5							10	SAND/SILTY SAND: GREY, WET, MEDIUM TO COARSE GRAIN SAND.
		28		NP	100	9		
	SP/SM							
		30		NP	100	7		
29.0	SM	22		NP	100	14		SILTY SAND: SAME AS ABOVE.
30.0								

TH84-2202

TH84-2202 STA 320+00 L EL. 56±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM	4		NP	98	9		SAND/SILTY SAND: BROWN, MOIST, LOOSE, SOME GRAVEL. NO PENETROMETER TEST DUE
3.0								SAND: SAME AS ABOVE.
							21	
	SP	2			97	3		
							4	
9.0								SAND/SILTY SAND: LIGHT BROWN, MOIST, L GRAIN SAND, SOME GRAVEL. BEGAN ADDING TO CAVING.
							5	
	SP/SM			NP	99	5		
							13	
15.0	SM			NP	99	14	11	SILTY SAND: LIGHT BROWN, MOIST, FINE COHESIVE, SOME GRAVEL.
18.0	SP/SM	40		NP	97	19	20	SAND/SILTY SAND: LIGHT BROWN, FINE GR SOME CLUMPS OF GREY SILT, STIFF, COHES
21.0	MH	39	50	15	100	53	5	SANDY SILT: DARK GREY, FINE GRAIN SIL FINE GRAIN SAND.
24.0	SM	30	31	2	100	49	22	SILTY SAND: BROWN, FINE GRAIN SAND, S
27.0	ML		34	1	100	73	13	SANDY SILT: SAME AS ABOVE.
30.0								

TH84-2203

TH84-2203 STA 310+00 L EL. 53±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP/SM	4		NP	98	7		SAND/SILTY SAND: LIGHT BROWN, LOOSE, FINE GRAIN SAND, SOME CLUMPS OF SILT.
3.0								SILTY SAND: SAME AS ABOVE.
							25	
	SM	5		NP	99	17		
							5	
9.0							7	SILTY SAND: BROWN, MOIST TO WET, LOOSE, COHESIVE, VERY FINE GRAIN SAND, SOME GRAVEL.
		29		NP	99	21		
							11	
	SM							
		34		NP	99	43	15	SAME: LARGE CLUMPS OF SILT.
				NP	100	23	4	
21.0		39	31	3	100	65	25	SANDY SILT: GREY, WET, STIFF, FINE GRAIN SAND, COHESIVE, LARGE CLUMPS.
	ML							
			31	4	100	52	20	
27.0	SM			NP	100	49		SILTY SAND: SAME AS ABOVE.
30.0								

TH83-2204

TH83-2204 STA 300+00 L EL. 51±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		4						SAND/SILTY SAND: BROWN-LIGHT BROWN, MOIST, GRAVEL TO 3/4 INCHES.
		1		NP	100	11		
	SW/SM							
		3						
9.0		[illegible]		NP	100	14		SILTY SAND: BROWN AND GREY, MOIST, FINE TO MEDIUM GRAIN SAND, LAYERED
		4						
	SM	18		NP	100	40		SAME: BROWN AND GREY, WET, FINE TO
		15		NP	100	13		SAME: GREY, WET, MEDIUM GRAIN SAND
		27		NP	100	45		SAME: GREY, WET.
23.5	ML	28		NP	100	52		SANDY SILT: GREY, WET, FINE GRAIN
24.0		25		NP	100	2		SILTY SAND: GREY, WET, MEDIUM GRAI
	SM							
		21		NP	100	28		SAME: YELLOWISH GREY, WET, MEDIUM
30.5	ML	28	35	12	100	79		SANDY CLAY: GREY, WET.
31.5								

VALUE ENGINEERING PAYS

TH84-2202

STA 320+00 L — EL. 56±

MC	LL	PI	-4	-200	N	DESCRIPTION
4		NP	98	9		SAND/SILTY SAND: BROWN, MOIST, LOOSE, FINE GRAINED SAND, SOME GRAVEL. NO PENETROMETER TEST DUE TO LARGE GRAVEL.
					21	SAND: SAME AS ABOVE.
2			97	3		
					4	
					5	SAND/SILTY SAND: LIGHT BROWN, MOIST, LOOSE, FINE TO COARSE GRAIN SAND, SOME GRAVEL. BEGAN ADDING DRILLING MUD DUE TO TO CAVING.
		NP	99	6		
					13	
		NP	99	[illegible]	11	SILTY SAND: LIGHT BROWN, MOIST, FINE GRAIN SAND, COHESIVE, SOME GRAVEL.
[illegible]		NP	97	10	20	SAND/SILTY SAND: LIGHT BROWN, FINE GRAIN SAND, COHESIVE, SOME CLUMPS OF GREY SILT, STIFF, COHESIVE.
[illegible]	50	15	100	53	5	SANDY SILT: DARK GREY, FINE GRAIN SILT, COHESIVE, SOME FINE GRAIN SAND.
[illegible]	41	2	100	40	22	SILTY SAND: BROWN, FINE GRAIN SAND, SOME COHESION.
	34	1	100	73	13	SANDY SILT: SAME AS ABOVE.

TT79-12

TT79-12 — STA 317+00 C — EL. 38±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		13			99	2		SAND: GREY, MOIST.
	SP							
3.5					88	1		SAME: GREY, MOIST, GRAVEL TO 3/4 INCHES.

GROUNDWATER ENCOUNTERED AT 3.5 FEET.

TH83-2204

STA 300+[illegible] — EL. 51±

MC	LL	PI	-4	-200	N	DESCRIPTION
4						SAND/SILTY SAND: BROWN-LIGHT BROWN, MEDIUM GRAIN SAND, MOIST, GRAVEL TO 3/4 INCHES.
[illegible]		NP	[illegible]	[illegible]		
		NP	100	24		SILTY SAND: BROWN AND GREY, MOIST, FEW GRAVEL TO 3/4", FINE TO MEDIUM GRAIN SAND, LAYERED SILTY SAND.
[illegible]		NP	100	60		SAME: BROWN AND GREY, WET, FINE TO MEDIUM GRAIN SAND.
[illegible]		NP	100	13		SAME: GREY, WET, MEDIUM GRAIN SAND.
[illegible]		NP	100	64		SAME: GREY, WET.
28		NP	100	51		SANDY SILT: GREY, WET, FINE GRAIN SAND.
[illegible]		NP	100	2		SILTY SAND: GREY, WET, MEDIUM GRAIN SAND.
21		NP	100	29		SAME: YELLOWISH GREY, WET, MEDIUM GRAIN SAND.
[illegible]	35	12	100	79		SANDY CLAY: GREY, WET.

NOTES:

1. SEE PLATE 22 FOR LOCATION OF TEST HOLES AND TEST TRENCHES.
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM.
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SCALE 1 IN=3 FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.320+00 TO STA.300+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-___-___ SHEET

VALUE ENGINEERING F

TT79-11

INVERT

TT79-11 STA 299+00 C EL. 36±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP/SM	4		NP	95	7		SAND/SILTY SAND: BROWN-GREY, MOIST.
3.0	SM	22		NP	100	95		SILTY SAND: BLACK, WET. GROUNDWATER ENCOUNTERED.
4.0								

TH83-2205

TH83-2205 STA 290+00 L EL. 49±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	CH	20	69	44	100	73		SANDY CLAY: DARK BROWN, ASPHALT CHIPS.
		4					19	SILTY SAND: LIGHT BROWN, FEW GRAVEL TO GRAIN SAND.
		4		NP	100	13	4	SAME: SAME AS ABOVE WITH LESS GRAVEL.
	SM	4					2	
							6	SAME: LIGHT BROWN, MEDIUM TO COARSE GRA LENS OF GRAVELLY SAND, GRAVEL TO 3/8 INC
		17		NP	100	45	7	SAME: BROWN, MOIST, FINE TO MEDIUM GRAI
16.0		9		NP	100	31		SAME: BROWN, MEDIUM GRAIN SAND.
17.0	ML/CL	28	27	7	100	70	5	SANDY SILT/SANDY CLAY: DARK BROWN, FINE
18.0	SM	14			100	15		SILTY SAND: BROWN, MEDIUM GRAIN SAND.
W 20.0		38	48	23	100	65	9	SANDY CLAY: DARK BROWN, WET, MEDIUM TO
		23						
24.0		26	48	21	100	72	7	SAME: GREY, WET, IRON OXIDE, FINE GRAIN
	SM	25		NP	100	29	6	SILTY SAND: GREY AND BROWN, WET, MEDIUM SAND.
30.0		22		NP	100	27	20	SAME: BROWN, WET, FINE TO MEDIUM GRAIN

TT84-2282

INVERT

TT84-2282 STA 275+00 C EL. 30±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP				94	3		SAND: MULTICOLORED, WET, FEW GRAVEL TO 1/2 INCH.
3.0	SM			NP	95	12		SILTY SAND: DARK GREY TO BLACK, WET, FINE TO MEDIUM GRAINED SAND, SOME COHESION. HIT RIP-RAP AT 5 FT.
5.0								

TT79-10

INVERT

TT79-10 STA 275+00 C EL. 30±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP/SM	3		NP	95	5		SAND/SILTY SAND: GREY, SOME GRAVEL TO WATER ENCOUNTED AT 3.5 FEET.
4.0								

VALUE ENGINEERING PAYS

TH83-2205

STA 290+00 ℄ — EL. 49±

C	LL	PI	-4	-200	N	DESCRIPTION
0	69	44	100	73		SANDY CLAY: DARK BROWN, ASPHALT CHIPS.
4					29	SILTY SAND: LIGHT BROWN, FEW GRAVEL TO 1 INCH, MEDIUM GRAIN SAND.
4		NP	100	13	4	SAME: SAME AS ABOVE WITH LESS GRAVEL.
4					2	
					6	SAME: LIGHT BROWN, MEDIUM TO COARSE GRAIN SAND, 1 " LENS OF GRAVELLY SAND, GRAVEL TO 3/8 INCHES.
[illegible]		NP	100	45	7	SAME: BROWN, MOIST, FINE TO MEDIUM GRAIN SAND.
[illegible]		NP	100	31		SAME: BROWN, MEDIUM GRAIN SAND.
8	27	7	100	70	5	SANDY SILT/SANDY CLAY: DARK BROWN, FINE GRAIN SAND.
4			100	15		SILTY SAND: BROWN, MEDIUM GRAIN SAND.
8	48	23	100	65	3	SANDY CLAY: DARK BROWN, WET, MEDIUM TO FINE GRAIN SAND.
[illegible]	48	21	100	77	7	SAME: GREY, WET, IRON OXIDE, FINE GRAIN.
[illegible]		NP	100	29	5	SILTY SAND: GREY AND BROWN, WET, MEDIUM TO FINE GRAIN SAND.
[illegible]		NP	100	27	20	SAME: BROWN, WET, FINE TO MEDIUM GRAIN SAND.

TH83-2206

TH83-2206 — STA 280+00 ℄ — EL. 47±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM			NP	100	29		SILTY SAND: BROWN, MOIST, GRAVEL TO 1/2 INCH, MEDIUM GRAIN SAND, 4 INCH ASPHALTIC CONCRETE PAVING.
3.0–3.5	CL		29	9	100	53		SANDY CLAY: BROWN, MOIST.
				NP	100	22	21	SILTY SAND: BROWN, MOIST, CLAY CLODS, MEDIUM TO FINE GRAIN SAND.
	SM			NP	100	19	12	
				NP	100	16	5	
		7		NP	100	14		
12.0	SP/SM	7		NP	100	12	9	SAND/SILTY SAND: GREY AND BROWN, MED. TO FINE GRAIN SAND.
13.0	ML	24	32	8	100	56		SANDY SILT: BROWN TO DARK BROWN, FINE GRAIN SAND.
15.0	SM	23		NP	100	50	9	SILTY SAND: BROWN TO DARK BROWN, FINE GRAIN SAND.
18.0		34	40	14	100	82		SANDY SILT: DARK GREY, ORGANICS.
W 21.0	ML	43						
24.0	SM	28		NP	100	21	9	SILTY SAND: GREY, WET, MEDIUM GRAIN SAND.
		26					14	
28.0	CL		42	20	100	92	8	SANDY CLAY: GREY TO DARK GREY, WET.
30.0								

NOTES:

1. SEE PLATE 22 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM.
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
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TT79-10

STA 275+00 ℄ — EL. 90±

MC	LL	PI	-4	-200	N	DESCRIPTION
3		NP	75	5		SAND/SILTY SAND: GREY, SOME GRAVEL TO 1/2-INCH. GROUND-WATER ENCOUNTERED AT 3.5 FEET.

SCALE: 1 IN = 3 FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS
STA.299+00 TO STA.276+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

VALUE ENGINEERING P

TH 83-2207

TH83-2207 STA 270+00 R EL. 45±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	5		NP	100	16	21	SILTY SAND: BROWN, MOIST, MEDIUM GRAIN SAND, GRAVEL TO 3/4 INCHES.
4.5		8		NP	99	27	7	SAME: BROWN TO DARK BROWN, MOIST, 1 INCH LAYERED CLAYEY SAND, FINE TO MEDIUM GRAIN SAND.
6.0	CL	26	49	25	100	65		SANDY CLAY: BROWN TO DARK BROWN, MOIST, MEDIUM TO FINE GRAIN SAND, PLASTIC.
8.0	SC	5	37	19	100	13	6	CLAYEY SAND: BROWN AND GREY, MOIST, MEDIUM TO COARSE GRAIN SAND, GRAVEL TO 3/8 INCHES.
		9		NP	98	19		SILTY SAND: BROWN, MOIST, MEDIUM GRAIN SAND, CLAY CLODS.
12.0	SM	5		NP	99	13	4	SAME: NO CLAY
14.0	SW/SM	5		NP	100	12		SAND/SILTY SAND: SAME AS ABOVE.
	SM	13	27	2	99	48		SILTY SAND: DARK BROWN, MOIST TO WET, COHESIVE.
17.0		8		NP	99	14	5	SAME: LIGHT BROWN, MOIST, NON-COHESIVE.
19.0	SP/SM	16		NP	100	7		SAND/SILTY SAND: BROWN, WET, MEDIUM TO COARSE GRAINED SAND.
	ML	36	45	18	100	76	3	SANDY SILT: GREY, WET, PLASTIC, ADDED DRILLING MUD TO REDUCE CAVING.
24.0		34	34	8	100	97	4	SILT: BROWN AND GREY, SAME AS ABOVE.
25.0	SP/SM	29		NP	100	10		SAND/SILTY SAND: GREY, FINE GRAINED SAND, NON-COHESIVE.
28.0	CH	33	50	23	100	91	3	CLAY: GREY, PLASTIC.
28.5	SM	22	30	5	100	32	10	SILTY SAND: BROWN, COHESIVE.

TH 83-2208

TH83-2208 STA 270+00 L EL. 45±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		5		NP	100	41		SILTY SAND: BROWN, MOIST, CLAY CLODS, MEDI
	SM	8					12	
9.0		10		NP	100	48	4	SAME: BROWN, MOIST, FINE GRAIN SAND.
12.0	CL	11	29	9	100	52	8	SANDY CLAY: BROWN, MOIST, FINE GRAIN SAND, CLODS.
15.0	SM	4		NP	100	27	5	SILTY SAND: BROWN, MOIST, MEDIUM TO FINE GR SOME CLAY CLODS.
16.5	ML	27		NP	100	74	9	SANDY SILT: SAME AS ABOVE.
17.0	CH	29	50	25	100	82		SANDY CLAY: BROWN, MOIST, IRON OXIDE, ORGAN
18.0	SP/SM	25			100	7		SAND/SILTY SAND: SAME AS ABOVE.
		48					8	CLAY: BROWN AND GREY, WET, MEDIUM GRAIN SAN
W 20.0		41	47	27	100	85		SAME: GREY, WET, ORGANICS.
		79					7	
	CL	29	45	22	100	80	9	SANDY CLAY: GREY, WET.
30.0		26	34	17	100	65	10	SAME: BROWN AND GREY.

TH 83-2208

+00 L | EL. 45±

-4	-200	N	DESCRIPTION
			SILTY SAND: BROWN, MOIST, CLAY CLODS, MEDIUM GRAIN SAND,
100	[illegible]		
		[illegible]	
100	[illegible]	[illegible]	SAME: BROWN, MOIST, FINE GRAIN SAND.
100	5?	[illegible]	SANDY CLAY: BROWN, MOIST, FINE GRAIN SAND, SOME CLAY CLODS.
[illegible]	[illegible]		SILTY SAND: BROWN, MOIST, MEDIUM TO FINE GRAIN SAND, SOME CLAY CLODS.
100	74	9	SANDY SILT: SAME AS ABOVE.
100	32		SANDY CLAY: BROWN, MOIST, IRON OXIDE, ORGANIC.
[illegible]	[illegible]		SAND/SILTY SAND: SAME AS ABOVE.
		[illegible]	CLAY: BROWN AND GREY, WET, MEDIUM GRAIN SAND.
[illegible]	[illegible]		SAME: GREY, WET, ORGANICS.
		[illegible]	
100	[illegible]	[illegible]	SANDY CLAY: GREY, WET.
[illegible]	[illegible]	[illegible]	SAME: BROWN AND GREY.

TH 83-2209

TH83-2209 | STA 260+00 L | EL. 44±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		6		NP	93	14		SILTY SAND: BROWN, DRY TO MOIST, MEDIUM GRAIN SAND, OCCASIONAL GRAVEL TO 3 INCHES.
	SM							
		10		NP	100	16		SAME: LESS FINES, FEW CLUMPS OF COHESIVE MATERIAL.
5.0							21	
	SM/SM	9		NP	37	11	9	SAND/SILTY SAND: BROWN AND GREY, MEDIUM GRAIN SAND.
9.0								
	CL		31	13	100	55		SANDY CLAY: BROWN, WET, CAVING OCCURRED.
13.0								
	ML	32		NP	100	87		SILT: BROWN, WET, MEDIUM GRAIN SAND.
15.0							5	
	CL	39	43	18	100	87		CLAY: BROWN, WET, MEDIUM GRAIN SAND, SOME PLASTICITY.
18.0								
	SM			NP	100	19		SILTY SAND: BROWN, WET, MEDIUM GRAIN SAND, GRAVEL TO 3 INCHES.
20.0	ML			NP	100	54	6	SANDY SILT: GREY, WET, TRACE OF IRON OXIDE.
21.0								
	CL	31	42	22	100	54		SANDY CLAY: SAME AS ABOVE.
24.0								
	SM			NP	100	35		SILTY SAND: BROWN, WET, MEDIUM GRAIN SAND.
25.5							11	
	CL	42	24	18	100	92		CLAY: GREY, WET, TRACE OF IRON OXIDE.
29.0								
	ML	30		NP	100	79	11	SANDY SILT: BROWN, GREY, FINE GRAIN SAND.
31.0								

SCALE: 1 IN=3FT

5 0 5 10

NOTES:

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2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

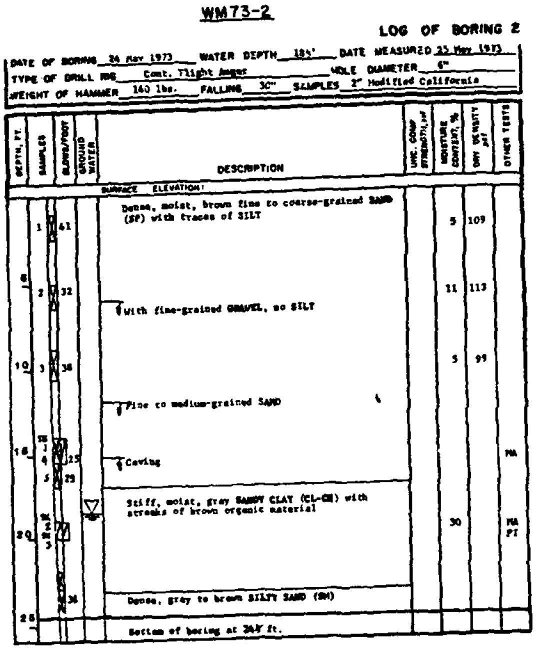
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

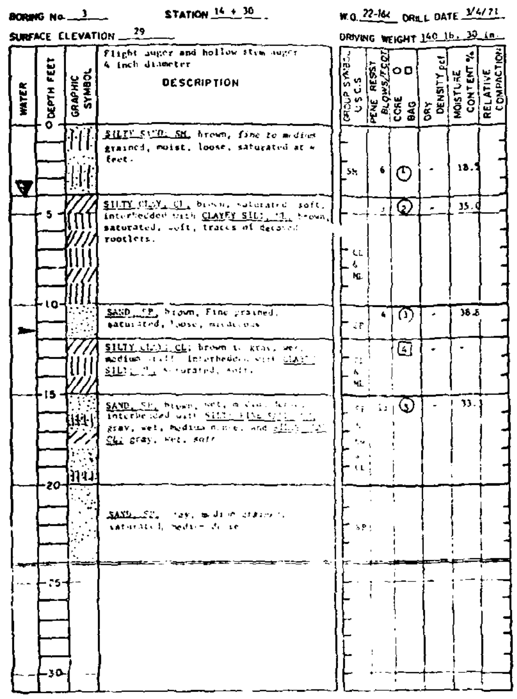
LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS
STA.270+00 TO STA.260+00

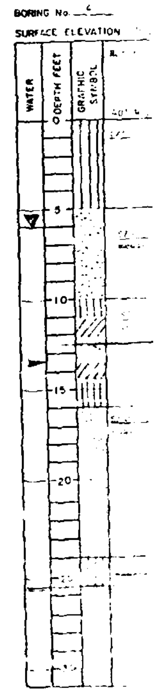
SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-____ B-____ | SHEET

WM73-2



GC71-3





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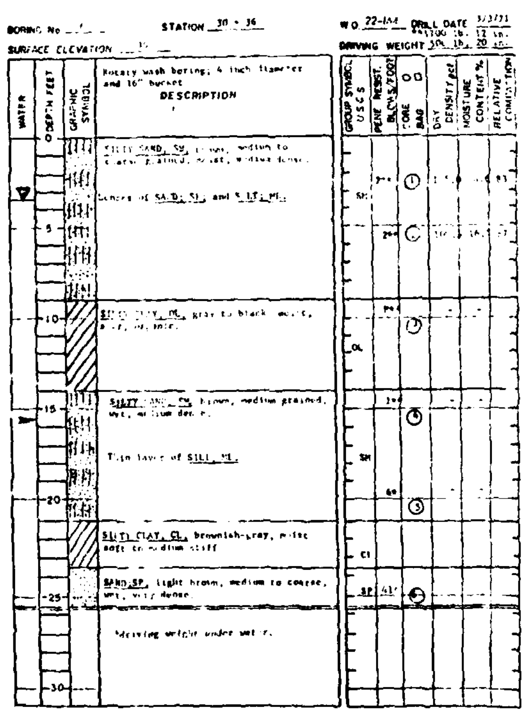

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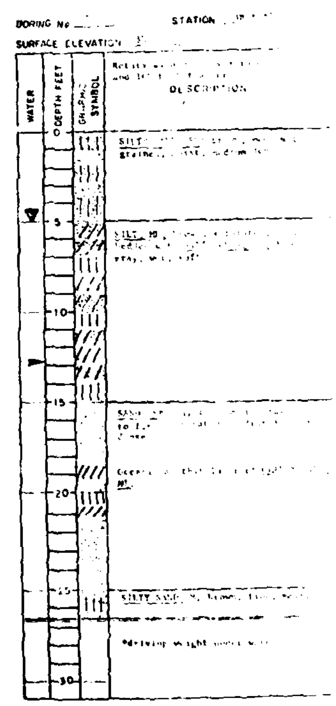
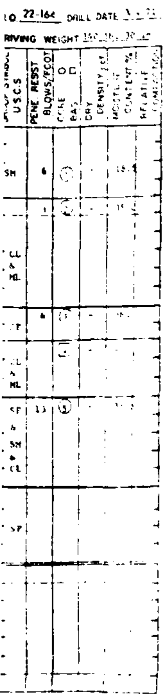


LUE ENGINEERING PAYS



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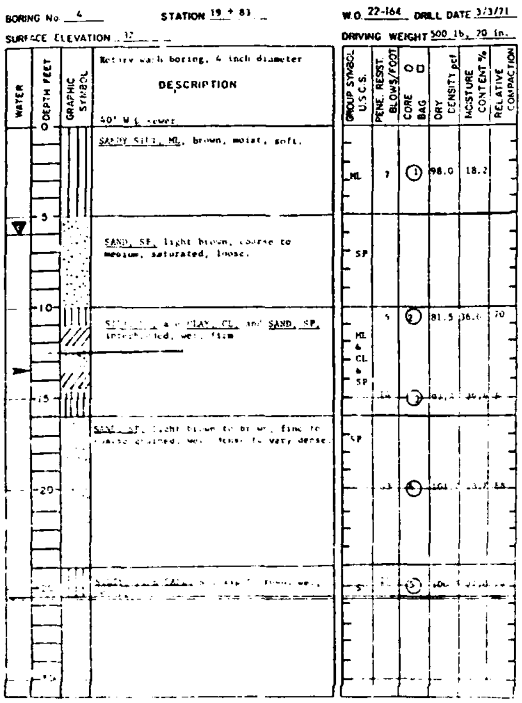

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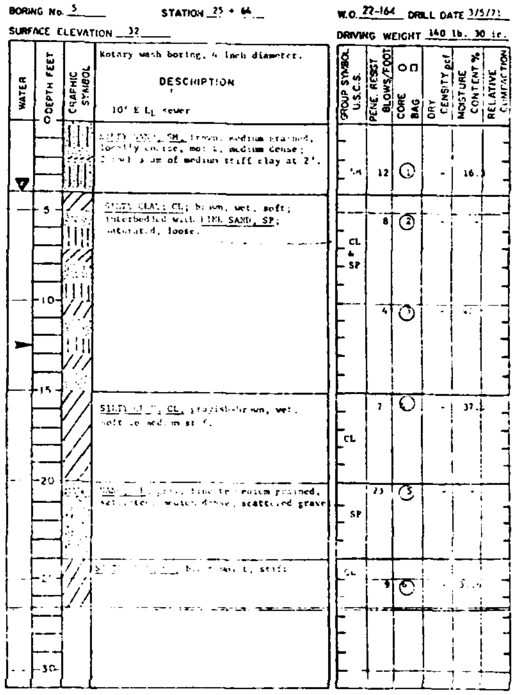
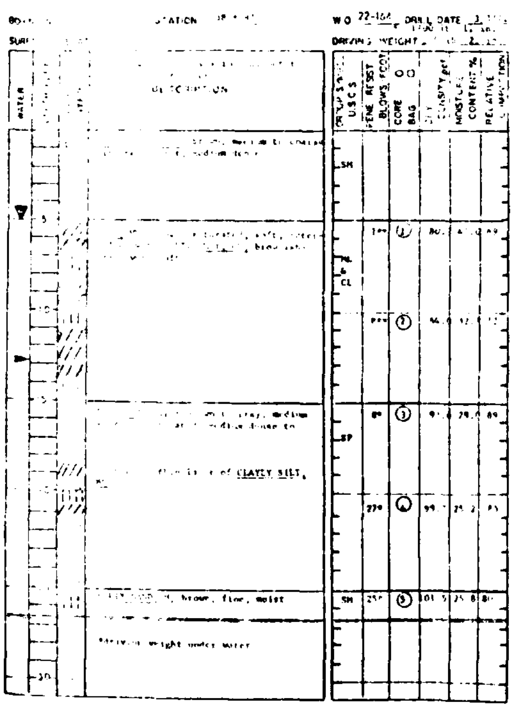


GC 71-7



NOTES

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SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS

STA.325+00 TO STA.260+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09- ____ B- ____ SHEET
DISTRICT FILE NO.

GC71-8

BORING No. 8 STATION 46 + 31 W.O. 22-164 DRILL DATE 3/3/71

SURFACE ELEVATION 34 DRIVING WEIGHT 500 lb. 20 in. ** 1700 lb. 12 in.

Rotary wash boring; 4 inch diameter and 16" bucket auger.

DESCRIPTION

100' W ℄ sewer

Depth (ft)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core/Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	SILTY SAND; SM brown, fine to medium grained, moist, medium dense.	SM					
~4.5	Thinly interbedded layers of very fine SAND; SP; and SILT; ML;		18*	①	87.9	22.[illegible]	75
~9.5			P**	②	95.7	34.[illegible]	81
~11	SANDY SILT, ML, gray, saturated, soft to firm, interbedded with SAND, SP, gray brown, saturated, loose.	ML					
~14.5			P**	③	78.4	49.5	67
~20	SILTY FINE SAND, ML, light brown, saturated, medium dense to dense.	ML	1[illegible]*	④	65.0	27.[illegible]	[illegible]
~24	[illegible] gray to black, saturated [illegible]	SC	22*	⑤	88.5	[illegible]	[illegible]

* [illegible] weight under water

GC71-9

BORING No. 9 STATION 52 + 28 W.O. 22-164 DRILL DATE 3/4/71

SURFACE ELEVATION 37 DRIVING WEIGHT 500 lb. 20 in. ** 1700 lb. 12 in.

Rotary wash boring; 4 inch diameter and 16" bucket auger

DESCRIPTION

Depth (ft)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core/Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	SILTY SAND; SM brown, coarse to fine grained, wet, loose to medium dense; saturated at 2.2'.	SM		1			
~5			P**	②	-	-	
~10			10*	③	100.5	29.0	95
15	SILTY CLAY, CL; grayish-brown, moist, soft.	CL	6*	④	103.5	27.0	88
20	SILTY SAND, SM; light brown, fine grained, wet, medium dense to dense. Thin layer of CLAYEY [illegible], at [illegible]	SM	9*	⑤	108.3	24.2	85
~25			16*	⑥	[illegible]	21.2	87

*driving weight under water.

BORING No. 10 STATION [illegible]

SURFACE ELEVATION 39

Rotary wash boring; [illegible] and 16" bucket [illegible]

DESCRIPTION

SILTY SAND, SM [illegible]

Saturated [illegible]

SAND [illegible] saturated [illegible]

[illegible]

GC71-12

BORING No. 12 STATION [illegible] W.O. 22-164 DRILL DATE 3/5/71

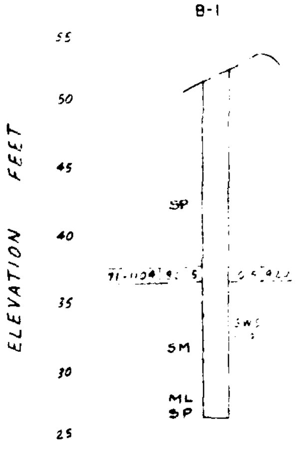
SURFACE ELEVATION [illegible] DRIVING WEIGHT 140 lb. 30 inches ** 1700 lb. 12 in.

Rotary wash boring; [illegible] inch diameter and [illegible] inch bucket auger

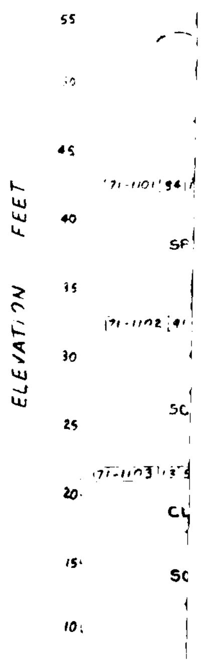
DESCRIPTION

Depth (ft)	Description	Group Symbol U.S.C.S.	Pene. Resist. Blows/Foot	Core/Bag	Dry Density pcf	Moisture Content %	Relative Compaction
0	SILTY [illegible], SM, brown, medium to coarse grained, [illegible], medium dense, interbedded with [illegible], brown, wet, firm.	SM & ML					
~5			1	①	-	44.0	
~8	SANDY [illegible] L, black, [illegible], soft.	CL	3	②	-	45.8	
~11	SILTY [illegible] [illegible] organic.	SM					
~15			6	○		-	
~16	SAND, SP light brown, medium grained, saturated, medium dense.	SP					
~19	SANDY CLAY, CL; dark gray, moist, soft, interbedded with SILTY CLAY, CL, gray wet, soft; trace of organic	CL	5	④	-	31.4	
~25			11	⑤	-	33.1	

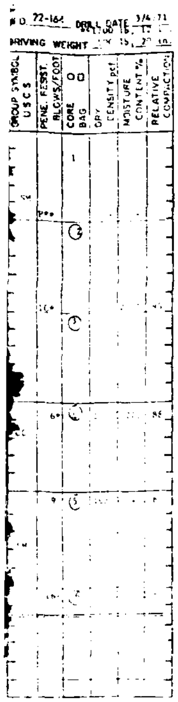
OC71-1



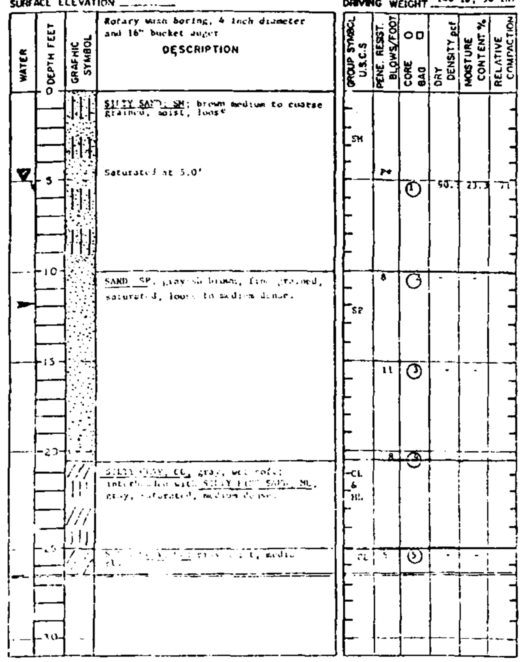
OC71



ALUE ENGINEERING PAYS



GC71-10



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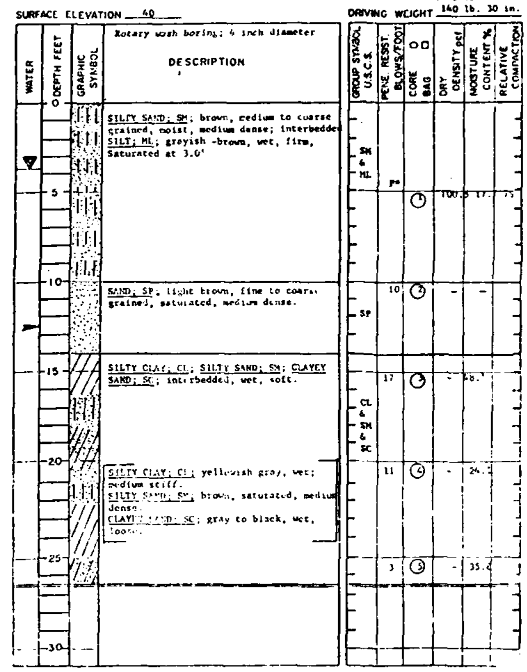
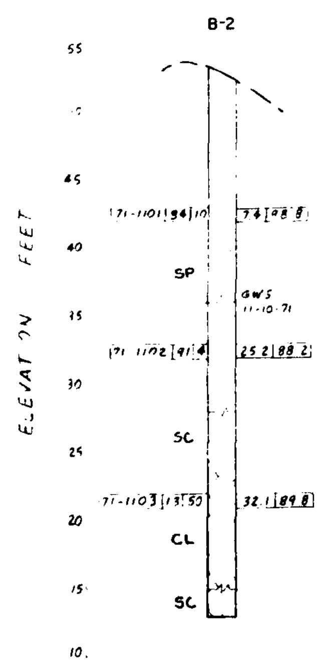


OC71-2



NOTES:

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SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

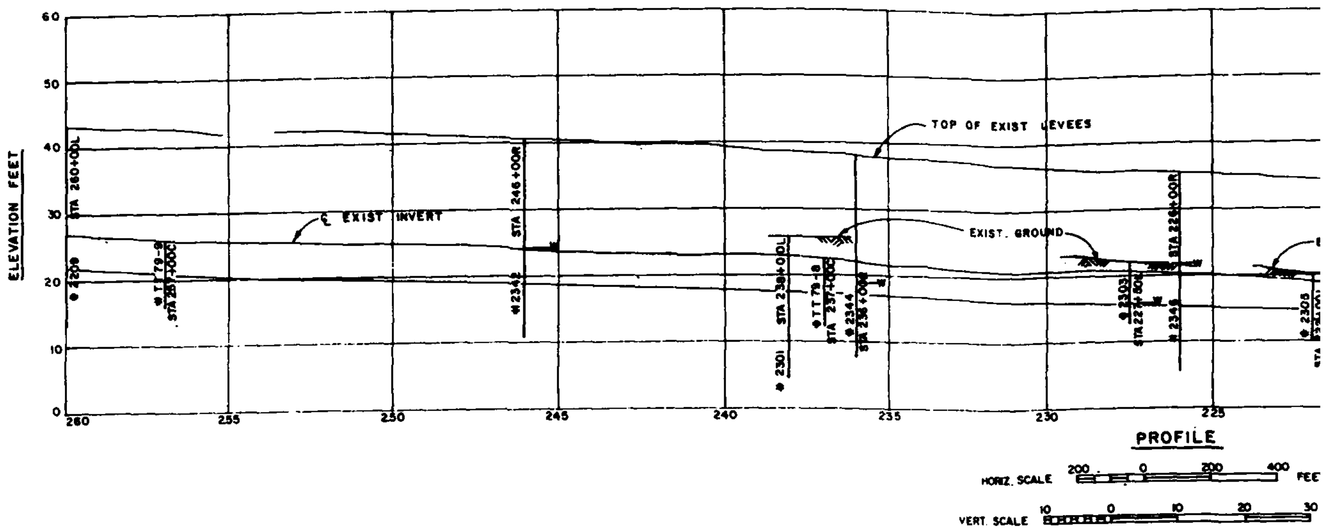
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

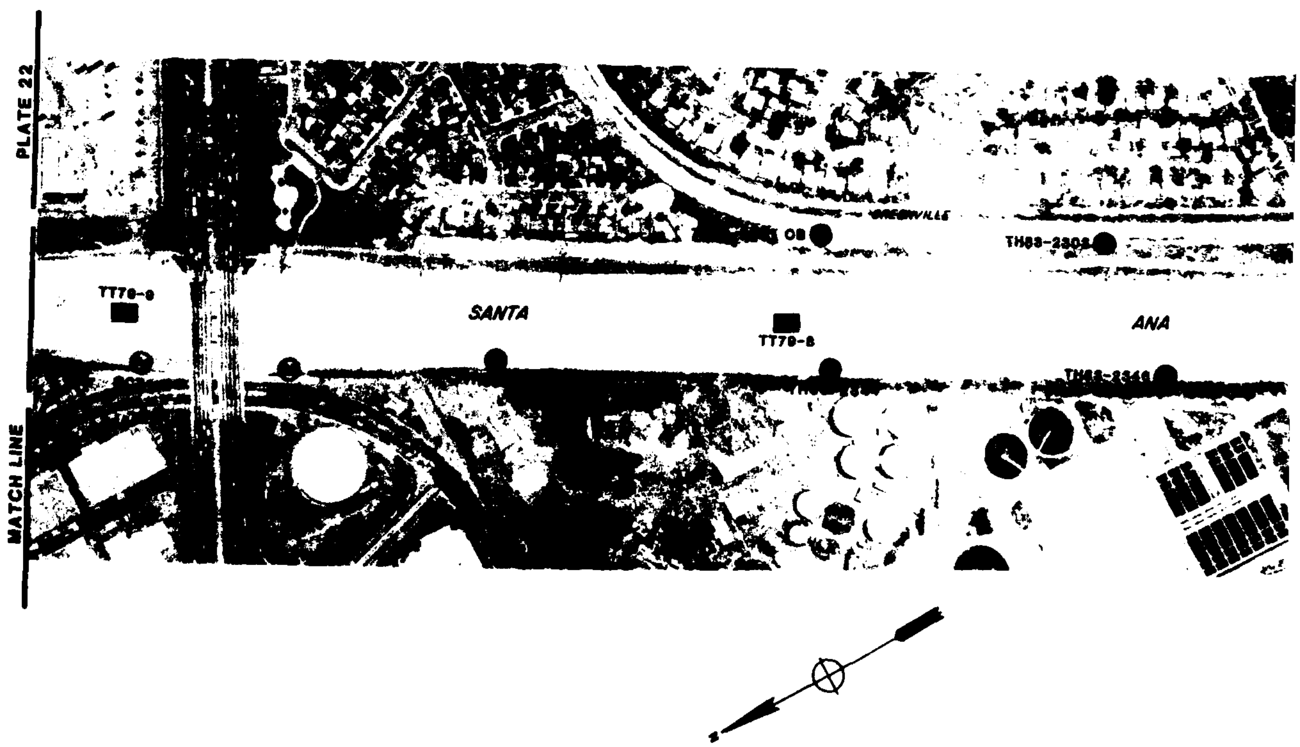
LOGS OF INVESTIGATION
BY OTHERS

STA.325+00 TO STA.260+00

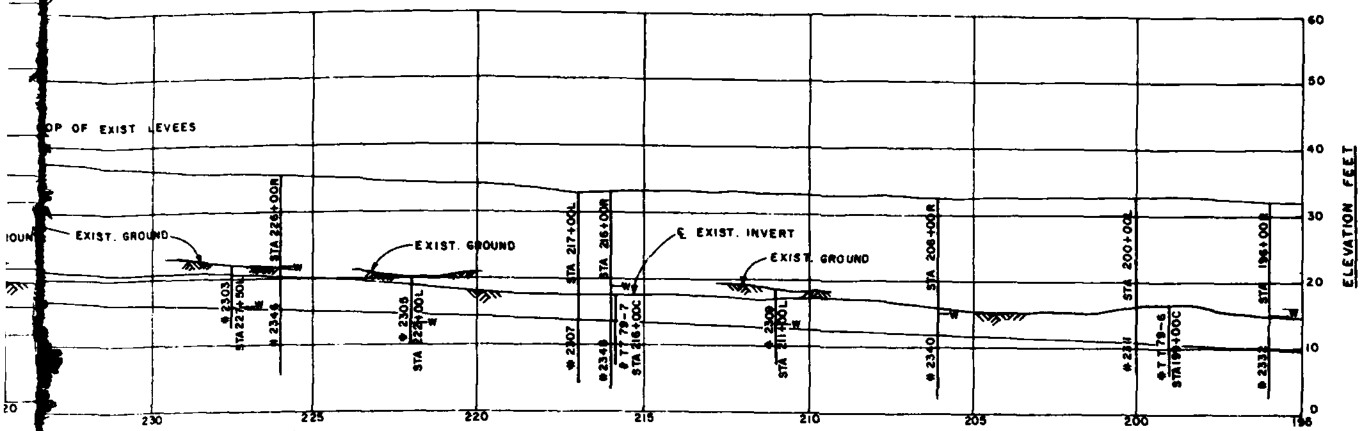
SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-____-____ | SHEET

VALUE ENGINEERING





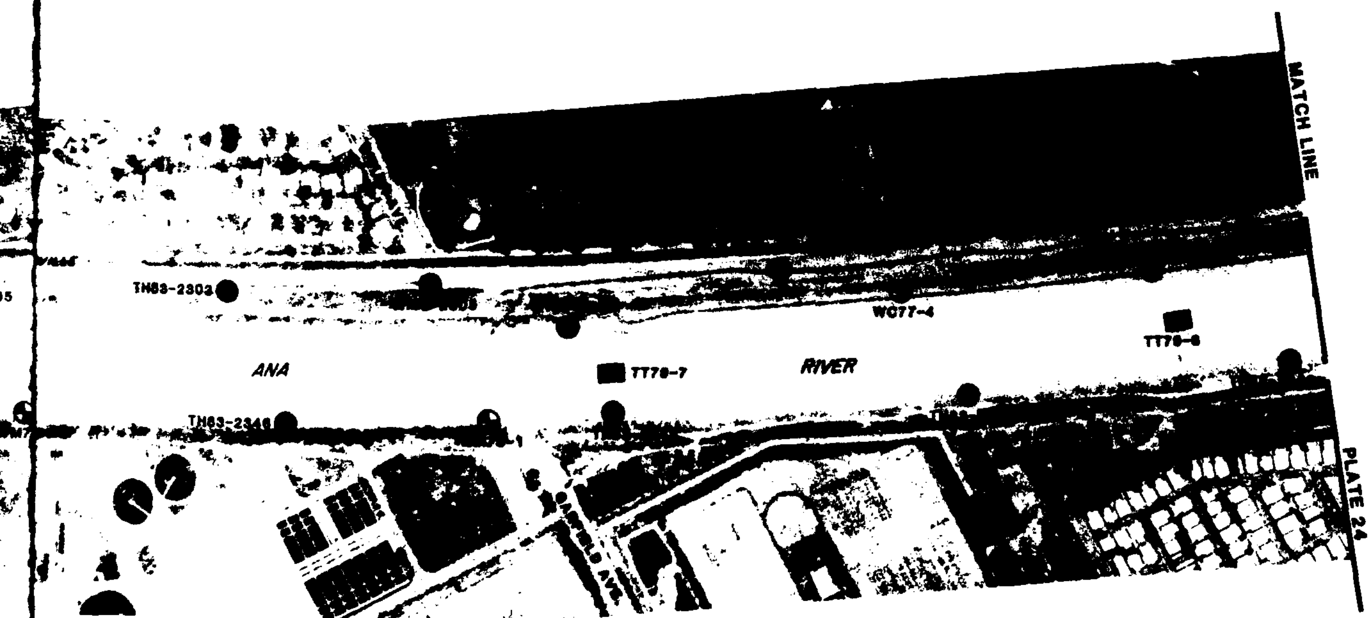
VALUE ENGINEERING PAYS



PROFILE

HORIZ SCALE 200 0 200 400 FEET

VERT SCALE 10 0 10 20 30 FEET



DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE
STA.260+00 TO STA.195+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW 09-___-B-___ SHEET
DISTRICT FILE NO.

NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

INVERT

TT79-9

TT79-9 STA 257+00 C EL. 26±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	3			89	2		SILTY SAND: GREY, DRY.
4.0								
		14			94	3		SAND: GREY, MOIST.
	SP							
		15			96	4		
10.0								

TH83-2342

TH83-2342 STA 246+00 R EL. 41±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTI
		8		NP	99	13		SILTY SAND: BROWN, MOIST, WET TO 1 INCH.
		15		NP	98	21		
	SM	6		NP	89	14		
		9		NP	98	17		SAME: BROWN, MEDIUM GRAINED.
		5	27	4	98	24		SAME: LIGHT TO DARK BROWN.
12.0								
	SP/SM	12		NP	99	6		SAND/SILTY SAND: LIGHT BROWN TO 1 INCH.
W 16.5								
	CL	33	41	17	100	75		SANDY CLAY: BROWN, WET, COHE
19.0								
	SP	19			100	4		SAND: GREY, WET.
22.5								
	SP/SM	27		NP	100	5		SAND/SILTY SAND: BROWN, WET,
25.5	ML	18	35	7	100	65		SANDY SILT: GREY, WET, COHES
26.5	SM	52	55	25	100	47		SILTY SAND: BROWN, WET, COHE
27.5								
	SP	42			100	4		SAND: GREY, WET.
30.0								

TH83-2344

TH83-2344 STA 236+00 R EL. 38±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		11		NP	98	19		SILTY SAND: BROWN, MOIST, FINE GRAINED, NON-COHESIVE.
	SM						27	
		9		NP	100	24		
5.0								
							20	SAND: LIGHT BROWN, MEDIUM GRAINED.
	SP	2			99	4		
							29	
9.5								
		3		NP	98	5		SAND/SILTY SAND: LIGHT BROWN, MEDIUM GRAINED.
		5		NP	98	6	25	
	SP/SM							
		11		NP	100	8	14	
17.0								
							30	SAND: LIGHT BROWN, WET, MEDIUM GRAINED.
W 19.0		20			100	4		
							8	
	SP							
		20			100	3		
							9	
		18			99	3		
27.0							7	
	CL	53	45	19	100	86		CLAY: DARK GREY, ORGANIC SMELL, COHESION.
28.5								
	SP	25			100	3		SAND: LIGHT GREY, FINE TO MEDIUM GRAINED.
30.0								

INVERT

TT79-8

TT79-8 STA 237+00 C EL. 2?

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRI
	SP/SM	3		NP	90	8		SAND/SILTY SAND: GREY, MOI
4.0								
		5			100	2		SAND: GREY, MOIST.
	SP							
		16			95	1		
10.0								

VALUE ENGINEERING PAYS

TH83-2342

STA 246+00 R EL. 41±

LL	PI	-4	-200	N	DESCRIPTION
	NP	99	13		SILTY SAND: BROWN, MOIST, MEDIUM TO FINE GRAINED GRAVEL TO 1 INCH.
	NP	98	21		
	NP	39	14		
	NP	98	17		SAME: BROWN, MEDIUM GRAINED.
27	4	98	24		SAME: LIGHT TO DARK BROWN.
	NP	99	6		SAND/SILTY SAND: LIGHT BROWN, MEDIUM GRAINED, FEW GRAVEL TO 1 INCH.
41	17	100	75		SANDY CLAY: BROWN, WET, COHESIVE.
		100	4		SAND: GREY, WET.
	NP	100	5		SAND/SILTY SAND: BROWN, WET, MEDIUM GRAINED.
35	7	100	65		SANDY SILT: GREY, WET, COHESIVE.
55	25	100	47		SILTY SAND: BROWN, WET, COHESIVE.
		100	9		SAND: GREY, WET.

EXISTING GROUND TH84-2301

TH84-2301 STA 238+00 L EL. 26±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	7		NP	97	3		SILTY SAND: BROWN, MOIST, LOOSE, FINE GRAINED SAND.
3.0							11	
	SP				99	4		SAND: BROWN, MOIST, LOOSE, FINE GRAINED SAND.
6.0							3	
	ML	34		NP	100	62		SANDY SILT: DARK BROWN, MOIST TO WET, LOOSE, FINE GRAINED SAND, SOME COHESION.
9.0							5	
		33		NP	100	47		SILTY SAND: DARK GREY, WET, LOOSE, FINE GRAINED SAND, SOME COHESION.
	SM						3	
				NP	99	27		SAME: BLACK, ORGANICS.
15.0								
	CL		41	24	100	75		SANDY CLAY: DARK GREY, MOIST TO WET, STIFF TO SOFT, SOME ORGANICS.
18.0								
	CH		51	25	100	76		SANDY CLAY: LIGHT GREEN, MOIST TO WET, STIFF TO SOFT, SOME GRAVEL.
21.0								

TT79-8

STA 237+00 C EL. 22±

LL	PI	-4	-200	N	DESCRIPTION
	NP	90	3		SAND/SILTY SAND: GREY, MOIST.
		100	[illegible]		SAND: GREY, MOIST.
		[illegible]	[illegible]		

EXISTING GROUND TH83-2303

TH83-2303 STA 227+50 L EL. 22±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	13		NP	100	25		SILTY SAND: BROWN, MOIST.
		21		NP	100	24		SAME: GREY, MOIST, CAVING.
3.0							8	
4.5	ML	30	34	13	100	88		SILT: MOIST, COHESIVE.
		25		NP	100	10	6	SAND/SILTY SAND: GREY, MOIST, FINE GRAINED.
W 6.5	SP/SM	26		NP	100	9		
							4	
9.5								

SCALE: 1 IN=3FT

5 0 5 10

NOTES:

1. SEE PLATE 23 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM.
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.257+00 TO STA.227+50

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

DISTRICT FILE NO.

TH 83 2346

TH83-2346 STA 226+00 R EL. 36±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	8		NP	99	17		SILTY SAND: BROWN, MOIST, NON COHESIVE.
				NP	100	24	34	
4.0								
	SW/SM	6		NP	99	12	10	SAND/SILTY SAND: GREY, MOIST, FINE TO MEDIUM GRAINED.
7.0								
	SM	6		NP	100	13	22	SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED.
10.0								
	SW/SM	9		NP	93	12	11	SAND/SILTY SAND: BROWN, MOIST, FINE TO MEDIUM GRAINED GRAVEL TO 1 INCH.
13.0								
		7		NP	99	11		SAND/SILTY SAND: GREY, WET, MEDIUM GRAINED.
W 15.0							10	
		26		NP	100	6		
							12	
		24		NP	100	5		
	SP/SM						9	
		24		NP	100	5	32	
							17	
				NP	100	5		
30.0							15	

TH 83 2305

TH83-2305 STA 222+00 L EL. 20±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	13		NP	96	34		SILTY SAND: BROWN, MOIST, FINE GR
2.5							21	
4.0	CL	28	41	21	100	71		SANDY CLAY: BROWN, DENSE, COHESIV
		25		NP	100	31	7	SILTY SAND: GREY, WET, FINE GRAIN
W 7.5	SM							
		29		NP	97	21	4	
10.0								
10.5	SP/SM	29		NP	100	12		SAND/SILTY SAND: GREY, WET, CAVIN

TH 83 2348

TH83-2348 STA 216+00 R EL. 33±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SILTY SAND: LIGHT BROWN, FINE GRAINED, NON-COHESIVE.
	SM	9		NP	99	20	61	
		8		NP	100	15	21	
7.0								
		6		NP	99	12	17	SAND/SILTY SAND: LIGHT BROWN, FINE GRAINED, NON-COHESIVE.
	SP/SM							
		3		NP	98	7	5	
13.5				NP	95	7		
W 14.0	SM			NP	100	30		SILTY SAND: BROWN, COHESIVE.
	SP/SM	22		NP	99	9	8	SAND/SILTY SAND: LIGHT BROWN, MEDIUM GRAINED, NON-COHESIVE.
17.0								
		42	33	9	100	66	6	SANDY SILT: BROWN, COHESIVE.
	ML							
		33	31	7	100	61		
21.0							21	
	CL	44	37	14	100	70		SANDY CLAY: BROWN-GREY, ORGANIC, COHESIVE.
23.0								
23.5	SM			NP	100	13		SILTY SAND: BROWN, FINE GRAINED.
24.0	CL	41	35	[illegible]	100	[illegible]		SANDY CLAY: BROWN, COHESIVE.
24.5	SP/SM	31		NP	100	[illegible]		SAND/SILTY SAND: BROWN, MEDIUM GRAINED.
25.0	SM			NP	100	[illegible]		SILTY SAND: SAME AS ABOVE.
	CL	22	32	11	100	88		SANDY CLAY: GREY, COHESIVE.
26.0								
	SM	28		NP	100	13	16	SILTY SAND: BROWN, MEDIUM GRAINED.
30.0								

TT 79-7

TT79-7 STA 215+00 C EL. 18±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SILTY SAND: GREY, MOIST, FEW C
	SM	7		NP	91	13		
4.0								
		17			100	2		SAND: GREY, MOIST.
	SP							
		16			99	2		
10.0								

LUE ENGINEERING PAYS

TH 83 2305

STA 222+[illegible] L — EL. 20±

LL	PI	-4	-200	N	DESCRIPTION
	NP	[illegible]	34		SILTY SAND: BROWN, MOIST, FINE GRAINED, SOME GRAVEL.
				21	
[illegible]	21	[illegible]	71		SANDY CLAY: BROWN, DENSE, COHESIVE.
	NP	[illegible]	21		SILTY SAND: GREY, WET, FINE GRAINED.
	NP	[illegible]	21	[illegible]	
	NP	100	[illegible]		SAND/SILTY SAND: GREY, WET, CAVING.

TH 83-2307

TH83-2307 — STA 217+00 L — EL. 18±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		7		NP	94	19		SILTY SAND: BROWN, MOIST, NON-COHESIVE, MEDIUM TO FINE GRAINED.
	SM							
		7		NP	98	21		
4.0								
	SW/SM	5		NP	92	12		SAND/SILTY SAND: SAME, GRAVEL TO 2 INCHES.
5.0								
		9	19	3	100	29	16	SILTY SAND: BROWN, MOIST, SOME COHESION, FINE GRAINED.
		8		NP	100	42		
	SM						24	
		10		NP	100	14		
		6		NP	95	20	21	
13.0								
	SC	16	25	8	100	41		CLAYEY SAND: DARK BROWN, COHESIVE.
14.0								
		7		NP	97	15		SILTY SAND: BROWN, MOIST, NON-COHESIVE, GRAVEL TO 3 INCHES.
		14	20	3	100	33		
	SM						16	SAME: GREY, MOIST, ORGANIC SMELL.
		13		NP	100	34		
		15		NP	100	21		
21.0							22	
	SP/SM	22		NP	100	7		SAND/SILTY SAND: BROWN.
22.0								
		23	30	2	100	49		
W 23.0	SM							SILTY SAND: GREY, WET.
		33		NP	100	46		
24.0							5	
	SC	39	41	17	100	46		CLAYEY SAND: GREY, WET, COHESIVE.
27.0							5	
	ML	41		NP	100	60		SANDY CLAY: SAME AS ABOVE.
29.0								
							5	

TT 79-7

STA 216+00 C — EL. 18±

LL	PI	-4	-200	N	DESCRIPTION
	NP	91	13		SILTY SAND: GREY, MOIST, FEW COBBLES TO 12-INCH.
		100	2		SAND: GREY, MOIST.
		99	2		

NOTES:

1. SEE PLATE FOR LOCATION OF TEST HOLES AND TEST TRENCHES.
2. SEE PLATE FOR LEGEND AND CLASSIFICATION SYSTEM.
3. SEE TABLE FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SCALE: 1 IN=3FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.226+00 TO STA.216+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

VALUE ENGINEERING F

EXISTING GROUND

TH83-2309

TH83-2309 STA 211+00 L EL. 19±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SILTY SAND: BROWN, MOIST, NON-COHESIVE.
	SM	15		NP	97	36	30	
5.0		14		NP	100	29		
W 6.5	ML	34	42	15	100	76	13	SANDY SILT: GREY, MOIST, COHESIVE.
8.0								
	SM	30		NP	100	16	2	SILTY SAND: GREY, WET, NON-COHESIVE.
11.0								
11.5	CL	51	42	19	100	93	3	SANDY CLAY: GREY.

TH83-2340

TH83-2340 STA 206+00 R EL. 34±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SILTY SAND: BROWN, MOIST, NON-COHESIVE
		14		NP	99	24	44	
		11		NP	100	19	25	
	SM	39		NP	100	20		SAME: LIGHT BROWN, LAYERED WITH DARKE
		11		NP	99	19	8	
		7		NP	100	44		
12.0								
12.5	SP/SM	3		NP	100	7	8	SAND/SILTY SAND: LIGHT BROWN, FINE GR
13.0	SM	[illegible]		NP	100	40		SILTY SAND: LIGHT BROWN.
								SAND/SILTY SAND: LIGHT BROWN, MEDIUM T
	SP/SM	27		NP	100	10	9	
16.0								
		28		NP	100	36		SILTY SAND: DARK BROWN.
W 19.0	SM	34		NP	100	27		SAME: BROWN, NON-COHESIVE.
		39	23	5	100	47		
21.5								
	MH	113	72	38	100	58		SANDY SILT: BROWN, COHESIVE.
24.5								
	SM	26		NP	100	23		SILTY SAND: GREY, FINE GRAINED, ORGAN
27.5								
	SP/SM			NP	100	9		SAND/SILTY SAND: GREY, FINE TO MEDIUM COHESIVE.
30.0								

TH83-2332

TH83-2332 STA 196+00 R EL. 32±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		9		NP	99	30		SILTY SAND: BROWN, MOIST, NON-COHESIVE.
	SM							
		5		NP	100	22	31	
4.0								
4.5	ML			NP	100	72		SANDY SILT: DARK BROWN, MOIST, COHESIVE.
	SM	6		NP	99	16	16	SILTY SAND: BROWN, MOIST, NON-COHESIVE.
7.0								
		3		NP	99	6	10	SAND/SILTY SAND: LIGHT BROWN, NON-COHESIVE.
	SP/SM	4		NP	100	8	9	
		4		NP	99	8		SAME: GREY.
14.5							8	
	SM	26		NP	99	26		SILTY SAND: BROWN, WET, LITTLE COHESION.
16.5								
W 17.0	ML			NP	100	53		SANDY SILT: BROWN, WET, COHESIVE.
		24		NP	100	6	8	SAND/SILTY SAND: GREY, NON-COHESIVE.
	SP/SM							
		24		NP	109	7	9	SAME: BROWN-GREY, NON-COHESIVE.
22.0								
	ML	40		NP	100	53		SANDY SILT: BROWN, COHESIVE.
23.0								
	MH	50	53	23	100	71		SANDY SILT: GREY, COHESIVE.
24.0								
	CH	42	51	24	100	69		SANDY CLAY: BROWN, COHESIVE.
25.0								
		53		NP	100	84		SANDY SILT: GREY, NON-COHESIVE.
	ML	40		NP	100	60	6	
		[illegible]	35	6	100	80		
30.0							16	

INVERT

TT79-6

TT79-6 STA 199+00 C EL. 16±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		12		NP	98	34		SILTY SAND: GREY, MOIST.
	SM							
		16		NP	100	41		SAME: BROWN, MOIST.
7.0								
	SP/SM	20		NP	100	10		SAND/SILTY SAND: BROWN, WET, GROUNDW
10.0								

LUE ENGINEERING PAYS

TH83-2340

STA 206+00 R — EL. 34±

[illegible]	PI	-4	-200	N	DESCRIPTION
					SILTY SAND: BROWN, MOIST, NON-COHESIVE.
	NP	99	29	44	
	NP	100	19	25	
	NP	100	20		SAME: LIGHT BROWN, LAYERED WITH DARKER SILTY SAND.
	NP	99	19	3	
	NP	100	44		
	NP	100	7	8	SAND/SILTY SAND: LIGHT BROWN, FINE GRAINED.
	NP	100	[illegible]		SILTY SAND: LIGHT BROWN.
					SAND/SILTY SAND: LIGHT BROWN, MEDIUM TO FINE GRAINED SAND.
	NP	100	10	9	
	NP	100	36		SILTY SAND: DARK BROWN.
					SAME: BROWN, NON-COHESIVE.
	NP	100	27		
	5	100	47		
					SANDY SILT: BROWN, COHESIVE.
	38	100	58		
					SILTY SAND: GREY, FINE GRAINED, ORGANIC SMELL, COHESIVE.
	NP	100	23		
	NP	100	3		SAND/SILTY SAND: GREY, FINE TO MEDIUM GRAINED, NON-COHESIVE.

TH83-2311

TH83-2311 — STA 200+00 L — FL. 33±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		11	24	4	100	46		SILTY SAND: BROWN, MOIST, SOME GRAVEL TO 3 INCHES.
							R	
		8		NP	100	34		
		8		NP	96	14	61	SAME: LIGHT BROWN, MOIST, MEDIUM TO FINE GRAINED, GRAVEL TO 1-1/2 INCHES.
	SM	9		NP	99	37	22	SAME: BROWN, MOIST, GRAVEL TO 3 INCHES.
		9		NP	100	31	15	
		12		NP	100	31		
15.0							24	
	ML	12		NP	100	51		SANDY SILT: DARK BROWN, MOIST, SOME COHESION, SOME GRAVEL TO 3 INCHES.
17.0		6			100	21	14	SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED.
		10		NP	100	35		
	SM	7		NP	96	17		
		16	24	3	100	31		SAME: LIGHT BROWN, MOIST, COHESIVE.
22.5								SANDY SILT: GREY, WET, SOFT, COHESIVE, SOME ROOTS.
W 24.0		34	34	7	100	75	5	
	ML	35	48	20	100	80		
27.0							5	

TT79-6

STA 199+00 C — EL. 16±

[illegible]	PI	-4	-200	N	DESCRIPTION
	NP	[illegible]	34		SILTY SAND: GREY, MOIST.
	NP	[illegible]	91		SAME: BROWN, MOIST.
	NP	[illegible]	1		SAND/SILTY SAND: BROWN, WET, GROUNDWATER ENCOUNTERED.

NOTES:

1. SEE PLATE 23 FOR LOCATION OF TEST HOLES AND TEST TRENCHES.
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM.
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SCALE: 1 IN=3 FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

CHECKED BY:

STA.211+00 TO STA.196+00

SUBMITTED BY: — DATE APPROVED: — SPEC. NO. DACW09-____ B-____ — SHEET

WC77-4

DATE OF BORING 29 Dec 76 WATER DEPTH 25 ft. DATE MEASURED 29 Dec 76
TYPE OF DRILL RIG Bucket HOLE DIAMETER 20 in.
WEIGHT OF HAMMER 1500 lb. Kelly FALLING 15 in. SAMPLER 2-in. dia. Modified Calif.

SURFACE ELEVATION:

SAMPLES	BLOWS/FOOT	GROUND WATER	DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
			Medium dense, to dense, moist, brown, SILTY SAND (SM)				
1	5		With trace of SILTY CLAY				MA CD
2	3						
			Slight odor, bluish gray				
3	4						MA CD
			Medium dense to dense, moist, light brown medium-grained SAND (SP) with some GRAVEL				
4	P		Stiff, moist, brown SILTY CLAY (CL)		6	87	
			Bluish gray with organic material				
5	4		Medium dense, moist, light brown medium-grained, SAND (SP)	3.0*	39	75	
			SANDY SILT (ML) with roots to 1"				
		▽	Wet, brown SILTY SAND (SM)				
6	3				28	93	
			Bottom of Boring at 26½ ft.				

Project SANTA ANA RIVER IMPROVEMENTS
Project No. A843I

LOG OF BORING B-4

Fig A-5

WM73-1

LOG OF BORING 1

DATE OF BORING 24 May 1973 WATER DEPTH ____ DATE MEASURED 24 May 1973
TYPE OF DRILL RIG Cont. Flight Auger HOLE DIAMETER 6"
WEIGHT OF HAMMER 140 lbs. FALLING 30" SAMPLES 2" Modified California

SURFACE ELEVATION:

DEPTH, FT.	SAMPLES	BLOWS/FOOT	GROUND WATER	DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
	1	33		Dense, damp, brown fine to coarse-grained SAND (SP) with trace of SILT		10	100	
5				Fine to medium-grained				
	2	26						MA F
10	3	16						MA F
15	4	20				4	96	MA
				Fine to coarse-grained, wet, caving				
20	SR 1 5	38	▽					
25		29		With trace of CLAY				

Bottom o' ing at 26 ft.

GC71-1

BORING No 1 STATION 3 + 27 W.O. 22-164 DRILL DATE 3/2/71
SURFACE ELEVATION [illegible] DRIVING WEIGHT 500 lb. 20 in.

Rotary wash boring, [illegible] inches diameter.

WATER	DEPTH FEET	DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE ○ BAG □	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION
	0	SILTY CLAY, CL, dark brown, moist, soft.	CL					
▼	5	SAND; SP, light brown to gray, coarse to medium grained, saturated, loose to medium dense.	SP	13	①	89.0	28.1	77
	10			15	②	100.5	20.5	87
		SILT CLAY, OL, black to gray, wet, soft, some organic interbedded with streaks of SAND, SP, saturated loose.						
	15		OL & SP	10*	③	96.7	25.0	83
	20	SILTY FINE SAND, SM, black, saturated, loose.	SM	9*	④	83.7	36.0	80
	25	* Driving weight under water.						
	30							

GC71-2

BORING No 2 STATION 7 + 39 W.O 72-164 DRILL DATE 3/3/71
SURFACE ELEVATION [illegible] DRIVING WEIGHT 500 lb.-20 in.

Rotary wash boring, [illegible]

WATER	DEPTH FEET	DESCRIPTION	GROUP SYMBOL U.S.C.S.	PENE. RESIST. BLOWS/FOOT	CORE ○ BAG □	DRY DENSITY pcf	MOISTURE CONTENT %	RELATIVE COMPACTION
	0	SILTY FINE SAND, SM, brown, [illegible]	SM					
▽	5			7	①	89.2	24.2	76
	10	SILTY CLAY, CL, black, wet, soft, some organic, interbedded with SILTY FINE SAND, SM, wet, loose.	CL & SM	8*	②	84.[illegible]	34.[illegible]	72
	15			8*	③	83.7	37.5	72
	20	SAND, SP, gray, fine grained, wet, loose.	SP	9*	⑥	88.8	29.8	76
	25	CLAY, OH, black, saturated, soft organic	OH	8*	⑤	68.5	53.6	59
		* Driving weight under water						
	30							

LUE ENGINEERING PAYS

LOG OF BORING 1

DATE MEASURED 24 May 1973
HOLE DIAMETER 6"
LES 2" Modified California

	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
grained SAND				
		10	100	
				MA P
				MA P
		4	96	MA

NOTES:

1. SEE PLATE 23 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

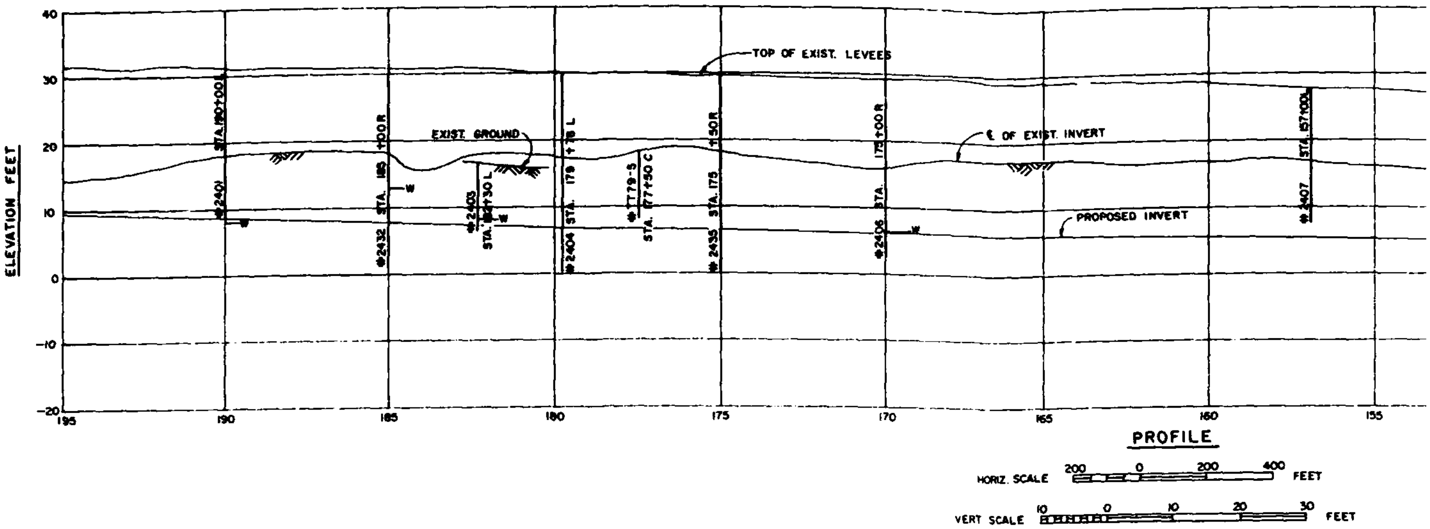
CHECKED BY:

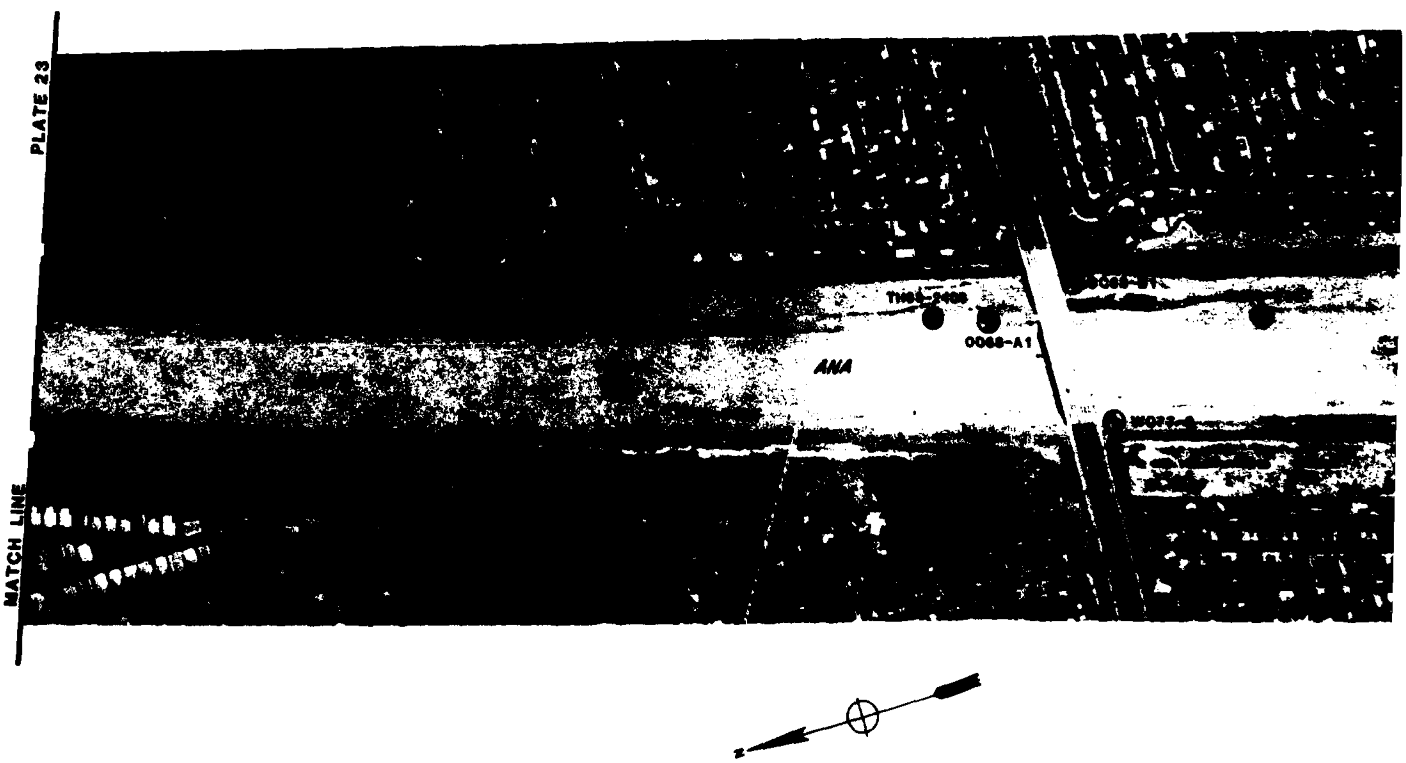
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS
STA.260+00 TO STA.195+00

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW 09-____ B-____ | SHEET

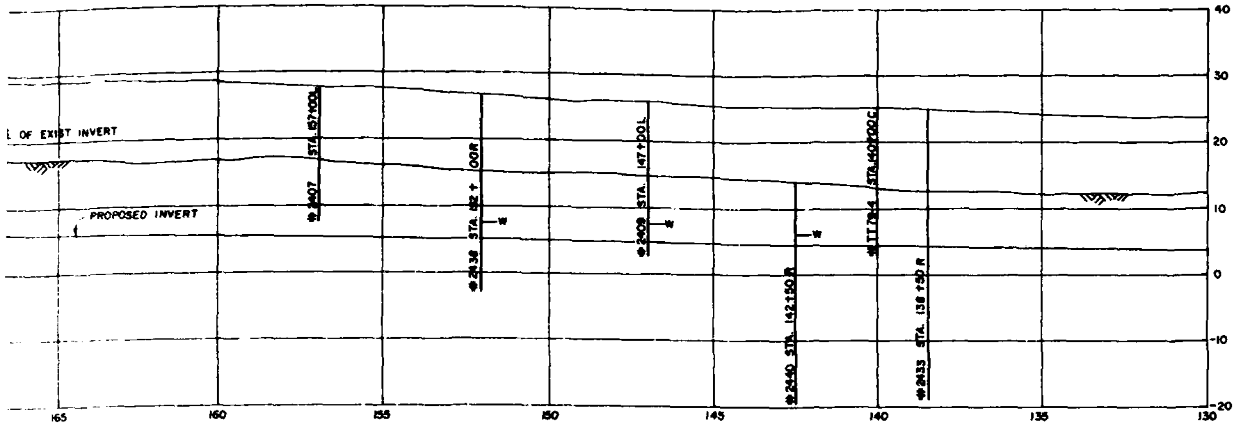
VALUE ENGINEERING PAYS





N

LUE ENGINEERING PAYS



PROFILE

HORIZ SCALE 200 0 200 400 FEET

SCALE 10 0 10 20 30 FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
REVISIONS			

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE

STA. 195+00 TO STA. 130+00

DESIGNED BY: | DRAWN BY: | CHECKED BY: | SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09- ___ B- ___ | SHEET | DISTRICT FILE NO.

VALUE ENGINEERING PAY

TH83-2401

TH83-2401 STA 190+00 L EL. 31±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		9		NP	99	27		SILTY SAND: BROWN, MOIST, NON-COHESIVE, FINE GRAINED.
							46	
		7		NP	99	30		SAME: OCCASIONAL COBBLE TO 4 INCHES.
	SM							
							36	
		8		NP	100	27		
		8		NP	100	39	22	
9.5								
	ML	15		NP	99	65		SANDY SILT: DARK BROWN, MOIST, FINE GRAINED, NO GRAVEL.
12.0							18	
		5		NP	97	20		SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED, NON-COHESIVE, NO GRAVEL.
							26	
	SM	6		NP	100	39		SAME: OCCASIONAL GRAVEL TO 1-1/2 INCHES.
		10		NP	100	29	24	
20.0	SC	20	22	5	100	42		CLAYEY SAND: GREY, MOIST.
21.0		24	29	3	100	67	9	SANDY SILT: GREY, WET, COHESIVE, FINE GRAINED.
	ML							
W 23.0								SAME: GREY, WET, COHESIVE, FINE GRAINED.
24.0							5	
	CL	30	29	7	100	55		SANDY CLAY: GREY, WET, FINE GRAINED.
27.0								
	ML	35	29	4	100	57		SANDY SILT: GREY, WET, COHESIVE. CAVING AT 29 FT.
29.0								
							2	

TH83-2432

TH83-2432 STA 185+00 R EL. 31±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
				NP	99	14		SILTY SAND: BROWN, MEDIUM GRAINED.
	SM						23	
		9		NP	100	18		
6.0							23	
		4		NP	100	9		SAND/SILTY SAND: LIGHT BROWN, MEDIUM GRAINED.
							8	
		2		NP	100	6		SAME: GREY, MOIST.
	SP/SM						6	
		5		NP	100	9		SAME: LIGHT BROWN, MEDIUM GRAINED.
							6	
				NP	100	9		SAME: GREY, MOIST, MEDIUM GRAINED.
17.5 / W 18.0							5	SANDY SILT: BROWN, MOIST.
	SM			NP	100	40		
							9	
22.5								
	ML	13		NP	100	65	9	SANDY SILT: BROWN, MOIST.
25.0 / 25.5	CL		38	14	100	66		SANDY CLAY: GREY, WET.
				NP	100	56	9	SANDY SILT: GREY, WET.
	ML							
				NP	100	66		
30.0							6	

TH83-2404

TH83-2404 STA 179+78 L EL. 30±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		10		NP	99	16		SILTY SAND: BROWN, MOIST, LOOSE, MEDIUM GRAINED, OCCASIONAL COBBLES TO 4 INCHES.
							31	
		3		NP	91	21		SAME: GRAVEL TO 3 INCHES.
	SM	5		NP	100	19	23	SAME: LIGHT BROWN, MOIST, FINE GRAINED, NO GRAVEL.
		11		NP	93	40		SAME: BROWN, LAYERS OF COHESIVE SANDY SILT.
		9		NP	100	25	28	SAME: OCCASIONAL GRAVEL TO 3/4 INCHES, NON-COHESIVE.
10.5								
	SW/SM	4		NP	95	12	34	SAND/SILTY SAND: BROWN, MOIST, NON-COHESIVE, MEDIUM TO FINE GRAINED, SOME COBBLES TO 6 INCHES.
16.5								
		9		NP	100	28	35	SILTY SAND: BROWN, MOIST, NON-COHESIVE, FINE GRAINED, SOME WOOD FRAGMENTS, NO GRAVEL.
	SM							
		7		NP	99	25	29	
19.0								
	SW/SM	5		NP	91	8		SAND/SILTY SAND: LIGHT BROWN, MOIST TO WET, MEDIUM TO FINE GRAINED, LAYERS OF SILTY SAND.
20.5 / 21.0	CH	43	69	39	100	86	14	SANDY CLAY: GREY W/ RUST STAINS, WET, FINE GRAINED.
	SM	12		NP	97	19		SILTY SAND: BROWN, WET, MEDIUM GRAINED, LAYERS OF LIGHT GREY SILT.
22.5								SANDY SILT: GREY, WET, SOFT, FINE GRAINED, COHESIVE.
	ML	34	29	3	100	73	9	
27.0								
	CH	50	54	25	100	82		SANDY CLAY: GREY, WET, SOFT, FINE GRAINED, COHESIVE.
30.0								

INVERT

TT79-5

TT79-5 STA 177+50 C EL. 18±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM			NP	79	11		GRAVELLY SAND/SILTY GRAVELLY SAND: GREY, [illegible] VEGETATION.
4.0								
	SM	22		NP	100	46		SILTY SAND: GREY, MOIST.
7.0								
	ML			NP	100	69		SANDY SILT: GREY, MOIST, SOME COHESION.
10.0								

VALUE ENGINEERING PAYS

TH83-2432

STA 185+00 R — EL. 31±

PI	-4	-200	N	DESCRIPTION
NP	99	14		SILTY SAND: BROWN, MEDIUM GRAINED.
			23	
NP	100	18		
			23	
NP	100	9		SAND/SILTY SAND: LIGHT BROWN, MEDIUM GRAINED.
			8	
NP	[illegible]	[illegible]		SAME: GREY, MOIST.
			6	
NP	[illegible]	[illegible]		SAME: LIGHT BROWN, MEDIUM GRAINED.
			6	
NP	[illegible]	[illegible]		SAME: GREY, MOIST, MEDIUM GRAINED.
			5	SANDY SILT: BROWN, MOIST.
NP	[illegible]	[illegible]		
			[illegible]	
NP		[illegible]	3	SANDY SILT: BROWN, MOIST.
[illegible]	[illegible]	[illegible]		SANDY CLAY: GREY, WET.
NP	[illegible]	[illegible]		SANDY SILT: GREY, WET.
			3	
NP	[illegible]	[illegible]		
			5	

EXISTING GROUND

TH83-2403

TH83-2403 — STA 182+30 L — EL. 14±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	14		NP	99	16		SILTY SAND: BROWN, MOIST, NON-COHESIVE.
							8	
		10		NP	100	17		
4.0								
W 5.5	SP/SM	9		NP	100	12		SAND/SILTY SAND: BROWN, MOIST, NON-COHESIVE.
							6	
7.0	CL	35	36	15	100	55		SANDY CLAY: DARK GREY, WET, COHESIVE.
8.0	SP/SM	24		NP	100	9	11	SAND/SILTY SAND: BROWN, WET, NON-COHESIVE, STOPPED DRILLING DUE TO CAVING.
10.0								

TT79-5

STA [illegible] — EL. 18±

PI	-4	N	DESCRIPTION
NP	[illegible]		GRAVELLY SAND/SILTY GRAVELLY SAND: GREY, MOIST, VEGETATION.
NP	[illegible]		SILTY SAND: GREY, MOIST.
NP	[illegible]		SANDY SILT: GREY, MOIST, SOME COHESION.

NOTES:

1. SEE PLATE 24 FOR LOCATION OF TEST HOLES AND TEST TRENCHES.
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM.
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SCALE: 1 IN = 3 FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.190+00 TO STA.177+50

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW 09- ____ B- ____ | SHEET

TH83-2435

TH83-2435 STA 175+00 R EL. 30±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		8		NP	100	29		SILTY SAND: BROWN, MOIST, MEDIUM GRAINED.
							41	
				NP	100	25		
							7	
				NP	99	13		SAME: LIGHT BROWN, DRY, FINE GRAINED.
	SM			NP	100	34		
							3	
								SAME: GREY-BROWN, MOIST.
				NP	100	23		
				NP	100	19	5	
15.0								
15.5	SP/SM			NP	100	9		SAND/SILTY SAND: GREY, MOIST, MEDIUM GRAINED.
	SM			NP	100	32	5	SILTY SAND: DARK GREY, MOIST, FINE GRAINED.
17.0	ML			NP	100	51		SANDY SILT: BROWN, MOIST, FINE GRAINED.
18.0	SM			NP	100	31		SILTY SAND: BROWN, MOIST.
19.0	ML			NP	100	57		SANDY SILT: BROWN, MOIST.
19.5	SM			NP	100	33		SILTY SAND: BROWN, MOIST.
20.0								
	CH		52	28	100	68		SANDY CLAY: DARK GREY, COHESIVE.
22.0								
22.5	SM			NP	100	3[illegible]		SILTY SAND: GREY, FINE TO MEDIUM GRAINED.
23.0	ML			NP	100	88		SILT: BROWN.
	SM			NP	100	49		SILTY SAND: BROWN.
24.0	CH		51	27	100	56		SANDY CLAY: DARK GREY.
25.0	ML			NP	100	50	15	SANDY SILT: GREY.
26.0								
26.5	SM			NP	100	43		SILTY SAND: DARK GREY.
	SM/SC		26	6	100	43		SILTY SAND/CLAYEY SAND: GREY.
27.5								
			34	7	100	79	17	SANDY SILT: DARK GREY.
	ML			NP	100	71		
30.0								

TH83-2406

TH83-2406 STA 170+00 L EL. 29±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		6		NP	99	24		SILTY SAND: BROWN, MOIST, OCCASIO 3 INCHES.
		7		NP	100	22		SAME: CLEAN SAND, NO GRAVEL.
		9		NP	99	24	31	
		13		NP	97	26		
	SM						15	
		14		NP	100	39	19	SAME: FINE GRAINED SAND, LENSES (
		8		NP	95	23		SAME: MEDIUM GRAINED, CHUNK OF A/ COHESIVE.
							8	
		19		NP	99	19		SAME: LIGHT BROWN, FINE GRAINED
								SAME: BROWN, MOIST.
		9		NP	100	27		
18.0							9	
	SP/SM	20		NP	100	11		SAND/SILTY SAND: LIGHT BROWN, FI NON-COHESIVE.
20.0								
21.0	CH	33	54	32	100	67		SANDY CLAY: BROWN, MOIST, COHESI
22.0	SM/SC	25	24	5	100	27	14	CLAYEY SAND: BROWN, MOIST, COHES
W 22.5	SM	27		NP	100	30		SILTY SAND: WET.
23.0								
	CL	35	43	34	100	87	6	CLAY: GREY, PLASTIC, SOFT.
		37	29	7	100	71	8	SANDY CLAY: GREY, FINE GRAINED S
26.0								

TH83-2438

TH83-2438 STA 152+00 R EL. 27±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
				NP	99	25		SILTY SAND: DARK BROWN.
				NP	99	35	12	
				NP	99	37		
	SM			NP	99	40	18	SAME: LIGHT BROWN, MOIST, FINE GRAINED.
				NP	98	38		
				NP	100	35		SAME: LIGHT BROWN TO GREY, LOOSE, DRY.
							6	
		2		NP	100	24		
12.0							9	
	SP/SM	3		NP	100	11		SAND/SILTY SAND: GREY, DRY, FINE TO MEDIUM GRAINED.
15.0							9	
	SM			NP	100	16		SILTY SAND: GREY, MOIST.
16.0								
16.5	ML			NP	100	78		SANDY SILT: DARK BROWN, MOIST.
17.0	SM			NP	100	14		SILTY SAND: GREY, MOIST.
	ML		36	30	6	100	61	SANDY SILT: DARK BROWN, MOIST.
18.0							6	
W 19.5								SANDY CLAY: DARK BROWN, WET.
	CL		38	14	100	80		
							6	
22.5	CH		54	26	100	95		CLAY: DARK GREY, COHESIVE.
23.5			27	5	100	53	12	
	ML		42	12	100	88		SANDY SILT: DARK BROWN-GREY.
26.5							14	
	SM			NP	100	49		SILTY SAND: DARK BROWN, FINE TO MEDIUM GRAINED.
30.0							9	

TH83-2409

TH83-2409 STA 147+00 L EL. 25±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	11		NP	99	42		SILTY SAND: BROWN, MOIST, NON-CO
3.0								
	ML	12		NP	96	54		SANDY SILT: BROWN, MOIST, FINE G
6.0							32	
		3		NP	96	37		SILTY SAND: LIGHT BROWN, MOIST.
							21	
	SM	6		NP	99	21		
							20	
		6		NP	100	27		
13.5								
	ML	15		NP	100	51	19	SANDY SILT: BROWN, MOIST, SOME
15.5								
		6		NP	100	15		SILTY SAND: LIGHT BROWN, MOIST.
W 18.5	SM						4	
		25		NP	100	46		SAME: BROWN, WET, CAVING.
20.0							5	CLAY: BROWN, WET, COHESIVE.
	CH	38	53	29	100	92		
23.5							5	
	ML	34		NP	100	47		SANDY SILT: BROWN, WET.
25.5								
							3	

LUE ENGINEERING PAYS

TH83-2406

STA 170+00 L — EL. 29±

LL	PI	-4	-200	N	DESCRIPTION
	NP	99	24		SILTY SAND: BROWN, MOIST, OCCASIONAL GRAVEL UP TO 3 INCHES.
	NP	100	22		SAME: CLEAN SAND, NO GRAVEL.
	NP	99	29	31	
	NP	97	26	15	
	NP	100	39	19	SAME: FINE GRAINED SAND, LENSES OF GREY SILT.
	NP	95	23		SAME: MEDIUM GRAINED, CHUNK OF A/C TO 3 INCHES, NON-COHESIVE.
	NP	99	19	8	SAME: LIGHT BROWN, FINE GRAINED SAND, NO GRAVEL, LOOSE.
	NP	100	27	9	SAME: BROWN, MOIST.
	NP	100	11		SAND/SILTY SAND: LIGHT BROWN, FINE GRAINED SAND, CAVING, NON-COHESIVE.
54	32	100	67	14	SANDY CLAY: BROWN, MOIST, COHESIVE.
24	5	100	27		CLAYEY SAND: BROWN, MOIST, COHESIVE.
	NP	100	30		SILTY SAND: WET.
23	34	100	87	6	CLAY: GREY, PLASTIC, SOFT.
29	7	100	71	3	SANDY CLAY: GREY, FINE GRAINED SANDS, CAVING FROM ABOVE.

TH83-2407

TH83-2407 — STA 157+00 L — EL. 28±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	10		NP	99	47	45	SILTY SAND: BROWN, MOIST, SOME COHESION, ONE BOULDER 4 INCHES X 10 INCHES.
	SM	9		NP	98	35		
	SM	4		NP	97	14	58	SAME: LIGHT BROWN, NON-COHESIVE, GRAVEL TO 1 INCH.
10.5	SM	4		NP	99	16	35	
14.0	SW/SM	4		NP	100	11	25	SAND/SILTY SAND: LIGHT BROWN, MEDIUM GRAINED.
	SM	10		NP	100	22		SILTY SAND: BROWN, WET, NON-COHESIVE, CAVING.
20.5	SM	19		NP	100	16		
21.0	SW/SM	12		NP	98	10	8	SAND/SILTY SAND: BROWN, WET, SOME GRAVEL.

TH83-2409

STA 147+00 L — EL. 25±

LL	PI	-4	-200	N	DESCRIPTION
	NP	99	42		SILTY SAND: BROWN, MOIST, NON-COHESIVE.
	NP	16	54	32	SANDY SILT: BROWN, MOIST, FINE GRAINED.
	NP	36	37	21	SILTY SAND: LIGHT BROWN, MOIST.
	NP	99	21	20	
	NP	100	27		
	NP	100	51	19	SANDY SILT: BROWN, MOIST, SOME COHESION.
	NP	100	15	4	SILTY SAND: LIGHT BROWN, MOIST.
	NP	100	46	5	SAME: BROWN, WET, CAVING.
[illegible]	29	100	92	5	CLAY: BROWN, WET, COHESIVE.
	NP	100	97	3	SANDY SILT: BROWN, WET.

NOTES:

1. SEE PLATE 24 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SCALE: 1 IN=3 FT

5 0 5 10

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS
STA.175+00 TO STA.147+00

DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-
SHEET

TH83-2440

TH83-2440 STA 142+50 R EL. 25±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		12		NP	100	32		SILTY SAND: LIGHT BROWN, MOIST, NON-COHESIVE.
							56	
	SM	10		NP	100	42		SAME: DARK BROWN.
							9	
		9		NP	100	38		SAME: LIGHT BROWN.
							8	
				NP	100	39		
11.0								
	SP/SC	4	32	11	100	12	14	SAND/CLAYEY SAND: LIGHT BROWN, MEDIUM TO FINE GRAINED SAND, NON-COHESIVE, 4 INCH THICK LAYER OF DARKER FINE SILTY SAND AT 12.5 FEET.
15.0								
	SP/SM	4		NP	100	9		SAND/SILTY SAND: LIGHT BROWN, MEDIUM TO FINE GRAINED SAND, NON-COHESIVE.
16.5								
		31	33	10	100	97	10	CLAY: LIGHT GREY TO LIGHT BROWN, COHESIVE, FINE GRAINED SAND, WATER AT 19.0 FEET.
W 19.0	CL							
		63	37	13	100	85	7	
22.5								
	ML		40	14	100	79	13	SANDY SILT: DARK GREY TO BROWN, MOIST, COHESIVE, FINE GRAINED SAND, ORGANIC.
25.5								
	CL	33	42	21	100	93		CLAY: DARK GREY, MOIST, ORGANIC.
27.0							10	
	ML	38	35	9	100	97		SILT: LIGHT BROWNISH GREY, MOIST, SLIGHTLY COHESIVE.
		41	43	16	100	89		SAME: DARK GREY, PLASTIC, COHESIVE, ORGANIC.
29.5								
	CL	35	44	20	100	85	5	SILTY CLAY: BROWNISH GREY, MOIST, COHESIVE, ALTERNATING 4 INCH LAYERS OF LIGHT GREY CLAY.
32.5								
	ML	33		NP	100	52	27	SANDY SILT: GREY, MOIST, NON-COHESIVE, FINE GRAINED SAND.
35.5								
		29		NP	100	37		SILTY SAND: GREY, WET, NON-COHESIVE, FINE GRAINED SAND.
	SM						32	
		35		NP	100	44		SAME: GREYISH BROWN, ALTERNATING 2 INCH LENSES AT 6 INCH SPACING OF DARK GREY ORGANIC SILTS.
39.5							9	
		44	38	17	100	74		SANDY CLAY: GREY, WET, COHESIVE, SHELL FRAGMENTS.
	CL						11	
		33	42	23	100	73		SAME: DARK GREY, MANY SHELLS, ORGANIC.
45.0								

TT79-4

INVERT

TT79-4 STA 140+00 C EL. 13[illegible]

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIP[illegible]
		6		NP	100	84		SANDY SILT: GREY, MOIST, VE[illegible]
	ML							
		14		NP	100	81		
7.0								
	CH	45	60	30	100	91		CLAY: GREY, WET.
10.0								

TT79-4

STA 140+00 C — EL. 13±

LL	PI	-4	-200	N	DESCRIPTION
	NP	100	84		SANDY SILT: GREY, MOIST, VEGETATION.
	NP	100	81		
[illegible]	30	100	31		CLAY: GREY, WET.

TH83-2433

TH83-2433 — STA 138+50 N — EL. 25±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	10		NP	100	32		SILTY SAND: LIGHT BROWN, MOIST, NON-COHESIVE, 2 INCH SILTY CLAYEY LENS AT 3 FEET.
3.0							45	
	SC	10	31	12	100	39		CLAYEY SAND: LIGHT BROWN, MOIST.
							19	
6.0								
		4		NP	100	29		SILTY SAND: MOIST, NON-COHESIVE, MEDIUM TO FINE GRAINED SAND.
							4	
	SM	6		NP	100	42		SAME: FINE GRAINED SAND.
							7	
		9		NP	100	36		
14.0								
	SP/SM	3		NP	100	10	10	SAND/SILTY SAND: MOIST, MEDIUM TO FINE GRAINED SAND, NON-COHESIVE.
16.0 ▽ 16.5								
	MH	40	51	20	100	53		SANDY SILT: MOIST, FINE GRAINED SAND, SLIGHT COHESION, WATER AT 16.5 FEET.
							12	
		39	71	37	100	96		
20.0 20.5	ML				100	61		SANDY SILT: WET, SLIGHT COHESION, FINE GRAINED SAND.
							10	
	CL	36	32	10	100	76		SANDY CLAY: LIGHT BROWN, MOIST, COHESIVE.
22.0	SM	37		NP	100	46		SILTY SAND: BRN, WET, SLIGHT COHESION, FINE GRAINED SAND.
23.0		47		NP	100	58		SANDY SILT: BRN, WET, SLIGHT COHESION, FINE GRAINED SAND.
							22	
		40		NP	100	69		SAME: BRNISH GREY, WET, MED TO FINE GRAINED SND, COHESIVE.
		33		NP	100	61		SAME: GREY, MOIST, COHESIVE, FINE GRAINED SAND.
							14	
		38		NP	100	94		SILT: LIGHT GREY, WET.
	ML							
		36		NP	100	51		SANDY SILT: SLIGHT COHESION, MED TO FINE GRAINED SAND.
		36		NP	100	89		SILT: LIGHT GREYISH BROWN, FINE GRAINED SAND, COHESIVE.
							17	SAME: GREYISH BROWN, COHESIVE, LESS COHESIVE WITH INCREASE IN DEPTH.
				NP	100	33		
34.0								
								SILTY SAND: GREY, MOIST, NON-COHESIVE, FINE GRAINED SAND.
	SM	38		NP	100	43		
							27	
39.0		38		NP	100	41		SAME: DARK GREY, WET, SLIGHTLY COHESION.
		40		NP	100	51		SANDY SILT: GREY, MOIST, SOME COHESION, SMALL SHELLS AND ORGANICS.
							11	
				NP	100	72		SAME: DARK GREY, COHESIVE.
	ML							SAME. GREYISH BROWN, SMALL SHELLS AND ORGANICS.
		45		NP	100	73		
							24	
		34		NP	100	77		
		31		NP	100	75		SAME: DARK GREY, WET, COHESIVE, FINE GRAINED SAND, MANY SHELLS, ORGANICS.
45.0								

SCALE: 1 IN=3FT

5 0 5 10

NOTES:

1. SEE PLATE 24 FOR LOCATION OF TEST HOLES AND TEST TRENCHES.
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM.
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

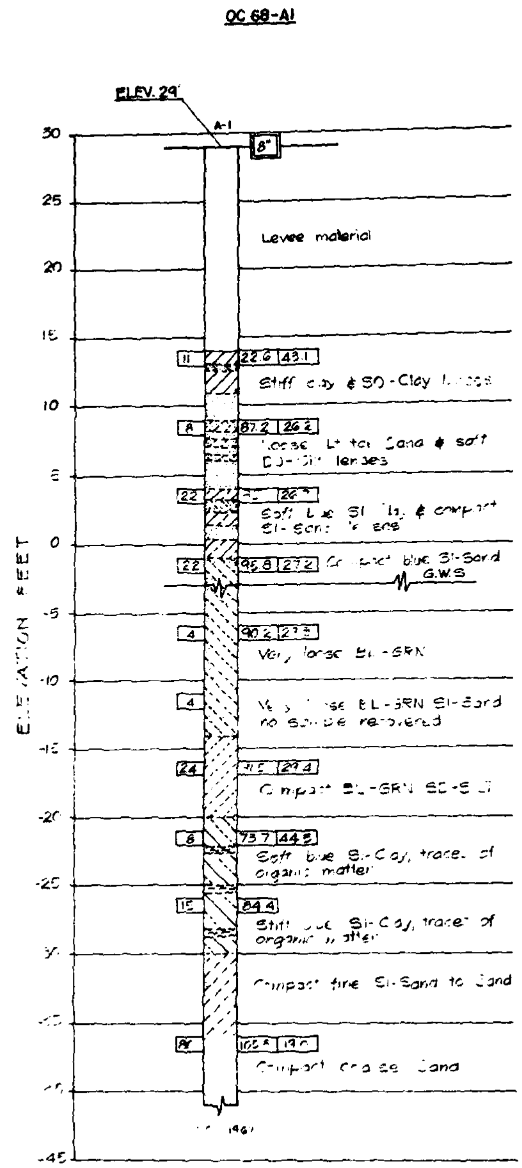
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

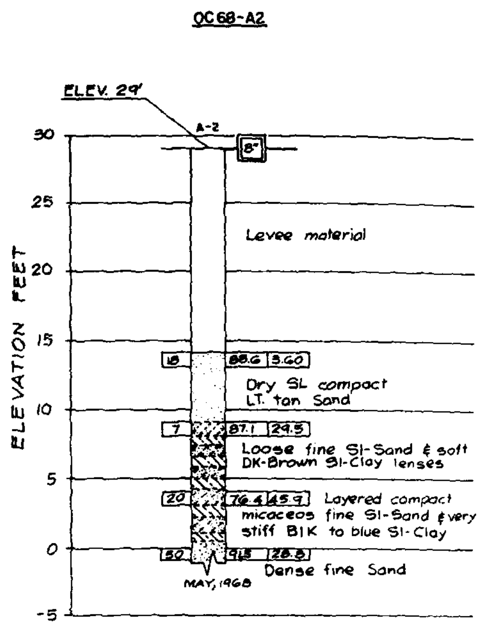
LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

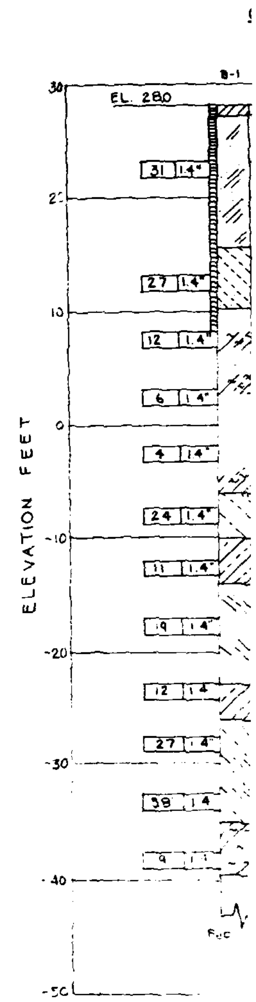
STA. 142+50 TO STA 138+50

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-____ B-____ | SHEET

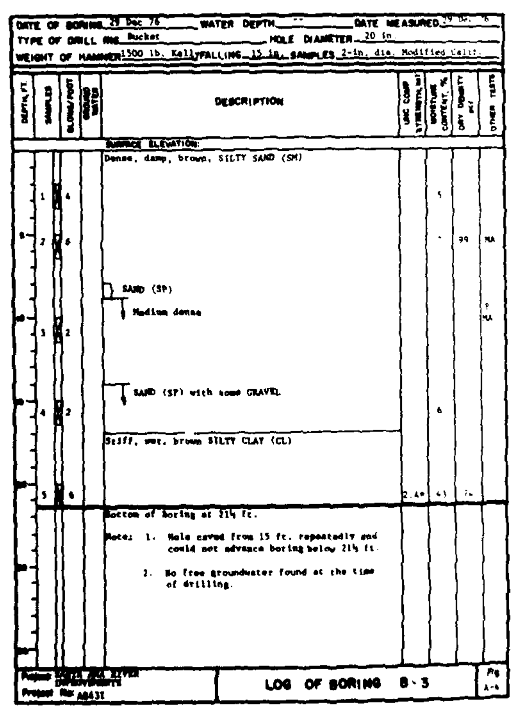
VALUE ENGINEERING







WC 77-3


DATE OF BORING 29 Dec 76 WATER DEPTH -- DATE MEASURED
TYPE OF DRILL RIG Bucket HOLE DIAMETER 20 in
WEIGHT OF HAMMER 1500 lb. Kelly FALLING 15 in. SAMPLES 2-in. dia. Modified Calif.

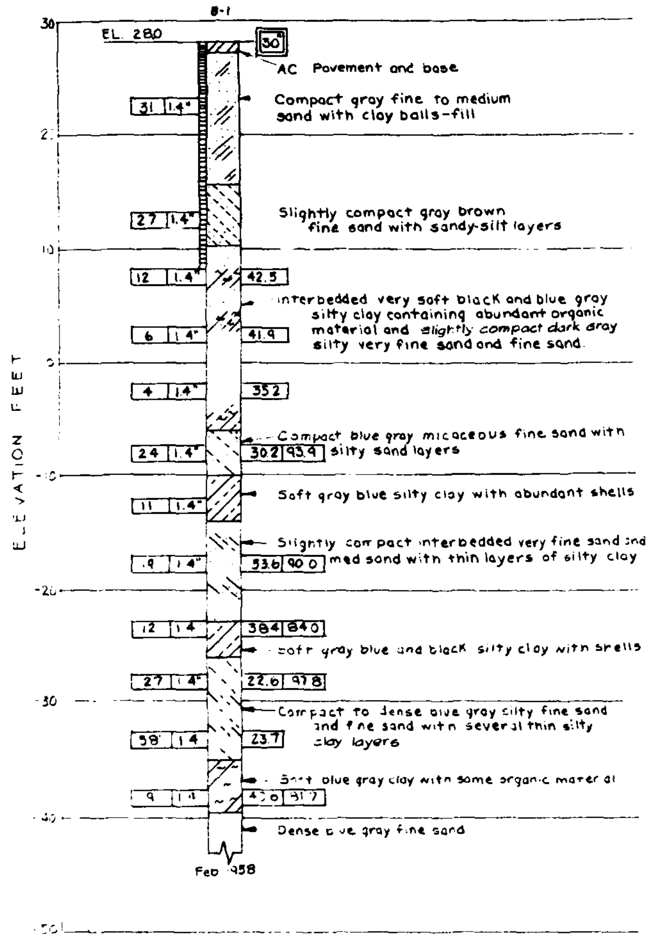
DEPTH, FT. | SAMPLES | BLOWS/FOOT | GROUND WATER | DESCRIPTION | UNC COMP STRENGTH, ksf | MOISTURE CONTENT, % | DRY DENSITY, pcf | OTHER TESTS

SURFACE ELEVATION:
Dense, damp, brown, SILTY SAND (SM)
SAND (SP)
Medium dense
SAND (SP) with some GRAVEL
Stiff, wet, brown SILTY CLAY (CL)
Bottom of Boring at 21½ ft.
Note: 1. Hole caved from 15 ft. repeatedly and could not advance boring below 21½ ft.
2. No free groundwater found at the time of drilling.

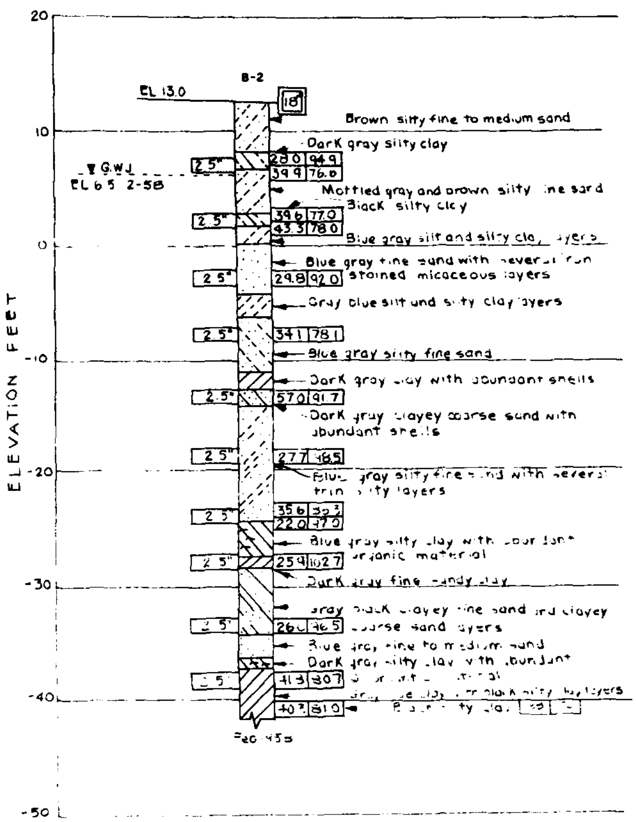
LOG OF BORING B-3

NOTES:
1.
2.
3.

OC68-B1



OC68-B2



NOTES:

1. SEE PLATE 24 FOR TEST SITE LOCATIONS.
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

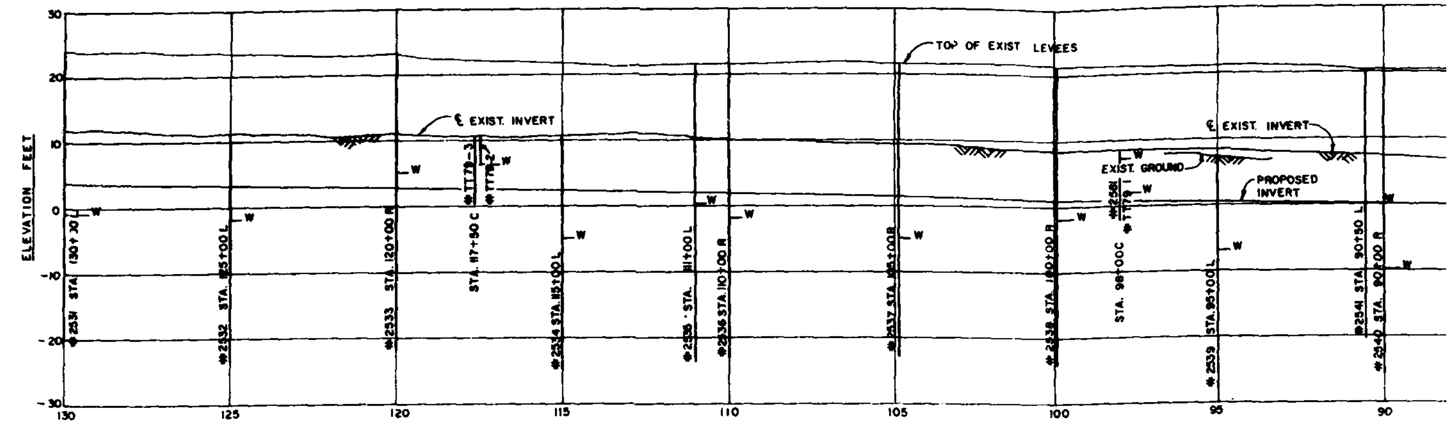
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS

STA.195+00 TO STA.130+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-___ B-___ SHEET

VALUE ENGINEERING PA

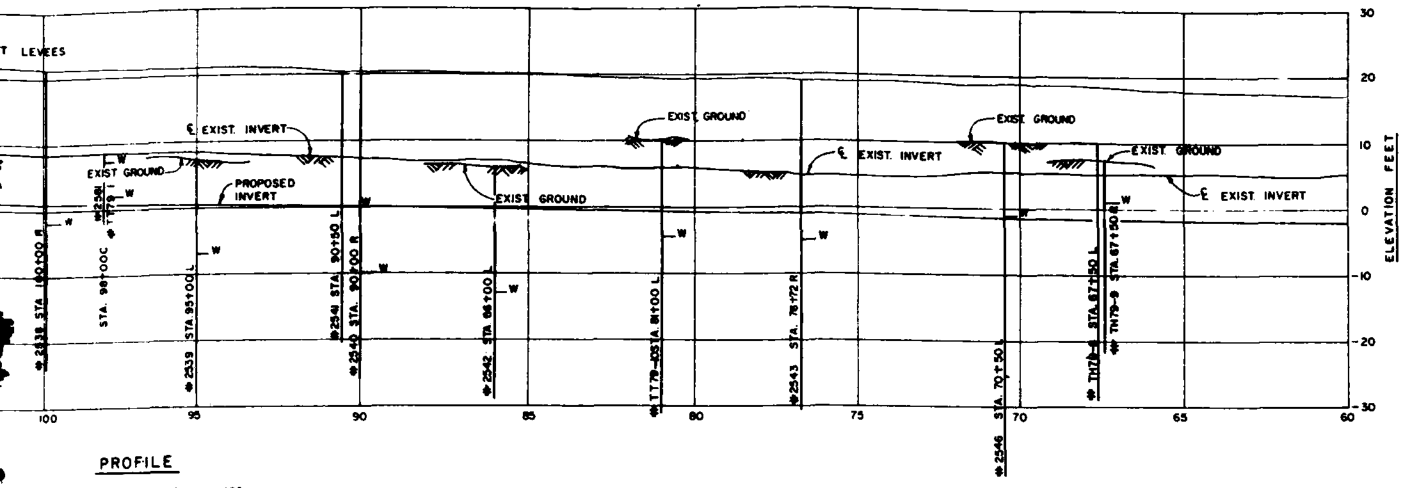


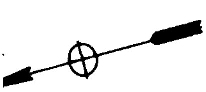
PROFILE

HORIZ SCALE 200 0 200 400 FEET

VERT SCALE 10 0 10 20 30 FEET

ALUE ENGINEERING PAYS





NOTES:

1. SEE PLATE 6 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE

STA. 130+00 TO STA. 60+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

TH83-2531

TH83-2531 STA 130+00 L EL. 24±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SILTY SAND: BROWN, MOIST, NON-COHESIVE, MEDIUM TO FINE GRAINED SAND.
	SM	5					58	
		10						SAME: FINE GRAINED SAND.
5.5							46	
								SANDY SILT: DARK BROWN, MOIST, SLIGHT COHESION.
		14						
	ML	21						SAME: LESS SAND AS DEPTH INCREASES.
							21	
12.5								
13.5	SM	13					37	SILTY SAND: DARK BROWN, MOIST, NON-COHESIVE.
	SP/SM	11						SAND/SILTY SAND: MOIST, NON-COHESIVE, FINE GRAINED SAND.
16.5							32	
	SP	7						SAND: LIGHT BROWN, MOIST, MEDIUM TO FINE GRAINED SAND.
18.0								
								SILTY SAND: MOIST, NON-COHESIVE, FINE GRAINED SAND.
	SM	15						
							11	
21.0								
21.5	ML							SANDY SILT: DARK BROWN, MOIST, COHESIVE.
23.0	SM	33						SILTY SAND: BROWNISH GREY, MOIST, SLIGHT COHESION.
							13	SANDY SILT: BROWNISH GREY, MOIST, COHESIVE, FINE GRAINED SAND, WATER AT 25.0 FEET.
W 25.0								
								SILTY CLAY: BROWN AND GREY INTERMIXED, WET, COHESIVE.
	CL	49					3	
								SAME: DARK GREY, COHESIVE, SHELL FRAGMENTS, ORGANIC.
28.5								
	CH	40	76	43	100	99		CLAY: GREY.
30.0								
	CL	34					14	SANDY CLAY: LIGHT GREY, INTERMIXED WITH BROWN SILT, WET, COHESIVE, FINE GRAINED SAND.
32.0								
	SC	43						CLAYEY SAND: DARK GREY, SLIGHT COHESION FINE GRAINED SAND, ORGANIC.
34.0							23	
								SAND/CLAYEY SAND: GREY, NON-COHESIVE, FINE GRAINED SAND.
	SP/SC	37						
		38						
38.0							16	
	CH	40						CLAY: GREY, WET, COHESIVE.
39.5								
								SANDY SILT.
	ML	30	32	7	100	77		
42.0								
	SC	33						CLAYEY SAND: DARK GREY, WET, NON-COHESIVE, FINE GRAINED SAND, SHELLS.
45.0								

TH83-2532

EXISTING GROUND

TH83-2532 STA 125+00 L EL. 11±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SP/SM							SAND/SILTY SAND: MOIST, MEDIUM GRAINED SAND
2.0	ML	16					20	SANDY SILT: BROWN, MOIST, NON-COHESIVE.
2.5	SP	20						SAND: MOIST, MEDIUM TO FINE GRAINED SAND.
	ML	15						SANDY SILT: BROWN, MOIST, NON-COHESIVE, FIN SAND.
							6	
5.5								
6.0	SM	27						SILTY SAND: LT BRN, MOIST, NON-COHSV., FINE
	CL	38						SILTY CLAY: LIGHT GREY WITH BROWN, MOIST, C
							5	
9.0								
	MH	42						SANDY CLAYEY SILT: GREYISH BROWN, MOIST, C GRAINED SAND.
							22	
12.0								
W 13.0								CLAY: GREY, WATER AT 13.0 FEET.
	CH	43	80	45	100	99		
14.5								
15.0	ML	45						CLAYEY SILT: BROWN, MOIST, COHESIVE.
	CH	53						CLAY: LIGHT GREY, VERY COHESIVE, SLIGHT INC SILT.
16.5								
								SILTY SAND: FINE GRAINED SAND.
	SM	[illegible]		NP	100	29		
19.0								
								SAND/SILTY SAND: WET.
							18	
	SP/SM	30/55						
							24	
25.5								
	CH	39						CLAY: GREY, WET, VERY COHESIVE.
26.5								
							11	SANDY CLAY: DARK GREY, COHESIVE, SHE...
	CL	32						
29.0								
	SP/SM	29					24	SAND/SILTY SAND: GREY, WET, NON-COHESIVE, 30.0 FEET.
32.0								
	CL	33						SANDY SILTY CLAY: GREY, COHESIVE, FINE GR
							14	
34.0								
	SC							CLAYEY SAND: GREY, WET, MEDIUM TO FINE GR

TT79-3

TT79-3 STA 117+50 C EL. 11±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SANDY SILT: GREY, MOIST, VEGETATION.
	ML	6		NP	100	34		
		14		NP	100	81		
7.0								
	CH	45	60	33	100	93		CLAY: GREY, MOIST.
10.0								

TT79-2

TT79-2 STA 117+50 C EL. 11±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		14			98	1		SAND: GREY, MOIST, VEGETATION.
	SP							
		26			100	2		SAME: MOIST TO WET.
4.0								
W 5.0								NO SAMPLE TAKEN: WATER AT 5.0 FEET.

.UE ENGINEERING PAYS

TH83-2532

25+00 L — EL. 11±

PI	-4	-200	N	DESCRIPTION
				SAND/SILTY SAND: MOIST, MEDIUM GRAINED SAND.
			20	SANDY SILT: BROWN, MOIST, NON-COHESIVE.
				SAND: MOIST, MEDIUM TO FINE GRAINED SAND.
			6	SANDY SILT: BROWN, MOIST, NON-COHESIVE, FINE GRAINED SAND.
				SILTY SAND: LT BRN, MOIST, NON-COHSV., FINE GRAINED SAND.
			5	SILTY CLAY: LIGHT GREY WITH BROWN, MOIST, COHESIVE.
			11	SANDY CLAYEY SILT: GREYISH BROWN, MOIST, COHESIVE, FINE GRAINED SAND.
45	100	99		CLAY: GREY, WATER AT 13.0 FEET.
				CLAYEY SILT: BROWN, MOIST, COHESIVE.
				CLAY: LIGHT GREY, VERY COHESIVE, SLIGHT INCLUSIONS OF SILT.
NP	100	29		SILTY SAND: FINE GRAINED SAND.
			13	SAND/SILTY SAND: WET.
			24	
				CLAY. GREY, WET, VERY COHESIVE.
			11	SANDY CLAY: DARK GREY, COHESIVE, SHELLS, ORGANIC.
			24	SAND/SILTY SAND: GREY, WET, NON-COHESIVE, SHELLS BELOW 30.0 FEET.
			24	SANDY SILTY CLAY: GREY, COHESIVE, FINE GRAINED SAND.
				CLAYEY SAND: GREY, WET, MEDIUM TO FINE GRAINED SAND.

TH83-2533

TH83-2533 — STA 120+00 R — EL. 23±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP/SM	9		NP	100	7		SAND/SILTY SAND: MEDIUM TO FINE GRAINED SAND.
3.0							48	
		13		NP	96	13		SILTY SAND: MEDIUM TO FINE GRAINED SAND.
							14	
	SM	9		NP	100	33		SAME: BRN, MOIST, MED. TO FINE GRAINED SAND, NON-COHESIVE.
								SAME: GREY.
		11		NP	100	18	9	
		10		NP	100	30		SAME: BROWN.
11.0								
	SP/SM	5		NP	100	10	10	SAND/SILTY SAND: NON-COHESIVE, FINE GRAINED SAND.
14.0								
		30	46	17	100	69	11	CLAYEY SAND SILT: BROWN, MOIST, FINE GRAINED SAND.
	ML							
		30	42	14	100	61		SAME: WET, TRACE OF CLAY, COHESIVE, WATER AT 18.0 FEET.
W 18.0							12	
19.0								
	MH	41	61	29	100	92		CLAYEY SILT: BROWN, WET, COHESIVE.
22.0							17	
	CL	44	44	18	100	30	15	SANDY SILTY CLAY: BROWN, MOIST, COHESIVE, FINE GRAINED SAND.
26.0								
	CH	38	62	34	100	94		CLAY: BROWN, MOIST, SOME RUST COLOR.
27.5	ML	44	42	14	100	96		CLAYEY SILT: BROWN, MOIST, COHESIVE.
28.5							11	
	MH	50	81	42	100	95		CLAYEY SILT: ORGANIC, BLACK, MOIST.
30.0							12	
								SANDY CLAY: BROWN, GREY AND BLACK, COHESIVE.
	CH	40	52	28	100	34		
			51	24	100	89		
34.0							11	
34.5	CL		37	17	100	88		CLAY: BLACK, WET, FEW SHELLS.
		32	34	6	100	63	21	SANDY SILT: DARK GREY, WET, COHESIVE, FINE GRAINED SAND.
								SAME: MEDIUM GRAINED SAND, SHELLS.
	ML	41					45	
		31		NP	100	50		
		38	30	4	100	78	25	SANDY SILT: GREY, COHESIVE, SHELLS.
		32	30	7	100	52		
43.5								
	SM	39		NP	100	20	26	SILTY SAND: GREY, WET, SHELLS.
45.0								

TT79-2

EL. 11±

N	DESCRIPTION
1	SAND: GREY, MOIST, VEGETATION.
2	SAME: MOIST TO WET.
	NO SAMPLE TAKEN. WATER AT 5.0 FEET.

SCALE: 1 IN=3 FT

5 0 5 10

NOTES:

1. SEE PLATE 25 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM.
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.130+00 TO STA.117+50

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____-____ SHEET

DISTRICT FILE NO.

EXISTING GROUND

TH83-2534

TH83-2534 STA 115+00 L EL. 11±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	8		NP	100	16		SILTY SAND: BROWN-GREY, MOIST, NON-COHESIVE, MEDIUM GRAINED SAND, SOME GRAVEL TO 1 INCH.
3.0							22R	
	ML	27		NP	100	91		SILT: BROWN TO LIGHT BROWN, MOIST, NON-COHESIVE, FINE GRAINED.
5.5							42	
	ML	26	32	6	100	72		SANDY SILT: BROWN, MOIST, NON-COHESIVE, MEDIUM GRAINED SAND.
7.0								
	CL	31	43	17	100	86	12	SILTY CLAY: BROWN, MOIST, NON-COHESIVE, FINE GRAINED SAND.
10.0								
	MH	53	62	30	100	91	16	CLAYEY SILT: BROWN, MOIST, COHESIVE.
		43		NP	100	97		
15.0								
▼16.0	ML			NP	100	89		SILT: GREY, MOIST, COHESIVE, WATER AT 16.0 FEET.
16.5								
		41		NP	100	38	23	SILTY SAND: GREY, WET, NON-COHESIVE, FINE GRAINED SAND, 9 INCH CLAYEY SAND LAYER AT 17.5 FEET.
	SM	29		NP	100	37	26	
		31		NP	100	50	43	
25.0							10	
	ML	32		NP	100	51	9	SANDY SILT: GREY, WET, NON-COHESIVE, FINE GRAINED SAND.
		28	35	10	100	51		SAME: SOME SHELL FRAGMENTS.
30.5								
31.5	SC	27	30	9	100	38		CLAYEY SAND: GREY, WET, NON-COHESIVE, SHELL FRAGMENTS.
	SM			NP	100	30		SILTY SAND: GREY, WET, NON-COHESIVE, FINE GRAINED SAND, SHELL FRAGMENTS.
33.5								
	[illegible]		46	26	100	90	9	CLAY: GREY, WET, COHESIVE.
35.0								

TH83-2535

TH83-2535 STA 111+00 L EL. 21±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	ML	13		NP	100	58		SANDY SILT: BROWN, MOIST.
3.0							47	
	CL	17	36	16	100	57		SANDY CLAY: BROWN, MOIST.
		20	39	17	100	76		
5.5							28	
	SM	14	25	4	100	44		SILTY SAND: BROWN, MOIST, FINE GRAINED SAND.
							28	
		11		NP	100	37		
							44	
		11		NP	100	41		
							22	
		9		NP	100	36		
							24	
		12		NP	100	34		SAME: 3 INCH LENS GREY SAND/SILTY SAND AT 17.5 FEE SAME: GREYISH BROWN.
19.5	CL							SILTY CLAY: DARK BROWN, 1 INCH LENS LIGHT GREY MED GRAINED SAND.
20.5								
▼21.0							9	CLAYEY SILT: GREY, WATER AT 21.0 FEET.
	MH	43	64	[illegible]	100	98		
23.5								
	CH	44	74	42	100	95		CLAY: GREY.
		34	50	[illegible]	100	53		SANDY CLAY: GREY AND DARK GREY, MICACIOUS.
27.0		54	58	30	100	97	7	CLAY: GREY.
	MH	39	53	24	100	80		SANDY SILT: GREY.
29.5							16	
	ML	36		NP	100	60		SANDY SILT: BLACK, SHELL FRAGMENTS.
		33		NP	100	50		
		32	[illegible]	[illegible]	100	51		
		28	[illegible]	[illegible]	100	51	33	SAME: DARK GREY AND BLACK.
37.0								
37.5	SM	25		NP	100	29		SILTY SAND: DARK GREY AND BLACK, SHELL FRAGMENTS.
	SP-SM	25		NP	100	12	38	SAND/SILTY SAND: DARK GREY AND BLACK, NON-COHESI 30 PERCENT SHELLS.
40.5								
41.0	ML	45	49	3	100	71		SANDY SILT: DARK GREY AND BLACK, SLIGHT COHES
	SM	42		NP	100	44	22	SILTY SAND: DARK GREY AND BLACK, WET, TRACE 50 PERCENT SHELL FRAGMENTS.
43.5	SP-SM	30		NP	100	7		SAND: DARK GREY AND BLACK, WET.
44.5								
45.5	CH	45	[illegible]	32	100	90		FAT CLAY: GREYISH BLACK, WET.

TH83-2535

111+00 L EL. 21±

PI	-4	-200	N	DESCRIPTION
NP	100	58		SANDY SILT: BROWN, MOIST.
			47	
16	100	57		SANDY CLAY: BROWN, MOIST.
17	100	75		
			28	
4	100	44		SILTY SAND: BROWN, MOIST, FINE GRAINED SAND.
			29	
NP	100	37		
			44	
NP	100	41		
			[illegible]	
NP	100	36		
			[illegible]	
NP	100	34		SAME. 3 INCH LENS GREY SAND/SILTY SAND AT 17.5 FEET. SAME. GREYISH BROWN.
				SILTY CLAY: DARK BROWN, 1 INCH LENS LIGHT GREY MEDIUM GRAINED SAND.
			5	
32	100	38		CLAYEY SILT: GREY, WATER AT 21.0 FEET.
42	100	35		CLAY: GREY.
29	100	53		SANDY CLAY: GREY AND DARK GREY, MICACIOUS.
30	100	37		CLAY: GREY.
24	100	[illegible]		SANDY SILT: GREY.
			16	
NP	100	[illegible]		SANDY SILT: BLACK, SHELL FRAGMENTS.
NP	100	[illegible]		
4	100	52		
5	100	[illegible]	[illegible]	SAME: DARK GREY AND BLACK.
NP	[illegible]	[illegible]		SILTY SAND: DARK GREY AND BLACK, SHELL FRAGMENTS.
NP	[illegible]	[illegible]	34	SAND/SILTY SAND: DARK GREY AND BLACK, NON-COHESIVE. 30 PERCENT SHELLS.
3	[illegible]	[illegible]		SANDY SILT: DARK GREY AND BLACK, SLIGHT COHESION.
NP	[illegible]	44	[illegible]	SILTY SAND: DARK GREY AND BLACK, WET, TRACE OF CLAY, 5[illegible] PERCENT SHELL FRAGMENTS.
NP	[illegible]			SAND: DARK GREY AND BLACK, WET.
39	[illegible]	[illegible]		FAT CLAY: GREYISH BLACK, WET.

TH83-2536

TH83-2536 STA 110+00 R EL. 21±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW	16		NP	100	29		SILTY SAND: MOIST, NON-COHESIVE, MEDIUM TO FINE GRAINED SAND.
2.5							20	
	SW/SM	16		NP	100	12		SAND/SILTY SAND: LIGHT BROWN, MOIST, 4 INCH LAYER BROWN SANDY SILT AT 3.5 FEET, FEW 3/8 INCH GRAVEL.
5.0								
		8		NP	100	40	53	SILTY SAND: BROWN, MOIST, NON-COHESIVE, 4 INCH LAYER MEDIUM TO FINE GRAINED SAND.
								SAME: LAYERS OF FINE GRAINED SANDS AND SILTY SANDS.
	SM	5		NP	100	36	13	
		17		NP	99	31	10	SAME: MORE SILT AS DEPTH INCREASES.
14.0								
		27	58	36	100	30	10	SAME: MORE SILT AS DEPTH INCREASES.
	CH							
			54	27	100	50	16	SANDY CLAY: GREY AND BROWN, MOIST, COHESIVE.
20.5								
¥ 22.0	MH	43	60	27	100	86	13	CLAYEY SILT: GREY-BROWN, COHESIVE, WATER AT 22.0 FEET.
23.0								
		39	72	39	100	97	20	CLAY: GREY, MOIST.
	CH							
		33	62	39	100	54	4	SANDY FAT CLAY: SAME, LIGHT GREY.
29.5								
	MH	36	79	42	100	97	5	CLAYEY SILT: GREY, COHESIVE, SHELLS, ORGANIC.
32.0								
	ML	33	30	2	100	55		SANDY SILT: DARK GREY, MOIST, SLIGHT COHESION, SHELLS, ORGANIC.
35.5							6	
	SM	29		NP	100	18		SILTY SAND: DARK GREY, WET, NON-COHESIVE, SHELLS.
39.0							39	
	SP/SM	23		NP	97	9		SAND/SILTY SAND: GREY, WET, NON-COHESIVE, SOME SHELLS.
42.0								
43.0	ML	51		NP	100	72		SANDY SILT: LIGHT GREY, WET, SHELLS.
	SM	29		NP	100	23		SILTY SAND: DARK GREY, WET, FINE GRAINED SAND.
45.0							20	

SCALE: 1 IN=5 FT

5 0 5 10

NOTES.

1. SEE PLATE 25 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 84 FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.115+00 TO STA.110+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-___-B-____ SHEET

DISTRICT FILE NO.

TH83-2537

TH83-2537 STA 105+00 L EL. 21±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		16	39	20	100	71		SANDY CLAY: BROWN, MOIST.
	CL						32	
		21	40	15	100	84		SAME: LIGHT BROWN, MOIST.
5.5								
	SM	9		NP	100	41		SILTY SAND: LIGHT BROWN, NON-COHESIVE.
9.0							16	
10.5	SM/SC	17	25	6	100	45		SILTY SAND/CLAYEY SAND: BROWN, MOIST, NON-COHESIVE.
	ML	14	29	6	100	58	28	SANDY SILT: LIGHT BROWN, MOIST, 1 INCH LENS CLAY, 1 INCH LENS DECOMPOSED WOOD.
13.5								
	CL	21	41	22	100	79	26	SANDY CLAY: LIGHT BROWN TO BROWN, MOIST.
16.0								
	SM	13		NP	100	44		SILTY SAND: GREY, MOIST, NON-COHESIVE.
18.0	CL	32	47	21	100	81	16	SANDY CLAY: BROWN, MOIST, COHESIVE, 1/2 INCH INTERMITTENT SILT LENS.
19.5								
	MH	51	60	25	100	94	14	CLAYEY SILT: BROWN, MOIST, COHESIVE, ORGANIC, SULFER ODOR, 2 INCH BLACK LENS.
23.0								
	CH	42	65	37	100	98	15	CLAY: BROWN, MOIST, COHESIVE.
25.5								
W 26.0		36	34	?	100	83		SANDY SILT: GREYISH BROWN, WET, NON-COHESIVE, WATER AT 26.0 FEET.
	ML						20	
		32	37	8	100	88		SILT: SAME, GREY.
30.0								
		32		NP	100	15		SILTY SAND: GREY, WET, NON-COHESIVE, FEW SMALL SHELL FRAGMENTS.
	SM						22	
		28		NP	100	47		
34.0								
35.0	SP/SM	26		NP	100	11	15	SAND/SILTY SAND: GREY, WET, NON-COHESIVE, 40 PERCENT SHELL FRAGMENTS.
	SM	26		NP	100	15		SILTY SAND: GREY, WET, NON-COHESIVE, 40 PERCENT SHELL FRAGMENTS.
37.5							31	
	SP/SM	29		NP	100	8		SAND/SILTY SAND: GREY, WET, NON-COHESIVE, 20 PERCENT SHELL FRAGMENTS.
39.5								
		23			100	3	7	SAND: GREY, WET, NON-COHESIVE, SHELL FRAGMENTS.
	SP							
		27			100	4	10	
44.2								

TH83-2538

TH83-2538 STA 100+00 R EL. 21±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
1.0	SP/SM	4		NP	99	11		SAND/SILTY SAND: BROWN, MOIST, NON-COHESION.
		11		NP	99	40		SILTY SAND: LIGHT BROWN, NON-COHESIVE, MEDIU[M] GRAINED SAND.
		20		NP	99	49		SAME: BROWN, MOIST, FINE GRAINED SAND.
							19	
		12		NP	100	41		
	SM						15	
		9		NP	100	32		
		12		NP	100	48	11	
		14	24	7	100	45		
		5		NP	99	14	7	SAME: GREY-BROWN.
16.0								
		30	53	24	100	77		SANDY CLAY: BROWN, MOIST, COHESIVE.
							13	
	CH	36	57	29	100	94		CLAY: WATER AT 23.0 FEET.
		48	58	30	100	96	15	
W 23.0								
	MH	36	58	27	100	95	16	SILT: BROWN, MOIST, COHESIVE.
		42	55	22	100	98		SAME: GREYISH BROWN.
26.0		85	55	23	100	86		SAME: DARK BROWN, COHESIVE, ORGANIC.
26.5	CH	43	62	36	100	99	5	CLAY: GREY, COHESIVE.
	MH	109	52	22	100	64		SANDY SILT: DARK GREYISH BROWN, COHESIVE, S[…]
27.5								
W 28.0								
		32	37	12	100	60		SANDY SILT: DARK GREY, COHESIVE, SHELL FRA[…]
	ML	32		NP	100	55	30	SAME: ORGANIC.
		32		NP	100	90		SAME: GREY, SLIGHT COHESION.
34.0							19	
	SP/SM	29		NP	99	8		SAND/SILTY SAND: GREY, WET, 50 PERCENT S[…]
36.0								
		25			98	4	32	SAND: DARK GREY, WET, 25 PERCENT SHELL FRA[…]
	SP							
		29			95	4	17	SAME: 10 PERCENT SHELL FRAGMENTS.
43.0							54	
	ML	29	37	11	100	54		SANDY SILT: DARK GREY, WET, COHESIVE, [...] FRAGMENTS.
44.0	SP/SM	25		NP	100	5		SAND/SILTY SAND: DARK GREY, WET, FEW SHE[…]
45.0								

TT79-1

INVERT

TT79-1 STA 98+00 C EL. 9±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	11		NP	98	19		SILTY SAND: LIGHT BROWN, MOIST, WEED GROWTH.
4.0								
	ML	39	33	9	100	74		SANDY SILT: GREY, WET, WATER AT 7.0 FEET.
W 7.0								
	CL	38	36	13	100	79		SANDY CLAY: BLACK, WET, ORGANIC SMELL.
10.0								

...LUE ENGINEERING PAYS

TH83-2538

? STA 100+00 R — EL. 21±

LL	PI	-4	-200	N	DESCRIPTION
	NP	99	[illegible]		SAND/SILTY SAND: BROWN, MOIST, NON-COHESION.
	NP	99	40		SILTY SAND: LIGHT BROWN, NON-COHESIVE, MEDIUM TO FINE GRAINED SAND.
	NP	99	40		SAME: BROWN, MOIST, FINE GRAINED SAND.
				29	
	NP	100	41		
				15	
	NP	[illegible]	[illegible]		
	NP	100	38	[illegible]	
[illegible]	2	100	[illegible]		
	NP	99	[illegible]		SAME: GREY-BROWN.
53	24	100	[illegible]		SANDY CLAY: BROWN, MOIST, COHESIVE.
				[illegible]	
57	29	100	[illegible]		CLAY: WATER AT 23.0 FEET.
58	30	100	[illegible]	15	
[illegible]	27	100	[illegible]	[illegible]	SILT: BROWN, MOIST, COHESIVE.
[illegible]	22	100	92		SAME: GREYISH BROWN.
[illegible]	23	[illegible]	[illegible]		SAME: DARK BROWN, COHESIVE, ORGANIC.
[illegible]	[illegible]	[illegible]	[illegible]		CLAY: GREY, COHESIVE.
52	22	[illegible]	[illegible]		SANDY SILT: DARK GREYISH BROWN, COHESIVE, SHELL FRAGMENTS.
37	12	100	[illegible]		SANDY SILT: DARK GREY, COHESIVE, SHELL FRAGMENTS.
	NP	100	[illegible]	[illegible]	SAME: ORGANIC.
	NP	100	[illegible]		SAME: GREY, SLIGHT COHESION.
				[illegible]	
	NP	[illegible]			SAND/SILTY SAND: GREY, WET, 50 PERCENT SHELL FRAGMENTS.
		36		[illegible]	SAME: DARK GREY, WET, 25 PERCENT SHELL FRAGMENTS.
		[illegible]			SAME: [illegible] PERCENT SHELL FRAGMENTS.
[illegible]	11	[illegible]	[illegible]		SANDY SILT: DARK GREY, WET, COHESIVE, [illegible] PERCENT SHELL FRAGMENTS.
	NP	[illegible]			SAND/SILTY SAND: DARK GREY, WET, FEW SHELL FRAGMENTS.

