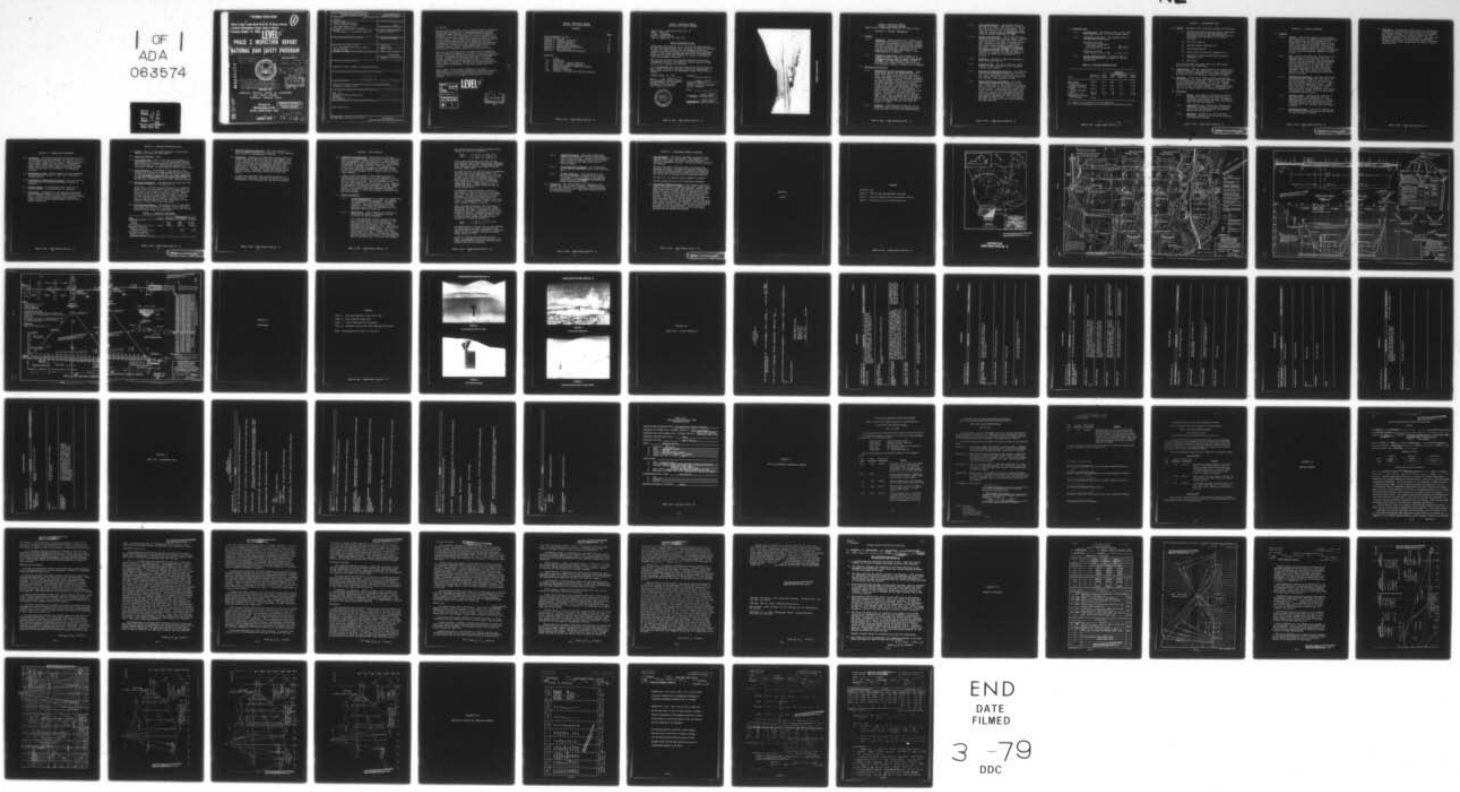
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(4) POTOMAC RIVER BASIN

(1) P.S.

(2) Name of Dam: Lower North River No. 78 (Briery Branch) Dam number

(5) Location: Rockingham County, State of Virginia

(3) Inventory Number: VA 16502

LEVEL II

PHASE I INSPECTION REPORT

(6) NATIONAL DAM SAFETY PROGRAM

Lower North River Dam Number 78 (Briery Branch) [redacted] (VA 16502). Potomac River Basin. Rockingham County, State of Virginia. Phase I Inspection Report.

(9) Final rept.,

AD A063574

(11) Aug 78 (12) 76 p.

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(10) Michael Baker, III

(15) DACW 65-78-D-0016

PREPARED FOR

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

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BEAVER, PENNSYLVANIA 15009

AUGUST 1978

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER VA16502	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Inspection Report National Dam Safety Program Lower North River No. 78 Rockingham County, State of Virginia		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Michael Baker, Jr., Inc.-Michael Baker III		8. CONTRACT OR GRANT NUMBER(s) DACW 65-78-D-0016
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Engineering District, Norfolk 803 Front Street Norfolk, VA 23510		12. REPORT DATE August 1978 13. NUMBER OF PAGES 54
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia 22151

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dams - VA
National Dam Safety Program Phase I
Dam Safety
Dam Inspection

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(See reverse side)

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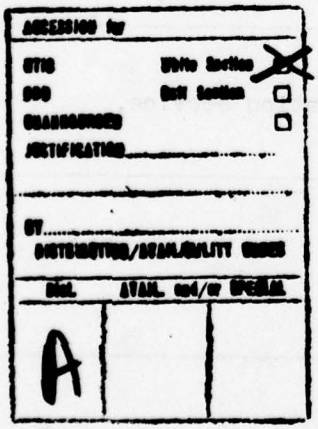
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20. Abstract

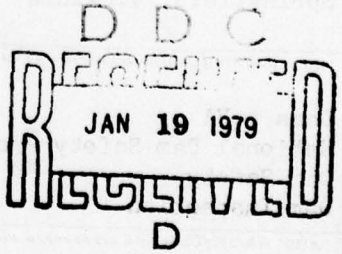
Pursuant to Public Law 92-367, Phase I Inspection Reports are prepared under guidance contained in the recommended guidelines for safety inspection of dams, published by the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I investigation is to identify expeditiously those 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.



LEVEL II



PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Lower North River No. 78
State: Virginia
County: Rockingham
Stream: Briery Branch
Date of Inspection: 15 June 1978

BRIEF ASSESSMENT OF DAM

Lower North River Dam No. 78 is an earth dam approximately 92 feet high and 762 feet long. The dam is owned and operated by the U.S. Forest Service and was designed by the Soil Conservation Service as part of the Potomac River Watershed Project. The visual inspections and review of engineering data, made in June 1978, indicate no serious deficiencies requiring emergency attention.

The spillway will pass the Probable Maximum Flood without overtopping the dam. No evidence of severe unstable slope conditions or seepage was observed.

It is recommended that the high stage trash rack be repaired and a means to control vehicular traffic be implemented. Small trees growing on the embankment slopes should also be removed.

MICHAEL BAKER, JR., INC.

Michael Baker, III, P.E.
Chairman of the Board and
Chief Executive Officer

COMMONWEALTH OF VIRGINIA
MICHAEL BAKER III
NO. 3176
CERTIFIED PROFESSIONAL ENGINEER

APPROVED:
Original signed by:
Douglas L. Haller
Douglas L. Haller
Colonel, Corps of Engineers
District Engineer

Date:

Submitted By: Original signed by JAMES A. WALSH

Recomended By: Original signed by ZANE M. GOODWIN



OVERALL VIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM: LOWER NORTH RIVER NO. 78 ID# VA 16502

SECTION 1 - PROJECT INFORMATION

1.1 General

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

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

1.2 Description of Project

1.2.1 Description of Dam and Appurtenances: Lower North River Dam No. 78 (Briery Branch) is a zoned earth dam 92 feet high and 762 feet long. The impervious core and zoned cut-off trench extending to firm bedrock were designed to provide seepage control. A rock toe drain has been provided. The emergency spillway is an earth side-channel type with a bottom width of 200 feet. The principal spillway is a side inlet structure consisting of a reinforced concrete riser, 36 inch diameter concrete water pipe, and a riprapped stilling basin. The reservoir is used for flood control. There is an inlet on the reservoir side of the riser at normal pool elevation 1989.0 feet. The reservoir may be drained by use of a hand-operated, 36 inch slide gate. A plan and typical sections are shown on Plates 1, 2 and 3.

1.2.2 Location: Lower North River Dam No. 78 is located on Briery Branch, approximately five miles upstream of the Town of Briery Branch.

1.2.3 Size Classification: The maximum height of the dam is 92 feet. The reservoir volume to the top of the dam is 2550 acre-feet. Therefore, the dam is in the "intermediate" size category as defined by the Recommended Guidelines for Safety Inspection of Dams.

1.2.4 Hazard Classification: Due to the five mile distance to the Town of Briery Branch, Virginia with a population of about 150, many lives could be lost in the event of failure of the dam. Therefore, this dam is considered in the "high" hazard category as defined by Section 2.1.2 of the Recommended Guidelines for Safety Inspection of Dams. The hazard classification used to categorize dams is a function of location only and has nothing to do with its stability or probability of failure.

1.2.5 Ownership: The dam is owned and operated by the U.S. Forest Service.

1.2.6 Purpose of Dam: The dam is used for flood control on the Lower North River Watershed (Potomac River Basin).

1.2.7 Design and Construction History: The existing facility was designed for the owner by the U.S. Soil Conservation Service (S.C.S.). The dam, which was built by the English Construction Company, was completed in 1968.

1.2.8 Normal Operational Procedures: No formal operating procedures are followed for this dam. Normal pool is controlled by an orifice inlet on the side of the riser at an elevation of 1989.0 feet. Since this dam is used for flood control, the principal spillway (riser crest) is located at an elevation of 2016.8 feet with excess flows diverted through the side-channel emergency spillway with a crest elevation of 2045.6 feet. It is not known how often the lift on the 36 inch slide gate has been operated.

1.3 Pertinent Data

1.3.1 Drainage Area: The drainage area of the Lower North River Dam No. 78 is 9.52 square miles.

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 . . . . . 226 c.f.s.
Pool level at top of dam . . 240 c.f.s.

Emergency Spillway:
Pool level at top of dam . . 21,000 c.f.s.

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

TABLE 1.1 DAM AND RESERVOIR DATA

Item	Elevation feet M.S.L.	Reservoir Capacity Area acres	Reservoir Capacity Acre-feet	Reservoir Capacity Watershed inches (a)	Length feet
Top of dam	2056.0	64.3	2550	5.0	0.63
Maximum pool, design surcharge	2049.9	59.4	2180	4.3	0.58
Emergency spillway crest	2045.6	55.7	1923	3.8	0.52
Principal spillway crest	2016.8	32.2	663	1.3	0.35
Normal pool (b)	1989.0	9.6	73	0.1	0.18
Streambed at centerline of dam	1975±	-	-	-	-

(a) Based on 9.52 square miles of watershed.
(b) Top of conservation pool and bottom of flood control pool.

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SECTION 2 - ENGINEERING DATA

2.1 Design: The design data reviewed included the following:

1) As-built drawings indicating plans, elevations and sections of the dam and appurtenant structures (logs of the test borings and test pits were also included in the as-built drawings).

2) Soil test results.

3) Geologic Report (Appendix VI).

4) Geotechnical Report.

5) Slope Stability Analyses (Appendix VII).

6) Analysis of Piping and Cracking Potential (Appendix VIII).

7) Work Plan.

All existing data have been filed with the Norfolk District for future reference.

2.2 Construction: The dam, constructed by the English Construction Company, was completed in 1968. Construction records were not available for this inspection report, but are on file in Washington, District of Columbia.

2.3 Operation: There are no formal operating procedures for this dam. The slide gate used to drain the reservoir is not periodically operated. There is no existing policy concerning the frequency of its use. Annual inspections are conducted through the joint effort of the S.C.S. and U.S. Forest Service. Inspection reports for the last three years are attached as Appendix V.

2.4 Evaluation

2.4.1 Design: The Stability Analyses and as-built drawings were adequate for evaluating the structural stability of the dam. Foundation conditions were determined using the Geotechnical and Geologic Reports.

2.4.2 Construction: No construction records were available. However, the as-built drawings should indicate modifications and changes made during construction.

2.4.3 Operation: Operation of the slide gate should be included in the annual maintenance and inspection program.

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SECTION 3 - VISUAL INSPECTION

3.1 Findings

3.1.1 General: The field inspection was performed on 15 June 1978. No unusual weather conditions were experienced and the reservoir was at normal pool. The dam and appurtenant structures were found to be in good overall condition at the time of inspection (see Photo 1). The problems noted during the visual inspection are considered minor. Nothing was observed in the field that required immediate remedial action.

3.1.2 Dam: Several footpaths were observed on the upstream slope of the dam near the left abutment and on the slope above the upstream side of the left abutment. Scattered debris has been deposited on the upstream face of the dam as a result of a high water level. Logs and debris had also been deposited on the riprap gutters at the left and right abutment. Many small trees were observed growing on both the downstream and upstream faces of the dam.

3.1.3 Appurtenant Structures: The high stage trash rack has several broken bolts that held the horizontal bars in position (see Photo 2). This is probably a result from ice or debris build-up during higher pool levels. Some minor erosion of the banks of the stilling basin (see Photo 3) was observed. This erosion is most likely caused by water levels overtopping the riprap in the stilling basin during high runoff periods.

3.1.4 Reservoir Area: Sloughing was observed on the left side of the reservoir near the emergency spillway (see Photo 4). A scarp approximately two feet long and five inches wide has formed at the top of the slough. Footpaths were also observed near this same location.

3.1.5 Downstream Channel: The outlet channels for the rpincipal and emergency spillways showed no serious signs of erosion.

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3.2 Evaluation: The problems listed above are maintenance problems and should be corrected as part of the annual maintenance program. The trees growing on the embankment should be removed. Vehicular traffic on the embankment slopes should be controlled. The trash rack should be repaired. The slough near the emergency spillway and the minor stilling basin erosion should be checked during annual inspections for signs of further deterioration.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures: No formal operational procedures are used on the Lower North River Dam No. 78, since it is a flood control structure and does not require the use of water supply intake valves or gates. The reservoir under normal conditions remains at the elevation of normal pool, 1989.0 feet, and has 56.6 feet of additional storage area to the crest of the emergency spillway.

4.2 Maintenance of Dam: Annual inspections are conducted through the joint effort of the S.C.S. and the U.S. Forest Service.

4.3 Maintenance of Operating Facilities: The lift for the slide gate is not routinely operated to check its function.

4.4 Warning System: At the present time, there is no warning system or evacuation plan in operation.

4.5 Evaluation: Maintenance of the operating facilities are considered adequate for the functions that they serve. However, formal records of the lift gate checks similar to the annual maintenance and inspection reports should be instituted perhaps as part of the annual inspections.

SECTION 5 - HYDRAULIC/HYDROLOGY DATA

5.1 Design: The S.C.S hydrologic/hydraulic calculations were not available for this report.

5.2 Hydrologic Records: None

5.3 Flood Experience: The 17 June 1949 flood peaked at a discharge of 11,100 c.f.s. at the stream gage located near Stokesville, approximately eight miles from Lower North River Dam No. 78. The peak corresponds to a recurrence interval of approximately once in sixty years.

5.4 Flood Potential: Performance of the reservoir was analyzed by routing the Probable Maximum Flood (P.M.F.) through the reservoir as required for a dam classified by the Recommended Guidelines for the Safety Inspection of Dams as a "intermediate" size-"high" hazard dam. The 100 year flood and one-half P.M.F. were also routed.

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

Regulation of the flow from the reservoir is automatic. Normal flows are controlled by the low stage inlet in the riser at an elevation of 1989.0 and the high stage drop-inlet with a crest elevation of 2016.8. Water flowing into these inlets flows through the dam in a 36 inch diameter concrete conduit. Water also flows past the dam through an ungated, vegetated, side-channel emergency spillway in the event water in the reservoir rises over the spillway crest.

5.6 Overtopping Potential: The probable rise in the reservoir and other pertinent information on the reservoir performance for the P.M.F., one-half P.M.F. and 100 year flood is shown in the following table:

TABLE 5.1 RESERVOIR PERFORMANCE

Item	Normal	Hydrographs 100 year	1/2 P.M.F.	P.M.F.
Peak flow, c.f.s.				
Inflow	-	2171	9050	18,100
Outflow	-	1039	8803	17,747
Peak elevation, ft. M.S.L.	1989.0	2028.8	2051.8	2055.2
Emergency spillway				
Depth of flow, ft.	-	-	3.8	6.0
Average velocity, f.p.s.	-	-	10.8	13.5
Non-overflow section				
Depth of flow, ft.	-	-	-	-
Average velocity, f.p.s.	-	-	-	-

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5.7 Reservoir Emptying Potential: The time required to draw the reservoir down from normal pool to the reservoir drain invert is approximately 11 hours.

5.8 Evaluation: Hydraulic and hydrologic determinations of the project were computed as part of this report. The P.M.F., one-half P.M.F. and 100 year hydrographs were routed through the dam and reservoir starting with pool level at the crest of the emergency spillway. The routed P.M.F. reached a maximum elevation of 2055.2 feet which is 0.8 feet lower than the minimum top of dam elevation. Therefore, the dam and spillway have adequate storage discharge capacities to pass the P.M.F.

It should be indicated that conclusions pertain to present day conditions, and that the effect of future development on the hydrology has not been considered.

SECTION 6 - DAM STABILITY

6.1 Foundation and Abutments: The majority of the dam rests on a coarse-grained alluvial flood plain consisting mainly of boulders, cobbles and gravel. Underlying the soil overburden is red, fine-grained, massive sandstone interbedded with some siltstone and shale. The attitude of the rock is generally N.75°E., 8°E. Along the centerline of the dam, the depth to sandstone bedrock in the flood plain area ranges from four feet at the toe of the left abutment to 27.5 feet at the toe of the right abutment.

A talus slope consisting of red sandstone boulders, cobbles and gravel occurs on the right abutment. At the centerline of the dam, the talus ranges in thickness from 0.5 feet to 22 feet. The left abutment is an alluvial bench deposit up to 60.3 thick. It is composed of sub-angular red and gray sandstone, boulders, cobbles and gravel with red brown silty sand filling the interstices. The cut-off trench was extended to bedrock, entailing removal of the coarse grained overburden from the left abutment.

