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NATIONAL DAM SAFETY PROGRAM. LAKE OF THE WOODS, INVENTORY NUMBE--ETC(U)
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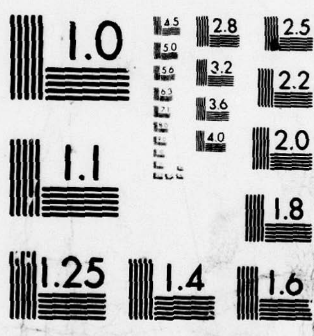

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

RAPPAHANNOCK RIVER BASIN

Name Of Dam: Lake of the Woods
Location: Orange County, State of Virginia
Inventory Number: VA 13701

LEVEL II

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

Lake of the Woods, Inventory Number: VA13701. Rappahannock River Basin, Orange County, State of Virginia. Phase I Inspection Report.

Final rept.

Michael Baker, III

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PREPARED FOR

NORFOLK DISTRICT CORPS OF ENGINEERS
803 FRONT STREET
NORFOLK, VIRGINIA 23510

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BY

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20. Abstract

Pursuant to Public Law 92-367, Phase I Inspection Reports are prepared under guidance contained in the recommended guidelines for safety inspection of dams, published by the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

Based upon the field conditions at the time of the field inspection and all available engineering data, the Phase I report addresses the hydraulic, hydrologic, geologic, geotechnic, and structural aspects of the dam. The engineering techniques employed give a reasonably accurate assessment of the conditions of the dam. It should be realized that certain engineering aspects cannot be fully analyzed during a Phase I inspection. Assessment and remedial measures in the report include the requirements of additional indepth study when necessary.

Phase I reports include project information of the dam and appurtenances, all existing engineering data, operational procedures, hydraulic/hydrologic data of the watershed, dam stability, visual inspection report and an assessment including required remedial measures.

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the design flood should not be interpreted as necessarily posing a highly inadequate condition. The design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

CONTENTS

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Lake of the Woods
State: Virginia
County: Orange
Stream: Flat Run
Date of Inspection: 29 November 1978

BRIEF ASSESSMENT OF DAM

Lake of the Woods Dam is an earthen dam approximately 65 feet high and 1475 feet long. The dam is owned, operated, and maintained by Lake of the Woods, Inc. and was designed by Bauer Engineering, Inc. The lake is used for recreation by Lake of the Woods residents. The visual inspection and review of engineering data, made in November 1978 and January 1979, indicate no deficiencies requiring emergency attention.

The spillway will pass 67 percent of the Probable Maximum Flood without overtopping the dam, which is considered inadequate but not seriously inadequate for the "intermediate" size-"high" hazard classification of Lake of the Woods Dam. Review of stability calculations and visual observations made in the field indicate no evidence of embankment instability or piping of an emergency nature. However, if an emergency condition developed that would require draining the reservoir; the inability of the reservoir drain to empty the reservoir in a reasonable period of time is considered an undesirable condition. A study should be instituted immediately to determine an alternate method to drain the reservoir.

It is recommended that the finger drain outlets at the toe be located and opened into the drainage channel along the toe of the dam. The epoxy patches in the spillway that are no longer adhering to the concrete should be repaired, especially around the sluice gate. Rock should be placed over the seepage and erosion area at the end of the right spillway wall beside the stilling basin. The area behind the left spillway wall, where settlement has occurred, should be filled with soil, compacted, and seeded. The following minor maintenance items should be accomplished as part of the yearly maintenance program: fill and seed bare areas on the embankment, remove small trees from the drainage ditch at the toe, replace disloged or missing riprap, remove any large debris from the reservoir area and spillway, and install a staff gage to monitor reservoir levels above normal pool.

MICHAEL BAKER, JR., INC.

Michael Baker, III, P.E.
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Date: MAR 19 1979

COMMONWEALTH OF VIRGINIA
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CERTIFIED PROFESSIONAL ENGINEER

NAME OF DAM: LAKE OF THE WOODS

OVERALL VIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM: LAKE OF THE WOODS ID# VA 13701

SECTION 1 - PROJECT INFORMATION

1.1 General

1.1.1 Authority: Public Law 92-367, 8 August 1972 authorized the Secretary of the Army, through the Corps of Engineers to initiate a national program of safety inspections of dams throughout the United States. The Norfolk District has been assigned the responsibility of supervising the inspection of dams in the Commonwealth of Virginia.

1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the Recommended Guidelines for Safety Inspection of Dams. The main responsibility is to expeditiously identify those dams which may be a potential hazard to human life or property.

1.2 Description of Project

1.2.1 Description of Dam and Appurtenances: Lake of the Woods Dam is a homogeneous earthfill dam approximately 1475 feet long and 65 feet high. Seepage control is provided by an 8 inch perforated C.M.P. which extends from abutment to abutment along the base of the dam approximately 30 feet downstream from the centerline (see Plate 2). A cutoff trench and filter drains provide additional seepage control at the downstream toe and beneath 12 inches of riprap on the upstream face.

The overflow spillway located in the left abutment area consists of a concrete ogee weir, 40 feet long and 6.5 feet high, with a paved chute spillway, approximately 135 feet long on a 3 horizontal to 1 vertical (3:1) slope. All outflow from the dam is through this overflow spillway. The chute spillway discharges into a 30 foot wide by 65 foot long stilling basin. The weir crest elevation is 317.5 feet M.S.L.

A two-foot-square sluice gate is located at the left end of the concrete weir and is used primarily to flush sediment that accumulates behind the weir.

The lake can be drained by means of a 12 inch ductile iron drainpipe which extends through the dam and outlets into a small stream at the downstream toe of the dam. The drain is controlled by a 12 inch plug valve located about 15 feet upstream of its outlet. The plan and typical sections of the dam are shown on Plates 1, 2, and 3.

1.2.2 Location: Lake of the Woods Dam is located on Flat Run just upstream of Virginia State Route 3, 7 miles northwest of Chancellorsville, Orange County, Virginia. A Location Plan is included in this report.

1.2.3 Size Classification: The maximum height of the dam is 65 feet above the old streambed of Flat Run. The reservoir volume to the top of the dam is 14,160 acre-feet. Therefore, the dam is in the "intermediate" size category as defined by the Recommended Guidelines for Safety Inspection of Dams.

1.2.4 Hazard Classification: A treatment plant is located in the floodplain approximately 0.4 mile downstream from the dam. Because of the proximity of this plant, loss of life could result in the event of failure of the dam. Therefore, the dam is considered in the "high" hazard classification as defined by Section 2.1.2 of the Recommended Guidelines for Safety Inspection of Dams. The hazard classification used to categorize dams is a function of location only and has nothing to do with its stability or probability of failure.

1.2.5 Ownership: Lake of the Woods Dam which is situated in a private residential community is owned, operated, and maintained by Lake of the Woods, Inc.

1.2.6 Purpose: Lake of the Woods Dam is a privately owned recreational facility.

1.2.7 Design and Construction History: The existing facility was designed for the owner by Bauer Engineering, Inc. of Chicago, Illinois and constructed by Shoosmith Bros., Inc.

1.2.8 **Normal Operational Procedures**: No formal operational procedures are followed for this dam since it is a recreational facility. Normal pool elevation of 317.5 feet M.S.L. is maintained by a concrete ogee overflow weir that is the only spillway. The two-foot-square sluice gate and the 12 inch reservoir drain are opened annually to flush out sediment deposits.

1.3 Pertinent Data

1.3.1 **Drainage Area**: The drainage area of the Lake of the Woods Dam is 7.23 square miles.

1.3.2 **Discharge at Dam Site**: The maximum discharge through the spillway is not known.

Spillway:
Pool level at top of dam . . . . 3801 c.f.s.

1.3.3 **Dam and Reservoir Data**: Pertinent data on the dam and reservoir are shown in the following table:

TABLE 1.1 DAM AND RESERVOIR DATA

Item	Elevation feet M.S.L.	Area acres	Reservoir Capacity: Acre-feet	Reservoir Capacity: Watershed inches	Length feet
Top of dam	325.0	625	14,160	36.7	14,600
Spillway crest	317.5	500	9880	25.6	13,400
Streambed at centerline of dam	260±	-	-	-	-

SECTION 2 - ENGINEERING DATA

2.1 Design: The design data reviewed included the following:

1) As-built drawings of the dam including plan, elevation, typical sections, structural details, boring logs, and test pits.

2) Partial construction report documents including revisions that were made to the side slopes and compaction requirements (Appendix V).

3) Final inspection report by the designer, Bauer Engineering, Inc., at time of construction completion (Appendix V).

4) Partial hydraulic and hydrologic design data by Bauer Engineering, Inc., including a flood routing for Probable Maximum Flood (PMF), was reviewed and is discussed further in Section 5.1.

5) Soils exploration reports by Dames and Moore (Appendix VI).

6) Stability analyses by Dames and Moore, and Bauer Engineering, Inc. are discussed further in Section 6.2.2 (Appendix VII).

All design data reviewed was borrowed from the owner.

2.2 Construction: The dam was built by the Shoosmith Bros., Inc. and was completed in March 1968. As-built drawings, change orders, and material requisitions were available for review. The as-built drawings were verified in the field.

According to correspondence reviewed from the owner's file; it is apparent that during construction of the embankment, 95% of modified density was difficult to maintain. It was decided that, although 95% compaction would be strived for, a lower limit for compaction of 92% to 93% would be permissible. Dames and Moore of Chicago, Illinois, performed field explorations and laboratory tests during construction. With the relaxation of compaction requirements, it was decided to flatten the final slopes to 4:1 upstream and 3.5:1 downstream. These were the final slopes as indicated on the as-built drawings. The final inspection of the dam, spillway, and appurtenant structures was made by the design engineer on 6 March 1968.

2.3 Operation: There is no formal operating procedure for this dam. However, the two-foot-square sluice gate located in the spillway is operated on an annual basis to flush out sediment deposits as is the 12 inch reservoir drain.

The filling of the reservoir commenced in 1967 according to the report by E. D'Appolonia in October 1969 (Appendix V, pp. 5-18). Although there was some concern about the "slow rate of filling of the reservoir," D'Appolonia felt that additional filling time should be allowed before concluding the lake would not reach its normal pool elevation without expensive remedial or artificial filling measures.

Bauer Engineering, Inc. conducted an inspection (see report and check list in Appendix V) in August 1970 at the request of the developer, Boise Cascade Corporation, and stated that in general the dam appeared to be in excellent condition.

2.4 Evaluation:

2.4.1 Design: The as-built drawings were adequate to aid in the assessment of the stability of the dam. Stability calculations for the earthen section of the dam are included in Appendix VII. Design calculations for different conditions were available for the concrete weir and adjoining retaining walls of the spillway.

2.4.2 Construction: The construction reports and correspondence reviewed indicated that construction methods used were in accordance with design criteria.

2.4.3 Operation: Operations performed by Lake of the Woods personnel are considered adequate for this structure.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

3.1.1 General: The field investigation was made on 29 November 1978. The weather was cloudy and rainy. The lake was at elevation 317.0 feet M.S.L. (0.5 foot below normal pool). The embankment and the appurtenant structures were found to be in good overall condition and do not require immediate remedial action.

3.1.2 Dam: The embankment was in good condition except for small areas on the crest and downstream face which have sparse topsoil and vegetation. These areas should be topsoiled and seeded. There is scattered driftwood on the riprap which should be removed. The stone riprap dislodged in a few small areas should be replaced.

The wet areas at the toe of the dam and on the slopes of the collection ditch nearby are probably caused by the finger outlets from the filter drain being partially blocked by topsoil. The outlets should be cleaned out and extended to the ditch where necessary. Trees growing in the ditch and dumped tree stumps should be removed.

3.1.3 Appurtenant Structures: The intake portion of the reservoir drain is submerged. The plug valve and outlet pipe appear to be in good condition. There was no flow from the outlet pipe (Photo 1).

The concrete spillway functions adequately in spite of minor deterioration which includes epoxy patching in nine areas with clear leakage at two locations. There are small popouts of aggregate on the crest of the weir and in the spillway. Minor settlement (less than 2 feet) of the backfill adjacent to the left (north) wall should be corrected by the addition of compacted soil and seeding. The clear seepage and eroded area at the end of the right wall beside the stilling basin should be covered with rock to prevent further erosion. There is some clear leakage in the patched stem of the weir adjacent to the slide gate. Photos 2-6 show the deterioration of the spillway.

3.1.4 Reservoir Area: The slopes in the reservoir area are apparently well vegetated with minor erosion.

3.1.5 Downstream Channel: The outlet channels for the reservoir drain and spillway are in satisfactory condition. There is some minor erosion on the slopes where clear seepage is present downstream from the spillway.

3.2 Evaluation: None of the above items is serious enough to represent an emergency condition. However, the following items should be completed within a year from the date of this report. Erosion control and seeding of bare areas should be included in the annual inspection and maintenance program. The repair of the filter drain outlets, elimination of trees growing in the downstream drainage ditch, removal of the pile of tree stumps, and repairs in the spillway area should also be completed.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 <u>Procedures</u>: Operational procedures are generally discussed in paragraphs 1.2.8 and 2.3. The owner opens the slide gate on the face of the concrete weir in the spillway and the reservoir drain annually to flush out sediments.

4.2 <u>Maintenance of Dam</u>: Maintenance of the dam is provided by personnel of Lake of the Woods, Inc.

4.3 <u>Maintenance of Operating Facilities</u>: Maintenance of the operating facilities is also provided by the owner. As previously mentioned, the slide gate on the weir in the spillway and the reservoir drain are operated and checked annually.

4.4 <u>Warning System</u>: At the present time, there is no formal warning system or evacuation plan in operation. It is recommended that a formal emergency procedure be prepared and prominently displayed, and furnished to all operating personnel. This should include:

1) How to operate the dam during an emergency.

2) Who to notify, including public officials, in case evacuation from the downstream area is necessary.

3) Procedures for evaluating inflow during periods of emergency operation.

4.5 <u>Evaluation</u>: Operational procedures are considered adequate for the existing facilities at Lake of the Woods Dam.

SECTION 5 - HYDRAULIC/HYDROLOGIC DATA

5.1 Design: Partial hydrologic and hydraulic design calculations were obtained from the owner. According to the design calculations, dated October 1966, by Bauer Engineering, Inc., the dam and spillway will pass the PMF with a maximum reservoir elevation of 324.2 feet M.S.L. The spillway discharge capacity was computed by Bauer Engineering, Inc. using a weir coefficient of 4.0 for all reservoir heads and a weir length of 50 feet. This would yield a maximum discharge at the top of dam elevation of approximately 4100 c.f.s.

5.2 Hydrologic Records: No rainfall or stream flow records were available at the dam.

5.3 Flood Experience: No records of high stage were available for this report. However during the heavy rains of July 1969, the reservoir was being filled and rose an additional 6 inches as a result of this rainfall. (Appendix V, p. 10.)

5.4 Flood Potential: Performance of the dam and reservoir by routing the PMF, the 1/2 PMF, and the 100-year flood is shown in Table 5.1.

Surface area and storage capacity data were obtained from the design data. Outlet discharge capacity hydrograph and routing determinations were computed as part of this report for comparison with design assumptions and calculations. Flood routings were started assuming the reservoir level was at normal pool (elevation 317.5 feet M.S.L.).

5.5 Reservoir Regulation: Pertinent dam and reservoir data are shown in Table 1.1, paragraph 1.3.3.

Regulation of flow from the reservoir is automatic under normal conditions. Normal pool (elevation 317.5 feet) is maintained by the crest of the overflow weir in the spillway. Normal outflow from the reservoir passes through this spillway, except for flow through the reservoir drain and slide gate when opened.

5.6 Overtopping Potential: The overtopping potential was evaluated by combining three separate inflow hydrographs for each flood analyzed. One inflow hydrograph represented inflow produced by direct runoff from rainfall over the lake surface area of 0.78 square mile. A second inflow hydrograph represented 3.40 square miles of watershed in the upper regions of the watershed, which was lagged 2 hours based on travel time behind the lake runoff hydrograph. A third inflow hydrograph represented the remaining 3.05 square miles of watershed, which included primarily the watershed around the lake. This watershed, having a short time of concentration, was lagged only 0.5 hour behind the lake runoff hydrograph. These three hydrographs were combined and routed through the reservoir to determine the outflow hydrograph.

The probable rise in the reservoir and other pertinent information on the reservoir performance in various hydrographs are shown in the following table:

TABLE 5.1 RESERVOIR PERFORMANCE

Item	Normal	Hydrographs 100 Year	1/2 PMF	PMF
Peak flow, c.f.s.				
Inflow	-	5996	12,609	25,218
Outflow	-	543	2769	13,804
Peak elev., ft. M.S.L.	317.5	319.6	323.6	326.7
Spillway				
Depth of flow, ft. (a)	-	1.4	4.1	6.1
Avg. velocity, f.p.s.	-	6.5	11.4	14.0
Non-overflow section				
Depth of flow, ft.	-	-	-	1.7
Average velocity, f.p.s.	-	-	-	3.5
Duration of overtopping, hrs.	-	-	-	6.3
Tailwater elev., ft. M.S.L.	262.0	-	-	-

(a) Estimated depth at ogee weir based on critical depth.

5.7 Reservoir Emptying Potential: Neglecting inflow, the reservoir elevation may be lowered from normal pool (elevation 317.5 feet M.S.L.) to elevation 310.5 feet M.S.L. in approximately 45 days by use of the two-foot-square, sluice gate outlet on the face of the weir and the 12 inch diameter reservoir drain. The reservoir below the sluice gate invert of elevation 310.5 feet M.S.L. can only be lowered by use of the reservoir drain with a maximum discharge (pool level at elevation 310.5 feet M.S.L.) of 11 c.f.s. Again neglecting inflow, it would take 1 year to lower the reservoir from elevation 310.5 feet M.S.L. to the invert of the reservoir at elevation 275.0 feet M.S.L. In the event of an emergency, the reservoir coult not be emptied in a reasonable time because of the small size of the reservoir drain (12 inch diameter pipe).

5.8 Evaluation: Lake of the Woods Dam is classified according to COE criteria as an "intermediate" size-"high" hazard structure requiring passage of a spillway design flood equal to the PMF. The spillway will only pass about 67% of the PMF without overtopping.

However according to design data computed by Bauer Engineering, Inc., the spillway will pass the PMF with a maximum reservoir elevation about 0.8 foot below the top of dam. The differences between the computations for the design and the computations completed as part of this report can probably be attributed to methods of analyses, difference in weir length of spillway, and difference in peak and volume of hydrographs. The peak used for the design hydrograph was 19,300 c.f.s. compared to the 25,200 c.f.s. used for the hydrograph listed in Table 5.1. The assumptions used in computing the design hydrograph are not known.

Therefore, the hydrographs computed as part of this report (shown in Table 5.1) were used in the evaluation of the spillway adequacy because they were considered to more accurately depict the actual conditions found in the field.

The inability to empty the reservoir in a reasonable period of time is considered undesirable and an alternate means of draining the reservoir during an emergency condition should be investigated.

Conclusions pertain to present day conditions and the effect of the future development on hydrology has not been considered.

SECTION 6 - DAM STABILITY

6.1 Foundation and Abutments: There is 3 feet of alluvial, silty sand and gravel (SP/GP) in the bottom of the stream valley with 5 to 8 feet of sandy silt at higher elevations nearer the base of the hills overlying gray, highly weathered gneiss. The slopes in the abutment area are covered by 5 feet of reddish-brown, clayey silt overlying brown and gray, sandy silt with rock fragments (decomposed rock) to a maximum depth of 50 feet. The top of the bedrock is gray and brown, highly weathered gneiss.

6.2 Stability Analysis

6.2.1 Visual Observations: No evidence of instability in the embankment, cut slopes, or concrete structures was observed. The only deficiencies observed were the partial settlement of the backfill adjacent to the left wall of the concrete spillway, and clear seepage and erosion at the end of the wall on the right side (see Photo 6). The flow, from the filter drain and clear seepage in the vicinity of the toe of the dam and parallel drainage ditch, occurs in several areas to the right of the reservoir drain outlet apparently from the covered granular finger outlets. The flow from the collector ditch into the stilling basin for the spillway was measured at 4 g.p.m., which was not considered excessive.

6.2.2 Design Data: The slope stability was checked in 1967 by the Swedish Circle Method for the homogeneous dam embankment. The analysis was computed by Dames and Moore. The embankment section chosen for these analyses had a crest elevation of 325.0 feet M.S.L., upstream slope of 4:1 ratio, and a downstream slope of 3:1. The following shear strength parameters were assumed for the foundation and embankment soils:

	Ø	C (p.s.f.)	Unit Weight (p.c.f.)
Homogeneous Embankment	20°	200	115
Foundation (Assumed)	28°	300	120

The shear strengths for the embankment were determined from the consolidated, saturated, undrained, triaxial shear and direct shear tests. The embankment soil on the slopes was assumed to be saturated. The homogeneous soil was assumed to be compacted to 90% of the maximum dry density. The parameters of the foundation soil immediately underlying the embankment were assumed. The minimum safety factors computed by Dames and Moore for the homogeneous embankment were 1.66 for the upstream slope and 1.35 for the downstream slope. Computations for the downstream slope assumed steady seepage with a straight phreatic line extending from the water level (equal to the spillway crest) on the upstream slope to the filter drain which is based on an adequate performance of the drain. The filter drain is located on the foundation just downstream from the crest.

The upstream slope was also checked at a later date by Bauer Engineering, Inc. A factor of safety of 1.726 for an upstream slope of 3:1 was calculated by the method of slices for a 0.05g seismic factor.

There was no available explanation for the different slope stability criteria used by the two consultants.

The stability analyses data are presented in Appendix VII.

6.2.3 Operating Records: The reports of several inspections of the dam from 1969 to 1972 by engineering firms are included in Appendix V. A few clear seepage zones in the vicinity of the toe of the dam were observed along with erosion areas, slow filling of the reservoir due to possible water loss, clear leakage through cracks in the spillway, and other minor conditions. Remedial measures were recommended for the deficiencies and some were undertaken by the owner, as indicated by the epoxy patching applied to the cracks in the concrete weir.

6.2.4 Post-Construction Changes: No significant alterations to the dam were apparent since it was constructed.

6.2.5 <u>Seismic Stability</u>: Lake of the Woods Dam is located in Seismic Zone 2 near the line of demarcation with Seismic Zone 1. Therefore, it is considered to have no hazard from earthquakes according to the <u>Recommended Guidelines for Safety Inspection of Dams</u>, provided static stability conditions are satisfactory and conventional safety margins exist.

6.3 <u>Evaluation</u>: The embankment section chosen is similar to the as-built drawings except the downstream slope was constructed at a 3.5:1 ratio which would result in a higher safety factor than previously calculated (1.35) for steady state seepage with headwater at the spillway crest. None of the available calculations indicate that stability under rapid drawdown conditions was performed. The 4:1 slope on the upstream side is usually adequate except in cases where the soil strength is extremely low, which is not the case for Lake of the Woods Dam based on available information. However, good engineering practice requires that stability under rapid drawdown should be examined.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment: The dam will pass approximately 67% of the PMF without overtopping which is considered inadequate but not seriously inadequate according to criteria established by the Recommended Guidelines for the Safety Inspection of Dams for an "intermediate" size-"high" hazard category.

Stability analyses were available (Appendix VII) for review. The stability analyses indicated sufficient factors of safety. No evidence of sloughing or seepage indicating embankment distress was observed during the field inspection. The embankments appeared uniform in section with no bulging or areas of depression evident. The grass cover on the embankments was in good condition with the exception of a few small bare areas.

The spillway appears to be functioning adequately. Epoxy patching is leaking (clear) in several places on the weir. There are also small popouts of aggregate on the crest of the weir and in the spillway. These items are not considered to deter proper spillway operation.

7.2 Recommended Remedial Measures: It is recommended that continued maintenance of the concrete surfaces in the spillway be provided. The clear leaks in the weir and around the slide gate should be patched where the old epoxy patching is no longer adhering to the concrete.

An alternate means of draining the reservoir in case of an emergency should be investigated immediately by a consultant since the reservoir cannot be drained in a reasonable period of time. In addition, the stability of the upstream slope under rapid drawdown should be examined.

The finger outlets from the filter drain should be located, cleaned, and extended to the drainage ditch along the toe of the dam. The drainage ditch should be cleaned of the tree stumps and other debris, and maintained to provide adequate drainage away from the dam.

The inspection revealed certain preventative maintenance items which should be scheduled as part of an annual maintenance program. These are:

1) Rock should be placed over the seepage and erosion area at the end of the right spillway wall beside the stilling basin.

2) The area behind the left wall of the spillway where settlement has occurred should be filled with compacted soil and seeded.

3) Fill and seed all bare areas on the embankment.

4) Remove all trees along the drainage ditch at the toe of the dam.

5) Replace any dislodged or missing riprap along the upstream embankment and approach channel to the spillway.

6) Remove all driftwood and other debris from the reservoir area.

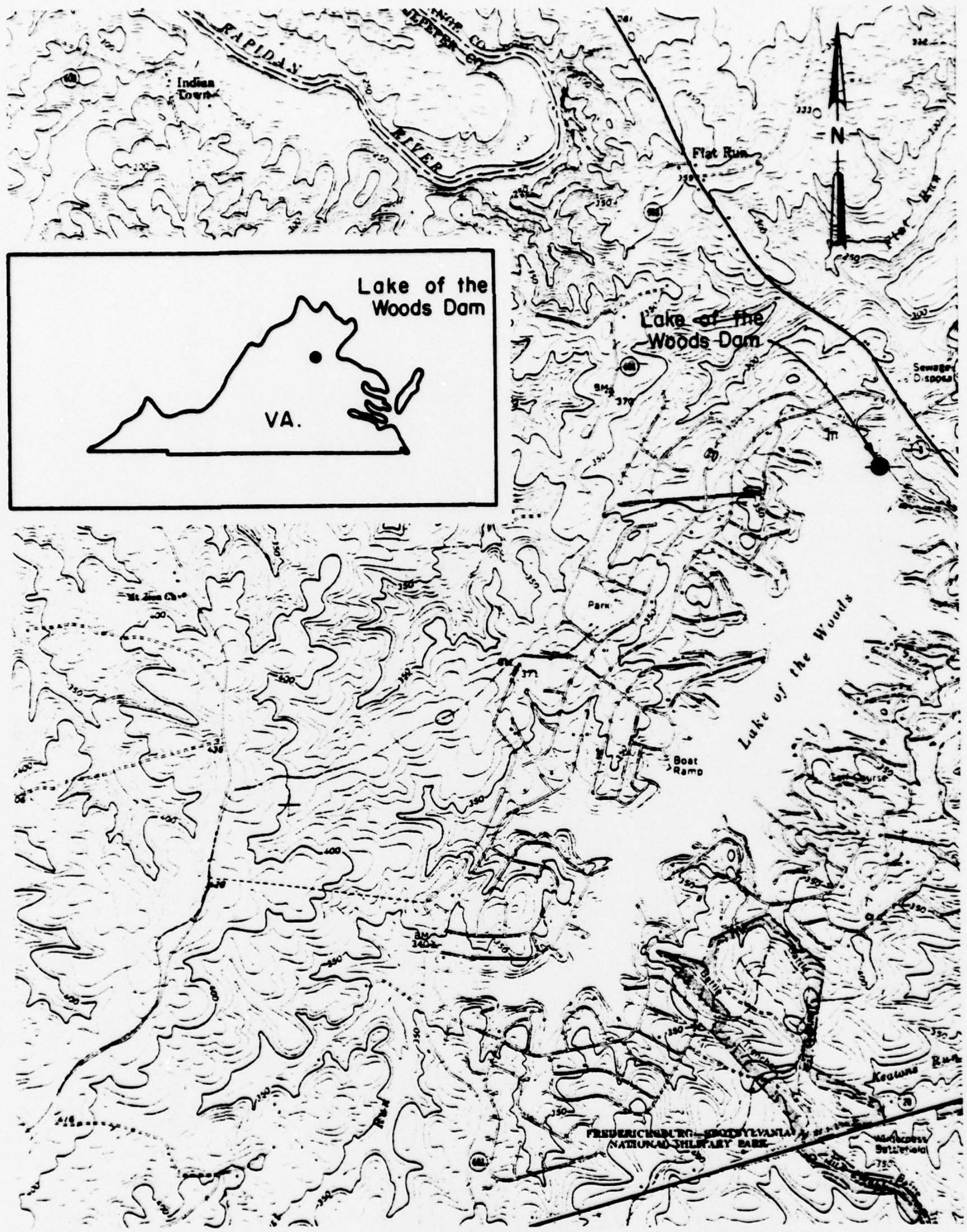
7) Install a staff gage to monitor reservoir levels above normal pool.

APPENDIX I

PLATES

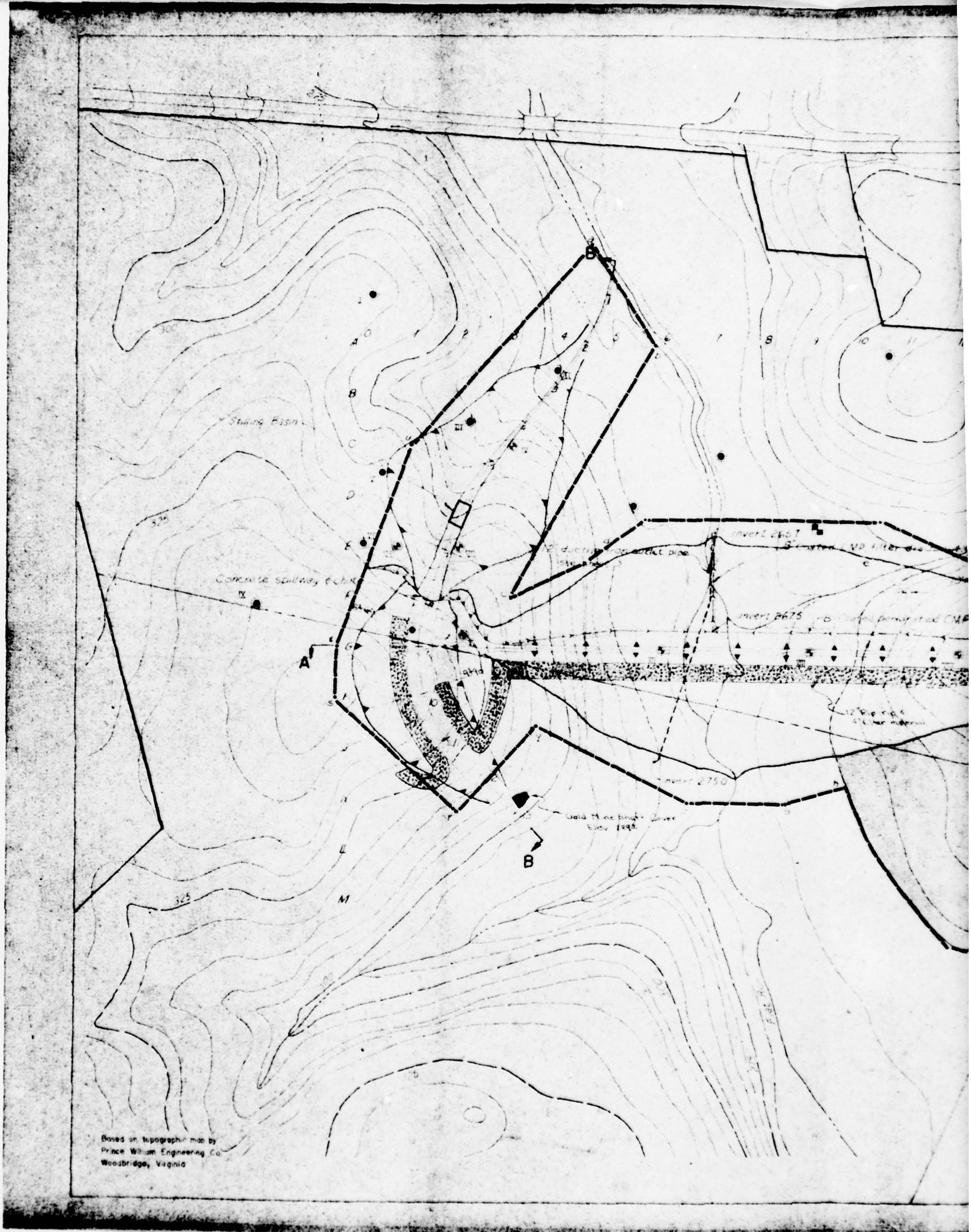
CONTENTS

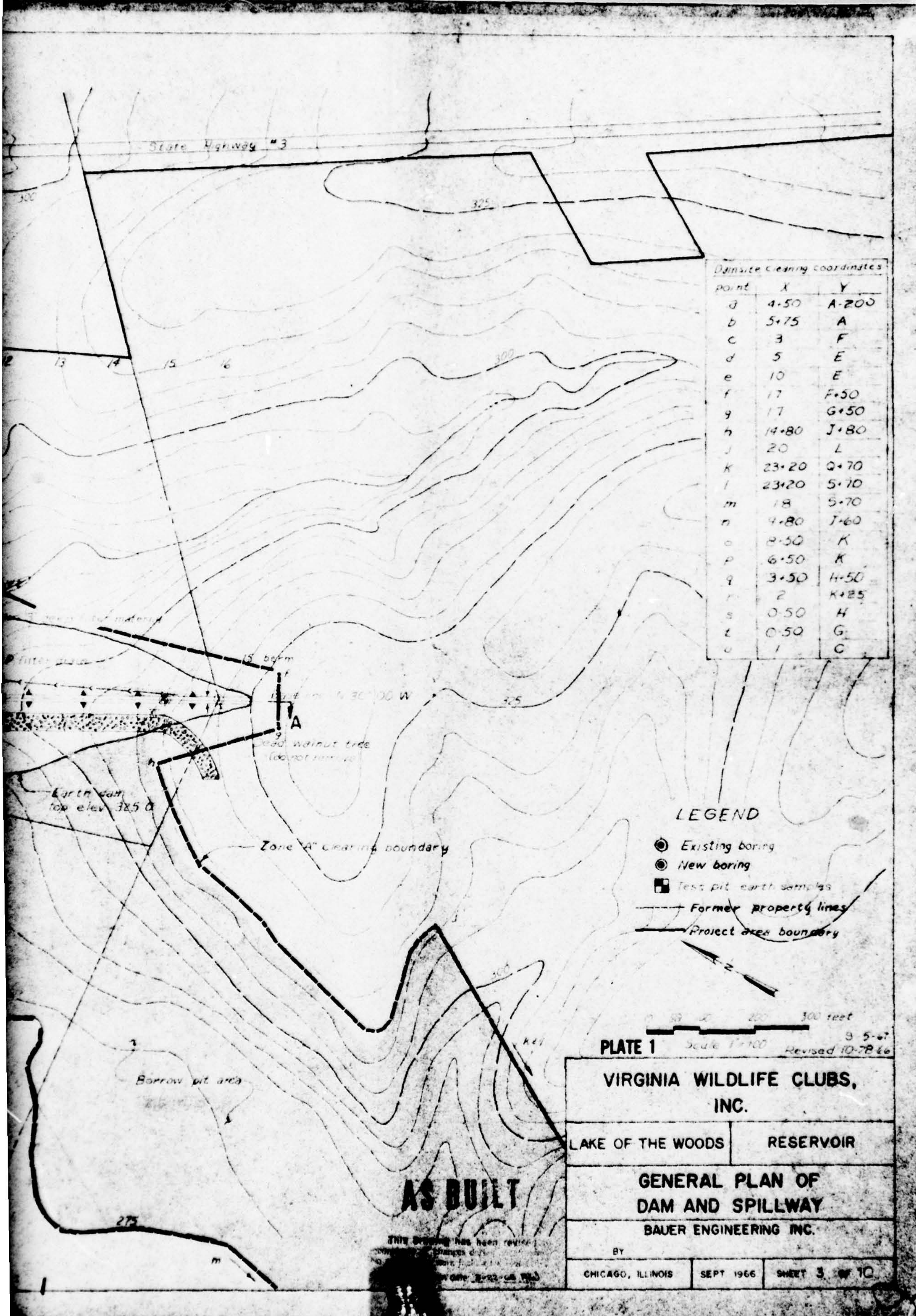
NAME OF DAM: LAKE OF THE WOODS



LOCATION PLAN

LAKE OF THE WOODS DAM


B
A
B
Stilling Basin
Concrete spillway & chute
Invert 2657
Invert 2675
Invert 2750
12" ductile iron outlet pipe
300
325
Based on topographic map by
Prince William Engineering Co.
Woodbridge, Virginia



Damsite Clearing coordinates

point	X	Y
a	4+50	A-200
b	5+75	A
c	3	F
d	5	E
e	10	E
f	17	F+50
g	17	G+50
h	14+80	J+80
j	20	L
k	23+20	Q+70
l	23+20	S+70
m	18	S+70
n	9+80	J+60
o	8+50	K
p	6+50	K
q	3+50	H+50
r	2	K+25
s	0+50	H
t	0+50	G
u	1	C

PLATE 1

9-5-67

Revised 10-28-66

VIRGINIA WILDLIFE CLUBS, INC.

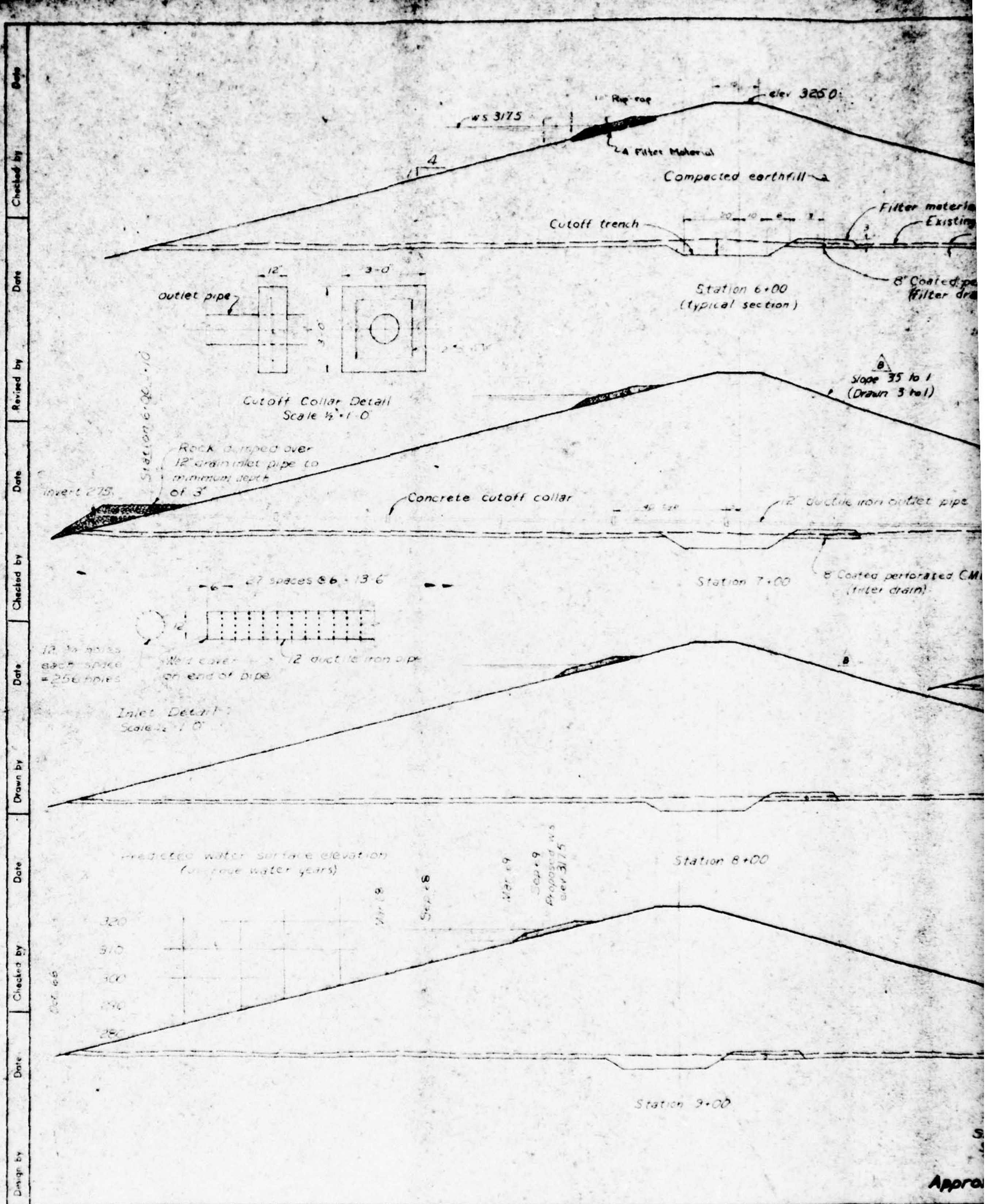
LAKE OF THE WOODS | RESERVOIR

GENERAL PLAN OF DAM AND SPILLWAY

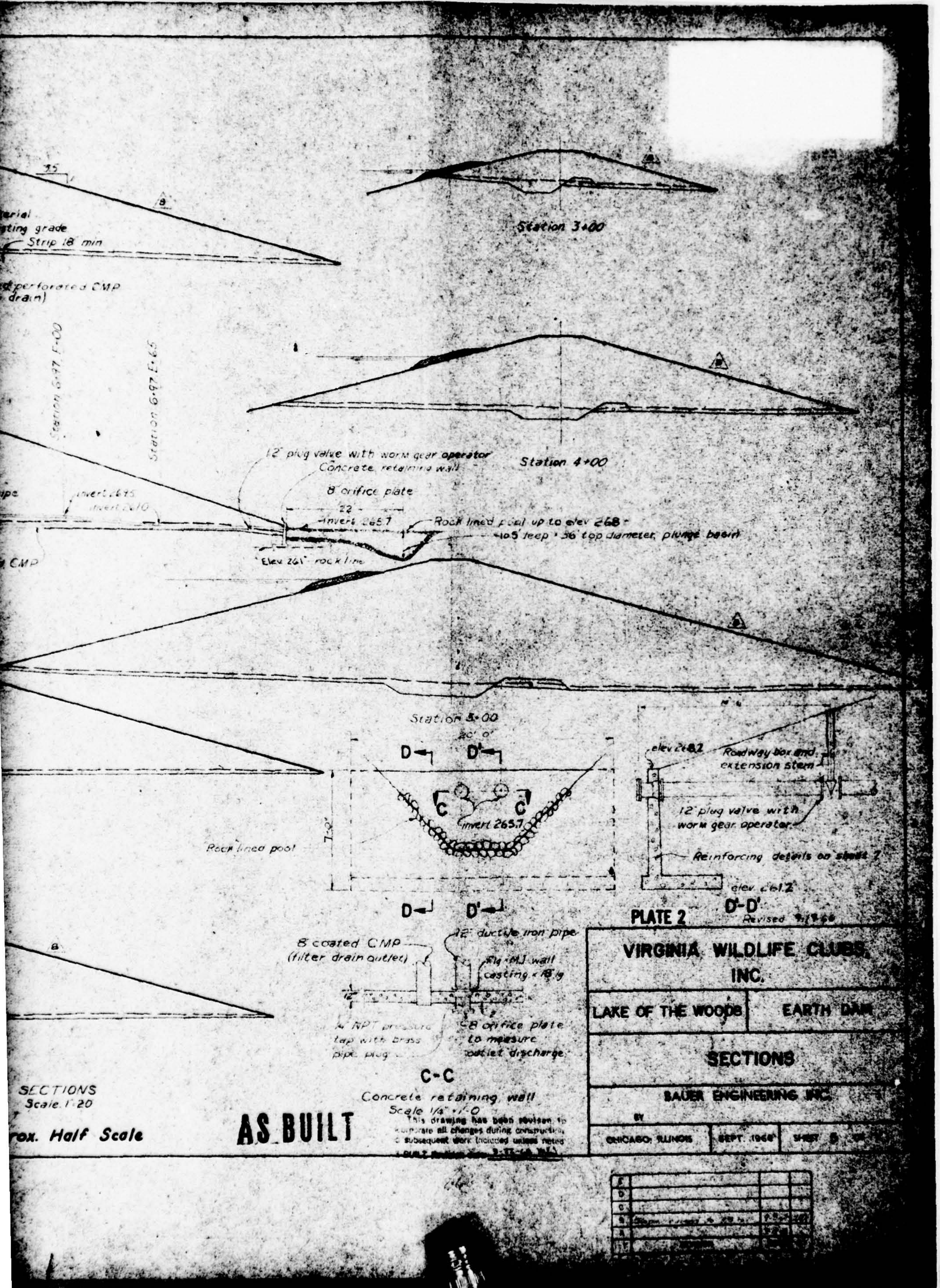
BAUER ENGINEERING INC.

