WATER RESOURCES DEVELOPMENT PROJECT

NORTH NASHUA RIVER BASIN

WHITMANVILLE LAKE

WHITMAN RIVER, MASSACHUSETTS

DESIGN MEMORANDUM NO. 8

EMBANKMENTS AND FOUNDATIONS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

AUGUST 1971

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

IN REPLY REFER TO:

NEDED-E

20 September 1971

SUBJECT: Whitmanville Lake, Whitman River, North Nashua River Basin - Design Memorandum No. 8, Embankments and Foundations

Chief of Engineers
ATTN: ENGCW-E

In accordance with ER 1110-2-1150, there is submitted for review and approval Design Memorandum No. 8, Embankments and Foundations, for the Whitmanville Lake Project, located in the North Nashua River Basin, Massachusetts.

FOR THE DIVISION ENGINEER:

Incl (10 cys)
as

JOHN WM. LESLIE
Chief, Engineering Division

DEPARTMENT OF THE ARMY
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WATER RESOURCES DEVELOPMENT PROJECT
North Nashua River Basin - Merrimack River
Massachusetts

Whitmanville Lake

Whitman River

Design Memoranda Index

No.	Title	Scheduled Submission	Date Submitted	Date Approved
1	Hydrology	May 1970	7 May 70	10 Jul 70
1	Hydrology (Revised)	July 1971	15 Jul 71	
2	General Design	July 1971	31 Aug 71	
3	Public Use - Land Use Requirement Plan	Sept 1971		
4	Relocations	Sept 1971		
5	Real Estate	Nov 1971		
6	Concrete Materials	Nov 1970	26 Feb 71	29 Mar 71
7	Site Geology	Dec 1970	31 Mar 71	29 Apr 71
8	Embankments and Foundations	Sept 1971	20 Sept 71	
9	Hydraulic Analysis	Sept 1971		
10	Detailed Design of Structures	June 1972		

WHITMANVILLE LAKE

DESIGN MEMORANDUM NO. 8

EMBANKMENTS AND FOUNDATIONS

TABLE OF CONTENTS

Paragraph	Subject	Page No.
	A. INTRODUCTION	
1.	Location and Description of Project	1
2.	Pertinent Data	1
3.	General Notes	2
	B. SUBSURFACE INVESTIGATIONS	
4.	Subsurface Explorations	2
5.	Laboratory Tests	2
6.	Presentation of Data	2
	C. CHARACTERISTICS OF EMBANKMENT FOUNDATION MATERIALS	
7.	Distribution and Description	3
8.	Shear Strengths	5
9.	Compaction	6
10.	Permeability	6
11.	Consolidation	6
	D. CHARACTERISTICS OF FOUNDATION BEDROCK	
12.	Bedrock Foundation for Dam Embankment	6
13.	Bedrock Foundation for Concrete Structures	7

Paragraph	Subject	Page No.
	E. CHARACTERISTICS OF EMBANKMENT MATERIALS	
14.	General	7
15.	Impervious Embankment Material	8
	a. Distribution and Description	8
	b. Permeability	9
	c. Consolidation	9
	d. Compaction Characteristics	9
	e. Shear Strength	10
16.	Embankment Materials from Required Excavations	10
	a. General	10
	b. Pervious Embankment Materials	10
	(1) Distribution and Description	10
	(2) Permeability	11
	(3) Shear Strength Characteristics	11
	c. Random Embankment Materials	11
	(1) Distribution and Description	11
	(2) Permeability	12
	(3) Consolidation	12
	(4) Compaction Characteristics	12
	(5) Shear Strength Characteristics	12
17.	Embankment Drainage Materials and Gravel Bedding	12
	a. General	12
	b. Gradation Specifications	12
	c. Permeability	13
	d. Shear Strength	14
18.	Rock Protection	14
	F. DESIGN OF EMBANKMENT	
19.	Design Criteria	14

Paragraph	Subject	Page No.
20.	Materials for Embankment Construction	14
	a. General	14
	b. Required Earth Excavations	15
	c. Required Rock Excavations	15
	d. Borrow Excavations	15
	e. Materials Furnished by Contractor	15
21.	Selection of Embankment Section	15
22.	Slope Protection	16
23.	Seepage Control	16
	a. Seepage through Embankment	16
	b. Seepage through Foundations	16
	c. Seepage Along Bedrock Surfaces	16
24.	Embankment Stability	17
	a. General	17
	b. Conditions Analyzed	17
	c. Selection of Design Values	19
	d. Sections Analyzed	20
	e. Use of Computer	21
	f. Results of Stability Analysis	21
25.	Settlements	22
26.	Instrumentation	22
27.	Removal and Disposal of Unsuitable Materials	22
28.	Environmental Considerations, Selection and Operation of Borrow Area	22
	a. Environmental Considerations and Selection	23
	b. Drainage	23
	c. Excavation	23
	d. Grading	23
	e. Haul Road	23

Paragraph	Subject	Page No.
29.	Highway Embankment	23
30.	Existing Westminster Dam	24
	a. General	24
	b. Dam Embankment	24
	c. Outlet Works	24
	d. Spillway	24
	e. Operation of Dam	25
	f. Conclusions	25
31.	Construction Considerations	26
	a. Dewatering Construction Areas	26
	b. Rate of Embankment Construction	26
	c. Construction of Intake Tower, Pier and Abutment for Service Bridge	26
	d. Sequence of Construction	26
32.	Methods of Compaction	27
	a. Impervious and Random Fills	27
	b. Other Fills	27
	G. PERMANENT CUT SLOPES	
33.	Earth Cut Slopes	27
34.	Rock Cut Slopes	27

LIST OF PLATES

PLATE NO.	TITLE
8-1	Reservoir Map
8-2	General Plan of Structure
8-3	Plan of Foundation Explorations
8-4	Engineering Log Profile A-A
8-5	Engineering Log Profile B-B
8-6	Engineering Log Profile C-C
8-7	Engineering Log Section D-D
8-8	Plan of Borrow Explorations, Area A
8-9	Selected Test Data, Foundation Materials
8-10	Selected Test Data, Undisturbed Explorations, FD-50U, FD-51U and FD-52U
8-11	Selected Shear Strength Data, Undisturbed Exploration FD-51U
8-12	Selected Test Data, Embankment Materials from Required Excavations
8-13	Selected Test Data. Impervious Embankment Material, Area A
8-14	Selected Shear Strength Data, Impervious Embankment Material, Area A.
8-15	Gradation Specifications
8-16	Filter Studies
8-17	Typical Embankment Sections
8-18	Outlet Works, Conduit, Profile And Sections

PLATE NO.	TITLE
8-19	Summary of Stability Analyses (Circle) No. 1
8-20	Summary of Stability Analyses (Circle) No. 2
8-21	Summary and Typical Stability Analysis (Wedge) Case I, End of Construction, Downstream
8-22	Summary and Typical Stability Analysis (Wedge) Case VII, Earthquake
8-23	Typical Stability Analysis (Circle) Case I, End of Construction, Upstream
8-24	Typical Stability Analysis (Circle) Case II, Sudden Drawdown from Maximum Pool
8-25	Typical Stability Analysis (Circle) Case III, Sudden Drawdown from Spillway Crest
8-26	Typical Stability Analysis (Circle) Case IV, Partial Pool with Steady Seepage
8-27	Typical Stability Analysis (Circle) Case V, Steady Seepage with Maximum Storage Pool
8-28	Typical Stability Analysis (Circle) Case VI, Steady Seepage with Surcharge Pool
8-29	Materials Usage Chart (Preliminary)

APPENDICES

APPENDIX	TITLE
A	Summary of Laboratory Test Results
B	Detailed Shear Test Data
C	Test Data and Undistrubed Sample Logs of FD-50U, FD-51U, FD-52U

WATER RESOURCES DEVELOPMENT PROJECT

NORTH NASHUA RIVER BASIN

WHITMANVILLE LAKE
WHITMAN RIVER, MASSACHUSETTS

DESIGN MEMORANDUM NO. 8

EMBANKMENTS AND FOUNDATIONS

A. INTRODUCTION

1. Location and Description of Project. The Whitmanville Lake Water Resources Development Project is located in the town of Westminster, Massachusetts, about 5 miles west of Fitchburg, Massachusetts. The damsite is located on the Whitman River about 4 miles upstream of the confluence with the North Nashua River all in the Merrimack River Basin. The completed structure will consist of an earthfill dam with appurtenant structures. Locations, arrangments and details of the structures are shown on Plates Nos. 8-1 and 8-2.

2. Pertinent Data.

a. Purpose. Flood control, recreation, water quality and replacement of existing industrial water supply.

b. Drainage Area at Damsite. 17.5 square miles.

c. Reservoir Elevations M.S.L.

(1)	Top of Dam	--	860.5
(2)	Maximum Surcharge Pool	--	856.2
(3)	Spillway Crest	--	845.0
(4)	Recreation Pool	--	826.6
(5)	Water Supply	--	817.5

d. Dam.

(1)	Maximum Height Above Streambed	--	76 feet
(2)	Length	--	1,440 feet

3. General Notes. Subsurface investigations and soils engineering studies undertaken for the design of the dam embankment for this project and to determine the condition of the existing Westminster Dam 0.7 miles upstream are discussed in this design memorandum. Subsurface investigations included programs of subsurface explorations and laboratory tests conducted to determine the distribution and characteristics of foundation and embankment materials and to determine soil conditions pertinent to excavations and to the design and construction of embankments, and certain of the concrete structures. Soil engineering studies based on data obtained from the subsurface investigations, were conducted to develop safe and economical earthwork designs and construction methods.

B. SUBSURFACE INVESTIGATIONS

4. Subsurface Explorations. Subsurface explorations were laid out and performed in conformance with current criteria and practices as described in Corps of Engineers Manuals EM 1110-2-1801, "Geological Investigations" and EM 1110-2-1803, "Subsurface Investigations - Soils." The majority of the explorations were drive-sample borings. In addition, undisturbed sampling procedures were employed in three drill holes in the dam foundation area. The subsurface exploration program completed to date is considered adequate for the design of the dam. The locations, types and general purposes of the explorations, as well as the site geology, are discussed in Design Memorandum No. 7, "Site Geology."

5. Laboratory Tests. All laboratory tests, except as noted, were performed in accordance with the provisions of EM 1110-2-1906, "Laboratory Soils Testing." All soils samples were visually classified according to the Unified Soil Classification System. The visual classification of representative soil samples were confirmed by grain size analyses and determinations of Atterberg Limits. Selected samples were tested to determine natural moisture content, natural density, compaction characteristics, permeability, consolidation characteristics and shear strength.

6. Presentation of Data. The results of subsurface investigations are presented in this memorandum. The logs of exploration are shown in D.M. No. 7. A summary of the results of laboratory tests is presented in Appendix A. Detailed shear, consolidation and compaction test reports are presented in Appendix B. A record of undisturbed samples from explorations FD-50U, 51U and 52U with gradation curves are presented in Appendix C. Soil profiles and sections of the dam embankment foundation, based upon engineering soil reports, are shown on Plates Nos. 8-4 through 8-7. These engineering soil reports were prepared for all pertinent explorations by the design soils engineer with the aid of laboratory test data and the assistance of an experienced soils clasifier. These reports include descriptions of the soils and soil strata based on the engineer's examination of the samples and his interpretation of the test results and pertinent exploration records. These

descriptions cover the consistency of the soil, estimated or measured percentages of the soil component, color, stratification, presence of foreign material, geological names and other information of significance to establishing soil characteristics for design and construction purposes. Plates Nos. 8-9 through 8-14 showing selected laboratory data are included in this memorandum.

C. CHARACTERISTICS OF EMBANKMENT FOUNDATION MATERIALS

7. Distribution and Description.

a. Left Abutment and Spillway. The overburden in the left abutment of the dam embankment foundation area northeast of about Station 13+00 and the adjacent spillway area is relatively thin averaging about 10 feet in thickness except near the lower end of the spillway discharge channel where the depth to bedrock is about 25 feet. Numerous boulders occur on the surface of the area northeast of the present Ashburnham Road. The overburden consists of a capping of about a foot of topsoil and forest litter overlying a glacial outwash and a modified till deposit. The irregular bedrock surface is generally blanketed by a modified till deposit varying in thickness from 2 to 15 feet. The till is overlain, in part, by a glacial outwash deposit which appears as a terrace feature along Ashburnham Road where it averages about 8 feet in thickness. Northeast of the road, the outwash deposit becomes thinner and discontinues appearing only as pockets and remnants. The materials in the modified till deposit consist of brown and gray brown, generally moderately compact to compact, non-plastic, gravelly silty sand (SM and SP-SM) and silty sandy gravel (GM) with numerous cobbles and boulders. The silt contents of these materials generally range from 15 to 40 percent of the component passing the No. 4 Sieve. The gravel contents of the silty sands generally range from 10 to 40 percent. The materials in the outwash deposit consist of brown, loose to compact, gravelly silty sands (SP-SM, SM) and silty sandy gravels (GP-GM, GM) with cobbles and boulders and occasional phases of sandy gravel (GP) and gravelly sand (SP). Gravel contents of the sands range from 10 to 40 percent while the silt contents of the sands and gravels generally range from 5 to 25 percent of the component passing the No. 4 Sieve. These materials tend to be more pervious below the road.

The subsurface water levels are variable and erratic generally following the upper surface of the till at depths of 1 to 5 feet or occurring at, or below, the bedrock surface at depths of about 5 to 10 feet.

b. Right Abutment. The overburden in the right abutment (southwest of Station 9+00) varies from about 18 to 40 feet in thickness and averages about 29 feet with the deeper portion occurring at the terrace feature near Station 8+50. The overburden consists of a capping of about 9 inches of topsoil and forest litter overlying glacial outwash

and modified glacial till deposits. The bedrock surface is generally blanketed with the modified till deposit varying in thickness from about 3 to 16 feet with the greater thicknesses occurring at the higher elevations. In the vicinity of the upstream toe near Station 8+00; however, this blanket is missing. In general, the till blanket is overlain by an outwash deposit which averages about 21 feet in thickness.

The material in the modified till deposit consists of brown and gray-brown, moderately compact to compact, nonplastic, gravelly silty sand (SP-SM, SM) silty sandy gravel (GP-GM) and sandy gravel (GP) with numerous cobbles and boulders. Gravel contents of the sands are generally less than 40 percent. The silt contents of these materials generally range from 10 to 35 percent of the component passing the No. 4 Sieve.

The materials in the outwash deposit consist generally of brown, loose to moderately compact, gravelly silty sands (SP-SM, SM, SW-SM), sandy gravels (GP) and silty sandy gravels (GP-GM) with numerous cobbles. The terrace feature between Station 8+00 and Station 9+00 contains some zones of stratified medium to fine sands (SP) and silty medium to fine sands (SM) with occasional thin layers of silt (ML). The silt contents of the sands and gravels generally range from 3 to 25 percent of the component passing the No. 4 Sieve with phases of the medium to fine sands and silty medium to fine sands having silt contents as high as 40 percent. Gravel contents are generally less than 40 percent. Subsurface water levels, in general, are at or below, the bedrock surface.

c. Valley. As indicated by the soil log profiles and sections on Plates Nos. 8-4 through 8-7, the overburden varies from about 35 feet in thickness on the right side of the valley near Station 9+00 to over 50 feet near Station 10+00, to only 10 to 20 feet in thickness on the left side of the valley in the vicinity of Station 13+00. The rock surface is generally blanketed with till deposits. Where they occur, the till deposits vary from about 2 to 17 feet in thickness with the thickest zone occurring near Station 10+00. The till materials consist of brown, gray-brown and gray, generally moderately compact to very compact, gravelly silty sand (SM) and silty sandy gravel (GP-GM, GW-GM, GM) with numerous cobbles and occasional boulders and with zones of sandy gravel (GP) and silty medium to fine sand (SM). Gravel contents of the silty sands generally run from 15 to 40 percent. Silt contents range from 7 to 60 percent but are generally less than 35 percent of the component passing the No. 4 Sieve.

Overlying the till deposits or bedrock is a glacial outwash deposit varying from 3 feet in thickness on the left side in the vicinity of Sta. 13+00 to over 35 feet with the greatest thickness occurring in the central portion of the valley between Sta. 10+00 and 11+00. The material in this deposit consists of variable, brown, generally loose to

moderately compact, silty sandy gravels (GP-GM, GW-GM), sandy gravels (GP-GW) and gravelly sands (SP-SM, SP) with numerous cobbles and some boulders and with some phases of silty sands (SP-SM, SM) and silty sandy gravels (GM). Gravel contents of the sands generally range from 5 to 45 percent. Silt contents range from 3 to 30 percent but are generally less than 20 percent of the component passing the No. 4 Sieve.

In the portion of the valley between Sta. 9+50 and Sta. 10+50 at the upstream toe of the dam, between Sta. 9+00 and Sta. 11+50 at the centerline and in the vicinity of Sta. 9+50 and Sta. 12+50 at the downstream toe of the dam, the outwash deposit contains a zone of fine-grained materials (referred to hereafter as the foundation silt layer). This deposit where encountered in the explorations, varies from 1 foot to over 8 feet in thickness with the greater thickness occurring in the vicinity of Sta. 9+50 at the downstream toe of the dam. The upper surface dips gently in a downstream direction from about elevation 783 at the upstream toe to about elevation 775 at the downstream toe. The materials in this zone consist of stratified, gray-brown and brown, loose to compact or very stiff, nonplastic, silt, fine-sandy silt (ML) and silty fine sand (SM) with occasional zones and thin layers of fine sandy clay (CL, CH). The materials are generally compact or very stiff above elev. 775. The silts contain some small leaves and other decayed organic materials. The sandy silts contain from 10 to 50 percent fine sand. The silt contents of the silty fine sands range from 7 to 40 percent while those of the other sands range from 5 to 40 percent. The sand layers range from 1/16 inch to 3 inches in thickness while the silt layers range from 1/2 inch to over 30 inches. The occasional clay layers range from 1/16 inch to about 18 inches in thickness. Reference is made to the soil profiles on Plates Nos. 8-4 through 8-7, Undisturbed Explorations FD50U, 51U, 52U, Plate No. 8-10 and Appendix C. The area is covered with 6 to 24 inches of surficial deposits of topsoil and forest litter. Subsurface water levels in this area are controlled by the level of the river.

8. Shear Strengths. Undisturbed samples were obtained from the foundation silt layer in the valley. Triaxial shear tests were performed on selected undisturbed silt specimens from exploration FD-51U. Five Q tests and five R tests were run, the results of which are shown on Plate No. 8-11. The adopted shear strength parameters for the fine-grained materials are as follows:

Condition	Ø - Degrees	C, T.S.F.
Q	6	0.25
R	13	0.25

Shear tests were not performed on samples of embankment foundation soils. It is considered that the soils in the till and modified till deposits will have shear strengths greater than those indicated by shear tests performed on samples of compacted impervious embankment material. On the

basis of experience with similar soils it is estimated that the soils in the glacial outwash deposits will have undisturbed shear strength parameters of ϕ=30 degrees, and C=0 for all conditions within the anticipated stress range.

9. Compaction. Compaction tests were performed on two undisturbed samples of the foundation silt layer. The Harvard Miniature compaction device (Spring = 40 lbs.) was used to determine the maximum test densities using the same specimen of soil for each point on the curve. On the basis of these tests, it is estimated that the natural dry densities of the foundation silts are between 73 and 91 percent and average about 80 percent of maximum compacted dry density.

10. Permeability. No permeability tests were performed on samples of foundation soils for this project. The ranges of coefficients of vertical permeability tabulated below have been estimated on the basis of visual examinations of the samples, their grain-size distribution curves, the results of the tests performed on samples of borrow materials and experience with similar materials.

Material	k_v cm/sec	k_h/k_v
Sandy Modified Glacial Till	0.1 to 75×10^{-4}	4 to 9
Outwash	1 to 200×10^{-4}	9 to 25
Fine-grained Materials	0.5 to 75×10^{-4}	9 to 25

11. Consolidation. Consolidation tests were not performed on samples of foundation soils. All soft and compressible surficial deposits will be removed prior to the construction of the embankment. The consolidation characteristics and natural densities of the bulk of the remaining soils are such that no significant post-construction foundation settlement is anticipated under the proposed embankment loadings. Although some of the soils in the foundation silt layer in the valley are compressible, settlements therein will be limited due to the thinness of the strata in the layer and will occur principally during construction. For purposes of stability studies; however, it has been assumed that the layer will not consolidate until after completion of the embankment.

D. CHARACTERISTICS OF FOUNDATION BEDROCK

12. Bedrock Foundation for Dam Embankment. The bedrock at the site consists mainly of granite gneiss with numerous zones of pegmatite and scattered but apparently thick, diabase dikes. The granite gneiss ranges from light to dark gray and from fine-grained and schistose to very coarse and granitic. Foliation is generally obscure and variable but where apparent in schistose phases of the gneiss, the foliation

dips commonly at low angles. The pegmatite which intrudes the gneiss in thin stringers, dikes and extensive irregular masses is very coarse-grained with thick pods of felted mica. The diabase is dark gray to black, very fine-grained and hard. The bedrock surface is typically rough and irregular with numerous low ridges and knobs between shallow troughs and hollows. The rock is generally closely jointed with numerous high and low angle joints along which slight weathering has occurred to depths up to 25 feet. A grout curtain will be constructed in the rock under the cut-off for the dam.

13. Bedrock Foundation for Concrete Structures. Foundations for concrete structures are located at relatively shallow depths in the bedrock. Close jointing and weathering at foundation grades may require more than usual foundation treatment to remove loose blocks and clean out weathered seams at structure locations. With adequate treatment; however, the rock is satisfactory for support of heavy structural loads. Presplitting will be required and line-drilling will be utilized as feasible to control breakage in the slopes for structure excavations. Grouting will be required in the rock along the cut-off at the outlet conduit and under the spillway walls and weir. Drain holes will be provided as required for relief of pressure at concrete slabs and walls. Detailed discussion of bedrock conditions in relation to concrete structures is included in Design Memorandum No. 7, "Site Geology" and Design Memorandum No. 10, "Detailed Design of Structures".

E. CHARACTERISTICS OF EMBANKMENT MATERIALS

14. General. The quantity of material from required excavations is not sufficient to construct the dam embankment. Reconnaissance for sources of borrow resulted in the location of a glacial till deposit on the left side of the valley about 5,500 feet north and upstream of dam embankment (Area A on Plate No. 8-1). Investigations in this area determined that a quantity of suitable material was available therein to complete the dam embankment. This deposit consists of relatively impervious soil of fairly uniform character. In selection of this borrow source, consideration was given to the environmental impact of its use in comparison with that for other potential sources (See para. 28a).

Extensive outwash deposits of silty sands and gravels occur in the Whitman River Valley upstream and downstream of the damsite.

Whitmanville Reservoir will be the site of an extensive general recreation development in conjunction with extensive conservation areas. The project will supply a much needed water-based recreation resource to the surrounding communities. The existing reservoir behind the Westminster Dam will be the area of general recreational use at the project. Some of the major assets of this area above the existing dam are the irregular and interesting shoreline and the islands in the pool and any alteration of the existing shoreline or islands to obtain pervious fills would be incompatible with the projected use of the area for recreational development; therefore, any areas capable of development as borrow areas must be located below the existing dam.

The paper companies which are located about 4 miles below the proposed dam use the water for industrial purposes and have pointed out the deleterious effects of silt-laden water on their paper processing operation as well as the any harmful effects of sedimentation on the presently good fishery in Crocker Pond located 1 mile downstream. Because of the potential harmful effects of sedimentation, the ecological considerations and possible damage to the reservoir recreation potential and the fact that the quantity requirements are relatively small, no source of embankment drainage materials capable of economical development as a borrow area within the reservoir area between the two dams was found, but several undeveloped and commercial sources were located within a reasonable haul distance of the site.

15. Impervious Embankment Material.

a. Distribution and Description. Impervious embankment material will be obtained from the glacial till deposit in Area A (about 25 acres). About 75 percent of the area is wooded, the remainder being cleared. The area is covered with 7 to 12 inches of topsoil and forest debris. Explorations in this area indicate that the lower limits of the till are determined by the bedrock surface at depths from 17 to over 55 feet below the ground surface. The bedrock surface outcrops near the north end of the area adjacent to and in the existing streambed and also just west of exploration BD-8 at about elev. 925. The impervious embankment material in this area consists principally of brown, gray-brown and gray, moderately compact to compact, gravelly silty-clayey sand (SC, SM-SC) and sandy silty clay (CL, ML-CL) with cobbles, occasional boulders and occasional minor zones of gravelly silty sand (SM). In some areas, boulders occur at the ground surface in thick concentrations. The fine content of the materials range from 30 to 65 percent of the component passing the No. 4 Sieve with the bulk of the material having fine contents ranging from 45 to 60 percent of the same component. Gravel contents are generally less than 25 percent. For the most part, the material is slightly plastic, exhibiting liquid limits from 20 to 26 and plasticity indices from 2 to 10. Activities (based upon the minus No. 40 Sieve size particles) range from 0.10 to 1.43 with an average of 0.43.

Observations in borings at the time of drilling indicate that water levels in the borrow area range from less than 1 foot to as much as 15 feet below the ground surface. In the dug water supply well adjacent to Bragg Hill Road and in an observation well installed at boring BD-3, periodic observations during the three summer months indicated a progressive drop in water levels from approximately 8 feet up to 15 feet below the ground surface. It is therefore apparent that in addition to considerable local variations in the depth to water throughout the area, the water level is also subject to considerable seasonal fluctuation as is typical in till.

b. Permeability. Permeability tests were performed on two samples of impervious material. On the basis of the results of these tests, visual examination of the other samples and the results of mechanical analysis, it is estimated that the coefficient of permeability of compacted impervious materials will range from 0.01×10^{-4} to 0.1×10^{-4} cm/sec., vertically, and that the horizontal will be about four times the vertical.

c. Consolidation. Two consolidation tests were performed on representative samples of impervious embankment materials (BT-1, B-3 and BT-2, B-2) which were compacted at a water content two percent above optimum. The test results for BT-1, B-3 indicate a compression index (C_c) of 0.080 and a coefficient of consolidation (C_v) of 45×10^{-4} cm^2/sec., at a loading equivalent to the maximum embankment loading while those test results for BT-2, B-2 indicate a compression index (C_c) of 0.083 and a coefficient of consolidation (C_v) of 75×10^{-4} cm^2/sec., at the same loading. On the basis of these test results and experience with compacted fills of similar materials, it is anticipated that most of the settlements in the fill will occur during construction and that post-construction settlement will be negligible.

d. Compaction Characteristics. Standard compaction tests were performed on four samples of impervious embankment materials from test pits BT-1, BT-2, and BT-3 with the following results:

Pit	Sample	Group Letter Symbol	Maximum Dry Density	Optimum Water Content
BT-1	B-3	SC	119.8 pcf	13.0 percent
BT-1	B-6	SC	124.6	11.2
BT-2	B-2	SC	125.6	10.7
BT-3	B-5	SM	119.7	12.4

These samples are considered to be representative of the bulk of the impervious embankment material in the area with the sample from BT-1, B-3 representing the finer phases and the sample from BT-2 representing the coarser phase. Natural dry densities of the components passing the No. 4 Sieve, as determined from chunk samples from BT-1, BT-2 and BT-3, ranged from 92 to 100 percent of maximum compacted dry density in the depth range of 2 to 10 feet below the ground surface. Information from other explorations indicates that at depths greater than about 10 feet, natural dry densities are higher and may exceed 100 percent of maximum compacted dry density. The natural moisture contents of samples from these test pits varied from 0.7 percent below to 4.6 percent above the corresponding optimum water contents. The water contents of the samples from the borings made in the area average 1.5 percent less those from the test pits. These lower values

reflect the effects of dry weather as the borings were made during the summer months and the pits during the fall. Considering these factors, it is concluded that the natural moisture contents of the impervious embankment materials in the borrow area may range from 2 percent below to 4 percent above optimum. It is anticipated that with the drying associated with excavating, hauling and spreading operations, placement moisture contents can be maintained between 2 percent below and 2 percent above optimum with little difficulty.

e. Shear Strength. Q, R. and S shear tests were performed on samples BT-1, B-3 and BT-2, B-2. Although these two samples are typical of the bulk of the impervious embankment materials in gradation characteristics, they are definitely more plastic than average and show activity values well above average, 1.43 and 0.65, as compared to an average of 0.43. With respect to shear strength, these samples are considered to represent the weaker phase of the impervious embankment material. The tests were performed on specimens prepared at moisture contents corresponding to 2 percent below optimum, optimum, and 2 percent above optimum at densities corresponding to 96 percent of maximum dry density and also at optimum water content and maximum dry density. The Q and R tests were controlled strain triaxial compression tests run at rates of strain of 0.06 and 0.01 inches per minute, respectively. The S tests were of the direct shear type. Specimens for the R tests were saturated by the back pressure method. Detailed shear test data reports are included in Appendix B of this report. Shear strength envelopes selected for design are shown on Plate No. 8-14.

16. Embankment Materials from Required Excavations.

a. General. The major excavations for this project are those of the foundation cut-off and spillway channel and to a lesser degree from the excavations for the foundation drain and conduit. All suitable material from these excavations will be utilized to the extent practicable in the permanent work. Most of the material from foundation cut-off and foundation drain excavations in the valley is of a pervious, granular character and will be used in the pervious fill zone of the embankment. The remainder of the material from the required earth excavations are of variable character and, for the most part, will be utilized in the random fill zones of the embankment.

b. Pervious Embankment Materials.

(1) Distribution and Description. Pervious fill material will be obtained principally from the portions of the required earth excavations for the foundation cut-off and foundation drain. The bulk of pervious fill material will be obtained from the excavation of the foundation cut-off between Sta. 7+50 and Sta. 13+00 and above certain elevations as shown on Plate No. 8-4, Engineering Soils Profile A-A. The remainder of the pervious material will be obtained

from the foundation drain between Sta. 6+50 and Sta. 9+20, and Sta. 12+75 and Sta. 13+50 and the spillway discharge channel downstream of Sta. 9+00. In these selected reaches, material meeting requirements for pervious fill can be obtained with only a minor degree of selection and separation. Material in the foundation silt layer of the foundation cut-off will be separated and utilized as random fill. The pervious embankment materials from these sources will consist of a variable, brown, generally loose to moderately compact, silty sandy gravels (GP-GM, GW-GM) sandy gravels (GP, GW), gravelly sands (SP-SM, SP) with numerous cobbles and some boulders and with some minor quantities of stratified m-f sands (SP) and silty m-f sands from the terrace feature between Sta. 8+00 and Sta. 9+00. Silt contents range from 3 to 30 percent but for the bulk of the materials are less than 15 percent of the component passing the No. 4 Sieve. Gravel contents of the sands generally range from 5 to 45 percent. Based upon borings, 80 percent of the material contains at least 20 percent gravel sizes and 60 percent of the material has over 40 percent gravel sizes.

(2) Permeability. Permeability tests were not performed on samples of pervious embankment materials. On the basis of visual examination of the samples and their grain-sized distribution curves, it is estimated that the permeability of the compacted pervious fill will have coefficients of vertical permeability ranging from 25 to 200×10^{-4} cm/sec., and with ratios of horizontal to vertical permeabilities ranging from 9 to 16.

(3) Shear Strength Characteristics. Shear tests were not performed on samples of pervious embankment materials. Experience with similar materials indicates that shear strength parameters of $\phi = 35^{\circ}$ and $C = 0$ are reasonable.

c. Random Embankment Material.

(1) Distribution and Description. Random embankment material, Class I, will be obtained from all required earth excavations other than those designated as sources of pervious fill material in Paragraph 16b(1) above.

Random embankment material Class II is the same as random fill Class I except that screenings produced in the preparation of rock protection will be utilized in Random Fill Class II. The random embankment material Class I from these sources will consist principally of variable, nonplastic, gravelly silty sands (SM, SP-SM) and silty sandy gravel (GM) (till) with some phases of sandy gravels (GP) and gravelly sands (SP), (outwash) and with numerous cobbles and boulders. The silt contents of these materials generally ranges from 5 to 40 percent of the component passing the No. 4 Sieve while the gravel contents of the sands generally range from 10 to 40 percent.

(2) Permeability. Permeability tests were not performed on samples of random embankment material, Class I. On the basis of visual examination of the samples and their grain size distribution curves, it is estimated that the permeability of the compacted random fill material, Class I, will be highly variable with the coefficient of vertical permeability ranging from 0.1×10^{-4} to 200×10^{-4} cm/sec., with the ratio of horizontal to vertical permeabilities ranging from 4 to 9.

(3) Consolidation. Consolidation tests were not performed on samples of random embankment material, Class I. Experience with similar materials indicates that the random embankment material Class I is of low compressibility when compacted and that no significant settlements will occur in compacted fills of this material.

(4) Compaction Characteristics. Compaction tests were not performed on samples of random embankment material, Class I. On the basis of experience with similar types of material, it is estimated that the maximum test densities would be in the order of 130 pounds per cubic foot. It is anticipated that placement moisture contents between optimum and 2 percent above optimum for the bulk of the materials (modified till) can be maintained with a moderate amount of moisture control.

(5) Shear Strength Characteristics. Shear tests were not performed on samples or random embankment material, Class I. Experience with similar material types indicates that while the shear strength will be variable, the weakest phase will have a shear strength only slightly greater than that of the impervious embankment material. In view of this and the fact that some impervious embankment material may be placed in portions of the random fill zone of the embankment, it is considered advisable to use the design shear strength parameters selected for the impervious embankment material, also for the random embankment material.

17. Embankment Drainage Materials and Gravel Bedding.

a. General. Sand fill, Processed Sand Fill, Gravel Fill and Gravel Bedding materials will be furnished by the contractor from commercial sources. Several commercial and undeveloped sources were located within 15 miles haul distance of the damsite.

b. Gradation Specifications.

(1) Investigations of the probable sources of gravel bedding, gravel fill, sand fill and processed sand fill materials indicate that the following gradation specifications can be satisfied by materials available from commercial and undeveloped sources within 15 miles of the damsite. The specifications for material which will act as a filter have been established in accordance with the filter design criteria set forth in EM 1110-2-1901, "Seepage Control."

(2) Gravel Bedding. Gravel Bedding material shall consist of sandy gravel composed of tough, durable particles of natural sand and gravel except that particles larger than 3/8-inch size may be crushed stone. The material shall be reasonably well-graded between the following limits:

Sieve Size (U.S. Standard)	Percent Passing by Dry Weight
6-inch	100
1-inch	50-85
No. 4	30-60
No. 16	15-40
No. 200	0-5

(3) Gravel Fill. Gravel fill material shall meet all requirements specified for gravel bedding with the additional requirement that no more than 10 percent, by dry weight, of the component passing the No. 4 Sieve shall pass the No. 200 Sieve.

(4) Sand Fill. Sand fill material will consist of approved bank-run, reasonably well-graded gravelly sand or sandy gravel furnished by the contractor. Of the component passing the 3-inch sieve, between 30 and 75 percent shall pass the No. 4 U.S. Sieve. Of the component passing the No. 4 Sieve between 10 and 50 percent shall pass the No. 40 Sieve and no more than 10 percent of the same component shall pass the No. 200 Sieve.

(5) Processed Sand Fill. Processed sand fill material shall meet all the requirements for fine concrete aggregate except for the fineness modulus.

(6) Oversize Stones. Stones having maximum dimensions greater than 2/3 the thickness of the loose layers in which any of the foregoing materials are to be placed, shall be removed at the source of the material or from the fill.

c. Permeability. Permeability tests were not performed on samples of embankment drainage materials. Based on the specified gradations and experience with similar material, the following permeability characteristics have been estimated for compacted fills of these materials:

Material	k_v - cm/sec.	k_h/k_v
Gravel Bedding	over 25×10^{-4}	4
Gravel Fill & Sand Fill	over 100×10^{-4}	9
Processed Sand Fill	over 200×10^{-4}	9

d. Shear Strength. Shear strengths were not performed on samples of gravel bedding and embankment drainage materials. On the basis of the specified gradations and experience with similar materials, it is considered that the following shear strength parameters are reasonably conservative:

Material	ϕ - degrees	c - tons/sf
Gravel Bedding	35	0
Gravel Fill & Sand Fill	35	0
Processed Sand Fill	35	0

18. Rock Protection. Rock for rock protection will be obtained from the required rock excavations. The excavations in rock are relatively shallow, and will be largely in rock which is broken by closely spaced weathered joints and dirt filled seams. It is expected that much of the rock will break to small sizes and the blasted rock will tend to contain a high proportion of dirt and fines. Particularly in pegmatite phases of the rock, many fines will be produced. It is considered necessary, therefore, that the blasted rock be processed over a 4-inch bar grizzly to remove surplus fines. The screenings produced in this operation will be utilized in the Random Fill, Class II zone of the embankment. It is estimated that losses incurred in blasting and handling will offset bulking of the blasted rock so that with processing, a factor of 1 to 1 of the in situ volume should be used for estimates.

F. DESIGN OF EMBANKMENT

19. Design Criteria. The design of the dam embankment for this project was developed in accordance with the criteria set forth in the pertinent sections of the Engineer Manual EM 1110-2-2300, "Earth Embankments" and other manuals and technical publications referred to therein.

20. Materials for Embankment Construction.

a. General. The quantities of embankment materials available from the required and borrow excavations and the proposed utilization are indicated on the preliminary materials usage chart on Plate No. 8-29. The quantities shown are subject to modifications during the

preparation of contract plans and specifications. The embankment has been designed so that most of the materials from the required excavations can be utilized in the embankment without stockpiling.

b. Required Earth Excavations. Of the estimated 257,000 c.y. of required earth excavations, about 63,000 c.y. will consist of topsoil and other stripping material unsuitable for use in the construction of the embankment. The remaining 194,000 c.y. will be utilized in the compacted random and pervious fill sections of the dam embankment. About 55,000 c.y. of this material will be suitable for use as pervious fill material while the remaining 139,000 c.y. will be suitable for use as random fill material.

c. Required Rock Excavations. It is estimated that about 49,000 c.y. of material will be excavated from the required rock excavations. It is anticipated that, after passing over a 4-inch bar grizzly, the embankment volume of suitable rock material will be about equal to this excavated volume.

d. Borrow Excavations. About 726,000 c.y. of earth are available from Area "A" of which as much as 71,000 c.y. would have to be removed as stripping. The remaining 655,000 c.y., available after stripping, will be suitable as impervious fill material. Although a stripping depth of 7 to 12 inches is considered adequate, an assumed stripping depth of 2 feet has been used in making the estimate.

e. Materials Furnished by the Contractor. Gravel bedding, gravel fill, sand fill and processed sand fill materials will be furnished by the contractor.

21. Selection of Embankment Section.

a. General. The selection of the dam embankment section was influenced chiefly by the availability of large quantities of impervious fill material from a nearby borrow source and materials from the required excavations, the availability from nearby sources of sand fill, processed sand fill, gravel fill and gravel bedding, and the presence of the foundation silt layer in the valley. The selected dam embankment section is shown on Plate No. 8-17. The selected section consists of a large upstream impervious fill zone with a contiguous impervious foundation cut-off to grouted bedrock, a downstream compacted random fill zone and berm, an inclined internal drain of compacted sand fill with a contiguous horizontal drainage blanket and layers of gravel bedding and rock protection. The downstream berm extends only across the valley, Station 9+00 to Station 13+00. The downstream drainage blanket composed, in part, of pervious fill and the downstream random fills zones provide room for the direct utilization of materials from the excavation of the cut-off, foundation drain and spillway in order to reduce the amount of necessary stockpiling of excavated materials.

b. Foundation Cut-Off Versus Upstream Blanket. The possibilities of utilizing an upstream impervious blanket to control seepage through the foundation was given serious consideration. It was found, however, that the quantity of seepage with a blanket would be on the order of from 2 to 7 c.f.s. with the reservoir at recreation pool level. With this rate of seepage, it was apparent that frequent drawdowns of the recreation pool in excess of 1.5 feet at the peak of the recreation season would be required to meet industrial water requirements. In view of this, it was decided to use an impervious foundation cut-off to bedrock so as to avoid this disruption of the recreational function of the project.

22. Slope Protection. There will be sufficient material from the required rock excavations after grizzlying to provide an upstream layer of rock protection 3 feet thick and a downstream layer 2 feet thick. The upstream layer will provide more than adequate protection against the action of waves up to the expected maximum height of 1.9 feet.

23. Seepage Control.

a. Seepage Through Embankment. Seepage through the embankment is controlled by the arrangement and differences in permeability of the impervious fill zone, the sand fill inclined drain and the horizontal drainage blanket.

The location of the internal wick drain was selected on the basis of intercepting seepage well within the embankment;thus, preventing the developing of seepage pressures, relieving pore pressures during construction and reducing stresses along a plane through the foundation silt layer, all of which could significantly effect the stability of the downstream portion of the embankment. In the valley bottom, the drainage blanket will include a layer of processed sand fill so as to provide additional drainage capacity without an excessive increase in blanket thickness.

b. Seepage Through Foundation. Seepage through the overburden in the dam foundation will be controlled by the impervious foundation cut-off having a maximum bottom width of 25 feet and extending to bedrock, by the horizontal drainage blanket and the foundation toe drain. Seepage through the foundation berock will be controlled by a grout curtain and for a limited reach over the left abutment, by the foundation drain. The foundation drain on both abutments has been designed to prevent the development of seepage pore pressures beneath the downstream portion of the dam resulting from seepage by-passing the cut-off or the grout curtain. Seepage along the conduit will be controlled by the construction of a concrete plug, contiguous with the foundation cut-off around the conduit for a longitudinal distance of 50 feet.

c. Seepage Along Bedrock Surfaces.

(1) Impervious Fill on Bedrock. In order to avoid the detrimental effects of seepage along the bedrock surface against which impervious fill is to be placed, such surfaces will be prepared by:

(a) The removal of all soil and loose rock fragments.

(b) The removal of all overhangs and irregularities in the bedrock surface which would interfere with the proper placement and compaction of the fill materials.

(c) The cleaning and mortaring of all cracks and openings in the bedrock surface.

(d) The filling of large depressions and cracks and areas beneath large overhangs with concrete where the use of mortar is impractical without extensive special rock excavation.

(2) Gravel Fill on Bedrock. It will be specified that all bedrock surfaces upon or against which gravel fill is to be placed shall be prepared in such a manner as to insure adequate drainage of the joints and similar openings in the bedrock.

24. Embankment Stability.

a. General. The embankment section of the dam embankment has been analyzed for stability against shear failure using the circular arc and the sliding wedge methods of analyses. The modified Swedish method ignoring the forces on the vertical sides of the slices was used for the circular arc analysis. The design shear strengths and unit weights for the impervious fill and materials in the foundation silt layer in the valley were selected on the basis of laboratory test results. The shear strengths and unit weights for random fill used in the analysis are those determined for impervious fill. It is considered that this represents a conservative approach in that the shear strength of the random fill will be significantly higher than that of the impervious fill. The design unit weights and shear strengths for the other embankment materials were selected on the basis of experience with similar materials.

b. Conditions Analyzed.

(1) Case I: End of Construction. The embankment was analyzed for the end of construction on the assumption that the time required to construct the embankment would be too short to permit either consolidation of the impervious and random fills or the foundation silt layer under the embankment loads or the dissipation by drainage of the induced pore pressures in the same materials. Since the conditions of this

assumption are analogous to those of the unconsolidated undrained (Q) shear test, the analyses were made using design shear strengths for the impervious and random fills and the foundation silt layer based on this test condition.

(2) Cases II and III: Sudden Drawdown. The upstream slope of the embankment was analyzed for the drawdown case on the assumption that the embankment is saturated by seepage during prolonged high reservoir stages, the pool is drawn down faster than pore water can escape thus resulting in excess pore water pressures and unbalanced seepage forces. The pool rises from elev. 817.5 (lowest recreation pool level) to spillway crest elev. 845 in about 15 hours and the maximum pool elev. 856 in about 20 hours. The maximum duration which the pool would be at or above spillway crest would be approximately two weeks. The rate of drawdown averages about 1 foot per 5 hours which amounts to 6 days to drawdown the pool to elev. 817.5. Reference is made to the graph of time versus pool elevation on Plate No. 8-19. Shear strengths are based upon the minimum of the combined R and S envelopes for the impervious and random fills, and the S tests for other materials. Drawdowns from maximum pool (Case II, elev. 856) and from spillway crest (Case III, elev. 845) to a minimum pool elevation of 817.0 (lowest recreation pool level) were considered in this analysis.

(3) Case IV: Partial Pool. The upstream slope of the dam embankment was analyzed with the pool at various levels to determine the pool level at which embankment stability would be a minimum. The analysis assumed that a condition of steady seepage had developed at these pool levels. Shear strengths are based upon a strength envelope midway between the R and S test envelopes where the S strength is greater than the R strength for the impervious and random fills and the foundation silt layer. The design shear strength for the other embankment and foundation materials was based upon the S test.

(4) Case V: Steady Seepage with Maximum Storage Pool. The downstream slope of the dam embankment was analyzed under the condition of steady seepage from the maximum water storage level, (Spillway Crest elev. 845) that could be maintained sufficiently long to produce a condition of steady seepage throughout the embankment. Shear strengths used are the same as used for Case IV. The design shear strength for the remainder of embankment and foundation soils was based upon the S test. A horizontal phreatic line in the impervious fill zone was assumed using both the wedge and circular arc method. Since the internal drain, drainage blanket, foundation drain, pervious fill zones and grout curtain have been designed to prevent the development of seepage pore pressures in locations where they could affect the embankment significantly, these analyses were made assuming no seepage pore pressures downstream of the internal drain.

(5) Case VI: Steady Seepage with Surcharge Pool. The downstream slope of the dam embankment was analyzed for the condition of steady seepage from maximum storage pool (elev. 845) with an additional horizontal thrust imposed by a surcharge pool at elev. 856 (maximum pool). Shear strengths used are the same as those used in Case V. The surcharge pool is considered as a temporary condition causing no saturation of impervious material above the steady seepage saturation line produced with the pool at elev. 845. The analysis was made assuming a horizontal phreatic line by both the wedge and circular arc methods.

(6) CASE VII: Earthquake. The dam embankment was analyzed for stability against earthquake shocks by imparting an additional horizontal force acting in the direction of potential failure and based upon a Zone 2 seismic coefficient of 0.10. The analysis was made for the downstream slope for Case I using the Wedge Method since this condition is the most critical.

c. Selection of Design Values.

(1) Unit Weights. The impervious and random fill material will be compacted with a sheepsfoot roller as described in paragraph 32, "Method of Compaction of Fills", and in accordance with a compaction specification which has been used by this Division in the past for embankments of similar material. Experience with this specification indicates that the densities of the layers compacted at moisture contents within the range anticipated for this project will average about 98 percent of maximum test densities. The design unit weight for the impervious embankment materials, therefore, has been selected on the basis of the compaction test densities adjusted to include the weight of the average stone contents. The design unit weight for the foundation silt layer is based on densities determined for undisturbed specimens. The design unit weights of the other embankment and foundation materials have been selected on a similar basis using estimated densities based on experience with similar materials. The various design unit weights selected for this project are tabulated below:

Material	Design Unit Weights in Pounds/Cu. Ft.			
	Dry	Moist	Saturated	Submerged
Rock Protection and Gravel Bedding	116	120	140	78
Random and Impervious Fill	128	140	143	80
Pervious Fill	130	140	145	83
Foundation Sands and Gravels	125	135	140	78
Foundation Silt Layer	93	-	120	58

(2) Design Shear Strengths. The design shear strength parameters for the impervious fill and the foundation silt layers have been selected on the basis of conservative interpretation of the shear test results. Since portions of the random fill will be similar in shear characteristics to impervious fill and since some impervious fill material may be placed in the random fill zones of the embankment, random fill for purposes of stability analyses have been considered to be identical to impervious fill with respect to shear strength. Shear strength parameters for the other foundation soils and embankment materials have been selected on the basis of experience with similar materials. The design shear strength parameters selected for the various materials are tabulated below:

Material	Q(UU)		R(CU)		S(CD)		Combined R & S	
	ϕ	C	ϕ	C	ϕ	C	ϕ	C
Rock Fill	-	-	-	-	40	0	-	-
Gravel Bedding	-	-	-	-	35	0	-	-
Pervious and Sand Fills	-	-	-	-	35	0	-	-
Impervious and Random Fills	10°	0.5 TSF	14°	0.1TSF	32°	0	14° 23°	0.10(a) TSF 0.10(b) TSF
Foundation Sands and Gravels	-	-	-	-	30°	0	-	-
Foundation Silt Layer	6°	0.25TSF	13°	0.25 TSF	32°	0	23°	0.13(b) TSF

(a) For Sudden Drawdown Analysis. Where normal stresses are less than 0.25 TSF use $\phi = 32°$, C = 0.

(b) For steady seepage and partial pool analysis. Where normal stresses are less than 0.25 TSF use $\phi = 32°$, C = 0 for impervious materials. Where normal stresses are less than 0.6 TSF use $\phi = 32°$, C = 0 for the foundation silt layer.

d. Sections Analyzed. The upstream portion of the embankment at Sta. 10+00 was chosen for analysis as being the most critical with respect to stability because it combines a high embankment height with an appreciable cross-sectional area of impervious fill. The downstream embankment at Sta. 10+50 was selected for analysis since it combines the maximum embankment height with the greater thickness of the foundation silt layer.

e. Use of Computer. The stability analyses were made on an electric computer (GE 427), for both the circular arc and wedge method.

f. Results of Stability Analyses. Summaries of the results of the embankment stability analyses are shown on Plates Nos. 8-19 through 8-22. Typical analyses for the critical arcs are shown on Plates Nos. 8-23 through 8-28 while typical wedges are shown on Plates Nos. 8-21 and 8-22. The minimum factors of safety against shear failure as determined by the analyses, are tabulated below. These minimum factors of safety are considered adequate and indicate that the selected embankment is safe against shear failure.

	Minimum Factor of Safety	Criteria
Case I: End of Construction		
a. Upstream Slope (Circle Analysis)	2.2	1.3
b. Downstream Slope (Wedge Analysis)	1.4	1.3
Case II: Sudden Drawdown - Maximum Pool (El. 856) to El. 817 (Circle Analysis)	1.1	1.0
Case III: Sudden Drawdown - Spillway Crest (El. 845) to El. 817 (Circle Analysis)	1.2	1.2
Case IV: Partial Pool (Circle Analysis)	1.8 (El. 840.5)	1.5
Case V: Steady Seepage - Maximum Storage Pool (El. 845)		
a. Circle Analysis	1.6	1.5
b. Wedge Analysis	2.2	1.5
Case VI: Steady Seepage - Surcharge Pool (El. 856)		
a. Circle Analysis	1.6	1.4
b. Wedge Analysis	2.2	1.4
Case VII: Earthquake (ψ = 0.10)		
For Case I - Downstream Slope - Wedge Analysis	1.0	1.0

25. Settlements. Except for the foundation silt layer materials, the foundation materials for the embankment are of the type normally exhibiting low compressibility. Settlements in this foundation silt layer will be limited due to the thinness of the strata and will occur principally during construction. Settlements in the impervious fill will be practically completed during construction.

26. Instrumentation. Four survey monuments will be installed immediately downstream of the embankment as shown on Plate No. 8-2. These will serve as reference points to monitor any movements that might occur along the foundation silt layer during embankment construction. An additional monument will be installed in the upstream slope of the embankment at the service bridge pier site to allow observation of any movements that might take place during embankment construction. These monuments will consist of concrete-filled plastic pipe casings set below frost depth.

27. Removal and Disposal of Unsuitable Materials. All topsoil and other surficial deposits of organic soils will be completely removed from the embankment foundation area and placed in the spoil area downstream of the dam embankment or used for topsoiling operations. No spoil material will be placed within 100 feet of the downstream toe of the dam. In addition, surficial boulders and rock blocks will be removed and rock of suitable size will be utilized in the rock protection to the extent practicable.

28. Environmental Considerations, Selection and Operation of the Borrow Area.

a. Environmental Considerations and Selection. Natural imimpervious earth fill for the dam must be obtained from till deposits. Till generally caps bedrock in the vicinity of the damsite at the higher elevations. The main problem of locating an impervious borrow area is to locate a till deposit with adequate depth. During the initial stages of design, field reconnaissance was made and two areas of till with possible adequate depths to bedrock were located. One was along the west side of Bragg Hill Road about 3/4 miles north from the north end of the dam. The other, a drumlin, located near Barrel Road about 2 miles north of the north end of the dam. The Bragg Hill Road area was selected for initial explorations since it is within an economical haul distance for scrapers. From an environment standpoint, the damages for the Bragg Hill Road area would be less than those for the drumlin area. The drumlin area would require construction of a greater length of haul road, greater areas to be cleared, leave final excavation that could be seen from a public road, the relocation of a power line and improved private road,

and the use of very productive, currently-operated farm-land. Adequate depth was found in the Bragg Hill Road area and the final borrow area has been located about 300 feet from the road in a sloping area containing third and fourth growth trees and brush. The land along the road is cleared and was part of an operated farm. The borrow area does not effect this land for use as farm-land or for building development. The final excavated area will be hidden from general view from any public road including the proposed relocated Ashburnham Road.

b. Drainage. Prior to stripping the borrow area, a permanent interceptor ditch will be constructed along the toe of the borrow area along about the elevation 950 contour. The ditch will be adequate to drain away all seepage water and surface run-off from the borrow area during and after construction and prevent any flow of water from the borrow area down the slope below the borrow area. The ditch will be designed with a slight gradient to prevent erosion and lead the flow to the well established channel of an existing brook which flows down the slope to the north of the borrow area. The bottom of the existing brook is well paved with stones and erosion is not anticipated.

c. Excavation. The borrow area will be separated into two parts. Initial borrow excavations will be restricted to that part of the borrow designated as Part 1. Clearing, stripping and excavation will be extended into Part 2 only to the extent necessary to obtain the required quantities of materials. At the time of each planting season (May and September) completed final excavation slopes will be topsoiled and seeded to minimize erosion.

d. Grading. It will be required to leave the excavation portion of the borrow areas with side slopes of 1 on 3 and a large nearly flat bottom. The final bottom will slope downward and toward the permanent interceptor ditch described in subparagraph b. above with a grade of approximately one percent. The surface areas of any bedrock exposed in the bottom of the excavation will be cleaned and not recovered. The final bottom and side slopes of the borrow area will be topsoiled and seeded as soon as practicable after the excavation is completed.

e. Haul Road. See Design Memorandum No. 2, "General Design."

29. Highway Embankment. Ashburnham Road which presently crosses the foundation of the dam embankments and portions of the proposed reservoir will be relocated and completed prior to start of construction for the dam. This relocation is currently under design by this agency. Special attention will be given to the adequacy of design and construction of those portions of the road to be built within the reservoir limits. Fills

of significant height shall be analyzed for stability under conditions of end-of-construction, partial pool and sudden drawdown. Appropriate rock protection will be placed where the embankment slopes will be subjected to wave action.

30. Existing Westminster Dam.

a. General. The Westminster Dam is located about 3/4 miles upstream of the proposed Whitmanville Dam. The existing dam is currently owned by the Nashua River Reservoir Company but will be acquired, operated and maintained by the Corps of Engineers. The dam will be used to maintain a recreational pool which will fluctuate from elev. 826.6 in the spring to about elev. 825.1 in the late summer. This was built in 1912 and rebuilt and raised a few feet in 1942.

b. Dam Embankment. The dam embankment is more than 1,000 feet long of which about 700 feet is less than 10 feet high. Only about 330 feet of the dam is higher than 10 feet and the embankment reaches a maximum height of about 30 feet above the old streambed. The side slopes of the dam are about 1 on 1.8 and the crest is about 10 feet wide. Both side slopes are grass-covered except for the reservoir side slopes at the westerly end of the dam embankment which are riprapped. The top of the riprap (about elev. 828) is about 4 feet from the top of dam.

There is no information available as to the interior make-up of the embankment or the characteristics of its foundation. Based upon visual observations and geology, the foundation and abutment soils are sands and gravels. The interior of the dam embankment probably has an interior impervious zone with a concrete core wall under the spillway weir. Evidently, there is no positive foundation cut-off since seepage is emerging at the downstream ground surface about 25 feet away from the toe of dam at several locations along the 330-foot westerly end of the dam embankment. The landside slope is dry except for one small, soft wet area immediately above the outlet works. There appears to be some sort of toe drain as indicated by two drain pipes which discharge at the Outlet Works Discharge Area.

c. Outlet Works. The Outlet Works consists of an upstream intake tower with a short span bridge, gated twin cast-iron pipes about 24 inches in diameter embedded in the foundation soil or in the embankment fill.

d. Spillway. At the westerly end of the dam there is a chute spillway about 50 feet wide. There are retaining walls on each side of the discharge channel for the full length. The spillway contains a reinforced concrete weir with flashboards, a 10-foot approach and a 23-foot discharge reinforced concrete slab (12 inches and 18 inches thick, respectively) with the remainder of the discharge channel

composed of a series of sloping steps on about an overall slope of 1 on 3. The remainder of the channel slopes appear to be paved with a hand-placed riprap. The slabs, paving and walls rest on earth, some of which is apparently the natural abutment soil. The old plans show portions of an old concrete core wall under the present location of the concrete weir. It is evident that alterations and patchwork have been done on the retaining walls and there is evidence suggesting that the structure consists basically of a mortared field stone with a capping and veneer of concrete.

e. Operation of Dam. The top of the dam embankment is at elev. 832.3. Because of the proposed extensive recreational facilities, the Westminster Dam will be retained and a two-pool system will be required. The pool behind the existing Westminster Dam will be the recreation pool and the storage between the new dam and the existing dam will become basically the water supply replacement pool for industrial water supply. Present plans envision operating the two-pool system by:

(1) Satisfying the initial demands for industrial water by a drawdown of 1.5 feet from both pools (elev. 826.6 to 825.1).

(2) To meet supplementary demands during the recreation season, the recreation pool would be maintained at elev. 825.1 and the water will be taken from the pool between the two dams. By operating in this fashion, the lower pool would be at about elev. 818.1 for an average year and at elev. 812.1 feet for the years of maximum expected usage of the industrial water. During critical drought period, industry may have a need for their full allotment supply of water. If this situation occurs during the recreation season after the pool has been drawdown to elev. 812.1, it will be necessary to forfeit some of the upstream recreation pool for water supply. Provision will be made so that the differential head between the two pools at no time will be greater than 13 feet.

f. Conclusions.

(1) The present spillway has passed all flood flows since 1912 and is considered reasonable adequate to pass those peak discharges that are likely to occur prior to submergence by flood regulation at the downstream Whitmanville Dam as well as those likely to occur during post flood drawdown. The capacity of existing spillway is considered adequate to insure against excessive erosion of the top of the dam due to overflow.

(2) That under the conditions of drawdown that would occur in an average year (7-ft.) and for a maximum expected usage year (13-ft.), the dam should perform satisfactorily from a seepage standpoint. The allowance of greater seepage heads would require major explorations and remedial work.

(3) Minor maintenance might be required on the downstream slope due to erosion by wave action or sloughing due to drawdown (improbably) but not to the extent that remedial provision should be made at the time of construction.

31. Construction Considerations.

a. Dewatering Construction Areas. Dewatering will be specified for all areas in which earth embankment fill is to be placed, including the foundation cut-off. The dewatering of other construction areas will be required to the extent necessary to facilitate construction operations. All earth excavations for the project shall be done in the dry. It is anticipated that the dewatering of the construction area, in general, will be possible by the usual methods of construction drainage including open pumping. Excavation for the foundation cut-off in the valley will require either wellpointing or wells.

b. Rate of Embankment Construction. The length of the dam embankment and the topography of its foundation are such that embankment construction in partial reaches is neither practical nor desirable. Construction of the dam embankment to its full length; therefore, will be specified. In general, it will be specified that the top surface of all embankment fill shall be maintained at an approximately horizontal level at all times during construction except for slight drainage slopes. Exceptions to this requirement will be made to allow construction of the embankment cofferdam and the initial random and pervious fill zones of the embankment in advance of the adjacent fill zones to facilitate direct utilization of materials from the required excavations.

c. Construction of Intake Tower, Pier and Abutment for Service Bridge. The service bridge abutment and pier will be founded on the upstream slope and berm of the dam embankment, respectively. In order to avoid possible detrimental movement of these features due to construction of the embankment, their construction will not be started until the embankment has been completed to within 3 feet of the top of dam. Provisions will be made in design of rockers or plates to accommodate possible post-construction movements. The intake tower will be founded on bedrock near the upstream toe of the dam embankment. In order to avoid stresses caused by any movement of the upstream slope, a zone of uncompacted impervious fill will be placed on the uphill side of the tower.

d. Sequence of Construction. The Ashburnham Road which presently crosses the reservoir and damsites will be relocated and completed prior to the start of dam construction in order that traffic will not be interrupted. All other excavations will be coordinated with the construction of the dam embankment so that the least practical quantity of excavated material other than stripping will be spoiled.

32. Methods of Compaction.

a. Impervious and Random Fills. Impervious and random fill materials shall be spread in layers of not more than 8 inches loose thickness. Each layer shall be compacted by at least six complete passes of a tamping roller. The roller shall consist of heavy duty drum unit with a minimum drum diameter and length of 60 inches. The roller shall weight less than 2,000 pounds per foot of drum length empty and more than 3,500 pounds per foot of drum length weighted. The moisture content of the material being compacted (impervious fill and bulk of random fill, Class I materials) shall be maintained within two percentage points of optimum.

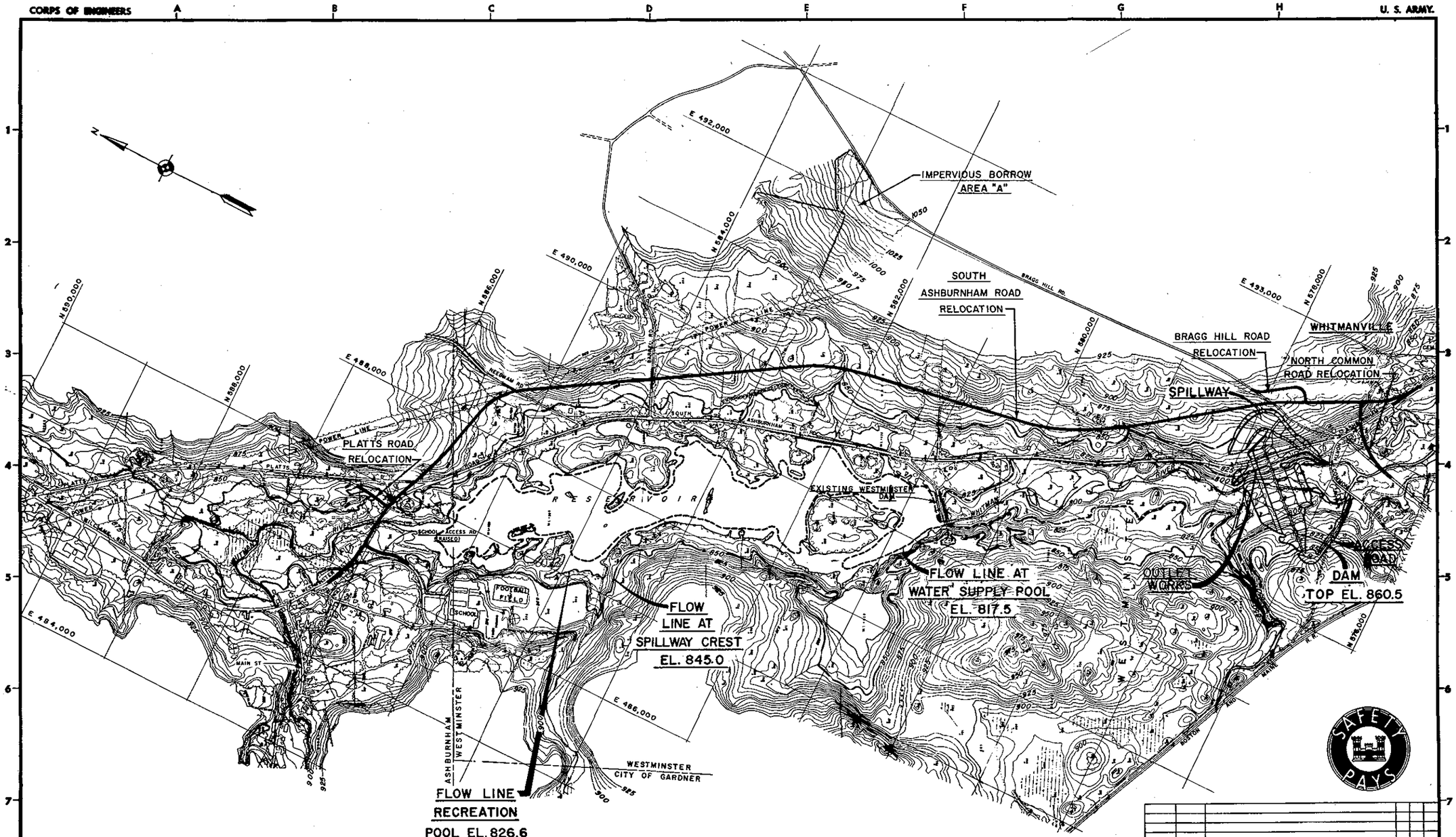
b. Other Fills. Pervious, processed sand, sand, and gravel fills materials shall be spread in layers of not more than six inches loose thickness. Each layer shall be compacted by not less than six coverages of the tread of a crawler-type tractor. The tractor shall weigh at least 35,000 pounds and exert a tread pressure of, at least, nine pounds per square inch. The moisture content of the material being compacted shall be controlled to the extent necessary to prevent excessive dust and rutting.

G. PERMANENT CUT SLOPES

33. Earth Cut Slopes. All permanent cut slopes in the spillway, intake and outlet channels will be 1 on 2 ; and, will be topsoiled and seeded for protection against erosion. Rock protection and gravel bedding will be placed on those slopes which may be subjected to damage from the action of waves or currents, run-off, seepage and frost action. Permanent earth cut side slopes in the impervious Borrow Area will be finished in natural earth slopes of 1 on 3 or flatter. The slopes will be topsoil and seeded.