6.2 Stability Analysis

6.2.1 Visual Observations: No evidence of instability in the embankment was observed. No seepage was observed in the embankment, abutments or foundation that would suggest an unstable condition. Sloughing was observed on the upstream side of the left abutment near the emergency spillway (Photo 4).

6.2.2 Design Data: Slope stability was checked in June 1965 and again in September 1965 by circular arc failure methods.

The zoned embankment section chosen for the first analysis had a crest elevation of 2056 feet and side slopes of two and one-half horizontal to one vertical (2.5:1) with an upstream bench at elevation 1990. The section indicated two embankment zones. The shell of the dam was shown adjacent to a core with slope ratios of 1.25:1. Steeper core slope ratios were also shown on the section; however, the Slope Stability section of the Geotechnical Report indicates that a wide core was assumed.

The following shear strength parameters were assumed for the first analysis:

core . . . $\phi = 29.5°$, $c = 350$ p.s.f.
shell. . . $\overline{\phi} = 36.0°$, $\overline{c} = 425$ p.s.f.
$\overline{\phi} = 38.5°$, $\overline{c} = 600$ p.s.f.

Total stress parameters were used for the core material while effective stress parameters were used for the shell. These shear strengths were determined from consolidated undrained triaxial shear tests.

Although two sets of effective stress parameters were assumed for the shell material, the analysis shows that parameters of $\overline{\phi} = 36°$ and $\overline{c} = 425$ p.s.f. yield the lowest safety factor. Minimum safety factors computed from the first analysis were 1.31 for the upstream slope under full drawdown and 1.97 for the downstream slope. Computations for the downstream slope assumed a drain at the toe of the center core.

An embankment section having a rock toe (instead of a drain at the toe of the core) and a smaller core was chosen for the second analysis. The shell of the dam was shown surrounding a core with slope ratios of 0.75:1. In this stability analysis, the core refers to Embankment Zones I and II while the shell refers to Zones III and IV.

Shear strength parameters were consistent in the second analysis since all total stress parameters were used. No change was found in converting the shell parameters to total from effective; however, strength parameters from a third triaxial shear test were used. The following shear strength parameters were assumed for the second analysis:

core . . . $\phi = 29.5°$, $c = 350$ p.s.f.
shell. . . $\phi = 40°$, $c = 0$

A minimum factor of safety of 1.91 was computed for the downstream slope. Upstream trials indicated that a 10 feet wide berm at elevation 2024.0 would be needed to provide a minimum safety factor of 1.33.

A check of the piping potential was also made. The gradations and plasticities of the expected embankment materials indicated that piping would not be a problem.

6.2.3 Operating Records: The yearly inspections indicate no deteriorating conditions beyond minor surface erosion. Debris on the upstream face of the dam indicates water has at least been as high as the riser crest with no serious damage.

6.2.4 Post-Construction Changes: No alternations of the dam were apparent since it was constructed.

6.2.5 Seismic Stability: Lower North River Dam No. 78 is located in Seismic Zone 2 and is considered to have no hazard of earthquakes according to the Recommended Guidelines for Safety Inspection of Dams.

6.3 Evaluation: The second stability analysis is compatible with the as-built drawings. Embankment Zones I and II were assumed to have identical shear strengths as were Zones III and IV. Additional analyses are not considered necessary.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment: The dam is designed to prevent overtopping under P.M.F. conditions. No seepage or slope failures were noted that would indicate potential piping or embankment failure. No major erosion problems are present.

The data available were sufficient to evaluate the adequacy of design. Although no hydraulic/hydrologic calculations were available, information collected in the field, and taken from the Work Plan and as-builts was sufficient to evaluate the overtopping potential.

The dam will not require urgent remedial treatment.

Further investigation is not considered necessary.

7.2 Recommended Remedial Measures: The slope on the left side of the reservoir, where erosion and sloughing were observed, should be graded and reseeded. Several areas where vegetation has been destroyed by vehicular and pedestrian traffic should also be reseeded in the near future. Several logs scattered on the upstream slope as well as debris on the riprap gutters should be removed. The small trees growing on both the upstream and downstream faces of the dam should be removed. Also, the bolts holding the horizontal bars in the high stage trash rack need to be replaced. If erosion above the existing riprap worsens, riprap should be placed on the banks of the stilling basin. These corrective measures can be accomplished as part of the annual maintenance and inspection program.

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APPENDIX I

PLATES

CONTENTS

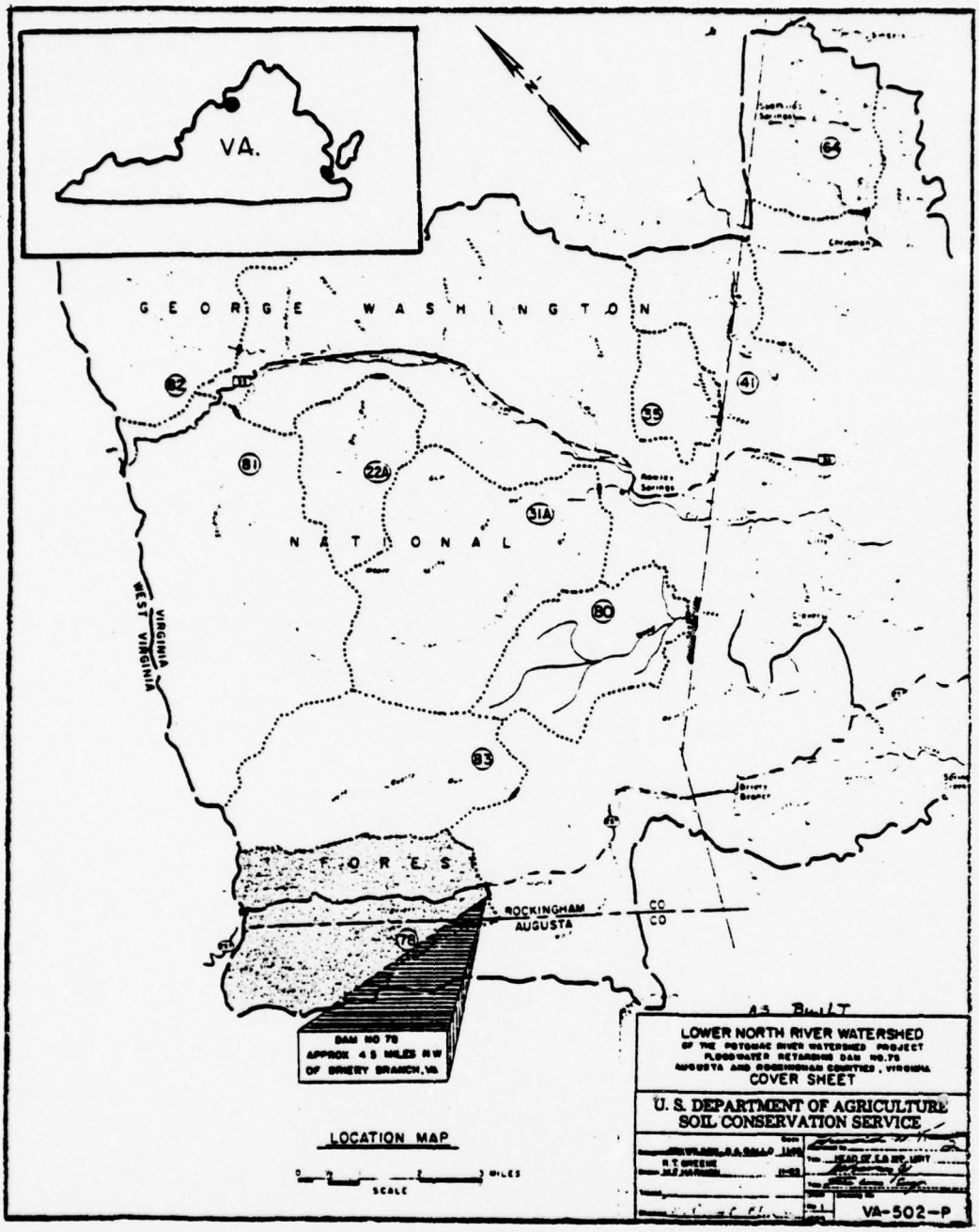
Location Plan

Plate 1: Plan of Dam and Emergency Spillway

Plate 2: Cut-Off Trench Details and Typical Section

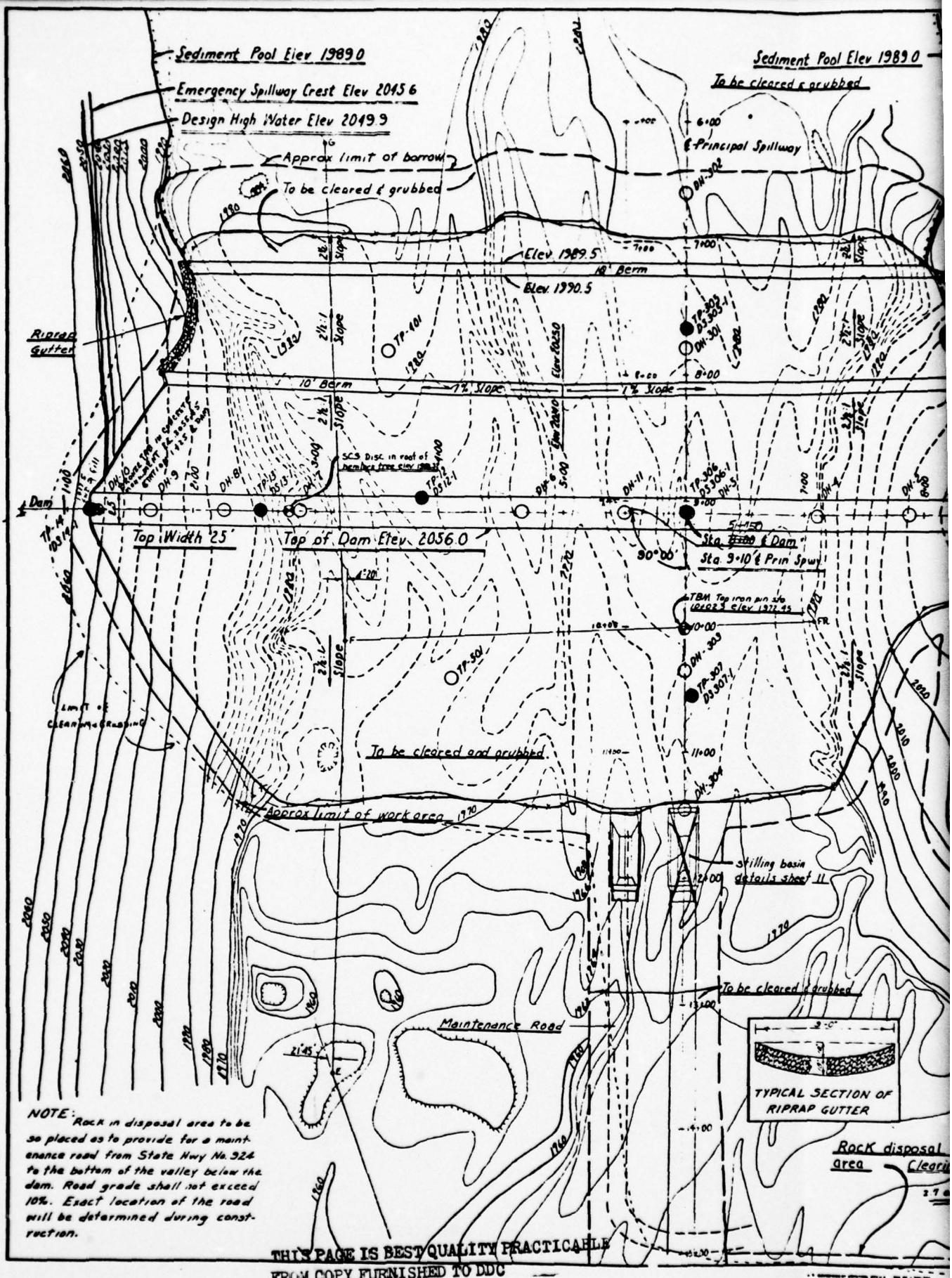
Plate 3: Plan-Profile of Principal Spillway

NAME OF DAM: LOWER NORTH RIVER NO. 78

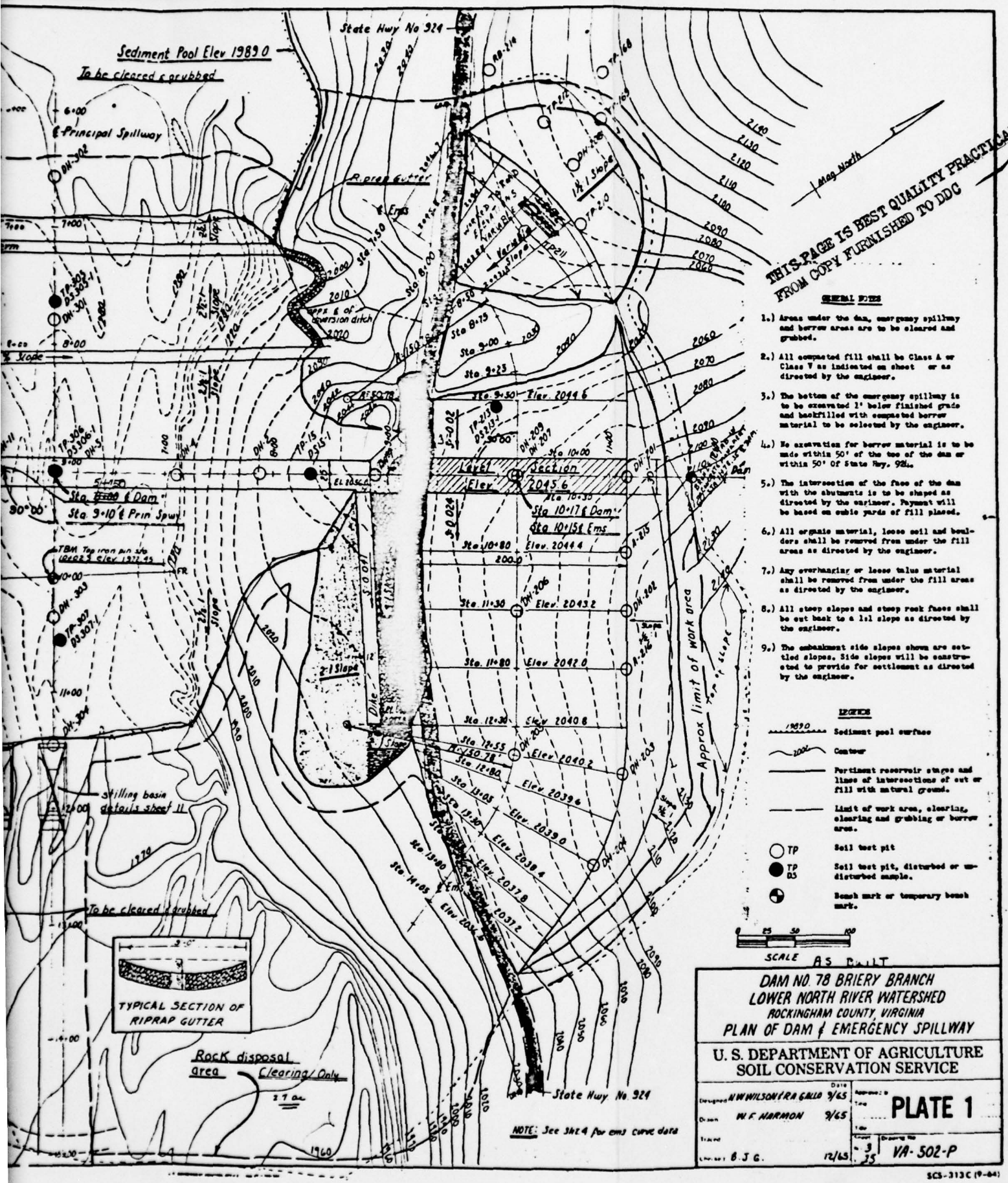


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LOCATION PLAN
LOWER NORTH RIVER NO. 78



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GENERAL NOTES

1.) Areas under the dam, emergency spillway and borrow areas are to be cleared and grubbed.

2.) All compacted fill shall be Class A or Class V as indicated on sheet or as directed by the engineer.

3.) The bottom of the emergency spillway is to be excavated 1' below finished grade and backfilled with compacted borrow material to be selected by the engineer.

4.) No excavation for borrow material is to be made within 50' of the toe of the dam or within 50' Of State Hwy. 924.

5.) The intersection of the face of the dam with the abutments is to be shaped as directed by the engineer. Payment will be based on cubic yards of fill placed.

6.) All organic material, loose soil and boulders shall be removed from under the fill areas as directed by the engineer.

7.) Any overhanging or loose talus material shall be removed from under the fill areas as directed by the engineer.

8.) All steep slopes and steep rock faces shall be cut back to a 1:1 slope as directed by the engineer.

9.) The embankment side slopes shown are settled slopes. Side slopes will be constructed to provide for settlement as directed by the engineer.

LEGEND

- 1989.0 — Sediment pool surface
- 2000 — Contour
- Pertinent reservoir stages and lines of intersections of cut or fill with natural ground.
- Limit of work area, clearing, clearing and grubbing or borrow area.
- TP — Soil test pit
- TP / DS — Soil test pit, disturbed or undisturbed sample.
- Bench mark or temporary bench mark.