BY

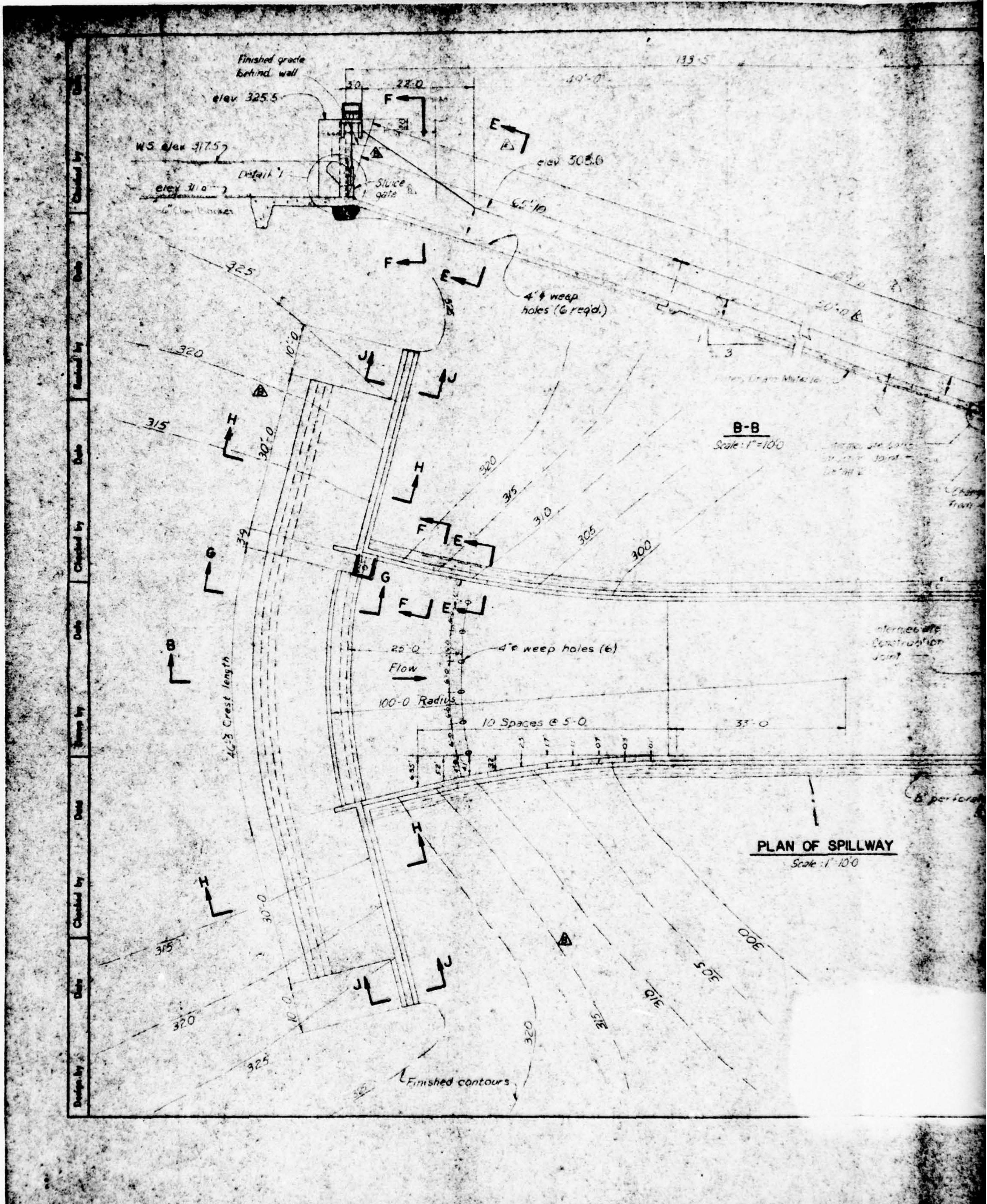
CHICAGO, ILLINOIS | SEPT 1966 | SHEET 3 OF 10



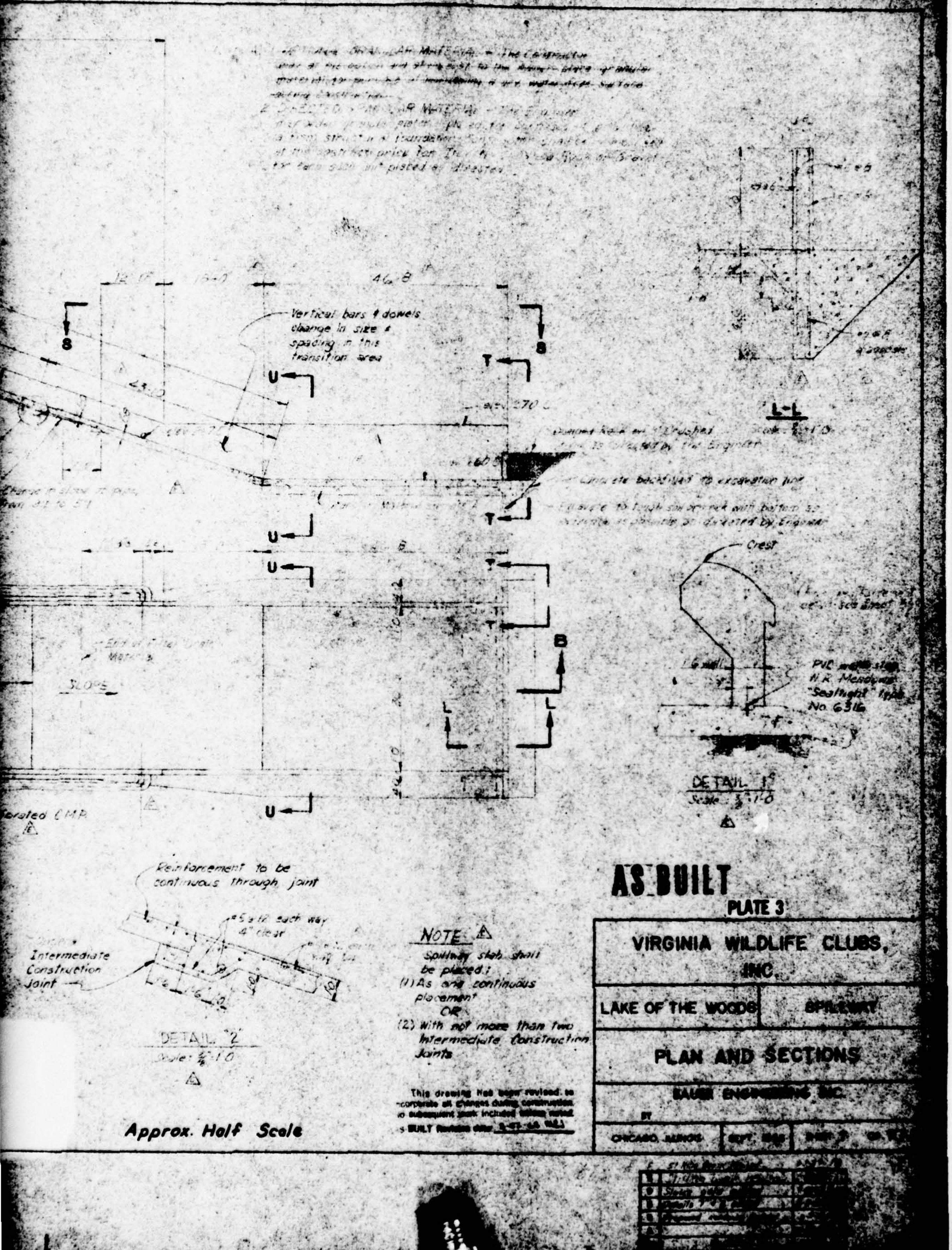
Date
Checked by
Date
Revised by
Date
Checked by
Date
Drawn by
Date
Checked by
Date
Design by
elev 3250
ws 3175
12" Rip-rap
A Filter Material
4
1
Compacted earthfill
Cutoff trench
Filter material
Existing
8" Coated pe
(filter dra
Station 6+00
(typical section)
outlet pipe
12"
3-0"
Cutoff Collar Detail
Scale ½"=1'-0"
Slope 35 to 1
(Drawn 3 to 1)
Rock dumped over
12" drain inlet pipe to
minimum depth
of 3'
invert 275
Concrete cutoff collar
12" ductile iron outlet pipe
Station 7+00
8" Coated perforated CM
(filter drain)
27 spaces @ 6" = 13'-6"
12 ductile iron pipe
Inlet Detail
Station 8+00
Predicted water surface elevation
Proposed ws
elev 3175
320
310
300
290
280
Station 9+00
Appro



Station 3+00
Station 4+00
Station 5+00
Station 6+97 E.00
Station 6+97 E.65
Strip 18" min
12" plug valve with worm gear operator
Concrete retaining wall
8" orifice plate
Invert 265.7
Rock lined pool up to elev 268
Elev 261 rock line
Rock lined pool
D
D'
C
C
D-D'
elev 268.2
Roadway box and extension stem
12" plug valve with worm gear operator
Reinforcing details on sheet 7
elev 261.2
8" coated CMP (filter drain outlet)
12" ductile iron pipe
8" orifice plate to measure outlet discharge
C-C
Concrete retaining wall
Scale 1/4" = 1'-0
SECTIONS
Scale 1:20
Approx. Half Scale
AS BUILT
This drawing has been revised to incorporate all changes during construction
PLATE 2
VIRGINIA WILDLIFE CLUBS, INC.
LAKE OF THE WOODS
EARTH DAM
SECTIONS
BAUER ENGINEERING INC.
CHICAGO, ILLINOIS
SEPT. 1968



Finished grade behind wall
elev 325.5
W.S. elev 317.5
elev 311.0
Detail 1
Sluice gate
elev 305.6
4" ϕ weep holes (6 req'd.)
B-B
Scale: 1" = 10'0
4" ϕ weep holes (6)
Flow
100-0 Radius
10 Spaces @ 5-0
Crest length
Finished contours
PLAN OF SPILLWAY
Scale: 1" = 10'0
Design by
Checked by
Drawn by
Date



Vertical bars & dowels change in size & spacing in this transition area
S
U
T
B
L
L-L
Crest
PVC waterstop W.R. Meadows "Sealtight" type No. 6316
DETAIL 1
Scale : 3/4"=1'-0
SLOPE
Reinforcement to be continuous through joint
4" clear
Intermediate Construction Joint
DETAIL 2
Scale: 3/4"=1'-0
NOTE
Spillway slab shall be placed:
(1) As one continuous placement
OR
(2) With not more than two Intermediate Construction Joints
Approx. Half Scale
AS BUILT
PLATE 3
VIRGINIA WILDLIFE CLUBS, INC.
LAKE OF THE WOODS
SPILLWAY
PLAN AND SECTIONS
CHICAGO, ILLINOIS

APPENDIX II

PHOTOGRAPHS

CONTENTS

Note: Photographs were taken on 29 November 1978.

NAME OF DAM: LAKE OF THE WOODS

LAKE OF THE WOODS DAM

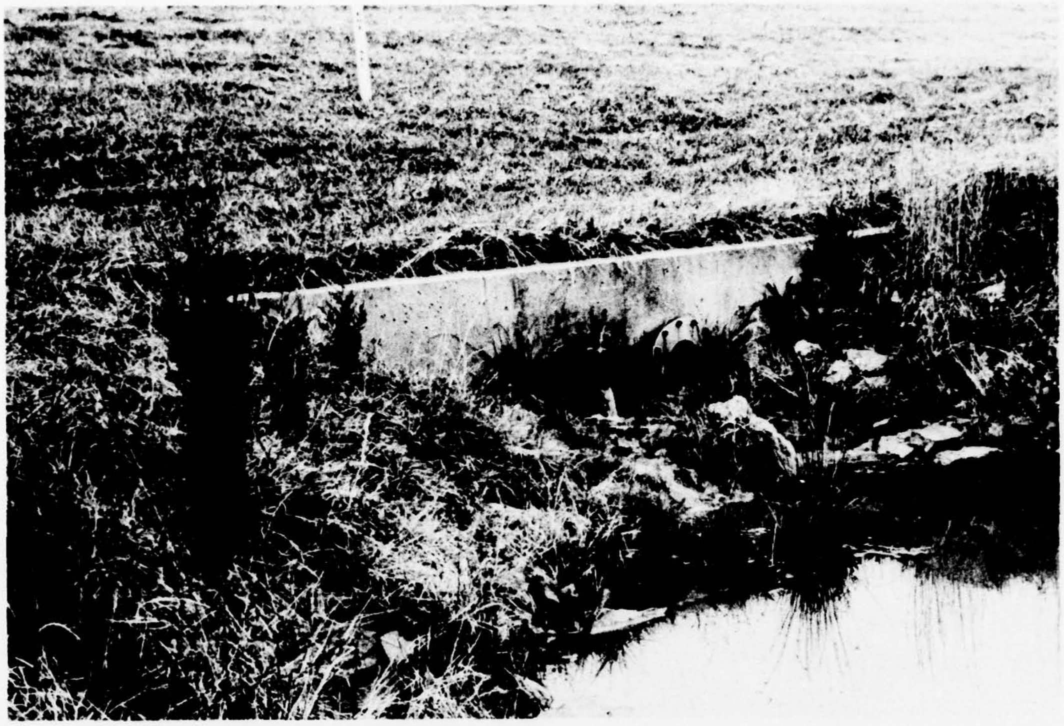


PHOTO 1. Head Wall Containing Filter Drainpipe (Left Side of Photo) and Reservoir Drainpipe (Right Side of Photo)

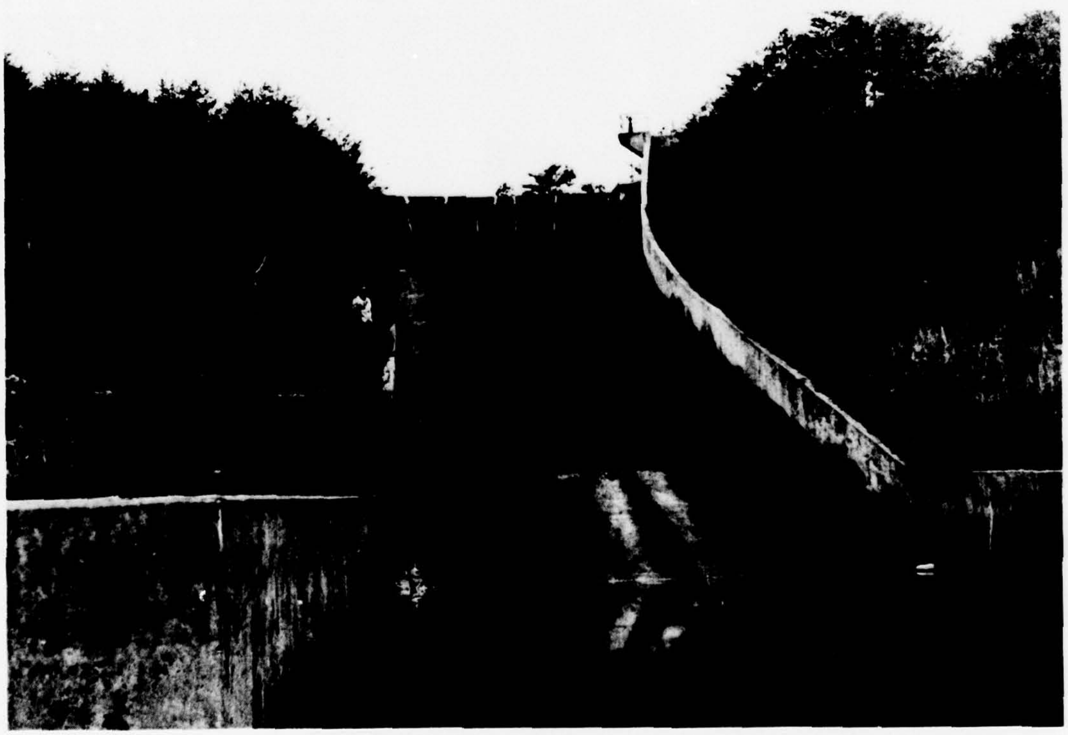


PHOTO 2. Discharge Channel for Concrete Spillway

LAKE OF THE WOODS DAM

PHOTO 3. Riprapped Approach Channel, Concrete Overflow Weir, Lift Pedestal and Slide Gate

PHOTO 4. Slide Gate on Downstream Face of Weir.

LAKE OF THE WOODS DAM

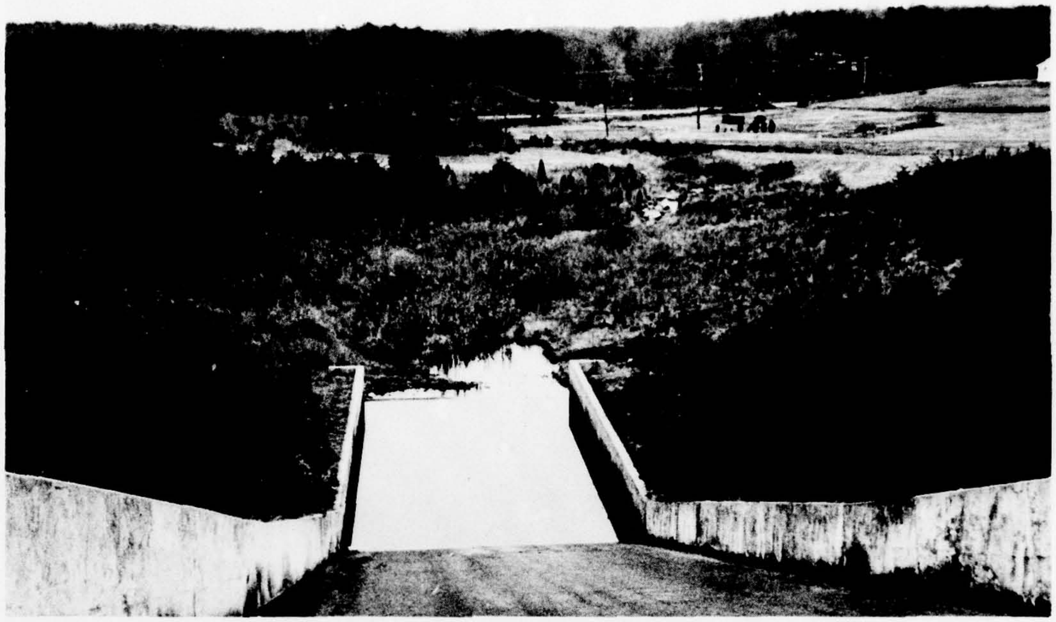


PHOTO 5. Spillway, Stilling Pool and Downstream Channel

PHOTO 6. Large, Wet Area on Left Abutment to Right of Spillway

APPENDIX III

CHECK LIST - VISUAL INSPECTION

Check List
Visual Inspection
Phase 1

Name of Dam Lake of the Woods County Orange State Virginia Coordinates Lat. 3821.0

Long. 7745.3

Date Inspection 29 November 1978 Weather Rainy, Cloudy Temperature 50°F.

Pool Elevation at Time of Inspection 317.0 ft. M.S.L. Tailwater at Time of Inspection 262.0 ft. M.S.L.

Inspection Personnel:

Virginia Water Control Board:	Michael Baker, Jr., Inc.:	Owner's Representatives:
Roy Murphy	T. W. Smith	Arthur Warren
Tim Perry	W. L. Sheafer	Dean Morley
	T. J. Dougan	

T. W. Smith Recorder

EMBANKMENT

Name of Dam: LAKE OF THE WOODS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	No surface cracks were observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	There was no movement or cracking observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	No sloughing or erosion of the embankment and abutment slopes was observed.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Good	
RIPRAP FAILURES	The riprap on the upstream slope at normal pool elevation and on the approach channel slopes for the emergency spillway is functioning properly. A few small areas have been partially removed and placed in piles. Grass is growing among the stones in some areas. There is scattered driftwood.	The debris should be removed, and the riprap should be replaced.

EMBANKMENT

Name of Dam: LAKE OF THE WOODS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
FOUNDATION	The foundation consists of 3 ft. of alluvial, silty sand and gravel in the bottom of the stream valley with 5 to 8 ft. of sandy silt overlying highly weathered gneiss at higher elevations. On the slopes of the valley, 5 ft. of reddish-brown, clayey silt and silty clay cover brown and gray, sandy silt (decomposed rock) which extends to a maximum depth of 50 ft. The underlying bedrock is a highly weathered, brown and gray gneiss. The subsurface data was obtained from the Report of Soils Exploration prepared by Dames and Moore. The cutoff trench is shown to be 30 ft. wide x 5 ft. deep on the as-built cross-sections.	
CONSTRUCTION MATERIALS AND SLOPES	The as-built typical sections and reports indicate that the compacted earthfill was unzoned and homogeneous with an appreciable quantity of silt. The soil observed on the surface consisted primarily of red, clayey silt with traces of rock fragments. Sandy silt and sand, and gravel were present in a few areas. The slopes (4:1 upstream and 3.5:1 downstream) were well-covered with grass, except for a few small bare areas which are primarily in the path on the crest and where some trees had been removed on the downstream slope. The compaction requirement was reduced from 95% to 88% of modified density.	The bare areas should be seeded.

EMBANKMENT

Name of Dam: LAKE OF THE WOODS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	The abutments are composed of reddish-brown, clayey silt (5 ft. average depth) overlying brown and gray, sandy silt with rock fragments (decomposed rock) to a maximum depth of 50 ft. The top of the bedrock is highly weathered gneiss. The slope gutters are unpaved and covered with grass. The left abutment slope is moderate with grass cover. A clubhouse is located nearby. There are pine trees with soil erosion on the hill near the approach channel on the left side.	
ANY NOTICEABLE SEEPAGE	Clear seepage was observed beside the ditch at the downstream toe in several areas apparently from the filter drain outlets. There is a seepage area (20 ft. diameter) extending 6 ft. up from the toe of the dam in the vicinity of the right abutment. The clear seepage may be caused by a partially blocked outlet from the filter drain or groundwater from the knoll at the abutment.	The clear seepage and filter drainage do not appear to be excessive.
STAFF GAGE AND RECORDER	Water levels of 0.5 ft. are painted on the right spillway wall, immediately upstream of concrete weir.	Install a staff gage to monitor reservoir levels above normal pool.
DRAINS	Plans show an 8 in. coated perforated filter drain extending along the length of dam from abutment to abutment with an 8 in. coated C.M.P. filter drain outletting alongside to the reservoir drainpipe. The 8 in. C.M.P. had 12 g.p.m. of clear flow indicating that the filter is functioning. The plans also show 6 sections of filter material extending from the 8 in. perforated filter drain and outletting at the toe of dam. These outlets appear to be covered by topsoil and grass. A gravel drain with a plastic cover was found at the ditch approximately 265 ft. to the right of the outlet pipe. The drainage ditch which collects the (continued on next page)	The ends of the filter material extending to the toe should be located and exposed. Also, the drainage ditch along the toe should be kept clear of debris and growth to allow normal drainage from the filter drains.

EMBANKMENT

Name of Dam: LAKE OF THE WOODS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
DRAINS (continued)	water from the outlets of the filter drain empties into the stilling basin at the rate of 4 g.p.m. The slopes of the ditch are vegetated with some small trees. The clay and silt slopes are partially eroded at the filter outlets. The ditch near the right abutment area has clear seepage and is blocked with dumped boulders with tree stumps and wood at its upper end.	

OUTLET WORKS

Name of Dam: LAKE OF THE WOODS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	No severe or unusual cracking and spalling of the head wall at the outlet was observed.	
INTAKE STRUCTURE	Intake end of drainpipe was submerged by the reservoir. No observation was possible.	
OUTLET STRUCTURE	Consists of a concrete retaining wall with the 8 in. C.M.P. filter drain outlet and the 12 in. ductile iron outlet pipe. The drain had a clear flow of 12 g.p.m. into the stilling basin. The outlet pipe is controlled by a 12 in. plug valve located 15 ft. from the outlet in a roadway box. There is no flow from the outlet pipe. The outlet structure and stilling basin are shown in Photo 1.	
OUTLET CHANNEL	The outlet channel flows away from the toe of the dam and joins the spillway channel beyond the left abutment. The stilling basin is lined with riprap. A drainage ditch at the toe of the dam flows into the stilling basin. A stream parallel to the ditch flows into the outlet channel downstream.	
EMERGENCY GATE	The reservoir can be lowered by either of two drains: 1) The 12 in. reservoir drain could be used to completely drain the reservoir. 2) The 2-ft.-square sluice gate located on the face of the spillway weir can be used to drain the reservoir to an elevation of 310.5 ft. M.S.L.	

UNGATED SPILLWAY

Name of Dam: LAKE OF THE WOODS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	The concrete weir of the spillway crest was laid out on a 100-ft. radius and is 46 ft. long. The weir elevation is 317.5 ft. M.S.L. The weir has been patched with epoxy in 9 places; 2 of the patches are leaking. Small aggregate popouts are present in the crest of the ogee weir (see photos 3 and 4).	
APPROACH CHANNEL	The approach channel to the concrete spillway is approximately 50 ft. wide with the side slopes protected by riprap to 5 ft. above normal water level. Sedimentation is minor because the 2-ft.-square sluice gate on the face of the concrete weir is opened yearly to discharge sediment that has built up (see Photo 3).	
DISCHARGE CHANNEL	The discharge channel has a 3:1 slope and exits into the stilling basin 150 ft. downstream from the weir. The granular filter drain under the spillway chute outlets through 2 pipes into the stilling basin. The discharge channel has expansion-contraction cracks (photo 5) at approximate 25 ft. intervals. Aggregate popouts are present. There is settlement (up to 2 ft. deep) in the soil backfill behind the right wall in the lower portion with erosion at the end and settlement at the end on the left side. A seepage-erosion area of the end of the right wall is shown in photo 6.	The settlement depressions next to both walls should be back filled, compacted, and seeded. Rock riprap placed at the end of the right wall will prevent erosion in the seepage area.
BRIDGE AND PIERS	None	
SLIDE GATE	The slide gate itself is in good condition. Some leakage in the stem of the weir section is present adjacent to the slide gate. The epoxy patchwork has lost its bonding ability and is separating from the concrete.	

INSTRUMENTATION

Name of Dam: LAKE OF THE WOODS

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None observed	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER		

RESERVOIR

Name of the Dam: LAKE OF THE WOODS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	The slopes are gentle to steep and partially wooded. The area has some recreational facilities. There has been erosion in the steep weathered bedrock slopes for the marina and the soil slopes in some of the tributaries which had been noted in the inspection report by E. D'Appolonia in 1969. An increase in the erosion could affect the access roadway.	
SEDIMENTATION	Very minor sedimentation is located immediately upstream at the concrete weir along the right wall.	
GOLD MINE	The shaft of an old gold mine in the reservoir near the approach channel of the emergency spillway was filled with 10 c.y. of concrete and a reinforced concrete cap was placed at the entrance as shown on the as-built drawings (see Plate 1). No details concerning the extent of the mine are known. The maximum dimensions of the shaft are 8 ft. x 14 ft. x unknown depth.	

DOWNSTREAM CHANNEL

Name of Dam: LAKE OF THE WOODS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The channel is lined with riprap for a short distance downstream of the stilling basin and is generally free of obstructions and debris. Photos 5 and 6 show the downstream channel and a seepage area on the right side at the end of the spillway.	
SLOPES	The slopes are varied with some clear seeps and small springs. The springs are principally near the base of the left hillside, 300 ft. past the end of the concrete spillway. There is a steeply dipping exposure of weathered metamorphic bedrock (uncertain age) with igneous intrusions at approximately 400 ft. downstream where reeds have grown. A clear seep in the right bank has caused erosion in the clay, silt, and sand 500 ft. downstream. Soft bedrock is in the streambed.	
APPROXIMATE NO. OF HOMES AND POPULATION	A treatment plant for the development is located 500 ft. downstream of the dam. A new development is planned directly downstream of the dam.	

APPENDIX IV

CHECK LIST - ENGINEERING DATA

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Name of Dam: LAKE OF THE WOODS

ITEM	REMARKS
PLAN OF DAM	A complete set of as-built drawings are available from the owner. A plan view of the dam is included in this report as Plate 1.
REGIONAL VICINITY MAP	is included in report as Location Plan.
CONSTRUCTION HISTORY	The foundation investigation was done in 1966 by Dames and Moore. The dam was designed by Bauer Engineering, Inc. (Chicago, Illinois) in 1966 and constructed by Shoosmith Bros., Inc. in 1967 and 1968.
TYPICAL SECTIONS OF DAM	Typical section of the dam is enclosed in the Phase I Inspection Report as Plate 2.
HYDROLOGIC/HYDRAULIC DATA	Partial hydrologic and hydraulic design data is available from the owner.
OUTLETS - PLAN, DETAILS, CONSTRAINTS, and - DISCHARGE RATINGS	are available from the owner.
RAINFALL/RESERVOIR RECORDS	Rainfall and reservoir level records are available from the owner.

Name of Dam: LAKE OF THE WOODS

ITEM	REMARKS
DESIGN REPORTS	Design reports, calculations, and specifications as prepared by Bauer Engineering, Inc. are available from the owner.
GEOLOGY REPORTS	A subsurface investigation consisting of test pits and test borings are part of the design documents. A report of soils investigation is available and enclosed in Appendix VI.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Dam stability analyses and seepage studies were available. Stability analyses are enclosed in Appendix VII.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Materials investigations, boring records, laboratory rest results, and field data were available.
POST-CONSTRUCTION SURVEYS OF DAM	Several inspections and reports were made between 1969 and 1972 by engineering firms (Appendix V). Remedial recommendations were prepared.
BORROW SOURCES	The borrow pit was located on the hillside upstream from the right abutment in the reservoir area as shown on the General Plan of the as-built drawings (Plate 1).

Name of Dam: LAKE OF THE WOODS

ITEM	REMARKS
MONITORING SYSTEMS	No monitoring system was designed into the dam.
MODIFICATIONS	Some relatively minor modifications which included surface maintenance were recommended after the inspections (Appendix V). It is not known whether all of them were carried out.
HIGH POOL RECORDS	No high water records were available.
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Post-construction engineering studies and inspection reports were available (Appendix V).
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None
MAINTENANCE OPERATION RECORDS	Recent inspection reports were not available.

Name of Dam: LAKE OF THE WOODS

ITEM	REMARKS
SPILLWAY PLAN, SECTIONS and DETAILS	Sections and details of the ungated concrete spillway are enclosed as Plate 3.
OPERATING EQUIPMENT PLANS & DETAILS	are contained in the as-built drawings.

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 7.23 sq.mi.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 317.5 ft. M.S.L. (9880 ac.-ft.)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 325 ft. M.S.L. (14,160 ac.-ft.)

ELEVATION MAXIMUM DESIGN POOL: 324.2 ft. M.S.L.

ELEVATION TOP DAM: 325.0 ft. M.S.L.

CREST: Principal Spillway

a. Elevation 317.5 ft. M.S.L.
b. Type Overflow type concrete spillway
c. Width 46 ft. crest width
d. Length Approximately 210 ft.
e. Location Spillover Outside left abutment
f. Number and Type of Gates 1 slide gate (2-ft.-sq.) on left side of weir (elev. 310.5 ft. M.S.L.)

OUTLET WORKS: Reservoir Drain

a. Type 12-in. diameter ductile iron pipe
b. Location Exits at toe of dam near center of embankment
c. Entrance inverts 275.0 ft. M.S.L.
d. Exit inverts 265.7 ft. M.S.L.
e. Emergency draindown facilities 2 x 2 ft. sluice gated outlet and 12 in. dia. blow-off pipe

HYDROMETEOROLOGICAL GAGES: None at dam site

a. Type
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE Unknown

Name of Dam: LAKE OF THE WOODS

APPENDIX V

INSPECTION REPORTS

BAUER ENGINEERING INC
CONSULTING ENGINEERS ENGINEERING HYDRAULICS
20 NORTH WACKER DRIVE
CHICAGO, ILLINOIS 60606

PROGRESS REPORT NO. 2

Lake of the Woods -- Dam Construction

As of April 21, 1967

After being closed for the winter months, construction on the main dam resumed April 12, 1967. Although the work proceeded slowly during the first week progress was steady.

Attaining the 95% (Modified AASHO) requirement remains a serious problem. Great effort is required by the contractor to dry and roll the variable soil encountered.

The compaction results indicate the following (as of 4/21/67):

Total tests taken	10
Range of test results	84% to 101%
Number of tests passing	3
Number of tests failing	7
Number of failing tests improved after rerolling	3
Moisture content range	18.3% to 26.6%
Average field moisture content	23.4%
Average optimum moisture	21.3%

With a concerted effort, the required densities on the average can be obtained.

The filter drain material was delivered and checked for gradation. The gradation indicates the material falls within the requirements and was approved.

The cutoff trench had been partially backfilled December, 1966 and through the winter months was saturated with water. This material was removed to the rock layer beneath and backfilled with selected soil.

Tests indicate 100% compaction achieved.

The temporary dam was completed during the winter and appears to be operating very well. Water has been impounded to the overflow elevation and the overflow pipe is operating as expected. No adverse effects were observed.

SUMMARY

Progress on the main dam is proceeding slowly. Complying with compaction requirements remains a problem. The Contractor will have to take extra care to insure the material being rolled has a low enough moisture content to achieve specified compaction, thus assuring a satisfactory end result.

Donald W. Wikan

DWW:fb

BAUER ENGINEERING, INC.

CONSULTING ENGINEERS · ENGINEERING HYDRAULICS

20 NORTH WACKER DRIVE

CHICAGO, ILLINOIS 60606

TELEPHONE FRANKLIN 2-6606

CABLE ADDRESS "BAUERENG CHICAGO"

March 21, 1968

RECEIVED 3-22-68

J. KEATING

~~J. FORD~~

Mr. Wesley T. Butler
Virginia Wildlife Clubs, Inc.
United States Land, Inc.
P.O. Box 631
Springfield, Virginia 22150

Subject: Lake-of-the-Woods

Dear Mr. Butler:

On March 6, 1968 a final inspection of the dam, spillway and appurtement work was made by me and Earl Turner, our engineer - inspector for the above project. We were accompanied by Mr. Jack Schaul of your organization and Mr. Bill Cantrell of Shoosmith Brothers.

We are pleased to report that the construction work is substantially completed in accordance with the plans and specifications except the fine grading, seeding and fertilizing in the spillway area beyond the chute and stilling basin walls, and in the vicinity of the plunge pool. This work should be completed soon after the backfill adjacent to the chute walls has subsided and been re-graded, and the weather permits.

We are preparing a set of as-built drawings and a tabulation of final quantities for the project, and hope to have this information in your hands in about a week.

The dam and spillway present an excellent appearance, and we believe that both United States Land and Shoosmith Brothers can be proud of the fine results.

It has been a pleasure for our firm to be associated with you on this project, and we send our best wishes for your continued success.

Very truly yours,

R. L. Hall
Chief Engineer

RLH:db

cc: Mr. J. S. Keating
Mr. Jack Ford ✓
~~Mr.~~ Jack Schaul
Mr. Gay Jones
Shoosmith Bros., Inc.

Project No. 69-181

BOISE CASCADE PROPERTIES, INC.
CHICAGO, ILLINOIS

LETTER REPORT
INSPECTION OF DAM AND RESERVOIR
LAKE OF THE WOODS
ORANGE COUNTY, VIRGINIA

E. D'APPOLONIA
CONSULTING ENGINEERS, INC.
PITTSBURGH, PENNSYLVANIA

OCTOBER 1969

E. D'APPOLONIA
CONSULTING ENGINEERS, INC.

October 27, 1969

15 DUFF ROAD
PITTSBURGH, PA. 15235

TELEPHONE
(412) 242-5107

Project No. 69-181

Mr. John Margosian
Boise Cascade Properties, Inc.
Lake of the Woods
P. O. Box 128
Springfield, Virginia 22401

<u>Inspection of Dam and Reservoir</u>
<u>Lake of the Woods</u>
<u>Orange County, Virginia</u>

Dear Mr. Margosian:

Enclosed are two copies of our letter report discussing the results of our inspection of the dam and reservoir at the Lake of the Woods project. We were initially requested to review the performance of the reservoir with respect to filling. However, as I have indicated in telephone conversations, certain other conditions at the site deserve discussion. Therefore, in addition to the section on filling, our letter report discusses other adverse conditions along with recommendations concerning remedial and preventive measures.

As requested, we are preparing a single invoice reflecting all of our costs on this project. The two previous, partial invoices should be ignored when the total invoice is submitted. I will include a description of the various cost items for your information.

Please feel free to call pertaining to any of the subjects discussed in the report.

Very truly yours,

Richard D. Ellison

Richard D. Ellison

RDE:pao

Enclosures

cc: Mr. J. W. Ford (2)

Corporate Office: 1177 McCULLY DRIVE, PITTSBURGH, PA. 15235

E. D'APPOLONIA
CONSULTING ENGINEERS, INC.

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E. D'APPOLONIA
CONSULTING ENGINEERS, INC.

October 25, 1969

15 DUFF ROAD
PITTSBURGH, PA. 15235

TELEPHONE
(412) 242-5107

Project No. 69-181

Mr. John Margosian
Boise Cascade Properties, Inc.
Lake of the Woods
P. O. Box 128
Springfield, Virginia 22401

Letter Report
Inspection of Dam and Reservoir
Lake of the Woods
Orange County, Virginia

Dear Mr. Margosian:

Pursuant to Mr. J. W. Ford's authorization in June, 1969, we conducted a visual inspection of the dam and reservoir at the subject site. Pertinent design and as-built drawings prepared by Bauer Engineering Company were also examined. Initially, the purpose of the examination was to assess the behavior of the dam and reservoir to date with respect to its filling rate and to make appropriate comments and observations. However, during the above examination and as subsequently discussed with Mr. Ford, additional conditions related to the condition of the dam and reservoir were noticed for which recommendations concerning remedial and preventive measures are also reported herein.

Description of Dam

The dam has a maximum height of almost 60 feet above the bed of Flat Run. It is of homogenous section except for the drainage system beneath the downstream portion of the embankment. The material in the dam was borrowed from the reservoir area immediately upstream of the dam. Examination of soils in the area indicates that this material contains an appreciable quantity of silt-sized particles and that its permeability when compacted is relatively low.

The downstream sub-embankment drainage system consists of a lateral filter, parallel to the dam axis, with embedded pipe draining from both sides towards the old bed of Flat Run. The system then runs along the creek bed and discharges at the toe of the dam. There is no indication that it is not functioning properly.

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The lateral drain, which is located immediately downstream of the axis of the dam, is augmented by "fingers" of filter material running transverse to the axis of the dam and presumably draining towards the toe. The downstream ends of these drains have apparently been covered with topsoil.

The performance of these finger drains is not known. A narrow strip of wet soil, as discussed below, exists just downstream of the toe of the dam. This would seem to indicate that at least some of the drains are functioning properly. However, as will be discussed, this wet zone could have a different origin.

Two important changes were made to the embankment design during construction of the dam. First, impervious blankets were provided in two parts of the borrow areas. They were apparently in response to the porous nature of the bedrock. Second, the 3:1 design slopes were changed to 3.5:1 downstream and 4:1 upstream. The reasons for the slope changes are not known.

Another change made during construction was to provide a continuous filter system under the spillway chute. The water collected in this filter discharges through two pipes into the stilling basin. The pipes are presently discharging water which would indicate that the drainage system under the chute is operating.

The as-built drawings show an abandoned mine shaft just upstream of the the spillway channel. The shaft is presently under water. No details concerning the extent of the mine are available.

A 6-inch pipe has been installed through the embankment adjacent to the right abutment. The pipe is close to the crest of the dam and serves no apparent purpose.

Performance of the Dam

The reservoir is presently being filled for the first time, and two seepage zones have appeared downstream of the dam. The approximate extent of the seepage zones as of August 17, 1969 is sketched in Drawing No. 69-181-E1. At that time, the reservoir was 4.75 feet below design elevation. (We understand that the lake level rose an additional 1.0 to 1.5 feet during the heavy rains associated with Hurrican Camille during the week of August 17, 1969) No correlation between the height of the reservoir and the seepage phenomena is available.

One seepage zone, (A)*, is entirely in cut downstream of the spillway stilling basin. Because of the proximity of the drainage blanket under the spillway chute, it would appear that the seepage zone may be fed from deeper within the underlying rock.

*Letters designated as ( ) correspond to similarly designated areas on Dwg. 69-181-E1.

The other seepage zone, (B), is in undisturbed ground downstream of the right abutment. This zone has extended into the dam embankment along a distance of approximately 100 feet. The maximum instrusion up the embankment is about 8 feet measured vertically.

A portion of Seepage Zone (B) is located over one of the finger drains described above. The downstream end of the drain was not located in the field because it apparently was covered during dressing of the slope. If the finger drain were functioning properly it would be expected to yield some water flow.

Part of Seepage Zone (B) runs in a narrow strip parallel to the toe of the dam. It may be that this "wet" strip is caused by discharge from the finger drains and not from seepage through the foundation of the dam. The other portion of the seepage zone undoubtedly is affected by seepage from the reservoir through the bedrock since it is directly across the creek bed paralleling the toe of the dam. It is difficult to judge whether the source of this seepage is primarily from groundwater flow out of the knoll to the west or if it is primarily due to increased groundwater pressure resulting from the partially filled reservoir. Records of the preconstruction condition of this area would be valuable in determining the source of this seepage.

Several surface erosional features have appeared on and around the dam. Shallow gullies, (C), have developed on the entire lower portion of the downstream slope; along the toe of the dam on the north side of the discharge basin for the under drain discharge pipes (D); and north of and generally parallel to the excavation for the spillway discharge channel, (E).

The water in the reservoir immediately adjacent to the riprap on the upstream slope of the dam is reddish in color. This indicates that a certain amount of erosion is taking place. Since the reservoir at time of observation was 4.75 feet below design elevation, it is not known whether the erosion is taking place below the riprap or through the lower portion of the riprap.

Erosion, due to rainfall runoff, is present at the portion of the spillway approach channel not protected with riprap, (G). Additional erosion should be expected when the water level rises and continual flow occurs through the channel.

<u>Performance of the Reservoir</u>

Filling of the reservoir commenced in 1967. The water level on August 17, 1969 was 4.75 feet below the design elevation. Because the time of filling thus far is still in the range of the estimates made by Bauer Engineering Company (35 months) and E. D'Appolonia Consulting Engineers, Inc. (23 months), conclusions regarding the rate of filling cannot be made at this time. However, it is somewhat disturbing that it has been reported that the reservoir rose only about six inches during July, 1969, while the local rainfall was about twice that amount. The rate of filling should be observed, in relation to rainfall, through the spring of 1970 prior to evaluating the time which will be required to fill the remainder of the lake.

An analysis of the flow into the reservoir was conducted on August 16 and 17, 1969. The flow into the lake was measured at each stream entering the lake at the locations shown on Dwg. 69-181-E2. The total inflow at the time of measuring was about 1.5 gallon per second. The total surface flow out of the reservoir was determined by measuring the flow in the discharge channel downstream from the dam. This flow was corrected to account for flow in the 36 inch diameter culvert located downstream from the south abutment as shown on Dwg. 69-181-E2. This analysis indicated that the reservoir on that date was filling at the rate of about 0.2 gallons per second; neglecting subsurface inflow and outflow which cannot be measured. (Details of the analysis are presented in Appendix A). This amount of inflow would have a negligible effect on the lake level.

It should also be noted that due to the relatively large size of the lake, the measured amount of surface leakage will not seriously effect the lake level once it has filled to the planned normal pool elevation.

Miscellaneous Observations Pertaining to the Reservoir

Two less serious problems associated with the reservoir were observed on August 17, 1969.

First, gullies several feet in depth have been eroded into the steep slopes cut into weathered rock to form the boat marina. The incompetent nature of the weathered rock and the concentrated flows which occur in this area make this a progressive condition.

The second concerns erosion of the surficial soils at many of the tributaries into the lake. In several instances, this erosion has progressed to the point where the stability of the site roadway may be affected.

Recommendations for Remedial and Preventive Measures

1. Dam and Appurtenances

Both seepage zones downstream of the dam can be expected to increase in size and rate of discharge as the reservoir rises to design elevation. The correlation between seepage discharge and reservoir discharge is purely conjectural at this time. However, it is entirely possible that the discharge will increase significantly with the last few feet of head. The present rate of seepage will not significantly affect the lake level once it has reached the design normal pool elevation and should not be sufficient to pose a threat to the overall stability of the dam due to piping. However, it is recommended that size of the seepage zones and the seepage discharge be closely observed so that large changes will be recognized at an early date. Also, that portion of the dam toe included in seepage zone (B) should be inspected regularly for evidence of piping or local shear failure.

As soon as possible the finger drains entering seepage zone (B) should be located and exposed to provide free flow of water from beneath this portion of the embankment. The flow from this finger drain as well as all other seepage from this zone should be collected into a well defined channel (F) and diverted to the old stream bed. This channel should be placed as far from the toe of the dam as possible.

If the condition of the toe of the dam deteriorates to the point where it poses a threat to stability, an inverted filter should be designed and placed over the significant portion of the seepage zone. This can be designed to protect against both piping failure and local shear failure.

It is not anticipated that seepage in the vicinity of the stilling basin will pose any threat to stability in the near future. However, it may be desirable for esthetic purposes and for prevention of problems with freezing behind the wall to provide drainage facilities behind the retaining walls of the stilling basin.

The erosion gullies do not at this time present any threat to the stability of the dam. However, due to the progressive nature of such erosion, it is prudent that preventive measures be taken as soon as possible. A shallow berm with paved gutters or half-round terra-cotta pipe gutters should be constructed about one-third way up the downstream face of the dam to collect runoff from the slope. Also, a lined terra-cotta pipe channel should be provided along the toe of the dam to the north of the discharge basin in the area designated as (D) on Dwg. 69-181-E1. The shallow erosion gullies, (C), on the downstream slope should be filled and seeded. Remedial and preventive work on the erosional features to the north of the discharge channel can be postponed indefinitely, but periodic observations should be made for re-evaluation of this condition.

The riprap in the spillway approach channel, (G), should be extended to the concrete structure to prevent further erosion in this area.

It is not possible at this time to determine whether the erosion of the dam at the present water line is taking place through the riprap or at a lower elevation. No remedial work in this area is recommended until the reservoir level is raised and the behavior of the riprap can be observed further. However, if the reservoir is maintained at or near its present level for a considerable period of time, the upstream face of the dam below the riprap should be inspected by one of our engineers trained in scuba diving.

It is not expected that the pipe through the top of the dam, (H), will ever carry water. Nevertheless, it should be removed or permanently sealed.

of the dam toe included in seepage zone (B) should be inspected regularly for evidence of piping or local shear failure.

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It is not expected that the pipe through the top of the dam, (H), will ever carry water. Nevertheless, it should be removed or permanently sealed.

2. Reservoir filling

While concern over the slow filling rate of the reservoir is well founded, "filling time" calculations indicate that additional time should be allowed before concluding that the lake will not reach its normal pool elevation without expensive remedial or artificial filling measures. A rational decision on whether to implement such plans could be made after correlation of reservoir level, local rainfall data and seepage data this winter and spring (1969 - 1970). The present magnitude of surface seepage will not have a significant effect upon maintaining a relatively constant lake level.

3. Reservoir (Miscellaneous)

Riprap protection should be provided at the road culverts for any tributaries where the erosion may cause costly disturbance to the roadway or culvert.

Finally, the cut slopes at the marina should be made flatter and/or a paved gutter should be provided along the top of the slope to retard the progressive erosion which is presently occurring. Also, riprap should be provided at the toe of the slope to eliminate erosion due to wave action which will occur when the lake level has reached its normal pool elevation.

Data Required

Additional information which will be required prior to conducting a more detailed study and prior to undertaking the recommended preventive and remedial measures include geologic reports prior to construction, geologic data obtained during construction, engineering properties of embankment material, and details of the mine shaft at the north abutment. Also, plans showing the location of roads and utilities are required for locating these facilities in the construction area.

Respectfully submitted,

Richard D. Ellison

Richard D. Ellison

Attachments

RDE:db

APPENDIX A

Lake of the Woods
Summary of Measured Flows
August 16 and 17, 1969

I: Surface inflows (see Dwg. 69-181-E2 for Tributary Locations)

Tributary Number	Remarks	Measured Flow in gallons/second
1A		dry
1B		dry
1C	Erosion has occurred to a depth of two feet. Some groundwater seepage is noticeable.	0.10
1D	Very little flow from flat swamp area.	TSTM*
2	30" φ culvert with considerable erosion at its outlet.	TSTM
3	Kaolinite weathered gneiss.	TSTM
4	30" φ culvert with considerable erosion in weathered rock at the road embankment.	dry
5A	18" φ culvert.	dry
5B	Kaolinite weathered grey granite - gneiss.	0.05
6	Very weathered schists.	0.05
7	42" φ culvert.	0.10
8A		dry
8B		dry
9A		dry
9B		TSTM

*TSTM - Too small to measure.

Tributary Number	Remarks	Measured Flow in gallons/second
10A		TSTM
10B	Some erosion has occurred in the weathered rock.	0.15
11	Erosion has occurred to a depth of 4 to 5 feet.	0.15
12		TSTM
13		0.05
14		0.50
15A		dry
15B		dry
15C		dry
15D		dry
16		0.05
17		TSTM
18	Erosion has occurred to a depth of 4 feet.	0.05
19		TSTM
20	Some ground water seepage noticeable.	TSTM
21	Erosion has occurred to a depth of 1.5 feet. Some ground water seepage is noticeable.	dry
22		dry
23A	Erosion is occurring in the weathered rock Some ground water seepage is noticeable	TSTM
23B	Erosion has occurred to a depth of 3 feet. Some ground water seepage is noticeable.	TSTM
24	36" ϕ culvert.	TSTM

Tributary Number Remarks

Tributary Number	Remarks	Measured Flow in gallons/second
25		dry
26	Very little erosion	dry
27	Erosion has occurred to a depth of 2 feet	TSTM
28A		dry
28B		dry

Summary of Inflow

Tributaries 1 to 28B	1.20 gallon/second
+ 14 x TSTM	0.30 gallon/second
Total surface inflow	1.50 gallon/second

II: Surface outflow

Flow at the local road downstream at the outflow channel	1.5 gallon/second
Flow through culvert ϕ 36" at south abutment	- 0.2 gallon/second
Total surface outflow	1.30 gallon/second

III: Net surface inflow = 1.50 - 1.30 = 0.20 gallon/second.

RECEIVED
SEP 4 1970
OPERATIONS
EAST

BAUER ENGINEERING, INC.
CONSULTING ENGINEERS LAND AND WATER RESOURCES
20 NORTH WACKER DRIVE
CHICAGO, ILLINOIS 60606

TELEPHONE
(312) 641-0210

CABLE ADDRESS
"BAUERENG CHICAGO"

August 27, 1970

Mr. Dominic DiOrio
Eastern Region Operations Manager
Boise Cascade Corporation
10400 W. Higgins Road
Rosemont, Illinois 60618

Re: Inspection Report Dam at Lake of the Woods 198.001

Dear Mr. DiOrio:

A thorough inspection of the main dam at Lake of the Woods, Virginia was made August 17, 1970 at your request. In general, the dam appeared to be in excellent condition.

The enclosed check list was used and appropriate comments made.

