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Name Of Dam: UPPER NORTH RIVER NO. 76 (ELKHORN LAKE)
Location: AUGUSTA COUNTY, VIRGINIA
Inventory Number: VA. NO. 01506

LEVEL II

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED FOR

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

Richmond, VA

BY

SCHNABEL ENGINEERING ASSOCIATES, P.C./
J. K. TIMMONS AND ASSOCIATES, INC.

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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.

NAME OF DAM: UPPER NORTH RIVER NO. 76 (ELKHORN LAKE)
LOCATION: AUGUSTA COUNTY, VIRGINIA
INVENTORY NUMBER: VA. NO. 01506

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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

BY

SCHNABEL ENGINEERING ASSOCIATES, P.C./
J. K. TIMMONS AND ASSOCIATES, INC.

PREFACE

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

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

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

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

TABLE OF CONTENTS

Name of Dam: Upper North River No. 76 Dam, Va. No. 1506
State: Virginia
County: Augusta County
USGS Quad Sheet: Stokesville
Coordinates: Lat 38° - 19.6' Long 79° - 13.25'
Stream: Upper North River
Date of Inspection: December 13, 1978

BRIEF ASSESSMENT OF DAM

Upper North River No. 76 is a zoned earthfill structure about 824 ft long and 118 ft high. The principal spillway consists of twin 42-inch prestressed cylinder concrete pipes which extend through the structure. Water is discharged into the principal spillway through a reinforced concrete riser and is expelled into a riprap – lined stilling basin along the downstream toe of the dam. The emergency spillway is a 215 ft wide vegetated earth and riprap side channel spillway. The dam is located on the Upper North River about 8 miles southwest of the community of Stokesville, Va., and was constructed for flood control and recreation. The dam was designed and constructed under the supervision of U.S. Soil Conservation Service, cooperating with the Shenandoah Valley Soil Conservation District, City of Staunton. The City of Staunton, Va., has a special land use permit with the U.S. Forest Service for the construction and operation of the dam.

The dam will pass the probable maximum flood (PMF). Therefore, based on criteria established by the Department of the Army, Office of the Chief of Engineers (OCE), the spillway is rated adequate.

The visual inspection revealed no apparent problems and there are no immediate needs for remedial measures. The actual embankment structure appears to be similar to the "as built" drawings. We do recommend that vegetation be routinely controlled. The slopes, the crest of the structure, and the spillway should be mowed several times a year and existing small trees or saplings removed at least once a year. The slopes of the dam meet the requirements recommended by the U.S. Bureau of Reclamation for zoned earthfill dams. A summary of the stability analysis of the upstream and downstream slopes under rapid drawdown and steady seepage conditions was reviewed and assumptions, test data, and the resultant factors of safety were found to be acceptable.

Submitted by:

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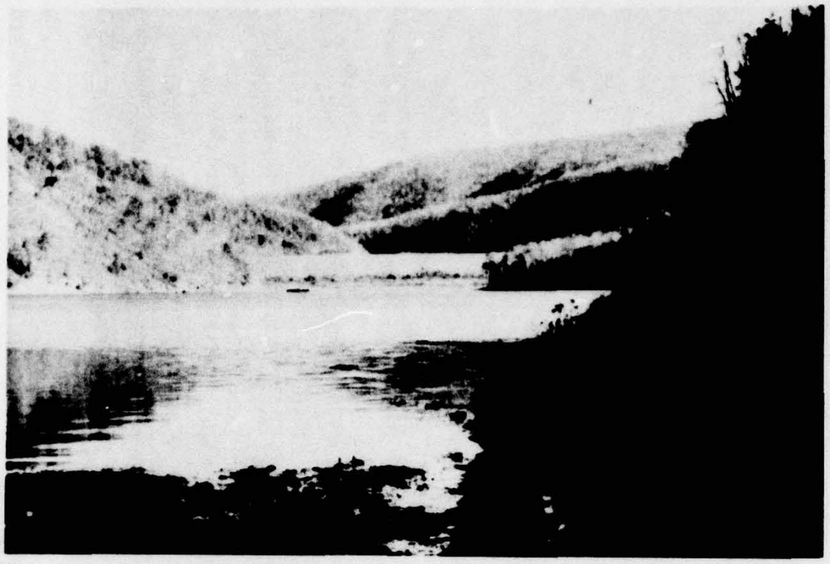
Date: MAR 15 1979



OVERALL VIEW - ELKHORN LAKE
(View from the West)

OUTLET STRUCTURES - ELKHORN LAKE
(View from the East)

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
UPPER NORTH RIVER NO. 76 DAM VA. # 1506
(ELKHORN LAKE DAM)

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 (see Reference 1, Appendix VI). The main responsibility is to expeditiously identify those dams which may be a potential hazard to human life or property.

1.2 Project Description:

1.2.1 Dam and Appurtenances: Upper North River Dam No. 76 is a zoned earth-fill structure about 824 feet long and 118 feet high. The top of the dam is 28 feet wide and is at elevation 2084.0 ft M.S.L. Side slopes are 2.5 horizontal to 1 vertical (2.5:1) on the downstream side and 3:1 on the upstream side. Ten foot wide berms exist on the downstream and upstream slopes at El 2025 and 2017, respectively.

The principal spillway consists of twin 42-inch diameter prestressed cylinder reinforced concrete pipes, running through the dam. Discharge into the conduits is provided by a 9 x 10.5 ft reinforced concrete riser with an inlet crest elevation of 2015.5 M.S.L. The riser has three inlets, each at a different elevation, located below the inlet crest. The inlets are used for low flow discharges or to drain the lake depending on sediment buildup. The riser is founded on sandstone and mudstone bedrock.

The emergency spillway, which is a vegetated earth channel having a bottom width of 215 feet, has a crest elevation of 2070.0 M.S.L., which is 14 feet below the top of the dam. The emergency spillway is in cut on the right side and on fill on the left side, and is located off the right end of the dam. The emergency spillway has a vegetative cover in all areas except where excavated rock forms the channel. The spillway has variable side slopes of about 1.25:1 to 2.5:1. The cut area of the emergency spillway is in weathered sandstone, shale, and mudstone bedrock. This information can be found in Appendix I, titled "Maps and Drawings", contained in this report.

1.2.2 Location: Upper North River Dam No. 76 is located on Upper North River about eight miles southwest of the community of Stokesville, Virginia. The reservoir formed by the dam is known locally as Elkhorn Lake. (See Sheet 1, Appendix I).

1.2.3 Size Classification: The dam is classified as a "large" size structure because of the dam height of 118 feet.

1.2.4 Hazard Classification: The dam is located in a rural and heavily forested area. However, based upon the close downstream proximity of Staunton Dam (the principal water supply source for the City of Staunton), the dam is assigned a "High" hazard classification. 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 City of Staunton has a special land use permit with the U.S. Forest Service for the construction and operation of the dam.

1.2.6 Purpose: Flood Control and Recreation

1.2.7 Design and Construction History: The dam was designed and constructed under the supervision of the U.S. Soil Conservation Service. Responsibility for construction was by Shenandoah Valley Soil Conservation District and the City of Staunton, during 1962-1963. The dam was completed in 1965.

1.2.8 Normal Operational Procedures: The principal spillway is ungated, therefore, water rising above the crest of the drop inlet automatically is discharged downstream in quantities based on the inlet capacity. Similarly, water is automatically passed through the emergency spillway in the event of an extreme flood which creates a pool elevation above that of the emergency spillway.

1.3 Pertinent Data:

1.3.1 Drainage Areas: The original design (SCS) indicated a drainage area of 27.1 square miles which has been verified and found to be reasonable.

1.3.2 Discharge at Dam Site: Maximum known flood at the dam site occurred in 1972. Inflow was approximately 2400 CFS and all discharge was through the principal spillway.

Principal Spillway:

Pool Elevation at Emergency Spillway Crest	805 CFS
Pool Elevation at Crest of Dam	862 CFS

Emergency Spillway:

Pool at Crest of Dam	41,200 CFS

1.3.3 *Dam and Reservoir Data:* See Table 1.1, below.

Table 1.1 DAM AND RESERVOIR DATA

		Reservoir			
			Capacity		
Item	Elevation feet M.S.L.	Area Acres	Acre Feet	Watershed Inches (a)	Length Miles
Crest of dam	2084.0	274	10,500(b)	7.6	1.4
Maximum pool, design surcharge	2074.7	227	8,090(b)	5.59	1.2
Emergency spillway crest	2070	221	7,020(b)	4.85	1.1
Principal Spillway crest	2015.5	53.5	3,066	3.5	0.5
Streambed at Center-line of dam	1966				

(a) Based on 27.1 sq.mi.
(b) From top of sediment pool

SECTION 2 - ENGINEERING DATA

2.1 Design: The dam was designed and constructed under the direction of the U. S. Soil Conservation Service (SCS) and was sponsored by the City of Staunton. As-built drawings and design data are available in the office of the State Conservationist, U. S. Soil Conservation Service, Federal Building, Room 9201, 5th and Marshall Streets, Richmond, Virginia 23240.

A subsurface investigation was conducted at the site by the SCS during the initial design stages. The investigation consisted of drilling 26 test borings and excavating 40 test pits. Subsurface profiles and a report of the investigation with foundation recommendations were prepared based upon permeability tests, test boring, and test pit data. The geologic report is available at the above referenced SCS office. Subsurface profiles are shown on Sheet 5, Appendix I.