TT84-2581

INVERT

TT84-2581 — STA 98+00 C — EL. 8±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
W 1.0 – 2.0	SP/SM			NP	100	6		SAND/SILTY SAND: MULTICOLORED, MOIST TO WET, MEDIUM TO FINE GRAINED SAND, OCCASIONAL GRAVEL, WATER AT 1.0 FEET.
2.0 – 5.0	ML		33	6	100	62		SANDY SILT: DARK BROWN, WET, COHESIVE.
5.0 – 7.0	CH		85	54	100	93		CLAY: LIGHT GREY WITH BROWN AND RED VEINS OF ORGANIC MATERIAL, COHESIVE
7.0 – 10.0	SM			NP	100	29		SILTY SAND: DARK GREY, WET, COHESIVE, FINE GRAINED SAND.

NOTES

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2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SCALE: 1 IN = 3 FT

5 0 5 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.105+00 TO STA.98+00

SUBMITTED BY: | DATE APPROVED: | SPEC NO. DACW09-____-B-____ | SHEET

DISTRICT FILE NO.

TH83-2539

EXISTING GROUND

TH83-2539 STA 95+00 L EL. 8±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	ML	19		NP	100	65		SANDY SILT: BROWN, MOIST, NON-COHESIVE.
3.0							14	
4.0	CL	13	46	21	100	82		SANDY CLAY: DARK BROWN, MOIST COHESIVE.
5.0	SM	13	24	2	100	29		SILTY SAND: LIGHT BROWN, MOIST, NON-COHESIVE.
6.0	ML	10		NP	100	58	17	SANDY SILT: LIGHT BROWN, MOIST, NON-COHESIVE.
7.0	CH				100	98		CLAY: BROWN, MOIST, COHESIVE.
8.0	ML	14		NP	100	54		SANDY SILT: BROWN, MOIST, NON-COHESIVE.
							6	SANDY CLAY: BROWN, MOIST.
	CL	44	48	25	100	78		
11.0								
	CH	51	71	40	100	70		SANDY CLAY: BROWN, MOIST.
		39			100	98		CLAY: GREY, MOIST.
14.0								
W 15.0	ML	33	26	4	100	54		SANDY SILT: GREY, MOIST, NON-COHESIVE. WATER AT 15.0 FT.
		33		NP	100	64		SAME: GREY-BROWN, WET, SOME COHESION.
		30						SAME: GREY, NON-COHESION.
16.5							33	
	SP				100	2		SAND: GREY, WET, 40 PERCENT SHELL FRAGMENTS.
19.0								
		22		NP	100	6	13	SAND/SILTY SAND: GREY, WET, 40 PERCENT SHELL FRAGMENTS.
	SP/SM							
				NP	100	5	3	SAME: FEW SHELLS.
25.0								
								SAND: GREY, WET, 40 PERCENT SHELL FRAGMENTS.
		24			100	3		
		27			100	2	22	SAND: GREY, WET, 40 PERCENT SHELL FRAGMENTS.
	SP	27			100	4		SAME: FEW SHELL FRAGMENTS.
		25			100	3		SAME: 40 PERCENT SHELL FRAGMENTS.
							10	
		22			100	1	37	
35.0								

TH83-2541

TH83-2541 STA 99+50 L EL. 20±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP-SM	17		NP	100	7		SAND/SILTY SAND: LIGHT BROWN, DRY, FINE
3.0								
								CLAYEY SAND: BROWN, MOIST, FINE GRAINE
		10	29	12	100	49		
	SC							
		6	41	18	100	19		SAME: BROWN AND GREY.
8.5								
								SANDY CLAY: DARK BROWN, MOIST, FINE GR
		23	31	17	100	67		
	CL							
		26	47	22	100	71		
		29	41	27	100	75		
		20	29	[illegible]	100	70		SAME: BROWN.
15.5								
17.0	ML	26	37	5	100	68		SANDY CLAYEY SILT: BROWN, MOIST, FINE
18.5	CL	45	42	[illegible]	100	96		SILTY CLAY: DARK BROWN, MOIST.
W 20.0	CH	29	51	23	100	92		CLAY: DARK BROWN, MOIST.
								SAME: LIGHT GREY, WATER AT 20.0 FEET.
23.5								
	SC	34	40	16	100	21		CLAYEY SAND: BROWN AND GREY, SATURATE
23.5 24.0	SP/SM			NP	100	11		SAND/SILTY SAND: GREY AND GREEN.
		28	56	[illegible]	100	14		SILTY SAND: DARK GREY AND MIXED WITH B
		28	61	[illegible]	100	15		SAME: DARK GREY, WHITE BROKEN SHELLS.
	SM	29		NP	100	43		SAME: DARK GREY WITH BROWN.
				NP	100	49		SAME: DARK GREY.
31.5								
	SP				100	4		SAND: DARK GREY, COARSE TO FINE GRAINE FRAGMENTS.
34.5								
								SAND/CLAYEY SAND: DARK GREY, WHITE SHE
	SP/SC		[illegible]	[illegible]	[illegible]	5		
40.5								

S
LUE ENGINEERING PAYS

TH83-2541

A 90+50 L — EL. 20±

PI	-4	-200	N	DESCRIPTION
NP	100	7		SAND/SILTY SAND: LIGHT BROWN, DRY, FINE GRAINED SAND.
12	100	49		CLAYEY SAND: BROWN, MOIST, FINE GRAINED SAND.
18	100	[illegible]		SAME BROWN AND GREY.
[illegible]	100	67		SANDY CLAY DARK BROWN, MOIST, FINE GRAINED SAND.
22	100	71		
23	100	75		
[illegible]	100	70		SAME BROWN.
9	100	58		SANDY CLAYEY SILT: BROWN, MOIST, FINE GRAINED SAND.
19	100	96		SILTY CLAY. DARK BROWN, MOIST.
[illegible]	100	90		CLAY. DARK BROWN, MOIST.
				SAME LIGHT GREY, WATER AT 20.0 FEET.
15	100	21		CLAYEY SAND: BROWN AND GREY, SATURATED.
NP	100	11		SAND/SILTY SAND. GREY AND GREEN.
[illegible]	100	14		SILTY SAND DARK GREY AND MIXED WITH BROWN.
[illegible]	100	15		SAME. DARK GREY, WHITE BROKEN SHELLS.
NP	100	43		SAME DARK GREY WITH BROWN.
NP	100	43		SAME DARK GREY.
	[illegible]	[illegible]		SAND DARK GREY, COARSE TO FINE GRAINED SAND, SHELL FRAGMENTS.
				SANDY CLAYEY SAND DARK GREY, WHITE SHELL FRAGMENTS.

TH83-2540

TH83-2540 — STA 90+00 R — EL. 20±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		9		NP	100	13	12	SILTY SAND: LIGHT BROWN, MOIST, MEDIUM TO FINE GRAINED SAND, NON-COHESIVE.
		8		NP	100	24	20	SAME: BROWN.
	SM	11		NP	100	41		SAME: LIGHT BROWN, FINE GRAINED SAND.
		7		NP	100	29	8	
		14		NP	100	38	6	
13.5		4		NP	100	16		
15.5	CL	24	37	18	100	55	17	SANDY CLAY: GREY-BROWN, MOIST, COHESIVE.
18.5	MH	34	52	22	100	88	11	SILT: GREY-BROWN, MOIST, COHESIVE.
20.5	CH	41	67	35	100	91		CLAY: DARK BROWN, MOIST, COHESIVE.
21.0	ML	35	38	11	100	92		CLAYEY SILT: LIGHT BROWN, COHESIVE, TRACES OF CLAY.
22.0	CL	41	49	23	100	93		SILTY CLAY: GREY, MOIST, STIFF, COHESIVE.
23.5	CH	39	78	47	100	92		CLAY: LIGHT GREY, MOIST, STIFF, COHESIVE.
26.5	SM	31		NP	100	37	29	SILTY SAND: DARK GREY, WET, NON-COHESIVE, ORGANIC.
W 30.0	CL	35	39	19	100	84	35	SANDY CLAY: DARK GREY, WET, WATER AT 30.0 FEET.
32.5							27	
36.5	SM	26		NP	97	15	19	SILTY SAND: DARK GREY, WET, NON-COHESIVE, COARSE TO FINE GRAINED SANDS, 20 PERCENT SHELL FRAGMENTS, ORGANIC.
		25		NP	35	11		SAND/SILTY SAND: DARK GREY, WET, NON-COHESIVE, 10 PERCENT SHELL FRAGMENTS, ORGANIC.
	SP/SM						25	SAME: 5 PERCENT SHELL FRAGMENTS.
								SAME: 10 PERCENT SHELL FRAGMENTS.
45.0							26R	

SCALE: 1 IN=3 FT

5 0 5 10

NOTES:

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SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.95+00 TO STA.90+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

VALUE ENGINEERING P

TH83-2542

EXISTING GROUND
TH83-2542 STA 86+00 L EL. 7±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SANDY SILT: BROWN, MOIST, NON-COHESIVE.
	ML	15	44	7	100	56		
							38	
		23		NP	100	50		SAME: COHESIVE.
4.5								
	SC	14	41	19	100	45	39R	CLAYEY SAND: GREYISH BROWN, MOIST, SOME CLUMPS OF SILT.
6.5								
	SM	8	60	21	100	20		SILTY SAND: GREYISH BROWN, MOIST, NON-COHESIVE, MEDIUM TO FINE GRAINED SAND.
8.0								
							24	SANDY CLAY: BROWN, MOIST, COHESIVE, SHELL FRAGMENTS.
	CL	21	47	24	[illegible]	72		
11.0								
	ML	22	64	31	100	57	24	SANDY SILT: BROWN, MOIST, COHESIVE, SHELL FRAGMENTS.
13.0								
	SM	18	62	29	100	48		SILTY SAND: LIGHT BROWN, MOIST, NON-COHESIVE, SOME SHELL FRAGMENTS.
14.5								
							24	SANDY CLAY: GREY, MOIST.
		24	48	21	100	61		
	CL							
							30	SAME: SLIGHT ORGANIC SMELL, WATER AT 20.0 FEET.
		23	42	19	100	56		
W 20.0								
20.5	ML	23	47	18	100	69		SANDY SILT: GREY, WET, ORGANIC, ROOTS.
	CH	52	60	32	100	94		CLAY: LIGHT GREY, MOIST.
21.5							18	
	SC	28	45	23	100	24		CLAYEY SAND: LIGHT GREY, WET.
24.0								
		31		NP	100	[illegible]	25	SILTY SAND: GREY, WET, NON-COHESIVE, FINE GRAINED SAND, SHELLS.
	SM							
		29		NP	100	35	29	SAME: ORGANIC.
30.0								
	SC	29	39	15	100	45	31	CLAYEY SAND: GREY, WET, FINE GRAINED SAND, SHELLS.
33.0								
33.5	SM	38		NP	100	36		SILTY SAND: GREY, WET, ORGANIC.
35.0	SP/SM	35		NP	100	6		SAND/SILTY SAND: GREY, WET, ORGANIC.

TH79-10

EXISTING GROUND
TH79-10 STA 81+00 L EL. 10±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	ML	14	29	6	100	66		SANDY SILT: LIGHT BROWN, MOIST, FIRM.
3.0								
							12	CLAY: SAME AS ABOVE.
	CL	34	42	21	100	86		SAME: STIFF.
								SAME: GREY BROWN WITH RUST, MOIST, FIRM
9.0								
							9	SANDY SILT: SAME AS ABOVE.
		32		NP	100	59		SAME: GREY, WET, FIRM TO STIFF, INTERBE FINE SAND.
W 14.5							15	
		39		NP	100	73		SAME: LIGHT GREY, WET, DENSE.
	ML						10	SAME: GREY, WET, FIRM TO STIFF, SLIGHTL
		33		NP	100	85		
							17	SAME: SCATTERED SHELL FRAGMENTS, INTERB
		30		NP	100	88		
30.5							15	
								SILTY SAND: SAME AS ABOVE.
	SM	17		NP	100	17		
								SAME: GREY, MOIST, VERY DENSE, SHELLS FRAGMENTS.
35.5							66	
								SAND: GREY, MOIST, VERY DENSE.
	SP	[illegible]			100	4		
40.5							104	

ALUE ENGINEERING PAYS

TH79-10

ND

STA 81+00 L — EL. 10±

LL	PI	-4	-200	N	DESCRIPTION
29	6	100	56		SANDY SILT: LIGHT BROWN, MOIST, FIRM.
				12	CLAY: SAME AS ABOVE.
42	21	100	86		SAME: STIFF.
					SAME: GREY BROWN WITH RUST, MOIST, FIRM TO SOFT.
				9	SANDY SILT: SAME AS ABOVE.
	NP	100	59		SAME: GREY, WET, FIRM TO STIFF, INTERBEDS OF SILT AND FINE SAND.
				15	
	NP	100	[illegible]		SAME: LIGHT GREY, WET, DENSE.
				10	SAME: GREY, WET, FIRM TO STIFF, SLIGHTLY MICACEOUS.
	NP	100	35		
				[illegible]	SAME: SCATTERED SHELL FRAGMENTS, INTERBEDS OF SILT.
	NP	100	89		
				[illegible]	
					SILTY SAND: SAME AS ABOVE.
	NP	[illegible]	[illegible]		
					SAME: GREY, MOIST, VERY DENSE, SHELLS AND SHELL FRAGMENTS.
				[illegible]	SAND: GREY, MOIST, VERY DENSE.
[illegible]		100	4		
				[illegible]	

TH83-2543

TH83-2543 — STA 76+72 R — EL. 19±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP						24	SAND: LIGHT BROWN, MEDIUM GRAINED, NON-COHESIVE.
3.0								
	SM	9						SILTY SAND: BROWN, MOIST, NON-COHESIVE.
6.0							12	
	SP/SM	10						SAND/SILTY SAND: BROWN TO LIGHT BROWN, FINE TO MEDIUM GRAINED, NON-COHESIVE.
8.0								
							5	SAND: LIGHT BROWN, FINE GRAINED, NON-COHESIVE.
	SP	8						
								SAME: GREY, DRY.
12.0							8	
	ML							SILT: BROWN, MOIST, COHESIVE.
13.5								
	CH	37	73	40	100	99		CLAY.
16.5								
	ML	25						SILT: BROWN, MOIST, COHESIVE.
18.5								
	CH	40	91	54	100	100		CLAY.
21.5								
	ML	35	41	14	100	89		SILT: WATER AT 24.0 FEET.
W 24.0								
24.5								
	SM	27		NP	100	14		SILTY SAND.
27.5								
	SP							SAND: GREY, SATURATED, 40 PERCENT SHELL FRAGMENTS.
28.5								
	CH							CLAY: GREY, MOIST.
29.0								
	SP/SM	15		NP	100	11		SAND/SILTY SAND.
31.5								
							52	SAND: GREY, SATURATED, SHELL FRAGMENTS.
		25						
		25					25R	
		29					23	
	SP	27					56	
		23						
							50R	
		24					25	SAME: LARGE SHELLS.
50.0								

SCALE: 1 IN = 3 FT

5 0 5 10

NOTES:

1. SEE PLATE 25 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.86+00 TO STA.76+72

SUBMITTED BY: — DATE APPROVED: — SPEC. NO. DACW09-____ B-____ — SHEET

DISTRICT FILE NO.

TH83-2546

EXISTING GROUND

TH83-2546 STA 70+50 L EL. 10±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	CL	18	32	9	100	81	15	SANDY CLAY: BROWN, MOIST.
3.0								
	ML	31		NP	100	82		SANDY SILT: BROWN, MOIST, NON-COHESIVE.
4.5								
							5	CLAY: BROWN, MOIST.
	CL	43	30	15	100	97		
8.0								
		27		NP	100	98		SILT: BROWN, WET, COHESIVE.
	ML							SANDY SILT: SAME, GREY, WATER AT 11.0 FEET.
W 11.0		37		NP	99	65		
12.0							21	
								SILTY SAND: GREY, SATURATED, NON-COHESIVE.
	SM	20		NP	100	39	24	
		25		NP	100	18		SAME: SHELL FRAGMENTS.
16.0	SP/SM	25			97	7		SAND/SILTY SAND: GREY, SATURATED, SHELL FRAGMENTS.
17.0							37	
		26		NP	99	27		SILTY SAND: GREY, SATURATED, 2 INCH LENS OF 50 PERCENT SHELL FRAGMENTS.
	SM	28		NP	100	15		SAME: NO LENS OF SHELL FRAGMENTS.
							36	
22.0								
								SAND: GREY, SATURATED.
							44P	
	SP	27			100	3		
					100	2	48	
28.0								
							12	SAND/SILTY SAND: GREY, SATURATED.
	SP/SM	25		NP	100	5		
							39	
31.0								
	SP	26			100	3	9	SAND: GREY, SATURATED.
33.0								
							18	SAND/SILTY SAND: GREY, SATURATED.
	SP/SM	26		NP	100	5	26	
36.0							32	
								SAND: GREY, SATURATED.
		25			100	3	33	
							17	
		25			100	3	57	
	SP						21	
		25			100	4	31	
							56	
		24			100	3		
							13	
							35	
		25			100	3	37	
51.5								

TH79-9

INVERT

TH79-9 STA 67+50 R EL. 8±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SAND/SILTY SAND: LIGHT BROWN, MOIST, LOOS
	SP/SM	11		NP	100	12		SAME: LIGHT GREY, MOIST, DENSE.
4.0							47	
								CLAY: LIGHT GREY, MOIST.
	CH	37	79	46	100	96		
								SAME: BROWN, MOIST.
8.0								
							18	SANDY SILT: DARK BROWN, MOIST.
	ML	31		NP	100	63		
13.0							10	
								SILTY SAND: DARK GREY, MOIST, SLIGHTLY MI
	SM	28		NP	100	28		
18.0								
							22	SANDY SILT: INTERBEDS OF SILT.
W 20.0								
		29		NP	100	73		
	ML							
							28	SILT: DARK GREY, MOIST.
		33		NP	100	89		
28.0							16	

VALUE ENGINEERING PAYS

TH79-9

STA 67+50 R — EL. 8±

PI	-4	-200	N	DESCRIPTION
				SAND/SILTY SAND: LIGHT BROWN, MOIST, LOOSE.
NP	100	12		SAME: LIGHT GREY, MOIST, DENSE.
			47	
				CLAY: LIGHT GREY, MOIST.
46	100	96		
				SAME: BROWN, MOIST.
			18	SANDY SILT: DARK BROWN, MOIST.
NP	100	63		
			10	SILTY SAND: DARK GREY, MOIST, SLIGHTLY MICACEOUS.
NP	100	28		
				SANDY SILT: INTERBEDS OF SILT.
			22	
NP	100	73		
			29	SILT: DARK GREY, MOIST.
NP	100	89		
			16	

TH 79-8

EXISTING GROUND

TH 79-8 — STA 67+50 L — EL. 10±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								CLAY: LIGHT BROWN, MOIST, SOFT.
	CH	25	62	33	100	86		
4.0							5	SANDY CLAY: GREY BROWN WITH RUST, MOIST, SOFT.
	CL	45	47	28	100	52		
8.0								
W 9.0							5	SAND/SILTY SAND: GREY, WET, MANY SHELL FRAGMENTS.
	SP/SM	25		NP	100	8	9	
18.0							33	SILTY SAND: GREY, WET, DENSE.
	SM	26		NP	100	14		
23.0							53	SAND/SILTY SAND: GREY, WET, VERY DENSE.
		23		NP	100	7		
	SP/SM						22	SAME: GREY, WET, MEDIUM DENSE, SHELL FRAGMENTS.
		24		NP	100	12		
								SAME: DENSE.
34.0								SILTY SAND: GREY, WET, DENSE, SHELL FRAGMENTS.
							36	
	SM	21		NP	100	17		
39.0								
							56	

SCALE: 1 IN=3 FT

5 0 5 10

NOTES:

1. SEE PLATE 25 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

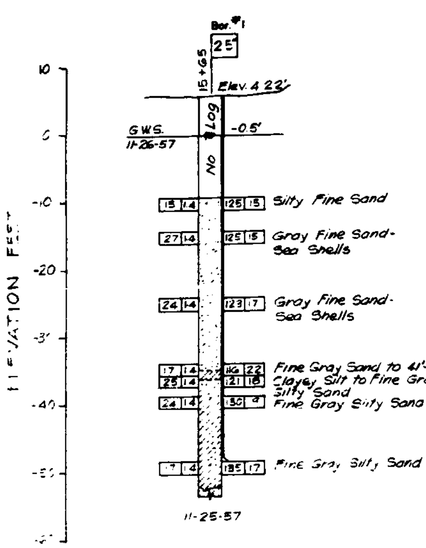
LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

CHECKED BY:

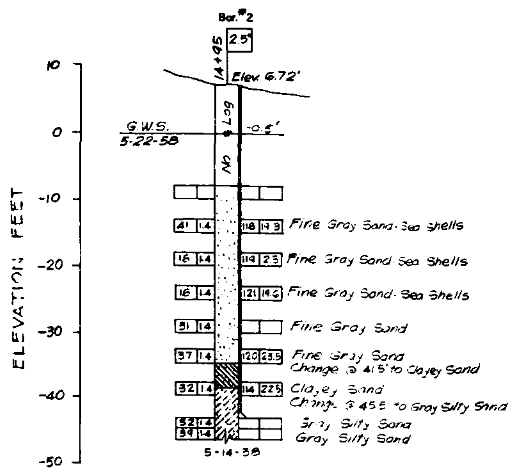
STA.70+50 TO STA.67+50

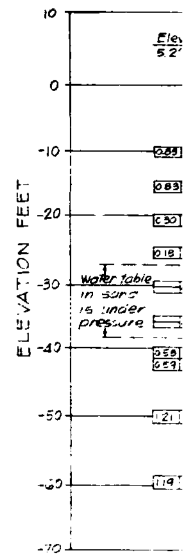
SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____-B-____ SHEET

OC76-1

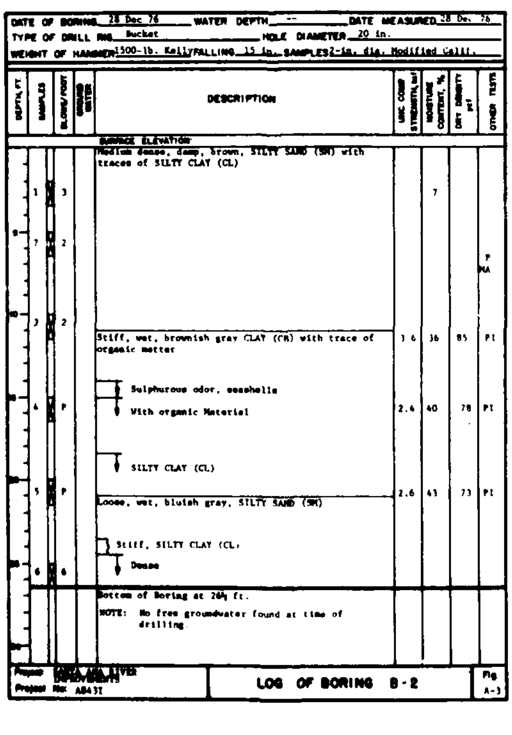


OC76-2





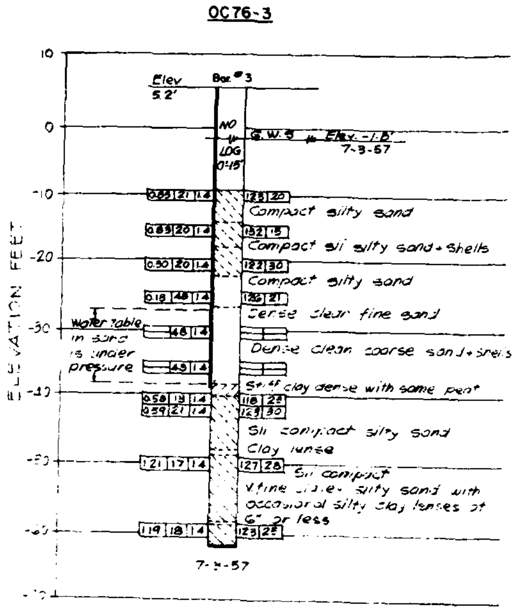
WC77-2

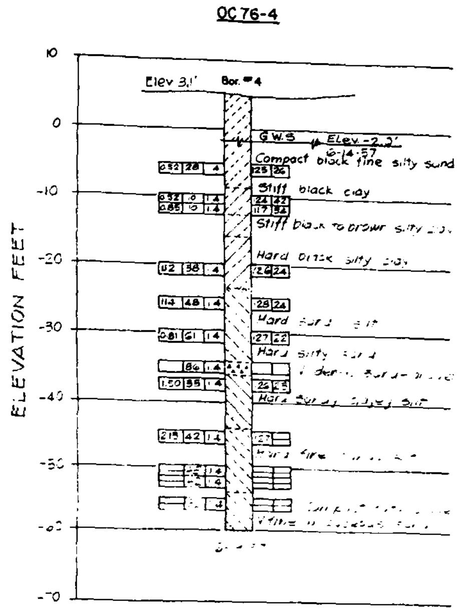


NOTES:

1. SEE PLATE 25 FOR TES
2. SEE TABLES 4 AND 5 FROM WHICH THESE LOGS AND EXPLANATIONS ARE C
3. LOGS BY OTHERS ARE ON DETERMINE THE GENERAL

'ALUE ENGINEERING PAYS





NOTES

1. SEE PLATE 25 FOR TEST SITE LOCATIONS
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WERE TAKEN. ALL LEGENDS AND EXPLANATIONS ARE CONTAINED WITHIN THE REPORTS
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

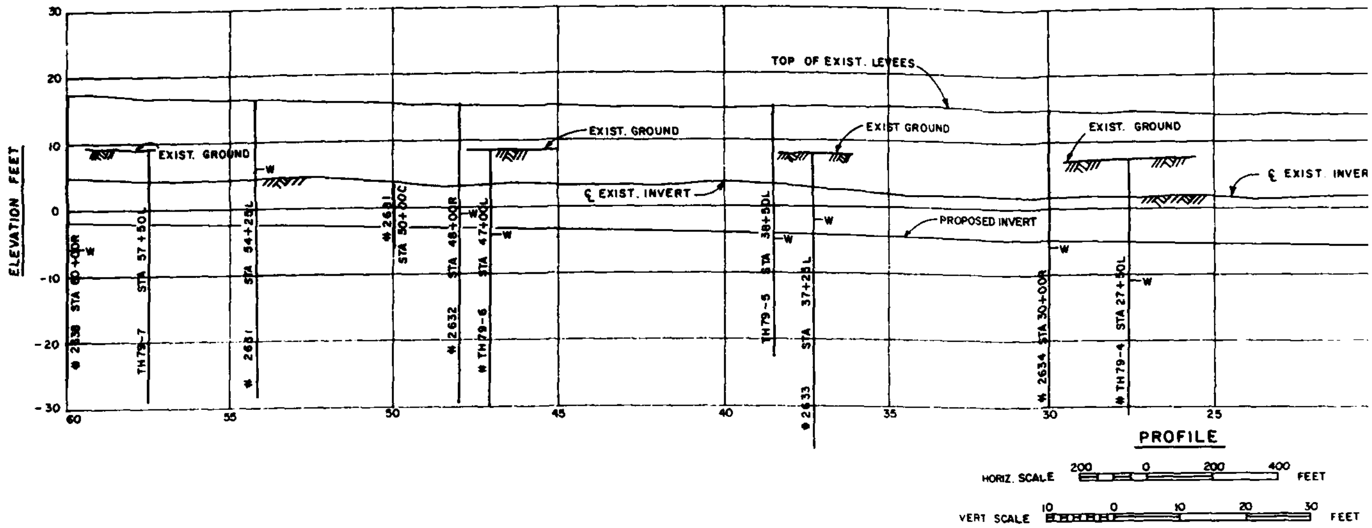
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATION
BY OTHERS

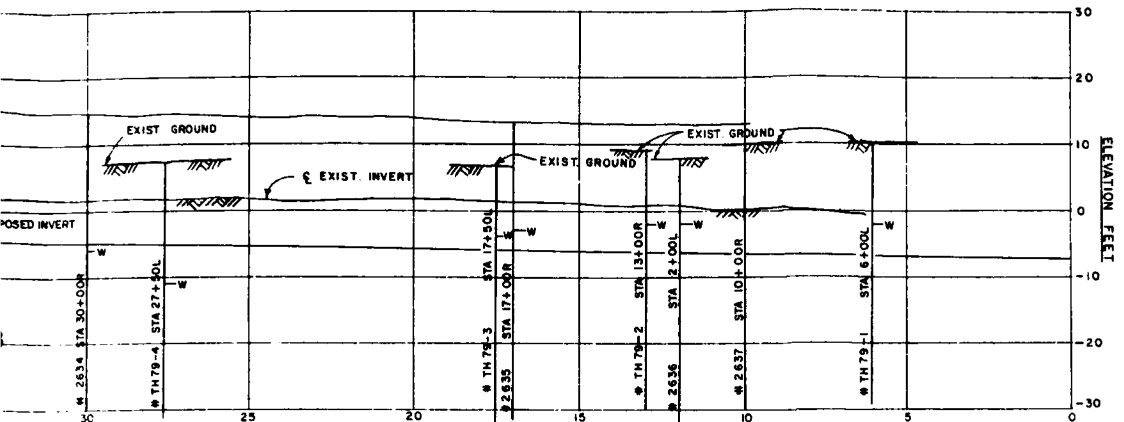
STA. 130+00 TO STA. 60+00

SUBMITTED BY: DATE: SPEC. NO. DACW09- SHEET

VALUE ENGINEERING P



ALUE ENGINEERING PAYS



PROFILE

HORIZ SCALE 200 0 200 400 FEET

ERT SCALE 10 0 10 20 30 FEET

NOTES:

1. SEE PLATE 8 FOR LEGEND AND GENERAL NOTES.
2. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATIONS.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE

STA.60+00 TO STA.0+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____-____ SHEET

DISTRICT FILE NO.

VALUE ENGINEERING

TH83-2638

TH83-2638 STA 60+00 R EL. 17±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SC	12	34	14	100	47		CLAYEY SAND: BROWN, MOIST, NON-COHESIVE, 2 INCH LENS OF SILT.
3.0							44	
	ML	15		NP	100	55		SANDY SILT: BROWN, MOIST, NON-COHESIVE.
5.0							8	SILTY SAND: LIGHT BROWN, MOIST, NON-COHESIVE, MEDIUM TO FINE GRAINED SAND.
		3		NP	100	16		
	SM						2	
		6		NP	100	35		
11.0							3	SILT: DARK BROWN, MOIST, COHESIVE, ORGANIC MATERIAL.
		32		NP	100	91		
							5	
W 17.5								
		39		NP	100	97		
	ML							
		34		NP	100	70	5	SANDY SILT: GREY, WET, NON-COHESIVE, MEDIUM TO FINE GRAINS, SOME SHELL FRAGMENTS.
		39		NP	100	50	4	
29.0								SILTY SAND: GREY, WET, FINE GRAINED SAND, SHELL FRAGMENTS.
	SM	41		NP	32	33		
33.0	SP/SM	25		NP	99	12		SAND/SILTY SAND: GREY, WET, FINE GRAINED SAND, SHELL FRAGMENTS.
34.0								SAND: GREY, WET, NON-COHESIVE, MEDIUM GRAINED SAND.
		24			100	4	20	
	SP							SAME: SHELL FRAGMENTS.
		26			100	4	4	
		24			35	4		
40.5		23		NP	100	3	17	SAND/SILTY SAND: GREY, SATURATED, MEDIUM GRAINED SANDS, SHELL FRAGMENTS.
	SP/SM	20		NP	30	7		
43.0	SM	30		NP	100	13		SILTY SAND: GREY, SATURATED, FINE GRAINED SAND.
5.0							17	

TH79-7

EXISTING GROUND

TH79-7 STA 57+50 L EL. 10±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	9		NP	100	37		SILTY SAND: ORANGE-BROWN, MOIST, MEDIU… GRAVEL TO 3/4 INCH.
2.0	MH	35	58	27	100	73		SANDY SILT: GREY-BROWN WITH RUST, MOIST…
4.0							3	SAND/SILTY SAND: GREY, MOIST, SOFT TO F… MICACEOUS, SMALL ROOTS.
	SP/SM	35		NP	100	11		
9.0							5	SILTY SAND: GREY, MOIST, SOFT TO FIRM, …
		19		NP	100	16		
W14.0							24	SAME: GREY, WET, MEDIUM DENSE, SHELL FR… 2 INCH LENS SILT, BROWN, WET, SOFT.
		23		NP	100	25		SAME: GREY, MOIST, MEDIUM DENSE, SHELL FRAGMENTS.
							23	
		18		NP	100	26		
	SM						33	
		32		NP	100	16		
							29	SAME: WET, MEDIUM DENSE TO DENSE.
		26		NP	100	21		
							29	
39.0							34	

TT84-2681

INVERT

TT84-2681 STA 50+00 C EL. 4±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP				100	1		SAND: MULTI-COLOR, WET, MEDIUM GRAINED SAND.
3.0								
	ML		48	15	100	71		SILT: DARK BROWN WITH REDDISH BROWN PARTICLES, WET, COHESIVE.
5.0								
			57	40	100	80		SANDY CLAY: LIGHT GREY, WET, COHESIVE.
	CH		54	25	100	98		CLAY: DARK BROWN WITH REDDISH BROWN PARTICLES, WET, COHESIVE.
10.0								

LUE ENGINEERING PAYS

TH79-7

+50 L   EL. 10±

	-4	-200	N	DESCRIPTION
	100	32		SILTY SAND: ORANGE-BROWN, MOIST, MEDIUM DENSE, SOME GRAVEL TO 3/4 INCH.
	100	73		SANDY SILT: GREY-BROWN WITH RUST, MOIST, SOFT.
			4	SAND/SILTY SAND: GREY, MOIST, SOFT TO FIRM, SLIGHTLY MICACEOUS, SMALL ROOTS.
	100	11		
			5	SILTY SAND: GREY, MOIST, SOFT TO FIRM, SLIGHTLY MICACEOUS.
	100	15		
			24	SAME: GREY, WET, MEDIUM DENSE, SHELL FRAGMENTS AT 15 FEET, 2 INCH LENS SILT, BROWN, WET, SOFT.
P	100	16		SAME: GREY, MOIST, MEDIUM DENSE, SHELLS AND SHELL FRAGMENTS.
			23	
P	100	26		
			33	
P	100	16		
			30	SAME: WET, MEDIUM DENSE TO DENSE.
P	100	[illegible]		
			[illegible]	
			[illegible]	

TH83-2631

EXISTING GROUND

TH83-2631   STA 54+25 L   EL. 17±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	ML	25		NP	100	92		SILT: LIGHT BROWN, MOIST, NON-COHESIVE.
3.0							18	
	CH	49	50	24	100	99		CLAY: BROWN, MOIST, VERY FINE MATERIAL, COHESIVE.
6.0								
	ML	47		NP	100	88		SILT: BROWN, MOIST, COHESIVE.
8.5								
		35		NP	100	41		SILTY SAND: GREY, MEDIUM GRAIN, MOIST, NON-COHESIVE, SOME SHELL FRAGMENTS.
11.0	SM							
		29		NP	94	36	19	SAME: GREY, SATURATED, MEDIUM GRAIN, NON-COHESIVE, 20 PERCENT SHELL FRAGMENTS.
13.0								
		19		NP	90	15		SAND/SILTY SAND: GREY, SATURATED, MEDIUM TO COARSE GRAINED, NON-COHESIVE, 40 PERCENT SHELL FRAGMENTS.
							25	
	SP/SM	20		NP	96	30		
							43	
		20		NP	95	12		
21.0								
	SP/SC	25	31	47	100	11		SAND/CLAYEY SAND: GREY, SATURATED, MEDIUM TO FINE GRAIN.
22.5								
	SP/SM	23		NP	94	9		SAND/SILTY SAND: GREY, SATURATED, MEDIUM GRAIN, SOME SHELL FRAGMENTS.
24.0							43	
		27		NP	100	15		SILTY SAND: GREY, SATURATED, MEDIUM GRAINED, FEW SHELL FRAGMENTS.
	SM	25		NP	100	[illegible]		
							35?	
		27		NP	[illegible]	[illegible]		
33.0								
		31		NP	[illegible]	[illegible]	[illegible]	SAND/SILTY SAND: GREY, SATURATED, MEDIUM TO FINE GRAINED, NON-COHESIVE.
		36		NP	[illegible]	[illegible]	4?	SAME: GREY, SATURATED, MEDIUM TO FINE GRAIN, NON-COHESIVE, FEW SHELL FRAGMENTS.
	SP/SM							
		23		NP	[illegible]	[illegible]	[illegible]	SAME: FEW SHELLS.
		[illegible]		NP	100	8		
40.0								

SCALE: 1 IN=3 FT

5 0 5 10

NOTES:

1. SEE PLATE 26 FOR LOCATION OF TEST HOLES AND TEST TRENCHES
2. SEE PLATE 84 FOR LEGEND AND CLASSIFICATION SYSTEM
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.60+00 TO STA.50+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____-B-____   SHEET

DISTRICT FILE NO.

TH83-2632

TH83-2632 STA 48+00 R EL. 16±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		9		NP	99	20		SILTY SAND: BROWN TO LIGHT BROWN, MOIST, NON-COHESIVE.
							23	
	SM	12		NP	95	35		SAME: BRN, MOIST, FEW GRAVEL TO 3/4 INCHES, NON-COHESIVE.
							19	
		12		NP	100	34		SAME: BROWN, MOIST, NON-COHESIVE.
9.0							9	
	SP/SM	4		NP	100	12		SAND/SILTY SAND: LIGHT BROWN, MOIST, NON-COHESIVE.
10.5	CL	29	42	23	97	58		SANDY CLAY: BROWN, MOIST.
11.5							5	
	SM	19		NP	100	44		SILTY SAND: LIGHT GREY, MOIST, FINE GRAINED, NON-COHESIVE.
		21		NP	100	43		SAME: GREY AND BROWN.
14.0							18	SILT: DARK GREY, MOIST, COHESIVE.
	ML	44		NP	100	93		
W 17.0								
20.0				NP	95	48	6	SILTY SAND: GREY, WET, FINE GRAIN, NON-COHESIVE, SOME SHELL FRAGMENTS.
	SP	19		NP	33	14		SILTY GRAVELLY SAND: GREY, WET, FINE TO MEDIUM GRAIN, NON-COHESIVE, SOME SHELL FRAGMENTS.
							35	
25.0	SP	23			98	4		SAND: GREY, WET, MEDIUM GRAINED, NON-COHESIVE, SOME SHELL FRAGMENTS.
27.0							23	
		25		NP	100	5		SAND/SILTY SAND: GREY, WET, FINE GRAINED SAND, NON-COHESIVE, SOME SHELL FRAGMENTS.
							29	
		21		NP	93	7		SAME: GREY, SATURATED, MEDIUM GRAIN, NON-COHESIVE, 40 PRECENT SHELL FRAGMENTS.
							47	
	SP/SM	23		NP	100	7		SAME: GREY, SATURATED, MEDIUM TO FINE GRAIN, NON-COHESIVE.
							24	
		27		NP	100	6		
							18	
		29		NP	100	5		
41.0								
	SP	30			100	4		SAND: GREY, SATURATED, FINE TO MEDIUM GRAINED, NON-COHESIVE.
45.0								

TH79-6

EXISTING GROUND

TH79-6 STA 47+00 L EL. 9±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								CLAY: BROWN, MOIST, SOFT TO FIRM.
	CH	36	53	26	100	96		
4.0							5	SILTY SAND: BROWN, MOIST, LOOSE.
		37		NP	100	10		
	SM							SAME: GREY, WET, LOOSE, ROOTS TO 11 FEET
							3	
		24		NP	100	13		
W 13.0								SAME: GREEN-BROWN, WET, SOFT.
14.0							29	SAND/SILTY SAND: GREY, WET, DENSE, SHEL
	SP/SM	20		NP	100	12		
19.0								SILTY SAND: GREY, WET, DENSE, SHELL FRAG
							31	
	SM	20		NP	100	19		
24.0								SAND/SILTY SAND: GREY, WET, DENSE, SHE
	SP/SM	21		NP	100	12		
29.0							65	SILTY SAND: GREY, WET, VERY DENSE, SHE
		27		NP	100	16		
	SM							SAME: GREY, WET, DENSE, SHELLS AND SHE
		21		NP	100	14		
39.0								
							33	

LUE ENGINEERING PAYS

TH79-6

STA 47+00 ... EL. 9±

PI	-4	-200	N	DESCRIPTION
				CLAY: BROWN, MOIST, SOFT TO FIRM.
26	100	96		
			5	SILTY SAND: BROWN, MOIST, LOOSE.
NP	100	[illegible]		
			[illegible]	SAME: GREY, WET, LOOSE, ROOTS TO 11 FEET.
NP	100	13		
				SAME: GREEN-BROWN, WET, SOFT.
			24	SAND/SILTY SAND: GREY, WET, DENSE, SHELL FRAGMENTS.
NP	100	12		
			[illegible]	[illegible] SAND: GREY, WET, DENSE, SHELL FRAGMENTS.
NP	100	13		
				SAND/SILTY SAND: GREY, WET, DENSE, SHELL FRAGMENTS.
NP	100	12		
			[illegible]	[illegible] SAND: GREY, WET, VERY DENSE, SHELL FRAGMENTS.
NP	100	16		
				SAME: GREY, WET, DENSE, SHELLS AND SHELL FRAGMENTS.
NP	100	14		
			[illegible]	

TH79-5

TH79-5 STA 38+50R EL. 15±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SANDY CLAY: BROWN, MOIST, STIFF.
	CH	43	62	35	100	77	15	
								SAME: LIGHT BROWN, MOIST.
								SAME: LIGHT BROWN WITH RUST, MOIST.
3.0							6	SANDY SILT: GREY BROWN WITH RUST, MOIST, SOFT.
	ML	40	48	20	100	89		
13.0							11	SILTY SAND: GREY, MOIST, MEDIUM DENSE.
	SM	29		NP	100	21		
18.0								SAND/SILTY SAND: GREY, MEDIUM DENSE, MOIST.
▼19.5							24	
								SAME: WET, SHELL FRAGMENTS.
		22		NP	100	7		
							32	SAME: GREY, WET, MEDIUM DENSE TO DENSE, MANY SHELL FRAGMENTS.
		20		NP	100	10		
28.0							28	
	SP/SM	23		NP	100	9		
33.0								
		26		NP	100	10		
38.0							27	

SCALE: 1 IN = 5 FT

5 0 5 10

NOTES

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2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM.
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SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA. 48+00 TO STA. 38+50

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

DISTRICT FILE NO

TH83-2633

EXISTING GROUND

TH83-2633 STA 37+25 L EL. 9±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	CL	10	32	13	100	56		SANDY CLAY: BROWN, MOIST, MEDIUM TO FINE GRAIN, NON-COHESIVE.
2.5							15	
	SM	10		NP	100	31		SILTY SAND: LIGHT BROWN, MOIST, FINE GRAIN, NON-COHESIVE.
4.5							14	
	CH	48	59	30	100	94		CLAY: BROWN, MOIST, COHESIVE.
7.0								
		27		NP	100	32	5	SILTY SAND: LIGHT BROWN TO GREY, MOIST, FINE GRAIN, NON-COHESIVE, SOME SHELL FRAGMENTS.
	SM						17	
W 10.9		23		NP	97	14		SAME: GREY, MOIST, MEDIUM TO FINE GRAIN, NON-COHESIVE, SOME SHELL FRAGMENTS.
13.0							36	
	SP/SM	22		NP	100	5	53	SAND/SILTY SAND: GREY, MEDIUM GRAIN, MOIST, NON-COHESIVE.
16.5							18	
							73	SAND: GREY, SATURATED, MEDIUM TO COARSE GRAIN, NON-COHESIVE.
	SP	20			100	2		
							42	
20.0							30	SAND/SILTY SAND: GREY, SATURATED, MEDIUM GRAINED.
	SP/SM	22		NP	100	5		
23.0							6	
							24	SAND: GREY, SATURATED, MEDIUM GRAINED.
	SP	25			99	4	32	
27.0							38	
	SP/SM	23		NP	100	5	34	SAND/SILTY SAND: GREY, SATURATED, MEDIUM GRAINED.
30.0							19	
		23			100	4	34	SAND: GREY, SATURATED, MEDIUM GRAINED.
	SP						39	
		22			100	4	50	
36.0							46	
	SP/SM	24		NP	100	5		SAND/SILTY SAND: GREY, SATURATED, MEDIUM GRAINED, FEW SHELL FRAGMENTS.
39.0								
		29		NP	100	25	30	SILTY SAND: GREY, SATURATED, FINE GRAIN, NON-COHESIVE, FEW SHELL FRAGMENTS.
	SM							
		28		NP	100	29		SAME: DARK GREY, SATURATED, NON-COHESIVE, ORGANIC.
45.0								

TH83-2634

TH83-2634 STA 30+00 R EL. 15±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		13	23	5	87	34		CLAYEY SAND: BROWN, MOIST, GRAV NON-COHESIVE.
							17	
	SC	15	24	5	100	24	9	SAME: BROWN, MOIST, FINE GRAINE
		14	29	11	100	35	10	
10.0		12	32	13	100	69		CLAY: LIGHT BROWN, MOIST, FINE
	CL				100	93		SAME: BROWN, MOIST, VERY FINE
		26	30	9	100	54		SAME: RED-BROWN, MOIST, FINE GRA
13.0								
13.5	SM	20		NP	100	22		SILTY SAND: RED TO LIGHT BROWN,
	CL	46	36	14	100	75		SANDY CLAY: GREY, MOIST, VERY F COHESIVENESS, ORGANIC.
15.5								
	SP			NP	100	3		SAND: GREY, MOIST.
18.0							14	
		32	38	12	100	31		SILTY SAND: DARK GREY, WET, FIN COHESIVE, ORGANIC, SOME SHELL FR
W 20.0							23	
	SM							SAME: GREY, WET, FINE GRAIN, NO FRAGMENTS.
		28		NP	100	19		
24.0							19	
	SP/SM	24		NP	100	5		SAND/SILTY SAND: GREY, WET, MET
27.0							11	
	SP	25			100	3		SAND: GREY, WET.
30.0							34	
	SP/SM			NP	100	5		SAND/SILTY SAND: GREY, WET, MEI
33.0							25R	
	SP	24			100	3		SAND: GREY, WET, NON-COHESIVE.
36.0							32	
	SP/SM	24		NP	100	5		SAND/SILTY SAND: GREY, WET.
38.5							15	
		22			97	2	12	SAND: GREY, WET, MEDIUM GRAIN, FRAGMENTS.
	SP						11	
		24			100	3	38	
45.0								

VALUE ENGINEERING PAYS

TH83-2634

STA 30+00 R EL. 15±

LL	PI	-4	-200	N	DESCRIPTION
23	5	37	34	17	CLAYEY SAND: BROWN, MOIST, GRAVEL 3/4 INCHES MAXIMUM, NON-COHESIVE.
24	5	100	24	9	SAME: BROWN, MOIST, FINE GRAINED, NON-COHESIVE.
29	11	100	35	10	
32	13	100	59		CLAY: LIGHT BROWN, MOIST, FINE GRAIN, NON-COHESIVE.
		100	93		SAME: BROWN, MOIST, VERY FINE MATERIAL, COHESIVE.
30	9	100	54		SAME: RED-BROWN, MOIST, FINE GRAIN W/ SOME COHESIVE CLODS.
	NP	100	22		SILTY SAND: RED TO LIGHT BROWN, FINE GRAIN, NON-COHESIVE.
[illegible]	14	100	75		SANDY CLAY: GREY, MOIST, VERY FINE MATERIAL, SOME COHESIVENESS, ORGANIC.
	NP	100	3	14	SAND: GREY, MOIST.
34	12	100	31	[illegible]	SILTY SAND: DARK GREY, WET, FINE TO VERY FINE MATERIAL, COHESIVE, ORGANIC, SOME SHELL FRAGMENTS.
	NP	100	13	[illegible]	SAME: GREY, WET, FINE GRAIN, NON-COHESIVE, SOME SHELL FRAGMENTS.
	NP	100	[illegible]	[illegible]	SAND/SILTY SAND: GREY, WET, MEDIUM GRAIN, NON-COHESIVE.
		100	[illegible]	[illegible]	SAND: GREY, WET.
	NP	100	5	25F	SAND/SILTY SAND: GREY, WET, MEDIUM GRAINED.
		100	[illegible]	[illegible]	SAND: GREY, WET, NON-COHESIVE.
	NP	[illegible]	[illegible]	[illegible]	SAND/SILTY SAND: GREY, WET.
		37	[illegible]	[illegible]	SAND: GREY, WET, MEDIUM GRAIN, NON-COHESIVE, SOME SHELL FRAGMENTS.
		[illegible]	[illegible]	[illegible]	

TH79-4

EXISTING GROUND

TH79-4 STA 27+50 EL. 8±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	17		NP	100	29		SILTY SAND: LIGHT BROWN, MOIST, MEDIUM DENSE.
2.0	ML	31	38	8	100	87		SANDY SILT: BLACK AND VERY DARK GREY, MOIST, SOFT, HIGHLY ORGANIC, SLIGHTLY MALODOROUS.
		28	40	8	100	85		
4.0								SILTY SAND: SAME AS ABOVE.
		22		NP	100	30	10	SAME: GREY, MOIST, MEDIUM DENSE, MANY SHELL FRAGMENTS.
	SM	14		NP	100	15	20	SAME: GREY, MOIST, MEDIUM DENSE.
14.0	SP	24			100	3	32	SAND: GREY, MOIST, DENSE.
W 18.5 / 19.0		26		NP	100	9		SAND/SILTY SAND: GREY, WET, DENSE.
	SP/SM	18		NP	100	9	24	
		22		NP	100	8	22	
34.0	SP	24			100	3		SAND: GREY, WET, MEDIUM DENSE, SHELL FRAGMENTS.
39.0							31	

SCALE: 1 IN = 5 FT

5 0 5 10

NOTES:

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SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.37+25 TO STA.27+50

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

TH79-3

EXISTING GROUND

TH79-3 STA 17+50 L EL. 7±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								FILL: SILTY FINE SAND, LIGHT BROWN, DAMP, LOOSE.
1.0								
	CL	29	44	21	100	93		CLAY: BLACK AND VERY DARK OLIVE GREEN, MOIST, SOFT, HIGHLY ORGANIC, SLIGHTLY MALODOROUS.
4.0								
								SAND/SILTY SAND: GREY-BROWN WITH RUST, MOIST, SOFT.
	SP/SM	21		NP	100	10		SAME: GREY, MOIST, MEDIUM DENSE, SHELL FRAGMENTS.
9.0								
								SAND: GREY, MOIST, MEDIUM DENSE, SHELL FRAGMENTS.
W 10.5							22	
	SP	23			100	4		
								SAME: WET.
14.0								
							36	SAND/SILTY SAND: GREY, WET, DENSE.
		24		NP	100	7		
							33	
		25		NP	100	5		
							35	SAND/SILTY SAND: SAME AS ABOVE.
	SP/SM	10		NP	100	5		
							54	SAME: GREY, WET, DENSE, SHELLS, GRAVEL TO 1/2 INCH.
		23		NP	100	7		
								SAME: LENS OF RUST AND BLACK.
		22		NP	100	5	52	
								SAME: GREY, WET.
39.0								
							52	

TH83-2635

TH83-2635 STA 17+00 R EL. 13±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
							26	SAND: DARK BROWN, FINE GRAINED.
	SP	14			92	3		
3.5								
							39	SILTY SAND: LIGHT BROWN, MOIST, FIN COHESIVE.
		9		NP	99	18		
		12		NP	100	16		
				NP	100	27	42	
								SAME: DARK GREY, MOIST, FINE GRAINE
	SM	13		NP	100	21		
							2WR	
		13		NP	100	17		
W 15.0							13	
		20		NP	100	13		
17.0								
	SP/SM	25		NP	100	6		SAND/SILTY SAND: GREY, WET, FINE GR
19.0							25	
								SILTY SAND: LIGHT GREY-BROWN, WET, COHESIVE.
	SM	30		NP	96	13		
22.0								
		22			100	2	6	SAND: LIGHT GREY, WET, FINE TO MEDI
	SP	24			100	4		
							28	
27.5								
							5	SAND/SILTY SAND: LIGHT GREY, FINE T
	SP/SM	27		NP	96	5		
30.5								
								SAND: LIGHT GREY, MEDIUM GRAINED, S
		17			97	2		
							26	
		19			97	2		
							26	
	SP	22			100	2		
		18		NP	100	4		
							35	
		19		NP	100	2		
45.0							32	

LUE ENGINEERING PAYS

TH83-2635

A 17+00 R   EL. 13±

PI	-4	-200	N	DESCRIPTION
	32	3	26	SAND: DARK BROWN, FINE GRAINED.
NP	39	13	39	SILTY SAND: LIGHT BROWN, MOIST, FINE GRAINED, NON-COHESI[illegible]
NP	100	15		
NP	[illegible]	27	[illegible]	
NP	[illegible]	21		SAME: DARK GREY, MOIST, FINE GRAINED, NON-COHESIVE.
			26R	
NP	[illegible]	17	[illegible]	
NP	[illegible]	[illegible]		
NP	[illegible]	5		SAND/SILTY SAND: GREY, WET, FINE GRAINED.
NP	[illegible]	[illegible]	15	SILTY SAND: LIGHT GREY-BROWN, WET, FINE GRAINED NON-COHESIVE.
	[illegible]	[illegible]	6	SAND LIGHT GREY, WET, FINE TO MEDIUM GRAINED.
	[illegible]	4	28	
NP	[illegible]	[illegible]	5	SAND/SILTY SAND: LIGHT GREY, FINE TO MEDIUM GRAINED.
	[illegible]	[illegible]		SAND LIGHT GREY, MEDIUM GRAINED, SOME GRAVEL TO 1/2 INCH.
	[illegible]		26	
	[illegible]		36	
NP		[illegible]	35	
NP			31	

TH79-2

EXISTING GROUND

TH79-2   STA 13+00 R   EL. 9±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	13		NP	100	46		SILTY SAND: FINE, LIGHT BROWN, MEDIUM DENSE.
9.0							21	SAND/SILTY SAND: DARK GRAY-BROWN, MOIST.
	SP/SM	23		NP	100	8		
9.0								SAME: GREY, MOIST, MEDIUM DENSE.
W 10.5								SAND: GREY, MOIST, MEDIUM DENSE.
		18			100	4		
							17	SAME: GREY, WET, DENSE, SHELL FRAGMENTS.
	SP	31			100	3		
							20	
							52	SAME: VERY DENSE, GRAVEL TO 1/2 INCH, MANY SHELL FRAGMENTS.
28.0								SAME: GREY, WET, VERY DENSE.
								SAND/SILTY SAND: GREY, WET, DENSE.
	SP/SM	13		NP	100	7		
33.0								SAND: GREY, WET, DENSE.
							35	
	SP	22			100	4		
							32	
39.5							50	

SCALE: 1 IN = 3 FT

NOTES:

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SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: DRAWN BY: CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA.17+50 TO STA.13+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-___ B-____   SHEET

DISTRICT FILE NO.

TH83-2636

EXISTING GROUND

TH83-2636 STA 12+00 L EL. 8±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		20		NP	100	61		SANDY SILT: BROWN, MOIST, FINE GRAINED, NON-COHESIVE.
	ML						15	
		21		NP	100	61	5	
5.5				NP	100	89		SILT: BROWN, COHESIVE.
6.0	SM			NP	100	32		SILTY SAND: BROWN, MOIST, NON-COHESIVE.
		59		NP	100	89		SILT: GREY, MOIST, COHESIVE, ORGANIC SHELL.
	ML	36		NP	100	62		SANDY SILT: GREY, WET, FINE TO MEDIUM GRAINED, NON-COHESIVE.
W 10.0								
		57		NP	100	93		SILT: SAME AS ABOVE, COHESIVE.
12.0								SAND/SILTY SAND: GREY, WET, MEDIUM TO COARSE GRAINED.
	SP/SM	18		NP	93	7		
15.0								
	MH	58	59	25	100	98		SILT: GREY, WET, COHESIVE.
17.0								SAND: GREY, WET, COARSE GRAINED.
		25			100	3		
		22			100	3		
	SP							
		20			100	2		
								SAME: GREY, WET, COARSE GRAINED, ORGANIC SHELL.
		23			100	2		
		22			100	2		
		21			100	2		
45.0								

TH83-2637

EXISTING GROUND

TH83-2637 STA 10+00 R EL. 10±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SM	7		NP	81	15		SILTY GRAVELLY SAND: BROWN, MOIST, NO
2.5							12	SAND: LIGHT BROWN, MOIST, NON-COHESIV SAND.
		4			99	4		
							8	
		4			99	3		
							6	
		12			98	2		
							15	SAME: LIGHT BROWN, WET, NON-COHESIVE, GRAINED SAND.
W 11.0								
							16	
					100	1	10	
		20			100	2		
					100	4		SAME: GREY, WET, NON-COHESIVE, MEDIUM FRAGMENTS.
	SP							
		13			100	3		
		14			94	2		
		15			100	2		SAME: GREY, SATURATED, MEDIUM TO COA NON-COHESIVE.
		14			99	2		
		15			98	2		
		17			100	3		
		17			100	2		SAME: GREY, SATURATED, COARSED GRAIN SHELL FRAGMENTS.
								SAME: FINE GRAINED SAND.
		24			100	2		
47.0								

ALUE ENGINEERING PAYS

TH83-2637

ND

STA 10+00 R — EL. 10±

LL	PI	-4	-200	N	DESCRIPTION
	NP	91	15		SILTY GRAVELLY SAND: BROWN, MOIST, NON-COHESIVE.
				12	SAND: LIGHT BROWN, MOIST, NON-COHESIVE, MEDIUM GRAINED SAND.
		99	[illegible]		
				8	
		[illegible]	[illegible]		
				6	
		98	2		
				15	SAME: LIGHT BROWN, WET, NON-COHESIVE, MEDIUM TO COARSE GRAINED SAND.
				15	
		100	[illegible]	10	
		100	2		
		100	4		SAME: GREY, WET, NON-COHESIVE, MEDIUM GRAINED, SHELL FRAGMENTS.
		100	[illegible]		
		94	[illegible]		
		[illegible]	[illegible]		SAME: GREY, SATURATED, MEDIUM TO COARSE GRAINED SAND, NON-COHESIVE.
		[illegible]	[illegible]		
		98	[illegible]		
		100	3		
		[illegible]			SAME: GREY, SATURATED, COARSED GRAINED SAND, NON-COHESIVE, SHELL FRAGMENTS.
					SAME: FINE GRAINED SAND.
		100	[illegible]		

TH79-1

EXISTING GROUND

TH79-1 — STA 6+00 L — EL. 10±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
								SAND: LIGHT BROWN, MOIST, LOOSE, SOME GRAVEL TO 1/2 INCH, SHELL FRAGMENTS.
		3			100	3		
	SP							
							6	SAME: MEDIUM DENSE.
		11			100	3		
								SAME: MOIST, GRAVEL TO 2-1/2 INCHES.
8.0								SAND/SILTY SAND: LIGHT BROWN, MEDIUM DENSE, WET, SHELL FRAGMENTS.
	SP/SM	22		NP	100	5		
W 12.0								SAME: GREY.
14.0							24	SAND: GREY, MEDIUM DENSE, WET.
		18			100	4		
	SP	16			100	4		
								SAME: GRAVEL TO 1/2 INCH.
							33	
		22			100	2		
29.0							13	SAND/SILTY SAND: GREY, MEDIUM DENSE, WET, GRAVEL TO 1/2 INCH.
	SP/SM	17		NP	100	8		
							33	
								SAME: FINE, DENSE, NO GRAVEL.
39.0							39	

SCALE: 1 IN = 3 FT

5 0 5 10

NOTES:

1. SEE PLATE 26 FOR LOCATION OF TEST HOLES AND TEST TRENCHES.
2. SEE PLATE 6A FOR LEGEND AND CLASSIFICATION SYSTEM.
3. SEE TABLE 6 FOR DATE DRILLED OR EXCAVATED AND TYPE OF EQUIPMENT USED.
4. ALL TEST HOLES AND TRENCHES WERE SET UP ON THE LEVEE CREST UNLESS OTHERWISE NOTED AS "INVERT" IN THE CHANNEL AND "EXISTING GROUND" ON BACK SIDE OF LEVEE.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

CHECKED BY:

STA. 12+00 TO STA. 6+00

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____-B-____ SHEET

DISTRICT FILE NO.

WC 77-1

DATE OF BORING 29 Dec 76 WATER DEPTH 24 ft. DATE MEASURED 29 Dec 76
TYPE OF DRILL RIG Bucket HOLE DIAMETER 20 in.
WEIGHT OF HAMMER 1500 lb. Kelly FALLING 15 in. SAMPLES 2-in. dia. Modified Calif.

DEPTH, FT.	SAMPLES	BLOWS/FOOT	GROUND WATER	DESCRIPTION	UNC. COMP. STRENGTH, ksf	MOISTURE CONTENT, %	DRY DENSITY pcf	OTHER TESTS
				SURFACE ELEVATION:				
				Medium dense, damp, light brown, SILTY SAND (SM)				
	1	2		SANDY SILT (ML)		10	93	MA
5	2	3				3	87	
				Loose, with trace of CLAY and shells				
10	3	P				16	88	
				Medium dense, wet, bluish gray SILTY SAND (SM)				
15	4	2				27	98	
20	5	4				21	107	
			▽	Medium dense, bluish gray fine-grained SAND (SP)				
25	6	2				20	107	MA
				Bottom of Boring at 26½ ft.				
30								

Project: SANTA ANA RIVER IMPROVEMENTS
Project No: A8431

LOG OF BORING B-1

Fig. A-2

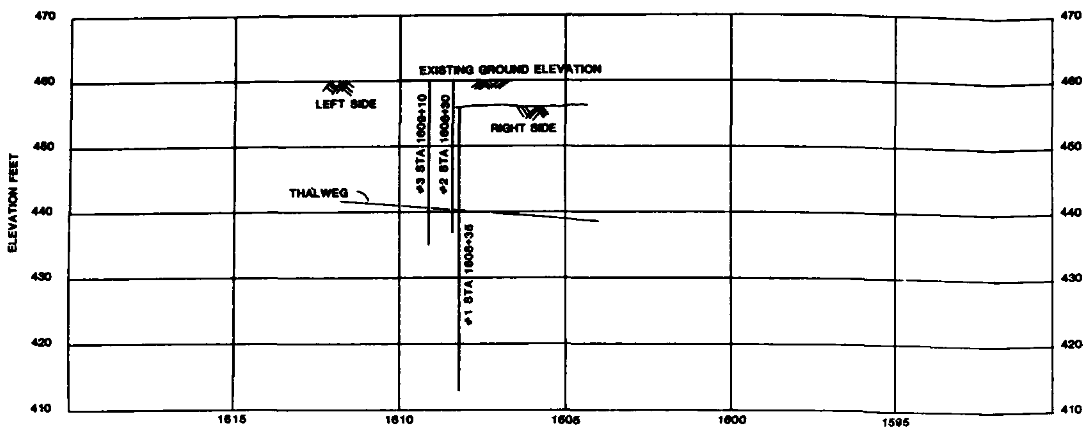
NOTES:

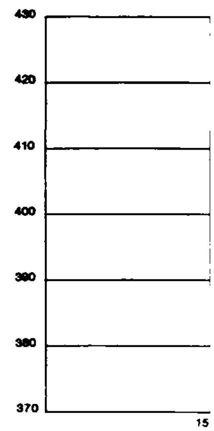
1. SEE PLATE 26 FOR TEST SITE LOCATIONS
2. SEE TABLES 4 AND 5 FOR LIST OF REPORTS FROM WHICH THESE LOGS WHERE TAKEN. ALL LEGENDS AND EXPLANATIONS AND CONTAINED WITHIN THE REPORTS.
3. LOGS BY OTHERS ARE ONLY TO BE USED TO DETERMINE THE GENERAL SOIL PROFILE.

LOWER SANTA ANA RIVER

LOGS OF INVESTIGATION BY OTHERS
STA. 60+00 TO STA. 0+00

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

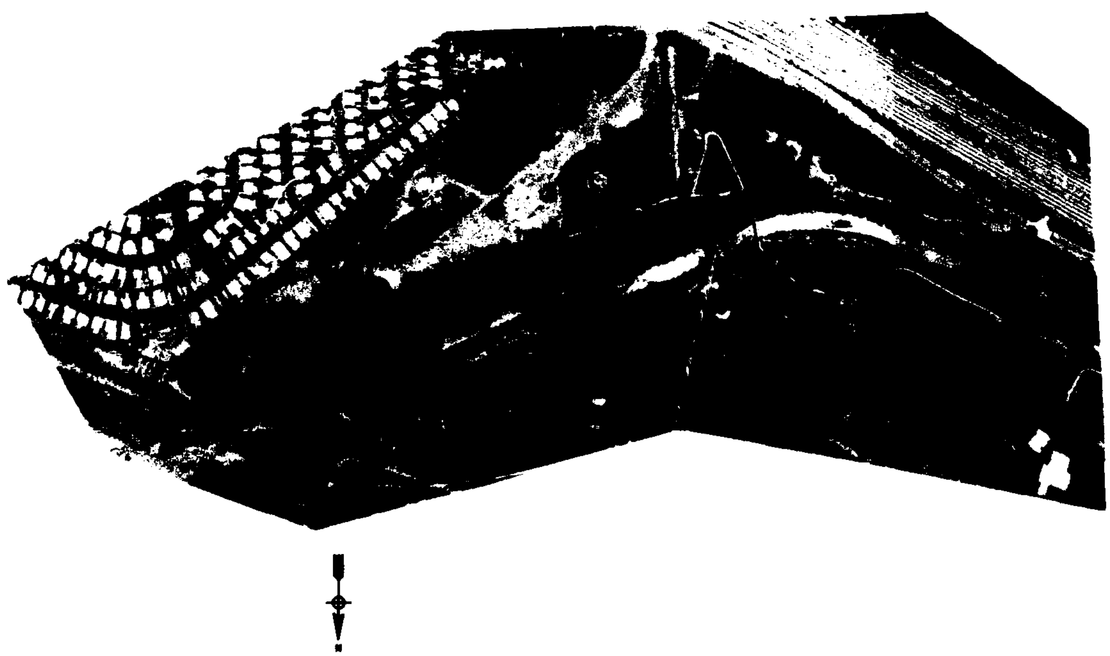




PROFILE

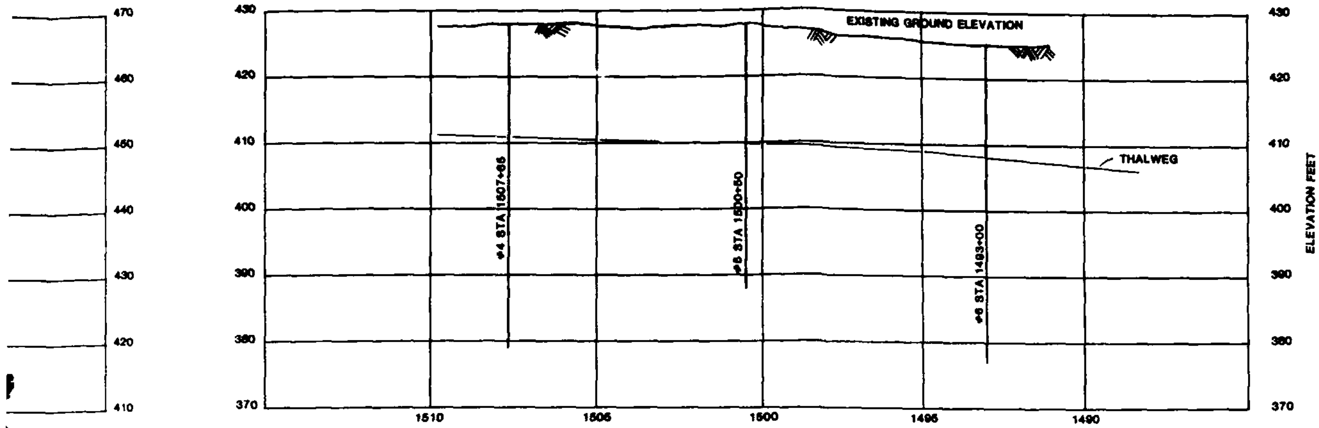
HORIZ. SCALE 200 0 200 400 FEET

VERT. SCALE 10 0 10 20 30 FEET



GENE

ALUE ENGINEERING PAYS



PROFILE

HORIZ. SCALE 200 0 200 400 FEET

T. SCALE 10 0 10 20 30 FEET

GENERAL NOTES:

1. SEE SUBSEQUENT PLATES IN THIS PLATE NUMBER SERIES FOR LOGS OF INVESTIGATION.
2. THESE REPRESENTATIVE PHOTOGRAPHS WERE TAKEN IN MAY 1987.
3. PROFILE ELEVATION WERE DETERMINED IN SEPTEMBER 1987.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN AND PROFILE
SANTA ANA CANYON

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09- ___ B- ___ SHEET

DISTRICT FILE NO.

VALUE ENGINEERING PA

TH87-1

TH87-1 STA. 1608+35 EL. 457±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
				NP	93	22		SILTY SAND: BROWN, MOIST.
							3	
	SM	12						
				NP	97	35		SAME: BROWN TO GREY, SLIGHTLY COHESIVE.
9.0				NP	97	22	3	SAME: LOOSE.
	SP/SM			NP	97	6		SAND/SILTY SAND: GREY, MOIST, LOOSE.
11.5								
					100	3	7	SAND: GREY, MOIST, LOOSE.
	SP							
		3			94	3		
20.0								
21.0	ML	46	63	9	100	78		SANDY SILT: DARK GREY, WET, COHESIVE, PLASTIC.
	GP				48	3		SANDY GRAVEL: GREY, COARSE GRAINED SAND, COBBLES TO 5 INCHES.
24.0								
	GP/GM			NP	48	12	9	SANDY GRAVEL/SILTY GRAVEL: DARK GREY, COARSE GRAINED SAND, THICK LAYERS OF COHESIVE MATERIAL.
26.0	CH	46	57	29	94	67		SANDY CLAY: BLUE GREY, MOIST, A FEW GRAVELS TO 1/2 INCH, VERY COHESIVE AND PLASTIC.
27.0								
	SM			NP	97	14		SILTY SAND: MULTI COLOR, A FEW GRAVEL TO 1 INCH.
29.0								
				NP	39	5	19R	SAND/SILTY SAND: MULTI-COLORED, COARSE GRAINED SAND, SOME GRAVELS TO 1 INCH.
	SP/SM							
				NP	53	9		SAME. GRAVEL TO 3 INCH, COBBLES TO 4 INCH.
34.0								
	SM	28	37	11	48	24		SANDY SILTY GRAVEL: BLUE GREY, BROWN LAYERS OF SAND, BROWN LAYERS OF SAND, GRAVEL TO 3 INCH.
36.0								
37.0	ML		33	1	89	62		SANDY SILT: GREY, FINE GRAINED SAND.
38.0	SM	34	41	9	89	28		SILTY SAND: BLUE, MOIST, COHESIVE, SLIGHTLY PLASTIC.
	SC		21	11	96	18		CLAYEY SAND: BROWN-GREY, SOME GRAVEL TO 2 INCHES COHESIVE, PLASTIC.
40.0								

TH87-2

TH87-2 STA. 1608+30 EL. 450±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SP/SM	9		NP	93	6	20	SAND/SILTY SAND: LIGHT BROWN, DRY, SL
4.0								
			42	10	98	55		SANDY SILT: BROWN, DRY, A FEW GRAVELS CHUNKS.
			32	5	93	69	29	SAME: DARK BROWN.
			24	3	99	68	18	SAME: MOIST, SOME WHITE STREAKS, COHE
	ML							
		31	48	15	99	65		SAME: GREY.
				NP	100	84	8	
		17		NP	100	53		SAME: BLUE WITH GREY STREAKS. SOME OR WOOD FIBERS.
18.0								
			30	1	100	40	11	SILTY SAND: BLUE GREY, MOIST, FINE GR FIBERS.
	SM							
				NP	100	32		
23.0								

TH87-3

TH87-3 STA. 1609+10 EL. 451±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
0.8	SP/SM			NP	100	12		SAND/SILTY SAND: BROWN, DRY, LOOSE.
			25	4	100	55	25	SANDY SILTY CLAY: DARK BROWN, DRY
	CL/ML							
5.0			20	4	95	54		SAME: LIGHT BROWN, SLIGHTLY CEMENTE
	SC/SM		25	4	99	44		SILTY CLAYEY SAND: LIGHT BROWN, DRY
7.5								
	ML	12	31	6	98	55	40	SANDY SILT: BROWN, MOIST, A FEW GRAV COHESIVE.
10.0								
	CL/ML		27	7	99	69		SANDY SILT: BROWN, MOIST, A FEW GRAV COHESIVE.
12.5								
	ML		49	21	99	82		SANDY SILT: GREY, MOIST.
14.5								
	SC	42	30	8	98	22		CLAYEY SAND: BLUE, MOIST, THIN LAYE ORGANIC SMELL, PLASTIC.
16.0							11	
	SC/SM	22	24	4	99	47		SILTY CLAYEY SAND: BLUE GREY WITH B FINE GRAINED SAND.
17.5								
	SM			NP	100	29		SILTY SAND: BLUE GREY, MOIST, FINE
21.0								
	SP/SM			NP	100	12		SAND/SILTY SAND: GREY, WET, FINE TO LARGE PIECES OF WOOD.
				NP	71	9		SAME: GRAVEL TO 1/2 INCH.
25.0								

NC

LUE ENGINEERING PAYS

TH87-2

STA. 1608+30 EL. 450±

LL	PI	-4	-200	N	DESCRIPTION
	NP	93	6	20	SAND/SILTY SAND: LIGHT BROWN, DRY, SLIGHTLY COHESIVE.
42	10	98	55		SANDY SILT: BROWN, DRY. A FEW GRAVELS, COMES UP IN CHUNKS.
32	5	93	69	29	SAME: DARK BROWN.
24	3	99	68	18	SAME: MOIST, SOME WHITE STREAKS, COHESIVE.
48	15	99	65		SAME: GREY.
	NP	100	94	8	
	NP	100	53		SAME: BLUE WITH GREY STREAKS, SOME ORGANIC MATERIAL, WOOD FIBERS.
40	[illegible]	100	90	11	SILTY SAND: BLUE GREY, MOIST, FINE GRAINED SAND, WOOD FIBERS.
	NP	100	52		

TH87-3

STA. 1509+10 EL. 451±

C	LL	PI	-4	-200	N	DESCRIPTION
		NP	100	22		SAND/SILTY SAND: BROWN, DRY, LOOSE.
	25	4	100	55	25	SANDY SILTY CLAY: DARK BROWN, DRY.
	29	4	45	54		SAME: LIGHT BROWN, SLIGHTLY CEMENTED.
	23	4	99	44		SILTY CLAYEY SAND: LIGHT BROWN, DRY.
2	31	[illegible]	98	55	40	SANDY SILT: BROWN, MOIST, A FEW GRAVEL TO 2 INCHES, COHESIVE.
	27	[illegible]	99	59		SANDY SILT: BROWN, MOIST, A FEW GRAVEL TO 2 INCHES, COHESIVE.
	49	21	99	92		SANDY SILT: GREY, MOIST.
2	40	3	98	22	11	CLAYEY SAND: BLUE, MOIST, THIN LAYERS OF SANDY MATERIAL, ORGANIC SMELL, PLASTIC.
2	29	4	99	47		SILTY CLAYEY SAND: BLUE GREY WITH BROWN STREAKS, MOIST, FINE GRAINED SAND.
		NP	100	29		SILTY SAND: BLUE GREY, MOIST, FINE GRAINED SAND.
		NP	100	12		SAND/SILTY SAND. GREY, WET, FINE TO COARSE GRAINED SAND, LARGE PIECES OF WOOD.
		NP	[illegible]	[illegible]		SAME. GRAVEL TO 1/2 INCH.

TH87-4

TH87-4 STA 1507+65 EL. 428±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
				NP	96	36	3	SILTY SAND: LIGHT BROWN, DRY, LOOSE, MEDIUM TO FINE GRAINED SAND, OCCASIONAL GRAVEL TO 1/2 INCH, SOME GRASS ROOTS.
				NP	100	28	12	SAME: FINE GRAINED SAND, NO GRAVEL, NO GRASS ROOTS. REVERT ADDED AT 4 FOOT.
	SM			NP	100	21		
				NP	99	23	14	SAME: BROWN WITH STREAKS OF RUST, A FEW GRAVEL.
				NP	100	17		SAME: LIGHT BROWN WITH STREAKS OF RUST.
				NP	99	14		SAME: GREY TO BROWN WITH STREAKS OF RUST.
15.0				NP	97	14		SAME: LIGHT BROWN, GRAVEL TO 2.5 INCHES.
				NP	66	6		SAND/SILTY SAND: GREY, FINE TO MEDIUM GRAINED SAND, GRAVEL TO 3 INCH, FEW COBBLES ROUNDED TO SUBROUNDED.
	SP/SM			NP	91	11		SAME: SOME GRAVEL TO 1/4 INCH.
18.0	SW/SM			NP	83	7		SAND/SILTY SAND: BROWN, FINE TO COARSE GRAINED SAND, GRAVEL TO 3 INCH COBBLES TO 7 INCHES, SUBROUNDED.
20.0	GP				48	3		SANDY GRAVEL: BROWN, COARSE GRAINED SAND, GRAVEL TO 3 INCH, COBBLES TO 6 INCH, ROUNDED AND ANGULAR, SOME POCKETS SILTY CLAYS.
23.0	GM		38	8	71	43		SILTY GRAVEL: DARK GREY, SOME COBBLES, COHESIVE, CAVING IN AT 24 FEET.
26.0				NP	100	43		SILTY SAND: DARK GREY, FINE GRAINED SAND, A FEW GRAVEL, SOME COHESION, SOME ORGANIC MATERIAL.
	SM			NP	97	28		SAME: MEDIUM TO COARSE GRAINED SAND, A FEW GRAVEL TO 1/2 INCH, ROUNDED COBBLES TO 5 INCHES.
31.0	SW/SM			NP	92	9		SAND/SILTY SAND: DARK GREY, MEDIUM, TO COARSE GRAINED SAND, SOME GRAVEL TO 1/2 INCH, ROUNDED COBBLES TO 5 INCHES.
34.0	SP				83	3		SAND: GREY, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 1-1/2 INCHES.
37.0	SP/SM			NP	65	6		GRAVELLY SAND/SILTY GRAVELLY SAND: GREY, MEDIUM TO COARSE GRAINED SAND. COBBLES TO 4 INCHES.
40.0				NP	77	5		GRAVELLY SAND/SILTY GRAVELLY SAND: GREY, COARSE GRAINED SAND, GRAVEL TO 3 INCHES COBBLES TO 5 INCHES, POCKETS OF SILT OR CLAY.
	SW/SM			NP	96	5		SAME: NO COBBLES.
46.0	SP				84	2		SAND: GREY TO MULTI-COLOR, COARSE GRAINED SAND, GRAVEL TO 1/2 INCH, SMALL POCKETS OF BROWN CLAY OR SILT.
49.0								

SCALE: 1 IN.= 3 FT.
2.5 0 2.5 5.0 7.5

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

NOTES.

1. SEE PLATE 27 FOR LOCATION OF TEST HOLES
2. SEE PLATE 6A FOR LEGEND AND CLASSIFICATION SYSTEM

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS
STA. 1608+35 TO STA. 1507+65

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-___-___ SHEET
DISTRICT FILE NO.

TH87-5 STA 1500+50 EL. 428±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
	SW/SM			NP	99	11	11	SAND/SILTY SAND: LIGHT BROWN, DRY, FINE GRAINED SAND, SOME GRAVEL, GRASS ROOTS, SOME COBBLES TO 5 INCHES.
3.0								
	SM			NP	99	34	4	SILTY SAND: LIGHT BROWN, MOIST, LOOSE, FINE GRAINED SAND, SMALL PIECES OF CEMENTED SAND, REVERT ADDED.
6.0								
			30	1	100	70		SANDY SILT: LIGHT BROWN WITH STREAK OF RUST, FINE GRAINED SAND.
	ML							
			49		100	90		
12.0								
	SM			NP	100	18		SILTY SAND: LIGHT BROWN, FINE TO MEDIUM GRAINED SAND.
15.0								
				NP	99	8	26	SAND/SILTY SAND: LIGHT BROWN, FINE TO MED., GRAINED SAND, SOME GRAVEL TO 3 INCHES, SUBROUNDED.
	SW/SM							
				NP	82	6		
23.0								
	SP				50	2		SANDY GRAVEL: LIGHT BROWN AND GREY, COARSE GRAINED SAND, COBBLES TO 4 INCHES.
26.0								
	SW/SM			NP	81	6		SAND/SILTY SAND: GREY, COARSE GRAINED SAND, GRAVEL TO 1 INCH, SOME SMALL POCKETS OF SILTS.
30.0								
			38	9	74	26		SILTY GRAVELLY SAND: GREENISH GREY, MOIST, FINE SAND, GRAVEL TO 3 INCHES, SOME COBBLES TO 4 INCHES, COHESIVE.
	SM							
			31	3	75	19		SAME: STREAKS OF RUST COLORED MATERIAL.
			41	9	72	44		SAME: VEINS OF COARSE GRAINED SAND.
38.0								
	SP/SM			NP	53	5		GRAVELLY SAND/GRAVELLY SILTY SAND: GREYISH GREEN, LOOSE, FINE TO COARSE GRAINED SAND, SOME COBBLES TO 10 INCHES, SOME ORGANIC MATERIAL.
40.0								

TH87-6 STA 1493+00 EL. 427±

DEPTH	LOG	MC	LL	PI	-4	-200	N	DESCRIPTION
		4	37	6	95	56		SANDY SILT: LIGHT BROWN, DRY, FINE GRAINED SAND, GRAVEL, LOOSE.
	ML	6	33	5	100	73		SAME: MOIST.
			41	[illegible]	99	71		SAME: SOME ORGANICS.
8.0								
	SM		24	4	100	31		SILTY SAND: LIGHT BROWN-GREY, FINE TO MEDIUM GRAI SAND.
11.0								
				NP	68	7		GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, FINE GRAINED SAND, SOME GRAVEL.
				NP	57	7		SAME: BROWN-GREY, MEDIUM TO COARSE GRAINED SAND, TO 3 INCHES, SUBANGULAR TO SUBROUNDED.
	SP/SM							
				NP	57	7		SAME: DARK BROWN, COARSE GRAIND SAND, GRAVEL TO 2 COBBLES TO 6 INCHES, DRILLING VERY DENSE.
21.5								
			25	1	66	16		SILTY GRAVELLY SAND: DARK GREY, COARSE GRAINED GRAVEL TO 3 INCHES, SOME COBBLES.
	SM							SAME: GRAVEL TO 1.5 INCHES.
			31	7	75	21		
29.0								
				NP	54	8		GRAVELLY SAND/SILTY GRAVELLY SAND: DARK GREY, COARSE GRAINED SAND, GRAVEL TO 3 INCHES, SOME SUBROUNDED, POCKETS OF COHESIVE MATERIAL.
	SW/SM							
				NP	68	10		
37.0								
	SP				58	3		GRAVELLY SAND: DARK GREY, MEDIUM TO COARSE GRAVEL TO 3 INCHES, COBBLES TO 10 INCHES,
39.0								
				NP	66	9		GRAVELLY SAND/SILTY GRAVELLY SAND: DARK GREY, COARSE GRAINED SAND, GRAVEL TO 3 INCHES, WHITISH-BLUE MATERIAL WHICH HAD A STRONG AT 42 FEET.
	SW/SM			NP	71	8		
				NP	88	9		
48.0								

NOTES

1 SEE PLATE 27

2 SEE PLATE 84 SYSTEM

LUE ENGINEERING PAYS

[illegible]+00 EL. 427±

-4	-200	N	DESCRIPTION
95	56		SANDY SILT: LIGHT BROWN, DRY, FINE GRAINED SAND, FEW GRAVEL, LOOSE.
100	73		SAME. MOIST.
99	71		SAME: SOME ORGANICS.
100	31		SILTY SAND: LIGHT BROWN-GREY, FINE TO MEDIUM GRAINED SAND.
68	[illegible]		GRAVELLY SAND/SILTY GRAVELLY SAND: BROWN, FINE TO COARSE GRAINED SAND, SOME GRAVEL.
57	[illegible]		SAME: BROWN-GREY, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 3 INCHES, SUBANGULAR TO SUBROUNDED.
57	[illegible]		SAME: DARK BROWN, COARSE GRAIND SAND, GRAVEL TO 2 INCHES, COBBLES TO 6 INCHES, DRILLING VERY DENSE.
56	[illegible]		SILTY GRAVELLY SAND: DARK GREY, COARSE GRAINED SAND, GRAVEL TO 3 INCHES, SOME COBBLES.
75	[illegible]		SAME: GRAVEL TO 1.5 INCHES.
54	[illegible]		GRAVELLY SAND/SILTY GRAVELLY SAND: DARK GREY, LOOSE, COARSE GRAINED SAND, GRAVEL TO 3 INCHES, SOME COBBLES, SUBROUNDED, POCKETS OF COHESIVE MATERIAL.
68	[illegible]		
58	[illegible]		GRAVELLY SAND: DARK GREY, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 3 INCHES, COBBLES TO 10 INCHES, ROUNDED.
56	[illegible]		GRAVELLY SAND/SILTY GRAVELLY SAND: DARK GREY, MEDIUM TO COARSE GRAINED SAND, GRAVEL TO 3 INCHES, CLUMPS OF A WHITISH-BLUE MATERIAL WHICH HAD A STRONG ORGANIC ODOR AT 42 FEET.
[illegible]	[illegible]		
48	[illegible]		

SCALE 1 IN = 3 FT

2.5 0 2.5 5.0 7.5

NOTES:

1. SEE PLATE 27 FOR LOCATION OF TEST HOLES
2. SEE PLATE 8A FOR LEGEND AND CLASSIFICATION SYSTEM

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

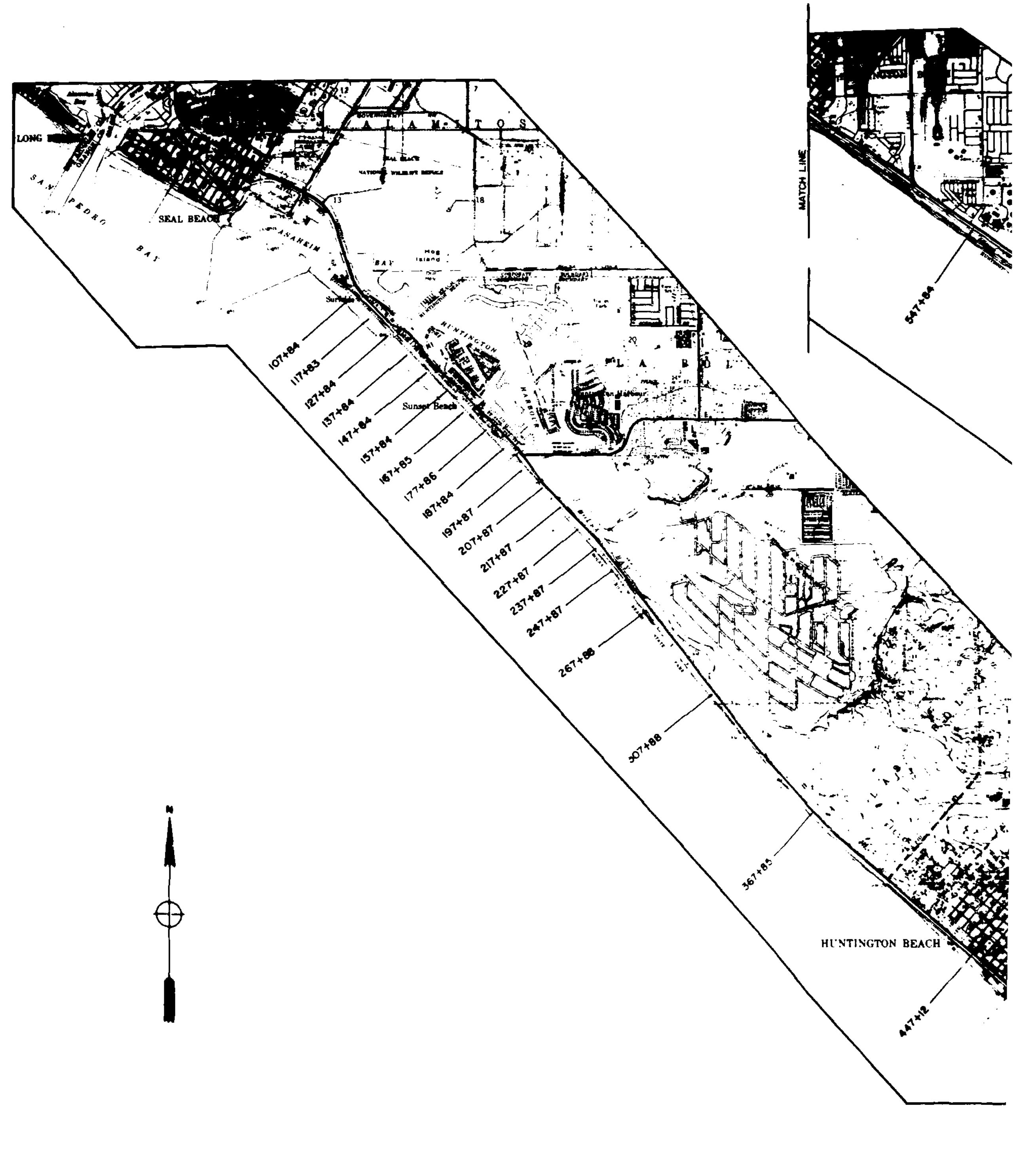
LOGS OF INVESTIGATIONS
CORPS OF ENGINEERS

STA. 1500+50 TO STA. 1493+00

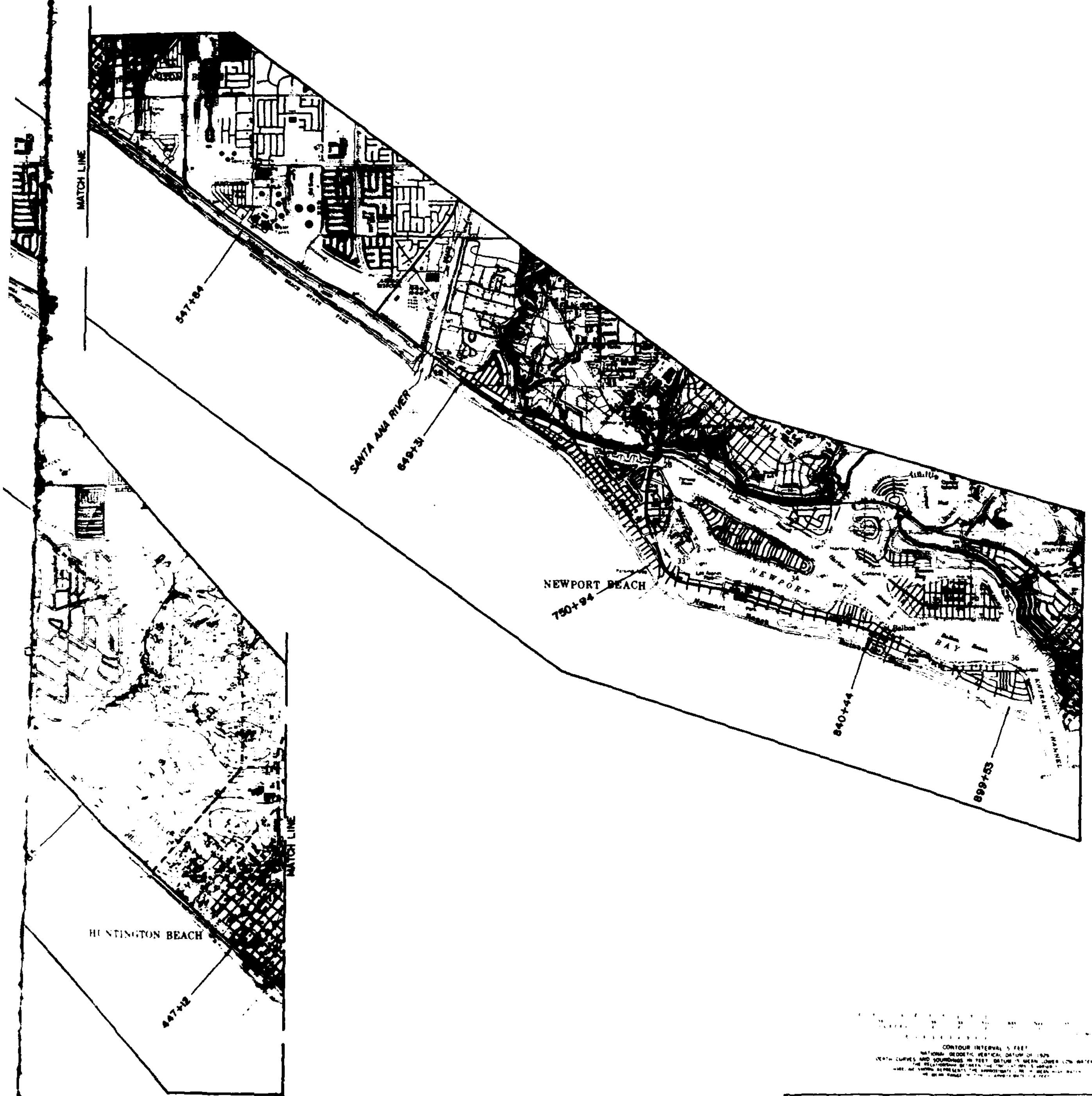
SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-___ SHEET

DISTRICT FILE NO.

VALUE ENGINEERIN



VALUE ENGINEERING PAYS



NOTES.

1. TRANSECT STATION NUMBERS SHOWN ADJACENT TO SAMPLE RANGE LINES.
2. SAMPLING DONE IN OCTOBER 1982.
3. GRAB SAMPLES OBTAINED ALONG EACH TRANSECT AT ELEVATIONS OF 12,6,0,-6,-12,-18,-24 AND -30 FEET MLLW.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

PLAN OF DISPOSAL BEACH INVESTIGATION

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW 09-____-B-____ | SHEET

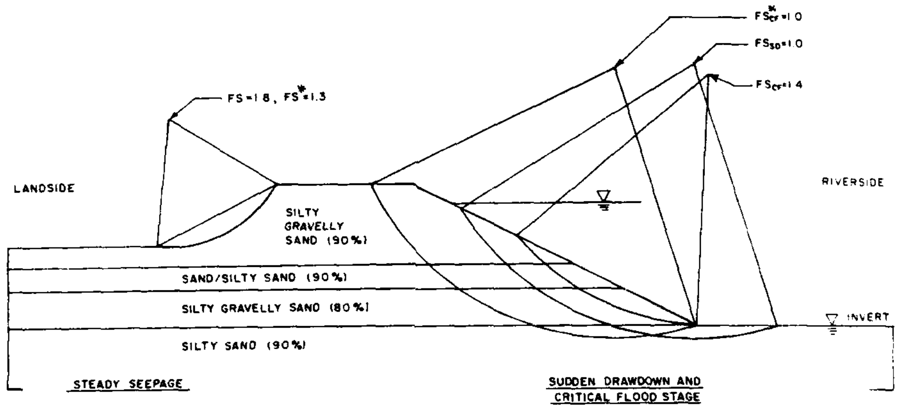
DISTRICT FILE NO.

LEVEE DESIGN PARAMETERS

DESIGN PARAMETER / SOIL TYPE	MAXIMUM DRY UNIT WEIGHT (ASTM 1557) γ_d (PCF)	OPTIMUM MOISTURE CONTENT W.C. (ASTM 1557) (%)	R STRENGTHS: LOOSE (80% COMPACTION) FRICTION ANGLE ϕ (DEGREES)	R STRENGTHS: LOOSE (80% COMPACTION) COHESION C (PSF)	R STRENGTHS: DENSE (90% COMPACTION) FRICTION ANGLE ϕ (DEGREES)	R STRENGTHS: DENSE (90% COMPACTION) COHESION C (PSF)	S STRENGTHS: LOOSE (80% COMPACTION) FRICTION ANGLE ϕ (DEGREES)	S STRENGTHS: LOOSE (80% COMPACTION) COHESION C (PSF)	S STRENGTHS: DENSE (90% COMPACTION) FRICTION ANGLE ϕ (DEGREES)	S STRENGTHS: DENSE (90% COMPACTION) COHESION C (PSF)	UNIT WEIGHT LOOSE (80% COMPACTION): AVERAGE DRY UNIT WEIGHT γ_d (PCF)	UNIT WEIGHT LOOSE (80% COMPACTION): MOIST UNIT WEIGHT γ_M (PCF)	UNIT WEIGHT LOOSE (80% COMPACTION): SATURATED UNIT WEIGHT γ_{SAT} (PCF)	UNIT WEIGHT DENSE (90% COMPACTION): AVERAGE DRY UNIT WEIGHT γ_d (PCF)	UNIT WEIGHT DENSE (90% COMPACTION): MOIST UNIT WEIGHT γ_M (PCF)	UNIT WEIGHT DENSE (90% COMPACTION): SATURATED UNIT WEIGHT γ_{SAT} (PCF)
CLAY	121	11	15	600	23	600	24	200	30	200	99	109	124	111	123	132
SILT	117	12	20	200	25	400	26	80	32	100	94	104	122	105	117	129
SILTY GRAVELLY SAND	130	8	28	0	35	0	32	0	37	0	104	112	128	117	127	136
SAND	118	13	27	0	33	0	31	0	36	0	94	106	122	106	120	129
SILTY SAND	119	12	24	200	30	300	28	0	34	0	95	107	123	107	121	130
SAND/SILTY SAND	123	11	26	0	32	0	30	0	35	0	98	109	124	111	122	131
CLAYEY SAND	130	8	22	400	27	400	26	100	32	100	104	113	128	117	127	136

REACH CROSS S

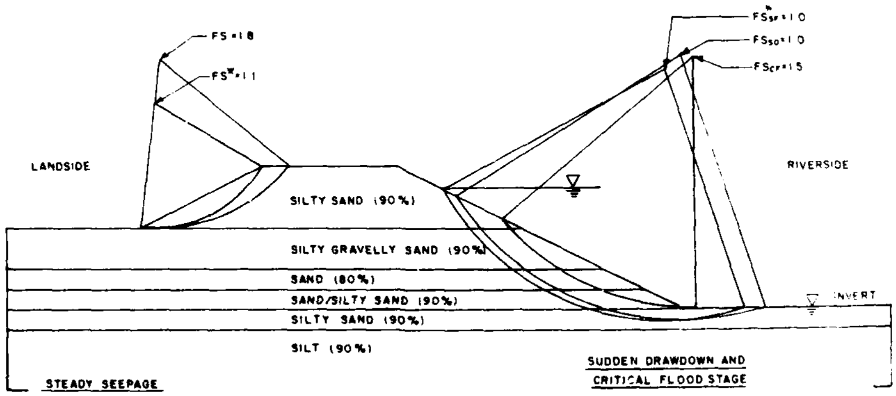
1. Left Ty
Right Ty
Left Co
Right Co



LEFT LEVEE

TYPICAL† CROSS SECTION

SCALE 1 IN = 10 FT



LEFT LEVEE

COMPOSITE† CROSS SECT

SCALE 1 IN = 10 FT

LEGEND

FS – FACTOR OF SAFETY.
FS* – FACTOR OF SAFETY WITH SEISMIC COEFFICIENT OF 0.15G.
FS_{SD} – FACTOR OF SAFETY FOR SUDDEN DRAWDOWN.
FS_{CF} – FACTOR OF SAFETY FOR CRITICAL FLOOD STAGE (MAXIMUM DESIGN FLOOD CONDITION)
† – TYPICAL CROSS-SECTION GENERALLY REPRESENTS THE MOST COMMON SOIL CONDITIONS; COMPOSITE CROSS-SECTION GENERALLY REPRESENTS WEAKER MATERIALS AND LOCALLY HIGHER LEVEES.
∇ – WATER SURFACE

NOTES:

1. END OF CONSTRUCTION ANALYSIS WAS NOT PERFORMED ON EXISTING LEVEES SINCE IT IS NOT APPLICABLE.
2. PERCENTS (90%, 80%) REPRESENT PERCENT RELATIVE COMPACTIONS USED IN ANALYSES; SEE LEVEE DESIGN PARAMETERS TABLE.
3. STABILITY CROSS SECTIONS ANALYZED WITH 1V ON 2H SIDE SLOPES.

ALUE ENGINEERING PAYS

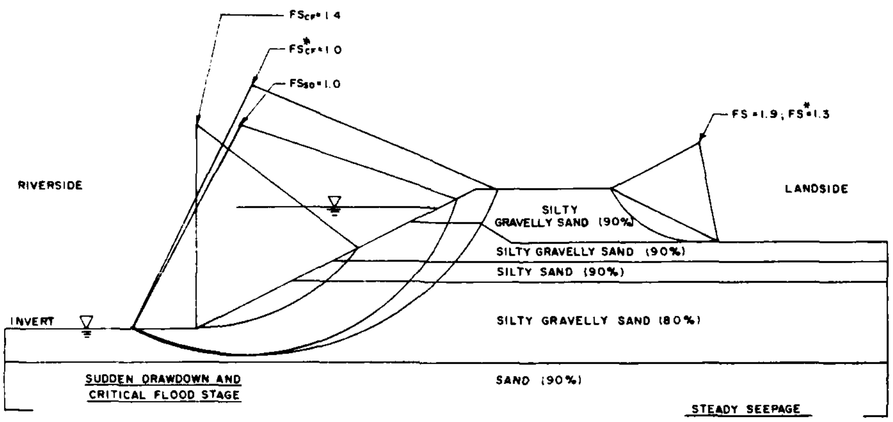
WEIGHT DENSE 90% COMPACTION MOIST UNIT WEIGHT γ_m (PCF)	SATURATED UNIT WEIGHT γ_{SAT} (PCF)
123	132
117	129
127	136
120	129
121	130
122	131
127	36

FACTOR OF SAFETY FOR SLOPE STABLITY ANALYSIS (EM 1110-2-1913 DATED 31 MARCH 1978)

REACH	CROSS SECTION	RIVERSIDE EOC	RIVERSIDE EOC W/EQ	RIVERSIDE SD	RIVERSIDE CR/FL - Stage	RIVERSIDE W/EQ	LANDSIDE EOC	LANDSIDE EOC W/EQ	LANDSIDE SS	LANDSIDE SS W/EQ
	(Req min FS)	1.3	1.0	1.0	1.4	1.0	1.3	1.0	1.4	1.0
1.	Left Typical - Existing	NA	NA	1.0	1.4	1.0	NA	NA	1.8	1.3
	Right Typical - Existing	NA	NA	1.0	1.4	1.0	NA	NA	1.9	1.3
	Left Composite - Existing	NA	NA	1.0	1.5	1.0	NA	NA	1.8	1.1
	Right Composite - Existing	NA	NA	1.0	1.4	1.0	NA	NA	1.7	1.2

FACTOR OF SAFETY TABLE NOTES:

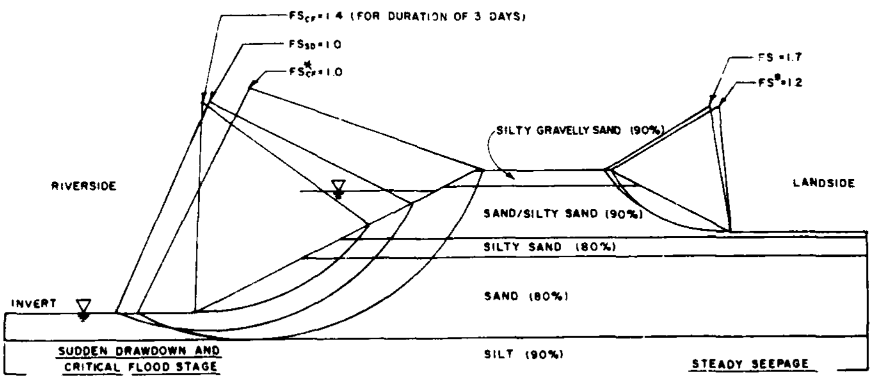
EOC..........End of Construction
SD..........Sudden Drawdown
Cr./Fl..........Critical Flood
SS..........Steady Seepage
W/EQ..........Applied Earthquake Seismic COEF = 0.15 G
NA..........Not Applicable



RIGHT LEVEE

TYPICAL† CROSS SECTION

SCALE 1 IN = 10 FT



RIGHT LEVEE

COMPOSITE† CROSS SECTION

SCALE 1 IN = 10 FT

SCALE 1 IN = 10 FT

10 0 10 20 30

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: | DRAWN BY: | CHECKED BY: | SUBMITTED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

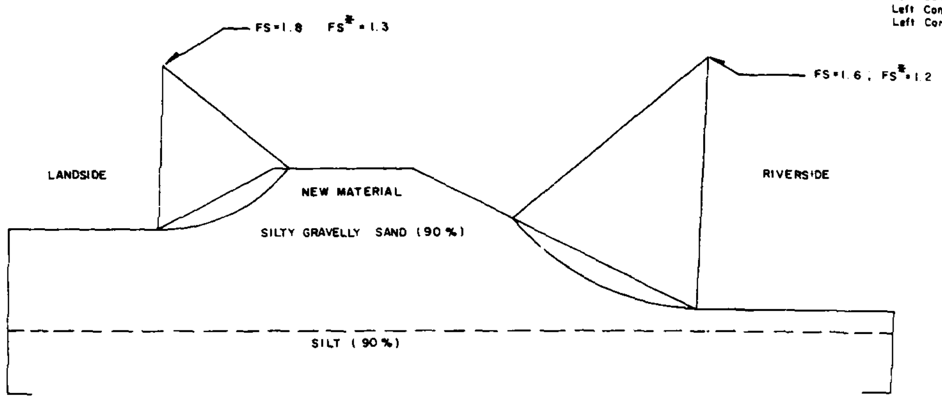
SLOPE STABILITY CONDITIONS
REACH 1
EXISTING SOIL CONDITIONS
RIGHT AND LEFT LEVEES

DATE APPROVED: | SPEC. NO. DACW09- ____ - B- ____ | SHEET

VALUE ENGINEERING

FACTOR OF SAFETY FOR SLOPE STABILITY ANA

REACH	CROSS SECTION	RIVERSIDE EOC	RIVERSIDE EOC W/EQ.	RIVERSIDE SD	RIVERSIDE Cr. / Fl. -Stage	RIVERSIDE W/EQ.	E
	(Req min FS)	1.3	1.0	1.0	1.4	1.0	1
1.	Left Composite - New	1.6	1.2	1.0	1.6	1.0	
	Left Composite - Exist. DF	NA	NA	1.0	1.5	NA	
	Left Composite - New DF	NA	NA	1.0	NA	NA	

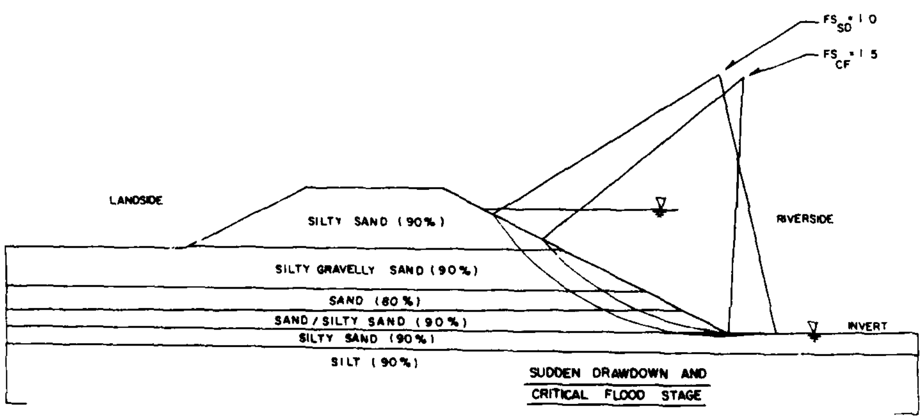


END OF CONSTRUCTION

NEW CONDITION (See notes 1 and 2)

COMPOSITE†CROSS SECTIOI

SCALE 1. IN = 10 FT.



EXISTING DRAINED FACE CONDITION

COMPOSITE†CROSS SECTIO

SCALE 1 IN = 10 FT

LEGEND

FS — FACTOR OF SAFETY

FS^* — FACTOR OF SAFETY WITH SEISMIC COEFFICIENT OF 0.15G.

FS_{SD} — FACTOR OF SAFETY FOR SUDDEN DRAWDOWN.

FS_{CF} — FACTOR OF SAFETY FOR CRITICAL FLOOD STAGE (MAXIMUM DESIGN FLOOD CONDITION).

† — TYPICAL CROSS SECTION GENERALLY REPRESENTS THE MOST COMMON SOIL CONDITIONS: COMPOSITE CROSS SECTION GENERALLY REPRESENTS WEAKER MATERIALS AND LOCALLY HIGHER LEVEES.

∇ — WATER SURFACE

NOTES:

1. NEW LEVEES WERE ANALYZED FOR END OF CONSTRUCTION.
2. "NEW" REFERS TO THE SOIL CONDITION AFTER RECONSTRUCTION.
3. SEE PLATE A-29 FOR LEVEE DESIGN PARAMETERS.
4. PERCENTS (90%, 80%) REPRESENT PERCENT RELATIVE COMPACTIONS USED IN ANALYSES. SEE LEVEE DESIGN PARAMETERS TABLE.
5. STABILITY CROSS-SECTIONS ANALYZED WITH 1V ON 2H SIDE SLOPES.

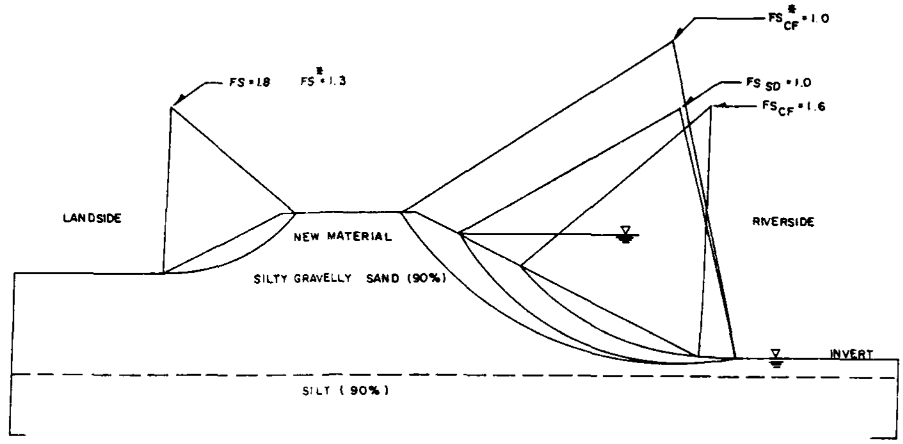
ALUE ENGINEERING PAYS

OR OF SAFETY FOR SLOPE STABILITY ANALYSIS

	RIVERSIDE					LANDSIDE			
	EOC	EOC W/EQ	SD	Cr./Fl.	-Stage W/EQ.	EOC	EOC W/EQ	SS	SS W/EQ
min FS)	1.3	1.0	1.0	1.4	1.0	1.3	1.0	1.4	1.0
ew	1.6	1.2	1.0	1.6	1.0	1.8	1.3	1.8	1.3
xist DF	NA	NA	1.0	1.5	NA	NA	NA	NA	NA
ew DF	NA	NA	1.0	NA	NA	NA	NA	NA	NA

FACTOR OF SAFETY TABLE NOTES

EOC........ End of Construction
SD.......... Sudden Drawdown
Cr./Fl...... Critical Flood
SS.......... Steady Seepage
W/EQ....... Applied Earthquake Seismic COEF. = 0.15G
NA.......... Not Applicable

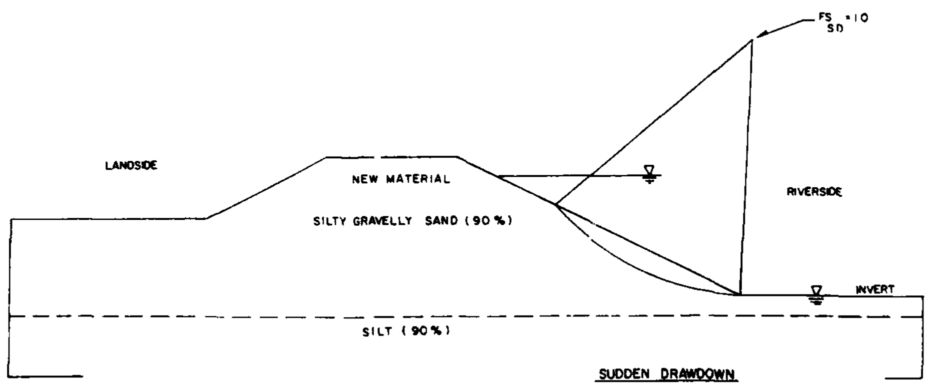


STEADY SEEPAGE

SUDDEN DRAWNDOWN AND CRITICAL FLOOD STAGE

NEW CONDITION (See notes 1 and 2)

COMPOSITE† CROSS SECTION
SCALE 1 IN = 10 FT



NEW DRAINED FACE CONDITION (SEE NOTES 1 AND 2)

COMPOSITE† CROSS SECTION
SCALE 1 IN = 10 FT

SCALE 1 IN = 10 FT
10 0 10 20 30

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
SLOPE STABILITY CONDITIONS
REACH 1
EXISTING SOIL CONDITIONS
LEFT LEVEE
REACH 1 AND REACH 2
NEW SOIL CONDITIONS

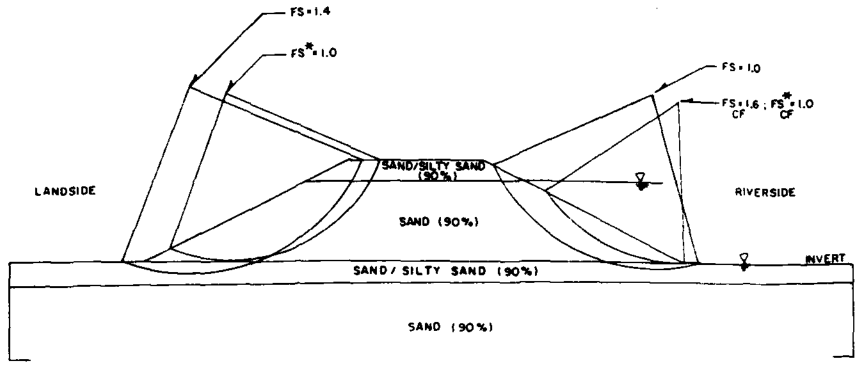
SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW 09-____ B-____ SHEET
DISTRICT FILE NO.

TABLE.

VALUE ENGINEERING I

FACTOR OF SAFETY FOR SLOPE STABILITY

REACH	CROSS SECTION	RIVERSIDE EOC	EOC W/EQ.	SD	Cr. / Fl.	Stage W/EQ
	(Req. min FS)	1.3	1.0	1.0	1.4	1.0
2	Left Typical - Existing	NA	NA	1.0	1.6	1.0
	Right Typical - Existing	NA	NA	1.0	1.5	1.0
	Left Composite - # 1	NA	NA	1.0	1.6	1.0
	Left Composite - # 2	NA	NA	1.0	1.5	1.0



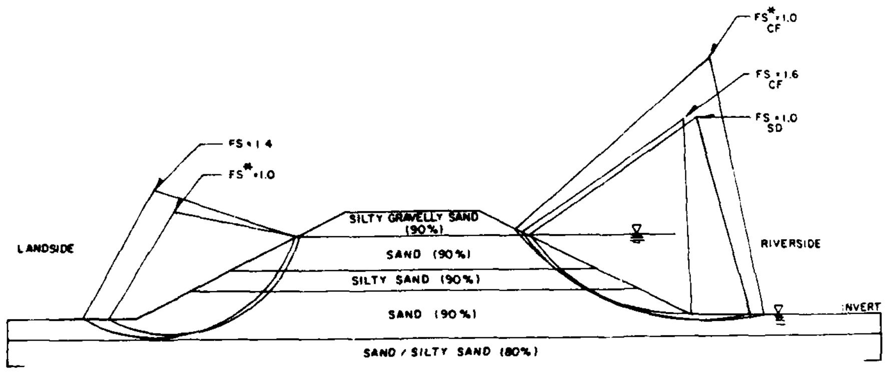
STEADY SEEPAGE

SUDDEN DRAWDOWN AND CRITICAL FLOOD STAGE

LEFT LEVEE

TYPICAL† CROSS S

SCALE 1 IN = 10 FT



STEADY SEEPAGE

SUDDEN DRAWDOWN AND CRITICAL FLOOD STAGE

LEFT LEVEE NO.1

COMPOSITE† CROS

SCALE 1 IN = 10 FT

FS — FACTOR OF SAFETY

FS* — FACTOR OF SAFETY WITH SEISMIC COEFFICIENT OF 0.15 G.

FS_{SD} — FACTOR OF SAFETY FOR FOR SUDDEN DRAWDOWN

FS_{CF} — FACTOR OF SAFETY FOR CRITICAL FLOOD STAGE (MAXIMUM DESIGN FLOOD CONDITION).

† — GENERAL CROSS-SECTION GENERALLY REPRESENTS THE MOST COMMON SOIL CONDITIONS; COMPOSITE CROSS-SECTION GENERALLY REPRESENTS WEAKER MATERIALS AND LOCALLY HIGHER LEVEES.

∇ — WATER SURFACE

NOTE:

1. END OF CONSTRUCTION ANALYSIS WAS NOT PERFORMED ON EXISTING LEVEES SINCE IT IS NOT APPLICABLE.
2. SEE PLATE A29 FOR LEVEE DESIGN PARAMETERS.
3. PERCENTS (90%, 80%) REPRESENT PERCENT RELATIVE COMPACTIONS USED IN ANALYSES; SEE LEVEE DESIGN PARAMETERS TABLE
4. STABILITY CROSS-SECTIONS ANALYZED WITH 1V ON 2H SIDE SLOPES.

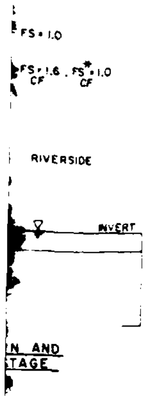
ALUE ENGINEERING PAYS

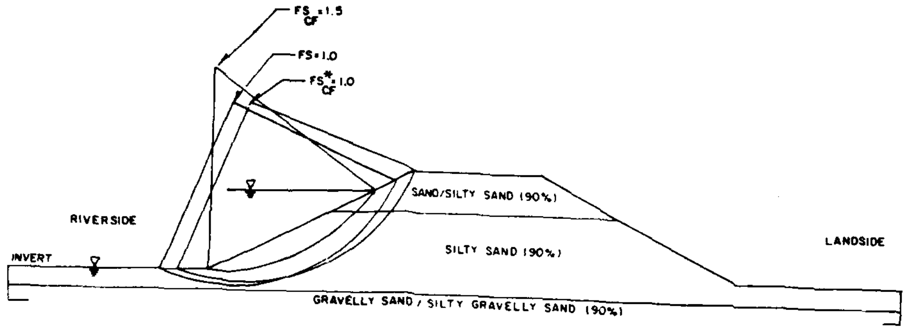
FACTOR OF SAFETY FOR SLOPE STABILITY ANALYSIS

ROSS SECTION	RIVERSIDE EOC	RIVERSIDE EOC W/EQ	RIVERSIDE SD	RIVERSIDE Cr./Fl. - Stage	RIVERSIDE W/EQ.	LANDSIDE EOC	LANDSIDE EOC W/EQ.	LANDSIDE SS	LANDSIDE SS W/EQ.
(Req. min FS)	1.3	1.0	1.0	1.4	1.0	1.3	1.0	1.4	1.0
bical - Existing	NA	NA	1.0	1.6	1.0	NA	NA	1.4	1.0
ypical - Existing	NA	NA	1.0	1.5	1.0	NA	NA	NA	NA
mposite - # 1	NA	NA	1.0	1.6	1.0	NA	NA	1.4	1.0
mposite - # 2	NA	NA	1.0	1.5	1.0	NA	NA	NA	NA

FACTOR OF SAFETY TABLE NOTES:

EOC. End of Construction
SD Sudden Drowdown
Cr./Fl Critical Flood
SS Steady Seepage
W/EQ Applied Earthquake Seismic COEF = 0.15G
NA......... Not Applicable

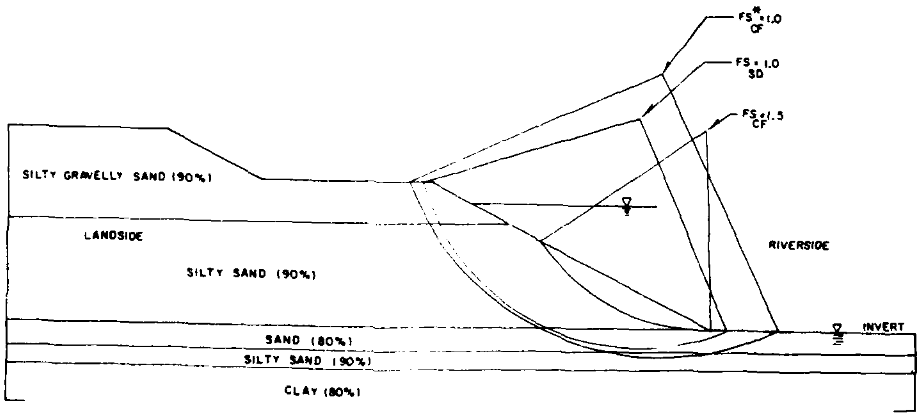




SUDDEN DRAWDOWN AND CRITICAL FLOOD STAGE

RIGHT LEVEE

TYPICAL† CROSS SECTION
SCALE 1 IN = 10 FT



SUDDEN DRAWDOWN AND CRITICAL FLOOD STAGE

LEFT LEVEE NO.2

COMPOSITE† CROSS SECTION
SCALE 1 IN = 10 FT

NVERT

SCALE 1 IN = 10 FT
10 0 10 20 30

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

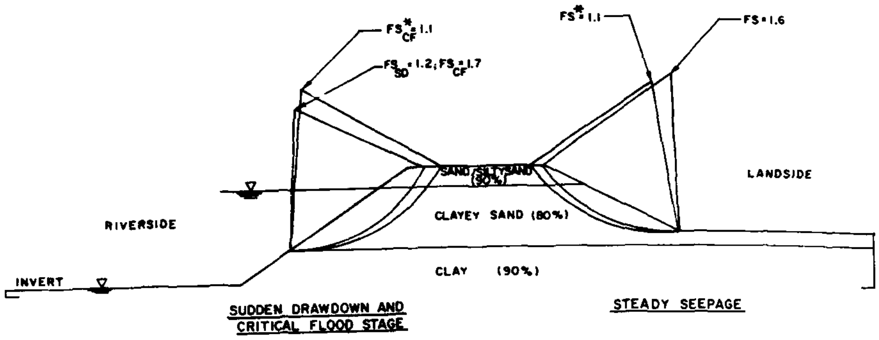
DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SLOPE STABILITY CONDITION
REACH 2
EXISTING SOIL CONDITIONS
RIGHT AND LEFT LEVEES

SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-___ B-___ | SHEET
DISTRICT FILE NO.

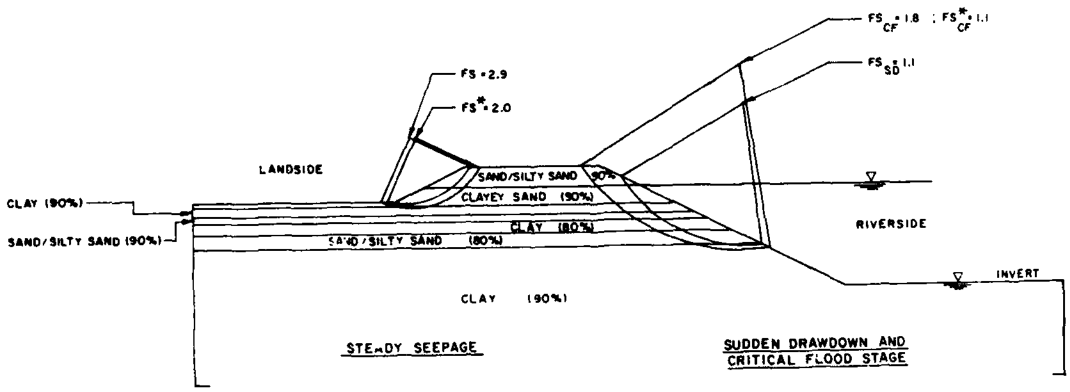
VALUE ENGINEERING P



RIGHT LEVEE

TYPICAL †CROSS SECTION

SCALE: 1 IN. = 10 FT.



LEFT LEVEE

COMPOSITE †CROSS SECTI

SCALE: 1 IN. = 10 FT.

LEGEND

FS — FACTOR OF SAFETY

FS* — FACTOR OF SAFETY WITH SEIMIC COEFFICIENT OF 0.15G.

FS_{SD} — FACTOR OF SAFETY FOR SUDDEN DRAWDOWN.

FS_{CF} — FACTOR OF SAFETY FOR CRITICAL FLOOD STAGE (MAXIMUM DESIGN FLOOD CONDITION).

† — TYPICAL CROSS-SECTION GENERALLY REPRESENTS THE MOST COMMON SOIL CONDITIONS: COMPOSITE CROSS-SECTION GENERALLY REPRESENTS WEAKER MATERIALS AND LOCALLY HIGHER LEVEES.

∇ — WATER SURFACE

NOTE:

1. END OF CONSTRUCTION ANALYSIS WAS NOT PERFORMED ON EXISTING LEVEES SINCE IT IS NOT APPLICABLE.
2. SEE PLATE A-29 FOR LEVEE DESIGN PARAMETERS.
3. PERCENTS (90%, 80%) REPRESENT PERCENT RELATIVE COMPACTIONS USED IN ANALYSES; SEE LEVEE DESIGN PARAMETERS TABLE.
4. STABILITY CROSS-SECTIONS ANALYZED WITH 1V ON 2H SIDE SLOPES.

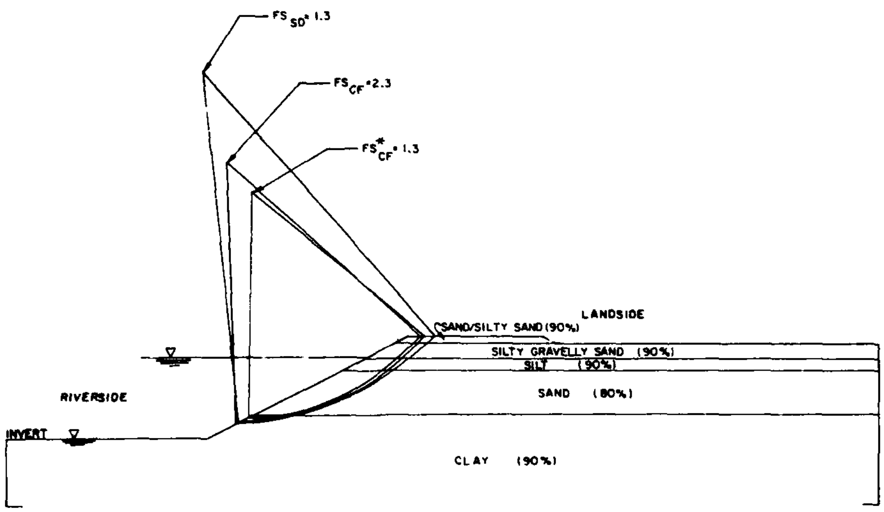
ALUE ENGINEERING PAYS

FACTOR OF SAFETY FOR SLOPE STABILITY ANALYSIS

REACH	CROSS SECTION	RIVERSIDE EOC	RIVERSIDE EOC W/EQ.	RIVERSIDE SD	RIVERSIDE Cr/Fl. STAGE	RIVERSIDE STAGE W/EQ.	LANDSIDE EOC	LANDSIDE EOC W/EQ.	LANDSIDE SS	LANDSIDE SS W/EQ.
	Req. min. FS	1.3	1.0	1.0	1.4	1.0	1.3	1.0	1.4	1.0
3	Right Typical - Existing	NA	NA	1.2	1.7	1.1	NA	NA	1.6	1.1
	Left Composite - Existing	NA	NA	1.1	1.8	1.1	NA	NA	2.9	2.0
	Right Composite - Existing	NA	NA	1.3	2.3	1.3	NA	NA	NA	NA

FACTOR OF SAFETY TABLE NOTES:

EOC .... End of Construction
SD .... Sudden Drawdown
Cr./Fl. .... Critical Flood
SS .... Steady Seepage
W/EQ. .... Applied Earthquake Seismic COEF = 0.15G
NA .... Not Applicable



SUDDEN DRAWDOWN AND CRITICAL FLOOD STAGE

RIGHT LEVEE

COMPOSITE† CROSS SECTION

SCALE: 1 IN. = 10 FT.

SCALE: 1 IN. = 10 FT.
10 0 10 20 30

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

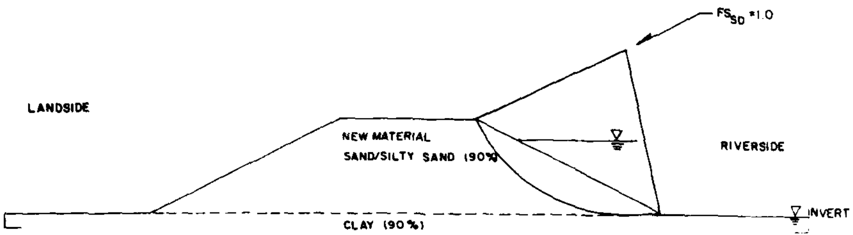
SLOPE STABILITY CONDITION
REACH 3
EXISTING SOIL CONDITIONS
RIGHT AND LEFT LEVEES

SUBMITTED BY:
DATE APPROVED:
SPEC. NO. DACW09-____-B-____
SHEET
DISTRICT FILE NO.

VALUE ENGINEERING PA

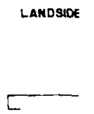
FACTOR OF SAFETY FOR SLOPE STABILITY ANALYSIS

REACH	CROSS SECTION	RIVERSIDE EOC	RIVERSIDE EOC W/EQ	RIVERSIDE SD	RIVERSIDE Cr./Fl.-Stage STAGE	RIVERSIDE Cr./Fl.-Stage W/EQ	LAN EOC	LAN EOC W/EQ
	(Req min FS)	1.3	1.0	1.0	1.4	1.0	1.3	1.0
3.	Left Typical - New, #1 D.F.	NA	NA	1.0	NA	NA	NA	NA
	Left Typical - New, #2 D.F.	NA	NA	1.1	NA	NA	NA	NA
	Left Typical - New	1.6	1.2	1.0	1.7	1.0	1.6	1.2



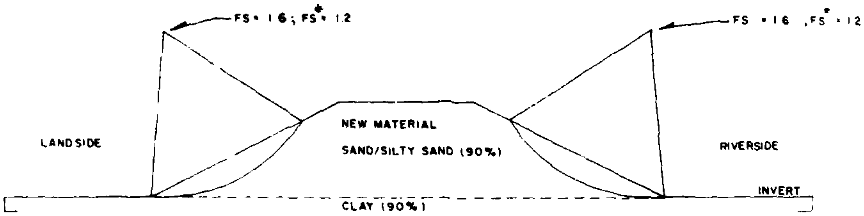
SUDDEN DRAWDOWN

LEFT LEVEE #1 DRAINED FACE



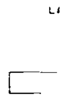
TYPICAL + CROSS SECTION

SCALE: 1 IN = 10 FT



END OF CONSTRUCTION

LEFT LEVEE



TYPICAL + CROSS SECTION

SCALE 1 IN 10 FT

LEGEND

- FS — FACTOR OF SAFETY.
- FS* — FACTOR OF SAFETY WITH SEISMIC COEFFICIENT OF 0.15G.
- FS_{SD} — FACTOR OF SAFETY FOR SUDDEN DRAWDOWN.
- FS_{CF} — FACTOR OF SAFETY FOR CRITICAL FLOOD STAGE (MAXIMUM DESIGN FLOOD CONDITION).
- + — TYPICAL CROSS SECTION GENERALLY REPRESENTS THE MOST COMMON SOIL CONDITIONS; COMPOSITE CROSS SECTION GENERALLY REPRESENTS WEAKER MATERIALS AND LOCALLY HIGHER LEVEES
- ∇ — WATER SURFACE

NOTES:

1. NEW LEVEES WERE ANALYZED FOR END OF CONSTRUCTION.
2. "NEW" REFEERS TO THE SOIL CONDITION AFTER RECONSTRUCTION.
3. SEE PLATE A-29 FOR LEVEE DESIGN PARAMETERS.
4. PERCENTS (90%, 80%) REPRESENT PERCENT RELATIVE COMPACTIONS USED IN ANALYSES; SEE LEVEE DESIGN PARAMETERS TABLE.

