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BAKER (MICHAEL) JR INC BEAVER PA  
NATIONAL DAM SAFETY PROGRAM. UPPER NORTH RIVER DAM, NUMBER 77 (--ETC(U)  
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DACW65-78-D-0016

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POTOMAC RIVER BASIN

**Name Of Dam:** UPPER NORTH RIVER, NO. 77 (HEARTHSTONE LAKE)

**Location:** AUGUSTA COUNTY, STATE OF VIRGINIA

**Inventory Number:** VA 1507

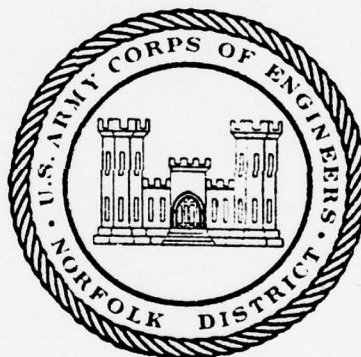
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# PHASE I INSPECTION REPORT

## NATIONAL DAM SAFETY PROGRAM

AD A063636

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**PREPARED FOR**

**NORFOLK DISTRICT CORPS OF ENGINEERS**

**803 FRONT STREET**

**NORFOLK, VIRGINIA 23510**

**AUGUST 1978**

**BY**

**MICHAEL BAKER, JR., INC.**

**BEAVER, PENNSYLVANIA 15009**

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## 20. Abstract

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

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

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



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# PHASE I INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

## CONTENTS

	<u>Page</u>
Brief Assessment of Dam . . . . .	1
Overall View of Dam . . . . .	3
Section 1: Project Information . . . . .	5
Section 2: Engineering Data . . . . .	9
Section 3: Visual Inspection . . . . .	11
Section 4: Operational Procedures . . . . .	13
Section 5: Hydraulic/Hydrologic Data . . . . .	15
Section 6: Dam Stability . . . . .	19
Section 7: Assessment/Remedial Measures . . . . .	21

## Appendices

- I. Plates
- II. Photographs
- III. Check List - Visual Inspection
- IV. Check List - Engineering Data
- V. Geologic Report
- VI. Stability Analyses
- VII. Annual Maintenance Inspection Report

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NAME OF DAM: UPPER NORTH RIVER NO. 77

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Upper North River No. 77  
State: Virginia  
County: Augusta  
River: Little River  
Date of Inspection: 13 June 1978

BRIEF ASSESSMENT OF DAM

Upper North River Dam No. 77 is an earth dam approximately 110 feet high and 700 feet long, owned and operated by the U.S. Forest Service and designed by the Soil Conservation Service on the Little River Watershed 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 emergency spillway will pass the Probable Maximum Flood without overtopping the dam. Stability analyses done for the dam design showed a sufficient factor of safety; however, a small clear seep was discovered on the downstream face of the dam approximately 25 feet higher than the outlet pipe. The clear seep may affect the embankment stability. Although the flow from the clear seep was less than one-half g.p.m. at the time of inspection; the flow rate could increase as the reservoir level rises. It is recommended; therefore, that the clear seep be monitored, especially during periods of high reservoir levels, to determine if the flow through the clear seep increases. If the flow rate does increase; then a more thorough investigation and possibly remedial measures will be necessary.

Michael Baker, Jr., Inc.



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



APPROVED:

Original signed by:

Douglas L. Haller

Douglas L. Haller  
Colonel, Corps of Engineers  
District Engineer

Date: AUG 16 1978

NAME OF DAM: UPPER NORTH RIVER NO. 77

OVERALL VIEW OF DAM



OVERALL VIEW OF DAM



PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM  
NAME OF DAM: UPPER NORTH RIVER NO. 77 ID# VA 1507

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: Upper North River Dam No. 77 (Hearthstone Lake Dam) is a zoned earth dam, 110.5 feet high and 701 feet long. Seepage control is provided by a impervious core and a cut-off trench extending to firm unweathered bedrock. A rock toe drain has been provided under the downstream toe. The emergency spillway is an earth side channel type with a bottom width of 250 feet. The principal spillway is a drop inlet structure consisting of a reinforced concrete riser, a 48 inch diameter concrete water pipe, and a riprapped stilling basin. The reservoir is used for flood control, and there is an orifice on the reservoir side of the riser at the normal pool elevation (1779.2 feet). The reservoir may be drained by the use of a hand operated, 24 inch slide gate located on the right side of the primary spillway. A plan and typical sections of the dam are shown on Plates 1 and 2.
- 1.2.2 Location: The Upper North River Dam No. 77 is located on Little River, a tributary of the North River. The dam is located approximately three miles northwest of Stokesville,

NAME OF DAM: UPPER NORTH RIVER NO. 77



Virginia in Augusta County. Regional and vicinity maps are included in this report as the Location Plan.

- 1.2.3     Size Classification: The dam is in the "large" size category as defined by the Recommended Guidelines for Safety Inspection of Dams. The maximum height of the dam is 110.5 feet and the reservoir capacity to the top of the dam is 3680 acre-feet.
- 1.2.4     Hazard Classification: Due to the proximity of the Town of Stokesville, Virginia with a population of about 100 and Camp May Flather (a Girl Scout Camp), 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 Little River in the 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, built by the English Construction Company, was completed in 1966.
- 1.2.8     Normal Operational Procedures: No formal operating procedures are followed on this dam. Normal pool is controlled by an orifice on the side of the riser at an elevation of 1779.2 feet. Since this dam is used for flood control, the principal spillway (riser crest) is located at an elevation of 1802 feet with excess flows diverted through the side channel emergency spillway with a crest elevation of 1844 feet.

NAME OF DAM: UPPER NORTH RIVER NO. 77

### 1.3 Pertinent Data

1.3.1 Drainage Area: The drainage area of the Upper North River Dam No. 77 is 16.01 square miles.

1.3.2 Discharge at Dam Site: The maximum known flow at this dam site is unknown.

#### Principal Spillway:

Pool Level at emergency

spillway crest . . . . . 457 c.f.s.

Pool level at top of dam . . . . . 482 c.f.s.

#### Emergency Spillway:

Pool level at top of dam . . . . . 27,248 c.f.s.

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

TABLE 1.1 DAM AND RESERVOIR DATA

Item	Elevation feet M.S.L.	Area acres	Reservoir Capacity		Length feet
			Acre- feet	Watershed inches (a)	
Top of dam	1854.5	92.6	3680	4.3	5600
Maximum pool, design surcharge	1851.0	89.3	3380	4.0	-
Emergency spillway crest	1844.0	81.6	2768	3.2	5000
Principal spillway crest (b)	1802.0	33.0	478	0.56	-
Normal pool (c)	1779.2	14.0	150	-	1500
Streambed at centerline of dam	1744.0	0	0	0	0

(a) Based on 16.01 square miles of drainage area.

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

(c) Normal pool is controlled by orifice in wall of riser.

NAME OF DAM: UPPER NORTH RIVER NO. 77

## 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) Hydrologic and hydraulic data.
- 3) Foundation and geologic reports -- geologic report is presented in Appendix V (the foundation report includes a check of the piping potential between embankment sections).
- 4) Slope stability analyses including the assumed properties of the materials (Appendix VI).
- 5) Results of laboratory tests and field permeability tests.
- 6) Work Plan.

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

2.2 Construction: The dam, constructed by the English Construction Company, was completed in 1966. No construction records were available for this inspection report, but the records are on file at the S.C.S. office in Washington, District of Columbia.

2.3 Operation: There are no formal operating procedures for this type of dam. The slide gate used to drain the reservoir is not periodically operated since there is no existing policy concerning the frequency of its use. Annual inspections are conducted through the joint efforts of the S.C.S. and U.S. Forest Service.

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 foundation and geologic reports. The hydrologic and hydraulic data provided was adequate for design review.

NAME OF DAM: UPPER NORTH RIVER NO. 77

- 2.4.2      Construction: No construction records were available, however, the as-built drawings indicate modifications and changes made during construction.
- 2.4.3      Operation: The slide gate should be periodically operated.

NAME OF DAM:    UPPER NORTH RIVER NO. 77



## SECTION 3 - VISUAL INSPECTION

### 3.1 Findings

- 3.1.1 General: The field inspection was performed on 13 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. The problems noted during the visual inspection are considered minor with exception of the clear seep found on the downstream slope of the embankment. Nothing was observed in the field that required immediate remedial action.
- 3.1.2 Dam: A small clear seep (see Photo 2) was noted during the visual inspection on the downstream face of the dam approximately 65 feet to the left of the outlet pipe along the upslope side of the bench on the embankment. The clear seep, approximately 25 feet higher than the outlet and one foot above the bench, is at an elevation of 1773 feet. The flow from the clear seep was not measurable and was estimated at less than one-half g.p.m. The reservoir elevation at the time of inspection was approximately 1778.5.
- No other seeping or sloughing was observed during the inspection. A few small trees were noted growing on the embankments.
- 3.1.3 Appurtenant Structures: At the time of inspection, some minor debris was lodged in the trash rack covering the normal pool inlet. The pipe encasing the lift stem for the pond drain is slightly bent (see Photo 3), possibly from the buildup of debris and/or ice. The lifting mechanism should be used to check for normal operation.
- The emergency spillway is well seeded and in good condition as shown in Photo 4.
- 3.1.4 Reservoir Area: No serious deficiencies were observed in the reservoir area (see Photo 5).
- 3.1.5 Downstream Channel: The outlet channels for the principal and emergency spillways showed no serious signs of past erosion.



- 3.2 Evaluation: None of the above items, with the exception of the clear seep on the embankment, is serious enough to warrant immediate repair since they do not intrinsically threaten the integrity of the dam. However, these repair items are considered good maintenance and should be accomplished as part of an annual maintenance program.

At the time of this inspection, the elevation of the clear seep was only 5.5 feet lower than the reservoir level and was flowing at less than one-half g.p.m. The exact source of the clear seep could not be determined by visual inspection alone. The clear seep should be monitored during periods of high reservoir levels to determine if the rate of flow increases. If it is determined that the flow is originating from the reservoir, then a more thorough investigation including a test boring program and piezometers would be necessary to determine the dam's phreatic surface and the source of the clear seep.

An inverted filter may be necessary to prevent piping, if the source of the clear seep is the reservoir. Piping could reach critical levels with the reservoir level at the emergency spillway crest.

The following maintenance items are suggested:

- 1) The small trees growing on the embankment should be removed.
- 2) Debris should be removed from the trash rack.
- 3) The stem and pipe casing should be repaired if the bent pipe hinders the operation of the slide gate.

## SECTION 4 - OPERATIONAL PROCEDURES

- 4.1 Procedures: No formal operational procedures are used on the Upper North River Dam No. 77 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 a normal pool elevation of 1779.2 feet above M.S.L. and has 64.8 feet of additional storage height to the crest of the emergency spillway.
- 4.2 Maintenance of Dam: Annual inspections are carried out through the joint effort of the S.C.S. and the U.S. Forest Service.
- 4.3 Maintenance of Operating Facilities: The lift gate is not routinely checked to verify proper functioning.
- 4.4 Warning System: At the present time, there is no warning system or evacuation plan in operation. It is recommended that a formal emergency procedure be prepared and prominently displayed and furnished to all operating personnel. This should include:
- 1) How to operate the dam during an emergency.
  - 2) Who to notify, including public officials, in case evacuation from the downstream area is necessary.
  - 3) Procedures for evaluating inflow during period of emergency operation.
- 4.5 Evaluation: Maintenance of the operating facilities are considered adequate for the functions that they serve. However, formal lift gate checks should be instituted as part of the annual inspections by the owner. In addition, the gate should be opened immediately to determine if the bend in the casing hinders the operation of the gate.

NAME OF DAM: UPPER NORTH RIVER NO. 77

## SECTION 5 - HYDRAULIC/HYDROLOGIC DATA

- 5.1 Design: Normal pool elevation (elevation 1779.2), controlled by a orifice inlet on the reservoir side of the riser, was established at the 100 year sediment level.