The dam is a zoned, compacted earthfill embankment. The design recommendations shown on Sheet 1, Appendix I, specify that SM or SC materials be used in the core or Section No. 1 of the dam. On the downstream side, the core is blanketed with a 20 ft± thick zone of GM and GW material, designated Section No. 2. Section No. 2 is covered by Section No. 3, which consists of coarse GW material. The upstream portion of the core is overlain with finer GW material designated Section No. 4. A thin zone of finer GW material is located behind the downstream toe drain and is designated Section No. 4-A. The pervious downstream shell of Section No's. 2 and 3 control the phreatic surface.

A review of design drawings indicates the dam is founded on overburden and includes a cutoff trench which extends approximately 1 ft± into bedrock. Both abutments are described as being water-tight, however, some water leakage was expected, principally through fracture zones in the rock beneath the dam. This was not considered critical in the design report and the possibility of piping was not believed a problem due to the hardness of the rock.

To control the phreatic water surface and to collect seepages, a rock toe drain was constructed along the downstream portion of the dam. This drainage system consists of a trench 10 ft wide at its base and a minimum 8 ft deep, filled with material graded in size from 1 to 24 inches. Twenty-three reinforced concrete anti-seep collars (see Sheet 8, Appendix I) were installed around the principal spillway pipes, under the entire dam and spaced at 24 ft intervals in order to control any potential piping problems along the pipes. Riprap gutters approximately 1.5 ft thick and ranging from 9 to 15 ft in width were constructed adjacent to both abutments to control local surface runoff.

The emergency spillway located adjacent to the right abutment was formed by making a side hill cut into residual soils and bedrock consisting primarily of very fine silty sandstone. Shale and mudstone were also probably encountered during excavation. Design drawings indicate compacted fill was placed locally to bring low areas in the spillway up to design grade. A berm was also constructed to form the left side of the spillway which is riprap lined.

The design report includes detailed laboratory test data describing the physical properties of the materials used to construct the embankment. Shear strength parameters used in design for the core, shell, and foundation material were determined by triaxial compression tests as follows:

SECTION	SHEAR STRENGTH PARAMETERS	
	Angle of Internal Friction	Cohesion
Core	$\phi = 23.5^\circ$	$C = 500$ psf
	$\phi' = 31.5^\circ$	$C' = 350$ psf
Shell	$\phi = 38.7^\circ$	$C = 0$
Foundation	$\phi = 36.0^\circ$	$C = 0$

The Modified Swedish Circle Method of Analysis was used and included evaluation of 1) the end of construction case, 2) the sudden drawdown case (I), and 3) the steady seepage case (III). Both effective and total strength parameters were utilized as dictated by the stability condition.

2.2 Construction: The construction records were not furnished by the SCS office in Richmond, but they are available from the SCS office in Washington, D.C.

2.3 Operation: There is no known operation and instrumentation procedure.

2.4 Evaluation: Engineering calculations are adequate and the design drawings are representative of the dam. There are no records available for dam performance.

SECTION 3 - VISUAL INSPECTION

3.1 General:

An inspection was made 13 December 1978 and the weather was partly cloudy with a temperature of 45°F. The pool elevation at the time of inspection was 2015.75 M.S.L. and the tailwater elevation was 1966.5 M.S.L., which corresponds to normal flows.

3.2 Findings: Field observations are outlined in Appendix III.

3.2.1 Dam and Spillway: There is tree and tall grass growth on the embankment and on the emergency spillway. Wet spots were observed along the drainage berm located at El 2026± on the downstream slope of the structure. An area of damp soil was also located about 20 ft right of the left abutment and about 50 ft. downstream of the drainage berm. Inlet structure and outlet works are in good condition.

3.2.2 Reservoir Area: Shoreline has no debris collection on banks or vegetation growth along shoreline in the water. Bank slopes are approximately 2:1 and show no sloughing or surface erosion. Inlet and outlet works show no deterioration.

3.2.3 Downstream Area: Staunton Dam is located approximately 9,000 feet downstream from Elkhorn Lake Dam and the U.S.G.S. mapping of the downstream area indicates no inhabited dwelling in the region.

3.3 Evaluation: Overall, the dam was in good condition at the time of inspection. However, some minor remedial measures are required. Uncontrolled growth encourages the development of deep rooted vegetation. This type of growth can encourage piping within the embankment and undermine riprap protection. Also, excessive growth inhibits effective visual inspections of the dam. The embankment, including its crest, slopes, and emergency spillway, should be mowed at least once a year, but more preferably twice a year. Small trees presently growing near the left abutment and on the downstream slope should be removed.

Wet spots observed along the drainage berm on the downstream slope are probably the result of recent ponding from precipitation, and runoff along low areas in the berm. The general location of these wet spots is illustrated on Sheet 2 in Appendix I. These wet spots occur at El 2026±, while normal pool is at El 2015.5, therefore, they are not the result of seepage. The downstream berm slopes toward both abutments to the riprap gutters, thus providing an adequate drainage system for collecting runoff. If increased ponding continues in the future, local grading may be required to allow better drainage of this berm.

The area of damp soil illustrated on Sheet 2, Appendix I, is believed to occur because of seepage of the water ponded above in the drainage berm. This condition is not believed to be related to seepage through the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures:

Elkhorn Lake is used as a source of water supply for the City of Staunton and for flood control purposes for Staunton Dam approximately 2 miles downstream. The normal pool elevation is maintained by a riser-type inlet acting as the principal spillway. During periods of below-normal flows, water flow is maintained through the dam by utilizing the valved inlets below the spillway crest. Operation of these inlets will lower the pool elevation below the spillway crest but will ensure flow to the City of Staunton water intake at Staunton Dam. During periods of above normal flows the pool elevation rises above the riser inlet increasing the flow through the inlet. Large increases in inflows which cannot be absorbed by storage are passed through the emergency spillway when the pool rises above elevation 2070.

4.2 Maintenance of Dam and Appurtenances: The maintenance is the responsibility of the City of Staunton and appears to be performed well. The operating appurtenances are in good working order, however, the vegetative growth on the embankment has not been maintained in the past year.

4.3 Warning System: No warning system exists. As noted, no inhabitable structures exist between this structure and Staunton reservoir.

4.4 Evaluation: The dam and appurtenances are in good operating condition and maintenance is being routinely performed except on the vegetative cover of the embankment. A mowing routine should be established and all trees removed from embankments.

SECTION 5 - HYDRAULICS/HYDROLOGIC DESIGN

5.1 Design: The Upper North River Dam (Elkhorn Dam) was designed by the Soil Conservation Service (SCS) as a multipurpose dam and complete hydrologic and hydraulic data is available. This structure is a Class "C" dam by the SCS classification method.

The crest of the riser of the principal spillway was established at elevation 2015.5 M.S.L., which would provide storage for a sediment pool and provide recreation (fishing and aesthetics). The capacity of the control structure was established to maintain a pool elevation below the emergency spillway during a 100-year flood. The emergency spillway is designed to accomodate the Probable Maximum Flood (PMF) without overtopping of the dam.

5.2 Hydrologic Records: There is a gaging station (1-6205) approximately one mile upstream of the structure on the North River measuring flow from 17.2 square miles. Records for this station have been maintained since 1947 by the U.S. Geological Survey. Some of the highest discharges recorded at this gaging station are 11,100 CFS in 1949, and 2400 CFS in 1972.

5.3 Flood Experience: The maximum pool elevation observed was reached during a storm in October 1972. The gaging station immediately upstream indicated a flow of 2400 CFS on October 5, 1972.

5.4 Flood Potential: The Probable Maximum Flood (PMF), ½ PMF, and 100-year Flood hydrographs were developed by the SCS method (Reference 4, Appendix VI). Precipation amounts for the flood hydrographs of the PMF, ½ PMF, and 100-year Flood were taken from the U. S. Weather Bureau information (References 5 & 6, Appendix VI). Appropriate adjustments for basin size and shape were accounted for and emergency spillway hydrograph determination procedures as outlined in Reference 5, Appendix VI were used for the flood hydrographs. These hydrographs were routed through the spillway to determine maximum pool elevations.

5.5 Reservoir Regulation: The principal spillway is a riser-type control structure with a combined throat opening of 21 linear feet. This structure passes water through two 42-inch concrete pipes. The principal spillway maintains a normal pool elevation of 2015.5 and has gates at elevations 2005, 1995, and 1979 for purposes of dewatering and maintaining flow during periods of extreme low flow. During periods of flooding, the principal spillway is designed to accommodate the 100-year Flood with 9'± freeboard on the emergency spillway. Stream flows in excess of the 100-year Flood are passed through the emergency spillway at elevation 2070. For routing purposes the pool elevation at the beginning of the flood was assumed to be 2015.5. Reservoir stage-storage data and stage-discharge data were taken from the

SCS hydraulic calculations available. Floods were routed through the reservoir using the principal spillway discharge up to a pool storage elevation of 2070 and a combined principal and emergency spillway discharge for pool elevations above 2070.

5.6 Overtopping Potential: The predicted rise of the reservoir pool and other pertinent data were determined by routing the flood hydrographs through the reservoir as previously described. The results for the two flood conditions (PMF, ½ PMF, and 100-year Flood) are shown in the following Table 5.1.

