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NATIONAL DAM SAFETY PROGRAM. RURAL RETREAT DAM (VA 19701), NEW --ETC(U)
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NEW RIVER BASIN

Name Of Dam: RURAL RETREAT DAM
Location: WYTHE COUNTY, VIRGINIA
Inventory Number: VA 19701

LEVEL

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED FOR

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

BY

GILBERT ASSOCIATES, INC.

AUGUST, 1978

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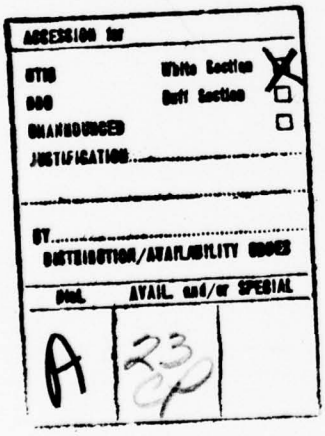
20. Abstract

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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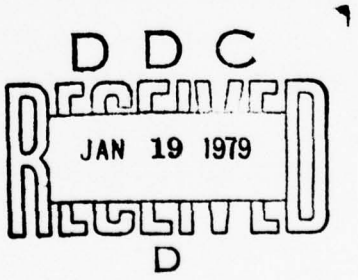

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

CONTENTS

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Rural Retreat
State:	Virginia
County:	Wythe
USGA Quadrangle Sheet:	Cedar Springs, Virginia
Stream:	South Fork of Reed Creek

The Rural Retreat Dam is an earth embankment dam 41 feet high and 595 feet long. A chute type overflow spillway is located on the right abutment. The reservoir is primarily used for recreational purposes.

This visual inspection found the dam in need of repair, and past geologic studies have raised significant questions concerning the construction of the dam and the stability of the embankment. (See Appendix VII, Conditions)

A flood routing study has found that the spillway can pass a flood of up to 62 percent of the probable maximum flood (PMF) before the dam is overtopped. A PMF will overtop the dam by 1.9 feet. According to inspection screening criteria, described in paragraph 5.8, the spillway is inadequate, but, it is not "seriously inadequate". The inspection also found that the spillway was in need of erosion protection.

The greatest concern is the stability of the dam. Previous studies have established poor foundation conditions and embankment materials well below the optimum compaction. A stability analysis was performed; however, the analysis was not sufficient to assess the stability under full loading conditions.

The questions related to the stability of the dam indicate that the dam could be hazardous depending on conditions and require immediate analysis and appropriate corrective action by the owner.

Plans for rehabilitating the dam are scheduled for this year (1978). The plans include work on the spillway and upstream embankment slope. The following recommendations are presented for the owner's consideration and implementation:

1. Have a consultant perform a stability analysis of the embankment and make recommendations for widening the base and crest of the dam. This analysis should be carried out within 90 days.

2. Improve the erosion resistance of the spillway within 90 days. Although the spillway is not "seriously inadequate", future consideration should be given to enlarging the spillway.

3. Repair the upstream slope and provide new riprap erosion protection.

4. Develop, within 30 days, a detailed emergency warning system to notify the downstream area of any impending danger, and determine, those areas subject to inundation from a dam break flood wave.

5. Establish an inspection program to monitor conditions of the dam.

6. Maintain a file of all available documents pertinent to the design, construction, and operation of the dam.

Until such time as the above recommendations can be implemented, during heavy rains the owner should provide for round-the-clock surveillance of the dam and prepare to implement the warning system procedures recommended in paragraph 4 above.

Prepared By:

APPROVED: Original signed by:

Douglas L. Haller

Douglas L. Haller
Colonel, Corps of Engineers
District Engineer

21 AUG 1978

Date

Original signed by
Submitted By: JAMES A. WALSH

Original signed by
Recomended By: ZANE M. GOODWIN

OVERVIEW - RURAL RETREAT

June 1978

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM: Rural Retreat Dam ID #: VA 19701

SECTION 1 - PROJECT INFORMATION

1.1 General

1.1.1 Authority: Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the U.S. Corps of Engineers to initiate a national program of safety inspections of non-Federal dams throughout the United States. The Norfolk District of the U.S. Corps of Engineers has been assigned the responsibility of the inspection of dams in the State of Virginia. Gilbert Associates, Inc. has entered into a contract with the Norfolk District to inspect this dam, Gilbert Work Order 06-7250-001.

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 any obvious remedial actions that may be indicated by the inspection.

1.2 Project Description

1.2.1 Dam and Appurtenances: Rural Retreat Fishing Lake Dam is a 41-foot high, 595-foot long, zoned earthfill dam with a clay core.

The upstream slope is at 3 horizontal to 1 vertical and the downstream slope is at 2-1/2 horizontal to 1 vertical. The top width was measured to be 17 feet. The existence of a central clay core is inferred from a 1970 soils report included as Appendix IV. The actual configuration of the embankment cross-section is unknown.

A 100-foot wide emergency spillway is located at the right abutment. The spillway has a 10-foot wide, 8-inch thick reinforced concrete ramp spanning its width at the crest.

The approach channel and emergency spillway chute were cut through the right abutment slope. The channels are unpaved and consist of in-situ soils. About 20 percent of the channel surface is lightly covered with weeds and grass.

Normal overflows are handled by the principal spillway which consists of a reinforced concrete tower located at the upstream toe of the dam. The

structure is open at the top and on one side and has stoplog slots provided so that the reservoir level can be varied by the removal of the boards. When the reservoir exceeds a certain level, an 8-inch cold water inlet also draws off water from a lower depth. At the base of the principal spillway tower a 20-inch inlet and valve has been provided for draining the reservoir. The valve is controlled from the surface by a valve wheel connected to the valve with a long rod. Both the principal spillway and the bottom inlet discharge into a 30-inch reinforced concrete pipe (RCP). The 30-inch pipe leads to a reinforced concrete masonry seine box (see drawings in Appendix I), which serves to hold fish, deliver water to the minnow pond, or discharge into the downstream channel. The minnow pond is located immediately downstream of the dam toe, to the left of the stream.

1.2.2 Location: The dam is constructed about 100 yards west of Virginia Route 749, across part of the South Fork of Reed Creek drainage, in Wythe County, Virginia.

1.2.3 Size Classification: The dam is classified as intermediate in size based upon the reservoir height of 41 feet and a storage volume of 2,266 acre-feet, in accordance with Section 2.1.1 of Reference 1 of Appendix VI.

1.2.4 Hazard Classification: Approximately 20 homes are located along the stream for about 4 miles below the dam. Based upon Section 2.1.2 of Reference 1 of Appendix VI, the dam should be classified as a high hazard potential. The hazard classification used to categorize dams is a function of location only and unrelated to the stability or probability of failure.

1.2.5 Ownership: The dam is owned and operated by the Commonwealth of Virginia, Commission of Game and Inland Fisheries, Richmond, Virginia.

1.2.6 Purpose of Dam: Rural Retreat Fishing Lake serves as a recreational area for boating and fishing.

1.2.7 Design and Construction History: The dam was designed for the Commission of Game and Inland Fisheries by R. S. Hummel Associates of Richmond, Virginia in 1967. The hydraulic design of the intake structure and spillway was supplied by the Game Commission, but the origin of the design is unknown.

1.2.8 Normal Operational Procedures: For normal operating conditions, the principal discharge structure is designed to maintain a pool level at elevation 2508.8 m.s.l. Operation of the reservoir is done by controls in the principal spillway tower. An opening (5.0 feet high by 3.9

feet wide) at the top of the structure, with removable 2-inch by 8-inch boards, allows the pool elevation to vary between elevations 2508.8 feet and 2505.1 feet m.s.l.

1.3 Pertinent Data

1.3.1 Drainage Area: The dam controls a drainage area of approximately 3.34 square miles.

1.3.2 Discharge at Dam Site: Maximum flood at dam site is not known.

Principal Spillway:

Pool level at emergency spillway crest . . . . . 122 c.f.s.
Pool level at top of dam . . . . . 132 c.f.s.

Emergency Spillway:

Pool level at top of dam . . . . . 5740 c.f.s.

1.3.3 Dam and Reservoir Data: Pertinent data on the dam and reservoir are shown in Table 1.1.

Table 1.1 DAM AND RESERVOIR DATA

Item	Elevation feet m.s.l.	Area acres	Reservoir Capacity		Length miles
			Acre-feet	Water Shed inches	
Top of Dam	2518.0	136.0	2266	12.7	1.1
Max. Pool, Design Surcharge	2514.0	114.0	1800	10.1	-
Emergency Spillway Crest	2510.8	96.0	1431	8.0	-
Principal Spillway Crest	2508.8	85.0	1250	7.0	1.0
Streambed at Centerline of Dam	2475.0	-	-	-	-

SECTION 2.0 - ENGINEERING DATA

2.1 Design: Two sheets of plans and details of the dam by R. S. Hummel and a flood routing by "others" were provided by the Commission of Game and Inland Fisheries. The hydraulic design of the intake and spillway was provided by the Commission of Game and Inland Fisheries for the original design of the dam; however, the source and whereabouts of this data are unknown.

The flood routing is inconsistent as to the level of the spillway, the storage capacity of the reservoir, and the discharge characteristics of the spillway. The routing may have been based upon a preliminary design, but it is not correct for the dam as it was built.

The Tinsley Mack Geologic Report to the Virginia Commission of Game and Inland Fisheries (Appendix IV) states that the dam is underlain by dolomitic limestone interbedded with red and gray shale which is generally hard and compact with pockets of weathered rock.

Shallow residual soil occurs on the left abutment, and shallow alluvial soil (4 to 9 feet) on the flood plain of the valley between the abutments. Colluvial soils occur on the right abutment up to 18 feet in depth.