34. Rock Cut Slopes. The side slopes of permanent rock cuts are up to 30 feet in depth. Although the general trend of the foliation in the rock is northeast-southwest, it is expected that local variations in trend, together with the observed wide variations in the attitude of foliation dip, does not provide any particularly favored direction for alignment of rock excavations. Side slopes of 4 vertical on 1 horizontal are considered reasonable. Because of close jointing in the relatively shallow cuts, however, and the occurrence of coarse pegmatite facilitating random breakage through large feldspar crystals and zones of felted mica, greater than normal overbreak must be anticipated. Presplitting will be used to assist in control of overbreak and, possibly, to obtain more stable slopes. Along the crest of the rock cuts in areas of very close jointing or weathering, it may be necessary to roll back the top of the slope to minimize fallouts. Overburden will be removed to provide a 10-foot berm at the rock surface. Rock bolts will be utilized as may be applicable. Continuous, thorough and judicious scaling will be done to minimize ravelling and to reduce hazard of rock falls.

CORPS OF ENGINEERS U. S. ARMY



RESERVOIR PLAN
SCALE: 1" = 400'

GRAPHIC SCALE
1" = 400' 400' 0 400' 800'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF PROJECT BRANCH

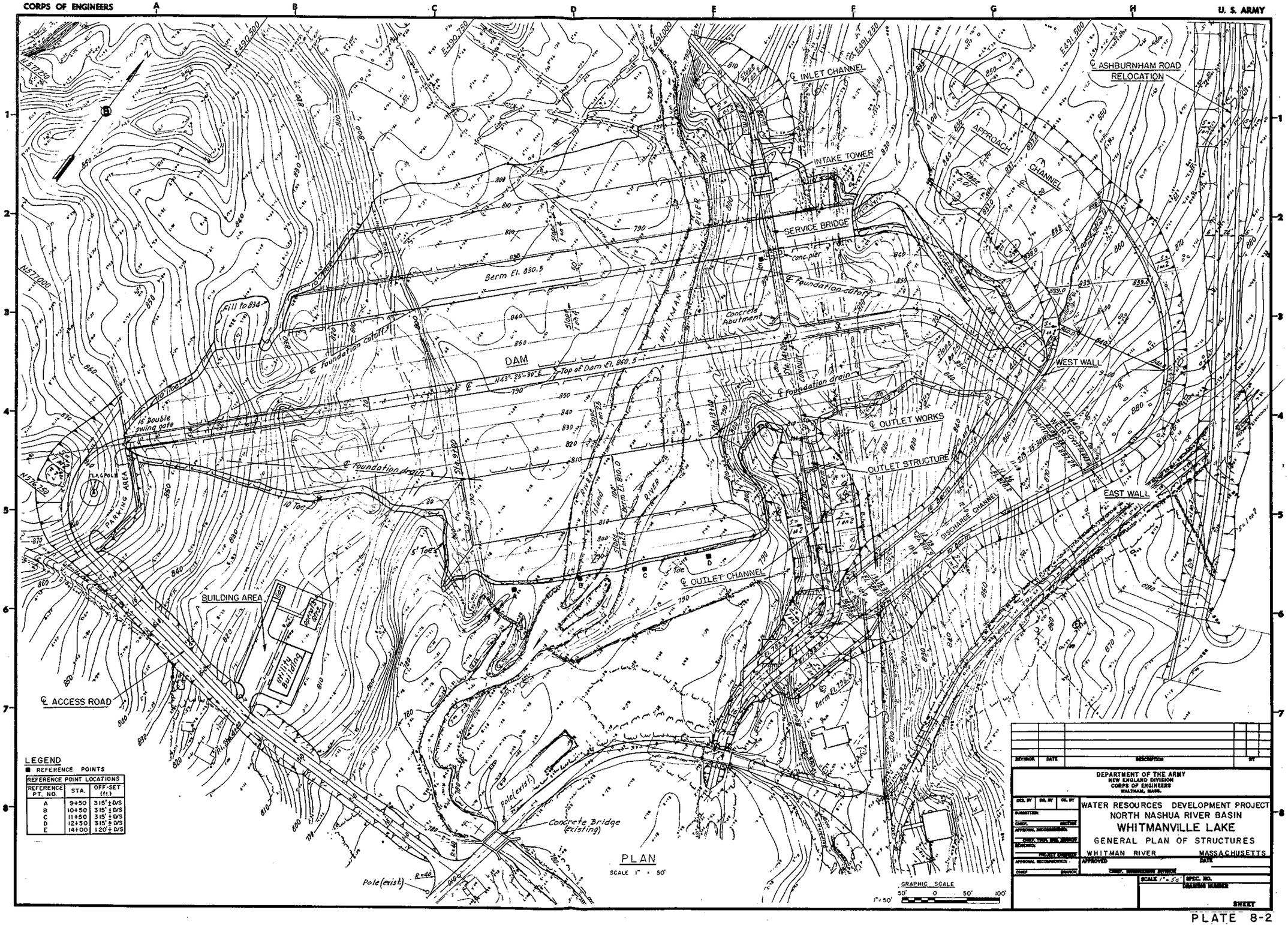
WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
RESERVOIR MAP
WHITMAN RIVER MASSACHUSETTS

APPROVED DATE
CHIEF, ENGINEERING DIVISION

SCALE: 1" = 400' SPEC. NO.
DRAWING NUMBER
SHEET

PLATE 8-1

CORPS OF ENGINEERS U. S. ARMY



PLAN

SCALE 1" = 50'

LEGEND

■ REFERENCE POINTS

REFERENCE POINT LOCATIONS		
REFERENCE PT. NO.	STA.	OFF-SET (ft.)
A	9+50	315' ± D/S
B	10+50	315' ± D/S
C	11+50	315' ± D/S
D	12+50	315' ± D/S
E	14+00	120' ± D/S

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. SERVICE
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF BRANCH

WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
GENERAL PLAN OF STRUCTURES
WHITMAN RIVER MASSACHUSETTS

APPROVED DATE
CHIEF, ENGINEERING DIVISION

SCALE 1" = 50' SPEC. NO.
DRAWING NUMBER
SHEET

PLATE 8-2

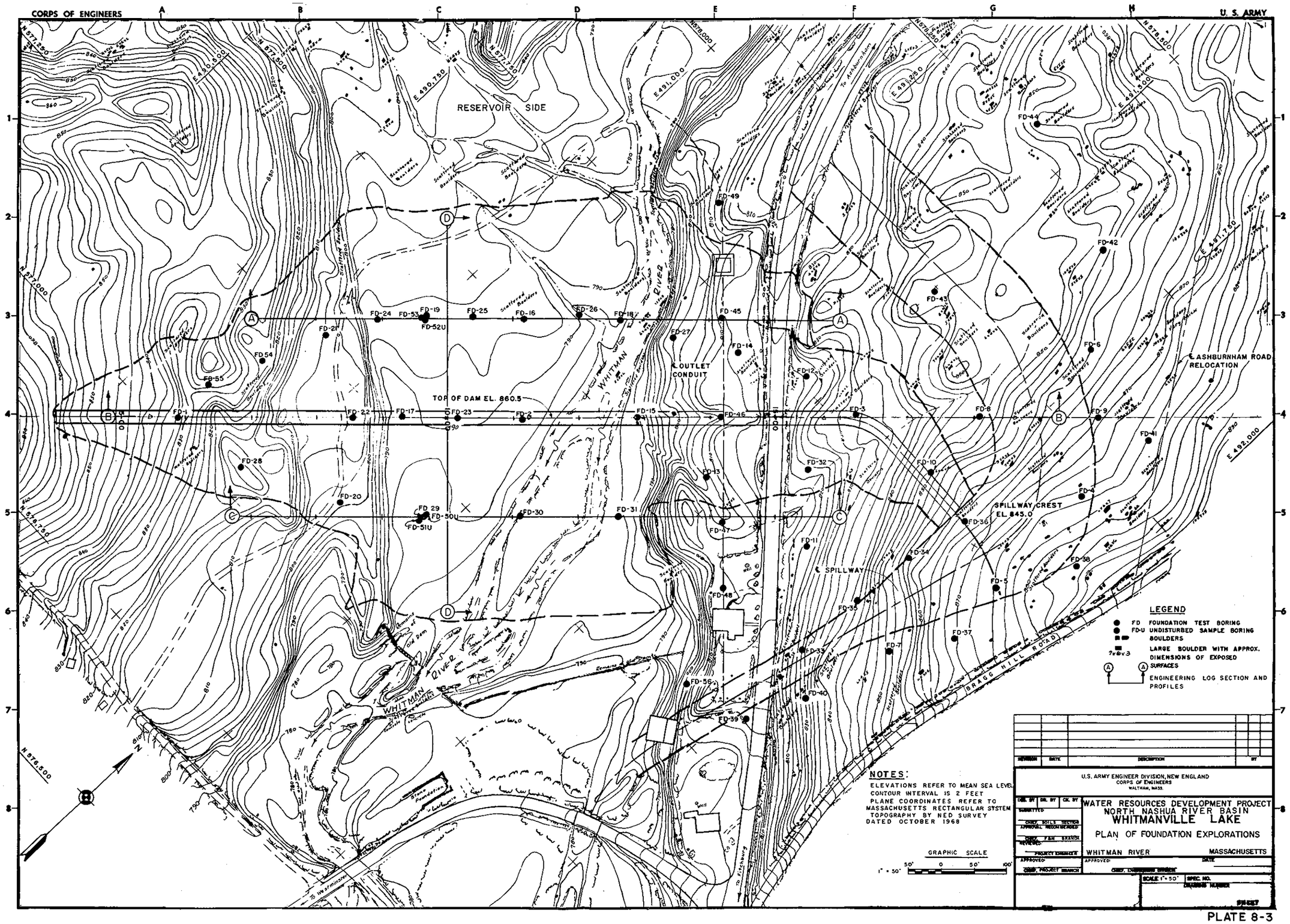
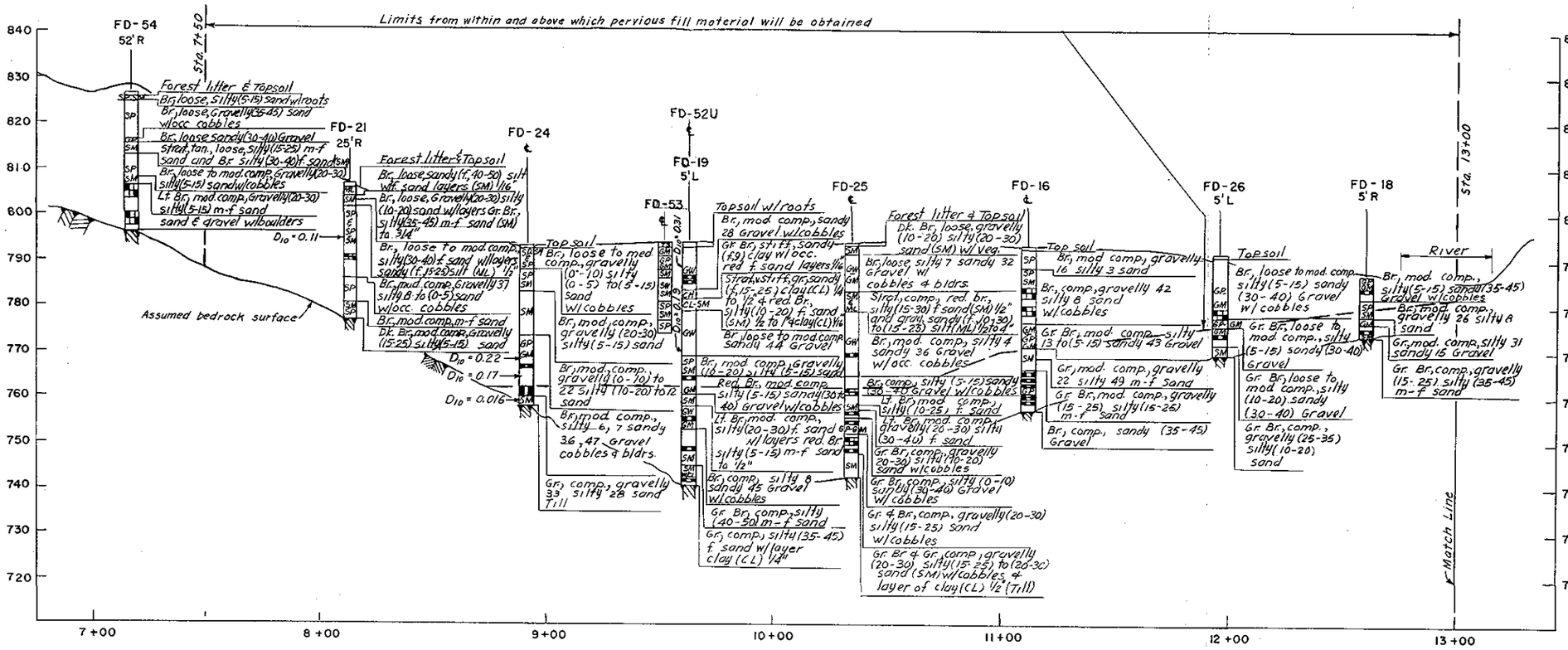

CORPS OF ENGINEERS
U. S. ARMY
RESERVOIR SIDE
WHITMAN RIVER
OUTLET CONDUIT
TOP OF DAM EL. 860.5
SPILLWAY CREST EL 845.0
SPILLWAY
ASHBURNHAM ROAD RELOCATION
BRAGG HILL ROAD
LEGEND
FD FOUNDATION TEST BORING
FD-U UNDISTURBED SAMPLE BORING
BOULDERS
LARGE BOULDER WITH APPROX. DIMENSIONS OF EXPOSED SURFACES
ENGINEERING LOG SECTION AND PROFILES
NOTES:
ELEVATIONS REFER TO MEAN SEA LEVEL
CONTOUR INTERVAL IS 2 FEET
PLANE COORDINATES REFER TO MASSACHUSETTS RECTANGULAR SYSTEM
TOPOGRAPHY BY NED SURVEY DATED OCTOBER 1968
GRAPHIC SCALE
1" = 50'
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
PLAN OF FOUNDATION EXPLORATIONS
WHITMAN RIVER
MASSACHUSETTS
SCALE 1" = 50'

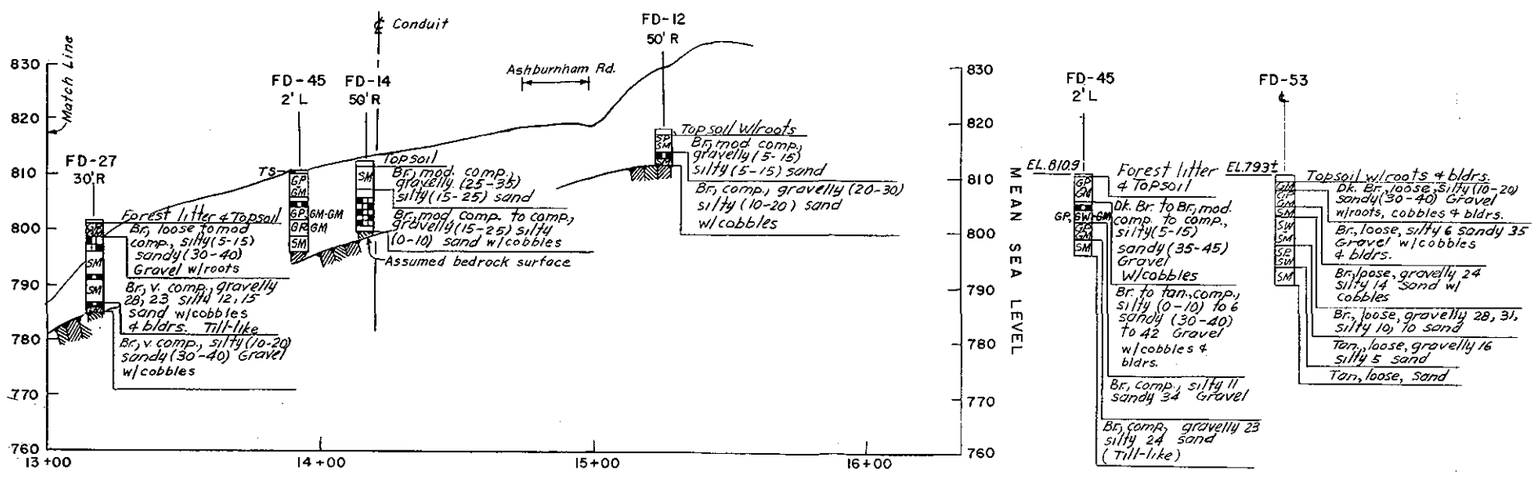
PLATE 8-3

CORPS OF ENGINEERS — U. S. ARMY



ENGINEERING LOG PROFILE A-A, 150 FEET UPSTREAM FROM DAM ℄

(LOOKING UPSTREAM-PROJECTED DAM ℄ STATIONING)



ENGINEERING LOG PROFILE A-A, (CONT.)

NOTES

FOR LOCATION OF EXPLORATIONS SEE PLATE 8-3

FOR LEGEND OF ENGINEERING LOGS SEE PLATE 8-6

SAFETY PAYS

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY — DR. BY WSK — CK. BY

SUBMITTED: CHIEF, GEOLOGY SECTION

APPROVAL RECOMMENDED: CHIEF, F & M BRANCH

REVIEWED: PROJECT ENGINEER

APPROVAL RECOMMENDED

APPROVED: CHIEF, ENGINEERING DIVISION

DATE

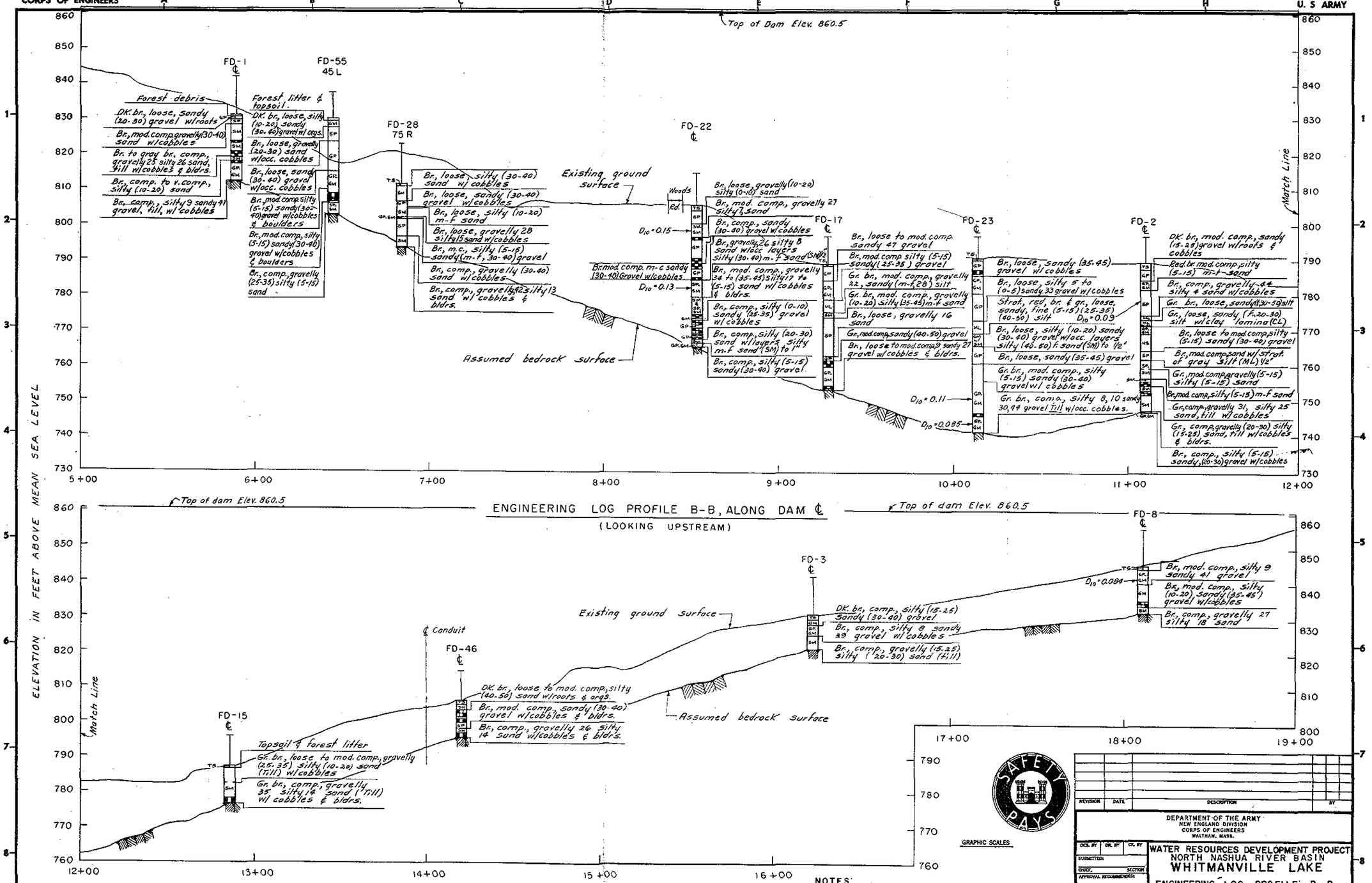
WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
ENGINEERING LOG PROFILE
A-A

WHITMAN RIVER — MASSACHUSETTS

SCALE — SPEC. NO. ENG. 19-016- — DRAWING NUMBER — SHEET

PLATE 8-4

CORPS OF ENGINEERS — U. S ARMY



ENGINEERING LOG PROFILE B-B, ALONG DAM ℄

(LOOKING UPSTREAM)

ENGINEERING LOG PROFILE B-B (CONT.)

NOTES:

For location of explorations see plate B-3

For legend of Engineering Logs, see plate B-6

GRAPHIC SCALES

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF BRANCH

WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE

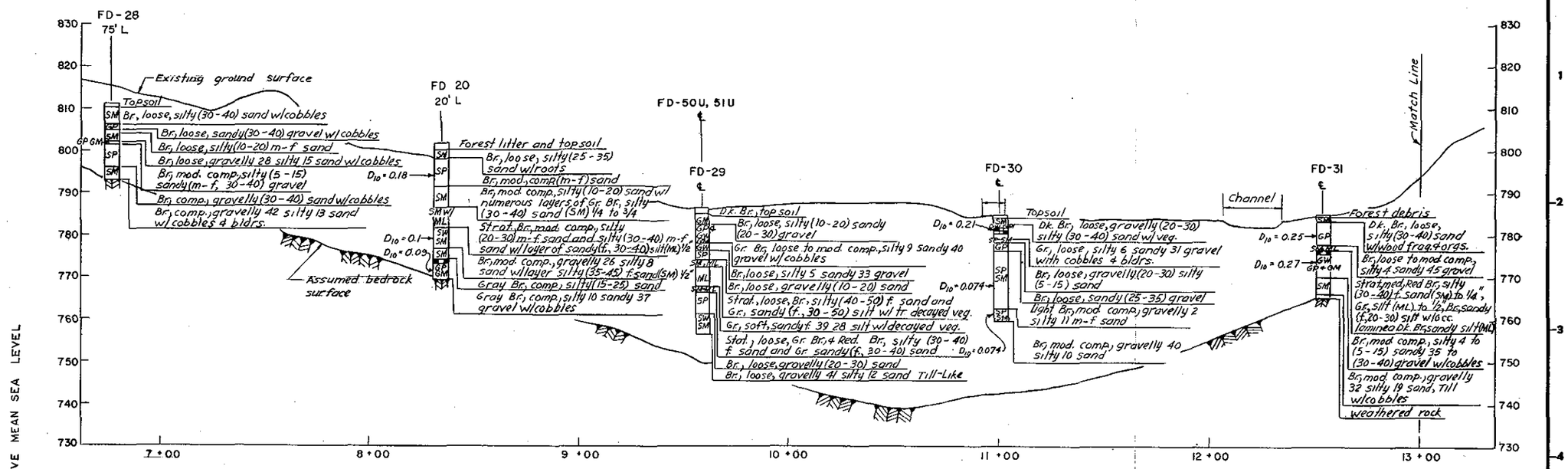
ENGINEERING LOG PROFILE B-B

WHITMAN RIVER — MASSACHUSETTS

APPROVED — DATE
CHIEF, ENGINEERING DIVISION

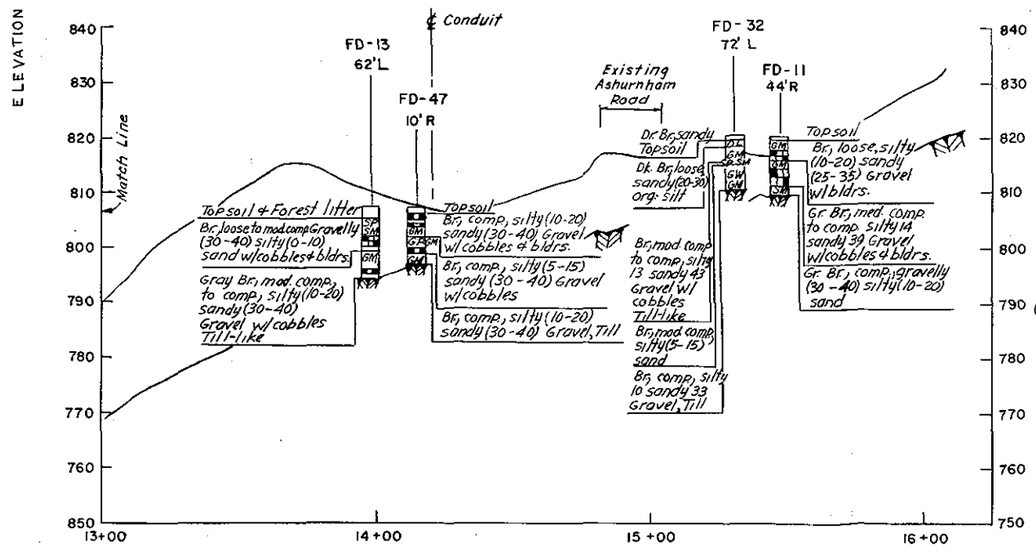
SCALE | SPEC. NO.
DRAWING NUMBER
SHEET

PLATE 8-5



ENGINEERING LOG PROFILE C-C, 150 FEET DOWNSTREAM FROM DAM ℄

(LOOKING UPSTREAM – PROJECTED DAM ℄ STATIONING)



ENGINEERING LOG PROFILE C-C (CONT.)

LEGEND FOR ENGINEERING LOG PROFILES

strat.	stratified	br.	brown	v.	very	m.	medium
org.	organic	gr.	gray	comp.	compact	c.	coarse
veg.	vegetation	bl.	black	w/	with	m-f	medium to fine
lt.	light	red.	reddish	occ.	occasional	bldrs.	boulders
dk.	dark	mod.	moderately	f.	fine		

D_{10} Effective grain size in millimeters.
LL Atterberg liquid limit.
PI Atterberg plasticity index.
NP Non-plastic.
W_n Natural water content of sample except for certain soils containing gravel for which W_n represents the water content of that part of the sample from which portions of the coarse sizes have been removed.
W_4 Natural water content determined for that portion of the soil passing the No. 4 U.S. Standard Sieve.
26 A single numerical following a soil component in the description of a soil represents the percentage, by weight, of that component in the soil as determined by a mechanical analysis.
(25-35) A range of numbers in parentheses following a soil component represents the estimated limits between which lies the percentage, by weight, of that component in the soil as determined by visual inspection.

SM Soil Symbol, Unified Soil Classification System.

Cobble or boulder (Core-drilled)

Cobbles or boulders, continuous or nested (Core drilled and/or blasted or chopped).

NOTES

1. For location of explorations see Plate 8-3
2. Selected Test Data and Selected Shear Strength Data of Undisturbed Exploration FD-50U, 51U, 52U shown on Plates 8-10 and 8-11
3. Test Data and Undisturbed Sample Logs of FD-50U, 51U, 52U bound in Appendix C

GRAPHIC SCALES

SAFETY PAYS

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY W S K | CK. BY

SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF, BRANCH

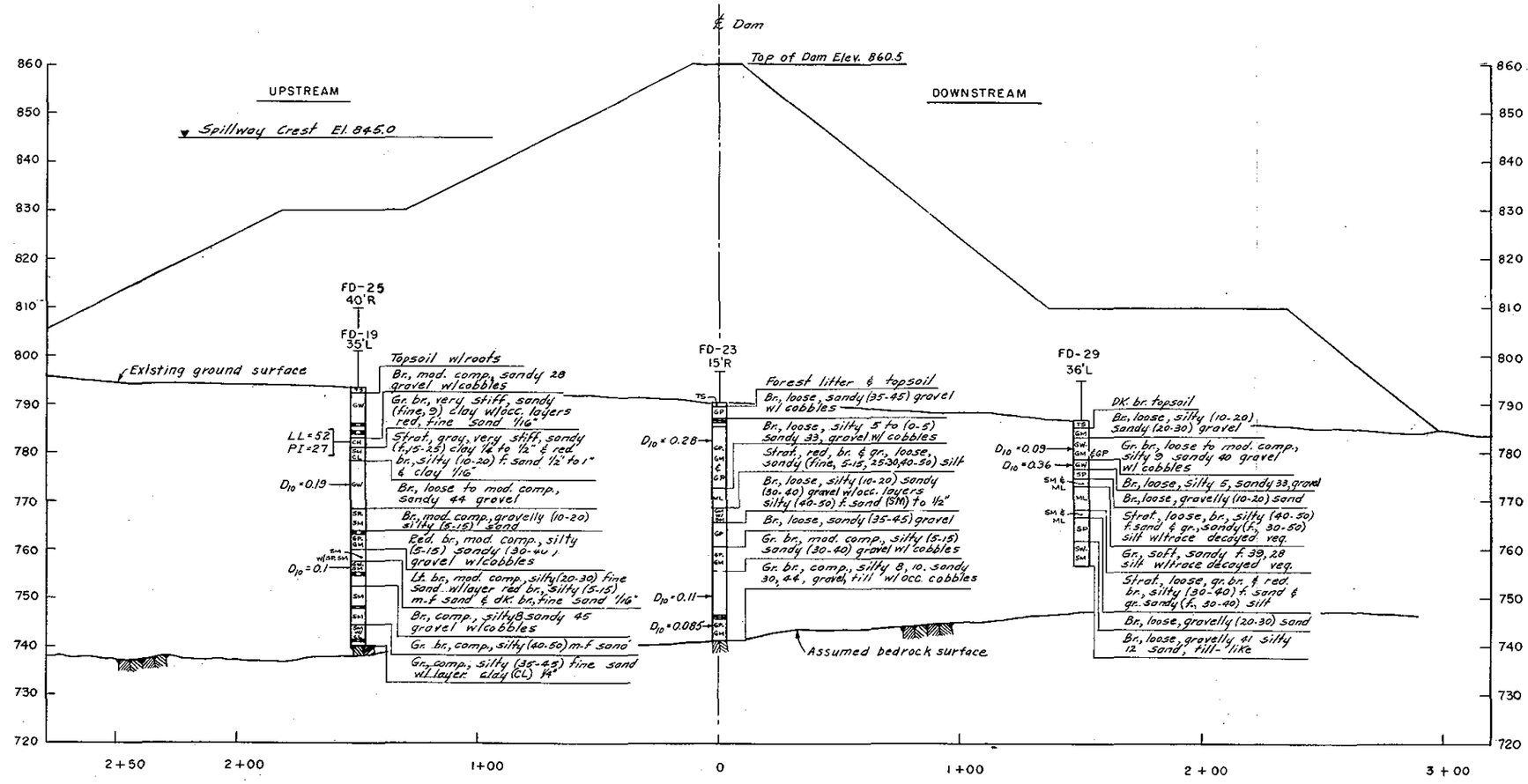
WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
ENGINEERING LOG PROFILE
C-C

WHITMAN RIVER MASSACHUSETTS

APPROVED DATE
CHIEF, ENGINEERING DIVISION

SCALE | SPEC. NO.
DRAWING NUMBER
SHEET

CORPS OF ENGINEERS A B C D E F G H U. S ARMY



ENGINEERING LOG SECTION D-D, AT STA. 10+00

(LOOKING NORTHEAST)

NOTES:

1. For location of Explorations, see plate 8-3
2. For legend of Engineering Logs, see plate 8-6

GRAPHIC SCALES

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF BRANCH

WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE

ENGINEERING LOG SECTION D-D

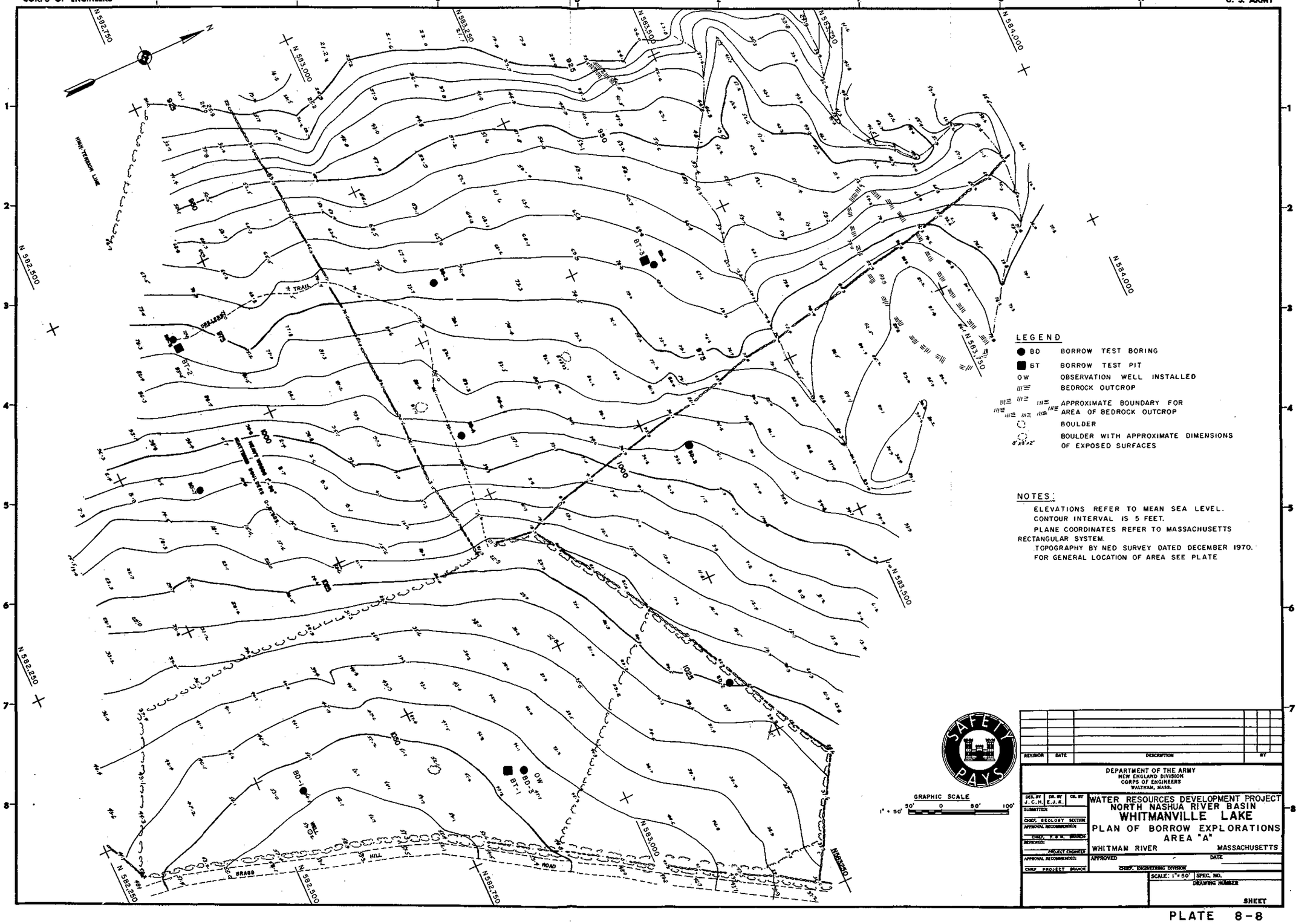
WHITMAN RIVER MASSACHUSETTS

APPROVED DATE
CHIEF, ENGINEERING DIVISION

SCALE | SPEC. NO.
DRAWING NUMBER
SHEET

PLATE 8-7

CORPS OF ENGINEERS U. S. ARMY



NOTES:

ELEVATIONS REFER TO MEAN SEA LEVEL.
CONTOUR INTERVAL IS 5 FEET.
PLANE COORDINATES REFER TO MASSACHUSETTS RECTANGULAR SYSTEM.
TOPOGRAPHY BY NED SURVEY DATED DECEMBER 1970.
FOR GENERAL LOCATION OF AREA SEE PLATE

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY J.C.H. | DR. BY E.J.K. | CK. BY

SUBMITTED:
CHIEF, GEOLOGY SECTION
APPROVAL RECOMMENDED:
CHIEF, F.&M. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF, PROJECT BRANCH

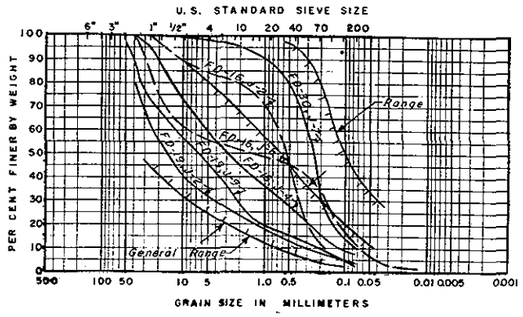
WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
PLAN OF BORROW EXPLORATIONS
AREA "A"
WHITMAN RIVER MASSACHUSETTS

APPROVED DATE
CHIEF, ENGINEERING DIVISION

SCALE: 1" = 50' | SPEC. NO.
DRAWING NUMBER
SHEET

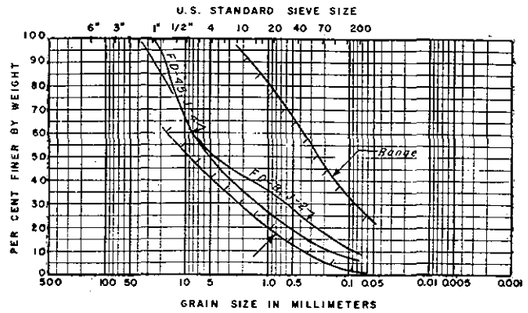
PLATE 8-8

CORPS OF ENGINEERS U. S ARMY



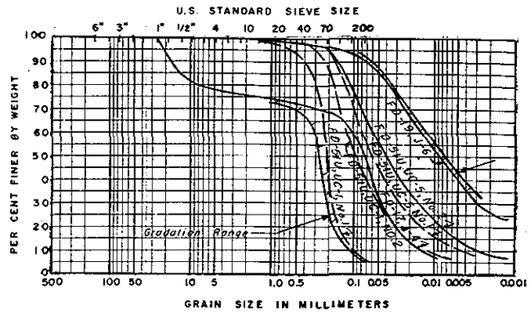
OUTWASH MATERIALS

(VALLEY AND RIGHT ABUTMENT AREAS)



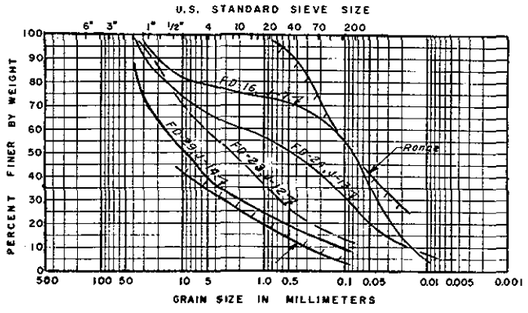
OUTWASH MATERIALS

(LEFT ABUTMENT AND SPILLWAY AREAS)



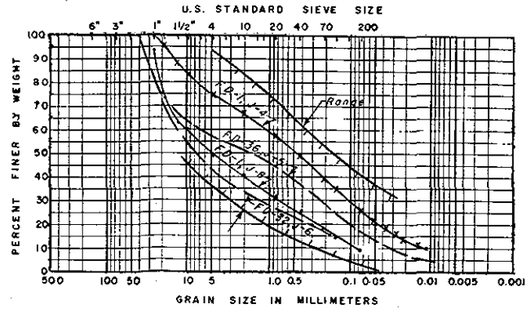
FINE GRAINED MATERIALS

(VALLEY)



GLACIAL TILL

(VALLEY AREA)



GLACIAL TILL

(ABUTMENTS AND SPILLWAY AREAS)

GRAPHIC SCALES

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF BRANCH

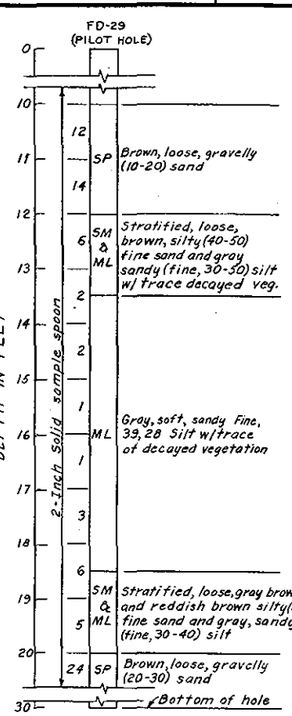
WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
SELECTED TEST DATA
FOUNDATION MATERIALS
WHITMAN RIVER MASSACHUSETTS

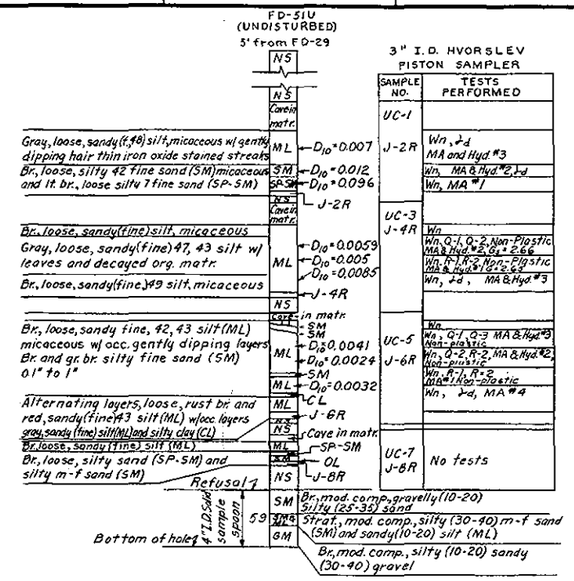
APPROVED DATE
CHIEF, ENGINEERING DIVISION

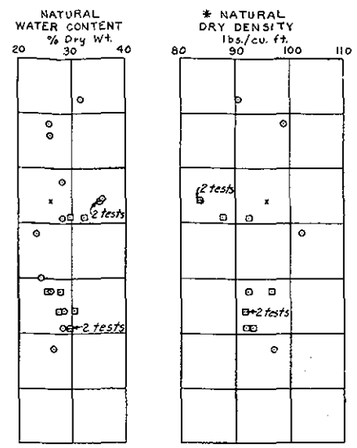
SCALE | SPEC. NO.
DRAWING NUMBER
SHEET

PLATE 8-9

CORPS OF ENGINEERS — U. S ARMY

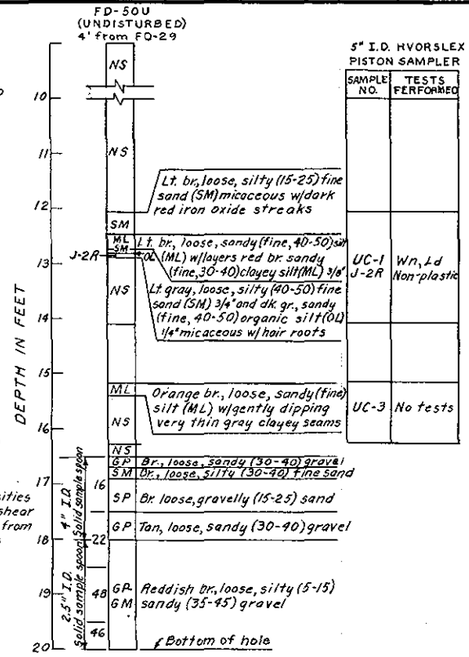






□ Shear test specimens
○ Small specimens from tube
x UC-1, FD-50U

* The natural dry densities were derived from shear test specimens and from small test specimens from each tube.

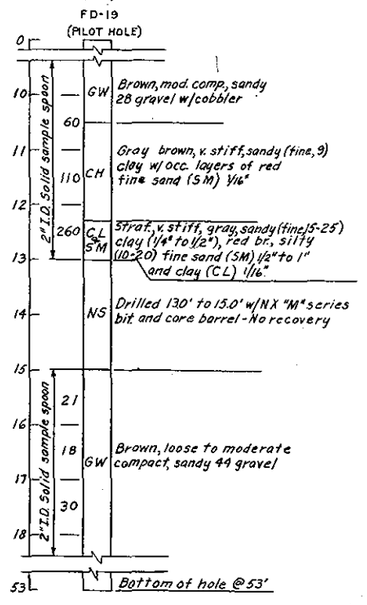


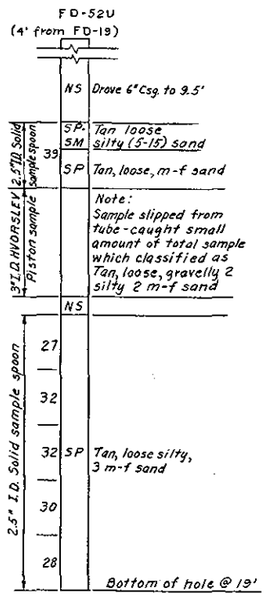
LEGEND FOR TESTS

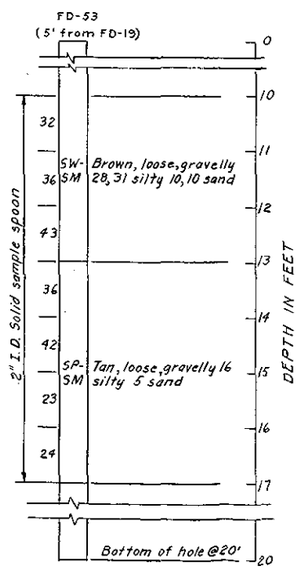
Wn Natural water content
MA Mechanical analysis
Hyd. Hydrometer test
G_s Specific gravity of solids
Q Triaxial compression, Q-test
R Triaxial compression, R-test
γd Natural dry density

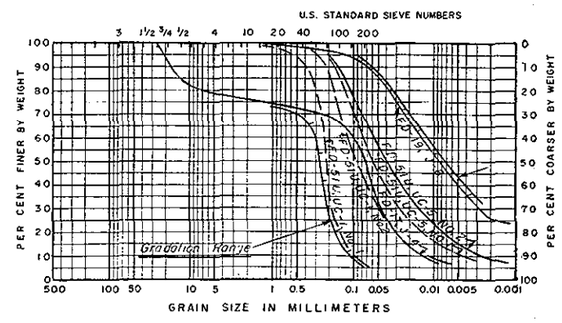
LEGEND FOR BLOW COUNTS

3 — Blows per foot of penetration considered most representative for each sample drive using a 350 pound hammer with a free fall of about 18-inches on a standard 5-foot solid sample spoon with a beveled sharpened drive shoe.









GRADATION RANGE

GRAPHIC SCALES

NOTE

Detailed Test Data and Undisturbed Sample Logs bound in Appendix C.

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

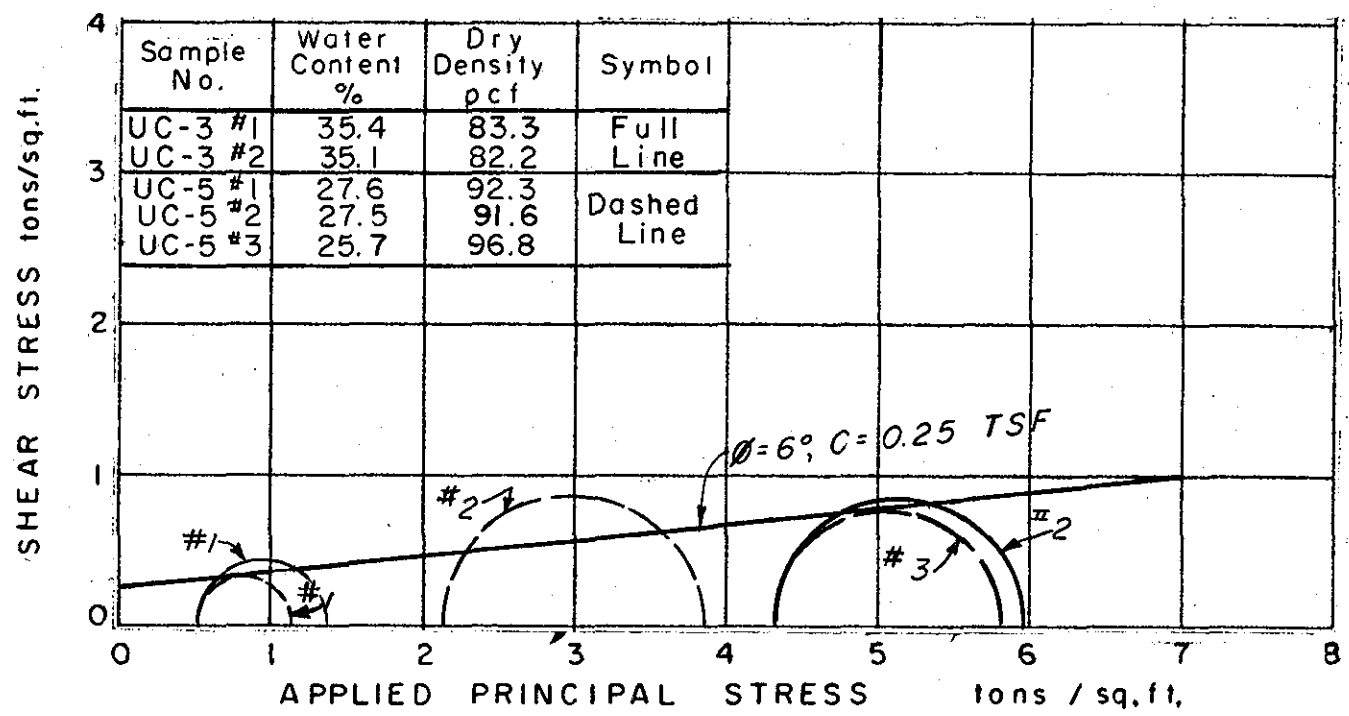
SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF BRANCH

WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
SELECTED TEST DATA
UNDISTURBED EXPLORATIONS
FD-50U, FD-51U AND FD-52U
WHITMAN RIVER — MASSACHUSETTS

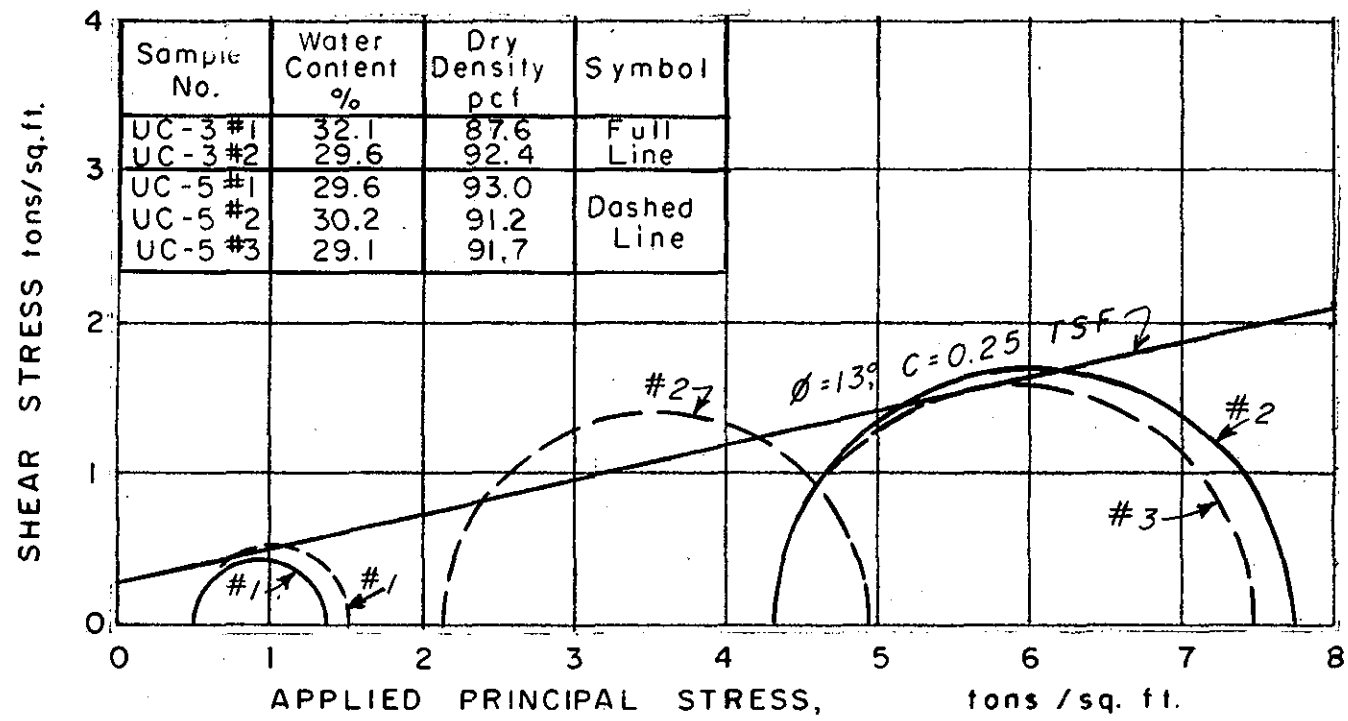
APPROVED — DATE
CHIEF, ENGINEERING DIVISION

SCALE | SPEC. NO.
DRAWING NUMBER
SHEET

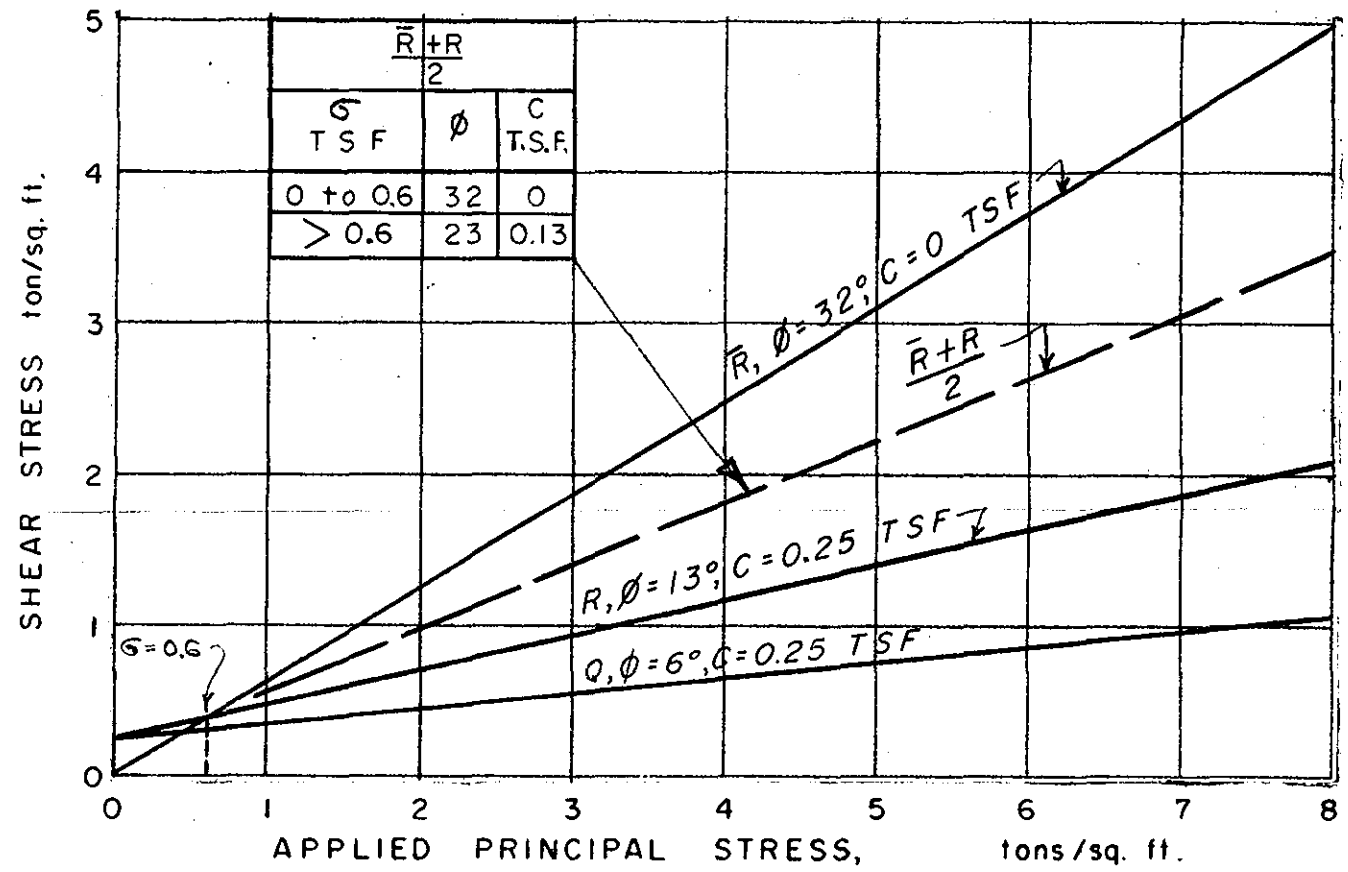
PLATE 8-10



Q TEST, FD-51 U, UC-3 and 5



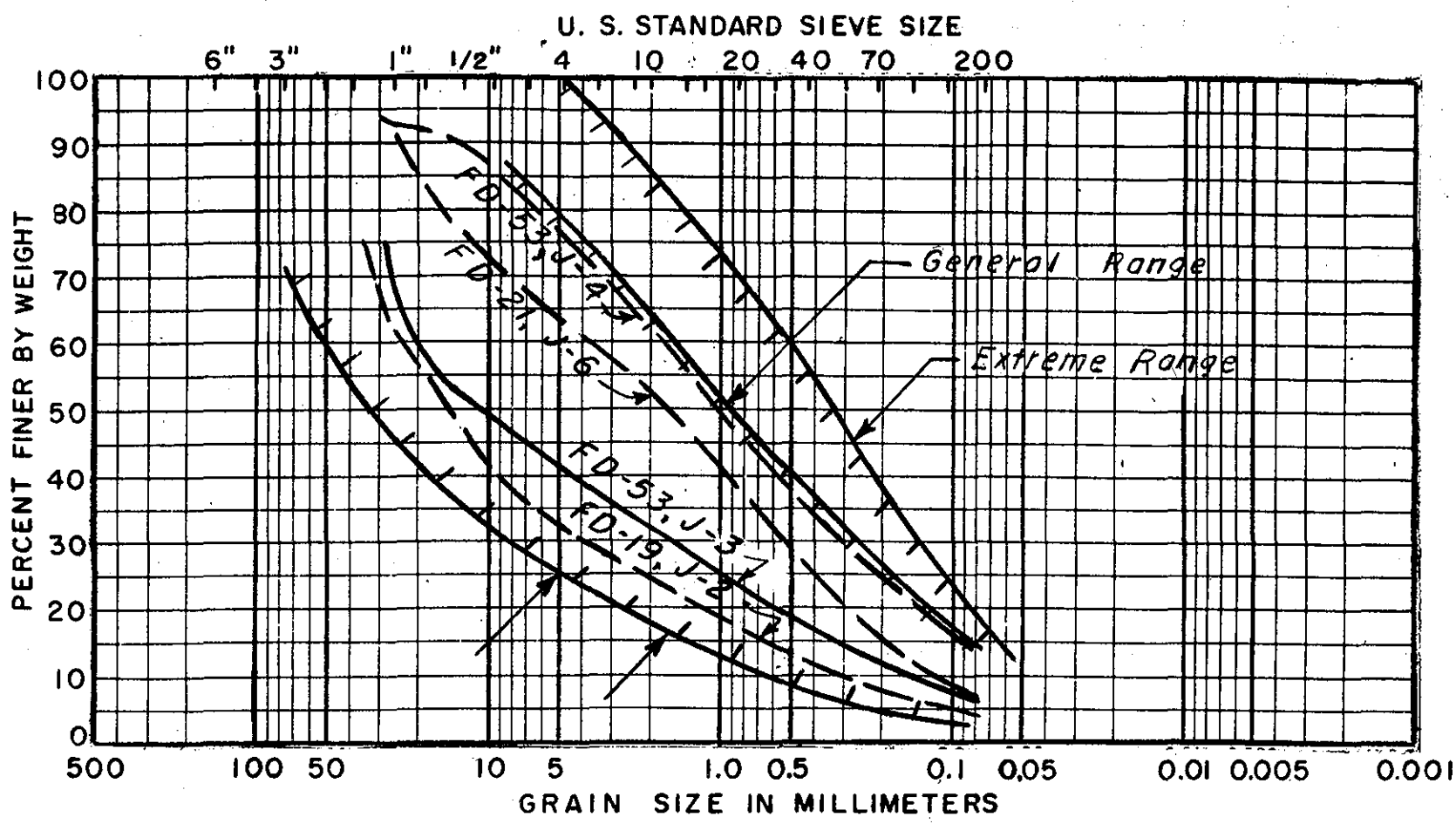
R TEST, FD-51 U, UC-3 and 5



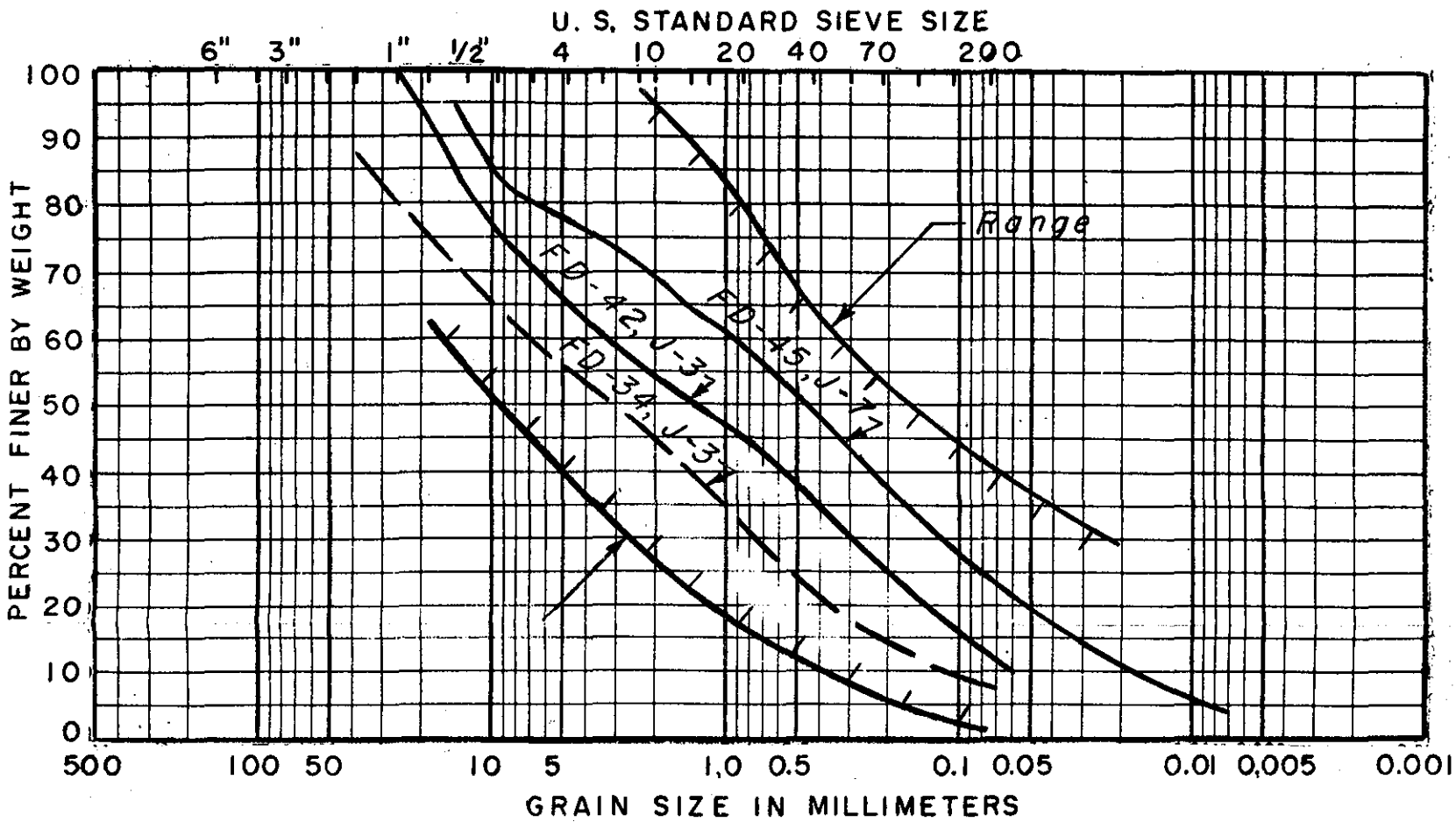
DESIGN SHEAR STRENGTHS

WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE

SELECTED SHEAR STRENGTH DATA
UNDISTURBED EXPLORATION FD-51U
WHITMAN RIVER MASSACHUSETTS



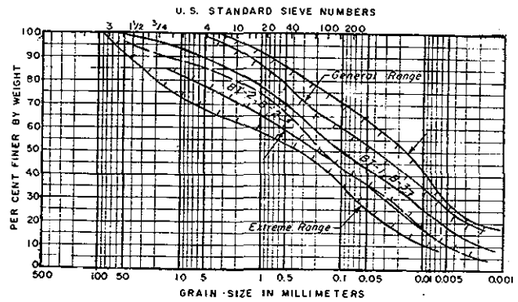
PERVIOUS EMBANKMENT MATERIALS



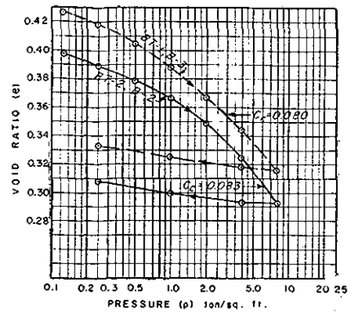
RANDOM EMBANKMENT MATERIALS

WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
SELECTED TEST DATA
EMBANKMENT MATERIALS
FROM REQUIRED EXCAVATIONS
WHITMAN RIVER MASSACHUSETTS

CORPS OF ENGINEERS — U. S. ARMY

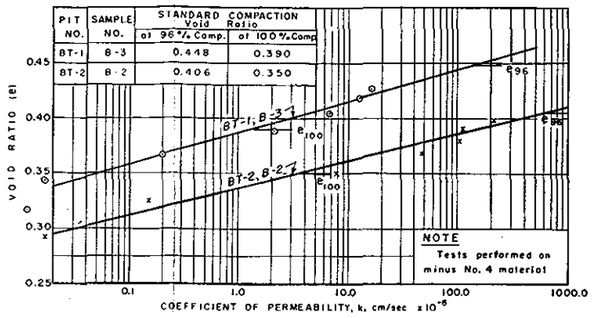


GRADATION RANGE

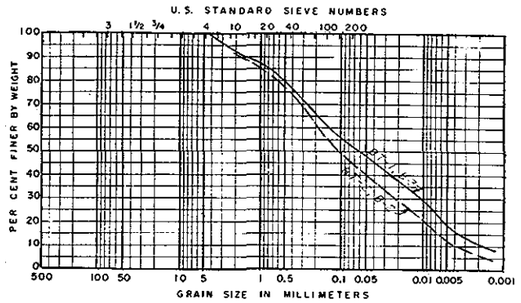


PRESSURE vs VOID RATIO

PIT NO.	SAMPLE NO.	STANDARD COMPACTION Void Ratio of 96 % Comp.	of 100 % Comp.
BT-1	B-3	0.448	0.390
BT-2	B-2	0.406	0.350

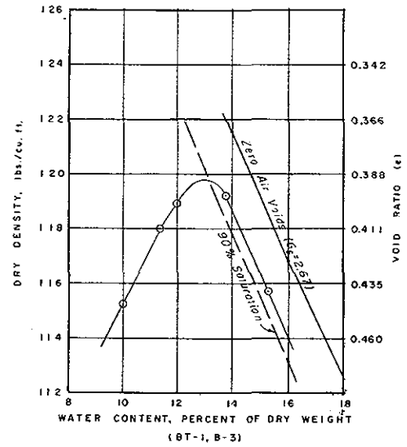


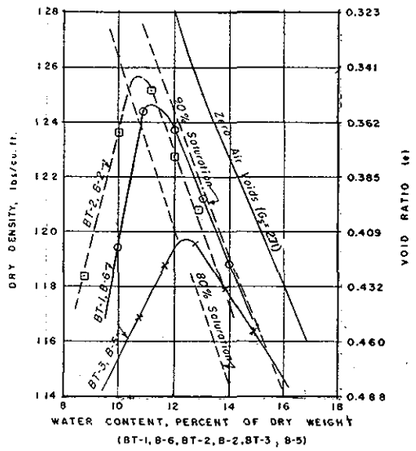
PERMEABILITY Vs VOID RATIO



BT-1, B-3 and BT-2, B-2 (MINUS NO. 4 COMPONENT MATERIAL)

GRADATION CURVES

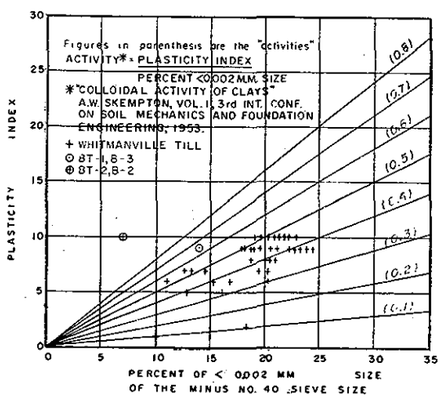




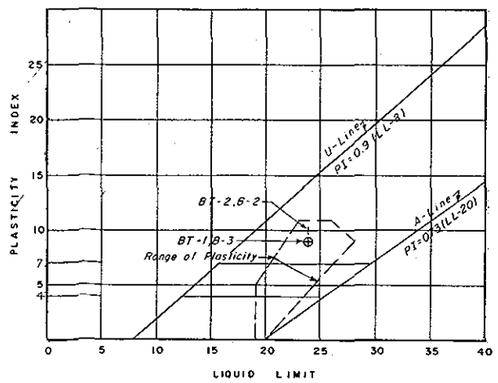
STANDARD COMPACTION CURVES

NOTE

Compaction, Consolidation and Permeability Tests were performed on minus No. 4 material.