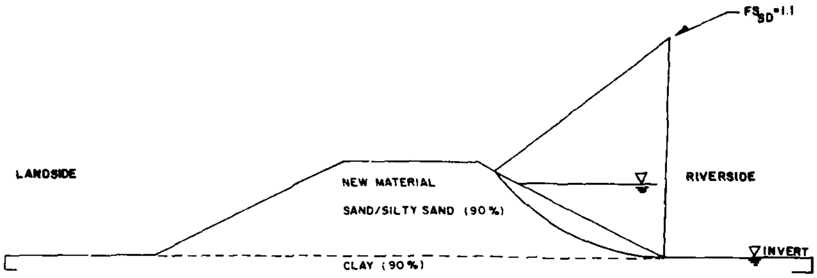
ALUE ENGINEERING PAYS

OR OF SAFETY FOR SLOPE STABILITY ANALYSIS

	RIVERSIDE					LANDSIDE			
	EOC	EOC W/EQ	SD	Cr./Fl. STAGE	-Stage W/EQ	EOC	EOC W/EQ	SS	SS W/EQ
n FS)	1.3	1.0	1.0	1.4	1.0	1.3	1.0	1.4	1.0
#1 D F	NA	NA	1.0	NA	NA	NA	NA	NA	NA
#2 D F	NA	NA	1.1	NA	NA	NA	NA	NA	NA
	1.6	1.2	1.0	1.7	1.0	1.6	1.2	1.4	1.1

FACTOR OF SAFETY TABLE NOTES:

EOC........ End of Construction
SD......... Sudden Drawdown
Cr./Fl...... Critical Flood
SS......... Steady Seepage
W/EQ...... Applied Earthquake Seismic COEF=0.15G
NA..... Not Applicable



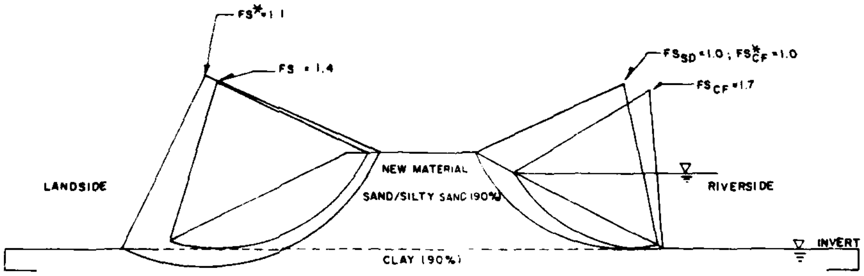
LEFT LEVEE #2 DRAINED FACE

INVERT

AL† CROSS SECTION

SCALE 1 IN = 10 FT

2



LEFT LEVEE

AL† CROSS SECTION

SCALE 1 IN 10 FT

SCALE 1 IN = 10 FT
10 0 10 20 30

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

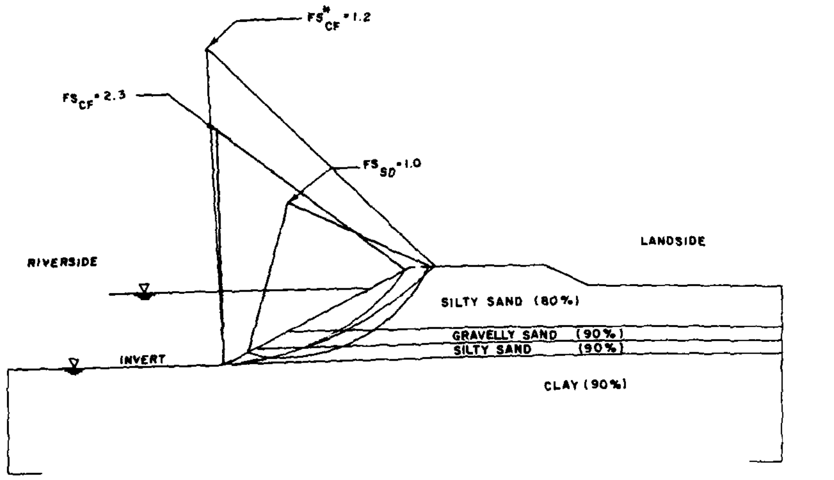
DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SLOPE STABILITY CONDITION
REACH 3 AND REACH 4
NEW SOIL CONDITIONS
LEFT LEVEE

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-___-B-____ SHEET

VALUE ENGINEERING PA)

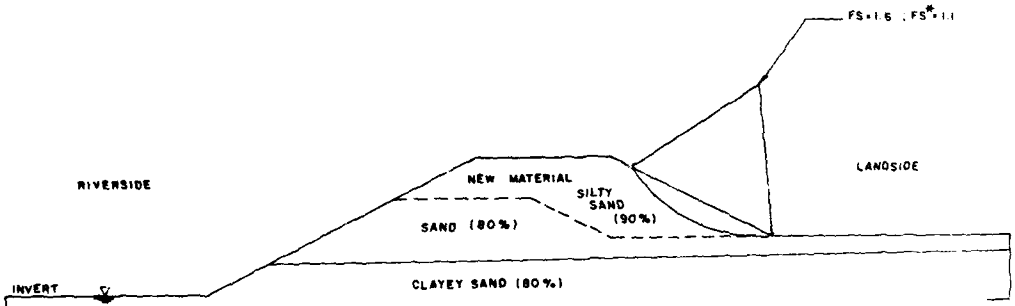


SUDDEN DRAWDOWN AND CRITICAL FLOOD STAGE

EXISTING CONDITION

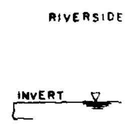
TYPICAL† CROSS SECTION

SCALE: 1 IN. = 10 FT.



END OF CONSTRUCTION

NEW CONDITION (SEE NOTES 1 AND 2)



COMPOSITE† CROSS SECTION

SCALE: 1 IN. = 10 FT.

LEGEND

- FS — FACTOR OF SAFETY
- FS^* — FACTOR OF SAFETY
- FS_{SD} — FACTOR OF SAFETY FOR SUDDEN DRAWDOWN.
- FS_{CF} — FACTOR OF SAFETY FOR CRITICAL FLOOD STAGE (MAXIMUM DESIGN FLOOD CONDITION).
- † — TYPICAL CROSS-SECTION GENERALLY REPRESENTS THE MOST COMMON SOIL CONDITIONS; *COMPOSITE CROSS-SECTION GENERALLY REPRESENTS* WEAKER MATERIALS AND LOCALLY HIGHER LEVEES.
- ▽ — WATER SURFACE

NOTES:

1. END OF CONSTRUCTION ANALYSIS WAS NOT PERFORMED ON EXISTING LEVEES SINCE IT IS NOT APPLICABLE.
2. "NEW" REFERS TO THE SOIL CONDITION AFTER RECONSTRUCTION.
3. SEE PLATE A-29 FOR LEVEE DESIGN PARAMETERS.
4. PERCENTS (90%, 80%) REPRESENT PERCENT RELATIVE COMPACTIONS USED IN ANALYSES; SEE LEVEE DESIGN PARAMETERS TABLE.

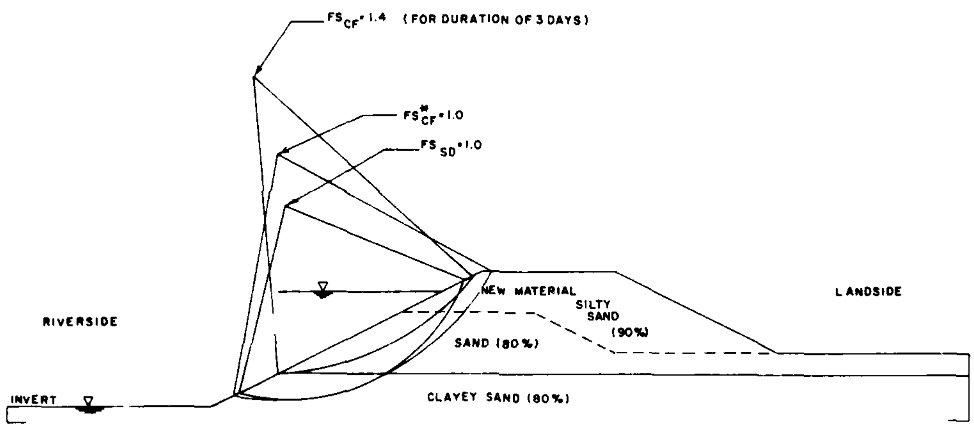
ALUE ENGINEERING PAYS

FACTOR OF SAFETY FOR SLOPE STABILITY ANALYSIS

REACH	CROSS SECTION	RIVERSIDE EOC	RIVERSIDE EOC W/EQ.	RIVERSIDE SD	RIVERSIDE Cr./Fl.	RIVERSIDE STAGE W/EQ.	LANDSIDE EOC	LANDSIDE EOC W/EQ.	LANDSIDE SS	LANDSIDE SS W/EQ.
	(Req min FS)	1.3	1.0	1.0	1.4	1.0	1.3	1.0	1.4	1.0
4	Right Typical - Existing	NA	NA	1.0	2.3	1.2	NA	NA	NA	NA
	Right Composite - Exist / New	NA	NA	1.0	1.4	1.0	1.6	1.1	NA	NA

FACTORY OF SAFETY TABLE NOTES:

EOC...... End of Construction
SD...... Sudden Drawdown
Cr./Fl.... Critical Flood
SS...... Steady Seepage
W/EQ.... Applied Earthquake Seismic COEF. = 0.15G
NA....... Not Applicable



SUDDEN DRAWDOWN AND CRITICAL FLOOD STAGE

EXISTING / NEW CONDITION (SEE NOTES 1 AND 2)

COMPOSITE † CROSS SECTION

SCALE: 1 IN. = 10 FT.

SCALE: 1 IN. = 10 FT.
10 0 10 20 30

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

SLOPE STABILITY CONDITION
REACH 4
NEW AND EXISTING SOIL CONDITIONS
RIGHT LEVEE

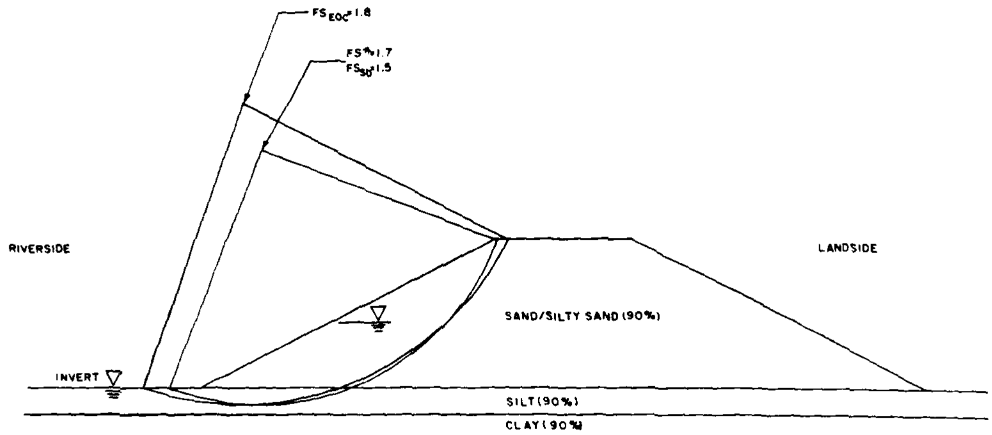
SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET
DISTRICT FILE NO.

TERS TABLE.

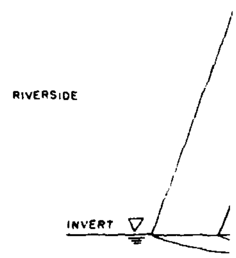
VALUE ENGINEERING P/

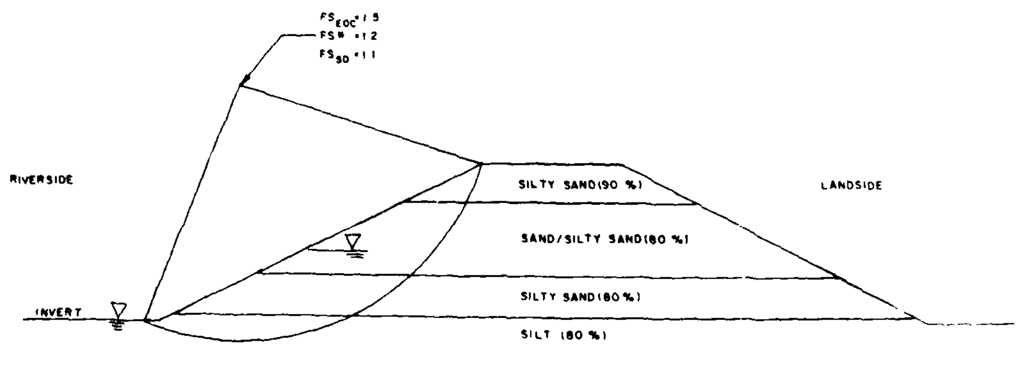
BEACH

5



TYPICAL† CROSS-SECTION





WEAK EMBANKMENT

LEGEND

FS - FACTOR OF SAFE
FS* - FACTOR OF SAFE
FS$_{EOC}$ - FACTOR OF S
FS$_{SD}$ - FACTOR OF SA
† - TYPICAL CRC
▽ - WATER SURF

NOTES:

1 SIDE SLOPES INREA
2 SEE PLATE 29 FI
3 PERCENTS (90 %, 8
SEE LEVEE DESIGN
4 STABILITY CROSS
5 NEW LEVEE WAS AI
6 "NEW" REFERS TO TH
7 EXISTING LEVEES W
PRESSURE BUILD
8 FOR SUDDEN DRAW
SEE PARAGRAPH 6

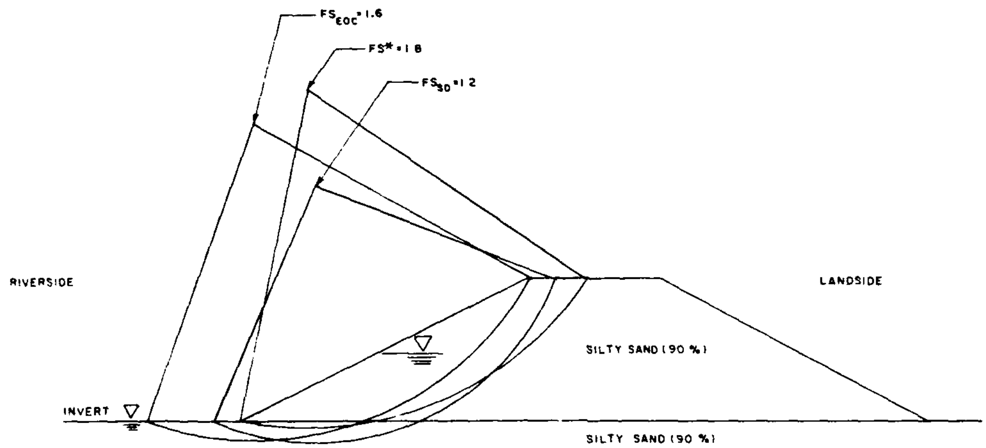
VALUE ENGINEERING PAYS

FACTOR OF SAFETY FOR SLOPE STABILITY ANALYSIS (EM 1110-2-1913 DATED 31 MARCH 1978)

BEACH	CROSS SECTION	RIVERSIDE EOC	RIVERSIDE EOC W/EQ	RIVERSIDE SD	RIVERSIDE CR/FL	RIVERSIDE Stage W/EQ	LANDSIDE EOC	LANDSIDE EOC W/EQ	LANDSIDE SS	LANDSIDE SS W/EQ
	(Req min FS)	1.3	1.0	1.0	1.4	1.0	1.3	1.0	1.4	1.0
5	TYPICAL-EXISTING	1.8	1.7	1.5	NA	NA	1.8	1.7	NA	NA
	WEAK EMBANKMENT-EXISTING	1.5	1.2	1.1	NA	NA	1.5	1.2	NA	NA
	NEW-TO BE CONSTRUCTED	1.6	1.8	1.2	NA	NA	1.6	1.8	NA	NA

FACTOR OF SAFETY TABLE NOTES:

EOC .... End of Construction
SD .... Sudden Drawdown
Cr/Fl .... Critical Flood
SS .... Steady Seepage
W/EQ .... Applied Earthquake Seismic COEF = 0.15G
NA ..... Not Applicable



NEW LEVEE

LEGEND:

FS - FACTOR OF SAFETY
FS* - FACTOR OF SAFETY WITH SEISMIC COEFFICIENT
FS_{EOC} - FACTOR OF SAFETY FOR END OF CONSTRUCTION.
FS_{SD} - FACTOR OF SAFETY FOR SUDDEN DRAWDOWN.
† - TYPICAL CROSS-SECTION GENERALLY REPRESENTS THE MOST COMMON SOIL CONDITIONS
▽ - WATER SURFACE

NOTES:

1. SIDE SLOPES IN REACH 5 ARE CONCRETE LINED
2. SEE PLATE 29 FOR LEVEE DESIGN PARAMETERS.
3. PERCENTS (90 %, 80 %) REPRESENT PERCENT RELATIVE COMPACTION USED IN ANALYSIS, SEE LEVEE DESIGN PARAMETERS TABLE.
4. STABILITY CROSS SECTIONS ANALYZED WITH 1V ON 2H SIDE SLOPES.
5. NEW LEVEE WAS ANALYZED FOR END OF CONSTRUCTION
6. "NEW" REFERS TO THE SOIL CONDITION AFTER RECONSTRUCTION
7. EXISTING LEVEES WERE ANALYZED AS STATIC CASES, I.E. WITHOUT EFFECTS OF EXCESS PORE PRESSURE BUILD UP
8. FOR SUDDEN DRAWDOWN CASE, SATURATED EMBANKMENT IS DUE TO HIGH GROUND WATER TABLE SEE PARAGRAPH 6-07

SCALE 1 IN = 10 FT
10 0 10 20 30

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

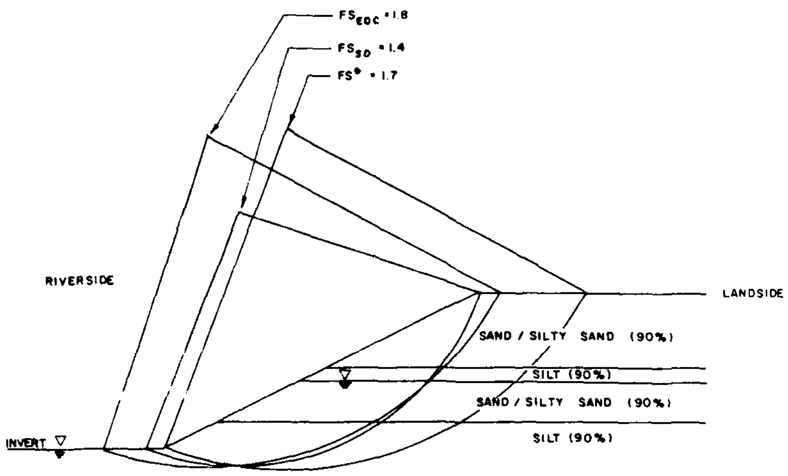
DRAWN BY: JY

SLOPE STABILITY CONDITION

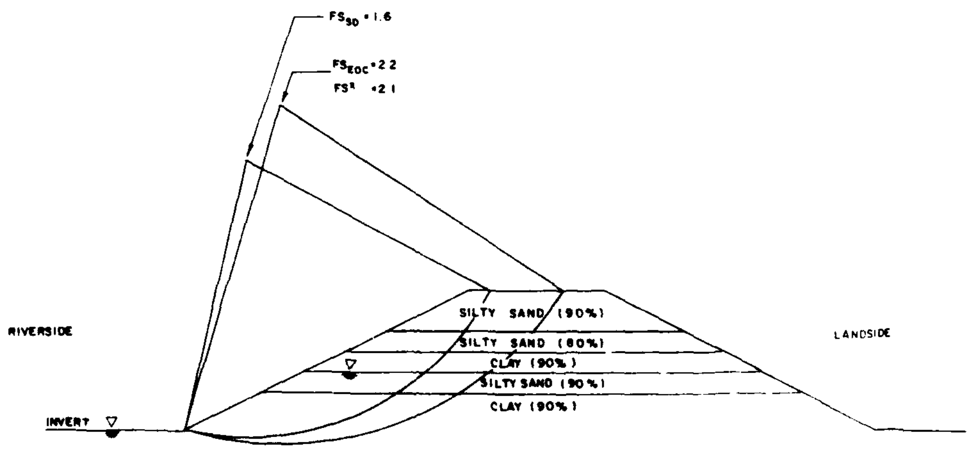
VALUE ENGINEERING P

BEACH

5



SILT FOUNDATION



CLAY FOUNDATION

RIVER

INVERT

FS - FACT
FS* - FACT
FS_{EOC} FACT
FS_{SD} FACT
▽ - WATE

NOTES:

1. SIDE
2. SEE
3. PERC COMP
4. STAB
5. END INST PRES
6. FOR GROU

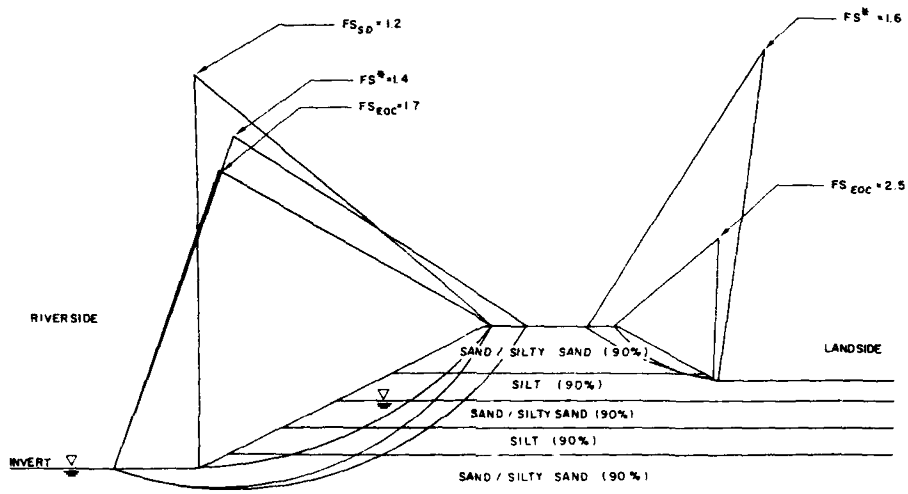
ALUE ENGINEERING PAYS

FACTOR OF SAFETY FOR SLOPE STABILITY ANALYSIS (EM 1110-2-1913 DATED 31 MARCH 1978)

REACH	CROSS SECTION	RIVERSIDE EOC	RIVERSIDE EOC W/EQ	RIVERSIDE SD	RIVERSIDE CR FL-Stage	RIVERSIDE W/EQ	LANDSIDE EOC	LANDSIDE EOC W/EQ	LANDSIDE SS	LANDSIDE SS W/EQ
	(Req min FS)	1.3	1.0	1.0	1.4	1.0	1.3	1.0	1.4	1.0
5	SILT FOUNDATION - EXISTING	1.8	1.7	1.4	NA	NA	NA	NA	NA	NA
	CLAY FOUNDATION - EXISTING	2.2	2.1	1.6	NA	NA	2.2	2.1	NA	NA
	SAND / SILTY SAND FOUNDATION - EXISTING	1.7	1.4	1.2	NA	NA	2.5	1.6	NA	NA

FACTOR OF SAFETY TABLE NOTES:

EOC........End of Construction
SD.........Sudden Drawdown
Cr./Fl.......Critical Flood
SS.........Steady Seepage
W/EQ......Applied Earthquake Seismic COEF = 0.15G
NA..........Not Applicable



SAND / SILTY SAND FOUNDATION

LEGEND

FS - FACTOR OF SAFETY
FS* - FACTOR OF SAFETY WITH SEISMIC COEFFICIENT
FS_{EOC} FACTOR OF SAFETY FOR END OF CONSTRUCTION
FS_{SD} FACTOR OF SAFETY FOR SUDDEN DRAWDOWN
▽ - WATER SURFACE

SCALE 1 IN = 10 FT

10 0 10 20 30

NOTES:

1 SIDE SLOPES IN REACH 5 ARE CONCRETE LINED.
2 SEE PLATE 29 FOR LEVEE DESIGN PARAMETERS
3 PERCENTS (90%, 80%) REPRESENT PERCENT RELATIVE COMPACTION USED IN ANALYSIS; SEE LEVEE DESIGN PARAMETER TABLE.
4. STABILITY CROSS SECTIONS ANALYZED WITH 1V ON 2H SIDE SLOPES.
5 END OF CONSTRUCTION ANALYSIS WAS NOT PERFORMED ON EXISTING LEVEES. INSTEAD A STATIC ANALYSIS WAS PERFORMED. I.E. WITHOUT EFFECTS OF PORE PRESSURE BUILD UP
6 FOR SUDDEN DRAWDOWN CASE, SATURATED EMBANKMENT IS DUE TO HIGH GROUND WATER TABLE SEE PARAGRAPH 6-07

LANDSIDE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: [signature] D.VILPPU

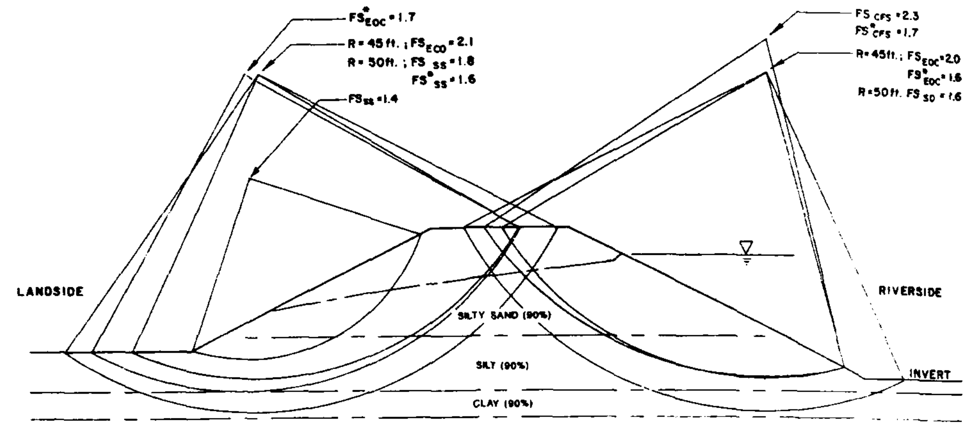
SLOPE STABILITY CONDITIONS

REACH 5

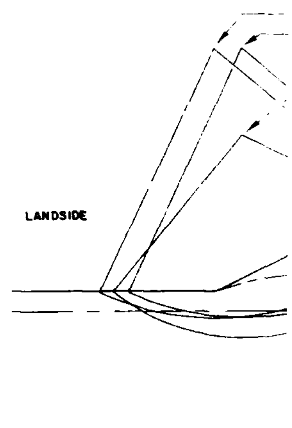
VALUE ENGINEERING P

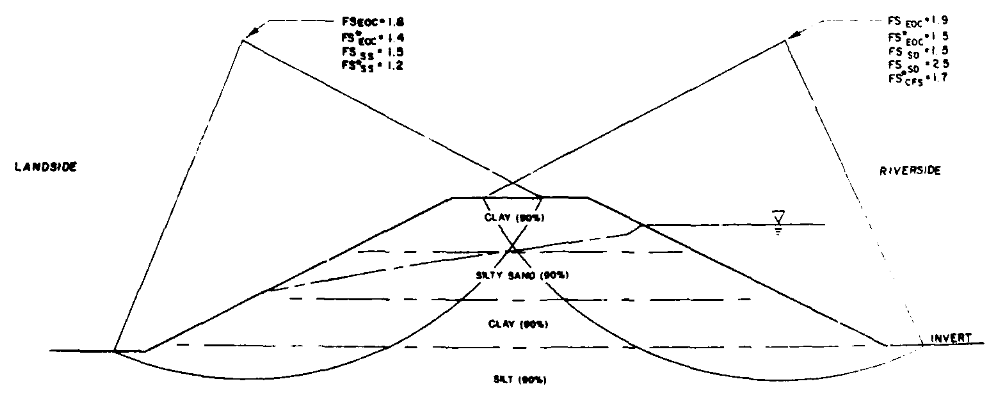
REACH	C
6	S
	C
7	1

REACH 6



SILTY SAND EMBANKMENT





CLAY / SAND EMBANKMENT

FS – FACTOR OF SA
FS* – FACTOR OF SA
FS_{EOC} FACTOR OF SA
FS_{SD} FACTOR OF SA
FS_{SS} FACTOR OF SA
FS_{CFS} FACTOR OF SA
▽ WATER SURFA

NOTES:

1. SIDE SLOPES
2. SEE PLATE 2
3. PERCENTS (90 COMPACTION U
4. STABILITY CRO
5. END OF CONST INSTEAD A STA PRESSURE BU
6. FOR SUDDEN GROUND WATE

FACTOR OF SAFETY FOR SLOPE STABILITY ANALYSIS (EM 1110-2-1913 DATED 5 MARCH 1978)

REACH	CROSS SECTION	FS	FS W/EQ	SD	CFS	STEADY W/EQ	FS	FS W/EQ	SS	SS W/EQ
	(See note 5)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	SILTY SAND EMBANKMENT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CLAYEY SAND EMBANKMENT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	TYPICAL EMBANKMENT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

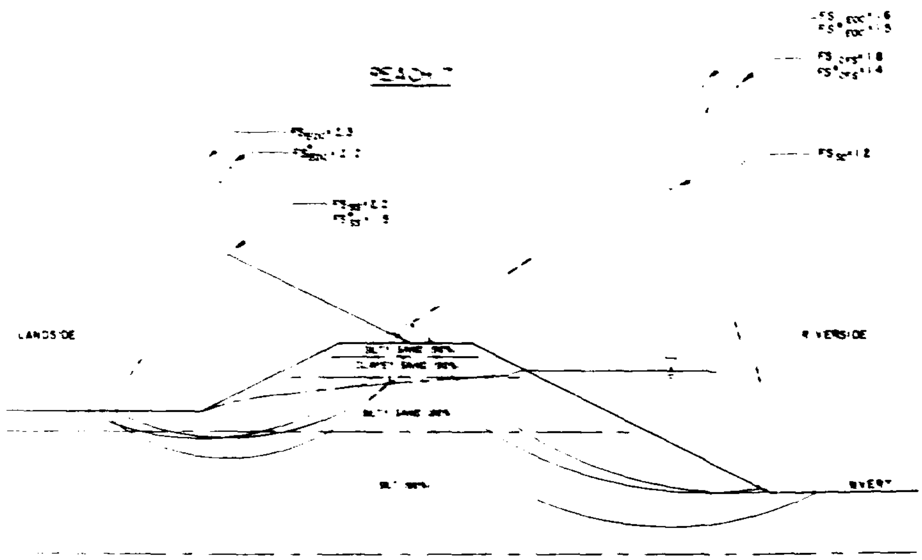
FACTOR OF SAFETY TABLE NOTES

[illegible]

FS_{EOC} = 2.0
FS_{EOC} = 1.6
FS_{SD} = 1.6

SIDE

INVERT



TYPICAL EMBANKMENT

INVERT

LEGEND

FS - FACTOR OF SAFETY
FS - FACTOR OF SAFETY WITH SEISMIC COEFFICIENT
FS_{EOC} FACTOR OF SAFETY FOR END OF CONSTRUCTION
FS_{SD} FACTOR OF SAFETY FOR SUDDEN DRAWDOWN
FS_{SS} FACTOR OF SAFETY FOR STEADY SEEPAGE
FS_{CFS} FACTOR OF SAFETY FOR CRITICAL FLOOD STAGE
WATER SURFACE

NOTES

1. SIDE SLOPES IN REACH 5 ARE CONCRETE LINED
2. SEE PLATE 20 FOR LEVEE DESIGN PARAMETERS
3. PERCENTS 95%, 90% REPRESENT PERCENT RELATIVE COMPACTION USED IN ANALYSIS. SEE LEVEE DESIGN PARAMETER TABLE
4. STABILITY CROSS SECTIONS ANALYZED WITH 1V ON 2H SIDE SLOPES.
5. END OF CONSTRUCTION ANALYSIS WAS NOT PERFORMED ON EXISTING LEVEES INSTEAD A STATIC ANALYSIS WAS PERFORMED I.E. WITHOUT EFFECTS OF PORE PRESSURE BUILD UP
6. FOR SUDDEN DRAWDOWN CASE SATURATED EMBANKMENT IS DUE TO HIGH GROUND WATER TABLE

SCALE IN FEET

REVISIONS

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE I GENERAL DESIGN MEMORANDUM

SLOPE STABILITY CONDITIONS

REACH 6 AND 7

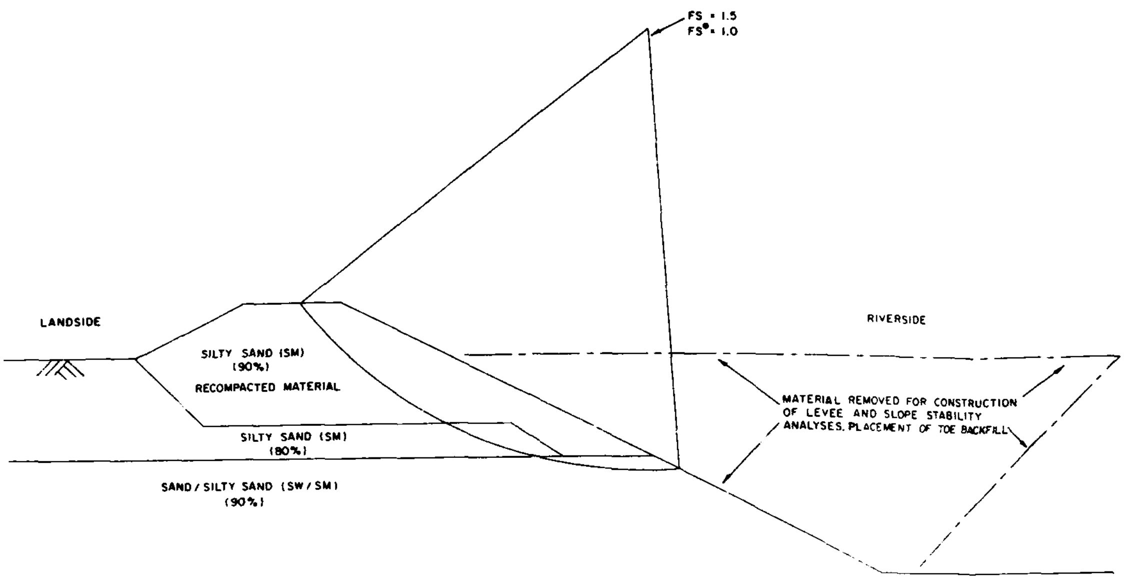
VALUE ENGINEERING PA

FAC

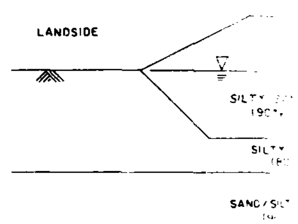
CROSS SECTIO

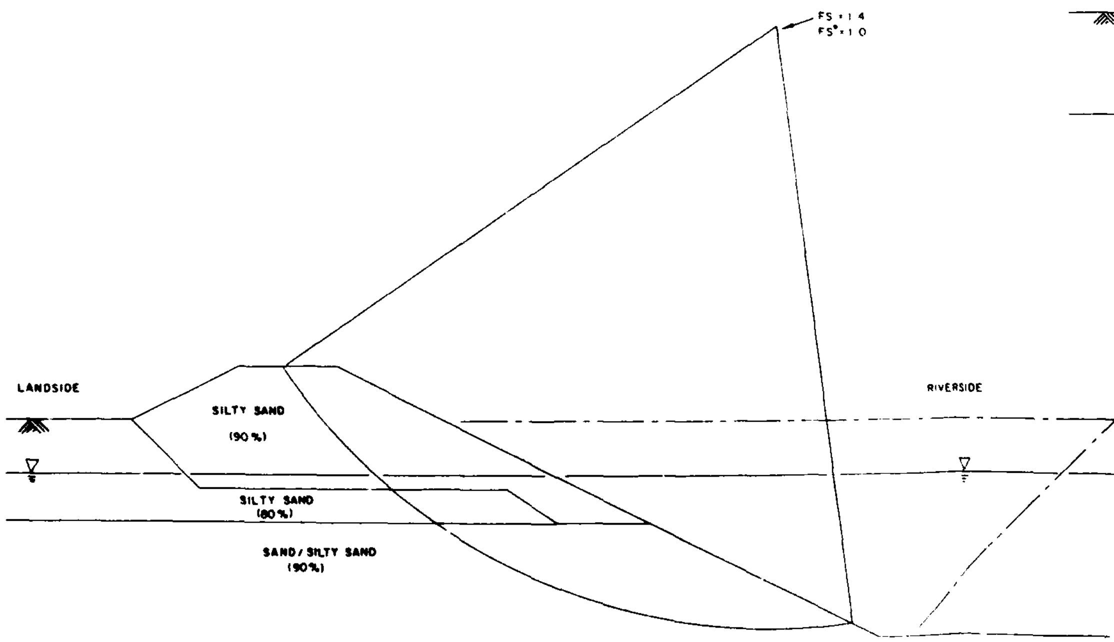
(Req

Left Typical



END OF CONSTRUCTION





CRITICAL FLOOD STAGE

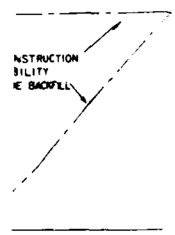
UE ENGINEERING PAYS

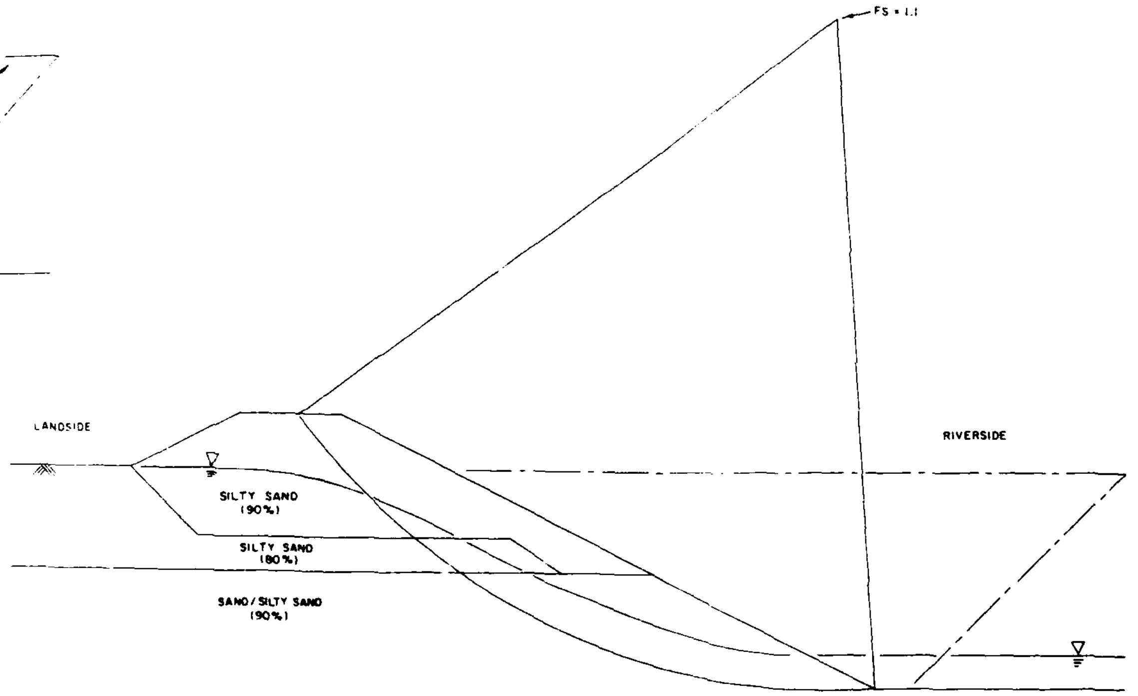
FACTOR OF SAFETY FOR SLOPE STABLITY ANALYSIS (EM 1110-2-1913 DATED 31 MARCH 1978)

CROSS SECTION	RIVERSIDE					LANDSIDE			
	EOC	EOC W/EQ	SD	CR/FL-Stage	W/EQ	EOC	EOC W/EQ	SS	SS W/EQ
(Req min FS)	1.3	1.0	1.0	1.4	1.0	1.3	1.0	1.4	1.0
Left Typical - New	1.5	1.0	1.1	1.4	1.0	NA	NA	NA	NA

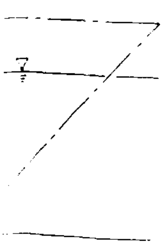
FACTOR OF SAFETY TABLE NOTES

EOC......... End of Construction
SD.......... Sudden Drawdown
Cr./Fl ..... Critical Flood
SS.......... Steady Seepage
W/EQ........ Applied Earthquake Seismic COEF = 0.15G
NA.......... Not Applicable





SUDDEN DRAWDOWN



SCALE: 1 IN. = 10 FT.

10 0 10 20 30

LEGEND

FS - FACTOR OF SAFETY
FS* - FACTOR OF SAFETY WITH SEISMIC COEFFICIENT
∇ - WATER SURFACE
- — - - TOE BACKFILL BOUNDARIES

NOTES:

1. STEADY SEEPAGE CONDITION WAS NOT INCLUDED; SINCE IT IS NOT APPLICABLE.
2. PERCENTS (90%, 80%) REPRESENT PERCENT RELATIVE COMPACTIONS USED IN ANALYSES; SEE LEVEE DESIGN PARAMETERS TABLE.
3. STABILITY CROSS SECTIONS ANALYZED WITH 1V ON 2H SIDE SLOPES.
4. FOR DESIGN PARAMETERS TABLE SEE PLATE A-29.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

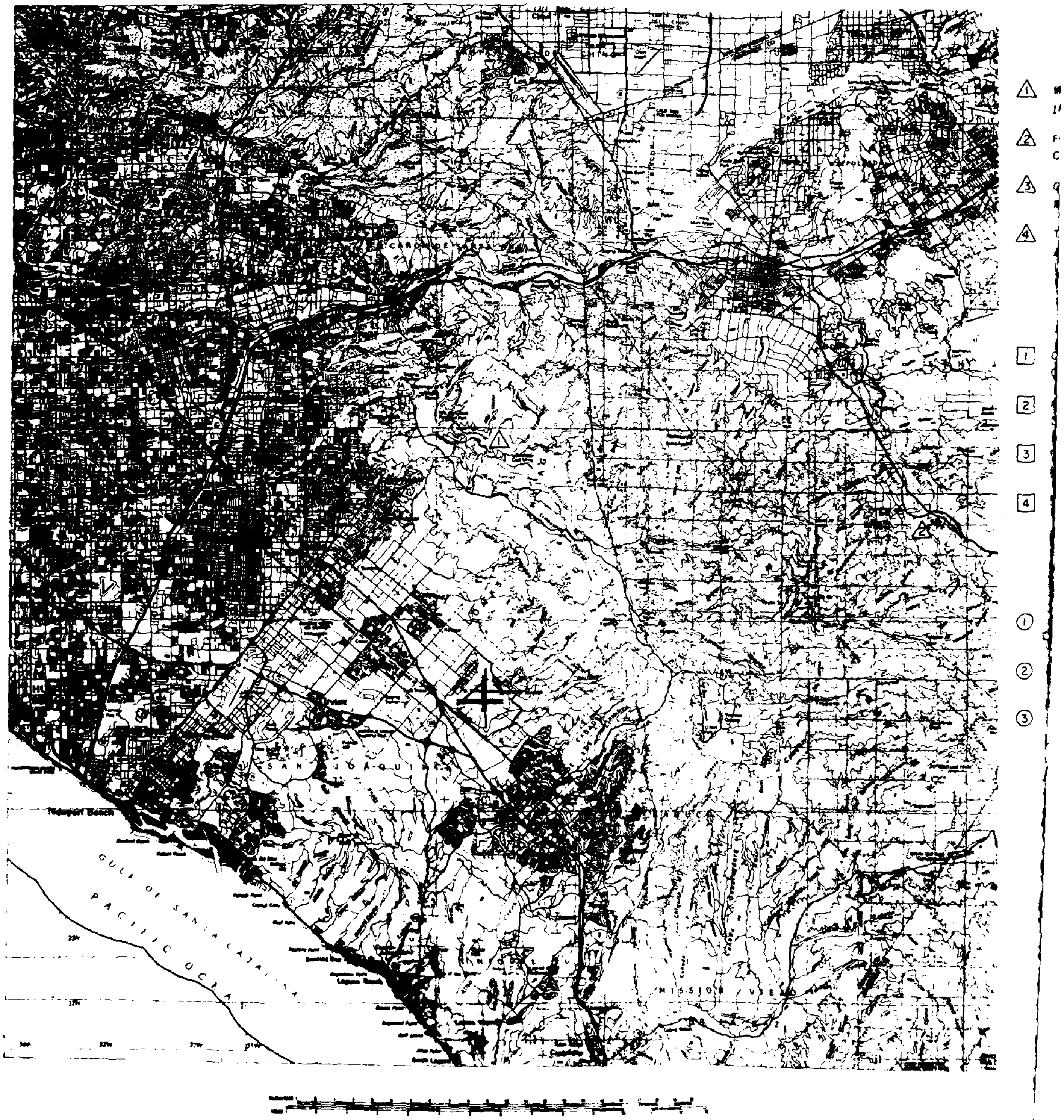
DRAWN BY: J.F.B.

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

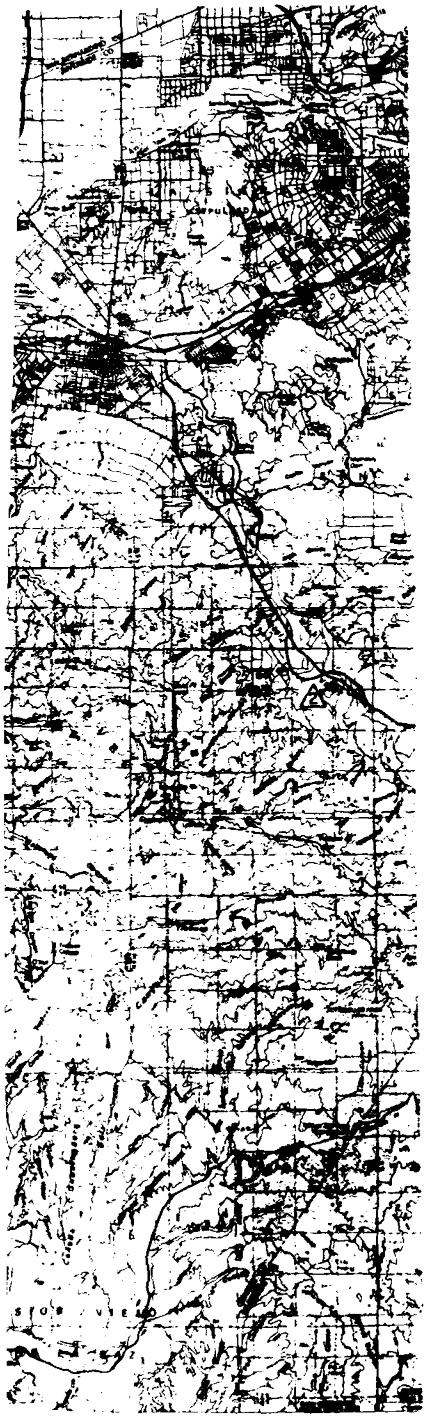
SLOPE STABILITY CONDITIONS
SANTA ANA CANYON
GREEN RIVER GOLF COURSE

SUBMITTED BY: DATE: SHEET



LOCATION MAP

VALUE ENGINEERING PAYS



AGGREGATE SOURCES

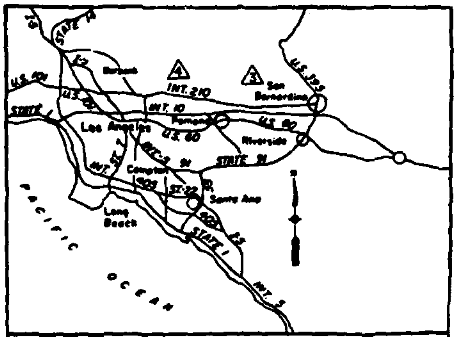
1. BLUE DIAMOND MATERIALS, IRVINE, CA.
2. FOSTER SAND AND GRAVEL CO., CORONA, CA.
3. OWL ROCK PRODUCTS CO., RIALTO, CA.
4. TRANSIT MIXED CONCRETE CO., AZUSA, CA.

CEMENT SOURCES

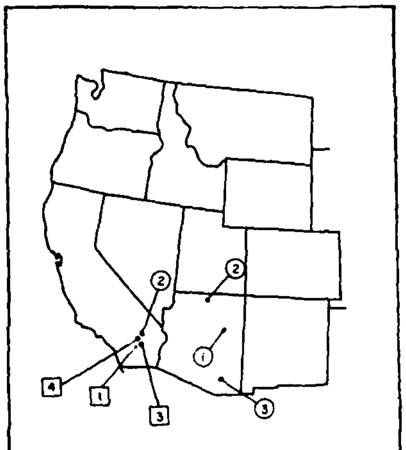
1. CALIFORNIA PORTLAND CEMENT CO., COLTON, CA.
2. KAISER CEMENT CO., LUCERNE VALLEY, CA.
3. RIVERSIDE CEMENT CO., RIVERSIDE, CA.
4. SOUTHWEST CEMENT CO., VICTORVILLE, CA.

POZZOLAN SOURCES

1. PHOENIX CEMENT, JOSEPH CITY, AZ.
2. WESTERN ASH CO., PAGE, AZ.
3. WESTERN ASH CO., COCHISE, AZ.



VICINITY MAP



GENERAL MAP

NO SCALE

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: XBa

CHECKED BY:

LOWER SANTA ANA RIVER CHANNEL

SOURCES OF AGGREGATES CEMENTS AND POZZOLANS

SUBMITTED BY:

DATE APPROVED:

SPEC. NO. DACW09-___-B-____

SHEET

DISTRICT FILE NO.

A GEOTECHNICAL

ATTACHMENT

DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION, CORPS OF ENGINEERS
LABORATORY

LOWER SANTA ANA RIVER

REPORT
OF
SOIL TESTS

EDITED

SAUSALITO, CALIFORNIA

January 1980

REPORT
OF
SOIL TESTS

LOWER SANTA ANA RIVER

JANUARY 1980

AUTHORIZATION

1. Results of tests reported herein were requested by the Los Angeles District in laboratory request No. CIV-80-12 dated 29 October 1979 and change order No. 1 dated 28 November 1979.

2. Three undisturbed and eight disturbed samples were received on 7 September 1979. Identification of the samples are shown on the Test Result Summary, plate 1.

TESTING PROGRAM

3. The program was in general accordance with the test request and included compaction, classification, specific gravity, direct shear, "R" triaxial compression, consolidation and permeability.

TEST METHODS

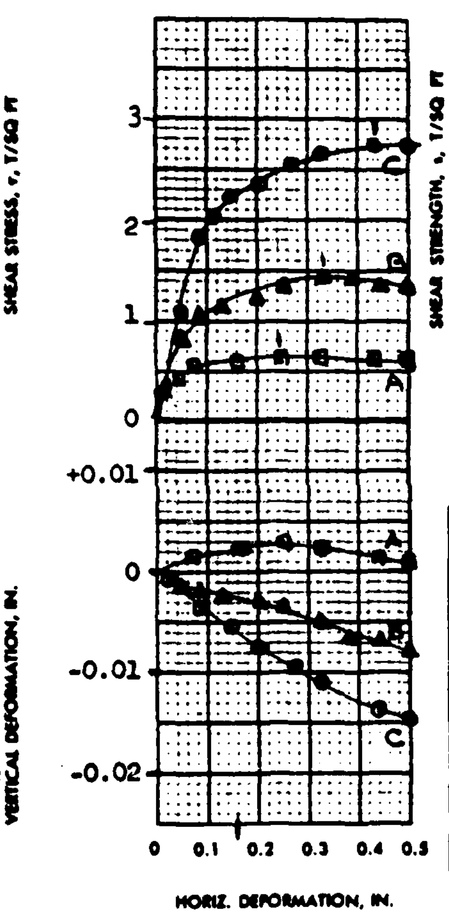
4. a. Grain-size Ananlysis, Atterberg Limits, Specific Gravity, Compaction, Permeability, Direct Shear, Triaxial Compression and Consolidation. Testing methods conformed to the procedure described in Engineer Manual, EM 1110-2-1906, "Laboratory Soil Testing, " 30 November 1970.

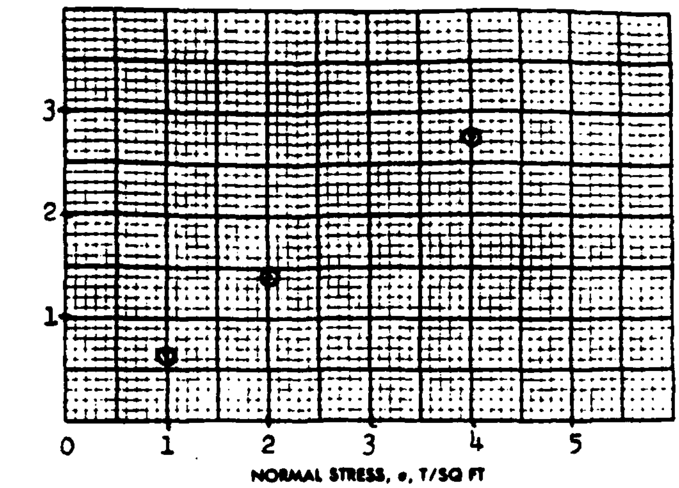
b. Classification. The soil was classified in accordance with "The Unified Soil Classification System," TM No. 3-357, Appendix A, April 1960.

RESULTS

5. Results of tests are shown on the following plates:

SUBJECT	PLATE NO.
Soil Test Result Summary	1
Plasticity Chart	2
Compaction Test Report	3 - 6
Direct Shear Test Report	7 - 11
Triaxial Compression Test Report	12 - 23
Consolidation Test Report	23 - 35
Permeability	36





SHEAR STRENGTH PARAMETERS

φ' = ______

TAN φ' = ______

c' = ______ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO.			A	B	C	
INITIAL	WATER CONTENT	w_o	19.7 %	19.6 %	19.6 %	%
	VOID RATIO	e_o	0.744	0.740	0.745	
	SATURATION	S_o	73 %	73 %	72 %	%
	DRY DENSITY, LB/CU FT	γ_d	98.1	98.3	98.0	
VOID RATIO AFTER CONSOLIDATION		e_c	0.717	0.700	0.686	
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.1	0.1	0.1	
FINAL	WATER CONTENT	w_f	26.3%	24.6%	23.2%	%
	VOID RATIO	e_f	0.721	0.674	0.636	
	SATURATION	S_f	100 %	100 %	100 %	%
NORMAL STRESS, T/SQ FT		σ	1.00	2.00	4.00	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.65	1.41	2.75	
ACTUAL TIME TO FAILURE, MIN		t_f	170	220	330	
RATE OF STRAIN, IN./MIN			.0015	.0015	.0014	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	-	-	-	

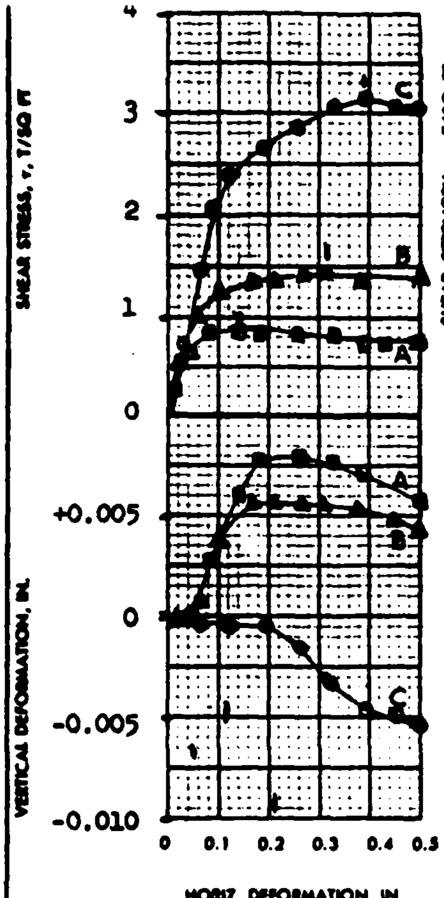
TYPE OF SPECIMEN Remolded		$3\frac{1}{2}$ IN. SQUARE	0.50 IN. THICK
CLASSIFICATION Sandy Clay (CL)			
LL 35	PL 22	PI 13	G_s 2.74

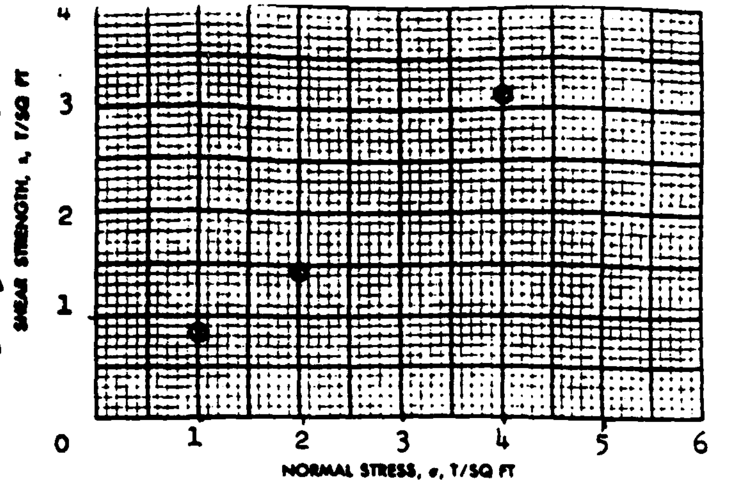
REMARKS Remolded to 95% maximum density at optimum water content.

PROJECT LOWER SANTA ANA RIVER

AREA

BORING NO. 79-9 SAMPLE NO 71822





SHEAR STRENGTH PARAMETERS

φ' = ____________

TAN φ' = ____________

c' = ____________ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO.			A	B	C	
INITIAL	WATER CONTENT	w_o	15.4 %	15.7 %	15.7 %	%
	VOID RATIO	e_o	0.633	0.639	0.635	
	SATURATION	S_o	66 %	67 %	67 %	%
	DRY DENSITY, LB/CU FT	γ_d	104.3	104.0	104.2	
VOID RATIO AFTER CONSOLIDATION		e_c	0.614	0.618	0.612	
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.1	0.1	0.1	
FINAL	WATER CONTENT	w_f	21.5 %	21.2 %	20.2 %	%
	VOID RATIO	e_f	0.613	0.608	0.574	
	SATURATION	S_f	96 %	95 %	96 %	%
NORMAL STRESS, T/SQ FT		σ	1.00	2.00	4.00	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.86	1.44	3.16	
ACTUAL TIME TO FAILURE, MIN		t_f	100	225	320	
RATE OF STRAIN, IN./MIN			.0014	.0014	.0013	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	-	-	-	

TYPE OF SPECIMEN Remolded		$3\frac{1}{4}$ IN. SQUARE	0.50 IN. THICK
CLASSIFICATION Silty Sand (SM)			
LL 23	PL 21	PI 2	G_s 2.73

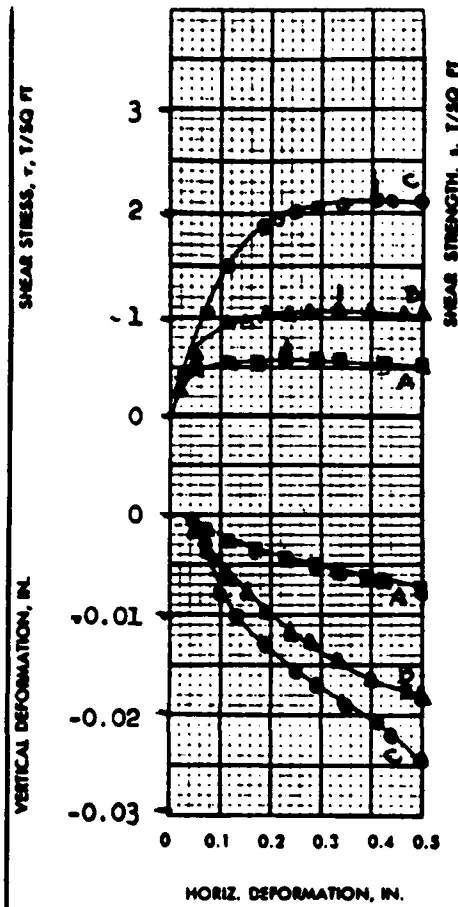
REMARKS Remolded to 94% maximum density at optimum + 1% water content.

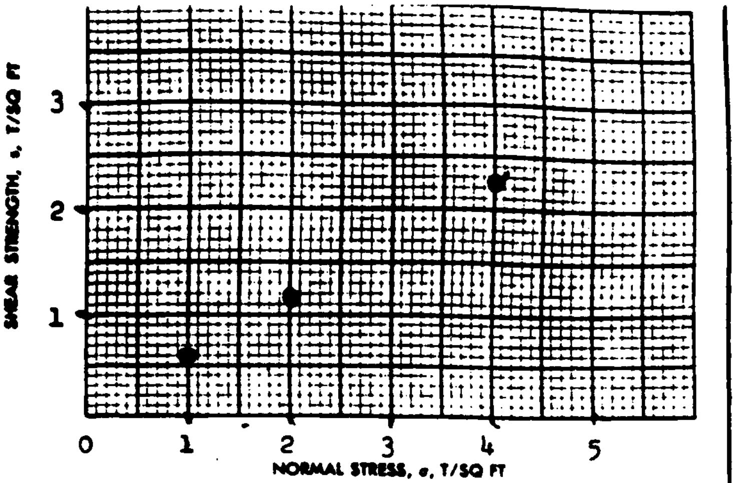
PROJECT LOWER SANTA ANA RIVER

AREA

BORING NO. 79-8 SAMPLE NO. 71823

DEPTH 9.0-15.0 DATE December 1979





SHEAR STRENGTH PARAMETERS

φ' = ____________

TAN φ' = ____________

c' = ____________ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO.			A	B	C	
INITIAL	WATER CONTENT	w_o	21.2 %	19.7 %	20.4 %	%
	VOID RATIO	e_o	0.755	0.737	0.745	
	SATURATION	S_o	77 %	73 %	75 %	%
	DRY DENSITY, LB/CU FT	γ_d	97.4	98.4	98.0	
VOID RATIO AFTER CONSOLIDATION		e_c	0.726	0.691	0.687	
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.1	0.1	0.1	
FINAL	WATER CONTENT	w_f	25.6 %	22.9 %	22.2 %	%
	VOID RATIO	e_f	0.701	0.628	0.610	
	SATURATION	S_f	100 %	100 %	100 %	%
NORMAL STRESS, T/SQ FT		σ	1.00	2.00	4.00	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.61	1.18	2.23	
ACTUAL TIME TO FAILURE, MIN		t_f	170	230	325	
RATE OF STRAIN, IN./MIN			.0014	.0015	.0013	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	-	-	-	

TYPE OF SPECIMEN	Remolded	$3\frac{1}{4}$	IN. SQUARE	0.50	IN. THICK
CLASSIFICATION	Silty Clay(CL)				
LL 44	PL 27	PI 17			G_s 2.74

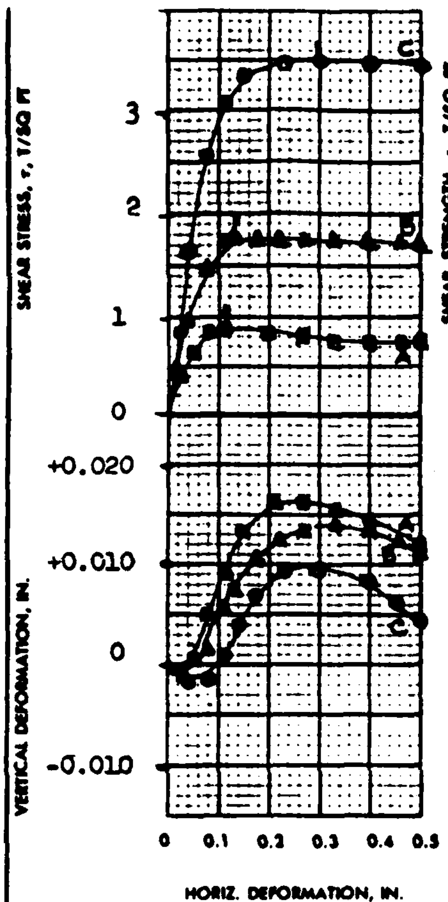
REMARKS Remolded to 95% maximum density at approx. optimum water content.

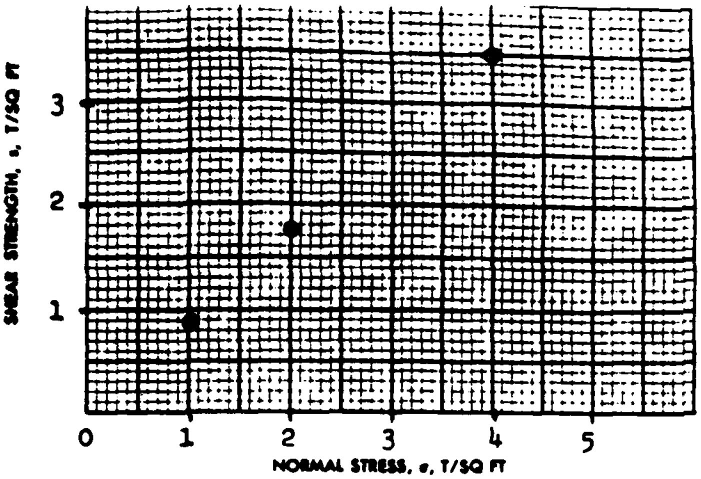
PROJECT LOWER SANTA ANA RIVER

AREA

BORING NO. 79-1 SAMPLE NO. 71824

DEPTH [illegible]





TEST NO.			A	B	C	
INITIAL	WATER CONTENT	w_o	0.2 %	0.3 %	0.4 %	%
	VOID RATIO	e_o	0.624	0.627	0.628	
	SATURATION	S_o	1 %	1 %	2 %	%
	DRY DENSITY, LB/CU FT	γ_d	103.0	102.8	102.7	
VOID RATIO AFTER CONSOLIDATION		e_c	0.609	0.605	0.602	
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.1	0.1	0.1	
FINAL	WATER CONTENT	w_f	22.9 %	22.3 %	23.1 %	%
	VOID RATIO	e_f	0.647	0.621	0.618	
	SATURATION	S_f	98 %	96 %	100 %	%
NORMAL STRESS, T/SQ FT		σ	1.00	2.00	4.00	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.89	1.78	3.51	
ACTUAL TIME TO FAILURE, MIN		t_f	80	120	240	
RATE OF STRAIN, IN./MIN			.0014	.0014	.0014	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	-	-	-	

SHEAR STRENGTH PARAMETERS

φ' = __________

TAN φ' = __________

c' = __________ T/SQ FT

☐ CONTROLLED STRESS
☒ CONTROLLED STRAIN

TYPE OF SPECIMEN Remolded — $3\frac{1}{4}$ IN. SQUARE — 0.50 IN. THICK

CLASSIFICATION Silty Sand (SP - SM)

LL — PL — PI NP — G_s 2.68

REMARKS Remolded at 95% maximum density at air-dry water content.

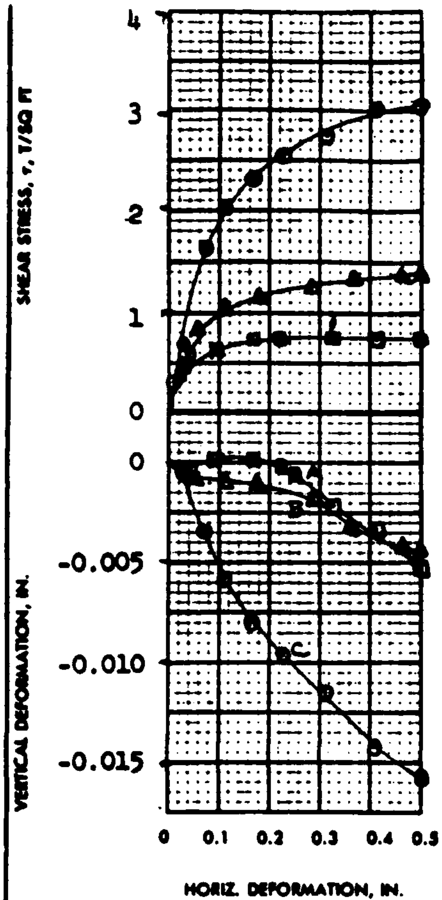
PROJECT LOWER SANTA ANA RIVER

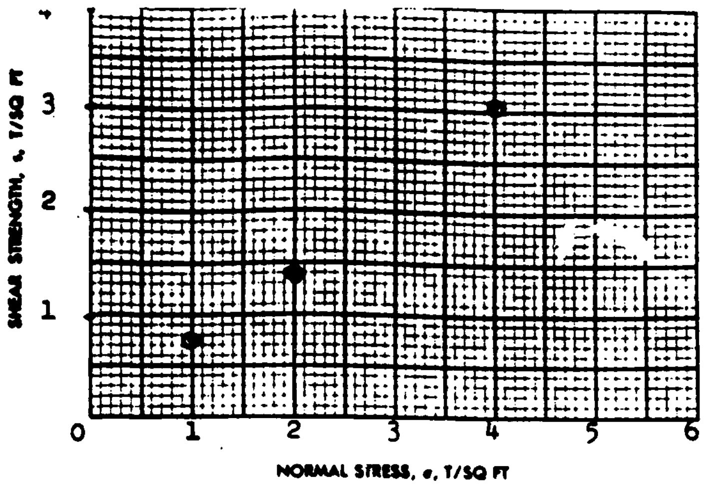
AREA

BORING NO. 79-2 — SAMPLE NO. 71825

DEPTH/EL 6.0 - 7.0 — DATE December 1979

DIRECT SHEAR TEST REPORT





SHEAR STRENGTH PARAMETERS

φ' = ____________

TAN φ' = ____________

c' = ____________ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

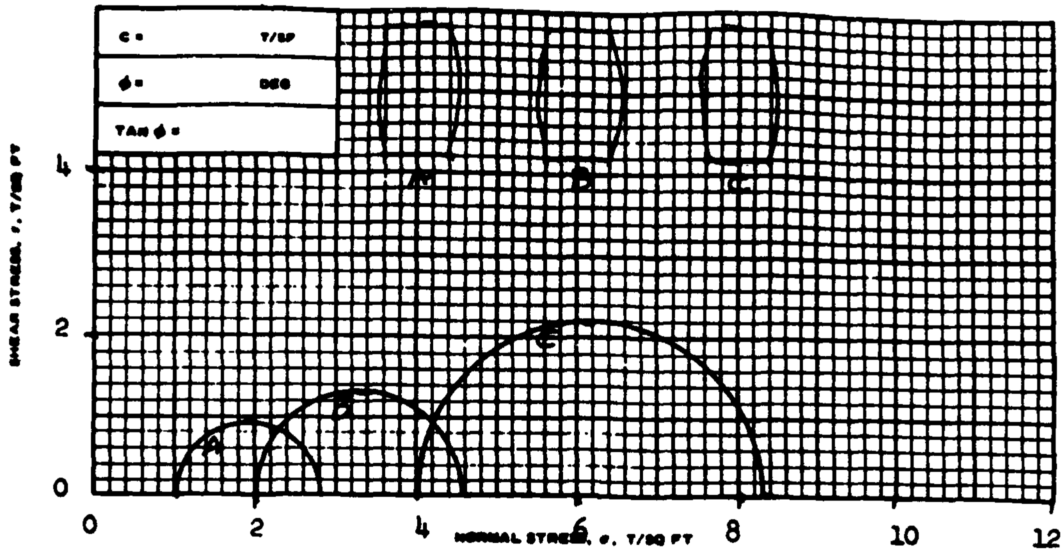
TEST NO.			A	B	C	
INITIAL	WATER CONTENT	w_o	14.9 %	15.3 %	15.6 %	%
	VOID RATIO	e_o	0.572	0.577	0.581	
	SATURATION	S_o	70 %	72 %	72 %	%
	DRY DENSITY, LB/CU FT	γ_d	107.1	106.9	106.6	
VOID RATIO AFTER CONSOLIDATION		e_c	0.550	0.548	0.581	
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.1	0.1	0.1	
FINAL	WATER CONTENT	w_f	19.4 %	17.7 %	17.2 %	%
	VOID RATIO	e_f	0.534	0.513	0.473	
	SATURATION	S_f	98 %	93 %	98 %	%
NORMAL STRESS, T/SQ FT		σ	1.00	2.00	4.00	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.77	1.41	3.08	
ACTUAL TIME TO FAILURE, MIN		t_f	230	285	385	
RATE OF STRAIN, IN./MIN			.0014	.0014	.0013	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	–	–	–	

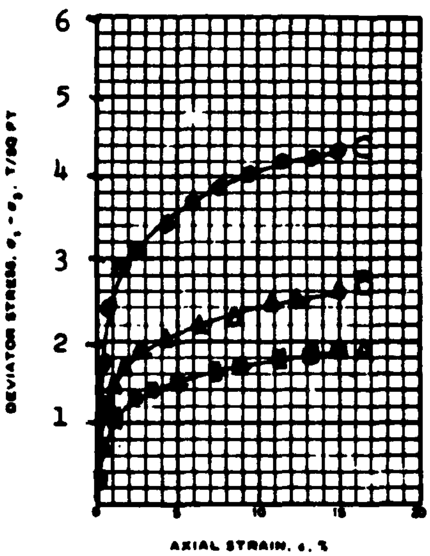
TYPE OF SPECIMEN Remolded		$3\frac{1}{4}$ IN. SQUARE		0.50 IN. THICK
CLASSIFICATION Clay-y Sand (SC)				
LL 28	PL 17	PI 11		G_s 2.70

REMARKS Remolded to 94% max. @ opt. + 1%

PROJECT LOWER SANTA ANA RIVER	
AREA	
BORING NO. 79-3	SAMPLE NO. 71827
DEPTH ft 6.0 - 9.0	DATE December 1979

DIRECT SHEAR TEST REPORT





SPECIMEN NO.			A	B	C
INITIAL	WATER CONTENT, %	w_o	19.7	20.1	20.5
	DRY DENSITY LB/CU FT	γ_{d_o}	101.3	101.1	100.7
	SATURATION, %	S_o	80	81	81
	VOID RATIO	e_o	0.675	0.679	0.685
BEFORE SHEAR	WATER CONTENT, %	w_c	22.5	22.9	21.2
	DRY DENSITY LB/CU FT	γ_{d_c}	105.2	104.9	107.6
	SATURATION, %	S_c	100	100	100
	VOID RATIO	e_c	0.613	0.624	0.578
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	1.90	2.63	4.36
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	296	351	339
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	-	-	-
INITIAL DIAMETER, IN.		D_o	2.8	2.8	2.8
INITIAL HEIGHT, IN.		H_o	6.45	6.45	6.45

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Sandy Silty Clay (CL)

LL 46	PL 25	PI 21	Gs 2.72	TYPE OF SPECIMEN Remolded	TYPE OF TEST $\bar{R}$

REMARKS: Remolded to 95% maximum density at optimum water content.

PROJECT LOWER SANTA ANA RIVER

BORING NO. 79-3 | SAMPLE NO. 71826

DEPTH/ELEV 1.0 - 4.0

LABORATORY SPD | DATE December 1979

TRIAXIAL COMPRESSION TEST REPORT

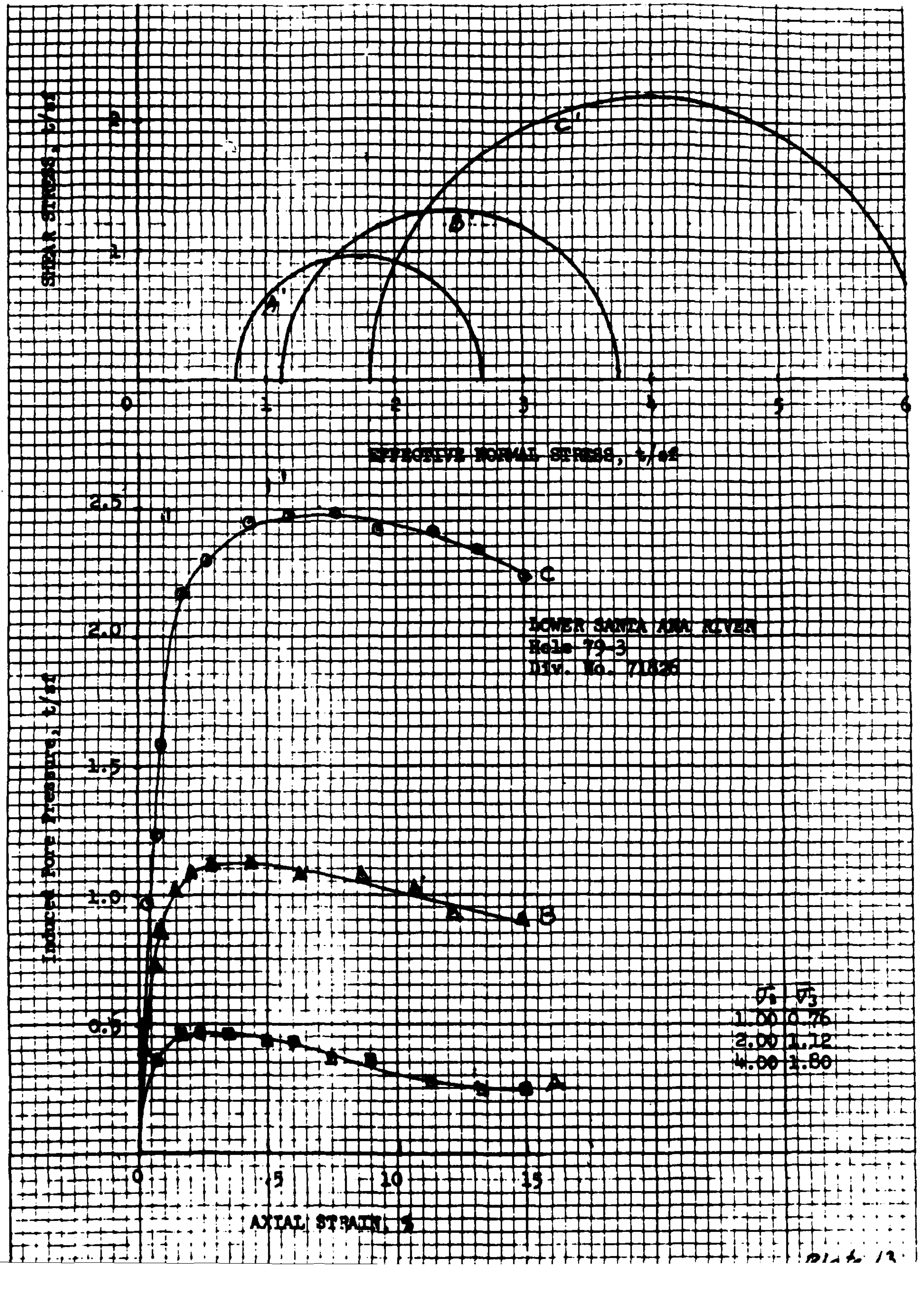
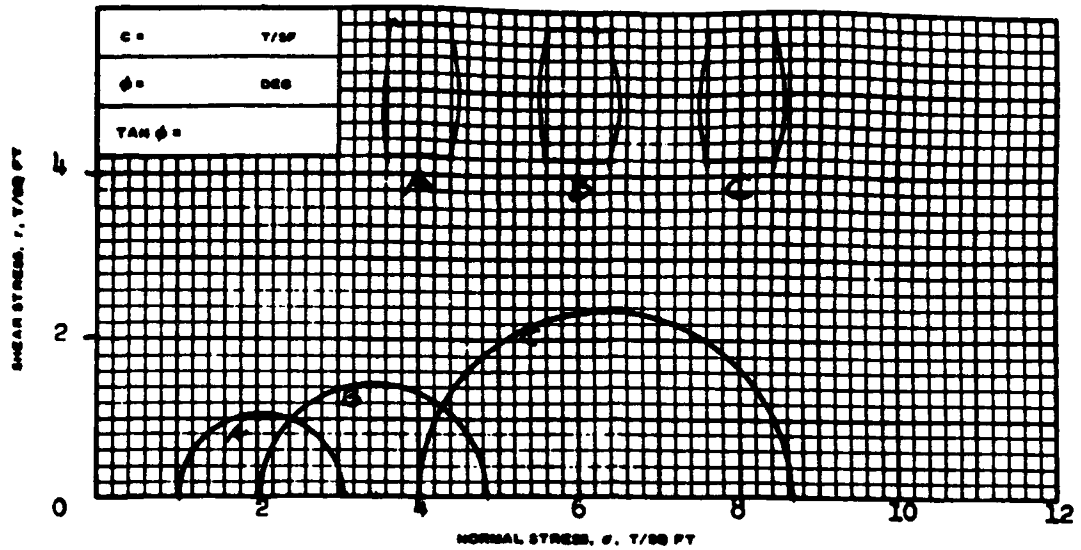
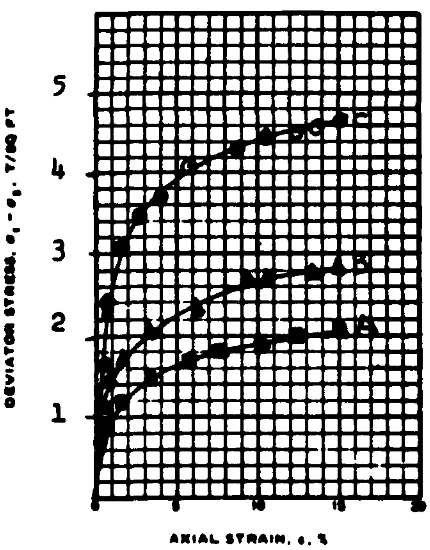

SHEAR STRESS, t/sf
EFFECTIVE NORMAL STRESS, t/sf
A'
B'
C'
Induced Pore Pressure, t/sf
AXIAL STRAIN, %
A
B
C
LOWER SANTA ANA RIVER
Hole 79-3
Div. No. 71826
$\bar{\sigma}_1$ | $\bar{\sigma}_3$
1.00 | 0.76
2.00 | 1.12
4.00 | 1.80

Plate 13





SPECIMEN NO.			A	B	C	
INITIAL	WATER CONTENT, %	w_o	20.8	21.0	20.8	
	DRY DENSITY LB/CU FT	γd_o	94.3	94.2	94.2	
	SATURATION, %	S_o	70	70	70	
	VOID RATIO	e_o	0.820	0.822	0.84	
BEFORE SHEAR	WATER CONTENT, %	w_c	28.1	27.6	26.3	
	DRY DENSITY LB/CU FT	γd_c	96.8	97.6	99.5	
	SATURATION, %	S_c	100	100	100	
	VOID RATIO	e_c	0.773	0.759	0.724	
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20	
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00	
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	2.06	2.84	4.67	
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_1	3.37	3.24	3.58	
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	-	-	-	
INITIAL DIAMETER, IN.		D_o	2.8	2.8	2.8	
INITIAL HEIGHT, IN.		H_o	6.45	6.45	6.45	

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Clayey Silt (ML)

LL 43 | PL 28 | PI 15 | G 2.75 | TYPE OF SPECIMEN Remolded | TYPE OF TEST R

REMARKS FSI

Remolded to 95% maximum density at optimum water content.

PROJECT LOWE[illegible] SANTA ANA RIVER

BORING NO. 79-6 SAMPLE NO. 71828

DEPTH/ELEV 0 - 4.0

LABORATORY SPDL DATE January 1900

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)

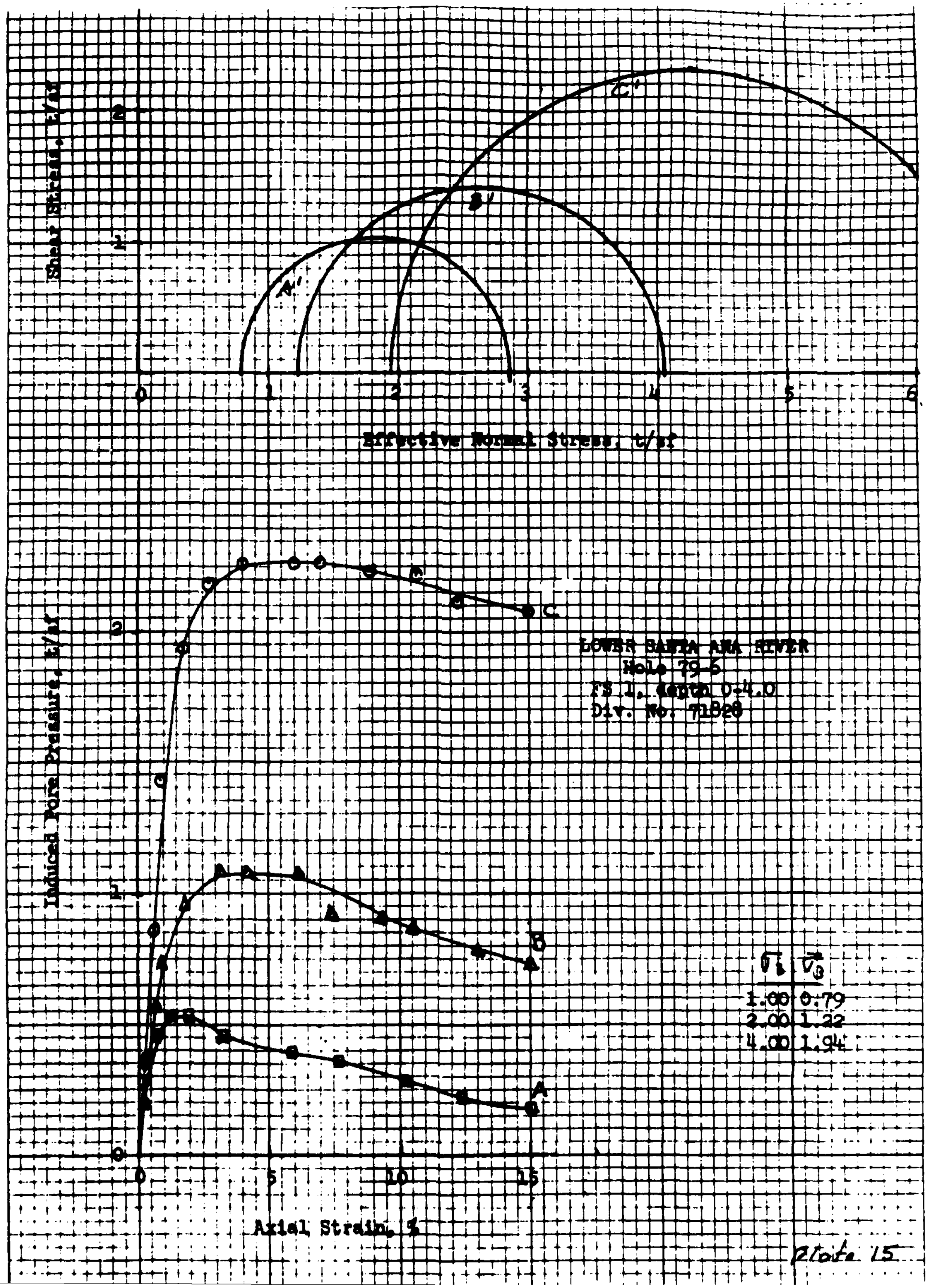
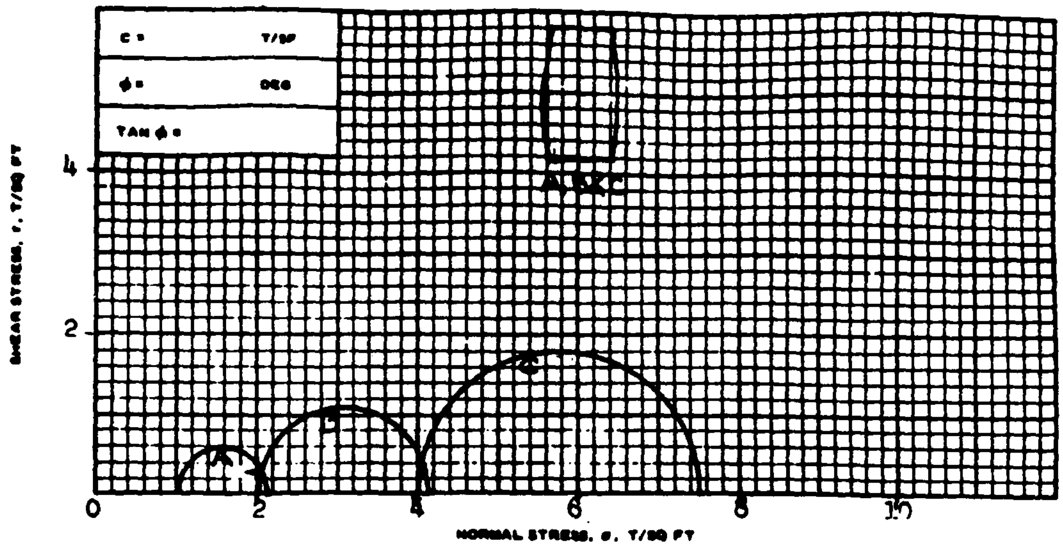
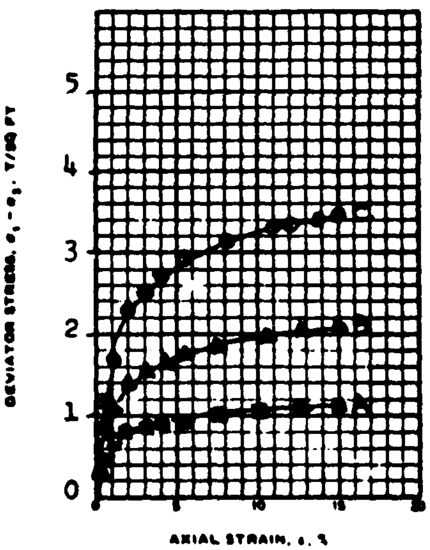

Shear Stress, t/sf
Effective Normal Stress, t/sf
A'
B'
C'
Induced Pore Pressure, t/sf
Axial Strain, %
A
B
C
LOWER SANTA ANA RIVER
Hole 79-6
FS 1, depth 0-4.0
Div. No. 71828
σ_3 $\bar{\sigma}_3$
1.00 0.79
2.00 1.22
4.00 1.94

Plate 15





SPECIMEN NO.			A	B	C
INITIAL	WATER CONTENT, %	w_o	20.7	20.5	21.3
	DRY DENSITY LB/CU FT	γ_{d_o}	94.9	95.1	94.4
	SATURATION, %	S_o	70	69	71
	VOID RATIO	e_o	0.828	0.824	0.837
BEFORE SHEAR	WATER CONTENT, %	w_c	28.3	27.0	25.0
	DRY DENSITY LB/CU FT	γ_{d_c}	97.1	99.0	102.3
	SATURATION, %	S_c	100	100	100
	VOID RATIO	e_c	0.786	0.751	0.696
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	1.16	2.14	3.51
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_1	279	323	363
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	-	-	-
INITIAL DIAMETER, IN.		D_o	2.8	2.8	2.8
INITIAL HEIGHT, IN.		H_o	6.45	6.45	6.45

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Silty Clay (CH)

LL 53	PL 28	PI 25	G 2.78	TYPE OF SPECIMEN Remolded	TYPE OF TEST $\bar{R}$

REMARKS FS.2

Remolded to 95% maximum density at optimum water content.

PROJECT LOWER SANTA ANA RIVER

BORING NO. 79-6 SAMPLE NO. 71829

DEPTH/ELEV 5 - 10

LABORATORY SPDL DATE January 1980

TRIAXIAL COMPRESSION TEST REPORT

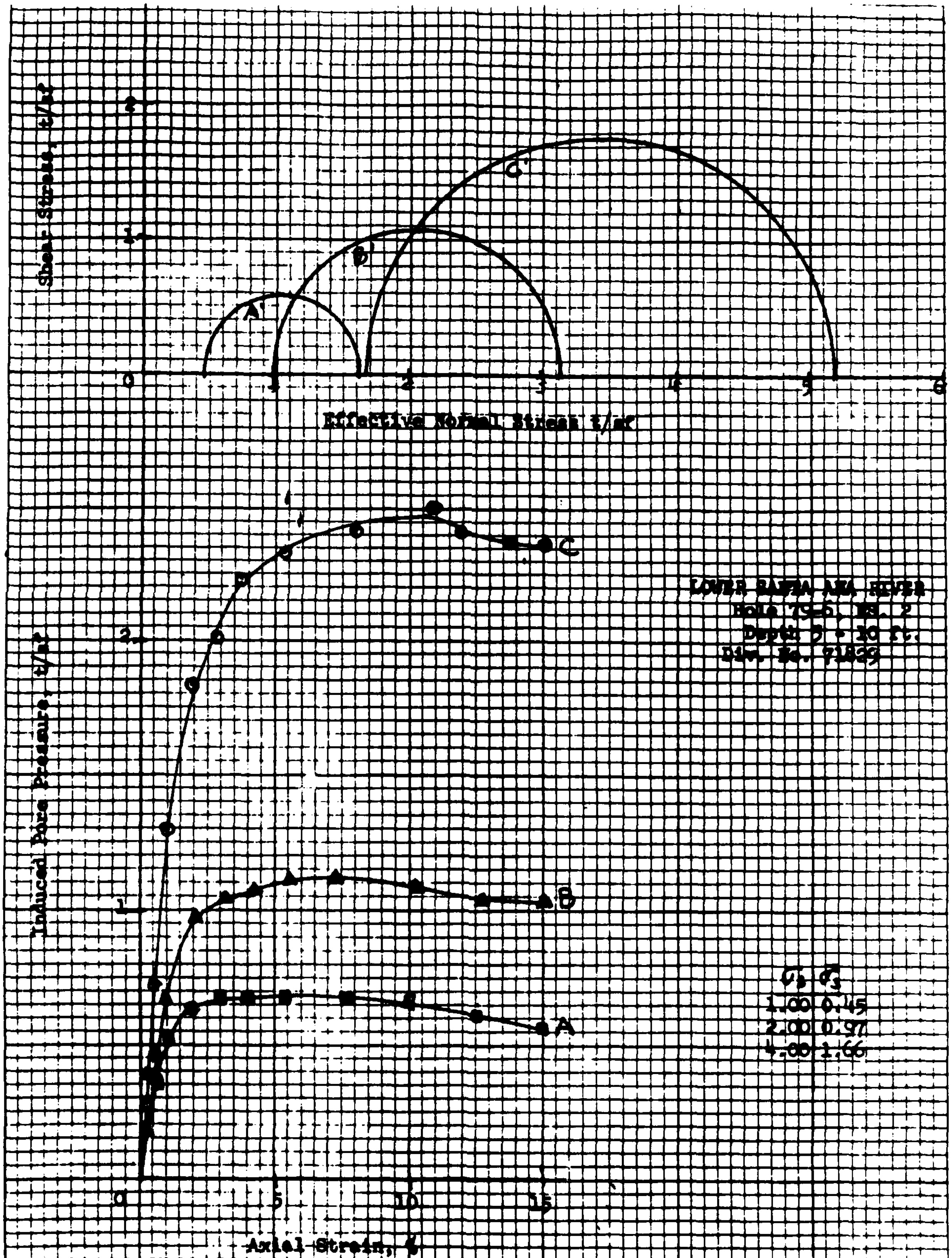
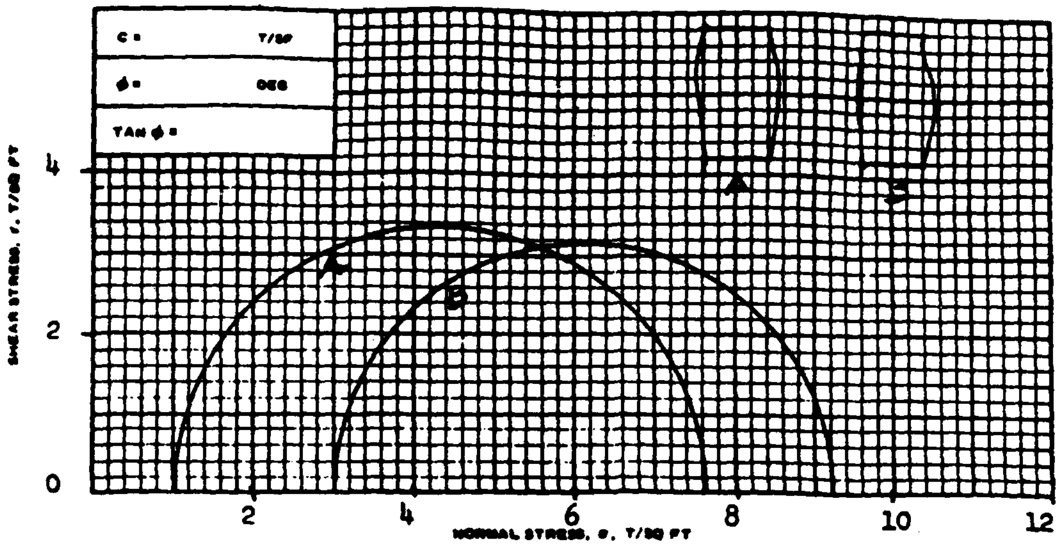
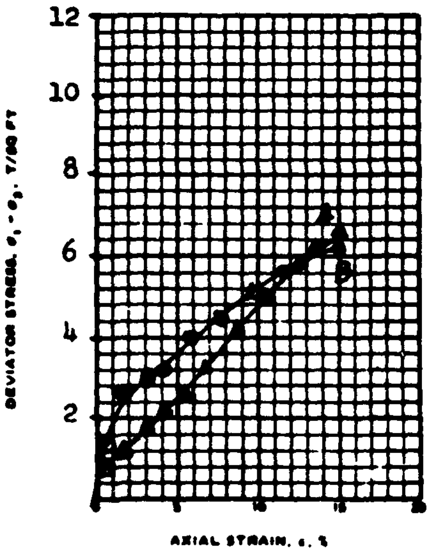

Shear Stress, t/sf
Effective Normal Stress t/sf
A'
B'
C'
Induced Pore Pressure, t/sf
Axial Strain, %
A
B
C
LOWER SANTA ANA RIVER
Hole 79-5, No. 2
Depth 5 - 10 ft.
Div. No. 71829
σ_3 $\bar{\sigma}_3$
1.00 0.45
2.00 0.97
4.00 1.66

Plate 17





SPECIMEN NO.			A	B		
INITIAL	WATER CONTENT, %	w_o	26.2	30.0		
INITIAL	DRY DENSITY LB/CU FT	γ_{d_o}	99.2	92.5		
INITIAL	SATURATION, %	S_o	100	98		
INITIAL	VOID RATIO	e_o	0.711	0.834		
BEFORE SHEAR	WATER CONTENT, %	w_c	24.1	27.0		
BEFORE SHEAR	DRY DENSITY LB/CU FT	γ_{d_c}	102.5	101.0		
BEFORE SHEAR	SATURATION, %	S_c	100	98		
BEFORE SHEAR	VOID RATIO	e_c	0.657	0.726		
BEFORE SHEAR	FINAL BACK PRESSURE, T/SQ FT	u_o	5.76	5.76		
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	3.00		
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	6.65	6.27		
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_1	341	408		
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	-	-		
INITIAL DIAMETER, IN.		D_o	2.79	2.86		
INITIAL HEIGHT, IN.		H_o	6.10	6.37		

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Sandy Silt (ML)

LL	PL	PI NP	G. 2.72	TYPE OF SPECIMEN Undisturbed	TYPE OF TEST $\bar{R}$

REMARKS: F.S. 1

PROJECT LOWER SANTA ANA RIVER

BORING NO. 79-9 SAMPLE NO. 71830

DEPTH/ELEV 15.0

LABORATORY SPDL DATE January 1980

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)

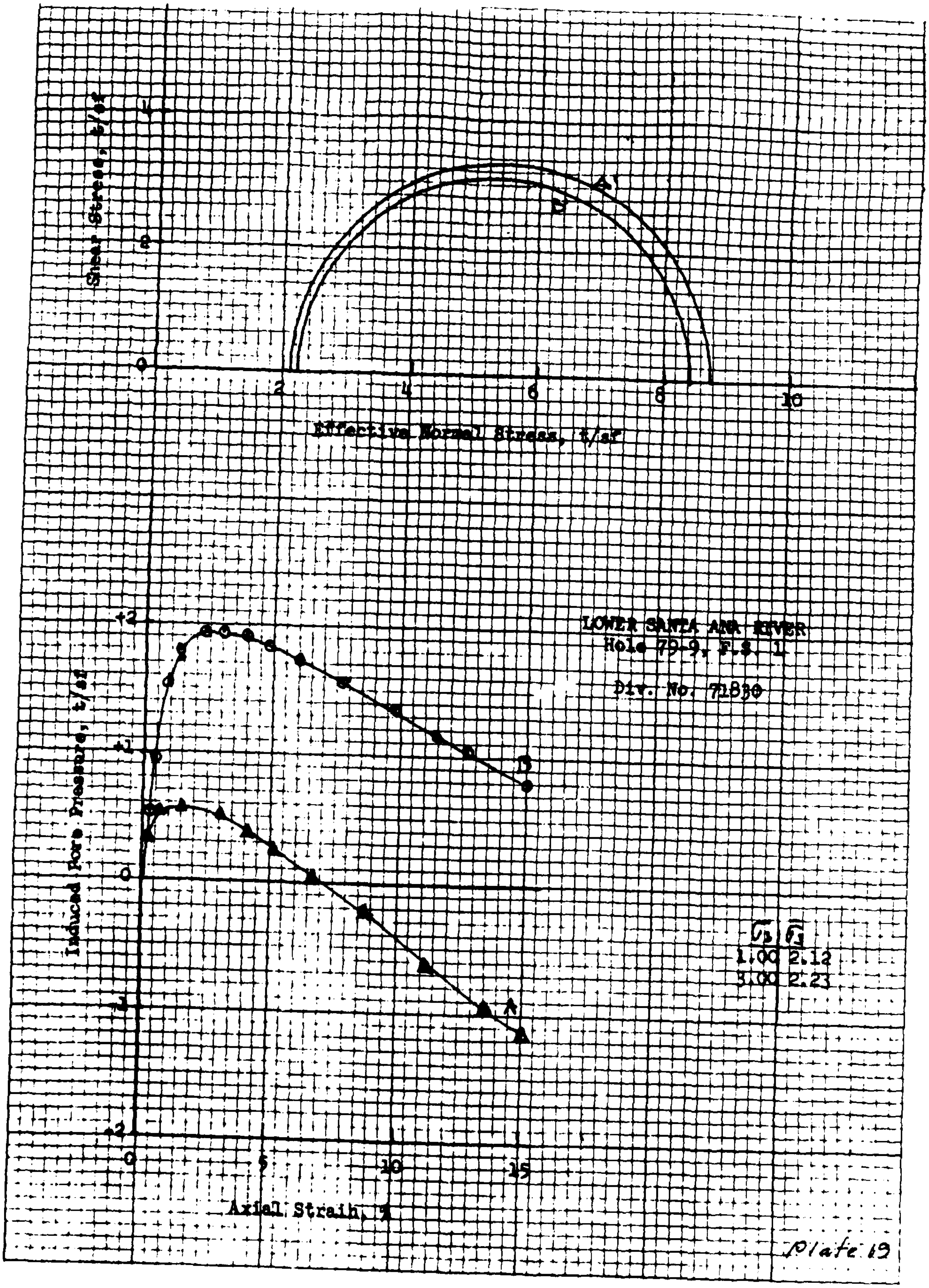
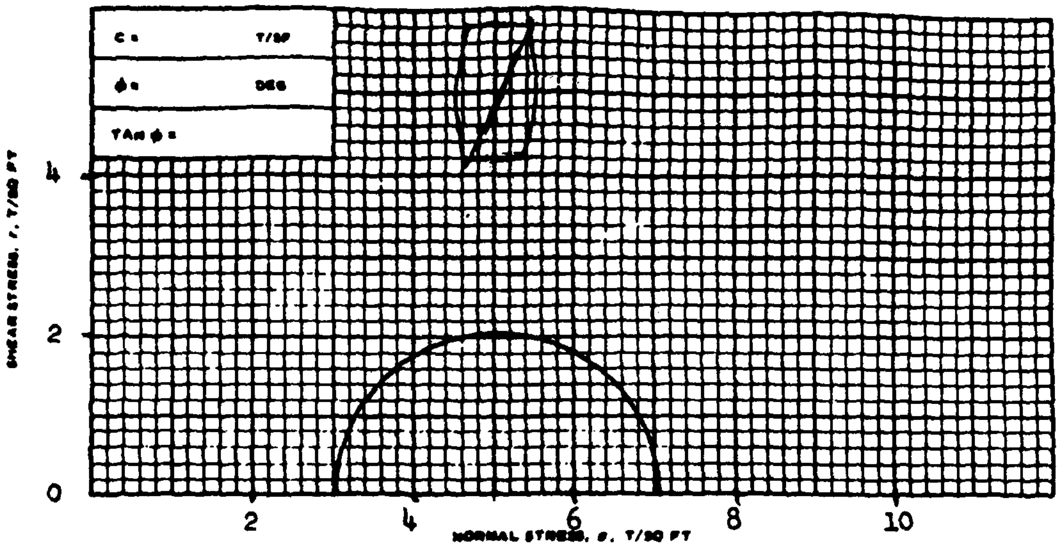
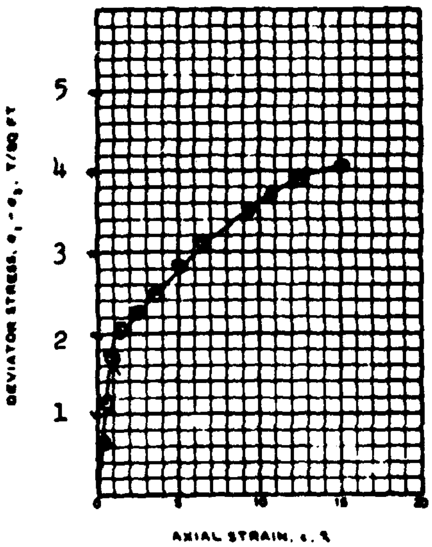

Shear Stress, t/sf
Effective Normal Stress, t/sf
Induced Pore Pressure, t/sf
Axial Strain, %
LOWER SANTA ANA RIVER
Hole 79-9, F.S. 1
Div. No. 71830
σ_3 σ_1
1.00 2.12
3.00 2.23

Plate 19





SPECIMEN NO.						
INITIAL	WATER CONTENT, %	w_o	30.2			
	DRY DENSITY LB/CU FT	γd_o	93.4			
	SATURATION, %	S_o	99			
	VOID RATIO	e_o	0.831			
BEFORE SHEAR	WATER CONTENT, %	w_c	25.6			
	DRY DENSITY LB/CU FT	γd_c	100.6			
	SATURATION, %	S_c	100			
	VOID RATIO	e_c	0.700			
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20			
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	3.00			
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	4.10			
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	315			
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	-			
INITIAL DIAMETER, IN.		D_o	2.85			
INITIAL HEIGHT, IN.		H_o	6.32			

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Silt (ML)

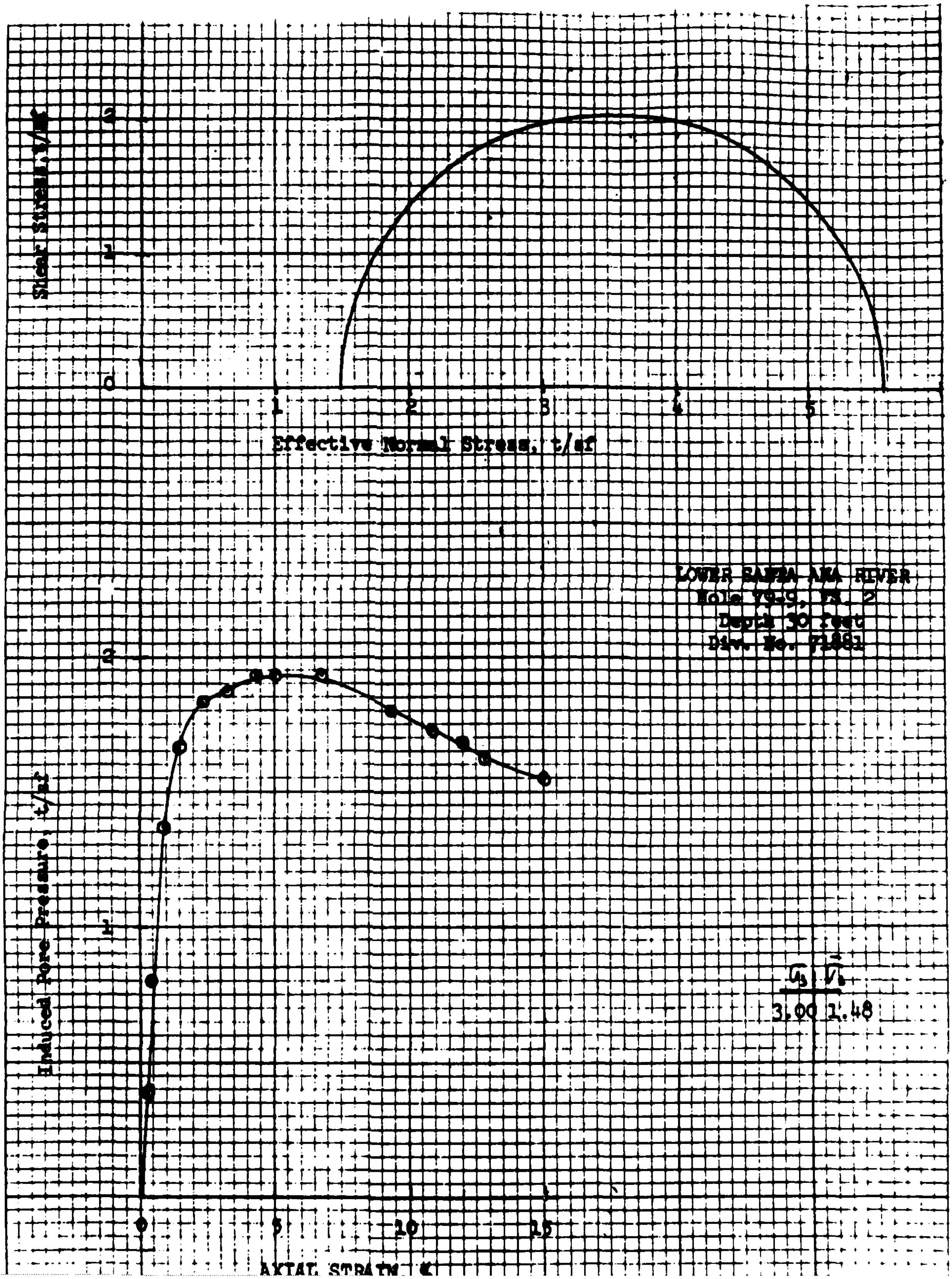
LL 33	PL 27	PI 6	Gs 2.74	TYPE OF SPECIMEN Undisturbed	TYPE OF TEST R

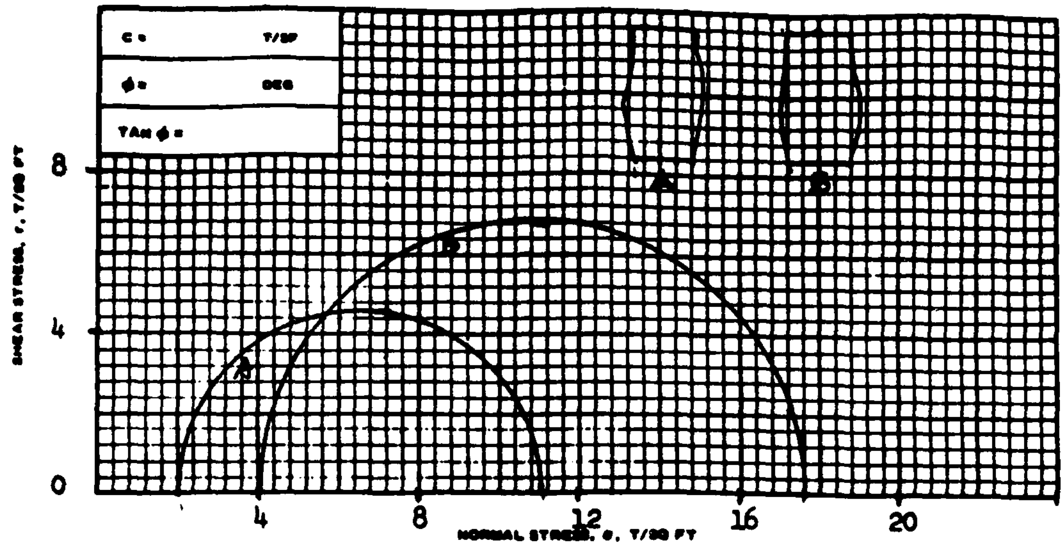
REMARKS: FS. 2

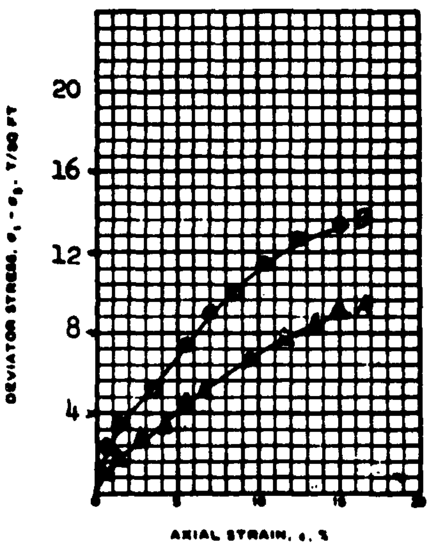
PROJECT LOWER SANTA ANA RIVER

BORING NO. 79-9	SAMPLE NO. 71831
DEPTH/ELEV 30 ft.	
LABORATORY SPDL	DATE January 1980

TRIAXIAL COMPRESSION TEST REPORT


Effective Normal Stress, t/sf
0
1
2
3
4
5
Induced Pore Pressure, t/sf
3.00 1.48
0
5
10
15





SPECIMEN NO.			A	B		
INITIAL	WATER CONTENT, %	w_o	30.2	30.6		
	DRY DENSITY LB/CU FT	γ_{d_o}	93.2	92.6		
	SATURATION, %	S_o	100	100		
	VOID RATIO	e_o	0.821	0.833		
BEFORE SHEAR	WATER CONTENT, %	w_c	27.9	27.0		
	DRY DENSITY LB/CU FT	γ_{d_c}	96.5	97.9		
	SATURATION, %	S_c	100	100		
	VOID RATIO	e_c	0.759	0.734		
	FINAL BACK PRESSURE, T/SQ FT	u_o	5.76	5.76		
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	2.00	4.00		
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	9.10	13.63		
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	399	400		
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	-	-		
INITIAL DIAMETER, IN.		D_o	2.77	2.81		
INITIAL HEIGHT, IN.		H_o	6.23	6.27		

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Sandy Silt (ML)

LL	PL	PI NP	G_s 2.72	TYPE OF SPECIMEN Undisturbed	TYPE OF TEST $\bar{R}$

REMARKS F.S. 1

PROJECT LOWER SANTA ANA RIVER

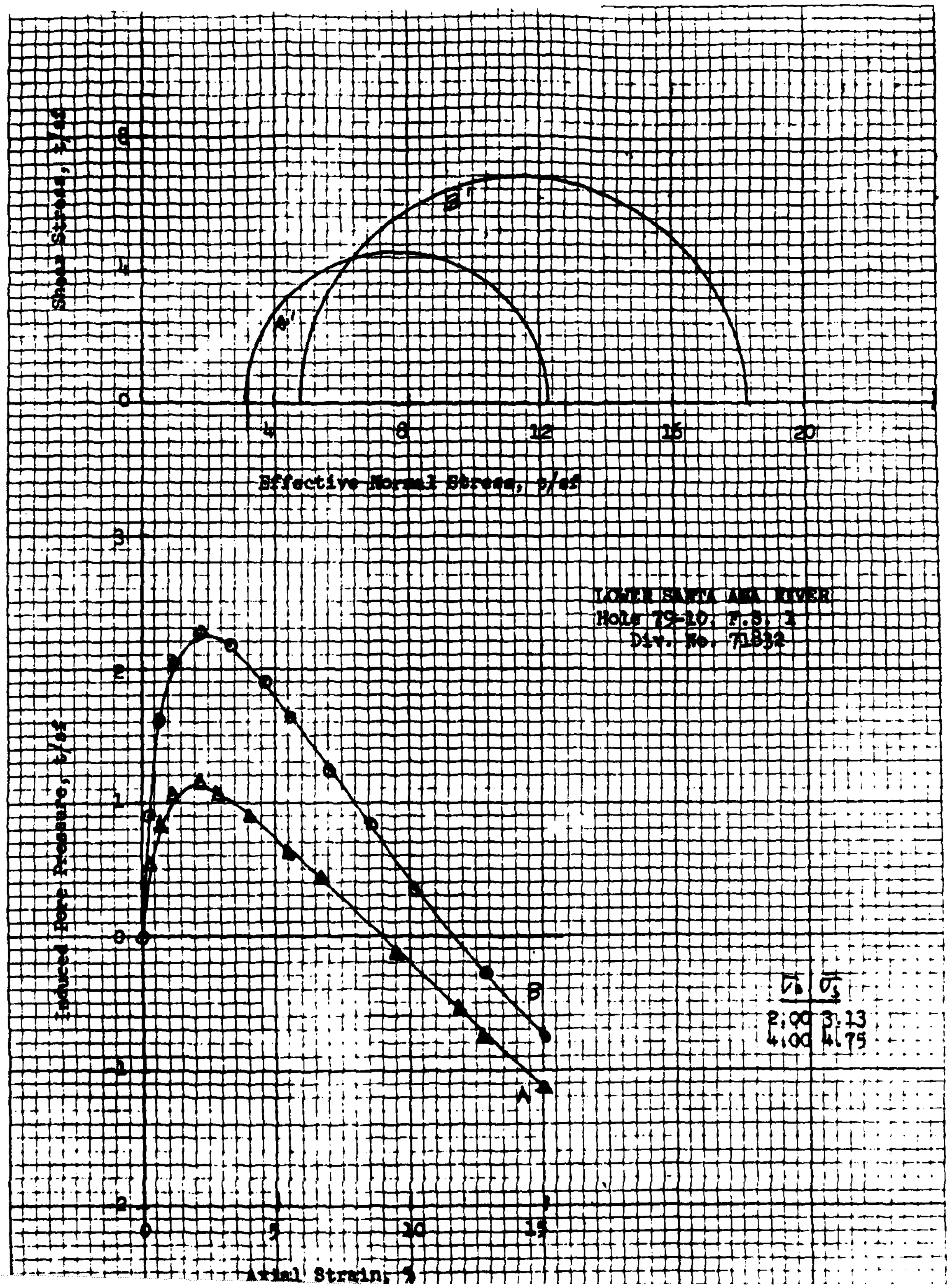
BORING NO. 79-10 SAMPLE NO. 71832

DEPTH/ELEV 16.0

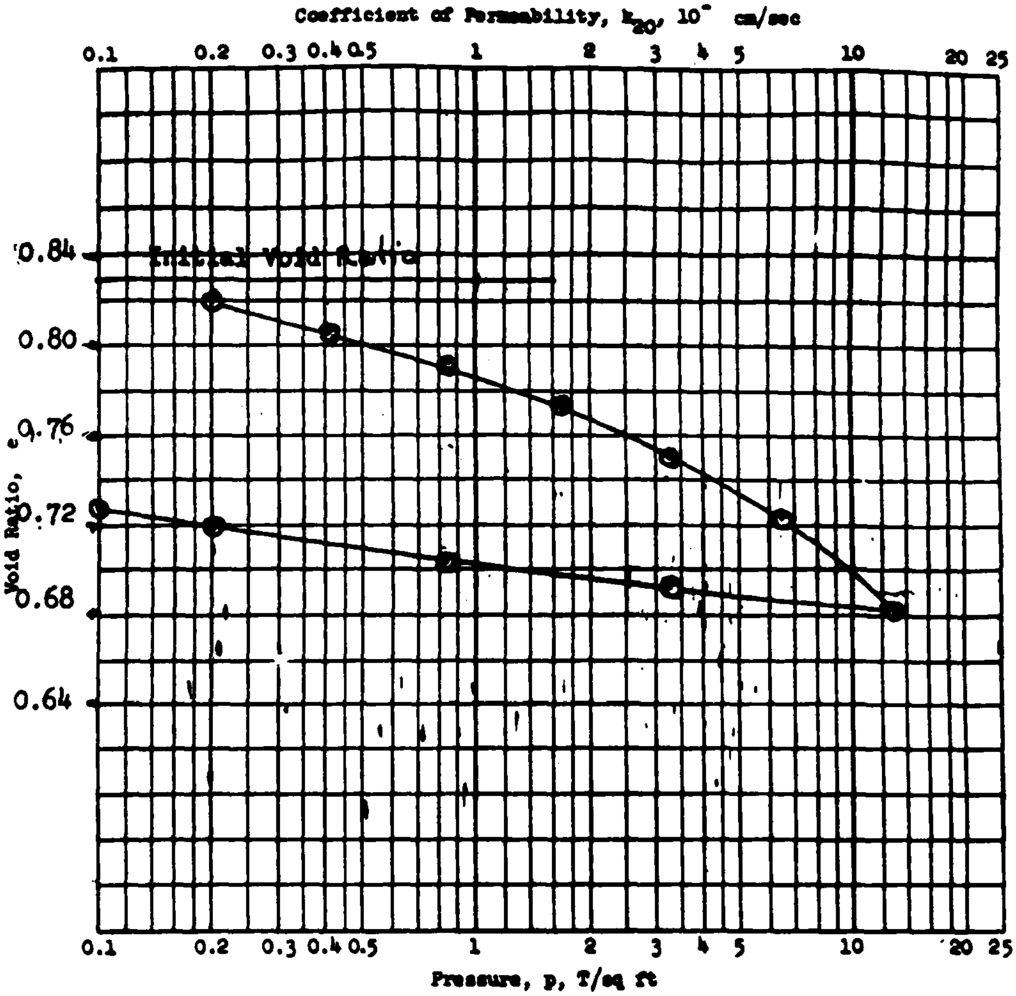
LABORATORY SPDL DATE January 1980

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)



Shear Stress, t/sf
Effective Normal Stress, t/sf
Induced Pore Pressure, t/sf
Axial Strain, %
LOWER SANTA ANA RIVER
Hole 79-10, P.S. 1
Div. No. 71832
A
B
$\bar{\sigma}_3$ $\bar{\sigma}_1$
2.00 3.13
4.00 4.75

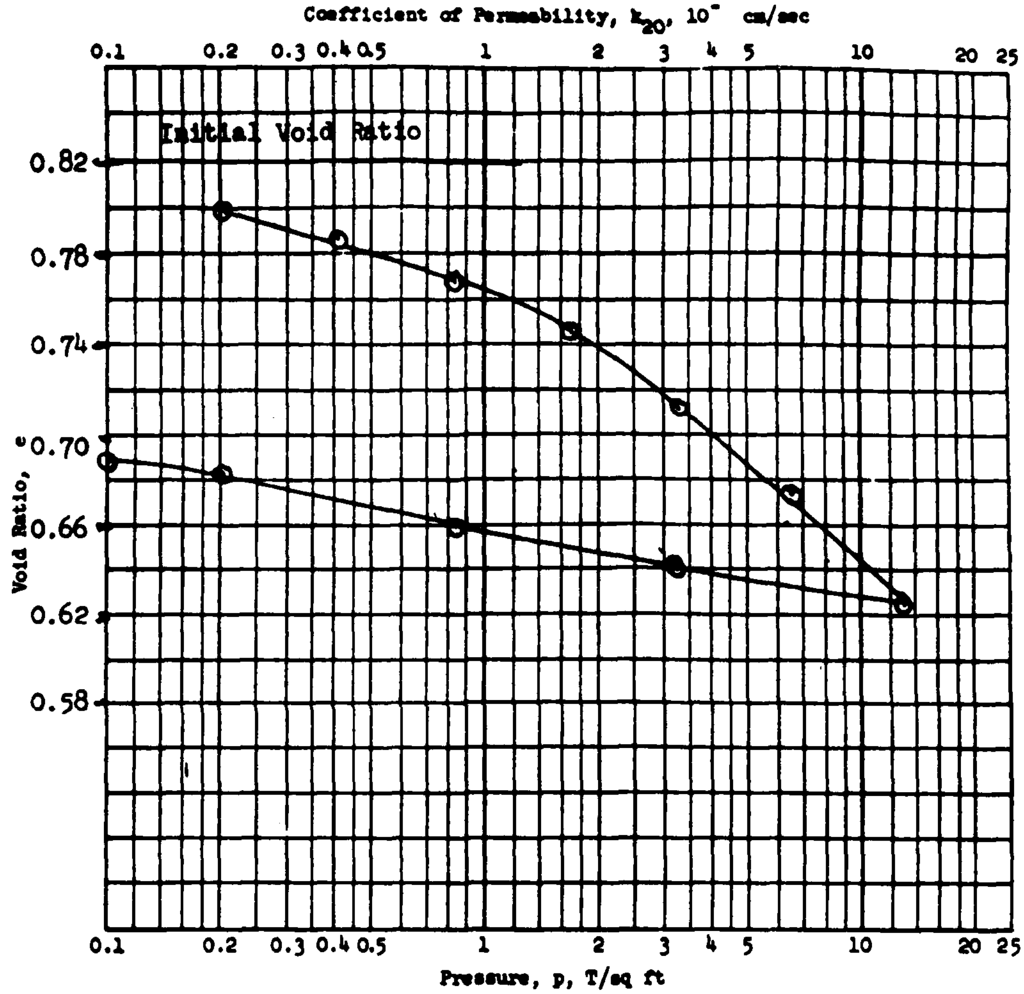


Type of Specimen Undisturbed		Before Test		After Test	
Diam 2.22 in.	Ht 0.50 in.	Water Content, w_o	29.4 %	w_f	28.0 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	0.830	e_f	0.762
Precónsol. Pressure, p_c T/sq ft		Saturation, S_o	96 %	S_f	100 %
Compression Index, C_c		Dry Density, γ_d	92.7 lb/ft^3		
Classification Sandy Silt (ML)		k_{20} at e_o = × 10^{-} cm/sec			

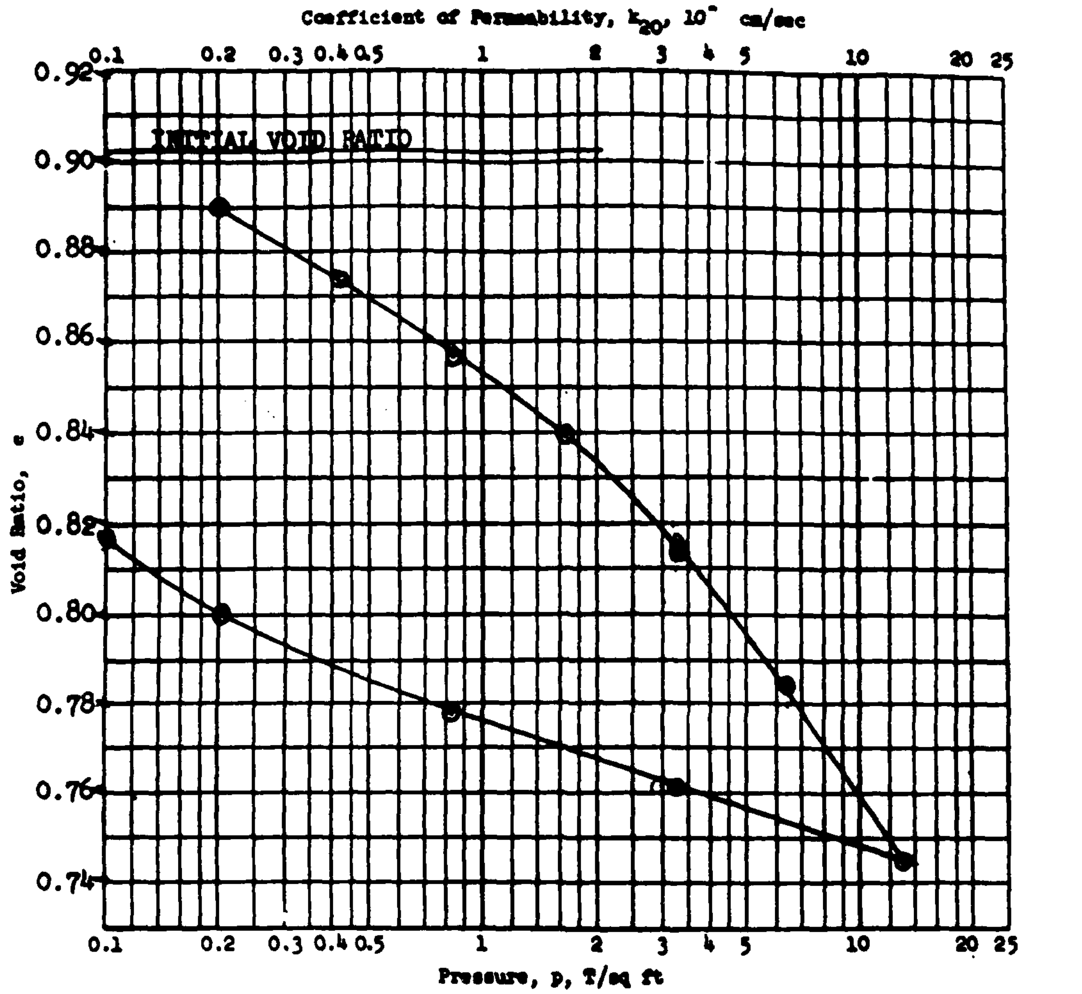
LL	G_s 2.72
PL NP	D_{10}
Remarks F.S. 1	

Project LOWER SANTA ANA RIVER	
Area	
Boring No. 79-9	Sample No. 71830
Depth El 15.0	Date January 1980

CONSOLIDATION TEST REPORT



Type of Specimen Undisturbed		**Before Test**		**After Test**	
Diam 2.22 in.	Ht 0.50 in.	Water Content, w_o	29.7 %	w_f	25.4 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	0.820	e_f	0.693
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	99 %	S_f	100 %
Compression Index, C_c		Dry Density, γ_d	93.9 lb/ft³		
Classification Silt (ML)		k_{20} at e_o = × 10⁻ cm/sec			
LL 33	G_s 2.74	Project LOWER SANTA ANA RIVER			
PL 7	D_{10}				
Remarks		Area			
		Boring No. 79-9		Sample No. 71831	
		Depth El 30.0		Date December 1979	
		CONSOLIDATION TEST REPORT			

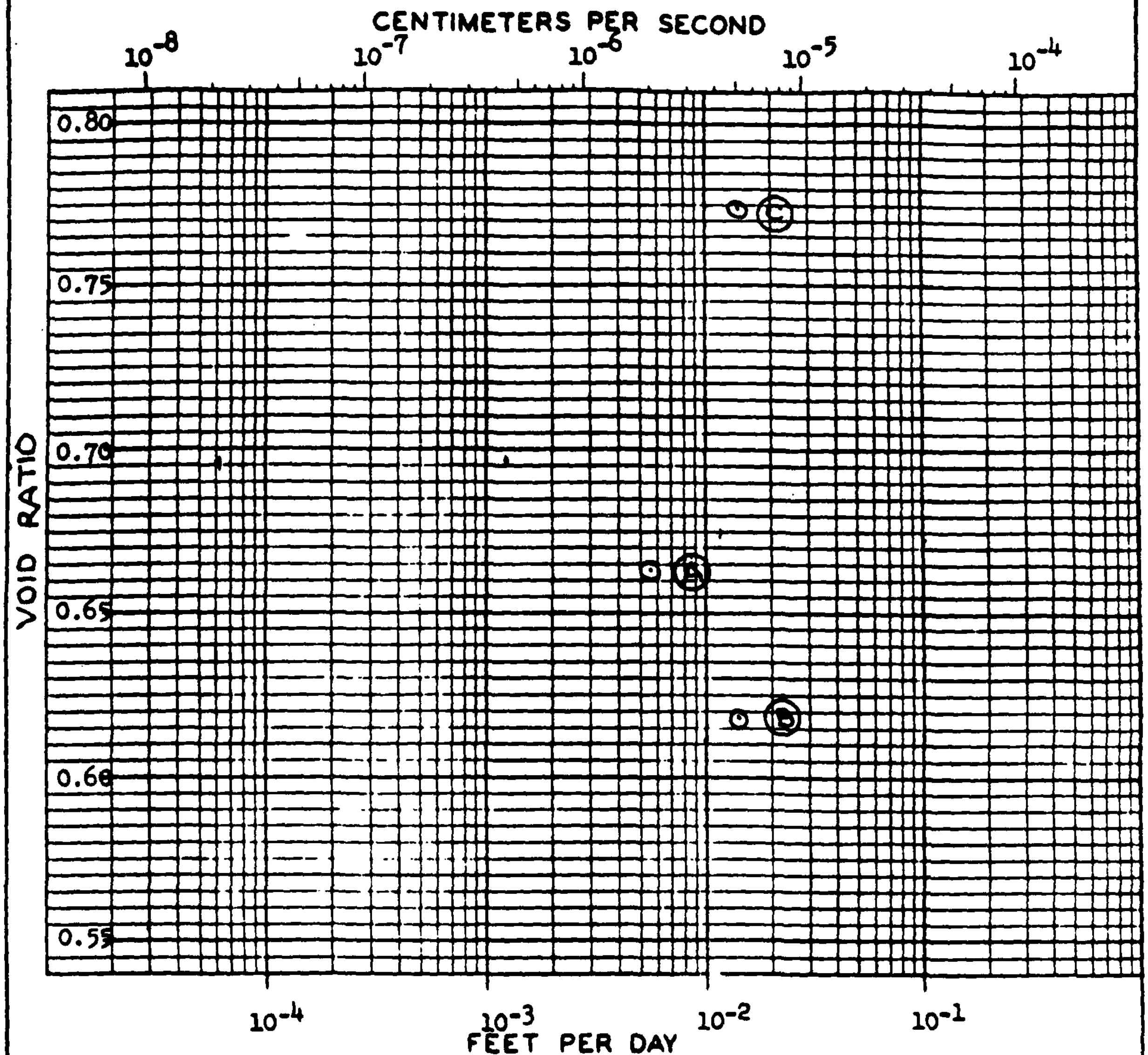


Type of Specimen Undisturbed		Before Test		After Test	
Diam 2.22 in.	Ht 0.50 in.	Water Content, w_o	32.4 %	w_f	31.0 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	0.9022	e_f	0.8375
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	98 %	S_f	100 %
Compression Index, C_c		Dry Density, γ_d	89.2 lb/ft^3		
Classification Sandy Silt (ML)		k_{20} at e_o = x 10^ cm/sec			
LL	G_s 2.72	Project LOWER SANTA ANA RIVER			
PL NP	D_{10}				
Remarks F.S. 1		Area			
		Boring No. 79-10		Sample No. 71832	
		Depth El 16.0		Date January 1980	

CONSOLIDATION TEST REPORT

SOUTH PACIFIC DIVISION LABORATORY

PERMEABILITY



COEFFICIENT OF PERMEABILITY (K) AT 50°F. (10°C.)

REMARKS:

CURVE	SPECIMEN DIAM. IN.	SPECIMEN HT. IN.	SPECIMEN MAX. PARTICLE	SPECIMEN CONDITION
A	2.79	2.53	No. 4	Undisturbed
B	2.76	2.09	No. 100	"
C	2.76	2.41	No. 10	"

DISTRICT: Los Angeles

PROJECT: LOWER SANTA ANA RIVER

CURVE	DIV. NO.	HOLE NO.	F.S. NO.	DEPTH FROM	DEPTH TO
A	71830	79-9	1	15	
B	71831	"	2	30	
C	71832	79-10	1	16	

TESTED	COMPUTED	DRAWN	CHECKED
DW			

DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION, CORPS OF ENGINEERS
LABORATORY

REPORT
OF
SOIL TESTS

SANTA ANA RIVER

EDITED

SEPTEMBER 1983

SAUSALITO, CALIFORNIA

REPORT
OF
SOIL TESTS

SANTA ANA RIVER

SEPTEMBER 1983

AUTHORIZATION

1. Results of tests reported herein were requested by the Los Angeles District in laboratory request No. CIV-83-108 dated 20 July 1983.