A geologic study and soils analysis of the site were performed by Froehling and Robertson in 1970. Copies of these are provided in Appendices IV and V.

The Froehling and Robertson study was commissioned because the dam was showing signs of piping. The exact nature of the seepage and its location were not specified, although the spillway was singled out as the main problem area.

Five borings were taken through the core of the dam and in the spillway. The analysis of the soils and the boring program are included in the Froehling and Robertson report. The testing program showed that the clay core of the dam was not uniformly compacted. The moisture content varied from 6.9 to 42.5 percent and the soil density as indicated by the standard penetration test ranged from 5 to 22 blows. In spite of these findings, the main problem was attributed to seepage through bedding planes of the rock under the spillway and underneath the embankment. A stability analysis was performed and it is discussed further in Section 6.0.

A number of recommendations were made in the Froehling and Robertson report but the only one which was carried out was the application of a clay blanket on the right abutment and embankment surface in the spillway area. According to the owner, this action proved ineffective in reducing the seepage flow rate.

According to the owner, the final solution to the seepage problem in the spillway was the installation of a drain pipe.

This arrangement was apparently devised by the owner and the town of Rural Retreat. The pipe is connected to the town's water system and the seepage is collected and used as part of the town's water supply. There are no records of this work.

At the time of this inspection, no seepage was found in the spillway but some seepage was observed at the base of the dam.

2.2 Construction: A correspondence file on the design and construction of the dam is available at the Game Commission office in Richmond, Virginia. No other records are available.

2.3 Operation: Records of reservoir operation are not kept.

2.4 Evaluation: The plans appear to adequately represent the dam as constructed except for some changes to the principal spillway. The spillway tower was accessible only by boat so the exact nature of the changes could not be determined.

SECTION 3 - VISUAL INSPECTION

3.1 Findings: The downstream slope of the dam has well established vegetation, including several small trees (approximately 10 to 15 feet high) near the left abutment, and one tree at the dam center, near the one-third point along the slope. In addition to the trees, several holes burrowed by animals were also seen in the abutment area. A complete failure of the riprap along the shoreline has resulted in severe erosion of the upstream face.

The erosion has formed a flat bench in the embankment at the waterline on the upstream slope. It runs along the entire upstream face of the dam. A photograph of the erosion is included in Appendix II.

The entire area at the base of the dam on the downstream side is very flat and consists of a large minnow pond to the left of a stream and a marshy area to the right. The minnow pond is shown on the plan drawing in Appendix I. The marshy area occupies the entire area to the right of the stream out to the end of the spillway. The seepage was estimated to be approximately 10 g.p.m., at a temperature of 60° F. The seepage area was distinguished by heavier vegetation growth with marshy characteristics.

Effluent from the seine box discharges into Reed Creek, which then passes under Route 749. The creek is a small channel, 2 to 4 feet deep, with vegetated, stabilized slopes. Flow was estimated to be 750 g.p.m.

The appurtenant structures consist of the principal spillway, the seine box and ramp, the emergency spillway, and the minnow pond. The principal spillway and intake tower were accessible only by boat. We did not operate the valve but were told by the owner's representative that it functioned normally. The valve wheel had been removed by the owner to prevent tampering. The seine box and ramp, which consist mainly of concrete masonry block reinforced internally with steel and concrete, were disintegrating and in need of repair. Specifically, the front face adjacent to the 30-inch discharge line was broken away, with the steel reinforcement and portions of the concrete fill exposed. Also, segments of the seine box retaining wall were separated from the backfill material, probably because of freeze-thaw action.

The emergency spillway (consisting of an approach channel, a 10-foot concrete spillway crest 100-feet wide, and a discharge channel) was generally in need of repair and maintenance. Most of the channel reach was sparsely covered with vegetation, with the downstream reach having gullies 1 to 2 feet deep (the gullies appear to have been formed from rainfall runoff, rather than from actual use of the spillway). The concrete spillway crest showed some spalling and also had some weeds growing at the bottom of the 2 horizontal to 1 vertical side slopes.

The emergency spillway channel was unpaved and appeared to consist of erodable natural soil, the same type of soil that has already been gullied in the exit channel.

The minnow pond had well-vegetated slopes with no apparent seepage or sloughing. A 6-inch iron pipe was found exiting from the embankment at the base of the dam, leading to the minnow pond. Although evidently some type of drainage pipe, it was completely dry. The pipe was not shown on the plans.

3.2 Evaluation: From visual observations, the dam does not appear to be in an imminently dangerous condition but is definitely in need of early repair and maintenance. Of first priority is repair to the upstream slope and providing adequate riprap protection before any further erosion occurs. The emergency spillway design does not appear to have adequately allowed for the
effects of erosion under the condition of high discharge. It is highly probable that the natural soils forming the crest and channel bottom of the spillway would be fully or partially eroded under a severe discharge condition, and the integrity of the adjoining part of the earth embankment may be seriously affected. Moreover, the stability of the cut slope at the right abutment may also be affected. The trees, brush, and burrow holes could present a threat to the dam by providing passages for piping erosion during periods of high water level. Repairing these items should be part of a regular maintenance procedure.

The seepage, while covering an extensive area below the dam, did not exit above the toe of the embankment and did not appear dangerous. Several small drainage ditches leading from the seepage area to the creek would improve the conditions at the toe of the dam and also allow a better estimate of seepage rates.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures: The normal water level in the lake is regulated by the overflow elevation set at the principal spillway intake tower. By removing or adding stop boards, the water elevation can vary between 2505.1 feet m.s.l. to 2508.8 feet m.s.l.

During normal operations, water is drawn off the surface into the intake tower (which also has a deep "cold water" inlet pipe) and discharged into the seine box, via a 30-inch RCP. The seine box, in turn, discharges into both the minnow pond and Reed Creek.

A 20-inch valve at the base of the tower can be used to drain or lower the reservoir. We did not operate the valve but were told by a representative of the owner that it functions normally.

4.2 Maintenance of Dam: At present, maintenance of the dam appears to be minimal. The walls of the seine box are in need of repair, the downstream embankment has overgrown vegetation and animal-burrowed holes, the emergency spillway channel is extensively eroded (along with the spalling of the concrete spillway crest), and the upstream dam embankment requires riprap.

4.3 Maintenance of Operating Facilities: None

4.4 Description of Any Warning System in Effect: No warning systems are known to exist.

4.5 Evaluation: The maintenance procedures for this dam are generally inadequate as indicated by the deficiencies outlined in Paragraph 4.2.

SECTION 5 - HYDRAULIC/HYDROLOGIC DATA

5.1 Design: The only hydraulic design datum is a graphical routing procedure, the source of which is unknown. The routing may have been based upon a preliminary design because several parameters are substantially different from what is presented on the plan drawings.

5.2 Hydrologic Records: None

5.3 Flood Experience: It was reported by a representative of the owner that there have not been any significant floods at the dam since it was constructed. (It was noted that the parking lot of a concession area at the upstream end of the reservoir is flooded almost every year.)

5.4 Flood Potential: The spillway was designed to pass a 100-year flood with 4.7 feet of freeboard. The 100 year flood level was recalculated for this study and is presented along with the probable maximum flood (PMF), and the one-half PMF levels in Table 5.1. These analyses pertain to present hydrologic conditions and do not consider future uncertain conditions, such as urbanization or other changes in the watershed.

5.5 Reservoir Regulation: There is no regulation procedure.

5.6 Overtopping Potential: The PMF, one-half the PMF, and 100-year flood hydrographs were developed for the Rural Retreat Reservoir drainage basin and routed through the reservoir. Table 5.1 summarizes the results of this procedure.

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 triangular unit hydrograph was developed from the drainage area and estimated time to peak (Reference 2 of Appendix VI). Probable maximum precipitation and 100-year precipitation data were obtained from U.S. Weather Bureau publications (References 3 and 4 of Appendix VI).

Information from design drawings was used to compute the storage-outflow relation. Losses were estimated at an initial loss of 1.0 inch and a constant loss rate of 0.3 inch/hr.

Appropriate reduction factors were applied to the PMF in accordance with the Corps of Engineers' directive and guidelines.

TABLE 5.1 - RESERVOIR PERFORMANCE

Item	Average Flow	Flood		
		One Percent (a)	1/2 PMF	PMF (b)
Peak Discharge, c.f.s.:				
Inflow -		4860	8,130	16,300
Outflow -		1560	4,530	13,150
Peak Elevation, feet m.s.l.		2513.6	2516.9	2519.9
Principal Spillway:				
Depth of Flow, feet		-	-	-
Average Velocity, f.p.s.		25	27	28
Emergency Spillway:				
Depth of Flow, feet (c)		1.8	3.8	5.7
Average Velocity, f.p.s.		7.5	11.1	13.6
Non-overflow Sections:				
Depth of Flow, feet (c)		-	-	1.2
Average Velocity, f.p.s.		-	-	6.2
Duration, hours		-	-	2.2
Tailwater elevation, feet m.s.l.		-	-	-

Notes:

(a) The 1 percent exceedence frequency flood has one chance in 100 of being exceeded in any given year.

(b) The PMF is an estimate of flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

(c) Critical depth.

5.7 A volume-elevation curve was not available for the reservoir; so, in order to estimate the hydraulic head on the outlet, the head was assumed to vary as the cube root of the storage volume, being equal to the head at normal pool elevation for a full reservoir and equal to zero for an empty reservoir. Using this assumption, it will take approximately 11 days to empty the reservoir, assuming the reservoir is initially at normal pool elevation and has an inflow of 4.3 c.f.s.