The elevation of the crest (elevation 1802.0) of the drop inlet to the principal spillway was established at an elevation which would provide storage of the five year, 10 day flood volume. The capacity (457 c.f.s. with the reservoir level at the crest of the emergency spillway) of the principal spillway was established by consideration of a number of factors including:

- 1) The capability of evacuating the flood storage space within a reasonable time ( $\pm$  10 days).
- 2) Not passing damaging flows downstream.
- 3) The capability of the reservoir to store the flood waters.

The crest (elevation 1844.5) of the emergency spillway was established at the maximum elevation required to store the 100 year, 10 day duration rainfall. The elevation of the top of the dam (elevation 1854.5) was established by the maximum elevation reached in passing the freeboard hydrograph. The freeboard hydrograph is that computed from rainfall comparable to the Probable Maximum Precipitation (P.M.P.) as used by the Corps of Engineers, and it is therefore comparable to the Probable Maximum Flood (P.M.F.).

- 5.2 Hydrologic Records: None

- 5.3 Flood Experience: The 17 June 1949 flood peaked at a discharge of 11,100 c.f.s. for a drainage area of 23.4 square miles according to the stream gage located downstream at Stokesville. This peak corresponds to a recurrence interval of approximately once in sixty years.

- 5.4 Flood Potential: Performance of the reservoir by routing various hydrographs as noted in paragraph 5.1 is an indication of the flood potential for the reservoir.

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

Regulation of flow from the reservoir is automatic. Normal flows are controlled by the low stage inlet in the riser at an elevation of 1779.2. Flood water begins flowing into the high stage drop inlet when the reservoir level exceeds the high stage crest elevation of 1802.0. Water flowing into these inlets flows through the dam in a 48 inch diameter concrete conduit. Water also flows past the dam through an ungated earth side channel emergency spillway in the event water in the reservoir rises over the crest of the spillway.

Outlet discharge capacity, reservoir area and storage capacity, and hydrograph and routing determinations were obtained from reports and computations furnished by the S.C.S. The routing of the emergency spillway and freeboard hydrographs began with the reservoir level at the crest of the principal spillway.

- 5.6 Overtopping Potential: The probable rise in the reservoir and other pertinent information on reservoir performance in various hydrographs is shown in the following table:

TABLE 5.1 RESERVOIR PERFORMANCE

Item	Normal	Hydrograph		
		Principal Spillway (a)	Emergency Spillway	Free-Board (b)
Peak flow, c.f.s.				
Inflow	-	-	14,694	26,525
Outflow	-	457	14,040	27,730
Peak elev., ft. M.S.L	1779.2	1844.0	1851.0	1854.0
Emergency Spillway				
Depth of flow, ft.	-	0	7.0	10.5
Avg. velocity, f.p.s	-	0	11.9	15.1
Non-overflow section				
Depth of flow, ft.	-	-	-	0
Avg. velocity, f.p.s.	-	-	-	-
Tailwater elev., ft. M.S.L.-	-	-	-	-

- (a) 100 year, 10 day volume produces the most conservatively large indication of flood control storage required. Detailed discharge hydrograph was not determined.
- (b) P.M.F. by C.O.E. standards.

NAME OF DAM: UPPER NORTH RIVER NO. 77



- 5.7 Reservoir Emptying Potential: The time to draw down the reservoir level from the crest of the emergency spillway (discharge of 457 c.f.s.) to the crest of the principal spillway (discharge of 177 c.f.s.) is 2.87 days. The time to draw the reservoir down from the principal spillway crest to the low stage inlet is 3.80 days. Therefore, the total drawdown time from flood control pool to normal pool is 6.67 days.
- 5.8 Evaluation: Hydrologic and hydraulic determinations of the project as prepared by the S.C.S. appear reasonable. The dam and spillway are designed to pass a flood essentially equal to the P.M.F., which would be developed under standards used by the Corps of Engineers. The project would pass the P.M.F. without overtopping the dam.

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 foundation of the dam consists of alluvial and terrace soils that contain cobbles, boulders and gravels. The soil thickness varies from five to eleven feet in the stream area to 11 to 19 on the terraces. Little soil cover exists on the left abutment. The right abutment contains as much as nine feet of colluvial soil consisting mainly of angular cobbles.

The bedrock is primarily sandstone and orthoquartzite with some carbonaceous shale, siltstone and anthracite coal. The strike of the bedrock is generally N.15°E. to N.31°E., and the dip is 27°E.

### 6.2 Dam Stability

- 6.2.1 Visual Observations: No tension cracks or other evidence of movement such as sloughing of the embankment slopes, or movement at or beyond the toe was observed. One clear seep was observed on the downstream slope about one foot above the berm at an approximate elevation of 1773 feet. The flow from this clear seep was estimated to be less than 0.5 g.p.m. However, the reservoir level at the time of the inspection was only at elevation 1778.5.
- 6.2.2 Design Data: Slope stability analysis was checked by the Swedish Circle Method on a zoned embankment section. Shear strength of the impermeable core was assumed as  $\bar{\phi} = 30^\circ$ ,  $\bar{c} = 200$  p.s.f. The transition zone as  $\bar{\phi} = 35^\circ$ ,  $\bar{c} = 0$ , the shell as  $\bar{\phi} = 37^\circ$ ,  $\bar{c} = 0$  and the foundation as  $\bar{\phi} = 35^\circ$  and  $\bar{c} = 0$ . The shear strength of these soils was determined from consolidated undrained triaxial shear tests. A minimum factor of safety of 1.22 was computed for the three horizontal to one vertical (3:1) upstream slope under full rapid drawdown from emergency spillway to the base. A minimum factor of safety of 1.6 was computed for a 2:1 downstream slope. This computation assumed steady seepage with a phreatic line extending from the emergency spillway elevation to a drain at the toe of the center core.

A check of piping potential between embankment sections was also made. The gradations and plasticities of the expected embankment

NAME OF DAM: UPPER NORTH RIVER NO. 77

- 6.2.3 Operating Records: The yearly inspections indicate no deteriorating conditions. However, there was also no mention of the clear seepage on the downstream slope.
- 6.2.4 Post-Construction Changes: No alterations of the dam were apparent since it was constructed.
- 6.2.5 Seismic Stability: Upper North River Dam No. 77 is in Seismic Zone 2 and is considered to have no hazard from earthquakes according to the Recommended Guidelines for Safety Inspection of Dams.
- 6.3 Evaluation: The stability analysis for the upstream slope is compatible with as-built conditions. However, the clear seepage on the downstream slope may indicate a phreatic line that exits on the downstream slope rather than terminating near the toe of the center core. (Considered for design because of the moderately permeable transition and shell materials.) If further observation indicates that the clear seepage is originating from the reservoir, additional stability analysis should be made using the existing phreatic surface.

NAME OF DAM: UPPER NORTH RIVER NO. 77

## SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

- 7.1 Dam Assessment: The dam is designed to prevent overtopping under P.M.F. conditions. One clear seep was observed on the downstream face. The consequences of this clear seep depend on whether the source of water is the reservoir or infiltration on the embankment crest and slopes, and the effect of the clear seepage on embankment stability. There is a potential for piping if the clear seepage originates from the reservoir.

The data available were sufficient to evaluate the adequacy of design. Data obtained during the inspection agrees very closely with the as-built drawings.

The dam will not require urgent remedial treatment; however, a regular observation schedule of inspecting the clear seep should be set up immediately to determine if the flow from the clear seepage increases with the reservoir level.

Further investigation will be necessary if, after monitoring the clear seep, it is determined that the flow is originating from the reservoir.

### 7.2 Recommended Remedial Measures

- 7.2.1 Clear Seep: Immediately, the owner should set up and maintain a regular observation schedule of inspecting the clear seep to determine its source, prevent erosion and prevent a worsening condition from going unobserved. If as a result of these periodic inspections, it is found that the flow is originating from the reservoir then an in-depth investigation including a test boring program and piezometers is recommended. An inverted filter may be needed to prevent piping if the source of the clear seep is determined to be the reservoir.

- 7.2.2 Other Recommendations: The lifting mechanism should be checked for normal operation. If the operation of the sludge gate is hindered by the bent pipe then the stem and pipe casing should be repaired. The trash rack should be cleaned of debris and cleaned frequently in the future. All small trees growing on the embankment should be removed. These items can be accomplished through the annual maintenance program.

NAME OF DAM: UPPER NORTH RIVER NO. 77

APPENDIX I

PLATES

## CONTENTS

Location Plan

Plate 1: Plan of Dam

Plate 2: Typical Sections of Dam

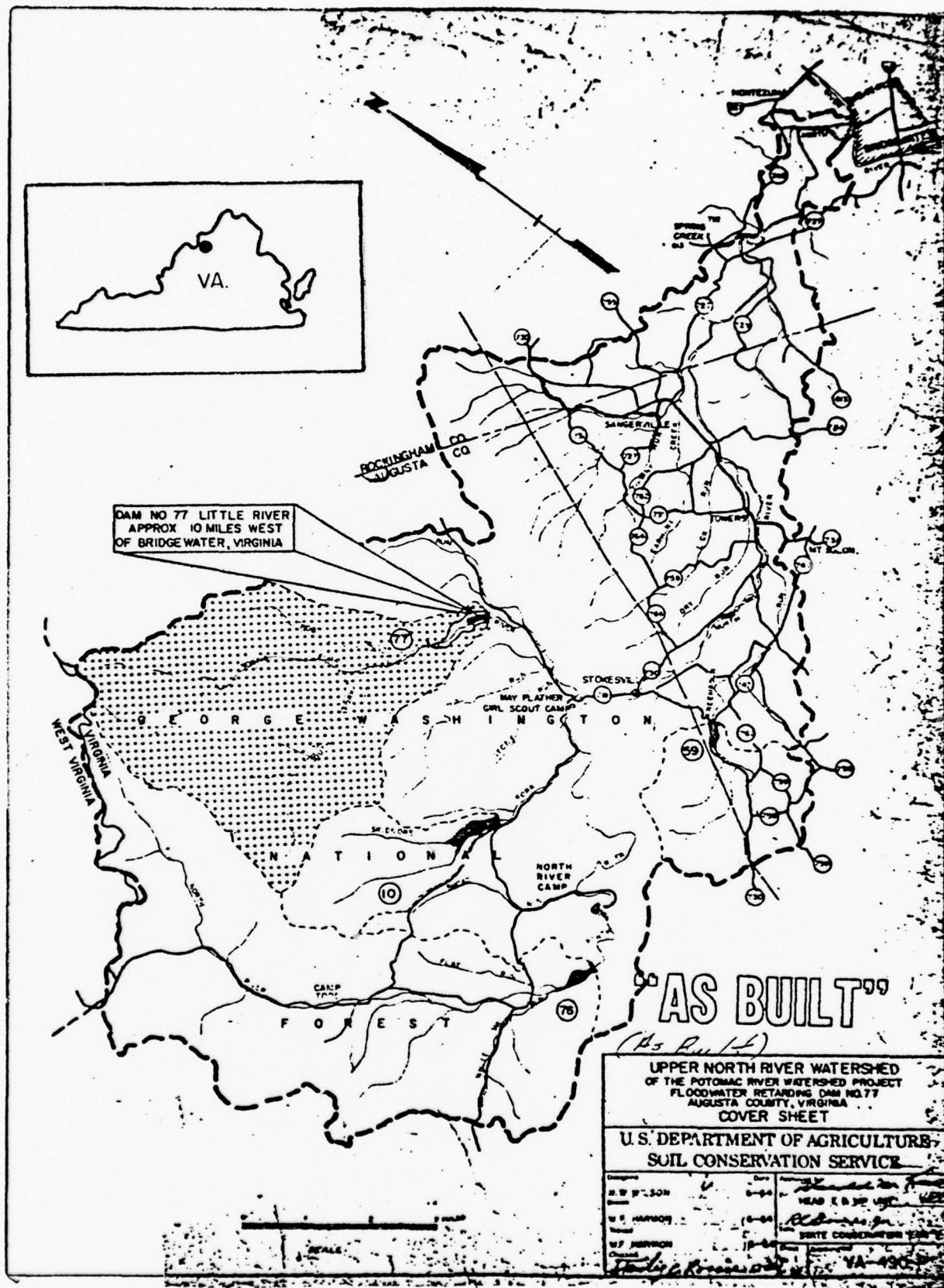
Plate 3: Plan and Profile of Principal Spillway