SAMPLES

2. Thirteen undisturbed tube samples and 17 sack samples were received on 21 June and 25 July 1983. Identification of samples is on the Soil Test Result Summary, plates 1 and 2.

TESTING PROGRAM

3. The program was in accordance with the test request and verbal instructions from Mr. C. Sands/SPLED-GD, and included laboratory classification tests, triaxial shear, field unit weight, and compaction tests.

TEST METHODS

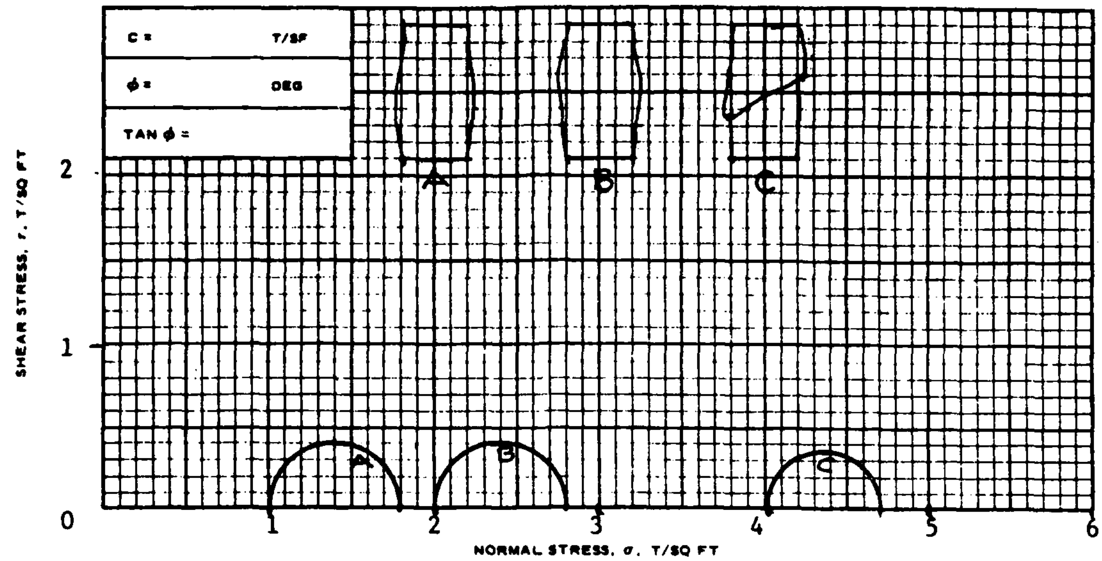
4. a. Grain-size Analysis, Atterberg Limits, Compaction, Specific Gravity, Field Unit Weight, and Triaxial Compression. Testing methods conformed to the procedures described in Engineer Manual, EM 1110-2-1906, "Laboratory Soil Testing", 30 November 1970.

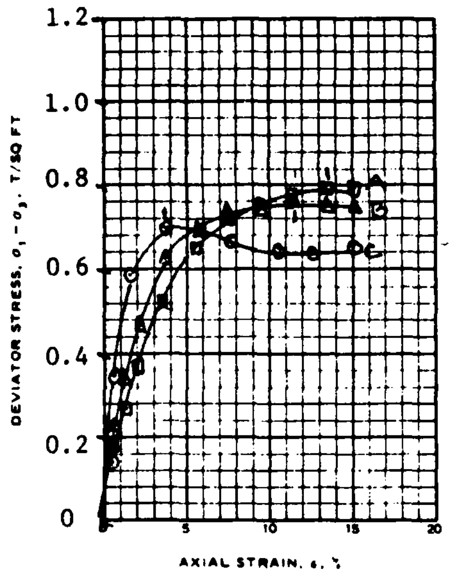
b. Classification. The soils were classified in accordance with the "Unified Soil Classification System", TM 3-337, Appendix A, April 1960, reprinted May 1967.

RESULTS

5. Results of tests are shown on the following plates:

Subject	Plate No.
Soil Test Result Summary	1 - 2
Plasticity Chart	3 - 4
Compaction Test Report	5 - 14
Triaxial Test Report	
Undisturbed	15
Remolded	16 - 19





SPECIMEN NO.			A	B	C
INITIAL	WATER CONTENT, %	w_o	46.1	54.5	48.5
	DRY DENSITY LB/CU FT	γ_{d_o}	75.2	68.2	70.0
	SATURATION, %	S_o	99	99	92
	VOID RATIO	e_o	1.273	1.505	1.442
BEFORE SHEAR	WATER CONTENT, %	w_c	46.0	54.6	51.1
	DRY DENSITY LB/CU FT	γ_{d_c}	75.6	68.5	70.7
	SATURATION, %	S_c	100	100	99
	VOID RATIO	e_c	1.260	1.496	1.417
	FINAL BACK PRESSURE, T/SQ FT	$-u_o$	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$	0.80	0.79	0.70
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f	14	11	4
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$	-	-	-
INITIAL DIAMETER, IN.		D_o	2.85	2.85	2.85
INITIAL HEIGHT, IN.		H_o	6.42	6.42	6.43

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS A & B - Silt (MH); C - Sandy Clay (CH)

LL 61, 59 PL 32, 24 PI 29, 35 Gs 2.74

TYPE OF SPECIMEN Undisturbed TYPE OF TEST Sat Q

REMARKS:

	Div. NO.	Hole
A	82835	2634
B	82835	2634
C	82834	2632

PROJECT SANTA ANA RIVER

BORING NO 2632, 2634 SAMPLE NO.

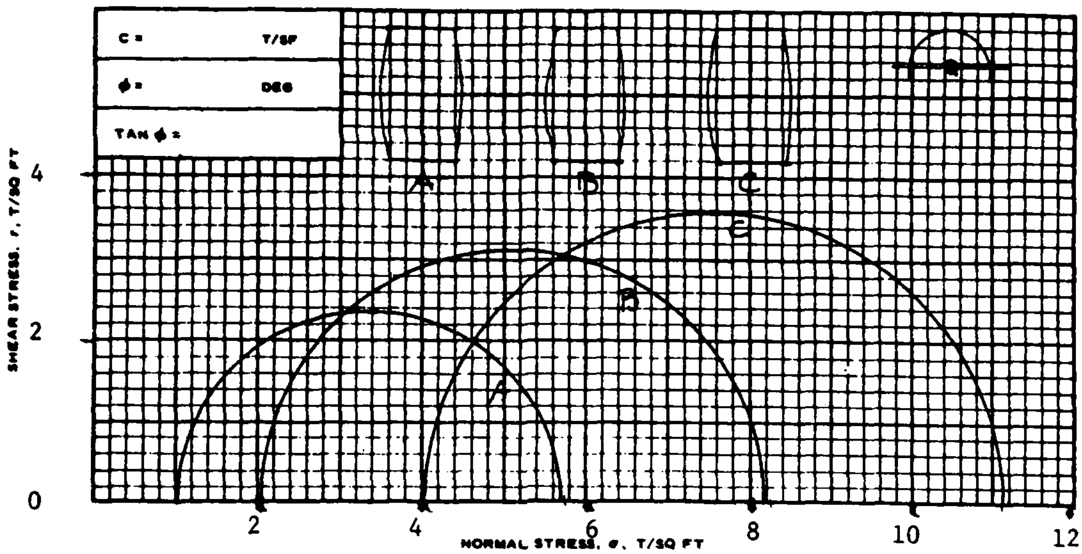
DEPTH ELEV

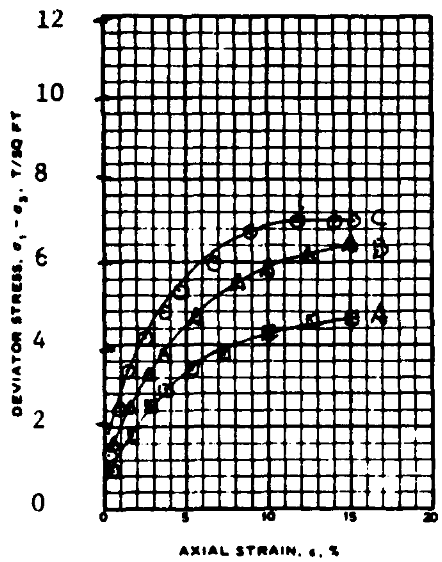
LABORATORY SPDL DATE September 1983

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT

Plate 15





SPECIMEN NO.			A	B	C	
INITIAL	WATER CONTENT, %	w_o	10.6	10.6	10.6	
	DRY DENSITY LB/CU FT	γ_{d_o}	111.0	111.0	111.1	
	SATURATION, %	S_o	55	55	55	
	VOID RATIO	e_o	0.518	0.518	0.517	
BEFORE SHEAR	WATER CONTENT, %	w_c	18.5	18.2	18.1	
	DRY DENSITY LB/CU FT	γ_{d_c}	111.8	112.3	112.4	
	SATURATION, %	S_c	99	98	98	
	VOID RATIO	e_c	0.506	0.501	0.499	
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20	
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00	
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	4.74	6.48	7.12	
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	186	148	175	
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	–	–	–	
INITIAL DIAMETER, IN.		D_o	2.80	2.80	2.80	
INITIAL HEIGHT, IN.		H_o	6.45	6.45	6.45	

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Silty Sand (SM)

LL 18	PL 17	PI 1	G_s 2.69	TYPE OF SPECIMEN Remolded	TYPE OF TEST $\overline{R}$

REMARKS: Remolded to 90% max. density at optimum water content.

Composite: 82538 & 82546

PROJECT SANTA ANA RIVER

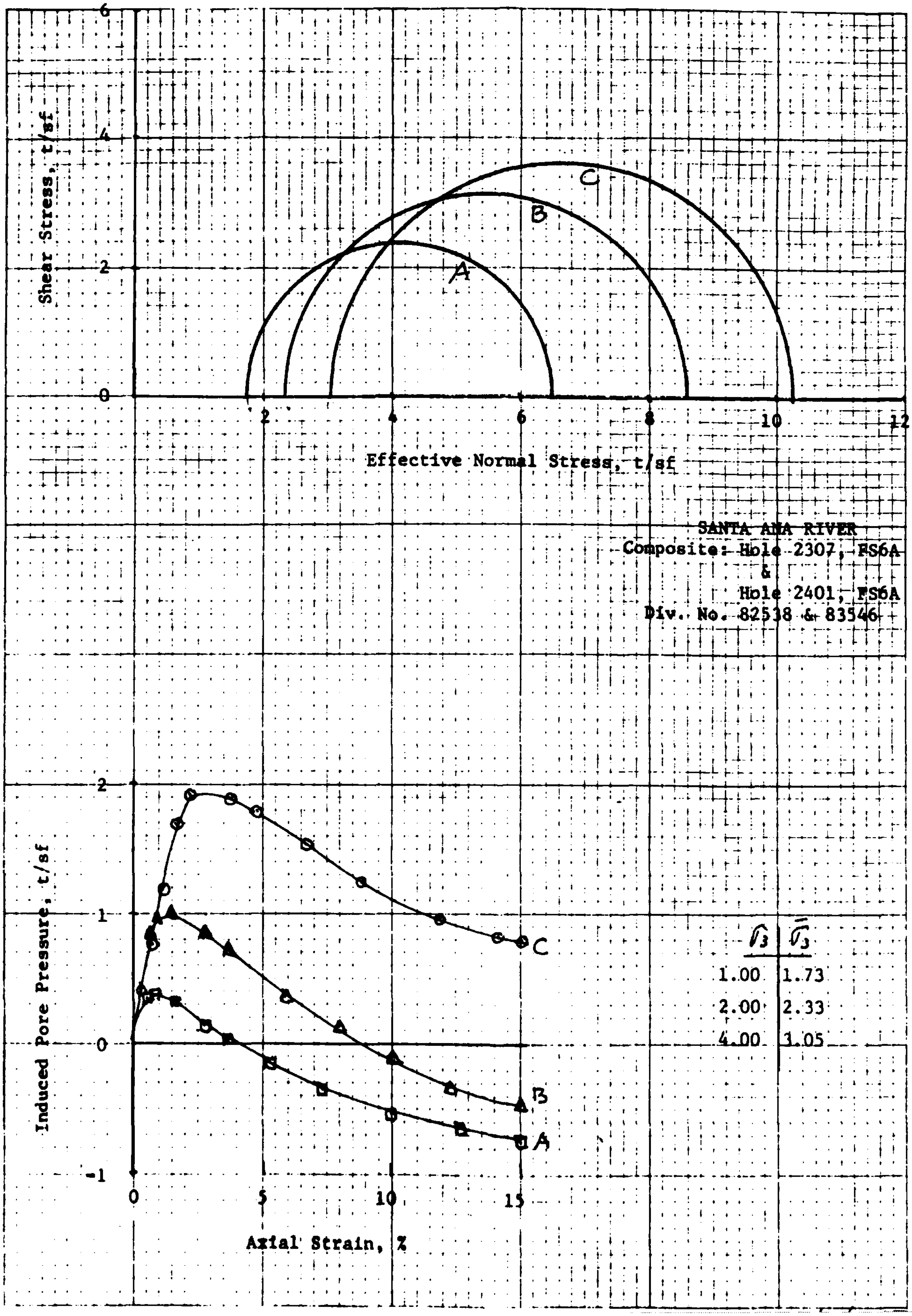
BORING NO. 2307 & 2401 SAMPLE NO. 6A & 6A

DEPTH. ELEV

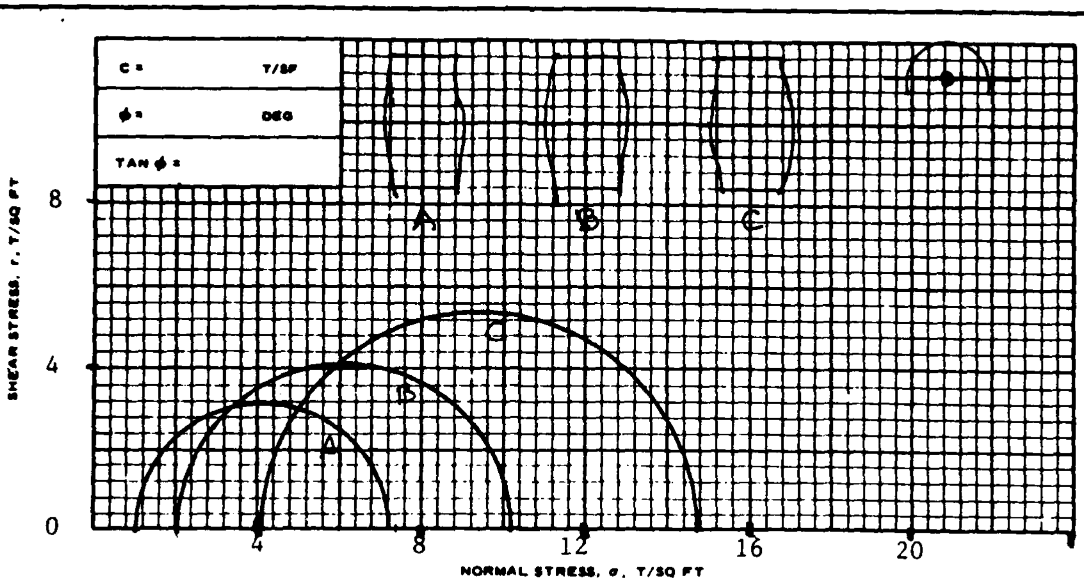
LABORATORY SPDL DATE September 1983

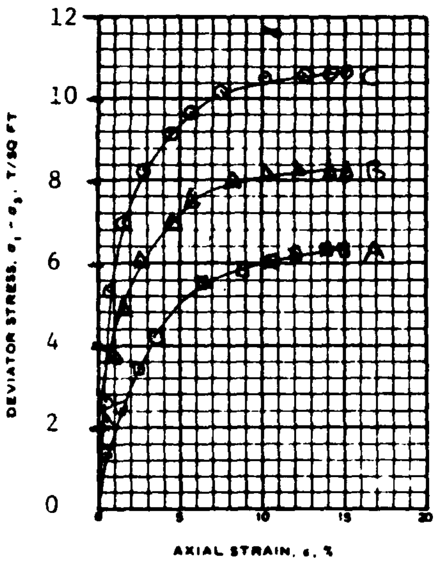
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)



Shear Stress, t/sf
Effective Normal Stress, t/sf
0
2
4
6
8
10
12
A
B
C
SANTA ANA RIVER
Composite: Hole 2307, FS6A
&
Hole 2401, FS6A
Div. No. 82538 & 83546
Induced Pore Pressure, t/sf
Axial Strain, %
-1
0
1
2
5
10
15
σ_3 | $\bar{\sigma}_3$
1.00 | 1.73
2.00 | 2.33
4.00 | 3.05





SPECIMEN NO.			A	B	C
INITIAL	WATER CONTENT, %	w_o	9.0	9.1	9.8
	DRY DENSITY LB/CU FT	γd_o	111.8	111.7	111.1
	SATURATION, %	S_o	48	49	51
	VOID RATIO	e_o	0.501	0.502	0.517
BEFORE SHEAR	WATER CONTENT, %	w_c	17.9	17.9	17.0
	DRY DENSITY LB/CU FT	γd_c	112.3	112.5	115.1
	SATURATION, %	S_c	98	98	99
	VOID RATIO	e_c	0.494	0.492	0.464
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$	6.42	8.21	10.76
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f	192	206	177
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$	-	-	-
INITIAL DIAMETER, IN.		D_o	2.80	2.80	2.80
INITIAL HEIGHT, IN.		H_o	6.45	6.45	6.45

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Silty Sand (SM)

LL 15	PL 15	PI 0	Gs 2.70	TYPE OF SPECIMEN Remolded	TYPE OF TEST R

REMARKS Remolded to 90% maximum density at optimum water content.

Composite: 82539 & 82549

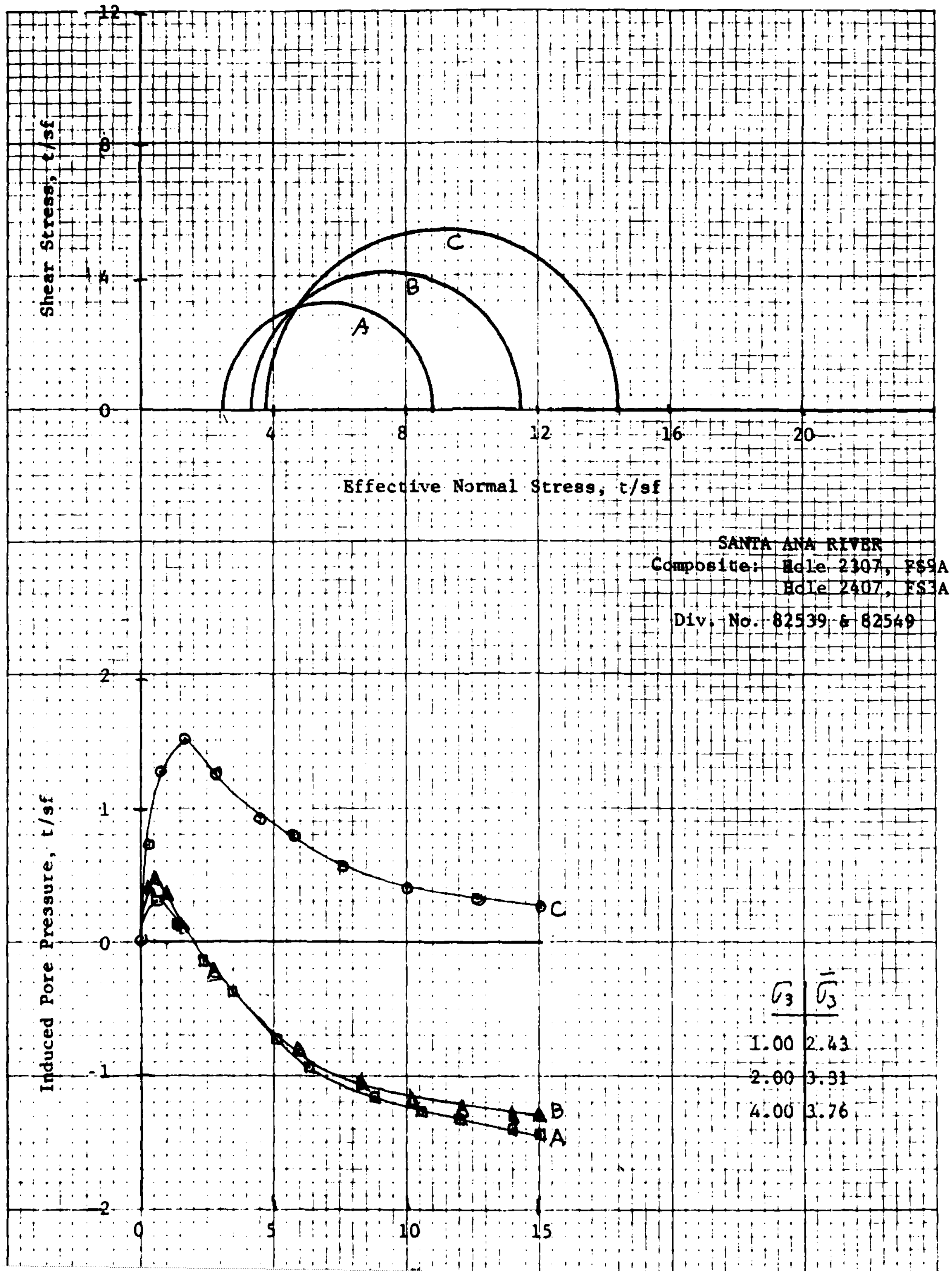
PROJECT SANTA ANA RIVER

BORING NO. 2307 & 2407 — SAMPLE NO. 9A & 3A

DEPTH/ELEV 5.0 - 16.0

LABORATORY SPDL — DATE September 1983

TRIAXIAL COMPRESSION TEST REPORT



12
8
4
0
Shear Stress, t/sf
C
B
A
4
8
12
16
20
Effective Normal Stress, t/sf
SANTA ANA RIVER
Composite: Hole 2307, FS9A
Hole 2407, FS3A
Div. No. 82539 & 82549
2
1
0
-1
-2
Induced Pore Pressure, t/sf
C
B
A
0
5
10
15
σ3 | σ̄3
1.00 | 2.43
2.00 | 3.31
4.00 | 3.76

DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION, CORPS OF ENGINEERS
LABORATORY

REPORT
OF
SOIL TESTS

LOWER SANTA ANA RIVER

EDITED

December 1985

SAUSALITO, CALIFORNIA

REPORT
OF
SOIL TESTS

LOWER SANTA ANA RIVER

December 1985

AUTHORIZATION

1. Results of tests reported herein were requested by the Los Angeles District in laboratory request No. E86-85-0057 dated 14 March 1985.

SAMPLES

2. Twenty-two undisturbed samples in brass and plastic tubes were received on 17 January 1985. Twenty-six disturbed samples in sacks were received on 25 March 1985. Identification of samples is on the Soil Test Result Summary, plates 1-2 and 36-37.

TESTING PROGRAM

3. The program was in accordance with the test request and included laboratory classification tests, unit weight, unconfined compresssion, direct shear, consolidation, triaxial shear and compaction.

TEST METHODS

4. a. Grain-size Anlaysis, Atterberg Limits, Unit Weight, Compaction, Specific Gravity, Triaxial Compression, Unconfined Compression, and Consolidation. Testing methods conformed to the procedures described in Engineer Manual, EM 1110-2-1906, "Laboratory Soil Testing", 30 November 1970.

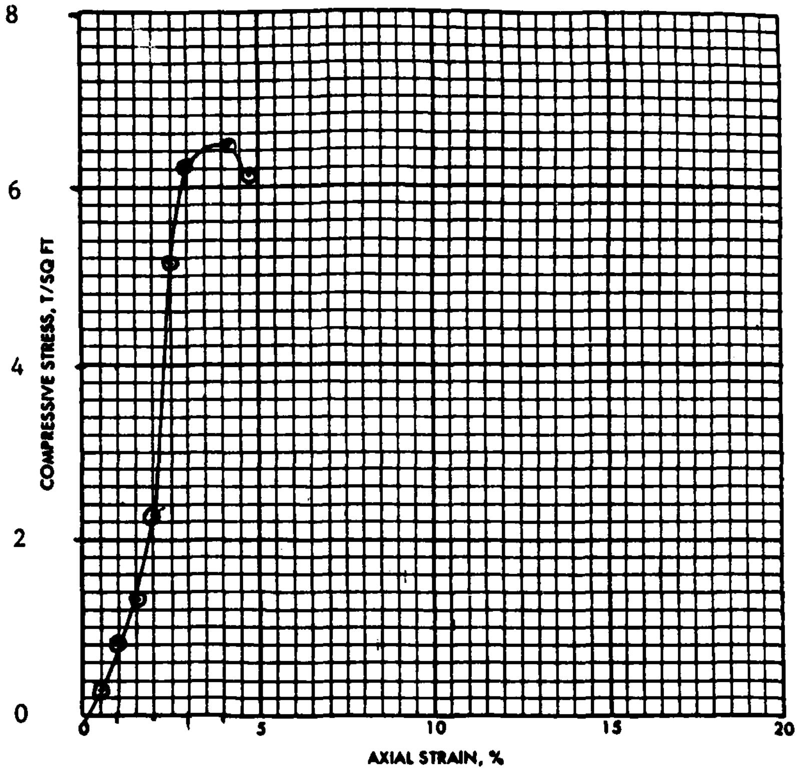
b. Classification. The soils were classified in accordance with the "Unified Soil Classification System", TM 3-337, Appendix A, April 1960, reprinted May 1967.

RESULTS

5. Results of tests are shown on the following plates:

Subject	Plate No.
Undisturbed samples:	
Soil Test Result Summary	1-2
Field Unit Weight Summary	3
Unconfined Compression Test Report	4-6
Triaxial Compression Test Report	7-19
Consolidation Test Report	20-35

FAILURE SKETCHES



☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO.						
TYPE OF SPECIMEN			UD			
INITIAL	WATER CONTENT	w_o	10.8 %	%	%	%
INITIAL	VOID RATIO	e_o	0.442			
INITIAL	SATURATION	S_o	66 %	%	%	%
INITIAL	DRY DENSITY, LB/CU FT	γ_d	117.3			
TIME TO FAILURE, MIN		t_f	6			
UNCONFINED COMPRESSIVE STRENGTH, T/SQ FT		q_u	6.47			
UNDRAINED SHEAR STRENGTH, T/SQ FT		s_u	3.23			
SENSITIVITY RATIO		S_t	-			
INITIAL SPECIMEN DIAMETER, IN		D_o	2.34			
INITIAL SPECIMEN HEIGHT, IN.		H_o	5.55			

CLASSIFICATION Sandy Clay(CL)

LL 34 | PL 15 | PI 19 | G_s 2.71

REMARKS
Div. No. 91044

PROJECT LOWER SANTA ANA RIVER

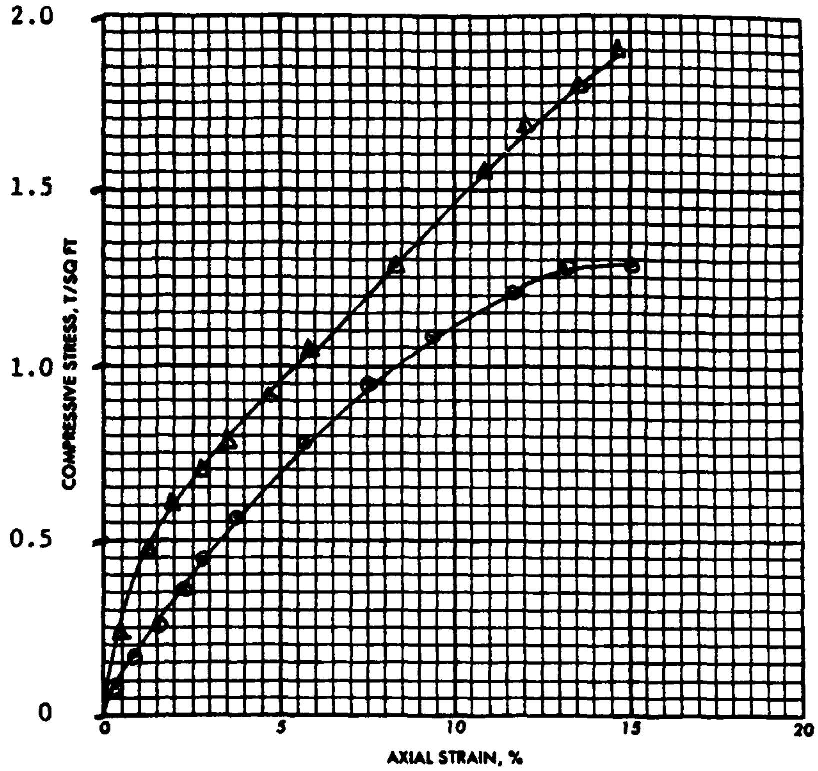
AREA

BORING NO. TH-84-1503 | SAMPLE NO. 9-1

DEPTH 36'-38' | DATE October 1985

FAILURE SKETCHES

1810B



☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO.			1510	1810B		
TYPE OF SPECIMEN			⊙	△		
INITIAL	WATER CONTENT	w_o	16.6 %	21.3 %	%	%
	VOID RATIO	e_o	0.483	0.682		
	SATURATION	S_o	94 %	85 %	%	%
	DRY DENSITY, LB/CU FT	γ_d	114.4	100.9		
TIME TO FAILURE, MIN		t_f	15	12		
UNCONFINED COMPRESSIVE STRENGTH, T/SQ FT		q_u	1.29	1.90		
UNDRAINED SHEAR STRENGTH, T/SQ FT		s_u	0.65	0.95		
SENSITIVITY RATIO		S_t	–	–		
INITIAL SPECIMEN DIAMETER, IN		D_o	2.42	1.41		
INITIAL SPECIMEN HEIGHT, IN.		H_o	5.50	3.23		

CLASSIFICATION ⊙ Sandy Clay (CL) △ Clay (CL)

LL 33, 36 | PL 15, 21 | PI 18, 15 | G_s

REMARKS

Div. No.	Hole	FS	Depth
91047	1510	11-2	38-40
91050	1810B	3-1	11.5

PROJECT LOWER SANTA ANA RIVER

AREA

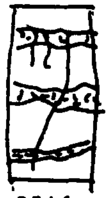
BORING NO. TH-84-1510 & 1810B | SAMPLE NO. 11-2, 3-1

DEPTH / EL | DATE October 1985

UNCONFINED COMPRESSION TEST REPORT

FAILURE SKETCHES

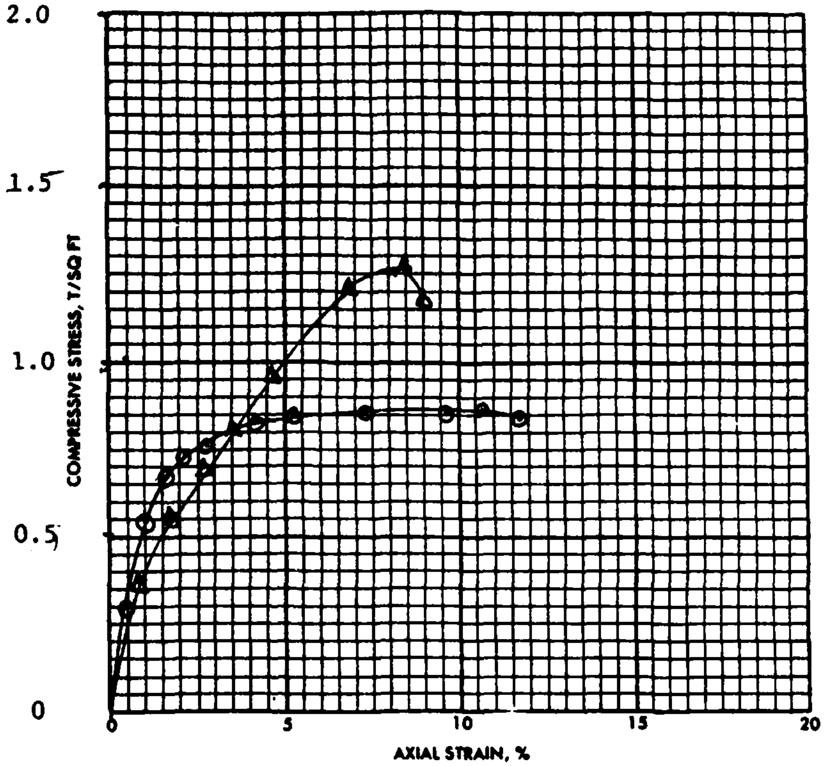
2301



2546

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN



TEST NO.			2301	2546		
TYPE OF SPECIMEN			○	△		
INITIAL	WATER CONTENT	w_o	28.3 %	32.67 %	%	%
	VOID RATIO	e_o	0.841	0.998		
	SATURATION	S_o	91 %	88 %	%	%
	DRY DENSITY, LB/CU FT	γ_d	91.5	84.3		
TIME TO FAILURE, MIN		t_f	8	6		
UNCONFINED COMPRESSIVE STRENGTH, T/SQ FT		q_u	0.87	1.28		
UNDRAINED SHEAR STRENGTH, T/SQ FT		s_u	0.44	0.64		
SENSITIVITY RATIO		S_t	-	-		
INITIAL SPECIMEN DIAMETER, IN		D_o	2.39	1.49		
INITIAL SPECIMEN HEIGHT, IN.		H_o	5.51	3.22		

CLASSIFICATION ○ Sandy Clay; △ Clay(CL)

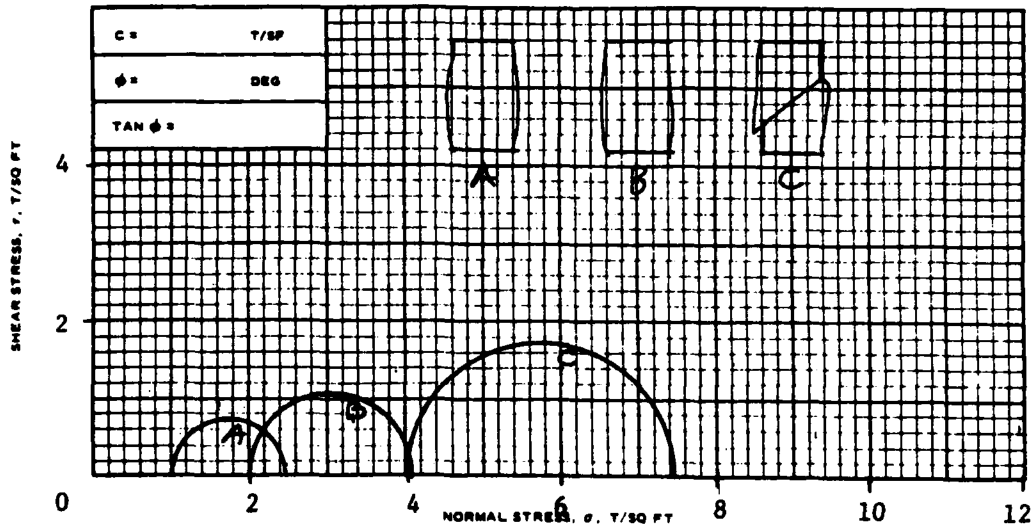
LL	PL	PI	G_s
43, 49	17, 25	26, 24	

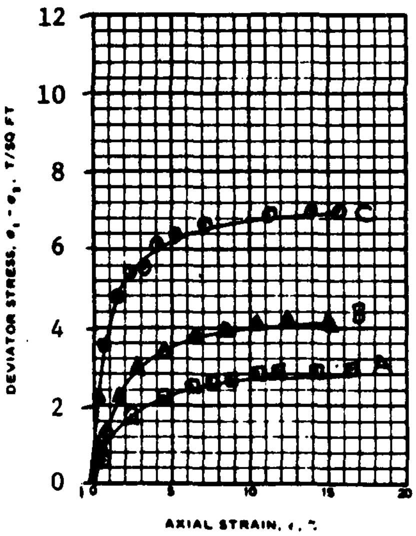
REMARKS

~~Div. No.~~	~~Hole~~	~~FS~~	~~Depth~~
91054	2301	5-2	15
91062	2546	1-1	4.5

PROJECT LOWER SANTA ANA RIVER	
AREA	
BORING NO. 2301 & 2546	SAMPLE NO. 5-2 & 1-1
DEPTH EL	DATE October 1985

UNCONFINED COMPRESSION TEST REPORT





SPECIMEN NO.			A	B	C
INITIAL	WATER CONTENT, %	w_o	32.3	33.6	40.1
	DRY DENSITY LB/CU FT	γ_{d_o}	89.4	87.3	80.0
	SATURATION, %	S_o	99	98	98
	VOID RATIO	e_o	0.877	0.923	1.099
BEFORE SHEAR	WATER CONTENT, %	w_c	30.8	32.3	33.7
	DRY DENSITY LB/CU FT	γ_{d_c}	91.8	89.9	88.0
	SATURATION, %	S_c	100	100	100
	VOID RATIO	e_c	0.828	0.868	0.907
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$	1.47	2.10	3.48
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f	215	210	164
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$	–	–	–
INITIAL DIAMETER, IN.		D_o	1.40	1.40	1.41
INITIAL HEIGHT, IN.		H_o	3.20	3.20	3.20

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Sandy Clay (CL)

LL 46 | PL 22 | PI 24 | Gs 2.69 | TYPE OF SPECIMEN Undisturbed | TYPE OF TEST R̄

REMARKS:
Div. No. 91043
(Substitute for 91046)

PROJECT Lower Santa Ana River

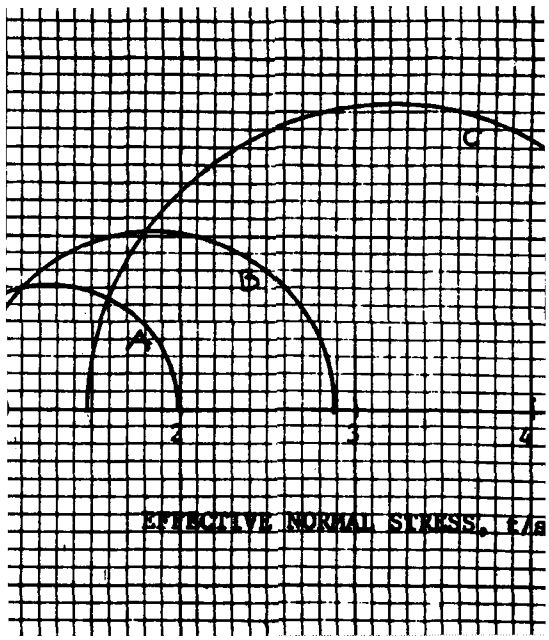
BORING NO. 0902 SAMPLE NO.

DEPTH/ELEV 33' - 37'

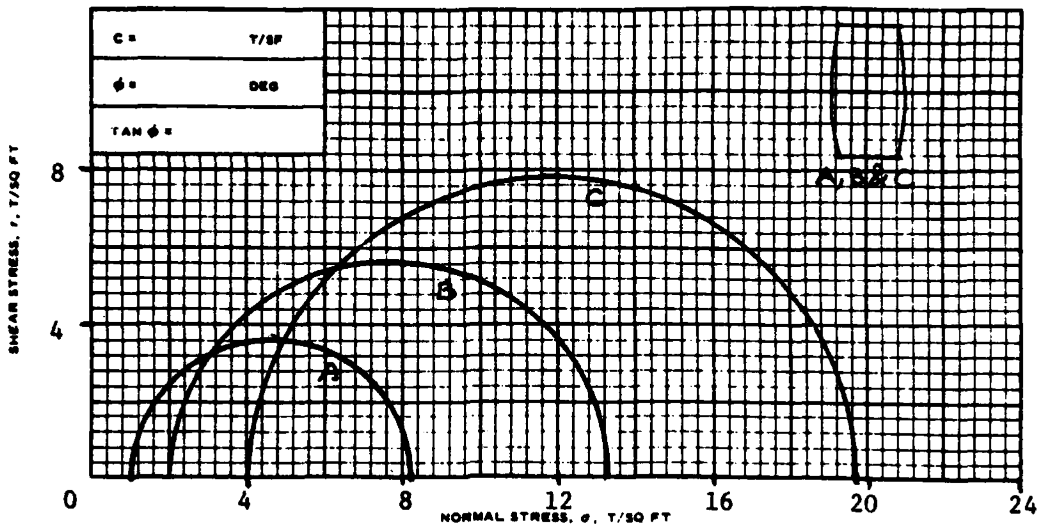
LABORATORY SPDL DATE May 1985

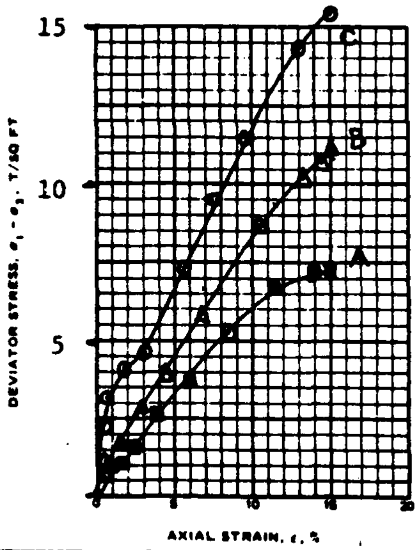
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089
REV JUNE 1970



C
B
A
2
3
4
EFFECTIVE NORMAL STRESS, t/s





SPECIMEN NO.			A	B	C
INITIAL	WATER CONTENT, %	w_o	22.1	24.5	25.3
	DRY DENSITY LB/CU FT	γ_{d_o}	92.3	96.8	96.9
	SATURATION, %	S_o	72	88	92
	VOID RATIO	e_o	0.840	0.753	0.750
BEFORE SHEAR	WATER CONTENT, %	w_c	30.5	24.6	25.7
	DRY DENSITY LB/CU FT	γ_{d_c}	92.8	101.7	99.9
	SATURATION, %	S_c	100	100	100
	VOID RATIO	e_c	0.830	0.669	0.699
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	7.36	11.21	15.74
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	181	198	170
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	-	-	-
INITIAL DIAMETER, IN.		D_o	1.41	1.40	1.40
INITIAL HEIGHT, IN.		H_o	3.20	3.20	3.22

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Sandy Silt (ML)

LL	PL	PI NP	Gs 2.72	TYPE OF SPECIMEN Undisturbed	TYPE OF TEST $\bar{R}$

REMARKS: Div. No. 91048

PROJECT Lower Santa Ana River

BORING NO. TH-84-1607 SAMPLE NO. 4-1

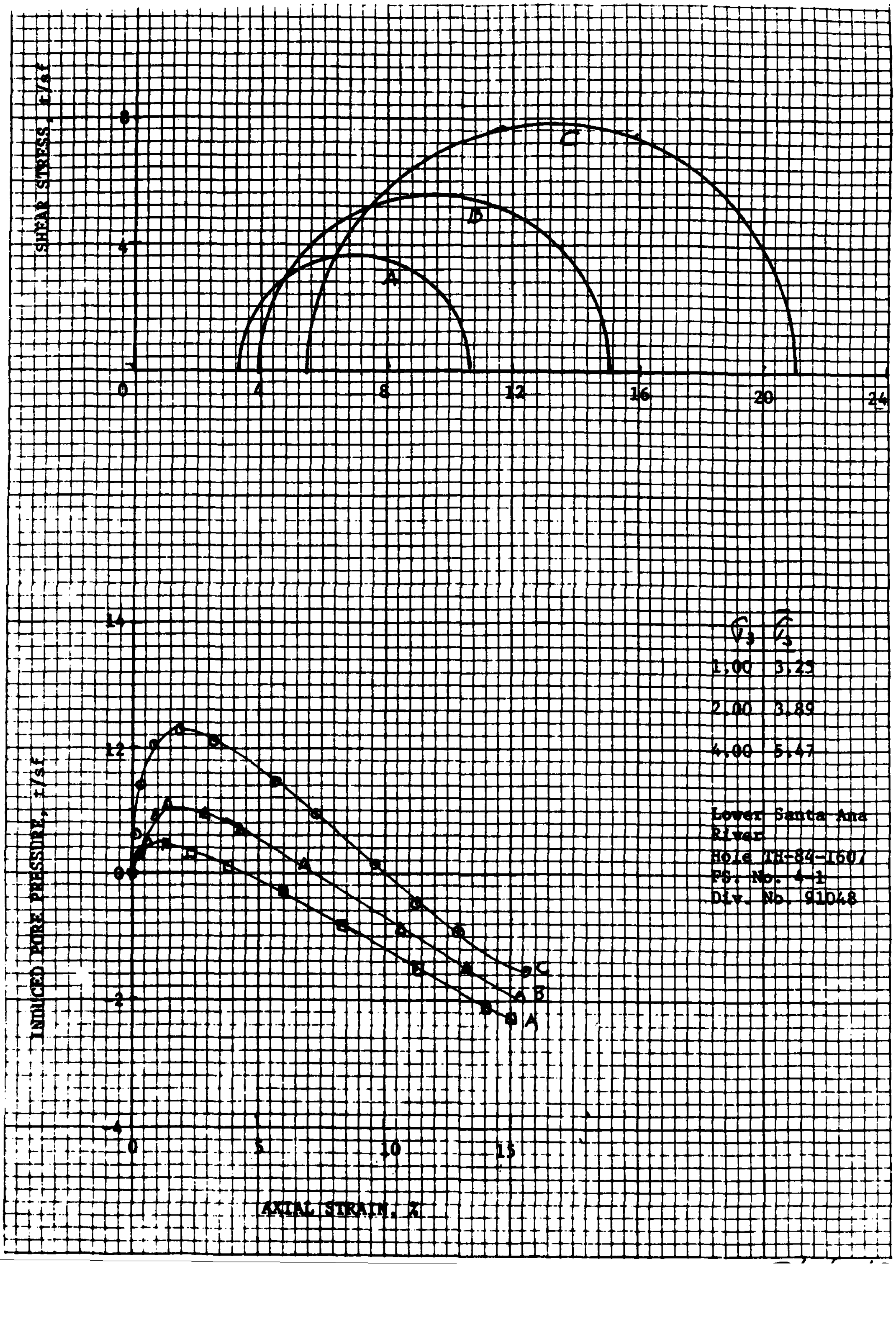
DEPTH/ELEV 18

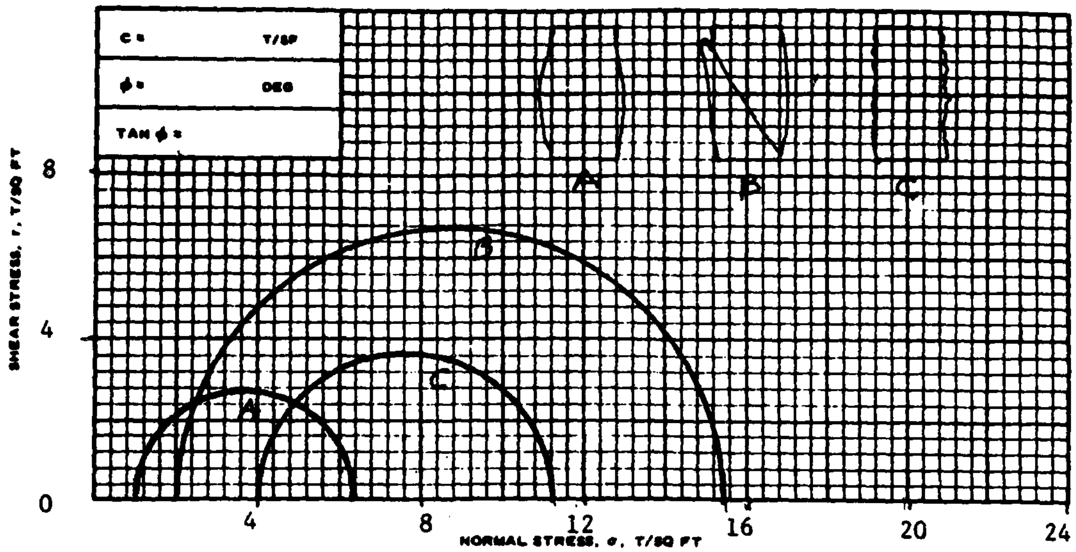
LABORATORY SPDL DATE May 1985

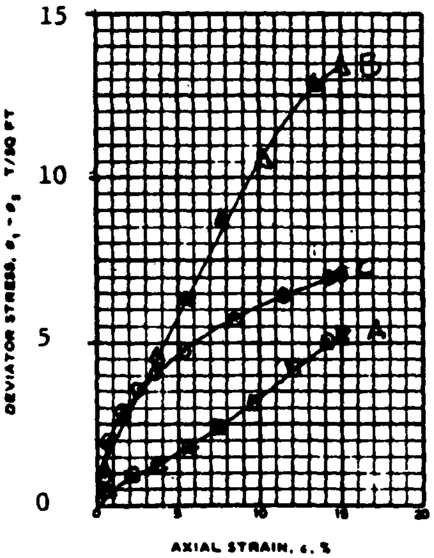
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089
REV JUNE 1970

Plate 9


SHEAR STRESS, t/sf
8
4
0
4
8
12
16
20
24
A
B
C
INDUCED PORE PRESSURE, t/sf
14
12
2
4
0
5
10
15
AXIAL STRAIN, %
σ_3 $\bar{\sigma}_3$
1.00 3.25
2.00 3.89
4.00 5.47
Lower Santa Ana
River
Hole TH-84-1607
PS. No. 4-1
Div. No. 91048





SPECIMEN NO.			A	B	C
INITIAL	WATER CONTENT, %	w_o	27.1	26.3	21.6
	DRY DENSITY LB/CU FT	γ_{d_o}	88.7	95.1	92.1
	SATURATION, %	S_o	81	92	70
	VOID RATIO	e_o	0.899	0.771	0.830
BEFORE SHEAR	WATER CONTENT, %	w_c	31.8	27.5	28.7
	DRY DENSITY LB/CU FT	γ_{d_c}	90.7	96.7	94.9
	SATURATION, %	S_c	100	100	100
	VOID RATIO	e_c	0.857	0.742	0.776
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	5.33	13.53	7.27
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	180	187	163
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	–	–	–
INITIAL DIAMETER, IN.		D_o	1.40	1.40	1.40
INITIAL HEIGHT, IN.		H_o	3.22	2.85	3.22

CONTROLLED- Strain TEST

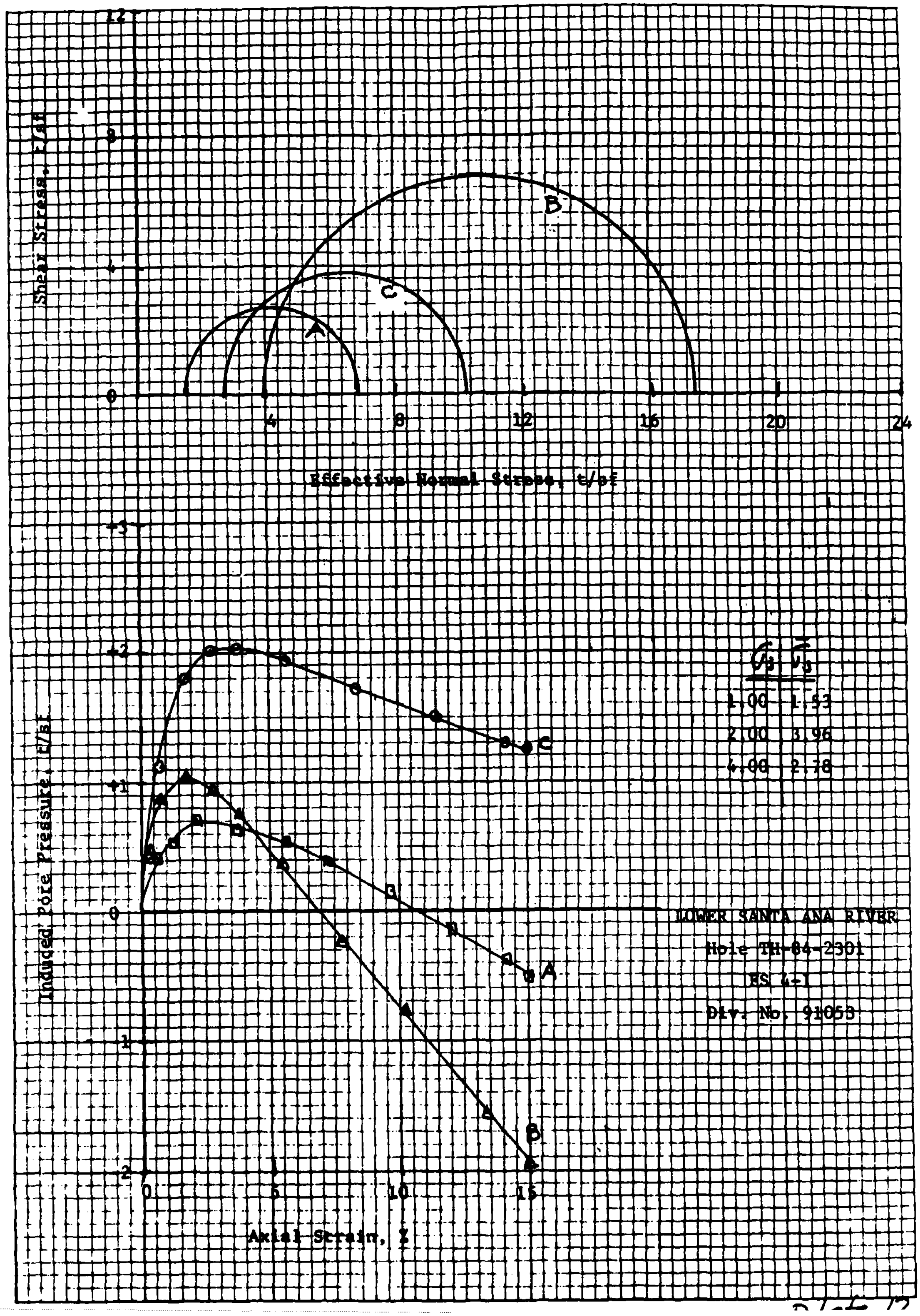
DESCRIPTION OF SPECIMENS Silty Sand(SM)

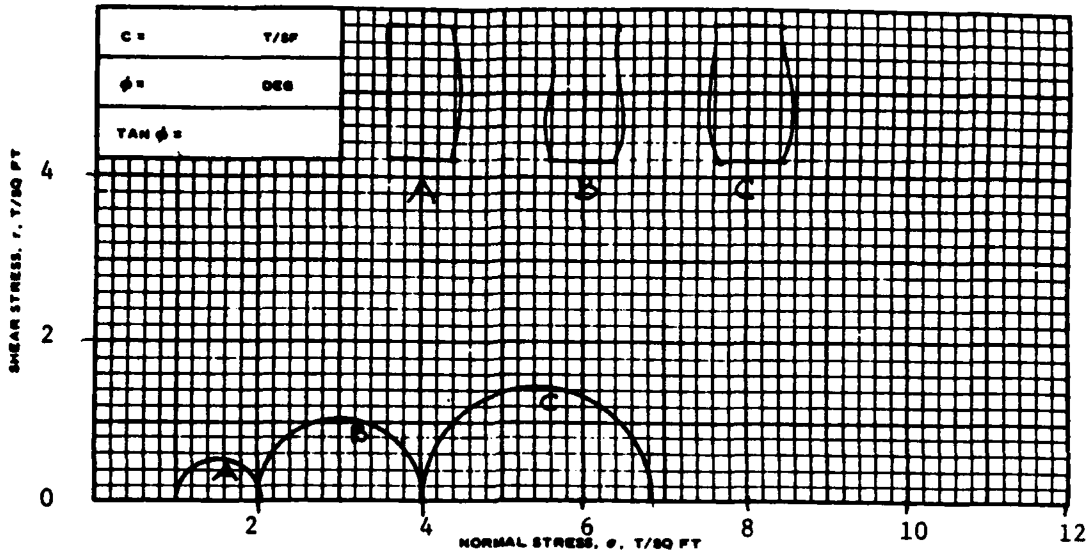
LL	PL NP	PI	Gs 2.70	TYPE OF SPECIMEN Undisturbed	TYPE OF TEST $\overline{R}$

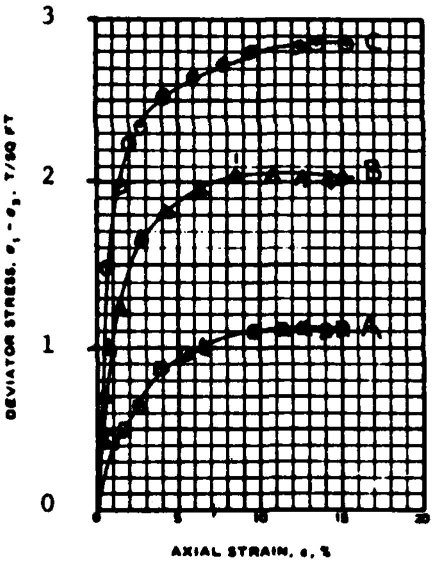
REMARKS Div. No. 91053	PROJECT LOWER SANTA ANA RIVER
	BORING NO. TH-84-2301 — SAMPLE NO. 4-1
	DEPTH/ELEV 10
	LABORATORY SPDL — DATE November 1985
	TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT *(EM 1110-2-1906)*

– 1 – ... 11


Shear Stress, t/sf
Effective Normal Stress, t/sf
A
B
C
Induced Pore Pressure, t/sf
Axial Strain, %
σ3 σ̄3
1.00 1.53
2.00 3.96
4.00 2.78
LOWER SANTA ANA RIVER
Hole TH-84-2301
FS 4-1
Div. No. 91053





SPECIMEN NO.			A	B	C	
INITIAL	WATER CONTENT, %	w_o	52.8	39.3	39.5	
INITIAL	DRY DENSITY LB/CU FT	γd_o	68.0	78.5	78.5	
INITIAL	SATURATION, %	S_o	96	92	92	
INITIAL	VOID RATIO	e_o	1.497	1.162	1.164	
BEFORE SHEAR	WATER CONTENT, %	w_c	52.3	39.7	38.0	
BEFORE SHEAR	DRY DENSITY LB/CU FT	γd_c	70.0	81.6	83.5	
BEFORE SHEAR	SATURATION, %	S_c	100	100	100	
BEFORE SHEAR	VOID RATIO	e_c	1.424	1.081	1.033	
BEFORE SHEAR	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20	
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00	
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$	1.11	2.05	2.85	
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f	90	81	170	
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$	-	2.02	-	
INITIAL DIAMETER, IN.		D_o	1.43	1.43	1.43	
INITIAL HEIGHT, IN.		H_o	3.22	3.15	3.13	

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Clay(CH)

LL 69	PL 26	PI 43	Gs 2.72	TYPE OF SPECIMEN Undisturbed	TYPE OF TEST $\bar{R}$

REMARKS: Div. No. 91056

PROJECT LOWER SANTA ANA RIVER

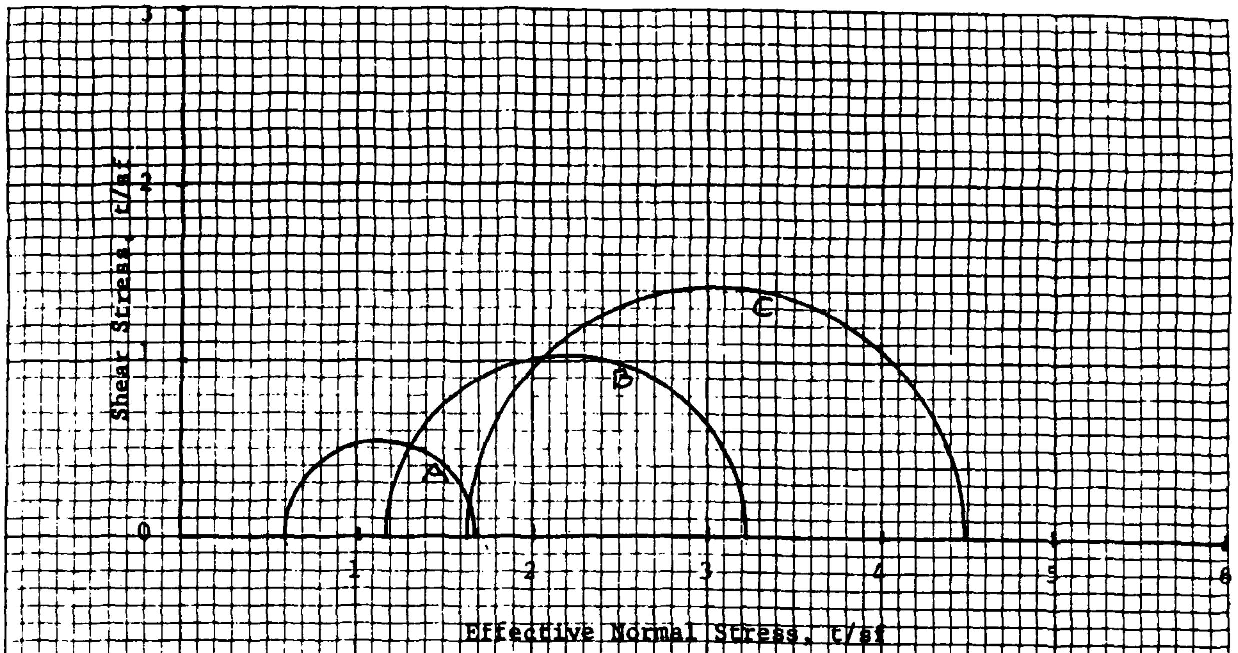
BORING NO. TH-84-2534 SAMPLE NO. 12-1

DEPTH/ELEV 12

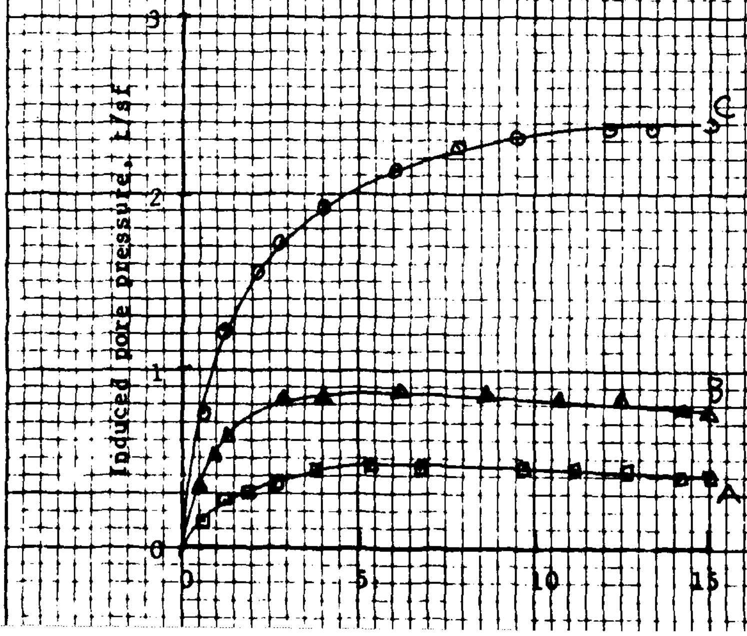
LABORATORY SPDL DATE November 1985

TRIAXIAL COMPRESSION TEST REPORT

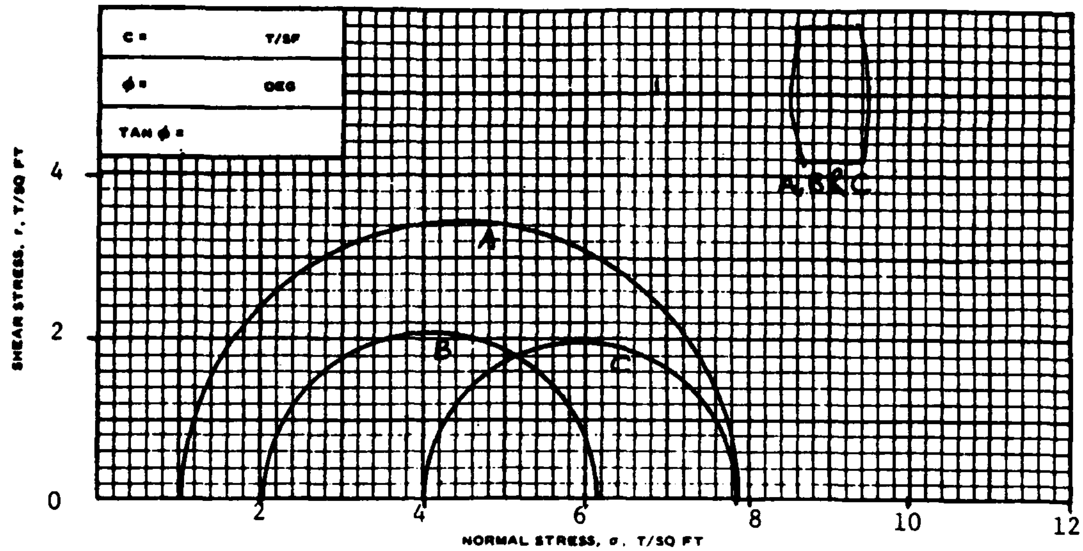
ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)

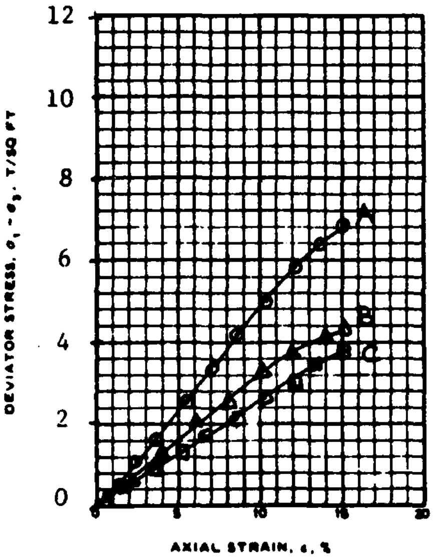


σ_3	$\bar{\sigma}_3$
1.00	0.59
2.00	1.17
4.00	1.63



LOWER SANTA ANA RIVER
Hole TH-84-2534
FS 12-1
Div. No. 91056





SPECIMEN NO.			A	B	C	
INITIAL	WATER CONTENT, %	w_o	28.4	31.9	31.7	
	DRY DENSITY LB/CU FT	γ_{d_o}	97.5	90.3	91.1	
	SATURATION, %	S_o	100	99	100	
	VOID RATIO	e_o	0.767	0.872	0.855	
BEFORE SHEAR	WATER CONTENT, %	w_c	28.3	32.2	31.6	
	DRY DENSITY LB/CU FT	γ_{d_c}	95.7	90.3	91.1	
	SATURATION, %	S_c	100	100	100	
	VOID RATIO	e_c	0.767	0.872	0.855	
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20	
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00	
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	6.89	4.40	3.83	
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	18	15	18	
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	–	–	–	
INITIAL DIAMETER, IN.		D_o	1.40	1.40	1.40	
INITIAL HEIGHT, IN.		H_o	3.18	3.18	3.18	

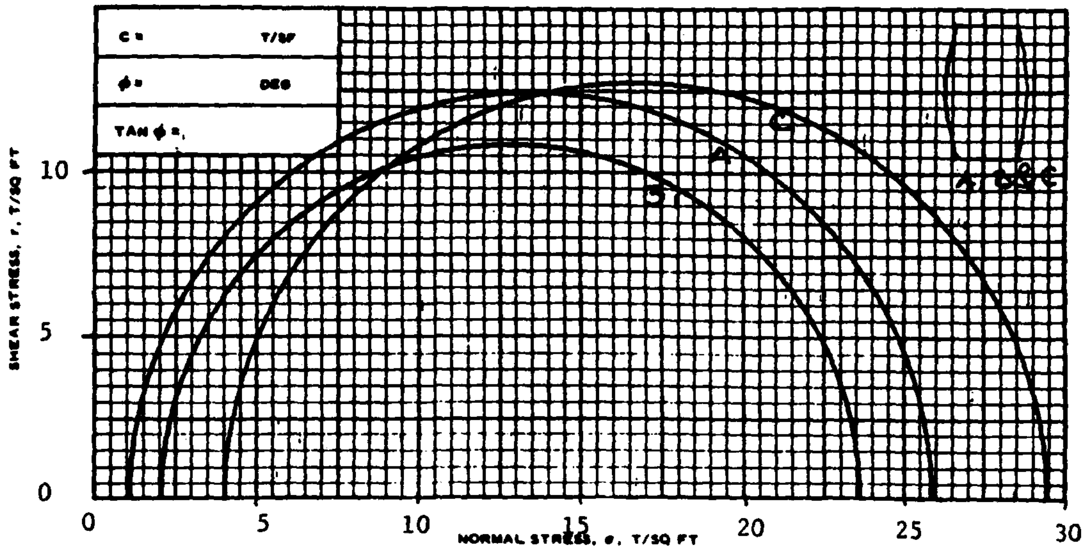
CONTROLLED- Strain TEST

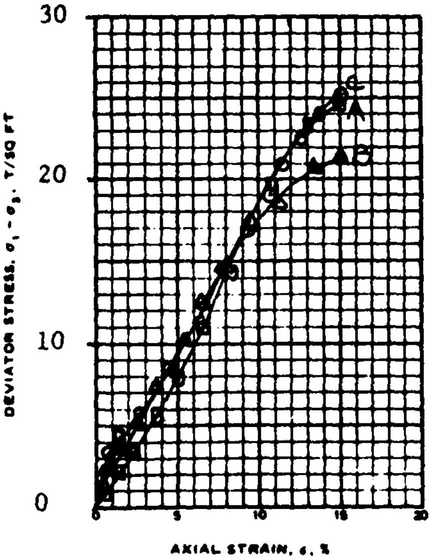
DESCRIPTION OF SPECIMENS Silr(ML)

LL 33	PL 32	PI 1	G 2.71	TYPE OF SPECIMEN Undisturbed	TYPE OF TEST Q Sat.

REMARKS:	PROJECT Santa Ana River
Div. No. 91057	
	BORING NO. TH-842534	SAMPLE NO. 15-1
	DEPTH/ELEV 15
	LABORATORY SPDL	DATE April 1985
	TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT *(EM 1110-2-1906)*





SPECIMEN NO.			A	B	C
INITIAL	WATER CONTENT, %	w_o	21.5	17.4	21.4
	DRY DENSITY LB/CU FT	γ_{d_o}	103.1	103.2	105.5
	SATURATION, %	S_o	93	75	98
	VOID RATIO	e_o	0.622	0.621	0.585
BEFORE SHEAR	WATER CONTENT, %	w_c	22.8	22.3	21.0
	DRY DENSITY LB/CU FT	γ_{d_c}	103.9	104.7	107.1
	SATURATION, %	S_c	100	100	100
	VOID RATIO	e_c	0.610	0.597	0.562
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$	24.91	21.59	25.37
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f	175	242	216
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$	-	-	-
INITIAL DIAMETER, IN.		D_o	1.40	1.40	1.41
INITIAL HEIGHT, IN.		H_o	3.22	3.22	3.22

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Silty Sand(SM)

LL	PL NP	PI	G_s 2.68	TYPE OF SPECIMEN Undisturbed	TYPE OF TEST $\overline{R}$

REMARKS:

Div. No. 91058

PROJECT LOWER SANTA ANA RIVER

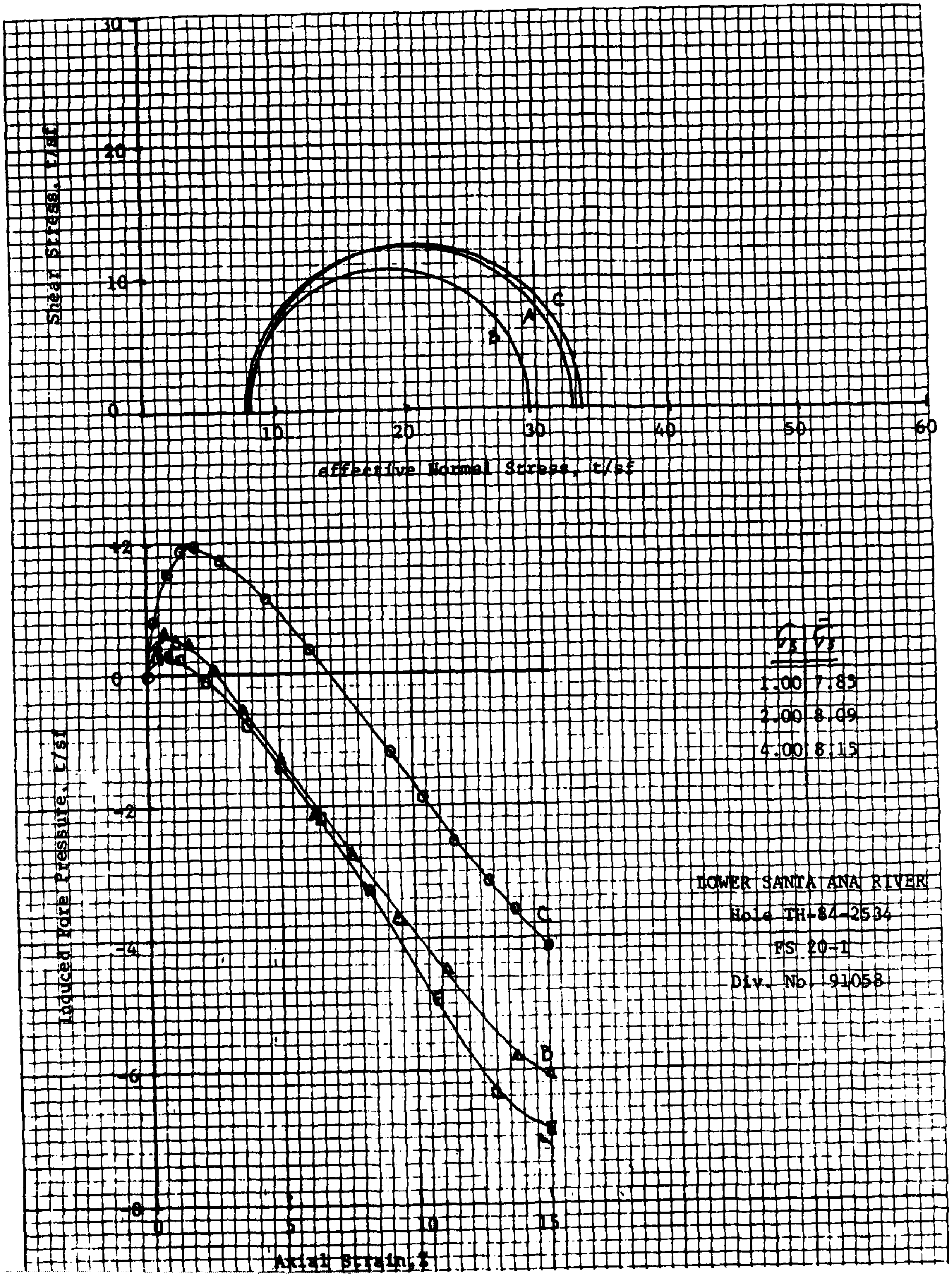
BORING NO. TH-84-2534 SAMPLE NO. 20-1

DEPTH/ELEV 20

LABORATORY SPDL DATE December 1985

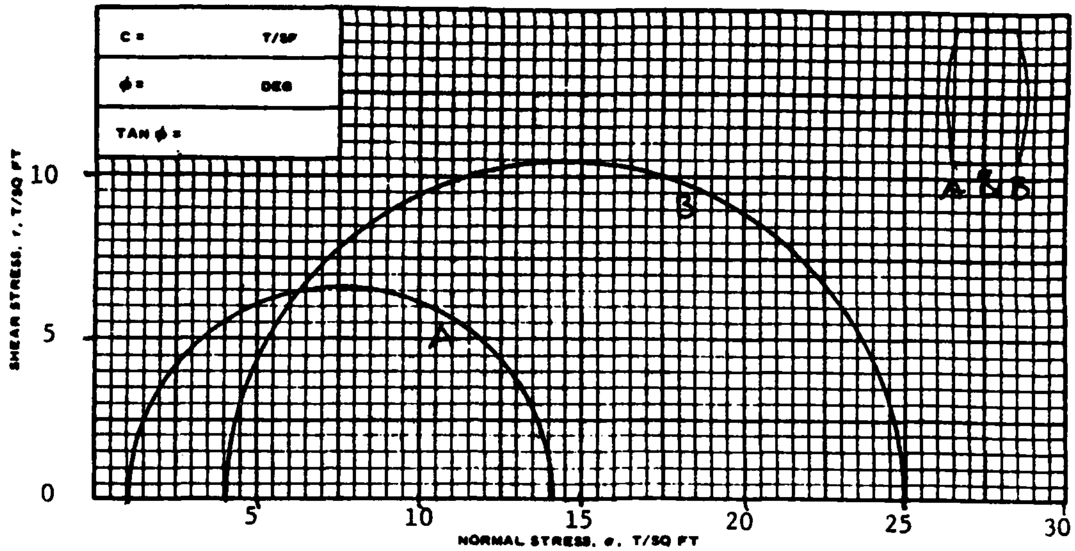
TRIAXIAL COMPRESSION TEST REPORT

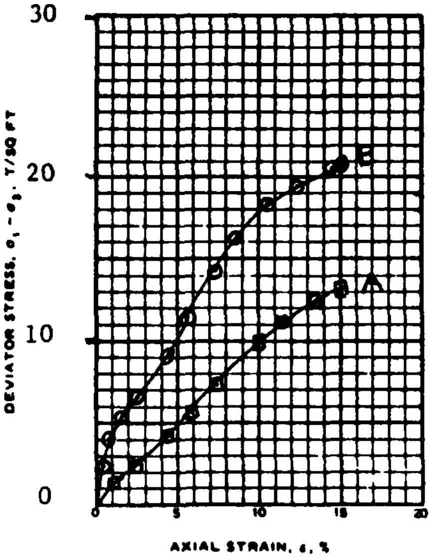
ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)



σ_3	$\bar{\sigma}_3$
1.00	7.85
2.00	8.09
4.00	8.15

LOWER SANTA ANA RIVER
Hole TH-84-2534
FS 20-1
Div. No. 91058





SPECIMEN NO.			A	B		
INITIAL	WATER CONTENT, %	w_o	24.8	23.8		
	DRY DENSITY LB/CU FT	γd_o	95.5	97.3		
	SATURATION, %	S_o	88	88		
	VOID RATIO	e_o	0.758	0.726		
BEFORE SHEAR	WATER CONTENT, %	w_c	27.7	26.0		
	DRY DENSITY LB/CU FT	γd_c	96.2	98.7		
	SATURATION, %	S_c	100	100		
	VOID RATIO	e_c	0.745	0.700		
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20		
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	4.00		
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$	13.15	21.01		
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f	223	208		
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$	-	-		
INITIAL DIAMETER, IN.		D_o	1.40	1.40		
INITIAL HEIGHT, IN.		H_o	3.22	3.22		

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Silty Sand(SP-SM)

LL	PL NP	PI	G_s 2.69	TYPE OF SPECIMEN Undisturbed	TYPE OF TEST $\bar{R}$

REMARKS: Division No. 91059

PROJECT Lower Santa Ana River

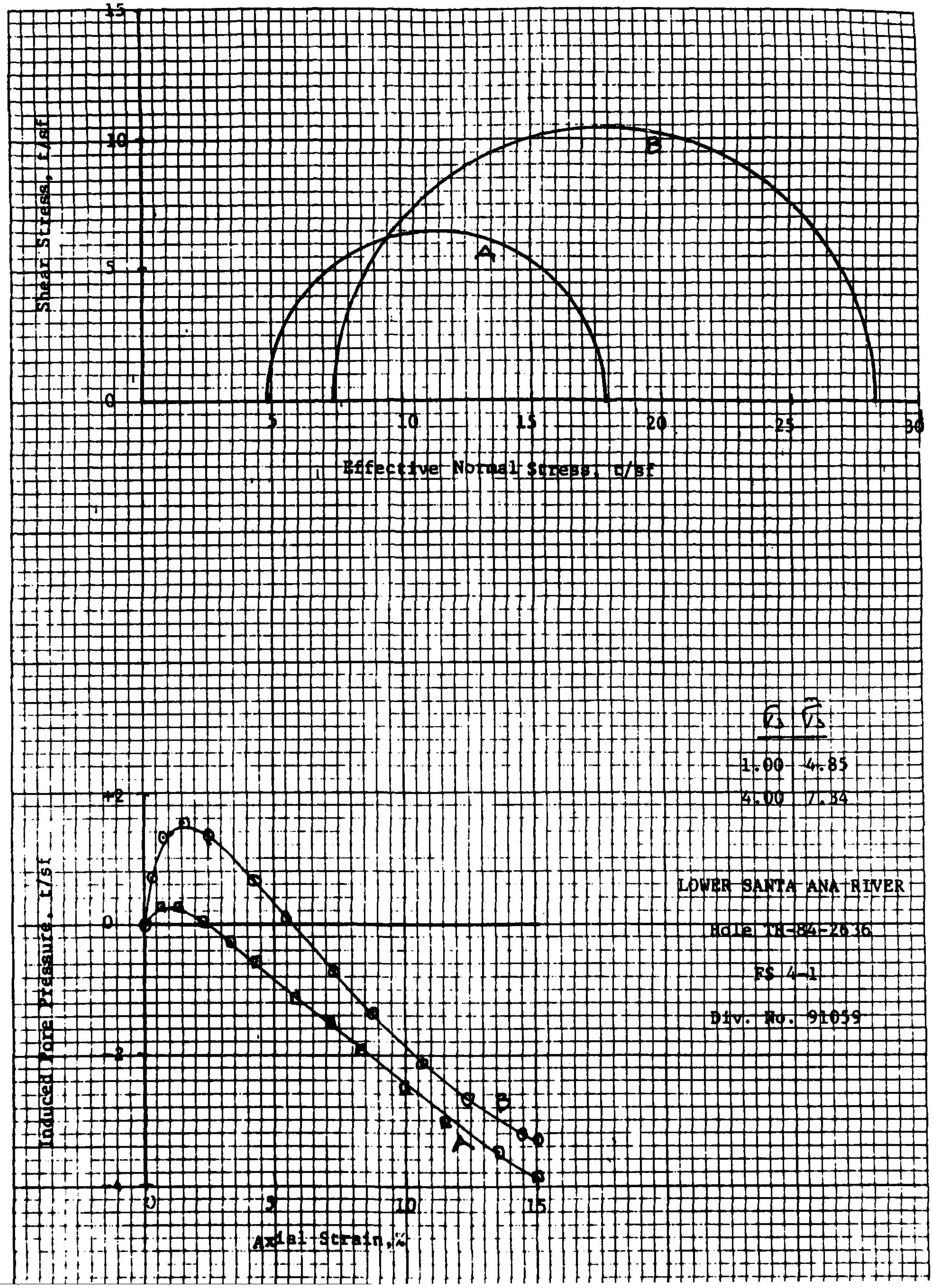
BORING NO. TH-84-2636 SAMPLE NO. 4-1

DEPTH/ELEV 13

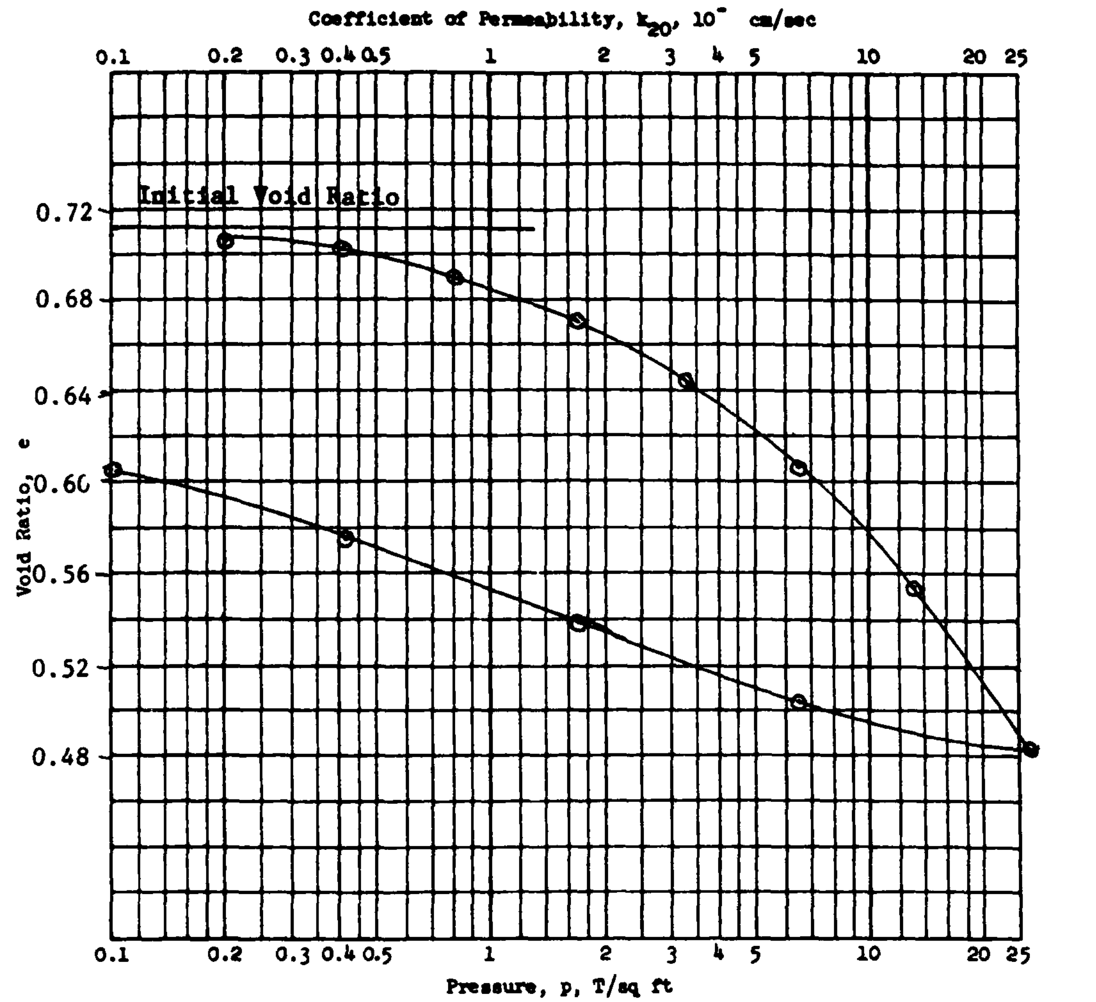
LABORATORY SPDL DATE December 1985

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)

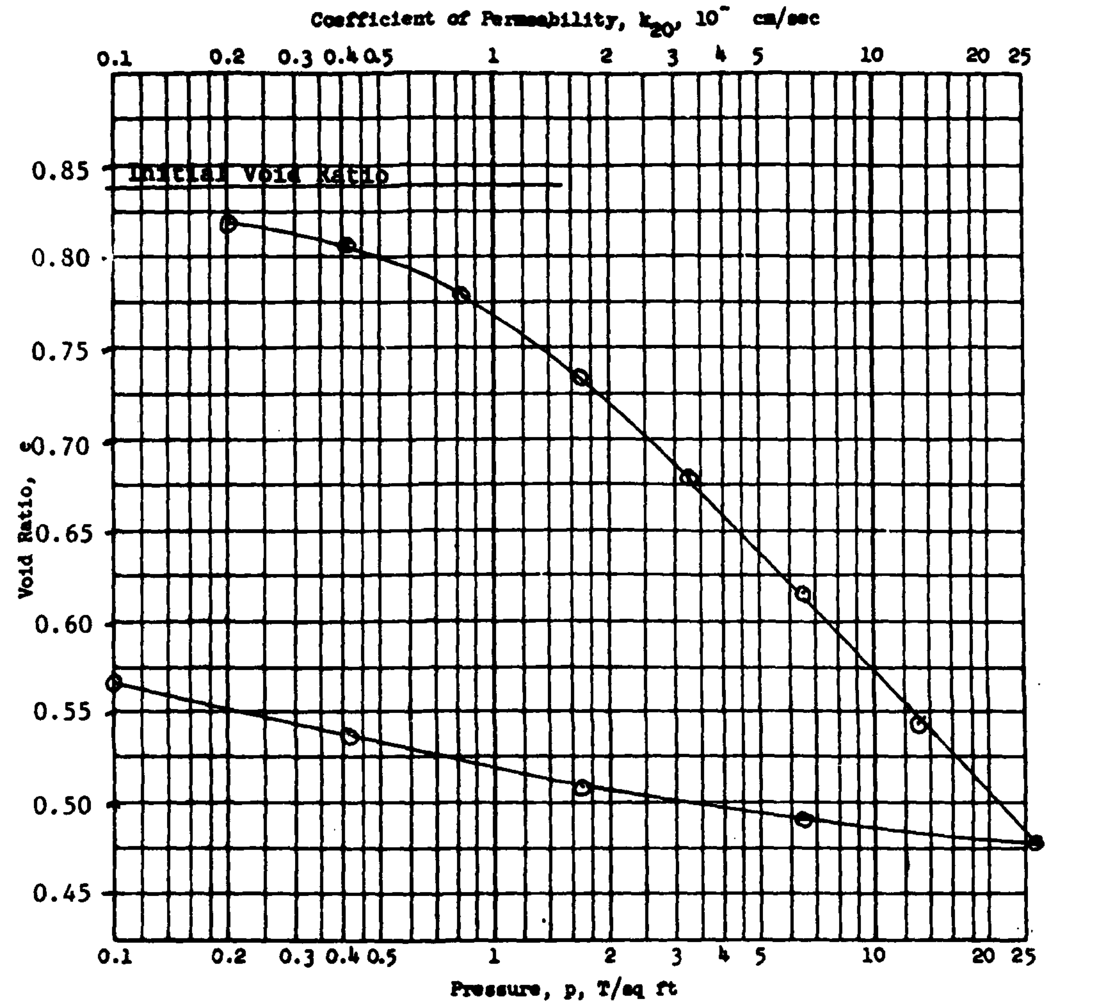


15
10
5
0
Shear Stress, t/sf
A
B
5
10
15
20
25
30
Effective Normal Stress, t/sf
+2
0
-2
-4
Induced Pore Pressure, t/sf
A
B
0
5
10
15
Axial Strain,%
σ_3 $\bar{\sigma}_3$
1.00 4.85
4.00 7.34
LOWER SANTA ANA RIVER
Hole TH-84-2636
FS 4-1
Div. No. 91059

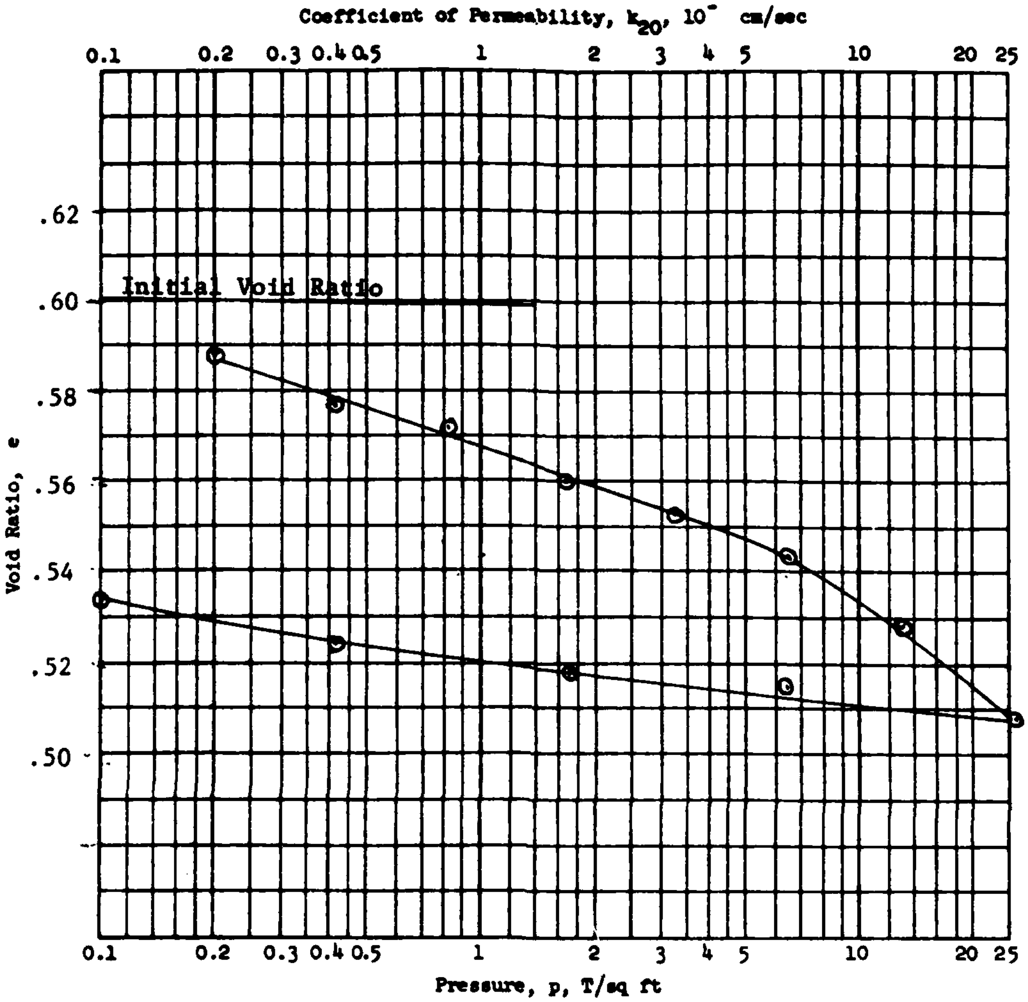


Type of Specimen Undisturbed		Before Test		After Test
Diam 2.2 in.	Ht 0.50 in.	Water Content, w_o	25.4 %	w_f 22.6 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	0.714	e_f 0.616
Precompsol. Pressure, p_c T/sq ft		Saturation, S_o	96 %	S_f 100 %
Compression Index, C_c		Dry Density, γ_d	99.0 lb/ft³	
Classification Clay (CH)		k_{20} at e_o = × 10⁻ cm/sec		
LL 56	G_s 2.72	Project LOWER SANTA ANA RIVER		
PL 23	D_{10}			
Remarks Div. No. 91051		Area		
		Boring No. 84-1810B	Sample No. 4-2	
		Depth El 15	Date April 1985	

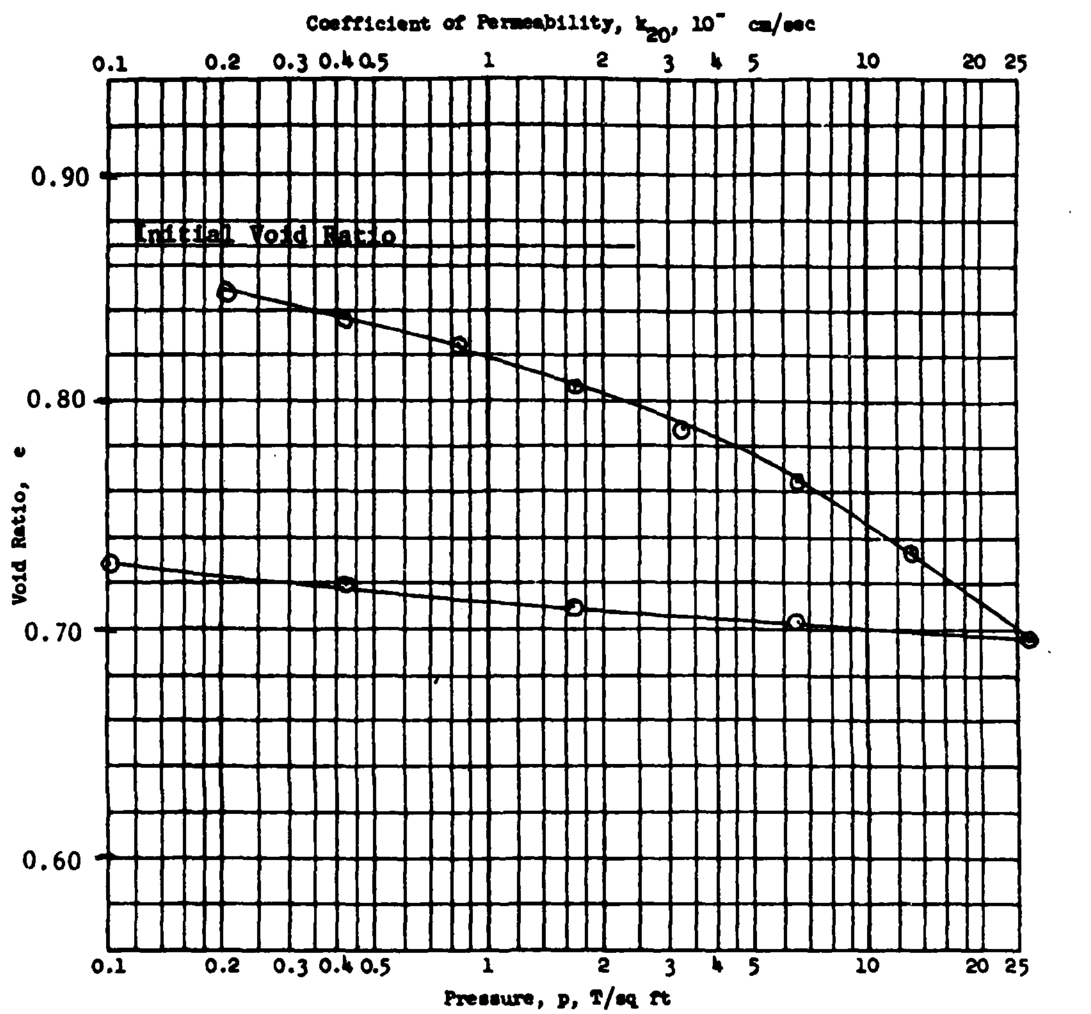
CONSOLIDATION TEST REPORT



Type of Specimen Undisturbed		Before Test		After Test	
Diam 2.2 in.	Ht 0.50 in.	Water Content, w_o	29.1 %	w_f	21.5 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	0.838	e_f	0.584
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	95 %	S_f	100 %
Compression Index, C_c		Dry Density, γ_d	92.3 lb/ft^3		
Classification Sandy Clay (CL)		k_{20} at e_o = × 10^{-} cm/sec			
LL 37	G_s 2.72	Project Lower Santa Ana River			
PL 18	D_{10}				
Remarks Div. No. 91055		Area			
		Boring No. TH-84-2301		Sample No. 7-3	
		Depth El 20		Date April 1985	
		CONSOLIDATION TEST REPORT			



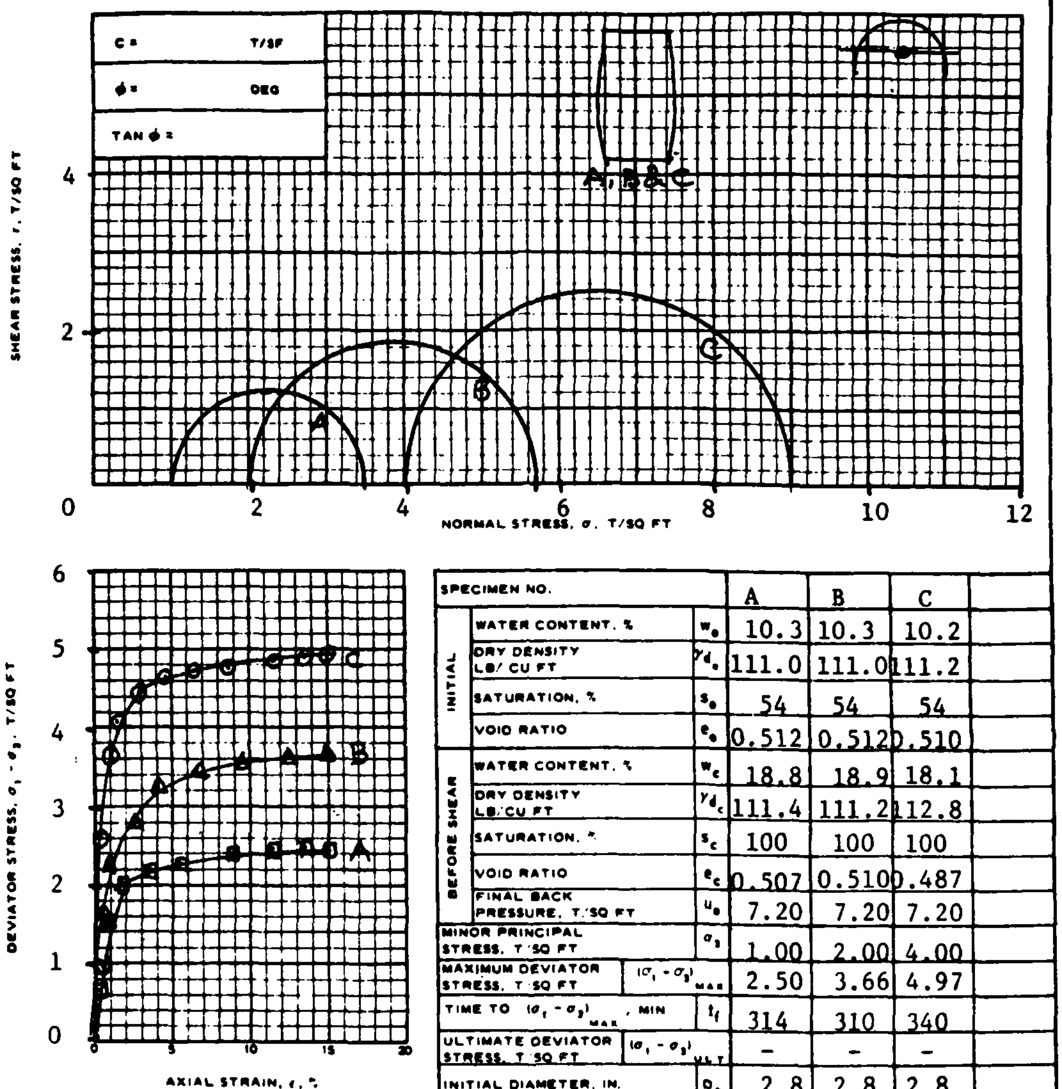
Type of Specimen Undisturbed		Before Test		After Test	
Diam 2.2 in.	Ht 0.50 in.	Water Content, w_o	21.3 %	w_f	19.4 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	0.600	e_f	0.546
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	95 %	S_f	95 %
Compression Index, C_c		Dry Density, γ_d	104.5 lb/ft^3		
Classification Silty Sand (SP-SM)		k_{20} at e_o = × 10^{-} cm/sec			
LL	G_s 2.68	Project Lower Santa Ana River			
PL NP	D_{10}				
Remarks Div. No. 91059		Area			
		Boring No. TH-84-2636		Sample No. 4-1	
		Depth El 13		Date April 1985	
		CONSOLIDATION TEST REPORT			



Type of Specimen Undisturbed		Before Test		After Test	
Diam 2.2 in.	Ht 0.50 in.	Water Content, w_o	19.8 %	w_f	24.8 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	0.870	e_f	0.735
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	62 %	S_f	91 %
Compression Index, C_c		Dry Density, γ_d	90.1 lb/ft^3		
Classification Silty Sand (SM)		k_{20} at e_o = × 10^{-} cm/sec			
LL	G_s 2.70	Project Lower Santa Ana River			
PL NP	D_{10}				
Remarks Div. NO. 91063		Area			
		Boring No. TH-84-2546		Sample No. 3-1	
		Depth El 12		Date May 1985	

CONSOLIDATION TEST REPORT

ENG FORM 1 MAY 63 2090 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) GPO 936-736 R 3424 plate 32



SPECIMEN NO.			A	B	C
INITIAL	WATER CONTENT, %	w_o	10.3	10.3	10.2
	DRY DENSITY LB/CU FT	γ_{d_o}	111.0	111.0	111.2
	SATURATION, %	S_o	54	54	54
	VOID RATIO	e_o	0.512	0.512	0.510
BEFORE SHEAR	WATER CONTENT, %	w_c	18.8	18.9	18.1
	DRY DENSITY LB/CU FT	γ_{d_c}	111.4	111.2	112.8
	SATURATION, %	S_c	100	100	100
	VOID RATIO	e_c	0.507	0.510	0.487
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$	2.50	3.66	4.97
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f	314	310	340
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$	-	-	-
INITIAL DIAMETER, IN.		D_o	2.8	2.8	2.8
INITIAL HEIGHT, IN.		H_o	6.45	6.45	6.45

CONTROLLED- Strain TEST

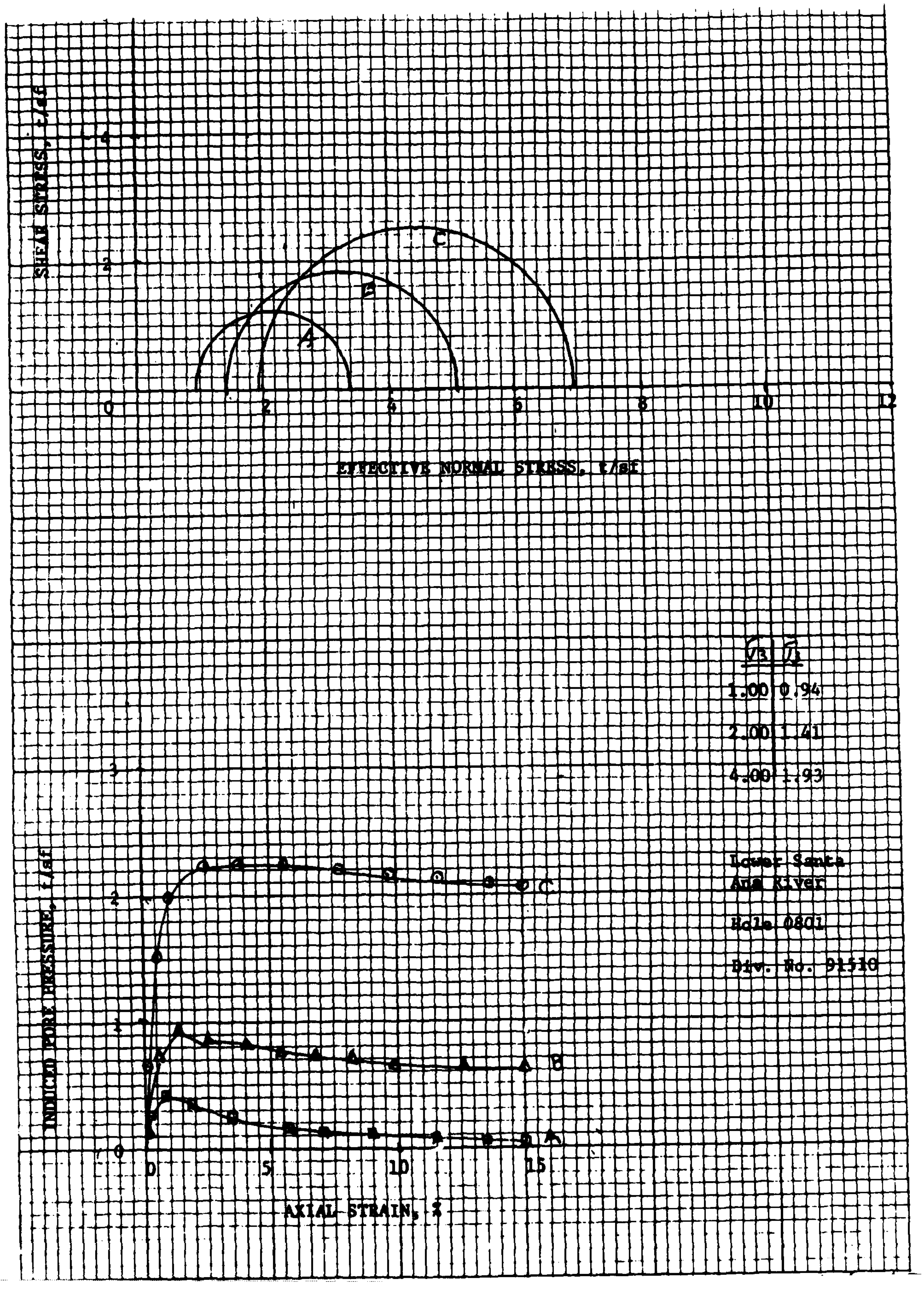
DESCRIPTION OF SPECIMENS Sandy Silty Clay (CL)

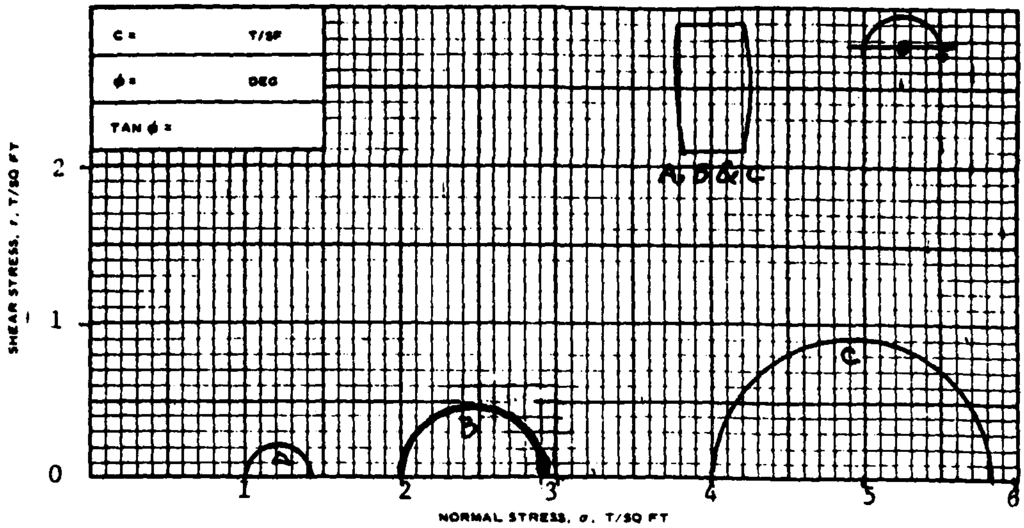
LL 41	PL 24	PI 17	G_s 2.69	TYPE OF SPECIMEN Remolded	TYPE OF TEST $\overline{R}$

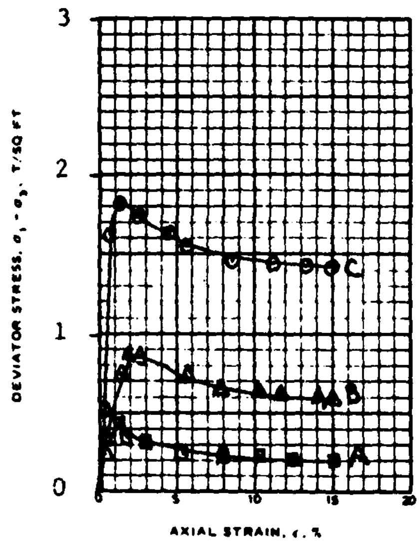
REMARKS: Div. No. 91510	PROJECT Lower Santa Ana River
Remolded to 90% max. density at	
optimum water content.	BORING NO. 0801 SAMPLE NO.
	DEPTH/ELEV 15-18
	LABORATORY SPDL DATE June 1985
	TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089
REV JUNE 1970

plate 44


SHEAR STRESS, t/sf
4
2
0
2
4
6
8
10
12
A
B
C
EFFECTIVE NORMAL STRESS, t/sf
σ3 σ̄3
1.00 0.94
2.00 1.41
4.00 1.93
Lower Santa Ana River
Hole 0801
Div. No. 91510
INDUCED PORE PRESSURE, t/sf
3
2
1
0
C
B
A
0
5
10
15
AXIAL STRAIN, %





SPECIMEN NO.			A	B	C	
INITIAL	WATER CONTENT, %	w_o	7.00	6.9	7.2	
	DRY DENSITY LB/CU FT	γ_{d_o}	108.[illegible]	108.2	107.9	
	SATURATION, %	S_o	35	34	36	
	VOID RATIO	e_o	0.535	0.534	0.538	
BEFORE SHEAR	WATER CONTENT, %	w_c	18.3	18.1	16.9	
	DRY DENSITY LB/CU FT	γ_{d_c}	111.6	112.1	114.6	
	SATURATION, %	S_c	100	100	100	
	VOID RATIO	e_c	0.487	0.480	0.448	
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20	
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00	
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	0.41	0.89	1.82	
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	15	20	30	
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	0.21	0.60	1.41	
INITIAL DIAMETER, IN.		D_o	2.8	2.8	2.8	
INITIAL HEIGHT, IN.		H_o	6.45	6.45	6.45	

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Silty Gravelly Sand (SM)

LL	PL NP	PI 2.66	GS	TYPE OF SPECIMEN Remolded	TYPE OF TEST R̄

REMARKS: Div. No. 91511

Remolded to 80% max. density at optimum water content.

PROJECT LOWER SANTA ANA RIVER

BORING NO. 0301 — SAMPLE NO. -

DEPTH/ELEV 24' - 25'

LABORATORY SPDL — DATE August 1985

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089
REV JUNE 1970

plate 46

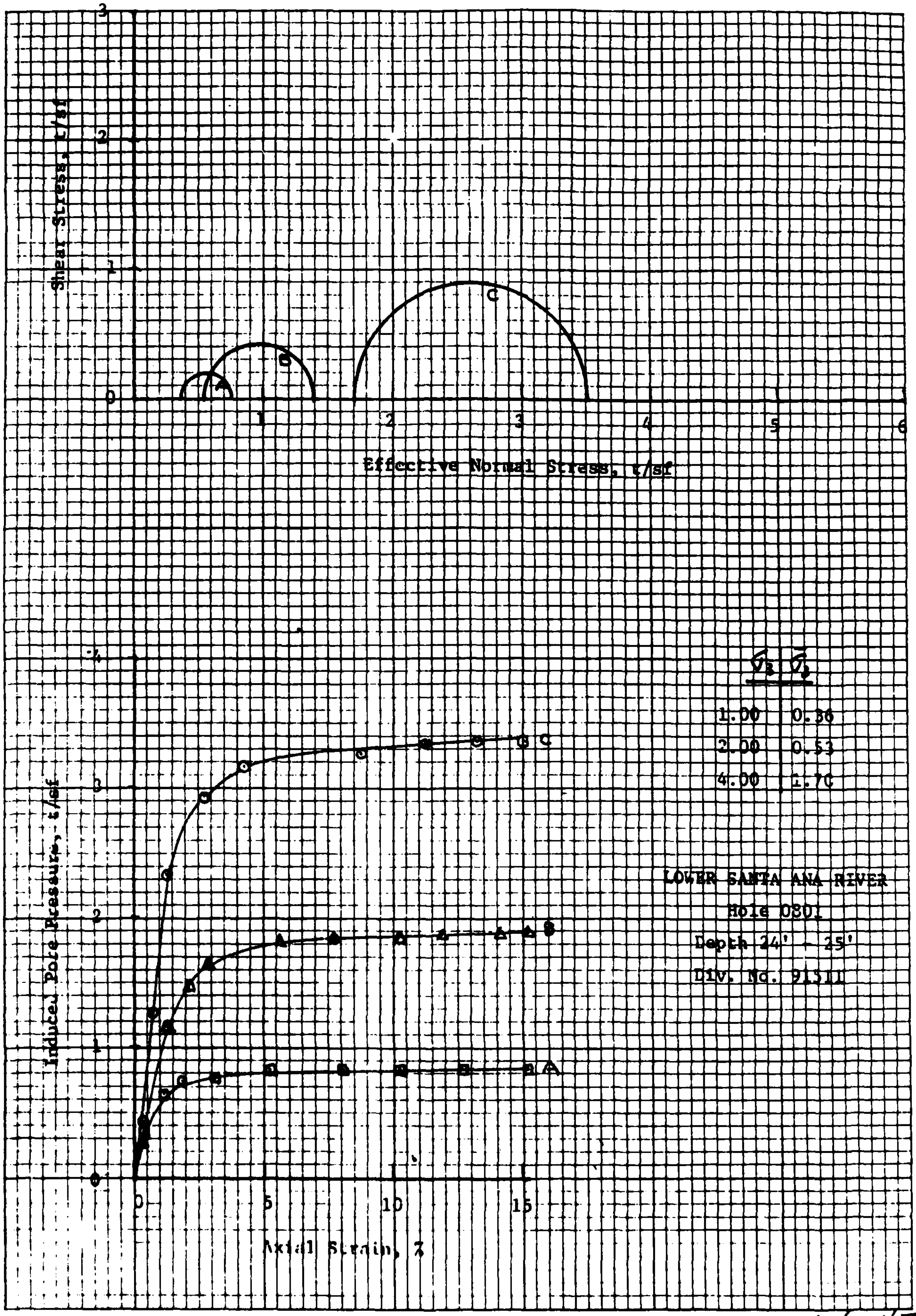
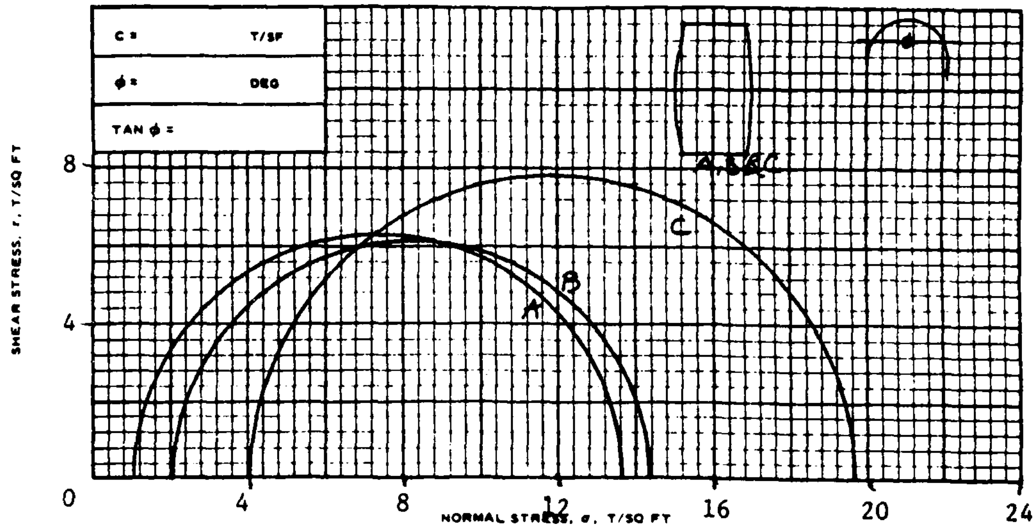
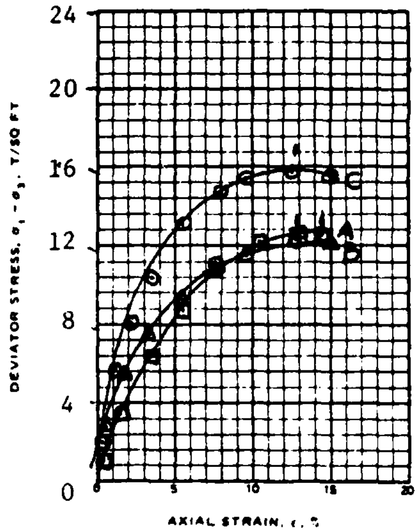

Shear Stress, t/sf
3
2
1
0
A
B
C
1
2
3
4
5
6
Effective Normal Stress, t/sf
Induced Pore Pressure, t/sf
4
3
2
1
0
C
B
A
0
5
10
15
Axial Strain, %
σ3 σ1
1.00 0.36
2.00 0.53
4.00 1.70
LOWER SANTA ANA RIVER
Hole 0801
Depth 24' - 25'
Div. No. 91511

Plate 47

C =	T/SF
φ =	DEG
TAN φ =	





SPECIMEN NO.			A	B	C	
INITIAL	WATER CONTENT, %	w_o	10.7	11.7	11.8	
	DRY DENSITY LB/CU FT	γ_{d_o}	108.0	106.8	106.8	
	SATURATION, %	S_o	53	56	56	
	VOID RATIO	e_o	0.537	0.554	0.555	
BEFORE SHEAR	WATER CONTENT, %	w_c	19.8	19.9	20.0	
	DRY DENSITY LB/CU FT	γ_{d_c}	108.4	107.7	108.4	
	SATURATION, %	S_c	99	99	100	
	VOID RATIO	e_c	0.531	0.541	0.531	
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20	
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00	
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	12.69	12.37	15.84	
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	285	286	180	
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	–	–	–	
INITIAL DIAMETER, IN		D_o	2.8	2.8	2.8	
INITIAL HEIGHT, IN		H_o	6.45	6.45	6.45	

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Sand (SP)

LL | PL | PI NP | Gs 2.66 | TYPE OF SPECIMEN Remolded | TYPE OF TEST R

REMARKS: Div. No. 91512
Remolded to 90% max. density at optimum water content.

PROJECT LOWER SANTA ANA RIVER

BORING NO. 0805 | SAMPLE NO.

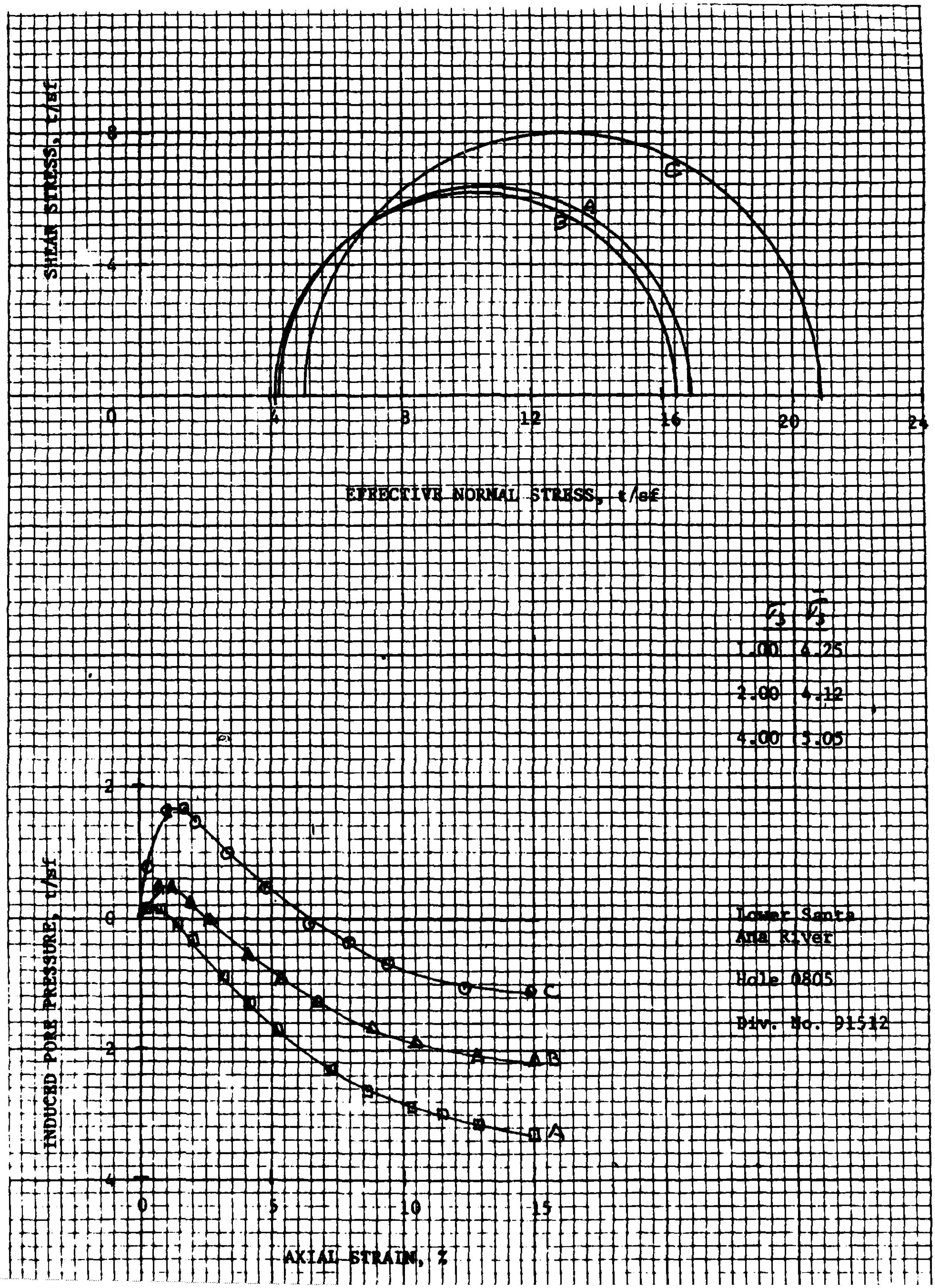
DEPTH/ELEV 3-9

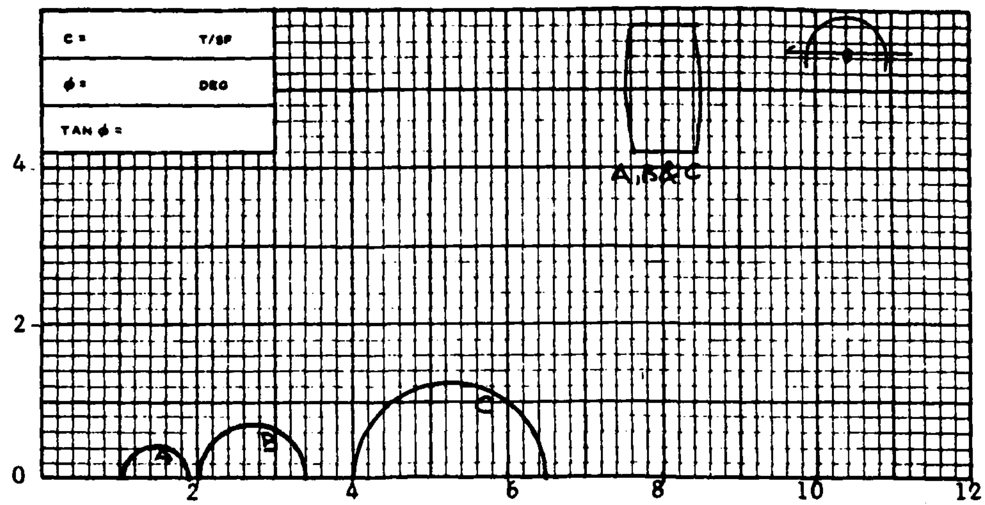
LABORATORY SPDL | DATE July 1985

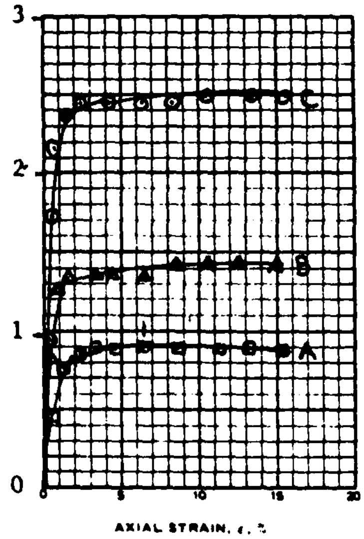
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089
REV JUNE 1970

Plate 48


SHEAR STRESS, t/sf
EFFECTIVE NORMAL STRESS, t/sf
0
4
8
12
16
20
24
C
A
B
INDUCED PORE PRESSURE, t/sf
AXIAL STRAIN, %
0
5
10
15
2
4
C
B
A
1.00 4.25
2.00 4.12
4.00 5.05
Lower Santa Ana River
Hole 0805
Div. No. 91512





SPECIMEN NO.			A	B	C
INITIAL	WATER CONTENT, %	w_o	12.4	11.8	12.0
	DRY DENSITY LB/ CU FT	γ_{d_o}	95.3	95.8	95.6
	SATURATION, %	S_o	44	42	43
	VOID RATIO	e_o	0.754	0.745	0.749
BEFORE SHEAR	WATER CONTENT, %	w_c	26.9	24.1	24.5
	DRY DENSITY LB/CU FT	γ_{d_c}	96.6	101.6	100
	SATURATION, %	S_c	99	100	98
	VOID RATIO	e_c	0.732	0.646	0.672
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$	0.91	1.44	2.50
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f	85	160	165
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$	0.89	-	-
INITIAL DIAMETER, IN.		D_o	2.8	2.8	2.8
INITIAL HEIGHT, IN.		H_o	6.45	6.45	6.45

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Silty Sand (SM)

LL	PL NP	PI	Gs 2.68	TYPE OF SPECIMEN Remolded	TYPE OF TEST $\bar{R}$

REMARKS: Div. No. 91513

Remolded to 80% maximum at optimum water content.

PROJECT LOWER SANTA ANA RIVER

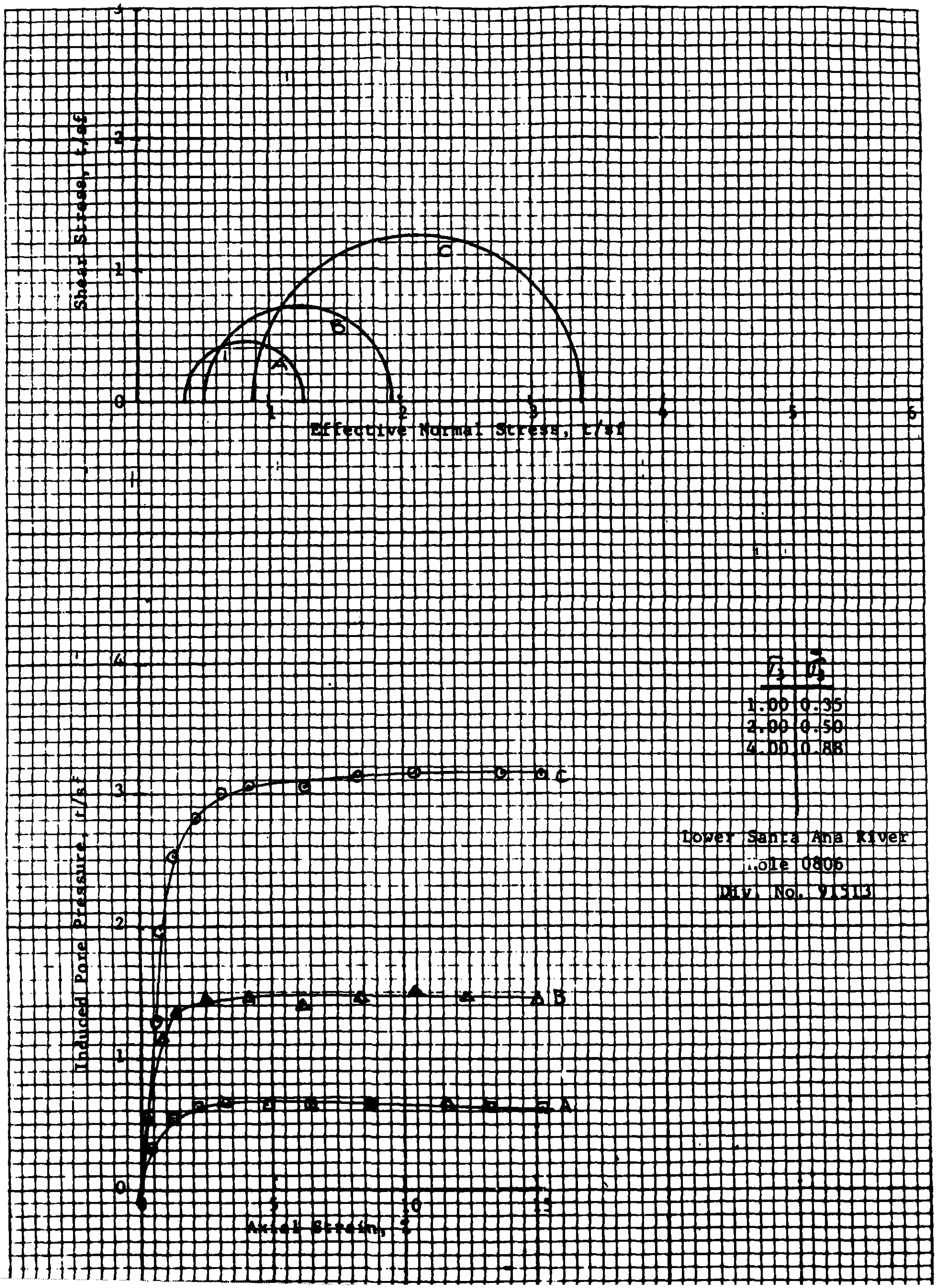
BORING NO. 0806 SAMPLE NO.