RELATIONSHIP BETWEEN PLASTICITY INDEX AND <0.002 MM SIZE



PLASTICITY CHART

GRAPHIC SCALES

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF BRANCH

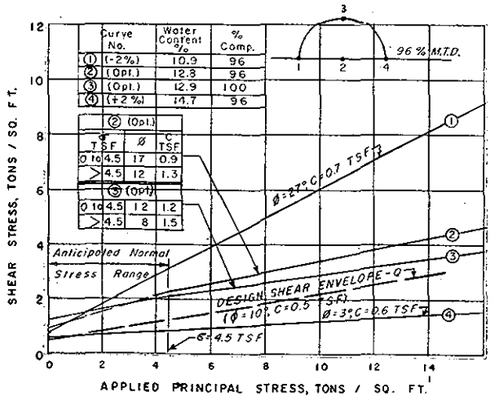
WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
SELECTED TEST DATA
IMPERVIOUS EMBANKMENT MATERIAL
AREA "A"
WHITMAN RIVER MASSACHUSETTS

APPROVED DATE
CHIEF, ENGINEERING DIVISION

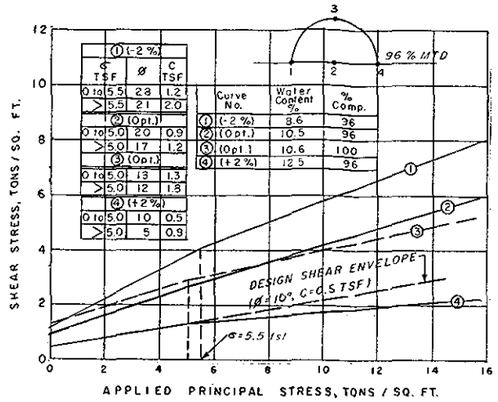
SCALE | SPEC. NO.
DRAWING NUMBER
SHEET

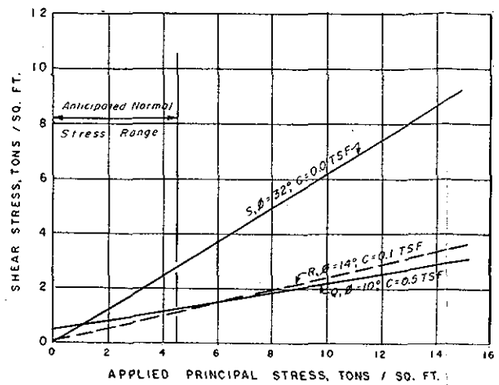
PLATE 8-13

BT-1, B-3



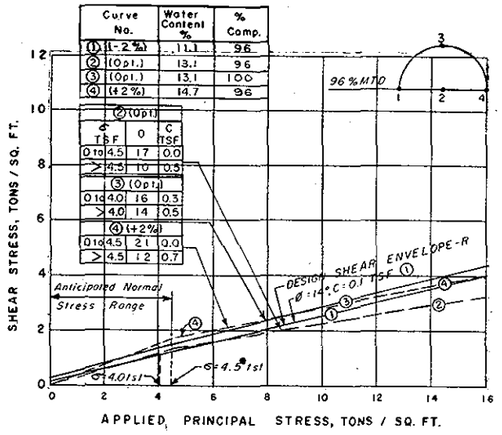
BT-2, B-2

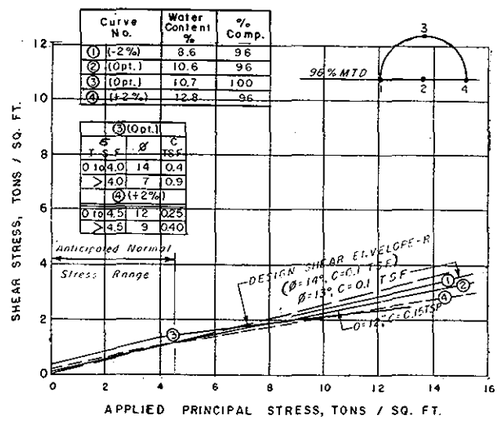


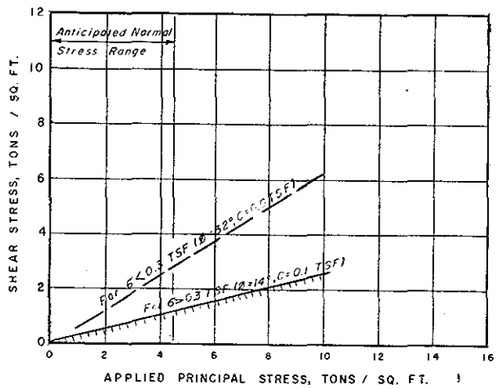


Q TESTS TRIAXIAL

DESIGN SHEAR STRENGTH ENVELOPES

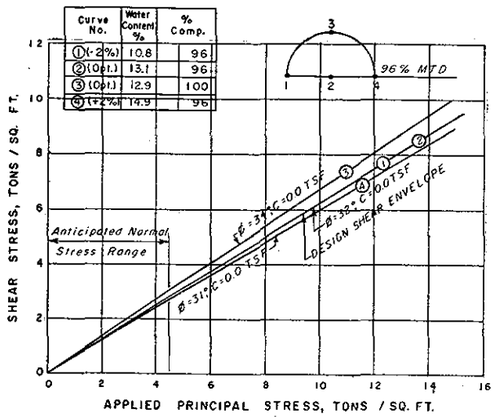


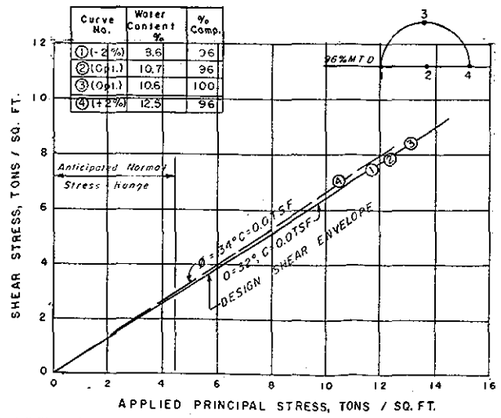


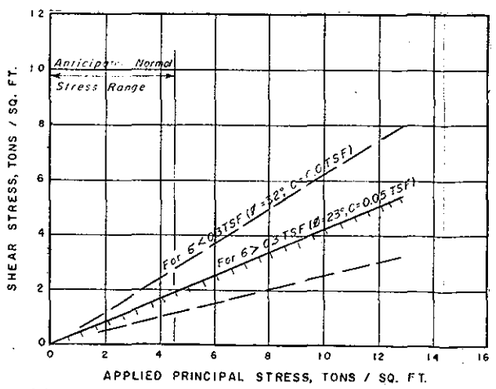


R TESTS - TRIAXIAL

COMBINED R & S SHEAR STRENGTH ENVELOPES FOR SUDDEN DRAWDOWN ANALYSIS







S TESTS - DIRECT SHEAR

COMBINED R&S SHEAR STRENGTH ENVELOPES FOR STEADY SEEPAGE & PARTIAL POOL ANALYSIS

REVISION	DATE	DESCRIPTION	BY

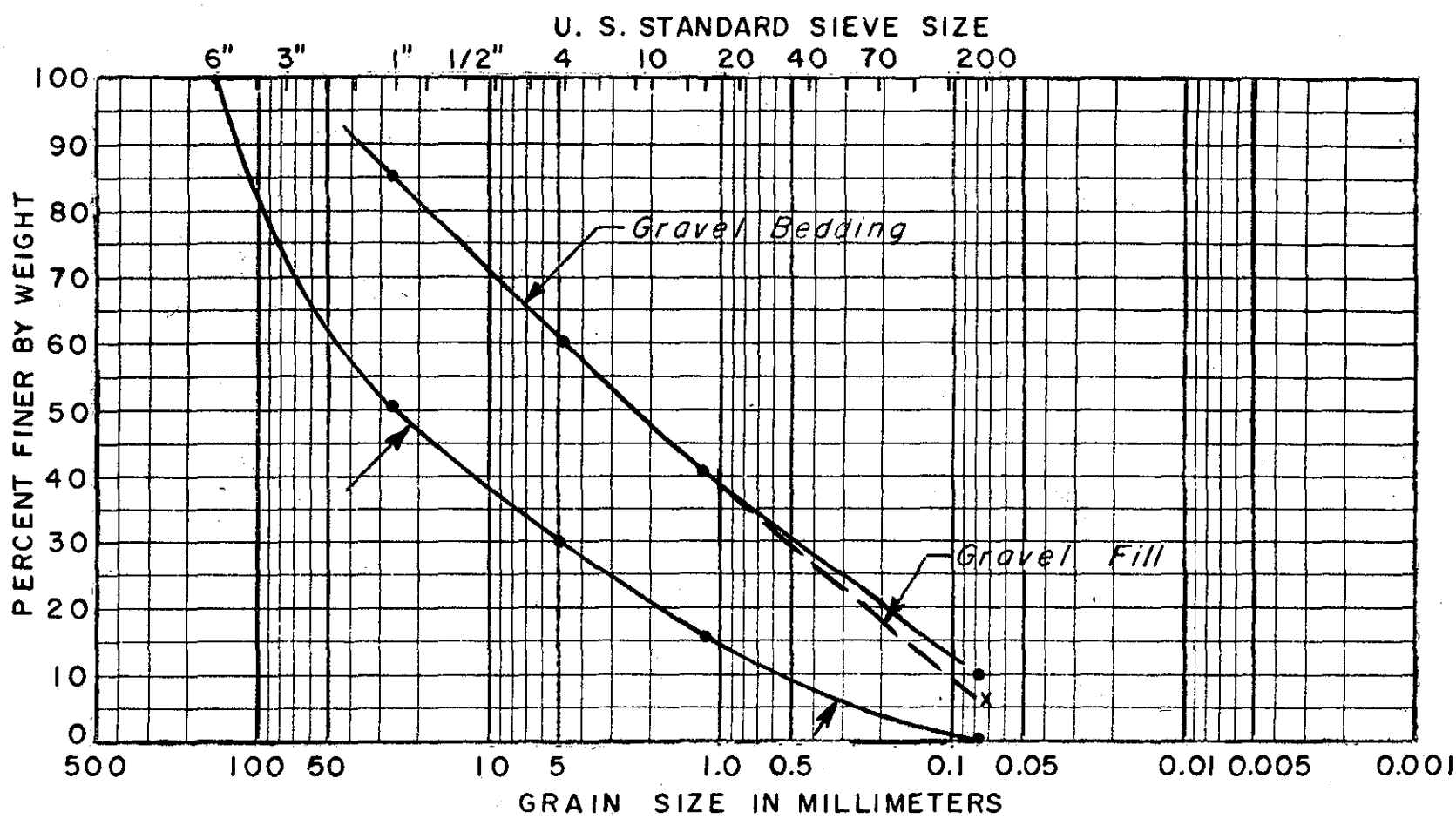
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY
SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF BRANCH

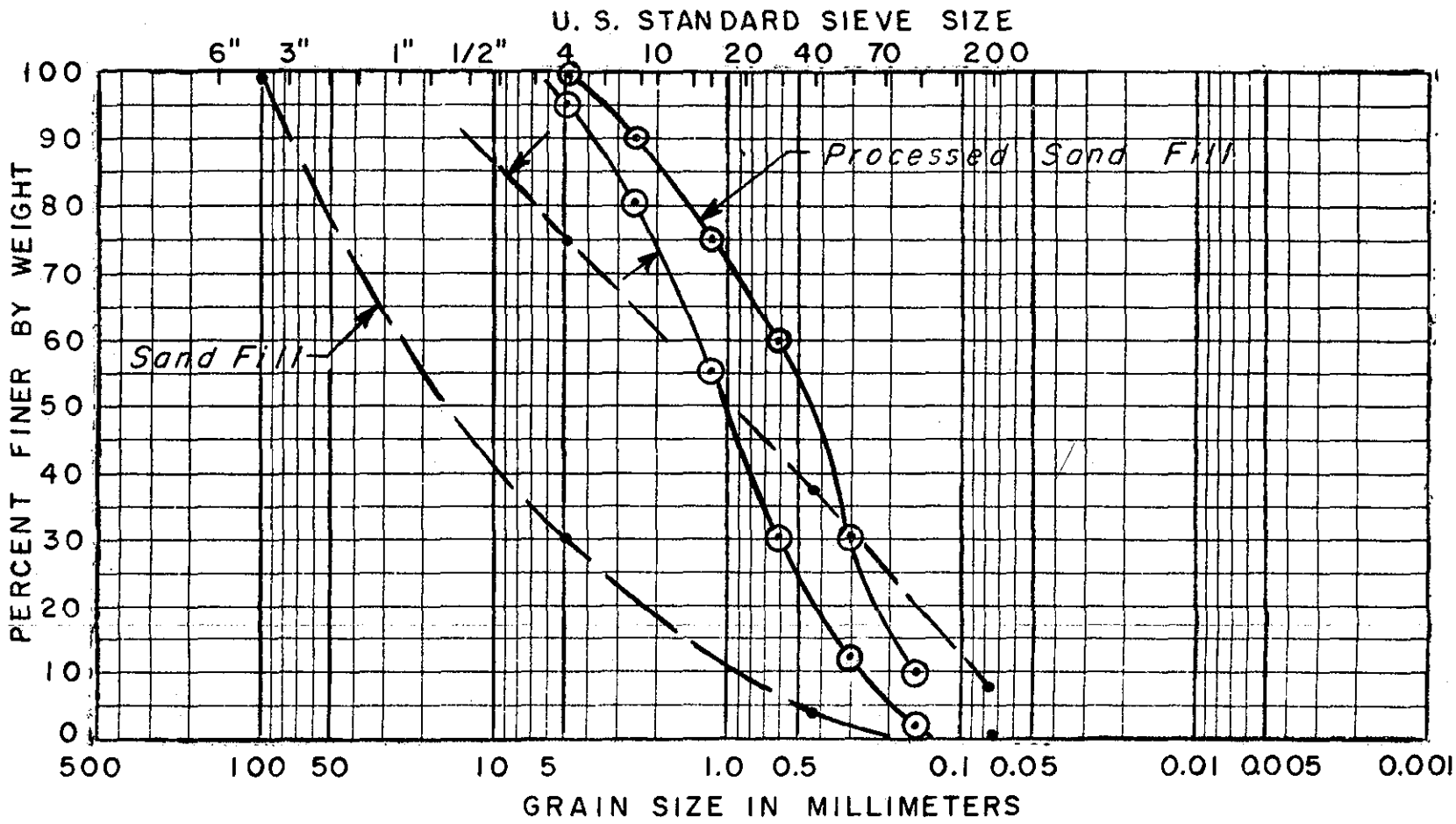
WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
SELECTED SHEAR STRENGTH DATA
IMPERVIOUS EMBANKMENT MATERIAL
AREA "A"
WHITMAN RIVER MASSACHUSETTS

APPROVED DATE
CHIEF, ENGINEERING DIVISION

SCALE | SPEC. NO.
DRAWING NUMBER
SHEET



GRAVEL BEDDING AND GRAVEL FILL



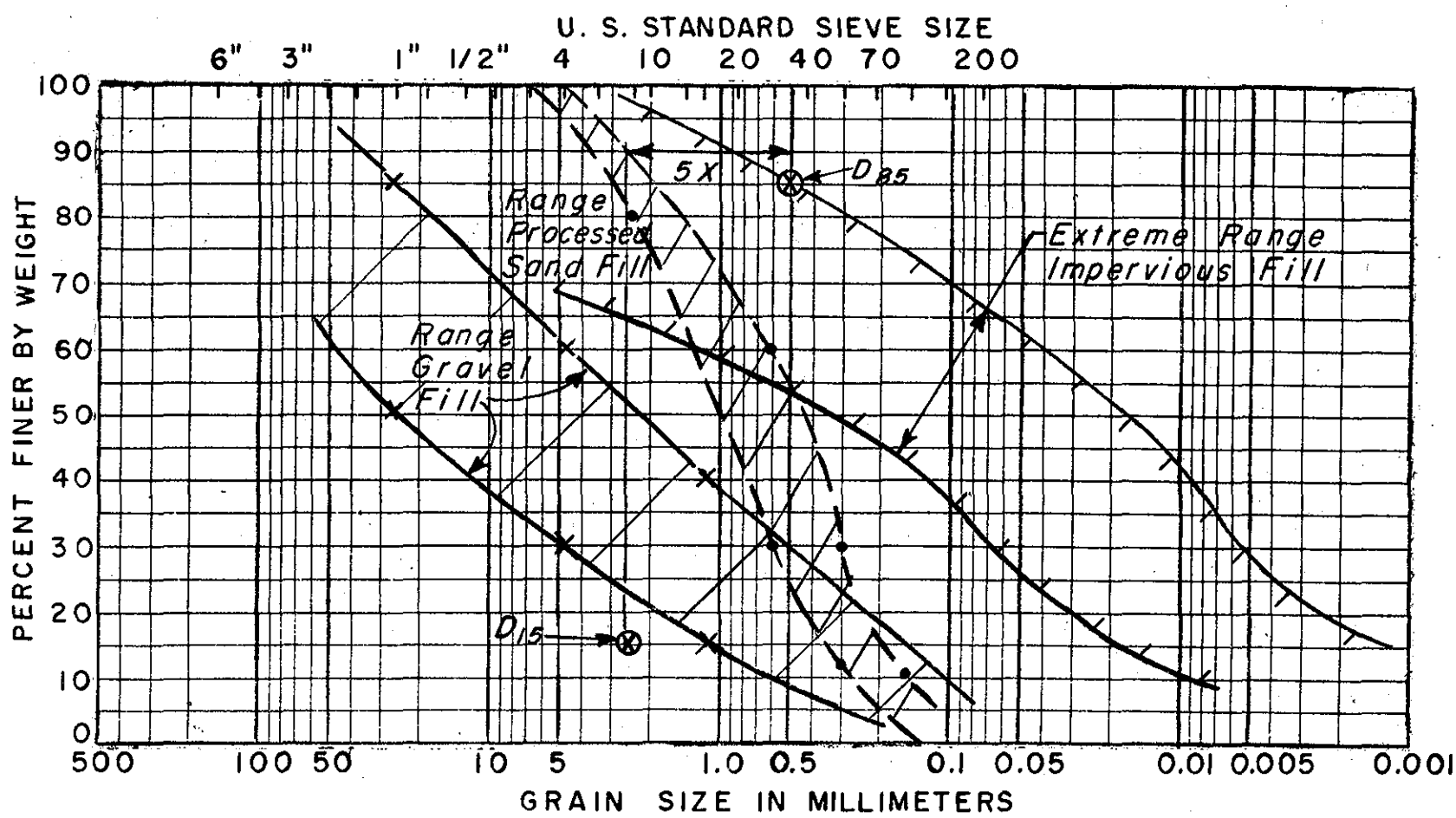
PROCESSED SAND FILL AND SAND FILL

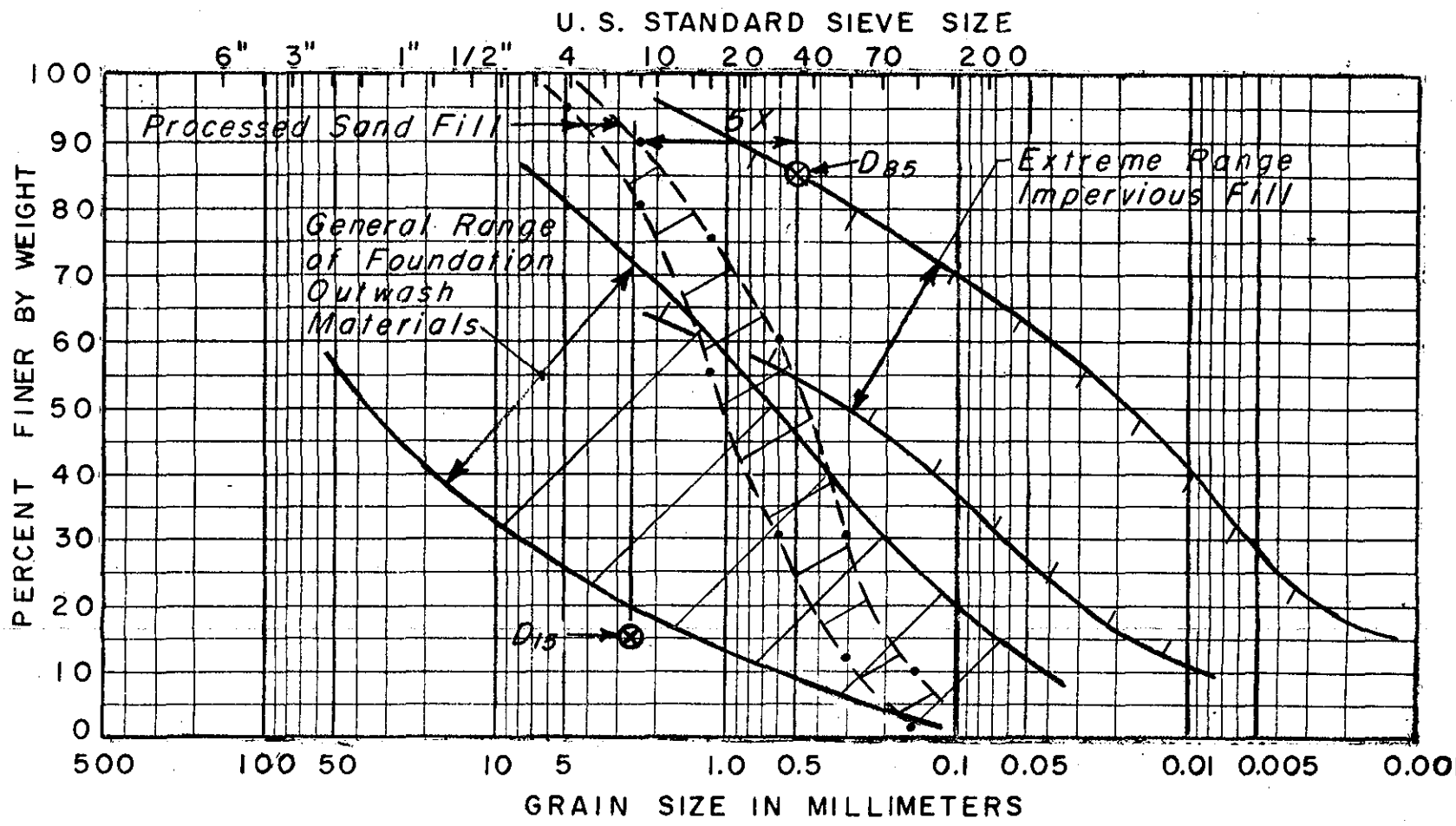
WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN

WHITMANVILLE LAKE

GRADATION SPECIFICATIONS

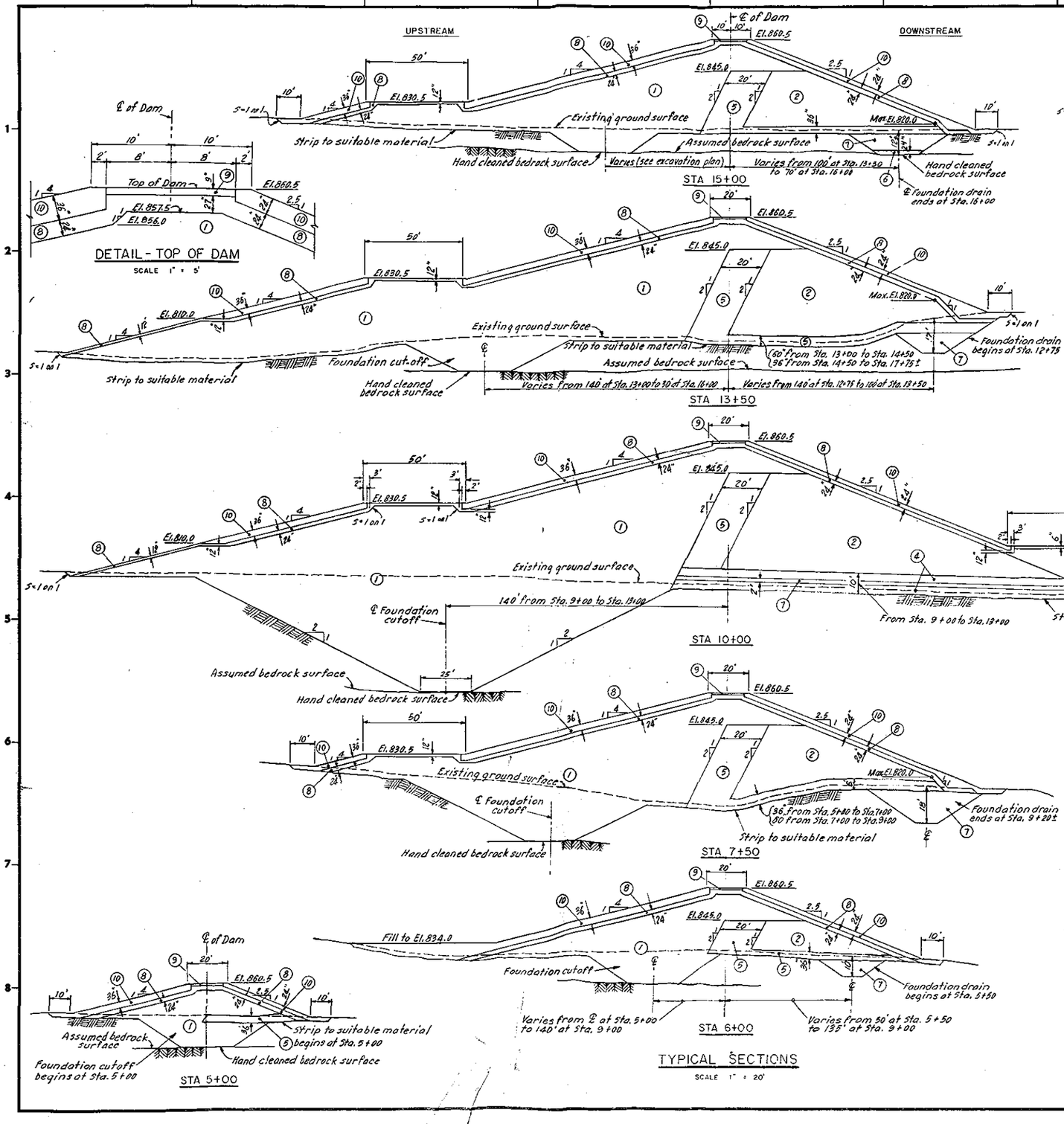
WHITMAN RIVER MASSACHUSETTS





WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
FILTER STUDIES
WHITMAN RIVER MASSACHUSETTS

CORPS OF ENGINEERS U. S ARMY



TYPICAL SECTIONS

SCALE 1" = 20'

FOUNDATION DRAIN DEPTHS			
STATION	DEPTH	STATION	DEPTH
5+50	10'	12+75	2'±
6+00	10'	13+00	5'±
6+50	10'	13+50	17'±
7+00	10'	14+00	12'± (to bedrock)
7+50	18'±	15+00	12'± (to bedrock)
8+00	10'	16+00	8'± (to bedrock)
8+50	10'		
9+00	6'±		
9+20	2'±		

Note: Depths to be measured from the existing ground surface.

LEGEND-MATERIALS	
MATERIAL DESIGNATION	DESCRIPTION
1	Compacted Impervious Fill.
2	Class I Compacted Random Fill.
3	Class II Compacted Random Fill.
4	Compacted Pervious Fill.
5	Compacted Sand Fill.
6	Compacted Gravel Fill.
7	Compacted Processed Sand Fill.
8	Gravel Bedding.
9	Road Gravel.
10	Rock Protection.
11	Compacted Impervious Backfill.
12	Compacted Gravel Backfill.
13	Topsoil
14u	Uncompacted Impervious backfill.

NOTES

1. Foundation cutoff is 25 ft. wide from Sta. 5+00 to Sta. 16+60± and 20 ft. wide from Sta. 16+60± to Spillway Ret. wall.
2. Side slopes of foundation cutoff are 1 on 1.5 from Sta. 5+00 to Sta. 7+00, vary from 1 on 1.5 at Sta. 7+00 to 1 on 2 at 7+50, are 1 on 2 from Sta. 7+50 to Sta. 13+50, vary from 1 on 2 at Sta. 13+50 to 1 on 1.5 at Sta. 14+00 and are 1 on 1.5 from Sta. 14+00 to Spillway Ret. wall.
3. Right abutment foundation drain is 10 ft. wide from Sta. 5+50 to Sta. 9+20±.
4. Left abutment foundation drain is 10 ft. wide from Sta. 12+75 to Sta. 14+00 and 20 ft. wide from Sta. 14+00 to Sta. 16+00.
5. Side slopes of foundation drains are 1 on 1.5.
6. Widths and side slopes of foundation cutoff and foundation drains are measured at right angles to their centerlines.

GRAPHIC SCALES

1" = 5' 5' 0 5' 10'

1" = 20' 20' 0 20' 40'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF BRANCH

WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
TYPICAL EMBANKMENT SECTIONS
WHITMAN RIVER MASSACHUSETTS

APPROVED DATE
CHIEF, ENGINEERING DIVISION

SCALE | SPEC. NO. | DRAWING NUMBER | SHEET

PLATE 8-17

CORPS OF ENGINEERS — U. S. ARMY

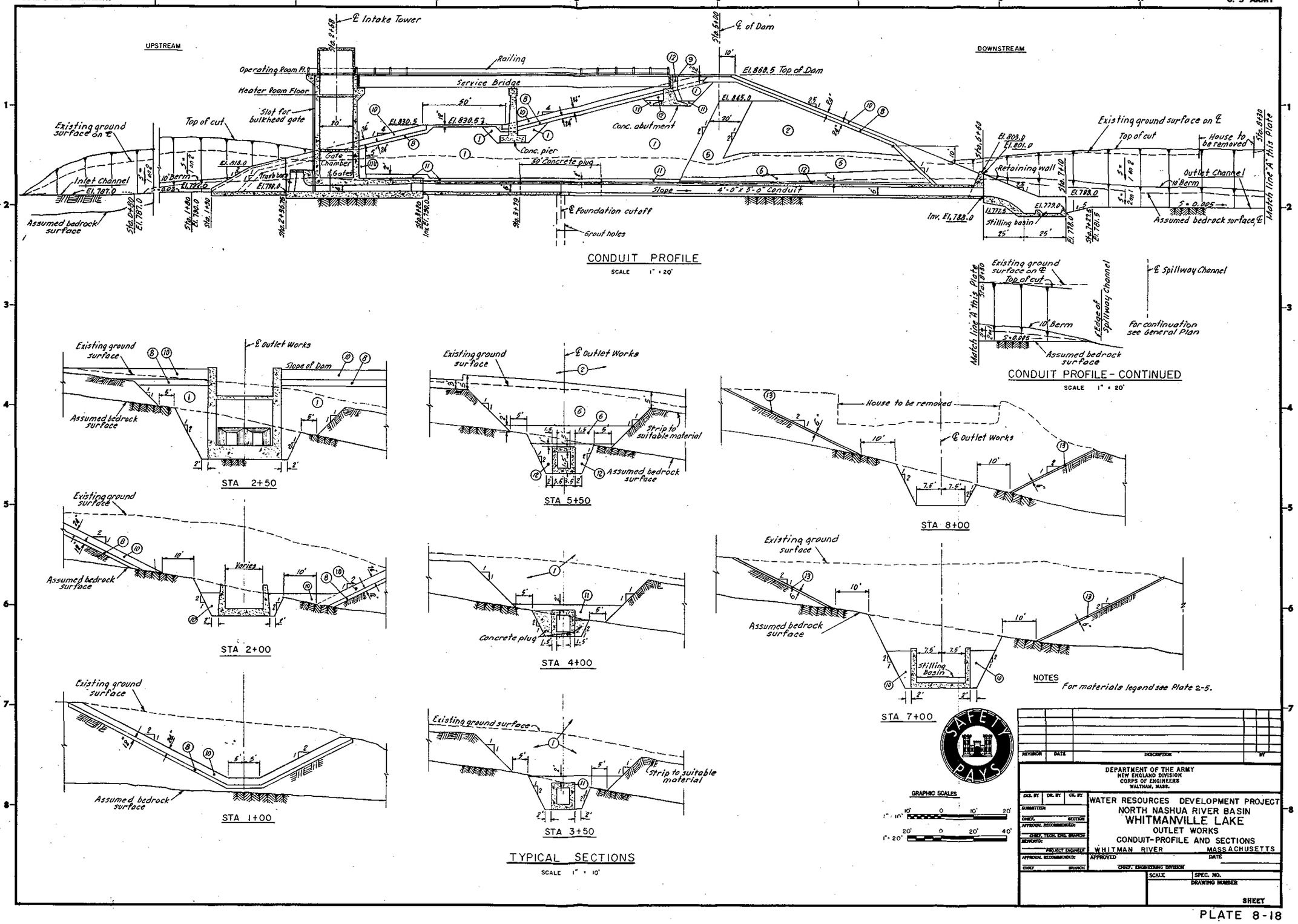
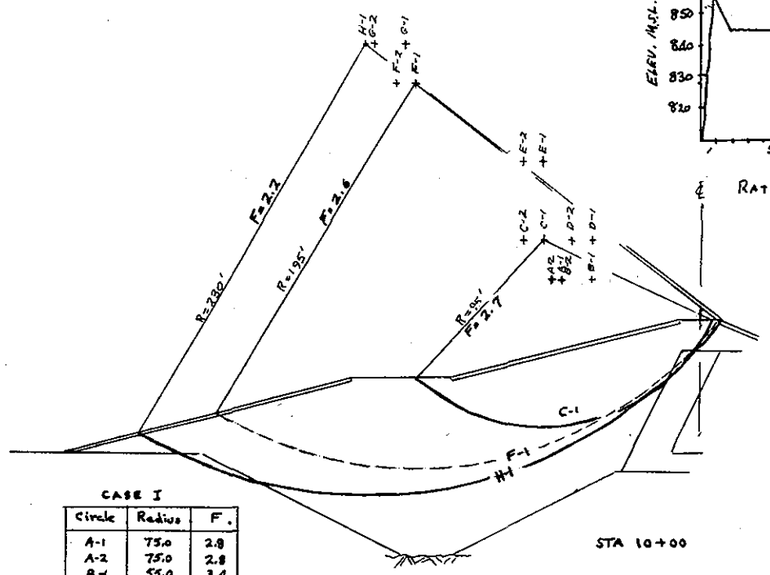


PLATE 8-18

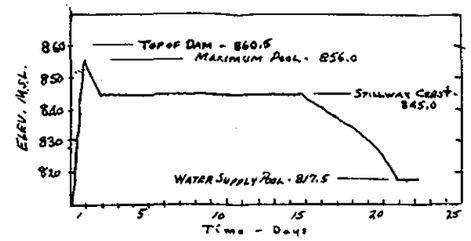


CASE I

Circle	Radius	F.
A-1	75.0	2.8
A-2	75.0	2.8
B-1	55.0	3.4
B-2	55.0	3.6
C-1	95.0	2.7
C-2	95.0	2.8
D-1	75.0	3.2
D-2	75.0	3.2
E-1	120.0	3.0
E-2	120.0	3.1
F-1	195.0	2.6
F-2	195.0	2.6
G-1	215.0	2.5
G-2	215.0	2.6
H-1	230.0	2.2 ← Min.

$F_{CRITERIA}$ = 1.3

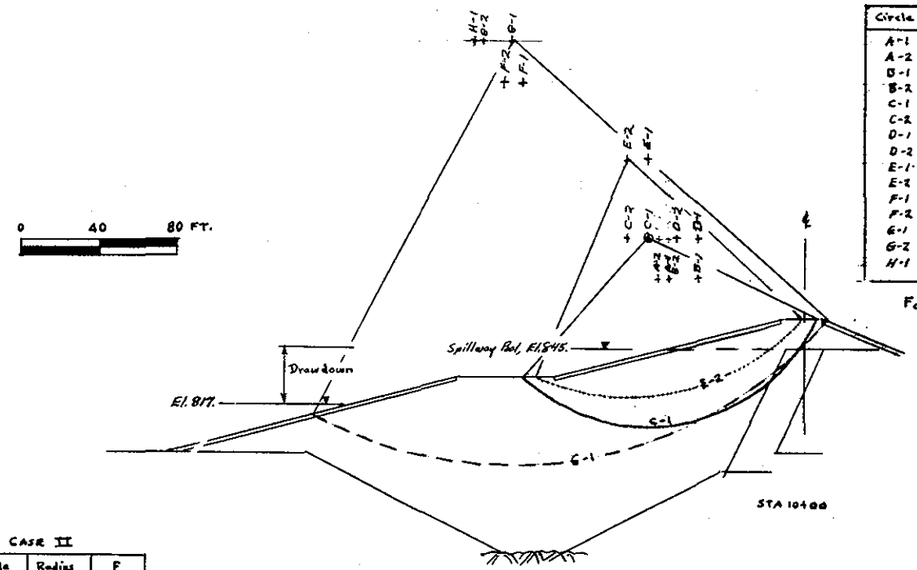
CASE I.
End-of-Construction
Upstream



RATE OF RESERVOIR RISE AND DRAWDOWN

DESIGN UNIT WEIGHTS AND SHEAR STRENGTHS

Material	Unit Weights p.c.f.			Shear Strengths					
				Q		R		S	
	Moist	Saturated	Buoyant	ϕ	c_q	ϕ	c	ϕ	c
Impervious & Random Fills	140.0	143.0	81.0	10.0°	0.5 TSF	14°	0.10 TSF	32.0	0
Rock Slope Protection & Gravel Bedding	120.0	140.0	78.0	-	-	-	-	35.0	0
Pervious Fill	140.0	143.0	81.0	-	-	-	-	35.0	0
Foundation Sands & Gravels	-	140.0	78.0	-	-	-	-	30.0	0
Foundation Silt Layer.	-	120.0	58.0	6.0°	0.25 TSF	13°	0.25 TSF	32.0	0

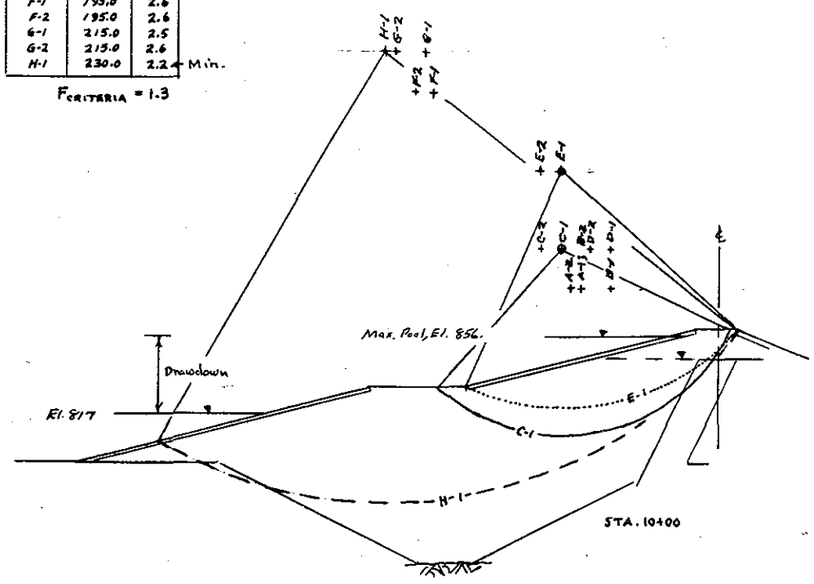


CASE III

Circle	Radius	F
A-1	75.0	1.3
A-2	75.0	1.2
B-1	55.0	1.5
B-2	55.0	1.4
C-1	95.0	1.2 ← Min.
C-2	95.0	1.2
D-1	75.0	1.4
D-2	75.0	1.3
E-1	120.0	1.2
E-2	120.0	1.2
F-1	195.0	1.2
F-2	195.0	1.2
G-1	215.0	1.2
G-2	215.0	1.2
H-1	230.0	1.3

$F_{CRITERIA}$ = 1.2

0 40 80 FT.



CASE II
Sudden Drawdown from
Maximum Pool, El. 856

CASE II

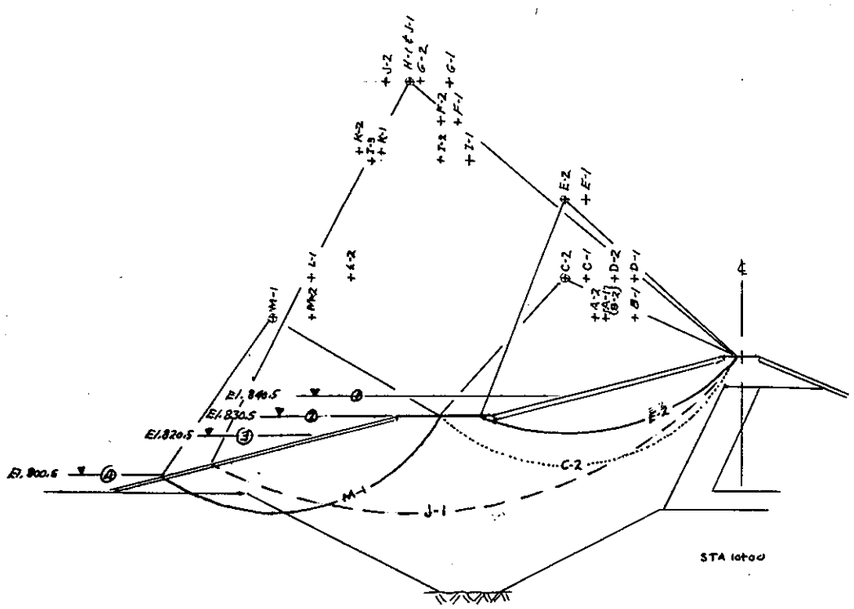
Circle	Radius	F
A-1	75.0	1.2
A-2	75.0	1.2
B-1	55.0	1.3
B-2	55.0	1.3
C-1	95.0	1.1 ← Min.
C-2	95.0	1.2
D-1	75.0	1.2
D-2	75.0	1.2
E-1	120.0	1.1
E-2	120.0	1.2
F-1	195.0	1.2
F-2	195.0	1.2
G-1	215.0	1.2
G-2	215.0	1.2
H-1	230.0	1.2

$F_{CRITERIA}$ = 1.0

CASE III
Sudden Drawdown from
Spillway Pool, El. 845

WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
SUMMARY OF STABILITY ANALYSES (CIRCLES)
NO. 1
WHITMAN RIVER MASSACHUSETTS

PLATE 8-19

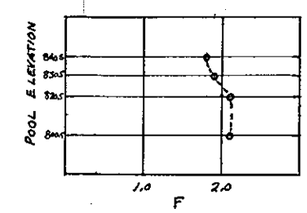


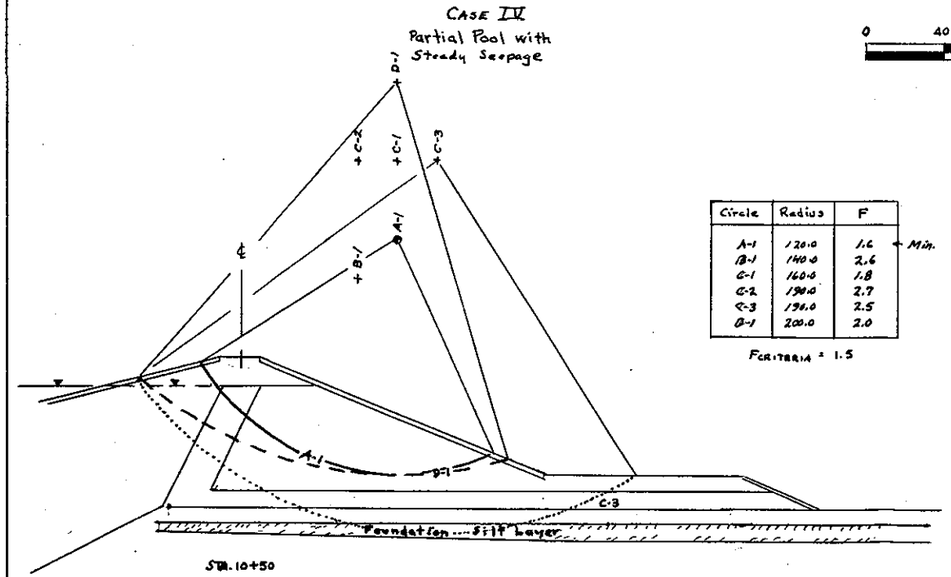
CASE IV
Partial Pool with
Steady Seepage

Circle	Radius	F Pool 1	F Pool 2	F Pool 3	F Pool 4
A-1	75.0	2.0	2.0	-	-
A-2	75.0	1.9	2.0	-	-
B-1	55.0	2.0	2.3	-	-
B-2	55.0	1.9	2.2	-	-
C-1	95.0	1.9	1.9	-	-
C-2	95.0	1.9	1.9 *	-	-
D-1	75.0	2.0	2.3	-	-
D-2	75.0	1.8	2.1	-	-
E-1	120.0	1.8	2.0	-	-
E-2	120.0	1.8 *	1.9	-	-
F-1	195.0	2.4	2.2	-	-
F-2	195.0	2.4	2.2	-	-
G-1	215.0	2.4	2.2	-	-
G-2	215.0	2.4	2.2	-	-
H-1	230.0	2.4	2.2	-	-
I-1	180.0	-	-	2.2	2.6
I-2	180.0	-	-	2.2	2.6
I-3	180.0	-	-	2.4	2.6
J-1	220.0	-	-	2.1 *	2.4
J-2	220.0	-	-	2.2	2.4
K-1	220.0	-	-	2.4	2.4
K-2	220.0	-	-	2.4	2.4
L-1	120.0	-	-	2.5	2.5
L-2	120.0	-	-	2.7	2.9
M-1	100.0	-	-	2.3	2.1 *
M-2	100.0	-	-	2.5	2.5

* Minimum F

$F_{CRITERIA} = 1.5$

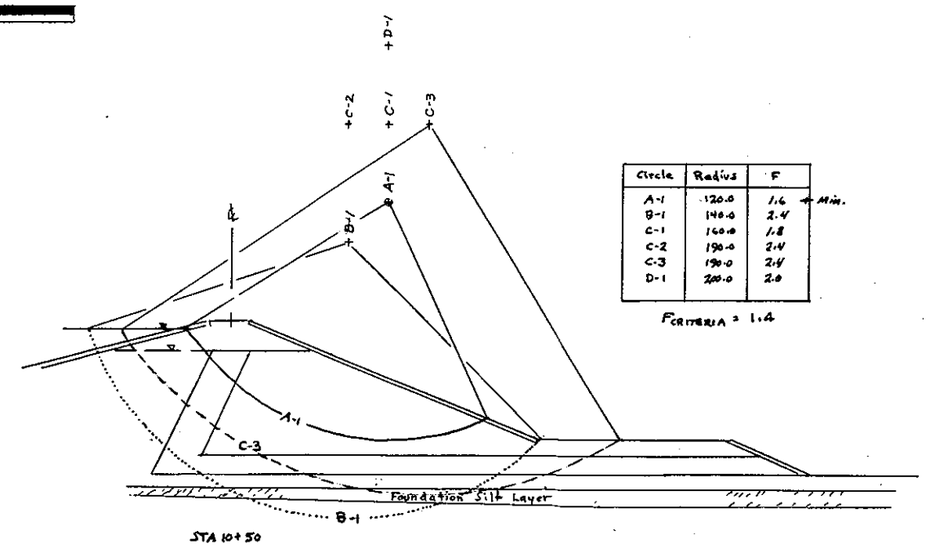




Circle	Radius	F
A-1	120.0	1.6 ← Min.
B-1	140.0	2.6
C-1	160.0	1.8
C-2	190.0	2.7
C-3	190.0	2.5
D-1	200.0	2.0

$F_{CRITERIA} = 1.5$

CASE V
Steady Seepage with Maximum
Storage Pool (El. 845.0)
Spillway Crest



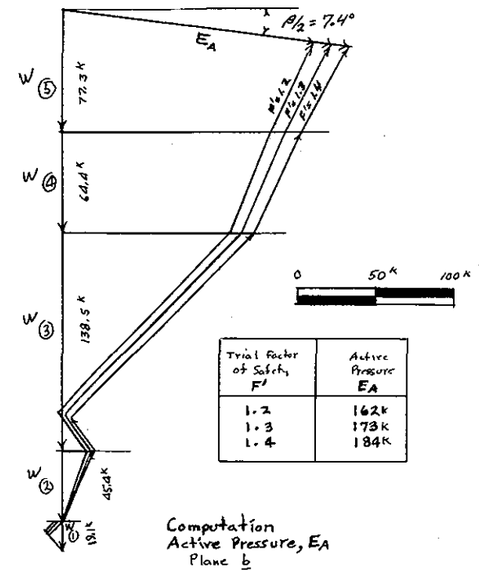
Circle	Radius	F
A-1	120.0	1.6 ← Min.
B-1	140.0	2.4
C-1	160.0	1.8
C-2	190.0	2.4
C-3	190.0	2.4
D-1	200.0	2.0

$F_{CRITERIA} = 1.4$

CASE VI
Steady Seepage with
Surcharge Pool (El. 850.0)

WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
SUMMARY OF STABILITY ANALYSES (CIRCLES)
NO. 2
WHITMAN RIVER MASSACHUSETTS

PLATE 8-20



Trial Factor of Safety F'	Active Pressure E_A
1.2	162 K
1.3	173 K
1.4	184 K

Computation
Active Pressure, E_A
Plane b

Computation Passive Resistance
at Toe of Berm
E_p

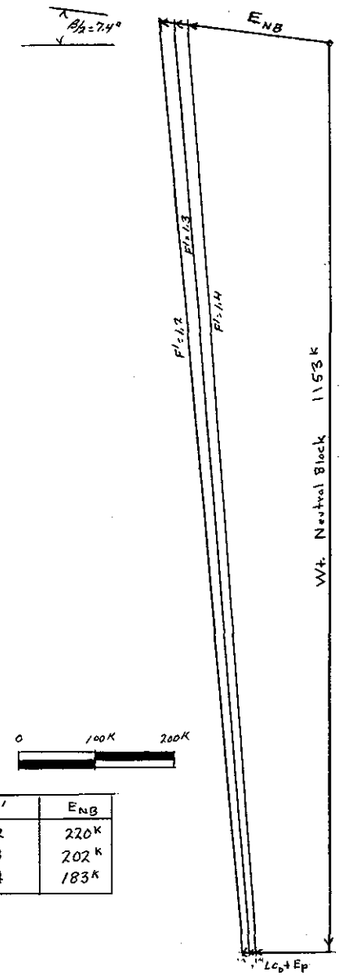
$E_p = \frac{1}{2}\gamma z^2 k_p = \frac{1}{2}(.078)\,9^2(k_p) = 3.16\,k_p$

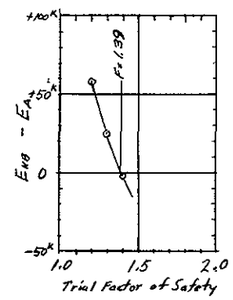
$k_p = \tan^2(45° + \phi_D/2)$

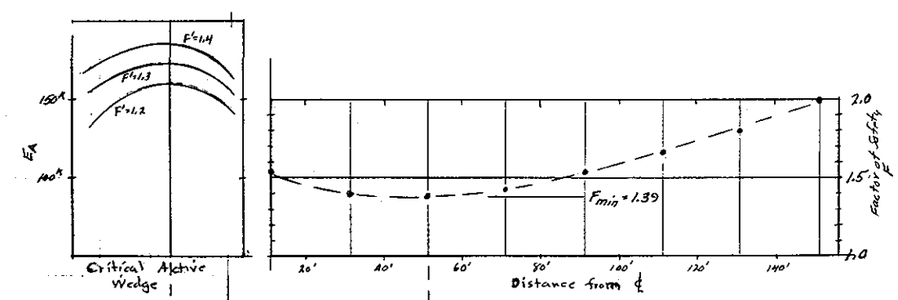
$\phi = 30°$

$\tan\phi_D = \tan 30°/F'$

F'	ϕ_D	k_p	E_p
1.2	25.8°	2.53	8.0 K
1.3	24.0°	2.37	7.4 K
1.4	22.4°	2.22	7.0 K

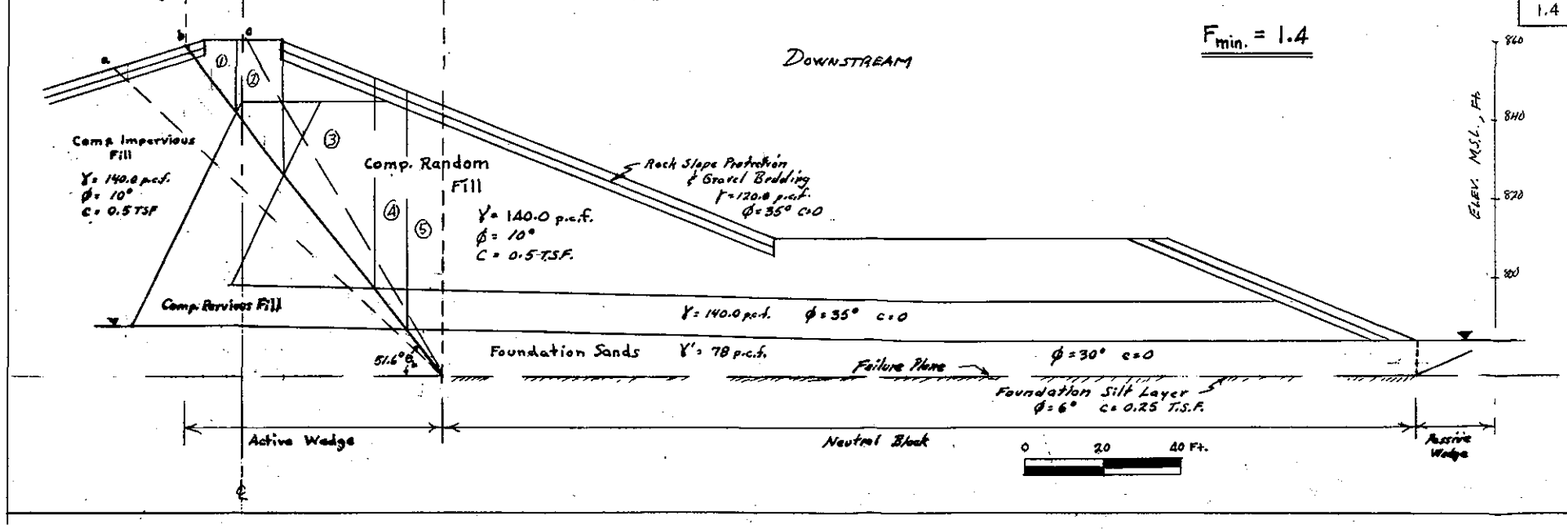






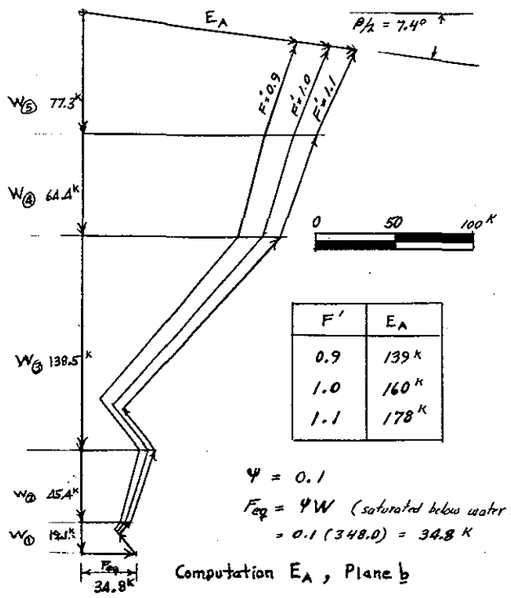
F'	E_{NB}
1.2	220 K
1.3	202 K
1.4	183 K

$F_{min.} = 1.4$



WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
SUMMARY & TYPICAL STABILITY ANALYSIS (WEDGE)
CASE I
END OF CONSTRUCTION
DOWNSTREAM
WHITMAN RIVER MASSACHUSETTS

PLATE 8-21



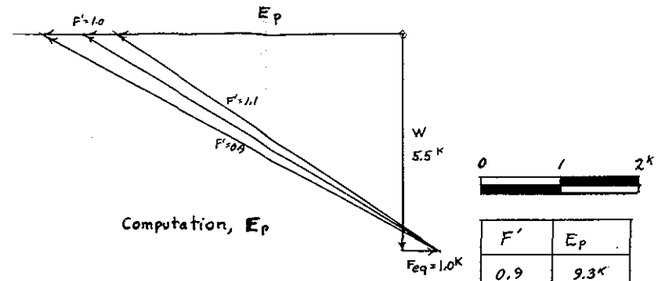
F'	E_A
0.9	139^K
1.0	160^K
1.1	178^K

$\psi = 0.1$

$F_{eq} = \psi W$ (saturated below water table)

$= 0.1\,(348.0) = 34.8^K$

Computation E_A, Plane b



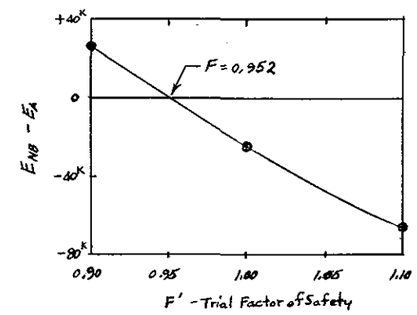
Computation, E_P

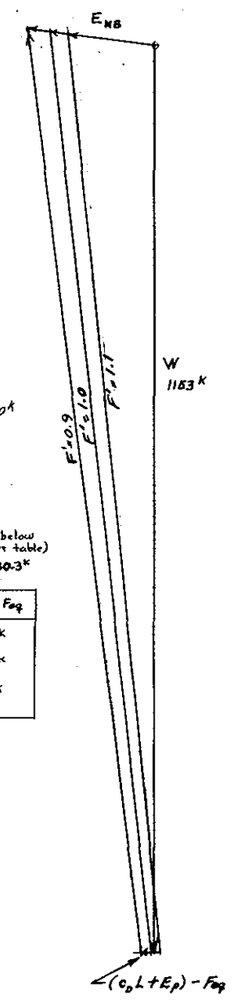
F'	E_P
0.9	9.3^K
1.0	8.2^K
1.1	7.4^K

$\psi = 0.1$

$F_{eq} = \psi W$ (sat. unit wt.)

$F_{eq} = (0.1)(10.0) = 1.0^K$





F'	E_{NB}
0.9	165^K
1.0	135^K
1.1	112^K

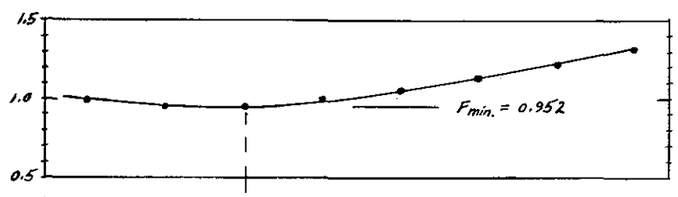
$\psi = 0.1$

$F_{eq} = \psi W$ (sat. below water table)

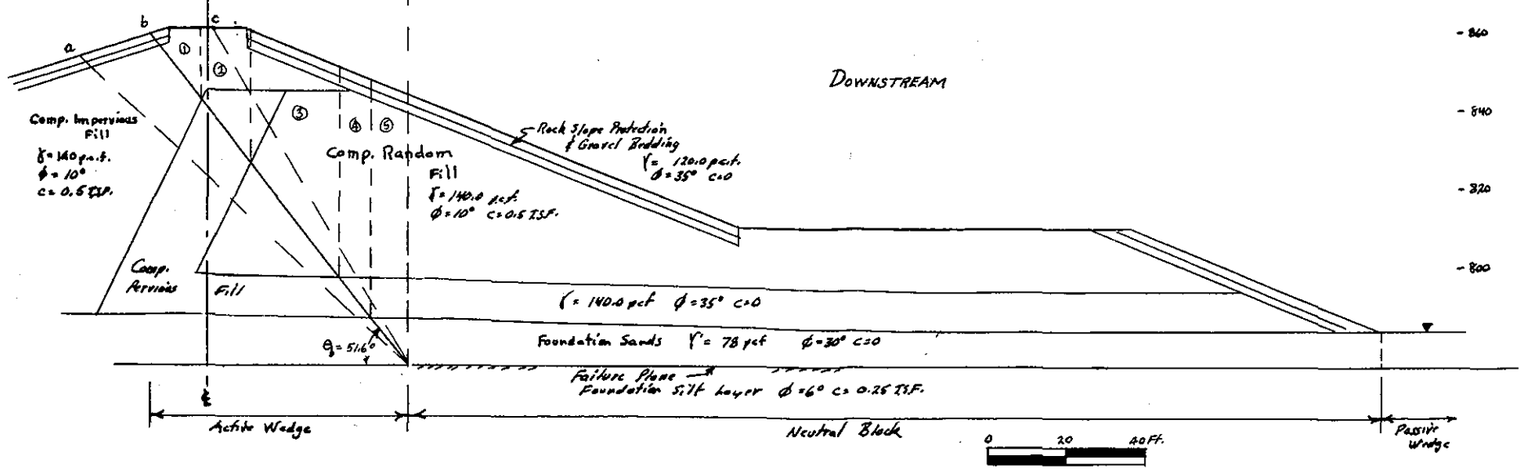
$F_{eq} = (0.1)(1303) = 130.3^K$

F'	$c_D L$	E_P	$(c_D L + E_P) - F_{eq}$
0.9	139.4^K	9.3^K	+ 18.0^K
1.0	125.2^K	8.2^K	+ 3.1^K
1.1	113.9^K	7.4^K	- 9.0^K

Computation, E_{NB}



$F_{min.} = 1.0$



WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
SUMMARY & TYPICAL STABILITY ANALYSIS (WEDGE)
CASE VII
EARTHQUAKE
WHITMAN RIVER MASSACHUSETTS

DESIGN SHEAR STRENGTHS & UNIT WEIGHTS

Material	Ø Degrees	c k.s.f.	Unit Wt p.c.f.	Scale Factor
Impervious Fill	10	1.0		
Moist			140	1.40
Bouyant			81	0.81
Rock Slope Protection & Gravel Bedding	35	0		
Moist			120	1.20
Foundation Soils	30	0		
Bouyant			78	0.78

COMPUTATIONS

Tangential Force — 1 sq. in. = 40 Kips

$A_T = 9.45 - 2.57 = 6.88$ sq. in.