0 25 50 100

SCALE AS BUILT

NOTE: See Sht 4 for ems curve data

DAM NO. 78 BRIERY BRANCH
LOWER NORTH RIVER WATERSHED
ROCKINGHAM COUNTY, VIRGINIA

PLAN OF DAM & EMERGENCY SPILLWAY

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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Drawn	W.F. HARMON	9/65
Traced		
Checked	B.J.G.	12/65

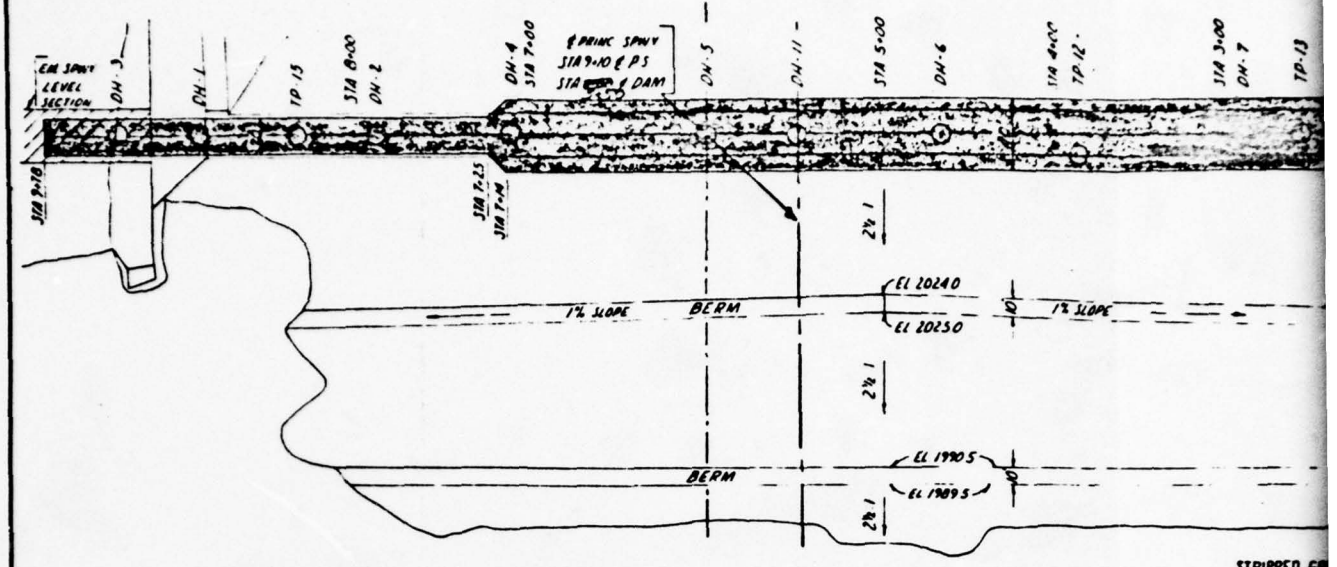
PLATE 1

Sheet 3 of 35 — Drawing No. VA-502-P

SCS-313C (9-64)

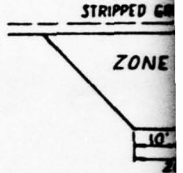
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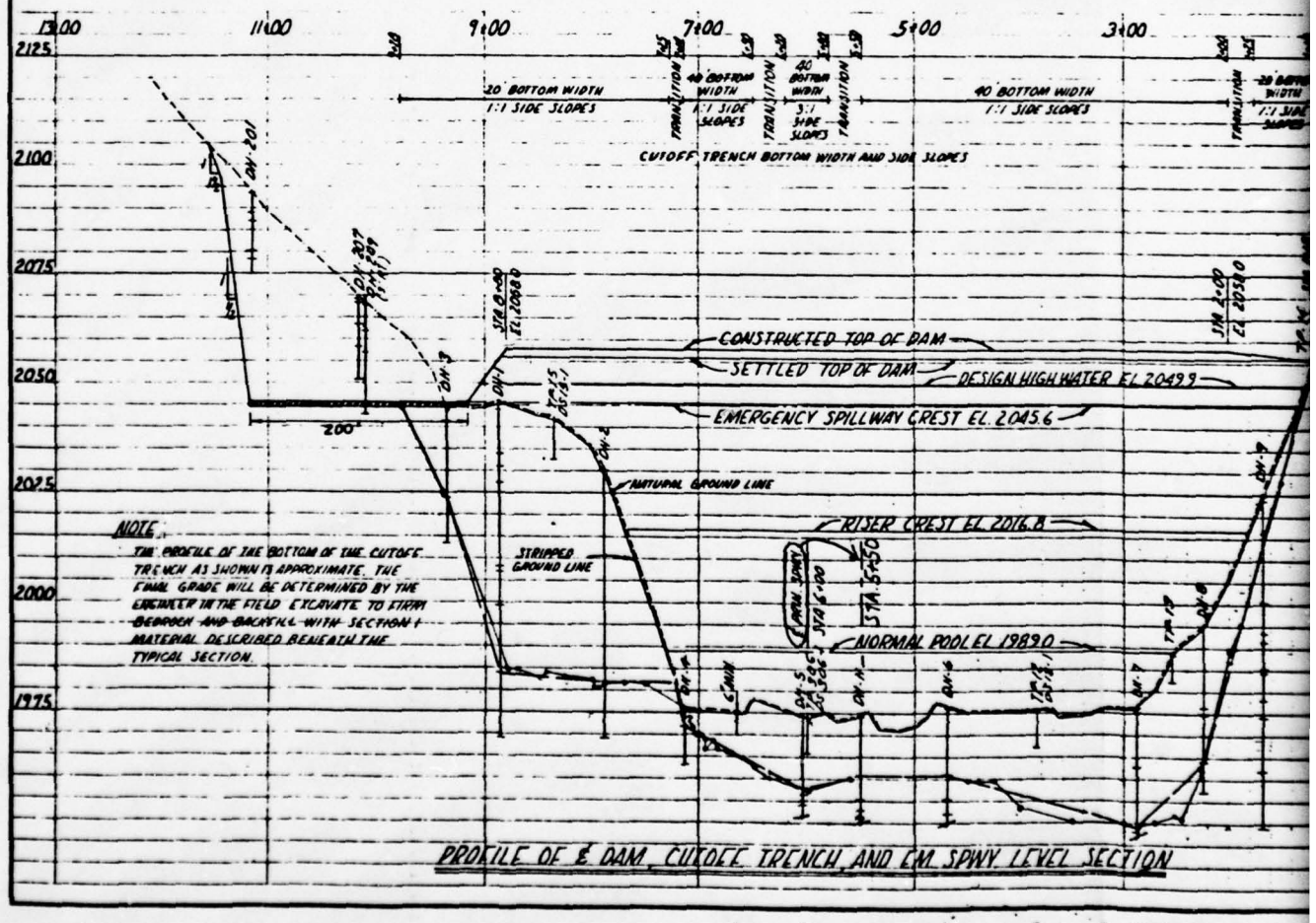


PLAN OF CUTOFF TRENCH

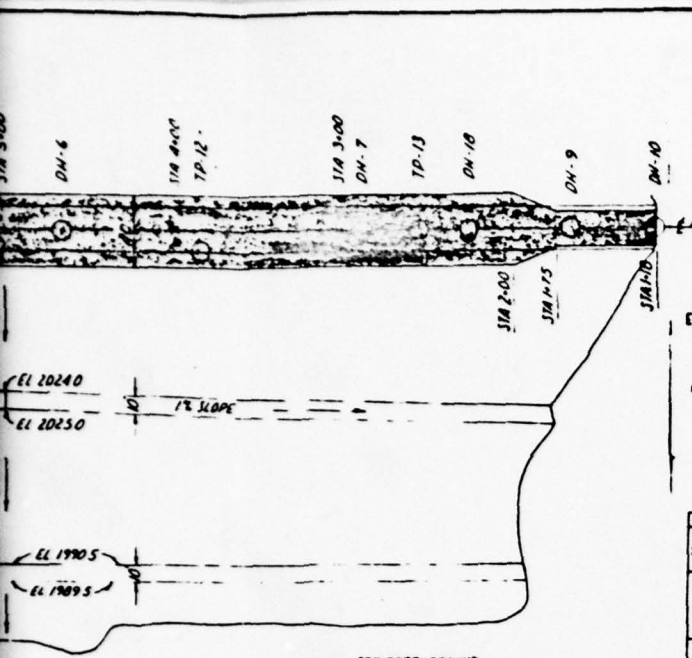
0 10 20 30 40 50 100 FEET
SCALE

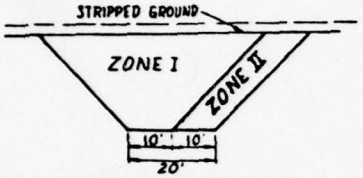


TYPICAL SECTI
TRENCH FROM

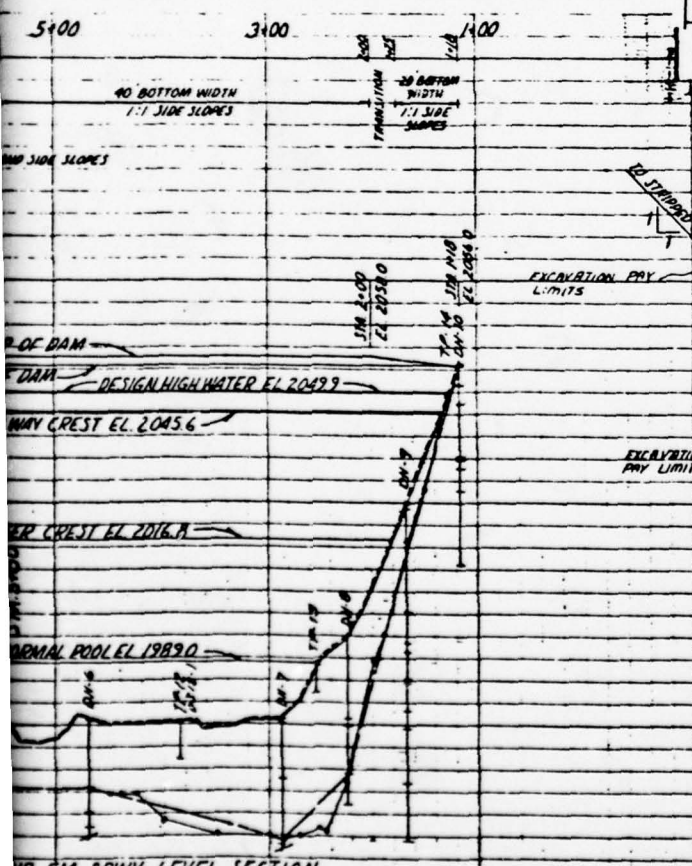


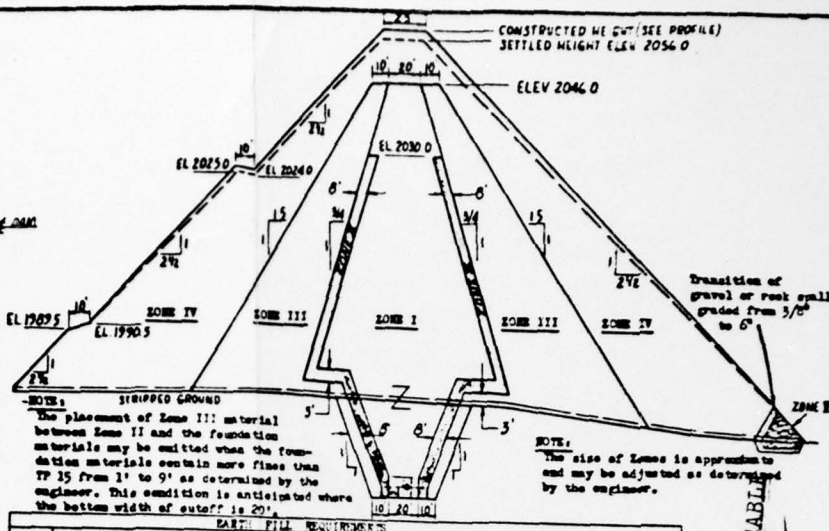
PROFILE OF E DAM, CUTOFF TRENCH AND EM. SPWY. LEVEL SECTION





TYPICAL SECTION OF CUTOFF TRENCH FROM STA 7+25 TO STA 9+78





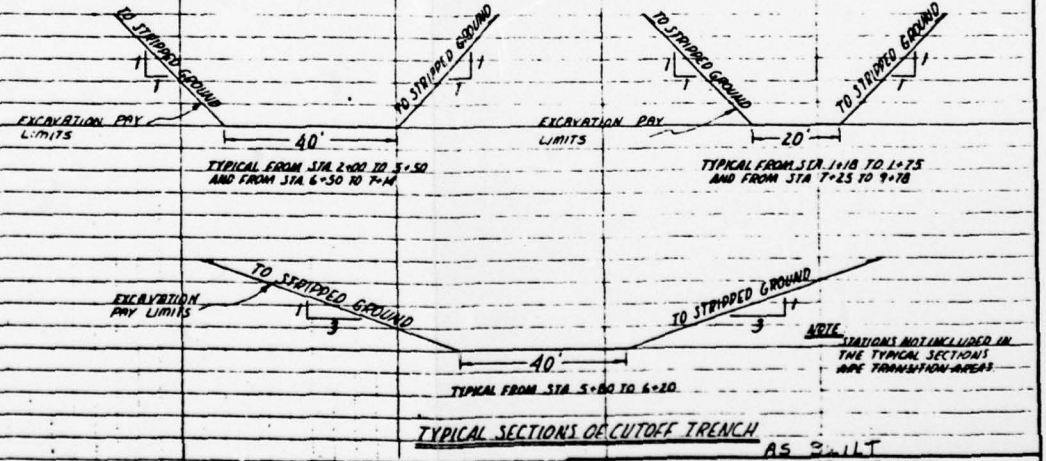
NOTE: The placement of Zone III material between Zone II and the foundation materials may be omitted when the foundation materials contain more fines than TP 15 from 1' to 9' as determined by the engineer. This condition is anticipated where the bottom width of cutoff is 20'.

NOTE: The size of Zones is approximate and may be adjusted as determined by the engineer.

EARTH FILL REQUIREMENTS

ZONE	MATERIAL	MAX. ROCK SIZE	MAX. LIFT THICK.	REQUIRED WATER CONTENT	COMPACTION CLASS	COMPACTION DEFINITION
I	Fine silty sand (SM) represented by TP 115 from 1' to 8', TP 143 from 3.1' to 10.2' and TP 148 from 1' to 5.5' selected from borrow areas "C" & "E".	6"	9"	Optimum to + 3%	A	100% max. density ASTM D698 Method A
II	Silty sand (SM) represented by TP 117 from 1' to 9.5' selected from borrow area "C".	6"	9"	From -1% to + 2% of optimum	A	100% max. density ASTM D698 Method C
III	Silty gravels (GM) represented by TP 211 from 1' to 9', TP 213 from 1' to 9.6' and TP 106 from 1' to 8', selected from the emergency spillway and borrow area "A".	16"	24"	See Spec 5A	V	See Spec. 5A.
IV	Gravels (GP-GM) represented by TP 102 from 1' to 8.2' selected from borrow area "A".	16"	24"	See Spec 5A	V	See Spec. 5A.
V	Oversize material removed from the other zones.	36"	36"	natural	-	See Spec 6A.

TYPICAL SECTION OF FILL



NOTE: STATIONS NOT INCLUDED IN THE TYPICAL SECTIONS ARE TRANSITION AREAS

TYPICAL SECTIONS OF CUTOFF TRENCH

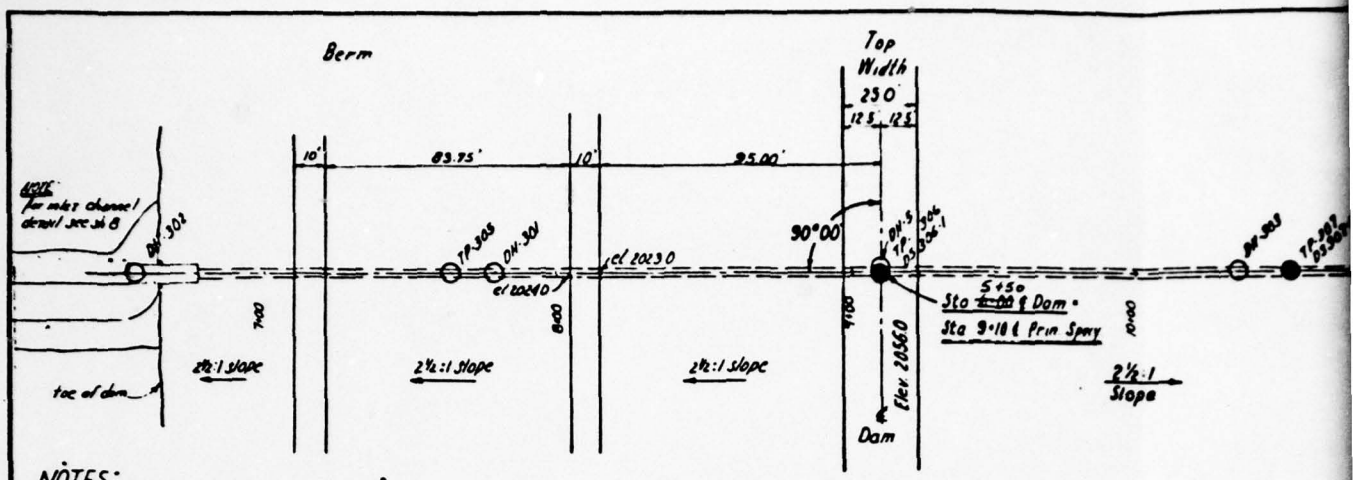
AS BUILT

DAM NO 78 BRIERY BRANCH
LOWER NORTH RIVER WATERSHED
ROCKINGHAM COUNTY, VIRGINIA
CUTOFF TRENCH DETAILS & TYPICAL SECTION

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	N.W. WILSON	Date	Approved by
	R.A. GALLO	10/65	
Drawn	W.F. HARMON		
	R.A. GALLO	10/65	PLATE 2
Traced			
Checked			Drawing No. VA-502-P

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PLAN VIEW

Scale

NOTES:

36" inside dia. reinf. conc water pipe
(27) 16'-0" sections
(1) wall fitting for 12° wall

Total length = ~~482.93~~ 480.95
Pressure head 81.2' (AHW)

