APPENDIX E

GEOTECHNICAL REPORTS

SF

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING
LOS ANGELES · SAN FRANCISCO · PORTLAND · SEATTLE · NEW YORK

TRENT R. DAMES
WILLIAM W. MOORE
L. LEROY CRANDALL
WILLIAM W. BREWER
VERNON A. SMOOTS
WILLIAM ENKEBOLL

DOUGLAS 2-6507
417 MARKET STREET
SAN FRANCISCO 5, CALIF.
WILLIAM W. MOORE
WILLIAM W. BREWER

September 4, 1951

Pacific Gas and Electric Company
245 Market Street
San Francisco 6, California

Attention: Mr. I. C. Steele
Vice President and Chief Engineer

Gentlemen:

Six copies of our Report, "Preliminary Foundation Investigation, Proposed Industrial Site near Pittsburg, California, For The Pacific Gas and Electric Company", are herewith submitted.

The investigation was planned in collaboration with representatives of the Engineering Department of the Pacific Gas and Electric Company. The information developed was discussed with your Engineers and the data were transmitted in preliminary form as they became available.

Yours very truly,

DAMES & MOORE

William W. Brewer

William W. Brewer

WWB-IEO MLF

PRELIMINARY FOUNDATION INVESTIGATION

PROPOSED INDUSTRIAL SITE

NEAR PITTSBURG, CALIFORNIA

FOR THE

PACIFIC GAS AND ELECTRIC COMPANY

This report presents the results of a preliminary foundation investigation performed for the Pacific Gas and Electric Company at a prospective industrial site located immediately east of the City of Pittsburg, California. The location of the proposed site, in relation to adjacent streets and other surface features, is shown on the Plot Plan, Plate 1. The purpose of this investigation was to ascertain (1) the general suitability of the underlying soils for foundation support, and (2) the availability of suitable hydraulic fill material from the Sacramento River adjacent to the subject site for consideration relative to possible purchase of the subject property. It is understood that the major structures involved in this development will impose heavy foundation loadings and that an areal fill of some five to ten feet in thickness would be placed to bring the site to the desired grade.

EXPLORATIONS

The land portion of the site was explored by the drilling of six 6-inch-diameter test borings at the locations indicated on the Plot Plan, utilizing cable-tool drilling equipment. The borings were drilled to minimum depths of 90 feet below the existing ground surface. To ascertain the

availability of sandy materials for dredge filling, three 5-inch-diameter wash borings were drilled from barge equipment at the locations indicated on the Plot Plan. Continuous observations of the materials encountered in the borings were recorded in the field and undisturbed core samples of the various soils were extracted employing the type of sampler illustrated on Appendix A, Soil Sampler, Type U. Graphical representations of the soils encountered in the borings are presented on Plates 2A through 2G, Log of Borings, in the manner described on the Soil Classification Chart and Key to Test Data appearing on Appendix B. The depths at which ground water was encountered are indicated on the logs.

LABORATORY TESTS

SHEAR TESTS:

To determine the strengths of the various foundation strata, undisturbed core samples of the soils were tested in direct double shear. The procedures employed for this testing are described in Appendix C, Method of Performing Shear and Friction Tests. The tests were performed in automatic testing and recording apparatus which has replaced the apparatus illustrated in Appendix C.*

The majority of the tests were performed at surcharge pressures equal to the weight of the overburden existing above the depths at which the samples were extracted. The results of the shear tests, including the determinations of moisture contents and dry densities of the soils, are shown by the test bars and figures on the graph adjacent to the log of each boring in the manner described in the Key to Test Data appearing on Appendix B.

---

* The Dames & Moore Automatic Shear Machine is described in an article entitled, "Machine Speeds Soil Shear Test", which appears in the January 26, 1950 Issue of Engineering News-Record.

CONSOLIDATION TESTS:

To provide data for estimating the probable settlements of various types of foundations, consolidation (confined compression) tests were performed on selected core samples. The procedures employed for these tests are described in Appendix D, Method of Performing Consolidation Tests. The results of these tests, in terms of consolidation in inches per inch, for various intensities of loading, are presented on the Graph, "Consolidation Test Data", appearing on the upper portion of Plate 3.

DISCUSSION AND CONCLUSIONS

GENERAL SOIL CONDITIONS -- LAND AREA:

The proposed building site is located in an area of reclaimed marsh land, bordering the Sacramento River and has surface elevations of about +1 to +4 feet above Mean Lower Low Water (M.L.L.W.). In general, soft to weak and compressible slough or marsh deposits were found to underlie the site to depths varying from some 10 to 50 feet below the present ground surface. These critical soils are materially thicker on the westerly portion of the site, particularly as compared to the more easterly portion where the firmer soils were disclosed near the ground surface. These soft to weak recent clays and peat deposits are underlain predominantly by firmer clay deposits. At elevations varying from -30 to -82 feet, extensive sand deposits were encountered. It is our opinion that the foundation costs for major structures and the behavior of minor structures placed on the sandy fills, would be more desirable on the easterly portion than on the westerly portion of the site.

GENERAL SOIL CONDITIONS -- WATER AREA:

The three exploration borings drilled immediately offshore of the project site in the Sacramento River, disclose a varying thickness in the surface cover of recent soils (clayey, peaty and silty materials) overlying the more sandy deposits. On the easterly portion of the area explored, some 10 feet of recent soils were found to overlie sand deposits; whereas, the westerly boring (Boring B) disclosed considerable clays and peaty material above sandy deposits. The sands encountered in the easterly two borings would provide excellent hydraulic fill material at economical dredge depths. It is believed that these sand deposits are probably of sufficient extent so that the necessary quantity of fill material for the site development (approximately 1,000,000 cubic yards) could be obtained from the more easterly area. However, in view of the limited number of fill explorations, it is not conclusive that the necessary yardage of sand fill is readily available at economical depths. Additional sand explorations would be required for confirmation.

AREAL SUBSIDENCE:

To provide data concerning the range of areal settlements which would be expected under the weights of fills to be placed, analyses were performed for two diverse soil conditions. As graphically presented on the graph, "Areal Subsidence", appearing on Plate 3, a five-foot sandy fill placed in the vicinity of Boring 4, may be expected to undergo an ultimate settlement of approximately three inches. For the conditions disclosed by Boring 2, where the soft clayey soils extend to depths of about 50 feet, the ultimate settlements for a ten-foot fill layer would be approximately two and one-half feet. If a five-foot sandy fill were placed in the proximity of Boring 2, an ultimate settlement of approximately one and one-half

feet would be expected. The severity of areal settlements could be minimized by placing the fills as far in advance as possible of the time of the actual foundation installations.

PILE FOUNDATIONS:

The support of any major structures will require the use of driven piling. It is estimated that cast-in-place concrete piles, such as Raymond Step-tapered, or Union Metal-type piles, could be satisfactorily driven to carry loads of at least 50 tons per pile. Approximate penetrations of piling below the existing ground surface to support 50-ton external design loads per pile, are as follows:

Boring 2, 80-foot penetration
Boring 3, 75-foot penetration
Boring 4, 50-foot penetration
Boring 6, 60-foot penetration
Boring 7, 50-foot penetration
Boring 8, 50-foot penetration.

In estimating the foregoing pile penetrations, consideration has been given to the probable future down-drag forces that would be imposed by the subsidence of the fills and soft slough deposits. In the structural design of the pile foundations, the combination of these down-drag forces and external loads should be considered with respect to stresses created within the piling. No calculations of the settlement behavior of pile groups have been made during this investigation. It is possible that lengthening of the piling to minimize settlements, particularly for the more critical structures, may be desirable. It is contemplated that these problems would be thoroughly investigated, if the site were purchased for the planned development.

The following plates and appendixes are attached and complete this report:

Plate 1 - Plot Plan

Plate 2A - Log of Boring 2 (Boring 1, not drilled)

Plate 2B - Log of Boring 3

Plate 2C - Log of Boring 4 (Boring 5, not drilled)

Plate 2D - Log of Boring 6

Plate 2E - Log of Boring 7

Plate 2F - Log of Boring 8

Plate 2G - Log of Boring A, B, and C

Plate 3 - Consolidation Test Data

Areal Subsidence

Appendix A - Soil Sampler, Type U

Appendix B - Soil Classification Chart and Key to Test Data

Appendix C - Method of Performing Shear and Friction Tests

Appendix D - Method of Performing Consolidation Tests.

Respectfully Submitted,

DAMES & MOORE

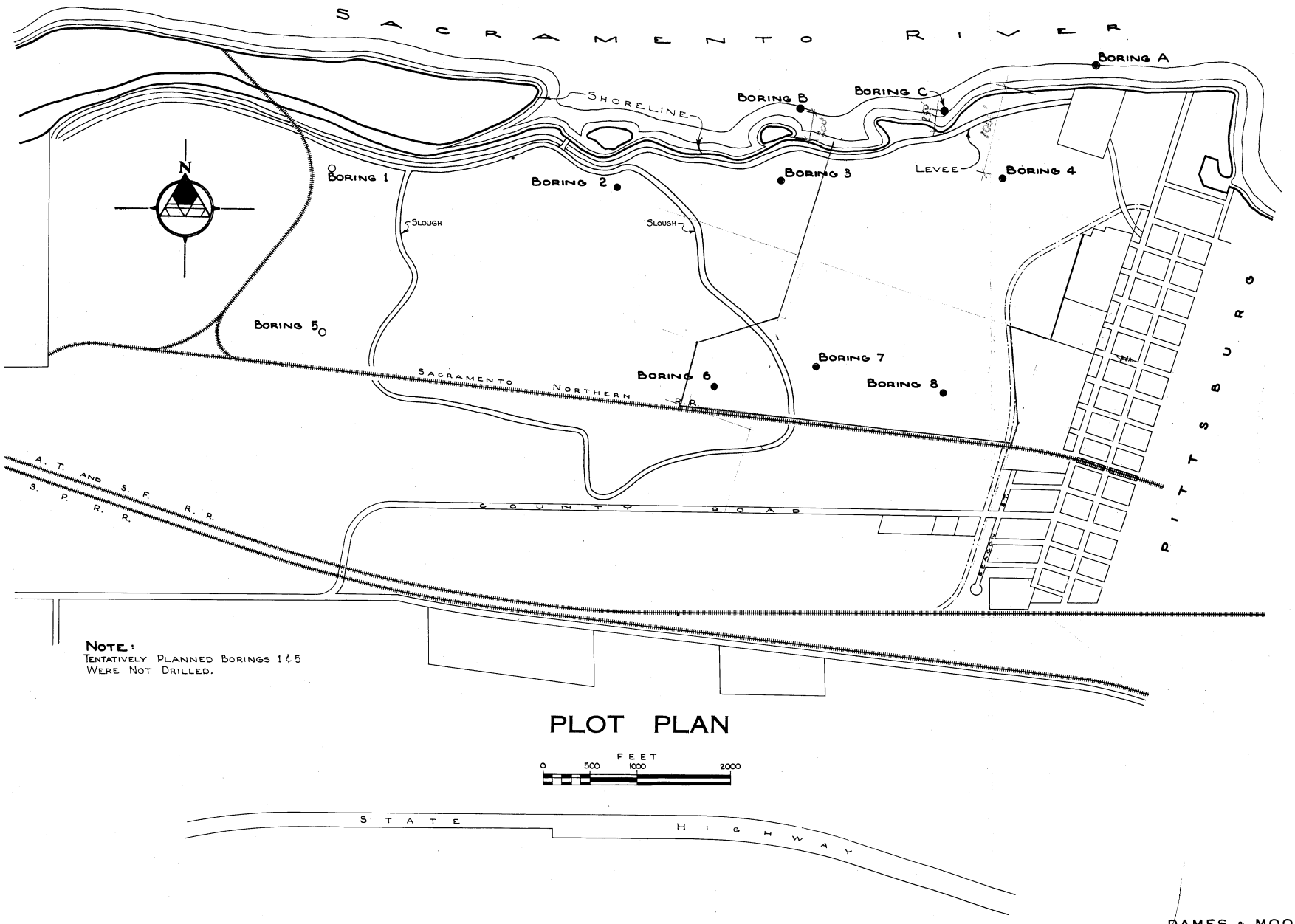
William W. Brewer

William W. Brewer

DAMES & MOORE
JOB No. 1060-A
THIS DRAWING IS ONE OF A SERIES OF 9 DRAWINGS

JOB TITLE FOUNDATION INVESTIGATION
LOCATION PITTSBURG
CLIENT UNKNOWN
DATE JOB STARTED

DRAWN BY: HARRY-J DATE 7-30-51
DATA CHECK BY: DS DATE 9-4-51
DRAFTING CHECK BY: DATE
REPORT DICTATED BY: DATE
DATE PRINTED



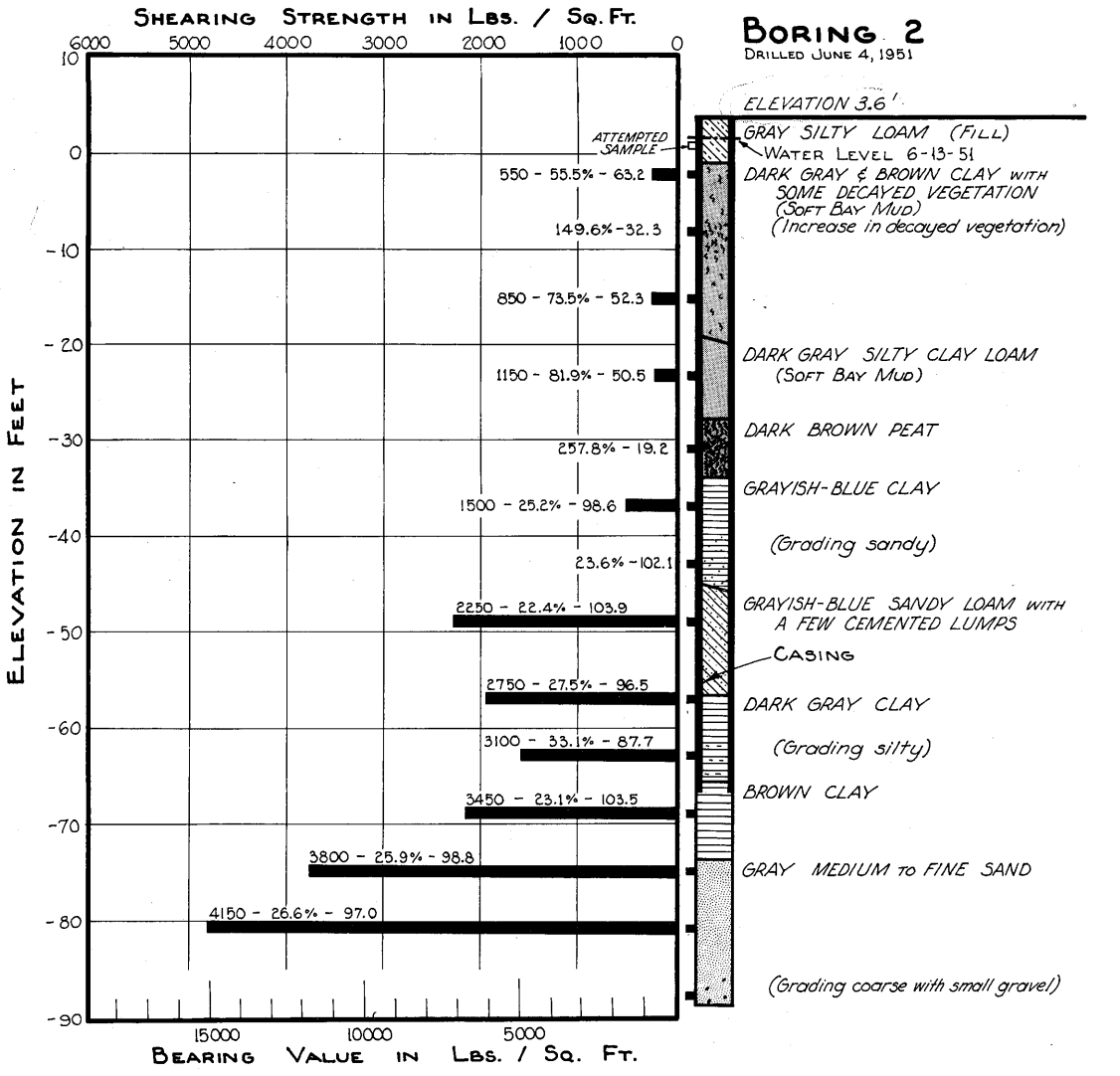
DAMES & MOORE
FOUNDATION ENGINEERS

PLATE 1

JOB No. 1060-A LOCATION PITTSBURG, CALIF. DATE 7-26-51
THIS DRAWING IS ONE OF A SERIES OF 9 DRAWINGS CLIENT OWEN UNKNOWN DATA CHECK BY
DATE JOB STARTED DRAFTING CHECK BY DS DATE
DATE PRINTED REPORT DICTATED BY DATE

BORING 1
NOT DRILLED

BORING 2
DRILLED JUNE 4, 1951

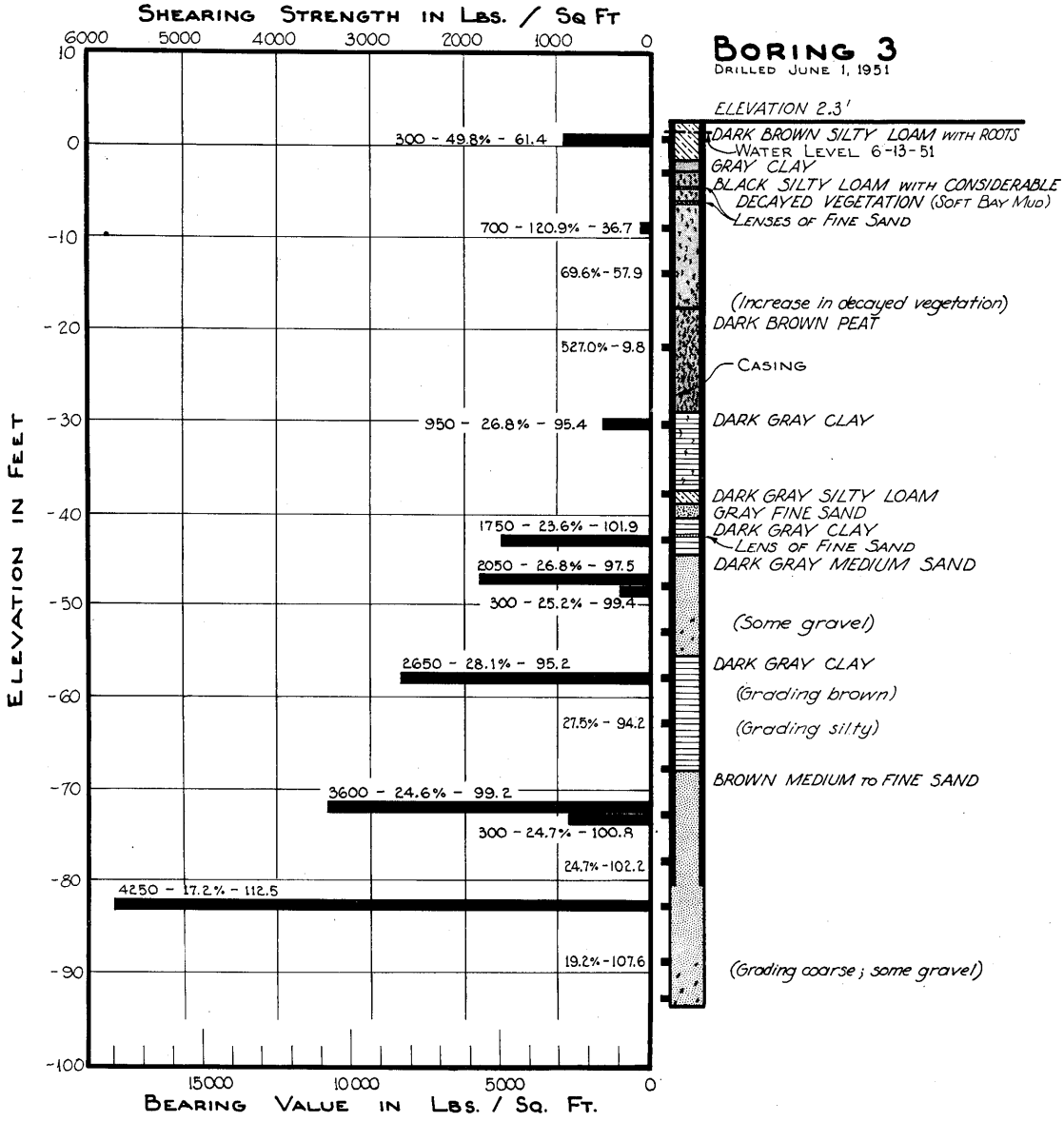


NOTE:
ELEVATION DATUM: M.L.L.W = 0.0'

LOG OF BORINGS

DAMES & MOORE
FOUNDATION ENGINEERS

PLATE 2A



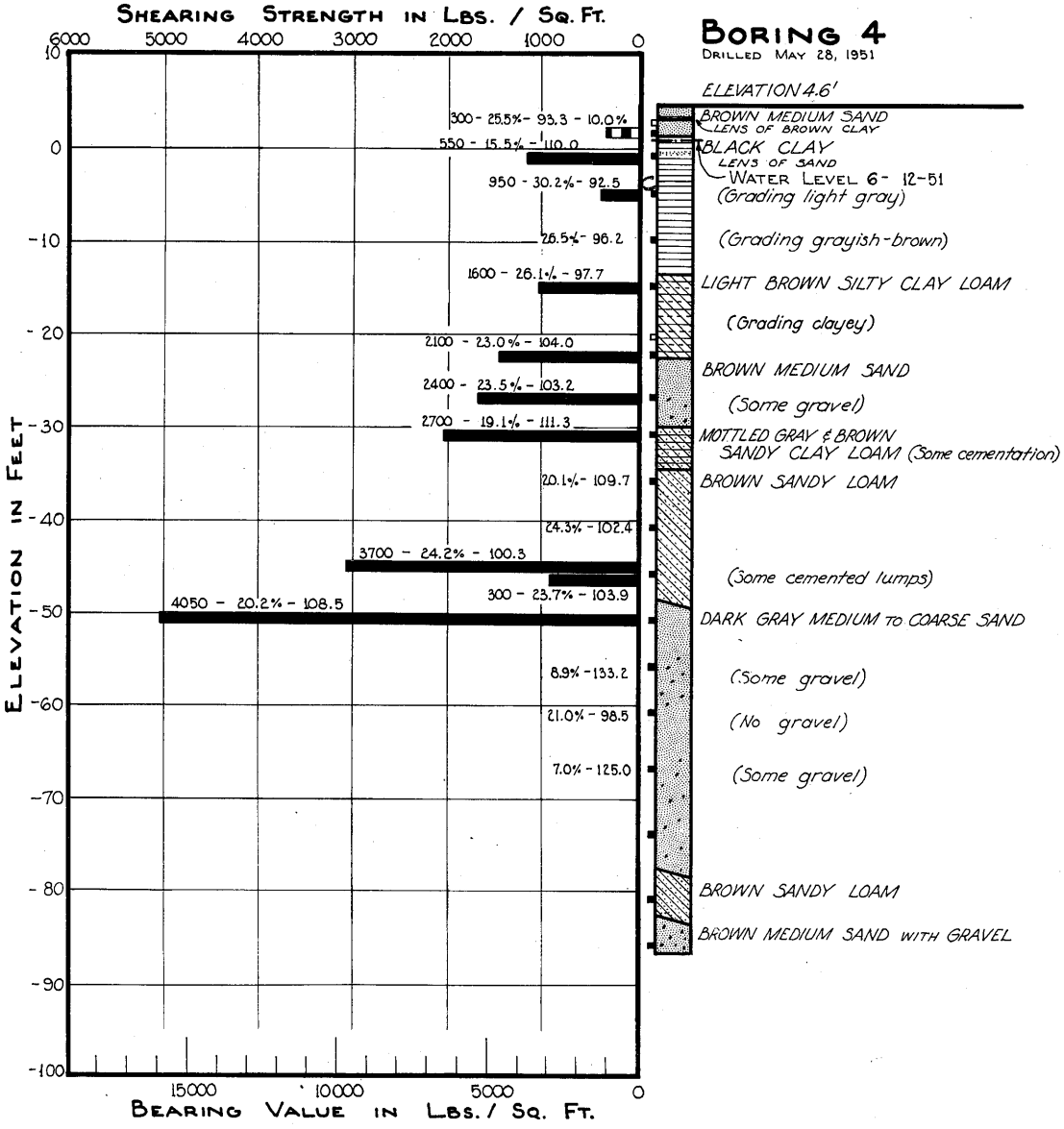
LOG OF BORINGS

DAMES & MOORE
FOUNDATION ENGINEERS

PLATE 2B

JOB No. 1080-A LOCATION PITTSBURG, CALIF.
THIS DRAWING IS ONE OF A SERIES OF 9 DRAWINGS
CLIENT CHEVRON OIL CO.
DATE JOB STARTED
DATE PRINTED
DATA CHECK BY
DRAFTING CHECK BY DS DATE 7-26-51
REPORT DICTATED BY
DATE
DATE

JOB No. 1060-A LOCATION PITTSBURG, CALIF.
THIS DRAWING IS ONE OF A SERIES OF 9 DRAWINGS
CLIENT OWEN UNKNOWN
DATE JOB STARTED
DATE PRINTED
DATA CHECK BY DATE 7-26-51
DRAFTING CHECK BY DS DATE
REPORT DICTATED BY DATE



LOG OF BORINGS

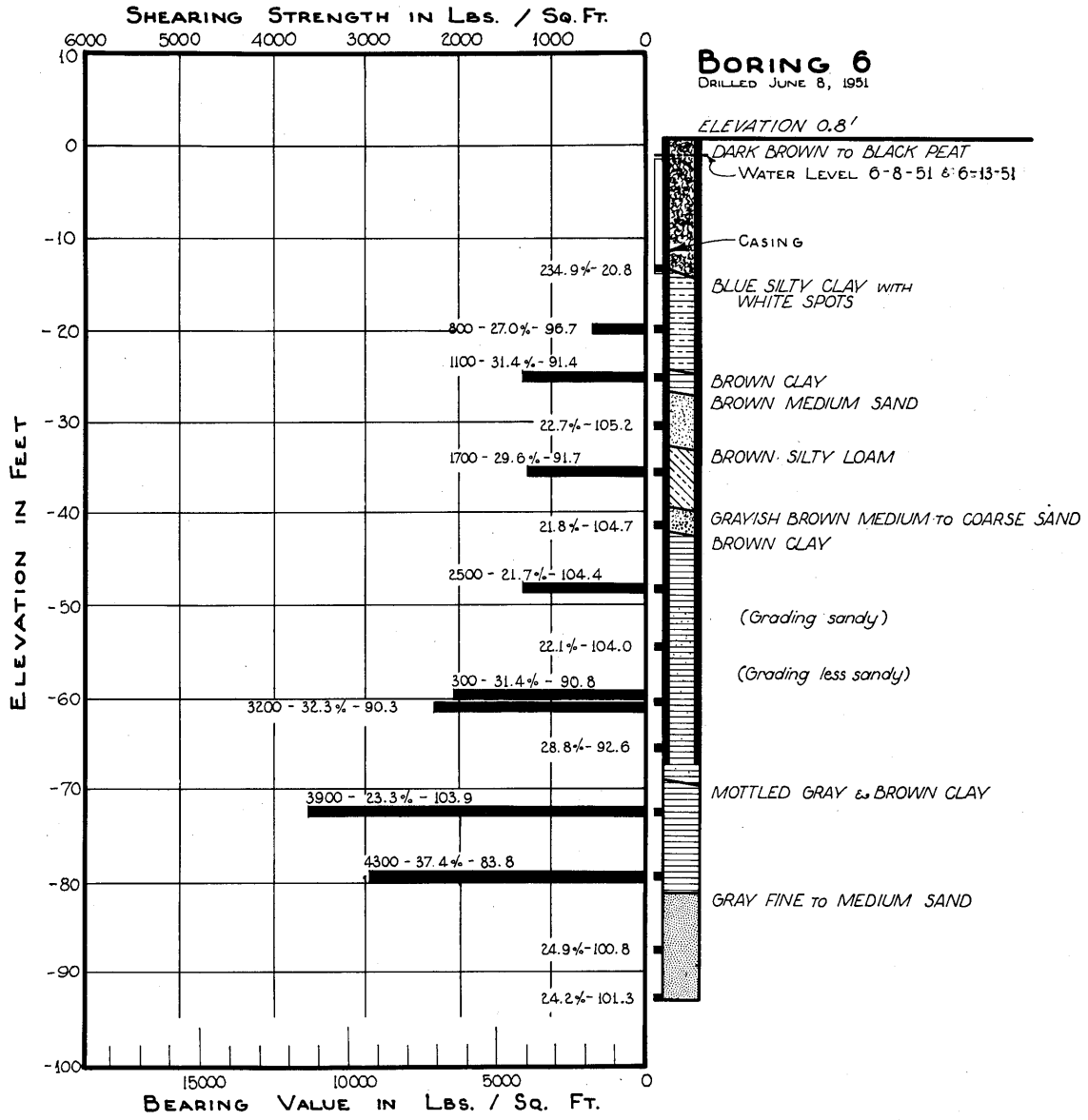
DAMES & MOORE
FOUNDATION ENGINEERS

PLATE 2C

JOB No. 1060-A LOCATION Pittsburg, Calif. DATE 7-26-51
THIS DRAWING IS ONE OF A CLIENT Owner Unknown DATA CHECK BY
SERIES OF 9 DRAWINGS DATE JOB STARTED DRAFTING CHECK BY DS DATE
DATE PRINTED REPORT DICTATED BY DATE

BORING 5
NOT DRILLED

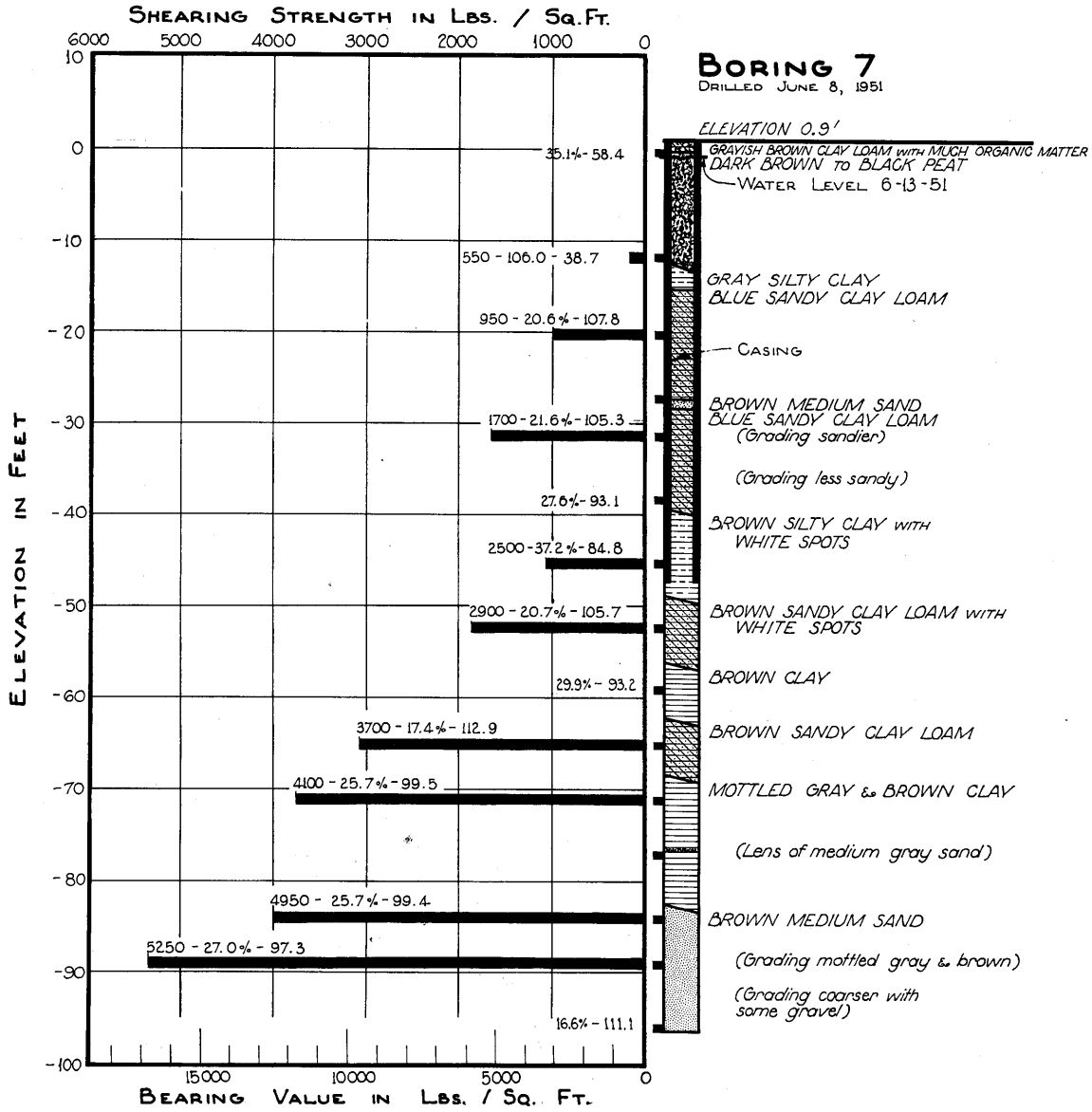
BORING 6
DRILLED JUNE 8, 1951



LOG OF BORINGS

DAMES & MOORE
FOUNDATION ENGINEERS

PLATE 2D

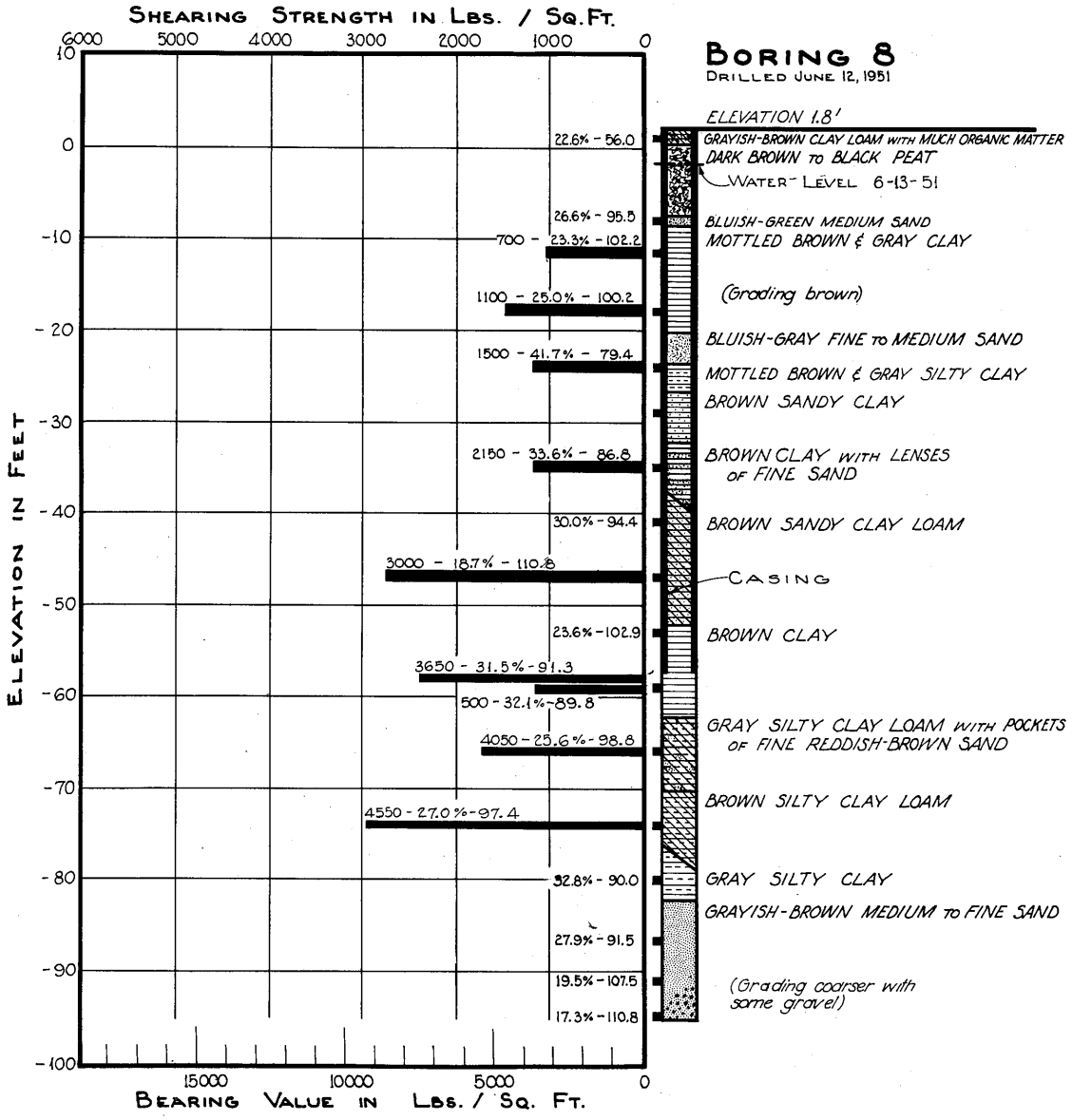


LOG OF BORINGS

DAMES & MOORE
FOUNDATION ENGINEERS

PLATE 2E

JOB No. 1060-A
THIS DRAWING IS ONE OF A SERIES OF 9 DRAWINGS
LOCATION PITTSBURG, CALIF.
CLIENT OWNER UNKNOWN
DATE JOB STARTED
DATE PRINTED
DATA CHECK BY
DRAFTING CHECK BY D.S
REPORT DICTATED BY
DATE 7-26-51
DATE
DATE



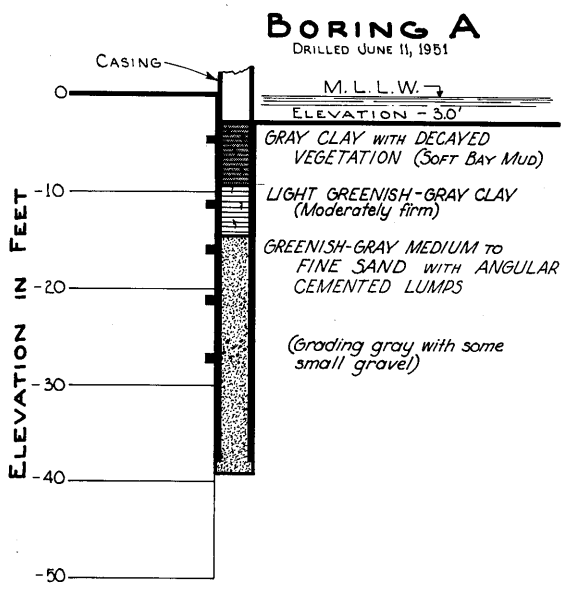
LOG OF BORINGS

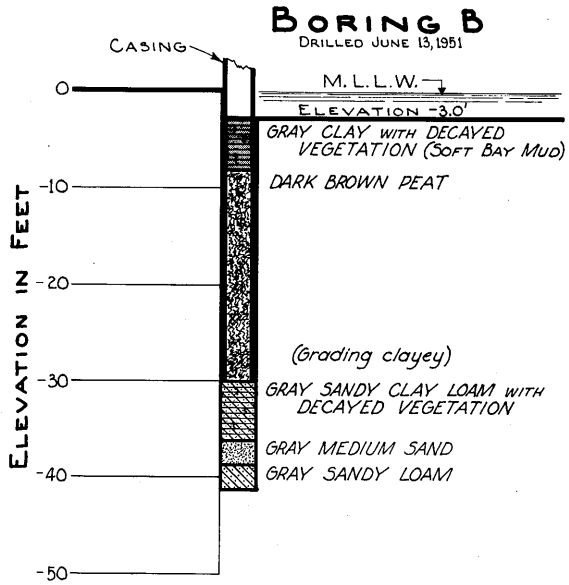
LOCATION Pittsburg, Calif.
CLIENT Owner Unknown
DATE JOB STARTED
DATE PRINTED
JOB No. 1060-A
THIS DRAWING IS ONE OF A SERIES OF 4 DRAWINGS
DATA CHECK BY
DATE 7-26-51
DRAFTING CHECK BY DS
DATE
REPORT DICTATED BY
DATE

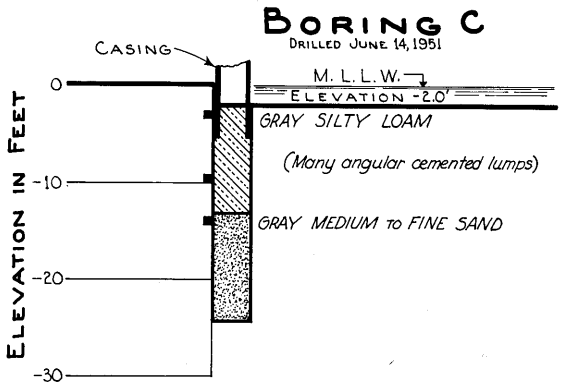
DAMES & MOORE
FOUNDATION ENGINEERS

PLATE 2F

JOB No. 1060-A LOCATION PITTSBURG, CALIF.
THIS DRAWING IS ONE OF A SERIES OF 9 DRAWINGS
CLIENT OWNER UNKNOWN DATE JOB STARTED DATE PRINTED
DATA CHECK BY JL DATE 7-26-51
DRAFTING CHECK BY DS DATE
REPORT DICTATED BY DATE



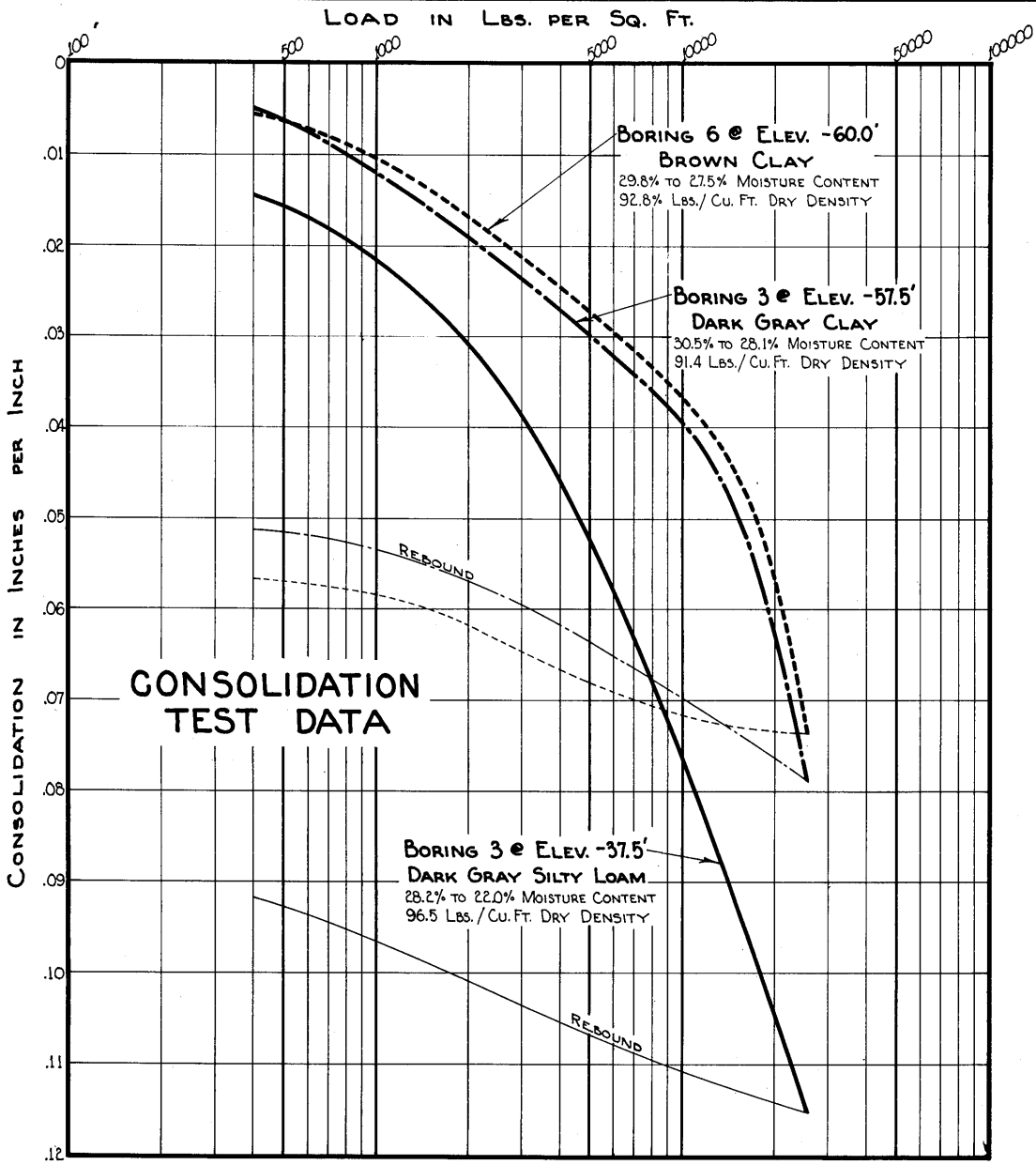


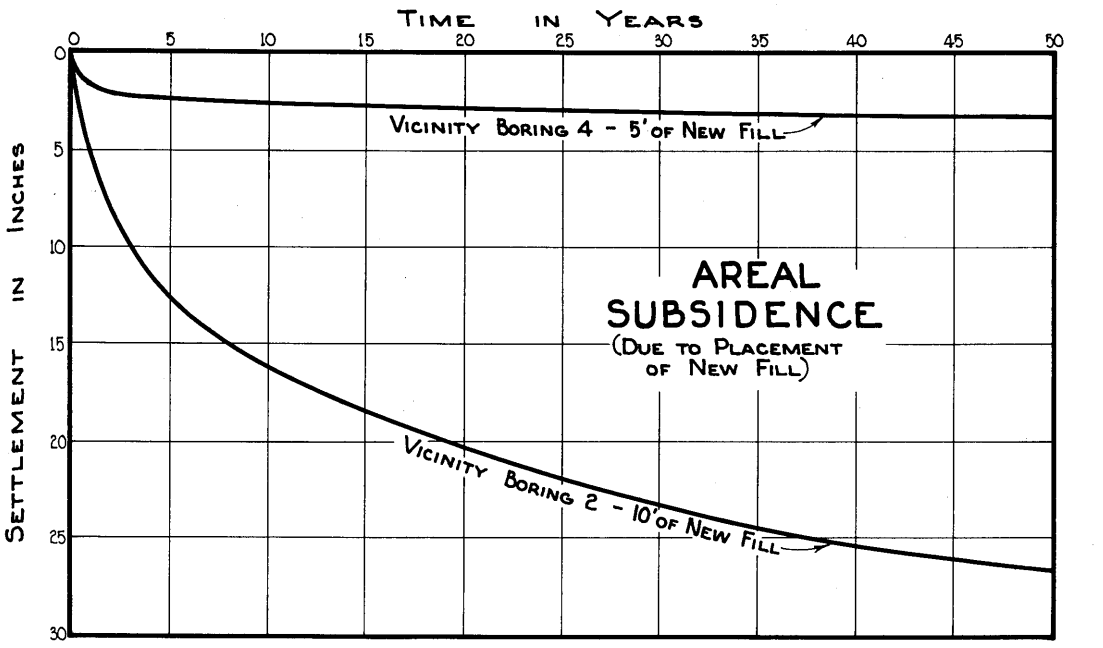


LOG OF BORINGS

DAMES & MOORE
FOUNDATION ENGINEERS

PLATE 2G





DAMES & MOORE
FOUNDATION ENGINEERS

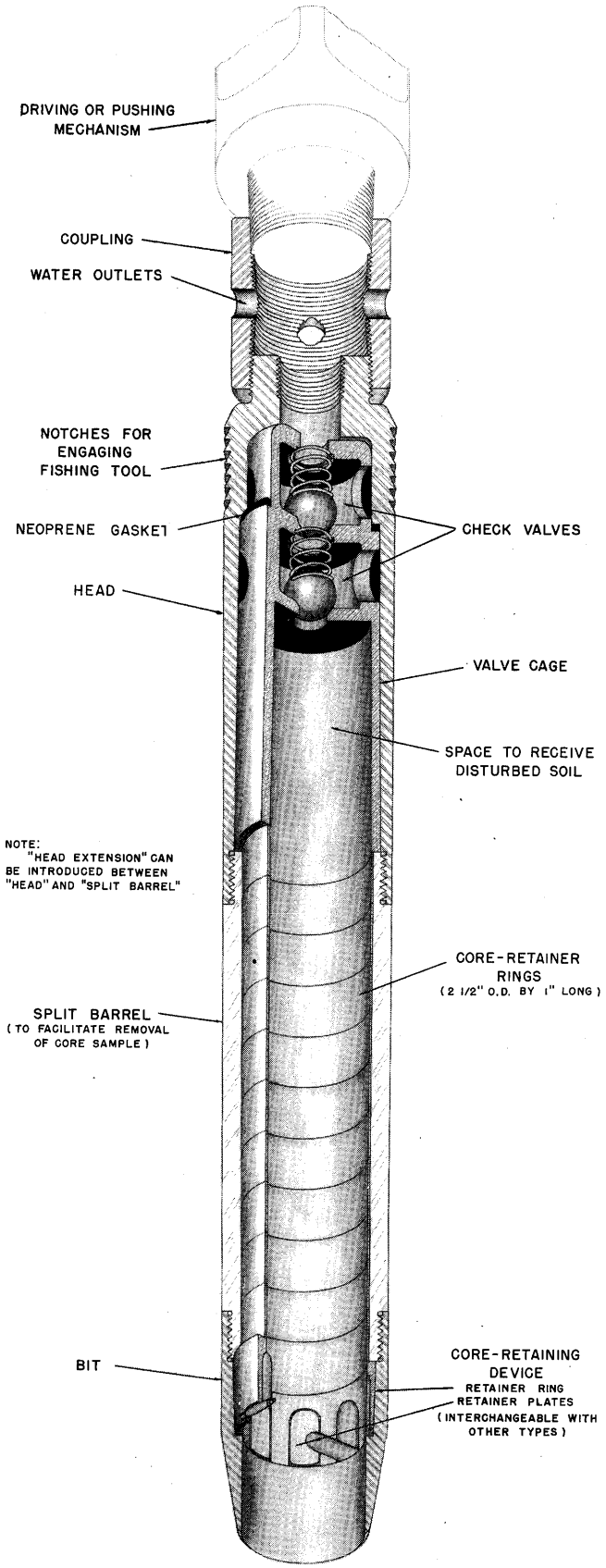
PLATE 3

JOB No. 1060-A LOCATION PITTSBURG DATA CHECK BY DATE
THIS DRAWING IS ONE OF A SERIES OF 9 DRAWINGS CLIENT OWNER UNKNOWN DRAFTING CHECK BY DATE
DATE JOB STARTED DATE PRINTED REPORT DICTATED BY DATE

APPENDIX A

SOIL SAMPLER TYPE U

FOR SOILS DIFFICULT TO RETAIN IN SAMPLER
U. S. PATENT NO. 2,318,062

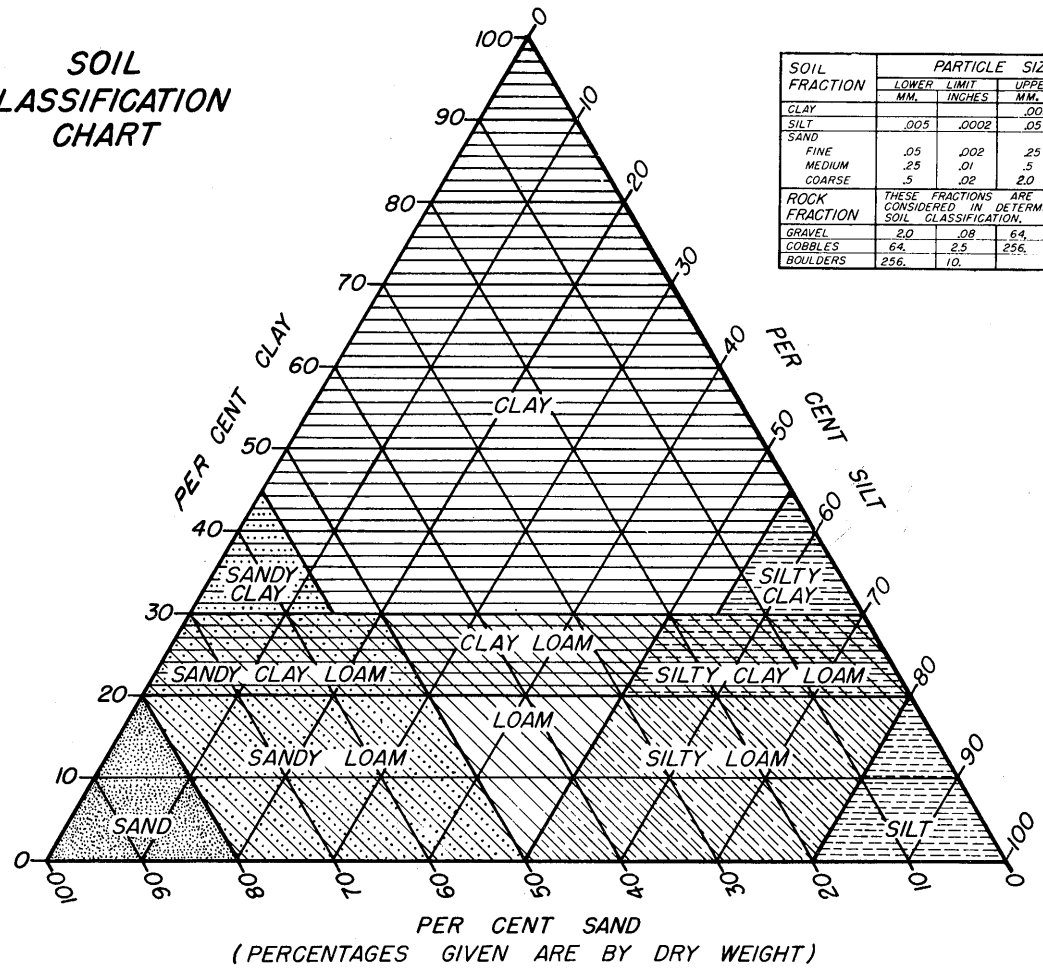


APPENDIX B

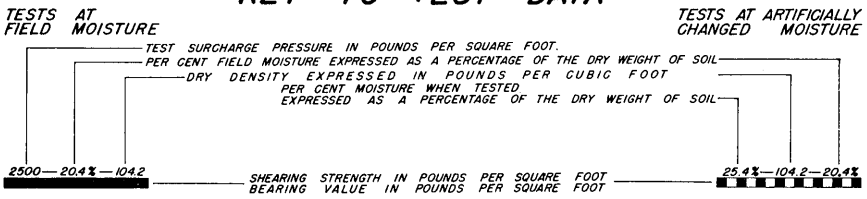
SOIL CLASSIFICATION CHART AND KEY TO TEST DATA

SOIL CLASSIFICATION CHART

SOIL FRACTION	PARTICLE SIZE			
	LOWER LIMIT		UPPER LIMIT	
	MM.	INCHES	MM.	INCHES
CLAY			.005	.0002
SILT	.005	.0002	.05	.002
SAND				
FINE	.05	.002	.25	.01
MEDIUM	.25	.01	.5	.02
COARSE	.5	.02	2.0	.08
ROCK FRACTION	THESE FRACTIONS ARE NOT CONSIDERED IN DETERMINING SOIL CLASSIFICATION.			
GRAVEL	2.0	.08	64.	2.5
COBBLES	64.	2.5	256.	10.
BOULDERS	256.	10.		



KEY TO TEST DATA



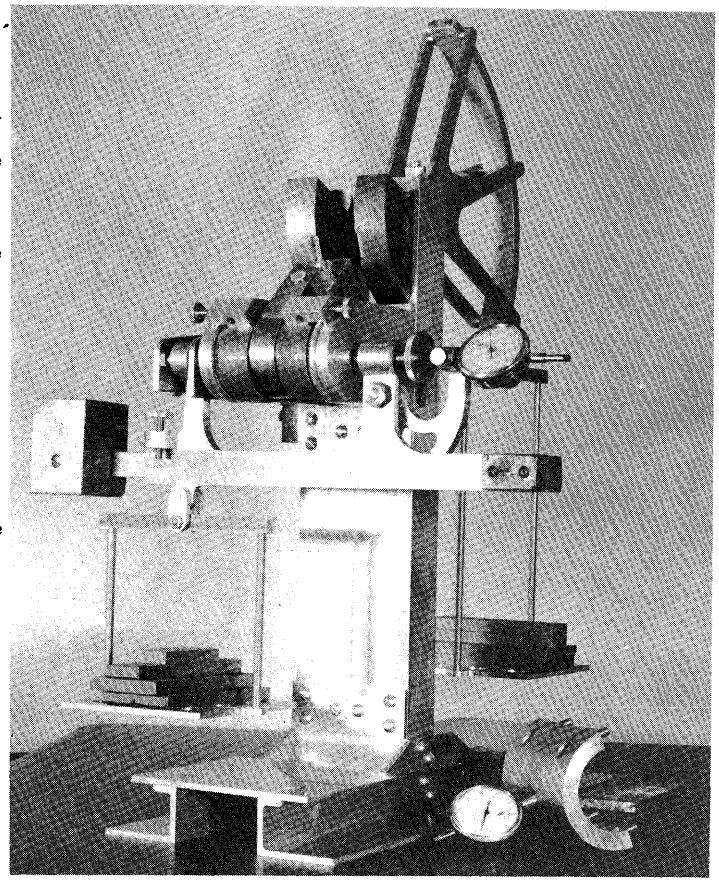
■ INDICATES DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED

417.11(1)

APPENDIX C

METHOD OF PERFORMING SHEAR AND FRICTION TESTS

In the performance of the shear tests, a three-inch length of the core sample is tested in double shear while confined within three of the retainer rings in which the sample was obtained. The sample is placed in the shearing apparatus under the surcharge pressure at which it is desired to determine the shearing strength of the soil and then, at equal time intervals, equal increments of load are applied in a direction perpendicular to the axis of the sample to the center ring of the three-ring sample of soil, while all transverse movements of the outer rings are prevented. The deflections of the center ring and the axial movements of the sample are measured for each load increment by micrometer dial gauges. These deflections are plotted against the shearing load, giving a stress-strain curve which is used to determine the yield point shearing strength of the core, this shearing strength being related to the bearing value in the ratio 3.1[4]*. The bearing value so computed is that yield point bearing value which would be established by a properly conducted field load test performed at the same conditions of moisture and confinement as the shear tests.



APPARATUS FOR PERFORMING SHEAR AND FRICTION TESTS
Shows lower half of sample carriage including shear dial removed to expose partly sheared core sample of soil.

In order to determine the decrease in strength which may occur with future increases in moisture content, the strength of the soil at possible future moisture conditions is determined by performing the shear test at an artificially increased moisture content. The change in moisture content is accomplished by immersing the sample in water for a period of at least 18 hours (The period is varied depending on the characteristics of the soil and the probable amount of moisture infiltration which may occur in the field.) while the sample is confined under the desired surcharge pressure.

Friction tests of the soil in contact with steel, wood, or concrete, representing the surfaces of the various types of driven piling, are performed in the same apparatus and at the same surcharge pressures, moisture contents, and densities as the corresponding shear tests. The method of performing the test is identical to that of the shear tests, the only difference being that the center ring of soil is replaced by a disk of steel, wood, or concrete.

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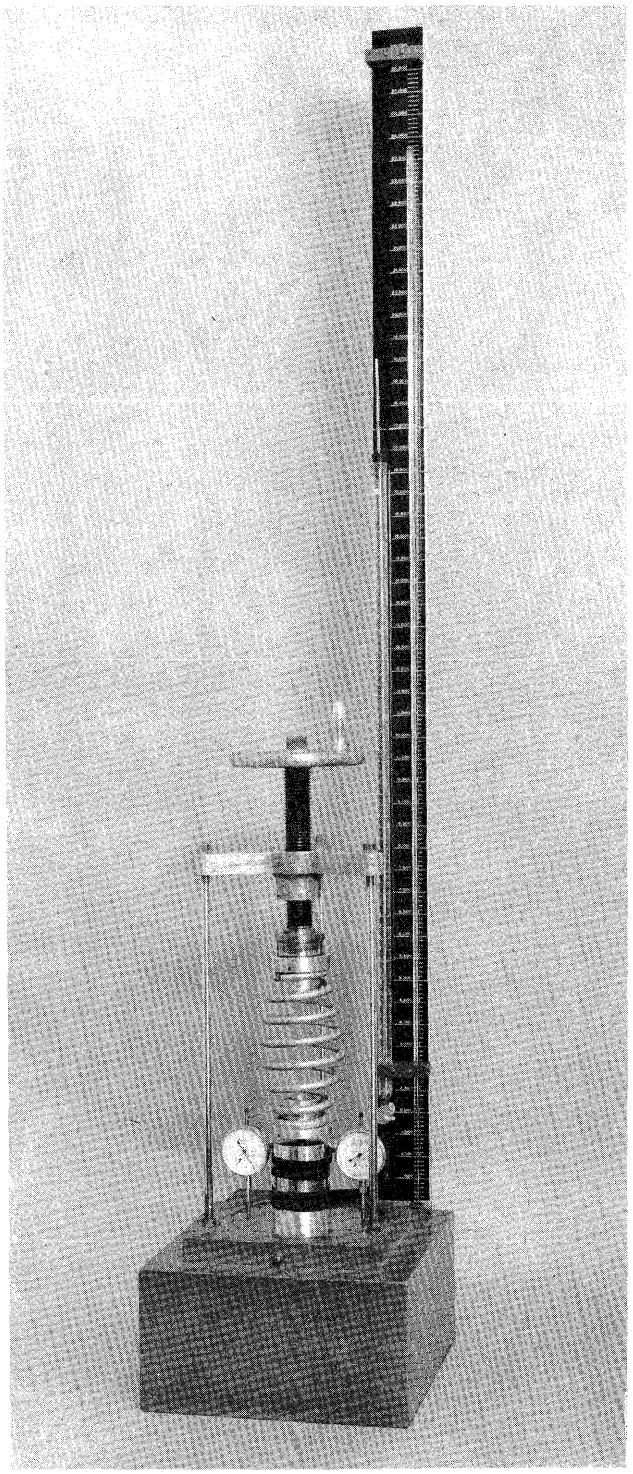
*"Practical Shear Tests for Foundation Design", Civil Engineering, December, 1940, Pages 784 and 785.

APPENDIX D

METHOD OF PERFORMING CONSOLIDATION TESTS

To determine the consolidation characteristics of the foundation soils so that settlement analyses may be performed, consolidation tests are performed in the consolidation apparatus on confined one-inch-thick core samples compressed between two porous stones. Axial loads are applied to the sample in increments and observations of the consolidation under the various load increments, as measured by micrometer dial gauges, are recorded at various time intervals. In general, each load is maintained constant until the rate of consolidation is observed to cease substantially, and then an additional load increment is applied and the observation repeated. From these data, time-versus-consolidation curves and load-versus-consolidation curves are obtained which enable estimates to be made of the probable magnitude and rate of settlement of foundations supported by the soil tested.



APPARATUS FOR PERFORMING CONSOLIDATION TESTS
Shows one-inch length of soil sample confined in retainer ring and under axial load.

417.3(2)

REPORT
OF
FOUNDATION INVESTIGATION

PART I
PRESENTATION OF DATA

PROPOSED PITTSBURG STEAM PLANT
PITTSBURG, CALIFORNIA

160-AC
PART I

FOR THE
PACIFIC GAS AND ELECTRIC COMPANY

DAMES & MOORE, *Civil Engineers*

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING
LOS ANGELES · SAN FRANCISCO · PORTLAND · SEATTLE · NEW YORK

ENT R. DAMES
LIAM W. MOORE
EROY CRANDALL
LIAM W. BREWER
RNON A. SMOOTS
LIAM ENKEBOLL

DOUGLAS 2-6507
417 MARKET STRE
SAN FRANCISCO 5,
WILLIAM W. MOOR
WILLIAM W. BREW

April 15, 1952

Pacific Gas and Electric Company
245 Market Street
San Francisco 6, California

Attention: Mr. Walter Dreyer
Vice President and Chief Engineer

Gentlemen:

Since the submission of our Report, "Foundation Investigation, Part I, Presentation of Data, Proposed Pittsburg Steam Plant, Pittsburg, California, For the Pacific Gas and Electric Company", dated March 3, 1952, it has come to our attention that an error exists on Plate 2AH, Log of Borings. The elevation scales for Logs of Borings L78 and L79 were improperly indicated with respect to the actual elevation of each boring.

Three copies of a revised plate (Plate 2AH - Revised) are enclosed. Will you please attach these prints to your copies of the report and invalidate the original plates? Thank you very much.

We regret the occurrence of this error and trust that it has not seriously inconvenienced you.

Yours very truly,

DAMES & MOORE

Irving E. Olsen

IEO-JEV ESH
(3 Copies Submitted)
Enclosures
cc: Bechtel Corporation (3)
Power Division
101 California Street
San Francisco 11, California
Attention: Messrs. James Laudis and Walter L. Dickey

SF

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING
LOS ANGELES · SAN FRANCISCO · PORTLAND · SEATTLE · NEW YORK

TRENT R. DAMES
WILLIAM W. MOORE
L. LEROY CRANDALL
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VERNON A. SMOOTS
WILLIAM ENKEBOLL

DOUGLAS 2-6507
417 MARKET STREET
SAN FRANCISCO 5, CALIF.
WILLIAM W. MOORE
WILLIAM W. BREWER

March 3, 1952

Pacific Gas and Electric Company
245 Market Street
San Francisco 6, California

Attention: Mr. Walter Dreyer
Vice President and Chief Engineer

Gentlemen:

Three copies of our Report "Foundation Investigation, Part I, Presentation of Data, Proposed Pittsburg Steam Plant, Pittsburg, California, for the Pacific Gas and Electric Company," are herewith submitted. These basic data have been and will be used in analyzing the foundation problems involved in the planned project. The results of these analyses will be submitted in a subsequent report, "Part II, Foundation Analyses".

The investigation was planned in collaboration with representatives of the Engineering Departments of the Pacific Gas and Electric Company and the Bechtel Corporation. The results of the investigation were reviewed with the interested parties as the data became available.

Yours very truly,

DAMES & MOORE

William W. Brewer

William W. Brewer

WWB-ET ESH

cc: Bechtel Corporation (3)
Power Division
101 California Street
San Francisco 11, California
Attention: Messrs. James Landis and Walter L. Dickey

Oakl

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING
LOS ANGELES · SAN FRANCISCO · PORTLAND · SEATTLE · NEW YORK

TRENT R. DAMES
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VERNON A. SMOOTS
WILLIAM ENKEBOLL

DOUGLAS 2-6507
417 MARKET STREET
SAN FRANCISCO 5, CALIF.
WILLIAM W. MOORE
WILLIAM W. BREWER

July 10, 1952

Pacific Gas and Electric Company
245 Market Street
San Francisco 6, California

Attention: Mr. Walter Dreyer
Vice President and Chief Engineer

Gentlemen:

Three copies of Plate 2AB, Log of Borings (Borings L-63 and L-64) are herewith submitted for inclusion in our Report "Foundation Investigation, Part I, Presentation of Data, Proposed Pittsburg Steam Plant, Pittsburg, California for the Pacific Gas & Electric Company." As mentioned in the subject report, Boring L-63 and L-64 could not be drilled at the time of presentation (March 3, 1952) because of ponded areas caused by rains.

Yours very truly,

DAMES & MOORE

William W. Brewer

William W. Brewer

WWB-ET EC
Attachment

cc: Bechtel Corporation (3)
Attn: Messrs. James Landis and Walter L. Dickey

SF extra
Av Field Use

DAMES & MOORE, *Civil Engineers*
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LLIAM ENKEBOLL

DOUGLAS 2-6507
417 MARKET STREET
SAN FRANCISCO 5, CALIF.
WILLIAM W. MOORE
WILLIAM W. BREWER

March 3, 1952

Pacific Gas and Electric Company
245 Market Street
San Francisco 6, California

Attention: Mr. Walter Dreyer
Vice President and Chief Engineer

Gentlemen:

Three copies of our Report "Foundation Investigation, Part I, Presentation of Data, Proposed Pittsburg Steam Plant, Pittsburg, California, for the Pacific Gas and Electric Company," are herewith submitted. These basic data have been and will be used in analyzing the foundation problems involved in the planned project. The results of these analyses will be submitted in a subsequent report, "Part II, Foundation Analyses".

The investigation was planned in collaboration with representatives of the Engineering Departments of the Pacific Gas and Electric Company and the Bechtel Corporation. The results of the investigation were reviewed with the interested parties as the data became available.

Yours very truly,

DAMES & MOORE

William W. Brewer

William W. Brewer

WWB-ET ESH

cc: Bechtel Corporation (3)
Power Division
101 California Street
San Francisco 11, California
Attention: Messrs. James Landis and Walter L. Dickey

REPORT

OF

FOUNDATION INVESTIGATION

PART I

PRESENTATION OF DATA

PROPOSED PITTSBURG STEAM PLANT

PITTSBURG, CALIFORNIA

for the

PACIFIC GAS AND ELECTRIC COMPANY

MARCH 3, 1952

DAMES & MOORE, *Civil Engineers*
FOUNDATION ENGINEERING · APPLIED SOIL MECHANICS

PREFACE

The subject site was previously investigated to provide soils information relative to possible purchase of this property; the results were submitted in our Report, "Preliminary Foundation Investigation, Proposed Industrial Site, near Pittsburg, California, For the Pacific Gas and Electric Company," dated September 4, 1951. The purposes of the more extensive ensuing investigations were (1) to confirm the quantities of hydraulic sandy fill materials believed to be available in the shallow waters of the Sacramento River adjacent to the site, (2) to determine the physical characteristics of the subsurface materials for foundation design, (3) to analyze the probable behavior of possible types of foundations, and (4) to recommend satisfactory methods for supporting the planned units.

In order to expedite presentation, the report is divided into two parts which will be bound seperately:

PART I. "PRESENTATION OF DATA" presents the results of the explorations conducted to determine the soil conditions beneath the site, the data obtained from tests performed to describe the pertinent physical soil properties, and the results of sand explorations conducted to confirm the quantities of available sandy hydraulic-fill materials.

PART II. "ANALYSES AND RECOMMENDATIONS" will present the results of analyses of the effect of soil behavior on foundation performance, and make specific recommendations as to foundation selection and design.

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INTRODUCTION

This report presents the results of a foundation investigation of the site of the Proposed Pittsburg Steam Plant near Pittsburg, California. The location of the property, some 230 acres, is shown in relation to the topographic features of the area on Plate 1A, Vicinity Map. This map has been reproduced from a portion of the United States Geological Survey's Antioch Quadrangle, surveyed during 1906 and 1907.

It is our understanding that this plant will be a 600,000-kilowatt steam-electric installation containing four 150,000-kilowatt generating units, the largest steam-electric generating plant in California. Fuel oil will be the principal fuel used for steam generation; however, provisions will be made so that these units can be converted into coal-burning units at a later date. The locations of the principal structures in relation to the property lines and to the coordinate system established by the Bechtel Corporation, are shown on Plate 1B, Plot Plan.

The foundation requirements of the boilers, turbines, stacks, and various appurtenant structures which will comprise the steam plant, will be discussed in Part II.

GENERAL SURFACE CONDITIONS

The 230-acre site, of which a large portion is reclaimed peat and marsh lands, is separated by a dyke from the Sacramento River. The north-easterly portion of the property is covered by sandy deposits derived from relatively recent dredging operations performed in conjunction with the

deepening of the ship channel of the Sacramento River. The underlying materials are of recent geological origin, consisting predominately of silty and sandy alluvial deposits.

The present ground surface varies from approximately Elevation +20 feet to Elevation 0 feet. All elevations in this report, unless otherwise noted, refer to the U. S. C. S. Datum (M.S.L.= 0). It is presently planned that the area north of coordinate N17+50 will be developed by the erection of Plant structures; for drainage purposes, this area will be graded from Elevation +8.0 feet along the northerly edge of the property to Elevation +6.0 feet toward coordinate N17+50. The southerly area will not be developed at the present time, although some preparations may be made for future tank storage in this area. The areas in the vicinity of the structures will be filled and the fills compacted by mechanical means, while the remaining areas will be brought to grade by hydraulically-placed fills.

With reference to flooding of the site (based on reports provided by the U.S.E.D. and U.S.C. & G.S.), it was concluded by engineering forces of the Pacific Gas & Electric Company, that the water level range at this site would fluctuate from a high of approximately Elevation +6 to a low of Elevation -3, with an estimated extreme high of Elevation +8.5 feet occurring at a frequency of once every 100 to 200 years.

EXPLORATIONS

The soil conditions at the site were explored by the drilling of 26 borings on water and 81 borings on land at the locations indicated on the Plot Plan. Of these borings, three water and six land borings were drilled previously, and the results were submitted in our Preliminary Report dated September 14, 1951. The previously drilled borings, situated within the

present property limits, are reproduced in this report for convenient reference. The logs of water Borings A, B, and C are presented on Plate 2, and the land Borings 4, 6, 7, and 8, on Appendix A.

WATER EXPLORATIONS

In order to define the limits of and to estimate the quantities of sandy material available for fill purposes, Borings W1 to W23 inclusive, were drilled with an air-lift or a wash-boring drill rig mounted on a floating barge. The air-lift method is faster and generally satisfactory for determining depths of suitable dredge materials and consequently was used whenever possible; however, in some localities, wash-boring equipment was required to penetrate firm clayey strata. Representative samples of the various strata encountered were retained in glass jars for visual observations. Graphical representations of the soils encountered appear on Plate 2 in a manner described by the Key, "Soil Types", appearing near the center of the same plate. The locations of the sand explorations are noted on the lower right of Plate 2, under the heading of "Location of Sand Deposits," and are also noted on the Plot Plan. The quantities of available sandy dredge materials were estimated by reference to contours entered on the right of Plate 2, and are tabulated on the lower right of the same plate.

LAND EXPLORATIONS

The land borings were drilled utilizing four types of drilling equipment -- the types being dependent upon, (1) the availability of drill rigs at the time particular soil data was needed, and (2) the accessibility of the site to certain types of drilling equipment. Specifically the locations and the equipment employed thereon were as follows:

(a) Borings L-1 to L-24 inclusive were 6 inches in diameter and were drilled with truck-mounted cable-tool drilling equipment.

(b) Borings L-25 through L-62 and L-67 through L-79 were 6 inches in diameter and were drilled with truck-mounted rotary drilling equipment.

(c) Borings L-63 and L-64, could not be drilled at the time of presentation of this report because of ponded areas caused by recent rains; these borings will be drilled and the data submitted as soon as site conditions are favorable.

(d) Borings L-65 and L-66 were 20 inches in diameter and were drilled with truck-mounted bucket-type drilling equipment.

Undisturbed core samples of the various strata encountered in the borings were extracted for physical testing in the laboratory. The soils penetrated were classified by visual and textural examination in the field; these observations were supplemented by examination of the samples in the laboratory. To ascertain the extent of possible thin weak clay or peat lenses in the area subsequently selected for the boilers and stack foundations, continuous samples were taken of soils from approximately Elevation +2.0 feet to a depth of 5 feet into the underlying sand formation. Representative portions of the samples were retained for possible further examination and the remaining portions were placed in core boxes at the site for inspection by interested parties.

Graphical representations of the soils encountered in each boring appear on Plates 2A through 2AH, Log of Borings; the nomenclature used is described by the Soil Classification Chart shown on Appendix B, Soil Classification Chart and Key to Test Data. The levels at which ground water was observed to stand in the borings and the levels to which casing or drillers'

mud was employed to prevent caving of the boring walls, are entered on the logs.

SUBSURFACE SECTIONS

In order that a general picture of the soil conditions underlying the site might be portrayed in a form free of inconsequential detail, generalized subsurface sections have been prepared and are presented on Plates 3A through 3D, Subsurface Sections. The locations of these sections are identified by the Key Plan shown on each plate. The sections were prepared by means of interpolation between the logs of the exploration borings and, while completely reliable only in the immediate vicinity of the borings, the sections are believed to describe the subsurface conditions at intermediate locations with fair accuracy.

LABORATORY TESTS

GENERAL:

The undisturbed core samples extracted from the foundation strata were subjected to a series of laboratory tests which included shear tests, consolidation tests, percolation tests, and sieve analyses. In conjunction with these tests, the moistures and densities of the soils were determined. Borings L1 through L24 were drilled primarily to develop general over-all soil information. Although considerable soil data had been developed prior to the drilling of Boring L25, additional borings were needed to help determine the extent of critical underlying soil strata. Because of the number of tests already performed, additional laboratory testing was kept to a minimum by determining the densities of the various samples from the additional borings

at their field moistures. The field density data for the soils encountered below the water table were converted into approximate dry densities. Both the field and dry densities in pounds per cubic foot, are noted to the left of the points of sampling on the boring logs.

SHEAR TESTS:

To obtain data for use in determining the support which the soils would offer to various types of foundations, selected undisturbed core samples were tested in double shear in the manner described in Appendix C, Method of Performing Shear and Friction Tests.* The majority of the samples were tested at the existing field moisture contents of the soils under confining surcharge pressures equivalent to the weight of overburden, compensated for the buoyant effect of ground water, above the point of sampling. A few samples were tested at artificially increased moistures to indicate the reduction in strength of these soils with possible severe increases in moisture. In addition, to ascertain the relationship of shearing strength and surcharge pressure, shear tests were performed on selected samples at increased surcharge pressures.

The results of the shear tests, together with the associated soil moistures and densities, are shown on the graph to the left of the logs in the manner described by the Key to Test Data on Appendix B. The lengths of the test bars using the upper scale of the graphs give the directly measured shearing strengths, and using the lower scale, those yield point bearing values which would be established by properly conducted field load tests performed at the same conditions of moisture and confinement as the shear tests.

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*The equipment shown on the appendix has been replaced by Automatic Recording Equipment.

For convenience in studying shearing strengths of the soils, the results of the shear tests have been summarized on the graph appearing on Plate 4, Summary of Shear Test Data. The symbols shown in the legend at the right of this plate identify the types of soils and denote the test moisture conditions. The shearing strengths selected for use in the analyses of the supporting capacities of piling, which will be discussed in Part II, are described by the solid lines which have been passed through the plotted test data.

CONSOLIDATION TESTS:

Consolidation (confined compression) tests were performed in the manner described in Appendix D, Method of Performing Consolidation Tests, on a series of selected core samples to obtain data for use in estimating the probable settlement behavior of different types of foundations. The results of these tests in terms of load versus consolidation and time versus consolidation are shown on Plates 5A through 5C, Consolidation Test Data. To provide a convenient reference, the plates are segregated according to soil groups.

PERCOLATION TESTS:

To provide basic data for estimating the probable quantities of water to be handled in dewatering the excavations for the turbines, boilers and stacks, and the intake and discharge structures, several of the undisturbed soil samples extracted from the borings drilled in these areas were subjected to percolation tests. These tests were performed in the manner described in Appendix E, Method of Performing Percolation Tests. The results of the tests are tabulated on Plate 6, Percolation Test Data.

PARTICLE SIZE ANALYSES:

Sieve analyses were performed on selected representative samples of sand, sand with some gravel, and sandy loam, to provide more detailed

information regarding the character of these deposits and to aid in evaluating the suitability of these materials for hydraulic filling and for dewatering operations. The grain-size distributions together with the effective size and coefficient of uniformity for each sample are presented on Plate 7, Particle Size Analyses.

COMPACTION STUDIES:

In order to determine the compaction characteristics of the soils considered for filling, compaction studies were performed on typical loose samples of the sandy soils blanketing the northeast corner of the site and also on a sample of imported material from the Alves Pit. The results of these studies are presented on a series of graphs appearing on Plate 8, Compaction Studies.

Samples CS-1 and CS-2, the "on-site" soils, were compacted in accordance with the Standard AASHO Method of Compaction, and the Alves Pit material, in accordance with the Modified AASHO Method of Compaction. These compaction methods are described in Appendix F, Method of Performing Compaction Tests. To aid in formulating design criteria and estimating probable settlements of foundations placed upon these compacted soils, shear and consolidation tests were performed on prepared specimens.

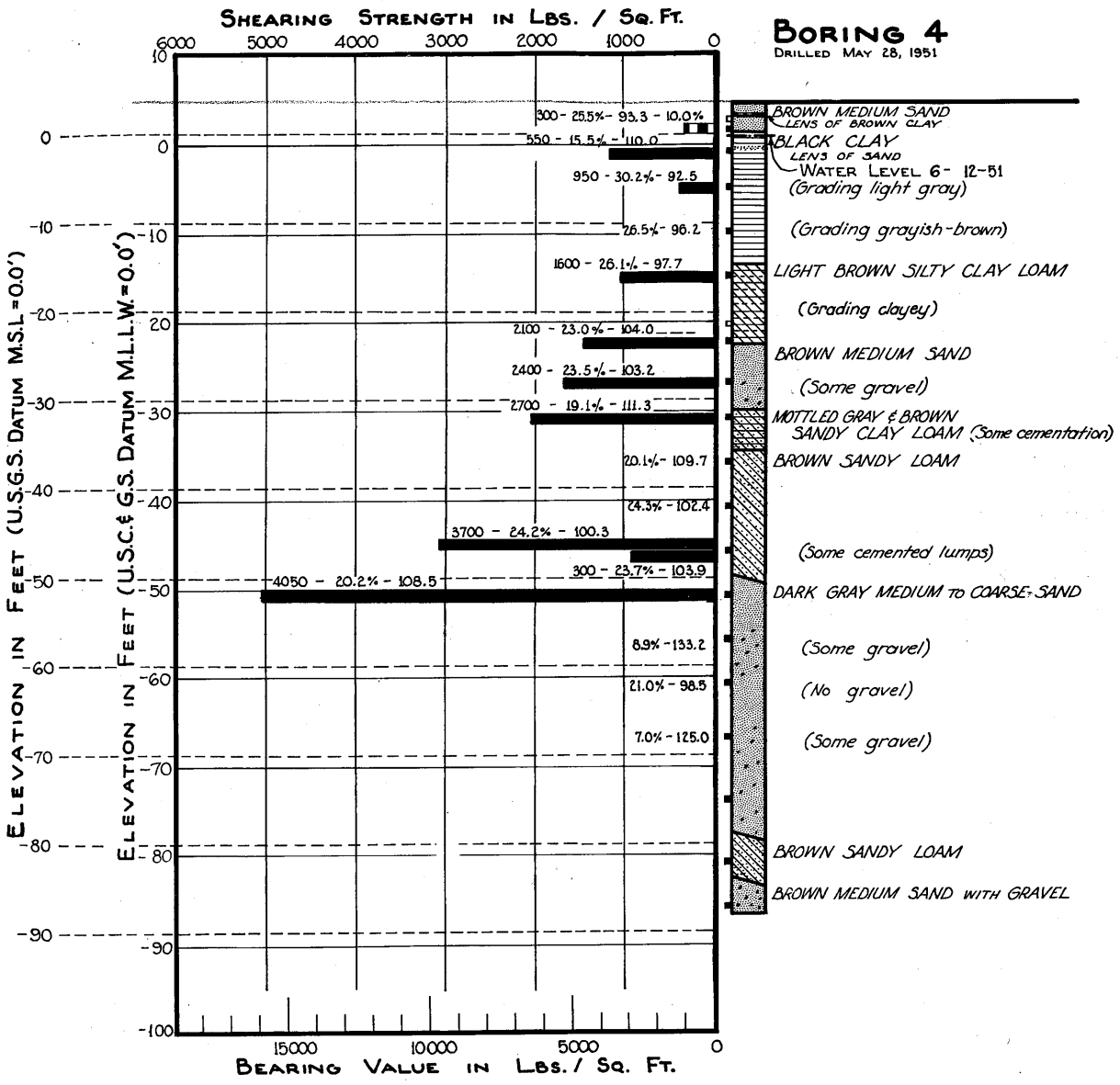
In addition to compacting the "on-site" soils by mechanical means, tests on Samples CS-1 and CS-2 were made to determine the suitability of these sandy materials if placed by flooding or ponding. The test procedures consisted of either pouring the sand through pond water, or depositing the sand in layers with water -- in some cases the prepared samples were subjected

to vibrating. The dry densities of the samples were determined in place without permitting drainage. The results of these tests, together with a particle-size analyses of the sands, are also graphically presented on Plate 8.

Respectfully submitted,

DAMES & MOORE

William W. Brewer

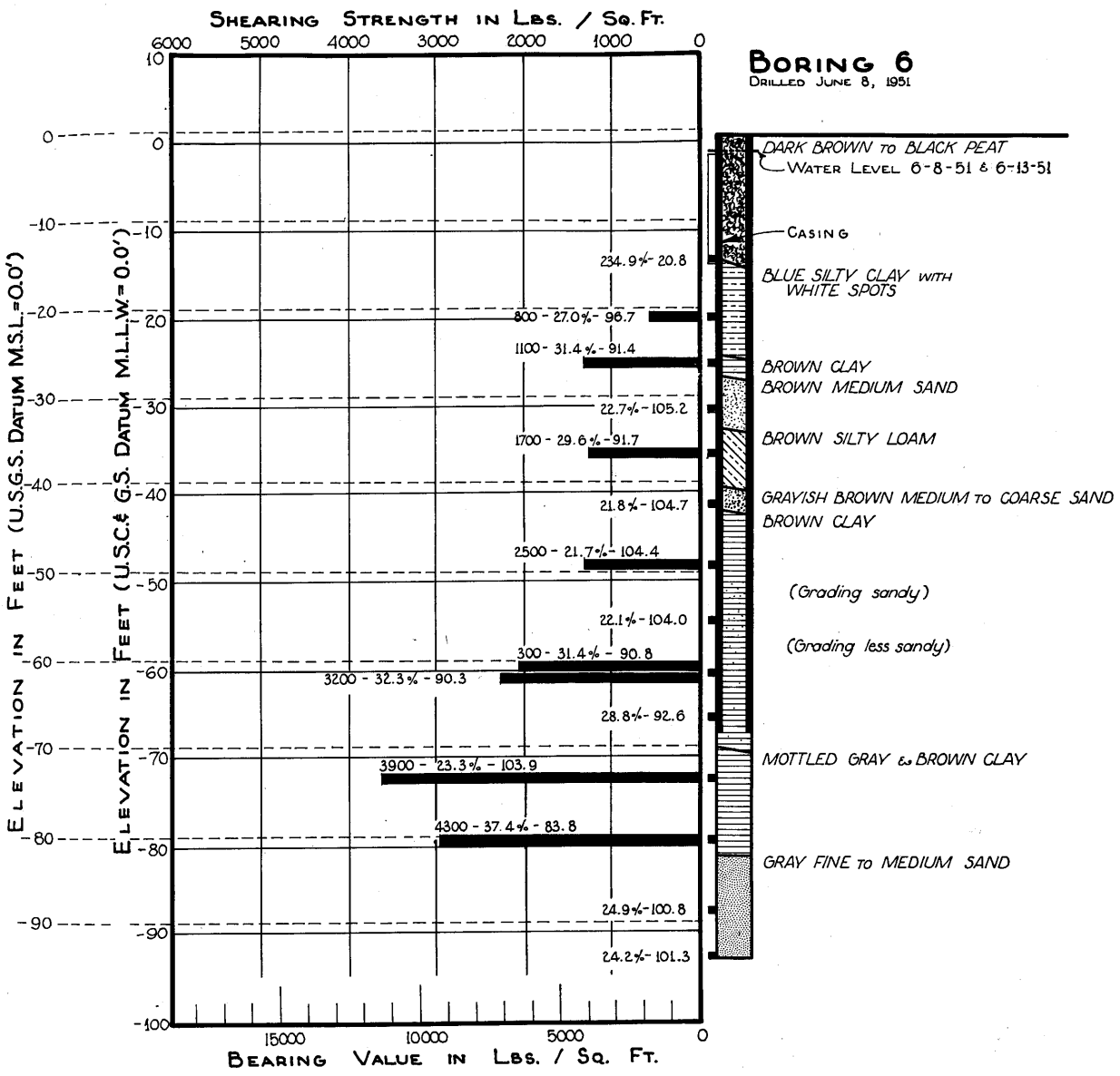


NOTE:

BORINGS 4,6,7 & 8 'DRILLED PREVIOUSLY;' SEE DAMES & MOORE REPORT "PRELIMINARY FOUNDATION INVESTIGATION, PROPOSED INDUSTRIAL SITE NEAR PITTSBURG, CALIF., FOR THE PACIFIC GAS AND ELECTRIC CO." DATED 9-4-51

LOG OF BORINGS

DAMES & MOORE
FOUNDATION ENGINEERS



LOG OF BORINGS

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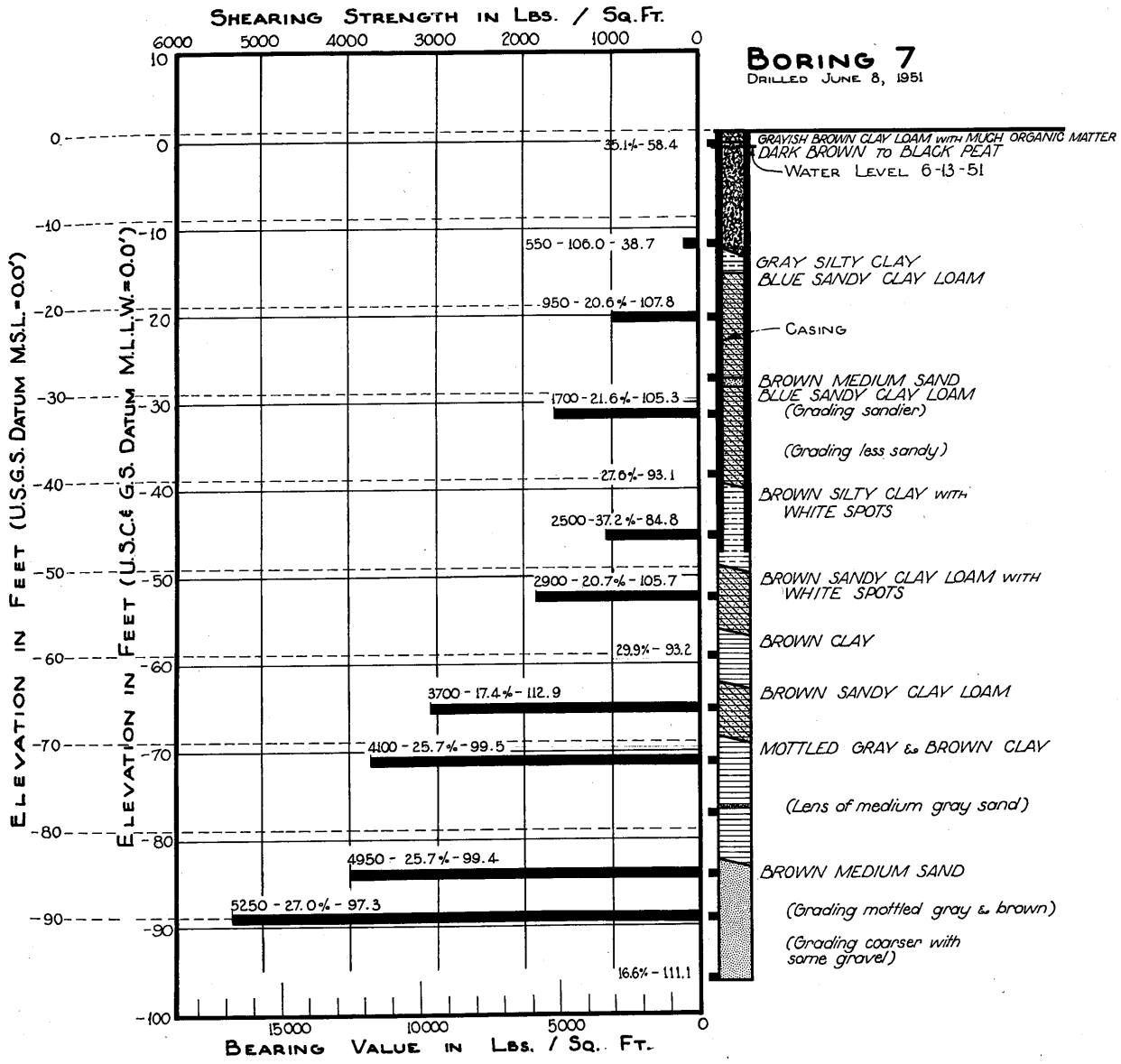
FOUNDATION ENGINEERS



LOG OF BORINGS

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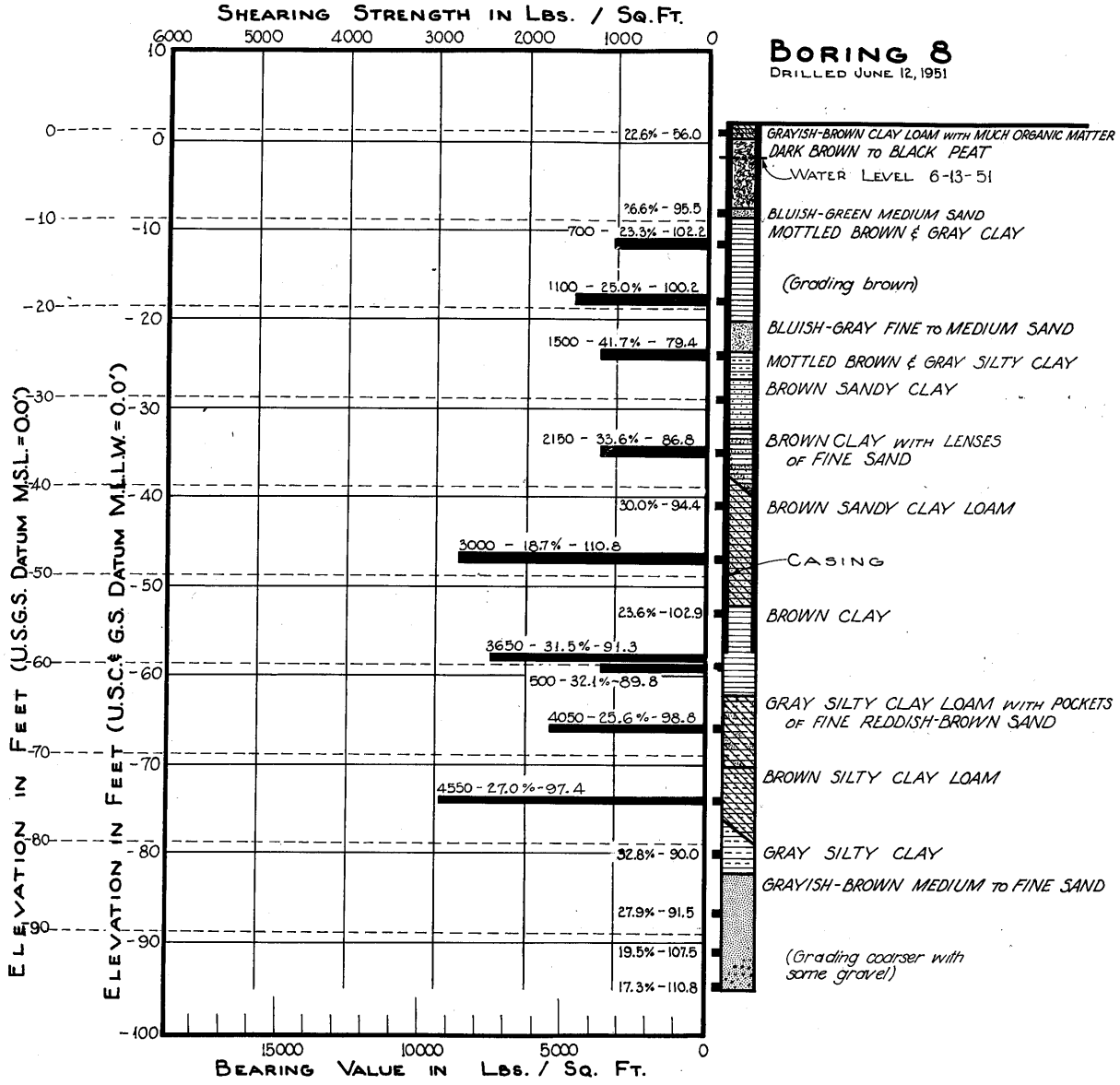
FOUNDATION ENGINEERS

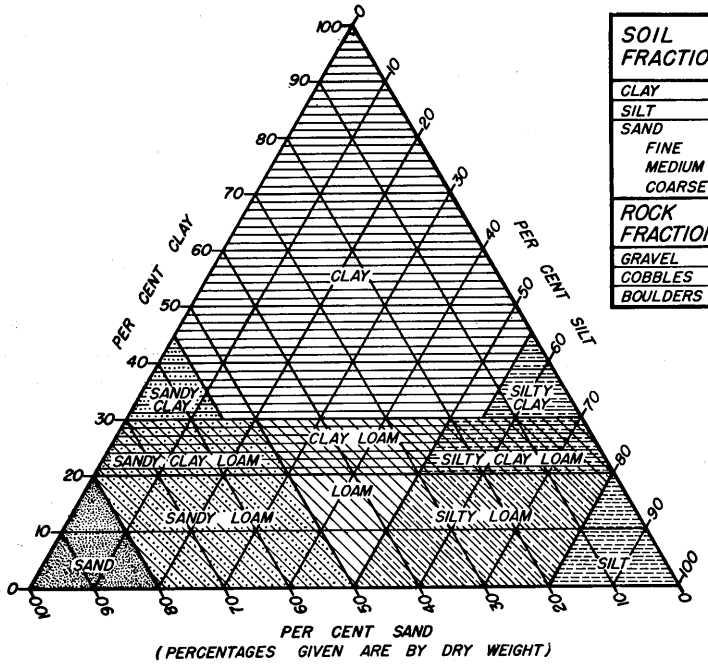


LOG OF BORINGS

DAMES & MOORE
FOUNDATION ENGINEERS

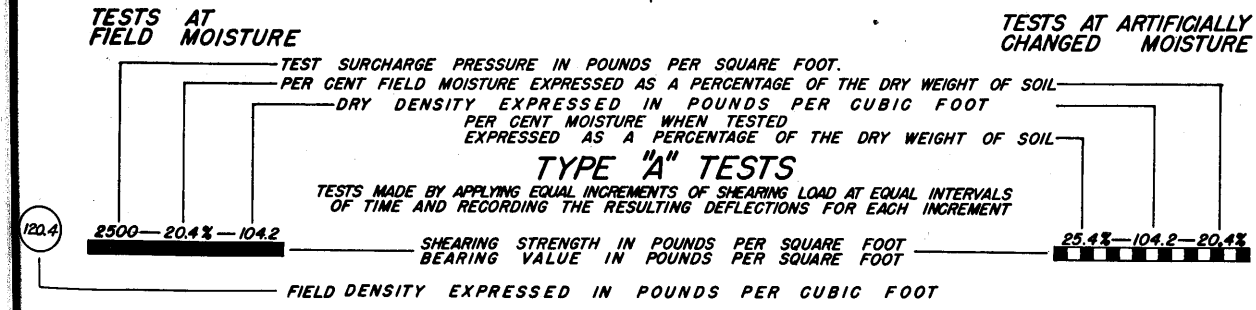
APPENDIX B

SOIL CLASSIFICATION CHART AND KEY TO TEST DATA



(PERCENTAGES GIVEN ARE BY DRY WEIGHT)

SOIL FRACTION	PARTICLE SIZE			
	LOWER LIMIT		UPPER LIMIT	
	MM.	INCHES	MM.	INCHES
CLAY			.005	.0002
SILT	.005	.0002	.05	.002
SAND				
FINE	.05	.002	.25	.01
MEDIUM	.25	.01	.5	.02
COARSE	.5	.02	2.0	.08
ROCK FRACTION	THESE FRACTIONS ARE NOT CONSIDERED IN DETERMINING SOIL CLASSIFICATION.			
GRAVEL	2.0	.08	64.	2.5
COBBLES	64.	2.5	256.	10.
BOULDERS	256.	10.		

