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NATIONAL DAM SAFETY PROGRAM. KEOKEE DAM (VA 10502), TENNESSEE R--ETC(U)
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1 OF 2
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TENNESSEE RIVER BASIN

Name Of Dam: KEOKEE DAM
Location: LEE COUNTY, VIRGINIA
Inventory Number: VA 10502

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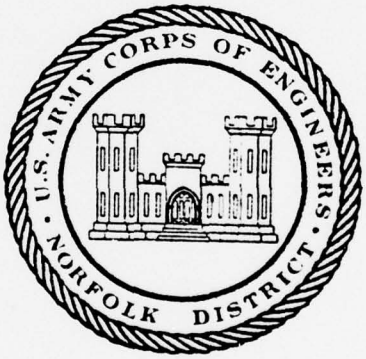
PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM



PREPARED FOR

NORFOLK DISTRICT CORPS OF ENGINEERS
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NORFOLK, VIRGINIA 23510

BY

GILBERT ASSOCIATES, INC.

AUGUST, 1978

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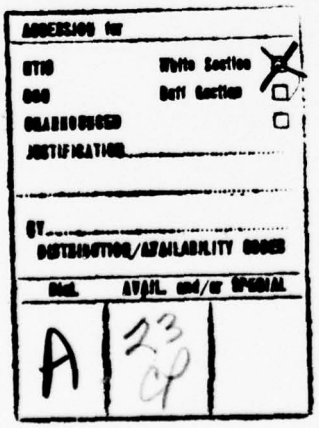
20. Abstract

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.



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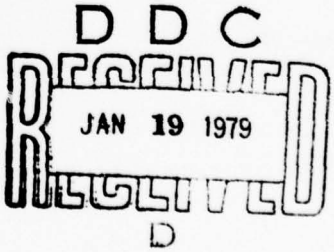

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name Of Dam:	Keokee
State:	Virginia
County:	Lee
USGS Quadrangle Sheet:	Big Stone Gap, Virginia
Stream:	North Fork, Powell River

This dam is a 50-foot high, 330-foot long homogeneous earth dam with a combination riser inlet and a 48-inch concrete pipe as a principal spillway. The emergency spillway is a separate structure consisting of a concrete slab placed on a natural saddle of the reservoir. The dam has been used for fishing since it was opened to the public in July of 1978. Based on the results of this Phase I inspection, the dam does not appear to pose an imminent hazard with the lowered reservoir but could pose a hazard under future conditions such as high runoff or partial or total blockage of the outlet structures. See Appendix VIII, Conditions.

The design spillway capacity of this dam will enable it to pass the probable maximum flood (PMF) without overtopping the dam. The design stability calculations were not available for this inspection. No visible signs of instability of the dam were observed. Excessive tree growth immediately downstream and in the approach channel of the emergency spillway should be removed within 30 days. An access road to the dam and emergency spillway should be constructed within 1 year for maintenance purposes. There has been a leak at the left abutment which the owner plans to seal. The reservoir has been lowered 5 feet to eliminate the flow at the leak. The repairs should be completed prior to permanently raising the reservoir level. In addition to the repairs, the effectiveness of the cutoff wall and the filter as well as the leakage potential and erodibility of the soils in the foundation and abutment areas should be studied in the next year. Many dead trees standing in the reservoir should be cut off some distance above the water and removed within six months. Since a 0.3 feet deep depression was noticed on the dam crest, it is recommended that in the next three months, a settlement survey of the dam crest be made by the owner. It is also recommended that in the next six months the owner develops a program of periodic maintenance for the dam and its appurtenances. Until such time as these recommendations are implemented, it is recommended that a warning system be furnished at this dam.

Prepared By:

APPROVED: Original signed by:
Douglas L. Haller

Douglas L. Haller
Colonel, Corps of Engineers
District Engineer

28 AUG 1978
Date

Submitted By: Original signed by JAMES A. WALSH

Recomended By: Original signed by ZANE M. GOODWIN

June 1978

OVERVIEW PHOTO - KEOKEE DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM: KEOKEE DAM I.D. NO.: VA 10502

SECTION I - PROJECT INFORMATION

1.1 General

1.1.1 Authority: Public Law 92-367, 8 August, 1972, authorized the Secretary of the Army, through the U.S. Corps of Engineers, to initiate a national program of safety inspections of non-federal dams throughout the United States. The Norfolk Office of the U.S. Corps of Engineers has been assigned the responsibility for supervising the inspection of dams in the Commonwealth of Virginia. Gilbert Associates, Inc. has entered into contract with the Norfolk Office to inspect this dam, Gilbert W.O. 06-7250-004.

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 (Reference 1 of Appendix VI), and contract requirements between Gilbert Associates, Inc. and the Corps of Engineers. The objectives are to expeditiously identify whether this dam apparently poses an immediate threat to human life or property and to recommend future studies and/or any obvious remedial actions that may be indicated by the inspection.

1.2 Project Description

1.2.1 Dam and Appurtenances: Keokee Dam is a homogeneous earthfill structure constructed of local clayey silty soil about 50 feet high and 330 feet long. It is a new dam, first filled late in 1975, and opened to the public in July of 1978. The top width is about 20 feet at elevation 2250 feet m.s.l. The record drawings and memos on file with the Virginia Department of Game and Inland Fisheries indicate that the dam was constructed up to 1 foot higher than the design elevation to allow for future settlement. The side slopes are 3 horizontal to 1 vertical on the downstream side and 3-1/2 horizontal to 1 vertical on the reservoir side, with an 8-foot wide bench about 2 feet below normal pool elevation. The principal spillway is a standard design of the U.S. Soil Conservation Service (SCS) with a covered intake riser, low level drain, 48-inch reinforced concrete pipe passing under the dam, and an impact stilling basin at the downstream toe. The emergency spillway is a 20-foot wide, 120-foot long paved and riprapped area at a natural topographical saddle about 1,000 feet north of the main dam.

1.2.2 Location: Keokee Dam is located in the Jefferson National Forest, 2 miles southeast of Keokee, Virginia, on the North Fork of the Powell River.

1.2.3 Size Classification: The dam is classified as an intermediate structure based on its height of 50 feet, according to Section 2.1.1 of Reference 1 of Appendix VI.

1.2.4 Hazard Classification: This dam is 3 miles upstream of the nearest dwelling shown on the 1955 USGS, 7-1/2 minute quadrangle maps of the area. A large distance to the nearest downstream dwelling was verified by Mr. D. McGregor, the local agent of the SCS. There are a few dwellings and a railroad track between that point and an area where the Powell River is shown to be much wider and passes through more heavily populated terrain. The dam is, therefore, given a significant hazard classification in accordance with the guidelines contained in Section 2.1.2 of Reference 1 of Appendix VI. The hazard classification system used to categorize dams is a function of location with respect to people and property only and has nothing to do with its stability or probability of failure.

1.2.5 Ownership: The dam is owned and maintained by the Virginia Commission of Game and Inland Fisheries, with main offices in Richmond, Virginia. The surrounding land is owned by the U.S. Forest Service.

1.2.6 Purpose of Dam: Fishing.

1.2.7 Design and Construction History: Soils investigation work was done by Froehling and Robertson of Richmond, Virginia. The soil borings were taken during 1970. The dam was designed about 1971 by Thompson and Litton, Consulting Engineers of Wise, Virginia. Some of the preliminary design decisions such as the location of the dam and emergency spillway were made by the owner according to a statement by the designer made in the design summary (Reference 3 of Appendix VI). The designer furnished project management and a field inspector during construction, according to letters on file. The general contractor for the dam construction, which took place during 1974, was the Wiley N. Jackson Company of Roanoke, Virginia. There were no reports of compaction, moisture content of fill materials, or concrete strength tests available to us at the time this report was written.

No modifications were observed to have been made on the dam since its original construction, other than a small wooden weir installed during 1977 to measure the seepage.

According to the information given to us over the telephone on June 30, 1978, by Mr. J. W. Engle, Jr., Chief, Lands and Engineering Division of the Virginia Commission of Game and Inland Fisheries, significant leakage was first noticed when the reservoir was initially filled to its normal pool elevation in December of 1975. Mr. Engle also mentioned that they intended

to place bentonite on the suspected leakage area in the reservoir to try to reduce the seepage rather than employ the grouting program suggested earlier in their studies. A memo by a Mr. Kalan and a memo by Mr. Engle are included in Appendix VII "Previous Inspection Reports" to describe a dye test and further history of this leakage. Mr. Jessee of the Commission has been recording the leakage since the weir was installed. He informed us of the following seepage history:

Table 1.1 SEEPAGE HISTORY

Date	Reservoir Level	Seepage Rate, g.p.m.
March 1977	2240	260
October 1977	2237	50±
February 1978	2240	260
April 1978	2235	Negligible
June 1978*	2235	5
July 1978	2235	0

*During the GAI inspection trip in June of 1978.

1.2.8 Normal Operational Procedure: There is no formal operational procedure for this dam. However, the intake riser will normally maintain the reservoir at elevation 2240. Flood hydrographs higher than this level will result in discharge through this structure. The riser structure is also equipped with stoplogs which can be used to lower the reservoir 5 feet below the normal pool level of elevation 2240 feet. There is also a 10-inch cold water discharge controlled by a butterfly valve and a 24-inch square slide gate which were designed to drain the reservoir into the riser structure.

1.3 Pertinent Data

1.3.1 Drainage Areas: The drainage area is 1.30 square miles and is, in general, densely forested.

1.3.2 Discharge at Dam Site: The maximum flood at the dam site is not known.

Principal Spillway:

Pool level at emergency spillway crest . . . . . 210 c.f.s.
Pool level at top of dam (2250 feet) . . . . . 350 c.f.s.

Emergency Spillway:

Pool level at top of dam . . . . . .2380 c.f.s.

1.3.3 Dam and Reservoir Data: Pertinent data on the dam and reservoir are given in Table 1.2 below.

Table 1.2 DAM AND RESERVOIR DATA

Item	Elevation feet m.s.l.	Reservoir Capacity Area acres	Acre feet	Watershed inches	Length miles
Top of Dam	2250	139	3130	45	0.8
Emergency Spillway Crest	2242	102	2150	31	-
Principal Spillway Crest (a)	2240	98	1950	28	-
Streambed at Centerline of Dam	2200	0	0	0	0

(a) Top of conservation pool and bottom of flood control pool.

For other details of the dam see the figures in Appendix I.

SECTION 2 - ENGINEERING DATA

2.1 Design: A design summary was prepared by the designer, Thompson and Litton (T&L) in 1972 (Reference 3 of Appendix VI) and is on file with the Virginia Commission of Game and Inland Fisheries. Also in the Commission's files are the soil investigation reports by Froehling and Robertson (F&R), design drawings, and construction specifications.

The soil investigation reports are given in Appendix IV. These reports show that the site terrain is fairly rugged and that the subsurface at the dam consisted of a 2 to 13 feet thickness of sandstone boulders and layers of clay (probably clayey silt) overlying the bedrock. The bedrock consists of interbedded fine to medium grained sandstone predominanting. The borings at the dam, taken 10 feet into the rock, encountered only the sandstone. The sandstone is arkosic, and contains a large proportion of feldspar grains and also shale partings of a few fractions of an inch in thickness. Based on the water-pressure tests in the borings, it was decided that the rock strata did not require grouting. However, the reports do not furnish the permeability of the rock strata. The cut-off for the dam was therefore taken to the top of the rock and consisted of a trench, 20 feet wide at the bottom and maximum 10 feet deep, backfilled with clayey (CL) soil. The sides of the trench were sloped 1.5 horizontal to 1 vertical.

2.2 Construction: Construction records including as-built drawings are available at the office of the Commission of Game and Inland Fisheries. Adequate information was not available on materials testing during construction. The records show that the dam axis was shifted 10 feet upstream due to an error in the field location (see Figure 10, Appendix I). After removing soft spots, the original ground-surface was proof-rolled using vibrating rollers. The fill was placed slightly wet of the optimum moisture content and compacted to 95 percent of the modified Proctor maximum density. The dam was constructed as a homogeneous dam using the calyey silty (CL-ML) soil borrowed from the reservoir area. For the internal drainage, a 4-foot thick horizontal blanket consisting of well-graded gravelly sand (with fines less than 3%) was placed as shown in Figure 3 of Appendix I. Details regarding the as-built riprap, the spillways etc. are given in Appendix I.

2.3 Operation: There is no operational history for this reservoir other than the lowering to alleviate the leakage condition.

2.4 Evaluation: The data provided appears to generally agree with the visual inspection. The geotechnical design data is incomplete. The data lacking is mentioned in Section 6. Data on design of the hydraulic structure, development of the design and flood hydrograph, flood routing, and other engineering data on hydraulic features of the project are adequate for this Phase I report.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

3.1.1 General: The Phase I dam inspection was performed by a team of Gilbert Associates, Inc. engineers on June 13, 1978. The inspection was part of a National Dam Safety Program administrated by the U.S. Army Corps of Engineers.

3.1.2 Dam: The upstream slope of the dam appeared to be uniform, although there were several shallow eroded gullies, generally less than 3 feet across and 6 inches deep just above the lowered water line. The riprap protection appeared to be intact. Since the reservoir water level was lowered to below the riprap line, the embankment soil on the upstream slope was exposed. The exposed soil was found to be sandy silt with trace to little clay. The downstream face of the dam was uniform and had no tree growth, noticeable cracking, instability, or erosion. There were about 5 gallons per minute of seepage coming from an area at the left abutment of the dam halfway up the slope. The seepage appeared clear and smelled like tannic acid which is a product of vegetative decomposition. It flowed down the riprapped junction of the dam and natural valley wall, to the measuring weir and into the downstream channel. The top of the dam was in fair alignment. A depression of approximately 0.3 feet was found near the center of the crest; however, the depression was not accompanied by cracking.

3.1.3 Appurtenant Structures: The covered intake riser and the impact energy dissipator showed no signs of distress or deterioration. The concrete at the crest of the emergency spillway showed no signs of significant deterioration. The downstream channel at the emergency spillway is densely forested and brush covered starting within a few feet of the edge of the spillway. Large trees were seen standing in the approach channel of the spillway.

3.1.4 Reservoir Area: There are many large standing dead trees visible in the reservoir. The dam and emergency spillway had no access road or trail. The only means of reaching these structures were by boat or a 30-minute walk along a narrow footpath. The road used during construction was flooded by the reservoir.

3.1.5 Downstream Channel: The downstream channel was forested with no apparent unusual erosion except for a small, disturbed, steep slope area on the right side of the channel near the discharge structure.

3.2 Evaluation: Based on observations during the field inspection and on facts derived from discussions with Mr. Jessee and Mr. Engle of the Virginia Commission of Game and Inland Fisheries, the dam and appurtenant structures appeared to pose no immediate hazard to residents downstream at the time of the inspection. While it must be considered as a very preliminary concept based on incomplete data, it was not the opinion of the inspection team that the seepage observed through the left side of the dam actually passed through the dam, but that the seepage is probably occuring through the pervious bedding planes of the sandstone strata at the reservoir periphery. Nevertheless, this seepage is a cause for concern. The 0.3-foot deep depression on the top of the dam is not considered a significant sign of distress due to absence of any cracking; however, it needs further examination. The dead trees in the reservoir area pose a threat of partially blocking the spillways. An undesireable condition which would be worsened by the dead trees floating out during high water is the dense wooded area just beyond the emergency spillway. Another undesireable situation noticed by the inspection team was that there is no land access to the dam or spillway for maintenance vehicles.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures: No formal operational procedures exist for this dam. For procedures used to date see paragraph 2.3.

4.2 Maintenance of Dam: Although it is planned to place a bentonite layer on the reservoir side of the dam in the area of the suspected leak, apparently no maintenance has been performed on this relatively new dam.

4.3 Maintenance of Operating Facilities: None

4.4 Description of Any Warning System in Effect: None

4.5 Evaluation: A program of periodic maintenance of the dam and appurtenant structures is lacking. The dam also lacks a warning system which would alert downstream residents of an impending hazardous condition.

SECTION 5 - HYDRAULIC/HYDROLOGIC DESIGN

5.1 Design: The U.S. Forest Service Manual, Water Storage and Transmission, Title 7500 and the U.S. Bureau of Reclamation (USBR) Design of Small Dams were used as references for hydraulic and hydrologic analysis and design of the dam and appurtenant structures.

The principal and emergency spillway crests are at 2240 and 2242 feet, respectively. Flood hydrographs for: 100 year storm; "100 year + 0.12 (PMF-100 year)"; "100 year + 0.40 (PMF-100 year)"; and PMF were computed by the designers for the project. As a result, when the 100 year storm was routed through the reservoir, the maximum elevation was 2240.85 feet. Routing a flood of a return period greater than 100 years, i.e. "100 year + 0.12 (PMF-100 year)" with emergency spillway at 2242.00 feet, gave a maximum pool elevation of 2241.97 feet just below the emergency spillway crest. This means the principal spillway is capable of handling a storm with a return period a little larger than 100 years. The other computed flood hydrographs were apparently not routed through the reservoir.

The hydraulic design of the impact stilling basin is based on USBR standards. It has the capability to handle the design flood passing over the principal spillway or flow through the sluice gate in case of emptying the lake.

5.2 Hydrologic Records: None

5.3 Flood Experience: No real experience data are available because of the inaccessibility of the site. The Commission personnel were able to visit the site three to four weeks after the 1977 spring flood. According to them, there were no signs of overtopping of the dam, no damage to any structure, and no evidence that a flood ever passed over the emergency spillway.

5.4 Flood Potentials: Design features of the dam were established by routing various hydrographs as noted in Paragraph 5.1.

5.5 Reservoir Regulation: The regulation of flows from the reservoir are automatic; i.e., water rising above the crest of the principal spillway passes through a 48-inch concrete pipe under the dam. Water also can flow over the emergency spillway in the event water in the reservoir rises over the crest of the emergency spillway.

5.6 Overtopping Potential: The probable maximum flood (PMF), one-half the PMF, and the 100-year flood hydrographs were developed by Gilbert Associates, Inc. for the Keokee Reservoir drainage basin and routed through the reservoir. Table 5.1 summarizes the results of the procedure:

Table 5.1 RESERVOIR PERFORMANCE

Item	Flood Hydrograph 100-year	1/2 PMF	PMF
Peak Flow, c.f.s.			
Inflow	1980	4710	9420
Outflow	217	1110	2610
Peak Elevation, feet m.s.l.	2242.0	2245.8	2249.7
Emergency Spillway			
Depth of Flow, feet (a)	0.0	3.8	7.7
Average Velocity, f.p.s.	0.0	2.3	2.6
Dam Overtopping			
Depth of Flow, feet	-	-	-
Average Velocity, f.p.s.	-	-	-
Tailwater Elevation, feet m.s.l.	-	-	-

Note: (a) Normal Depth

The hydrographs were developed and routed by using the HEC-1 computer program (Reference 2 of Appendix VI) and appropriate precipitation, unit hydrograph, and storage volume versus outflow data as input. The three inflow and outflow hydrographs are listed in Table 5.1. The triangular unit hydrograph was developed from the drainage area and estimated time to peak (Reference 5 of Appendix VI). Probable maximum precipitation and 100-year precipitation data were obtained from U.S. Weather Bureau publications (References 4 and 6 of Appendix VI). The storage-outflow relation was obtained from the design report (Reference 3 of Appendix VI). Losses were estimated at an initial loss of 1.0 inch and a constant loss rate of 0.30 inch/hour.

5.7 Reservoir Emptying Potential: The reservoir can be emptied by opening the 24-inch x 24-inch sluice gate which discharges through a 48-inch concrete pipe. The reservoir will empty in about 12 days at an outflow rate of 120 c.f.s. at elevation 2240 feet, the crest elevation of the principal spillway.

5.8 Evaluation: The results indicate that the reservoir is capable of passing the PMF without overtopping the dam. The spillway is considered adequate in accordance with paragraph 3.5.1 of Reference 1 of Appendix VI. The conclusions are based on present day conditions of the watershed and the effect of future development on hydrology has not been considered.

SECTION 6 - STRUCTURAL STABILITY

6.1 Stability Analysis: Gilbert Associates, Inc. has not received a copy of any stability analysis performed for this dam. The design summary (Reference 3 of Appendix VI) indicates one was performed by a consultant other than the dam designer. However, if the dam was compacted and built of materials in accordance with the specifications for the dam construction, the upstream and downstream slopes apparently meet present-day criteria for stability against anticipated steady state and drawdown conditions.

6.2 Foundation and Abutments: As explained in Section 2, the cutoff was taken to the top of the rock to prevent seepage through the boulderly top layer of the original ground. Records indicate that proper care was taken to compact the contact areas of the cutoff with natural soils and the rock surface. The dam and appurtenant structures have been stable under previous flooding conditions. Although the dam is located in the relatively stable Zone 2 on Algermissen's Seismic Risk Map of the United Stated (1969 Edition), a stability analysis was not available for this inspection and must be obtained to verify that the conditions specified in Section 4.4 of Reference 1 of Appendix VI prior to assessing the seismic stability of the dam. Seepage studies, if made, to examine effectiveness of the filter and erodibility of the silty foundation soils, especially along the contact zones at the foundation and abutments, have not been made available to Gilbert Associates, Inc. Due to bedded sandstone strata and use of the upstream area for borrowing the embankment soils, the potential for seepage through the base of the dam needs further examination. There is an absence of significant settlement, cracking and downstream seepage at the present time.

6.3 Evaluation: Records on stability and seepage analyses have not been made available to Gilbert Associates, Inc. However, based on a study of the available information and the visual inspection, the dam embankment apparently has an adequate stability factor of safety as it is constructed in accordance with the present day practice. Also, the foundation and the abutments presently appear structurally stable. Seepage and internal erosion, especially along the contact zones, need further examination. The data on the leakage potential of rocks at shallow depths and in the 2-foot to 13-foot thick overburden need verification.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

The assessment, recommendations and remedial measures contained in this Report are based on the provisions of Appendix VIII, Conditions.

7.1 Dam Assessment: On the basis of the field inspection, available records, and performance, the dam in its present condition does not show major and critical signs of distress such as severe slope failure, embankment cracking, unanticipated settlement, or significant underseepage. The spillway capacity is adequate to pass the Probable Maximum Flood without overtopping the dam. However, there are several areas of concern regarding the dam's future condition.

a. There is excessive tree growth immediately downstream of the emergency spillway which could contribute to reducing the flow capacity significantly under certain conditions.

b. There is currently no means of vehicular access to the dam or emergency spillway. This may result in less frequent or less thorough inspections, more difficult and costly or smaller scale normal repair methods, and lengthy delays should emergency repairs be required.

c. There is an area of leakage at the left abutment which has not been repaired, although the owner has lowered the reservoir, temporarily stopping the leak. He has a plan for sealing a portion of the reservoir with bentonitic clay where he believes the leak to be originating based on a dye test (See Appendix VI-B). The leakage could be detrimental to the safety of the dam if allowed to continue. An eroded area caused by this seepage exists on the downstream valley wall.

d. There are many dead trees in the reservoir area including the approach channel of the emergency spillway which were not removed during original construction of the facility and could fall and float into the emergency spillway, thereby reducing its capacity to perform as designed.

e. A 0.3 feet deep depression was noticed on the crest of the dam during the inspection. The depression was near the center of the dam. Although the depression was unaccompanied by cracking, it needs further examination.

f. There is apparently no formal program of periodic maintenance established for this dam. The remoteness of the site and the lack of access, except by footpath or boat, make a maintenance program desirable for this site.

g. Leakage and internal erosion needs further study. Data on leakage potential needs verification. It should be confirmed that adequate seepage analyses exist for this dam.