Table 5.1 RESERVOIR PERFORMANCE

	Normal Flow	Hydrograph		
		100-Yr	½ PMF	PMF
Peak flow, C.F.S.				
Inflow		9284	18,446	43,700
Outflow		708	803	36,232
Maximum Elevation, ft M.S.L.	2015.5	2048.14	2069.63	2082.94
Freeboard (ft)		35.86	14.37	1.06
Emergency Spillway (El 2070)				
Depth of flow, ft	N/A	N/A	N/A	12.94
Duration, hours				1.0
Velocity, F.P.S.				20.75
Principal Spillway (El 2015.5)				
Head, ft		32.64	96	110
Duration, hours	N/A	4.0	3.0	1.0
Velocity, F.P.S.		39	41.8	45
Tailwater Elevation, ft M.S.L.	1966.5*	1968.75	1968.9	1986.5

*This is the tailwater elevation observed during inspection and it corresponds to a normal flow.

5.7 Reservoir Emptying Potential: A 36-inch circular gate at elevation 1979.0 will drain the reservoir through two 42-inch aqueducts. Assuming that the lake is at normal pool elevation (2015.5) and an average inflow of 21 CFS is maintained, it would take approximately 2.5 days to lower the reservoir to elevation 1979.0. There are no methods for lowering the reservoir below this elevation.

5.8 Evaluation: Flood routing calculations indicate that the reservoir will rise to within one foot of the top of the earth embankment for the PMF and discharge for a period of 1 hour at a velocity of 17.5 feet per second. Hydrologic and hydraulic determinations of the project as prepared by the SCS appear reasonable. The appropriate spillway design flood is the PMF due to the "High" hazard conditions existing downstream. The emergency spillway will pass 100 per cent of the PMF.

Hydrologic data used in evaluation pertain to present day conditions with no consideration given to future development.

SECTION 6 - DAM STABILITY

6.1 Foundation and Abutments: Upper North River Dam No. 76 is founded on alluvial, colluvial and/or residual soils, all of which are underlain by the Hampshire Formation. The structure includes a 20 to 50 ft± wide cutoff trench, which extends to bedrock. The principal spillway is founded primarily on sandstone, however, the outlet is underlain by sandy mudstone. The emergency spillway is in cut material, which included weathered sandstone, siltstone and mudstone. "As-built" drawings of these various areas are shown on Sheets 2 and 5, Appendix I. The test boring and test pit logs are included as Sheets 3 and 4, Appendix I.

The dam site is located within the Valley and Ridge Physiographic Province of Virginia, which is underlain by sedimentary rocks from Middle Cambrian through Early Mississippian age (see Reference 3, Appendix VI). In the Staunton area, the province consists of the Shenandoah Valley to the east and a series of much narrower valleys and intervening ridges to the west. The eastern portion of the province includes southeastward-dipping thrust faults and asymetric folds, which are overturned to the northwest. More open folds are common in the central and western areas. Most ridges are "held up" by sandstones and conglomerates, whereas valleys are underlain by less resistant shales and limestones.

The dam site is underlain by rocks of the Hampshire formation of Late Devonian age. The Hampshire is approximately 2200 ft thick and includes moderately to thick-bedded, brown, medium-grained, arkosic and micaceous sandstone and lumpy red to green mudrock and shale. The structure rests on the west limb of the West Mountain Syncline, approximately 2000 ft west of the synclinal axis, which strikes 40 degrees ± to the northeast. The left abutment consists of a steep natural slope (70°±). The right abutment/emergency spillway is bound by a very steep manmade cut over 100 ft in height. This cut includes three 10 ft wide berms.

Sandstone bedrock is exposed in the left abutment, while sandstone, shale and mudstone are exposed in the emergency spillway cut. The sandstone is brown to gray in color, fine to medium grained, thin to massive bedded and close-jointed. The shale is brown to red in color. The geologic report describes bedrock strikes ranging from north to 70 degrees northeast and dips ranging from 9 to 15 degrees southeast. Measured attitudes in the field agree with those reported above. Wedge-shaped joint patterns were observed in the north abutment. These joints dip steeply and strike from 25 degrees northwest to 85 degrees northeast. No faults were observed in the field during this investigation and geologic maps of the area do not show the presence of faults in the immediate vicinity.

The potential for seepage does exist within the foundation since the dam is founded, at least in part, on sandy and gravelly soils. This material ranged in depth up to 40 ft± in the terrace deposits encountered in the right abutment. Rock was exposed in the stream channel. Field permeability tests show that this material is permeable to very permeable. In an attempt to control potential seepage, a cutoff trench was constructed and reportedly extends 1 ft± into firm bedrock. The geologic report describes the underlying bedrock as being quite impermeable; however, some seepage was expected through joint systems in the rock.

6.2 Embankment: The upstream slope is 3 horizontal to 1 vertical with crest at El 2084. At El 2017 the slope flattens to 10 horizontal to 1 vertical forming a berm for a vertical distance of 1 ft. The slope continues at 3 horizontal to 1 vertical to natural ground. Normal pool level is El 2015.5 or 0.5 ft below this berm. The downstream slope is 2.5 horizontal to 1 vertical with a drainage berm at El 2025. This 10 ft wide berm slopes towards the dam at 10 horizontal to 1 vertical. A sloping core consisting of SM and SC material with 3/4 horizontal to 1 vertical slope is provided to El 2070, the same grade as the crest of the emergency spillway. A typical section of the dam is included on Sheet 6, Appendix I. The core material is designated Section No. 1. The material comprising the downstream shell becomes progressively coarser ranging from GM and GW in Section No. 2 to GW in Section No. 3. The upstream shell designated Section No. 4 is also GW material with a finer gradation than the downstream shell. The downstream shell may be considered pervious with drainage from the core or underseepage from the foundation passing to the downstream rock toe drain, Section 4A.

6.3 Evaluation:

6.3.1 Foundation and Abutments: Dam foundations must be evaluated on the basis of potential settlement, sliding and seepage. Excessive settlement of the dam is not believed to be a problem because the structure rests upon fairly competent bedrock and firm to compact alluvial, colluvial, and/or residual soils. Gradual consolidation of underlying soils would be expected during application of fill materials. The underlying soils probably had essentially fully consolidated under the applied load at the end of the construction period.

Sliding within the foundation bedrock does not appear likely based upon the design load and the nature of the Hampshire formation. In addition, a review of the geologic data indicates that there are probably no adversely oriented weak planes within the foundation rock that would act as a potential sliding plane.

Seepage was not considered a problem in design because the underlying bedrock was believed not to be susceptible to piping. Since construction reports were not available for review, an accurate determination of the foundation conditions under the cutoff trench is not possible.

The steep slopes which form the right side of the emergency spillway are cut into partially weathered sandstone, shale and mudstone, and were considered safe and stable at the time of investigation.

6.3.2 Embankment: The embankment slopes meet the requirement recommended by the U.S. Bureau of Reclamation for small zoned earthfill dams on stable foundation. Since no undue settlement, cracking or seepage was noted at the time of inspection, it appears that the embankment is adequate for maximum pool level with water at El 2074.7.

The stability analysis was performed with a section slightly different than actually constructed. However, the geometry of the dam corresponds very closely to "As-Built" drawings. The differences are not considered significant. The strength parameters described in Section 2 were used in the stability analysis. The report describing the engineering design data used in the stability analysis is included in Appendix IV. These data were reviewed along with the stability analyses and were found to be acceptable. The factor of safety of the upstream slope for the drawdown condition is 1.52 as given in Appendix IV. Reference 1, Appendix VI recommends a factor of safety of 1.2. The factor of safety for the downstream slope under steady seepage condition with drain (shell) at c/b = 0.6 is 1.82. The required factor of safety is 1.5 according to Reference 1.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment: The Upper North River No. 76 Dam at the time of inspection appeared sound and in a safe operating condition. The spillway will pass the PMF without overtopping the dam and is considered adequate. There is no apparent problem that requires immediate action for the normal pool conditions based on the visual inspection and a review of existing records. The actual embankment structure appears to be similar to the "as-built" drawings. Without the construction records, the conformance of the embankment material properties to design requirements cannot be assessed. The design factor of safety for rapid drawdown and steady seepage cases meet the requirement of Reference 1, Appendix VI, and the embankment slopes meet the requirements recommended by the U. S. Bureau of Reclamation, Reference 2, Appendix VI, for small zoned earthfill dams on stable foundations.