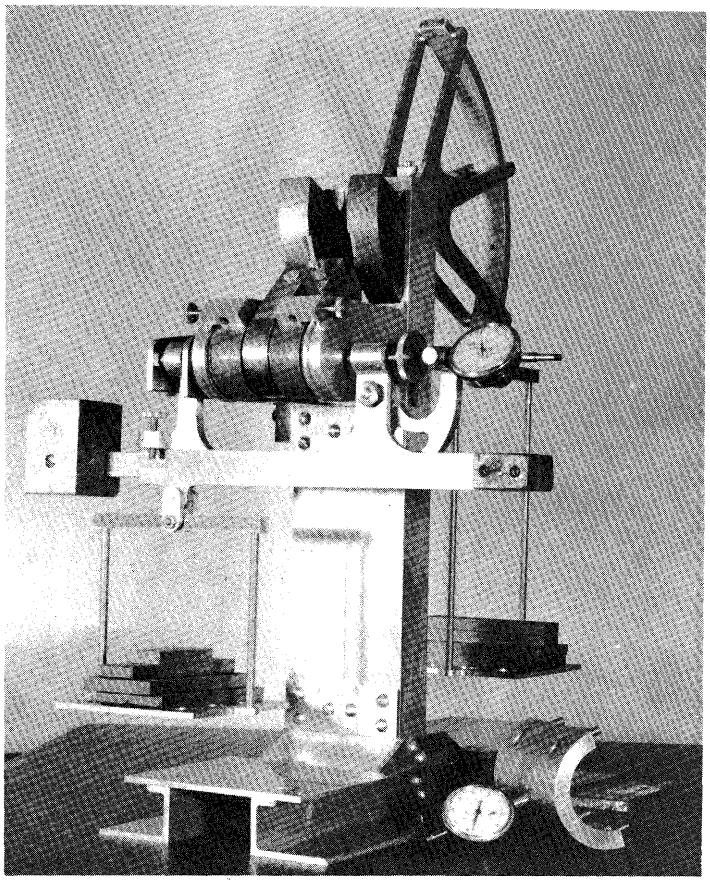


■ INDICATES DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED

APPENDIX C

METHOD OF PERFORMING SHEAR AND FRICTION TESTS

In the performance of the shear tests, a three-inch length of the core sample is tested in double shear while confined within three of the retainer rings in which the sample was obtained. The sample is placed in the shearing apparatus under the surcharge pressure at which it is desired to determine the shearing strength of the soil and then, at equal time intervals, equal increments of load are applied in a direction perpendicular to the axis of the sample to the center ring of the three-ring sample of soil, while all transverse movements of the outer rings are prevented. The deflections of the center ring and the axial movements of the sample are measured for each load increment by micrometer dial gauges. These deflections are plotted against the shearing load, giving a stress-strain curve which is used to determine the yield point shearing strength of the core, this shearing strength being related to the bearing value in the ratio 3.14*. The bearing value so computed is that yield point bearing value which would be established by a properly conducted field load test performed at the same conditions of moisture and confinement as the shear tests.



APPARATUS FOR PERFORMING SHEAR AND FRICTION TESTS
Shows lower half of sample carriage including shear dial removed to expose partly sheared core sample of soil.

In order to determine the decrease in strength which may occur with future increases in moisture content, the strength of the soil at possible future moisture conditions is determined by performing the shear test at an artificially increased moisture content. The change in moisture content is accomplished by immersing the sample in water for a period of at least 18 hours (The period is varied depending on the characteristics of the soil and the probable amount of moisture infiltration which may occur in the field.) while the sample is confined under the desired surcharge pressure.

Friction tests of the soil in contact with steel, wood, or concrete, representing the surfaces of the various types of driven piling, are performed in the same apparatus and at the same surcharge pressures, moisture contents, and densities as the corresponding shear tests. The method of performing the test is identical to that of the shear tests, the only difference being that the center ring of soil is replaced by a disk of steel, wood, or concrete.

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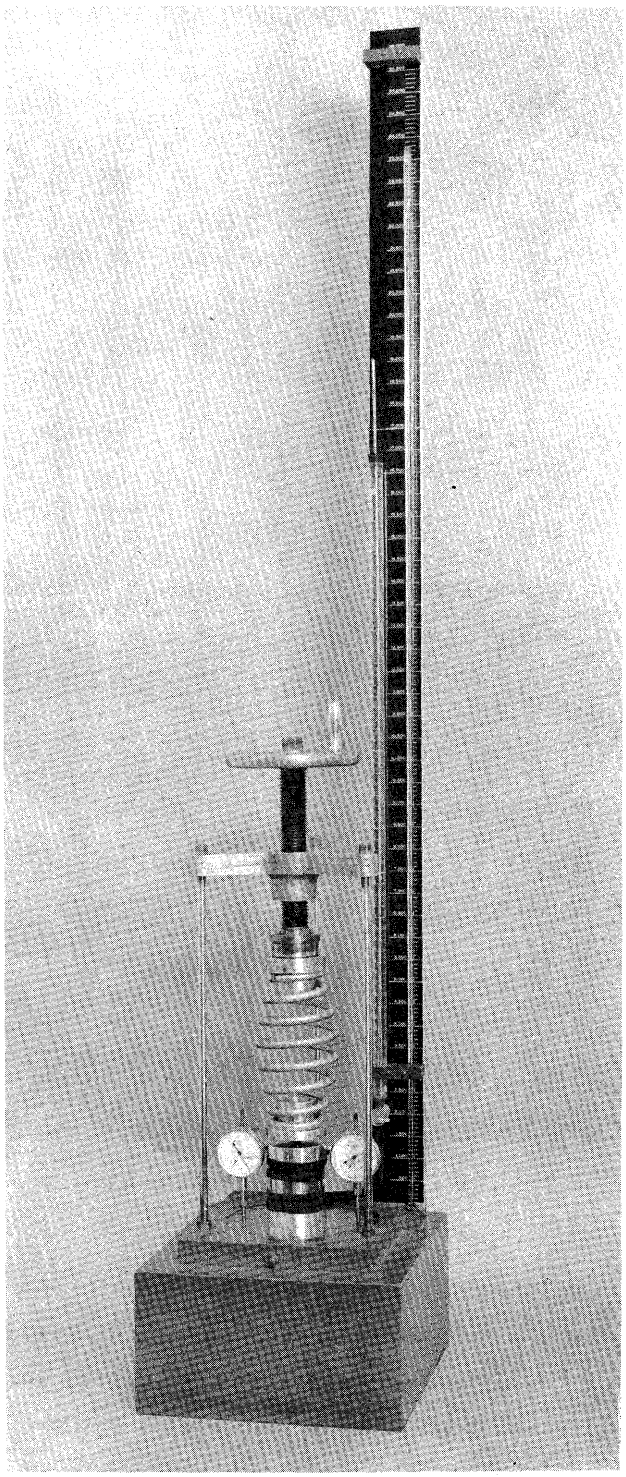
*"Practical Shear Tests for Foundation Design", Civil Engineering, December, 1940, Pages 784 and 785.

APPENDIX D

METHOD OF PERFORMING CONSOLIDATION TESTS

To determine the consolidation characteristics of the foundation soils so that settlement analyses may be performed, consolidation tests are performed in the consolidation apparatus on confined one-inch-thick core samples compressed between two porous stones. Axial loads are applied to the sample in increments and observations of the consolidation under the various load increments, as measured by micrometer dial gauges, are recorded at various time intervals. In general, each load is maintained constant until the rate of consolidation is observed to cease substantially, and then an additional load increment is applied and the observation repeated. From these data, time-versus-consolidation curves and load-versus-consolidation curves are obtained which enable estimates to be made of the probable magnitude and rate of settlement of foundations supported by the soil tested.



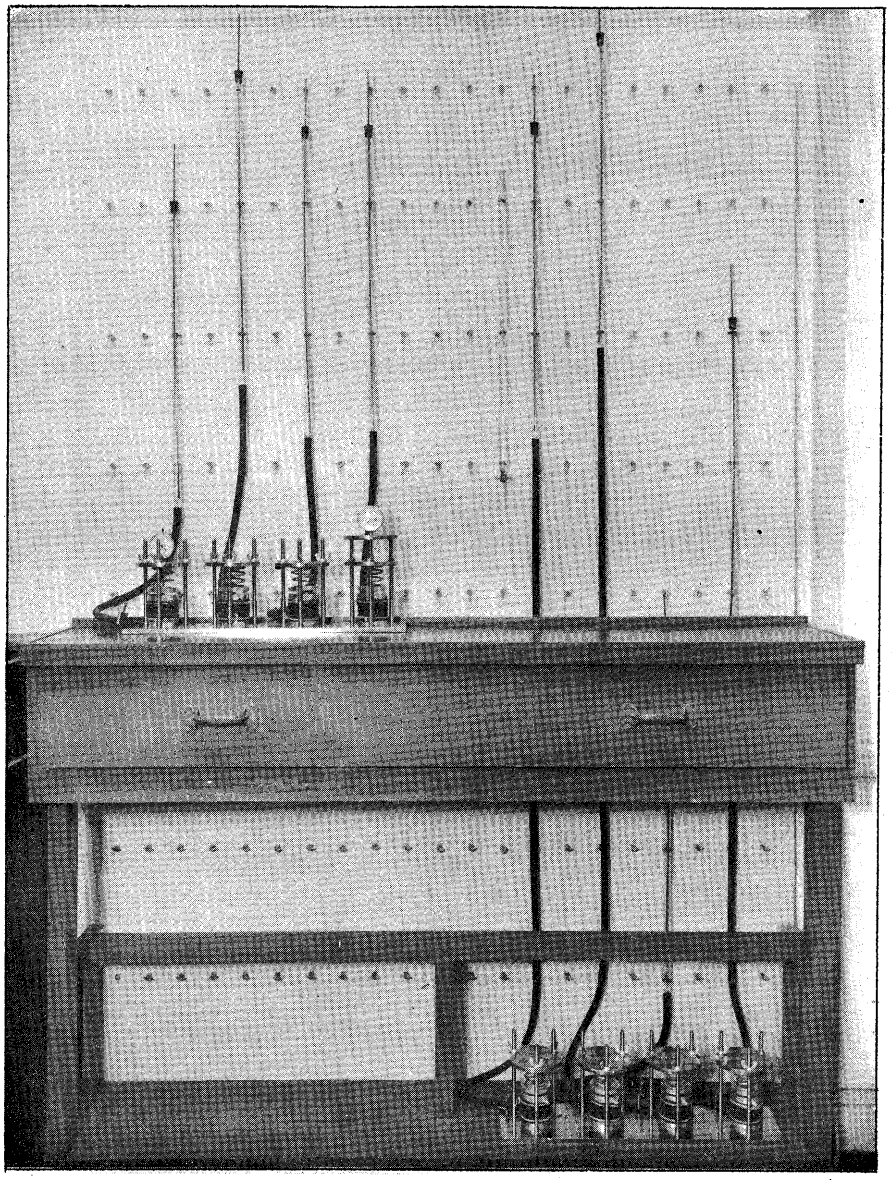
APPARATUS FOR PERFORMING CONSOLIDATION TESTS
Shows one-inch length of soil sample confined in retainer ring and under axial load.

APPENDIX E

METHOD OF PERFORMING PERCOLATION TESTS

The quantity and the velocity of flow of water which will escape through an earth structure or percolate through soil are dependent upon the permeability of the earth structure or soil. The permeability of soil has often been calculated by empirical formulas but is best determined by laboratory tests, especially in the case of compacted soils.

A one-inch length of the core sample is sealed in the percolation apparatus, placed under a confining load, or surcharge pressure, and subjected to the pressure of a known head of water. The percolation rate is computed from the measurements of the volume of water which flows through the sample in a series of time intervals. These rates are usually expressed as the velocity of flow in feet per year under a hydraulic gradient of one and at a temperature of 20 degrees Centigrade. The rate so expressed may be adjusted for any set of conditions involving the same soil by employing established physical laws. Generally, the percolation rate varies over a wide range at the beginning of the test and gradually approaches equilibrium as the test progresses.



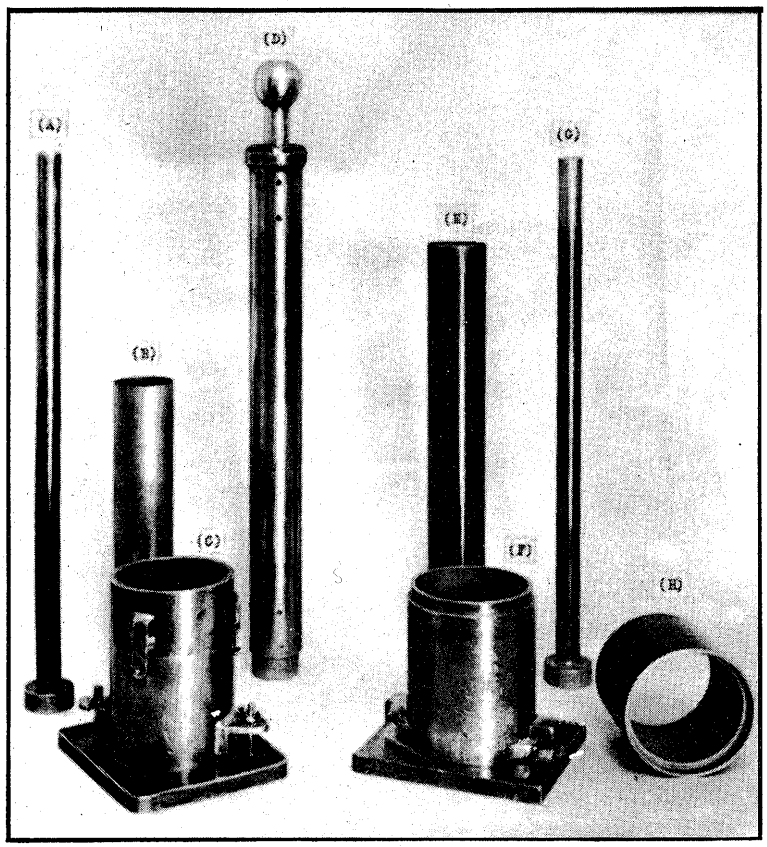
APPARATUS FOR PERFORMING PERCOLATION TESTS
Shows tests in progress on eight samples simultaneously.

During the performance of the test, continuous readings of the deflection of the sample are taken by means of micrometer dial gauges. The amount of compression or expansion, expressed as a percentage of the original length of the sample, is a valuable indication of the compression of the soil which will occur under the action of load or the expansion of the soil as saturation takes place.

APPENDIX F

METHOD OF PERFORMING COMPACTION TESTS

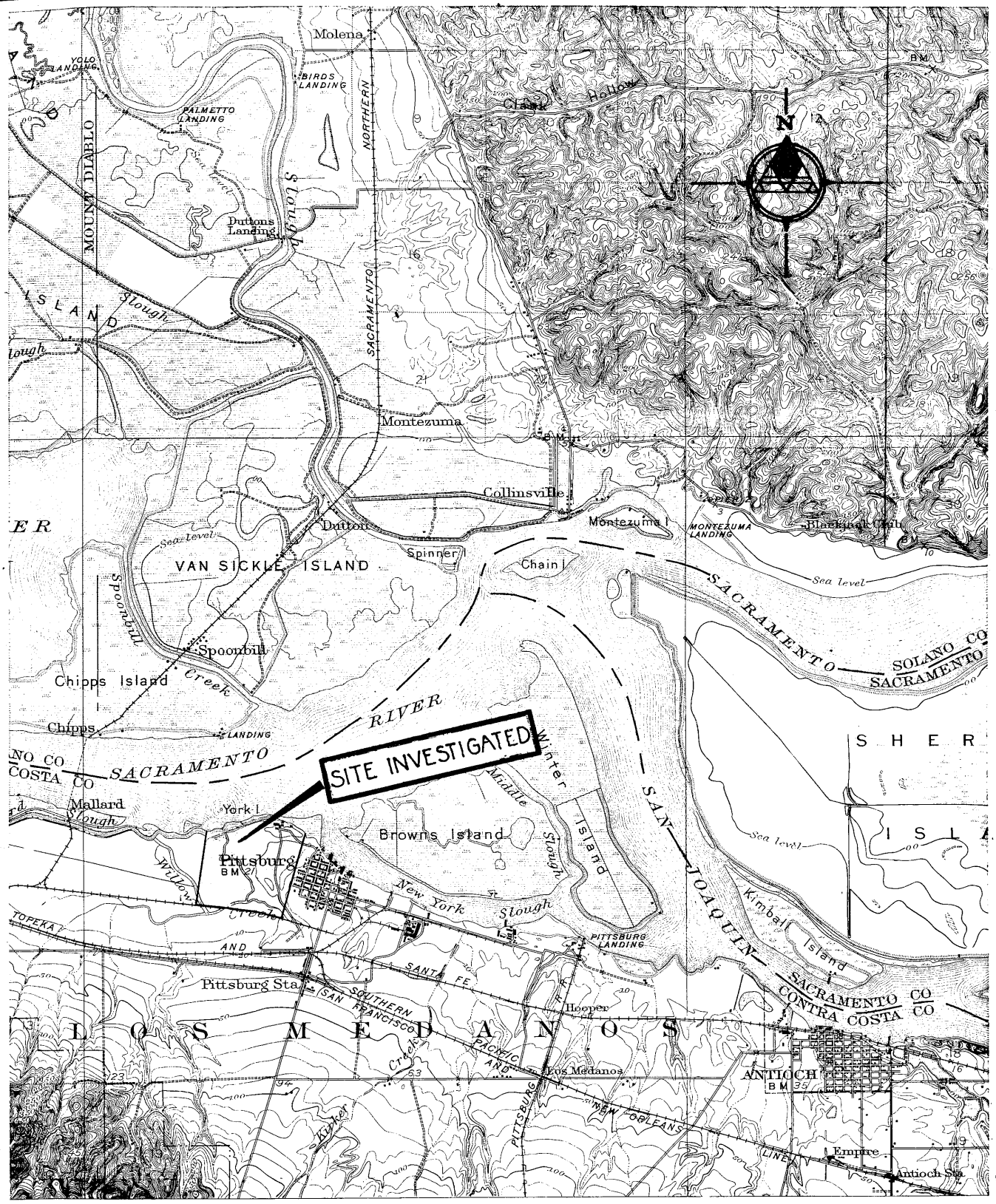
It has been established that, when compacting effort is held constant, the density of a rolled earth fill increases with added moisture until a maximum dry density is obtained at a moisture content termed the "optimum moisture content", after which the dry density decreases. The compaction curve showing the relationship between density and moisture content for a specific compacting effort is determined by experimental methods -- the most commonly used methods are described in the following paragraph.



APPARATUS FOR PERFORMING COMPACTION TESTS
(A), 5½-pound rammer; (B), sleeve controlling 12" height of drop; (C), 1/30-cubic-foot cylinder with removable collar and base plate, (D), 10-pound rammer within sleeve; (E), sleeve controlling 18" height of drop; (F), 1/20-cubic-foot cylinder and removable base plate; (G), 5½-pound rammer; (H), removable collar.

For the "Standard A.A.S.H.O." method of compaction, the soil sample is compacted in accordance with the "Standard Laboratory Method of Test for the Compaction and Density of Soil" as specified by the American Association of State Highway Officials under Designation T99-38. In this method of testing, a portion of the soil sample is compacted at a specific moisture content in three equal layers in a standard compaction cylinder having a volume of 1/30 cubic foot, using twenty-five 12-inch blows of a standard 5½-pound rammer to compact each layer. In the "Modified A.A.S.H.O." compaction method, a portion of the soil sample is compacted at a specific moisture content in five equal layers in a standard compaction cylinder having a volume of 1/30 cubic foot, using twenty-five 18-inch blows of a 10-pound rammer to compact each layer. In the "Proctor" method of compaction, a portion of the soil sample is compacted at a specific moisture content in three two-inch layers in a standard Proctor-type compaction cylinder having a volume of 1/20 cubic foot, using twenty-five 18-inch blows of a standard 5½-pound rammer to compact each layer.

For all methods, the wet density of the compacted sample is determined by weighing the known volume of soil; the moisture content, by measuring the loss of weight of a portion of the sample when oven dried; and the dry density, by computing it from the two determined quantities. A series of such compactions is performed at increasing moisture contents until a sufficient number of points defining the moisture-density relationship have been obtained to permit the plotting of the compaction curve. The maximum dry density and optimum moisture content for the particular compacting effort are determined from the compaction curve.



Edition of Nov. 1908, reprinted 1951

Polyconic projection. North American datum

VICINITY MAP

1 ½ 0 1 2 3 4 Miles

1000 500 0 1000 2000 3000 4000 5000 6000 7000 Yards

1000 0 3000 6000 9000 12000 15000 18000 Feet

1 .5 0 1 2 3 4 5 Kilometers

Contour interval 10 feet

Datum is mean sea level

DAMES & MOORE, *Civil Engineers*

FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 1A

BORING LOCATIONS

BORING	CO-ORDINATES	
L-1	S 95 + 45	E 25 + 00
L-2	S 33 + 45	E 25 + 00
L-3	S 80 + 45	E 25 + 00
L-4	S 50 + 45	E 30 + 00
L-5	S 95 + 95	E 30 + 00
L-6	S 95 + 95	E 35 + 00
L-7	S 95 + 95	E 35 + 00
L-8	S 95 + 95	E 35 + 00
L-9	S 95 + 95	E 35 + 00
L-10	S 95 + 45	E 35 + 00
L-11	S 95 + 45	E 30 + 00
L-12	S 95 + 45	E 30 + 00
L-13	S 95 + 45	E 30 + 00
L-14	S 95 + 45	E 30 + 00
L-15	S 95 + 45	E 30 + 00
L-16	S 95 + 45	E 30 + 00
L-17	S 95 + 45	E 30 + 00
L-18	S 95 + 45	E 30 + 00
L-19	S 95 + 45	E 30 + 00
L-20	S 95 + 45	E 30 + 00
L-21	S 95 + 45	E 30 + 00
L-22	S 95 + 45	E 30 + 00
L-23	S 95 + 45	E 30 + 00
L-24	S 95 + 45	E 30 + 00
L-25	S 95 + 45	E 30 + 00
L-26	S 95 + 45	E 30 + 00
L-27	S 95 + 45	E 30 + 00
L-28	S 95 + 45	E 30 + 00
L-29	S 95 + 45	E 30 + 00
L-30	S 95 + 45	E 30 + 00
L-31	S 95 + 45	E 30 + 00
L-32	S 95 + 45	E 30 + 00
L-33	S 95 + 45	E 30 + 00
L-34	S 95 + 45	E 30 + 00
L-35	S 95 + 45	E 30 + 00
L-36	S 95 + 45	E 30 + 00
L-37	S 95 + 45	E 30 + 00
L-38	S 95 + 45	E 30 + 00
L-39	S 95 + 45	E 30 + 00
L-40	S 95 + 45	E 30 + 00
L-41	S 95 + 45	E 30 + 00
L-42	S 95 + 45	E 30 + 00
L-43	S 95 + 45	E 30 + 00
L-44	S 95 + 45	E 30 + 00
L-45	S 95 + 45	E 30 + 00
L-46	S 95 + 45	E 30 + 00
L-47	S 95 + 45	E 30 + 00
L-48	S 95 + 45	E 30 + 00
L-49	S 95 + 45	E 30 + 00
L-50	S 95 + 45	E 30 + 00
L-51	S 95 + 45	E 30 + 00
L-52	S 95 + 45	E 30 + 00
L-53	S 95 + 45	E 30 + 00
L-54	S 95 + 45	E 30 + 00
L-55	S 95 + 45	E 30 + 00
L-56	S 95 + 45	E 30 + 00
L-57	S 95 + 45	E 30 + 00
L-58	S 95 + 45	E 30 + 00
L-59	S 95 + 45	E 30 + 00
L-60	S 95 + 45	E 30 + 00
L-61	S 95 + 45	E 30 + 00
L-62	S 95 + 45	E 30 + 00
L-63	S 95 + 45	E 30 + 00
L-64	S 95 + 45	E 30 + 00
L-65	S 95 + 45	E 30 + 00
L-66	S 95 + 45	E 30 + 00
L-67	S 95 + 45	E 30 + 00
L-68	S 95 + 45	E 30 + 00
L-69	S 95 + 45	E 30 + 00
L-70	S 95 + 45	E 30 + 00
L-71	S 95 + 45	E 30 + 00
L-72	S 95 + 45	E 30 + 00
L-73	S 95 + 45	E 30 + 00
L-74	S 95 + 45	E 30 + 00
L-75	S 95 + 45	E 30 + 00
L-76	S 95 + 45	E 30 + 00
L-77	S 95 + 45	E 30 + 00
L-78	S 95 + 45	E 30 + 00

BORING	CO-ORDINATES	
L-97	S 7 + 95	E 10 + 00
L-98	S 95 + 95	E 10 + 00
L-99	S 95 + 95	E 10 + 00
L-100	S 95 + 95	E 10 + 00
L-101	S 95 + 95	E 10 + 00
L-102	S 95 + 95	E 10 + 00
L-103	S 95 + 95	E 10 + 00
L-104	S 95 + 95	E 10 + 00
L-105	S 80 + 00	E 10 + 00
L-106	S 11 + 00	E 10 + 00
L-107	S 11 + 00	E 10 + 00
L-108	S 11 + 00	E 10 + 00
L-109	S 11 + 00	E 10 + 00
L-110	S 95 + 10	E 10 + 00
L-111	S 95 + 10	E 10 + 00
L-112	S 95 + 10	E 10 + 00
L-113	S 11 + 00	E 10 + 00
L-114	S 11 + 00	E 10 + 00
L-115	S 11 + 00	E 10 + 00
L-116	S 11 + 00	E 10 + 00
L-117	S 11 + 00	E 10 + 00
L-118	S 11 + 00	E 10 + 00
L-119	S 11 + 00	E 10 + 00
L-120	S 11 + 00	E 10 + 00
L-121	S 11 + 00	E 10 + 00
L-122	S 11 + 00	E 10 + 00
L-123	S 11 + 00	E 10 + 00
L-124	S 11 + 00	E 10 + 00
L-125	S 11 + 00	E 10 + 00
L-126	S 11 + 00	E 10 + 00
L-127	S 11 + 00	E 10 + 00
L-128	S 11 + 00	E 10 + 00
L-129	S 11 + 00	E 10 + 00
L-130	S 11 + 00	E 10 + 00
L-131	S 11 + 00	E 10 + 00
L-132	S 11 + 00	E 10 + 00
L-133	S 11 + 00	E 10 + 00
L-134	S 11 + 00	E 10 + 00
L-135	S 11 + 00	E 10 + 00
L-136	S 11 + 00	E 10 + 00
L-137	S 11 + 00	E 10 + 00
L-138	S 11 + 00	E 10 + 00
L-139	S 11 + 00	E 10 + 00
L-140	S 11 + 00	E 10 + 00
L-141	S 11 + 00	E 10 + 00
L-142	S 11 + 00	E 10 + 00
L-143	S 11 + 00	E 10 + 00
L-144	S 11 + 00	E 10 + 00
L-145	S 11 + 00	E 10 + 00
L-146	S 11 + 00	E 10 + 00
L-147	S 11 + 00	E 10 + 00
L-148	S 11 + 00	E 10 + 00
L-149	S 11 + 00	E 10 + 00
L-150	S 11 + 00	E 10 + 00
L-151	S 11 + 00	E 10 + 00
L-152	S 11 + 00	E 10 + 00
L-153	S 11 + 00	E 10 + 00
L-154	S 11 + 00	E 10 + 00
L-155	S 11 + 00	E 10 + 00
L-156	S 11 + 00	E 10 + 00
L-157	S 11 + 00	E 10 + 00
L-158	S 11 + 00	E 10 + 00
L-159	S 11 + 00	E 10 + 00
L-160	S 11 + 00	E 10 + 00
L-161	S 11 + 00	E 10 + 00
L-162	S 11 + 00	E 10 + 00
L-163	S 11 + 00	E 10 + 00
L-164	S 11 + 00	E 10 + 00
L-165	S 11 + 00	E 10 + 00
L-166	S 11 + 00	E 10 + 00
L-167	S 11 + 00	E 10 + 00
L-168	S 11 + 00	E 10 + 00
L-169	S 11 + 00	E 10 + 00
L-170	S 11 + 00	E 10 + 00
L-171	S 11 + 00	E 10 + 00
L-172	S 11 + 00	E 10 + 00
L-173	S 11 + 00	E 10 + 00
L-174	S 11 + 00	E 10 + 00
L-175	S 11 + 00	E 10 + 00
L-176	S 11 + 00	E 10 + 00
L-177	S 11 + 00	E 10 + 00
L-178	S 11 + 00	E 10 + 00

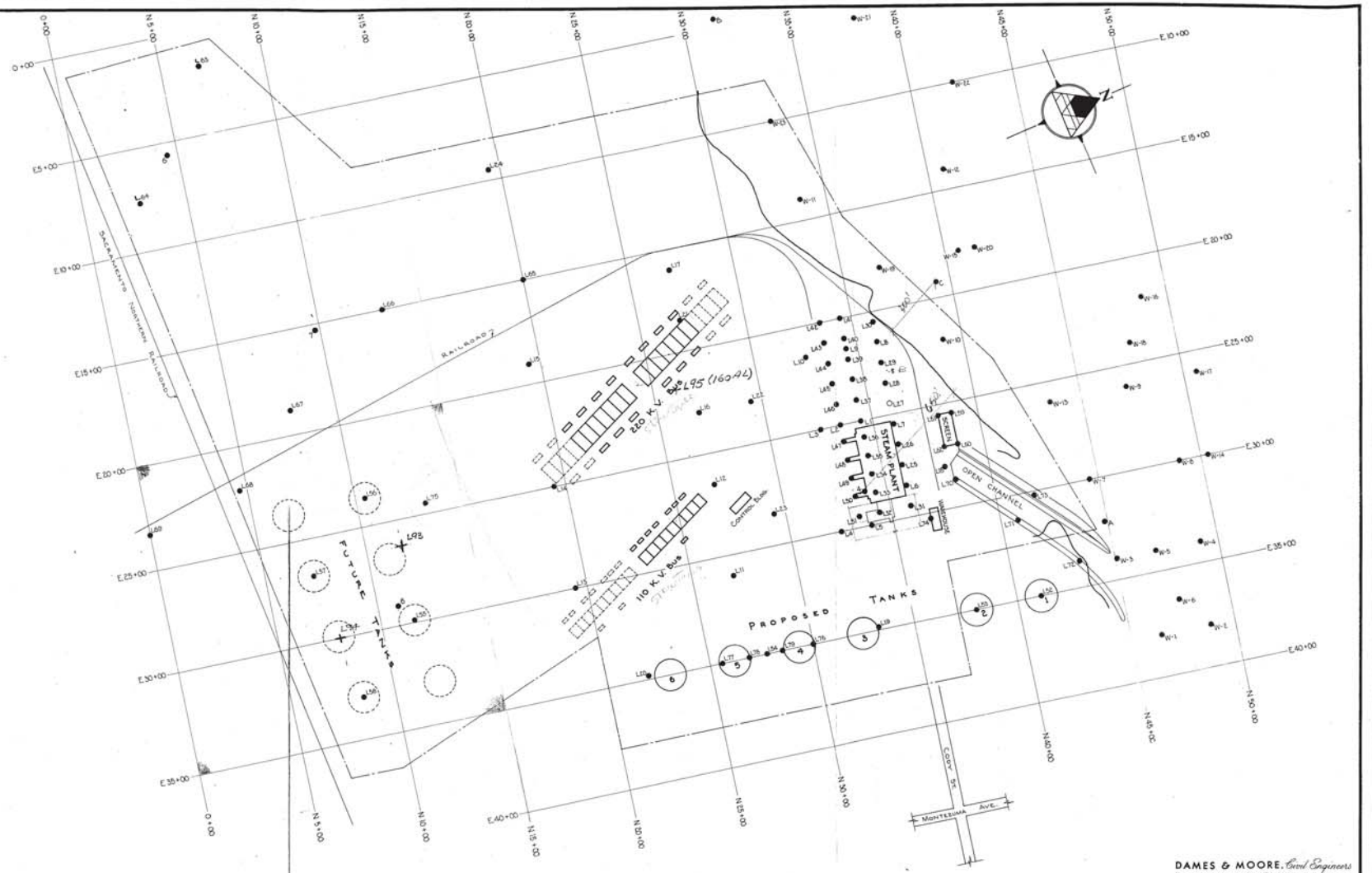
PREVIOUS EXPLORATIONS		
A	S 55 + 95	E 10 + 00
B	S 55 + 95	E 10 + 00
C	S 55 + 95	E 10 + 00
D	S 55 + 95	E 10 + 00
E	S 55 + 95	E 10 + 00
F	S 55 + 95	E 10 + 00
G	S 55 + 95	E 10 + 00
H	S 55 + 95	E 10 + 00
I	S 55 + 95	E 10 + 00
J	S 55 + 95	E 10 + 00
K	S 55 + 95	E 10 + 00
L	S 55 + 95	E 10 + 00
M	S 55 + 95	E 10 + 00
N	S 55 + 95	E 10 + 00
O	S 55 + 95	E 10 + 00
P	S 55 + 95	E 10 + 00
Q	S 55 + 95	E 10 + 00
R	S 55 + 95	E 10 + 00
S	S 55 + 95	E 10 + 00
T	S 55 + 95	E 10 + 00
U	S 55 + 95	E 10 + 00
V	S 55 + 95	E 10 + 00
W	S 55 + 95	E 10 + 00
X	S 55 + 95	E 10 + 00
Y	S 55 + 95	E 10 + 00
Z	S 55 + 95	E 10 + 00

* BORING TO BE DRILLED WHEN SITE CONDITIONS PERMIT

REFERENCE:
DRAWING NO. 410801 - CHANGE 3, TITLED "SOIL TEST BORING LOCATIONS" PITTSBURG STEAM PLANT - PACIFIC GAS AND ELECTRIC COMPANY - DRAWING PREPARED BY BECHTEL CORPORATION - NOV. 9, 1951.

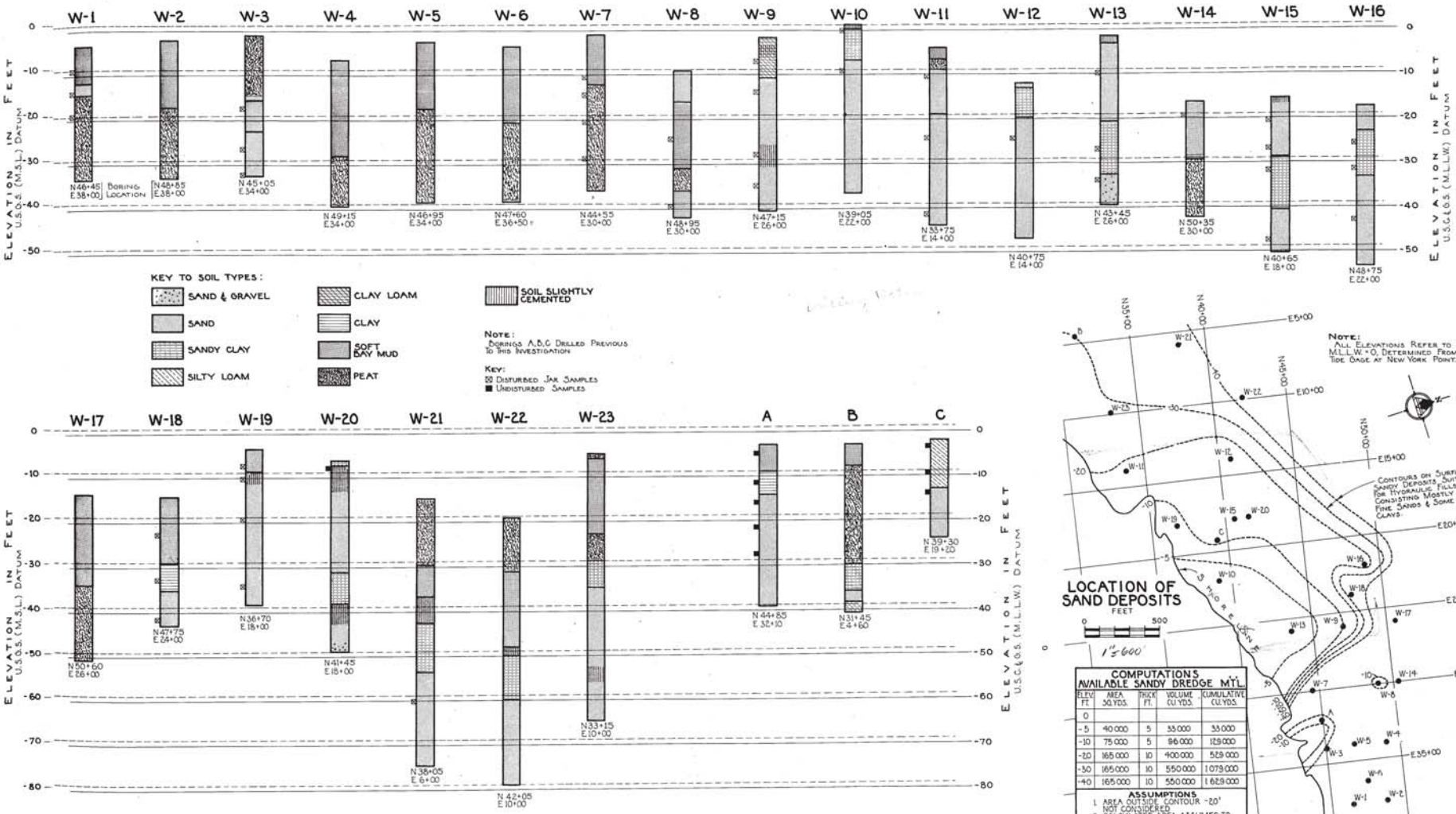
PLOT PLAN

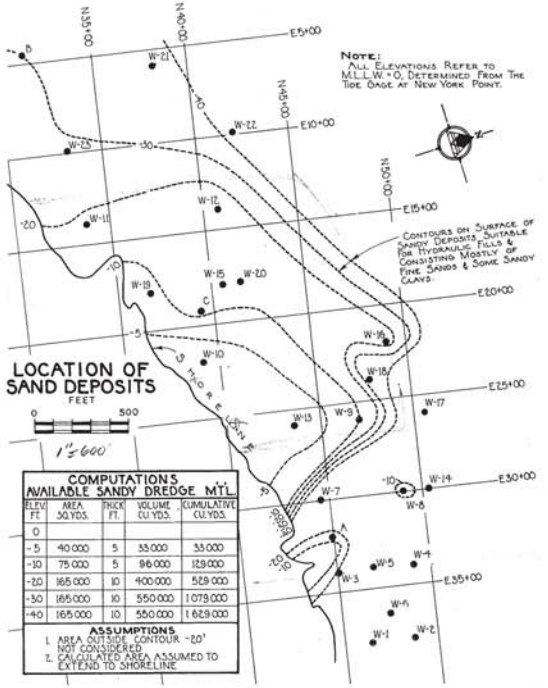
FEET
100 0 100 200 300 400 500



DAMES & MOORE, *Soil Engineers*
FOUNDATION INVESTIGATIONS - SOIL MECHANICS ENGINEERING

PLATE 1B

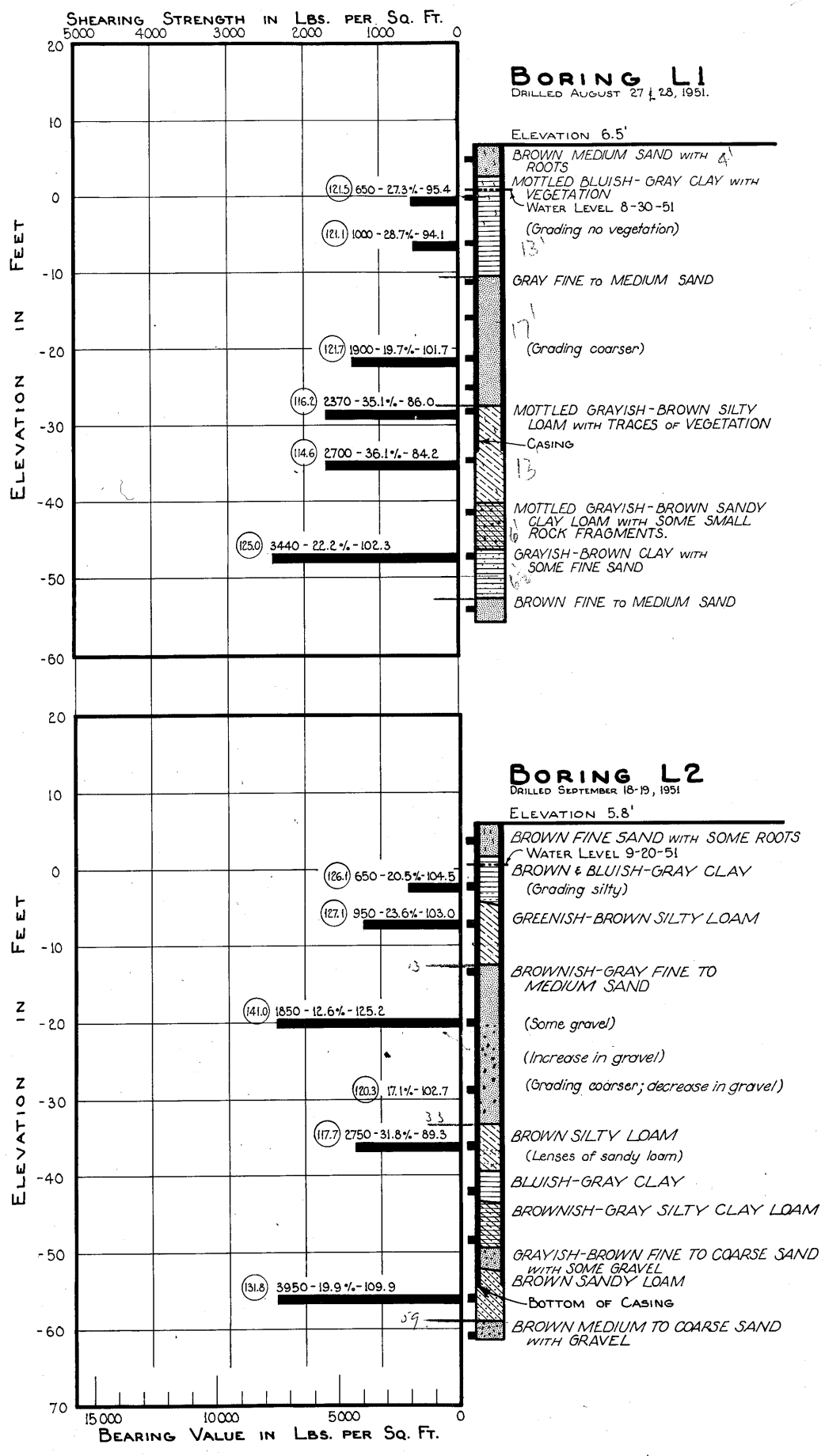




LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS - SOIL MECHANICS ENGINEERING

PLATE 2

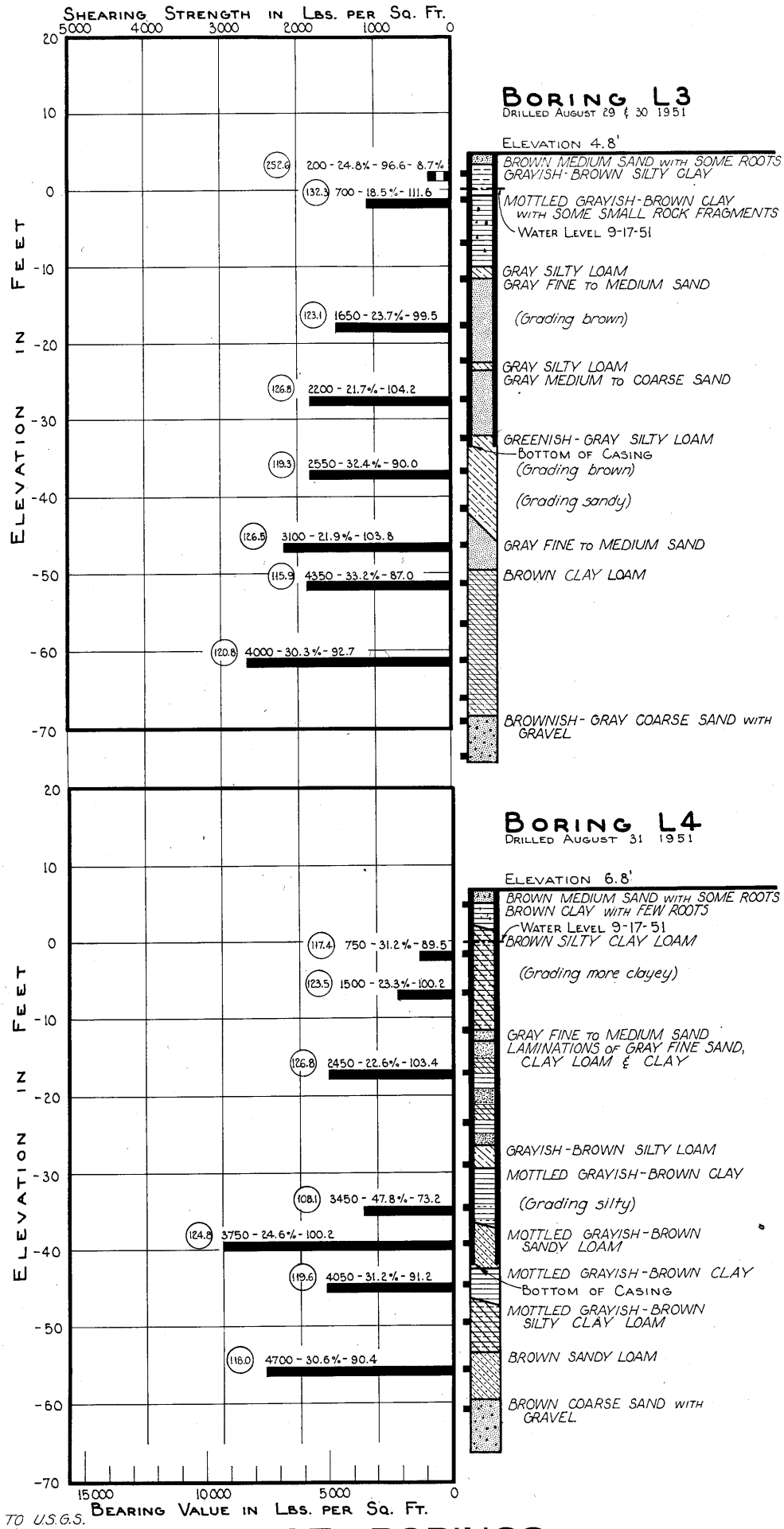


NOTE
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2A

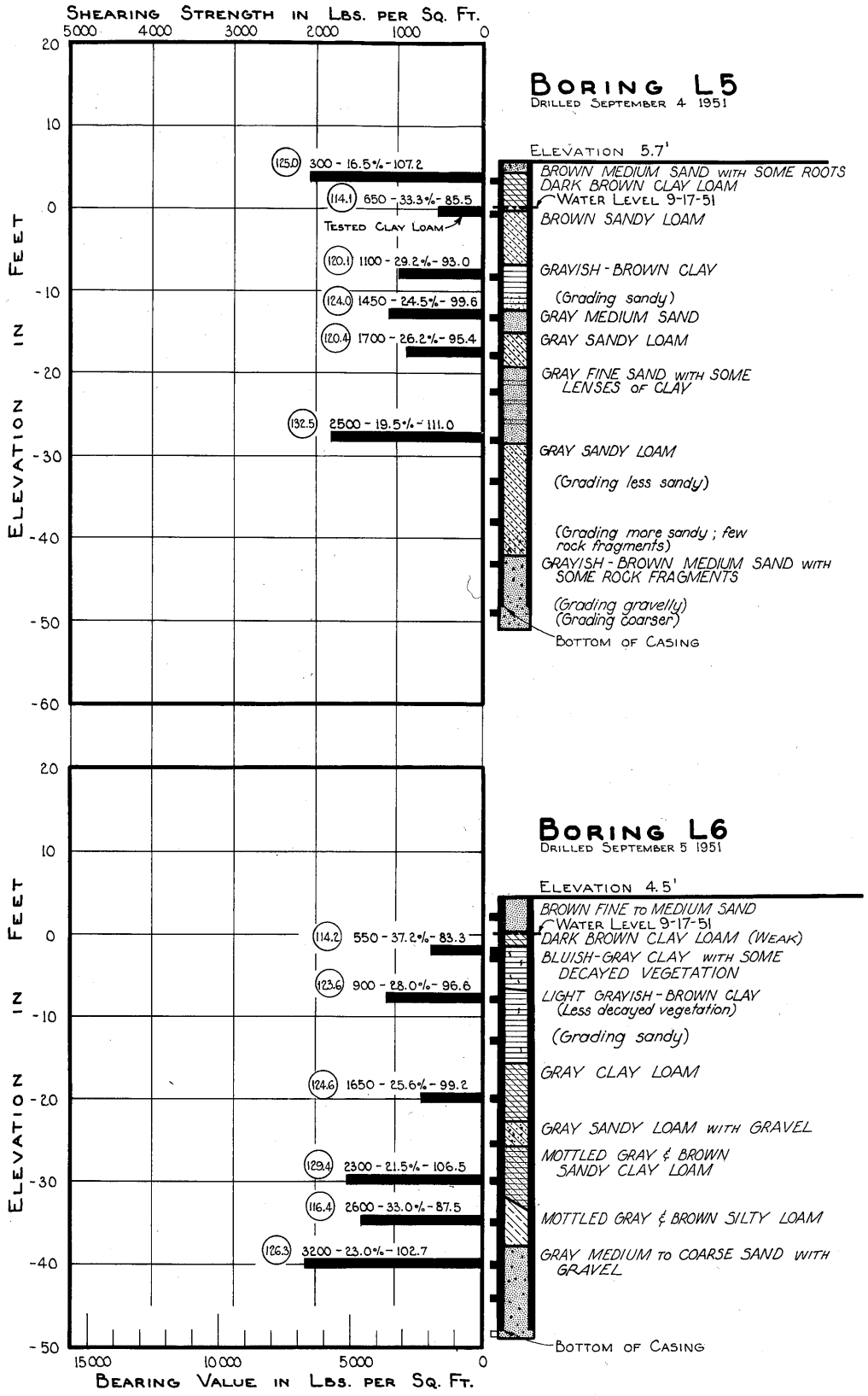


NOTE
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2B



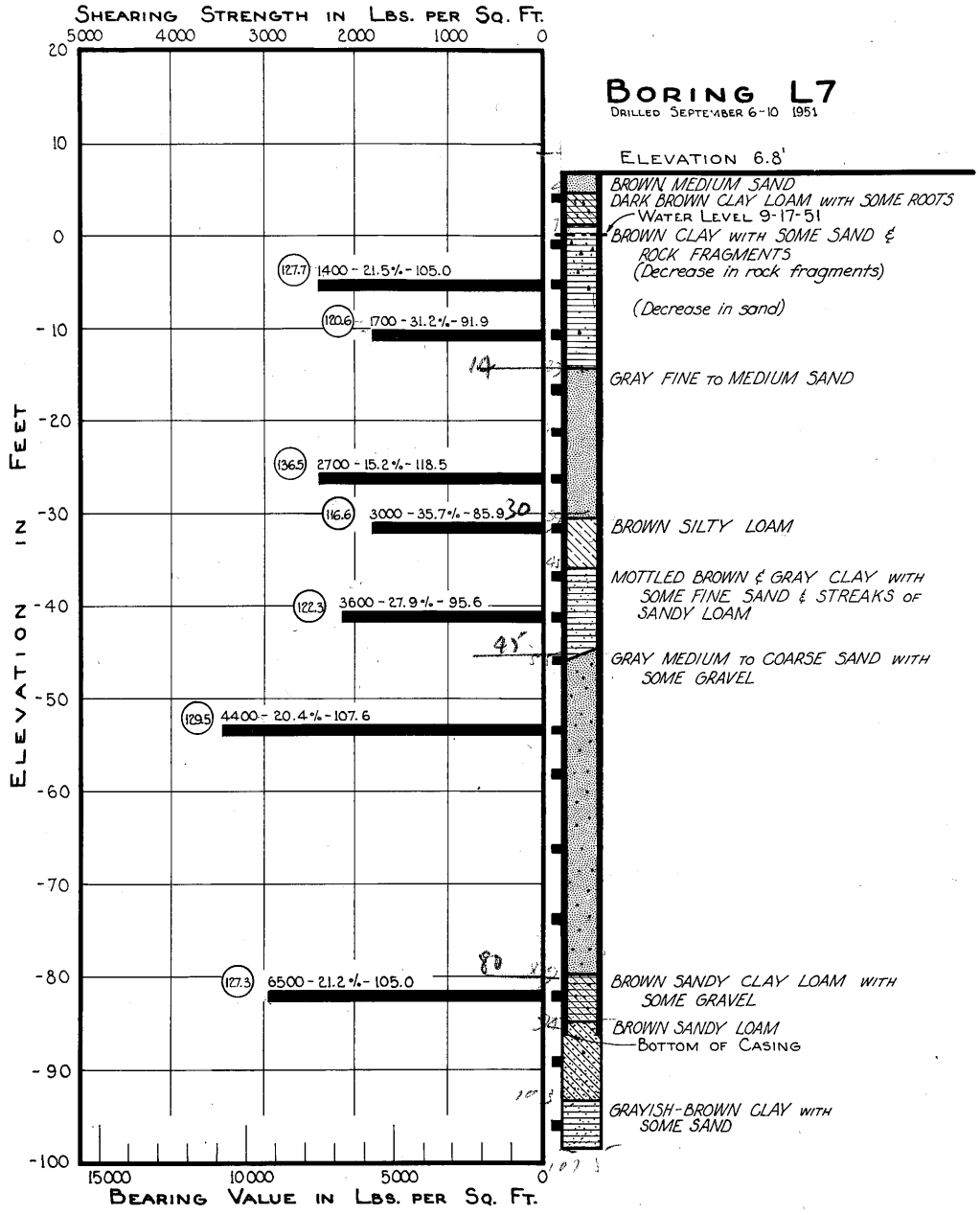
LOG OF BORINGS

NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2C



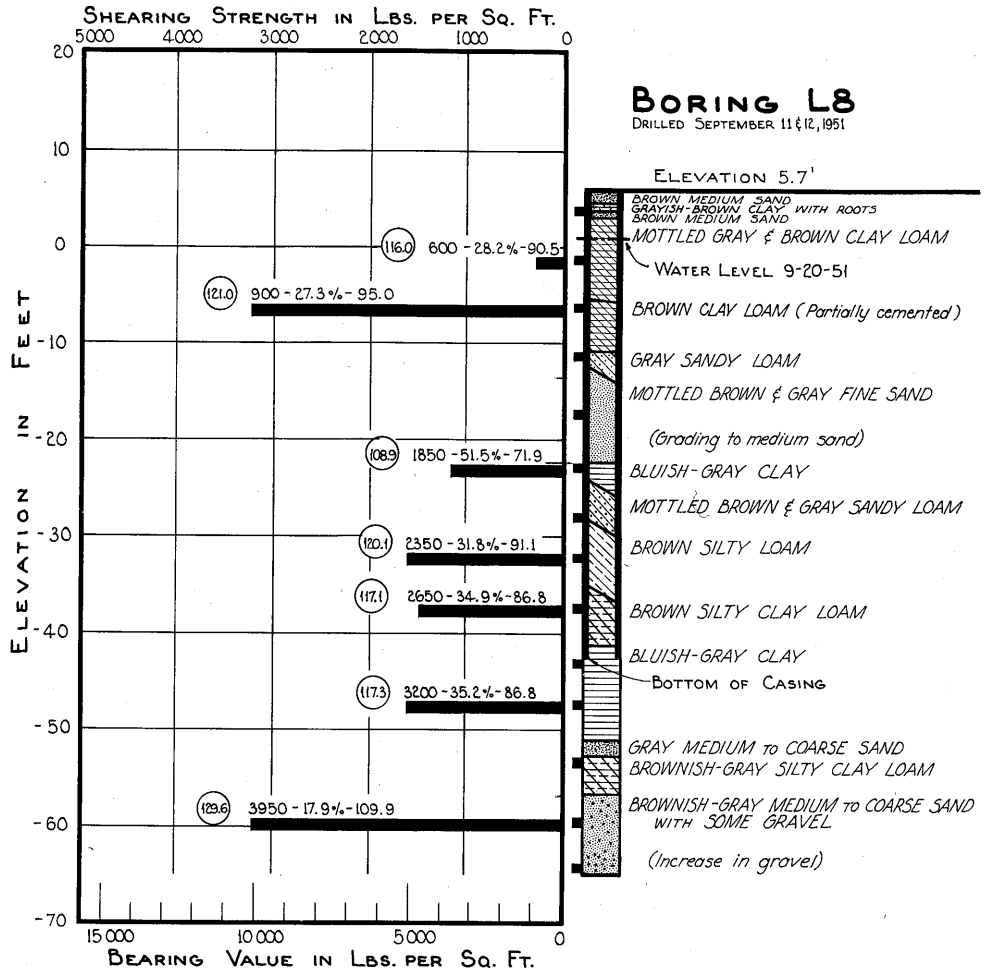
LOG OF BORINGS

NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L.=0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2D



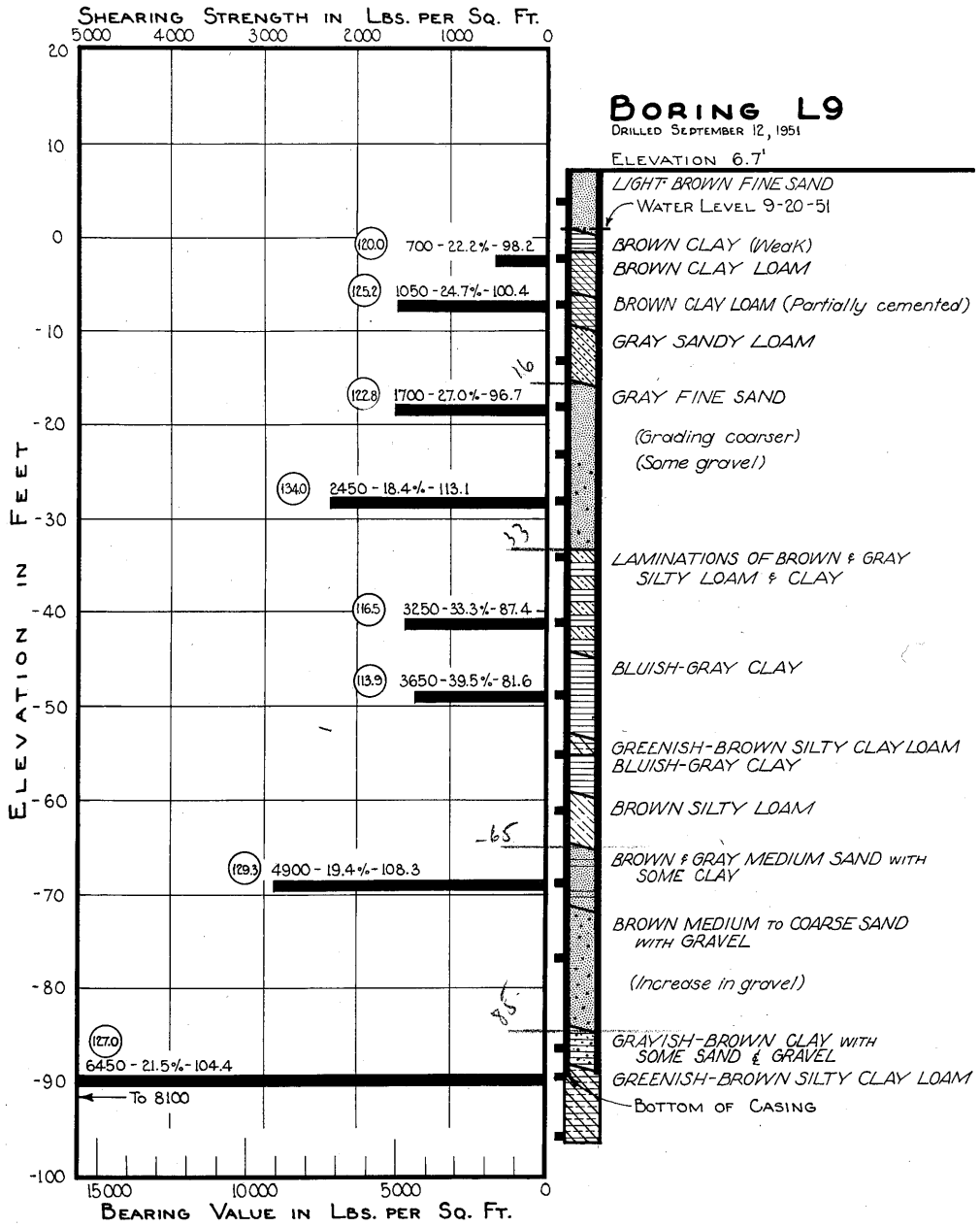
LOG OF BORINGS

NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2E



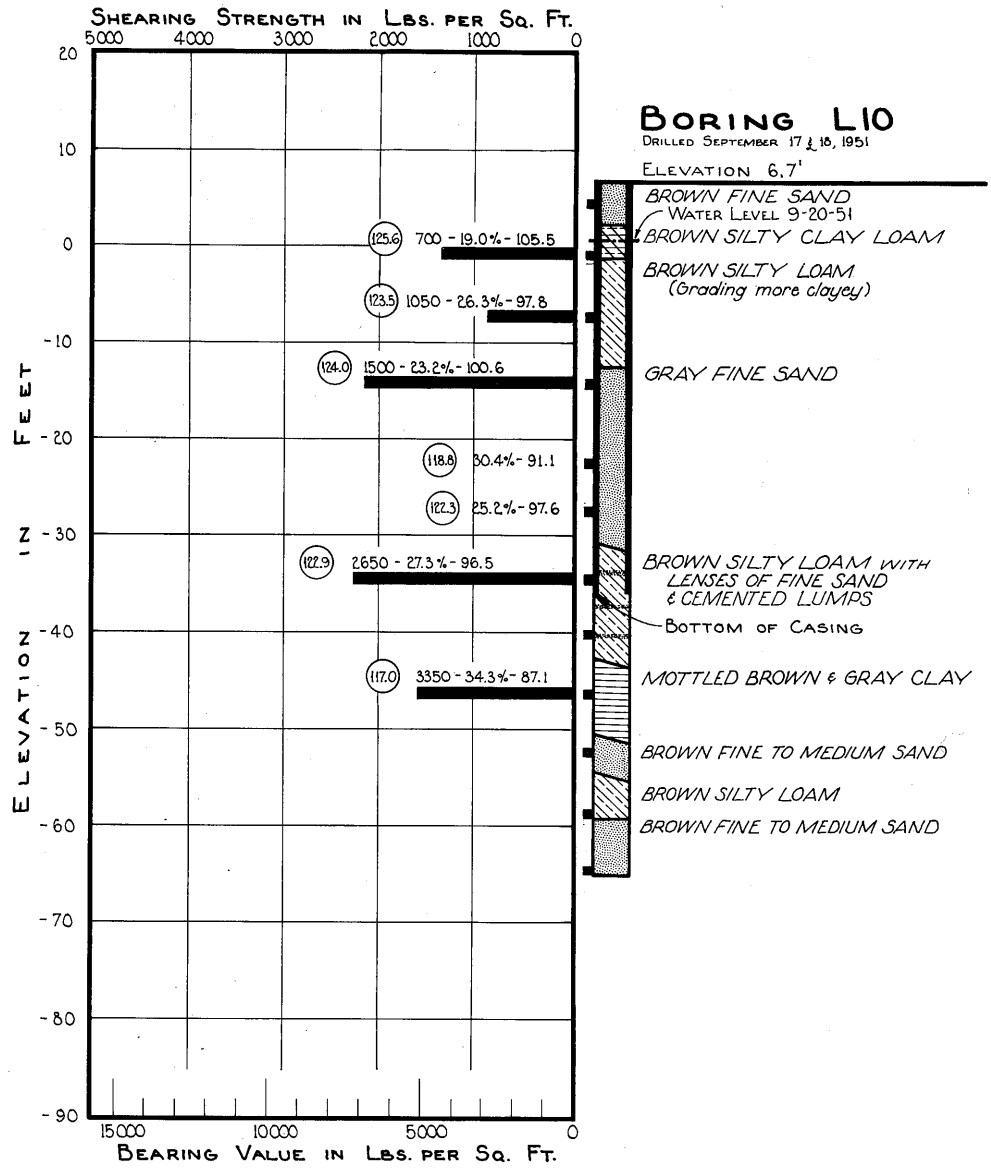
LOG OF BORINGS

NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2F



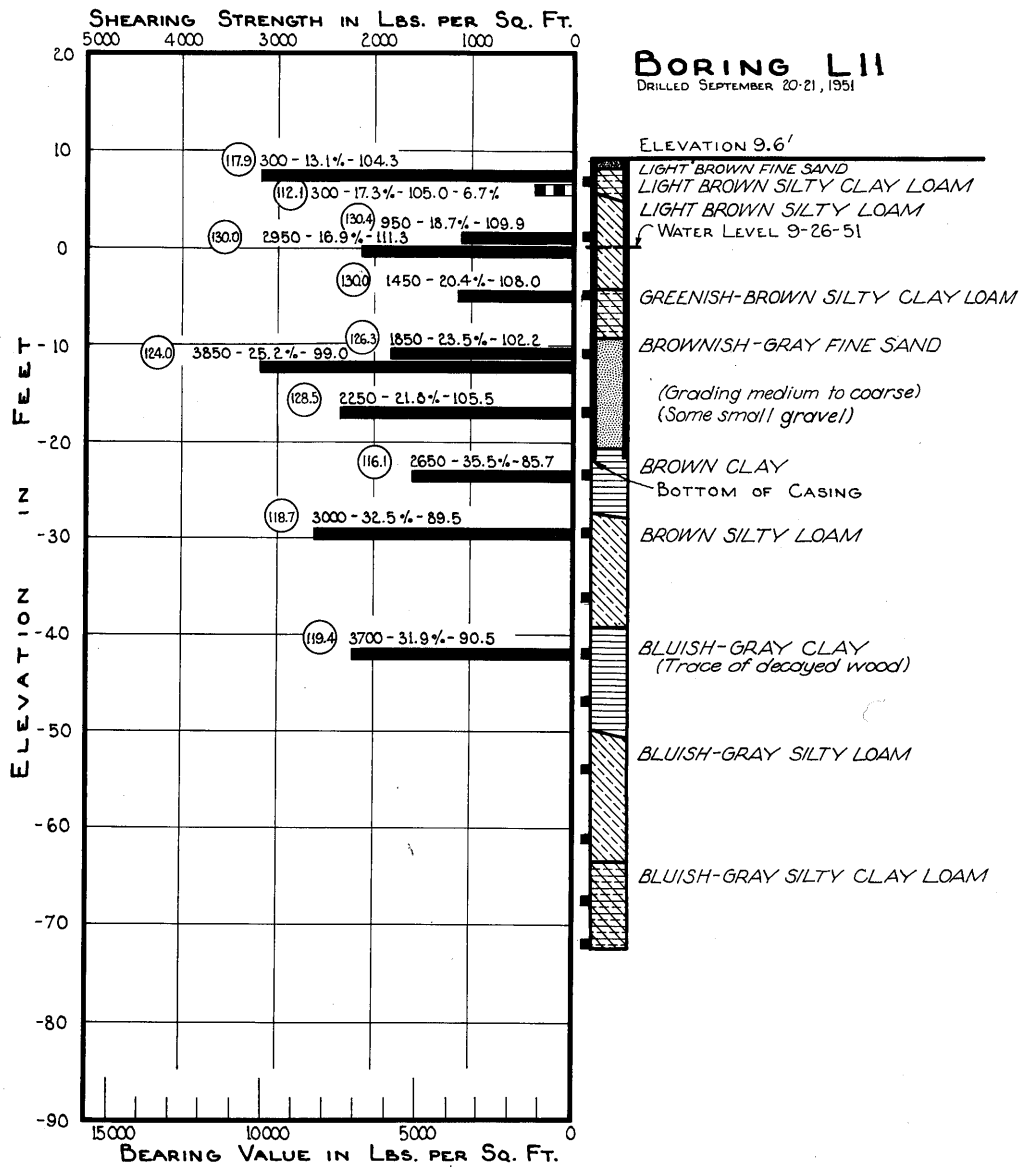
LOG OF BORINGS

NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 26



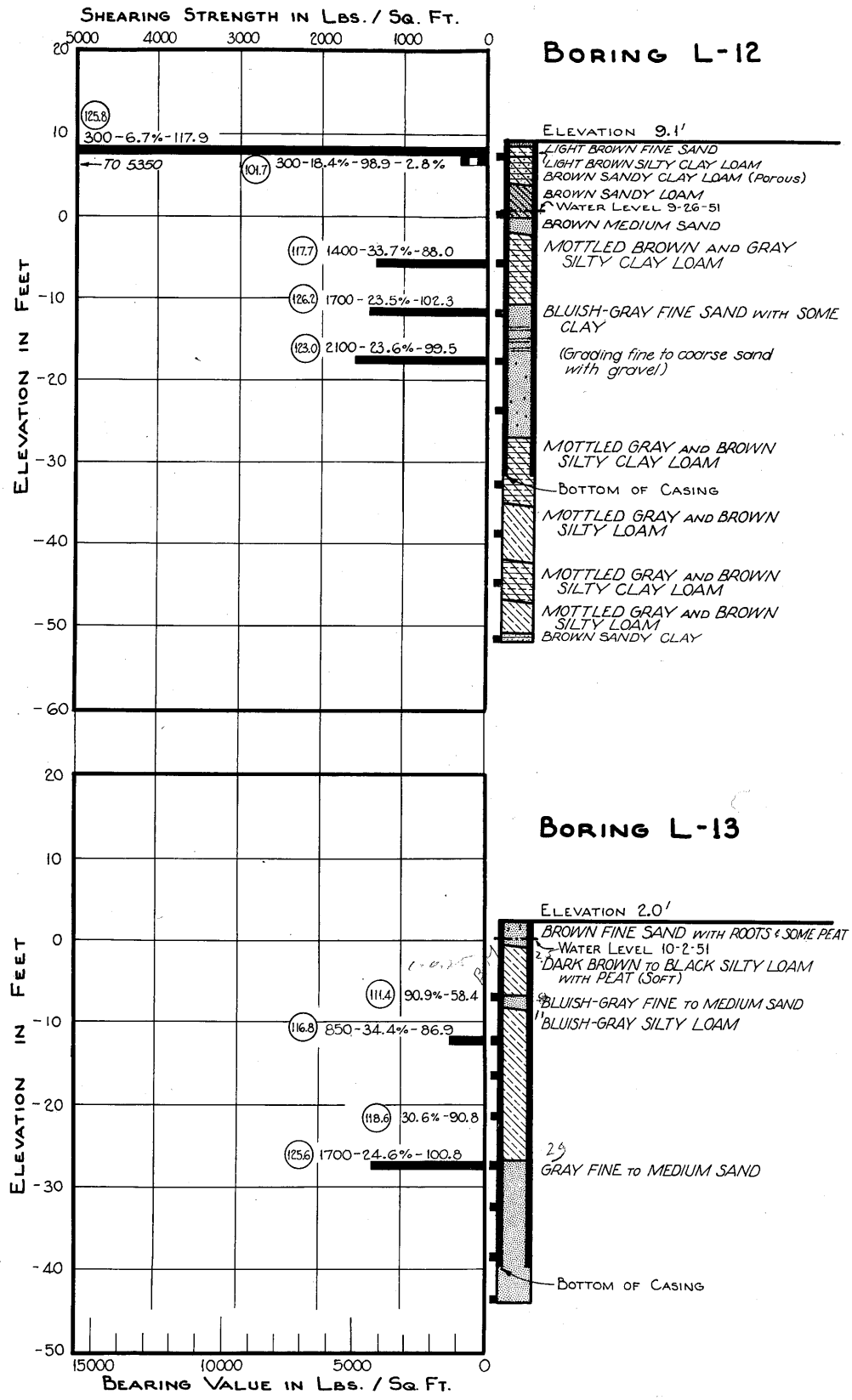
LOG OF BORINGS

NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2H



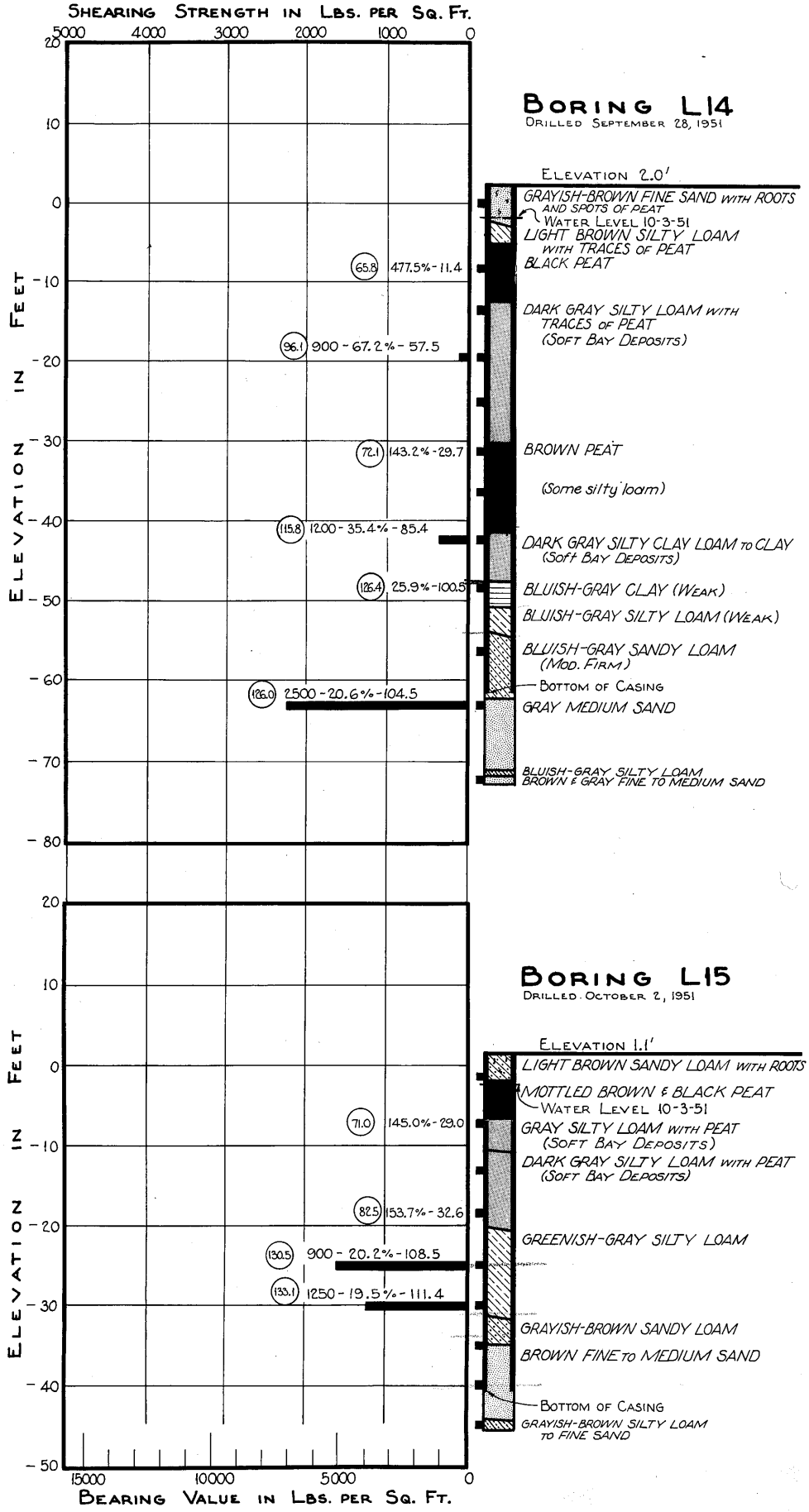
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L.= 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 21

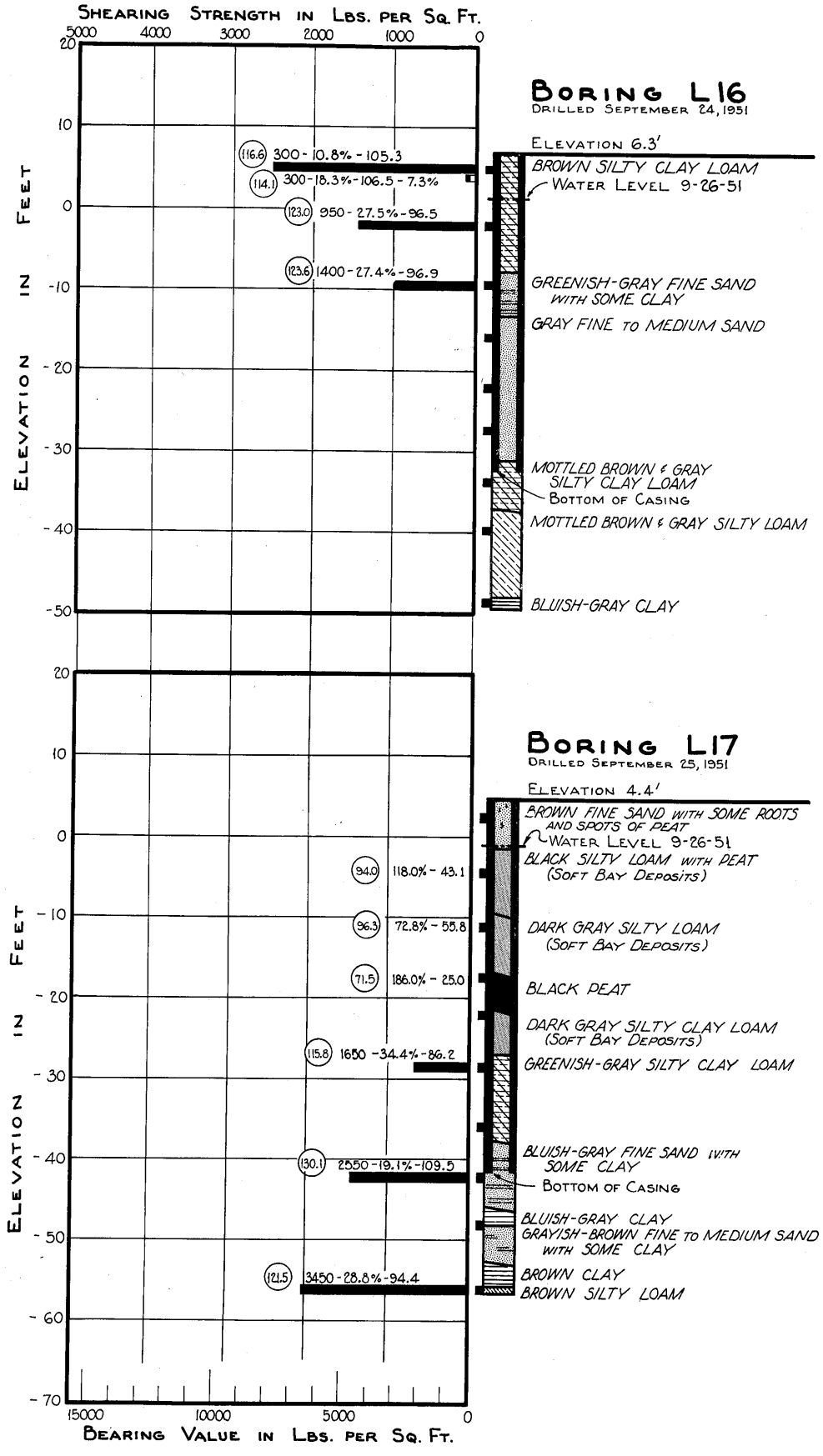


NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L.=0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING



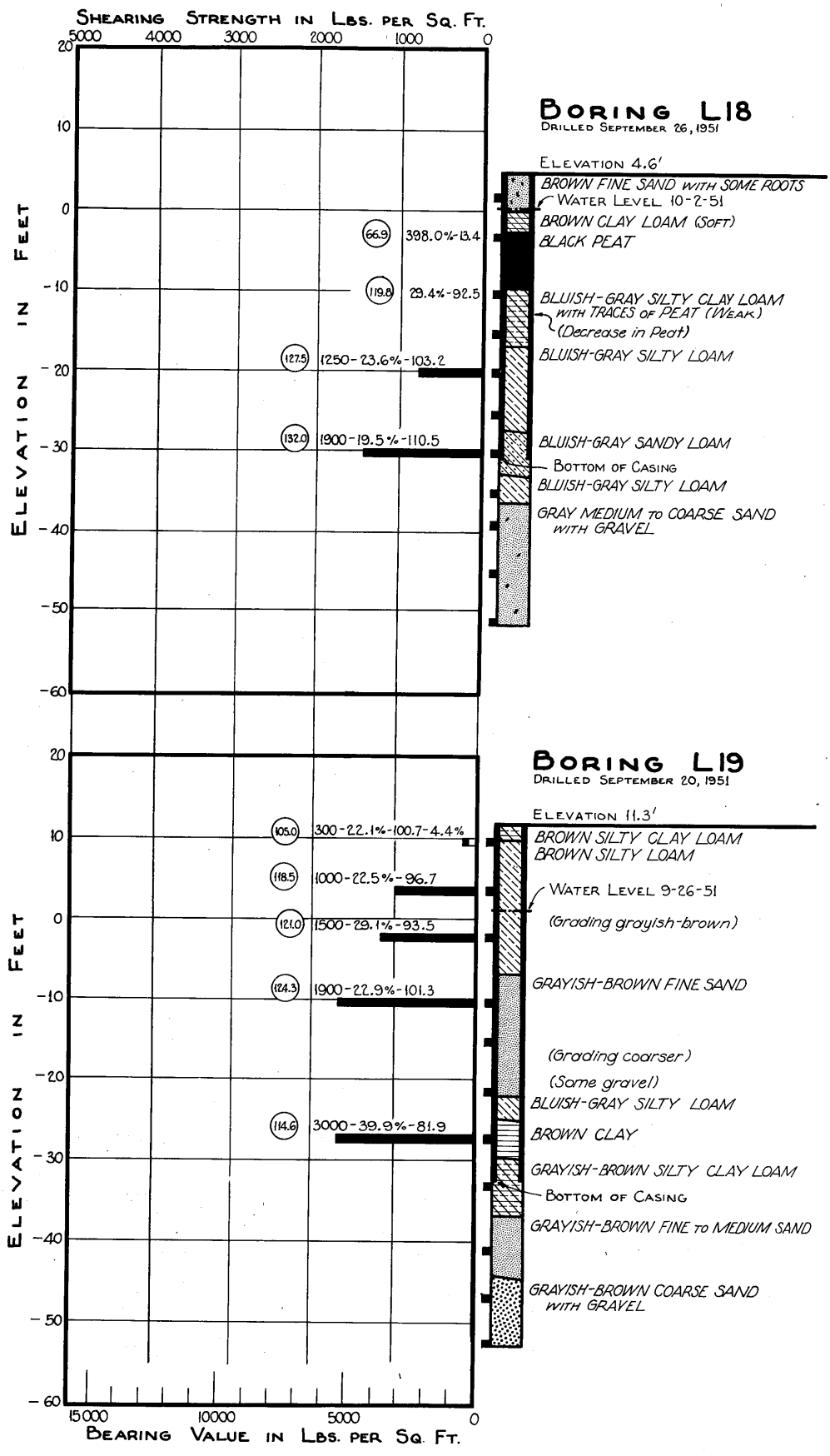
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2K



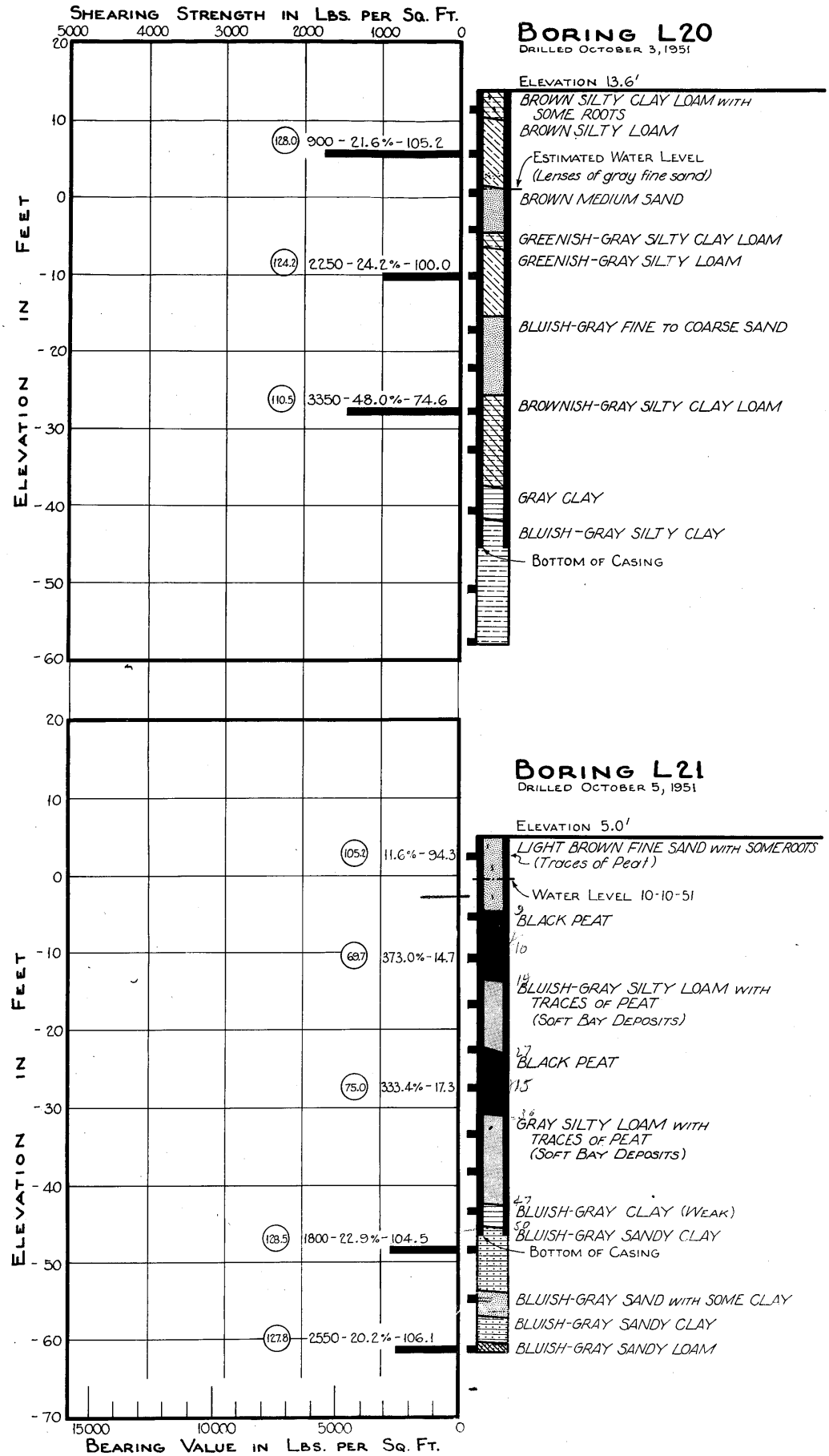
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L.= 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2L



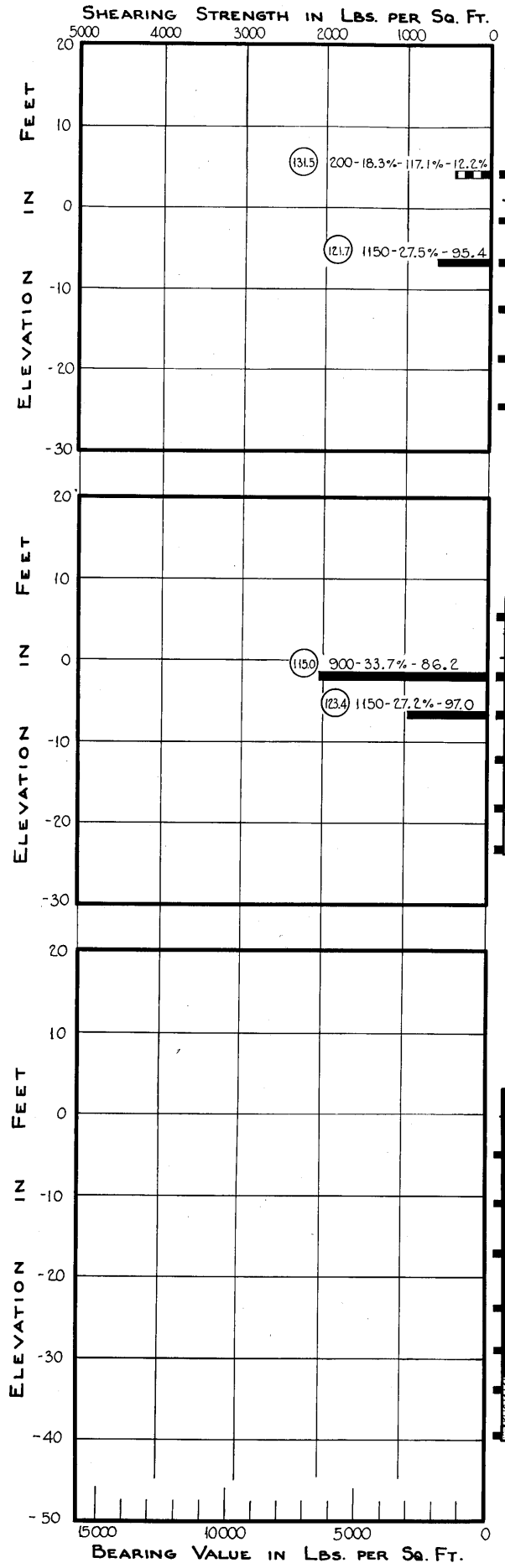
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2M