J-1 to J-7 and J-24 to outlet

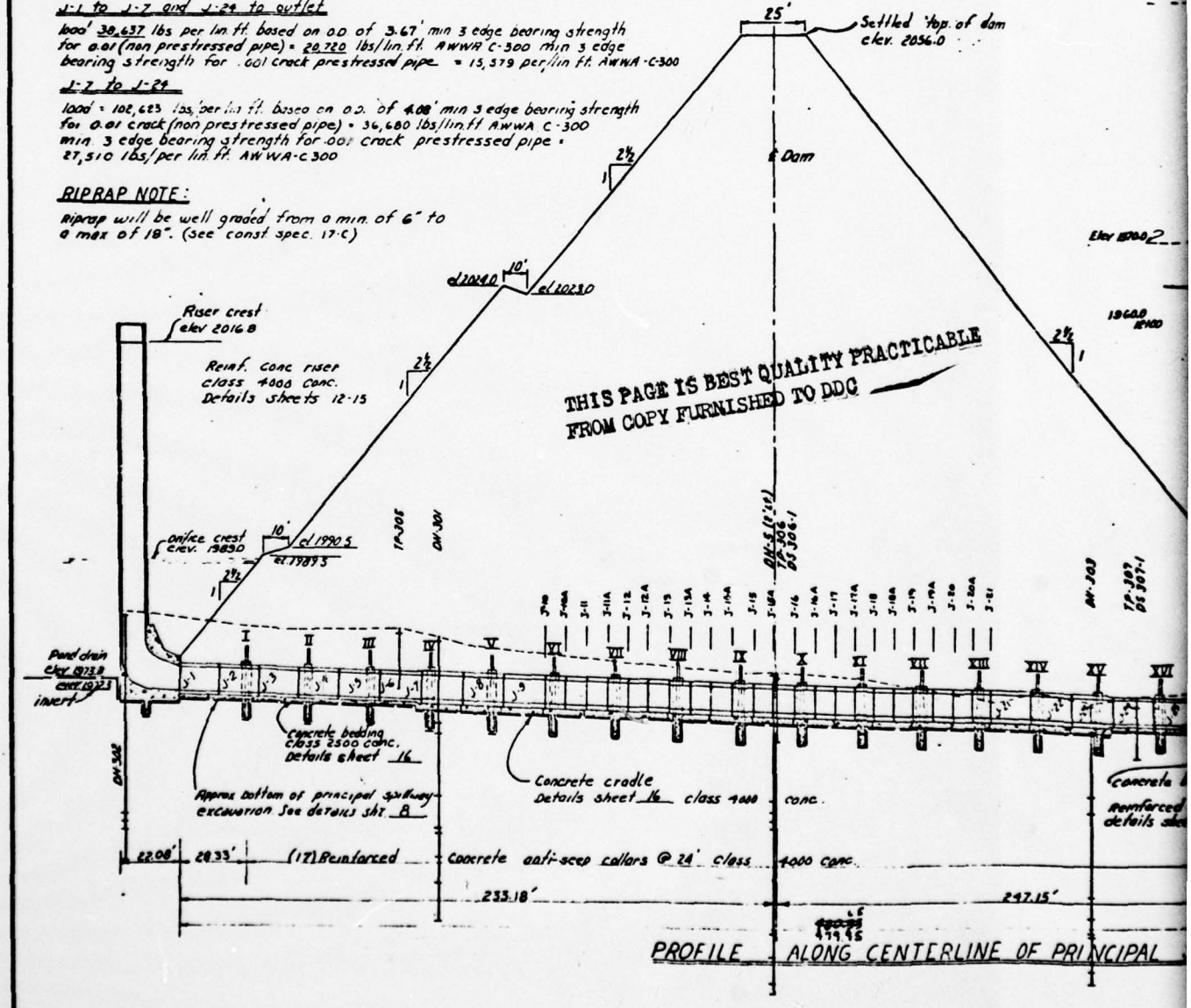
1000' 38,637 lbs per lin ft based on O.D of 3.67' min 3 edge bearing strength for 0.01 (non prestressed pipe) = 20,720 lbs/lin.ft. AWWA C-300 min 3 edge bearing strength for .001 crack prestressed pipe = 15,379 per/lin ft. AWWA-C-300

J-7 to J-24

1000' = 102,623 lbs per lin ft based on O.D. of 4.08' min 3 edge bearing strength for 0.01 crack (non prestressed pipe) = 36,680 lbs/lin.ft AWWA C-300 min. 3 edge bearing strength for .001 crack prestressed pipe = 27,510 lbs/per lin ft. AWWA-C 300

RIPRAP NOTE:

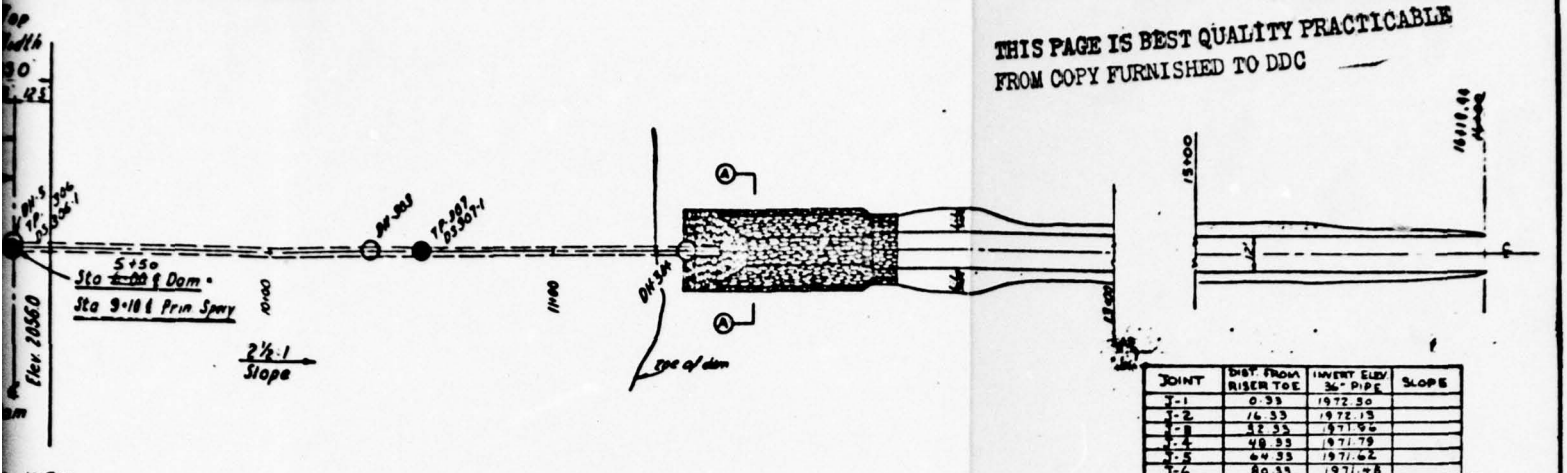
Riprap will be well graded from a min. of 6" to a max of 18". (See const spec. 17-C)

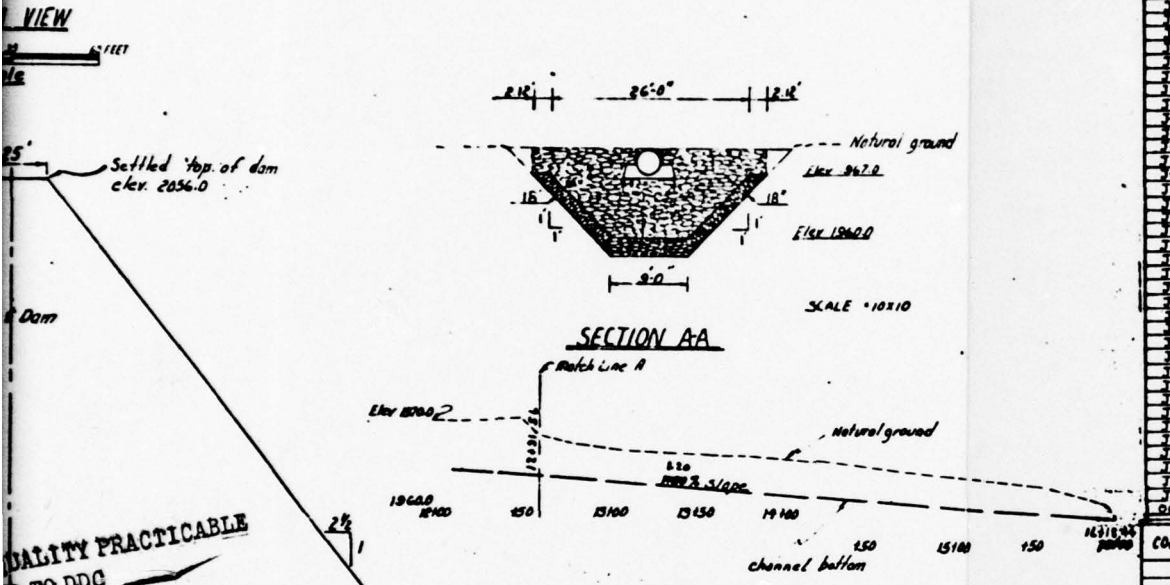


PROFILE ALONG CENTERLINE OF PRINCIPAL

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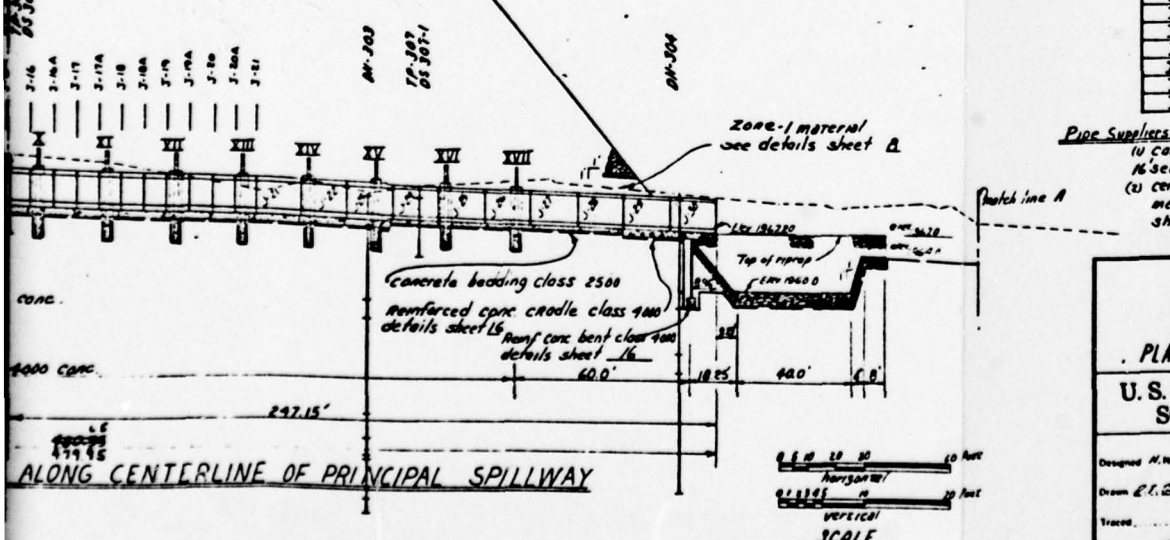




JOINT	DIST. FROM RISER TOE	INVERT ELEV 36" PIPE	SLOPE
J-1	0.33	1972.30	
J-2	16.33	1972.13	
J-3	32.33	1971.96	
J-4	48.33	1971.79	
J-5	64.33	1971.62	
J-6	80.33	1971.45	
J-7	96.33	1971.28	
J-8	112.33	1971.11	
J-9	128.33	1970.94	
J-10	144.33	1970.77	
J-10A	152.33	1970.69	
J-11	160.33	1970.60	
J-11A	168.33	1970.52	
J-12	176.33	1970.43	
J-12A	184.33	1970.35	
J-13	192.33	1970.26	
J-13A	200.33	1970.18	
J-14	208.33	1970.09	
J-14A	216.33	1970.01	
J-15	224.33	1969.92	
J-15A	232.33	1969.84	
J-16	240.33	1969.75	
J-16A	248.33	1969.67	
J-17	256.33	1969.58	
J-17A	264.33	1969.50	
J-18	272.33	1969.41	
J-18A	280.33	1969.33	
J-19	288.33	1969.24	
J-19A	296.33	1969.16	
J-20	304.33	1969.07	
J-20A	312.33	1968.99	
J-21	320.33	1968.90	
J-22	336.33	1968.73	
J-23	352.33	1968.56	
J-24	368.33	1968.39	
J-25	384.33	1968.22	
J-26	400.33	1968.05	
J-27	416.33	1967.88	
J-28	432.33	1967.71	
J-29	448.33	1967.54	
J-30	464.33	1967.37	
OUTLET	480.33	1967.20	

Dimensions for pipe lengths are based on nominal pipe lengths and do not include creep

COLLAR	DIST. FROM RISER TOE	INVERT ELEV. 36" PIPE	SLOPE
I	28.33	1972.00	SLOPE: 0.010625"/' SLOPE: 0.255"/COLLAR
II	52.33	1971.75	
III	76.33	1971.49	
IV	100.33	1971.24	
V	124.33	1970.98	
VI	148.33	1970.73	
VII	172.33	1970.47	
VIII	196.33	1970.22	
IX	220.33	1969.96	
X	244.33	1969.71	
XI	268.33	1969.45	
XII	292.33	1969.20	
XIII	316.33	1968.94	
XIV	340.33	1968.69	
XV	364.33	1968.43	
XVI	388.33	1968.18	
XVII	412.33	1967.92	



Pipe Suppliers note
(1) cast outside of spigot ring with concrete on one(1) ½ section of pipe
(2) certification to state joint extensibility measured from ℄ gasket to flare of bell, see sheet 17 for joint details

AS BUILT

DAM NO. 78 BRIERY BRANCH
LOWER NORTH RIVER WATERSHED
ROCKINGHAM COUNTY, VIRGINIA
PLAN-PROFILE OF PRINCIPAL SPILLWAY

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed N.W. WILSON L.R.R. Date 2/63
Drawn E.F. GRAGG JR. C.W.F. Hanson 12/63
Traced
Checked B.J.G. 1/63
Approved
Title PLATE 3
Sheet No. 11 of 25
Drawing No. VA-502-P

2

APPENDIX II

PHOTOGRAPHS

CONTENTS

Photo 1: Riser and Reservoir from Top of Dam

Photo 2: Riser Showing Trash Rack

Photo 3: Outlet Pipe and Stilling Basin

Photo 4: Sloughing and Erosion Below Emergency Spillway

Note: Photographs were taken 15 June 1978.