Please Note the following corrective actions are indicated as being necessary:

1. TOP OF DAM

The top of the dam appears to be irregular and rutted. A profile should be made along the center-line of the dam to determine if the dam is at the designed grade. Since no bench marks may be available, I suggest the elevation of the spillway crest be used as elevation 317.5. The dam then should have an elevation no lower than 325 or 7.5 feet above the spillway crest. If it is found that the elevation of the top of dam is lower than elevation 325 material, either clay or well graded crushed rock, should be added. If clay is used the existing surface should be scarified and the new material rolled with a sheepsfoot in layers not exceeding 8 inches thick.

If the elevation is found to be higher than 325, the top should be scarified and reshaped with a blade in order to obtain a uniform section which will drain (preferably into the lake) and which has no ruts.

2. ABUTMENTS

Generally the abutments are in excellent condition. No seepage was noted where the fill contacts the original ground. However, some erosion was noticed at the downstream slope of the north abutment. The grade is steep and a grass cover from seed will be difficult to grow. Sod is suggested here in order to stop further deterioration.

3. DOWNSTREAM SLOPE

This also appears to be in good condition. No adverse seepage is evident. One filter drain is flowing slowly, but this is normal and will cause no trouble. Some erosion was noticed. The downstream slope should be repaired and seeded such that a good stand of grass checks further erosion. Regular mowing should be done in order to prevent trees from growing.

A wrench should be provided for the outlet valve.

4. DOWNSTREAM FROM TOE

No problems noted.

5. SPILLWAY

Generally the spillway is in excellent condition. Some small hairline cracks were noted. These are simply shrinkage and in no way will impair the performance of the concrete. In time (2 or 3 years) these cracks may become larger. At that time they could require cleaning, widening and filling with a sealant. I suggest using "Sika Colma Joint Sealer - NS" in accordance with Manufacturer's instructions.

This dam appears to be in excellent condition and is safe.

I hope this report serves your needs. If I can be of any more service please let me know.

Yours very truly,

D. W. Wikan P.E.
Chief Engineer

DWW:mb

W. J. Bauer
President

CAUER ENGINEERING, INC.

Job No. 198.001 Date 8/17/70
Job Name Lake of the Woods
Client Boise Cascade

DAM INSPECTION CHECK LIST

UPSTREAM SLOPE	
1. EROSION	
A. SLOPE ABOVE WATER	No erosion - good condition
B. SLOPE BELOW WATER	Could not see below water line
C. RIPRAP	Good condition
D. RIPRAP FILTER	Good condition
2. ANIMAL BURROWS	None seen
3. CRACKS	None
4. SLIDES OR SLOUGHS	None
5. REMARKS	Generally good condition
TOP OF EMBANKMENT	
1. CRACKS	None
2. SETTLEMENT (OR CONSOLIDATION)	Some - check profile
3. DRAINAGE OF TOP (EROSION, etc.)	Poor - should fill & regrade to slope to Lake
4. ANIMAL BURROWS	None
5. REMARKS	Run profile, bring to planned elevation or higher thruout
ABUTMENTS	
1. EROSION AT CONTACT OF EMBANKMENT & ABUTMENT	Some (should sod)
2. SEEPAGE AT JUNCTION OF EMBANKMENT & ABUTMENT	None
3. EROSION FROM SURFACE DRAINAGE	Not serious
4. WET SPOTS AT ABUTMENT	None
5. SPRINGS - GULLIES - BOILS - etc.	None
6. REMARKS	Generally in good condition
DOWNSTREAM SLOPE	
1. CRACKS	None
2. SLIDES OR SLOUGHS	None
3. SEEPAGE	At drains only which is proper

BAUER
ENGINEERING,
INC.

Job No. ______ Date ______
Job Name ______
Client ______

DAM INSPECTION CHECK LIST (CONT'D)

4. BRUSH — None
5. DAMP OR WET "BANDS" — None
6. FILTER - FREE DRAINING? Yes — IS WATER CLEAR? Yes
7. PIPE DRAIN - OBSTRUCTIONS? None — VALVE No wrench to operate
8. SLOPE EROSION — Some - should repair and seed or sod
9. REMARKS — In general looks good - slight erosion should be repaired. No need to worry about wet spots these will gradually diminish

DOWNSTREAM FROM TOE

1. BOILS — None
2. EROSION GULLIES — None
3. OTHER WET SPOTS — None noticed
4. REMARKS — OK

SPILLWAY

1. COMPARE WITH PLANS — OK
2. DEBRIS — None
3. CRACKS — Slight 1/8" to hairline, not serious at this time, eventually should filled
4. HOLLOW CONCRETE — None
5. SLIDE GATE — Leaks - should adjust wedges
6. EROSION AROUND WALLS, etc. — None
7. REINFORCING STEEL EXPOSED — None
8. OUTLET CHANNEL — OK
9. REMARKS — Generally in excellent condition

BAUER
ENGINEERING,
INC.

Job No. 193.001 Date 8/17/70
Job Name Lake of the Woods
Client Boise Cascade

DAM INSPECTION CHECK LIST

UPSTREAM SLOPE	
1. EROSION	
A. SLOPE ABOVE WATER	No erosion - good condition
B. SLOPE BELOW WATER	Could not see below water line
C. RIPRAP	Good condition
D. RIPRAP FILTER	Good condition
2. ANIMAL BURROWS	None seen
3. CRACKS	None
4. SLIDES OR SLOUGHS	None
5. REMARKS	Generally good condition
TOP OF EMBANKMENT	
1. CRACKS	None
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3. DRAINAGE OF TOP (EROSION, etc.)	Poor - should fill & regrade to slope to Lake
4. ANIMAL BURROWS	None
5. REMARKS	Run profile, bring to planned elevation or higher throut
ABUTMENTS	
1. EROSION AT CONTACT OF EMBANKMENT & ABUTMENT	Some (should sod)
2. SEEPAGE AT JUNCTION OF EMBANKMENT & ABUTMENT	None
3. EROSION FROM SURFACE DRAINAGE	Not serious
4. WET SPOTS AT ABUTMENT	None
5. SPRINGS - GULLIES - BOILS - etc.	None
6. REMARKS	Generally in good condition
DOWNSTREAM SLOPE	
1. CRACKS	None
2. SLIDES OR SLOUGHS	None
3. SEEPAGE	At drains only which is proper

DAUER
ENGINEERING,
INC.

Job No. ________ Date ________
Job Name ________________
Client ________________

DAM INSPECTION CHECK LIST (CONT'D)

4. BRUSH — None

5. DAMP OR WET "BANDS" — None

6. FILTER - FREE DRAINING ? Yes — IS WATER CLEAR ? Yes

7. PIPE DRAIN - OBSTRUCTIONS ? None — VALVE No wrench to operate

8. SLOPE EROSION — Some - should repair and seed or sod

9. REMARKS In general looks good - slight erosion should be repaired. No need to worry about wet spots these will gradually diminish

DOWNSTREAM FROM TOE

1. BOILS — None
2. EROSION GULLIES — None
3. OTHER WET SPOTS — None noticed
4. REMARKS — OK

SPILLWAY

1. COMPARE WITH PLANS. — OK
2. DEBRIS — None
3. CRACKS — Slight 1/8" to hairline, not serious at this time, eventually should filled
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5. SLIDE GATE — Leaks - should adjust wedges
6. EROSION AROUND WALLS, etc. — None
7. REINFORCING STEEL EXPOSED — None
8. OUTLET CHANNEL — OK
9. REMARKS — Generally in excellent condition

FACILITIES STUDY

MARTIN, CLIFFORD & ASSOCIATES
STAFFORD, WILLIAMSBURG AND
CHARLOTTESVILLE, VIRGINIA

SECTION IV

DAMS, SPILLWAYS AND LAKES

Situated within the confines of the Lake of the Woods development, are two lakes, one approximately 500 acres and the other 25 acres. The larger one is intended for water skiing, sailboating, swimming and other recreational purposes, whereas the smaller lake is mainly for fishing. The large lake was reviewed in two basic areas, lake portion and spillway and dam portion with the following appropriate comments:

Lake

One of the main concerns of the lake was the possibility of silt deposits. In order to evaluate this situation, fathometer readings were taken and recorded. See attached schedule and location map at the end of this section. Certain discrepancies were found between the readings taken and the topographical data that was made available. It is believed that this could be accountable to the fact that the topographical information was not "as-built", that is, up-dated after construction of the facility was completed.

The readings taken do not show an appreciable difference, or unexplainable difference between the topographical information and the soundings taken, but it must be borne in mind that the readings were taken on just one occasion, and as such, it is difficult to compare them with the information that was made available. Although a significant difference is not shown, these same readings should be taken on a periodic basis to insure that the build-up of silt is not occurring. It is interesting to note that of the twelve point samples taken, those in the finger areas where silting would seem to be occurring, such as in the vicinity of Tidewater Street, the difference between the topo and the soundings is negligible.

In certain areas of the shoreline, some of the lot owners have attempted to protect their banks by placing rip-rap. Normal water level being elevation 317.5, this rip-rap should be laid two feet above and below this level to assure sufficient coverage during anticipated variance. The sections covered in this manner noticeably prevented shortly, the effects of erosion of the property compared to the adjoining lots have none. The wave action from both the prevailing winds and the passage of speedboats will neccessitate this or some other similar method be undertaken by all owners of waterfront lots. As the majority of this work could be done by a barge working from the lake, it would be an economic advantage to the owners to employ one contractor to do the entire undertaking.

Spillway and Dam

The major evaluation of this section was accomplished by reviewing the drawings prepared by the Bauer Engineering Company, and the files available at the office of the Attorney, Mr. Moore, in Orange County. The files included such items as design criteria and calculations; correspondence among the deisgn engineer and the engineering firm employed to review their work, the developer and the contractor who performed the work; and daily time sheets of the inspector who was present during construction.

The files indicate that there were minor differences of opinion between the two engineering firms, but no significant differences concerning final plans on all major items. Our review of the plans indicate that all is according to sound engineering principals, and was executed in a professional manner. In calculation of a flood routing for a 100 year storm, the difference between their figure (320.0) and ours (319.5) was six inches. This is a relatively insignificant difference, and the discrepancies could be attributed to the method selected.

The crack in the spillway wall adjacent to the gate structure was inspected and it is reasonable to assume that it was caused by a temperature change. Over a period of time the entrance of water will cause freezing and thawing problems along with deterioration to the reinforcing steel. With this in mind, this crack will eventually have to be repaired.

The concrete walls of the spillway show practically no signs of wear. The spillway itself is spalling in some areas, but compared to the thickness of the concrete, it is of little consequence. Possibly after several years a thin coating of new concrete should be applied. This is frequently done with concrete structures and will restore the spillway to a new appearance after it has been exposed to the elements for many years.

The seeding of the bank of the dam was at one time somewhat of a problem to the maintenance people. With the advice and aid from the Soil Conservation Service, the crews are now conditioning the soil with lime and adding fertilization with noticeably good results. Assuming this plan is followed on a regular basis, adequate vegetation will remain on the banks.

On the down stream side of the dam there is a certain amount of moisture constantly present in two locations. One is located to the west of the outlet valve and the other is to the east of the bottom of the spillway. Although no soil borings were taken of the area, it was felt that both problems are attributable to the impermeability of the soil at these locations and not a fault of the dam. By providing drainage ditches or conduits the water can easily be directed to the water discharging from the outlet valve and the spillway.

On two separate occasions, samples were collected from the two lakes. The samples were taken directly to our water chemistry laboratory for analysis. The samples were preserved by refrigeration prior to testing.

APPENDIX VI

REPORT OF SOILS EXPLORATION

REPORT OF SOILS EXPLORATION

PROPOSED DAM-LAKE OF THE WOODS RESERVOIR
ORANGE COUNTY, VIRGINIA

FOR

BAUER ENGINEERING, INC.

5651-001-07

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

ATLANTA · NEW YORK · CHICAGO · PORTLAND · HONOLULU · SALT LAKE CITY · HOUSTON · SAN FRANCISCO · LOS ANGELES · SEATTLE · WASHINGTON, D.C. · MADRID, SPAIN · SAINT JOHN N B CANADA · TEHRAN IRAN

309 WEST JACKSON BOULEVARD · CHICAGO, ILLINOIS 60606 · 312-922-1772
PARTNERS: JAMES B. THOMPSON · GEORGE D. LEAL

October 21, 1966

Bauer Engineering, Inc.
20 North Wacker Drive
Chicago, Illinois 60606

Attention: Mr. William J. Bauer, President

Gentlemen:

Ten copies of our "Report of Soils Exploration, Proposed Dam-Lake of the Woods Reservoir, Orange County, Virginia" are herewith submitted.

The scope of our soils exploration was planned in collaboration with Messrs. William J. Bauer, Robert L. Hall, and D. R. Knouse of Bauer Engineering, Inc.

Preliminary data were provided to Messrs. Bauer, Hall and Knouse during the course of the investigation.

Yours very truly,

DAMES & MOORE

James B. Thompson

James B. Thompson

JBT:WJG:mf

CABLE ADDRESS DAMEMORE

REPORT OF SOILS EXPLORATION

PROPOSED DAM-LAKE OF THE WOODS RESERVOIR

ORANGE COUNTY, VIRGINIA

FOR

BAUER ENGINEERING, INC.

INTRODUCTION

This report presents the results of our soils exploration performed at the site of the Proposed Dam-Lake of the Woods Reservoir to be constructed in Orange County, Virginia. The proposed dam will impound the water flowing in Flat Run Creek and the water derived from the upstream water shed area in the vicinity of the proposed dam. The proposed dam will be located approximately one-fifth of a mile upstream from where Flat Run Creek flows under Virginia State Highway 3. This is approximately 1 mile southeast of Flat Run, Virginia on Virginia State Highway 3.

The field explorations included the drilling of 18 test borings and the excavation of one test pit. The locations of the test borings and test pit are shown with respect to the proposed dam on Plate 1, Plot Plan.

SCOPE

The scope of our soils exploration were as follows:

1 - To explore the subsurface soil and water conditions at the dam site to the depths which will be influenced by the proposed construction.

2 - To determine the classification and pertinent physical characteristics including compaction and strength properties of representative materials encountered within the proposed borrow area.

GEOLOGY

The site of the Proposed Flat Run Creek Dam is located in an area known as the Piedmont Upland Province. This province is bordered on the west by the Appalachian Mountains and on the east by the Atlantic Coastal Plain. The typical landscape is a rolling surface of gentle slopes and no great relief. Average relief is approximately 50 to 100 feet.

The rock formations of the Piedmont Upland consist of gneisses, schists, slates and other metamorphic rocks, all of which have been deformed by mountain-making movements.

The soils of this area are basically residual with small areas of recent alluvial deposits around major streams. The residual soils are the products of weathering of the generally strong metamorphic rocks. The residual soil is quite thick in some localities and thus sound rock will usually be at considerable depths.

SURFACE CONDITIONS

The site of the proposed dam is located within a small broad valley which contains Flat Run Creek. The flow of Flat Run Creek is to the north. The maximum relief in the immediate area is approximately 85 feet. At the present time, the majority of the land around the proposed dam is wooded.

SUBSURFACE CONDITIONS

The subsurface conditions encountered at the site are as follows:

1 - Brown silty topsoil

2 - Reddish brown silty clay and clayey silt

3 - Mottled brown and gray sandy silt (decomposed rock)

4 - Highly weathered rock (gneiss)

All of the soils in the area investigated are basically residual in origin except for a few recent alluvial sand and gravel deposits along Flat Run Creek. The thickness of the topsoil varies throughout the site with greater depths being found on gentle slopes and flat areas. Underlying this topsoil is a reddish brown silty clay and clayey silt. The thickness of this soil is generally on the order of five feet. In the areas around Boring XIV and adjacent to Flat Run Creek this soil is absent. This absence is probably due to the erosional affect of Flat Run Creek. Underlying this stratum there is a layer of mottled brown and gray sandy silt (decomposed rock). The structure of the rock from which this residual soil has formed can still be seen in undisturbed samples obtained from this stratum. Below the mottled brown and gray sandy silt (decomposed rock) weathered gneiss is encountered. To assist you in visualizing the subsurface conditions encountered at the site of the proposed dam, graphical illustrations are presented on Plates 2A and 2B, Subsurface Sections.

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

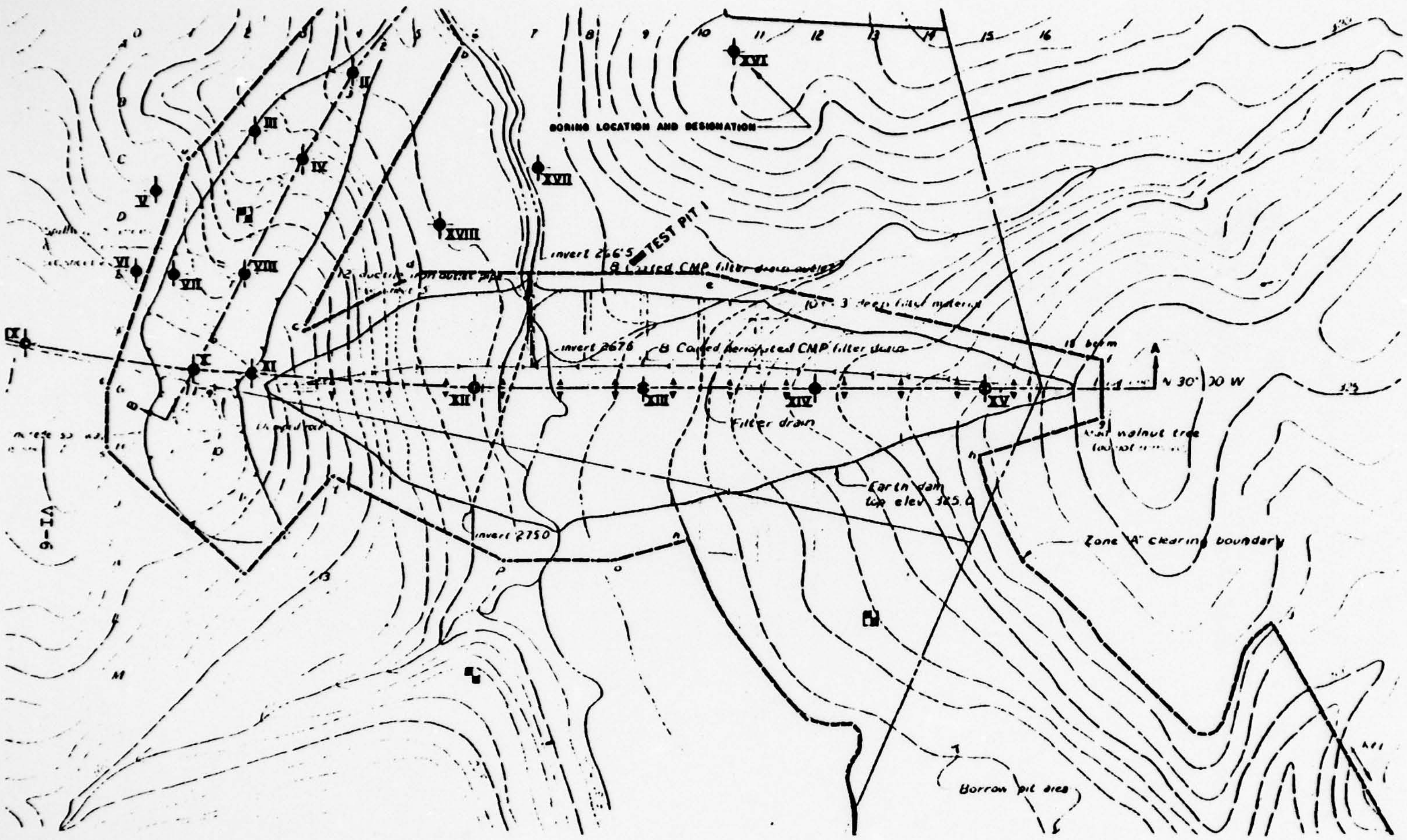
Plate 1	-	Plot Plan
Plate 2A	-	Subsurface Section A-A
Plate 2B	-	Subsurface Section B-B
Appendix	-	Explorations And Laboratory Tests

Respectfully submitted,

DAMES & MOORE

James B. Thompson

James B. Thompson



PLOT PLAN

FEET 100 0 100 200

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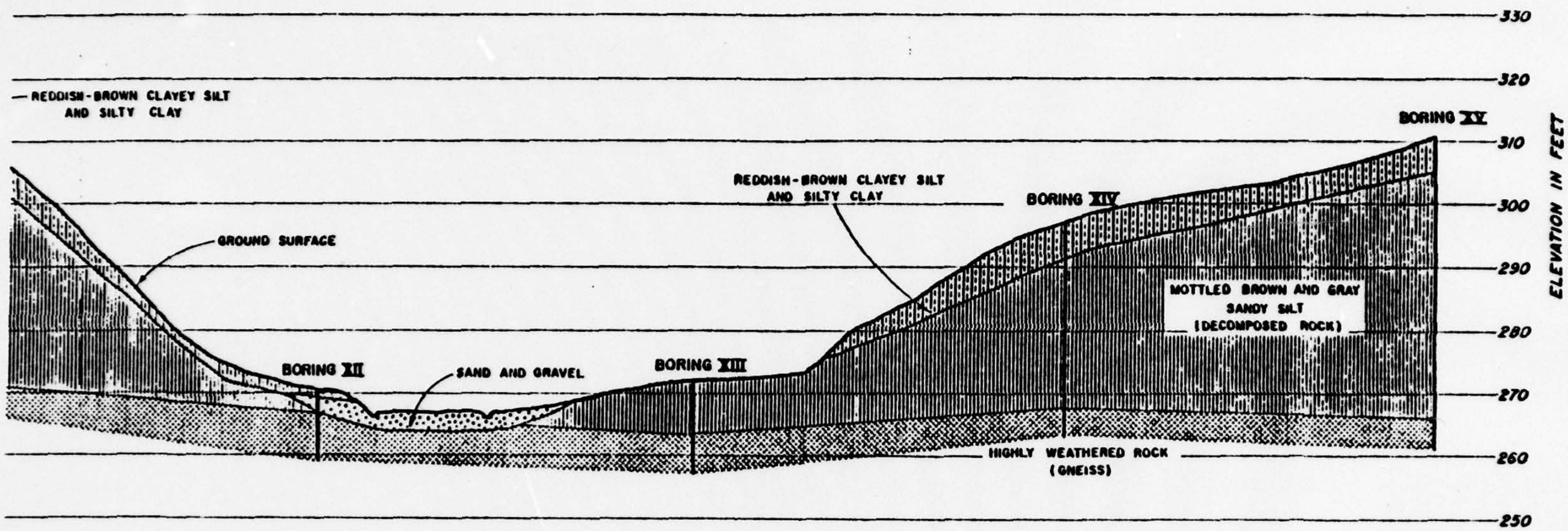
PLATE 1



SUBSURFACE SECTION A-A

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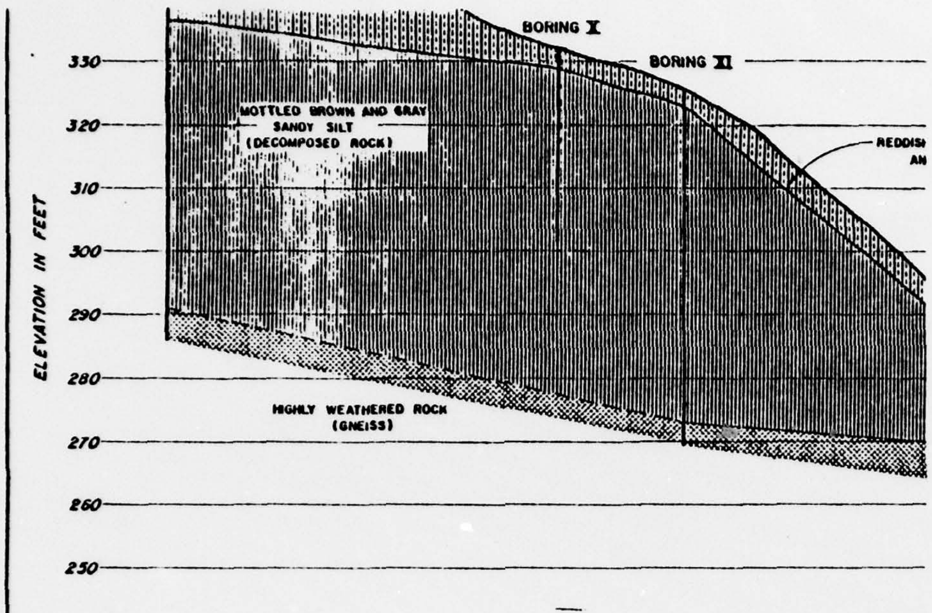
PLATE 2-A



NOTES:

ELEVATIONS REFER TO USGS DATUM

GROUND SURFACE ELEVATIONS WERE OBTAINED FROM A DRAWING ENTITLED - GENERAL PLAN OF DAM AND SPILLWAY, PROPOSED FLAT RUN CREEK DAM, DATED SEPTEMBER 1966.

THE DEPTH AND THICKNESS OF THE SOIL STRATA INDICATED ON THE SUBSURFACE SECTION WERE OBTAINED BY INTERPOLATING BETWEEN TEST BORINGS. INFORMATION ON ACTUAL SOIL CONDITIONS EXISTS ONLY AT THE LOCATIONS OF THE TEST BORINGS AND IT IS POSSIBLE THAT THE SOIL CONDITIONS BETWEEN THE TEST BORINGS MAY VARY FROM THOSE INDICATED.

AD-A073 631 BAKER (MICHAEL) JR INC BEAVER PA F/G 13/2
NATIONAL DAM SAFETY PROGRAM. LAKE OF THE WOODS, INVENTORY NUMBE--ETC(U)
MAR 79 M BAKER DACW65-78-D-0016

UNCLASSIFIED NL

2 OF 3

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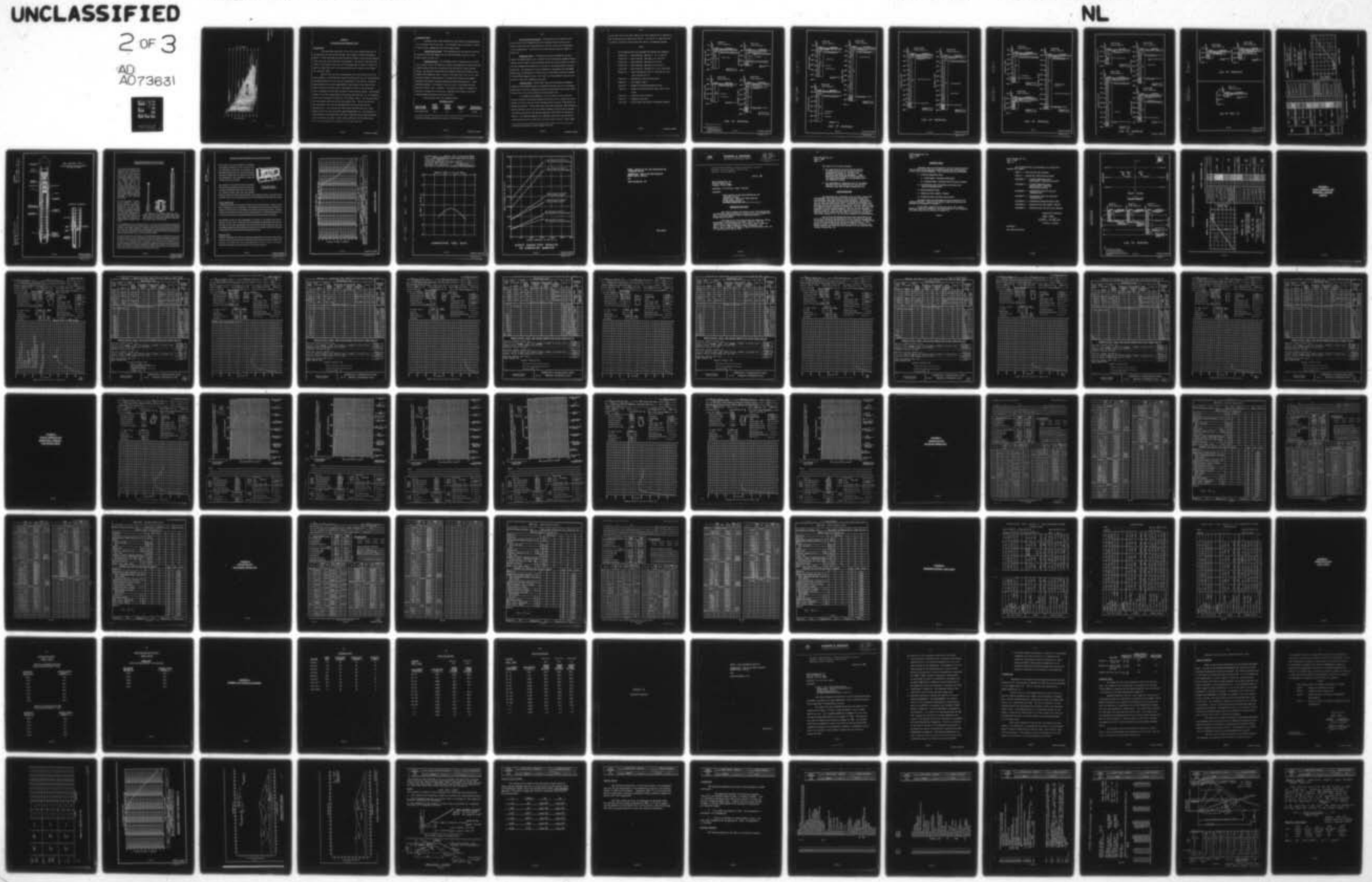
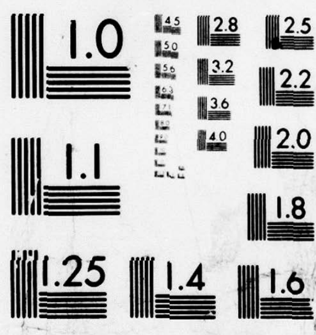
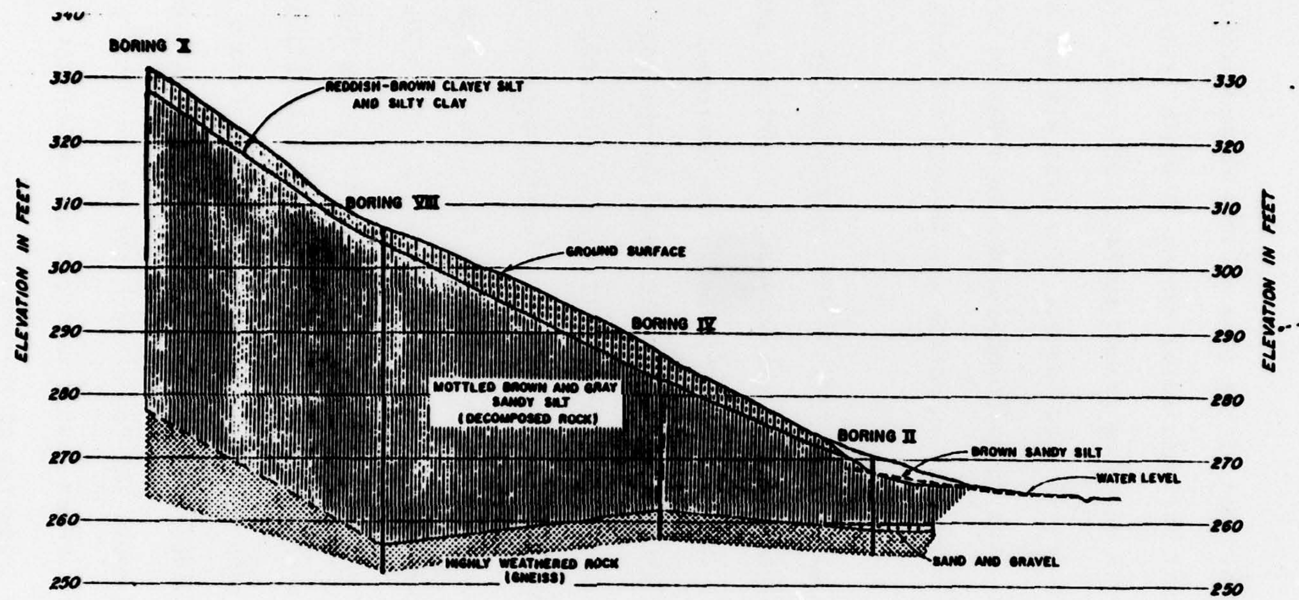
A073631





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



SUBSURFACE SI

FEET
50 0

APPENDIX

EXPLORATIONS AND LABORATORY TESTS

EXPLORATIONS:

The subsurface conditions at the site of the proposed dam were investigated by drilling 18 test borings, which ranged in depth from approximately 11 to 56 feet below the existing ground surface, utilizing truck mounted rotary wash and rotary auger drilling equipment. One test pit was also excavated in the proposed borrow area of the proposed dam in order to visually inspect the subsurface soils to be used as borrow and to obtain a bulk sample for laboratory tests.

The drilling and test pit operations were supervised by one of our field engineers, who maintained a log of the borings and test pit and obtained undisturbed samples of soils and rock encountered in the borings. Graphical representation of the soils encountered in the borings and the test pit are shown on Plate A-1A through A-1F. The method utilized in classifying the soils is defined on Plate A-2, Unified Soil Classification System. Undisturbed samples of the soils penetrated by the borings were obtained in a soil sampler of the type illustrated on Plate A-3, Soil Sampler Type U. The rock was cored utilizing double tube core barrels and diamond bits. The boring locations were obtained in the field by representatives from the Prince William Engineering Co. The elevations of the borings were obtained from a topographic map of the area provided by Bauer Engineering, Inc. The ground surface elevation is presented above the log of each boring and these elevations refer to the U.S.G.S. Datum. Water levels recorded in the borings during our field investigation are presented on the Log of Borings.

LABORATORY TESTS:

Laboratory tests were performed on bulk samples of proposed borrow soil excavated from the test pit. The laboratory tests consisted of identification tests, compaction tests and strength tests.

Identification Tests - The Atterberg Limits and particle size distribution of the bulk samples of soil were determined to assist in the identification of the soil.

Atterberg Limits - The Atterberg Limits, consisting of the liquid limit, plastic limit, and plasticity index, were determined to facilitate the classification of the soil according to the Unified Soil Classification System. The method of performing the Atterberg Limits may be found in most standard Soil Mechanics texts. Briefly, the liquid limit of a soil is that moisture content at which the soil is practically liquid but presumably possesses the smallest shearing strength which may be measured by a standardized procedure. The plastic limit of a soil is the lowest moisture content of which a soil is plastic. The plasticity index is a measure of the plastic properties of soils and is defined as the range in moisture content between the plastic and liquid limits.

The Atterberg Limits are tabulated below:

ATTERBERG LIMITS

TEST PIT AND DEPTH IN FEET	LIQUID LIMIT PERCENT*	PLASTIC LIMIT PERCENT*	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
TP-1 @ 2½ to 3½	39	24	15	ML-CL

* Moisture content expressed as percent of the dry weight.

<u>Particle Size Distribution</u> - Determination of the particle size distribution of the proposed borrow soil obtained from the test pit was made to facilitate the classification of the soil and to aid in the design of the proposed dam. The particle size distribution curves are shown on Plate A-6.

<u>Compaction Tests</u> - A compaction test was performed on the bulk sample of proposed borrow soil to determine the relationship between moisture content and dry density under controlled conditions and to establish criteria for the placement and compaction of the soil in the construction of the proposed dam. The compaction test was performed in accordance with the AASHO* Compaction Test Designation T 180-57 which is described on Plate A-4, Method of Performing Compaction Tests. The results of the compaction test are presented on Plate A-7, Compaction Test Data.

<u>Strength Tests</u> - Direct shear tests were performed on compacted samples of the proposed borrow soil obtained from the test pit in the manner described on Plate A-5, Method of Performing Direct Shear and Friction Tests. Stress-strain curves were plotted for each strength test.

Six samples were compacted a little on the dry side of optimum moisture content to 90 percent maximum dry density and six samples were compacted a little on the dry side of optimum moisture content to 95 percent of maximum dry density. Direct shear tests were then performed, under different normal pressures, on half of the samples compacted to 90 percent of maximum dry density and half of the samples compacted to 95 percent of maximum dry density. The remaining samples were submerged under water and various surcharge pressures for five days prior to direct shear testing. Direct shear

* American Association of State Highway Officials

tests were also run on other samples that were compacted wet of optimum to 84 and 88 percent of maximum dry density. The results of these tests are plotted on Plate A-8, Direct Shear Test Results on Compacted Samples.

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The following Plates are attached and complete this Appendix:

Plate A-1A - Log of Borings (Borings I, II, III and IV)

Plate A-1B - Log of Borings (Borings V, VI, and VII)

Plate A-1C - Log of Borings (Borings VIII and IX)

Plate A-1D - Log of Borings (Borings X, XI and XII)

Plate A-1E - Log of Borings (Borings XIII, XIV, XV and XVI)

Plate A-1F - Log of Borings and Test Pit (Borings XVII and XVIII and Test Pit 1)

Plate A-2 - Unified Soil Classification System

Plate A-3 - Soil Sampler Type U

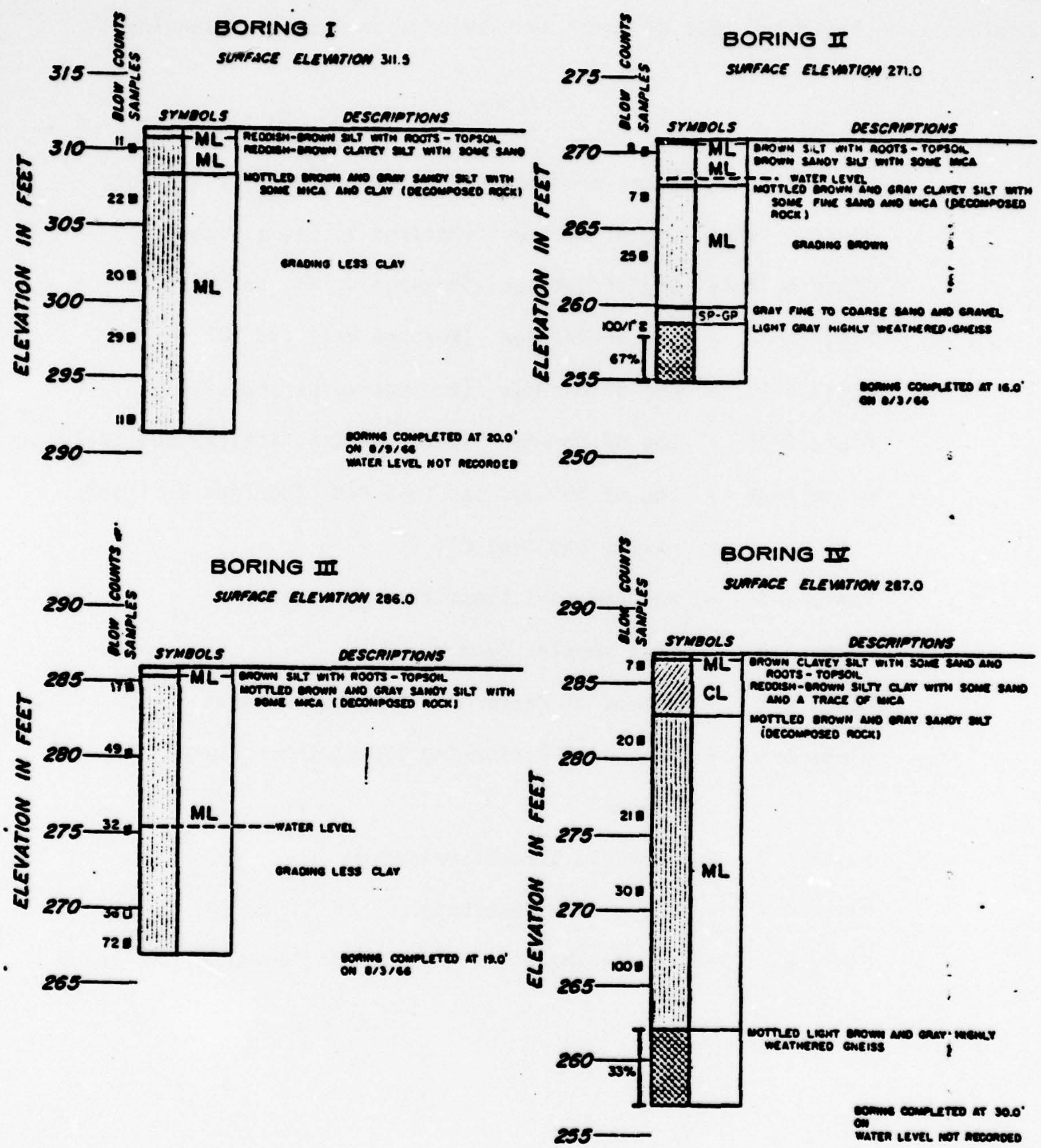
Plate A-4 - Method of Performing Compaction Tests

Plate A-5 - Method of Performing Direct Shear and Friction Tests

Plate A-6 - Particle Size Distribution

Plate A-7 - Compaction Test Data

Plate A-8 - Direct Shear Test Results on Compacted Samples



LOG OF BORINGS

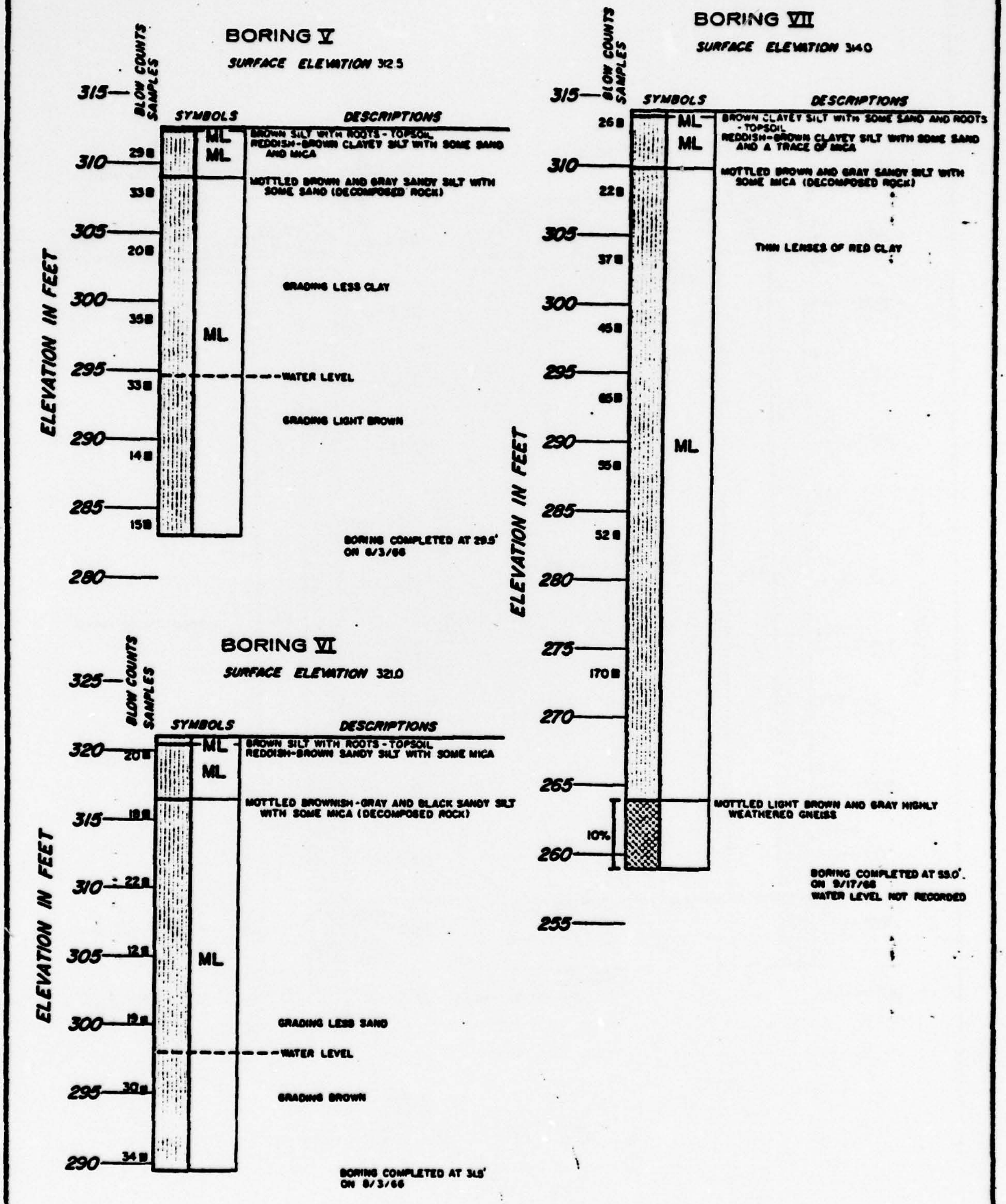
NOTES:
ELEVATIONS REFER TO U.S.G.S. DATUM.

100% I INDICATES DEPTH, LENGTH AND PERCENT OF CORE RUN RECOVERED.

FIGURES UNDER THE BLOW COUNT COLUMN INDICATE THE NUMBER OF BLOWS REQUIRED TO DRIVE A DAMES & MOORE SAMPLER ONE-FOOT WITH A 300 LB. WEIGHT FALLING 18 INCHES.