BORING L22

DRILLED OCTOBER 8, 1951

ELEVATION 6.2'

LIGHT BROWN FINE SAND
BROWN SANDY CLAY LOAM
BROWN SILTY CLAY LOAM
BROWN MEDIUM SAND
WATER LEVEL 10-10-51
GREENISH-BROWN SILTY LOAM
BOTTOM OF CASING
BLUISH-GRAY FINE SAND

BORING L23

DRILLED OCTOBER 9, 1951

ELEVATION 7.3'

BROWN SILTY CLAY LOAM
WATER LEVEL 10-10-5
BROWN SILTY LOAM (CEMENTED)
BOTTOM OF CASING
GRAY FINE SAND
(Grading fine to coarse sand)

BORING L24

DRILLED OCTOBER 9, 1951

ELEVATION 3.1'

BROWN FINE SAND WITH SOME ROOTS
BLACK SILTY LOAM WITH PEAT (SOFT BAY DEPOSITS)
WATER LEVEL (ESTIMATED)
BROWN AND BLACK PEAT
GRAY SILTY LOAM WITH PEAT (SOFT BAY DEPOSITS)
BLACK PEAT
BLUISH-GRAY SILTY CLAY LOAM (WEAK)
BLUISH-GRAY SILTY LOAM
GREENISH-GRAY SILTY CLAY LOAM
BOTTOM OF CASING
(Grading sandy)
GREENISH-GRAY FINE TO MEDIUM SAND

NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L.=0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

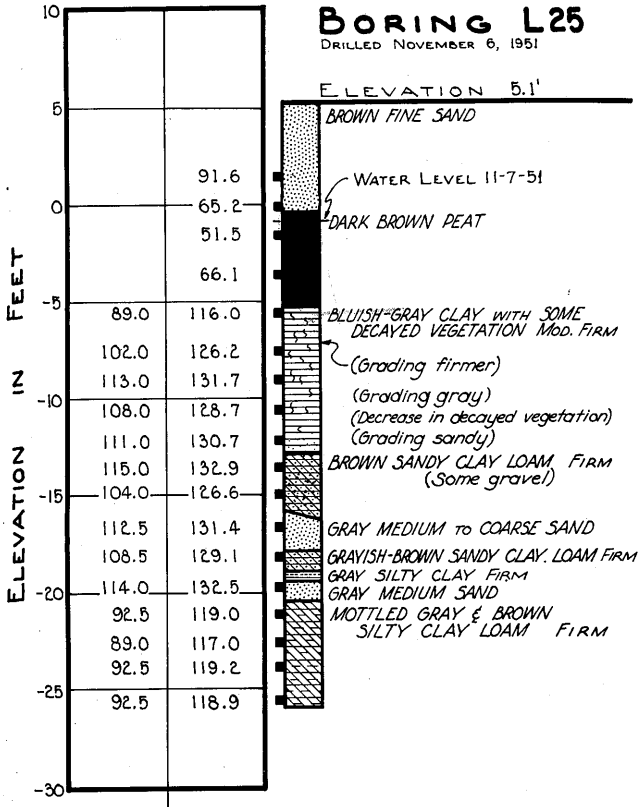
DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2N

BORING L25

DRILLED NOVEMBER 6, 1951

ELEVATION 5.1'

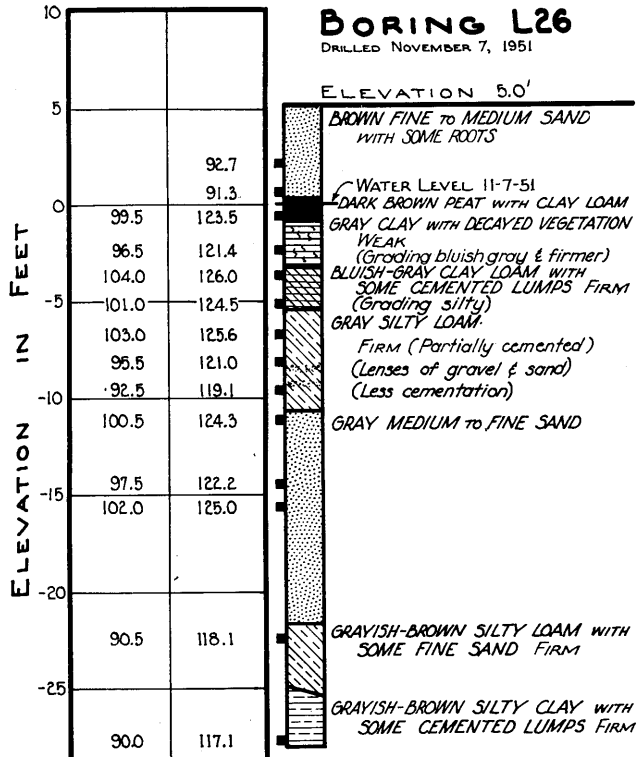


DRY DENSITY	FIELD DENSITY
	91.6
	65.2
	51.5
	66.1
89.0	116.0
102.0	126.2
113.0	131.7
108.0	128.7
111.0	130.7
115.0	132.9
104.0	126.6
112.5	131.4
108.5	129.1
114.0	132.5
92.5	119.0
89.0	117.0
92.5	119.2
92.5	118.9

BORING L26

DRILLED NOVEMBER 7, 1951

ELEVATION 5.0'

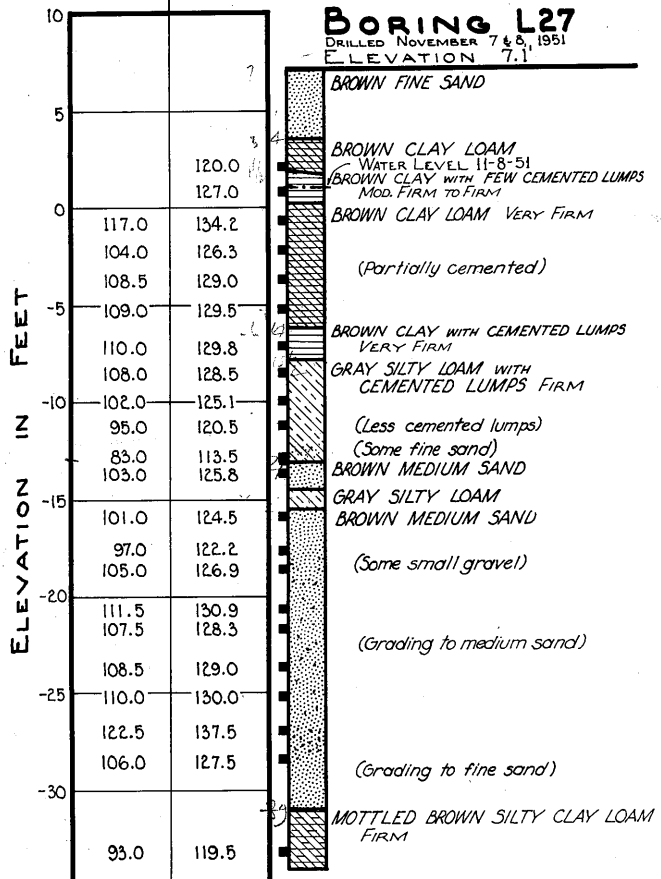


DRY DENSITY	FIELD DENSITY
	92.7
	91.3
99.5	123.5
96.5	121.4
104.0	126.0
101.0	124.5
103.0	125.6
95.5	121.0
92.5	119.1
100.5	124.3
97.5	122.2
102.0	125.0
90.5	118.1
90.0	117.1

BORING L27

DRILLED NOVEMBER 7 & 8, 1951

ELEVATION 7.1'

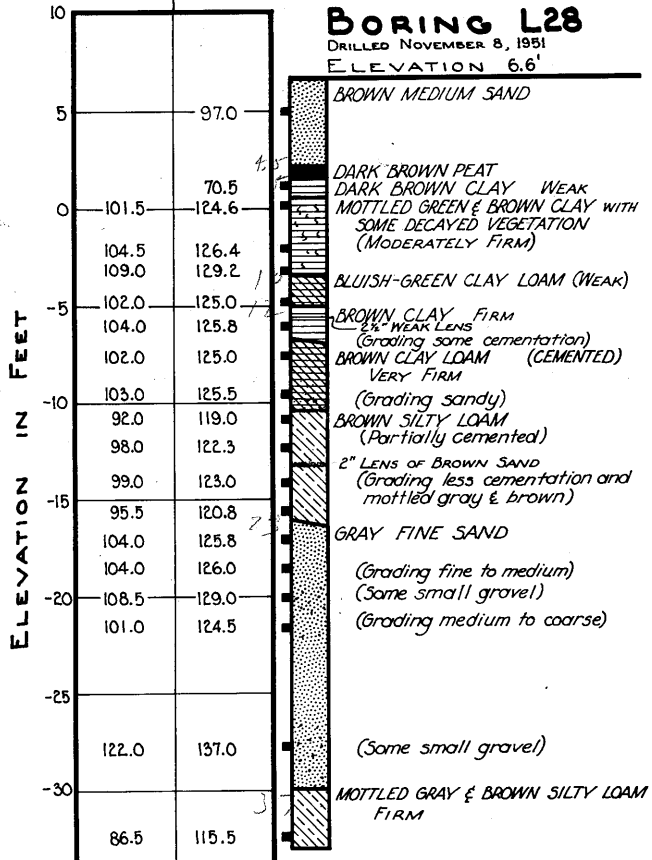


DRY DENSITY	FIELD DENSITY
	120.0
	127.0
117.0	134.2
104.0	126.3
108.5	129.0
109.0	129.5
110.0	129.8
108.0	128.5
102.0	125.1
95.0	120.5
83.0	113.5
103.0	125.8
101.0	124.5
97.0	122.2
105.0	126.9
111.5	130.9
107.5	128.3
108.5	129.0
110.0	130.0
122.5	137.5
106.0	127.5
93.0	119.5

BORING L28

DRILLED NOVEMBER 8, 1951

ELEVATION 6.6'



DRY DENSITY	FIELD DENSITY
	97.0
	70.5
101.5	124.6
104.5	126.4
109.0	129.2
102.0	125.0
104.0	125.8
102.0	125.0
103.0	125.5
92.0	119.0
98.0	122.3
99.0	123.0
95.5	120.8
104.0	125.8
104.0	126.0
108.5	129.0
101.0	124.5
122.0	137.0
86.5	115.5

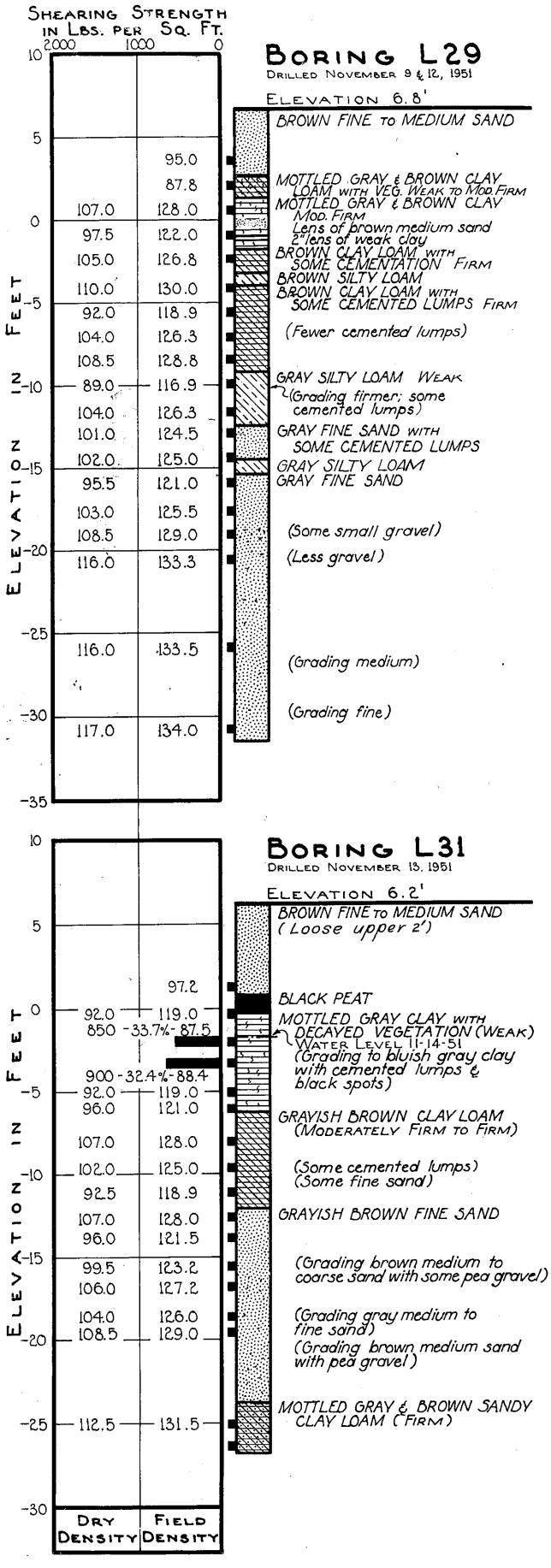
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L.= 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2-0



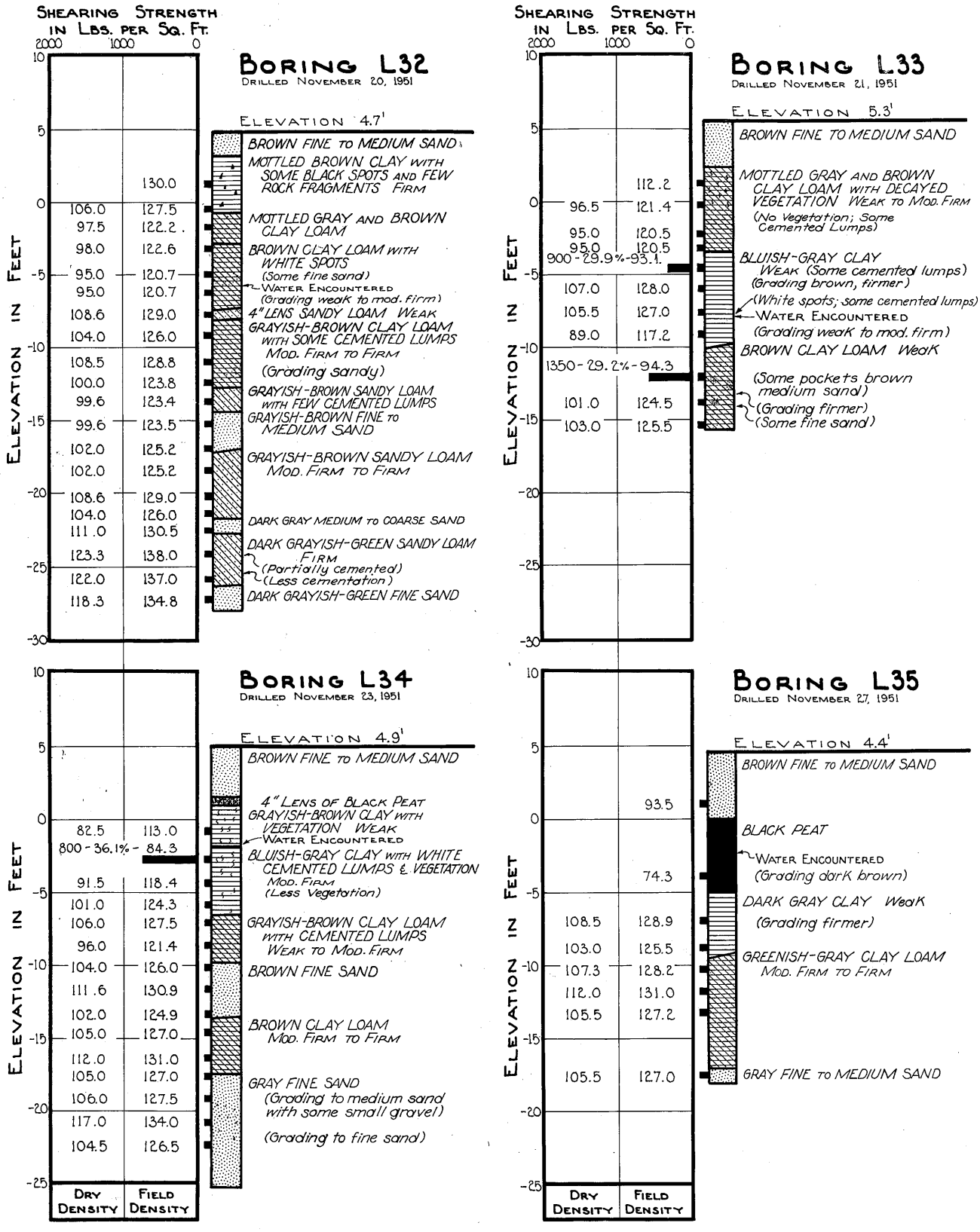
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2P

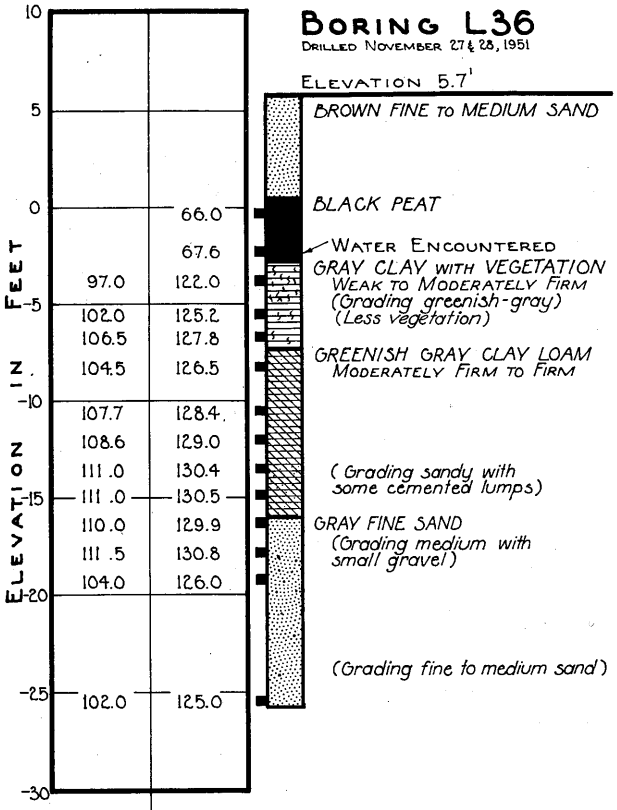


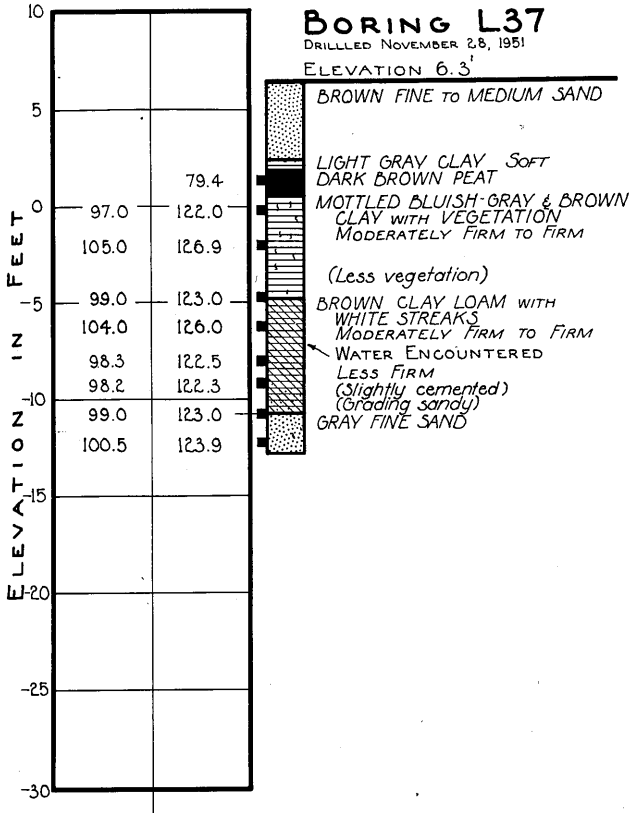
NOTE
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

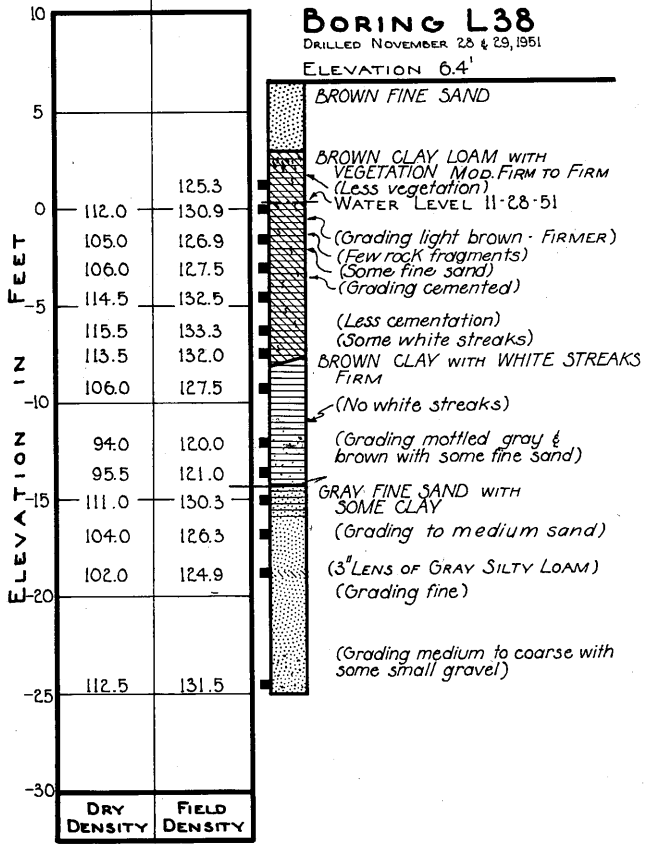
LOG OF BORINGS

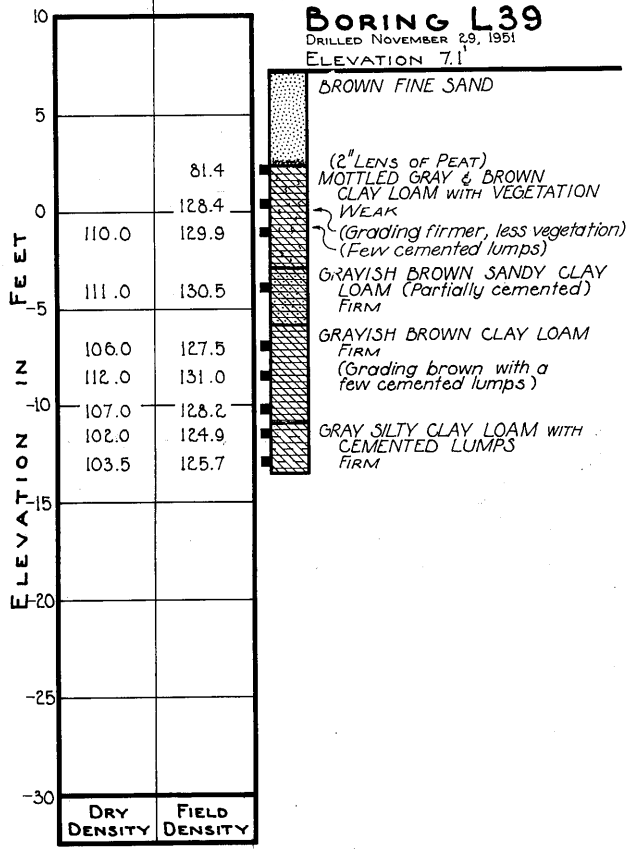
DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 20









NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

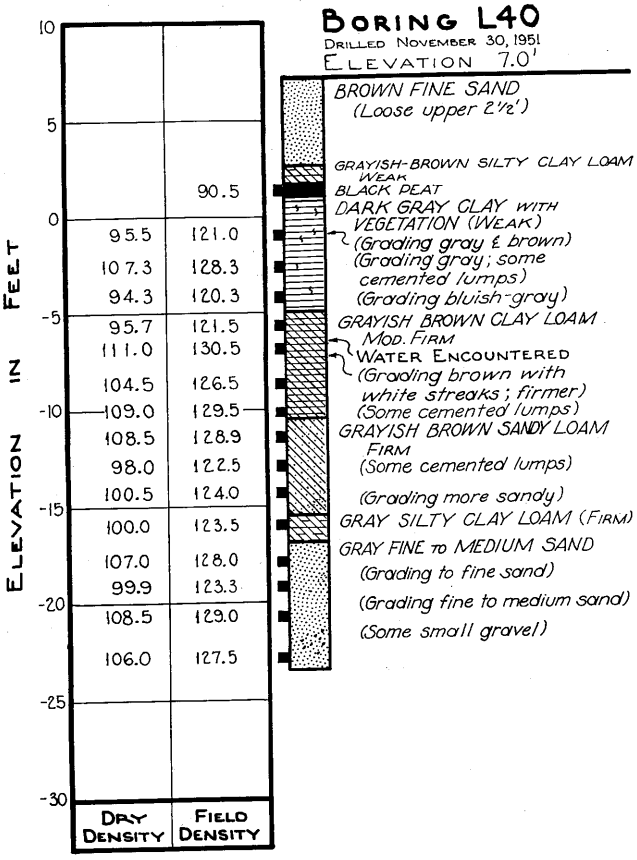
DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2R

BORING L40

DRILLED NOVEMBER 30, 1951

ELEVATION 7.0'

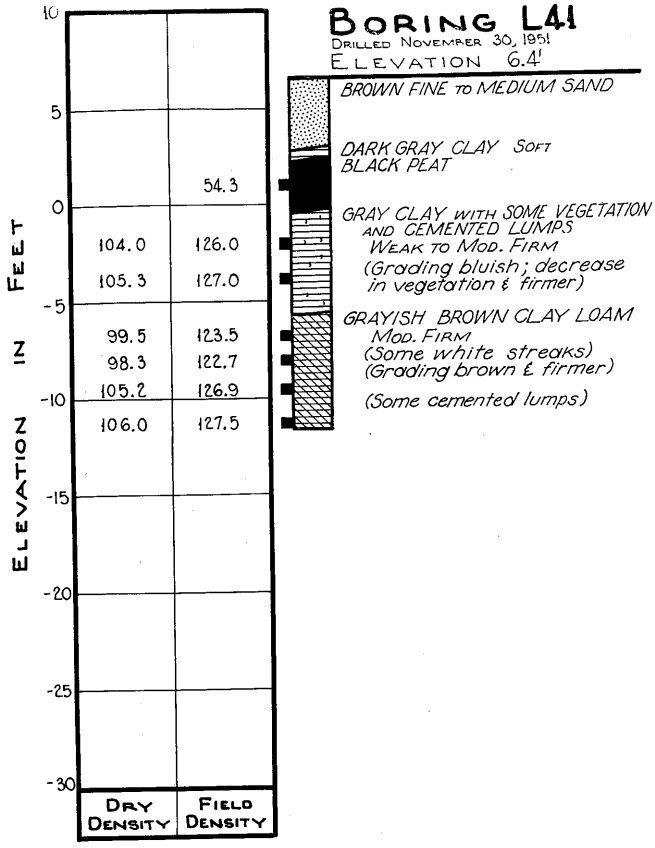


DRY DENSITY	FIELD DENSITY
	90.5
95.5	121.0
107.3	128.3
94.3	120.3
95.7	121.5
111.0	130.5
104.5	126.5
109.0	129.5
108.5	128.9
98.0	122.5
100.5	124.0
100.0	123.5
107.0	128.0
99.9	123.3
108.5	129.0
106.0	127.5

BORING L41

DRILLED NOVEMBER 30, 1951

ELEVATION 6.4'



DRY DENSITY	FIELD DENSITY
	54.3
104.0	126.0
105.3	127.0
99.5	123.5
98.3	122.7
105.2	126.9
106.0	127.5

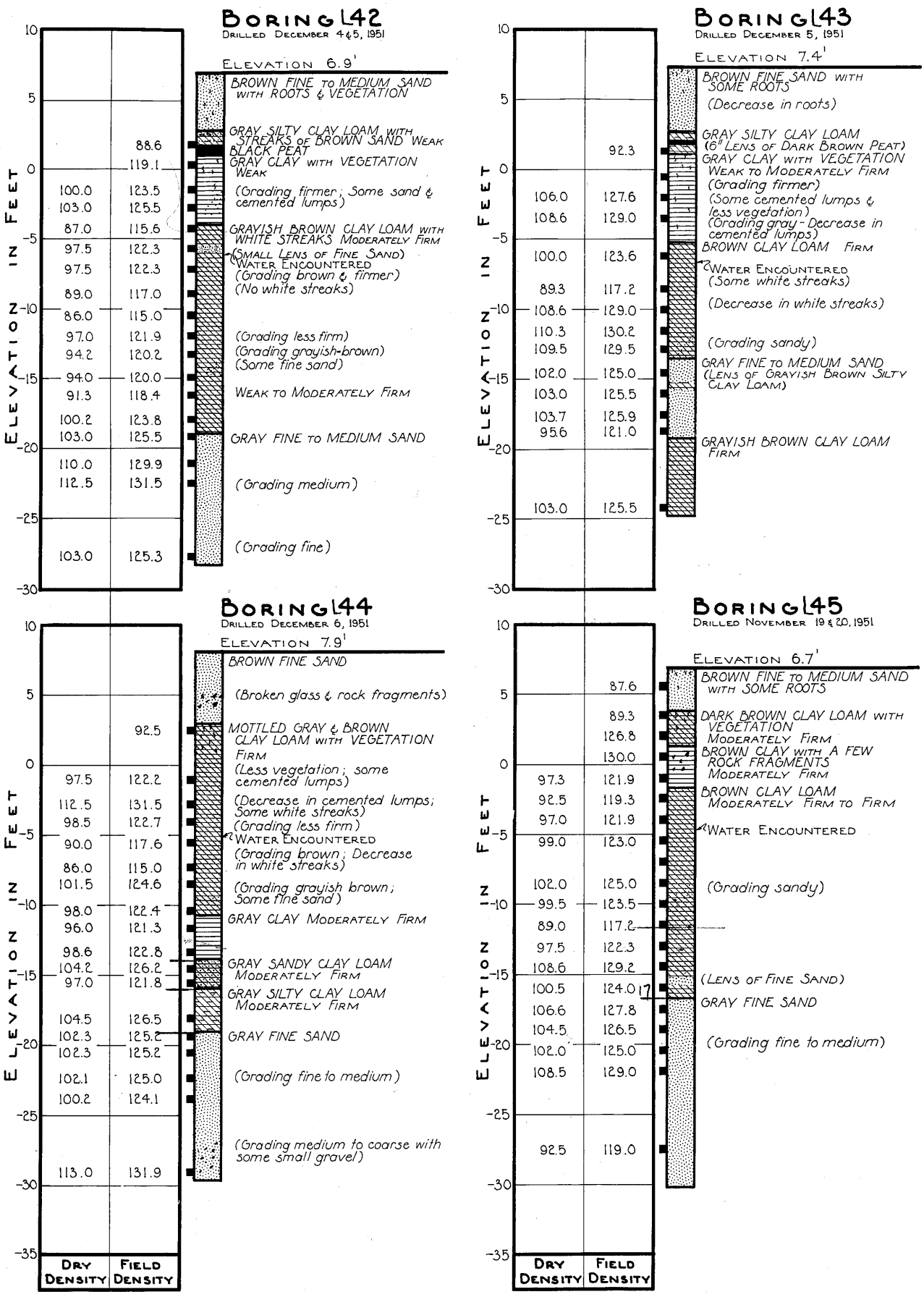
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L.=0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 25



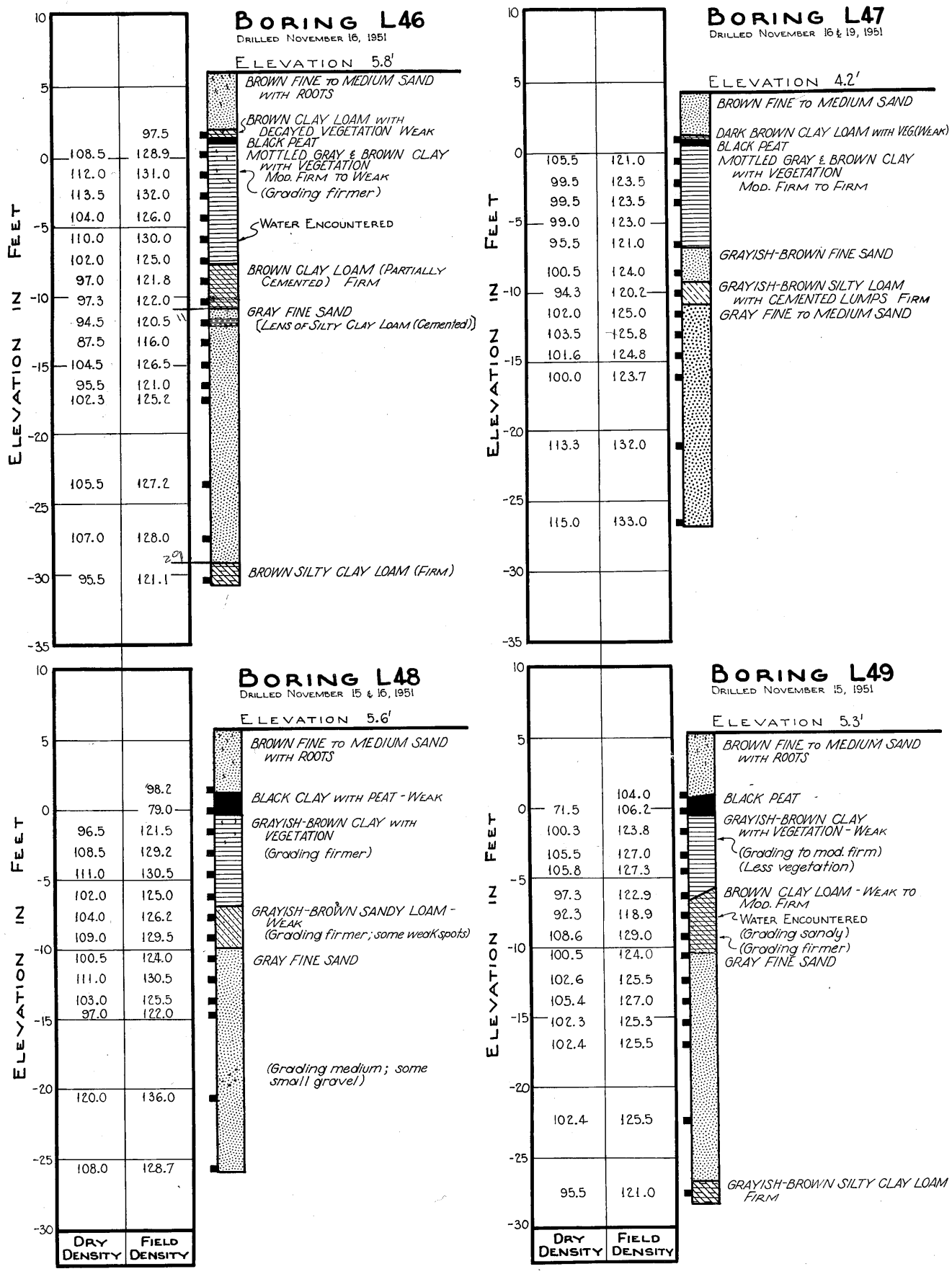
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2T



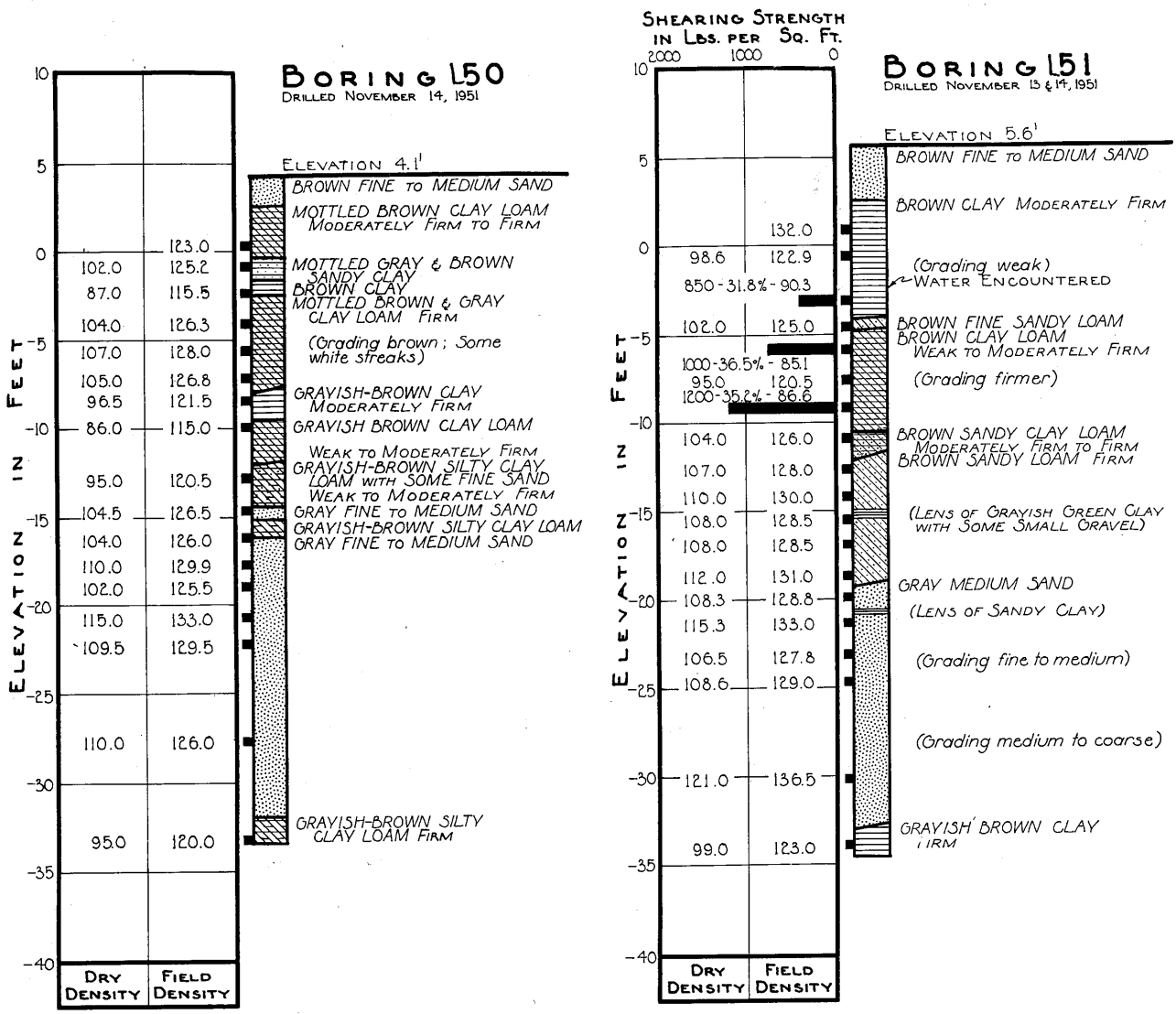
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2U

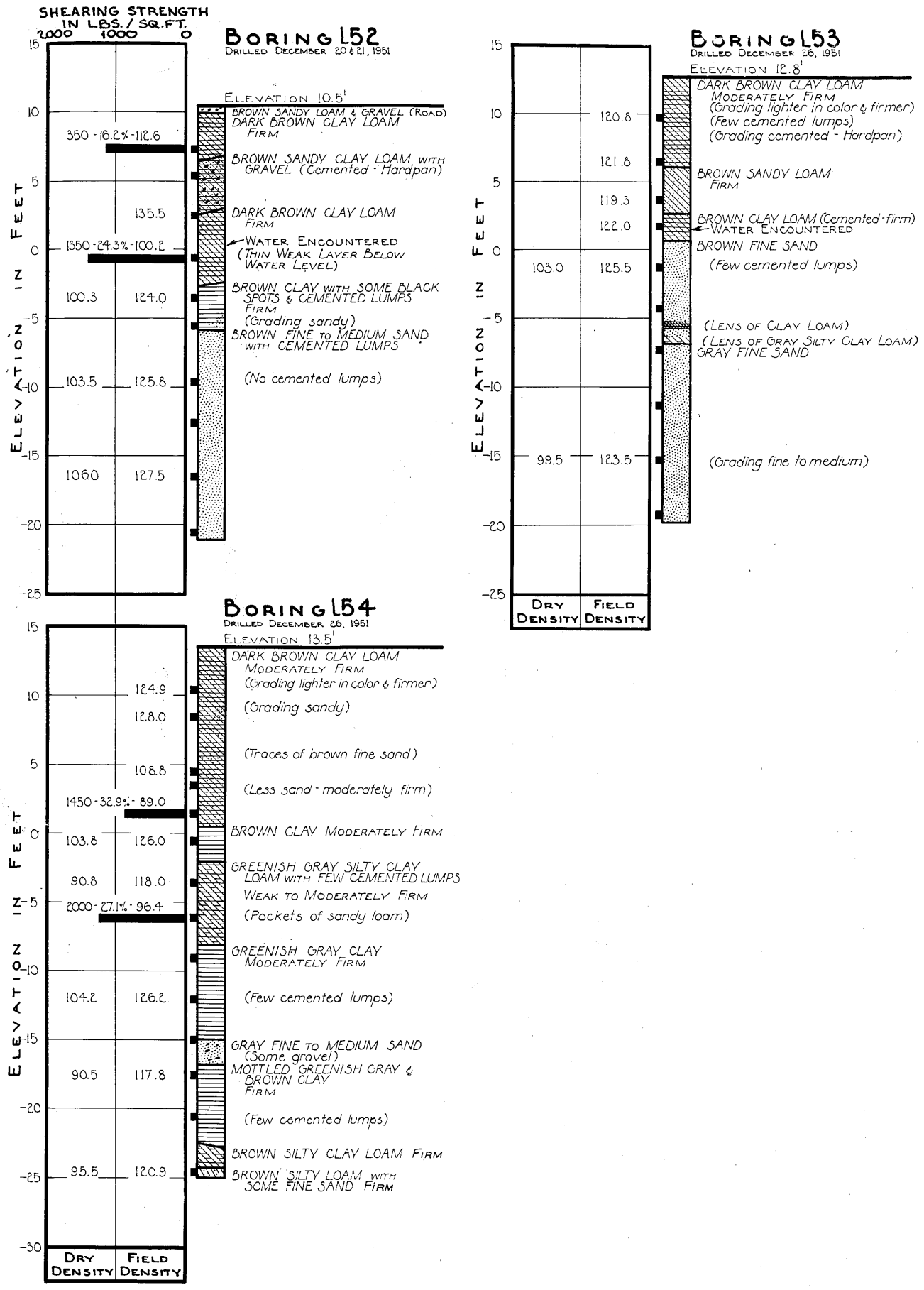


NOTE
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L.=0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2V



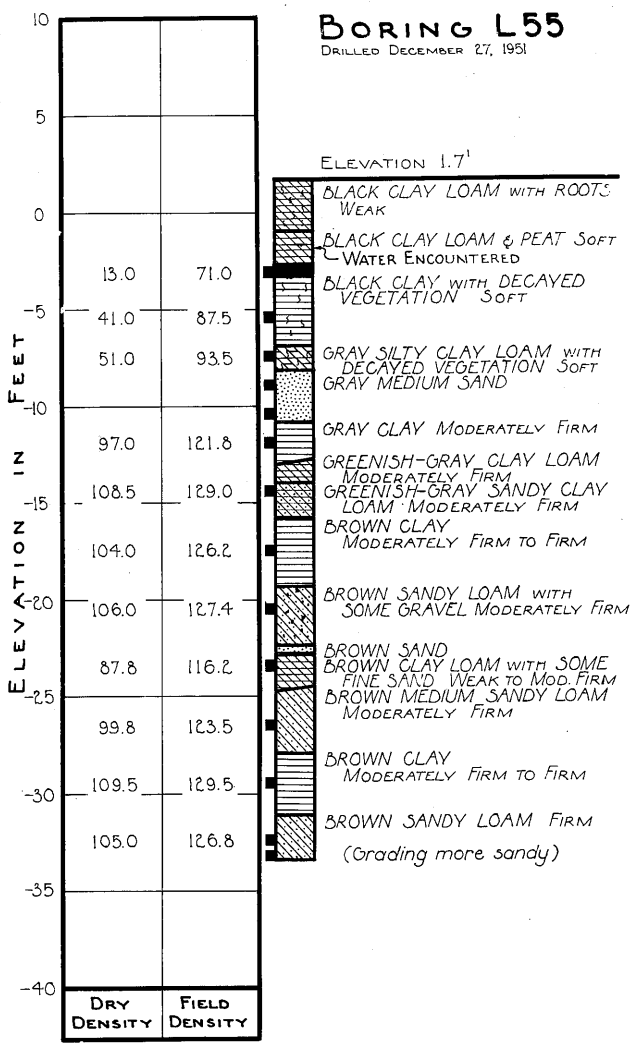
L 50 L 51

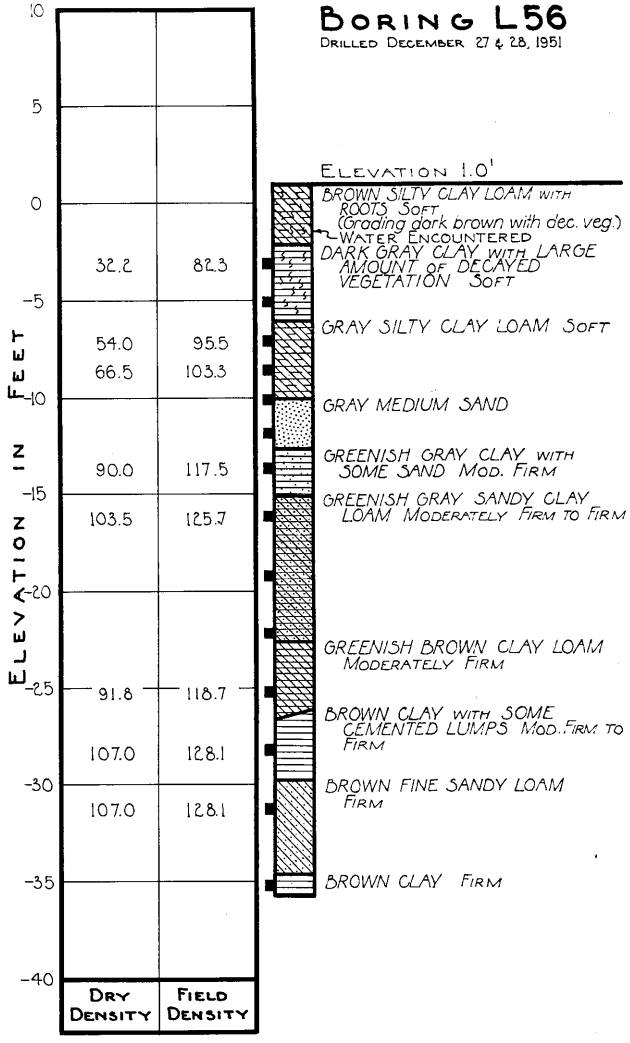
NOTE,
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" D.I.A. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2W





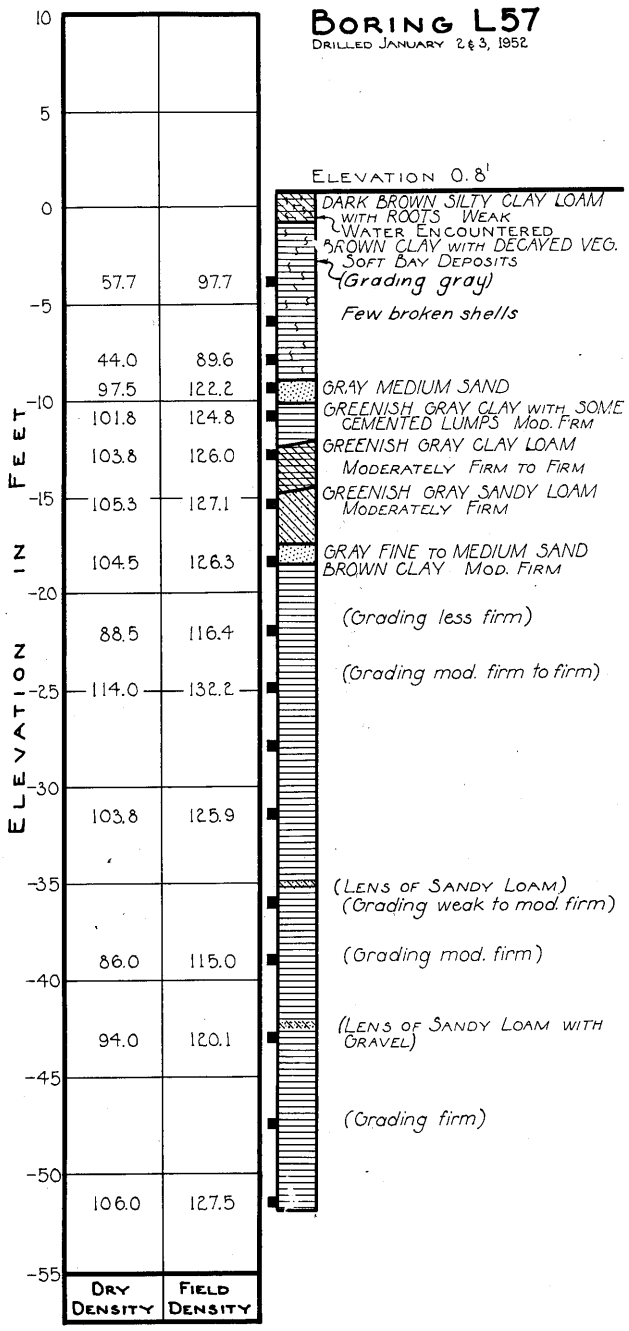
NOTE
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

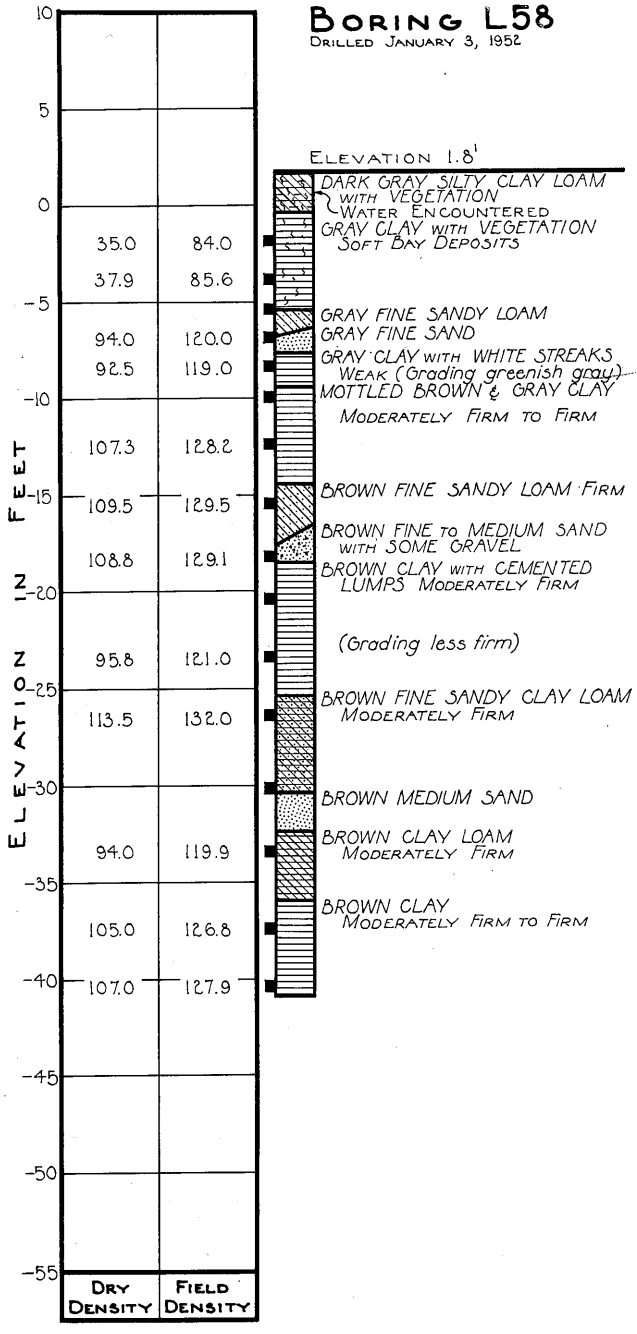
LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2X

L5N L53



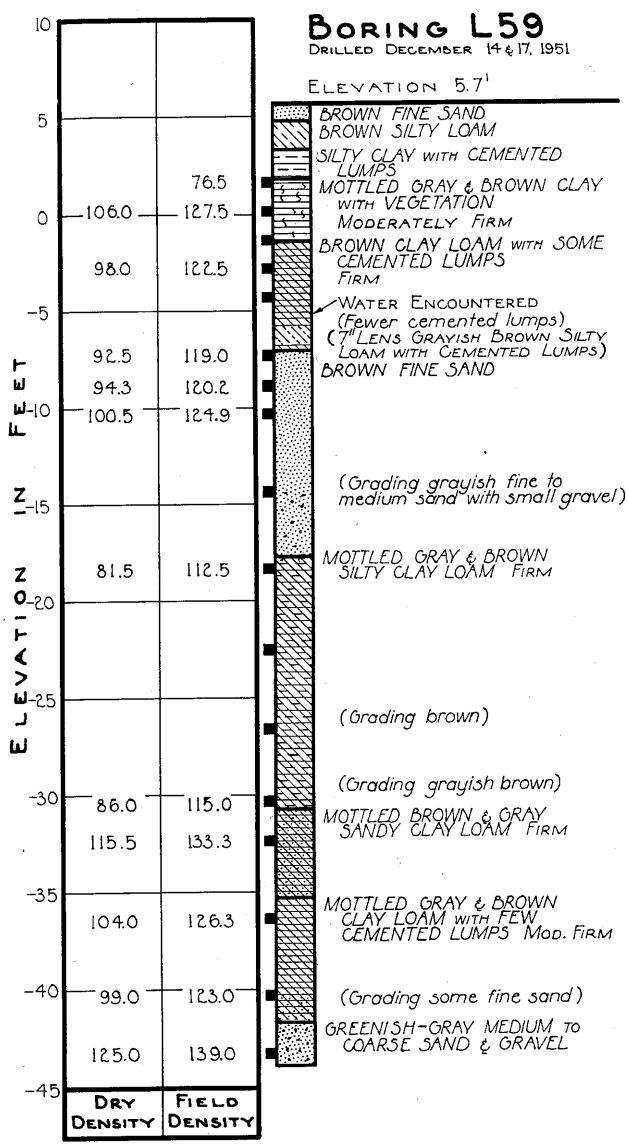


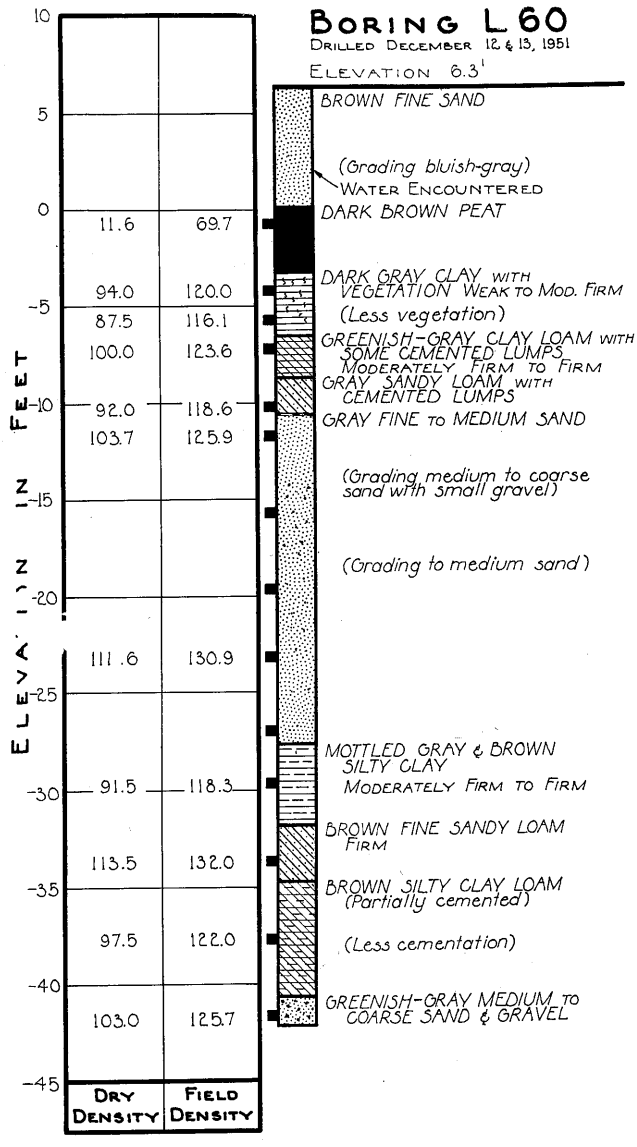
NOTE
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2Y



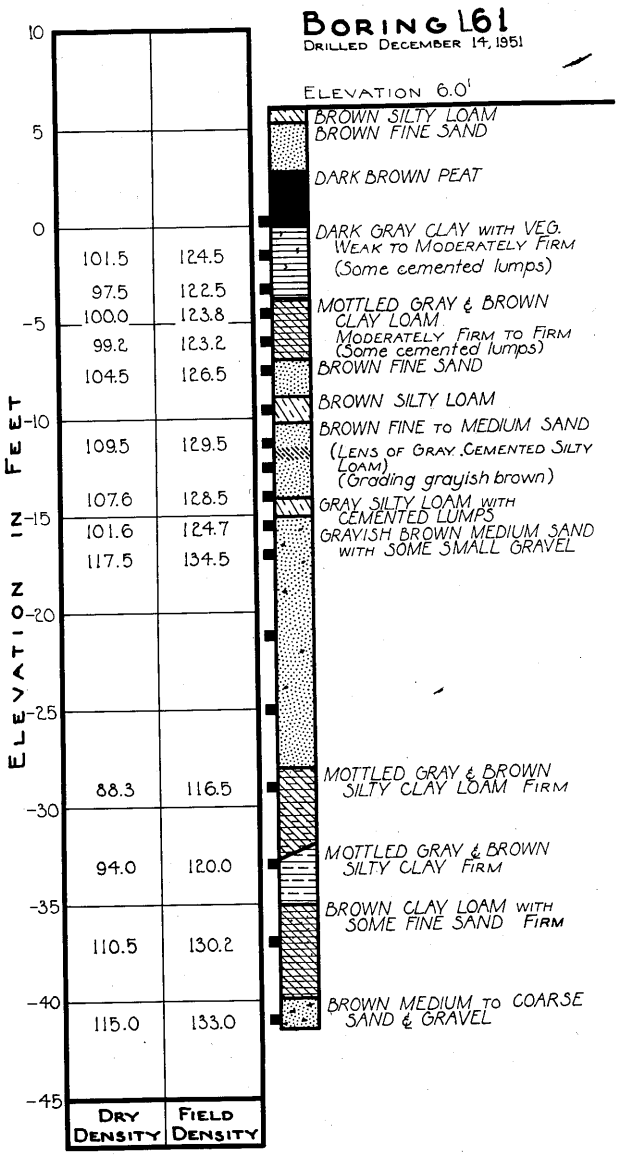


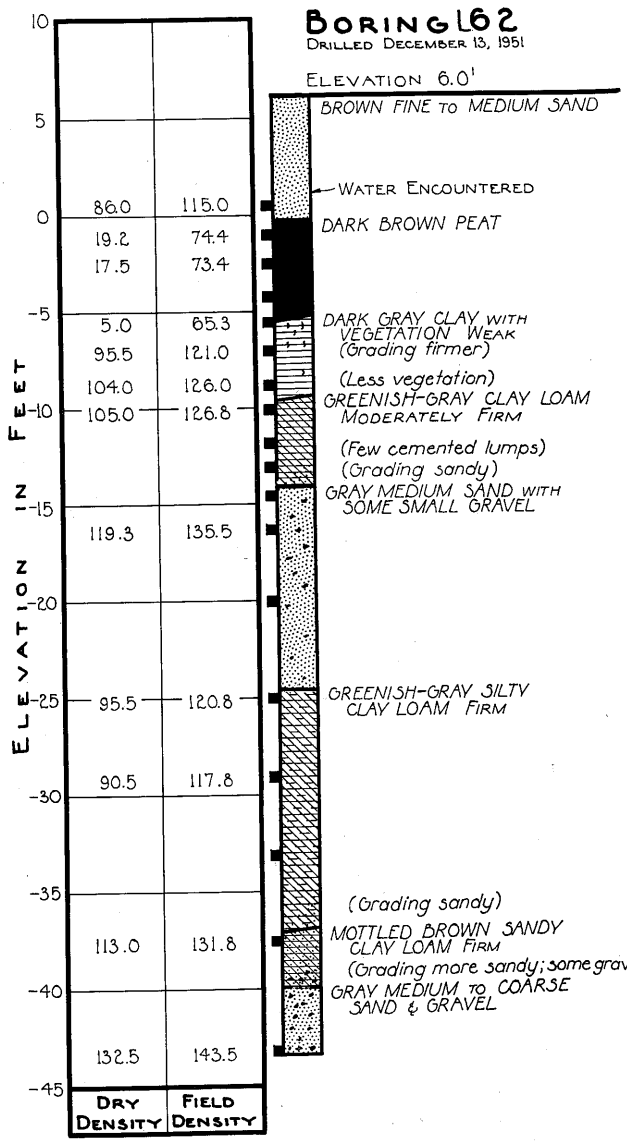
NOTE
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 22





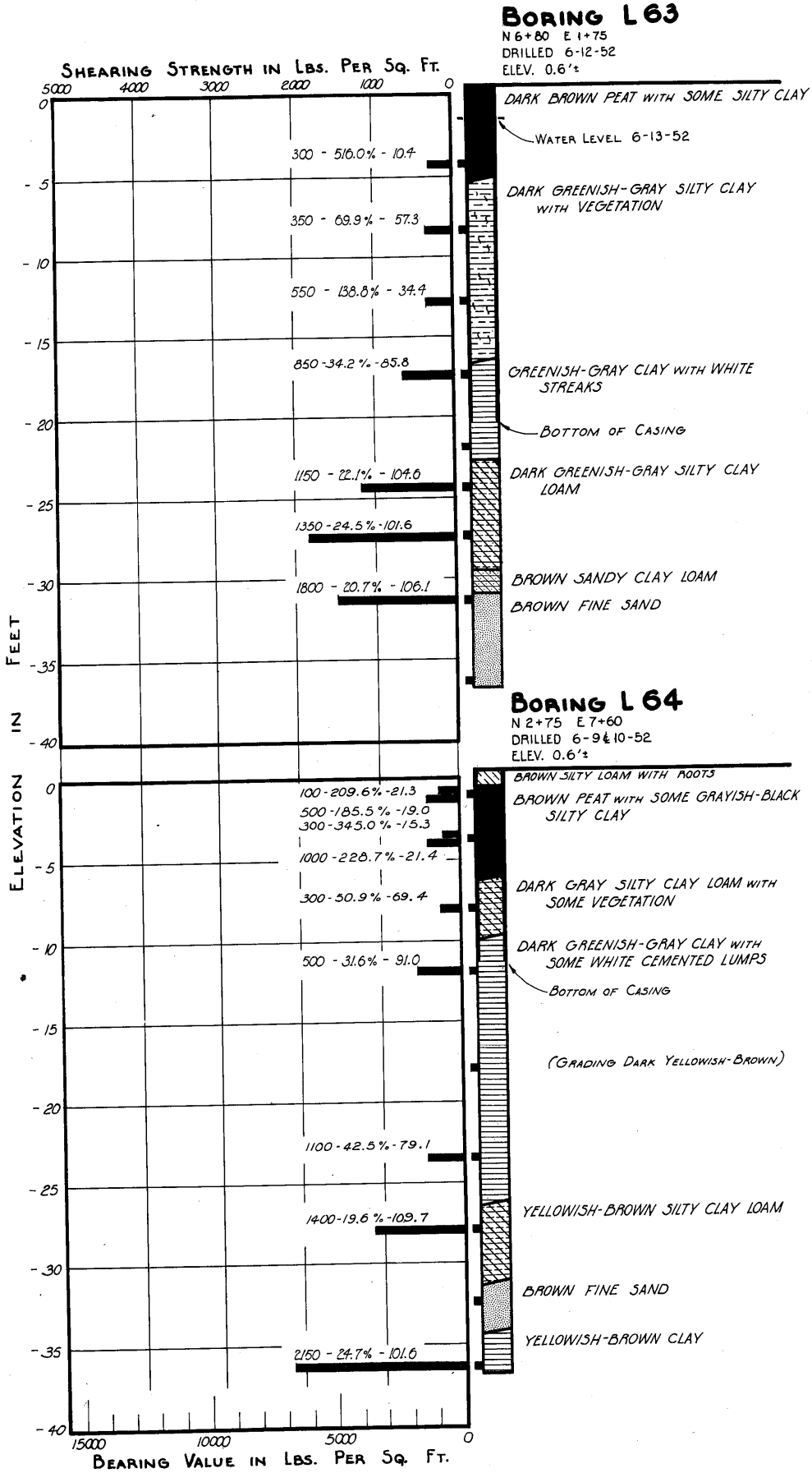
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2AA

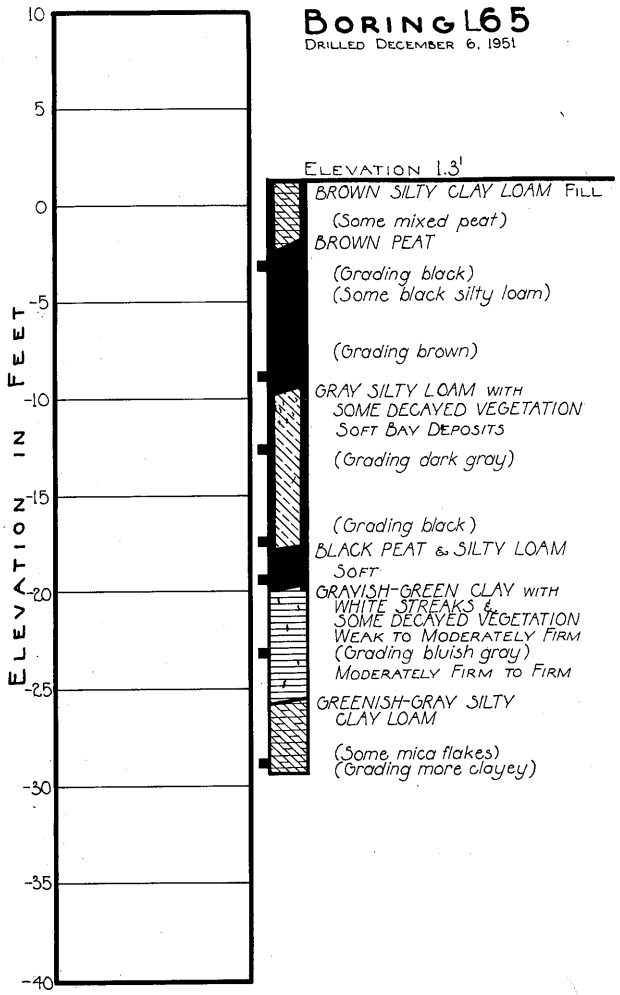


LOG OF BORINGS

NOTE:
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0')
BORINGS DRILLED WITH 4" DIAMETER ROTARY-WASH EQUIPMENT

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS :: SOIL MECHANICS ENGINEERING

PLATE 2AB (7-10-52)



BORING L65

DRILLED DECEMBER 6, 1951

ELEVATION 1.3'

BROWN SILTY CLAY LOAM FILL

(Some mixed peat)

BROWN PEAT

(Grading black)

(Some black silty loam)

(Grading brown)

GRAY SILTY LOAM WITH SOME DECAYED VEGETATION SOFT BAY DEPOSITS

(Grading dark gray)

(Grading black)

BLACK PEAT & SILTY LOAM SOFT

GRAYISH-GREEN CLAY WITH WHITE STREAKS & SOME DECAYED VEGETATION WEAK TO MODERATELY FIRM

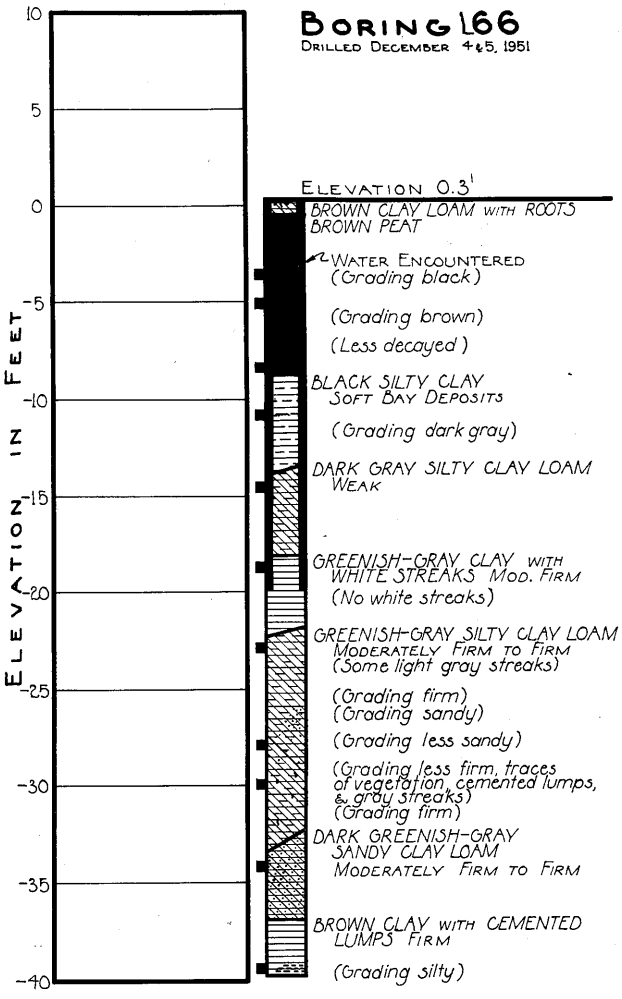
(Grading bluish gray)

MODERATELY FIRM TO FIRM

GREENISH-GRAY SILTY CLAY LOAM

(Some mica flakes)

(Grading more clayey)



BORING L66

DRILLED DECEMBER 4 & 5, 1951

ELEVATION 0.3'

BROWN CLAY LOAM WITH ROOTS
BROWN PEAT

WATER ENCOUNTERED

(Grading black)

(Grading brown)

(Less decayed)

BLACK SILTY CLAY SOFT BAY DEPOSITS

(Grading dark gray)

DARK GRAY SILTY CLAY LOAM WEAK

GREENISH-GRAY CLAY WITH WHITE STREAKS MOD. FIRM

(No white streaks)

GREENISH-GRAY SILTY CLAY LOAM MODERATELY FIRM TO FIRM

(Some light gray streaks)

(Grading firm)

(Grading sandy)

(Grading less sandy)

(Grading less firm, traces of vegetation, cemented lumps, & gray streaks)

(Grading firm)

DARK GREENISH-GRAY SANDY CLAY LOAM MODERATELY FIRM TO FIRM

BROWN CLAY WITH CEMENTED LUMPS FIRM

(Grading silty)

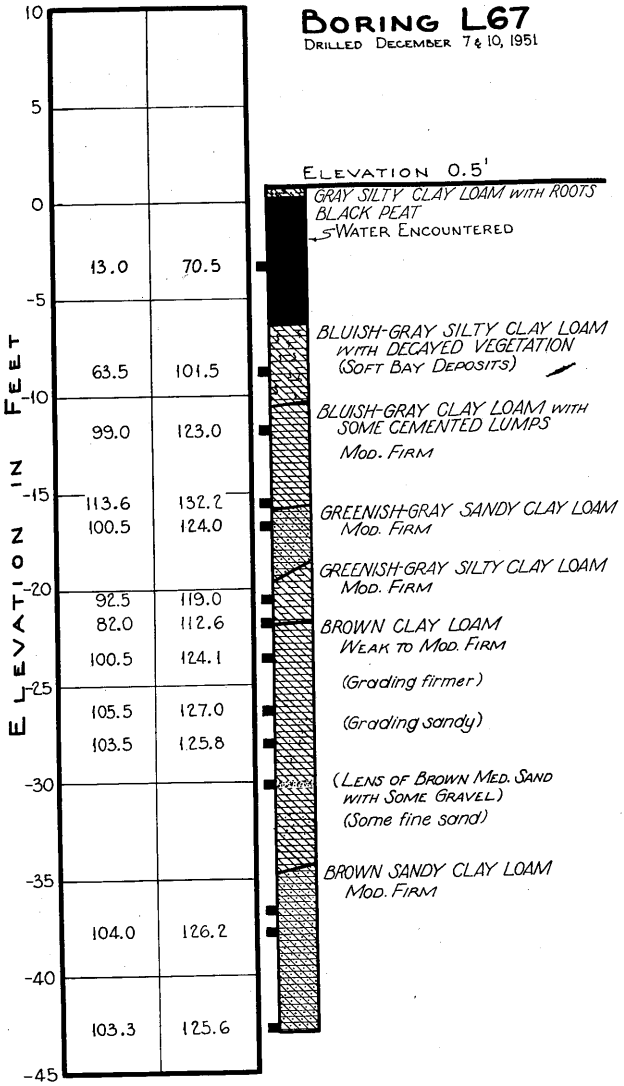
NOTE

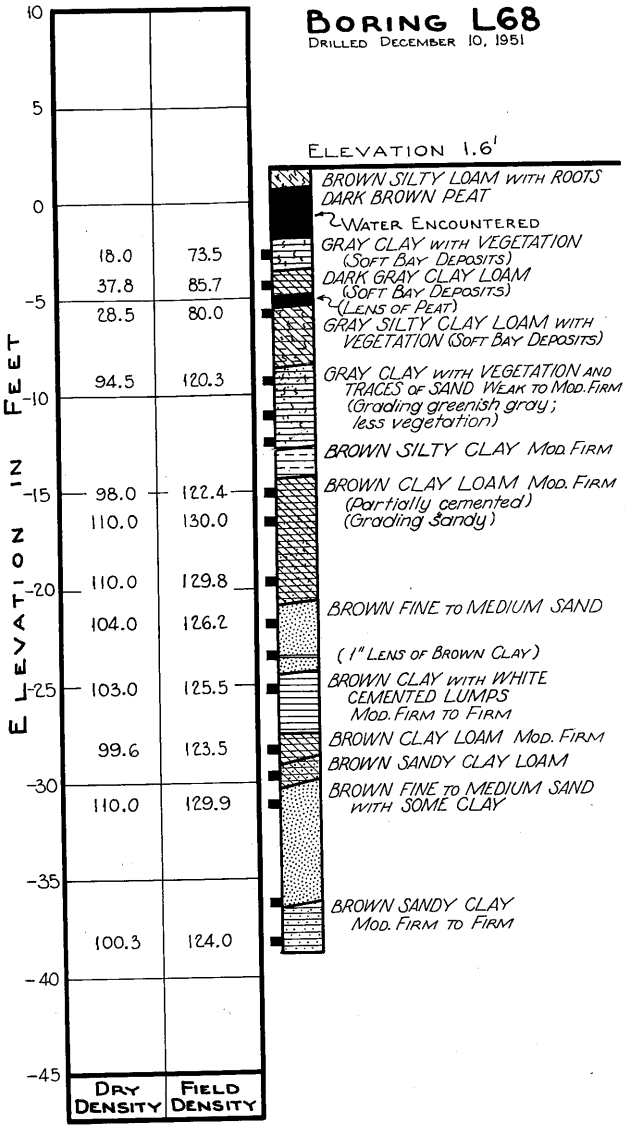
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 20" DIAM. BUCKET-TYPE EQUIPMENT.

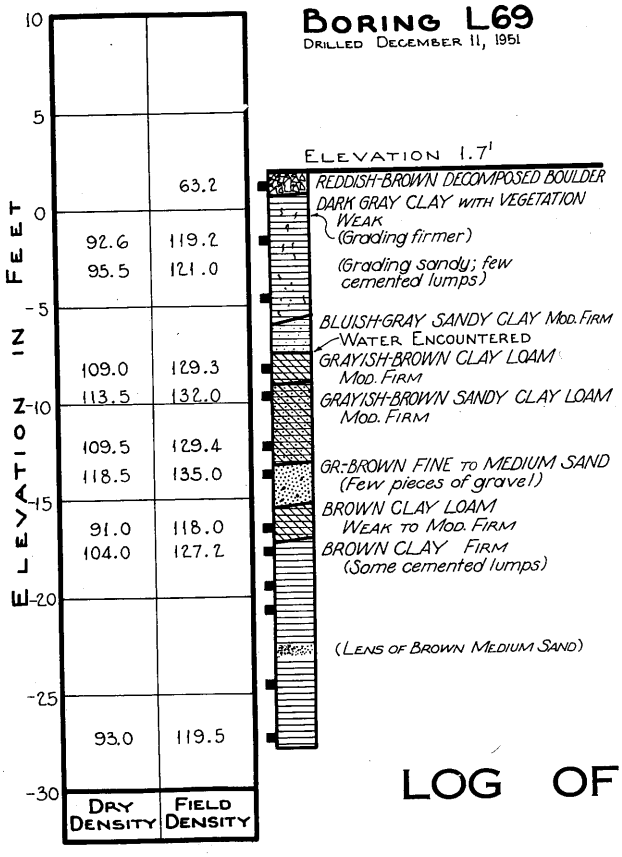
LOG OF BORINGS

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2AC







LOG OF BORINGS

NOTE
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L.=0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2AD

BORING L70

DRILLED DECEMBER 18, 1951

ELEVATION 5.3'

DRY DENSITY	FIELD DENSITY	
		BROWN FINE TO MEDIUM SAND
		WATER ENCOUNTERED
104.0	126.0	DARK BROWN PEAT
25.2	78.0	DARK GRAY CLAY WITH VEGETATION WEAK
75.5	108.6	
92.6	119.3	(Grading firmer)
		GRAY CLAY LOAM WITH SOME VEGETATION & CEMENTED LUMPS MODERATELY FIRM
99.8	123.5	(Grading some fine sand, less vegetation)
		(Grading less sand)
99.0	123.0	(Grading more sand)
		GRAYISH-BROWN MEDIUM SAND
118.5	135.0	(Grading medium to coarse; some clay)
104.0	126.0	MOTTLED GRAY & BROWN CLAY FIRM
115.5	133.2	MOTTLED GRAY & BROWN SANDY CLAY LOAM FIRM

BORING L71

DRILLED DECEMBER 18, 1951

ELEVATION 6.2'

DRY DENSITY	FIELD DENSITY	
		BROWN FINE TO MEDIUM SAND
99.0	123.0	BLACK PEAT
95.5	127.0	DARK GRAY CLAY LOAM WITH VEGETATION WEAK
		MOTTLED GRAY & BROWN CLAY WEAK TO MODERATELY FIRM (Grading moderately firm)
106.0	127.3	BROWN CLAY LOAM WITH WHITE STREAKS FIRM
117.5	134.5	(MODERATELY FIRM LENS) GRAY FINE SAND
95.5	121.0	(Grading fine to medium)
		(Grading medium to coarse; some small gravel)
108.0	128.4	MOTTLED BROWN SANDY CLAY LOAM FIRM

BORING L72

DRILLED DECEMBER 19 & 20, 1951

ELEVATION 6.8'

DRY DENSITY	FIELD DENSITY	
		BROWN FINE SAND
		BROWN CLAY LOAM FIRM
97.5	122.3	WATER ENCOUNTERED
		BROWN SANDY LOAM
104.0	126.2	BROWN FINE SAND WITH CEMENTED LUMPS
		BROWN CLAY LOAM WITH WHITE STREAKS
104.0	126.2	BROWN FINE TO MEDIUM SAND
		(3" LENS OF BROWN CLAY)
101.6	124.6	(Grading to fine sand)
		(9" LENS OF BROWN SANDY LOAM)
		GRAYISH-BROWN CLAY LOAM (Grading sandy, moderately firm)
		GRAY MEDIUM SAND
115.0	133.0	GRAYISH-BROWN SANDY CLAY LOAM MOD. FIRM
		(Grading firmer)
110.0	129.9	(Grading some cemented lumps)
		GRAY MEDIUM SAND WITH SOME CLAY
109.6	129.5	

BORING L73

DRILLED DECEMBER 19, 1951

ELEVATION 4.4'

DRY DENSITY	FIELD DENSITY	
		BROWN FINE TO MEDIUM SAND WITH ROOTS
		WATER ENCOUNTERED
	127.2	(Grading fine)
		GRAY SANDY CLAY WITH ROOTS
		DARK BROWN PEAT
5.0	66.0	
54.5	95.8	DARK GRAY CLAY WITH VEGETATION WEAK
95.5	121.0	(Grading firmer)
		GRAY CLAY LOAM WITH SOME VEGETATION WEAK TO MODERATELY FIRM
108.6	129.0	
		GRAY SANDY LOAM WEAK TO MODERATELY FIRM
107.0	127.8	GRAY MEDIUM SAND
110.0	130.0	
107.0	127.8	(Grading medium to coarse with some small gravel)

ELEVATION IN FEET: 10, 5, 0, -5, -10, -15, -20, -25, -30, -35

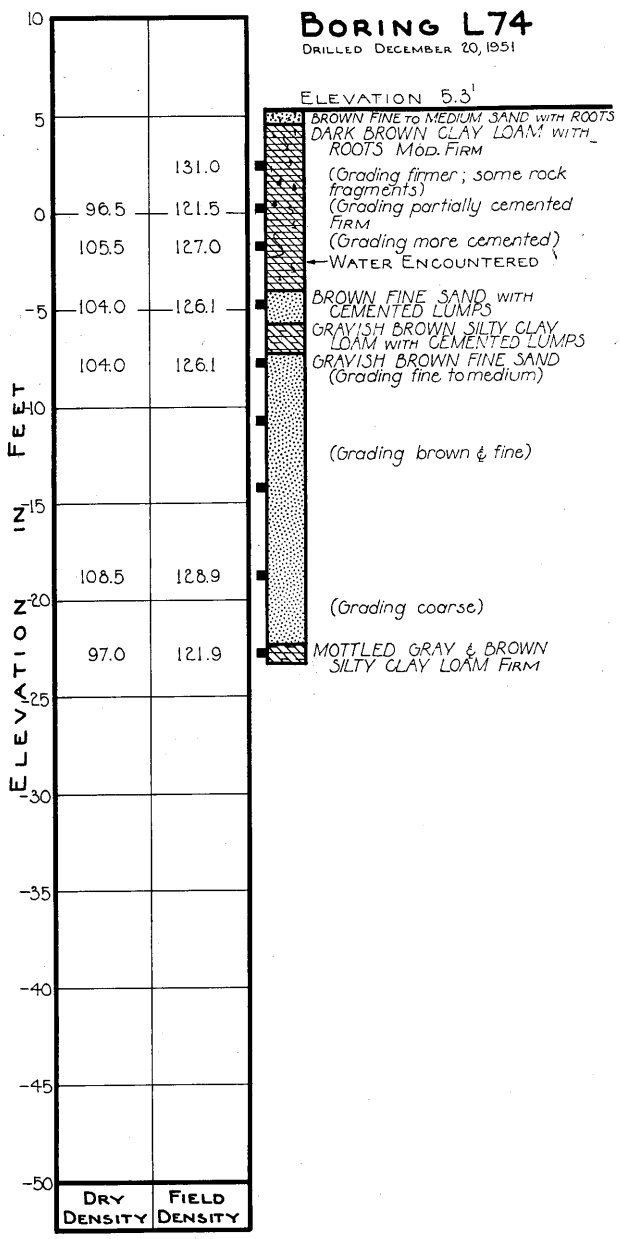
NOTE

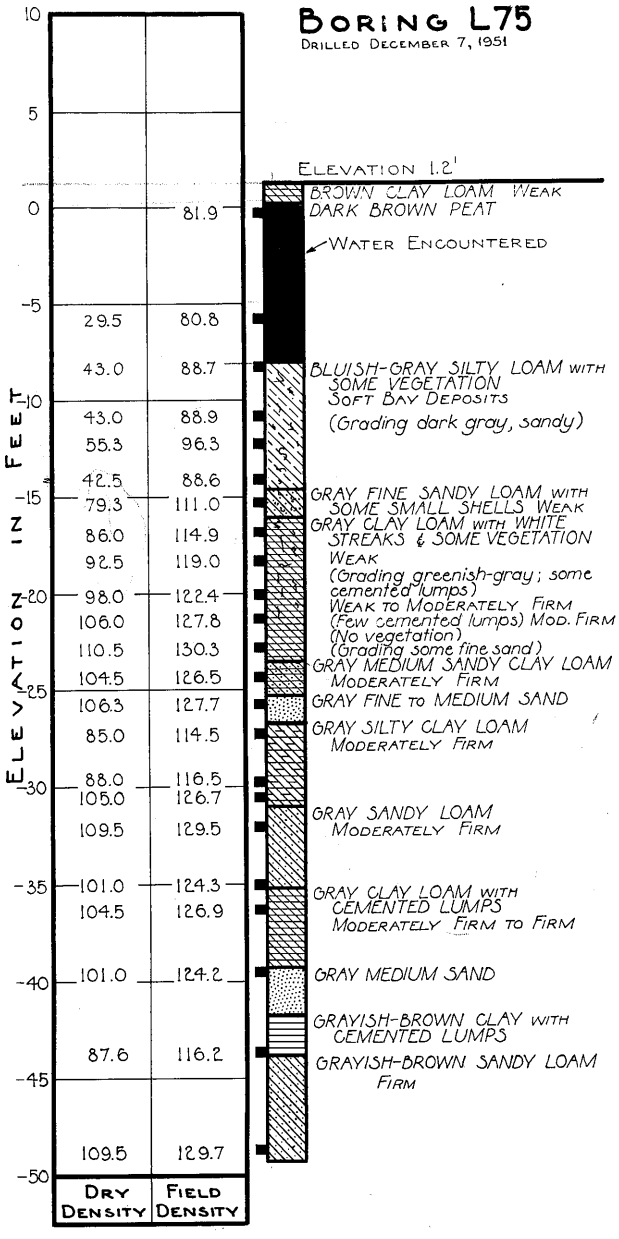
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2AE





NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L.= 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

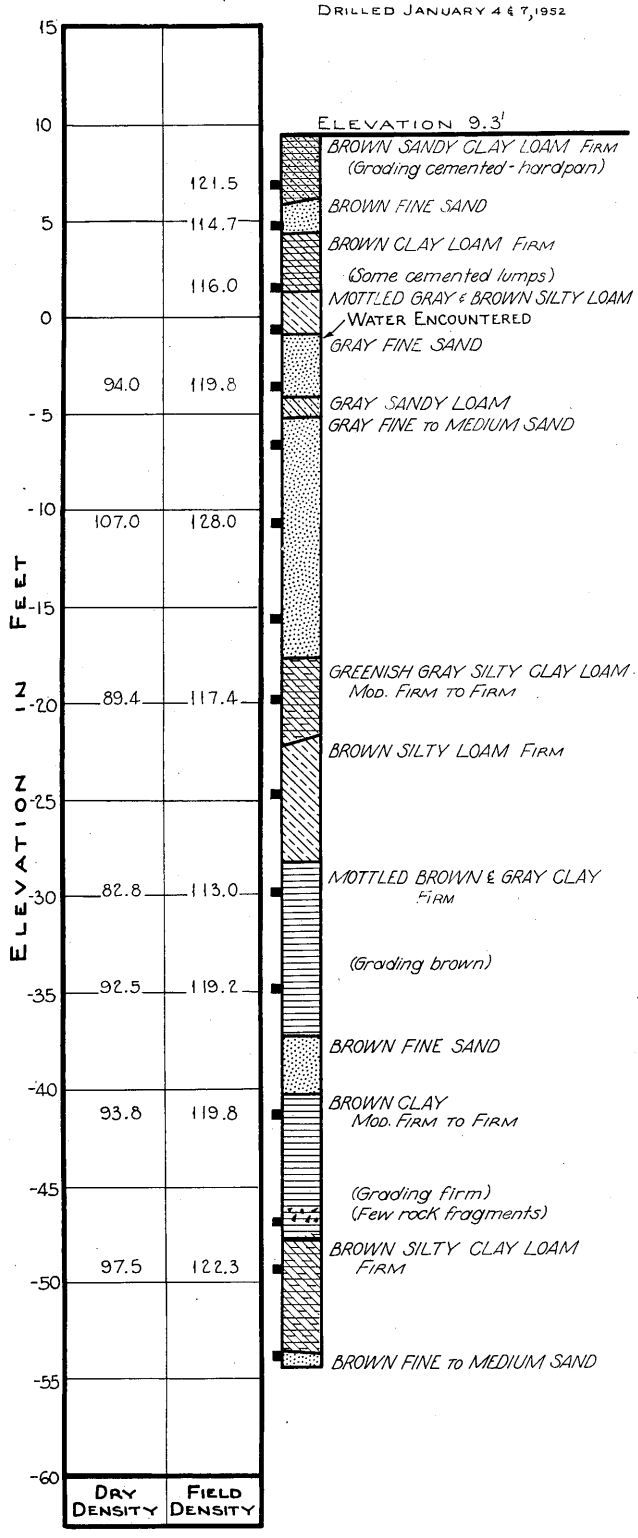
LOG OF BORINGS

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2AF

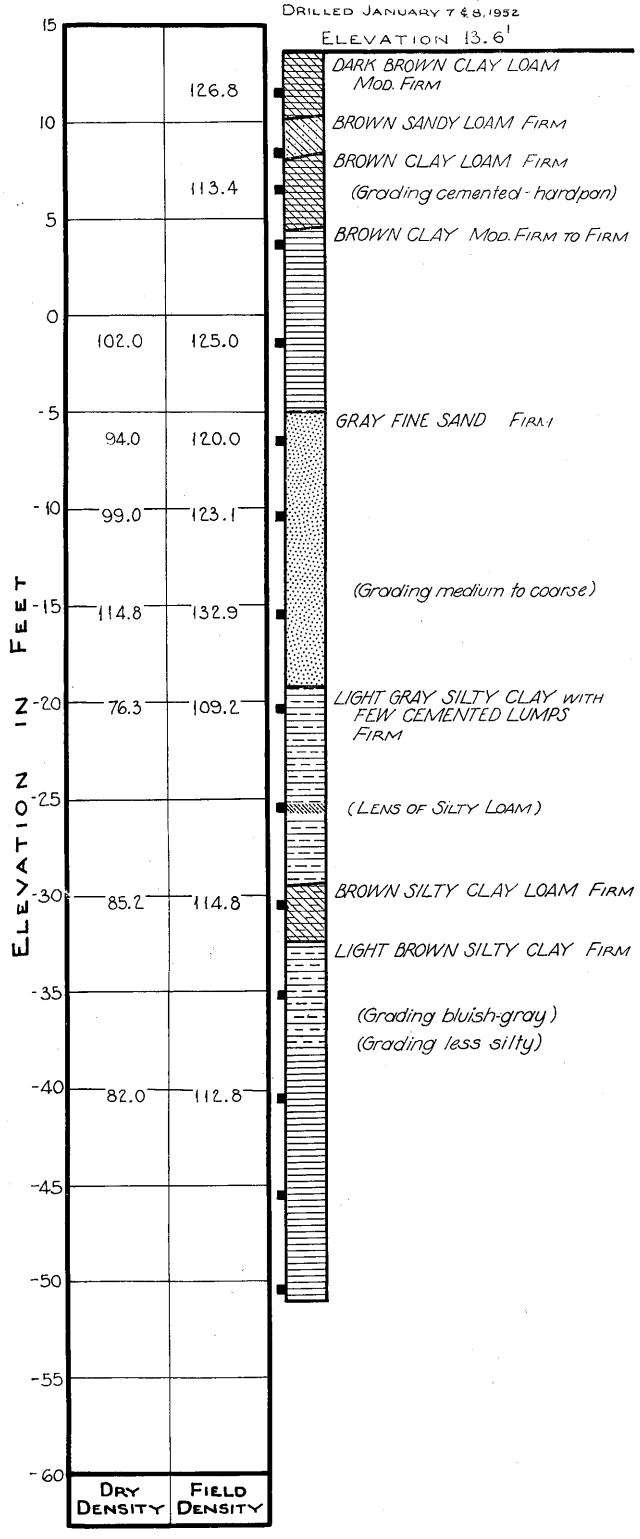
BORING L76

DRILLED JANUARY 4 & 7, 1952



BORING L77

DRILLED JANUARY 7 & 8, 1952

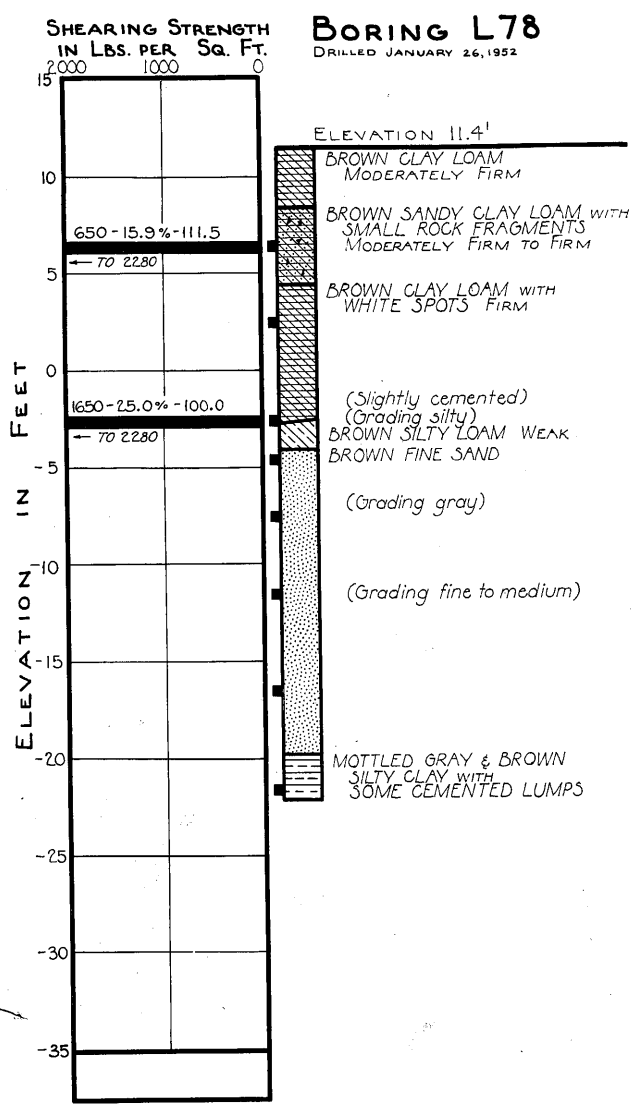


NOTE
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

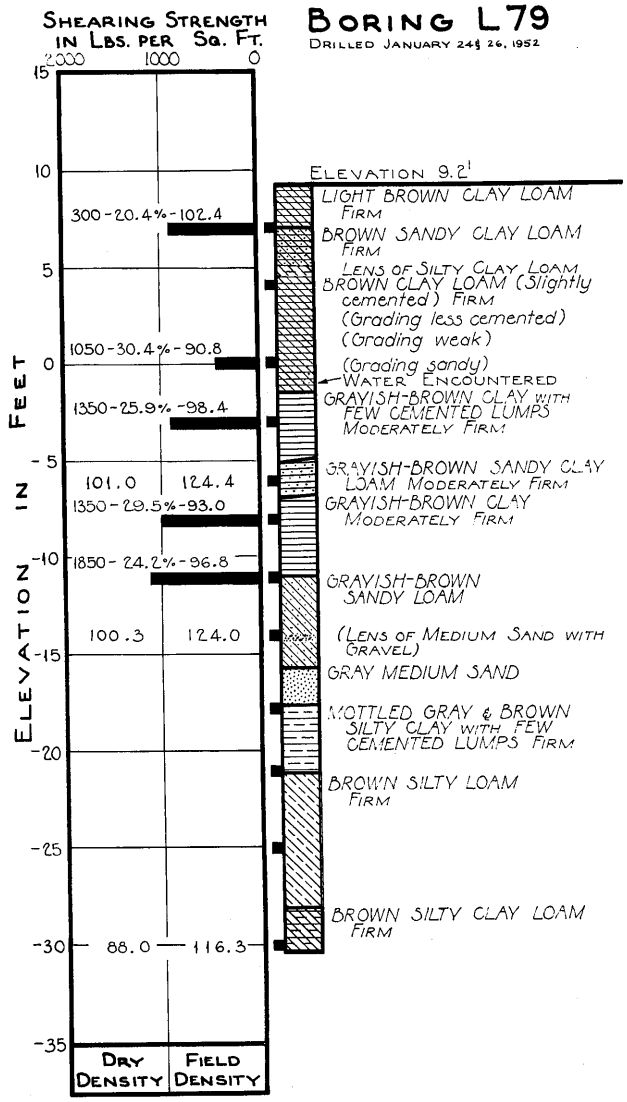
DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2AG



BORING L78

DRILLED JANUARY 26, 1952



BORING L79

DRILLED JANUARY 24 & 26, 1952

NOTE

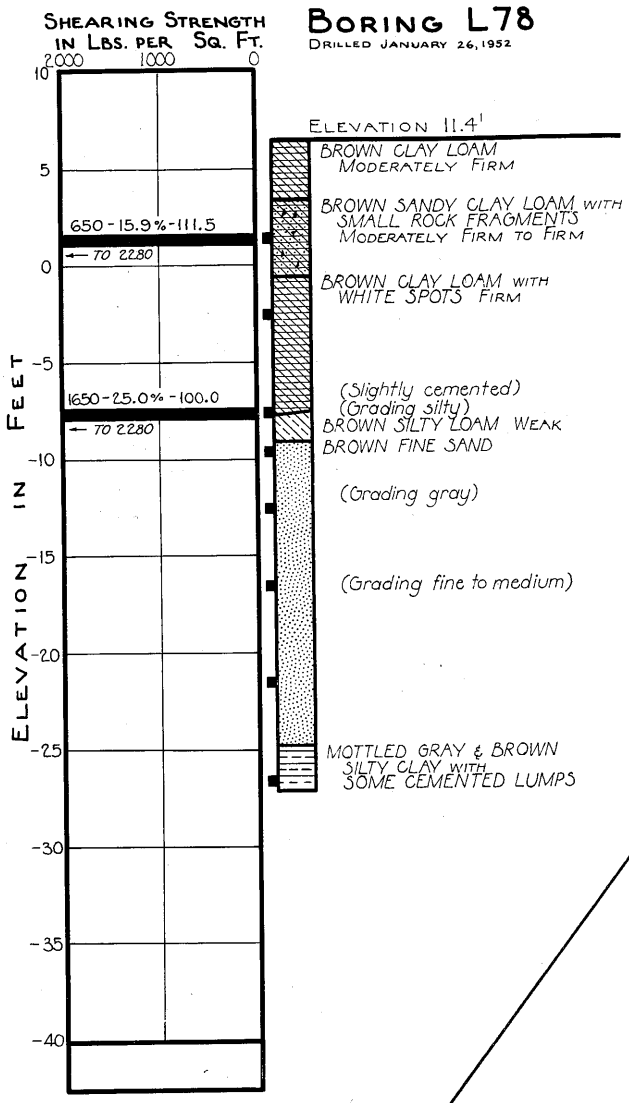
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

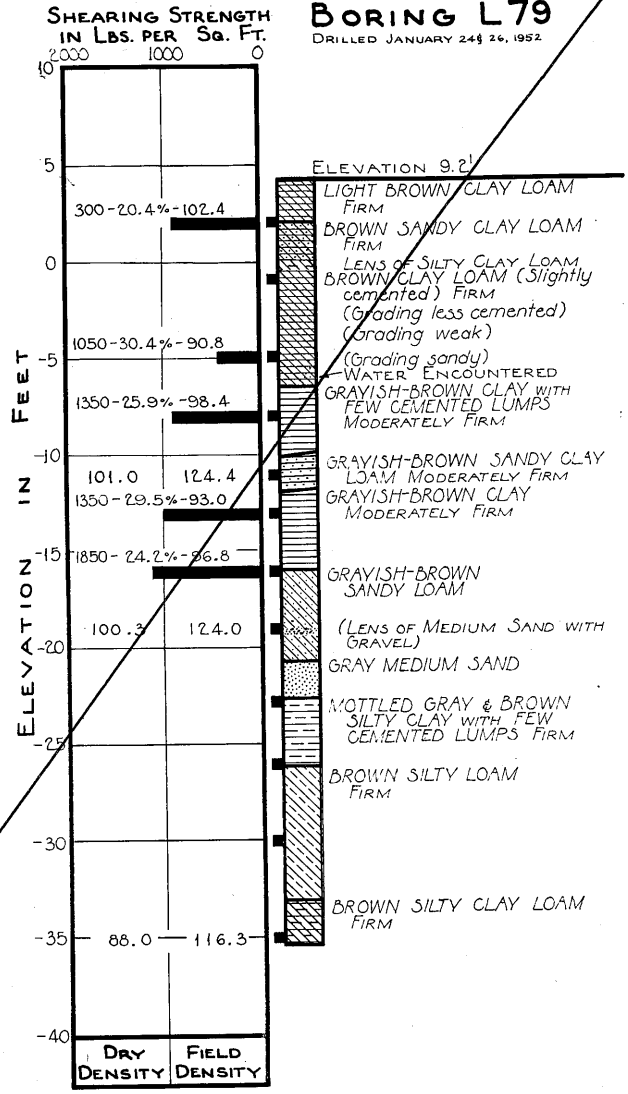
BORING L78

DRILLED JANUARY 26, 1952



BORING L79

DRILLED JANUARY 24 & 26, 1952



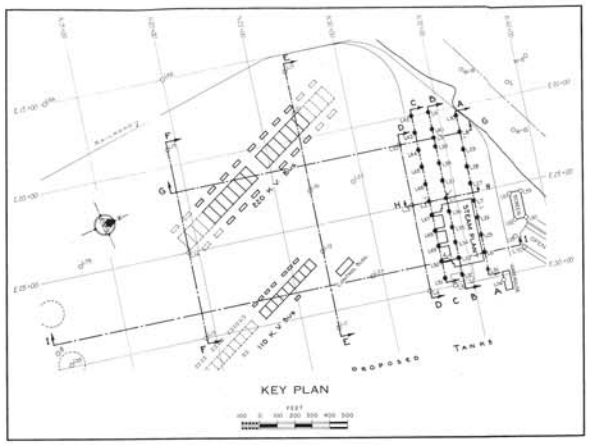
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY-WASH EQUIPMENT.