Plate 4: Borrow Area Locations

Plate 5: Emergency Spillway

NAME OF DAM: UPPER NORTH RIVER NO. 77





LOCATION PLAN

UPPER NORTH RIVER No. 77

# UPPER NORTH RIVER WATERSHED OF THE POTOMAC RIVER WATERSHED PROJECT FLOODWATER RETARDING DAM NO. 77

AUGUSTA AND ROCKINGHAM COUNTIES, VIRGINIA

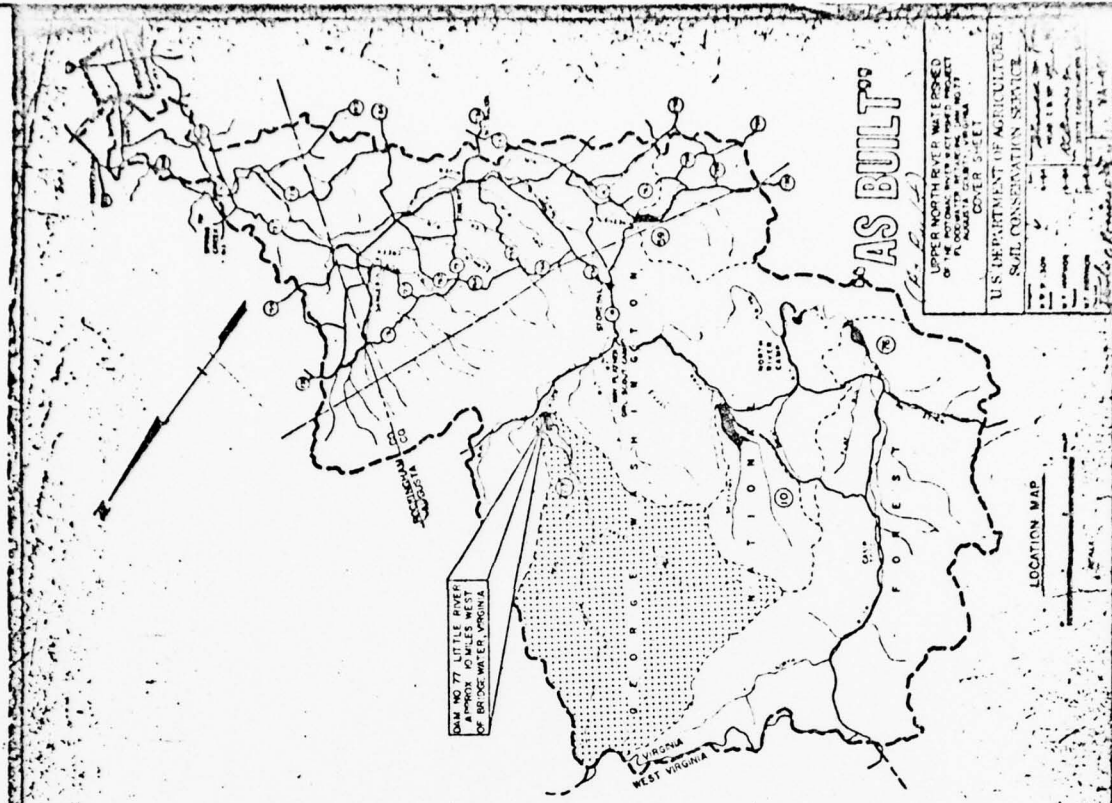
DRAINAGE AREA	10,246 ACRES
FLOOD STORAGE IN EMERGENCY SPILLWAY GUEST TO NORMAL FLOOD LEVEL	2,768 ACRE FEET
WATER SURFACE AREA	14 ACRES
HEIGHT OF DAM	102.5 FEET
VOLUME OF FILL	525,484 CUBIC YARDS

SOIL CONSERVATION SERVICE  
OF THE  
U.S. DEPARTMENT OF AGRICULTURE  
COOPERATING WITH  
SHENANDOAH VALLEY SOIL CONSERVATION DISTRICT

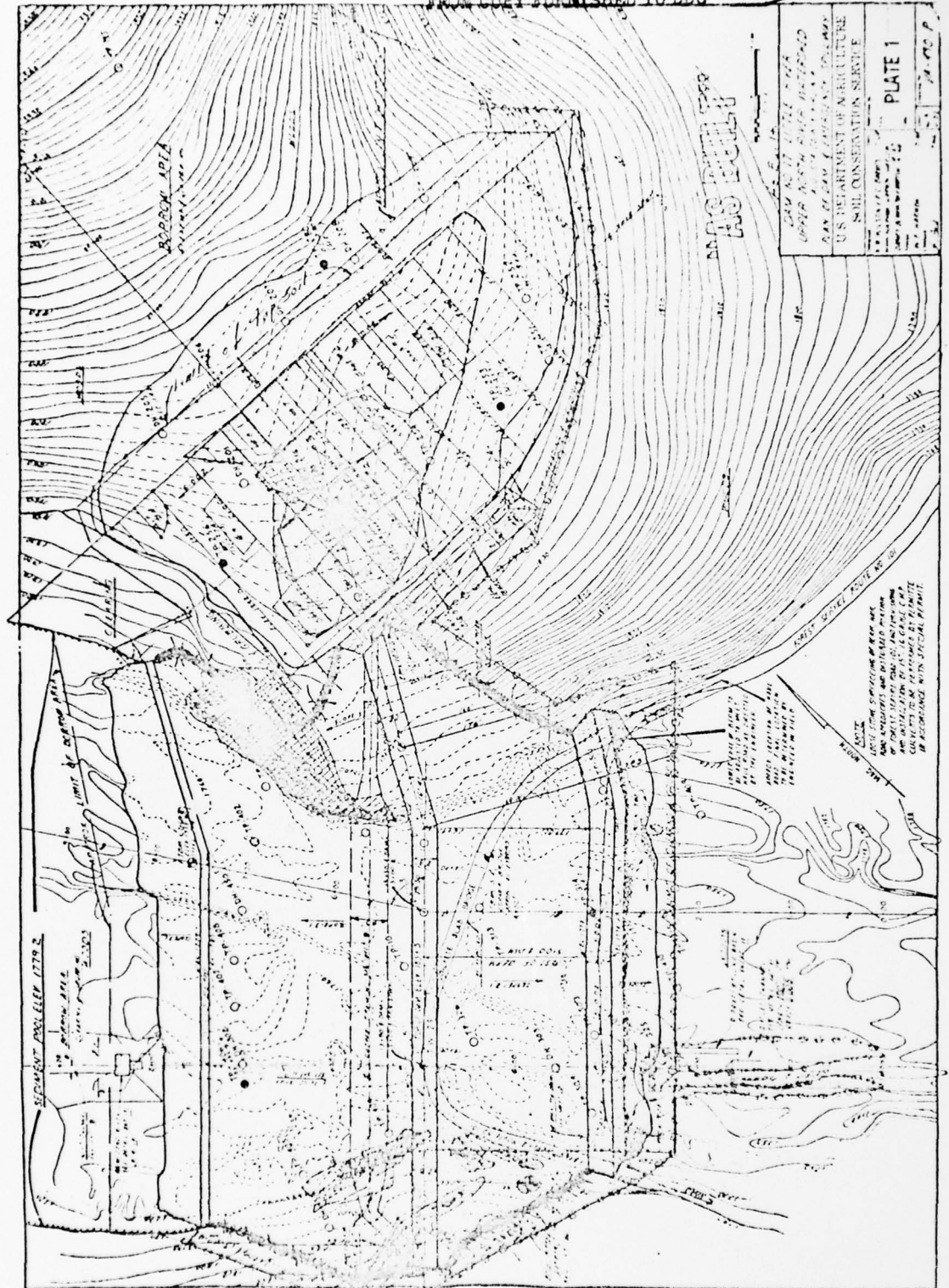
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## INDEX

- SHEET NO.
- 1 COVER SHEET
  - 2 RESEARCH AREA MAP
  - 3 TYPICAL SECTION OF FILL
  - 4 PLAN OF DAM & EMERGENCY SPILLWAY
  - 5 RESEARCH AREA - LEFT ABUTMENT
  - 6 RESEARCH AREA - RIGHT ABUTMENT
  - 7 SITE LOCATION MAP
  - 8 SITE LOCATION MAP
  - 9 PHOTOS
  - 10 ROCK TOE DRILL & MISC DETAILS
  - 11 PLAN PROFILE OF PRINCIPAL SPILLWAY
  - 12 LOGS OF TEST HOLES
  - 13 LOGS OF TEST HOLES
  - 14 LOGS OF TEST HOLES
  - 15 LOGS OF TEST HOLES
  - 16 LOGS OF TEST HOLES
  - 17 RISER DETAILS
  - 18 RISER BENT STEEL DETAILS
  - 19 RISER BENT STEEL DETAILS
  - 20 CRADLE, COLLAR, BENT & POINT STEEL SCHEDULE
  - 21 TRASH RACE & LAUNDER DETAILS
  - 22 GOLF WATER RELEASE & MISC DETAILS