NAME OF DAM: LOWER NORTH RIVER NO. 78

LOWER NORTH RIVER DAM NO. 78

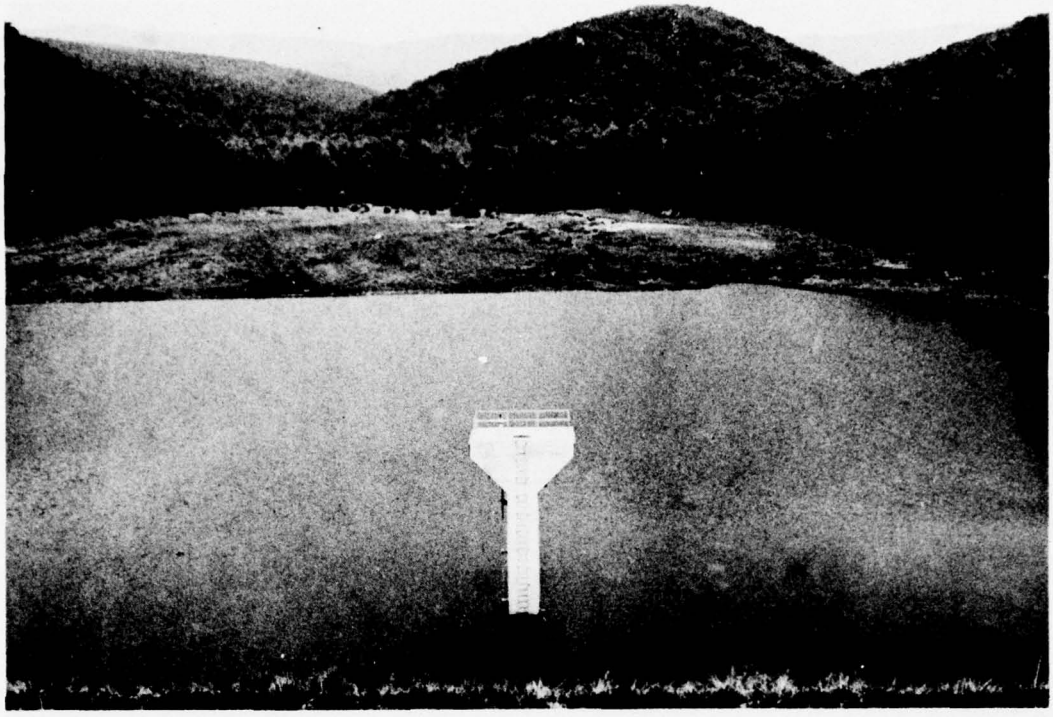


PHOTO 1

Riser and Reservoir From Top of Dam

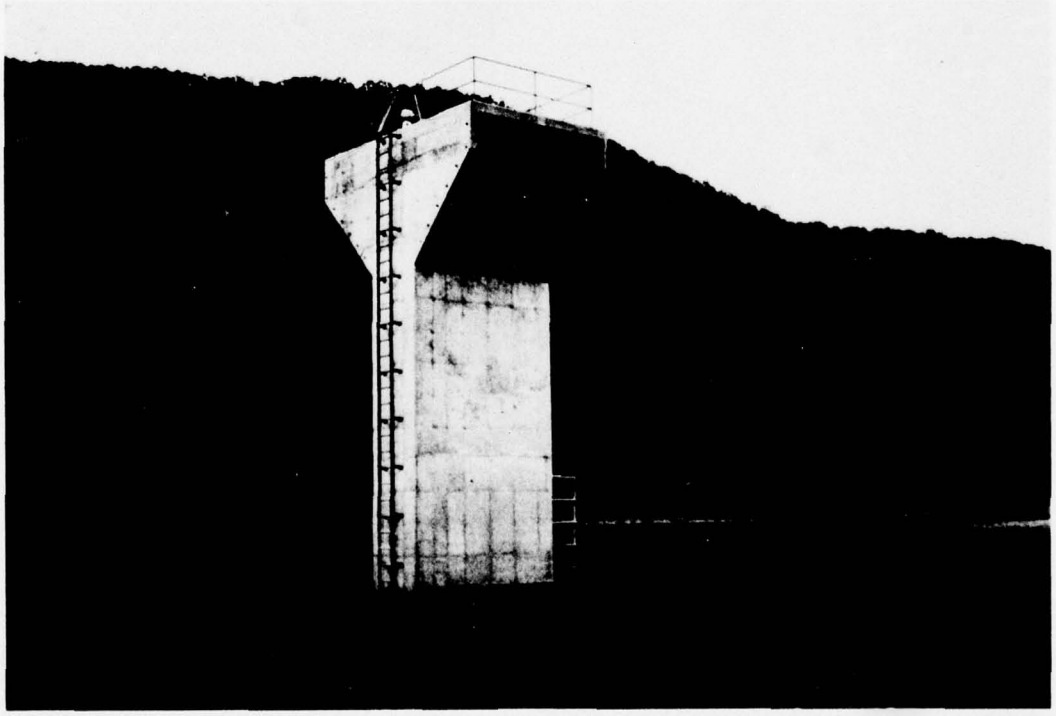


PHOTO 2

Riser Showing Trash Rack



PHOTO 3

Outlet Pipe and Stilling Basin

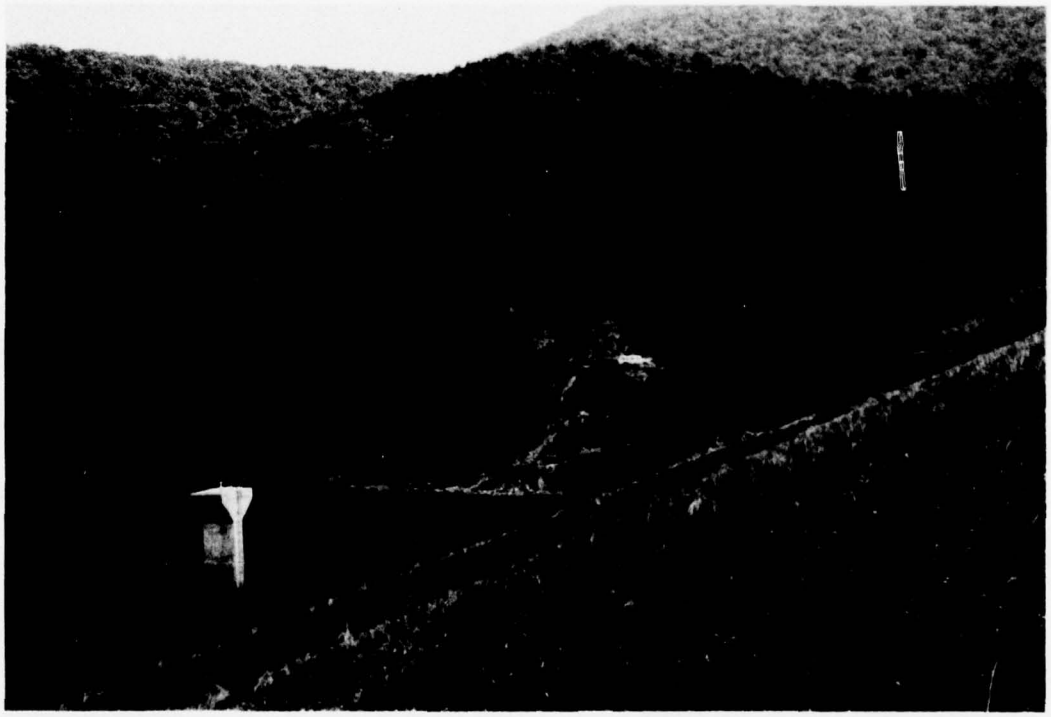


PHOTO 4

Sloughing and Erosion Below Emergency Spillway

APPENDIX III

CHECK LIST - VISUAL INSPECTION

Check List
Visual Inspection
Phase 1

Name Dam Lower North River No. 78 (Briery Branch Dam) County Rockingham State Virginia Coordinates Lat. 3826.9 Long. 7909.6

Date Inspection 15 June 1978 Weather Partly Cloudy Temperature 78°F.

Pool Elevation at Time of Inspection 1989.4' M.S.L. Tailwater at Time of Inspection 1967.3' M.S.L.

III-1

Inspection Personnel:

MICHAEL BAKER, JR., INC.:

Maurice H. Moore
Michele Mill
Thomas W. Smith

Thomas W. Smith Recorder

EMBANKMENT

Lower North River No. 78

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	A surface scarp was observed on the slope above the upstream side of the left abutment. The scarp was approximately two feet long and five inches wide. This scarp appears to be an indication of surface sloughing only. The slope here is steep.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	No unusual movement or cracking at or beyond the toe was observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Footpaths were observed on the upstream slope of the dam near the left abutment and on the slope above the upstream side of the left abutment. No sloughing of the embankment or abutment slopes was observed. A trash line was observed on the upstream face of the dam. The embankment appears to have been constructed with 2.5:1 slopes. Many small trees are growing on both the downstream and upstream faces of the dam.	It is recommended that the footpaths be seeded, the trees be removed, and the debris be removed from the upstream face of the dam.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Crest alignment is good. No bulging or bowing was observed.	
RIPRAP FAILURES	Logs and debris have been deposited on the riprap gutters at the left and right abutments.	Debris should be removed.

EMBANKMENT

Lower North River No. 78

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No erosion or seepage was observed at the junction of the embankment and abutment, spillway and dam.	
ANY NOTICEABLE SEEPAGE	No noticeable seepage was observed.	
STAFF GAGE AND RECORDER	There are none.	
DRAINS	A rock toe and riprapped gutters at the abutments have been provided.	

OUTLET WORKS

Lower North River No. 78

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	No noticeable deterioration of concrete pipe.	Good condition.
INTAKE STRUCTURE	No cracking or abnormal spalling of the drop-inlet type reinforced concrete riser were observed. Several bolts are missing from the high stage trash rack on the emergency spillway side of riser.	Bolts should be replaced.
OUTLET STRUCTURE	The concrete pipe with concrete cradle have no noticeable signs of cracking or spalling. No erosion under the concrete cradle was observed.	
OUTLET CHANNEL	Some minor erosion near top edges of stilling basin from high tailwater depths. Stilling basin generally working correctly. Downstream channel has no restrictive vegetation.	Erosion in stilling basin is minor and should not present problem to outlet works.
EMERGENCY GATE	Only gate on intake is pond drain operated by a hand crank from top of the riser.	Pond drain should be checked for proper operation periodically.

UNGATED SPILLWAY

Lower North River No. 78

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	None, earth side-channel spillway.	
APPROACH CHANNEL	Consists of asphalt road and grasses. No noticeable erosion.	
DISCHARGE CHANNEL	Discharges down the asphalt road and grass covered area. No noticeable erosion.	
BRIDGE AND PIERS	There are none.	

INSTRUMENTATION

Lower North River No. 78

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None were observed.	
OBSERVATION WELLS	No wells were noted.	
WEIRS	There are none.	
PIEZOMETERS	None were observed.	
OTHER		

RESERVOIR

Lower North River No. 78

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Sloughing was observed on the left side of the reservoir near the emergency spillway. Footpaths were also observed at the same location.	This area should be reseeded.
SEDIMENTATION	Only minor sedimentation.	

DOWNSTREAM CHANNEL

Lower North River No. 78

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Downstream channel is clear and in good condition.	
SLOPES	The downstream channel slopes are between one and two percent.	
APPROXIMATE NO. OF HOMES AND POPULATION	In the first two miles downstream of the dam, there are approximately ten to fifteen homes. Further downstream (about 5.3 miles) lies the Town of Briery Branch with another 50 to 60 homes along Briery Branch of Beaver Creek. The population in this area is estimated to be 150 people.	

APPENDIX IV

CHECK LIST - ENGINEERING DATA

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Lower North River No. 78

ITEM	REMARKS
PLAN OF DAM	As-builts which contain plans of the dam are available from the Rockingham County S.C.S.
REGIONAL VICINITY MAP	Vicinity map is contained in the as-builts and in the Location Plan of this report.
CONSTRUCTION HISTORY	Contractor and completion date were obtained from the Corps of Engineers. The dam was designed by the S.C.S. and built by the English Construction Company in 1968.
TYPICAL SECTIONS OF DAM	Typical sections are shown in the as-builts.
HYDROLOGIC/HYDRAULIC DATA	Not available for this inspection report.
OUTLETS - PLAN and DETAILS	are shown in as-builts.
- CONSTRAINTS and DISCHARGE RATINGS	Not available for this inspection report.
RAINFALL/RESERVOIR RECORDS	No rainfall or reservoir records are available at the dam.

Lower North River No. 78

ITEM	REMARKS
DESIGN REPORTS	A design report was not made available for this inspection report.
GEOLOGY REPORTS	A geologic report was made available for this inspection report.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Hydrology and hydraulic calculations were not available for this inspection report. Stability Analyses were available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Boring records and results of field permeability and water pressure tests are presented in the as-built drawings.
POST-CONSTRUCTION SURVEYS OF DAM	No known post-construction surveys were found.
BORROW SOURCES	Borrow areas in the left abutment and reservoir areas are shown in the as-builts.

Lower North River No. 78

ITEM	REMARKS
MONITORING SYSTEMS	No monitoring systems have been provided.
MODIFICATIONS	Data obtained during the inspection agrees very closely with the as-builts indicating that no major modifications were made.
HIGH POOL RECORDS	None are available.
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None are available.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	No prior accidents or failure of the dam have been noted.
MAINTENANCE OPERATION RECORDS	The S.C.S. and the U.S. Forest Service conduct annual inspections with recommendations for maintenance and upgrading of the dam and reservoir areas if needed.

Lower North River No. 78

ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS and DETAILS	Information contained in the as-builts.
OPERATING EQUIPMENT PLANS & DETAILS	Information contained in the as-builts.

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 9.52 square miles (primarily forested)

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1989.0 (73 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 2045.6 (1923 acre-feet) Emergency Spillway Crest

ELEVATION MAXIMUM DESIGN POOL: 2049.9

ELEVATION TOP DAM: 2056.0 (settled)

CREST: Emergency Spillway

a. Elevation 2045.6 feet
b. Type Side-channel earthen
c. Width 200 feet
d. Length 200 feet (approach length)
e. Location Spillover Outside left abutment
f. Number and Type of Gates None

OUTLET WORKS:

a. Type Drop-inlet riser
b. Location Riser in reservoir with three feet reinforced concrete pipe
c. Entrance inverts Normal pool (1989.0 feet)
Principal Spillway (2016.8 feet)
d. Exit inverts 1967.2 feet (3 feet diameter concrete outlet pipe)
e. Emergency draindown facilities Pond drain only (36 inch slide gate)

HYDROMETEOROLOGICAL GAGES: None available

a. Type
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE Unknown

Name of Dam: Lower North River No. 78

APPENDIX V

ANNUAL MAINTENANCE INSPECTION REPORTS

S... OAH VALLEY SOIL AND WATER CONSERVATION DISTRICT

Report of Annual Maintenance Inspection of Watershed Dams in

LOWER NORTH RIVER WATERSHED PROGRAM

April 12, 1978

An inspection was made on 5 dam sites in Lower North River Watershed. Those present on the inspection were:

Gerald Fawley	Chairman District Board
James Moyers	Chairman Watershed Committee
Arlis Frymyer	District Director
John Crist	Soil and Water Conservation Commission
Don Parslow	U.S. Forest Service
Randy Maupin	Soil Conservation Service

The following observaions were made by members of the inspection party.

Site No.	Date Completed	Date of last Inspection	Remarks
22 B	4-67	4-23-77	Additional rail or large stone needed to control traffic in borrow area above spilway where new guard rails were placed. Work reported needed in Borrow Area C has not been completed.
81 C	10-75	-	Site in good condition. Suggest top of dam be fertilized at regular intervals to maintain grass stands.
80	3-67	4-20-77	Repairs needed on path that has been worn to waters edge on wet side of dam.
83	4-65	4-20-77	Vehicle traffic has worn off vegetation in several areas. No repair needed at this time.
78	11-65	4-20-77	Trash rack needs repair. Bolts broken that hold steel bars in place. Vegetation has been worn off by vehicle traffic in several areas but repairs not suggested at this time.

SHENANDOAH VALLEY SOIL AND WATER CONSERVATION DISTRICT
REPORT OF ANNUAL MAINTENANCE INSPECTION OF WATERSHED DAMS IN

LOWER NORTH RIVER WATERSHED PROGRAM

May 28, 1976

On May 28, 1976 E. B. Craun, Shenandoah Valley Soil and Water Conservation District Director; Don Parslow, U. S. Forest Service; and Randy Maupin, District Conservationist Soil Conservation Service, made an annual maintenance inspection of the completed flood control structures in Rockingham County, Virginia.

The following observations were made by the members present on the inspection team:

Dam No. 78 -- Area between highway and lake has a steep bank that is sloughing off of approximately 1,000 square feet. It should be overseeded with a mixture of fescue and serecia lespedeza plus fertilizer.

Dam No. 83 -- Upper borrow area shows evidence of sheet erosion. Suggest that overseeding be done over the approximate 2 acres with a mixture of fescue and serecia lespedeza. Gully on south side of road at second waterbreak up stream from spillways. Forest service will take care of this problem.

Dam No. 80 -- On dry side of dam traffic is apparently stopped and it is felt that it will revegetate naturally. Foot path on wet side of dam near center is still getting traffic and will need further study to determine remedy.

Dam No. 22B -- Borrow area no. C has break in diversion also about ¼ acre bare of vegetation. This area needs attention as soon as possible. On dry side of dam jeep trail is still being used. Gate has not been installed, therefore, need to inquire as to status from city of Harrisonburg.

This report is concurred by:

E. B. Craun

E. B. Craun, Shenandoah Valley Soil and Water Conservation District Director

Randolph J. Maupin

Randolph J. Maupin, District Conservationist, Soil Conservation Service

Don Parslow

Don Parslow, United States Forest Service

DISTR: State Ofc.
Area Office
Rockingham Ofc.
U.S. Forest Service
Shenandoah Valley SWCD
City of Harrisonburg

Site No.	Date Completed	Date of last Inspection	Remarks
22 B	4-67	5-28-76	Vehicle traffic on the dry side of Dam has worn away vegetation. Vehicle traffic into borrow area east of the spillway has created two small gullies approximately 200 feet long. Traffic control and seeding needed. Borrow area C above the lake site has a break in berm and some bare areas above and below. 1/3 acres of revegetation needed.

Mr. Locker agreed that the City of Harrisonburg will assist the District with making the necessary repairs on this site.

This report is concurred by:

Carl B. Lively, Shenandoah Valley Soil and Water Conservation District

Gerald E. Fawley, Shenandoah Valley Soil and Water Conservation District

Harold H. Bush, Shenandoah Valley Soil and Water Conservation District

Don Parslow, United States Forest Service

Randolph J. Maupin, District Conservationist, Soil Conservation Service

Edward Loker, City of Harrisonburg

SHENANDOAH VALLEY SOIL AND WATER CONSERVATION DISTRICT

Report of Annual Maintenance Inspection of Watershed Dams in

LOWER NORTH RIVER WATERSHED PROGRAM

April 20 and 23, 1977

On April 20, 1977 Carl Lively and Gerald Fawley, District Directors, and Randy Maupin, District Conservationist, Soil Conservation Service, made an annual maintenance inspection of Dam Sites #78, Briery Branch, #83, Hone Quarry, and #80, Union Springs. Don Parslow of the U.S. Forest Service was called on a forest fire and was unable to make the inspection tour with the group, but had visited site #78 and #80 recently.

The following observations were made by members of the inspection team:

April 20, 1977

Site No.	Date Completed	Date of last Inspection	Remarks
78	11-65	5-28-76	Area sited as needing seeding in last years report in stabilizing. Vehicle traffic is creating damage to outer slope of spillway. Seeding not needed at this time but control of traffic needed. Few large logs on wet slope of Dam should be removed.
83	4-65	5-28-76	Vehicle traffic on steep slopes in borrow area needs control. Few large logs on wet slope of Dam need removal.
80	3-67	5-28-76	Traffic near the center on the wet side of the Dam is continuing. Vegetation is being worn away. This is not a hazard to the structure at this time.

April 23, 1977

Dam #22 B was inspected by Harold H. Bush, District Director, Ed Locker, City of Harrisonburg, Don Parslow, U.S. Forest Service, and Randy Maupin, District Conservationist, Soil Conservation Service.

APPENDIX VI

GEOLOGIC REPORT

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

10-59

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DETAILED GEOLOGIC INVESTIGATION OF DAM SITES

GENERAL

State Virginia County Rockingham, — ¼, — ¼, Sec —, T — R —, Watershed Lower North River

Subwatershed Briery Branch and class _____ (FP 2, WP 1, etc) Site number 78 Site group I Structure class c

Investigated by T. Mack (signature and title), Geologist Equipment used Sprague & Henwood Drill (Type, size, make, model, etc.) Date Feb.-Apr. 1965

International - LeRoy Backhoe

SITE DATA hand augers

Drainage area size 9.52 sq mi. 6093 acres Type of structure Earth Fill Purpose Flood Prevention

Direction of valley trend (downstream) Southeast Maximum height of fill 87.0 feet. Length of fill 800 feet.

Estimated volume of compacted fill required 441,321 yards

STORAGE ALLOCATION

	Volume (ac ft.)	Surface Area (acres)	Depth at Dam (feet)
Sediment	76	10.0	
Floodwater	1727	55.5	76.5

SURFACE GEOLOGY AND PHYSIOGRAPHY

Physiographic description Ridge & Valley Province Topography Mountainous Attitude of beds Dip 8°E Strike N75°E

Steepness of abutments Left 65 percent, Right 47 percent Width of floodplain at centerline of dam 420 feet

General geology of site Lower North River Site #78 is located in western Rockingham County in the George Washington National Forest. The site is in the folded Appalachian Mountains. It is underlain by the Hampshire formation which is upper Devonian age. In this area the Hampshire formation is a red fine grained massive sandstone interbedded with some siltstone and shale. Some red shale interformational breccia and manganese sandstone is present. The Hampshire formation here occurs as the western limb of a gentle syncline (Butts 1940). The eastern limb of this syncline is truncated by the north mountain thrust fault. The fracture pattern is a network of vertical and approximately horizontal fracture planes. These planes form 90 degree joint sets in the indurated competent sandstone.

Briery Branch flows in a narrow valley between steep valley walls that are of old alluvium or sandstone talus material. This stream flows a strongly entrenched dendritic stream pattern. The low angle of dip the strata has caused this dendritic stream pattern to develop as opposed to the trellis stream pattern, which is more common in the folded

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appalachians. Briery Branch is strongly degrading. This degrading action is now in the process of flushing out the fines in the cobbles and boulders in the stream valley. Former aggradation of the stream is shown by the thick alluvial terraces which are present.