LOG OF BORINGS

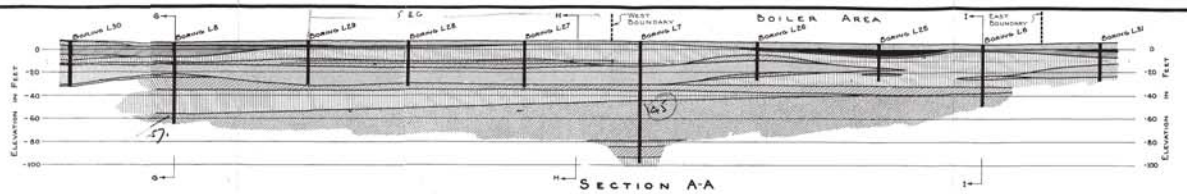
DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

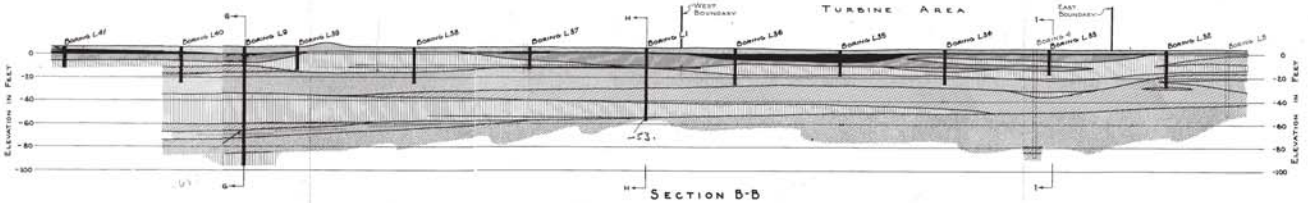
PLATE 2AH VOID

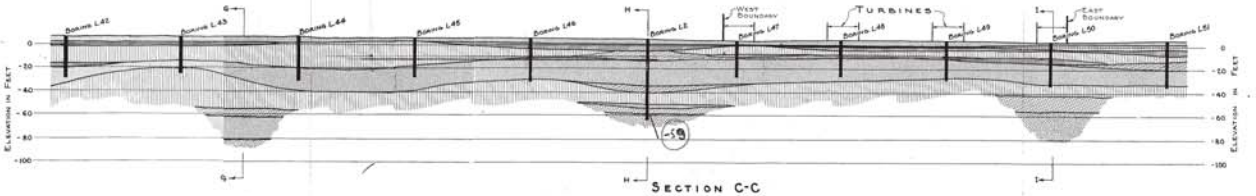


LEGEND

- PEAT
- SOFT RECENT BAY & DELTA DEPOSITS
- VERY TO MODERATELY FIRM SOILS
- MOD. FIRM TO FIRM CLAYEY SOILS
- FIRM SILTY LOAMS & SANDY LOAMS
- SILTS
- SILTS & CLAYEY





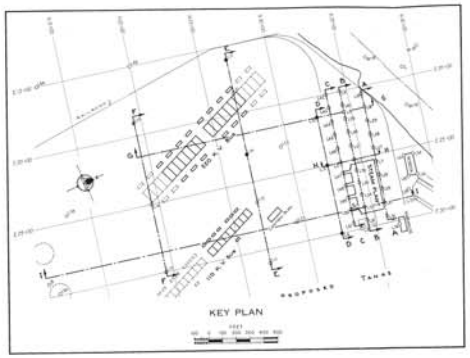


NOTE:
ALL ELEVATIONS REFER TO U.S.G.S. DATUM. (M.S.L.=0.0')

SUBSURFACE SECTIONS

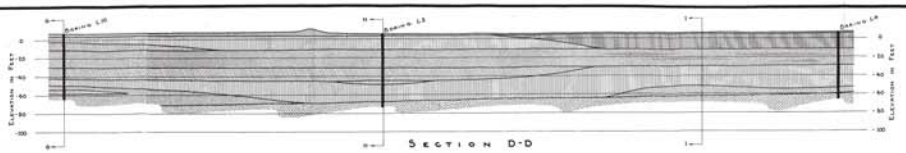
DAMES & MOORE, Soil Engineers
Foundation Investigations · San Francisco Peninsula

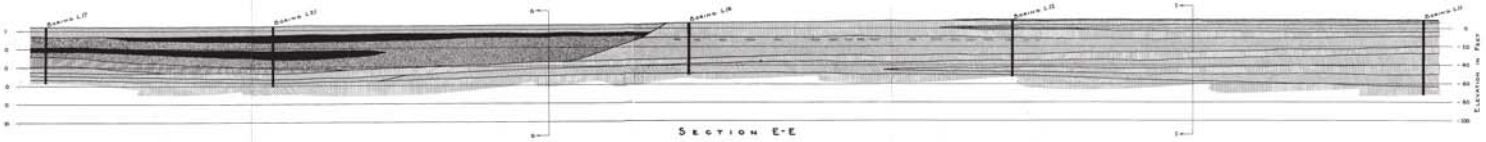
PLATE 3A

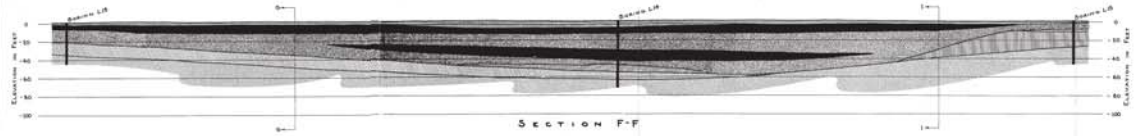


LEGEND

- PEAT
- SOFT RECENT BAY & SWAMP DEPOSITS
- WEAK TO MODERATELY FIRM SOILS
- MED. FIRM TO FIRM CLAYEY SOILS
- FIRM SILTY LOAM & SANDY LOAM
- SAND
- LOAM & GRAVEL





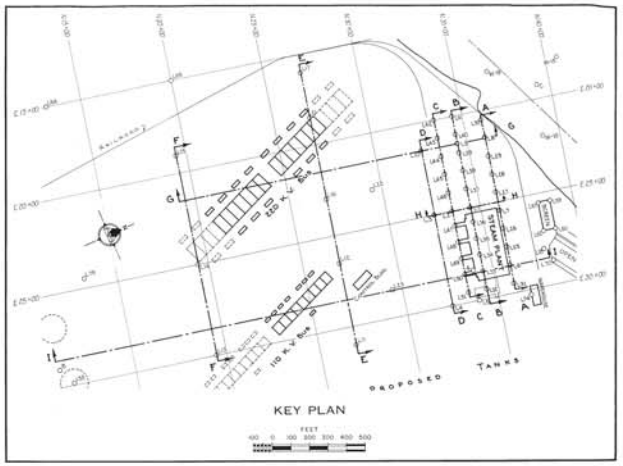


NOTE:
ALL ELEVATIONS REFER TO
MEAN LOWER LOW WATER

SUBSURFACE SECTIONS

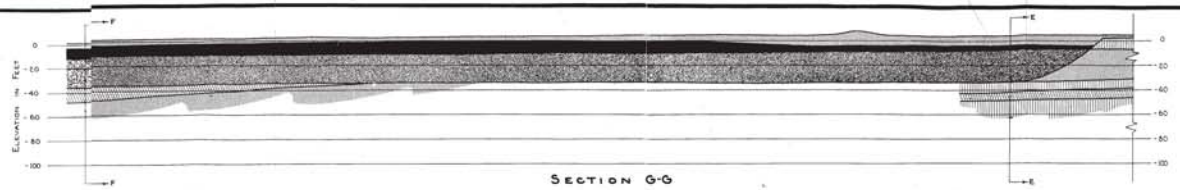
DAMES & MOORE, *Soil Engineers*

PLATE 35

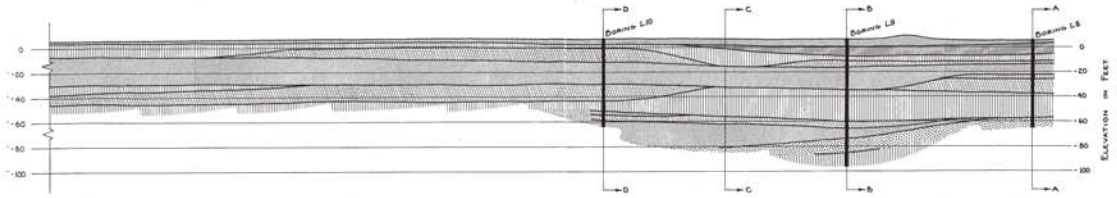


LEGEND:

- PEAT
- SOFT RECENT BAY & SLOUGH DEPOSITS
- WEAK TO MODERATELY FIRM SOILS
- MOD. FIRM TO FIRM CLAYEY SOILS
- FIRM SILTY LOAM & SANDY LOAM
- SAND
- SAND & GRAVEL



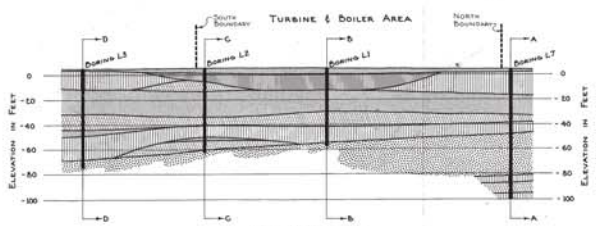
SECTION G-G



SECTION G-G (CONCLUDED)

NOTE:
ALL ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L.=0.0')

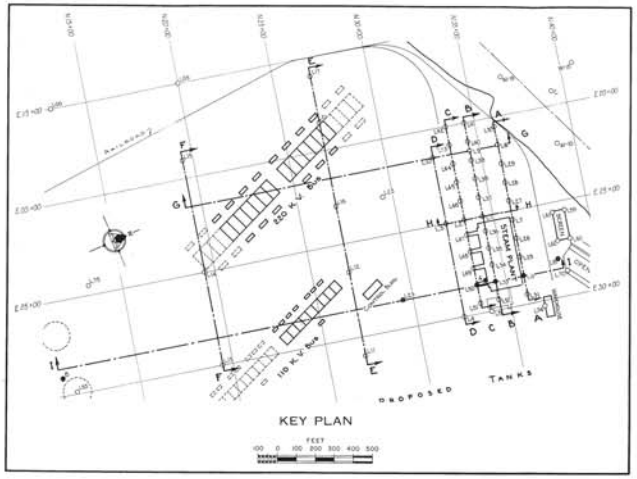
SUBSURFACE SECTIONS



SECTION H-H

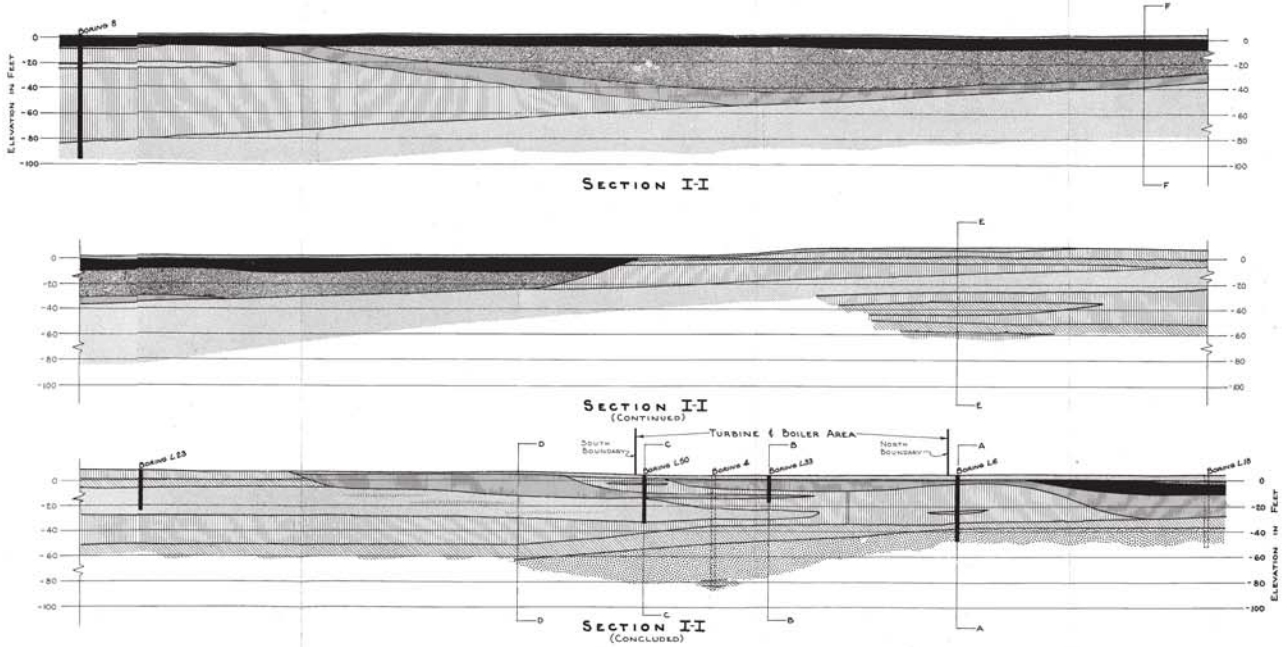
DAMES & MOORE, *Soil Engineers*
Foundation Investigations - Rock Mechanics Engineering

PLATE 3C



LEGEND:

- PEAT
- SOFT RECENT BAY & SLOUGH DEPOSITS
- WEAK TO MODERATELY FIRM SOILS
- MOD. FIRM TO FIRM CLAYEY SOILS
- FIRM SILTY LOAM & SANDY LOAM
- SAND
- SAND & GRAVEL

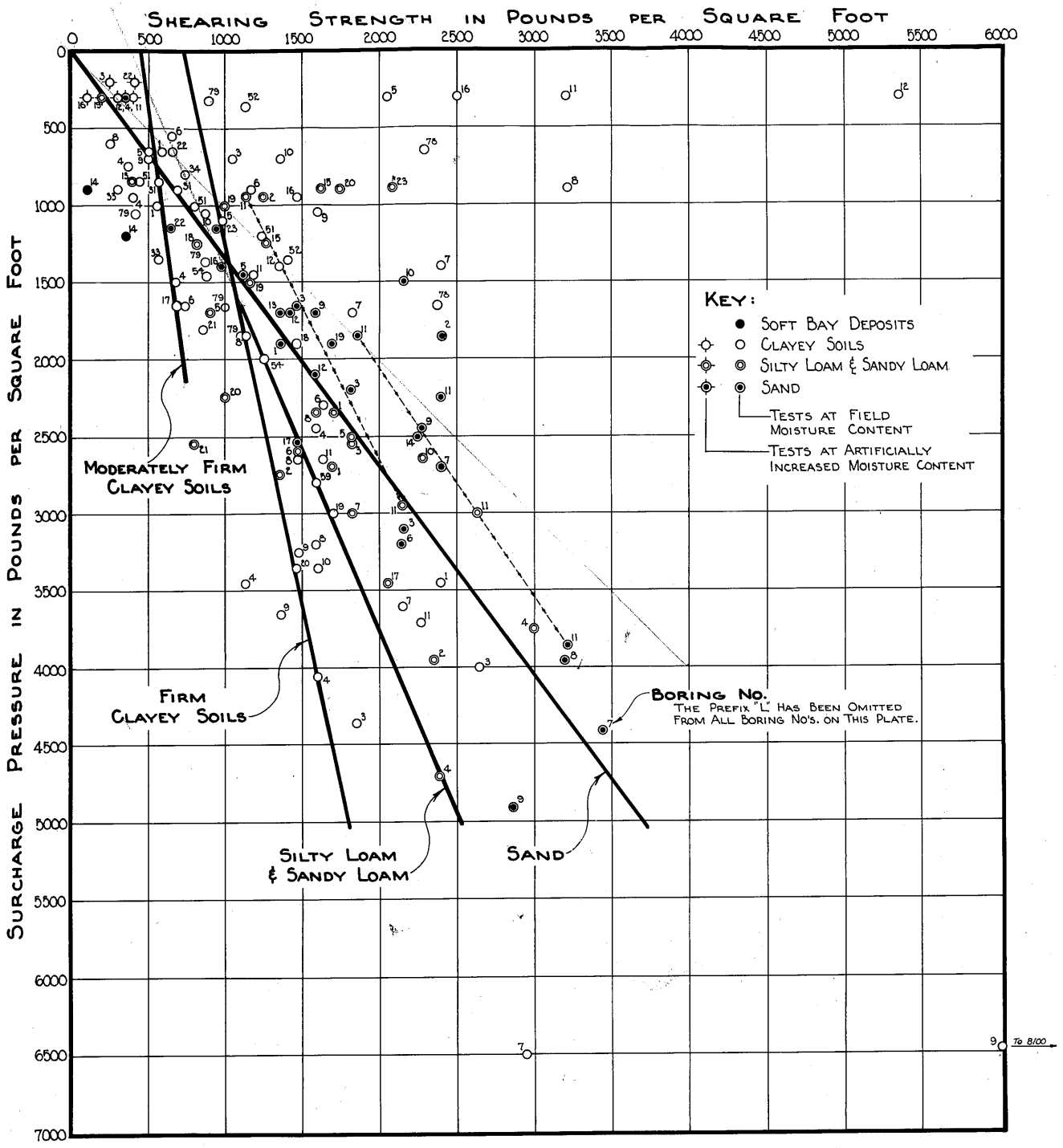


NOTE:
ALL ELEVATIONS REFER TO U.S.G.S. DATUM. (M.S.L. = 0.0')

SUBSURFACE SECTIONS

DAMES & MOORE, Soil Engineers
Foundation Investigations · Soil Mechanics Engineering

PLATE 3D

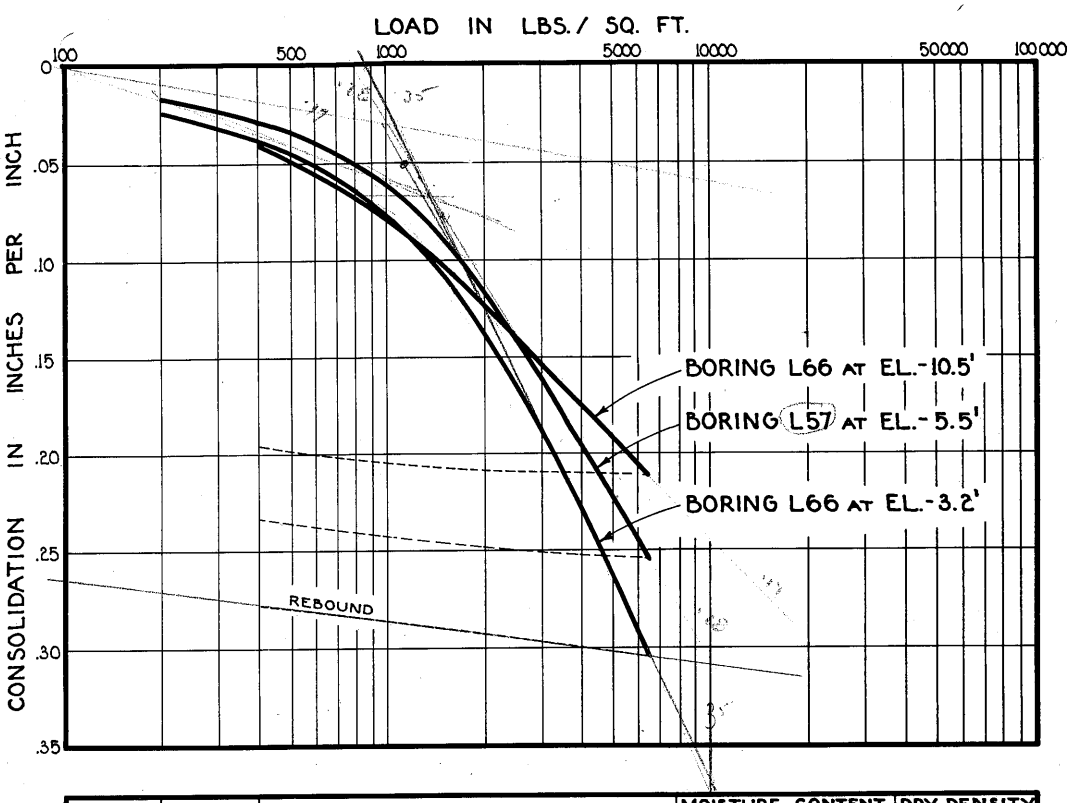


SUMMARY OF SHEAR TEST DATA

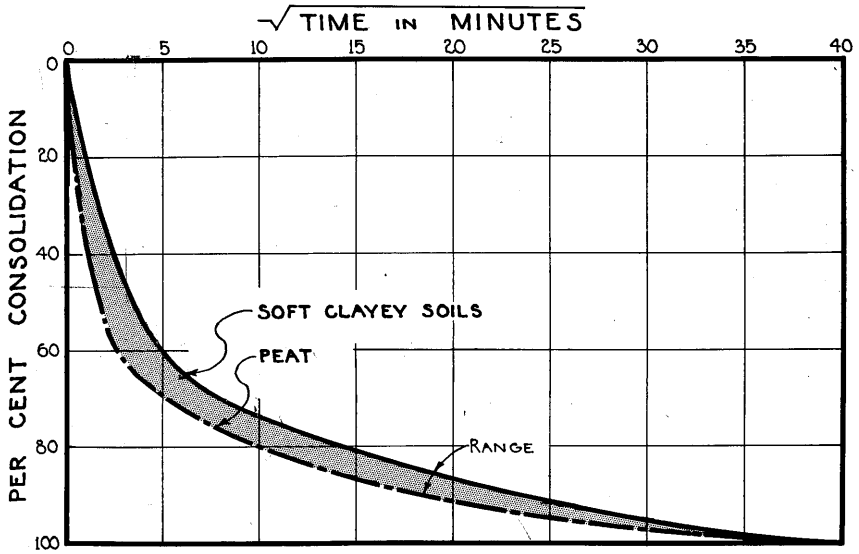
DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 4

SOFT SOILS



BORING	ELEV.	SOIL	MOISTURE CONTENT		DRY DENSITY
			BEFORE TEST	AFTER TEST	IN LBS./ CU. FT.
L66	-10.5'	BLACK SILTY CLAY (SOFT BAY DEPOSITS)	72.8%	50.7%	56.3
L66	-3.2'	BROWN & BLACK PEAT	754%	67.5%	25.2
L57	-5.5'	GRAY CLAY WITH FEW BROKEN SHELLS (SOFT BAY DEPOSITS)	83.8%	57.3%	50.3

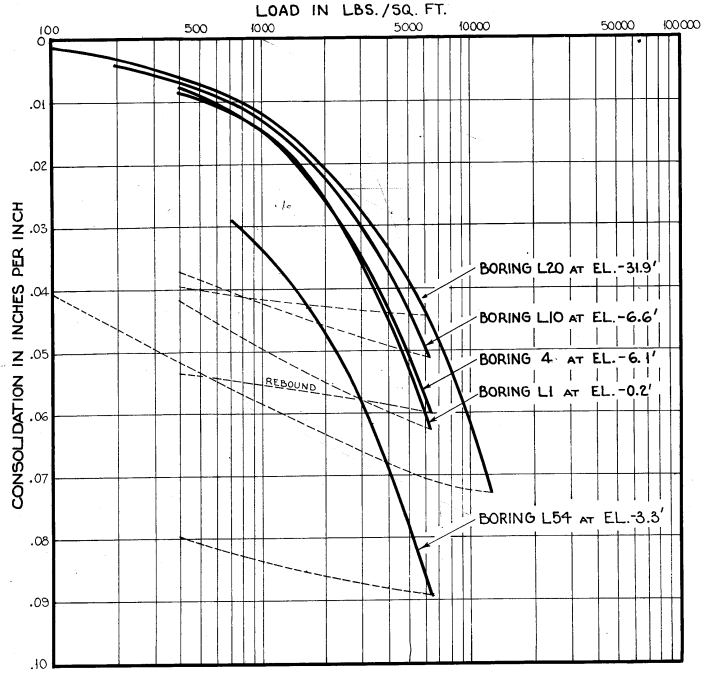


CONSOLIDATION TEST DATA

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

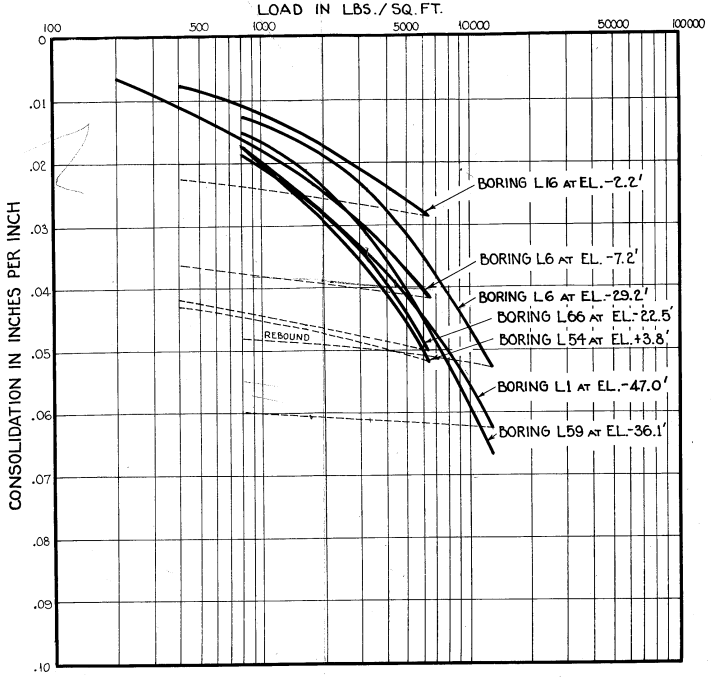
PLATE 5A

WEAK TO MODERATELY FIRM CLAYEY SOILS

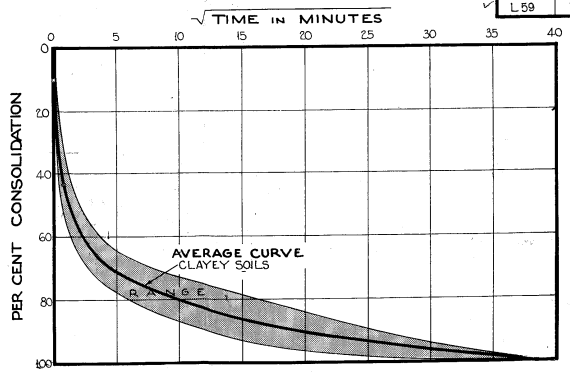


BORING	ELEV.	SOIL	MOISTURE CONTENT		DRY DENSITY
			BEFORE TEST	AFTER TEST	IN LBS./CU.FT.
L1	- 0.2'	BLUISH-GRAY CLAY	29.2%	27.4%	92.5
4	- 6.1'	LIGHT GRAY CLAY	32.5%	29.1%	86.5
L10	- 6.6'	BROWN SILTY CLAY LOAM	26.6%	25.5%	95.6
L20	-31.9'	LIGHT BROWN SILTY CLAY LOAM	39.8%	38.6%	82.5
L54	- 3.3'	GRAY SILTY CLAY LOAM	41.4%	35.2%	79.5

MODERATELY FIRM TO FIRM CLAYEY SOILS



BORING	ELEV.	SOIL	MOISTURE CONTENT		DRY DENSITY
			BEFORE TEST	AFTER TEST	IN LBS./CU.FT.
L16	- 2.2'	BROWN SILTY CLAY LOAM	26.2%	25.6%	96.2
L6	- 7.2'	LIGHT GRAYISH-BROWN CLAY	28.4%	25.5%	95.1
L6	-29.2'	MOTTLED GRAY & BROWN CLAY	21.4%	19.0%	107.2
L1	-47.0'	GRAYISH-BROWN SILTY CLAY	22.3%	12.5%	103.2
L66	-22.5'	GRAY SILTY CLAY LOAM	21.7%	18.9%	105.2
L54	+ 3.8'	BROWN SILTY CLAY LOAM	29.3%	27.1%	92.4
L59	-36.1'	MOTTLED GRAY & BROWN CLAY LOAM	25.2%	21.7%	100.8

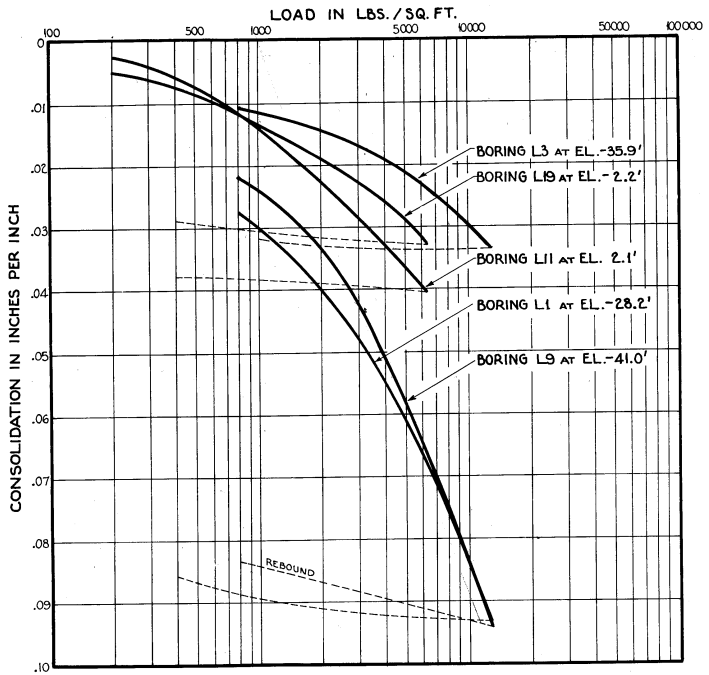


CONSOLIDATION TEST DATA

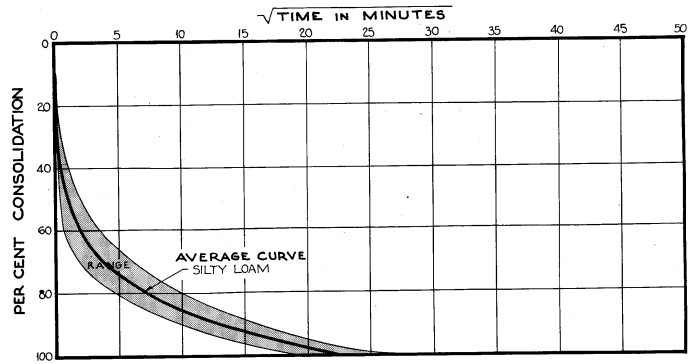
DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 5B

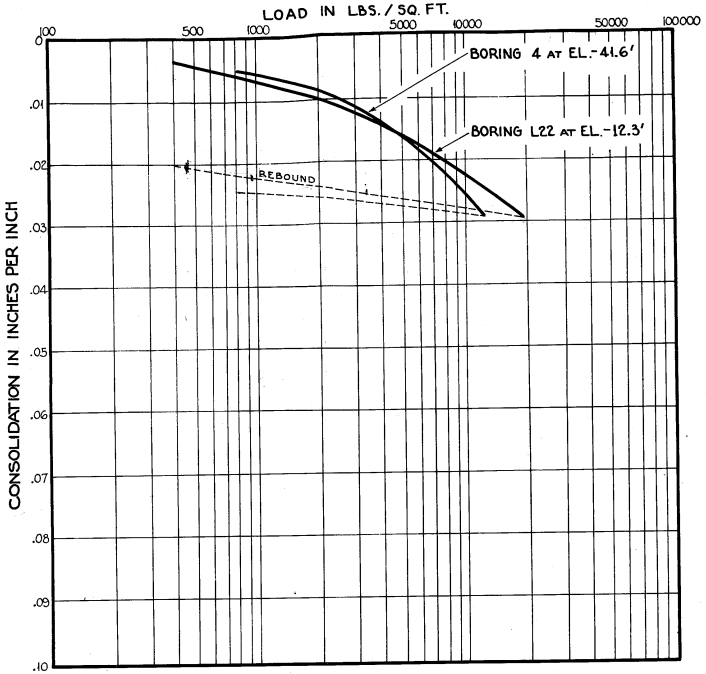
SILTY LOAM



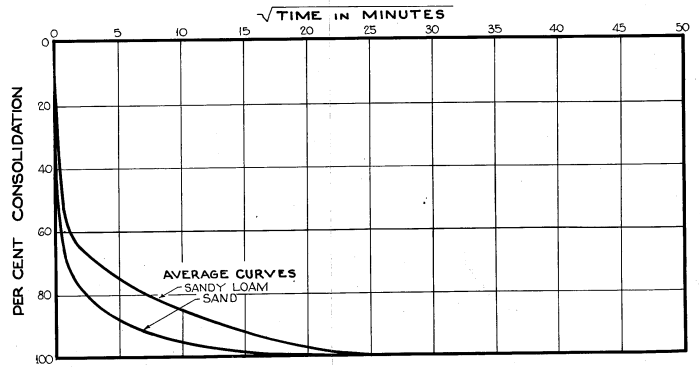
BORING	ELEV.	SOIL	MOISTURE CONTENT BEFORE TEST	MOISTURE CONTENT AFTER TEST	DRY DENSITY IN LBS/CU.FT.
L11	2.1'	MOTTLED BROWN & GRAY SILTY LOAM	20.1%	18.6%	106.2
L19	-2.2'	GR-BROWN SILTY LOAM WITH TRACES OF FINE SAND	25.8%	23.1%	100.5
L1	-28.2'	MOTTLED GRAY & BROWN SILTY LOAM	36.8%	30.8%	84.8
L3	-35.9'	MOTTLED GRAY & BROWN SILTY LOAM	29.8%	14.7%	91.3
L9	-41.0'	BROWN SILTY LOAM	36.7%	29.4%	86.1



SAND & SANDY LOAM



BORING	ELEV.	SOIL	MOISTURE CONTENT BEFORE TEST	MOISTURE CONTENT AFTER TEST	DRY DENSITY IN LBS./CU.FT.
L22	-12.3'	GRAY FINE SAND	30.3%	26.4%	94.2
4	-41.6'	BROWN SANDY LOAM WITH CEMENTATION	19.1%	17.6%	107.0



CONSOLIDATION TEST DATA

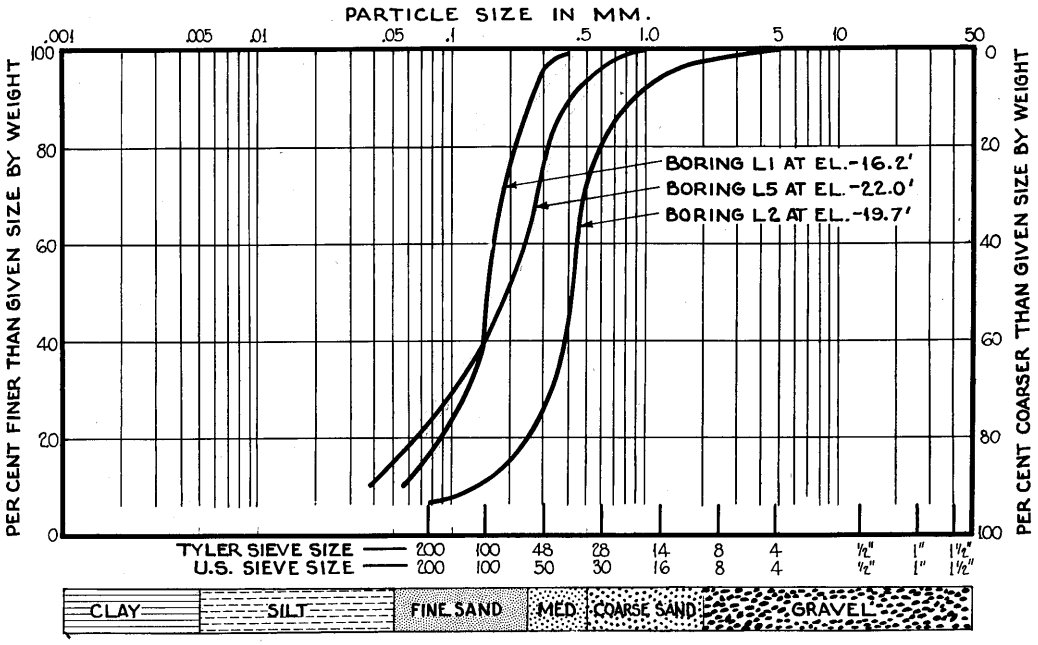
DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 5C

BORING NO.	ELEV.*	SOIL	SURCHARGE IN LBS./SQ.FT.	PERMEABILITY i=1, t=20°C GAL/SQ.FT/DAY	PERMEABILITY i=1, t=20°C FT./YR.	PER CENT MOISTURE CONTENT BEFORE TEST	PER CENT MOISTURE CONTENT AFTER TEST	DRY DENSITY LBS./CU.FT.
L 2	-6.7'	SILTY CLAY LOAM	300	.0014	.069	24.9	25.5	100.4
L 2	-6.7'	SILTY CLAY LOAM	1500	.00092	.045	23.8	24.9	99.4
L 2	-12.9'	BROWNISH-GRAY FINE TO MEDIUM SAND	300	153	7480	23.8	25.8	91.1
L 2	-12.9'	BROWNISH-GRAY FINE TO MEDIUM SAND	1500	130	6330	27.5	29.1	90.9
L 10	-13.8'	GRAY FINE SAND (Near sandy loam)	300	29	1420	26.6	27.7	93.7
L 10	-13.8'	GRAY FINE SAND (Near sandy loam)	1500	5.6	275	24.8	25.8	96.0
L 18	-2.9'	BLACK PEAT	300	18	878	352.5	385.0	13.9

* ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L.= 0.0')

PERCOLATION TEST DATA

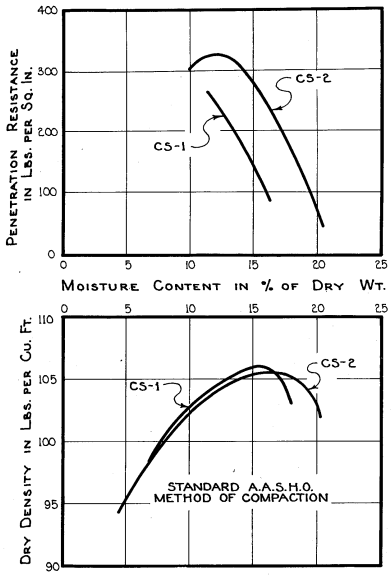


BORING	ELEV.	SOIL	COEFF. OF UNIFORMITY	EFFECTIVE SIZE
L1	-16.2'	GRAY FINE TO MEDIUM SAND	2.9	.055 mm
L2	-19.7'	BROWN FINE TO COARSE SAND, SOME GRAVEL	3.2	.135 mm
L5	-22.0'	GRAY FINE TO MEDIUM SAND	6.2	.037 mm

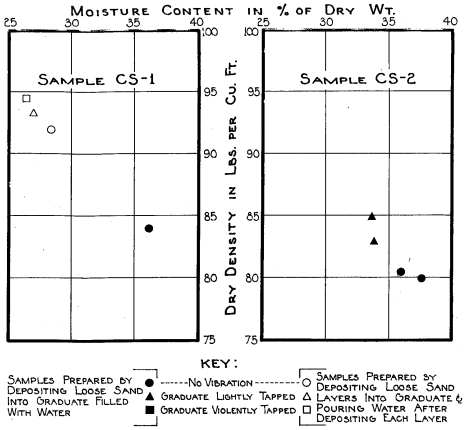
PARTICLE SIZE ANALYSES

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

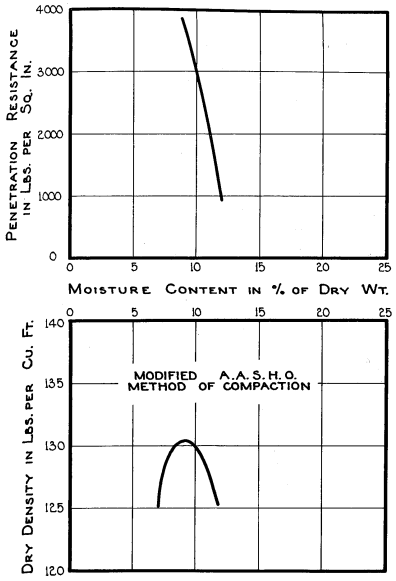
PLATE 7



COMPACTION TEST DATA

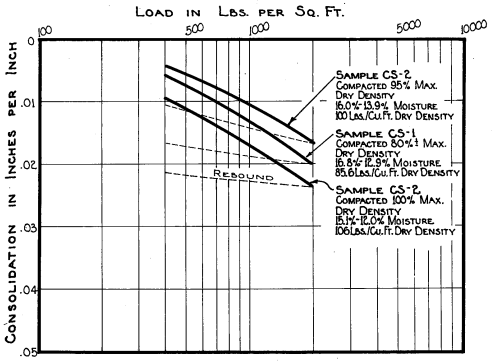


DENSITY DATA
COMPACTION BY FLOODING

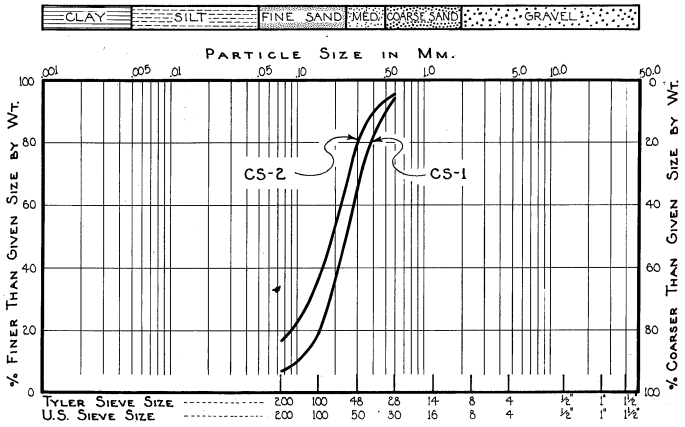


COMPACTION TEST DATA

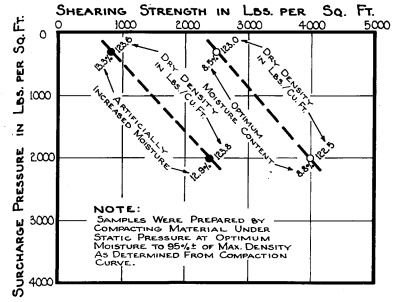
NOTE:
COMPACTION & SHEAR TESTS PERFORMED ON PORTION OF MATERIAL PASSING TYLER NO. 4 SIEVE.



CONSOLIDATION TEST DATA



PARTICLE SIZE ANALYSES



SHEAR TEST DATA

LOCAL MATERIAL

KEY:
CS-1 ---- COMPACTION SAMPLE (BROWN FINE SAND) OBTAINED NEAR BORING L25 AT A DEPTH OF 0'-4½'

CS-2 ---- COMPACTION SAMPLE (BROWN FINE SAND - NEAR SANDY LOAM) OBTAINED 15 S.E. OF BORING L29 AT A DEPTH OF 1½' - 3'

IMPORTED MATERIAL

ALVES PIT

BROWN SANDY LOAM WITH GRAVEL & ROCK FRAGMENTS (36.6% BY WT. RETAINED ON TYLER NO. 4 SIEVE.)

COMPACTION STUDIES

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

REPORT
OF
FOUNDATION INVESTIGATION

PART II
ANALYSES AND RECOMMENDATIONS

PROPOSED PITTSBURG STEAM PLANT
PITTSBURG, CALIFORNIA

160-AQ
PART-II

FOR THE
PACIFIC GAS AND ELECTRIC COMPANY

DAMES & MOORE, *Civil Engineers*

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING
LOS ANGELES · SAN FRANCISCO · PORTLAND · SEATTLE · NEW YORK

NT R. DAMES
IAM W. MOORE
ROY CRANDALL
IAM W. BREWER
NON A. SMOOTS
IAM ENKEBOLL

DOUGLAS 2-6507
417 MARKET STREET
SAN FRANCISCO 5, CALIF.
WILLIAM W. MOORE
WILLIAM W. BREWER

May 26, 1953

Pacific Gas and Electric Company
245 Market Street
San Francisco 6, California

Attention: Mr. Walter Dreyer
Vice President and Chief Engineer

Gentlemen:

Three copies of our Report, "Foundation Investigation, Part II, Analyses and Recommendations, Proposed Pittsburg Steam Plant, Pittsburg, California, for the Pacific Gas and Electric Company", are herewith submitted.

Part I of the subject Report, "Presentation of Data", was submitted on March 3, 1952. During the progress of the work, the information was reviewed and discussed on a number of occasions with representatives of the Engineering Departments of the Pacific Gas and Electric Company and the Bechtel Corporation. The results of the analyses and our recommendations were submitted to the interested parties in a series of progress reports to expedite the design of foundations for the Proposed Steam Plant.

Yours very truly,

DAMES & MOORE

William W. Brewer

William W. Brewer

WWB-HT ESH

cc: Bechtel Corporation (3)
Power Division
101 California Street
San Francisco 11, California
Attention: Messrs. James Landis and Walter L. Dickey

REPORT

OF

FOUNDATION INVESTIGATION

PART II

ANALYSES AND RECOMMENDATIONS

PROPOSED PITTSBURG STEAM PLANT

PITTSBURG, CALIFORNIA

FOR THE

PACIFIC GAS AND ELECTRIC COMPANY

MAY 26, 1953

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PREFACE

In order to expedite presentation, this Report "Foundation Investigation, Proposed Pittsburg Steam Plant, Pittsburg, California, for the Pacific Gas and Electric Company," has been divided into two parts which are bound separately:

Part I - PRESENTATION OF DATA presents the results of the explorations conducted to determine the soil conditions beneath the site, the data obtained from tests performed to describe the pertinent physical properties, and the results of sand explorations conducted to confirm the quantities of available sandy hydraulic fill materials.

Part II - ANALYSES AND RECOMMENDATIONS presents the results of the effect of soil behavior on foundation performance, and makes specific recommendations as to foundation selection and design. At the time of writing this report, decisions had been reached concerning selection of the types of foundations for support of the structures. However, for your records, discussions and results of analyses of the other types of foundations considered are also included in this Report. Contained within the Appendix of this Report are the results of additional explorations and laboratory tests which were deemed necessary to further explore sand deposits for filling, and to provide supplemental data for design of specific structures.

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*Appendixes A through F embodied in Part I of our Foundation Report

INTRODUCTION

As discussed under the heading, Introduction, in Part I of this Report, the Proposed Steam Plant will include four 150,000-kilowatt generating units, boilers, turbines, stacks, bus structures, tanks, and various appurtenant structures. At some later date, additional units are contemplated which would double the capacity of the presently proposed plant. The locations of all of the Proposed Units (present and future) are identified on Plate 9, Plant Map.

To simplify presentation, discussions of the foundation requirements reported to us for the planned structures, the soil types underlying those structures, and our foundation recommendations have been grouped into a number of topics listed under the main heading, "Foundations for Specific Structures".

Since presentation of "Part I" of this Report, a total of 29 additional borings were drilled to provide data for design of specific structures and to establish more definitely boundaries of available sand deposits for fill use. These boring locations are noted on Plate 9. Borings W24 through W37 (W25 was not drilled) and Boring L82 were drilled from floating equipment. Of these borings, Borings W32 through W37 were drilled to determine more accurately the extent of sand deposits for fill purposes; the other borings were drilled to explore the underlying soils for revetment and intake studies. Borings L80, L81 and L83 through L95 were drilled on land to further explore foundation conditions for specific structures. Graphical representations of the materials encountered and the results of tests performed are contained in Appendixes G, H and I of this Report.

FOUNDATIONS FOR SPECIFIC STRUCTURES

POWER BUILDING:

General. During the early planning stages of the site development, the turbines, boilers and stacks were considered as separate structures. Preliminary soils data disclosed the area selected for the locations of these structures to be blanketed by some 10 to 12 feet of peaty and soft clayey soils. Because of these weak soils, consideration was first given to support of major structures by means of driven piling.

The turbine structure was planned to occupy an area of approximately 150 by 350 feet in dimensions with the floor at Elevation -1.5 feet. All elevations in this Report, unless otherwise noted, refer to U.S.G.S. Datum (Mean Sea Level=0). As additional soil data became available, consideration was given to supporting the turbine structure on a mat-type foundation established at Elevation -8.5 feet. The weaker soils which were found to exist below the turbine area were to be removed and replaced with sand fills. Later, consideration was given to lowering the turbine structure to Elevation -10 feet. Soon after completion of the field explorations in the turbine, boiler and stack area, consideration was given to combining these units within a single structure on a mat foundation established at Elevation -10 feet. Based on our engineering analyses and on cost studies performed by others, it was concluded that a mat-type foundation would be more desirable, and this scheme was subsequently selected for support of the Power Building. The results of analyses which were performed as the job progressed are contained herein.

Dewatering of Turbine Structure Excavation. Calculations were performed to estimate the amount of pumping that would be necessary to adequately

dewater the turbine structure excavation. An area of 150 by 350 feet in dimensions was planned to be dewatered by means of wellpoints to Elevation -8.5 feet, a depth of approximately 9 feet below the ground-water level. The results of our analyses indicated that a pumping capacity of 500 gallons per minute would be required at the start of pumping and approximately 200 gallons per minute would be needed to maintain equilibrium. At the time of actual dewatering, pumping records were maintained by Bechtel's Engineers. These records are contained in Appendix J of this Report.

Pile Supported. The supporting capacities of 14- by 14-inch precast concrete piles and 11-1/8-inch-diameter tip Raymond cast-in-place concrete piling were computed by a method of calculation and analyses based on conservative values of the shearing strengths of the foundation soils.* In evaluating the supporting capacities, the extreme variations in soil conditions were considered. For soil conditions similar to those encountered in Boring 16, analyses were performed for piling driven for the full depth of penetration without jetting; it was assumed that the upper six feet of soil would neither offer support nor create an eventual drag on the driven piling. The results of the pile calculations for these conditions are presented graphically on the upper portion of Plate 10, Computed Pile Capacities. For soil conditions similar to Boring L7, the supporting capacities were evaluated for two methods of pile placement, (1) piling driven for the full depth of penetration without jetting, and (2) piling driven and jetted to Elevation -30 feet and then driven to final penetration. In the first case, displacement of the soils by the piles would result in high lateral pressures against the piles, and it is believed that the development of such pressures would

*"Experiences with Predetermining Pile Lengths," by William W. Moore, published in the "Proceedings of the American Society of Civil Engineers", November, 1947.

severely limit the pile penetrations that could be obtained using conventional pile driving equipment. In the latter case, it was assumed in the calculations that the lateral pressure against the piling would be approximately equal to that of the soil overburden. The results of the pile calculations for the sizes and types of piling considered are presented graphically on the lower portion of Plate 10.

Using information obtained from Boring L7, it was estimated that ultimate settlements of approximately 1½ to 2 inches could be expected for heavy structures supported on piling driven to tip Elevations of approximately -30 feet. These settlements could be substantially reduced by jetting and driving piling into the lower sand with gravel stratum encountered at Elevation -42 feet.

Mat Supported. As previously discussed, a scheme for supporting the turbines, boilers and stacks on a single mat-type foundation at Elevation -10 feet was finally selected.* The outline of the mat foundation showing the arrangement of units is indicated on the "Foundation Plan" on the upper left of Plate 11, Foundation Analyses, Power Building. The soil conditions which were found to exist beneath the foundation pad, as determined by exploration borings and examination of the actual foundation conditions, are shown on Plate 11 as Section B'-B'.

The results of analyses performed to determine the probable behavior of a mat-supported structure are presented diagrammatically on Plate 11. The graph "Loading Diagram" depicts by means of a solid line the estimated loadings (including the weight of the mat), and by dashed lines, the

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*The Power Building excavation was inspected by us and our findings and recommendations were furnished to the interested parties in a series of correspondence. These letters were reproduced and were resubmitted under one cover on January 30, 1953.

assumed loading used for analyses. As noted on the graph, the estimated mat structural loading varies from 2,100 to 2,500 pounds per square foot; however, due to removal of soils and the buoyant effect of the ground water for the mat constructed at Elevation -10 feet, the total foundation loadings would be reduced by some 1,600 pounds per square foot resulting in net abnormal loadings of 500 to 900 pounds per square foot. These latter loadings were used in our analyses of settlements.

The behavior of the mat foundation supporting the Power Building is in part dependent upon the degree of rigidity built into the reinforced concrete mat to distribute the structural loads to the underlying soils, as well as upon the length of time that the dewatering system remains in operation. Computations were performed for two limiting conditions of mat stiffness; namely, (1) a flexible mat considered to act without restraint insofar as differential settlements are concerned, and (2) a rigid mat that would allow no warping of its surface. The relative rigidity of the actual mat would lie between the extremes computed; accordingly, the actual behavior should be interpolated between the extreme cases for which the analyses have been performed. The variations in ultimate settlement that would occur between fully flexible- and rigid-type mats are presented graphically under the heading, "Ultimate Settlements", on Plate 11. The reaction pressures on the underside of a flexible mat sustaining a uniformly distributed load would be uniform, while that of a rigid mat would be larger at the edges and smaller at the center as shown by the sketch entitled, "Reaction Pressures on Mat".

The stress distribution below flexible-type foundations could be more readily analyzed than rigid-type foundations. Consequently, analyses were performed initially for the flexible-type foundations and the results

of the flexible foundation analyses are shown graphically under the heading, "Settlement Contours, Flexible Mat". Since the mat as constructed is relatively rigid, the differential settlement pattern would be reduced in proportion to the degree of rigidity. Based on a dewatering period of six months, the amount of settlement to be expected after the settlements have occurred during an 18-month period, after start of construction, are shown on the graph. The ultimate settlements from the start of construction are also entered on the print. The time-rate of settlement is described on the graph entitled, "Time-Rate of Settlements." It should be noted that 80% of the ultimate settlement would take place within 18 months from the start of construction and that 90% of the ultimate settlement would occur within a period of two years. Should the dewatering system be continued for one year instead of six months, but with the previously indicated rate of loading, the rate of settlement during this period would be accelerated and the amount of initial settling would be slightly in excess of the ultimate 2½ inches. After dewatering is discontinued, the reduced loading caused by the buoyant effect of the ground water would allow a slight rebound in the foundation soils.*

INTAKE STUDIES:

General. The intake structures will be comprised of a Screen House, Pump Platforms, an Open Channel and/or Enclosed Tubes. Consideration was given to situating the inlet toward the northeasterly corner of the site in order to provide the greatest advantage from an operational standpoint; however, because of unsatisfactory soil conditions at this location, (as will be subsequently discussed) the inlet was moved to a location immediately north of

*Bench marks for recording settlements have been established and should provide valuable factual data with reference to settlements of the Steam Plant which is under construction.

the Power Building.

As disclosed by our test borings, the shore line is underlain by variable soil formations. The various conditions are grouped into approximate areas and are described as follows:

> Between coordinates E8+00 and E20+00, weak clay and compressible peat deposits are present and vary from 6 to 32 feet in thickness.
>
> From E20+00 to E28+00 firmer soils with relatively few thin layers of soft soils are present.
>
> From E28+00 to E33+00 some 15 feet of weak soils are covered by approximately 5 feet of sand.
>
> From E33+00 to E37+00 the underlying soils on the shoreward side of the bank are relatively firm--a 2½-foot-thick stratum of bay mud exists five feet below the surface near the eastern portion of this area.
>
> From E37+00 to the originally proposed location of the screen structures at approximately E48+00, weak and compressible soils are present to depths of some 55 feet below the surface.

Intake - Northeasterly Location. It was planned that the Pump House would be located near the Power Building and the Screen Structure would be situated near the northeast corner of the property. The two structures would be connected by means of an open channel which might vary from some 50 to 150 feet in width. The Screen House would be some 40 by 180 feet in dimensions and would be established at Elevation -20 feet. One of the main problems concerning this location was the construction of the intake channel.

An earth-constructed channel would be utilized wherever soil conditions permitted. It was planned to dredge a channel approximately 30 feet wide with a bottom Elevation of -12 feet. The channel banks would be carried to an Elevation of -2 feet with side slopes of one (vertical) on four (horizontal) and then continued to a top Elevation of +9 feet with side

slopes of one on two; the channel bank on the river side would be five feet wide across the top and the outer bank would be sloped on a one on two incline to the existing river bottom. The slopes above Elevation -2 feet would be protected against erosion or scour by riprap.

It is our opinion that the channel described could be constructed between coordinates E25+00 and E37+00. The channel portion between E25+00 and E33+00, which is underlain by a compressible peaty formation, would have a factor of safety of approximately 1.5 against major over-all sliding. The channel banks in this area would undergo ultimate settlements of approximately one and one-half feet due to the weight of fills placed. The factor of safety against failure could be increased and the bank settlements greatly reduced by removing the peaty soils from under the banks of the channel and replacing them with an imported sandy fill.

The walls of the intake channel east of coordinate E37+00 could be constructed of sheet piling designed as a cantilevered wall stiffened with buttress piles provided fills are not placed against the exterior of the channel walls. To provide lateral stability the piling should be driven 10 to 15 feet into the firmer underlying soils and a sand and rock blanket some 6 to 10 feet thick should be placed on the bottom of the excavated channel.

If fills are placed on the outside of the intake channel walls to Elevation 6, a cellular-type sheet-pile wall construction with cells some 30 to 40 feet in diameter would be required to support the banks. The soft peaty soils within the cells would have to be partly removed and replaced with sandy material. Further studies for the intake structures at the northeasterly location have been deferred by the Pacific Gas and Electric Company and the Bechtel Corporation.

Intake - Northerly Location. Our studies for facilities at this northerly location were limited to those problems which developed during the initial planning stages. The foundation of the Screen House, near Boring W16 and adjacent to the deep river channel, presents many design and construction problems due to adverse soil conditions. It was tentatively planned that sheet piling would be driven around the perimeter of the proposed structure and the material within the sheet pile wall would be excavated to Elevation -26 feet. A tremie concrete seal would be poured to Elevation -20 feet to form the floor of the Screen Structure. To provide data for design to resist hydrostatic uplift forces, analyses were performed to determine the uplift capacities of driven steel sheet piling and untreated wood piling--the wood piling for these soil conditions would be driven butt-end down to provide greater uplift capacities. The results of these studies are presented on Plate 12, Computed Pile Capacities.

Another problem that required investigation was the construction of an earth-fill jetty commencing at the shore line near Coordinate E35+00 and extending into the river approximately 600 feet in a northerly direction. This jetty would serve two purposes: (1) to separate the warmer discharge water from the cooler intake water, and (2) to support an oil line for transportation of fuel from river-going transports to storage tanks on shore. It is planned to construct the jetty of hydraulically-placed fills to a top Elevation of 8 utilizing one on two side slopes. The jetty would be 10 feet wide across the top and the side slopes above low water would be protected against scour by approximately a two-foot thickness of riprap.

As disclosed by our test borings, the proposed jetty location is underlain by as much as 45 feet of weak clayey and peaty soils. From the results of stability analyses, the weak soils underlying a jetty constructed

of fills placed on a one on two slope would tend to slide and cause mud waves if the fills were initially placed to heights greater than Elevation 5 feet. Fills placed to this elevation and allowed to settle for a period of approximately six months would strengthen these underlying soft soils so that the factor of safety for the over-all stability of the jetty would be improved. After this six-month period, the height of the fills could be increased to Elevation 8 feet. It is estimated that ultimate settlements on the order of three feet can be expected from the weight of the planned fill.

SHORE REVETMENT:

Consideration is being given to the construction of a 2½-foot-wide dike at Elevation 9 feet placed on a one-to-one side slope. The revetment would be composed of Class II rock having average weights of 600 pounds. This scheme would probably be unstable if located along the shore line between Coordinates E8+00 and E20+00; however, sufficient stability against lateral failure could be gained by a combination of a sand blanket used in conjunction with driven untreated wood piling located on some six- to ten-foot centers. A possibly more desirable method would be to construct a dredged sand fill to the planned elevation with slopes of approximately one on four. At a later date, the exposed shore line could be protected from scour by placing a layer of riprap facing some two feet thick. This method of placement could also be used from Coordinate E20+00 to E33+00; however, this area is underlain by firmer soils, and a rock dike with slopes of one on one could be satisfactorily constructed.

SWITCH YARD:

General. The switch yard will be comprised of 230 K.V. Structures, 115 K.V. Structures, transformer mats and transmission towers. The location of

the Bus Structures in relation to the existing coordinate system is indicated on the Plant Map, Plate 9. As presently planned, the greater portion of the switch yard area will be filled to approximately Elevation 7.5 feet by hydraulically-placed fills--the southwest corner would remain at the original grade.

As disclosed by the exploration borings, the greater portion of the switch yard area is underlain by deposits of peaty and weak clayey soils varying from some 10 to 50 feet in thickness. Shallow deposits of these weaker soils underlie the southerly portion of the 115 K. V. Bus Structures while the northerly end is underlain by moderately firm to firm natural soils. In areas wherein the surface is underlain by shallow deposits of peaty and weak clayey soils, foundation support could be gained from the underlying firmer soils. For thicker deposits of undesirable foundation soils, support for the subject structures should be gained by means of piling driven into the firmer underlying soils. While consideration was given to support of these structures on compacted fills, incorporating the use of sand drains, it was concluded that this method was not satisfactory.

Bus Structures - Mat Supported. The 230 K. V. and 115 K. V. Bus Structures will cover areas of approximately 220 by 800 feet and 110 by 420 feet, respectively. Units which are part of the 230 K. V. Bus Structures, if supported on footings approximately three feet square, would impose pressures as great as 2,000 pounds per square foot on the underlying soils. Other units on footings approximately 7 by 21 feet in dimensions would impose soil pressures as much as 1,200 pounds per square foot.

To provide data concerning the range of areal settlements which would be expected under the weights of fills to be placed, analyses were performed for two diverse soil conditions. A five-foot sandy fill placed over

approximately 10 feet of weak clayey soils may be expected to undergo an ultimate settlement of some three inches. In areas where soft bay deposits extend to depths of approximately 50 feet, the ultimate settlements for a ten-foot fill would be approximately 30 inches.

In order to determine the advisability of installing sand drains to accelerate the time-rate of settlement of the softer soils caused by fills and structural loadings, analyses were performed for 12-inch-diameter sand drains spaced at 10-foot centers. The spacing of the sand drains is shown on the "Plan" on the top of Plate 13, and as noted, extend outside the perimeter of the footing for a minimum distance of five feet. The soil condition of Boring L-21 (45 feet of soft deposits) was used for these analyses. In order to compensate for the expected settlement so that a final grade of Elevation 6.5* may be maintained it would be necessary to fill the area initially to Elevation 9.5 feet. The results of these analyses are illustrated by "Scheme I" on Plate 13. Employing this scheme, it would be necessary to delay construction for a period of approximately eight years in order that the expected total and differential settlements would be within permissible limits.

In view of the long delay that would be required before construction could be started for Scheme I, analyses were performed giving consideration to acceleration of settlements by means of surcharge fills placed over the footing area and extending five to eight feet outside of this area. The results of analyses for five feet of surcharge fills are shown by "Scheme II" on Plate 13. With this procedure the construction of the structures should be delayed for a period of approximately two and one-half years after the placement of surcharge fills.

*Since these studies were made, the final grade of the switch yard was revised to Elevation 7.5 feet.

While analyses were not performed for shallower thickness of soft deposits, it is estimated that soft deposits of approximately 20 feet in thickness would require fills to Elevation 8 in order to compensate for the future expected fill and structural settlements. If sand drains were used as in Scheme I, the construction of the structures could be undertaken after the initial five-year period. For Scheme II, with five feet of surcharge fill, the construction could be undertaken within approximately one and one-half years after the application of the surcharge loads.

As an indication of the approximate cost for installing vertical sand drains, a summary sheet entitled "Test of Projects in Which Vertical Sand Drains Were Constructed in California Between 1934 and 1937" is submitted in Appendix K. The installation of sand drains would be quite costly and waiting periods would be necessary to restrict settlements to permissible amounts; therefore, it was decided during discussions with Bechtel's Engineers to utilize wood piling for support of the Bus Structures.

Bus Structures - Pile Supported. The supporting capacities of driven 8-inch tip, taper one inch in ten feet, wood piling were computed for the soil conditions disclosed in Borings L14 and L21. Consideration was given in the analyses to the probable future down-drag forces that would be imposed by the subsidence of the fills and consolidation of the underlying soft deposits. The safe permanent capacities for driven piles are presented on Plate 14, Computed Pile Capacities, Bus Structures. For purposes of more accurate determinations of pile lengths, Borings L89 through L92 were drilled to determine the elevations of the surface of firm soils. The graphical representations of the materials disclosed by these exploration borings are shown on Appendix E, Plates E5 through E8, Log of Borings.

To provide data for estimating the lengths of wood piling (8-inch-diameter tip and one inch per ten feet taper) for ten-ton total design loads per pile, contours depicting the pile tip elevations are indicated on Plate 15, Pile Tip Contours. Further, a 15-ton capacity per pile may be obtained by penetrating an additional 3± feet. At the northerly end of the 115 K. V. Bus Structures where the firmer soils are encountered immediately below the surface, wooden piling supporting total loads of 15 tons should be driven to tip elevations of approximately -13 feet. The contours are only accurate at the location of the borings and could vary appreciably if underground depressions or ridges should be encountered. The pile cut-off of untreated piles should be below Elevation 0 (U.S.C.S. Datum)--the piles may extend a few feet above this elevation provided the extension is completely encased in concrete. These opinions are based on the assumption that the ground-water table would not be lowered due to plant operation.

Transformers. A concrete pad some 40 by 110 feet in over-all dimensions and situated near Boring L91, will be constructed for support of transformers. The transformers will be on track-mounted trucks with wheels at six-foot centers and will impose individual wheel loads of 50,000 pounds.

For support of the concrete pad and transformers, it is estimated that wood piles supporting external total loads of 25 tons should be driven to tip elevations of approximately -25 feet. Pile tip elevations should be expected to vary because of variable soil conditions. The cut-off of untreated piles should be at or below Elevation 0.

Transmission Towers. At locations indicated on Plate 16, seventeen transmission towers will be constructed at intervals of as much as 1300 feet apart. It is proposed to support each of the four-legged steel towers at a base elevation of 8.0 feet on rigid concrete pads. These towers will impose

total design loads of 165,000 pounds upon the supporting soils. It is anticipated that short duration uplift pressures of 132,000 pounds might be developed at each leg based on wind loads and broken wires. As a construction expedient, the Engineering Department of the Pacific Gas and Electric Company has prepared standard designs for power towers. These designs include a standard procedure for placement of spread footings in relatively firm soils and an alternate scheme for providing 15-ton capacity driven piling for weak soils. Since variable thicknesses of undesirable soils were found to underlie all of the proposed power tower locations, driven wood piling were selected for foundation support. The elevations to which 8-inch tip wooden piling need be driven to provide 15-ton load carrying capacities are noted on Plate 16. Pile tip elevations should be expected to vary because of variable soil conditions and the cut-off of untreated piles should be at or below Elevation 0.

FUEL OIL STORAGE TANKS:

Presently Proposed Tanks. Presently, six fuel oil tanks 160 feet in diameter and 48 feet in height are to be situated near the east edge of the property as indicated on the Plant Map. The storage tanks will impose loadings of 2,600 pounds per square foot on the underlying soils.

Included on Plate 17 is a Key Plan showing the tank locations with respect to plant coordinates, a Subsurface Section depicting the underlying soil conditions, a graphical analyses of the settlement behavior of Tanks 3, 4, and 6, and cross-section indicating suggested thicknesses for the tank pads.

As noted on the Subsurface Section, the area of the proposed tanks is underlain generally by moderately firm to firm sandy and clayey soils. In order to obtain a reasonably uniform support for the tanks, it is recommended

that a minimum of two feet of the surface clayey soils be removed and replaced by a good quality compacted fill. This would also eliminate the possibility of overstressing the soil at the edge of the tank due to stress concentrations at that point. If a minimum tank grade elevation is to be maintained, it would be necessary to place additional compacted fills below the tanks to compensate for the expected settlements. As an indication of the additional amounts of fill that might be required, analyses were performed for various tanks and the results are presented on the lower portion of the plate. For these analyses, it was assumed that the individual tanks would exert foundation pressures of 2,600 pounds per square foot and would be established at an Elevation of 8.0 feet. The dome shape of the tank pad is desired to compensate for the greater settlements at the center of the tanks. Although no analyses were made for Tanks 1, 2, and 5, it is believed that the probable behavior of these tanks can be approximated by logical comparisons with the soil conditions found underlying Tanks 3, 4, and 6. Due to the expected settlements, consideration should be given in design to the flexibility of the piping system at and adjacent to the tanks.

These required fills should be of a predominantly granular material. A sample specification for the "Placing of Compacted Fills" is submitted as Appendix L of this Report.

Future Tanks. At some later date, for future needs, six additional 160-foot-diameter tanks are planned for construction at locations indicated on the Plant Map. The height of the Proposed Tanks would be governed by the stability of the underlying soils.

An inspection of the exploration and test data indicates that the area of the future tanks is underlain by some eight to 20 feet of weak, compressible soils. These soils will be left in place and the grade of the

site will be raised to Elevation 8 by placing approximately seven feet of hydraulic sandy fills. If the weak underlying soils are permitted to consolidate and strengthen gradually under the fill loads, the factor of safety for the over-all stability of the fuel oil storage tanks would be considerably enhanced. As noted on Plate 18, the weight of the fill alone will cause the weaker soils to consolidate some seven to ten inches within a period of approximately 12 months.

Engineering analyses indicate that if the tanks were constructed some 12 months after the placement of the fills, the factor of safety for the over-all stability would be slightly in excess of one immediately after the storage tanks were filled to a height of 20 feet; however, due to strengthening of the soils under these loadings, the factor of safety under 20-foot loading would be increased to at least 1.5 over a period of approximately six months. The tank loads could then be increased gradually to the planned 32-foot height. A factor of safety of approximately 1.2 is indicated after the weak, compressible soils have fully consolidated under the full tank loads.

To provide a reasonable factor of safety for the over-all stability of the tanks and to reduce local yielding of the soils at the edges of the tanks, it is recommended that (1) the hydraulic fills be placed at least six months in advance of construction; (2) the upper two feet of material be adequately compacted; (3) a two-foot-thick well compacted crushed rock or gravel ring extending three feet outside and two feet inside the tank perimeter be placed below the tank edge; (4) the storage facilities be initially limited to a height of 20 feet for a period of some six months or until settlements have substantially ceased; the capacity could then be gradually increased to a height of 32 feet. Even though accidental failures are not

anticipated, it is suggested that the tanks be water tested and settlement observations be made, especially during the initial loading of the storage tanks, so that advance warning of any unexpected soil yielding would be obtained in sufficient time to reduce the tank load before serious damage occurs. (From previous investigations, higher tanks have been erected on fills overlying soft, compressible clayey soils by using somewhat similar construction procedures. Even though ultimate tank settlements of some 20 inches were predicted, the tanks have been operating successfully since construction).

As noted on Plate 18, the centers of the proposed tanks will undergo settlements of approximately 16 to 20 inches; the edge settlements will be approximately two-thirds of these values. It is suggested that the tank pads be crowned to compensate for these differential settlements. Sufficient flexibility in the pipe lines should be made to permit the expected settlements to occur without damage to the lines. If practical, it is suggested that permanent pipe connections be delayed until after the initial loading period, that is, after the initial settlement has occurred under the proposed water test.

Fire Walls. Concrete walls approximately 300 feet in diameter and 17½ to 21½ feet above finished grade will be constructed around each fuel oil tank. The walls will be designed to resist the pressures imposed by the liquid from the tanks in case of tank failures.

In the area of the presently planned fuel oil tanks, the walls will be underlain by relatively firm soils. Wall footings resting on the firmer soils may be designed to impose limiting dead plus real loads of 2,000 pounds per square foot, and total design loads of 3,000 pounds per square foot. A minimum footing depth of two feet below the lowest adjacent final

grade is recommended. It is estimated that footings imposing dead plus real loads of 2,000 pounds per lineal foot of wall would undergo settlements of less than one-half inch.

In the future tank area it is recommended that the wall footings gain support from the hydraulically-placed fill. The design loads to be imposed will be dependent upon the strengths and characteristics of the hydraulically-placed fills; for the sandy-type material that is planned to be placed, it is believed that dead plus real loads of at least 1,000 pounds per square foot could be imposed at a minimum footing depth of two feet below the lowest adjacent final grade. The influence of the pressures imposed by a fire wall would be essentially dissipated within the fill. Consequently, the differential settling for a uniformly loaded wall would be dependent upon the uniformity of the fill. The areal settlements, as indicated on Plate 18, would directly influence the settlement behavior. As presently planned, the tanks and fire walls will not be constructed until at least one and one-half years after placement of fills, at which time the expected areal settlements would have substantially ceased.

SPUR TRACK:

As indicated on the Plant Map, a railroad spur is planned to extend from the Southern Pacific tracks adjacent to the southern boundary of the site in a northerly direction toward the banks of the Sacramento River and toward the Power Building. The railroad bed will be located over marsh lands which are underlain by peaty and weak, clayey soils varying from two to 26 feet in thickness. Because of these conditions, consideration was given to (1) the amount of settlement that might be expected if the railroad were supported on fills and, (2) the stability of the bank adjacent to the

Sacramento River due to added weight of the proposed railroad and cars.

With reference to problem (1) and for soil conditions such as found in Boring L17, it was computed that side slopes of approximately one on six would be required to prevent a shear failure and to safely maintain a railroad fill 16 feet wide with a top Elevation of 8 feet. For these conditions, it was estimated that ultimate settlements would be as much as 2½ feet. In discussions with Engineers of the Southern Pacific Railroad Company, Bechtel Corporation, and the Pacific Gas and Electric Company, it was concluded that the proposed railroad should be supported on fills with the understanding that some periodic maintenance would be required.

With reference to problem (2) slope stability analyses were performed for the following conditions: (1) the railroad spur would be constructed near the river bank, (2) the top of the ballast which supports the tracks is 12 feet wide and at Elevation 9 feet, (3) the track is supporting a box car weighing 100 tons, and (4) the bottom of the river at that point is at Elevation -1 foot. For these conditions it was determined that a slope of one on three would provide a factor of safety of about 1.4. This slope should be protected by riprap varying from at least 3 feet thick toward the bottom of the bank to two feet toward the top.

COAL STORAGE AREA:

In the vicinity of the northwest corner of the site, as designated on the Plant Map, provisions are being made for coal storage. If soil conditions permit, it would be desirable to store coal in a stack at least 30 feet high. The coal would be transported to the storage area by means of tractors and Tournapulls and spread out in 10-inch layers. The coal would be replaced as it is being used so that approximately 80% of the coal would remain in the

storage area at all times.

As disclosed by our test borings, the coal storage area is underlain by some 20 to 32 feet of weak, clayey and peaty deposits. This area which is presently at Elevation 3 feet will be filled hydraulically to approximately Elevation 8 feet. From our laboratory testing and engineering analyses, it is our opinion that fill will consolidate and gradually strengthen the underlying weak and compressible soils so that six months after placement of fills, coal could be safely stacked to a height of 30 feet on a one on four slope. These restrictions would provide a factor of safety of 1.3 against a major slip failure within the weaker underlying materials. It is estimated that the combined weight of the fill and coal pile will ultimately settle approximately 5 feet. Of this 5-foot settlement, two feet will take place under the weight of the fill. With reference to the rate of settlement, it is estimated that 20 to 30 per cent of the indicated settlements would occur within one year and 50 to 70 per cent would take place within approximately ten years.

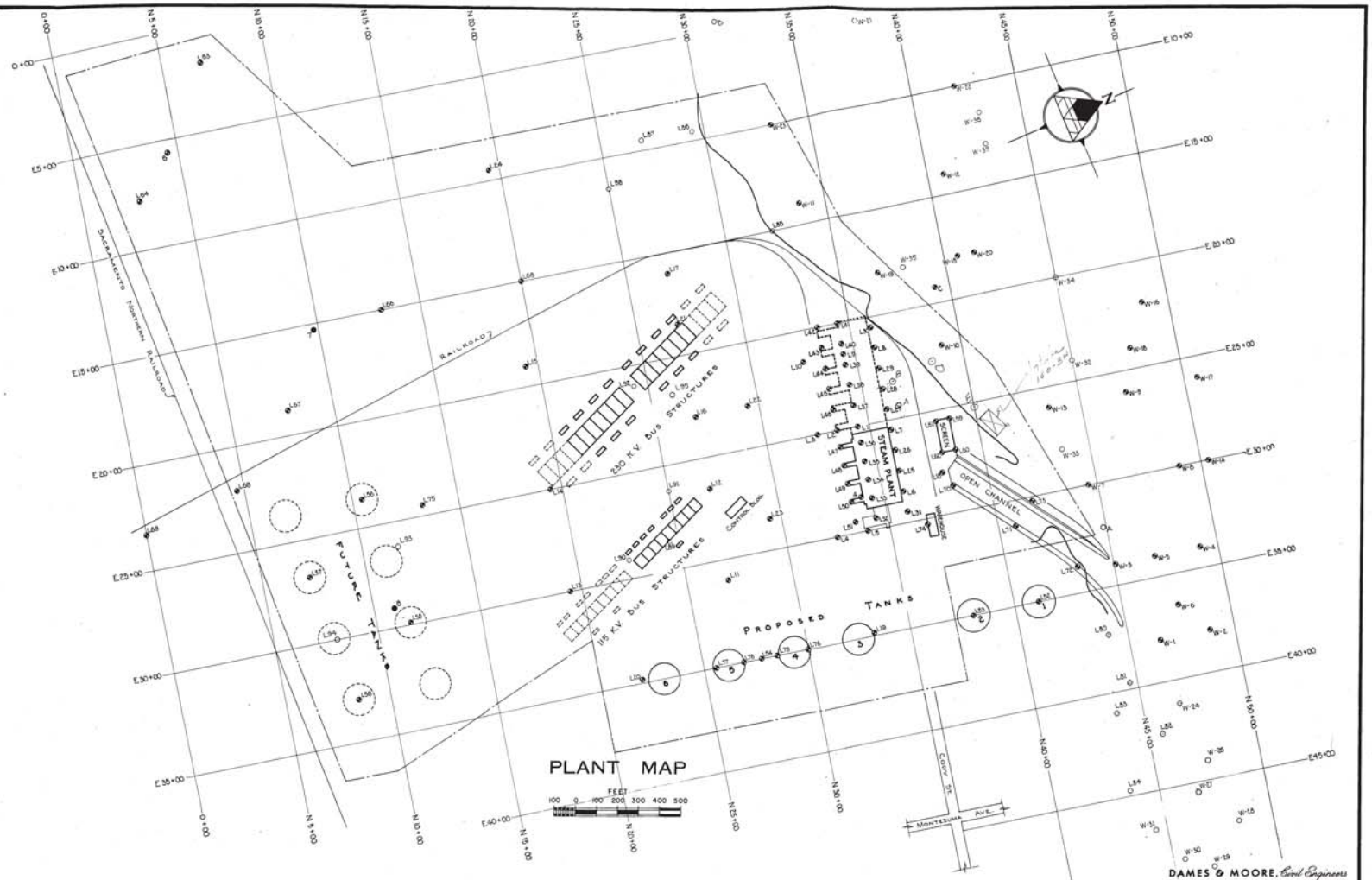
Respectfully submitted,

DAMES & MOORE

William W. Brewer

PLATES

BORING	CO-ORDINATES	
L 80	N 44 - 08	E 37 - 22
L 81	N 44 - 60	E 32 - 66
L 82	N 45 - 69	E 42 - 40
L 83	N 43 - 73	E 43 - 00
L 84	N 43 - 70	E 44 - 78
L 85	N 32 - 21	E 15 - 00
L 86	N 22 - 40	E 9 - 50
L 87	N 26 - 95	E 9 - 50
L 88	N 25 - 00	E 13 - 50
L 89	N 24 - 55	E 28 - 60
L 90	N 22 - 50	E 29 - 12
L 91	N 25 - 00	E 26 - 25
L 92	N 24 - 30	E 21 - 00
L 93	N 31 - 70	E 26 - 20
L 94	N 8 - 00	E 30 - 00
L 95	N 26 - 04	E 21 - 74
W 24	N 46 - 77	E 41 - 15
W 25	NOT	OBTAINED
W 26	N 47 - 50	E 44 - 07
W 27	N 46 - 57	E 45 - 49
W 28	N 46 - 45	E 47 - 20
W 29	N 46 - 79	E 49 - 05
W 30	N 45 - 45	E 48 - 40
W 31	N 44 - 40	E 46 - 88
W 32	N 45 - 00	E 24 - 00
W 33	N 43 - 64	E 28 - 01
W 34	N 45 - 00	E 20 - 00
W 35	N 38 - 00	E 18 - 00
W 36	N 43 - 00	E 11 - 50
W 37	N 43 - 00	E 13 - 00

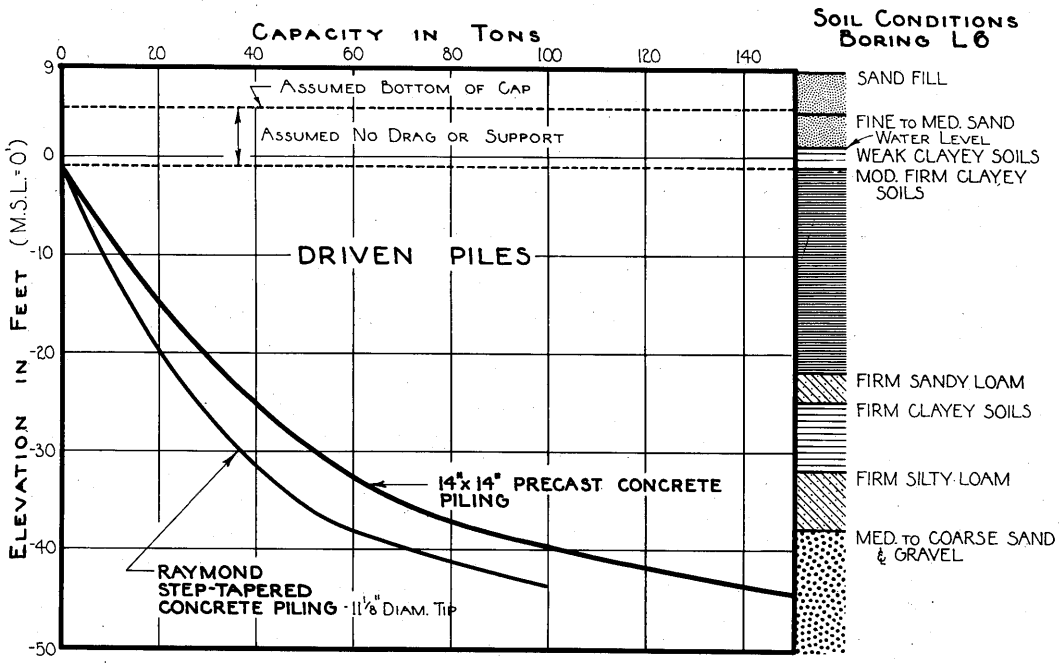


REFERENCE:
DRAWING NO. 410801 - CHANGE 3, TITLED "SOIL TEST BORING LOCATIONS" PITTSBURG STEAM PLANT - PACIFIC GAS AND ELECTRIC COMPANY - DRAWING PREPARED BY BECHTEL CORPORATION - NOV. 9, 1951.

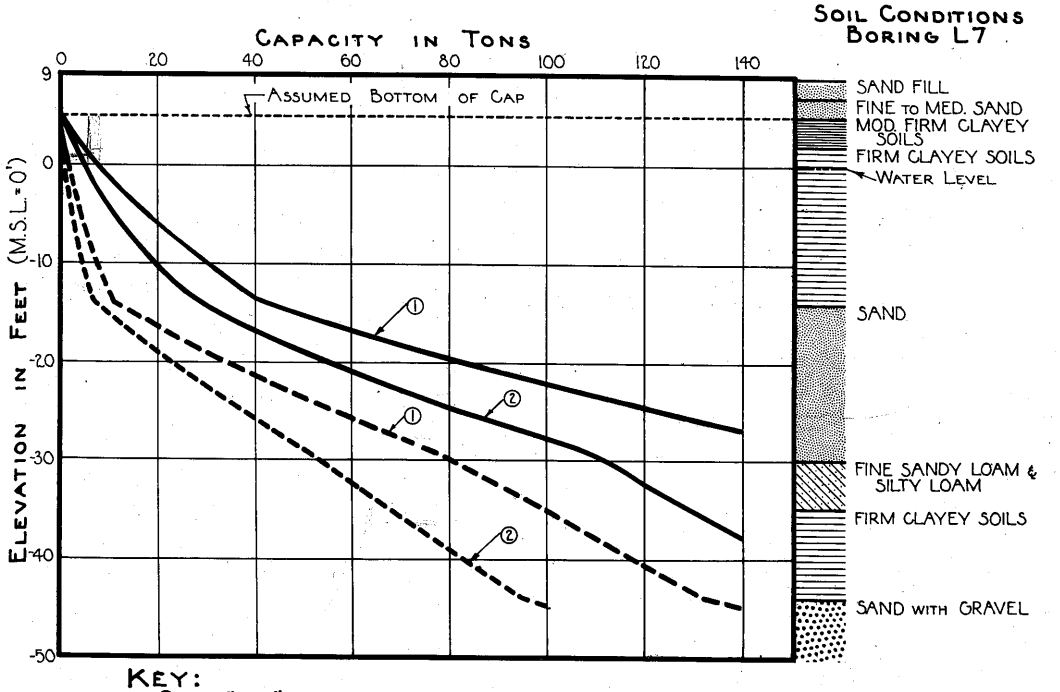
KEY:
- O SUPPLEMENTAL BORINGS
- ● BORINGS DRILLED PREVIOUSLY, SEE DAMES & MOORE, "REPORT OF FOUNDATION INVESTIGATION, PROPOSED PITTSBURG STEAM PLANT, PITTSBURG, CALIFORNIA FOR THE PACIFIC GAS & ELECTRIC COMPANY - PART I - PRESENTATION OF DATA" DATED 3-3-52
- PRESENTLY PROPOSED STRUCTURES
- FUTURE DEVELOPMENT

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS - SOIL MECHANICS ENGINEERING

PLATE 9



NOTE:
THE INDICATED CAPACITIES ARE INTENDED TO APPLY TO THE TOTAL OF ALL LOADS, DEAD, LIVE AND SEISMIC; THE TOTAL OF ALL PERMANENTLY AND / OR FREQUENTLY APPLIED REAL LOADS SHOULD BE LIMITED TO TWO-THIRDS OF THE INDICATED CAPACITIES.