$T = 6.88 \times 40 = \underline{\underline{275 \text{ Kips}}}$

Resisting Forces

$A_{N1} = 0.04$ sq. in — $N1 = 40 \times 0.04 = 1.6$ K. — $N1 \tan 35° = \underline{1.1 K}$

$A_{N2} = 0.53$ sq. in. — $N2 = 40 \times 0.53 = 21.2$ K — $N2 \tan 10° = \underline{3.7 K}$

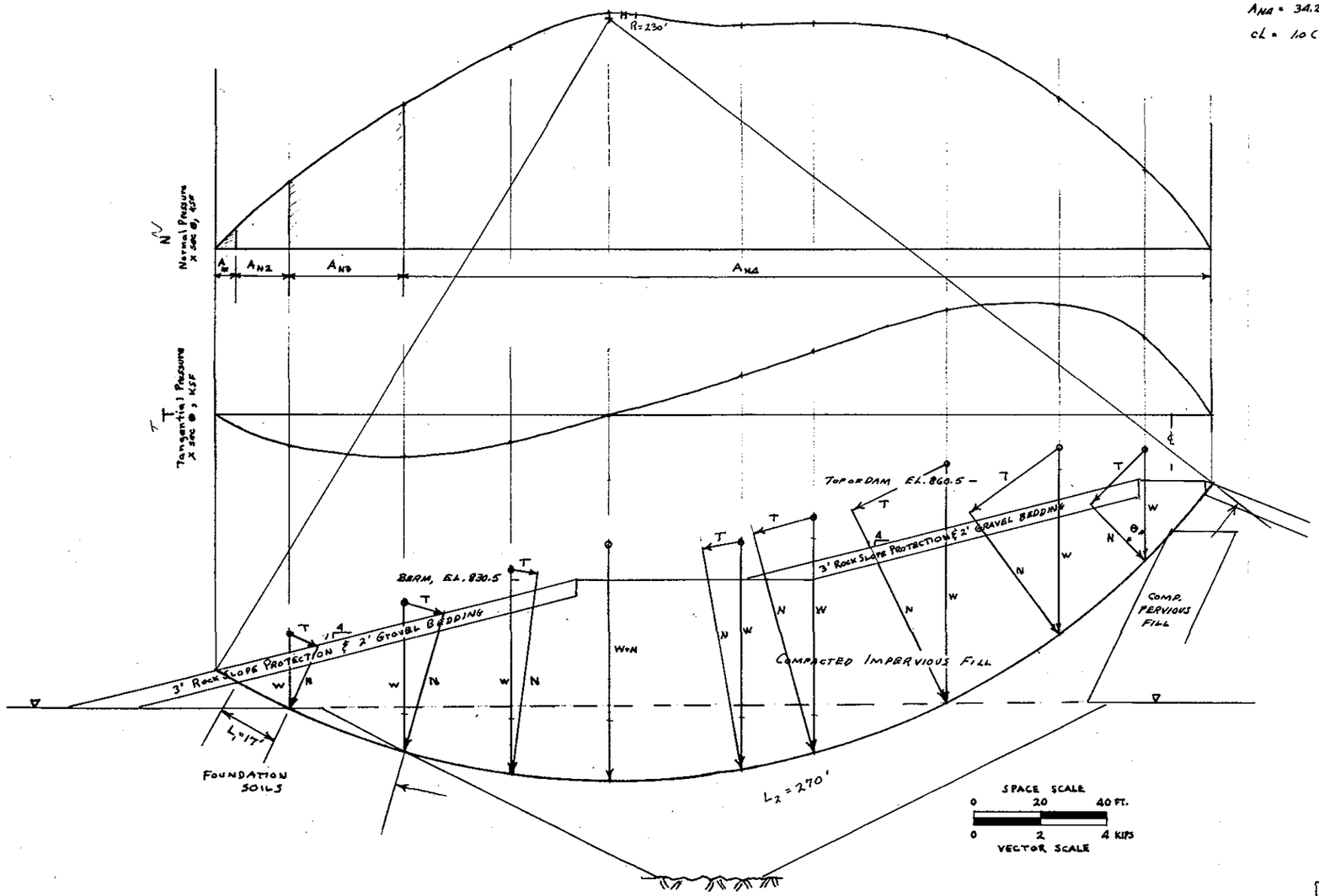
$A_{N3} = 2.85$ sq. in. — $N3 = 40 \times 2.85 = 114.0$ K — $N3 \tan 30° = \underline{66.0 K}$

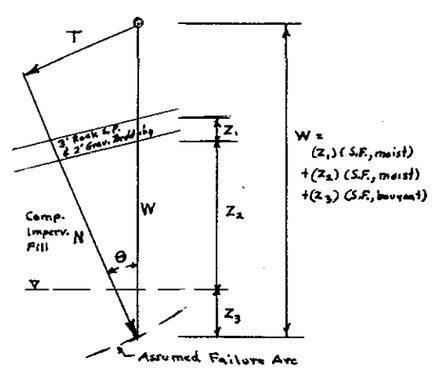
$A_{N4} = 34.22$ sq. in — $N4 = 40 \times 34.22 = 1369.0$ K — $N4 \tan 10° = \underline{241.0 K}$

$cL = 1.0\,(17 + 270) = \underline{287.0 K}$

$$F = \frac{1.1 + 3.7 + 66.0 + 241.0 + 287.0}{275} = \frac{599}{275} = 2.18$$

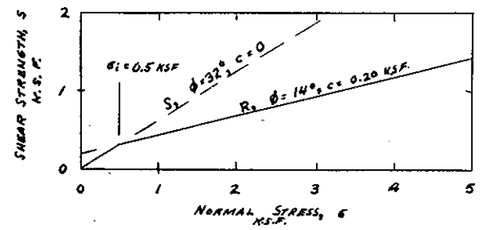
$$\underline{\underline{F = 2.2}}$$





TYPICAL VECTOR DIAGRAM
(Not to Scale)

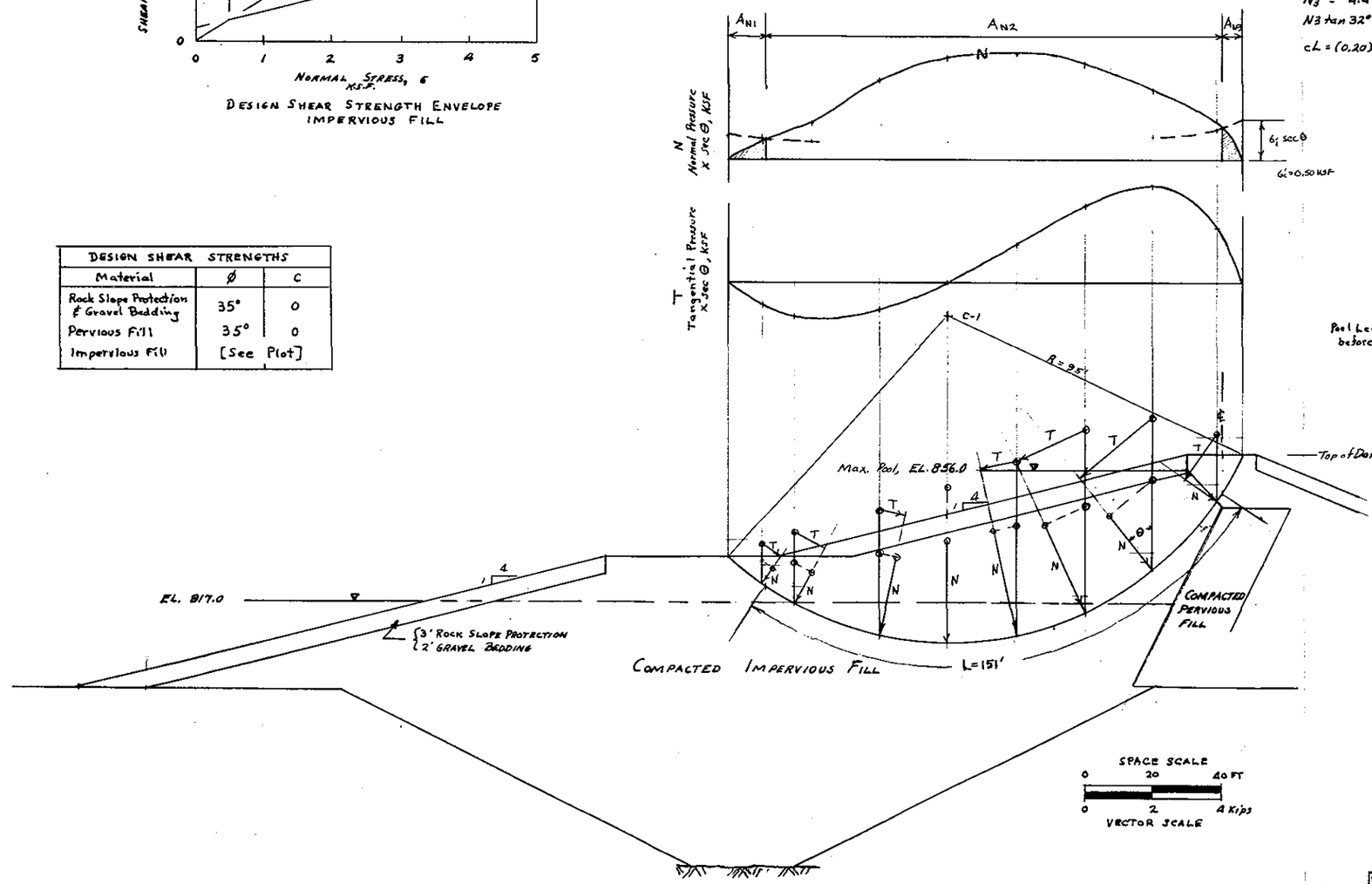
WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
TYPICAL STABILITY ANALYSIS (CIRCLE)
CASE I
END OF CONSTRUCTION (U/S)
WHITMAN RIVER — MASSACHUSETTS



DESIGN SHEAR STRENGTH ENVELOPE
IMPERVIOUS FILL

VECTOR SCALE FACTORS		
Material	Unit Weight p.c.f.	Scale Factor
Impervious Fill		
Moist	140	1.40
Saturated	143	1.43
Bouyant	81	0.81
Rock Slope Protection & Gravel Bedding		
Moist	120	1.20
Saturated	140	1.40
Bouyant	78	0.78

DESIGN SHEAR STRENGTHS		
Material	φ	c
Rock Slope Protection & Gravel Bedding	35°	0
Pervious Fill	35°	0
Impervious Fill	[See Plot]	



COMPUTATIONS

1 sq. in. = 40 Kips

Tangential Force

$A_T = 3.64 - 1.17 = 2.47$ sq. in.

$T = 2.47 \times 40 = \underline{98.8 \text{ Kips}}$

Resisting Forces

$A_{N1} = 0.17$ sq. in.
$N1 = 6.8$ Kips
$N1 \tan 32° = \underline{4.2 \text{ Kips}}$

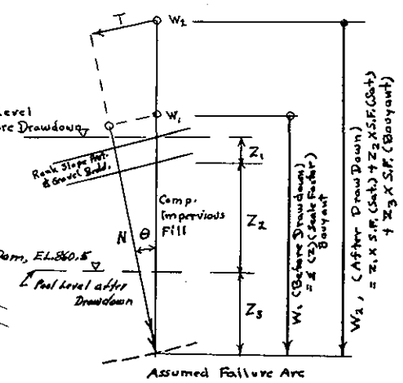
$A_{N2} = 7.39$ sq. in.
$N2 = 295.6$ Kips
$N2 \tan 14° = \underline{73.6 \text{ Kips}}$

$A_{N3} = 0.11$ sq. in.
$N3 = 4.4$ Kips
$N3 \tan 32° = \underline{2.8 \text{ Kips}}$

$cL = (0.20)(151) = \underline{30.2 \text{ Kips}}$

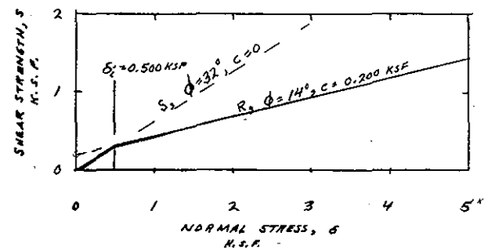
$$F = \frac{4.2 + 73.6 + 2.8 + 30.2}{98.8} = \frac{110.8}{98.8} = 1.12$$

F = 1.1



TYPICAL VECTOR DIAGRAM
(Not to Scale)

WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
TYPICAL STABILITY ANALYSIS (CIRCLE)
CASE II
SUDDEN DRAWDOWN FROM MAXIMUM POOL
WHITMAN RIVER MASSACHUSETTS



DESIGN SHEAR STRENGTH ENVELOPE
IMPERVIOUS FILL

DESIGN SHEAR STRENGTHS		
Material	ϕ	c
Rock Slope Protection & Gravel Bedding	35°	0
Pervious Fill	35°	0
Impervious Fill	[See	Plot]

VECTOR SCALE FACTORS		
Material	Unit Weight p.c.f.	Scale Factor
Impervious Fill		
Moist	140	1.40
Saturated	143	1.43
Bouyant	81	0.81
Rock Slope Protection & Gravel Bedding		
Moist	120	1.20
Saturated	140	1.40
Bouyant	78	0.78

COMPUTATIONS

1 sq. in. = 40 Kips

Tangential Force

A_T = 3.55 − 1.05 = 2.50 sq. in.

T = 2.50 X 40 = 100.0 Kips

Resisting Forces

A_{N1} = 0.07 sq. in.

N_1 = 2.8 Kips

N_1 tan 32° = 1.8 Kips

A_{N2} = 8.35 sq. in.

N2 = 334. Kips

N2 tan 14° = 83.4 Kips

A_{N3} = 0.08 sq. in.

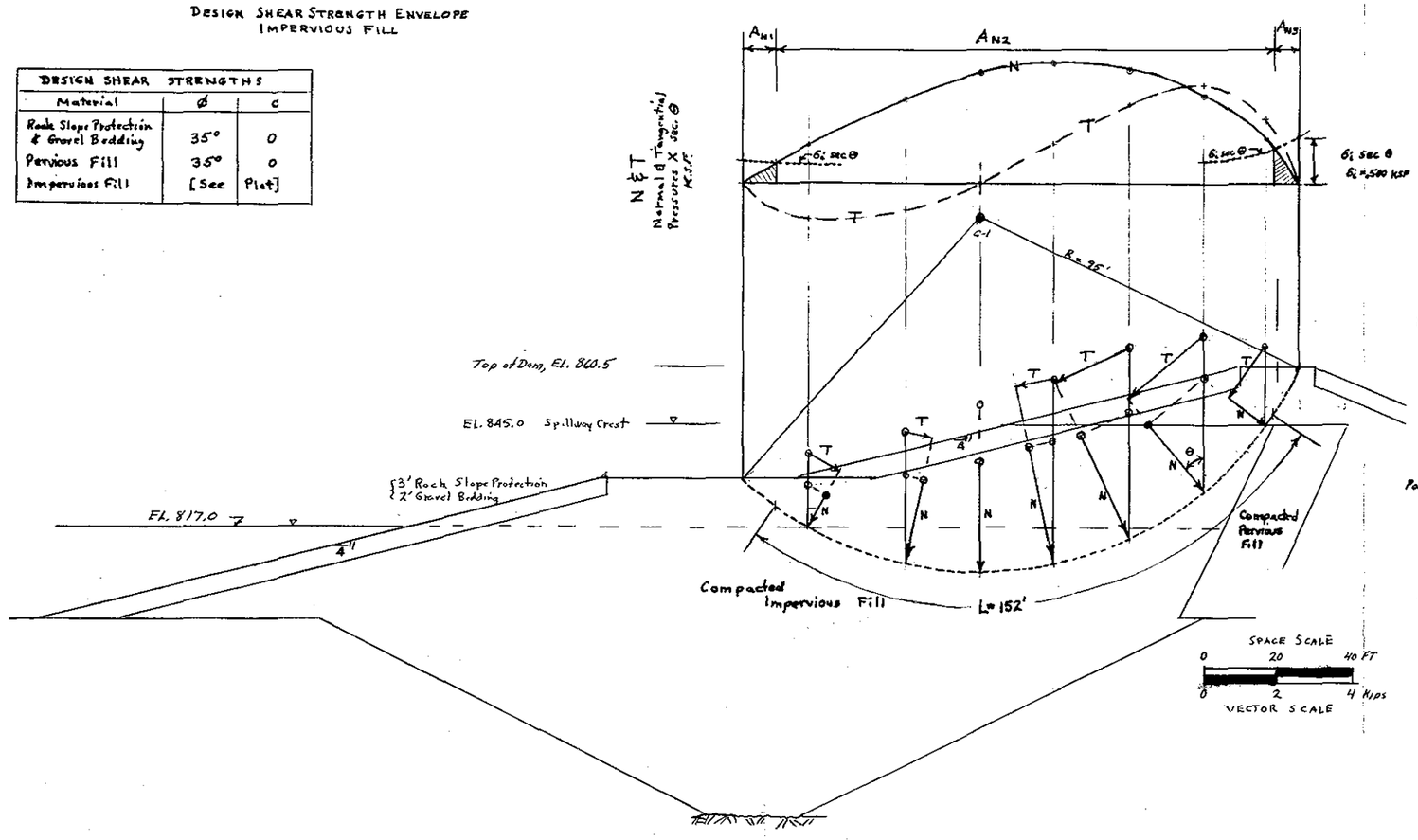
N_3 = 3.2 Kips

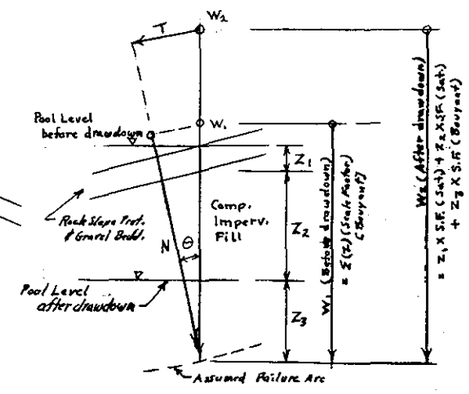
N_3 tan 32° = 2.0 Kips

cL = (0.200)(152) = 30.4 Kips

$$F = \frac{1.8 + 83.4 + 2.0 + 30.4}{100.0} = \frac{117.6}{100.0} = 1.18$$

F = 1.2

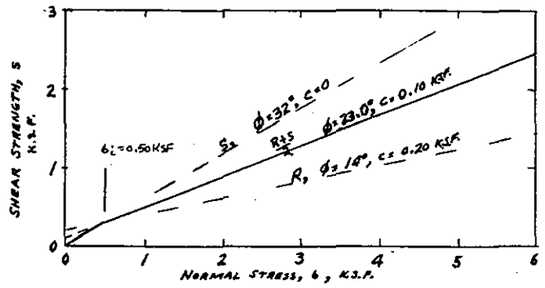




TYPICAL VECTOR DIAGRAM
(Not to Scale)

WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
TYPICAL STABILITY ANALYSIS (CIRCLE)
CASE III
SUDDEN DRAWDOWN FROM SPILLWAY CREST
WHITMAN RIVER MASSACHUSETTS

PLATE 8-25



DESIGN SHEAR STRENGTH ENVELOPE
IMPERVIOUS FILL

DESIGN SHEAR STRENGTHS & UNIT WEIGHTS

Material	φ Degrees	c K.S.F.	Unit Wt. p.c.f.	Scale Factor
Impervious Fill	[See Plot]			
Moist			140	1.40
Bouyant			81	0.81
Rock Slope Protection & Gravel Bedding	35	0		
Moist			120	1.20
Bouyant			78	0.78
Foundation Soils	30	0		
Bouyant			78	0.78

COMPUTATIONS

Tangential Force — 1 sq.in. = 40 kips

$A_T = 1.54 - 0.20 = 1.34$ sq.in.

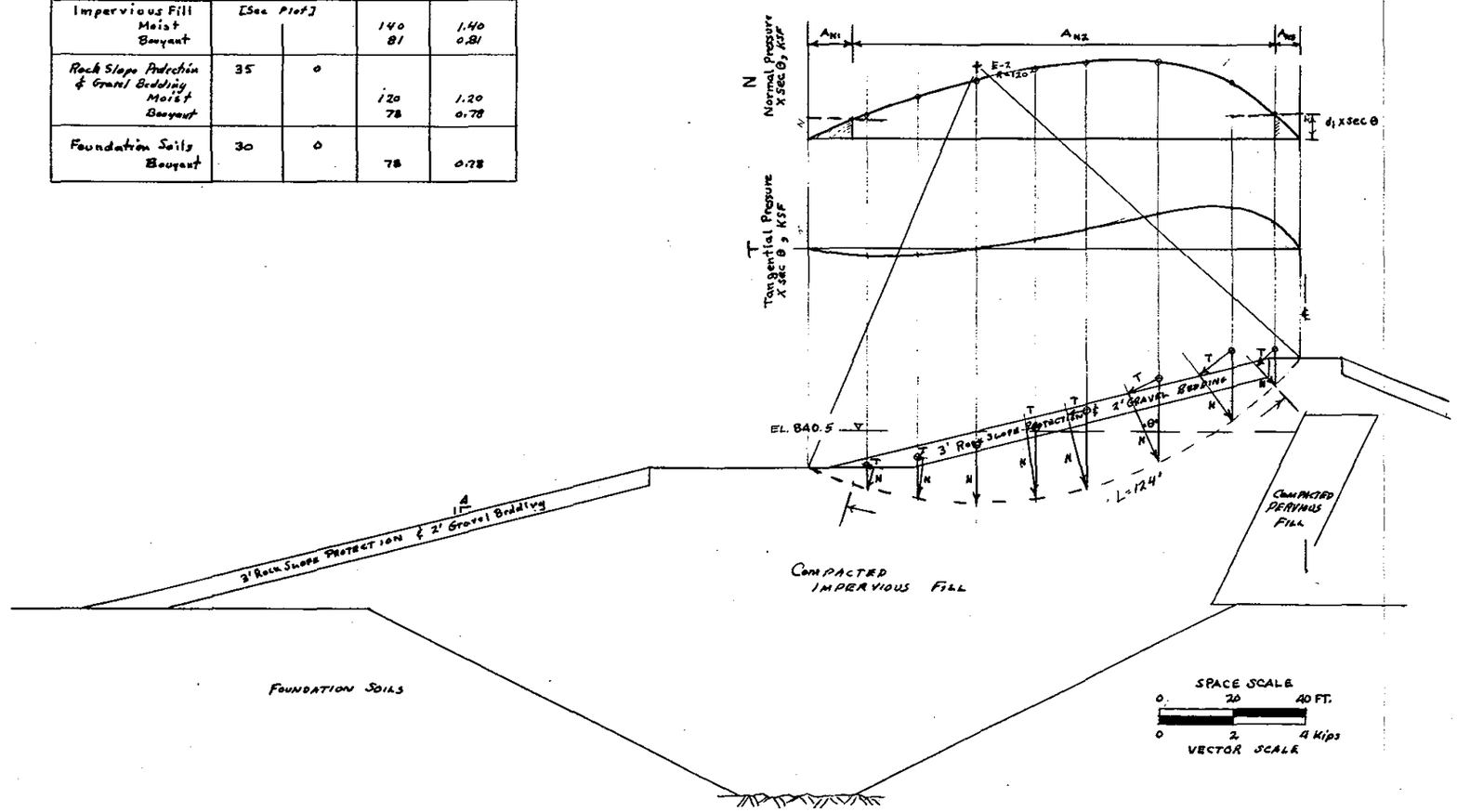
$T = 1.34 \times 40 = 53.6$ Kips

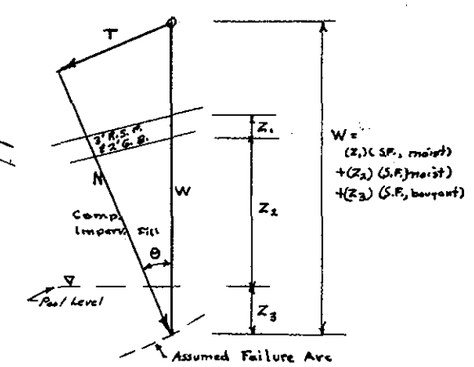
Resisting Forces

$A_{N1} = 0.07$ sq.in	$N1 = 2.8$ Kips	$N1 \tan 32° = 1.8K$
$A_{N2} = 4.78$ sq.in	$N2 = 191.$ Kips	$N2 \tan 23° = 81.0K$
$A_{N3} = 0.06$ sq.in	$N3 = 2.4$ Kips	$N3 \tan 32° = 1.5K$
$cL = (0.10)(124) =$		$12.4K$

$$F = \frac{1.8 + 81.0 + 1.5 + 12.4}{53.6} = \frac{96.7}{53.6} = 1.80$$

F = 1.8

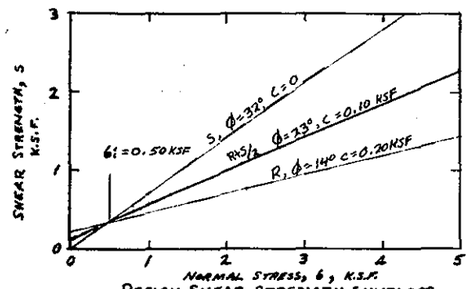




TYPICAL VECTOR DIAGRAM
(Not to Scale)

WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
TYPICAL STABILITY ANALYSIS (CIRCLE)
CASE IV
PARTIAL POOL WITH STEADY SEEPAGE
WHITMAN RIVER MASSACHUSETTS

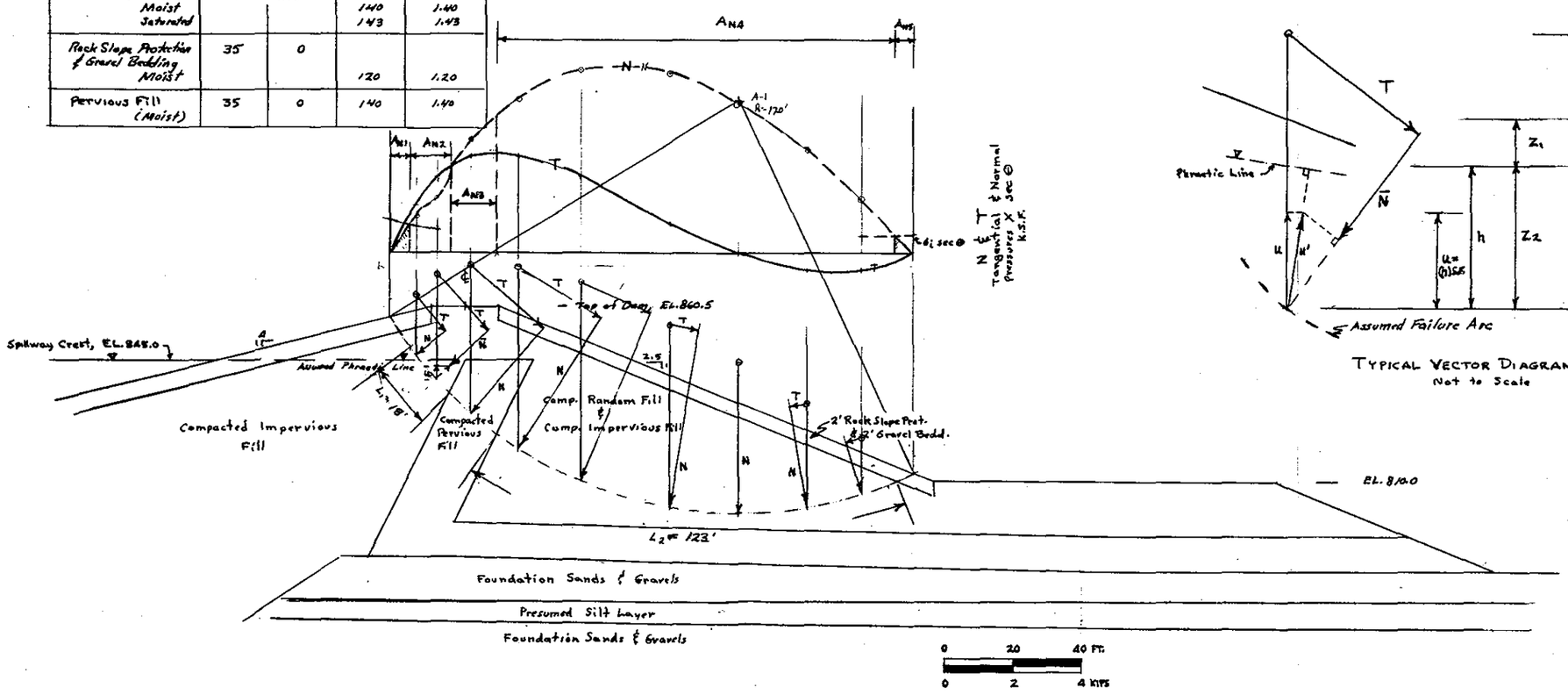
PLATE 8-26



DESIGN SHEAR STRENGTH ENVELOPE
Random & Impervious Fills

DESIGN SHEAR STRENGTHS & UNIT WEIGHTS

Material	φ Degrees	c K.S.F.	Unit Wt. p.c.f.	Scale Factor
Impervious & Random Fills	[See Plot]			
Moist			140	1.40
Saturated			143	1.43
Rock Slope Protection & Gravel Bedding, Moist	35	0	120	1.20
Pervious Fill (Moist)	35	0	140	1.40



COMPUTATIONS

Tangential Force

$A_T = 4.42 - 0.45 = 3.97$ sq.in.

$T = 3.97 \times 40 = 159.0$ Kips

1 sq. in. = 40 Kips

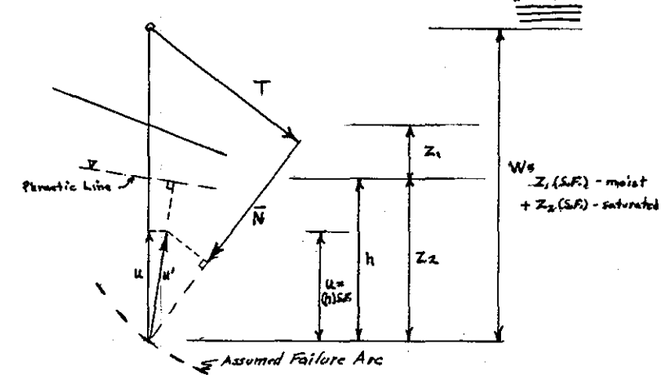
Resisting Forces

$A_{N1} = 0.05$ sq.in	$N1 = 2.0$ Kips	$N1 \tan 32° = 1.2K$
$A_{N2} = 0.44$ sq.in.	$N2 = 18.0$ Kips	$N2 \tan 23° = 7.6K$
$A_{N3} = 1.12$ sq.in	$N3 = 44.8$ Kips	$N3 \tan 35° = 31.4K$
$A_{N4} = 11.90$ sq.in.	$N4 = 476$ Kips	$N4 \tan 23° = 202.0K$
$A_{N5} = 0.02$ sq.in.	$N5 = 0.8$ Kips	$N5 \tan 35° = 0.6K$

$cL = (123 + 1/8)(0.10) = 14.1K$

$$F = \frac{1.2 + 7.6 + 31.4 + 202.0 + 0.6 + 14.1}{159.0} = \frac{256.9}{159.0} = 1.62$$

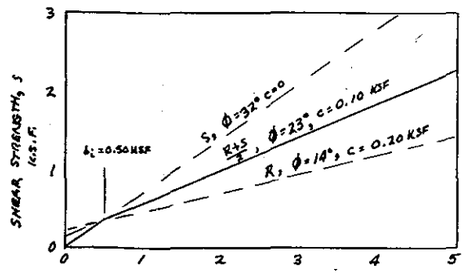
F = 1.6



TYPICAL VECTOR DIAGRAM
Not to Scale

WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
TYPICAL STABILITY ANALYSIS (CIRCLE)
CASE V
STEADY SEEPAGE WITH MAXIMUM STORAGE POOL
WHITMAN RIVER MASSACHUSETTS

PLATE 8-27



DESIGN SHEAR STRENGTH ENVELOPE
Random & Impervious Fills

DESIGN SHEAR STRENGTHS & UNIT WEIGHTS

Material	φ Degrees	c K.S.F.	Unit Wt p.c.f.	Scale Factor
Impervious & Random Fills	[See Plot]			
Moist			140	1.40
Saturated			143	1.43
Rock Slope Protection & Gravel Bedding	35	0		
Moist			120	1.20
Saturated			140	1.40
Pervious Fill	35	0		
Moist			140	1.40

COMPUTATIONS

Tangential Force

$A_T = 4.45 - 0.45 = 4.00$ sq. in.

$T = 4.00 \times 40 = 160.0$ Kips

1 sq. in. = 40 Kips

Resisting Forces

$A_{N1} = 0.05$ sq. in. $N1 = 2.0$ K $N1 \tan 32° = 1.2$ K

$A_{N2} = 0.44$ sq. in. $N2 = 18.0$ K $N2 \tan 23° = 7.6$ K

$A_{N3} = 1.12$ sq. in. $N3 = 44.8$ K $N3 \tan 35° = 31.4$ K

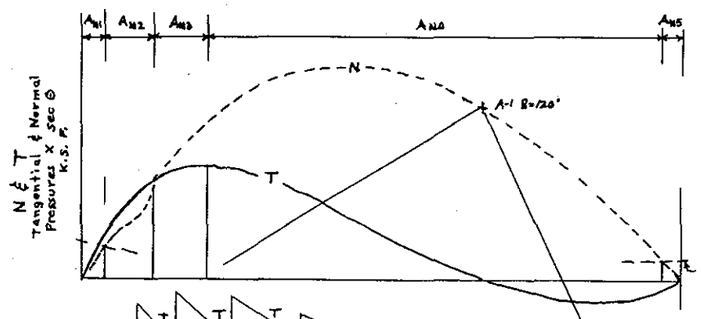
$A_{N4} = 11.90$ sq. in. $N4 = 476$ K $N4 \tan 23° = 202.0$ K

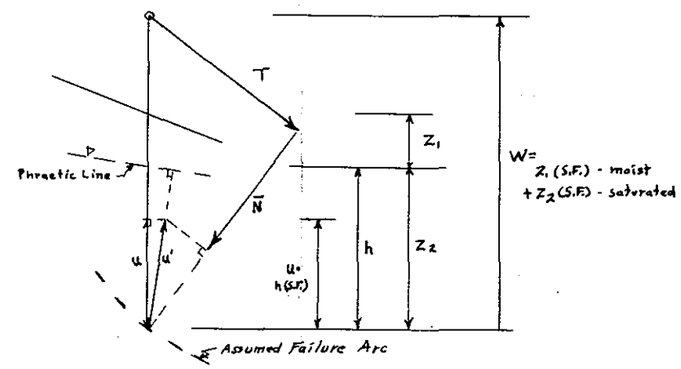
$A_{N5} = 0.02$ sq. in. $N5 = 0.8$ K $N5 \tan 35° = 0.6$ K

$cL = (123+18)(0.10) = 14.1$ K

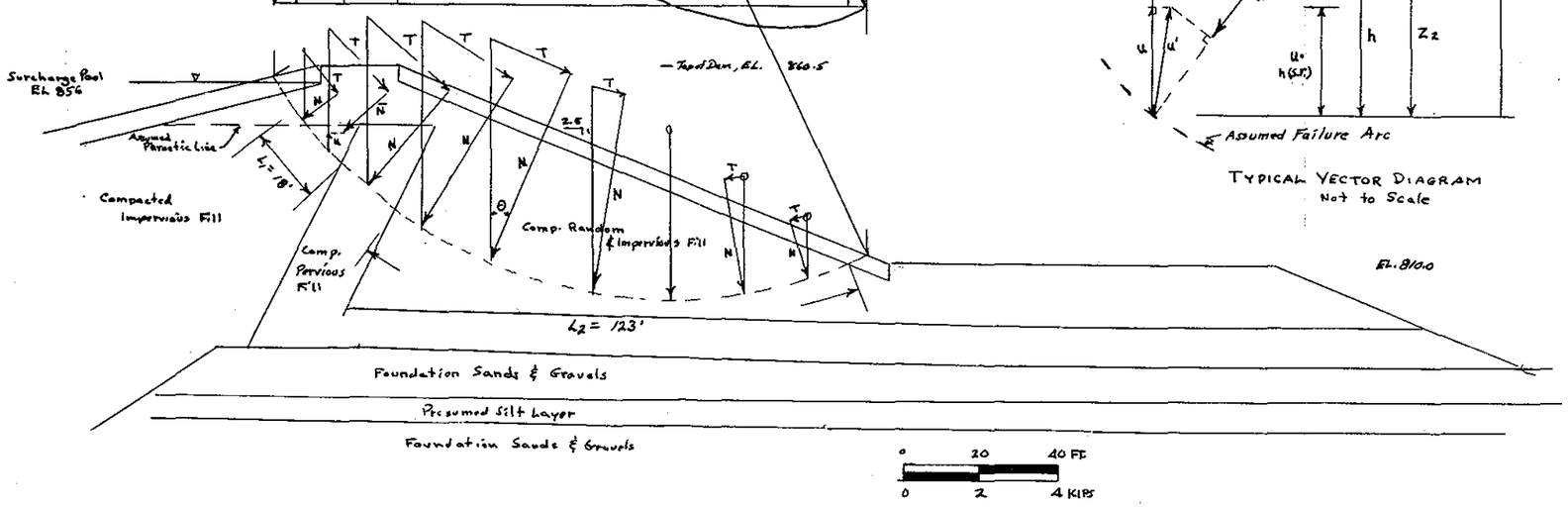
$$F = \frac{1.2 + 7.6 + 31.4 + 202.0 + 0.6 + 14.1}{160.0} = \frac{256.9}{160.0} = 1.61$$

F = 1.6

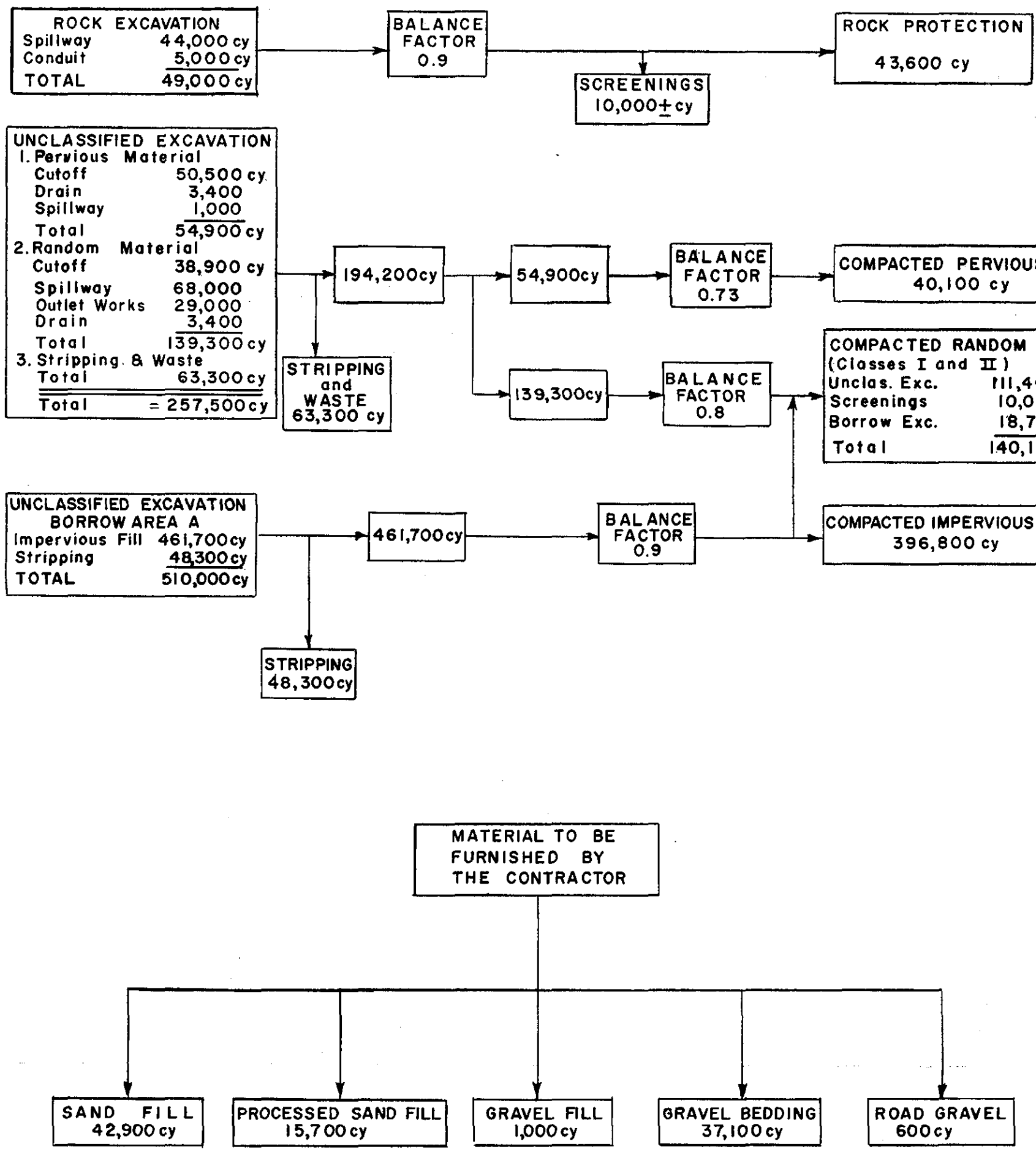




TYPICAL VECTOR DIAGRAM
Not to Scale



WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
TYPICAL STABILITY ANALYSIS (CIRCLE)
CASE VI
STEADY SEEPAGE WITH SURCHARGE POOL
WHITMAN RIVER MASSACHUSETTS



WATER RESOURCES DEVELOPMENT PROJECT
NORTH NASHUA RIVER BASIN
WHITMANVILLE LAKE
MATERIALS USAGE CHART
(PRELIMINARY)
WHITMAN RIVER MASSACHUSETTS

APPENDIX A

SUMMARY OF LABORATORY TEST RESULTS

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	-NO4	COMPACTION DATA ~~STND AASHO~~ OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CUFT TOTAL	-NO4	OTHER TESTS SHEAR	CONSOL.	PERM.
FD-1	831.1	J-4	5.0- 7.6	SM	25	49	26	0.011													
		J-8	14.5-18.9	GP-GM	50	41	9	0.090													
FD-2	789.3	J-4	10.0-15.0	SP	44	52	4	0.090													
		J-12	33.0-33.8	SM	31	44	25	0.015													
FD-3	832.3	J-2	3.0- 4.6	GP-GM	53	39	8	0.10													
FD-5	874.0	J-3	5.0- 7.8	SM	26	50	24	0.015													
		J-5	10.3-14.2	SM	30	56	14	0.05													
FD-6	860.8	J-2R	2.0- 5.0	GM								13.0	17.4								
		J-4R	5.0- 8.0	GM								9.1	19.4								
FD-8	847.5	J-2	1.0- 5.0	GP-GM	50	41	9	0.084													
		J-3R	1.0- 5.0	GP-GM								10.0	14.1								
		J-5R	5.0-10.0	GM								11.6	15.7								
		J-6	12.0-13.3	SM	27	55	18	-													
		J-7R	12.0-13.3	SM								11.1	18.7								
FD-9	868.4	J-3R	1.0- 5.0	GP-GM								7.7	18.4								
		J-4	5.0- 7.8	SM	24	49	27	0.014													
		J-5R	5.0- 7.8	SM								9.7	16.1								
		J-6	12.5-14.1	SP-SM	40	51	9	0.087													
FD-11	821.0	J-3	4.5- 5.5	GM	47	39	14	0.044													

NED FORM JUL 63 510

* PROVIDENCE VIBRATED DENSITY TEST

WHITMANVILLE LAKE

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	- NO4	COMPACTION DATA ~~STND AASHO~~ OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CUFT TOTAL	- NO4	OTHER TESTS SHEAR	CONSOL.	PERM.
FD-15	787.8	J-3	5.0- 9.1	SM	35	51	14														
FD-16	792.4	J-2	0.8- 5.0	SP	16	81	3	0.18													
		J-4	5.0- 8.9	SP-SM	42	50	8	0.1													
		J-6	17.0-22.0	GM	44	43	13	0.061													
		J-7	22.0-27.0	SM	22	29	49	0.015													
FD-17	788.6	J-1	0.4- 4.6	GP	50	47	3	0.5													
		J-4	10.0-15.0	ML	22	28	50	0.013													
		J-6	15.0-20.0	SP	16	81	3	0.24													
		J-9	29.5-34.5	GP-GM	64	27	9	0.09													
FD-18	785.8	J-2	5.0- 9.0	SP-SM	26	66	8	0.11													
		J-4	9.0-11.7	GM	54	15	31	0.013													
FD-19	793.4	J-2	1.0- 5.0	GW	68	28	4	0.31													
		J-6	10.5-13.0	CH	0	9	91	<0.001	52	25											
		J-9	20.0-25.0	GW	53	44	3	0.19													
		J-15	36.0-38.3	GW-GM	47	45	8	0.1													
FD-20	802.1	J-2	3.4- 5.0	SP	2	94	4	0.18													
		J-6	20.0-25.0	SW-SM	26	66	8	0.1													
		J-8	29.0-32.2	GP-GM	53	37	10	0.09													
FD-21	806.2	J-6	10.0-15.0	SP-SM	37	55	8	0.11													

NED FORM JUL 63 510

* PROVIDENCE VIBRATED DENSITY TEST

WHITMANVILLE LAKE

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	-NO4	COMPACTION DATA ~~STND. AASHO~~ OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CU FT TOTAL	-NO4	OTHER TESTS SHEAR	CONSOL.	PERM.	
FD-22	805.5	J-4	5.0- 9.0	SW-SM	27	66	7	0.15														
		J-9	21.0-26.0	SP-SM	26	66	8	0.13														
		J-11	26.0-31.0	SM	34	49	17	-														
FD-23	790.5	J-3	5.0-10.0	GP-GM	62	33	5	0.28														
		J-12	40.0-44.2	GP-GM	62	30	8	0.11														
		J-14	45.5-49.9	GP-GM	46	44	10	0.085														
FD-24	792.8	J-8	15.0-20.0	SM	22	66	12	-														
		J-10	20.0-25.0	GP-GM	58	36	6	0.22														
		J-13	27.0-31.2	GP-GM	46	47	7	0.17														
		J-15	33.0-35.0	SM	33	39	28	0.016														
FD-25	793.0	J-4	5.0-10.0	GW-GM	61	32	7	0.19														
		J-8	15.0-19.0	GW	60	36	4	0.33														
FD-27	801.5	J-3	5.5-10.0	SP-SM	28	60	12	-														
		J-4	10.5-15.0	SM	23	62	15	-														
FD-28	811.5	J-5	6.8- 9.5	SM	28	57	15	-														
		J-8	15.0-17.0	SM	42	45	13	-														
FD-29	786.6	J-5	6.5- 8.0	GW-GM	51	40	9	0.09														
		J-6	8.0-10.0	GW	62	33	5	0.36														
		J-9	13.5-15.0	ML	0	39	61	0.0024														
		J-10	15.0-18.5	ML	0	28	72	0.0025	NP	NP												
		J-14	25.0-30.0	SW-SM	41	47	12	-														

NED FORM JUL 63 510

* PROVIDENCE VIBRATED DENSITY TEST

WHITMANVILLE LAKE

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	- NO4	COMPACTION DATA STND. AASHO OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CU FT TOTAL	- NO4	OTHER TESTS SHEAR	CONSOL.	PERM.
FD-30	784.8	J-3	2.0- 2.6	GW-GM	63	31	6	0.21													
		J-7	10.0-15.0	SP-SM	2	87	11	-													
		J-8	22.0-25.0	SP-SM	40	50	10	0.074													
FD-31	785.2	J-2	1.5- 5.0	GP	51	45	4	0.25													
		J-7	10.0-15.0	GW	61	35	4	0.27													
		J-9	15.0-19.0	SM	32	49	19	-													
FD-32	821.5	J-3	2.0- 5.0	GM	44	43	13	-													
		J-6	5.5-10.0	GW-GM	57	33	10	0.074													
FD-34	857.0	J-3	1.5- 3.5	SP-SM	45	46	9	0.1													
		J-5	5.0-10.0	SP-SM	33	56	11	-													
FD-36	863.7	J-5	5.0-10.0	GM	42	41	17	0.03													
		J-6R	5.0-10.0	GM								5.1	8.5								
		J-8R	10.0-13.1	GM								8.6	11.6								
FD-38	883.4	J-6R	10.0-13.2	SM								5.8	8.6								
FD-39	810.3	J-2	0.7- 5.0	GP	50	46	4	0.21													
FD-42	854.6	J-3	1.5- 5.0	SM	34	53	13	-													

NED FORM JUL 63 510

* PROVIDENCE VIBRATED DENSITY TEST

WHITMANVILLE LAKE

PLATE NO. 14-1

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS				ATT. LIMITS		SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT		COMPACTION DATA			NAT. DRY DENSITY LBS/CU FT		OTHER TESTS			
														STND. AASHO								
					GRAVEL %	SAND %	FINES %	D_{10} mm.	LL	PL		TOTAL	- NO4	OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO4	SHEAR	CONSOL.	PERM.	
FD-45	810.9	J-4	8.0- 9.0	GW-GM	52	42	6	0.18														
		J-5	9.0-12.0	GP-GM	55	34	11	-														
		J-6R	9.0-12.0	GP-GM								8.2	13.2									
		J-7	12.0-14.9	SM	23	53	24	0.018														
		J-8R	12.0-14.9	SM								10.5	15.6									
FD-46	806.9	J-4	8.0- 9.3	SM	26	60	14															

PLATE NO. 4A-2

NED FORM JUL 63 510

* PROVIDENCE VIBRATED DENSITY TEST

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	-NO4	COMPACTION DATA STND. AASHO OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CU FT TOTAL	-NO4	OTHER TESTS SHEAR	CONSOL.	PERM.	
FD-49	812.9	J-5	11.0-15.4	SM	39	44	17	-														
		J-6	15.4-19.2	SM	34	50	16	-														
FD-50U	786.6	UC-1	12.1-14.1	SM,ML					NP	NP		26.3	26.3				95.5	95.5				2.67
		UC-3	15.2-16.3	ML								25.6	25.6									
FD-51U	786.6	UC-1																				
		#1	9.9-11.9	SP-SM	0	93	7	0.096				26.0	26.0									
		#2	9.9-11.9	SM	0	58	42	0.012				25.7	25.7				98.9	98.9				
		#3	9.9-11.9	ML	0	48	52	0.007				31.6	31.6				90.4	90.4				
		UC-3																				
		#1	11.8-13.7	ML	0	47	53	0.005	NP	NP	2.65	28.2	28.2	14.2	112.9				X			
		#2	11.8-13.7	ML	0	43	57	0.0059	NP	NP	2.66	35.8	35.8						X			
		#3	11.8-13.7	ML	0	49	51	0.0085	-	-		23.4	23.4				102.1	102.1				
		UC-5																				
		#1	13.7-15.8	ML	0	37	63	0.0041	NP	NP		28.1	28.1	13.0	117.2				X			
		#2	13.7-15.8	ML	0	33	67	0.0024	NP	NP		28.3	28.3						X			
		#3	13.7-15.8	ML	0	42	58	0.0032	NP	NP		25.9	25.9						X			
		#3	13.7-15.8	ML	0	43	57	-				26.5	26.5				97.5	97.5				
FD-52U	793±	J-3	11.7-13.7	SP	2	96	2	0.14														
		J-4	14.0-19.0	SP	0	97	3	0.14														

X INDICATES TEST PERFORMED

PLATE NO. 5A

NED FORM JUL 510 * PROVIDENCE VIBRATED DENSITY TEST

WHITMANVILLE LAKE

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	-NO4	COMPACTION DATA ~~STND.AASHO~~ OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CUFT TOTAL	-NO4	OTHER TESTS SHEAR	CONSOL.	PERM.	
ED-53	793±	J-3	5.0- 6.0	GP-GM	59	35	6	0.15														
		J-4	6.0- 7.0	SM	24	62	14	-														
		J-6	7.7- 9.0	SW-SM	28	62	10	0.8														
		J-8	11.0-13.0	SW-SM	31	59	10	0.9														
		J-10	15.0-17.0	SP-SM	16	79	5	0.12														

PLATE NO. 6A

NED FORM JUL 63 510 * PROVIDENCE VIBRATED DENSITY TEST

WHITMANVILLE LAKE

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	- NO4	COMPACTION DATA ~~STND AASHO~~ OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CUFT TOTAL	- NO4	OTHER TESTS SHEAR	CONSOL.	PERM.
BD-1	1053+	J-2	0.8- 2.4	SM	8	45	47	0.0031	NP	NP											
		J-4R	2.4- 5.0	ML-CL								12.1	12.5								
		J-6	5.0- 7.6	ML-CL	3	32	65	<0.001	26	19											
		J-8	10.0-15.0	CL	8	36	56	<0.001	26	17											
		J-9R	10.0-15.0	CL								13.9	14.0								
		J-11	15.0-20.0	CL	14	32	54	<0.001	26	16											
		J-12R	15.0-20.0	CL								11.3	11.5								
		J-14	20.0-25.0	SC-SM	10	43	47	0.0022	22	15											
		J-15R	20.0-25.0	SC-SM								9.9	10.0								
		J-18R	25.0-30.0	SC-SM								8.2	9.3								
		J-20	30.0-35.0	SC	8	50	42	<0.001	22	13											
		J-21R	30.0-35.0	SC								9.7	10.0								
		J-25R	36.6-38.3	SC								8.7	8.8								
		J-26	40 -45	SC	8	46	46	<0.001	24	14											
		J-27R	40 -45	SC								9.0	9.5								
		J-29R	45 -50.0	SC								11.8	12.0								
		J-31R	50.0-55.0	SC								10.3	11.6								
BD-2	1024.9	J-3R	1.3- 5.0	SM-SC								14.1	14.2								
		J-5	5.0-10.0	SC-SM	4	49	47	<0.001													
		J-6R	5.0-10.0	SC-SM								11.5	11.9								
		J-8	10.0-11.0	CL	4	44	52	<0.001	25	15											
		J-10	14.0-15.0	SC	17	44	39	0.001	24	14											
		J-11R	14.0-15.0	SC								9.4	10.8								
		J-12	15.0-16.9	SC	23	42	35	0.0019	23	15											
		J-13	16.9-20.0	SC	15	43	42	<0.001	23	15											

NED FORM JUL 63 510

* PROVIDENCE VIBRATED DENSITY TEST

WHITMANVILLE LAKE

PLATE NO. 7A

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	- NO4	COMPACTION DATA ~~STND AASHO~~ OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CUFT TOTAL	- NO4	OTHER TESTS SHEAR	CONSOL.	PERM.
BD-2	Continued																				
	1024.9	J-14R	16.9-20.0	SC								10.0	10.3								
		J-17R	20.0-25.0	SC								10.4	11.5								
		J-20R	25.0-30.0	SC								9.8	12.1								
		J-22R	30.0-35.0	SC								11.7	12.3								
		J-24	35.0-36.0	SC	8	46	46	<0.001	23	15											
		J-25R	35.0-36.0	SC								8.4	11.3								
BD-3	1047±	J-2	4.0- 5.0	ML-CL	2	33	65	<0.001	24	17											
		J-4	5.8-10.0	CL	5	40	55	<0.001	25	16											
		J-5R	5.8-10.0	CL								12.4	13.8								
		J-8R	10.0-13.2	CL								14.1	14.5								
		J-10	13.2-15.0	CL	3	43	54	<0.001	24	16											
		J-11R	13.2-15.0	CL								12.2	13.4								
		J-12	15.0-20.0	SM-SC	23	34	43	0.002	20	15											
		J-13R	15.0-20.0	SM-SC								9.3	10.8								
		J-16R	20.0-22.6	SM-SC								10.1	11.2								
		J-18R	22.6-25.0	SM-SC								9.5	10.1								
		J-20	25.0-30.0	SM-SC	4	46	50	<0.001	20	14											
		J-21R	25.0-30.0	SM-SC								9.6	9.9								
		J-24R	30.0-35.0	SM-SC								10.1	10.3								
		J-28R	38.0-40.0	CL								11.2	11.4								
		J-29	40.0-41.1	CL	2	44	54	<0.001	24	15											
		J-30R	40.0-41.1	CL								9.9	10.2								
		J-32	43.0-45.0	SC	6	46	48	<0.001	23	14											
		J-33R	43.0-45.0	SC								10.3	11.5								
		J-35R	45.0-50.0	SC								10.3	10.7								

NED FORM JUL 63 510 * PROVIDENCE VIBRATED DENSITY TEST

WHITMANVILLE LAKE

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	- NO4	COMPACTION DATA ~~STND AASHO~~ OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CUFT TOTAL	- NO4	OTHER TESTS SHEAR	CONSOL.	PERM.
BD-4	992.9	J-3	1.0- 2.9	SM-SC	8	43	49	0.0018	22	16											
		J-4R	1.0- 2.9	SM-SC								11.1	12.2								
		J-6	2.9- 5.0	SM	10	60	30	0.09													
		J-7R	2.9- 5.0	SM								9.5	10.2								
		J-10	5.3-10.0	SC	21	41	38	<0.001	24	15											
		J-11R	5.3-10.0	SC								9.6	10.0								
		J-14R	10.0-15.0	SC								9.7	10.5								
		J-17R	15.0-17.4	SC								8.9	11.1								
		J-18	17.4-20.0	SC	8	46	46	<0.001	24	14											
		J-19R	17.4-20.0	SC								10.2	10.7								
		J-21	20.0-25.0	SC	11	46	43	<0.001	23	15											
		J-22R	20.0-25.0	SC								8.7	11.4								
		J-24	25.0-30.0	SC	21	40	39	<0.001	25	15											
		J-25R	25.0-30.0	SC								9.8	11.6								
		J-28R	30.0-35.0	SC								9.7	10.4								
		J-30	35 -40	SC	31	33	36	<0.001	25	15											
		J-31R	35 -40	SC								9.9	12.0								
		J-34R	40 -41.0	SC								11.2	12.4								
BD-5	972.7	J-3R	0.8- 2.3	SM								10.3	11.2								
		J-4	2.3- 5.0	CL	7	40	53	<0.001	23	15											
		J-5R	2.3- 5.0	CL								11.8	12.2								
		J-8	5.4- 9.2	SM	16	53	31	0.0051													
		J-9R	5.4- 9.2	SM								7.9	9.5								
		J-11R	9.2-10.0	SC								11.8	11.9								
		J-12	10.0-12.9	SC	7	45	48	<0.001	25	15											

NED FORM JUL 63 510

* PROVIDENCE VIBRATED DENSITY TEST

WHITMANVILLE LAKE

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	- NO4	COMPACTION DATA ~~STND AASHO~~ OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CUFT TOTAL	- NO4	OTHER TESTS SHEAR	CONSOL.	PERM.
BD-5 Continued																					
	972.7	J-13R	10.0-12.9	SC								10.1	11.2								
		J-16R	12.9-15.0	SC								10.0	10.9								
		J-18	15.0-20.0	SC	17	51	42	<0.001	23	14											
		J-19R	15.0-20.0	SC								8.9	10.4								
		J-22R	20.0-25.0	SC								8.4	10.6								
		J-24	25.0-26.2	SC	12	44	44	<0.001	23	14											
		J-25R	25.0-26.2	SC								12.0	12.8								
		J-28R	26.2-27.1	SM-SC								13.6	15.5								
BD-6	977.9	J-3R	1.2- 2.8	SM								10.9	11.2								
		J-5	2.8- 5.0	SM-SC	6	47	47	<0.001	20	14											
		J-6R	2.8- 5.0	SM-SC								11.1	11.3								
		J-9R	5.0- 8.1	SM-SC								11.0	12.1								
		J-14R	10.2-12.9	SM-SC								9.1	11.0								
		J-16	13.4-14.3	SC	13	43	44	<0.001	24	15											
		J-17R	13.4-14.3	SC								9.9	10.3								
		J-19R	14.3-15.0	SC								9.2	9.7								
		J-20	15.0-20.0	SC	5	49	46	<0.001	23	14											
		J-21R	15.0-20.0	SC								11.3	11.7								
		J-23	20.0-25.0	SC	10	44	46	<0.001	24	14											
		J-24R	20.0-25.0	SC								11.5	11.9								
		J-27R	25.0-30.0	SC								11.0	11.8								
		J-30R	30.0-35.0	SC								10.9	11.7								
		J-33R	35.0-40.0	SC								10.5	11.8								
		J-35	40.0-45.0	SC	12	41	47	<0.001	24	15											
		J-36R	40.0-45.0	SC								10.0	13.3								

NED FORM JUL 63 510 * PROVIDENCE VIBRATED DENSITY TEST

WHITMANVILLE LAKE

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	- NO4	COMPACTION DATA ~~STND. AASHO~~ OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CU FT TOTAL	- NO4	OTHER TESTS SHEAR	CONSOL.	PERM.
BD-7	1008.7	J-3R	0.4- 1.5	SM								8.7	9.1								
		J-4	1.5- 3.2	SM	13	42	45	0.0045	-	-											
		J-5R	1.5- 3.2	SM								8.3	8.8								
		J-7R	3.2- 5.0	SM								9.6	10.4								
		J-9	5.0- 7.4	ML-CL	3	45	52	0.002	20	15											
		J-10R	5.0- 7.4	ML-CL								11.0	11.4								
		J-13R	7.4-10.0	ML-CL								11.3	11.9								
		J-16R	10.0-15.0		7	53	42	<0.001	-	-		9.8	10.5								
		J-20R	15.4-20.0	SC								9.7	11.0								
		J-22	20.0-25.0	SC	9	47	44	<0.001	23	14											
		J-23R	20.0-25.0	SC								11.2	11.7								
		J-26R	25.0-30.0	SC								11.9	13.2								
		J-28	30.0-35.0	SC	11	45	44	<0.001	23	14											
		J-29R	30.0-35.0	SC								12.2	12.7								
		J-32R	35.0-40.0	SC								10.7	11.9								
		J-34	40.0-45.0	SC	15	44	41	<0.001	24	14											
		J-35R	40.0-45.0	SC								6.5	12.4								
BD-8	969.0																				
		J-3R	0.6- 2.1	SM								19.3	21.4								
		J-4	2.1- 3.4	ML	6	33	61	0.0034	-	-											
		J-5R	2.1- 3.4	ML								10.1	10.7								
		J-7R	3.4- 5.0	SM								11.6	12.7								
		J-9	5.0- 8.8	SM	15	39	46	0.0048	-	-											
		J-10R	5.0- 8.8	SM								9.2	11.2								
		J-14	10.0-10.9	SM	18	39	43	0.0049	-	-											

PAGE NO. 11A

NED FORM JUL 63 510

* PROVIDENCE VIBRATED DENSITY TEST

WHITMANVILLE LAKE

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	-NO4	COMPACTION DATA STD. AASHO OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CU FT TOTAL	-NO4	OTHER TESTS SHEAR	CONSOL.	PERM.
BD-8	969.0	Continued																			
		J-15R	10.0-10.9	SM								12.2	12.8								
		J-17R	10.9-13.6	SM								6.4	9.8								
		J-21R	15.0-16.8	SM-SC								8.6	10.2								
BD-9	996.5	J-3R	0.5- 2.1	SM								11.1	11.3								
		J-5	2.6- 3.4	SM								9.9	10.0								
		J-7	3.4- 5.0	ML-CL	2	45	53	0.0013	21	14											
		J-8R	3.4- 5.0	ML-CL								12.0	12.4								
		J-11	5.9-10.0	SC	8	47	45	<0.001	24	15											
		J-12R	5.9-10.0	SC								9.7	12.8								
		J-14R	10.0-11.2	SC								11.4	12.0								
		J-16R	11.2-13.0	SC								9.9	12.5								
		J-18R	13.0-14.6	SC								10.0	10.9								
		J-21R	15.3-17.4	SC								10.9	11.5								
		J-23	17.4-20.0	SC	16	42	42	<0.001	24	15											
		J-24R	17.4-20.0	SC								11.8	12.3								

* PROVIDENCE VIBRATED DENSITY TEST

NED FORM JUL 63 510

WHITMANVILLE LAKE

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	-NO4	COMPACTION DATA OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CUFT TOTAL	-NO4	OTHER TESTS SHEAR	CONSOL.	PERM.
BT-1	1047±	B-1	1.0- 4.0	SM-SC	9	44	47	0.0032	23	17											
		J-2R	1.0- 4.0	SM-SC								7.8	8.2								
		B-3	4.0- 6.0	SC	11	43	46	0.002	24	15	2.67			13.0	119.8				x	x	x
		C-4	4.0- 6.0	SC	24							11.4	15.1				125.3	115.5			
		C-4	4.0- 6.0	SC	12							12.6	14.3				121.1	116.6			
		J-5R	4.0- 6.0	SC								14.7	15.0								
		B-6	6.0-12.0	SC	11	45	44	<0.001	24	15	2.71			11.2	124.6						
		C-7	6.0-12.0	SC	25							10.2	13.5				129.8	120.4			
		C-7	6.0-12.0	SC	8							14.1	15.3				117.5	114.1			
		J-8R	6.0-12.0	SC								12.1	12.7								
BT-2	978±	C-1	1.0- 9.0	SC	21							11.3	14.4				125.7	117.5			
		C-1	1.0- 9.0	SC	25							11.5	15.3				124.4	114.4			
		B-2	1.0- 9.0	SC	14	47	39	0.005	24	14	2.72			10.7	125.6				x	x	x
		J-3R	1.0- 9.0	SC								13.4	14.8								
		C-4	9.0-10.0	SC	6							9.3	10.0				131.5	129.4			
		C-4	9.0-10.0	SC	12							8.9	10.0				132.2	128.5			
		B-5	9.0-10.0	SC	12	46	42	0.001	23	14											
		J-6R	9.0-10.0	SC								11.5	12.2								
BT-3	969±	C-1	2.0- 4.0	ML-CL	5							13.4	14.1				117.6	115.8			
		C-1	2.0- 4.0	ML-CL	9							13.4	14.7				116.9	113.4			
		B-2	2.0 -4.0	ML-CL	11	32	57	0.002	25	18											
		J-3R	2.0- 4.0	ML-CL								13.5	14.9								
		C-4	4.0-10.0	ML-CL	6							12.3	13.1				118.7	116.7			
		C-4	4.0-10.0	ML-CL	33							8.1	12.0				128.7	115.1			

x Indicates tests performed

NED FORM JUL 63 510

* PROVIDENCE VIBRATED DENSITY TEST

WHITMANVILLE LAKE

SOIL TESTS RESULTS

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	- NO 4	COMPACTION DATA OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CU FT TOTAL	- NO 4	OTHER TESTS SHEAR	CONSOL.	PERM.	
BT-3	969+ (Continued)																					
		B-5	4.0-10.0	SM	32	32	36	0.0023	20	18	2.71			12.4	119.7							
		J-6R	4.0-10.0	SM								11.7	12.2									