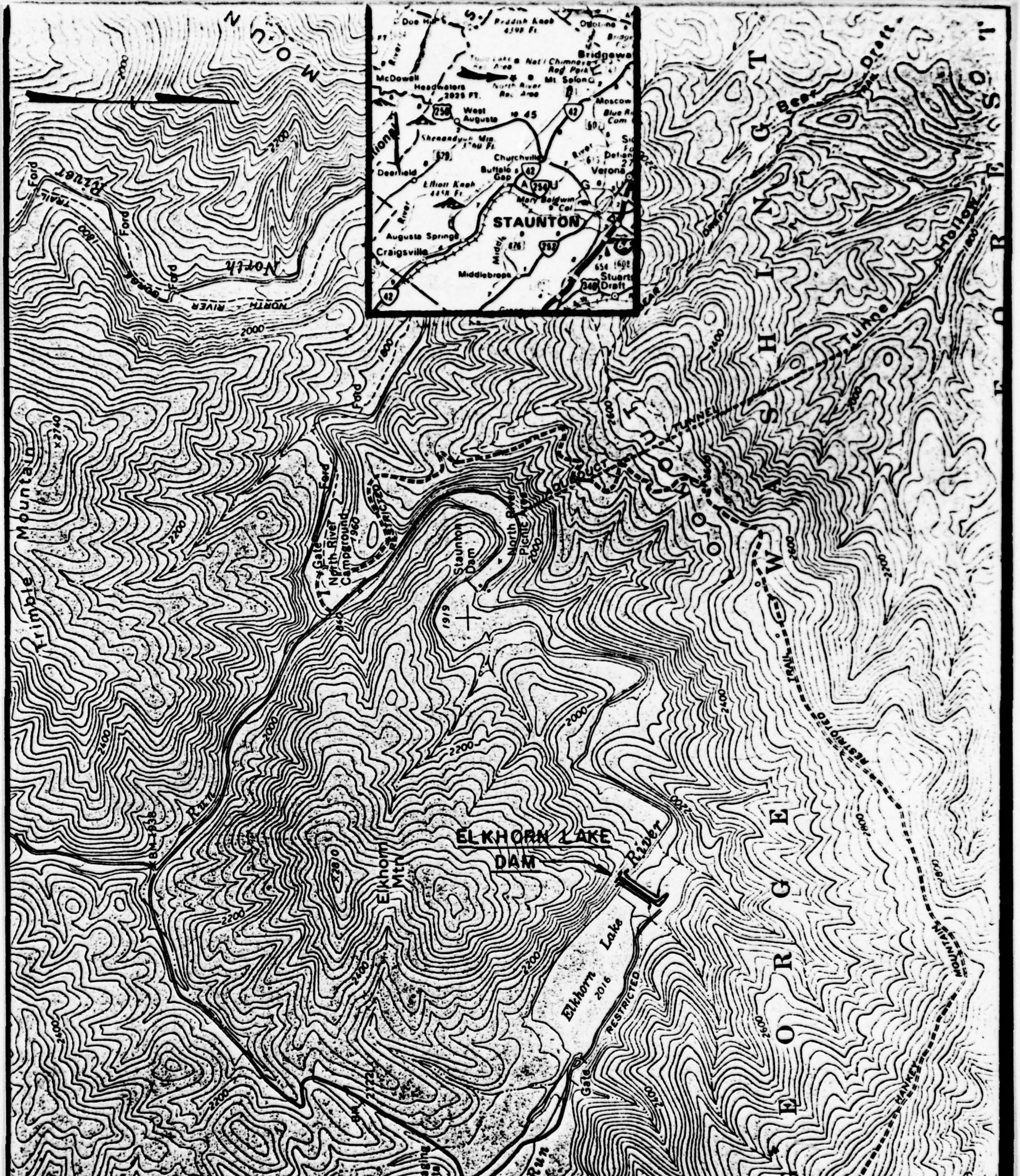
7.2 Remedial Measures: There is no immediate need for remedial measures; however, the following maintenance is suggested and should be initiated yearly. These measures are suggested for monitoring and maintenance purposes only.

7.2.1 The grass and weeds along the dam crest, slopes, and within the emergency spillway should be cut at least once and preferably twice a year. We would recommend maintenance in the early summer and fall.

7.2.2 Removal of all trees or saplings from the above described areas should be accomplished every year.

APPENDIX I

MAPS AND DRAWINGS

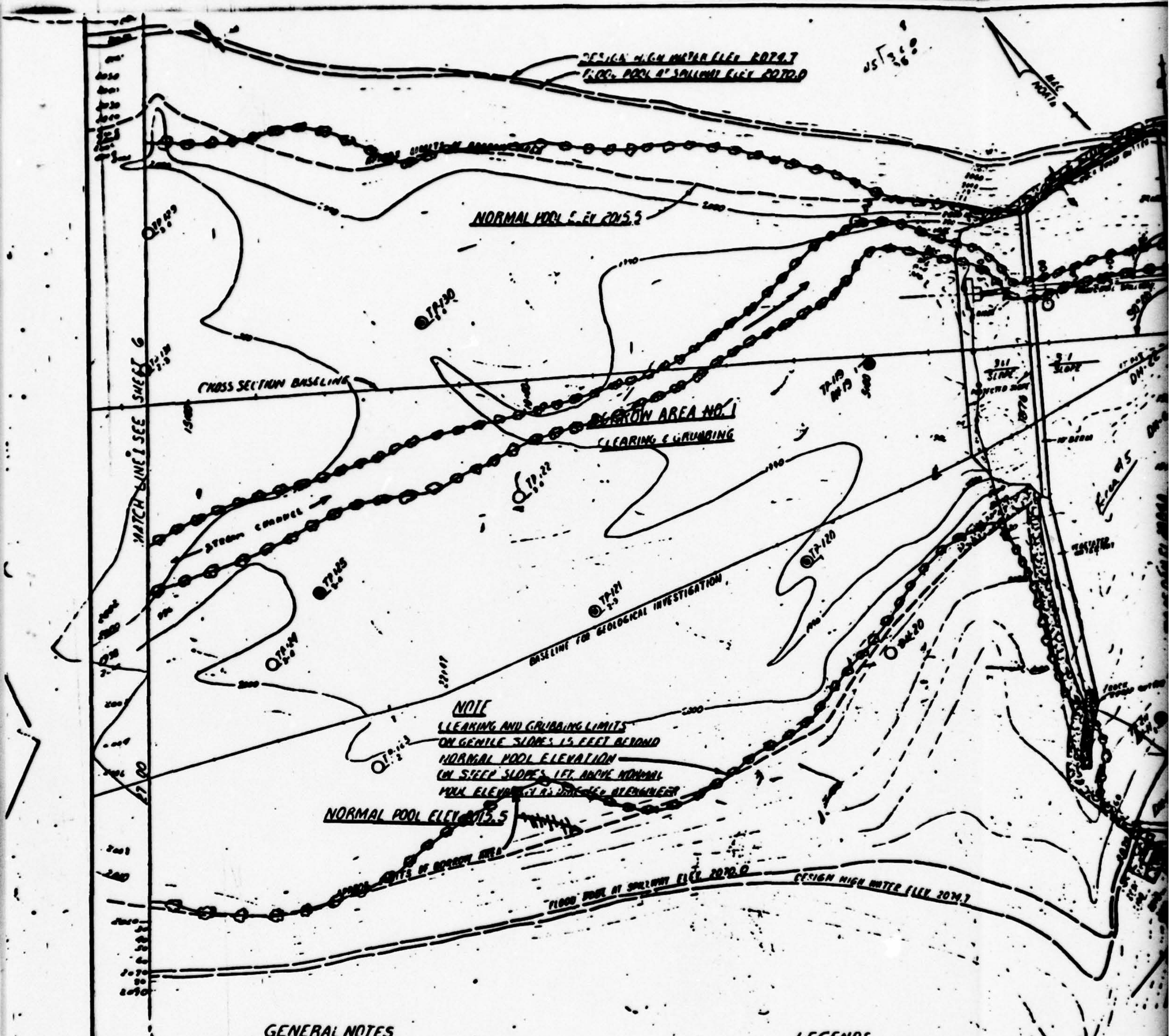


SCALE 1" = 2000' ±

STOKESVILLE, VA.

SW/4 PARNASSUS 15' QUADRANGLE

SHEET 1



NOTE

CLEARING AND GRUBBING LIMITS ON GENTLE SLOPES 15 FEET BEYOND NORMAL POOL ELEVATION ON STEEP SLOPES 1FT. ABOVE NORMAL POOL ELEVATION AS DIRECTED BY ENGINEER