7.2 Recommendations/Remedial Measures: To address the concerns mentioned above, the following recommendations are made:

a. The trees and brush should be removed from the immediate downstream channel of the emergency spillway within 30 days and the slopes immediately stabilized after removal of the trees. Use of an environmentally acceptable growth preventative on low cut stumps would seem to be adequate rather than stump removal in this area.

b. A road, at least passable by four wheel drive vehicles should be provided to the dam and emergency spillway within 1 year. The study which would be part of this should consider routes from at least Olanger and/or Keokee. Such a road is considered a minimal requirement for a structure such as this.

c. The owner should successfully complete his attempt at sealing the reservoir to stop or reduce the downstream left abutment seepage soon. In any event, the leakage should be permanently stopped prior to raising the reservoir level.

d. If bank erosion is noted due to the low water level over an extended period of time, riprap should be considered for the shoreline at the dam.

e. The effectiveness of the cutoff and the filter as well as leakage potential and erodibility of the soil that constitute the transition and contact zones at the foundation and the abutments should be studied in the next year.

f. Also, the leakage potential of the rock strata at shallow depths needs further verification. Very soon after repairs are made on the leakage area, the eroded downstream area should be repaired.

g. The dead or dying trees in the reservoir area and in the approach channel of the emergency spillway should be removed in the next six months so no more than 3 feet or so of the trees extend above the common pool level

(this may be normal or lower if the abutment leak is not repaired for an extended period and the pool is kept low). This would encourage a fish habitat around the root system as Mr. Martel requested and yet reduce the probability of large trees blocking the outflow spillways of the dam. If and when stumps are observed at the surface of the reservoir, they should be removed immediately to prevent possible blockage of the outlets.

h. In the next three months a settlement survey of the crest of the dam should be performed. If significant and unanticipated settlement is recorded, the cause should be investigated immediately and appropriate remedial action taken.

i. In the next six months, a program of periodic inspections and maintenance should be developed for this dam and its appurtenant structures. Additionally, further information is required at this time on a stability analysis, a seepage analysis, and the leakage potential of the rocks below and to the sides of the dam. The owner should obtain all available and necessary information on these subjects within a reasonable time of receiving this report.

j. It is recommended that seepage, internal erosion and data on the leakage potential of the foundation and abutment strata be studied and verified in the next year.

k. Until such time as these recommendations are implemented, it is recommended that a warning system be furnished at this dam.

APPENDIX I

MAPS AND DRAWINGS

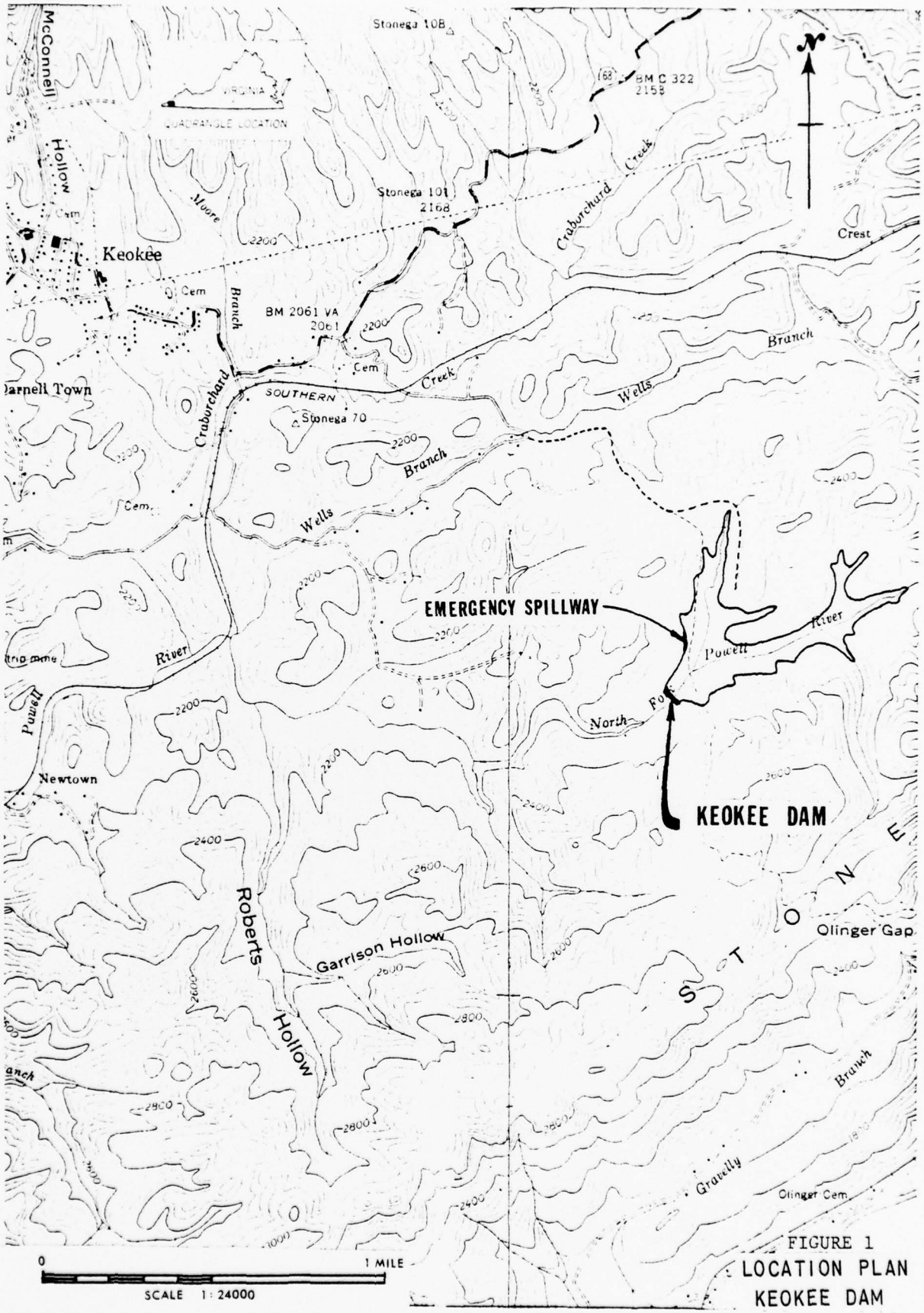


FIGURE 1
LOCATION PLAN
KEOKEE DAM

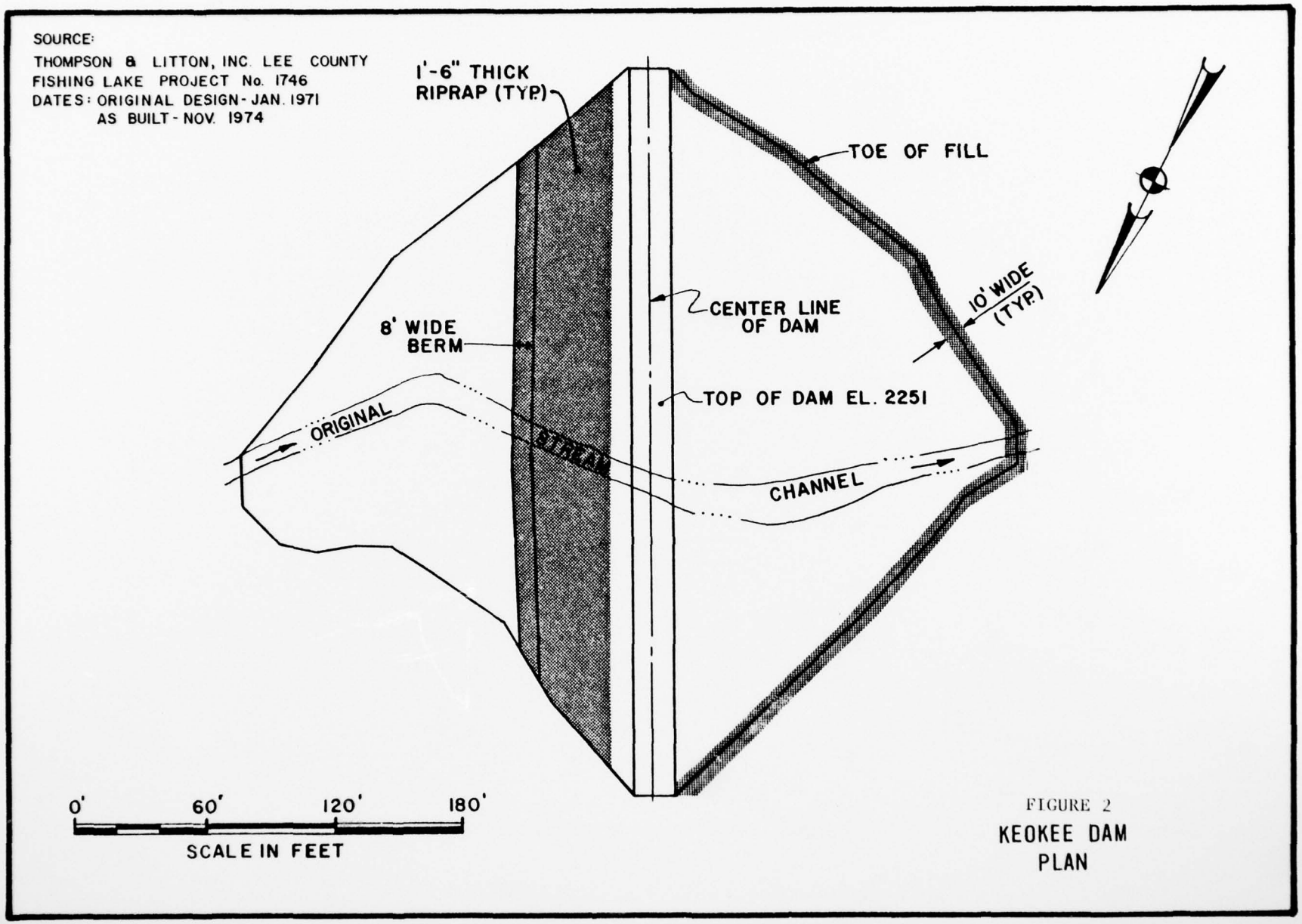
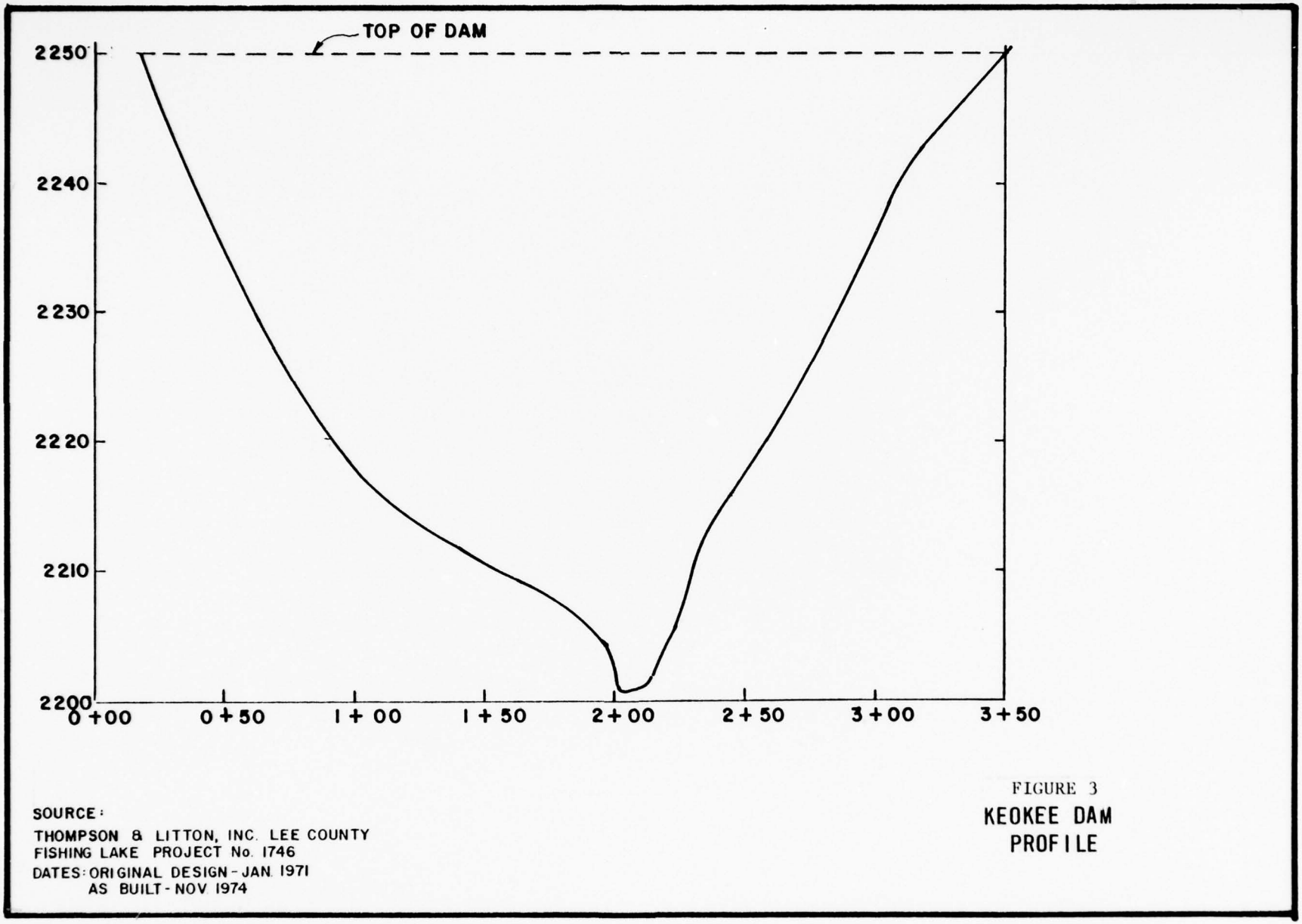


FIGURE 2
KEOKEE DAM
PLAN



SOURCE:
THOMPSON & LITTON, INC. LEE COUNTY
FISHING LAKE PROJECT No. 1746
DATES: ORIGINAL DESIGN - JAN. 1971
AS BUILT - NOV. 1974

FIGURE 3
KEOKEE DAM
PROFILE

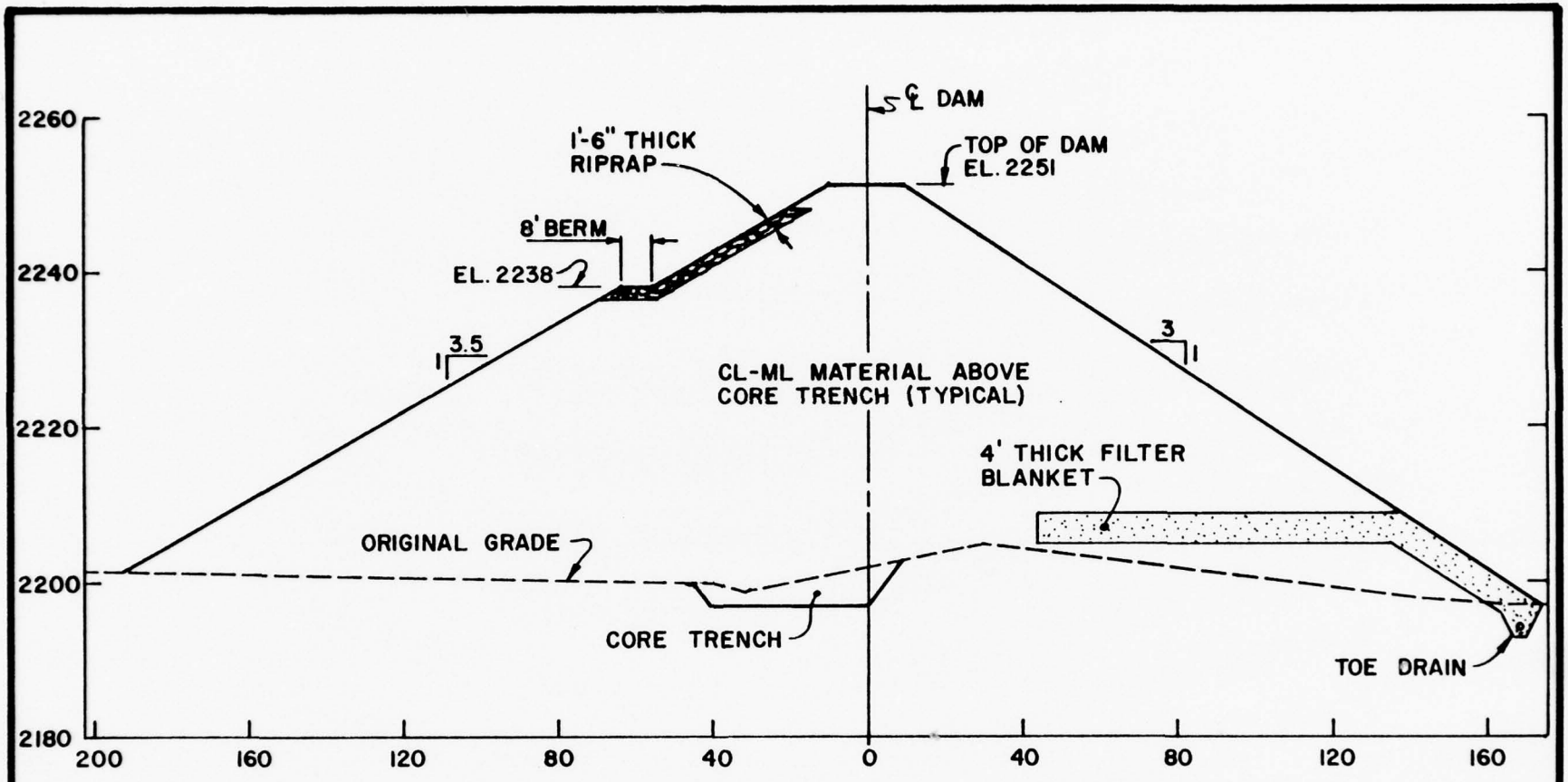


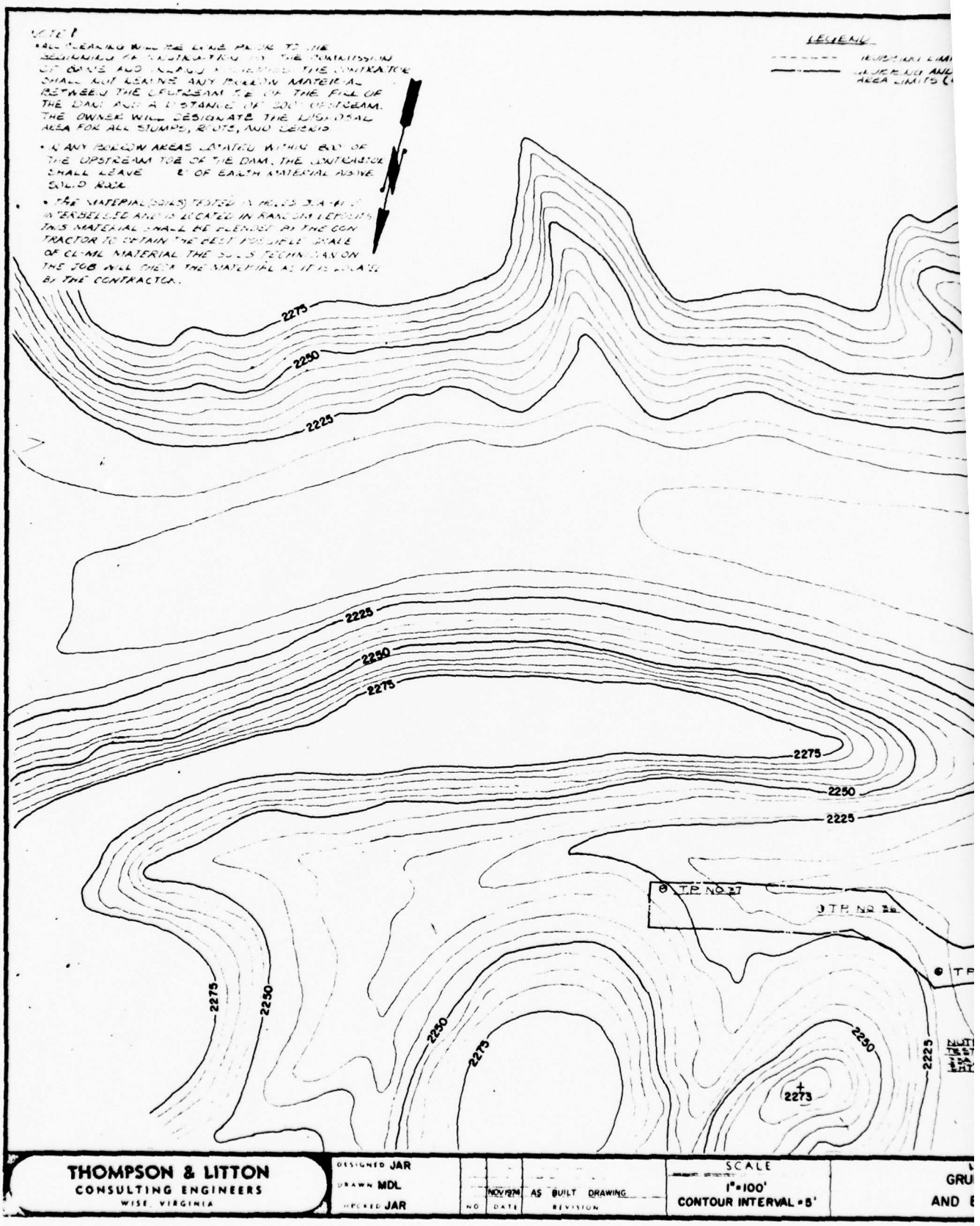
FIGURE 4

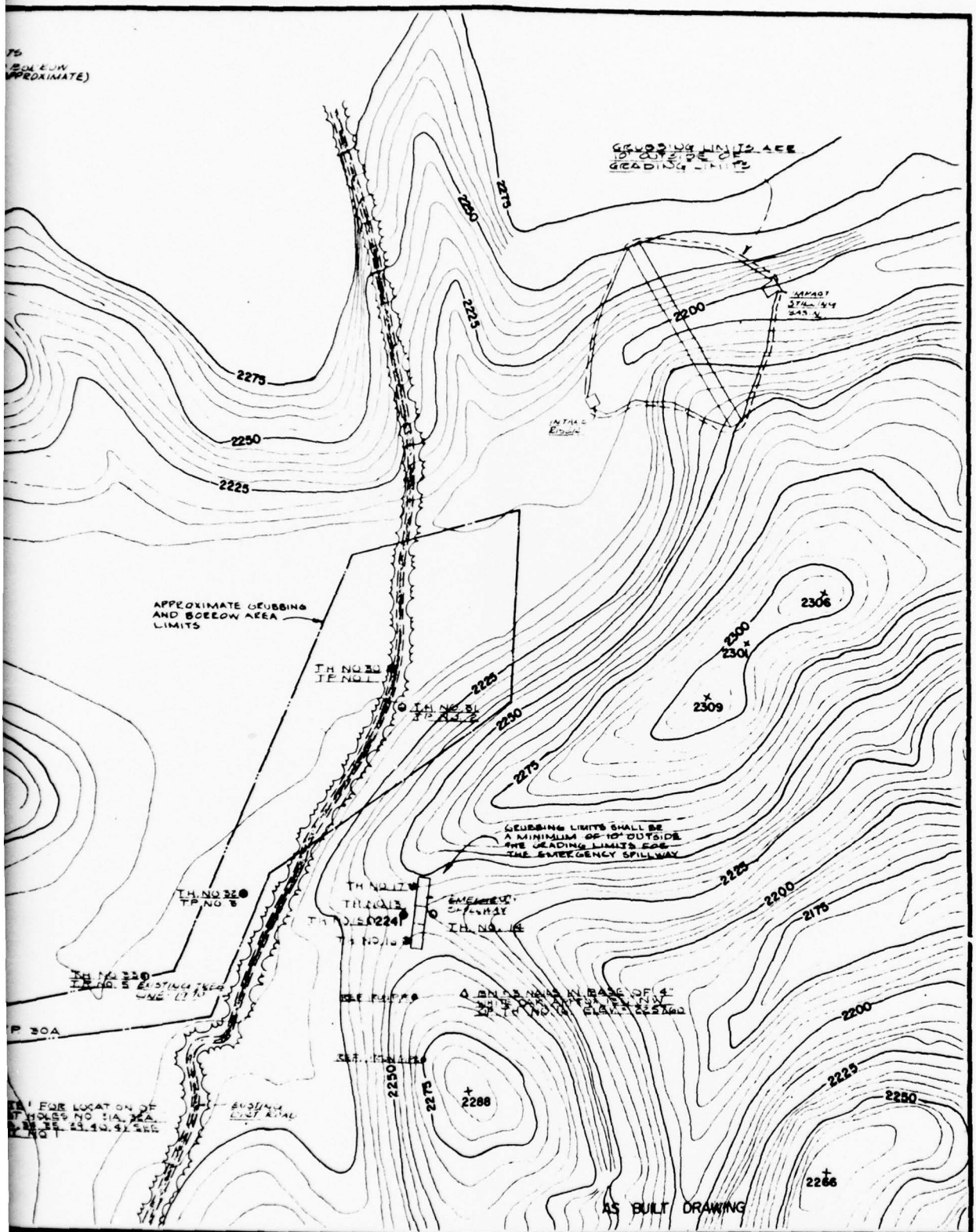
KEOKEE DAM

CROSS SECTION

SOURCE:

THOMPSON & LITTON, INC. LEE COUNTY
FISHING LAKE PROJECT No. 1746
DATES: ORIGINAL DESIGN - JAN. 1971
AS BUILT - NOV. 1974

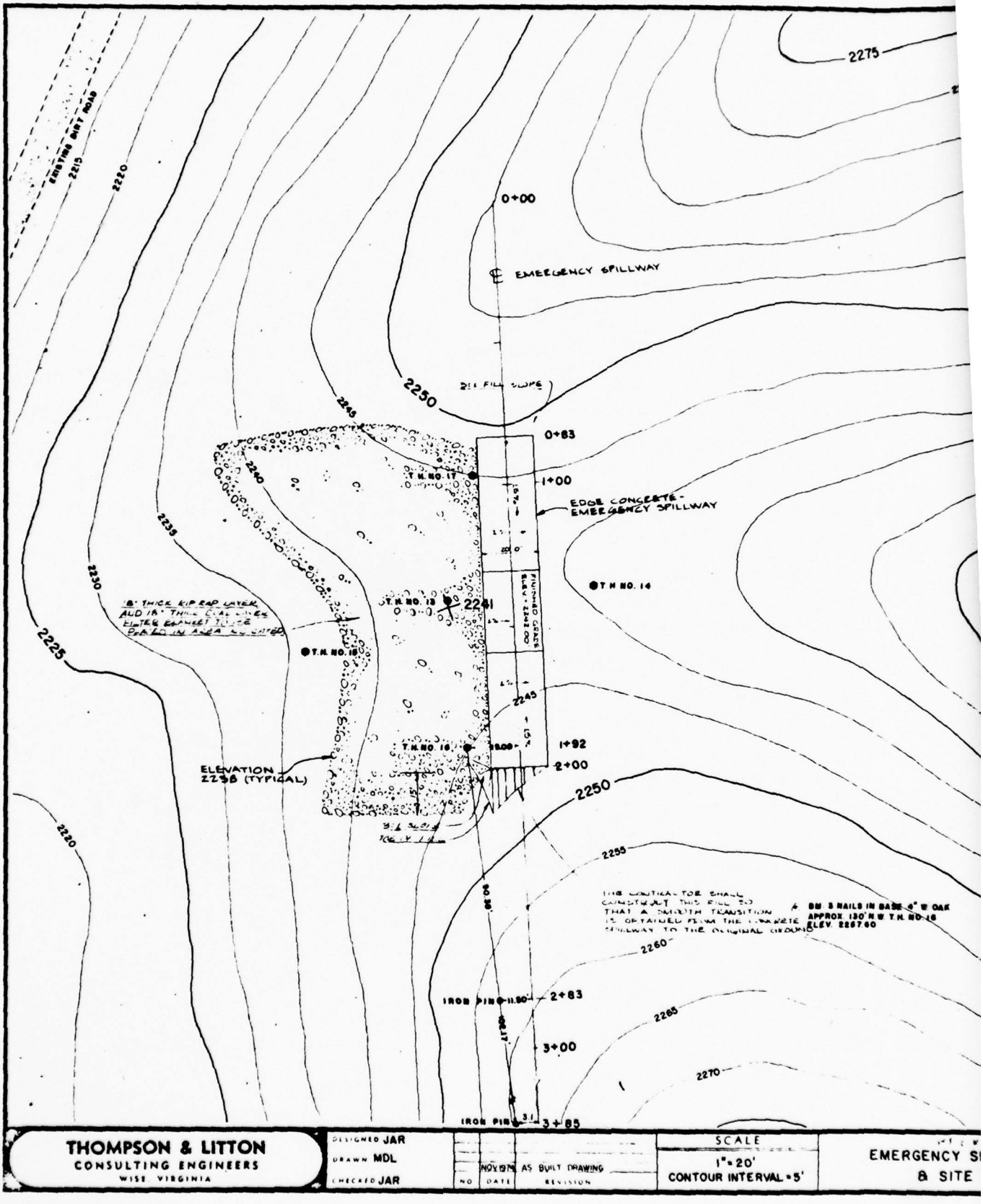

NOTE:
• ALL CLEARING WILL BE LIMITED TO THE MINIMUM NECESSARY FOR CONSTRUCTION OF DAMS AND CANALS. THE CONTRACTOR SHALL NOT LEAVE ANY BORROW MATERIAL BETWEEN THE UPSTREAM TOE OF THE FILL OF THE DAM AND A DISTANCE OF 200' UPSTREAM. THE OWNER WILL DESIGNATE THE DISPOSAL AREA FOR ALL STUMPS, ROOTS, AND DEBRIS
• IN ANY BORROW AREAS LOCATED WITHIN 800' OF THE UPSTREAM TOE OF THE DAM, THE CONTRACTOR SHALL LEAVE 8' OF EARTH MATERIAL ABOVE SOLID ROCK
• THE MATERIAL (SOILS) TESTED IN HOLES 3A-81 IS INTERBEDDED AND IS LOCATED IN RANDOM LENSES. THIS MATERIAL SHALL BE FLENDED BY THE CONTRACTOR TO OBTAIN THE BEST POSSIBLE BLEND OF CLAY MATERIAL. THE SOILS TECHNICIAN ON THE JOB WILL CHECK THE MATERIAL AS IT IS PLACED BY THE CONTRACTOR.
LEGEND
2275
2250
2225
TP NO 27
TP NO 26
2273
THOMPSON & LITTON
CONSULTING ENGINEERS
WISE, VIRGINIA
DESIGNED JAR
DRAWN MDL
TRACED JAR
NO
NOV 1974
DATE
AS BUILT DRAWING
REVISION
SCALE
1"=100'
CONTOUR INTERVAL = 5'



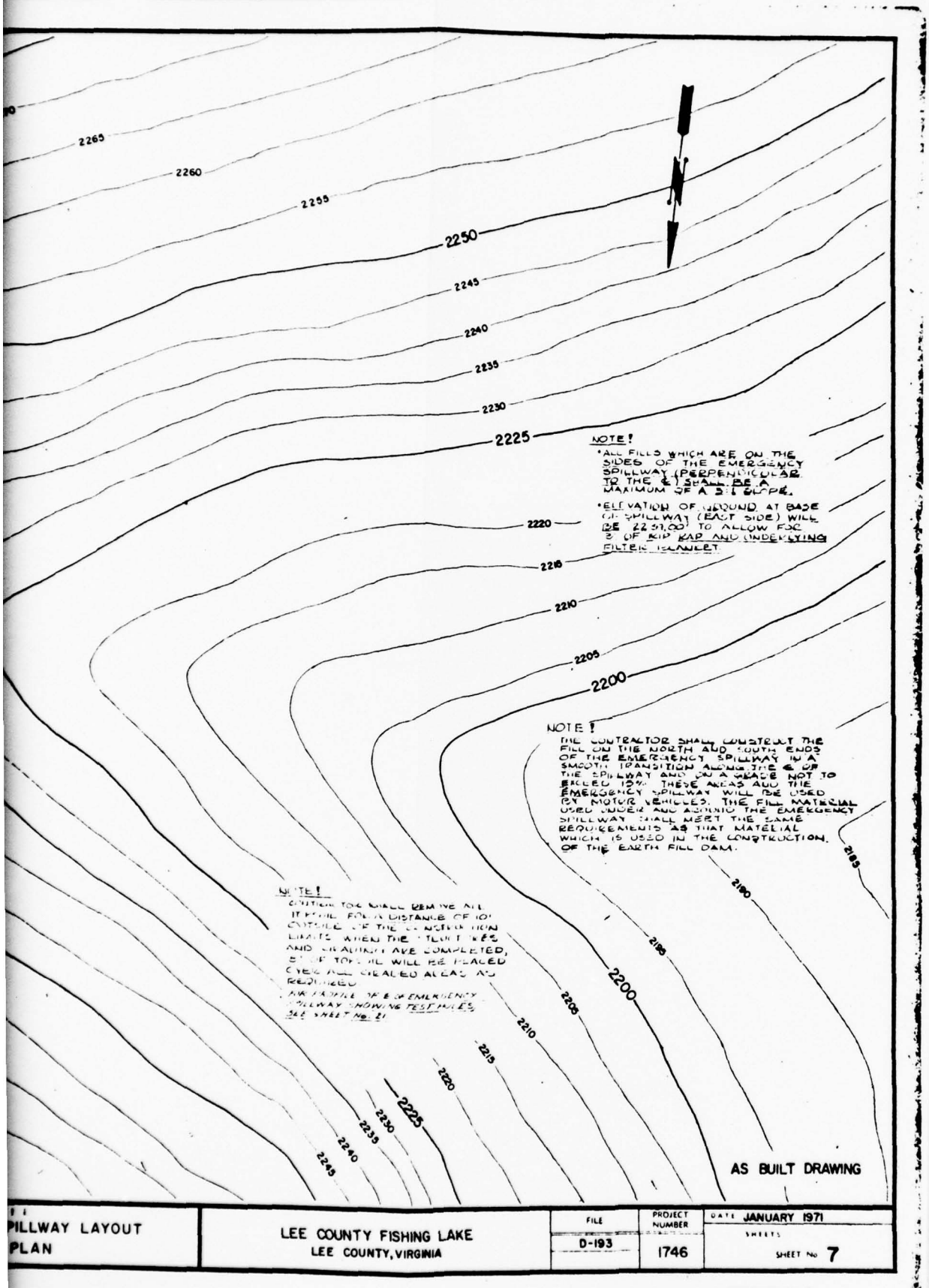
BBING PLAN BORROW AREA	LEE COUNTY FISHING LAKE LEE COUNTY, VIRGINIA	FILE D-193	PROJECT NUMBER 1746	DATE JANUARY 1971 SHEETS SHEET No 3

FIGURE 5

2

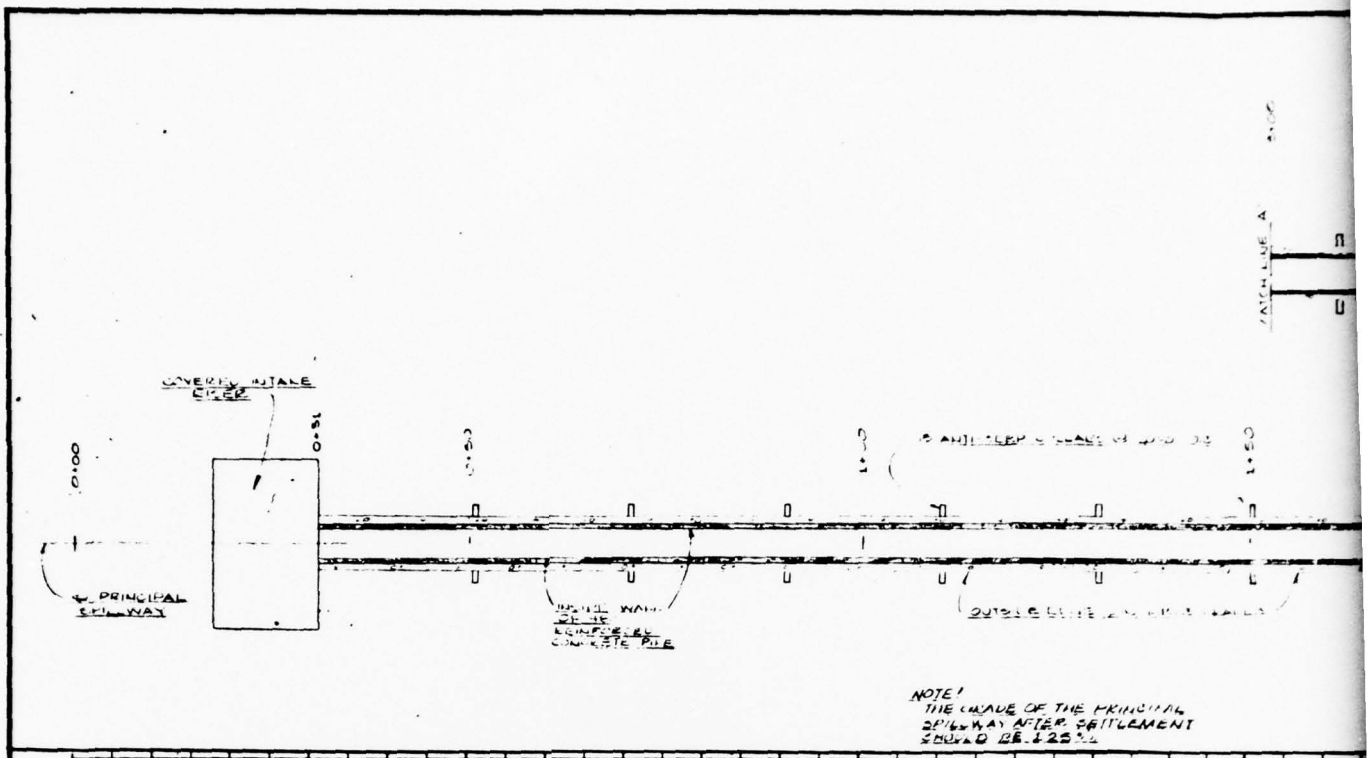


THOMPSON & LITTON CONSULTING ENGINEERS WISE VIRGINIA	DESIGNED JAR DRAWN MDL CHECKED JAR	NO. / DATE / REVISION NOV 1974 AS BUILT DRAWING	SCALE 1" = 20' CONTOUR INTERVAL = 5'	EMERGENCY SI & SITE

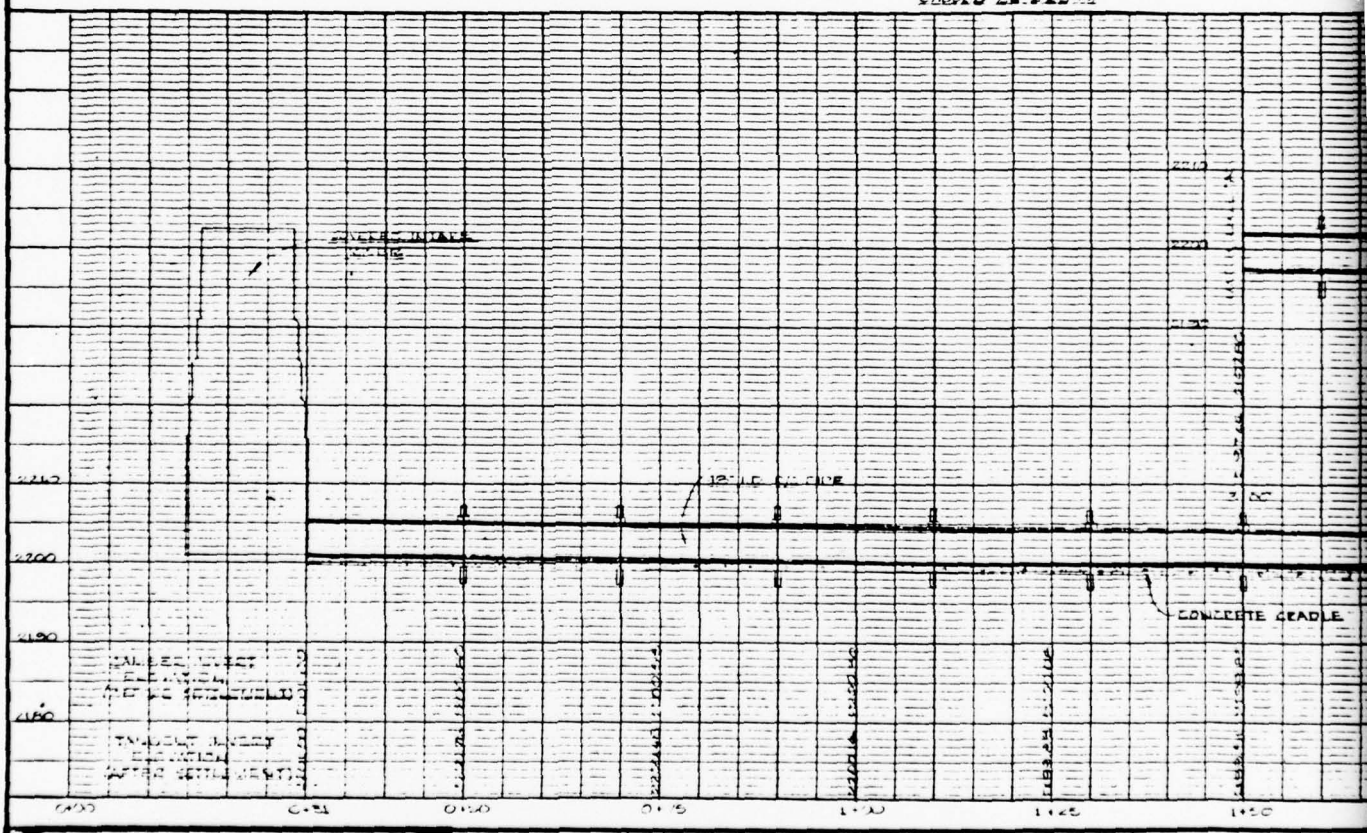


SPILLWAY LAYOUT PLAN	LEE COUNTY FISHING LAKE LEE COUNTY, VIRGINIA	FILE D-193	PROJECT NUMBER 1746	DATE JANUARY 1971 SHEETS SHEET No 7