PAGE NO. 11A

NED FORM JUL 63 510 * PROVIDENCE VIBRATED DENSITY TEST

WHITMANVILLE LAKE

APPENDIX B

DETAILED SHEAR TEST DATA

APPENDIX B

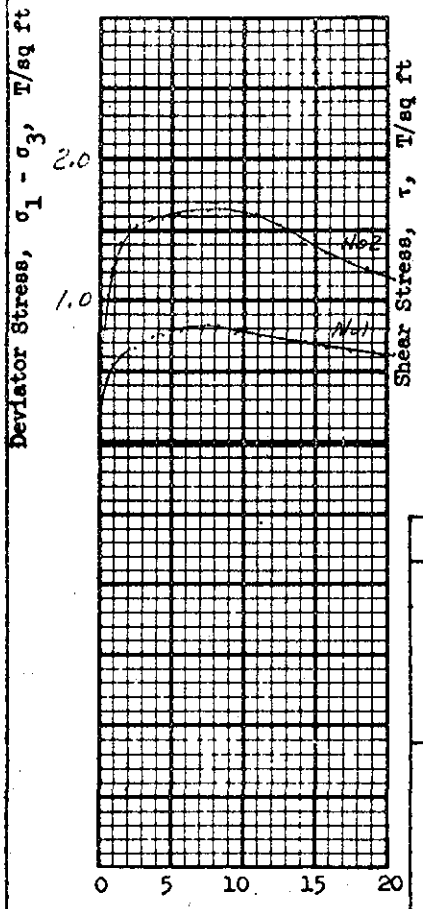
DETAILED SHEAR TEST DATA

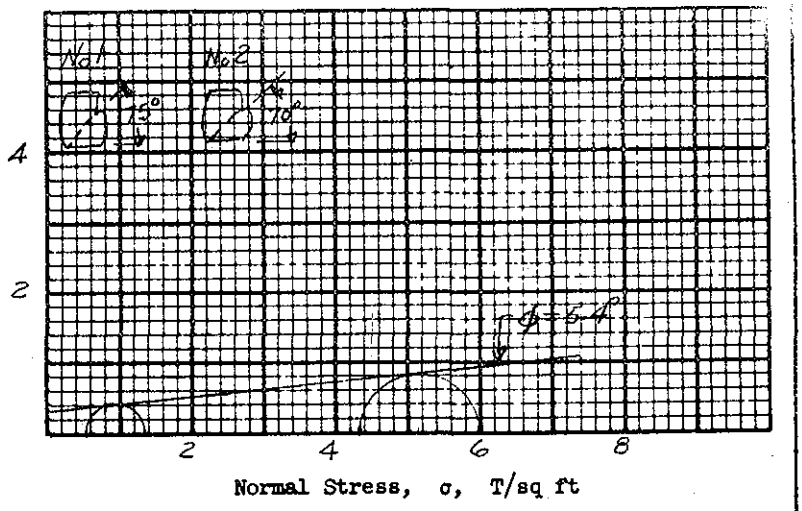
WHITMANVILLE LAKE

PLATE NO.	TITLE
	FINE-GRAINED FOUNDATION MATERIALS
	FD-51U
B-1	Q Triaxial Test UC-3
B-2	Q Triaxial Test UC-5
B-3	R Triaxial Test UC-3
B-4	$\bar{R}$ Triaxial Test UC-3
B-5	R Triaxial Test UC-5
B-6	$\bar{R}$ Triaxial Test UC-5
	IMPERVIOUS EMBANKMENT MATERIALS
	BT-1, B-3
B-7	Gradation Curve
B-8	Compaction Test Report
B-9	Consolidation Test Report
B-9a	Consolidation Test Report
B-10	Q Triaxial Test - Optimum - 2%
B-11	Q Triaxial Test - Optimum
B-12	Q Triaxial Test - Optimum (100% MTD)
B-13	Q Triaxial Test - Optimum +2%
B-14	R Triaxial Test - Optimum -2%

PLATE NO.	TITLE
	IMPERVIOUS EMBANKMENT MATERIALS
B-15	$\bar{R}$ Triaxial Test - Optimum -2%
B-16	R Triaxial Test - Optimum
B-17	$\bar{R}$ Triaxial Test - Optimum
B-18	R Triaxial Test - Optimum (100% MTD)
B-19	$\bar{R}$ Triaxial Test - Optimum (100% MTD)
B-20	R Triaxial Test - Optimum +2%
B-21	$\bar{R}$ Triaxial Test - Optimum +2%
B-22	S Direct Shear Test - Optimum -2%
B-23	S Direct Shear Test - Optimum
B-24	S Direct Shear Test - Optimum (100% MTD)
B-25	S Direct Shear Test - Optimum +2%
	BT-1, B-6
B-26	Gradation Curve
B-27	Compaction Test Report
	BT-2, B-2
B-28	Gradation Curve
B-29	Compaction Test Report
B-30	Consolidation Test Report
B-30a	Consolidation Test Report
B-31	Q Triaxial Test - Optimum -2%
B-32	Q Triaxial Test - Optimum
B-33	Q Triaxial Test - Optimum (100% MTD)

PLATE NO.	TITLE
	IMPERVIOUS EMBANKMENT MATERIALS
B-34	Q Triaxial Test - Optimum +2%
B-35	R Triaxial Test - Optimum -2%
B-36	$\bar{R}$ Triaxial Test - Optimum -2%
B-37	R Triaxial Test - Optimum
B-38	$\bar{R}$ Triaxial Test - Optimum
B-39	R Triaxial Test - Optimum (100% MTD)
B-40	$\bar{R}$ Triaxial Test - Optimum (100% MTD)
B-41	R Triaxial Test - Optimum +2%
B-42	$\bar{R}$ Triaxial Test -Optimum +2%
B-43	S Direct Shear Test - Optimum -2%
B-44	S Direct Shear Test - Optimum
B-45	S Direct Shear Test - Optimum (100% MTD)
B-46	S Direct Shear Test - Optimum +2%
	BT-3, B-5
B-47	Gradation Curve
B-48	Compaction Test Report





Test No.			1	2		
Initial	Water content	w_o	35.4 %	35.1 %	%	%
	Void ratio	e_o	0.994	1.022		
	Saturation	S_o	95.2 %	96.4 %	%	%
	Dry density, lb/cu ft	γ_d	83.3	82.2		
Before Shear	Water content	w_c	– %	– %	%	%
	Void ratio	e_c	–	–		
	Saturation	S_c	– %	– %	%	%
	Final back pressure, T/sq ft	u_o	–	–		
Final	Water content	w_f	– %	– %	%	%
	Void ratio	e_f	–	–		
Minor principal stress, T/sq ft		σ_3	0.54	4.32		
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	0.83	1.65		
Time to failure, min		t_f	7.4	8.0		
Rate of strain, percent/min			1.03	1.02		
			–	–		
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	0.69*	1.38*		
Initial diameter, in.		D_o	1.40	1.40		
Initial height, in.		H_o	3.15	3.19		

Shear Strength Parameters

ϕ = 5.4 °

tan ϕ = 0.095

c = 0.32 T/sq ft

Method of saturation None

☐ Controlled stress

☒ Controlled strain

Type of test Q | Type of specimen Undisturbed

Classification Fine sandy SILT (ML)

LL NP	PL NP	PI NP	D_{10} 0.006	G_s 2.66

Remarks * Stress @ 15% Strain

Insufficient material for more than two specimens

Project Whitman Dam

Area

Boring No. FD-5111 | Sample No. UC-3

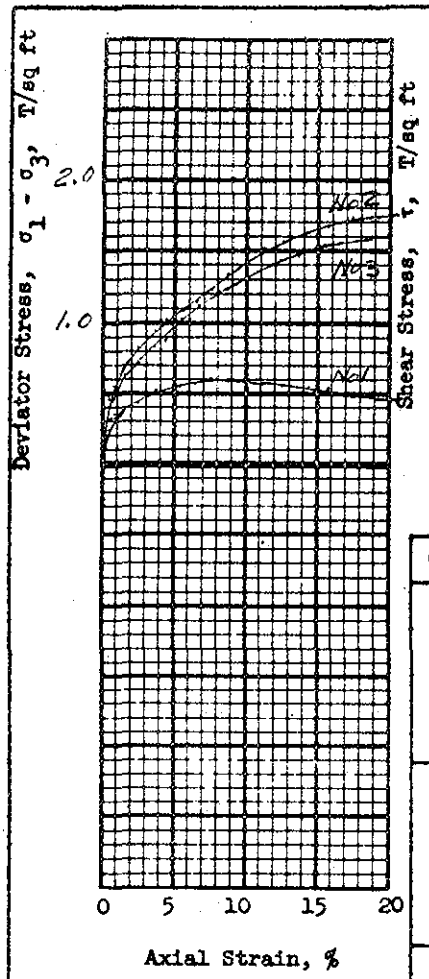
Depth El 11.75' - 13.74' | Date August 1970

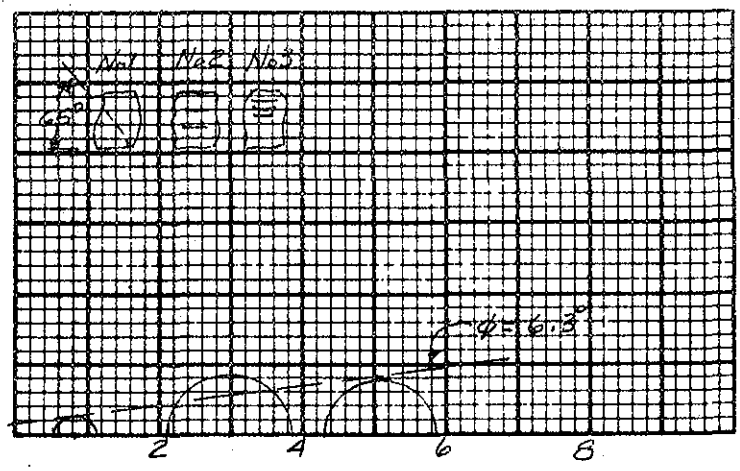
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

TRANSLUCENT

PLATE NO. B-1





Test No.			1	2	3	
Initial	Water content	w_o	27.6 %	27.5 %	25.7 %	%
	Void ratio	e_o	0.815	0.827	0.730	
	Saturation	S_o	93.7 %	94.2 %	98.7 %	%
	Dry density, lb/cu ft	γ_d	92.3	91.6	96.8	
Before Shear	Water content	w_c	— %	— %	— %	%
	Void ratio	e_c	—	—	—	
	Saturation	S_c	— %	— %	— %	%
	Final back pressure, T/sq ft	u_o	—	—	—	
Final	Water content	w_f	— %	— %	— %	%
	Void ratio	e_f	—	—	—	
Minor principal stress, T/sq ft		σ_3	0.54	2.16	4.32	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	0.60	1.66*	1.53*	
Time to failure, min		t_f	7.4	14.5	15.0	
Rate of strain, percent/min			1.03	1.03	1.00	
			—	—	—	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	0.54*	—	—	
Initial diameter, in.		D_o	1.43	1.42	1.43	
Initial height, in.		H_o	3.15	3.15	3.25	

Shear Strength Parameters

ϕ = 6.3 °

tan ϕ = 0.110

c = 0.2 T/sq ft

Method of saturation None

☐ Controlled stress

☒ Controlled strain

Type of test Q	Type of specimen Undisturbed		
Classification Fine sandy SILT (ML)			
LL NP	PL NP	PI NP	D_{10} 1 & 3: 0.003, 2: 0.0025	G_s 2.68

Remarks *Stress @ 15% strain

Project Whitmanville Dam

Area

Boring No. FD-51U | Sample No. UC-5

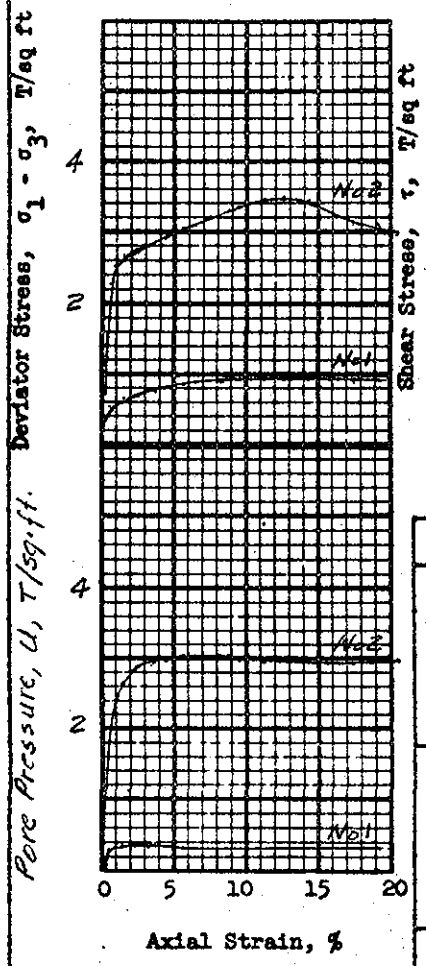
Depth 13.74' - 15.75' | Date August 1970

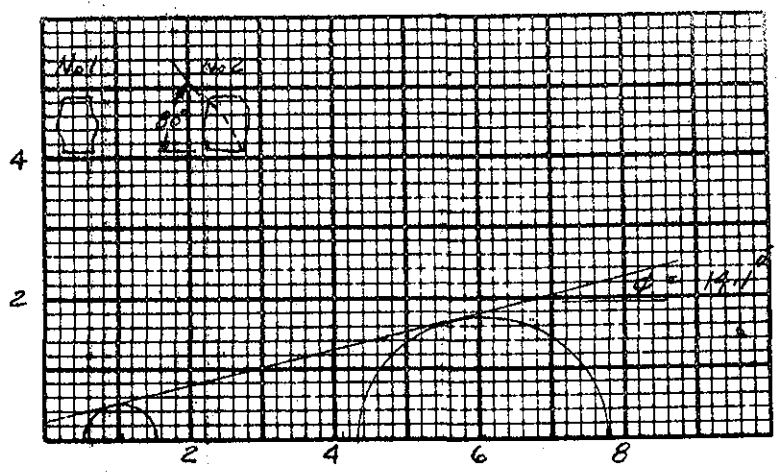
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

TRANSLUCENT

PLATE NO. B-2





Shear Strength Parameters

ϕ = 14.1 °

tan ϕ = 0.251

c = 0.25 T/sq ft

Method of saturation Back pressure

☐ Controlled stress

☒ Controlled strain

Test No.			1	2		
Initial	Water content	w_o	32.1 %	29.6 %	%	%
	Void ratio	e_o	0.891	0.793		
	Saturation	S_o	95.5 %	98.9 %	%	%
	Dry density, lb/cu ft	γ_d	87.6	92.4		
Before Shear	Water content	w_c	31.9 %	26.4 %	%	%
	Void ratio	e_c	0.846	0.699		
	Saturation	S_c	100 %	100 %	%	%
	Final back pressure, T/sq ft	u_o	7.20	7.20		
Final	Water content	w_f	31.9 %	26.4 %	%	%
	Void ratio	e_f	0.846	0.699		
Minor principal stress, T/sq ft		σ_3	0.54	4.32		
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	0.98	3.45		
Time to failure, min		t_f	83.1	73.9		
Rate of strain, percent/min			0.17	0.17		
Pore Pressure T/sq.ft.		U	+0.33	+2.94		
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	0.97 *	3.36 *		
Initial diameter, in.		D_o	1.42	1.41		
Initial height, in.		H_o	3.15	3.21		

Type of test R | Type of specimen Undisturbed

Classification Fine sandy SILT (ML)

LL NP | PL NP | PI NP | D_{10} 0.005 | G_s 2.65

Remarks * Stress @ 15% Strain
Insufficient material for more than two specimens.

Project Whitmanville Dam

Area

Boring No. FD-51U | Sample No. UC-3

Depth El. 11.75' - 13.74' | Date August, 1970

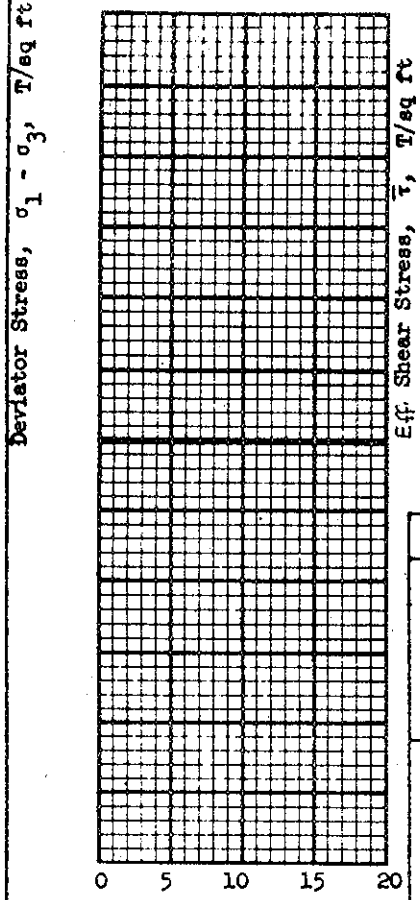
Sheet 1 of 2

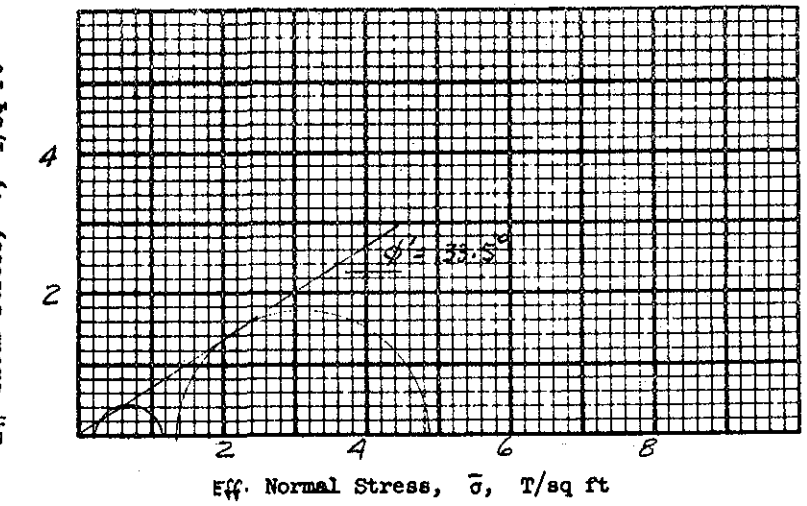
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

TRANSLUCENT

PLATE NO. B-3





Test No.			1	2		
Initial	Water content	w_o	%	%	%	%
	Void ratio	e_o				
	Saturation	S_o	%	%	%	%
	Dry density, lb/cu ft	γ_d				
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final back pressure, T/sq ft	u_o				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
Minor principal stress, T/sq ft Eff.		$\bar{\sigma}_3$	0.21	1.38		
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$				
Time to failure, min		t_f				
Rate of strain, percent/min						
Major Principal Stress, T/sq ft. Eff.		$\bar{\sigma}_1$	1.19	4.82		
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$				
Initial diameter, in.		D_o				
Initial height, in.		H_o				

Shear Strength Parameters

$\bar{\phi}$ = 33.5 °

tan $\bar{\phi}$ = 0.663

$\bar{c}$ = 0 T/sq ft

Method of saturation Backpressure

☐ Controlled stress

☒ Controlled strain

Type of test $\bar{R}$	Type of specimen Undisturbed			
Classification Fine sandy SILT (ML)				
LL NP	PL NP	PI NP	D_{10} 0.005	G_s 2.65

Remarks See sheet 1 of 2 for additional data.

Project Whitmanville Dam

Area

Boring No. FD-514 Sample No. UC-3

Depth 11.75' - 13.74' Date August, 1970

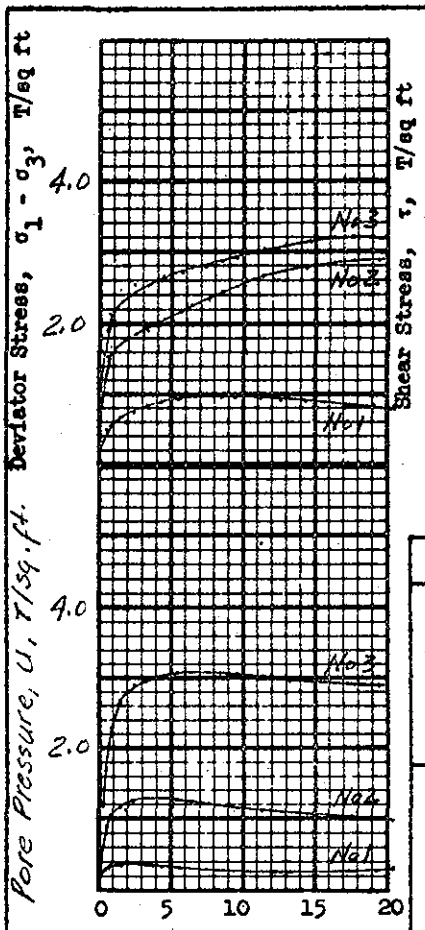
Sheet 2 of 2

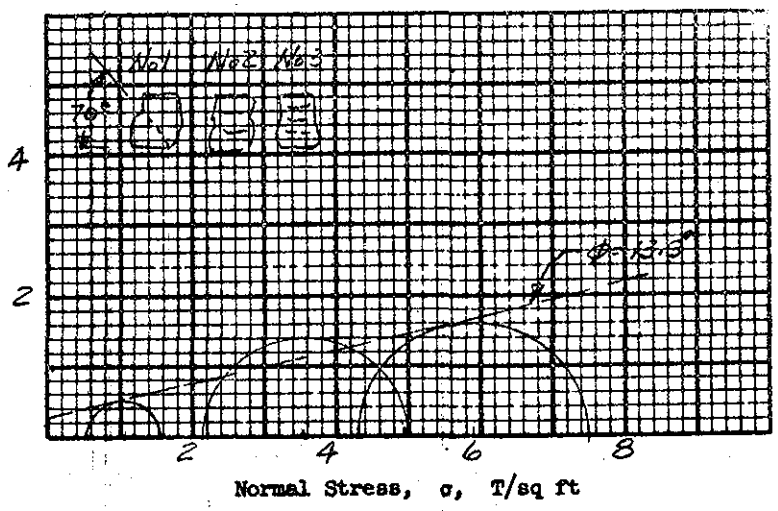
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

TRANSLUCENT

PLATE NO. B-4





Test No.			1	2	3	
Initial	Water content	w_o	29.6 %	30.2 %	29.1 %	%
	Void ratio	e_o	0.800	0.835	0.826	
	Saturation	S_o	99.3 %	97.2 %	94.5 %	%
	Dry density, lb/cu ft	γ_d	93.0	91.2	91.7	
Before Shear	Water content	w_c	30.0 %	27.6 %	25.5 %	%
	Void ratio	e_c	0.805	0.741	0.685	
	Saturation	S_c	100 %	100 %	100 %	%
	Final back pressure, T/sq ft	u_o	7.20	7.20	7.20	
Final	Water content	w_f	30.0 %	27.6 %	25.5 %	%
	Void ratio	e_f	0.805	0.741	0.685	
Minor principal stress, T/sq ft		σ_3	0.54	2.16	4.32	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	1.00	2.81*	3.18*	
Time to failure, min		t_f	48.0	85.7	84.9	
Rate of strain, percent/min			0.17	0.17	0.18	
Pore Pressure T/sq.ft		U	+0.29	+1.05	+2.96	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	0.90*	—	—	
Initial diameter, in.		D_o	1.42	1.42	1.42	
Initial height, in.		H_o	3.15	3.15	3.15	

Shear Strength Parameters

ϕ = 13.9 °

tan ϕ = 0.248

c = 0.25 T/sq ft

Method of saturation Backpressure

☐ Controlled stress

☒ Controlled strain

Type of test R | Type of specimen Undisturbed

Classification Fine sandy SILT (ML)

LL NP | PL NP | PI NP | D_{10} 1&3: 0.0040, 2: 0.0025 | G_s 2.68

Remarks *Stress @ 15% Strain

Project Whitmanville Dam

Area

Boring No. FD-51U | Sample No. UC-5

Depth 13.74'-15.75' | Date August 1970

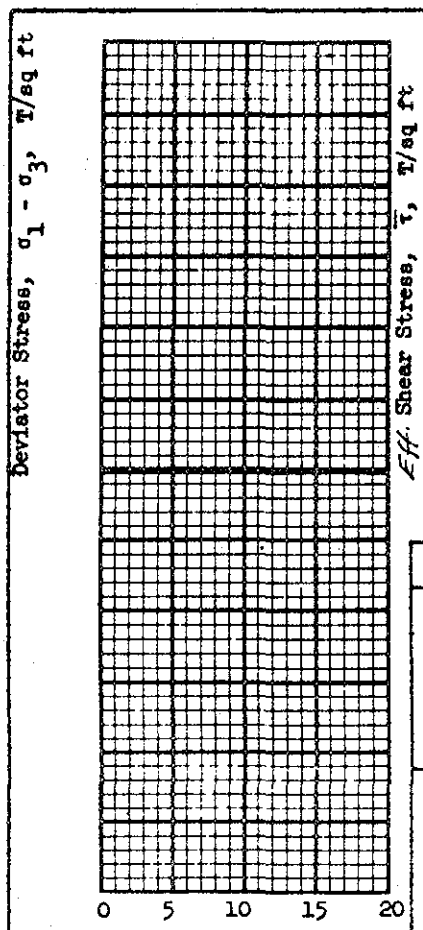
Sheet 1 of 2

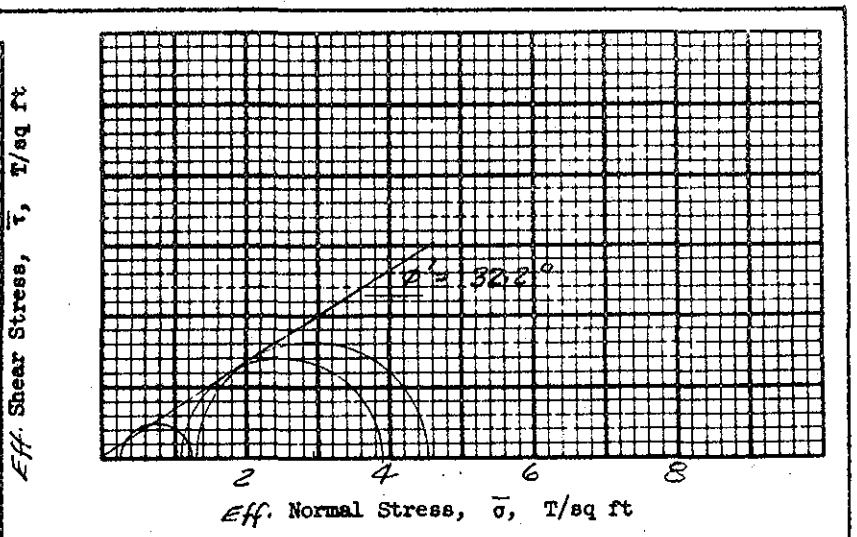
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-5

TRANSLUCENT





Test No.			1	2	3	
Initial	Water content	w_o	%	%	%	%
	Void ratio	e_o				
	Saturation	S_o	%	%	%	%
	Dry density, lb/cu ft	γ_d				
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final back pressure, T/sq ft	u_o				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
Minor principal stress, T/sq ft		$\bar{\sigma}_3$	0.25	1.11 *	1.36 *	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$				
Time to failure, min		t_f				
Rate of strain, percent/min						
Major principal stress, T/sq.ft.		$\bar{\sigma}_1$	1.25	3.91*	4.53*	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$				
Initial diameter, in.		D_o				
Initial height, in.		H_o				

Shear Strength Parameters

ϕ = 32.2 °

tan ϕ = 0.630

c = 0 T/sq ft

Method of saturation Back pressure

☐ Controlled stress

☒ Controlled strain

Type of test $\bar{R}$ | Type of specimen Undisturbed

Classification Fine sandy SILT (ML)

LL NP | PL NP | PI NP | D_{10} 1&3 0.004, 2 0.0025 | G_s 2.68

Remarks *Stress @ 15% strain

See sheet 1 of 2 for additional data.

Sheet 2 of 2

Project Whitmanville Dam

Area

Boring No. FD-51U | Sample No. UC-5

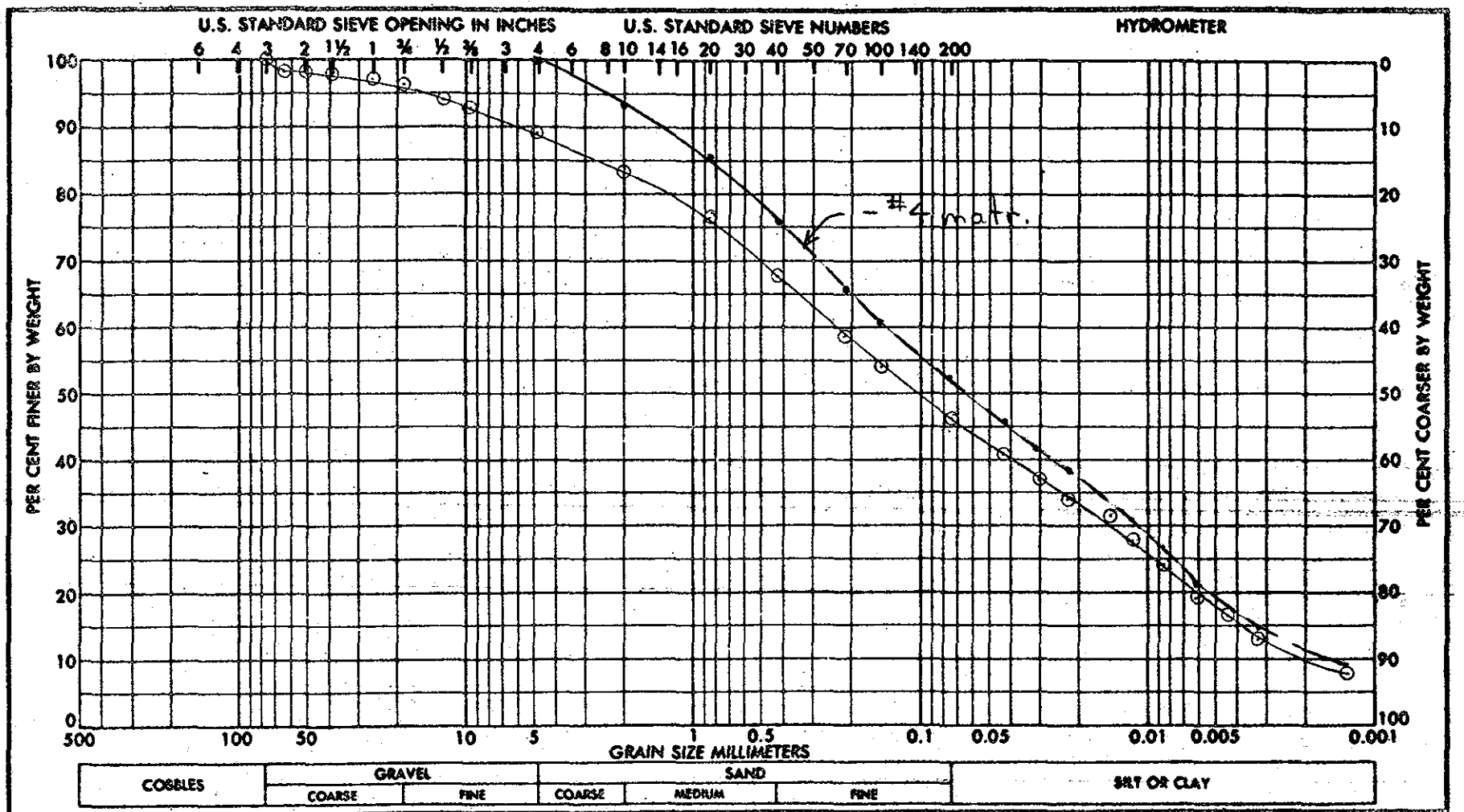
Depth ~~El.~~ 13.74'-15.75' | Date August 1970

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

TRANSLUCENT

PLATE NO. B-6



SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
B-3	4.0' - 6.0'	Gravelly clayey SAND (SC)		24	15	9

PROJECT Whitmanville Dam & Lake

AREA

BORING NO. BT-1

DATE October 1970

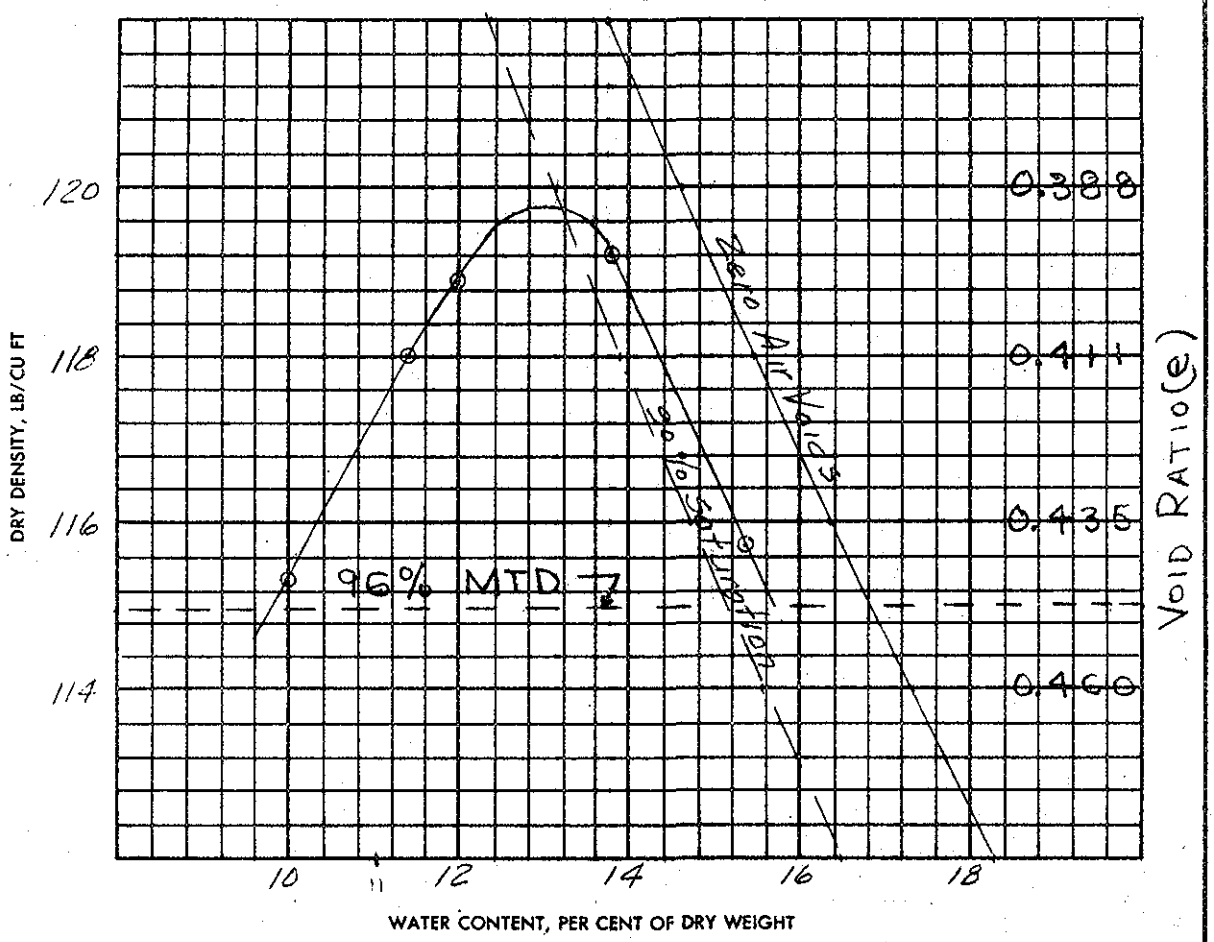
GRADATION CURVES

PLATE NO. B-7

ENG FORM 2087
1 MAY 63

REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

U.S. GOVERNMENT PRINTING OFFICE : 1963 OF—



Standard COMPACTION TEST

25 BLOWS PER EACH OF 3 LAYERS, WITH 5.5 LB RAMMER AND

12 INCH DROP. 4.0 INCH DIAMETER MOLD

SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	G	LL	PL	% > NO. 4	% > ¾ IN.
B-3	4.0'-6.0	Gravelly clayey SAND (SC)	2.67	24	15	10.6	4.1

SAMPLE NO.	B-3			
NATURAL WATER CONTENT IN PER CENT				
OPTIMUM WATER CONTENT IN PER CENT	13.0			
MAX DRY DENSITY IN LB/CU FT	119.8			

REMARKS Test run on -No4 material

PROJECT Whitmanville Dam & Lake

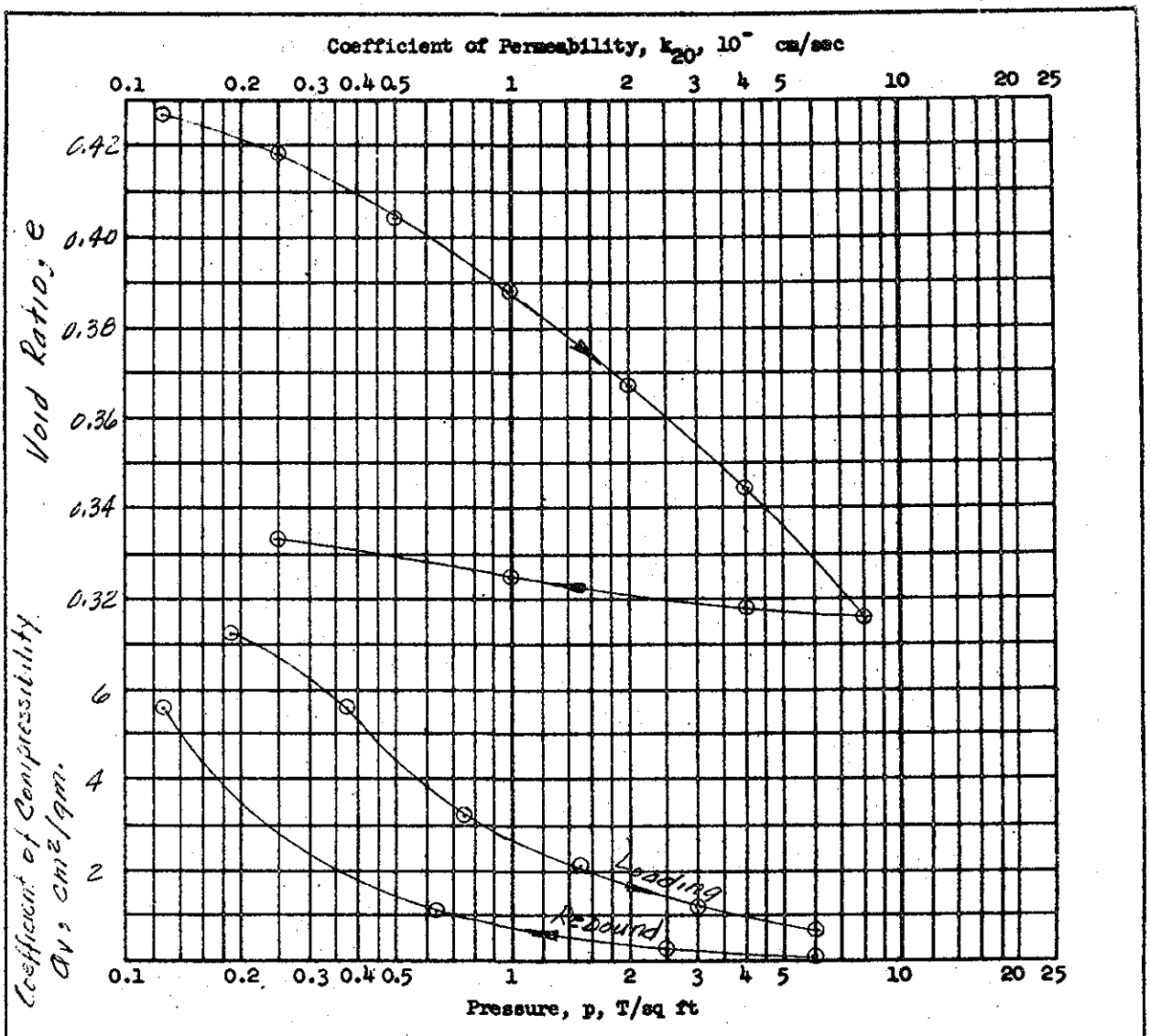
AREA

BORING NO. BT-1 DATE October, 1970

COMPACTION TEST REPORT

ENG FORM 1 MAY 63 2091 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) GPO : 1964 OF—715-178

PLATE NO. B-8

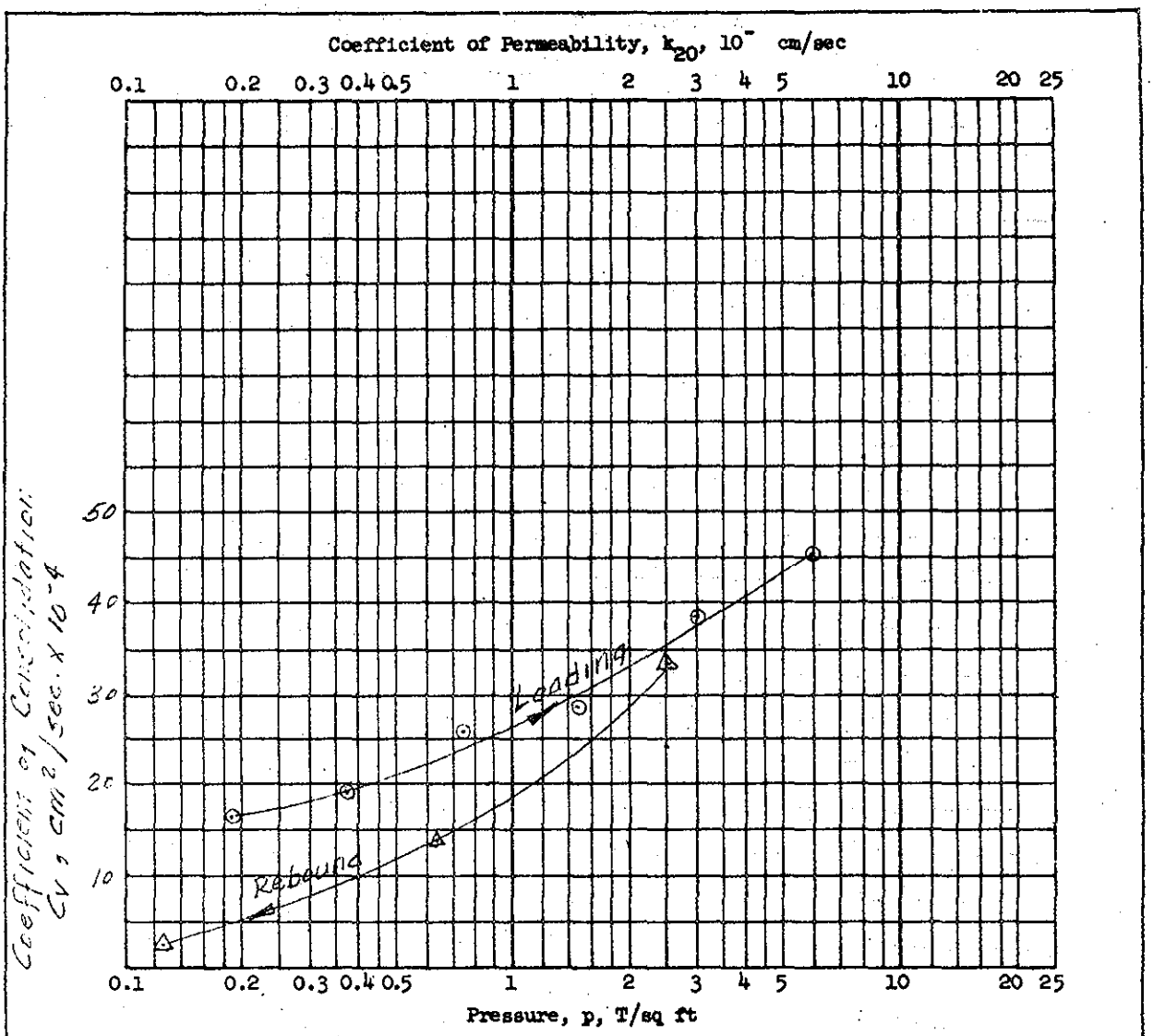


Type of Specimen Remolded		Before Test		After Test	
Diam 4.44 in.	Ht 1.0 in.	Water Content, w_o	14.9 %	w_f	13.0 %
Overburden Pressure, Po T/sq ft		Void Ratio, e_o	0.449	e_f	0.345
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	88.6 %	S_f	100 %
Compression Index, C_c		Dry Density, γ_d	115.0 lb/ft³		
Classification Gravelly clayey SAND (SC)		k_{20} at e_o =	x 10^{-} cm/sec		
LL 24	G_s 2.67	Project Whitmanville Dam and Lake			
PL 15	D_{10} 0.002				
Remarks Specimen molded with No 4 mat'l. at approx. water content of 15.0% and approx. dry density of 115.0 pcf. Opt. water content plus 2% and 96% of max. density as determined from Std. Compaction test curve.		Area			
		Boring No. BT-1		Sample No. B-3	
		Depth 4.0'-6.0'		Date Jan. 1971	

CONSOLIDATION TEST REPORT

ENG FORM 1 MAY 63 2090 PREVIOUS EDITIONS ARE OBSOLETE.

PLATE NO. B-9

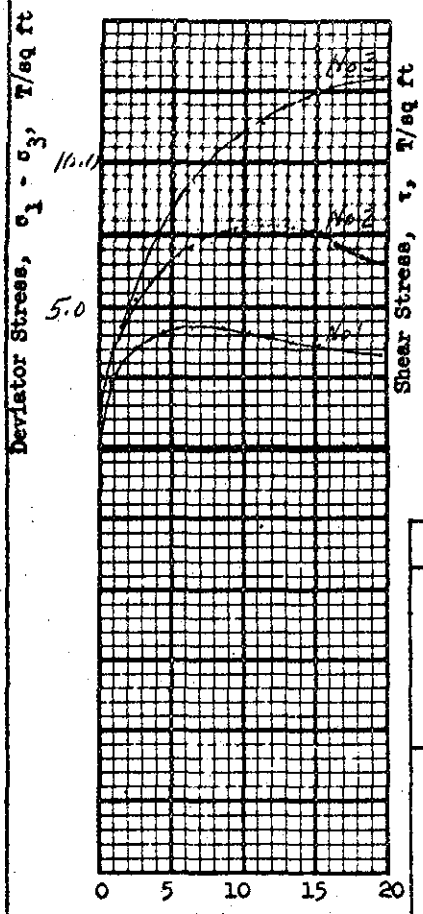


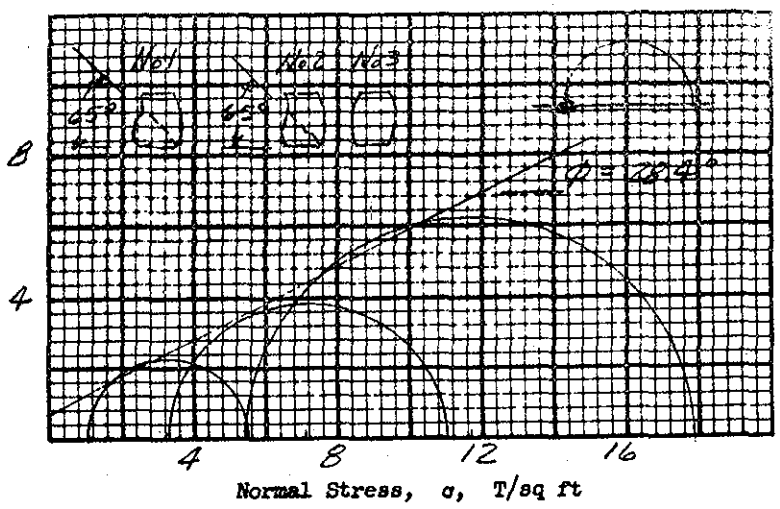
Type of Specimen *Remolded*		Before Test		After Test	
Diam *4.44* in.	Ht *1.0* in.	Water Content, w_o	*14.9* %	w_f	*13.0* %
Overburden Pressure, p_o	T/sq ft	Void Ratio, e_o	*0.449*	e_f	*0.345*
Preconsol. Pressure, p_c	T/sq ft	Saturation, S_o	*88.6* %	S_f	*100* %
Compression Index, C_c		Dry Density, γ_d	*115.0* lb/ft³		
Classification *Gravelly Clayey SAND (SC)*		k_{20} at e_o =	× 10^{-} cm/sec		
LL *24*	G_s *2.67*	Project *Whitmanville Lake*			
PL *15*	D_{10} *0.002*				
Remarks *Specimen molded with -#4 mat'l at approx. water content of 15.0% and approx. dry density of 115.0 pcf. Cpt. water content plus 2% and 90% of max. density as determined from std compaction test curve.*		Area			
		Boring No. *BT-1*		Sample No. *B-3*	
		Depth *4.0'-6.0'*		Date *July 1971*	

CONSOLIDATION TEST REPORT

ENG FORM 1 MAY 63 2090 PREVIOUS EDITIONS ARE OBSOLETE.

Plate No. B-9a





Test No.			1	2	3	
Initial	Water content	w_o	11.0 %	11.0 %	10.8 %	%
	Void ratio	e_o	0.452	0.451	0.449	
	Saturation	S_o	65.1 %	65.3 %	64.3 %	%
	Dry density, lb/cu ft	γ_d	114.8	114.8	115.1	
Before Shear	Water content	w_c	— %	— %	— %	%
	Void ratio	e_c	—	—	—	
	Saturation	S_c	— %	— %	— %	%
	Final back pressure, T/sq ft	u_o	—	—	—	
Final	Water content	w_f	— %	— %	— %	%
	Void ratio	e_f	—	—	—	
Minor principal stress, T/sq ft		σ_3	1.08	3.24	5.40	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	4.35	7.83	12.46*	
Time to failure, min		t_f	7.2	12.0	15.1	
Rate of strain, percent/min			0.99	0.99	0.99	
			—	—	—	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	3.67*	7.56*	—	
Initial diameter, in.		D_o	2.80	2.80	2.80	
Initial height, in.		H_o	6.31	6.30	6.30	

Shear Strength Parameters

ϕ = 28.4°

tan ϕ = 0.540

c = 0.7 T/sq ft

Method of saturation None

☐ Controlled stress

☒ Controlled strain

Type of test Q | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL 24	PL 15	PI 9	D_{10} 0.002	G_s 2.67

Remarks *Stress @ 15% Strain
Specimens molded with #04 mat'l at approx. water content of 11.0% and approx. dry density of 115.0 pcf. Opt. water content - 2% and 96% of max. density as determined from std compaction curve

Project Whitmanville Dam and Lake

Area

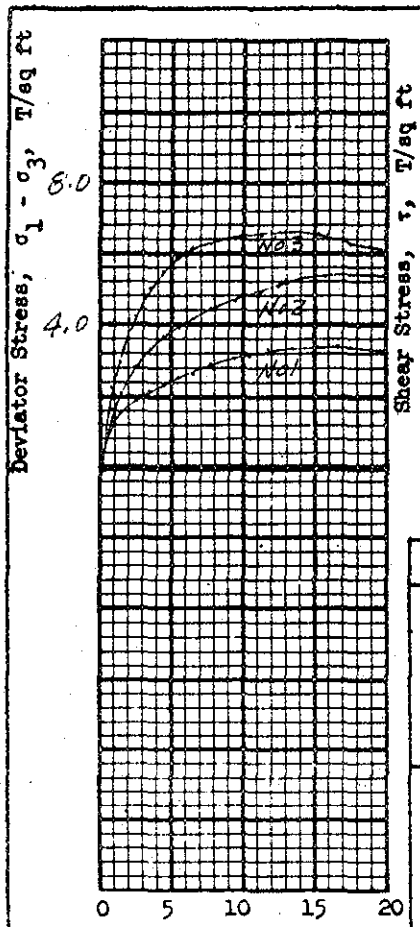
Boring No. BT-1 | Sample No. B-3

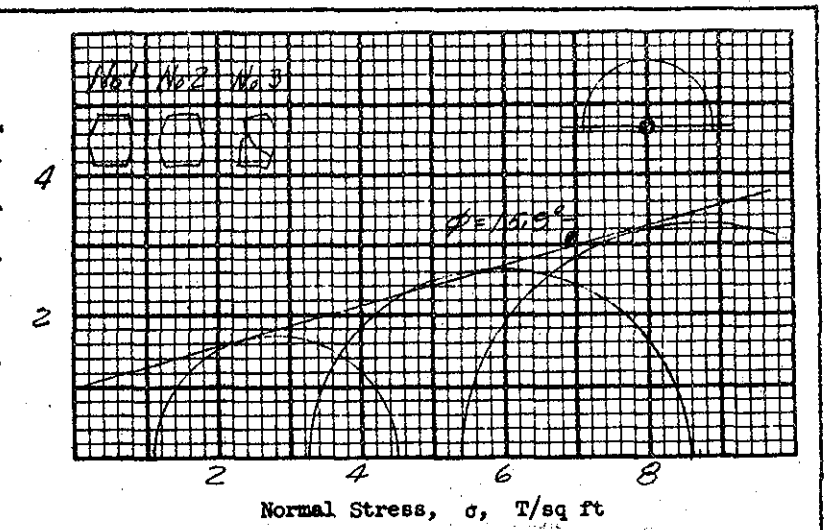
Depth 4.0'-6.0' | Date Jan 1971

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

TRANSLUCENT





Test No.			1	2	3	
Initial	Water content	w_o	12.8 %	12.9%	12.8%	%
	Void ratio	e_o	0.448	0.448	0.451	
	Saturation	S_o	76.6%	76.8%	75.6%	%
	Dry density, lb/cu ft	γ_d	115.1	115.1	114.8	
Before Shear	Water content	w_c	— %	— %	— %	%
	Void ratio	e_c	—	—	—	
	Saturation	S_c	— %	— %	— %	%
	Final back pressure, T/sq ft	u_o	—	—	—	
Final	Water content	w_f	— %	— %	— %	%
	Void ratio	e_f	—	—	—	
Minor principal stress, T/sq ft		σ_3	1.08	3.24	5.40	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	3.41*	5.34*	6.57	
Time to failure, min		t_f	15.1	15.1	13.6	
Rate of strain, percent/min			0.99	0.99	0.99	
			—	—	—	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	—	—	6.51*	
Initial diameter, in.		D_o	2.80	2.80	2.80	
Initial height, in.		H_o	6.30	6.30	6.31	

Shear Strength Parameters

ϕ = 15.9 °

tan ϕ = 0.285

c = 1.0 T/sq ft

Method of saturation None

☐ Controlled stress

☒ Controlled strain

Type of test Q	Type of specimen Remolded		
Classification Gravelly clayey SAND (SC)			
LL 24	PL 15	PI 9	D_{10} 0.002	G_s 2.67

Remarks *Stress @ 15% Strain. Specimens molded with -No4. mat'l at approx. water content of 13.0% and approx. dry density of 115.0 pcf, opt water content and 96% of max. density as determined from Std compaction test curve.

Project Whitmanville Dam and Lake

Area

Boring No. BT-1 | Sample No. B-3

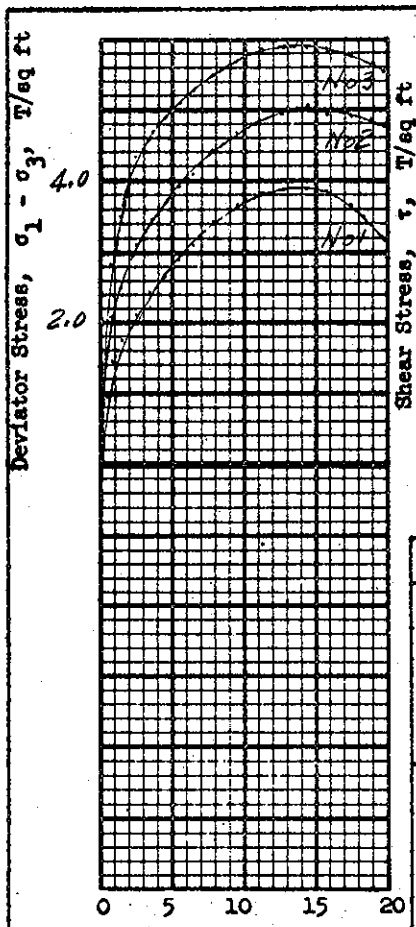
Depth El 4.0' - 6.0' | Date Jan. 1971

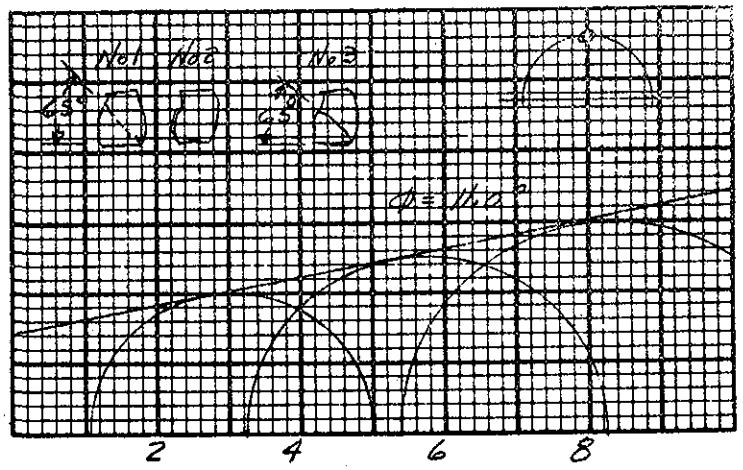
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-22

TRANSLUCENT





Test No.			1	2	3	
Initial	Water content	w_o	12.9 %	12.9 %	12.8 %	%
	Void ratio	e_o	0.388	0.388	0.387	
	Saturation	S_o	88.6 %	88.6 %	88.3 %	%
	Dry density, lb/cu ft	γ_d	120.1	120.1	120.2	
Before Shear	Water content	w_c	— %	— %	— %	%
	Void ratio	e_c	—	—	—	
	Saturation	S_c	— %	— %	— %	%
	Final back pressure, T/sq ft	u_o	—	—	—	
Final	Water content	w_f	— %	— %	— %	%
	Void ratio	e_f	—	—	—	
Minor principal stress, T/sq ft		σ_3	1.08	3.24	5.40	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	3.91	5.01	5.92	
Time to failure, min		t_f	14.4	14.4	14.4	
Rate of strain, percent/min			0.99	0.99	0.99	
			—	—	—	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	3.89*	5.01*	5.90*	
Initial diameter, in.		D_o	2.80	2.80	2.80	
Initial height, in.		H_o	6.30	6.30	6.30	

Shear Strength Parameters

ϕ = 11.0 °

tan ϕ = 0.195

c = 1.40 T/sq ft

Method of saturation None

☐ Controlled stress

☒ Controlled strain

Type of test Q | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL 24	PL 15	PI 9	D_{10} 0.002	G_s 2.67

Remarks *Stress @ 15% Strain
Specimens molded with -No4 mat'l. at approx. water content of 13% and approx. dry density of 119.8 pcf, opt. water content and max. density as determined from standard compaction test curve.

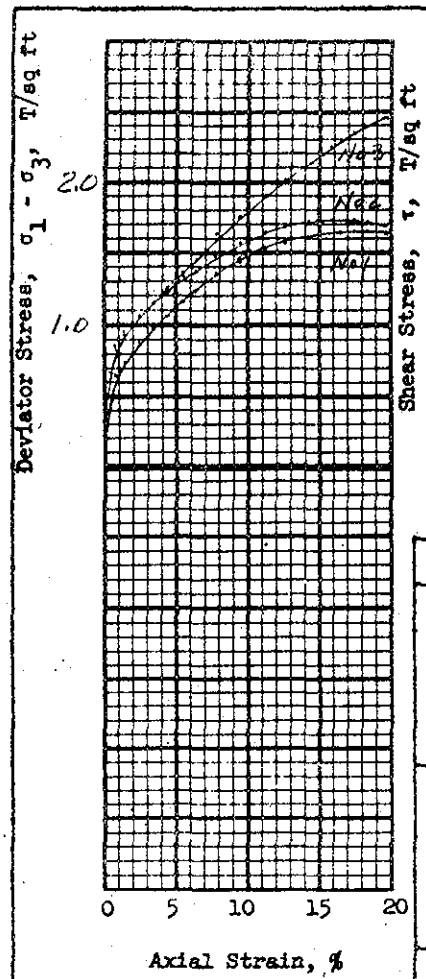
Project Whitmanville Dam and Lake

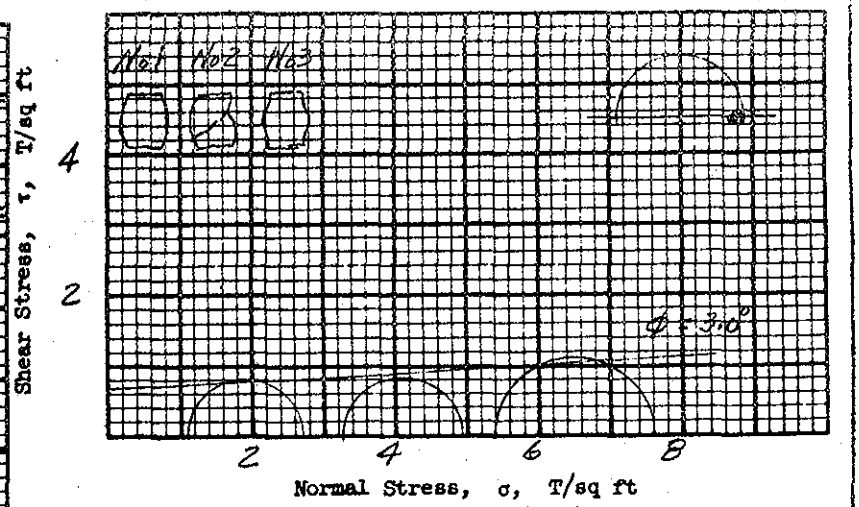
Area

Boring No. BT-1 | Sample No. B-3

Depth 4.0'-6.0' | Date Jan. 1971

TRIAXIAL COMPRESSION TEST REPORT





Test No.			1	2	3	
Initial	Water content	w_o	14.6 %	14.8 %	14.7 %	%
	Void ratio	e_o	0.448	0.447	0.440	
	Saturation	S_o	86.8 %	88.3 %	89.1 %	%
	Dry density, lb/cu ft	γ_d	115.1	115.2	115.8	
Before Shear	Water content	w_c	— %	— %	— %	%
	Void ratio	e_c	—	—	—	
	Saturation	S_c	— %	— %	— %	%
	Final back pressure, T/sq ft	u_o	—	—	—	
Final	Water content	w_f	— %	— %	— %	%
	Void ratio	e_f	—	—	—	
Minor principal stress, T/sq ft		σ_3	1.08	3.24	5.40	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	1.63*	1.71*	2.19*	
Time to failure, min		t_f	15.2	15.2	15.1	
Rate of strain, percent/min			0.99	0.99	1.00	
			—	—	—	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	—	—	—	
Initial diameter, in.		D_o	2.80	2.80	2.80	
Initial height, in.		H_o	6.31	6.31	6.28	

Shear Strength Parameters

ϕ = 3.0 °

tan ϕ = 0.053

c = 0.70 T/sq ft

Method of saturation None

☐ Controlled stress

☒ Controlled strain

Type of test Q	Type of specimen Remolded			
Classification Gravelly clayey SAND (SC)				
LL 24	PL 15	PI 9	D_{10} 0.002	G_s 2.67

Remarks * Stress @ 15% Strain. Specimen molded with -No4 mat'l at approx. water content of 15.0% and approx. dry density of 115.0 pcf. Opt. water content plus 2% and 96% of max. density as determined from Std. compaction test curve.