In the valley of Briery Branch the alluvium is red and gray sandstone and green lamprophyre cobbles and gravels (GM) with some silty sand occurring between the +4 material. This type material is also present on the alluvial terraces. The more gentle slopes on the mountains that border Briery Branch are covered with colluvial soil. The steeper slopes are covered by residual soil, talus or rock outcrops.

Methods and Procedures

1. Methods and procedures used in this report are either standard or self-explanatory to the trained geologist. However, a very brief resume' of these is given here.

2. Standard drilling tests were employed such as blow count for penetration resistance, permeability tests and pressure tests. Core recovery was also logged. All fracture planes and joints were recorded. It is to be remembered that in the measuring of back-pressure, the water meter is measuring water flowing in a reverse direction from normal. This may not give a completely accurate measurement. Also this flow of water back through the gage could not be permitted for too long to save the silting of the gage. Pressure tests were made with increasing pressure then with decreasing pressure. This shows whether the fractures are opening or closing.

3. Coarse grain gradations were taken in the coarser material. From some of these coarse grain gradations, samples of material that have a mean diameter smaller than 3 inches were sent to the laboratory. By the correlation chart, the unsampled minus 3-inch material can be correlated to the sampled minus 3-inch material.

4. The borrow materials are grouped into areas and depths that are correlated to samples by use of both the Unified soil texture classification and the U. S. Department of Agriculture soil classification system. Use of the latter of these systems facilitates the outlining of soil areas into a soil map.

5. To determine rock depths in the borrow areas use was made of a two geophone seismograph. This instrument was used in the finer grained (SM to CL) material. To determine rock depths in coarser grained material (GM) a resistiviter was used. This is due to the fact that wet cobbles and boulders that are tight in place have a density that approaches that of shale or even sandstone. As seismic velocity is related to density and induration, a seismic velocity in this GM material will approach that of rock. This will cause confusion as to the location of the interface between GM material and

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rock. As geophysical data is inadmissible in this report, depth obtained by geophysical means is summarized on a geophysical sheet.

Centerline of the Dam

The centerline of the dam is located on a steep talus slope, an alluvial flood plain, a high bench and a low bench. Eleven drill holes (DH 1 through DH 11) and four test pits (TP 12 through TP 15) were used to identify the overburden and rock present.

The rock present under the centerline of the dam is the Hampshire sandstone. This formation here is predominantly red massive fine to very fine grained sandstone. Interbedded in this is some siltstone, a thin layer of brown manganese sandstone and a layer of red shale breccia. The breccia has angular red shale pieces in a red sandstone matrix. This type of breccia has been called an interformational breccia. It is of small extent and does not mark any large break in sedimentation. Interformational breccias and conglomerates are considered to be related to turbidity currents which can have a tectonic origin. (Pettijohn 1957). The attitude of the rock as measured with a compass is approximately N75°E, 8°E. The attitude of the manganese sandstone as determined from drill holes is N66°E, 8°E. The strike of the centerline of the dam is N 34°E. The gentle dip of the rock has caused parallel type of folding to take place. In this type of folding the thickness of the beds remains the same (Billings 1942). This has caused fracture planes to form parallel to the bedding as the beds slip over each other in folding. Slickensides observed in DH 10 show that these horizontal fractures were formed under folding compression. The vertical fracture planes are formed mostly in the gentle plunge of the syncline to the north. However, some vertical fracture planes were possibly caused by disarrangement of the beds in the parallel folding. The vertical fracture planes present on the centerline of the dam are more open than the horizontal planes. From observation of rock outcrops it has been estimated that vertical joint set areas occur approximately every 45 feet in the area on the dam centerline. Out of the eleven holes drilled here, two holes (DH 5 and DH 9) happened to be implaced in these vertical joint set zones. Here passage of water through the rock was relatively high under pressure testing. Attitudes taken on the vertical fracture planes range from N 67° E, 87° W and N 15° W, 84° E to N 73° E, 90° and N 21° W, 87° E. These joint set attitudes were taken on the right abutment on outcrops that occur near the top of the dam. The vertical fractures do not continue in a straight line. They form a hatchured pattern.

The combination of vertical and horizontal fracture planes and joint sets has caused the sandstone to be broken up into cube blocks. The 90 degree angles on these blocks are caused by the high competency of the sandstone. The fact that these blocks are somewhat free to move is shown by the high back pressure that was effected

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in the drill holes in the flood plain. This back pressure is caused by pressure forcing the sandstone blocks against each other. The silt present appears to seal off any passage present. Where silt is not present in the fracture zones in the right abutment (DH 9) the fractures do not seal when the pressure is lowered. The drill holes on the centerline of the dam in the left abutment are generally unfractured. Little water passed through unweathered rock here. Correlation of the rock strata penetrated in the drill holes on the centerline of the dam showed no faults to be present in the flood plain or on the abutments. The apparent dip as measured on the centerline of the dam agreed reasonably with the apparent dip as calculated from the strike and dip. The major source of error involved in these dips is that the strike of the sandstone as measured with a compass is probably incorrect.

A talus slope occurs on the right abutment from station 2+20 on the centerline of dam to the top of the dam. This material is angular gravels cobbles and boulders (GM) of red sandstone that has slipped down the hill from large outcrops above the top of the dam. It ranges in thickness from 0.5 feet thick at station 1+18 on the centerline of the dam to 22 feet in thickness at station 2+20 on the centerline of the dam. Silty red brown sand (SM) is interspersed between the +4 material. This +4 material is estimated to comprise 80% of the talus. The talus slope is overlain by 0.5 feet of silty organic sand (SM) that contains leaves, needles, and roots. A mainly hardwood cover is present on this talus.

Between the talus slope and the flood plain there occurs a small bench which rises 18 feet above the flood plain. Subangular cobbles, gravels and boulders (GM) of red and gray sandstone and green lamprophyre comprise the +4 fraction present here. This coarse material makes up an estimated 70% of the bench. The remainder is red silty sand (SM) interspersed in the larger particles. The depth to rock below this bench is 31.5 feet. A 0.5 foot layer of brown sandy topsoil (SM) overlays this small bench.

The alluvial flood plain extends from station 2+85 on the centerline of the dam to station 7+15 on the centerline of the dam. The highest layer present here is 0.5 feet of brown sandy topsoil (SM). Below this layer is a layer of subangular to subrounded cobbles gravels and boulders (GM). Red and gray sandstone and green lamprophyre make up this layer. This +4 fraction comprises an estimated 60 to 75 percent of the overburden. The -4 fraction present is red brown silty sand (SM). Water levels in the flood plain range from 2.2 to 4.4 feet below the ground surface. Permeability coefficients for this material range from 22.6 to 854 cubic feet/square foot/day. The depth to sandstone bedrock here ranges from 4.0 feet at the toe of the left abutment to 27.5 feet at the toe of the right abutment.

The left abutment is a thick bench deposit. It extends from station 7+15 on the centerline of the dam to the top of the dam.

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The deposit ranges in thickness up to 60.3 feet. It is composed of subangular red and gray sandstone, cobbles, gravels and boulders (GM) with red brown silty sand (SM) filling the interstices. The +4 fraction of this bench ranges from 60 to 70 percent. Permeability coefficients for this material are generally high to moderate. They range up to 1,080 cubic feet/square foot/day. This bench is the product of alluvial deposition from both Briery Brach and a small tributary of Briery Branch. The rock below this deposit is tight. When permeability tests are conducted the water flows from the top of the rock at station 7+20 on the centerline of the dam.

Principal Spillway

The proposed principal spillway crosses the centerline of the dam at station 6+00 on the centerline of the dam and station 9+10 on the centerline of the pipe. Four drill holes (DH 301 through DH 304) and 3 test pits (TP 305 through TP 307) were used to identify the material and conditions present here.

The rock under the centerline of the pipe is predominantly red massive fine-grained sandstone. Interbedded in this red sandstone are layers of interformational breccia, siltstone and claystone, shale and brown manganese sandstone. The permeability of the rock is moderate with the majority of the fractures closing. Correlation of the beds in the drill holes shows that there is no fault present in the rock on the centerline of the pipe.

Subangular to subrounded cobbles, gravels, and boulders (GM) of red and gray sandstone and green lamprophyre form the majority of the alluvial overburden on the centerline of the pipe. Interspersed in this coarse material is brown red silty sand (SM). The +4 fraction comprises an estimated 70 percent of overburden. Permeability in this layer is generally high. It ranges from a K factor of 905 to 40.4 cubic feet/square feet/day.

Foundation

The majority of the foundation rests on the alluvial flood plain through which Briery Branch flows. In addition to the test pits dug on the centerline of the dam and the centerline of the pipe two test pits (TP 401 and TP 501) were dug in flood plain under the foundation. Besides the flood plain the foundation rests on a high bench (left abutment), a low bench and a talus slope (right abutment). All the foundation is on coarse grained material that is composed of at least 75 percent cobbles, gravels, and boulders (GM). A content of 26 percent or less of -4 fraction will allow the +4 fraction particles to touch each other (Dunnigan, 1964). The fact that this condition exists in the foundation gives a high bearing strength to the foundation (Earth Manual, 1960). Permeability values for this material are generally high. On the left abutment the permeability is high in the top 15 feet of the bench. Below this layer the permeability tends to decrease. In the stream valley the permeability of the alluvium is shown by small streams that disappear into the alluvium when they enter the valley from steep mountain slopes.

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Emergency Spillway

The emergency spillway is located on the left side of the stream valley. The centerline of the dam crosses the centerline of the emergency spillway at station 10+17 on the centerline of the dam and 10+15 on the centerline of the emergency spillway. A live stream crosses at generally right angles the centerline of the emergency spillway at station 8+87. A 3.2 foot culvert has been installed below Route 257 to pass this stream under the road. The valley of this stream will separate the emergency spillway cut into two parts.

Shallow Lehew soil occurs on the left side of the emergency spillway from station 10+30 to station 12+30 on the centerline of the emergency spillway. This series has 0.3 feet of topsoil (SM) present. Below this is a layer approximately 1.5 feet thick of red brown silty sand (SM). This is underlain by red fractured fine-grained sandstone. A talus slope (GM) that ranges up to 6.5 feet thick occurs downstream from station 12+30 on the centerline of the emergency spillway. This material is underlain by red massive sandstone. Waynesboro series occurs upstream from station 10+30 on the centerline of the emergency spillway. It also covers the right side of the emergency spillway downstream from this station. It blends into the talus slope at the outlet of the emergency spillway. The Waynesboro alluvium has 0.5 feet of topsoil present. Below this is a layer that ranges from 6.5 to 31.0 feet of cobbly sand and gravel (SM to GM).

Approximately 60,000 cubic yards of rock will have to be removed from the emergency spillway cut. This rock is predominantly red, massive, fine grained sandstone with some siltstone, claystone, and shale present. It ranges from fractured rock to very slightly fractured massive rock. Near the top of rock the fracture planes have been opened and enlarged by weathering.

Borrow Area

Six borrow areas were investigated. These have been ~~investigated~~ designated as Borrow Areas A through F. To classify soil material in these areas 70 test pits (TP 101 through 170) and 10 auger holes (A 177 and A 179 through A 189) were dug. Also the road cuts on State Route 257 were logged 7 times (RB 170 through 176 and RB 178).

Seven soil types were observed in the borrow areas. A brief description and the pedology of each of these types is given below.

Recent alluvium -- Cobbles, gravels and boulders of sandstone with brown red silty sand that has been deposited very recently in the modern stream valleys. This material covers the valleys of Briery Branch and Mines Run.

Waynesboro series -- Old alluvium of cobbles, gravels and boulders with brown red to red silty sand that has been deposited on high benches (50 to 100 feet) above the modern stream valley.

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This bench material resembles closely the modern alluvium present here. It was deposited under similar sedimentary conditions. Despite its age, it shows little effects of alteration.

Sequatchie series -- Moderately old alluvium that has a layer of red silty sand overlying red cobbly silt. It is intermediate in elevation between recent alluvium and the Waynesboro series. It is the product of slower sedimentation than either of these first two materials.

Hayter series -- Young, generally thick red colluvial soil that has slipped off of steep slopes rather rapidly. It contains up to 30 percent angular red sandstone cobbles. It is sandy to clayey. It collects at toe of slopes on alluvial benches.

Caylor series -- Moderately old brown and red colluvial soil. Its upper brown layer shows that it has undergone gray-brown podzolic weathering after it has been colluvially emplaced. It is silty in the overlying brown layer but sandy in the lower red layer.

Allen series -- Old red deep clayey and sandy colluvial soil. It almost always forms in colluvial fans. It has been subjected to red podzolic weathering that has developed a clay (CL) material from the silt (ML) material of the younger colluvial soils.

Lehew series -- Shallow red sandy residual soil that is the product of weathering over red sandstone.

Borrow Area A occurs in the permanent pool area. Recent alluvium is the only soil type present here. This soil has 0.6 feet of red brown sandy top soil (SM) present above a thick layer of subangular to subrounded cobbles, gravels and boulders (GM) of red and gray sandstone. Silty sand (SM) is present in the interstices between this coarse material. The +4 fraction ranges from an estimated 65 to 85 percent. TP 101 through TP 107 were used to investigate this borrow area.

Borrow Area B is located 2,500 feet upstream from the centerline of the dam. It covers a moderately high bench on the left side of Briery Branch. Waynesboro series is the predominating soil present here. This soil has 0.5 feet of brown sandy topsoil present. Below this layer is a layer of red sand, cobbles, silt and gravels (GM) that ranges from 6.0 to greater than 8.0 feet in thickness. TP 108 through TP 113 were used to investigate this area.

Borrow Area C is located 4,800 feet upstream from the centerline of dam on the right side of Briery Branch. A colluvial-alluvial bench occurs here. Hayter, Waynesboro, Sequatchie, and Lehew soils are present in this area. The Hayter series has 0.4 feet of silty brown topsoil (ML) present. Below this is a layer of red cobbly sandy clay (ML or CL). At the toe of the hill where the Hayter is

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not associated with the Waynesboro series this layer is at least 9.5 feet thick. Angular platy red sandstone cobbles make up from 16 to 30 percent of this colluvium. The Sequatchie series has 0.4 feet of brown silty topsoil (ML) present. Below this layer is 3.0 to 4.0 feet of red fine sandy silt (ML). This layer is underlain by at least 4.0 feet of sandy red cobbles. The Waynesboro series underlies the Hayter series on the stream side of the colluvial-alluvial bench present here. This material is cobbly silt sand (SM). It is at least 5.0 feet in thickness. TP 114 through TP 123 were used to identify the material in Borrow Area C.

Borrow Area D is located approximately one mile upstream on Briery Branch from the centerline of the dam. It occurs on a bench that extends upstream from the bench in Borrow Area C. Hayter and Waynesboro soils occur on this bench. The Hayter series and the Hayter over Waynesboro soils are similar to these respective materials in Borrow Area C. The Waynesboro series in Borrow Area D is similar to the Waynesboro series described in Borrow Area B. TP 130 through TP 137 and A 179 and A 180 were used to identify the soils in Borrow Area D.

Borrow Area E is the largest of the borrow areas investigated. It occurs on a slope to the northeast of State Route 257. This is on the left abutment of Briery Branch stream valley extending from 300 feet to 2,100 feet upstream from the centerline of the dam. Allen, Caylor, Lehew, and Waynesboro soils occur here. The Allen series soils occur in an alluvial fan that spreads off of the mountain on the left abutment (Hone Quarry Mountain). The series has 0.5 feet of silty topsoil (ML) present. Below this is approximately 2.5 feet of brown sandy silt (ML). This is underlain by a layer of red to yellow sandy clay to clayey sand (CL to SC). This sandy clayey layer is at least 23 feet thick. The Caylor series occurs on the uphill side of the alluvial fan off Hone Quarry Mountain. It also overlays the Allen series. This overlay could be due to both movement of soil downhill by gravity and to gray-brown podzolic alteration of the red podzolic Allen series. This series has 0.5 feet of silty topsoil (ML) present. Below this is a layer of brown sandy silt (ML) that ranges in thickness from 2.0 to 4.0 feet. This material is underlain by a layer of red fine sand and silt (ML to SM) that ranges in thickness from 3.0 - 5.4 feet. The residual Lehew series occurs on the ridges above the alluvial fan. It also is on the ridges that encompass this fan both upstream and downstream. The Lehew series has a layer of red silty cobbly sand that ranges in thickness from 2.0 to 4.5 feet. This layer is underlain by red massive sandstone. The Waynesboro series occurs on the stream edge of the alluvial fan. It has 0.5 feet of topsoil present. Below this is at least 30 feet of sand, cobbles and gravels. To investigate this borrow area 30 test pits (TP 139 through 169), and one auger hole (A 177) were dug. The road banks on Route 257 were logged 7 times (RB 170 through RB 176 and RB 178).

Borrow Area F is located on the left abutment of Mines Run. This borrow area is 3,700 feet up the stream valley from the centerline of the dam. Waynesboro, Caylor, and Lehew soils occur in this area. These soils are generally similar to the respective soil series described in Borrow Area E. The major part of the fine grained usable borrow material is in Caylor series soil. Waynesboro soil occurs upstream from the alluvial - colluvial bench on which this borrow area is located. Lehew series occurs uphill on the residual area from the colluvial material. To investigate this borrow area 8 auger holes (# 181 through [illegible] and 184 through 189) were dug. A backhoe or dozer could not climb up on this bench due to sandstone ledges that f[illegible]eam edge of the alluvial - colluvial bench.

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DETAILED GEOLOGIC INVESTIGATION OF DAM SITES

State Virginia County Rockingham Watershed Lower North River Subwatershed Briery Branch

Site no. 78 Site group I Structure class C Investigated by D. Mack (signature and title) Geologist Date Feb.-Apr. 1965

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INTERPRETATIONS AND CONCLUSIONS

1. A cutoff should be installed and taken to rock. This will entail removal of 60 feet of cobbly overburden from the left abutment.

2. The cobbles, gravels, and boulders in the flood plain and on the abutments are considered to have more than enough shearing strength to bear the weight of the dam.