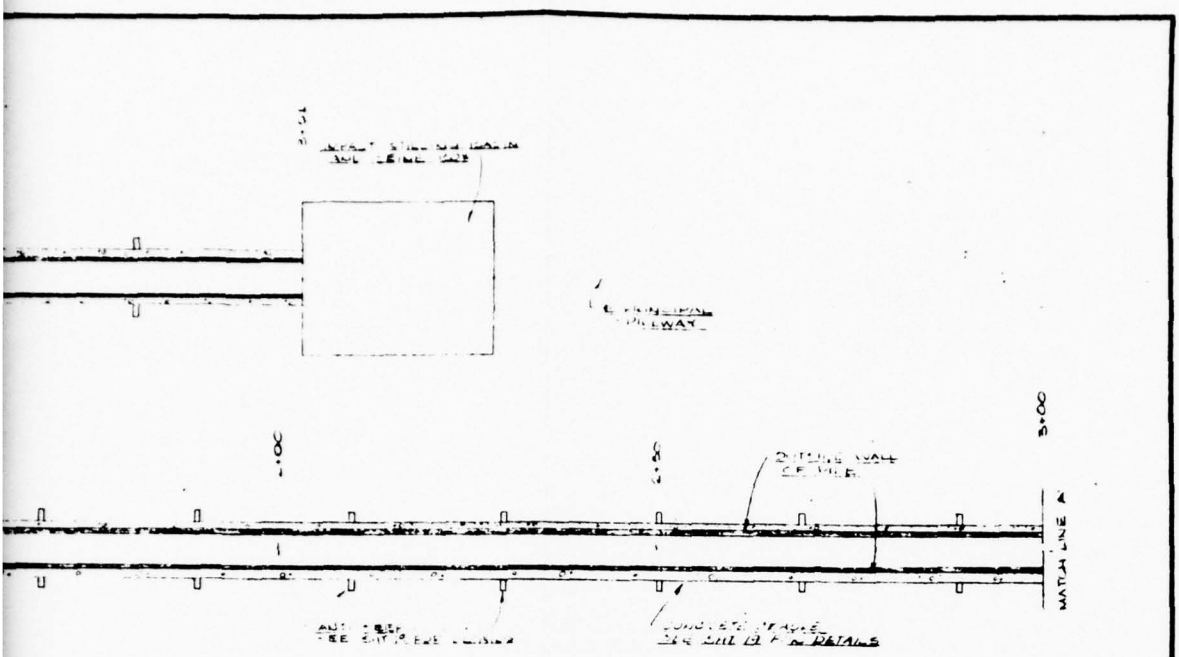
FIGURE 6

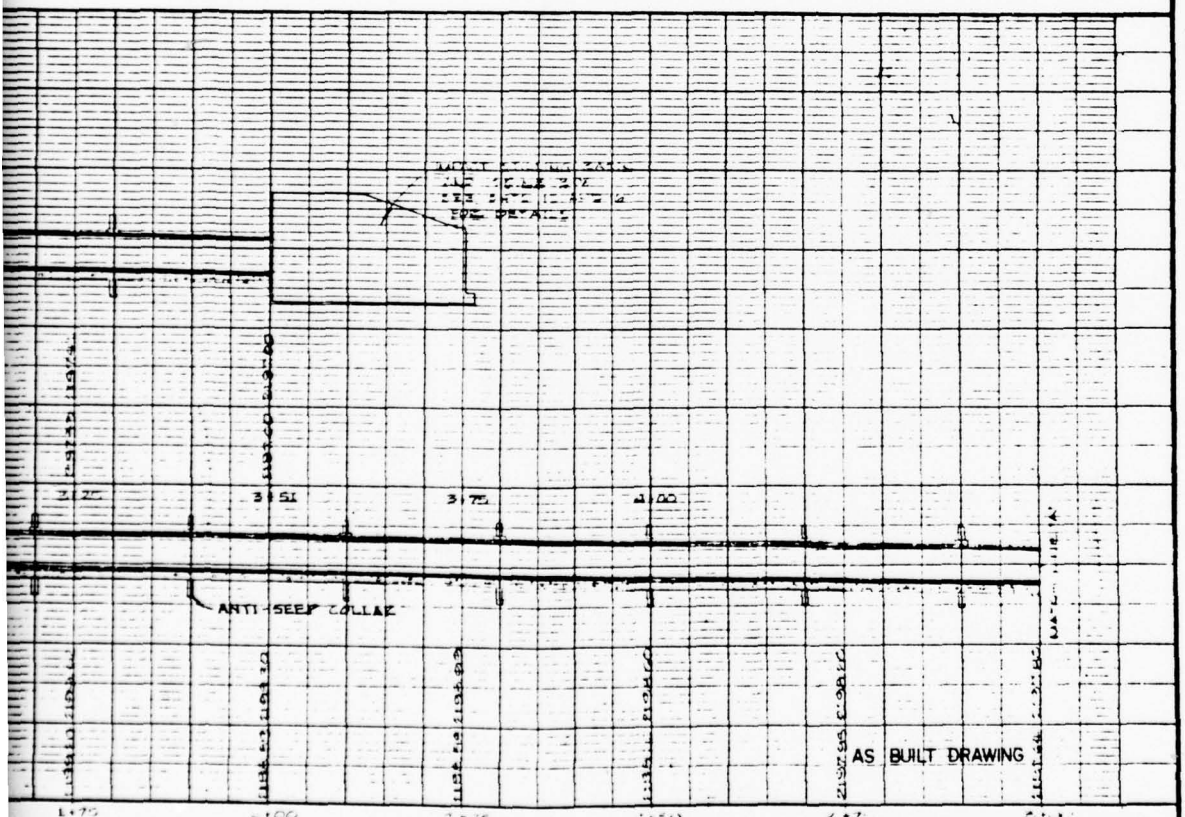


NOTE!
THE GRADE OF THE PRINCIPAL SPILLWAY AFTER SETTLEMENT SHOULD BE 1.25%



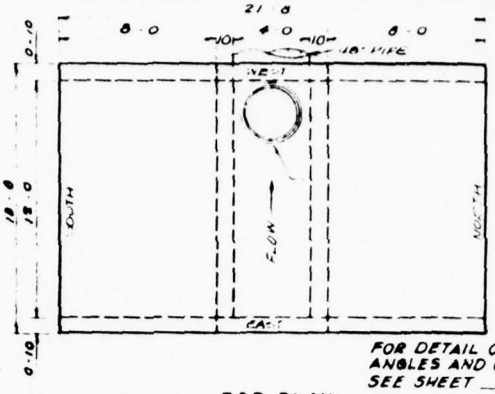
THOMPSON & LITTON CONSULTING ENGINEERS WISE, VIRGINIA	DESIGNED JAR & DHS DRAWN MDL CHECKED JAR & DHS	NO	NOV 1974 DATE	AS BUILT DRAWING REVISION	SCALE HORZ 1" = 10' VERT 1" = 10'	PLAN AN PRINCIPAL





PROFILE SPILLWAY	LEE COUNTY FISHING LAKE LEE COUNTY, VIRGINIA	FILE D-193	PROJECT NUMBER 1746	DATE JANUARY 1971 SHEETS SHEET No. 8

FIGURE 7

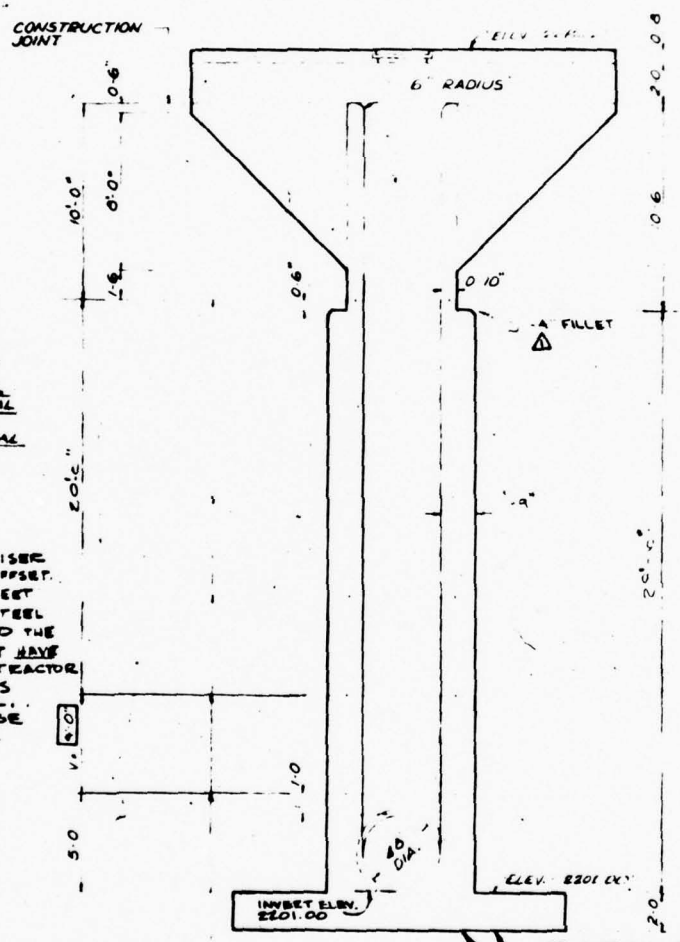


NOTE!
THE COMMISSION OF GAME AND INLAND FISHERIES INTENDS TO USE A PRESSURE AIR BUBBLER SYSTEM AND/OR THE DIAMETER OF THE INTAKE RISER TO PREVENT ICE FROM FORMING AGAINST THE

MANHOLE FRAME FOR DETAIL SEE SHEET 10

FOR DETAIL OF TRASHRACK ANGLES AND GRATING SEE SHEET 18

TOP PLAN



NOTE!
SHEETS 9, 10, 11 AND 12 OF THESE PLANS (SHEETS 1-4 OF THE SOIL CONSERVATION SERVICE) HAVE BEEN INCLUDED IN THESE PLANS AT THE REQUEST AND APPROVAL OF THE COMMISSION OF GAME AND INLAND FISHERIES. SEE SHTS. 13 AND 14 FOR ADDITIONAL DETAILS OF THE INTAKE RISER. SEE SHEETS 10, 18 AND 17 FOR ADDITIONAL DETAILS OF THE INTAKE RISER.

NOTE!
ADDENDUM MAY 16, 1979
THE OUTSIDE FACE OF THE INTAKE RISER WAS REVISED TO ELIMINATE THE OFFSET. THIS REVISION IS SHOWN ON SHEET NO. 9, 10 & 11 OF THE PLANS. THE STEEL AND CONCRETE QUANTITIES AND THE STEEL SCHEDULE ON THIS SHEET HAVE NOT BEEN REVISED. THE CONTRACTOR SHALL SUBMIT SHOP DRAWINGS FOR THE REINFORCING STEEL. THE STEEL QUANTITIES WILL BE CHECKED AT THAT TIME.

PLACE CONSTRUCTION JOINT, FOR DETAIL SEE SHEET 11

SECTION B-B

SEE SHEET No. 15 FOR FOOTER DETAILS

NOTE
THERE WAS 5' OF UNDERCUT EXCAVATION UNDER THIS FOOTER, TO SOLID ROCK.

SIDE

STANDARD COVERED RISER		
DESIGN CONSTANTS	f'_c = 4000 psi	f_c = 1600 psi
	n = 8	f_s = 20 000 psi
STANDARD DWG NO	ES 3048 4020R	
DATE 10-78	SHEET 1 OF 4	

DRAFTED BY
LOEWER AND ASSOCIATES
ARCHITECTS & ENGINEERS
3720 FARRAGUT AVE KENSINGTON, MD

0 2 4 8
SCALE IN FEET
1/4" = 1'-0"

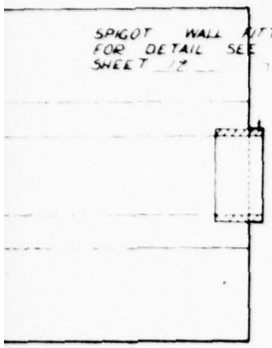
THOMPSON & LITTON
CONSULTING ENGINEERS
WISE, VIRGINIA

DESIGNED PPS
DRAWN
CHECKED PPS

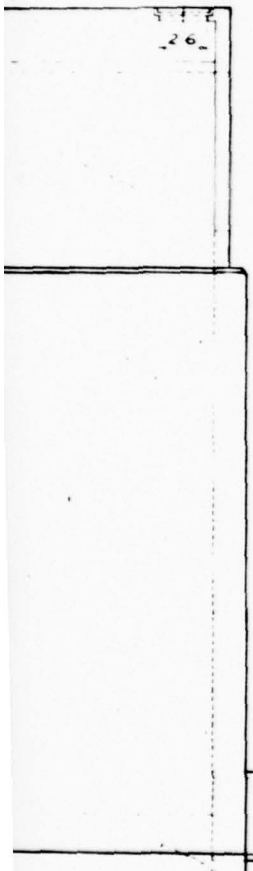
NO	DATE	REVISION
1	NOV 1979	AS BUILT DRAWING

SCALE
AS SHOWN

KE
COVERED I
STRUCTURA



SECTION A-A



EWALL ELEVATION

STEEL SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TYPE	B	C	TOTAL LENGTH
B1	6	30	16-6	1			495-0
B2	6	17	5-0	1			255-0
B3	6	60	13-3	21	4-9	8-0	795-0
B4	6	17	5-0	1			255-0
B5	6	14	6-6	1			221-0
B6	6	4	6-10	1			27-4
B7	6	7	3-5	21	1-0	8-5	22-11
B8	6	6	9-5	21	1-0	8-5	56-6
B9	6	24	9-5	21	1-0	8-5	226-0
B10	6	2	9-5	21	1-0	8-5	18-10
B11	7	14	13-0	1			182-0
B12	6	6	5-0	1			90-0
B13	6	22	13-2	21	4-7	8-7	289-0
B14	6	4	10-3	21	1-8	8-7	41-0
B15	6	4	9-11	21	1-4	8-7	39-8
B16	6	4	9-8	21	1-1	8-7	38-8
B17	6	4	9-7	21	1-0	8-7	38-4
B18	6	2	10-10	21	2-3	8-7	21-8
B19	6	2	3-3	1			6-6
B20	6	2	2-6	1			5-0
B21	6	1	2-4	1			2-4
B22	6	2	2-4	1			4-8
B23	6	2	2-10	1			5-8
R1	6	24	10-11	1			268-0
R2	6	8	3-11	1			44-0
R3	6	30	5-6	1			165-0
R4	6	14	8-6	1			119-0
R5	7	7	15-0	1			105-0
R6	6	6	5-0	1			30-0
R7	6	8	3-2	21	4-7	8-7	132-4
R8	6	4	3-0	1			12-0
R9	6	10	5-0	1			50-0
R10	6	30	2-0	21	4-5	8-5	442-0
R11	6	30	3-4	1			90-0
R12	6	4	4-4	1			60-0
R13	6	4	2-11	21	4-2	10-2	42-4
R14	6	4	6-6	1			106-0
R15	6	8	6-11	1			55-4
R16	6	20	4-6	1			92-0
R17	6	4	4-6	1			69-0
R18	6	4	3-0	1			102-0
R19	6	10	5-0	1			50-0
R20	6	30	2-4	21	4-2	8-2	444-0
R21	6	3	4-4	1			12-0
R22	6	4	4-4	1			20-8
R23	6	4	2-2	21	4-1	8-1	40-0
R24	6	24	6-7	1			158-0
R25	6	8	6-7	1			52-8
R26	6	20	4-6	1			26-0
R27	6	8	4-6	1			54-0
R28	6	4	13-0	1			102-0
R29	6	10	5-0	1			50-0
R30	6	24	2-2	21	4-1	8-1	292-0
R31	6	28	4-6	1			112-0
R32	6	2	4-0	1			48-0
R33	6	4	11-0	21	5-10	7-10	40-8
R34	6	24	6-7	1			158-0
R35	6	8	6-7	1			52-8
R36	6	20	4-6	1			26-0
R37	6	8	4-6	1			54-0
R38	6	4	12-8	1			177-4
R39	5	10	4-0	1			46-8
R40	6	24	11-8	21	3-10	7-10	280-0
R41	5	28	3-8	1			102-8
R42	5	12	3-8	1			44-0
R43	6	4	11-4	21	3-8	7-8	45-4
T1	5	24	9-6	1			228-0
T2	8	8	12-3	1			98-0
T3	5	4	8-6	1			34-0
T4	5	4	7-3	1			29-0
T5	5	4	6-0	1			24-0
T6	5	4	4-9	1			19-0
T7	5	4	3-6	1			14-0
T8	5	4	14-0	10	2-9	11-3	56-0
T9	8	16	12-9	1			204-0
T10	5	8	12-9	1			102-0
T11	5	2	4-9	1			9-6
T12	5	2	5-9	1			11-6
T13	5	2	8-3	1			16-6
T14	5	2	10-8	1			21-4
T15	5	2	13-3	1			26-6
T16	5	2	15-9	1			31-6
T17	5	2	18-3	1			36-6
T18	5	2	20-9	1			41-6
T19	5	20	5-8	1			103-0
T20	5	10	12-3	1			122-6
T21	5	4	9-3	1			37-0
T22	5	4	8-0	1			32-0
T23	5	4	6-9	1			27-0
T24	5	4	5-6	1			22-0
T25	5	4	4-3	1			17-0
T26	5	4	3-0	1			12-0
T27	5	4	14-0	10	2-9	11-3	56-0
T28	6	32	11-3	21	3-7½	7-7½	360-0
T29	5	16	11-0	21	3-6	7-6	176-0
T30	5	2	6-3	1			12-6
T31	5	2	8-8	1			17-4
T32	5	2	11-3	1			22-6
T33	5	2	13-9	1			27-6
T34	5	2	16-3	1			32-6
T35	5	2	18-9	1			37-6
T36	5	2	21-3	1			42-6
T37	5	4	21-3	1			85-0
T38	5	4	21-3	1			85-0
T39	5	30	18-9	1			562-6
T40	5	5	9-3	1			46-3
T41	4	11	21-3	1			233-9
T42	4	4	9-3	1			37-0
T43	4	11	21-3	1			233-9
T44	4	4	9-3	1			37-0
T45	5	36	9-3	21	1-10	7-5	333-0
T46	5	2	11-6	21	1-11	8-7	23-0
T47	5	2	2-9	21	0-11	1-10	5-6

QUANTITIES

STEEL	#4 BARS	541-6	362	LBS
	#5 BARS	4187-7	4368	LBS
	#6 BARS	6490-6	9743	LBS
	#7 BARS	273-0	558	LBS
	#8 BARS	795-0	2123	LBS
			17154	LBS

CONCRETE = 959 + 253V = 1024 CU YDS

LENGTH OF #4 BARS = 537.91 + LENGTH OF BARS R THROUGH R38 ROUND

LENGTH OF #7 BARS = 1182.01 + LENGTH OF BARS R51

AS BUILT DRAWING

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed — Date — Approved by — Title — Checked — Title — Traced — Drawing No. — Quantities — Title