DAMES & MOORE

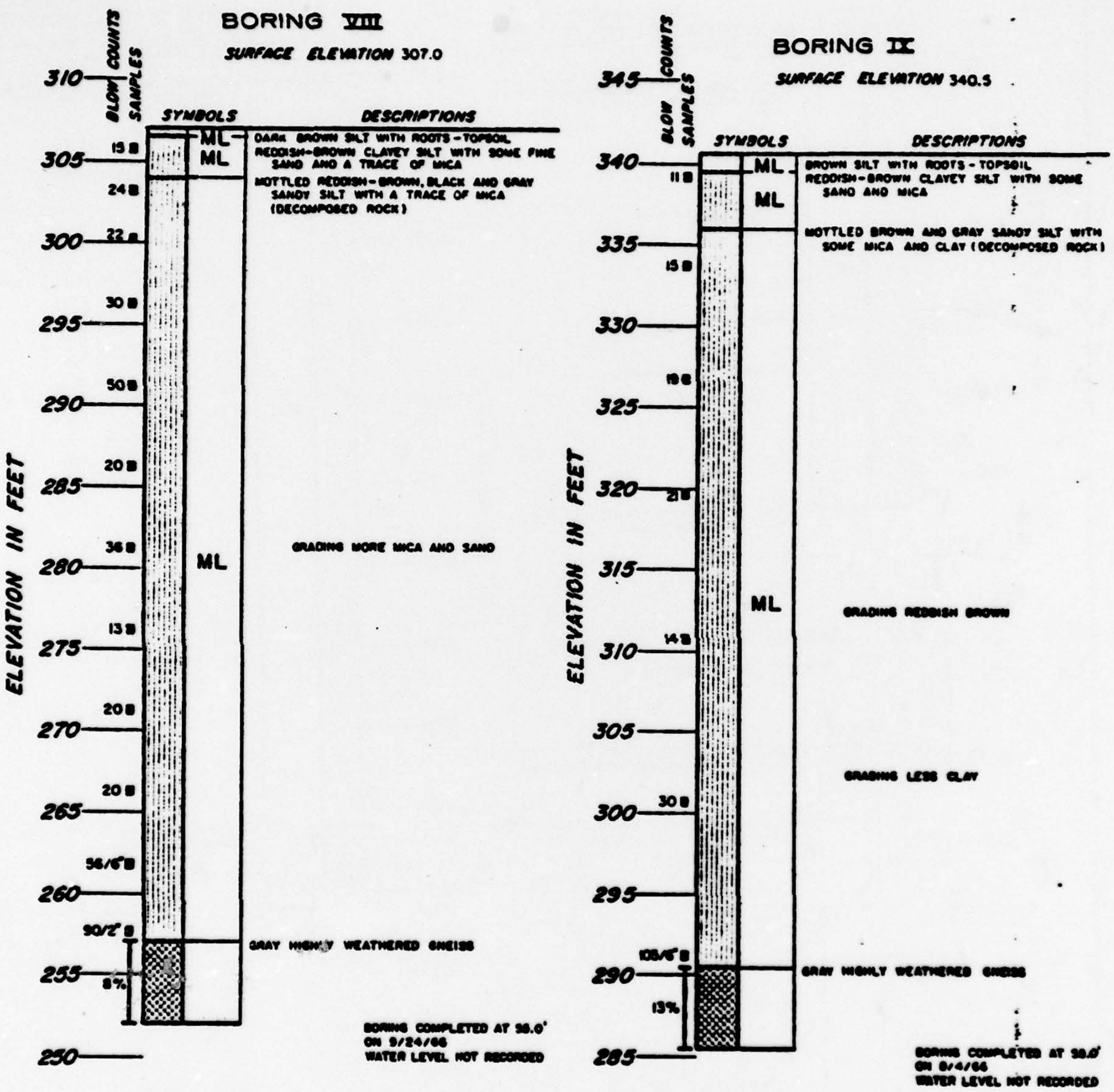
PLATE A-1A



LOG OF BORINGS

DAMES & MOORE

PLATE A-18



LOG OF BORINGS

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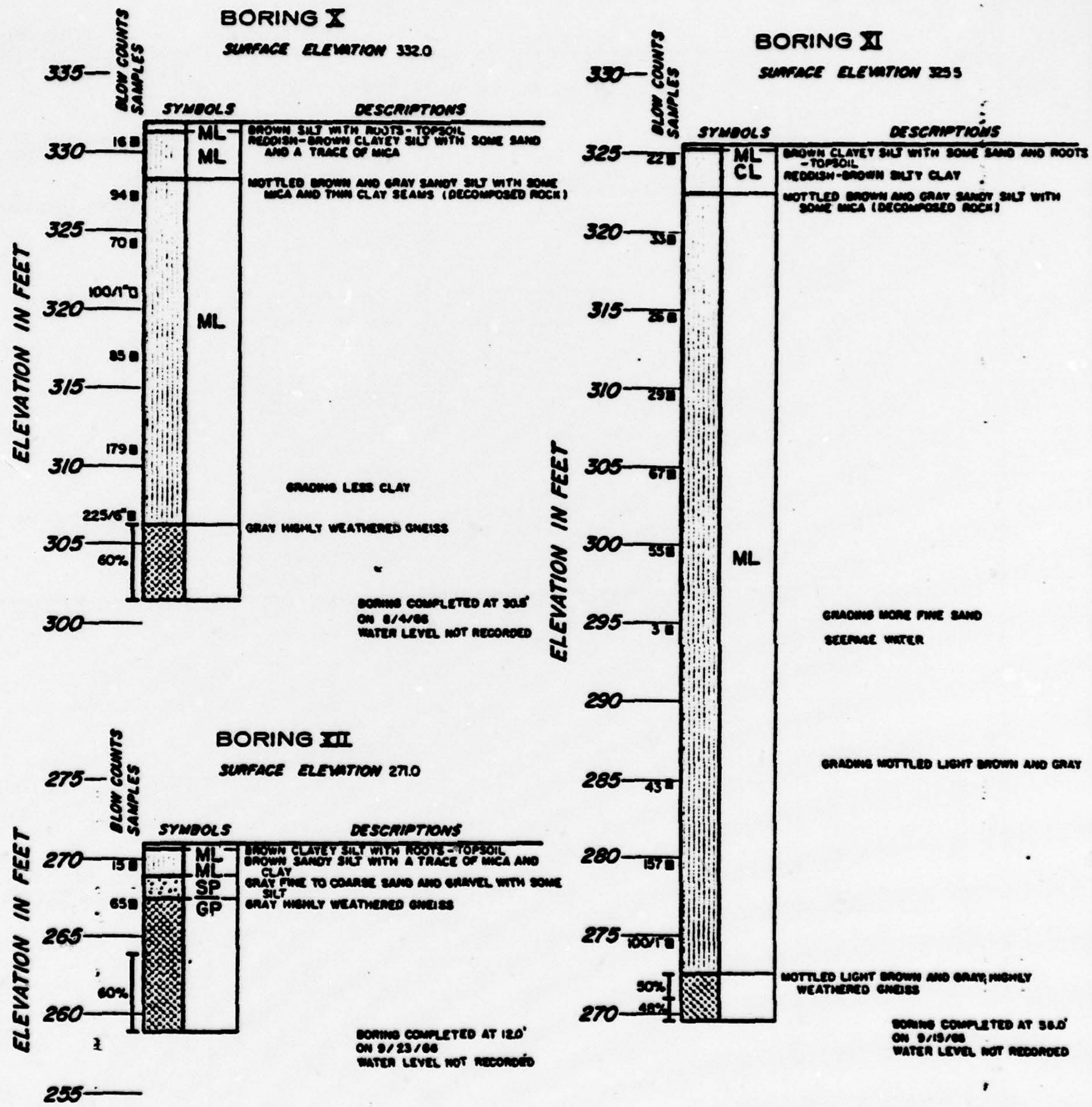
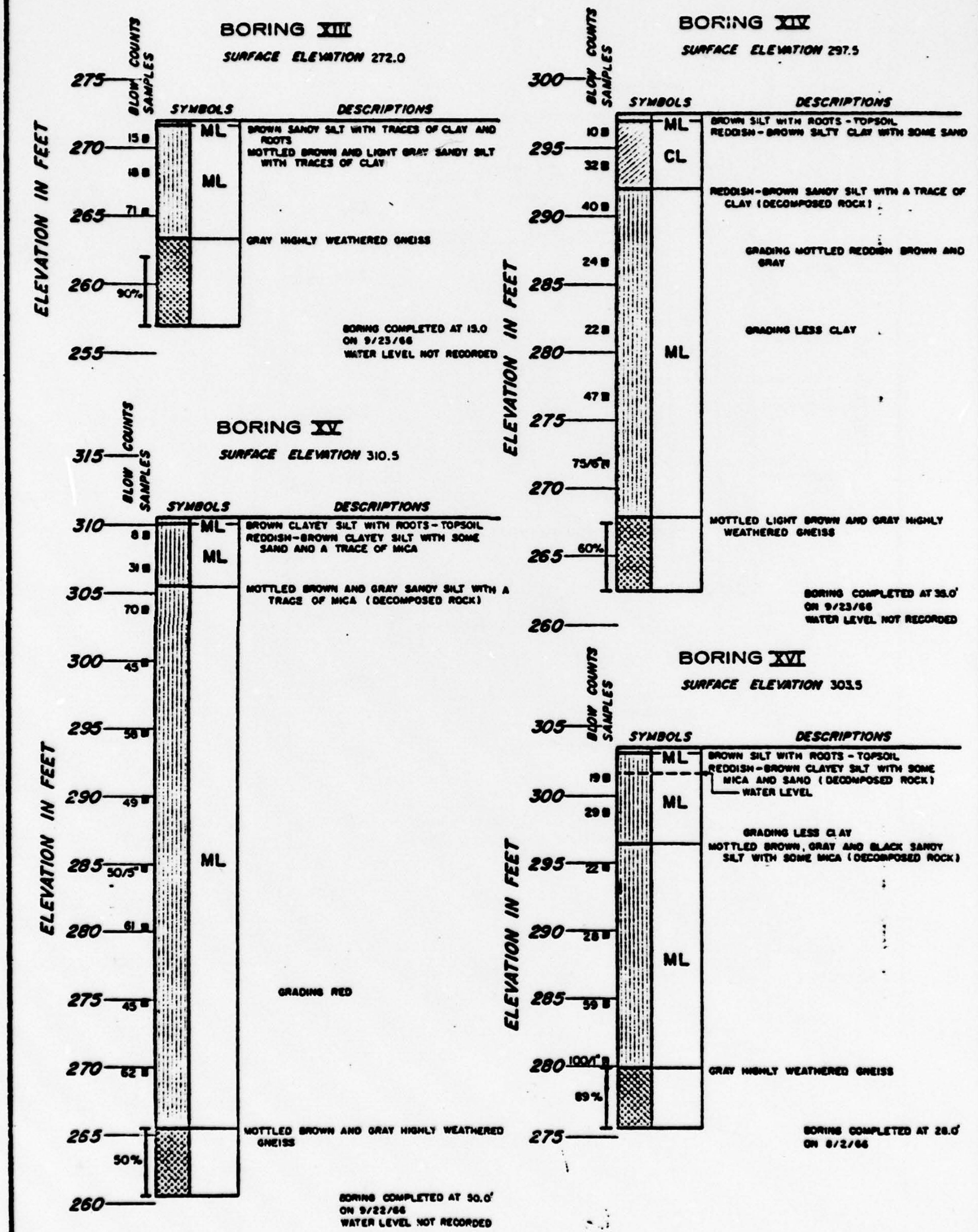
PLATE A-1C



LOG OF BORINGS

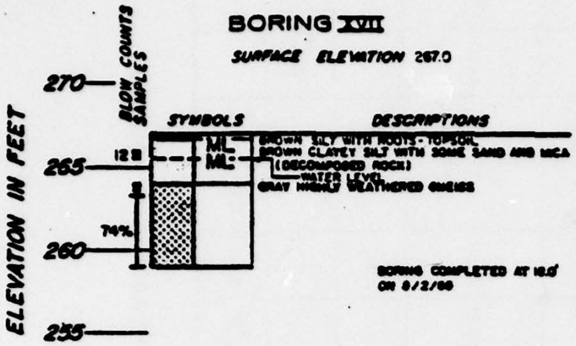
DAMES & MOORE

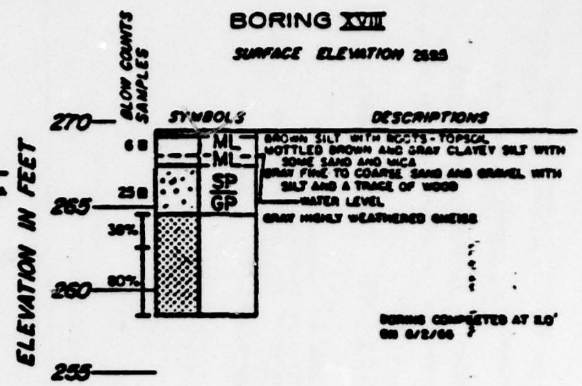
PLATE A-10



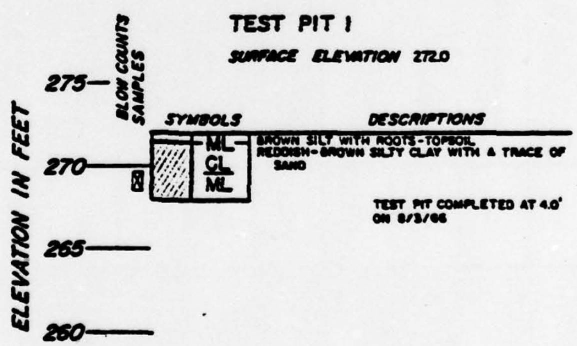
LOG OF BORINGS

DAMES & MOORE





LOG OF BORINGS



LOG OF TEST PIT

DAMES & MOORE

PLATE A-1F

COARSE GRAINED SOILS	AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE			SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

SOIL CLASSIFICATION CHART

— PER CENT FIELD MOISTURE EXPRESSED AS A PERCENTAGE OF THE DRY WEIGHT OF SOIL
— DRY DENSITY EXPRESSED IN POUNDS PER CUBIC FOOT
— SHEARING STRENGTH IN POUNDS PER SQUARE FOOT (FROM MOHR CIRCLE)

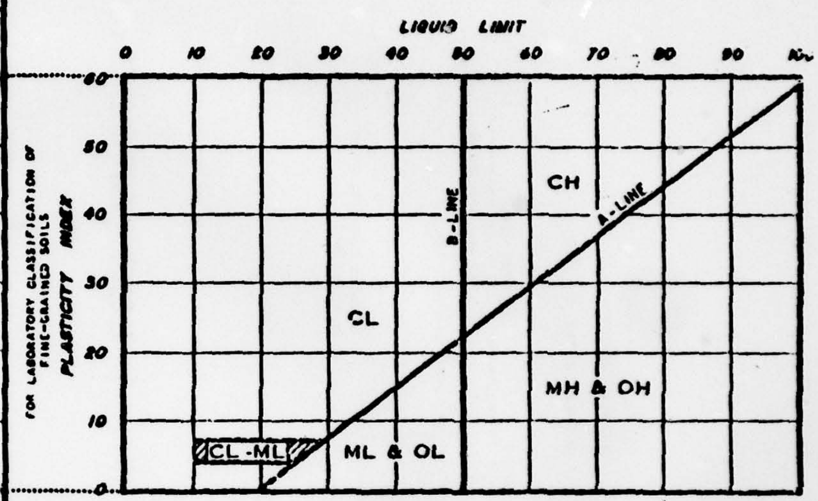
ROCK COMPRESSION TESTS

— COMPRESSIVE STRENGTH IN POUNDS PER SQUARE INCH

KEY TO TEST DATA

- ■ INDICATES DEPTH OF UNDISTURBED SAMPLE
- ● INDICATES DEPTH OF DISTURBED SAMPLE
- □ INDICATES DEPTH OF SAMPLING ATTEMPT WITH NO RECOVERY
- ▣ INDICATES DEPTH OF SPLIT-SPOON SAMPLE
- I INDICATES DEPTH AND LENGTH OF CORING RUN

KEY TO SAMPLES



PLASTICITY CHART

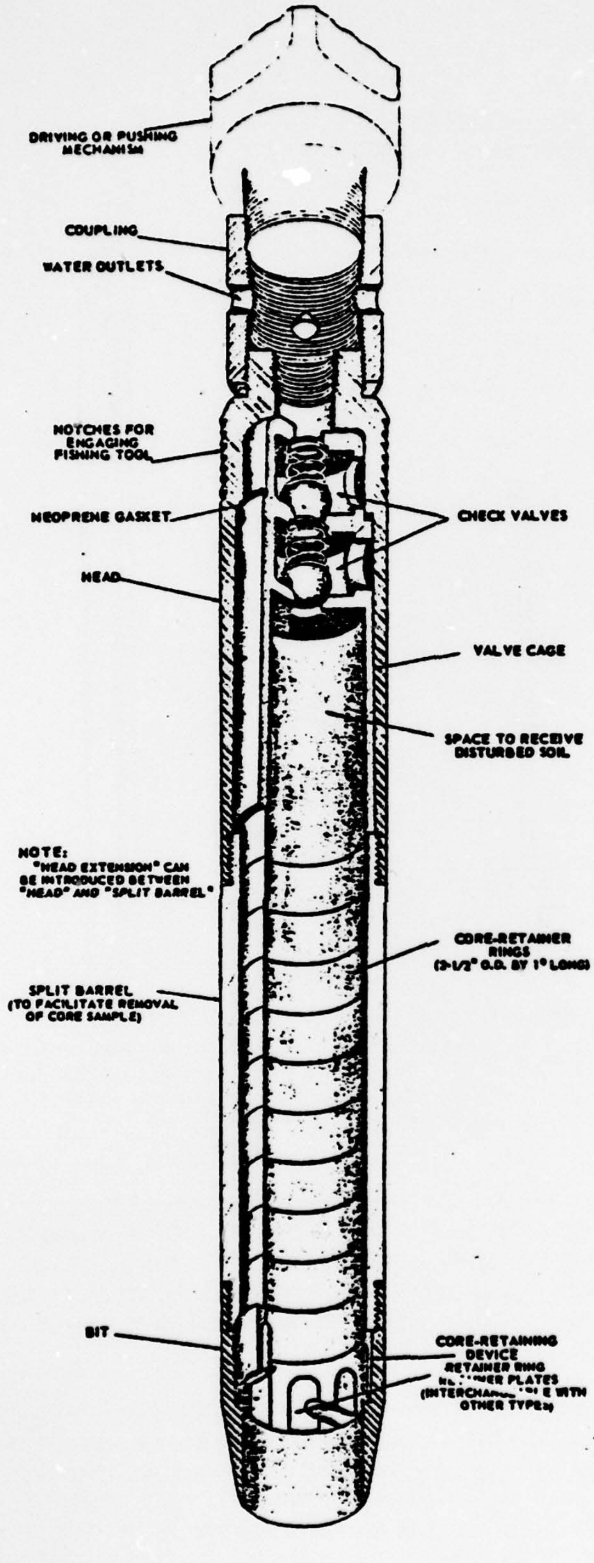
UNIFIED SOIL CLASSIFICATION SYSTEM

DAMES & MOORE

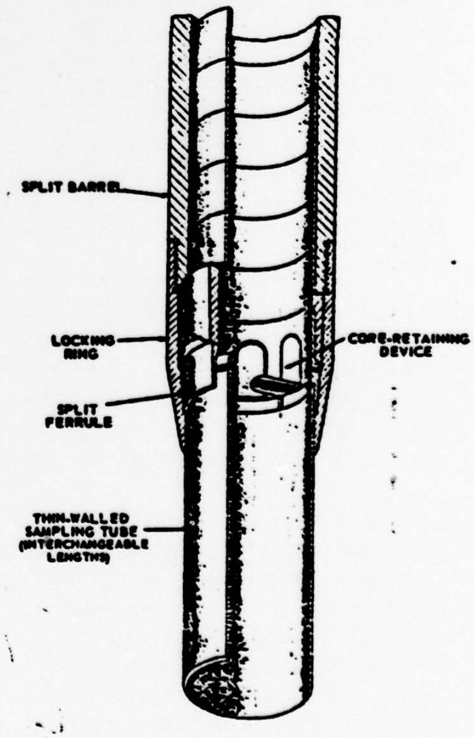
REVISIONS
BY ______ DATE ______
BY ______ DATE ______ TO GO ______

SOIL SAMPLER TYPE U

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



ALTERNATE ATTACHMENTS



BY ______ DATE ______
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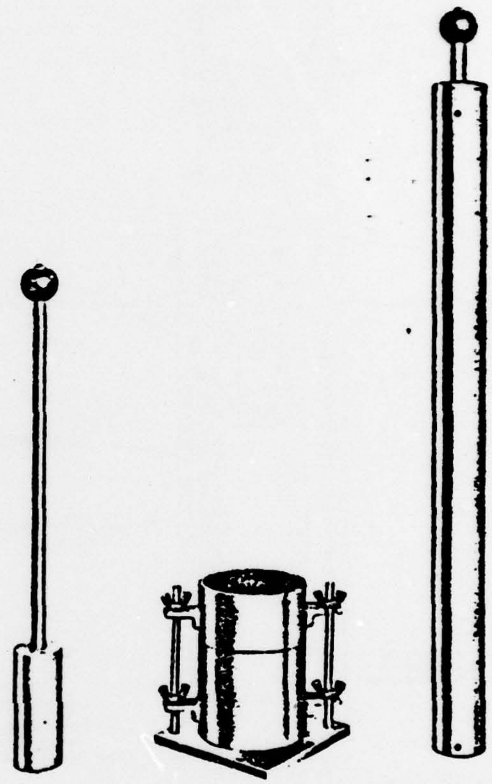
DAMES & MOORE
APPLIED EARTH SCIENCES

PLATE A-3

Method Of Performing Compaction Tests
(STANDARD AND MODIFIED A.A.S.H.O. METHODS)

IT HAS BEEN ESTABLISHED THAT WHEN COMPACTING EFFORT IS HELD CONSTANT, THE DENSITY OF A ROLLED EARTH FILL INCREASES WITH ADDED MOISTURE UNTIL A MAXIMUM DRY DENSITY IS OBTAINED AT A MOISTURE CONTENT TERMED THE "OPTIMUM MOISTURE CONTENT," AFTER WHICH THE DRY DENSITY DECREASES. THE COMPACTION CURVE SHOWING THE RELATIONSHIP BETWEEN DENSITY AND MOISTURE CONTENT FOR A SPECIFIC COMPACTING EFFORT IS DETERMINED BY EXPERIMENTAL METHODS. TWO COMMONLY USED METHODS ARE DESCRIBED IN THE FOLLOWING PARAGRAPHS.

FOR THE "STANDARD A.A.S.H.O." (A.S.T.M. D698-58T & A.A.S.H.O. T99-57) METHOD OF COMPACTION A PORTION OF THE SOIL SAMPLE PASSING THE NO. 4 SIEVE IS COMPACTED AT A SPECIFIC MOISTURE CONTENT IN THREE EQUAL LAYERS IN A STANDARD COMPACTION CYLINDER HAVING A VOLUME OF 1/30 CUBIC FOOT, USING TWENTY-FIVE 12-INCH BLOWS OF A STANDARD 5-1/2 POUND RAMMER TO COMPACT EACH LAYER.



SOME APPARATUS FOR PERFORMING COMPACTION TESTS
Shows, from left to right, 5-1/2 pound rammer (sleeve controlling 12" height of drop removed), 1/30 cubic-foot cylinder with removable collar and base plate, and 10 pound rammer within sleeve.

IN THE "MODIFIED A.A.S.H.O." (A.S.T.M. D-1557-58T & A.A.S.H.O. T 180-57) METHOD OF COMPACTION A PORTION OF THE SOIL SAMPLE PASSING THE NO. 4 SIEVE IS COMPACTED AT A SPECIFIC MOISTURE CONTENT IN FIVE EQUAL LAYERS IN A STANDARD COMPACTION CYLINDER HAVING A VOLUME OF 1/30 CUBIC FOOT, USING TWENTY-FIVE 18-INCH BLOWS OF A 10-POUND RAMMER TO COMPACT EACH LAYER. SEVERAL VARIATIONS OF THESE COMPACTION TESTING METHODS ARE OFTEN USED AND THESE ARE DESCRIBED IN A.A.S.H.O. & A.S.T.M. SPECIFICATIONS.

FOR BOTH METHODS, THE WET DENSITY OF THE COMPACTED SAMPLE IS DETERMINED BY WEIGHING THE KNOWN VOLUME OF SOIL; THE MOISTURE CONTENT, BY MEASURING THE LOSS OF WEIGHT OF A PORTION OF THE SAMPLE WHEN OVEN DRIED; AND THE DRY DENSITY, BY COMPUTING IT FROM THE WET DENSITY AND MOISTURE CONTENT. A SERIES OF SUCH COMPACTIONS IS PERFORMED AT INCREASING MOISTURE CONTENTS UNTIL A SUFFICIENT NUMBER OF POINTS DEFINING THE MOISTURE-DENSITY RELATIONSHIP HAVE BEEN OBTAINED TO PERMIT THE PLOTTING OF THE COMPACTION CURVE. THE MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT FOR THE PARTICULAR COMPACTING EFFORT ARE DETERMINED FROM THE COMPACTION CURVE.

DAMES & MOORE
APPLIED EARTH SCIENCES

PLATE A-4

REVISIONS BY ____ DATE ____

METHOD OF PERFORMING DIRECT SHEAR AND FRICTION TESTS

DIRECT SHEAR TESTS ARE PERFORMED TO DETERMINE THE SHEARING STRENGTHS OF SOILS. FRICTION TESTS ARE PERFORMED TO DETERMINE THE FRICTIONAL RESISTANCES BETWEEN SOILS AND VARIOUS OTHER MATERIALS SUCH AS WOOD, STEEL, OR CONCRETE. THE TESTS ARE PERFORMED IN THE LABORATORY TO SIMULATE ANTICIPATED FIELD CONDITIONS.

DIRECT SHEAR TESTING & RECORDING APPARATUS

EACH SAMPLE IS TESTED WITHIN THREE BRASS RINGS, TWO AND ONE-HALF INCHES IN DIAMETER AND ONE INCH IN LENGTH. UNDISTURBED SAMPLES OF IN-PLACE SOILS ARE TESTED IN RINGS TAKEN FROM THE SAMPLING DEVICE IN WHICH THE SAMPLES WERE OBTAINED. LOOSE SAMPLES OF SOILS TO BE USED IN CONSTRUCTING EARTH FILLS ARE COMPACTED IN RINGS TO PREDETERMINED CONDITIONS AND TESTED.

DIRECT SHEAR TESTS

A THREE-INCH LENGTH OF THE SAMPLE IS TESTED IN DIRECT DOUBLE SHEAR. A CONSTANT PRESSURE, APPROPRIATE TO THE CONDITIONS OF THE PROBLEM FOR WHICH THE TEST IS BEING PERFORMED, IS APPLIED NORMAL TO THE ENDS OF THE SAMPLE THROUGH POROUS STONES. A SHEARING FAILURE OF THE SAMPLE IS CAUSED BY MOVING THE CENTER RING IN A DIRECTION PERPENDICULAR TO THE AXIS OF THE SAMPLE. TRANSVERSE MOVEMENT OF THE OUTER RINGS IS PREVENTED.

THE SHEARING FAILURE MAY BE ACCOMPLISHED BY APPLYING TO THE CENTER RING EITHER A CONSTANT RATE OF LOAD, A CONSTANT RATE OF DEFLECTION, OR INCREMENTS OF LOAD OR DEFLECTION. IN EACH CASE, THE SHEARING LOAD AND THE DEFLECTIONS IN BOTH THE AXIAL AND TRANSVERSE DIRECTIONS ARE RECORDED AND PLOTTED. THE SHEARING STRENGTH OF THE SOIL IS DETERMINED FROM THE RESULTING LOAD-DEFLECTION CURVES.

FRICTION TESTS

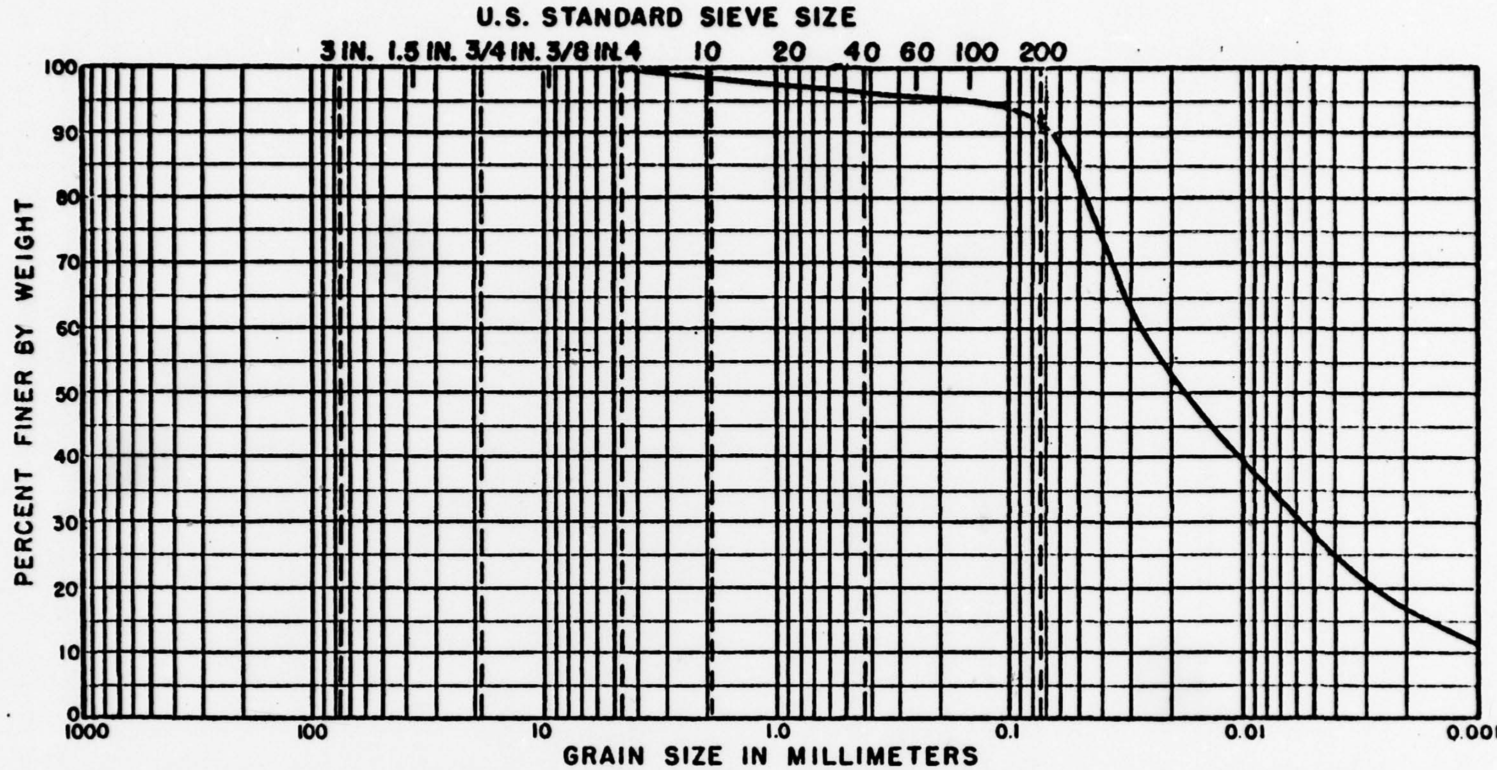
IN ORDER TO DETERMINE THE FRICTIONAL RESISTANCE BETWEEN SOIL AND THE SURFACES OF VARIOUS MATERIALS, THE CENTER RING OF SOIL IN THE DIRECT SHEAR TEST IS REPLACED BY A DISK OF THE MATERIAL TO BE TESTED. THE TEST IS THEN PERFORMED IN THE SAME MANNER AS THE DIRECT SHEAR TEST BY FORCING THE DISK OF MATERIAL FROM THE SOIL SURFACES.

BY ____ FILE ____

BY ____ DATE ____ CHECKED BY ____

DAMES & MOORE
APPLIED EARTH SCIENCES

PLATE A-5

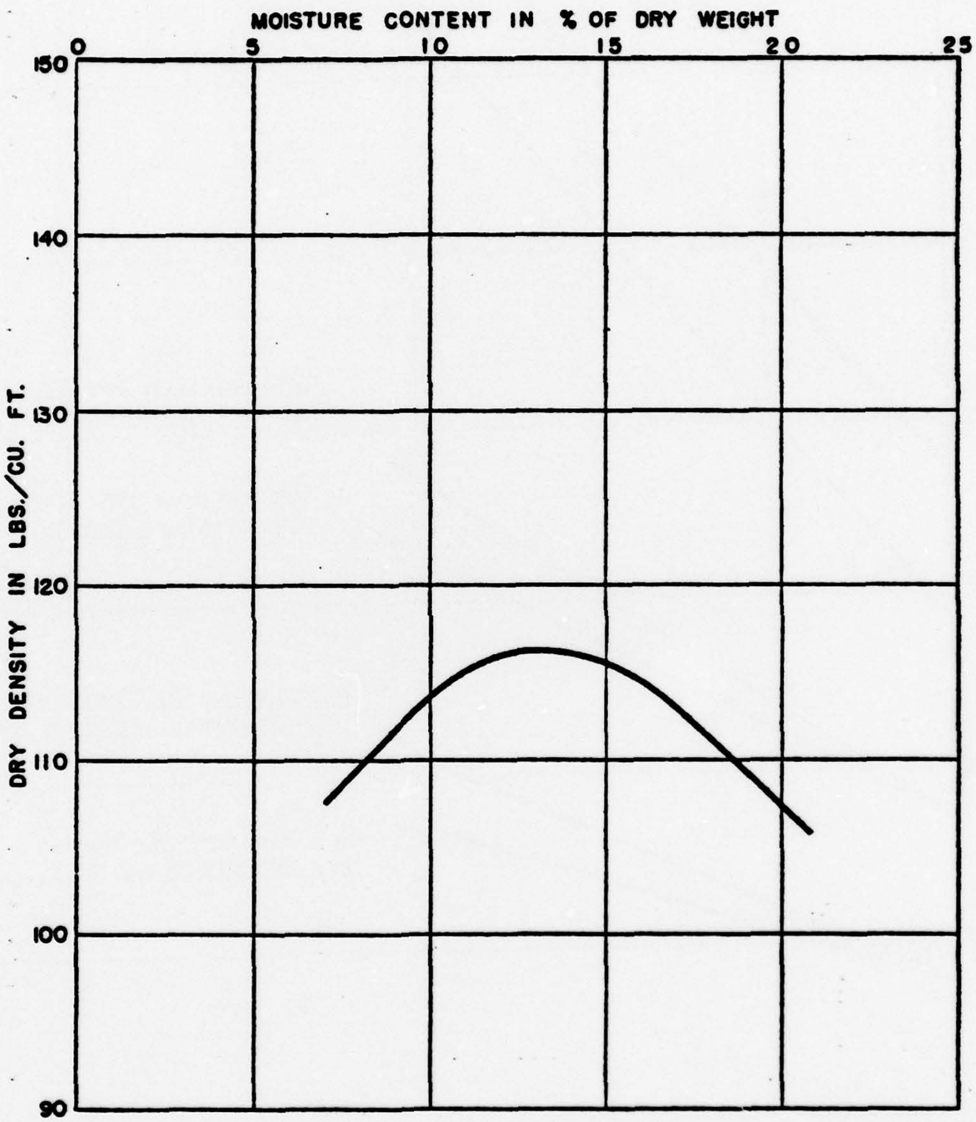


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LOCATION	DEPTH	CLASSIFICATION		NAT. WC	LL	PL	PI	
TEST PIT I	2.5' TO 3.5'	CL-ML	SILTY CLAY WITH SAND		39	24	15	

GRADATION CURVE

SAMPLE NO. 1 DEPTH 2.5' ELEVATION 269.5
SOIL REDDISH-BROWN SILTY CLAY WITH TRACE OF SAND
LOCATION TEST PIT 1
OPTIMUM MOISTURE CONTENT 13.0 %
MAXIMUM DRY DENSITY 116 LBS./CU. FT.
METHOD OF COMPACTION A.A.S.H.O. T180-57(METHOD A)

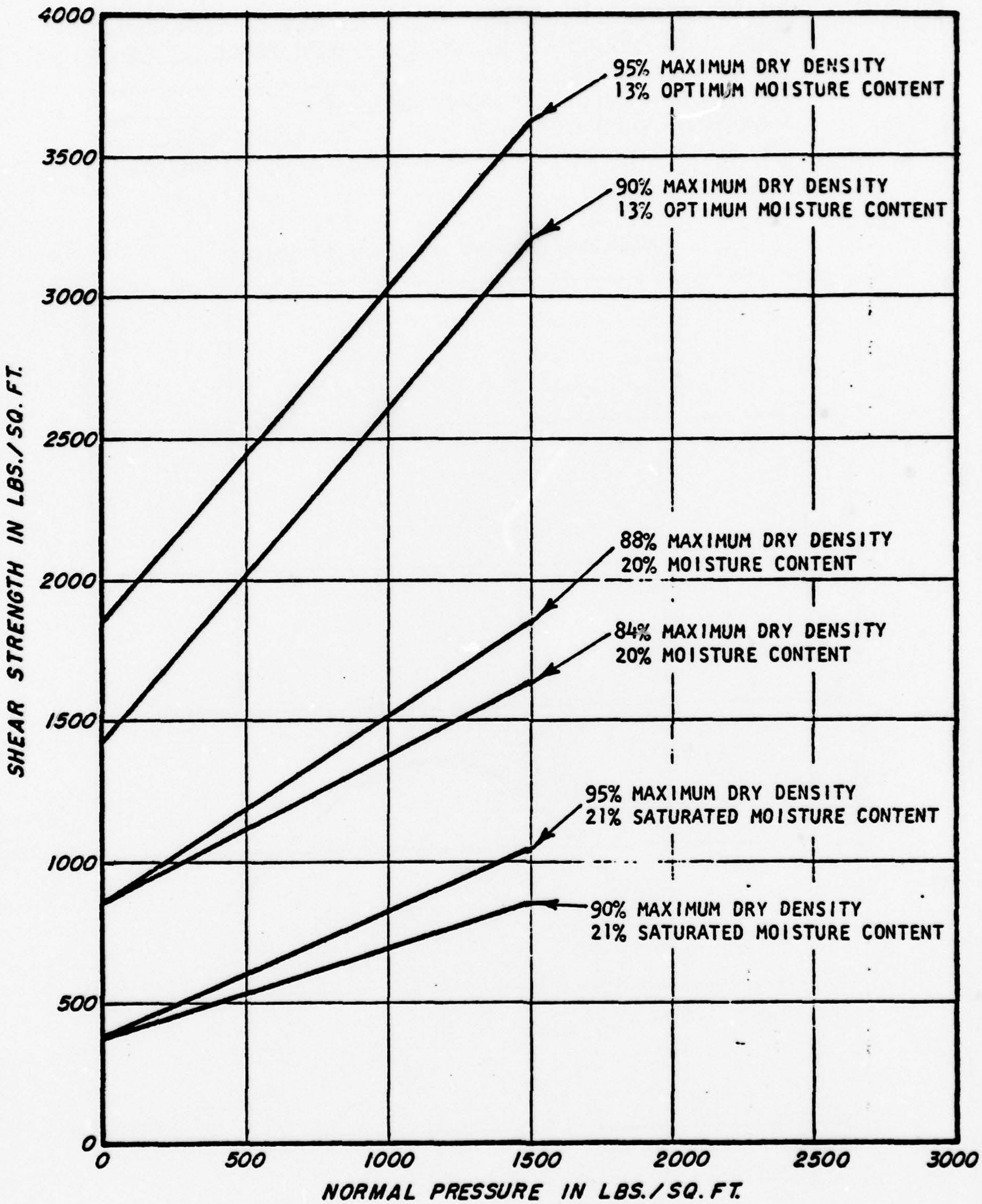


COMPACTION TEST DATA

DAMES & MOORE

PLATE A-7

BY ____ DATE ____
BY ____ DATE ____
CHECKED BY ____ DATE ____
JJK 10/10/66



DIRECT SHEAR TEST RESULTS ON COMPACTED SAMPLES

DAMES & MOORE
APPLIED EARTH SCIENCES

PLATE A-8

REPORT - RESULTS OF THE FIELD EXPLORATIONS AND LABORATORY TESTING

PROPOSED DAM - LAKE OF THE WOODS RESERVOIR
ORANGE COUNTY, VIRGINIA

FOR

BAUER ENGINEERING, INC.

5651-003-07

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

ATLANTA · NEW YORK · CHICAGO · PORTLAND · HONOLULU · SALT LAKE CITY · HOUSTON · SAN FRANCISCO · LOS ANGELES · SEATTLE · WASHINGTON, D.C.
MADRID, SPAIN · SAINT JOHN, N.B. CANADA · TEHRAN, IRAN

309 WEST JACKSON BOULEVARD · CHICAGO, ILLINOIS 60606 · 312-922-1772
PARTNERS: JAMES B. THOMPSON · GEORGE D. LEAL
ASSOCIATE: WILLIAM G. PARATORE

June 7, 1967

Bauer Engineering, Inc.
20 North Wacker Drive
Chicago, Illinois 60606

Attention: Mr. William J. Bauer, President

Gentlemen:

Report-Results of the Field Explorations and Laboratory Testing
Proposed Dam - Lake of the Woods Reservoir
Orange County, Virginia
For Bauer Engineering, Inc.

INTRODUCTION AND SCOPE

This report presents the results of our field explorations and laboratory testing performed in connection with the Proposed Dam - Lake of the Woods Reservoir which is being constructed in Orange County, Virginia.

The scope of our field explorations and laboratory testing was planned in collaboration with Messrs. Robert L. Hall and Donald Wikan of Bauer Engineering, Inc., Messrs. Gay D. Jones and Jack W. Burke of Howard, Needles, Tammen & Bergendoff, and Messrs. John S. Keating and Robert L. Boone of United States Land, Inc. at a meeting held on May 10, 1967.

CABLE ADDRESS: DAMEMORE

The scope of our services included:

1 - The supervision of the drilling and sampling of three exploration test borings drilled at approximately Station 7 + 25 within the partially constructed dam embankment. These operations were performed to obtain representative undisturbed samples of the embankment soils for laboratory testing.

2 - The performance of laboratory tests on the embankment soils and the presentation of the original laboratory test data to Bauer Engineering, Inc.

FIELD EXPLORATIONS

The subsurface soil conditions of the partially constructed dam embankment were explored by drilling three test borings with truck mounted, auger type caisson drilling equipment. The borings were 12 inches in diameter and penetrated through the embankment fill and into the underlying natural soils. Undisturbed soil samples were obtained from the test borings by hydraulically pushing a Dames & Moore Soil Sampler having a thin-wall bit extension. Two test pits were also excavated utilizing backhoe equipment. One test pit was excavated adjacent to Boring 1 and the other adjacent to Boring 3. Shelby tubes were hydraulically pushed into the sides of the test pits to obtain undisturbed samples of soil for horizontal permeability determinations.

The drilling and backhoe operations were supervised by one of our field engineers who maintained a log of the soils encountered. The location of the borings and test pits, and graphical representations of the soils penetrated by the borings are shown on Plate 1. The method utilized in classifying the soils is defined on Plate 2. The boring locations and elevations were provided to us by representatives of Bauer Engineering, Inc.

LABORATORY TESTS

Laboratory tests were performed on the soil samples obtained from the test borings and pits to obtain certain physical properties of the in-situ earth embankment. The following tests were performed:

1 - Triaxial Compression Tests

a - Consolidated - Undrained (Saturated)

b - Unconsolidated - Undrained (Field Moisture Content)

2 - Consolidation Tests (To determine horizontal and vertical permeabilities)

3 - Moisture-Density Tests

4 - Compaction Tests (AASHO T 180-57)

5 - Atterberg Limits and Grain Size Analyses

The above tests were performed utilizing conventional soil testing procedures. Copies of the original laboratory test data are presented in Attachments A through G.

It has been a pleasure to work with you on this project. Should you need any assistance in the interpretation of the laboratory test data, please do not hesitate to contact us.

--oOo--

The following Plates and Attachments are enclosed and complete this report:

Plate 1 - Plot Plan and Log of Borings

Plate 2 - Unified Soil Classification System

Attachment A - Triaxial Compression Tests Consolidated - Undrained, Saturated

Attachment B - Triaxial Compression Tests Unconsolidated - Undrained, Field Moisture Content

Attachment C - Consolidation Tests For Vertical Permeabilities

Attachment D - Consolidation Tests For Horizontal Permeabilities

Attachment E - Supplementary Moisture-Density Tests

Attachment F - Compaction Test Data (AASHO T 180-57)

Attachment G - Atterberg Limits and Grain Size Analyses

Respectfully submitted,

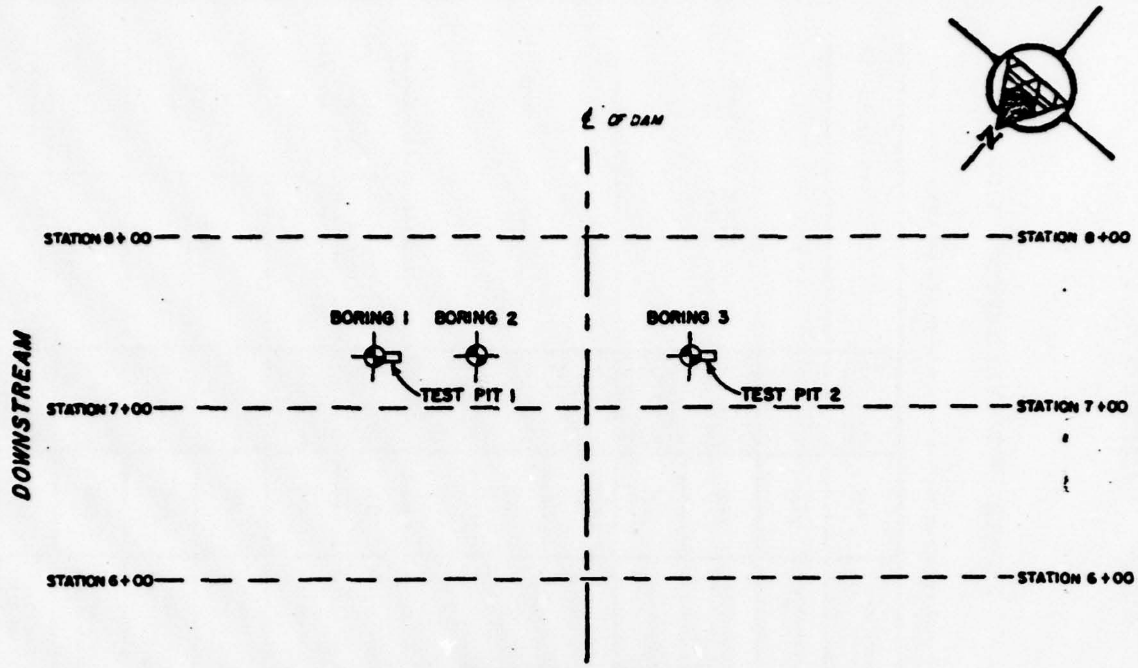
DAMES & MOORE

William G. Paratore

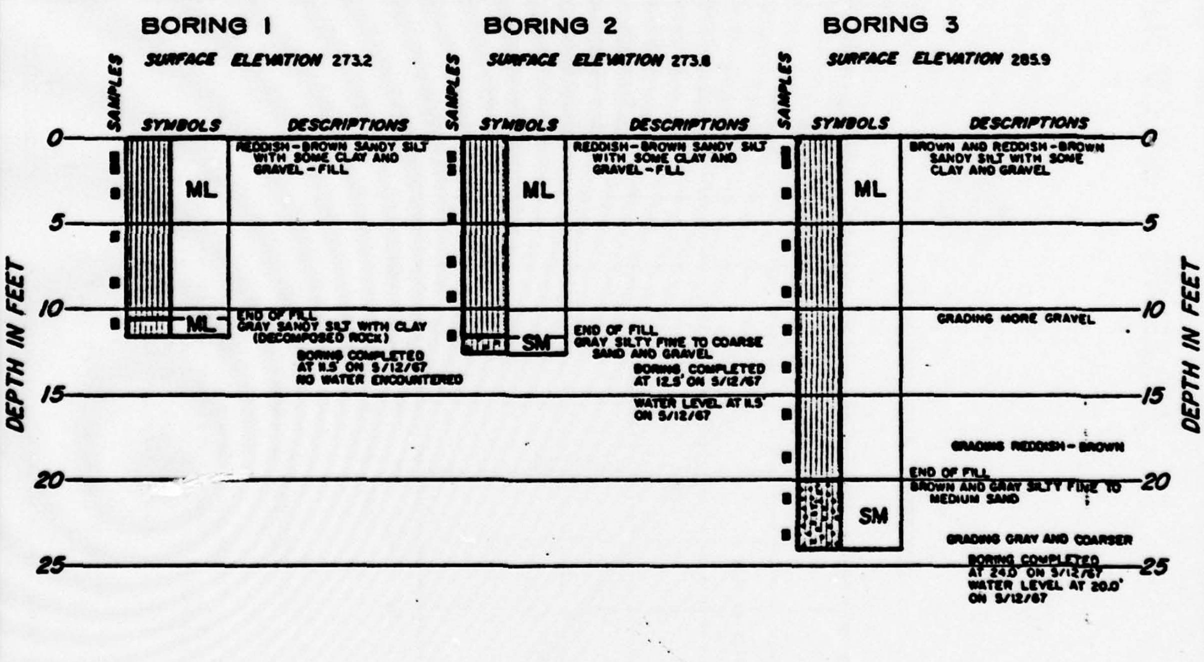
William G. Paratore

WGP:MLK:mf

Four Copies Submitted



PLOT PLAN



LOG OF BORINGS

NOTES:

ELEVATIONS REFER TO U.S.G.S. DATUM.

ALL SOILS WERE CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM.

ALL SAMPLES WERE OBTAINED BY PUSHING HYDRAULICALLY A DAMES & MOORE SOIL SAMPLER TYPE U WITH A THIN-WALLED SAMPLING TUBE.