5.8 Evaluation: The screening criteria for assessing the adequacy of the spillway design flood allow essentially no risk of loss of life from dam failure by overtopping. Experience indicates that very few existing non-Federal dams were designed with such conservative criteria. Therefore, the Phase I inspection findings will indicate noncompliance with the spillway design flood screening criteria for most non-Federal dams. In accordance with Corps of Engineers' Engineer Technical Letter 1110-2-234, a further classification is required based upon the percent of the PMF flood passed by the spillway before overtopping occurs, and the consequences of the dam being overtopped and failing. Based upon these criteria the spillway may be further classified as "seriously inadequate."

The results of this study found that the spillway capacity was sufficient to pass up to 62 percent of the PMF before overtopping of the dam. The PMF would overtop the dam by 1.9 feet. Based on these findings the spillway is classified as inadequate, but not "seriously inadequate."

SECTION 6 - DAM STABILITY

6.1 Stability Analysis: In 1970, the embankment and foundation were investigated by the firm of Froehling and Robertson because of suspected piping under the embankment spillway. The investigation included core borings and a stability analysis. Their report found the dam "acceptable under marginal conditions," but recommended several corrective measures including a toe drain, an upstream clay blanket, and repair of the riprap. The body of the report is presented in Appendix IV and their stability analysis is in Appendix V.

The stability analysis was based upon the soil properties of samples taken from the core of the dam. The results of the borings revealed widely varying soil properties indicating a poorly controlled placement of materials. The computed factor of safety was 1.1. Review has determined that the slope stability analysis is not acceptable and should be performed again. Comments on the analysis are included in paragraph 6.3.

6.2 Foundation and Abutments: Two geologic studies are available for the site. One is an undated report by the Commission of Game and Inland Fisheries. The other is a portion of the report referred to in paragraph 6.1. Both reports are presented in Appendix IV. All of the comments concerning foundation materials and analyses are based upon the findings of the Froehling and Robertson Report.

The spillway was formed by a cut through the right abutment of the dam and lies in natural soils. As shown in the Froehling and Robertson Report (see Appendix IV), borings in this area showed high water movement through the shale in the spillway, interbedded layers of pervious strata, and moisture contents ranging up to 60 percent. The dam lies above nearly vertical strata of easily weathered rock, with the bedding surfaces passing from the upstream side of the dam to the downstream side. The quality of the rock was described as "usually poor." The opinion of the authors of the report was that these strata provide excellent channels for the passage of water and were apparently the source of seepage below the dam and in the spillway. It was also their opinion that the channels would increase in size as the easily weathered rock deteriorated from contact with water. In 1970, the seepage was estimated at 7 g.p.m. Our inspection found seepage at about 10 g.p.m.

6.3 Evaluation: Based on the available soils data as reported, the condition of the foundation and embankment materials is such that it would be impossible to accept the dam as stable without a great deal of further studies. It is believed that the stability analysis was not performed correctly and did not examine a full range of possible failure modes.

A summary of the review of the Froehling and Robertson's stability analysis is listed below:

a. No basis was given for the soil parameters used in the analysis.

b. The analysis assumes the same soil parameters for the entire failure surface, neglecting the differences in properties of the shell, the core and the foundation strata.

c. There is no indication that more than one failure surface was examined. The circle used may not have been a critical failure surface.

d. In computing the weights of circle segments the unsaturated weights were used in portions assumed to be saturated.

e. In computing the frictional resistance along the slip circle, the total soil weight was used rather than the effective weight.

f. In computing the term "R sin θ" the first three values should have been negative.

g. The rapid drawdown condition was analyzed for the downstream slope of the dam rather than the saturated upstream slope.

h. The assumption regarding the phreatic surface is too approximate.

Apparently only one of the Froehling and Robertson recommendations was carried out. It was reported by a representative of the owner that the upstream clay blanket was installed on the right abutment and a portion of the embankment and proved ineffective in reducing the flow. Instead of the recommended toe drain, a tile collection system was installed in the spillway and the water was incorporated into the water system of the town of Rural Retreat. Plans and details of this work are not available. At the time this inspection was made, there was no seepage apparent in the spillway area. The upstream slope of the dam is still heavily eroded.

The questions related to the stability of the dam indicate that the dam could be hazardous depending on conditions and it should receive immmediate attention, from the standpoint of repairs and investigation and analysis.

The dam is located within Zone 2 on the Algermissen Seismic Risk Map of the United States (1969 edition) and there are uncertainties with respect to the static stability of the dam, as described in paragraph 6.1. Therefore, in accordance with paragraph 3.6.4 of Reference 1 of Appendix VI, assessments should be made regarding seismic stability, based on the studies outlined in paragraph 7.2.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

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

7.1 Dam Assessment: The visual inspection revealed several deficiencies which are primarily the result of poor maintenance. However, more serious is the deficiency in design reflected by the riprap failure and the spillway.

The spillway was found to have a capacity sufficient to pass 62 percent of a PMF. Although this is inadequate according to the Corps of Engineers' guidelines, it is not considered "seriously inadequate." The primary fault with the spillway is that it is not designed with sufficient consideration of the erosive capacity of a high velocity discharge. There is a good chance that under a large discharge flow severe erosion would occur.

Particularly disturbing is the soils test report (Appendix IV) which found evidence that the core materials were not compacted properly and that the dam is founded on a poor foundation.

Those features of the dam which were visible to inspection were found to be in poor condition and in need of repair. Those features less visible but identified in the soils report could be the indication of a hazardous condition which should be analysed and corrected immediately.

7.2 Recommendations and Remedial Measures: The following actions are recommended for the owner's consideration to improve the safety of the dam:

a. Stability Analysis: It is recommended that the owner obtain the services of a qualified consultant to re-evaluate the embankment stability. This work should be completed within 90 days of receipt of this report.

b. Spillway Protection: The spillway should be protected against erosion and slope instability. It is recommended that the owner enlist the services of a consultant to design an erosion resistant covering for the spillway crest and chute. The spillway capacity was not found to be "seriously inadequate", but future consideration should be given to enlarging it to meet the PMF design flood criteria. This work should be carried out in conjunction with the recommendation of paragraph b.

c. Slope Repair: The upstream slope should be repaired and new riprap installed on the slope. This should be done within 90 days.

d. Warning System: A detailed emergency warning system should be developed as soon as possible to notify downstream inhabitants of an impending dam failure. In order for the warning system to be effectively applied, a study of the downstream area should be made so that the areas subject to flooding as a result of a dam break can be identified.

e. Inspection Program: It is recommended that the owner establish a semi-annual inspection program to monitor the conditions at the dam. Particular attention should be given to monitoring seepage rates and wear of the riprap on the upstream face of the dam.

f. Design Documents: A complete set of available design documents should be maintained by the owner. These files should include available design drawings, calculations, pertinent correspondence, and maintenance records.