DEPTH ELEV 21-24

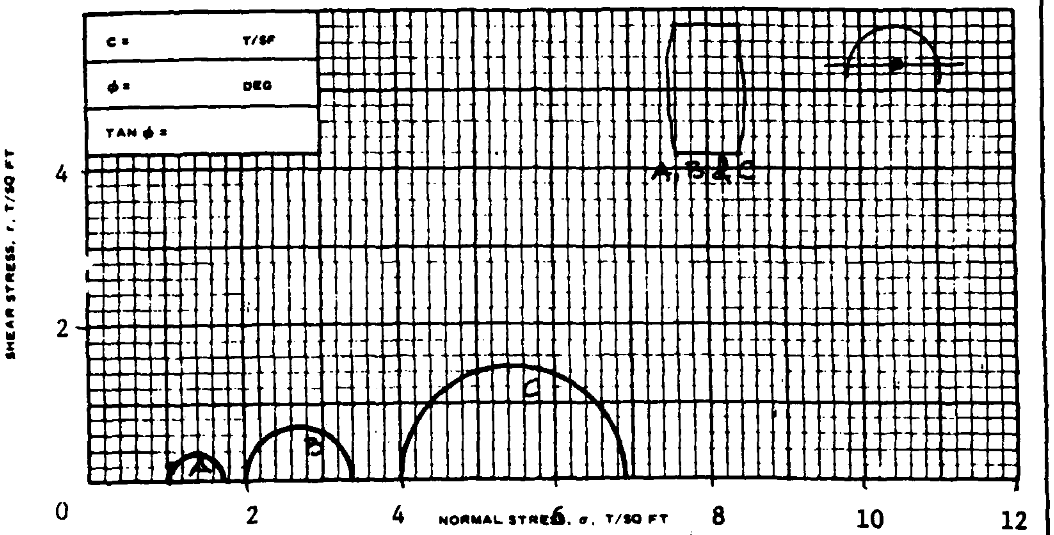
LABORATORY SPDL DATE July 1985

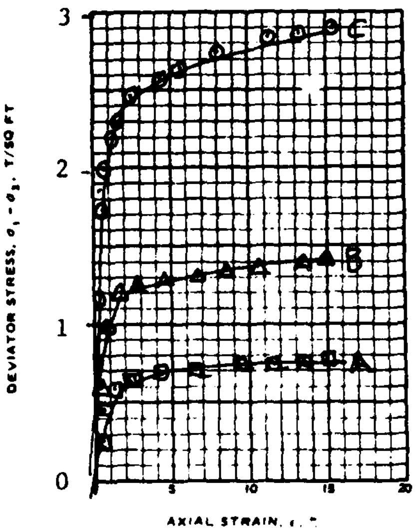
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089
REV JUNE 1970



Shear Stress, t/sf
Effective Normal Stress, t/sf
Induced Pore Pressure, t/sf
Axial Strain, %
A
B
C
σ_3 $\bar{\sigma}_3$
1.00 0.35
2.00 0.50
4.00 0.88
Lower Santa Ana River
Hole 0806
Div. No. 91513





				A	B	C
SPECIMEN NO.				A	B	C
INITIAL	WATER CONTENT, %		w_o	10.3	10.1	10.1
	DRY DENSITY LB/CU FT		γ_{d_o}	102.9	103.1	103.1
	SATURATION, %		S_o	45	44	44
	VOID RATIO		e_o	0.607	0.604	0.603
BEFORE SHEAR	WATER CONTENT, %		w_c	22.3	20.6	18.0
	DRY DENSITY LB/CU FT		γ_{d_c}	103.8	107.1	112.2
	SATURATION, %		S_c	100	100	100
	VOID RATIO		e_c	0.592	0.545	0.474
	FINAL BACK PRESSURE, T/SQ FT		u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT			σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$		0.79	1.43	2.90
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN			t_f	255	231	260
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$		–	–	–
INITIAL DIAMETER, IN.			D_o	2.8	2.8	2.8
INITIAL HEIGHT, IN.			H_o	6.45	6.45	6.45

CONTROLLED- Strain TEST

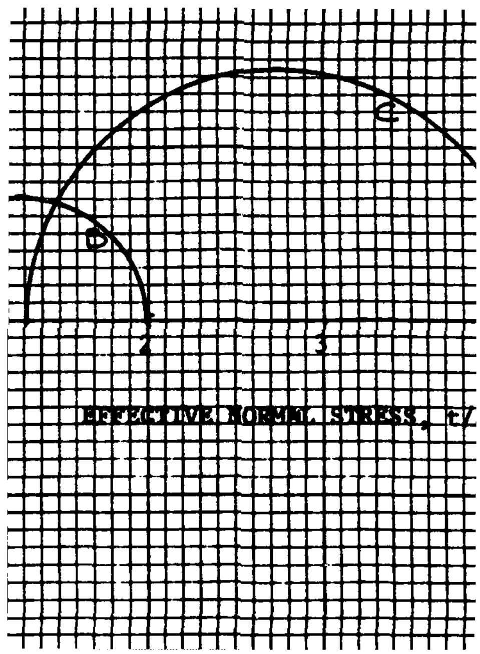
DESCRIPTION OF SPECIMENS Sandy Clay (CL)

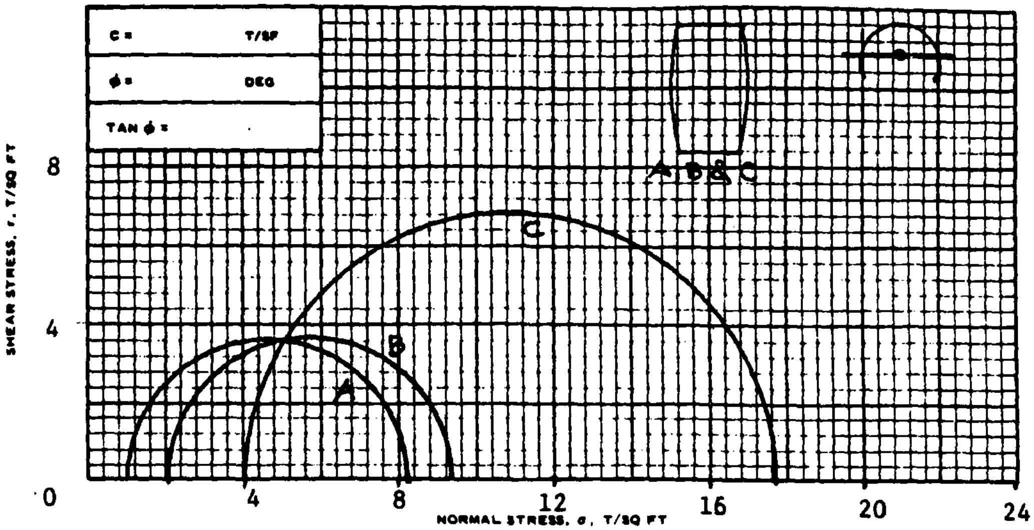
LL 42	PL 22	PI 20	G_s 2.65	TYPE OF SPECIMEN Remolded	TYPE OF TEST $\bar{R}$

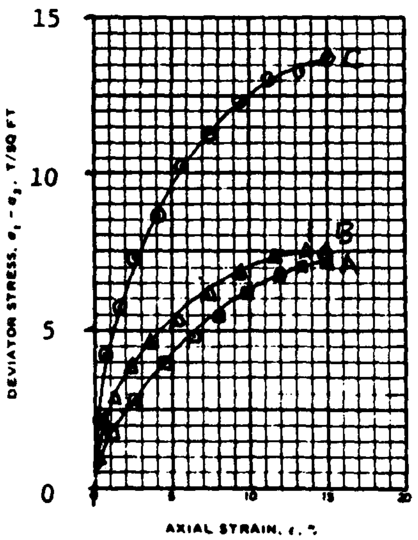
REMARKS: Div. No. 91518	PROJECT Lower Santa Ana River
Remolded to 80% max. density at	BORING NO. 1001 SAMPLE NO.
optimum water content.	DEPTH/ELEV 26' - 30'
	LABORATORY SPDL DATE July 1985
	TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089
REV JUNE 1970

plate 52


C
B
2
3
EFFECTIVE NORMAL STRESS, t/





SPECIMEN NO.			A	B	C
INITIAL	WATER CONTENT, %	w_o	10.2	10.4	10.3
	DRY DENSITY LB/CU FT	γ_{d_o}	110.6	110.4	110.6
	SATURATION, %	S_o	54	55	54
	VOID RATIO	e_o	0.506	0.509	0.507
BEFORE SHEAR	WATER CONTENT, %	w_c	18.7	18.6	17.2
	DRY DENSITY LB/CU FT	γ_{d_c}	111.0	111.3	113.9
	SATURATION, %	S_c	100	100	99
	VOID RATIO	e_c	0.501	0.498	0.462
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$	7.32	7.51	13.73
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f	266	250	244
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$	–	–	–
INITIAL DIAMETER, IN.		D_o	2.8	2.8	2.8
INITIAL HEIGHT, IN.		H_o	6.45	6.45	6.45

CONTROLLED- Strain TEST

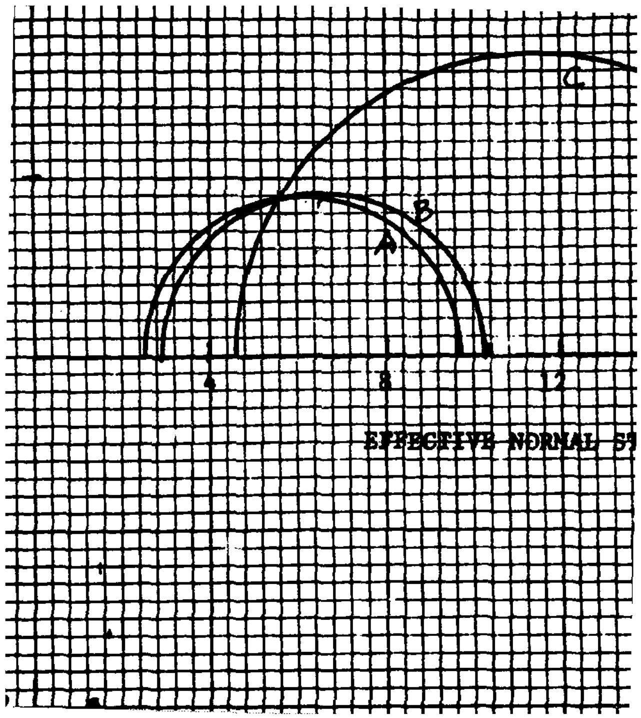
DESCRIPTION OF SPECIMENS Silty Sand (SW-SM)

LL	PL NP	PI	Gs 2.67	TYPE OF SPECIMEN Remolded	TYPE OF TEST $\bar{R}$

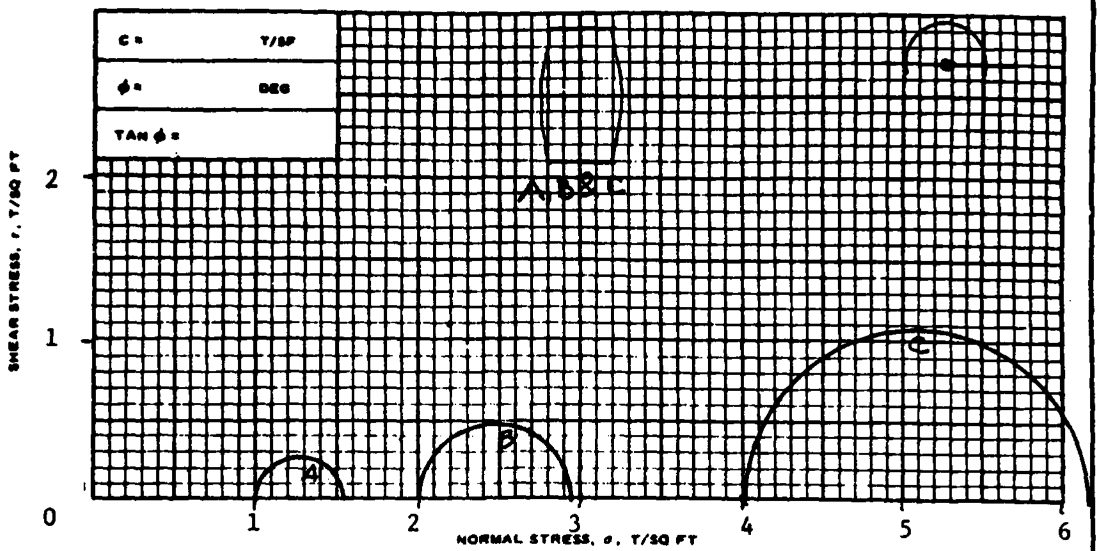
REMARKS: Div. No. 91519	PROJECT Lower Santa Ana River
Remolded to 90% max. density at optimum water content.	BORING NO. 1004 / SAMPLE NO.
	DEPTH/ELEV 27'-30'
	LABORATORY SPDL / DATE July 1985
	TRIAXIAL COMPRESSION TEST REPORT

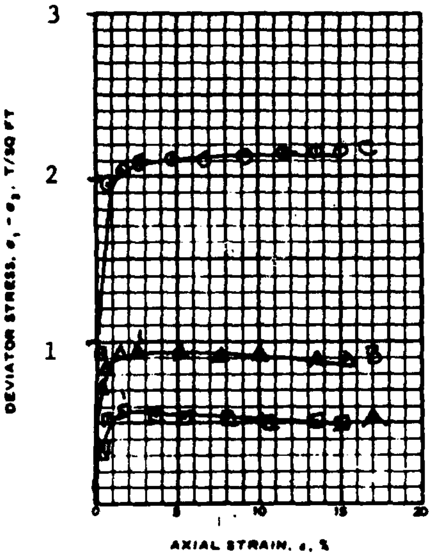
ENG FORM NO. 2089
REV JUNE 1970

Plate 54



C
B
A
4
8
12
EFFECTIVE NORMAL ST





SPECIMEN NO.			A	B	C
INITIAL	WATER CONTENT, %	w_o	8.1	8.1	8.0
	DRY DENSITY LB/CU FT	γd_o	104.4	105.7	104.5
	SATURATION, %	S_o	35	37	35
	VOID RATIO	e_o	0.614	0.594	0.612
BEFORE SHEAR	WATER CONTENT, %	w_c	19.9	18.3	17.4
	DRY DENSITY LB/CU FT	γd_c	109.6	112.7	114.6
	SATURATION, %	S_c	100	100	100
	VOID RATIO	e_c	0.537	0.495	0.471
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	0.56	0.96	2.19
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	20	75	180
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	0.49	0.90	2.08
INITIAL DIAMETER, IN.		D_o	2.8	2.8	2.8
INITIAL HEIGHT, IN.		H_o	6.45	6.45	6.45

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS Clayey Sand (SC)

LL 28 | PL 18 | PI 10 | Gs 2.70 | TYPE OF SPECIMEN Remolded | TYPE OF TEST $\overline{R}$

REMARKS: Div. No. 91525
Remolded to 80% max. density at optimum water content.

PROJECT LOWER SANTA ANA RIVER

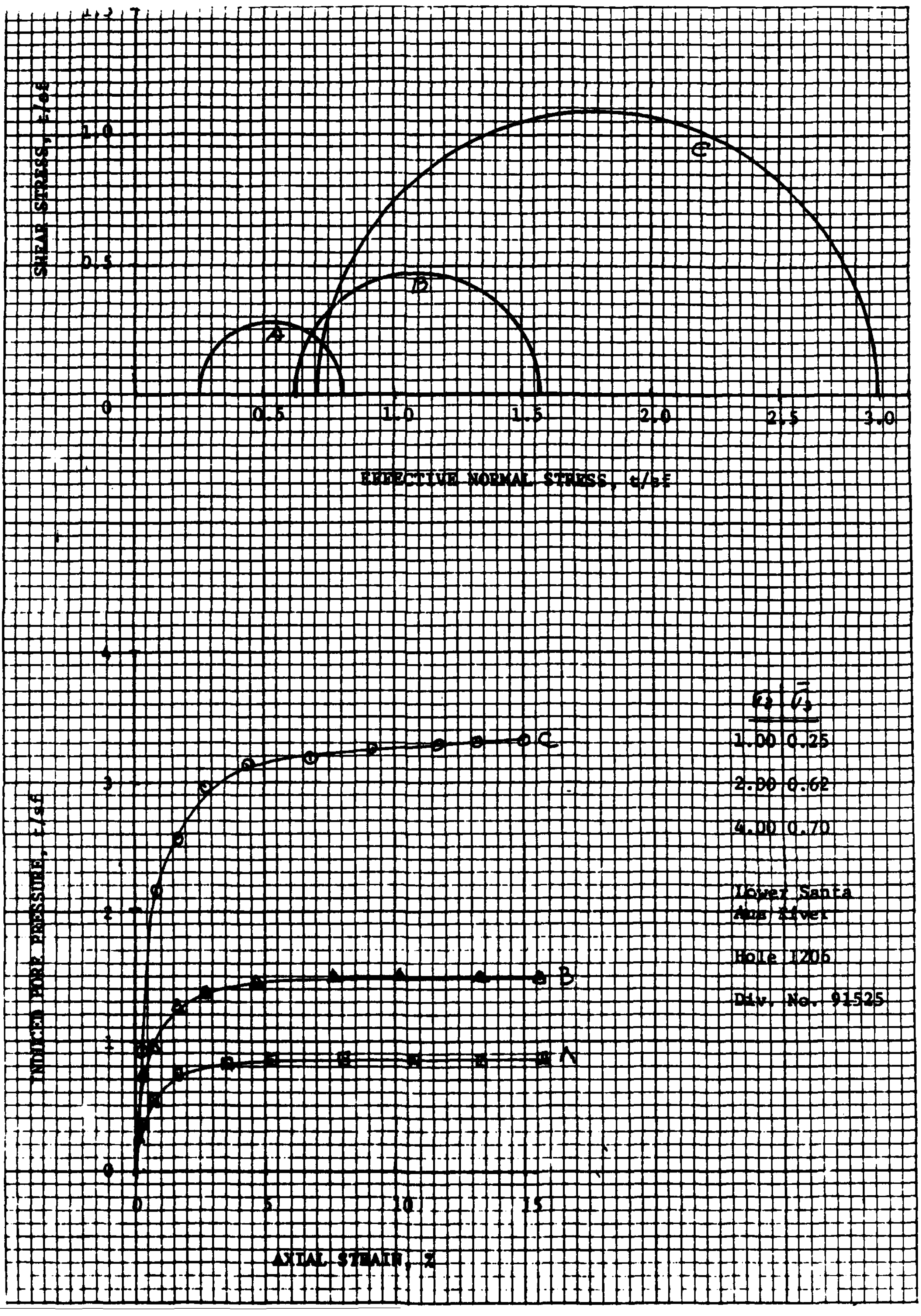
BORING NO. 1206 | SAMPLE NO.

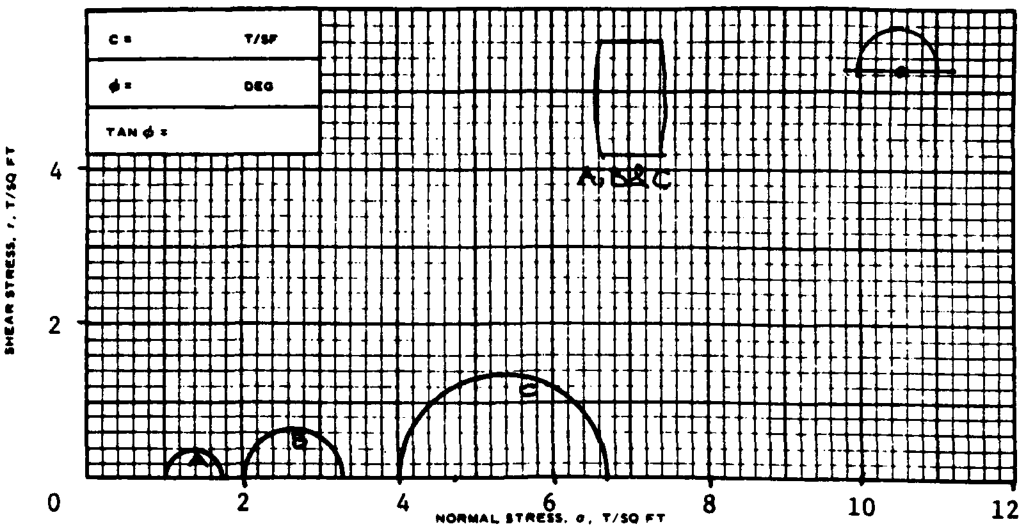
DEPTH/ELEV 25-27

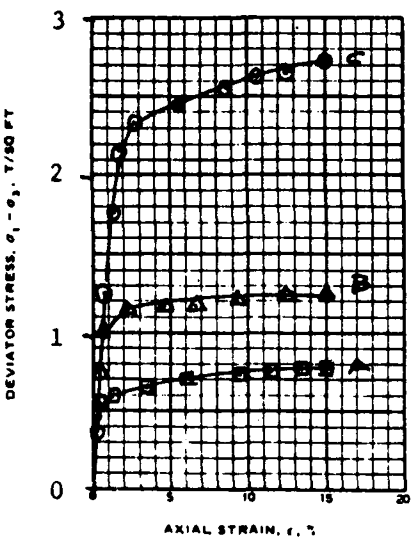
LABORATORY SPDL | DATE July 1985

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089 REV JUNE 1970 PREVIOUS EDITION IS OBSOLETE TRANSLUCENT (EM 1110-2-1906)


SHEAR STRESS, t/sf
1.0
0.5
0
A
B
C
0.5
1.0
1.5
2.0
2.5
3.0
EFFECTIVE NORMAL STRESS, t/sf
INDUCED PORE PRESSURE, t/sf
4
3
2
1
0
0
5
10
15
AXIAL STRAIN, %
σ_3 $\bar{\sigma}_3$
1.00 0.25
2.00 0.62
4.00 0.70
Lower Santa Ana River
Hole 1206
Div. No. 91525





SPECIMEN NO.			A	B	C	
INITIAL	WATER CONTENT, %	w_o	11.2	11.5	11.4	
	DRY DENSITY LB/CU FT	γd_o	92.2	91.8	91.9	
	SATURATION, %	S_o	35.9	37	37	
	VOID RATIO	e_o	0.848	0.855	0.854	
BEFORE SHEAR	WATER CONTENT, %	w_c	29.3	28.4	25.6	
	DRY DENSITY LB/CU FT	γd_c	94.6	95.9	99.6	
	SATURATION,	S_c	100	100	98	
	VOID RATIO	e_c	0.801	0.777	0.711	
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20	
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00	
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	0.78	1.25	2.77	
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	255	230	267	
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	–	–	–	
INITIAL DIAMETER, IN.		D_o	2.80	2.80	2.80	
INITIAL HEIGHT, IN.		H_o	6.45	6.45	6.45	

CONTROLLED- Strain TEST

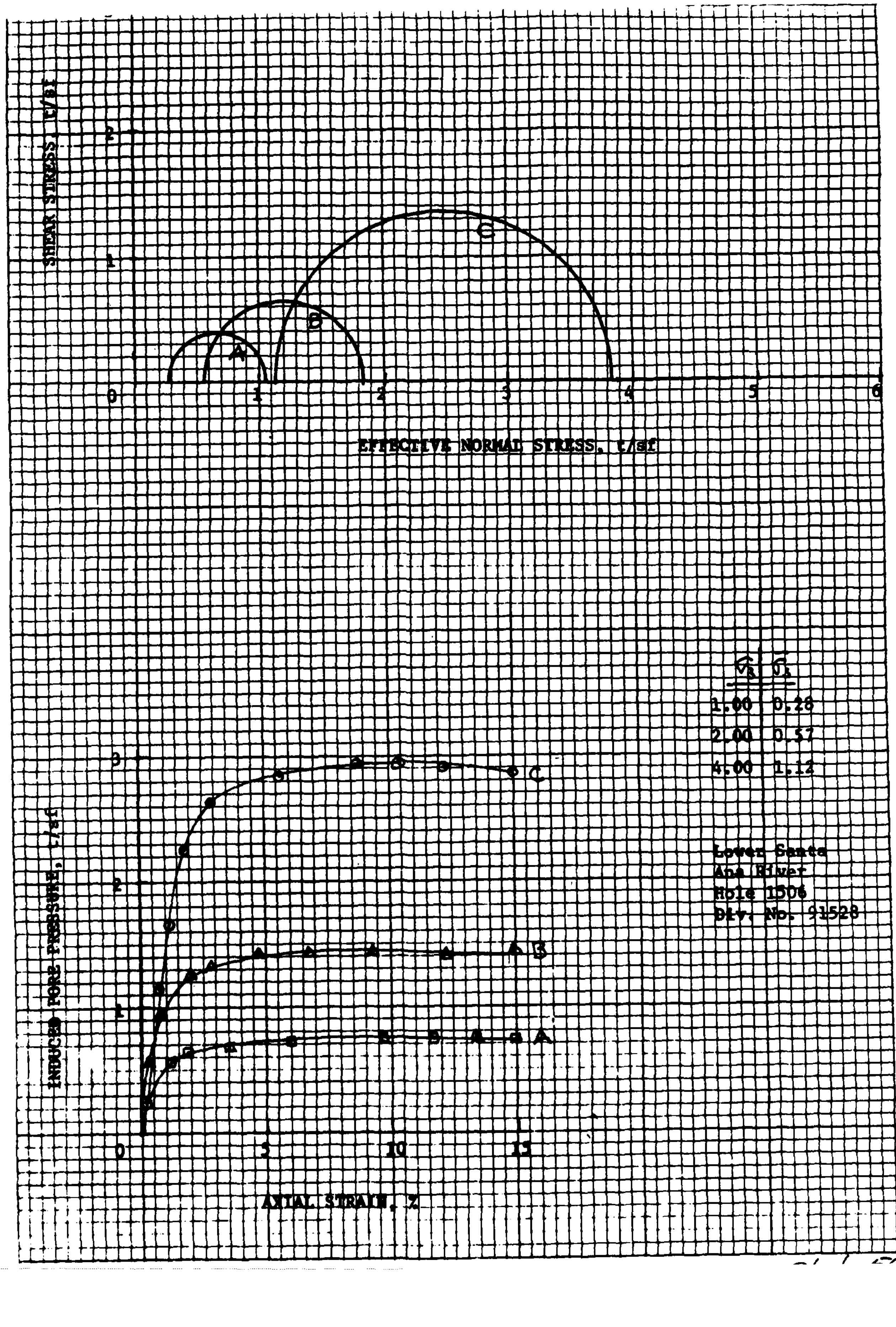
DESCRIPTION OF SPECIMENS Sandy Silty Clay (CL)

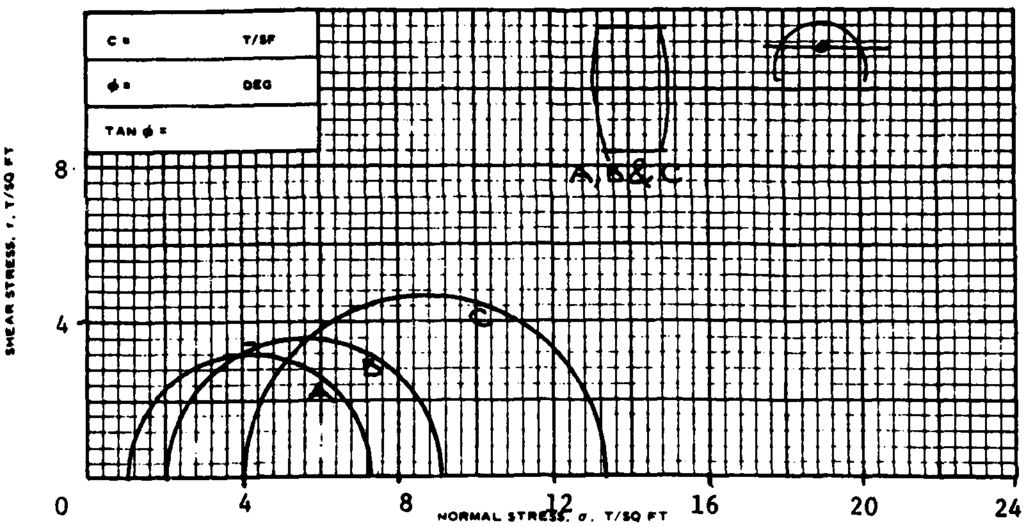
LL 35	PL 24	PI 11	Gs 2.73	TYPE OF SPECIMEN Remolded	TYPE OF TEST $\overline{R}$

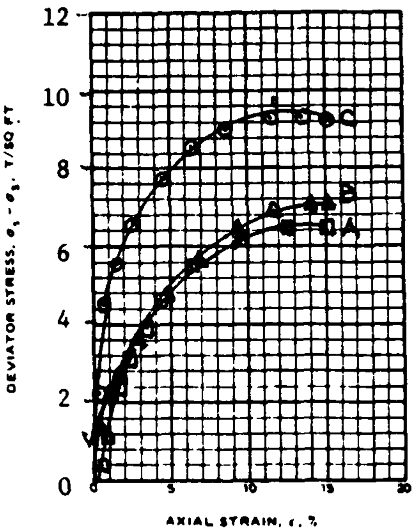
REMARKS: Div. No. 91528	PROJECT Lower Santa Ana River	
Remolded to 80% max. density at		
optimum water content.	BORING NO. 1506	SAMPLE NO.
	DEPTH/ELEV 40	
	LABORATORY SPDL	DATE July 1985
	TRIAXIAL COMPRESSION TEST REPORT	

ENG FORM NO. 2089
REV JUNE 1970

plate 58


SHEAR STRESS, t/sf
EFFECTIVE NORMAL STRESS, t/sf
A
B
C
INDUCED PORE PRESSURE, t/sf
AXIAL STRAIN, %
σ3 σ1
1.00 0.28
2.00 0.57
4.00 1.12
Lower Santa
Ana River
Hole 1506
Div. No. 91528





SPECIMEN NO.			A	B	C
INITIAL	WATER CONTENT, %	w_o	9.3	9.6	9.2
	DRY DENSITY LB/CU FT	γ_{d_o}	107.4	107.1	107.7
	SATURATION, %	S_o	44	45	44
	VOID RATIO	e_o	0.569	0.574	0.565
BEFORE SHEAR	WATER CONTENT, %	w_c	20.7	20.7	20.2
	DRY DENSITY LB/CU FT	γ_{d_c}	108.0	108.1	109.1
	SATURATION, %	S_c	100	100	100
	VOID RATIO	e_c	0.561	0.559	0.545
	FINAL BACK PRESSURE, T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS, T/SQ FT		σ_3	1.00	2.00	4.00
MAXIMUM DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{max}$	6.48	7.18	9.35
TIME TO $(\sigma_1 - \sigma_3)_{max}$, MIN		t_f	187	210	185
ULTIMATE DEVIATOR STRESS, T/SQ FT		$(\sigma_1 - \sigma_3)_{ult}$	-	-	-
INITIAL DIAMETER, IN.		D_o	2.8	2.8	2.8
INITIAL HEIGHT, IN.		H_o	6.45	6.45	6.45

CONTROLLED- Strain TEST

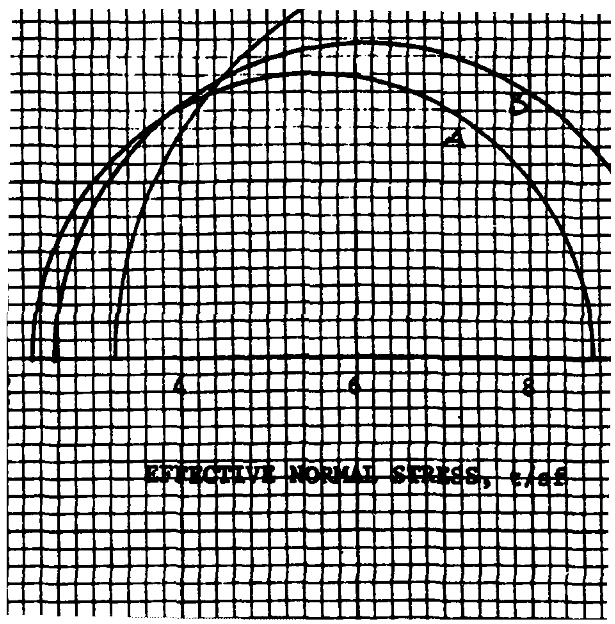
DESCRIPTION OF SPECIMENS Silty Sand (SM)

LL	PL NP	PI	G_s 2.70	TYPE OF SPECIMEN Remolded	TYPE OF TEST $\bar{R}$

REMARKS: Div. No. 91530	PROJECT Lower Santa Ana River
Remolded to 90% max. density at	BORING NO. 1509 — SAMPLE NO.
optimum water content.	DEPTH/ELEV 27-30
	LABORATORY SPDL — DATE July 1985
	TRIAXIAL COMPRESSION TEST REPORT

ENG FORM NO. 2089
REV JUNE 1970

Plate 60



B
A
4
6
8
EFFECTIVE NORMAL STRESS, t/sf

DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION, CORPS OF ENGINEERS
LABORATORY

REPORT
OF
SOIL TESTS

LOWER SANTA ANA RIVER

EDITED

January 1986

SAUSALITO, CALIFORNIA

REPORT
OF
SOIL TESTS

LOWER SANTA ANA RIVER

January 1986

AUTHORIZATION

1. Results of tests reported herein were requested by the Los Angeles District in laboratory request No. E86-86-0033 dated 10 December 1985.

REFERENCE

2. "Report of Soil Test, Lower Santa Ana River", December 1985, South Pacific Division Laboratory, Sausalito, California.

SAMPLES

3. Disturbed samples contained in sacks were received 25 March 1985. Identification of samples is shown on the Soil Test Result Summary, Plate 1, and in referenced report.

TESTING PROGRAM

4. The program was in general accordance with the test request and included compacation and permeability.

TEST METHODS

5. Permeability and Compaction. Testing conformed to the procedures described in Engineer Manual, EM 1110-2-1906, "Laboratory Soil Testing," 30 November 1970.

RESULTS

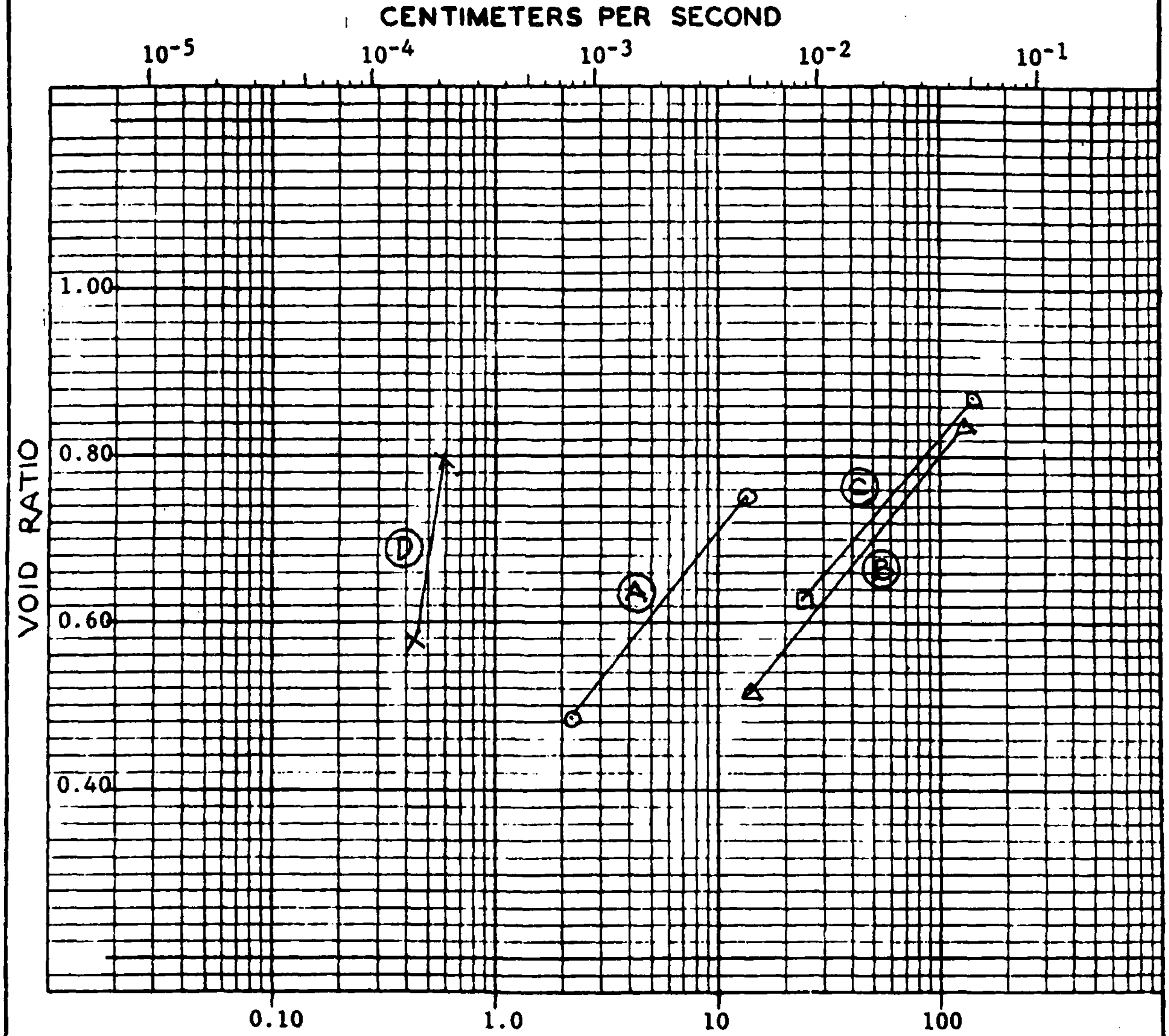
6. Results of tests are shown on the following plates:

Subject	Plate No.
Soil Test Result Summary	1
Compaction Test Report	2
Permeability	3

CORPS OF ENGINEERS — U. S. ARMY

SOUTH PACIFIC DIVISION LABORATORY

PERMEABILITY



COEFFICIENT OF PERMEABILITY (K)

REMARKS:

CURVE	SPECIMEN DIAM. IN.	HT. IN.	MAX. PARTICLE	CONDITION
A	4.0	2.0	No. 4	Remolded to
B	"	"	No. 4	95 & 80% of
C	"	"	No. 4	maximum
D	"	"	No. 10	density

DISTRICT: LOS ANGELES

PROJECT: LOWER SANTA ANA RIVER

CURVE	DIV. NO.	HOLE NO.	F.S. NO.	DEPTH FROM	TO
A	91527	1506		24	27
B	91531	1601		21	22
C	91532	1602		18	21
D	91534	2203		27	30

B COASTAL DESIGN

APPENDIX B
COASTAL DESIGN

CONTENTS

Contents (Continued)

Contents (Continued)

Tables

Photographs

Figures

Plates

I. GENERAL

Purpose and Scope

1-01 This section presents the results of investigations made for the Lower Santa Ana River in connection with the flood control channel improvement as the River empties into the Pacific Ocean. The objective of this appendix is to provide the structural design of the Santa Ana River Channel Jetties, the training dike, and to determine the impact of shoreline changes as a result of the Santa Ana River Flood Control Project.

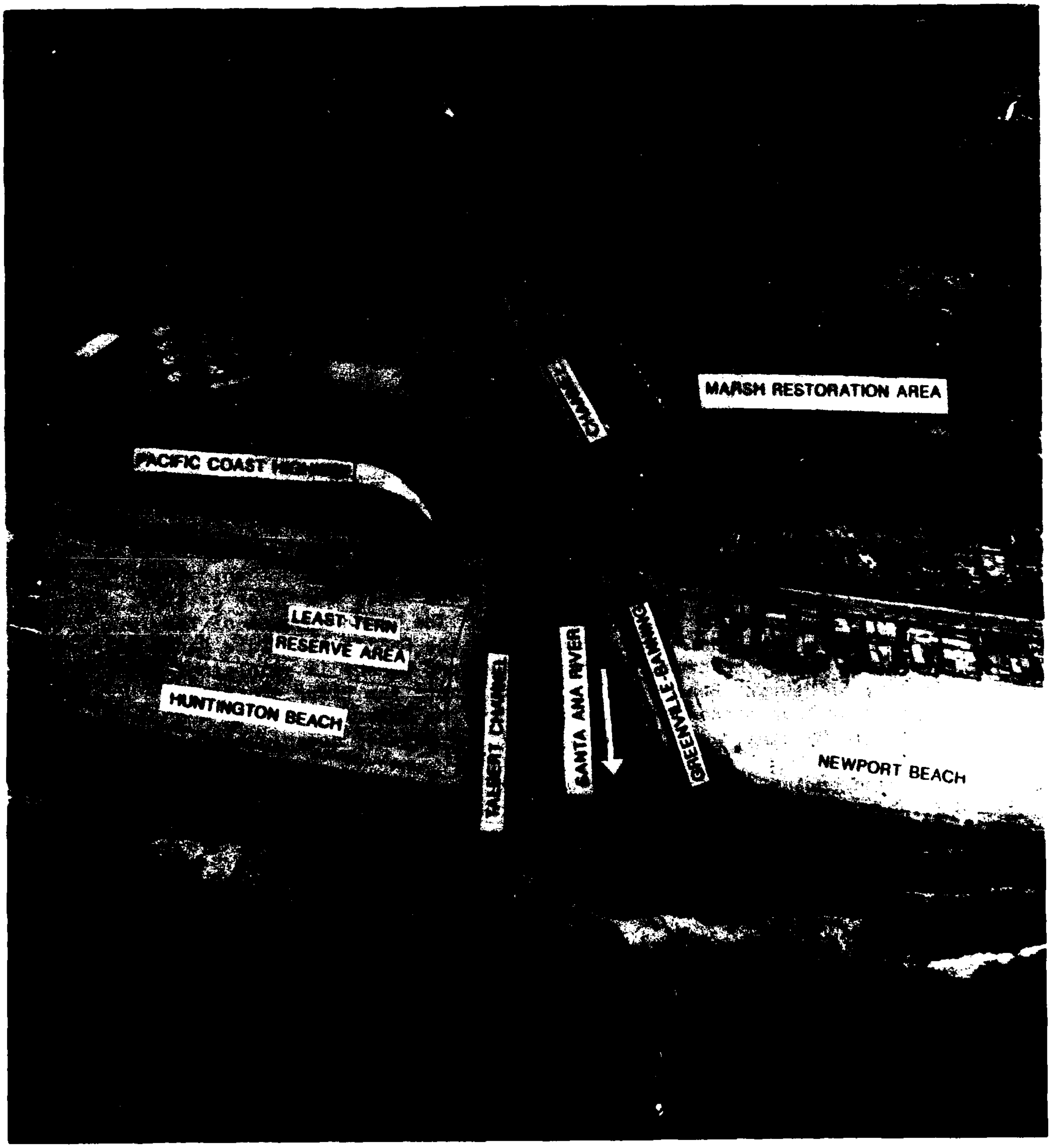


PHOTO 1: LOOKING UPSTREAM FROM MOUTH. LEAST TERN NESTING COLONY TO THE LEFT OF TALBERT CHANNEL.

II. EXISTING CONDITION

Location

2-01 Flows from the Santa Ana River empty into the Pacific Ocean between the cities of Huntington Beach and Newport Beach. The two cities occupy the plateau area which rises about 40 feet above the shoreline. Adjacent to the river on the northeast side of the Pacific Coast Highway is a degraded marsh area used for oil production. The shoreline is a continuous beach broken by the Santa Ana River jetties, and the beach is about 700-800 feet wide. The beach upcoast of the river (Huntington Beach) is maintained by the California State Parks and Recreation while the beach downcoast (Newport Beach) is maintained by the City of Newport Beach. The existing Santa Ana River mouth is composed of four stone jetties separating the Talbert, Greenville-Banning, and the Santa Ana River channel ocean outlets.

2-02 The center and main channel is the Santa Ana River flood-control outlet. The downcoast outlet is the Greenville-Banning and the upcoast outlet is the Talbert Channel. See photo 1, page B-I-2.

Santa Ana River Jetties

2-03 The Santa Ana River jetties consist of two rubble mound structures from Pacific Coast Highway (PCH) to the ocean, terminating near the low water line on Huntington Beach, a distance of about 900 feet. The two jetties form the main channel of the Santa Ana River. The east jetty (downcoast) is about 850 feet long. The west jetty (upcoast) is about 480 feet long and connects with a vertical concrete wall about 420 feet long to PCH. The crest elevations of the two jetties are about +10 feet mean sea level (MSL). The river side slopes of the jetties is 1V on 2H and 1V to 1.75H on the back side.

Shoaling of Santa Ana River

2-04 The Santa Ana River jetties were constructed in 1958, to convey floods from the Santa Ana River to the ocean. The width of the river varies from about 170 feet at PCH to about 320 feet at the ocean. The invert of the river was excavated to a -4.76 feet MSL or -1.96 feet mean lower low water (MLLW) by Orange County Flood Control District during the construction of the two jetties in 1958. Since 1958, the river mouth has shoaled with littoral material to an estimated elevation of +5.0 feet MSL or +7.8 feet MLLW. The Flood Control District often times has to remove portions of the littoral material during the summer months in the riverbed to provide a low flow channel for tidal exchange in the river.

2-05 A river mouth closure study was made by Tekmarine, Incorporated, Sierra Madre, California, for the Los Angeles District in 1986. Fifteen aerial photographs taken between June 1974 and July 1985 were analyzed. Six of the photos were taken during the summer (May-Oct) and nine were taken during the winter months (Nov-Apr). The analysis indicated that the Santa Ana River was open on 11 occasions (73 percent). The analysis also indicated that when the Santa Ana River mouth was closed, the sand plug appeared to have been created by littoral material moving to the northwest (upcoast direction).

Talbert Channel Jetty

2-06 The Talbert Channel jetty is a rubble mound structure about 200 feet long that begins near the low water line on the State Beach extending landward to join with the stone revetment of the Talbert Channel. The crest elevation of the jetty is about +10 feet MSL. The slopes of the jetty is 1V to 2H on the channel face and 1V to 1.5H on the back side.

Shoaling of Talbert Channel

2-07 The rubble mound jetty and stone revetment on the upcoast end of the Talbert Channel and the Santa Ana River west jetty form the ocean outlet for the Talbert Channel. The outlet is about 880 feet long from PCH to the ocean. Talbert Channel is a trapezoidal earth channel that was constructed by Orange County Flood Control District in the 1960's to collect and convey local storm runoff in the cities of Fountain Valley and Huntington Beach to the ocean, a distance of about 5.7 miles. The outlet channel is about 70 feet wide. The Talbert Channel outlet is opened to the ocean about 93 percent of the time for tidal exchange. On the occasions when the outlet was closed, the sand plug appeared to have been created by littoral material moving to the southeast (downcoast direction).

Remolded to 90% max. density at optimum water content.

BORING NO. 1509		SAMPLE NO.	
DEPTH/ELEV	27-30		
LABORATORY	SPDL	DATE	July 1985
TRIAXIAL COMPRESSION TEST REPORT			

ENG FORM NO. 2089
REV JUNE 1970

plate 60

III. TIDES

3-01 The tides along the Pacific Coast have a semidiurnal inequality. Tidal data for the Santa Ana River and vicinity are given in the following table 1:

Table 1. Tidal Data.

Location	Mean Range Feet	Diurnal Range Feet
Balboa (ocean pier)	3.6	5.3
Santa Ana River Entrance (inside)	2.4	3.3
Los Patos (Warner Avenue Bridge)	3.4	4.7
Long Beach, Outlet Harbor Pier A	3.7	5.3

3-02 The mean tidal range is the difference in height between mean high water and mean low water. The diurnal range is the difference in height between mean higher high water and mean lower low water. The maximum annual tide range is from minus 1.9 feet to plus 7.3 feet (MLLW).

3-03 At the Newport Bay Entrance is the closest tide station for which long-term records have been obtained (July 1955 to the present). The most recent tidal elevation data available for the Newport Bay Entrance station are summarized in the following table 2. All elevations are based upon the 1960-1978 tidal epoch with the exception of Extreme High and Extreme Low Water, which represent the historical maximum and minimum water levels recorded at the station.

3-04 The Mean Sea Level Datum (0.0 MSL) is equal to +2.8 feet Mean Lower Low Datum (+2.8 MLLW) for the Newport Bay Entrance.

Table 2. Tidal Elevations at Newport Bay Entrance.

Extreme High Water.	7.86 ft mllw
Mean Higher High Water	5.40 ft mllw
Mean High Water	4.65 ft mllw
Mean Tide Level	2.79 ft mllw
Mean Sea Level	2.76 ft mllw
Mean Low Water	0.93 ft mllw
Mean Lower Low Water	00.0 ft mllw

Note: Station located at 33°36'N; 117°53'W.

IV. CLIMATE

Temperature and Precipitation

4-01 Average daily minimum/maximum temperatures (degrees Fahrenheit) range from 46/63 in winter to 63/74 in summer. All-time low/high extremes of temperature are about 27/110. The area does not experience significant periods of freezing temperatures. Normal annual precipitation over the Lower Santa Ana River ranges from about 10 to 12 inches.

General Winter Storms

4-02 Most precipitation over southern California coastal drainages occurs during the cool season, primarily from November through early April, as mid-latitude cyclones from the north Pacific Ocean occasionally move across the West Coast of the United States to bring precipitation to southern California. Most of these storms are of the general winter type, with hours of light to moderate steady precipitation, but with occasionally heavy showers or thunderstorms embedded. Although these storms frequently produce significant snow in the upper Santa Ana River basin and other high-altitude drainages above 6,000 feet, snowfall and snowmelt are almost non-existent in the Lower Santa Ana River basin.

Local Thunderstorms

4-03 Local thunderstorms can occur in southern California at any time of the year, but are least common and least intense during the late spring. These types of storms occur fairly frequently in the coastal areas during or just after general winter storms. They can also occur between early July and early October, when desert thunderstorms occasionally drift westward across the mountains into coastal areas, sometimes enhanced by moisture drifting northward from tropical storms off the west coast of Mexico. Local thunderstorms can also occur throughout the fall, as upper-level low-pressure centers sometimes trigger left-over summer moisture. These local thunderstorms can at times result in very heavy rain for short periods of time over small areas, causing very rapid runoff from small drainages. Intense thunderstorms can also be accompanied by hail and strong, very erratic winds. On a rare occasion, a severe thunderstorm can spawn a small tornado or waterspout in southern California.

General Summer Storms

4-04 General summer storms in southern California are quite rare, but on occasion a tropical storm from off the west coast of Mexico can drift far enough northward to bring rain, occasionally heavy, to southern California, sometimes with very heavy thunderstorms embedded. The season in which these storms are the most likely to significantly affect southern California is mid-August through early October, although there have been some effects in southern California from tropical storms as early as late June and as late as early November.

4-05 On rare occasions, southern California has received light rain from non-tropical general summer storms, some of which have exhibited some characteristics of general winter storms.

Wind

4-06 The prevailing wind in northern Orange County is the sea breeze. This gentle onshore wind is normally strongest during late spring and summer afternoons, with speeds over the Lower Santa Ana River basin normally 10 to 15 miles per hour. The prevailing wind near the mouth of the Santa Ana River between April and November is west to west-southwest about 7-9 mph. The Santa Ana is a dry desert wind that blows from out of the northeast, most frequently during late fall and winter. Santa Ana winds over the Lower Santa Ana River basin typically average 15 to 20 mph, with gusts to 30-35 mph. On frequent occasions, however, these winds can reach 40 to 45 mph with extreme gusts to 65 mph or greater. These winds are sometimes accompanied by considerable blowing dust and sand.

4-07 Rainstorm-related winds are the next most common type in southern California. Winds from the southwest ahead of an approaching storm average 20-25 mph, with occasional gusts to more than 40 mph. West to northwest winds behind storms often exceed 25 mph, with gusts to 35 mph, but on occasion can rival the Santa Ana winds for speed and gustiness.

Evaporation

4-08 Few formal studies of evaporation have been made in Orange County. Studies from nearby locations indicate that mean daily evaporation ranges from about one-quarter inch in winter to about one-half inch in summer. On days of very strong, dry Santa Ana winds, evaporation can be considerably greater than one inch.

Fog

4-09 Dense Fog is fairly common along the southern California coast, especially during the late fall and winter months. On occasion, visibility along the coast between Newport Beach and Seal Beach can decrease to less than 100 feet during the night and early morning hours. Foggy days average about 1 to 2 per month during November, December, and January. During the late spring and early summer, a low cloud deck, some known as "high fog" is prevalent in coastal southern California during night and morning hours, but visibility is seldom reduced to less than 1 mile.

V. WAVE CLIMATE

Wave Exposure Windows

5-01 The section of coastline where the Santa Ana River discharges into the Pacific Ocean is protected to a significant degree from open ocean wave attack by the sheltering effects afforded by the offshore islands of San Clemente, Santa Catalina, San Nicolas, San Miguel, Santa Rosa, Santa Cruz, and, to a lesser extent, Anacapa and Santa Barbara. The shielding provided by the coastline orientation also limits direct wave approach from the northwest direction, since Point Fermin effectively precludes northern hemisphere swell or sea from propagating down the Santa Barbara Channel and into San Pedro Bay (see fig. 1).

5-02 Northern hemisphere swell generated by storms on the North Pacific Ocean can approach the Santa Ana River mouth study region from basically two wave exposure windows. The first window permits northern hemisphere swell propagating from essentially a westward direction to pass through the Santa Cruz Basin between San Nicolas and Santa Cruz Islands, cross the San Pedro Channel, and approach the coastline of interest. This exposure window extends from about azimuth 265 deg to about azimuth 277 deg. A second wave exposure window permits northern hemisphere swell generated by storms on the North Pacific Ocean, and southern hemisphere swell generated by storms on the South Pacific Ocean, to reach the Santa Ana River mouth region from southerly directions. Such swell passes between the mainland coast of southern California and San Clemente and Santa Catalina Islands, traverses the Gulf of Santa Catalina, and impacts the study area. This exposure window extends from the coastline in a southerly direction with an aziumuth of approximately 155 deg to an azimuth directed from the study region toward San Clemente Island, an azimuth of approximately 200 deg. Sea waves can approach the study region from all directions of possible generation from about azimuth 155 deg to about azimuth 277 deg.

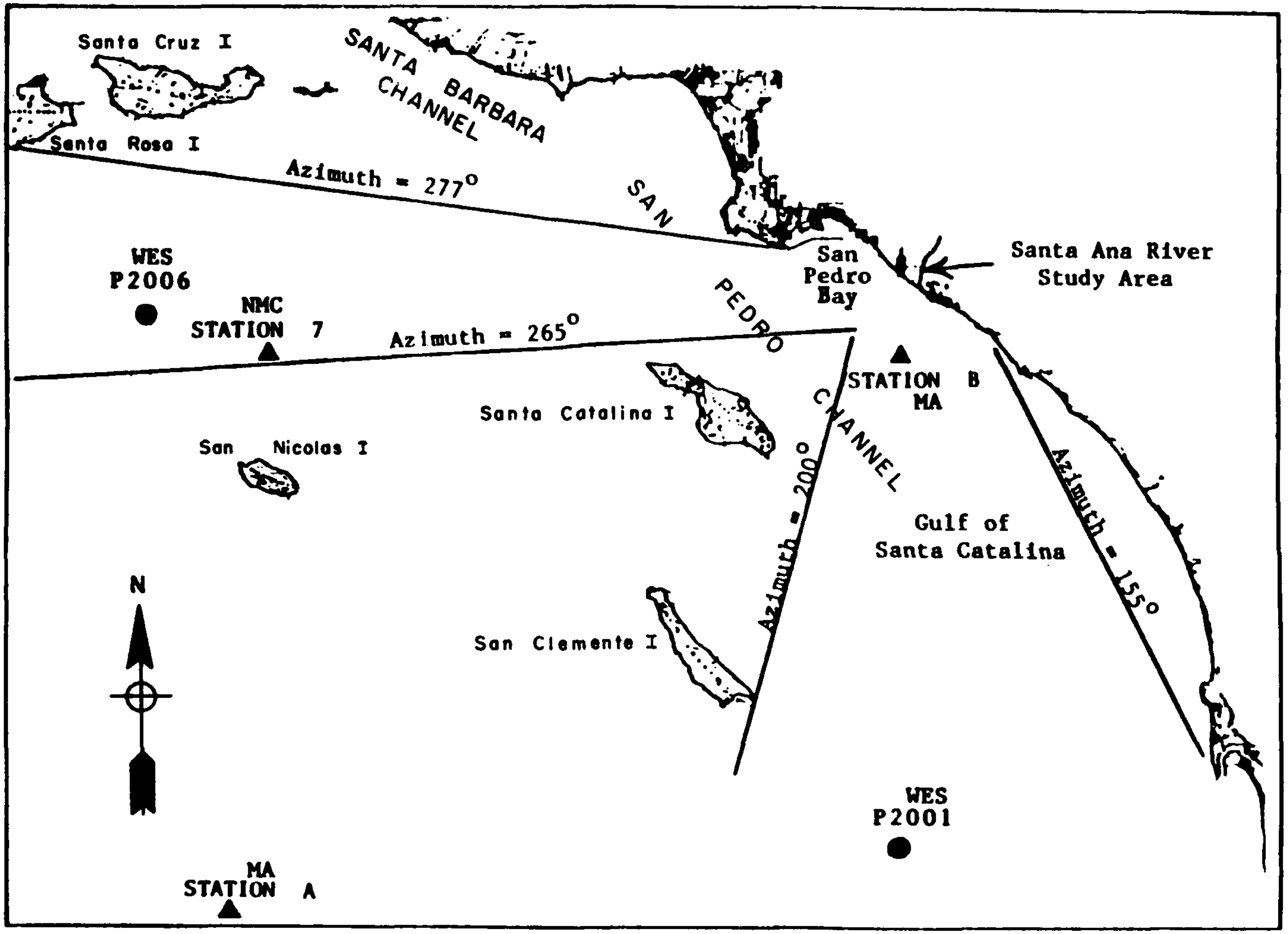


Figure 1 Wave exposure windows and hindcast data stations in southern California coastal waters for Marine Advisers (MA), National Marine Consultants (NMC), and U. S. Army Engineer Waterways Experiment Station (WIS).

Wave Data Sources

MARINE ADVISERS (1961)

5-03 Wave hindcasts have been prepared by Marine Advisers (1961) for three specific locations in deep water off the southern California coastline, one of which (Station A) is located in the open ocean beyond the sheltering islands. Station A is located approximately 65 nautical miles southwest of San Clemente Island, and is exposed to open water influences from southeast through west to north-northwest. Station A is considered to be representative of conditions outside the offshore islands. Wave hindcast frequency of occurrence data have been developed at Station A for sea, northern hemisphere swell, and southern hemisphere swell, for 3 years of record (1956-1958). Marine Advisers (1961) Station B is located approximately 8 nautical miles off Newport Beach in sheltered deep water. Decayed sea data from Station A were transferred past the sheltering islands and combined with locally generated sea to produce a sea wave climate at Station B which consisted of decayed plus local sea arriving from southeast through northwest directions. These decayed and local sea hindcast wave data of Station B are an indication of relatively short period waves which exist in the Gulf of Santa Catalina and San Pedro Channel, and which may approach the shore of southern California near the Santa Ana River mouth region. Station B also contains information regarding sheltered northern hemisphere swell and southern hemisphere swell which was transferred past the offshore islands by numerical techniques capable of deducing the reduction in wave height and sheltered direction of approach after passing the islands.

NATIONAL MARINE CONSULTANTS (1960)

5-04 National Marine Consultants (1960) also developed hindcast wave statistics for sea and northern hemisphere swell at Station 7 in deep water off the coast of southern California, for the same 3 years of record (1956-1958). Station 7 is located in the Santa Cruz Basin between San Nicolas Island and Santa Cruz Island, due west of San Pedro Bay. During the development of the hindcast wave statistics at Station 7, consideration was given to the effects of San Nicolas Island to the south, and to Santa Cruz and Santa Rosa Islands to the north. Hence, the resulting hindcast sea and northern hemisphere swell statistics deduced for Station 7 which arrive from a westerly direction propagate directly across the San Pedro Channel and approach the coastline of southern California in the vicinity of the Santa Ana River mouth region.

WAVE INFORMATION STUDY

5-05 A new generation of hindcast wave data are being developed for the Pacific Coast of the United States by the Wave Information Study (WIS) of the U.S. Army Engineer Waterways Experiment Station (WES), for a much greater time period than the 3 years of record used by Marine Advisers (1961) and National Marine Consultants (1960). WIS has computed the wave climatology of sea and northern hemisphere swell for the U.S. Pacific Coast for three different phases, utilizing 20 years of record (1956-1975) computed at 3-hour intervals. Phase I data have been computed with a grid spacing of 120 nautical miles, and have established 35 stations located near the Pacific coastline. Phase II data have been computed for 53 stations closer to the shore than the Phase I stations. The Phase II grid spacing was established at 30 nautical miles, to provide a better representation of the effects of the geometry of the coastline (but not the effects of the offshore islands) on wave generation near the Pacific coast. Phase III nearshore wave transformation data have been computed for 134 stations from the Canadian border to Point Conception, with each coastal segment being approximately 10 nautical miles in length. The nearshore wave transformation procedures applied to the coastal region between the Canadian border and Point Conception are not applicable to the sheltered Southern California Bight region adjacent to the Santa Ana River mouth region of southern California. Actual nearshore wave hindcasting is presently being performed for the Bight with a much finer grid (10 nautical miles and 5 nautical miles) than that previously used in Phase II hindcasting. Efforts are presently underway to make the nearshore wave hindcast data available for the Southern California Bight, and thus for the San Pedro Channel, San Pedro Bay, and the Gulf of Santa Catalina. Southern Hemisphere swell are also being developed as part of this effort. Upon completion, this WIS study will provide the most complete and detailed wave climate of any coastal region of the nation for the Southern California Bight. Several wave roses are shown in figures 2 through 5.

Wave Conditions

5-06 Wind-generated surface gravity waves produce the most powerful wave forces to which coastal structures are subjected (except for seismic waves). In the absence of a wave gaging program at the project site, the wave characteristics are usually determined by hindcast methods in deep water and then analytically propagated shoreward to the structure. This method has been applied for the Santa Ana River, where the deep water unsheltered wave hindcast data of Marine Advisers (1961) Station A for southern hemisphere swell, and National Marine Consultants (1960) Station 7 for northern hemisphere swell, and Marine Advisers (1961) Station B decayed and local sea have been utilized. Adjustments for island sheltering effects were also included. The deep water waves were then refracted and shoaled by numerical wave propagation methods, resulting in a frequency of occurrence of waves of various heights, periods, and directions of approach at the project area. This analysis is detailed by U.S. Army Engineer Waterways Experiment Station (WES) Technical Report HL-80-9, 1980. Western and southern wave exposures of the Santa Ana River study area are shown in figure 1.

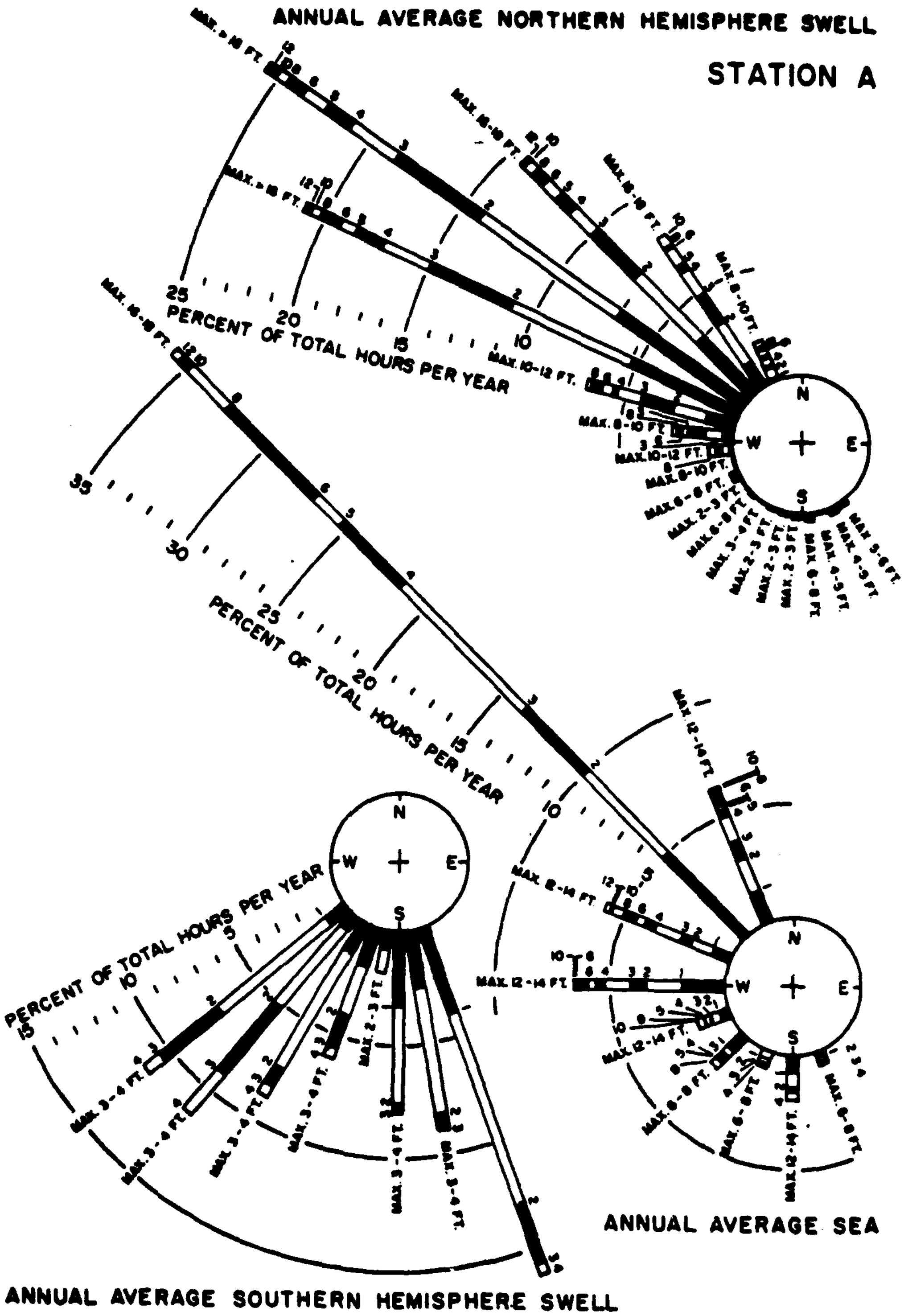


Figure 2 Average annual hindcast wave statistics, southern California coastal waters, Station A, sea, northern hemisphere swell, and southern hemisphere swell (after Marine Advisers, 1961).

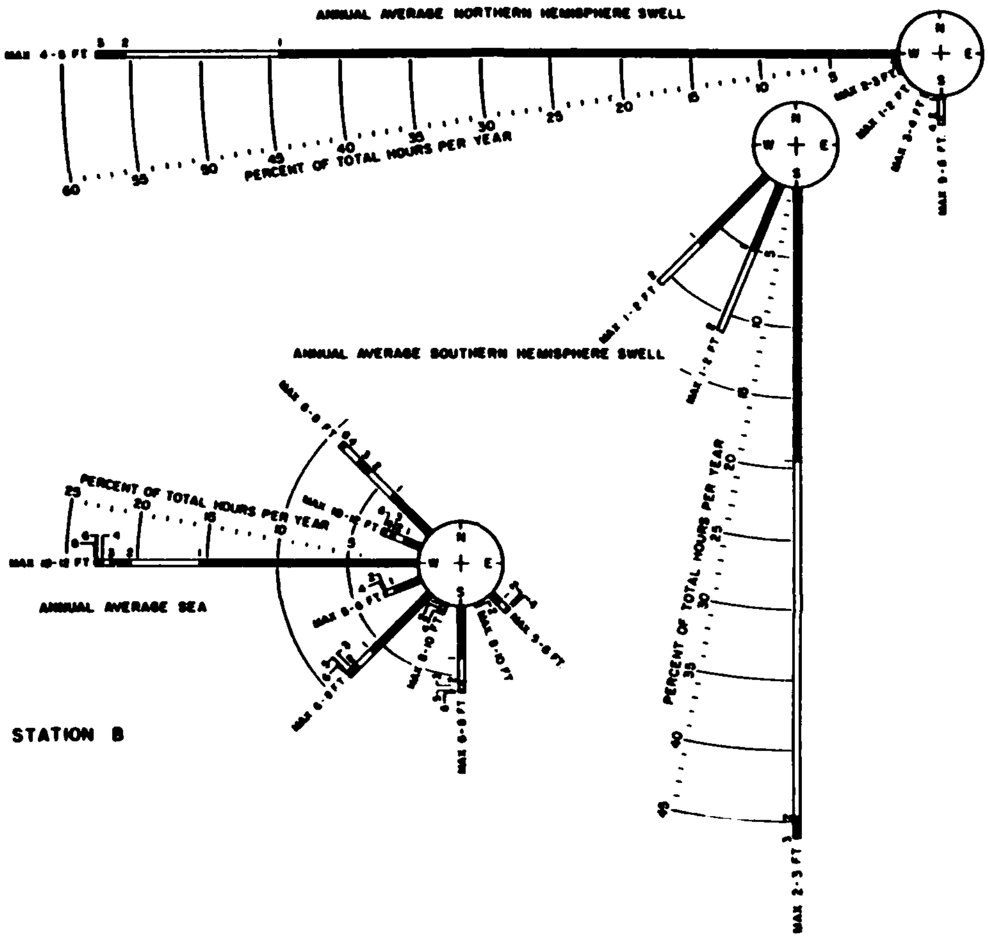


Figure 3 **Average annual hindcast wave statistics, southern California coastal waters, Station B, sea, northern hemisphere swell, and southern hemisphere swell (after Marine Advisers, 1961).**

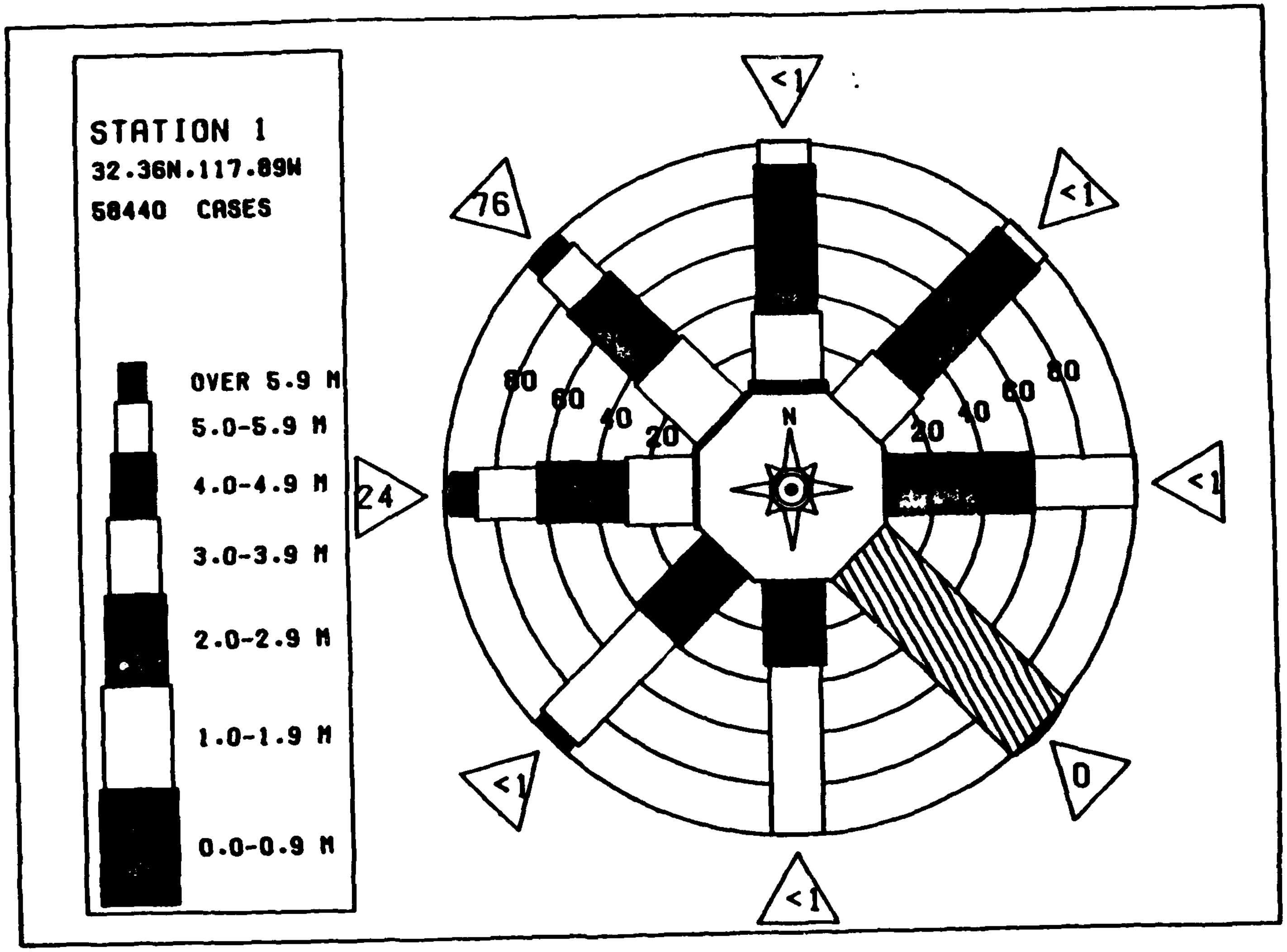


Figure 4 . Combined sea and northern hemisphere swell, Phase II, Station 1 (P2001), U. S. Army Engineer Waterways Experiment Station (WES) Wave Information Study (WIS) (after Corson, et al., 1987).

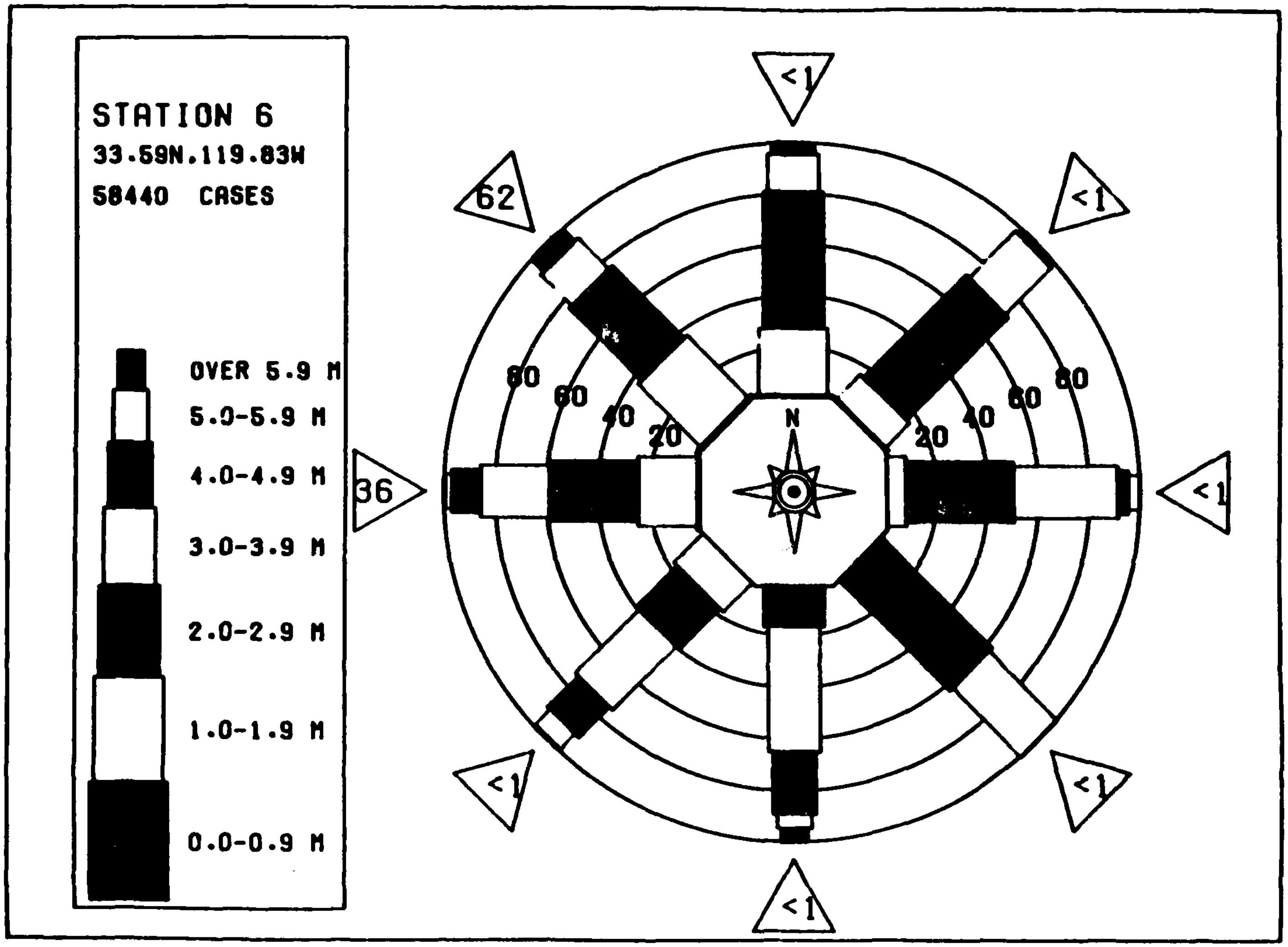


Figure 5 . Combined sea and northern hemisphere swell, Phase II, Station 6 (P2006), U. S. Army Engineer Waterways Experiment Station (WES) Wave Information Study (WIS) (after Corson, et al., 1987).

5-07 It was determined by Hales (1980) that the Santa Ana River mouth region is exposed to southern hemisphere swell arriving from azimuths 155 degrees to 200 degrees, with unrefracted sheltered deepwater significant wave heights ranging up to 4 feet. These heights, even with periods up to 20 seconds, are not adequate to inflict significant structural damage. Northern hemisphere swell arrives from azimuths 265 degrees to 277 degrees, with unrefracted sheltered deepwater significant wave heights ranging from 13 feet to 15 feet, and associated periods of 10 seconds to 14 seconds. These waves are capable of causing extensive structural damages; however, water depth-limiting conditions on wave heights reduce these extreme wave heights through the breaking process, and such excessive wave heights never break directly on the rubble structure. Shorter-period, locally generated waves with correspondingly large heights exist periodically in deep water off the Santa Ana River mouth region, but the depth-limited breaking process prevents these local sea from striking the structures with extremely high waves. The actual damage caused by the depth-limited breaking wave is inflicted by northern hemisphere swell instead of locally generated sea. Breaking wave damage increases with wave period, other factors remaining constant.

Wave Frequency

5-08 Damage to rubble mound structures is usually progressive, and an extended period of destructive wave action is required before a structure ceases to provide protection. It is, therefore, necessary in selecting a design wave to consider both frequency of occurrence of damaging waves and economics of construction and rehabilitation. The highest waves with the longest periods which occur with some significant discernible degree of frequency at this location are the 10.0-12.0 second waves (0.05 percent occurrence) and the 12.0-14.0 second waves (0.09 percent occurrence) approaching from a westerly direction (azimuth = 270 degrees) (table 3).

5-09 These data are Station 7 data from National Marine Consultants, (1960). Source: Hales (1980).

Design Stillwater Level

5-10 The actual wave conditions at a structure site at any time depend critically on the water level. Consequently, a design still water level must be established in determining the maximum wave forces on a structure. For the Santa Ana River project, the design still water level (SWL) has been established at +7.0 feet MLLW, or +4.2 feet MSL. The design still water level is based on the 1986 high and low water predictions at the Long Beach (Outer Harbor) station by the National Oceanic and Atmospheric Administration (NOAA). The NOAA predicted that a tide level of 7 feet would be exceeded eight times in 1986, once in January, twice in June and December, and thrice in July. The high water prediction by NOAA for 1986 range from 7.0 to 7.3 feet. The extreme high-water level observed by NOAA was 7.86 feet on January 28, 1983.

Table 3. Frequency of Annual Occurrence in Percent of Year, Northern Hemisphere Swell; Santa Ana River Mouth, California.

Deepwater Approach Azimuth = 259° - 281°

Significant Wave Height, Feet	Wave Period, seconds						
	6-7.9	8-9.9	10-11.9	12-13.9	14-15.9	16-17.9	18+
1.0-1.9	0.02	0.48	0.23	0.02	0.05		
2.0-2.9	0.88	2.07	1.06	0.62	0.35	0.11	0.02
3.0-3.9	0.42	0.87	0.50	0.35	0.02	0.09	0.02
4.0-4.9	0.16	0.48	0.23	0.09	0.12	0.02	
5.0-5.9	0.12	0.28	0.32	0.14	0.10		
6.0-6.9		0.31	0.32	0.12	0.07	0.05	
7.0-8.9		0.22	0.32	0.20	0.02		
9.0-10.9		0.02	0.23	0.16	0.10		
11.0-12.9			0.17	0.02	0.07	0.02	
13.0-14.9			0.05	0.09			
15.0-16.9							

Design Wave

5-11 The proposed Santa Ana River jetties and training dike will terminate at the river mouth in approximately the same location as the existing stone jetties at a depth of about -4.0 feet MLLW. The head sections of the jetties and training dike will be subjected to the full force of ocean waves generated on the Pacific Ocean and propagating past the offshore sheltering islands toward the coastline. Because of the reduction in height afforded by the islands, the waves which finally reach shore will be limited in height to the maximum wave sustainable in water at that specific depth. The forces created by these depth limited breaking waves will constitute the greatest wave forces which the structure will be expected to withstand. These maximum wave forces may arrive simultaneously with extreme high tide and flood conditions on the river, resulting in a larger resultant total force on the structure elements.

5-12 In determining the design wave for the Santa Ana River jetties and training dike, it is assumed that the flood control channel will be excavated to an invert elevation or -4 feet MLLW at the toe of the end of the jetties, and excavation will be maintained horizontally ($m = 0$) until this elevation intersects the existing beach slope seaward of the structure. Hence, the greatest water depth will occur when the SWL is at +7 feet MLLW immediately after construction of the flood channel to an elevation of -4 feet MLLW (assuming the channel does not degrade below the design invert elevation). This maximum still water depth will be 11 feet. The largest wave height which can be maintained in water 11 feet deep on a horizontal slope is about 9 feet ($H = 0.78 \times 11$). Table 3 indicates the 14 second wave occurs with significant regularity.

Thus, the 14 seconds, 9 feet breaking wave is considered to be the design wave for the Santa Ana River jetties and the training dike. Other sections further upstream between the ocean and the Pacific Coast Highway will experience broken or diffracted waves of lesser magnitude.

5-13 The design wave at the ocean end of the Santa Ana River jetties (14 sec. 9 ft. breaking wave) is the extreme worst wave condition to be reasonably expected under conditions of complete channel excavation. When this excavated channel shoals to some extent by longshore transport of littoral material in the surf zone or by river transport from upstream, the breaking wave conditions on the structure will be reduced from the maximum valued produced by the design wave height of 9 feet. The actual wave forces depend on the actual wave height, which in turn depends on the actual water depth at the local site.

5-14 Because of inherent instabilities in the breaking process, and since waves will approach at a range of angles to the shoreline (up to plus or minus 30 degrees), breaking of the design wave (14 sec., 9 ft. breaking wave) may not always occur precisely at the tip of the rubble structure head section. However, breaking of the design wave should occur within about 200 feet of the river entrance. That is, all breaking of the design wave should take place before it propagates upriver past west jetty station 9+60 (east jetty sta. 10+30). Hence, the design wave (14 sec., 9 ft. breaking wave) is utilized for both the rubble structure head section and structure trunk section (west jetty stas. 7+90 to 9+60 and east jetty stas. 8+60 to 10+30).

5-15 The wave height reduction by diffraction upriver from the rubble structure head section was estimated by graphical methods for non-breaking waves as discussed in the Shore Protection Manual (1984). For breaking waves, after breaking, the reformed wave height is estimated to be approximately equal to 40 percent of the local water depth. The broken and reformed wave height will be 0.4 x 11.0 = 4.4 feet, say 5 feet, upriver beyond the trunk section (west jetty stas. 9+60 to 11+90 and east jetty stas. 10+30 to 12+60). This value is larger than a non-breaking diffracted wave upriver between the jetties, and is used to design the riprap for the embankment of the jetties. Further up the channel, waves get smaller. Between west jetty stations 11+90 and 13+52 (east jetty stas. 12+60 to 14+22) waves will be about 3 feet high.

VI. LITTORAL TRANSPORT

Condition of Existing Beaches

6-01 The region of southern California coastline encompassed by a study of littoral transport past the Santa Ana River mouth should commence at approximately the eastern end of the Los Angeles-Long Beach Harbor complex (Anaheim Bay east jetty) and extend southeasterly for a distance of approximately 17 miles to the Newport Bay west jetty. This region is so distinctly separated from the adjacent coastlines by Point Fermin on the north and the Newport Submarine Canyon on the south that it can be effectively considered as a littoral cell, referred to as the San Pedro Littoral Cell by Inman (1976) (see fig. 6). A littoral cell is defined as a coastal segment that contains a complete sedimentation cycle including sources, transport paths, and sinks. This region of coastline satisfies these requirements: i.e., the source being the feeder beach located immediately east of Anaheim Bay (Surfside-Sunset Beach) and infrequent transport to the beach by flooding of the Santa Ana River; the transport path being the surf zone energized by breaking waves; and the ultime sink to the south being either the Newport Submarine Canyon or the shoal region off the Newport Beach region.

6-02 The direction of net longshore transport of littoral material in this vicinity is considered to be southerly by most researchers (Emery, 1960; Shepard and Wanless, 1971; Inman, 1976; Hales, 1980). Any material that may be drifting south past Point Fermin will be deposited in the deep water of San Pedro Bay outside the Los Angeles-Long Beach Harbor breakwaters. Correspondingly, any littoral material drifting south past the Newport Beach groin field will either be lost down the Newport Submarine Canyon, or deposited in deep water on the shoal region of the continental shelf located on the west side of the Canyon (Felix and Gorsline, 1971).

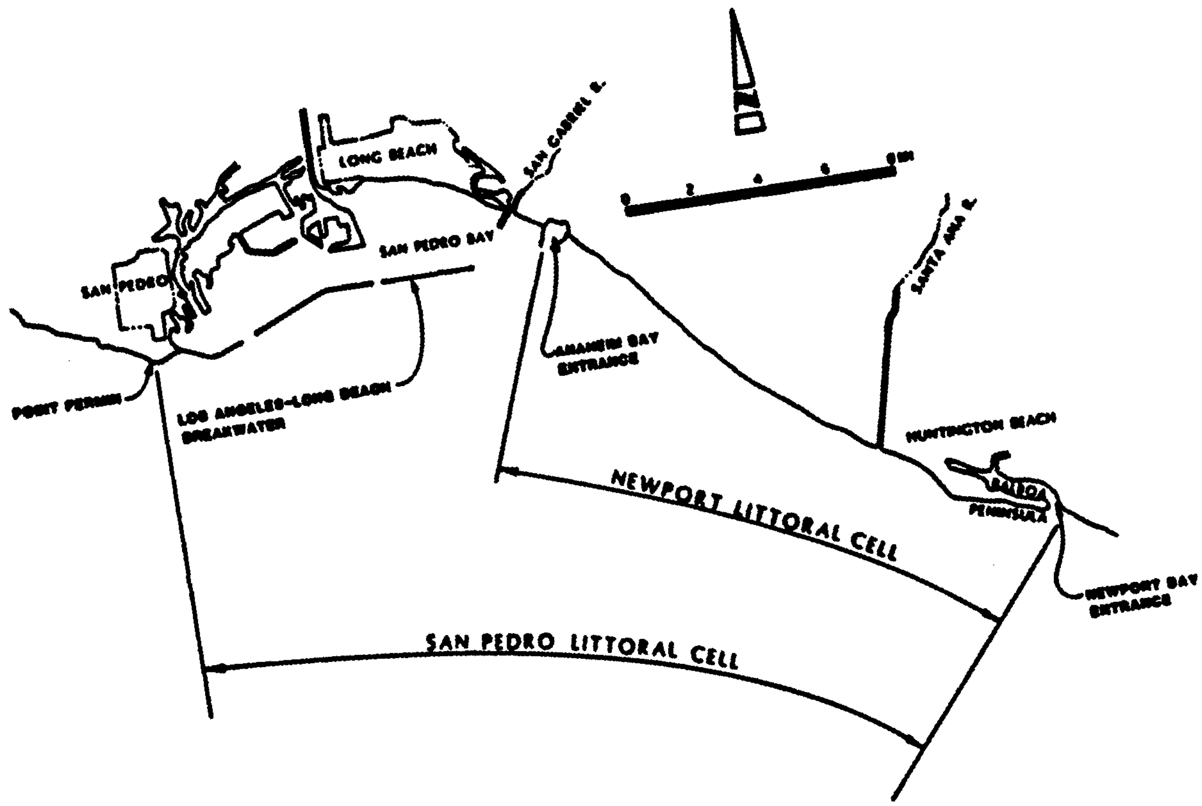


Figure 6 Newport Littoral Cell, a portion of previously defined San Pedro Littoral Cell (after Everts 1987).

6-03 Since construction of the Anaheim Bay east jetty in 1944, serious erosion of the beaches at Surfside-Sunset Beach has been a continually recurring problem that has necessitated the periodic placement of nourishment material to maintain an acceptable beach for recreation, and for protection of private and public property. The average annual rate of erosion in this area (based on placement volumes and hydrographic surveys) in recent years has been on the order of 300,000 cubic yards per year. Indications are that the net annual littoral drift of material in surf zone is in a southerly direction. Periodic renourishment of the Surfside-Sunset Beach region serves as feeder beach material for Bolsa Chica State Beach, Huntington Beach, and Newport Beach.

6-04 The Santa Ana River enters the Pacific Ocean at the lower extremities of the littoral cell, and has historically contributed a significant amount of sediment to the surf zone. However, in recent years, periods of prolonged drought and the construction of floodwater retarding structures on the river have drastically reduced the amount of river-transported sediment to the ocean. Reduction in the supply of sand to the beaches carries the potential for serious beach erosion. This potential for erosion has been alleviated by extensive beach nourishment at Surfside-Sunset Beach.

6-05 The Santa Ana River mouth region lies immediately upcoast of the Newport Beach groin field. Here, the beaches are relatively wide and stable. The existence of the wide beach upcoast of the Santa Ana River mouth toward Huntington Beach is attributed by Simons, Li, and Associates, Inc. (1987) to the stabilizing control afforded by the location of the west jetty to Talbert Channel, and to the volume of net downcoast movement of littoral material in the surf zone. Immediately after the construction of the west jetty to Talbert Channel, the fillet accumulation against the jetty gradually extended upcoast asymptotically until the existing Huntington Beach shoreline reached a position of dynamic equilibrium. In general, the beach is approximately ±600 feet wide on the upcoast side of the Santa Ana River mouth, and remains at this width because the downcoast end of this segment is fixed at the west jetty to Talbert Channel, and because the adequate nourishment placed on Surfside-Sunset Beach sufficiently reestablishes the asymptotic dynamic location of Huntington Beach following each winter and summer beach cyclic movement offshore and onshore, respectively.

6-06 Further south, the beach near Newport Beach has been stabilized with a groin field, and is approximately ±400 feet wide in this region. The groin field is located immediately north of the Newport Submarine Canyon. This prevents the apparent southerly net movement of littoral drift from depleting the beaches, as it moves either down the Newport Submarine Canyon or onto the shoal adjacent to the Canyon located offshore of the groin field. In either event, this net southerly transport of littoral material is removed from the littoral system, and the reversal in transport direction to the north during summer months would deplete the southern portion of the San Pedro littoral cell were it not for the existence of the Newport Beach groin field.

Littoral Transport Estimate

6-07 Potential longshore sediment transport is defined as the amount of littoral material that a specific wave climate will transport past a region in the presence of an unlimited source (supply) of material. When the feeder beach at Surfside-Sunset Beach has been nourished, an essentially unlimited supply of material exists for transport downcoast past the Santa Ana River mouth region, and on towards the Newport Submarine Canyon and eventually out of the system. Because of the necessity for maintaining a protective beach in the Surfside-Sunset Beach region, ensuing stable beaches result downcoast, and the actual longshore sediment transport past the Santa Ana River mouth region approximates the potential longshore sediment transport of the area.

6-08 Hales (1980) estimated the net longshore transport of littoral material in the surf zone to be toward the southeast with a magnitude of approximately 112,000 cubic yards per year (see table 4). The results of that study compare favorably with historical beach nourishment data for the Surfside-Sunset Beach area (Simons, Li, and Associates, Inc., 1987). This agreement suggests that these littoral estimates provide a reasonable approximation of the actual longshore transport rates. These littoral estimates compare favorably with estimates developed from more recent wave hindcast data by WIS (Phase II), although the definition of sea and swell may not be entirely consistent between the older wave hindcast data of Marine Advisers (1961) and National Marine Consultants (1960), and the more recent WIS data by WES.

Consequence of Littoral Transport Disruption

6-09 For a computational reach of southern California shoreline centered on the Santa Ana River mouth, the net longshore transport of littoral material in the surf zone is toward the southeast, with a magnitude of about 112,000 cubic yards per year on an average annual basis. In consequence, any major disruption of the dynamic equilibrium which presently exists in this region (such as the construction of a long jetty across the surf zone) is likely to cause erosion in the Newport Beach area unless beach nourishment material is placed on the beach south of the Santa Ana River mouth, and in the Newport Beach groin field for that period of time when the Huntington Beach shoreline is responding asymptotically to any lengthened jetty structure across the surf zone. Both the magnitude and direction of longshore transport exhibit distinct seasonal variations, with strong transport toward the southeast dominating in the winter months (January through April), and moderate transport toward the northwest occurring in the summer months (July through October). This annual cycle implies that littoral material would possibly have the capacity for temporary closure of the entrance to the Santa Ana River.

Table 4. Summary of Potential Longshore Transport Computations
Santa Ana River Mouth Region, California.
(All values in cubic yards)

Month	Sea + North	Sea - South	Northern Swell + North	Northern Swell - South	Southern Swell + North	Southern Swell - South	Sum + North	Sum - South	Net + North	Net - South	Gross
Jan	11,682	28,159	0	68,230	0	0	11,682	96,389		84,707	108,071
Feb	66,681	24,159	0	151,881	0	0	66,681	176,040		109,359	242,721
Mar	24,463	38,253	0	47,827	0	0	24,463	86,350		61,887	110,813
Apr	3,445	29,085	0	48,424	0	0	3,445	77,509		74,064	80,954
May	1,557	22,567	0	10,517	39,604	0	41,161	33,084	8,077		74,245
Jun	1,720	16,882	0	2,938	19,429	0	21,149	19,820	1,329		40,969
Jul	3,681	17,752	5,237	0	84,507	0	93,425	17,752	75,673		111,177
Aug	2,083	16,182	6,498	0	68,904	0	77,485	16,182	61,303		93,667
Sep	958	16,625	15,438	570	53,077	0	69,473	17,195	52,278		86,668
Oct	3,810	11,181	3,421	14,168	56,780	0	64,011	25,349	38,662		89,360
Nov	902	14,446	0	2,070	0	0	902	16,516		15,614	17,418
Dec	23,220	12,848	0	14,010	0	0	23,220	26,858		3,638	50,078
Annual	144,202	248,139	30,594	360,635	322,301	0	497,097	609,044	237,322	349,269	1,106,141
Net		103,937		330,041	322,301			11,947		111,947	

Source: Hales (1980).

VII. LITTORAL TRANSPORT

Sources of Littoral Material

7-01 The region of coastline between the Anaheim Bay east jetty and the Newport Submarine Canyon is essentially a semi-closed system in that major sources of littoral material input are restricted to two finite locations (assuming no significant onshore movement of material from deep water by wave energy). The more significant source of material to the system is the feeder beach region at Surfside-Sunset Beach. Here, it is estimated that, on the average, approximately 360,000 cubic yards of material are placed annually.

7-02 A less significant source of material to the system is riverborne sediment transport by the Santa Ana River. The significance of this source is limited both by the volume of material transported, and by the location of the river mouth near the downcoast extremity of the littoral cell, which experiences a large downcoast movement of material in the surf zone. Any volume of material transported to the coast by the river which is less than the difference between the average annual downcoast transport of littoral material and the average annual net transport will be carried out of the system by deposition into the Newport Submarine Canyon, or placed on the continental shelf adjacent to the Canyon. No river mouth delta will form under these conditions. Only under extreme floodflow conditions on the river will significant quantities of riverborne sediment be transported to the coast sufficient for delta creation. It has been estimated by the Los Angeles District (1987) that for the period 1941-1978, sand outflow to the coast by the Santa Ana River was 80,000 cubic yards per year, on the average. The amount of sand outflow for future years without project is estimated to be only 25,000 cubic yards per year, on the average. With project, the sand outflow to the ocean for future years is estimated to increase to 36,000 cubic yards per year, on the average.

7-03 The ultimate repository for all littoral material removed from the system is the open ocean. Material which disappears from the beach will either be transported alongshore and out of the littoral cell by movement down the Newport Submarine Canyon, or will be carried offshore by wave forces and deposited in shoal regions sufficiently far from shore to preclude returning to the nearshore zone.

Beach Materials

7-04 It is generally considered that, subsequent to the construction of the Anaheim Bay east jetty in 1944, materials comprising the dynamic surf zone portion of the beaches downcoast to the Santa Ana River mouth have originated as nourishment material placed on Surfside-Sunset Beach. The beaches between the Santa Ana River mouth and Newport Beach consist of a combination of materials, including materials placed on Surfside-Sunset Beach, riverborne sediments transported to the coast by the Santa Ana River, and by placement material used to fill the Newport Beach groin field. Sediment samples were taken from the foreshore slope and backshore of Surfside-Sunset Beach (U.S. Army Engineer District, Los Angeles, 1978) and subjected to mechanical analyses. Results of the analyses indicated that the exposed area of the beach was composed of extremely clean, predominantly medium to coarse grained sand. Those samples contained fines no greater than 2 percent. The subtidal zone of the sandy beach shoreline became more silty. The higher percentage of fines in the subtidal zone appeared to be the result of previous beach nourishment operations, although much of this fine material could have been washed by wave action from the surf zone and transported offshore. Mechanical analyses of samples taken from Surfside-Sunset Beach in 1987 also indicated a similar trend toward finer grained materials offshore (U.S. Army Engineer District, Los Angeles, 1987c).

Offshore Materials

7-05 An offshore source of beach material designated Borrow Area B for nourishing Surfside-Sunset Beach is centered 6,900 feet off Sunset Beach (U.S. Army Engineer District, Los Angeles, 1978). This source lies on the shoreward boundary of an area previously determined by the U.S. Army Coastal Engineering Research Center to contain suitable beach material. That area designated as Area A-II is approximately 7 miles long by 2 miles wide, extending from Seal Beach to Bolsa Chica State Beach. That offshore sand inventory indicated that 220,000,000 cubic yards of suitable sand exists in the area adjacent to Borrow Area B. As is characteristic of San Pedro Bay, the ocean floor encompassing Area A-II is uniformly flat and slopes an average of 0.3 percent. Within Borrow Area B, the floor is also relatively flat, varying from a minimum depth of -31 feet to -41 feet MLLW. No extreme irregularities were found to exist within this borrow area.

7-06 Exploration of Borrow Area B by Los Angeles District, (1978) indicated that the area is covered with a gray, slightly silty, medium grain sand extending to the first silt or clay stratum. These silt and clay strata vary in thickness from 6 inches to 6 feet, are laterally discontinuous, and occur at depths ranging from 3 feet to over 20 feet.

They would not be suitable for use as beach replenishment; only that sand above the first stratum would be considered suitable. The statistical average of fines is 9 percent in the available material for the total borrow area. Laterally, indications were that the shore side of the borrow area should be avoided because of the more shallow clay strata and the greater percentage of fines in the sand. The better material tends to occur seaward and toward the south corner. It was estimated that dredging a section to 20-foot depth and 1,000 feet wide from this region would produce 1.75 million cubic yards of suitable material.

7-07 A study by the University of Southern California for the State of California (Osborne, et al., 1983) defines sand borrow source materials for the offshore region of the San Pedro Littoral Cell. That study indicated that 13 test holes were drilled offshore, a distance of 3,000 to 18,000 feet between the Huntington Beach Pier and the Newport Beach Pier. A sand borrow area exists between Huntington Beach Pier and the Newport Beach Pier, with approximate dimensions of 10,000 feet by 8,000 feet and 6 feet deep, which would yield about 17,000,000 cubic yards of material. The area lies between the 35- and 130-foot MLLW contours. The upcoast and downcoast limits are 12,000 and 4,000 feet, respectively, upcoast of the Newport Beach Pier, and parallel to the shoreline. The seaward limits extend 2,500 to 12,500 feet offshore. Although that study does not provide the depth or detailed material descriptions of each hole, the study report does indicate that the sediments encountered in the test holes are either suitable or marginally fine sand that could be used for beach replenishment (Los Angeles District, 1987).

VIII. SEDIMENT BUDGET

Newport Littoral Cell

8-01 Everts (1987) noted that the southeastern one-half of the contigious San Pedro Littoral Cell also satisfies the requirements for being identified as a littoral cell, and termed this portion the Newport Littoral Cell (see fig. 6). The Santa Ana River discharges into the Pacific Ocean at about the southeastern one-third portion of the Newport Littoral Cell. Before 1899 the San Pedro Littoral Cell extended from Point Fermin to Corona Del Mar. However, since that time, the northern half of the cell has been greatly modified. Today, coastal processes north of Anaheim Bay are essentially completely controlled by artificial structures. Waves are effectively blocked by the Los Angeles-Long Beach Harbor complex breakwaters, thereby eliminating littoral sediment transport behind the structures. Sand delivery to the cell by the Los Angeles and San Gabriel Rivers has been significantly reduced by the construction of sediment impoundment and flood control structures on the rivers. The jetties at Anaheim Bay essentially eliminate all transport of littoral material from the west into the Newport Littoral Cell. Hence, the coastal processes aspects pertaining to sand supply of the Newport Littoral Cell are dominated by beach nourishment projects and the minimal supply of sediments to the coastline by the Santa Ana River (see fig. 7).

Shoreline Changes

8-02 The Newport Littoral Cell is bounded by complete barriers to the longshore transport of sand. Its western boundary consists of the east jetty to Anaheim Bay, and its eastern boundary is the west jetty to Newport Bay, although the approximately 2.5-mile section of the cell between the Newport Submarine Canyon and the west jetty to Newport Bay (the Balboa peninsula) may not be significant to an analysis of the sediment budget of the Newport Littoral Cell. The shoreline of the Newport Littoral Cell is in a state of dynamic equilibrium, with most portions of the cell oscillating about a relatively stable position.

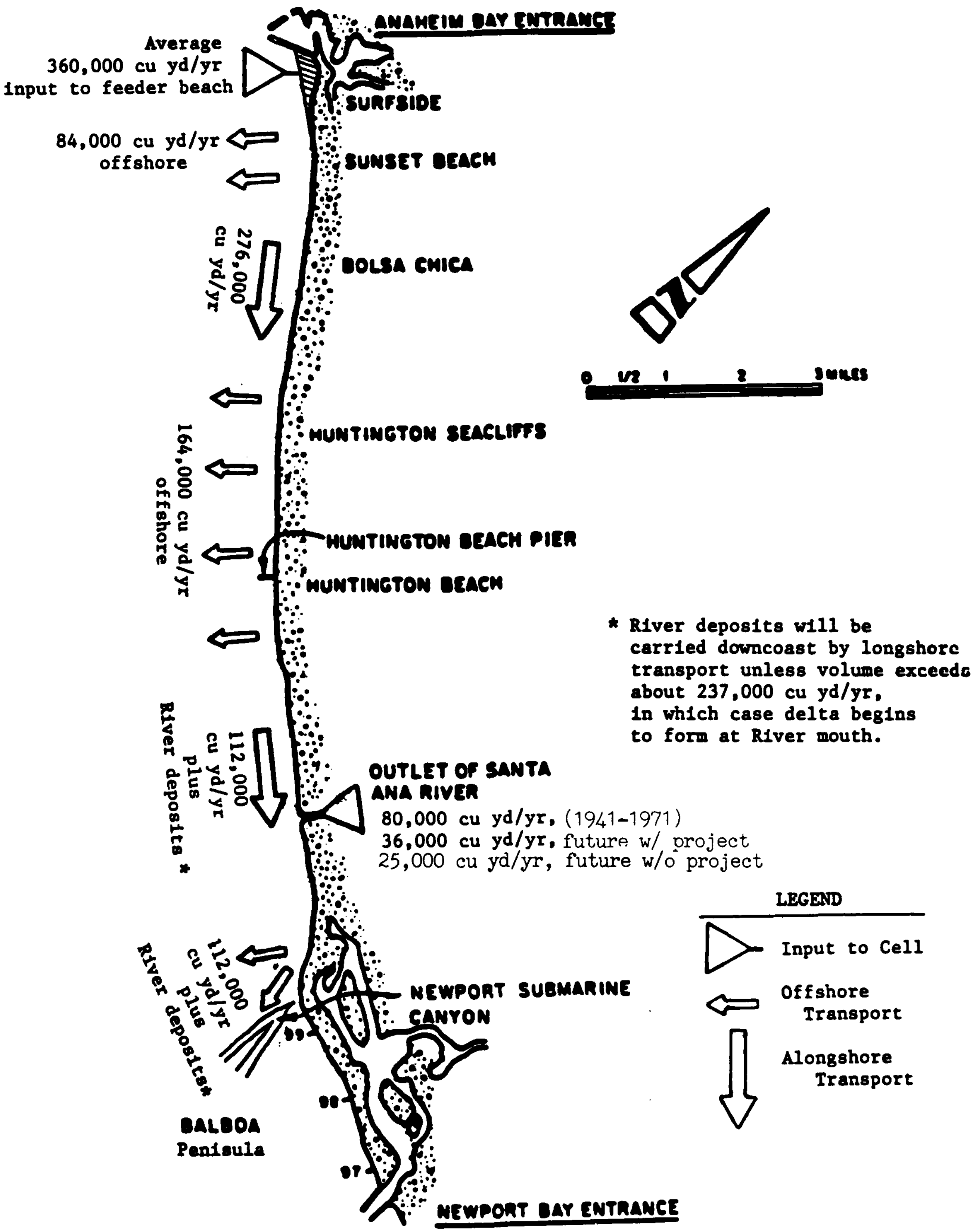


Figure 7. Sediment sources, transport paths, and sinks for Newport Littoral Cell.

The region most susceptible to shoreline change is the Surfside-Sunset Beach renourishment region, with the change being as much as 500 feet over 5- to 10-year periods between renourishment intervals. Other regions of the cell show relatively insignificant changes over long time intervals.

Newport Littoral Cell Sediment Budget

SEDIMENT SOURCES

8-03 The primary source of sediment to the Newport Littoral Cell is the feeder beach renourishment area at Surfside-Sunset Beach. Renourishment activities supply about 360,000 cubic yards per year, on the average, to the cell. A secondary source of sediment to the Newport Littoral Cell is riverborne transport by the Santa Ana River. Under previous conditions, the river contributed about 80,000 cubic yards per year, on the average. After river flood control channel improvements have been completed, the river will contribute only about 36,000 cubic yards per year, on the average.

TRANSPORT PATHS

8-04 The transport path for sediments of the Newport Littoral Cell is the surf zone which is energized by breaking waves arriving from the open ocean. For the section of relatively straight coastline from Surfside-Sunset Beach to Huntington Beach, the net downcoast transport of littoral material in the surf zone is estimated to be about 276,000 cubic yards per year, on the average. For the section of relatively straight coastline from Huntington Beach to Newport Beach groin field (past the Santa Ana River mouth), the net downcoast transport littoral material in the surf zone is estimated to be about 112,000 cubic yards per year, on the average.

SEDIMENT SINKS

8-05 Approximately 360,000 cubic yards of material is placed on Surfside-Sunset Beach each year, on the average; however, the wave climate apparently is able to transport only about 276,000 cubic yards net per year of this material downcoast. Hence, the difference between these two quantities (84,000 cubic yards per year, on the average), is probably being transported offshore to known regions of sand deposits.

8-06 The wave climate in the Surfside-Sunset Beach region is capable of transporting approximately 276,000 cubic yards net per year of littoral material, on the average. However, in the vicinity of the Santa Ana River mouth, the wave climate is capable of transporting only about 112,000 cubic yards net per year, on the average. Since no visible accumulation of sediments is occurring, the difference between these two quantities (164,000 cubic yards per year, on the average), is probably being transported offshore to known regions of sand deposits.

8-07 The net downcoast transport of littoral materials past the Santa Ana River mouth of approximately 112,000 cubic yards per year, on the average, is being lost from the littoral system, either down the Newport Submarine Canyon or onto the continental shelf to the west of the canyon where known regions of sand deposits exist. In addition to the net downcoast transport of littoral material of 112,000 cubic yards per year, the wave climate is also capable of transporting that riverborne sediment which is carried to the ocean by the Santa Ana River, as long as the sum of the riverborne sediment plus the net downcoast transport of littoral material in the surf zone does not exceed the gross downcoast transport capacity of the wave field. Hence, as long as the sediment volume carried to the Pacific Ocean by the Santa Ana River does not exceed 237,000 cubic yards per year, on the average, the wave climate will transport both the riverborne sediments and the net downcoast transport of littoral material past the Newport Beach groin field and out of the littoral system. Under severe flood conditions where riverborne sediment transport to the coast exceeds 237,000 cubic yards per year, temporal deltas and perturbations to the coastline in the vicinity of the Santa Ana River mouth will develop. Such deltas and other perturbations will dissipate as dynamic equilibrium returns to the coastline of the Newport Littoral Cell.

IX. TIDAL INLET

Existing Inlet Conditions

9-01 The recommended plan for coastal structure improvement at the mouth of the Santa Ana River includes a relocation of the Talbert Channel approximately 1,000 feet upcoast, with its base width expanded from 70 feet to 160 feet. The ocean entrance of the river will be expanded from its existing base width of 317 feet to a new base width of 450 feet, with a channel invert elevation established at -4.00 feet MLLW. The Greenville-Banning Channel will merge with the river about 1.5 miles upstream from the Pacific Ocean. To mitigate the loss of 8 acres of coastal salt marsh required for river expansion, and to preserve and enhance an 84-acre habitat for endangered bird species, the recommended plan includes the acquisition and improvement of approximately 92 acres of degraded marshland located east of the river immediately upriver from the Pacific Coast Highway. To the maximum extent possible, it is also necessary to ensure that the relocated Talbert Channel remains open to the ocean; thereby, providing tidal exchange for a proposed 17-acre marsh restoration, located north of the Pacific Coast Highway and upstream from the outlet, by Orange County. It is essential to provide tidal exchange for the planned 92-acre marsh east of the Santa Ana River by keeping the river outlet open to the ocean. The hydraulic design of the mouth of the Santa Ana River provides adequate flushing ability to maintain the tidal inlet system open from the closure effects of littoral transport in the surf zone.

9-02 The tidal range at the project site is of importance both because it will play a central role in the design of the topography and hydraulic inlet structures for the 92-acre marsh, and because it will determine the energy available for scouring littoral material from the Talbert Channel and Santa Ana River outlets during ebb tidal flow. Tidal conditions inside the river mouth at the entrance to the proposed 92-acre marsh will depend upon the extent to which the coastal tides are affected by head losses in the new channel, and by partial or total blockage of the mouth by littoral material.

Existing Tides at the Marsh Entrance

9-03 Tide gauge data obtained in the Greenville-Banning Channel by the Orange County Environmental Management Agency supports the conclusions that the channel outlet is frequently blocked. A small water-level fluctuation (generally less than 1 foot) occurs in the channel during closure episodes, apparently as the result of leakage through permeable areas in the intermediate jetties. When the channel is open to the ocean, the tidal range is significantly less than that which occurs along the coast. Whereas the mean tidal range at Newport Bay Entrance is about 3.7 feet, the tidal range recorded at the gauge exceeded 1.5 feet only 46 percent of the 1983-1984 period. The primary cause of the reduced tidal range in the channel appears to be a bar or "sill" at the ocean outlet which obstructs the lower portion of the tidal excursion.

Existing Tides in the Talbert Channel

9-04 Tide measurements analogous to those obtained in the Greenville-Banning Channel are not available for the Talbert Channel or the Santa Ana River. To provide preliminary information on the presence or absence of a sill across the Talbert Channel outlet, the water level upstream of the outlet was determined on 22 September 1986. Whereas the predicted low water elevation at Newport Bay Entrance was +1.0 feet MLLW, the measured water level in the Talbert Channel (1,000 feet upstream of the outlet) did not fall below +2.0 feet MLLW. It thus appears that a sill may exist at the Talbert Channel outlet, but at a lower elevation than that which obstructs the Greenville-Banning Channel outlet. This conclusion is consistent with the observation that the Talbert Channel remains open far more frequently than the Greenville-Banning Channel.

Recommended Structure Configuration

9-05 The existing jetties at the project site will be replaced by four new jetties; (a) two to stabilize the outlet of the widened Santa Ana River, and (b) two to stabilize the outlet of the relocated Talbert Channel. A training dike will also be required for the Santa Ana River outlet.

9-06 The jetty configuration at the new Talbert Channel outlet has been designed to minimize the closure frequency of the outlet while avoiding significant adverse impacts on the existing littoral transport regime. The jetties will terminate approximately 900 feet seaward of the Pacific Coast Highway, a location analogous to that of the existing northwest jetty in terms of proximity to the typical MLLW shoreline. The ability of the existing Talbert Channel to remain open suggests that the new jetties, which will also extend to the MLLW contour, will be sufficient to assist the channel outflow in penetrating the zone of beach drift.

Because the jetties will not extend beyond the present shoreline, however, they will not impound appreciable quantities of littoral material. It is anticipated that sand will bypass the new outlet in much the same manner as it bypasses the existing Talbert Channel outlet, and that the net drift of material toward the southeast will not be materially affected. The alignment of the new jetties is approximately perpendicular to the shoreline.

9-07 Potential sand migration through the proposed structure will not create the sand plug presently experienced at the mouth of the river. Both jetties and the training dike at the mouth of Santa Ana River will terminate at proximity of the MLLW contour. Most of the littoral transport occurs below this elevation. The sand plug is being created almost entirely by the material moving in the littoral zone and entering around the jetties. The small portion of the sand which will penetrate the river through the proposed permeable training dike or the jetties will easily be flushed by the tidal action.

Tidal Inlet and Tidal Exchange System

9-08 Historically, the Santa Ana River and Greenville-Banning Channel have experienced frequent closure. The existing marsh relies on a single tidal gate for exchange of tidal and riverine flows with Greenville-Banning Channel. Tidal exchange in the marsh is extremely poor and should be improved to support future marsh restoration plans. On the other hand, tidal exchange in the existing Talbert Channel has been satisfactory and should be maintained. Restoration of a 17-acre marsh adjacent to the Talbert Channel is currently being planned by others, and will rely on exchange of tidal and riverine flows with the Talbert Channel.

9-09 The tidal exchange system as shown on figure 8 was analyzed by Simons. Li, and Associates, Inc. (1987). It included the following: (a) Training Dike No. 1, to provide a 90-foot channel in the proposed Santa Ana River to prevent littoral sedimentation which may result from channel widening; (b) Training Dike No. 2, located in the middle of the proposed Talbert Channel to retain the self-cleaning capability of the existing Talbert Channel; (c) Tidal Gate No. 1, located on the Santa Ana River east bank above the Pacific Coast Highway to have a similar function as the existing gate; (d) Tidal Gate No. 2, located on the Santa Ana River east bank near the upper end of the proposed 92-acre marsh to provide additional flow exchange to the marsh; and (e) Tidal Gate No. 3, located at the confluence of the proposed Santa Ana River and existing Talbert Channel to provide tidal exchange between the proposed Santa Ana River and the proposed Talbert Channel.

9-10 Because of potential tidal exchange through Tidal Gate No. 3 and the existing Talbert Channel between the proposed Santa Ana River and the proposed Talbert Channel, both the 92-acre marsh and the 17-acre marsh have an auxiliary system to provide tidal or riverine flows, if the primary system fails to function due to unexpected closure of either outlet.

9-11 Performance of the proposed tidal exchange system was carefully evaluated and a general guideline for operation and maintenance was recommended by Simons, Li, and Associates, Inc. (1987). With the proposed training dike structures, the sediment flushing capability and the river mouth opening potential of Santa Ana River and Talbert Channel are comparable with the existing Talbert Channel. The tidal ranges in the Santa Ana River and Talbert Channel near the proposed 92-acre marsh and the 17-acre marsh will be increased when compared to the existing condition. With the proposed Tidal Gates Nos. 1 and 2, and the conceptual 92-acre marsh restoration plan, the tidal range and flow circulation in the marsh can be significantly improved.

9-12 Training Dike No. 2 (located in the Talbert Channel) may be deferred in construction to reduce initial cost, and to allow for observation of performance of remaining aspects of the tidal exchange system. This dike is not as effective as Training Dike No. 1 in increasing the sediment flushing capability of the proposed channel. The requirement and location of this dike can be determined based on field observation following channel construction. During the observation period, tidal exchange may be provided through the proposed Santa Ana River system (with Training Dike No. 1 and Tidal Gate No. 3). If there is a tendency for Talbert Channel to close, construction of Training Dike No. 2 should proceed immediately.

X. SANTA ANA RIVER JETTY DESIGN

10-01 The design of improvements recommended in this appendix is based upon standard engineering practice, consultations with specialists in coastal engineering oceanography and geology, and technical references listed at the end. Plan, profile, and sections of the jetties are shown on plate 1.

General

10-02 Rubble-mound jetties are selected as replacement for the existing rubble-mound jetties in the Santa Ana River mouth. The rubble-mound jetties would be acceptable to Orange County for esthetical and safety aspect, and the character of the shoreline. Other factors for selecting rubble-mound structures for the Santa Ana River jetties are the availability of material, acceptable performance, depth of water, wave action, exposure to the ocean, and construction costs.

Stability Coefficients

10-03 Stability coefficients (K_D) are dimensionless coefficients used in the determination of the weight of armor units of rubble structures. A rubble structure is composed of several layers of random-shaped and random-placed stones, and is protected with a cover layer of selected armor units of either quarrystone or specially shaped concrete units. Relatively satisfactory experience with the existing Santa Ana River jetty design at the Pacific Ocean outlet has provided guidance for the design of proposed channel improvements in this region. The design of the ocean outlet includes jetty head and structure sections comprised of rough angular quarrystone, with random placement of two units of thickness in the armor layer. For the structure head section designed to withstand breaking waves of 14 sec., 9 ft. height, the stability coefficient, K_D is 1.6; for the structure trunk to withstand the same design breaking wave, the stability coefficient, K_D, is 2.0. Upriver from east jetty station 10+30 (west jetty sta. 9+60), non-breaking waves are expected immediately after construction of the flood control channel. However, after normal shoaling created by riverborne and littoral sediment transport accumulates in the excavated channel section breaking of waves on this section with heights less that the design 9 feet wave height may occur. Hence, the stability coefficient for a breaking wave condition should still be utilized in this section of rubble structure (K_D = 2.0) even though the maximum broken wave height will not exceed approximately 5 feet in height.

Side Slope

10-04 The flatter the side slope of a rubble mound structure, the more stable the slopes will be. Side slopes should not be steeper than 1V on 1.5H. Based on empirical knowledge obtained from historical experience with similar rubble structures under corresponding wave and tide conditions, structure head slopes of 1V on 2H have been found to be satisfactory, particularly in light of the fact that this slope is then utilized in conjunction with the appropriate stability coefficient K_D, to determine the stable armor stone size. That is, a change in structure head slope requires a compensating chance in stability coefficient, K_D, to determine the stable armor stone size. Based on previous experience, the slopes of the head sections of the Santa Ana River jetties from west jetty station 7+90 to station 9+60 (east jetty stas. 8+60 to 10+30) should be 1V oh 2H in order to provide greater assured resistance to forces from the design wave breaking directly on the seaward end of the structure.

10-05 Upriver beyond the rubble structure head section above west jetty station 9+60 (east jetty sta. 10+30), the side slopes of the jetty structure trunk actually constitute the side slopes of the flood control channel, and the armor stone also functions as channel riprap. The stability of riprap bank revetments is affected by the steepness of channel side slopes. Side slopes on which stone is placed by machine or dumped should not be steeper than 1V on 2H (EM 1110-2-1601, Engineering and Design: Hydraulic Desigh of Flood Control Channels, 1 July 1970). Hence, the 1V on 2H side slopes utilized for the rubble structure jetty head section will be continued for the structure trunk section upriver between the head section and the transition section from the rubble jetty structure to the flood control channel.

Crest Elevation

10-06 The crest elevation of the Santa Ana River flood control channel levee has been established at +11.0 feet MLLW (+8.1 feet MSL) at the outlet of the channel. This results in the head section of the flood control channel having a freeboard of 4.5 feet for the design flood.

10-07 Overtopping of rubble structures such as the Santa Ana River flood control channel terminating jetties can be tolerated only if it does not cause damaging conditions behind the structures. Whether overtopping will occur depends on, among other things, the wave characteristics of height and period, and the maximum tide level. For design SWL = +7.0 feet MLLW, and a design wave at the structure of 14 sec., 9 ft. height, minor overtopping of the jetties will occur at these extreme wave and tide conditions. The design wave arriving at the design SWL will overtop the seaward end of the jetties by about 0.5 feet. The frequency of occurrence of such an event is extremely low and, additionally, such overtopping will not cause damage to the structure or otherwise adversely affect the flood control channel or other adjacent structure or feature of the landscape. Such minor overtopping may not only be tolerated, it is conceivable that such overtopping will actually be beneficial by allowing wave overflow to backwash fillet formation sand around the tips of the jetties and be transported back into the littoral system.

10-08 Hence, considering the low frequency of occurrence of a minor amount of overtopping which may be actually beneficial, the crest elevation of the terminating jetties of the Santa Ana River flood control channel at the Pacific Ocean is considered to be +11.0 feet MLLW (+8.1 feet MSL).

Armor Stone

10-09 The capstone forms the protective covering of the jetties and covers the corestone, the seaward end, and both sides of the jetties. Capstone weight, crest width, and layer thickness are important factors in the stability of the primary cover layer. The minimum weight requirement for individual capstones is based on the stability formula for rubble-mound structures as follows:

$$W = \frac{w_r H^3}{K_D\ (S_r - 1)^3 \cot a}$$

Where: W = Weight of armor unit in primary cover layer, pounds

W_r = Unit weight of armor unit, pounds/cubic foot

H = Design wave height measured at the location of the proposed structure, feet

S_r = Specific gravity of armor unit relative to sea water

a = Angle of jetty slope measured from horizontal, degrees

K_D = Stability coefficient.

The minumum required weight for individual capstone, Class A, for a design wave of 9 feet high, a K_D of 1.6, a slope of 1V on 2H, and a unit weight of stone of 160 pounds per cubic foot, is 5 tons. Therefore, the armor stones between west jetty stations 7+90 and 9+60 (east jetty stas. 8+60 to 10+30) can range from about 4 to 6 tons, with about 50 percent of the individual stones weighing more than 5 tons. The armor stone layer thickness is 8 feet and the crest width is 12 feet. Further up the channel between west jetty stations 9+60 and 11+90 (east jetty stas. 10+30 to 12+60), the weight of individual capstone should be 3 tons and the layer thickness 6 feet. Between west jetty stations 11+90 and 13+52 (east jetty stas. 12+60 to 14+22) the weight for individual capstone should be 2 tons and the layer thickness 5 feet. The crest width remains 12 feet along the jetties.

10-10 The proposed jetty stone size is larger than the existing. Design wave analysis of the Santa Ana River jetties and the training dike resulted in the breaking 9 feet wave height. According to the Hudson formula a 5-ton armor layer is required for stability of the structures. Design wave conditions are constrained by a depth limited breaking wave height. The 14 feet of water depth results from a +7 feet (MLLW) tide and scour elevation to -4 feet (MLLW) which is also a design invert elevation. Offshore wave conditions which can produce the 9 feet breaking wave height can occur several times a year and are typically associated with the winter storm season when maximum scour elevations are expected. Therefore, it is believed that the 5-ton size stone is justified.

Corestone

10-11 Class B stone will be used as corestone to form a dense compact mound to support the cap stone. In accordance with SPM (1984), the weight of the corestone is approximately one tenth the weight of the cap stone units. The corestone is not subject to eroding forces from wave action and will have the following gradation:

Weight of Pieces, Pounds	Percent by Weight Smaller Than
1,000	100
500	80-95
200	40-60
50	5-25
10	0-5

Bedding Layer

10-12 A bedding layer is used to protect the foundation of the rubble-mound jetties from scour and migration. The bedding layer prevents erosion during and after construction by dissipating forces from horizontal wave, tide, and longshore currents. A one-foot thickness is allowed to assure that bottom irregularities are completely covered.

An additional one-foot thickness is required to compensate for disturbance by placement of larger stones, for a total bedding layer thickness of 2 feet. The bedding stone will be quarry waste material, reasonably well graded with the limits specified below.

Weight of Pieces, Pounds	Percent by Weight Smaller Than
50	100
30	40-60
10	20-40
1	0-20

Toe Protection

10-13 Toe protection for the head of the Santa Ana River jetty was designed against maximum scour force based on the following two conditions, outlined in SPM (1984). The first condition is the occurrence of water depth at the toe that is less than twice the height of the maximum unbroken wave height. The estimated maximum unbroken wave height is about 8 feet. The water depth at the toe at a stillwater level of +7 feet is about 11 feet and, therefore, is less than twice the maximum unbroken wave height of 16 feet. The second condition that requires maximum scour force protection is a structure wave reflection coefficient, x, that equals or exceeds 0.25, which is generally true for slopes steeper than about 1V on 3H. The seaward slope of the Santa Ana River jetty is about 1V on 2H and therefore, the reflection coefficient, x, would exceed 0.25.

10-14 As a result, the two conditions in the Shore Protection Manual (1984) govern. The toe protection would have a layer two stone thick of stone weighing about one-thirteenth the weight of the primary armor stone. The toe protection would be 2 feet thick and the weight of the minimum toe protection stone will be about 400 pounds. The width of the toe protection would be 4 feet.

Scour Protection

10-15 The riprap to protect against channel scouring caused by floodflows was designed in accordance with procedures in appendix IV of EM 1110-2-1601 for scour. The riprap against scouring will have a thickness of 5 feet, a slope of 1V on 2H and will extend 10 feet below the flood control channel invert. The stone size W_{50} will be 700 pounds and will range from 2,800 to 90 pounds. The riprap would be connected to the armor stone that will be extended one stone thick (2 feet) into the invert of the channel improvement.

XI. SANTA ANA RIVER - TRAINING DIKE DESIGN

General

11-01 Plan, profile, and sections of the training dike are shown on plate 2. The training dike is designed in accordance with the design criteria and engineering assumptions used in the design of the Santa Ana River jetties. The design wave at the ocean end of the training dike is the 14 seconds, 9 feet breaking wave. The stability coefficient, K_D, is 1.6 for the structure head and 2.0 for the structure trunk.

Side Slopes and Crest Elevation

11-02 The side slopes are 1V on 2H. The crest elevation varies from +5.0 feet MSL at the structure head to +3.0 feet MSL at the end of the training dike. The crest elevations are designed to the elevation of the existing sand plug in the river mouth.

Armor Stone

11-03 The armor stones for the training dike are 5 tons and can range from about 4 to 6 tons, with about 50 percent of the individual stones weighing more than 5 tons. The armor stone layer thickness is 8 feet and the crest width is 12 feet.

Corestone

11-04 Class B stone will be used as corestone to form a compact mound to support the capstone. The corestone would not be subject to eroding forces from wave action and will have the following gradations.

Weight of Pieces, Pounds	Percent by Weight Smaller Than
1,000	100
500	80-95
200	40-60
50	5-25
10	0-5

Bedding Layer

11-05 The bedding layer to protect the foundation of the training dike from undermining will be 2 feet thick. The bedding stone will be quarry waste material, reasonably well graded with the limits specified below.

Weight of Pieces, Pounds	Percent by Weight Smaller Than
50	100
30	40-60
10	20-40
1	0-20

Toe Protection

11-06 Toe protection for the head of the training dike was designed against maximum scour force used for the Santa Ana River jetties.

11-07 The toe protection will have a layer two stone thick of stone weight about one-thirteenth the weight of the primary armor stone. The toe protection will be 2 feet thick and the weight of the toe protection will be about 400 pounds. The width of the toe protection will be 4 feet.

Scour Protection

11-08 The riprap to protect against channel scouring caused by floodflows was designed in accordance with procedures in appendix IV of EM 1110-2-1601 for scour. The riprap will have a thickness of 5 feet, a slope of 1V on 2H and will extend 10 feet below the flood control channel invert. The stone size W_{50} will be 700 pounds and will range from 2,800 to 90 pounds. The riprap will be connected to the armor stone that has been extended one armor stone thick (2 feet) into the invert of the channel improvement.

XII. CONSTRUCTION MATERIALS

Sources of Stone

12-01 Sufficient quantities of suitable stone will be available from the existing structures and from privately owned quarries mostly located near Riverside and Corona, California. The unit weight of stone from these quarries ranges from about 164 to 175 pounds per solid cubic foot, and a unit weight of 160 pounds per solid cubic foot was used in the jetty design. Recent laboratory quality compliance tests have been made on stone samples from selected quarries in connection with several other similar Corps of Engineers projects. Although the majority of the stone sources tested have produced acceptable stone in the past, it cannot be assumed that they will continue to do so. Therefore, any stone source considered for use as slope protection, either a quarry or existing structure, will require further field inspection and evaluation and may require additional quality compliance testing prior to stone placement. A list of potential stone sources for which recent laboratory test results are available is shown in the Geotechnical Appendix.

Existing Stone

12-02 Approximately 27,000 tons of Class A, 8,000 tons of Class B, and 24,000 tons of Class C quarry stones were used during the construction of the Santa Ana, Talbert, and Greenville-Banning jetties in 1958 by the Orange County Flood Control District. The weight of the Class A stone, in general, ranged between 0.5 and 3 tons each, with 50 percent by weight not less than 1,500 pounds nor more than 3 tons each. The minimum weight of the Class B stone was 200 pounds, each, and not less than 50 percent by weight of the Class B stone weighted between 600 and 1,500 pounds each. The Class C stone was used for invert and embankment paving and the stone pieces ranged from 8 to 30-inches. Wherever possible, the three grades of stones will be salvaged for the construction of the jetties.

XIII. RECOMMENDED PLAN - MOUTH OF SANTA ANA RIVER

13-01 The recommended plan for the coastal features consists of (1) Santa Ana River jetties to form the ocean entrance of the flood control channel and (2) a training dike to provide an ocean inlet for tidal exchange between the ocean and 92-acre salt marsh. The recommended plan is shown in figure 8.

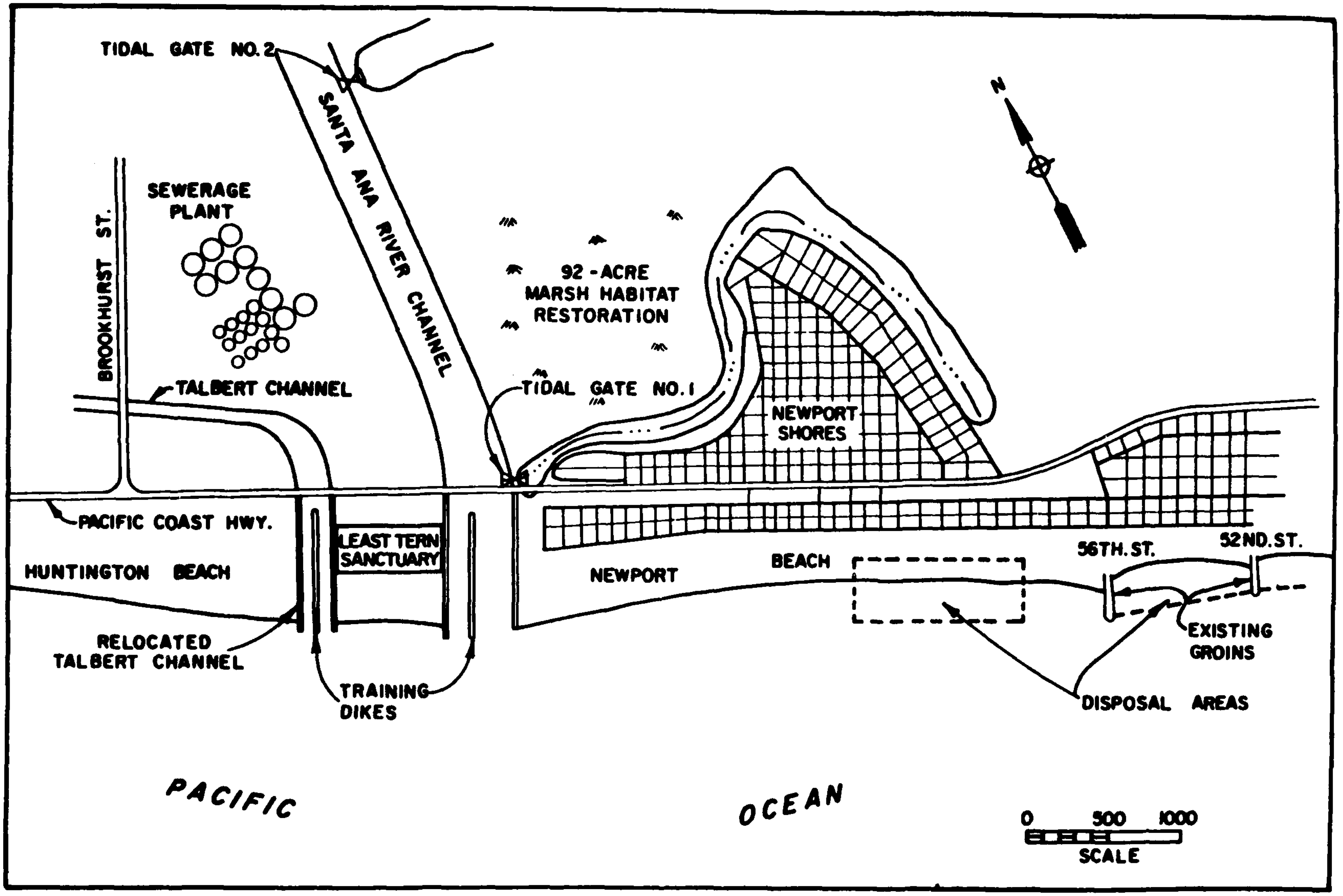
13-02 The Santa Ana River jetties will begin at approximately the same location as the existing jetties (MSL). The two jetties will extend upstream along the river about 500 feet. The Santa Ana River jetties will increase the existing river width from 317 to 450 feet. The existing Talbert Channel will be relocated by local interests on the upcoast end of the Least Tern colony nest.

13-03 The 850-foot-long training dike will be constructed in the river, paralleling the Santa Ana River west jetty. The dike and the west jetty will form a 90-foot wide trapezoidal ocean inlet to provide for tidal exchange between the Santa Ana River and the 92-acre Saltmarsh, should the river mouth shoal. The trapezoidal ocean inlet will have a sediment cleaning capability to remain open, about 2.5 times greater than the existing Talbert Channel, based on studies by Simon, Li, and Associates (1987).

13-04 Consideration was given to constructing the Santa Ana River jetties about 140 feet south of the recommended alignment to avoid the State Beach. However, the plan was not considered feasible because it would remove 12 residences and would eliminate about 9 acres of marsh land for the 92-acre Saltmarsh restoration project. In addition, the existing Pacific Coast Highway bridge would have to be lengthened 140 feet.

Access Road

13-05 Adequate road access exists for the construction of the Santa Ana River jetties and the training dike via the Santa Ana River.



RECOMMENDED PLAN--MOUTH OF SANTA ANA RIVER FIGURE 8

Disposal of Channel Material

13-06 Approximately 4,260,000 cubic yards of material will be excavated from the Santa Ana River during construction of the flood control channel. It is estimated that out of this amount about 2,750,000 cubic yards could be utilized for beach nourishment. During the initial stage of construction, approximately 1,384,000 cubic yards will be removed from the first reach, which extends about two miles up the channel. It is proposed to place 1,000,000 cubic yards of this material within the Newport groin field, filling the cells up to capacity. The remaining 384,000 cubic yards could be used to nourish the beach about 2,000 feet down coast from the mouth of the river.

13-07 Stage two construction will excavate approximately 1,367,000 cubic yards of material from the second reach, which extends up to 5 miles up the river channel. Depending on the time and the wave conditions between these two stages of construction, material placed between the groins and on the beach will be partially depleted due to the coastal processes. Therefore, placement of the material during the first stage of construction can be repeated for the second stage.

Operation and Maintenance

13-08 The existing rubble-mound jetties at the Santa Ana River mouth have sustained little or no damage over the 28-year period they have been in service (1958-1986). Since the new jetties will utilize a larger capstone and will not be exposed to larger waves, very little maintenance is expected. A damage criteria of 0 to 5 percent of the cost of the capstone is used to determine the maintenance cost over the 50 years of the structure life.

XIV. EFFECT OF THE RECOMMENDED PLAN ON THE SHORELINE AND TIDAL INLET

General

14-01 The major improvements contemplated for the Santa Ana River flood control channel from Prado Dam to the Pacific Ocean have the potential for influencing coastal processes at the river mouth from three different aspects.

a. The enlargement of the flood control channel by the excavation of over 4,000,000 cubic yards of material will affect the outflow of sediment transported to the coastline under floodflow conditions as aggradation within the channel will be influenced following construction, and for that period of time until equilibrium conditions have reestablished.

b. The excavated material must be disposed at either:

(1) upland disposal sites,

(2) in the open ocean,

(3) utilized as beach nourishment if suitable, or

(4) by combinations of the first three possibilities.

Disposal of large quantities of material in the open ocean or utilization as beach nourishment material by placement on beaches either upcoast or downcoast of the river mouth may affect potential for closure of the river mouth by wave transport of littoral material.

c. The physical location of the oceanward termination of the rubble jetties for stabilization of the location of the improved Santa Ana River will influence the asymptotic orientation of the shoreline upcoast and downcoast of the river mouth.

Santa Ana River Sediment Transport

14-02 For the period 1941-1971, an estimate of the coarse sediment discharge by the Santa Ana River was made by Kroll (1975). This estimate was adjusted by the Los Angeles District (1987a) by including sediment outflow to represent the period up to 1978. The estimated average annual sand deposition in the river channel under existing conditions was 60,000 cubic yards per year, and the estimated average annual sand outflow to the ocean under existing conditions during 1941-1978 was determined to be 80,000 cubic yards per year. Under with project conditions, the average annual channel deposition and sand outflow to the Pacific Ocean were estimated to be 31,000 and 36,000 cubic yards per year, respectively. The without project average annual deposition and sand outflow to the coastline were estimated to be 24,000 and 25,000 cubic yards per year, respectively. Hence, the with project condition (from mathematical projections into the future) will increase the quantity of coarse sediment to the coastline by 11,000 cubic yards annually when compared to the without project condition (also computed in the same manner).