OKEE
INTAKE RISER
IL DETAILS

LEE COUNTY FISHING LAKE
LEE COUNTY, VIRGINIA

FILE: D-193

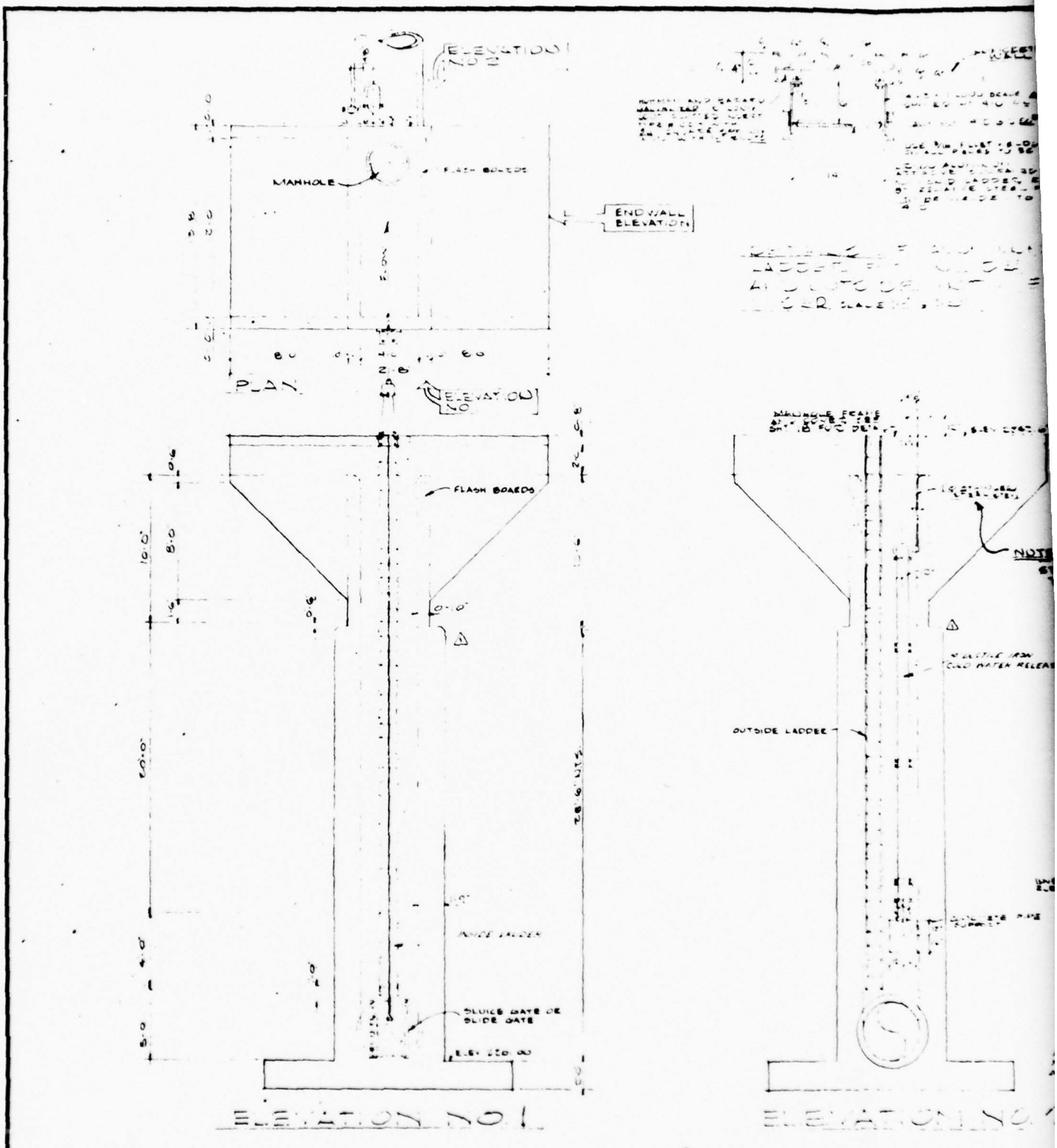
PROJECT NUMBER: 1746

DATE: JANUARY 1971

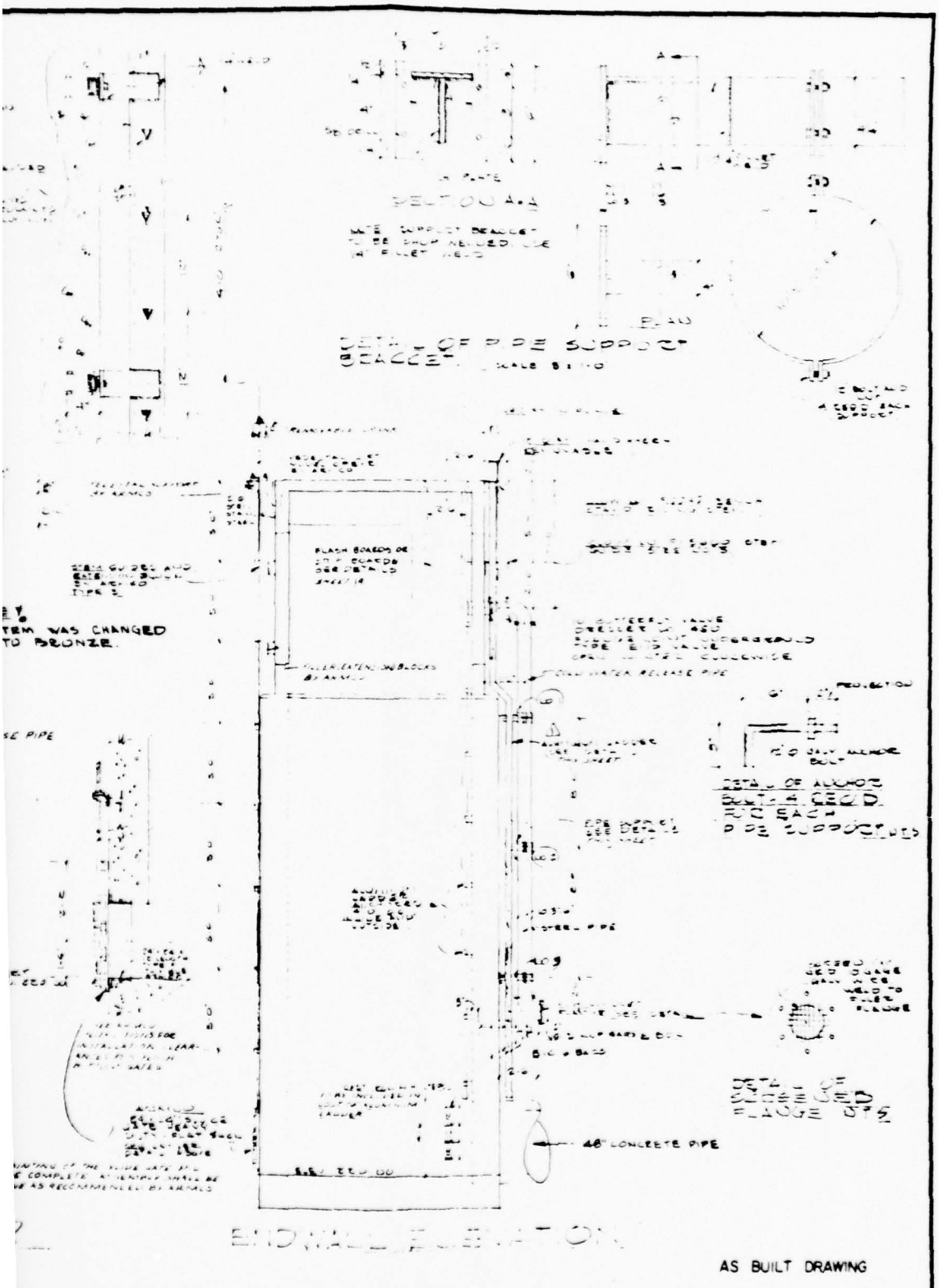
SHEETS

SHEET NO. 9

FIGURE 8

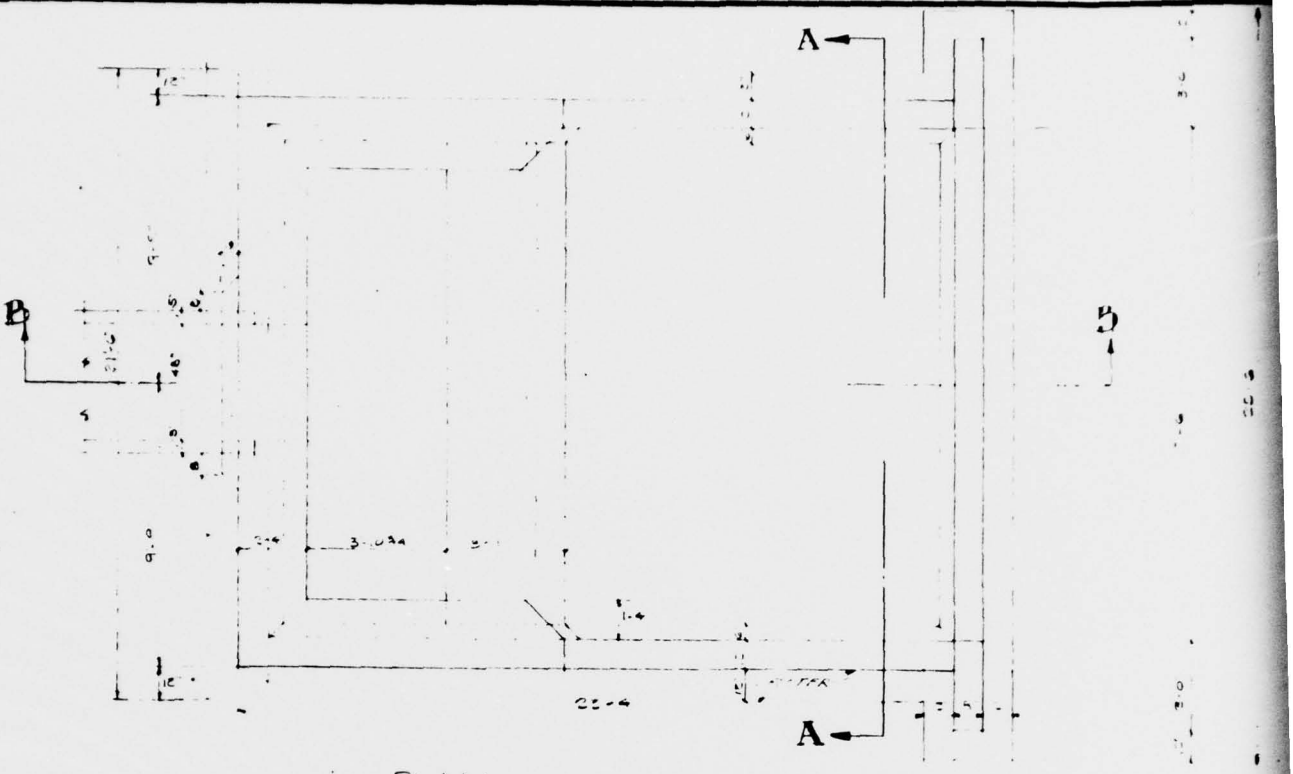


THOMPSON & LITTON CONSULTING ENGINEERS WISE, VIRGINIA	DESIGNED PPS & JAR DRAWN JFM CHECKED PPS & JAR	NO.	DATE	REVISION AS BUILT
				SCALE 1/4" = 1'-0"
				COVERED INTA STRUCTURAL

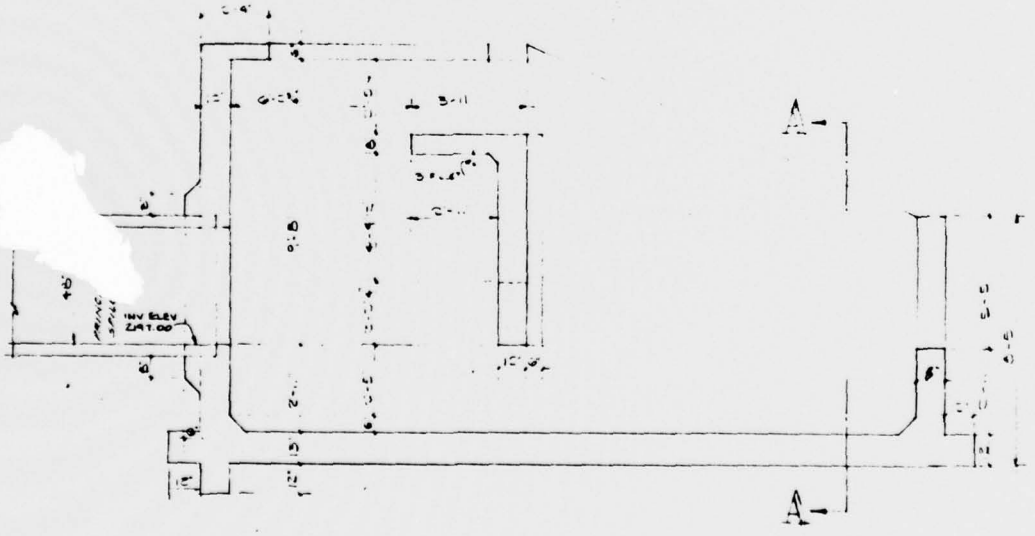


RISER TAILS	LEE COUNTY FISHING LAKE LEE COUNTY, VIRGINIA	FILE D-193	PROJECT NUMBER 1746	DATE JANUARY 1971 SHEET NO 14

FIGURE 9

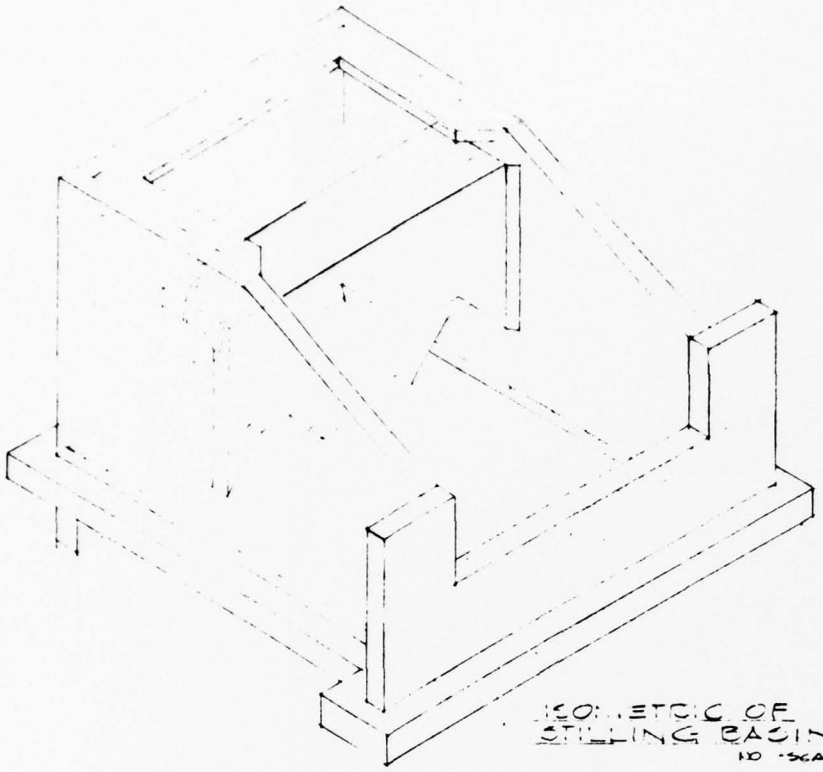


PLAN

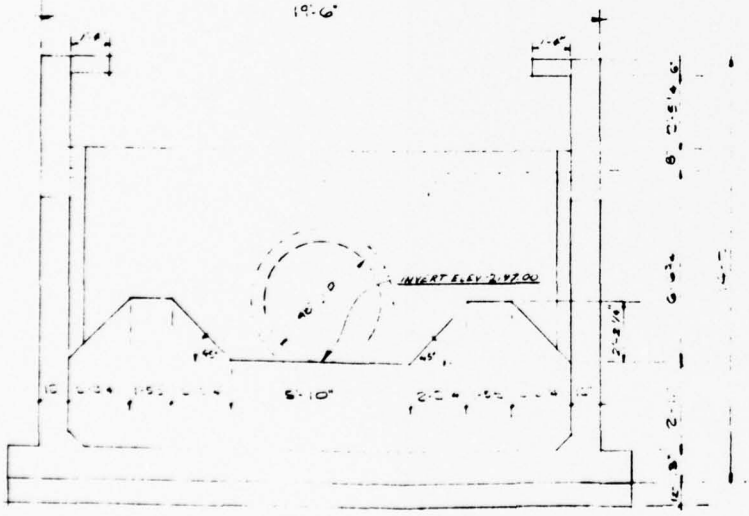


SECTION B-3

THOMPSON & LITTON CONSULTING ENGINEERS WISE, VIRGINIA	DESIGNED PPS & JAR DRAWN JFM CHECKED PPS & JAR	NO	NOV 1974 DATE	AS BUILT DRAWING REVISION	SCALE 3/8" = 1'	IMPACT STILLING BASIN A STRUCTURAL DE



ISOMETRIC OF STILLING BASIN
NO SCALE

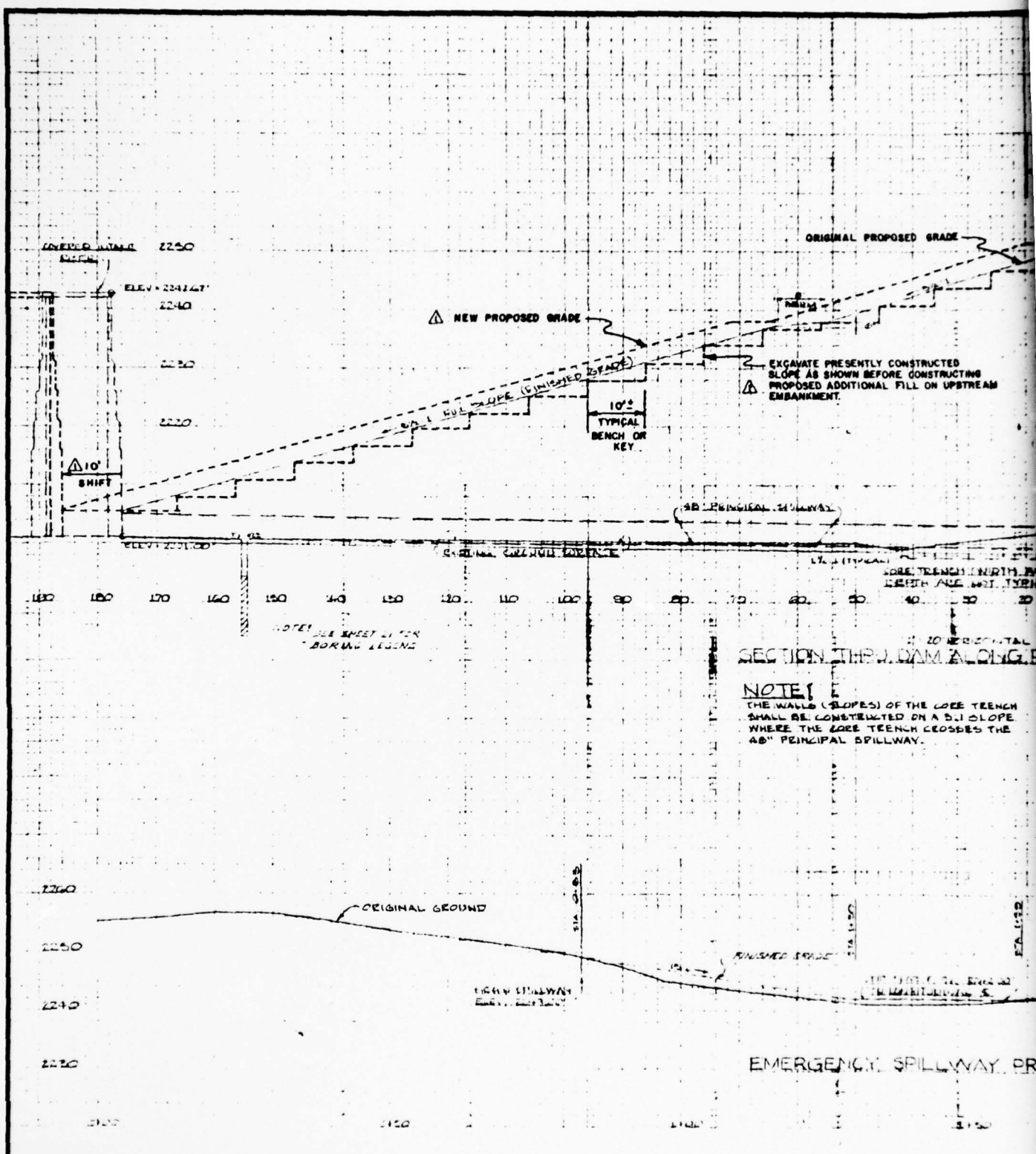


SECTION A-A

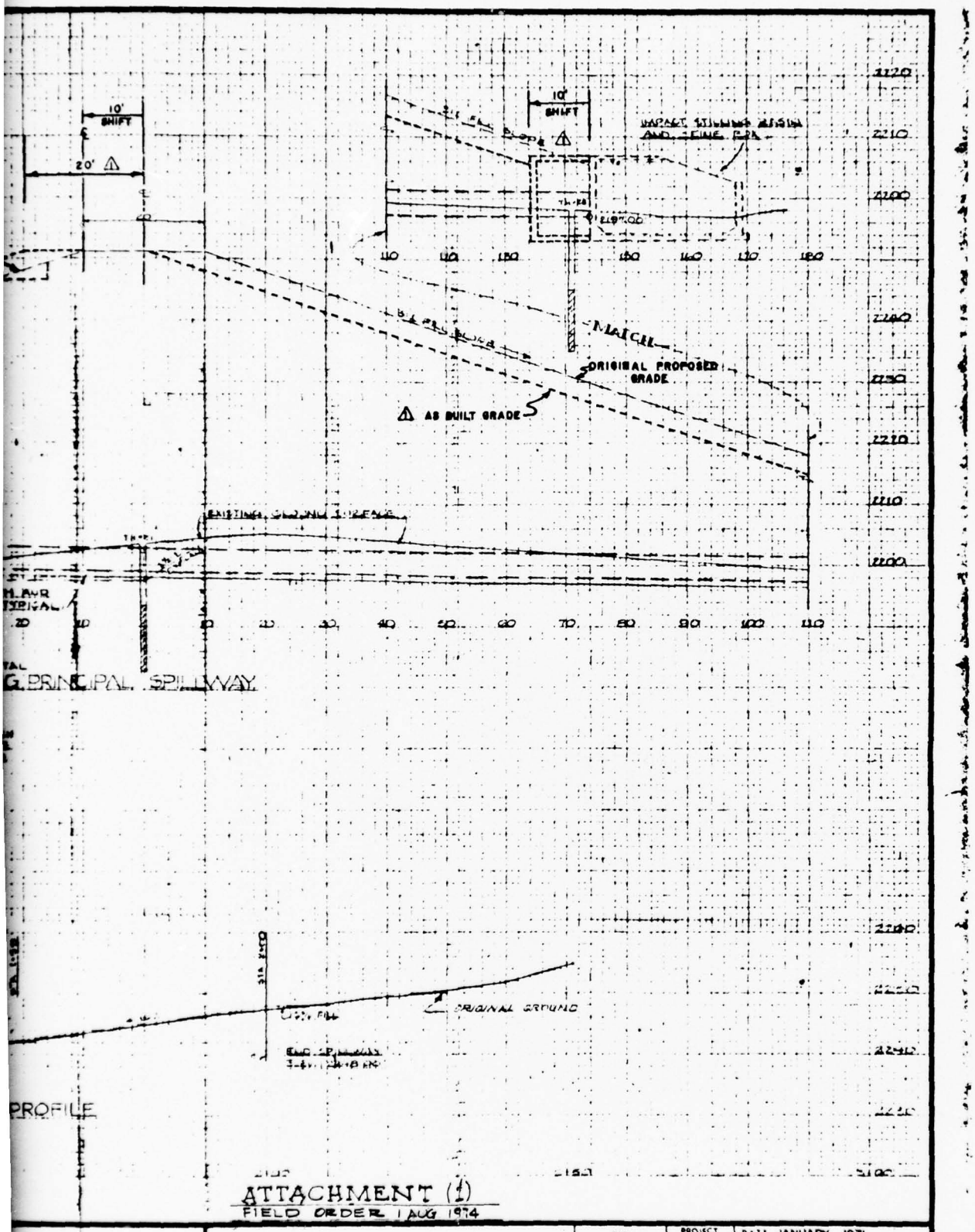
AS BUILT DRAWING

NEE ASIN AND SEINE BOX AL DETAILS	LEE COUNTY FISHING LAKE LEE COUNTY, VIRGINIA	FILE D-193	PROJECT NUMBER 1746	DATE JANUARY 1971 SHEETS SHEET No 15

FIGURE 10



THOMPSON & LITTON CONSULTING ENGINEERS WISE, VIRGINIA	DESIGNED JAR DRAWN MDL CHECKED JAR	NO. 1 DATE JULY 74 REVISION: REVISED SLOPE	SCALE 1" = 10' HORIZONTAL & VERTICAL EXCEPT AS NOTED	DAM SECTION ALONG PR EMERGENCY SPILL



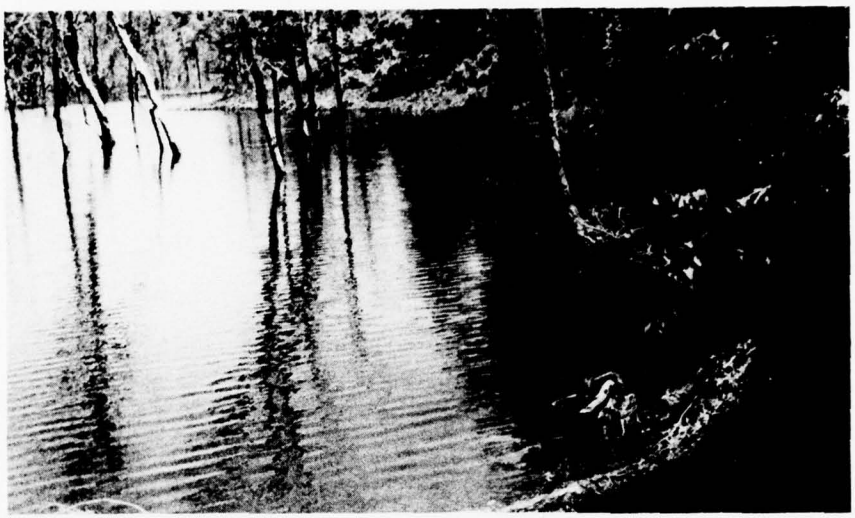
ATTACHMENT (1)
FIELD ORDER 1 AUG 1974

PRINCIPAL SPILLWAY ILLWAY PROFILE	LEE COUNTY FISHING LAKE LEE COUNTY, VIRGINIA	FILE D-193	PROJECT NUMBER 1746	DATE JANUARY 1971 SHEETS SHEET No 20

FIGURE 11

APPENDIX II

PHOTOGRAPHS



June 1978

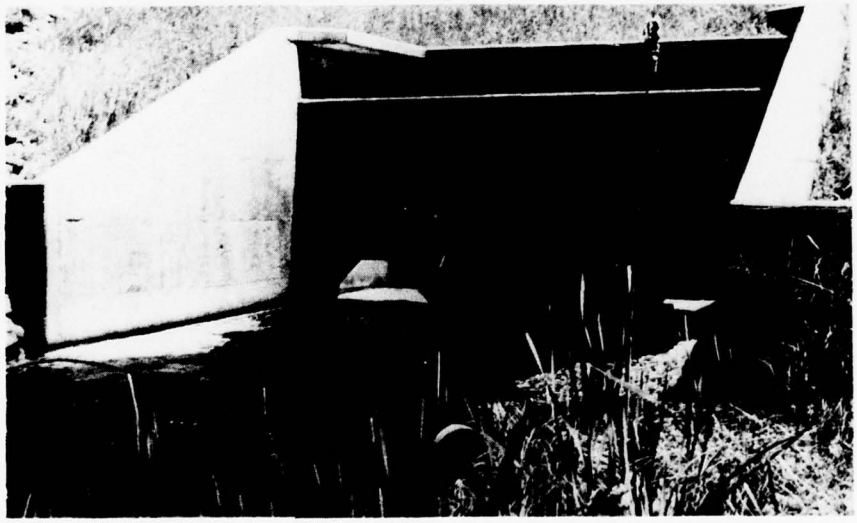
RESERVOIR SHORELINE AT LEFT:
NOTE DEAD TREES IN WATER

June 1978

RIPRAP ON UPSTREAM SLOPE
OF DAM

June 1978

EMERGENCY SPILLWAY
NOTE: DENSE TREE GROWTH BLOCKING ITS DISCHARGE CHANNEL



June 1978

IMPACT STILLING BASIN AND SEINE BOX

June 1978

CLOSE-UP OF THE LEAK AREA AT LEFT ABUTMENT

June 1978

LEAK AREA AT LEFT ABUTMENT

June 1978

RESERVOIR SIDE OF EMERGENCY SPILLWAY
NOTE: RIPRAP, ALSO DEAD TREES IN WATER

June 1978

WOODEN MEASURING WEIR

APPENDIX III

FIELD OBSERVATIONS

APPENDIX III-FIELD OBSERVATIONS
VISUAL INSPECTION CHECK LIST
PHASE I

Name Dam: Keokee County: Lee State: Virginia Coordinators: Norfolk District-Corps of Engineers

Date(s) Inspection: June 13, 1978 Weather: Clear Temperature: 85°F

Pool Elevation at Time of Inspection: 2235 feet m.s.l. Tailwater at Time of Inspection: None

Gilbert Associates, Inc.
Inspection Personnel:

James A. Hagen
Yogesh S. Shah
Nazir A. Qureshi

Also Present:

Gary Martel - Virginia Commission of Game and Inland Fisheries
Buck Arnold - Virginia State Water Control Board
Duncan McGregor - U.S. Soil Conservation Service

James A. Hagen - Recorder

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	No sloughing or significant erosion of the embankment or abutment slopes was observed. Minor erosion was evident at the downstream leak area, approximately halfway up the left dam abutment contact.	*The eroded portions should be* repaired after the leak is plugged.
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	Both alinements are good. A depression, approximately 0.3 feet deep, was noticed on the crest nearer to the center of the dam.	The cause of the depression must be investigated. Observations must be continued on this depression. A settlement survey of the crest should be performed.
RIPRAP FAILURES	Not significant.	
JUNCTION OF EMBANKMENT AND ABUTMENTS, SPILLWAY AND DAM	Leakage observed at the left downstream abutment junction of the dam (see next item below). There was no visual evidence of structural distress at either abutment.	See below.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	About 5 GPM of seepage was observed in an area of approximately 12 feet x 15 feet located approximately halfway up the downstream slope at the junction of the left abutment. The seeping water was tannic but clear.	The path of the leakage may be within a probable rock outcrop on the upstream side at the dam abutment junction. This leak is being studied by the Commission which is planning to make repairs. Permanent, rather than temporary, measures should be taken.
STAFF GAGE AND RECORDER	None.	
DRAINS	No significant flow from the drain was observed.	None.