APPENDIX I

MAPS AND DRAWINGS

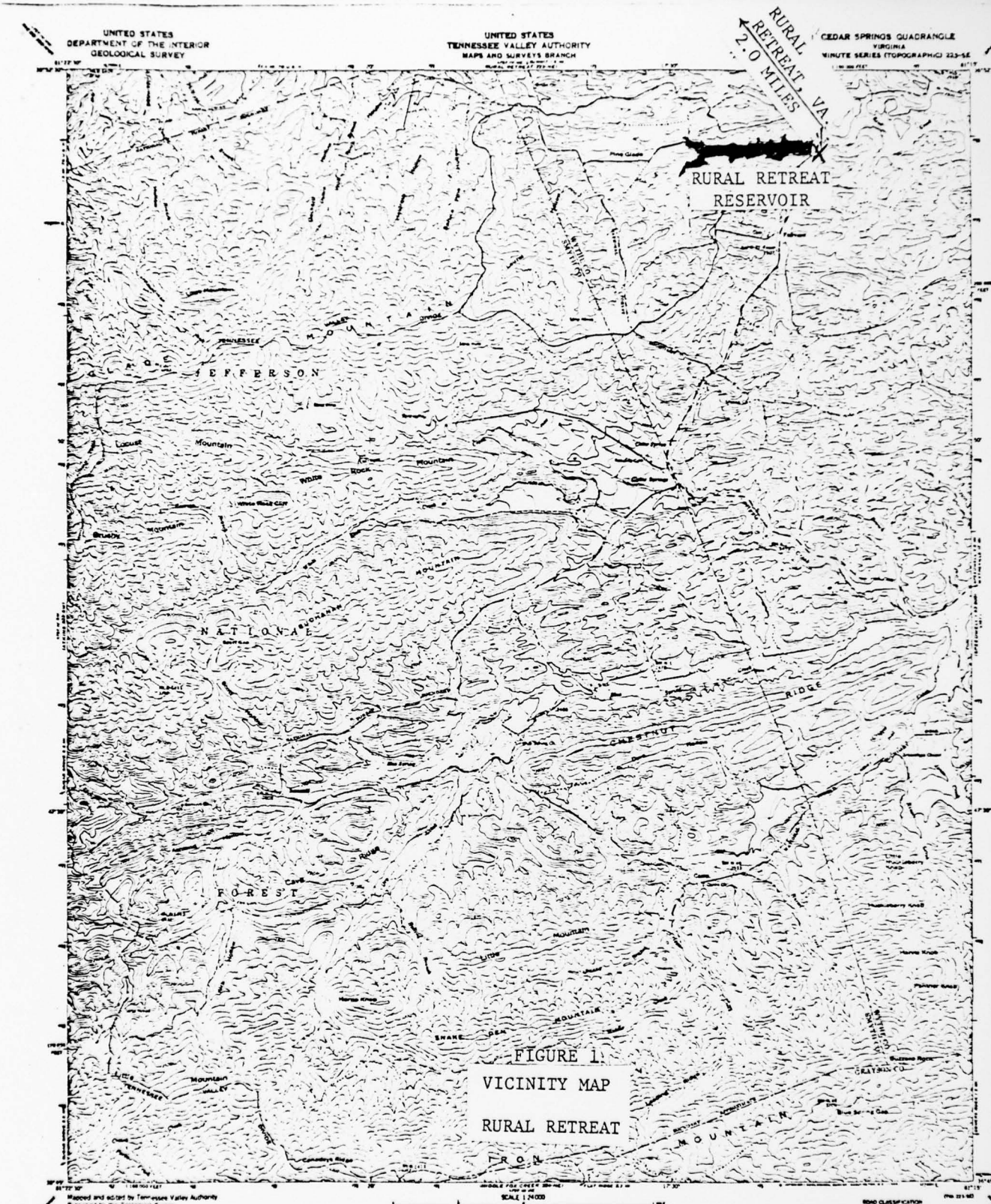
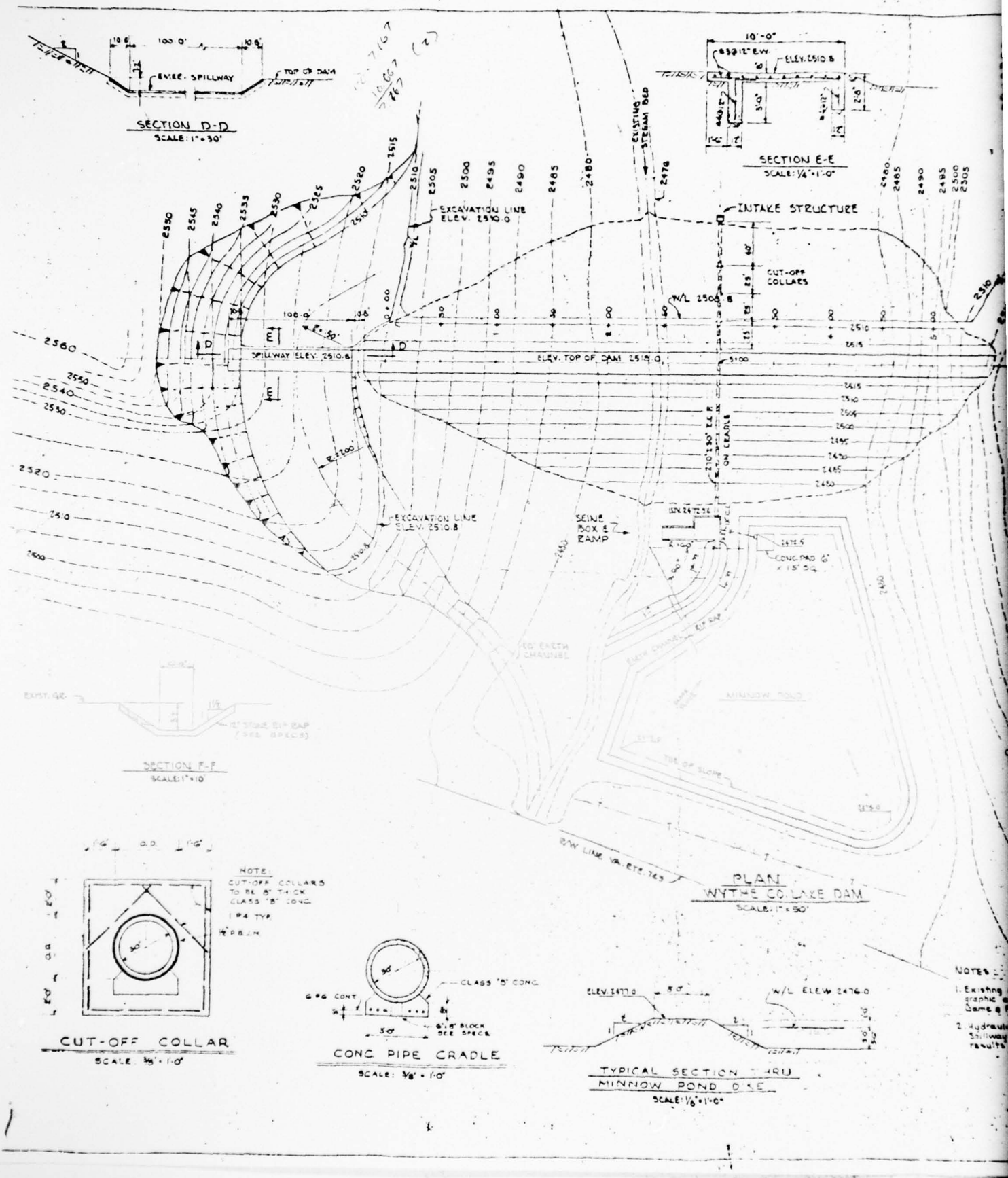
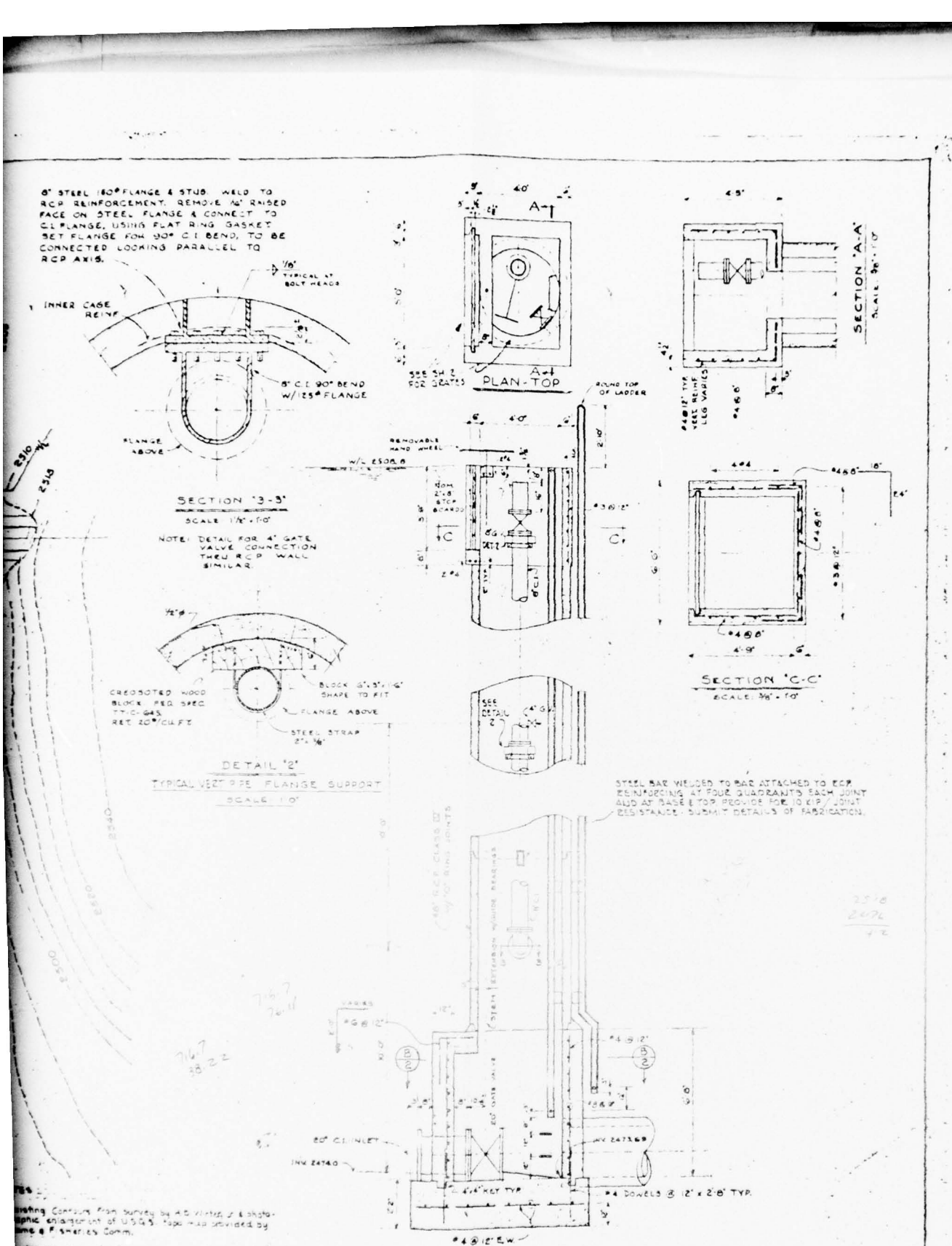


FIGURE 1

VICINITY MAP

RURAL RETREAT


SECTION D-D
SCALE: 1"=30'
SECTION E-E
SCALE: 1/4"=1'-0"
INTAKE STRUCTURE
EXCAVATION LINE ELEV. 2500.0
CUT-OFF COLLARS
SPILLWAY ELEV. 2510.8
ELEV. TOP OF DAM 2519.0
EXCAVATION LINE ELEV. 2510.8
SEINE BOX & RAMP
CONC PAD 6" x 15' SQ.
EXIST. GR.
SECTION F-F
SCALE: 1"=10'
NOTE
CUT-OFF COLLARS TO BE 8" THICK CLASS "B" CONC.
CUT-OFF COLLAR
SCALE: 3/8"=1'-0"
CONC PIPE CRADLE
SCALE: 3/8"=1'-0"
PLAN
WYTHE COUNTY LAKE DAM
SCALE: 1"=50'
TYPICAL SECTION THRU MINNOW POND DIKE
SCALE: 1/8"=1'-0"



Existing Contours from survey by A.S. Vietti Jr & Photographic enlargement of U.S.G.S. Topo Map provided by Game & F. Sheries Comm.