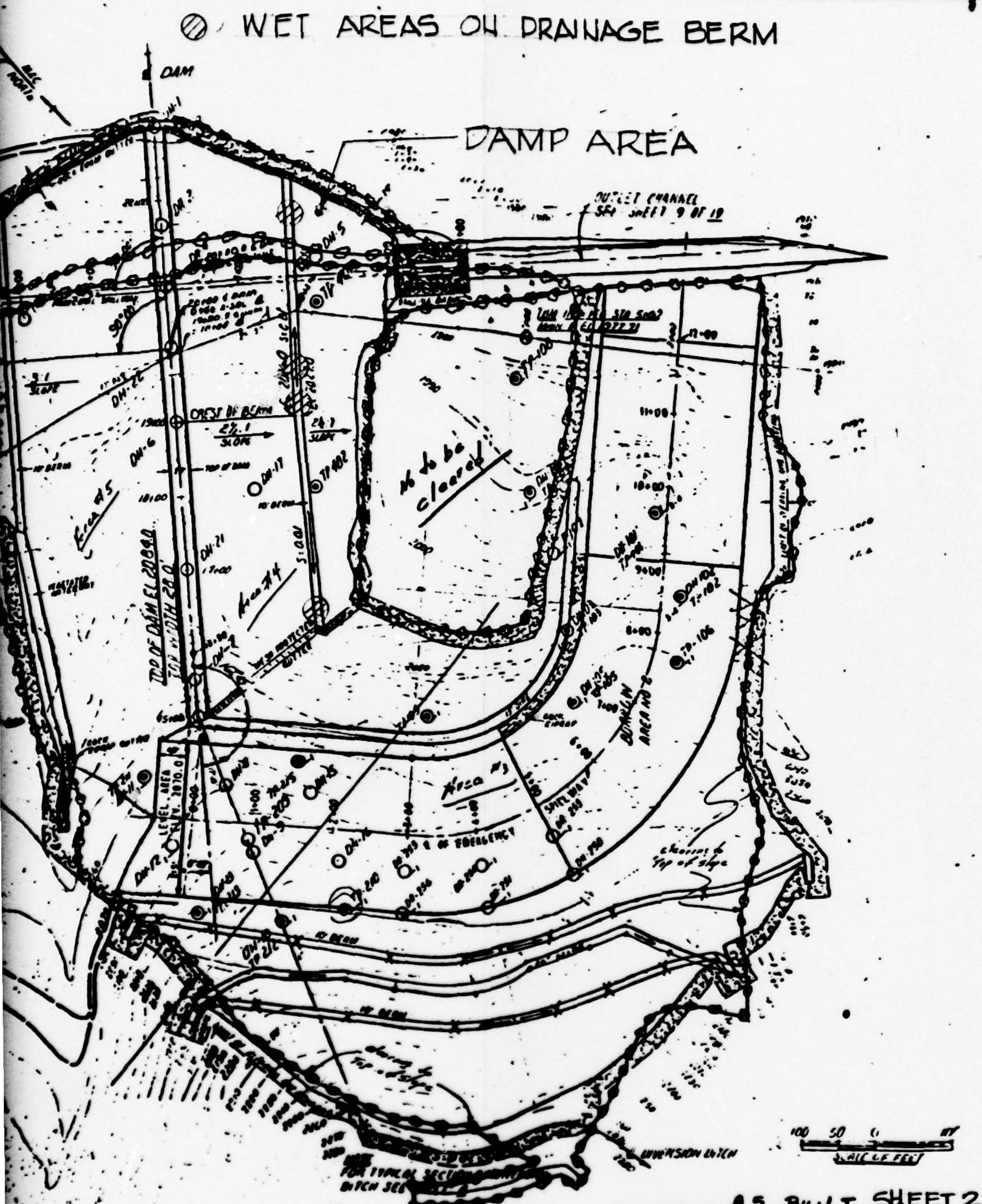
GENERAL NOTES

1. AREAS UNDER FILL, BORROW AREAS, AND EMERGENCY SPILLWAY TO BE CLEARED AND GRUBBED.
2. ENTIRE NORMAL POOL AREA TO BE CLEARED AND GRUBBED.
3. ALL COMPACTED FILL SHALL BE CLASS B-2 AND C, PLACED AS SHOWN ON PLANS AND AS DIRECTED BY ENGINEER IN FIELD.
4. THERE ARE APPROXIMATELY 25.7 ACRES OF LIMING, FERTILIZING, SEEDING PREPARATION AND MULCHING THIS INCLUDES THE EMBANKMENT ABOVE THE NORMAL POOL, EMERGENCY SPILLWAY SIDE SLOPES AND BOTTOM, AND ANY OTHER DISTURBED AREAS.

LEGENDS

~2000~	CONTOUR LINE
— — — —	NORMAL POOL LINE ELEV-2015.5
—•—•—	STREAM
⁓⁓⁓	LIMIT OF CLEARING & GRUBBING
DH or TP ○	TEST PIT OR DRILL HOLE (SOIL)
TP ●	TEST PIT - DISTURBED SAMPLE

TP OR DH ○$_{2}$ - ◎$_{2}$ TEST PIT FROM WHICH CONSTRUCTION MATERIAL WILL BE OBTAINED AND SUBSCRIPT INDICATES SECTION OF DAM WHERE IT WILL BE USED.



AS BUILT SHEET 2

UPPER NORTH RIVER WATERSHED
OF THE POTOMAC RIVER WATERSHED PROJECT
MULTIPLE PURPOSE DAM NO 77
AUGUSTA AND ROCKINGHAM COUNTIES, VIRGINIA
SITE LOCATION MAP

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

N. W. WILSON, R.S. BARNES JR. 6-62	
L.S. COFFMAN 8-62	
	VA-472-P 2

DH-1 Elev. [illegible]

Talus of weathered sandstone

Weathered very fine sandstone and siltstone

Hard well indurated silty sandstone very fine and very hard, rock, quartz

This mudstone area at [illegible], thin bedded to laminated with siltstone and very fine sandstone. Gray to dark gray. Lost water at [illegible].

Mudstone, red (dark) with some gray mottling (massive)

Gray silty mudstone. Very hard massive to 30'.

30-33.5 Interbedded very fine sandstone and siltstone and mudstone Gray to Black. Zone between 32-34 some iron on bedding planes to indicate water passage.

33.5 - 36 Basically a silty mudstone dark red with some very fine sandstone and siltstone interbedded with the massive mudstone.

Some gray mottled zones of very fine sandstone at 54, 56, 58, 62, 66 and 72'.

Some SiO_2 along bedding planes at 65', 66, 66.5, 74, 76'.

74 - 76 Black siltstone massive.

76 - 90 Interbedded massive red mudstone and gray to black very fine sandstone and siltstone.

Same as above.

Red massive mudstone with interbedded siltstone (gray).

90-103 Gray to black massive very fine sandstone, SiO_2 seam at 91'.

This sandstone has been fractured but these fractures are filled with SiO_2

This zone is hard like whole section. Quartz seam at 95.5. Some evidence of H20 movement.

103-107 very fine very hard mudstone with sandstone, almost a Quartzite and mudstone (Black).

107-120 very fine gray sandstone, some SiO_2 seams scattered throughout, filled joint between 107-111 filled by SiO_2.

Last run from 114.8 - 120 came out of core barrel in one piece had to be broken to put in core box, very hard well indurated Silica cemented very fine sandstone and some Carbonaceous material in lower sandstone and some Fe_2O_3. (Marcasite or pyrite)

DH-2 Elev. [illegible]

Talus

Siltstone very hard with seams of sandstone and black mudstone, some carbon flakes, black stain along joint faces, very hard and impervious bedrock.

Sandstone, siliceous, almost a quartzite, some black and iron stain along joints abundant carbon flakes and seams at 18'-19' and 21-25 (almost coal seams) Abundant iron stain at 25', evidence of water movement through this zone.

Mudstone, black very impermeable, core broken up between 41-42' leakage zone. Some splits of siltstone and very fine sandstone present but not enough to note location.

Transitional zone of mudstone and sandstone.

Silty quartzite, very fine and hard, pure quartz sand with sparce mica. Thin mudstone split with pyrite at 67'. This rock is very impermeable and competent.

DH-3 Elev. 1983.3'

Gravel, silty to well graded, rounded to subrounded pebbles to boulders. GM or GW

Quartzite very fine, some carbon along bedding 12' - 13' broken up along joints, iron stained

Mudstone silty black, with sandstone splits at 19 -21 and 22 - 23, rock is very impermeable, no evidence of leakage below 16'.

DH-4 Elev. [illegible]

Gravel, well graded to silty, [illegible]

Boulders with interstitial sand

Sandstone very fine to silty, weathered, abundant carbon flakes

Siltstone sandy or silty sandstone abundant carbon flakes and some mica

Mudstone silty, gray green

Siltstone sandy very fine, gray to black, abundant carbon, this rock is very hard.

Sandstone, like above but a silty sandstone, almost a quartzite, abundant carbon flakes and seams, 26-27' (carbon seams and pyrite) also at 29.5-30.5. Rock is very impermeable and this is shown by pressure testing data. There doesn't appear to be any water in rock as no pore space is present.

DH-5 Elev. 1976.0'

GW Gravel well graded, pebb
boulders

Mudstone, silty black to
gray, some evidence of
but not enough to
Black coating along joint
Rock is hard and impermeabl

DH-9 Elev. 2104.03'

ML or CL
Highly weathered siltstone, some clay and sand, forms a sandy silt ML or clay CL. Blow Count 8-16-31.

Same as above. Blow Count 14-26-41. ML

SM
Highly weathered sandstone, silty with pebbles of hard sandstone forms an SM. Blow Count 12-26-36.

Same as above but finer with little or no pebbles. Blow Count 16-28-42.

SM or ML
Weathered siltstone to sandstone, very fine, forms a SM to ML. Blow Count 18-29-52.

Sandstone weathered, very fine to silty, massive, some mica, black stain on joint faces.

Mudstone-siltstone yellow, some mica.

Sandstone, very fine to silty, tan black stain on joint faces, one foot mudstone split at 47'.

Mudstone, dark red, massive, all rock is weathered in this hole.

DH-10 Elev. 2128.3'
TP-212

GM or GW
Sandy to silty gravel, tan, very fine sandstone pebbles to cobbles.

Highly weathered silty sandstone SM or ML

Weathered silty sandstone forms a silty sand to sandy silt. SM-ML

Mudstone, silty

Sandstone weathered massive, siliceous in 38-43 hard, almost a quartzite. Some black stain along joints, some mica. Sandstone is very fine to silty. 47-50 abundant carbon flakes and thin coal seams.

Mudstone green

Sandstone, siltstone and mudstone interbedded, very weathered, some iron stain.