DAMES & MOORE

PLATE 1

BY M.R.B. DATE 6-1-67
CHECKED BY DATE

GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
		GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES
		SC	CLAYEY SANDS, SAND-CLAY MIXTURES
SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
		CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
		CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
		OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
ONLY ORGANIC SOILS		PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

SOIL CLASSIFICATION CHART

— TEST NORMAL PRESSURE IN POUNDS PER SQUARE FOOT (FROM MOHR CIRCLE)
— PER CENT FIELD MOISTURE EXPRESSED AS A PERCENTAGE OF THE DRY WEIGHT OF SOIL
— DRY DENSITY EXPRESSED IN POUNDS PER CUBIC FOOT
— SHEARING STRENGTH IN POUNDS PER SQUARE FOOT (FROM MOHR CIRCLE)

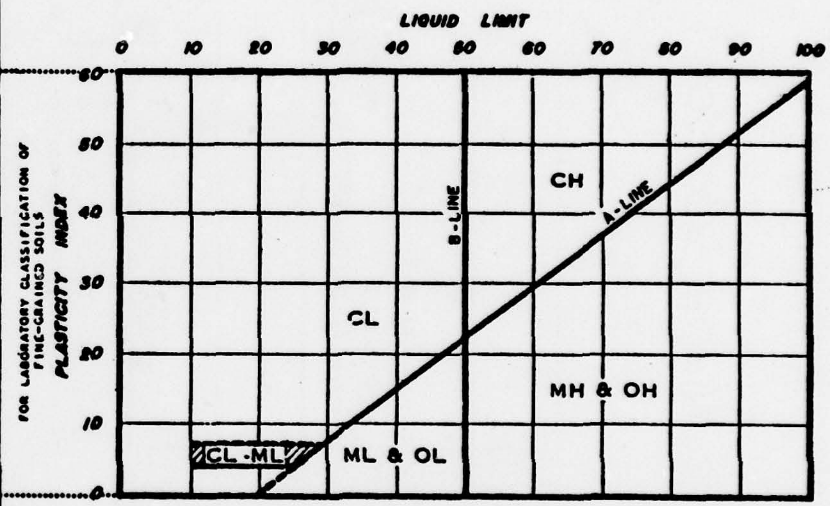
ROCK COMPRESSION TESTS

— COMPRESSIVE STRENGTH IN POUNDS PER SQUARE INCH

KEY TO TEST DATA

- INDICATES DEPTH OF UNDISTURBED SAMPLE
- INDICATES DEPTH OF DISTURBED SAMPLE
- INDICATES DEPTH OF SAMPLING ATTEMPT WITH NO RECOVERY
- INDICATES DEPTH OF SPLIT-SPOON SAMPLE
- INDICATES DEPTH AND LENGTH OF CORING RUN

KEY TO SAMPLES



PLASTICITY CHART

UNIFIED SOIL CLASSIFICATION SYSTEM

ATTACHMENT A

TRIAXIAL COMPRESSION TESTS

CONSOLIDATED - UNDRAINED

SATURATED

JOB # 5651-003-07

OWNER Bauer Forges Co LOCATION Orange County BORING # 1

SOIL TYPE Red Brown & Yellow Sandy clayey silt, trace of decomposed Shale (ML-FILL) DEPTH 3.0

SAMPLE # 23

SAMPLED KB 5/12/67 SET-UP S 5/19/67 TESTED S 5/21/67 (SF OFFICE)

SATURATED TEST ☒ FIELD MOISTURE TEST ☐ TEST LATERAL PRESSURE 2250 PSF

TYPE OF TEST R/cu SR=0.005"/min

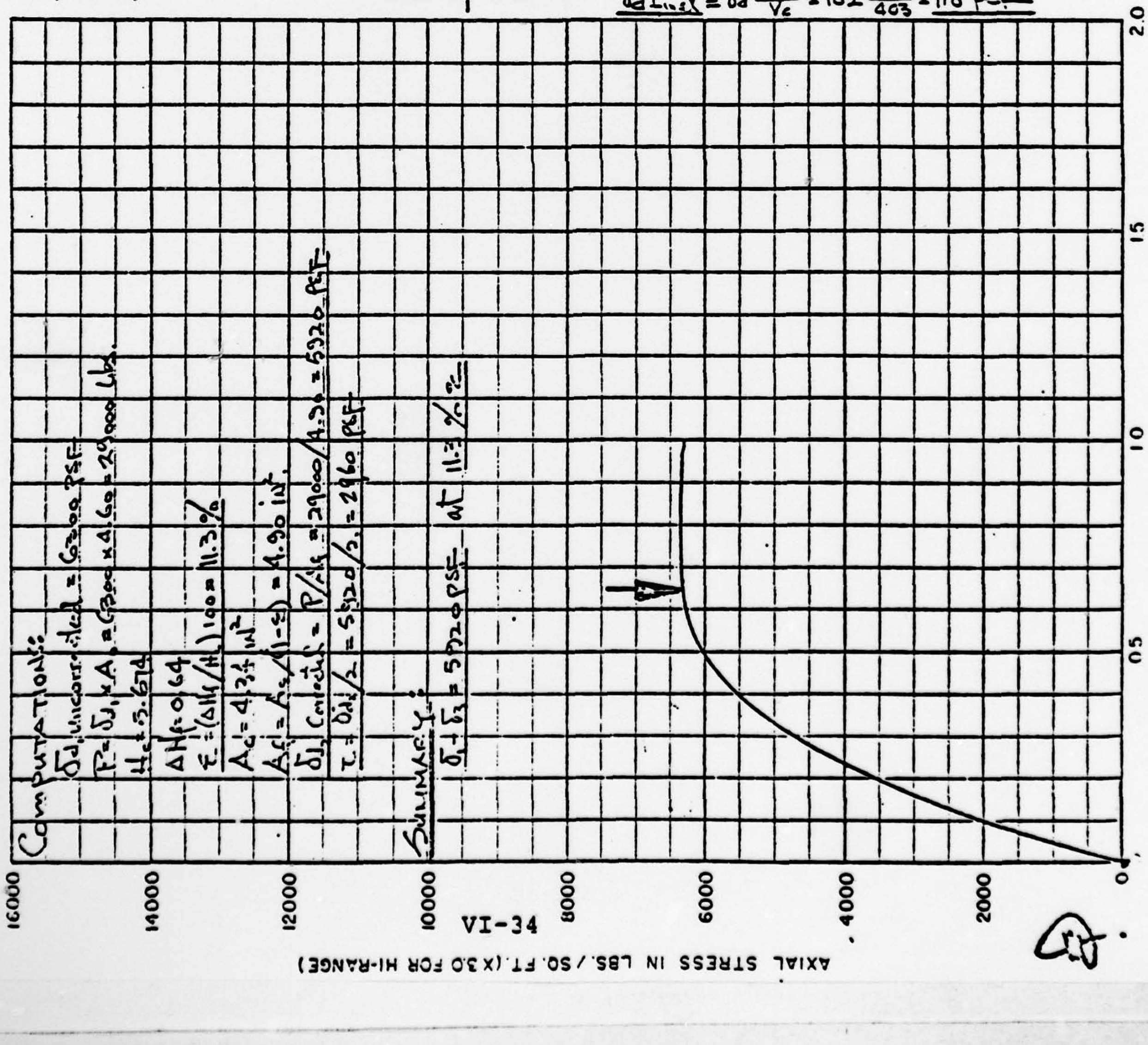
SOFTER & CLAYEYER ZONE

	BEFORE	AFTER 323
Weight soil & dish no.	868	218.2
Dry weight soil & dish	712	175.3
Net loss of moisture	156	42.9
Weight of dish only		
Net weight of dry soil		
Moisture, % of dry weight	21.9	24.5

Wt. solids + moisture	W_o	868 gms.	886	
W_o + 454	W'_o	lbs.		
Weight solids	W_s	gms.		
Wet density W'_o + V'_o		124 pcf	127	
Dry density		102 pcf	102	

Net diameter	D_o	2.42 in.
Area (0.785 D_o^2)	A_o	4.60 sq.in.
Height	H_o	5.8 in.
Volume (A_oH_o) + 1728	V'_o	cu.ft.
Volume (A_oH_o) × 16.4	V_o	437 cc
Specific gravity of solids	G_s	
Volume of solids W_s + G_s	V_s	cc
(V_o - V_s) + V_s	e_i	
Initial burette reading		cc
Burette reading under pressure		cc
(V_p - V_s) + V_s	e_p	

$\gamma_{d\,final} = \gamma_d \frac{V_o}{V_c} = 102 \frac{437}{403} = 110$ PCF



BORING: 1 SAMPLE NO.: 2B DEPTH (FT): 3.0 TYPE OF TEST: Tx/CU

SATURATION DATA								CONSOLIDATION DATA	
TIME DATE	σ CHAMBER (PSI)	σ BACK PRESS (PSI)	EXTERNAL BURETTE (CC)	SATURATION BURETTE (CC)	PORE PRESSURE (PSI)	Δ	B	ELAPSED TIME MIN.	INTERIOR VOL. BURETTE (CC)
3/19/67									
1730	25.0	22.0	-	-	22.0	-	-		
1900	30.0	closed	-	-	22.0/24.1	2.1	.42		
1920	40.0	37.0	-	-	37.0	-	-		
3/20/67									
1300	45.0	closed	-	-	37.0/41.2	4.2	.84		
1320	40.0	37.0	-	-	37.0	-	-		
1500	45.0	closed	-	-	37.0/41.2	4.2	.84		
		CONSOLIDATION							
1530	2250 = 15.6 psi	0	-	-	-	-	-	0	109.0
(								.1	111.6
								.25	112.5
)								.5	113.6
1531								1	115.0
1532								2	116.7
1534								4	119.1
1539								~~8~~ 9	123.0
1546								16	125.2
1600								30	128.7
1630								60	133.6
1730								120	135.4
1930								240	138.6
2330								480	—
3/21 1530								1440	143.0

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_o)........ 5.800 IN.

INITIAL DIAL: 0.000 FINAL DIAL: 0.126, CHANGE IN HEIGHT (ΔH)... 0.126 IN.

SAMPLE HEIGHT AFTER CONSOLIDATION (H_c)........ 5.674 IN.

PERCENTS DEFLECTION. (E)........ 2.2 %

ORIGINAL SAMPLE VOLUME (V_o)........ 437 CC.

INITIAL BURETTE: 109.0 FINAL BURETTE: 143.0, CHANGE IN VOLUME (ΔV)... 34 CC.

SAMPLE VOLUME AFTER CONSOLIDATION (V_c)........ 403 CC.

ORIGINAL SAMPLE AREA (A_o)........ 4.60 IN^2.

AREA CORRECTION:

$$A_c = A_o(1 - \Delta V/V_o \,/\, 1 - E)$$

$$= 4.60\,(1 - 34/437 \,/\, 1 - 0.022)$$

$$= 4.60\,(0.922/0.978)$$

= 4.34 SQ. IN.

DAMES & MOORE
APPLIED EARTH SCIENCES

SATURATION & CONSOLIDATION PHASE

VI-35 TRIAXIAL COMPRESSION TEST

TRIAXIAL COMPRESSION TEST DATA SHEET

JOB # 5651-003-07

OWNER Bauer Engr. Co. LOCATION Orange County BORING # 1 *

SOIL TYPE Red & Brown Clayey Sandy silt with some Gravel DEPTH 6.0'

SAMPLE # 3A

SAMPLED JBR 5/12/67 SET-UP [initials] 5.19.67 TESTED [initials] 5.23.67 (SF OFFICE)

SATURATED TEST X FIELD MOISTURE TEST ☐ TEST LATERAL PRESSURE 3000 PSF

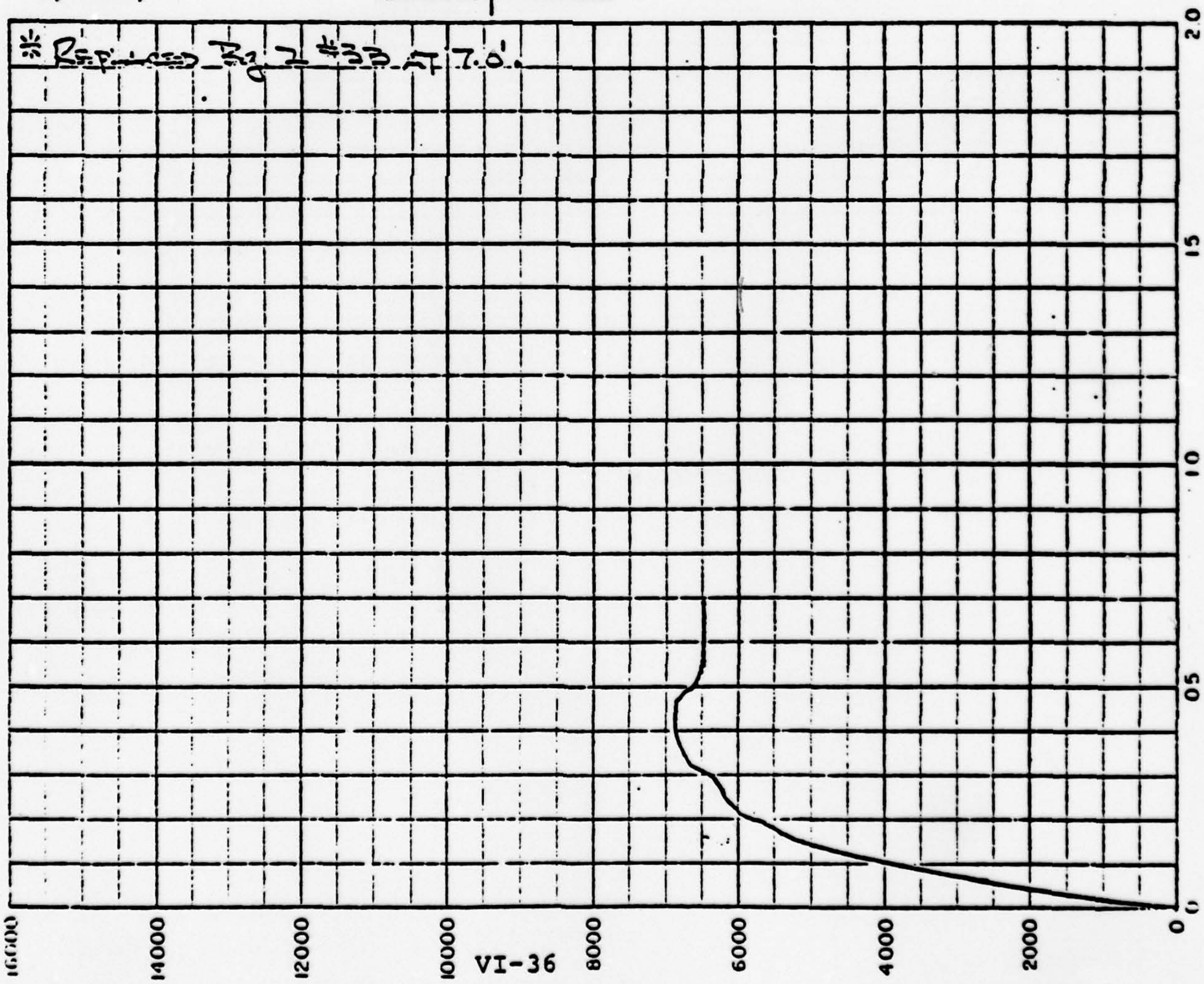
TYPE OF TEST TX/CM

	Before	After
Dish no.		232
Weight soil & dish	842	289.6
Dry weight soil & dish	697	234.4
Net loss of moisture	145	55.2
Weight of dish only		
Net weight of dry soil		
Moisture, % of dry weight	20.8	23.5

Gravels.

		Before		After
Wt. solids + moisture	W_o	842	gms.	862
$W_o \div 454$	W_o'		lbs.	
Weight solids	W_s		gms.	
Wet density $W_o' \div V_o'$		125	pcf	128
Dry density		104	pcf	104

Net diameter	D_o	2.42	in.
Area $(0.785\ D_o^2)$	A_o	4.60	sq.in.
Height	H_o	5.6	in.
Volume $(A_oH_o) \div 1728$	V_o'		cu.ft.
Volume $(A_oH_o) \times 16.4$	V_o	430	cc
Specific gravity of solids	G_s		
Volume of solids $W_s \div G_s$	V_s		cc
$(V_o - V_s) \div V_s$	e_i		
Initial burette reading			cc
Burette reading under pressure			cc
$(V_p - V_s) \div V_s$	e_p		



BORING: 7 SAMPLE NO.: 3B DEPTH (FT): 7.0 TYPE OF TEST: Tx/CU

SATURATION DATA								CONSOLIDATION DATA	
TIME DATE [illegible]	σ CHAMBER (PSI)	σ BACK PRESS (PSI)	EXTERNAL BURETTE (CC)	SATURATION BURETTE (CC)	PORE PRESSURE (PSI)	Δ	B	ELAPSED TIME MIN.	INTERIOR VOL. BURETTE (CC)
[illegible]	3	0	[illegible]	[illegible]	–	–	–		
[illegible]									
[illegible]	30	27	–	–	27.0	–	–		
1600	35	[illegible]	–	–	27.0 / 31.0	4.0	.80		
1620	30	27	–	–	27.0	–	–		
5/22/7[illegible]									
1100	35	[illegible]	–	–	27.0 / 31.8	4.8	.96		
			(CONSOLIDATION)						
1130	[illegible]	0	–	–	–	–	–	0	136.0
/								.1	137.5
)								.25	13[illegible].2
)								.5	133.[illegible]
1131								1	139.[illegible]
1132								2	141.2
1134								4	14[illegible]
1139								8-9	145.[illegible]
1146								16	1[illegible]
1200								30	146.5
1230								60	[illegible]
1330								120	15[illegible]
1530								240	15[illegible]
1930								480	161.[illegible]
[illegible] 1130								1440	162.5

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_o).. 5.600 IN.
INITIAL DIAL: 0.000 FINAL DIAL: 0.075, CHANGE IN HEIGHT (ΔH):.. .075 IN.
SAMPLE HEIGHT AFTER CONSOLIDATION (H_c)........................ 5.525 IN.
PERCENTS DEFLECTION.(E).. ______ %

ORIGINAL SAMPLE VOLUME (V_o)...................................... 430.0 CC.
INITIAL BURETTE: 136.0 FINAL BURETTE: 162.5, CHANGE IN VOLUME (ΔV)... 26.5 CC.
SAMPLE VOLUME AFTER CONSOLIDATION (V_c)........................ 403.5 CC.

ORIGINAL SAMPLE AREA (A_o)...................................... 4.60 IN^2.
AREA CORRECTION:

$$A_c = A_o(1 - \Delta V/V_o \,/\, 1 - E)$$

= ____________________

= ____________________

= __________ SQ. IN.

DAMES & MOORE
APPLIED EARTH SCIENCES

SATURATION & CONSOLIDATION PHASE

 TRIAXIAL COMPRESSION TEST

JOB # 6551-003-07

OWNER Bauer Engr. Co. LOCATION Orange County BORING # 2

SOIL TYPE Red brown very clayey, sandy silt with some gravel (ML-FILL) DEPTH 1.5'

SAMPLE # 13

SAMPLED JBR 5/12/67 SET-UP [illegible] 5/21/67 TESTED [illegible] 5/23/67 (SF OFFICE)

SATURATED TEST ☒ FIELD MOISTURE TEST ☐ TEST LATERAL PRESSURE 4500 PSF

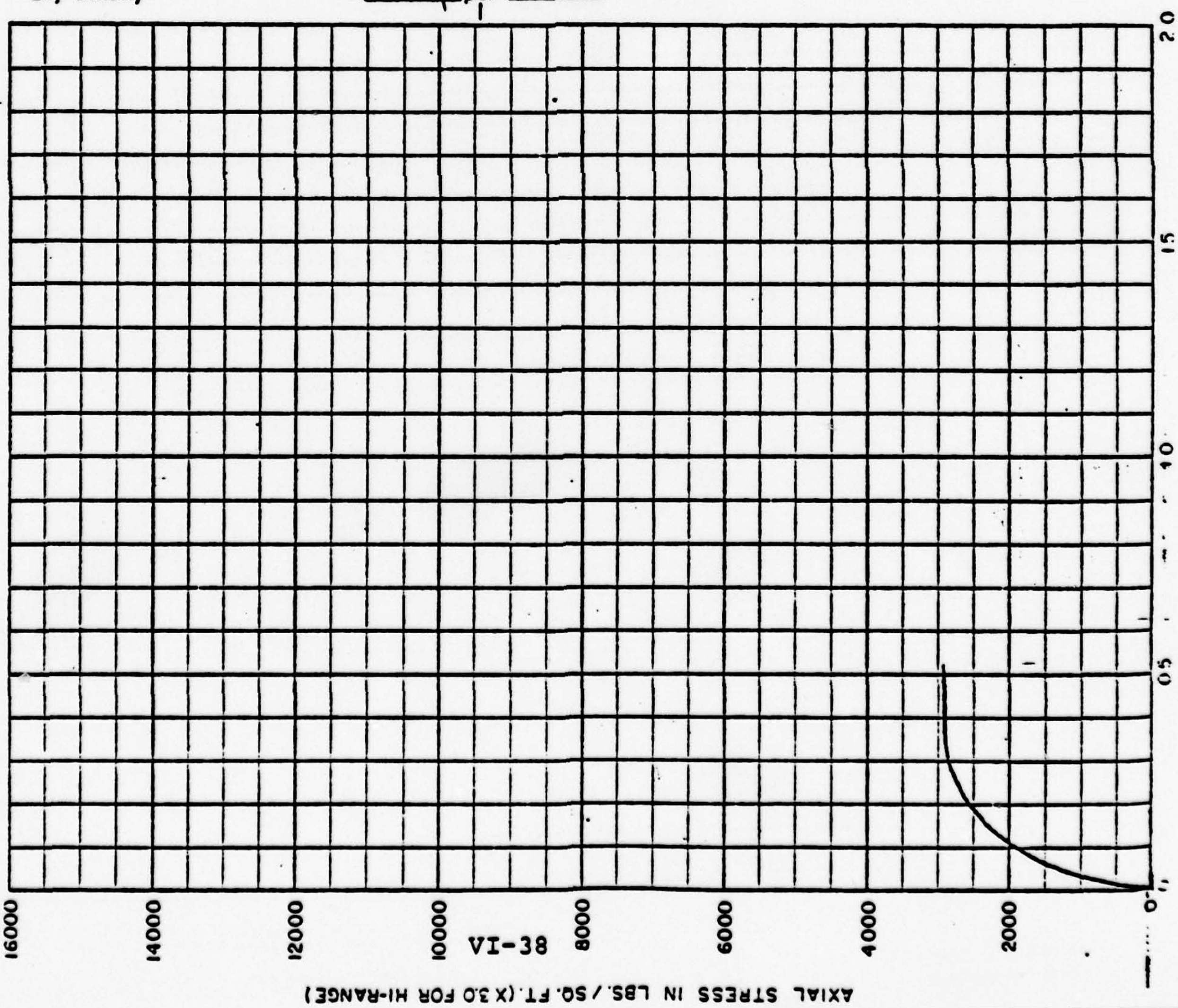
TYPE OF TEST TX/CU

	Before	After
		404
Weight soil & ~~dish~~ no.	361	316.2
Dry weight soil & ~~dish~~	687	247.7
Net loss of moisture	174	68.5
Weight of dish only		
Net weight of dry soil		
Moisture, % of dry weight	25.4	27.7

SOFT ZONE

Net diameter	D_o	2.42 in.
Area $(0.785\ D_o^2)$	A_o	4.60 sq.in.
Height	H_o	6.0 in.
Volume $(A_oH_o) \div 1728$	V_o'	cu.ft.
Volume $(A_oH_o) \times 16.4$	V_o	453 cc
Specific gravity of solids	G_s	
Volume of solids $W_s \div G_s$	V_s	cc
$(V_o - V_s) \div V_s$	e_i	
Initial burette reading		cc
Burette reading under pressure		cc
$(V_p - V_s) \div V_s$	e_p	

		Before	After
Wt. solids + moisture	W_o	861 gms.	876
$W_o \div 454$	W_o'	lbs.	
Weight solids	W_s	gms.	
Wet density $W_o' \div V_o'$		119 pcf	122
Dry density		95.4 pcf	95.4



BORING: [illegible] SAMPLE NO.: [illegible] DEPTH (FT): [illegible] TYPE OF TEST: TX/CU

SATURATION DATA								CONSOLIDATION DATA	
TIME DATE	σ CHAMBER (PSI)	σ BACK PRESS (PSI)	EXTERNAL BURETTE (CC)	SATURATION BURETTE (CC)	PORE PRESSURE (PSI)	Δ	B	ELAPSED TIME MIN.	INTERIOR VOL. BURETTE (CC)
5/21/[illegible]	5.0	0	[illegible]		—	—	—		
[illegible] 1150	35.0	30		—	30.0	—	—		
1230	40.0	[illegible]	—	—	30.0/34.1	4.1	.82		
1330	35.0	30	—	—	30.0	—	—		
1550	40.0	[illegible]	—	—	30.0/34.8	4.8	.96		
1630	35.0	30	—	—	30.0	—	—		
1750	40.0	[illegible]	—	—	30.0/34.8	4.8	.96		
		—	Consolidation —						
1730						TOP	BOT		
	[illegible]	0				72.0	45.0	0	0
						71.8	45.0	.1	
						71.2	44.1	.25	
						70.9	[illegible]	.5	
1731						70.8	[illegible]	1	
1732						68.7	[illegible]	2	
1734						67.2	[illegible]	4	
1742						65.8	42.6	8 12	
1746						64.0	39.7	16	
1800						63.6	36.4	30	
1830						62.7	34.6	60	
1930						62.3	33.2	120	
2130						62.0	31.8	240	
—						—	—	480	
[illegible] 1730						61.5	32.8	1440	

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_o).. 6.000 IN.
INITIAL DIAL: 0.000 FINAL DIAL: 0.054, CHANGE IN HEIGHT (ΔH): .. 0.054 IN.
SAMPLE HEIGHT AFTER CONSOLIDATION (H_c).............................. 5.946 IN.
PERCENTS DEFLECTION.(E).. %

ORIGINAL SAMPLE VOLUME (V_o)... 453.0 CC.
INITIAL BURETTE: 117.0 FINAL BURETTE: 92.3, CHANGE IN VOLUME (ΔV)... 24.7 CC.
SAMPLE VOLUME AFTER CONSOLIDATION (V_c).............................. 428.3 CC.

ORIGINAL SAMPLE AREA (A_o).. 4.60 IN^2.

AREA CORRECTION:

$$A_c = A_o (1 - \Delta V/V_o \,/\, 1 - E)$$

= ____________________

= ____________________

= __________ SQ. IN.

DAMES & MOORE
APPLIED EARTH SCIENCES

VI-39

SATURATION & CONSOLIDATION PHASE
TRIAXIAL COMPRESSION TEST

JOB # 5631-003-07

OWNER Bauer Engr. Co. LOCATION Orange County BORING # 2

SOIL TYPE Red & Yellow Clayey, Sandy Silt with DEPTH 4.5

Scatter Gravels (ML-Fill) SAMPLE # 2A

SAMPLED 5/12/67 SET-UP 5/19/67 TESTED 5/22/67 (OFFICE)

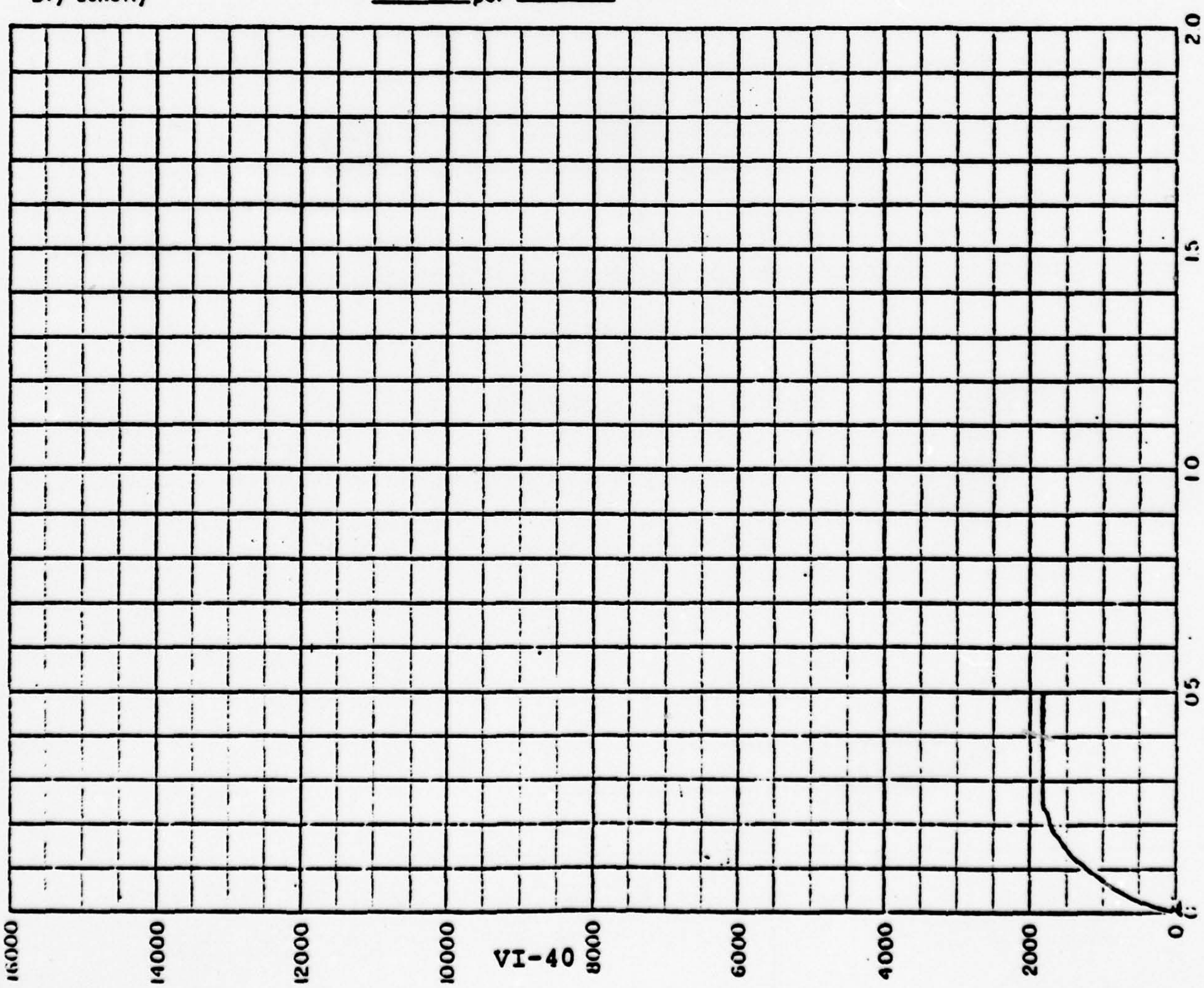
SATURATED TEST ☒ FIELD MOISTURE TEST ☐ TEST LATERAL PRESSURE 1500 PSF

TYPE OF TEST R/CU

	Before	After
		267
Weight soil & dish no.	924	264.6
Dry weight soil & dish	781	314.4
Net loss of moisture	143	50.2
Weight of dish only		
Net weight of dry soil		
Moisture, % of dry weight		

Net diameter	D_o	2.42 in.
Area $(0.785\ D_o^2)$	A_o	4.60 sq.in
Height	H_o	6.0 in.
Volume $(A_oH_o) \div 1728$	V'_o	cu.ft.
Volume $(A_oH_o) \times 16.4$	V_o	453 cc
Specific gravity of solids	G_s	
Volume of solids $W_s \div G_s$	V_s	cc
$(V_o - V_s) \div V_s$	e_i	
Initial burette reading		cc
Burette reading under pressure		cc
$(V_p - V_s) \div V_s$	e_p	

		Before		After
Wt. solids + moisture	W_o	924	gms.	964
$W_o \div 454$	W'_o		lbs.	
Weight solids	W_s		gms.	
Wet density $W'_o \div V'_o$		129	pcf	134
Dry density			pcf	



VI-40

BORING: ~ SAMPLE NO.: ?A DEPTH (FT): 4.5 TYPE OF TEST: ?/CU

	SATURATION DATA							CONSOLIDATION DATA	
TIME DATE	σ CHAMBER (PSI)	σ BACK PRESS (PSI)	EXTERNAL BURETTE (CC)	SATURATION BURETTE (CC)	PORE PRESSURE (PSI)	Δ	B	ELAPSED TIME MIN.	INTERIOR VOL. BURETTE (CC)
5/19/??									
1720	3.0	0	[illegible]		-	-	-		
5/20/??									
1750	30	27	-	-	27.0	-	-		
2000	35	closed	-	-	27.0/31.2	4.2	.88		
2020	30	27	-	-	27.0	-	-		
5/21/??									
1200	35	closed	-	-	27.0/31.7	4.7	.94		
			CONSOLIDATION						
1230	[illegible]	-						0	[illegible]
|								.1	[illegible]
|								.25	[illegible]
|								.5	[illegible]
1231								1	[illegible]
1232								2	[illegible]
1234								4	[illegible]
1238								8	-
1246								16	-
1300								30	[illegible]
1330								60	151.2
1430								120	[illegible]
1630								240	[illegible]
2030								480	-
?/22 1230								1440	[illegible]

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_o).. 6.000 IN.

INITIAL DIAL: 0.000 FINAL DIAL: 0.042, CHANGE IN HEIGHT (ΔH):.. 0.042 IN.

SAMPLE HEIGHT AFTER CONSOLIDATION (H_c)........................ 5.958 IN.

PERCENTS DEFLECTION.(E).. 0.70 %

ORIGINAL SAMPLE VOLUME (V_o).. 453.0 CC.

INITIAL BURETTE: [illegible] FINAL BURETTE: [illegible], CHANGE IN VOLUME (ΔV)... 18.3 CC.

SAMPLE VOLUME AFTER CONSOLIDATION (V_c)........................ 434.7 CC.

ORIGINAL SAMPLE AREA (A_o).. 4.60 IN.

AREA CORRECTION:

$A_c = A_o(1 - \Delta V/V_o \,/\, 1 - E)$

= ______________________

= ______________________

= __________ SQ. IN.

DAMES & MOORE
APPLIED EARTH SCIENCES

SATURATION & CONSOLIDATION PHASE

VI-41 TRIAXIAL COMPRESSION TEST

OWNER Bixler Engr. Co LOCATION Orange County BORING # 3

SOIL TYPE Yellow & Brown Sandy Clayey Silt DEPTH 1.5'
With Gravel & Shale fragment (ML - FILL) SAMPLE # 13

SAMPLED JBR 5/12/69 SET-UP Sr 5/22/69 TESTED Sr 5/24/69 (S.F. OFFICE)

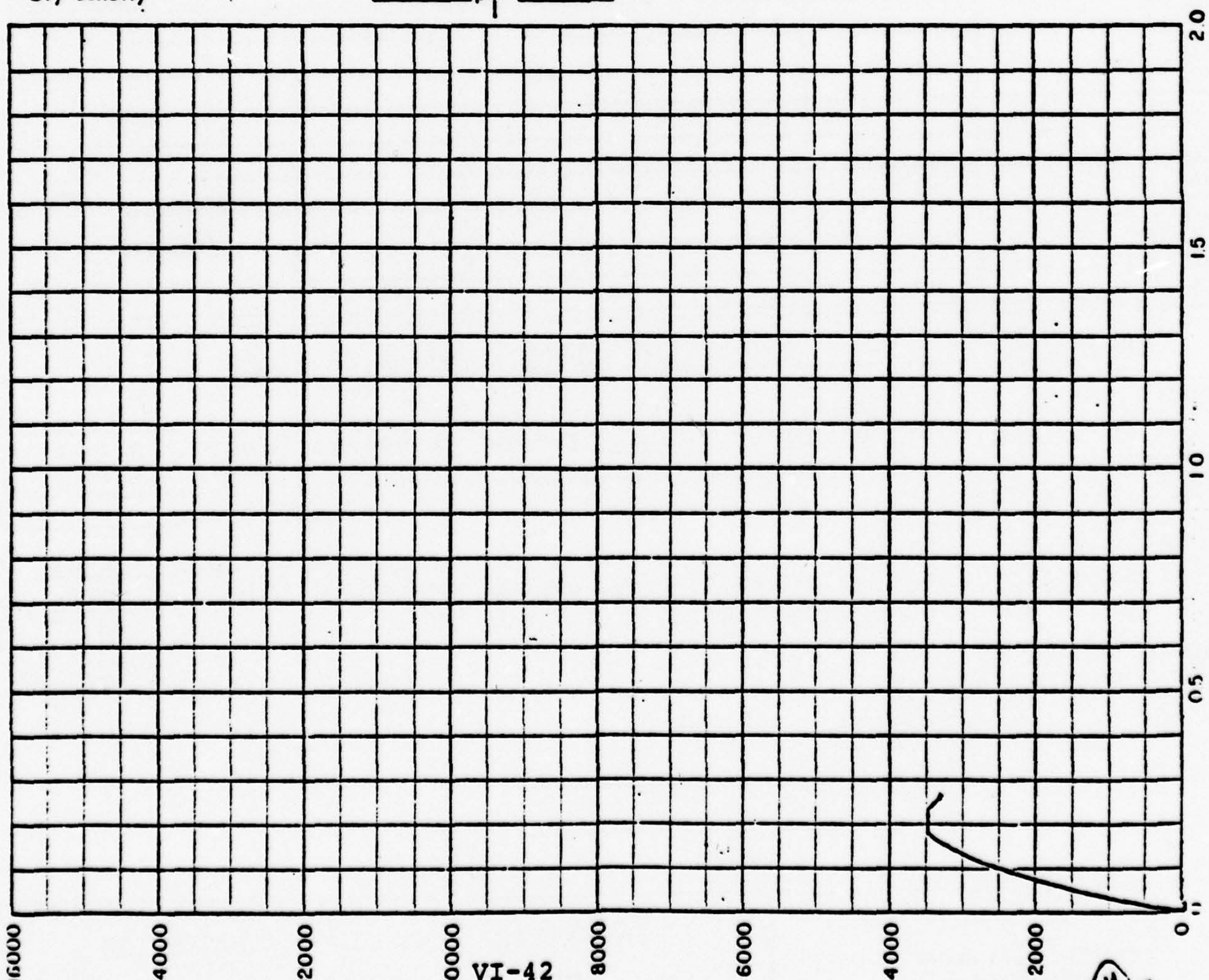
SATURATED TEST ☒ FIELD MOISTURE TEST ☐ TEST LATERAL PRESSURE 1500 PSF

TYPE OF TEST TX/CU

	Before	After
		106
Weight soil & ~~dish~~ no.	933	286.7
Dry weight soil & ~~dish~~	806	241.4
Net loss of moisture	127	45.3
Weight of dish only		
Net weight of dry soil		
Moisture, % of dry weight	15.8	18.8

Net diameter	D_o	2.42	in.
Area $(0.785\ D_o^2)$	A_o	4.60	sq.in.
Height	H_o	5.9	in.
Volume $(A_oH_o) \div 1728$	V_o'		cu.ft.
Volume $(A_oH_o) \times 16.4$	V_o	445	cc
Specific gravity of solids	G_s		
Volume of solids $W_s \div G_s$	V_s		cc
$(V_o - V_s) \div V_s$	e_i		
Initial burette reading			cc
Burette reading under pressure			cc
$(V_p - V_s) \div V_s$	e_p		

		Before		After
Wt. solids + moisture	W_o	933	gms.	955
$W_o \div 454$	W_o'		lbs.	
Weight solids	W_s		gms.	
Wet density $W_o' \div V_o'$		131	pcf	134
Dry density		113	pcf	113



VI-42

BORING: 3 SAMPLE NO.: 13 DEPTH (FT): 1.5 TYPE OF TEST: [illegible]

SATURATION DATA								CONSOLIDATION DATA	
TIME DATE 5/23/69	σ CHAMBER (PSI)	σ BACK PRESS (PSI)	EXTERNAL BURETTE (CC)	SATURATION BURETTE (CC)	PORE PRESSURE (PSI)	Δ	B	ELAPSED TIME MIN.	INTERIOR VOL. BURETTE (CC)
[illegible]	30.0	25.0	–	–	25.0	–	–		
[illegible]	35.0	[illegible]	–	–	[illegible] 28.5	[illegible]	.7[illegible]		
[illegible]	30.0	25.0	–	–	25.0	–	–		
[illegible]									
1200	35.0	[illegible]	–	–	25.0/29.8	4.9	.96		
1230	30.0	25.0	–	–	25.0 –	–	–		
1730	35.0	[illegible]	–	–	25.0/29.9	4.9	.98		
			Consolidation Test						
1800	1500 psf	0	–	–	–	–	–	0	144.0
								.1	
								.25	
								.5	
								1	
								2	
								4	
								8	
								16	
								30	
								60	
2000								120	155.0
								240	
5/24/69								480	
1305								1440 1445	[illegible]

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_o).. 5.900 IN.
INITIAL DIAL: 0.000 FINAL DIAL: 0.046, CHANGE IN HEIGHT (ΔH):.. 0.046 IN.
SAMPLE HEIGHT AFTER CONSOLIDATION (H_c)........................ 5.854 IN.
PERCENTS DEFLECTION.(E).. ______ %

ORIGINAL SAMPLE VOLUME (V_o).................................. 445.0 CC.
INITIAL BURETTE: 144.0 FINAL BURETTE: 158.6, CHANGE IN VOLUME (ΔV)... 14.6 CC.
SAMPLE VOLUME AFTER CONSOLIDATION (V_c)........................ 430.4 CC.

ORIGINAL SAMPLE AREA (A_o)...................................... 4.60 IN^2.
AREA CORRECTION:

$$A_c = A_o(1 - \Delta V/V_o \;/\; 1 - E)$$

= ______________________

= ______________________

= __________ SQ. IN.

DAMES & MOORE
APPLIED EARTH SCIENCES

VI-43 SATURATION & CONSOLIDATION PHASE
TRIAXIAL COMPRESSION TEST

JOB # 2551-003-01

OWNER Bauer Bros Co. LOCATION Orange County BORING # 3

SOIL TYPE Yellow-Brown Sandy Silt with Decomposed Shale & Trace of Gravel (ML- FILL) DEPTH 3.0'

SAMPLE # 23

SAMPLED JBR 5/23/67 SET-UP GK 5/23/67 TESTED GK 5/25/67 (SF OFFICE)

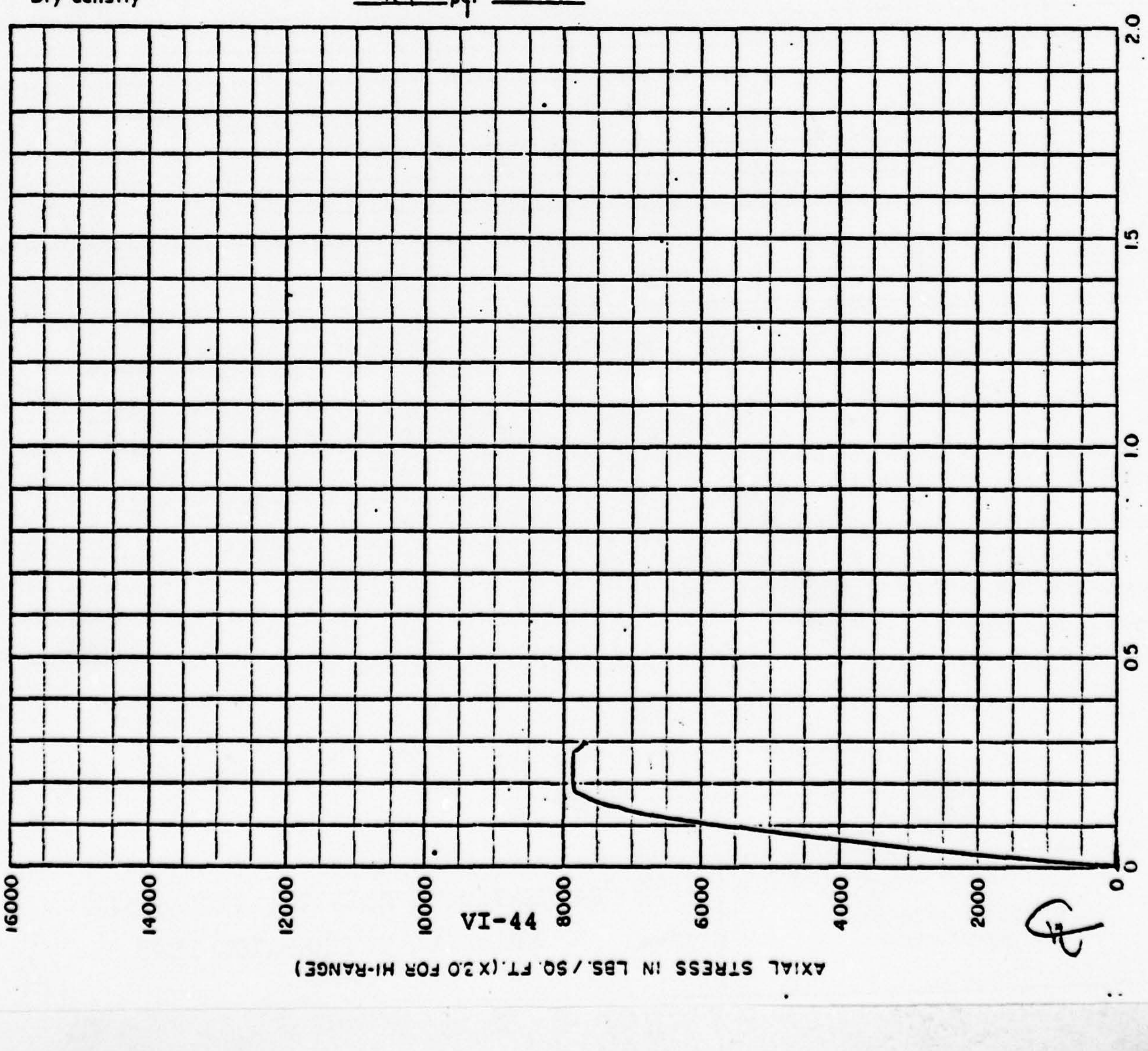
SATURATED TEST ☒ FIELD MOISTURE TEST ☐ TEST LATERAL PRESSURE 3000 PSF

TYPE OF TEST Tx/CU

	Before	After
Weight soil & ~~dish~~ no.	932.0	213.1
Dry weight soil & ~~dish~~	811.0	182.1
Net loss of moisture	121.0	31.0
Weight of dish only		
Net weight of dry soil		
Moisture, % of dry weight	14.9	17.1

Wt. solids + moisture	W_o 932 gms.		951
W_o ÷ 454	W'_o	lbs.	
Weight solids	W_s	gms.	
Wet density $W'_o \div V'_o$	131	pcf	132
Dry density	114	pcf	114

Net diameter	D_o 2.42	in.
Area (0.785 D_o^2)	A_o 4.60	sq.in.
Height	H_o 5.9	in.
Volume (A_oH_o) ÷ 1728	V'_o	cu.ft.
Volume (A_oH_o) × 16.4	V_o	cc
Specific gravity of solids	G_s	
Volume of solids $W_s \div G_s$	V_s	cc
$(V_o - V_s) \div V_s$	e_i	
Initial burette reading		cc
Burette reading under pressure		cc
$(V_p - V_s) \div V_s$	e_p	



VI-44

GK

BORING: 3 SAMPLE NO.: 2B DEPTH (FT): 3.5' TYPE OF TEST:

TIME DATE	σ CHAMBER (PSI)	σ BACK PRESS (PSI)	EXTERNAL BURETTE (CC)	SATURATION BURETTE (CC)	PORE PRESSURE (PSI)	△	B	CONSOLIDATION DATA: ELAPSED TIME MIN.	CONSOLIDATION DATA: INTERIOR VOL. BURETTE (CC)
[illegible]	[illegible]								
[illegible]	5.0	0	Seepage Saturation		—	—	—		
[illegible]									
1330	30.0	25.0	—	—	25.0	—	—		
1500	35.0	closed	—	—	25.0 / 27.9	2.9	.58		
1530	30.0	25.0	—	—	25.0	—	—		
1930	35.0	closed	—	—	25.0 / 28.6	3.6	.72		
1950	30.0	25.0	—	—	25.0	—	—		
[illegible] 1250	35.0	closed	—	—	25.0 / 29.9	4.9	.98		
			Consolidation						
1630	3000 psf	0						0	143.0
								.1	145.5
								.25	145.8
								.5	146.1
								1	146.3
								2	146.5
								4	146.9
								8	
								16	
								30	147.0
								60	148.2
								120	
								240	
								480	
1030								1440	[illegible]

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_o).. 5.900 IN.