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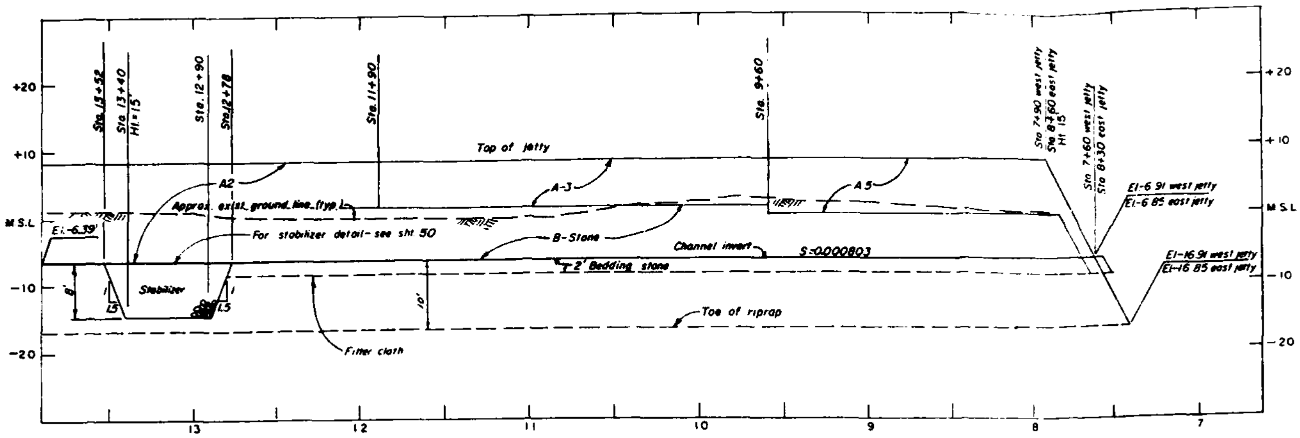
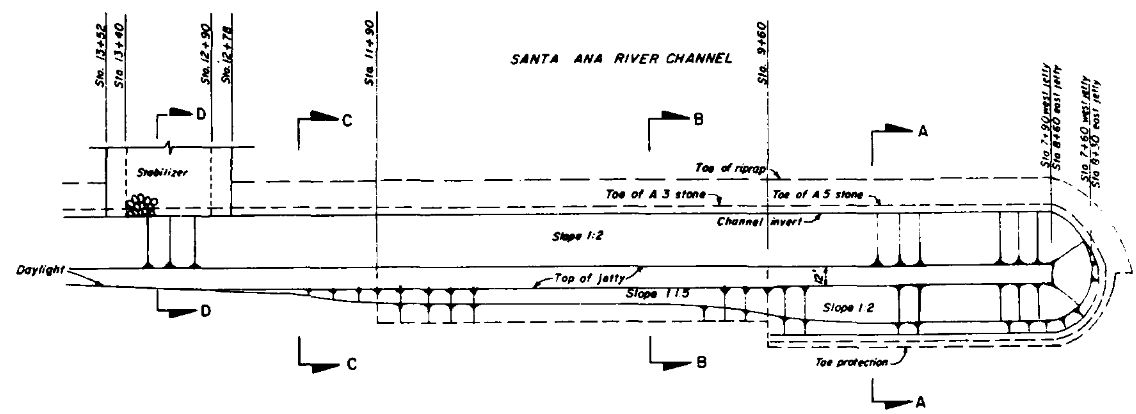


PROFILE-SANTA ANA RIVER WEST JETTY

HORIZ. SCALE: 1 IN.=40 FT
VERT. SCALE: 1 IN.=10 FT.

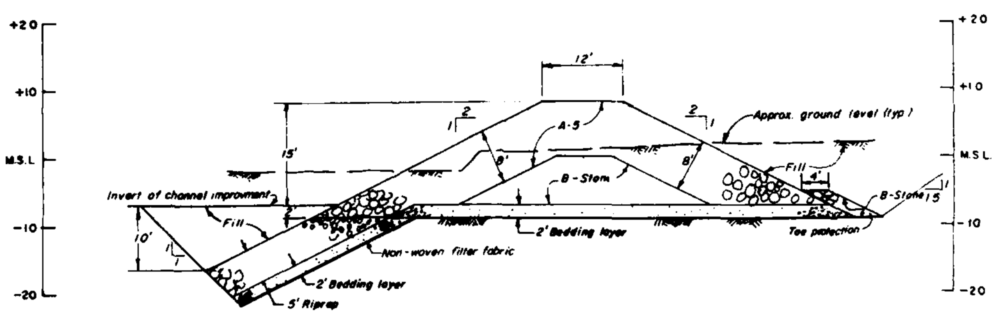
NOTE EAST JETTY SIMILAR
REFER TO SHEET — FOR HYDRAULIC ELEMENTS.



PLAN-SANTA ANA RIVER WEST JETTY

SCALE: 1 IN. = 40 FT.

NOTE WEST JETTY SHOWN, EAST JETTY SIMILAR



SECTION A-A

STA. 8+60 TO STA. 9+60 - WEST JETTY
STA. 7+90 TO STA. 9+60 - EAST JETTY
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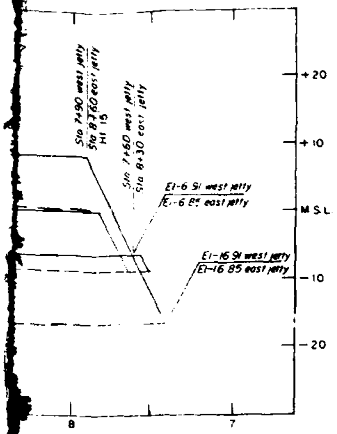
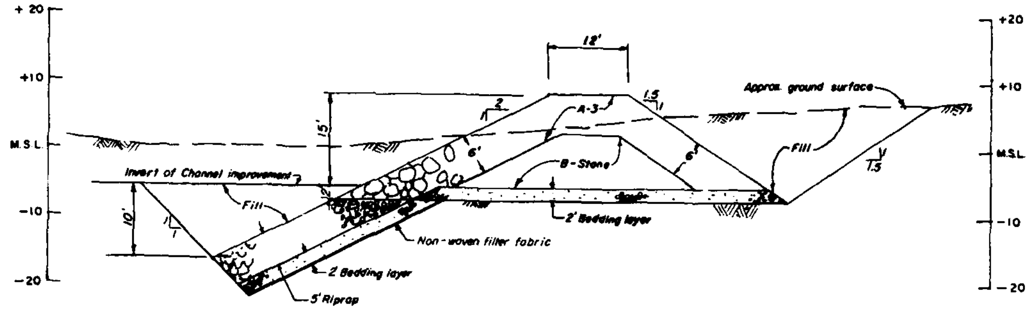
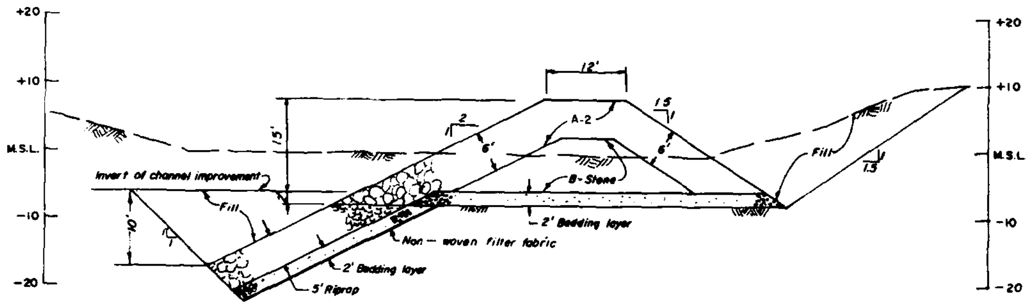
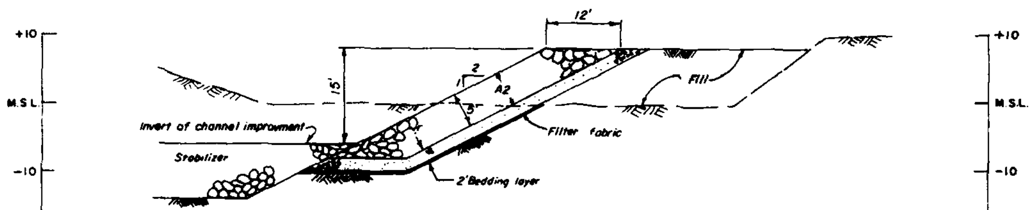




SECTION B-B
STA. 9+60 TO STA.11+90

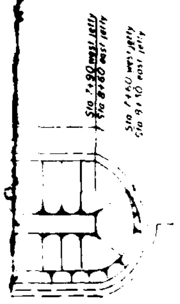


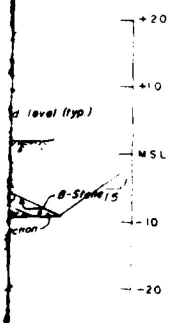
SECTION C-C
STA.11+90 TO STA.12+78



SECTION D-D
STA.12+90 TO STA 13+40

The mean sea level datum (0.0 MSL) equals +2.8 feet
Mean lower low water datum (+2.8 MLLW)





DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

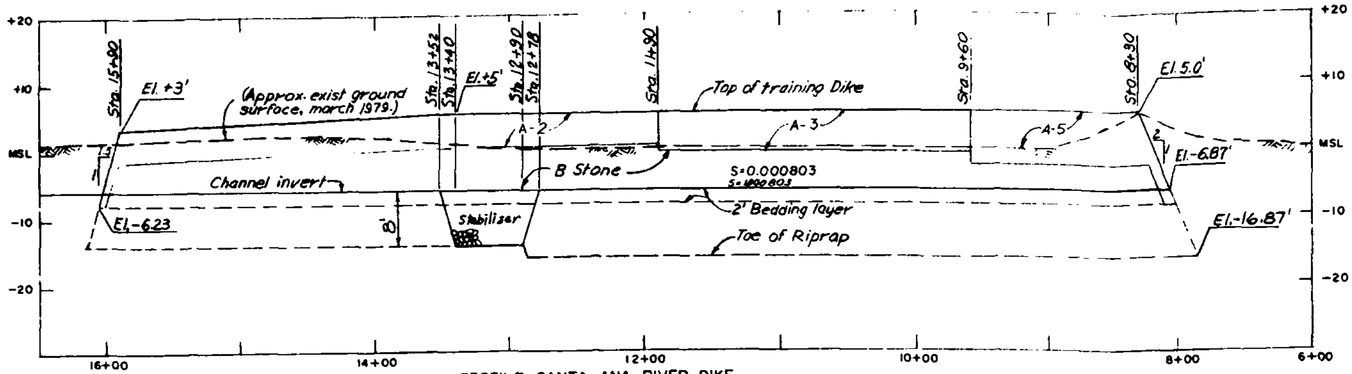
REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

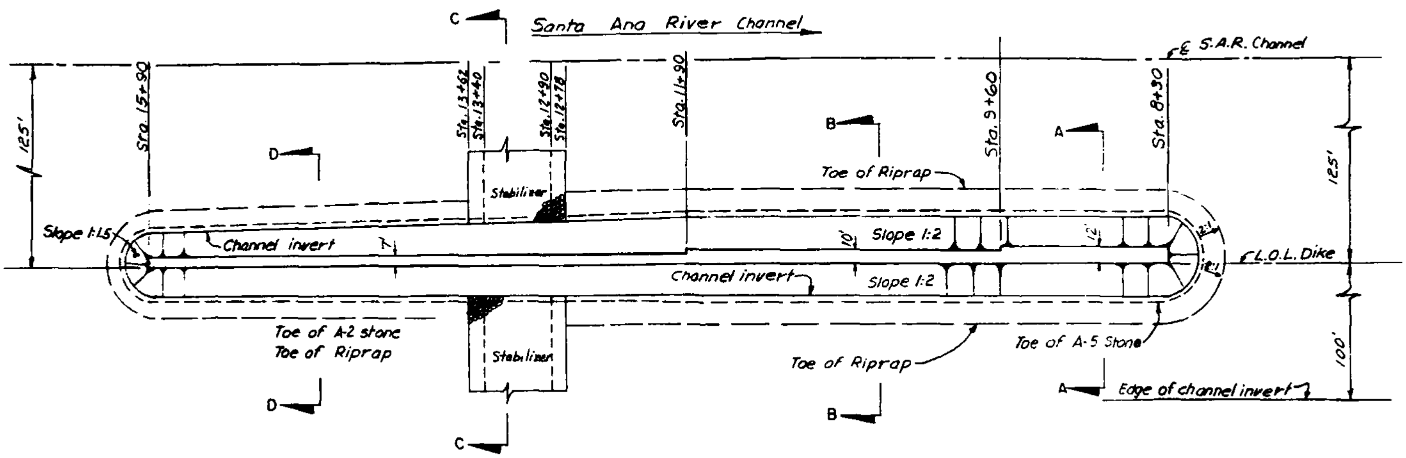
DESIGNED BY:	SANTA ANA RIVER MAINSTEM, CALIFORNIA PHASE II GENERAL DESIGN MEMORANDUM
DRAWN BY: H. M.	LOWER SANTA ANA RIVER CHANNEL JETTY CONSTRUCTION
CHECKED BY:	

SUBMITTED BY:	DATE APPROVED:	DISTRICT FILE NO.	SHEET
CHIEF, BRANCH			

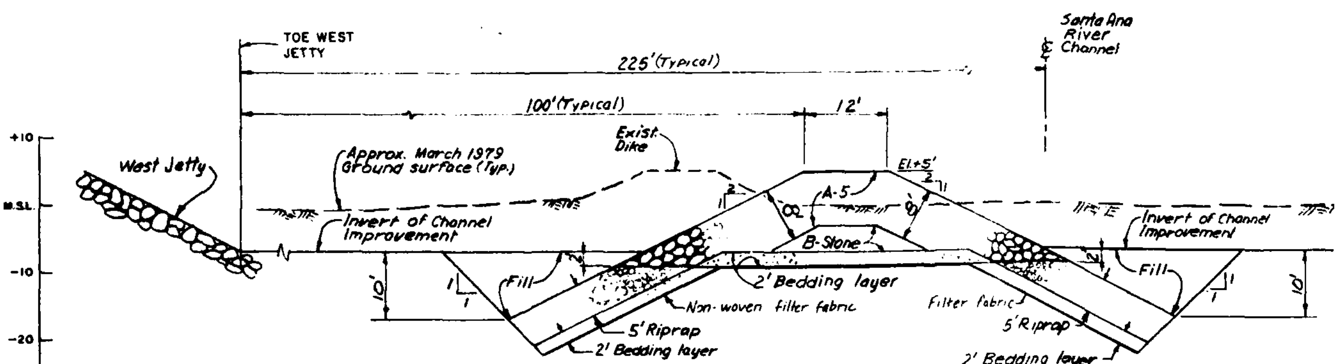
SAFETY PAYS



PROFILE-SANTA ANA RIVER DIKE
HORIZ. SCALE 1 IN. = 50 FT.
VERT. SCALE 1 IN. = 10 FT.



PLAN-SANTA ANA RIVER DIKE
SCALE 1 IN. = 50 FT.



SECTION A-A
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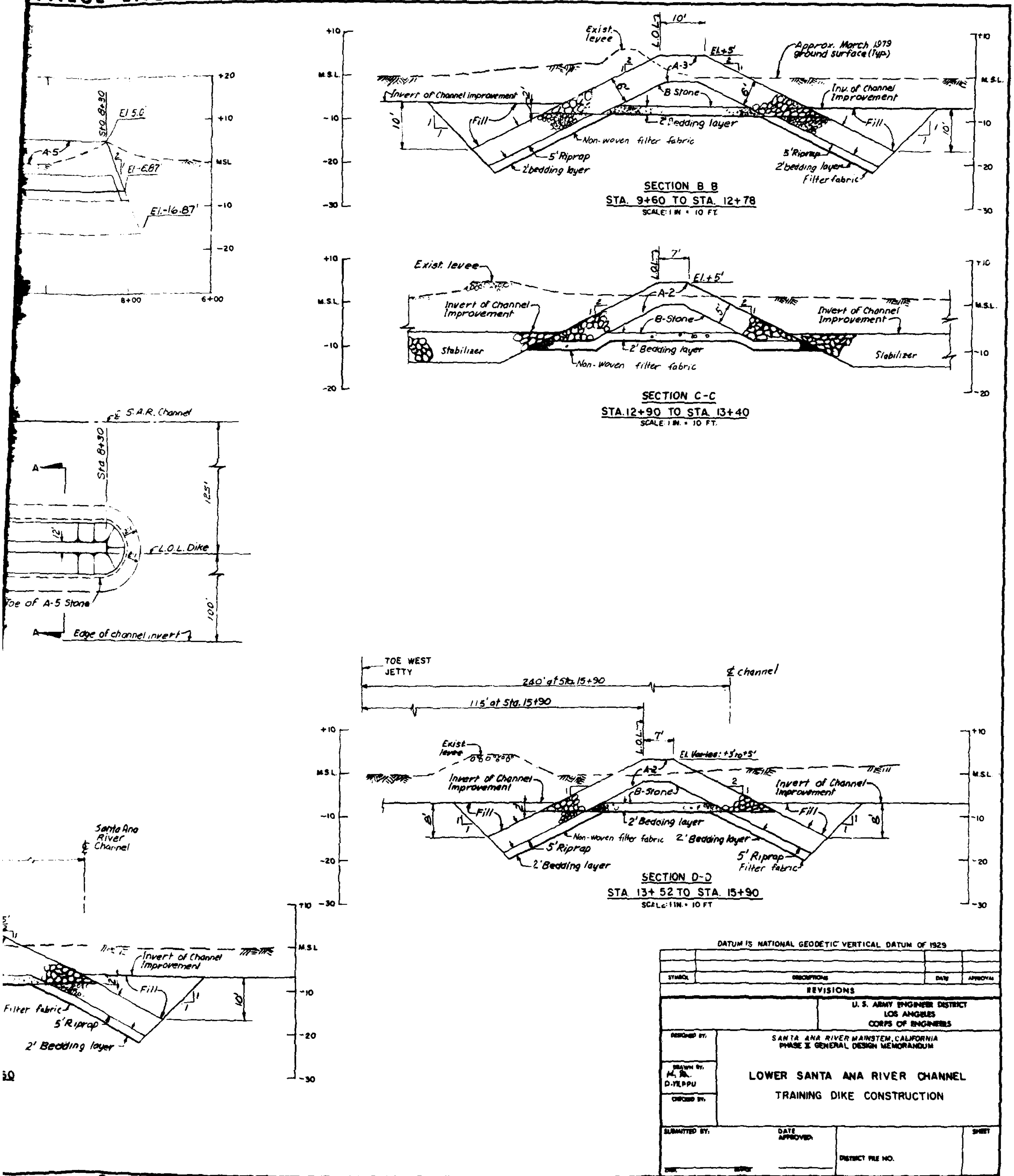
SECTION B-B
STA. 9+60 TO STA. 12+78
SCALE: 1 IN. = 10 FT.
Exist. levee
L.O.L.
10'
El.+5'
Approx. March 1979 ground surface (Typ.)
A-3
Invert of Channel improvement
B Stone
Inv. of Channel Improvement
Fill
2' Bedding layer
Non-woven filter fabric
5' Riprap
2' bedding layer
Filter fabric
SECTION C-C
STA. 12+90 TO STA. 13+40
SCALE: 1 IN. = 10 FT.
Exist. levee
7'
El.+5'
A-2
B-Stone
Invert of Channel Improvement
Stabilizer
2' Bedding layer
Non-woven filter fabric
SECTION D-D
STA. 13+52 TO STA. 15+90
SCALE: 1 IN. = 10 FT.
TOE WEST JETTY
240' at Sta. 15+90
115' at Sta. 15+90
℄ channel
El. Varies: +3' to +5'
5' Riprap
Filter fabric
Sta. 8+30
El. 5.0
A-5
El. -6.87'
El. -16.87'
8+00
6+00
℄ S.A.R. Channel
125'
L.O.L. Dike
Toe of A-5 Stone
100'
Edge of channel invert
Santa Ana River Channel
M.S.L.
DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929
REVISIONS
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
LOWER SANTA ANA RIVER CHANNEL
TRAINING DIKE CONSTRUCTION
DISTRICT FILE NO.

C Sediment Transport Analysis

APPENDIX C

Sediment Transport Analyses
Lower Santa Ana River

Appendix C contains three reports. The first report - Main Report- discusses the entire sediment transport analysis using the Phase I GDM channel configuration. The second report is an independent review; which was requested by the Office of the Chief of Engineers. The third report is an addendum to the main report describing the sediment analysis for a trapezoidal channel configuration.

EXECUTIVE SUMMARY

The sediment transport study for the Lower Santa Ana River consists of a complex linking of a large number of basic steps. The executive summary capsulizes how the steps link together and describes the final results.

Main Report

The hydraulic design of the proposed Santa Ana River flood control channel improvement was analyzed to ensure that the channel would function properly under anticipated sediment loads during the design flood and more frequent floods. The study reach extends approximately 31 miles from Prado Dam to the Pacific Ocean and is otherwise referred to as the Lower Santa Ana River (LSAR). The study reach of the LSAR under project conditions was subdivided into four distinct reaches. The four reaches are identified as the canyon reach, drop structure reach, concrete channel reach, and the soft-bottom channel ocean reach. The latter three reaches comprise the proposed channel improvement approximately 24 miles long (referred to in text as the improved channel). Santiago Creek is the only significant tributary and it enters the LSAR approximately 11 miles upstream of the Pacific Ocean. Specifically, the proposed channel was analyzed to: (1) identify reaches of aggradation and degradation; (2) determine channel design requirements to accommodate scour/deposition by the design flood in terms of flow capacity in reaches of aggradation and invert stabilization in reaches of degradation; (3) assess the long term deposition for operations and maintenance requirements of the channel; and (4) assess the long-term sand outflow to the Pacific Ocean. A summary of the sediment analysis follows:

Data collection efforts turned up maintenance records that indicate the average annual sediment deposition in the study reach is 55,000 cubic yards per year. Aerial photos were available for 1982, 1974, and 1938. Bed material analysis indicates about 90 percent sand and 10 percent gravel. Channel surveys were performed after the 1978 and 1980 flood events. Project channel geometry was taken from the Phase I GDM.

Streamflow data was recorded below Prado Dam, at Imperial Highway, at Ball Road and at Fifth Street. Suspended sediment measurements were also made at these gauging sites. The gauge measurements were corrected to account for the unmeasured sediment load.

A qualitative analysis using the Lane relationship indicated that the drop structure reach will experience aggradation; the area just upstream from the Santiago Creek confluence will remain stable; the all concrete reach will flush sediments through maintaining its design invert elevation; the channel ocean reach downstream from the San Diego Freeway will experience deposition.

An equilibrium slope analysis using Yang's equation yields general results similar to the qualitative analysis. It was determined that bed armoring would be unlikely during the design flood due to the relatively small representative grain size. The armor grain size is between 10 and 70 mm. The d_{95} grain size, however, is 2 mm.

A limiting degradation slope was estimated using four different methods: Schoklitsch bedload equation, Meyer-Peter Muller bedload equation, Shields diagram, and Lane's critical tractive force method. These methods yielded limiting degradation slopes of 0.000029, 0.000029, 0.0000073, and 0.000004, respectively which are milder than the design slopes.

A relationship between sediment discharge and water discharge was developed. The relationship incorporated all sediment sources in the canyon reach upstream from the proposed project inlet at Weir Canyon Road. Stream gauge data was available for sediment loads for discharges up to 14,000 cfs. The computer program HEC-6 was used to estimate sediment loads for higher discharges. Tatum's method was used to estimate sediment yield from the canyon watershed during a design storm. Bank erosion estimates were made by examining aerial photographs. The Pacific Southwest Inter-Agency Committee method and the Flaxman method were also used to estimate sediment yield. A sediment yield rate of 1.64 acre-feet/square-mile/year was determined for the canyon watershed between Prado Dam and the improved channel reach. This yield rate compared well to reservoir deposition data indicating a 1.45 acre-feet/square-mile/year sediment yield rate at nearby Santiago Reservoir. An average annual sediment inflow of up to 132,000 cubic-yards/year was determined to enter the improved channel reach. This value includes sand, silt, and clay sizes.

Sedimentation analysis was carried out using the Corps of Engineers' computer program HEC-6 and a WES modified version known as H6NBS36. The geometric data covered the project inlet at Weir Canyon Road to its outlet at the Pacific Ocean. The program was calibrated using data from the flood of 1978. Yang's unit stream power method was used as a transport function in HEC-6. The calibration was performed by adjusting the Manning's "n" value of each section until agreement was obtained between computed and observed bed changes. The calibrated data set was verified using records from the 1980 flood. The bed changes were reproduced fairly well except for the reach downstream from the Santiago Creek confluence. In this reach, computed degradation was less than the degradation observed during the 1980 flood. The degradation was attributable to finer bed material found only in this reach. The HEC-6 model would not be affected by this fine material since this reach under project conditions calls for a concrete-lined channel.

The data set for the project condition was developed from plans in the Hydraulic Appendix in the Phase I GDM. Grain size analyses were performed throughout the study area and a single representative grain size distribution was used (pl. 3). The project condition was evaluated using balanced hydrographs representing 10-, 25-, 50-, and 100-year frequency flood events as well as the design event. The following roughness values were used for the project condition: n = 0.02 for the downstream channel ocean reach, n = 0.015 for the concrete lined middle reach, n = 0.025 for the drop structure reach. Form drag caused by bed forms was included in the development of "n" values.

The design flood was simulated for the project condition using the HEC-6 computer program. Two different inflowing load curves were used to encompass maximum streambed changes in terms of maximum deposition and scour. The results indicate that deposition of up to 2.2 feet will occur in the upstream subreach of the drop structure reach. Deposition of up to 7.3 feet will occur in the downstream portion of the concrete reach extending into the channel ocean reach. A second simulation using clear water inflow at the improved channel inlet indicated 6 to 8 feet of scour in drop structure reaches. This worst case erosion scenario was used to estimate toe depths of lined banks.

A sensitivity analysis was performed to account for the uncertainties involved in sedimentation analysis. The Manning's "n" value was increased to 0.03 in all reaches. This had only a small effect on computed bed changes. The D_{50} grain size of the bed material was increased from 0.5 mm to 0.75 mm but this also had little effect on the computed results. A sand plug often forms at the Santa Ana River mouth during the summer months. Analysis shows that the sand plug would wash out before the peak of the design flood. An antecedent flow of 5,000 cfs for 30 days resulted in twice as much deposition near the river mouth during the design flood event. A tidal elevation of 2.54 MHHW feet was used for the downstream boundary condition for the design event. Variations in the tidal elevation had little effect on the riverbed near the ocean.

The incremental probability method was used to compute the average annual sand outflow to the ocean and the average annual deposition for the with and without project conditions. The results indicate that 31,000 (with project) and 24,000 (without project) cubic yards of sand per year deposited in the channel reach. The sand outflow to the beach was 36,000 (with project) and 25,000 (without project) cubic yards per year. From gauge records, it was estimated that the sand outflow to the ocean is 80,000 cubic yards per year. It was estimated that the frequency of maintenance in the channel ocean reach would be approximately every 20 years. No maintenance is expected in the concrete and drop structure reaches.

Addendum Report

An additional sedimentation analysis was conducted using the HEC-6 program to determine channel bed profiles for the redesigned channel. The geometric configuration of the channel was changed from a rectangular to a trapezoidal channel in the channel ocean and concrete channel reach. The HEC-6 analysis was performed using similar floods and procedures described in the main report.

The design flood simulation was computed with HEC-6 using two different inflowing loads curves to encompass maximum streambed changes. The results for high sediment inflow indicate general deposition of up to 7.5 feet will occur in the concrete channel reach extending into the channel ocean reach. The second simulation with zero inflowing load at the concrete channel inlet indicates general scour 9 feet below design invert in the channel ocean reach. Results of scour in the drop structure reach were the same as in the main report.

The incremental probability method was applied in the redesigned channel reach to compute average annual deposition and sand outflow. The results indicated deposition in the concrete and channel ocean reach of 37,000 cubic yards per year. The sand outflow was 30,000 cubic yards per year. Based on the upper grade limit in the main report, the estimated frequency of sediment removal maintenance is once every 18 years.

Sediment Transport Study Results

The sediments transport results used for the hydraulic design in terms of the top of and toe of levees were derived from the trapezoidal channel analysis (Addendum Report) for the channel ocean and concrete channel reaches and from the main report analysis for the drop structure reach. The combined results of both studies for project condition are summarized as follows:

1. Plates 2A and 3A shown in the addendum report display the design streambed profile with and without sedimentation, respectively. The water surface profile to determine top of levee was computed by applying the design sedimentation slopes in reaches of aggradation and the design slope in the other reaches.

2. The design of levee toe depth for general scour is:

Minimum Toe Depth Below Design Invert (ft)	Reach Phase II Stationing
8	1204+20 - 1156+60
5	1156+60 - 535+00
10	150+50 - Ocean Outlet

3. Plate 14 of main report titled "Upper Sediment Level Sta. 8+50 to 223+35", displays the allowable sediment deposition. Long term average annual deposition is estimated at 37,000 cubic yards per year.

Frequency of sediment removal is once every 18 years. No sediment removal maintenance is anticipated in the upper portion of the concrete channel and in the drop structure reach.

4. Project sand outflow over project life is estimated at 30,000 cubic yards per year.

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Plates

Attachments

1. INTRODUCTION

Study Objectives

1-01 The hydraulic design of the proposed Santa Ana River flood control channel improvement was analyzed to ensure that the channel would function properly under anticipated sediment loads during the design flood and lesser frequency floods. The study reach extends approximately 31 miles from Prado Dam to the Pacific Ocean, otherwise referred to as the Lower Santa Ana River (LSAR). The study reach of the LSAR under project conditions was subdivided into four distinct reaches. The four reaches are identified as the canyon reach, drop structure reach, concrete channel reach, and the soft-bottom channel ocean reach. The latter three reaches comprise the proposed channel improvement approximately 23 miles long (referred to in text as the improved channel). Santiago Creek is the only significant tributary and it enters the LSAR approximately 11 miles upstream of the Pacific Ocean. Specifically, the proposed channel was analyzed to: (1) identify reaches of aggradation and degradation; (2) determine channel design requirements to accommodate scour/deposition by the design flood in terms of flow capacity in reaches of aggradation and invert stabilization in reaches of degradation; (3) assess the long term deposition for operation and maintenance requirements of the channel; and (4) assess the long-term sand outflow to the Pacific Ocean.

Scope of Work

1-02 The analysis of the sediment transport conditions includes the following major tasks:

1. Collect and evaluate available data including such items as historical channel conditions, stream gauge records, bed sampling, and aerial photography.

2. Determine the sediment inflow into the improved channel from the Lower Santa Ana River tributaries for the design flood as well as from the long term runoff patterns.

3. Analyze the sediment transport scour/deposition in the proposed project for the design flood.

4. Determine the average annual sediment deposition in the project reach and sand outflow to the Pacific Ocean.

5. Identify and design any required mitigation measures.

Description of Existing River Conditions

1-03 The portion of the river considered as the Lower Santa Ana River extends from the Pacific Ocean upstream about 31 miles to Prado Dam (see pl. 1). The river from the dam to about 8 miles downstream is known as the Santa Ana River Canyon (referred to as the canyon reach) and is fed by several small tributaries from both sides of the river. In the canyon, the river is somewhat natural with reaches of bank stabilization. The low flow channel ranges from 100 to 400 feet wide and up to 7 feet deep and will carry about 5,000 cfs. Larger floodflows will flood across the canyon bottom with flood widths up to 1,000 feet. The average invert slope of the river is 0.003. The bed material consists mainly of medium size sands with small aprons of cobble material forming armor layers. A recent trench excavation for sewer line placement across the river exposed layers of large material beneath the surface. From a generally meandering flow path through the canyon reach, except near Featherly Park where the river is braided, the river enters a relatively straight alignment as an improved channel. The improved channel extends from just upstream of Weir Canyon Road southwesterly through an urbanized reach to the Pacific Ocean for a length of 23 miles. In the improved reach, the channel is soft-bottom with both vertical drop structures and sloping drop stabilizers. The side slopes are stone-revetted in the drop structure reach from Weir Canyon Road to the Garden Grove Freeway. There is a short subreach where the side slopes are grass-lined at the confluence with Santiago Creek. The side slopes are concrete lined downstream of Santiago Creek to the Pacific Ocean. The channel bottom width ranges from 180 to 320 feet with depths up to 18 feet. The invert slope ranges from 0.003 to 0.001 near the ocean. The natural slope along the channel alignment (without drop structures) is about 0.0025 or 13.5 feet/mile.

1-04 The bed material consists mainly of sand sizes. For most of any given year, the river is dry except for very low flows (100 to 150 cfs) that are diverted for ground water recharge in the drop structure reach.

Project Description

1-05 The proposed channel improvement from the Phase I General Design Memorandum begins immediately upstream of Weir Canyon Road and follows the existing alignment to the Pacific Ocean. There are also some minor improvements, consisting of several reaches of bank stabilization and a levee in the Santa Ana River Canyon just downstream of the Southern

Pacific Railroad crossing to protect a trailer park community. A schematic illustration of proposed channel geometry and grade is given on plate 2. In general, the proposed plan calls for: partial levee and bank improvement from Prado Dam to Weir Canyon Road (canyon reach); a soft-bottom trapezoidal channel from Weir Canyon Road to Santiago Creek confluence (drop structure reach); a trapezoidal concrete channel from about Santiago Creek to downstream of San Diego Freeway (concrete channel reach); a rectangular soft bottom channel from about the San Diego Freeway downstream from Adams Street, then transitioning to a trapezoidal soft bottom channel formed by two jetties at the ocean mouth.

Study Results for the Phase I GDM Channel Configuration

1-06 The following summary outlines the sediment transport results for the original channel configuration shown in the Phase I GDM.

a. Plate 11 titled "Streambed Profile at Peak of Design Hydrograph" displays the deposition slope in reaches of aggradation.

b. The design of levee toe depth for general scour is:

Toe Depth Minimum (feet)	Reach (Phase(II) Stationing)		
8	1204+70	-	1156+60
5	1156+60	-	535+00
6	150+50	-	Ocean Outlet

c. Plate 14 titled "Upper Sediment Level Sta 8+50 to 223+35", (Phase II Stationing) displays the allowable sediment deposition. Average annual deposition is estimated at 31,000 cubic yards per year. Frequency of cleanout is once every 20 years. No maintenance is expected in the upper portion of the concrete channel and drop structure reach.

d. Sand outflow over project life is estimated at 36,000 cubic yards per year.

e. Concrete channel is appropriate between station 535+00 to 150+50.

f. The number of drop structures and stabilizers are adequate.

2. DATA COLLECTION

General

2-01 An extensive data collection effort was conducted to obtain existing data relevant to the evaluation of sediment transport for the Lower Santa Ana River. A summary of existing data is presented in this section.

Aerial Photography

2-02 Aerial photos of the river from the Pacific Ocean to Prado Dam were taken in 1982, 1974, and as far back as 1938. Behavior of the river was particularly evident from the 1938 photos, which was photographed shortly after the flood of March 2. The aerial photos reveal a meandering tendency in the confined canyon reach changing downstream to a braided or sheetflow condition in the flat flood plain (outside of the levees).

2-03 In addition, the photos reveal reaches of significant bank erosion. These observations would aid in the development of bank erosion estimates in the canyon reach.

Geometric Data

EXISTING CONDITIONS

2-04 The existing Santa Ana River channel has undergone numerous channel improvements as a result of the damaging floods of 1938, and more recently after the floods of 1969, 1978, 1980, and 1983. The data available for the study in the improved reach consists of as-built channel plans and cross-sectional surveys. Survey data was obtained for the years 1977 to 1983. Geometric data for the canyon reach was obtained from topographic maps (scale 1" = 200', 4' contour interval) prepared by E.L. Pearson and Association for the Orange County Flood Control District (currently known as OCEMA). Examination of the data revealed that there was sufficient data to calibrate the HEC-6 model to the 1978 flood event. For verification of the model, the verification could only be conducted in the improved reach (downstream of Weir Canyon Road) for the 1980 flood event due to the absence of sufficient survey data and some man-made changes in the canyon reach.

2-05 Project conditions cross-sectional data were obtained from the plan and profile sheets of the Phase I General Design Memoramdum (GDM), for the reach from Weir Canyon Road (Improved Channel Inlet) to Pacific Ocean. For the Phase II GDM, detailed discussion of the design features can be found in the Hydraulic Design, Volume 3. Although some of the Phase II channel features differ from those in the Phase I GDM, the differences are insignificant with respect to sediment transport. Thus, the study results are valid for the Phase II Design.

Hydrologic Data

HISTORICAL FLOW DATA

2-06 There are several locations on the Lower Santa Ana River in which historical streamflow data is available since construction of Prado Dam in 1941. These gauges are operated by the United States Geological Survey (USGS). Pertinent gauge data are provided in table 1.

Table 1. Stream Gauge Data.

Location	Period of Record	Peak Discharges (cfs)	Date
Below Prado Dam	1940 to current	7,440	Feb 21, 1980
	1930's (intermittent)	100,000*	Mar 2, 1938
At Imperial Hwy	1973 to 1978	4,000	Mar 4, 1978
At Ball Road	1976 to Current	18,500	Mar 1, 1983
		11,070	Feb 16, 1980
At Fifth St.	1923 to Current	20,100	Mar 1, 1983
		16,100	Mar 4, 1980
		17,800	Feb 18, 1978
		19,100	Feb 25, 1969
		46,300*	Mar 3, 1938

*Based on slope-area measurement of maximum flow.

2-07 The streamflow data from these gauges were used to develop the hydrographs for the sediment transport model-calibration and verification phase of the study.

DESIGN FLOOD AND FREQUENCY FLOOD DATA

2-08 The development of the design flood hydrograph and balanced hydrographs at Imperial Highway with assigned frequencies of 10-, 25-, 50-, and 100-year along the main stem were generated from hydrologic study material that supports the Phase I GDM. Residual flood hydrographs for tributaries were also generated for the Santa Ana River Canyon and Santiago Creek. Comparison of the main stem design flood hydrograph from the Phase I GDM with the recently generated main stem hydrograph under the revised Upper Santa Ana River Dam alternative indicates differences are insignificant. Therefore, no adjustment was made to the hydrographs. Further discussion of the hydrologic data is presented in the Hydrology appendix, Volume 7 of this report and from reference 15.

Sediment Deposition and Removal

2-09 Previous investigations (ref. 15) cite deposition and removal quantities for the lower portion of Santa Ana River for the period since 1969. Sediment removal records prior to 1969 are not available; however, according to Orange County Environmental Management Agency (OCEMA), sediment deposition between the time the channel was built after 1938 to 1969 was probably insignificant due to the lack of major flows. An estimate of total sediment removal using information from OCEMA, indicates about 2.7 million cubic yards (yd^3) removed between 1969 and 1983. Of that amount, about 500,000, 650,000, and 200,000 yd^3 were removed after the 1969, 1980, and 1983 flood seasons, respectively. Using the 48-year period from 1938 to 1986 would indicate an average annual removal of about 55,000 yds^3.

2-10 Estimates of sediment deposition during the 1969 flood season vary between 500,000 and 1 million yd^3. During the 1983 flood, about 200,000 yd^3 of sediment were deposited. Both the 1969 and 1983 floods produced a depositional grade line of S = 0.0011 downstream of Slater Avenue bridge. No estimates were available for the 1978 or 1980 flood seasons.

Bed Material Gradation

2-11 Bed material samples were collected and analyzed at numerous locations from Prado Dam to the Pacific Ocean. The location of the samples are noted on plate 1, and the resulting sieve analysis of each sample are on file in the Los Angeles District. Riverbed samples were collected using a shovel and hand augar to a maximum depth of 2 feet below the surface. In the canyon reach, samples were taken from both the bed and bank of the low flow channel and from the bed of primary tributaries just upstream from the main stem. Occasional patches of surface armor layer, consisting of cobble sizes, were encountered on the bed. These materials were not included in the sampling since they are not representative of the underlying bed material nor the general surface conditions. In the improved channel reach from Weir Canyon Road to the Pacific Ocean the bed materials appear to be similar, except for a clay lense outcrop near Slater Avenue.

2-12 The results of the sieve analysis indicate that the bed, bank, and tributary materials in the canyon reach consist of less than 5 percent fines, 60 to 90 percent sands, and up to 40 percent gravels or larger. The bed materials for the improved channel reach indicate no fines, except for the clay outcrop near Slater Avenue where about 30 percent of the materials are fines. Bed materials typically consist of 90 to 100 percent sands, with up to 10 percent gravels.

2-13 The bed material gradation for Santiago Creek was obtained from a previous study (ref. 15). The bed material gradations for Santiago Creek were defined by distinct layering beneath the surface. A composite average of bed materials in Santiago Creek indicate about 25 percent fines, about 40 percent sands, and 35 percent gravels.

2-14 The grain size distribution for the canyon reach as represented in the HEC-6 model for various points along the canyon reach, was based on the nearest sample rather than the averaging of all of the samples. The model analysis was established in this manner to account for the large materials entering into the main stem from the tributaries.

2-15 In the improved channel reach, a representative grain size distribution was developed by overlaying the gradation curves and graphically compiling a single representative gradation curve (see pl. 3). The method was used to achieve a stable solution in the HEC-6 model and to avoid anomalies in sampling. The clay lense at Slater Avenue was not modeled because the improved channel would cover this reach with concrete. Clay material would therefore not enter into sediment transport calculations.

Sediment Data

2-16 The sediment data required for development of sediment transport relationships is available from the same gauging stations used to establish hydrologic data (see table 1). The period of record for sediment data is not as extensive as that for the water data, but data is available from recent floods of 1978 and 1980. Sediment data from the gauging stations was obtained from USGS published records (ref. 5) and from USGS in-house unpublished data. The data consisted of suspended-sediment measurements (measured load) along with the corresponding water discharge, water temperature, and particle size distribution. Additionally, the unmeasured load for a few events was estimated by the USGS using the Modified Einstein procedure to obtain the total instantaneous load. The sediment data were collected for water discharges ranging up to 7,000 cfs below Prado, 2,000 cfs at Imperial Hwy, 14,000 cfs at Ball Road, and 6,000 cfs at the Fifth Street gauge. The data from gauges below Prado Dam and at Ball Road was judged adequate to develop rating curves of water discharges versus sediment discharge. The data at Imperial Highway and Fifth Street was inadequate because of bed scouring at Fifth Street gauge during measurements invalidating the data and because the low water discharges at Imperial were useless for establishing the high flow portion of the rating curve.

3. PRELIMINARY ANALYSIS

General

3-01 The preliminary analysis was subdivided into two separate analyses: (1) a qualitative aggradation-degradation assessement of the river to assess the response to conditions imposed by the improved channel and (2) a quantitative analysis to determine equilibrium and limiting bed slopes. The preliminary analysis evaluates riverbed changes in the proposed river system. The results of the preliminary analysis are used subsequently to verify trends in the HEC-6 detailed sediment routing analysis.

Qualitative Aggradation Degradation Analysis

3-02 Trends of aggradation and degradation were qualitatively identified in the improved channel reach by applying Lane's relationship of dynamic equilibrium. The Lane relationship (ref. 1) can be written

$$q_s \, D_{50} \propto q \, S$$

where:

q_s = The sediment discharge per unit width of the channel
D_{50} = Median sediment size
q = Water discharge per unit width
S = Slope of the channel

3-03 In this relationship, the qualitative response of the riverbed can be evaluated for a given reach by comparing parameters with those for the reach immediately upstream. An increase in either water discharge or slope will result in an increase in the sediment transport capacity, assuming the median sediment size is constant. When sediment transport rate increases, degradation will occur and the bed slope will flatten. Conversely, a decrease in water discharge or slope will result in a decrease of the sediment transport capacity; deposition will occur and the bed slope will steepen. By comparing average values of unit water discharge (varying with channel width) and bed slope in representative reaches of the improved channel with the representative width and slope of the supply (canyon) reach, the change in bed slope to maintain equilibrium can be qualitatively assessed. The supply reach (canyon) above the upper end of the improved channel is assumed in equilibrium. The improved channel reach was subdivided into five subreaches with the results shown in table 2. The overall response of the project indicates that the upper drop structure reach (subreaches 2 and 3) will be in an aggrading mode; reach 4, just upstream of the concrete reach, will be in a fairly stable mode; the concrete reach (reach 5) will be in a degrading mode, and the downstream reach (reach 6) will be in an aggrading mode.

Table 2. Evaluation of Qualitative Response Lower Santa Ana River Project Channel.

SUBREACH (Location)	STATION From (phase I)	STATION To	Invert Slope	CHANNEL (CONFIGURATION) Average Channel Bottom Width (ft)	CHANNEL (CONFIGURATION) Side Slope H:V	RESPONSE* Due To Pro-file	RESPONSE* Due To Width	RESPONSE* Overall
DAM 1	Natural (Canyon reach)		0.003	200 L 1/ 500 H		N/D	N/D	N/D
2 (Drop Structure Reach)	1196+70	1023+60	0.0016- 0.0017	290 L 290 H	2:1	+ +	0 -	+ +
3 (Drop Structure Reach)	1023+60	708+90	0.0017- 0.0022	320	2:1	0	+	+
4 (Drop Structure Reach)	708+90	528+00	0.00166- 0.0025	270	2:1	0	0	0
5 (Concrete Channel Reach)	528+00	192+45	0.0017- 0.002	240 250	Vert	0	-	-
6 (Channel Ocean Reach)	192+45	Pacific Ocean	0.0008	200 480	Vert	+	+	+

*TREND DEFINITIONS:
- \+ Corresponds to increase in slope, or aggradation.
- \- Corresponds to decrease in slope, or degradation.
- 0 Corresponds to no change in slope.
- 1/ L = low flows
  H = high flows
- N/D Not determined

3-04 The response of the bed slope to improved channel conditions can also be qualitatively predicted by examining historical bed trends since the two conditions generally conform to each other. Based on channel surveys and field observations of the 1980 flood, long duration flows on the order of 5,000 cfs tend to produce minimal bed changes in the upstream drop structure reach, significant degradation in the soft bottom reach downstream of Santiago Creek, and aggradation near the outlet to the ocean. Under improved channel conditions, the channel reach subject to severe degradation will be lined with concrete. The bed response in the other soft bottom reaches should be similar to that experienced in 1980 existing channel conditions.

Quantitative Analysis

3-05 The quantitative analysis consists of (1) determining the aggradation/degradation response of the channel bed using the concept of equilibrium bed slopes and (2) determining the limit of general degradation (stable slope) for reduced inflowing sediment loads. The following sections discuss the methodology and results of the quantitative analysis.

EQUILIBRIUM BED SLOPES

3-06 The concept of equilibrium bed slopes was applied to further identify trends of aggradation and degradation and to estimate the bed slope that the river would seek under project conditions. The equilibrium slope is that bed slope for which the capacity of the stream to transport sediment is just equal to the sediment supply flowing into a given reach. If the slope of the streambed is greater than the equilibrium slope, the bed will tend to degrade; conversely, if the bed slope is less than the equilibrium slope, the bed will tend to aggrade.

3-07 Equilibrium slopes were estimated for a range of discharges for improved channel conditions. Yang's Unit Stream Power equation was used to compute sediment transport capacity at representative sections in the project. The use of Yang's equation is explained in paragraphs 5-08 through 5-10. For each value of sediment supply and water discharge, the equilibrium slope was calculated using a trial procedure by which the bed slope was varied until the transport capacity was equal to the sediment supply. The inflowing load was based on the sediment discharge rating curve developed at the Ball Road gauge from observed data, translated upstream to the improved channel inlet. Translating the rating curve upstream 3 miles was judged acceptable since the bed change was stable during the period of measurement.

3-08 The results of the analysis, summarized in table 3, generally agrees with the qualitative analysis. The results indicate that the equilibrium slopes are sensitive to the water discharge and corresponding sediment inflow. This can be seen from the opposing trends of degradation and aggradation for the low and high flow conditions in reaches 2 and 5.

Table 3. Equilibrium Slopes Santa Ana River Project Channel.

REACH	STATION From	STATION To	Q (x1000 cfs)	DESIGN INVERT SLOPE	EQUILIBRIUM SLOPE	TREND*
1	Upstream of 1196+70		-		-	-
2	1196+70	1023+60	5	0.0017	0.0014	-
			15	0.0017	0.0018	0
			30	0.0017	0.0021	+
				0.0017		
3	1023+60	708+90	5	0.0022	0.0030	+
			15	0.0022	0.0039	+
			30	0.0022	0.0049	+
4	708+90	528+00	5	0.0025	0.0022	0
			15	0.0025	0.0026	+
			30	0.0025	0.0030	+
5	528+00	192+45	5	0.0020	0.0016	-
			15	0.0020	0.0020	0
			30	0.0020	0.0023	+
6	192+45	Pacific Ocean	5	0.0008	0.0029	+
			15	0.0008	0.0035	+
			30	0.0008	0.0042	+

*TREND: + aggradation, - degradation, 0 no change

LIMITING DEGRADATION SLOPES

3-09 A bracketing approach to establish the lower limit of bed slope due to degradation was investigated for the case of reduced sediment supply from the canyon reach into the improved channel reach. The reduced supply reflects the possible condition that the canyon will be depleted of sediment during large flood events of long duration. As a result, the bed response expected in the improved channel reach would be general degradation. The depth of general degradation upstream of invert control locations such as drop structures and stabilizers can be quantified through the bed armor and stable slope concepts. Analysis revealed that degradation was not controlled by armoring, but rather by stable slope conditions. The following sections present the methodologies and results for both concepts.

Bed Armoring

3-10 The type of sediment forming the bed may limit the vertical degradation by development of an armor layer. The armor process is generally defined as the condition whereby there is sufficient quantities of coarse materials which cannot be transported by normal river discharges. As the degradation progresses, coarse size materials segregate from fine materials during transport. The armor layer develops as the fine materials are sorted and moved downstream while the coarse materials settle down into the bedsurface and accumulate. Eventually, enough coarse materials accumulate to form an armor layer over the entire bed surface. The underlying materials are trapped and vertical degradation is arrested. The bed slopes are computed by applying the depth of degradation upstream of invert control locations.

3-11 The methods used to determine the armor size, as summarized by the Bureau of Reclamation (ref. 16) and repeated herein, are:

1. Meyer-Peter, Muller (bedload transport equation)
2. Competent bottom velocity
3. Lane's tractive force theory
4. Shields diagram
5. Yang incipient motion

It should be noted that several of the equations apply correction factors to account for mixing of units.

Meyer-Peter, Muller (Bedload Transport Equation)

3-12 Bedload transport equations provide a method to compute a nontransportable particle size representing coarse bed material capable of forming an armoring layer. To describe a nontransportable size, the Meyer-Peter, Muller bedload equation for beginning transport of individual particle sizes was applied.

$$D_c = \frac{dS}{K \left(\frac{n_s}{D_{90}^{1/6}} \right)^{3/2}}$$

where:

D_c = Individual particle size in millimeters
K = 0.19 inch-pound units
d = Mean water depth at dominant discharge, ft
S = Slope of energy gradient, ft/ft
n_s = Manning's "n" for bed of stream
D_{90} = Particle size in millimeter at which 90 percent of bed material by weight is finer.

Competent Bottom Velocity

3-13 The competent bottom velocity method for determining armoring size is computed from a relationship between mean channel velocity with armoring size by the equation:

$$D_c = 1.88\ V_m^{\ 2}$$

where:

D_c = Armor size, mm
V_m = Mean channel velocity, ft/s

Lane's Tractive Force

3-14 The tractive force method relates the critical tractive force versus the mean particle size diameter in millimeters, which is reproduced in figure 1. This method entails computing the critical tractive force using the channel hydraulics for dominant discharge. By selecting an appropriate curve from figure 1, usually the recommended set of "curves for canals with clear water in coarse noncohesive material," a critical tractive force can be obtained which gives the lower size limit of the nontransportable material D_c.

$$T_c = \gamma_w dS$$

where:

T_c = Critical tractive force, lb/ft^2
γ_w = Specific weight) (mass) of water, 62.4 lb/ft^3
d = Mean water depth, ft
S = Slope, ft/ft

Shields Diagram

3-15 Many investigators use the Shields diagram figure 2, to define the initiation of motion for various particle sizes. In the process of armoring of a streambed for predominantly gravel size material greater than 1.0 mm and high Reynold's number R* greater than 500, the Shields parameter given below provides a method for determining an armor size.

$$T_* = \frac{T_c}{(\gamma_s - \gamma_w) D_c} = 0.06$$

where:

T_* = Dimensionless shear stress
T_c = Critical shear stress = $_w$dS, lb/ft^2
γ_s = Specific weight (mass) of the particle, 165 lb/ft^3
γ_w = Specific weight (mass) of water, 62.4 lbs/ft^3
D_c = Diameter of particle, ft

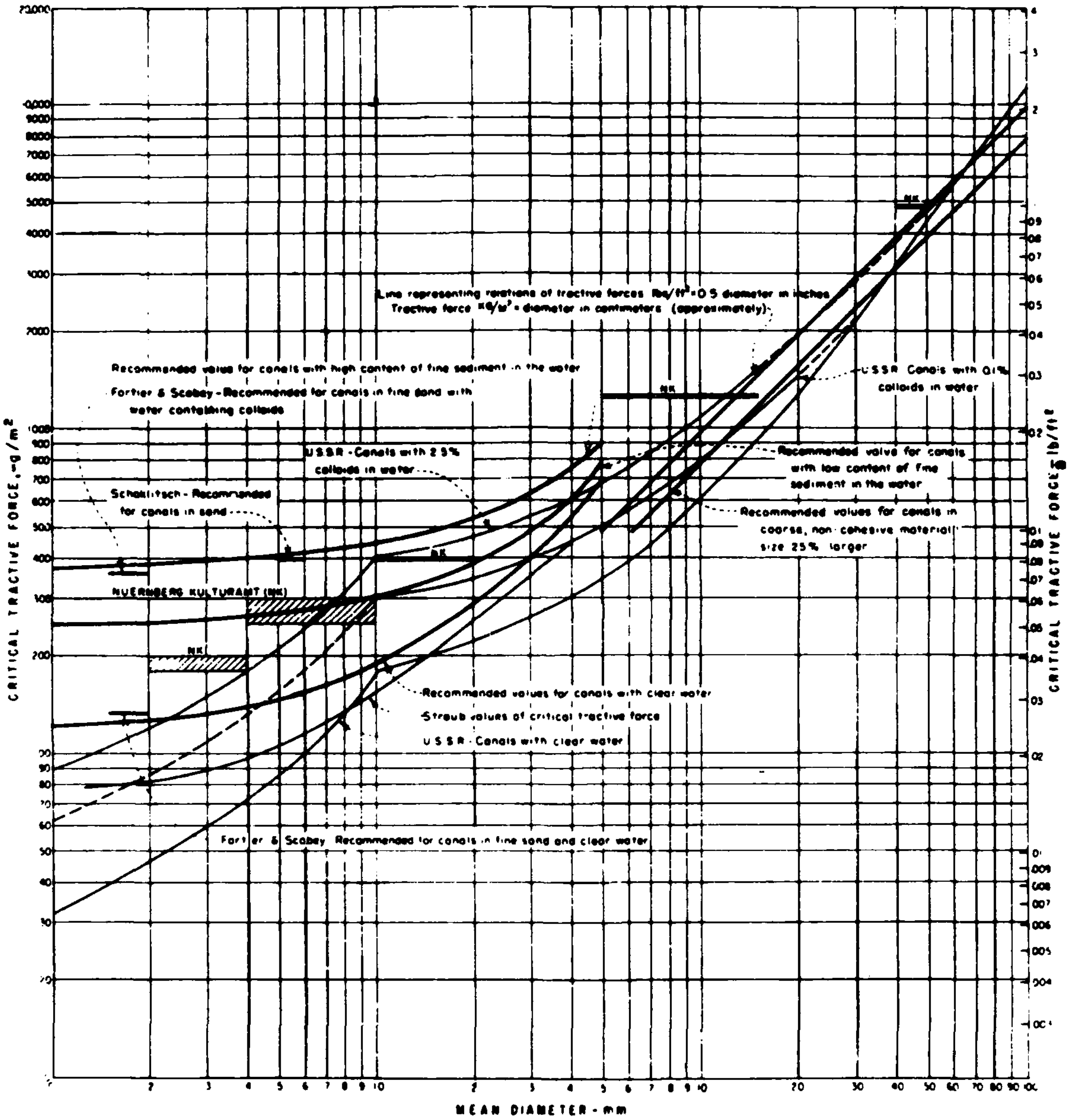

Figure 1. Tractive Force vs. Tranportable Sediment Size (reprinted from ref. 16).

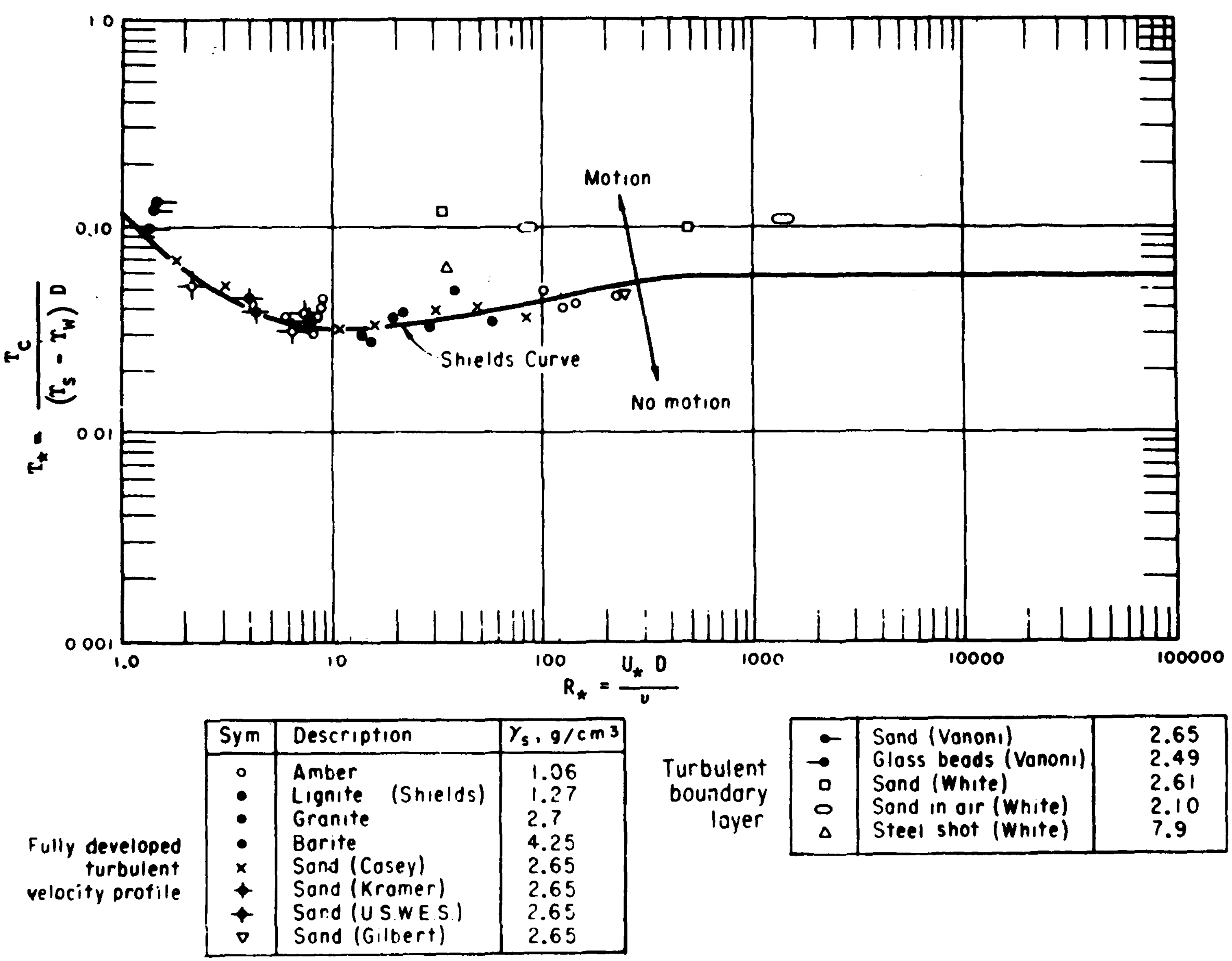

Figure 2. Shields diagram for initiation of bed material movement (reprinted from ref. 16).

Inch-pound units

w = 62.4 lb/ft^3
s = 165 lb/ft^3
d = Depth, ft
S = Slope, ft/ft
D_c = Size, ft

Yang Incipient Motion

3-16 Yang relates the dimensionless critical velocity, V_{cr}/w, and shear velocity Reynold's number, R_*, at incipient motion. Under rough regime conditions where R_* is greater than 70, the equation for incipient motion is:

$$\frac{V_{cr}}{w} = 2.05$$

The settling velocity for material larger than 2 mm in diameter will approximate the fall velocity by:

$$w = 6.01\ D_c^{1/2}$$

These equations can be combined to give:

$$D_c = 0.00659\ V_{cr}^2$$

where:

V_{cr} = Critical average water velocity at incipient motion, ft/s
w = Terminal fall velocity, ft/s
D_c = Size, ft

3-17 The above equations were applied using hydraulic computations for design discharges in the drop structure reach. Table 4 summarizes the results of the computations. The results indicate that degradation would not be limited by armoring because the minimum armor particle size (10 mm) is not available in sufficient quantities in the bed material, since the d_{95} of the bed material is 2 mm. The method of stable slope was then applied to determine the limiting degradation slope.

Table 4. Bed Armor Size.

Method	Particle Size (mm)
1. Meyer-Peter Muller	10
2. Competent bottom velocity	65
3. Lane's tractive force theory	23
4. Shield's diagram	20
5. Yang incipient motion	70

Stable Slope

3-18 In cases where the general degradation is not limited by the armoring process, the concept of stable slope can be applied. The stable slope method for computing degradation is based on degradation processes occurring until a slope is reached which results in negligible bedload transport. The stable slope is determined by applying several relationship for bed movement (ref. 16).

1. Schoklitsch bedload equation.
2. Meyer-Peter, Muller bedload equation.
3. Shields diagram for no motion.
4. Lane's relationship for critical tractive force.

The methods are described as follows:

Schoklitsch Method

3-19 The Schoklitsch equation for zero bedload transport is expressed as follows:

$$S_L = K \left(\frac{DB}{Q}\right)^{3/4}$$

where:

S_L = Stable slope, ft/ft
K = 0.00174 inch-pound units
D = Mean particle size, mm
B = Channel width, ft
Q = Dominant discharge, ft^3/s

Meyer-Peter, Muller Method

3-20 Limiting slope computations by the Meyer-Peter, Muller beginning transport equation are:

$$S_L = \frac{\left(K \frac{Q}{Q_B}\right)\left(\frac{n_s}{D_{90}\ ^{1/6}}\right)^{3/2} D}{d}$$

where:

S_L = Stable slope, ft/ft
K = 0.19 inch-pound units
$\frac{Q}{Q_B}$ = Ratio of total flow in ft^3/s to flow over bed of stream (ft^3/s). Usually defined at dominant discharge where $\frac{Q}{Q_B}$ = 1 for wide channels
D_{90} = Particle size at which 90 percent of bed material by weight is finer
n_s = Manning's "n" for bed of stream
D = Mean particle size
d = Mean depth, ft

Shields Diagram Method

3-21 The use of Shields diagram for computing a stable slope involves the relationship of the boundary Reynold's number R_* varying with the dimensionless shear stress T_* shown in figure 5 as follows:

$$R_* = \frac{U_*\ D}{\upsilon}$$

where:

R_* = Boundary Reynold's number
U_* = Shear velocity $S_L R_g$, ft/s
S_L = Slope, ft/ft
R = Hydraulic radius or mean depth for wide channels
g = Acceleration due to gravity, 32.2 ft/s^2
D = Particle diameter, ft
υ = Kinematic viscosity of water varying with temperature, ft^2/s

and

$$T_* = \frac{Tc}{(\gamma s - \gamma w)\ D} \qquad (16)$$

where:

T_* = Dimensionless shear stress
c = Critical shear stress lb/ft^2 equal to $_{w}dS_L$
γs = Specific weight (mass) of particles, 165.4 lb/ft^3 (2.65 t/m^3)
γw = Specific weight (mass), 62.4 lb/ft^3
d = Mean depth, ft
S_L = Slope, ft/ft
D = Particle diameter, ft

Lane's Tractive Force Method

3-22 Critical tractive force is defined as the drag or shear acting on the wetted area of the channel bed and is expressed as:

$$Tc = \gamma_w d S_L \tag{17}$$

rewriting in terms of S_L

$$S_L = \tau c / \gamma w^d \tag{18}$$

where:

τc = Critical tractive force, lb/ft^2 (may be read from the curve in figure 1. Enter the abscissa scale with the D_{50} or D_m in millimeters and read the critical tractive force value from the curves for canals with clear water).
γw = Specific weight (mass) of water, lb/ft^3
d = Mean water depth for dominant discharge, ft

3-25 Generally, the method of stable slope would be applied to the dominant discharge. However, to determine the maximum potential for degradation, the method was applied using hydraulic computations for the design discharge. Table 5 summarizes the results of the computations.

Table 5. Stable Slope.

Method	Slope
(1) Schoklitsch	0.000029
(2) Meyer-Peter, Muller	0.000029
(3) Shield	0.0000073
(4) Lane	0.000004

3-26 By applying the mildest of these slopes to reaches upstream of invert control points, it was found that general degradation would be no greater than 5 feet below the design invert.

4. SEDIMENT INFLOW

General

4-01 Sediment inflow into the improved channel reach was estimated for the design flood and on an average annual basis. The objective was to determine the bed response and annual maintenance in the improved channel reach. The sources of sediment are from the Santa Ana River Canyon and from Santiago Creek. Other tributaries in the main project reach drain urbanized area and therefore contribute clearwater flow as a result. Design flood and long-term sediment inflow from the canyon reach was estimated with methodologies described in subsequent sections.

4-02 Santiago Creek sediment inflow was developed using the Yang Unit Stream Power sediment transport equation. The total sediment inflow into the improved channel reach consisted of the supply from the canyon reach at Weir Canyon Road and the supply from Santiago Creek at the confluence with the Santa Ana River. The two sediment inflow points were applied in the HEC-6 detailed routing analysis for the design flood to determine the bed response in the improved channel reach. For the long term sediment inflow, only the canyon was considered as the sediment contributor in the HEC-6 analysis since low flows under long term conditions in Santiago Creek will not contribute a significant quantity of sediment.

Design Flood

GENERAL

4-03 The quantification of the sediment supply for the design flood involves considering the sources of sediment from the Santa Ana River canyon and Santiago Creek. In the canyon reach, the analysis addresses sediment contributions from the riverbed, the banks, the tributaries entering into the canyon, and the outflow from Prado Dam. To account for the net effect of these sources, a rating curve of water discharge versus sediment discharge was developed at the downstream end of the canyon using two methods. First, a sediment discharge rating curve was established based on actual sediment load measurements from stream gauges located at Ball Road and downstream of Prado Dam. Second, the Corps of Engineers' HEC-6 sediment computer program was utilized to route sediment in the canyon reach during the design flood including sediment contributions from both tributaries and bank erosion. A comparison of the two sediment discharge rating curves revealed that the curves were fairly close. As a result, the rating curve developed from the HEC-6 canyon analysis was selected for the design flood analysis into the improved channel reach. The HEC-6 rating curve was considered to be the maximum sediment load available into the improved channel reach during the design flood event. The analysis and results of both methods are presented in the subsequent paragraphs.

STREAM GAUGE WATER SEDIMENT DISCHARGE RATING CURVES

4-04 As discussed previously in paragraph 2-07, there is sufficient data to establish water-sediment rating curves for the stream gauges located below Prado Dam and at Ball Road. To account for the total sand discharge, the suspended load measurements were adjusted to exclude the wash load (i.e., material finer than 0.062 mm) and to include the unmeasured load (bed load). The unmeasured load was estimated by the Modified Einstein Procedure or the Colby Method (ref. 4). The Colby Method was used where the USGS did not estimate the unmeasured load with the Modified Einstein Procedure. The water sediment discharge ratings were developed in the following form:

$$Q_s = aQ_w^{b}$$

where Q_s is the sediment transport load in tons per day, Q_w water discharge in cfs, and a and b are the best-fit coefficient and exponent from regression analysis of water sediment discharge data.

The resulting relationships are:

$$Q_s = 0.003\ Q_w^{1.42} \quad \text{below Prado Dam}$$

$$Q_s = 0.181\ Q_w^{1.564} \quad \text{at Ball Road}$$

4-05 These relationships were based on flow measurements up to 7,000 cfs below Prado Dam and 14,000 cfs at Ball Road. To account for the sediment discharge at the design discharge, straight-lined extrapolation of these relationships on a log-log scale was considered to be reasonable and was used to give insight on the potential for sediment inflow. The translation of the Ball Road rating curve to the project inlet was judged applicable since the channel between these locations has remained fairly stable during the period of record. It should be noted that data from the Fifth Street gauge was unreliable due to the invalidation of the rating curve as a result of scouring of the bed during the 1980 flood event.

HEC-6 CANYON ANALYSIS

4-06 Sediment transport in the Santa Ana River Canyon was simulated using the HEC-6 sediment program for the design flood event. The HEC-6 analysis included the additional sources of sediment from tributaries and from bank erosion. Tatum's method was applied to estimate tributary sediment inflow and aerial photos along with topographic maps were used to identify areas of potential bank erosion. The HEC-6 method was of significant value since it provided a reasonable estimate of the maximum potential for sediment inflow from the canyon reach for flows in excess of actual measured flows, that is, for flows from 14,000 cfs to the design peak of 38,000 cfs. The resulting outflow of sediment from the canyon reach represents the net effect from all possible sources of materials. The results of the HEC-6 analysis were translated into water-sediment discharge rating curves (see pl. 6) to be used for input data in the HEC-6 analysis for the proposed downstream project (improved channel reach). The rating curves represents the relationship between water and the bed-material load. It was assumed that the wash load, as defined previously, would be transported throughout the improved channel without deposition. The rating curves presented on plate 6 are the sediment load discharges during the rising side and the recession side of the design flood hydrograph. The difference in the rating curves reflects the depletion of available sediment into the project. The analysis and the results of the application of Tatum's method and the bank erosion are presented in the subsequent paragraphs.

Tatum's Method

4-07 Tatum's method (ref. 23), was applied to the Santa Ana River Canyon watershed to estimate the sediment volume that could occur during design flood event. The use of Tatum's method was deemed applicable because it would be applied to tributary watersheds similar to watersheds in Los Angeles County from which the data was drawn. The factors that influence debris production are:

1. Drainage area
2. Average slope of the longest water course from the uppermost representative elevation to the downstream concentration point.
3. Drainage density or ratio of total stream length.
4. Hypsometric index or relative elevation at which the drainage area is divided into two equal parts.
5. Three-hour rainfall.
6. Burn effect.

4-08 This method involves estimation of the total debris production for a one square mile area and adjustment of that value to account for the above six factors. Factors relating to the topography of the study watershed were obtained from USGS Quadrangle maps. Plate 4 defines the tributary boundaries. The 3-hour rainfall values were used for the 3-hour SPF local thunderstorm, which represents a worse case scenario for sediment inflow into the main stem. Table 6 lists the tributaries and the results of the Tatum calculations. The debris productions rates shown represent ground conditions 4 to 5 years after 100 percent burn.

The rates were judged reasonable for use as tributary sediment inflow during the design flood. The tributary sediment was input into the program during the rising side of the design hydrograph and consisted of sand sizes.

Santa Ana River Canyon Bank Erosion

4-09 A one-dimensional program such as HEC-6 for sediment transport modeling is limited to estimating the vertical aggradation/degradation trends in a river. The lateral component of bank erosion cannot be calculated in most sediment transport programs due to problems associated with the prediction of bank erosion. Thus, in order to account for the sediment contribution from bank erosion from the low flow bank line to the edge of bank stabilization or canyon sides, an estimate of the gross volume of eroded sediment was made. This data was then input into the program as a constant rate of sediment inflow consisting of sand sizes for the entire period of the design flood hydrograph.

Table 6. Results of Tatum Calculations for Tributary Sediment Inflow.

Tributary	Drainage Area (mi^2)	Debris Production (yd^3) x 1000
A. Blue Mud	4.44	219
B. *	0.60	46
C. Box Cyn	0.65	65
D. Bee Cyn	1.32	89
E. *	0.56	55
F. Brush Cyn	1.52	82
G. Aliso	10.47	291
H. *	0.73	56
I. Walnut	2.36	95
J. *	0.52	46
K. *	1.12	60
L. Weir	2.00	35
M. Gypsum	5.17	204
N. Coal	2.03	265
O. *	0.65	122
P. Fresno	.170	189
Q. Wardlow Wash	5.71	83
Total	41.55	2,002,000 yd^3

*Unnamed Tributaries.

4-10 Basically, banks that are unprotected by revetment and located on curves, that is, banks subject to impinging flood flows, were identified as potential areas for erosion. The limits of bank erosion were estimated primarily by engineering judgement using 1938 aerial photos, observations of erosion caused by recent floods, HEC-2 overflow analysis, and (1982) topographical maps, see plate 5. The volume of sediment was computed as the plan view area of erosion multiplied by the height of the bank. Table 7 presents the results of the analysis. This estimate applies only to the design flood event.

Table 7. Results of Bank Erosion for Design Flood.

Location on Plate 5	Plan View Area Eroded (ft^2 x 1000)	Height of bank (ft)	Volume of Eroded Bank (yd^3 x 1000)
E1	245	10	90
E2	1,110	11	448
E3	245	13	118
E4	1,820	8	540
E5	555	9	185
E6	190	8	56
E7	1,213	11	494
E8	220	13	106

Total = 2,037,000 yd^3

SANTIAGO CREEK-DESIGN FLOOD SEDIMENT TRANSPORT

4-11 Santiago Creek is the only other possible source of sediment to the main stem of the lower Santa Ana River. The total drainage area is 102 square miles. The available bed material load to the Santa Ana River, however, would be severely reduced by the construction of the Santiago Creek Project and the existing gravel pits and reservoirs located on the creek. The drainage area is comprised of: Santiago Reservoir (Drainage Area (D.A.) = 63 square miles), located 13 miles upstream from the confluence; Villa Park Dam (Incremental D.A. below Santiago Reservoir = 20 sq. mi.), located 10 miles upstream of the confluence; and gravel pits (Incremental D.A. below Villa Park Dam = 9.1 sq. mi.), located 7 miles upstream of the confluence. The incremental drainage area downstream of the gravel pits, consisting of urbanized development, is 8.1 square miles. In general, the Santiago Creek Project would consist of enlarging the existing gravel pits and channel stabilization of the lower 6,000 feet of channel immediately upstream from the confluence with the LSAR. The gravel pits would serve as a regulating reservoir, but would also be a sediment trap for the inflowing bed-material load. The channel improvements downstream of the gravel pits would be designed to prevent erosion. The combined improvements would result in a negligible quantity of sediment load into the LSAR.

4-12 For design flood conditions, a worse case scenario for sediment inflow into the improved channel was developed to include both the Santa Ana River Canyon and Santiago Creek. The analysis objective was to ensure that the project would function under these heavy load conditions. To estimate the sediment inflow from Santiago Creek, a simplified procedure utilizing a sediment discharge rating curve was employed. The rating curve was established using the Yang Unit Stream Power transport function. The necessary hydraulic data was generated from normal depth computations for a representative reach in Santiago Creek. The resulting rating curve was then applied to the coincident design flood hydrograph.

Sediment Yield

4-13 Sediment yield was estimated in the Santa Ana River Canyon to verify the average annual sediment outflow to the Pacific Ocean and the deposition within the channel, both of which were computed on an event basis. The analytical methods presented for determining sediment yield were developed from watersheds in the southwestern United States. Estimates of sediment yield (long term supply of sediment) were made by applying the Pacific Southwest Interagency Committee (PSIAC) method, Flaxman's method, and from sediment depositional data from a nearby Santiago reservoir. The sediment yield estimates developed from the PSIAC and Flaxman methods would then be verified with actual sediment yield measurement from Santiago reservoir.

Pacific Southwest Interagency Committee Method

4-14 The Pacific Southwest Interagency Committee (ref. 22) has developed a method of rating sediment yield from a watershed for use as an aid for broad planning purposes only. The method consists of numerically rating nine factors that influence sediment production in the watershed and then summing up the ratings. This final rating corresponds to a range of sediment yields in acre-feet per square mile. The ranges of estimated yield values indicate that precision is not the intended result of the PSIAC method.

4-15 The PSIAC Committee has tested their method against actual sediment-yield values measured in ponds and dams in the southwest. The comparisons were made on watersheds with drainage areas less than about 20 square miles. The PSIAC results either agreed with or were slightly lower than the actual measurements.

4-16 The nine factors that are rated in the PSIAC method are surface geology, soil, climate, runoff, topography, ground cover, land use, upland erosion, and channel erosion/sediment transport. These factors were rated for the contributing watershed on the basis of data obtained from aerial photography, topographic maps, Soil Conservation Service soil maps, and on site observation. The nine factors were applied to obtain an average annual yield of 1.64 acre-feet per square mile per year.

Flaxman Method

4-17 A relationship for predicting sediment yield in the western United States was developed by Flaxman (refs. 18, 19 and 20). The equation relates sediment yield to climate, topography, hydrology, and two soil characteristics i.e., percent particles coarser than 1 mm and aggradation or dispersion characteristics of clay size particles. Several forms of the equation exist but the form used in this study is from a paper by Flaxman (ref. 20):

$$y^{0.5} = -86.07 - 5.30\,(x_1)^{0.5} + 7.33\,(x_2)^{0.5} - 1.63\,(x_3)^{0.5} + 10.79\,(x_4)^{0.5} + 0.92\,(x_5)^{0.5}$$

where:

y = Sediment yield in tons per square mile;

x_1 is the ratio, in percent, of the average annual precipitation in inches to the average annual temperature in degrees F, quantity divided by 1.43;

x_2 is the average slope of the watershed in percent;

x_3 is the percentage of particles coarser than 1.0 mm in the surface 2 inches of soil, divided by 72;

x_4 is the percent of clay in the surface 2 inches of soil plus 100 if the pH of the soil is greater than seven, 100 minus the percent of clay if the pH of the soil is equal to or less than seven; and

x_5 is the 2-year flood discharge in cubic feet per second per square mile (csm).

4-18 A special note should be made here that the units for Y do not work out if a rigid unit analysis is made considering variable units only. As discussed in the 1982 San Diego Sediment Seminar, the coefficients include conversion factors that adjust the input data such that Y is in terms of tons per square mile. The theory used in employing the above variables is as follows:

X_1: The precipitation to temperature (P/T) ratio is intended as an indirect expression of the natural response of vegetation to climate. It was assumed that the higher the P/T ratio, the better the vegetative cover, except when the watershed is disturbed. The divisor of 1.43 represents the best cover as indicated by the highest P/T ratio.

X_2: Almost all efforts at predicting erosion and sediment yield have used slope as an influencing factor.

X_3: The purpose of using soil particles coarser than 1 mm was to determine the effect of desert pavement on erosion and yield. The divisor, 72, is the highest percentage of rock fragments in the population.

X_4: This factor is intended to be an indicator of the aggregation or dispersion characteristics of the soil, with an alkaline reaction assumed to symbolize dispersion, an acid reaction, aggregation.

X_5: The 2-year flood peak discharge, cubic feet per second per square mile is assumed to resemble average annual maximum climatic stress on a watershed.

4-19 Pertinent data and results of the analysis are presented in table 8. Average annual yield ranges from 49 to 1,156 ton per square mile per year (0.02 - 0.59 acre-feet per square mile per year).

Measured Data

4-20 Sediment yield data was available from Santiago Reservoir, which is located in the Santa Ana mountains about 6.5 miles south of the Santa Ana River Canyon. The data indicated a yield rate of about 1.45 acre-ft/mi^2/year for a 16.8 year period of record starting December 1931 through September 1948.

Selected Sediment Yield Rate

4-21 Results of sediment yield analysis indicate that the yield rate from the PSIAC method is reasonable for the area based on comparison to sediment data on Santiago Reservoir. The yield rate from the Flaxman method was unreasonably low. Therefore, the PSIAC method was selected for this study. Applying the PSIAC yield rate of 1.64 AF/mi^2/year to the contributing drainage area of the canyon of about 42 to 50 mi^2 would yield 68.8 to 82 AF/year. Converting units to cubic yards would yield 108,000 to 132,000 yds/year. By applying a ratio that 40 percent of the sediment yield is comprised of sand, which was presented by Brownlie et. al. (ref 7), the sand sediment yield range would be 43,200 to 52,800 cubic yards per year. These figures would later be used for comparison with the average annual sand outlfow and the channel deposition computed using the incremental probability method.

Other Tributaries

4-22 Other tributaries in the improved channel reach are the Greenville-Banning and the Carbon Canyon Diversion channels, which enter into the Santa Ana River at river mile 1.3 and 15.9, respectively, upstream from the river mouth.

Table 8. Flaxman's Method For Sediment Yield.

VARIABLE			X1	X2	X3	X4	X5		
Sub area	D.A mi^2	Precip (P) in	P/T 1/ T=63°F (%)	Slope %	Soil 1mm %	Clay %	2 yr Flood (cfs/sq mi)	.5 Y	Yield Tons (mi^2)
A	4.44	12.0	.19 (13)	6	.26	86	11	15	225
B	0.60	12.2	.19 (13)	7	.26	86	17	17	289
C	0.65	12.0	.19 (13)	9	.26	86	18	20	400
D	1.32	12.0	.19	7	.26	86	12	17	289
E	0.56	12.0	.19	10	.26	86	18	21	441
F	1.52	12.0	.19	5	.26	86	13	14	196
G	10.47	12.0	.19	2	.26	86	7	7	49
H	0.73	13.0	.21	7	.26	86	15	17	289
I	2.36	12.0	.19	4	.29	85	13	11	121
J	0.52	12.0	.19	7	.29	85	19	17	289
K	1.12	12.0	.19	5	.29	85	14	13	169
L	2.00	12.0	.19	6	.29	85	14	15	225
M	5.17	13.0	.21	6	.29	85	11	13	169
N	2.03	13.0	.21	15	.29	85	13	25	625
O	0.65	13.0	.21	25	.29	85	20	34	1156
P	1.70	13.0	.21	16	.29	85	13	26	676
Q	5.71	13.0	.21	7	.29	85	11	16	256

1/ Avg temp = 63°F @ 710' MSL (1974 SAR Survey Report)
Avg precip from Santa Ana River Survey Report 1974, Plate 3, "Mean Seasonal Precipitation".

4-23 The drainage area on Greenville-Banning is 10.4 square miles. Bed-material load to the Santa Ana River is judged insignificant because the tributary drains urbanized area and therefore clearwater flow. In addition, the magnitude of coincident tributary flow of 1,000 cfs is small as compared to the design flow of 46,000 cfs on the main stem.

4-24 The total drainage area for Carbon Canyon Diversion Channel is 34.2 square miles. The drainage area is comprised of: Carbon Canyon Dam (drainage area = 19.3 sq. mi.), located 5.0 miles upstream from the confluence; and the Miller Stilling Basin (incremental drainage area below the dam of 14.9 sq. mi.), located 1.5 miles upstream from the confluence. There is no significant incremental drainage area downstream of the basin. Bed-material load to the Santa Ana River is also judged insignificant because of the dam and basin cutting off sediment to the downstream channel. The coincident tributary flow of 2,000 cfs is small as compared to the design flow of 38,000 cfs on the main stem.

4-25 This sediment study, therefore, does not include any sediment inflow from the aforementioned tributaries for the design flood and for the smaller floods on the Santa Ana River.

5. SEDIMENT TRANSPORT ANALYSIS IN THE IMPROVED CHANNEL REACH

General Approach

5-01 The sediment transport in the improved channel reach was simulated using both the Corps of Engineers' Hydrologic Engineering Center sediment transport computer program HEC-6 and a HEC-6 modified version H6NBS36 developed by Waterways Experiment Station. Sediment transport in the project was simulated for the design flood and for the 10-, 25-, 50-, and 100-year floods under with project conditions. The computer simulation with HEC-6 involved a detailed process summarized as follows:

1. Preparation and input of geometric, sediment and hydrologic data for the program.

2. Calibration and verification of the various hydraulic and sediment program parameters from known prototype events.

3. Execution of the program under project conditions for various floods of interest.

4. Analysis of degradation and aggradation trends and recommendations for design water surface profile computations.

5. Sensitivity analysis of the various program parameters and of various design conditions.

The improved channel reach analyzed with the HEC-6 program extended from the inlet at Weir Canyon Road downstream to the Pacific Ocean.

Calibration of the Program Data

5-02 The calibration process is the initial step in the development of the HEC-6 model for latter use in bed response prediction under improved channel conditions. Calibration of the HEC-6 model involves adjusting and selecting various hydraulic and sediment parameters in the model in order to reproduce known historical bed aggradation and degradation trends in the river over a given period of time. The calibrated model will then serve as a basis for trial against a second set of conditions associated with a flood event to test the model for bed change prediction. This second procedure is referred as the verification of the model. Once the model has been calibrated and verified to reconstitute historical events reasonably, then the model can be used to predict bed changes of different flood events with confidence.

5-03 The geometric data set selected for calibrating the model was the flood of 1978. Sufficient cross-sectional survey data were available before and after the 1978 flood to determine the resulting bed changes for the river reach from Prado Dam to the Pacific Ocean with the exception of the reach near the confluence with Santiago Creek. To be consistent with the model geometric adjustment, which uses a uniform bed elevation change across the cross-section, the average 1978 vertical bed change in each cross section was determined graphically from the survey data plots. Plate 7 presents the before and after 1978 flood invert bed profile. Hydrologic data was obtained from the USGS for the stream gauges located on the Lower Santa Ana River, as discussed in paragraph 2-06. The various parameters in the calibration process which were considered are:

a. the sediment transport function
b. the bed material gradation
c. the sediment inflow load
d. the percent of the moveable bed surface between cross sections
e. the Manning's "n" values

5-04 Although setting one of the above parameters may influence another parameter, the most important parameter is the sediment transport function, which is discussed later in paragraphs 5-08 to 5-10. The bed material gradation used in this HEC-6 calibration analysis is shown on plate 3. The sediment inflowing load was zero since the model would begin just downstream of Prado Dam. The data from the stream gauge below Prado Dam indicated virtually zero bed material load passing through the dam. The limits of the movable bed widths were established considering the flow conditions and hardpoints such as revetted banks.

5-05 The actual calibration was performed by setting "n" values based on current field conditions and executing each of the four transport functions available on HEC-6. The Yang transport function was selected (see paragraphs 5-08 through 5-10) and used in all the subsequent analysis with HEC-6 because the Yang function reconstituted the actual changes closer than the other functions. The "n" values were adjusted until a close agreement was accomplished with the observed bed changes. The results of the HEC-6 calibration process are shown on plate 7. It was concluded that the HEC-6 model was calibrated and that it would be reasonable to proceed to the verification procedure.

Verification

5-06 The verification of the calibrated HEC-6 model entails executing the model against an entirely different flood event from which the model was calibrated. The model is said to be verified when it reconstitutes the observed river bed changes. To verify the model, the 1980 flood was selected since there was adequate channel survey and hydrologic data from which to determine the river bed changes and the corresponding flood discharges. The Santa Ana River Canyon reach, however, was the only reach where survey data was unreliable due to numerous man-made changes. Consequently, the verification process was conducted for the reach downstream of Weir Canyon Road, which is at the downstream end of the canyon. To account for the sediment inflow from the canyon reach, a sediment-discharge rating curve was instituted using the sediment-discharge curve developed at the Ball Road stream gage (see paragraph 4-04 to 4-05. Translating the curve upstream to Weir Canyon Road, which is the project channel inlet location, was judged reasonable, since the channel between these two locations experienced insignificant bed change during the 1980 flood.

5-07 The results of the verification run using Yang's transport function indicate that the model agrees fairly well with the actual bed changes, except for the channel reach extending from confluence with Santiago Creek to the San Diego Freeway. In this reach, the model underestimated the degradation of the channel. To reconstitute the degradation quantities, the model was adjusted (calibrated) on a preliminary basis by inputting a finer bed material gradation to simulate the fine material existing in the channel, (see paragraph 2-11). The adjusted model did reproduce the degradation in this reach. However, the adjustment was judged to be unnecessary because the project calls for lining the channel with concrete in this reach, thus preventing erosion. The bed material gradation in the model should rather represent the material entering into the concrete reach. Therefore, the model was considered to be verified without the preliminary bed material adjustment. Plate 8 displays the before and after 1980 invert bed profile and the results of the HEC-6 verification simulation.

Sediment Transport Function

5-08 The HEC-6 program contains four different sediment transport functions for computing the sediment transport in the river. The four options are: (1) Toffaleti's method, (2) Madden's modification of Lursen's relationship, (3) Yang's Unit Stream Power method, and (4) DuBoy's method.

5-09 The selection of the appropriate sediment transport function was based on two approaches. First, each function in HEC-6 was tested against the historical bed changes in the calibration process assuming the same basis of "n" values, sediment inflowing load, and bed-material gradation. Application of the Toffaleti and the DuBoy's methods in the program produced changes in bed elevation that were much less than and much greater than the historical, respectively. Attempts were made to use the Laursen method, but internal problems with the program code caused this method to be excluded from the calibration process. Lastly, the Yang function was tested and resulted in predicted bed changes that were in close agreement with the historical.

5-10 Second, the functions were tested against the measured load at the Ball Road stream gage by using the program to compute the sediment load with each function. In addition, the Ackers-White equation was computed manually for comparison with the measured load for possible application in the program if the other functions proved to be unsuccessful. The results of the computed load versus measured load are shown on plate 9. The results indicate that for the measured flow range of 1,000 to about 7,000 cfs, the Duboy and Yang function were fairly close to the measured load. The Ackers-White equation produced lower sediment discharge values than the Yang function and was dropped from further analysis. Additionally, the Yang function proved to be the most successful in calibrating against historical bed changes and was within an acceptable range with the measured load. As a result of this analysis, the Yang Unit Stream Power equation was selected for estimating the bed-material load in the river. The Yang equation (ref. 10) used in this study is:

$$\log C_t = 5.435 - 0.286 \log \frac{wd}{v} - 0.457 \log \frac{U^*}{w}$$

$$+ (1.799 - 0409 \log \frac{wd}{v} - 0.314 \log \frac{U^*}{w}) \log (\frac{VS}{w} - \frac{VcrS}{w})$$

where:

C_t = Total sediment concentration, in parts per million by weight,
w = Terminal fall velocity of sediment particles, ft/sec
d = Median sieve diameter of bed material, ft
v = Kinematic viscosity, ft^2/sec
U* = Shear velocity, ft/sec
VS = Unity stream power, ft/sec. ft/ft
$V_{cr}S$ = Critical unit stream power at incipient motion, ft/sec

HEC-6 Input Data

CHANNEL GEOMETRY

5-11 The channel geometry under project conditions was obtained from plan and profiles sheets in the Phase I GDM. Cross sections were encoded into the HEC-6 model beginning at the project inlet at Weir Canyon Road downstream to the Pacific Ocean. Spacing of the cross sections ranged from 100 to 1,500 feet apart with an average of about 1,000 feet. Cross sections were also located at control invert points in the river such as drop structures and stabilizers.

BED MATERIAL GRADATION

5-12 The representative bed material gradation, as discussed previously in paragraph 2-15, was used in the HEC-6 project analysis for all the various floods, (10-, 25-, 50-, 100-year) including the design flood. The program requires a gradation with each cross section defined in the geometry data set. In order for the HEC-6 to represent the concrete-lined channel and invert hardpoints such as drop structures and stabilizers, the model was encoded with a bed material layer of 0.1 feet to exist on the design invert. The 0.1 feet thick of bed material allows the program to execute in a deposition potential mode only. Scour of the bed will not occur in the concrete reach or at channel invert hardpoints.

HYDROLOGIC DATA

5-13 Several different flood events were investigated with the HEC-6 program to evaluate the adequacy of the project design with respect to sediment transport. The floods analyzed were the project design flood (170-year) and the 10-, 25-, 50-, and 100-year flood frequency events.

5-14 The hydrologic analysis for the Santa Ana River was conducted with the Corps of Engineers' Los Angeles District Flood Hydrograph Package (LADFHP). Flood hydrographs for the design flood were provided along the project reach that included residual flow from tributaries in the Santa Ana River Canyon and Santiago Creek. For all floods, balanced hydrographs were developed based on with project condition and based on both peak and volume frequency analysis from regulated releases out of Prado Dam. For these floods, tributary inflow was neglected since there are numerous coincident flow combinations between the main stem and each tributary. To account for the inflow of sediment from tributaries in the canyon reach, a sediment discharge rating curve was used at the project inlet at Weir Canyon Road. For Santiago Creek, inflow of sediment would be negligible with construction of a stable channel. Plate 10 displays the balanced hydrographs. It should be noted that tributary inflow from Greenville-Banning Channel and Carbon Canyon Diversion Channel would not impact on transport of sediment since the inflow discharges are small relative to discharges on the main stem.

IMPROVED CHANNEL HYDRAULIC ROUGHNESS

5-15 Hydraulic roughness is accounted for in the HEC-6 program by the use of Manning's roughness coefficient "n". Under project channel conditions, three different reaches were considered in terms of the roughness coefficient. The first reach was the channel ocean reach with soft bottom channel and vertical concrete floodwalls at the lower end. The second reach was the rectangular concrete lined channel downstream of the confluence with Santiago Creek, and the third reach was the trapezoidal soft bottom channel drop structure reach from Santiago to the improved channel inlet. The "n" values used in the calibration procedures were numerically estimated using Cowan's method described in Chow's Open Channel Hydraulics (ref. 2) and adjusted to produce the historical bed change. These "n" values would be utilized in the channel ocean reach and drop structure reach; however, they would not be applicable to the concrete lined reach.

5-16 In a concrete lined channel with ephemeral high velocity flow, the standard procedure would be to design the channel using a Manning's roughness coefficient of 0.014. The deposition of sand on the concrete invert could increase this value. If the amount of deposition is less than 0.5 feet, then the increase would be due mainly to grain resistance. Otherwise, any amount greater than this would result in the possibility of bed formation, that is, the development of ripples, dunes, or antidunes, which would cause form drag and increase the resistance to flow. From the initial HEC-6 runs, the amount of deposition was found to be generally greater than 0.5-foot. Deposition would occur in the lower (downstream) portion of the concrete channel reach from station 257+00 downstream to station 150+50. Therefore, the Manning's "n" value would be adjusted to account for bed forms. The remaining part of the concrete channel reach would not experience deposition and be designed with the standard "n" value of 0.014.

5-17 For both the lined concrete and unlined channel ocean and drop structure reaches, the bed forms for various discharges were determined using the methodology by Vanoni (ref. 8). The result of the bed form analysis indicated that at high flows, the bed form for the channel ocean reach and lower part of the concrete channel would be in plane bed, while the drop structure reach would be in plane bed or antidunes. From reference 1, the corresponding Manning's "n" values for these bed forms would range from 0.012 to 0.022 for plane bed and 0.015 to 0.031 for antidunes. Moreover, the suggested values for sediment transport analysis were 0.02 for plane bed and 0.025 for antidunes.

5-18 In summary, the Manning's "n" values utilized in the HEC-6 computations for the Santa Ana River were 0.02 for the unlined channel ocean reach and the deposition portions of the lined concrete channel reach, 0.014 for the concrete channel reach without deposition and 0.025 for the drop structure reach. The effect on the "n" value from the revetment on the side slopes was not investigated because the side slope "n" value applied against the riverbed would not significantly change the composite "n" value. It should be noted that no significant vegetation will be permitted in the channel. Operation and maintenance clearing of vegetation and brush over 3 feet high is required. Low flows will bend over and uproot smaller vegetation. In addition, the current practice using temporary diversion levees located within the channel for ground water recharge at low flows will be permitted since uncompacted sand levees historically wash out at relatively low floodflows of 2,000 cfs.

Results

GENERAL

5-19 The results obtained from the HEC-6 simulation of the design flood as well as the lesser frequency floods appear to be reasonable. Since it is beyond the state-of-the-art capability to accurately predict the scour or deposition at specific locations, the results presented herein are in terms of the general trends of aggradation and degradation. To ensure that the results are applicable in design, a sensitivity analyses was conducted of various transport parameters in the HEC-6 program which influence the sediment transport calculations. In addition, various channel conditions were investigated since it is possible that the channel would not be at the design invert at the start of the design flood.

DESIGN FLOOD

5-20 The HEC-6 simulation of the design flood was conducted for the reach from the improved channel inlet at Weir Canyon Road downstream to the Pacific Ocean using two different cases of sediment inflow since the sediment inflow would be variable over the project life. The two cases are the maximum and minimum sediment inflow into the improved channel reach. The objective was to bracket the trend of aggradation and degradation within the channel for use in hydraulic design.

5-21 For the case of the maximum sediment inflow, the results of the HEC-6 analysis indicate that at the peak of the design flood, deposition would be significant just downstream of the improved channel inlet and at the lower end of the concrete channel and channel ocean reach. For the first drop structure reach (stations 1204+70 to 1157+60), the depth of deposition would be up to 2.2 feet. The other drop structure reaches show no bed change. In the lower end (stations 242+60 to 0+00), the deposition would be up to 7.3 feet. At the end of the design hydrograph, there are some additional subreaches in the drop structure reach that experience deposition. The overall sediment depths were 1 to 2 feet higher. In the channel ocean reach and downstream end of the concrete channel, the depositional slope ranged from S = 0.0006 to 0.0012 at the peak flow and at the end of the design hydrograph. The depositional slope of 0.0012 compares favorably with the historical slope of S = 0.0011. As a result, the preliminary design depositional slope was selected as that slope that was present at the maximum river water surface elevation, which for all reaches coincided with the peak of the design hydrograph. The preliminary design slope was tested and further refined in the sensitivity part of the analysis. The design of the channel levee heights could be established with these results.

5-22 In contrast, the HEC-6 analysis for the minimum sediment inflow was performed by using a zero value for the inflowing load from all sources. The results indicate a potential for general scour of up to 8 feet below the design invert between invert control points in the upstream reach of the drop structures (station 1204+20 to 1157+60). In the reach just downstream of the concrete-lined channel (channel ocean reach), the scour would be up to 6 feet below the design invert. Although this is an extreme opposite of the analysis above with sediment inflow, the result provides for design of the slope protection toe depths in this reach.

SENSITIVITY ANALYSIS

5-23 Because of the uncertainties involved in the sediment transport theory, additional sensitivity analyses were made of the various HEC-6 program input variables and of various channel conditions likely to occur preceding the design event. The program parameters include the roughness coefficient "n" and the bed-material gradation. The alternative channel conditions include the formation of a sand plug at the ocean outlet, initial deposition in the channel, and high and low downstream water surface elevations with respect to tidal fluctuation.

Roughness Coefficient "n"

5-24 As previously discussed in paragraphs 5-15 to 5-18, the "n" values used in the analysis were based on the channel conditions including the effect of bed forms. To ensure that the improved channel will function in terms of deposition on the bed during the design flood, the "n" value was increased to 0.03 in all reaches of the HEC-6 model. The higher value will result in reduced sediment transport capacities which in turn may result in higher deposition. The result of the computations indicate that the quantity of channel aggradation is not sensitive to the "n" value. The deposition with n = 0.03 was less than or equal to the design deposition amount.

Bed Material Gradation

5-25 The bed material gradation used in the analysis was based on a graphical average of the samples obtained directly from the streambed. The sensitivity of the gradation was examined by increasing the size fraction of the larger particles such that the d_{50} particle size increased from 0.5 to 0.75 mm. The amount of increase was based on the gradation range of the individual samples. The amount of aggradation was found to be insensitive to the increased particle size. The deposition for particle size of d_{50} equal to 0.75 mm was less than or equal to the design deposition amount.

Sand Plug

5-26 Under existing conditions, the littoral drift of sand across the ocean outlet forms a sand plug that reduces tidal ocean waters from flushing in and out of the river. To address the impact of this plug forming under project conditions, the HEC-6 analysis geometric data was adjusted by estimating that the sand would deposit up to elevation 0.0 feet NGVD for the entire lower reach. The design invert daylights at elevation 0.0 feet NGVD approximately 1.9 miles upstream from the outlet and drops to elevation -7.0 feet NGVD at the stabilizer near the ocean outlet. The results of the computations indicate that the sand plug would wash out before the peak of the design flood. The amount of aggradation did not exceed the design deposition slope.

Antecedent Flow

5-27 In addition to a sand plug forming, deposition in the channel ocean reach could also form as a result of lower frequency floods or antecedent floods preceding the design event. In order to simulate the initial movement of sediment prior to the design event, a flow of 5,000 cfs for a period of 38 days, which represents the volume of water to empty Prado Basin, was considered applicable. The flow rate of 5,000 cfs corresponds to historic releases. The sediment deposition during the design flood was quite sensitive to the initial bed conditions. It was found that the quantity of deposition in the channel ocean reach was twice the amount with antecedent flow than without. As a result, a new depositional design slope was determined. It is important to note that this new depositional design slope was considered as the final design slope for use in the subsequent hydraulic design for computing water surface elevations. Plate 11 graphically displays the channel invert profile and the sedimentation profiles for the hydraulic design of the channel at peak design discharge. At the end of the design hydrograph, there are some additional subreaches that experience deposition. Plate 12 graphically presents these results. Plate 12 is provided for trend information only and is not intended to be used in the hydraulic design.

Tidal Influence

5-28 The fluctuation of the starting water surface elevations (WSEL) for backwater computations could influence the sediment transport characteristics and capacity of the downstream channel as noted in a paper by Dixon et al (ref. 30). In the Los Angeles District, the current design practice for the starting WSEL is to use the peak discharge of the design event coincident with the mean higher water (MHHW) elevation above mean-sea-level (MSL). A starting WSEL of 2.54 ft. MHHW was used in this analysis throughout the design hydrograph. To examine the sensitivity of this value with respect to sediment deposition in the downstream channel, an evaluation of the peak flows and higher high tides was conducted using tidal data obtained from NOAA (ref 31). The tidal data was in the form of a statistical month based on 17 years of recorded data at Newport Beach, which is just south of the outlet channel. The timing of the starting WSEL in the model was adjusted such that the peak flow for the design flood hydrograph was coincident with peak MHHW of the statistical month tidal hydrograph. Plate 13 graphically displays the tidal hydrograph. The peak MHHW is about 4.22 ft (MSL Datum), which is only 1.68 ft higher than design condition. The results of the computation indicate that aggradation is not sensitive to the fluctuation. The reason is because the tidal hydrograph fluctuate more rapidly than the design flood hydrograph. The fluctuation in downstream WSEL cause less backwater at low tide levels and transports the aggraded sediment further into the ocean.

6. AVERAGE ANNUAL DEPOSITION AND SAND OUTFLOW TO THE PACIFIC OCEAN

Methodology and Results

6-01 An analysis was conducted to determine the average annual aggradation in the project reach and the sand outflow to the Pacific Ocean for maintenance and mitigation measures as a result of the project. Estimates of average annual aggradation and sand outflow for the with and without improved channel (project) conditions over the project life were determined using the weighted incremental probability method. Estimates of average annual aggradation and sand outflow for historical conditions after closure of Prado Dam in 1941 were performed using existing available data.

6-02 For the with project condition, the incremental probability method is applied by evaluating the 10-, 25-, 50-, 100-year floods, and the design flood, which has a frequency of 170-year, with the HEC-6 program to determine the volume of deposition and sand outflow for each flood. The sediment volumes are then weighted by the incremental probability of occurrence for any given year by the relationship:

$$Qs_{annual} = .006\,(VOL_{170}) + .004\,\frac{(VOL_{170} + VOL_{100})}{2} + .01\,\frac{(VOL_{100} + VOL_{50})}{2}$$

$$+\ .02\,\frac{(VOL_{50} + VOL_{25})}{2} + .06\,\frac{(VOL_{25} + VOL_{10})}{2}$$

Where Qs is average annual (deposition or sand outflow) and the 170-, 100-, 50-, 25-, 10- are the subcripts for floods with their respective return period in years. Floods less than the 10-year flood were not included in the analysis because these smaller floods would not contribute a significant quantity of sediment in terms of channel deposition or sand outflow. Under improved channel conditions, the average annual channel deposition and sand outflow to the Pacific Ocean were estimated to be 31,000 and 36,000 cubic yards, respectively. The total of the two is 67,000 cubic yards.

6-03 For the without project condition, the same procedures were applied as for the with project condition except for the design flood. In this case the design flood would cause levee failure of the existing channel, resulting in sediment exiting into the flood plain. The sediment volumes, not including the design flood, are weighted by the incremental probability occurrence by the relationship:

$$Qs_{annual} = 0.01\ (Vol_{100}) + 0.01\ \frac{(Vol_{100} + Vol_{50})}{2}$$

$$+\ 0.02\ \frac{(Vol_{50} + Vol_{25})}{2} + 0.06\ \frac{(Vol_{25} + Vol_{10})}{2}$$

6-04 The without project average annual deposition and sand outflow to the Pacific Ocean were estimated to be 24,000 and 25,000 cubic yards, respectively. The total of the two is 49,000 cubic yards. By not including the design flood, the difference of 18,000 cubic yards (67,000 minus 49,000) reflects the average annual deposition into the flood plain. It should be noted that this figure is a gross estimate since it does not include wash load and it does not account for timing of the levee breach during the design event.

6-05 The average annual deposition and sand outflow under historical conditions were computed by using data from stream gage and historical channel removal records. For the period from 1941 to 1971, an estimate of the coarse sediment discharge was made by the USGS (ref. 6) for the stream gage at Fifth Street in Santa Ana. The estimate was adjusted by the Corps of Engineers by including sediment outflow to represent the period up to 1978. The adjusted sand discharge at the gage was about 140,000 cubic yards per year. From reference 15, the estimated average annual sand deposition downstream of the gage for about the same time period was 60,000 cubic yards per year. Thus, subtracting the deposition yield from the sand discharge yield produces an estimated average annual sand outflow of 80,000 cubic yards per years. It is important to note that these estimates would slightly increase with the inclusion of the recent flood events. However, an attempt to include these events was found to be difficult because of the problem with the streamgage records at Fifth Street during 1980 flood and the channel scour downstream of the gage producing an additional source of sediment. Consequently, the above values without the recent floods were considered reasonable for the long term historical average.

6-06 The average annual deposition and sand outflow for the with and without project channel conditions were estimated with the equation noted previously. The deposition was found to occur in the lower 4 miles of the project channel. Table 9 summarizes the deposition and sand outflow quantities for with and without project conditions and for historical conditions.

Table 9. Sediment Yields for Various Floods.

Channel Condition	Flood (year)	Sediment Deposition (X 1000 yd^3)	Sand Outflow (X 1000 yd^3)
With project	170	1,509	2,303
	100	679	524
	50	367	324
	25	180	195
	10	39	54
	annual	31	36
Without project	170	1/	1/
	100	484	923
	50	340	336
	25	231	136
	10	90	11
	annual	24	25
Historical Condition (1941-1978)	annual	60	80

1/ Not included in annual computations because flood would breach levees, resulting in sediment exiting the channel system.

Comparison With Average Annual Yield Calculations for the Santa Ana River Canyon

6-07 In order to determine the reasonableness of the estimate of the with-project average annual sediment production, a comparison was made between the sediment yield estimate of the canyon reach with the project yield. As discussed in paragraph 4-21, several methods were used to estimate the canyon sediment yield. From that analysis, it was determined that the sand sediment yield would range from 43,200 to 52,800 cubic yards per year. The with-project sand sediment yield of 67,000 cubic yards per year compares favorably and would be considered very reasonable with respect to the sediment yield of the canyon. In other words, the difference in sediment yield estimates of about 30 percent is well within the accuracy in sediment transport technology with respect to sediment yield determination.

Frequency of Cleanout

6-08 As part of maintenance requirements for the channel design, an upper grade limit was established to identify the sediment removal required from the channel to maintain the design flood protection. Sediment would be allowed to accumulate to the upper grade limit line shown on plate 14. Once sediment deposition exceeds this limit, the sediment must be removed to the design invert.

6-09 The upper grade limit was based on the bed change in the HEC-6 analysis after antecedent flow of 5,000 cfs for 38 days. The bed change encompassed a deposition bed slope of 0.0007986. This corresponds to a deposition volume of about 660,000 cubic yards. Based on the average annual sediment deposition of 31,000 cubic yards per year, the channel in the lower reach would have to be cleaned out on the long term average of once every 21 years.

6-10 The upper grade limit was raised to elevation 0.0 feet msl in the reach downstream of where the upper grade limit crosses elevation 0.0 at station 69+33. The adjustment was made to allow sediment to accumulate upstream of the sand plug that usually forms at the river mouth. This geometric condition was also tested in the design HEC-6 analysis. The resulting bed change did not exceed the design deposition amount. Therefore, sediment will be allowed to accumulate to the adjusted limit. No sediment removal maintenance is expected in the drop structure concrete channel reach from the inlet at Weir Canyon Road downstream to the concrete channel station 223+35.

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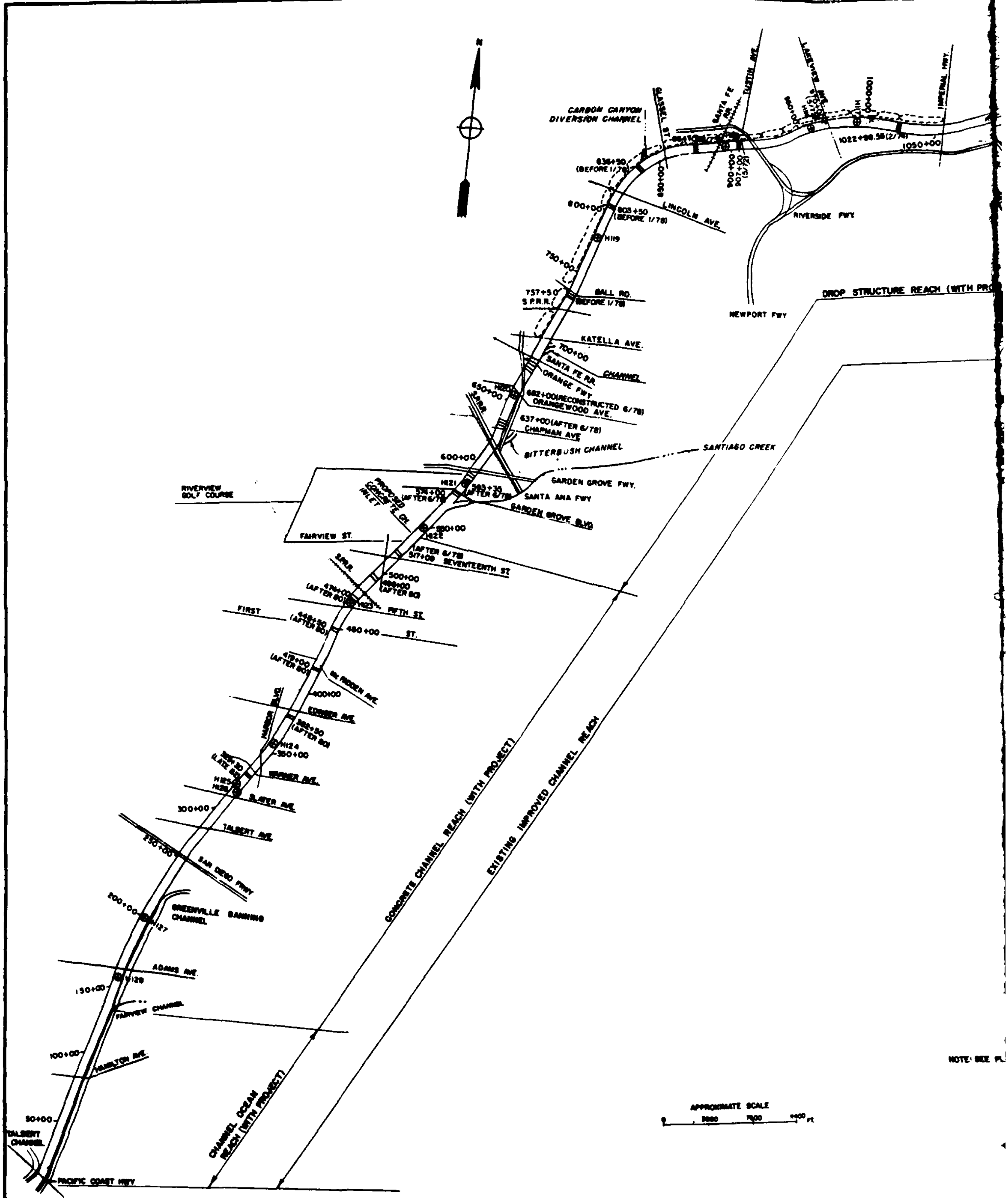
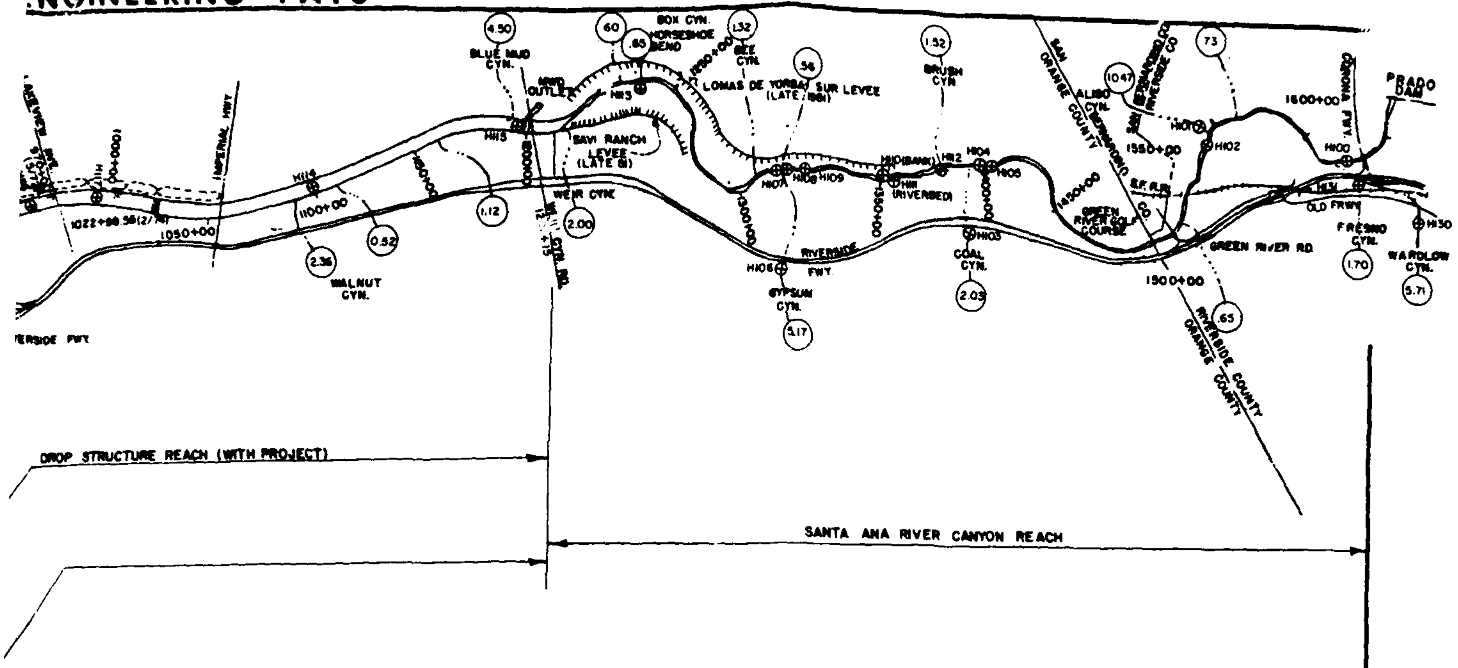
C Sediment Transport Analysis

PLATES


N
CARBON CANYON DIVERSION CHANNEL
GLASSEL ST.
SANTA FE RR.
TUSTIN AVE.
IMPERIAL HWY.
1022+98.58(2/74)
1050+00
836+50 (BEFORE 1/78)
900+00
907+00 (5/72)
800+00
803+50 (BEFORE 1/78)
LINCOLN AVE.
RIVERSIDE FWY.
H119
750+00
737+50 S.P.R.R.
BALL RD. (BEFORE 1/78)
NEWPORT FWY
DROP STRUCTURE REACH (WITH PRO
KATELLA AVE.
700+00
SANTA FE RR.
CHANNEL
ORANGE FWY
H120
650+00
682+00(RECONSTRUCTED 6/78)
ORANGEWOOD AVE.
637+00(AFTER 6/78)
CHAPMAN AVE
BITTERBUSH CHANNEL
SANTIAGO CREEK
600+00
RIVERVIEW GOLF COURSE
H121
593+35 (AFTER 6/78)
574+00 (AFTER 6/78)
GARDEN GROVE FWY.
SANTA ANA FWY
GARDEN GROVE BLVD.
FAIRVIEW ST.
550+00
H122
(AFTER 6/78) 517+00
SEVENTEENTH ST
S.P.R.R.
500+00
486+00 (AFTER 80)
474+00 (AFTER 80)
H123
FIFTH ST
FIRST
449+50 (AFTER 80)
450+00
ST.
419+00 (AFTER 80)
McFADDEN AVE.
400+00
EDINGER AVE.
HARBOR BLVD.
382+50 (AFTER 80)
H124
350+00
WARNER AVE.
H125
H126
SLATER AVE.
300+00
TALBERT AVE.
250+00
SAN DIEGO FWY
200+00
GREENVILLE BANNING CHANNEL
H127
ADAMS AVE.
150+00
H128
FAIRVIEW CHANNEL
100+00
HAMILTON AVE.
50+00
TALBERT CHANNEL
PACIFIC COAST HWY
CONCRETE CHANNEL REACH (WITH PROJECT)
EXISTING IMPROVED CHANNEL REACH
CHANNEL OCEAN REACH (WITH PROJECT)
APPROXIMATE SCALE
NOTE: SEE PL



LEGEND

RECHARGE BASINS
SOIL SAMPLE LOCATION
STABILIZER (APPROXIMATE DATE CONSTRUCTED)
DROP STRUCTURE
LEVEE (SLOPING TOWARD RIVER)
TRIBUTARY DRAINAGE AREA (SQ. MILES)

NOTE: SEE PLATE 2 FOR PROJECT CHANNEL FEATURES.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

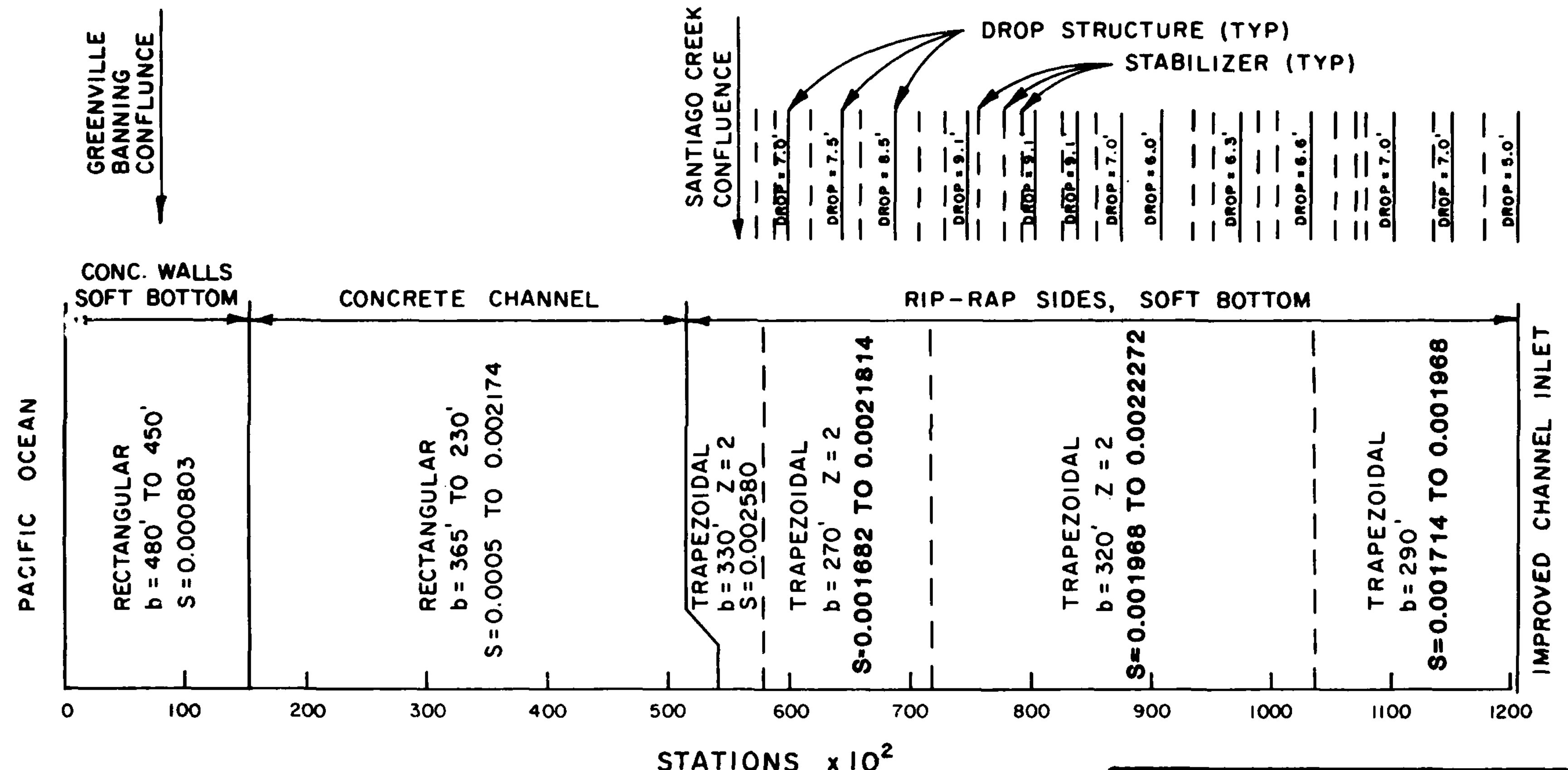
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER, CALIFORNIA

SANTA ANA RIVER CHANNEL
EXISTING CONDITIONS
MARCH 1983

DESIGNED BY | DRAWN BY | CHECKED BY | SUBMITTED BY: | DATE APPROVED: | SPEC. NO. DACW09-___ B-___ | DISTRICT FILE NO. | SHEET 1 OF 1

PLATE 1-C



NOTE:

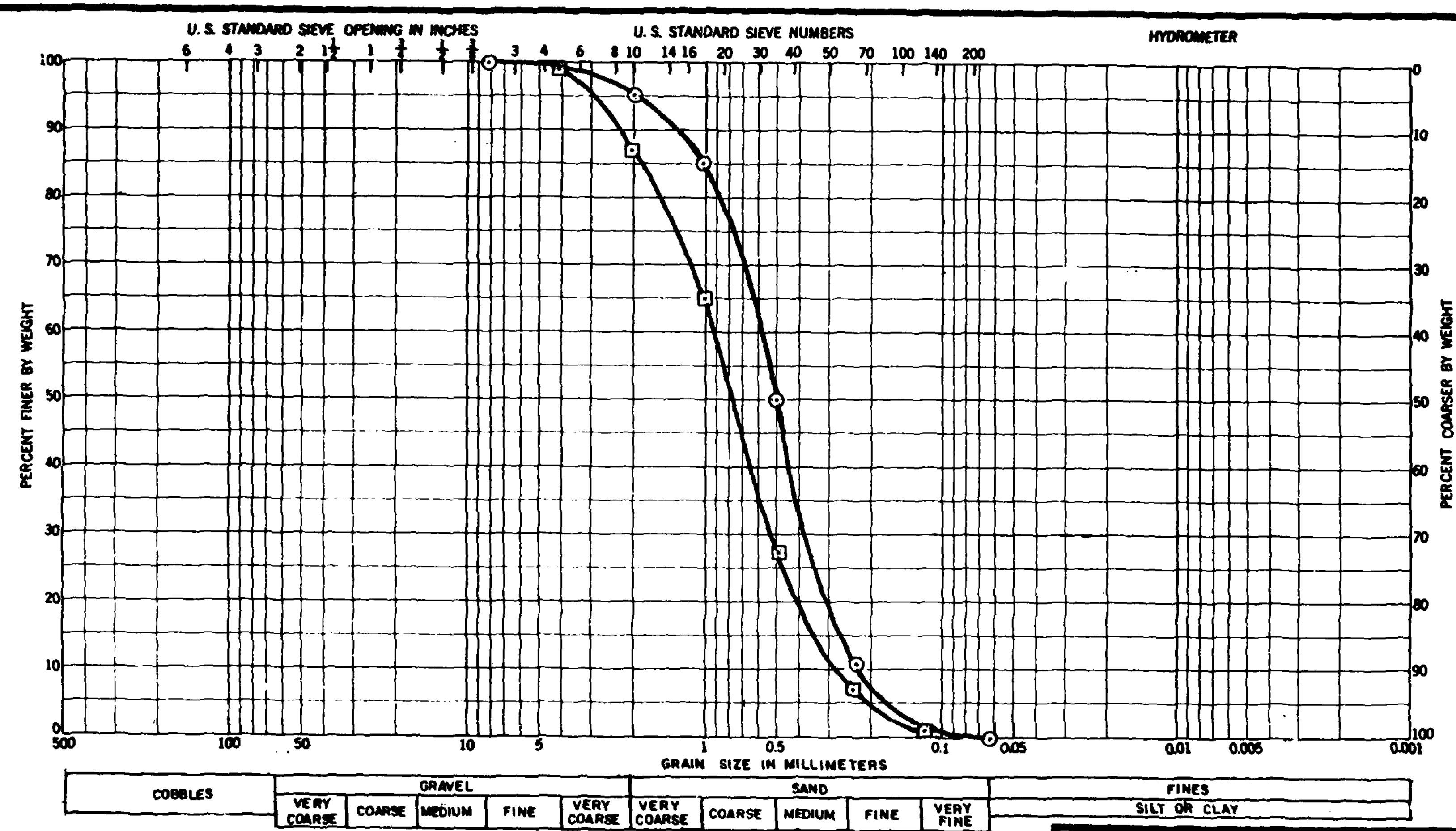
SCHEMATIC SHOWN CORRESPONDS TO THE INITIAL DESIGN OF THE LSAR, UPON WHICH THE SEDIMENTATION ANALYSIS WAS BASED. MINOR MODIFICATIONS HAVE BEEN MADE TO THE CHANNEL DIMENSIONS AND STATIONING. REFER TO PLATES IN HYDRAULIC DESIGN APPENDIX FOR FINAL DESIGN.

b = BOTTOM WIDTH

Z = SIDE SLOPE

S = CHANNEL GRADE

LOWER SANTA ANA RIVER ORANGE COUNTY, CALIFORNIA
CHANNEL SCHEMATIC
U. S. ARMY ENGINEER DISTRICT LOS ANGELES, CORPS OF ENGINEERS



LEGEND

SAMPLE	DEPTH	SYMBOL	
		O———O	PROJECT ANALYSIS
		□———□	SENSITIVITY ANALYSIS

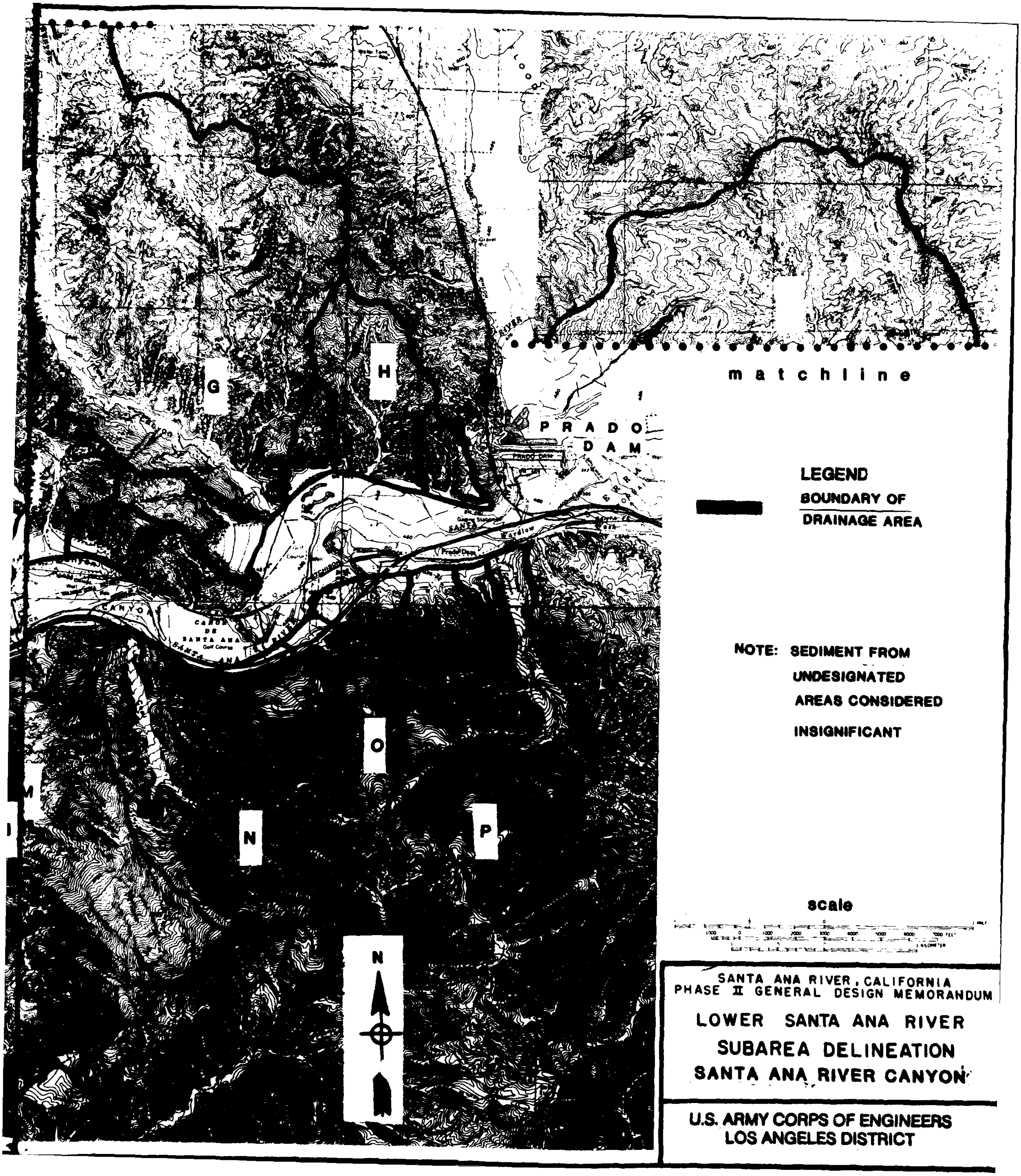
SANTA ANA RIVER
PHASE II GDM-SEDIMENT STUDY

REPRESENTAIVE BED-MATERIAL GRADATION CURVE WEIR CANYON TO PACIFIC OCEAN

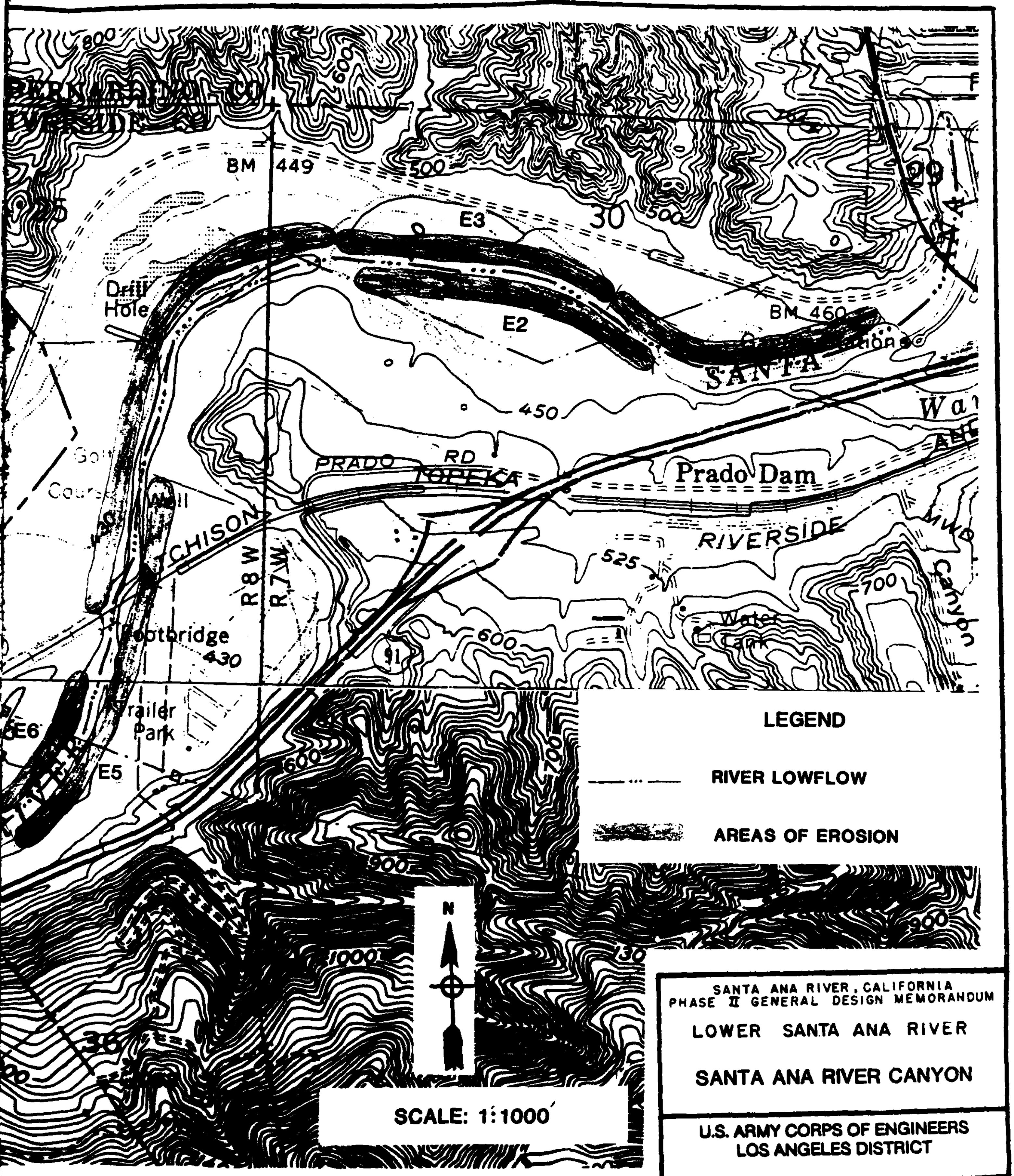
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

PLATE 3-C

matchline
A
C
D
E
F
G
K
L
M
I
SANTA ANA
SANTA ANA CANYON
CAÑON DE SANTA ANA


matchline
G
H
PRADO
DAM
O
N
P
M
LEGEND
BOUNDARY OF DRAINAGE AREA
NOTE: SEDIMENT FROM UNDESIGNATED AREAS CONSIDERED INSIGNIFICANT
scale
N
SANTA ANA RIVER, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
LOWER SANTA ANA RIVER
SUBAREA DELINEATION
SANTA ANA RIVER CANYON
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

SAN BERNARDINO CO
RIVERSIDE CO
Drill Hole
Golf Course
BM 437
E8
SANTIAGO
CANYON
CANON
DE
SANTA ANA
Golf Course
E6
E5
Trailer Park
Footbridge
RIVERSIDE
900
800
1000
700



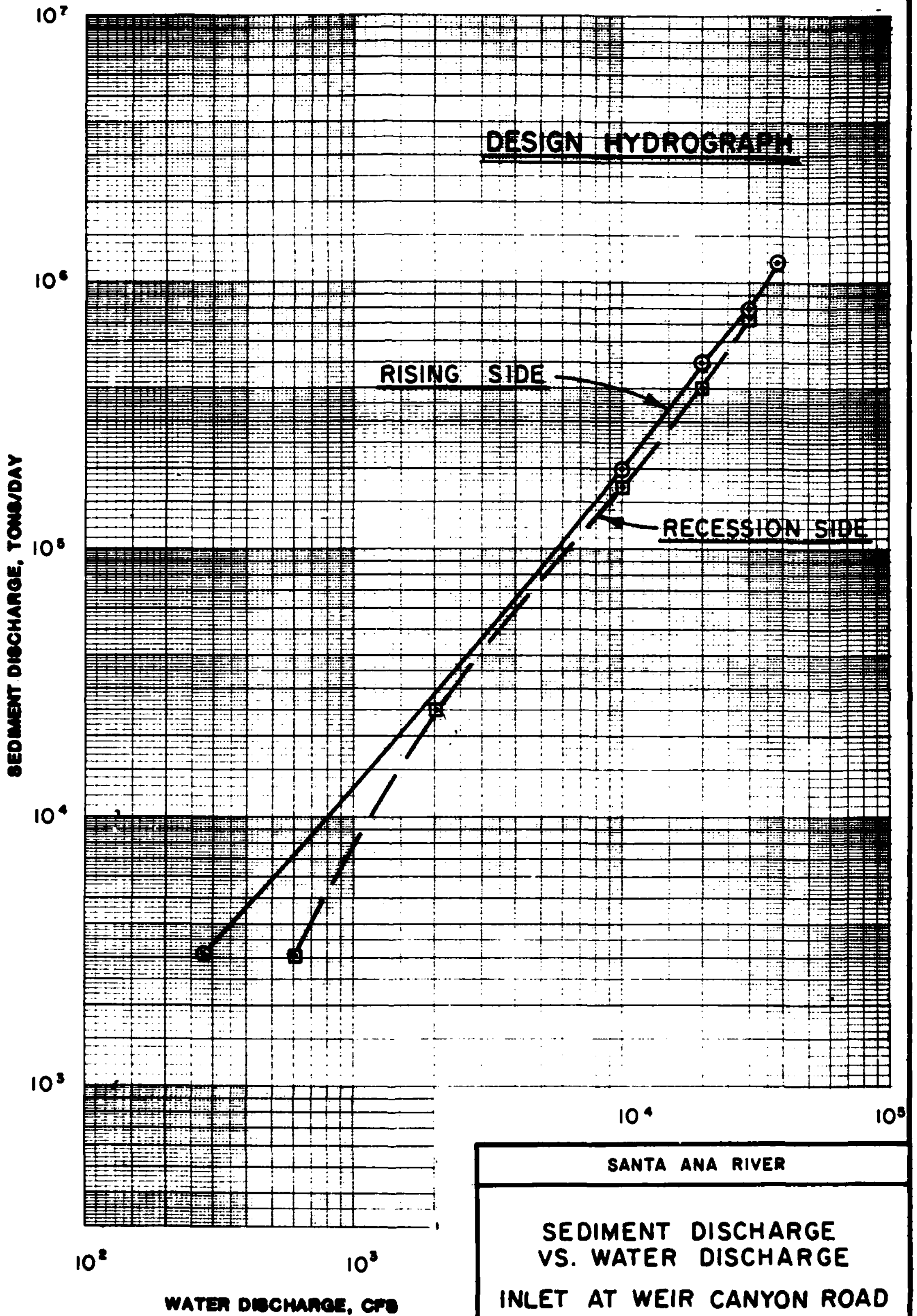
SANTA ANA RIVER, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER

SANTA ANA RIVER CANYON

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE 5 - C

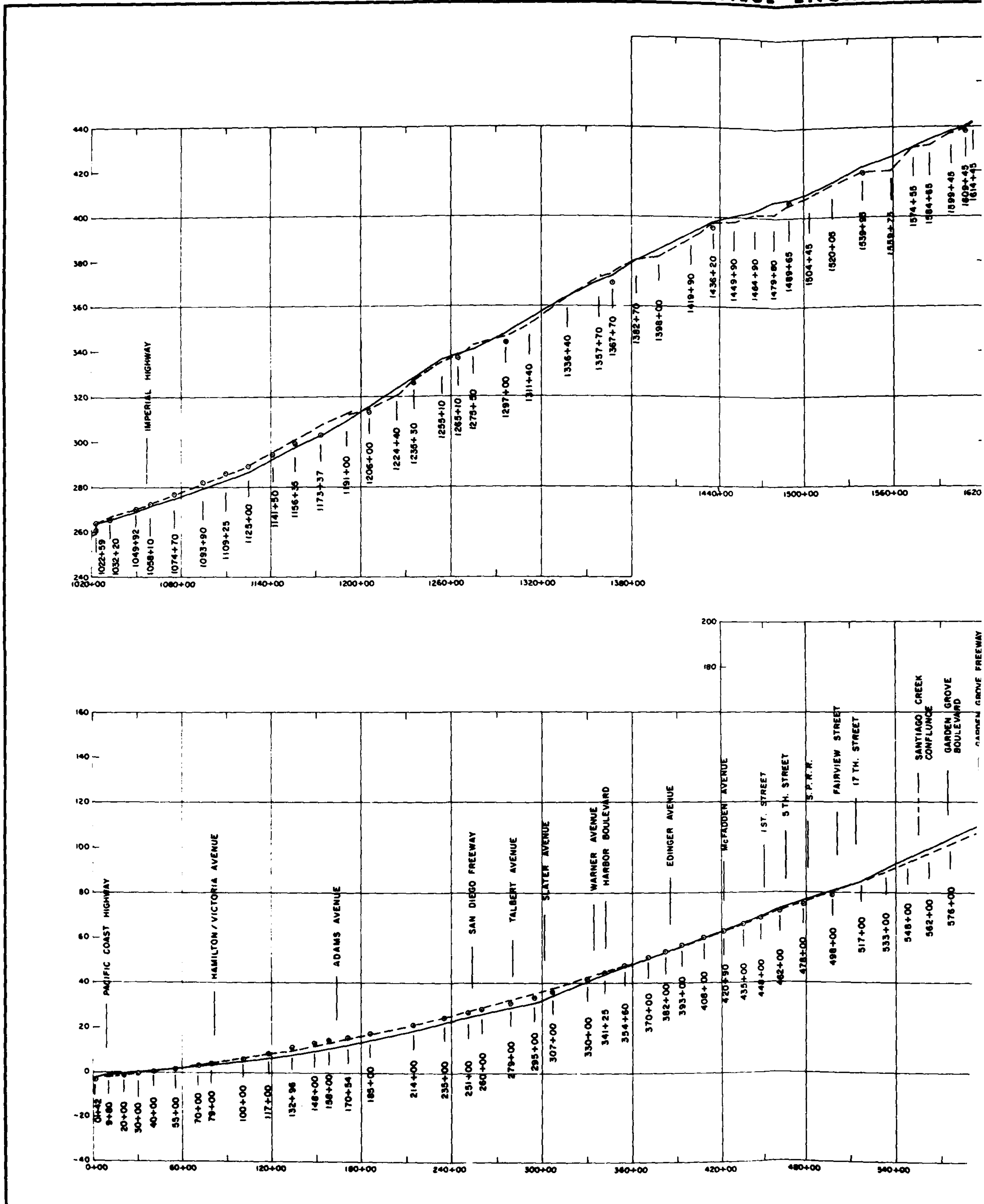


SANTA ANA RIVER

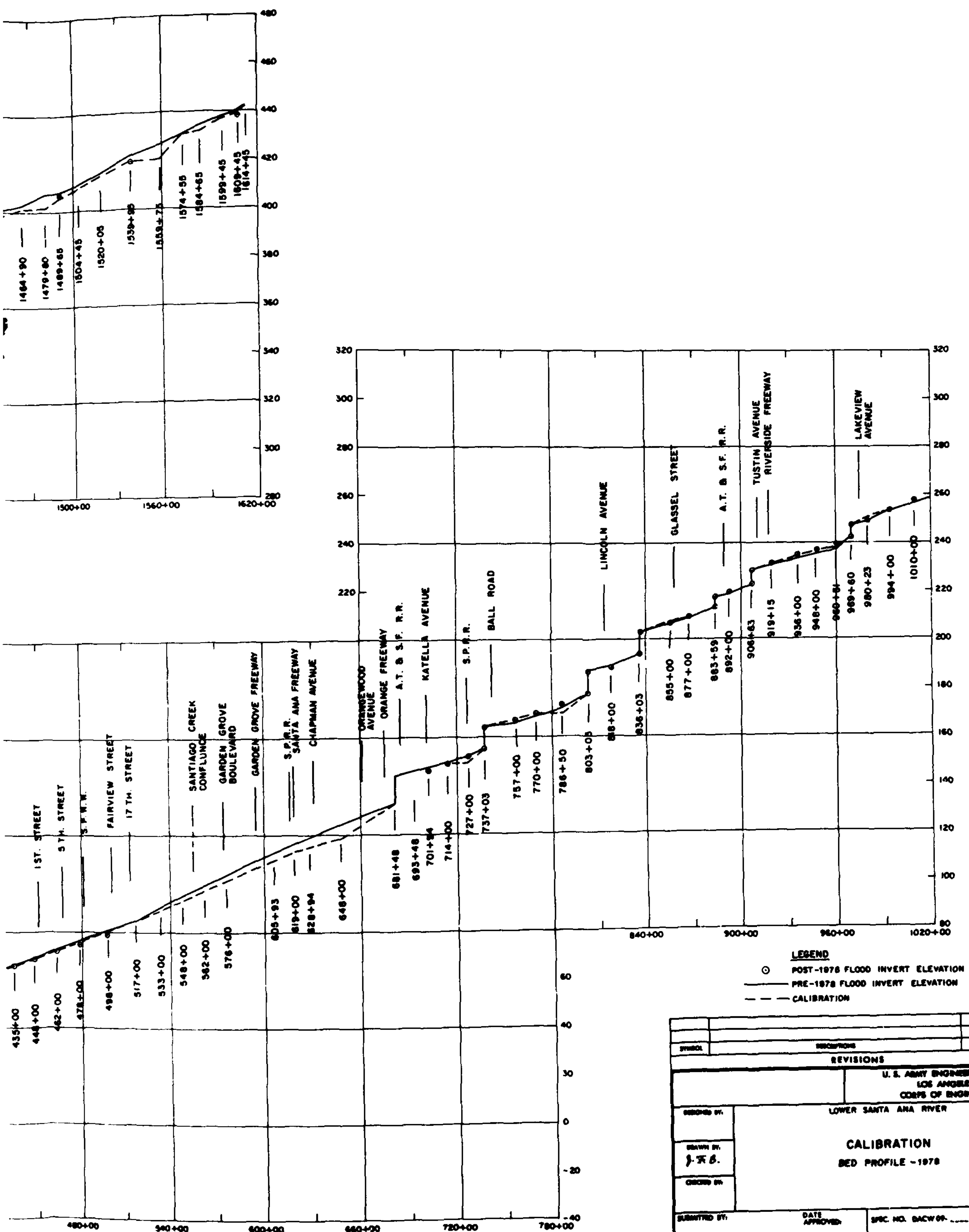
SEDIMENT DISCHARGE VS. WATER DISCHARGE

INLET AT WEIR CANYON ROAD

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS


IMPERIAL HIGHWAY
PACIFIC COAST HIGHWAY
HAMILTON / VICTORIA AVENUE
ADAMS AVENUE
SAN DIEGO FREEWAY
TALBERT AVENUE
SLATER AVENUE
WARNER AVENUE
HARBOR BOULEVARD
EDINGER AVENUE
McFADDEN AVENUE
1ST. STREET
5 TH. STREET
S.P.R.R.
FAIRVIEW STREET
17 TH. STREET
SANTIAGO CREEK CONFLUNCE
GARDEN GROVE BOULEVARD

LUE ENGINEERING PAYS



LEGEND

⊙ POST-1978 FLOOD INVERT ELEVATION

——— PRE-1978 FLOOD INVERT ELEVATION

– – – CALIBRATION

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: J.K.B.