LOCATION PLAN

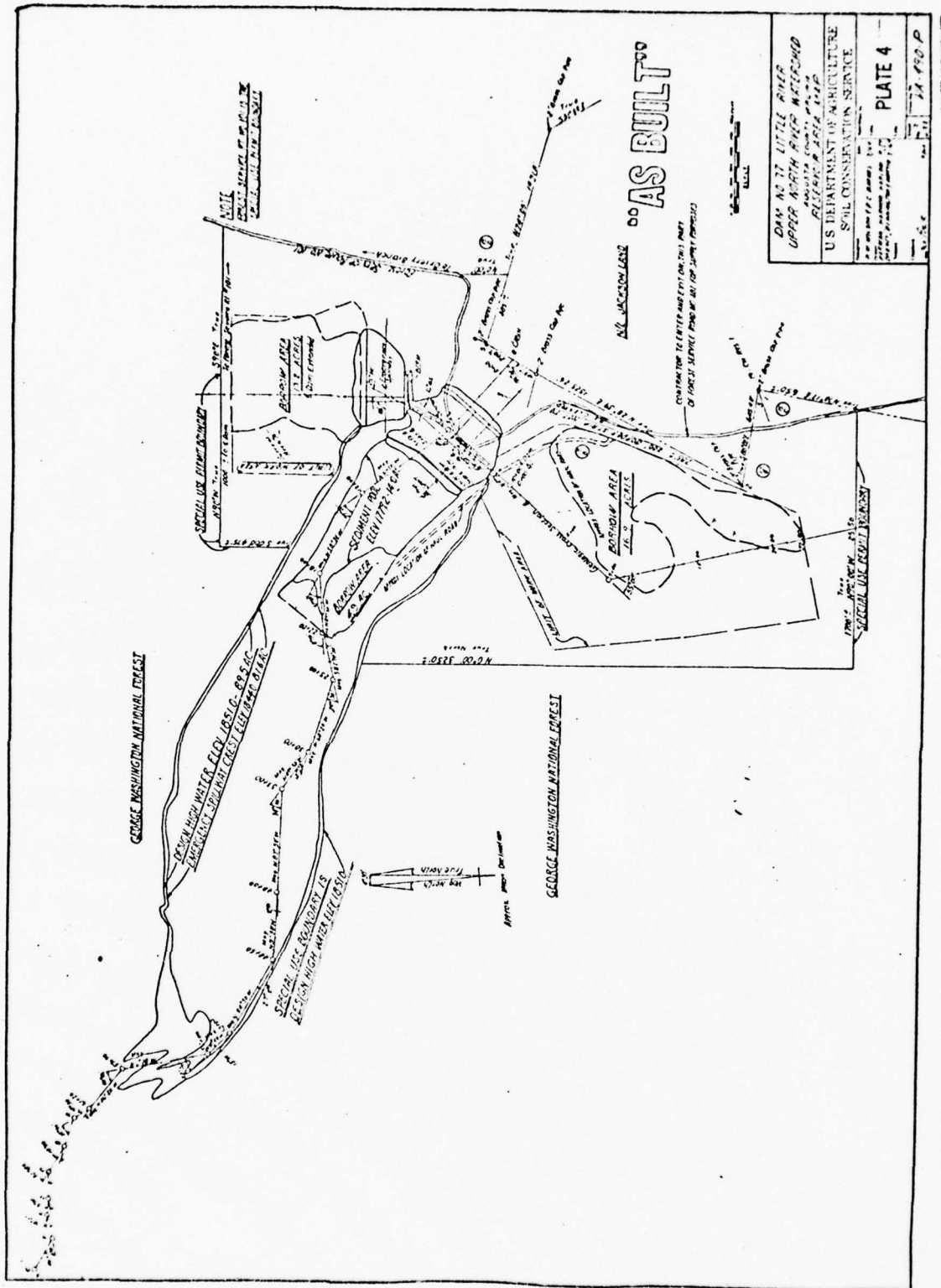






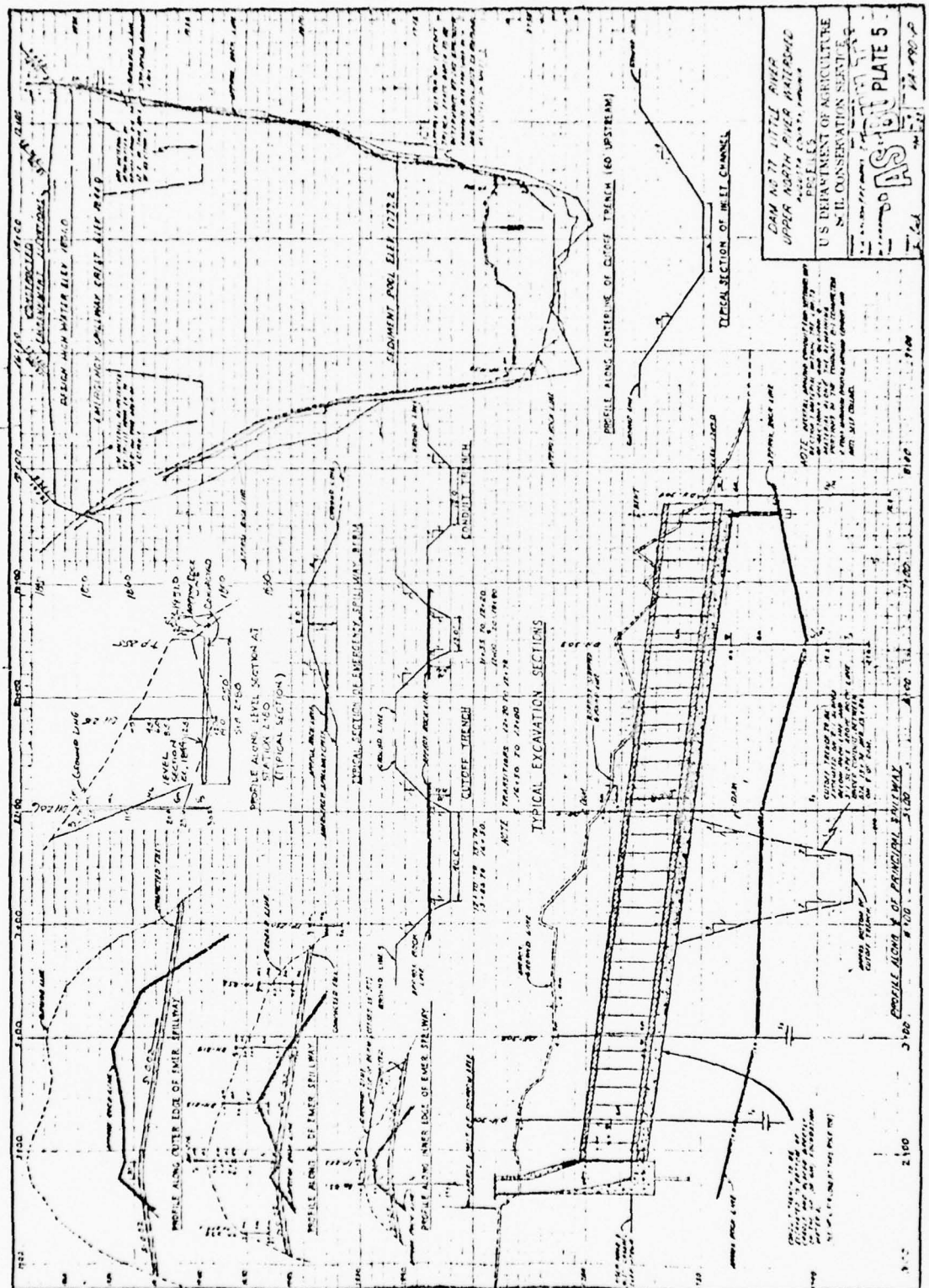






DOW NO 17 LITTLE RIVER	
UPPER NORTH RIVER WATERSHED	
PLANNING AREA 1000	
US DEPARTMENT OF AGRICULTURE	
SOIL CONSERVATION SERVICE	
PLATE 4	
1:25,000 Scale	
1950	

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APPENDIX II

PHOTOGRAPHS

## CONTENTS

- Photo 1: Overall view of Downstream Face of Dam and Outlet Pipe
- Photo 2: Clear Seep on Downstream Face of Dam
- Photo 3: View of Riser Showing Bent Lift Stem
- Photo 4: View of Emergency Spillway and Left Abutment
- Photo 5: Reservoir Area as Viewed From Crest of Dam
- Photo 6: View of Stilling Basin and Downstream Channel

Note: Photographs were taken in June 1978.

DAM NAME: UPPER NORTH RIVER DAM NO. 77



PHOTO 1



PHOTO 2





PHOTO 3



PHOTO 4



PHOTO 5

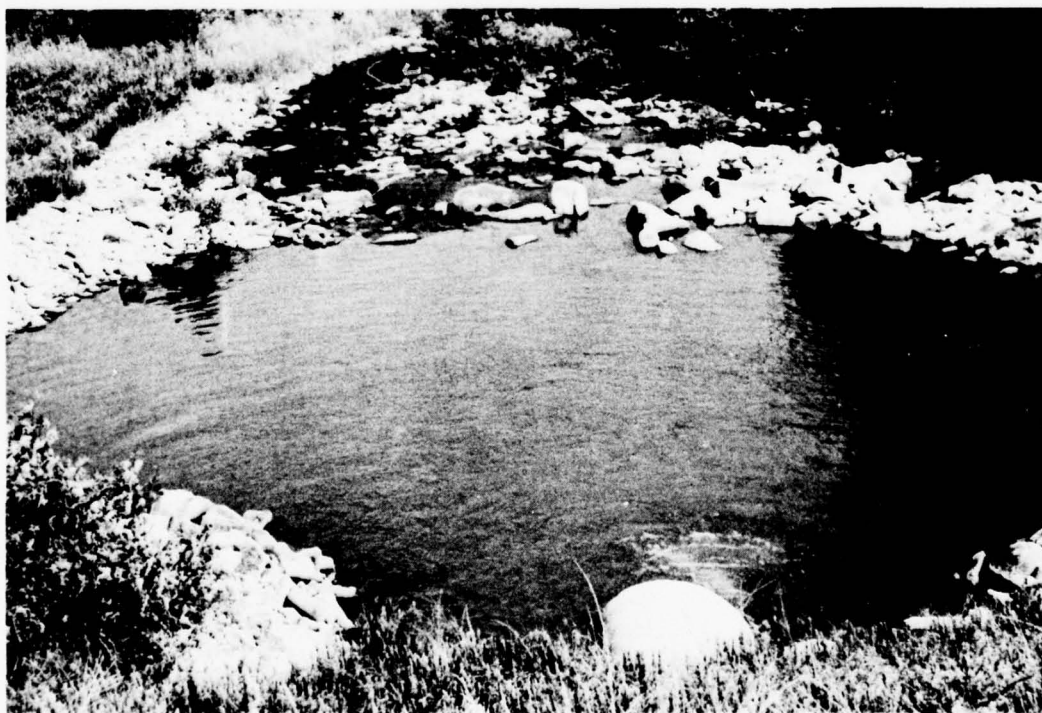


PHOTO 6

Check List  
Visual Inspection  
Phase 1

Name Dam Upper North River No. 77 County Augusta State Virginia Coordinates Lat. 3823.6°  
(Hearthstone Lake) Long. 7909.6°

Date Inspection 13 June 1978 Weather Sunny and clear Temperature 80°F.

Pool Elevation at Time of Inspection 1778.5 M.S.L. Tailwater at Time of Inspection 1747.5 M.S.L.

HHH-I

Inspection Personnel:

MICHAEL BAKER, JR., INC.:

M. H. Moore  
M. Mill  
T. W. Smith

T. W. Smith Recorder

EMBANKMENT

Upper North River No. 77

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	No surface cracks were observed.	

UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE      No apparent earth movements or bulges were observed.

SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES      No sloughing or erosion was observed. Embankment appears to have been constructed with 2:1 downstream slopes and 3:1 upstream slopes. Small trees are growing on the embankment slopes.

VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST      Crest alignment is good, no bulging or bowing was observed.

RIPRAP FAILURES      None were observed.

EMBANKMENT

Upper North River No. 77

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 abutments or at the spillway and dam.	
ANY NOTICEABLE SEEPAGE	One clear seep was observed on the down- stream slope of dam approximately one (1) foot above road across slope of dam at elevation 1173 M.S.L. The clear seep is located 65 feet to left of outlet pipe when facing downstream along the upstream edge of road across dam.  Reservoir level at time of inspection was approximately five feet above clear seep. Flow in clear seep is minimal (estimated at less than 0.5 g.p.m.).	The clear seep should be monitored at higher reservoir levels to determine how much the flow increases with higher reservoir levels.
STAFF AND GAGE AND RECORDER	There are none.	
DRAINS	The drains are composed of the rock toe below the road across the downstream face of dam.	



# OUTLET WORKS

Upper North River No. 77

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Minor spalling has occurred on the invert of the four feet diameter concrete pipe. No cracking was observed on either the pipe or the concrete cradle.	Spalling of pipe is nominal.
INTAKE STRUCTURE	Pipe encasing the lift stem for pond drain anchored on right side of riser is bent. No cracking was observed on the intake structure. Some debris observed on low stage trash rack.	Drain pipe probably bent from ice or debris build-up. Pond drain lift should be operated and repaired if necessary. Debris removal from trash racks should be part of routine maintenance.
OUTLET STRUCTURE	Four feet diameter concrete pipe is supported by a concrete cradle. Concrete in good condition, no cracking or abnormal spalling has occurred.	
OUTLET CHANNEL	There are no signs of unusual erosion in the stilling basin. There is normal growth of vegetation in the exit channel which would not cause restrictions during high discharges at present.	Several small trees are growing in the channel downstream of the stilling basin.
EMERGENCY GATE	Only gate on intake is a pond drain operated by a hand crank from the top of the riser.	Pond drain should be checked for proper operation periodically.

# UNGATED SPILLWAY

Upper North River No. 77

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	None - Earth side channel emergency spillway.	