INITIAL DIAL: 0.550 FINAL DIAL: 0.052, CHANGE IN HEIGHT (ΔH): .. 0.552 IN.

SAMPLE HEIGHT AFTER CONSOLIDATION (H_c).............................. 5.349 IN.

PERCENTS DEFLECTION (ε).. %

ORIGINAL SAMPLE VOLUME (V_o)... 445.0 CC.

INITIAL BURETTE: 143.0 FINAL BURETTE: 157.1, CHANGE IN VOLUME (ΔV)... 14.4 CC.

SAMPLE VOLUME AFTER CONSOLIDATION (V_c)............................. 430.6 CC.

ORIGINAL SAMPLE AREA (A_o).. 4.60 IN^2.

AREA CORRECTION:

$A_c = A_o (1 - \Delta V/V_o \,/\, 1 - \varepsilon)$

= ______________________

= ______________________

= __________ SQ. IN.

DAMES & MOORE
APPLIED EARTH SCIENCES

SATURATION & CONSOLIDATION PHASE

VI-45 TRIAXIAL COMPRESSION TEST

JOB # 5651-005-01

OWNER Bauer Exc Co. LOCATION Orange County BORING # 3

SOIL TYPE Red, Gray & brown Sandy clay silt DEPTH 9.0

with Some gravels (ML-FILL) SAMPLE # 4A

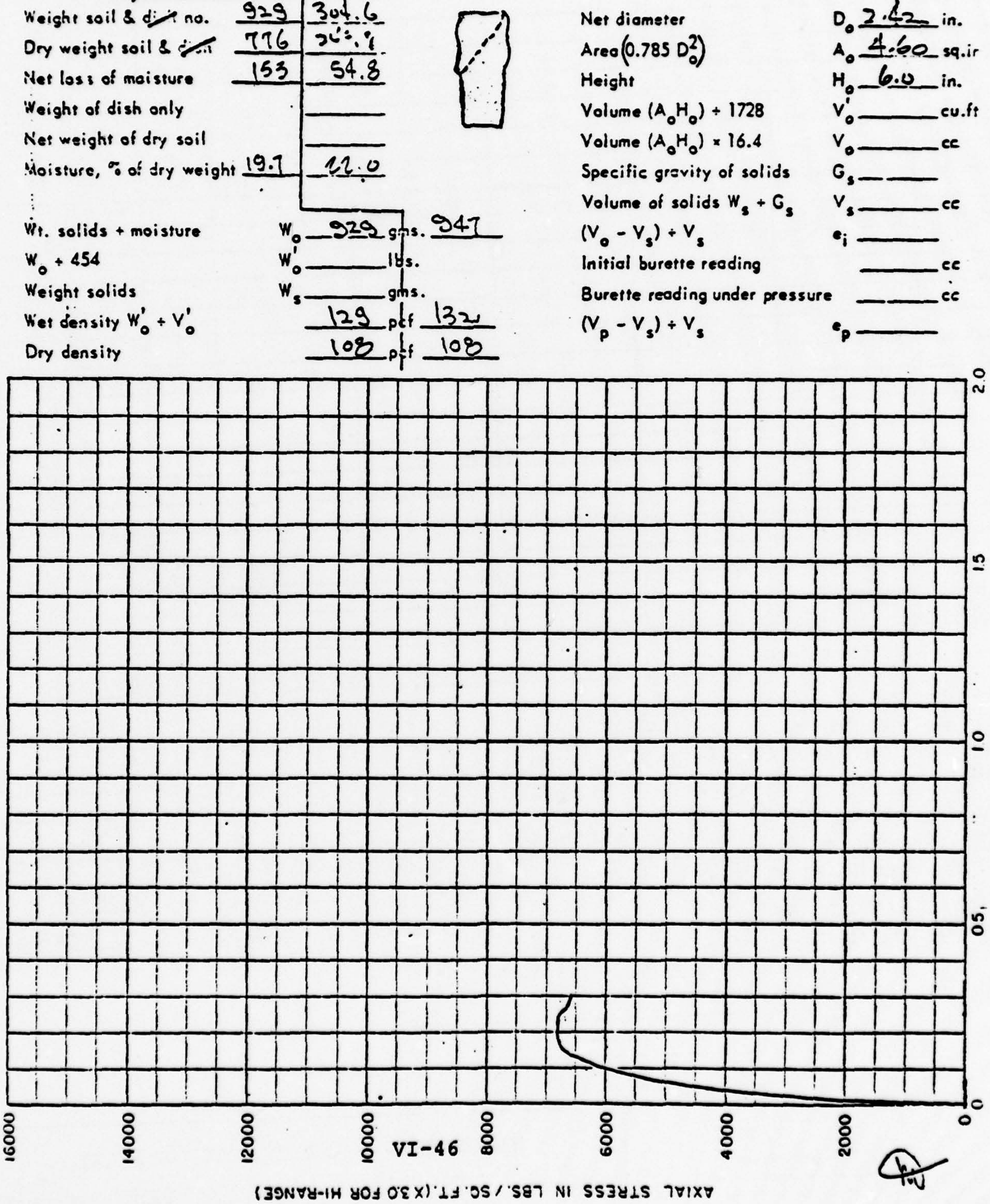
SAMPLED YHR 5/12/67 SET-UP G 5/24/67 TESTED G 5/26/67 (SF OFFICE)

SATURATED TEST ☒ FIELD MOISTURE TEST ☐ TEST LATERAL PRESSURE 4000 PSF

TYPE OF TEST TX/CU

		Before	After
			376
Weight soil & dish no.		929	304.6
Dry weight soil & dish		776	249.8
Net loss of moisture		153	54.8
Weight of dish only			
Net weight of dry soil			
Moisture, % of dry weight		19.7	22.0
Wt. solids + moisture	W_o	929 gms.	947
W_o + 454	W'_o	lbs.	
Weight solids	W_s	gms.	
Wet density $W'_o \div V'_o$		129 pcf	132
Dry density		108 pcf	108

Net diameter	D_o	2.42 in.
Area $(0.785\ D_o^2)$	A_o	4.60 sq.in
Height	H_o	6.0 in.
Volume $(A_oH_o) \div 1728$	V'_o	cu.ft
Volume $(A_oH_o) \times 16.4$	V_o	cc
Specific gravity of solids	G_s	
Volume of solids $W_s \div G_s$	V_s	cc
$(V_o - V_s) \div V_s$	e_i	
Initial burette reading		cc
Burette reading under pressure		cc
$(V_p - V_s) \div V_s$	e_p	



BORING NO.: [illegible] SAMPLE NO.: [illegible] DEPTH (FT): 3.0 TYPE OF TEST: TX/CU

SATURATION DATA								CONSOLIDATION DATA	
TIME DATE	σ CHAMBER (PSI)	σ BACK PRESS (PSI)	EXTERNAL BURETTE (CC)	SATURATION BURETTE (CC)	PORE PRESSURE (PSI)	△	B	ELAPSED TIME MIN.	INTERIOR VOL. BURETTE (CC)
200	10.0	5.0	-	-	5.0 -	-	-		
[illegible]	30.0	25.0	-	-	25.0 -	-	-		
1330	35.0	Closed	-	-	25.0 - 28.0	3.0	0.60		
1400	30.0	25.0	-	-	25.0				
1700	35.0	closed	-	-	25.0 / 28.6	3.6	.72		
1730	30.0	25.0	-	-	25.0	-	-		
[illegible]									
1100	35.0	closed	-	-	25.0 / 29.8	4.8	.96		
[illegible]			Consolidation						
[illegible]	45.0 PSI	0						0	150.0
								.1	
								.25	
								.5	
								1	
								2	
								4	
								8	
								16	
								30	
								60	
								120	
1600								240	165.0
[illegible]								480	
1200								1440	168.[illegible]

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_o).. 6.000 IN.

INITIAL DIAL: 0.000 FINAL DIAL: 0.057, CHANGE IN HEIGHT (ΔH):.. 0.057 IN.

SAMPLE HEIGHT AFTER CONSOLIDATION (H_c)........................ 5.943 IN.

PERCENTS DEFLECTION.(E).. ______ %

ORIGINAL SAMPLE VOLUME (V_o).. 453.0 CC.

INITIAL BURETTE: 150.0 FINAL BURETTE: 168.1, CHANGE IN VOLUME (ΔV)... 18.1 CC.

SAMPLE VOLUME AFTER CONSOLIDATION (V_c)........................ 434.6 CC.

ORIGINAL SAMPLE AREA (A_o).. 4.60 IN^2.

AREA CORRECTION:

$$A_c = A_o(1 - \Delta V / V_o \,/\, 1 - E)$$

= ____________________

= ____________________

= ________ SQ. IN.

DAMES & MOORE
APPLIED EARTH SCIENCES

SATURATION & CONSOLIDATION PHASE

VI-47 TRIAXIAL COMPRESSION TEST

ATTACHMENT B

TRIAXIAL COMPRESSION TESTS

UNCONSOLIDATED - UNDRAINED

FIELD MOISTURE CONTENT

JOB # 5631-053-07

OWNER Bauer Engr. Co. LOCATION Orange County BORING # 1

SOIL TYPE Red Clayey, Sandy Silt, Trace of Gravel (ML-Fill) DEPTH 1.0'

SAMPLE # 1A

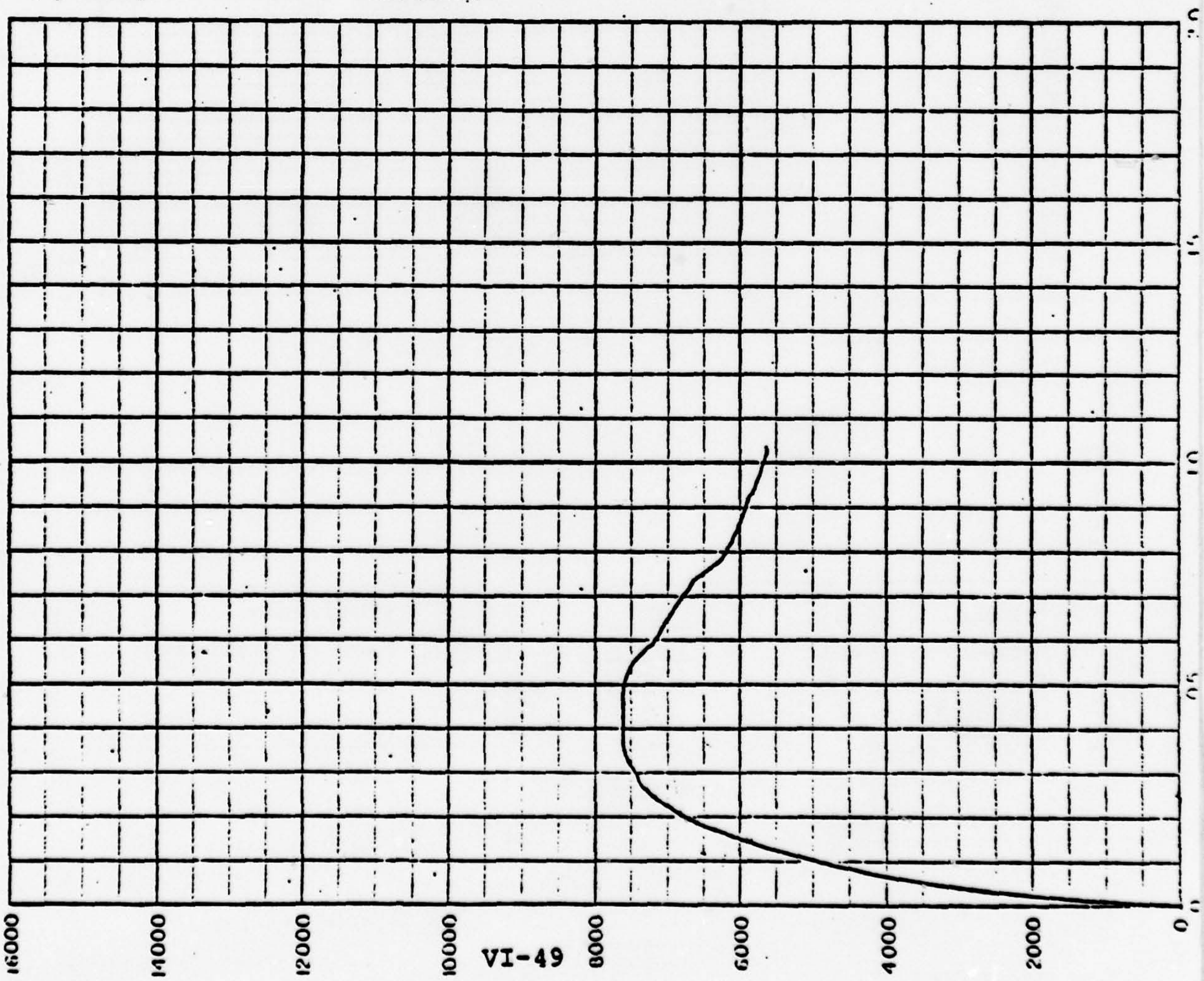
SAMPLED JBR 5.12.67 SET-UP / / TESTED 5.21.67 (SF OFFICE)

SATURATED TEST ☐ FIELD MOISTURE TEST X TEST LATERAL PRESSURE 1500 PSF

TYPE OF TEST TX/UU 253 Rate = 0.125"/min.

Weight soil & dish no.	320.5	
Dry weight soil & dish	266.7	
Net loss of moisture	53.8	
Weight of dish only		
Net weight of dry soil		
Moisture, % of dry weight	20.2	
Wt. solids + moisture	W_o 904	gms.
W_o ÷ 454	W'_o	lbs.
Weight solids	W_s	gms.
Wet density $W'_o \div V'_o$	126	pcf
Dry density	105	pcf

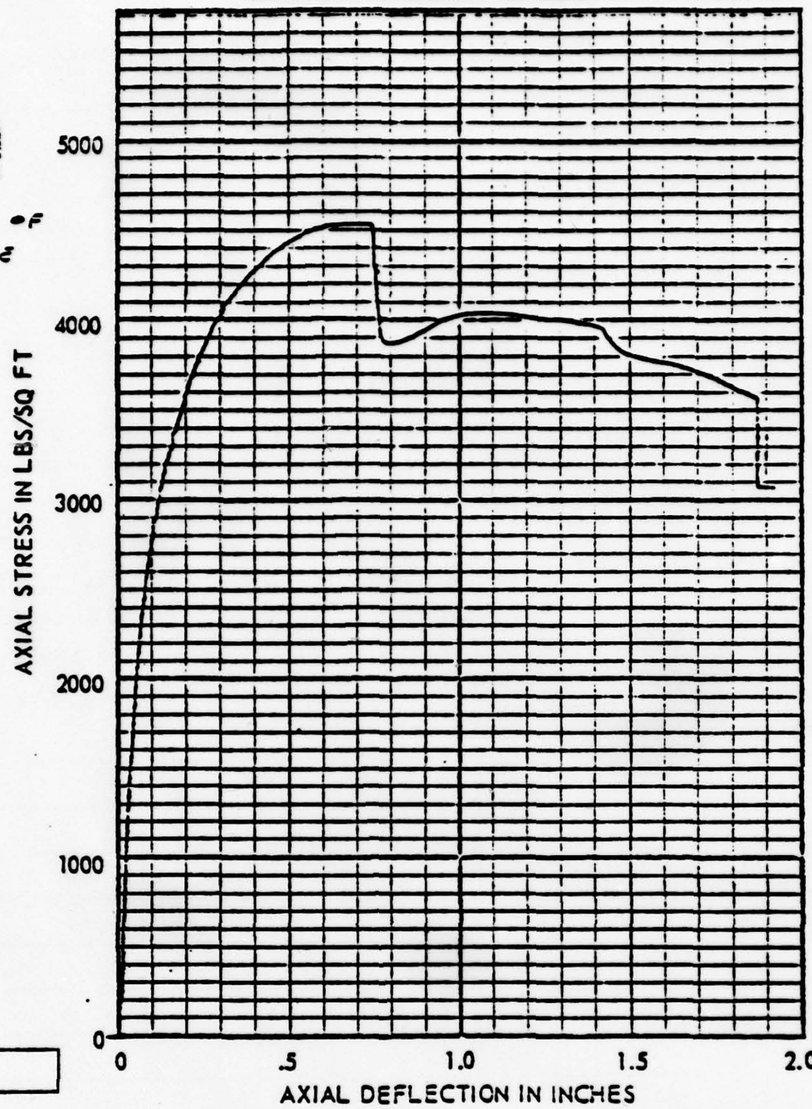
Net diameter	D_o 2.42	in.
Area (0.785 D_o^2)	A_o 4.60	sq.in.
Height	H_o 6.0	in.
Volume (A_oH_o) ÷ 1723	V'_o	cu.ft.
Volume (A_oH_o) × 16.4	V_o	cc
Specific gravity of solids	G_s	
Volume of solids $W_s \div G_s$	V_s	cc
($V_o - V_s$) ÷ V_s	e_i	
Initial burette reading		cc
Burette reading under pressure		cc
($V_p - V_s$) ÷ V_s	e_p	



SKETCH OF FAILURE

☒ IF HIGH RANGE MODE OF RECORDING DATA IS SET AT BEGINNING OF TEST, OR IF RECORDER IS AUTOMATICALLY SET TO HIGH RANGE DURING TEST, CHECK BOX & MULTIPLY AXIAL STRESS × 4

AXIAL STRESS IN LBS/SQ FT



5651-00E
JOB NO.

1 2
BORING NO.

3.0'
DEPTH

ML-FILL
SOIL TYPE

BY MEB/5/-
TESTED

CHICAGO
OFFICE

4500
CONFINING PRESSURE

☒ FIELD MOISTURE

☐ SATURATED TEST

TX-QT
TYPE OF TEST

NOTES

MOISTURE CONTENT		
Dish No.		I
Wet weight soil & dish		139.0
Dry weight soil & dish		118.4
Net loss of moisture		20.6
Weight of dish only		25.0
Net weight of dry soil		93.4
Moisture, % of dry weight		22.0

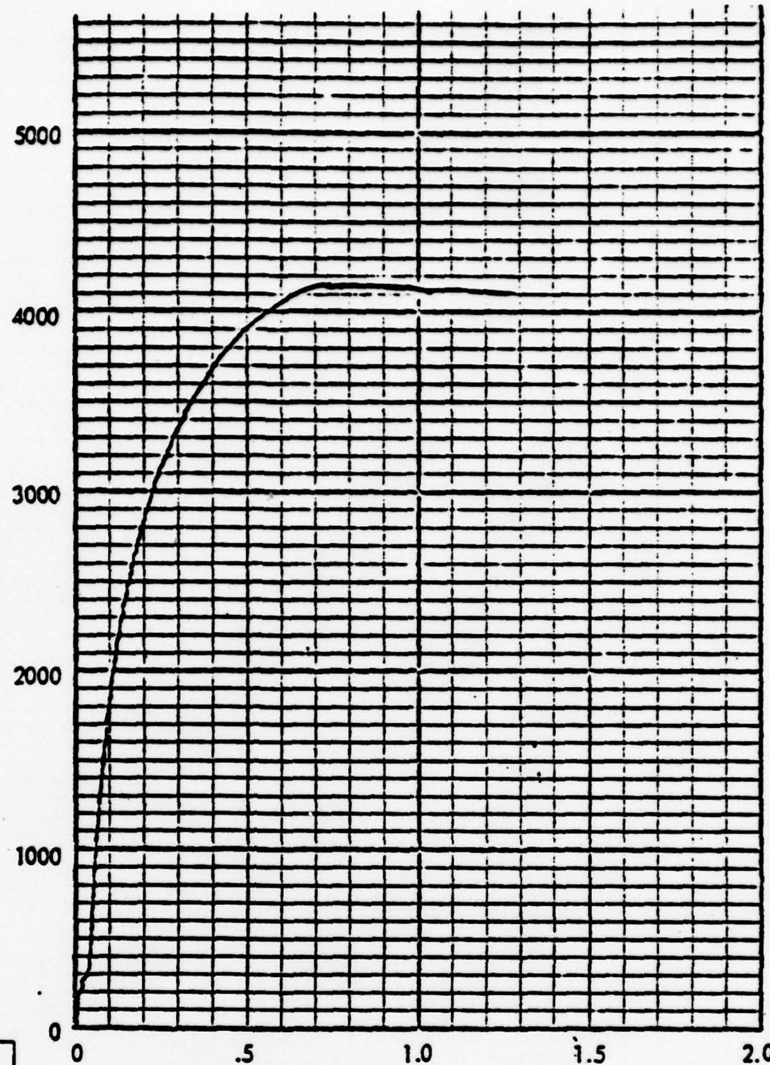
DRY DENSITY			
Wt. solids + moisture	W_o	956.0	gms.
W_o ÷ 454	W_o'		lbs.
Weight solids	W_s		gms.
Wet density W_o' ÷ V_o'		123.2	pcf
Dry density		101	pcf

SAMPLE VOLUME			
Net diameter	D_o		in.
Area $(0.785\ D_o^2)$	A		sq.in.
Height	H_o	5.75	in.
Volume (A_oH_o) ÷ 1728	V_o'		cu.ft.

VOID RATIO			
Volume (A_oH_o) × 16.4	V_o		cc
Specific gravity of solids	G_s		
Volume of solids W_s ÷ G_s	V_s		cc
$(V_o - V_s) \div V_s$	e_i		
Initial burette reading			cc
Burette reading under pressure			cc
$(V_p - V_s) \div V_s$	e_p		

VI-50

☒ IF HIGH RANGE MODE OF RECORDING DATA IS SET AT BEGINNING OF TEST, OR IF RECORDER IS AUTOMATICALLY SET TO HIGH RANGE DURING TEST, CHECK BOX & MULTIPLY AXIAL STRESS × 4



AXIAL STRESS IN LBS SQ FT

JOB NO.

3 2A
BORING NO.

3
DEPTH

BR CL SI w/ SO ST & SV
SOIL TYPE

BY RH 6/1/6
TESTED

CH
OFFICE

4500
CONFINING PRESSURE

☒ FIELD MOISTURE

☐ SATURATED TEST

TRIAX UU
TYPE OF TEST

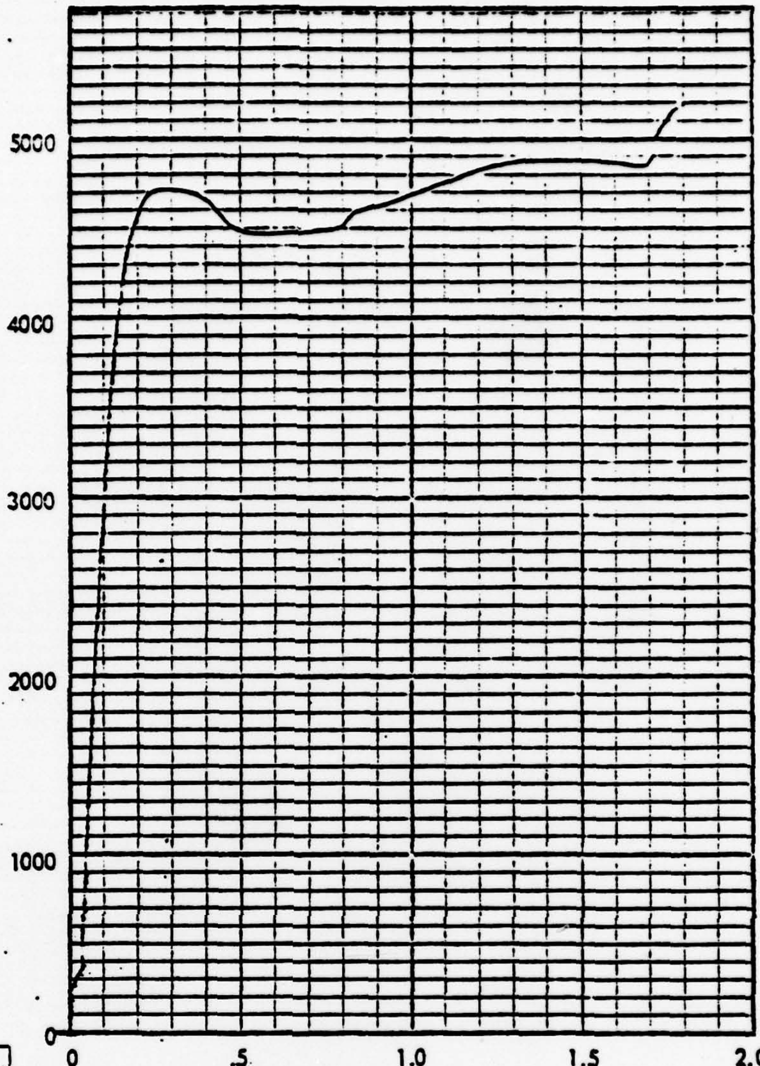
NOTES

MOISTURE CONTENT	Dish No.		Y
	Wet weight soil & dish		158.5
	Dry weight soil & dish		136.5
	Net loss of moisture		22.0
	Weight of dish only		24.8
	Net weight of dry soil		111.7
	Moisture, % of dry weight		19.7
DRY DENSITY	Wt. solids - moisture	W_o	757 gms.
	$W_o \div 454$	W'_o	lbs.
	Weight solids	W_s	gms.
	Wet density $W'_o \div V'_o$		129.5 pcf
	Dry density		108 pcf

SAMPLE VOLUME	Net diameter	D_o	in.
	Area $(0.785\ D_o^2)$	A	sq.in.
	Height	H_o	4.87 in.
	Volume $(A_oH_o) \div 1728$	V'_o	cu.ft.
VOID RATIO	Volume $(A_oH_o) \times 16.4$	V_o	cc
	Specific gravity of solids	G_s	
	Volume of solids $W_s \div G_s$	V_s	cc
	$(V_o - V_s) \div V_s$	e_i	
	Initial burette reading		cc
	Burette reading under pressure		cc
VI-51	$(V_p - V_s) \div V_s$	e_p	

IF HIGH RANGE MODE OF RECORDING DATA IS SET AT BEGINNING OF TEST, OR IF RECORDER IS AUTOMATICALLY SET TO HIGH RANGE DURING TEST, CHECK BOX 8c MULTIPLY AXIAL STRESS × 4

[X]



AXIAL STRESS IN LBS SQ FT

5651-OC JOB NO.

3 BORING NO.

6.0' DEPTH

ML-FILL SOIL TYPE

BY MRB / 5 / TESTED

CHICAGO OFFICE

450C CONFINING PRESSURE

[X] FIELD MOISTURE

[ ] SATURATED TEST

TX-Q TYPE OF TEST

NOTES

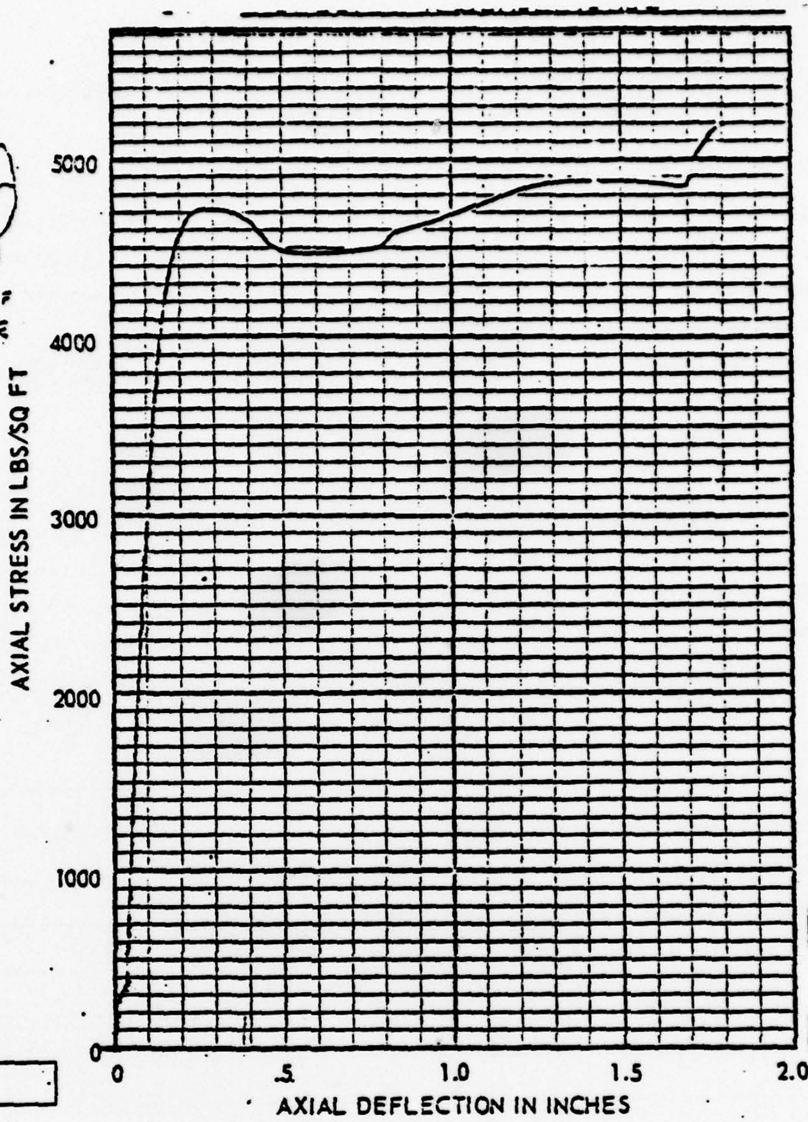
MOISTURE CONTENT	Dish No.	IV		SAMPLE VOLUME	Net diameter	D_o	in.
	Wet weight soil & dish	165.1			Area $(0.785\ D_o^2)$	A	sq.in.
	Dry weight soil & dish	141.0			Height	H_o 5.80	in.
	Net loss of moisture	24.1			Volume $(A_oH_o) \div 1728$	V_o'	cu.ft.
	Weight of dish only	24.5		VOID RATIO	Volume $(A_oH_o) \div 16.4$	V_o	cc
	Net weight of dry soil	116.5			Specific gravity of solids	G_s	
	Moisture, % of dry weight	20.7			Volume of solids $W_s \div G_s$	V_s	cc
DRY DENSITY	Wt. solids - moisture	W_o 876.3	gms.		$(V_o - V_s) \div V_s$	e_i	
	$W_o \div 454$	W_o'	lbs.		Initial burette reading		cc
	Weight solids	W_s	gms.		Burette reading under pressure		cc
	Wet density $W_o' - V_o'$	125.4	pcf	VI-52	$(V_p - V_s) - V_s$	e_p	
	Dry density	104	pcf				

IF HIGH RANGE MODE OF RECORDING DATA IS SET AT BEGINNING OF TEST, OR IF RECORDER IS AUTOMATICALLY SET TO HIGH RANGE DURING TEST, CHECK BOX & MULTIPLY AXIAL STRESS × 4

[X]

AXIAL STRESS IN LBS SQ FT

SKETCH OF FAILURE



5651-003
JOB NO.

3
BORING NO.

6.0'
DEPTH

ML-FILL
SOIL TYPE

BY MRB /5/
TESTED

CHICAGO
OFFICE

4500
CONFINING PRESSURE

[X] FIELD MOISTURE

[ ] SATURATED TEST

TX-Q
TYPE OF TEST

NOTES

MOISTURE CONTENT	Dish No.	IV	
	Wet weight soil & dish	165.1	
	Dry weight soil & dish	141.0	
	Net loss of moisture	24.1	
	Weight of dish only	24.5	
	Net weight of dry soil	116.5	
	Moisture, % of dry weight	20.7	
DRY DENSITY	Wt. solids + moisture	W_o 878.3	gms.
	W_o ÷ 454	W_o'	lbs.
	Weight solids	W_s	gms.
	Wet density W_o' ÷ V_o'	125.6	pcf
	Dry density	104	pcf

SAMPLE VOLUME	Net diameter	D_o		in.
	Area (0.785 D_o^2)	A		sq.in.
	Height	H_o	5.50	in.
	Volume (A_oH_o) ÷ 1728	V_o'		cu.ft.
VOID RATIO	Volume (A_oH_o) × 16.4	V_o		cc
	Specific gravity of solids	G_s		
	Volume of solids W_s ÷ G_s	V_s		cc
	(V_o − V_s) ÷ V_s	e_i		
	Initial burette reading			cc
	Burette reading under pressure			cc
VI-53	(V_p − V_s) ÷ V_s	e_p		

JOB # 5651-003-07

OWNER Baker Engr. Co. LOCATION Orange County BORING # 3

SOIL TYPE Brown, Red & Yellow clayey sandy DEPTH 13.5'

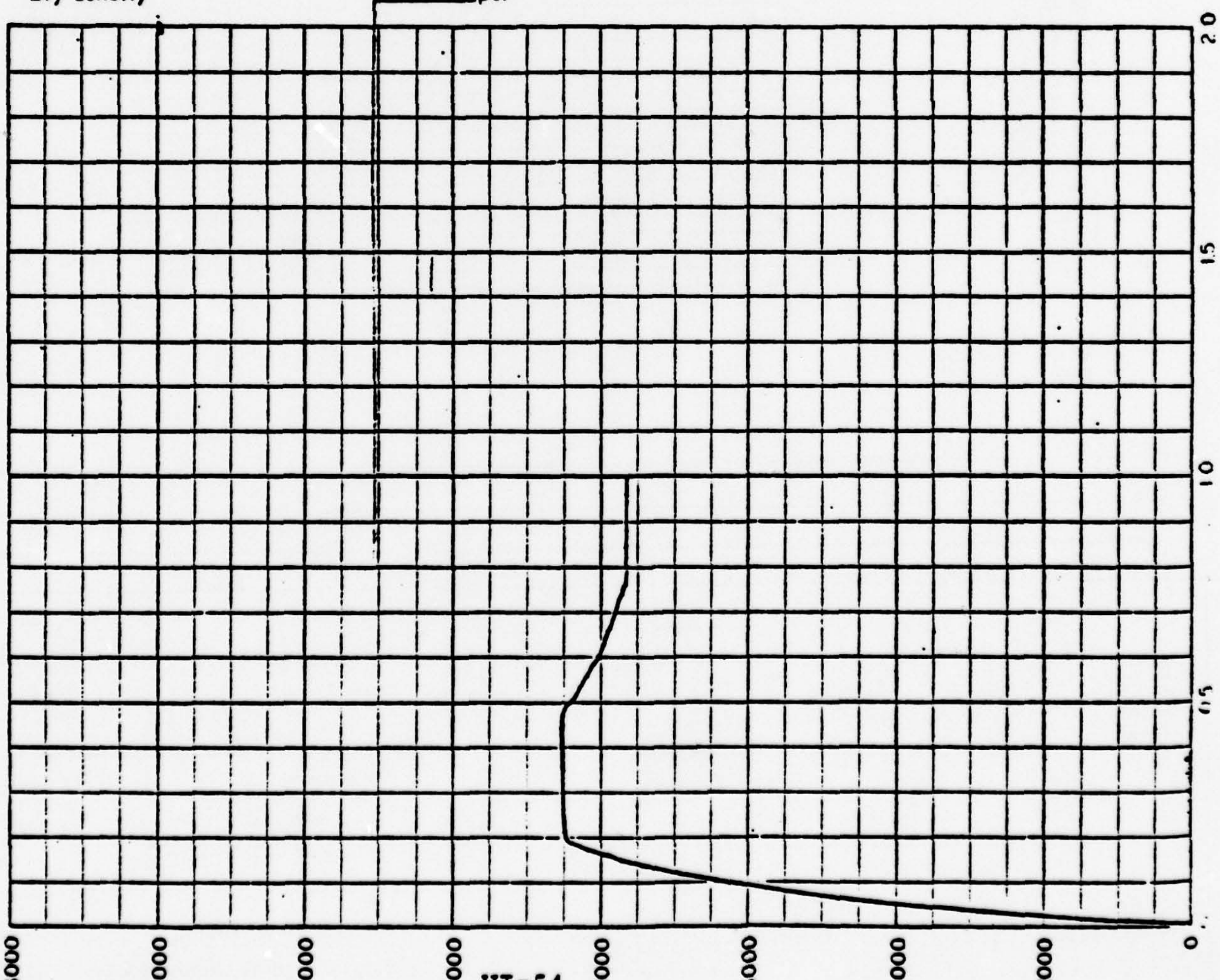
Silt (ML-Fill) SAMPLE # 6A

SAMPLED JBR 5/12/67 SET-UP / / TESTED [initials] 5/21/67 (SF OFFICE)

SATURATED TEST ☐ FIELD MOISTURE TEST ☒ TEST LATERAL PRESSURE 1500 PSF

TYPE OF TEST TX/UU 104 SR. = 0.125"/min

Weight soil & dish no.	285.1	Net diameter	D_o 2.42 in.
Dry weight soil & dish	244.9	Area $(0.785\ D_o^2)$	A_o 4.60 sq.in.
Net loss of moisture	40.2	Height	H_o 5.70 in.
Weight of dish only		Volume $(A_oH_o) \div 1728$	V'_o cu.ft.
Net weight of dry soil		Volume $(A_oH_o) \times 16.4$	V_o cc
Moisture, % of dry weight	16.4	Specific gravity of solids	G_s
		Volume of solids $W_s \div G_s$	V_s cc
Wt. solids + moisture	W_o 885 gms.	$(V_o - V_s) \div V_s$	e_i
$W_o \div 454$	W'_o lbs.	Initial burette reading	cc
Weight solids	W_s gms.	Burette reading under pressure	cc
Wet density $W'_o \div V'_o$	129 pcf	$(V_p - V_s) \div V_s$	e_p
Dry density	111 pcf		



AXIAL STRESS IN LBS./SQ.FT.(X 30 FOR HI-RANGE)

OWNER Baker Edge Co. LOCATION Orange County BORING # 3

SOIL TYPE Red Brown & Yellow Sandy Clayey Silt DEPTH 16.0

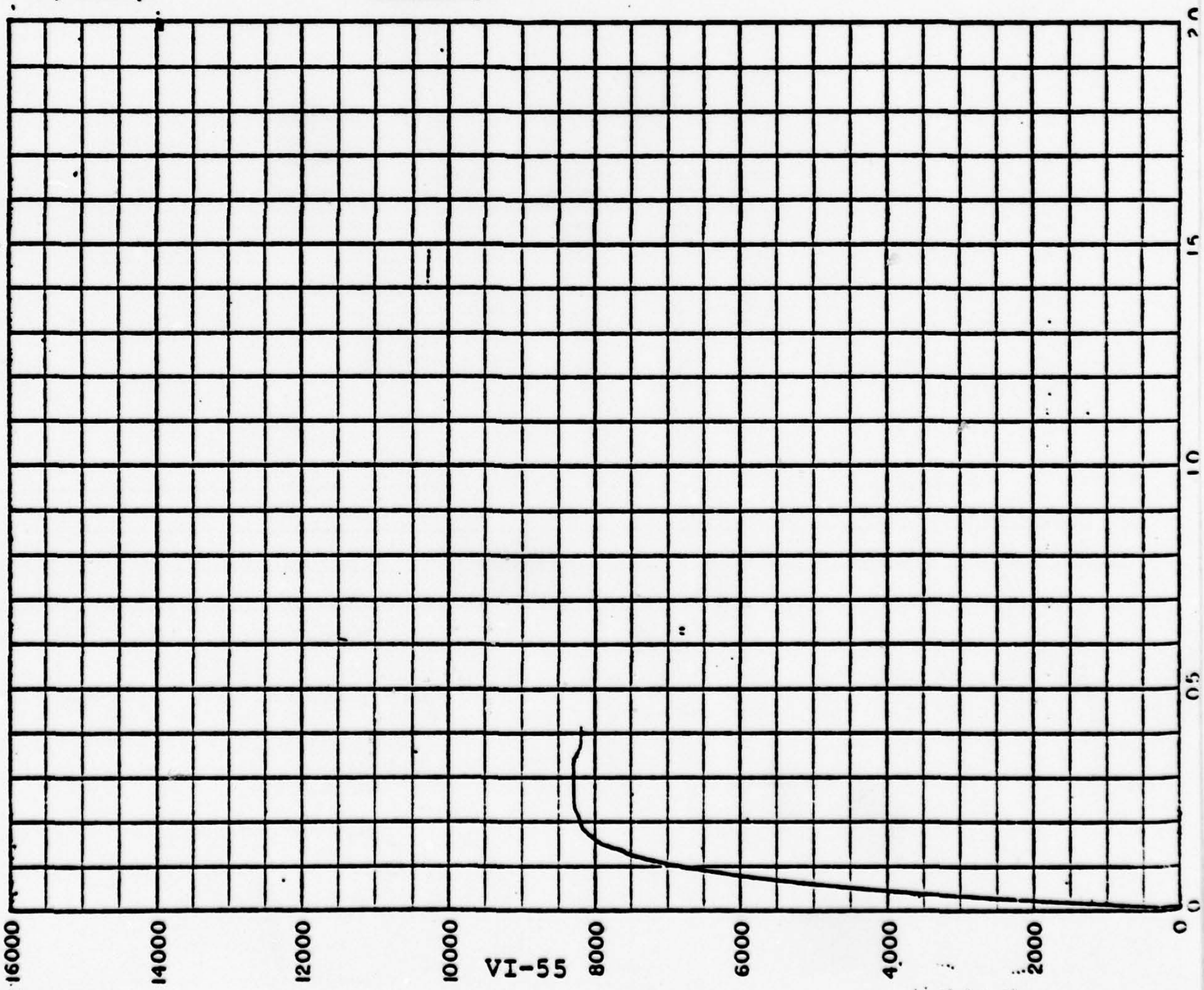
With Gravel & Decomposed Shale Fragments (ML-Fill) SAMPLE # 7A

SAMPLED JBR 5/12/67 SET-UP ____ / / TESTED [illegible] 5/21/67 (SF OFFICE)

SATURATED TEST ☐ FIELD MOISTURE TEST ☒ TEST LATERAL PRESSURE 3000 PSF

TYPE OF TEST TX/UU SR. = 0.125"/min.

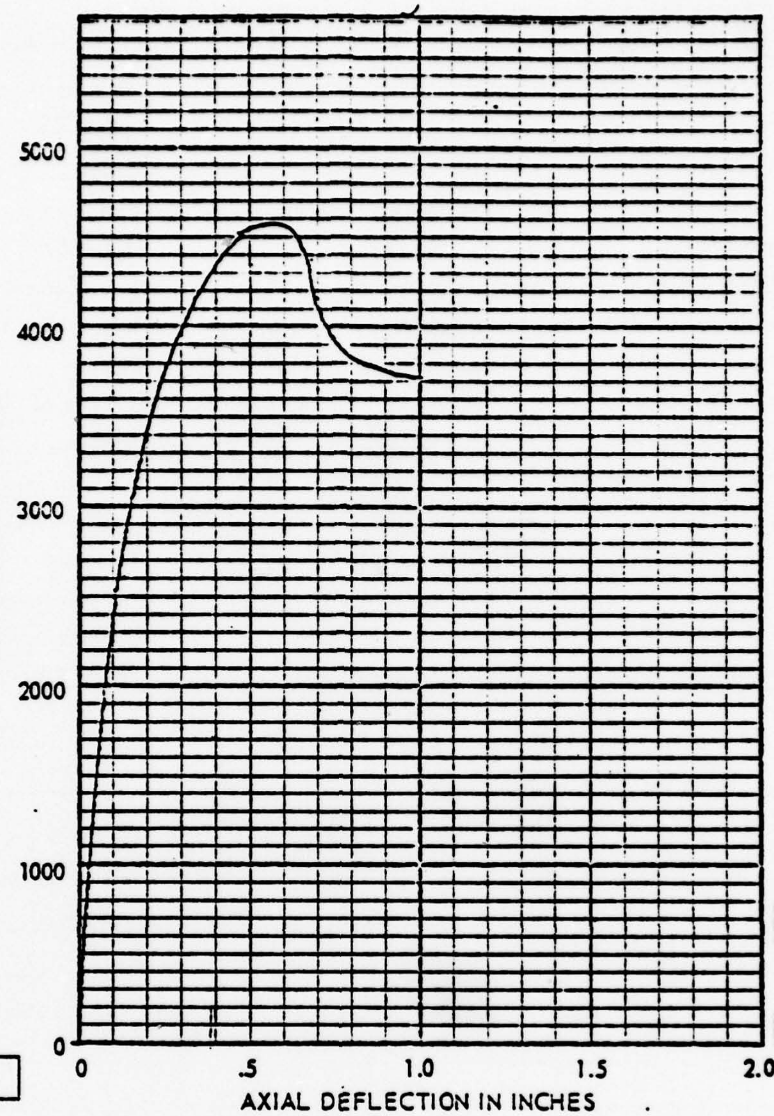
Weight soil & ~~dish~~ no.	372 / 279.5		Net diameter	D_o 2.42 in.
Dry weight soil & ~~dish~~	240.8		Area $(0.785\ D_o^2)$	A_o 4.60 sq.in
Net loss of moisture	38.7		Height	H_o 6.0 in.
Weight of dish only			Volume $(A_oH_o) \div 1728$	V'_o ____ cu.ft
Net weight of dry soil			Volume $(A_oH_o) \times 16.4$	V_o ____ cc
Moisture, % of dry weight	16.1		Specific gravity of solids	G_s ____
			Volume of solids $W_s \div G_s$	V_s ____ cc
Wt. solids + moisture	W_o 913 gms.		$(V_o - V_s) \div V_s$	e_i ____
$W_o \div 454$	W'_o ____ lbs.		Initial burette reading	____ cc
Weight solids	W_s ____ gms.		Burette reading under pressure	____ cc
Wet density $W'_o \div V'_o$	127 pcf		$(V_p - V_s) \div V_s$	e_p ____
Dry density	109 pcf			



VI-55

957.41

☒ IF HIGH RANGE MODE OF RECORDING DATA IS SET AT BEGINNING OF TEST, OR IF RECORDER IS AUTOMATICALLY SET TO HIGH RANGE DURING TEST, CHECK BOX 8c MULTIPLY AXIAL STRESS × 4



AXIAL STRESS IN LBS/SQ FT: ______

3631-003
JOB NO.

3 B1
BORING NO.

13½
DEPTH

Br [illegible] w/ so [illegible]
SOIL TYPE

BY RH 6/1/67
TESTED

CH
OFFICE

3000
CONFINING PRESSURE

☒ FIELD MOISTURE

☐ SATURATED TEST

TRIAX: U-
TYPE OF TEST

NOTES ______

MOISTURE CONTENT		
Dish No.		R
Wet weight soil & dish		197.1
Dry weight soil & dish		170.2
Net loss of moisture		26.9
Weight of dish only		24.4
Net weight of dry soil		145.8
Moisture, % of dry weight		18.5

DRY DENSITY			
Wt. solids − moisture	W_o	757	gms.
$W_o \div 454$	W_o'		lbs.
Weight solids	W_s		gms.
Wet density $W_o' \div V_o'$		130	pcf
Dry density		110	pcf

SAMPLE VOLUME			
Net diameter	D_o		in.
Area $(0.785\ D_o^2)$	A		sq.in.
Height	H_o	4.86	in.
Volume $(A_oH_o) \div 1728$	V_o'		cu.ft.