Project Whitmanville Dam and Lake

Area

Boring No. BT-1 | Sample No. B-3

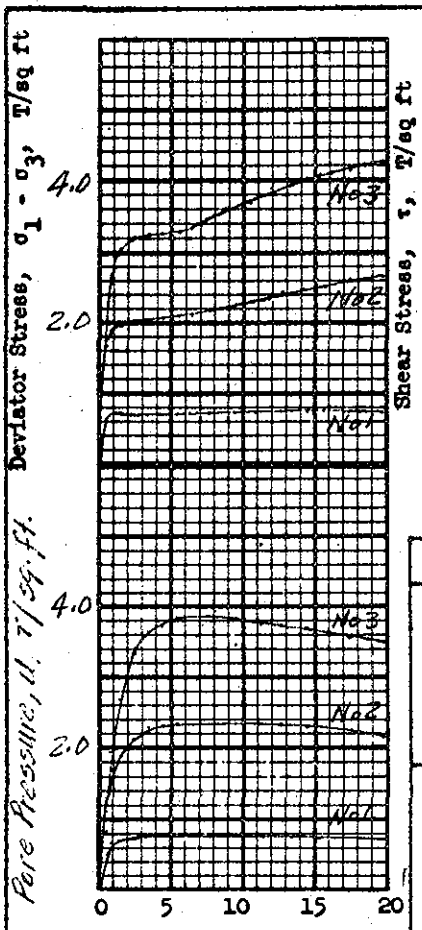
Depth ~~Ft~~ 4.0'-6.0' | Date Jan 1971

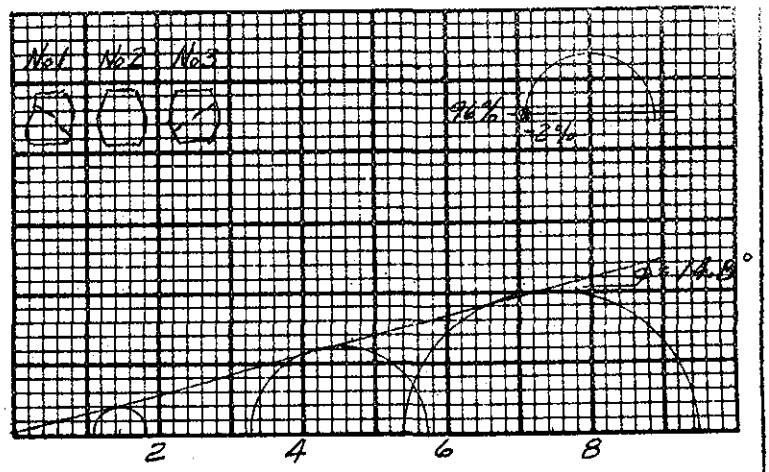
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-33

TRANSLUCENT





Test No.			1	2	3	
Initial	Water content	w_o	11.1 %	11.0 %	11.2 %	%
	Void ratio	e_o	0.451	0.450	0.453	
	Saturation	S_o	65.6 %	65.4 %	65.9 %	%
	Dry density, lb/cu ft	γ_d	114.9	115.0	114.7	
Before Shear	Water content	w_c	17.3 %	15.9 %	14.8 %	%
	Void ratio	e_c	0.461	0.423	0.394	
	Saturation	S_c	100 %	100 %	100 %	%
	Final back pressure, T/sq ft	u_o	7.20	7.20	7.20	
Final	Water content	w_f	17.3 %	15.9 %	14.8 %	%
	Void ratio	e_f	0.461	0.423	0.394	
Minor principal stress, T/sq ft		σ_3	1.08	3.24	5.40	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	0.72	2.52*	4.05*	
Time to failure, min		t_f	10.8	101.6	101.0	
Rate of strain, percent/min			0.15	0.15	0.15	
Pore Pressure T/sq. ft.		u	+0.73	+2.29	+3.69	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	0.70	—	—	
Initial diameter, in.		D_o	2.80	2.80	2.80	
Initial height, in.		H_o	6.30	6.31	6.32	

Shear Strength Parameters

ϕ = 14.8 °

tan ϕ = 0.265

c = 0.10 T/sq ft

Method of saturation Back pressure

☐ Controlled stress

☒ Controlled strain

Type of test R | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL	PL	PI	D_{10}	G_s
24	15	9	0.002	2.67

Remarks *Stress @ 15% Strain. Specimens molded with -No4 matl at approx. water content of 11.0% and approx. dry density of 115.0 pcf. 96% of max. density and opt. water content minus 2% as determined from std compaction curve.

Sheet 1 of 2

Project Whitnanville Dam and Lake

Area

Boring No. BT-1 | Sample No. B-3

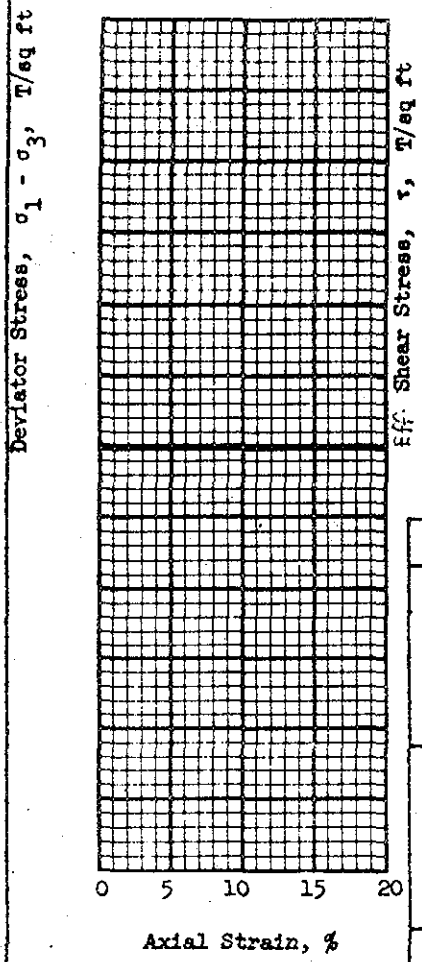
Depth 4.0'-6.0' | Date Jan. 1971

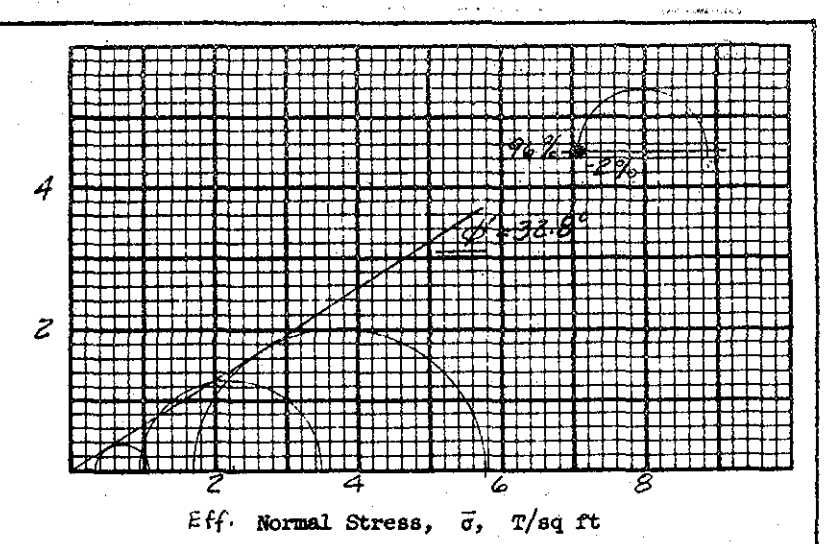
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-14

TRANSLUCENT





Test No.			1	2	3	
Initial	Water content	w_o	%	%	%	%
	Void ratio	e_o				
	Saturation	S_o	%	%	%	%
	Dry density, lb/cu ft	γ_d				
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final back pressure, T/sq ft	u_o				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
Minor principal stress, T/sq ft Eff		$\bar{\sigma}_3$	0.35	0.95*	1.71*	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$				
Time to failure, min		t_f				
Rate of strain, percent/min						
Major Principal Stress, T/sq. ft.		$\bar{\sigma}_1$	1.07	3.48*	5.76*	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$				
Initial diameter, in.		D_o				
Initial height, in.		H_o				

Shear Strength Parameters

$\bar{\phi}$ = 32.8 °

tan $\bar{\phi}$ = 0.645

$\bar{c}$ = 0 T/sq ft

Method of saturation Backpressure

☐ Controlled stress

☒ Controlled strain

Type of test $\bar{R}$ | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL 24	PL 15	PI 9	D_{10} 0.002	G_s 2.67

Remarks *Stress @ 15% Strain

See Sheet 1 of 2 for other data.

Sheet 2 of 2

Project Whitmanville Dam and Lake

Area

Boring No. BT-1 | Sample No. B-3

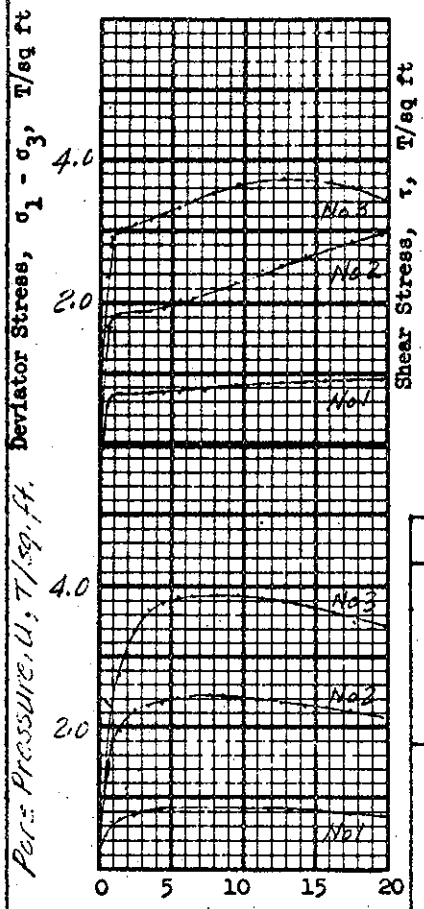
Depth 4.0'-6.0' | Date Jan 1971

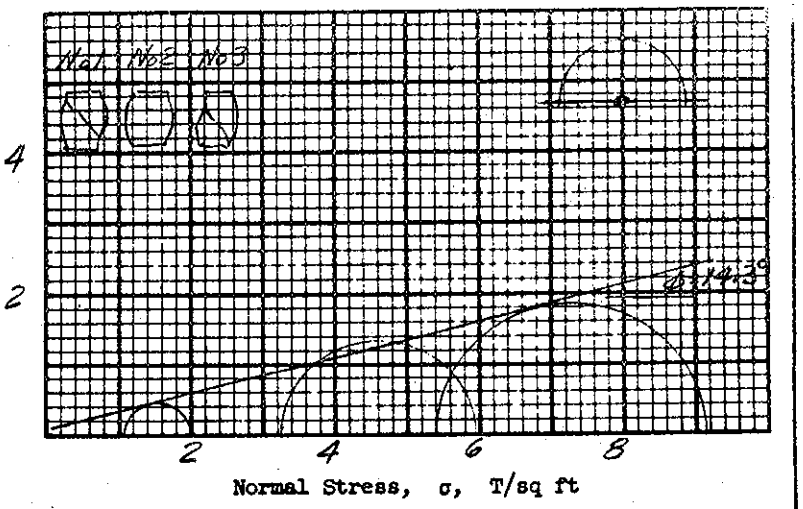
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

TRANSLUCENT

PLATE NO. B-15





Test No.			1	2	3	
Initial	Water content	w_o	13.1 %	13.1 %	13.0 %	%
	Void ratio	e_o	0.451	0.431	0.450	
	Saturation	S_o	77.5 %	81.4 %	77.3 %	%
	Dry density, lb/cu ft	γ_d	114.9	116.5	115.0	
Before Shear	Water content	w_c	16.9 %	14.8 %	14.4 %	%
	Void ratio	e_c	0.451	0.395	0.384	
	Saturation	S_c	100 %	100 %	100 %	%
	Final back pressure, T/sq ft	u_o	7.20	7.20	7.20	
Final	Water content	w_f	16.9 %	14.8 %	14.4 %	%
	Void ratio	e_f	0.451	0.395	0.384	
Minor principal stress, T/sq ft		σ_3	1.08	3.24	5.40	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	0.92*	2.72*	3.74	
Time to failure, min		t_f	102.1	101.9	86.4	
Rate of strain, percent/min			0.15	0.15	0.15	
Pore Pressure T/sq.ft.		U	+0.81*	+2.31*	+3.81	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	—	—	3.71*	
Initial diameter, in.		D_o	2.80	2.77	2.80	
Initial height, in.		H_o	6.30	6.34	6.30	

Shear Strength Parameters

ϕ = 14.3 °

tan ϕ = 0.255

c = 0.1 T/sq ft

Method of saturation Back pressure

☐ Controlled stress

☒ Controlled strain

Type of test R | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL 24 | PL 15 | PI 9 | D_{10} 0.002 | G_s 2.67

Remarks *Stress @ 15% Strain
Specimens molded with No.4 mat'l at approx. water content of 13.0% and approx. dry density of 115.0 pcf (opt. water content and 96% of max. density as determined from std compaction test curve.

Project Whitmanville Dam and Lake

Area

Boring No. BT-1 | Sample No. B-3

Depth El 4.0'-6.0' | Date Jan. 1971

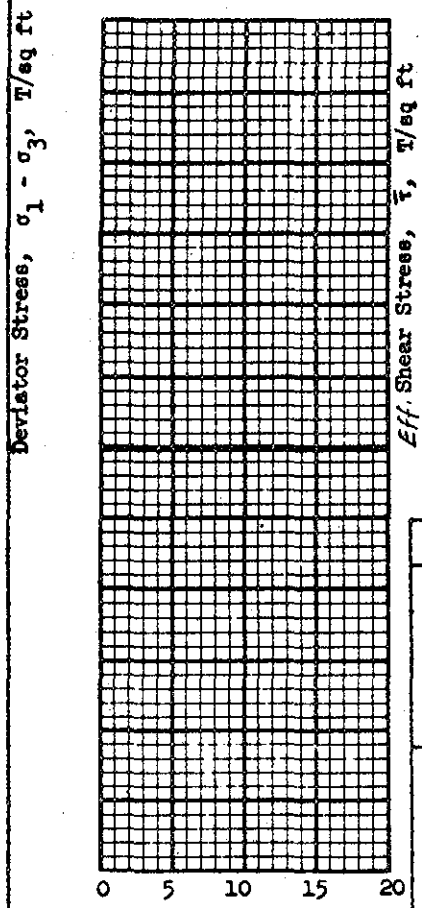
Sheet 1 of 2

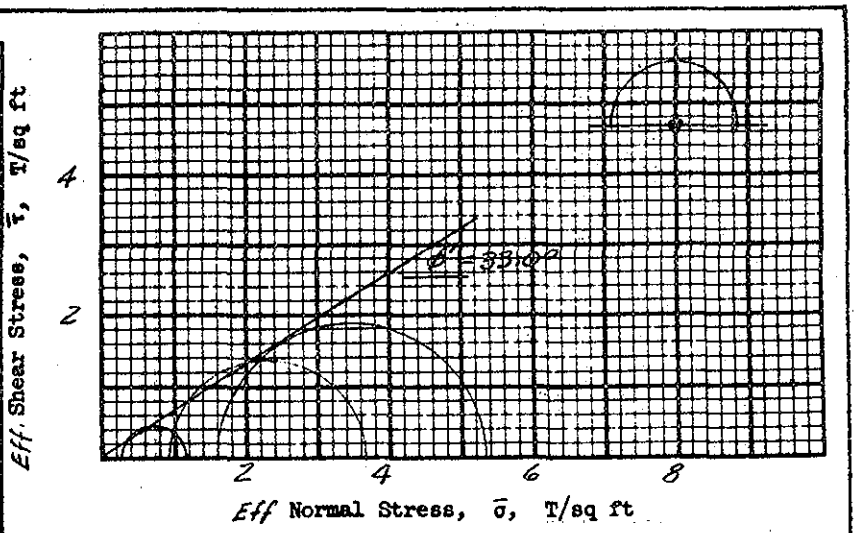
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-16

TRANSLUCENT





Test No.			1	2	3	
Initial	Water content	w_o	%	%	%	%
	Void ratio	e_o				
	Saturation	S_o	%	%	%	%
	Dry density, lb/cu ft	γ_d				
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final back pressure, T/sq ft	u_o				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
Minor principal stress, T/sq ft Eff.		$\bar{\sigma}_3$	0.27*	0.94*	1.59	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$				
Time to failure, min		t_f				
Rate of strain, percent/min						
Major principal stress, T/sq ft. Eff.		$\bar{\sigma}_1$	1.18*	3.65*	5.33	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$				
Initial diameter, in.		D_o				
Initial height, in.		H_o				

Shear Strength Parameters

ϕ = 33.0 °

tan ϕ = 0.650

c = 0 T/sq ft

Method of saturation Backpressure

☐ Controlled stress

☒ Controlled strain

Type of test $\bar{R}$ | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL	PL	PI	D_{10}	G_s
24	15	9	0.002	2.67

Remarks *Stress @ 15% Strain

See Sheet 1 of 2 for other data.

Sheet 2 of 2

Project Whitmanville Dam and Lake

Area

Boring No. BT-1 | Sample No. B-3

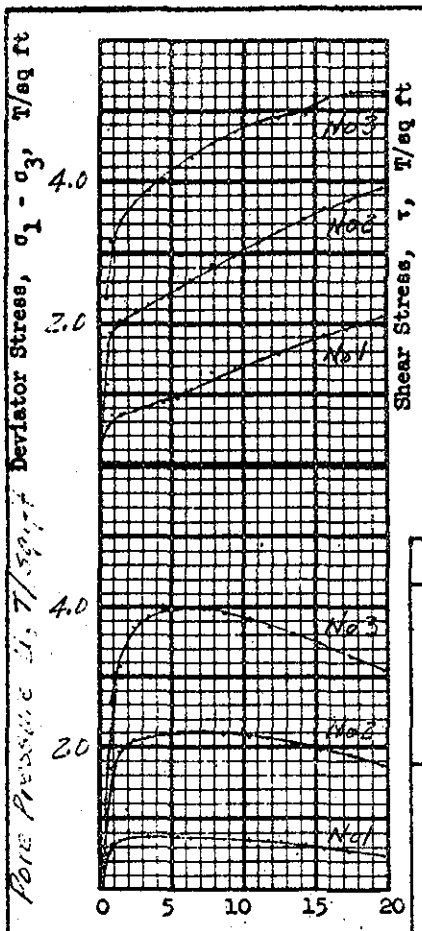
Depth 4.0'-6.0' | Date Jan. 1971

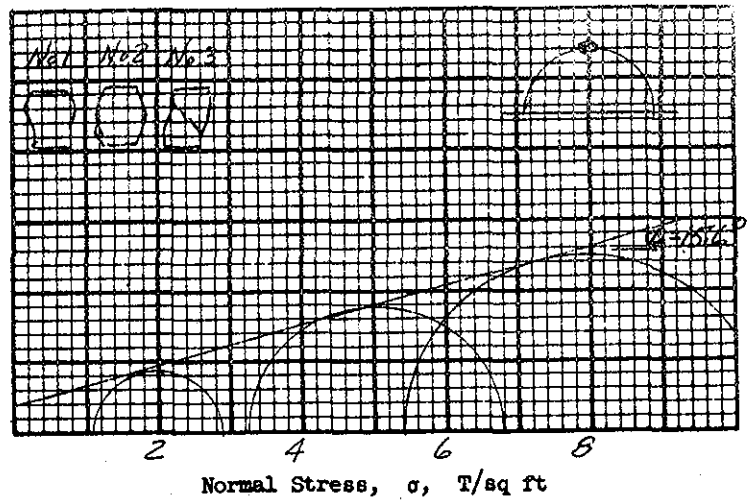
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-17

TRANSLUCENT





Test No.			1	2	3	
Initial	Water content	w_o	12.9 %	13.1 %	13.2 %	%
	Void ratio	e_o	0.385	0.392	0.393	
	Saturation	S_o	89.5 %	89.1 %	89.6 %	%
	Dry density, lb/cu ft	γ_d	120.3	119.8	119.6	
Before Shear	Water content	w_c	14.4 %	14.3 %	13.9 %	%
	Void ratio	e_c	0.385	0.382	0.372	
	Saturation	S_c	100 %	100 %	100 %	%
	Final back pressure, T/sq ft	u_o	7.20	7.20	7.20	
Final	Water content	w_f	14.4 %	14.3 %	13.9 %	%
	Void ratio	e_f	0.385	0.382	0.372	
Minor principal stress, T/sq ft		σ_3	1.08	3.24	5.40	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	1.79*	3.54*	5.03*	
Time to failure, min		t_f	102.7	102.5	101.6	
Rate of strain, percent/min			0.15	0.15	0.15	
Pore Pressure T/sq. ft.		u	+0.61*	+1.98*	+3.49*	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	—	—	—	
Initial diameter, in.		D_o	2.79	2.79	2.80	
Initial height, in.		H_o	6.34	6.34	6.30	

Shear Strength Parameters

ϕ = 15.6 °

tan ϕ = 0.280

c = 0.4 T/sq ft

Method of saturation Backpressure

☐ Controlled stress

☒ Controlled strain

Type of test R | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL 24	PL 15	PI 9	D_{10} 0.002	G_s 2.67

Remarks *Stress @ 15% Strain
Specimens molded with - No 4 mat'l. at approx water content of 13.0% and approx. dry density of 119.8 pcf as determined from standard compaction test curve at maximum density and opt. water content

Sheet 1 of 2

Project Wilmanville Dam and Lake

Area

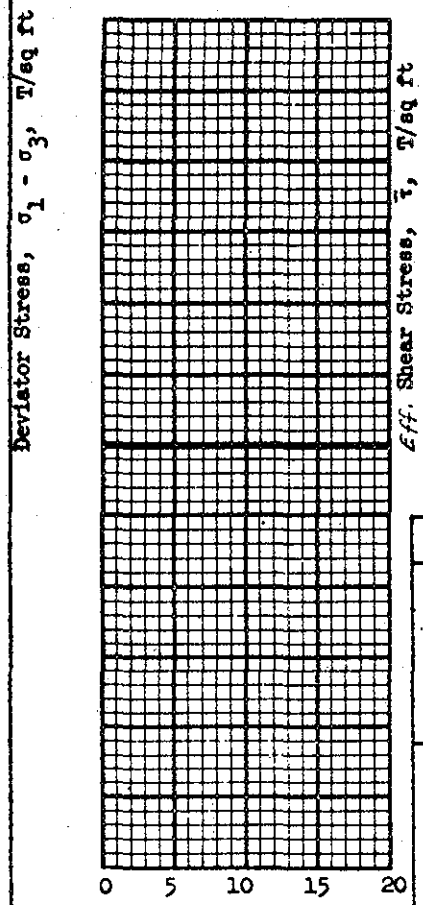
Boring No. BT-1 | Sample No. B-3

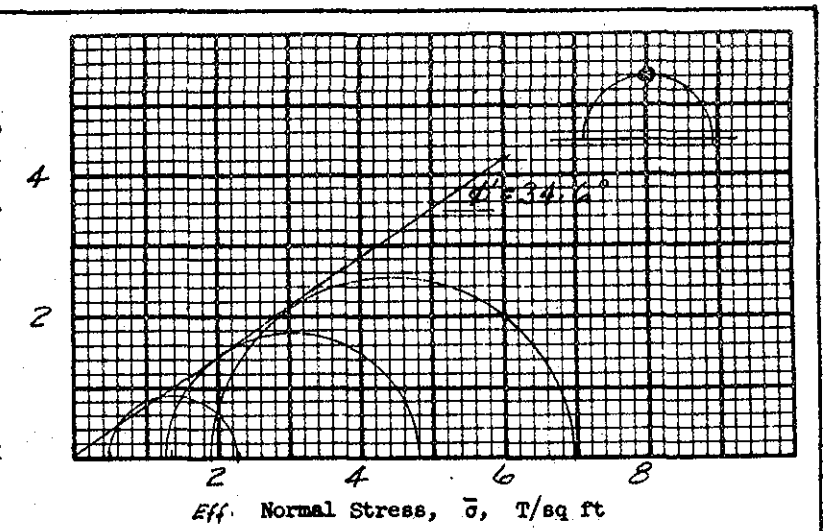
Depth El. 4.0' - 6.0' | Date Jan. 1971

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

TRANSLUCENT





Test No.			1	2	3	
Initial	Water content	w_o	%	%	%	%
	Void ratio	e_o				
	Saturation	S_o	%	%	%	%
	Dry density, lb/cu ft	γ_d				
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final back pressure, T/sq ft	u_o				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
Minor principal stress, T/sq ft Eff.		$\bar{\sigma}_3$	0.47*	1.26*	1.91*	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$				
Time to failure, min		t_f				
Rate of strain, percent/min						
Major Principal Stress, T/sq.ft Eff.		$\bar{\sigma}_1$	2.26*	4.80*	6.94*	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$				
Initial diameter, in.		D_o				
Initial height, in.		H_o				

Shear Strength Parameters

$\phi' =$ 34.6°

$\tan \phi' =$ 0.690

$c' =$ 0 T/sq ft

Method of saturation Back pressure

☐ Controlled stress

☒ Controlled strain

Type of test $\bar{R}$ | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL 24	PL 15	PI 9	D_{10} 0.002	G_s 2.67

Remarks *Stress @ 15% Strain
See Sheet 1 of 2 for other data

Project Whitmanville Dam and Lake

Area

Boring No. BT-1 | Sample No. B-3

Depth 4.0'-6.0' | Date Jan. 1971

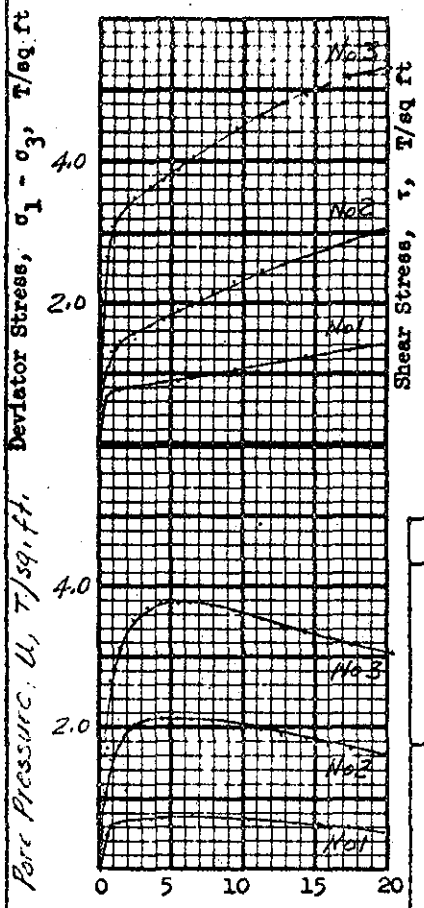
Sheet 2 of 2

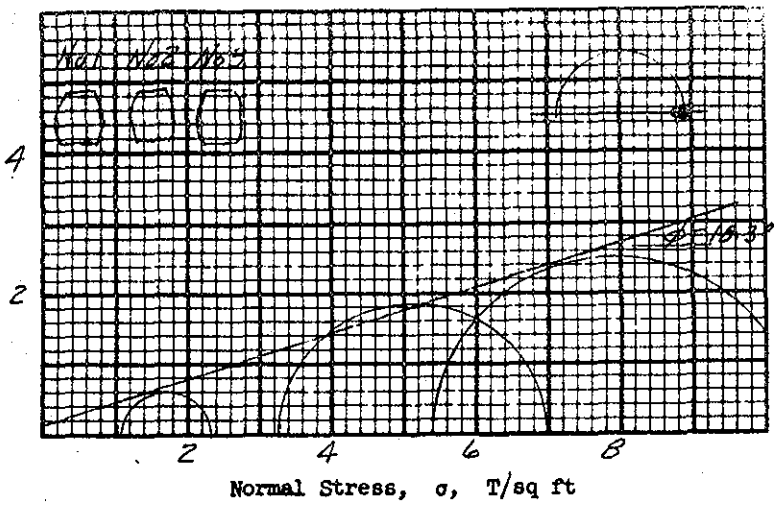
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-19

TRANSLUCENT





Test No.			1	2	3	
Initial	Water content	w_o	14.6 %	14.8 %	14.8 %	%
	Void ratio	e_o	0.439	0.447	0.444	
	Saturation	S_o	89.0 %	88.5 %	88.8 %	%
	Dry density, lb/cu ft	γ_d	115.9	115.2	115.4	
Before Shear	Water content	w_c	16.2 %	15.0 %	14.6 %	%
	Void ratio	e_c	0.431	0.401	0.390	
	Saturation	S_c	100 %	100 %	100 %	%
	Final back pressure, T/sq ft	u_o	7.20	7.20	7.20	
Final	Water content	w_f	16.2 %	15.0 %	14.6 %	%
	Void ratio	e_f	0.431	0.401	0.390	
Minor principal stress, T/sq ft		σ_3	1.08	3.24	5.40	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	1.27*	3.74*	4.99*	
Time to failure, min		t_f	101.4	98.8	96.9	
Rate of strain, percent/min			0.15	0.15	0.15	
Pore Pressure T/sq.ft.		u	+0.65*	+1.83*	+3.36*	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	—	—	—	
Initial diameter, in.		D_o	2.80	2.80	2.80	
Initial height, in.		H_o	6.27	6.30	6.30	

Shear Strength Parameters

ϕ = 18.3 °

tan ϕ = 0.330

c = 0.15 T/sq ft

Method of saturation Backpressure

☐ Controlled stress

☒ Controlled strain

Type of test R | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL	PL	PI	D_{10}	G_s
24	15	9	0.002	2.67

Remarks *Stress @ 15% Strain
Specimens molded with No 4 Mat'l, at approx. water content of 15% and approx. dry density of 115.0 pcf, Optimum water content plus 2% and 96% of max. density as determined from std compaction curve.

Sheet 1 of 2

Project Whitmanville Dam and Lake

Area

Boring No. BT-1 | Sample No. B-3

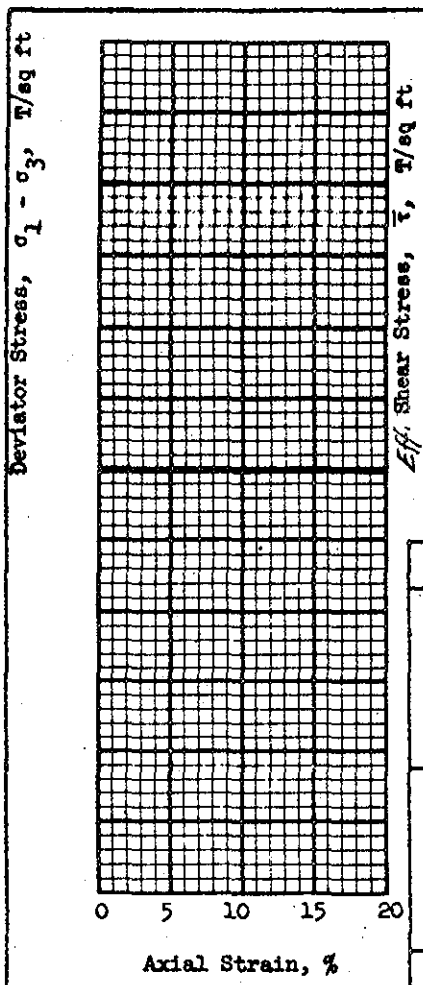
Depth 4.0'-6.0' | Date Jan. 1971

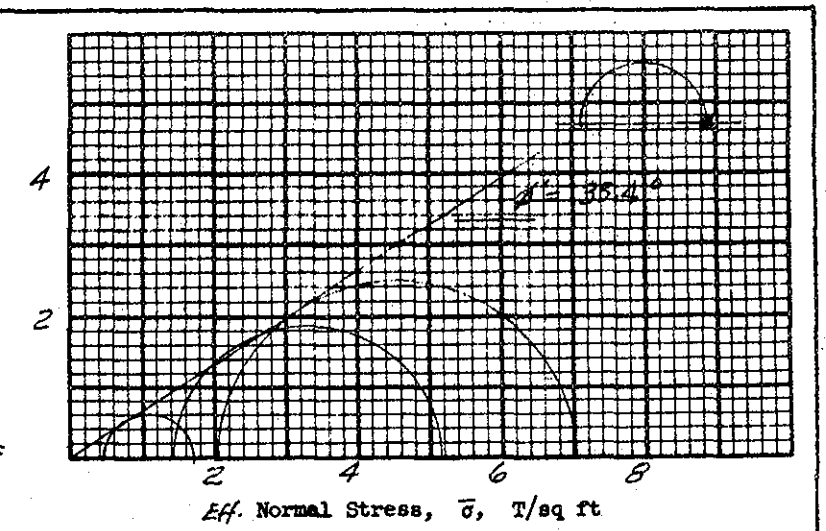
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-20

TRANSLUCENT





Test No.			1	2	3	
Initial	Water content	w_o	%	%	%	%
	Void ratio	e_o				
	Saturation	S_o	%	%	%	%
	Dry density, lb/cu ft	γ_d				
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final back pressure, T/sq ft	u_o				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
Minor principal stress, T/sq ft Eff		$\bar{\sigma}_3$	0.43*	1.42*	2.04*	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$				
Time to failure, min		t_f				
Rate of strain, percent/min						
Major Principal Stress, T/sq.ft. Eff.		$\bar{\sigma}_1$	1.70*	5.15*	7.03*	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$				
Initial diameter, in.		D_o				
Initial height, in.		H_o				

Shear Strength Parameters

$\phi' =$ 33.4 °

$\tan \phi' =$ 0.660

$c' =$ 0 T/sq ft

Method of saturation Backpressure

☐ Controlled stress

☒ Controlled strain

Type of test $\bar{R}$	Type of specimen Remolded			
Classification Gravelly clayey SAND (SC)				
LL 24	PL 15	PI 9	D_{10} 0.002	G_s 2.67

Remarks *Stress @ 15% Strain
See Sheet 1 of 2 for other data.

Project Whitmanville Dam and Lake

Area

Boring No. BT-1 | Sample No. B-3

Depth ~~El~~ 4.0'-6.0' | Date Jan. 1971

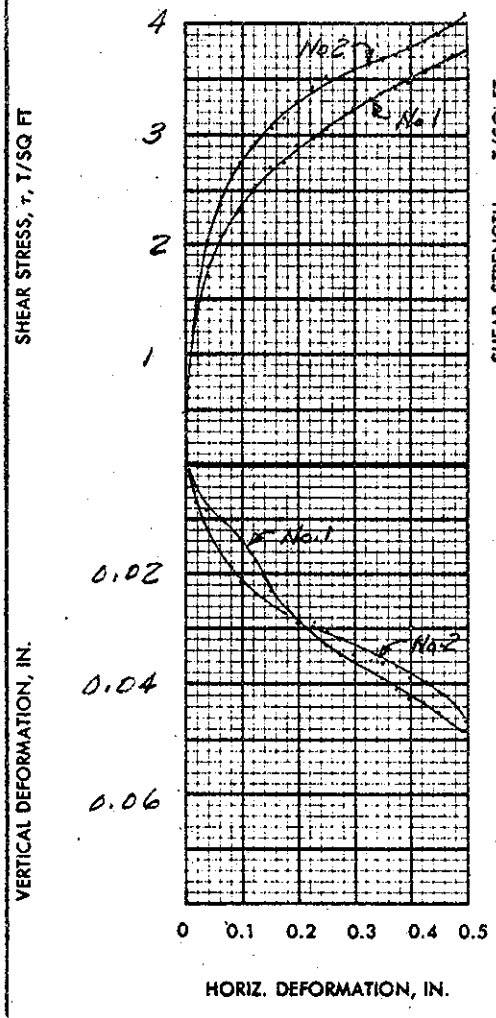
Sheet 2 of 2

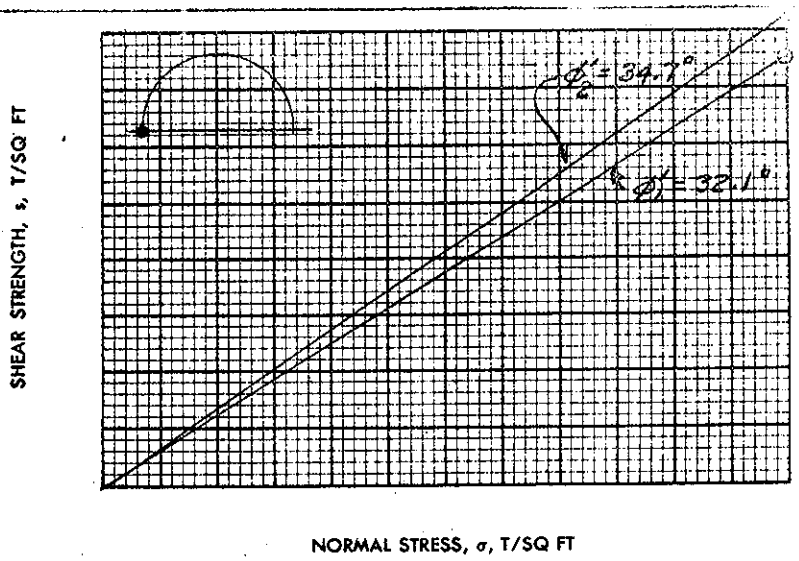
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

TRANSLUCENT

PLATE NO. B-21





TEST NO.			1	2		
INITIAL	WATER CONTENT	w_o	10.8 %	10.8 %	%	%
	VOID RATIO	e_o	0.447	0.440		
	SATURATION	S_o	64.8%	65.8%	%	%
	DRY DENSITY, LB/CU FT	γ_d	115.2	115.7		
VOID RATIO AFTER CONSOLIDATION		e_c	0.390	0.392		
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.48	0.48		
FINAL	WATER CONTENT	w_f	12.9%	12.5%	%	%
	VOID RATIO	e_f	0.255	0.261		
	SATURATION	S_f	100+%	100+%	%	%
NORMAL STRESS, T/SQ FT		σ	6.00	6.00		
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	3.77	4.16		
ACTUAL TIME TO FAILURE, MIN		t_f	98	95		
RATE OF STRAIN, IN./MIN			0.005	0.005		
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	—	—		

SHEAR STRENGTH PARAMETERS

ϕ' = 32.1°

TAN ϕ' = 0.628

c' = 0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN Remolded 3.0 IN. SQUARE 0.5 IN. THICK

CLASSIFICATION Gravelly clayey SAND (SC)

LL 24 PL 15 PI 9 D_{10} 0.002 G_s 2.67

REMARKS Specimens molded with -No4 mat'l. at approx. water content of 11.0% and approx. dry density of 115.0 pcf, opt. minus 2% and 96% of max. density as determined from std compaction curve.

PROJECT Whitmanville Dam and Lake

AREA

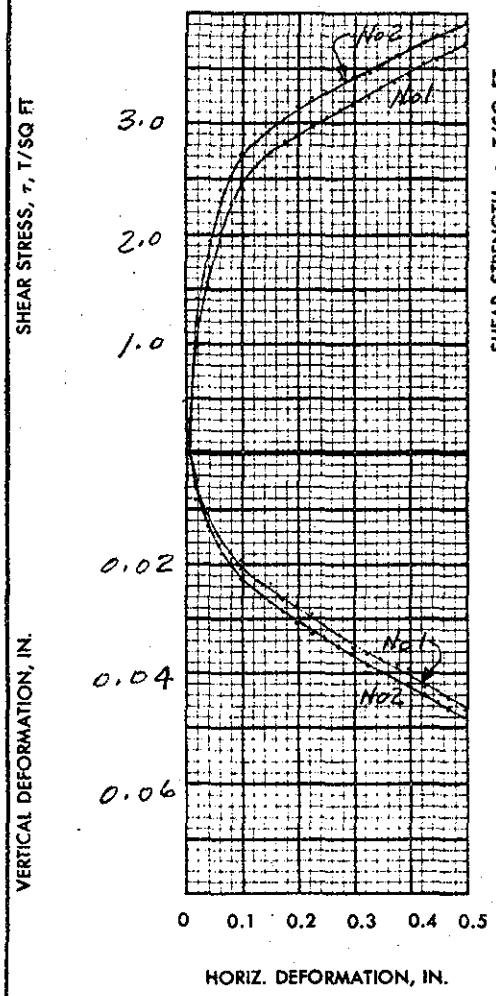
BORING NO. BT-1 SAMPLE NO. B-3

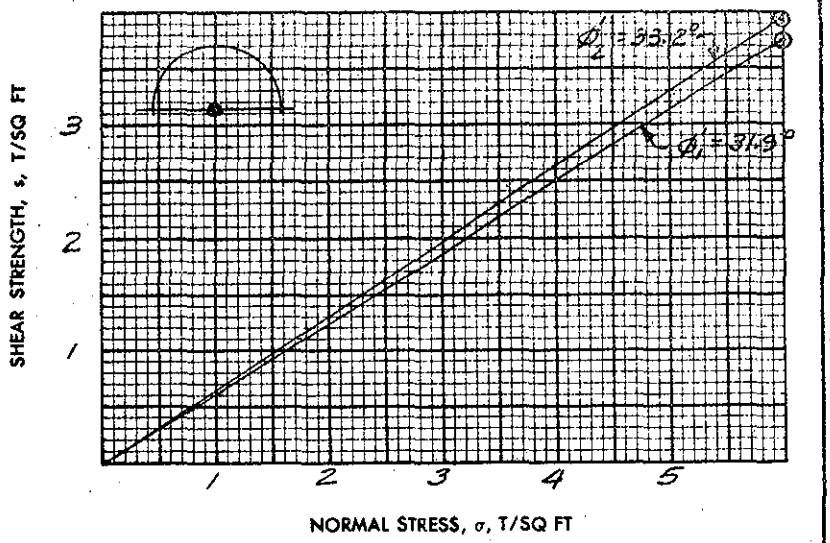
DEPTH EL 4.0'-6.0' DATE Dec. 1970

DIRECT SHEAR TEST REPORT PLATE NO. B-22

ENG FORM 1 JUN 65 2092 (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) GPO : 1966 OF—214-945

PLATE IX-3





TEST NO.			1	2		
INITIAL	WATER CONTENT	w_o	13.1 %	13.1 %	%	%
	VOID RATIO	e_o	0.445	0.446		
	SATURATION	S_o	78.5%	78.3%	%	%
	DRY DENSITY, LB/CU FT	γ_d	115.4	115.2		
VOID RATIO AFTER CONSOLIDATION		e_c	0.379	0.400		
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.40	0.50		
FINAL	WATER CONTENT	w_f	12.8 %	12.9%	%	%
	VOID RATIO	e_f	0.252	0.268		
	SATURATION	S_f	100+ %	100 %	%	%
NORMAL STRESS, T/SQ FT		σ	6.00	6.00		
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	3.74	3.93		
ACTUAL TIME TO FAILURE, MIN		t_f	125	124		
RATE OF STRAIN, IN./MIN			0.004	0.004		
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	—	—		

SHEAR STRENGTH PARAMETERS

ϕ' = 31.9°

TAN ϕ' = 0.623

c' = 0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN Remolded — 3.0 IN. SQUARE — 0.5 IN. THICK

CLASSIFICATION Gravelly clayey SAND (SC)

LL 24	PL 15	PI 9	D_{10} 0.002	G_s 2.67

REMARKS Specimens molded with No4 mat'l at approx. water content of 13.0% and approx. dry density of 115.0 pcf, opt. water content and 96% of max density as determined from std compaction curve

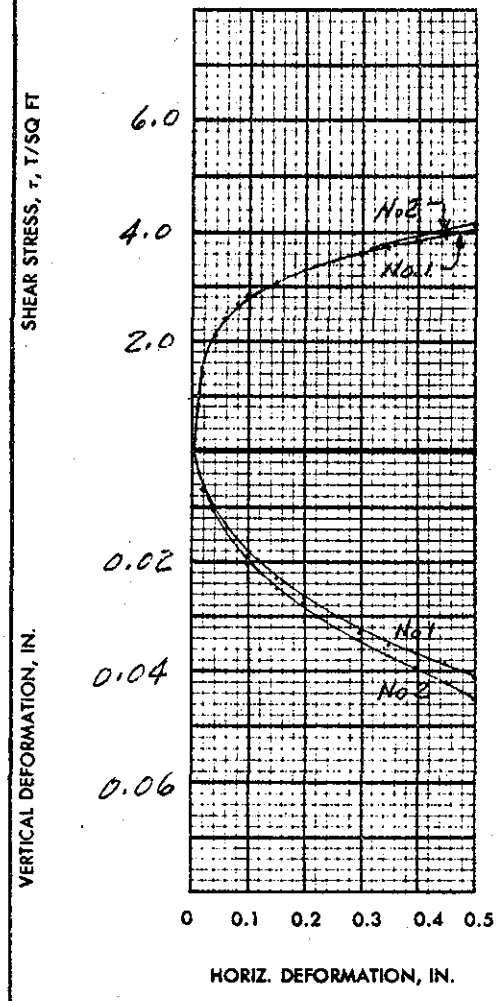
PROJECT Whitmanville Dam and Lake

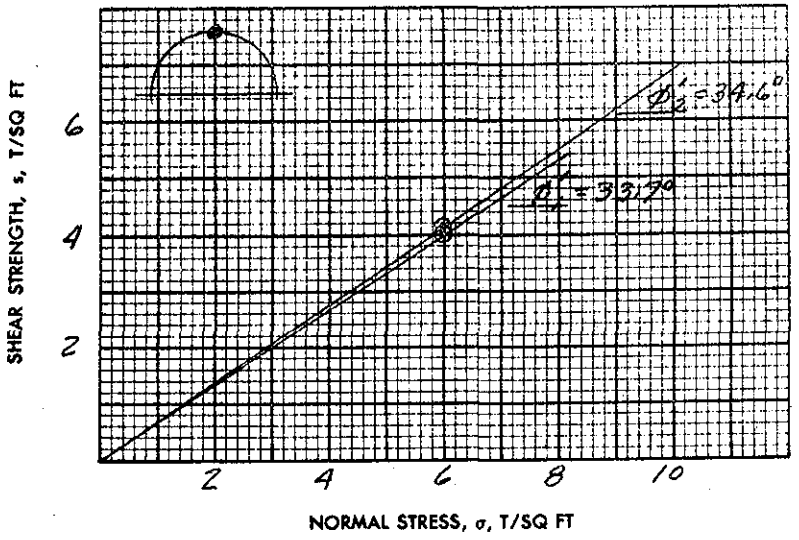
AREA

BORING NO. BT-1 — SAMPLE NO. B-3

DEPTH 4.0'-6.0' — DATE Jan. 1971

DIRECT SHEAR TEST REPORT PLATE NO. B-23





TEST NO.			1	2		
INITIAL	WATER CONTENT	w_o	12.8 %	12.9 %	%	%
	VOID RATIO	e_o	0.391	0.381		
	SATURATION	S_o	87.1%	90.4%	%	%
	DRY DENSITY, LB/CU FT	γ_d	119.8	120.7		
VOID RATIO AFTER CONSOLIDATION		e_c	0.362	0.342		
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.58	0.45		
FINAL	WATER CONTENT	w_f	12.9%	13.4 %	%	%
	VOID RATIO	e_f	0.255	0.225		
	SATURATION	S_f	100 %	100 %	%	%
NORMAL STRESS, T/SQ FT		σ	6.00	6.00		
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	4.02	4.14		
ACTUAL TIME TO FAILURE, MIN		t_f	92	60.0		
RATE OF STRAIN, IN./MIN			0.005	0.008		
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	—	—		

SHEAR STRENGTH PARAMETERS

ϕ' = 33.7°

TAN ϕ' = 0.6698

c' = 0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN	Remolded	3.0 IN. SQUARE	0.5 IN. THICK
CLASSIFICATION	Gravelly clayey SAND (SC)		
LL 24	PL 15	PI 9	D_{10} 0.002	G_s 2.67

REMARKS Specimens molded with No.4 mat'l at approx. water content of 13.0% and approx. dry density of 119.8 pcf. Opt. water content and max density as determined from std compaction test curve.

PROJECT Whitmanville Dam and Lake

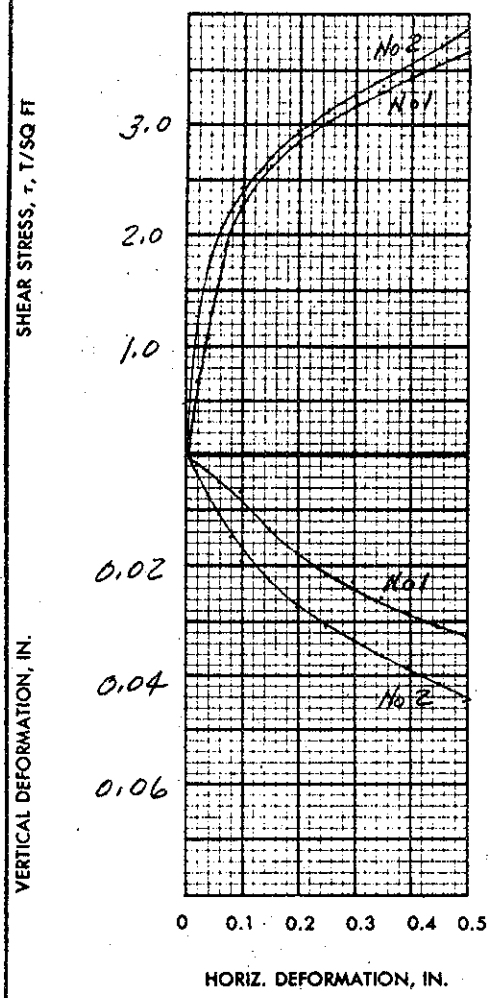
AREA

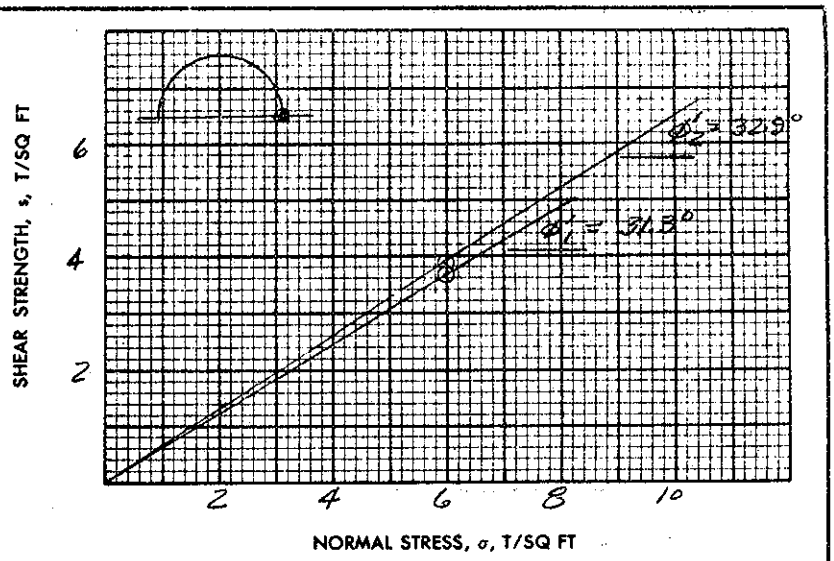
BORING NO. BT-1 SAMPLE NO. B-3

DEPTH 4.0'-6.0' DATE Jan 1971

DIRECT SHEAR TEST REPORT PLATE NO. B-21

ENG FORM 1 JUN 65 2092 (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) GPO : 1966 OF—214-945





TEST NO.			1	2		
INITIAL	WATER CONTENT	w_o	14.9%	14.9%	%	%
	VOID RATIO	e_o	0.450	0.446		
	SATURATION	S_o	88.6%	89.4%	%	%
	DRY DENSITY, LB/CU FT	γ_d	115.0	115.3		
VOID RATIO AFTER CONSOLIDATION		e_c	0.360	0.375		
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.46	0.44		
FINAL	WATER CONTENT	w_f	12.6%	12.8%	%	%
	VOID RATIO	e_f	0.270	0.263		
	SATURATION	S_f	100%	100%	%	%
NORMAL STRESS, T/SQ FT		σ	6.00	6.00		
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	3.65	3.88		
ACTUAL TIME TO FAILURE, MIN		t_f	124	94		
RATE OF STRAIN, IN./MIN			0.004	0.005		
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	—	—		

SHEAR STRENGTH PARAMETERS

ϕ' = 31.3°

TAN ϕ' = 0.609

c' = 0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN Remolded — 3.0 IN. SQUARE — 0.5 IN. THICK

CLASSIFICATION Gravelly clayey SAND (SC)

LL	PL	PI	D_{10}	G_s
24	15	9	0.002	2.67

REMARKS Specimens molded with No 4 mat'l at approx. water content of 15.0% and approx. dry density of 115.0 pcf., Opt. plus 2% water content and 96% of max. density as determined from Std. Compaction test curve

PROJECT Whitmanville Dam and Lake

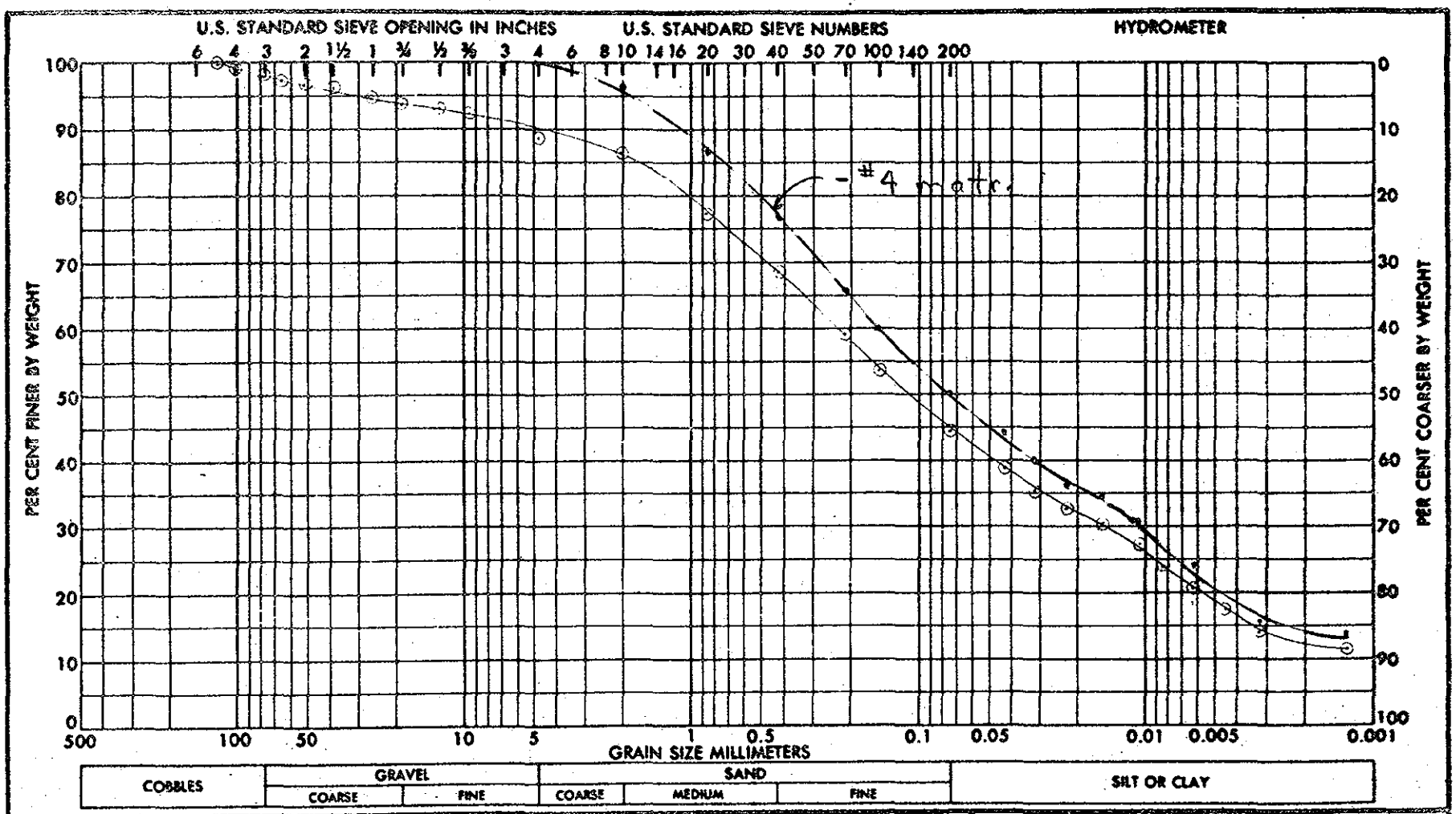
AREA

BORING NO. BT-1 — SAMPLE NO. B-3

DEPTH 4.0'-6.0' — DATE Jan. 1971

DIRECT SHEAR TEST REPORT PLATE NO. B-25

ENG FORM 1 JUN 65 **2092** (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) GPO : 1966 OF—214-945



SAMPLE NO.	ELEV-OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
B-6	6.0'-12.0'	Gravelly clayey SAND (SC)		24	15	9

PROJECT Whitmanville Dam & Lake

AREA

BORING NO. BT-1

DATE October 1970

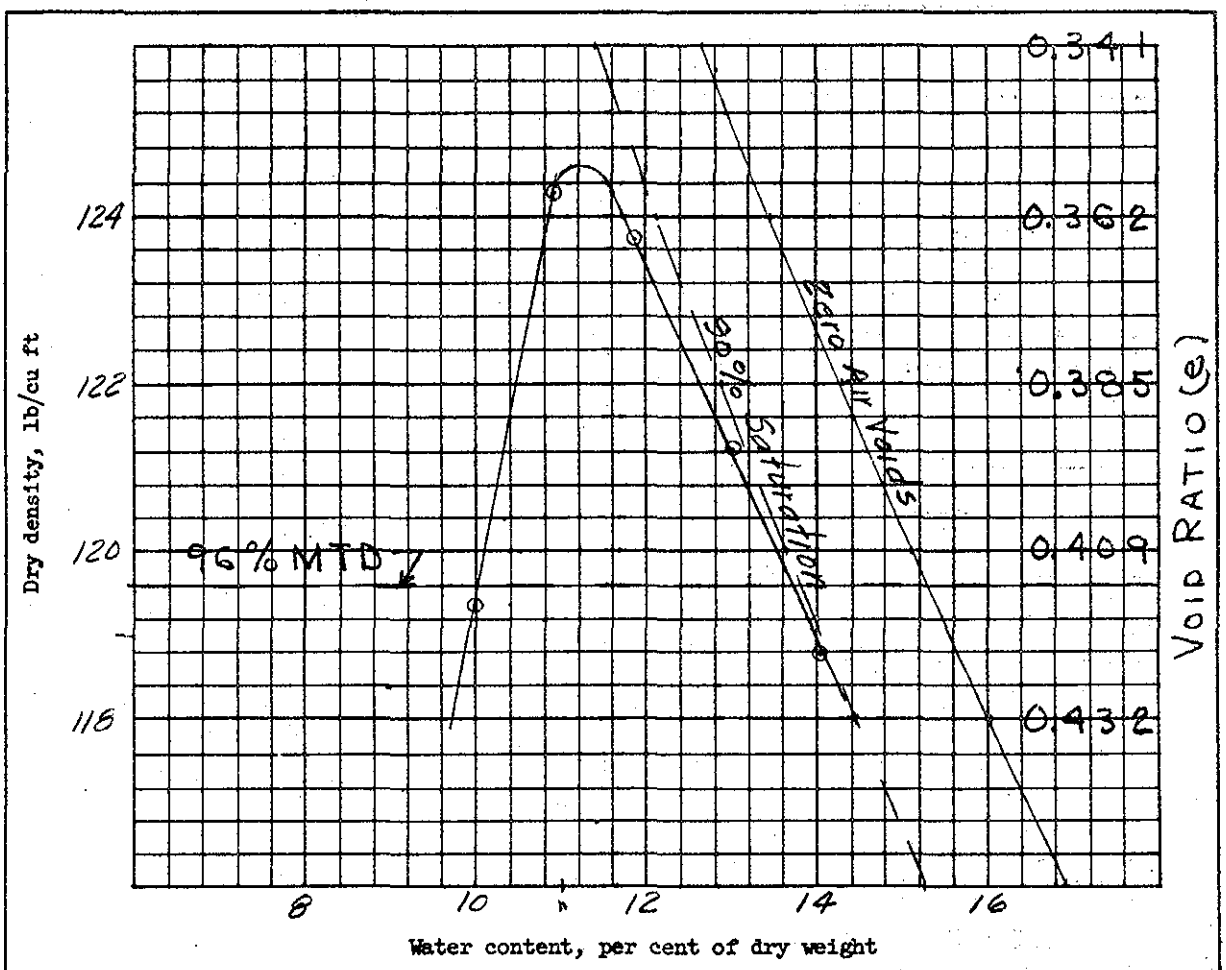
GRADATION CURVES

PLATE NO. B-26

ENG FORM 2087
1 MAY 63

REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

U.S. GOVERNMENT PRINTING OFFICE



Standard compaction test

25 blows per each of 3 layers, with 5.5 lb rammer and

12 inch drop. 4.0 inch diameter mold

Sample No.	~~Elev or~~ Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in.
B-6	6.0'-12.0'	Gravelly clayey SAND (SC)	2.71	24	15	11.1	5.9

Sample No.				
Natural water content in per cent				
Optimum water content in per cent	11.2			
Max dry density in lb/cu ft	124.6			

Remarks Test run on -No4 material.

Project Whitmanville Dam and Lake

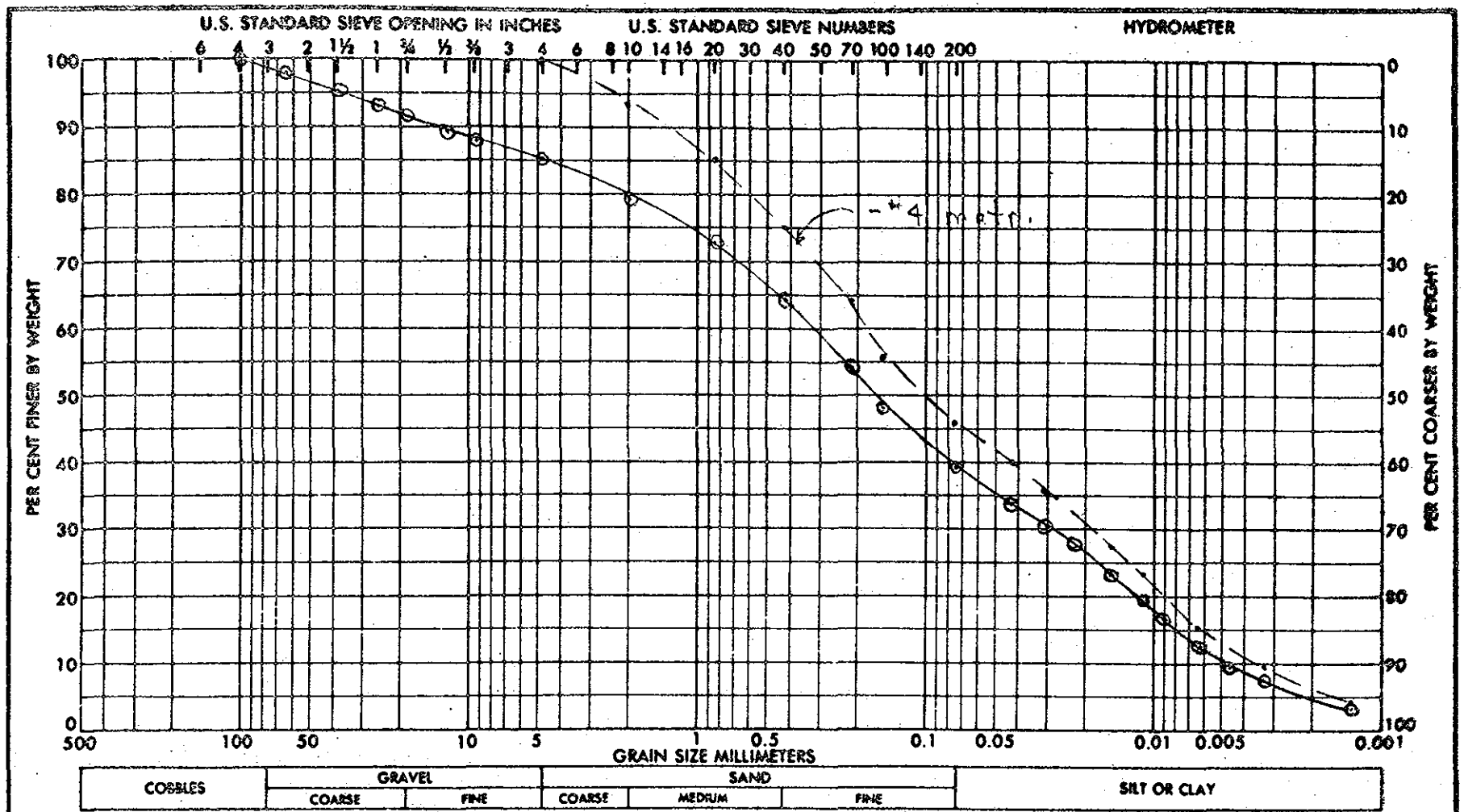
Area

Boring No. BT-1 Date October 1970

COMPACTION TEST REPORT

ENG FORM 1 MAY 63 2091 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) G 3426

PLATE NO.B-27



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
B-2	1.0'-9.0'	Gravelly clayey Sand (SC)		24	14	10

PROJECT

AREA

BORING NO. BT-2

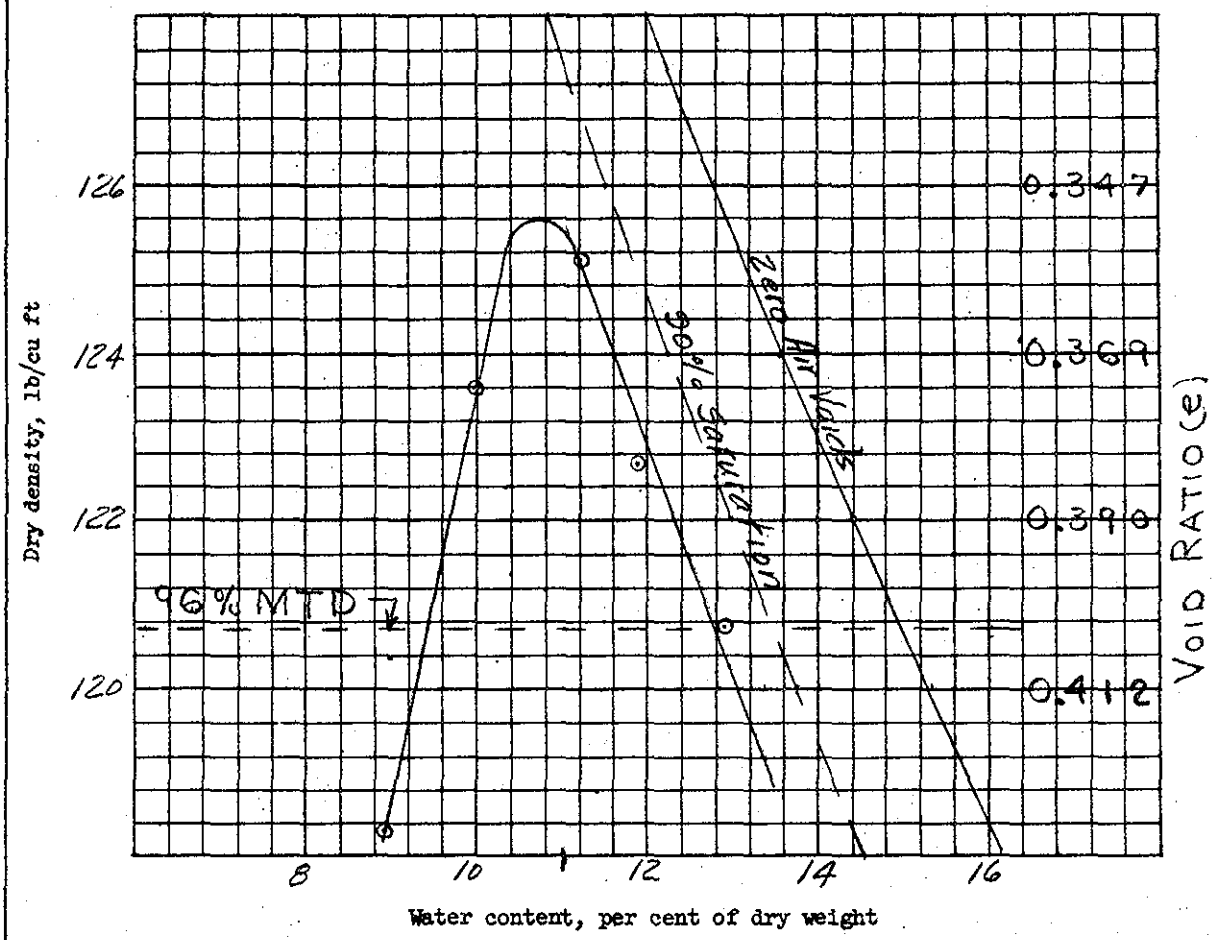
DATE Nov. 1970

GRADATION CURVES

ENG FORM 1 MAY 63 **2087** REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

U.S. GOVERNMENT PRINTING OFFICE

PLATE NO. B-28



Standard compaction test

25 blows per each of 3 layers, with 5.5 lb rammer and

12 inch drop. 4.0 inch diameter mold

Sample No.	Elev or Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in.
B-2	1.0'-9.0	Gravelly clayey SAND (SC)	2.72	24	14	14.5	8.6

Sample No.	B-2			
Natural water content in per cent				
Optimum water content in per cent	10.7			
Max dry density in lb/cu ft	125.6			

Remarks Test run on -No4 mat'l.