## APPROACH CHANNEL

No erosion was observed. The approach channel is covered with vegetation consisting of grasses only; no trees or brush are growing in spillway.

## DISCHARGE CHANNEL

No erosion was observed. The channel was covered with vegetation (grasses to the end of spillway at edge of woods).

## BRIDGE AND PIERS

There are none.

# INSTRUMENTATION

Upper North River No. 77

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		

APPENDIX III

CHECK LIST - VISUAL INSPECTION

# DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

CONDITION  
(OBSTRUCTIONS,  
DEBRIS, ETC.)

Downstream channel is clear of debris with some trees and brush in the overbanks.

SLOPES

The downstream channel slope is less than one percent.

III-8

APPROXIMATE NO.  
OF HOMES AND  
POPULATION

One cabin is located immediately downstream on left bank of the stream. The May Flather Girl Scout Camp is located approximately two miles downstream. Stokesville, with a population of around 100 people and approximately 30 to 40 homes, is located about three miles downstream.



RESERVOIR

Upper North River No. 77

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

SLOPES

No sloughing or sliding of reservoir slopes was observed. Reservoir slopes are generally tree covered.

SEDIMENTATION

Only minor sedimentation was noted.

APPENDIX IV

CHECK LIST - ENGINEERING DATA

CHECK LIST  
ENGINEERING DATA  
DESIGN, CONSTRUCTION, OPERATION

Upper North River No. 77

ITEM	REMARKS
PLAN OF DAM	As-builts are available from the Augusta County S.C.S. The plan of this dam is shown on Plate 1.
REGIONAL VICINITY MAP	Vicinity map is shown on the Location Plan.
CONSTRUCTION HISTORY	Contractor and date of completion provided by the Corps of Engineers.
TYPICAL SECTIONS OF DAM	Typical sections are shown in the as-builts.
HYDROLOGIC/HYDRAULIC DATA	These data are contained in the Design Report.
OUTLETS - PLAN	Shown in the as-builts.
- DETAILS	Shown in the as-builts.
- CONSTRAINTS	Design Report contains information on rating and constraints.
- DISCHARGE RATINGS	Design Report contains information on rating and constraints.
RAINFALL/RESERVOIR RECORDS	No rainfall or reservoir records are available at the dam.

Upper North River No. 77

ITEM	REMARKS
DESIGN REPORTS	Design Reports were obtained from the Augusta County S.C.S.
GEOLOGY REPORTS	Data on Detailed Geologic Investigations is contained in the Design Report, and included in the Appendix.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Contained in the Design Report, Sections I and II. Contained in the Design Report, Sections I and II. Dam stability analyses are contained in the Design Report.
IV-2 MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	This information is contained in the as-builts.
POST-CONSTRUCTION SURVEYS OF DAM	No known surveys have been made.
BORROW SOURCES	As shown on as-builts, borrow areas are: <ol style="list-style-type: none"> <li>1. Borrow Area - Left Abutment</li> <li>2. Borrow Area - Right Abutment</li> <li>3. Borrow Area - Reservoir</li> </ol>



Upper North River No. 77

ITEM	REMARKS
MONITORING SYSTEMS	No monitoring systems have been established.
MODIFICATIONS	No physical modifications were indicated on the as-built drawings.
HIGH POOL RECORDS	None are available.
IV-3	
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	No known studies or reports have been completed.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	No prior accidents of failures have been reported.
MAINTENANCE OPERATION RECORDS	Annual operation and maintenance inspection reports were provided by the S.C.S.

Upper North River No. 77

ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS	Information contained in as-builts.
DETAILS	Information contained in as-builts.
OPERATING EQUIPMENT PLANS & DETAILS	Information on pond drain contained in as-builts.

CHECK LIST  
HYDROLOGIC AND HYDRAULIC DATA  
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 16.01 square miles (mostly forested)  
ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1779.2 feet M.S.L.  
(150 acre-feet)  
ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 1844.0 feet  
Emergency Spillway Crest (2768 acre-feet)  
ELEVATION MAXIMUM DESIGN POOL: 1854.5 feet (3680 acre-feet)  
ELEVATION TOP DAM: 1854.5 feet (settled)  
CREST: Side channel emergency spillway

- a. Elevation 1844.0 feet
- b. Type Earth side channel with vegetation cover
- c. Width 250 feet
- d. Length 200 feet
- e. Location Spillover Outside left abutment
- f. Number and Type of Gates One pond drain only (24 inch diameter  
slide gate)

OUTLET WORKS: Principal spillway  
a. Type Drop inlet riser  
b. Location Riser in reservoir with four feet concrete pipe extending to  
stilling basin  
c. Entrance Inverts (crest elevation--1802.0 feet)  
(cold water inlet--normal pool--1779.2)  
d. Exit Inverts Invert of four feet diameter concrete pipe--1749.0 feet  
e. Emergency draindown facilities Pond drain only--24 inch slide gate

HYDROMETEOROLOGICAL GAGES: None available  
a. Type \_\_\_\_\_  
b. Location \_\_\_\_\_  
c. Records \_\_\_\_\_

MAXIMUM NON-DAMAGING DISCHARGE Not known

APPENDIX V

GEOLOGIC REPORTS



10-59

## DETAILED GEOLOGIC INVESTIGATION OF DAM SITES

### GENERAL

State Virginia County Augusta ; 1 4, 1 4, Sec. 1, T. 1 R. 1 ; Watershed Upper North River  
Subwatershed Little River Fund class FP Site number 77 Site group 1 Structure class C  
(FP-2, WP-1, etc.) (Sprague & Henwood)  
Investigated by Mack, T., Geologist Equipment used Case backhoe, core drill Date 8-10-63  
(signature and title) (Type, size, make, model, etc.)

### SITE DATA

Drainage area size 16.01 sq. mi., 10,240 acres. Type of structure Earth Fill Purpose Flood Prevention  
Direction of valley trend (downstream) South Maximum height of fill 93.0 feet. Length of fill 685 feet.  
Estimated volume of compacted fill required 557,105 yards

### STORAGE ALLOCATION

	Volume (ac. ft.)	Surface Area (acres)	Depth at Dam (feet)
Sediment	<u>161</u>	<u>15.6</u>	<u>16.0</u>
Floodwater	<u>2550</u>	<u>77.0</u>	<u>82.0</u>

### SURFACE GEOLOGY AND PHYSIOGRAPHY

Physiographic description Ridge & Valley Topography Mountainous Attitude of beds: Dip 27° 0' Strike N16°30'E  
Steepness of abutments: Left 36 percent; Right 82 percent. Width of floodplain at centerline of dam 335 feet  
General geology of site: Site #77 is located in Augusta County in the George Washington National Forest. The bedrock present is part of the Price-Pocono formation which is the lowest formation of the Mississippian system present in Virginia. Approximately 500 feet of Price-Pocono formation lie below the rocks that occur at the centerline of the dam and the unconformity at the base of the Mississippian system. Below this unconformity is the Hampshire formation which is of upper Devonian age.

The lithology of the underlying bedrock present under the foundation of the dam is an alternation of sandstone, orthoquartzite, black shale, dark gray siltstone, silty anthracite coal and gray green shale. As can be observed from the stratigraphic section of the bedrock under the centerline of the dam, the lithologic sequence follows approximately the typical Appalachian or Piedmont type cyclothem.

The dam site is on the western limb of a syncline that has the Price-Pocono formation as the uppermost central member. The structure is a parallel class of folds. This accounts for the low angle of dip that occurs in Price-Pocono formation upstream from the dam site and the steeper dips that occur to the east downstream. At the centerline of the dam the attitude of the beds is N16°30'E and 27°E. In the area of the foundation,

however, the strike ranges from N 12° E to N 31° E. This is due in part to the gentle secondary folds that strike at approximately right angles to the strike of the primary fold. It is also due in part to the cross bedding in the sandstone which is as extensive as any present in the folded Appalachians. The cross bedding is produced by typical scour and fill sedimentation. The greatest difference in the dip of scour to that of the fill is 32° - approximate strike of the scour channels is N 80° E. At the centerline of the dam the channel of Little River crosses the strike of the rock at a 39° angle.

A well-developed joint pattern is present in the strata. In the sandstone and orthoquartzite the joint sets have a mean strike of N 15° E and N 75° W. That the joint set angle is 90° clearly shows the competence of the rock. Less competent rocks such as the siltstone and coal have been shattered in the joint planes. In these rocks the angles of joint sets are less than 90°. In the coal and siltstone the joint sets show slight or no recementation. In the sandstone and quartzite there has been moderate to strong recementation due to the slight solution of quartz under the static pressure of the overlying rock. The presence of cliffs in both abutments shows the extent to which the recementation of joint sets in the sandstone and quartzite has proceeded.

Upstream from the dam site Little River flows in a strongly entrenched dendritic pattern. Downstream there is the development of a trellis drainage pattern. The stream is degrading. This degrading action is so strong that a large percentage of fines have been flushed out from the present alluvium in the narrow stream valley.

Approximately 60 percent of the subrounded boulders and cobbles in this stream alluvium are red sandstone from the Hampshire formation. As the silt and sand in the alluvial fines have the typical Indian red color of the Hampshire formation, it can be assumed that this sediment is from the Hampshire formation. The top of this formation occurs two and one-half miles upstream from the centerline of the dam. Most of the remaining percentage of boulders and cobbles are light gray sandstone and quartzite from the Price-Pocono formation. There also occurs less than one percent of subangular to subrounded cobbles of dike rock. The majority of these are from a basic dike that occurs approximately 4 miles upstream. The cobbles are green porphyritic lamprophyre with fibers of white plagioclase feldspar forming the porphyries. Also present are a few cobbles of acid dike rock. This light gray felsitic porphyry has hornblende laths as the porphyries. The cobbles are from a large acid dike that occurs on Shenandoah Mountain near the Virginia state line.

No faults were observed near the dam foundation. However, a thrust fault that strikes along the eastern crest of narrow ridge mountain was noted in a road cut. This thrust passes within three quarters of a mile east of the dam site. Also the North Mountain fault that thrusts Cambrian rocks over Devonian rocks occurs two and two-fifth miles east of the dam site. The influence of these thrusts is present in the tight compression ~~point~~<sup>joint</sup> pattern occurring at the dam location.

The effect of some post-Schooley peneplanation is noticeable. The benches on the mountain slopes that occur at approximately 2,000 feet elevation are

VA-490-G

tentatively correlated to the Harrisburg peneplane. Lower benches that occur at approximately 1,800 feet are tentatively correlated to the Somerville peneplane. The emergency spillway occurs on one of these latter benches. The fact that a high terrace soil such as the Waynesboro series occurs on Somerville peneplanation shows that this bench was formed at the start of the glacial epoch.

#### Methods and Procedures:

1. Seismic surveys were taken at several test pit locations in the borrow area. The base plate was placed near the test pit and the geophone extended in a line away from the test pit. This was to determine the depth of the non-rippable sandstone below rippable material such as the Allen soil or the siltstone. Also the rippability of the materials present can be determined by the velocity of the seismic wave through this material. In determining whether a material is rippable the Rippability Chart for the D-9 compiled by the Caterpillar Tractor Company is taken as the standard. To estimate the degree of rippability reference can be made to this chart. Within reasonable limits correlation was obtained between observed horizons in the test pits and the change in the seismic velocity at these points. The largest discrepancy observed was approximately two feet. However, the depths of horizons could vary this amount within twenty or thirty feet from the test pit. A seismic survey taken along the centerline of the emergency spillway showed a discrepancy of three-tenths of a foot in the depth of the non-rippable sandstone as checked by drill holes along this centerline. In the flood plain, however, no valid seismic information could be obtained. This is because seismic velocity is directly related to the density. Thus a tightly packed boulder bed could approximate the density of sandstone. A seismic survey taken in the flood plain showed a ten foot discrepancy to sandstone bedrock as determined by a drill hole.
2. Pressure tests were made up to maximum pressure and then made back to minimum pressure. This determines whether the fractures are subject to flushing out or sealing under applied water pressure.
3. Soils that are to be used as construction material are classified according to the standard agricultural classification of soils by series names. Horizons of these series are correlated to the samples both in the correlation chart and in the cross sections. Standard descriptions of the series named are included in the report.
4. Cross sections and geologic maps show the location of the strata in the foundation and the emergency spillway. Descriptive geometry plats are shown for the foundation area to show the theoretical location of beds. Actual location of these beds shows reasonable correlation.
5. Statements made on Form SCS-376-c are to be considered as suggestions and not as recommendations. Terseness of technical writing may make these statements appear to be recommendations.