Mudstone green to gray, very fine

Sandstone, siliceous, massive, jointed black stain on joint faces (This zone may be too hard to rip) 62-66 abundant carbon flakes and seams.

Mudstone, silty gray-green, weathered.

Mudstone silty, red, massive, this rock should rip with difficulty.

DH-11 Elev. 2055.6'

Silty sand with pebbles, product of weathered sandstone tan to brown. Blow Count 8-16-24.

Same as above, forms almost a pebbly silt weathered very fine silty sandstone. Blow Count 11-40-56. SM

Highly weathered sandstone with abundant pebbles forms an SM. Blow Count 17-21-46. SM

Sandstone weathered, dark red, silty, broken up, some mica.

DH-12 Elev. 2061.7

SM Highly weathered sandst
very fine to silty, forms a
sand, with pebbles. Blow C
18-14-26.

SM Highly weathered sandst
siltstone, forms a very fi
sand. Blow Count 16-31-42.

SM or ML Highly weathered
to mudstone forms a SM to
fragments of mudstone. Blow
21-107-64

SM Weathered sandstone
sandstone fragments with
sand. Blow Count 16-31-

Sandstone, very fine to si
yellow-brown, some mica,
weathered.

Mudstone, red

Sandstone, siltstone and
interbedded, red-brown bla
black stain on joints

Mudstone, red massive

DH-17 Elev. 2007.86

GM
Silty gravel with sandstone pebbles to cobbles. *Blow Count 5-6.5' - 24-17-38.

Silty gravel same as above. Boulder at 10 feet. Blow count 140 blows for 0.3'.

Same as above, blow count 16-21-13 GM

GM or GW
Same as above, some very fine evidently abundant boulders. Blow Count 20-20.5 - 114 with a 1400 hammer and 20.5-21.5 using a 3000 hammer blow count was 15 and 23.

Silty to sandy gravel-GM or GW, this zone is quite permeable so probably a GW. Blow Count 11-10-14.

Well graded gravel, permeable, this may be some weathered bedrock. Blow Count 30-33-90. GW or GM

Mudstone, red, massive, very hard, some thin splits of very fine sandstone, sparce pyrite.

Interbedded sandstone, siltstone and mudstone, massive to laminated, abundant mica along lamina (This rock is present in the other centerline hole.)

*Blow count is for 0.5' increments.

DH-18 Elev. 1984.93

GM Silty gravel with pebbles to cobbles.

Mudstone, silty, black, some stain at 10, 13, & 16', silty and sandy in places, some pyrite, very impermeably and competent.

Quartzite zone in the mudstone.

Mudstone, silty, massive, impermeable very hard.

DH-19 Elev. 1987.56

GM Gravel, silty to sandy, rounded pebbles to boulders.

Quartzite very hard, silty, some conglomerates at 11 foot like DH-20.

Mudstone, silty black, abundant iron stain in zone 15-26'. Sandstone split at 19-20'. This mudstone shows some evidence of weathering, but is very impermeable and competent. Some zone of sandstone and siltstone but basically rock is mudstone. Some conglomerates at bottom of hole with pebbles of quartz and muddy matrix.

DH-20 Elev. 2015.8

GM Gravel with sand and silt alluvial and colluvial terrace. Slowly permeable. Blow Count 36-38-56

GM Same as above but gravel fraction is coarser and less rounded. Blow count 21-32-24

GM Gravel well graded to silty sandstone and siltstone pebbles More permeable than above because of the smaller amount of silt. Blow count 45-31-62.

Same as above. Blow count 56-63-57. (Evidently higher blow count for last two samples for 1st 0.5 foot is due to pebbles from above.) GM

GM Same as above. Blow count 22-18-15.

GM Gravel with silty sand matrix, some of gravel breaks up to form sand. Blow count 61-78-56.

GM Same as above. Blow count 50-68-73 (21.5-30.5')

Weathered sandstone, refusal, Blow count 61-102. (30.5-32')

Quartzite very fine light gray massive some iron stain at 33.5' and 36-37' very competent and impermeable, some sparse carbon flakes and seams (32-41')

Mudstone, silty gray to black, some weathering between sandstone and mudstone at 42'.

Quartzite, some bleaching in this zone, some conglomerate present at 66' and 69'. One foot cavity at 67, drill dropped 1 foot, but evidently just a cavity without an outlet, pressure testing shows no leakage. (46-67')

(67-81') Mudstone silty, black very hard, impermeable and compete

DH-21 Elev. 2022.46

GM Silty sandy gravel, ro
to subangular. Blow Count

GM Silty gravel with subang
angular fragments quite pe
Blow Count 21-36-56.

GM Well graded to silty gr
rounded to subrounded pebb
cobbles. Blow Count 31-40-

GM Well graded to silty gr
angular to subangular pebb
cobbles. Blow Count 36-56-
is colluvial and alluvial

GM or GC Silty to clayey g
rounded to angular pebbles
cobbles. Blow Count 35-50-

GM Silty to clayey gravel,
to subangular pebbles of
siltstone and mudstone. Bl
57-74-101.

GM Silty sand with pebbles
to subrounded residual
Blow Count 16-26-36.

GM Silty gravel formed fro
weathered silty sandsto
Count 17-26-40.

Sandstone very fine,
45 feet, some carbon fl
seams, light gray with
from carbon.

Siltstone, muddy with
in places, dark gray to b
impermeable hard rock,
fine mica flakes.

BH-6 Elev. 2011.9

GP or GM Gravel with sand and silt

Drive sampled 63 blows
Drive sampled 3' blows first .5'
SM or GM Drive sampled 40 blows silty gravel to silty sand
GM Cobbles, sand and silt
GM Gravel, 175 blows to go 0.5'
GM Gravel and cobbles

GM Gravel 35 blows from 15-15.5'
GM 69 blows from 15.5-16'
GM Gravel and cobbles

GM Gravel and cobbles 75 blows 20-20.5
GM Gravel and cobbles 98 blows 20.5 - 21
GM Gravelly cobbles
GM Gravelly cobbles 63 blows 25 - 25.5
GM 56 blows 25.5 - 26'
GM Same as above

GM . Gravel
· Boulder

Interbedded sandstone, siltstone and mudstone, hard, some carbon flakes and seams, core is broken up but no iron stain is present. 42-55 Sandstone, quartzite, very fine. 47-46 Almost a siltstone 46-55 Definitely a sandstone there are scattered carbon flakes and seams. From 46-52 is very broken up and has abundant iron stain along bedding planes, and joint faces.

Dense quartzite some carbon flakes at 55 feet, very competent impermeable rock where not fractured. 55

BH-7 Elev. 20[illegible]

SM Silty sand with pebbles, colluvial, brown product of weathered sandstone. Blow Count 11-14-31

SM Silty sand with angular sandstone pebbles like above, slowly permeable. Blow Count 19-31-50

SM Weathered sandstone with interbeds of siltstone. Blow Count 28-46-76. Forms as SM

Weathered sandstone breaks up as gravel and sand but can't sample with spoon any deeper. Use 20 as bedrock. Blow count 21-92-106

Sandstone, very fine weathered, light brown

Mudstone, silty dark red, weathered firm for foundation

Sandstone very fine to silty, massive, some mica dark red to dark gray, this rock is almost a siltstone

Mudstone, red, massive

Sandstone, very fine, hard some iron stain along joints, some mica

Siltstone, sandstone, mudstone, massive dark grey to red.

Mudstone, silty dark red, massive

Mudstone, brown to yellow, very fine

Sandstone, grey, abundant carbon flakes and seams, some siltstone and mudstone intermixed. Similar to other grey carbonaceous sandstone in area. Some pyrite present with carbon. Black stain on joint faces also iron stain particularly at 60'. Rock is very hard, competent, well cemented. 67

BH-8 Elev. 20[illegible]

SM Highly weathered sandstone, very fine to silty, forms as SM with angular pebbles. Blow count [illegible]

SM or ML Siltstone to mudstone highly weathered, sandy, forms a SM to ML with some pebbles. Blow Count 21-46-52

SM Sandstone highly weathered, dark brown, silty, forms a silty sand. Blow Count 28-45-76.

SM Same as above but more pebbles and more silt and clay. Blow Count 16-46-70.

SM Same as above but more like 10-15, less fines more sand, Blow Count 33-49-72

SM Sandstone becoming less weathered forms a silty sand with sandstone fragments. Blow Count 21-56-108.

No bedrock in this hole. All sandstone is highly weathered to weathered.

BH-13 Elev. 2110.06'

SM or GM Weathered sandstone with pebbles brown. Blow Count 11-16-21

5' SM Weathered sandstone, 8.5-9' Blow Count 120

9 Siltstone, sandy, red to light brown with some mudstone, massive to laminated, some carbon along joints.

Sandstone, very fine to silty, 1 ft mudstone split at 19' abundant mica and carbon with iron staining on joint faces

BH-15 Elev. 2074.35

SM Weathered very fine sandstone with some interbedded siltstone and mudstone, brown to yellow.
5.5 Blow Count 11-21-29

SM Same as above. Blow Count 16-31-42

SM Sandstone, weathered very fine to siltstone. Blow Count 21-36-49

SM Weathered sandstone fine grained brown seems to be made up of sand with a small amount of smaller particles of silt. Blow Count 16-34-58

SM Very fine sandstone to siltstone with some mudstone fragments.
Blow Count 31-64-92

SM Interbedded sandstone, siltstone with a firm sandstone at 30 feet, this rock is weathered. Blow Count 41-74-103

Sandstone weathered to hard for split spoon sampling.