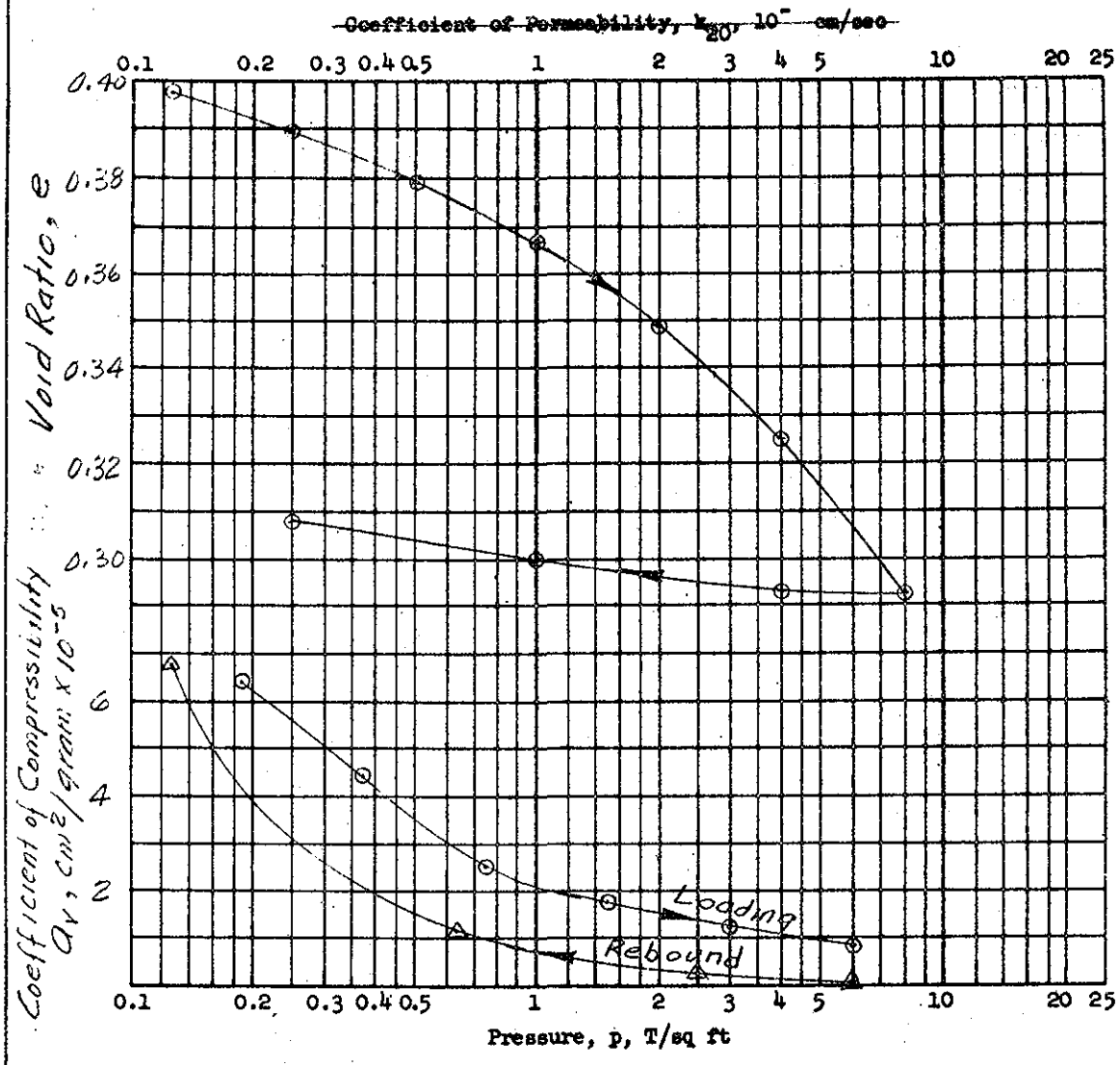
Project Whitmanville Dam and Lake

Area

Boring No. BT-2 Date Nov. 1970

COMPACTION TEST REPORT

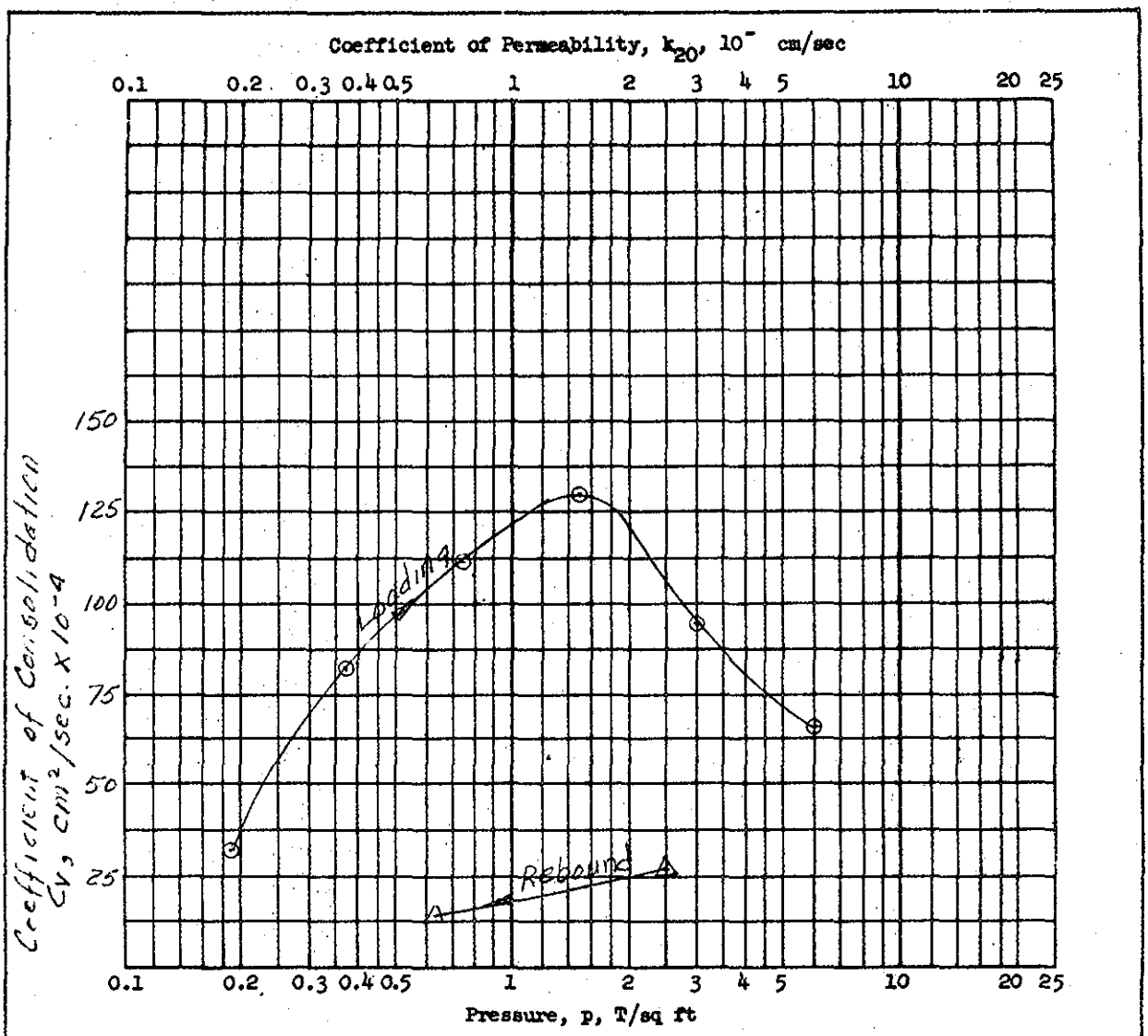
ENG FORM 1 MAY 63 2091 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) G 3425



Type of Specimen *Remolded*		Before Test		After Test	
Diam *4.44* in.	Ht *1.0* in.	Water Content, w_o	*12.5* %	w_f	*12.0* %
Overburden Pressure, p_o	T/sq ft	Void Ratio, e_o	*0.408*	e_f	*0.325*
Preconsol. Pressure, p_c	T/sq ft	Saturation, S_o	*83.4* %	S_f	*100* %
Compression Index, C_c		Dry Density, γ_d	*120.5* lb/ft³		
Classification *Gravelly clayey SAND(SC)*		k_{20} at e_o =	x 10⁻ cm/sec		
LL *24*	G_s *2.72*	Project *Whitmanville Dam and Lake*			
PL *14*	D_{10} *0.005*				
Remarks *Test run on -No4 mat'l at approx. water content of 12.7% and approx. dry density of 120.6 pcf. Opt. Water content plus 2% and 96% of max. density as determined from Std compaction test curve.*		Area			
		Boring No. *BT-2*		Sample No. *B-2*	
		Depth *1.0'-9.0'*		Date *Jan. 1971*	

CONSOLIDATION TEST REPORT

ENG FORM 1 MAY 63 2090 PREVIOUS EDITIONS ARE OBSOLETE.

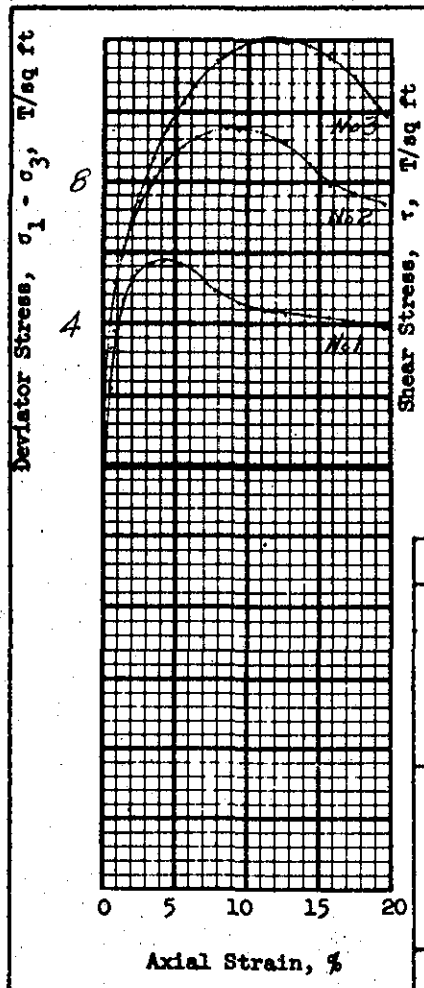


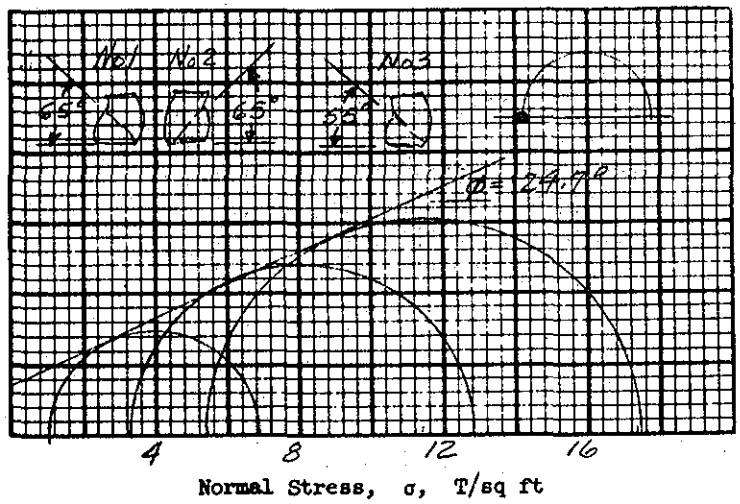
Type of Specimen *Remolded*		Before Test		After Test	
Diam *4.44* in.	Ht *1.0* in.	Water Content, w_o	*12.5* %	w_f	*12.0* %
Overburden Pressure, p_o	T/sq ft	Void Ratio, e_o	*0.408*	e_f	*0.325*
Preconsol. Pressure, p_c	T/sq ft	Saturation, S_o	*83.4* %	S_f	*100* %
Compression Index, C_c		Dry Density, γ_d	*120.5* lb/ft^3		
Classification *Gravelly clayey SAND (SC)*		k_{20} at e_o =	$\times 10^{-}$ cm/sec		
LL *24*	G_s *2.72*	Project *Whitmanville Lake*			
PL *14*	D_{10} *0.005*				
Remarks *Test run on #4 mat'l at approx. water content of 12.7% and approx. dry density of 120.6 pcf Opt. water content plus 2% and 96% of max. density as determined from std. compaction test curve.*		Area			
		Boring No. *BT-2*		Sample No. *B-2*	
		Depth ~~El~~ *1.0'-9.0'*		Date *July 1971*	

CONSOLIDATION TEST REPORT

ENG FORM 1 MAY 63 2090 PREVIOUS EDITIONS ARE OBSOLETE.

Plate No. B-30A





Test No.			1	2	3	
Initial	Water content	w_o	8.6 %	8.7 %	8.6 %	%
	Void ratio	e_o	0.413	0.412	0.417	
	Saturation	S_o	56.6 %	57.3 %	56.2 %	%
	Dry density, lb/cu ft	γ_d	120.2	120.3	119.8	
Before Shear	Water content	w_c	— %	— %	— %	%
	Void ratio	e_c	—	—	—	
	Saturation	S_c	— %	— %	— %	%
	Final back pressure, T/sq ft	u_o	—	—	—	
Final	Water content	w_f	— %	— %	— %	%
	Void ratio	e_f	—	—	—	
Minor principal stress, T/sq ft		σ_3	1.06	3.24	5.40	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	5.77	9.58	12.03	
Time to failure, min		t_f	4.3	8.8	11.2	
Rate of strain, percent/min			0.99	0.99	0.99	
			—	—	—	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	4.18*	8.17*	11.77*	
Initial diameter, in.		D_o	2.81	2.80	2.81	
Initial height, in.		H_o	6.30	6.31	6.31	

Shear Strength Parameters

ϕ = 24.7 °

tan ϕ = 0.460

c = 1.4 T/sq ft

Method of saturation None

☐ Controlled stress

☒ Controlled strain

Type of test Q | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL	PL	PI	D_{10}	G_s
24	14	10	0.005	2.72

Remarks *Stress @ 15% Strain
Specimens molded with -No 4 Mat'l at approx. water content of 8.7% and approx. dry density of 120.6 pcf. Opt. water content minus 2% and 96% of max. density as determined from Std Compaction test curve.

Project Whitmanville Dam and Lake

Area

Boring No. BT-2 | Sample No. B-2

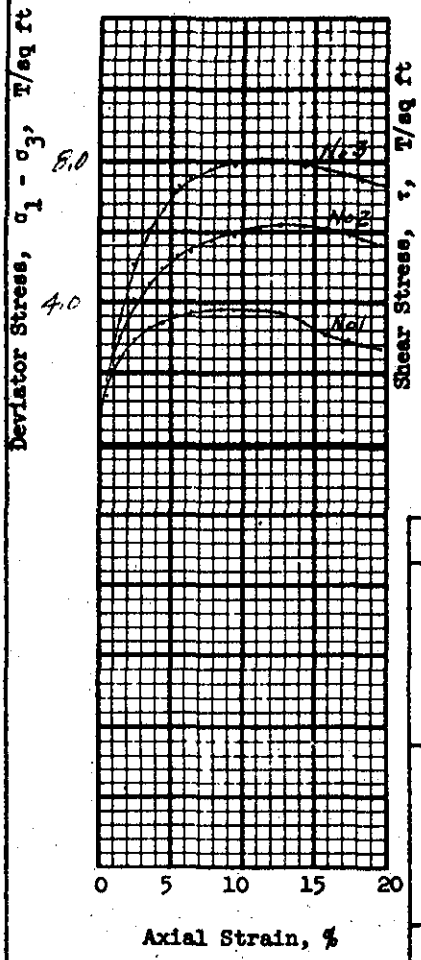
Depth 1.0'-9.0' | Date Jan. 1971

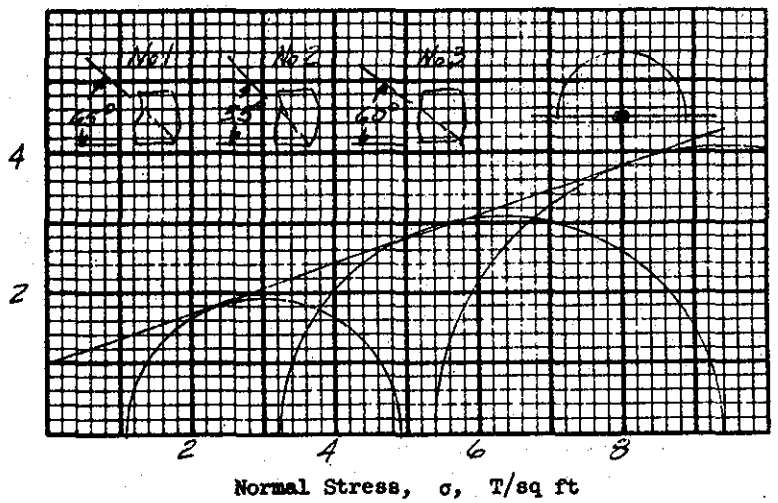
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

TRANSLUCENT

PLATE NO. B-31





			Test No.	1	2	3	
Initial	Water content	w_o	10.5 %	10.6 %	10.5 %	%
	Void ratio	e_o	0.407	0.408	0.406	
	Saturation	S_o	70.1 %	70.8 %	70.2 %	%
	Dry density, lb/cu ft	γ_d	120.7	120.6	120.8	
Before Shear	Water content	w_c	— %	— %	— %	%
	Void ratio	e_c	—	—	—	
	Saturation	S_c	— %	— %	— %	%
	Final back pressure, T/sq ft	u_o	—	—	—	
Final	Water content	w_f	— %	— %	— %	%
	Void ratio	e_f	—	—	—	
Minor principal stress, T/sq ft		σ_3	1.08	3.24	5.40	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	3.83	6.15	8.03	
Time to failure, min		t_f	8.8	12.8	11.2	
Rate of strain, percent/min			0.99	0.99	0.99	
			—	—	—	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	3.26*	6.08*	7.87*	
Initial diameter, in.		D_o	2.80	2.80	2.80	
Initial height, in.		H_o	6.30	6.30	6.30	

Shear Strength Parameters

ϕ = 19.2°

tan ϕ = 0.348

c = 1.0 T/sq ft

Method of saturation None

☐ Controlled stress

☒ Controlled strain

Type of test Q	Type of specimen Remolded			
Classification Gravelly clayey SAND (SC)				
LL 24	PL 14	PI 10	D_{10} 0.005	G_s 2.72

Remarks *Stress @ 15% Strain
Specimens molded with #4 Mat'l at approx. water content of 10.7% and approx. dry density of 120.6 pcf, optimum water content and 96% of max. density as determined from std. compaction test curve

Project Whitmanville Dam and Lake

Area

Boring No. BT-2 Sample No. B-2

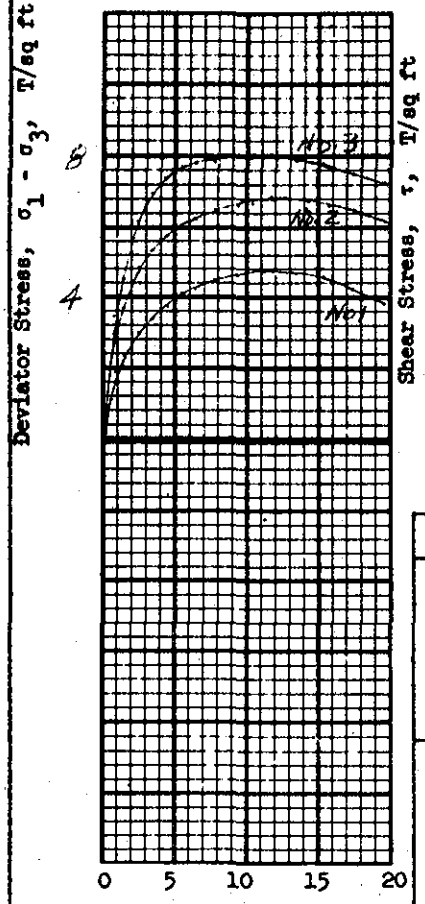
Depth ~~B3~~ 1.0'-9.0' Date Jan. 1971

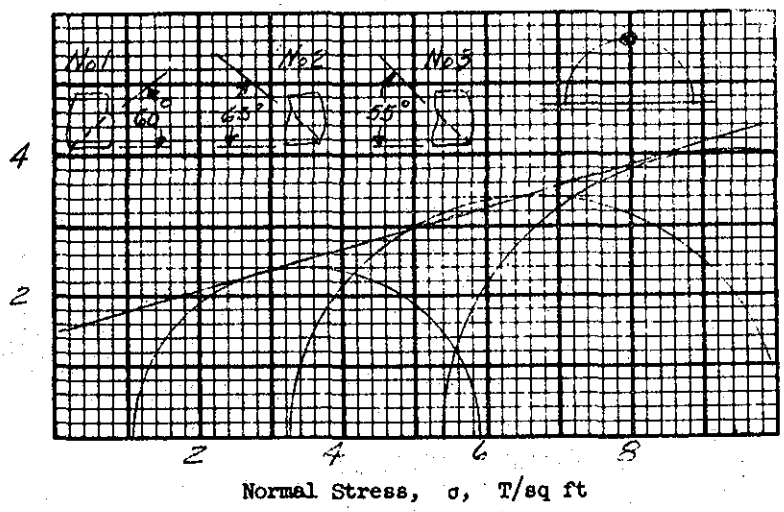
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-32

TRANSLUCENT





Test No.			1	2	3	
Initial	Water content	w_o	10.6 %	10.6 %	10.5 %	%
	Void ratio	e_o	0.353	0.352	0.350	
	Saturation	S_o	81.7 %	82.1 %	81.6 %	%
	Dry density, lb/cu ft	γ_d	125.5	125.5	125.6	
Before Shear	Water content	w_c	— %	— %	— %	%
	Void ratio	e_c	—	—	—	
	Saturation	S_c	— %	— %	— %	%
	Final back pressure, T/sq ft	u_o	—	—	—	
Final	Water content	w_f	— %	— %	— %	%
	Void ratio	e_f	—	—	—	
Minor principal stress, T/sq ft		σ_3	1.08	3.24	5.40	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	4.79	6.84	8.02	
Time to failure, min		t_f	11.6	12.0	10.4	
Rate of strain, percent/min			0.99	0.99	0.99	
			—	—	—	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	4.59*	6.75*	7.82*	
Initial diameter, in.		D_o	2.80	2.80	2.80	
Initial height, in.		H_o	6.30	6.30	6.30	

Shear Strength Parameters

ϕ = 16.2 °

tan ϕ = 0.290

c = 1.5 T/sq ft

Method of saturation None

☐ Controlled stress

☒ Controlled strain

Type of test Q | Type of specimen Remolded

Classification Gravelly Clayey SAND (SC)

LL 24	PL 14	PI 10	D_{10} 0.005	G_s 2.72

Remarks *Stress @ 15% Strain
Specimens molded with -No 4 mat'l at approx. water content of 10.7% and approx. dry density of 125.6 pcf. Optimum water content and max. density as determined from std. compaction test curve.

Project Whitmanville Dam and Lake

Area

Boring No. BT-2 | Sample No. B-2

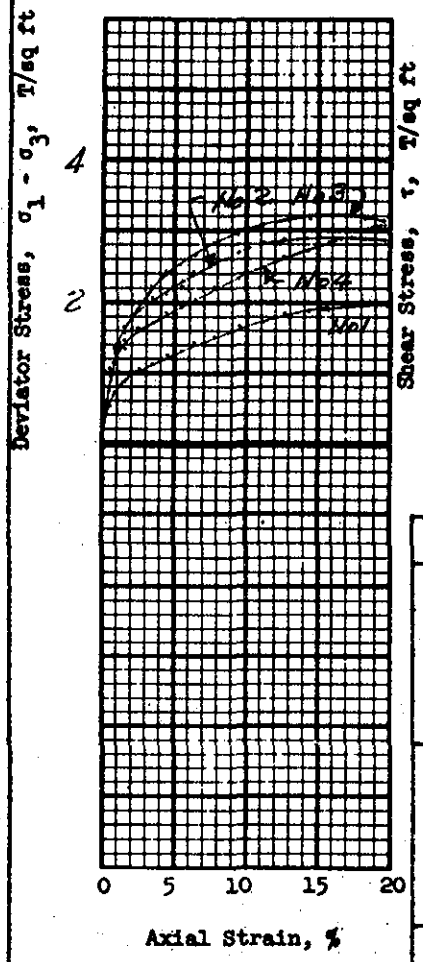
Depth El 1.5'-9.0' | Date Jan. 1971

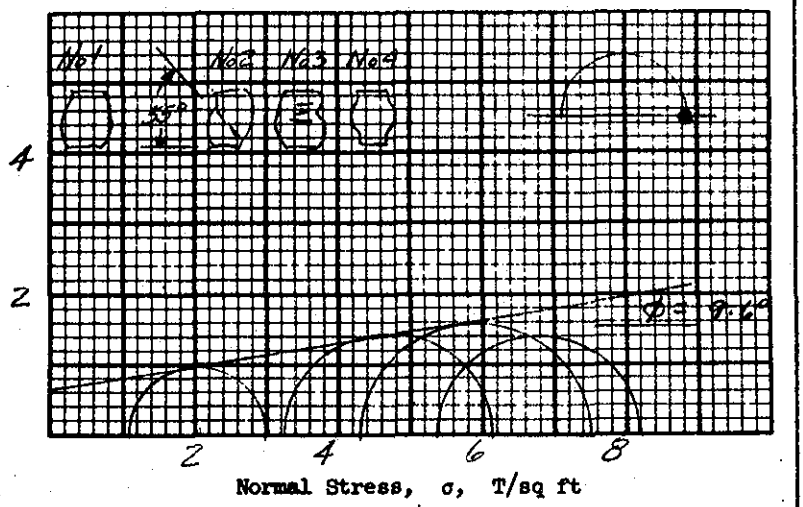
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-33

TRANSLUCENT





Test No.			1	2	3	4
Initial	Water content	w_o	12.9 %	12.4 %	12.2 %	12.5 %
	Void ratio	e_o	0.408	0.405	0.402	0.406
	Saturation	S_o	85.9 %	83.1 %	82.7 %	86.4 %
	Dry density, lb/cu ft	γ_d	120.6	120.8	121.1	120.8
Before Shear	Water content	w_c	— %	— %	— %	— %
	Void ratio	e_c	—	—	—	—
	Saturation	S_c	— %	— %	— %	— %
	Final back pressure, T/sq ft	u_o	—	—	—	—
Final	Water content	w_f	— %	— %	— %	— %
	Void ratio	e_f	—	—	—	—
Minor principal stress, T/sq ft		σ_3	1.08	3.24	4.32	5.40
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	1.93*	2.91*	3.19*	2.77*
Time to failure, min		t_f	15.1	15.1	15.1	15.1
Rate of strain, percent/min			0.99	0.99	0.99	0.99
			—	—	—	—
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	—	—	—	—
Initial diameter, in.		D_o	2.80	2.80	2.80	2.80
Initial height, in.		H_o	6.30	6.30	6.30	6.30

Shear Strength Parameters

ϕ = 9.6 °

tan ϕ = 0.170

c = 0.63 T/sq ft

Method of saturation None

☐ Controlled stress

☒ Controlled strain

Type of test Q | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL	PL	PI	D_{10}	G_s
24	14	10	0.005	2.72

Remarks *Stress @ 15% strain. Specimens molded with No4 mat'l. at approx. water content of 12.7% and approx. dry density of 120.6 pcf. Opt. water content plus 2% and 96% of max density as determined from std. compaction test curve

Project Whitmanville Dam and Lake

Area

Boring No. BT-2 | Sample No. B-2

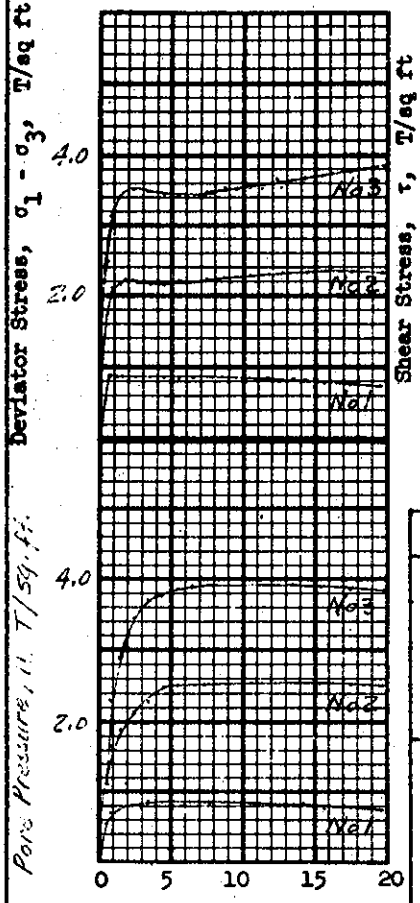
Depth ~~El~~ 1.0' - 9.0' | Date Jan. 1971

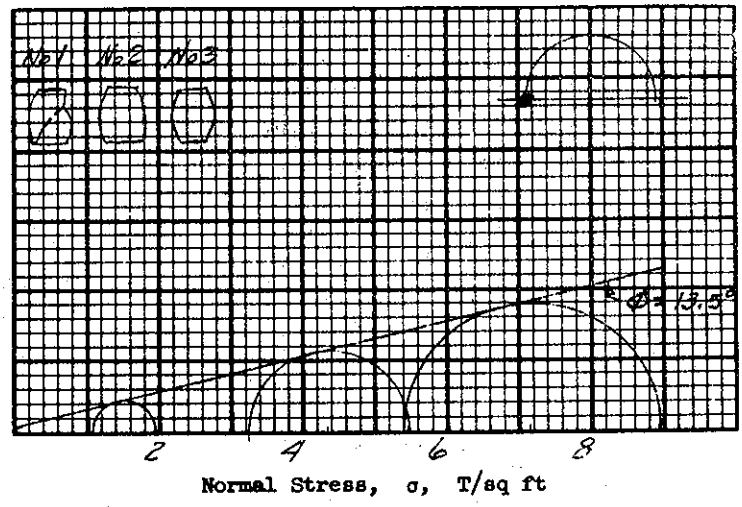
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

TRANSLUCENT

PLATE NO. B-34





Test No.			1	2	3	
Initial	Water content	w_o	8.6 %	8.7 %	8.6 %	%
	Void ratio	e_o	0.418	0.418	0.411	
	Saturation	S_o	55.8 %	56.4 %	57.1 %	%
	Dry density, lb/cu ft	γ_d	119.8	119.8	120.3	
Before Shear	Water content	w_c	15.4 %	13.9 %	13.2 %	%
	Void ratio	e_c	0.420	0.378	.359	
	Saturation	S_c	100 %	100 %	100 %	%
	Final back pressure, T/sq ft	u_o	7.20	7.20	7.20	
Final	Water content	w_f	15.4 %	13.9 %	13.2 %	%
	Void ratio	e_f	0.420	0.378	0.359	
Minor principal stress, T/sq ft		σ_3	1.08	3.24	5.40	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	0.89	2.22	3.54	
Time to failure, min		t_f	5.4	13.0	15.1	
Rate of strain, percent/min			0.15	0.15	0.15	
Pore Pressure T/sq.ft.		u	+0.67	+2.07	+3.37	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	0.81 *	2.18	3.44	
Initial diameter, in.		D_o	2.80	2.80	2.80	
Initial height, in.		H_o	6.33	6.32	6.31	

Shear Strength Parameters

ϕ = 13.5 °

tan ϕ = 0.240

c = 0.10 T/sq ft

Method of saturation Backpressure

☐ Controlled stress

☒ Controlled strain

Type of test R **Type of specimen**

Classification Gravelly clayey SAND (SC)

LL 24	PL 14	PI 10	D_{10} 0.005	G_s 2.72

Remarks * Stress @ 15% Strain
Specimens molded with No 4 nat'l at approx. water content of 8.7% and approx. dry density of 120.6 pcf, at water content minus 2% and 96% of the max. density as determined from standard compaction curve

Sheet 1 of 2

Project Whitmanville Dam and Lake

Area

Boring No. BT-2 **Sample No.** B-2

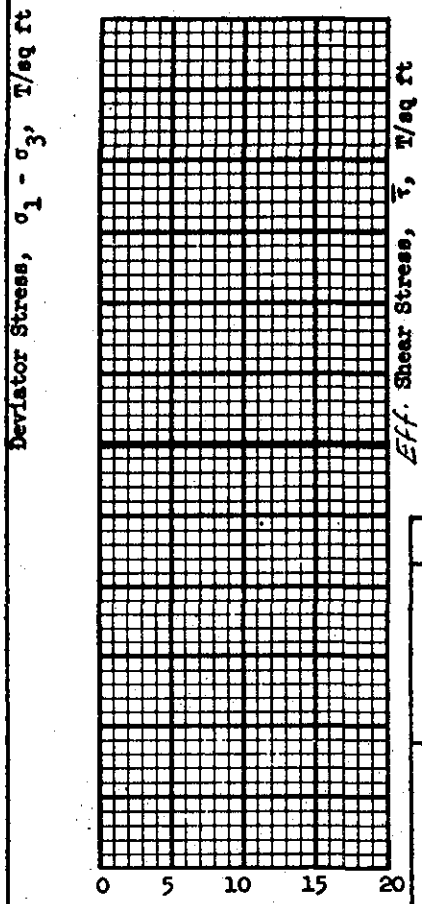
Depth 1.0'-9.0' **Date** Jan. 1971

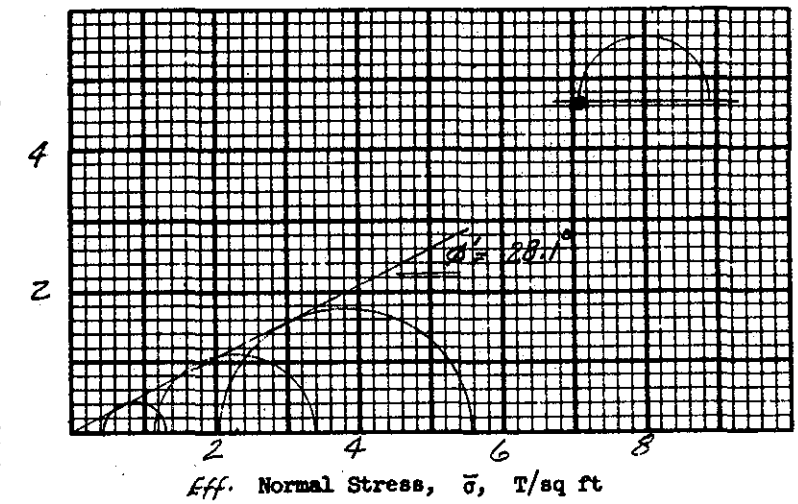
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

TRANSLUCENT

PLATE NO. B-35





Test No.			1	2	3	
Initial	Water content	w_o	%	%	%	%
	Void ratio	e_o				
	Saturation	S_o	%	%	%	%
	Dry density, lb/cu ft	γ_d				
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final back pressure, T/sq ft	u_o				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
Minor principal stress, T/sq ft Eff		$\bar{\sigma}_3$	0.41	1.17	2.04	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$				
Time to failure, min		t_f				
Rate of strain, percent/min						
Major Principal Stress, T/sq.ft. Eff		$\bar{\sigma}_1$	1.30	3.39	5.57	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$				
Initial diameter, in.		D_o				
Initial height, in.		H_o				

Shear Strength Parameters

$\bar{\phi}$ = 28.1 °

tan $\bar{\phi}$ = 0.535

$\bar{c}$ = 0 T/sq ft

Method of saturation backpressure

☐ Controlled stress

☒ Controlled strain

Type of test $\bar{R}$	Type of specimen Remolded		
Classification Gravelly clayey SAND (SC)			
LL 24	PL 14	PI 10	D_{10} 0.005	G_s 2.72

Remarks See Sheet 1 of 2 for other data.

Project Whitmanville Dam and Lake

Area

Boring No. BT-2 Sample No. B-2

Depth 1.0' - 9.0' Date Jan. 1971

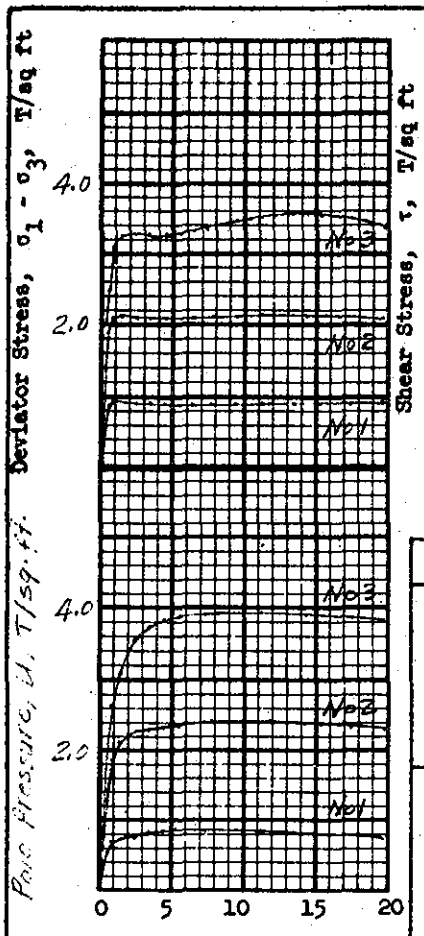
Sheet 2 of 2

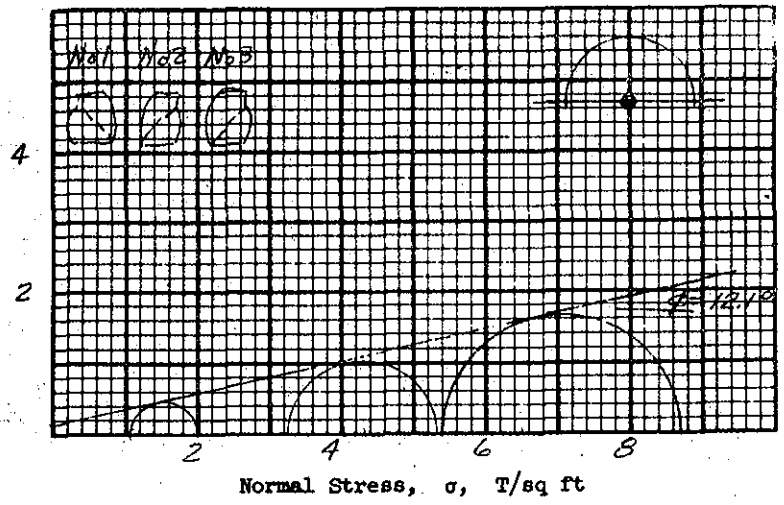
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-36

TRANSLUCENT





Shear Strength Parameters

ϕ = 12.1 °

tan ϕ = 0.215

c = 0.15 T/sq ft

Method of saturation Backpressure

☐ Controlled stress

☒ Controlled strain

Test No.			1	2	3	
Initial	Water content	w_o	10.5 %	10.6 %	10.6 %	%
	Void ratio	e_o	0.406	0.407	0.406	
	Saturation	S_o	70.3 %	70.9 %	70.7 %	%
	Dry density, lb/cu ft	γ_d	120.8	120.7	120.7	
Before Shear	Water content	w_c	15.6 %	14.8 %	13.4 %	%
	Void ratio	e_c	0.424	0.401	0.366	
	Saturation	S_c	100 %	100 %	100 %	%
	Final back pressure, T/sq ft	u_o	7.20	7.20	7.20	
Final	Water content	w_f	15.6 %	14.8 %	13.4 %	%
	Void ratio	e_f	0.424	0.401	0.366	
Minor principal stress, T/sq ft		σ_3	1.08	3.24	5.40	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	0.95	2.11	3.28	
Time to failure, min		t_f	7.6	9.7	15.1	
Rate of strain, percent/min			0.15	0.15	0.15	
Pore Pressure T/sq.ft.		U	+0.74	+2.09	+3.51	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	0.89	2.05	3.22	
Initial diameter, in.		D_o	2.80	2.80	2.80	
Initial height, in.		H_o	6.30	6.30	6.30	

Type of test R	Type of specimen Remolded		
Classification Gravelly clayey SAND (SC)			
LL 24	PL 14	PI 10	D_{10} 0.005	G_s 2.72

Remarks Specimens molded with -No4 mat'l at approx. water content of 10.7% and approx. dry density of 120.6 pcf, opt. water content and 96% of max. density as determined from std compaction test curve.

Sheet 1 of 2

Project Whitmanville Dam and Lake

Area

Boring No. BT-2 | Sample No. B-2

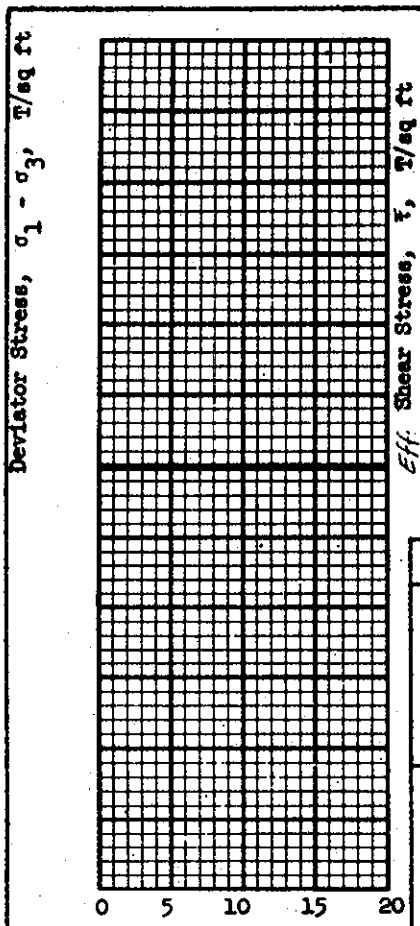
Depth 1.0'-9.0' | Date Jan. 1971

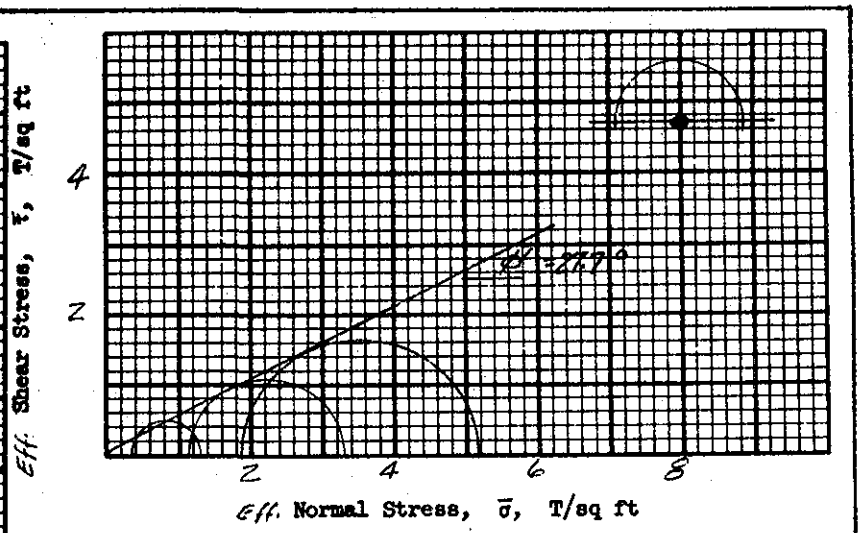
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-37

TRANSLUCENT





Test No.			1	2	3	
Initial	Water content	w_o	%	%	%	%
	Void ratio	e_o				
	Saturation	S_o	%	%	%	%
	Dry density, lb/cu ft	γ_d				
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final back pressure, T/sq ft	u_o				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
Minor principal stress, T/sq ft Eff		$\bar{\sigma}_3$	0.34	1.15	1.89	
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$				
Time to failure, min		t_f				
Rate of strain, percent/min						
Major Principal Stress, T/sq.ft. Eff.		$\bar{\sigma}_1$	1.29	3.26	5.16	
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$				
Initial diameter, in.		D_o				
Initial height, in.		H_o				

Shear Strength Parameters

$\bar{\phi}$ = 27.7 °

tan $\bar{\phi}$ = 0.525

$\bar{c}$ = 0 T/sq ft

Method of saturation Backpressure

☐ Controlled stress

☒ Controlled strain

Type of test $\bar{R}$ | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL 24	PL 14	PI 10	D_{10} 0.005	G_s 2.72

Remarks See Sheet 1 of 2 for other data.

Project Whitmanville Dam and Lake

Area

Boring No. BT-2 | Sample No. B-2

Depth 1.0'-9.0' | Date Jan. 1971

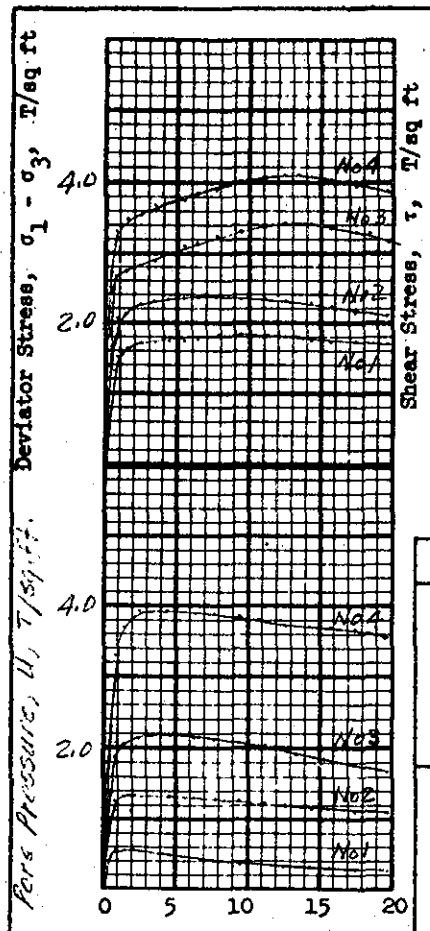
Sheet 2 of 2

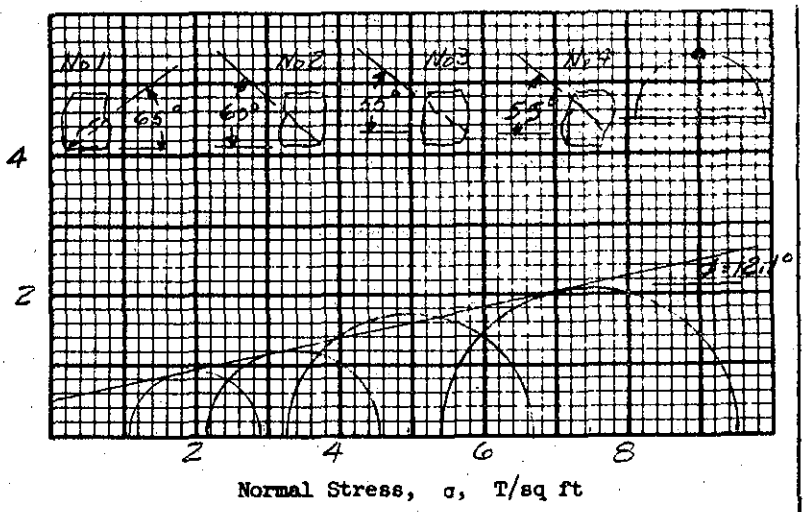
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-38

TRANSLUCENT





Test No.			1	2	3	4
Initial	Water content	w_o	10.5 %	10.7 %	10.7 %	10.7 %
	Void ratio	e_o	0.356	0.353	0.351	0.362
	Saturation	S_o	80.7 %	82.3 %	82.7 %	80.4 %
	Dry density, lb/cu ft	γ_d	125.3	125.5	125.7	124.7
Before Shear	Water content	w_c	13.6 %	13.4 %	13.1 %	12.2 %
	Void ratio	e_c	0.371	0.364	0.357	0.331
	Saturation	S_c	100 %	100 %	100 %	100 %
	Final back pressure, T/sq ft	u_o	7.20	7.20	7.20	7.20
Final	Water content	w_f	13.6 %	13.4 %	13.1 %	12.2 %
	Void ratio	e_f	0.371	0.364	0.357	0.331
Minor principal stress, T/sq ft		σ_3	1.08	2.16	3.24	5.40
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	1.82	2.39	3.43	4.08
Time to failure, min		t_f	64.8	54.0	91.8	91.8
Rate of strain, percent/min			0.15	0.15	0.15	0.15
Pore Pressure T/sq.ft.		U	+0.38	+1.30	+1.93	+3.76
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	1.77*	2.24*	3.40*	4.02*
Initial diameter, in.		D_o	2.80	2.80	2.80	2.80
Initial height, in.		H_o	6.32	6.30	6.31	6.34

Shear Strength Parameters

ϕ = 12.1 °

tan ϕ = 0.215

c = 0.5 T/sq ft

Method of saturation Backpressure

☐ Controlled stress

☒ Controlled strain

Type of test R | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL	PL	PI	D_{10}	G_s
24	14	10	0.005	2.72

Remarks *Stress @ 15% Strain. Specimens molded with -No4 Mat'l at approx. water content of 10.7% and approx. dry density of 125.6 pcf Opt. Water content and max. density as determined from std. compaction test curve.

Project Whitmanville Dam and Lake

Area

Boring No. BT-2 | Sample No. B-2

Depth El 1.0'-9.0' | Date Jan. 1971

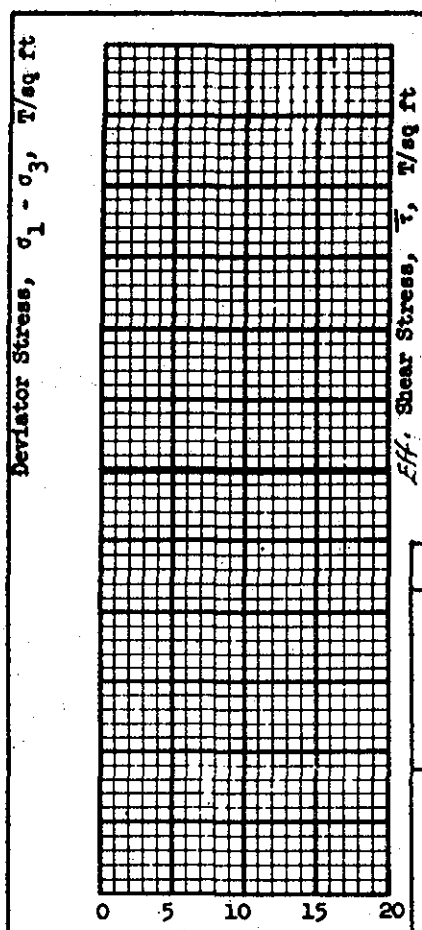
Sheet 1 of 2

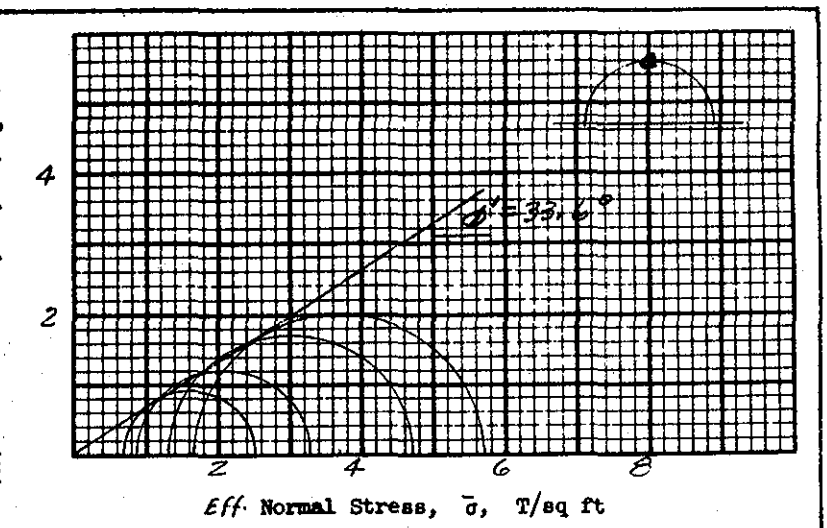
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-39

TRANSLUCENT





Test No.			1	2	3	4
Initial	Water content	w_o	%	%	%	%
	Void ratio	e_o				
	Saturation	S_o	%	%	%	%
	Dry density, lb/cu ft	γ_d				
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final back pressure, T/sq ft	u_o				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
Minor principal stress, T/sq ft Eff		$\bar{\sigma}_3$	0.70	0.86	1.31	1.64
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$				
Time to failure, min		t_f				
Rate of strain, percent/min						
Major Principal stress, T/sq ft. Eff		$\bar{\sigma}_1$	2.52	3.25	4.73	5.72
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$				
Initial diameter, in.		D_o				
Initial height, in.		H_o				

Shear Strength Parameters

ϕ = 33.6 °

tan ϕ = 0.665

c = 0 T/sq ft

Method of saturation Backpressure

☐ Controlled stress

☒ Controlled strain

Type of test $\bar{R}$ | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL 24 | PL 14 | PI 10 | D_{10} 0.005 | G_s 2.72

Remarks See Sheet 1 of 2 for other data

Project Whitmarville Dam and Lake

Area

Boring No. BT-2 | Sample No. B-2

Depth 1.0'-9.0' | Date Jan. 1971

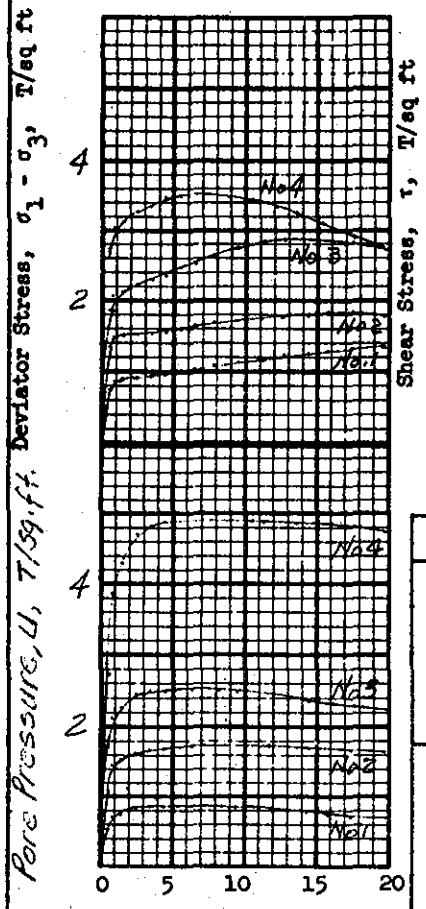
Sheet 2 of 2

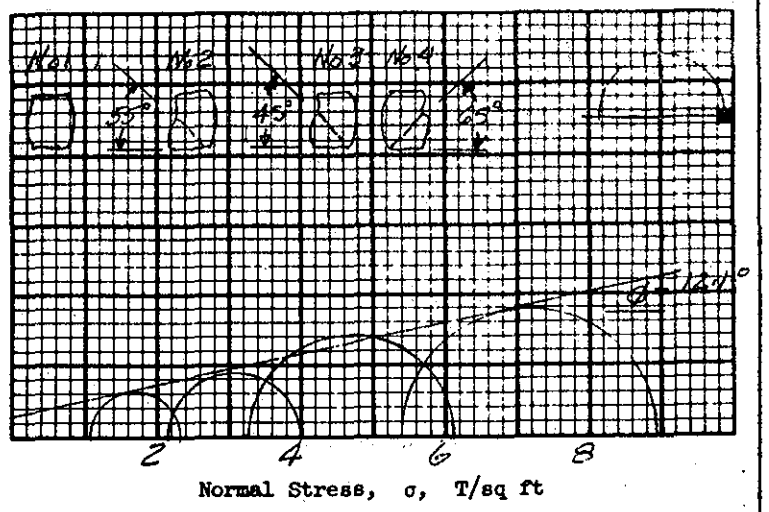
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-40

TRANSLUCENT





Test No.			1	2	3	4
Initial	Water content	w_o	12.8 %	12.5 %	12.8 %	13.0 %
	Void ratio	e_o	0.404	0.404	0.405	0.409
	Saturation	S_o	86.4 %	84.2 %	86.3 %	86.7 %
	Dry density, lb/cu ft	γ_d	120.9	121.0	120.8	120.5
Before Shear	Water content	w_c	14.3 %	13.9 %	13.1 %	12.9 %
	Void ratio	e_c	0.388	0.379	0.357	0.351
	Saturation	S_c	100 %	100 %	100 %	100 %
	Final back pressure, T/sq ft	u_o	7.20	7.20	7.20	7.20
Final	Water content	w_f	14.3 %	13.9 %	13.1 %	12.9 %
	Void ratio	e_f	0.388	0.379	0.357	0.351
Minor principal stress, T/sq ft		σ_3	1.08	2.16	3.24	5.40
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$	1.27*	1.81*	2.86	3.55
Time to failure, min		t_f	101.7	101.5	97.2	48.6
Rate of strain, percent/min			0.15	0.15	0.15	0.15
Pore Pressure T/sq.ft.		U	+0.77*	+1.72*	+2.38	+4.90
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$	—	—	2.85*	3.14*
Initial diameter, in.		D_o	2.80	2.80	2.80	2.80
Initial height, in.		H_o	6.30	6.30	6.29	6.30

Shear Strength Parameters

ϕ = 12.1 °

tan ϕ = 0.215

c = 0.30 T/sq ft

Method of saturation Backpressure

☐ Controlled stress

☒ Controlled strain

Type of test R | Type of specimen Remolded

Classification Gravelly clayey SAND (SC)

LL 24	PL 14	PI 10	D_{10} 0.005	G_s 2.72

Remarks *Stress @ 15% Strain
Specimens molded with -No4 Mat'l at approx. water content of 12.7% and approx. dry density of 120.6 pcf Opt. plus 2% and 96% of max. density as determined from std compaction test curve.

Project Whitmanville Dam and Lake

Area

Boring No. BT-2 | Sample No. B-2

Depth El 1.0'-9.0' | Date Jan. 1971

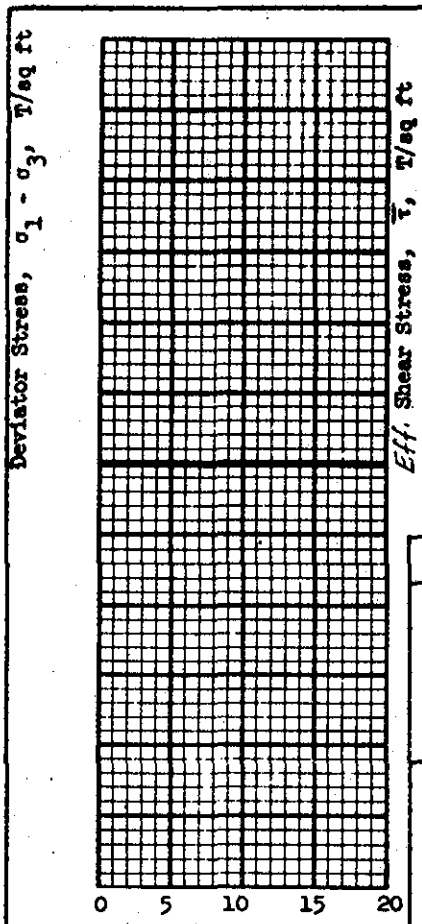
Sheet 1 of 2

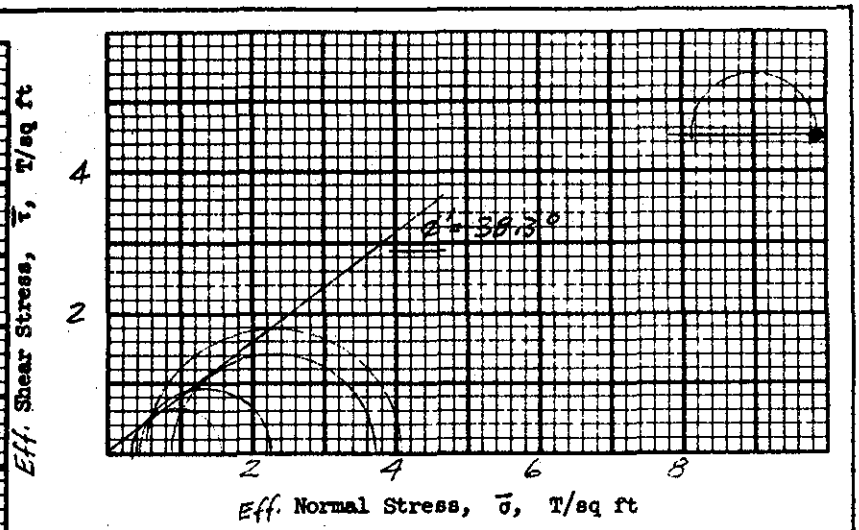
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-41

TRANSLUCENT





Test No.			1	2	3	4
Initial	Water content	w_o	%	%	%	%
	Void ratio	e_o				
	Saturation	S_o	%	%	%	%
	Dry density, lb/cu ft	γ_d				
Before Shear	Water content	w_c	%	%	%	%
	Void ratio	e_c				
	Saturation	S_c	%	%	%	%
	Final back pressure, T/sq ft	u_o				
Final	Water content	w_f	%	%	%	%
	Void ratio	e_f				
Minor principal stress, T/sq ft Eff.		$\bar{\sigma}_3$	0.31*	0.44*	0.86	0.50
Max deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{max}$				
Time to failure, min		t_f				
Rate of strain, percent/min						
Major Principal Stress, T/sq ft. Eff.		$\bar{\sigma}_1$	1.59*	2.25*	3.71	4.05
Ult deviator stress, T/sq ft		$(\sigma_1-\sigma_3)_{ult}$				
Initial diameter, in.		D_o				
Initial height, in.		H_o				

Shear Strength Parameters

$\phi' =$ 38.3°

$\tan \phi' =$ 0.790

$c' =$ 0 T/sq ft

Method of saturation Back pressure

☐ Controlled stress

☒ Controlled strain

Type of test R	Type of specimen Remolded			
Classification Gravelly clayey SAND (SC)				
LL 24	PL 14	PI 10	D_{10} 0.005	G_s 2.72

Remarks *Stress @ 15% Strain
See Sheet 1 of 2 for other data

Project Whitmanville Dam and Lake

Area

Boring No. BT-2 Sample No. B-2

Depth ~~El~~ 1.0' - 9.0' Date Jan. 1971

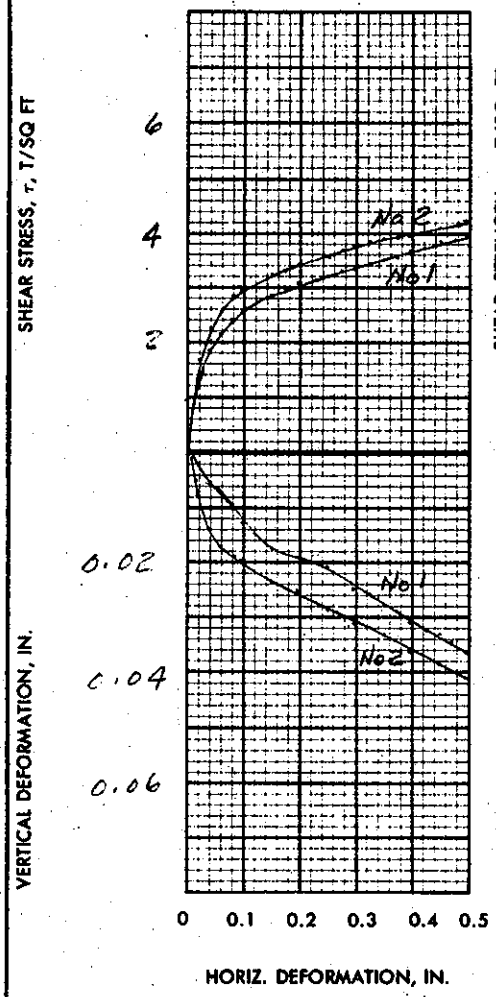
Sheet 2 of 2

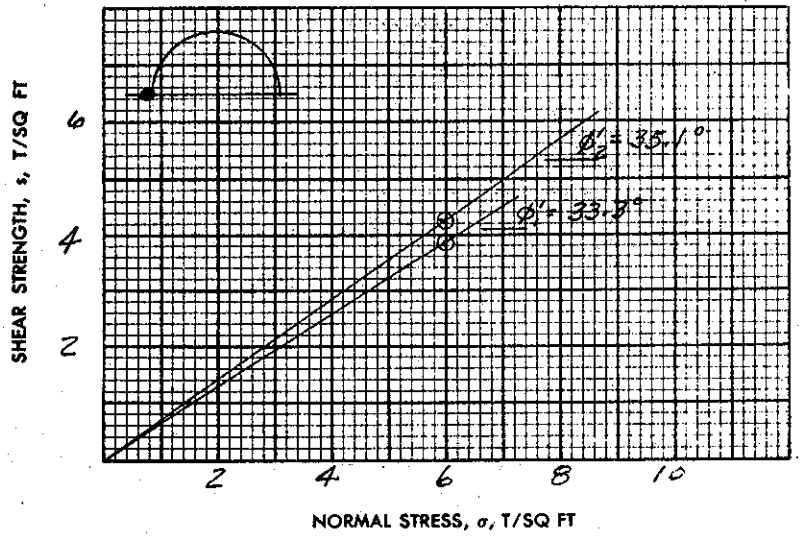
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 JUN 65 2089 (EM 1110-2-1902) PREVIOUS EDITIONS ARE OBSOLETE

PLATE NO. B-42

TRANSLUCENT





TEST NO.			1	2		
INITIAL	WATER CONTENT	w_o	8.6 %	8.6 %	%	%
	VOID RATIO	e_o	0.405	0.407		
	SATURATION	S_o	57.9%	57.7%	%	%
	DRY DENSITY, LB/CU FT	γ_d	120.9	120.7		
VOID RATIO AFTER CONSOLIDATION		e_c	0.333	0.347		
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.56	0.65		
FINAL	WATER CONTENT	w_f	10.8 %	10.5%	%	%
	VOID RATIO	e_f	0.237	0.238		
	SATURATION	S_f	100 %	100 %	%	%
NORMAL STRESS, T/SQ FT		σ	6.00	6.00		
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	3.94	4.23		
ACTUAL TIME TO FAILURE, MIN		t_f	91	91		
RATE OF STRAIN, IN./MIN			0.005	0.005		
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	—	—		

SHEAR STRENGTH PARAMETERS

ϕ' = 33.3°

TAN ϕ' = 0.657

c' = 0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN Remolded — 3.0 IN. SQUARE — 0.5 IN. THICK

CLASSIFICATION Gravelly clayey SAND (SC)

LL 24	PL 14	PI 10	D_{10} 0.005	G_s 2.72

REMARKS Specimens molded with -No 4 Mat'l at approx. water content of 8.7% and approx. dry density of 120.6 pcf., opt. minus 2% and 96% of max. density as determined from std compaction curve.