#### Centerline of the Dam:

The centerline of the dam is along steep abutments and a flat alluvial area. The alluvial flood plain is almost equally divided between a low terrace deposit and the wide stream channel of a braided stream. The low terrace is below the left abutment. The braided stream is below the right abutment. The sedimentary



materials underlying each of these topographic features are similar. This consists of boulders, cobbles and gravels with sand and silt completely filling the interclies. The material larger than sand size forms approximately 70 percent of the flood plain sediments. This material is subrounded red and gray sandstone and subrounded gray quartzite particles. The sand and silt are colored a dark red. This color is often referred to by geologists as indian red. The depth of the stream alluvium in the low terrace ranges from 13 to 17 feet. In the braided stream the depth ranges from 7 to 10 feet. The rockline in the flood plain is level. It has a range in elevation of less than 1 foot in over 225 feet on the centerline of the dam.

Sandstone and orthoquartzite are the predominant rocks that underlie the centerline of the dam. The other rocks present are carbonaceous shale and siltstone and anthracite coal. A stratum of anthracite coal crosses the centerline of the dam in two places. It crosses on the right abutment and in the flood plain below this abutment as shown by DH 3 this layer is fractured in the flood plain area. Here it is also fairly pure coal. On the right abutment this layer is less fractured and is also impure coal. At DH 1 at the top of the right abutment this layer has become sufficiently impure to be classed as a carbonaceous shale. Generally, the rocks on the right abutment show a slight facies change to sandstone or littoral sedimentary environment.

On the right abutment there is a void nine-tenths of a foot thick that outcrops at station 12+65. Above this void the rock is highly fractured. DH2 which drilled into this fractured and weathered area had to have casing to below the void area. A permeability test on the void area in DH 2 shows a water loss of 42 gpm. The fact that this void and the highly fractured and weathered zone above it do not extend into the abutment with the strike of the beds is shown by the relatively low water loss under pressure in DH 1 from a depth of 35 to 45 feet. This void area and the fractured and weathered zone above it are caused by the intersection of the zone of weathering, a joint plane and the strata of interbedded siltstone and sandstone. This joint plane intersects DH 1 at 27 to 33 feet depth and DH 5 at approximately 23 foot depth. Low water loss under pressure testing was obtained in other depth locations in the right abutment.

The flood plain has several fracture zones present. The black carbonaceous shale that occurs at the base of the left abutment is fractured. Indicative of this is the moderately high water loss in this zone under water pressure testing of DH 4.

The centerline of the left abutment had little water loss under pressure testing. The exception to this is the zone from 5.0 to 15.0 feet in DH 6. Here a joint plane occurs.

The lithology along the centerline of the dam is given in the cross section. As the beds are not overturned the stratigraphic section can be read downward.

#### Emergency Spillway:

The emergency spillway is located in the left abutment. It occurs on a bench that is underlain by hard sandstone with one or more thin seams of shale interbedded within the sandstone. The downstream slope from this bench is underlain by a brown and gray ripplable siltstone. The rockline underlying the floor of the central

VA-490-G



section of the emergency spillway is fairly regular. This causes the soils to be deep on the left side of the emergency spillway.

Three soils series are present in the emergency spillway area. The Muskingum series occurs on the right side. It is an acid shallow residual soil weathered from sandstone, siltstone and shale. Over the sandstone this soil is extremely shallow, ranging from two to three feet in depth. It is only slightly deeper over the siltstone. This siltstone, however, is rippable. The central portion of the bench and some of both upstream and downstream slopes are overlain by Waynesboro soil. This soil is formed by the weathering of an old high terrace deposit. It contains weathered and unweathered subrounded boulders and cobbles of red sandstone. This terrace deposit is deepest on the upstream edge of the bench and on the upstream slope adjacent to this bench. It becomes thinner downstream.

The alluvial material blends into colluvial material on the left side of the emergency spillway. The alluvial material is sandier and less clayey than the colluvial Allen series material. The colluvial material contains unweathered angular to subangular cobbles of gray Price-Pocono sandstone. The old alluvium contains red subrounded cobbles of Hampshire sandstone. The Allen series material is relatively deep. This shows the strong action of former colluvialization. A fossil soil with clay oolites is present at depth in the colluvial material.

The Muskingum series material is covered by sample DS 253-1. As this light yellow brown fine sandy silt covers both the Allen and Waynesboro "B" horizons, the top layers of these latter soils are also covered by this sample. The Waynesboro series material below this layer is covered by sample DS 256-1. The Allen series material below this layer is covered by sample DS 280-1. Each of these soils has a "c" layer that is complex. Also these soils intersperse together. Thus assigning only one sample to each of these sequence of soil materials is a generalization.

#### Principal Spillway:

Two tentative principal spillway locations were investigated. The first of these investigated is normal to 1550 on the centerline of the dam. This proposed location lies mainly in the braided stream bed. Only the riser location is on the low terrace. Along this proposed location the rockline will be close to the cradle. The top of the rock lies approximately one-half foot below the riser. Rock lies approximately three and one-half feet below the bottom of the pipe on the centerline of the dam. Also rock lies approximately five feet below the bottom of the pipe at the bent location. The bedrock present consists of sandstone orthoquartzite, siltstone and anthracite coal. The more competent sandstone and orthoquartzite comprise the majority of the rock. Six strata of siltstone and shale cross this proposed principal spillway foundation. One stratum of anthracite coal is present. Locations of these rock types can be seen in the cross section. The rockline under this proposed location appears even. The reason that this natural location was abandoned is that it will discharge in a line with a cabin owned by Mr. Kirkle in Staunton. It was thought that the outflow from this proposed spillway will wash out this cabin which is located on the edge of the left side of the braided streambank.

VA-490-G

Because of this condition involving a privately-owned cabin a second proposed principal spillway was investigated. This location is on the low terrace. The depth of the clastic stream alluvium here under the proposed riser location is 19 feet. The depth of clastic overburden under the centerline of the dam is 14 feet. As the pipe will be placed approximately over an old stream channel, the rockline along this foundation is regular. The only irregularity is a gentle depression that occurs between the centerline of the dam and the bent. The same rock types that occur under the other proposed principal spillway occur here. But as the centerline of the dam intersects the strike of the rock at an acute angle, the strata occur further downstream. The bent is located on the right edge of the stream channel. The centerline of this proposed principal spillway intersects the stream at a  $20^{\circ}$  angle. The riser of this proposed pipe will be approximately four feet above competent rock, the centerline of the dam will be approximately four feet above competent rock, and the bent will be approximately two feet above competent rock. A fracture zone that carries artesian water occurs on the centerline at Station 3+00. Other fracture zones are present downstream.

#### Foundations:

The foundation of the dam will rest on a low terrace, a braided stream bed and steep abutments. The low terrace has a thin layer of soil over subrounded red cobbles, boulders and gravels. This thin soil supports a heavy forest. The layer of clastic material ranges from 11 to 19 feet in thickness. The clastic material in the stream bed ranges in depth from five to eleven feet.

A steep cliff occurs in the foundation area on the left abutment upstream from the centerline of the dam. This cliff is held up by highly compact sandstone and orthoquartzite. A layer of carbonaceous shale forms a narrow ledge on this cliff. Downstream on the left abutment from this cliff the slope is less steep. Downstream from the centerline of this abutment there are few rock outcrops. But hand auger borings show that the rockline is close to the surface here. On the downstream toe on this abutment a rock outcrop occurs as a road cut.

The right abutment contains several large rock outcrops. Three vertical cliffs occur. One is upstream from the dam centerline at the base of the abutment. One extends downstream from the upstream toe of the dam midway down the abutment. The third is located at the top of the dam along the centerline of the dam. A fractured area occurs from five to twenty-five feet below DH 2. A small colluvial terrace is present on the upstream toe of the dam on the right abutment. This terrace extends into the foundation area. The top of this colluvial terrace is thirty feet above the flood plain. DH 451 was drilled into the downstream portion of this bench. Here there is present nine feet of colluvial soil that contains angular cobbles of sandstone. Downstream from this terrace is a talus slope of angular sandstone boulders.

An old stream channel occurs below the present flood plain alluvium. This former channel appears on the top-of-rock contour map. The bed of this old channel approximates the centerline of the proposed principal spillway normal to 13+80 on the centerline of the dam. It underlies the low terrace on the right side of the flood plain. The modern stream flows on the left side of the flood plain.

VA-490-G

The rock types previously described are present in the foundation area. The sandstone and quartzite are the more competent rock. The coal and siltstone are the less competent. A strong flow of artesian water is present at Station 3+00 on the centerline of the pipe normal to Station 13+80 on the centerline of the dam. This is along a joint plane that strikes into the adjacent right abutment. As taken from the cross section of the centerline of the dam the approximate attitude of this joint plane is N 74° E, 66° E. The dip of the joint plane as taken in a road cut on the right abutment is 70° E. Three other joint planes were found in the foundation area. Others may be present.

A light duty gravel road crosses the foundation area. A concrete slab bridge is present. This bridge contains 951 cubic yards of concrete. The concrete slab has been poured on the cobbles and boulders in the stream bed. These particles have been incorporated into the concrete. The bridge appears not to be anchored to bedrock. It is held in place by gravity. An orthographic projection of the surface of this structure is given.

#### Borrow Areas

Three borrow areas were investigated. One borrow area is in the clastic material that lies in the flood plain. The other two borrow areas are on the hill slopes that occur on each side of this flood plain. The flood plain borrow area lies below the waterline in the permanent pool area. Two land forms are present. One is the braided stream, the other is a low terrace. The alluvium appears generally homogeneous between these two areas. This material in the stream bed consists of sand, silty (45%), cobbles (50%), and boulders (5%) as taken at TP-109. The material on the low terrace consists of sand, silty (56%), cobbles (38%), and boulders (6%) as taken at TP-101. The boulders and cobbles are predominantly (75%) red sandstone from the Hampshire formation. Of minor importance is gray Price-Pocono sandstone and quartzite. Little or no clay is present. A layer of large boulders (GP) generally covers the bedrock present.

The largest borrow area is located on the right side of the dam between two ridges that strike downstream with Little River. The pedology of this area is simple. Muskingum is the only residual series that occurs. Two colluvial soils occur. These are the Leadvale and Allen series. The Leadvale is a recent colluvial soil whereas the Allen is an old colluvial soil. The Muskingum series is shallow. It ranges from two to four feet in depth. This material is a pale brown fine sandy silt. The Muskingum series overlies hard sandstone, carbonaceous shale and siltstone and some impure anthracite coal. It occurs on the steeper slopes. The Allen series is generally composed of two layers. The upper of these is the same as the Muskingum series. Below this is a mottled yellow red and red clayey silt. In this borrow area the Allen series occupies the lower and less steep slopes at the base of the two ridges present. It ranges from eight to thirteen feet in depth. Generally, it overlies sandstone. The Leadvale series occurs in two places in this borrow area. One is in the far southwestern corner of the area covered by the topographic survey in a flat talus fan. The colluvial soil is mixed with flaggy sandstone talus boulders to the extent that it cannot be dug with a backhoe. Rippability is doubtful. The other area of Leadvale soil is in a draw between the two ridges in the approximate center of the borrow area. Here this soil is mixed with few talus boulders. However, it can easily be dug with a backhoe to a depth ranging from five to eight feet.