OUTLET WORKS (Principal Spillway)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	No cracking or spalling was observed.	
INTAKE STRUCTURE	Showed no signs of distress or deterioration.	
OUTLET STRUCTURE	Showed no signs of distress or deterioration.	
OUTLET CHANNEL	Densely forested and fairly free of obstructions; one small exposed, steep slope area on right side of channel.	None
EMERGENCY GATE	Not visible.	

UNGATED SPILLWAY (Emergency Spillway)

VISUAL EXAMINATION OF	OBSERVATIONS	REMAKRS OR RECOMMENDATIONS
CONCRETE WEIR	Appears stable.	None.
APPROACH CHANNEL	An excessive number of trees were seen standing in the approach channel about 200 to 300 feet from the spillway. The side slopes in the vicinity of the emergency spillway were flat (less than approximately 35°) and stable. The dumped riprap was intact in the approach channel.	All the trees should be removed to avoid blockage of the spillway in case of high water conditions.
DISCHARGE CHANNEL	Large trees and bushes were seen to block the channel in the immediate vicinity of of the spillway and beyond.	The channel must be cleared of all trees and bushes.
BRIDGE AND PIERS	Not applicable.	

INSTRUMENTATION

Sheet 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	A 2-foot long x 1-1/4-foot deep x 1-5/8-inch thick weir board was temporarily installed near the the downstream toe at the left side end to measure the flow quantity at the leakage area. Water was flowing from under the board also.	The flow at the bottom of the board should be stopped by plugging for correct assessment of the flow quantity.
PIEZOMETERS	None.	
OTHER	None.	

RESERVOIR

Sheet 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	The slopes were relatively flat, wooded, and stable. There were no signs of significant erosion or slope failures.	None.
SEDIMENTATION	Not visible.	
MISCELLANEOUS	Many tall trees were seen standing in the reservoir area. The reservoir water was very tanic. There is no access road to the structure on the reservoir.	The trees must be removed. A road should be constructed to the dam and spillway.

DOWNSTREAM CHANNEL

Sheet 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	There was a densely forested downstream valley; however, the channel itself was fairly free of obstructions. See Emergency Spillway-Discharge channel also.	None.
SLOPES	See above.	
APPROXIMATE NO. OF HOMES AND POPULATION	There are about 30 buildings indicated on the 1955-1957 USGS 7-1/2 minute quadrangle maps within 7 miles of the dam. Based on that, the population is estimated to be 120 people. For more detail see paragraph 1.2.4.	

APPENDIX IV

GEOLOGY AND SOILS REPORTS

FROEHLING & ROBERTSON, INC.
ENGINEERS • CHEMISTS • BACTERIOLOGISTS
CABLE ADDRESS—"FROEHLING"

MAIN OFFICES AND LABORATORIES
BRANCH LABORATORIES

Richmond, Virginia
May 12, 1970

No. V-1550-S

Report of: Soil Borings

Made for: Commonwealth of Virginia
Commission of Game & Inland Fisheries
Box 11104
Richmond, Virginia 23230

Project: Preliminary Site Investigation - Dam Site

Location: On North Fork Powell River Lee Co., Va.

Date Made: April 14 thru May 4, 1970

Upon authorization from Mr. G. R. Hills, Engineer of the Commission of Game & Inland Fisheries, test borings were made at a proposed dam site on the North Fork of the Powell River, Lee Co., Va.

The test borings were made by means of diamond core boring and drive sample borings. The penetration resistance of the soil was determined by means of the standard penetration test at each change in strata or at five foot intervals, whichever occurs first. In the standard penetration test a 140 lb. hammer dropping 30" is used to drive a 2"O.D. 1.375"I.D. split spoon sampler 1 foot into the soil.

Penetration tests were judged worthless in the boulder complexes encountered as noted on the logs and were not attempted unless soil pockets were encountered.

The boring layout had been staked in the field by the owner. Elevations as shown were taken in the field by hand level. Elevation 0 was assumed from center line stream level. The strike of the rock in the area was N.E. and the rock had approximately a 15° dip. The formation encountered on the site is the Wise formation consisting of interbedded sandstone and shales, only sandstone was encountered in our borings.

As authorized by Mr. G. R. Hills, a Soil Engineer was on the site on April 28 & 29. The results of auger borings made April 14 through April 17 had failed to locate any suitable borrow material for the construction of the clay core for the proposed dam. The purpose of the Engineer's site visit was to locate a suitable borrow material. Some apparently suitable material was found in the proposed embayment area but, upon testing, this material classified as a M.L. on the Unified Soil Classification System and was deemed unsuitable for use as a core material. The test results of this material are enclosed.

All the rock encountered was sound and there was no sign of leakage. The site basis of the preliminary investigation appears satisfactory for the proposed d provided some satisfactory source of fill material can be found.

Very truly yours,

FROEHLING & ROBERTSON, INC.

W. H. Vogelsang, Director
Foundation Investigation

WHV/dw

FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS
Cable Address—"FROEHLING"

MAIN OFFICE AND LABORATORIES

BRANCH LABORATORIES

Richmond, Virginia
November 17, 1970

Report No. V-2039-11

Report of: Site Investigation

Made for: Commonwealth of Virginia
Commission of Game & Inland Fisheries
Box 11104
Richmond, Virginia 23230
Attn: Mr. G. A. Mills

Project: Additional Site Investigation
Borrow Area and Rock Pressure Testing

Location: North Fork Powell River Lee Co., Va.

Upon authorization from Mr. G. A. Mills, Chief Engineer of the Commission of Game and Inland Fisheries, additional test borings were made at proposed site. The test borings were made by means of diamond core boring and drive sample borings. The penetration resistance of the soil was determined by means of the standard penetration test at each change in strata or at five foot intervals, whichever occurs first. In the standard penetration test a 140 lb. hammer dropping 30" is used to drive a 2"O.D.-1.375"I.D. split spoon sampler 1 feet into the soil.

The terrain of the site is fairly rugged and except for some recent stream alluvium the soil on the job are residual soils developed by in place weathering. Some soil creep occurred on the slope. The Foundation Formation is the Wise Formation of Pennsylvania Age.

In the area of the job site the Wise Formation consists of interbedded sandstones and shales, with the sandstone predominating. The sandstones are Arkosic and contain a large proportion of feldspar grains which on weathering give the formation its characteristic white speckled appearance. The shale is carbonaceous and is moderately to badly weathered where encountered on the site. Moderate interbedding has given the sandstone numerous small clayey shale partings of a few fractions of an inch in size. These shale partings do not seem to be a problem on the centerline of the dam.

Dam Centerline

Borings No. 18 through 27 were redrilled on this site and then pressure tested to determine the permeability of the ledge rock.

The results of the test borings and pressure testing were favorable here. A keyway excavation into sound rock should provide the proposed dam with a positive cutoff. We

do not on the basis of the test results see any need for a grout cutoff. The Keyway excavation should be carefully inspected prior to any placing of fill and any minor adjustment in its depth made at that time.

Usually rock that upon water pressure testing will take less than 10 gallons per minute at a pressure equal to psi to the depth in feet of the strata in question will not accept grout.

Boring Nos. 28 and 29 were made respectively upstream and downstream at the toe slope. These borings were also satisfactory and water take on pressure testing indicates the rock was relatively sound and that no problems were indicated here.

Soil classifications as given on the boring logs are visual classifications based on the Unified Classification System.

Emergency Spillway
Spillway Area

Borings No. 13 through 17 were made for the proposed emergency spillway. We have no data on the location of these borings or the depth of cut for the spillway.

Proposed Borrow Area

Borings No. 30, 32 and 33 were made in the proposed borrow area. These borings indicate approximately 10' of a usable material for the proposed dam. We have no data on the location of these borings so we cannot make any evaluation as to quantity.

Laboratory test results from these borings are also enclosed and these test results show the soils in the borrow area to be acceptable for use in the dam. They would make excellent core material.

Tabulation of the laboratory and field data are enclosed.

We have enjoyed working with you on this project and hope that all data will be explanatory. If you have any questions, please feel free to call the writer

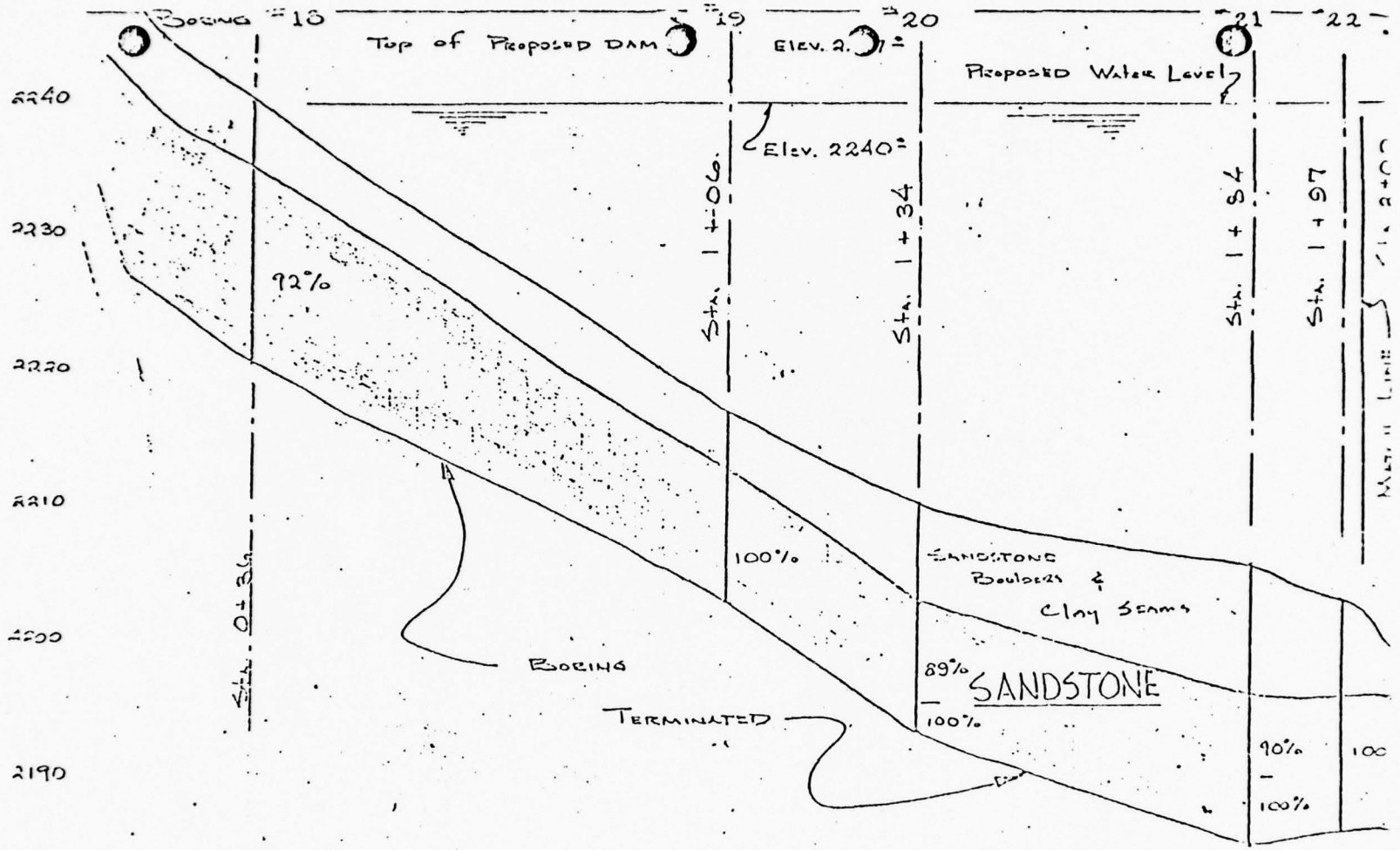
We were unable to cover some points as completely as is our usual practice because of lack of information on the final design. We will be pleased to go further into it if you feel it is desirable.

Very truly yours,

FROEHLING & ROBERTSON, INC.

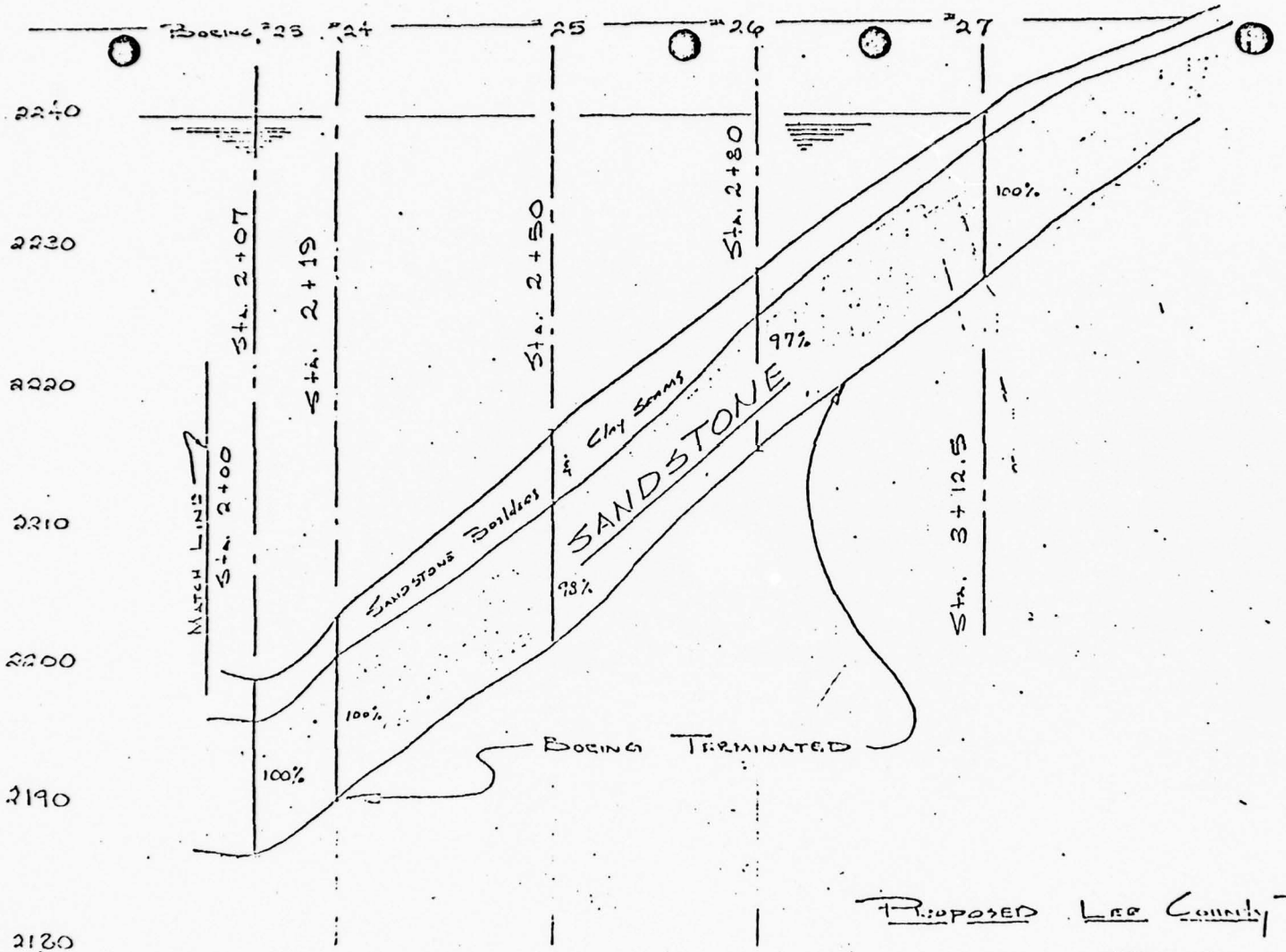
W. H. Vaselsang, Director
Foundation Investigation

WHV/dw



PROPOSED LEE COUNTY DAM

— BORING PROFILE —

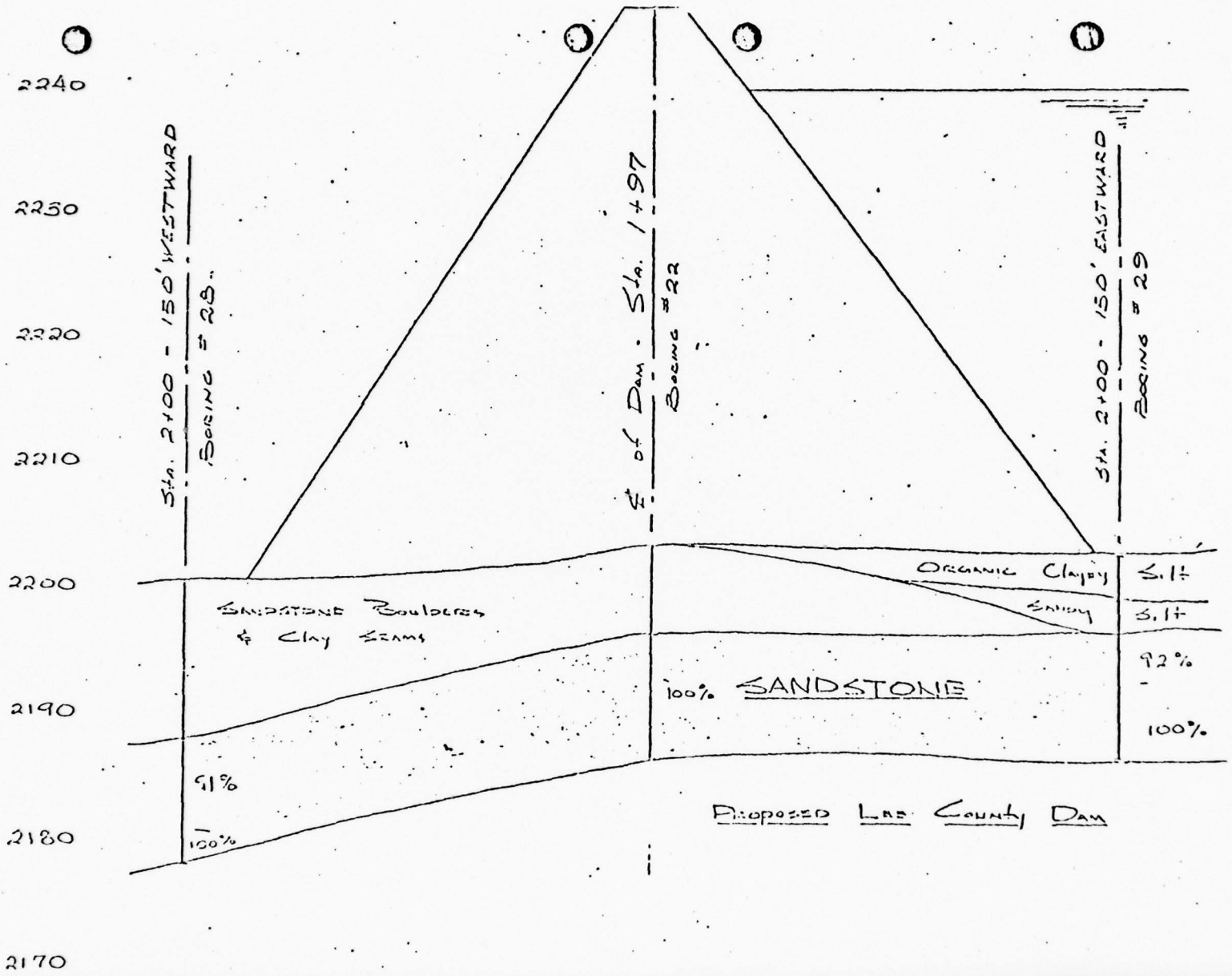


Proposed Lee County Dam

— Boring Profile —

Scale: Hor. - 1" = 20'

Vert - 1" = 10'


2240
2250
2220
2210
2200
2190
2180
2170
Sta. 2+00 - 150' WESTWARD
Boring # 28
℄ of Dam - Sta. 1+97
Boring # 22
Sta. 2+00 - 150' EASTWARD
Boring # 29
Sandstone Boulders & Clay Seams
Organic Clayey Silt
Sandy Silt
92%
100% SANDSTONE
100%
91%
100%
Proposed Lee County Dam

BD-3A

BORING LOG

FROEHLING & ROBERTSON, INC.
ENGINEERS • CHEMISTS • BACTERIOLOGISTS

Project No. V-2039-11 DATE November 16, 1970

Owner: Commonwealth of Va. Comission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No. 12 Total Depth 14.1 Elevation-Top of Hole 2245.2 Location Emergency Spillway

Type of Boring 2½"Casing 2"Dia.Bit Started 10/15/70 Completed 10/15/70 By Watts

Elevation	Depth	Sample	Classification of Materials	Blows per 6"	Core Recovery	Remarks
			Tan Silty Clay	16	2.0 3.0	
2241.1	4.1					Started Core Drilling 4.1' w/2" Dia. Bit
			Gray & Brown Fine Grained Sandstone, Moderately Weathered & Fractured - Fairly Frequent Shale Partings - Badly Fractured to 7.0'		100	
2235.1	9.1				100	
2231.1	14.1		Boring Terminated			

BD-3A

BORING LOG

FROEHLING & ROBERTSON, I
ENGINEERS • CHEMISTS • BACTERIOL

Project No. V-2039-11 DATE November 16, 1970

Owner: Commonwealth of Va. Comission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No. 10 Total Depth 14.8 Elevation-Top of Hole 2250.0 Location Center Line Spil.

Type of Boring 2½"Casing 2"Dia.Bit Started 10/23/70 Completed 10/23/70 By Watts

Elevation	Depth	Sample	Classification of Materials	Blows per 6"	Core Recovery	Remarks
2250.0	0.0		Sandstone Boulders & Clay Seams			
2235.2	4.8					Started Core Drill 4.8' with 2" Dia.
			Brown & Gray Sandstone (Fine Grain Slightly Weathered Moderately Fractured, Some Shale Partings		92%	
2220.4	14.8		Boring Terminated			

NO 2660's for rock?