Hydraulic design for Intake Structure, Underspillway & Flood Routing performed by others & results provided by Game & F. Sheries Comm.

Rural Retreat Quad

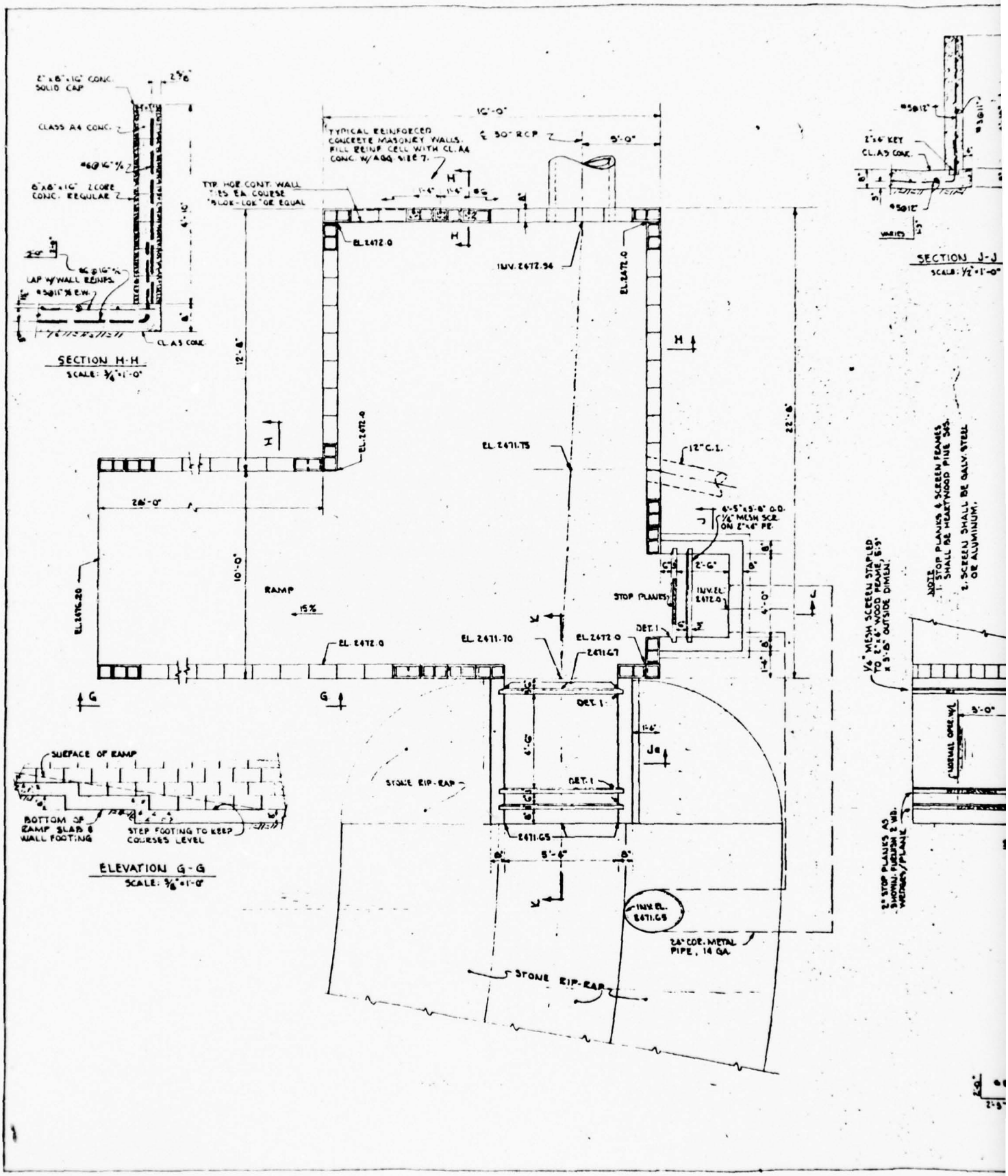
FIGURE 2

COMMISSION OF GAME & INLAND FISHERIES
RICHMOND, VIRGINIA

WYTHE COUNTY LAKE

DATE: AUG. '67 SCALE: AS SHOWN SHEET #1

BY R.S. HUMMEL ASSOC. CONSL. ENGRS.


8"x8"x16" CONC. SOLID CAP
CLASS A4 CONC.
#6@16" c/c
8"x8"x16" 2 CORE CONC. REGULAR
#5@16" c/c
LAP w/WALL REINFS.
#5@12" E.W.
CL. A5 CORE
SECTION H-H
SCALE: 3/8"=1'-0"
TYPICAL REINFORCED CONCRETE MASONRY WALLS. FILL REINF CELL WITH CL. A4 CONC. w/ASTM SIZE 7.
TYP. HOR. CONT. WALL TIES EA COURSE "BLOK-LOK" OR EQUAL
EL. 2672.0
INV. 2672.54
EL. 2671.75
12" C.I.
6'-5"x5'-8" O.D. 1/4" MESH SCR. ON 2"x4" PR.
STOP PLANKS
INV. EL. 2672.0
RAMP
15%
EL. 2676.20
EL. 2671.70
EL. 2672.0
2671.67
DET. 1
2671.65
SURFACE OF RAMP
BOTTOM OF RAMP SLAB & WALL FOOTING
STEP FOOTING TO KEEP COURSES LEVEL
ELEVATION G-G
SCALE: 3/8"=1'-0"
STONE RIP-RAP
INV. EL. 2671.65
24" COR. METAL PIPE, 14 GA.
2"x6" KEY
CL. A5 CONC.
SECTION J-J
SCALE: 1/2"=1'-0"
NOTE
1. STOP PLANKS & SCREEN FRAMES SHALL BE HEARTWOOD PINE S4S.
2. SCREEN SHALL BE GALV. STEEL OR ALUMINUM.
1/4" MESH SCREEN STAPLED TO 2"x6" WOOD FRAME, 6'-5" x 5'-6" OUTSIDE DIMEN.
2" STOP PLANKS AS SHOWN. FURNISH 2 WD. WEDGES/PLANK