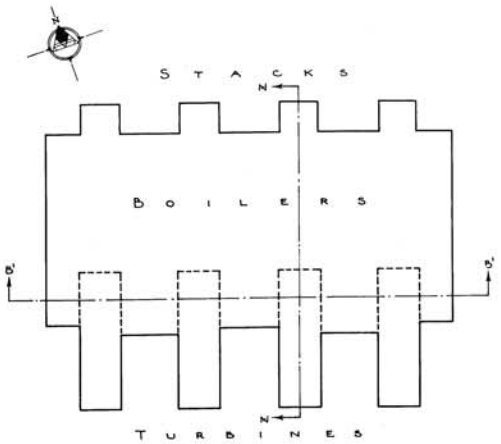


KEY:
① 14"x14" PRECAST CONCRETE PILING
② RAYMOND STEP-TAPERED CONCRETE PILING - 11⅛" DIAM. TIP
——— PILES DRIVEN TO TOTAL DEPTH OF PENETRATION.
- - - - PILES JETTED TO ELEV. -30' AND THEN DRIVEN WITHOUT JETTING.

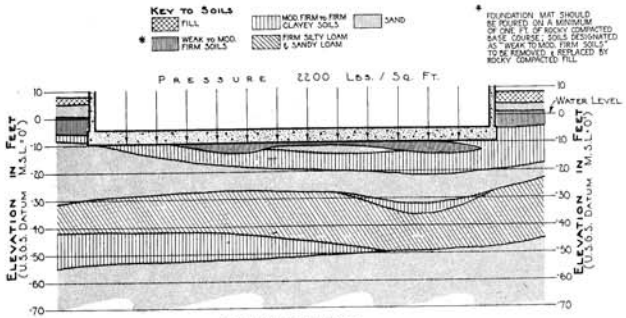
COMPUTED PILE CAPACITIES

POWER BUILDING

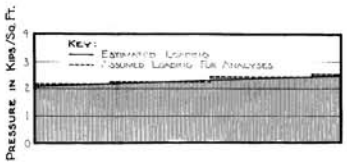
DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING



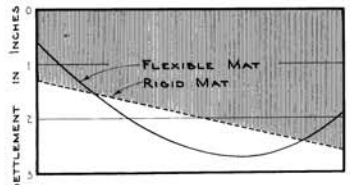
FOUNDATION PLAN
FEET
50 0 50 100



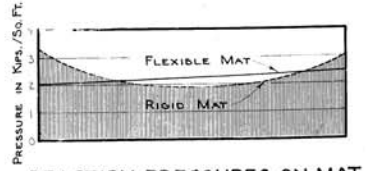
ELEVATION
SECTION B'-B'
FEET
50 0 50 100



LOADING DIAGRAM
(WITHOUT BUNKER LOADS)
SECTION Z-Z

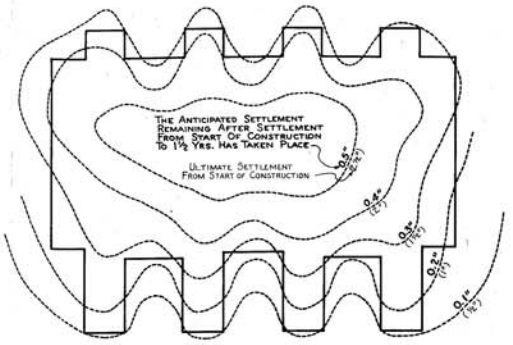


ULTIMATE SETTLEMENTS
SECTION Z-Z



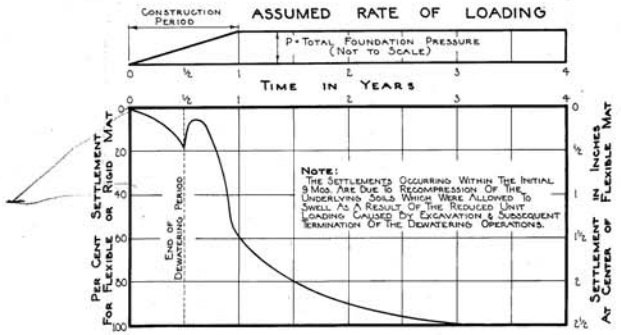
REACTION PRESSURES ON MAT
SECTION Z-Z

FOUNDATION ANALYSES
POWER BUILDING



SETTLEMENT CONTOURS
FLEXIBLE MAT
FEET
50 0 50 100

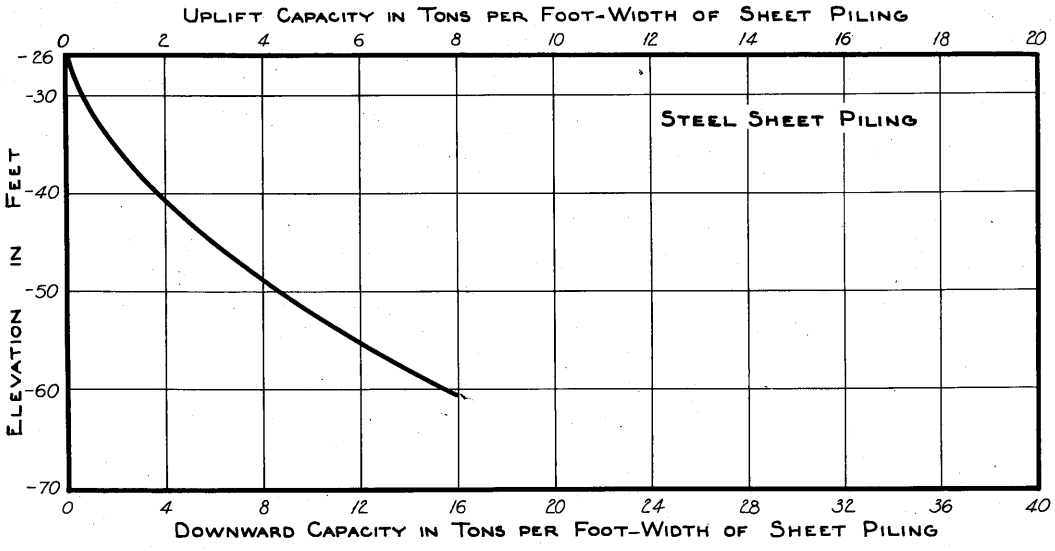
NOTE:
THE DIFFERENTIAL SETTLEMENTS WOULD BE REDUCED DUE TO THE RIGIDITY OF THE FOUNDATION MAT AS ILLUSTRATED ON SECTION Z-Z.

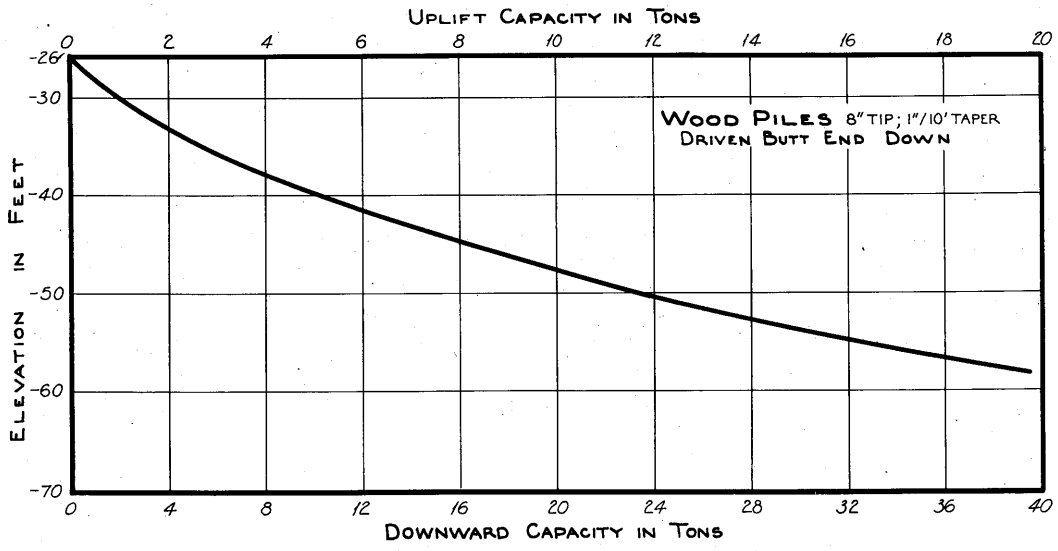


TIME-RATE OF SETTLEMENTS
based on 675 psf mat

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 11





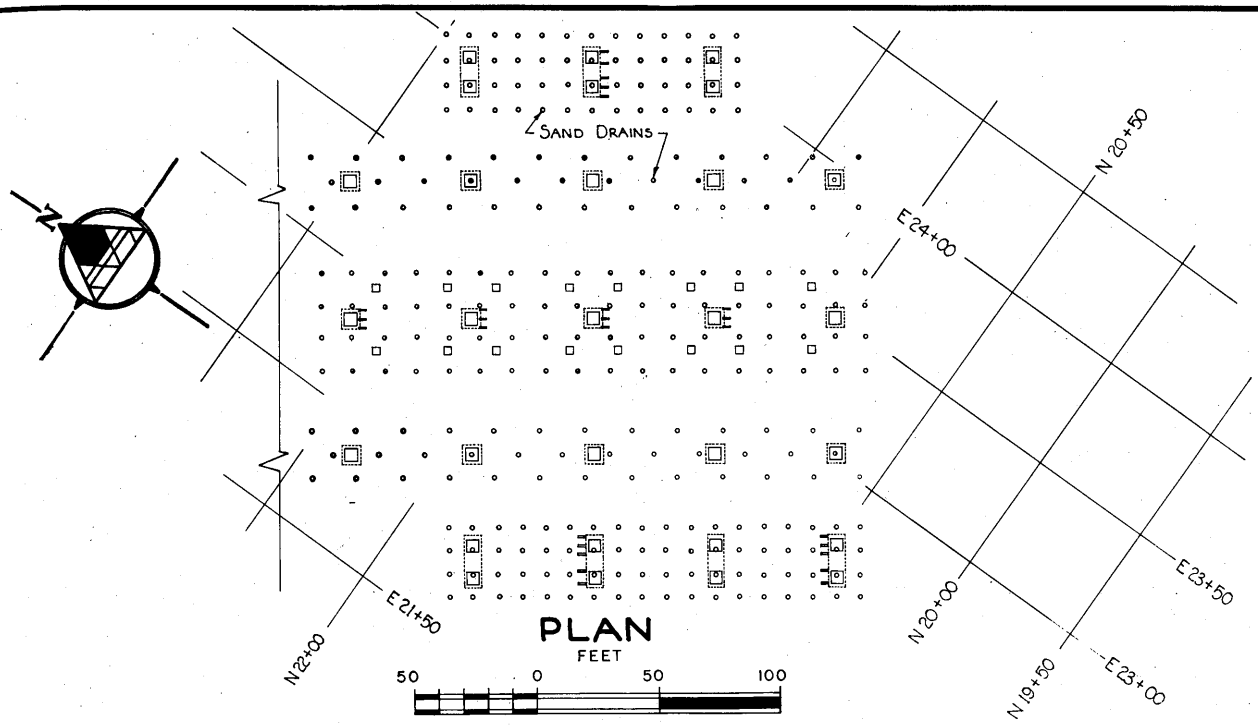
NOTE:

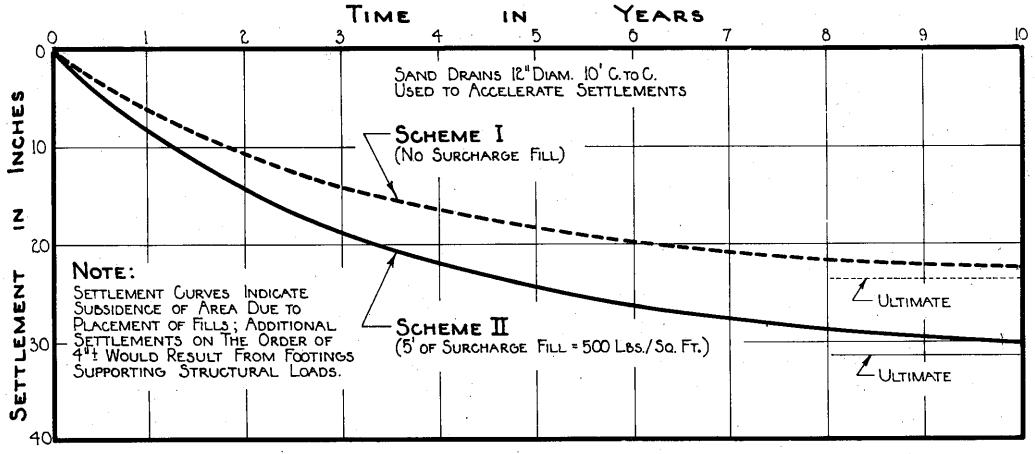
INDICATED CAPACITIES WERE COMPUTED FOR THE PROPOSED LOCATION OF THE SCREEN STRUCTURE IN THE VICINITY OF BORINGS W16 & W18.

PLANNED EXCAVATION FOR STRUCTURE TO EXTEND TO ELEV. -26' WITH TREMIE SEAL TO ELEV. -20'.

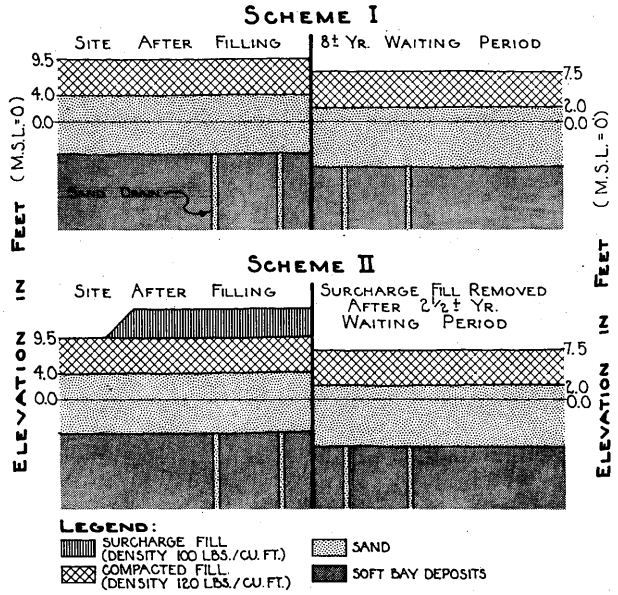
COMPUTED PILE CAPACITIES

SCREEN STRUCTURE





SETTLEMENT ANALYSES



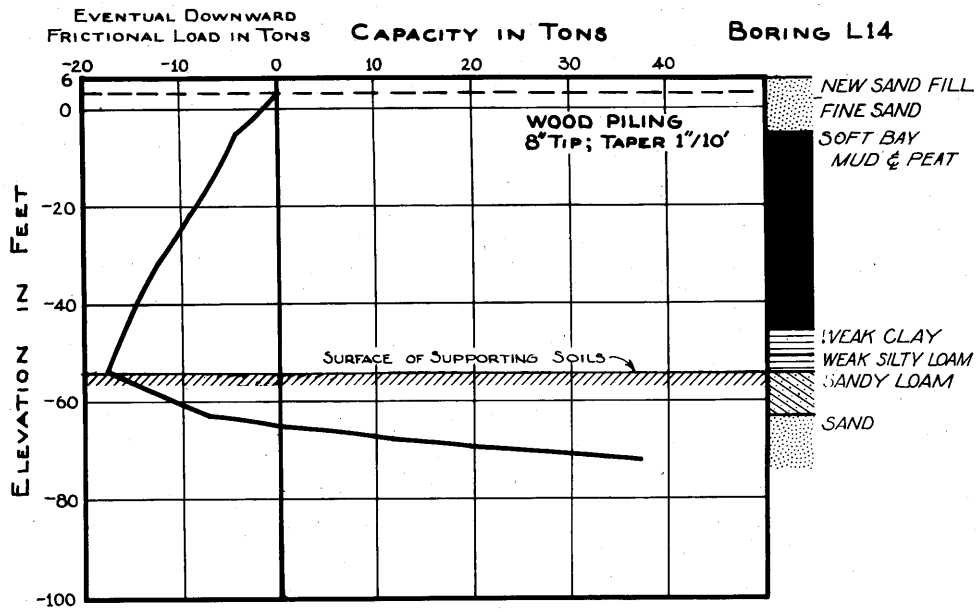
NOTE:
THE WAITING PERIOD INDICATES TIME AFTER WHICH BUILDING CONSTRUCTION COULD BE STARTED; THESE PERIODS WERE SELECTED ASSUMING FUTURE TOTAL SETTLEMENTS OF FOOTINGS WOULD NOT EXCEED 6" & DIFFERENTIAL SETTLEMENTS OF FOOTINGS WOULD NOT EXCEED 2".

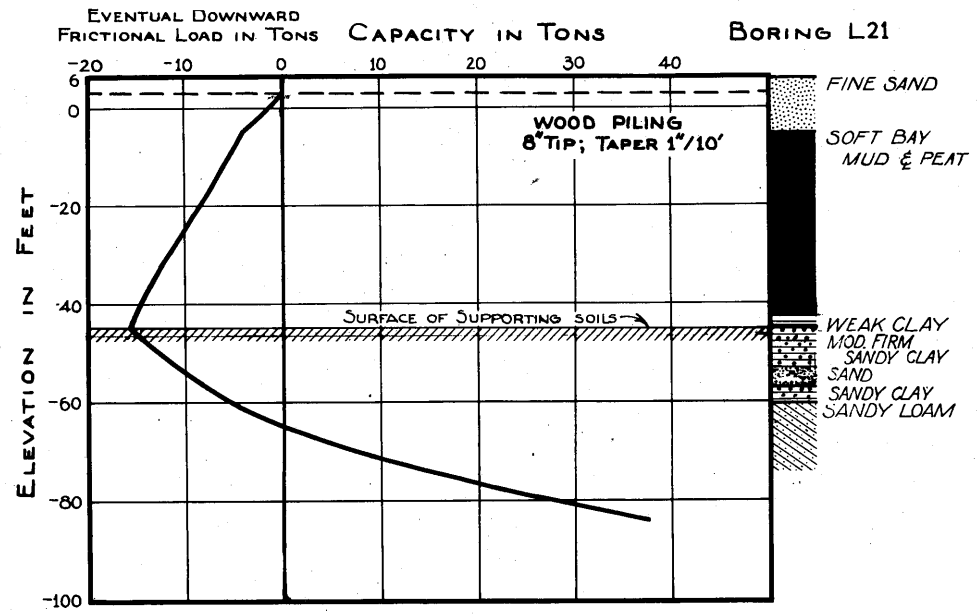
SECTIONS

SETTLEMENT ANALYSES

SAND DRAINS
230 K.V. & 115 K.V. BUS STRUCTURES

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING



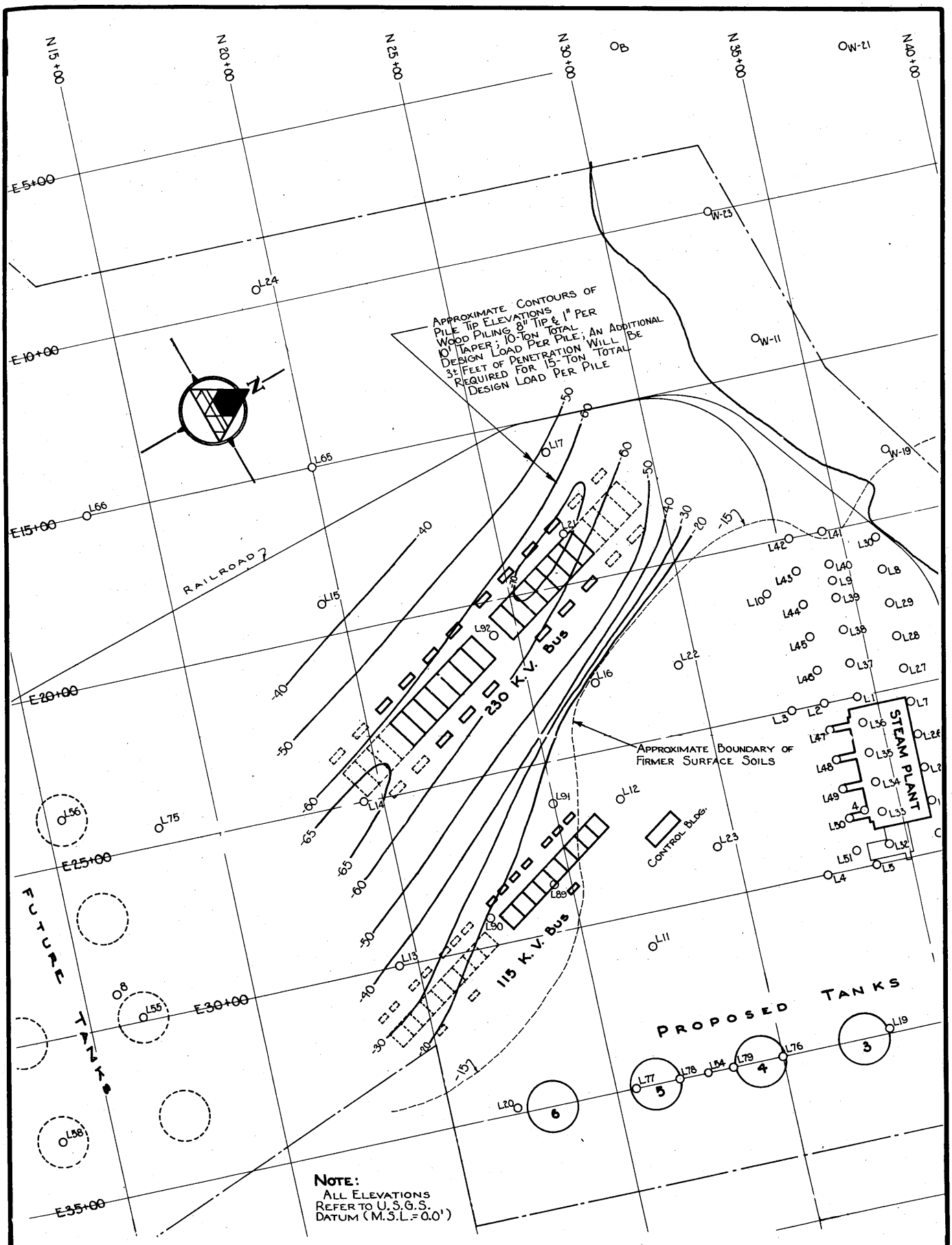


NOTE:
ELEVATIONS REFER TO M.S.L. = 0.0'

COMPUTED PILE CAPACITIES
BUS STRUCTURES

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

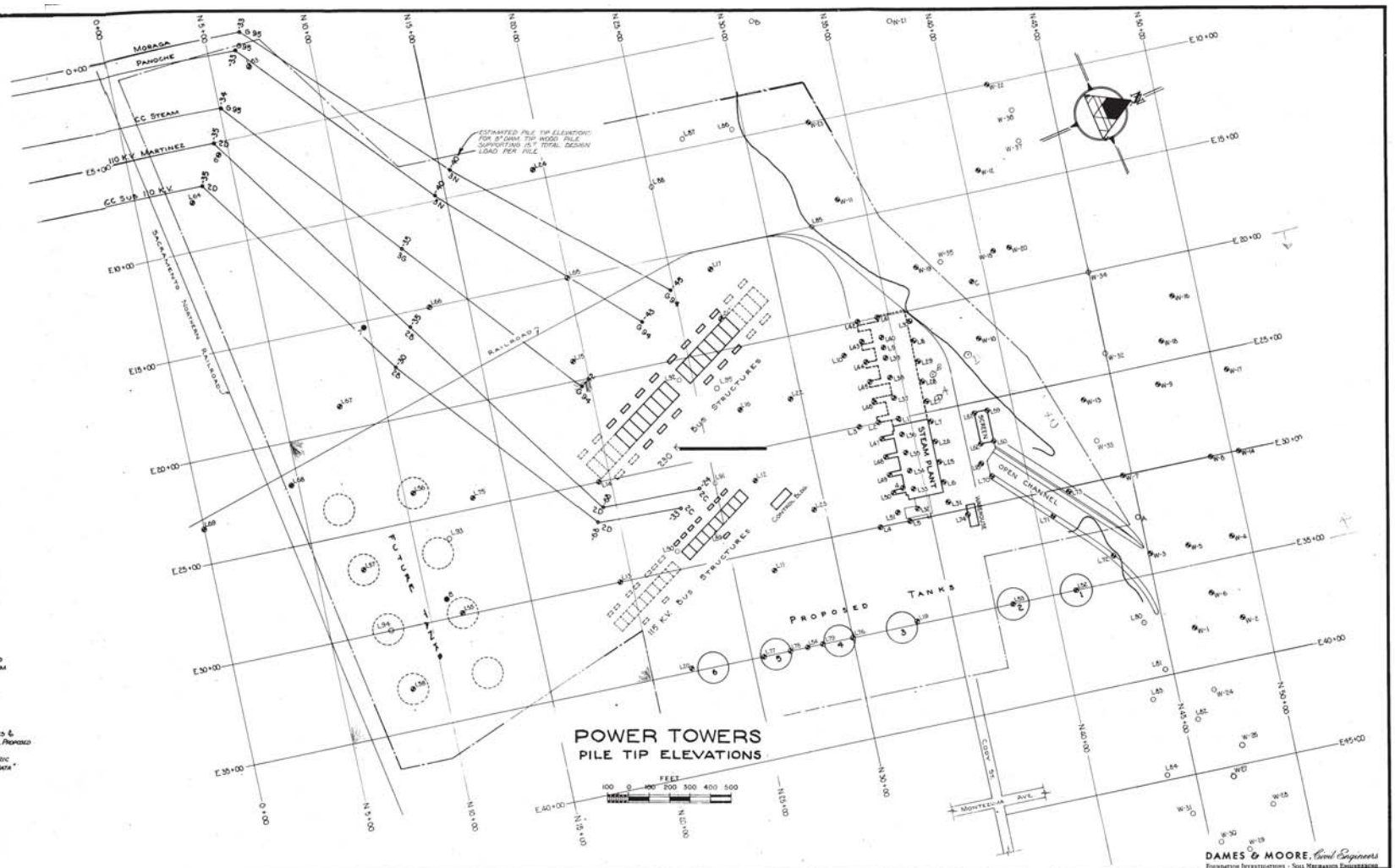
PLATE 14



PILE TIP CONTOURS
BUS STRUCTURES

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 15



POWER TOWERS
PILE TIP ELEVATIONS

BORING	CO-ORDINATES	
L 80	N 44 - 08	E 37 - 22
L 81	N 44 - 60	E 39 - 66
L 82	N 45 - 69	E 42 - 43
L 83	N 43 - 73	E 41 - 06
L 84	N 43 - 70	E 44 - 78
L 85	N 37 - 21	E 35 - 00
L 86	N 27 - 40	E 9 - 50
L 87	N 26 - 95	E 9 - 50
L 88	N 25 - 00	E 11 - 50
L 89	N 24 - 55	E 28 - 60
L 90	N 28 - 50	E 29 - 13
L 91	N 25 - 00	E 26 - 25
L 92	N 24 - 30	E 21 - 00
L 93	N 11 - 70	E 26 - 20
L 94	N 8 - 00	E 30 - 00
L 95	N 26 - 04	E 21 - 75

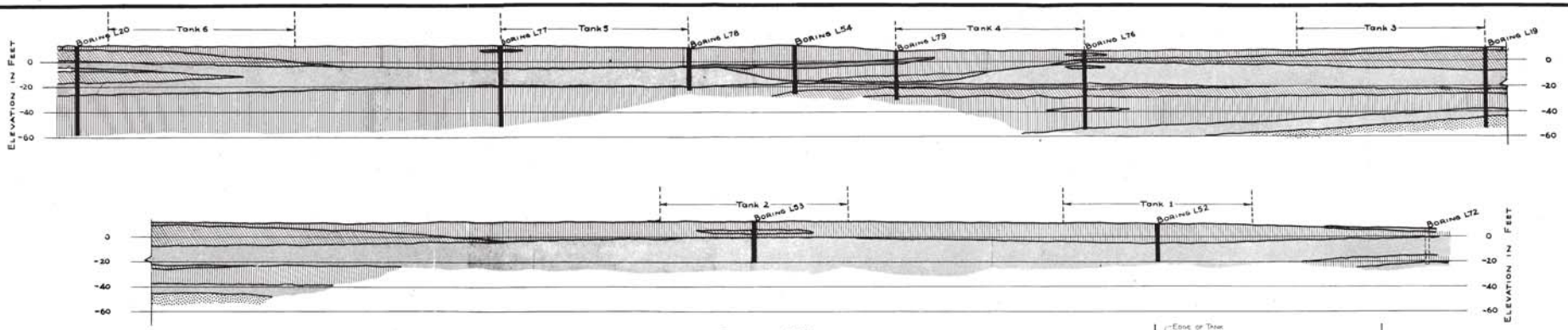
W 24	N 46 - 77	E 41 - 15
W 25	NOT	DRILLED
W 26	N 47 - 50	E 44 - 07
W 27	N 46 - 57	E 45 - 40
W 28	N 48 - 35	E 47 - 20
W 29	N 46 - 75	E 49 - 05
W 30	N 45 - 45	E 48 - 40
W 31	N 44 - 40	E 46 - 80
W 32	N 45 - 20	E 24 - 00
W 33	N 43 - 84	E 28 - 01
W 34	N 45 - 00	E 20 - 00
W 35	N 38 - 00	E 18 - 00
W 36	N 43 - 00	E 11 - 50
W 37	N 43 - 00	E 13 - 00

REFERENCE:
DRAWING NO. 410801 - CHANGE 3, TITLED "SOIL TEST BORING LOCATIONS" PITTSBURG STEAM PLANT - PACIFIC GAS AND ELECTRIC COMPANY - DRAWING PREPARED BY BECHTEL CORPORATION - NOV. 9, 1951.

KEY:
- ○ SUPPLEMENTAL BORINGS
- ● BORINGS DRILLED PREVIOUSLY, SEE DAMES & MOORE, "REPORT OF FOUNDATION INVESTIGATION, PROPOSED PITTSBURG STEAM PLANT, PITTSBURG, CALIFORNIA, FOR THE PACIFIC GAS & ELECTRIC COMPANY - PART I - PRESENTATION OF DATA" DATED 3-3-52
- PRESENTLY PROPOSED STRUCTURES
- FUTURE DEVELOPMENT

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS - SOIL MECHANICS ENGINEERING

PLATE 16



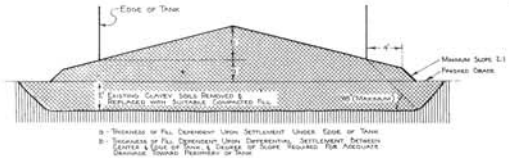
SECTION J-J

LEGEND:

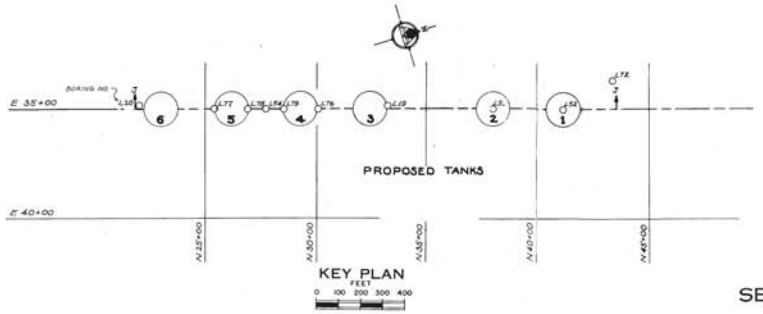
- WEAK TO MODERATELY FIRM SOILS
- MOD. FIRM TO FIRM CLAYEY SOILS
- FIRM SILTY LOAM & SANDY LOAM
- SAND
- SAND & GRAVEL

NOTE:
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0')

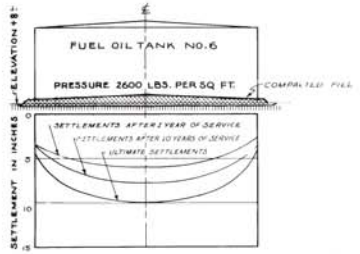
FEET
50 0 50 100



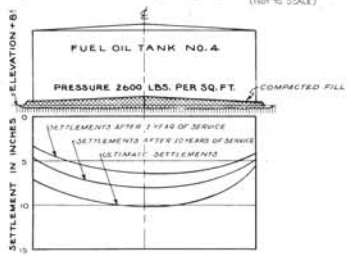
SUGGESTED THICKNESS OF TANK PAD
(NOT TO SCALE)



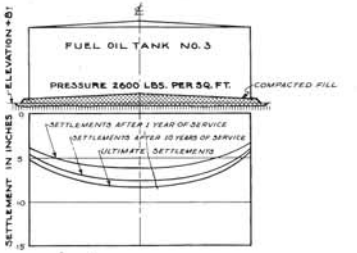
KEY PLAN
FEET
0 100 200 300 400



SETTLEMENT CURVES



SETTLEMENT CURVES



SETTLEMENT CURVES

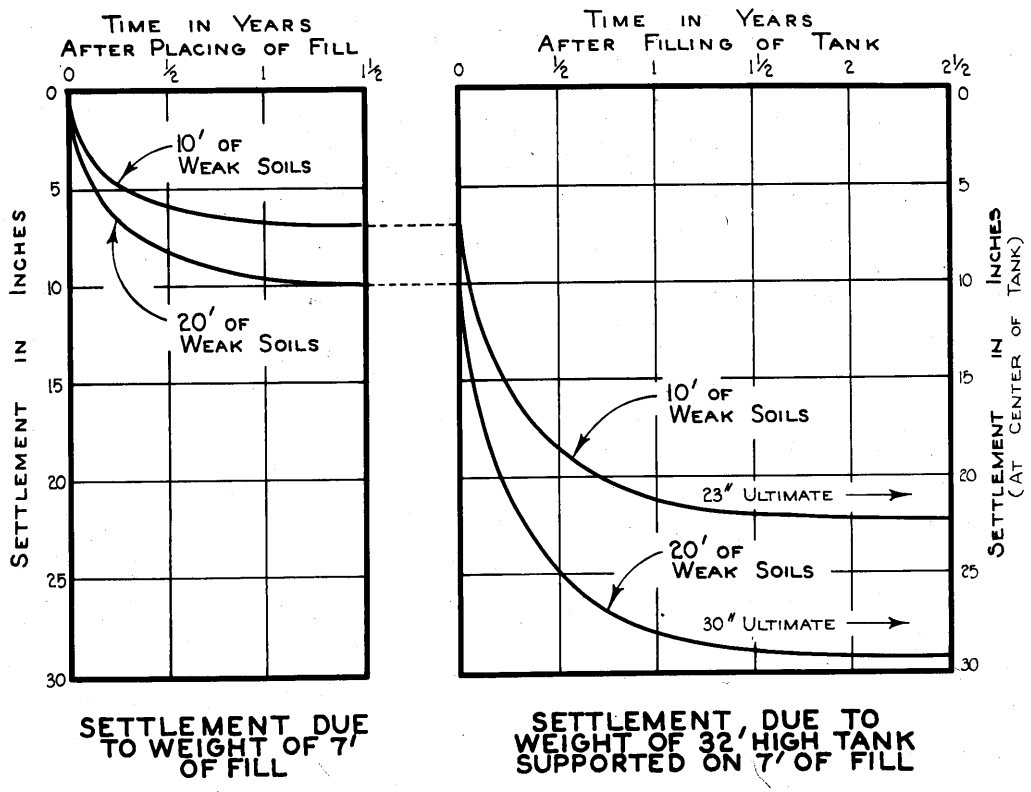
SETTLEMENT ANALYSES

PROPOSED TANKS (160' DIAM.)

FEET
50 0 50 100

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS - SOIL MECHANICS ENGINEERING

PLATE 17



SETTLEMENT ANALYSES

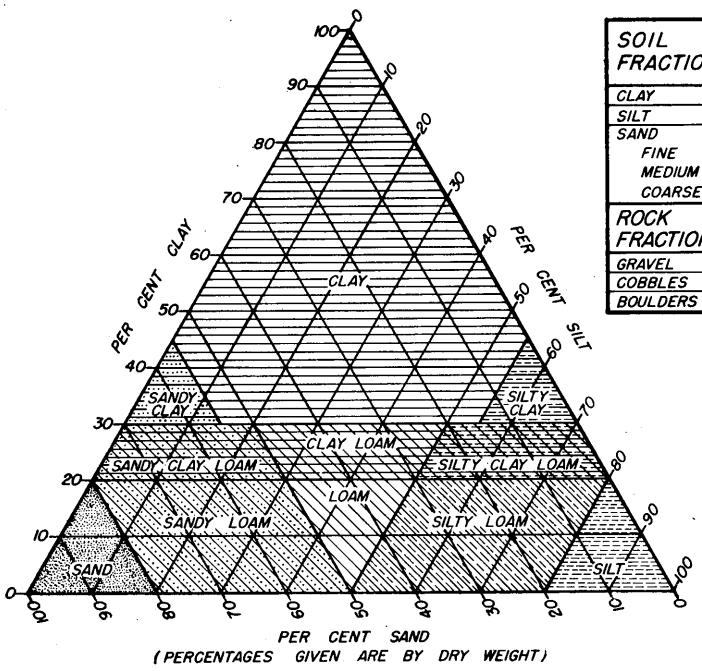
FUTURE TANKS

(160' DIAMETER)

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

APPENDIX B-1

SOIL CLASSIFICATION CHART AND KEY TO TEST DATA



SOIL FRACTION	PARTICLE SIZE			
	LOWER LIMIT		UPPER LIMIT	
	MM.	INCHES	MM.	INCHES
CLAY			.005	.0002
SILT	.005	.0002	.05	.002
SAND				
FINE	.05	.002	.25	.01
MEDIUM	.25	.01	.5	.02
COARSE	.5	.02	2.0	.08
ROCK FRACTION	THESE FRACTIONS ARE NOT CONSIDERED IN DETERMINING SOIL CLASSIFICATION.			
GRAVEL	2.0	.08	64.	2.5
COBBLES	64.	2.5	256.	10.
BOULDERS	256.	10.		

□ INDICATES DEPTH AT WHICH DISTURBED SAMPLE WAS EXTRACTED

■ INDICATES DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED

TESTS AT FIELD MOISTURE

TEST SURCHARGE PRESSURE IN POUNDS PER SQUARE FOOT.
PER CENT FIELD MOISTURE EXPRESSED AS A PERCENTAGE OF THE DRY WEIGHT OF SOIL
DRY DENSITY EXPRESSED IN POUNDS PER CUBIC FOOT

TYPE "A" TESTS

TESTS MADE BY APPLYING EQUAL INCREMENTS OF SHEARING LOAD AT EQUAL INTERVALS OF TIME AND RECORDING THE RESULTING DEFLECTIONS FOR EACH INCREMENT

2500—20.4%—104.2

SHEARING STRENGTH IN POUNDS PER SQUARE FOOT

TYPE "B" TESTS

TESTS MADE BY SHEARING AT A CONSTANT RATE OF DEFLECTION AND RECORDING THE RESISTING LOAD DEVELOPED AT VARIOUS DEFLECTIONS

SHEARING STRENGTH IN POUNDS PER SQUARE FOOT

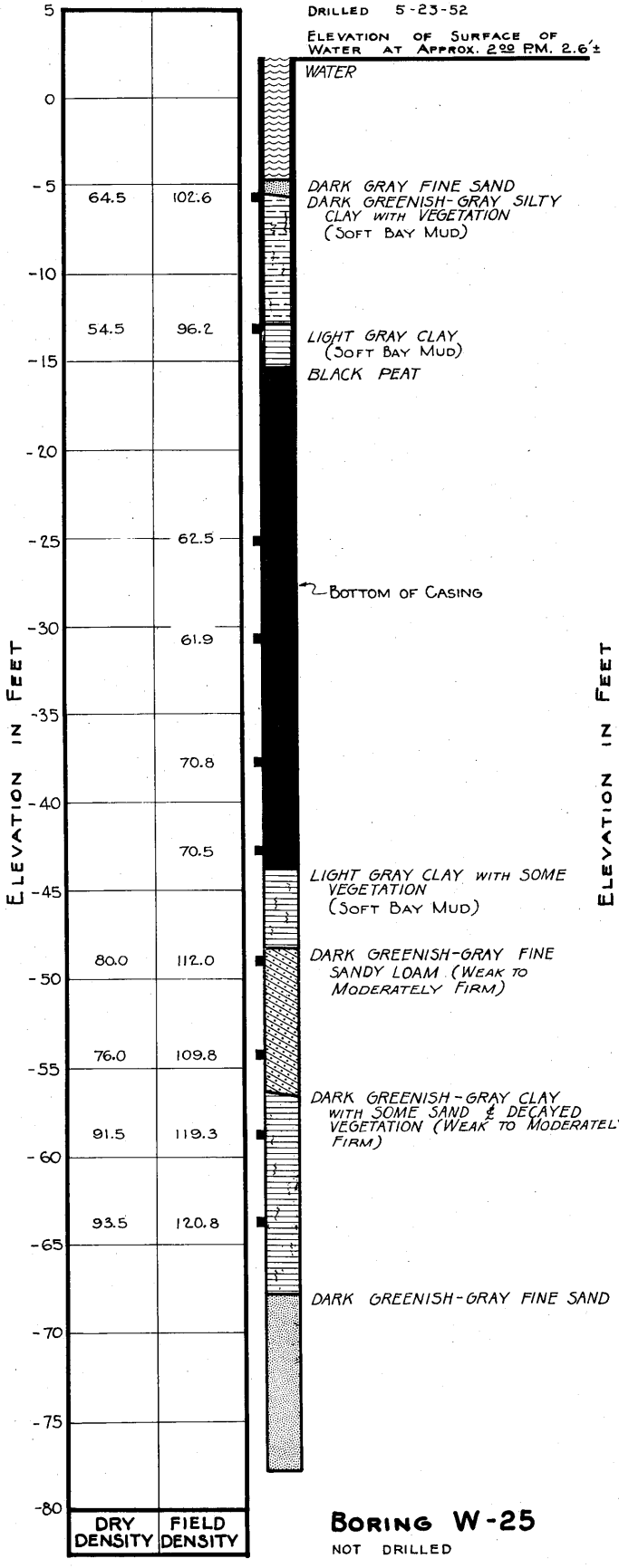
APPENDIX G

Log of Borings - W24 through W37

BORING W 24

DRILLED 5-23-52

ELEVATION OF SURFACE OF WATER AT APPROX. 2^00 PM. 2.6'±



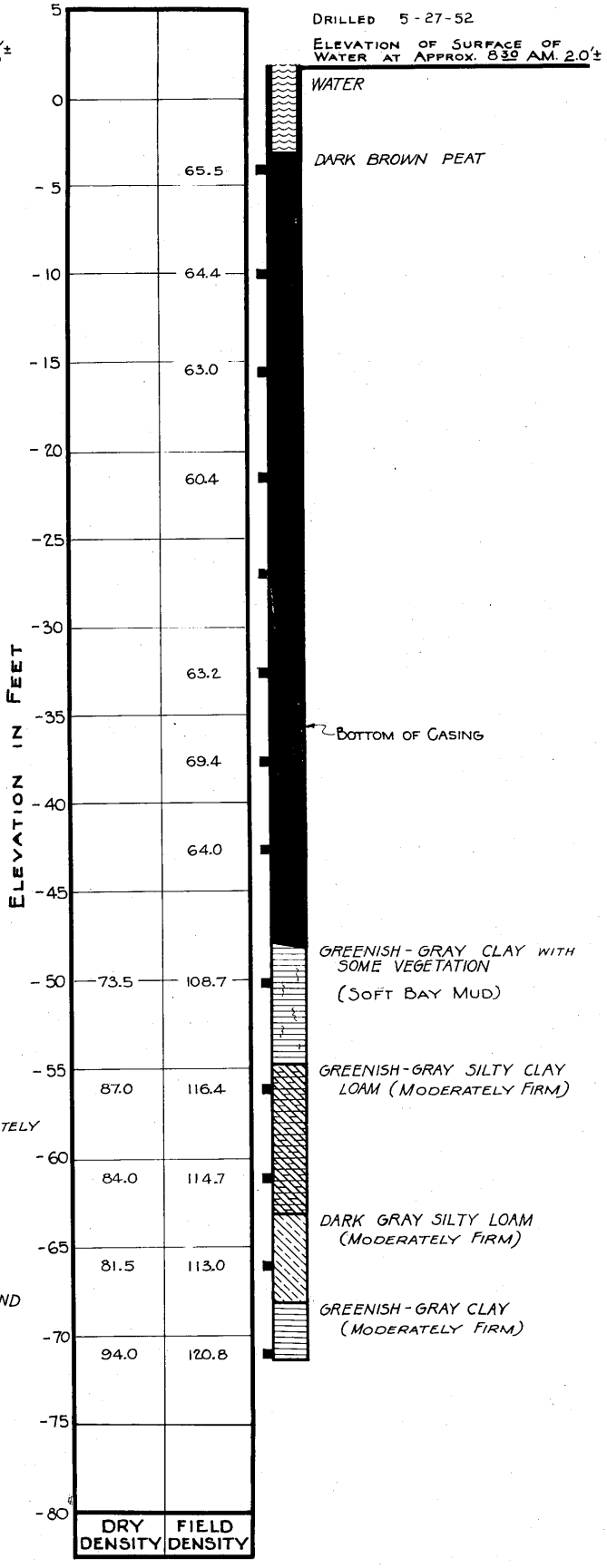
BORING W-25

NOT DRILLED

BORING W 26

DRILLED 5-27-52

ELEVATION OF SURFACE OF WATER AT APPROX. 8^30 AM. 2.0'±



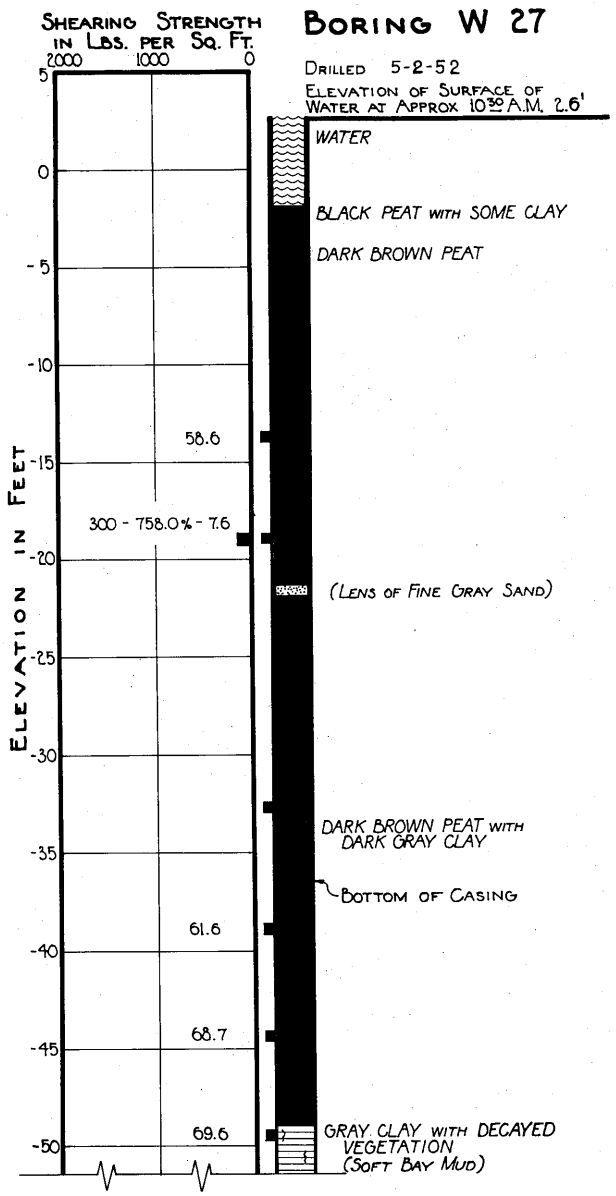
LOG OF BORINGS

NOTES:

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 4" DIAM. GOW-TYPE WASH EQUIPMENT.

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE G1



BORING W 27

DRILLED 5-2-52

ELEVATION OF SURFACE OF WATER AT APPROX 10³⁰ A.M. 2.6'

WATER

BLACK PEAT WITH SOME CLAY

DARK BROWN PEAT

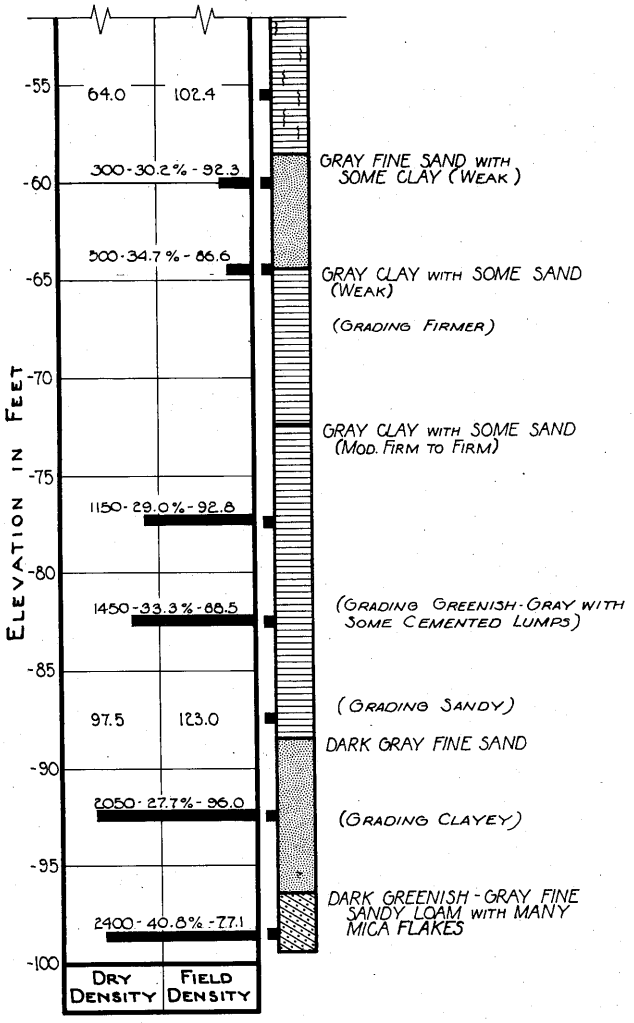
(LENS OF FINE GRAY SAND)

DARK BROWN PEAT WITH DARK GRAY CLAY

BOTTOM OF CASING

GRAY CLAY WITH DECAYED VEGETATION (SOFT BAY MUD)

BORING W 27 CONTINUED



GRAY FINE SAND WITH SOME CLAY (WEAK)

GRAY CLAY WITH SOME SAND (WEAK)

(GRADING FIRMER)

GRAY CLAY WITH SOME SAND (MOD. FIRM TO FIRM)

(GRADING GREENISH-GRAY WITH SOME CEMENTED LUMPS)

(GRADING SANDY)

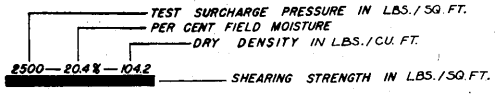
DARK GRAY FINE SAND

(GRADING CLAYEY)

DARK GREENISH-GRAY FINE SANDY LOAM WITH MANY MICA FLAKES

LOG OF BORINGS

KEY:

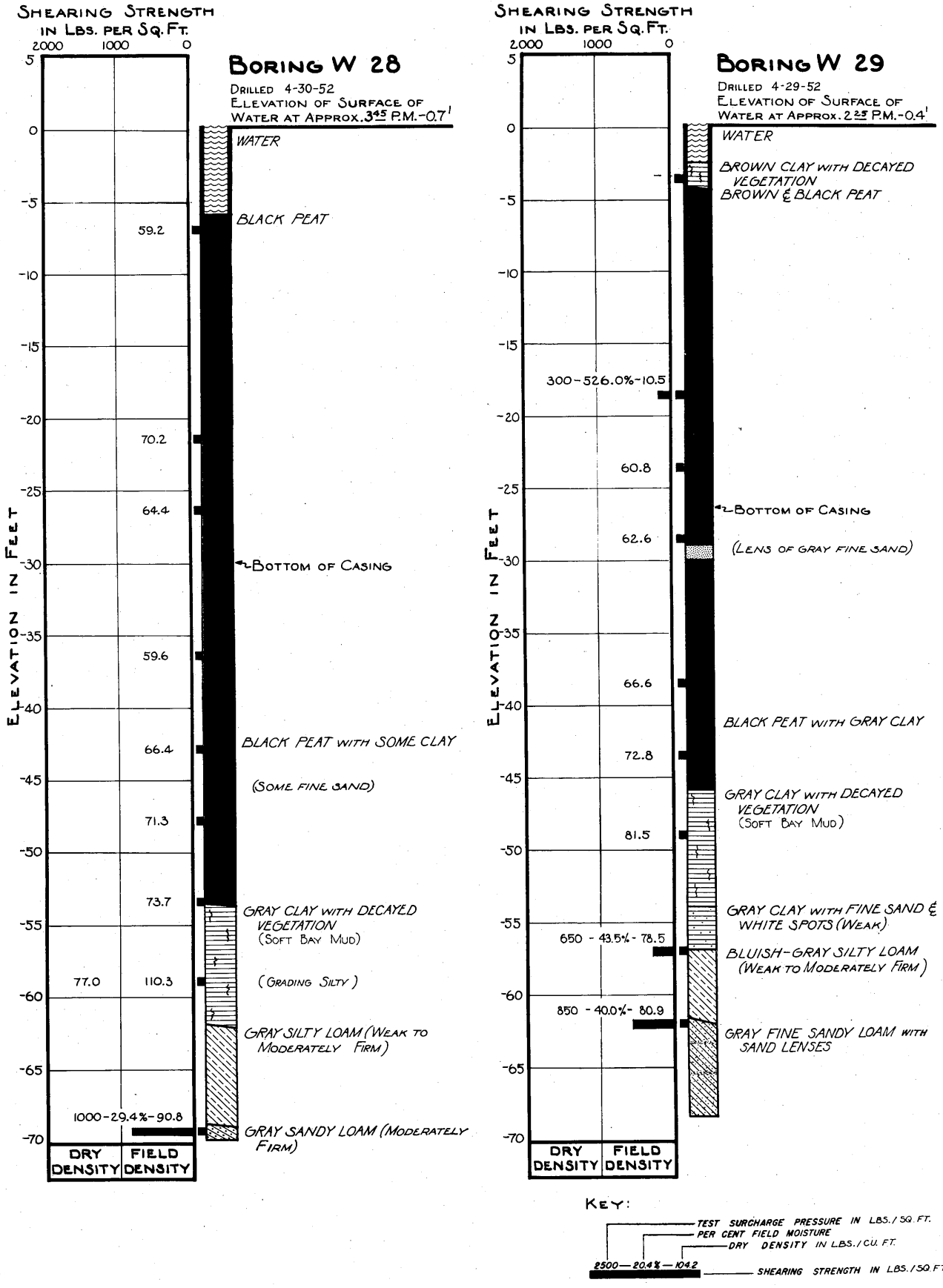


NOTES:

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORING DRILLED WITH 4" DIAM. GOW-TYPE WASH EQUIPMENT.

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE G2



LOG OF BORINGS

NOTES:
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 4" DIAM. GOW-TYPE WASH EQUIPMENT.

DAMES & MOORE, Civil Engineers
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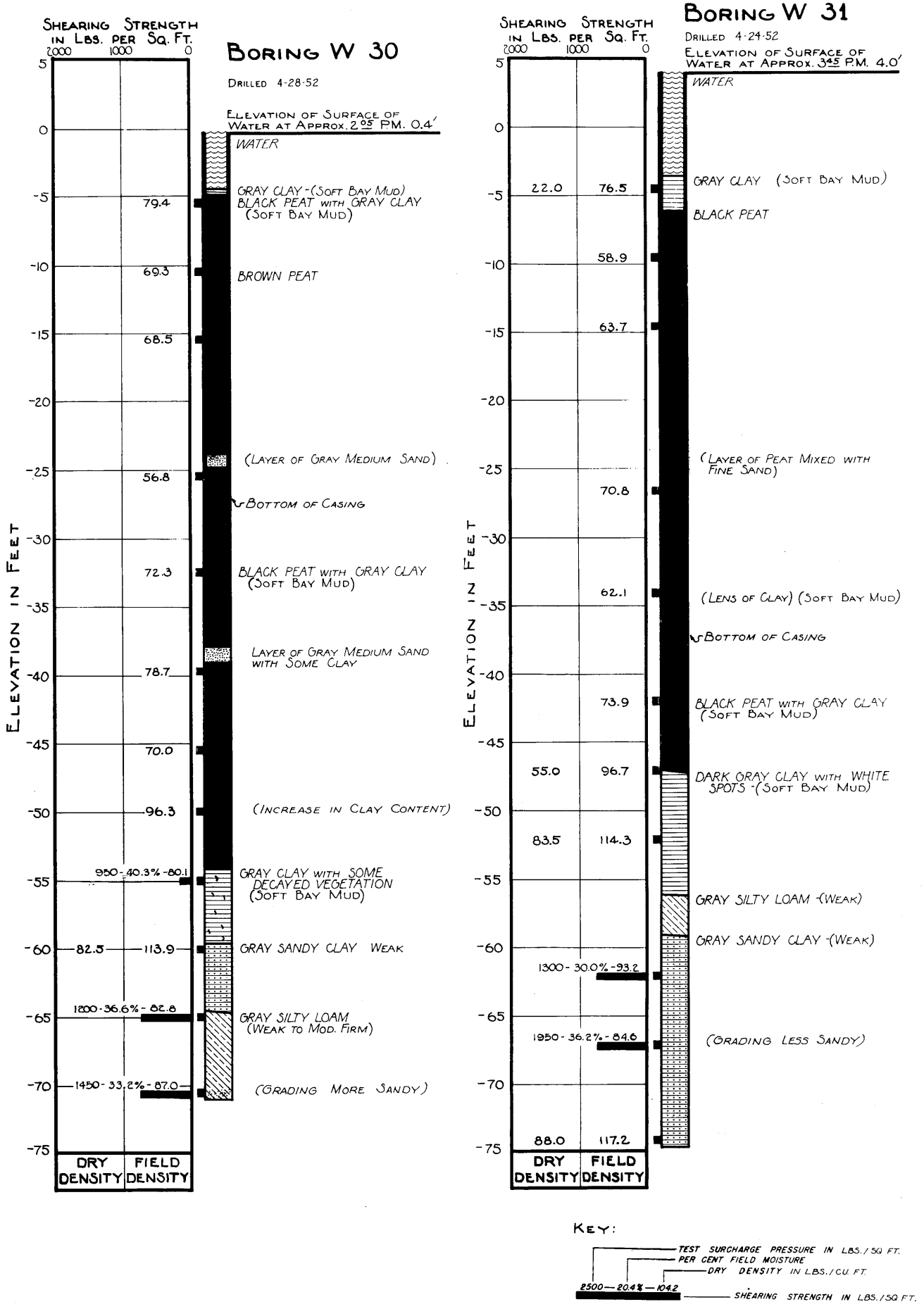
PLATE 63



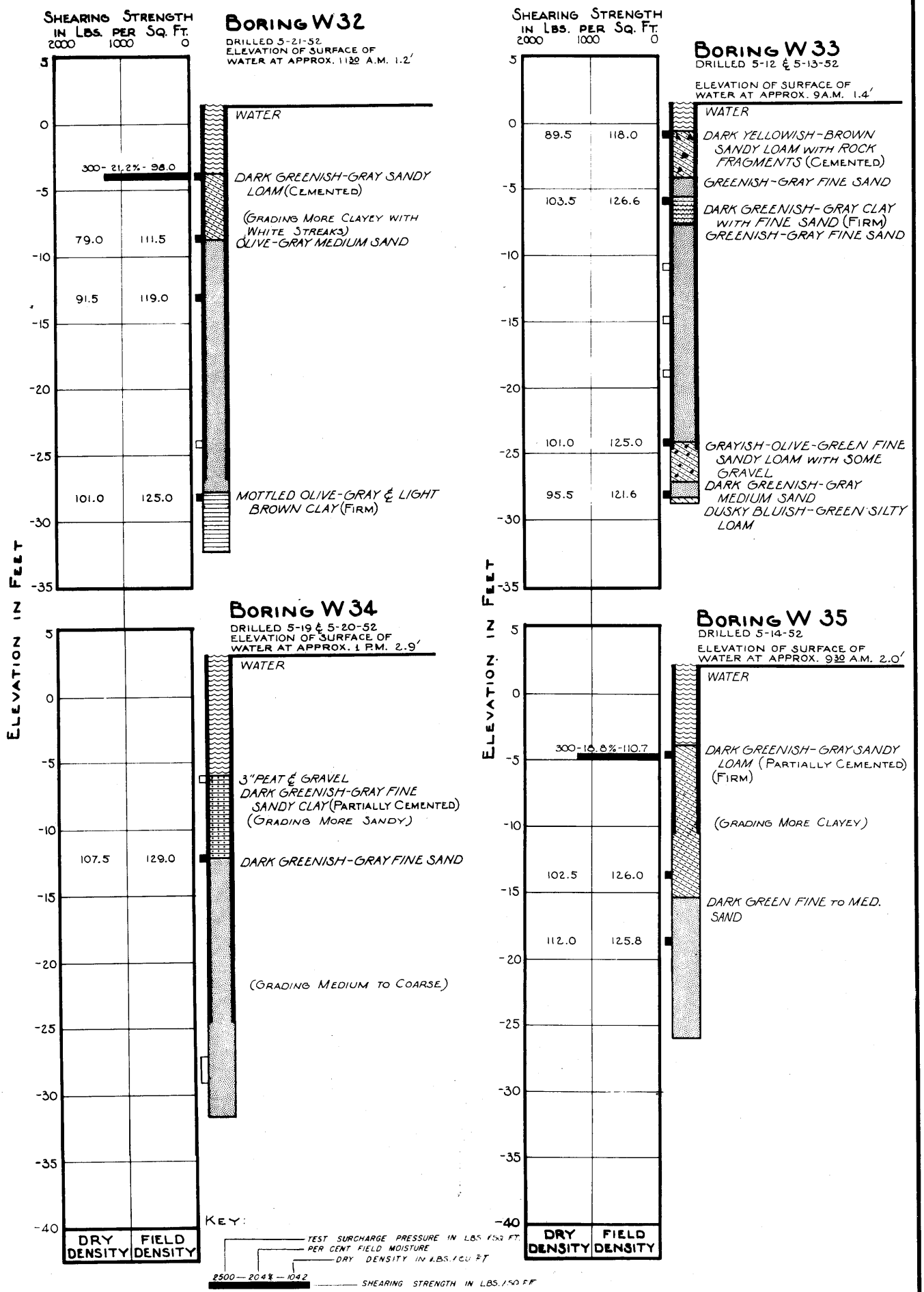
NOTES:

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 4" DIAM. GOW-TYPE WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE G4

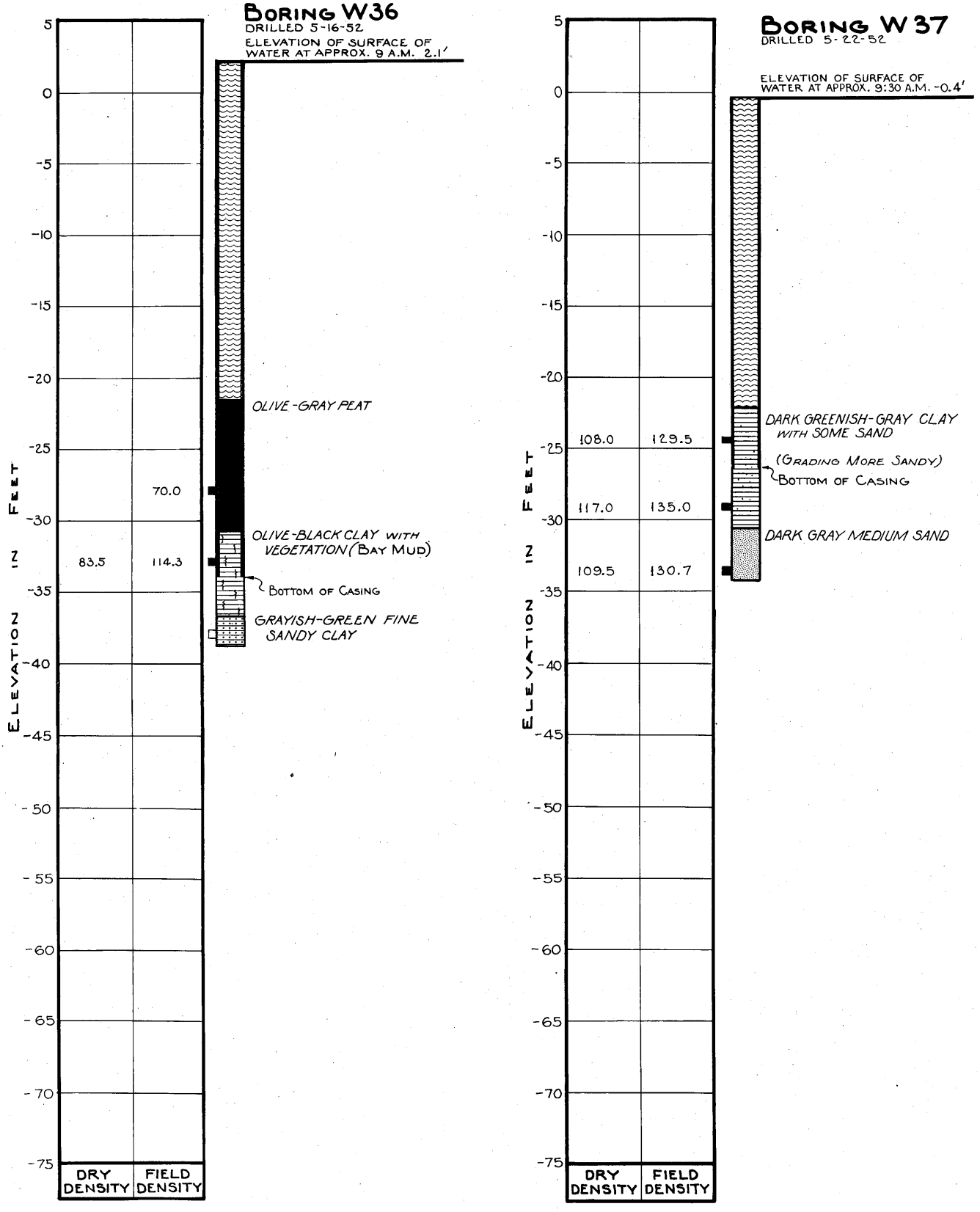


NOTES:
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 4" DIAM GOW-TYPE WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE G5



LOG OF BORINGS

NOTES:
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 4" DIAM. GOW-TYPE WASH EQUIPMENT.

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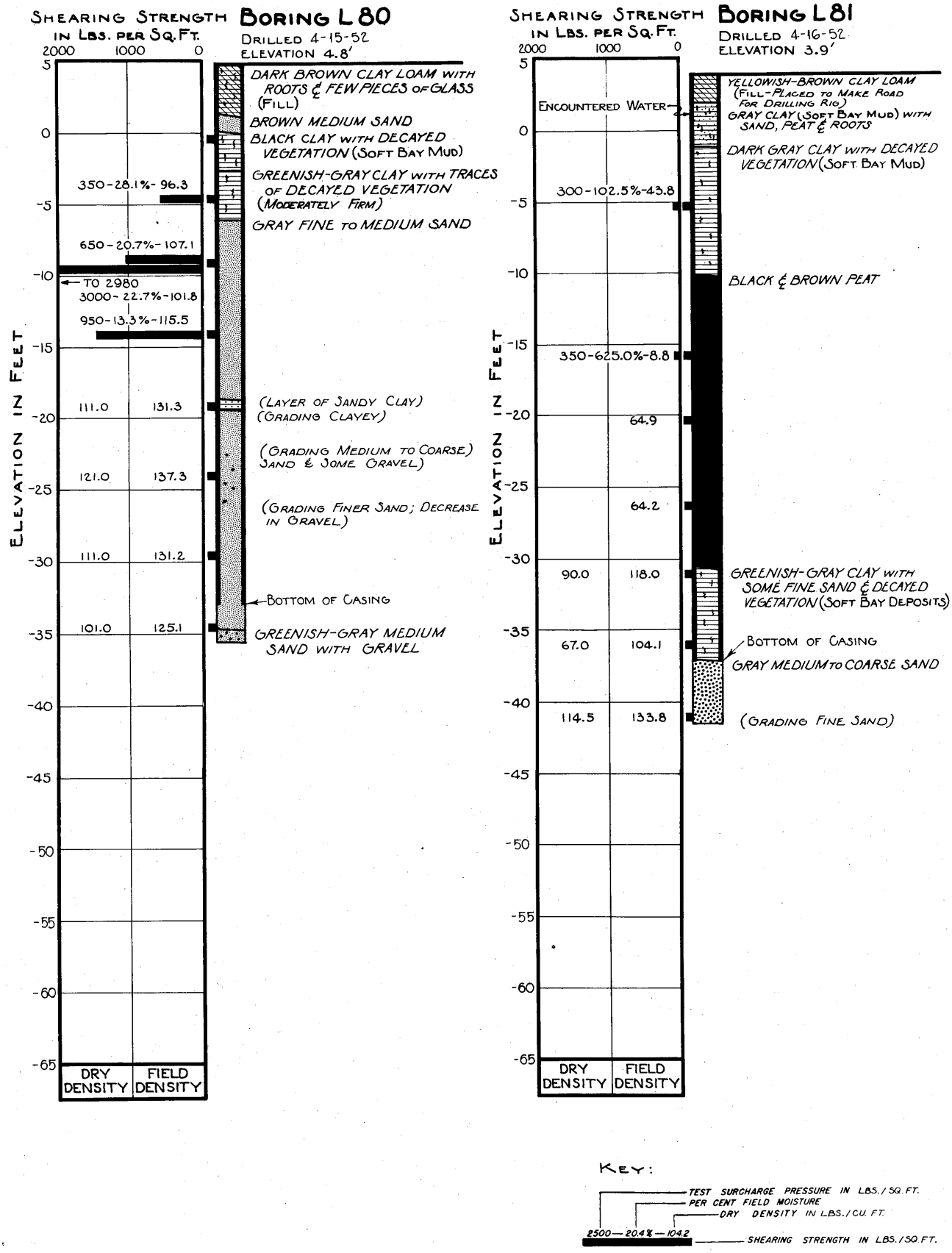
PLATE G6

A P P E N D I X H

Log of Borings - L80 through L95



LOG OF BORINGS

NOTES:

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE TOOL EQUIPMENT.

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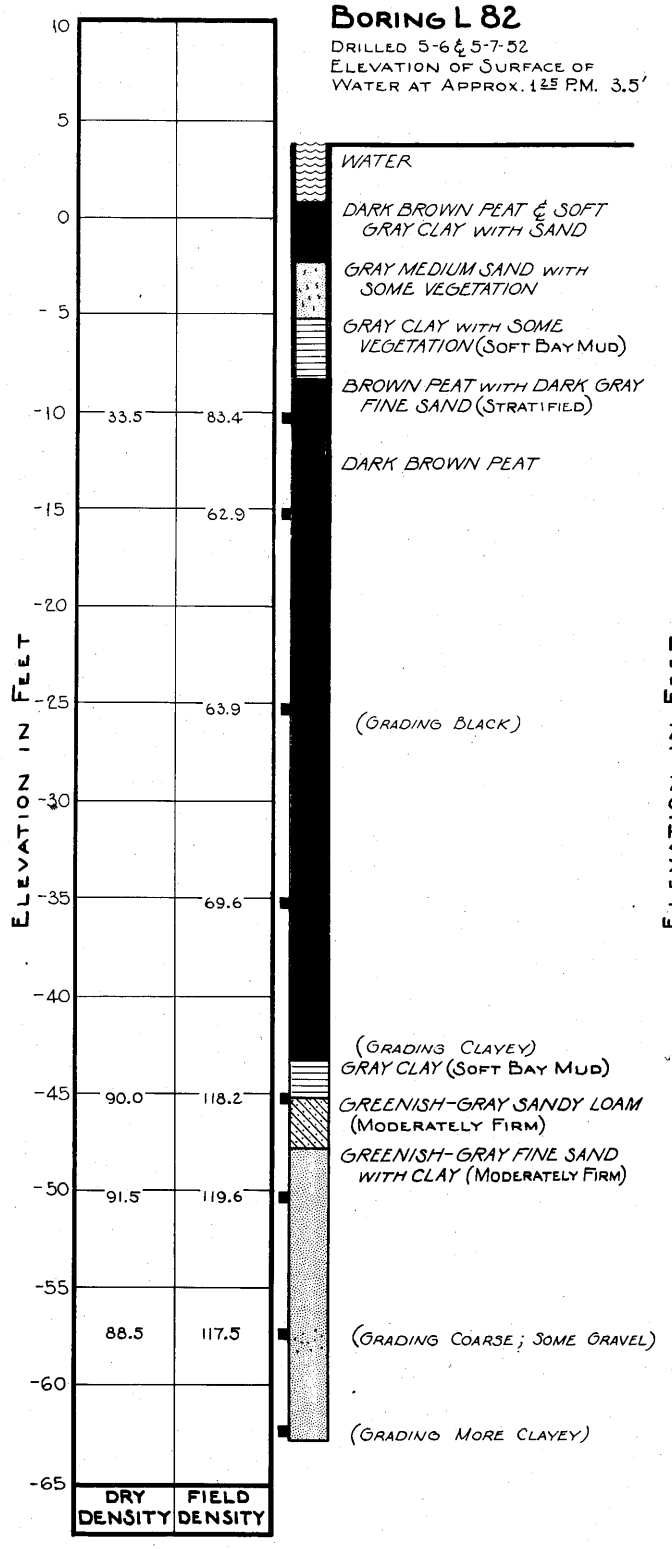
PLATE H1

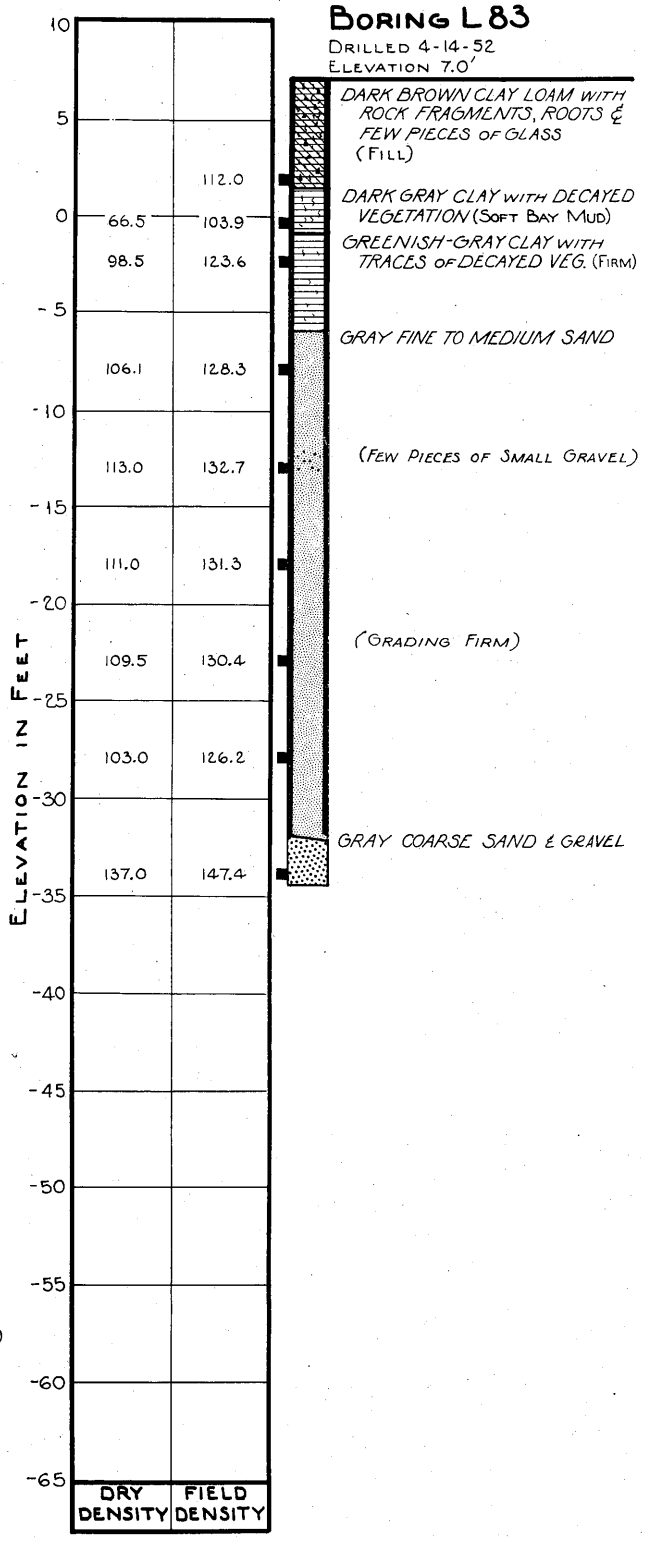
BORING L 82

DRILLED 5-6 & 5-7-52
ELEVATION OF SURFACE OF WATER AT APPROX. 1 25 P.M. 3.5'



BORING L 83

DRILLED 4-14-52
ELEVATION 7.0'



LOG OF BORINGS

NOTES:

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORING L82 DRILLED WITH 4" DIAM. GOW-TYPE WASH EQUIPMENT.
BORING L83 DRILLED WITH 6" DIAM CABLE TOOL EQUIPMENT.

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PLATE H2

BORING L 84

DRILLED 4-17-52

SHEARING STRENGTH IN LBS. PER SQ. FT.

2000 1000 0

ELEVATION 6.0'

BROWN CLAY LOAM WITH GRAVEL & FRAGMENTS OF ROCK & CONCRETE (FILL)

(BOULDER)

(BOULDER)

(LENS OF PEAT)

GREENISH-GRAY CLAY WITH SOME SAND (MODERATELY FIRM)

GRAY FINE TO MEDIUM SAND

LAMINATIONS OF GRAY CLAY (SOFT BAY MUD) PEAT & SAND (SOFT)

BLACK AND BROWN PEAT

(POCKETS OF BAY MUD)

GREENISH-GRAY CLAY WITH FINE SAND (WEAK)

GREENISH-GRAY FINE SANDY LOAM (WEAK TO MODERATELY FIRM)

BOTTOM OF CASING

GREENISH-GRAY CEMENTED SAND

ELEVATION IN FEET

10, 5, 0, -5, -10, -15, -20, -25, -30, -35, -40, -45, -50, -55, -60, -65

	DRY DENSITY	FIELD DENSITY
-15	1100 - 739.0%	- 7.9
-25		63.3
-30		63.0
-35		63.7
-45		65.0
-50	92.5	120.0
-55	103.5	126.6
-65	110.5	131.1

DRY DENSITY | FIELD DENSITY

BORING L85

DRILLED 4-29-52

SHEARING STRENGTH IN LBS. PER SQ. FT.

2000 1000 0

ELEVATION 9.8'±

BROWN FINE SANDY LOAM WITH SMALL ROOTS (FILL)

BROWN CLAY LOAM WITH SMALL ROOTS (FILL)

MOTTLED GRAY & REDDISH-BROWN CLAY WITH CEMENTED LUMPS (FIRM FILL)

BROWN CLAY LOAM (WEAK TO MODERATELY FIRM)

BROWN CLAY WITH LENSES OF FINE SAND (WEAK)

(GRADING DARK GRAY WITH MUCH PEAT)

GREENISH-GRAY SILTY CLAY LOAM WITH DECAYED VEGETATION & WHITE STREAKS (MODERATELY FIRM)

(LESS VEGETATION & MORE FIRM)

BROWN CLAY WITH WHITE STREAKS (FIRM)

DARK GRAY SILTY CLAY LOAM WITH CEMENTED LUMPS

GRAY FINE TO MEDIUM SAND

ELEVATION IN FEET

10, 5, 0, -5, -10, 15, -20, -25, -30, -35, -40, -45, -50, -55, -60, -65

	DRY DENSITY	FIELD DENSITY
5		124.4
0		119.2
-5	54.5	96.2
-10	350 - 139.9%	- 32.6
15	103.5	126.9
-20	101.0	125.1
-25	107.5	129.2
-30	98.5	123.8
-35	108.5	130.5
-65	116.0	134.6

DRY DENSITY | FIELD DENSITY

KEY:

TEST SURCHARGE PRESSURE IN LBS./SQ FT.
PER CENT FIELD MOISTURE
DRY DENSITY IN LBS./CU. FT.

2500 — 20.4% — 104.2

SHEARING STRENGTH IN LBS./SQ FT.

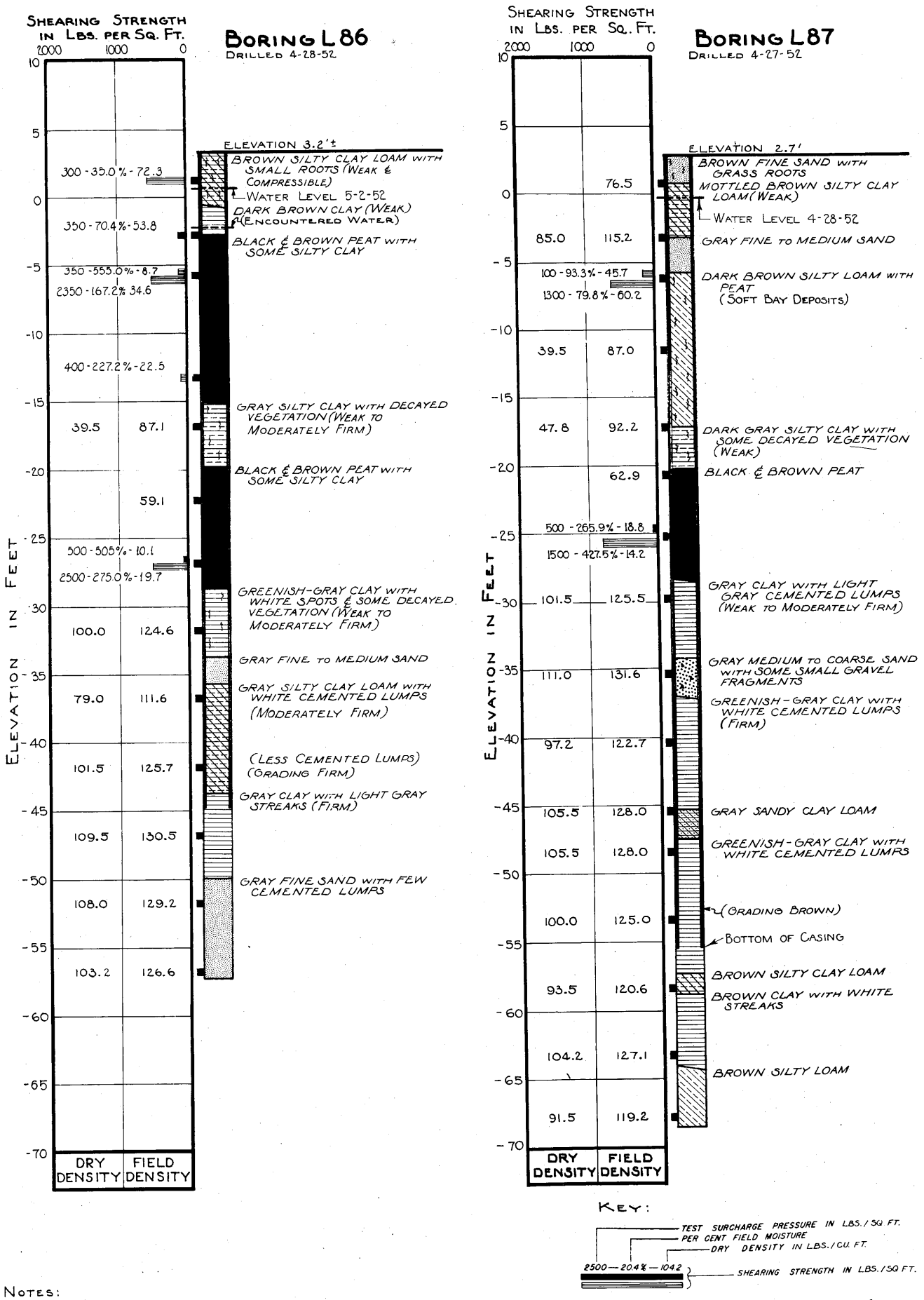
NOTES:

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE H3



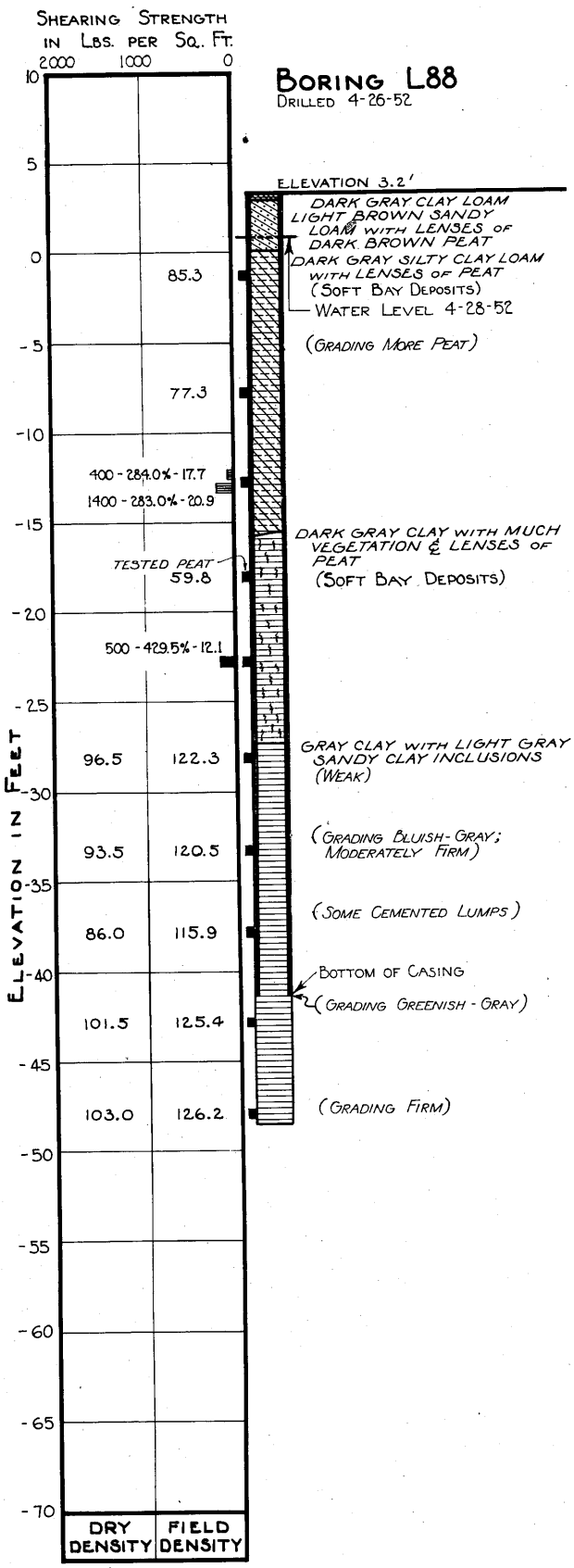
NOTES:

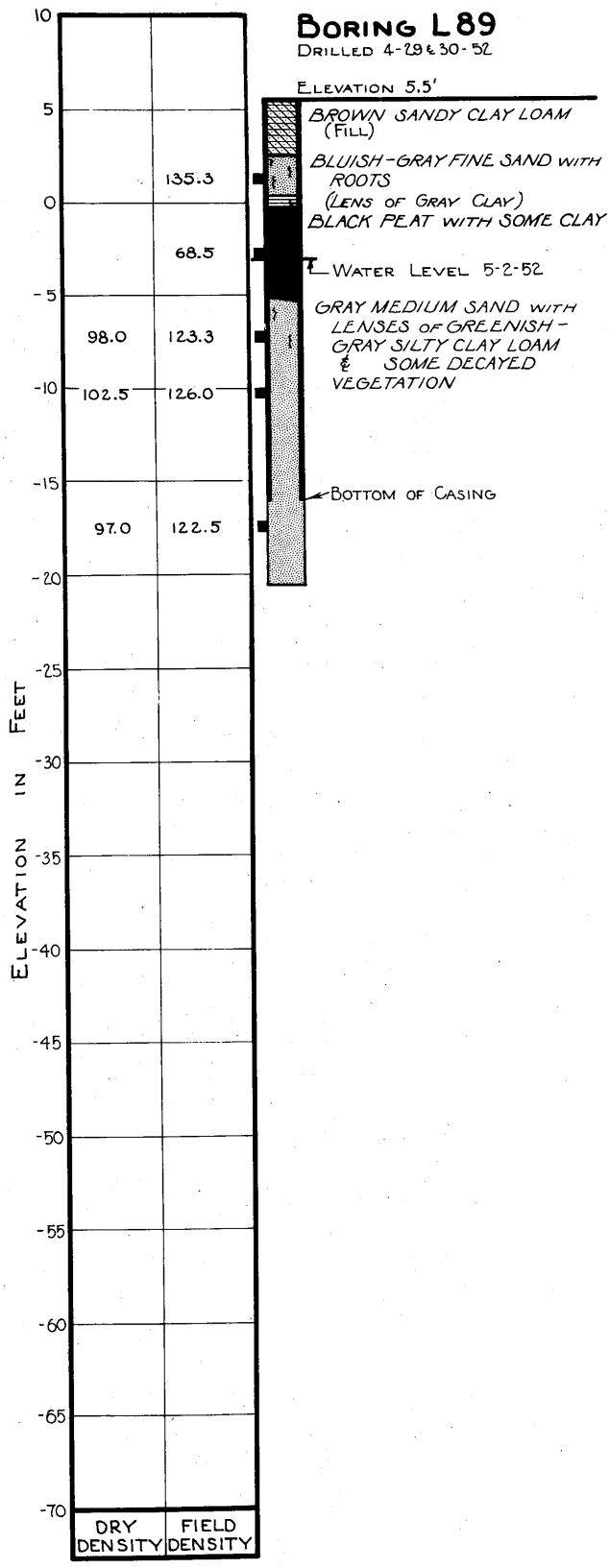
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE TOOL EQUIPMENT.

LOG OF BORINGS

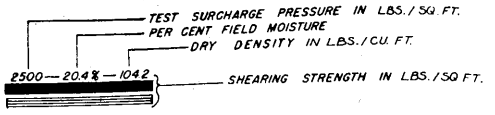
DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE H 4





KEY:



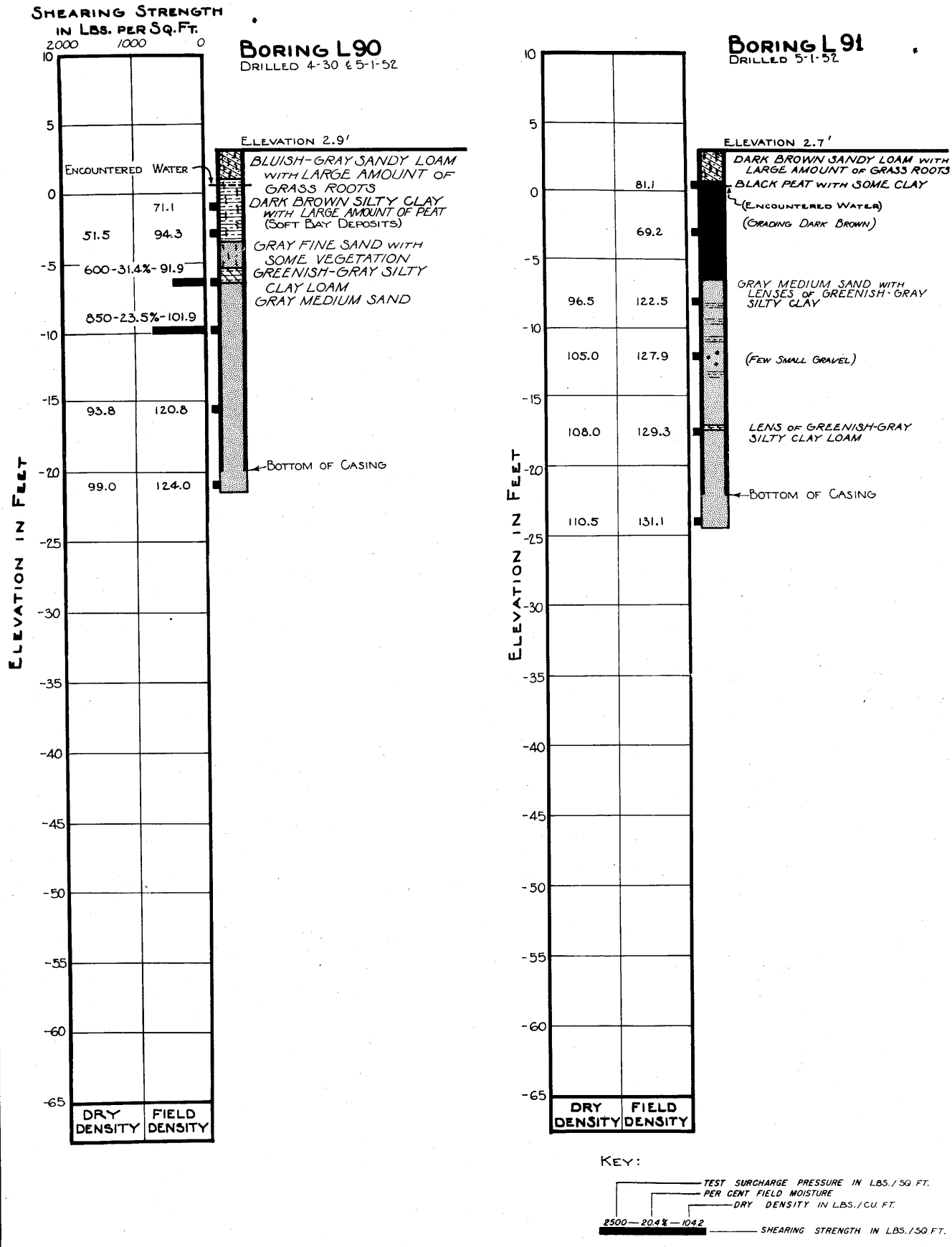
NOTES:

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM CABLE TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE H5



LOG OF BORINGS

NOTES:

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM CABLE TOOL EQUIPMENT.