VOID RATIO			
Volume $(A_oH_o) \times 16.4$	V_o		cc
Specific gravity of solids	G_s		
Volume of solids $W_s \div G_s$	V_s		cc
$(V_o - V_s) \div V_s$	e_i		
Initial burette reading			cc
Burette reading under pressure			cc
$(V_p - V_s) \div V_s$	e_p		

ATTACHMENT C

CONSOLIDATION TESTS

FOR VERTICAL PERMEABILITIES

CONSOLIDATION TEST DATA SHEET PAGE___OF_____

JOB [illegible] JOB NO. [illegible]

DATE SAMPLED [illegible] BORING NO. [illegible]

TEST STARTED [illegible] BY [illegible] TEST FINISHED____ BY____ DEPTH [illegible]

SOIL TYPE [illegible]

CONSOLIDOMETER NO. 9 INITIAL SAMPLE HEIGHT [illegible]

MOISTURE & DENSITY DATA	BEFORE TEST	AFTER TEST
WT. OF RING(S) + SOIL	197.10	197.45
WT. OF RING(S) ONLY	45.10	45.10
WT. OF SOIL (NET)	152.00	152.35
WET DENSITY IN LBS/CU. FT.*	127	127
WT. OF WET SOIL + DISH NO. 40?A	197.25	197.45
WT. OF DRY SOIL + DISH	176.34	171.60
WT. OF LOST MOISTURE	21.91	25.85
WT. OF DISH ONLY	56.13	45.10
WT. OF DRY SOIL	120.21	126.50
MOISTURE AS % OF DRY WT.	18.2	20.4
DRY DENSITY IN LBS/CU. FT.	107	106

TEST INSTRUCTIONS

LOAD CYCLE

[illegible]

[illegible] 3AT

SPECIAL INSTRUCTION AND NOTES

[illegible]

[illegible]

[illegible]

[illegible]

DATE	TIME	ELAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOLIDATION
5-1?						
			[illegible]			
	1400			4765		
			[illegible]			
	[illegible]			4765		[illegible]
			[illegible]			
				47??	[illegible]	
			200			
	[illegible]			47??		0024
				4743	[illegible]	
			[illegible]			
	1410			4737		[illegible]
	1414			4736	[illegible]	
			640			
	1415			4702		
	1500			[illegible]		4765
	1710			[illegible]		[illegible]
5-19	950			4669		[illegible]
			1600			
	1000	0		4699		
		1		4673		
		15		4671		
		30		4667		
	1001	1		4667		
	[illegible]	2		4665		
		4		[illegible]		
	9	9		4661		
	15	15		[illegible]		
		30		[illegible]		
	1100	60		[illegible]		

DATE	TIME	ELAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOLIDATION
	1200	120		[illegible]		
	1400	240		4653		[illegible]
	1800	480		4653		[illegible]
5-20	1000	1440		4653		[illegible]
			3200			
	1000	0		4657		
	1	1		4600		
	1	15		[illegible]		
	V	30		[illegible]		
	1001	1		[illegible]		
	1002	2		4575		
	[illegible]	[illegible]		4575		
	[illegible]	8		4572		
	1015	[illegible]		4570		
	[illegible]	30		4567		
	[illegible]	[illegible]		4565		
	[illegible]	120		[illegible]		
	[illegible]	[illegible]		[illegible]		[illegible]
	1400	[illegible]		[illegible]		[illegible]
5-21	0900	1440		[illegible]		[illegible]

*MULTIPLY WEIGHT OF SOIL IN GRAMS BY 0.332 WHEN ONE STANDARD D & M SAMPLE IS USED.

CONTINUED ON REVERSE SIDE

DATE	TIME	ELAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOL-IDATION
			6450			
	940	0		4556		
		6		4446		
		15		4435		
		30		4426		
	941	1		4419		
	942	2		4411		
	944	4		4404		
	949	9		4397		
	955	15		4394		
	1010	30		4390		
	1040	60		4387		
	1140	120		4383		
	1340	240		4379		4765
	1740	480		4374		4371
5-22	940	1440		4371		0394
			12,800			
	940	0		4371		
		6		4248		
		15		4233		
		30		4219		
	941	1		4204		
	942	2		4188		
	944	4		4174		
	949	9		4164		
	955	15		4160		
	1010	30		4155		
	1040	60		4151		
	1140	120		4147		
	1340	240		4144		4765
	1740	480		4141		4135
5-23	940	1440		4135		0630
			25600			
	945	0		4135		
		6		3997		
		15		3975		
		30		3954		
	946	1		3929		
	947	2		3901		
	949	4		3900		
	954	9		3863		
	1000	15		3856		
	1015	30		3850		
	1045	60		3845		
	1215	180		3838		
	1345	240		3835		4165
	1745	480		3832		3827
5-24	945	1440		3827		937
			51200			
	945	0		3827		
		6		3692		
		15		3662		
		30		3633		
	946	1		3606		
	947	2		3571		
	949	4		3544		
	954	9		3525		

DATE	TIME	ELAPSED TIME IN MINS.	LOAD (PSF) 51200	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOL-IDATION
	1000	15		3518		
	1015	30		3511		
	1045	60		3506		
	1145	120		3501		
	1345	240		3497		4765
	1745	480		3493		3827
5-25	945	1440		3487		1278
			102,400			
	945	0		3487		
		6		3350		
		15		3318		
		30		3257		
	946	1		3245		
	947	2		3202		
	949	4		3160		
	954	9		3145		
	1000	15		3138		
	1015	30		3132		
	1045	60		3125		
	1145	120		3121		
	1345	240		3117		4765
	1745	480		3113		3105
5-26	945	1440		3105		1660
			100			
	946	1		3431		
	1400			3984		
	1800			4001		

WORK SHEET - SPECIFIC GRAVITY TESTS

Project: Bauer Engr. Co	Job No. 5531-[illegible]	Hole No. 1	Date 5/21/[illegible]

SPECIFIC GRAVITY OF SOLIDS (G_s)

Sample No.			2A	[illegible]				
Flask No.			A					
Temperature of Water and Soil, T, °C			22.5					
Pan No.								
Wt. in grams	Pan + Dry Soil		446.03					
	Pan		327.76					
	Dry Soil	W_s	118.27					
	Flask + Water at T, °C	W_{bw}	65[illegible]					
	$W_s + W_{bw}$		77[illegible]					
	Flask + Water + Immersed Soil	W_{bws}	733.88					
	Displaced Water, $W_s + W_{bw} - W_{bws}$		[illegible]					
Correction Factor		K	.9996					
$(W_sK) \div (W_s + W_{bw} - W_{bws})$		G_s	2.71					

APPARENT (G_a) AND BULK (G_m) SPECIFIC GRAVITY

						Temp. °C	Corr. Factor K
Sample No.							
Temperature of Water and Soil, T, °C						14	1.0010
Wt. in grams	Pan + Saturated Surface - Dry Soil					15	1.0009
	Tare Weight					16	1.0007
	Saturated Surface - Dry Soil	B				17	1.0006
	(Wire Basket + Soil) in Water					18	1.0004
	Wire Basket in Water					19	1.0002
	Saturated Soil in Water	C				20	1.0000
	Tare Weight + Dry Soil					21	0.9998
	Tare Weight					22	0.9996
	Dry Soil	A				23	0.9993
Correction Factor		K				24	0.9991
(AK) ÷ (A-C) (Apparent)		G_a				25	0.9988
(AK) ÷ (B-C) (Bulk)		G_m				26	0.9986
Remarks:						27	0.9983
						28	0.9980
All - Fill						29	0.9977
						30	0.9974
						31	0.9971

Tested by: P.C	Computed by: [illegible]	Checked by: [illegible]

CONSOLIDATION TEST DATA SHEET   PAGE___OF_____

JOB: [illegible] Engineering Co.   JOB NO. [illegible]

DATE SAMPLED ______   BORING NO. [illegible]

TEST STARTED [illegible] BY [illegible] TEST FINISHED ______ BY ______ DEPTH [illegible]

SOIL TYPE [illegible]

CONSOLIDOMETER NO. 14   INITIAL SAMPLE HEIGHT [illegible]

MOISTURE & DENSITY DATA	BEFORE TEST	AFTER TEST
WT. OF RING(S) + SOIL	193.64	193.34
WT. OF RING(S) ONLY	44.90	44.90
WT. OF SOIL (NET)	148.74	148.44
WET DENSITY IN LBS/CU. FT.*	123.0	123.0
WT. OF WET SOIL + DISH NO. 253	185.73	193.34
WT. OF DRY SOIL + DISH	161.15	166.50
WT. OF LOST MOISTURE	24.58	26.84
WT. OF DISH ONLY	55.44	44.90
WT. OF DRY SOIL	105.71	121.60
MOISTURE AS % OF DRY WT.	23.3	22.1
DRY DENSITY IN LBS/CU. FT.	100	101

TEST INSTRUCTIONS

LOAD CYCLE _____ _____ _____

SPECIAL INSTRUCTION AND NOTES

[illegible]

[illegible]

[illegible]

[illegible]

DATE	TIME	E-LAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOL-IDATION
5-18						
			0			
	[illegible]			[illegible]		
			100			
	[illegible]			[illegible]		[illegible] ✓
			[illegible]			
	[illegible]			[illegible]	[illegible]	
			[illegible]			
	[illegible]			[illegible]		4010
	1540			4882		[illegible]
	1740			4881		[illegible] ✓
	[illegible]			[illegible]	[illegible]	
			400			
	[illegible]			[illegible]		4010
5-19	[illegible]			[illegible]		[illegible]
	[illegible]			[illegible]		[illegible] ✓
			800			
	[illegible]	0		4861		
		6		[illegible]		
		15		[illegible]		
		[illegible]		[illegible]		
	[illegible]	1		[illegible]		
	[illegible]	[illegible]		[illegible]		
	[illegible]	[illegible]		[illegible]		
	[illegible]	9		[illegible]		
	[illegible]	15		[illegible]		
	[illegible]	30		[illegible]		
	[illegible]	60		[illegible]		
	[illegible]	[illegible]		[illegible]		
	[illegible]	[illegible]		[illegible]		

DATE	TIME	E-LAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOL-IDATION
	1825	410		[illegible]		[illegible]
5-20	[illegible]	[illegible]		[illegible]		[illegible]
			1600			
	1025	[illegible]		[illegible]		
	[illegible]	[illegible]		[illegible]		
	[illegible]	15		[illegible]		
	[illegible]	[illegible]		[illegible]		
	[illegible]	1		[illegible]		
	[illegible]	2		[illegible]		
	[illegible]	[illegible]		4784		
	[illegible]	[illegible]		[illegible]		
	[illegible]	[illegible]		[illegible]		
	1055	[illegible]		[illegible]		
	1125	[illegible]		[illegible]		
	1225	[illegible]		[illegible]		
	[illegible]	[illegible]		4777		[illegible]
	[illegible]	[illegible]		4775		[illegible]
5-21	[illegible]	[illegible]		4774		[illegible]
			3200			
	[illegible]	[illegible]		[illegible]		
		6		[illegible]		
	[illegible]	[illegible]		4717		
	[illegible]	[illegible]		[illegible]		
	[illegible]	1		[illegible]		
	[illegible]	2		[illegible]		
	[illegible]	4		[illegible]		
	[illegible]	[illegible]		[illegible]		
	[illegible]	[illegible]		[illegible]		
	[illegible]	[illegible]		[illegible]		
	[illegible]	[illegible]		[illegible]		

*MULTIPLY WEIGHT OF SOIL IN GRAMS BY 0.832 WHEN ONE STANDARD D & M SAMPLE IS USED.

CONTINUED ON REVERSE SIDE

DATE	TIME	LAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOLIDATION
			3200	Continued		
	1205	120		4701		4919
	1405	240		4699		[illegible]
	1805	480		4696		0225
5-22	1305	1440		4694		
			6400			
	1005	0		4694		
	)	6		4669		
	(	15		4664		
	(	30		46[illegible]		
	1006	1		4601		
	1007	2		4599		
	1009	4		4597		
	1014	9		4595		
	1020	15		4593		
	[illegible]	30		[illegible]		
	1105	60		4590		
	1205	120		4587		
	1405	240		4585		4919
	1805	480		4583		4581
5-23	1005	1440		4581		0338
			12800			
	1005	0		4581		
	)	6		4471		
	(	15		4464		
		30		4458		
	1006	1		4453		
	1051	2		4450		
	1009	4		4447		
	1014	9		4443		
	1020	15		4441		
	1035	30		4439		
	1105	60		4437		
	1305	180		4433		
	1505	300		4431		4919
	1805	480		4429		4422
5-24	1005	1440		4427		.0492
			25600			
	1105	0		4427		
	)	6		4251		
	(	15		4242		
		30		4235		
	1106	1		42[illegible]		
	1107	2		4225		
	1109	4		4221		
	1014	9		4217		
	1020	15		4214		
	1035	30		4211		
	1105	60		4207		
	1205	120		4205		
	1405	240		4201		4919
	[illegible]	[illegible]		4198		4195
5-25	1010	1425		4195		0724

DATE	TIME	E-LAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOLIDATION
			51200			
	1000	0		4195		
	)	6		3975		
	(	5		3939		
		30		3928		
	1001	1		3918		
	1002	2		3911		
	1004	4		3905		
	1009	9		3898		
	1015	15		3895		
	1030	30		3890		
	1100	60		3887		
	1200	120		3883		
	1400	240		3880		4919
	1800	480		3878		3872
5-26	1600	1440		3872		1047
			102400			
	1000	0		3872		
	(	6		3566		
	)	15		3512		
		30		3490		
	1001	1		3474		
	1002	2		3461		
	1004	4		3455		
	1009	9		3413		
	1015	15		3357		
	1030	30		3331		
	1100	60		3325		
	1200	120		3420		
	1400	240		3215		
	1800	480		3211		
~~5-27~~	~~1000~~	~~1440~~				
			100			
	1801	1		3900		

WORK SHEET - SPECIFIC GRAVITY TESTS

Project: Bauer Edson Co	Job No. 5651-003	Hole No. 3	Date 5/21/67

SPECIFIC GRAVITY OF SOLIDS (G_s)

Sample No.		1	2 1.5'				
Flask No.		C					
Temperature of Water and Soil, T, °C		22.5					
Pan No.							
Wt. in grams: Pan + Dry Soil		393.26					
Pan		283.07					
Dry Soil	W_s	110.19					
Flask + Water at T, °C	W_{bw}	657.29					
W_s + W_{bw}		767.48					
Flask + Water + Immersed Soil	W_{bws}	727.26					
Displaced Water, $W_s + W_{bw} - W_{bws}$		40.22					
Correction Factor	K	.9995					
$(W_sK) \div (W_s + W_{bw} - W_{bws})$	G_s	2.74					

APPARENT (G_a) AND BULK (G_m) SPECIFIC GRAVITY

					Temp. °C	Corr. Factor K
Sample No.						
Temperature of Water and Soil, T, °C					14	1.0010
Wt. in grams: Pan + Saturated Surface - Dry Soil					15	1.0009
Tare Weight					16	1.0007
Saturated Surface - Dry Soil	B				17	1.0006
(Wire Basket + Soil) in Water					18	1.0004
Wire Basket in Water					19	1.0002
Saturated Soil in Water	C				20	1.0000
Tare Weight + Dry Soil					21	0.9998
Tare Weight					22	0.9996
Dry Soil	A				23	0.9993
Correction Factor	K				24	0.9991
(AK) ÷ (A-C) (Apparent)	G_a				25	0.9988
(AK) ÷ (B-C) (Bulk)	G_m				26	0.9986
Remarks:					27	0.9983
ML - FILL					28	0.9980
					29	0.9977
					30	0.9974
					31	0.9971

Tested by: B	Computed by: B	Checked by: [illegible]

ATTACHMENT D

CONSOLIDATION TESTS

FOR HORIZONTAL PERMEABILITIES

JOB Bowen Engineering JOB NO. 5451-003-07

DATE SAMPLED ______ BORING NO. TP1 #3

TEST STARTED 5-18-67 BY PTB TEST FINISHED 5/21 BY [illegible] DEPTH 3.0

SOIL TYPE [illegible]

CONSOLIDOMETER NO. 2 INITIAL SAMPLE HEIGHT 1 inch

MOISTURE & DENSITY DATA	BEFORE TEST	AFTER TEST
WT. OF RING(S) + SOIL	199.5	200.7
WT. OF RING(S) ONLY	45.1	45.1
WT. OF SOIL (NET)	154.4	155.6
WET DENSITY IN LBS/CU. FT.*	128.3	130.3
WT. OF WET SOIL + DISH NO. 372	193.2	200.7
WT. OF DRY SOIL + DISH	170.1	171.7
WT. OF LOST MOISTURE	23.6	29.0
WT. OF DISH ONLY	56.3	45.1
WT. OF DRY SOIL	113.8	126.6
MOISTURE AS % OF DRY WT.	20.7	23.0
DRY DENSITY IN LBS/CU. FT.	106.3	105.1

TEST INSTRUCTIONS

LOAD CYCLE

SPECIAL INSTRUCTION AND NOTES

1. [illegible] loading
2. [illegible]
3. Do not allow expansion

[illegible] loading

DATE	TIME	ELAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOLIDATION
5-18-67			0			
	1355			5100		
			100			
	1356			5095		.0015
			SAT			
				5086	[illegible]	
			200			
	1358			5083		.0017
				5084	240	
			400			
	1359			5075		.0025
				5076	240	
			800			
	1400			5071		.0029
	1404			5072	240	
			1600			
	1405			5052		
	1406			5052		.0048
	1511			5053	240	
			3200			
	1542			5025		
	1705			5013		
5-19	830			5010		.0090
			6400			
	1005	0		5010		
	↓	6		4975		
	↓	15		4966		
	↓	30		4962		
	1006	1		4959		
	1007	2		4956		

DATE	TIME	ELAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOLIDATION
	1009	4		4953		
	1014	9		4950		
	1020	15		4947		
	1035	30		4947		
	1105	60		4946		
	1205	120		4944		
	1405	240		4942		5100
	1805	480		4941		4939
5-20	1005	1440		4939		.0161
			12800			
	1005	0		4939		
	↓	6		4893		
	↓	15		4875		
	↓	30		4869		
	1006	1		4863		
	1007	2		4856		
	1009	4		4852		
	1014	9		4847		
	1020	15		4844		
	1035	30		4842		
	1105	60		4840		
	1205	120		4838		
	1405	240		4835		510[illegible]
	1809	482		4833		48[illegible]
5-21	0900			4833		[illegible]

*MULTIPLY WEIGHT OF SOIL IN GRAMS BY 0.832 WHEN ONE STANDARD D & M SAMPLE IS USED.

CONTINUED ON REVERSE SIDE

DATE	TIME	ELAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOLIDATION
			[illegible]			
	0930	0		[illegible]		
		6		4756		
		15		4743		
		30		4731		
	0931	1		4717		
	0932	2		4704		
	934	4		4695		
	939	9		4687		
	945	15		4684		
	1000	30		4681		
	1030	60		4678		
	1130	120		4675		
	[illegible]	[illegible]		4671		5100
	1730	[illegible]		4667		4664
[illegible]	[illegible]	[illegible]		4664		0436 ✓
			512 [illegible]			
	0930	0		4664		
		6		4554		
		15		4533		
		30		4514		
	931	1		4488		
	932	2		4462		
	934	4		4442		
	939	9		4428		
	945	15		4424		
	1000	30		4419		
	1030	60		4415		
	1130	120		4410		
	1330	[illegible]		4406		5100
	1730	[illegible]		4403		4397
5-23	930	1440		4397		0703 ✓
			102400			
	930	0		4397		
		6		4270		
		15		4235		
		30		4204		
	931	1		4160		
	932	2		4112		
	934	4		4068		
	939	9		4033		
	945	15		4028		
	1000	30		4019		
	1030	60		4012		
	1130	120		4005		
	[illegible]	[illegible]		[illegible]		5100
	1730	[illegible]		3993		3986
5-24	930	[illegible]		3986		1114 ✓
			100			
	931			4365		
	1450			4799		
	1730			4825		[illegible]
5-25	930			[illegible]		[illegible]
	[illegible]			[illegible]		[illegible] ✓

DATE	TIME	ELAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOLIDATION

WORK SHEET - SPECIFIC GRAVITY TESTS

Project: Bauer Engr. Co.	Job No. 5651-003	Hole No. TP-1	Date 5/21/67

SPECIFIC GRAVITY OF SOLIDS (G_s)

Sample No.		1	@ 3.0'				
Flask No.		B.					
Temperature of Water and Soil, T, °C		22.5					
Pan No.							
Wt. in grams: Pan + Dry Soil		440.30					
Wt. in grams: Pan		320.24					
Wt. in grams: Dry Soil	W_s	120.06					
Wt. in grams: Flask + Water at T, °C	W_{bw}	653.60					
Wt. in grams: $W_s + W_{bw}$		773.66					
Wt. in grams: Flask + Water + Immersed Soil	W_{bws}	731.07					
Wt. in grams: Displaced Water, $W_s + W_{bw} - W_{bws}$		42.59					
Correction Factor	K	.9994					
$(W_sK) \div (W_s + W_{bw} - W_{bws})$	G_s	2.81					

APPARENT (G_a) AND BULK (G_m) SPECIFIC GRAVITY

					Temp.	Corr. Factor
Sample No.					°C	K
Temperature of Water and Soil, T, °C					14	1.0010
Wt. in grams: Pan + Saturated Surface - Dry Soil					15	1.0009
Wt. in grams: Tare Weight					16	1.0007
Wt. in grams: Saturated Surface - Dry Soil	B				17	1.0006
Wt. in grams: (Wire Basket + Soil) in Water					18	1.0004
Wt. in grams: Wire Basket in Water					19	1.0002
Wt. in grams: Saturated Soil in Water	C				20	1.0000
Wt. in grams: Tare Weight + Dry Soil					21	0.9998
Wt. in grams: Tare Weight					22	0.9996
Wt. in grams: Dry Soil	A				23	0.9993
Correction Factor	K				24	0.9991
(AK) ÷ (A-C) (Apparent)	G_a				25	0.9988
(AK) ÷ (B-C) (Bulk)	G_m				26	0.9986
Remarks: ML-FILL					27	0.9983
					28	0.9980
					29	0.9977
					30	0.9974
					31	0.9971

Tested by: BC	Computed by: BC	Checked by: [illegible]

CONSOLIDATION TEST DATA SHEET

PAGE ___ OF ___

JOB [illegible] Co.   JOB NO. [illegible]

DATE SAMPLED ________   BORING NO. [illegible]

TEST STARTED [illegible] BY [illegible] TEST FINISHED ________ BY ________ DEPTH [illegible]

SOIL TYPE [illegible]

CONSOLIDOMETER NO. 11   INITIAL SAMPLE HEIGHT 1 inch

MOISTURE & DENSITY DATA	BEFORE TEST	AFTER TEST
WT. OF RING(S) + SOIL	188.84	139.43
WT. OF RING(S) ONLY	22.9	44.90
WT. OF SOIL (NET)	143.94	144.53
WET DENSITY IN LBS/CU. FT.*	119.6	120.0
WT. OF WET SOIL + DISH NO. 125	202.86	139.43
WT. OF DRY SOIL + DISH	178.73	163.00
WT. OF LOST MOISTURE	24.13	26.43
WT. OF DISH ONLY	54.30	44.90
WT. OF DRY SOIL	124.43	118.10
MOISTURE AS % OF DRY WT.	19.4	22.4
DRY DENSITY IN LBS/CU. FT.	100	98.3

TEST INSTRUCTIONS

LOAD CYCLE ________

SPECIAL INSTRUCTION AND NOTES

[illegible]

[illegible]

[illegible]

24-hour load [illegible]

DATE	TIME	ELAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOLIDATION
5-17?						
			0			
	1557?			[illegible]		
			[illegible]			
	[illegible]			[illegible]		[illegible]
			[illegible]			
				[illegible]	[illegible]	
			200			
	[illegible]			[illegible]		[illegible]
	15[illegible]			[illegible]	[illegible]	
			400			
	1541			4580		
	1710			[illegible]		[illegible]
5-19	955			[illegible]		4501
	1019			4591		[illegible]
			800			
	1020	0		4571		
		[illegible]		[illegible]		
		15		[illegible]		
		[illegible]		4567		
	[illegible]	1		[illegible]		
	[illegible]	2		[illegible]		
	[illegible]	4		[illegible]		
	[illegible]	9		[illegible]		
	[illegible]	15		[illegible]		
	[illegible]	30		[illegible]		
	[illegible]	[illegible]		[illegible]		
	[illegible]	120		[illegible]		[illegible]
	[illegible]	[illegible]		[illegible]		[illegible]
	[illegible]	[illegible]		4557		[illegible]
5-20	[illegible]	[illegible]		4557		

DATE	TIME	ELAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOLIDATION
			1600			
	1020	0		[illegible]		
		[illegible]		[illegible]		
		15		[illegible]		
		[illegible]		[illegible]		
	1031	1		4519		
	[illegible]	2		[illegible]		
	[illegible]	4		4517		
	[illegible]	9		[illegible]		
	[illegible]	15		[illegible]		
	[illegible]	[illegible]		4514		
	1120	[illegible]		[illegible]		
	[illegible]	[illegible]		4511		
	1420	[illegible]		4510		[illegible]
	[illegible]	[illegible]		[illegible]		[illegible]
5-21	[illegible]	[illegible]		[illegible]	✓	[illegible]
			3200			
	0950	[illegible]		4509		
		6		[illegible]		
		15		[illegible]		
		30		[illegible]		
	[illegible]	1		[illegible]		
	952	[illegible]		[illegible]		
	[illegible]	[illegible]		[illegible]		
	[illegible]	9		[illegible]		
	1005	[illegible]		[illegible]		
	[illegible]	[illegible]		[illegible]		
	[illegible]	[illegible]		[illegible]		
	115[illegible]	[illegible]		[illegible]		
	[illegible]			[illegible]		

*MULTIPLY WEIGHT OF SOIL IN GRAMS BY 0.832 WHEN ONE STANDARD D & M SAMPLE IS USED.

CONTINUED ON REVERSE SIDE

[illegible]

DATE	TIME	ELAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOL-IDATION
5-21-[illegible]	·	3200 Continued				·
	1350	240		4430		4653
	1750	480		4427		4425
5-22	0950	1440		4425		.0228
			6400			
	0950	0		4425		
		6		4345		
		15		4341		
		30		4339		
	951	1		4331		
	952	2		4327		
	954	4		4334		
	959	9		4322		
	1005	15		4321		
	1020	30		4319		
	1050	60		4317		
	1150	120		4315		
	1350	240		4313		4653
	1750	480		4310		4307
5-23	0950	1440		4307		.0346
			12,800			
	950	0		4307		
		6		4161		
		15		4154		
		30		4150		
	951	1		4146		
	952	2		4143		
	954	4		4140		
	959	9		4137		
	1005	15		4135		
	1020	30		4132		
	1050	60		4130		
	1150	120		4126		
	1350	240		4124		4653
	1750	480		4122		4118
9-24	950	1440		4119		.0535
			25,600			
	950	0		4119		
		6		3896		
		15		3888		
		30		3882		
	951	1		3877		
	952	2		3872		
	954	4		3867		
	959	9		3862		
	1005	15		3860		
	1020	30		3856		
	1050	60		3853		
	1150	120		3850		
	1350	240		3846		4653
	1750	480		3843		3837
9-25	950	1440		3838		.0815

DATE	TIME	ELAPSED TIME IN MINS.	LOAD (PSF)	DIAL READING (.0001 IN.)	CONSOL. UNDER THIS LOAD	TOTAL CONSOL-IDATION
5-25			51,200			
	950	0		3834		
		6		3534		
		15		3512		
		30		3506		
	951	1		3497		
	952	2		3490		
	954	4		3484		
	959	9		3481		
	1005	15		3473		
	1020	30		3468		
	1050	60		3463		
	1150	120		3459		
	1350	240		3455		4653
	1750	480		3452		3445
5-26	950	1440		3445		.1208
			102,400			
	0950	0		3445		
		6		3041		
		15		3022		
		30		3010		
	0951	1		2999		
	0952	2		2990		
	0954	4		2982		
	0959	9		2972		
	1005	15		2963		
	1020	30		[illegible]		
	1050	60		2956		
	1150	120		2951		
	1350	240		[illegible]		
	1750	480		[illegible]		
~~5-27~~	~~950~~	~~1440~~				
			100			
	1751			3515		

WORK SHEET - SPECIFIC GRAVITY TESTS

Project: Brown Engr. Co.	Job No. 651-003	Hole No. TP2	Date 5/21/67

SPECIFIC GRAVITY OF SOLIDS (G_s)

Sample No.			1	aT 3.0				
Flask No.			D.					
Temperature of Water and Soil, T, °C			22.5					
Pan No.								
Wt. in grams	Pan + Dry Soil		354.15					
	Pan		260.20					
	Dry Soil	W_s	93.95					
	Flask + Water at T, °C	W_{bw}	648.56					
	$W_s + W_{bw}$		742.51					
	Flask + Water + Immersed Soil	W_{bws}	708.20					
	Displaced Water, $W_s + W_{bw} - W_{bws}$		34.31					
Correction Factor		K	.9995					
$(W_s K) \div (W_s + W_{bw} - W_{bws})$		G_s	2.73					

APPARENT (G_a) AND BULK (G_m) SPECIFIC GRAVITY						Temp.	Corr. Factor
Sample No.						°C	K
Temperature of Water and Soil, T, °C						14	1.0010
Wt. in grams	Pan + Saturated Surface - Dry Soil					15	1.0009
	Tare Weight					16	1.0007
	Saturated Surface - Dry Soil	B				17	1.0006
	(Wire Basket + Soil) in Water					18	1.0004
	Wire Basket in Water					19	1.0002
	Saturated Soil in Water	C				20	1.0000
	Tare Weight + Dry Soil					21	0.9998
	Tare Weight					22	0.9996
	Dry Soil	A				23	0.9993
Correction Factor		K				24	0.9991
(AK) ÷ (A-C) (Apparent)		G_a				25	0.9988
(AK) ÷ (B-C) (Bulk)		G_m				26	0.9985
Remarks: ML - Fill						27	0.9983
						28	0.9980
						29	0.9977
						30	0.9974
						31	0.9971

VI-70

Tested by: BC	Computed by: BC	Checked by: [illegible]

ATTACHMENT E

SUPPLEMENTARY MOISTURE - DENSITY TESTS

MOISTURE AND DENSITY DETERMINATIONS

DAMES & MOORE

CLIENT BAUER ENGINEERING　　JOB NO. 5551-003

LOCATION ORANGE COUNTY, VIRGINIA　　

SAMPLE & SOIL TYPE	BORING	1	1	1	1	2	2	2
	SAMPLE NO.	1B	4A	5A	5B	1A	1C	3A
	SAMPLE DEPTH	1.5	8.5	10.0	11.0	1.5	2.0	7.0
	DATE SAMPLED BY JAR	5-12						↑
	DATE TESTED BY MRB	5-17						↑
	SOIL TYPE							
	LABORATORY IDENTIFICATION							
DENSITY	NO. OF RINGS	6	6	4	3	THIN WALL HEIGHT=5.00"	3	4
	WT. OF WET SOIL & RINGS	1141	1131	747	598		542	721
	WT. OF RINGS	270	270	180	135	—	135	180
	WT. OF WET SOIL					743.5		
	WET DENSITY (LBS./CU.FT.)	120.9	119.5	118.0	128.4	123.2	112.8	112.4
	DRY DENSITY (LBS./CU.FT.)	97	95	94	107	101	88	91
MOISTURE CONTENT	DISH NO.	25	V	P	IV	26	24	2-13
	WT. OF WET SOIL & DISH	180.1	157.5	151.0	167.9	144.5	132.0	149.9
	WT. OF DRY SOIL & DISH	149.0	130.0	125.5	144.0	122.2	107.5	124.5
	NET LOSS OF MOISTURE	31.1	27.5	25.5	23.9	22.3	24.5	25.4
	WT. OF DISH	22.5	24.4	24.3	24.5	22.4	22.4	20.3
	WT. OF DRY SOIL	126.5	105.6	101.2	119.5	99.8	85.1	104.2
	MOISTURE CONTENT (% DRY WT.)	24.7	26.0	25.2	20.0	22.4	28.8	24.4

797.4 (9-62)

DAMES & MOORE

CLIENT ....

LOCATION ....

JOB NO. 5651-003

SAMPLE & SOIL TYPE	BORING	2	2	2	3	3	3	3	3
	SAMPLE NO.	4	5A	5B	1B	2A	3A	3B	4B
	SAMPLE DEPTH	9.0	11.5	11.7	1.0	3.5	6.5	6.8	8.5
	DATE SAMPLED BY JBR	5-12							
	DATE TESTED BY MRB	5-17							
	SOIL TYPE								
	LABORATORY IDENTIFICATION								
DENSITY	NO. OF RINGS	5	6	4	4	2	6	4	3
	WT. OF WET SOIL & RINGS	912	1231	728	722	381	1203	737	585
	WT. OF RINGS	225	270	180	180	90	270	180	135
	WT. OF WET SOIL								
	WET DENSITY (LBS./CU.FT.)	114.3	133.3	114.0	112.8	120.9	129.5	116.0	124.8
	DRY DENSITY (LBS./CU.FT.)	93	101	86	94	101	108	96	113
MOISTURE CONTENT	DISH NO.	Z-10	4	V	20	N	18	G	17
	WT. OF WET SOIL & DISH	133.5	137.5	171.9	155.9	152.0	164.3	135.1	143.8
	WT. OF DRY SOIL & DISH	111.9	109.0	135.0	133.5	131.0	139.9	115.5	132.2
	NET LOSS OF MOISTURE	21.6	28.5	36.9	22.4	21.0	24.4	19.6	11.6
	WT. OF DISH	21.0	21.5	24.5	20.9	24.7	21.5	21.8	22.3
	WT. OF DRY SOIL	90.9	87.5	110.5	112.6	106.3	118.4	93.7	109.9
	MOISTURE CONTENT (% DRY WT.)	23.8	32.6	33.4	19.9	19.8	20.6	20.9	10.1

737.4 (9-62)

MOISTURE AND DENSITY DETERMINATIONS

DAMES & MOORE

CLIENT .... JOB NO. 5651-003

LOCATION .... PAGE 3 OF 3

SAMPLE & SOIL TYPE	BORING	3	3	3	3	3	3	3	
	SAMPLE NO.	5	6B	8A	8B	9A	9B	10	
	SAMPLE DEPTH	11.0	14.0	18.5	18.7	21.0	21.4	22.0	
	DATE SAMPLED BY JBR	5-12	→	→	→	→	→	→	
	DATE TESTED BY MRB	5-17	→	→	→	→	→	→	
	SOIL TYPE								
	LABORATORY IDENTIFICATION								
DENSITY	NO. OF RINGS	2	3	6	4	5	4	6	
	WT. OF WET SOIL & RINGS	373	598	1190	742	1026	816	1267	
	WT. OF RINGS	90	135	270	180	225	180	270	
	WT. OF WET SOIL								
	WET DENSITY (LBS./CU.FT.)	117.5	128.5	127.4	116.8	133.2	132.3	138.3	
	DRY DENSITY (LBS./CU.FT.)	96	105	104	97	116	115	121	
MOISTURE CONTENT	DISH NO.	M	W	III	I	VIII	E	8	
	WT. OF WET SOIL & DISH	140.5	111.2	165.0	153.1	176.9	172.9	155.0	
	WT. OF DRY SOIL & DISH	119.3	95.5	139.2	131.1	157.5	153.2	139.5	
	NET LOSS OF MOISTURE	21.2	15.7	25.8	22.0	19.4	19.7	16.5	
	WT. OF DISH	25.4	24.2	25.0	25.0	25.2	21.6	22.2	
	WT. OF DRY SOIL	93.9	71.3	114.2	106.1	132.3	131.6	117.3	
	MOISTURE CONTENT (% DRY WT.)	22.6	22.1	22.6	20.8	14.5	14.9	14.1	

757.4 (9-62)

ATTACHMENT F

COMPACTION TEST DATA

AASHO T 180-57

F-1

COMPACTION TEST DATA

AASHO T 180-57

TEST PIT 1 @ A DEPTH OF 8.0 FEET

IN-SITU MOISTURE CONTENT = 24.1%

DRY DENSITY LBS./CU. FT.	MOISTURE CONTENT PERCENT
104.2	7.2
111.8	11.4
113.1	13.0
113.6	14.4
113.4	15.0
111.2	17.3
98.7	24.1
93.8	26.9

TEST PIT 2 @ A DEPTH OF 6.0 FEET

IN-SITU MOISTURE CONTENT = 16.3%

DRY DENSITY LBS./CU. FT.	MOISTURE CONTENT PERCENT
107.6	6.0
111.0	8.4
113.7	11.4
114.1	13.1
113.0	15.5
106.9	19.9

COMPACTION TEST DATA (CONT'D.)

AASHO T 180-57

BORROW AREA

IN-SITU MOISTURE CONTENT - NOT DETERMINED

DRY DENSITY LBS./CU. FT.	MOISTURE CONTENT PERCENT
114.0	9.5
115.2	12.0
115.3	12.8
113.8	15.5
108.4	17.9

ATTACHMENT G

ATTERBERG LIMITS AND GRAIN SIZE ANALYSES

ATTERBERG LIMITS

LOCATION	DEPTH FEET	LIQUID LIMIT PERCENT	PLASTIC LIMIT PERCENT	PLASTICITY INDEX
Boring 1	1.5	47	41	6
Boring 2	4.5	42	34	8
Boring 2	7.0	44	36	8
Boring 3	6.5	41	38	3
Boring 3	13.5	37	32	5
Boring 3	18.5	42	34	8
Test Pit 1	8.0	43	35	8
Test Pit 2	6.0	36	35	1
Borrow Area	---	34	32	2

GRAIN SIZE ANALYSES

LOCATION		Boring 2	Boring 3
DEPTH - FEET		4.5	13.5
U.S. STANDARD SIEVE SIZE	SIEVE OPENING MM	PERCENT FINER BY WEIGHT	PERCENT FINER BY WEIGHT
No. 10	2.00	100.0	100.0
No. 16	1.19	96.4	96.9
No. 20	0.841	94.6	95.1
No. 40	0.420	89.5	89.6
No. 50	0.297	86.8	86.1
No. 60	0.250	85.7	84.9
No. 100	0.149	81.0	80.2
No. 140	0.105	77.1	77.1
No. 200	0.074	73.6	74.4
No. 325	0.044	67.2	70.4
----	0.020	34.9	30.7
----	0.005	9.1	5.1
----	0.001	0.1	1.2

GRAIN SIZE ANALYSES

LOCATION		Test Pit 1	Test Pit 2	Borrow Area
DEPTH - FEET		8.0	6.0	-----
U.S. STANDARD SIEVE SIZE	SIEVE OPENING MM	PERCENT FINER BY WEIGHT	PERCENT FINER BY WEIGHT	PERCENT FINER BY WEIGHT
No. 10	2.00	100.0	100.0	100.0
No. 16	1.19	97.2	96.3	97.2
No. 20	0.841	95.0	92.4	93.8
No. 40	0.420	90.0	82.7	81.5
No. 50	0.297	87.1	78.1	75.2
No. 60	0.250	85.7	76.1	72.7
No. 100	0.149	79.8	69.9	65.3
No. 140	0.105	75.0	67.6	61.1
No. 200	0.074	71.2	64.3	58.7
No. 325	0.044	65.9	57.1	50.7
-----	0.020	38.2	24.6	18.2
-----	0.005	11.3	2.3	1.1
-----	0.001	0.2	0.1	0.0

APPENDIX VII

STABILITY ANALYSIS

REPORT - SOILS ENGINEERING SERVICES

PROPOSED DAM - LAKE OF THE WOODS RESERVOIR
ORANGE COUNTY, VIRGINIA

FOR

BAUER ENGINEERING, INC.

5651-002-07

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

ATLANTA · NEW YORK · CHICAGO · PORTLAND · HONOLULU · SALT LAKE CITY · HOUSTON · SAN FRANCISCO · LOS ANGELES · SEATTLE · WASHINGTON D.C.
MADRID, SPAIN · SAINT JOHN N.B. CANADA · TEHERAN, IRAN

309 WEST JACKSON BOULEVARD · CHICAGO, ILLINOIS 60606 · 312-922-1772
PARTNERS: JAMES B. THOMPSON · GEORGE D. LEAL
ASSOCIATE: WILLIAM G. PARATORE

January 31, 1967

Bauer Engineering, Inc.
20 North Wacker Drive
Chicago, Illinois 60606

Attention: Mr. William J. Bauer

Gentlemen:

Report - Soils Engineering Services
Proposed Dam - Lake of the Woods Reservoir
Orange County, Virginia
For Bauer Engineering, Inc.

This letter presents the results of our Soils Engineering Services performed in connection with the Proposed Dam - Lake of the Woods Reservoir to be constructed in Orange County, Virginia.

The scope of our Soils Engineering Services was planned in collaboration with Messrs. William J. Bauer and Robert L. Hall of Bauer Engineering, Inc. Soil strength parameters of proposed fill soils were provided to Bauer Engineering, Inc. on January 11, 1967. The results of our stability analyses were provided on January 12, 1967. An estimated coefficient of permeability equal to 0.2 feet per year for Material II compacted to 90 percent of the maximum dry density as determined in accordance with the AASHO T 180-57 Method of Compaction, was provided on January 23, 1967.

CABLE ADDRESS: DAMEMORE

The scope of our soils engineering services was as follows:

1 - The performance of laboratory tests to determine the strength characteristics of the remoulded compacted fill soils to be used to construct the Proposed Dam. The compacted fill soils were evaluated at the following density criteria: (a) 90 percent of the maximum dry density as determined in accordance with AASHO T 180-57 Method of Compaction, (b) 95 percent of the maximum dry density as determined in accordance with the ASTM D 698 Method of Compaction, and (c) 90 percent of the maximum dry density as determined in accordance with ASTM D 698 Method of Compaction. The laboratory strength tests consisted of triaxial tests and direct shear tests.

2 - Engineering analyses to evaluate the stability of two proposed dam embankments. One dam embankment is to consist entirely of soil compacted to 90 percent of the maximum dry density as determined in accordance with the AASHO T 180-57 Method of Compaction. The other embankment, as proposed by the Contractor, is to consist of a core approximately 50 feet wide, located near the center of the dam, compacted to 95 percent of the maximum dry density as determined in accordance with ASTM D 698 Method of Compaction. The soil to be placed on each side of the core will be compacted to 90 percent of the maximum dry density as determined in accordance with ASTM D 698 Method of Compaction. Both proposed embankments will have an upstream slope of one vertical to four horizontal and a downstream slope of one vertical to three horizontal.

3 - Additional engineering analyses, if required, for the proposed embankment consisting entirely of soil compacted to 90 percent of the maximum dry density as determined in accordance with AASHO T 180-57 Method of Compaction will be performed to determine the optimum design cross section with respect to slope stability and economy of known materials.

INTRODUCTION:

Representative bulk samples of the proposed borrow materials were obtained by our field engineer on December 20, 1966 from test pits excavated in the Proposed Borrow Pit. Test pit locations were established by Bauer Engineering, Inc.

The soil profile in the Proposed Borrow Pit area is similar to the soil profiles presented in our "Report of Soil Exploration, Proposed Dam - Lake of the Woods Reservoir, Orange County, Virginia for Bauer Engineering, Inc." dated October 21, 1966. The soils are residual in origin and were derived from the weathering of gneisses, schists, and other metamorphic rocks. The Proposed Borrow Pit is blanketed by topsoil and the topsoil is underlain by reddish brown silty clays, clayey silts, and silts with sand and clay which in turn are underlain by brown and gray sandy silts and sandy clays.

From visual inspection of the test pits and inspection of bulk samples in the laboratory, it was determined that the soils in the Proposed Borrow Pit consist essentially of three soil types. The three soil types and the coordinates of the respective test pits and depths at which bulk samples of the three soil types were obtained are as follows:

	SOIL TYPE	COORDINATE OF TEST PITS	GROUND SURFACE ELEVATION AT TEST PIT (FEET)	DEPTH OF BULK SAMPLE (FEET)
MATERIAL I	Reddish Brown Clayey Silt	K + 60 13 + 20	292	6
MATERIAL II	Reddish Brown Silt with Sand and Clay	K + 60 13 + 20	292	11.5
MATERIAL III	Brown Sandy Clay	L + 30 15 + 80	307	8

LABORATORY TESTS:

Two compaction tests were performed on each of the three soil types. One compaction test was performed in accordance with the AASHO T 180-57 Method of Compaction, and the second compaction test was performed in accordance with the ASTM D 698 Method of Compaction.

Remoulded samples of each soil type, compacted to 90 percent of the maximum dry density as determined in accordance with the AASHO T 180-57 Method of Compaction and to 95 percent and 90 percent of the maximum dry density as determined in accordance with the ASTM D 698 Method of Compaction, were then subjected to strength tests. The strength tests consisted of direct shear tests and undrained triaxial tests. The strength tests were performed on remoulded samples having a moisture content approximately equal to the anticipated fill moisture content at the time of placement and compaction of the fill and on saturated or near-saturated remoulded samples.

The Atterberg limits were determined for Materials I and II. Specific gravity determinations were performed on all three soil types and a grain size analysis was performed on Material II.

Laboratory test results are presented on Plates 1 and 2.

STABILITY ANALYSES:

Stability analyses were performed on the two proposed dam embankments. For each of the proposed dam embankments the stabilities of both upstream and downstream slopes were evaluated. The strength parameters used in the stability analyses were those of Material II. It is considered that the Proposed Dam will consist primarily of Material I and Material II. Material II has the lowest strength parameters of the three predominant soil types encountered in the Proposed Borrow Pit. It was judged advisable by Dames & Moore and Bauer Engineering, Inc. to use the lower of the strength parameters in the stability analyses. The phreatic line in both of the proposed dam embankments was assumed, for purposes of stability analyses, to be a straight line from the water level on the upstream slope to the filter drain. This assumption is based on a filter drain that is performing adequately. The soil on both the upstream and downstream slopes was assumed to be saturated. The proposed dam site is in a seismically active area and an earthquake loading equal to five percent of the acceleration due to gravity was utilized in the stability analyses.

The results of the stability analyses on the proposed homogeneous dam embankment consisting entirely of soil compacted to 90 percent of the maximum dry density as determined in accordance with the AASHO T 180-57 Method of Compaction are shown on Plate 3. The parameters of the foundation soil immediately underlying the dam embankment were assumed.

The results of the stability analyses on the proposed alternate dam embankment, as proposed by the Contractor, are shown on Plate 4.

This embankment contains a core approximately 50 feet wide compacted to 95 percent of the maximum dry density as determined in accordance with the ASTM D 698 Method of Compaction to 90 percent of the maximum dry density as determined in accordance with the ASTM D 698 Method of Compaction. Material II when compacted to 90 percent of the ASTM D 698 maximum dry density has a cohesion equal to zero and an angle of internal friction which is less than the slope angles of the embankment. Thus the side slopes of the embankment, as proposed by the Contractor, are unstable.

--o0o--

The following Plates are attached and complete this report:

Plate 1 - Summary of Laboratory Test Data

Plate 2 - Gradation Curve of Material II

Plate 3 - Results of Stability Analyses of Homogeneous Dam Embankment

Plate 4 - Results of Stability Analyses of Proposed Alternate Dam Embankment.