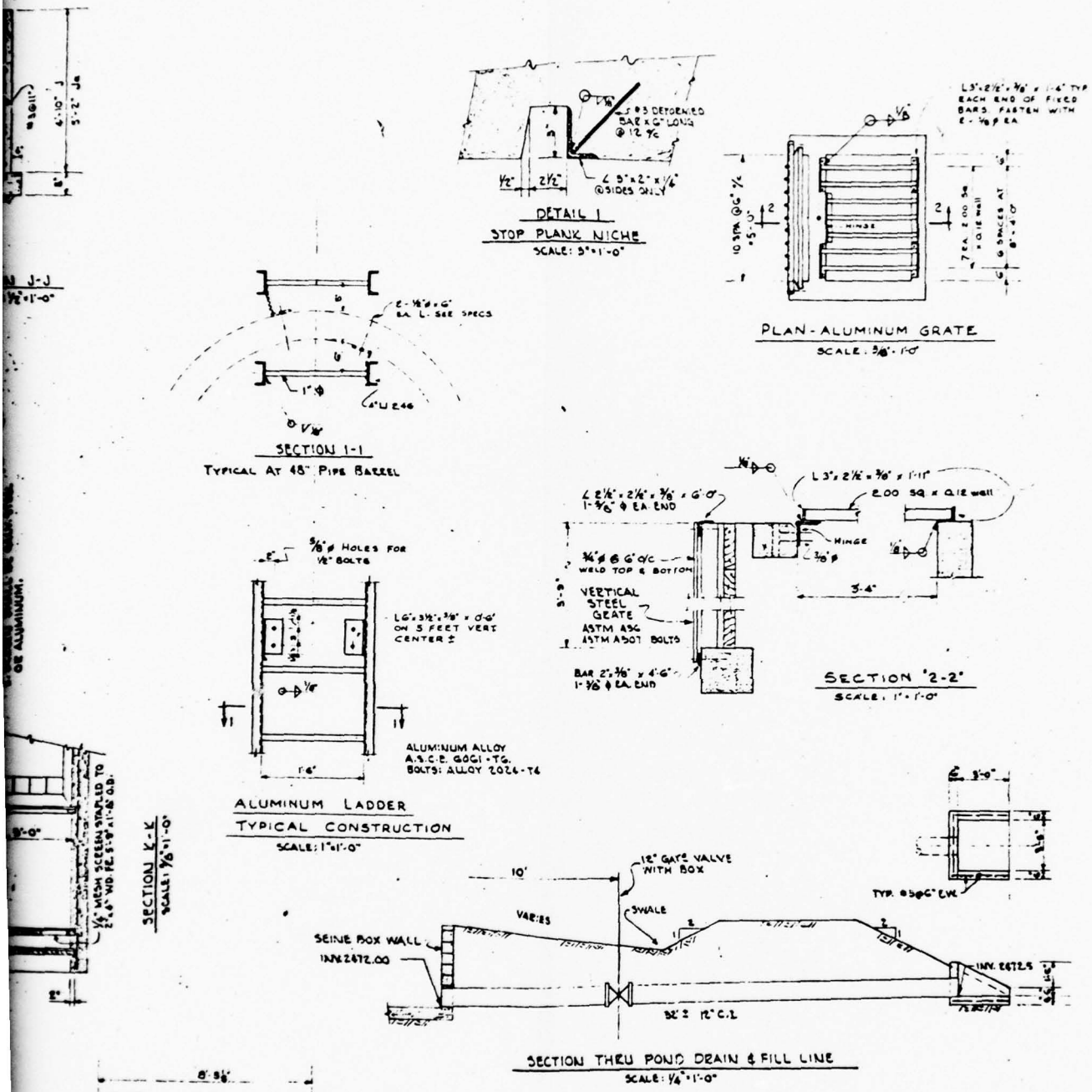


FIGURE 3

COMMISSION OF GAME & INLAND FISHERIES
RICHMOND, VIRGINIA

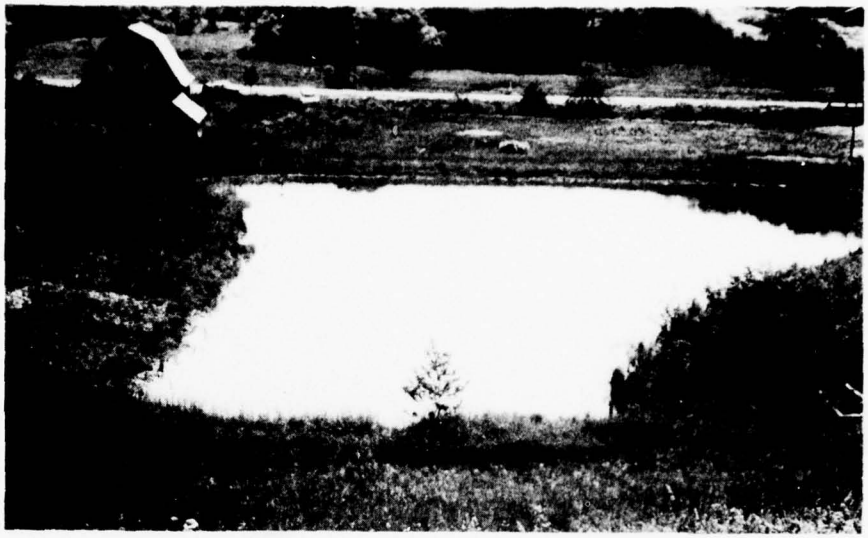
WYTHE COUNTY LAKE

DATE 11 Aug '67 SCALE AS SHOWN SHEET # 2

BY R.S. HUMMEL ASSOC. CONS. ENGRS.

APPENDIX II

PHOTOGRAPHS



June 1978

MINNOW POND BELOW DAM AS VIEWED FROM THE CREST.

June 1978

SPILLWAY CHUTE SHOWING EROSION ON LEFT SIDE.

June 1978

DROP INLET INTAKE STRUCTURE

June 1978

UPSTREAM FACE OF DAM SHOWING RIPRAP FAILURE
AND SEVERE EROSION OF THE SLOPE

APPENDIX III

FIELD OBSERVATIONS

Check List
Visual Inspection
Phase 1

Name Dam Rural Retreat County Wythe State Virginia Coordinators Norfolk District Corps of Engineers

Date(s) Inspection June 6, 1978 Weather Clear Temperature 80°F

Pool Elevation at Time of Inspection 2508.1 feet m.s.l. Tailwater at Time of Inspection 2473.4 feet m.s.l.

Gilbert Associates, Inc.
Inspection Personnel:

Thomas W. Schreffler

William J. Santamour

Thomas E. Roberts

Also Present:

Buck Arnold Virginia State Water Control Board

R. E. Wollitz Commission of Game and Inland Fisheries

Thomas E. Roberts Recorder

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	No cracks were visible but animal burrows were observed on left abutment. Embankment was covered with two foot high grass.	Burrows should be eliminated.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	See spillway.	
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST.	The crest was straight and level.	
RIPRAP FAILURES	Complete failure of the riprap. Limestone riprap is scattered on the slope, and a three foot vertical drop and a ten foot bench exists on the upstream slope at the waterline.	Plans are completed and preparations being made for repair of the slope and riprap.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No seepage or erosion on abutments but some erosion on spillway.	
ANY NOTICEABLE SEEPAGE	A large seepage area exists at the toe of the dam to the right of the outlet. The flow is estimated at about 10 g.p.m. Also a small amount of seepage is entering the fish trap just to the right of the outlet.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
STAFF GAGE AND RECORDER	None	
DRAINS	A 6-inch pipe leaves the toe of the embankment and drains into the pond. The invert was dry. The location of pipe entrance is not shown on the drawings.	

OUTLET WORKS

Sheet 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	The 30-inch concrete pipe was in good condition but the concrete block structure is deteriorating.	
INTAKE STRUCTURE	The intake is a tower in the reservoir. Inflows pass over the top and through a 30-inch discharge pipe. Water level appeared to be about 15 inches below the overflow level. The hand operated gate stem was missing the wheel.	Appears slightly different than shown on plans.
OUTLET STRUCTURE	The pipe discharges into a cinder block and concrete fish trap structure. There are some failures of the cinder block and seepage is coming through the wall nearest the embankment.	
OUTLET CHANNEL	A shallow creek, 4-feet wide and 2-feet deep.	
EMERGENCY GATE	None	

ATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	A 10-foot long, 100-foot wide flat concrete sill at the crest. In fair condition. Some spalling and weeds in construction joints.	Under high flows, erosion is likely to undermine the concrete.
APPROACH CHANNEL	A channel cut into the right abutment. The channel is unpaved and consists of natural soils.	
DISCHARGE CHANNEL	Two to three foot gullies have eroded into chute below the crest.	
BRIDGE AND PIERS	None.	

INSTRUMENTATION

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

RESERVOIR

Sheet 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	No apparent failures.	Viewed embankment but did not traverse reservoir.
SEDIMENTATION	None apparent.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	A highway culvert is several hundred feet downstream. The channel is narrow and shallow.	
SLOPES	The flood plain is wide and flat along the stream.	
APPROXIMATE NO. OF HOMES AND POPULATION	A building count on 1968 USGS Quadrangle maps indicates approximately 20 homes for a distance of 4 miles below the dam.	

APPENDIX IV

GEOLOGY REPORTS

Commission of Game &
Inland Fisheries
Richmond, Virginia

Dam Site Wythe County Lake Dam

Location: 2½ miles southeast Rural Retreat
Wythe County, Virginia

General Geology

The proposed dam at Wythe County Lake is located in the Appalachian physiographic province. It is 2½ miles southeast of Rural Retreat, Virginia on the head waters of Reed Creek.

The rock underlying the proposed site is part of the Rome formation. This formation here is composed of light gray doloinitic limestone interbedded with red and gray shale. The formation here occurs on the eastern limb of a gentle double plunging anticline. The attitude of the beds is N 55° E and 46° E. The rock is generally hard and compact with zones of weathered rock present in pockets below the top of rock.

The stream pattern is trellis with a dendritic pattern developing in the broader valleys. The streams are strongly entrenched. The valleys are generally broad in the softer limestone and shale rocks.

Residual colluvial and alluvial soil is present. Deep residual soil occurs on the higher hills in the valley areas. These hills are flat. They are part of the Harrisburg or valley floor peneplane. Such a gentle flat top hill occurs above the right abutment of the dam. The steeper slopes that slope down to the streams have shallow residual soil. Colluvial soil is present on the gentle slopes that extend from the Harrisburg peneplane surface. Shallow alluvial soil is present in the stream valleys.

Centerline of the Dam

The left abutment on the centerline of the dam is on a steep slope. Shallow residual soil occurs here. This slope extends from station 4+50 to the top of the dam.

Shallow alluvial soil is present in the flood plain area on the dam centerline. This area extends from station 1+60 to station 4+50 on the centerline of the dam. This alluvial soil consists

of red brown sandy silt (ML) that ranges in depth from 4.0 to 9.0 feet. It is of medium strength and moist with the water table occuring generally above the top of rock.

Deep colluvial soil occurs on the gentle slope of the right abutment. This is red brown silt (ML) that ranges in depth to 18 feet. This colluvial slope is present from station 1+60 on the centerline of the dam to the top of the dam.

Linda Mack

Richmond, Virginia
October 29, 1970

Report No. V-7029-10

Report of: Field and Laboratory Investigation

Made for: Commonwealth of Virginia
Commission of Game and Inland Fisheries
Box 11104
Richmond, Virginia 23230
Attention: Mr. G. R. Mills
Chief Engineer

Project: Rural Retreat Fishing Lake
Rural Retreat, Virginia

Upon authorization from Mr. G. R. Mills, Chief Engineer of the Commission of Game and Inland Fisheries, a field trip was made to the above dam site to investigate an existing dam that was showing signs of piping. The observation made on this initial trip led to the establishment of a testing program for the dam.

The results of the testing program showed that the clay core of the dam did not exist in a very homogenous condition, as a properly controlled and constructed core should. The degree of compaction and moisture contents varied widely. Standard penetration test results varied from 5 to 22 blows. The Standard Penetration Test gives values indicating the relative density of the soils. Moisture contents varied from 42.5% to 6.9%.

Laboratory tests as listed later on show the soils in the core to be mainly a C.L. This material is well suited for its intended use. A pocket of S.M. material was found overlying rock in Boring No.5. This is a marginal material of high permeability and low shear strength. A pocket of M.L.-C.L. material was encountered in Boring No.1. This material should also be relatively impervious.

The average percentage of compaction in the dam ranges between 70 to 90% of a standard proctor. Normally 90% compaction would be required for placement of a core.

Moisture contents range from approximately optimum moisture to well above this. Most moisture contents however, do appear to be close to optimum moisture. Tests on a composite C.L. sample from the core show a maximum density of 112.3 lbs cubic ft. and optimum moisture of 21.3% AASHO T-99.