DAMES & MOORE, *Civil Engineers*
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE H6

BORING L92
DRILLED 5-1 & 2-52

SHEARING STRENGTH IN LBS. PER SQ. FT.
2000 1000 0

ELEVATION IN FEET
10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65

ELEVATION 4.5'
DARK BROWN CLAY LOAM
BROWN FINE SANDY LOAM WITH SOME GRASS ROOTS
WATER LEVEL 5-2-52
BLACK PEAT WITH SOME CLAY
(GRADING DARK BROWN)
GRAY SILTY CLAY LOAM WITH VEGETATION (SOFT BAY DEPOSITS)
(LENS GRAY MEDIUM SAND) (GRADING DARK GRAY)
DARK BROWN PEAT
GRAY CLAY WITH SOME FINE SAND & TRACES OF VEGETATION (WEAK TO MODERATELY FIRM)
(GRADING GREENISH-GRAY WITH WHITE CEMENTED LUMPS)
(GRADING FIRM)
(GRADING BROWN)
GREENISH-GRAY SILTY CLAY LOAM WITH CEMENTED LUMPS
BOTTOM OF CASING
GRAY FINE TO MEDIUM SAND

DRY DENSITY	FIELD DENSITY
84.5	104.5
	115.0
	76.0
	71.5
33.0	83.1
48.5	92.8
	55.6
	61.5
1100-23.9%-100.8	
1400-30.2%-93.8	
1700-30.6%-92.0	
101.5	125.5
107.5	129.2
105.0	127.6
114.2	133.3

BORING L93
DRILLED 6-17-52

SHEARING STRENGTH IN LBS. PER SQ. FT.
2000 1000 0

ELEVATION IN FEET
10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65

ELEVATION 1.5' ±
LIGHT BROWN SILTY CLAY LOAM WITH ROOTS
GRAYISH-BLACK SILTY CLAY & BROWN PEAT (SOFT BAY DEPOSITS)
DARK GRAY SILTY CLAY LOAM WITH LARGE AMOUNT OF VEG. (SOFT BAY DEPOSITS)
WATER LEVEL 6-17-52
DARK GRAY FINE SAND WITH SOME CLAY & TRACES OF VEGETATION
GRAYISH-BLACK SILTY CLAY LOAM WITH SOME VEGETATION (SPONGY) (WEAK)
BOTTOM OF CASING
DARK GREENISH-GRAY CLAY WITH WHITE CEMENTED LUMPS (MODERATELY FIRM)
GREENISH-GRAY SILTY CLAY LOAM (WEAK)
GREENISH-GRAY CLAY (MODERATELY FIRM)

300-125.4%-37.0
350-65.8%-59.2
500-35.5%-85.5
600-140.0%-33.1
750-24.2%-100.9
33.0%-89.4

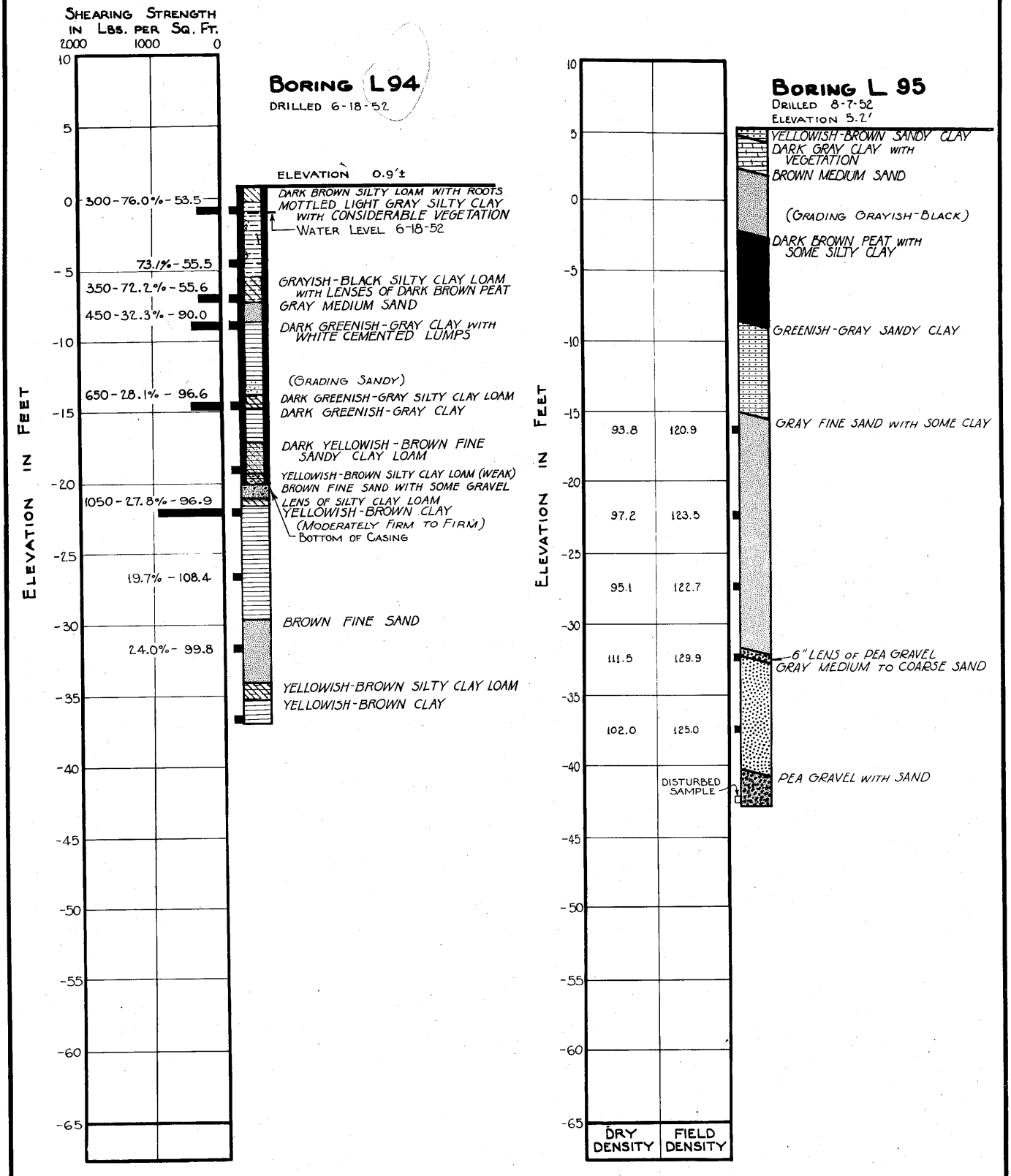
KEY:
TEST SURCHARGE PRESSURE IN LBS./SQ. FT.
PER CENT FIELD MOISTURE
DRY DENSITY IN LBS./C.U. FT.
2500—20.4%—104.2
SHEARING STRENGTH IN LBS./SQ. FT.

NOTES:
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORING L92 DRILLED WITH 6" DIAM. CABLE TOOL EQUIPMENT.
BORING L93 DRILLED WITH 4" DIAM. GOW-TYPE WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE H 7



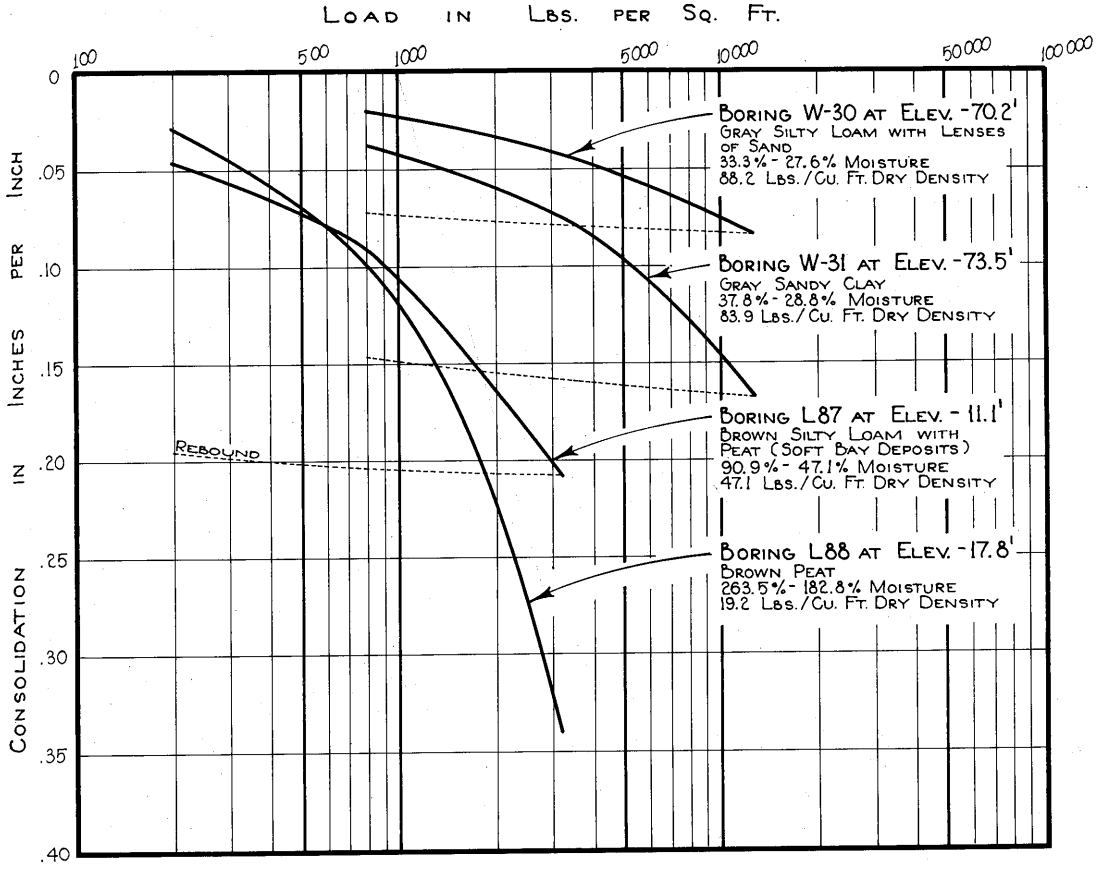
NOTES:

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORING L94 DRILLED WITH 4" DIAM. GOW-TYPE WASH EQUIPMENT.
BORING L95 DRILLED WITH 6" DIAM. ROTARY WASH EQUIPMENT.

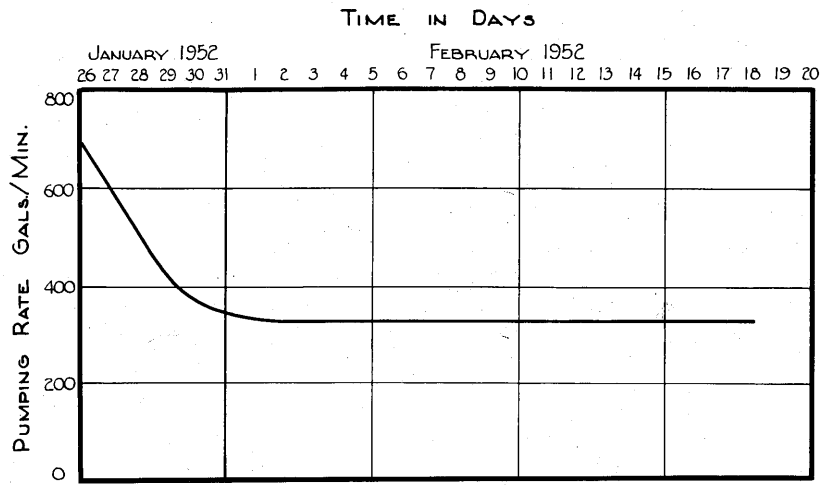
LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE H8



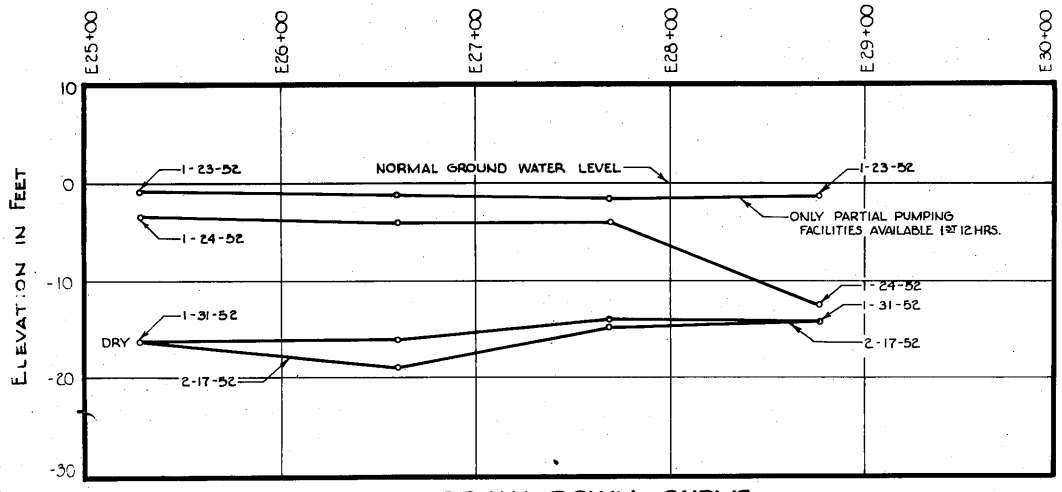
CONSOLIDATION TEST DATA



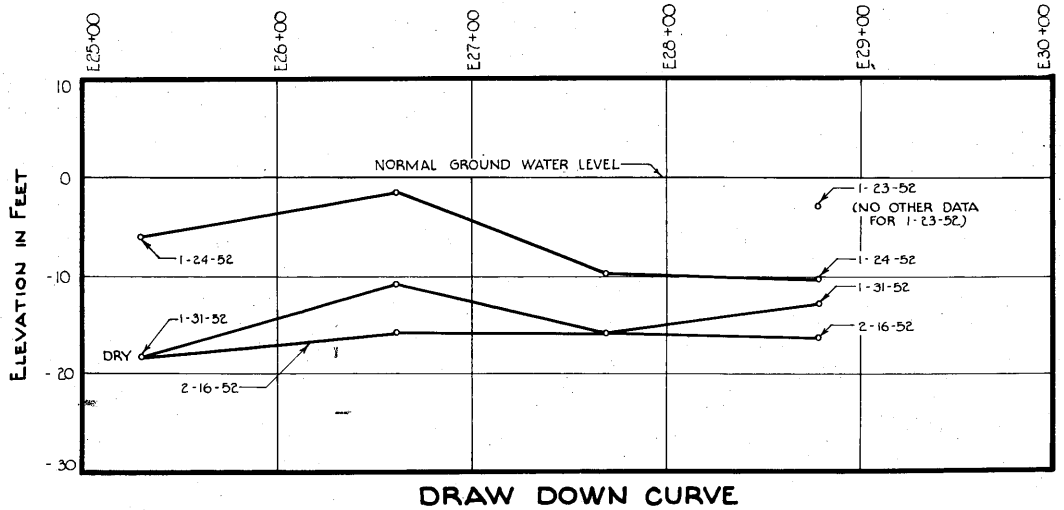
q = 350 gals/min

NOTE:
WELL POINTS WERE INSTALLED AROUND THE PERIMETER OF THE 290 BY 380 FOOT AREA AT APPROXIMATELY 9 FOOT CENTERS WITH THE STRAINERS LOCATED AT ELEVATION -24 FEET AND THE HEADER AT ELEVATION 0 FEET. TWO PUMPS WERE INSTALLED AT DIAGONALLY OPPOSITE CORNERS OF THE EXCAVATION.

AVERAGE PUMPING RATE VS. TIME IN DAYS



DRAW DOWN CURVE
OBSERVATION WELLS AT NORTHERLY PORTION OF POWER PLANT SITE



DRAW DOWN CURVE
OBSERVATION WELLS AT SOUTHERLY PORTION OF POWER PLANT SITE

NOTE:
WATER LEVEL IN WELL POINTS APPROXIMATELY AT ELEV. -19'

DEWATERING DATA
POWER PLANT SITE

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APPENDIX J

TABLE I

LIST OF PROJECTS IN WHICH VERTICAL SAND DRAINS WERE CONSTRUCTED IN CALIFORNIA BETWEEN 1934 and 1947

Location	County	Year Completed	Height of fill (feet)	Depth of drains (feet)	Diam. of drains (inches)	Spacing of Drains (feet)	Method of Installation	Total Lineal feet of drain	Cost of Drain and Backfill per lin.ft.
Beatrice Flat	Humboldt	-1934	3	40 - 50	20	10 x 10	Rotary Drill	3,530	
El Cerrito	Alameda	1936	12	4 - 30	24 - 30	10 x 10	" "	4,871	0.72
School House Canyon	San Luis Obispo	1937	60	12 - 76	20 - 24	15 x 15	" "	1,204	
" " "	" " "	1937	60	48	13 - 15	10 x 10	Driven Mandrel	11,256	1,06
Little Potato Slough	San Joaquin	1940	27	15 - 30	24	10 x 10	Rotary Drill	10,644	0,62
Eureka Slough	Rumboldt	1940	20	15 - 45	28	9 x 11	" "	15,045	1,18
San Luis Obispo Crk.	San Luis Obispo	1940	10 - 25	7 - 66	18 - 26	10 x 10	" "	22,700	0.74
Ontario Gulch	" " "	1941	63 - 70	8 - 56	18	12 x 12	" "	19,902	0.69
Harkins Slough	Santa Cruz	1941	34	6 - 21	20	11 x 13	" "	6,799	0.47
Watsonville Slough	" "	1941	12	4 - 45	20	11 x 13	" "	8,246	0.47
Mokolumne River	Sacramento	1941	34	25 - 64	18	9 x 11	Rotary Jet	45,865	0,66
Quay Wall - Mare Isl.	Napa	1942	25	79	14	8 x 10	Driven Mandrel	28.000	
Casmalia	Santa Barbara	1943	45	38 - 75	20 - 24	11 x 13	Rotary Drill	14,126	1,54
Port Chicago - NAD	Contra Costa	1944	17	11 - 60	14	10 x 10	Rotary Jet	17,470	1,00
" " "	" "	1944	15	15 - 26	14	12 x 12	Driven Mandrel	49,061	1,00
" " "	" "	1945	17	25 - 60	14	10 x 10	" "	185,263	1,00
" " "	" "	1945	7	30 - 40	14	9 x 9	" "	167,648	0,60
Bayshore Freeway	San Mateo	1946	9 - 14	15 - 56	18	10 x 10	" "	40,764	1,33
" "	" "	1947	8 - 14	15 - 56	18	10 x 10	" "	221,374	0,84
Nicholson Approach	Los Angeles	1946	12 - 31	40	18 - 22	7 x 14	Jetted Mandrel	13,240	1,29
Terminal Isl.Freeway	" "	1946	6 - 30	35 - 50	18 - 22	10 x 10	" "	119,123	1,09
Pac. Coast Highway	" "		12 - 42	32 - 48	18 - 22	9 x 11	" "	102,676	1,02

APPENDIX L

SAMPLE SPECIFICATIONS

FOR THE
PLACING OF COMPACTED FILLS, TANKAGE AREA

PROPOSED STEAM PLANT

PITTSBURG, CALIFORNIA

SCOPE OF WORK

The work under this specification includes the furnishing of all labor, materials, tools, and equipment necessary for the excavation, grading, and proper placement of fills. This includes the excavation, stock piling, and removal in certain cases, of designated surface soils as prescribed herein, furnishing of suitable fill material from an outside source, and the rolling, watering and otherwise compacting the fill material in place, all as shown and noted in this specification and on drawings:

INVESTIGATION OF SITE AND SOIL CONDITIONS

The Contractor shall visit the site and familiarize himself with the actual ground conditions. To assist the Contractor with further investigations, the Contractor may review at the office of Dames & Moore, Civil Engineers, 417 Market Street, San Francisco, data on the subsoil conditions at the site.

CLEARING OF SITE

The Contractor shall take the building site in its present condition and shall clear it of all trees, stumps, roots, vegetation, etc. These materials shall be removed from the Tankage site.

COMPACTED FILL REQUIREMENTS AND TESTS TO BE PERFORMED

The fill within the limits of work shall be brought to the required grades, noted on the plans, and shall be uniformly compacted to a dry density of 95 per cent of the maximum density determined in accordance with the "Modified Laboratory Method of Test for the Compaction and Density of Soil" as specified by the American Association of State Highway Officials. It is estimated that this specified dry density will also be equivalent to approximately 95 per cent of the maximum density determined in accordance with the "Compaction Test, Impact or Field" test as specified under Section 6 (g) of the State of California, Department of Public Works, Standard Specification, dated January, 1949. The density of the fill in place as determined by tests conducted by soil testing engineers shall be the basis upon which the satisfactory completion of the work is judged. All fill material from an outside source must be approved by the Soils Engineer prior to the placement of any fill.

It is anticipated that five to eight roller passes with a sheepsfoot roller, imposing a pressure on each tamper foot of 250 pounds per square inch will be required to obtain the necessary compaction, but, in any event, rolling shall be continued until the required degree of compaction has been obtained. The final grade of the fills shall be completed by blading and compacting with a smooth-type roller, or the fills shall be brought to above final grade, compacted with sheepsfoot rollers, and then bladed to final grade.

The Soils Engineer may reject any material which in his opinion would be unsuitable for the intended use of the planned fill. Fill soils shall not contain brush, roots, sod, rubbish or other perishable materials.

The densities attained shall be determined by field density tests and/or by extraction of undisturbed core samples from the completed fill for moisture and density determinations. The results of these tests shall be the basis upon which the satisfactory completion of the work is judged.

A sufficient time shall be allotted to the Soils Engineer to perform the necessary testing for approval of the fill material prior to the placing of any fill, and to perform all of the control tests necessary for assuring that a properly placed compacted fill is being obtained: i.e., the filling operations should be so arranged as to permit the making of the necessary control tests for each lift prior to the placing of subsequent lifts.

PLACING OF COMPACTED FILL

The exposed surface soils occasioned by the required preliminary grading and excavating shall be properly moistened and rolled prior to the placing of any fill material.

The fill soils shall be spread in successive layers of a thickness that will result in compacted layers of approximately six-inch-thicknesses. No compaction will be performed until the moisture content is deemed correct by the Soils Engineer. A drying period may be necessary if the material should be too wet; if the materials are too dry, water must be applied uniformly in a manner that will permit uniform penetration of water into the soil. Cultivation, plowing or other methods may be required before and/or during the application of the water, or during a drying out period if the materials should become too wet for satisfactory compaction. Facilities shall be provided for supplying the necessary water at all points of the work.

Compacting of the fill materials by ponding will not be permitted. The rollers used for compacting the earth fill may be of the sheepsfoot type, combination of sheepsfoot and flat-wheeled rollers, rubber-tired rollers, or other suitable compacting equipment -- the selection of compacting equipment is left to the Contractor and it is his responsibility to furnish satisfactory equipment to meet the specifications for the completed fill.

CONTROL OF COMPACTED FILL

For the purpose of assisting the Contractor in obtaining a compacted fill that will meet the specified densities or strengths, a representative of Dames & Moore, the Soils Engineer, will be present at the site during the placing and compacting of the fill to determine the moisture contents of the fill materials, to check the density achieved in placing the fill, and to perform such other tests as may be necessary.

The Contractor shall be responsible for the installation of the compacted fill according to specifications and should the Contractor fail to meet these specifications, he shall make the necessary adjustments until a satisfactory fill is obtained.

REPORT

PRELIMINARY FOUNDATION INVESTIGATION
PITTSBURG POWER PLANT, UNIT 7
PITTSBURG, CALIFORNIA

FOR THE PACIFIC GAS AND ELECTRIC COMPANY

DAMES & MOORE

Job No. 0160-130-03

EARTH SCIENCES

DAMES & MOORE

CONSULTING ENGINEERS IN THE APPLIED EARTH SCIENCES

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500 SANSOME STREET · SAN FRANCISCO, CALIFORNIA 94111 · (415) 433-0700

PARTNERS: WILLIAM W. MOORE · WILLIAM ENKEBOLL · ROBERT D. DARRAGH · CHARLES L. NICHOLS · DONALD F. JAVETE
ASSOCIATES: GEORGE D. ROBERTS · DENNIS J. R. HODGSON · ROBERT C. K. AU · CARL W. GARBE · PETER E. QUINN

October 18, 1968

Mr. J. D. Worthington, Vice President,
Engineering
Pacific Gas and Electric Company
245 Market Street
San Francisco, California 94106

Attention: Mr. B. W. Shackelford,
Chief Civil Engineer

Gentlemen:

Twenty-five copies of our report, "Preliminary Foundation Investigation, Pittsburg Power Plant, Unit 7, Pittsburg, California", are herewith submitted. The scope of this investigation was planned in collaboration with Messrs. Bettinger and Wollak and other members of your engineering staff. Frequent discussions were held with them during the course of the work regarding our findings and recommendations.

Subsequent to submitting a draft of this report in September, final foundation requirements for the turbine-generator and boiler were revised, and the fuel oil storage tank location was moved to an area south of Unit No. 1. This preliminary report has been modified to incorporate final decisions regarding the power plant foundations. The discussion of foundation conditions for the initially proposed tank location is included for future reference.

Foundation support for the Unit 7 Power Plant will be obtained from an 18 to 23-foot-thick upper sand layer about 20 feet below the present ground surface. The boiler and stack will be supported on 50-ton driven concrete piles; the turbine-generator will be founded on a deep mat foundation to accommodate construction of the circulating water system. For preliminary foundation loads the average settlements of the boiler and turbine-generator were computed to about two inches

for foundations in the upper sand layer. Final design loadings for the boiler are greater than were used in our preliminary analyses and computed settlements for final foundation conditions will be about three inches. The computed average settlement of the stack founded on short piles is about four inches.

Our studies indicate that a fuel oil storage tank could have been supported at grade at the initially proposed location if the area were surcharged with 10 to 15 feet of fill for three to four months prior to tank construction. Tank settlements after surcharging with 10 feet of fill would be on the order of one-half foot at the center and a few inches at the edges.

Subsequent reports will include the results of supplementary borings and analyses for final design of the Unit 7 Power Plant structures, switchyard, new tank location and circulating water system.

Should any questions arise concerning the data presented in this report, please contact us.

Yours very truly,

DAMES & MOORE

Robert D. Darragh

James H. Klick

RDD:JHK:is

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PRELIMINARY FOUNDATION INVESTIGATION

PITTSBURG POWER PLANT, UNIT 7

PITTSBURG, CALIFORNIA

FOR THE PACIFIC GAS AND ELECTRIC COMPANY

INTRODUCTION

This report presents the results of our initial foundation investigation for Unit 7 and supporting facilities at the Pittsburg Power Plant. The proposed unit is rated at 750 megawatts and will be constructed east of existing Units 5 and 6 at the location shown on the Plot Plan, Plate 1. The present location is about 40 feet north of the preliminary location at the time the field explorations were laid out.

The logs of borings and test data used to develop the recommendations in this report are presented in Appendix A, Field Explorations and Laboratory Testing. Previous work, types of foundations for Units 1 through 6, and foundation performance are summarized in Appendix B, Previous Investigations and Foundations, Pittsburg Power Plant. Logs of borings from previous investigations pertinent to Unit 7 construction are presented in Appendix C.

All elevations in this report are in feet and refer to the Plant Datum, which is 0.43 feet below the U.S.G.S. Datum of Mean Sea Level.

SCOPE OF PRESENT INVESTIGATION

The foundation investigation for Unit 7 will be presented as a series of reports in order to meet design schedules. This initial investigation includes a limited number of borings and supporting foundation analyses for Unit 7 Power Plant, Stack, and preliminary location for the Fuel Oil Storage Tank. Other reports will include supplementary borings and analyses required for the final design of Unit 7 structures, switchyard and circulating water system.

Stack, Boiler, Turbine-Generator Area - Three foundation alternatives were studied for the boiler and turbine-generator units:

1. Mat foundations at Elevation -1, on firm supporting soils, after excavation of weak upper marsh deposits.

2. Short pile foundations extending to an upper sand layer about 30 feet below the existing ground surface. Final designs for the turbine-generator required study of mat foundation support for the unit on this layer.

3. Deep pile foundations into a lower sand layer about 70 to 90 feet below the ground surface.

Only pile foundations were studied for the stack because spread foundations were considered uneconomical because of the high overturning loads.

Fuel Storage Tank (Preliminary Location) - The safe supporting capacity and settlement behavior of a grade supported tank at Elevation +17 were studied for a tank located approximately 700 feet south of existing tanks. Recommendations were developed for surcharging or controlled water testing to overcome the difficulties due to compressible peat layers encountered in the two test borings.

PLANNED CONSTRUCTION

GENERAL

A preliminary layout of the power plant foundations is shown on Plate 2. The plate also shows the total dead plus operating loads, including foundations, which were used in the preliminary settlement analyses.

The alignment of the turbine-generator intake and discharge cooling water conduit was revised after preliminary analyses were performed. The planned invert elevation of conduit at -17 make it impractical to use shallow mat construction for the unit. Alternative deep mat foundations at Elevation -20 were studied and selected, as discussed in a later section.

The final layout of columns for the boiler structure are slightly different from that shown on Plate 2. Also, final column loads are considerably greater than those provided us for these preliminary studies. Lateral loadings on boiler foundations are also somewhat greater than were anticipated. The effect of the increased vertical and horizontal loadings on foundations are discussed in a later section.

SOIL CONDITIONS

The subsurface conditions in the power plant area were explored by 8 borings, Nos. 1 through 5, 7, 10 and 11, at the locations shown on the Plot Plan. The significant soil strata determined from these borings and previous subsurface information are summarized in Table I.

FILL

A five to seven-foot-thick fill overlies the entire Unit 7 area. Materials consist generally of one to two feet of gravels at the surface, underlain by loose to moderately compact sands. Some borings encountered a thin layer of medium stiff to stiff clay between the gravel and sand fill. Although the thickness of the clay layer could vary significantly between borings, the fills appear to be predominantly granular. The gravel and sand portions are generally good quality and suitable for most backfilling purposes.

The majority of the site was brought to grade in about 1951 with sandy soils derived from dredging of the ship channel in the Sacramento River. The fills in the proposed Unit 7 area were probably not compacted at the time of placement.

OLD MARSH DEPOSITS (PEAT AND SOFT CLAY)

These deposits are soft to medium stiff. Though only two to three feet thick in the Unit 7 area, they are very compressible, as they are consolidated only to the fill overburden loads. If excavated, they should be wasted.

UPPER CLAYS

These clays are medium stiff to stiff and are preconsolidated to pressures in excess of 3,000 pounds greater than the present overburden loads. The clays are only moderately compressible and would provide satisfactory support for spread foundations if low bearing pressures were used.

UPPER SANDS

These sands were found to be generally clean and appear to be continuous between the test borings. Standard penetration tests and laboratory shear tests indicate that they are dense and would provide satisfactory support for pile foundations, as discussed in a later section.

LOWER CLAYS

These clays are stiff to very stiff and are preconsolidated to pressures in excess of 10,000 pounds greater than present overburden loads. The strata are not homogeneous, ranging from very clayey to very silty in

depth. Based on the consolidation test data and settlement observations for Units 1 through 6, these lower clays are moderately compressible under heavy plant loads but consolidate rapidly as the structural loads are imposed. As indicated in Table I, the thickness varies in a southerly direction from about 21 to 28 feet below the turbine-generator and boiler area, to 51 to 55 feet in the vicinity of the stack.

LOWER SANDS

These sands are dense to very dense with some silts and gravels and thin clay layers. The depth generally increases in a southerly direction, being about 90 feet in the vicinity of the stack. The lower sands would provide excellent support for high capacity driven piling and almost negligible settlements.

GROUNDWATER

The groundwater level varied slightly between the borings, but was generally at the interface of the fills and underlying marsh deposits. The water levels did not appear to fluctuate significantly with the tide. Because of the granular nature of the fill and lack of paving in the plant area, it is likely that the water level will rise significantly during periods of heavy rainfall. Complete dissipation would probably be measured in weeks rather than in hours after a rainfall.

T A B L E I

STRATUM	STACK AREA			BOILER AND TURBINE-GENERATOR AREA		
	TOP OF STRATUM ELEVATION (Feet)		THICKNESS (Feet)	TOP OF STRATUM ELEVATION (Feet)		THICKNESS (Feet)
	MAX.	MIN.		MAX.	MIN.	
FILL	+8	+6	±5	+9	+8	5 to 8
MARSH DEPOSITS (PEAT AND SOFT CLAYS)	+3	+2	±3	+4	+1	2 to 3
UPPER CLAYS	0	0	10 to 12	+1	-2	14 to 18
UPPER SANDS	-10	-14	19 to 23	-12	-18	18 to 21
LOWER CLAYS	-33	-33	51 to 55	-32	-39	21 to 28
LOWER SANDS	-84	-87	*	-58	-62	>56 (Boring No. 1)

* Thickness is estimated to be greater than 30 feet.

PLANT FOUNDATIONS

COMPUTED SETTLEMENTS

Settlement analyses for the preliminary dead plus operating loads shown on Plate 2 are summarized below:

TYPE OF FOUNDATION	SETTLEMENT IN INCHES		
	TURBINE-GENERATOR pedestals	BOILER (Main Structure) columns	STACK center
1. MAT FOUNDATIONS (Founded at Elevation -1)			
Average	4.0	3.7	not
Maximum	4.6	4.0	computed
Minimum	2.9	3.1	
2. SHORT PILES* (Pile tips at Elevation -25)			
Average	1.9	1.7	4.2
Maximum	2.1	2.2	-
Minimum	1.3	1.4	-
3. LONG PILES (Pile tips at Elevation -70)			
Estimated	About 1/2 inch		Less than 1 inch

*The detailed settlements for the short pile scheme are shown on Plate 2 adjacent to the columns.

Note: Calculated settlements are shown to 0.1 inch for comparative purposes only.

Turbine-Generator - The final designs for the turbine-generator cooling water system required deep foundations and mat foundations in the upper sands will be used. Consequently, the settlements reported in the preceding summary for mat foundations at Elevation -1 are included for interest only. The computed turbine-generator settlements for short piles are also applicable to the planned deep mat foundations on the same bearing stratum, except that differential settlements will be somewhat less because of the greater rigidity of the deep mat foundation.

Boiler - The final boiler column loads are higher than were used in the preliminary studies. Consequently, the total settlements will be greater (averaging 2-1/2 to 3 inches instead of 1.7). However, the differential settlements between columns are expected to be about the same as calculated for the preliminary loads. Final settlement analyses for the boiler are now in progress; the results will be summarized in a supplementary report.

Stack - The stack is a very rigid structure and any differential settlement would cause it to tip slightly rather than dish. We expect that differential settlement will be less than 1 inch across the 76-foot base for the selected short pile scheme.

The computed settlements for the Unit 7 structures supported on short pile foundations are considerably greater than the observed settlements

for Units 1 through 6, which are founded on similar soils (average settlement - 1/2 to 3/4 inch). The difference is due to three factors:

1. Clay layers underlying Units 1 through 6 are not as thick as those for Unit 7.

2. The turbine-generators and boilers in all previous units have deep basements, which lower the net stresses imposed on the supporting soils from the mat foundations, whereas Unit 7 structures will not have basements.

3. The unit foundation loads are considerably heavier than the actual operating loads for previous units.

PILING

Because pile selection was needed for the proposed Unit 7 stack at an early stage and foundation requirements were similar to the stacks for Units 6 and 7 at the Moss Landing Plant, the design loadings were made identical to the Class I and Class II piles specified for those structures. Subsequent studies have indicated that these were reasonable pile capacities for the Unit 7 soil conditions. These design loadings, along with suitable types, sizes, penetrations and other pile requirements, are shown in Table II, Pile Types.

TABLE II - PILE TYPES

	UNITS	SHORT PILES CLASS I	SHORT PILES CLASS II	LONG PILES CLASS II
1. Pile Capacities				
a. Dead plus live loads	Kips	100	225	225
b. Dead plus live and seismic loads	Kips	190	450	450
c. Maximum Uplift	Kips	40	100	100
d. Lateral Loads				
Shear	Kips	6	13	13
Moment	Foot-Kips	18	55	55
2. Estimated Number of Piles for Unit 7 Structures	-	1,000	550	550
3. Minimum Pile Spacing (concrete piles)	Feet	3.5	4.5	4.5
4. Predrilling Required	-	no	no	yes
5. Number of Pile Load Tests	-	none	2	none
6. Pile Dimensions				
a. Prestressed Precast Concrete	Inches	10 x 10	16 x 16	14 x 14
b. Raymond Pile (Tip Diameter)	Inches	$10\frac{1}{4}$	-	$12\frac{1}{4}$
7. Estimated Tip Elevation				
a. Prestressed, Precast Concrete	Feet	-25	-23	-72
b. Raymond Pile	Feet	-25	-	-72

Cost estimates prepared by piling contractors* for the indicated piling showed that:

1) The cost of short pile foundations would be about 2/3 of the cost of long piles.

2) The cost differential between the short Class I and Class II piling was small (Class II piles were approximately 5 percent less).

It is our opinion that plant foundations supported on short Class I or long Class II piles are a more conservative and safe approach to foundation design than the short Class II piles. Past experience has shown that installation problems and engineering costs are greatly increased by the combination of high-capacity piles driven into a relatively thin bearing stratum. While it is believed that the short Class II piles could be installed satisfactorily, they would require more careful installation techniques and field control than the other piles.

MAT AND/OR SPREAD-TYPE FOUNDATIONS

Shallow Mats - Mat or spread-type foundations at Elevation -1 or above could be used if the old marsh deposits underlying fills are excavated. Foundations could be placed either directly on the lower clay soils or on a

*At the request of the contractors, the cost estimates are not included in this report.

compacted backfill placed in the excavation. For foundation design, a bearing pressure of 2,000 pounds per square foot may be used for dead plus live load design and increased by 1/3 for seismic loadings.

The settlement of mat foundations for the boiler were discussed in a previous section. For other individual foundations supporting up to 500 kips total loads, the settlements would be less than 2 inches.

Deep Mats - Deep mat foundations at Elevation -20 are planned for turbine-generator support. The unit bearing pressure imposed will be less than the allowable bearing value for the sands at the planned elevation. The excavation to -20 could be unsupported were it not for interference with adjacent structures and construction. Present plans will require a braced bulkhead along at least three sides of excavation (east, west and south sides) during construction to avoid such problems.

Careful design and construction will be required to:

1) Limit lateral movements of the bulkhead to acceptable amounts (not greater than about one inch).

2) Prevent quick conditions from developing in the foundation soils due to inadequate dewatering.

SELECTED FOUNDATIONS

During the progress of our work, all data were transmitted either verbally during discussions or by letter to P.G.&E. engineers. Cost estimates were made by P.G.&E. engineers for mat and pile foundations for comparative purposes. These estimates, along with foundation performance data, were the basis for selecting the short pile method of foundation support for Unit 7 boiler, stack and most minor plant structures. The turbine-generator mat foundation on the upper sands, at Elevation -20, was selected because engineering studies indicated simpler construction, and possible savings over the short pile scheme. Class I piles were selected because the cost difference between Class I and Class II short piles was small, and the Class I piles are simpler to install.

Performance - For the selected short pile method of foundation support, two plates are presented: Plate 2, Preliminary Plant Layout and Computed Settlements, Foundation Support on Short Piles in Upper Sands; and Plate 3, Computed Rate of Settlements, Short Piles in Upper Sands. The estimated time rates of settlement shown on Plate 3 are based on the schedule for Unit 7 construction. As previously noted, settlement and foundation performance of the turbine-generator unit on a deep mat should be comparable to support on short piles. It should be noted that while the stack settlements are approximately twice the settlements of the other structures, the post-construction differentials between structures should be small.

LATERAL LOADINGS

The detailed recommendations for lateral resistance of foundations will be part of the second phase work, as final foundation requirements for structures are still in the development stage. Only general comments concerning lateral resistance of foundations are presented here:

Stack - The criteria for stack design supplied to bidders gave the following allowable soil resistance for lateral force design:

1. Equivalent Fluid Weight - 500 pounds per cubic foot

2. Maximum - 4,000 pounds per square foot at a depth of 8 feet.

To achieve these values, structural backfills will have to be placed for some distance beyond foundations. The configuration and depth of the fills will be a function of 1) the values used for design, and 2) the depth of the perimeter wall of the pile cap.

Boiler - Some preliminary analyses have been performed based on the recently received final design information and preliminary foundation layout drawings for the boiler. These analyses indicate that special provisions, such as structural backfills, will not be required for boiler foundations. We anticipate that piling will be required to carry a portion of the lateral load, though the distribution between piles and soils has not been worked out.

Turbine-Generator - The deep excavation for the turbine-generator foundations and substructure will provide ample passive resistance to lateral loadings.

PRELIMINARY FUEL OIL STORAGE TANK LOCATION

PLANNED CONSTRUCTION

Tank - The proposed fuel storage tank location is shown on the Plot Plan. The tank details are as follows:

Diameter	160 feet
Height	48 feet
Product Unit Weight	57 pcf
Present Grade	Approximately Elevation +12
Planned Tank Grade	Elevation +15

Protective Dikes or Concrete Retaining Wall - We understand there is not sufficient area to construct earth retaining dikes around a tank at this location, and a concrete retaining wall would be used. The concrete wall would be similar to those encircling existing tanks and would impose a dead load on the order of 2,000 pounds per lineal foot of wall.

SOIL CONDITIONS

Two borings, Nos. 8 and 9, were drilled at the locations shown on the Plot Plan. The soils underlying this proposed tank area consist of the following basic strata.

SOIL STRATA	THICKNESS IN FEET Boring 8	Boring 9
Fill	7½	10
Old Marsh Deposits	9	4
Sand	10½	11
Peat	3½	None
Depth to firm clayey soils	30	25

The soils most effecting tank foundations would be the peat and very compressible old marsh deposits.

Groundwater was encountered near the interface of fill and old marsh deposits in both borings.

TANK FOUNDATIONS

Our analyses indicate that a tank could be supported at grade providing the area is surcharged for three to four months prior to tank construction or a carefully staged water testing program is undertaken. Relevelling of the tank by mud jacking techniques would probably be necessary if the latter method were used. The purpose of the surcharging or the water testing program would be to preconsolidate and strengthen the weak marsh deposits underlying fills prior to placing the tank into service. With the tank grade at Elevation +17, the staged water testing would be more to prevent damage to the tank due to differential settlement rather than for stability; however, either method would accomplish both.

Alternatively, a tank could be supported on pile foundations or the upper compressible soils excavated and replaced with fill, if the computed settlements for the grade support methods are not acceptable.

COMPUTED SETTLEMENT

The computed settlements for a tank located between borings 8 and 9 under product loads are summarized below:

SOIL CONDITIONS	BORING 8		BORING 9
SETTLEMENT (AFTER TANK IS BUILT)	Edge of Tank	Center of Tank Range Depending on Thickness of Compressible Soils	Edge of Tank
1. (No Surcharge)*	12"	20"	8"	4"
2. After surcharging (with 10 feet of fill)	3"	8"	3"	1"
3. After surcharging (with 15 feet of fill)	0	6"	2" - 3"	0

*The above settlements assume that the tank pad has been in place three to four months prior to tank construction and consolidation of the old marsh deposits is complete.

SURCHARGING

Surcharging the tank would be an effective means to reduce tank settlement as well as ensuring tank stability. The surcharging period is estimated to be about three to four months; however, a somewhat longer period should be allowed for in the event time rates of settlement are

slower than anticipated. Settlement markers should be placed on the surcharge of fills and shot at regular intervals to evaluate settlements. Surcharge materials could consist of excess soils from the plant area or imported fills.

WATER TESTING

Water testing could be used to consolidate and strengthen the compressible weak soils. The anticipated settlements during the water testing would be on the order of those shown in the above summary for settlement without surcharging. The method would require:

1. Placing a tank pad approximately three months prior to tank construction.

2. A period of six to nine months for water testing after tank construction.

3. Regular surveying at approximately 8 to 12 points on the perimeter of the tank and periodic shots on the interior columns during water testing.

4. Relevelling by mud-jacking techniques after water testing is complete. It is possible that mud-jacking might have to be performed at some intermediate stage in the event of severe differential settlement and tank stress.

OTHER TYPES OF FOUNDATIONS

Piles or removal of compressible soils have not been considered in any detail, as it is believed that surcharging or water testing would be cheaper and foundation performance satisfactory. However, both methods would reduce the time for tank construction and would limit settlements to small amounts. In the event they are seriously considered, additional analyses would be required.

TANK PAD AND RING WALL

Tank Pad - A proposed tank would be elevated above surrounding grades on about a 5-foot-thick pad. The pad should extend for a minimum of 10 feet beyond the edge of the tank and then sloped downward at 3 horizontal to 1 vertical to existing grades.

Prior to placing fill for the tank pad, the area should be scarified and pad fill well keyed to existing fills. The pad should be compacted to 95 percent of the maximum density determined by Modified A.A.S.H.O. Compaction Tests (ASTM Test Designation T 180-57).

Ring Wall - It is recommended that a tank be supported on a crushed stone ring wall. The ring wall should be about 2-1/2 feet deep by about 3 feet in width at the base. It should be well compacted with vibrators, and the upper exposed portion adjacent to the tank should be sealed to prevent runoff water from infiltrating into the gravel foundations.

DISCUSSION

The decision on whether to surcharge or stage water test and relevel the tanks would have to be based on:

1. Cost estimates.
2. The time available.

Surcharging would be the faster of the two, as tank construction could begin immediately after the four-month surcharge period. On the basis of past experience, tanks can undergo considerable distortion from differential settlement and still function satisfactorily. The remaining settlement after the surcharging period would appear to be nominal and should not require tank relevelling in the future.

On the other hand, consolidation could be more rapid than we have indicated, and the water test loads could be applied at a more rapid rate. The actual time between the incremental water loads would have to be based on a review of the settlement data.

PROTECTIVE RETAINING DIKES OR WALLS

EARTH DIKES

Earth retaining dikes could be constructed of either imported fill or on the better on-site soils excavated from the plant area. Side slopes would depend somewhat on the material used; however, 2 horizontal to 1 vertical

should be satisfactory for most soils. Requirements such as height, design slopes and placement of dike materials should be reviewed prior to final design.

STRUCTURAL RETAINING WALL

A structural retaining wall could be constructed on spread foundations if very low bearing pressures, on the order of 200 to 300 pounds per square foot, are used. Settlements would be small, on the order of an inch, and differential settlement would be spread over long distances. Alternatively, the wall could be pile supported if settlements would have to be limited to less than one inch.

Specific design criteria have not been supplied to us for a retaining structure. When such information is available, additional studies may be required for the proper selection of the wall foundations.

The following plates and appendices are attached and complete this report:

Plate 1 - Plot Plan

Plate 2 - Preliminary Plant Layout and Computed Settlements, Foundation Support on Short Piles in Upper Sands

Plate 3 - Computed Rate of Settlements, Short Piles in Upper Sands

Appendix A - Field Explorations and Laboratory Testing

Appendix B - Previous Investigations and Foundations, Pittsburg Power Plant

Appendic C - Logs of Borings From Previous Investigations

Respectfully submitted,

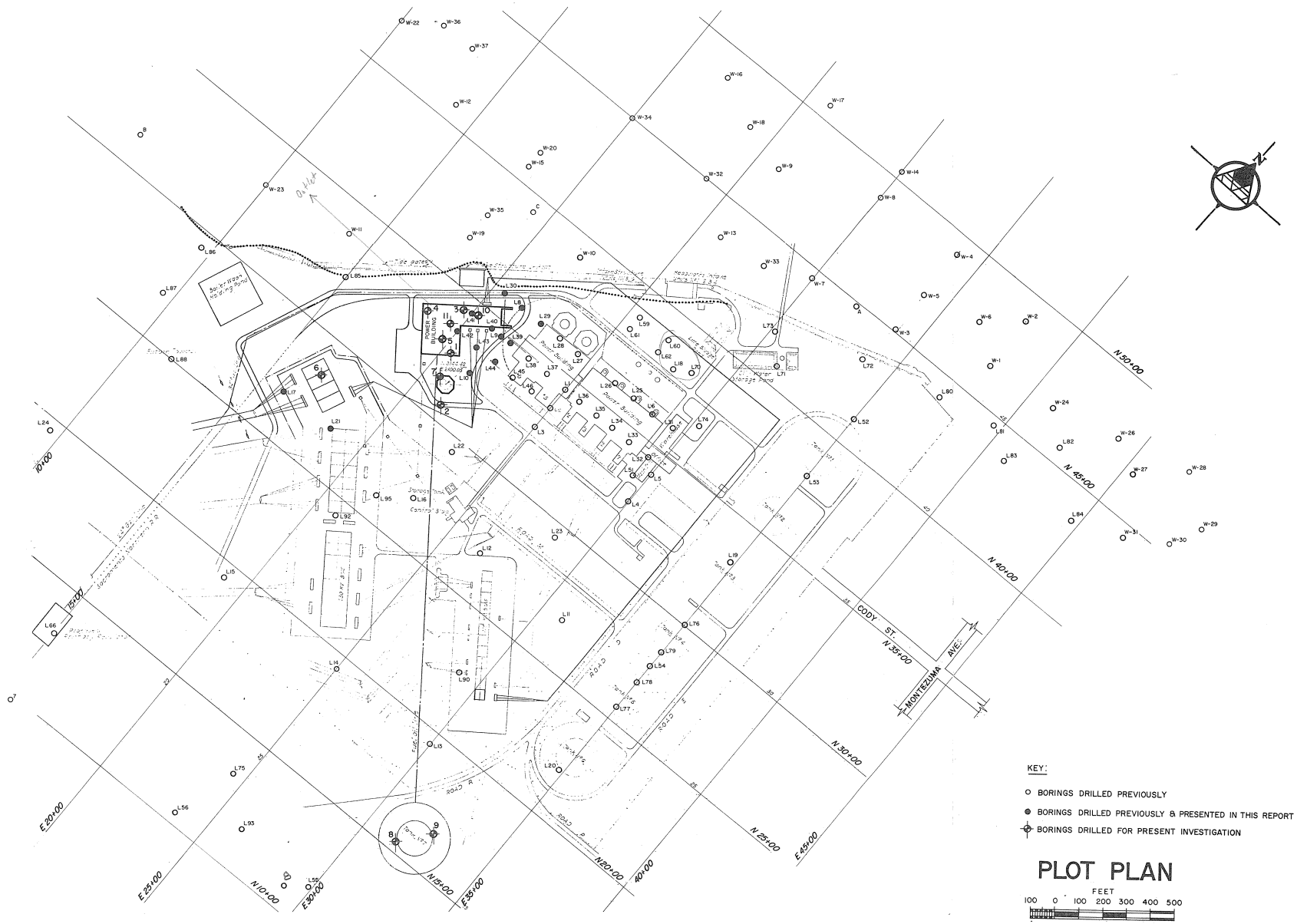
DAMES & MOORE

Robert D. Darragh

James H. Klick

October 17, 1968

Job No. 160-130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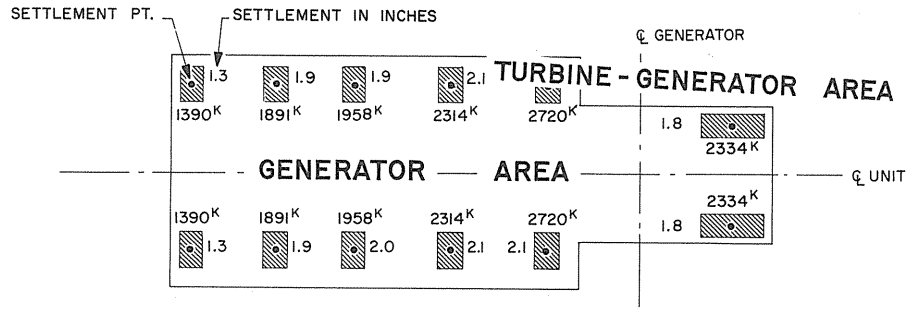
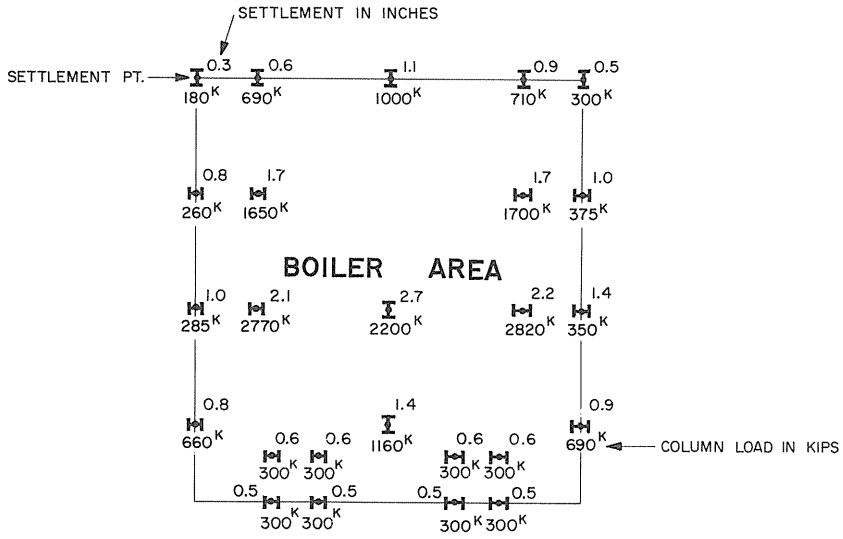
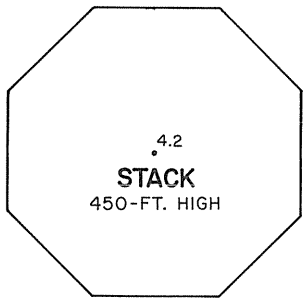
KEY:
BORINGS DRILLED PREVIOUSLY
BORINGS DRILLED PREVIOUSLY & PRESENTED IN THIS REPORT
BORINGS DRILLED FOR PRESENT INVESTIGATION
PLOT PLAN
FEET
100 0 100 200 300 400 500
DAMES & MOORE

PLATE 1







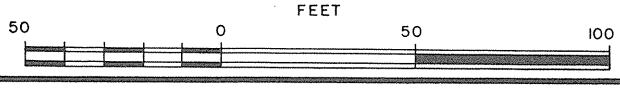
LOADS IN KIPS:

STACK + FOUNDATION = 15,000 KIPS
TANK + WATER = 6,500 KIPS
TOTAL = 21,500 KIPS

NOTE:
ALL LOADS SHOWN ARE DEAD PLUS OPERATING & INCLUDE FOUNDATIONS. CALCULATED SETTLEMENTS ARE SHOWN TO 0.1 INCH FOR COMPARATIVE PURPOSES ONLY.

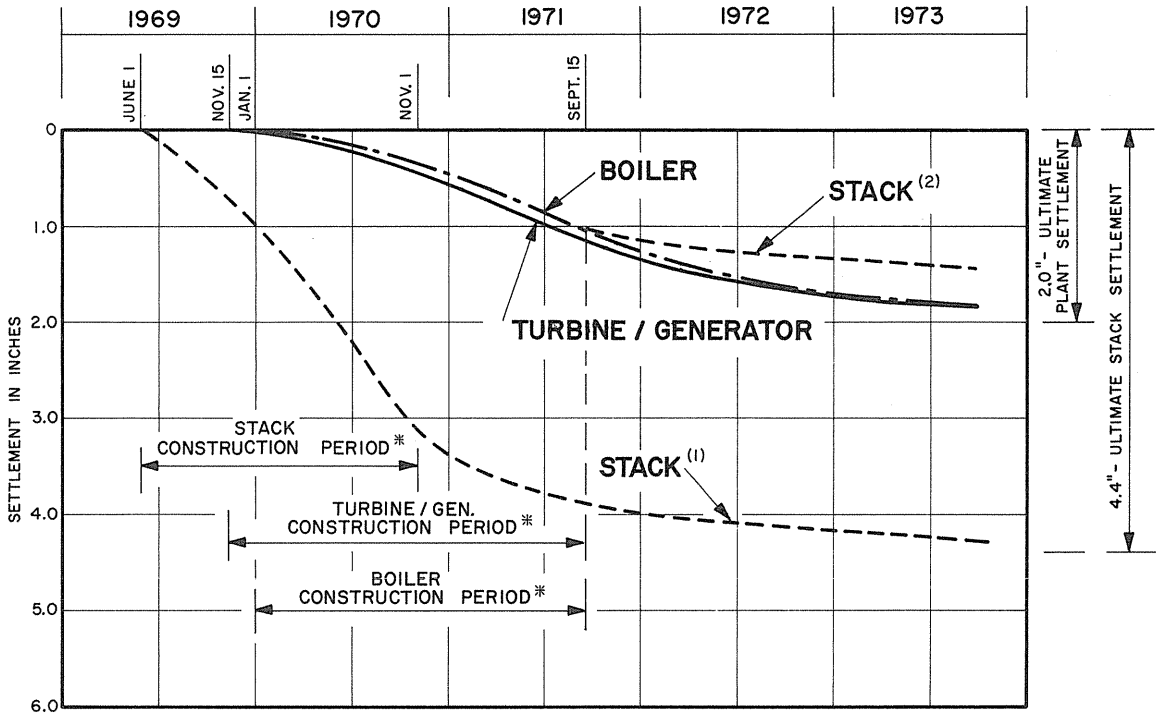
PRELIMINARY PLANT LAYOUT & COMPUTED SETTLEMENTS

FOUNDATION SUPPORT ON SHORT PILES IN UPPER SANDS



DAMES & MOORE

PLATE 2



*DATES FROM P.G. & E. "PROJECT SCHEDULE" (LATEST REV. 5-3-68) UNIT 7

(1) TOTAL SETTLEMENT

(2) POST CONSTRUCTION SETTLEMENT RELATIVE TO OTHER STRUCTURES

COMPUTED TIME/SETTLEMENT RATES

DAMES & MOORE

PLATE 3

APPENDIX A

FIELD EXPLORATIONS AND LABORATORY TESTING

FIELD EXPLORATIONS

Subsurface conditions in the proposed construction area were explored by drilling 11 test borings at the locations shown on the Plot Plan, Plate 1. The 6-inch-diameter borings were drilled with truck-mounted rotary-wash-type equipment. All field work was performed under the direction of one of our engineers, who logged the borings, classified the soils, and extracted undisturbed samples at approximately 5-foot intervals in the borings. Eight of the test borings were drilled in the proposed Unit 7 area, 2 in the proposed Tank area, and 1 in the Switchyard area. The total footage was 760 feet.

Undisturbed samples were recovered using the Dames & Moore piston sampler and soil sampler, Type U, shown on Plates A4A and A4B. The piston sampler, which minimizes sample disturbance, was used primarily in the cohesive soils. The type U drive sampler was used in the more dense sands. Standard penetration tests (ASTM 1586-64T) were also made in the sand strata to obtain additional information on the density of the formations. The Logs of Borings are presented on Plates A1A through A1J. The Soil Classification and Plasticity Chart is presented on Plate A1L. The type of sampler used along with the number of blows required to drive the sampler one foot are shown to the left of the soil graph. The driving mechanisms are described on Plate A1K.

LABORATORY TESTING

All samples recovered in the field were inspected and visually classified by our field engineer. The piston samples were extruded from the sampling tubes and packaged in the field to reduce disturbance. All samples were further examined in the laboratory, and a testing program was prepared. Unit weights and moisture contents were measured on all samples.

The laboratory testing can be divided into three parts:

1. Identification Tests - Grain-size analyses, Atterberg limits and Specific Gravity determinations. The grain-size analyses consisted of hydrometer analyses on fine-grained soils (cohesive) and sieve analyses for the coarse-grained sandy soils. The results are presented on Plates A2A through A2C, Grain-Size Distribution.

The Atterberg limits and Specific Gravity determinations are presented on the boring logs.

2. Strength Tests - Seventeen unconsolidated-undrained triaxial tests were performed on samples of the upper and the lower clay strata. Eleven direct shear tests were performed on samples of the sand strata. The tests were performed at a slow strain rate to simulate free-draining conditions. In addition, a three-stage multiphase triaxial test with pore pressure measurements was performed on a sample of the upper sands. The results of this test include strength parameters for total and effective stress conditions.

All strength tests were strain controlled. The results of all strength tests are presented on the logs of borings.

3. Consolidation Tests - Fourteen consolidation tests were performed on samples of the upper and lower clay strata, and the results are presented on Plates A3A through A3E.

The following plates are attached and complete this appendix:

Plate A1A - Log of Boring (Boring 1)
Plate A1B - Log of Boring (Boring 2)
Plate A1C - Log of Boring (Boring 3)
Plate A1D - Log of Boring (Boring 4)
Plate A1E - Log of Boring (Boring 5)
Plate A1F - Log of Boring (Boring 6)
Plate A1G - Log of Boring (Boring 7)
Plate A1H - Log of Boring (Boring 8)
Plate A1I - Log of Boring (Boring 9)
Plate A1J - Log of Borings (Borings 10 and 11)
Plate A1K - Key to Test Data
Plate A1L - Soil Classification and Plasticity Chart
Plate A2A - Grain-Size Distribution
Plate A2B - Grain-Size Distribution
Plate A2C - Grain-Size Distribution
Plate A3A - Consolidation Test Data
Plate A3B - Consolidation Test Data
Plate A3C - Consolidation Test Data
Plate A3D - Consolidation Test Data
Plate A3E - Consolidation Test Data
Plate A4A - Dames & Moore Piston Sampler
Plate A4B - Dames & Moore Type U Soil Sampler

BORING I

DRILLED 4/10-11/68

COORDINATES: N 32 + 59
E 20 + 36

TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_N or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
		DS/CU		500	540			7	100	U	30
		DS/CU		1000	830			29	90	P	
C	A 3A	TX/UU	2470	1440		72	21	29	93	P	
		TX/UU	1460	1440				20	105	P	
								20	97	P	
		DS/CD		2000	1900			26	101	U	39
										SP	93
SA (10%)	A 2B	DS/CD		3000	2745			29	95	U	39
										SP	96
		DS/CD		4000	3955			26	97	U	82
										SP	68
								34	89	U	34
								35	85	U	45
								36	85	U	45
								39	82	U	25
		TX/UU	5540	4320				32	91	U	40
								34	89	U	82
SA (9%)	A 2B							34	90	U	129
										SP	66
								34	89	U	56
								20	94	U	28
								19	112	U	180
										SP	250
SA (0%)	A 2B							20	102	U	145
										SP	270/7"
								24	102	U	227
								26	100	U	195
								21	108	U	130

ELEVATION IN FEET: +10, 0, -10, -20, -30, -40, -50, -60, -70, -80, -90, -100, -110, -120

ELEVATION +8.1'

SM	DARK GRAYISH-BROWN SAND, SOME SILT
SP	BROWN FINE TO MEDIUM SAND (LOOSE) (WATER LEVEL 4-15-68) — FILL
PT	BLACK PEAT (VERY SOFT)
CH	GRAY SILTY CLAY WITH SMALL POCKETS OF BROWN SILT, AND SOME ORGANIC MATTER (ROOTS, WOOD FRAGMENTS) (MEDIUM STIFF)
CH	BROWNISH-GRAY SILTY CLAY (MEDIUM STIFF TO STIFF) (GRADING SOME FINE SAND) (GRADING STIFF)
SP	GRAY FINE TO MEDIUM SAND (DENSE TO VERY DENSE)
	(GRADING VERY DENSE)
	(GRADING SOME SILT)
CL	BROWNISH-GRAY SILTY CLAY, TRACE OF FINE SAND (STIFF)
	(GRADING MORE CLAY) (SOME GRAVEL)
SP	(THIN LAYER OF FINE SAND)
	(GRADING MOTTLED GRAY AND BROWN)
	(GRADING VERY STIFF)
	(GRADING SANDIER)
SP	BROWNISH-GRAY MEDIUM TO FINE SAND (DENSE TO VERY DENSE)
CL	BROWNISH-GRAY SILTY CLAY (VERY STIFF) (GRADING WITH TRACE OF FINE SAND)
SP	GRAY MEDIUM TO FINE SAND (VERY DENSE)
	(GRADING BROWN) (GRADING MORE FINE SAND)
	(TRACE OF GRAVEL)
SM	GRAY FINE SAND, SOME SILT (SOME CEMENTATION) (VERY DENSE)

LOG OF BORINGS

DAMES & MOORE

PLATE A IA

BORING 2

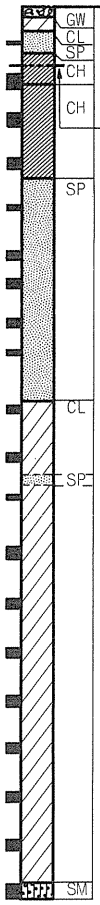
DRILLED 4/11-12/68

COORDINATES: N 30 + 65
E 21 + 40

TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_s, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
								4	100	U	21
		TX/UU	2440	720				22	104	P	
								22	104	P	
		TX/UU	3750	2160				22	102	P	
(4%)								24	101	U	43
										SP	57
SA (4%)	A 2B	DS/CD		4000	4245			25	101	U	100
										SP	78
								31	93	U	60
										SP	31
C G = 2.78	A 3C					43	23	33	90	P	
								33	89	U	58
								33	89	P	
C G = 2.78	A 3C	TX/UU	8320	5760		55	26	32	91	P	
(94%)								30	93	TW	42
HA	A 2A							29	95	TW	42
								29	96	TW	48
								29	96	TW	49
								28	97	TW	65
								22	106	TW	135

ELEVATION IN FEET: +10, 0, -10, -20, -30, -40, -50, -60, -70, -80, -90, -100

ELEVATION +8.3'



GW BROWN SANDY GRAVEL, SOME SILT — FILL
CL BROWN SILTY CLAY
SP GRAY MEDIUM TO FINE SAND (LOOSE)
CH GRAY SILTY CLAY, TRACE OF ORGANIC MATTER (ROOTS)
(SOFT TO MEDIUM STIFF)
CH LIGHT BROWN SILTY CLAY (STIFF)
(WATER LEVEL 4-15-68)
(GRADING SOME FINE SAND)
(GRADING GRAY AND SANDIER)
SP GRAY MEDIUM TO FINE SAND (DENSE)
CL BROWN SILTY CLAY (STIFF)
(GRADING LESS CLAY AND SOME FINE SAND)
SP (ONE FOOT THICK GRAVEL AND SAND LAYER)
(SEAMS OF FINE SAND)
(GRADING MORE CLAY)
(GRADING BLUISH-DARK GRAY)
(GRADING HARD)
(GRADING MORE SILT)
(GRADING SOME FINE SAND)
(GRADING MORE CLAY)
SM GRAY AND BROWN MEDIUM TO FINE SAND, SOME SILT
(VERY DENSE)

LOG OF BORINGS

DAMES & MOORE

PLATE A 1B

BORING 3

DRILLED 4/12/68

COORDINATES: N 34 + 40
E 19 + 60

ELEVATION IN FEET	TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
+10									9	96	U	25
			DS/CU		800	830			24	170	U	5
0	HA	A 2A	TX/UU	1570	720				24	103	P	
	C	A 3A					72	21	29	96	P	
	G = 2.77											
-10									27	97	P	
	SA (4%)	A 2B	DS/CD		2000	2170			25	103	U	65
-20											SP	68
	(2%)								34	88	U	106
-30											SP	83
									31	93	TW	83
-40									34	87	TW	53
									43	78	TW	56
-50			TX/UU	4800	4320				34	88	TW	50
									25	101	U	59
-60									27	98	TW	64
									30	95	U	64
-70									34	88	U	50
-80									20	111	U	136
-90												

ELEVATION +8.6'

GW	BROWNISH-GRAY SANDY GRAVEL, SOME SILT	FILL
SP	DARK GRAY FINE SAND, TRACE OF SILT (LOOSE)	
PT	DARK BROWN PEAT (SOFT)	
CH	GRAY AND BROWNISH-GRAY SILTY CLAY	
	(TRACE OF ORGANIC MATTER AT TOP OF STRATUM)	
	(MEDIUM STIFF)	
	(MOTTLED BLUISH-GRAY WITH WHITE STREAKS)	
	(GRADING TRACE OF FINE SAND)	
	(GRADING SANDIER)	
SP	GRAY FINE TO MEDIUM SAND (DENSE TO VERY DENSE)	
	(GRADING VERY DENSE)	
	(GRADING SOME GRAVEL AND CLAY)	
CL	BROWNISH-GRAY SILTY CLAY (STIFF)	
	(BROWN STREAKS)	
	(THIN LAYER OF FINE SAND)	
	(GRADING SOME FINE SAND)	
	(GRADING DARK GRAY)	
	(GRADING VERY STIFF)	
	(GRADING BROWNISH-GRAY)	
	(GRADING BLUISH-GRAY)	
SM	BROWNISH-GRAY MEDIUM TO FINE SAND, SOME SILT	
	(DENSE TO VERY DENSE)	
	(SILT LENSES)	
SP	BROWN MEDIUM TO FINE SAND (VERY DENSE)	

LOG OF BORINGS

DAMES & MOORE

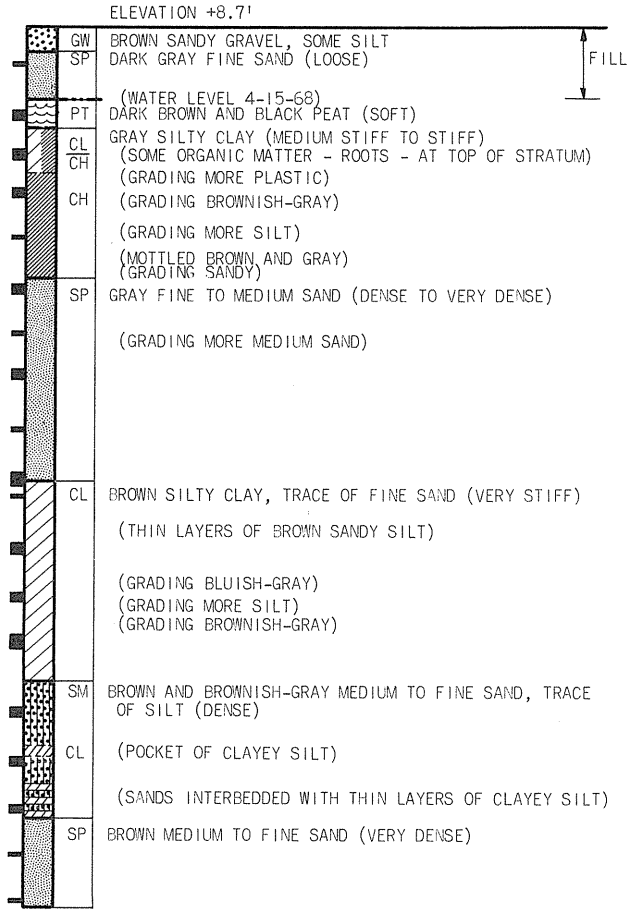
PLATE A IC

BORING 4

DRILLED 4/12-13/68

COORDINATES: N 33 + 35
E 18 + 50

TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS (σ_1-σ_3) IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT	ELEVATION IN FEET
								22	87	U	19	+10
								150	27	P		0
C	A 3A	TX/UU	1930	720		43	19	25	103	P		
G = 2.73		TX/UU	2080	720		72		29	93	P		
						33		29	93	P		-10
								30	93	P		
SA (1%)	A 2B	TX/CU	20840	5040				5	120	U	123	-20
		PP/MØ	28770	6680						SP	75	
(4%)		DS/CD		4000	3800			27	97	U	128	-30
C	A 3C					40	25	38	85	SP P	30	-40
HA	A 2A							34	88	TW	85	
								30	94	TW	31	-50
		TX/UU	6450	5760				30	94	P		
								32	91	TW	98	-60
								34	87	TW	50	-70
								37	85	TW	64	
								21	107	U	130	-80
								21	105	U	140	-90



LOG OF BORINGS

DAMES & MOORE

PLATE A ID

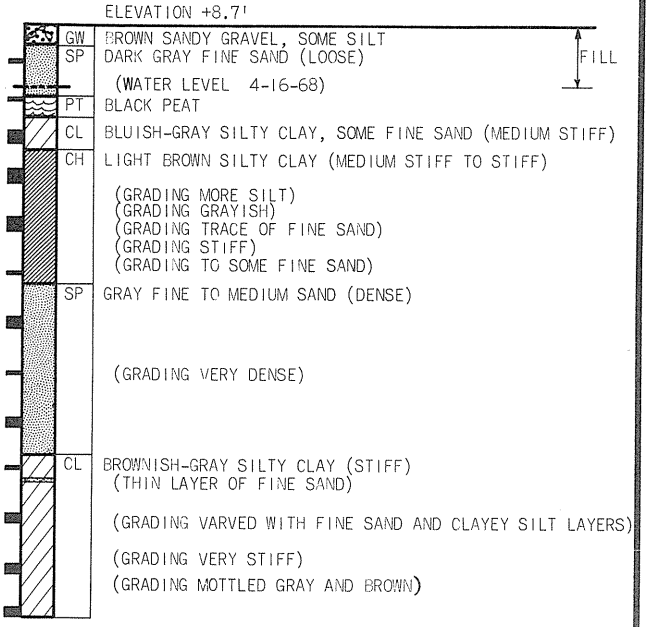
BORING 5

DRILLED 4/15/68

COORDINATES: N 32 + 85
E 19 + 70

TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
								10	101	U	29
								150	30	U	6
C	A 3B	TX/UU	2520	1440		29	13	23	104	P	
C	A 3B					70	19	35	88	P	
		TX/UU	3680	2160				25	99	P	
(69%)								28	95	U	33
(8%)										SP	47
(4%)								24	101	U	88
										SP	64
								35	87	U	33
								36	85	TW	57
								38	84	TW	76
								33	90	P	

ELEVATION IN FEET: +10, 0, -10, -20, -30, -40, -50, -60



LOG OF BORINGS

DAMES & MOORE

PLATE A IE

BORING 6

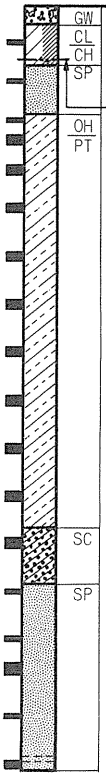
DRILLED 4/16/68

COORDINATES: N 28 + 50
E 16 + 75

TESTS REPORTED ELSEWHERE		SHEAR TEST DATA				ATTERBERG LIMITS				(3)	(4)
(1) TYPE OF TEST	SECTION OF APPENDIX	(1) TYPE OF TEST	DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	(2) σ_n or σ_3, IN PSF	PEAK SHEAR STRENGTH IN PSF	LIQUID LIMIT IN %	PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	TYPE OF SAMPLER	BLOWS/FOOT
								20	108	U	18
								51	76	U	7
								86	51	U	4
C	A 3E					134	90	173	28	P	
								137	36	P	
		TX/UU	1080	1440				95	45	P	
								62	63	P	
								700	11	P	
								700	11	P	
G = 2.72											
C	A 3E	TX/UU	1030	2880		73	45	76	53	P	
HA	A 2C							91	47	P	
								76	68	P	
(33%)		DS/CD		3000	2120			25	101	P	
								27	99	U	46
SA	A 2C	DS/CD		4000	3150			28	97	U	45
										SP	98
								29	95	U	98
										SP	185

ELEVATION IN FEET: +10, 0, -10, -20, -30, -40, -50, -60, -70, -80

ELEVATION +6.5'



GW BROWN SANDY GRAVEL, SOME SILT
CL BLACK SILTY CLAY WITH MEDIUM SAND LENSES AND SOME SMALL ROOTS (MEDIUM STIFF)
CH
SP DARK GRAY FINE SAND WITH POCKETS OF PEAT AND FRAGMENTS OF WOOD. ROOTS
WATER LEVEL(4-16-68)
FILL
OH DARK GRAY AND BLACK SILTY CLAY WITH ORGANIC MATTER
PT AND PEAT POCKETS (VERY SOFT TO SOFT)

SC DARK GRAY CLAYEY FINE TO MEDIUM SAND (DENSE)
(GRADING LESS CLAY)
SP DARK GRAY FINE TO MEDIUM SAMD, TRACE OF SILT (MEDIUM DENSE TO DENSE)
(THIN LENSES OF CLAY)
(GRADING VERY DENSE)
(LENS OF COARSE SAND)

LOG OF BORINGS

DAMES & MOORE

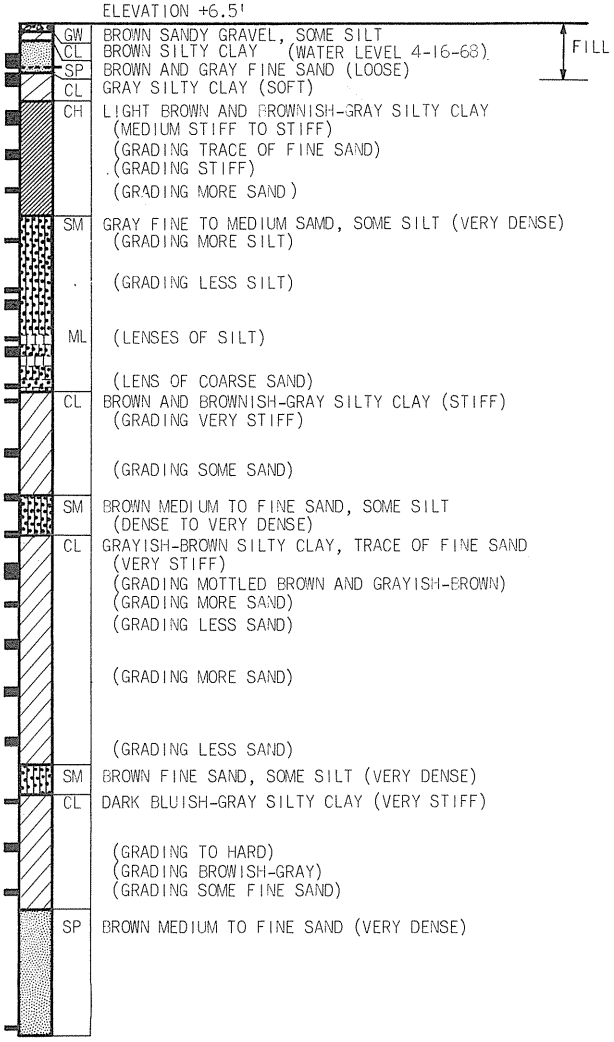
PLATE A IF

BORING 7

DRILLED 4/16-17/68
COORDINATES: N 31 + 50
E 20 + 70

TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA (1) DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
										U	4
G = 2.72		TX/CU	2620	800		35		22	101	P	
HA	A 2A										
C	A 3B					67	23	22	105	P	
		TX/UU	4040	2160				23	99	P	
								28	96	P	
(42%)								30	91	P	
(7%)								28	97	U	65
(24%)										SP	61
(28%)		DS/CD		4000	3700			30	93	U	109
										SP	84
								31	97	U	86
										SP	60
C	A 3D	TX/UU	4360	4320		38	25	33	90	P	
										P	
								33	89	U	60
								32	91	P	
C	A 3D	TX/UU	8600	4320		50	26	34	89	P	
G = 2.81											
								31	90	P	
								27	99	P	
C	A 3D					41	25	33	90	P	
		TX/UU	4700	5040				30	93	U	58
								29	96	P	
								34	89	P	
										U	175/8"

ELEVATION IN FEET: +10, 0, -10, -20, -30, -40, -50, -60, -70, -80, -90, -100



LOG OF BORINGS

DAMES & MOORE

PLATE A IG

BORING 8

DRILLED 4/18/68

COORDINATES: N 15 + 40
E 31 + 50

TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA (1) DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS / FOOT	ELEVATION IN FEET
												+20
								12	88	U	8	+10
								17	101	U	13	
								54	65	P		
								103	44	P		0
								28	97	U	25	
		DS/CD		1000	935			38	83	U	23	-10
								263	19	U	7	
								280	23	P		
								30	94	P		-20
		TX/UU	2920	2880				24	98	P		
								31	93	P		-30
								26	95	P		
								20	108	P		-40
												-50

ELEVATION +13.0'

ML	BROWN SANDY SILT	FILL
SP	BROWN MEDIUM TO FINE SAND, TRACE OF SILT (MEDIUM DENSE)	
OH PT	MOTTLED GRAY AND BLACK CLAY AND PEAT (LARGE AMOUNT OF ROOTS, DECAYED GRASS, WOOD FRAGMENTS) (GRADING SILTY)	
SP	DARK GRAY FINE SAND, TRACE OF SILT (MEDIUM DENSE TO DENSE)	
PT	DARK BROWN PEAT (VERY SOFT)	
CH	GRAY SILTY CLAY (STIFF)	
CL	BROWN SILTY CLAY WITH WHITE SAND STREAKS (STIFF) (GRADING SANDY)	
SM	BROWNISH-GRAY FINE SAND AND SILT (DENSE)	

LOG OF BORINGS

DAMES & MOORE

PLATE A-1H

BORING 9

DRILLED 4/18/68

COORDINATES: N 16 + 60
E 32 + 50

TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA (1) DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_1 or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
								9	112	U	20
								29	98	U	5
										P	
								110	41	P	
								25	102	U	23
		DS/CD		2000	1545			21	107	U	20
										SP	20
								28	97	U	24
		TX/UU	1890	2880				25	100	P	

ELEVATION IN FEET: +20, +10, 0, -10, -20, -30

ELEVATION +12.0'

SM	BROWN SILTY SAND (MEDIUM DENSE) (ROOTS ENCOUNTERED AT UPPER TWO FEET) (GRADING TO MEDIUM TO FINE SAND) (SOME GRAVEL)	FILL
PT	DARK BROWN PEAT (SOFT)	
SP	GRAY MEDIUM TO FINE SAND, TRACE OF CLAY (MEDIUM DENSE) (GRADING MORE CLAY)	
CL	BROWNISH-GRAY AND BROWN SILTY CLAY (STIFF) (THIN LAYERS OF WHITE FINE SAND AT UPPER PORTION OF STRATUM)	

LOG OF BORINGS

DAMES & MOORE

PLATE A II

BORING 10

DRILLED 4/17/68
COORDINATES: N 34 + 50
E 20 + 20

ELEVATION IN FEET	TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
+10									8	88	U	10
			TX/CU	1260	800				320	16	P	
0			DS/CU		800	70			24	102	P	
									25	102	P	
-10												
-20												

ELEVATION +8.1'

GW	BROWN SANDY GRAVEL, SOME SILT	FILL
CL	BROWN CLAY (SOFT)	
SP	GRAY FINE TO MEDIUM SAND	
PT	BLACK PEAT WITH LENSES OF GRAY CLAY (VERY SOFT)	
CH	GRAY SILTY CLAY (SOFT TO MEDIUM STIFF)	
	(TRACE OF ORGANIC MATTER AT TOP OF STRATUM)	
	(GRADING STIFF)	
	(GRADING BROWNISH-GRAY)	

BORING 11

DRILLED 4/17/68
COORDINATES: N 33 + 70
E 19 + 52

ELEVATION IN FEET	TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
+10									10	98	U	30
			DS/CU		500	750			280	17	P	
0			DS/CU		1000	720			105	41	P	
									26	97	P	
-10												
-20												

ELEVATION +8.1'

GW	BROWN SANDY GRAVEL, SOME SILT	FILL
CL	BROWN GRAVELLY CLAY (SOFT)	
SM	BROWN FINE SAND, SOME SILT	
	(GRADING CLAYEY)	
PT	BLACK PEAT (VERY SOFT)	
CH	GRAY SILTY CLAY WITH SOME ORGANIC MATTER (ROOTS)	
	(SOFT TO MEDIUM STIFF)	

LOG OF BORINGS

DAMES & MOORE

PLATE A IJ

SYMBOL	TYPE OF TEST (1)
M	MOISTURE
QD	QUICK MD TEST BASED ON ASSUMED SPECIFIC GRAVITY
MD	MOISTURE-DENSITY
CD	CHUNK DENSITY ON BULK SAMPLE
RD	RELATIVE DENSITY
COMP	COMPACTION CURVE
CI	CALIFORNIA IMPACT TEST
CC	COMPACTED CORE
G	SPECIFIC GRAVITY
P^H	HYDROGEN ION CONCENTRATION
MA	MECHANICAL ANALYSIS *
SA (10%)	SIEVE ANALYSIS (+200 ONLY) — INDICATES PERCENT PASSING #200 SIEVE
HA	HYDROMETER ANALYSIS (-200 ONLY)
AL	ATTERBERG LIMITS (LL & PL)
SL	SHRINKAGE LIMIT
FS	FREE SWELL
SS	SHRINK-SWELL
EXP	EXPANSION
C	CONSOLIDATION
VC	VIBRATING CONSOLIDATION TEST
P	PERMEABILITY
UC	UNCONFINED COMPRESSION
	TRIAXIAL COMPRESSION:
TX/UU	1. UNCONSOLIDATED-UNDRAINED
TX/CU	2. CONSOLIDATED-UNDRAINED
TX/CU/MΦ	3. CU/MULTIPHASE **
TX/CU/PP	4. CU/ WITH PORE PRESSURE MEASUREMENTS
TX/CD	5. CONSOLIDATED-DRAINED
	DIRECT SHEAR TEST:
DS/UU	1. UNCONSOLIDATED-UNDRAINED
DS/CU	2. CONSOLIDATED-UNDRAINED
DS/CD	3. CONSOLIDATED-DRAINED
DS/CD/MΦ	4. CD/MULTIPHASE **
TV	TORVANE SHEAR (LAB VANE SHEAR)

* INCLUDES COMPLETE ANALYSIS, SIEVING AND HYDROMETER
** SERIES OF TESTS RUN ON ONE SAMPLE

STRENGTH CHARACTERISTICS OF COHESIVE SOILS
AS DETERMINED BY UNCONSOLIDATED UNDRAINED SHEAR TESTS

TERM	SHEAR STRENGTH (LBS./SQ. FT.)
VERY SOFT	0 TO 250
SOFT	250 TO 500
MEDIUM STIFF	500 TO 1,000
STIFF	1,000 TO 2,000
VERY STIFF	2,000 TO 4,000
HARD	OVER 4,000

RELATIVE DENSITY OF COHESIONLESS SOILS

TERM	BLOWS PER FOOT *
VERY LOOSE	0 - 4
LOOSE	5 - 10
MEDIUM DENSE OR COMPACT	11 - 30
DENSE	31 - 50
VERY DENSE	OVER 50

* BLOWS ARE MEASURED WITH 2-INCH O.D., 1-3/8-INCH I.D. SAMPLER DRIVEN 1 FOOT BY 140 POUND HAMMER FALLING 30 INCHES AFTER SAMPLER HAS BEEN SEATED 6 INCHES. SEE "TENTATIVE METHOD FOR PENETRATION TEST AND SPLIT-BARREL SAMPLING OF SOILS", ASTM DESIGNATION D1586-64T.

KEY TO SAMPLES

▣ - INDICATES DEPTH OF SAMPLE

⊠ - INDICATES DEPTH OF SAMPLING ATTEMPT WITH NO RECOVERY

TYPES OF SOIL SAMPLERS (3)

P - PISTON SAMPLER

U - D & M UNDERWATER SAMPLER TYPE U ON 265 POUND SLIP-JARS FALLING APPROX. 30"

TW - D & M UNDERWATER SAMPLER TYPE U WITH THIN-WALLED SAMPLING TUBE ON 265 POUND SLIP-JARS FALLING APPROX. 30"

SP - STANDARD PENETRATION TEST * (SEE ABOVE) 140 POUND WEIGHT FALLING 30 INCHES

NOTES ON LOGS:

(1) TYPE OF TEST (SEE TABLE ABOVE)

(2) σ_N OR σ_3, IN PSF
σ_N = NORMAL PRESSURE IN DIRECT SHEAR TEST
σ_3 = LATERAL CONFINING PRESSURE IN TRIAXIAL COMPRESSION TEST AT PEAK DEVIATOR STRESS. IN TESTS WITH PORE PRESSURE MEASUREMENTS, THE EFFECTIVE STRESSES, σ_1 AND σ_3 ARE GIVEN FOR MAXIMUM PRINCIPLE STRESS RATIO.