Yours very truly,

DAMES & MOORE

William G. Paratore

James B. Thompson

WGP:JBT:DGS:ac
Ten Copies Submitted

MATERIAL I						119	36	400	15
[illegible]	97.2 PCF & 28.6 %	84.7 PCF & 31.4 %	30 - 80	83*	80.6	1 109	35	600	23
T-56						2 114	41	300	11
INDEX-13				78**	75.8	1 102	35	400	22
...AVITY - 2.79						2 111	47	200	8
MATERIAL II				90	82.5	1 110	34	750	29
						2 115	40	200	20
BROWN ...AND & CLAY	91.6 PCF & 27.8 %	79.1 PCF & 35.0 %	35-80	82*	75.1	1 105	40	500	24
...T-53 ...INDEX-6 ...RAVITY-2.79						2 110	47	100	15
				78**	71.5	1 100	41	350	21
						2 108	51	0	13
MATERIAL III				90	109.5	1 127	16	1200	26
						2 133	21	400	19
...N ...AY	121.6 PCF & 13.0 %	110.3 PCF & 15.6 %	20-30	86*	104.5	1 124	19	700	20
...GRAVITY-2.73						2 129	24	300	19
				82**	99.6	1 119	19	500	20
						2 126	27	200	19

* 95% ASTM D698
** 90% ASTM D1598

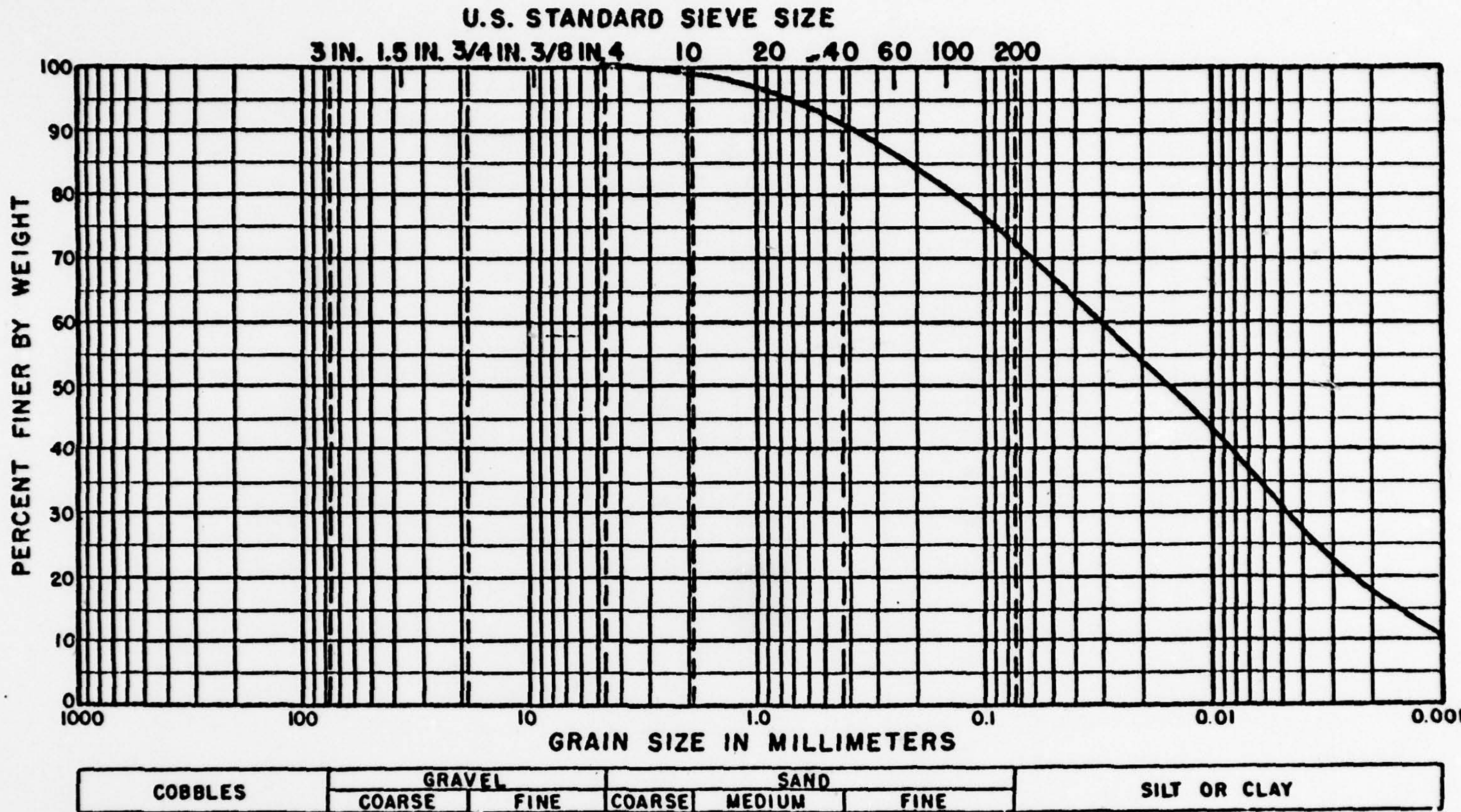
NOTES:
1 REFERS TO SOIL AT ANTICIPATED FIELD MOISTURE CONTENT
2 REFERS TO SATURATED SOIL

VII-7

SUMMARY OF LABORATORY TEST DATA

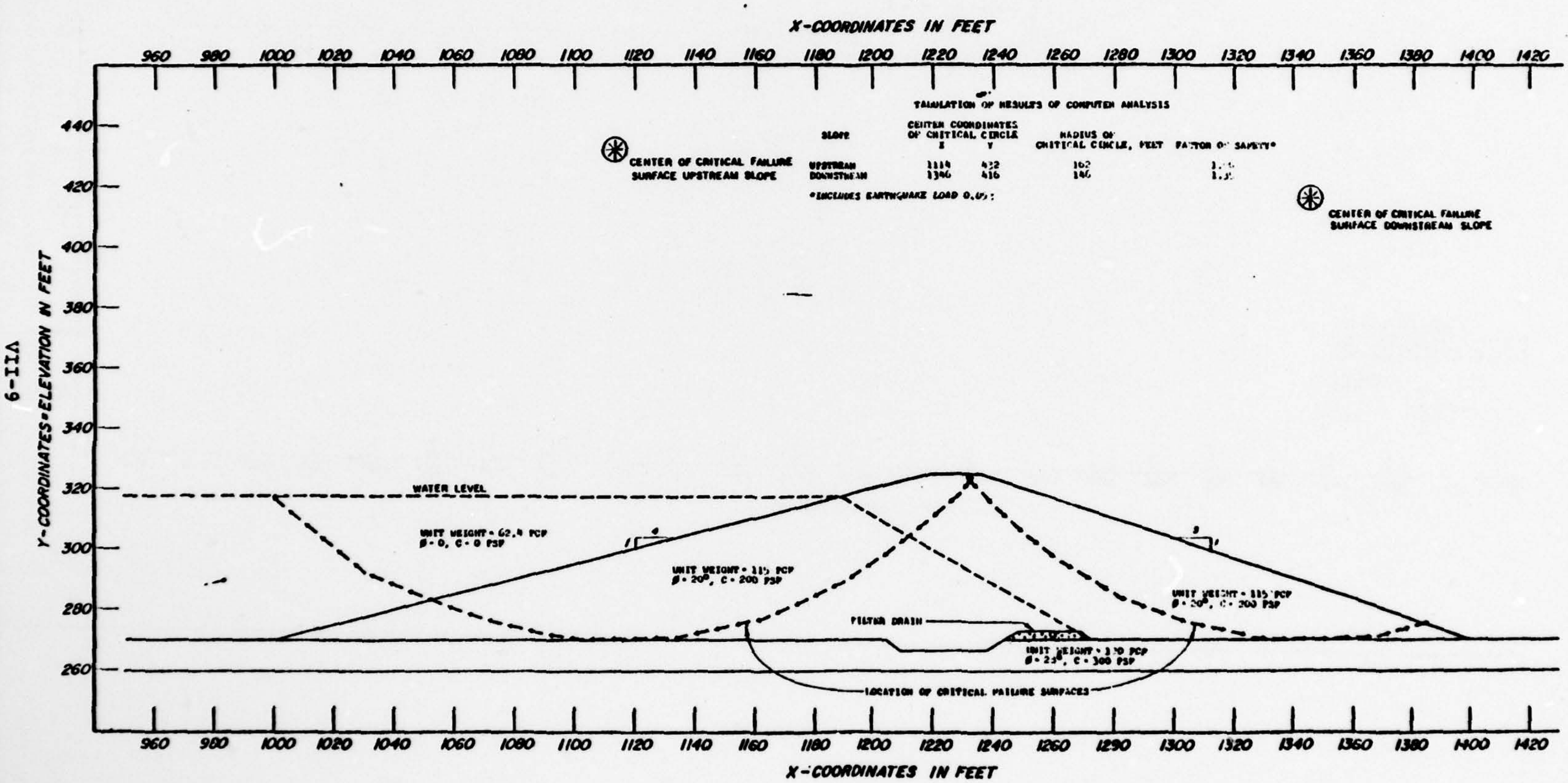
DAMES & MOORE

PLATE I



CLASSIFICATION	NAT. WC	LL	PL	PI
RD-BR SILT W/ SAND & CLAY	35-50	53	47	6

GRADATION CURVE FOR MATERIAL II



RESULTS OF STABILITY ANALYSES
OF HOMOGENEOUS DAM EMBANKMENT

PLATE 3

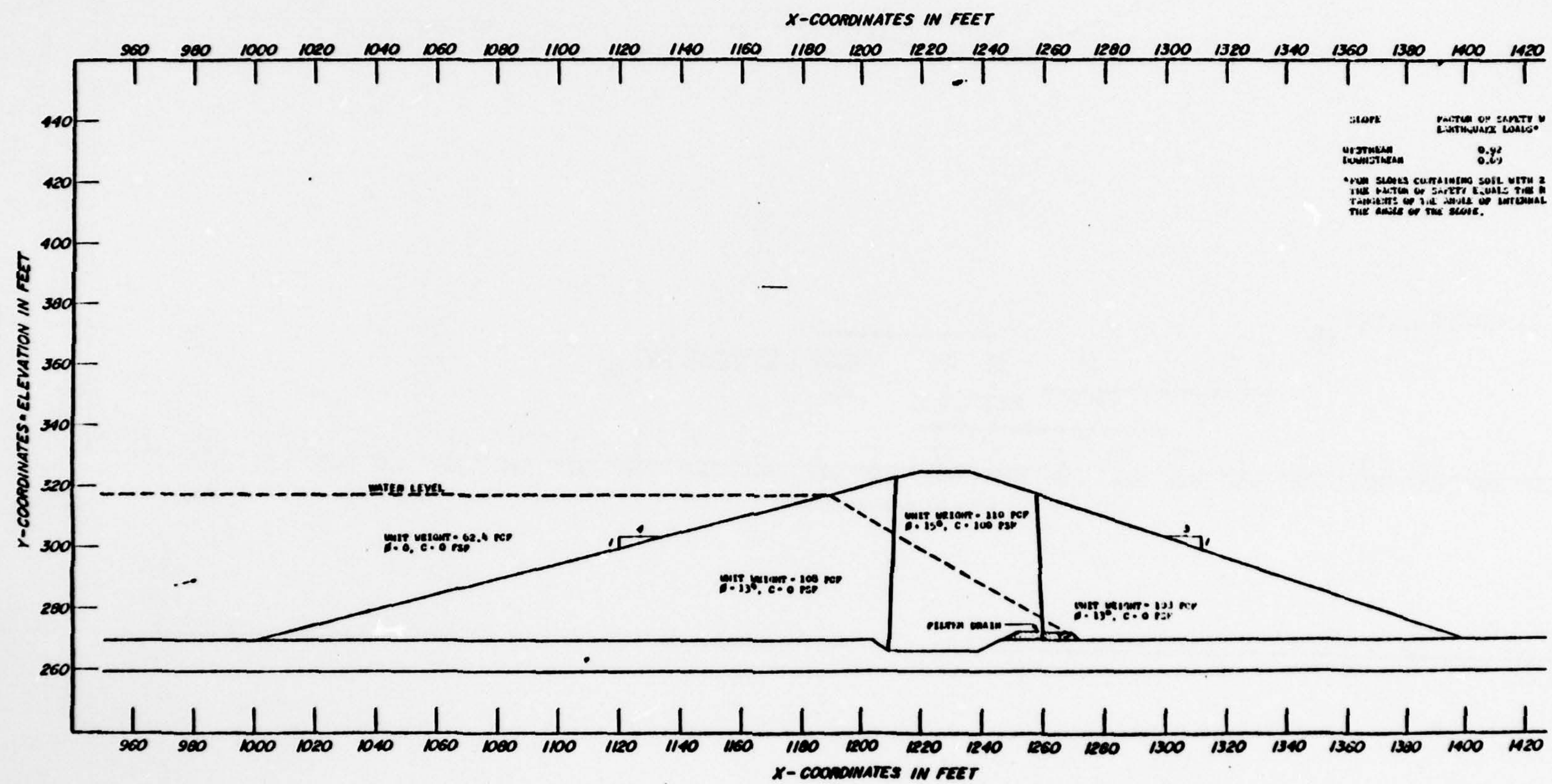


PLATE 4

VII-10

EMBANKMENT
RESULTS OF STABILITY ANALYSES OF PROPOSED ALTERNATE DAM A

The purpose of this standard is to pull together the materials developed over a period of time regarding the design of earth dams as far as the stability of the slopes is concerned. Until superseded by another standard covering the same subject, this procedure will be used in the analysis of all earth dams which fall within the scope of this procedure.

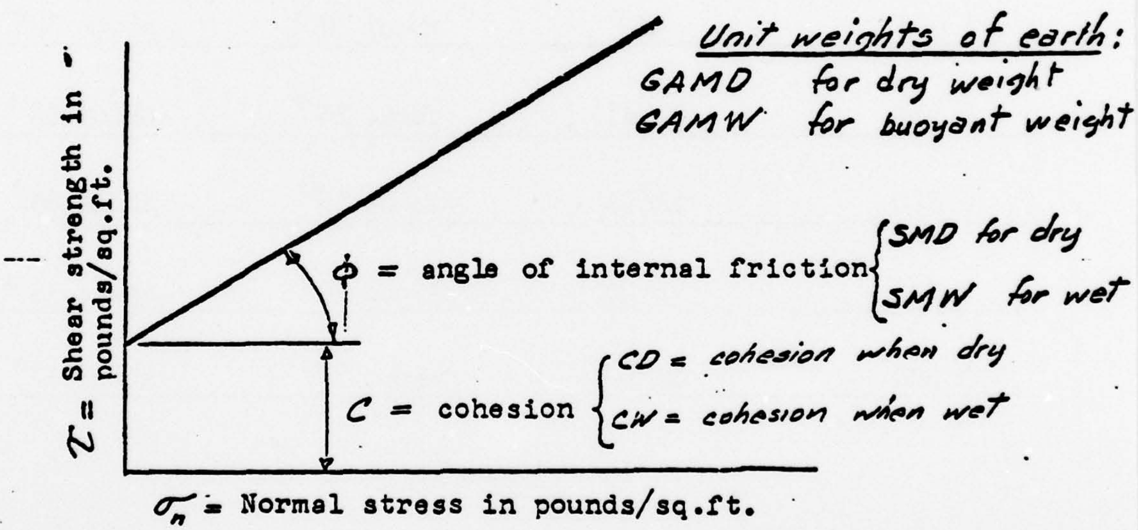
Scope

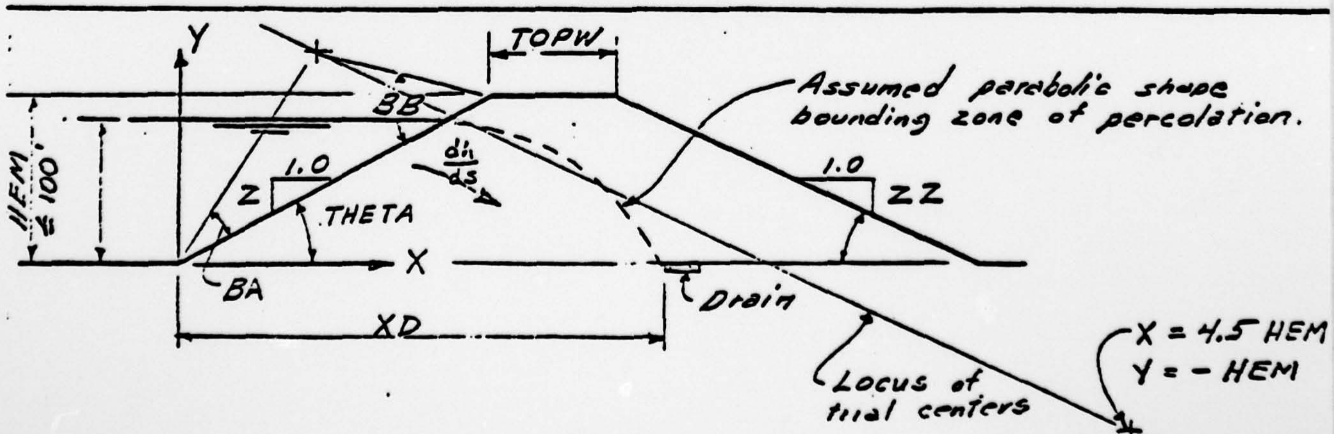
This standard procedure covers dams under 100' in height with the following characteristics:

1. The upstream and downstream slopes are uniform and approximately equal.

2. The foundation material is at least equal in strength to the compacted material comprising the embankment.

3. The strength of the material in shear may be described as a straight-line plot on a diagram as follows:





DEFINITION SKETCH

Locus of Trial Centers

The location of the center of the slip circle of least Factor of Safety may be estimated with the aid of the Locus of Trial Centers shown on the Definition Sketch, which was obtained from Jumikis, Soil Mechanics, page 698. The values of angles BA and BB are estimated with the aid of the following table:

Z	THETA	BA	BB
1.732	60°	about 29°	about 40°
1.000	45°	about 28°	about 38°
0.667	33°41'	about 26°	about 35°
0.500	25°34'	about 25°	about 35°
0.333	18°26'	about 25°	about 35°
0.200	11°19'	about 25°	about 37°

Seismic Factor

The horizontal acceleration is the primary factor to be considered. The ratio of this acceleration to the acceleration of gravity is the Seismic Factor, or SEIF in the program. Commonly, SEIF = 0.10, and this value shall be used unless a particular earthquake history indicates a greater or lesser value to be appropriate.

The water waves set up by an earthquake are generally small. For example, the wave height resulting from SEIF = 0.1 with a period of 0.25 seconds is on the order of 0.1 to 0.2 foot for a dam 50 feet high. This effect is usually ignored in earth dam stability computations.

Assumptions

The following assumptions are made in this procedure for small earth dams:

1. The piezometric gradient of internal pore pressure indicated on the Definition Sketch of page 1 as dh/ds is ignored. This is a substantial stabilizing force which would ordinarily be taken into account in designing higher dams. However, for dams under 100 feet in height, it may be safely ignored in the interests of conservatism and simplified design.

2. No cracks are assumed to exist. The embankment is considered to be homogeneous.

3. There is no problem of rapid drawdown, which is not more than compensated for by ignoring the dh/ds as explained in 1. preceding.

Computer Program

The following pages give the steps in the computer program:

BAUER ENGINEERING INC. CHICAGO	SUBJECT: Earth Dams: Stability	PROJECT: Design Standard
	COMPUTED: Bauer CHECKED:	FILE No. DATE: 4-5-67 PAGE 5 OF PAGES

```
          NUMBER
     CF   PROGRAM DAMSTA
          DIMENSION X(20),Y(20),FS(20),XF12(50),YF1(50),YF2(50)
     CF   READ 0,HEM,Z,TOPW,XD,ZZ,BA,BB,SMD,SMW,CD,CW,GAMD,GAMW
          THETA=ATAN(Z)
          BAR=BA/57.295779
          BBR=BB/57.295779
          ANGO=3.1415926-THETA-BAR-BBR
          S1=HEM/SIN(THETA)
          S2=S1*SIN(BAR)/SIN(ANGO)
          X0=S1*COS(THETA)-S2*COS(BBR)
          Y0=S1*SIN(THETA)+S2*SIN(BBR)
          PLM=(HEM+Y0)/(X0-4.5*HEM)
          ALB=Y0+X0*(Y0+HEM)/(4.5*HEM-X0)
          XLIM=HEM/Z+TOPW
     CF   READ 0,N,HW,DELX
     CF   READ 0,M,SFIF
          AM=M
          MM=M+1
          HWF=HW-0.767*SFIF*SFIF*HEM
          PRINT 4,HEM,TOPW,Z
          PRINT 8
          PRINT 5,GAMD,CD,SMD
          PRINT 9
          PRINT 5,GAMW,CW,SMW
          PRINT 11
          PRINT 7,HW,SFIF
          PRINT 6,X0,Y0
          PRINT 1
          DO 28 I=1,N
          AI=I
          X(I)=X0-AI*DELX
          Y(I)=Y0-AI*DELX*PLM
          R=X(I)**2+Y(I)**2
          R=SQRT(R)
          TEMP1=X(I)/R
          TEMP2=ABS(TEMP1)
          IF(TEMP1)20,30,30
       20 ANGI=ARSIN(TEMP2)
          GO TO 40
       30 ANGI=-(ARSIN(TEMP2))
       40 ALPHA=ARCOS((Y(I)-HEM)/R)-ANGI
          DELANG=ALPHA/AM
          ANGH=DELANG/2.
          DIST=DELANG*R
          XF12(1)=0.
          YF1(1)=0.
          YF2(1)=0.
          PHI=ANGI
```

BAUER ENGINEERING INC. CHICAGO	SUBJECT: Earth Dams: Stability	PROJECT: Design Standard
	COMPUTED: Bauer CHECKED:	FILE NO. DATE: 4-5-67 PAGE 6 OF PAGES

```
      SUMM=0.
      SUMW=0.
      SUMD=0.

      SUMT=0.
      DO 26 J=2,MM
      PHI=PHI+DFLANG
      XF12(J)=R*SIN(PHI)+X(I)
      YF1(J)=Y(I)-R*COS(PHI)
      YF2(J)=YF2(J-1)+(XF12(J)-XF12(J-1))*Z
      X1=HW/Z
      XX=(XF12(J)+XF12(J-1))/2.
      YY=(XX-X1)/(XD-X1)
      HWJ=HW*(1.-YY*YY)
      IF(XX-X1)45,45,46
   45 HWJ=HW
   46 IF(YF2(J)-UEM)60,60,50
   50 IF(XF12(J)-XLIM)52,52,54
   52 YF2(J)=UEM
      GO TO 60
   54 YF2(J)=UEM-(XF12(J)-XLIM)*Z
   60 YY1=(YF1(J-1)+YF1(J))/2.
      YY2=(YF2(J-1)+YF2(J))/2.
      YDRY=YY2-HWJ
      YWET=HWJ-YY1
      IF(YWET)70,70,80
   70 YWET=0.
      YDRY=YY2-YY1
      YW=Y(I)-YY1
      YD=Y(I)-YY1-YDRY/2.
      GO TO 199
   80 IF(YDRY)90,90,140
   90 YDRY=0.
      YWET=YY2-YY1
      YW=Y(I)-YY2+YWET/2.
      YD=Y(I)-YY2
      GO TO 199
  140 YW=Y(I)-YY1-YWET/2.
      YD=Y(I)-YY2+YDRY/2.
      YDRY=YY2-HWJ
      YWET=HWJ-YY1
```

```
199 WEITW=(XE12(J)-XE12(J-1))*YWET*GAMW
    WEITD=(XE12(J)-XE12(J-1))*YDRY*GAMD
    PHIC=PHI-ANGH
    PRES=(WEITD+WEITW)*(COS(PHIC)-SEIF*SIN(PHIC))
    PRES=PRES/DIST
    IF(PRES)170,175,175
170 PRES=0.
175 IF(YY1-HWJ)180,180,185
180 SUMT=SUMT+(CW+PRES*SMW)*DIST*R
    GO TO 190
185 SUMT=SUMT+(CD+PRES*SMD)*DIST*R
190 SUMW=SUMW+(WEITD+WEITW)*((XE12(J)+XE12(J-1))/2.-X(I))
    XX=HW-HWF
   0SUMD=31.2*XX*XX*(Y(I)-HW+2.*XX/3.)+31.2*XX*HWF*(Y(I)-HWF+2.*HWF/3.
   4)
    SUMH=SUMH+WEITW*YW*SEIF+WEITD*YD*SEIF
 26 CONTINUE
    FS(I)=SUMT/(SUMD+SUMH+SUMW)
 28 PRINT 2,X(I),Y(I),SUMT,SUMW,SUMD,SUMH,FS(I)
  1OFORMAT(//,90H        X              Y                    SUMT                 SUMW
  4        SUMD               SUMH           FS    )
  2 FORMAT(2F10.2,4F15.0,F10.3)


  40FORMAT(//,10X,20HHEIGHT OF THE DAM =   ,F11.1,3H FT/,10X,23HTOP WID
   1TH OF THE DAM =   ,F8.0,3H FT/,10X,19HSLOPE OF THE DAM =   ,F4.2,6H
   4TO 1.)
  8 FORMAT(/,10X,9HDRY SOIL;   )
  50FORMAT(10X,26HUNIT WEIGHT OF THE SOIL =    ,F11.2,9H LBS/CUFT  /,10
   1X,23HCOHESION OF THE SOIL =   ,F14.2,9H LBS/SQFT  /,10X,29HCOEF. OF
   4 INTERNAL FRICTION =    ,F10.4)
  9 FORMAT(10X,9HWET SOIL;   )
  60FORMAT(/,10X,71HCOORDINATE OF THE CENTER OF THE RUPTURE SURFACE FO
   4R PURE COHESIVE SOIL;  /,10X,4HX =   ,F12.2/,10X,4HY =   ,F12.2)
  70FORMAT(10X,14HWATER LEVEL =   ,F13.2,3H FT /,10X,17HSEISMIC FACTOR
   4=   ,F10.2)
 11 FORMAT()
    END
```

EXAMPLE FROM LAKE-OF-THE-WOODS - JOB # 6692

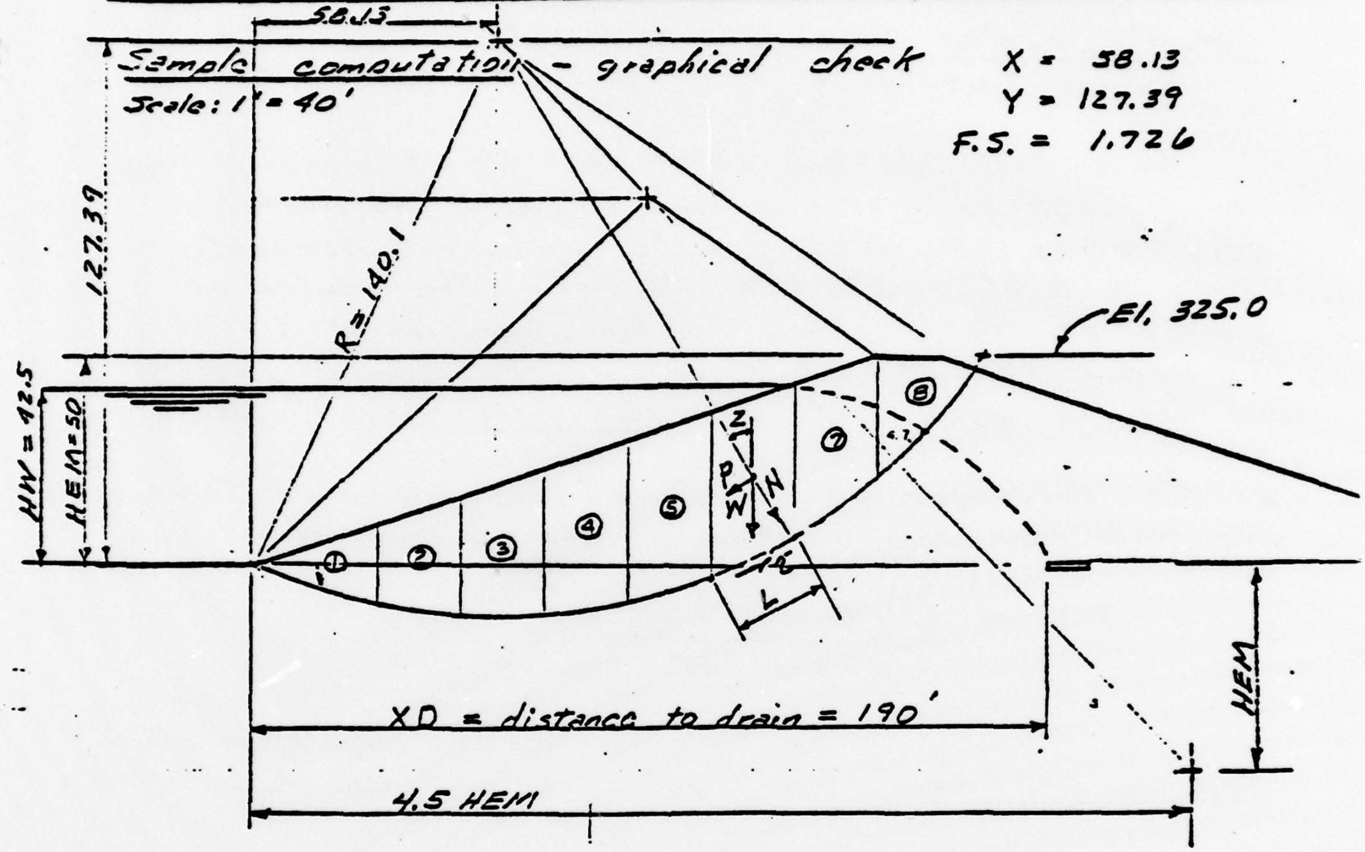
95% AASHO modified
Using the extrap. Value
Upstream: 1:3
(see pages 12 — 14
for selected
Design Values "A")

```
HEIGHT OF THE DAM =          50.0 FT
TOP WIDTH OF THE DAM =        15. FT
SLOPE OF THE DAM = 0.33 TO 1.

DRY SOIL;
UNIT WEIGHT OF THE SOIL =         115.00 LBS/CUFT
COHESION OF THE SOIL =            250.00 LBS/SQFT
COEF. OF INTERNAL FRICTION =        0.4245
WET SOIL;
UNIT WEIGHT OF THE SOIL =          52.60 LBS/CUFT
COHESION OF THE SOIL =            250.00 LBS/SQFT
COEF. OF INTERNAL FRICTION =        0.4245

WATER LEVEL =           42.50 FT
SEISMIC FACTOR =         0.05

COORDINATE OF THE CENTER OF THE RUPTURE SURFACE FOR PURE COHESIVE SOIL;
X =          94.13
Y =          89.12
```

X	Y	SUMT	SUMN	SUMD	SUMH	FS
88.13	95.50	36900281.	17815673.	10336.	2544168.	1.811
82.13	101.88	32594329.	15679281.	11147.	2286410.	1.813
76.13	108.26	29299423.	14824357.	11958.	2080345.	1.732
70.13	114.63	26095905.	12957792.	12769.	1854990.	1.760
64.13	121.01	23465008.	11809912.	13579.	1664365.	1.740
58.13	127.39	21261411.	10808177.	14390.	1494250.	1.726
52.13	133.77	19244232.	9599124.	15201.	1326845.	1.759
46.13	140.15	17505402.	8521606.	16012.	1174232.	1.802
40.13	146.53	15927407.	7344906.	16823.	1026531.	1.899
34.13	152.90	14564660.	6303823.	17034.	892784.	2.019

STATEMENT ENCOUNTERED DURING EXECUTION

BAUER ENGINEERING INC. CHICAGO	SUBJECT Earth Dams: Stability	PROJECT Design Standard
		FILE No.
	COMPUTED Bauer CHECKED	DATE 4-5-67 PAGE 9 OF PAGES



	Segment →	1	2	3	4	5	6	7	8
	ΔX	−38	−18	2	22	42	62	82	102
	ΔY	127	126	123	119	114	107	97	87
115	ΔP/ΔN	−.28/.95	−.14/1.00	0/1.00	.18/1.00	.34/.93	.50/.86	.64/.76	.76/.64
52.6	W	15.7*	25.0	33.0	39.0	41.5	40.0	40.7	36.0
	N	15.0	25.0	33.0	39.0	39.0	34.4	31.0	23.0
	P	−4.3	−3.5	0	7.0	14.0	20.0	26.5	27.5
	L	30	20	20	20	21	23	26	30
	250L = C	7.5	5.0	5.0	5.0	5.25	5.75	6.50	7.50
	$0.4245\,N = \tau_1$	6.4	10.6	14.0	16.5	16.5	14.60	13.20	9.70
	$C + \tau_1 = \tau$	13.9	15.6	19.0	21.5	21.75	20.35	19.70	17.30

$\Sigma P = -7.8 + 95 = 87.2$

$\Sigma \tau = 149.1$

$$F.S. = \frac{149.1 \times 140.1}{87.2 \times 125} = 1.92$$

Compare 1.957 in machine comp. with seismic factor = 0, p. 11

Seismic Factor - approximate analysis using preceding sample computation.

Note that the sum of W for the 8 slices is equal to 270.9 kips. Assuming a seismic horizontal acceleration of 0.05 g, the equivalent horizontal force = 0.05 x 270.9 = 13.54^K. The center of gravity of the 8 slices is by inspection at Y = 12, so arm = 127.39 - 12 = 115'. The moment produced is then the equivalent of $\frac{13.5 \times 115}{140.1} = 11.1^K$ placed at the perimeter of the circle. The Factor of Safety = F.S. resulting from the addition of the seismic effect is:

$$F.S. = \frac{(149.1 - 11.1)\ 140.1}{87.2 \times 125} = 1.77$$

Compare 1.726 from machine computation including seismic drawdown effect.

Seismic Drawdown

Line	α/g Seismic Factor	T Vibration Period	Δx Horizontal Movement	HEM Embankment Height	ΔHW Seismic Drawdown
1	0.10	0.25 sec.	0.012'	50'	0.13'
2	0.05	0.25 sec.	0.006'	50'	0.065'

Force = 25' x .065 x .0625 = 0.1^K - neglect.

AD-A073 631 BAKER (MICHAEL) JR INC BEAVER PA F/G 13/2
NATIONAL DAM SAFETY PROGRAM. LAKE OF THE WOODS, INVENTORY NUMBE--ETC(U)
MAR 79 M BAKER DACW65-78-D-0016

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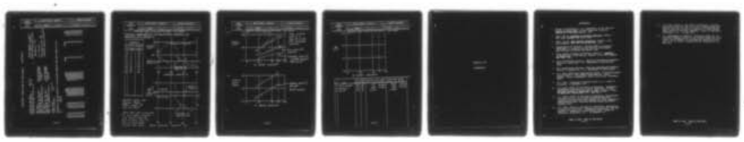

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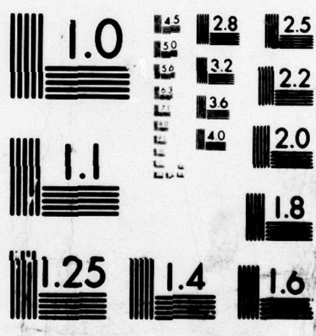

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

EXAMPLE FROM LAKE OF THE WOODS, JOB #6692

HEIGHT OF THE DAM = 50.0 FT
TOP WIDTH OF THE DAM = 15. FT
SLOPE OF THE DAM = 0.33 TO 1.

DRY SOIL;
UNIT WEIGHT OF THE SOIL = 115.00 LBS/CUFT
COHESION OF THE SOIL = 250.00 LBS/SQFT
COEF. OF INTERNAL FRICTION = 0.4245
WET SOIL;
UNIT WEIGHT OF THE SOIL = 52.60 LBS/CUFT
COHESION OF THE SOIL = 250.00 LBS/SQFT
COEF. OF INTERNAL FRICTION = 0.4245

WATER LEVEL = 42.50 FT
SEISMIC FACTOR = 0.

95% AASHO modified using extrapolated values
Upstream 1:3
no seismic.
(see pages 12-14 for selected design values "A")

COORDINATE OF THE CENTER OF THE RUPTURE SURFACE FOR PURE COHESIVE SOIL;
X = 94.13
Y = 89.12

X	Y	SUMT	SUMW	SUMD	SUMH	FS
88.13	95.50	37699266.	18590618.	0.	0.	2.028
82.13	101.88	33200767.	16173505.	0.	0.	2.053
76.13	108.26	29848563.	15300947.	0.	0.	1.951
70.13	114.64	26635390.	13553688.	0.	0.	1.965
64.13	121.01	23888076.	12189094.	0.	0.	1.960
58.13	127.39	21599294.	11039205.	0.	0.	1.957
52.13	133.77	19510907.	9729184.	0.	0.	2.005
46.13	140.15	17719382.	8587697.	0.	0.	2.063
40.13	146.53	16099470.	7375119.	0.	0.	2.183
34.13	152.91	14704565.	6313731.	0.	0.	2.329

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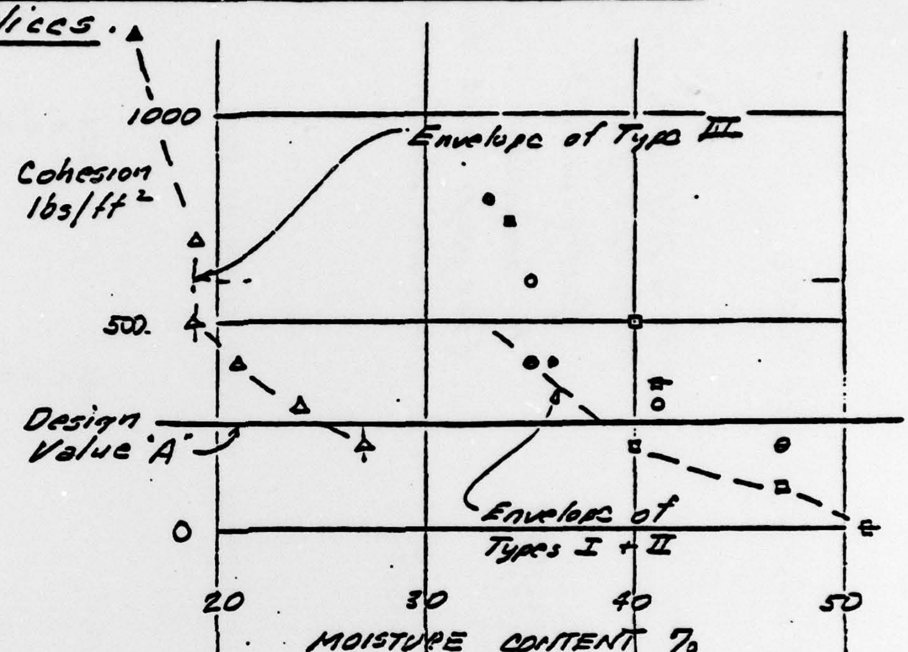
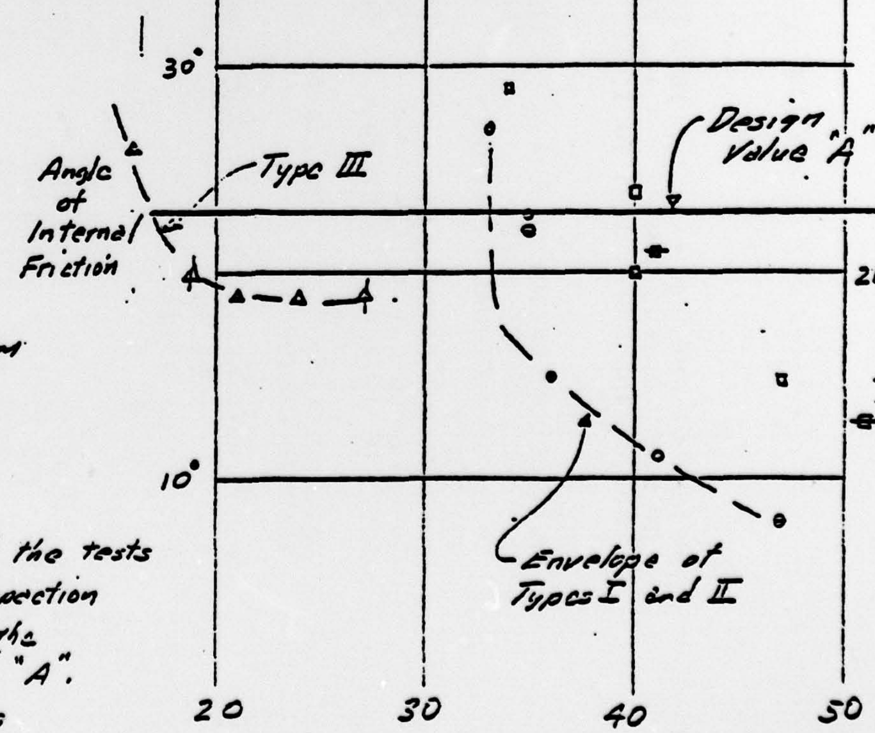
EXAMPLE FROM LAKE-OF-THE-WOODS - JOB #6692

Sample computation of earth-dam stability by method of slices.

LEGEND		
Symbol	SOIL TYPE	% COMP. AASHO
●	I	90
○	I	83
⊖	I	78
■	II	90
□	II	82
⊟	II	78
▲	III	90
△	III	86
⏃	III	82





Plotted points from Dames + Moore letter report of Jan. 31, 1967.

Note that most of the tests for 90% AASHO compaction give results above the levels of Design Value "A". Only saturated samples lie below these values.

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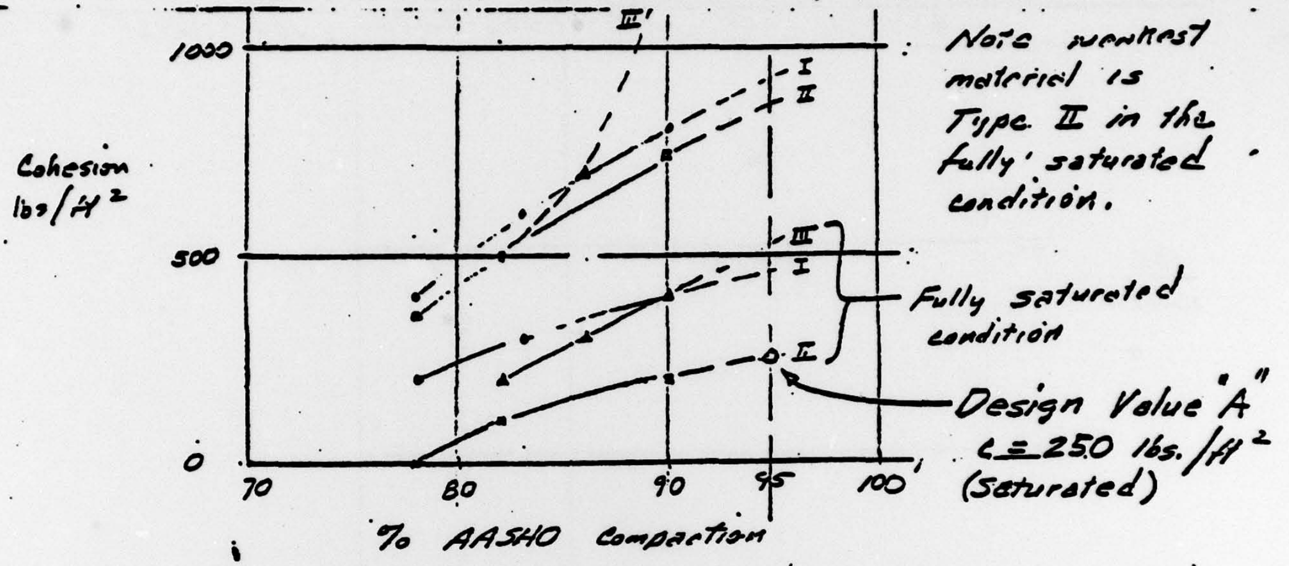
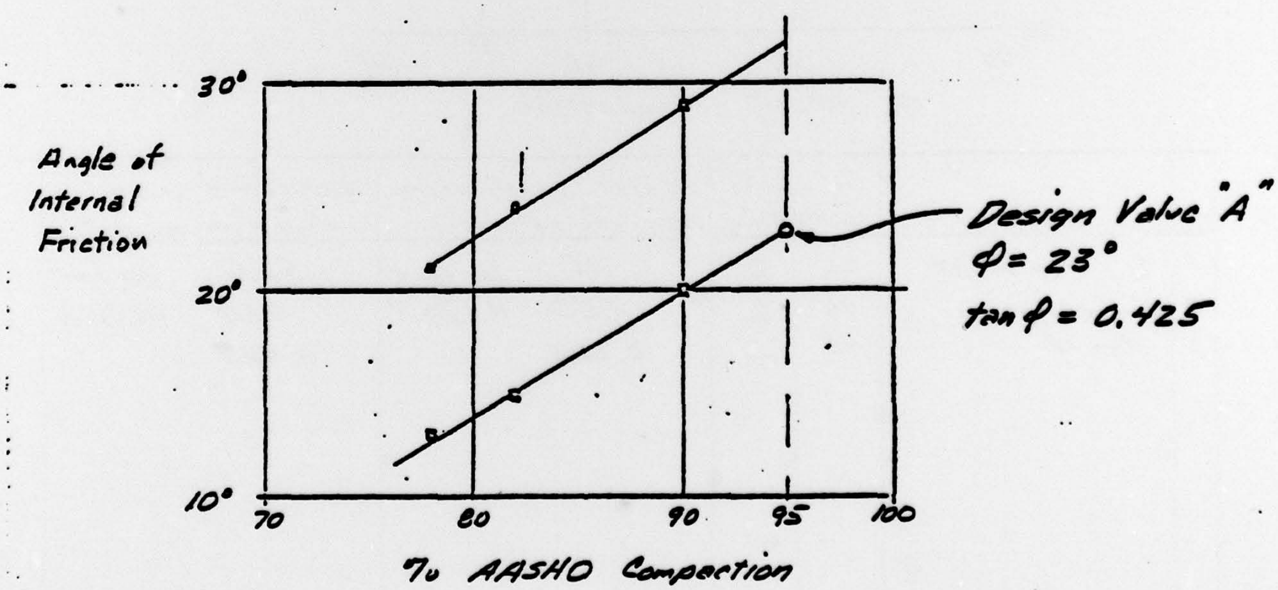
EXAMPLES FROM LAKE-OF-THE-WOODS, JOB # 6632





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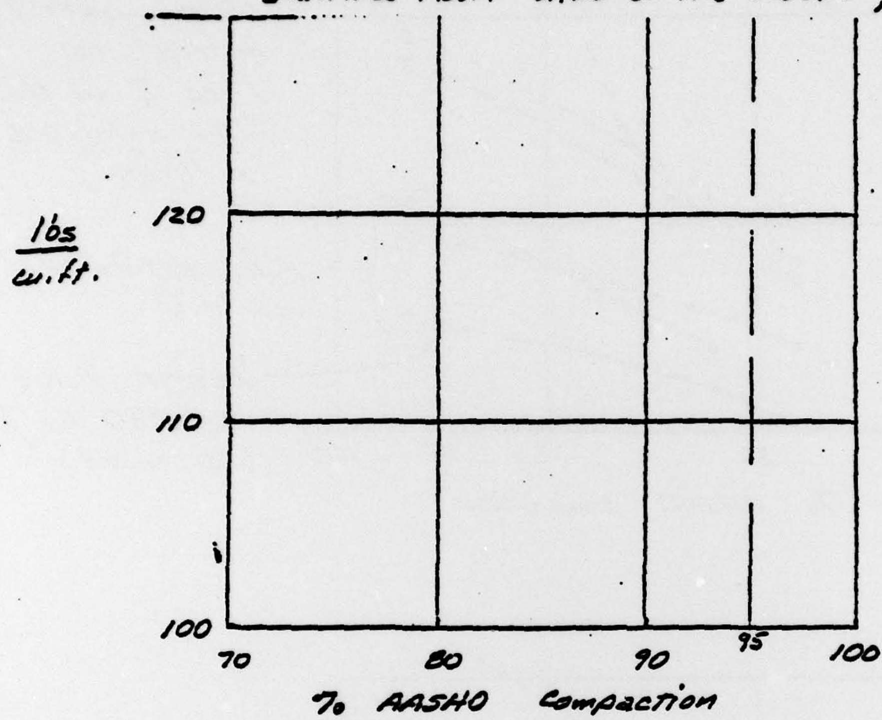
EXAMPLE FROM LAKE-OF-THE-WOODS, JOB #6692



#	Item	% AASHO	Soil Type	Moist earth above line of saturation		Saturated earth below line of sat.	
1	Unit weight	95	II	115	lbs./cu.ft	52.6	lbs./cu.ft
2	Cohesion	95	II	850	lbs./sq.ft.	250	lbs./sq.ft
3	Tan φ	95	II	0.625		0.425	

APPENDIX VIII

REFERENCES

REFERENCES

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