3. The pipe will rest on cobbles, gravels, and boulders. This material is considered sufficiently strong not to consolidate and cause breaking of the pipe. Where the pipe crosses the cut-off differential consolidation between the foundation and the cutoff may cause settling of the cradle over the cutoff.

4. Some water may pass through the rock under the dam. This is expected to be generally smaller than the pressure tests indicate due to the irregular joint pattern present in the rock. The silt in the 90° fracture pattern in the flood plain causes most of the joints to be closing. Where no silt is present on the right abutment (DH 9) the joints are opening.

5. Approximately 60,000 cubic yards of rock will have to be removed from the emergency spillway cut. This rock occurs downstream from the small creek that crosses the emergency spillway. No rock is expected to occur upstream from this small creek. From examination of core and pressure test records the rippability of the rock was estimated. The rippable zones in the drill holes are: DH 201, none; DH 202, 2.3-6.6; DH 203, none; DH 204, 7.0-15.0 (rippable to marginal rippable); DH 205, 5.0-12.9; DH 206, 6.0-10.0; DH 207, 7.0-11.6.

6. The Class C material that is expected to be placed in the slopes occurs in the permanent pool area and the emergency spillway cut. The material that will be removed from the cutoff is also Class C material. Additional Class C material can be obtained by extending the permanent pool area or by using Waynesboro series material from Borrow Area B or E. First choice for core material is placed on the colluvial Allen and Caylor series in Borrow Area E. Second choice is the colluvial Hayter series in Borrow Area C. Colluvial soils in Borrow Areas D and F were investigated only as reserve core material. Sufficient Class C and Class B-2 borrow material is considered available to build the dam.

Topsoil present should be stockpiled and used for topdressing.

8. If a rock toe is to be installed, the sandstone present in the emergency spillway cut could be used for this purpose.

Co Hamilton Co Rockbridge Co

APPENDIX VII

STABILITY ANALYSES

FORM SCS-357
12-68

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

N.A.V. SECTION

SOIL MECHANICS LABORATORY

SUMMARY - SLOPE STABILITY ANALYSIS

State VIRGINIA Project LOWER NORTH RIVER #73

Date 6-12-65 Analysis Made By G.N.G. Checked By

Method of Analysis SWEDISH CIRICLE

Location of Material			EMB 130 pcf GM		EMB 122.7 pcf GM		EMB 95% Std. SM			
Sample No.			65F949		65F949		65F952			
γ_d			130.0		122.7		108.2			
γ_m			139.0		134.0		120.0			
γ_s			143.0		139.0		128.0			
γ_D			80.5		76.5		65.5			
Condition	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.
ϕ				39.5°		36.0°		29.5°		
Tan ϕ				0.824		0.727		0.566		
K										
C				600		425		350		

UPSTREAM SLOPE			
Trial	Slope	Conditions	Fs
1	2½:1	Fulldrawdown-100'berm@elev.1990. Arc cut in same slope thru EMB of (39.5°-600) only.	1.91
1A	2½:1	Same as #1 but EMB = (36°-425) only.	1.55
2	2½:1	Fulldrawdown-10'berm@elev.1990. Arc cut from opp. shoulder thru *Zoned EMB only.	1.36
3	2½:1	Fulldraw down-10'berm@elev.1990. Arc cut from opp shoulder thru *Zoned EMB only.	1.54
4	2½:1	Fulldraw down-10'berm @ elev.1990. Arc cut from opp. shoulder thru *Zoned EMB only.	1.31
5	2½:1	Fulldraw down-10'berm @ elev. 1990. Arc cut from opp. shoulder thru *Zoned EMB only.	1.44

DOWNSTREAM SLOPE			
Trial	Slope	Conditions	Fs
6	2½:1	Drain @ toe of Core - No berm - Arc cut from opp. shoulder thru *Zoned EMB only.	1.97
7	2½:1	Drain @ toe of Core - No berm. Arc cut from opp. shoulder thru *Zoned EMB only.	2.0

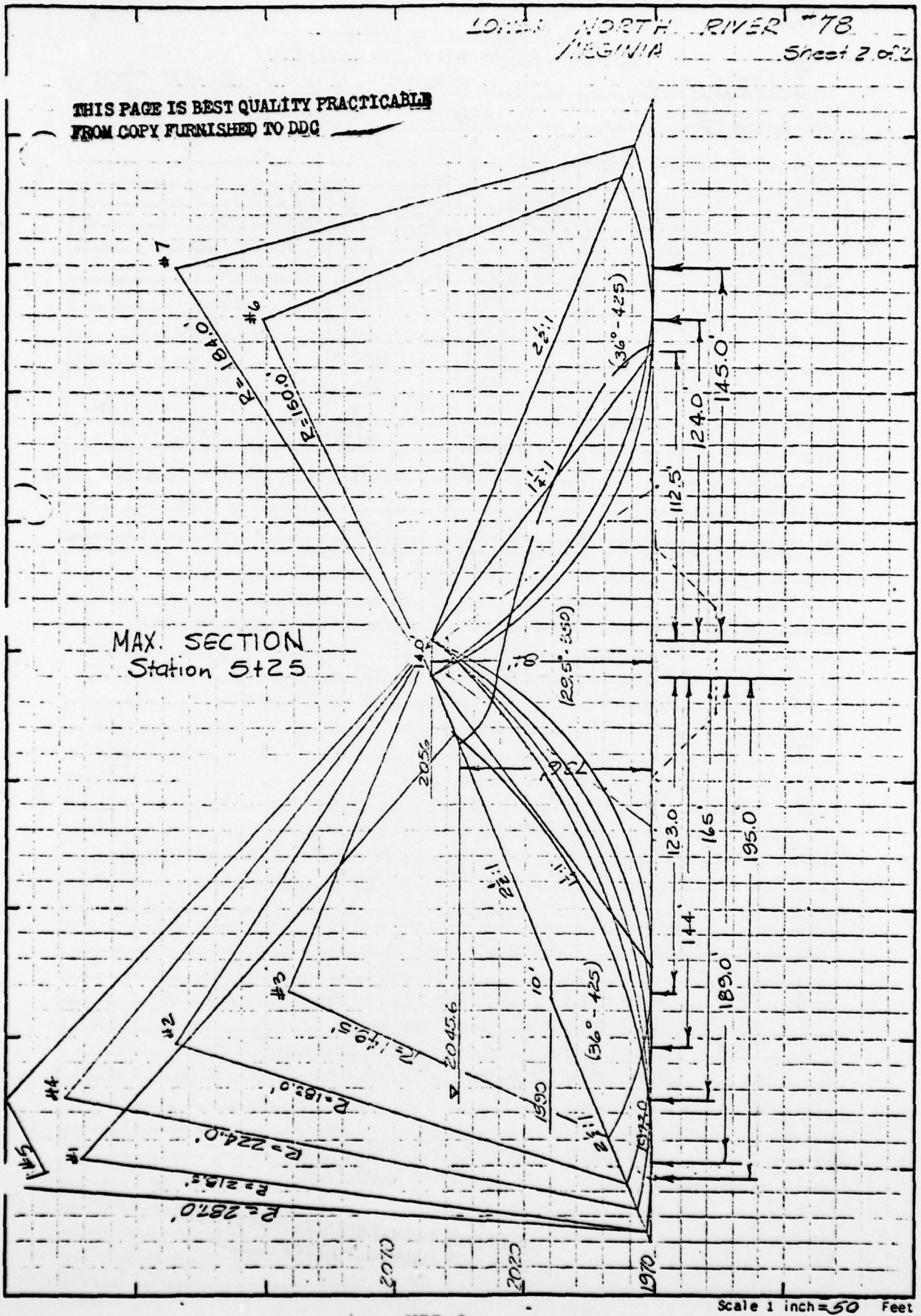
* EMB Zoning = (Core) = (29.5°-350)
(Shell) = (36.0°-425)

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COMPUTATION SHEET
SCS 523 REV 5 58

U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE VIRGINIA PROJECT LOWER NORTH RIVER SITE 78

BY RAG DATE 9/65 CHECKED BY DATE JOB NO VA - 502 - E

SUBJECT SLOPE STABILITY ANALYSIS SHEET 31 OF 42

Phreatic lines as they might exist were developed at the emergency spillway crest and the normal pool. The method used to determine these was suggested by Mr. Rossier based on papers by C. Newlin and A. Casagrande. This method depends largely on the relative permeabilities between adjacent fill sections. Since these perm rates are highly questionable, the phreatic surfaces developed may not be realistic, but the assumption that most of the head is lost in section I is probably true.

For determining the stability of the upstream slope, the phreatic line developed by the above method is used, but for the downstream section a much more conservative estimation of the phreatic line is used. Here it is assumed that the head decreases uniformly from the crest at the upstream slope to the near point of the rock toe.

The stability of the slopes is based on a dissertation by S.C. Rossier, " STABILITY OF EARTH EMBANKMENTS SUBJECTED TO VARYING IMPOUNDMENT LEVELS ". The upstream slope is considered subjected to drawdown from the ems. crest to the normal pool. The pore pressure is still developed from the high stage and the fill is saturated to the high stage, but the resisting force of the water behind the structure is not present.

The downstream condition that Rossier suggests analizing is when a sudden 100-year storm comes and raises the pore water pressure without actually raising the line of saturation. The pore water pressure in the downstream shell would probably not rise to any great extent, but the conservative line mentioned above was used.

Rossier recommends that shear parameters be consistent in any one structure. That is, either use all effective or all total parameters. In this case, total parameters were used on section I and no change was found in converting section 2 parametors to total from effective.

There is no information on the foundation shear parameters but the shearing resistance will be high. Therefore no analysis is made on the foundation. Also, a sliding wedge failure is not expected for the same reason.

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SECTION 1
CONTINUITY CHECK:
WATER SURFACE AT EMS CREST

$Q = K \frac{H_L}{L_{avg}} A_{avg}$

$Q = (.003)\frac{(60)}{(83)}(59)$

$Q = 1.28 FT^3/day$

$H_L = 60' \pm$

$L_{avg} = 83' \pm$

$A_{avg} = 59 FT^2 \pm$

$1.28 \approx 1.31$ ok!

SECTION 2
CONTINUITY CHECK:

$H_L = 14' \pm$

$L_{avg} = 160' \pm$

$A_{avg} = 3 FT^2 \pm$

$Q = (5.0)\frac{(4)}{(160)}(3)$

$Q = 1.31 FT^3/day$

SECTION 1
CONTINUITY CHECK:
WATER SURFACE AT NORMAL POOL

$H_L = 16' \pm$

$L_{avg} = 100' \pm$

$A_{avg} = 10 FT^2 \pm$

$Q = (0.03)\frac{(16)}{(100)}(40)$

$Q = 0.05 FT^3/day$

SECTION 2
CONTINUITY CHECK:

$H_L = 4' \pm$

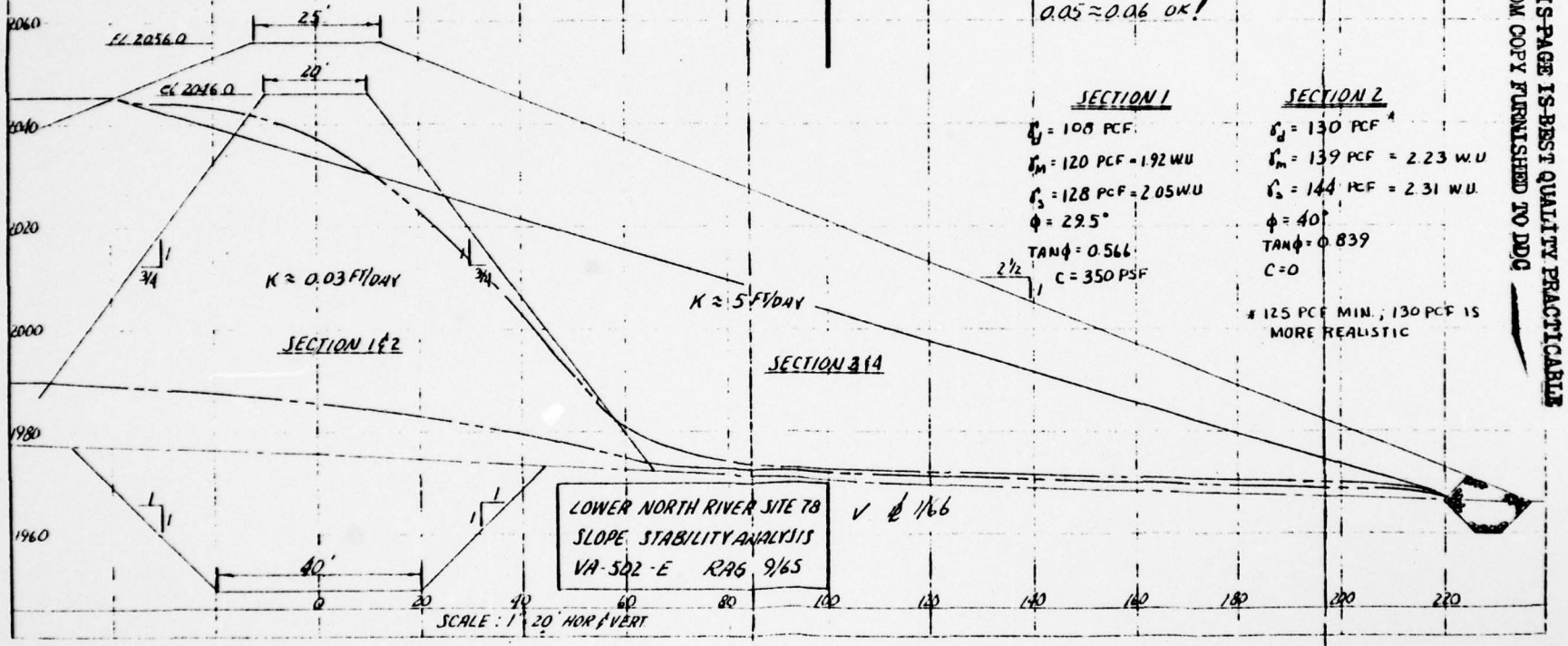
$L_{avg} = 160' \pm$

$A_{avg} = 0.5 FT^2$

$Q = (5.0)\frac{(4)}{(160)}(0.5)$

$Q = 0.06 FT^3/day$

$0.05 \approx 0.06$ ok!



SECTION 1

γ_d = 108 PCF

γ_m = 120 PCF = 1.92 W.U

γ_s = 128 PCF = 2.05 W.U

ϕ = 29.5°

TAN ϕ = 0.566

C = 350 PSF

SECTION 2

γ_d = 130 PCF *

γ_m = 139 PCF = 2.23 W.U

γ_s = 144 PCF = 2.31 W.U.