(3) TYPE OF SAMPLER: (SEE TABLE AT LOWER RIGHT)

(4) BLOWS/FOOT: LAST 12 INCHES OUT OF 18 INCHES DRIVEN OR AS INDICATED

KEY TO TEST DATA

DAMES & MOORE
APPLIED EARTH SCIENCES

PLATE AIK

REVISIONS BY DATE

BY DATE FILE

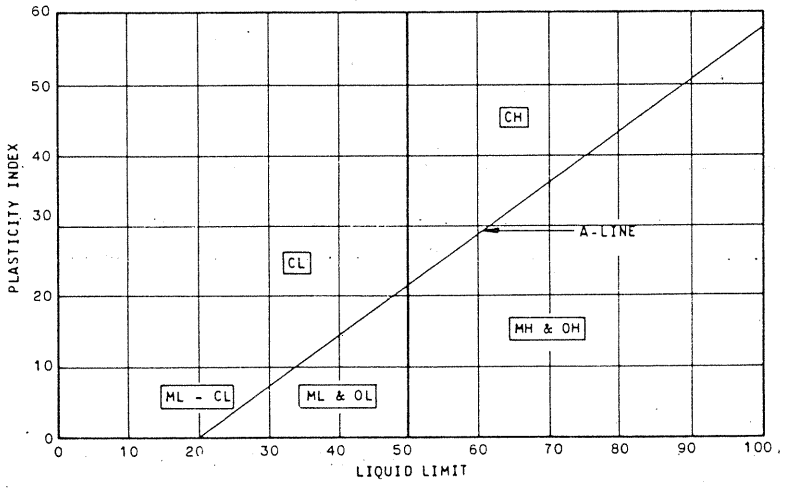
CHECKED BY DATE

SYMBOL	LETTER	DESCRIPTION	MAJOR DIVISIONS		
	GW	WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	CLEAN GRAVELS (little or no fines)	GRAVELS — MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	COARSE-GRAINED SOILS — MORE THAN HALF OF MATERIAL IS LARGER THAN NO.200 SIEVE SIZE
	GP	POORLY-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES			
	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	GRAVELS WITH FINES (appreciable amount of fines)		
	GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES			
	SW	WELL-GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES	CLEAN SANDS (little or no fines)	SANDS — MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE.	
	SP	POORLY-GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES			
	SM	SILTY SANDS, SAND-SILT MIXTURES	SANDS WITH FINES (appreciable amount of fines)		
	SC	CLAYEY SANDS, SAND-CLAY MIXTURES			
	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50		FINE-GRAINED SOILS — MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE
	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS			
	OL	ORGANIC SILTS AND ORGANIC SILT-CLAYS OF LOW PLASTICITY			
	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50		
	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS			
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS			
	PT	PEAT AND OTHER HIGHLY ORGANIC SOILS	HIGHLY ORGANIC SOILS		

for visual classification, the ¼" size may be used as equivalent to the no. 4 sieve size.

the no. 200 sieve size is about the smallest particle visible to the naked eye

SOIL CLASSIFICATION CHART
UNIFIED SOIL CLASSIFICATION SYSTEM



PLASTICITY CHART

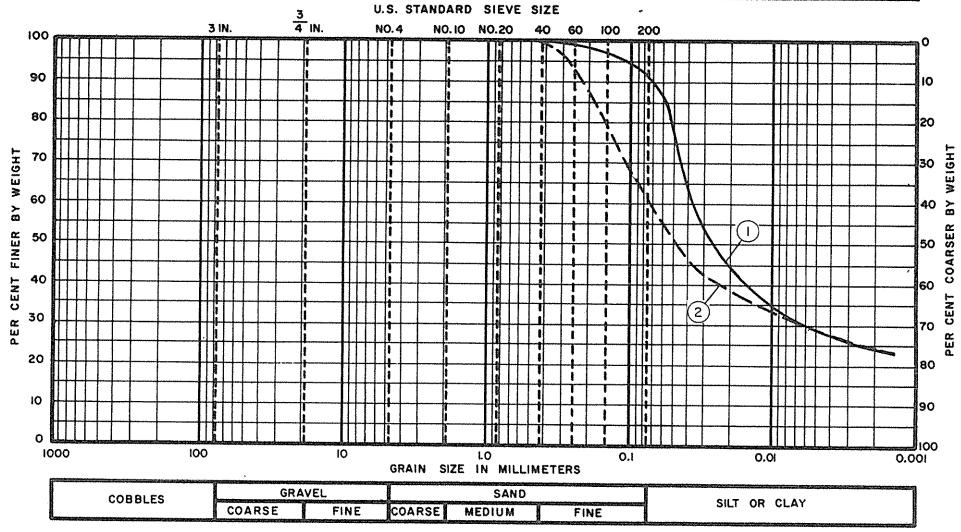
SOIL CLASSIFICATION CHART & KEY TO TEST DATA

DAMES & MOORE
APPLIED EARTH SCIENCES

PLATE A IL

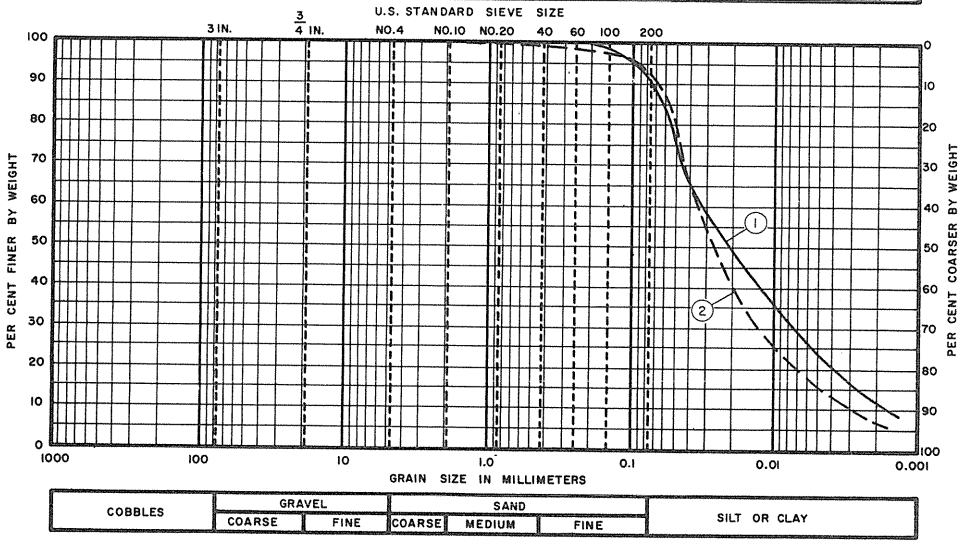
REV. 1-71)

BORING	DEPTH	ELEV	SAMPLE	LIQUID LIMIT	PLASTIC LIMIT	SOIL CLASSIFICATION	DESCRIPTION	KEY
3	12.5'	-3.9'	3	–	–	CH	GRAY & BROWNISH GRAY SILTY CLAY	①
7	10.5'	-4.0'	3	67%	23%	CH	LIGHT BROWN & BROWNISH-GRAY SILTY CLAY	②



STRATUM NO. 1 : UPPER CLAYS

BORING	DEPTH	ELEV.	SAMPLE	LIQUID LIMIT	PLASTIC LIMIT	SOIL CLASSIFICATION	DESCRIPTION	KEY
2	72.5'	-64.3'	16	–	–	CL	BROWN SILTY CLAY	①
4	54.5'	-45.8'	12	–	–	CL	BROWN SILTY CLAY, TRACE OF FINE SAND	②



STRATUM NO. 3 : LOWER CLAYS

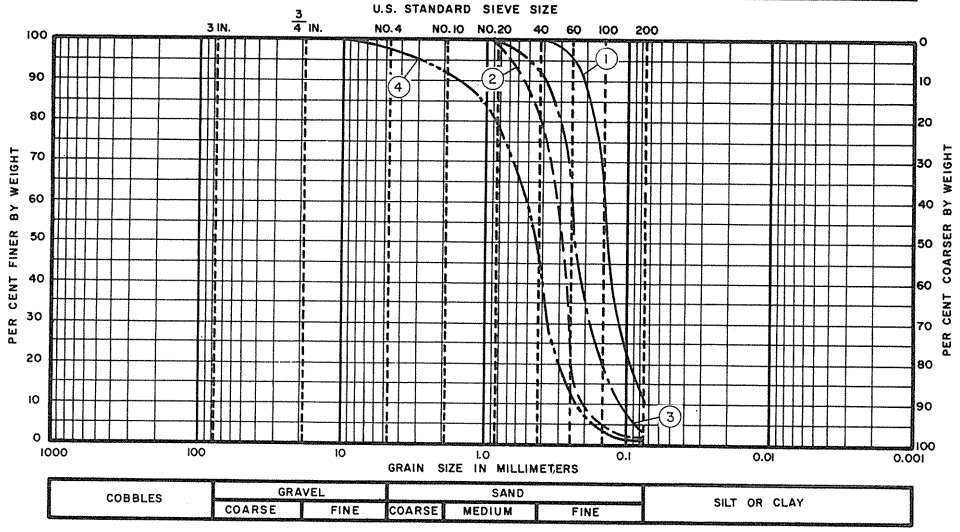
GRAIN-SIZE DISTRIBUTION

(UNIFIED SOIL CLASSIFICATION SYSTEM)

DAMES & MOORE

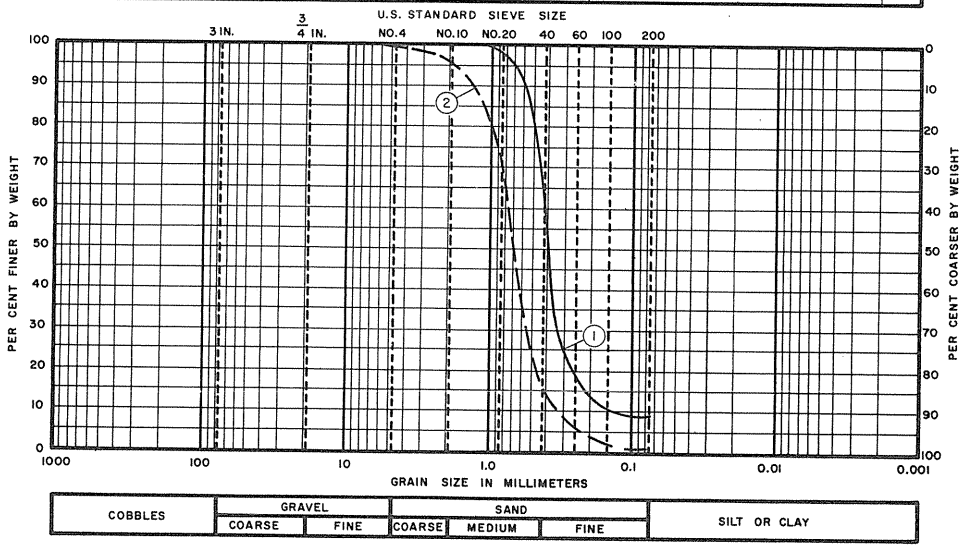
PLATE A 2A

BORING	DEPTH	ELEV	SAMPLE	LIQUID LIMIT	PLASTIC LIMIT	SOIL CLASSIFICATION	DESCRIPTION	KEY
1	31'	-22.9'	8	–	–	SP	GRAY FINE SAND	(1)
2	29.3'	-21.0'	7	–	–	SP	GRAY MEDIUM TO FINE SAND	(2)
3	26.1'	-17.5'	6	–	–	SP	GRAY FINE TO MEDIUM SAND	(3)
4	32'	-23.3'	7	–	–	SP	GRAY MEDIUM TO FINE SAND	(4)



STRATUM NO. 2 : UPPER SANDS

BORING	DEPTH	ELEV.	SAMPLE	LIQUID LIMIT	PLASTIC LIMIT	SOIL CLASSIFICATION	DESCRIPTION	KEY
1	71'	-62.9'	18	–	–	SP	BROWNISH-GRAY MEDIUM TO FINE SAND, TRACE OF SILT	(1)
1	96'	-87.9'	24	–	–	SP	BROWN MEDIUM TO FINE SAND	(2)



STRATUM NO. 4 : LOWER SANDS

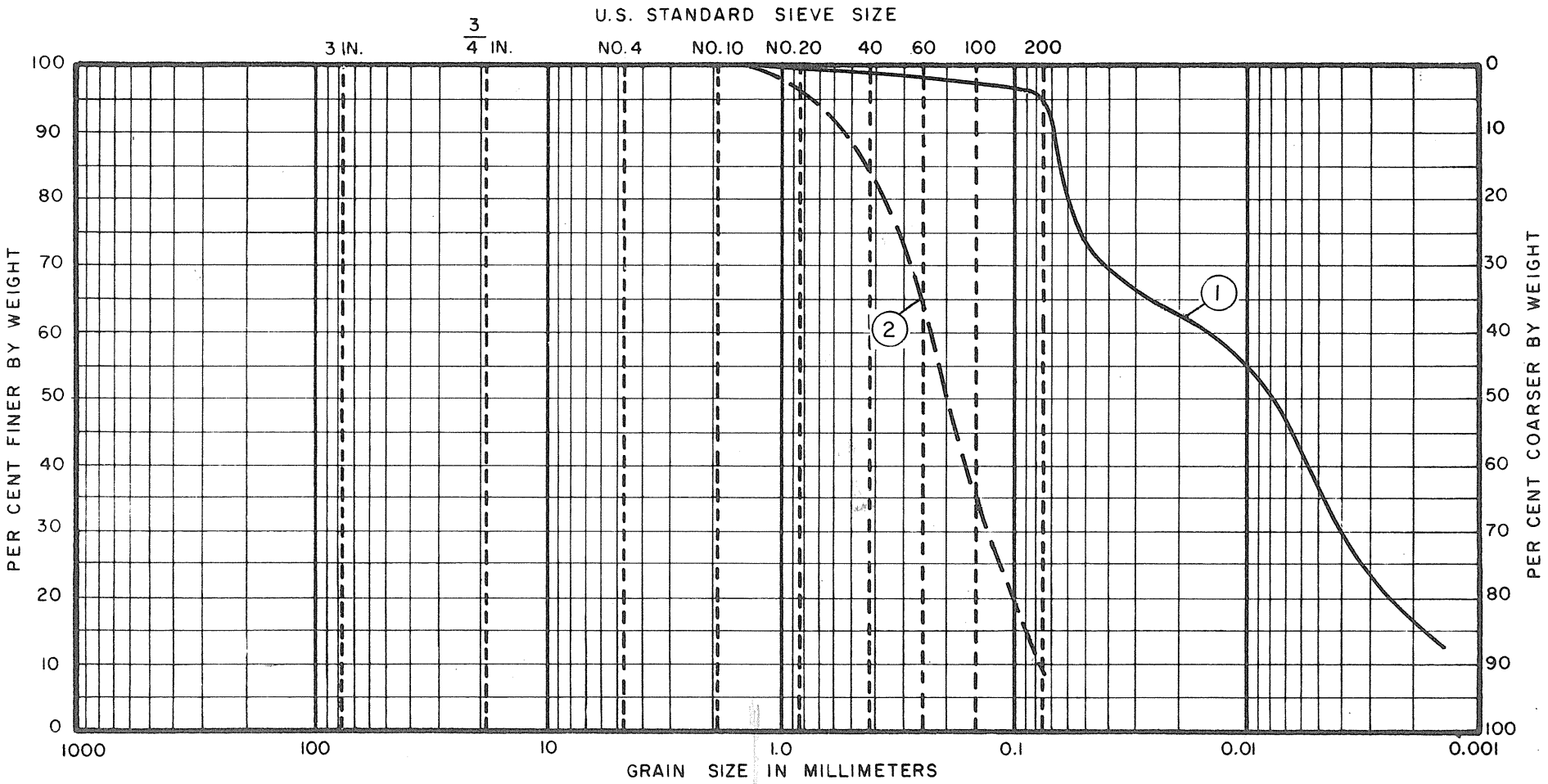
GRAIN-SIZE DISTRIBUTION

(UNIFIED SOIL CLASSIFICATION SYSTEM)

DAMES & MOORE

PLATE A 2B

BORING	DEPTH	ELEV.	SAMPLE	LIQUID LIMIT	PLASTIC LIMIT	SYMBOL	SOIL CLASSIFICATION	KEY
6	46.5'	-40.0'	11			OH/PT	BLACK ORGANIC SILTY CLAY WITH PEAT	(1)
6	66.5'	-60.0'	15			SP	DARK GRAY FINE TO MEDIUM SAND	(2)

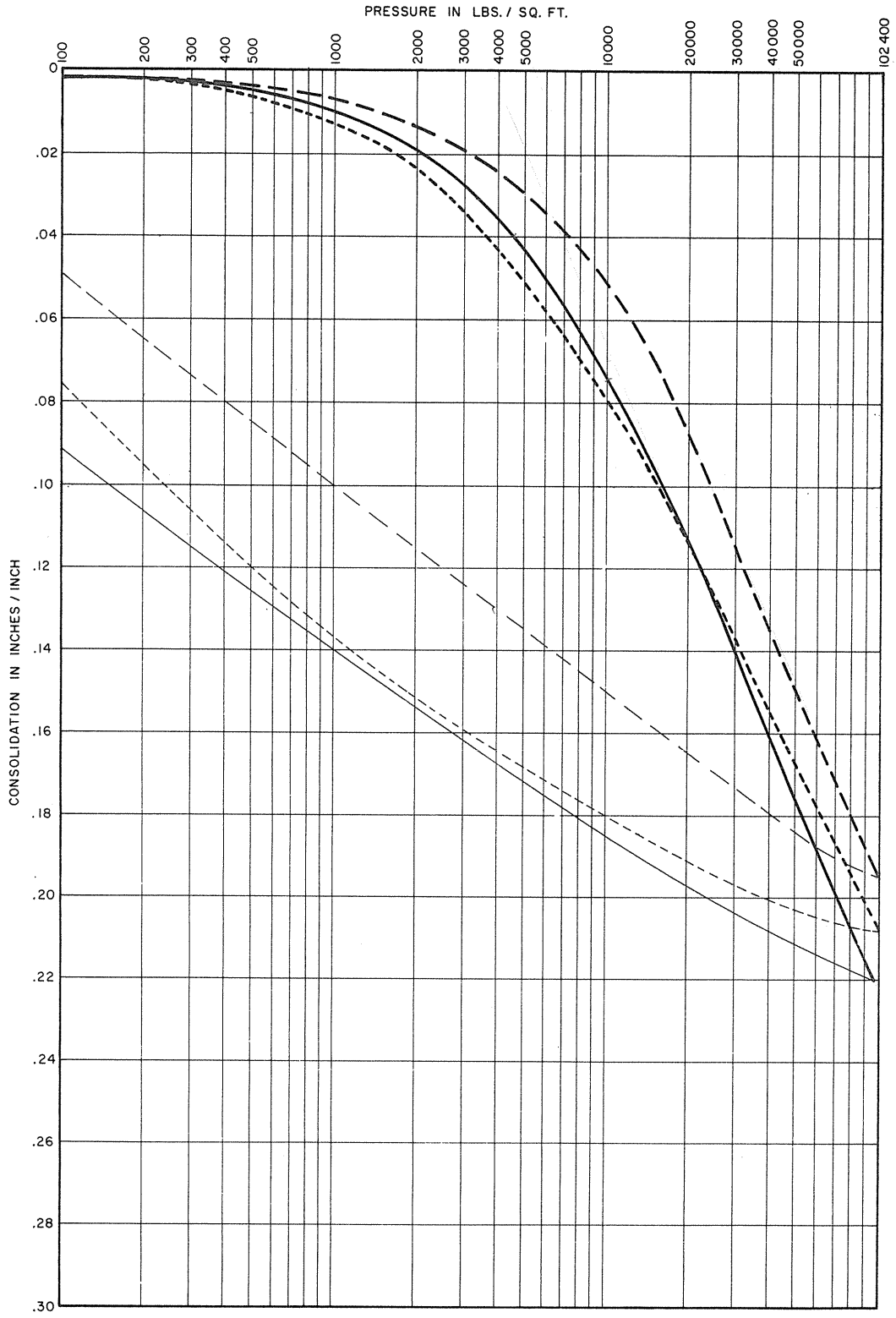


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

GRAIN-SIZE DISTRIBUTION
(UNIFIED SOIL CLASSIFICATION SYSTEM)

DAMES & MOORE
CONSULTANTS IN APPLIED EARTH SCIENCES
SOIL MECHANICS · ENGINEERING GEOLOGY · GEOPHYSICS

PLATE A 2C



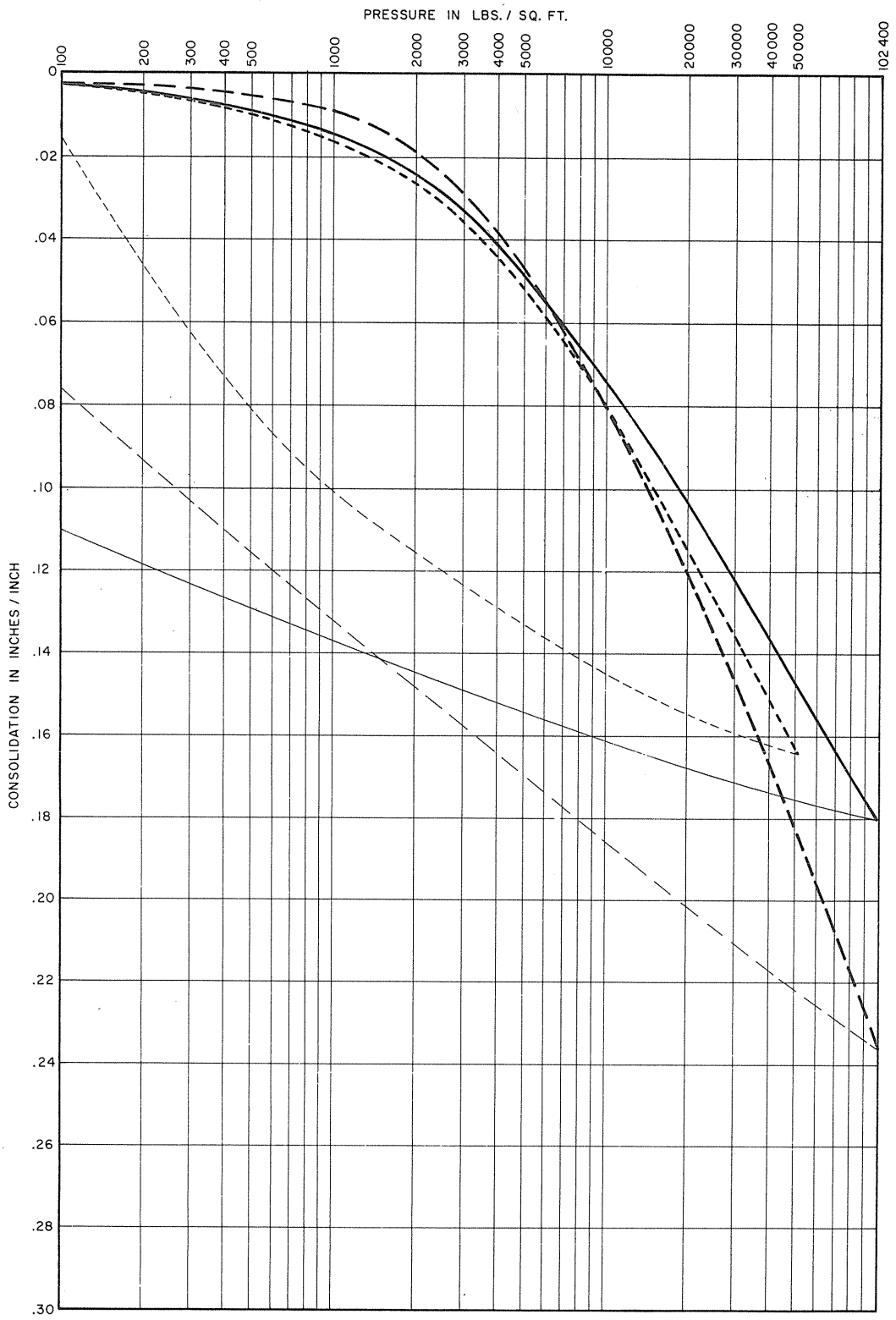
STRATUM NO. 1 : UPPER CLAYS

KEY	BORING	ELEV.	SOIL CLASSIFICATION	DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE, %		DRY DENSITY PCF		VOID RATIO		EFFECTIVE OVERBURDEN PRESSURE PSF	PRECONSOL. PRESSURE PSF
							BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER		
———	1	-4.4'	CH	BROWNISH-GRAY SILTY CLAY	72	21	29	26	93	102	0.86	0.70	1160	5500
— —	3	-8.0'	CH	GRAY & BROWNISH-GRAY SILTY CLAY	72	21	29	27	96	101	0.81	0.71	1310	9500
-----	4	-4.8'	CL	GRAY SILTY CLAY	43	19	25	22	103	112	0.68	0.55	1250	4100

CONSOLIDATION TEST DATA

DAMES & MOORE

PLATE A 3A



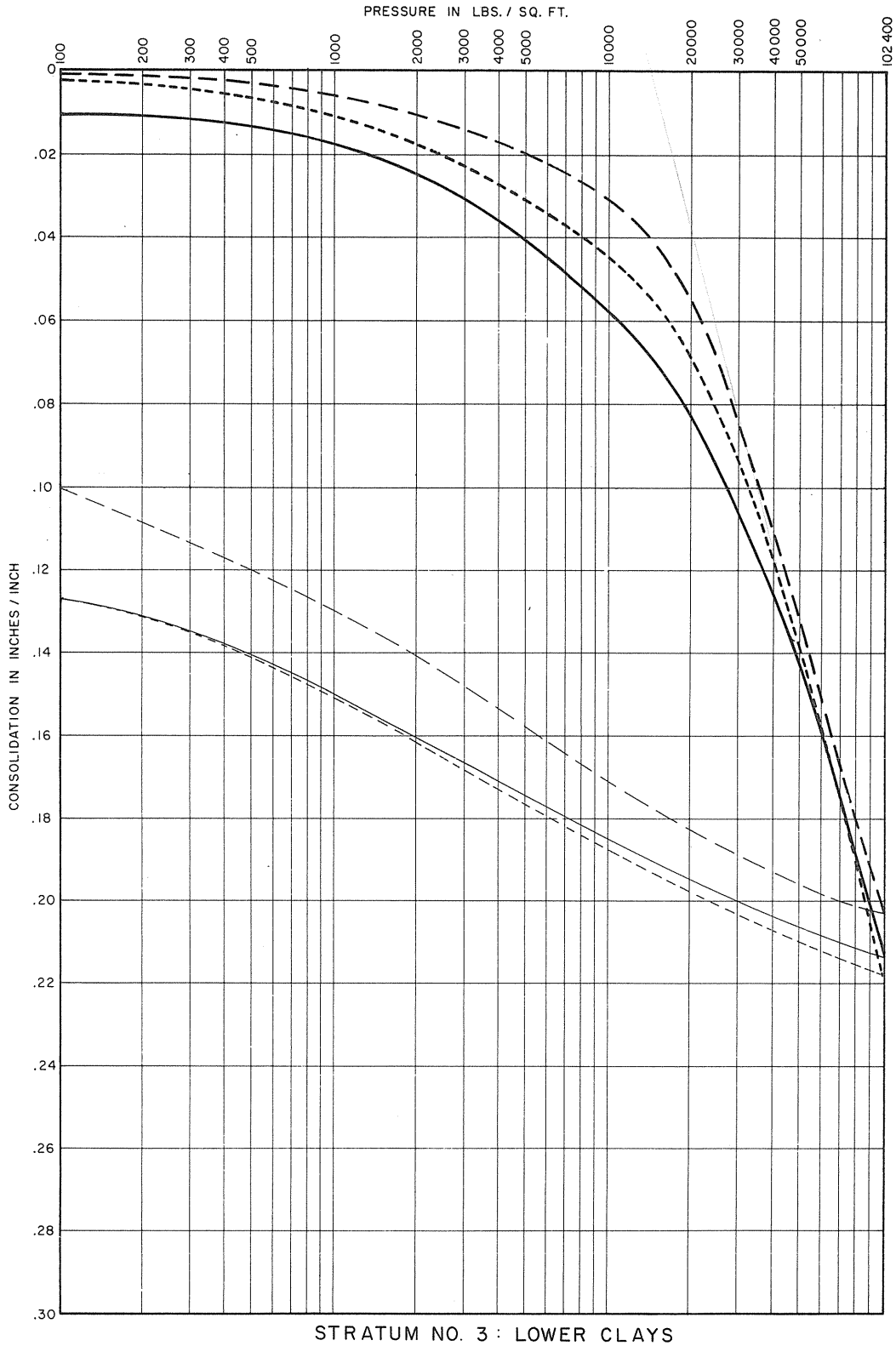
STRATUM NO. 1 : UPPER CLAYS

KEY	BORING	ELEV.	SOIL CLASSIFICATION	DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE, %		DRY DENSITY PCF		VOID RATIO		EFFECTIVE OVERBURDEN PRESSURE PSF	PRECONSOL. PRESSURE PSF
							BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER		
——	5	-3.8'	CL	BLUISH-GRAY SILTY CLAY, SOME FINE SAND	29	13	23	17	104	115	0.67	0.51	1180	4700
— —	5	-7.8'	CH	LIGHT BROWN SILTY CLAY	70	19	35	31	88	95	0.97	0.82	1440	5500
----	7	-4.0'	CH	LIGHT BROWN & BROWNISH-GRAY SILTY CLAY	67	23	22	25	105	107	0.66	0.63	970	4500

CONSOLIDATION TEST DATA

DAMES & MOORE

PLATE A 3B



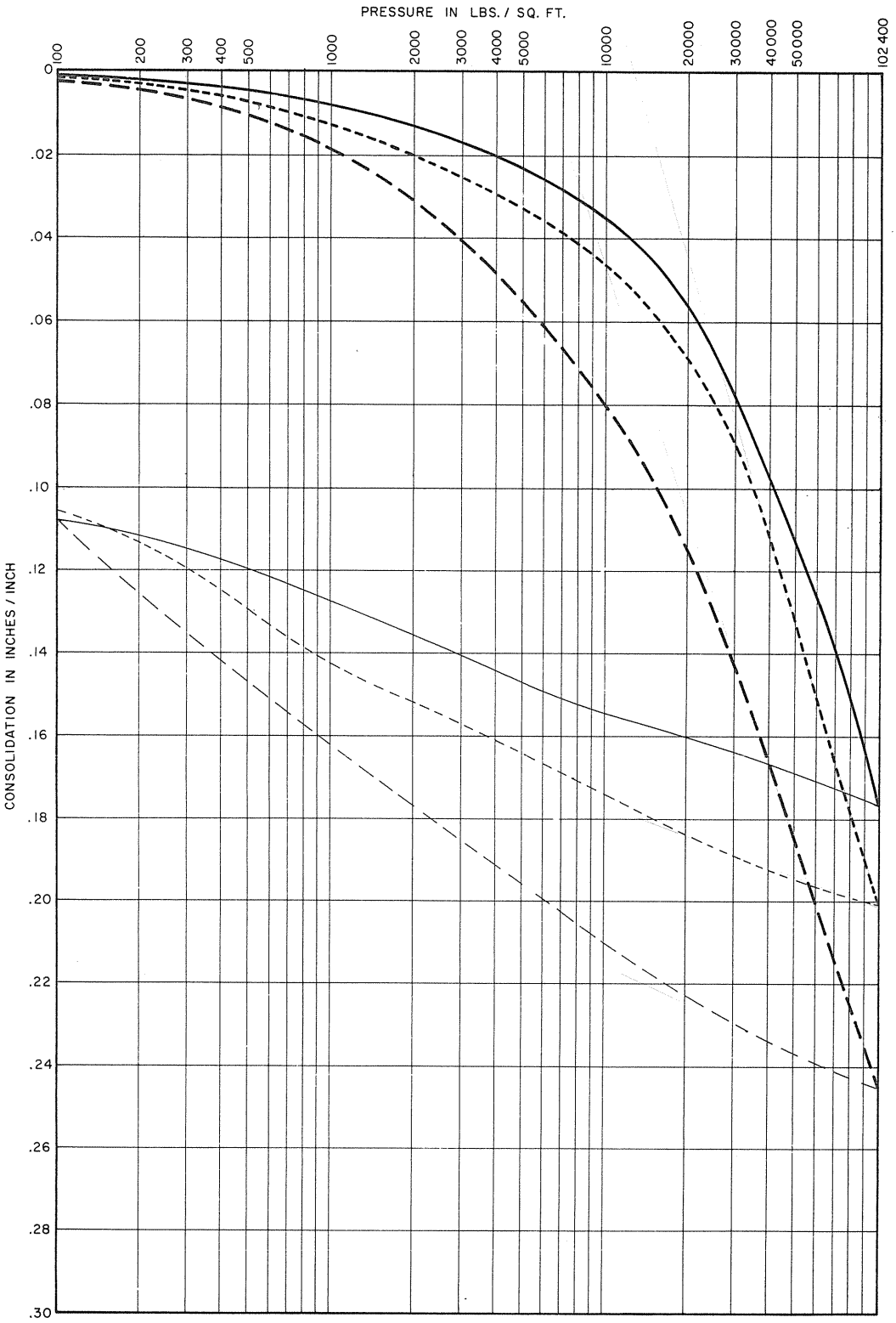
STRATUM NO. 3 : LOWER CLAYS

KEY	BORING	ELEV.	SOIL CLASSIFICATION	DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE, %		DRY DENSITY PCF		VOID RATIO		EFFECTIVE OVERBURDEN PRESSURE PSF	PRECONSOL. PRESSURE PSF
							BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER		
——	2	-39.2'	CL	BROWN SILTY CLAY	43	23	33	26	90	103	0.93	0.68	3210	10000
— —	2	-54.2'	CH	BLUISH DARK GRAY SILTY CLAY	55	26	32	27	91	101	0.91	0.72	4120	18000
------	4	-40.3'	CL	BROWN SILTY CLAY, TRACE OF FINE SAND	40	25	38	30	85	97	1.04	0.79	3530	20000

CONSOLIDATION TEST DATA

DAMES & MOORE

PLATE A 3C



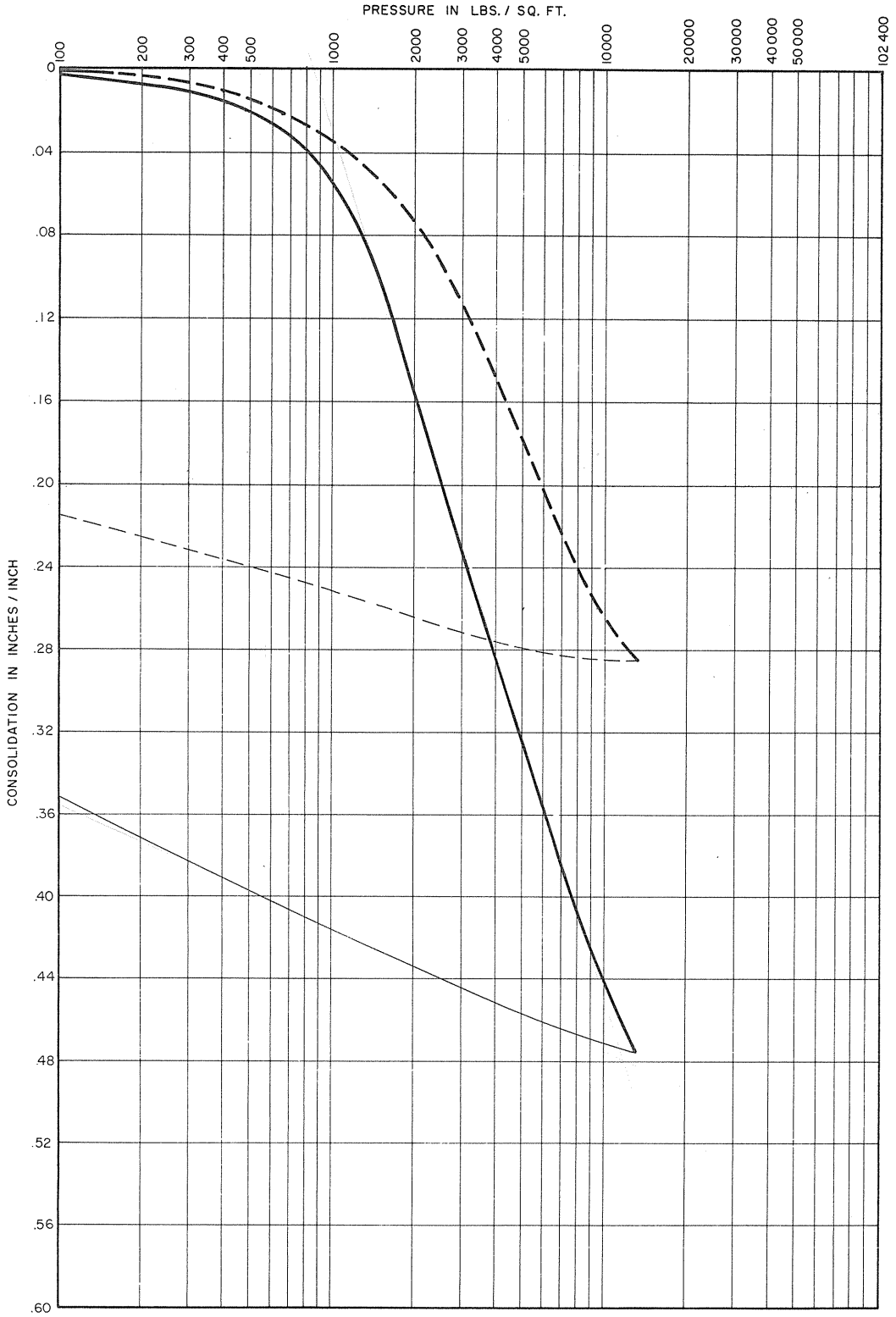
STRATUM NO. 3 : LOWER CLAYS

KEY	BORING	ELEV.	SOIL CLASSIFICATION	DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE,%		DRY DENSITY PCF		VOID RATIO		EFFECTIVE OVERBURDEN PRESSURE PSF	PRECONSOL. PRESSURE PSF
							BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER		
———	7	-38.5'	CL	BROWNISH-GRAY SILTY CLAY,	38	25	33	27	90	101	0.93	0.72	3070	21000
— — —	7	-54.0'	CL	GRAYISH-BROWN SILTY CLAY, TRACE OF FINE SAND	50	26	34	28	89	99	0.95	0.75	3970	9500
- - - - -	7	-68.5'	CL	GRAYISH-BROWN SILTY CLAY	41	25	33	27	90	100	0.93	0.73	4870	20000

CONSOLIDATION TEST DATA

DAMES & MOORE

PLATE A 3D

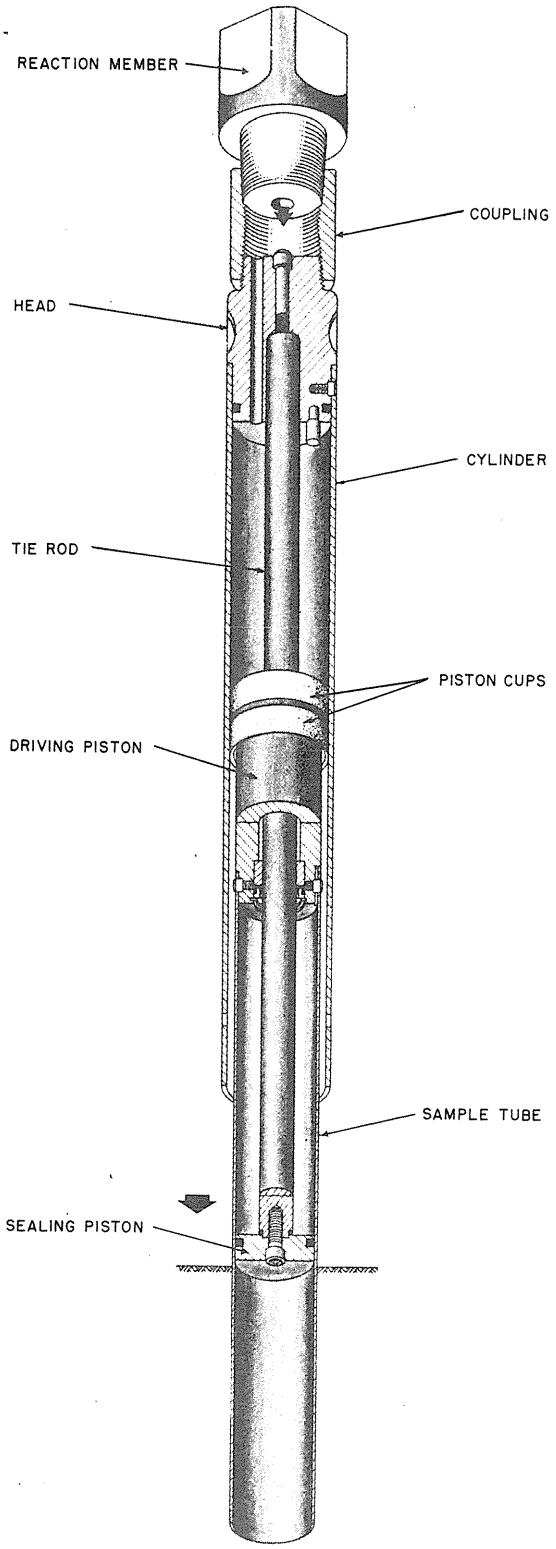


KEY	BORING	ELEV.	SOIL CLASSIFICATION	DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE,%		DRY DENSITY PCF		VOID RATIO		EFFECTIVE OVERBURDEN PRESSURE PSF	PRECONSOL. PRESSURE PSF
							BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER		
——	6	-6.8'	OH/PT	DARK GRAY SILTY CLAY & BLACK PEAT	134	90	173	105	28	44	-	-	1000	1000
— —	6	-33.8'	OH	DARK GRAY ORGANIC SILTY CLAY	73	45	76	56	53	68	2.2	1.5	1600	1600

CONSOLIDATION TEST DATA

DAMES & MOORE

PLATE A 3E



PISTON SAMPLER

THE DAMES & MOORE PISTON SAMPLER HAS BEEN DEVELOPED TO OBTAIN SAMPLES OF SOFT SOILS WITH A MINIMUM OF DISTURBANCE. THE MOST SIGNIFICANT FEATURES ARE THE SEALING PISTON WHICH CONFINES THE SOIL DURING SAMPLING AND THE SAMPLE TUBE WHICH HAS A WALL THICKNESS OF ONLY 0.042 INCHES.

AT THE START OF THE SAMPLING, THE LOWER END OF THE SAMPLE TUBE IS ADJACENT TO THE SEALING PISTON AT THE BOTTOM OF AN EXPLORATION TEST BORING. THE SEALING PISTON, CYLINDER, HEAD, AND REACTION MEMBER REMAIN STATIONARY DURING SAMPLING. COMPRESSED AIR, COMPRESSED NITROGEN, OR WASH WATER ARE FORCED INTO THE CYLINDER THROUGH THE SAMPLING RODS FROM THE DRILLING EQUIPMENT. THE DRIVING PISTON MOVES THE SAMPLE TUBE DOWNWARD INTO THE SOIL.

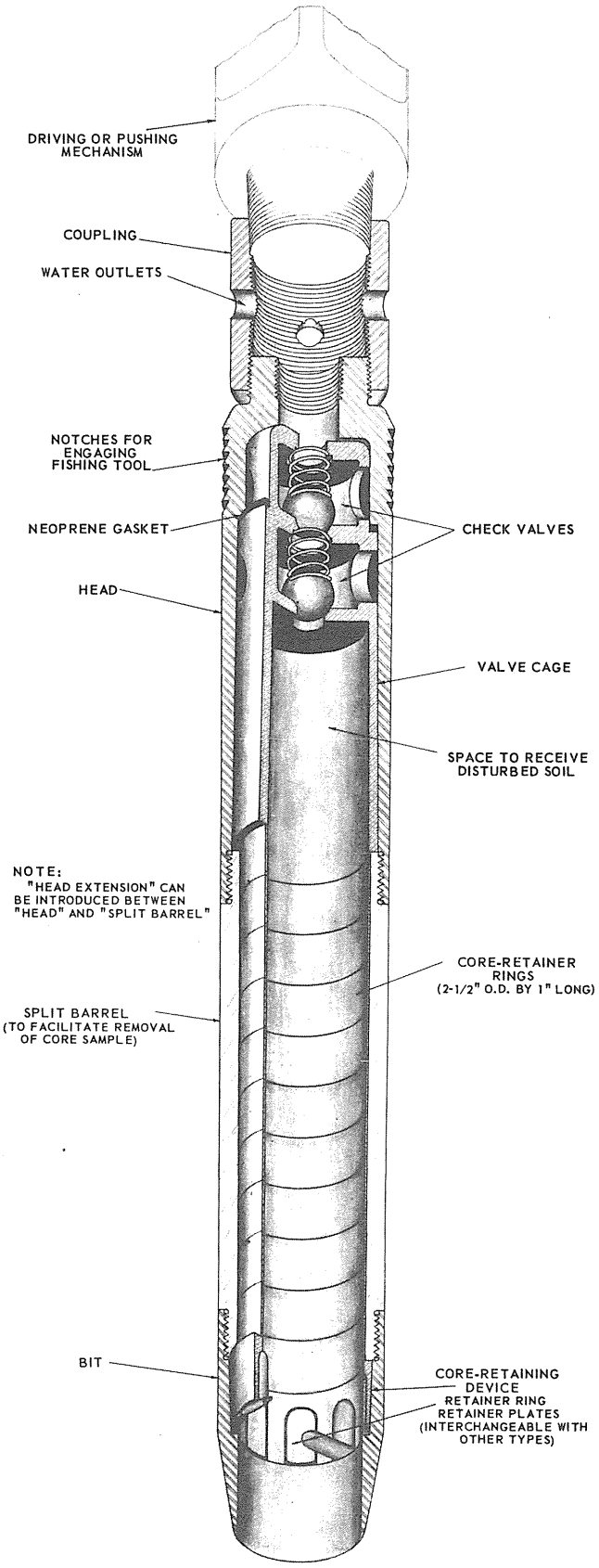
(19-4) 31-414

DAMES & MOORE

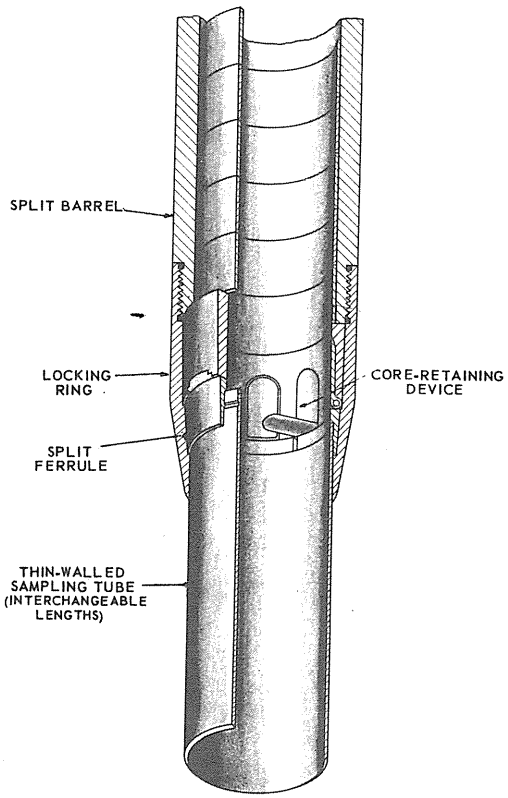
PLATE A4A

SOIL SAMPLER TYPE U

FOR SOILS DIFFICULT TO RETAIN IN SAMPLER
U. S. PATENT NO. 2,318,062



ALTERNATE ATTACHMENTS



417.9(6-61)

DAMES & MOORE

PLATE A4B

APPENDIX B

PREVIOUS INVESTIGATIONS AND FOUNDATIONS
PITTSBURG POWER PLANT

Since 1951, several foundation investigations have been conducted at this site. They include:

1. "Preliminary Foundation Investigation, Proposed Industrial Site near Pittsburg, California, For the Pacific Gas and Electric Company," dated September 4, 1951.

2. Units 1, 2, 3 and 4:

   a. "Foundation Investigation, Part I, Presentation of Data, Proposed Pittsburg Steam Plant, Pittsburg, California, For The Pacific Gas and Electric Company," dated March 3, 1952.

   b. "Foundation Investigation, Part II, Analyses and Recommendations, Proposed Pittsburg Steam Plant, Pittsburg, California, For the Pacific Gas and Electric Company," dated May 22, 1953.

3. Units 5 and 6, "Soil Investigation and Consultation, Additions to Steam Plant, Pittsburg, California, For the Pacific Gas and Electric Company," dated June 24, 1958.

FOUNDATIONS FOR EXISTING UNITS

Units 1, 2, 3 and 4 - Boilers, turbine-generators and stacks for each of these 150-megawatt units are supported on a single mat foundation at Elevation -10 which imposed a net loading of between 500 to 900 pounds per square foot on the supporting soils. Foundation settlements since plant construction in 1952 have amounted to 1/2 to 1 inch.

Tanks (Units 1 through 6) - The existing fuel oil storage tanks are located east of Units 1 through 4 in an area not underlain by soft river deposits. The tanks are supported at grade on spread foundations. Tanks are surrounded by concrete fire walls on the order of 12 inches thick and 12 feet high, which are also supported on spread foundations. Performance of these units has been satisfactory.

Switchyard - The switchyard area is underlain by relatively deep compressible soils topped with a thin layer of fill. The 125 and 230-KV units are on treated timber piling for settlement control. Performance of the pile-supported units has been generally satisfactory, but areal subsidence due to fill loads has caused problems with non pile-supported underground conduits, particularly at connections with pile-supported structures. The high groundwater level has also contributed to significant maintenance problems for the underground conduits.

Units 5 and 6 - These 300-megawatt units are supported on pile and mat foundations, as follows:

1. Stack foundations consist of short driven piling with tips at about Elevation -22. The piling are 40-ton Raymond step-taper cast-in-place piles.

2. The boiler area is on a pile-supported mat with its base at Elevation -13. The piling are timber piles jetted through the upper sands to tip elevations of between -50 and -55. These wood piling were driven for settlement control purposes, as the original concept for the units included loads from large coal bins which were never constructed.

3. The turbine-generator units are supported on mat foundations at about Elevation -10. This mat is continuous with the pile-supported mat for the boiler area.

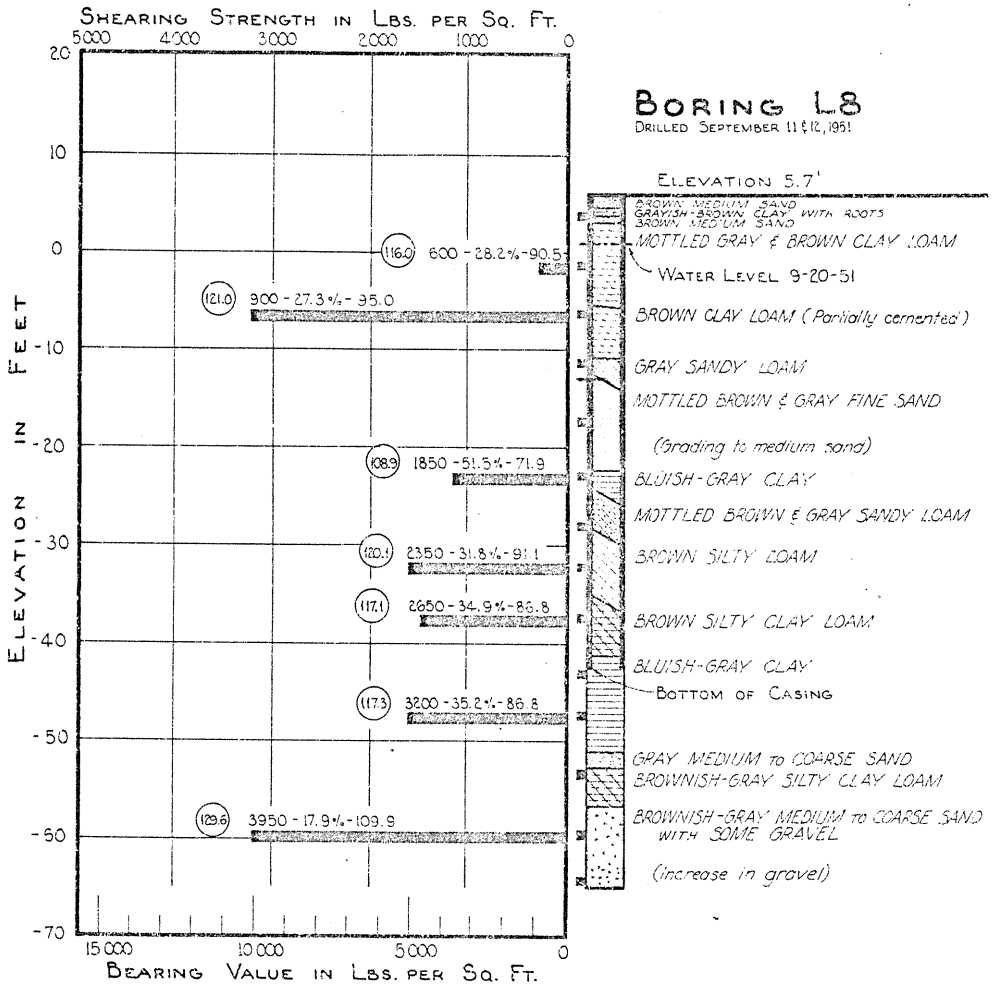
4. The headworks structure is on a mat foundation on sand between Elevations -15.5 and -17.5.

Foundation settlements since the start of construction in 1958 have been relatively uniform, averaging 0.5 to 0.75 inch. A maximum settlement of 0.8 inch occurred at the Unit 5 stack. The settlement data for Unit 5 and 6 stacks have been particularly useful in the settlement analyses for Unit 7.

Based on a review of the settlement data, inspection of the existing facilities, and discussions with P. G. & E. personnel, it appears that foundations have performed satisfactorily and that there are no apparent problems with existing facilities.

APPENDIX C

LOGS OF BORINGS FROM PREVIOUS INVESTIGATIONS



LOG OF BORINGS

NOTE

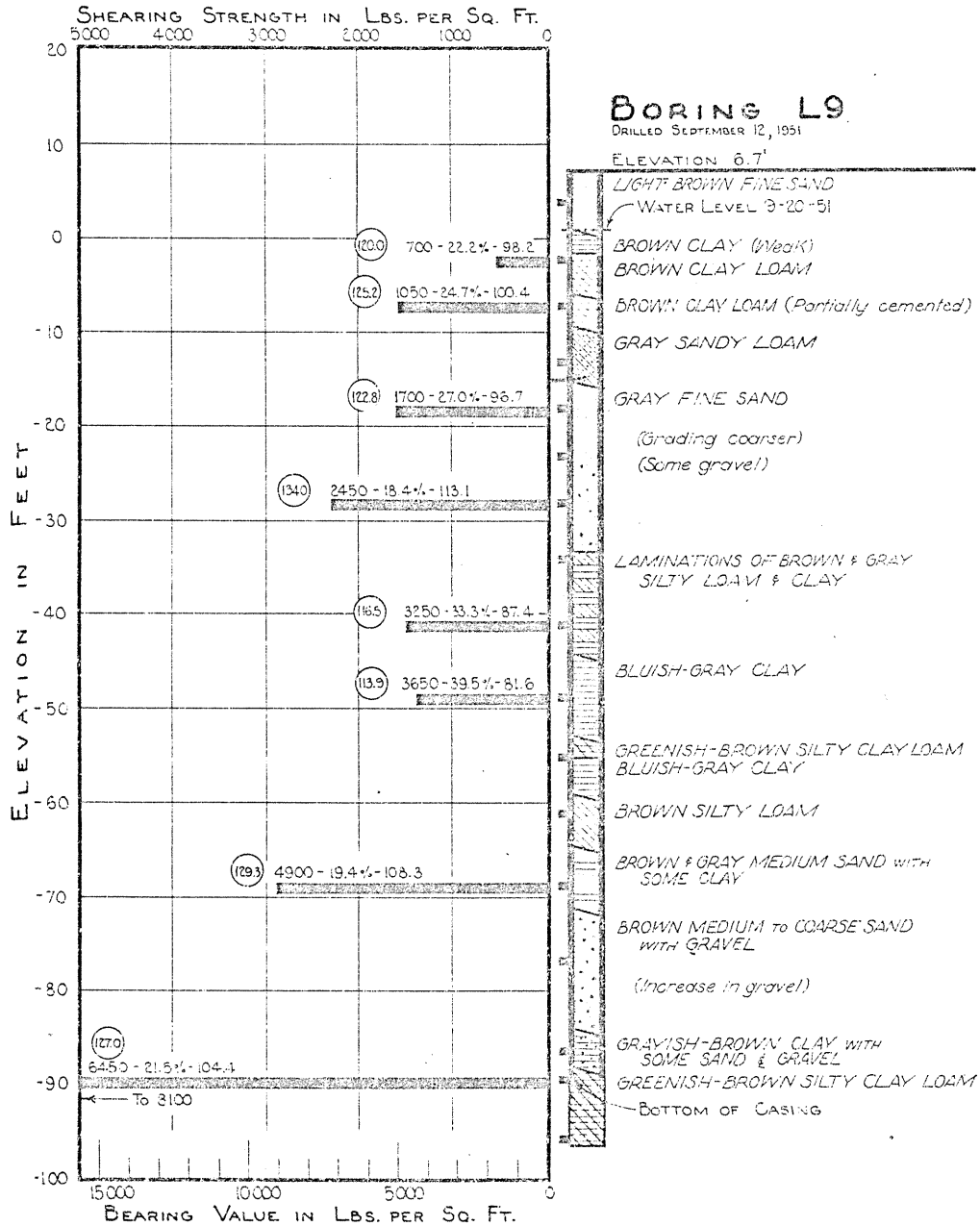
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0')

BORING DRILLED WITH CONVENTIONAL CABLE-TOOL EQUIPMENT.

DAMES & MOORE, Soil Engineers
FOUNDATION INVESTIGATIONS - SOIL MECHANICS ENGINEERING

PLATE 2E

DAMES & MOORE
JOB NO. 50
JOB TITLE
LOCATION
CLIENT
DATE JOB STARTED
DATE PRINTED
THIS DRAWING IS ONE OF A SERIES OF ____ DRAWINGS
DRAFTING CHECK BY
REPORT DICTATED BY
DATE 12-21-51
DATE
DATE



LOG OF BORINGS

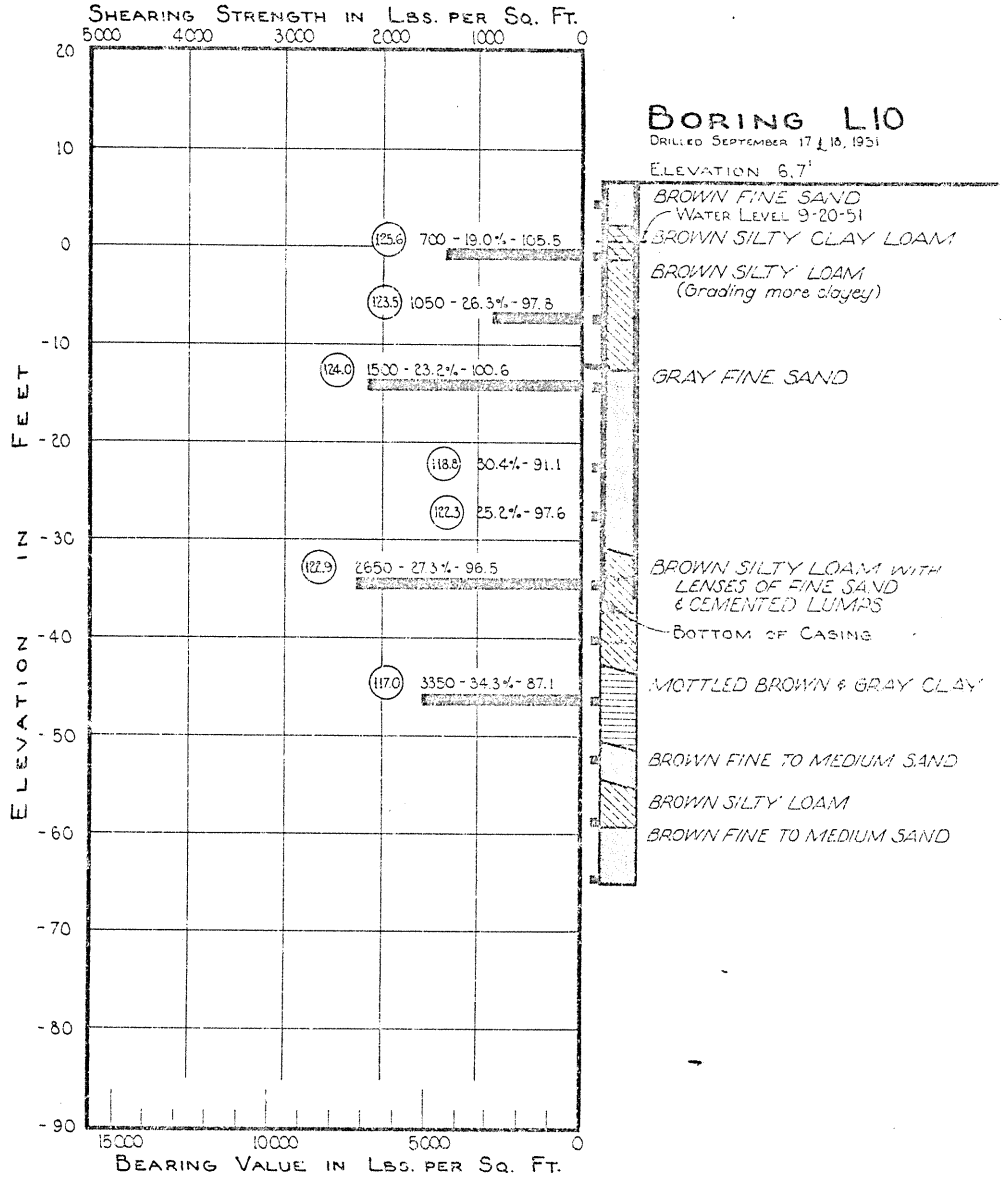
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').

BORINGS DRILLED WITH STANDARD CABLE-TOOL EQUIPMENT.

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2.5

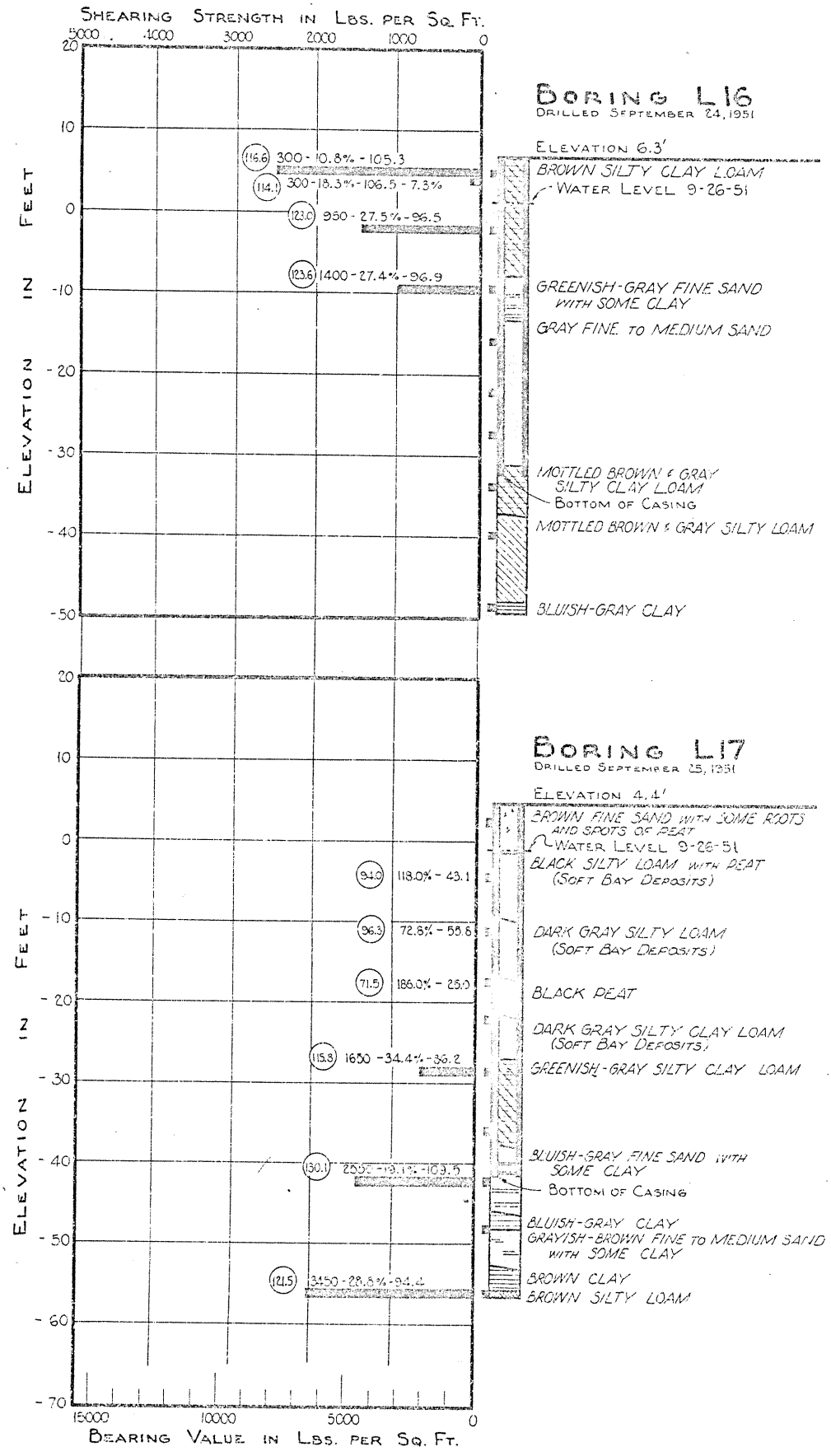


LOG OF BORINGS

NOTE
ELEVATIONS REFER TO U.S.G.S.
DATUM (M.S.L. = 0.0)
BORINGS DRILLED WITH 6" DIAM.
CABLE-TOOL EQUIPMENT.

DAMES & MOORE, Inc. Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 26



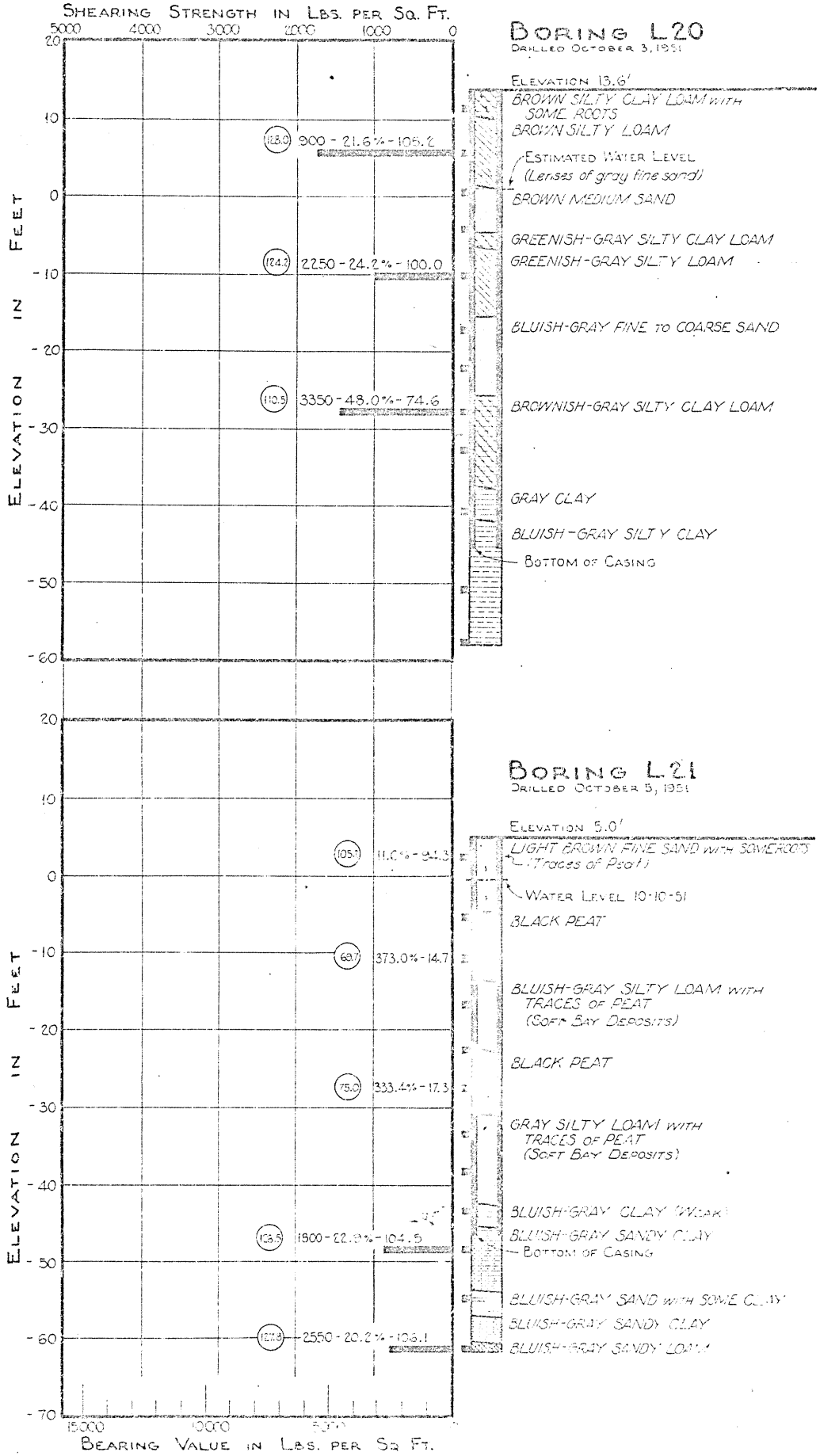
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2K



NOTE

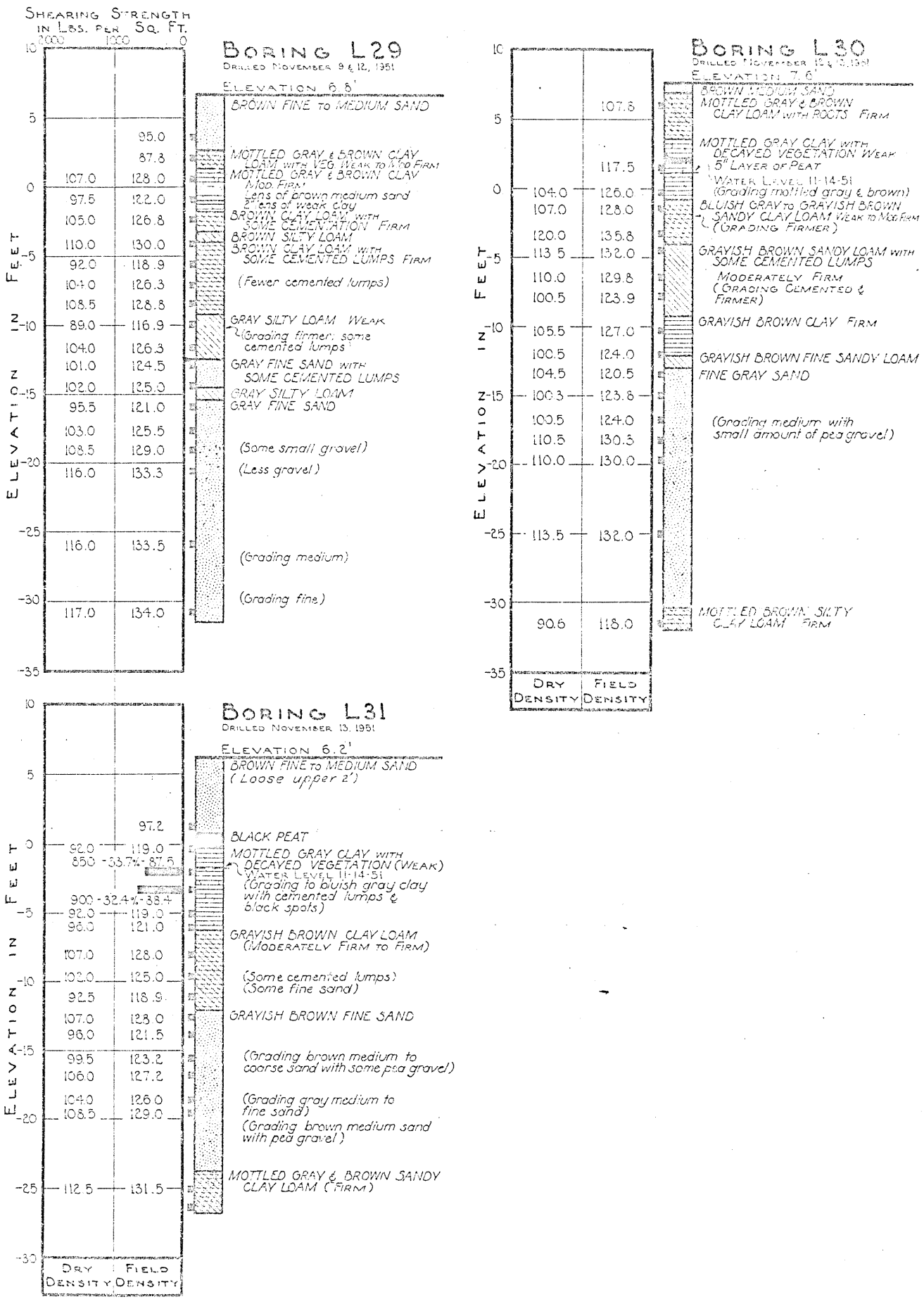
ELEVATIONS REFER TO U.S.G.S. DATUM MSL = 0.0'.

BORINGS BY [illegible]

LOG OF BORINGS

DAMES & MOORE

PLATE 2M



NOTE.
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L.=0.0').
BORINGS DRILLED WITH 6" DIAM. ROTARY WASH EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Soil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2P

JOB NO. 150AC(1050-S) LOCATION PITTSBURG, CALIF.
THIS DRAWING IS ONE OF A SERIES OF 52 DRAWINGS CLIENT P.G. & E. DATE JOB STARTED Aug. 27, 1951 DATE PRINTED Feb. 29, 1952
DR. DATA CHECK BY DRAFTING CHECK BY REPORT DICTATED BY DATE

BORING L36

Drilled November 27 & 28, 1951

Elevation 5.7'

Elevation in Feet	Dry Density	Field Density
0		66.0
		67.6
	97.0	122.0
-5	102.0	125.2
	106.5	127.8
	104.5	126.5
-10	107.7	128.4
	108.6	129.0
	111.0	130.4
-15	111.0	130.5
	110.0	129.9
	111.5	130.8
-20	104.0	126.0
-25	102.0	125.0

BROWN FINE TO MEDIUM SAND

BLACK PEAT

WATER ENCOUNTERED

GRAY CLAY WITH VEGETATION
WEAK TO MODERATELY FIRM
(Grading greenish-gray)
(Less vegetation)

GREENISH GRAY CLAY LOAM
MODERATELY FIRM TO FIRM

(Grading sandy with some cemented lumps)

GRAY FINE SAND
(Grading medium with small gravel)

(Grading fine to medium sand)

BORING L37

Drilled November 28, 1951

Elevation 6.3'

Elevation in Feet	Dry Density	Field Density
		79.4
0	97.0	122.0
	105.0	126.9
-5	99.0	123.0
	104.0	126.0
	98.3	122.5
	98.2	122.3
-10	99.0	123.0
	100.5	123.9

BROWN FINE TO MEDIUM SAND

LIGHT GRAY CLAY SOFT
DARK BROWN PEAT

MOTTLED BLUISH GRAY & BROWN CLAY WITH VEGETATION
MODERATELY FIRM TO FIRM

(Less vegetation)

BROWN CLAY LOAM WITH WHITE STREAKS
MODERATELY FIRM TO FIRM

WATER ENCOUNTERED
LESS FIRM
(Slightly cemented)
(Grading sandy)

GRAY FINE SAND

BORING L38

Drilled November 28 & 29, 1951

Elevation 6.4'

Elevation in Feet	Dry Density	Field Density
		125.3
0	112.0	130.9
	105.0	126.9
	106.0	127.5
-5	114.5	132.5
	115.5	133.3
	113.5	132.0
	106.0	127.5
-10	94.0	120.0
	95.5	121.0
-15	111.0	130.3
	104.0	126.3
	102.0	124.9
-20	112.5	131.5

BROWN FINE SAND

BROWN CLAY LOAM WITH VEGETATION MOD. FIRM TO FIRM
(Less vegetation)
WATER LEVEL 11-28-51

(Grading light brown - FIRMER)
(Few rock fragments)
(Some fine sand)
(Grading cemented)

(Less cementation)
(Some white streaks)

BROWN CLAY WITH WHITE STREAKS
FIRM

(No white streaks)

(Grading mottled gray & brown with some fine sand)

GRAY FINE SAND WITH SOME CLAY
(Grading to medium sand)

(3" LENS OF GRAY SILTY LOAM)
(Grading fine)

(Grading medium to coarse with some small gravel)

BORING L39

Drilled November 29, 1951

Elevation 7.1'

Elevation in Feet	Dry Density	Field Density
		81.4
		128.4
0	110.0	129.9
	111.0	130.5
-5	106.0	127.5
	112.0	131.0
-10	107.0	128.2
	102.0	124.9
	103.5	125.7

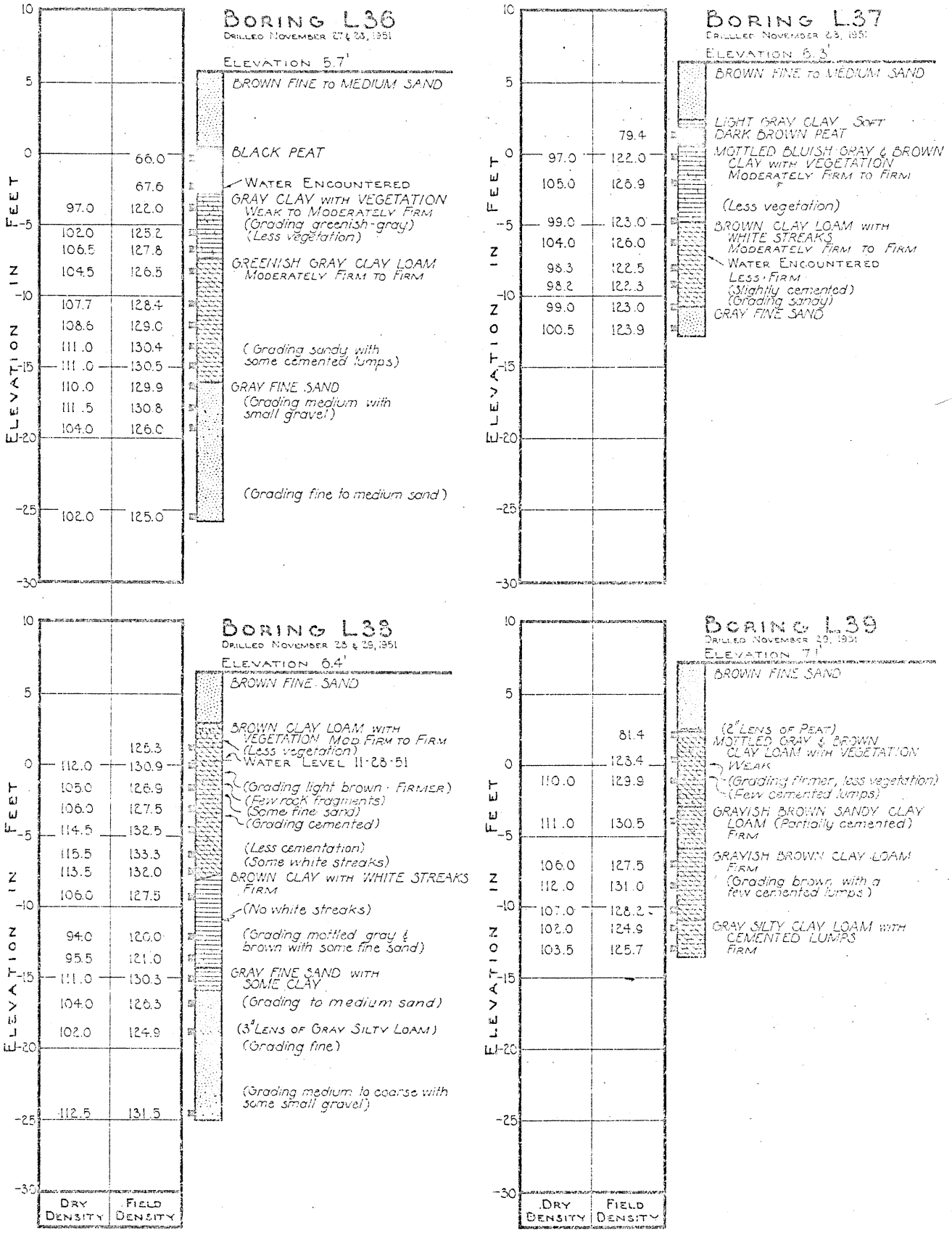
BROWN FINE SAND

(2" LENS OF PEAT)
MOTTLED GRAY & BROWN CLAY LOAM WITH VEGETATION
WEAK
(Grading firmer, less vegetation)
(Few cemented lumps)

GRAYISH BROWN SANDY CLAY LOAM (Partially cemented)
FIRM

GRAYISH BROWN CLAY LOAM
FIRM
(Grading brown with a few cemented lumps)

GRAY SILTY CLAY LOAM WITH CEMENTED LUMPS
FIRM



NOTE

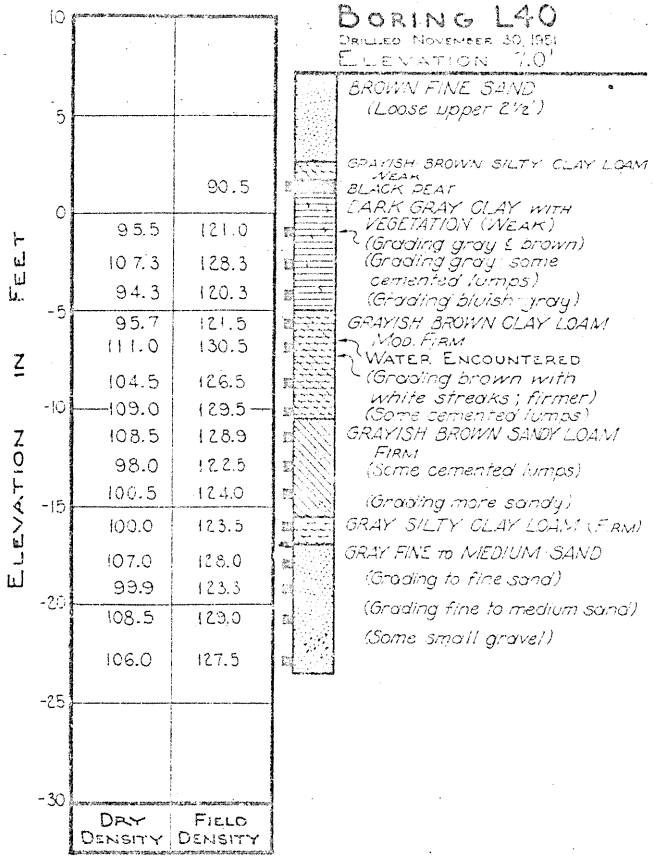
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0')
BORINGS DRILLED WITH 6" DIAM. ROTARY WASH EQUIPMENT

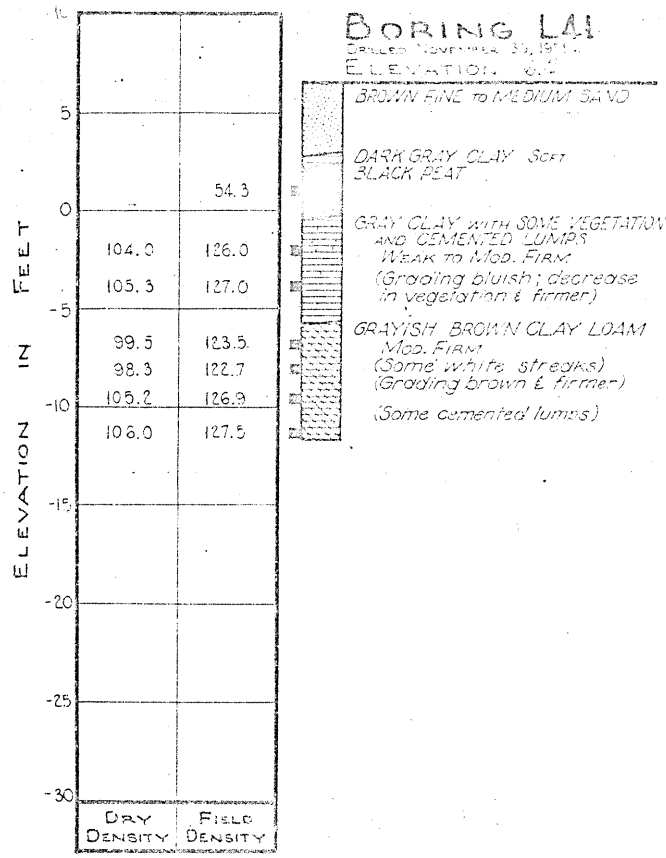
LOG OF BORINGS

DAMES & MOORE, Civil Engineers
Foundation Investigations · Soil Mechanics Engineering

PLATE 2R

DAMES & MOORE
NO. 11 SIDE
THIS DRAWING IS ONE OF A SERIES OF 52 DRAWINGS
CLIENT P.G. & E. Co.
DATE JOB STARTED 8-27-51
DATE PRINTED 2-29-52
DRAFTING CHECK BY
REPORT DICTATED BY
DATE





NOTE

ELEVATIONS REFER TO U.S.A.A. DATUM (MSL) = 2.0'

MEAN LOW WATER AT PIER 1 = 1.0'

LOG OF BORINGS

DAMES & MOORE, Soil Engineers
FOUNDATION INVESTIGATIONS • SOIL MECHANICS • ENGINEERING

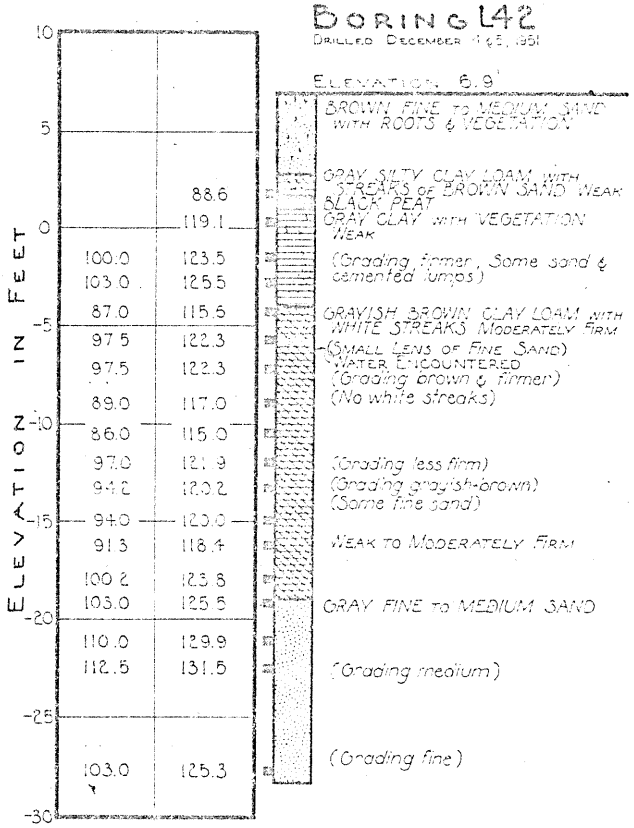
PLATE 28

JAM 1952 BOAT INVES
ING BOTTOM (1950 C.) LOCATION PITTSBURG, CALIF.
THIS DRAWING IS ONE OF A SERIES OF 52 DRAWINGS CLIENT P.G. & E.
DATE JOB STARTED Aug. 27, 1952 DATE PRINTED Feb. 28, 1952
DRAFTING CHECK BY DATE
REPORT DICTATED BY DATE

BORING L42

DRILLED DECEMBER 1 & 3, 1951

ELEVATION 6.9'

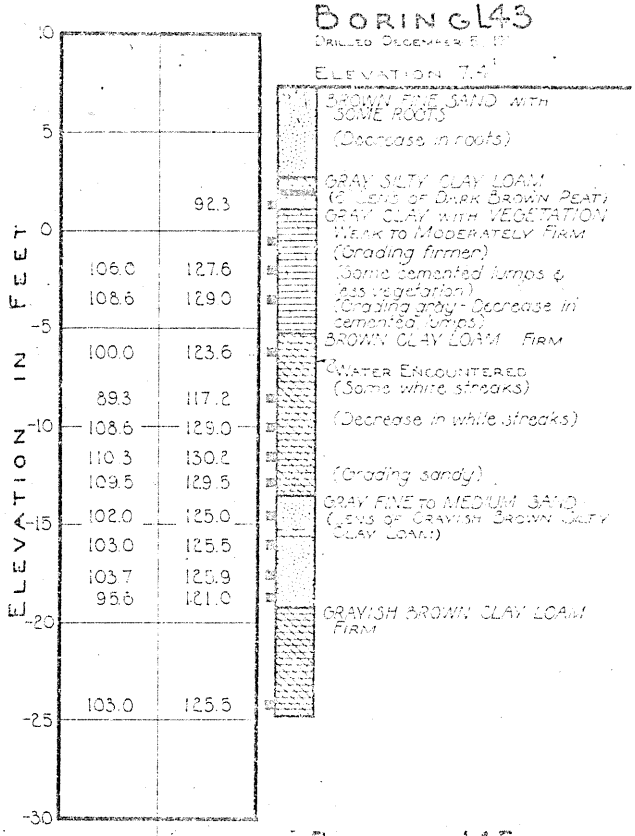


DRY DENSITY	FIELD DENSITY
	88.6
	119.1
100.0	123.5
103.0	125.5
87.0	115.6
97.5	122.3
97.5	122.3
89.0	117.0
86.0	115.0
97.0	121.9
94.2	120.2
94.0	120.0
91.3	118.4
100.2	123.8
103.0	125.5
110.0	129.9
112.6	131.6
103.0	125.3

BORING L43

DRILLED DECEMBER [illegible]

ELEVATION 7.4'

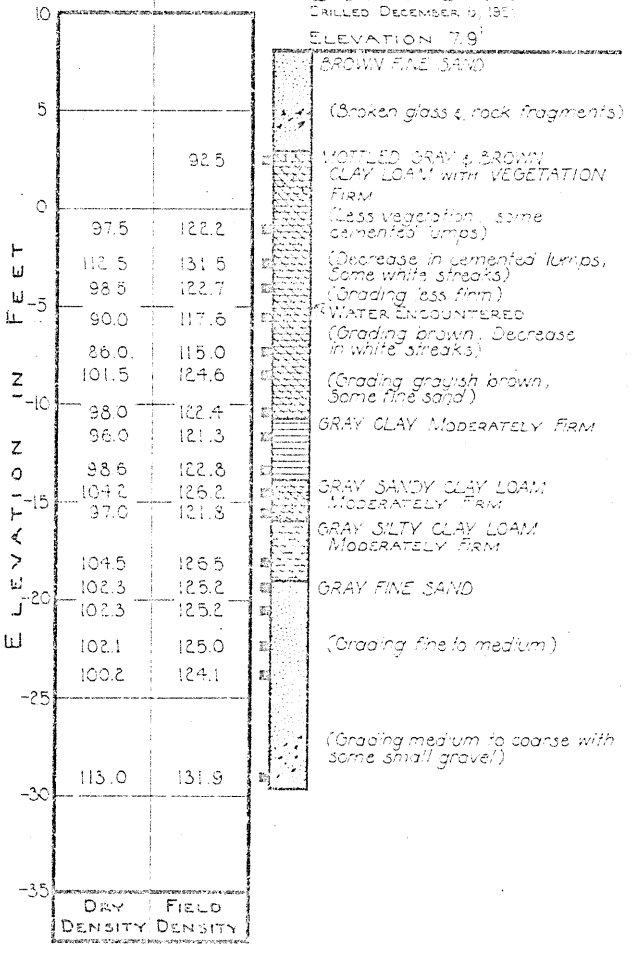


DRY DENSITY	FIELD DENSITY
	92.3
106.0	127.6
108.6	129.0
100.0	123.6
89.3	117.2
108.6	129.0
110.3	130.2
109.5	129.5
102.0	125.0
103.0	125.5
103.7	125.9
95.6	121.0
103.0	125.5

BORING L44

DRILLED DECEMBER 6, 1951

ELEVATION 7.9'

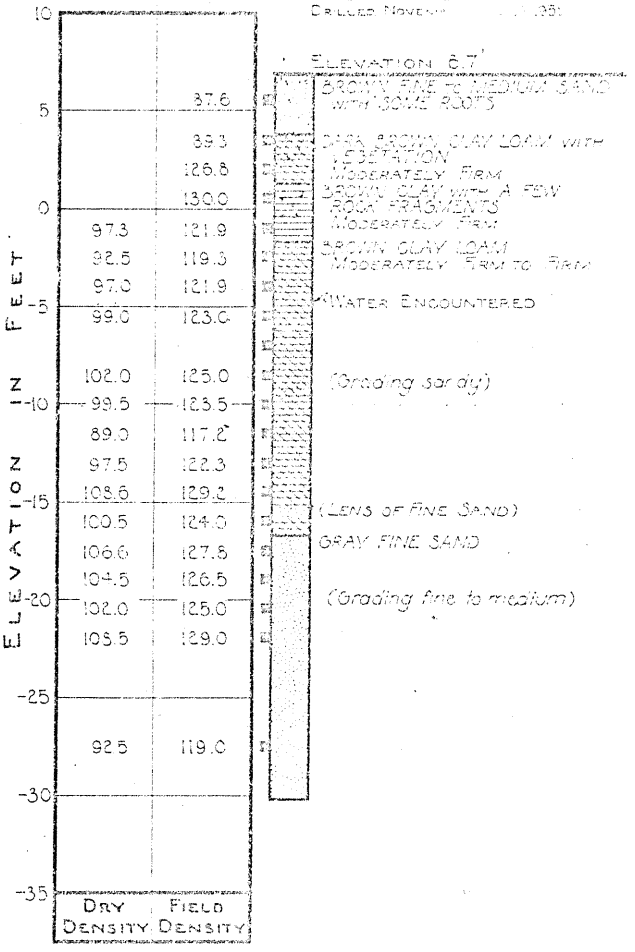


DRY DENSITY	FIELD DENSITY
	92.5
97.5	122.2
112.5	131.5
98.5	122.7
90.0	117.6
86.0	115.0
101.5	124.6
98.0	122.4
96.0	121.3
98.6	122.8
104.2	126.2
97.0	121.8
104.5	126.5
102.3	125.2
102.3	125.2
102.1	125.0
100.2	124.1
113.0	131.9

BORING L45

DRILLED NOVEMBER [illegible] 1951

ELEVATION 6.7'



DRY DENSITY	FIELD DENSITY
	87.6
	89.3
	126.8
	130.0
97.3	121.9
92.5	119.3
97.0	121.9
99.0	123.0
102.0	125.0
99.5	123.5
89.0	117.2
97.5	122.3
108.6	129.2
100.5	124.0
106.6	127.6
104.5	126.5
102.0	125.0
105.5	129.0
92.5	119.0

NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM AT LAKE SITE

BORINGS DRILLED WITH 6" & 8" DIAM. ROTARY AUGER EQUIPMENT

LOG OF BORINGS

DAMES & MOORE, [illegible]

FOUNDATION INVESTIGATIONS · SOIL MECHANICS · ENGINEERING

PLATE 27

AME [illegible] DOR [illegible] DRAFTING CHECK BY [illegible] DRAWN BY DS DATE 2-27 REPORT DICTATED BY [illegible] DATE

JOB NO. HE/PSL/1062 LOCATION [illegible] TITLE [illegible] DRAWN [illegible] INVESTIGATION

THIS DRAWING IS ONE OF A SERIES OF 52 DRAWINGS CLIENT P.G. & E. DATE JOB STARTED AUG. 27, 1951 DATE PRINTED FEB. 29, 1952

FINAL RECOMMENDATIONS FOR PILING AND SUPPLEMENTARY FIELD INVESTIGATION PITTSBURG POWER PLANT, UNIT 7 PITTSBURG, CALIFORNIA

FOR PACIFIC GAS AND ELECTRIC COMPANY

DAMES & MOORE

Job No. 0160-130-03

EARTH SCIENCES

DAMES & MOORE

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PARTNERS: WILLIAM W. MOORE · WILLIAM ENKEBOLL · ROBERT D. DARRAGH · CHARLES L. NICHOLS · DONALD F. JAVETE
ASSOCIATES: GEORGE D. ROBERTS · DENNIS J. R. HODGSON · ROBERT C. K. AU · CARL W. GARBE · PETER E. QUINN

October 29, 1968

Mr. J. D. Worthington, Vice President,
Engineering
Pacific Gas and Electric Company
245 Market Street
San Francisco, California 94106

Attention: Mr. B. W. Shackelford, Chief
Civil Engineer

Gentlemen:

Twenty-five copies of our report, "Final Recommendations for Piling and Supplementary Field Investigation, Pittsburg Power Plant, Unit 7, Pittsburg, California", are herewith submitted. Our preliminary foundation investigation report, dated October 18, 1968, presented a discussion of alternative and selected foundation support for Unit 7.

This report presents final design recommendations for the 50-ton design load concrete piles for the Unit 7 boiler and stack, and the 25-ton design load timber piles for the 115KV and 230KV Bus and Switch structures. We also assisted your engineering staff in the preparation of specifications for the piling contract; pile foundation requirements not specifically covered in this report are contained in the specifications.

The results of the supplementary field investigation in the Unit 7 plant area and for the Intake and Discharge structures found soil conditions similar to those discussed in our preliminary foundation investigation report. The upper sand layer, which will provide foundation support for the turbine-generator deep mat foundation and the boiler and stack concrete piles, is continuous and reasonably uniform in surface elevation, thickness and density throughout the Unit 7 area. This sand strata also extends out to the area of the Intake and Discharge structures.

No additional borings were drilled in areas of the 115KV and 230 KV Bus and Switch areas and recommendations are based on previous subsurface information. The boring in the vicinity of the new fuel oil storage tank location confirmed that no soft, compressible soils underlie the tank site as had been encountered at the initially selected tank location.

Subsequent reports will summarize our final settlement analyses of the Unit 7 power plant and submit our recommendations for foundation design and construction of the new fuel oil tank and the circulating water system.

Should any questions arise concerning the data presented in this report, please contact us.

Yours very truly,

DAMES & MOORE

Robert D. Darragh

James H. Klick

RDD:JHK:is

FINAL RECOMMENDATIONS FOR PILING
AND SUPPLEMENTARY FIELD INVESTIGATION
PITTSBURG POWER PLANT, UNIT 7
PITTSBURG, CALIFORNIA

INTRODUCTION

This report presents final recommendations for concrete and wood foundation piling for the Unit 7 Power Plant and switchyard additions, and the results of the supplementary field investigation. The final layout of Unit 7 in relation to other units, and locations of all test borings performed at the site to date are shown on the Plot Plan, Plate 1. The detailed layout of the Unit 7 as presently planned, is shown on Plate 2, Planned Layout of Unit 7 Power Plant. The logs of supplementary borings and related test data are presented in Appendix A. Our report, "Preliminary Foundation Investigation, Pittsburg Power Plant, Unit 7, Pittsburg, California", dated October 18, 1968, presented a discussion of alternative and selected foundation support for Unit 7.

All elevations in this report are in feet and refer to the Plant Datum, which is 0.43 feet below the U.S.G.S. Datum of Mean Sea Level.

SCOPE

The scope of this report covers:

1. Final design recommendations for foundation piles as follows:
   a. Fifty-ton design load concrete piles for power plant structures.

b. Twenty-five-ton design load, Class B, treated timber piles for 115KV and 230 KV Bus and Switch structures.

2. A subsurface investigation to:

a. Supplement preliminary soils information within the Unit 7 plant area for continuity and density of an upper sand layer where piles will be founded (four borings).

b. Investigation subsurface conditions at the proposed Intake and Discharge Structures and Conduits (four land borings).

c. Supplement old boring data in the vicinity of the final tank location (one boring).

Subsequent reports will present final settlement analyses for Unit 7 plant structures, mat design criteria for the turbine-generator unit, recommended foundations for miscellaneous structures, foundation design data for the new tank location and circulating water system.

SUBSURFACE CONDITIONS

The results of the supplementary field explorations and laboratory testing are presented in Appendix A. Supplementary borings in the Unit 7 plant area, Borings 12, 13, 14 and 19, and borings for the Intake and Discharge

facilities, Borings 15 through 18, found subsurface conditions to be similar to those described in our October 18 report. The surface elevation (-10 to -18), thickness (18 to 23 feet), and density of the upper sand layer appears to be relatively uniform below the Unit 7 plant area shown on Plate 2. Subsurface conditions in the vicinity of the Intake and Discharge Structures will be discussed in more detail in a subsequent report.