Pressure testing of the rock in the 3 dam borings showed low to moderate water loss and do not present a problem.

Based on the data available for the dam itself, we find the dam to be acceptable under marginal conditions. However, the following corrective measures should be taken.

A toe drain as originally called for in the plans should be added. The purpose of this drain is to provide toe restraint and to act to lower the Phreatic Profile. The toe drain should incorporate features of a graded filter to prevent loss of fines from the dam. This should be constructed after the dam has been dewatered and allowed to sit for some period of time to allow for dissipation of neutral stress. The purpose of this is to prevent any possibility of development of a critical hydraulic gradient at which the effective stress in the soil mass (intergranular pressure) becomes [illegible] water level in the dam should be lowered slowly over a period of time.

A wave cut bench was also noted on the upstream face of the dam indicating the presence of insufficient rip rap.

The two borings made in the spillway area show the main problem to exist here. The spillway was reported to be natural ground that was only cut to grade. It is probable that construction activity in the cutting of the Dam Keyway opened up the bedding planes in the shale.

Ground water movement here based on the results of the rock pressure testing

gave water movement up to 19.25 ft per day. This is excessive. Moisture contents of the soil were also high ranging up to 60% in a soft plastic clay.

Various corrective measures to correct the excessive water leakage have been investigated. These included grout curtains, relief wells at the toe of the dam, Bentonite dumping into the reservoir and upstream clay blankets. Relief wells were ruled out because of the horizontal bedding of the shale ledge rock.

There are no structural features in the rock that would provide a cut off and no valid assumptions could be made on up or down dip water movement. The only water loss high enough to indicate the possibility of a grout take was in borings 8 & 9. The use of a grout curtain was also ruled out due to the vertical attitude of the ledge rock. The Bentonite dumping method was ruled out because of the near vertical cut along one side of the lake.

An upstream clay blanket would seem the best solution to the leakage problem. The embayment area should be stripped and brought to a slope suitable for the use of normal earth moving equipment.

A layer of clay 2' thick in its compacted state should be placed in the embayment area. Local soils would provide a suitable clay for this purpose, judging by the materials found in the core. The local shales weather back to a silty clay that would be sufficiently impervious. The clay blanket should be compacted to 90% of AASHO Method T-99.

GEOLOGY

About 2.5 miles south of the city of Rural Retreat, Wythe County, Virginia, on State Route 749, is the South Fork of Reed Creek. Drainage of this stream and its tributaries is generally in an ENE direction which largely follows the regional strike of the underlying Paleozoic rocks. Incision of the stream was noted to have produced a relief of about 75 to 100 feet and valleys which are several hundred yards wide at their crests. Small floodplains are also developed but seem to be more or less localized

with sediment filling a few feet thick. At the time of examination only a small volume of water was noted in the stream.

The dam has been constructed about 100 yards west of State Route 749 across part of the South Fork of Reed Creek drainage. The dam, some 550'± long at its crest is about 90' high at its maximum point and 250' wide at its base. Water, impounded behind the structure, is reported to be about 30 feet deep at the overflow standpipe.

Materials used for the earthern dam are saprolites from shales and siltstones of the Rome (Cambrian) formation which underlies and flanks the dam and the lake in every direction for hundreds of yards. The Rome is a reddish-brown, easily weathered rock which breaks down into a soft clay and silt. Furthermore, the Rome has been subjected, in the ancient past, to extensive and intensive tectonic compressional forces which have not only tilted and faulted it, along with all other Paleozoic formations in the Appalachian mountains but also have internally deformed it through drag-folding because of its low competency - or inability to resist such deformation. In addition, the Rome beds have, probably, in many cases, acted regionally as glide planes for the huge overthrust plates, generated by sole-faulting, which have contorted it still more as they over-rode it during the times of thrusting.

Consequently, today, after erosion has removed the overlying beds to expose the Rome formation, it maybe seen to occur in narrow strike belts (from SW to NE) and to possess vertical or nearly vertical dips in many areas. The Rome's petrologic and tectonic incompetency has, in many areas, determined the position of streams which have created valleys within the strike belts. These are termed "subsequent" streams and valleys because they are controlled by the strike of the underlying beds. Such is the case at the dam across the Reed Creek drainage.

Outcrops in the vicinity of the dam have an average strike of N 66° E and a dip ranging from about 60° to 90° to the southeast. The dam, on the other hand, lies squarely across the strike (or more or less parallel to the dip direction) and rests upon Rome strata which are nearly vertical (77°). Thus bedding surfaces of the Rome pass from the upstream side of the dam to the downstream side and are, because of

weathering and probable construction activity effects, excellent channels for the passage of water. But, with the dam, and impounding of the lake water to a depth of at least 30 feet, great additional hydrostatic pressure has been created on the vertical Rome beds forming the dam's foundation. Apparently, therefore, considerable leakage has developed beneath the dam and spillway through the above described passages.

Observations made at one point at the immediate toe of the dam, on the downstream side, showed clear water, at a temperature of 60°F. issuing from the fill material at a rate estimated to be about 1 cubic foot per minute. Other temperature measurements, in the lake, and from the overflow standpipe leakage also were 60 F. Thus, it is certain that such channelways have developed, and, quite likely, will increase in size due to the low strength of the Rome rock as well as to its rapid rate of breakdown in the presence of water. ?

TESTING PROGRAM

A total of 5 borings were made on the site as shown on the enclosed cross section and individual boring logs. The borings were made in conformity with the following standard procedures - Soil Borings ASTM D-1586, Core Borings ASTM D-2113, Water Pressure Testing SCS Specifications. All laboratory tests were also made in conformity with ASTM specifications. Soils were classified on the basis of the Unified Soils Classification System. Moisture contents on individual soil samples are shown on the cross section. Pressure test results in rock are shown in tabulated form.

Laboratory Test Data

Test on shale - 8 cycles - saturating and oven drying
1 day per cycle - total wt. loss 38 grams or
5% of total weight.
No noticeable volume change in water

Shale appears to be a moderately dense compaction type that will weather back to a clay.

Atterberg Limits on Crushed Shale Soil Sample

Liquid Limit 18.7

Plastic Index N.P.

Soil Classification M.L.

Boring No.	Depth	L.L.	P.I.	Classification
1	19-20'	47.2	25.5	CL
3	4-5'	40.6	17.4	CL
9	24-25'	52.4	23.6	CH
9	29-30'	34.5	12.8	CL
9	4-5'	37.4	13.6	CL
9	19-20'	27.5	N.P.	SP
8	14-15'	24.4	N.P.	SP
8	9-10'	25.4	N.P.	ML
5	24-25'	23.8	N.P.	SM
1	4-5'	43.0	20.7	CL
1	24-25'	21.0	5.8	CL-ML
3	35-36'	29.6	8.8	CL

The five test borings made on the site are shown on the enclosed print. Boring 1, 3 and 5 are located at Stations 0+00, 2+00 and 4+00 along the crest of the dam.

The borings made in the centerline section of the dam show considerable variation in the density and moisture contents of the soil inplace. The quality of the rock on which the dam is founded also varies considerably but is usually poor. A good sound shale should give core recoveries of 50% or more. Core recovery in the first five feet of the core boring range from 16% to 20%. The maximum core recovery encountered was 60%. Part of the low core recovery however, was also due to the nearly 90° angle of bedding to the horizontal plane.

The pattern of joints, shear zones and bedding in a rock mass reduce the shear strength and increases permeability to a considerable extent at least in a direction parallel to these discontinuities. However, water loss on pressure testing was not excessive and no problems in regard to shear strength of the rock exist under the dam.

The worst condition encountered was in Boring Nos. 8 and 9 in the spillway area. These two borings showed interbedded pervious soil strata in the soil profile. Rock conditions encountered were very similar to those discussed for borings on the dam and the same conclusions appear valid.

Water loss on pressure testing was at its highest here with a maximum of 19.25 ft. per day. This is the only area where water losses were high enough to indicate that some grout take was possible. Generally, rock that upon water pressure testing will take less than 10 gallons per minute at a pressure equal in PSI to the depth of the strata in feet will not accept grout. As previously discussed, due to the angle of the bedding, we do not consider a grout curtain as being usable here.

We appreciate having the opportunity of working with you on this project. We hope we have presented all data in logical form.

The Professional Personnel working on this report consisted of Russell Burney and John Thornton, Soil Engineers, Dr. A. C. Munyan and W. H. Vogelsang, Engineering Geologists.