SO-2A

BORING LOG

FROEHLING & ROBERTSON, INC.
ENGINEERS • CHEMISTS • BACTERIOLOGISTS

Project No. V-2039-11 DATE November 16, 1970

Owner: Commonwealth of Va. Commission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No. 13 Hole Depth 14.0 Elevation Top of Hole 2217.0 Location Center Line 1+05

Type & Size of Casing 2"Dia. Bit Started 10/22/70 Completed 10/22/70 Water Depth

Elevation	Depth	Casing Blows	Classification of Materials (Description)	Sample No.	Core Recovery	Remarks
2217.0	0.0		Sandstone Boulders & Clay Seams			
2213.0	4.0					Started Core Drilling 4.0' with 2" Dia. Bit
			Gray Fine Grained Sandstone Slightly Weathered & Fractured Sounder with depth - Slickensided Shale Seam @ 6.0' - Seam 3/8" Thick		100%	
2203.0	14.0		Boring Terminated			

64

SO-2A

BORING LOG

FROEHLING & ROBERTSON
ENGINEERS • CHEMISTS • BACTE

Project No. V-2039-11 DATE November 16, 19

Owner: Commonwealth of Va. Commission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No. 20 Hole Depth 17.6 Elevation Top of Hole 2210.6 Location Center Line 1+

Type & Size of Casing 2"Dia. Bit Started 10/19/70 Completed 10/19/70 Water Depth

Elevation	Depth	Casing Blows	Classification of Materials (Description)	Sample No.	Core Recovery	Remarks
2210.6	0.0		Sandstone Boulders & Layers of Clay			
2203.2	7.4					Started Core Dr 7.4' with 2" Di
			Tan to Gray Fine Grained Sandstone, Some Shale Partings 6.0' & 16.0' Medium Fractured & Weathered		89%	
2195.8	14.8				100%	
2193.0	17.6		Boring Terminated			

FROEHLING & ROBERTSON, INC.

BORING LOG

Project No. V-2017-11 Date November 16, 1970

Client Commonwealth of Va. Comission of Game & Inland Fisheries

Project Preliminary Site Investigation - Dam Site Lee Co., Va.

Boring No. 21 Total Depth 20.7 Ground Surface Elevation 2206.0 Coordinates Center Line 1+84

Classification of Materials (Description)

Elevation	Depth	Graphic Log	Classification of Materials (Description)	Sample No.	Recovery	Remarks
	0.0		Sandstone Boulders & Layers of Clay			
2196.3	9.7					Started Core Drilling 9.7' with 2" Dia. Bit
			Grey Sandstone Dense Fine Grained Unweathered Sandstone - Moderately Weathered top 2' - Slightly Fractured Zone @ 11.0'		90%	
2190.3	15.7				100%	
2185.3	20.7		Boring Terminated			

FROEHLING & ROBERTSON

BORING LOG

Project No. V-2017-11 Date November 16, 19

Client Commonwealth of Va. Comission of Game & Inland Fisheries

Project Preliminary Site Investigation - Dam Site Lee Co., Va.

Boring No. 22 Total Depth 17.0 Ground Surface Elevation 2203.5 Coordinates Center Line 1+

Classification of Materials (Description)

Elevation	Depth	Graphic Log	Classification of Materials (Description)	Sample No.	Recovery	Remarks
	0.0		Brown Sandstone Boulders & Layers of Clay			
2196.4	7.0					Started Core Dri 7.0' with 2" Dia
			Gray Fine Grained Slightly Weathered Sandstone - Some Slightly Interbedded shale @ 10.0' - Shale weathered back to a Clay - No apparent cont. seams Fractured zone 9.0' to 10.5'		100%	
2186.4	17.0		Boring Terminated			

SO-5A

BORING LOG

FROEHLING & ROBERTSON, INC.

Project No. V-2033-11 DATE November 16, 1970

Client: Commonwealth of Va. Comission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No. 23 Ground Surface Elev. 2208.5 Location: Center Line 2+07

Type of Boring 2" Casing 2" Dia. Rig Started 10/19/70 Completed 10/19/70 Driller Wells

Elevation	Depth	Sample No.	Classification of Materials (Descriptions)	Blows per 6"	Core Recovery	Remarks
2205.5	3.0		Sandstone Boulders & Sand			Started Core Drilling 3.0' with 2" Dia. Bit
			Gray Medium to Fine Grained Sandstone - Slightly Weathered Moderately Fractured Some Shale Partings		100%	
2191.5	8.0				100%	
2186.5	13.0		Boring Terminated			

SO-5A

BORING LOG

FROEHLING & ROBERTSON

Project No. V-2039-11 DATE November 16, 197

Client: Commonwealth of Va. Comission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No. 24 Ground Surface 13.0 Location: 2201.5 Center Line 2+

Type of Boring 2" Casing 2" Dia. Rig Started 10/21/70 Completed 10/21/70 &

Elevation	Depth	Sample No.	Classification of Materials (Descriptions)	Blows per 6"	Core Recovery	Remarks
			Gray Sandstone Boulders & Layers of Clay			
2200.5	3.0					Started Core Dri 3.0' with 2" Dia
			Gray Medium to Fine Grained Sandstone, Slightly Weathered Moderately Fractured Some Clay Partings 8.0' - 10.0'		100%	
2190.5	13.0		Boring Terminated			

50-3A

BORING LOG

FROEHLING & ROBERTSON, INC.
ENGINEERS • CHEMISTS • RADIOLOGISTS

Project No. V-2032-11 DATE November 16, 1970

Owner: Commonwealth of Va. Comission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No. 26 Total Depth 15.5 Elevation Top of Hole 2217.2 Location Center Line 2+50

Type Boring 2½" Casing 2"OD, B Bit Started 10/26/70 Completed 10/26/70 Water Meets

Elevation	Depth	Sample	Classification of Materials (Description)	Water Level	Core Recovery	Remarks
2217.2	0.0		Sandstone Boulders & Clay Seams			
2211.7	5.5					Started Core Drilling 5.5' with 2" Dia. Bit
			Tan to Gray Medium Grained Sandstone, Unfractured & Unweathered - Few Shale Partings		98%	
2201.7	15.5		Boring Terminated			

50-3A

BORING LOG

FROEHLING & ROBERTSON
ENGINEERS • CHEMISTS • RADIOLOGISTS

Project No. V-2032-11 DATE November 16, 197

Owner: Commonwealth of Va. Comission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No. 26 Total Depth 13.0 Elevation Top of Hole 2228.6 Location Center Line 2+

Type Boring 2½" Casing 2"OD, B Started 10/26/70 Completed 10/26/70 Water Meets

Elevation	Depth	Sample	Classification of Materials (Description)	Water Level	Core Recovery	Remarks
2228.6	0.0		Tan Silty Clay			
2225.6	3.0					Started Core Dri 3.0' with 2" Dia
			Tan Fine Grained Sandstone Moderately Weathered & Fractured Some Shale Partings - Top 6" Badly Fractured		97%	
2215.6	13.0		Boring Terminated			

80-8A

BORING LOG

FROEHLING & ROBERTSON, INC.
ENGINEERS • CHEMISTS • BACTERIOLOGISTS

Project No. V-2039-11 DATE November 16, 1979

Made for Commonwealth of Va. Commission of Game & Inland Fisheries

Project Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No. 22 Total Depth 12.0 Elevation 2240.0 Location Center Line 3+12.5

Type of Casing 2"Dia. Set at 10/26/79 Completed 10/26/79 Water Wells

ELEVATION	DEPTH	CASING	CLASSIFICATION OF MATERIALS (Description)	SAMPLE	CORE RECOVERY	REMARKS
2238.0	2.0		Tan Silty Clay			Started Core Drilling 2.0' with 2" Dia. Bit
			Tan Fine Grained Sandstone Moderately Weathered & Fractured to 3.0' - Sounder with depth Some slight indication of shale parting		100%	
2228.0	12.0		Boring Terminated			

80-8A

BORING LOG

FROEHLING & ROBERTSON
ENGINEERS • CHEMISTS • BACTERIOLOGISTS

Project No. V-2039-11 DATE November 15, 1979

Made for Commonwealth of Va. Commission of Game & Inland Fisheries

Project Preliminary Site Investigation - Dam Site Lee Co., Va. Sta. 3+

Hole No. 20 Total Depth 23.1 Elevation 2201.3 Location Standpipe 150' [illegible]

Type of Casing 2" Casing 2"Dia. Set at 11/27/79 Completed 11/27/79 Water [illegible]

ELEVATION	DEPTH	CASING	CLASSIFICATION OF MATERIALS (Description)	SAMPLE	CORE RECOVERY	REMARKS
2201.3	0.0		Brown Sandstone Boulders & Clay			
2188.2	13.1		Gray Fine Grained Sandstone Unweathered, Moderately Fractured Some Shale Partings		91%	Started Core Drill 13.1' w/2" Dia. B
2180.9	20.4				100%	
2178.2	23.1		Boring Terminated			

SINCE
1881
FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS
CABLE ADDRESS—"FROEHLING"

MAIN OFFICE AND LABORATORIES
P. O. BOX 1537 4TH WEST CARY STREET
RICHMOND, VIRGINIA 23208
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BRANCH LABORATORIES
DURHAM, CHARLOTTE, RALEIGH
WASHINGTON, BALTIMORE
GREENVILLE, ROANOKE, FAYETTEVILLE
ASHEVILLE

Richmond, Virginia
May 12, 1970

No. V-1880-5

Report of: Soil Borings

Made for: Commonwealth of Virginia
Commission of Game & Inland Fisheries
Box 11104
Richmond, Virginia 23230

Project: Preliminary Site Investigation - Dam Site

Location: On North Fork Powell River Lee Co., Va.

Date Made: April 14 thru May 4, 1970

Upon authorization from Mr. G. R. Mills, Engineer of the Commission of Game & Inland Fisheries, test borings were made at a proposed dam site on the North Fork of the Powell River, Lee Co., Va.

The test borings were made by means of diamond core boring and drive sample borings. The penetration resistance of the soil was determined by means of the standard penetration test at each change in strata or at five foot intervals, whichever occurs first. In the standard penetration test a 140 lb. hammer dropping 30" is used to drive a 2"O.D. 1.375"I.D. split spoon sampler 1 foot into the soil.

Penetration tests were judged worthless in the boulder complexes encountered as noted on the logs and were not attempted unless soil pockets were encountered.

The boring layout had been staked in the field by the owner. Elevations as shown were taken in the field by hand level. Elevation 0 was assumed from center line stream level. The strike of the rock in the area was N.E. and the rock had approximately a 15° dip. The formation encountered on the site is the Wise Formation consisting of interbedded sandstone and shales, only sandstone was encountered in our borings.

As authorized by Mr. G. R. Mills, a Soil Engineer was on the site on April 28 & 29. The results of auger borings made April 14 through April 17 had failed to locate any suitable borrow material for the construction of the clay core for the proposed dam. The purpose of the Engineer's site visit was to locate a suitable borrow material. Some apparently suitable material was found in the proposed embayment area but, upon testing, this material classified as a M.L. on the Unified Soil Classification System and was deemed unsuitable for use as a core material. The test results of this material are enclosed.

All the rock encountered was sound and there was no sign of leakage. The site on the basis of the preliminary investigation appears satisfactory for the proposed dam provided some satisfactory source of fill material can be found.

Very truly yours,

FROEHLING & ROBERTSON, INC.

W. H. Vogelsang, Director
Foundation Investigation

WHV/dw

LABORATORY TEST RESULTS

on Proposed Borrow Area upstream from the Dam
Center Line on 100' spacing

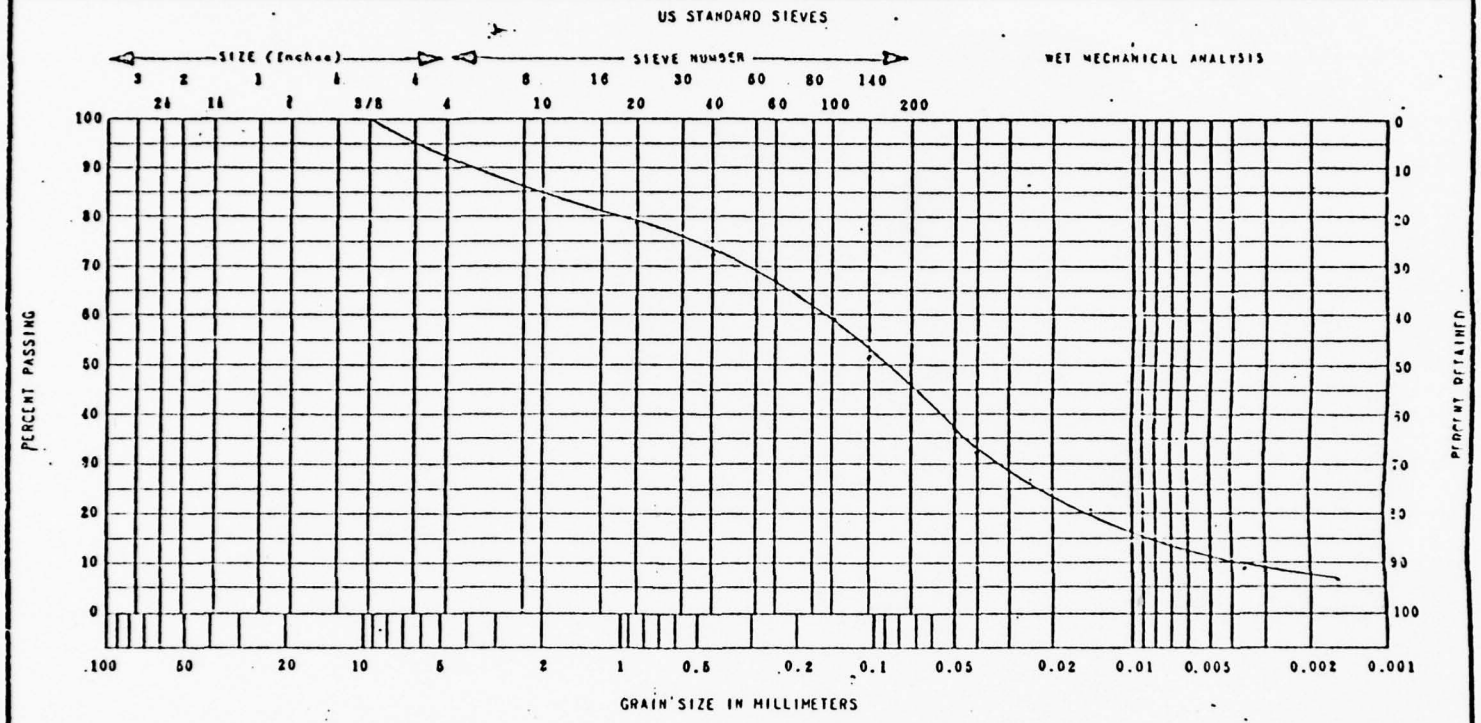
No. 1	100' upstream	L.L.	19.5%	P.I.	1.6%
No. 2	200' upstream	L.L.	18.5%	P.I.	N.P.
No. 3	300' upstream	L.L.	20.6%	P.I.	0.4%

The above materials are very similar so a composite sample was tested for grain size distribution. (See Graph)

GRAIN SIZE DISTRIBUTION GRAPH - AGGREGATE GRADING CHART

DATE

PROJECT

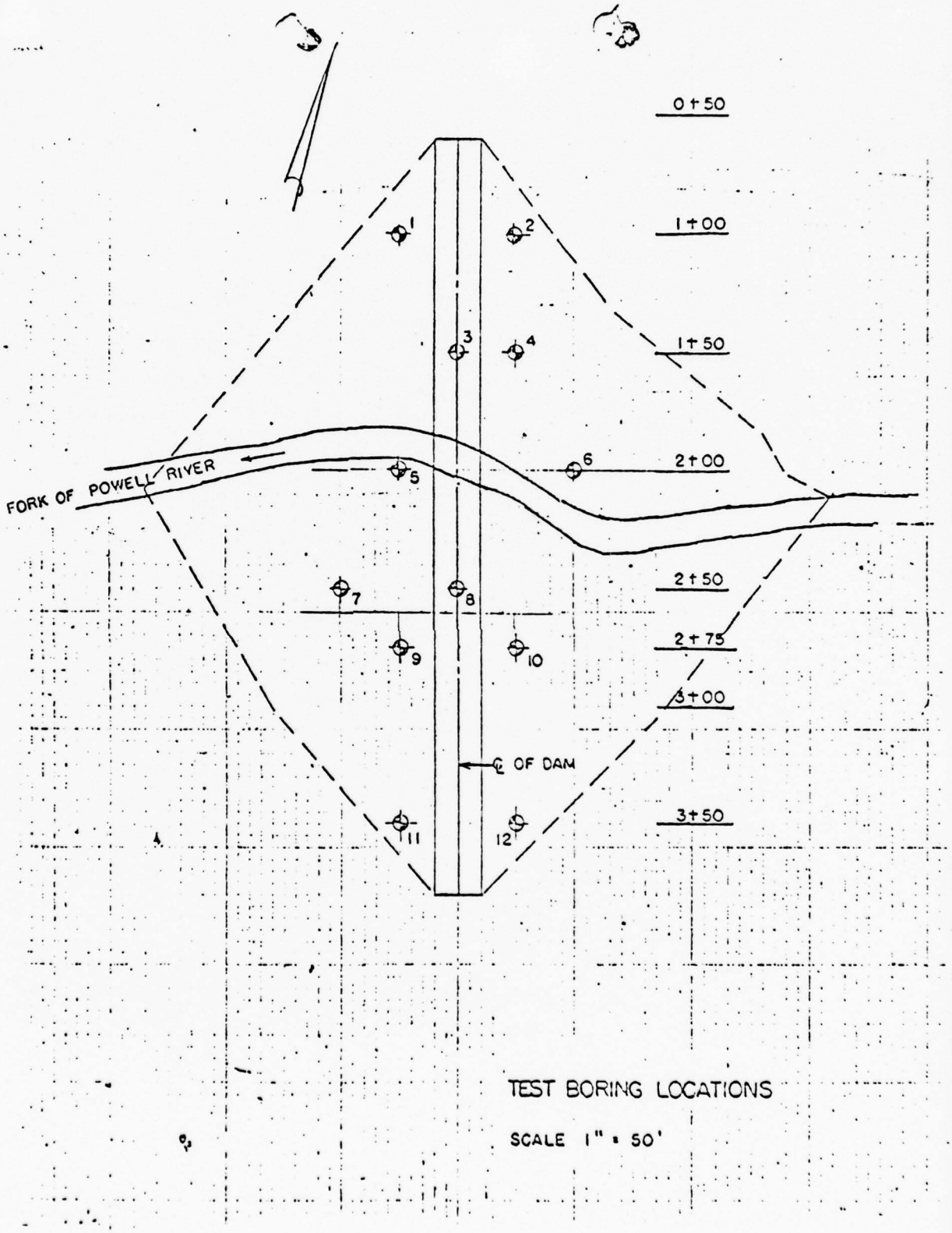


EXCAVATION NUMBER	SAMPLE NUMBER	NATURAL % MOISTURE	W_L	W_P	I_P	CLASSIFICATION	REMARKS
DAM SITE						M.L.	COMBINATION

TECHNICIAN (Signature)

PLOTTED BY (Signature)

CHECKED BY (Signature)



TEST BORING LOCATIONS

SCALE 1" = 50'

SO-SA

BORING LOG

FROEHLING & ROBERTSON, INC.
SINCE [F&R] 1881
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

Report No. V-1880-5 DATE May 11, 1970

Made for: Commonwealth of Virginia Commission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site - Lee Co., Va.

Hole No.: 1 | Total Depth: 8.0 | Elevation—Top of Hole: 36.5± | Hole Location:

Type of Boring: 2½" Casing | Started 4/20/70 | Completed 4/20/70 | Driller: Watts

Elevation	Depth	Casing Blows	CLASSIFICATION OF MATERIALS (Description)	Sample Blows	% Core Recovery	REMARKS
36.5	0.0		Tan Clayey Silt		2.0	No Water Table Encountered
33.5	3.0			14	3.0	Started Core Drilling 3.0' with 2" Dia. Bit
			Brown & Gray Sandstone		86%	
28.5	8.0		Boring Terminated			

*No. of Blows 140-lb. Hammer, 15 in. Fall, Required to Drive Casing One Foot.

30-3A

BORING LOG

FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS
SINCE F&R 1881

Report No. V-1880-5 DATE May 11, 1970

Made for:	Commonwealth of Virginia Commission of Game & Inland Fisheries				
Project:	Preliminary Site Investigation - Dam Site Lee Co., Va.				
Hole No.:	2	Total Depth: 7.0	Elevation—Top of Hole: 34.5±	Hole Location	
Type of Boring:	2½" Casing	Started 4/20/70	Completed 4/20/70	Driller	Watts

Elevation 34.5	Depth 0.0	*Casing Blows	CLASSIFICATION OF MATERIALS (Description)	**Sample Blows	% Core Rec. (%)	REMARKS
33.5	1.0		Tan Clayey Silt	3	1.0	No Water Table Encountered
32.5	2.0		Sandstone Boulders			Started Core Drilling 2.0' with 2" Dia: Bit
			Brown Sandstone		92%	
27.5	7.0		Boring Terminated			

*No. of Blows 350 lb. Hammer 30 in. Fall Required to Drive Casing One Foot

BORING LOG

SINCE 1881 FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

Report No. V-1880-5 DATE May 11, 1970

Made for: Commonwealth of Virginia Commission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No.: 3 Total Depth: 9.6 Elevation—Top of Hole: 19.0± Hole Location:

Type of Boring: 2½" Casing Started 4/21/70 Completed 4/21/70 Driller: Watts

Elevation	Depth	Casing Blows	CLASSIFICATION OF MATERIALS (Description)	Sample Blows	% Core Recovery	REMARKS
19.0	0.0		Tan Silty Clay		1.0	
				5	2.0	No Water Table Encountered
					3.6	
15.0	4.0					
14.4	4.6		Brown Weathered Sandstone	25	4.6	Started Core Drilling 4.6' with 2" Dia. Bit
			Brown Sandstone		94%	
9.4	9.6					
			Boring Terminated			

BORING LOG

SINCE 1881 FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

Report No. V-1880-5 DATE May 11, 1970

Made for: Commonwealth of Virginia Commission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No.: 4 | Total Depth: 9.5 | Elevation—Top of Hole: 17.0± | Hole Location:

Type of Boring: 2½" Casing | Started 4/22/70 Completed 4/22/70 Driller Watts

Elevation	Depth	Casing Blows	CLASSIFICATION OF MATERIALS (Description)	Sample Blows	% Core Recovery	REMARKS
17.0	0.0		Tan Clayey Silt		2.0	No Water Table Encountered
				14	3.0	
12.5	4.5					Started Core Drilling 4.5' with 2" Dia. Bit
			Brown Sandstone		90%	
7.5	9.5		Boring Terminated			

LOG

SINCE 1881 FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

1880-5 DATE May 11, 1970

Commonwealth of Virginia Commission of Game & Inland Fisheries

Preliminary Site Investigation - Dam Site Lee Co., Va.