CHECKED BY:

LOWER SANTA ANA RIVER

CALIBRATION

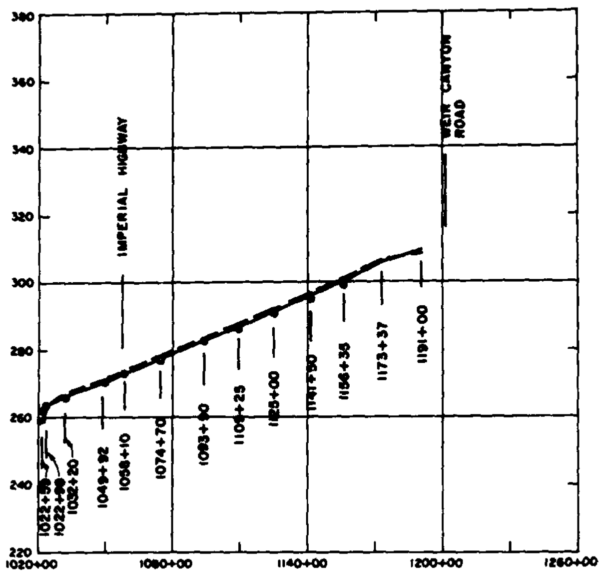
BED PROFILE - 1978

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

DISTRICT FILE NO.

SAFETY PAYS

PLATE 7-C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WEIR CANYON ROAD
1022+38
1022+98
1032+20
1049+92
1058+10
1074+70
1093+90
1109+25
1125+00
1141+50
1156+35
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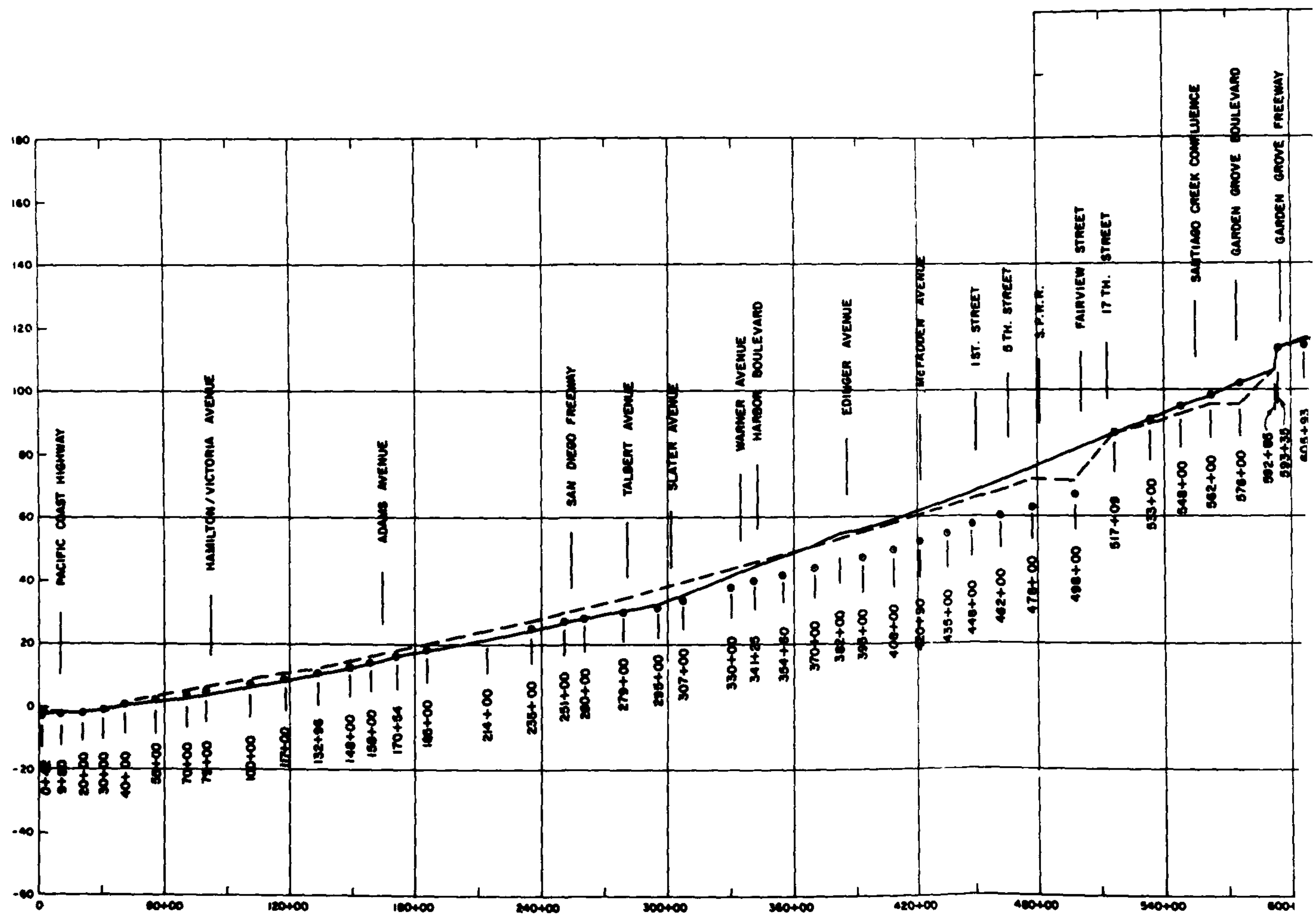
1140+00
1200+00
1260+00


PACIFIC COAST HIGHWAY
HAMILTON/VICTORIA AVENUE
ADAMS AVENUE
SAN DIEGO FREEWAY
TALBERT AVENUE
SLATER AVENUE
WARNER AVENUE
HARBOR BOULEVARD
EDINGER AVENUE
McFADDEN AVENUE
1ST. STREET
5 TH. STREET
S.P.R.R.
FAIRVIEW STREET
17 TH. STREET
SANTIAGO CREEK CONFLUENCE
GARDEN GROVE BOULEVARD
GARDEN GROVE FREEWAY
214+00
235+00
251+00
260+00
279+00
295+00
307+00
330+00
370+00
382+00
406+00
435+00
448+00
462+00
478+00
498+00
517+00
533+00
548+00
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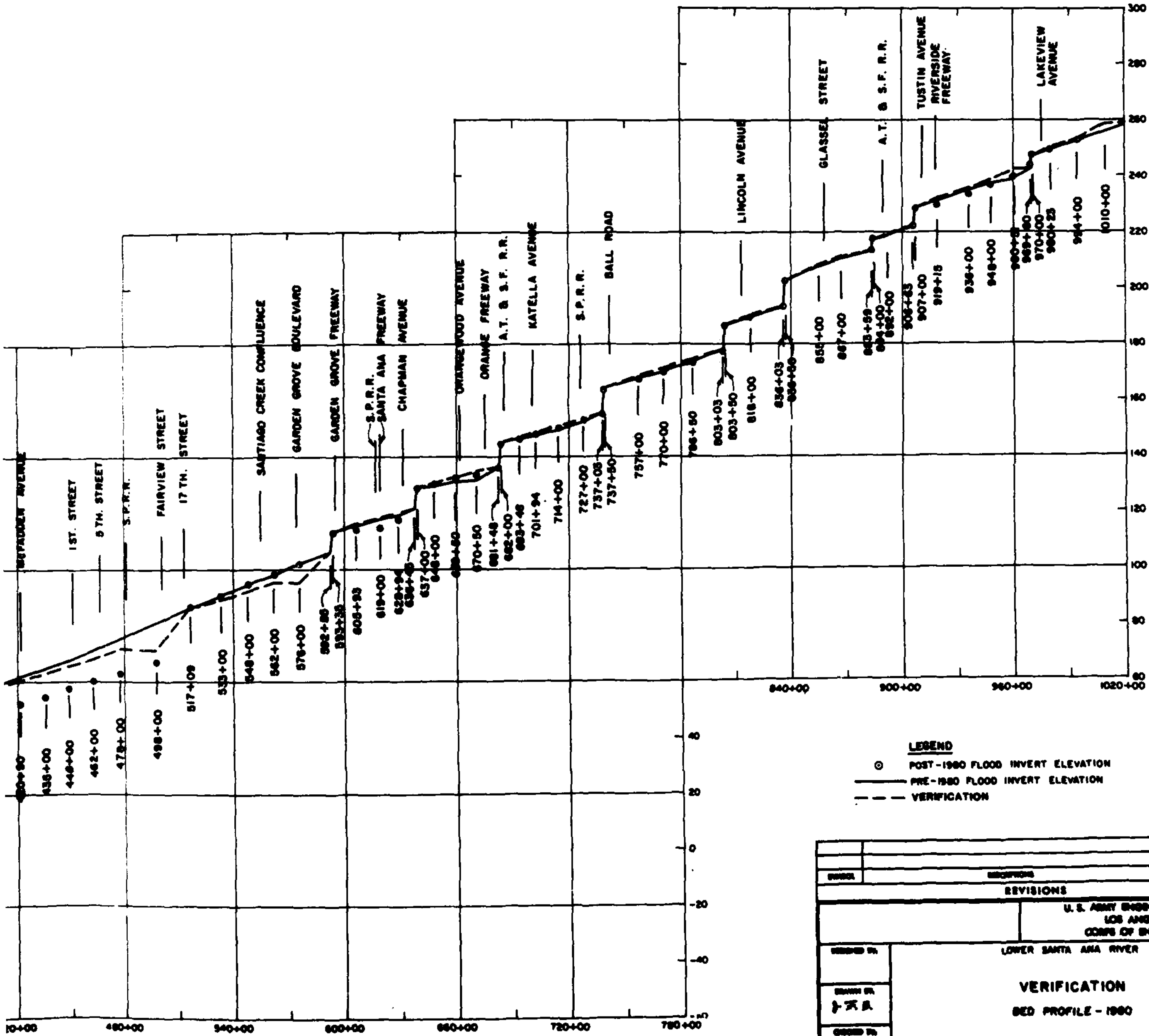
420+00
480+00
540+00



LEGEND

⊙ POST-1980 FLOOD INVERT ELEVATION

——— PRE-1980 FLOOD INVERT ELEVATION

– – – VERIFICATION

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

LOWER SANTA ANA RIVER

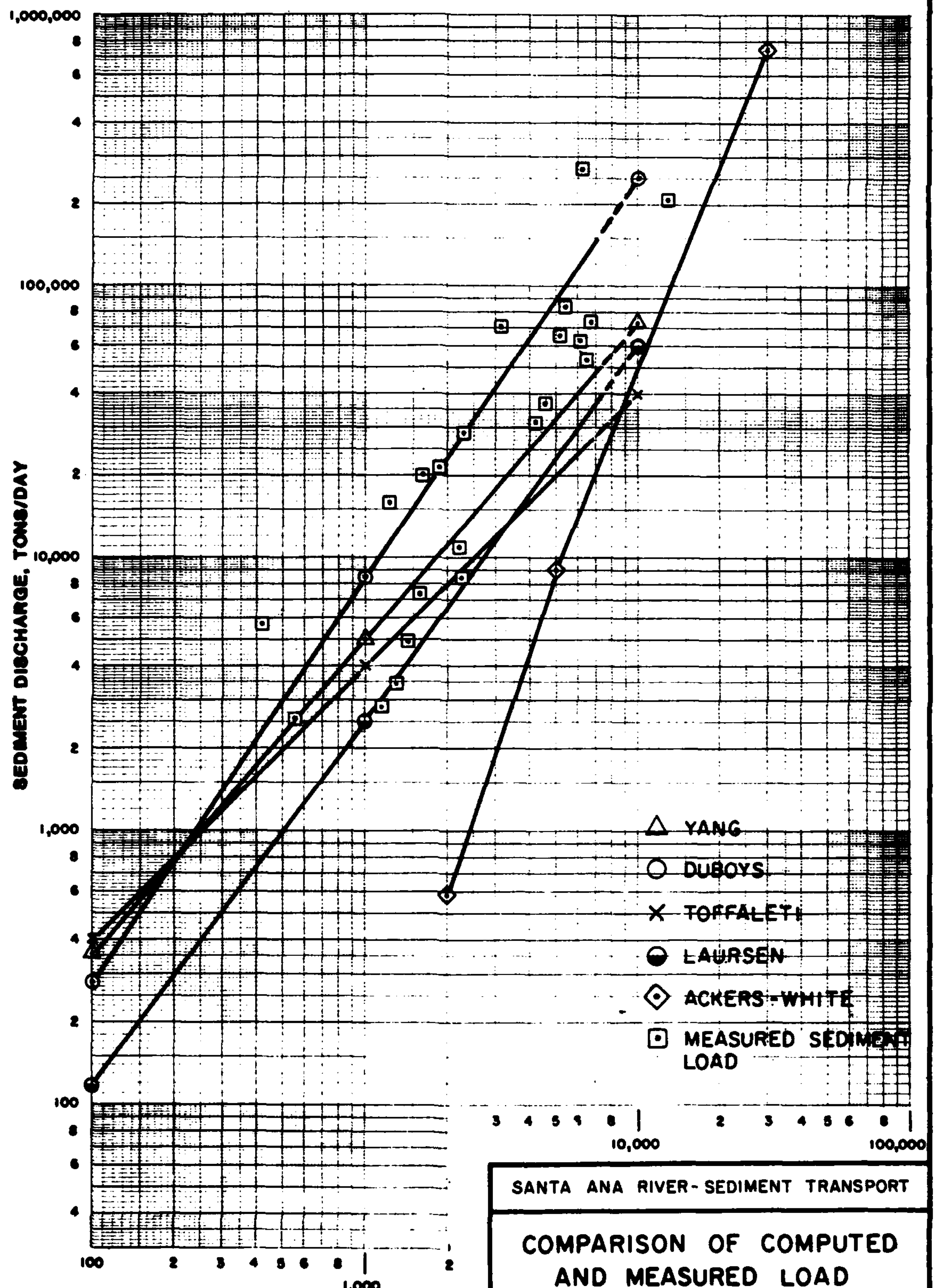
VERIFICATION

BED PROFILE - 1980

SPEC. NO. DACW09-

DISTRICT FILE NO.

PLATE 8-C

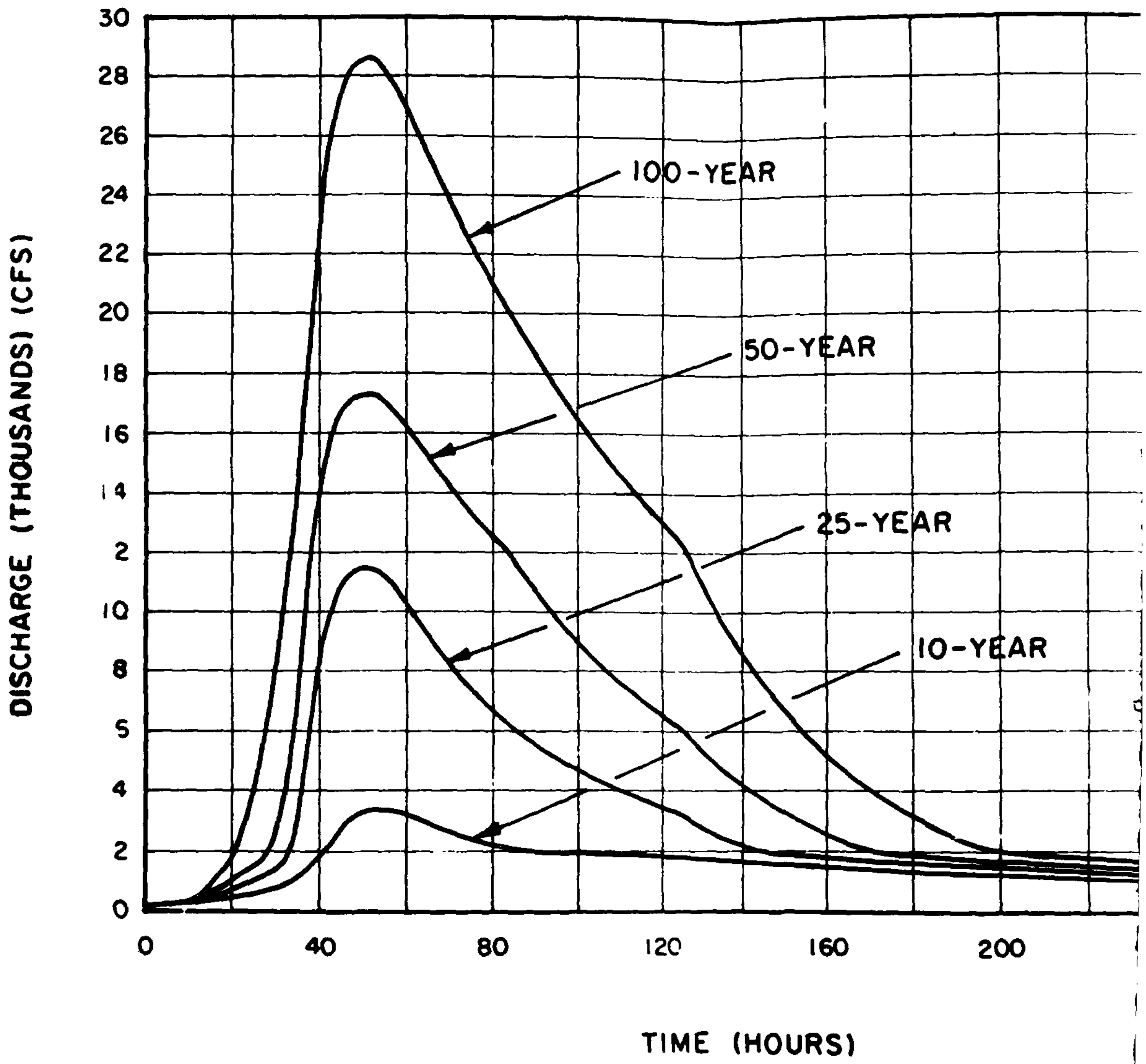


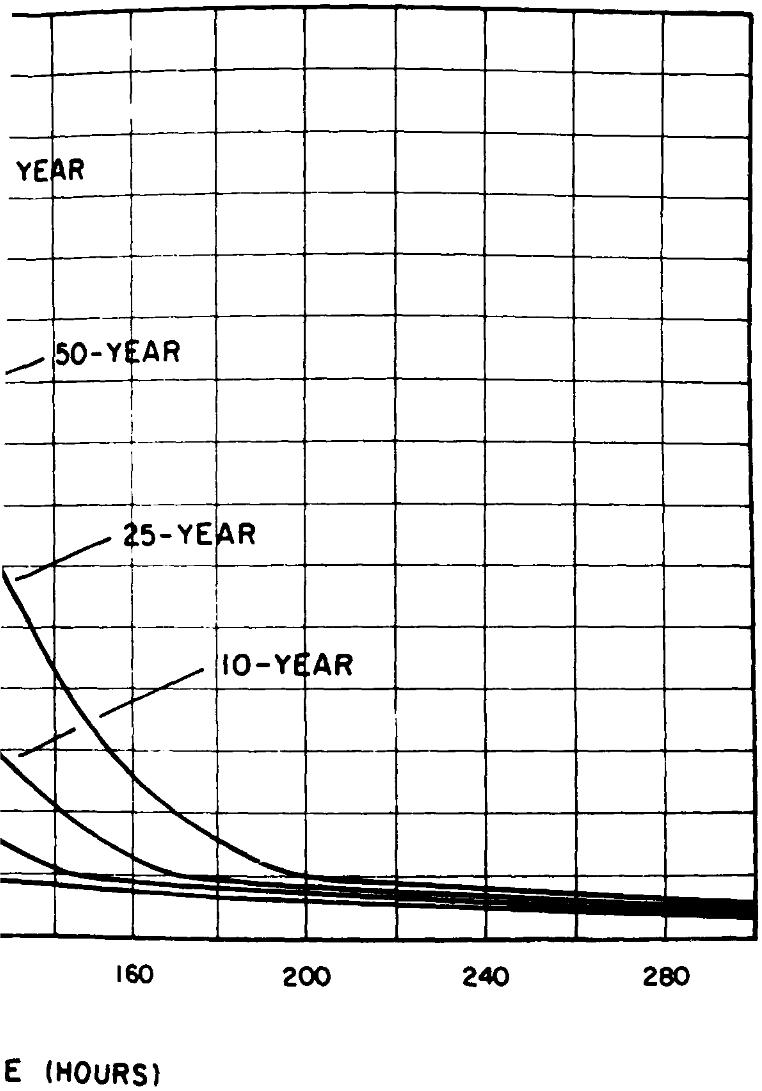
SANTA ANA RIVER-SEDIMENT TRANSPORT

COMPARISON OF COMPUTED AND MEASURED LOAD BALL ROAD GAGE

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED:

U. S. ARMY ENGINEER DISTRICT

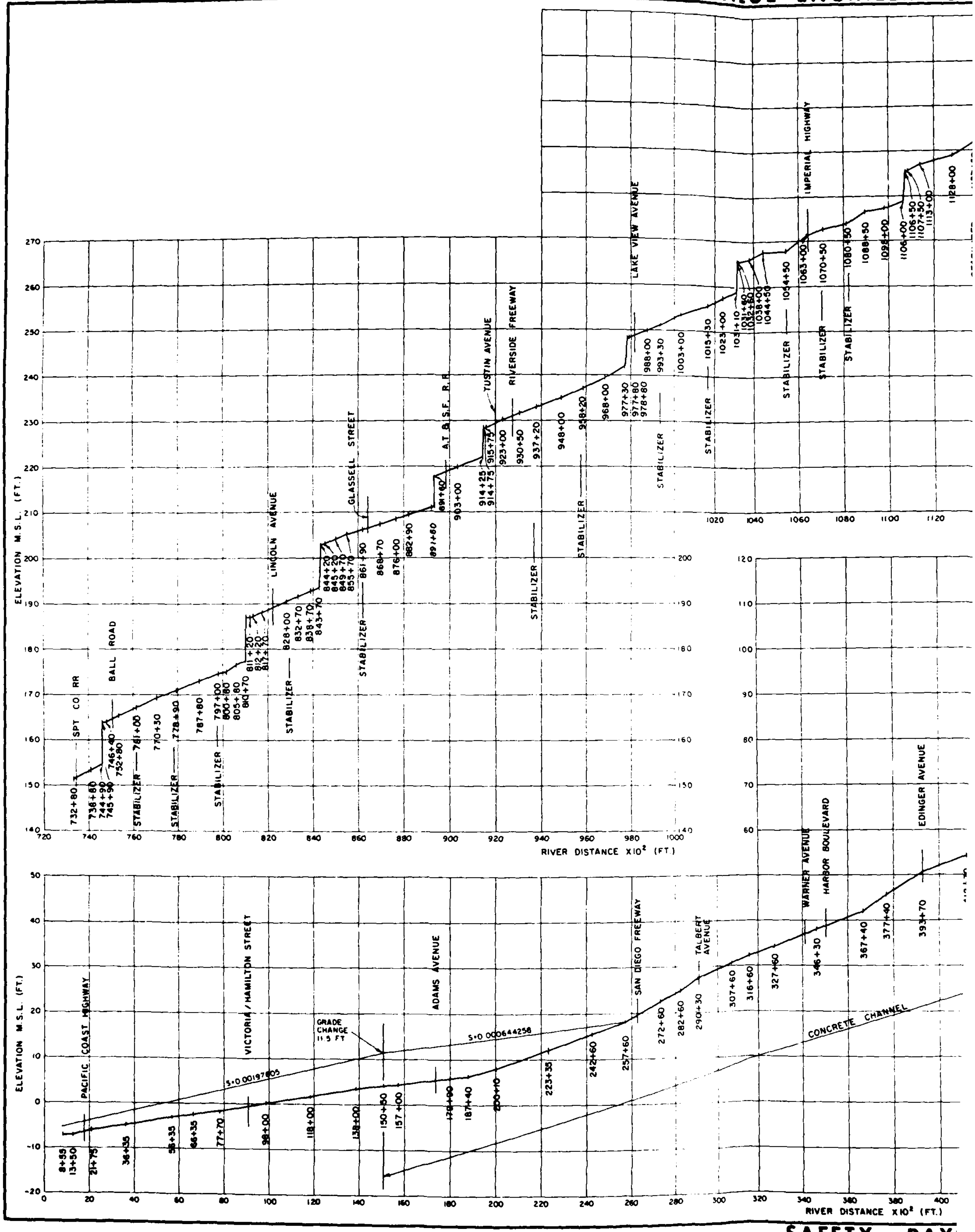




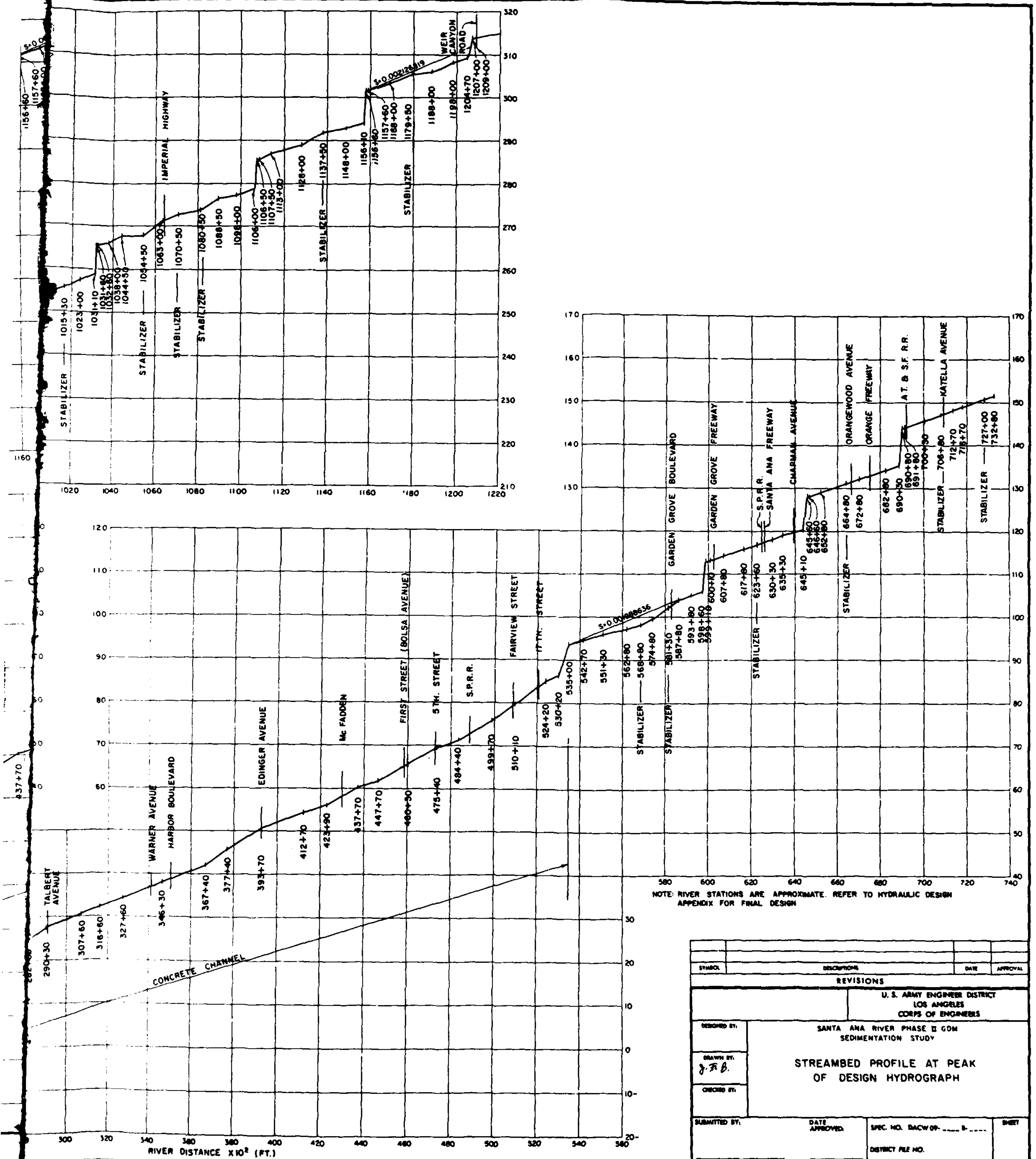
SANTA ANA RIVER

BALANCED HYDROGRAPHS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS


ELEVATION M.S.L. (FT.)
RIVER DISTANCE X10² (FT.)
SPT CO RR
BALL ROAD
LINCOLN AVENUE
GLASSELL STREET
A.T. & S.F. R.R.
TUSTIN AVENUE
RIVERSIDE FREEWAY
LAKE VIEW AVENUE
IMPERIAL HIGHWAY
STABILIZER
PACIFIC COAST HIGHWAY
VICTORIA / HAMILTON STREET
ADAMS AVENUE
SAN DIEGO FREEWAY
TALBERT AVENUE
WARNER AVENUE
HARBOR BOULEVARD
EDINGER AVENUE
GRADE CHANGE 11.5 FT
S=0.00197605
S=0.000644258
CONCRETE CHANNEL

VALUE ENGINEERING PAYS



SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER PHASE II GDM
SEDIMENTATION STUDY

DRAWN BY: J. F. B.

STREAMBED PROFILE AT PEAK
OF DESIGN HYDROGRAPH

CHECKED BY:

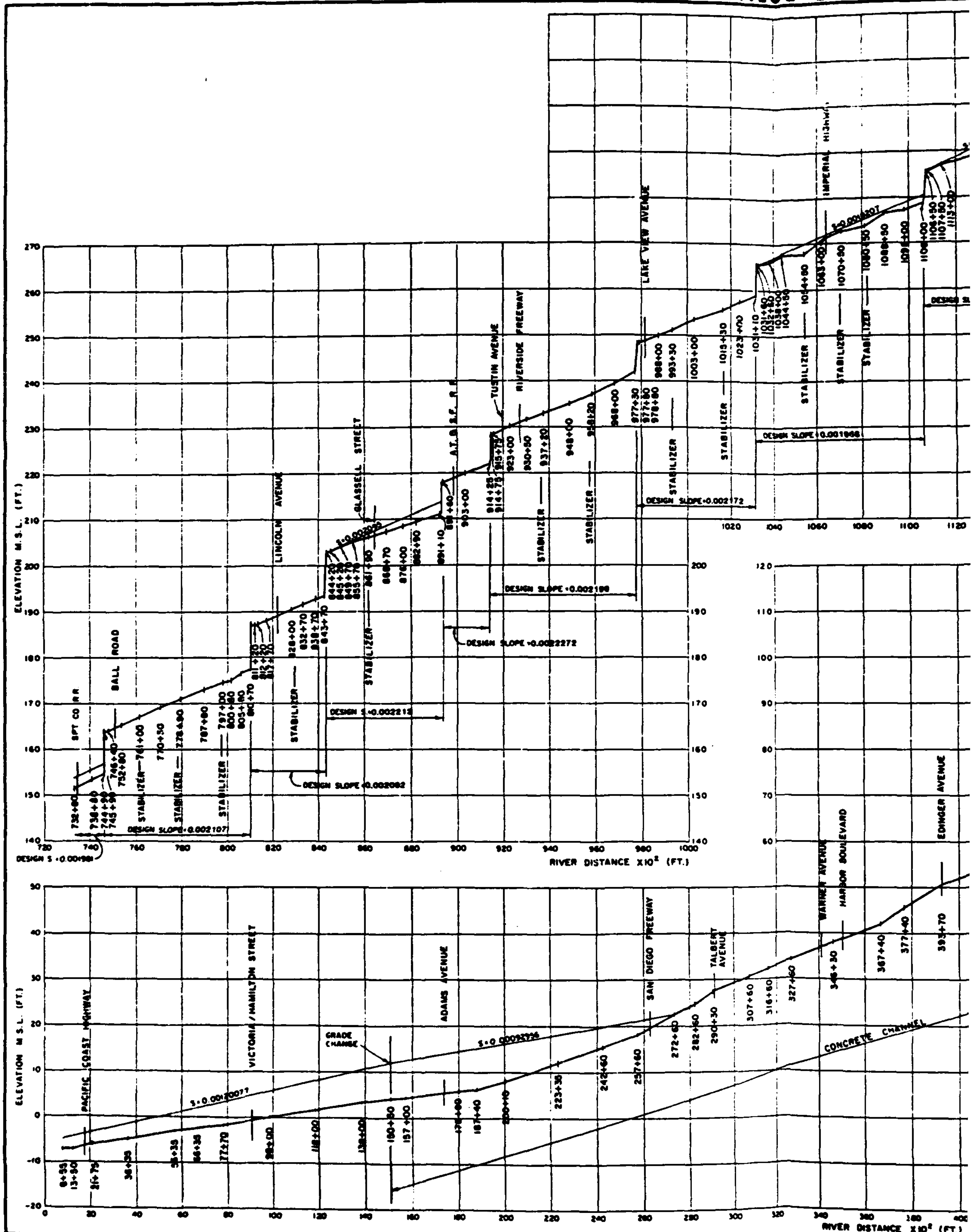
SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-____ B-____ SHEET

DISTRICT FILE NO.

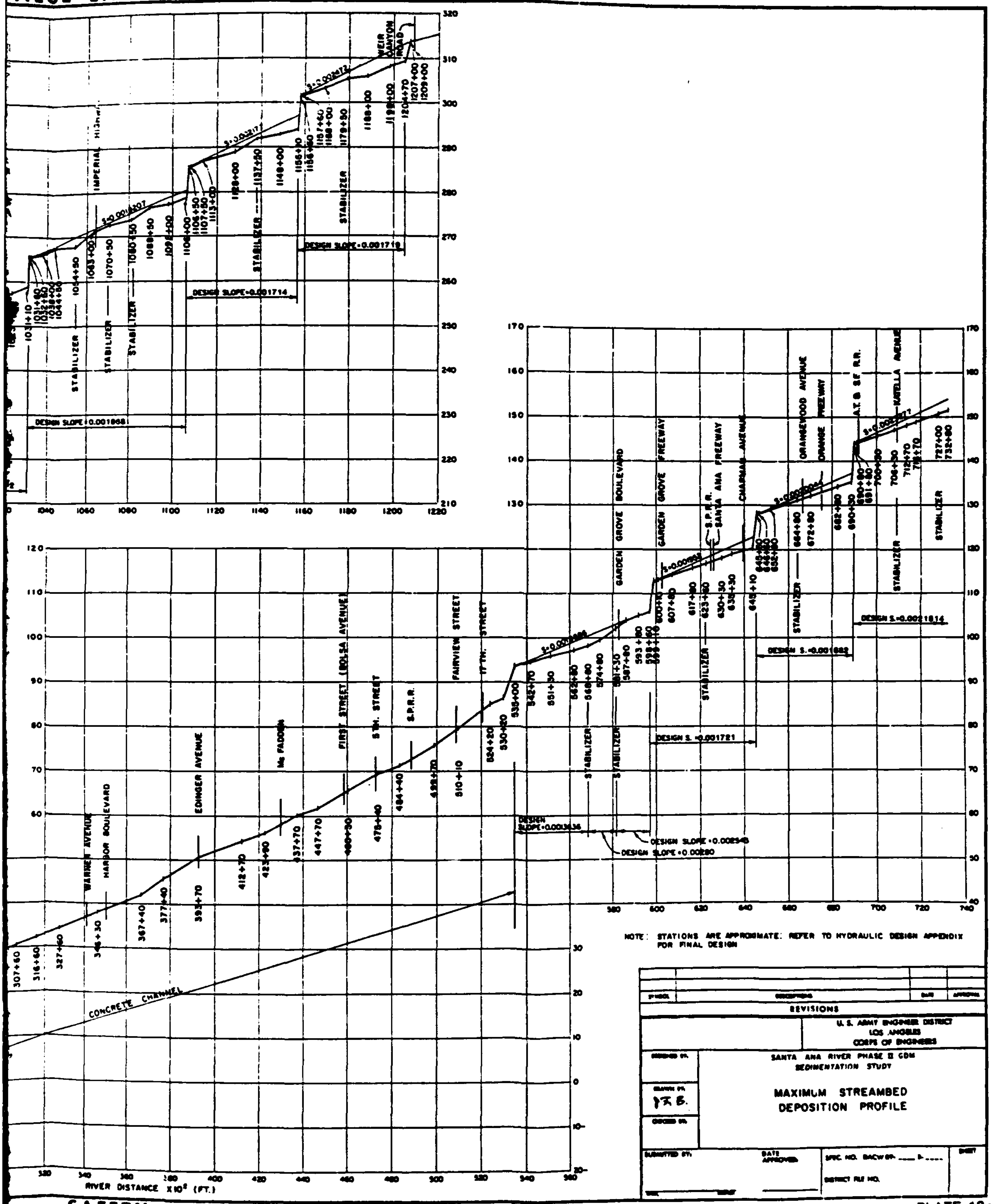
SAFETY PAYS

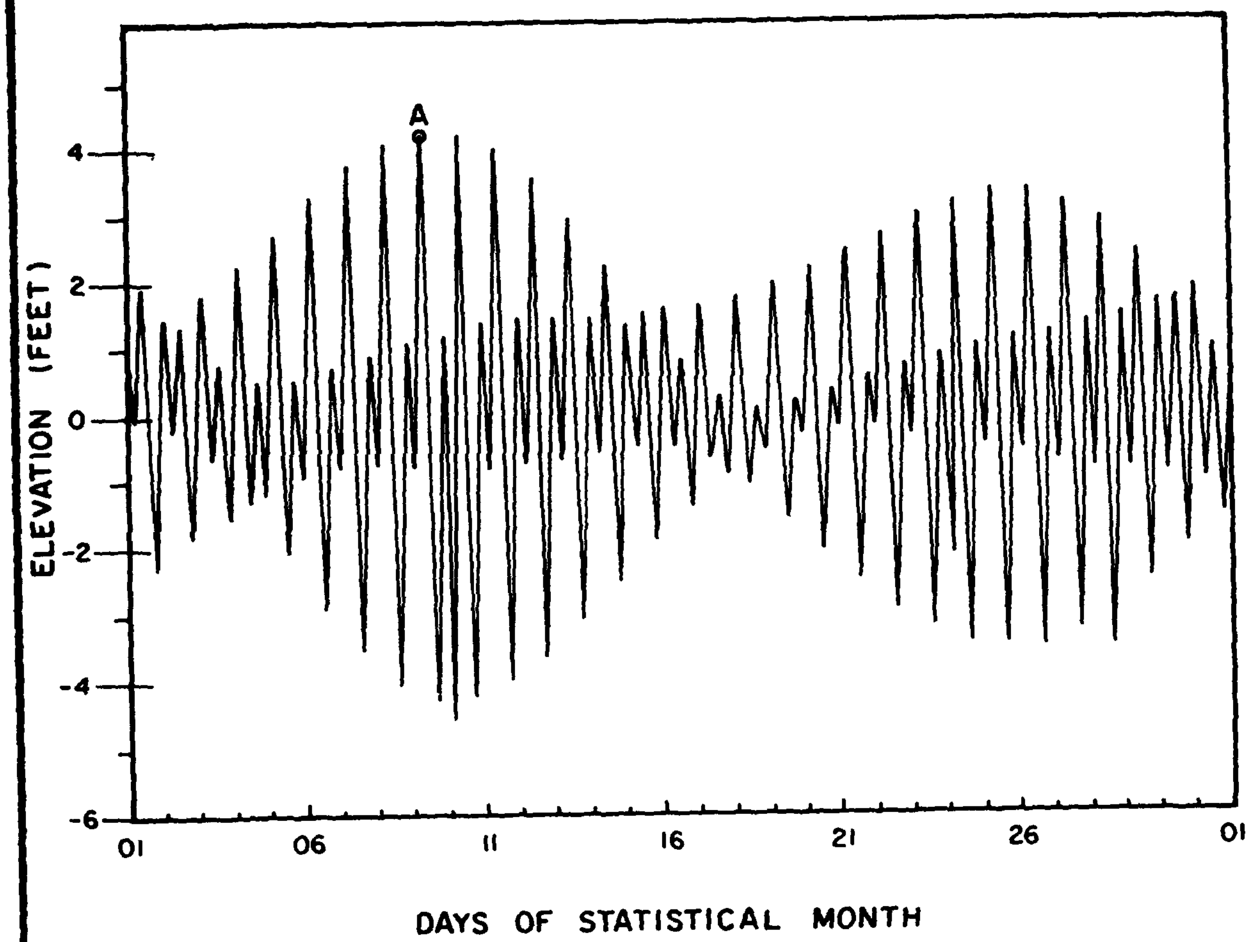
PLATE 11-C

VALUE ENGINEERIN



SAFETY PAY


WEIR CANYON ROAD
IMPERIAL HIGHWAY
DESIGN SLOPE = 0.001968
DESIGN SLOPE = 0.001714
DESIGN SLOPE = 0.001719
STABILIZER
GARDEN GROVE BOULEVARD
GARDEN GROVE FREEWAY
S.P.R.R.
SANTA ANA FREEWAY
CHAPMAN AVENUE
ORANGEWOOD AVENUE
ORANGE FREEWAY
A.T. & S.F. R.R.
KATELLA AVENUE
DESIGN S. = 0.0021814
DESIGN S. = 0.001682
DESIGN S. = 0.001721
DESIGN SLOPE = 0.0013636
DESIGN SLOPE = 0.002545
DESIGN SLOPE = 0.00280
WARNER AVENUE
HARBOR BOULEVARD
EDINGER AVENUE
Mc FADDEN
FIRST STREET (BOLSA AVENUE)
5 TH. STREET
S.P.R.R.
FAIRVIEW STREET
17 TH. STREET
CONCRETE CHANNEL
RIVER DISTANCE X10² (FT.)
NOTE: STATIONS ARE APPROXIMATE; REFER TO HYDRAULIC DESIGN APPENDIX FOR FINAL DESIGN
REVISIONS
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
SANTA ANA RIVER PHASE II GDM
SEDIMENTATION STUDY
MAXIMUM STREAMBED
DEPOSITION PROFILE



NOTES:

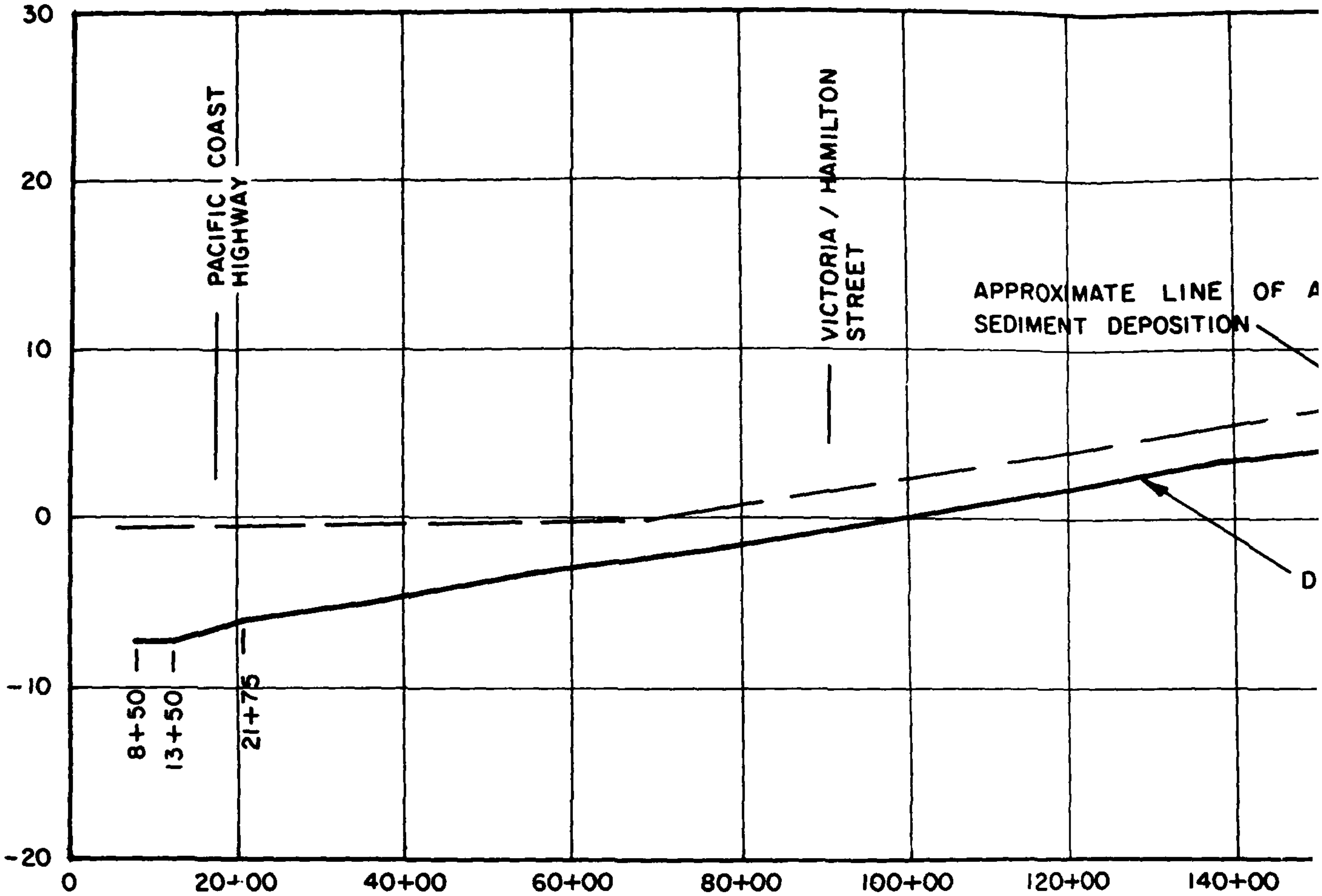
1. NOAA TIDAL DATUM EPOCH 1960-1978.
2. POINT A WAS SET COINCIDENT WITH THE PEAK DISCHARGE OF THE DESIGN FLOOD HYDROGRAPH.
3. EL. 0.0 NGVD DATUM.

LOWER SANTA ANA RIVER
ORANGE COUNTY, CALIFORNIA

NEWPORT BEACH
TIDAL HYDROGRAPH
AT SANTA ANA RIVER
MOUTH

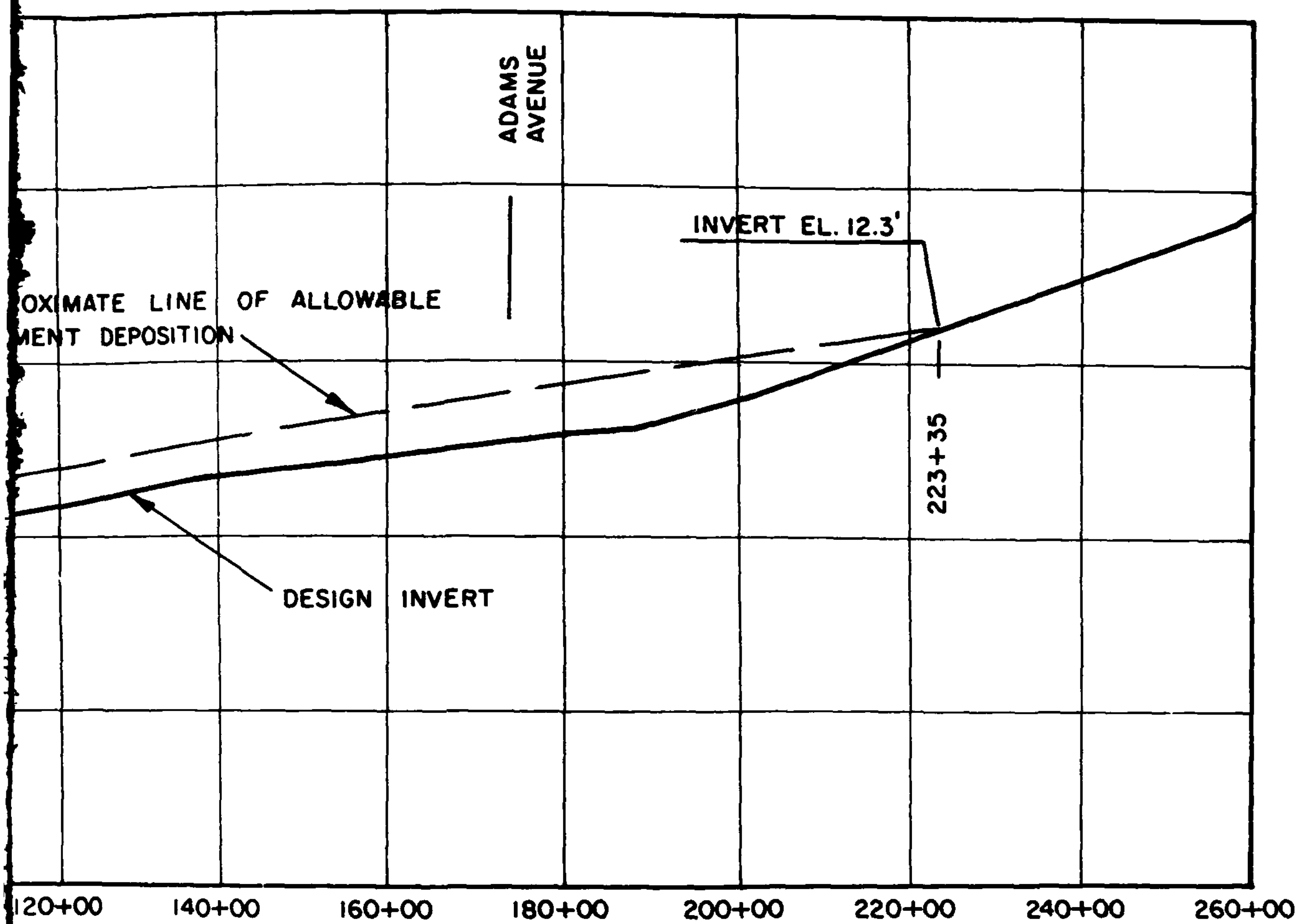
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

PLATE 13-C



PROFILE

HORIZ. SCALE: 1 IN. = 200
VERT. SCALE: 1 IN. = 10 F



PROFILE

SCALE: 1 IN. = 2000 FT.
SCALE: 1 IN. = 10 FT.

LOWER SANTA ANA RIVER
ORANGE COUNTY, CALIFORNIA

UPPER SEDIMENT LEVEL

STA. 8+50 TO STA. 223+35

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

C Sediment Transport Analysis

ATTACHMENT

FINAL REPORT

REVIEW OF THE
DRAFT SEDIMENTATION REPORT
OF THE LOWER SANTA ANA RIVER,
PHASE II GENERAL DESIGN MEMORANDUM

Prepared for

Department of Army
Los Angeles District Corps of Engineers
P.O. Box 2711
300 N. Los Angeles Street
Los Angeles, CA 90053

Prepared by

Simons, Li & Associates, Inc.
3901 Westerly Place, Suite 101
Newport Beach, CA 92660

SLA Project No. CA-COE-16
(R1029/N-57)

June 5, 1987

Attachment 1

TABLE OF CONTENTS

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LIST OF FIGURES

I. BACKGROUND

The Santa Ana River drains a large, arid watershed and conveys flood water through developed areas valued at many billions of dollars. The lower river is virtually dry most of the year but has experienced peak discharges of up to 327,000 cfs for the flood of January, 1882. The flood of 1938 had a peak discharge of approximately 100,000 cfs and its damage inspired major channelization efforts as well as the construction of Prado Dam. The next major flood occurred in January and February, 1969 and had a peak discharge of approximately 36,000 cfs. The floods of March, 1978 and February, 1980 also caused notable damage.

The Phase I GDM calls for significant improvements to the Lower Santa Ana River. From Weir Canyon Road to the Santiago Creek confluence, the plan calls for a soft bottom, trapezoidal channel with 18 to 24 inch riprap on the banks. From the Santiago Creek confluence to the San Diego Freeway, the channel will be trapezoidal with concrete sides and bottom. From the San Diego Freeway to the river mouth, the channel will be rectangular with concrete sides and a soft bottom. Since this portion of the river has historically been a reach of deposition, there is no need for lining the bottom of the channel.

II. DESCRIPTION OF SEDIMENTATION STUDY

The objectives of the sedimentation study for the Lower Santa Ana River design include the following:

(1) Convey flood waters safely to the ocean without overtopping in the main stem or its tributaries.

(2) Account for erosion of the river bed and banks durings a flood event.

(3) Account for local scour at road crossings, tributary inflows, etc.

(4) Estimate maintenance involved in removing large quantities of sediment in deposition reaches, especially near the river mouth.

Because of the relationship between hydrualics and sediment transport, it is important to incorporate their effects upon each other into the project design. In order to analyze this complex problem correctly and completely, the following approach was used by the Los Angeles Corps of Engineers.

(1) Assess the behavior of the existing Santa Ana River using available data and historical accounts of previous floods.

(2) Use measured data such as flood stages and sediment concentrations to determine the applicability of the HEC-6 computer program "Scour and Depsoition in Rivers and Reservoirs."

(3) Determine the response of the proposed project to the design flood using HEC-6. Areas of scour and deposition should, in general, correspond to historical events.

(4) Use several qualitative and quantitative methods in addition to numerical modeling to perform sedimentation analysis to provide support for conclusions drawn.

(5) Conduct a sensitivity analysis by varying parameters that have a large uncertainty such as roughness and sediment loading. Determine the effect of these variations on the computed solution.

This approach is thorough and systematic. It uses available historic data and uses several different analysis methods to verify the results. The following chapter is a summary of the results and procedures of the Phase II GDM sedimentation report for the lower Santa Ana River.

III. SUMMARY OF LOWER SANTA ANA RIVER SEDIMENTATION REPORT

The study was conducted by the Los Angeles District Corps of Engineers, Engineering Division, Hydraulics/Hydrology Branch. A summary of the Corps of Engineers' study follows.

The study reach starts from the river mouth at the Pacific Ocean and ends at Prado Dam approximately 31 miles upstream. From the ocean to river mile 23, the river is channelized with both concrete and revetted side slopes and a soft bottom. From river mile 24 to Prado Dam there is essentially a natural channel through what is known as the Santa Ana River Canyon. Santiago Creek is the main tributary and it enters at approximately river mile 11.

Data collection efforts turned up maintenance records that indicate the average annual sediment deposition in the study reach is 55,000 cubic yards per year. Aerial photos were available for 1982, 1974 and 1938. Bed material analysis indicates about 90% sand and 10% gravel. Channel surveys were performed after the 1978 and 1980 flood events. Project channel geometry was taken from the Phase I GDM. Streamflow data was recorded below Prado Dam, at Imperial Highway, at Ball Road and at Fifth Street. Suspended sediment measurements were also made at these gaging sites. The gage measurements were corrected to account for the unmeasured sediment load.

A qualitative analysis using the Lane relationship indicated the upper portion of the channelized project reach will experience aggradation; the area just upstream from the Santiago Creek confluence will remain stable; the all concrete reach will maintain its design invert elevation; and deposition will occur downstream from the San Diego Freeway. The results are shown in Table 2 of the Corps study.

An equilibrium slope analysis using Yang's equation yields general results similar to the qualitative analysis. It was determined that bed armoring would be unlikely to occur during the design flood due to the relatively small representative grain size. Table 4 indicated the armor grain size is between 10 and 70 mm. The d_{95} grain size however is 2 mm.

A limiting degradation slope was estimated using 4 different methods: Schoklitsch bedload equation, Meyer-Peter Muller bedload equation, Shields diagram and Lane's critical tractive force method. These methods yielded stable slopes of 0.000029, 0.000029, 0.0000073 and 0.000004 respectively.

A relationship between sediment discharge and water discharge was developed. It incorporated all sediment sources in the canyon reach upstream from the proposed project. Stream gage data was available for sediment loads for discharges up to 14,000 cfs. The computer program HEC-6 was used to estimate sediment loads for higher discharges. Tatum's method was used to estimate sediment yield from the watershed during a design storm. Bank erosion estimates were made by examining aerial photographs. The Pacific Southwest Interagency Committee method and the Flaxman method were also used to estimate sediment yield. A sediment yield rate of 1.64 acre-feet/square-mile/year was determined for the canyon watershed above the project reach. This compared well to reservoir deposition data indicating a 1.45 acre-feet/square-mile/year sediment yield rate at nearby Santiago Reservoir. An average annual sediment inflow of up to 132,000 cubic-yards/year was determined to enter the project reach. Note that this number includes sand, silt and clay sizes.

Sedimentation analysis was carried out using the Corps of Engineers computer program HEC-6 and a modified version known as H6NBS36. The geometric data covered the project inlet at Weir Canyon Road to its outlet at the Pacific Ocean. The program was calibrated using data from the flood of 1978. Yang's unit stream power method was used as a transport function in HEC-6. The calibration was performed by adjusting the Manning's n value of each section until agreement was obtained between computed and observed bed changes. The calibrated data set was verified using records from the 1980 flood. The bed changes were reproduced fairly well except for the reach downstream from the Santiago Creek confluence. In this reach, computed degradation was less than the degradation observed during the 1980 flood.

The data set for the project condition was developed from plans in the Hydraulic Appendix in the Phase I GDM. Grain size analyses were performed throughout the study area and a single representative grain size distribution was used (Plate 3). The project condition was evaluated using balanced hydrographs representing 10, 25, 50 and 100 year frequency flood events as well as the design event. The following roughness values were used for the project condition: n=0.02 for the downstream reach, n=0.015 for the concrete lined middle reach, n=0.025 for the unlined upper reach (drop structure reach). Form drag caused by bed forms was included in the development of n values.

The design flood was simulated for the project condition using the HEC-6 computer program. Two different inflowing load curves were used to encompass maximum and minimum streambed changes. The results indicate that deposition of up to 2.2 feet will occur in the upstream reach. Deposition of up to 7.3 feet will occur in the downstream reach. The middle reach remained fairly stable. Note that all three reaches are channelized. A second simulation using clear water inflow indicated 6 to 8 feet of scour in unlined drop structure reaches. This worst case erosion scenario was used to estimate toe depths of lined banks.

A sensitivity analysis was performed to account for the uncertainties involved in sedimentation analysis. The Manning's *n* value was increased to 0.03 in all reaches but had only a small effect on computed bed changes. The D_{50} grain size of the bed material was increased from 0.5mm to 0.75mm but this also had little effect on the computed results. The reason for this is because all reaches with unlined channel bottoms experienced deposition thus bed grain size should have no effect upon solutions computed by HEC-6. A sand plug often forms at the Santa Ana River mouth during the summer months. The sand plug would wash out before the peak of the design flood. An antecedent flow of 5,000 cfs for 30 days resulted in twice as much deposition near the river mouth during the design flood event. A tidal elevation of 2.72 feet was used for the downstream boundary condition for the design event. Variations in the tidal elevation had little effect on the riverbed near the ocean.

The incremental probability method was used to compute the average annual sand outflow to the ocean and the average annual deposition in the project reach. The results indicated that 31,000 cubic yards of sand per year deposited in the project reach. The sand outflow to the beach was 36,000 cubic yards per year. From gage records, it was estimated that the sand outflow to the ocean is 80,000 cubic yards per year. It was estimated that the frequency of maintenance in the downstream reach would be approximately every 20 years. No maintenance is expected in the upstream or middle reaches.

IV. REVIEW OF SEDIMENTATION ANALYSIS

4.1 Qualitative Analysis

A qualitative analysis using the relationship

$$q_s \; D_{50} \alpha q S \qquad (4.1)$$

Where q_s = sediment discharge per unit width
D_{50} = median sediment size
q = water discharge per unit width
S = channel slope

This relationship is based upon Lane's Work (see Reference 1). Section III B of the Phase II GDM states, "When sediment transport rate increases, degradation will occur and the bed slope will flatten. Conversely, a decrease in one of the right hand side variables will result in a decrease of the sediment transport rate; deposition will occur and the bed slope will steepen." The results shown in Table 2 (Evaluation of Qualitative Response of Santa Ana River) of the COE report are basically correct. SLA suggests that the sentence referenced above be modified to "When the sediment transport capacity increases, degradation will occur. When the channel slope decreases, aggradation will occur."

4.2 Bed Armoring Potential

Five methods were used to compute the particle size for which bed armoring would occur. The size ranged from 10 mm to 70 mm. Only a small amount of coarse material is available so bed armoring is not expected to be a dominant physical process in the project reach below Weir Canyon Road. Bed armoring may occur, however, in the canyon reach above the project, especially at lower sustained discharges. The impact will be to slow down bed erosion in the canyon reach. The COE analysis took into account the potential range of sediment supply and the corresponding slope changes. SLA concurs with the COE analysis.

4.3 Equilibrium Slope Analysis

Yang's unit stream power equation was used to compute the slope for which the bed would be stable. This analysis yields results that can be expected under normal flooding and sediment supply conditions. This is sometimes referred as "dynamic equilibrium" condition. The results generally agree with the qualitative analysis.

4.4 Limiting Channel Slope

The stable slope is estimated based upon incipient motion criteria for a given particle size and represents a situation that may occur if there is little or no inflowing sediment load. This is sometime referred to as "static equilibrium" condition. A stable slope was computed using four different methods. The design discharge was used to compute the expected bed shear. The stable slope ranged from 0.000004 to 0.000029. This is substantially less than the existing average channel slope and could result in general degradation of up to five feet. SLA concurs that this is a conservative estimate of bed erosion and can be used to estimate toe down on bank lining.

4.5 Sediment Discharge Relationships from Stream Gage Data

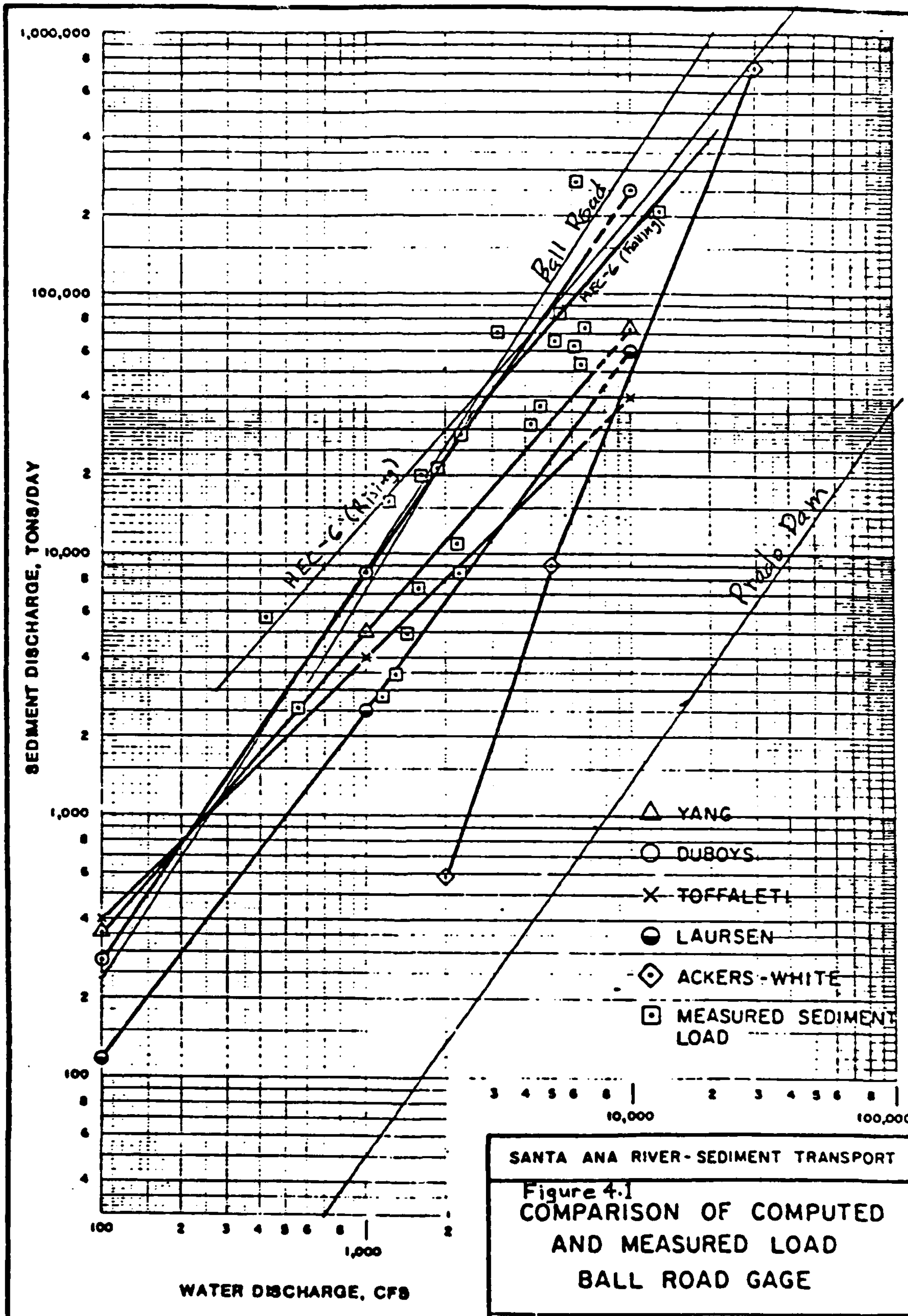
The USGS measurements were corrected to exclude wash load and to include an estimate for the unmeasured load. Figure 4.1 shows a comparison of the measured sediment load at Ball Road to load curves predicted by various analytical methods. The inflowing load computed by HEC-6 agrees quite well with measured data. Since there are no sediment or discharge gaging stations at the river mouth, SLA agrees with the COE procedure to use the Ball Road gage to estimate sand outflow to the coast.

4.6 Sediment Yield from Canyon Reach

Several techniques were used to estimate the average annual sediment yield from the canyon reach which is just upstream from the project inlet. The Pacific Southwest Interagency Committee (PSIAC) method gave a sediment yield of 1.64 acre-feet/square-mile/year. The contributing drainage area is 42 to 50 square miles. The average annual sediment inflow to the project reach is 108,000 to 132,000 cubic yards/year. The sediment yield estimate based on deposition data from a nearby reservoir indicate a sediment yield rate of 1.45 acre-feet/ square-mile/year. The PSIAC method gives the total sediment yield. The sand yield ranged from 43,200 to 52,800 cubic yards per year. SLA finds that the results of the PSIAC method are resonable based on comparison with the reservoir data.

4.7 Sediment Transport Analysis Using HEC-6

The input data set for HEC-6 was adjusted to reproduce the flood of 1978. The method used was to change the n values until computed bed changes matched



SANTA ANA RIVER-SEDIMENT TRANSPORT

Figure 4.1
COMPARISON OF COMPUTED AND MEASURED LOAD
BALL ROAD GAGE

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED:

the observed changes. A separate HEC-6 data set was used to reproduce the flood event which occurred in 1980. Although there were slight changes in the channel geometry, the river characteristics were similar during the 1978 and 1980 flood events. The second computer simulation revealed that HEC-6 underestimated the severe degradation that occurred downstream from the Santiago Creek confluence during the 1980 flood. It did, however, reproduce the depth and location of the initial degradation (downstream from Fairview St. Bridge). SLA agrees with the Phase II GDM requirement for complete lining of this reach because both observed and computed data indicate that bed degradation would occur if it was unlined. The successful reproduction of the two aforementioned flood events indicate that HEC-6 is an appropriate simulation tool for this flood event.

The Yang equation for total sediment load was used throughout the study. This procedure assumes that the amount of sediment transported is proportional to the unit stream power (the product of the average velocity and the energy slope). This equation was developed by using numerous laboratory and field data pertaining to sand size and the unit stream power is a key parameter in determing the transport capacity. As long as the physical conditions occur near the range of data from which the equation was developed, the results will be reasonable. Plate 9 (Comparison of Computed and Measured Load, Ball Road Gage) of the Phase II GDM indicates that of all the relationships available in HEC-6, the Yang equation fits the observed data the best. SLA concurrs with this choice.

A table should be included that lists the n values used for each reach for each of the various runs. The source of the value should also be listed (either from calibration or from estimation). Any other calibration parameters used in the study should also be displayed in a table. SLA concurs with the values of Manning's n used for the HEC-6 analysis in this study.

Figure 4.2 shows a plot of total sediment volume vs. exceedance probability. The curve was developed by computing the sediment inflow to the project reach for each flood hydrograph using the transport relationships from the HEC-6 analysis of the canyon reach. Using the incremental probability method indicates that the average annual sediment inflow for the project reach is 68,900 cubic yards per year. This is slightly more than the estimated sand yield from the canyon reach of 43,200 to 52,800 cubic yards per year. The deposition (31,000 yd^3/year) plus sand outflow (36,000 yd^3/year) for the project condition was very close to the HEC-6 inflow volume of 68,900 cubic yards. An HEC-6 analysis for existing conditions may give more insight into the impacts of the project on sand delivery to the beach. Comparing the computed results for project

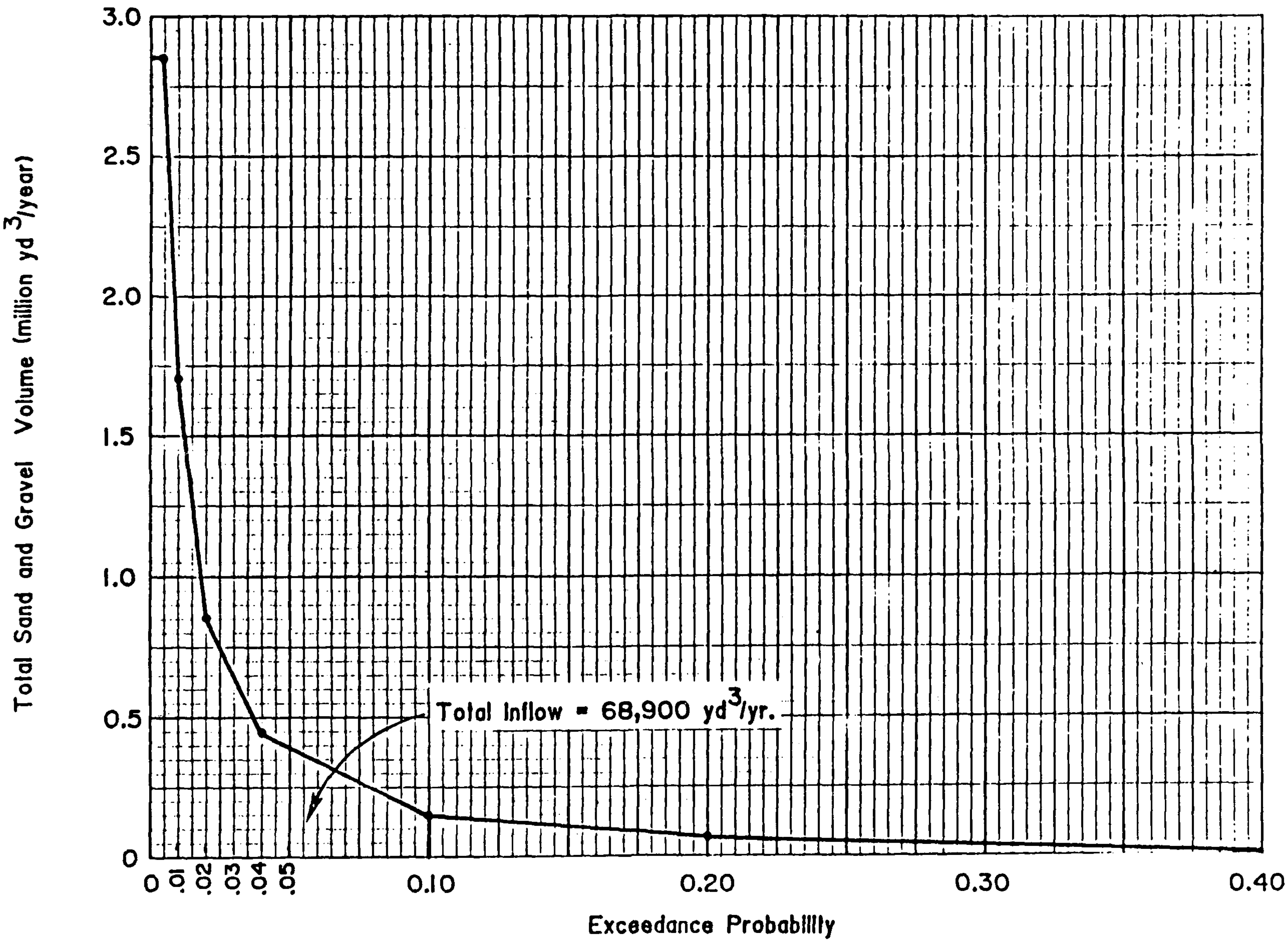


Figure 4.2 Sediment Inflow at Weir Canyon Road Computed Using HEC-6.

conditions to the observed measurements for existing conditions may not give an accurate picture of the potential project impacts. For example, the Draft Phase I GDM for the Santa Ana River states that slightly more sand will reach the ocean under project conditions (page 58). The source of this conclusion is not known but SLA recommends that additional analysis for the sand outflow estimates would be worthwhile.

4.8 Sensitivity Analysis

A sensitivity analysis was performed to test the reliability of the HEC-6 numerical simulations. It is possible that n values could be 0.03 or higher if vegetation is allowed to grow in the channel. This case was tested and found to have only a minor effect on sediment transport behavior. Other factors tested were bed-material gradation, the formation of a sand plug at the river mouth, the effect of a significant antecedent flow before a flood event and the effect of changing the tidal boundary condition. The only factor that had a large effect on sedimentation behavior was the presence of a significant antecedent flow which resulted in a change initial bed condition. This is an important facet of the study because the presence of a dam upstream usually results in a decrease of peak flood discharges and a substantial increase in the duration of a flood. The hydraulic design was performed using the maximum amount of deposition expected during an event. This accounts for the additional freeboard necessary when there are sand deposits on the bed. SLA finds the sensitivity analysis to have been performed appropriately.

4.9 Channel Maintenance

The allowable sediment deposition gradeline is shown in Plate 14 (Upper Sediment Level). The COE estimates that the channel will reach this level about every 20 years. SLA fines this reasonable based upon the estimated average annual sediment deposition of 31,000 cubic yards per year.

V. INDEPENDENT SLA ANALYSIS

In order to check the results obtained by the Corps of Engineers, Simons, Li & Associates performed some additional analysis. A brief description follows:

5.1 Sediment Routing

The Meyer-Peter, Muller bedload equation along with a modified Einstein integration procedure was used to estimate the total sand transport capacity of the river. The river was divided into 20 reaches of similar hydraulic characteristics. Depths and velocities for the design discharge were provided by the Corps of Engineers. Table 5.1 shows the computed sediment transport results. The change in sediment transport capacity divided by the reach length and bottom width yields the rate of deposition or scour. The upper reach has a transport capacity of approximately 1 million tons per day at the design discharge. At station 745+40, near Katella Avenue, the design velocity decreases due to a change in slope. This causes the transport capacity to drop to about 650,000 tons/day. The computations indicate that deposition will occur at the design discharge for this reach (reach No. 11). Reach number 10, downstream from the Katella Avenue reach, indicates that scour will occur at the design discharge. This is because the transport capacity is greater than the amount of sediment supplied by the reach just upstream. Although the design slope of this scour reach is the same as the deposition reach just upstream, the channel width decreases so the design velocity increases. Figure 5.1 shows a plan and profile view of the river section discussed here. The channel is likely to develop a new equilibrium slope in reach number 11 after 1 to 2 feet of deposition occur. This will slow down the general scour in reach number 10. The transport capacity in the fully lined reaches (numbers 5 and 6) seems sufficiently high to prevent deposition. Reaches 1 through 4 indicate deposition. In general, SLA finds this analysis to agree with the HEC-6 results for the project condition. SLA suggests that the potential deposition in Reach 11 and the potential scour in reach 10 should be further evaluated.

TABLE 5.1 SEDIMENT ROUTING SUMMARY

REACH NMBR.	STATION NUMBERS	DESCRIPTION	Q (CFS)	CHANNEL SLOPE	AVERAGE DEPTH (FT)	AVERAGE VELOCITY (FT/SEC)	AVERAGE WIDTH (FT)	TRANSPORT CAPACITY (TON/DAY)	BED CHANGE (FT/DAY)
1	0+30 TO 146+32	PACIFIC O	46500	0.00120	11.9	8.6	400	666136	EQUIL
2	146+32 TO 191+85	ADAMS AVE	46000	0.00064	13.5	9.3	365	642920	+1.2
3	191+85 TO 248+00		46000	0.00064	10.1	10.6	246	889936	+2.8
4	248+00 TO 273+00	S.D. FWY	46000	0.00182	11.4	11.4	246	1128324	+6.3
5	273+00 TO 398+00	EDINGER AV	46000	0.00280	14.0	16.3	200	4342350	CLEAN
6	398+00 TO 525+30	17TH ST	46000	0.00275	14.6	15.1	210	3447692	CLEAN
7	525+30 TO 600+75	GDN GRV BL	42000	0.00199	12.9	11.4	300	1447640	-2.0
8	600+75 TO 644+36	S ANA FWY	42000	0.00172	13.3	10.7	300	1107607	-0.5
9	644+36 TO 689+35	ORNGWD AVE	41000	0.00168	13.1	10.6	300	1057380	-1.4
10	689+35 TO 716+80	ORANGE FWY	40000	0.00194	13.3	10.2	296	912874	-4.2
11	716+80 TO 745+40	KATELLA AVE	40000	0.00194	12.7	9.1	344	655278	+6.4
12	745+40 TO 810+90	BALL ROAD	40000	0.00210	11.0	10.6	340	1168328	EQUIL
13	810+90 TO 843+90	LINCOLN AV	40000	0.00209	11.4	10.2	340	1008455	EQUIL
14	843+90 TO 891+40	GLASSELL	38000	0.00221	10.7	10.4	340	1077819	EQUIL
15	891+40 TO 914+85	AT&SF RR	38000	0.00223	10.6	10.5	340	1118608	EQUIL
16	914+85 TO 977+90	RVRSIDE FWY	38000	0.00220	10.6	10.6	340	1160898	EQUIL
17	977+90 TO 1031+70	LKVIEW AVE	38000	0.00217	10.6	10.5	340	1115251	EQUIL
18	1031+70 TO 1106+30	IMPRL HWY	38000	0.00197	11.6	10.5	310	1033108	EQUIL
19	1106+30 TO 1156+30		38000	0.00171	11.9	10.2	310	988588	+2.4
20	1156+30 TO 1203+50	WEIR CYN	38000	0.00213	11.2	10.9	310	1201188	EQUIL

NOTES:

BED CHANGE BASED ON BED WIDTH AND REACH LENGTH

"EQUIL" INDICATES THAT SEDIMENT INFLOW AND OUTFLOW IS APPROXIMATELY BALANCED.

"CLEAN" INDICATES A FULLY LINED REACH IN WHICH NO DEPOSITION OCCURS.

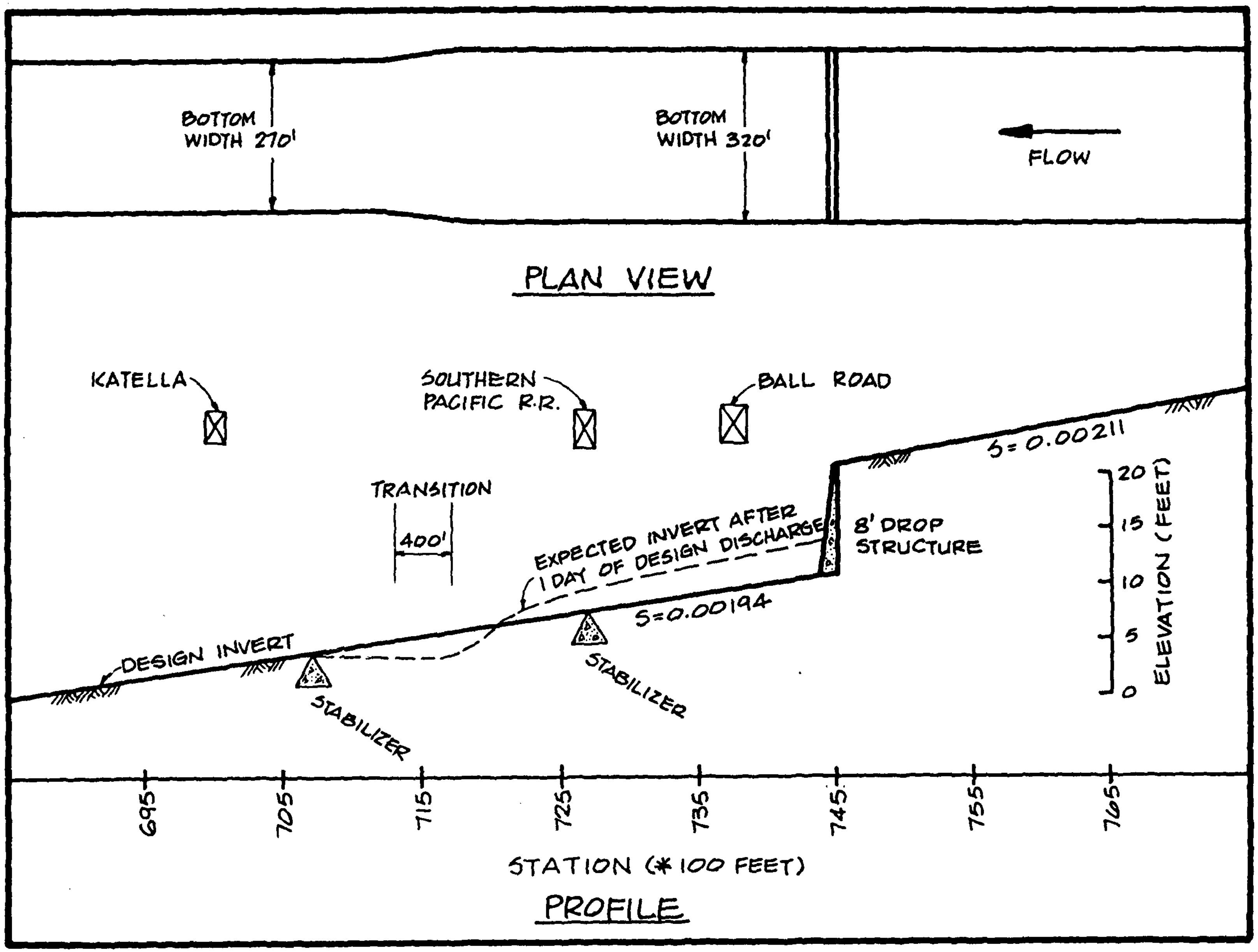


FIGURE 5.1 PLAN AND PROFILE FOR REACH 10-12

5.2 Toe Depth of Channel Lining

The following design criteria were employed to obtain the toe depth of the channel bank lining.

Situation	Toe Depth (ft)
Near Drop Structures	15
Near Stabilizers	10
Near Bridges	5 to 8
Drop Structurs Reach	5 to 8
Coastal Reach (STA 0+00 to 150+30)	8 (rip rap), 20 (cut off wall)
Golf Course Reach (STA 535+00 to 565+00)	5

In general, a conservative estimate of toe depth is the sum of degradation, general scour, local scour and a safety factor of about one foot. Degradation and general scour can be estimated by an equilibrium slope analysis or by incipient motion criteria. The latter gives the more conservative value. For the channelized section, the local embankment scour due to the angle of attack is minimized, thus the local scour can be estimated as one-half of the antidune height which is 88% of the velocity head (Sediment Transport Technology, by D.B. Simons and F. Senturk, 1977, p. 230).

The degradation and general scour were computed in Table 5 (Stable Slope) of the Phase II GDM. These computed slopes are essentially flat. If a flat slope was extended upstream from each drop or stabilizer, the maximum amount of degradation in any reach is shown in Table 5.2. The general scour is insignificant because there are no abrupt channel width restrictions. Using an average velocity of 12 feet/sec, the local scour is about 2.2 feet. The total expected scour is shown in column 7 to Table 5.2. The design toe depth at the point of maximum degradation is shown in column 8. The difference between estimated and design toe depths is shown in column 9. Negative values indicate the toe depth is underdesigned at that location. Although the levee toe depths are, in general, adequate, some minor changes should be made. The only area of concern is the drop structure at Station 600+75 (near Garden Grove Freeway). The calculations indicate 7.9 feet of degradation which is well below the toe depth of 5 feet. SLA recommends an additional stabilizer at approximately Station 584+00 (see Figure 5.2) along with an increase of maximum levee toe depth to 7 feet in this reach. The sediment routing in Table 5.1 indicates that this is a reach of scour so the suggested design modification is appropriate. The stabilizer at Station 558+00 appears to be underdesigned but in reality since the channel uses the Riverview Golf as an overbank in this reach the design velocity is lower and thus the scour potential is small.

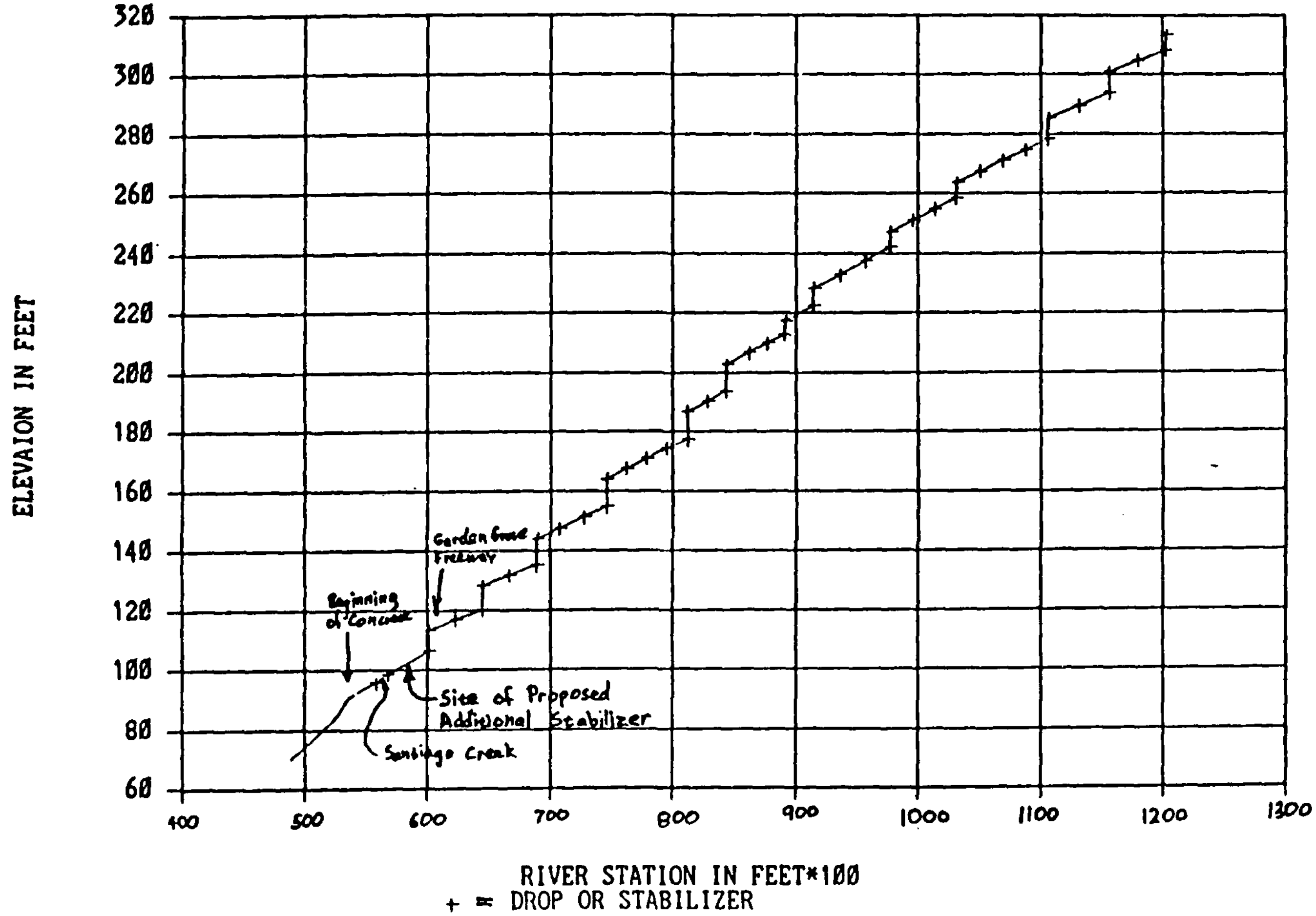
TABLE 5.2 LEVEE TOE DEPTH EVALUATION

(1) STATION (FT=100)	(2) DESCRIPTION	(3) ELEVATION (FT)	(4) MAXIMUM GENERAL SCOUR(FT)	(5) MAXIMUM LOCAL SCOUR(FT)	(6) SAFETY FACTOR (FT)	(7) TOTAL SCOUR (FT)	(8) DESIGN TOE DEPTH	(9) DESIGN MINUS ESTIMATE
1203.00	DROP STRUCTURE	313.50	N/A	N/A	N/A	N/A	N/A	
1202.50	(AT WEIR CANYON RD)	308.50	3.50	2.2	1	6.70	10.0	3.30
1179.50	STABILIZER	305.00	4.00	2.2	1	7.20	11.0	3.80
1156.30	DROP STRUCTURE	301.00	N/A	N/A	N/A	N/A	N/A	0.00
1155.90	(NO LANDMARK)	294.00	4.30	2.2	1	7.50	10.0	2.50
1151.30	STABILIZER	289.70	4.20	2.2	1	7.40	7.0	-0.40
1106.30	DROP STRUCTURE	285.50	N/A	N/A	N/A	N/A	N/A	0.00
1105.90	(NO LANDMARK)	278.50	3.60	2.2	1	6.80	7.0	0.20
1087.65	STABILIZER	274.90	3.64	2.2	1	6.84	6.5	-0.34
1060.00	STABILIZER	271.26	3.76	2.2	1	6.96	6.5	-0.46
1050.35	STABILIZER	267.50	3.63	2.2	1	6.83	7.0	0.17
1031.70	DROP STRUCTURE	263.07	N/A	N/A	N/A	N/A	N/A	0.00
1031.01	(AT IMPERIAL HWY)	258.07	3.87	2.2	1	7.07	6.5	-0.57
1013.50	STABILIZER	255.00	3.80	2.2	1	7.00	6.5	-0.50
995.70	STABILIZER	251.20	3.91	2.2	1	7.11	7.0	-0.11
977.90	DROP STRUCTURE	247.29	N/A	N/A	N/A	N/A	N/A	0.00
977.21	(AT LAKEVIEW RD)	242.29	4.69	2.2	1	7.89	7.0	-0.89
956.90	STABILIZER	237.60	4.60	2.2	1	7.80	7.0	-0.80
935.05	STABILIZER	233.00	4.57	2.2	1	7.77	8.0	0.23
914.05	DROP STRUCTURE	228.43	N/A	N/A	N/A	N/A	N/A	0.00
914.16	(AT TUSTIN AVE)	222.43	5.05	2.2	1	8.25	8.0	-0.25
891.90	DROP STRUCTURE	217.40	N/A	N/A	N/A	N/A	N/A	0.00
890.00	(AT AT&SF RAILROAD)	213.00	2.90	2.2	1	6.10	6.5	0.40
876.77	STABILIZER	210.10	3.10	2.2	1	6.30	6.5	0.20
862.15	STABILIZER	207.00	4.10	2.2	1	7.30	7.5	0.20
844.00	DROP STRUCTURE	202.90	N/A	N/A	N/A	N/A	N/A	0.00
843.20	(AT GLASSELL)	194.00	3.50	2.2	1	6.70	7.0	0.30
828.50	STABILIZER	190.50	3.50	2.2	1	6.70	7.0	0.30
811.40	DROP STRUCTURE	187.00	N/A	N/A	N/A	N/A	N/A	0.00
812.00	(AT LINCOLN AVE)	177.50	2.90	2.2	1	6.10	7.0	0.90
794.90	STABILIZER	174.60	3.50	2.2	1	6.70	6.5	-0.20
778.40	STABILIZER	171.10	3.50	2.2	1	6.70	6.5	-0.20
761.90	STABILIZER	167.60	3.50	2.2	1	6.70	7.0	0.30
746.00	DROP STRUCTURE	164.10	N/A	N/A	N/A	N/A	N/A	0.00
745.40	(NEAR BALL ROAD)	155.00	3.50	2.2	1	6.70	7.0	0.30
727.00	STABILIZER	151.50	3.90	2.2	1	7.10	7.0	-0.10
707.00	STABILIZER	147.60	3.30	2.2	1	6.50	6.5	0.00
689.05	DROP STRUCTURE	144.30	N/A	N/A	N/A	N/A	N/A	0.00
689.00	(NEAR ORANGE FWY)	135.30	3.30	2.2	1	6.50	6.5	0.00
667.00	STABILIZER	132.00	3.70	2.2	1	6.90	7.0	0.10
644.95	DROP STRUCTURE	128.50	N/A	N/A	N/A	N/A	N/A	0.00
644.36	(AT CHAPMAN)	120.30	3.20	2.2	1	6.40	7.0	0.60
622.50	STABILIZER	117.10	3.70	2.2	1	6.90	7.0	0.10
601.25	DROP STRUCTURE	113.40	N/A	N/A	N/A	N/A	N/A	0.00
600.75	(AT GARDEN GRV FWY)	105.40	7.90	2.2	1	11.10	5.0	-6.10
567.50	STABILIZER	90.50	2.50	2.2	1	5.70	10.0	4.30
550.00	STABILIZER	86.00	5.00	2.2	1	8.20	5.0	-3.20
535.00	BEGIN CONCRETE CHNL	81.00	N/A	N/A	N/A	N/A	N/A	0.00
525.30	END TRANSITION	84.00	N/A	N/A	N/A	N/A	N/A	0.00
409.00	GRADE CHANGE	78.00	N/A	N/A	N/A	N/A	N/A	0.00

NOTES:

1) DESIGN TOE DEPTH IS AT POINT OF MAXIMUM GENERAL SCOUR
2) LOCAL SCOUR IS 80% OF THE VELOCITY HEAD
3) COLUMN (9): NEGATIVE VALUE INDICATES UNDERDESIGN
4) N/A INDICATES THE UPSTREAM STATION OF A DROP STRUCTURE
5) GENERAL SCOUR IS COMPUTED USING A HORIZTAL (S=0.0) SLOPE

FIGURE 5.2 SANTA ANA RIVER PROFILE



5.3 Limiting Deposit Velocity

To insure that the concrete lined channel reach remains clean, flow velocities should be higher than the limiting deposit velocity V_L. The ASCE Sedimentation Engineering Handbook (Reference 4) page 262 indicates that the deposition Froude number F_d should be at least 1.3

$$F_d = V_L/\sqrt{gD} \tag{5.1}$$

Where V_L is the average channel velocity that prevents sand deposition and D is the hydraulic depth. In the completely lined reach, the typical velocity is about 22 ft/sec and the typical hydraulic depth is 9 feet. The value of F_d for these quantities is 1.29 so the channel should remain clean. SLA finds the design limiting deposit velocity to be reasonable.

5.4 Summary

The configuration of drop structures and bed stabilizers will insure a stable channel for the upper reaches. The concrete channel is of adequate length and slope to prevent scour and excessive deposition. SLA finds the COE sedimentation study to be thorough and complete, resulting in an effective design for the Lower Santa Ana River.

ADDENDUM REPORT TO THE SEDIMENT TRANSPORT ANALYSIS
LOWER SANTA ANA RIVER

CONTENTS

TABLE

PLATES

1. General: A detailed sediment transport analysis was conducted in support of the Phase II General Design Memorandum (GDM) using the channel configuration shown in the Phase I GDM. Subsequent to that report (referred to in text as the main report) and the independent review, the channel configuration in the concrete and channel ocean reach was changed from a rectangular channel to a trapezoidal channel. As a result, a sediment transport analysis using HEC-6 was deemed necessary to predict channel bed profiles for the design flood and to determine the average annual channel deposition and sand outflow. This report describes the sediment transport analysis and the results for the trapezoidal channel design. This report is appended as part of the sediment transport main report found herein, since it covers only the changes to the Phase II design.

2. Revised Channel Features: The redesign of the channel extends from the Pacific Ocean upstream to and including the channel through the Riverview Golf Course. The differences in channel design from the Phase I GDM configuration consist of: changing to a trapezoidal channel from the river mouth upstream to Station 150+00 and in the reach from Station 273+00 upstream to Station 600+73, with base widths varying from 160 feet to 410 feet and side slopes of 1 vertical on 2 horizontal; lowering the channel invert in the reach from Station 460+00 upstream to just upstream of the confluence with Santiago Creek; adding a drop structure and invert stabilizer in the golf course reach; and lowering the crest of the drop stucture located at Station 689+85. A detailed discussion of the project features is presented in the hydraulic design report.

3. Study Approach: The impact to the results shown in the main report are the HEC-6 results which established the design deposition slope, design of the levee toe depths, and the determination of the average annual deposition and sand outflow. Sediment transport in the improved channel reach, including the revised trapezoidal channel, was simulated for the design flood and for the 10-, 25-, 50-, and 100-year floods. Two different inflowing sediment load curves were used for the design flow simulation to bracket the bed changes, that is, deposition in the case of high sediment inflow and scour in the case of reduced sediment inflow. The analysis with HEC-6 was streamlined to use only those program parameters that were sensitive to the changes in bed elevation during the design event. The results from the HEC-6 sensitivity analysis indicate the that bed changes were sensitive to the initial channel geometric condition and the antecendent flow hydrograph. To provide a worse case scenerio for the initial geometric condition the channel invert data in HEC-6 for the design flood simulation was adjusted to the upper grade limit established in the main report (see pl. 14 main report). For the design flood scour analysis and the more frequent flood analyses, the channel invert data was set at the design invert (see pl. 3A). In the design flood analysis conducted in the main report, the design hydrograph was combined with an antecedent flow hydrograph of 5,000 cfs for 38 days. The purpose was to represent a worse case flood scenerio. This combined hydrograph, however, was overly conservative and would not be representative of the project release schedule for Prado Dam. To account for the possibility of a flood preceding the design flood, the 1969 flood, which was a major flood event, was selected. The 1969 flood was routed through Prado Dam to provide the project condition antecendent flood hydrograph. The 1969 flood was then followed by the design flood to represent a worse case flood scenerio.

Other program parameters discussed are the Manning's "n" value, the tidal hydrograph, and the bed material gradation. The Manning's coefficient "n" was set in accordance with those values used in the original analysis, n = 0.02 in the channel ocean reach, n = 0.015 in the concrete channel reach, n = 0.025 for the drop structure reach, and checked for sensitivity by assigning a high "n" value of 0.03 in all reaches. The HEC-6 analysis using a tidal hydrograph or an increase in bed material gradation was not conducted because both were found to be insensitive to the channel bed deposition at the peak of the design flood. This study considered only the detailed sediment routing analysis using HEC-6 for which the results are presented in subsequent paragraphs.

4. Results of the HEC-6 Analysis

4.1 Design Flood: The HEC-6 analysis was conducted by initially setting the streambed at the upper grade limit, and computing bed changes using the combined hydrograph of the 1969 flood followed by the design flood. The results of the HEC-6 computations of the streambed profile for the combination antecedent flow and design flood are reasonable in the trend prediction. The bed change results were depicted at the peak of the design flood hydrograph. The maximum water surface elevation in the channel, including the bed change, also occurred at the peak of the design flood hydrograph. The results are similar to the results found with the Phase I channel configuration. However, the location and quantity of the depositional bed change for the case of high sediment inflow in both the channel ocean reach and the downstream portion of the concrete reach were slightly different. To represent the general magnitude of deposition, a deposition design profile was developed that encompassed the bed changes. The deposition design profile starts at Station 272+60 at elevation 23.0 feet NGVD, extends downstream at a slope of 0.001072 to Station 56+35. At Station 56+35, the deposition profile breaks slope to 0.00035 and continues downstream to Station 36+35. At Station 36+35, the deposition profile again breaks slope to 0.001478 and continues downstream to the ocean outlet at river mouth Station 8+55 at elevation -5.0 feet NGVD. This deposition design profile was also analyzed for sensitivity by applying a higher "n" value of 0.03 in all reaches in the HEC-6 model. The results indicated that the depositional bed change was below the depositional design profile at the peak of the design flood. No significant bed change occurred in the concrete reach upstream of Station 272+60 to the concrete inlet and in the revised channel in the golf course reach. The results obtained in the drop structure reach, including the lowered drop structure at Station 689+85, were the same as shown in the main report (see pl. 11). Plates 2A and 3A display the design streambed profiles with and without sedimentation, respectively, over the entire reach from the Pacific Ocean to the improved channel inlet upstream of Weir Canyon Road bridge. Using the combination of the deposition design profile in the reaches of aggradation with the design invert slopes in the other reaches, the design water surface profile was computed and the levee heights were determined as described in the hydraulic design report.

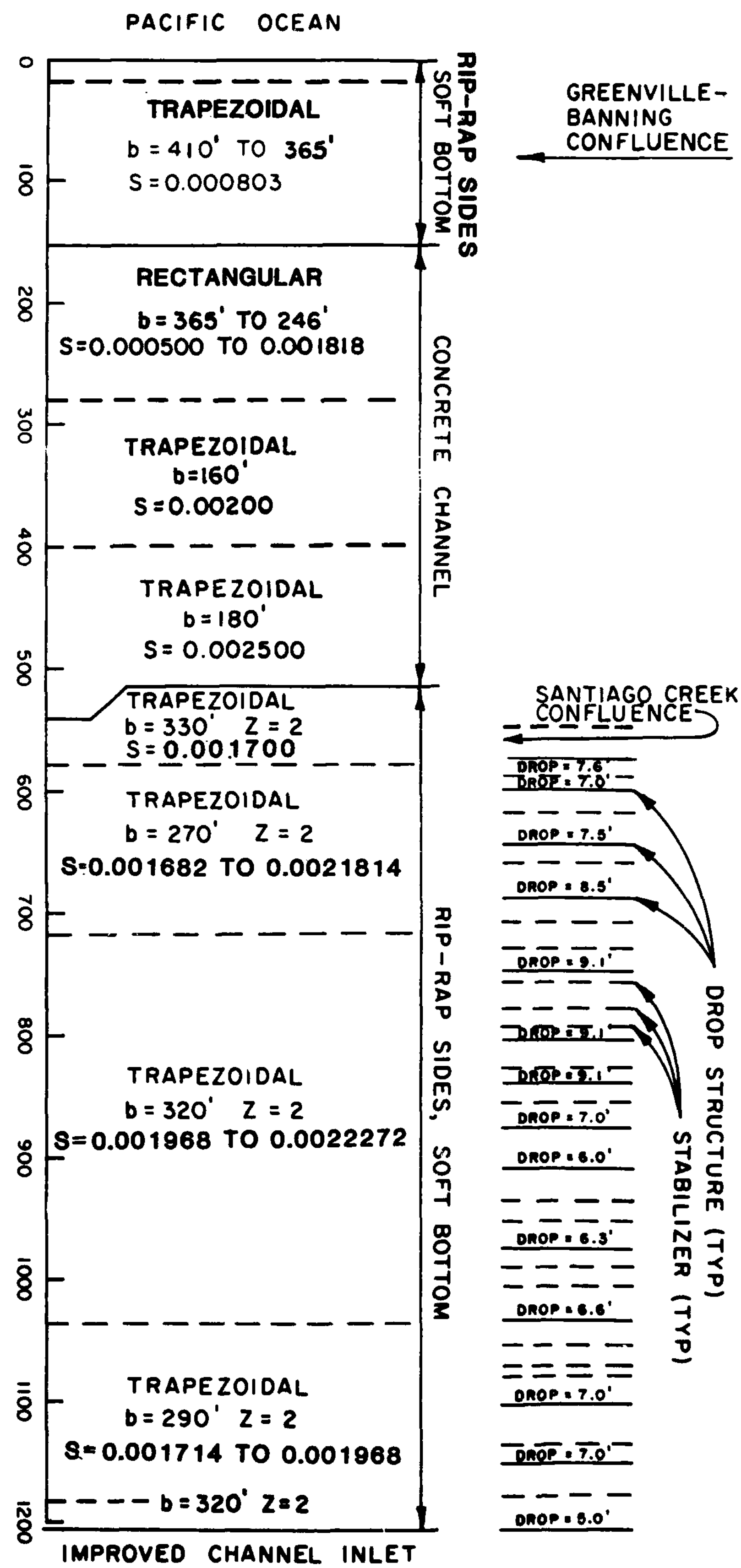
The HEC-6 analysis for the other design case of levee toe depth was performed for just the trapezoidal channel downstream of the concrete channel inlet. The HEC-6 analysis was conducted by setting the inflowing sediment load to zero at the concrete channel inlet. The HEC-6 results for general degradation in the channel ocean reach were slightly greater that the results of the Phase I configuration. The maximum general degradation was about 9 feet below the design invert in the portion of the channel ocean reach just downstream of the concrete channel. Based on these results, the levee toe depths were increased from 6 feet to a minumum of 10 feet below the design invert for the entire length of the earth bottom channel ocean reach. The levee toe analysis and results for the drop structure reach can be found in the main report.

4.2 Average Annual Deposition and Sand Outflow: The average annual deposition and sand outflow was analyzed for the trapezoidal channel using the incremental probability method. The method was applied in the HEC-6 analysis for the design flood, 100-, 50- , 25-, and 10-year floods to determine the volume of deposition and sand outflow for each flood. Table 1A summarizes the deposition and sand outflow quantities.

Table 1A. Sediment Yield for Various Flood Downstream Trapezoidal Channel.

Flood (year)	Sediment Deposition (x1000 yd^3)	Sand Outflow (x1000 yd^3)
170	1,590	2,222
100	762	441
50	447	244
25	234	141
10	79	14
Annual	37	30

The results indicate an increase in the average annual deposition from 31,000 cubic yards for the Phase I channel configuration to 37,000 cubic yards for the trapezoidal channel. The results also show a decrease in the average sand outflow from 36,000 to 30,000 cubic yards. Using the upper grade limit with a corresponding volume of 660,000 cubic yards, sediment will have to be removed from the downstream channel reach on an average of once every 18 years. It should be noted that because the annual volume of water/sediment can vary significantly, the average annual deposition rate and maintenance are considered long term averages. No sediment removal maintenance is anticipated in the concrete reach upstream of Station 223+35 and in the drop structure reach, including the golf course.



NOTE:

SCHEMATIC SHOWN CORRESPONDS TO THE REVISED DESIGN OF THE LSAR, UPON WHICH ADDENDUM SEDIMENTATION ANALYSIS WAS BASED. REFER TO PLATES IN HYDRAULIC DESIGN APPENDIX FOR FINAL DESIGN.

b = BOTTOM WIDTH

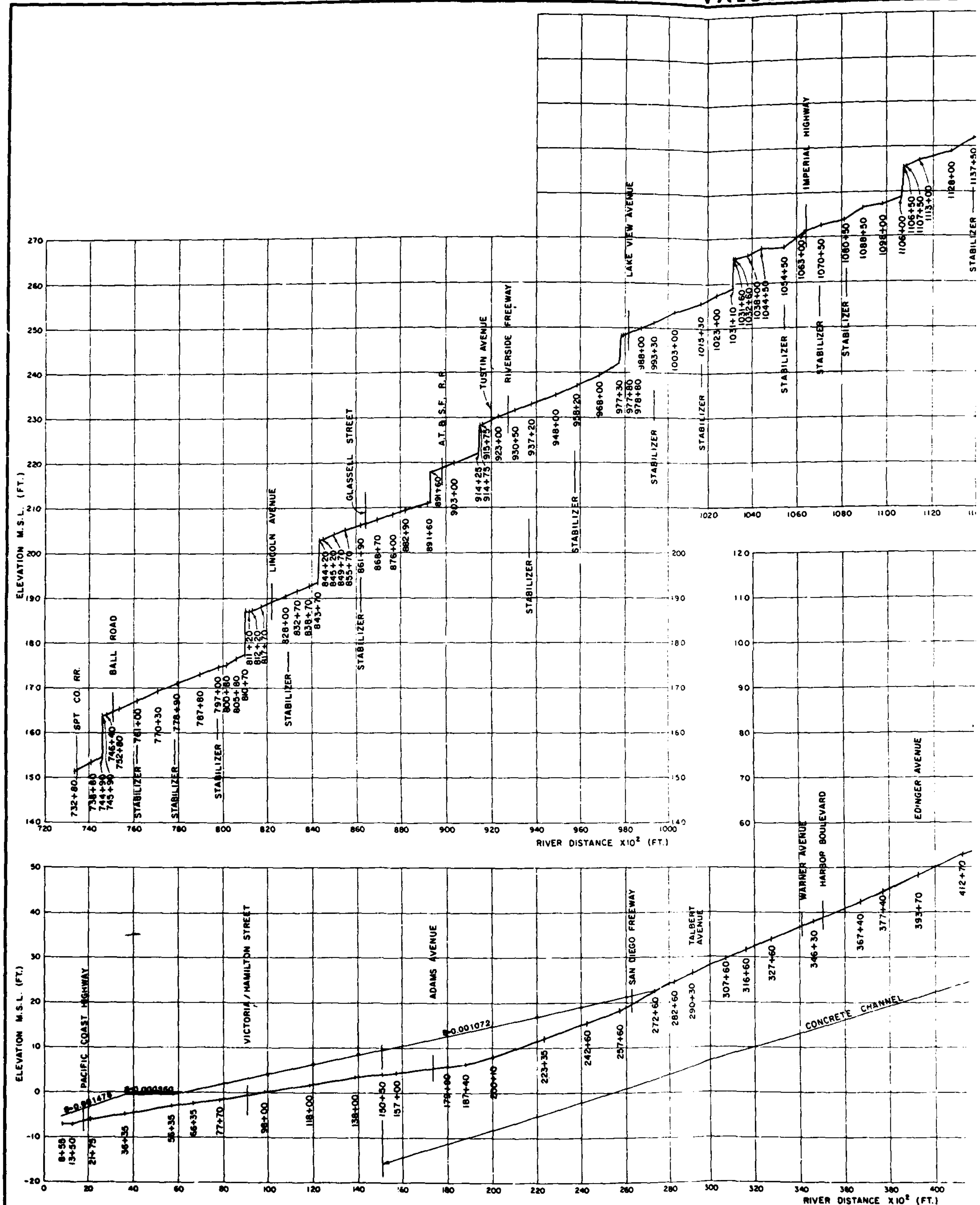
Z = SIDE SLOPE

S = CHANNEL GRADE

LOWER SANTA ANA RIVER
ORANGE COUNTY, CALIFORNIA

CHANNEL SCHEMATIC
(DOWNSTREAM TRAPEZOIDAL CHANNEL)

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS


ELEVATION M.S.L. (FT.)
RIVER DISTANCE X10² (FT.)
SPT CO. RR.
BALL ROAD
LINCOLN AVENUE
GLASSELL STREET
A.T. & S.F. R.R.
TUSTIN AVENUE
RIVERSIDE FREEWAY
LAKE VIEW AVENUE
IMPERIAL HIGHWAY
STABILIZER
EDINGER AVENUE
WARNER AVENUE
HARBOR BOULEVARD
TALBERT AVENUE
SAN DIEGO FREEWAY
ADAMS AVENUE
VICTORIA / HAMILTON STREET
PACIFIC COAST HIGHWAY
CONCRETE CHANNEL
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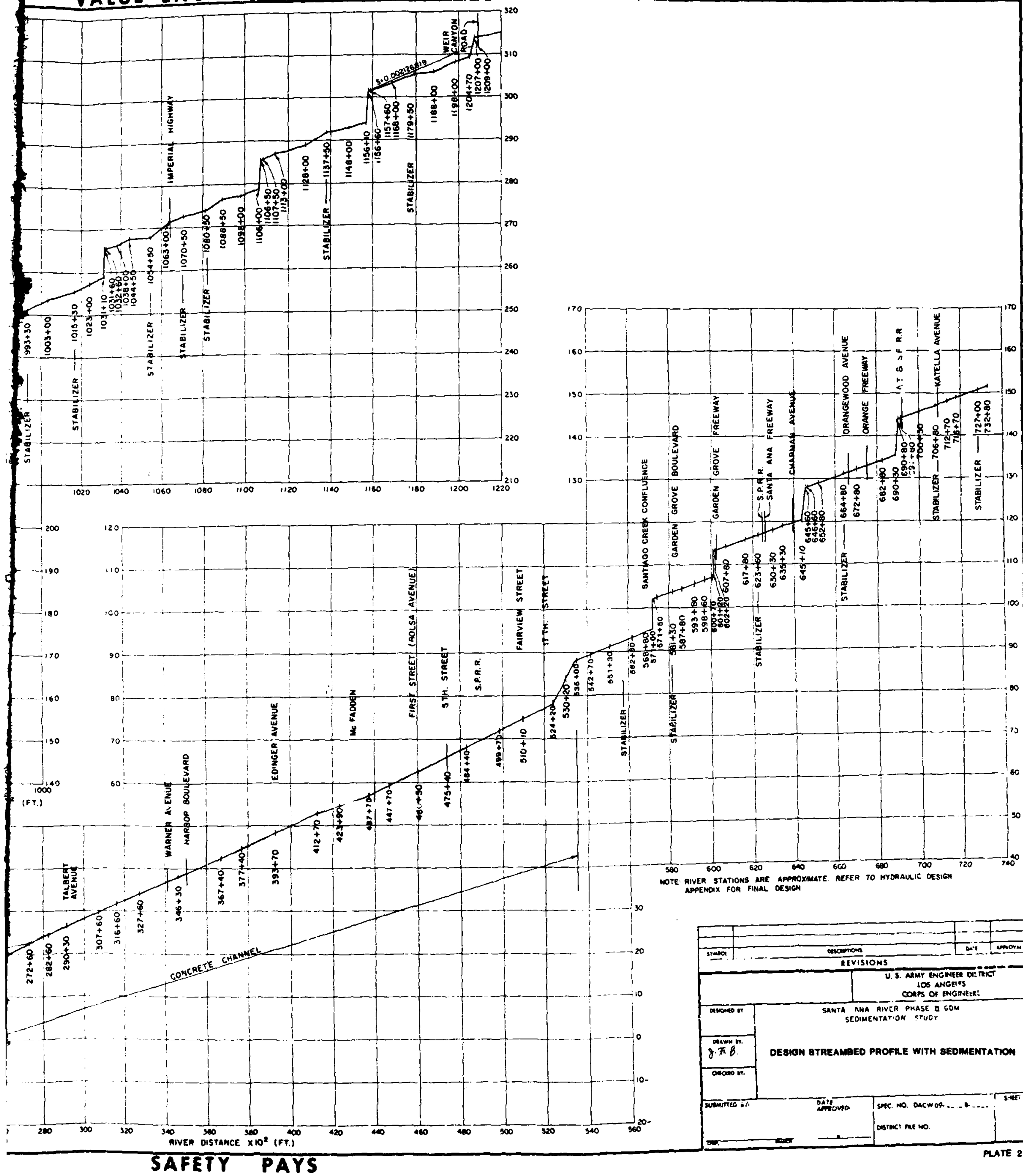
S=0.000350

VALUE ENGINEERING PAYS



NOTE: RIVER STATIONS ARE APPROXIMATE. REFER TO HYDRAULIC DESIGN APPENDIX FOR FINAL DESIGN

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY

DRAWN BY: J. F. B.

CHECKED BY:

SANTA ANA RIVER PHASE II GDM
SEDIMENTATION STUDY

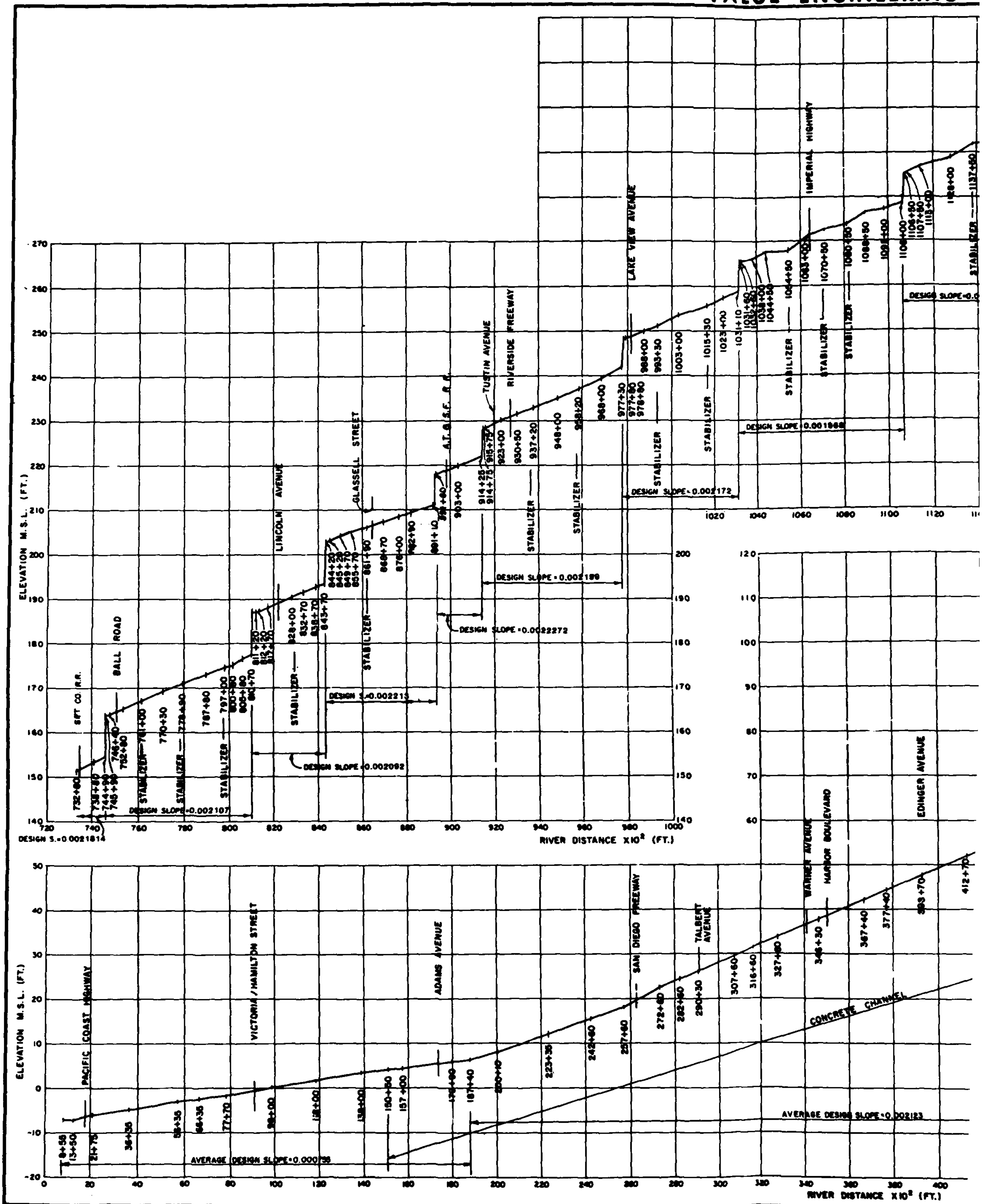
DESIGN STREAMBED PROFILE WITH SEDIMENTATION

SUBMITTED BY: DATE APPROVED: SPEC. NO. DACW09-__ B-____ SHEET

DISTRICT FILE NO.

PLATE 2A-C

SAFETY PAYS


ELEVATION M.S.L. (FT.)
RIVER DISTANCE X10² (FT.)
SPT CO R.R.
BALL ROAD
LINCOLN AVENUE
GLASSELL STREET
A.T. & S.F. R.R.
TUSTIN AVENUE
RIVERSIDE FREEWAY
LAKE VIEW AVENUE
IMPERIAL HIGHWAY
STABILIZER
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DESIGN SLOPE=0.002107
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PACIFIC COAST HIGHWAY
VICTORIA / HAMILTON STREET
ADAMS AVENUE
SAN DIEGO FREEWAY
TALBERT AVENUE
WARNER AVENUE
HARBOR BOULEVARD
EDINGER AVENUE
CONCRETE CHANNEL
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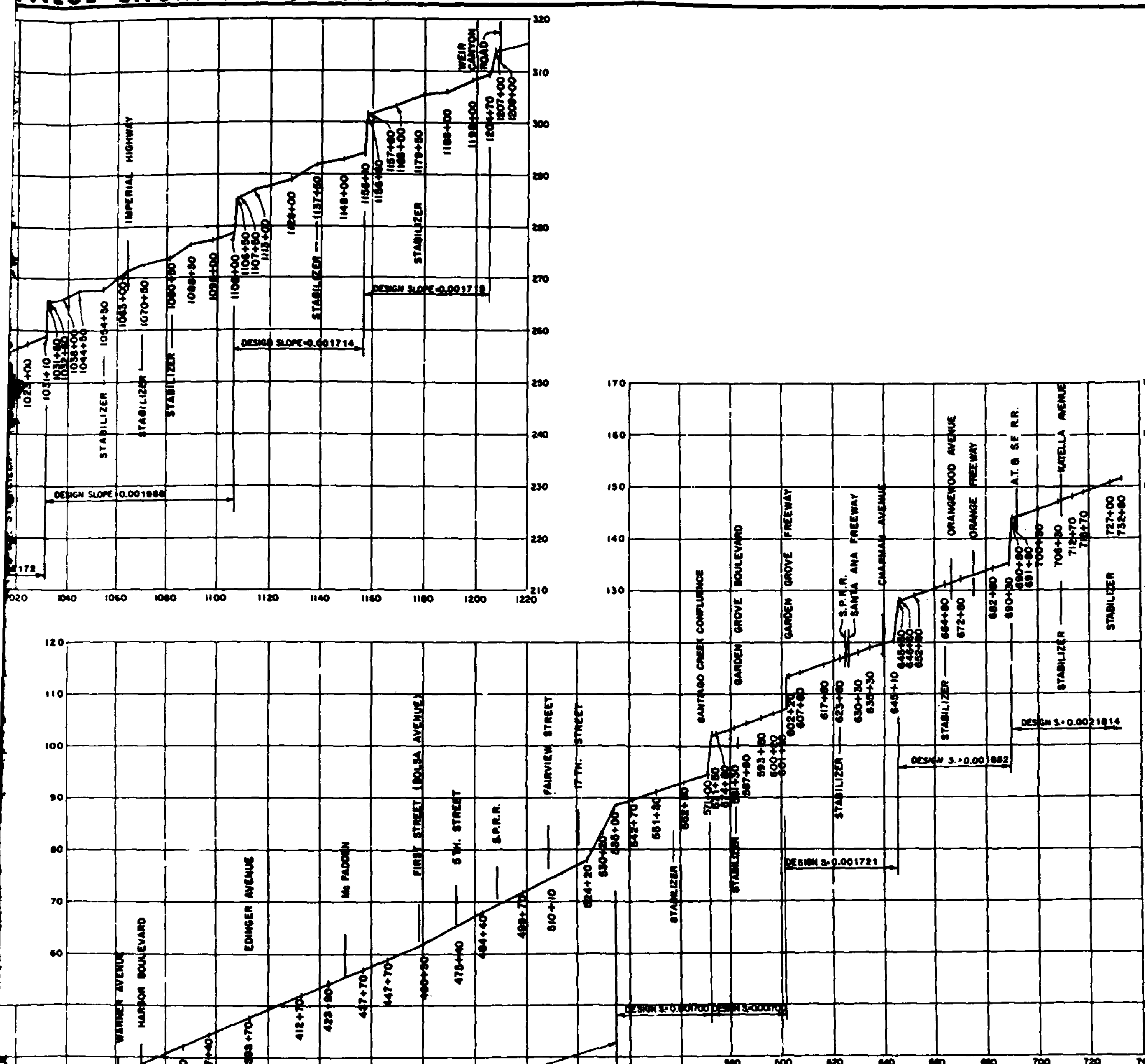

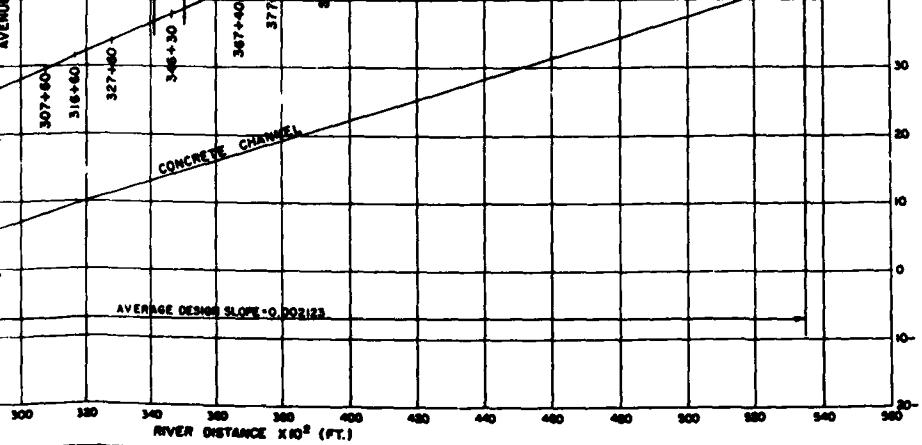

NOTE: STATIONS ARE APPROXIMATE: REFER TO HYDRAULIC DESIGN APPENDIX FOR FINAL DESIGN

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER PHASE II GDM
SEDIMENTATION STUDY

DESIGN STREAMBED PROFILE

DESIGNED BY:

DRAWN BY: J.T.B.