BH-16 Elev. 2099.6

Leaves and top soil

Silty sand with about 10 percent clay with small rounded pebbles, weathered sandstone. Blow Count 5-5.5 - 24, 5.5-6 - 26 (SM or ML)

SM Same as above - Blow Count 10-11.5 in 0.5' increments 13-29-48. This material is a weathered sandstone.

SM Weathered sandstone, silty, drilled from 11.5 to 15 but got no core, cutting were very fine, sand, and silt. Blow Count 40-3[illegible]-3[illegible]. Weathered sandstone forms a sand with small angular pebbles.

SM Weathered sandstone, silty. Blow count 60-130

SM Weathered sandstone tried to core poor core recovery. Blow Count 31-55

SM Weathered sandstone very fine to silty tried to get sample at 30' but too hard. Split spoon sample 35-36. Blow Count 76-166.

Tried to core 36-39 got foot of core

SM Interbedded sandstone and siltstone. Blow Count 35-35.5 = 60
Blow Count 35.5-3[illegible] = 100

Interbedded siltstone, sandstone and mudstone dirty brown, black stain along joints, some mica.

Mudstone, silty grey-green, some mica, some is very fine mudstone.

Mudstone, silty, dark red, massive

54

BH-22 Elev. 1981.4

GW or GM Gravel, sandy and silty pebbles to cobbles.

9 Mudstone, sandy to silty, some pure mudstone in places, some carbon flakes and seam 12-13'. Iron stained joints 17-18', but rocks didn't leak under pressure.

20 Quartzite, very fine to silty, leakage some at 21' abundant iron stain, with coal seam, core is quite broken up. Sooty joints 25-30'. Rock is very hard but broken up. Rock is very competent.

30

BH-101 Elev. 2013.34

GM Weathered very fine sandstone with some silt, forms a silty gravel. Blow Count 1/ 39-42-55

This is angular material with some fines, may be a GM-GW. Slowly permeable in places.

GM Same as above with less fines.

GM Weathered sandstone. Blow Count 17-36-53

Weathered sandstone.

GM Weathered sandstone forms a GM or GW. Blow Count 35-36-81

GM Weathered sandstone, very fine

GM Weathered sandstone. Blow Count 66-38-27

GM Weathered very fine sandstone

GM Blow Count 36-43-60

GM Weathered sandstone-this material in this hole is probably a combination of alluvial and colluvial and residual material from a sandstone parent material. Blow Count [illegible] like above

BH-102 Elev. 2026.56

GM Weathered sandstone, colluvial and alluvial material forms a GM or GW 55 [illegible]

5.5 GM or SM Weathered very fine sandstone forms a GM or SM. This material is slowly permeable in places Blow Count 2[illegible]-26-37

GM or SM Weathered sandstone same as above. Blow Count 47-52-57 GM or SM

GM or GW Weathered sandstone and colluvial sand and gravel, GM or GW. Blow Count 30-45-66

SM Weathered fine sandstone, permeable, forms a fine to very fine pebbly SM. Blow Count 61-75-77

GM Firm to hard sandstone, very fine to silty forms a GM or GW Blow Count 63-28-79

30

SHEET 3

*BH-101 Split Spoon Sample, Glass for sample 1/ Blow Counts are for 0.5' intervals unless otherwise noted.
*BH-102 Split Spoon, glass for sample.

~~As Built~~

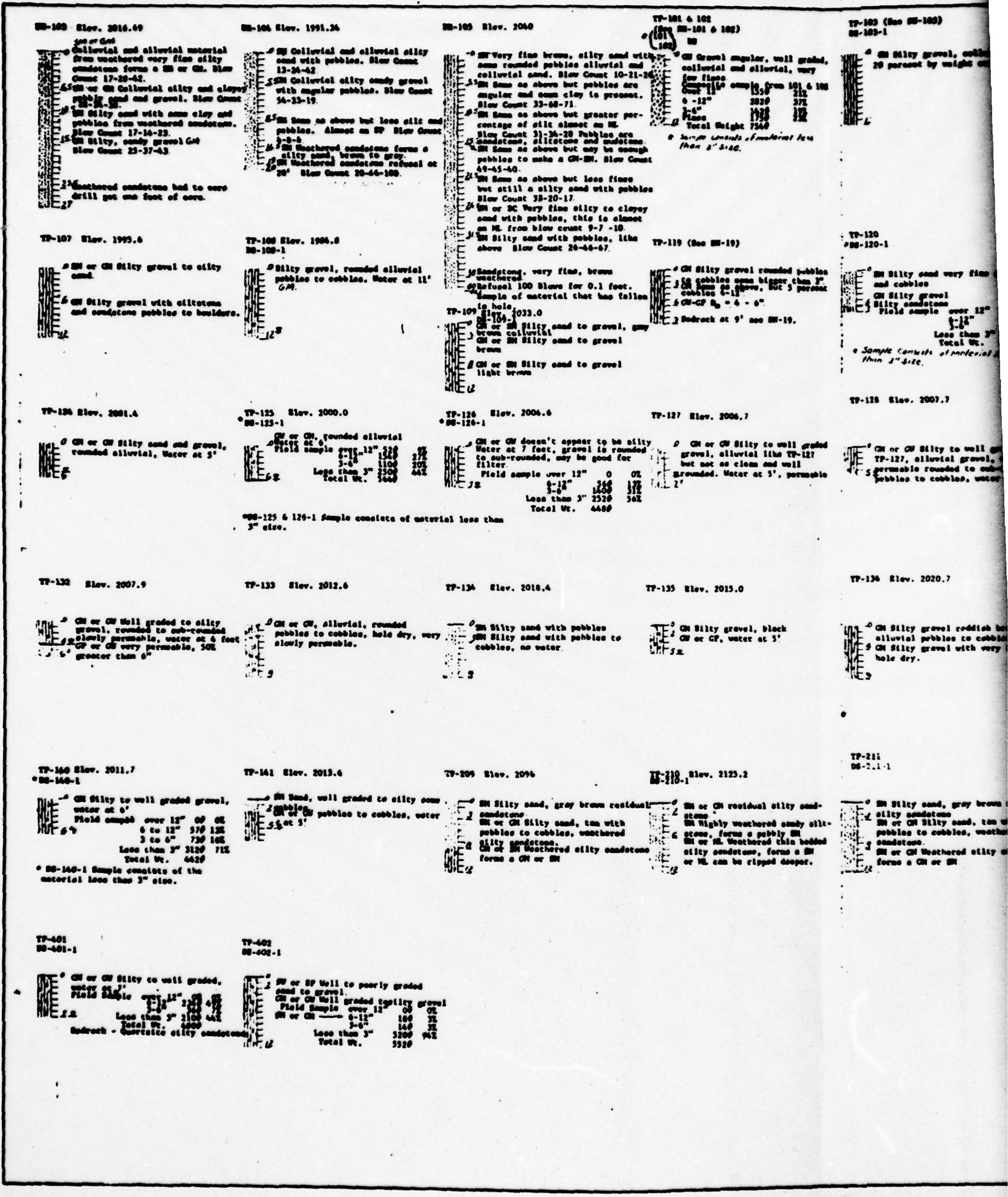
NOTE: ALL SOIL AND ROCK DESCRIPTIONS AND CLASSIFICATIONS DETERMINED BY VISUAL INSPECTION.

UPPER NORTH RIVER WATERSHED
OF THE POTOMAC RIVER WATERSHED PROJECT
MULTIPLE PURPOSE DAM NO 76
AUGUSTA AND ROCKINGHAM COUNTIES, VIRGINIA
SOILS INFORMATION

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

[illegible]	Date	Approved by	
H. A. WILSON, R. C. BARNES JR	8-62	Title	
DOUGLAS [illegible], JEAN S. [illegible]			
C. S. COFFMAN	8-62	Title	
Traced			
R.F. Fonner	8-2362	Sheet No 7 of 19	Drawing No. VA-472-P

2



DH-103 Elev. 2016.69

SM or GM

0 Colluvial and alluvial material from weathered very fine silty sandstone forms a SM or GM. Blow Count 17-20-42.

6.5 SM or GM Colluvial silty and clayey pebbly sand and gravel. Blow Count 25-26-35.

10.5 SM Silty sand with some clay and pebbles from weathered sandstone. Blow Count 17-14-23.

15 GM Silty, sandy gravel GM Blow Count 25-37-43.

23.5 Weathered sandstone had to core drill got one foot of core.

27

DH-104 Elev. 1991.34

0 SM Colluvial and alluvial silty sand with pebbles. Blow Count 13-26-42

5 GM Colluvial silty sandy gravel with angular pebbles. Blow Count 54-33-19.

8.5 SM Same as above but less silt and pebbles. Almost an SP Blow Count 5-8-6

16.5 SM Weathered sandstone forms a silty sand, brown to gray.

19.5 SM Weathered sandstone refusal at 20' Blow Count 20-44-100.

DH-105 Elev. 2040

0 SM Very fine brown, silty sand with some rounded pebbles alluvial and colluvial sand. Blow Count 10-21-26.

5.5 SM Same as above but pebbles are angular and some clay is present. Blow Count 33-68-71.

10.5 SM Same as above but greater percentage of silt almost an ML Blow Count 31-36-28 Pebbles are sandstone, siltstone and mudstone.