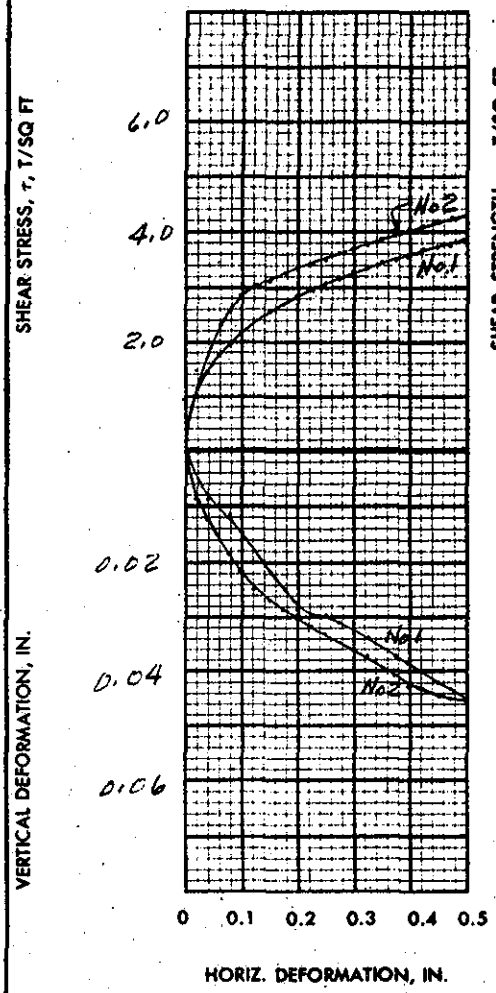
PROJECT Whitmanville Dam and Lake

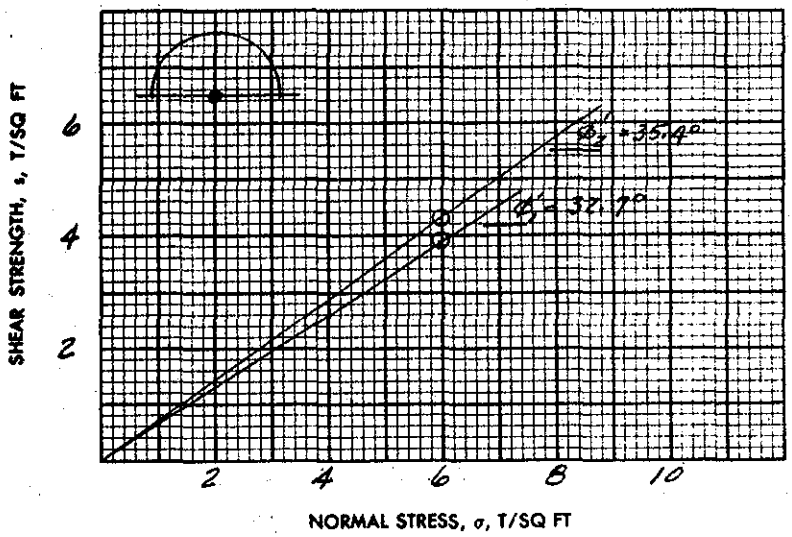
AREA

BORING NO. BT-2 — SAMPLE NO. B-2

DEPTH EL 1.0' - 9.0' — DATE Jan. 1971

DIRECT SHEAR TEST REPORT PLATE NO. B-43





TEST NO.			1	2		
INITIAL	WATER CONTENT	w_o	10.7 %	10.7 %	%	%
	VOID RATIO	e_o	0.407	0.410		
	SATURATION	S_o	71.2%	70.7%	%	%
	DRY DENSITY, LB/CU FT	γ_d	120.7	120.5		
VOID RATIO AFTER CONSOLIDATION		e_c	0.353	0.370		
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.46	0.45		
FINAL	WATER CONTENT	w_f	11.1 %	10.8 %	%	%
	VOID RATIO	e_f	0.232	0.250		
	SATURATION	S_f	100 %	100 %	%	%
NORMAL STRESS, T/SQ FT		σ	6.00	6.00		
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	3.85	4.27		
ACTUAL TIME TO FAILURE, MIN		t_f	152	153		
RATE OF STRAIN, IN./MIN			0.003	0.003		
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	—	—		

SHEAR STRENGTH PARAMETERS

ϕ' = 32.7°

TAN ϕ' = 0.642

c' = 0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN Remolded 3.0 IN. SQUARE 0.5 IN. THICK

CLASSIFICATION Gravelly Clayey SAND (SC)

LL	PL	PI	D_{10}	G_s
24	14	10	0.005	2.72

REMARKS Specimens molded with No 4 mat'l at approx. water content of 10.7% and approx. dry density of 120.6 pcf., opt. water content and 96% of max. density as determined from std compaction curve

PROJECT Whitmanville Dam and Lake

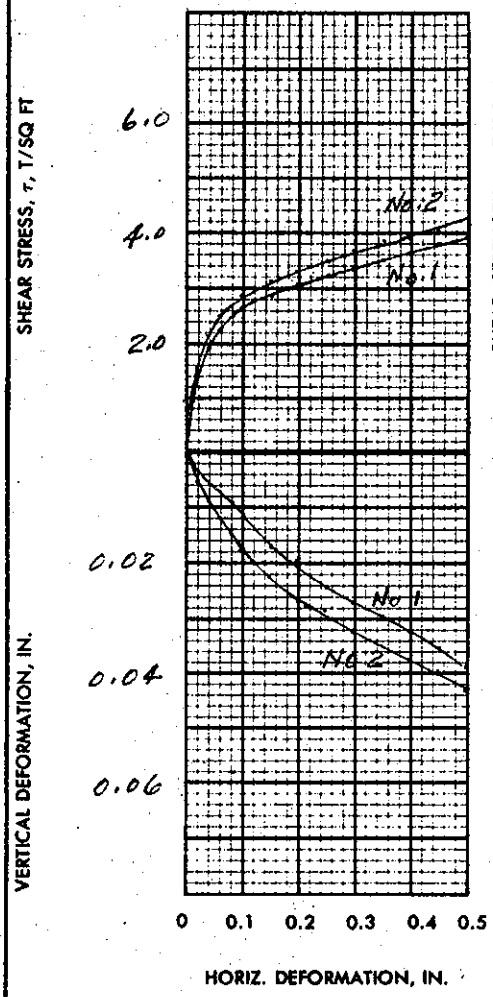
AREA

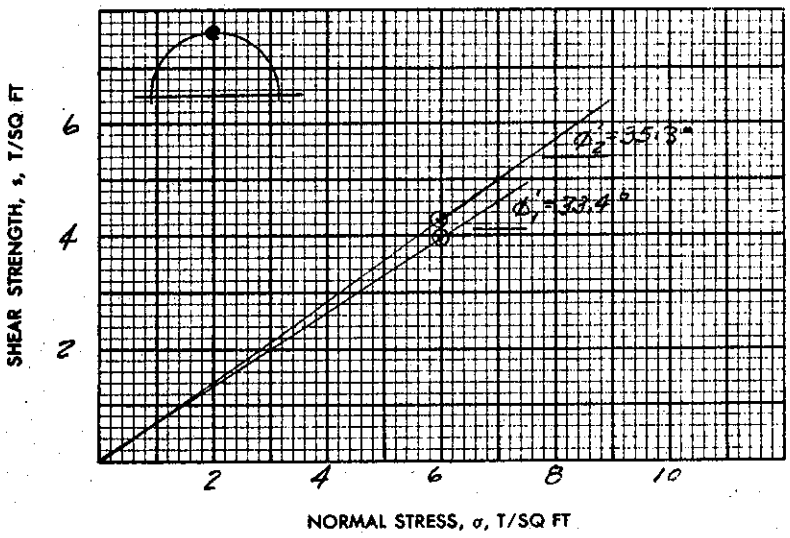
BORING NO. BT-2 SAMPLE NO. B-2

DEPTH 1.0'-9.0' DATE Jan 1971

DIRECT SHEAR TEST REPORT PLATE NO. 44

ENG FORM 2092 (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) GPO : 1966 OF—214-945





TEST NO.			1	2		
INITIAL	WATER CONTENT	w_o	10.6 %	10.6 %	%	%
	VOID RATIO	e_o	0.349	0.350		
	SATURATION	S_o	82.9 %	82.6 %	%	%
	DRY DENSITY, LB/CU FT	γ_d	125.9	125.8		
VOID RATIO AFTER CONSOLIDATION		e_c	0.291	0.319		
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.60	0.48		
FINAL	WATER CONTENT	w_f	11.1 %	10.7 %	%	%
	VOID RATIO	e_f	0.191	0.209		
	SATURATION	S_f	100 %	100 %	%	%
NORMAL STRESS, T/SQ FT		σ	6.00	6.00		
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	3.95	4.25		
ACTUAL TIME TO FAILURE, MIN		t_f	95	96		
RATE OF STRAIN, IN./MIN			0.005	0.005		
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	—	—		

SHEAR STRENGTH PARAMETERS

ϕ' = 33.4°

TAN ϕ' = 0.659

c' = 0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN Remolded — 3.0 IN. SQUARE — 0.5 IN. THICK

CLASSIFICATION Gravelly clayey SAND (SC)

LL	PL	PI	D_{10}	G_s
24	14	10	0.005	2.72

REMARKS Specimens molded with No 4 Mat'l at approx. water content of 10.7% and approx. dry density of 125.6 pcf, opt. water content and max. density as determined from Std compaction curve

PROJECT Whitnanville Dam and Lake

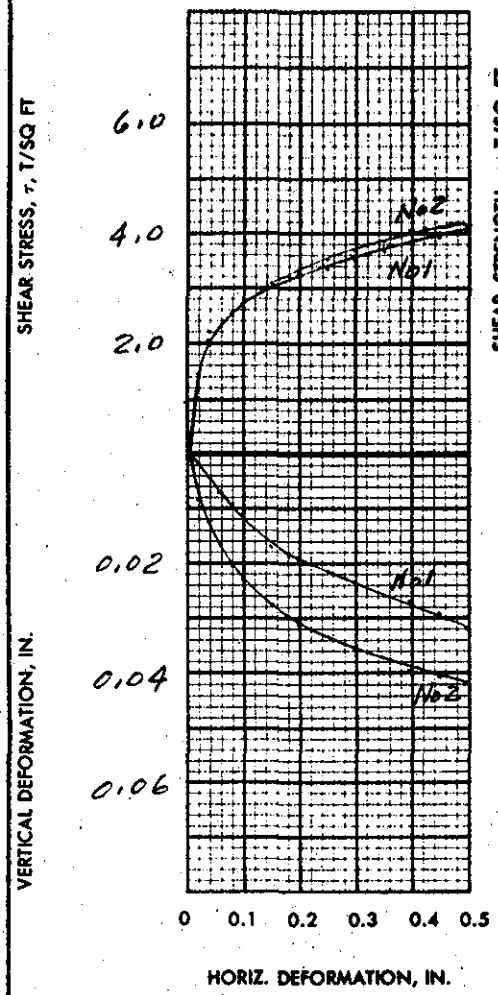
AREA

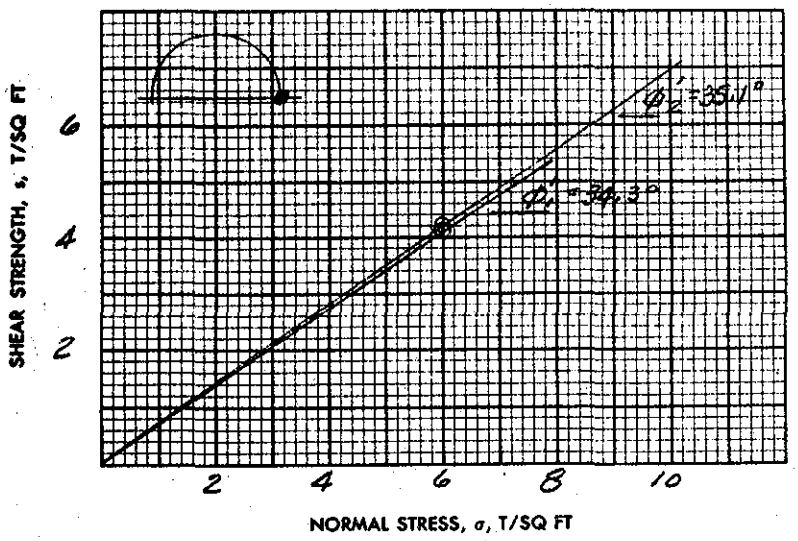
BORING NO. BT-2 — SAMPLE NO. B-2

DEPTH 1.0' - 2.0' — DATE Jan. 1971

DIRECT SHEAR TEST REPORT PLATE NO. 45

ENG FORM 1 JUN 65 2092 (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) GPO : 1966 OF—214-945





TEST NO.			1	2		
INITIAL	WATER CONTENT	w_o	12.5 %	12.5 %	%	%
	VOID RATIO	e_o	0.406	0.405		
	SATURATION	S_o	84.0%	84.3%	%	%
	DRY DENSITY, LB/CU FT	γ_d	120.8	120.8		
VOID RATIO AFTER CONSOLIDATION		e_c	0.344	0.354		
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	0.40	0.40		
FINAL	WATER CONTENT	w_f	11.5 %	11.1 %	%	%
	VOID RATIO	e_f	0.259	0.244		
	SATURATION	S_f	100.%	100.%	%	%
NORMAL STRESS, T/SQ FT		σ	6.00	6.00		
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	4.09	4.21		
ACTUAL TIME TO FAILURE, MIN		t_f	94	91		
RATE OF STRAIN, IN./MIN			0.005	0.005		
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	—	—		

SHEAR STRENGTH PARAMETERS

ϕ' = 34.3°

TAN ϕ' = 0.682

c' = 0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN Remolded — 3.0 IN. SQUARE — 0.5 IN. THICK

CLASSIFICATION Gravelly clayey SAND (SC)

LL	PL	PI	D_{10}	G_s
24	14	10	0.005	2.72

REMARKS Specimens molded with No 4 Mat'l at approx. water content of 12.7% and approx. dry density of 120.6 pcf. Opt. water content plus 2% and 96% of max. density as determined from Std. compaction test curve.

PROJECT Whitmanville Dam and Lake

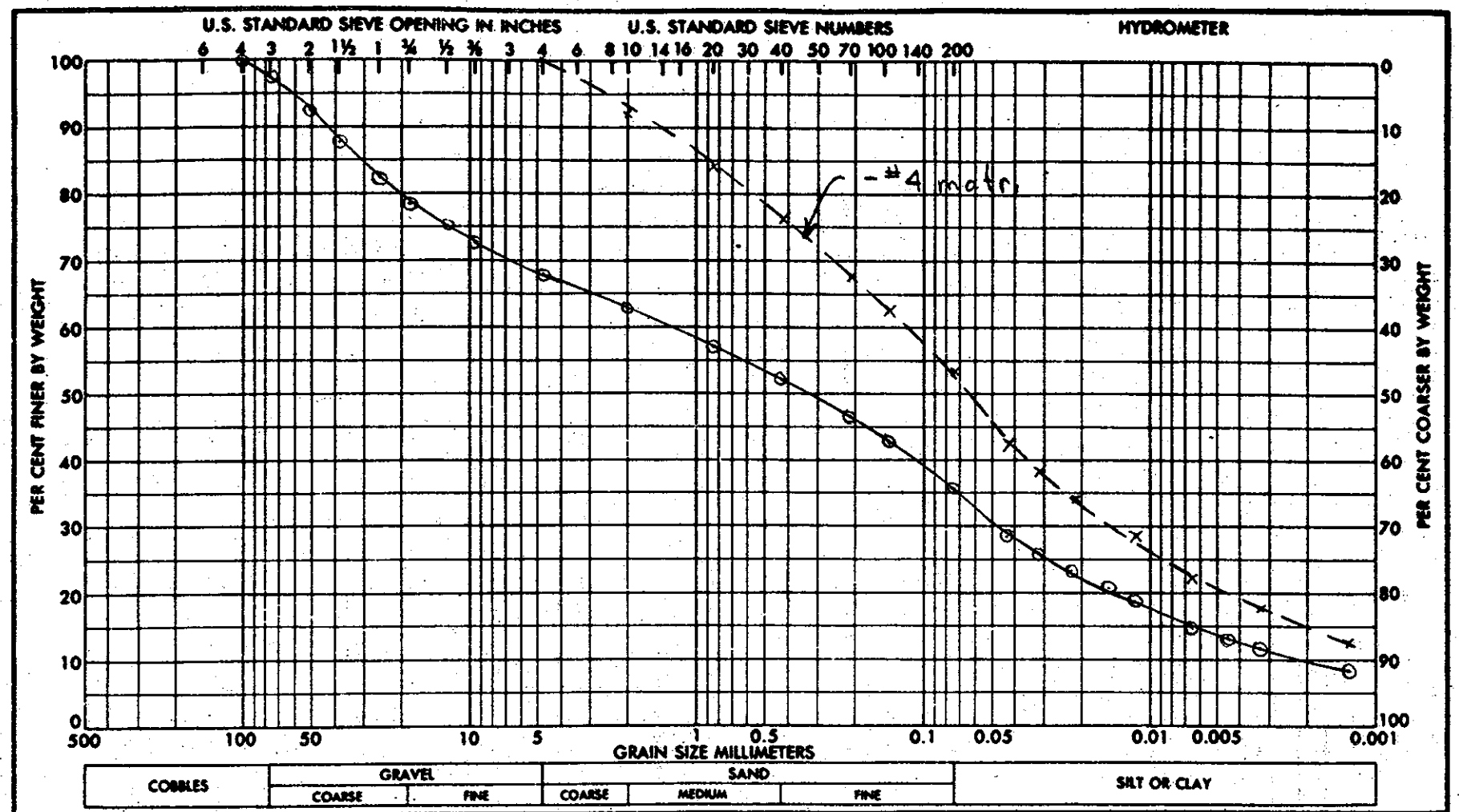
AREA

BORING NO. BT-2 — SAMPLE NO. B-2

DEPTH ~~EL~~ 1.0'-9.0' — DATE Jan 1971

DIRECT SHEAR TEST REPORT PLATE NO. B-16

ENG FORM 1 JUN 66 2092 (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) GPO : 1966 OF—214-945



SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
B-5	4.0' - 10.0'	Gravelly silty Sand (SM)		20	18	2

PROJECT Whitmanville

AREA

BORING NO. BT-3

DATE Nov. 1970

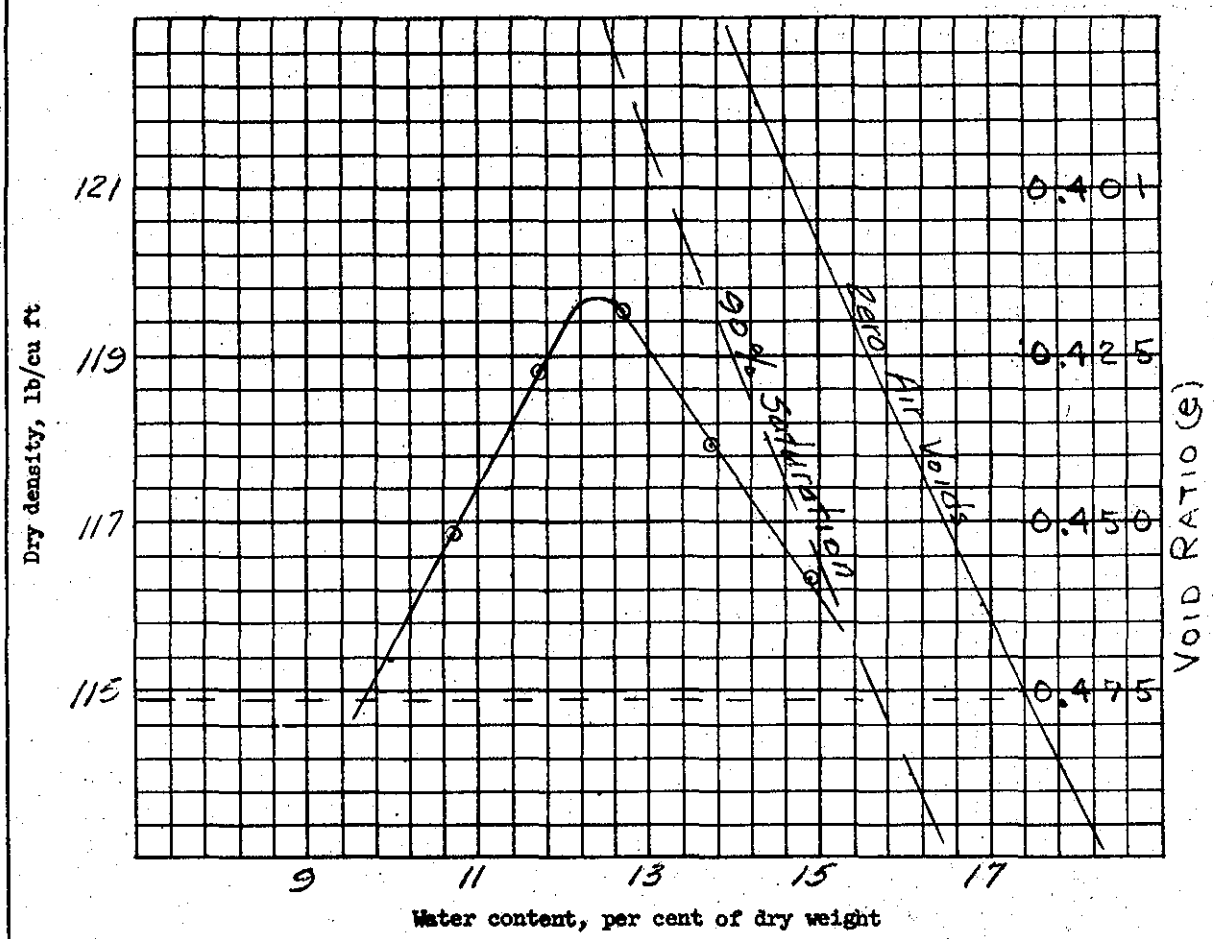
GRADATION CURVES

PLATE NO. B-47

ENG FORM 2087
1 MAY 63

REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

U.S. GOVERNMENT PRINTING OFFICE : 1963 OF—700-126



Standard compaction test

25 blows per each of 3 layers, with 5.5 lb rammer and

12 inch drop. 4.0 inch diameter mold

Sample No.	~~Elev or~~ Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in.
B-5	4.0'-10.0'	Gravelly silty SAND (SM)	2.71	18	2	32.2	20.9

Sample No.	B-5			
Natural water content in per cent				
Optimum water content in per cent	12.4			
Max dry density in lb/cu ft	119.7			

Remarks Test run on - No 4 mat'l.

Project Whitmanville Dam and Lake

Area

Boring No. BT-3 Date Nov. 1970

COMPACTION TEST REPORT

ENG FORM 1 MAY 63 2091 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) 0 3425

PLATE NO. B-48

APPENDIX C

TEST DATA AND UNDISTURBED SAMPLE

APPENDIX C

TEST DATA AND UNDISTURBED SAMPLE LOGS OF FD-50U, FD-51U AND FD-52U

TEST DATA AND UNDISTURBED SAMPLE LOGS OF FD-50U

PLATE NO.	TITLE
C-1	Undisturbed Sample Log, UC-1

TEST DATA AND UNDISTURBED SAMPLE LOGS OF FD-51U

PLATE NO.	TITLE
C-2	Undisturbed Sample Log, UC-1
C-3	Gradation Curves, UC-1
C-4	Undisturbed Sample Log, UC-3
C-5	Gradation Curves, UC-3
C-6	Compaction Test Report, UC-3
C-7	Undisturbed Sample Log, UC-5
C-8	Gradation Curves, UC-5
C-9	Gradation Curve, UC-5
C-10	Compaction Test Report, UC-5
C-11	Undisturbed Sample Log, UC-7

TEST DATA AND UNDISTURBED SAMPLE LOG FD-52U

C-12	Gradation Curve, J-3
C-13	Gradation Curve, J-4

BORING NO. FD-500 PROJECT Whitmanville
SAMPLE NO. UC-1 DATE Aug. 1970
DEPTH: 12.09 to 14.10 ft. COMP. By WCS CHK'D By RJS

LABORATORY LOG	DESCRIPTION	W, CAN NO.	TEST SAMPLES
SM	Light brownish gray very moist silty fine SAND (SM), micaceous, 0.02' thick. 39.2% passing No 200 sieve		
SM	Light rust brown very moist silty fine SAND (SM) micaceous w/dark reddish brown iron oxide stained streaks. 0.37' thick layer 18.5% passing No 200 Sieve		
ML	Light brown wet fine sandy SILT (ML). 0.08' thick layer 58.3% passing No. 200 sieve	γ_d = 95.5 pcf, W_n = 26.3%	LL = NP, PL = NP, PI = NP
ML	Reddish brown very moist fine sandy, clayey SILT (ML). 0.03' thick 64.0% passing No 200 sieve		LL = NP PL = NP
ML	Light brown wet fine sandy SILT (ML). 0.15' thick, 58.3% passing No 200 sieve		LL = NP PL = NP
SM	Light gray silty fine SAND (SM) micaceous, w/trace of organic, 0.06' thick, 46.6% passing 200 Sieve.		
OL	Dark gray fine sandy organic SILT (OL), wet, micaceous, w/hair roots, 0.02' thick layer, 51.2% Passing No 200 Sieve		LL: NP PL = NP 2.67% Organic

Bottom of Sample

SAMPLE DEPTH IN FEET

SAMPLE LENGTH IN INCHES

Length of Sample, L 8.76 in.
Weight of Tube and Wet Soil 5938.5 g.
Weight of Tube 676.9 g.
Weight of Wet Soil, W 5261.6 g.
Diameter of Tube, D 5.0 in.
Total Unit Weight, $\gamma_t = \frac{4.85\,W}{L\,D^2}$ 116.5 lbs/cu.ft.

LEGEND

W_n — Natural Water Content
MA — Mechanical Analysis
LL — Atterberg Limits
G — Specific Gravity
C — Consolidation
Q — Unconsolidated Undrained
γ_d — Dry Density
R — Consolidated Undrained
S — Consolidated Drained
UC — Unconfined Compression

UNDISTURBED SAMPLE LOG

NED FORM 501

Plate No. C-1

BORING NO. FD-511U
SAMPLE NO. UC-1
DEPTH: 9.90 to 11.91 ft.

PROJECT Whitmanville Dam
DATE August, 1970
COMP. By WCS CHK'D By RJS

LABORATORY LOG	DESCRIPTION	W, CAN NO.	TEST SAMPLES
ML	Cave-in material		
	Gray, very moist, easily friable, fine sandy SILT (ML) micaceous, with gently dipping, hair thin iron oxide stained streaks.		γ_d = 90.4 pcf. W_n = 31.6 % MA & Hydr-3
SM	Brown, very moist, easily friable silty fine SAND (SM), micaceous w/ gently dipping occaisional red and gray spletches		MA & Hydr-2 γ_d = 98.9 pcf. W_n = 25.7 %
SP-SM	Light brown, wet, easily friable silty fine SAND (SP-SM)		MA-1 W_n = 26.0 %
	Bottom of sample		
	Note: Free water found on top of sample when opened. Determination of overall density of sample was not feasible due to cave-in material found on top of sample.		

SAMPLE DEPTH IN FEET

SAMPLE LENGTH IN INCHES

Length of Sample, L 19.86 in.
Weight of Tube and Wet Soil ____ g.
Weight of Tube ____ g.
Weight of Wet Soil, W ____ g.
Diameter of Tube, D ____ in.
Total Unit Weight, $\gamma_t = \frac{4.85\,W}{L\,D^2}$ ____ lbs/cu.ft.

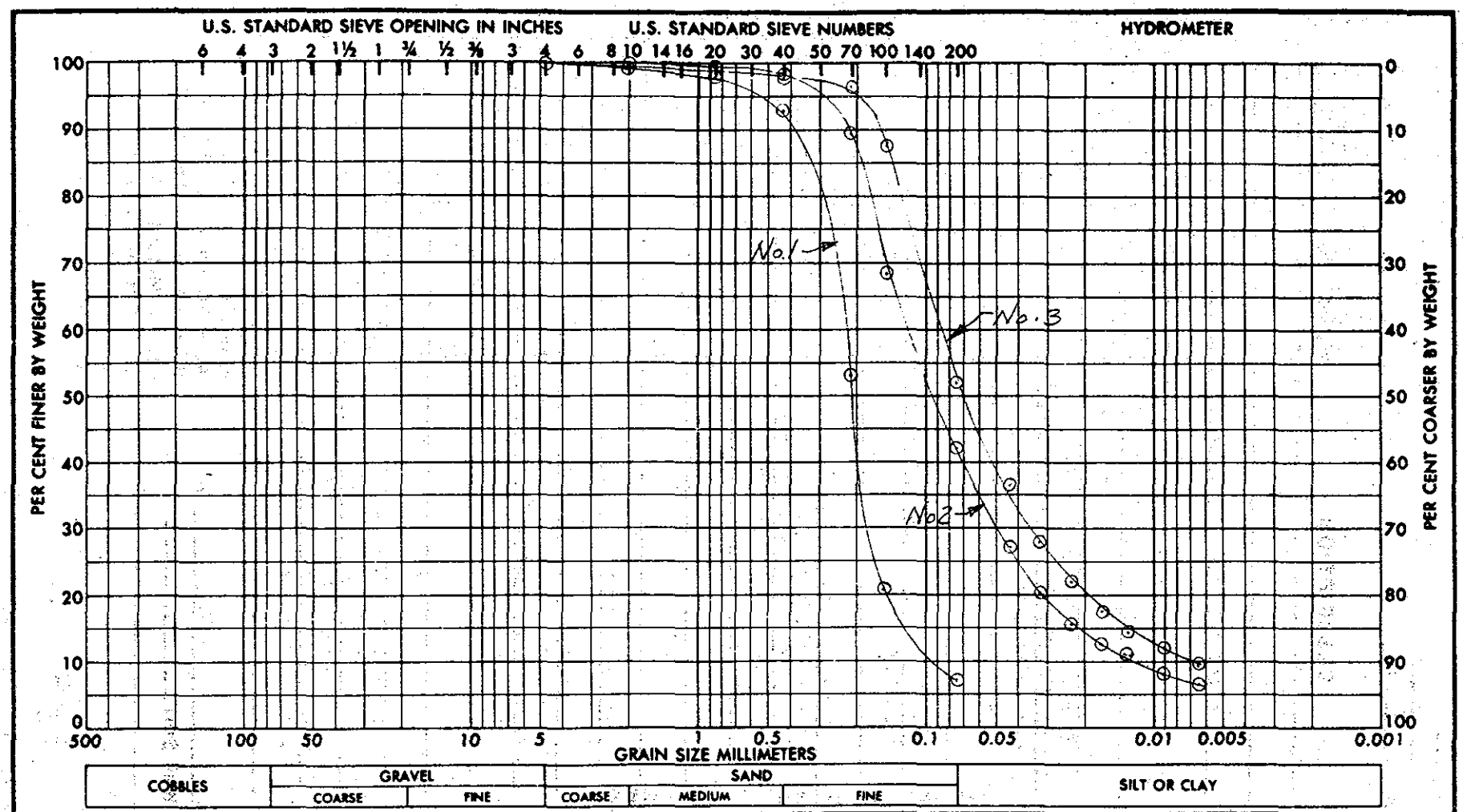
LEGEND

W_n — Natural Water Content
MA — Mechanical Analysis
LL — Atterberg Limits
G — Specific Gravity
C — Consolidation
Q — Unconsolidated Undrained
γ_d — Dry Density
R — Consolidated Undrained
S — Consolidated Drained
UC — Unconfined Compression

UNDISTURBED SAMPLE LOG

NED FORM 501

Plate No. C-2



SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
UC-1 No.1	9.90'-11.91'	Silty fine SAND (SP-SM)				
UC-1 No 2	9.90'-11.91'	Silty fine SAND (SM)				
UC-1 No 3	9.90'-11.91'	Fine sandy SILT (ML)				

PROJECT Whitmanville Dam

AREA

BORING NO. FD-51 U

DATE August 1970

GRADATION CURVES

ENG FORM 2087
1 MAY 63

REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

U.S. GOVERNMENT PRINTING OFFICE : 1963 OF—709-126

BORING NO. ED-51 U
SAMPLE NO. UC-3
DEPTH: 11.75 to 13.74 ft.

PROJECT Whitmanville Dam
DATE August, 1970
COMP. By WCS CHK'D By RJS

LABORATORY LOG	DESCRIPTION	W, CAN NO.	TEST SAMPLES
	Cave-in material		
	Brown, very moist fine sandy SILT (ML), micaceous, easily friable		Wn = 28.3%
	Dark gray-black organic seam 0.01' thick		Q-1 & Q-2 MA & Hydr-2 LL = NP PL = NP PI = NP G = 2.66 Wn = 35.8%
	Gray, moist fine sandy SILT (ML), easily friable, w/ leaves and other decayed organic material		R-1 & R-2 MA & Hydr-1 LL = NP PL = NP PI = NP G = 2.65 Wn = 28.2%
	Hair thin red streak		
	Brown, moist fine sandy SILT (ML), micaceous and easily friable.		γ_d = 102.1% Wn = 23.4% MA & Hydr-3
	Bottom of Sample		

SAMPLE DEPTH IN FEET

SAMPLE LENGTH IN INCHES

24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

Notes: Free water on top of sample when opened. Overall sample density not determined due to cave-in material

Length of Sample, L 19.65 in.
Weight of Tube and Wet Soil _____ g.
Weight of Tube _____ g.
Weight of Wet Soil, W _____ g.
Diameter of Tube, D _____ in.
Total Unit Weight, $\gamma_t = \frac{4.85\,W}{L\,D^2}$ _____ lbs/cu.ft.

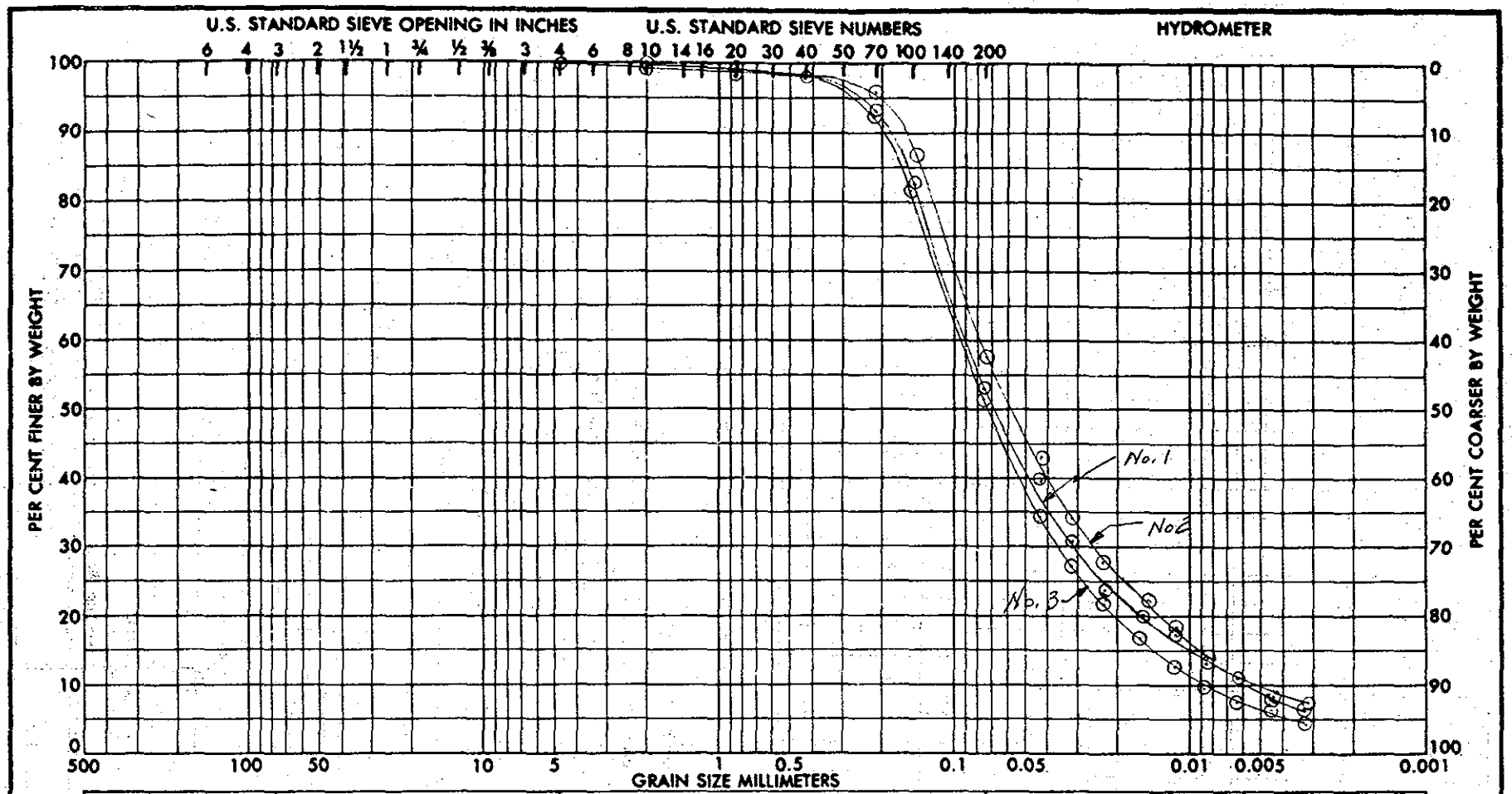
LEGEND

W_n — Natural Water Content
MA — Mechanical Analysis
LL — Atterberg Limits
G — Specific Gravity
C — Consolidation
Q — Unconsolidated Undrained
γ_d — Dry Density
R — Consolidated Undrained
S — Consolidated Drained
UC — Unconfined Compression

UNDISTURBED SAMPLE LOG

NED FORM DEC 62 501

Plate No. C-4



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
UC-3 No. 1	11.75'-13.74'	Fine sandy SILT (ML)		NP	NP	NP
UC-3 No 2	11.75'-13.74'	Fine sandy SILT (ML)		NP	NP	NP
UC-3 No 3	11.75'-13.74'	Fine sandy SILT (ML)				

PROJECT Whitmanville Dam

AREA

BORING NO. FD-51 U

DATE August 1970

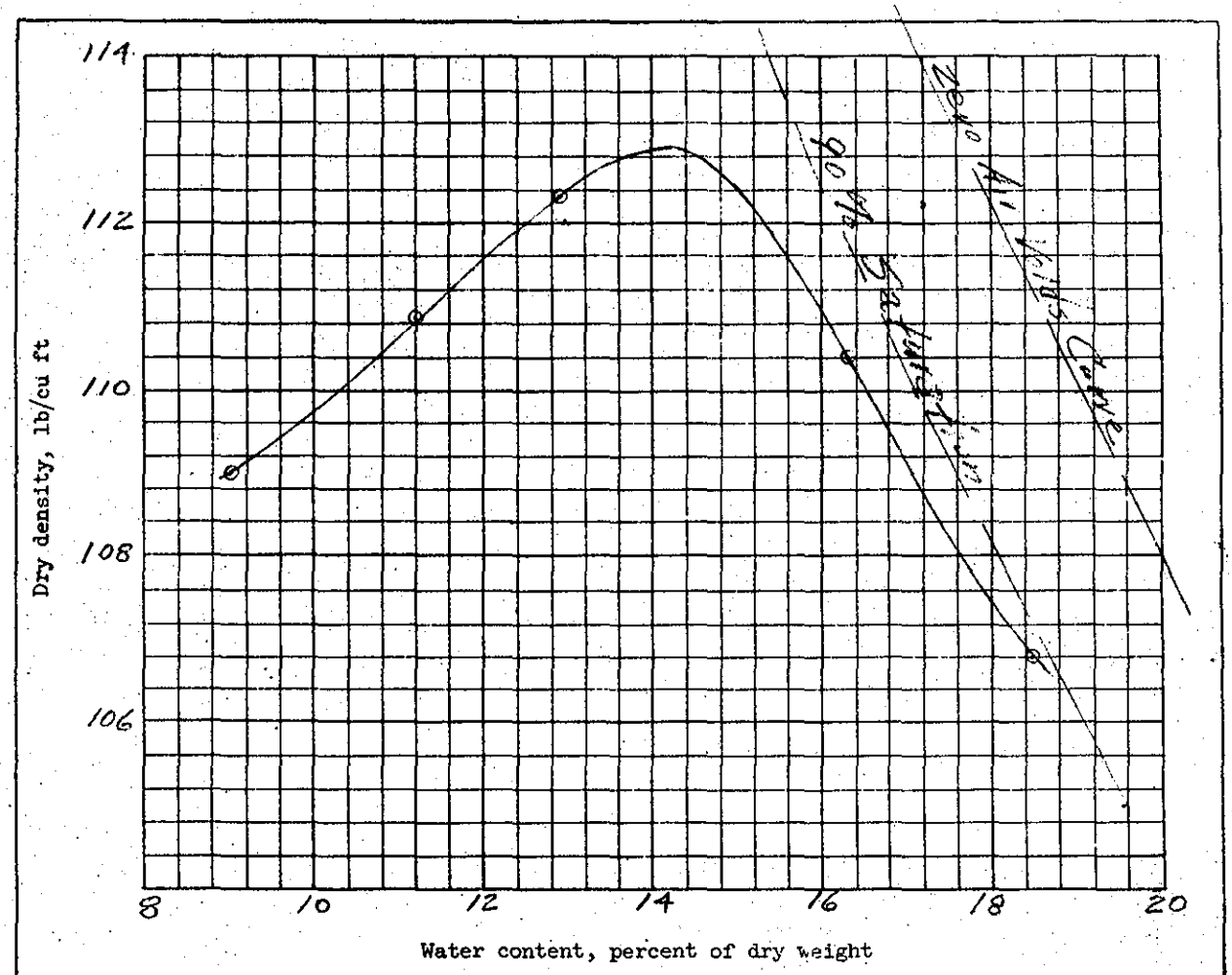
GRADATION CURVES

ENG FORM 2087
1 MAY 63

REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

U.S. GOVERNMENT PRINTING OFFICE : 1963 O7—709-126

Plate No. C-5



Harvard Miniature compaction test

25 ~~blows~~ tamps per each of 3 layers, with 40# SPRING ~~lb~~ rammer and

— inch drop. 1 5/16 inch diameter mold

Sample No.	~~Elev or~~ Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in.
UC3	11.91'-13.74'	Fine Sandy SILT (ML)	2.65	NP	NP	0	0

Sample No.	UC3			
Natural water content, percent				
Optimum water content, percent	14.2			
Max dry density, lb/cu ft	112.9			

Remarks Minimum density performed on this sample with the same compaction effort, indicated a value of 76.9 pcf.

Project Whitmanville Dam

Area

Boring No. FD-51U

Date 15 Jan. 1971

COMPACTION TEST REPORT

ENG FORM 1 JUN 65 2091 (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE TRANSLUCENT A 23559

Plate No. C-6

BORING NO. FD-51 LI
SAMPLE NO. UC-5
DEPTH: 13.74 to 15.75 ft.

PROJECT Whitmanville Dam
DATE August 1970
COMP. By WCS CHK'D By RJS

LABORATORY LOG	DESCRIPTION	W, CAN NO.	TEST SAMPLES
	Cave in material		
	Brown, very moist, fine sandy SILT (ML), micaceous easily friable, slightly sticky		Wn = 24.2%
	Brown silty fine SAND (SM) lens gently dipping, 0.03' thick and 0.01' thick		Q-1 & Q-3 MA & Hydr-3 Wn = 25.9%
		G = 2.68	Q-2 & R-2 MA & Hydr-2 Wn = 28.3%
	Zone of iron oxide stained streaks		
	Grayish brown, wet, silty fine SAND (SM)		R-1 & R-2 MA & Hydr-1 Wn = 28.1%
			γ_d = 97.5 pcf
	Very moist soft silty CLAY (CL) lens		Wn = 26.5% MA-4
	Alternating rust brown and red seams of fine sandy SILT (ML)		
	Gray fine sandy SILT (ML) lens 0.025' thick		
	Bottom of Sample		
	Note: Overall density of sample not determined due to cave-in mat'l.		

SAMPLE DEPTH IN FEET

SAMPLE LENGTH IN INCHES

Length of Sample, L 22.0 in.
Weight of Tube and Wet Soil _____ g.
Weight of Tube _____ g.
Weight of Wet Soil, W _____ g.
Diameter of Tube, D _____ in.
Total Unit Weight, $\gamma_t = \frac{4.85\,W}{L\,D^2}$ _____ lbs/cu.ft.

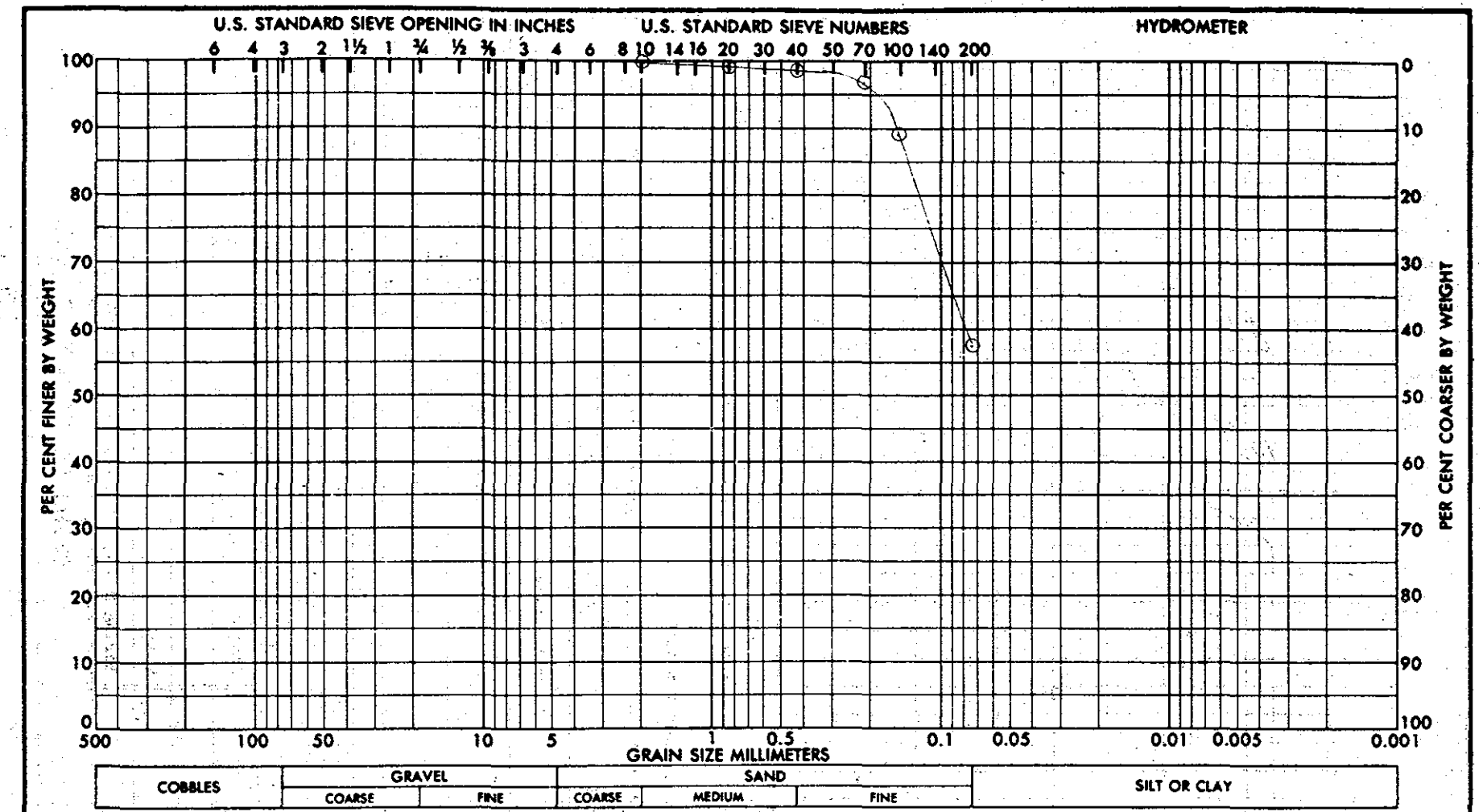
UNDISTURBED SAMPLE LOG

LEGEND

- W_n — Natural Water Content
- MA — Mechanical Analysis
- LL — Atterberg Limits
- G — Specific Gravity
- C — Consolidation
- Q — Unconsolidated Undrained
- γ_a — Dry Density
- R — Consolidated Undrained
- S — Consolidated Drained
- UC — Unconfined Compression

NED FORM DEC 62 501

Plate No. C-7



SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
UC-5 No4	13.74'-15.75'	Fine sandy SILT (ML)				

PROJECT Whitmanville Dam

AREA

BORING NO. FD-51 U

DATE August, 1970

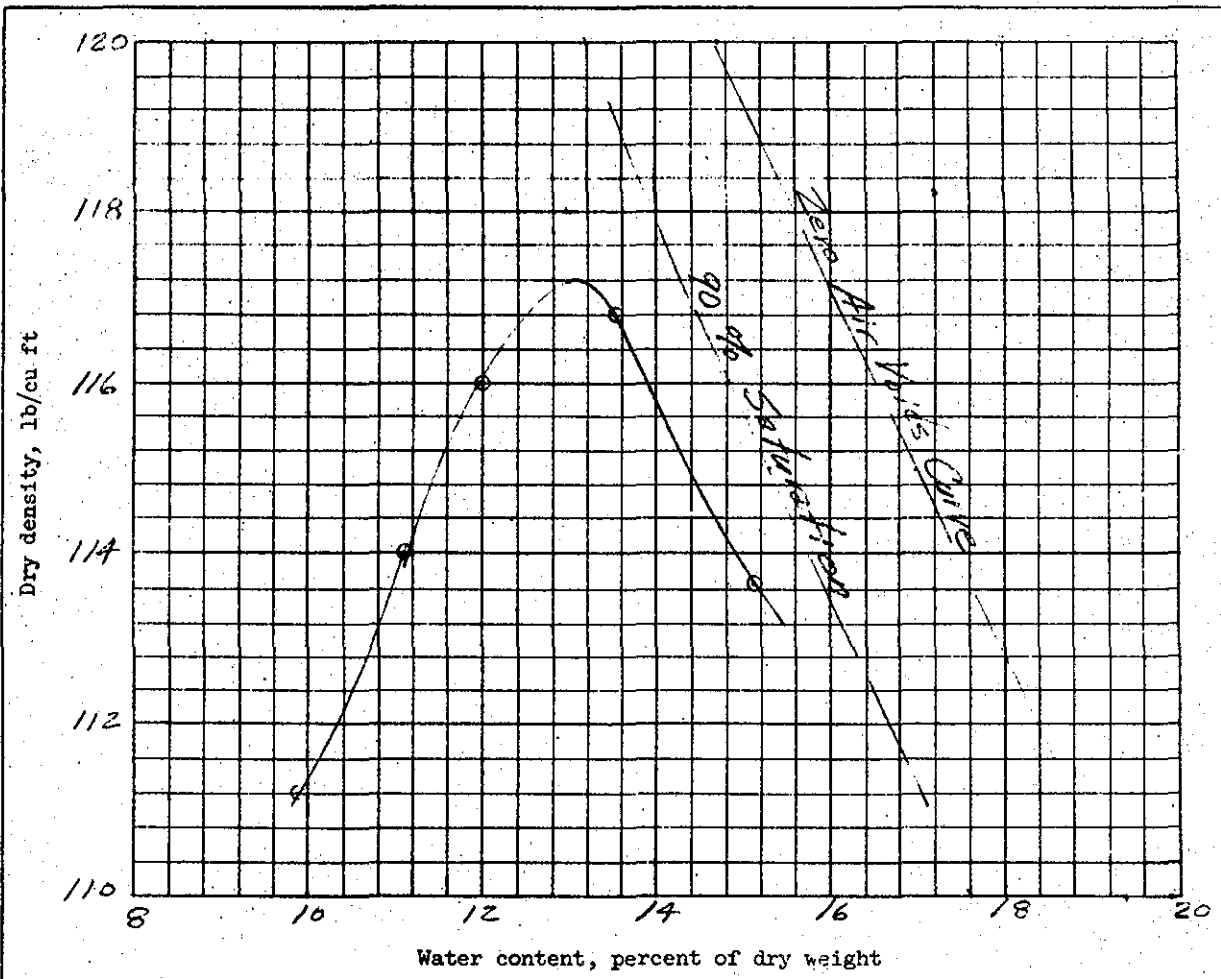
GRADATION CURVES

ENG FORM 2087
1 MAY 63

REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

U.S. GOVERNMENT PRINTING OFFICE . 1963 OF—709-126

Plate No. C-9



Hand Miniature compaction test

25 blows per each of 3 layers, with 40 # SPRING rammer and

— inch drop. 1 5/16 inch diameter mold

Sample No.	Elev or Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in.
UC5	13.74-15.75'	Fine Sandy SILT (ML)	2.68	—	—	0	0

Sample No.	UC5			
Natural water content, percent				
Optimum water content, percent	13.0			
Max dry density, lb/cu ft	117.2			

Remarks Minimum density performed on this sample with the same compaction mold, indicated as value of 74.9 pcf

Project Whitmanville Dam

Area

Boring No. FD-51U Date 20 JAN. 1971

COMPACTION TEST REPORT

ENG FORM 1 JUN 65 2091 (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE TRANSLUCENT A 23569

Plate No. C-10

BORING NO. FD-51U
SAMPLE NO. UC-7
DEPTH: 15.95 to 16.97 ft.

PROJECT Whitewater River
DATE August, 1970
COMP. By M.B. CHK'D By E.J.S.

LABORATORY LOG	DESCRIPTION	W, CAN NO.	TEST SAMPLES
	Wax Plug		
	Cave-in material		
	Brown, very moist fine sandy SILT (ML)		
	Brown, wet, silty coarse-fine SAND (SP-SM), 0.038' thick		
	Black organic zone, 0.005' thick		
	Brown, red w/ black streaks silty m-f SAND (SM)		
	Weakly cemented, black, dark gray & orange brown sandstone at bottom of sample		
	Note: No tests performed as directed.		

SAMPLE DEPTH IN FEET: 24, 23, 22, 21, 20, 19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0

SAMPLE LENGTH IN INCHES

Length of Sample, L _____ in.
Weight of Tube and Wet Soil _____ g.
Weight of Tube _____ g.
Weight of Wet Soil, W _____ g.
Diameter of Tube, D _____ in.
Total Unit Weight, $\gamma_t = \frac{4.85\,W}{L\,D^2}$ _____ lbs/cu.ft.

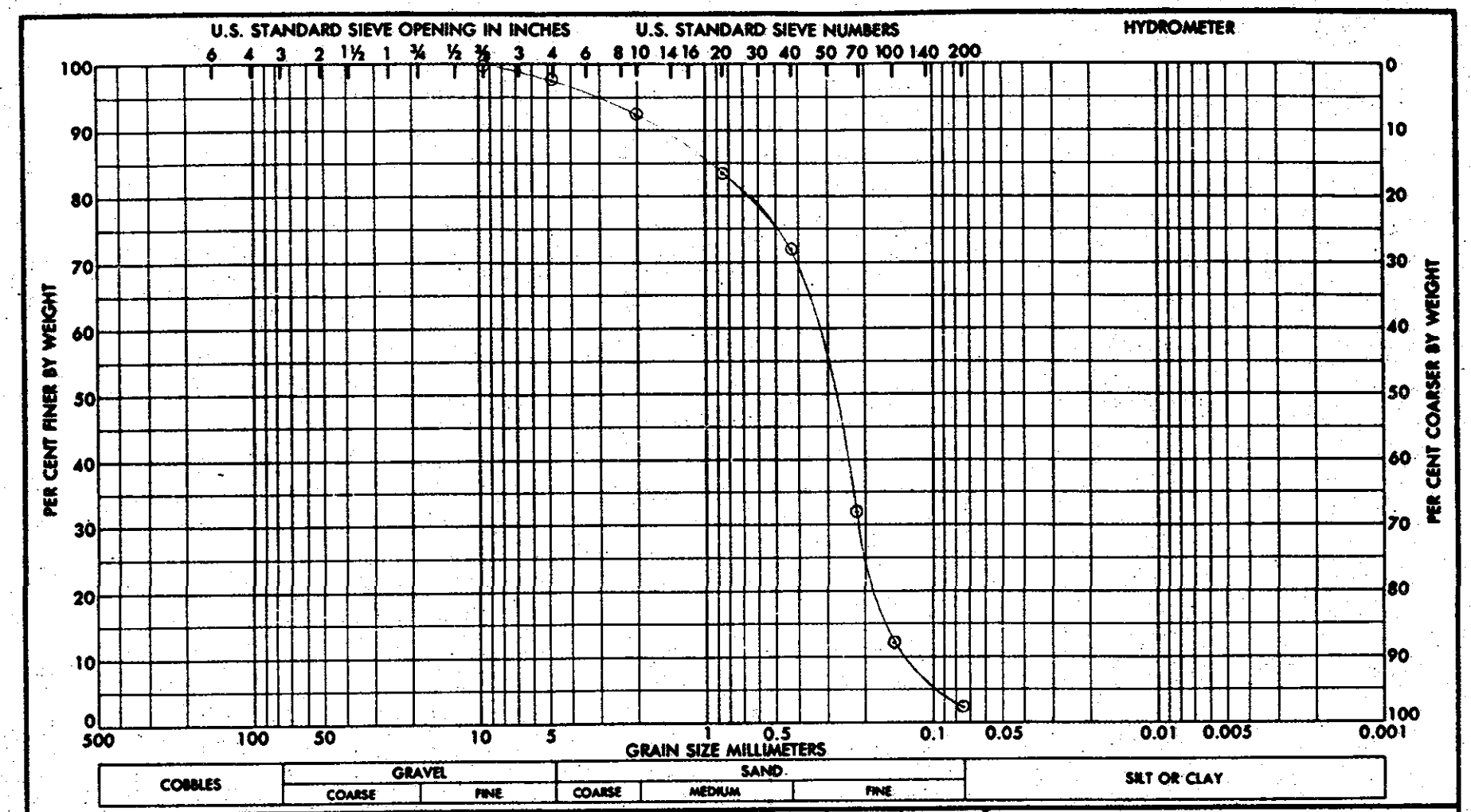
LEGEND

W_n — Natural Water Content
MA — Mechanical Analysis
LL — Atterberg Limits
G — Specific Gravity
C — Consolidation
Q — Unconsolidated Undrained
γ_d — Dry Density
R — Consolidated Undrained
S — Consolidated Drained
UC — Unconfined Compression

UNDISTURBED SAMPLE LOG

NED FORM 501

Plate No. C-11



SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
J-3	11.70'-13.66'	m-f SAND (SP)				

PROJECT Whitmanville Dam

AREA

BORING NO. FD-52U

DATE Aug. 1970

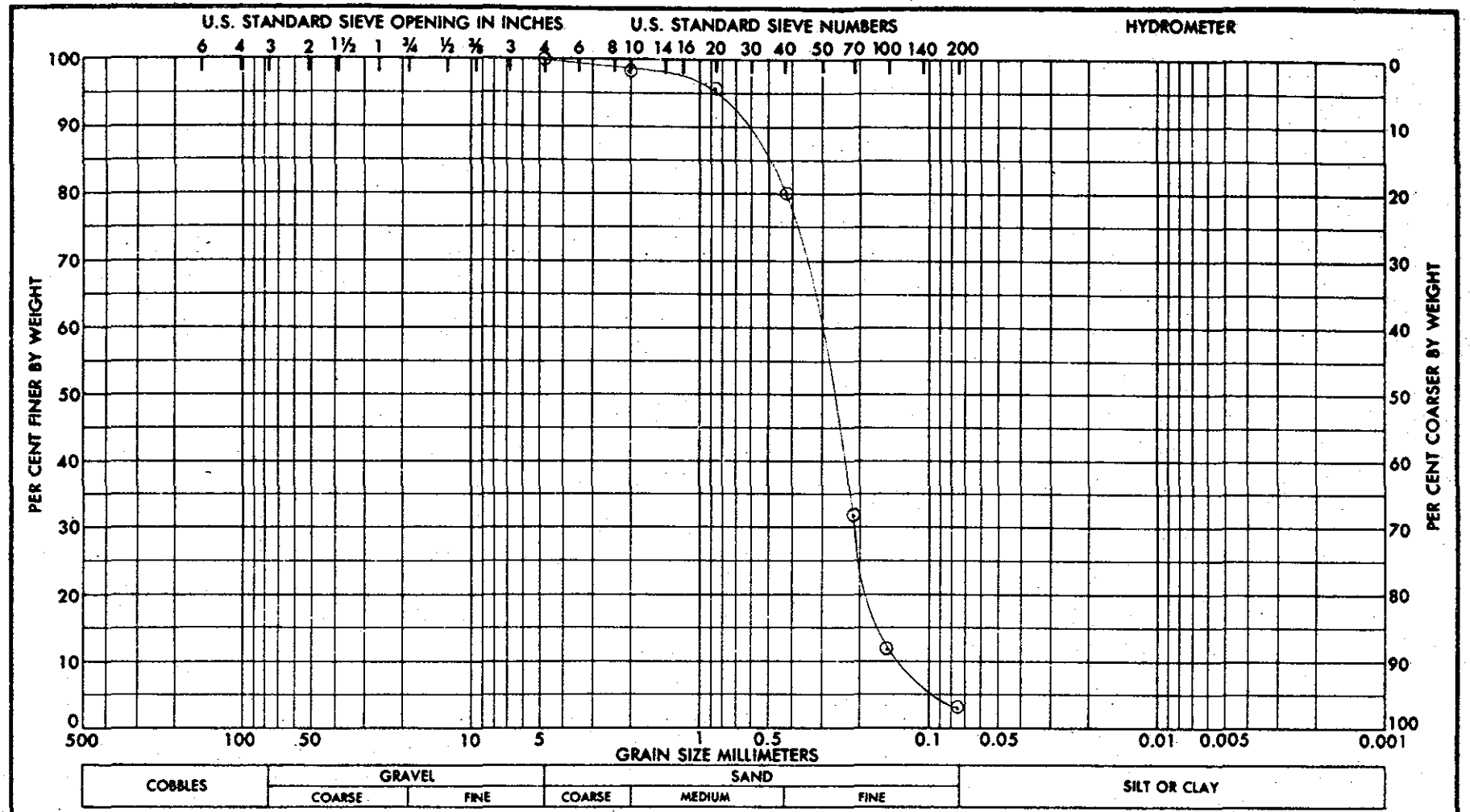
GRADATION CURVES

Plate No. C-12

ENG FORM 2087
1 MAY 63

REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

U.S. GOVERNMENT PRINTING OFFICE : 1963 O-7—709-126



SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
J-4	14.0'-19.0'	m-f SAND (SP)				

PROJECT Whitmanville Dam

AREA

BORING NO. FD-521

DATE Aug. 1970

GRADATION CURVES

ENG FORM 2087
1 MAY 63

REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

U.S. GOVERNMENT PRINTING OFFICE : 1963 OF—709-

Plate No. C-13