CHECKED BY:

SUBMITTED BY:

DATE APPROVED:

SPEC. NO. DACW09-____-B-____

DISTRICT FILE NO.

SHEET

D RECREATION

RECREATION APPENDIX
to the
PHASE II GENERAL DESIGN MEMORANDUM
SANTA ANA RIVER
MAINSTEM FEATURE

Counties of Orange
and Riverside
Cities of Newport Beach
and Huntington Beach, California

U.S. ARMY ENGINEERING DISTRICT
LOS ANGELES, CALIFORNIA

APPENDIX D

CONTENTS

Contents (Continued)

Tables

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Attachments

I. INTRODUCTION

1-01 The following text details the background and authority, purpose, scope, and basic assumptions of this appendix.

Background and Authority

1-02 A "Review Report for Flood Control, Santa Ana River, Mainstem", dated December 1975, was prepared by the Los Angeles District, Corps of Engineers. It presented a plan of trails and other recreation facilities to be developed with the proposed Santa Ana River flood control project.

1-03 Subsequent to the Review Report was the preparation of the Phase I General Design Memorandum. The purpose of the Phase I General Design Memorandum was to examine the 1975 Review Report and to affirm the validity of the previous plan in light of current conditions and criteria, or to re-formulate the plan as required by such conditions and criteria. Nearly 5 years had elapsed since the Survey Report study conclusions had been made.

1-04 The initial study of recreation potential for the Santa Ana River Mainstem, Santiago Creek, and Oak Street Drain was authorized by the Federal Water Project Act of 1965, and as required by the Federal Water Project Recreation Act of 1965, Public Law 89-72, whereby full consideration must be given to the opportunities for public outdoor recreation afforded by the water resource development project. The Water Resource Development Act of 1976, Section 109, authorized the Phase I advanced engineering and design for the Santa Ana River Project. The Phase I General Design Memorandum, including recreation as a project purpose was submitted in September 1980, and approved in January 1982. The recommended plan for recreation development proposed for the Santa Ana River Mainstem and Santiago Creek was found to be economically justified and desirable. Authorization for construction of the Santa Ana River Mainstem Project, including Santiago Creek, was contained in the Water Resource Development Act of 1986.

Purpose

1-05 The purpose of this appendix is to identify the recreational and environmental resources along the mainstem of the Santa Ana River Flood Control Project, present public use projections, and show the level of recreational development appropriate to accommodate the anticipated use. The appendix will also serve as a general guide to the orderly and coordinated development and management of the environmental resources of the project lands. Cost estimates for the proposed recreation facilities are provided. The Santa Ana River Flood Control project has been authorized as a local protection project and as a result no Master Plan will be prepared. The information contained in the Phase II General Design Memorandum is considered sufficient for the preparation of plans and specifications.

Scope

1-06 The coverage of this appendix is limited to specific information required to insure an understanding of the basic recreational and environmental resources inherent within the Mainstem Feature of the Santa Ana River Flood Control Project. The information provided consists of the demographic characteristics of the project area; topographical, geological and ecological features; a narrative description of existing and proposed recreational facilities, market area analysis, projected development costs, and coordination activities involving other agencies. The intent of this appendix is to present a plan for the public use of project lands that is compatible with the preservation of existing environmental resources.

Basic Assumptions

1-07 The Corps participation along the mainstem of the Santa Ana River for recreation improvements is limited to lands acquired for flood control purposes. Lands outside the flood control rights-of-way may be acquired for health, safety, and public access on a cost shared basis if required. Flood control improvements by the Corps consist of channel improvements between the Pacific Ocean and Weir Canyon Road, construction of a levee within the canyon at Green River Golf Course, and an inlet structure just below Route 71.

1-08 The recreation plan for the Santa Ana Mainstem was developed in conjunction with the Resource Use Master Plan at Prado Dam and the Santiago Creek recreation plan in order to maintain continuity of the Mainstem recreation system. All features will be designed in an efficient and economic manner to reduce operation and maintenance costs.

1-09 The Environmental Management Agency (EMA) of the County of Orange is implementing a master plan of countywide bikeways. This plan was originally adopted by the Orange County Board of Supervisors on September 29, 1971 as a component of the recreation element of Orange

County's General Plan, and on September 23, 1980 ratified it as a component of the transportation element of the general plan. In conjunction with this plan is an adopted county wide master plan for riding and hiking trails, dated September 1984. The county of Riverside has also developed a bike and equestrian trail network within the county boundary. Local city bicycle and equestrian routes would also make connection to the regional trail in order to establish community links with the 30-mile system. The proposed Santiago Creek bicycle trail, located within the vicinity of River View Golf Course, will also provide an additional important segment or link to the overall regional trail network.

1-10 Much of the existing trail system, including the bridge underpasses, was partially funded under the Land and Water Conservation Fund Act of 1965. This act requires that any removed facilities be replaced with ones of equal value and utility (Section 5F of Public Law (88-579). With the proposed flood control improvements, most of the existing Lower Santa Ana River trails and bridge underpasses will be removed due to channel widening and rebuilding. They will be replaced as part of the flood control project. Their replacement will be treated as a relocation cost. Under current cost-sharing policies, relocation is 100 percent a local cost.

1-11 For the purpose of this report, 28.5 miles of Lower Santa Ana River trail is considered a relocation. Improvements to the remaining 3.5 miles of trails is discussed in sections 5-03 through 5-06.

1-12 Development of previously agricultural and open space lands has dramatically increased the population of the area adjacent to the flood control project. The increased urbanization has produced an urgent need for additional recreation facilities.

II. DESCRIPTION OF PROJECT AREA

2-01 A comprehensive description of the project area is included in the Environmental Impact Statement. Project area features covered in this section are pertinent only to the formulation of the recreation plan.

2-02 Below Prado Dam, the Santa Ana River enters Orange County via the Santa Ana Canyon, flowing in a southwesterly direction. It follows a natural meandering course for approximately 7 miles to Weir Canyon Road. Beginning here, the river becomes channelized. Continuing on its way to the ocean, from Imperial Highway to Katella Avenue, the river flows through a series of water spreading basins, controlled by the Orange County Water District. Now heading in a south-southwesterly direction, it crosses the coastal plain in Orange County to the Pacific Ocean at Huntington Beach. A salt water marsh is located on the east side of the channel at the river's mouth.

Biological and Ecological Features and Resources

2-03 Santa Ana Canyon supports a relatively high value natural riparian habitat for over 200 species of plant and animal life. These include herons, hawks, quail, mice, racoons, coyotes and gray fox. Vegetation along the river varies considerably. In areas downstream of the canyon little vegetation exists, especially near the coast. The mouth of the Santa Ana River is ecologically sensitive and therefore has been eliminated from extensive recreation planning. Within Orange County, the output from sand and gravel mining operations along the river was at one time the second highest in the State. Other minerals have been found in the canyon but not in quantities sufficient to allow for profitable operations. The names of Coal Canyon and Gypsum Canyon, which enter the Santa Ana Canyon, are indicators of earlier mining operations.

Climate

2-04 The climate is mediterranean (mild winters and hot summers). Dry, seasonal winds called the "Santa Anas," come from the desert areas to the northeast and east. Annual precipitation averages 12 inches per year, with 92 percent of it falling between November and April.

2-05 Climate conditions in the immediate coastal area are directly influenced by the surrounding marine air conditions which produce moderate to hot summers and mild winters. There is moderate to heavy fog occurring primarily from mid-December to March. Low clouds are mainly restricted to the late afternoon to mid-mornings.

Topography

2-06 The Lower Santa Ana River basin is relatively flat with a gradient suited for both a bicycle and equestrian trail. Elevations vary from -6 feet near the mouth to +450 feet at the upstream drop structure (sta. 1607+50), a distance of 30 river miles. Surrounding the Santa Ana Canyon are mountain ranges separated by an intermediate valley with the low lying Chino Hills to the north and the Santa Ana Mountains to the south. The remaining route of the river is through the generally level coastal plain.

Geology and Soil Characteristics

2-07 The coastal plain, a physiographic and structural basin, contains a thick sequence (up to 30,000 feet) of chiefly marine and nonmarine clastic sedimentary rocks overlying igneous and metamorphic basement rocks. These sediments derived from surrounding highland areas, were deposited in the ever deepening basin; an ongoing process which during the most recent geologic time has resulted in the accumulation of up to several hundred feet of alluvium in modern stream channels and associated floodplain and alluvial fans, and beaches.

Access and Circulation

2-08 The urbanized section of the Lower Santa Ana River is crossed by many arterial roads as well as one major highway (Pacific Coast Highway) and five freeways (Garden Grove, Riverside, Santa Ana, Orange, and San Diego). Access to the bicycle and equestrian trails would be provided at all street crossings.

2-09 Due to the dense urbanization of the area between Weir Canyon Road and the Pacific Coast Highway arterial roads are subject to extremely heavy traffic conditions that discourage their use by most bikers. The bike and equestrian trails provide a safe transporation corridor through this region and encourage increased use of the Santa Ana River Regional Trail System. Completion of both trails in the Santa Ana Canyon will maximize trail usage by providing connecting links to other inter-county and city trail systems.

Operational Limitations

2-10 Disruption to trail use will occur during reconstruction of the river channel, bridges, and bridge ramp undercrossings which may effectively close the trails for years. During construction periods, temporary routes would need to be provided to assure the maximum interim use possible of the public trail facilities.

2-11 The proposed bicycle and equestrian trails at Green River Golf Course cross underneath the Santa Fe Railroad bridge. An easement from the railroad must be acquired in order to allow trail access through this area. To date the railroad, anticipates no problems with granting this access, pending review of final design. In the event the easement is denied, undercrossings of both trails would need to be re-studied for development of alternative routes.

2-12 Storm conditions could produce high velocity flows within the river. Equestrian use of the riverbed wet crossings during these conditions will be interrupted periodically. Streamflow during non-storm conditions are anticipated to range from 200 to 300 cfs.

III. RECREATION MARKET AREA

Boundaries/Region Served

3-01 The recreation market area for the Lower Santa Ana River Flood Control Project consists of those residents located within 5 miles of the river's centerline, from the Orange County border to the Pacific Ocean. This area and distance were chosen because 5 miles is considered to be a reasonable travel distance for use of a regional trail. It is anticipated that a minimum of 80 percent of the day use of the bike trail would originate within this zone. Additional usage from outside the market area is also anticipated because the trail makes efficient use of the channel right-of-way and encourages alternate transportation modes within the urban area, it provides direct access to major recreational areas, and serves as a link to the trail corridor extending up Santiago Creek. Because the Corps development would be an integral part of the 30-mile proposed trail system, market area and demand have been analyzed for the entire Lower Santa Ana River trail corridor.

Socio-Economic Characteristics

3-02 Users of the trail system will come primarily from portions of 12 Orange County cities that lie within the lower basin area. Those are Yorba Linda, Placentia, Fullerton, Villa Park, Anaheim, Orange, Garden Grove, Santa Ana, Fountain Valley, Huntington Beach, Costa Mesa, and Newport Beach. Over 1,000,000 people reside or work within this area. Projected populations for the Lower Santa Ana River market area are shown in the table below. The market area for Santiago Creek overlaps portions of the Lower Santa Ana River market area and therefore has been netted out of the 5-mile service area.

Table D-1. Projected Population[1] in Lower Santa Ana Market Area, 1980-2000

1980	1985	1990	1995	2000
931,394	1,004,696	1,055,731	1,109,599	1,138,710

[1] Based on information provided by Southern California Association of Governments and Orange County Preferred Projections 1985 (Orange County Department of Administration - Forecast and Analysis Center).

According to the U.S. Bureau of Census it estimated the uncounted population to be about 2.5 percent. The figures reflected in this appendix do not account for these persons.

3-03 The lower basin is highly urbanized with mostly residential housing. The Santa Ana Canyon area located downstream of Prado Dam to Wier Canyon Road, is the only major area of undeveloped land in the lower basin. Population growth has slowed because developable land within the basin has largely been used up. Because the Santa Ana Canyon River Basin overall is thriving economically, it is a highly desirable place to live. Employment growth in the basin has continued strong since the 1975 Survey Report, but has not increased at as high a rate as the upper basin area. Income levels in the lower basin remain higher, though, than those in the upper basin. Manufacturing, trade, and service continue to dominate basin employment. Pressure to develop remaining open space remains high in the lower basin, particularly in the Santa Ana Canyon area. The percentage of athletically oriented adults and children is higher than average.

Inventory of Existing and Proposed Facilities

3-04 Currently existing trail development in the lower reach of the Santa Ana River includes 26 miles of bicycle and equestrian trails extending from the Pacific Ocean up to Gypsum Canyon Road. Additionally, in the Santa Ana Canyon, between Gypsum Canyon Road in Featherly Regional Park and the Green River Golf Course entrance is 2.5 miles of bicycle and equestrian trails. The existing and proposed facilities are shown on plates 1 through 5.

3-05 The existing trails include underpasses at all bridges and access to trails at all street crossings. In addition, access is available from three adjoining Orange County regional parks--Centennial, Yorba, and Featherly, plus two local parks, located, respectively, in Santa Ana and Huntington Beach.

3-06 The bike trail currently has four bridges crossing the trail over the river, with three additional bridges proposed. The equestrian trail has one proposed bridge crossing and four proposed wet crossings (pls. 1 and 2). The four wet crossings are located in the canyon area where the river is not channelized. There are private horse rental and boarding stables adjacent to the equestrian trail at several locations in the city of Anaheim and Santa Ana canyon.

3-07 Eight trail rest stops currently exist along the entire channel reach. The local cost sharing agency has no plans to develop additional sites at this time. Because the lower 28.5 miles of trail system, from Featherly Regional Park to the Pacific Ocean, is considered strictly replacement, any improvements to the trail within this reach will not be eligible for cost sharing and therefore must be funded entirely by the local agency.

3-08 In order for both trails to run continuously along the entire system all proposed new bridge construction and replacement must be completed.

3-09 Future development of bicycle and equestrian trails below Prado Dam would consist of completing the remaining trails planned under the countywide master plan for Orange County and local city wide plans to establish community links with the Santa Ana River regional trail system. For example, the city of Yorba Linda has 12 miles of equestrian and hiking trails that could tie into the Santa Ana River trail.

3-10 The most significant recreation facility imposing major impacts on the lower river is the Chino Hills State Park development, located directly west of Prado Basin (pl. 2). The proposed system of trails, campsites, picnic areas and open space will form a land use interface with adjacent recreational areas including the Santa Ana River trails. The State Department of Parks and Recreation estimates that final development of the recreation facilities will include 42 miles of equestrian trails and 18 miles of bicycle trails.

3-11 Demand for recreational activities proposed for the Lower Santa Ana River is based upon the application of per capita participation rates to the market area population 5 years of age and older. The recreation market area had a trail demand of over 11.3 million activity days during peak summer months in 1985 and will have over 22.8 million activity days during peak summer months in the year 2000. This is based upon summer season per capita particiation rates and growth factors provided in the Orange County Recreation Needs and Regional Park Study (table D-2).

Table D-2. Potential Trails Demand for Lower Santa Ana River Market Area For Summer Season[1], 1985 and 2000.

	Per Capita Participation Rates[2]		Market Area	
	1985	2000	1985	2000
Population				
Five Years of Age & Over (thousands)[3]	NA	NA	894,179	1,024,839
Activities				
Bicycling	12.15	21.50	10,864,274	22,034,038
Horseback Riding	.52	.83	464,973	50,616
Total Trails Demand			11,329,247	22,884,654

1. Memorial Day through Labor Day.
2. For Population Five Years of Age and Older.
3. 89% of Total Population in 1985, 90% in 2000.

3-12 The Lower Santa Ana River trails could accommodate approximately .4 percent of ultimate trails demand in 1990 and .2 percent of ultimate demand in 2000. This is based upon a maximum peak season use of 55,242 shown in the following table D-3.

Table D-3. Maximum Use During Peak Summer Season for Lower Santa Ana River Trail (From Prado Basin to the Pacific Ocean).

ACTIVITY	DENSITY x	UNITS x	TURN-OVER x	DUPLI-CATION RATIO =	# OF MAX DAILY RECRE-ATION DAYS x	WEEK-END DAYS IN PEAK MONTH =	TOTAL WEEK-END USE IN PEAK MONTH ÷	% OF PEAK USE ON WEEK-END =	TOTAL USE DUR-ING PEAK MONTH x	# OF PEAK MONTHS IN SUMMER SEASON =	TOTAL USE DUR-ING PEAK SEASON
bicycling	20	31	1	1	620	9	5,580	.5	11,160	3.3	36,828
horseback riding	10	31	1	1	310	9	2,790	.5	5,580	3.3	18,414
											55,242

IV. RESOURCE USE OBJECTIVES

Definition

4-01 Resource use objectives state the scope and intent of planning within which the proposed plan of physical development was formulated and outline the plan for optimum use of project lands and resources.

4-02 The upper portion of the lower river reach starts in the Santa Ana Canyon, where Green River Golf Course, owned and operated privately, is bisected by the river's natural course. This area provides an outstanding example of a natural riparian community. The Santa Ana Canyon is one of the few remaining open space habitats in the area. Below this reach of the river, starting just upstream of Weir Canyon Road, the river becomes channelized for 23 miles to the Pacific Ocean. The river is completely contained within channel levees to protect the densely populated, broad, gently shaped coastal plain of Orange County. There are several spreading basins in this 23-mile reach.

Basic Objectives

4-03 The basic objectives are outlined below:

a. To provide a high quality experience for bicycling, hiking and equestrian riding opportunities through a well-planned trail system. Those sections within the flood control right-of-way not stipulated for channelization or as prime floodways are excellent resource areas for trail development. Esthetic treatment, provision for convenient comfort facilities, multi-seasons use capability and convenient public access are necessary for a quality experience.

b. To locate trails and ancillary facilities with respect to resources sensitive to human use.

c. To interpret the project resources to the public. Public education of the value of the Lower Santa Ana River's natural ecological systems would be increased through personal interactions and experiences with the natural environment.

d. To limit incompatible development. Trails would be built in a manner which is in harmony with surrounding and abutting uses. Landscaping would provide shade and screening. General esthetic treatments would benefit both the trail users and abutting land users. Structures and signage should be consistent with the surrounding environment.

Resource Use Objectives

4-04 Objective 1: To provide a scenic, safe, high quality bicycle and equestrian trail that would function as an integral component of the 32-mile Santa Ana River Regional Bicycle Trail.

(Discussion) The analysis of pertinent factors indicates there exists a high demand for regional bicycle and equestrian trail development. No additional Class I trails are currently planned within the market area that would compete with the 32-mile Lower Santa Ana River Regional trail. The County of Orange has indicated that development of a county-wide bikeway system would increase the use of regional recreation sites within or on the edge of the metropolitan zone. This project, with its outstanding scenic qualities within the canyon and its central location, provides a key segment in this integrated system. The County of Orange has funded construction of other downstream portions of this trail system with the expectation of Corps involvement. Increased urbanization of the lands surrounding the flood control project would provide a high user rate for the bicycle trail. With the trails gradient suited for bicycle users, a more enjoyable experience will be provided.

4-05 Objective 2: To develop an erosion control and esthetic treatment plan to complement the flood control project.

(Discussion) Construction of the flood control channel would disrupt the surrounding natural environment. Vegetation provided for erosion control and esthetic treatment should be compatible with the existing native vegetation located within immediate surroundings, thereby maintaining the identity and character of that particular area in addition to providing for screening, shading and visual enhancment. Certain non-native plant material noted for its color, foliage and/or flower could be introduced along the lower reach provided it is compatible with the plant communities being established.

V. RECOMMENDED PLAN OF PHYSICAL DEVELOPMENT

General

5-01 The availability of prime vacant land in the middle of a heavily urbanized area, in conjunction with the need to provide safe bicycling and equestrian trails for recreation and transportation, has provided the impetus for providing recreation facilities as an integral element of the Lower Santa Ana River Flood Control Project. As a result of previously unrestrained commercial and residential growth in the northern Orange County area, lands available for open space, and recreation are rapidly decreasing. Lands adjacent to and made available for the single-purpose use of flood control provide a logical choice for multipurpose recreation enhancement. The optimum use of flood control lands is based on the consideration of the open space potential of such lands. This consideration establishes the interrelationship between flood control and recreation use.

5-02 Corps participation in the Lower Santa Ana River trail would be cost shared development of approximately 3.5 miles of paved bike trail and 4.0 miles of graded equestrian trail, located entirely in the Santa Ana Canyon area. Beginning at Green River Golf Course, both trails would connect to the 28.5 miles of replaced downstream trails and would both terminate just below Route 71 at river station number 1607+50 (see pl. 2).

Proposed Trail System

5-03 The proposed flood control project in the Green River Golf Course area provides for a levee on the south side of the river. Starting at the Santa Fe railroad bridge, it extends downstream for approximately 2600 feet, ending just upstream of the Green River Golf Course entrance bridge. The 12-foot-wide asphalt bike trail would run along the top of this levee after crossing over the bridge road. It then crosses under the AT&SF railroad bridge and turns west over the river across a new bicycle bridge. Once across, the trail would then run parallel with the railroad tracks on a separate lower graded surface, approximately 1800 feet, then follows the Santa Ana River Regional Interceptor (SARI) right-of-way to its connection point with trails going into Prado Basin (sta. 1607+50) - (see pl. 2). Support facilities such as restrooms and drinking fountains have not been proposed for development along this reach of trail system because utility connections are not available, and the remote location would encourage vandalism resulting in excessive operation and maintenance costs. The County of Riverside is currently proceeding with a request for a 30-foot trail easement from the Santa Ana Watershed Project Authority (SAWPA) which has controlling authority over the right-of-way.

5-04 The railroad tracks are not within the floodplain area, as the trails are, but are located on a raised graded surface, primarily to separate the tracks for safety and clear lines of sight.

5-05 The proposed equestrian trail begins further downstream across the river from the eastern most boundary of Featherly Regional Park, approximately at station 1429+25. A wet crossing from Featherly Park picks up the new section of trail on the north river bank From this point the trail runs parallel to and between the Santa Fe railroad tracks and the Green River Golf Course until it reaches the river (see pl. 2). The trail then swings under the railroad bridge, to the left and continues along side the bicycle trail from this point on until river station 1607+50, where the trails into Prado Basin will connect.

5-06 Once completed, the entire 32-mile system of trails would provide direct off road access to major recreational facilities at the Pacific Ocean and proposed facilities within Prado Basin and Chino Hills State Park. The trail is a significant element in a comprehensive recreation plan, consisting of a mountains-to-sea trail corridor, extending from the Pacific Ocean to the San Bernardino National Forest, and tying into the Pacific National Trail as well as various local and community parks adjacent to the trail corridor. The trail would support national and state goals to reduce energy consumption by helping to minimize dependence on motor vehicle transportation to recreation areas.

VI. COORDINATION WITH OTHER AGENCIES

6-01 The following Federal, State, County, and local agencies have been contacted. The roles they played in the planning and coordination of the proposed plan are briefly summarized.

Federal Agencies

6-02 There was no involvement with other Federal agencies in the development of the recreation plan for the Lower Santa Ana River.

State Agencies

6-03 California State Parks and Recreation Department was contacted for information regarding the proposed Chino Hills State Park and general recreation planning data for southern California. The California Transportation Department (CALTRANS) was contacted regarding the design and construction schedule of the Pacific Coast Highway bridge at the mouth of the Santa Ana River.

County Agencies

6-04 The County of Orange, Department of Parks and Recreation, Transportation Planning Division and the Department of Administration-Forecast and Analysis Center. Contacts were made concerning local planning in regard to replaced portions of the of downstream bicycle and equestrian trails, development of the recommended plan for trails through Santa Ana Canyon, and demographic information.

6-05 County of Riverside, Parks Department. This agency was contacted development of the recommended plan for recreation trails through Santa Ana Canyon.

Local Groups

6-06 Cities of Newport Beach and Huntington Beach. Contact was made with these agencies concerning the design of the bicycle trail at the mouth of the Santa Ana River.

6-07 Huntington Beach Wetlands Conservancy. Coordination was made with this agency concerning local planning and design of the bicycle trail at the mouth of the Santa Ana River.

Special Problems

6-08 Disruption of trail use will occur during reconstruction of the river channel, bridges, and bridge ramp underpasses. This could effectively close the already existing portions of trail for years. However, according to County policy, the lead agency responsible for the project at hand, would be required to undertake measures to provide bypass routes in order to assure maximum interim use of the public trail facility.

6-09 In the event that the Santa Fe Railroad does not process the easement request for access underneath their railroad trestle, both the bicycle and equestrian trails would need to be redesigned in order to access trails going into Prado Dam.

6-10 The existing recreation trails are considered as a utility, and their replacement will be treated as a relocation to be funded by the County of Orange. Portions of the existing trails have been funded under the Land and Water Conservation Fund Act. The County of Orange, Environmental Management Agency, has assumed the responsibility of determining what clearances or approvals are required in connection with this funding, or any other grant funding, and initiating the appropriate action to maintain compliance with all pre-existing contractural agreements entered into by the County of Orange and other State and Federal Agencies.

VII. MANAGEMENT AND COST SHARING

7-01 The operation and management of all recreation facilities so constructed under this authority will be the responsibility of the local cost sharing agency.

7-02 Public Law 78-534, The Flood Control Act of 1944, Section 4, authorizes the Corps of Engineers, to construct, operate and maintain public recreational facilities at water resource development projects, and to permit local interests to operate and maintain such facilities. Public Law 89-72, The Federal Water Project Recreation Act of 1965, provides a basis for the development of recreation facilities on a cost shared 50-50 basis between a local sponsoring agency and the Federal Government. Proposed recreation facilities are consistent with recreation policy regulation ER 1165-2-400, and all subsequent policy directives. The paved top of levee doubling as maintenance and access roads will be charged to project cost only. The proposed paving of the bicycle trail that is off levee, is not a feature of the flood control project and will be charged to the recreation account. The 28.5 miles of existing trails will be treated as a utility and relocated at 100 percent local expense.

VIII. ENVIRONMENTAL QUALITY

8-01 The flood control project is expected to have very minimal impact on the riparian habitat located directly adjacent to the Santa Ana River as it runs within Santa Ana Canyon, and no impact on the surrounding grasslands to the north of the river. A levee along the east river embankment will be constructed to protect an existing mobile home park (pl. 2), and the bicycle trail will be located on top of this levee. No additional landscaping for recreation is proposed beyond that required for erosion control and bank stabilization and thus no landscaping costs are presented in table D-4, on page D-IX-2, volume 3, appendix D.

8-02 The bicycle trail will pass under the existing Santa Fe railroad bridge on the east bank of the Santa Ana River, and will cross to the west bank on a new bridge to be constructed directly upstream from the railroad bridge (pl. 2). The equestrian trail will pass under the railroad bridge on the west bank and merge with the bicycle trail immediately upstream of the railroad bridge. From this point on up to Prado Dam, both trails will be located on an existing dirt farm road adjacent to the Chino Hills State Park currently being developed by the State of California Department of Parks and Recreation. This stretch of trail is on open ranch land in a natural grassland environment. It has been requested by the State and the local counties that we do not disturb or change the nature or environmental characteristics within the Santa Ana Canyon. The canyon contains several distinct and diverse biological communities ranging from the ephemerally inundated community along the river through the riparian, grassland, upland chaparral, to the oak woodland at higher elevations. The ecological value is not only in the communities themselves but in the diverse and varied ecotones created between these communities. In view of the above considerations no additional landscaping along the recreation trails is proposed throughout this reach. No landscaping costs are presented in table D-4, on page D-IX-2. A discussion of the recommended landscape and erosion control plan is included in the General Design Memorandum, Volume 3, on page D-XII-1.

IX. COSTS

General

9-01 All separable costs attributed to recreation will be cost shared on a 50/50 basis with local interests. The bike and equestrian trails will be constructed concurrent to the flood control project.

Cost Summary and Estimate

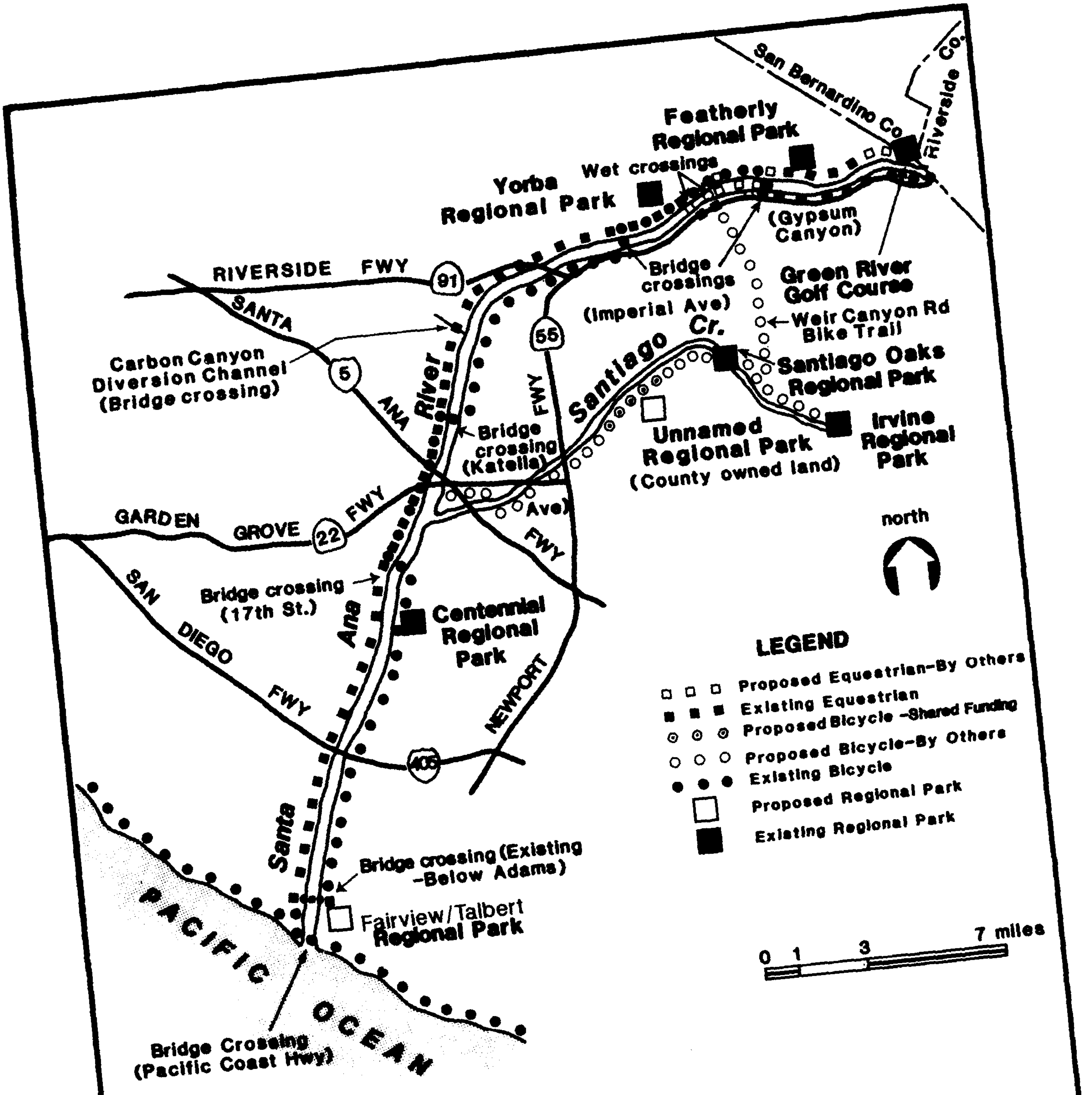
9-02 A detailed cost estimate for the proposed bicycle and equestrian trails is presented in table D-4.

Table D-4. Recreational Development Cost Estimate.
Santa Ana River Canyon

Description	Quantity	Unit	Unit Cost	Totals
Bike Trail	18,100	LF	17.50	316,750.00
Equestrian/Hiking Trail	21,375	LF	4.50	66,200.00
Bridge (10' x 90')	1	EA	65,000	65,000.00
Signs (Marker)	18,100	LF	.25	4,525.00
Signs (Entrance-Directional)	10	EA	600	6,000.00
Signs (Traffic)	6	EA	600	3,600.00
Gate	1	EA	1,000	1,000.00
Subtotal				463,074.00
Contingencies				67,926.00
Subtotal				531,000.00
Engineering and Design				37,000.00
Supervision & Administration				32,000.00
TOTAL RECREATION				600,000.00

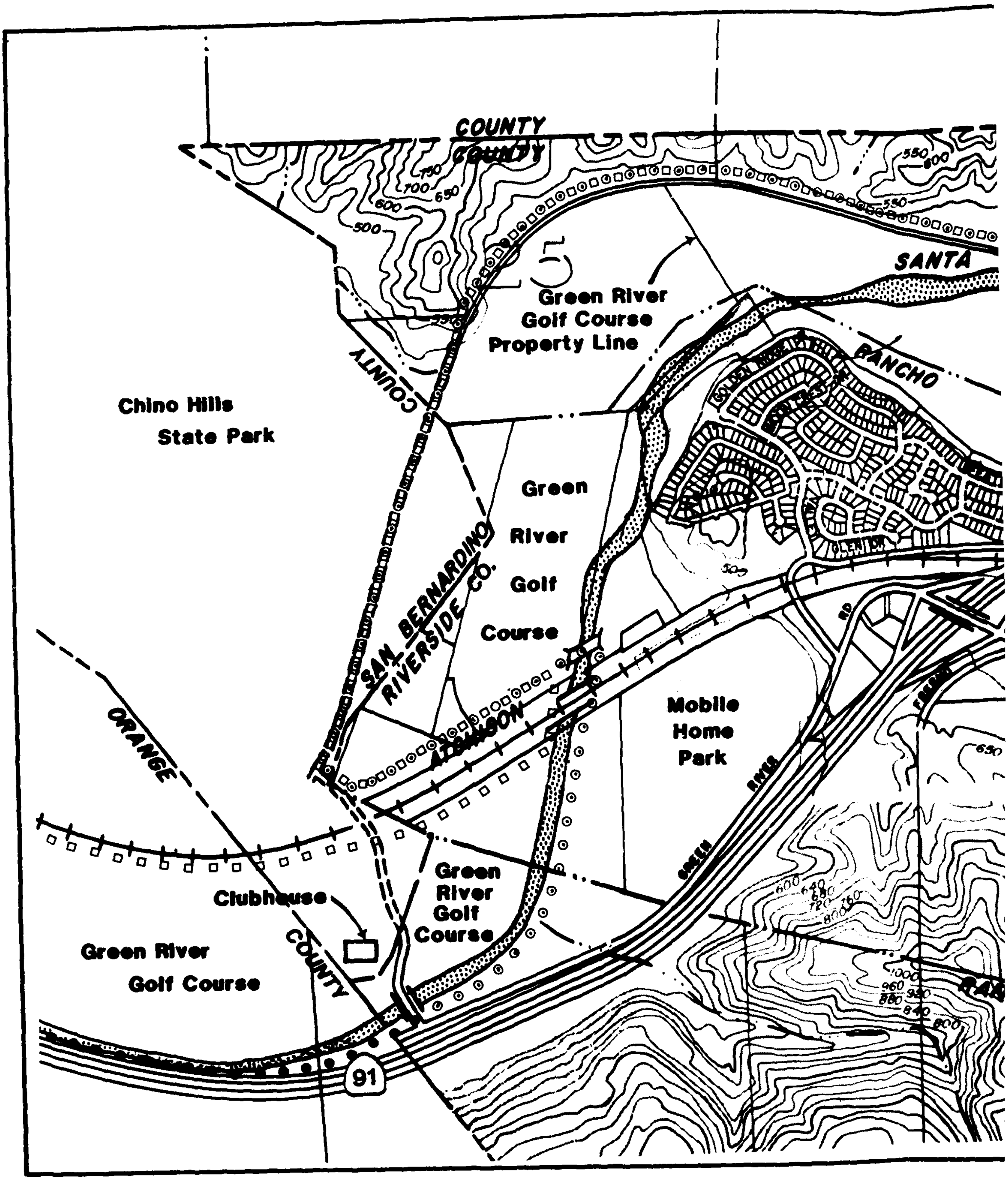
D RECREATION

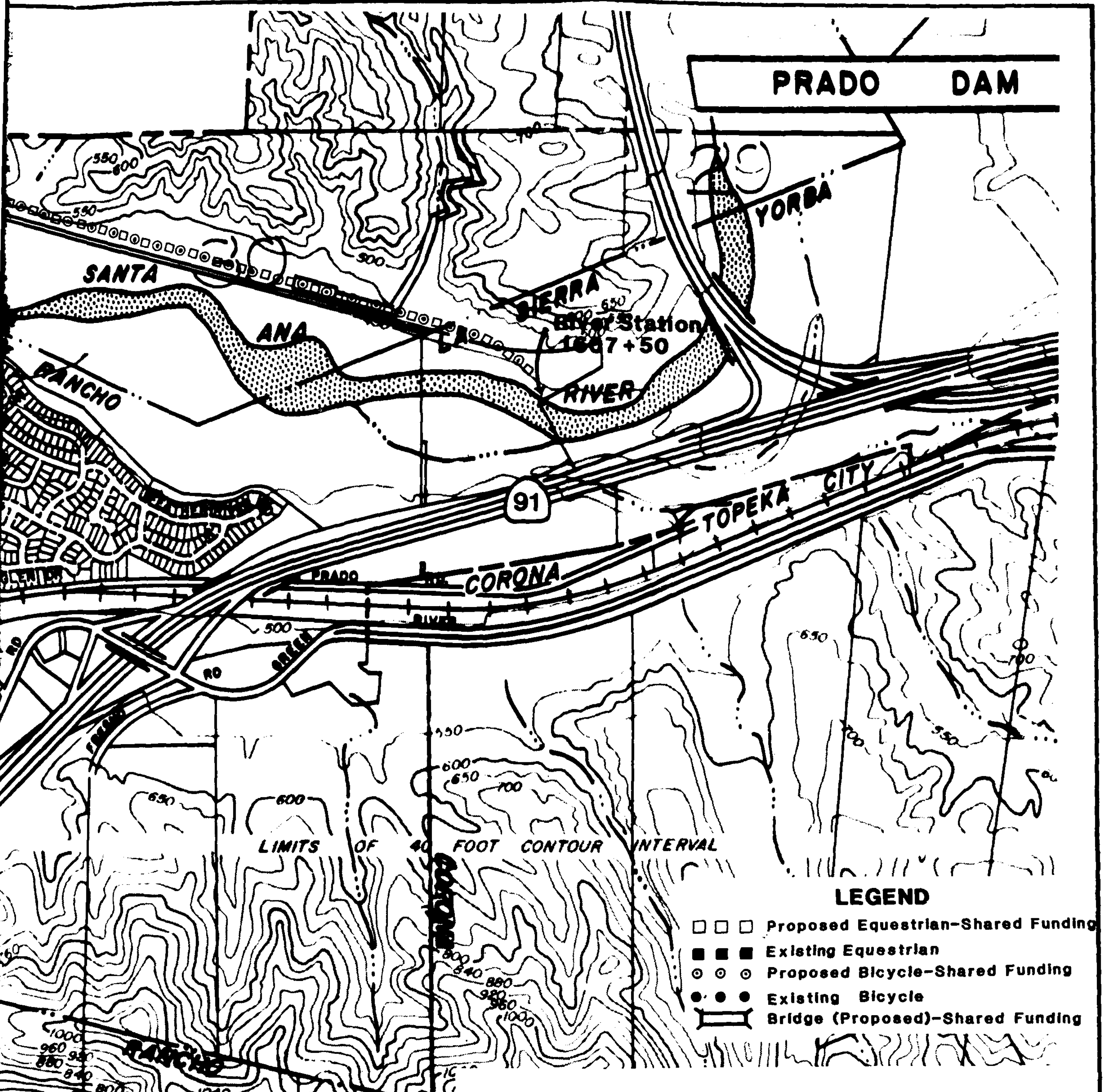
PLATES
AND
ATTACHMENT



LOWER SANTA ANA RIVER
regional parks and trails

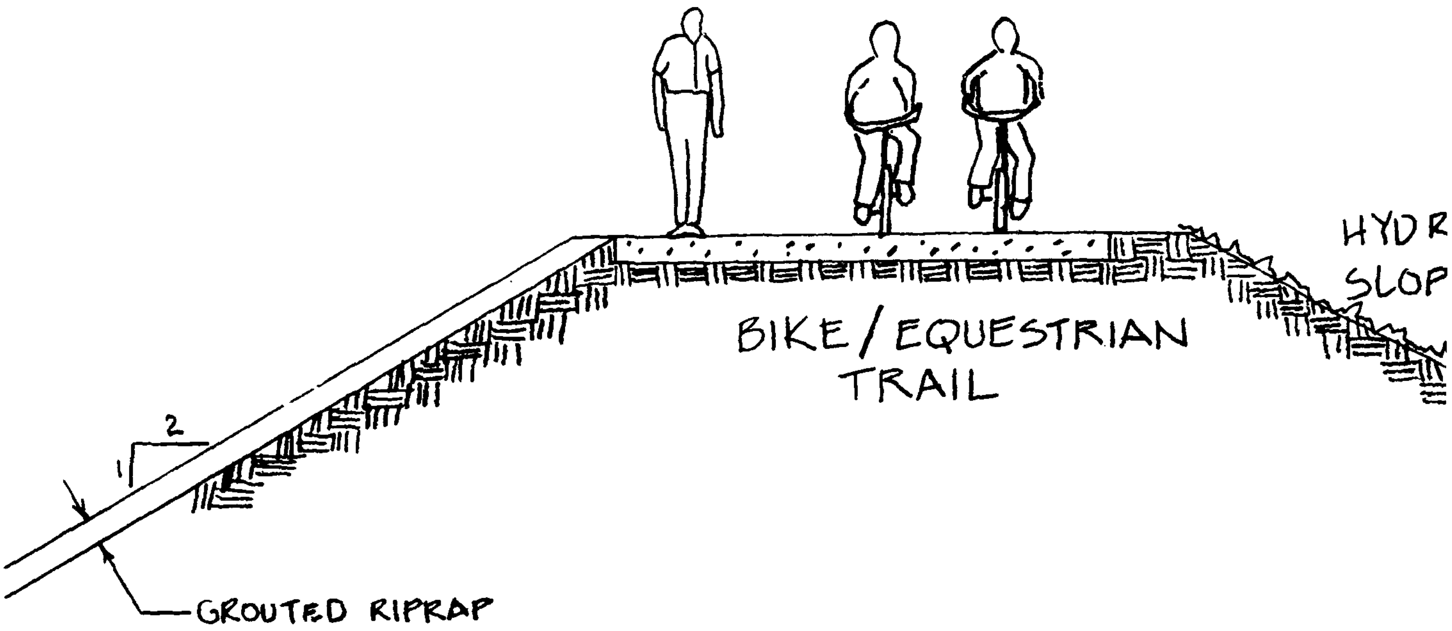
PLATE 1-D


COUNTY
COUNTY
SANTA
Green River
Golf Course
Property Line
RANCHO
Chino Hills
State Park
COUNTY
Green
River
Golf
Course
SAN BERNARDINO
RIVERSIDE CO.
Mobile
Home
Park
ORANGE
Clubhouse
Green
River
Golf
Course
COUNTY
Green River
Golf Course
91
GREEN
RIVER

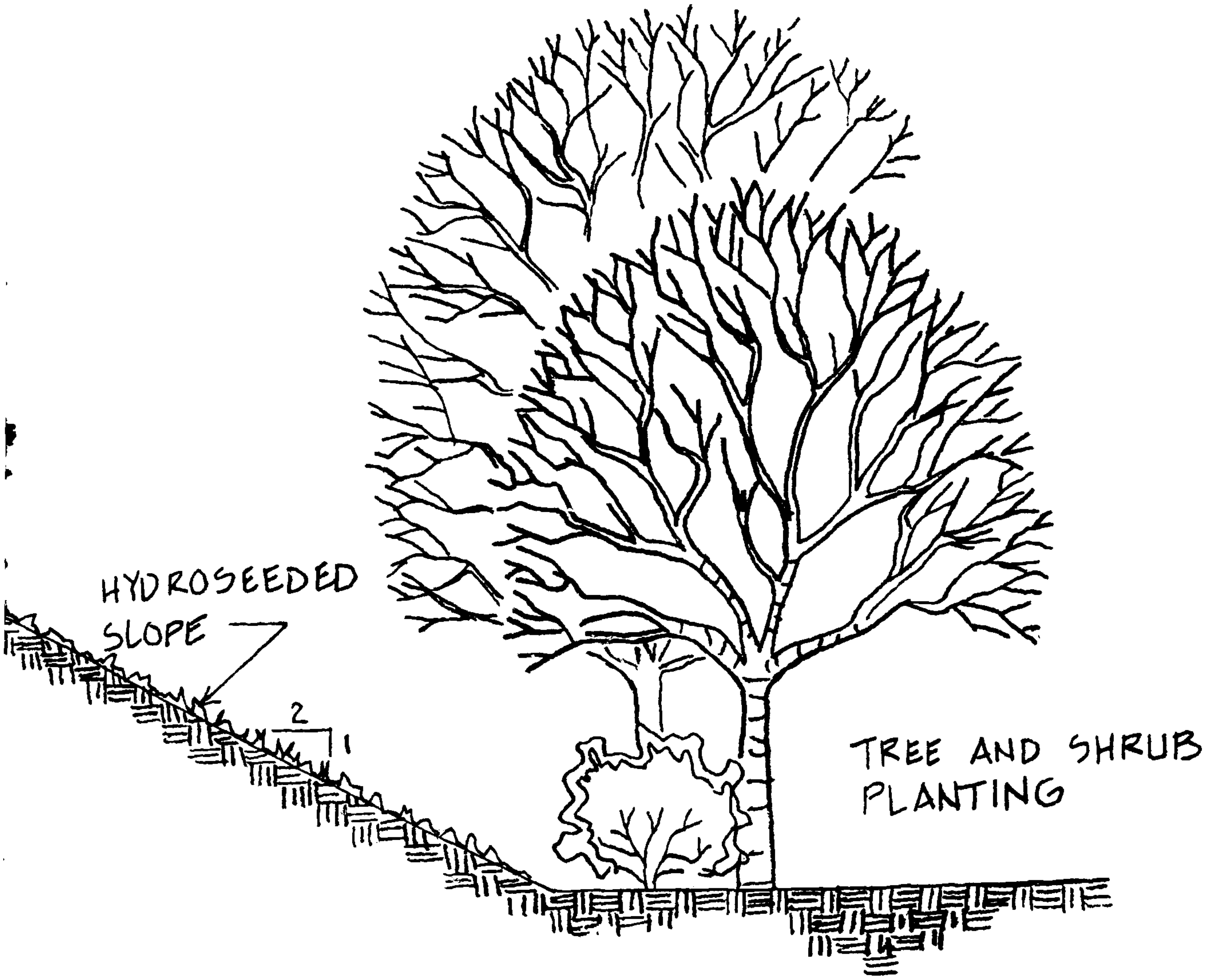


PROPOSED RECREATION PLAN - SANTA ANA CANYON

PLATE 2-D



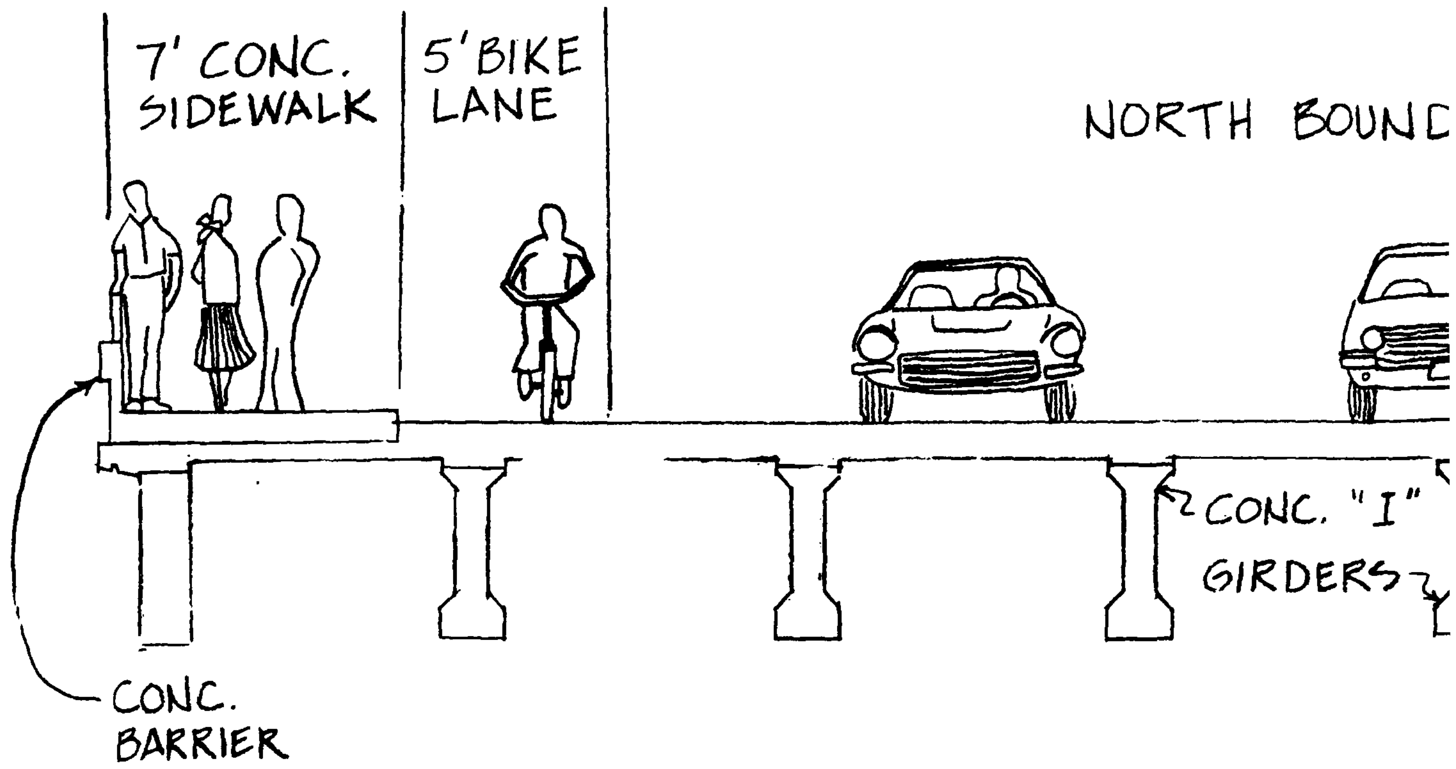
TYPICAL TRAIL SECTION ON TOI



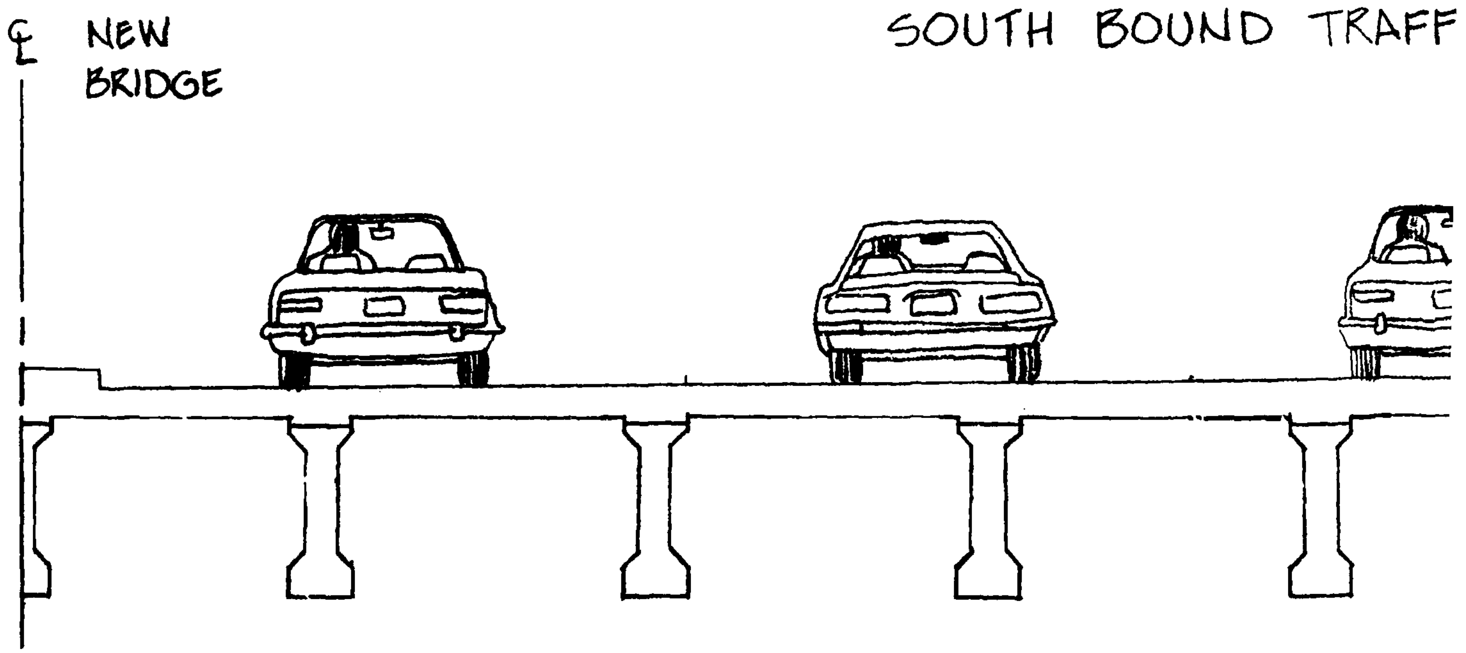
ON TOP OF LEVEE

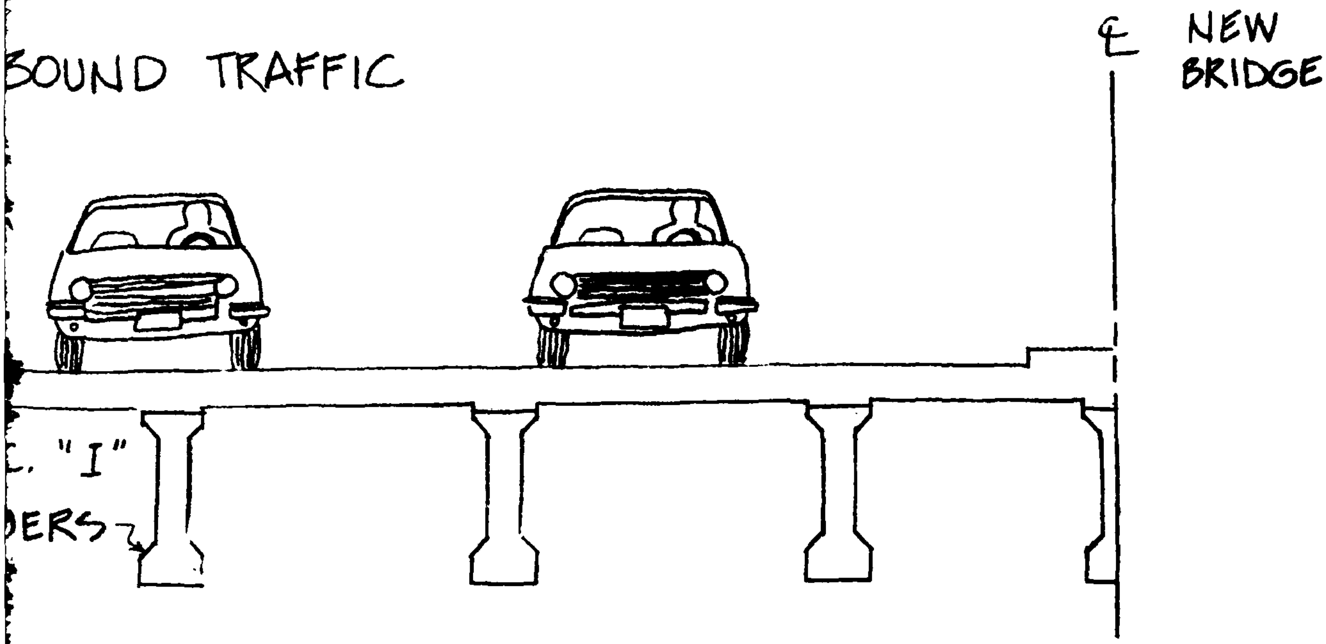
SCALE : 1" = 4'

PLATE 3-D



BIKE TRAIL ON TOP OF BRIDGE





IDGE AT PACIFIC COAST HWY

SCALE: 1" = 4'

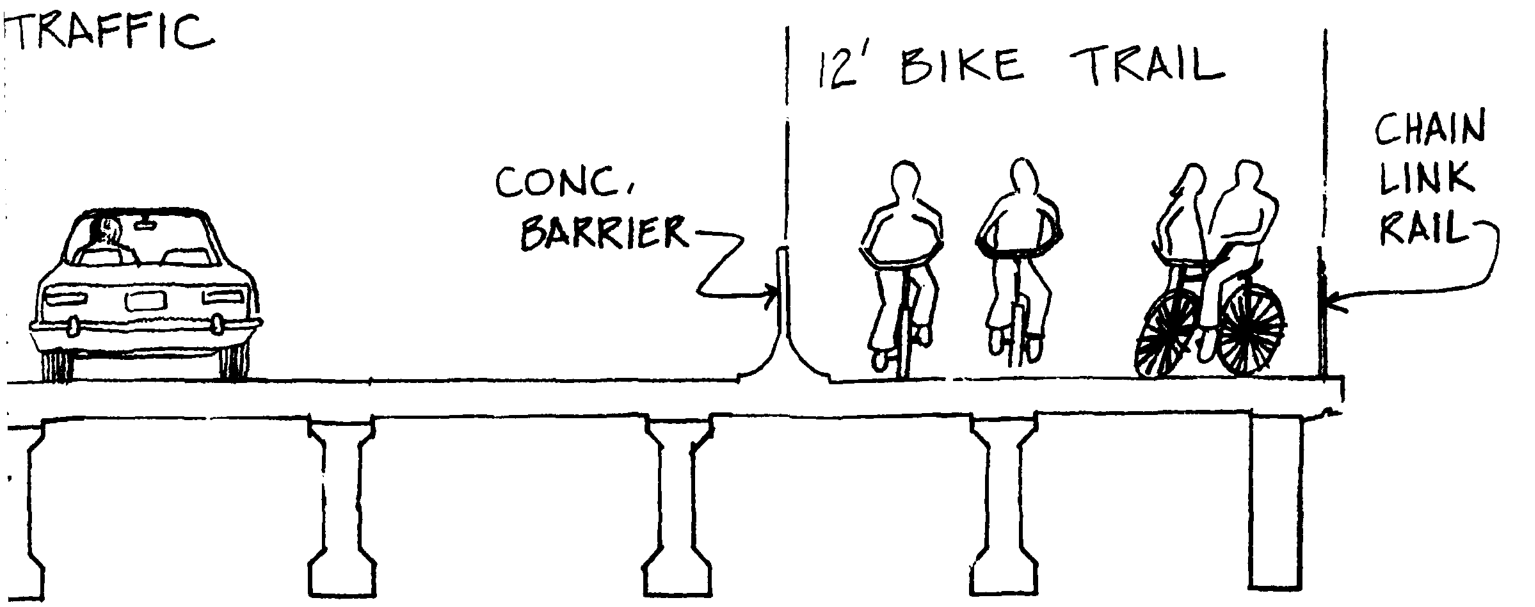
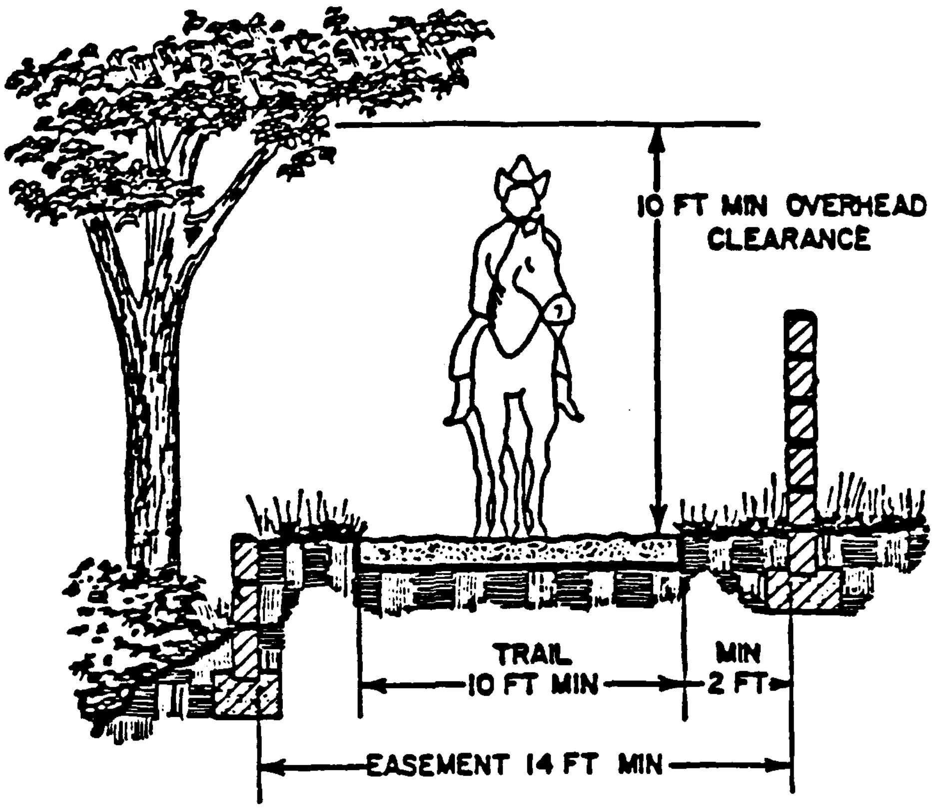
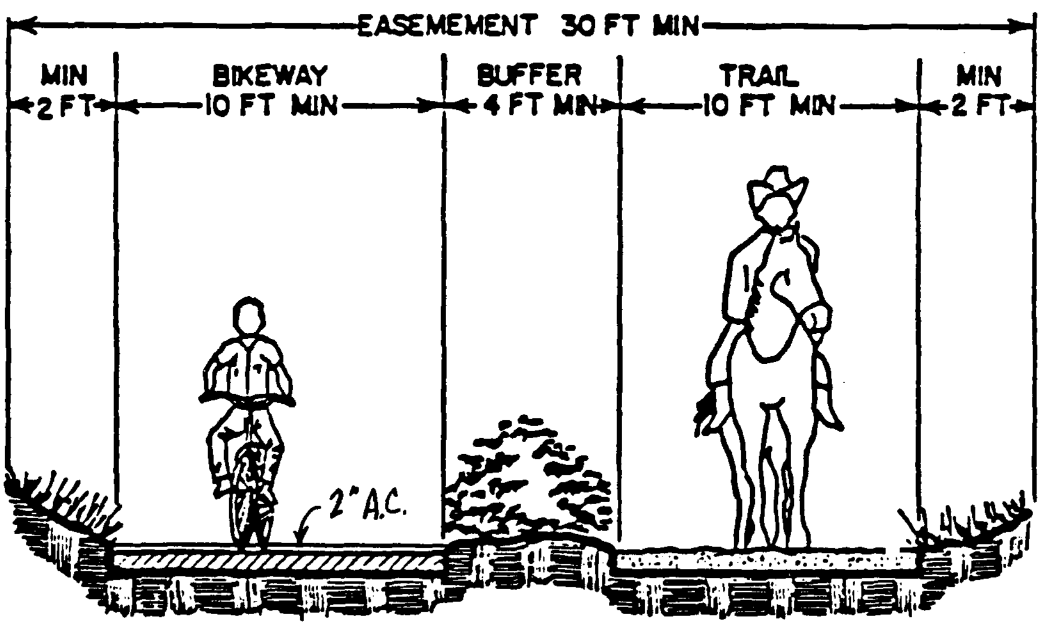


PLATE 4-D



EQUESTRIAN TRAIL



TRAIL AND BIKEWAY COMBINATION

TRAIL DETAILS

PLATE 5-D

CONTRACT BETWEEN
THE UNITED STATES OF AMERICA
AND
COUNTY OF ORANGE
FOR
RECREATION DEVELOPMENT
MAINSTEM FEATURE
OF THE
SANTA ANA RIVER FLOOD CONTROL PROJECT
SANTA ANA RIVER BASIN, CALIFORNIA

THIS CONTRACT entered into this _____ day of _____, 19__ by and between the UNITED STATES OF AMERICA (hereinafter called the "Government"), represented by the Contracting Officer executing this contract and the County of Orange (hereinafter called "County"),

WITNESSETH THAT:

WHEREAS, construction of the lower reach of the Santa Ana River Flood Control Project, Santa Ana River Basin, Orange County, California (hereinafter called the "Project") was authorized by the Flood Control Act of 1944 (Public Law 534, 78th Congress); and

WHEREAS, pursuant to Section 4 of the 1944 Flood Control Act, as amended by Section 207 of the 1962 Flood Control Act, as amended (16 U.S.C. 460d), the Government is authorized to make contracts with non-Federal public bodies for development, management, and administration of the recreation resources of Federal water resources projects; and

WHEREAS, the office of Chief of Engineers has established certain policy for recreation development at Federal non-reservoir water resources projects consistent with Congressional intent as expressed in the Federal Water Resource Project Recreation Act of 1965 (Public Law 89-72).

NOW, THEREFORE, the parties agree as follows:

ARTICLE 1 - DEFINITION OF TERMS. For the purpose of this contract certain terms are defined as follows:

(a) First Costs: Used interchangeably with the terms "capital costs" and "project costs," are the initial capital costs of the recreation features of the project, including: engineering, design, supervision, and administration; land acquisition and construction.

(b) Recreation lands: Project lands acquired for flood control or other project purposes as described in a joint use agreement with the Flood Control District of Orange County.

(c) Recreation facilities: Those facilities for recreation which may be installed pursuant to this agreement.

ARTICLE 2 - LANDS AND FACILITIES.

(a) The County is required to provide all recreation lands through a joint use agreeement with the Flood Control District of Orange County (hereinafter called the "District"). Lands not required for the construction and operation of the flood control project are not subject to the provisions of this contract.

(b) The Government, in cooperation with the County, will prepare a mutually acceptable General Design Memorandum-Phase II which will depict and identify the types and quantities of recreation facilities which the Government and the County of Orange will construct in accordance with this contract. The presently estimated cost of facilities to be provided is contained in Exhibit A, entitled "Estimated Recreation First Cost", attached hereto and made a part hereof. Such estimate of facility cost is subject to reasonable adjustment as appropriate upon approval of the above mentioned Phase II - General Design Memorandum.

(c) The facilities as shown in Exhibit A, as it may be adjusted in accordance with paragraph (b) above, shall be constructed jointly by the parties through mutually satisfactory division of responsibility for construction that takes into account direct and indirect cost savings which may be gained by the parties in the public interest for certain specific facilities, provided, that the facilities to be constructed by each party shall be formally agreed upon by the two parties prior to construction, consistent with the provisions of Article 3.

(d) Title to all lands and recreation facilities constructed on flood control project lands, shall at all times be in the County and the County shall not transfer title to any non-public entity. The County shall, under this agreement, dedicate the land for recreation use.

(e) The performance of any obligation or the expenditure of any funds by the Government under this contract is contingent upon Congress making the necessary appropriations and funds being allocated and made available for the work required hereunder.

ARTICLE 3 - CONSIDERATION AND PAYMENT. Each party hereto will pay or contribute in kind fifty percent (50%) of the first costs of recreation development.

(a) Development. Fifty percent (50%) of the estimated first costs of recreation development is estimated to be $300,000. Prior to the advertisement of the first construction contract hereunder and again prior to the advertisement of each subsequent construction contract thereafter, the Government Contracting Officer shall calculate the estimated expenditures which each party shall have made up to the time of advertising of the applicable contract. If the total estimated expenditures by the Government shall exceed those of the County, the County shall pay to the Government such sum as will equalize the expenditures of both parties, prior to award of such contract. In computing expenditures, there shall be considered, in addition to cash expenditures, contributions in kind such as facilities, at the fair market value thereof at the time such land and facilities are provided, which value shall not include enhancement due to the project. Upon completion of recreation development, an adjustment will be made on the basis of actual costs incurred. It is understood and agreed that the County's share of the cost of the construction shall be computed on the basis of actual costs to the Government of the work included in the Government construction contract above and on the basis of unit prices in the Government contract and final quantities covering labor, materials, and equipment required for the work under the Government construction contract plus the actual amount, estimated at thirty-one percent (31), of the Government's costs for engineering, design, supervision and administration and not on the basis of prior estimates.

(b) Other Federal Funds. No payment credit of any kind whatsoever will be allowed the County for expenditures financed by, involving, or consisting of, either in whole or in part, contributions or grants of assistance received from any Federal agency in providing any lands or facilities for recreation enhancement hereunder.

(c) Adjustments to Reflect Costs. The dollar amounts set forth in this Article are based upon the Government's best estimates, and are subject to adjustments based on the costs actually incurred. Such estimates are not to be construed as representations of the total financial responsibilities of each of the parties.

ARTICLE 4 - CONSTRUCTION AND OPERATION OF ADDITIONAL FACILITIES. Certain types of facilities including but not necessarily limited to restaurants, lodges, golf courses, cabins, clubhouses, overnight or vacation-type structures, stables, marinas, swimming pools, commissaries, chairlifts, and such similar revenue-producing facilities may be constructed by the City or third parties and may be operated by the City or by third parties on a concession basis. Any such construction and operation of these types of facilities shall be compatible with all project purposes and shall be subject to the prior approval of the Contracting Officer. However, the County shall not receive credit for costs of such facilities against amounts due and payable under Article 3.

ARTICLE 5 - FEE AND CHARGES. The County may assess and collect fees for entrance to developed recreation areas and for use of the project facilities and areas, in accordance with a fee schedule mutually agreed to by the parties. Not less often than every five (5) years, the parties will review such schedule and upon the request of either, renegotiate the schedule. The renegotiated fee schedule shall, upon written agreement thereto by the parties, supersede prior schedules without the necessity of modifying this contractual document.

ARTICLE 6 - FEDERAL AND STATE LAWS.

(a) In acting under its rights and obligations hereunder, the County agrees to comply with all applicable Federal and State laws and regulations, including but not limited to the provisions of the Davis-Bacon Act (40 U.S.C. 276 a-a (7); the Contract Work Hours and Safety Standards Act (40 U.S.C. 327-333); and part 3 of Title 29, Code of Federal Regulations.

(b) The County furnishes its assurances that it will comply with Title VI of the Civil Rights Act of 1964 (78 Stat. 42 U.S.C. 2000d, et seq) and Department of Defense Directive 5500.11 issues pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations. The County agrees also that it will obtain such assurances from all its concessionaires.

(c) The County furnishes its assurances that it will comply with Sections 210 and 305 of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646).

ARTICLE 7 - OPERATION AND MAINTENANCE. The County shall be responsible for operation, maintenance, and replacement without cost to the Government, of all facilities developed to support Project recreation opportunities. The City shall maintain all recreation project lands, waters and facilities in a manner satisfactory to the Contracting Officer.

ARTICLE 8 - RELEASE OF CLAIMS. The Government and its officers and employees shall not be liable in any manner to the County for or on account of damage caused by the development, operation, and maintenance of the recreation facilities of the Project. The County hereby releases the Government and agrees to hold it free and harmless and to indemnify it from all damages, claims, or demands that may result from development, operation, and maintenance of the recreation areas and facilities. The County will not be responsible for Corps negligence or that of the construction contractor during the time the Corps is supervising such construction.

ARTICLE 9 - TRANSFER OR ASSIGNMENT. The County shall not transfer or assign this contract nor any rights acquired thereunder, nor grant any interest, privilege or license whatsoever in connection with this contract without prior approval of the Secretary of the Army or his authorized representative except as provided in Article 4 of this contract.

ARTICLE 10 - DEFAULT. In the event the County fails to meet any of its obligations under this agreement, the Government may terminate the whole or any part of this contract. The rights and remedies of the Government provided in this Article shall not be exclusive and are in addition to any other rights and remedies provided by law or under this contract.

ARTICLE 11 - EXAMINATION OF RECORDS. The Government and the County shall maintain books, records, documents, and other evidence pertaining to costs and expenses incurred under this contract, to the extent and in such detail as will properly reflect all net costs, direct and indirect, of labor, materials, equipment, supplies, and services, and other costs and expenses of whatever nature involved therein. The Government and the County shall make available at their offices at reasonable times, the accounting records for inspection and audit by an authorized representative of the parties to this contract during the period this contract is in effect.

ARTICLE 12 - <u>RELATIONSHIP OF PARTIES</u>. The parties to this contract act in an independent capacity in the performance of their respective functions under this contract and neither party is to be considered the officer, agent, or employee of the other.

ARTICLE 13 - <u>INSPECTION</u>. The Government shall at all times have the right to make inspections concerning the operation and maintenance of the lands and facilities to be provided hereunder.

ARTICLE 14 - <u>OFFICIALS NOT TO BENEFIT</u>. No member or delegate to the Congress, or Resident Commissioner, shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefits.

ARTICLE 15 - <u>COVENANT AGAINST CONTINGENT FEES</u>. The County warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon agreement or understanding for a commission, percentage, broker-age, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the County for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this contract without liability or in its discretion to add to the contract price or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 16 - <u>ENVIRONMENTAL QUALITY</u>.

(a) In furtherance of the purpose and policy of the National Environmental Policy Act of 1969 (Public Law 91-190, 42 U.S.C. 4321, 4331-4335) and Executive Order 11514, entitled "Protection and Enhancement of Environmental Quality," March 5, 1970 (35 Federal Register 4247, Mar 7, 1970) the Government and the County recognize the importance of preservation and enhancement of the quality of the environment and the elimination of environmental pollution. Actions by either party will occur after considerations of all possible effects upon the Project Environmental Resources and will incorporate adequate and appropriate measures to insure that the quality of the environment will not be degraded or unfavorably altered.

(b) During construction and operation undertaken by either party, specific actions will be taken to control environmental pollution that could result from their activities and to comply with applicable Federal, State and local regulations concerning environmental pollution. Particular attention should be given to (1) reduction of air pollution by control of burning, minimization of dust, containment of chemical vapors, and control of engine exhaust gases and smoke from temporary heaters; (2) reduction of water pollution by control of sanitary facilities, storage of fuels and other contaminants, and control of turbidity and siltation from erosion; (3) minimization of noise levels; (4) on and off site disposal of waste and spoil activities; and (5) prevention of landscape defacement and damage; and (6) reduction of groundwater mining through safe-yield pumping of wells.

ARTICLE 17 - EFFECTIVE DATE. This contract shall take effect upon approval by the Secretary of the Army or his authorized representative.

IN WITNESS WHEREOF, the parties hereto have executed this contract as of the day and year first above written.

THE UNITED STATES OF AMERICA

By ______________________________
Colonel, Corps of Engineers
District Engineer
Contracting Officer

DATE ______________________________

APPROVED:

____

DATE ______________________________

THE COUNTY OF ORANGE

By ______________________________
Chairman,
Board of Supervisors

ATTEST:

____
(Title)

Exhibit A

Estimated Recreation First Cost
Santa Ana River Mainstem, including
Santiago Creek - County of Orange
Mainstem Feature

Item No.	Description	Local Cost	Federal Cost
1.	Bike Trail	$158,375	$158,375
2.	Equestrian/Hiking Trail	33,100	33,100
3.	Bridge (10' x 90')	32,500	32,500
4.	Signs (Marker)	2,262	2,262
5.	Signs (Entrance/Directional)	3,000	3,000
6.	Signs (Traffic Control)	1,800	1,800
7.	Gate	500	500
	Subtotal	$231,537	$231,537
	Contingencies	33,963	33,963
	Subtotal	265,500	265,500
	Engineering and Design	18,500	18,500
	Supervision and Administration	16,000	16,000
	TOTAL RECREATION	$300,000	$300,000

Exhibit B

The undersigned, as Chief Legal Officer for the County of Orange approves the foregoing agreement as to form and legality this ____ day of   19__. I have reviewed the contract in the light of the requirements of Section 221 of Public Law 91-611. I further find the County of Orange is a legally constituted body having full legal authority to enter into the foregoing agreement and to respond in damages in the event that it fails to fulfill its contractual obligations.

____
Title

E SIDE DRAIN TABULATION

100-YEAR

LOCAL STORM PEAK DISCHARGE

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	DRAIN CAPACITY CFS	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
1	"A"	0.84	1100	680	1800	RECT CHANNEL 13.5 x 8' RCB	1206+9	JOIN EXIST BOX	NO EXCESS FLOW
2				360	360	66" RCP	1202+04	JOIN EXIST PIPE	NO EXCESS FLOW
3				80	240	* 72" RCP	1189+90	JOIN EXIST PIPE	NO EXCESS FLOW
4				80	240	* 72" RCP	1189+80	JOIN EXIST PIPE	NO EXCESS FLOW

* OVERLAND FLOW DRAINS INTO DROP STRUCTURE FROM REGIONAL PARK AREA

** THE WATER SURFACE ELEVATION FOR THE CONTEMPORANEUS LOCAL STORM DISCHARGE IN THE RIVER WAS USED TO DETERMINATE THE DRAIN CAPACITY (TYPICAL ALL PAGES)

EFL 1113, 22 May 1961

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
5	"C"	4.41	4500	60	100	* 48" CMP	1186+90	JOIN EXIST PIPE	NO EXCESS FLOW
6				60	100	* 48" CMP	1184+95	JOIN EXIST PIPE	NO EXCESS FLOW
7				60	95	* 48" CMP	1184+20	JOIN EXIST PIPE	NO EXCESS FLOW
8				60	90	* 48" CMP	1184+00	JOIN EXIST PIPE	NO EXCESS FLOW
9				70	100	* 48" CMP	1183+25	JOIN EXIST PIPE	NO EXCESS FLOW
10				70	100	* 48" CMP	1183+00	JOIN EXIST PIPE	NO EXCESS FLOW
11				60	100	* 48" CMP	1182+10	JOIN EXIST PIPE	NO EXCESS FLOW
12				60	100	* 48" CMP	1181+90	JOIN EXIST PIPE	NO EXCESS FLOW
13				4000	3500	19' x 8.5' RCB (FROM YORBA REGIONAL PARK)	1180+80	JOIN EXIST BOX	EXCESS FLOW WILL GO DOWNSTREAM ON ESPERNAZA RD AND WILL BE PICK-UP BY DRAINS # 32 & 42

* OVERLAND FLOW DRAINS INTO DROP STRUCTURE FROM REGIONAL PARK

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
14	"B"	1.89	2600	1100	1100	8'x9.5' RCB	1211+10	JOIN EXIST BOX	NO EXCESS FLOW
15				1050	1050	8'x8' RCB (EXIST)	1202+20	JOIN EXIST RCB	NO EXCESS FLOW
						PROPOSED 24" RCP W/FG FOR LOWER AREA		PROVIDE OPN'G FOR PROPOSED 24" RCP	
16				430	450	60" RCP (EXIST)	1184+50	JOIN EXIST RCP	NO EXCESS FLOW
						PROPOSED 24" RCP W/FG FOR LOWER AREA		PROVIDE OPN'G FOR PROPOSED 24" RCP	
17				20	22	24" CMP (CALTRANS DRAIN)	1171+90	JOIN EXIST PIPE	NO EXCESS FLOW

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ.MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
18	"D"	1.22	1520	20	35	24" RCP	1166+60	JOIN EXIST PIPE	NO EXCESS FLOW
19				700	1000	(2) - 8'x5' RCB FREEWAY BOXES	1163+00	JOIN EXIST BOX	NO EXCESS FLOW
20				800	800	(2) - 6'x5' RCB FREEWAY BOXES	1157+90	JOIN EXIST BOX	NO EXCESS FLOW
21	"G1"	0.69	840	15	42	24" RCP	1154+40	JOIN EXIST PIPE	NO EXCESS FLOW
22				15	45	24" RCP	1150+90	JOIN EXIST PIPE	NO EXCESS FLOW
23				15	37	24" RCP	1145+90	JOIN EXIST PIPE	NO EXCESS FLOW
24				780	670	3'x6' RCB (EXISTING) 48" RCP (PROPOSED)	1134+70	JOIN EXIST BOX PROVIDE OPN'G FOR 48" RCP	NO EXCESS FLOW
25				15	32	24" RCP	1124+40	JOIN EXIST PIPE	NO EXCESS FLOW

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS: STATION	REMARKS	DISPOSITION OF EXCESS FLOW
26				1100	1100	(2)-8'x8' RCB	1114+90	JOIN EXIST PIPE	NO EXCESS FLOW
	" " G2	0.79	1120						
27				20	45	24" RCP	1105+90	JOIN EXIST PIPE	NO EXCESS FLOW

SPL 413, 22 May 1963

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
28				40	70	* 48" CMP	1174+95	JOIN EXIST PIPE	NO EXCESS FLOW
29	"ED"	0.1	125	40	110	* 72" CMP	1169+00	JOIN EXIST PIPE	NO EXCESS FLOW
30				45	110	* 72" CMP	1168+90	JOIN EXIST PIPE	NO EXCESS FLOW

* OVERLAND FLOW DRAINS INTO DROP STRUCTURES AT REGIONAL PARK

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
31				30	32	24" RCP	1148+95	JOIN EXIST PIPE	NO EXCESS FLOW
	"E"	0.55	650						
32				620	1000	102" RCP	1148+95	JOIN EXIST PIPE	NO EXCESS FLOW

SPL 113, 22 May 1962

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ.MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS: STATION	REMARKS	DISPOSITION OF EXCESS FLOW
33				60	230	66" CMP	1146+50	JOIN EXIST PIPE	NO EXCESS FLOW
34				70	300	72" CMP	1141+00	JOIN EXIST PIPE	NO EXCESS FLOW
35				60	120	39" RCP	1113+90	JOIN EXIST PIPE	NO EXCESS FLOW
36	"FG"	0.35	650	60	90	66" CMP (PARK DRAIN)	1124+97	JOIN EXIST PIPE	NO EXCESS FLOW
37				60	200	66" CMP (PARK DRAIN)	1114+20	JOIN EXIST PIPE	NO EXCESS FLOW
38				100	240	54" RCP	1099+20	JOIN EXIST PIPE	NO EXCESS FLOW
39				240	1000	(3)-72" CMP	1095+30	JOIN EXIST PIPE	NO EXCESS FLOW

SPL 433, 22 May 1963

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
40				400	400	72" RCP	1130+50	JOIN EXIST. PIPE	NO EXCESS FLOW
41	"F"	0.87	1040	60	180	42" RCP	1130+50	JOIN EXIST PIPE	NO EXCESS FLOW
42				580	1200	60" & 84" RCP	1116+70	JOIN EXIST PIPES	NO EXCESS FLOW

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
43	"JJ"	0.10	130	40	80	36" RCP W/ FLAP GATE	1076+40	JOIN EXIST PIPE	NO EXCESS FLOW
44				90	180	54" RCP	1075+70	JOIN EXIST PIPE	NO EXCESS, FLOW

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ.MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
46	"H"	2.54	2250	2250	4500	(3) - 12'X7' RCB	1096+40	JOIN EXIST BOX	NO EXCESS FLOW
46	"J" & "L"	0.57	1720	1233	1440	(3) - 8'x7' RCB (EXISTING)	1075+00	JOIN EXIST. BOX	PONDING AREA SOUTH OF RIVERSIDE FWY WHICH IS OUTSIDE OF PROJECT AREA
47				30	30	24" RCP W/ FLAP GATE	1065+80	JOIN EXIST PIPE	NO EXCESS FLOW
48				70	100	48" RCP	1062+30	JOIN EXIST PIPE PROVIDE FLAP GATE	NO EXCESS FLOW

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
49	"I"	0.35	550	550	750	8'x6' RCB	1066+50	JOIN EXIST BOX	NO EXCESS FLOW
50	"K"	2.72	2300	4400	2400	20'x11.5' RCB	1059+40	JOIN EXIST BOX.	NO EXCESS FLOW

SPL 433, 22 May 1962

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
51 51A				460	300	54" RCP (EXIST)	1046+70	JOIN EXIST 54" RCP	NO EXCESS FLOW
					160	60" RCP (PROPOSED)		PROVIDE OUTLET STRUCT.	
	"L2"	0.61	600					FOR PROPOSED 60" RCP	
52				140	200	54" RCP	1037+90	JOIN EXIST PIPE	NO EXCESS FLOW
53				480	580	54" RCP (EXIST.)	1029+20	JOIN EXIST 54" RCP	NO EXCESS FLOW
						42" RCP (PROPOSED)		PROVIDE OUTLET STR.	
						BY CITY OF ANAHAIM		FOR PROPOSED 42" RCP	
54	"L3"	0.48	640	15	50	12" STL PIPE	1021+9[illegible]	REPLACE 12" STL	NO EXCESS FLOW
						24" RCP (PROP.)		WITH 24" RCP	
55				15	20	18" CMP	1013+60	JOIN EXIST PIPE	NO EXCESS FLOW
56				180	760	(4) - 48" RCP	1007+40	JOIN EXIST. PIPE	NO EXCESS FLOW
								INSTALL FLAP GATES	

SPL 433, 22 May 1961

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
57				440	480	(2) - 60" RCP (EXIST)	994+70	JOIN EXIST (2)-60" RCP	
						(1) - 36" RCP (EXIST)	994+70	JOIN EXIST 36" RCP	NO EXCESS FLOW
						72" RCP (PROPOSED)		PROVIDE OUTLET STRUCT.	
								FOR PROPOSED 72" RCP	
58	"L4"	0.44	600	60	100	(2) - 30" CMP	990+90	JOIN EXIST PIPES	NO EXCESS FLOW
59				100	160	43" RCP	934+50	JOIN EXIST PIPE	NO EXCESS FLOW

ENG 1 113, 22 May 1963

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
60				30	65	30" RCP	1046+50	JOIN EXIST PIPE	NO EXCESS FLOW
61				*	*	(3)-36" CMP W/F.G DIVERSION WORKS (FROM POND TO RIVER)	1031+30	JOIN EXIST PIPE	NO EXCESS FLOW
62				*	*	(4) - 36" CMP W/F.G (DIV. WORKS) (LOCATED IN RIVER)	1030+40	JOIN EXIST PIPE	NO EXCESS FLOW
63	"NL"	0.35	360	280	700	72" RCP (TO SPREADING GROUND)	1019+10	JOIN EXIST PIPE	NO EXCESS FLOW
64				50	55	36" RCP (TO SPREADING GROUND)	1019+05	JOIN EXIST PIPE	NO EXCESS FLOW
65				*	*	(4)-36" CMP W/GATES (DIVERSION WORKS)	979+50	JOIN EXIST PIPE	NO EXCESS FLOW

* OCWD DIVERSION WORKS FOR GROUND WATER RECHARGE BASINS (NO LOCAL STORM FLOW)

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION – LOWER SANTA ANA RIVER

LEFT BANK

DRAIN	SUBAREA			TOTAL	SIDE-DRAINAGE REQUIREMENTS			REMARKS	DISPOSITION OF EXCESS FLOW
NO.	NAME	SIZE SQ.MI.	DISCHARGE PEAK C.F.S.	Q C.F.S.	INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION		
66				60	130	42" RCP	978+40	JOIN EXIST PIPE	NO EXCESS FLOW
67				20	20	18" CMP	975+65	JOIN EXIST PIPE	NO EXCESS FLOW
68	"L5"	0.63	900	20	50	24" RCP	970+60	JOIN EXIST PIPE	NO EXCESS FLOW
69				120	1250	10'x6' RCB (DEERFIELD CHANNEL)	965+85	JOIN EXIST BOX	NO EXCESS FLOW
70				80	100	42" CMP	958+30	JOIN EXIST PIPE	NO EXCESS FLOW

SPL 113, 22 May 1962

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
71	"LG"	0.50	750	20	35	24" CMP	955+10	JOIN EXIST PIPE	NO EXCESS FLOW
72				80	120	42" CMP	948+65	JOIN EXIST PIPE	NO EXCESS FLOW
73				170	150	42" RCP (EXIST)	938+65	JOIN EXIST. PIPE	NO EXCESS FLOW
					45	24" RCP (PROPOSED)		INSTALL ADDITIONAL 24" RCP.	
74				480	200	54" RCP (EXIST)	928+50	JOIN EXIST. PIPE	NO EXCESS FLOW
					400	2-54" RCP (PROPOSED)		INSTALL ADDITIONAL 2-54" RCP.	

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS: STATION	REMARKS	DISPOSITION OF EXCESS FLOW
75	"N16"	0.32	510	510	*	(4) - 36" RCP	916+25	JOIN EXIST PIPES	NO EXCESS FLOW
						W/ GATES		DIVERSION WORKS	
						/DIVERSION WORKS		TO THE SPREADING	
								GROUND	

* INTAKE DRAINS FOR OCWD GROUND WATER RECHARGE BASIN (NO LOCAL STORM DRAIN)

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER.

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
76	"LTA"	0.51	870	200	200	60" CMP	926+45	JOIN EXIST PIPE	NO EXCESS FLOW
77				40	70	36" RCP	923+75	JOIN EXIST PIPE	NO EXCESS FLOW
78				20	21	18" RCP	923+05	JOIN EXIST PIPE	NO EXCESS FLOW
79				200	300	(2) - 48" RCP w/ F.G.	907+85	JOIN EXIST PIPES	NO EXCESS FLOW
80				140	200	48" RCP & 42" RCP w/ FLAP GATES	898+00	JOIN EXIST PIPES	NO EXCESS FLOW
81				270	270	60" RCP	871+10	JOIN EXIST PIPE	NO EXCESS FLOW

SPL 113, 22 May 1961

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION – LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
82	"OOP"				*	(4) 24" CMP w/ GATES DIVERSION WORKS	893+90	JOIN EXIST PIPES	NO EXCESS FLOW
83					*	(4) 36" RCP (DIVERSION WORKS) DRAIN TO SPREADING GROUND PONDS RELEASE FLOW INTO CARBON CANYON DIVERSION	852+15	JOIN EXIST PIPE	NO EXCESS FLOW

* OVERFLOW DRAINS FOR OCWD GROUND WATER RECHARGE BASINS (NO LOCAL STORM FLOW)

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
84	"MI"	3.80	5300	5300	5500	TRAP. CHANNEL	846+25	CARBON CANYON	NO EXCESS FLOW
						(CARBON CANYON)		CHANNEL CONFLUANCE	
								STRUCTURE	
85				~	*	DIVERSION WORKS	844+45	JOIN EXIST PIPE	NO EXCESS FLOW
						36" CMP w/ F.G			DRAIN TO SPREADING GROUND POND
86				~	*	(4) - 36" CMP w/GATE	844+25	JOIN EXIST PIPES	NO EXCESS FLOW
	"OOP"	0.05							
87				~	*	(2) - 36" CMP w/GATE	813+80	JOIN EXIST PIPE	NO EXCESS FLOW
						(DIVERSION WORKS)		ADD SLIDE GATE	
88			114	114	65	42" RCP w/FG	709+20	JOIN EXIST PIPE	EXCESS FLOW WILL
						48" RCP w/FG (PROP)	709+00	ADD 48" RCP W/F.G. TO EMPTY	BE CONTAINED IN THE
88A								PONDING AREA	POND, SEE DWG 1B

* INTAKE PIPES FOR OCWD
WATER RECHARGE BASINS (NO LOCAL STORM DRAIN)

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ.MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
89				23	60	30" RCP	805+35	JOIN EXIST PIPE	NO EXCESS FLOW
90				33	100	36" CMP	799+95	JOIN EXIST PIPE	NO EXCESS FLOW
91	"P"	1.62	1800	44	160	42" RCP	797+40	JOIN EXIST PIPE	NO EXCESS FLOW
92				1700	1800	(2) 7'x7' RCB	788+05	JOIN EXIST BOX	NO EXCESS FLOW
93	"Q"	0.32	400	400	400	66" RCP	763+50	JOIN EXIST PIPE	NO EXCESS FLOW
94-1	"OPP"	0.01	20	20	31	24" CMP (DRAIN FOR GRAVEL PIT)	830+20	JOIN EXIST. PIPE	NO EXCESS FLOW

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ.MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
95				6	6.5	16" CMP	749+75	JOIN EXIST PIPE	NO EXCESS FLOW
								ADD FLAP GATE	
96				34	160	54" RCP	748+15	JOIN EXIST PIPE	NO EXCESS FLOW
97	"S"	0.39	200	100	180	42" RCP	740+35	JOIN EXIST PIPE	NO EXCESS FLOW
98				20	40	14" ACP.	724+80	JOIN EXIST PIPE	NO EXCESS FLOW
						(FORCE MAIN FROM			
						PUMP STATION)			
99				40	40	27" RCP	710+00	JOIN EXIST PIPE	NO EXCESS FLOW
						W/ FLAP GATE			

SPL 133, 22 May 1961

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
100	"O"	2.03	1400	1400	1400	* 12' x 9.5' RCB	747+90	DISCHARGE TO SPREADING GROUND BASIN.	NO EXCESS FLOW

* INTAKE FOR OCWD GROUND WATER RECHARGE BASIN (NO LOCAL STORM DRAIN)

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
101	"R"	4.90	3700	3700	3700	(2) 12'x12' RCB (COLLINS CHANNEL)	699+20	JOIN EXIST BOX TIE BACK LEVEE TO ELEV. 163.0±	NO EXCESS FLOW

EFL 613, 28 May 1962

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
102				~	*	12'x 12' RCB (OVERFLOW FROM SPREADING GROUND BASIN	735+10	JOIN EXIST BOX (OUTLET TO SANTA ANA RIVER FROM BASIN)	NO EXCESS FLOW
	"UU"	0.15	230 (102–104)						
103				70	70	36" CMP (MAINTENANCE YARD DRAINAGE)	688+60	JOIN EXIST PIPE	NO EXCESS FLOW
104				160	160	48" RCP	686+30	JOIN EXIST. PIPE	NO EXCESS FLOW

* DISCHARGE TO SANTA ANA RIVER FROM OCWD GROUND WATER RECHARGE BASIN (NO LOCAL STORM FLOW)

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
105				60	140	48" RCP W/ F.G	695+70	JOIN EXIST PIPE	NO EXCESS FLOW
106				20	38	24" RCP	682+70	JOIN EXIST PIPE	NO EXCESS FLOW
107	"TT"	1.53	310	110	210	48" RCP W/ F.G.	669+70	JOIN EXIST PIPE	NO EXCESS FLOW
108				110	110	48" RCP	659+00	JOIN EXIST PIPE INSTALL FLAP GATE	NO EXCESS FLOW
109				10	14	18" CMP	654+40	JOIN EXIST PIPE	NO EXCESS FLOW
110	"T"	1.53	1400	1400	2200	(2) 12'x9' RCB TRAP. CHANNEL	628+60	JOIN EXIST. BOX TIE BACK RIVER LEVEE TO BITTERBUSH CHANNEL	NO EXCESS FLOW

SPL 113, 22 May 1962

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ.MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
111				70	115	48" RCP	625+90	JOIN EXIST PIPE	NO EXCESS FLOW
112	"V"	0.56	620	400	750	(3) 5'x5' RCB	625+55	JOIN EXIST BOX	NO EXCESS FLOW
113				130	380	*(6) 2'x3' RCB w/F.G	621+10	JOIN EXIST BOX	NO EXCESS FLOW
114				20	20	* 24" CMP	605+10	JOIN EXIST PIPE	NO EXCESS FLOW

* FREEWAY DRAINS

SPL 113, 22 May 1961

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
115	"U"	2.61	1600	1600	1600	10'x11' RCB (EXIST)	643+40	JOIN EXIST BOX	EXCESS FLOW WILL
115A						24" RCP (PROPOSED)	640+00	ADD 24"x24" C.B.	GO ALONG THE ROAD
								WITH 24" RCP TO	TO THE LOW POINT
								CARRY EXCESS OF 30 CFS	AT CHAPMAN AVE
								BACK TO THE RIVER	BRIDGE. PROVIDE
									C.B. & PIPE CONNEC
									THROUGH THE LEVEE
									A THIS POINT.
116				50	56	(2) 30" CMP	627+10	JOIN EXIST PIPE	NO EXCESS FLOW
						W/ F.G			
								JOIN EXIST PIPE	EXCESS FLOW WILL
117				80	30	42" CMP W/F.G	620+60	PROVIDE PONDING AREA	BE CONTAINED IN THE
117A	"UV"	0.16	230			36" RCP (PROP)	618+20	INSTALL 36" RCP W/F.G	POND SEE SHT. 21
118				80	40	42" RCP W/F.G.	607+20	JOIN EXIST. PIPE	EXCESS FLOW WILL BE
								PROVIDE PONDING AREA	CONTAINED IN THE PON
									SEE DWG 22.
119				20	20	24" CMP W/F.G	607+10	JOIN EXIST. PIPE	EXCESS FLOW WILL BE
119A						36" CMP (PROP).		PROVIDE PONDING AREA	CONTAINED IN THE
								& 36" RCP DRAIN	POND. SEE DWG 22

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ.MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
120				40	110	36" RCP	600+75	JOIN EXIST PIPE PROVIDE FLAP GATE	NO EXCESS FLOW
121				40	120	36" RCP	600+30	JOIN EXIST PIPE PROVIDE FLAP GATE	NO EXCESS FLOW
122	"UVU"	0.11	190	80	190	54" RCP W/ F.G	583+20	JOIN EXIST PIPE	NO EXCESS FLOW
123				30	50	30" RCP	583+30	JOIN EXIST PIPE	NO EXCESS FLOW

SPL 433, 22 May 1963

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
								JOIN EXIST. PIPE	
124	"WV4"	0.04	90	93	28	24" RCP (EXIST)	583+50	PROVIDE ADDITIONAL	NO EXCESS FLOW
					65	36" RCP (PROPOSED)		36" RCP W/ F.G	
125	"W"	102.7	5000	5000	5000	TRAP. CHANNEL	566+00	SANTIAGO CREEK	NO EXCESS FLOW
						(SANTIAGO CREEK)		CHANNEL CONFLUANCE	
								STRUCTURE	

SPL 123, 28 May 1963

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
126				100	160	48" RCP	560+85	JOIN EXIST. PIPE	NO EXCESS FLOW
	"WVI"	0.07	130						
127				64	45	30" RCP W/F.G.	554+00	JOIN EXIST. PIPE	EXCESS FLOW WILL BE PARTIALY DIVERTED AND PARTIALLY WILL BE PONDED WITHIN THE STREETS SEE DWG 23.

SPL 113, 22 May 1963

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
128	"WV5"	0.11	99	99	99	36" CMP	536+65	JOIN EXIST PIPE	NO EXCESS FLOW
129	"WV"	0.34	400	55	115	36" RCP W/F.G	528+40	JOIN EXIST PIPE	NO EXCESS FLOW
130				15	130	36" RCP	522+40	JOIN EXIST PIPE	NO EXCESS FLOW
131				280	290	60" RCP	509+35	JOIN EXIST PIPE	NO EXCESS FLOW
132				50	140	36" RCP W/F.G	498+35	JOIN EXIST PIPE	NO EXCESS FLOW

SPL 123, 22 May 1962

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
133				100	20	24" CMP	554+90	JOIN EXIST. PIPE. ADD FLAP GATE	EXCESS FLOW WILL BE CONTAINED IN THE POND. SEE DWG 23
134				120	180	58" x 36" ARCH	534+55	JOIN EXIST. PIPE	NO EXCESS FLOW
135	"WVL"	1.21	1040	30	38	24" RCP	532+70	JOIN EXIST PIPE	NO EXCESS FLOW
136				40	80	30" RCP	529+40	JOIN EXIST PIPE	NO EXCESS FLOW
137				750	750	(3) 48" RCP W/F.G	523+10	JOIN EXIST PIPE	NO EXCESS FLOW

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ.MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
138	"WV3"	0.83	750	750	1700	(2) 10'x5'-1" RCB	503+65	JOIN EXIST BOX	NO EXCESS FLOW
						F.G NOT REQUIRED			
139	"WV6"		100	100	200	48" RCP	490+00	JOIN EXIST PIPE	NO EXCESS FLOW

SPL 113, 22 May 1961

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ.MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
140	"WVX"	0.05	60	60	50	30" RCP (EXIST)	399+70	JOIN EXIST. PIPE	NO EXCESS FLOW
						24" RCP (PROP)		INSTALL ADDITIONAL	
								24" RCP	
141	"XI"	0.39	380	75	75	(2) 24" RCP W/ F.G	353+65	JOIN EXIST PIPES	NO EXCESS FLOW
						(FORCE MAIN)		FROM PUMP STATION	
142				305	380	60" RCP W/ F.G	352+40	JOIN EXIST PIPE	NO EXCESS FLOW

SPL 113, 22 May 1961

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
143	"X3"	0.40	515	15	15	24" RCP W/ F.G. (SMALL FORCE MAIN FROM EDISON CO. YARD)	208+10	JOIN EXIST PIPE	DURING THE PEAK FLOW IN THE RIVER FLOW WILL BE DIVERT TO TAUBER CHANNE
144				500	500	(3)-36" RCP W/ F.G (FROM PUMP STATION 3 PUMPS 150,000 GPM EA)	159+10	JOIN EXIST. PIPE (ADDITIONAL 2-36" PIPES WILL BE INSTALLED)	NO EXCESS FLOW
145	"X2"	0.78	810	810	810	(4)-42" RCP FORCED MAINS W/ F.G (FROM PUMP STATION 3 PUMPS x 150,000 GPM)	91+05	JOIN EXIST PIPE (ADDITIONAL 2-42" RCP WILL BE INSTALLED)	NO EXCESS FLOW

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TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - GREENVIEW BANNING CHANNEL

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ.MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
146				92	*	42" RCP SA	189+90	PROPOSED RCP	NO EXCESS FLOW
	J1	0.17	241			GB	124+40	COLLECTOR PIPE	
								CONNECTING THOSE	
147				81	*	42" RCP SA	182+55	OUTLETS. COLLECTOR	—"—
						GB	115+40	WILL BRING FLOW	
								TO THE PUMP	
148			363	68	*	42" RCP SA	174+55	STATION LOCATED	—"—
						GB	107+80	AT THE INTERSECTION	
								OF FAIRVIEW	
								CHANNEL (SEE	
149				67	*	36" RCP SA	166+45	DWG. 47)	—"—
	01	0.09	122			GB	100+60		
								PUMPS WILL	
								DISCHARGE THE	
150				55	*	30" RCP SA	159+80	WATER TO SANTA	—"—
						GB	93+25	ANA RIVER.	
								USE 3 PUMPS	
								50.000 GPM EA.	
								CONSTRUCT CONCRETE	
								SUMP 50'x20'x20'DEEP	

* DRAINED AREA IS APPROX. 1.5' LOWER THEN 100 YRS WATER SURFACE IN GREENVILLE - BANNING CHANNEL

TABLE 1 100-YR LOCAL STORM PEAK DISCHARGE

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE SQ. MI.	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
151	GV4	2.37	2400	2400	2400	TRAP CHANNEL	152+90	CONFLUANCE STRUCT. WITH GREENVIEW BANNING CHANNEL.	NO EXCESS FLOW
152	"GV5" + "GV4" + "GV3" + "GV2"	10.5	5800	5800	5800	GREENVIEW BANNING CHANNEL INTO SANTA ANA RIVER AT HAMILTON AVE	83+00	GREENVIEW BANNING CHANNEL CONFLUANCE STRUCTURE.	NO EXCESS FLOW

SPF

LOCAL STORM PEAK DISCHARGE

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA PEAK DISCHARGE C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: INDIVIDUAL Q** C.F.S.	SIDE-DRAINAGE REQUIREMENTS: DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS: STATION	REMARKS	DISPOSITION OF EXCESS FLOW
1.				1200	1250	RECT CHANNEL 13.5'x8' RCB	1206+90	JOIN EXIST. BOX	NO EXCESS FLOW
2.				640	240	66" RCP	1202+04	JOIN EXIST PIPE	LOCAL FLOODING AS INDICATED ON PLATE NO (REGIONAL PARK)
	"A"	0.84	2140						
3.				150	150	72" RCP	1189+90	JOIN EXIST. PIPE	NO EXCESS FLOW
4				150	130	72" RCP (EXIST)	1189+80	JOIN EXIST PIPE	NO EXCESS FLOW
					25	ADD 30" RCP		ADD ADDITIONAL 30" RCP	

** THE WATER SURFACE ELEVATION FOR THE SPF LOCAL STORM DISCHARGE IN THE RIVER WAS USED TO DETERMINATE THE DRAIN CAPACITY. TYPICAL ALL PAGES

SPL 113, 22 May 1963

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
5				100	75	* 48" CMP	1186+90	JOIN EXIST PIPE	
6.				100	85	* 48" CMP	1184+95	JOIN EXIST PIPE	
7.				100	80	* 48" CMP	1184+20	JOIN EXIST PIPE	LOCAL FLOODING
8				100	50	* 48" CMP	1184+00	JOIN EXIST PIPE	AS INDICATED ON PLATE No
9.	"C"	4.41	7370	120	75	* 48" CMP	1183+25	JOIN EXIST PIPE	(REGIONAL PARK)
10				120	75	* 48" CMP	1183+00	JOIN EXIST PIPE	
11				100	70	* 48" CMP	1182+10	JOIN EXIST PIPE	
12				100	70	* 48" CMP	1181+90	JOIN EXIST PIPE	
13				6550	3000	19'x 8.5' RCB (FROM YORBA REGIONAL PARK	1180+[illegible]	JOIN EXIST BOX	LOCAL FLOODING AS INDICATED ON PLATE No (REGIONAL PARK)

* OVERLAND FLOW DRAINS INTO DROP STRUCTURE FROM REGIONAL PARK AREA

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
14				1660	1660	8'x9.5' RCB	1211+10	JOIN EXIST. BOX	NO EXCESS FLOW
15				1580	900	8'x8' RCB (EXIST)	1202+20	ADD 8'x8' RCB &	NO EXCESS FLOW
					900	8'x8' RCB (PROPOSED)		PROVIDE OUTLET	
						PROPOSED 24" RCP		STRUCTURE FOR 2	
	"B"	1.89	3920			W/F.G FOR LOWER AREA		8'x8' RCB & 24" RCP	
16				640	650	60" RCP (EXIST)	1184+50	JOIN EXIST. PIPE	NO EXCESS FLOW
						PROPOSED 24" RCP		PROVIDE OPN'G FOR	
						W/F.G. FOR LOWER AREA		24" RCP	
17				40	40	24" CMP (EXIST)	1171+90	REPLACE 24" CMP	NO EXCESS FLOW
						(CALTRANS DRAIN)		WITH 36" CMP	
						REPLACE WITH 36" RCP			

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

_____ BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
18				30	30	24" RCP	1166+60	JOIN EXIST PIPE	NO EXCESS FLOW
19	"D"	1.22	2280	1050	700	(2)-8'x5' RCB FREEWAY BOXES	1163+00	JOIN EXIST BOX UNDER FRWY.	LOCAL FLOODING AS INDICATED ON PLATE (BEHIND F-WY EMB'T)
20				1200	400	(2)-6'x5' RCB FREEWAY BOXES	1157+90	JOIN EXIST BOXES UNDER FRWY	LOCAL FLOODING AS INDICATED ON PLATE
21				25	40	24" RCP	1154+40	JOIN EXIST. PIPE	NO EXCESS FLOW
22				25	35	24" RCP	1150+90	JOIN EXIST. PIPE	NO EXCESS FLOW
23	"G1"	0.59	1290	25	28	24" RCP	1145+90	JOIN EXIST. PIPE	NO EXCESS FLOW
24				1190	550	8'x6' RCB (EXIST) 48" RCP (PROP)	1134+70	JOIN EXIST BOX UNDER FRWY. PROVIDE 48" RCP AT LEVEE.	LOCAL FLOODING AS INDICATED ON PLATE NO
25				25	25	24" RCP	1124+40	JOIN EXIST. PIPE	NO EXCESS FLOW

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
26				1680	0*	(2)-8'x8' RCB	1114+90	JOIN EXIST BOX UNDER FR-WY.	LOCAL FLOODING AS INDICATED ON PLATE NE
	"G2"	0.79	1710						
27				30	35	24" RCP	1105+90	JOIN EXIST. PIPE	NO EXCESS FLOW

* BLOCKED GRAVITY CONDITIONS

SPL 113, 22 May 1961

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
28				80*	0	48" CMP	1174+95	JOIN EXIST PIPE	LOCAL FLOODING AS INDICATED ON PLATE № (IN REGIONAL PARK)
29	"ED"	0.1	265 (for drains 28–30)	90*	0	72" CMP	1169+00	JOIN EXIST. PIPE	LOCAL FLOODING AS INDICATED ON PLATE № (IN REGIONAL PARK) (for drains 29–30)
30				95*	0	72" CMP	1168+90	JOIN EXIST. PIPE	

* BLOCKED GRAVITY CONDITIONS

L.L. 413, 22 May 1962

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
31	"E"	0.55	1320	60	22	24" RCP	1148+95	JOIN EXIST PIPE	LOCAL FLOODING AS INDICATED ON PLATE No (IN REGIONAL PARK)
32				1260	900	102" RCP	1148+95	JOIN EXIST. PIPE	LOCAL FLOODING AS INDICATED ON PLATE No (IN REGIONAL PARK)

SPL 433, 22 May 1963

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS: STATION	REMARKS	DISPOSITION OF EXCESS FLOW
33				90	200	66" CMP	1146+50	JOIN EXIST. PIPE	NO EXCESS FLOW
34				100	230	72" CMP	1141+00	JOIN EXIST. PIPE	NO EXCESS FLOW
35				90	90	39" RCP	1113+90	JOIN EXIST. PIPE	NO EXCESS FLOW
36	"FG"	0.35	970	90	0*	66" CMP (PARK DRAIN)	1124+97	JOIN EXIST. PIPE	LOCAL FLOODING AS INDICATED ON PLATE A2 (IN REGIONAL PARK)
37				90	180	66" CMP	1114+20	JOIN EXIST. PIPE	NO EXCESS FLOW
38				150	200	54" RCP	1099+20	JOIN EXIST. PIPE	NO EXCESS FLOW
39				360	750	(3)-72" CMP	1095+30	JOIN EXIST. PIPES	NO EXCESS FLOW

* BLOCKED GRAVITY CONDITION

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TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS: STATION	REMARKS	DISPOSITION OF EXCESS FLOW
40				650	400	72" RCP (EXIST)	1130+50	JOIN EXIST PIPE	NO EXCESS FLOW
					250	60" RCP (PROP)		INSTALL ADDITIONAL 60" RCP	
41	"F"	0.87	1700	90	130	42" RCP	1130+50	JOIN EXIST. PIPE	NO EXCESS FLOW
42				960	1000	60" & 84" RCP	1116+70	JOIN EXIST. PIPES	NO EXCESS FLOW

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS: STATION	REMARKS	DISPOSITION OF EXCESS FLOW
43	"JJ"	0.10	260	80	80	36" RCP w/ FLAP GATE	1076+40	JOIN EXIST PIPE	NO EXCESS FLOW
44				180	135	54" RCP (EXIST)	1075+70	JOIN EXIST PIPE INSTALL ADDITIONAL 36" RCP	NO EXCESS FLOW.
					45	36" RCP (PROP)			

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
45	"H"	2.54	3440	3440	1950	(3) - 12'x7' RCB	1096+40	JOIN EXIST BOX UNDER FRWY	LOCAL FLOODING AS INDICATED ON PLATE NO (IN REGIONAL PARK)
46	"J" & "L"	0.57	2970	2790	750	(3) - 8'x7' RCB (EXISTING)	1075+00	JOIN EXIST. BOX	LOCAL FLOODING SOUTH OF RIVERSIDE FRWY, OUTSIDE OF THE PROJECT AREA
47				60	18	24" RCP (EXIST) W/ FLAP GATE	1065+80	JOIN EXIST PIPE INSTALL ADDITIONAL 36" RCP W/ F.G.	NO EXCESS FLOW
					42	36" RCP (PROP) W/ FLAP GATE			
48				120	0*	48" RCP	1062+30	JOIN EXIST PIPE PROVIDE FLAP GATE	LOCAL FLOODING AS INDICATED ON PLATE NO (BETWEEN FRWY AND LEVEE)

* BLOCKED GRAVITY CONDITION

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
49	"J"	0.35	840	840	600	8'×6' RCB (EXIST)	1066+50	JOIN EXIST BOX	NO EXCESS FLOW
					240	60" RCP (PROP)		INSTALL ADDITIONAL 60" RCP.	
50	"K"	2.72	3960	3960	4000	20'×11.5' RCB	1059+90	JOIN EXIST. BOX	NO EXCESS FLOW

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
51	"L2"	0.61	1330	1020	90 120	54" RCP (EXIST) 60" RCP (PROP)	1046+70	JOIN EXIST. 54" RCP INSTALL ADDITIONAL 60" RCP	LOCAL FLOODING AS INDICATED ON PLATE No
52				290	190 100	54" RCP (EXIST) 42" RCP (PROP)	1037+90	JOIN EXIST. PIPE INSTALL ADDITIONAL 42" RCP	NO EXCESS FLOW
53	"L3"	0.48	1050	700	250 500	54" RCP (EXIST) 66" RCP (PROP)	1029+20	JOIN EXIST. 54" RCP INSTALL ADDITIONAL 66" RCP	NO EXCESS FLOW
54				25	40	12" STL (EXIST) 24" RCP (PROP)	1021+95	REPLACE 12" STL WITH 24" RCP	NO EXCESS FLOW
55				25	30	18" CMP (EXIST) 30" CMP (PROP)	1013+60	REPLACE 18" CMP WITH 30" CMP	NO EXCESS FLOW
56				960	640	(4) - 48" RCP	1007+40	JOIN EXIST PIPES INSTALL FLAP GATES	LOCAL FLOODING AS INDICATED ON PLATE No

S.L. 1113, 22 MAY 1961

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION – ______ BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
57				740	740	2-60" RCP (EXIST)	994+70	REPLACE EXIST 2-60"	NO EXCESS FLOW
						36" RCP (EXIST)		RCP & 36" RCP WITH	
						72" RCP (PROP)		72" RCP. PROVIDE	
								OUTLET STRUCTURE	
58	"L4"	0.44	1000	100	70	2-30" CMP (EXIST.)	990+90	JOIN EXIST PIPES	NO EXCESS FLOW
					30	30" CMP (PROP)		INSTALL ADDITIONAL	
								30" CMP	
59				160	115	48" RCP	984+50	JOIN EXIST. PIPE	LOCAL FLOODING
									AS INDICATED ON
									PLATE №

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
60	"NL"	0.35	790	65		30" RCP (EXIST)	1046+50	REPLACE 30" RCP	NO EXCESS FLOW
					65	36" RCP (PROP)		WITH 36" RCP	
61				*	*	(3) - 36" CMP W/ F.G.	1031+30	JOIN EXIST. PIPE	NO EXCESS FLOW
						DIVERSION WORKS			
						FROM POND TO RIVER			
62				*	*	(4) - 36" CMP	1030+40	JOIN EXIST. PIPE	NO EXCESS FLOW
						W/ F.G. (DIV. WORKS)			
						LOCATED IN RIVER			
63				610	610	72" RCP	1019+10	JOIN EXIST. PIPE	NO EXCESS FLOW
						(TO SPREADING GRD)			
64				115	115	36" RCP	1019+05	JOIN EXIST. PIPE	NO EXCESS FLOW
						(TO SPREADING GRD)			
65				*	*	(4) - 36" CMP	979+50	JOIN EXIST. PIPE	NO EXCESS FLOW
						W/ GATES			
						(DIVERSION WORKS)			

* O.C.W.D. DIVERSION WORKS FOR GROUND WATER RECHARGE BASINS (NO LOCAL STORM FLOW)

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
66				100	110	42" RCP	978+40	JOIN EXIST. PIPE	NO EXCESS FLOW
67				35		18" CMP (EXIST)	975+65	REPLACE 18" CMP	NO EXCESS FLOW
					35	36" CMP (PROP)		WITH 36" CMP	
68	"L5"	0.63	1490	35	40	24" RCP	970+60	JOIN EXIST. PIPE	NO EXCESS FLOW
69				1190	1200	10'x6' RCB	965+85	JOIN EXIST. BOX	NO EXCESS FLOW
						(DEERFIELD CHANNEL)			
70				130	130	42" CMP	958+30	JOIN EXIST. PIPE	NO EXCESS FLOW

SPL 433, 22 May 1962

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
71				30	30	24" CMP	955+10	JOIN EXIST PIPE	NO EXCESS FLOW
72				130	100	42" CMP	948+65	INCREASE TO 48"	NO EXCESS FLOW
					(130)			CMP.	
73	"LG"	0.50	1240	290	150	42" RCP (EXIST)	938+65	JOIN EXIST. PIPE	NO EXCESS FLOW
					150	48" RCP (PROP)		INSTALL ADDITIONAL	
								48" RCP	
74				660	150	54" RCP (EXIST)	928+50	JOIN EXIST PIPE	LOCAL FLOODING
				130	300	2-54" RCP (PROP)		INSTALL ADDITIONAL	AS INDICATED ON
								2-54" RCP	PLATE NO

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
75	"N1G"	0.32	780	780	*	(4) - 36" RCP w/ GATES (DIVERSION WORKS)	916+25	JOIN EXIST. PIPES DIVERSION WORKS TO THE SPREADING GROUND	NO EXCESS FLOW

* INTAKE DRAINS FOR OCWD GROUND WATER RECHARGE BASIN (NO LOCAL STORM DRAIN)

SPL FL 22 Nov 1963

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
76				340	500	60" CMP	926+45	JOIN EXIST. PIPE	NO EXCESS FLOW
77				70	70	36" RCP	923+75	JOIN EXIST. PIPE	NO EXCESS FLOW
78				35	19	18" RCP (EXIST)	923+05	JOIN EXIST 18" RCP &	NO EXCESS FLOW
					19	18" RCP (PROP)		INSTALL ADDITIONAL	
	" "							18" RCP.	
79	L7A	0.50	1500	345	250	(2) - 48" RCP	907+85		
						w/ F.G. (EXIST)		JOIN EXIST 2-48" RCP	NO EXCESS FLOW
					125	48" RCP w/ FG (PROP)		INSTALL ADDITIONAL	
								48" RCP w/ F.G.	
80				240	150	48" RCP & 42" RCP	898+00		
						w/ F.G (EXIST)		JOIN EXIST 48" & 42"	NO EXCESS FLOW
					90	48" RCP w/ F.G (PROP)		INSTALL ADDITIONAL 48" RCP.	
								W/ F.G.	
81				410	240	60" RCP (EXIST)	871+10		
					240	60" RCP (PROP)		JOIN EXIST 60" RCP	NO EXCESS FLOW.
								INSTALL ADDITIONAL	
								60" RCP.	

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
B2	"OOP"				*	(4) 24" CMP w/ GATES DIVERSION WORKS	B93+90	JOIN EXIST. DRAINS TO RECHARGE BASIN	NO EXCESS FLOW
B3					*	(4) 36" RCP (DIVERSION WORKS) DRAIN TO SPREADING GROUND PONDS RELEASE FLOW INTO CARBON CAN. DIVERSION	B52+15	JOIN EXIST DRAINS TO RECHARGE BASIN	NO EXCESS FLOW

* OVERFLOW DRAINS FOR O.C.W.D. GROUND WATER RECHARGE BASINS (NO LOCAL STORM FLOW)

SPL 113, 22 May 1962

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
84	"MI"	3.80	5500	5500	5500	TRAP. CHANNEL (CARBON CANYON)	846+25	JOIN CARBON CANYON CHANNEL CONFLUANCE STRUCTURE	NO EXCESS FLOW
85				*	*	36" CMP W/ F.G. BASIN INLET	844+45	JOIN EXIST. INLET DRAIN (NOT A STORM DRAIN)	NO EXCESS FLOW
86				*	*	(4) - 36" CMP W/ GATE BASIN INLET	844+25	JOIN EXIST. INLET DRAINS (NOT A STORM DRAIN)	NO EXCESS FLOW
87				*	*	(2) - 36" CMP W/ GATE (DIVERSION WORKS)	813+80	JOIN EXIST. INLET DRAINS ADD SLIDE GATE (NOT A STORM DRAIN)	NO EXCESS FLOW
88	"OOP"	0.06	180	180	0	42" RCP W/ F.G. EXIST.	709+20	JOIN EXIST PIPE	EXCESS FLOW WILL BE PONDED. SEE SHT № 18.
88A						48" RCP W/ F.G. PROP.	709+10	ADD 48" RCP W/ F.G TO EMPTY OVERFLOW POND	

* INTAKE PIPES FOR O.C.W.D. WATER RECHARGE BASINS (NO LOCAL STORM FLOW)

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
89	"P"	1.62	2760	40	55	30" RCP	805+35	JOIN EXIST. PIPE	NO EXCESS FLOW
90				50	30	36" CMP	799+95	JOIN EXIST. PIPE	NO EXCESS FLOW
91				70	150	42" RCP	797+40	JOIN EXIST. PIPE	NO EXCESS FLOW
92				1600	1600	(2) 7'x7' RCB	788+05	JOIN EXIST BOX	LOCAL FLOODING AS INDICATED ON PLATE NO
93	"Q"	0.32	610	610	320 320	66" RCP (EXIST) 66" RCP (PROP)	763+50	JOIN EXIST PIPE INSTALL ADDITIONAL 66" RCP.	NO EXCESS FLOW.
94	"OPP"	0.01	30	30	30	24" CMP (DRAIN FOR GRAVEL PIT)	830+20	JOIN EXIST. PIPE	NO EXCESS FLOW

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
95				20		16" CMP (EXIST)	749+75	REPLACE 16" CMP	NO EXCESS FLOW
					25	30" CMP (PROP)		WITH 30" CMP W/F.G.	
96				110	70	54" RCP	748+15	JOIN EXIST. PIPE	LOCAL FLOODING
									AS INDICATED ON
									PLATE NO
97	"5"	0.39	690	345	170	42" RCP	740+35	JOIN EXIST. PIPE	LOCAL FLOODING
									AS INDICATED ON
									PLATE NO
				70	70	14" ACP	724+80	JOIN EXIST PIPE	NO EXCESS FLOW
98						(FORCE MAIN		(FORCE MAIN)	
						FROM PUMP STATION)			
99				145		27" RCP (EXIST)	710+00	REPLACE 27" RCP	NO EXCESS FLOW
					150	48" RCP (PROP)		WITH 48" RCP.	

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
100	"O"	2.03	2200	2200	1800	* 12'x 9.5' RCB	747+90	THIS IS THE RCB BOX DISCHARGING TO THE SPREADING GROUND BASIN.	NO EXCESS FLOW

* INTAKE PIPES FOR OCWD GROUND WATER RECHARGE BASIN (NO LOCAL STORM DRAIN)

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN	SUBAREA			TOTAL	SIDE-DRAINAGE REQUIREMENTS			REMARKS	DISPOSITION OF EXCESS FLOW
NO.	NAME	SIZE	DISCHARGE PEAK C.F.S.	Q C.F.S.	INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION		
101	"R"	4.90	6280	6280	4000	(2) 12'x12' RCB	699+20	JOIN EXIST BOX	COLLINS CHANNEL
						(COLLINS CHANNEL)		TIE BACK LEVEES	DESIGN CAPACITY
								TO ELEV. ± 163.0	IS 3200 CFS. EXCESS
									FLOWS WILL FLOOD
									AT THE INLETS TO

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS: STATION	REMARKS	DISPOSITION OF EXCESS FLOW
102				*	*	12'x12' RCB (OVERFLOW FROM SPREADING GROUND BASIN)	735+10	JOIN EXIST BOX (OUTLET TO SANTA ANA RIVER FROM BASIN	NO EXCESS FLOW
103	"UU"	0.15	370	110	120	36" CMP (EXIST) 48" RCP (PROP)	688+60	REPLACE 36" CMP WITH 48" RCP TO DRAIN MAINTENANCE YARD.	NO EXCESS FLOW
104				260	260	48" RCP (EXIST) 60" RCP (PROP)	686+30	REPLACE 48" RCP WITH 60" RCP	NO EXCESS FLOW

* DISCHARGE TO SANTA ANA RIVER FROM OCWD GROUND WATER RECHARGE BASIN (NO LOCAL STORM FLOW)

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
105	"TT"	0.29	590	115	65	48" RCP W/ F.G.	695+70	JOIN EXIST. PIPE	NO EXCESS FLOW
					50	42" RCP W/ FG (PROP)		INSTALL ADDITIONAL 42" RCP W/ F.G.	
106				35	35	24" RCP	682+70	JOIN EXIST. PIPE	NO EXCESS FLOW
107				210	210	48" RCP W/ F.G. (F-WY DRAIN)	669+70	JOIN EXIST. PIPE	NO EXCESS FLOW
108				180	55	48" RCP	659+00	JOIN EXIST PIPE	LOCAL FLOODING AS INDICATED ON PLATE NO
109				50	10	18" CMP	654+40	REPLACE 18" CMP WITH 36" CMP	NO EXCESS FLOW
110	"T"	1.53	2060	2060	1500	(2) 12'x9' RCB TRAP CHANNEL	628+60	JOIN EXIST. BOX TIE BACK RIVER LEVEE TO BITTER-BUSH CHANNEL	LOCAL FLOODING AS INDICATED ON PLATE NO

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS: STATION	REMARKS	DISPOSITION OF EXCESS FLOW
111	"V"	0.56	1040	115		48" RCP (EXIST)	625+90	REPLACE 48" RCP	NO EXCESS FLOW
					120	60" RCP (PROP)		WITH 60" RCP.	
112				670	510	(3) 5'x5' RCB	625+55	JOIN EXIST. BOX	LOCAL FLOODING AS INDICATED ON PLATE No
113				210	220	# (6) 2'x3' RCB W/ F.G.	621+10	JOIN EXIST BOXES	NO EXCESS FLOW
114				45		# 24" CMP (EXIST)	605+10	REPLACE 24" CMP	NO EXCESS FLOW
					50	48" CMP (PROP)		WITH 48" CMP	

\# FREEWAY DRAINS

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
115	"U"	2.61	2460	2460	1800	10'x11' RCB	643+40	JOIN EXIST BOX	EXCESS FLOW WILL FLOW
						24" RCP (PROP.)	640+00	ADD 24"x24" CATCH	TO LOW POINT AT CHAPMAN
								BASIN & 24" RCP	AV. WHERE CB & 24"
									RCP WILL BE INSTALLED
116				80	24	(2) 30" CMP	627+10	JOIN EXIST PIPES	LOCAL FLOODING AS
						W/ F.G			INDICATED ON
									PLATE N2
117				120	0	42" CMP W/ F.G	620+60	JOIN EXIST PIPE.	EXCESS FLOW WILL BE
117A	"UV"	0.16	350			36" RCP W/ F.G.	618+20	PROVIDE PONDING AREA	CONTAINED IN THE
						(PROP.)		& 36" RCP DRAIN W/ F.G.	POND. SEE SHT. 21
118				120	0	42" RCP W/ F.G.	607+20	JOIN EXIST PIPE	EXCESS FLOW
								PROVIDE PONDING	CONTAINED IN THE
								AREA	POND. SEE SHT. 22
119				30	0	24" CMP W/ F.G	607+10	JOIN EXIST. PIPE	EXCESS FLOW
119A						36" RCP W/ F.G	605+50	PROVIDE PONDING	CONTAINED IN THE
						(PROP)		AREA & 36" RCP	POND. SEE SHT. 22
								DRAIN FOR PONDING	
								AREA	

SPL FORM 223, 28 Nov 1961

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
120				60	100	36" RCP	600+75	JOIN EXIST. PIPE (PROVIDE FLAP GATE)	NO EXCESS FLOW
121	"UVU"	211	280	60	110	36" RCP	600+30	JOIN EXIST. PIPE PROVIDE FLAP GATE	NO EXCESS FLOW
122				120	145	54" RCP W/F.G	583+20	JOIN EXIST. PIPE	NO EXCESS FLOW
123				40	40	30" RCP	583+30	JOIN EXIST. PIPE	NO EXCESS FLOW

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN	SUBAREA			TOTAL	SIDE-DRAINAGE REQUIREMENTS			REMARKS	DISPOSITION OF EXCESS FLOW
NO.	NAME	SIZE	DISCHARGE PEAK C.F.S.	Q C.F.S.	INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION		
124	"WV4"	0.04	130	180	0	24" RCP (EXIST)	585+50	JOIN EXIST PIPES	LOCAL FLOODING
						36" RCP (PROP.)		INSTALL ADDITIONAL	AS INDICATED ON
								36" RCP.	PLATE N2
125	"W"	102.7	5000	5000	5000	TRAP CHANNEL	566+00	SANTIAGO CREEK	NO EXCESS FLOW
						(SANTIAGO CREEK)		CONFLUANCE STRNG	

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
126				240	120	48"RCP (EXIST)	560+85	JOIN EXIST PIPE	NO EXCESS FLOW
126A					120	48" RCP (PROP.)		INSTALL ADDITIONAL 48" RCP.	
	"WVI"	0.07	320						
127				80		30"CMP w/F.G.	554+00	REPLACE 30" CMP WITH 48" CMP w/F.G.	NO EXCESS FLOW
						48"CMP w/F.G (PROP)			

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
128	"WVS"	0.11	300	300	20	36" CMP	536+65	JOIN EXIST PIPE	LOCAL FLOODING AS INDICATED ON PLATE №
129				95	100	36" RCP w/F.G.	528+40	JOIN EXIST PIPE	NO EXCESS FLOW
130	"WV"	0.34	690	25	120	36" RCP	522+40	JOIN EXIST. PIPE	NO EXCESS FLOW
131				480	210	60" RCP (EXIST)	509+35	JOIN EXIST PIPE	NO EXCESS FLOW
					270	66" RCP (PROP)		INSTALL ADDITIONAL 66" RCP. PROVIDE OPN'G	
132				90	125	36" RCP w/F.G.	498+35	JOIN EXIST PIPE	NO EXCESS FLOW

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS: DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS: STATION	REMARKS	DISPOSITION OF EXCESS FLOW
									EXCESS FLOW WILL
133				30	0	24" CMP	554+90	JOIN EXIST PIPE	BE CONTAINED IN
								(ADD FLAP GATE)	THE GOLF COURSE
									POND. SEE SHT 23
134				290	150	58" X 36" ARCH	534+55	JOIN EXIST PIPE	LOCAL FLOODING
									AS INDICATED ON
									PLATE №
135	"WV2"	1.21	1440	50		24" RCP (EXIST.)	532+70	REPLACE 24" RCP	NO EXCESS FLOW
					50	30" RCP (PROP.)		WITH 30" RCP.	
136				60	70	30" RCP	529+40	JOIN EXIST PIPE	NO EXCESS FLOW
137				1010	600	(3) 48" RCP W/F.G.	523+10	JOIN EXIST. PIPE	LOCAL FLOODING
									AS INDICATED ON
									PLATE №

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN	SUBAREA			TOTAL	SIDE-DRAINAGE REQUIREMENTS			REMARKS	DISPOSITION OF EXCESS FLOW
NO.	NAME	SIZE	DISCHARGE PEAK C.F.S.	Q C.F.S.	INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION		
188	"WV3"	0.83	1290	1290	1600	(2) 10'x5'-1" RCB	503+65	JOIN EXIST BOX	NO EXCESS FLOW
189	"WV6"	0.07	170	170	190	48" RCP	490+00	JOIN EXIST PIPE	NO EXCESS FLOW

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
140	"WVX"	0.03	90	90	22	30" RCP (EXIST)	349+70	JOIN EXIST PIPE	NO EXCESS FLOW
					70	48" RCP (PROP.)		INSTALL ADDITIONAL 48" RCP	
141	" XI "	0.39	580	110	110	(2) 24" RCP w/ F.G.	353+65	JOIN EXIST PIPE (FORCE MAIN)	NO EXCESS FLOW
142				470	200	60" RCP w/ F.G.	352+40	JOIN EXIST PIPE (EXCESS FLOW)	LOCAL FLOODING AS INDICATED ON PLATE No

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

RIGHT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
143	"X3"	0.40	770	25	25	24" RCP W/ F.G. (SMALL FORCE MAIN FROM EDISON YARD)	208+10	JOIN EXIST PIPE FORCE MAIN DRAIN SMALL SUMP	NO EXCESS FLOW DURING THE PEAK FLOW IN THE RIVER FLOW WILL BE DIVERTED TO TAUBER CHANNEL.
144				745	745	(3)-36" RCP W/ F.G. (FROM PUMP STAT. 3 PUMPS X 150,000 GPM EA)	159+10	JOIN EXIST PIPE (FORCE MAIN) (ADDITIONAL 2-36" WILL BE INSTALLED BY CITY.	NO EXCESS FLOW
145	"X2"	0.78	1240	1240	1240	(4)-42" RCP FORCED MAINS W/F.G. FROM PUMP STATION (8 PUMPS X 150,000 GPM EA)	91+05	JOIN EXIST PIPE (FORCE MAIN) (ADDITIONAL 2-42" RCP WILL BE INSTALLED BY CITY.	NO EXCESS FLOW

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	DRAIN CAPACITY CFS	DESCRIPTION	STATION	REMARKS	DISPOSITION OF EXCESS FLOW
146				135	*	42" RCP	189+90	DRAIN TO PROPOSED HOLDING POND	NO EXCESS FLOW
147				120	*	42" RCP	182+55	DRAIN TO PROPOSED HOLDING POND	NO EXCESS FLOW
148	"GV3"	0.49	530	100	*	42" RCP	174+55	DRAIN TO PROPOSED HOLDING POND	NO EXCESS FLOW
149				90	*	36" RCP	166+45	DRAIN TO PROPOSED HOLDING POND	NO EXCESS FLOW
150				85	*	30" RCP	159+80	DRAIN TO PROPOSED HOLDING POND	NO EXCESS FLOW

* DRAINED AREA IS APPROX. 1.5' LOWER THEN 100 YRS WATER SURFACE IN GREENVILLE-BANNING CHANNEL. PROVIDE HOLDING POND.

TABLE 2 SPF LOCAL STORM PEAK DISCHARGES

PERTINENT INFORMATION ON SIDE-DRAINAGE INVESTIGATION - LOWER SANTA ANA RIVER

LEFT BANK

DRAIN NO.	SUBAREA NAME	SUBAREA SIZE	SUBAREA DISCHARGE PEAK C.F.S.	TOTAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS INDIVIDUAL Q C.F.S.	SIDE-DRAINAGE REQUIREMENTS DESCRIPTION	SIDE-DRAINAGE REQUIREMENTS STATION	REMARKS	DISPOSITION OF EXCESS FLOW
161	" " GV4	2.37	3000	3000	3000	TRAP. CHANNEL	152+90	CONFLUANCE STRUCT WITH GREENVIEW-BANNING CHANNEL	NO EXCESS FLOW
162	GV5 GV4 GV3 GV2	10.5	9300	9300	9300	GREENVIEW-BANNING CHANNEL INTO SANTA ANA RIVER AT HAMILTON AV.	B3+00	GREEN VIEW-BANNING CHANNEL CONFLUANCE STRUCTURE	NO EXCESS FLOW

SPL FORM 22 Mar 1951