ϕ = 40°

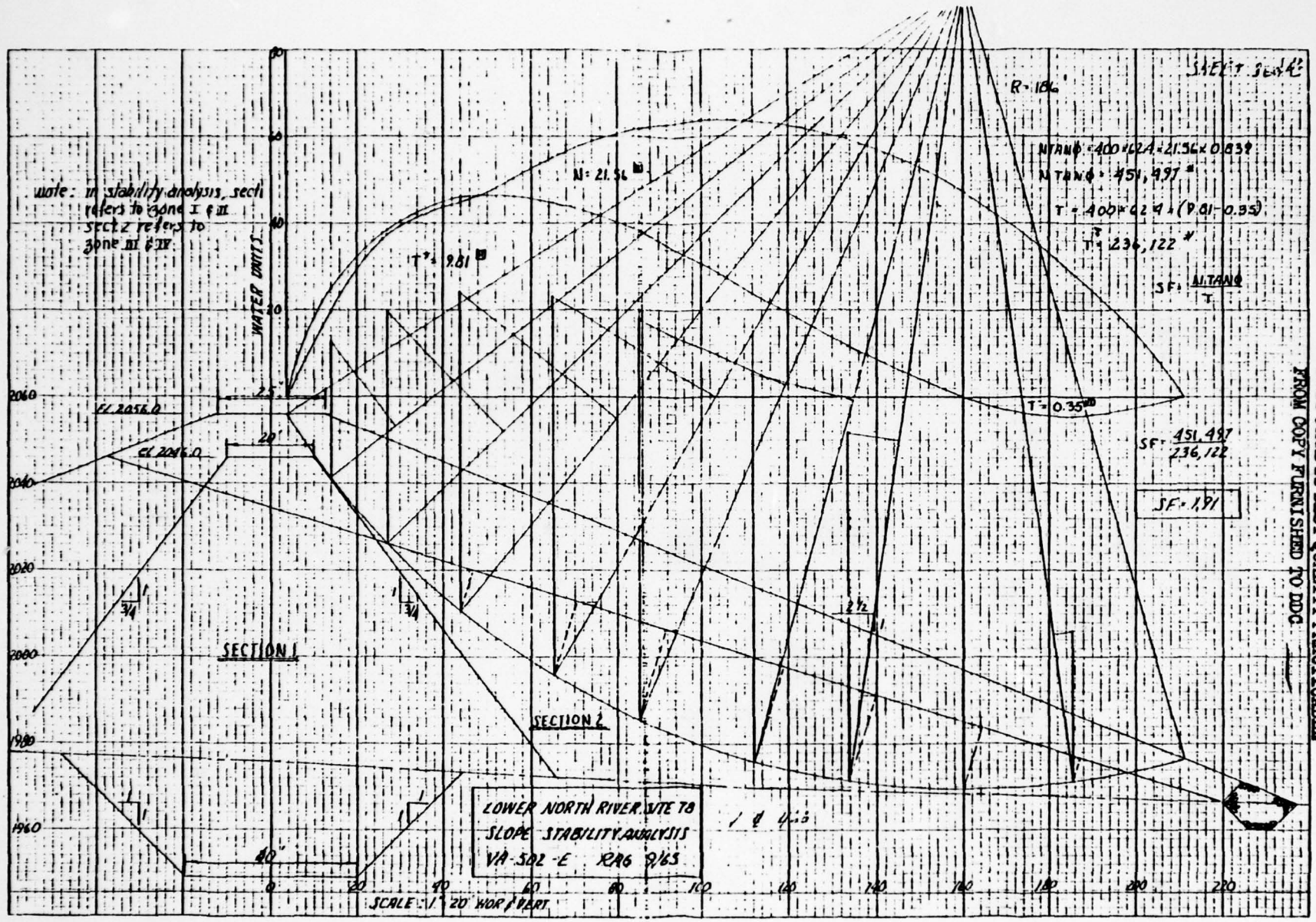
TAN ϕ = 0.839

C = 0

* 125 PCF MIN.; 130 PCF IS MORE REALISTIC

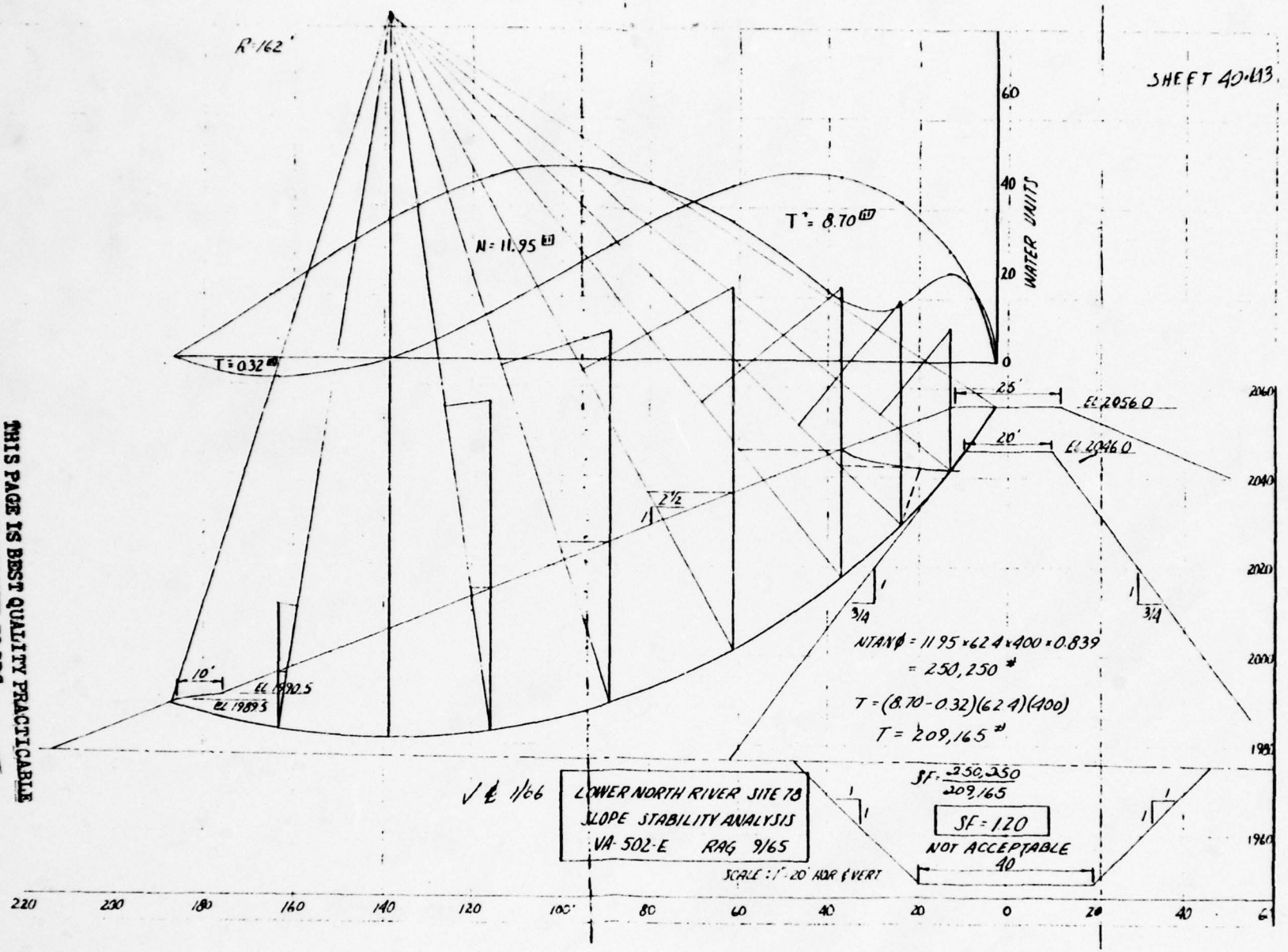
LOWER NORTH RIVER SITE 78
SLOPE STABILITY ANALYSIS
VA-502-E RAG 9/65

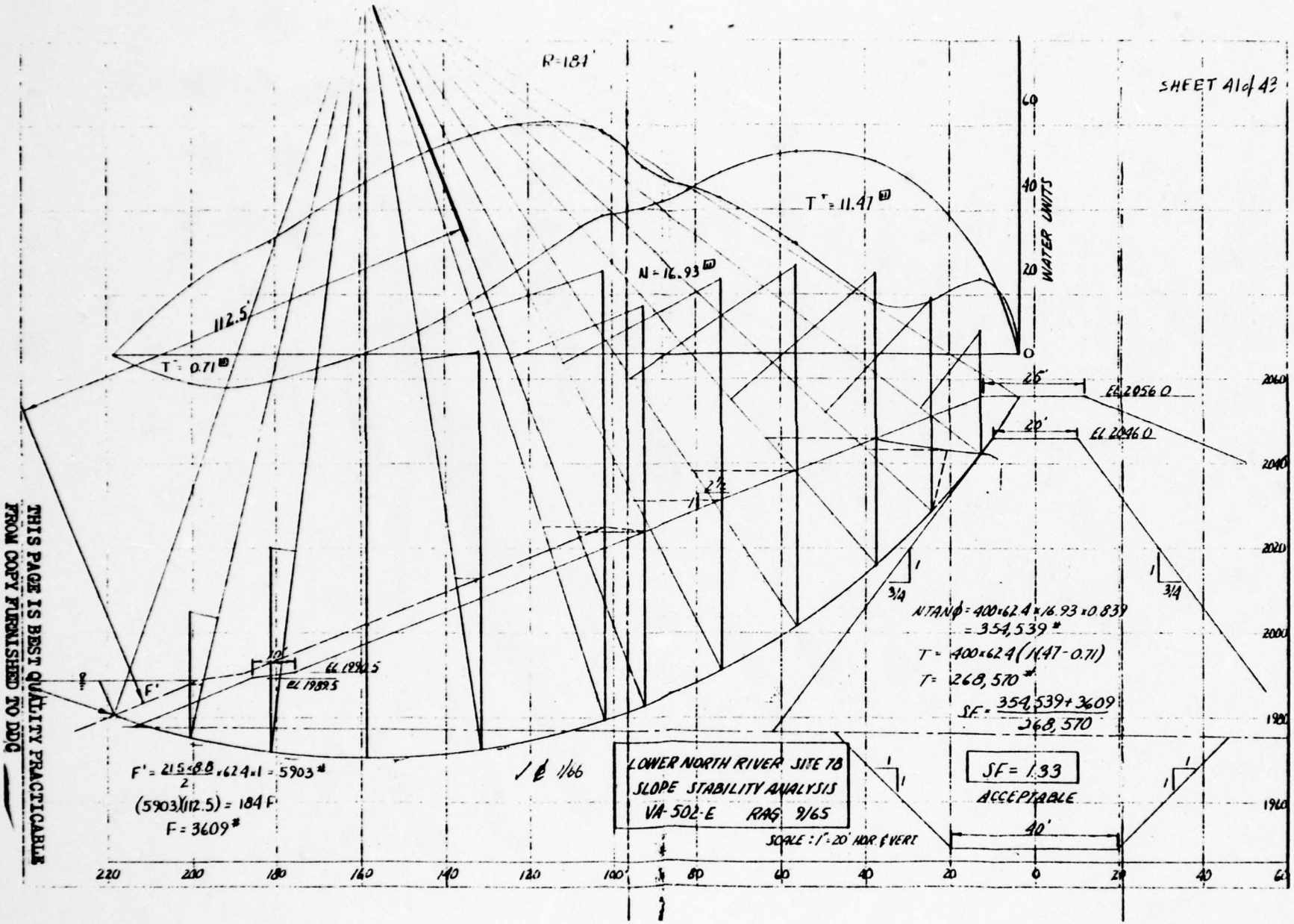
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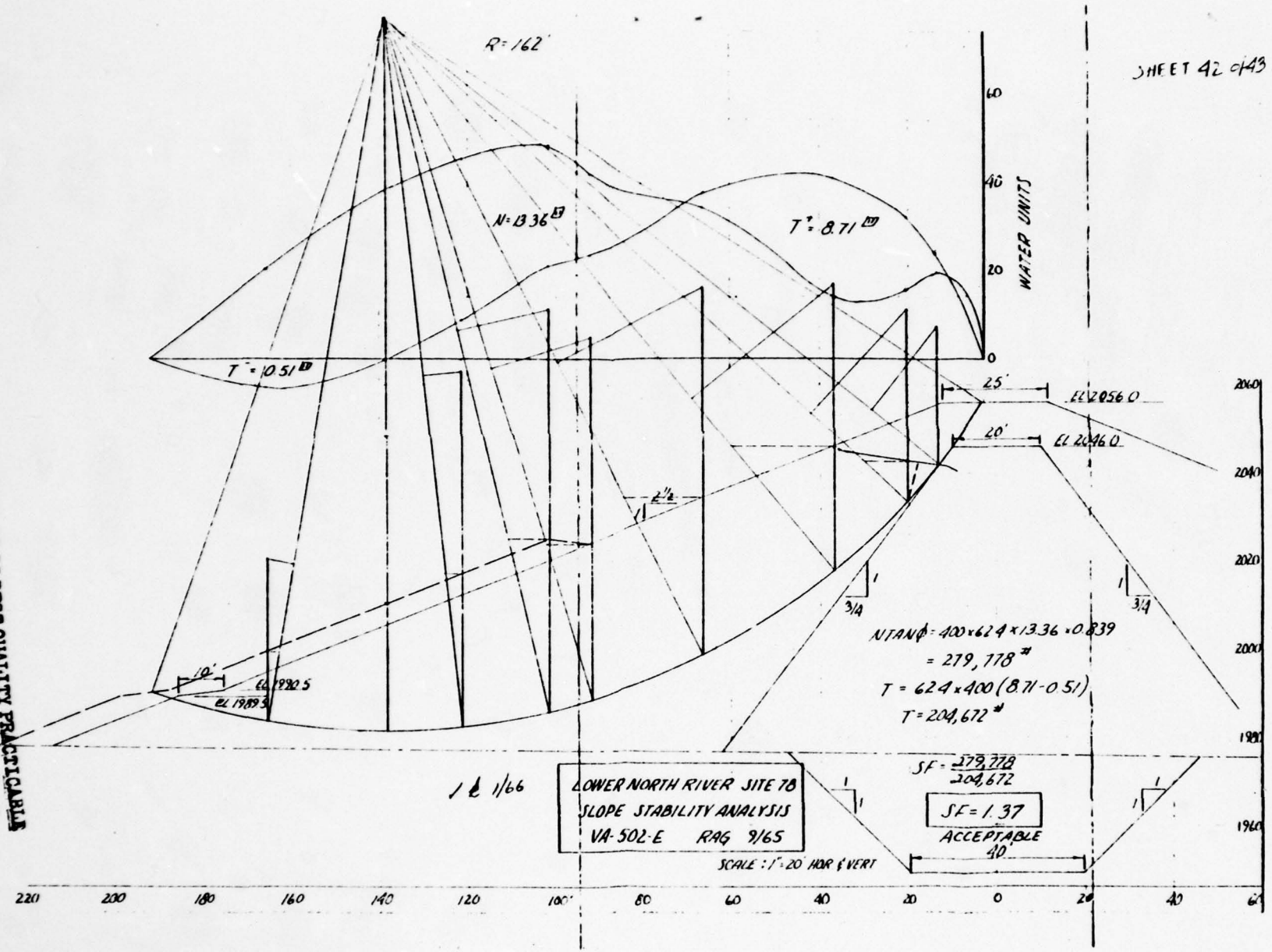
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J & 1/66

LOWER NORTH RIVER SITE 7B
SLOPE STABILITY ANALYSIS
VA-502-E RAG 9/65

SCALE: 1" = 20' HOR & VERT

APPENDIX VIII

ANALYSIS OF PIPING AND CRACKING POTENTIAL

COMPUTATION SHEET
SCS 522 REV 5 58

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE VIRGINIA PROJECT LOWER NORTH RIVER SITE 78
BY DATE CHECKED BY DATE JOB NO VA-502-E
SUBJECT PIPING & CRACKING SHEET 26 OF 43

SAMPLE	DEPTH	U.S.C.S	D_{50} mm	P.I.	L.L.	% 005 mm	PIPING *	CRACKING *	REMARKS
211.1	1-9	GM	5.0	2	18	9	2	4	most likely by piping
213.1	1-9.6	GC-GM	8.0	5	22	9	2	4	most likely by piping
102.1	1-8.2	GP-GM	12.0	N.P.	N.P.	3	2	4	most likely by piping
106.1	1-8	GM	0.7	N.P.	N.P.	7	2	4	"
115.1	1-8	SM	0.23	3	20	18	2	4	"
117.1	1-9.5	SM or GM	4.7	2	20	15	2	4	most likely by piping
143.1	3.1-10.2	SM	0.12	N.P.		15	1	2	high by either
148.1	1-5.5	SM	0.08	2	19	23	1	2	high by either
153.1	2.1-5	SM	0.14	N.P.	N.P.	15	1	2	"
161.1	2-6.7	SM	0.14	1	17	18	1	2	"

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* DEGREE OF SUSCEPTIBILITY (1 GREATEST TO 6 LEAST) TAKEN FROM "FLEXIBILITY OF CLAY AND CRACKING OF EARTH DAMS" BY LEONARDS & NARAIN, ASCE PROCEEDINGS VOL. 89, SM 2, MARCH 1963, PP 50 & 51

Samples 211.I, 213.I, 102.I, 106.I, 117.I, and 115.1 fall in group II and have low to intermediate resistance to piping and intermediate susceptibility to cracking.

Samples 143.I, 148.I, 153.I, and 161.I are in group III and are most likely to fail by either piping or cracking. Material represented by these samples should not be placed in the cutoff or in the upper portion of the core directly over the beginning of the abutments.

All materials should be placed at or above optimum moisture to aid in the effort to restrict cracking. Core and cutoff material should be placed at 100% standard proctor and the shell material should be at a minimum mass density of 125 $\#/ft^3$.

COMPUTATION SHEET
SCS-522 REV 5-58

U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE _____ PROJECT _____

BY _____ DATE _____ CHECKED BY _____ DATE _____ JOB NO _____

SUBJECT _____

SHEET _____ OF _____

Since Cutoff and Core material is susceptible to Piping, Check the gradation of the material with criteria as follows - Criteria from Navdocks DM-7 Dec 1-5 1.3:

A.1) If $C_u > 1.5$ then $\frac{D_{15}\text{ f}}{D_{85}\text{ c}} < 5$ ← Applies to this site

2) If $C_u < 1.5$ then $\frac{D_{15}\text{ f}}{D_{85}\text{ c}} \leq 6$

B.1) If $C_u < 1.5$ then $\frac{D_{15}\text{ f}}{D_{85}\text{ c}} < 25$ ← Do not apply to this site

C.1) If $C_u < 4$ then $\frac{D_{15}\text{ f}}{D_{15}\text{ c}} < 20$.

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2) If $C_u > 4$ then $\frac{D_{15}\text{ f}}{D_{15}\text{ c}} \leq 40$ ← Applies to this site

CUTOFF & CORE MATERIAL					SHELL & ALLUVIUM				
SAMPLE	$C_u = \frac{D_{60}}{D_{10}}$	D_{15} (mm)	D_{85} (mm)	D_{50} (mm)	SAMPLE	$C_u = \frac{D_{60}}{D_{10}}$	D_{15} (mm)	D_{85} (mm)	D_{50} (mm)
115.1	>4	0.04	14.32	0.16	211.1	>4	0.033	40.0	
117.1	>4	0.05	25.4	0.42	210.1	>4	0.044	42.0	
140.1	>4	0.05	8.94	0.13	102.1	>4	0.225	5.7	
153.1	>4	0.03	5.88	0.15	106.1	>4	0.074	11.5	
					12.1	>4	0.103	7.0	
					13.1	>4	0.037	27.0	
					304.1	>4	0.08	6.0	
					301.1	>4	0.08	4.0	
					5.1	>4	0.05	3.0	

Case C2) is satisfied in every case except that sample 102.1 material should not be used in contact with cutoff & core material

$$\frac{D_{15}\ (102.1)}{D_{15}\ (117.1 \text{ thru } 153.1)} = \frac{.225}{0.0033} = 67.40 \therefore \text{Not Acceptable}$$

Case A1) is satisfied in every case.

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COMPUTATION SHEET
SCS-522 REV 5-58

U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE Ia PROJECT Lower North Fork [illegible]

BY CCR DATE 2/60 CHECKED BY [illegible] DATE 2/60 JOB NO [illegible]

SUBJECT Stability Against Piping [illegible] SHEET 31 OF [illegible]

Cutoff & Core Material *				Shell *				Foundation *			
Sample	Cu	D_{15}	D_{85}	Sample	Cu	D_{15}	D_{85}	Sample	Cu	D_{15}	D_{85}
115.1	>4	.006	85	211.1	>4	.42	280	306.1	>4	7.00	280
117.1	>4	.022	95	213.1	>4	.45	200	307.1	>4	.45	350
143.1	>4	.005	3.24	102.1	>4	3.66	323	12.1	>4	.20	195
153.1	>4	.005	5.44	106.1	>4	.27	300	13.1	>4	.05	200
								14.1	>4	.02	95
								15.1	>4	.07	191
								501	>4	17.0	343

* Field Gradation

Case A (1) All materials in contact at any interface are satisfactory.

Case C (3)

Material 115.1 may be placed against the shell material except 102.1 and all Foundation material except 306.1 & 501

Materials 115.1, 143.1 & 153.1 should not be placed in contact with any shell materials and foundation materials 306.1, 307.1 and 501.

Summary:

Require a 5' min width Transition zone below elev. 1030 using material represented by sample 117.1.

Permit only Emergency spillway materials represented by 211.1 and 213.1 and Alluvium represented by 106.1 to contact This Transition.

Where the cutoff Trench is excavated in Terrace Alluvium represented by 306.1, 307.1 and 501, place 2.5' Layer of material represented by samples 211.1, 213.1 & 106.1 between Zone II and the foundation.