Backhoe refusal was effected by a tightly packed talus deposit of large boulders. The Leadvale soil here is a silty clay or a clayey sand. As a spring occurs in in the draw, the soil is moist to wet. Weathered and unweathered carbonaceous shale, siltstone and impure coal occur in this borrow area. Its easy rippability is shown by its low seismic velocities.

The third borrow area is located on the ridge that forms the left abutment. It borders the left slope of the emergency spillway. Only two soils are present. These are the shallow residual Muskingum series and the deeper colluvial Allen series. The Muskingum and Allen soils here are respectively similar to these series in the borrow area on the right abutment. Carbonaceous shale, siltstone and impure anthracite coal also occur in this borrow area on the left abutment.

As the borrow areas containing residual and colluvial soils cover a large area, several samples of each soil type were submitted for analysis. This was to cover this area with a proctor analysis for construction control. A list and classification of these samples is included.

VA-490-G



1-59

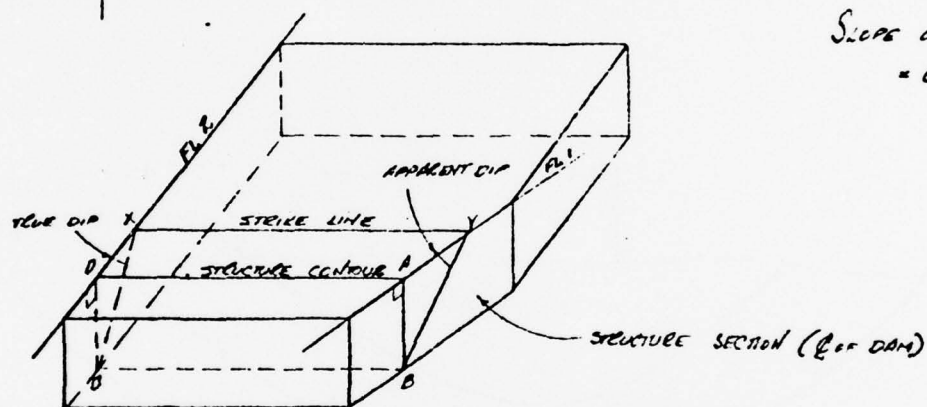
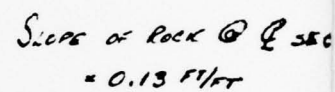
## DETAILED GEOLOGIC INVESTIGATION OF DAM SITES

to Virginia County Augusta Watershed Upper North Subwatershed Little River  
River  
number 77 Site group 1 Structure class C Investigated by T. Mack, geologist Date 8-10/63  
(signature and title)

### INTERPRETATIONS AND CONCLUSIONS

1. An impermeable cut off needs to be installed and anchored to bedrocks. This is necessary because of the fact that the permeability of the coarse grained clastic alluvium in the stream valley ranges from slowly permeable ( $k=4.3 \times 10^4$  ft/yr. to permeable ( $k=5.3 \times 10^4$  ft/yr.)
2. This permeability should allow an investigation into the elimination of a toe drain. A rock toe can be substituted for this. Rock that is blasted out in the removal of the cliffs can be used for this rock toe.
3. Removal should be considered to the depth of 21 feet of material at station 12+36 on the centerline of the dam. This material is highly fractured and weathered with a void present from 16.2 to 17.1 feet below the surface. From 10 to 20 feet  $k=2.85 \times 10^5$  ft/yr. at 21.9 feet sandstone is present and over 100 percent recovery was obtained. This appears to be sufficiently firm and impermeable.
4. The rock cliffs that occur on both abutments are almost vertical. To avoid differential settling between the fill and the rocks present these cliffs should be removed and the correct slopes as determined by the engineer should be installed.
5. Of the two pipe trenches investigated, the pipe trench normal to 13+80 centerline of the dam is the preferred location. This is because the trends normal to 15+50 may cause a cabin to be washed away. This cabin is located on the centerline of this pipe trench, 600 feet downstream from the centerline of the dam. As this cabin is considered to have sentimental value by the owner, any attempts to remove it by purchase are obviously useless. However, both of the pipe trenches require measures to be taken to counteract the differential settling of the competent clastic alluvium present in the stream valley and the less competent silty material in the cutoff trench. This clastic alluvium in the stream valley is well able to stand almost any strain placed upon it.
6. The sandstone and orthoquartzite present in the foundation area are competent rock. Shale siltstone and anthracite coal present are less competent rock. Also those latter rocks are more subject to brecciation under fracturing stresses. However, the beds of shale siltstone and coal present in the foundation area are relatively thin. Thus they detract but little from the general strenght of the foundation rocks present.

7. The abutments with the exception of the locality mentioned previously appear firm and fairly impervious.
8. The artesian water along a joint plane should be considered in the design of the dam. The cheapest way to deal with this is to place the cutoff trench on the centerline of the dam. Class C fill will then cover this area. As this flow of water was located on the pipe trench, this should be considered in the construction of the cradle.
9. The most feasible location for the cutoff trench is along the centerline of the dam. This will simplify construction of the dam.
10. Approximately 28,000 cubic yards of hard sandstone is above grade in the emergency spillway. To decrease this amount of rock excavation consideration can be given to increasing the height of the dam. Another way that the rock excavation can be reduced is to move the control section of the emergency spillway to the centerline of the dam. This area is the place where the rockline is highest on the emergency spillway. The shale and siltstone present in the emergency spillway is considered rippable.
11. Competent sandstone underlies both the proposed riser and bent location on the pipe trench normal to 13+80 on the centerline of the dam.
12. Sufficient borrow is present. The floodplane will yield the class c material. This material has a greater slope stability than the other borrow materials present. Materially this clastic material should be placed on the slopes. Almost all of the other borrow material present can be used for core with the exception of the Waynesboro soil. This soil may in some places have sufficient unweathered-red sandstone cobbles present to warrant its being placed on the slopes. The most prevalent soil is the shall residual Muskingum series (ML). The most desirable soil present for core material is the Allen series (ML). It is thought that this soil has sufficient clay present to form a fairly impermeable seal. The Leadvale series is also good core material. However, this series is of limited extent. It also contains talus boulders that can cause trouble in construction. The Leadvale area in the far southeast corner of the borrow area on the right abutment is worthless. This is due to the large number of talus boulders present. Shale siltstone and impure anthracite coal are to be considered as borrow material so that can be used in the core of the dam. When a sheepsfoot roller is passed over these materials it is considered that they will disintergrate and blend into the soil present.



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SANDSTONE

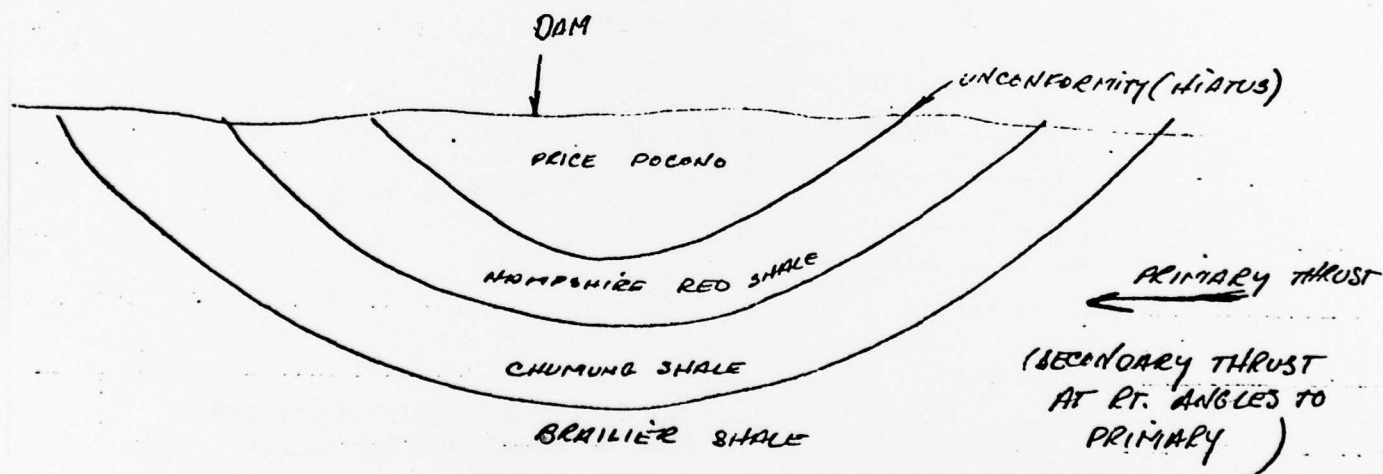
ORTHOQUARTZITE (CLASTIC SEDIMENTARY ROCK COMPOSED OF SILICA CEMENTED  
QUARTZ SAND)

BLACK SHALE

DARK GRAY SILTSTONE

SILTY ANTHRACITE COAL

~~AND~~ GRAY GREEN SHALE

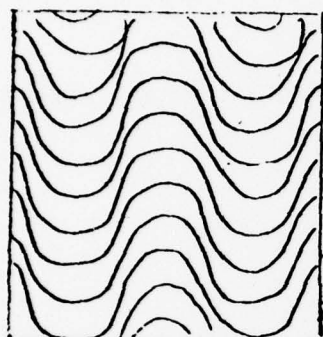




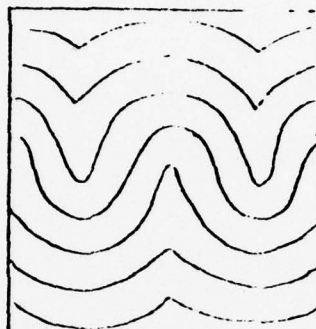
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## ① PARALLEL CLASS OF FOLDS.

THE FORM OF THE FOLD IS NOT PROPAGATED INDEFINITELY  
IN AN UPWARD AND DOWNWARD DIRECTION



SIMILAR FOLDING

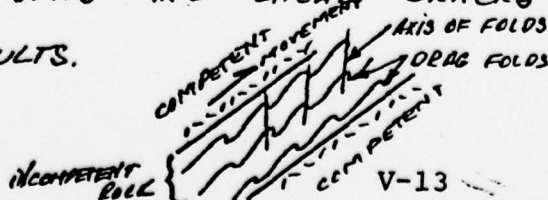


PARALLEL FOLDING

ZONE OF  
SEVERE  
FRACTURING  
AND DEFORMATION

DAM IS LOCATED IN FOLDS  
OF THIS TYPE

② COMPETENCE OF ROCK IN THIS CASE MEANS ITS ABILITY  
TO WITHSTAND STRESSES WHICH TEND TO CAUSE IT TO  
DEFORM. A COMPETENT ROCK (SANDSTONE, ORTHOQUARTZITE), <sup>(GREATER THAN ITS SHEARING STRENGTH)</sup>  
WILL FRACTURE WHEN SUBJECTED TO STRESSES AS  
OPPOSED TO AN INCOMPETENT ROCK WHICH WILL DEFORM  
PLASTICALLY UNDER SEVERE STRESSES. A 90° JOINT PATTERN  
SIGNIFIES AN EXTREMELY COMPETENT ROCK.  
DURING THE PLASTIC DEFORMATION OF AN INCOMPETENT ROCK  
SMALL "DRAG FOLDS" WILL FORM AND THE SHEAR STRESSES  
ALONG THE AXES OF THE FOLDS WILL BE GREATER THAN THE  
SHEAR STRENGTHS AND SHEAR CRACKS <sup>OCUR</sup> ~~RESULT~~. A SHATTERED  
ZONE RESULTS.



INCOMPETENT ROCK:  
SHEAR CRACKS



(2)

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NOTE THE SILTSTONE AND COAL SEAM AND SHALE BEDS ARE LESS  
COMPETENT THAN THE SANDSTONE AND ORTHE QUARTZITE.