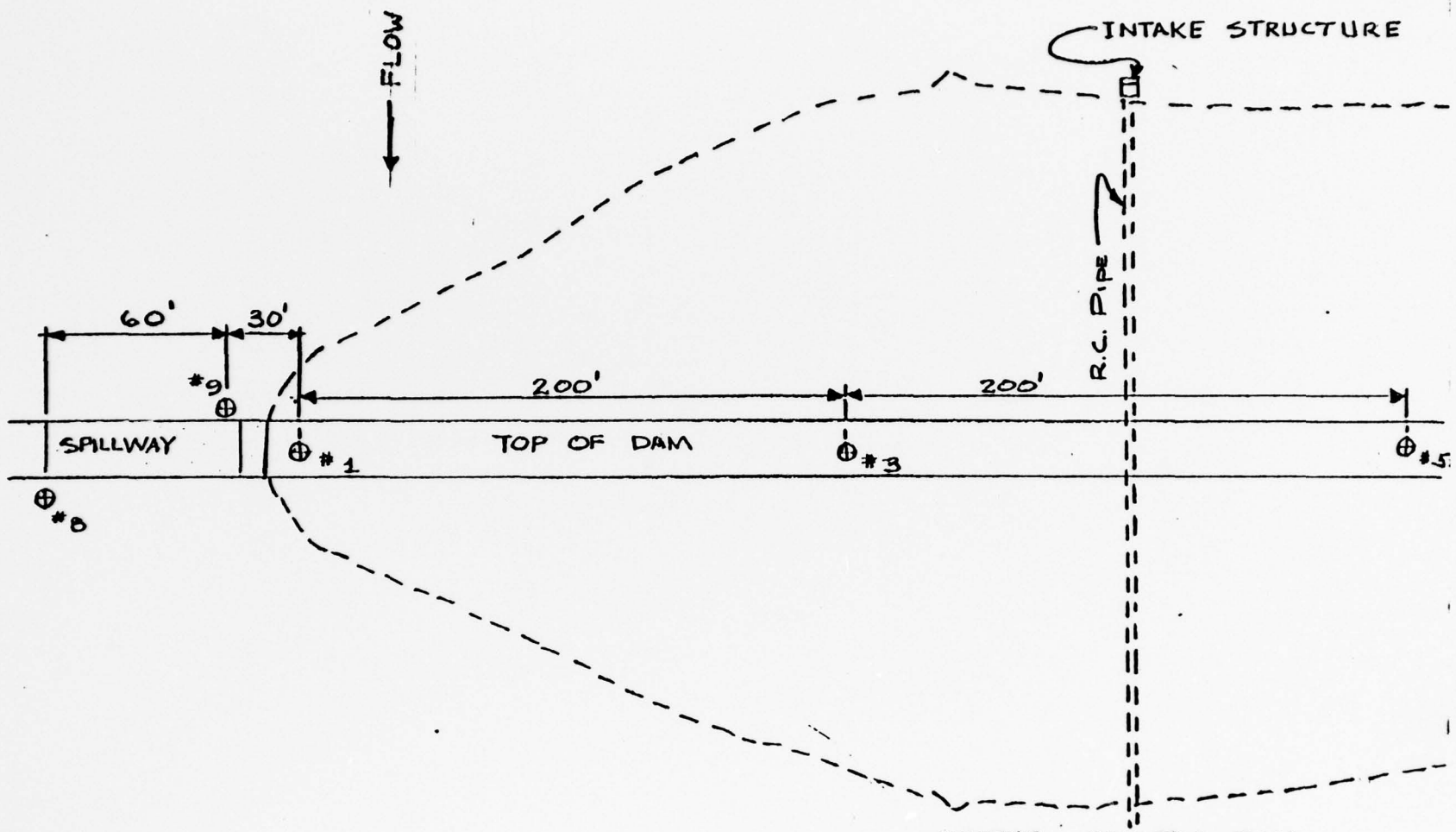
If you have any questions, please contact the writer.

Very truly yours,

FROEHLING & ROBERTSON, INC.

W. H. Vogelsang, Director
Foundation Investigation

WHV/dw



—WYTHE COUNTY DAM—
BORING LOCATION PLAN

FROEHLING & ROBERTSON
30 OCTOBER 1970

APPENDIX V

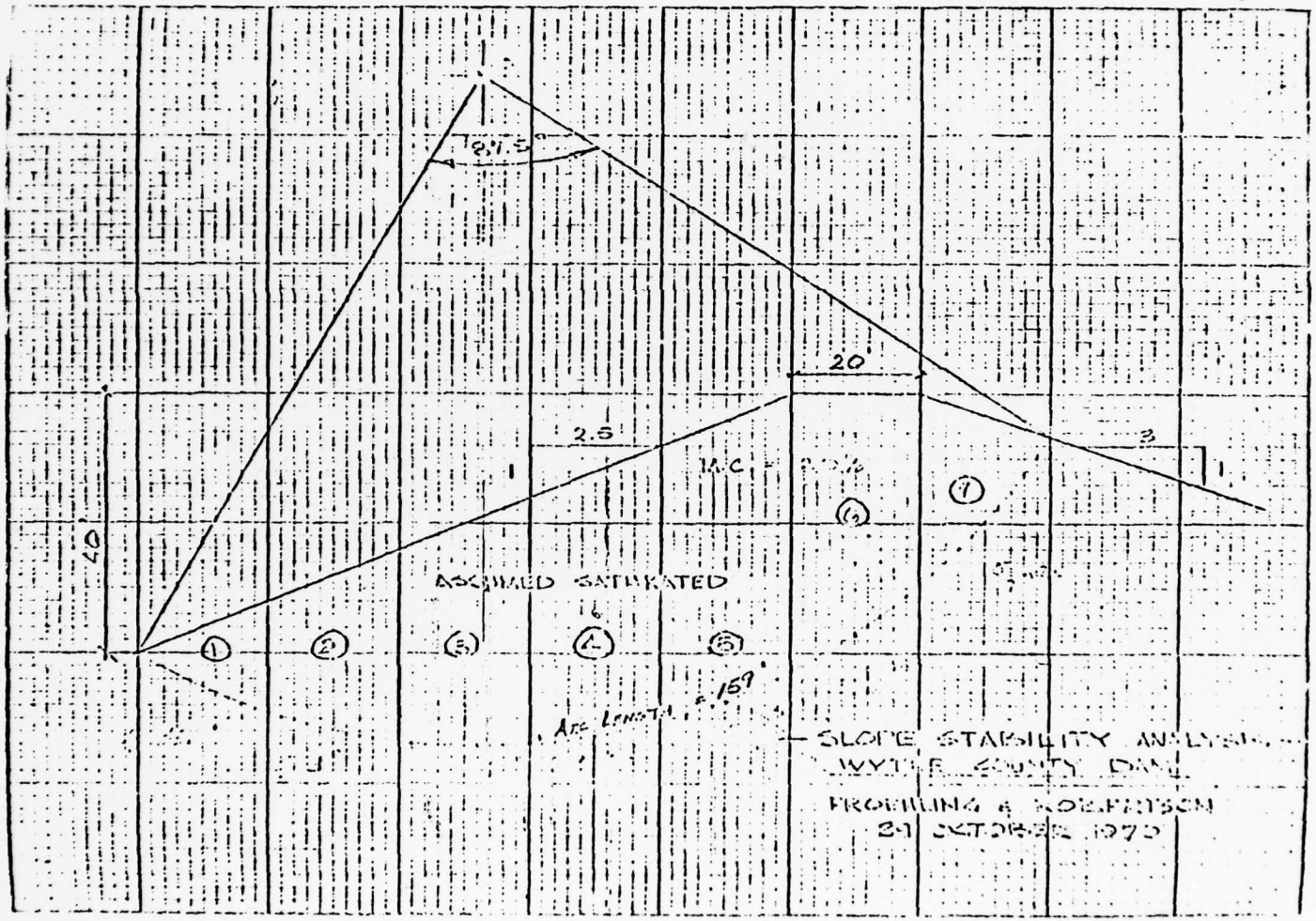
STABILITY ANALYSIS

APPENDIX V

STABILITY ANALYSIS

The following pages are a portion of the Froehling and Robertson report presented in Appendix IV. Because of an extremely poor original copy much of the figures are illegible but the basic approach and assumption should be fairly clear.

A review of this material has revealed numerous errors and deficiencies such that the results of the analysis are not considered valid. A summary of their findings is given in paragraph 6.3 of this report.


87.5°
20
2.5
1
3
1
40
ASSUMED SATURATED
1
2
3
4
5
6
7
ARC LENGTH = 159'
SLOPE STABILITY ANALYSIS
WYTH COUNTY DAM
PROWELL & NORFLEET
31 OCTOBER 1975

ASSUMPTIONS

The slope stability analysis is based on the following assumptions:

(1) Rapid Drawdown has just occurred
(This is the most severe condition)

(2) The soil is saturated to elevation 2498
with a unit weight of 140 pcf.

(3) The soil above elevation 2498 has a moisture
content of 20% with a unit weight of 110 pcf.

(4) Cohesion (c) for the clay is 800 psf

(5) Angie of Internal friction (ø) for the clay is 6°

(6) Factor of Safety = $\frac{c + \Sigma N \tan \phi}{\Sigma T}$

Section	N x Tanϕ	(illegible)	ϕ-6'
1	27.2 x .[illegible]	8.86	
2	51.4	5.40	
3	44.9	7.86	
4	91.5	9.60	
5	91.3	9.60	
6	76.0	8.98	
7	30.1	3.16	
	Σ	46.48	

A = LENGTH x C = TOTAL COHESION

159' x 800 = 127.2

Sections	Radius (FT in Arc)
1	16.8
2	11.9
3	1.9
4	15.3
5	34.1
6	50.3
7	37.8
	ΣT = 158T

$$F.S. = \frac{\text{[illegible]}}{\Sigma T} = \frac{127.2 + 46.5}{153.1} = \frac{173.7}{153.1}$$

[illegible] of Safety = 1.1

STABILITY ANALYSIS

Section	AREA (FT³)	[illegible]	[illegible]	[illegible]
1	270	× 110		= 29.7
2	480	× 110		= 52.8
3	680	× 110		74.9
4	160	× 110		
	620 ~~340~~		× 140	= 92.8
5	320	× 110		
	520 ~~420~~	×	140	= 97.5
6	480	× 110		
	320		× 140	= 91.2
7	250	× 110		
	4.8			= 44.5

FOR ANY SECTION (SEE SKETCH)

$\sin\theta = \frac{T}{R}$

$T = \sin\theta R$

$\cos\theta = \frac{N}{R}$

$N = R\cos\theta$

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 lood Hydrograph Package, (Hydrologic Engineering Center, U.S. Army Corps of Engineers, January 1973).

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

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

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

APPENDIX VII

CONDITIONS

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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.