B-5 | Total Depth 19.6 | Elevation—Top of Hole 10.7± | Hole Location:

2½" Casing | Started 4/27/70 Completed 4/27/70 | Driller: Watts

Depth	Elev.	Casing Blows	CLASSIFICATION OF MATERIALS (Description)	Sample Blows	% Core Recovery	REMARKS
0.0						
			Tan Clayey Silt		1.0	Water Data:
				16	2.0	5.0' @ 0 hr.
1.1	3.0				3.0	6.1' @ 24 hr.
				43	4.0	
			Brown Clayey Sand		5.0	
				17	6.0	
					7.0	
				22	8.0	
					9.0	
				18	10.0	
-0.3	11.0				11.0	
				21	12.0	
			Gray Silty Sand		13.0	
				30	14.0	
-3.9	14.6					Started Core Drilling 14.6' with 2" Dia. Bit
			Gray Sandstone		86%	
-8.9	19.6					
			Boring Terminated			

BORING LOG

SINCE 1881 FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

Report No. V-1880-5 DATE May 11, 1970

Made for: Commonwealth of Virginia Commission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No.: 6 | Total Depth: 10.3 | Elevation—Top of Hole: 6.7± | Hole Location:

Type of Boring: 2½" Casing | Started 4/24/70 | Completed 5/3/70 | Driller: Watts

Elevation	Depth	Casing Blows	CLASSIFICATION OF MATERIALS (Description)	Sample Blows	% Core Recovery	REMARKS
6.7	0.0					
			Brown Sand & Organic		2.0	Water Data: 2.5' @ 24 hr.
3.7	3.0			6	3.0	
			Gray Sand & Gravel		4.0	
1.4	5.3			37	4.9	Started Core Drilling 5.3' with 2" Dia. Bit
			Gray Sandstone		100%	
-3.6	10.3					
			Boring Terminated			

. of Blows 250-lb. Hammer, 30-in. Fall, Required to Drive Casing One Foot.
. of Blows 140-lb. Hammer, 30-in. Fall, Required to Drive [illegible]

BORING LOG

SINCE F&R 1881 FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

Report No. V-1880-5 DATE May 11, 1970

Made for: Commonwealth of Virginia Commission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No.: 7 | Total Depth: 15.5 | Elevation—Top of Hole: 7.7± | Hole Location:

Type of Boring: 2½" Casing | Started 4/27/70 Completed 4/27/70 Driller: Watts

Elevation	Depth	Casing Blows	CLASSIFICATION OF MATERIALS (Description)	** Sample Blows	% Core Recovery	REMARKS
7.7	0.0		Sandstone Boulders & Clay Seams		3.0	Water Data: 1.5' @ 24 hr.
				14	4.0	
					9.0	
-2.8	10.5			78	10.0	Started Core Drilling 10.5' with 2" Dia. Bit
			Brown & Gray Sandstone		92%	
-7.8	15.5		Boring Terminated			

** No. of Blows 250-lb. Hammer, 30-in. Fall, Required to Drive Casing One Foot
of Blows 140 lb. [illegible]

BORING LOG

SINCE 1881 FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

Report No. V-1880-5 DATE May 11, 1970

Made for: Commonwealth of Virginia Commission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No.: 8 | Total Depth: 15.0 | Elevation—Top of Hole: 8.7± | Hole Location:

Type of Boring: 2½" Casing | Started 4/24/70 | Completed 4/24/70 | Driller: Watts

Elevation	Depth	Casing Blows*	CLASSIFICATION OF MATERIALS (Description)	Sample Blows**	% Core Recovery	REMARKS
8.7	0.0		Sandstone Boulders & Clay Seams		3.0	Water Data: 5.2' @ 24 hr.
				31	4.0	
3.7	5.0		Gray Sandstone & Clay Seams		30%	Started Core Drilling 5.0' with 2" Dia. Bit
-1.3	10.0		Gray & Brown Sandstone		96%	
-6.3	15.0		Boring Terminated			

*No. of Blows 250-lb. Hammer, 30-in. Fall, Required to Drive Casing One Foot.
**No. of Blows 140-lb. Hammer, 30-in. Fall, Required to Drive 2-in. O.D., 1 3/8 in I.D. Sample One Foot.

Scale 1"=

BORING LOG

SINCE 1881 FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

Report No. V-1330-S DATE May 11, 1970

Made for: Commonwealth of Virginia Commission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No.: 9 | Total Depth: 20.0 | Elevation—Top of Hole: 9.7± | Hole Location:

Type of Boring: 2½" Casing | Started 4/30/70 | Completed 4/30/70 | Driller: Watts

Elevation	Depth	* Casing Blows	CLASSIFICATION OF MATERIALS (Description)	** Sample Blows	% Core Recovery	REMARKS
9.7	0.0		Gray Sandstone Boulder & Clay Seams		3.0	Water Data: No Water Table Encountered
				18	4.0	
3.1	6.6		Brown & Gray Sandstone		76%	Started Core Drilling 6.6' with 2" Dia. Bit
-0.3	10.0		Gray Sandstone		98%	
-5.3	15.0				100%	
-10.3	20.0		Boring Terminated			

* Blows of 140 lb. Hammer 30 in. Fall Required to Drive Casing One Foot

BORING LOG

SINCE 1881 FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS · CHEMISTS · BACTERIOLOGISTS

Report No. V-1880-5 DATE May 11, 1970

Made for: Commonwealth of Virginia Commission of Game & Inland Fisheries

Project: Preliminary Site Investigation - Dam Site Lee Co., Va.

Hole No.: 10 | Total Depth: 15.0 | Elevation—Top of Hole: 10.7± | Hole Location:

Type of Boring: 2½" Casing | Started 4/30/70 | Completed 4/30/70 | Driller: Watts

Elevation	Depth	* Casing Blows	CLASSIFICATION OF MATERIALS (Description)	** Sample Blows	% Core Recovery	REMARKS
10.7	0.0		Sandstone Boulder & Clay Seams		3.0	Water Data: 6.5' @ 0 hr.
				31	4.0	
3.3	7.4		Brown & Gray Sandstone		81%	Started Core Drilling 7.4' with 2" Dia. Bit
0.7	10.0		Brown & Gray Sandstone		100%	
-4.3	15.0		Boring Terminated			

*No. of Blows 250-lb. Hammer, 30-in. Fall, Required to Drive Casing One Foot.
**No. of Blows 140-lb. Hammer, 30-in. Fall, Required to Drive 2-in. O.D., 1.375 in I.D. Sample One Foot

Scale 1" =

BORING LOG

SINCE 1881 FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

Report No. V-1380-5 DATE May 12, 1970

Made for:	Commonwealth of Virginia Commission of Game & Inland Fisheries				
Project:	Preliminary Site Investigation - Dam Site Lee Co., Va.				
Hole No.:	11	Total Depth: 9.5	Elevation—Top of Hole:	Hole Location:	
Type of Boring:	2½" Casing	Started 5/1/70	Completed 5/1/70	Driller:	Watts

Elevation	Depth	Casing Blows*	CLASSIFICATION OF MATERIALS (Description)	Sample Blows**	% Core Recovery	REMARKS
	0.0		Sandstone Boulders & Clay Seams			No Water Table Encountered
	4.5					Started Core Drilling 4.5' with 2" Dia. Bit
			Brown Sandstone		100%	
	9.5		Boring Terminated			

*No. of Blows 250-lb. Hammer, 30-in. Fall, Required to Drive Casing One Foot.

Scale 1" =

SO-SA

BORING LOG

SINCE 1881 FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS

Report No. V-1880-5 DATE May 12, 1970

Made for:	Commonwealth of Virginia Commission of Game & Inland Fisheries				
Project:	Preliminary Site Investigation - Dam Site Lee Co., Va.				
Hole No.: 12	Total Depth: 9.0	Elevation—Top of Hole		Hole Location:	
Type of Boring: 2½" Casing	Started 5/4/70	Completed 5/4/70		Driller: Watts	

Elevation	Depth	* Casing Blows	CLASSIFICATION OF MATERIALS (Description)	** Sample Blows	% Core Recovery	REMARKS
	0.0		Sandstone Boulders & Clay Seams			No Water Table Encountered
	4.0		Brown Sandstone		94%	Started Core Drilling 4.0' with 2" Dia. Bit
	9.0		Boring Terminated			

APPENDIX V

STABILITY CALCULATIONS
(LATER)

APPENDIX VI

REFERENCES

APPENDIX VI

REFERENCES

1. Recommended Guidelines for Safety Inspection of Dams, (Washington, D.C., Department of the Army, Office of the Chief of Engineers).

2. HEC-1 Flood Hydrograph Package, (Hydrologic Engineering Center, Corps of Engineers, U.S. Army, January, 1973).

3. Final Design Summary, Lee County Fishing Lake, Lee County Virginia, (Wise, Virginia, Thompson & Litton, Inc., July, 1972).

4. "Rainfall Frequency Atlas of the United States," Technical Paper No. 40, (U.S. Weather Bureau, May, 1961).

5. Design of Small Dams, (U.S. Department of the Interior, Bureau of Reclamation, Second Edition, 1973).

6. "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian," Hydrometeorological Report No. 33, (U.S. Weather Bureau, April, 1956).

APPENDIX VII

PREVIOUS INSPECTION REPORTS

APPENDIX VII

July 7, 1977

Mr. Michael J. Penfold
Forest Supervisor
U. S. Department of Agriculture
Forest Service
3517 Brandon Avenue, SW
Roanoke, Virginia 24018

RE: Lake Keokee Dam
Clinch Ranger District

Dear Mike,

As you know, we are concerned with a flow of water which has developed between the dam structure and one natural abutment. If you will, let me give you the background on this problem.

On January 12, 1976 the senior inspector for Thompson & Litton, Inc., Mr. Clarence Jordan, visited the Lake and made the following observations:

> "Approximately halfway up the southern most portion of the downstream slope, where the earth work of the dam ties into the existing ground, an 18 inch layer of rip rap stone was placed for slope protection and this constructed open-swell type ditch. There were two streams of water at approximate elevation of 2215. The largest stream was estimated to be some three inches. A smaller stream was located a short distance out of the ditch and away from the dam, and this stream was one inch. There is no knowledge or any records of any springs or any wet weather springs being located in this area. It is possible that these two sources of water could be coming from wet weather springs. There also might be water flowing or originating from underneath the dam and following some rock strata under the sand filter blanket. There is also the possibility that this stream of water is being charged from the Lake."

The end result of this report was a recommendation to employ the services of a qualified geologist who has experience with underground streams of water and perhaps who has had some experience in analyzing this type of problem around earth fill dams.

In June, 1976 a follow up visit to the Lake indicated that the volume of water appeared to have increased. Since the stream had gotten larger, it was suspected that water from the Lake is following an aquifer in the original strata at or near its southerly shore to the vicinity of the southern abutment, then surfaces under spring-like pressure along the toe of the fill along the abutment at an elevation between 15 and 25 feet below the Lake level.

At this stage, the Game Commission contacted Geotechnics, Inc., located at Vinton, Virginia to inspect and recommend a remedy to the situation.

In October, 1976 Geotechnics, Inc., sent us their recommendations on how to correct the problem; the technique provides for the placement of a grout curtain in the original strata perpendicular to the southerly abutment. It is preferable to grout from the bottom of the hole upward by withdrawing the grout pipe up and thus eliminating the grout connections or markedly reducing them. The basic premise in any grouting operation is to get the mix sufficiently fluid and of low viscosity so it will move into the voids and openings and then increase the solids to a degree that they will gradually plug or seal the openings. Simply stated, start with a thin mix and thicken as rapidly as possible taking care to avoid plugging the openings, suddenly, by an excessively thick mix.

In January, 1977 the Engineering Section of the Game Commission submitted their required specifications for grouting repairs (copy attached) to the Division of Engineering and Building for funding approval. At the same time, we requested permission to hire a geological firm (Geotechnics, Inc., of Vinton, Virginia) to supervise the grouting operation.

As you are aware, we are taking every opportunity to conserve funds and while the water flow is not a true emergency we, nevertheless, feel that we should continue to keep abreast of conditions and we should be in a position to proceed with repairs in the event conditions change. We are now at the point where the Capital Outlay Project has been approved. We can initiate repair work when conditions require these repairs.

In March, 1977 the Engineering Section and the area fish Biologist jointly inspected the dam and at that time the area in question was staked. The area fish biologist agreed to check the dam monthly to insure that the water did not increase in size. He also installed a weir wheel to check the volume and took the temperature of the Lake and the flow of water on each monthly inspection. As of the end of June, the following conclusions were reached: the area of the flow had moved slightly but volume had not increased since March, and the temperature of the Lake and of the water flowing from the dam were approximately the same.

We have not had any experience with grouting operations and we would appreciate any additional assistance or guidance on this project that the U. S. Forest Service could offer.

Sincerely,

J. W. Engle, Jr.
Chief, Lands and Engineering
Division

MPK/ga

Enclosure

cc: Mr. C. F. Phelps
Mr. J. F. McInteer, Jr.
Mr. J. M. Hoffman

COMMONWEALTH OF VIRGINIA

COMMISSION OF GAME AND INLAND FISHERIES

MEMORANDUM

TO : Lloyd Byrd

DATE: October 13, 1977

FROM: M. P. Kalan

SUBJECT: Lee County Lake Leak

Tuesday, 11 October, 1977, John Jessee and I conducted a dye test at Lee County Lake to see if we could determine whether or not the lake water was leaking through the dam.

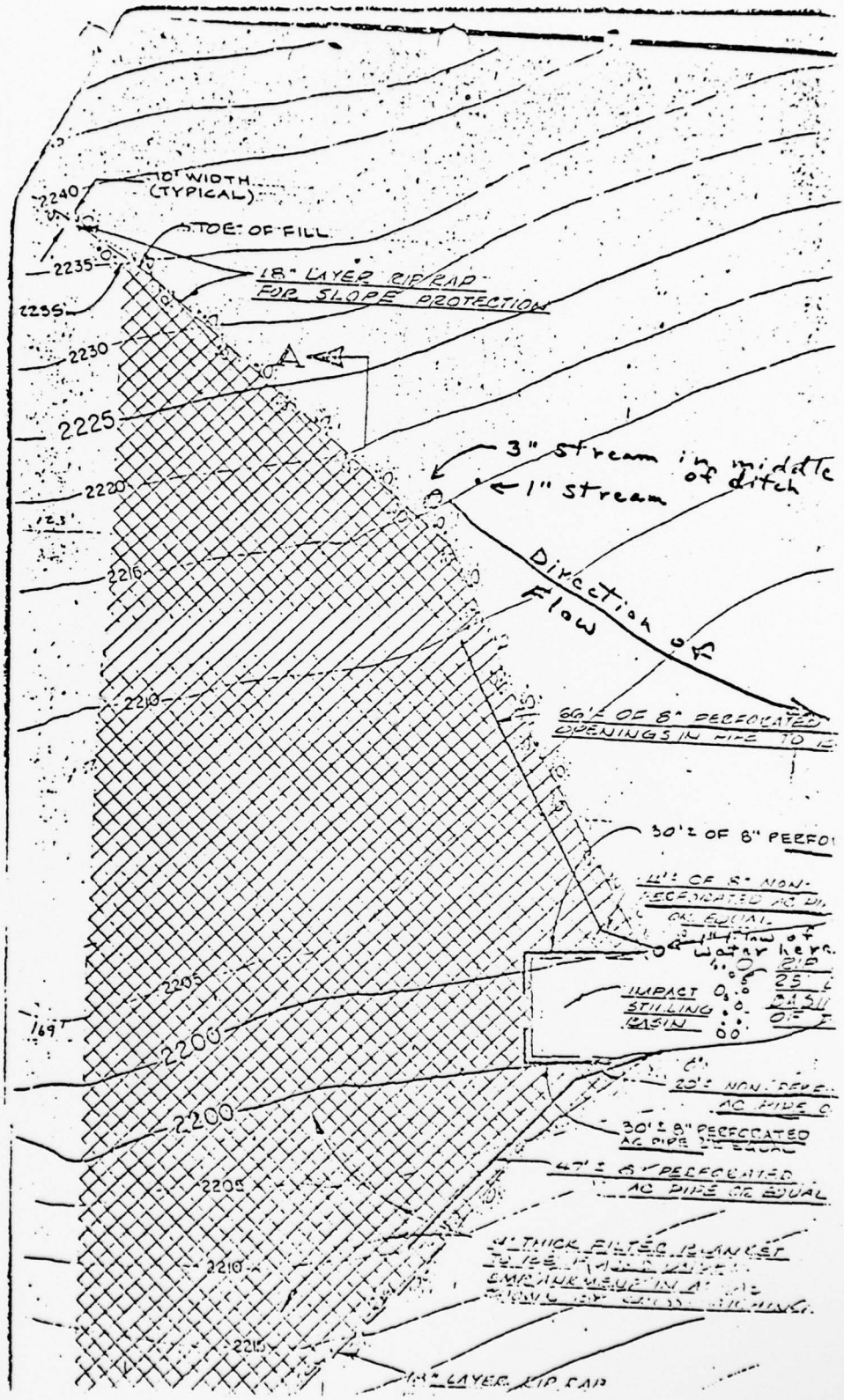
Prior to the start of the test we checked the temperature of the flow of water coming out of the dam, it was 61°, the water in the lake was 58°, We put the dye in the water at approximately 8 feet below the surface. In roughly 30 minutes there was a trace of dye showing at the strongest point of the leak. We also ran ~~clearly~~ carefully test to see if the dye showed up on the meter. The meter showed 92° with dye added and 93° without the dye. In an hour there were definite traces of the dye coming through the dam. The dye was very apparent to the naked eye.

Based on this test both John Jessee and I feel that the dam is definitely leaking and that it takes about 30 minutes to travel the 75 feet through the dam. It appears that the leak is about 8-10 feet below the surface. John Jessee and I feel that we should lower the lake about 10 feet to see if that relieves the pressure on the leak. Lowering of the lake at this time would not effect fish population, as the lake is out of balance now.

Do you want me to discuss the lowering of the lake with the Fish Division or do you want to do it? I will inform TVA people of the result of the test.

MPK/pl

cc: Jim Engle
Jack Hoffman


10' WIDTH (TYPICAL)
TOE OF FILL
18" LAYER RIP RAP FOR SLOPE PROTECTION
2240
2235
2230
2225
2220
2216
2210
2205
2200
2195
2210
2215
123'
169'
3" stream in middle of ditch
1" stream
Direction of Flow
IMPACT STILLING BASIN
18" LAYER RIP RAP

APPENDIX VIII

CONDITIONS

AD-A063 509 GILBERT ASSOCIATES INC READING PA F/G 13/2
NATIONAL DAM SAFETY PROGRAM. KEOKEE DAM (VA 10502), TENNESSEE R--ETC(U)
AUG 78 T E ROBERTS DACW65-78-D-0014
NL

UNCLASSIFIED

2 OF 3
AD
A063 509

END
DATE
FILMED
3--79
DDC

APPENDIX VIII

CONDITIONS

This Report is based on a visual inspection of the dam, a review of available engineering data and a hydrologic analysis performed during a Phase I Investigation as set forth in the U.S. Corps of Engineers' "Recommended Guidelines for Safety Inspection of Dams" and the contract between the U.S. Corps of Engineers and Gilbert Associates, Inc.

The foregoing inspection, review and analysis are by their nature limited in scope. It is possible that conditions exist which are hazardous, or which might in time develop into safety hazards, that are not detectable by this inspection, review and analysis. Accordingly, Gilbert Associates, Inc. cannot and does not warrant or represent that conditions which are hazardous, or which may in time develop into safety hazards, do not exist.

FROEHLING & ROBERTSON, INC.
INSPECTION ENGINEERS • CHEMISTS • BACTERIOLOGISTS
CABLE ADDRESS—"FROEHLING"
1881

[illegible]
BRANCH LABORATORIES
[illegible]

Richmond, Virginia
March 23, 1971

Commonwealth of Virginia
Commission of Game & Inland Fisheries
Box 11104
Richmond, Virginia 23230

Attn: Mr. G. R. Mills

Ref: Lee County Dam
Lee County, Va.

Gentlemen:

On March 10 and 11, 1971 the writer, upon authorization of Mr. Mills, visited the proposed site of the Lee County Dam for the purpose of obtaining undisturbed samples for settlement analysis in the dam area. These samples were to be obtained from the tan clayey silt encountered in some of the previous borings.

Since weathered conditions hampered the mobility of the equipment, auger probes were only taken in the bottom area of the proposed dam site adjacent to the creek. No cohesive material suitable for shelby tube sampling was encountered in this area. Sand, silty sand, and silty sand with trace of clay was encountered. The slopes, where the clayey silt was previously encountered, were impossible to reach even with the assistance of a crawler tractor and winch. The area had been stripped of vegetation and logged. Large stumps and logs retarded movement of the equipment. Six "undisturbed" samples were obtained, however, by pushing the tubes into the soil with as constant a pressure as possible being exerted by the crawler tractor blade. Many roots and rock fragments were present over the entire site which made it extremely difficult to obtain an undisturbed sample. These tubes were then sealed and transported to the laboratory for testing.

The contents of the tubes were extruded in the laboratory and examined. Various measurements and tests were run on the soil to determine unit weight, moisture content, sieve analysis, etc.. (see data sheet) All of the samples were a brown clayey silt with some roots, organic material, and weathered rock fragments. The natural moisture content varied from about 25% to 30% and the natural unit weight, as far as could be determined, was approximately 110 pcf. Most samples seemed to be disturbed.

One tube was not as badly disturbed as the others and a sample for consolidation was obtained. A single section of the undisturbed sample was extruded from its sampling tube for consolidation testing. The samples were then trimmed into a disc 2.4 inches in diameter and 1 inch thick. The disc was confined in a brass ring and sandwiched between porous plates. It was then subjected to incrementally increasing vertical loads and the resulting deformations measured with a micrometer dial guage. The test results are presented in the form of a pressure vs. void ratio curve on the accompanying Consolidation Test Sheets.

Using the information obtained from the consolidation test, boring logs, and plan sheets, settlement calculations were run. A maximum thickness of five feet of clayey silt, and a maximum additional load of 2.4 TSF (120 PCF - 40 ft deep) were used in the settlement calculations. The settlement calculations yielded an approximate settlement of 5 inches. It was also calculated that 90% of this settlement would occur within .5 days upon application of load.

In conclusion, due to the nature of material (rock fragments, random array, roots, etc.) and the nature of sampling procedures, we question the absolute validity of the results. We do believe however, that due to the disturbance present in the sample tested, the calculated settlement of 5 inches will be a maximum and that the time for this settlement to occur will be longer than the five days calculated. We believe no appreciable settlement will occur after construction of the dam due to the relatively short time for settlement. We believe, as stated in our letter of February 25, 1971, that the area should be stripped of organic material (which is thick in some places) roots, etc. and proofrolled with a vibratory compactor prior to placement of any controlled fill. The fill should be placed wet of optimum moisture to provide flexibility in the structure and to allow for some small settlement. It is our feeling, that if the above mentioned suggestions are followed, no detrimental settlement will occur in the dam.

Very truly yours,

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