(PLAT.)

1) A DIAGRAM DRAWN TO SCALE SHOWING ALL ESSENTIAL DATA PERTAINING  
TO THE BOUNDRIES OF FORMATIONS.

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Comments: Design Report VA-490-G  
Upper North River, Site 77

1. The upstream location of the cut-off was suggested to avoid the possibility of differential settlement in the foundation of the principal spillway at the point of greatest load, centerline of dam.

2. Definitions:

1ST-CYCLE ORTHOQUARTZITE - METAMORPHISED DETHOQUARTZITE  
SECOND-CYCLE ORTHOQUARTZITE - METAMORPHISED 1ST CYC  
etc  
(CLASTIC SEDIMENTARY ROCK COMPOSED OF SILICA CEMENTED QUARTZ SAND)

a. orthoquartzite - Sandstone partially altered to quartzite by metamorphism or heat and pressures resulting from crustal movements

b. cyclothems - a cycle of sedimentary deposition commonly found associated with the coasts. They are associated with fairly broad areas of shallow seas and low land.

c. cross-bedding - The diagonal bedding arrangement of sandstones found within a sandstone formation, usually associated with sand dune, delta or river channel deposits - Mack has associated

them with channel deposits.

- d. Dikes - a dike consists of a molten igneous mass that has been injected nearly vertical into joints and faults of the overlying sedimentary rocks. The dike material is called a porphyry ~~rock~~ at site 77. ~~Two~~ <sup>Two</sup> porphyry ~~rocks~~ <sup>dikes</sup> were noted to contribute gravels to the site from their headwater locations, a dark green basic one with thin needle like stringers of feldspar and a light gray acid one containing dark hornblende needle laths.

- e. Peneplain is a terrace or topographic level common to a broad section of the country, regardless of rock structure or stratigraphy which reflects a former base level of streams or seas. The present location such as the Schaeley at 2000 MSL or the Somerville at 1800 MSL may be higher today than its original. The land surface was thought to be depressed during glacial times due to the 10-20,000 foot thickness of the overlying ice.

OR THE QUARTZITE - CLASTIC SEDIMENTARY ROCK

CONSTITUENTS - QUARTZ SAND

CEMENTING MATERIAL - SILICA

1. Clastic - clastic rocks are those usually found <sup>in place</sup>, broken, or shattered or weathered from their parent rock. <sup>(SCATTERED & BROKEN PIECES HAVE BEEN CEMENTED TOGETHER)</sup> Depending upon which definition is being used, they are not usually associated with alluvial deposits (water transported).

### 3. Methods and Procedures

a. The Caterpillar Tractor Company reproducibility chart is not a standard, it is commonly used as a guide to interpretation. I would suggest that item 1. be shortened to <sup>simply</sup> state: ~~that~~ "Seismic <sup>surveys</sup> studies" ever made in the barrow area, emergency spillway and flood plain to obtain <sup>seismic velocities</sup> ~~as for geologic~~ interpretation of the subsurface conditions. ~~of this report~~ ~~if the report~~ is distributed beyond the Service.

b. Delete item 5 from the report and insert it as a foreword to Interpretations and Recommendations L.S. 376-C. Again for other agency use.

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4. Looking downstream, ~~at~~ the Centerline of Dam, the low terrace is at the base of the right abutment and the braided stream on the left side of the valley. The report should be checked with the plans to see if other directions are correct.
5. The competency of the sandstone is exhibited by  $90^{\circ}$  joints. The less competent shales and siltstones have lower angled joints which reflect that some shearing and crushing took place during the mountain uplift and folding.
6. Geol Report should be edited <sup>before</sup> ~~it~~ distributed to other Agencies — R77.



APPENDIX VI

STABILITY ANALYSES

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50' R=230  
TO CENTER OF APC

$$N \tan \phi = 300 \times 0.577 [0.10 \times 0.754 + 4.12 \times 0.7 + 2.09 \times 0.754]$$

$$N \tan \phi = 36,160 [0.0754 + 2.88 + 1.54]$$

$$N \tan \phi = 252,462$$

$$T = (3.86 - 0.19) 62.7 \times 900$$

$$T = 206,107$$

$$SF = \frac{N \tan \phi}{T}$$

$$SF = \frac{252,462}{206,107}$$

$$SF = 1.22$$

RAG 4/29/64

BLG 4/64

WATER UNITS			$\phi$ TAN $\phi$	
SECT	$X_m$	$R_s$		
1	2.00	2.07	30°	0.577
2	2.08	2.16	35°	0.700
FOUND, 544	2.20	2.32	37°	0.754

UPPER NORTH RIVER  
SITE 77  
E 0.94 VA  
1° 30' H & V

10X10 TO THE INCH 350,000 G  
REPRODUCED

SE 30

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WATER UNITS

38°

0.16°

SECT 1-3

1820

SECT A

1820

SECT 2

1800

SECT 1

1770

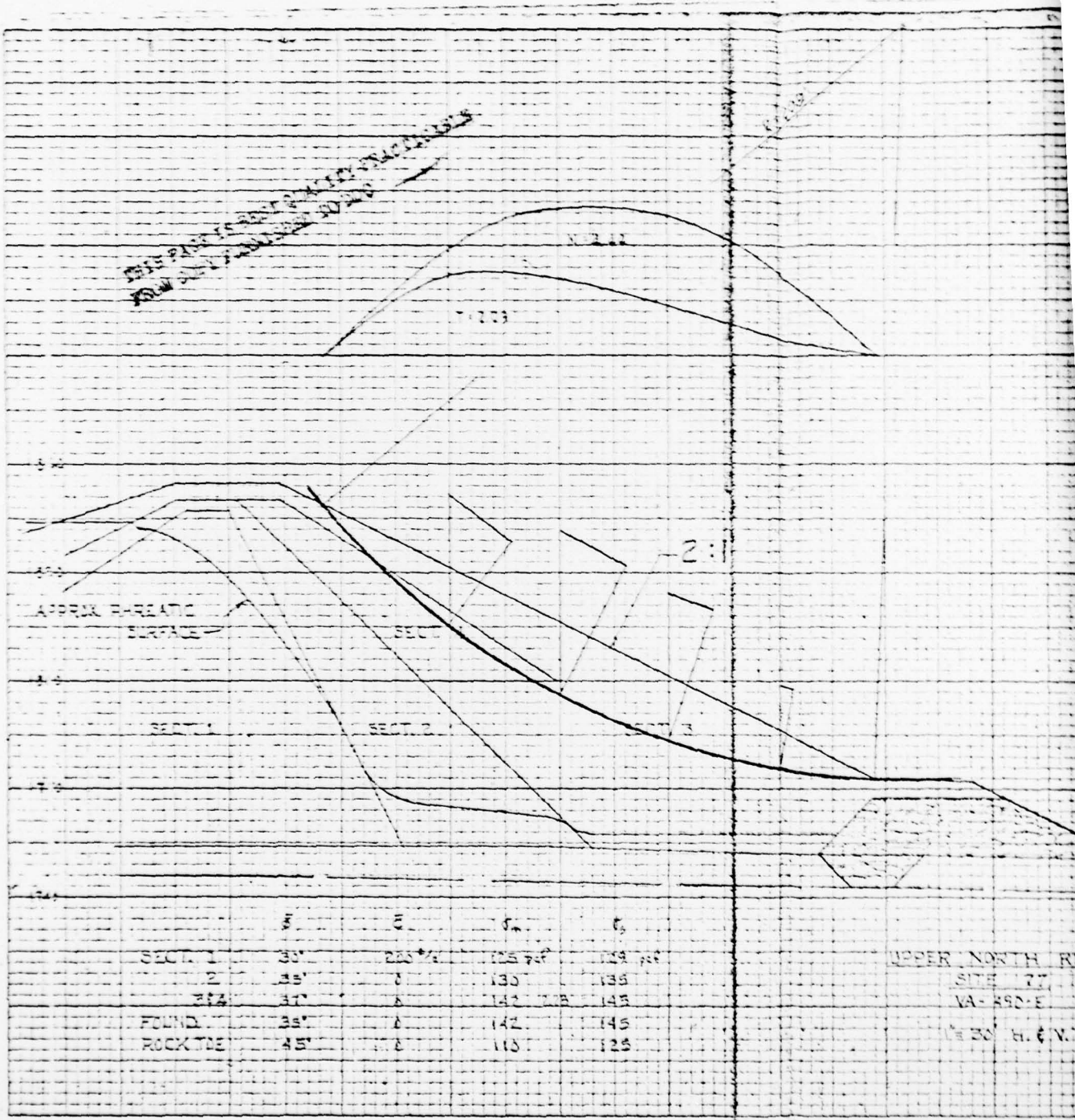
1740

	0	1	2	3
SECT. 1	35	200	125	129
2	35	0	130	135
34	37	0	142	145
EDUND.	35	0	142	145
ROCK	45	0	110	125

2



THIS PART IS NOT EXACTLY FACTUAL  
 FOR ONLY APPROXIMATE TO 200'



	W	E	S	N
SECTION 1	30'	220' ±	125' ±	129' ±
SECTION 2	45'	0	130	135
SECTION 3	35'	0	142' ±	145
FOUND.	35'	0	142	145
ROCK TIE	45'	0	110	125

UPPER NORTH RY  
 SITE 77  
 VA-890-E  
 1:20 H. & V.



					EM 35
N TAN 2	=	900	x	62.4 x 4.42	= 187.912
T	=	900	x	62.4 x 2.02	= 117.374
S.F.	=	187.912	=	1.60	
		117.374			

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3.0.0. 4.0.0  
1.0.0. 4.0.0

APPENDIX VII

ANNUAL MAINTENANCE INSPECTION REPORT

## Upper North River Watershed Structures

The Operation and Maintenance Inspection of the Upper North River Watershed Dams Nos. 76, 77, and 10 was made May 24, 1978. The inspection team consisted of E. Folger Taylor, W. E. Lucas, Jr., of the Headwaters SWCD; John Hart, Jr., City of Staunton; Don Parslow, U. S. Forest Service; and Wayne M. Hypes, SCS.

Dam #76 - Elkhorn Lake - The Report of Inspection of 1977 was referred to. The City of Staunton had removed the woody debris from the wet surface of the dam. A seedbed had been prepared and area seeded to Ky 31 Fescue and other grass. The grass is coming up nicely. Damage done to the small woody growth had been cleaned up.

The pipe overflow and trash rack appear to be in good shape. The catwalk has worked off its base at face of the dam. No structural weakness is caused by this. The catwalk has shifted a few inches out of line.

The seep on the dry slope, between the berm and toe approximately 20 feet from the gutter does not appear to be changing any. No sluffing is being created; therefore, no weakness. The rubble gutters are both in good shape. The outlets of the pipes are sound and the stilling basin is functioning properly.

Considerable Crownvetch is beginning to establish on the emergency spillway berm slopes. The floor of emergency spillway outlet has good vegetation on it and is in good shape. The outlet to the drainage for the control section of the spillway has become clogged by falling stone. The damage at present does not justify disturbing a large area to remove the accumulated loose stone. The berm on the wet side of the dam needs to be observed.

The City of Staunton is to be commended for their good job of removing the debris and reseeding the area of the dam.

It should be pointed out that if the rest of the dam is not mowed before long there will be a much larger area to be reseeded. The woody growth (locust and wild cherry) is getting started along the gutters and needs to be cut and killed. There is one locust that is now approximately six inches in diameter and many that are two inches or larger.

The area adjacent (in the emergency spillway) to the debris disposal that was scrap piling the debris should be observed closely this summer, and if the vegetation is weak or sparse, it should be fertilized and overseeded this fall.

Dam #77 - Hearthstone Lake - While woody growth was mowed and the stumps treated in 1977, the structure needs to be mowed to control the vegetation in the future.

The riser, trash racks and outlet pipe appear to be sound. The stilling basin is working properly. The berms and gutters are in good shape.