Boring No. 20, drilled in the vicinity of the new tank location, encountered soils similar to those in old Borings, Nos. L-4 and L-23. The boring confirmed that the old shoreline did not extend to the vicinity of the new tank and no soft, very compressible soils underlie the tank area.

Logs of old borings pertinent to the Bus and Switch, and tank areas are presented in Appendix B, Logs of Borings From Previous Investigations.

FOUNDATION PILING

POWER PLANT

The turbine-generator will be founded on a deep mat foundation to accommodate construction of the circulating water system.

The boiler, stack, and structures adjacent to the boiler and south side of the turbine-generator will be supported on 50-ton, cast-in-place, or prestressed concrete piles. Foundation piling for these units will be driven into the 18-to 23-foot-thick upper sand layer about 20 feet below the present ground surface. The foundation piling contract will be issued prior to an

excavation and foundation contract, and the piles will be installed from existing grades prior to excavation for pile caps. The recommended driving criteria and pile penetrations for bidding are presented in the following Table:

DESIGN LOADS	
Dead plus Live Loads	50-Ton
Dead plus Live plus Seismic Loads	95-Ton
Uplift Load	20-Ton
Lateral Loads	
Stack Piles	6 Kips
Boiler Piles	3 Kips
MINIMUM PILE DIMENSIONS	
Prestressed Precast Concrete	10-inch by 10-inch square
or	12-inch octagonal
Raymond Step-Taper Cast-in-Place Concrete (Tip Diameter)	$10\frac{1}{4}$-inch
MINIMUM PILE SPACING	3.5 Feet
Replacement piles may be driven as close as practical to rejected piles	
MINIMUM HAMMER ENERGY	19,000 Foot-pounds per blow
RECOMMENDED TIP ELEVATION FOR BIDDING	
All piles	Elevation -27

DRIVING CRITERIA

Penetration into Sand* (Feet)	Blows per Foot
5	150
9	90
13	60

*The blow count defining the surface of the sand will be interpreted from test drive pile records.

PREDRILLING

Not permitted unless necessary to prevent heaving of piles during driving. Predrilled hole size should be limited to 75 percent of minimum pile area

The driving criteria shown are for the minimum recommended hammer energies. Final driving criteria will be modified on the basis of:

1. Actual equipment and type of piles used.

2. Effects of followers on blow count.

3. Results of preliminary pile driving tests.

4. Results of pile load tests if performed.

PILE PENETRATIONS

For bidding purposes, a uniform tip elevation of -27 has been recommended to simplify the evaluation of bids. However, the surface of bearing soils varies over the plant site (Elevations -10 to -18) and pile penetrations into the sand strata are also expected to vary. Our review of pile driving records for Units 5 and 6 stack piles shows a gradual build-up in blow count can be expected with penetration into the sand bearing stratum. We anticipate similar driving characteristics for the Unit 7 piles. Where variations in the sand densities result in higher blow counts at shallow penetrations, the piles may be stopped at higher elevations, as reflected in the driving criteria in the Table.

Test Drive Piles - We have recommended to your engineers that 24 test drive piles be driven prior to commencing full scale pile driving operations in order to:

1. Establish likely variations in driving characteristics across the site.

2. Evaluate the adequacy of driving equipment and the effectiveness of a follower (if used).

3. Provide a basis for setting final driving criteria and to establish whether load tests will be required.

Our specific recommendations for the test driving program have been incorporated into the piling specifications.

Pile Load Tests - Pile load tests will not be required for the planned 50-ton piles unless unusual conditions are encountered during the driving of the initial test drive piles or of a significant number of foundation piles. Criteria for such load tests have been incorporated into the piling specifications.

Lateral and Uplift Pile Loading - The lateral and uplift loads on concrete piles are tabulated in the Table. Piling subjected to these loads should be designed to resist the shear, moment, and uplift values presented on Plate 3, Structural Design Criteria for Concrete Piles.

The lateral loads on piles in the boiler area were determined by analysis which assumed that the entire slab area between column lines J and R and 11.5 and 21 would move as a mass under the design seismic loadings. The pile lateral load was assumed to be the difference between the total lateral load and the sum of the passive resistance of soils at the edge of the slab and the shear of the soft soils at about Elevation 0, over the slab area.

The more severe lateral loads for the stack piling was based upon a design assumption that the total moment capacity of the prestressed piles would be developed under combined bending and uplift loads.

The distribution of uplift load along the pile versus depth for design of tensile steel is included on Plate 3.

230KV AND 115KV BUS AND SWITCH FOUNDATIONS

The location of the planned additions to the 115KV and 230KV Bus and Switchyard structures are shown on the Plot Plan, Plate 1. It is planned to support the units on 25-ton design load, Class B, treated timber piles. The recommended allowable uplift loadings for these piles is 12.5 tons. Any increase in the uplift loading on piles will require individual study of the percentage of live to permanently applied uplift loads and soil conditions. The soil conditions in the new 115KV and 230KV areas are different and are discussed separately in the following sections.

230KV BUS AND SWITCH FOUNDATIONS

Soil Conditions - The soil conditions in the 230KV Bus and Switch area consist of a few feet of fill over up to 45 feet of soft, compressible recent soils. The underlying firm bearing soils range from predominantly clayey soils (Boring L-21), in the southeasterly areas, to thick layer of sand in the westerly area (Borings 6 and L-17). Plate 4, Estimated Contours of Surface of Firm Soils, shows the surface of the bearing soils.

Pile Penetrations - Uplift loads for the 230KV Bus and Switchyard structures will be resisted predominantly by the thick upper soft soils, and penetration into the bearing soils is not critical for developing the full 12.5-ton design uplift on piles. However, a penetration of 35 feet into clayey soils will be required to develop the 25-ton design and downdrag loads (negative friction) on piles from subsiding fills. We recommend that pile lengths for bidding purposes be based on the 35-foot penetration into firm soils. Where dense sand layers 10 feet or more in thickness exist, lesser penetrations are acceptable if adequate driving resistance is achieved. In some instances high driving resistance may be encountered in thin sand layers below the soft soils, which are not sufficiently thick to support the required pile and downdrag loads. In this event predrilling (six-inch maximum hole size), or carefully controlled pilot jetting may be necessary to achieve required penetrations. Jetting restrictions should include:

1. No side jetting.

2. Over-jetting would be cause for rejection.

3. Limit jetting to the bottom of the sand layer.

Driving Criteria - The following equipment and driving criteria are recommended:

Minimum Hammer Energy	15,000 foot-pounds per blow
Refusal Blow Count	60 blows per foot or 7 blows per inch

PILE PENETRATIONS INTO FIRM* SOILS	MINIMUM FINAL DRIVING RESISTANCE (Blows per Foot)
10	40
20	25
35	10

*Minimum driving resistance in firm soils 8± blows per foot.

It is recommended that six test drive piles be driven before other piles to establish driving patterns. Final driving criteria and pile penetrations would be modified on the basis of these initial piles.

115KV BUS AND SWITCH FOUNDATIONS

Soil Conditions - The soil conditions in this area consist of a few feet of fill over only a few feet of soft compressible recent soils. The underlying firm bearing soils are generally composed of sandy soils (Borings L-13 and L-93). Plate 4 shows the estimated surface contours of the firm soils.

Pile Penetration - The required penetration of piles designed for both downward and uplift loads is 30 feet into firm soils. To achieve the required penetration, it is anticipated that predrilling or pilot jetting will be necessary. All predrilling and jetting restrictions discussed for the 230KV area piles are applicable.

Driving Criteria - Driving criteria similar to that recommended for the 230KV area would be appropriate for this area, except that piles will require the full 30 feet penetration into firm soils. It is recommended that three test drive piles be driven prior to other piles to establish final driving criteria for this area.

The following Plates and Appendices are attached and complete this report:

Plate 1	-	Plot Plan
Plate 2	-	Planned Layout of Unit 7 Power Plant
Plate 3	-	Structural Design Criteria for Concrete Piles
Plate 4	-	Estimated Contour of Surface of Firm Soils (Bus and Switch Areas)
Appendix A	-	Field Explorations and Laboratory Testing
Appendix B	-	Logs of Borings From Previous Investigations

Respectfully submitted,

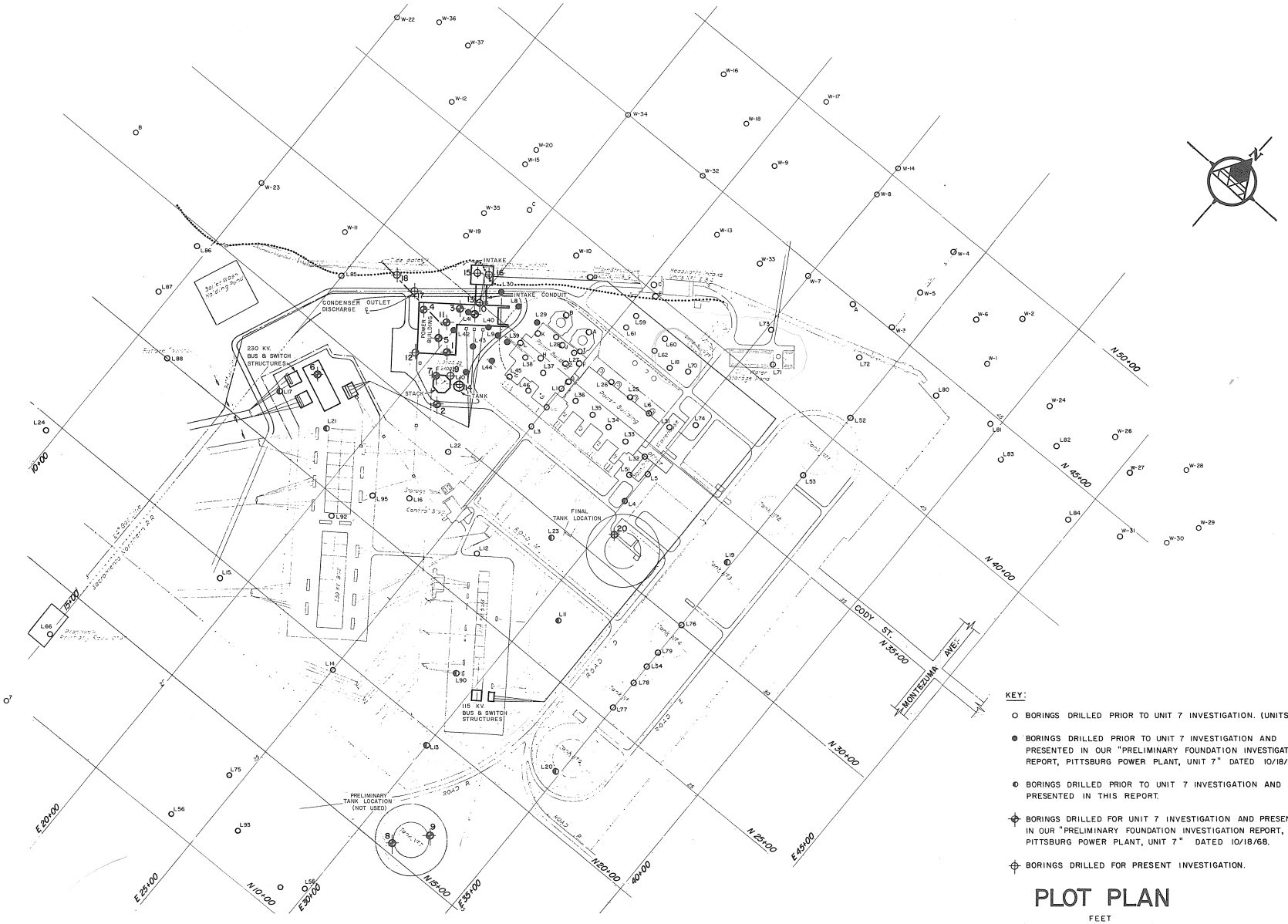
DAMES & MOORE

Robert D. Darragh

James H. Klick

October 29, 1968

Job No. 160-130



KEY:

- ○ BORINGS DRILLED PRIOR TO UNIT 7 INVESTIGATION. (UNITS 1-6).
- ● BORINGS DRILLED PRIOR TO UNIT 7 INVESTIGATION AND PRESENTED IN OUR "PRELIMINARY FOUNDATION INVESTIGATION REPORT, PITTSBURG POWER PLANT, UNIT 7" DATED 10/18/68.
- ◐ BORINGS DRILLED PRIOR TO UNIT 7 INVESTIGATION AND PRESENTED IN THIS REPORT.
- ⊕ BORINGS DRILLED FOR UNIT 7 INVESTIGATION AND PRESENTED IN OUR "PRELIMINARY FOUNDATION INVESTIGATION REPORT, PITTSBURG POWER PLANT, UNIT 7" DATED 10/18/68.
- ⊕ BORINGS DRILLED FOR PRESENT INVESTIGATION.

PLOT PLAN

FEET

100 0 100 200 300 400 500

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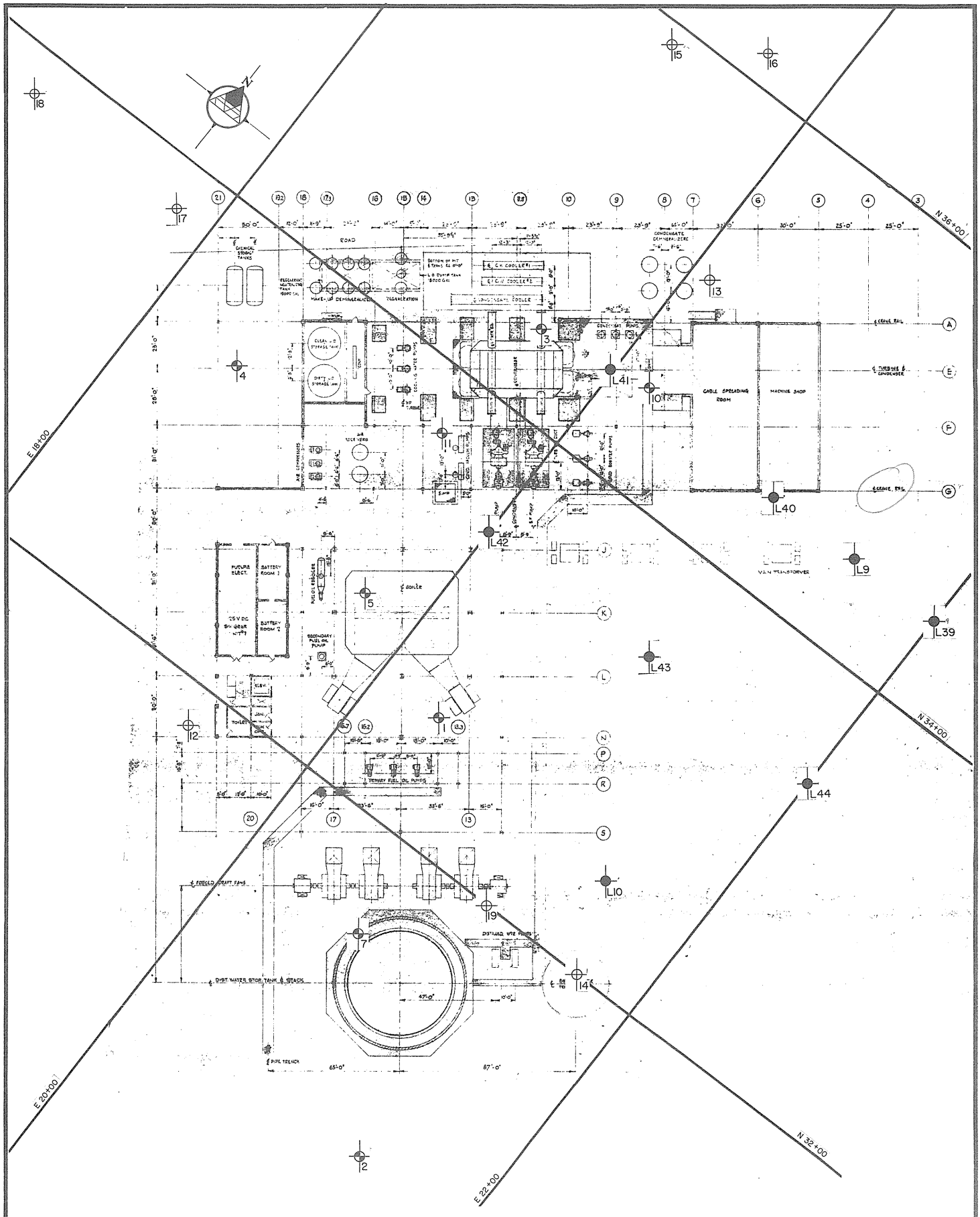
PLATE 1

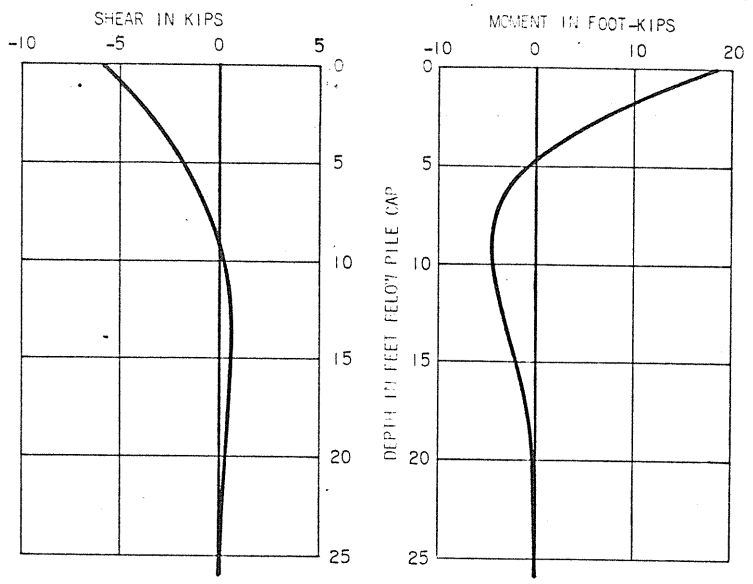


PLANNED LAYOUT OF UNIT 7
POWER PLANT

FEET
64 32 16 0 64

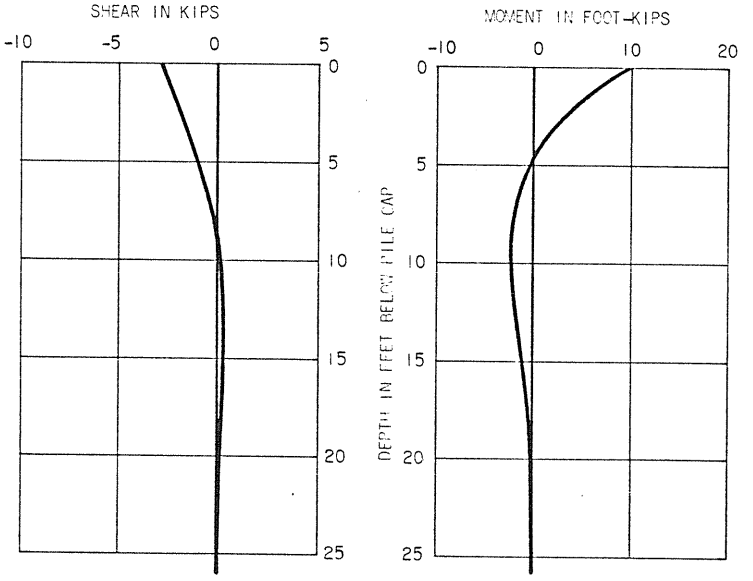
DAMES & MOORE
APPLIED EARTH SCIENCES

PLATE 2



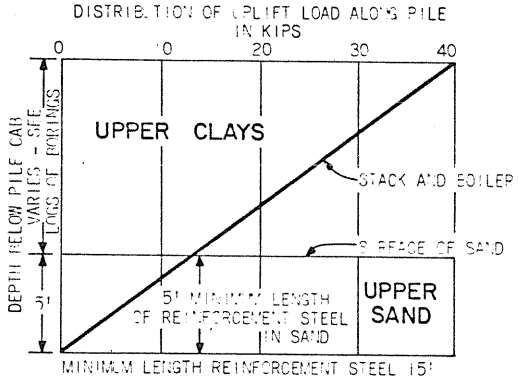
STRUCTURAL CAPACITY OF PILES - STACK

HORIZONTAL SHEAR AND MOMENTS



STRUCTURAL CAPACITY OF PILES- BOILER

HORIZONTAL SHEAR AND MOMENTS



DISTRIBUTION OF UPLIFT LOADS ALONG PILES FOR TENSION STEEL DESIGN

ALL UPLIFT PILES SHOWN ON THE PLANS SHALL BE DESIGNED TO RESIST 40 KIPS OF UPLIFT LOAD. THE DISTRIBUTION OF UPLIFT RESISTANCE AS A FUNCTION OF DEPTH MAY BE DETERMINED FROM CHART SHOWN AT LEFT.

STRUCTURAL DESIGN CRITERIA FOR CONCRETE PILES

(50 - TON DESIGN LOAD PILES)

ALL PILES SHALL BE DESIGNED TO RESIST THE FOLLOWING VERTICAL LOADS:

1. 100 KIPS DEAD PLUS LIVE LOADS,
2. 190 KIPS DEAD PLUS LIVE PLUS SEISMIC LOADS.

ALL PILES MUST BE DESIGNED IN ACCORDANCE WITH THE COUNTY OF CONTRA COSTA BUILDING CODES.

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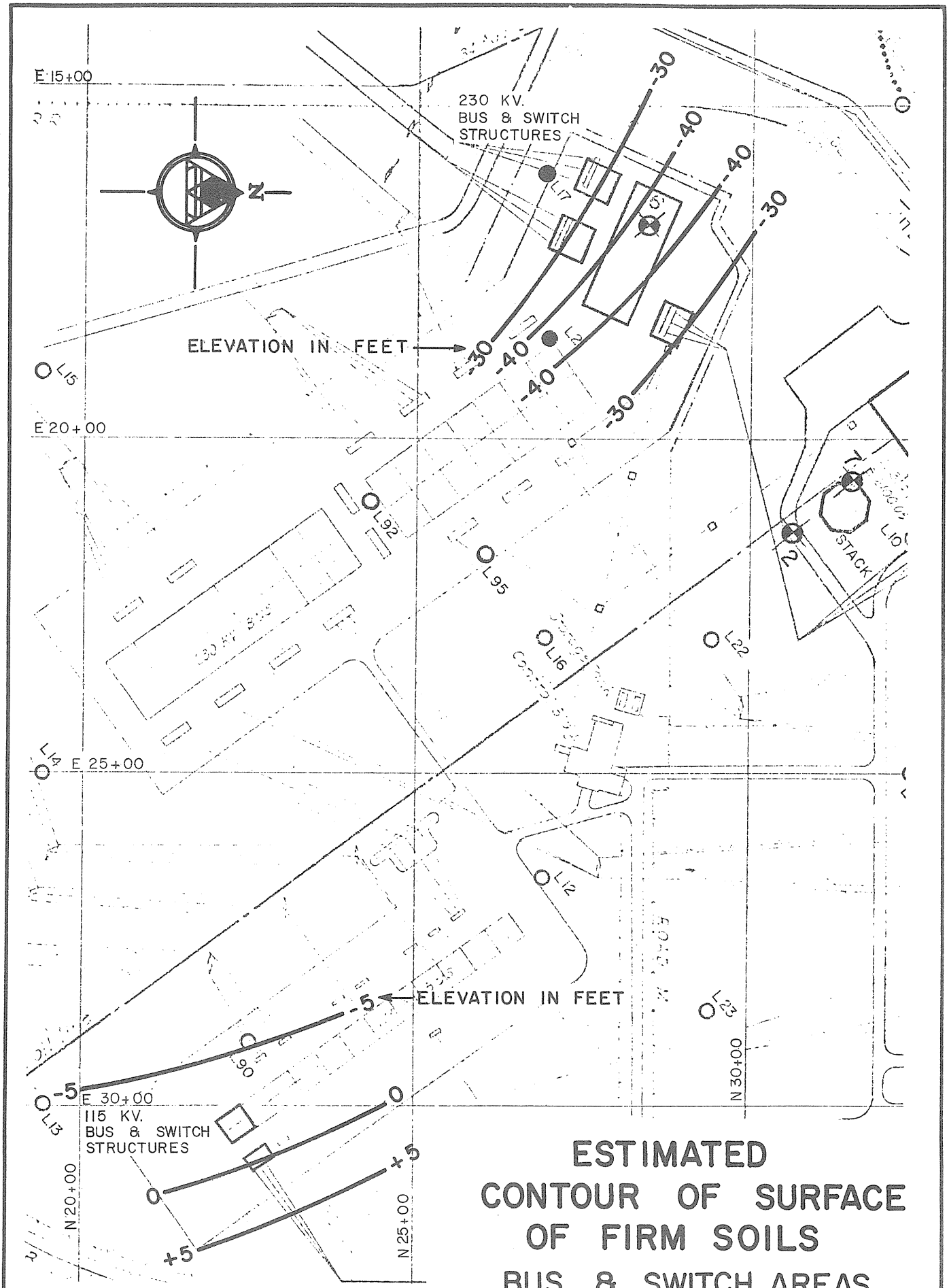
PLATE 3



ESTIMATED CONTOUR OF SURFACE OF FIRM SOILS

BUS & SWITCH AREAS

DAMES & MOORE

PLATE 4

APPENDIX A

FIELD EXPLORATIONS AND LABORATORY TESTING

FIELD EXPLORATIONS

The field explorations consisted of four borings in the Unit 7 Plant area (Nos. 12, 13, 14 and 19), four borings for Intake and Discharge structures (Nos. 15 through 18), and one boring (No. 20) in the vicinity of the fuel oil storage tank. Due to a surveying base line error in the field, Boring 19 was drilled 60 feet off location and Boring 14 was drilled at the intended location. A similar error for a discharge boring was compensating as the error placed Boring 18 close to one of the pre-selected boring locations and an additional boring was not required. Boring 17 was then drilled at the correct location.

All boring locations are shown on the Plot Plan, Plate 1, together with the location of borings drilled previously. The six-inch-diameter borings were drilled with truck-mounted rotary-wash-type equipment. All field work was performed under the direction of one of our engineers, who logged the borings, classified the soils, and extracted undisturbed samples. The total footage drilled was 450 feet.

Undisturbed samples were recovered using the Dames & Moore piston sampler and soil sampler, Type U, shown on Plates A3A and A3B. The piston sampler, which minimizes sample disturbance, was used primarily in the cohesive soils. The Type U drive sampler was used in the more dense sands. Standard penetration tests (ASTM 1586-64T) were also made in the sand strata

to obtain information on the relative density of these formations. The Logs of Borings are presented on Plates A1A through A1F. The Key to Test Data and Soil Classification and Plasticity Chart are presented on Plates A1G and A1H, respectively. The type of sampler used along with the number of blows required to drive the sampler one foot are shown to the left of the soil graph. The driving mechanisms are described on Plate A1G.

LABORATORY TESTING

All samples recovered in the field were inspected and visually classified by our field engineer. The piston samples were extruded from the sampling tubes and packaged in the field to reduce disturbance. All samples were further examined in the laboratory, and a testing program was prepared. Unit weights and moisture contents were measured on all samples.

The laboratory testing can be divided into three parts:

1. Identification Tests - Two types of tests were made for the purpose of identification and/or correlation with the soils described in our "Preliminary Foundation Investigation Report, Pittsburg Power Plant", dated October 18, 1968.

One-point liquid limit tests were performed on clay soils, and the percentage of soils passing the No. 200 sieve was determined in sandy soils. The results are presented on the Logs of Borings.

2. Strength Tests - Thirteen unconsolidated-undrained triaxial tests were performed on samples of the upper clay stratum. Four direct shear tests were performed on samples of the sand strata. All tests were strain-controlled. The direct shear tests were performed at a slow strain rate to insure drainage. The results of all strength tests are presented on the Logs of Borings.

3. Consolidation Tests - Three consolidation tests were performed on one sample from the upper clay stratum, and two from the lower clay stratum. The results are presented on Plate A2A.

The following Plates are attached and complete this appendix:

Plate A1A - Log of Borings (Borings 12 and 13)

Plate A1B - Log of Borings (Boring 14)

Plate A1C - Log of Boring (Boring 15)

Plate A1D - Log of Boring (Boring 16)

Plate A1E - Log of Borings (Borings 17 and 18)

Plate A1F - Log of Borings (Borings 19 and 20)

Plate A1G - Key to Test Data

Plate A1H - Soil Classification and Plasticity Chart

Plate A2A - Consolidation Test Data

Plate A3A - Dames & Moore Piston Sampler

Plate A3B - Dames & Moore Type U Soil Sampler

BORING 12

DRILLED 10/9/68

COORDINATES: N 31 + 85
E 19 + 40

TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
								22	109	U	23
								53	70	U	27
								140	29	U	6
								30	94	P	
								27	99	P	
								29	96	P	
										P	
		DS/CD		2000	1750			27	98	U	60
										SP	44
		DS/CD		5000	4350			27	94	U	88
										SP	45
								18	115	U	89
										SP	57
								34	90	U	42

ELEVATION IN FEET: +10, 0, -10, -20, -30, -40

ELEVATION +7.0'

GW	BROWNISH GRAY SANDY GRAVEL (LOOSE)
CL	BROWN SILTY CLAY (SOFT)
SP	GRAYISH BROWN FINE TO MEDIUM SAND (LOOSE) (WATER LEVEL 10/9/68)
PT	BLACK PEAT (SOFT)
CH	GRAY SILTY CLAY WITH SOME PEAT (MEDIUM STIFF)
	(GRADING WITH FINE SAND)
	(GRADING STIFF)
SP	GRAY FINE TO MEDIUM SAND, TRACE OF SILT (DENSE)
	(GRADING VERY DENSE)
CL	BROWNISH GRAY SILTY CLAY (STIFF)

FILL

BORING 13

DRILLED 10/11/68

COORDINATES: N 35 + 10
E 20 + 10

TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
								11	104	U	29
								12	103	U	9
										P	
		TX/UU	650	1500				65	61	P	
		TX/UU	1820	1500				30	92	P	
		TX/UU	5350	2000		43		22	104	P	
		TX/UU	3620	2000				26	96	P	
								26	100	U	60
										SP	51
		DS/CD		2500	2400			25	102	U	90
										SP	61
		DS/CD		5000	4500			24	102	U	85
										SP	68
								24	104	U	88
										SP	60
						40		34	89	P	

ELEVATION IN FEET: +10, 0, -10, -20, -30, -40

ELEVATION +9.0'±

GW	BROWNISH GRAY SANDY GRAVEL WITH SOME SILT
SM	(MEDIUM DENSE)
	BROWN SILTY FINE TO MEDIUM SAND WITH POCKETS OF SILTY CLAY (MEDIUM DENSE)
	(GRADING LOOSE)
CH	(WATER LEVEL 10/14/68)
PT	(GRADING WITH FINE GRAVEL)
CH	(GRADING WITH ORGANIC MATTER, PIECES OF WOOD, ROOTS)
	BLACK PEATY CLAY (SOFT)
	GRAY SILTY CLAY (MEDIUM STIFF)
	(GRADING MOTTLED GRAY AND BROWNISH GRAY)
	(GRADING SOME FINE SAND)
SP	GRAY FINE TO MEDIUM SAND (DENSE TO VERY DENSE)
	(TRACE OF COARSE SAND)
CL	LIGHT BROWNISH GRAY SILTY CLAY (VERY STIFF)

FILL

LOG OF BORINGS

DAMES & MOORE

PLATE A1A

BORING 14

DRILLED 10/15/68

COORDINATES: N 32 + 00
E 21 + 68

TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS (σ_1-σ_3) IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS / FOOT	ELEVATION IN FEET
								7	122	U	34	+10
								13	96		26	
											17	
										P		0
								24	97		44	
												-10
C	A2A											
(40%)								27	97		70	
(35%)										SP	53	
								31	94		95	-20
										SP	44	
								32	91		49	
										SP	79	
(86%)								25	102		61	-30
								33	89		57	
												-40

ELEVATION +9.0'±

GW	2" ASPHALT CONCRETE	FILL
	BROWN SANDY GRAVEL BASE	
SP	GRAY FINE TO MEDIUM SAND (MEDIUM DENSE TO DENSE)	
CH	BROWN SILTY CLAY (STIFF)	
	(WATER LEVEL 10/15/68)	
	(GRADING WITH FINE SAND)	
	(GRADING MORE FINE SAND)	
SM	GRAY SILTY FINE TO MEDIUM SAND (DENSE)	
CL	BROWNISH GRAY SILTY CLAY (STIFF)	

LOG OF BORINGS

DAMES & MOORE

PLATE A1B

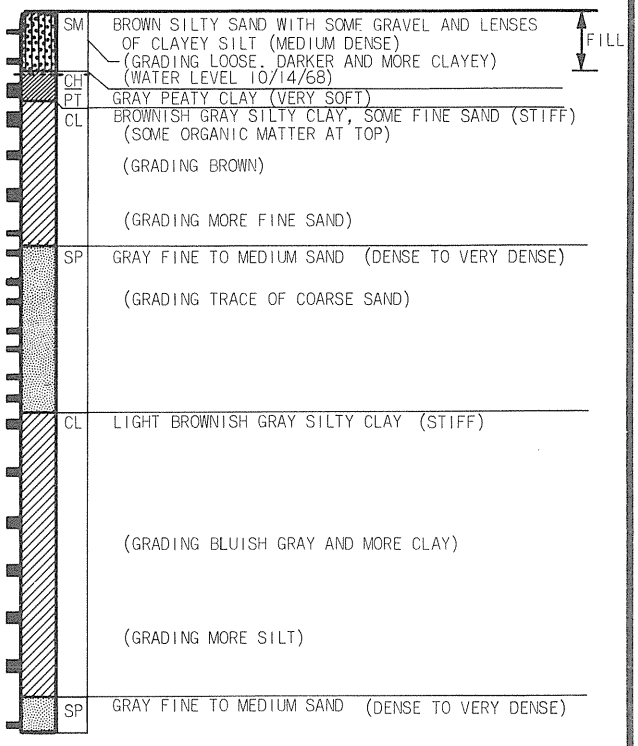
BORING 15

DRILLED 10/11/68

COORDINATES: N 35 + 90
E 19 + 25

ELEVATION +9.0'±

ELEVATION IN FEET	TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS / FOOT
+10									17	107	U	24
									20	104	U	8
0			TX/UU	1380	1200				79	41	P	
			TX/UU	2100	1500				23	103	P	
			TX/UU	5700	2000		27		17	112	P	
-10			TX/UU	3200	2000				26	99	P	
									30	95	U	29
											SP	34
-20									25	102	U	63
											SP	63
									22	108	U	102
											SP	87
-30									22	107	U	90
											SP	114
							52		37	87	P	
-40	C	A2A									P	
									34	88	P	
-50									48	74	P	
	C	A2A							34	88	P	
-60									31	93	P	
									21	108	U	49
-70												



LOG OF BORINGS

DAMES & MOORE

PLATE A1C

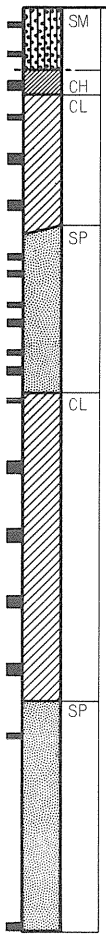
BORING 16

DRILLED 10/14/68

COORDINATES: N 36 + 15
E 19 + 65

ELEVATION +9.0'±

ELEVATION IN FEET	TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_3 or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
+10									54	69	U	43
									24	104	U	14
0			TX/UU	1330	1500				28	95	P	
											P	
			TX/UU	2090	2000				22	103	P	
-10	(86%)								25	103	P	
									27	99	U	67
											SP	64
-20									24	105	U	95
											SP	67
									34	88	U	56
-30											SP	32
									34	88	U	40
-40									34	89	P	
									47	75	P	
-50									37	85	P	
-60									30	94	P	
									21	108	U	83
-70												
-80												
-90											U	82 9"



SM	LIGHT BROWN SILTY FINE TO MEDIUM SAND WITH POCKETS OF CLAYEY SILT (MEDIUM DENSE) (GRADING WITH ORGANIC MATTER) (WATER LEVEL 10/15/68) — FILL
CH	DARK GRAY PEATY CLAY (SOFT)
CL	GRAY SILTY CLAY (STIFF)
	(GRADING WITH FINE SAND)
	(GRADING MORE SAND)
SP	GRAY FINE TO MEDIUM SAND (DENSE TO VERY DENSE) (CEMENTED ZONES)
	(GRADING WITH SEAMS OF SILTY CLAY)
CL	BROWNISH GRAY SILTY CLAY (STIFF)
	(GRADING STIFFER)
	(GRADING WITH SOME FINE SAND)
SP	BROWNISH GRAY FINE TO MEDIUM SAND (VERY DENSE)
	(GRADING WITH COARSE SAND)
	(GRADING WITH SOME GRAVEL)

LOG OF BORINGS

DAMES & MOORE

PLATE AID

BORING 17

DRILLED 10/14/68

COORDINATES: N 33 + 75
E 17 + 80

ELEVATION IN FEET	TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
+10									14	109	I	23
									17	88	I	18
0									43	78	I	7
									204	26	P	
			TX/UU	2160	2000				52	80	P	
-10			TX/UU	1240	2000				37	84	P	
			TX/UU	980	2500				44	78	P	
	(88%)								32	93	U	20
-20											SP	66
									24	104	U	8
											SP	64
									30	93	U	72
-30											SP	57
-40												

ELEVATION +9.0'±

GW	BROWNISH GRAY SILTY SANDY GRAVEL (MEDIUM DENSE)	FILL
SM	GRAY FINE TO MEDIUM SAND WITH POCKETS OF CLAY (MEDIUM DENSE)	
	(WATER LEVEL 10/15/68)	
	(GRADING SILTY)	
PT	DARK BROWN PEAT (SOFT)	
CH	GRAY SILTY CLAY (MEDIUM STIFF TO STIFF)	
	(GRADING BROWN)	
	(GRADING STIFFER)	
	(GRADING SOME FINE SAND)	
SP	GRAY FINE TO MEDIUM SAND. (DENSE)	

BORING 18

DRILLED 10/10/68

COORDINATES: N 33 + 80
E 16 + 95

ELEVATION IN FEET	TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
+10									10	91	U	18
			TX/UU	1190	1000				75	54	P	
0									374	14	P	
			TX/UU	1180	1000				63	61	P	
			TX/UU	2140	2000		44		27	97	P	
-10			TX/UU	3580	2000		83		34	87	P	
			TX/UU	1420	2000				44	78	P	
	(84%)								32	91	U	17
-20	(21%)								21	108	U	54
											SP	51
									20	110	U	68
											SP	75
-30									27	99	U	65
											SP	95
									26	100	I	95/10"
											SP	68
-40									19	112	I	50
									34	89	P	
-50												

ELEVATION +9.0'±

SM	BROWN SILTY FINE TO MEDIUM SAND (MEDIUM DENSE)	FILL
CH	BROWN AND GRAY SILTY CLAY WITH SOME ORGANIC	
CH	MATTER (SOFT)	
PT	BLACK PEATY CLAY (SOFT)	
	(WATER LEVEL 10/11/68)	
	(LAYER OF PEAT)	
CH	GRAY SILTY CLAY (MEDIUM STIFF TO STIFF)	
	(GRADING WITH FINE SAND)	
SP	GRAY FINE TO MEDIUM SAND (DENSE TO VERY DENSE)	
	(GRADING LAYERS OF COARSE SAND)	
	(GRADING COARSER)	
CL	LIGHT BROWNISH GRAY SILTY CLAY (STIFF)	

LOG OF BORINGS

DAMES & MOORE

PLATE A1E

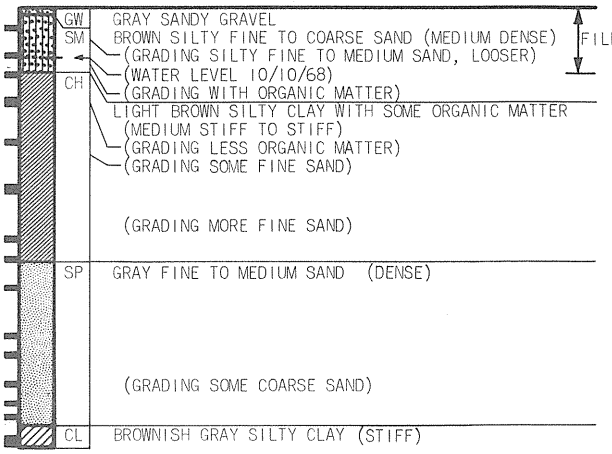
BORING 19

DRILLED 10/9/68

COORDINATES: N 32 + 00
E 21 + 10

ELEVATION IN FEET	TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA (1) DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
+10									44	78	U	16
									53	70	U	8
0							23		25	101	U	5
									25	102	P	
							23		24	104	U	24
-10									24	104	P	
									27	99	U	31
											SP	45
-20									27	99	U	92
											SP	54
									29	97	U	49
-30											SP	54
									27	99	U	33
											SP	24
-40							50		36	86	P	

ELEVATION +9.0'±



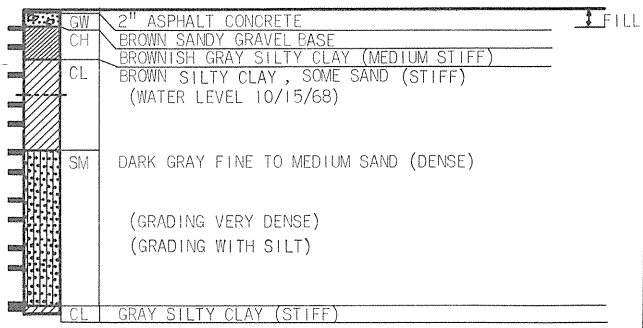
BORING 20

DRILLED 10/15/68

COORDINATES: N 31 + 22
E 30 + 70

ELEVATION IN FEET	TESTS REPORTED ELSEWHERE (1) TYPE OF TEST	TESTS REPORTED ELSEWHERE (1) SECTION OF APPENDIX	SHEAR TEST DATA (1) TYPE OF TEST	SHEAR TEST DATA (1) DEVIATOR STRESS $(\sigma_1-\sigma_3)$ IN PSF AT PEAK	SHEAR TEST DATA (2) σ_n or σ_3, IN PSF	SHEAR TEST DATA PEAK SHEAR STRENGTH IN PSF	ATTERBERG LIMITS LIQUID LIMIT IN %	ATTERBERG LIMITS PLASTIC LIMIT IN %	MOISTURE CONTENT IN %	DRY DENSITY IN LBS./CU.FT.	(3) TYPE OF SAMPLER	(4) BLOWS/FOOT
+10									18	108	I	13
									28	99	I	11
0	(76%)								24	95	U	58
									20	107	I	62
											SP	4
									30	89	U	30
											SP	32
-10									27	99		65
											SP	63
	(59%)								19	113	U	91
											SP	74
-20									31	92	I	50
-30												

ELEVATION +9.0'±



LOG OF BORINGS

DAMES & MOORE

PLATE A1F

SYMBOL	TYPE OF TEST (1)
M	MOISTURE
QD	QUICK MD TEST BASED ON ASSUMED SPECIFIC GRAVITY
MD	MOISTURE-DENSITY
CD	CHUNK DENSITY ON BULK SAMPLE
RD	RELATIVE DENSITY
COMP	COMPACTION CURVE
CI	CALIFORNIA IMPACT TEST
CC	COMPACTED CORE
G	SPECIFIC GRAVITY
p^H	HYDROGEN ION CONCENTRATION
MA	MECHANICAL ANALYSIS *
SA (10%)	SIEVE ANALYSIS (+200 ONLY) — INDICATES PERCENT PASSING #200 SIEVE
HA	HYDROMETER ANALYSIS (-200 ONLY)
AL	ATTERBERG LIMITS (LL & PL)
SL	SHRINKAGE LIMIT
FS	FREE SWELL
SS	SHRINK-SWELL
EXP	EXPANSION
C	CONSOLIDATION
VC	VIBRATING CONSOLIDATION TEST
P	PERMEABILITY
UC	UNCONFINED COMPRESSION
	TRIAXIAL COMPRESSION:
TX/UU	1. UNCONSOLIDATED-UNDRAINED
TX/CU	2. CONSOLIDATED-UNDRAINED
TX/CU/MΦ	3. CU/MULTIPHASE **
TX/CU/PP	4. CU/ WITH PORE PRESSURE MEASUREMENTS
TX/CD	5. CONSOLIDATED-DRAINED
	DIRECT SHEAR TEST:
DS/UU	1. UNCONSOLIDATED-UNDRAINED
DS/CU	2. CONSOLIDATED-UNDRAINED
DS/CD	3. CONSOLIDATED-DRAINED
DS/CD/MΦ	4. CD/MULTIPHASE **
TV	TORVANE SHEAR (LAB VANE SHEAR)

* INCLUDES COMPLETE ANALYSIS, SIEVING AND HYDROMETER

** SERIES OF TESTS RUN ON ONE SAMPLE

STRENGTH CHARACTERISTICS OF COHESIVE SOILS
AS DETERMINED BY UNCONSOLIDATED UNDRAINED SHEAR TESTS

TERM	SHEAR STRENGTH (LBS./SQ. FT.)
VERY SOFT	0 TO 250
SOFT	250 TO 500
MEDIUM STIFF	500 TO 1,000
STIFF	1,000 TO 2,000
VERY STIFF	2,000 TO 4,000
HARD	OVER 4,000

RELATIVE DENSITY OF COHESIONLESS SOILS

TERM	BLOWS PER FOOT *
VERY LOOSE	0 - 4
LOOSE	5 - 10
MEDIUM DENSE	11 - 30
DENSE	31 - 50
VERY DENSE	OVER 50

* BLOWS ARE MEASURED WITH 2-INCH O.D., 1-3/8-INCH I.D. SAMPLER DRIVEN 1 FOOT BY 140 POUND HAMMER FALLING 30 INCHES AFTER SAMPLER HAS BEEN SEATED 6 INCHES. SEE "TENTATIVE METHOD FOR PENETRATION TEST AND SPLIT-BARREL SAMPLING OF SOILS", ASTM DESIGNATION D1586-64T.

KEY TO SAMPLES

■ - INDICATES DEPTH OF SAMPLE

⊠ - INDICATES DEPTH OF SAMPLING ATTEMPT WITH NO RECOVERY

TYPES OF SOIL SAMPLERS (3)

P - PISTON SAMPLER

U - D & M UNDERWATER SAMPLER TYPE U ON 265 POUND SLIP-JARS FALLING APPROX. 30"

TW - D & M UNDERWATER SAMPLER TYPE U WITH THIN-WALLED SAMPLING TUBE ON 265 POUND SLIP-JARS FALLING APPROX. 30"

SP - STANDARD PENETRATION TEST * (SEE ABOVE) 140 POUND WEIGHT FALLING 30 INCHES

NOTES ON LOGS:

(1) TYPE OF TEST (SEE TABLE ABOVE)

(2) σ_N OR σ_3, IN KSF

σ_N = NORMAL PRESSURE IN DIRECT SHEAR TEST

σ_3 = LATERAL CONFINING PRESSURE IN TRIAXIAL COMPRESSION TEST AT PEAK DEVIATOR STRESS. IN TESTS WITH PORE PRESSURE MEASUREMENTS, THE EFFECTIVE STRESSES, σ_1 AND σ_3 ARE GIVEN FOR MAXIMUM PRINCIPLE STRESS RATIO.

(3) TYPE OF SAMPLER: (SEE TABLE AT LOWER RIGHT)

(4) BLOWS/FOOT: LAST 12 INCHES OUT OF 18 INCHES DRIVEN OR AS INDICATED

KEY TO TEST DATA

DAMES & MOORE
APPLIED EARTH SCIENCES

PLATE A1G

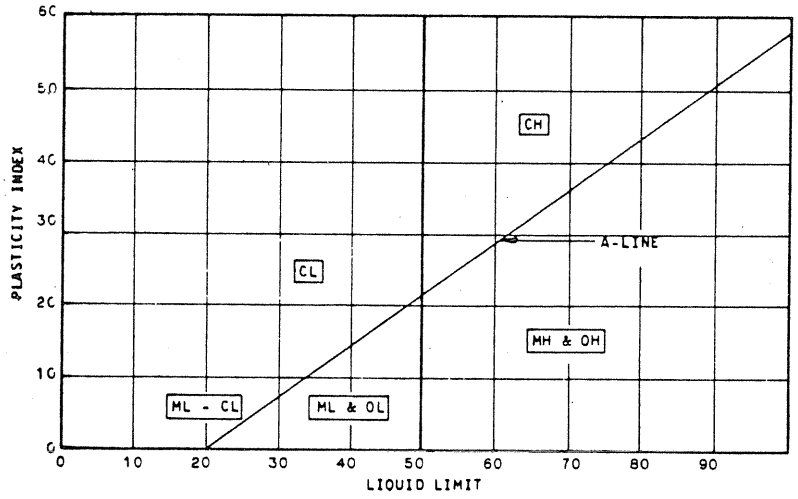
SYMBOL	LETTER	DESCRIPTION	MAJOR DIVISIONS		
	GW	WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	CLEAN GRAVELS (little or no fines)	GRAVELS — MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	COARSE-GRAINED SOILS — MORE THAN HALF OF MATERIAL IS LARGER THAN NO.200 SIEVE SIZE
	GP	POORLY-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES			
	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	GRAVELS WITH FINES (appreciable amount of fines)		
	GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES			
	SW	WELL-GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES	CLEAN SANDS (little or no fines)	SANDS — MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE.	
	SP	POORLY-GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES			
	SM	SILTY SANDS, SAND-SILT MIXTURES	SANDS WITH FINES (appreciable amount of fines)		
	SC	CLAYEY SANDS, SAND-CLAY MIXTURES			
	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50		FINE-GRAINED SOILS — MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE
	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS			
	OL	ORGANIC SILTS AND ORGANIC SILT-CLAYS OF LOW PLASTICITY			
	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50		
	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS			
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS			
	PT	PEAT AND OTHER HIGHLY ORGANIC SOILS	HIGHLY ORGANIC SOILS		

for visual classification, the ¼" size may be used as equivalent to the no. 4 sieve size.

the no. 200 sieve size is about the smallest particle visible to the naked eye

SOIL CLASSIFICATION CHART

UNIFIED SOIL CLASSIFICATION SYSTEM



PLASTICITY CHART

■ INDICATES DEPTH OF UNDISTURBED SAMPLE

⊠ INDICATES DEPTH OF DISTURBED SAMPLE

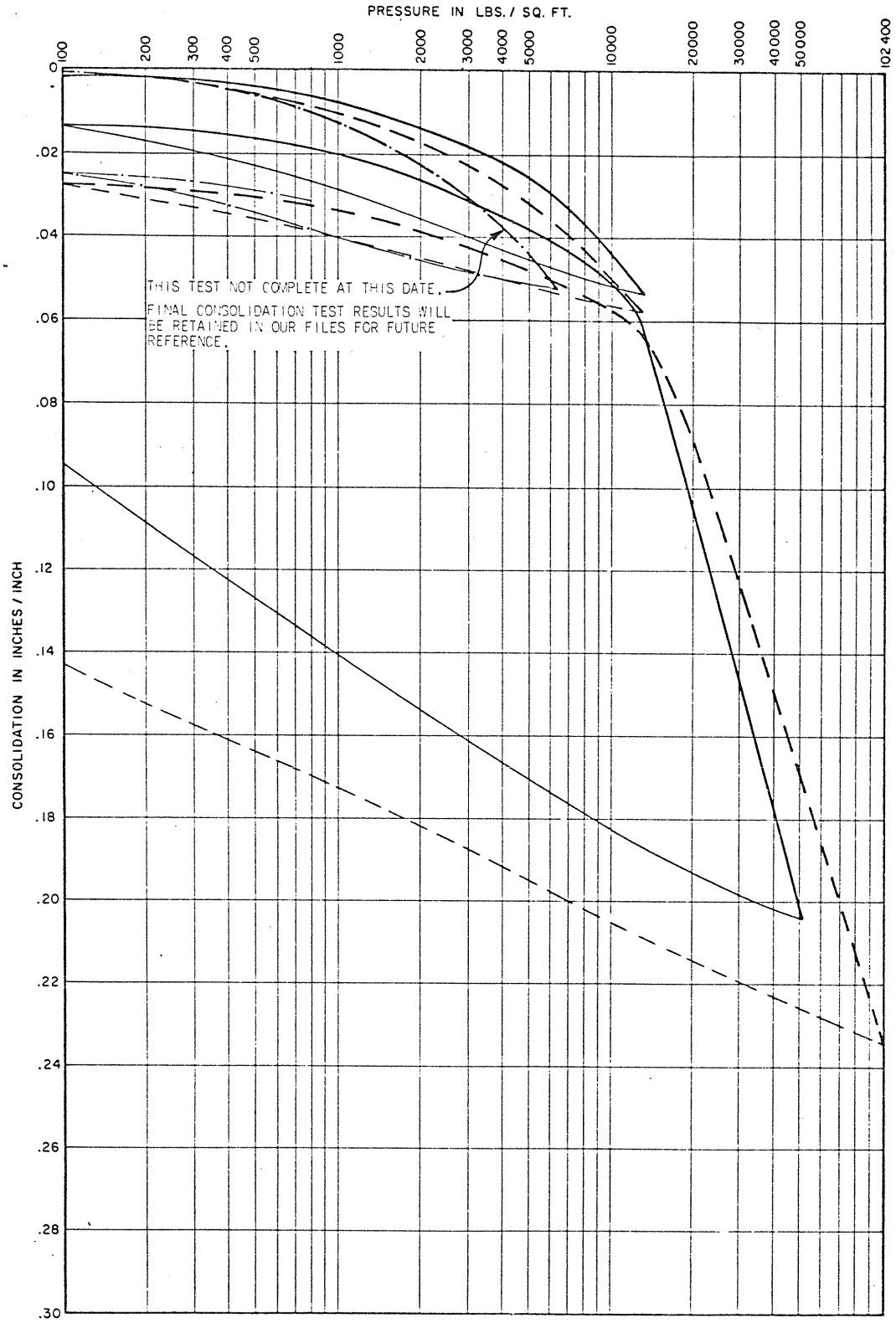
[B] INDICATES DEPTH OF BULK SAMPLE

KEY TO SAMPLES

SOIL CLASSIFICATION CHART & KEY TO SAMPLES

DAMES & MOORE

PLATE A1H

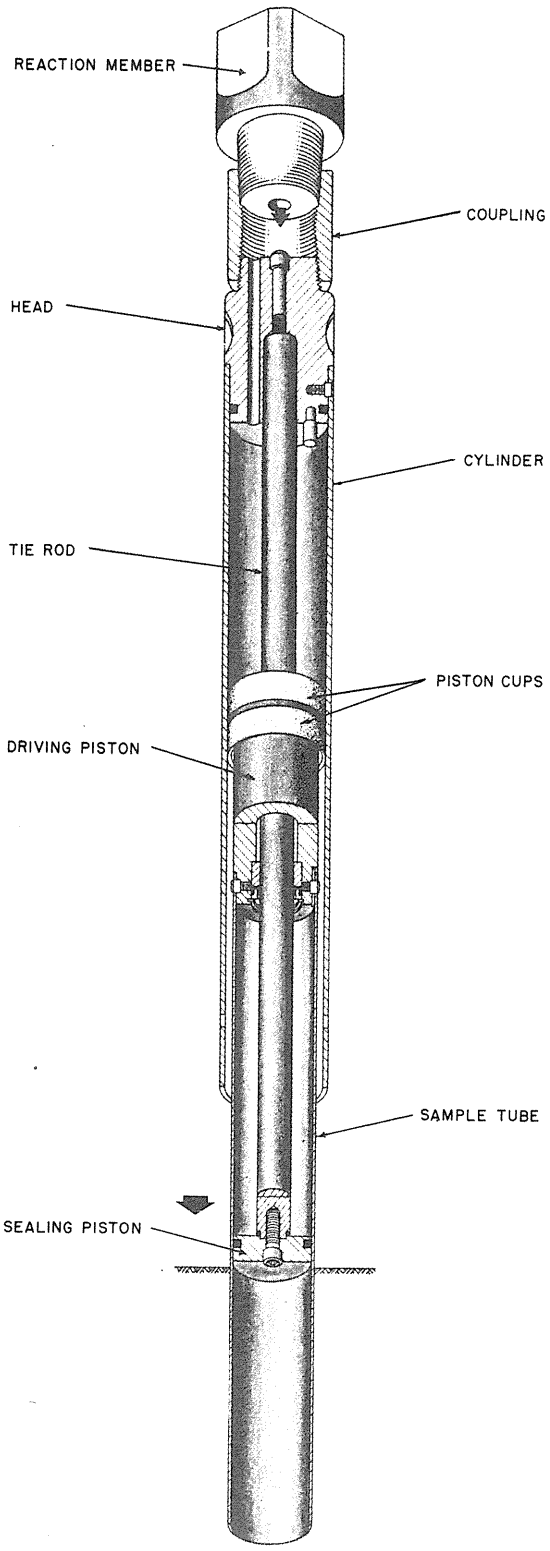


KEY	BORING	ELEV	SOIL CLASSIFICATION	DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE, %		DRY DENSITY, PCF		VOID RATIO		EFFECTIVE OVERBURDEN PRESSURE, PSF	PRECONSOL PRESSURE, PSF
							BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER		
———	15	-54	CL	BLUISH GRAY SILTY CLAY	-	-	39	32	85	94	0.96	0.78	4300	6000
— —	15	-39	CL	LIGHT BROWNISH GRAY SILTY CLAY	-	-	33	26	89	104	0.87	0.60	3300	6000
—·—	14	-12	CL	BROWN SILTY CLAY WITH SOME FINE SAND	-	-							1700	

CONSOLIDATION TEST DATA

DAMES & MOORE

PLATE A 2A



PISTON SAMPLER

THE DAMES & MOORE PISTON SAMPLER HAS BEEN DEVELOPED TO OBTAIN SAMPLES OF SOFT SOILS WITH A MINIMUM OF DISTURBANCE. THE MOST SIGNIFICANT FEATURES ARE THE SEALING PISTON WHICH CONFINES THE SOIL DURING SAMPLING AND THE SAMPLE TUBE WHICH HAS A WALL THICKNESS OF ONLY 0.042 INCHES.

AT THE START OF THE SAMPLING, THE LOWER END OF THE SAMPLE TUBE IS ADJACENT TO THE SEALING PISTON AT THE BOTTOM OF AN EXPLORATION TEST BORING. THE SEALING PISTON, CYLINDER, HEAD, AND REACTION MEMBER REMAIN STATIONARY DURING SAMPLING. COMPRESSED AIR, COMPRESSED NITROGEN, OR WASH WATER ARE FORCED INTO THE CYLINDER THROUGH THE SAMPLING RODS FROM THE DRILLING EQUIPMENT. THE DRIVING PISTON MOVES THE SAMPLE TUBE DOWNWARD INTO THE SOIL.

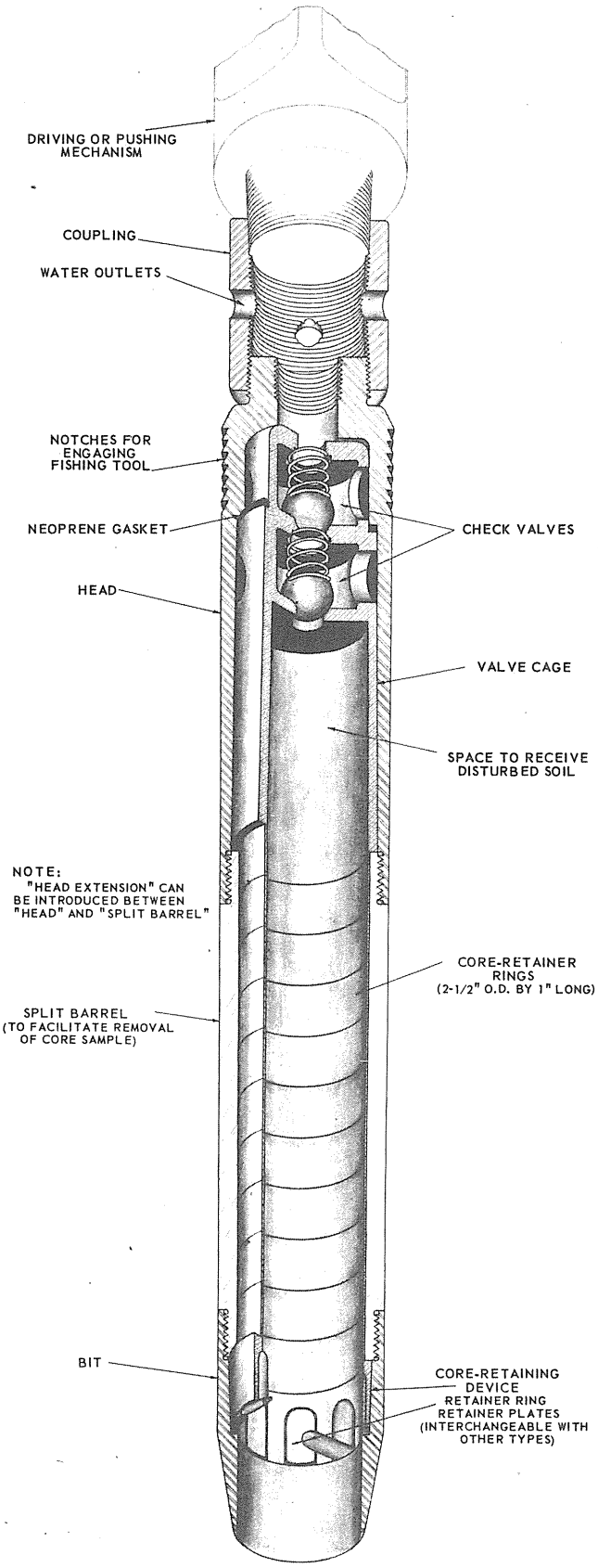
417-13 (4-61)

DAMES & MOORE

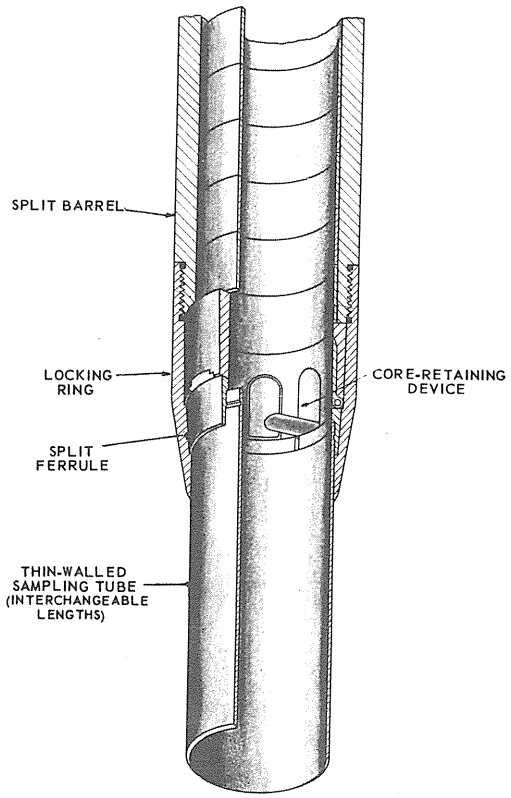
PLATE A3A

SOIL SAMPLER TYPE U

FOR SOILS DIFFICULT TO RETAIN IN SAMPLER
U. S. PATENT NO. 2,318,062



ALTERNATE ATTACHMENTS



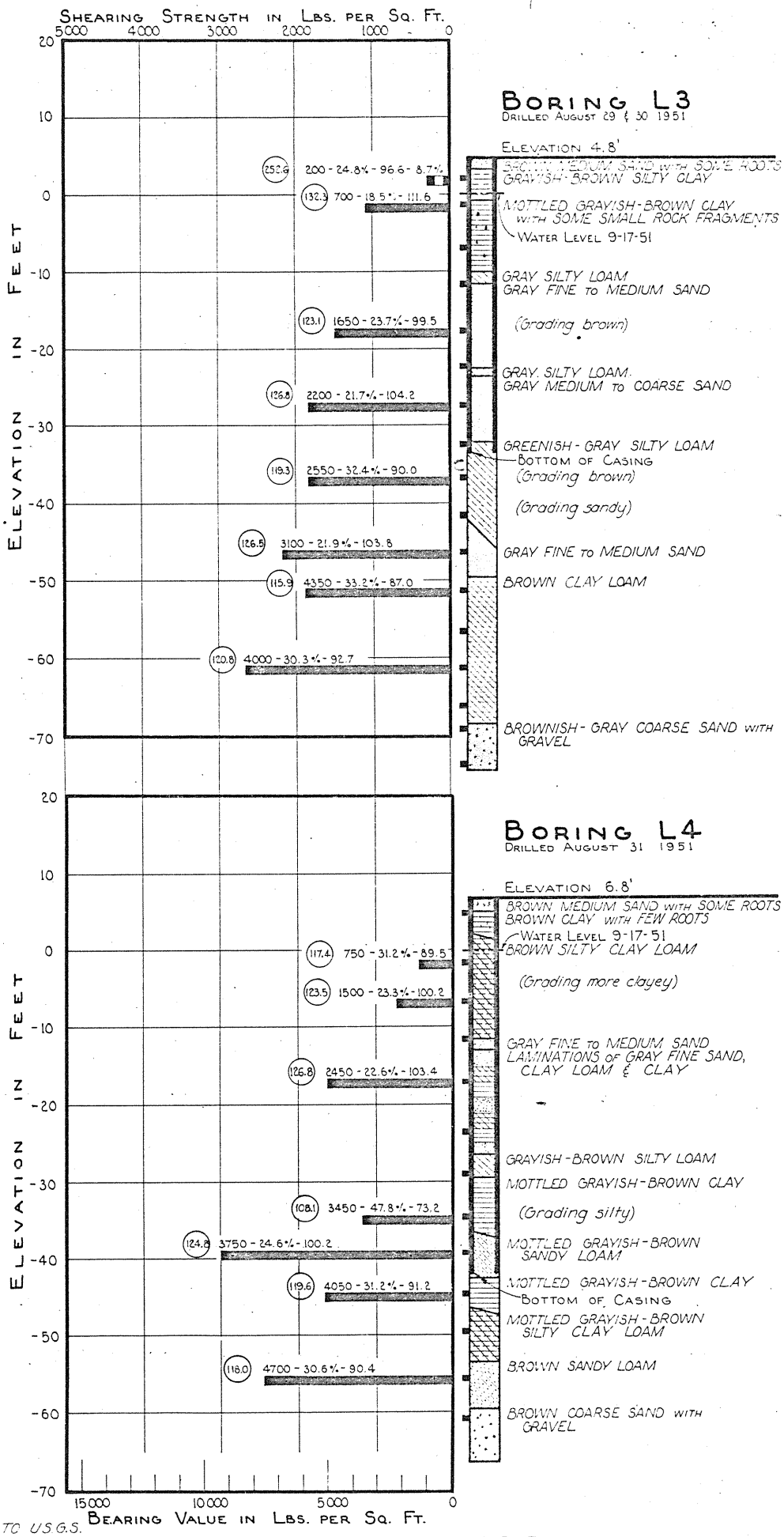
DAMES & MOORE

PLATE A3B

417.6(6-61)

APPENDIX B

LOGS OF BORINGS FROM PREVIOUS INVESTIGATIONS



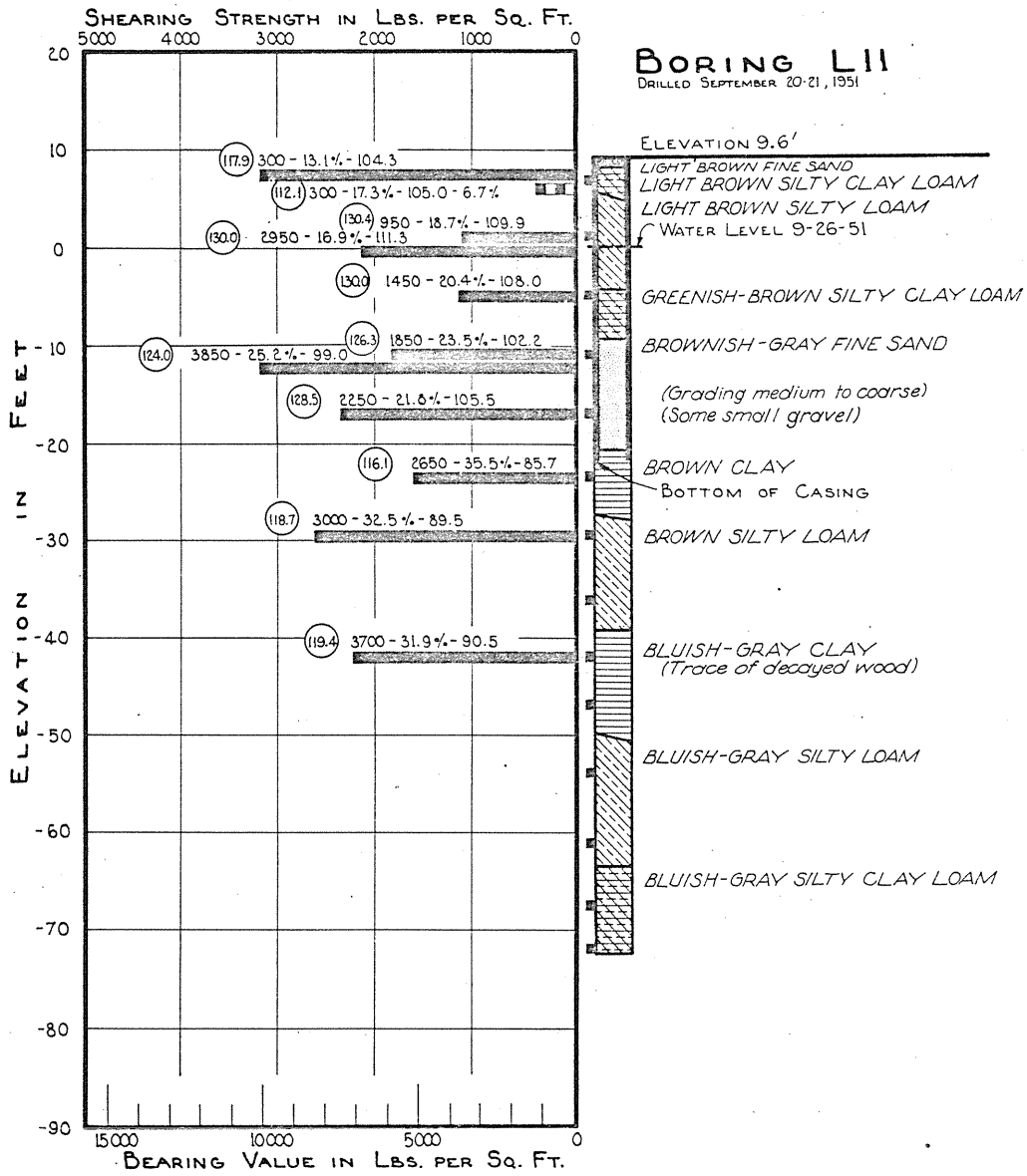
NOTE
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
Foundation Investigations · Soil Mechanics Engineering

PLATE 2B

DAMES & MOORE
JOB TITLE Foundation Investigation
DRAWN BY SJP
DATE 11-23-51
DRAFTED BY
REPORT DICTATED BY
DATE
SERIES OF DRAWINGS
DATE JOB STARTED
DATE PRINTED

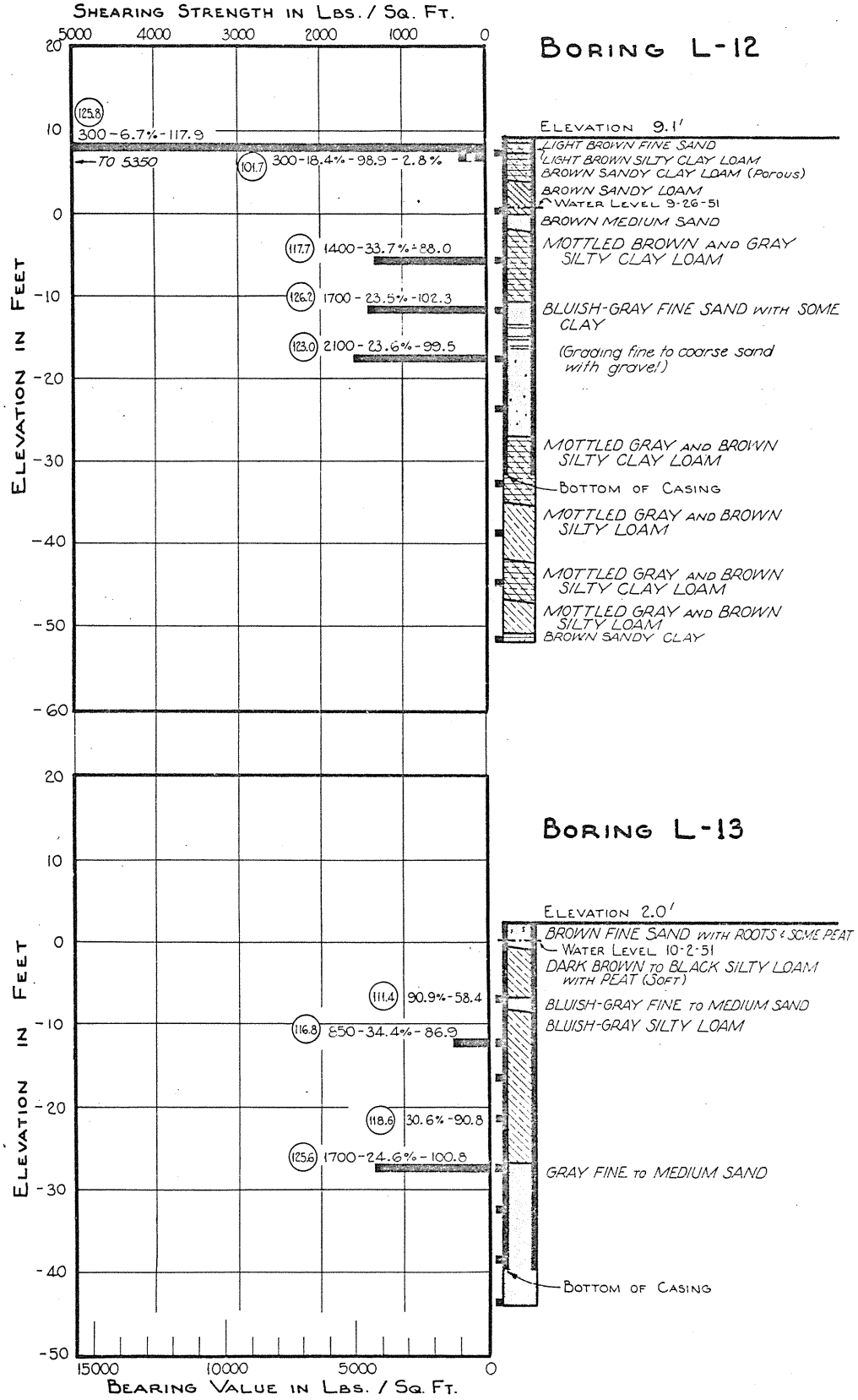


LOG OF BORINGS

NOTE
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

DAMES & MOORE, Soil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2H



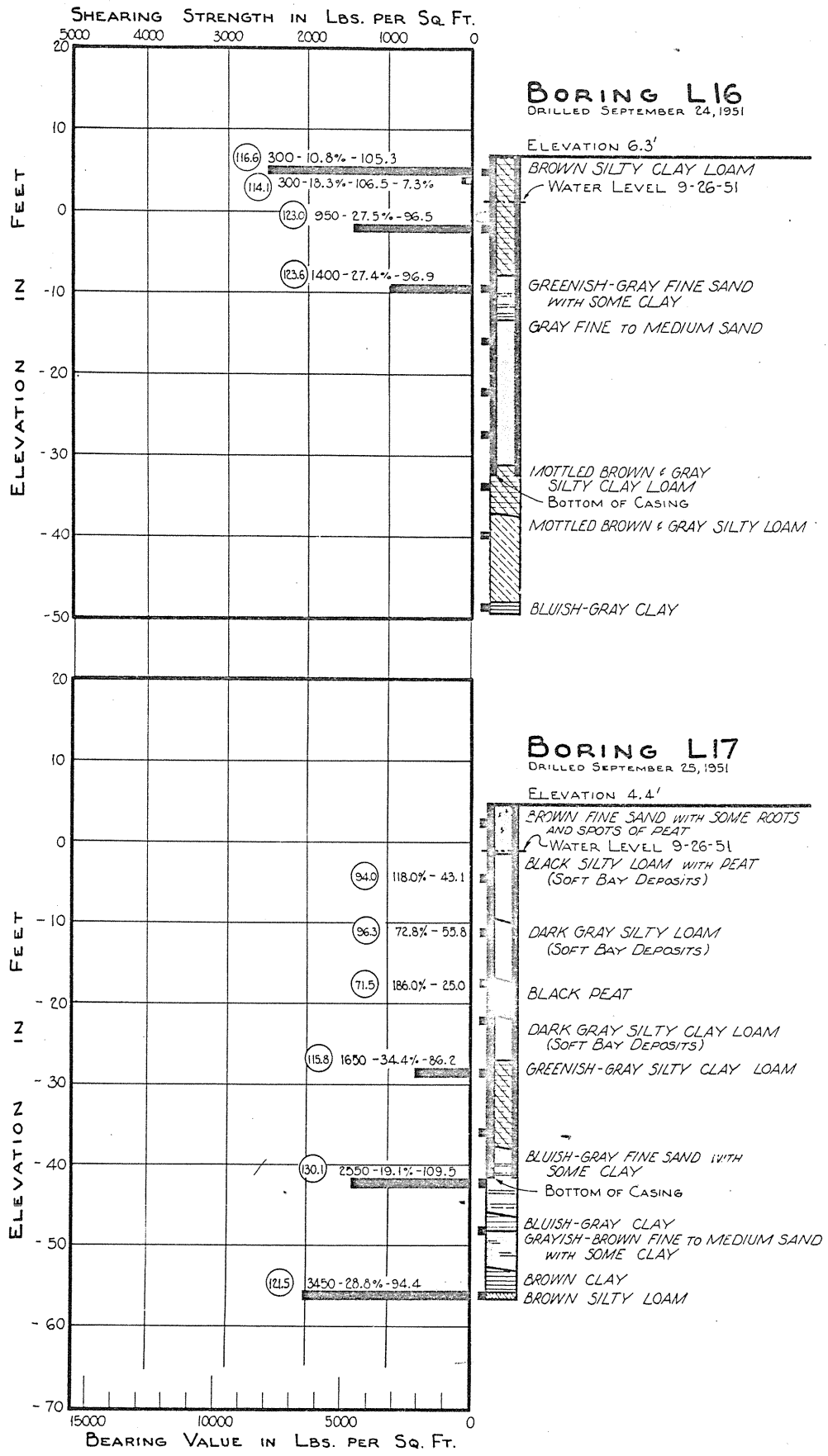
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 21



NOTE

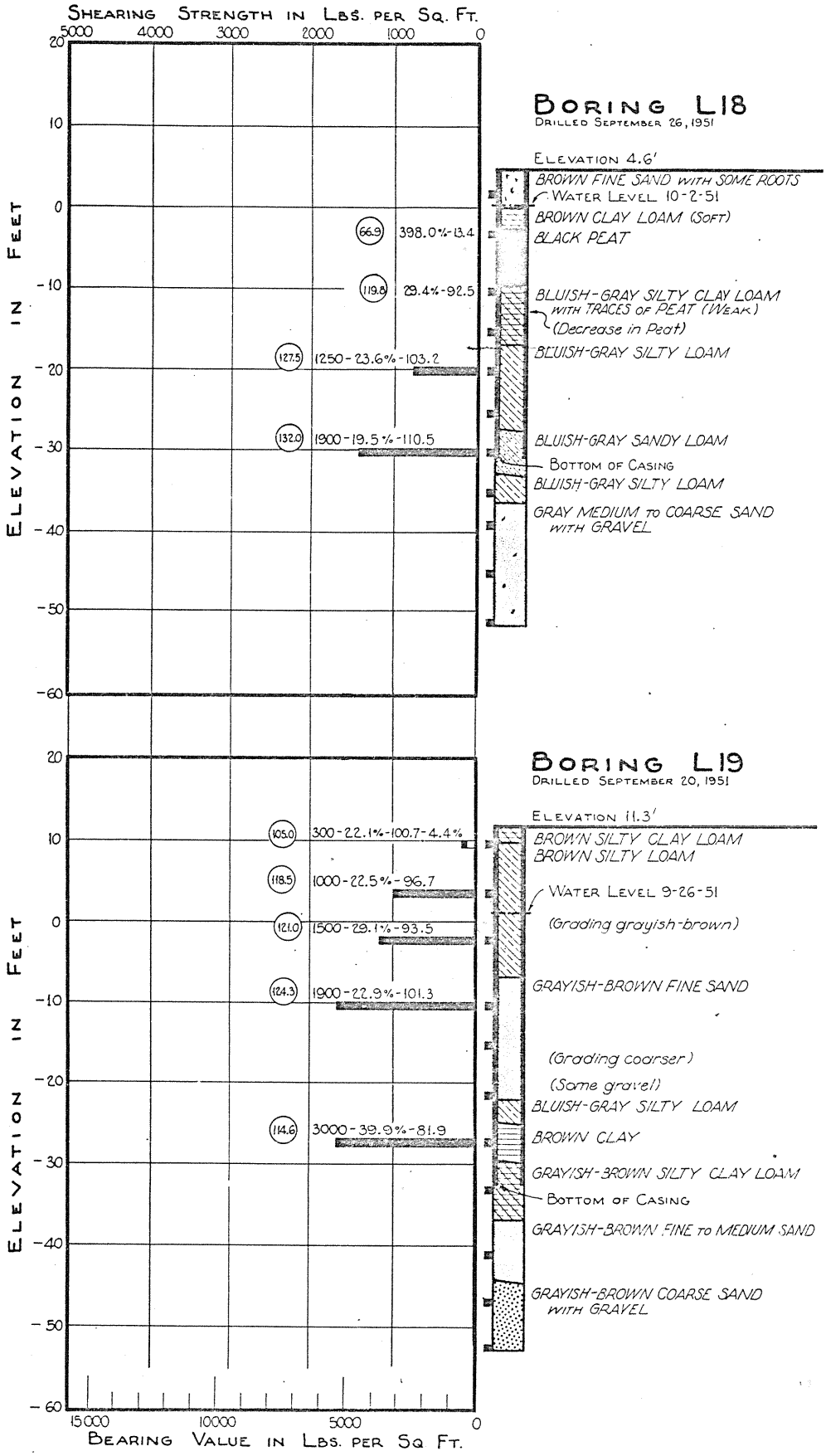
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').

BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2K



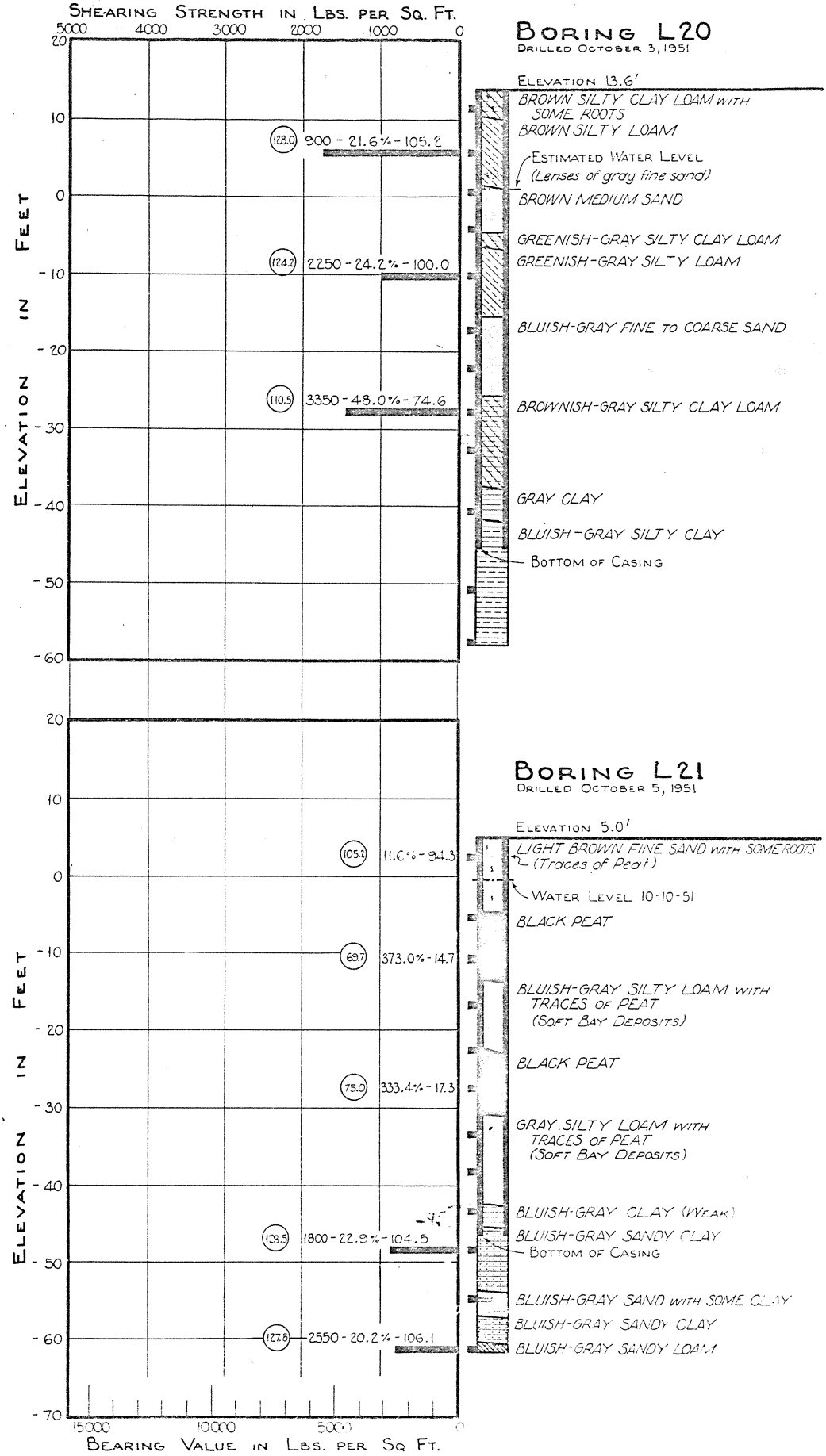
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2L



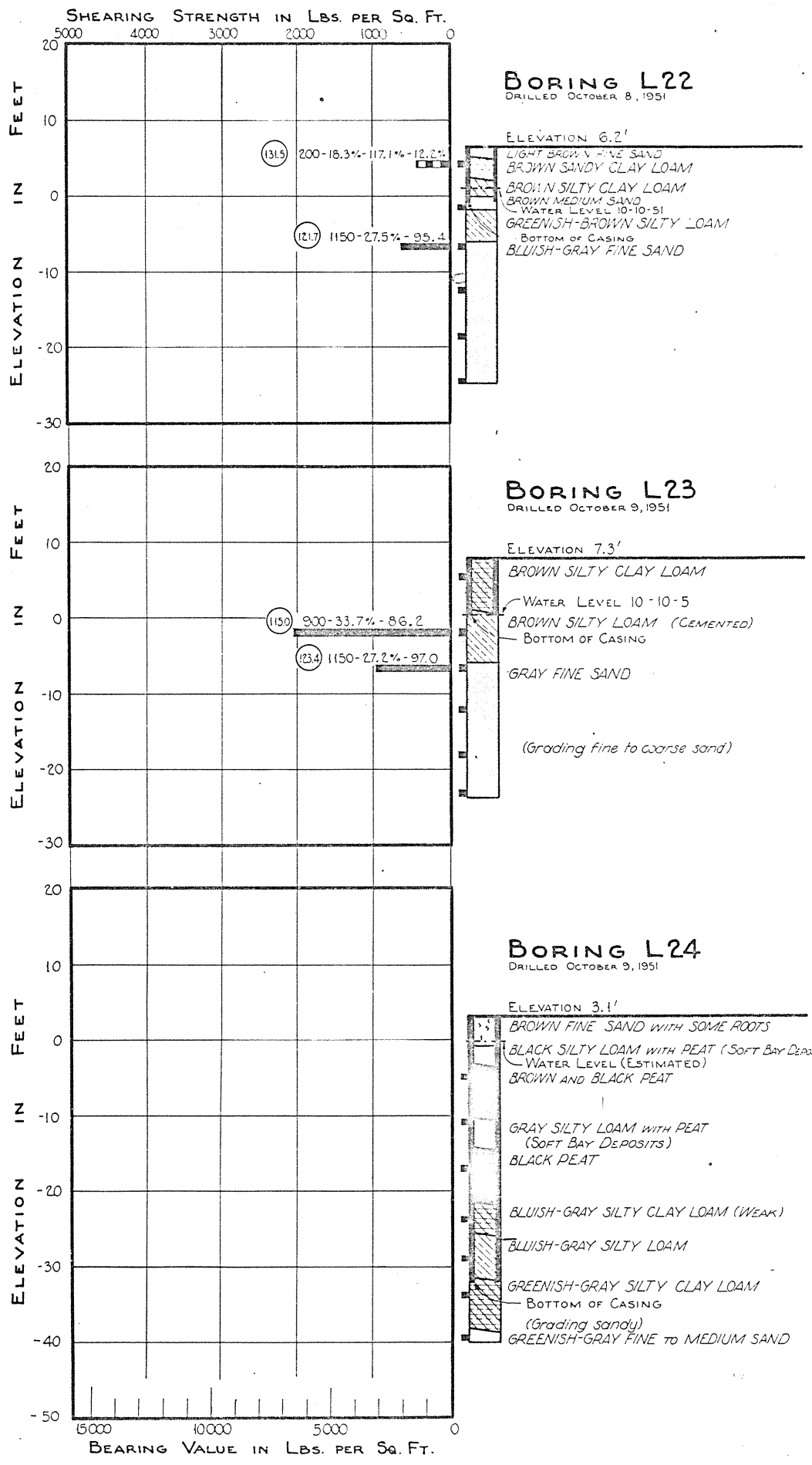
NOTE

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L = 0.0').
BORINGS DRILLED WITH 8" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Consulting Engineers
Foundation Investigations · Soil Mechanics Engineering

PLATE 2M



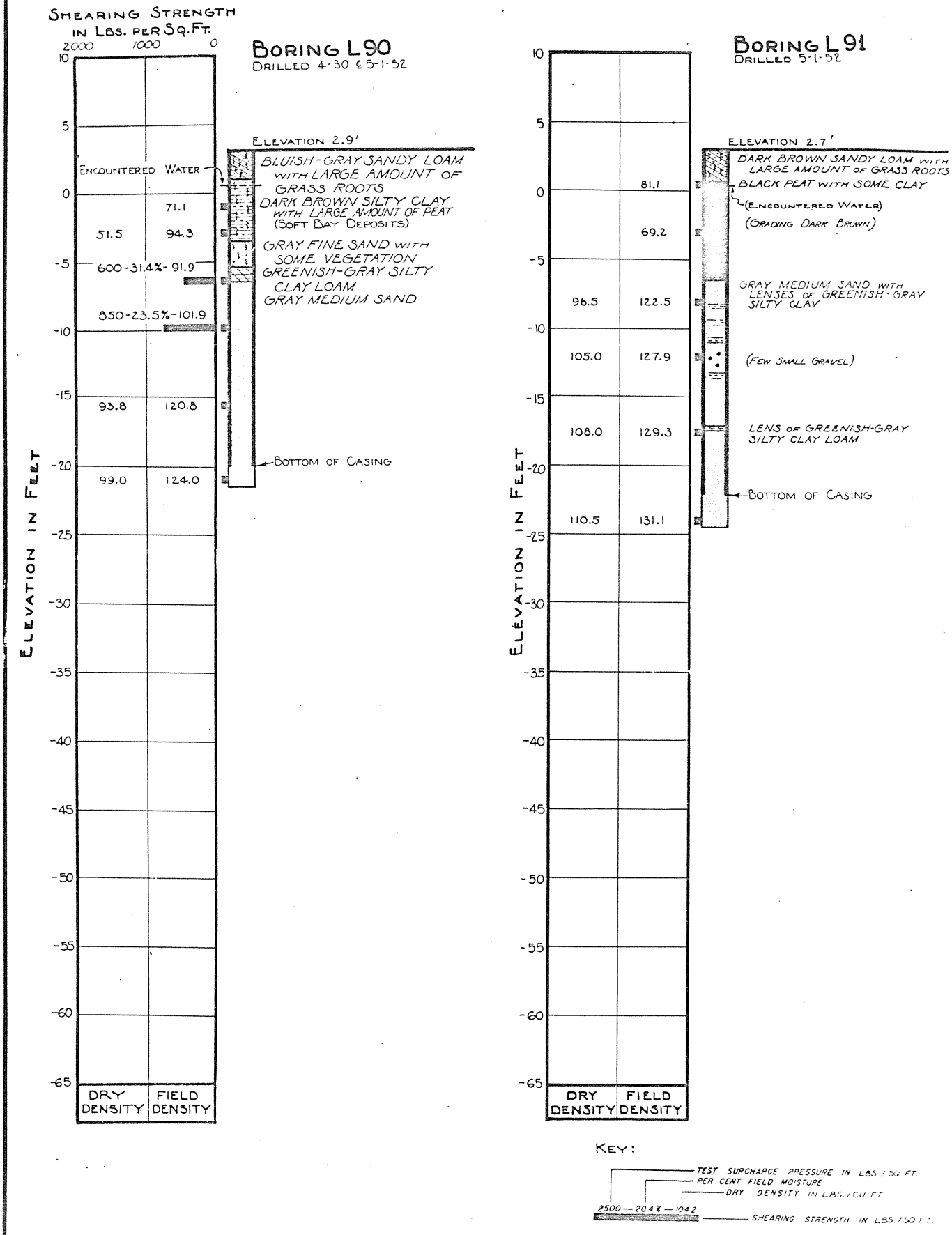
NOTE
ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE-TOOL EQUIPMENT.

LOG OF BORINGS

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE 2N

THIS DRAWING IS ONE OF A SERIES OF ____ DRAWINGS
CLIENT ____ DATE JOB STARTED ____ DATE PRINTED ____
DRAWN BY ____ DATE ____ DRAFTING CHECK. BY ____ DATE ____ REPORT DICTATED BY ____ DATE ____



LOG OF BORINGS

NOTES:

ELEVATIONS REFER TO U.S.G.S. DATUM (M.S.L. = 0.0').
BORINGS DRILLED WITH 6" DIAM. CABLE TOOL EQUIPMENT.

DAMES & MOORE, Civil Engineers
FOUNDATION INVESTIGATIONS · SOIL MECHANICS ENGINEERING

PLATE H6