15 SM Same as above but may be enough pebbles to make a GM-SM. Blow Count 49-45-40.

21.5 SM Same as above but less fines but still a silty sand with pebbles Blow Count 33-20-17.

26 SM or SC Very fine silty to clayey sand with pebbles, this is almost an ML from blow count 9-7 -10.

31.5 SM Silty sand with pebbles, like above Blow Count 26-46-67.

38 Sandstone, very fine, brown weathered.

40 Refusal 100 Blows for 0.1 foot.

40.1 Sample of material that has fallen in hole.

TP-101 & 102
(See DH-101 & 102)

* (101, 102) DS

0 GM Gravel angular, well graded, colluvial and alluvial, very few fines

Composite sample from 101 & 102

Over 12"	1350	21%
6 -12"	2820	37%
3-6"	1420	19%
Fines	1950	23%
Total Weight	7540	

12

* Sample consists of material less than 3" size.

TP-103 (See DH-103)
DS-103-1

0 GM Silty gravel, colluv
20 percent by weight

6

TP-107 Elev. 1993.6

0 SM or GM Silty gravel to silty sand.

6 GM Silty gravel with siltstone and sandstone pebbles to boulders.

12

TP-108 Elev. 1984.8
DS-108-1

0 Silty gravel, rounded alluvial pebbles to cobbles. Water at 11' GM.

12.5

TP-109 Elev. 2033.0
DS-109-1

0 GM or SM Silty sand to gravel, gray brown colluvial

3 GM or SM Silty sand to gravel brown

8 GM or SM Silty sand to gravel light brown

12

TP-119 (See DH-19)

0 GM Silty gravel rounded pebbles to cobbles some bigger than 3".

3 GM Same as above, but 5 percent cobbles 6-12"

6 GM-GP D_m = 4 - 6".

9 Bedrock at 9' see DH-19.

TP-120
***DS-120-1**

0 SM Silty sand very fine
and cobbles

GM Silty gravel

5 Silty sandstone

Field sample over 12"
6-12"
3-6"
Less than 3"
Total Wt.

* Sample consists of material
than 3" size.

TP-124 Elev. 2001.4

0 GM or GW Silty sand and gravel, rounded alluvial, Water at 5'

5

TP-125 Elev. 2000.0
***DS-125-1**

0 GW or GM, rounded alluvial Water at 6'

Field sample	over 12"	520	9%
	6-12"	1540	27%
	3-6"	1100	20%
	Less than 3"	2500	44%
	Total Wt.	5660	

6.5

TP-126 Elev. 2004.6
***DS-126-1**

0 GM or GW doesn't appear to be silty Water at 7 feet, gravel is rounded to sub-rounded, may be good for filter.

Field sample	over 12"	0	0%
	6-12"	560	13%
	3-6"	1400	31%
	Less than 3"	2520	56%
	Total Wt.	4480	

7.5

*DS-125 & 126-1 Sample consists of material less than 3" size.

TP-127 Elev. 2006.7

0 GM or GW Silty to well graded gravel, alluvial like TP-127 but not as clean and well grounded. Water at 5', permeable

7'

TP-128 Elev. 2007.7

0 GM or GW Silty to well
TP-127, alluvial gravel,
5 permeable rounded to sub
pebbles to cobbles, water

TP-132 Elev. 2007.9

0 GM or GW Well graded to silty gravel, rounded to sub-rounded slowly permeable, water at 4 foot

4 GP or GW very permeable, 50% greater than 6"

6

TP-133 Elev. 2012.6

0 GM or GW, alluvial, rounded pebbles to cobbles, hole dry, very slowly permeable.

9

TP-134 Elev. 2018.4

0 SM Silty sand with pebbles

3 SM Silty sand with pebbles to cobbles, no water

8

TP-135 Elev. 2015.0

0 GM Silty gravel, black

2 GW or GP, water at 5'

5.5

TP-136 Elev. 2020.7

0 GM Silty gravel reddish b
alluvial pebbles to cobbl

5 GM Silty gravel with very
hole dry.

9

TP-140 Elev. 2011.7
***DS-140-1**

0 GM Silty to well graded gravel, water at 6'

Field sample	over 12"	00	0%
	6 to 12"	570	13%
	3 to 6"	730	16%
	Less than 3"	3120	71%
	Total Wt.	4420	

6.5

* DS-140-1 Sample consists of the material less than 3" size.

TP-141 Elev. 2013.6

0 SM Sand, well graded to silty some pebbles

2 GM or GW pebbles to cobbles, water at 5'

5.5

TP-209 Elev. 2096

0 SM Silty sand, gray brown residual sandstone

3 SM or GM Silty sand, tan with pebbles to cobbles, weathered silty sandstone.

8 GM or SM Weathered silty sandstone forms a GM or SM

12

TP-210 Elev. 2125.2
DS-210-1

0 SM or GM residual silty sandstone

2 SM Highly weathered sandy siltstone, forms a pebbly SM

6 SM or ML Weathered thin bedded silty sandstone, forms a SM or ML can be ripped deeper.

12

TP-211
DS-211-1

0 SM Silty sand, gray brown
silty sandstone

4 SM or GM Silty sand, tan
pebbles to cobbles, weathe
sandstone.

9 SM or GM Weathered silty
forms a GM or SM

12

TP-401
DS-401-1

0 GM or GW Silty to well graded, water at 3'

Field Sample	over 12"	00	0%
	6-12"	2200	47%
	3-6"	[illegible]	7%
	Less than 3"	2100	44%
	Total Wt.	4800	

2.5

Bedrock - Quartzite silty sandstone

TP-402
DS-402-1

0 SW or SP Well to poorly graded sand to gravel.

2 GM or GW Well graded to silty gravel

Field Sample	over 12"	00	0%
SM or GM ——	6-12"	180	3%
	3-6"	140	3%
	Less than 3"	5200	94%
	Total Wt.	5520	

12

*TP-104 (See BB-104)

GM Silty gravel, alluvial and colluvial with rounded to angular pebbles to boulders. Water at 7'.

*TP-104 SS-Split Spoon
J-Glass Jar

TP-105 (See BB-105)
BB-105-1

GM Silty gravel, with no cobbles larger than 6" most are less than 3".
GM or ML Residual GM to ML, some weathered to from almost a pure silt, with pebbles to boulders.
GM or ML Weathered, very fine sandstone to siltstone with siliceous nodules 12+ See BB-105

TP-106 Elev. 2031.8
BB-106-1

GM Colluvial silty gravel, brown with angular to subrounded, sandstone to siltstone cobbles, 50% greater than 3" about 10 percent greater than 12". Very little clay.

TP-121 Elev. 1996.5
BB-121-1

GM Silty to well graded gravel, rounded, alluvial. Water at 8'.

Field sample			
	over 12"	0	0%
	6-12"	1250	36%
	3-6"	900	26%
	Less than 3"	1530	42%
	Total Wt.	3680	

* Sample consists of material less than 3" size.

TP-122 Elev. 1995.6

SW or SP clean alluvial
Silty gravel rounded cobbles to boulders
Cobbles and boulders Water at 6'. See 121-1

TP-123

SM or SW Silty gravel, rounded to subrounded pebbles to boulders
See 121-1

TP-129 Elev. 2003.4

SM or GM Silty sand to gravel alluvial and colluvial GM or GW
GM or GW alluvial, sub-rounded to rounded. Water at 6', slowly permeable.

TP-130 Elev. 1997.4
*BB-130-1

GW Silty to well graded gravel, sub to well rounded, slowly permeable. Water at 6'.

Field sample			
	over 12"	350	8%
	6-12"	1640	41%
	3-6"	840	21%
	Less than 3"	1200	30%
	Total wt.	4030	

*Sample consists of material less than 3" size.

TP-131 Elev. 2001.6

SM Silty sand with pebbles to cobbles, alluvial, slowly permeable, rounded to sub-rounded
GM or GW Well graded to silty gravel,
water at 5' See TP-120

TP-137 Elev. 2020.2

SM Silty sand with pebbles, brown to black
GM Gravel, silty with water at 6'

TP-138 Elev. 2008.5
*BB-138-1

SM Silty sand with pebbles and cobbles
GM Gravel, well graded to silty
Water at 5'

Field sample			
	over 12"	950	19%
	6-12"	410	8%
	3-6"	950	18%
	Less than 3"	2830	55%
	Total Wt.	5140	

*Sample consists of material less than 3" size.

TP-139 Elev. 2006.8

GM or GW Silty to well graded gravel.
Water at 5'

TP-212 (See DH-10)
BB-212-1

SM or GM Silty sand to gravel, tan residual silty sandstone.
SM Highly weathered silty sandstone, SM with pebbles.
SM or ML Weathered very fine silty sandstone forms a SM or ML with pebbles

TP-213 (See DH-13)
Elev. 2110.06
BB-213-1

SM or GM Sandy silty gravel, dark brown
GM or SM Highly weathered very firm silty sandstone, brown to red brown very fine in place, enough residual pebbles and cobbles to form a GM
GM or SM Weathered very fine sandstone to siltstone, siliceous nodules and residual sandstone pebbles to cobbles to form a silty gravel.

TP-215 Elev. 2060.3
BB-215-1

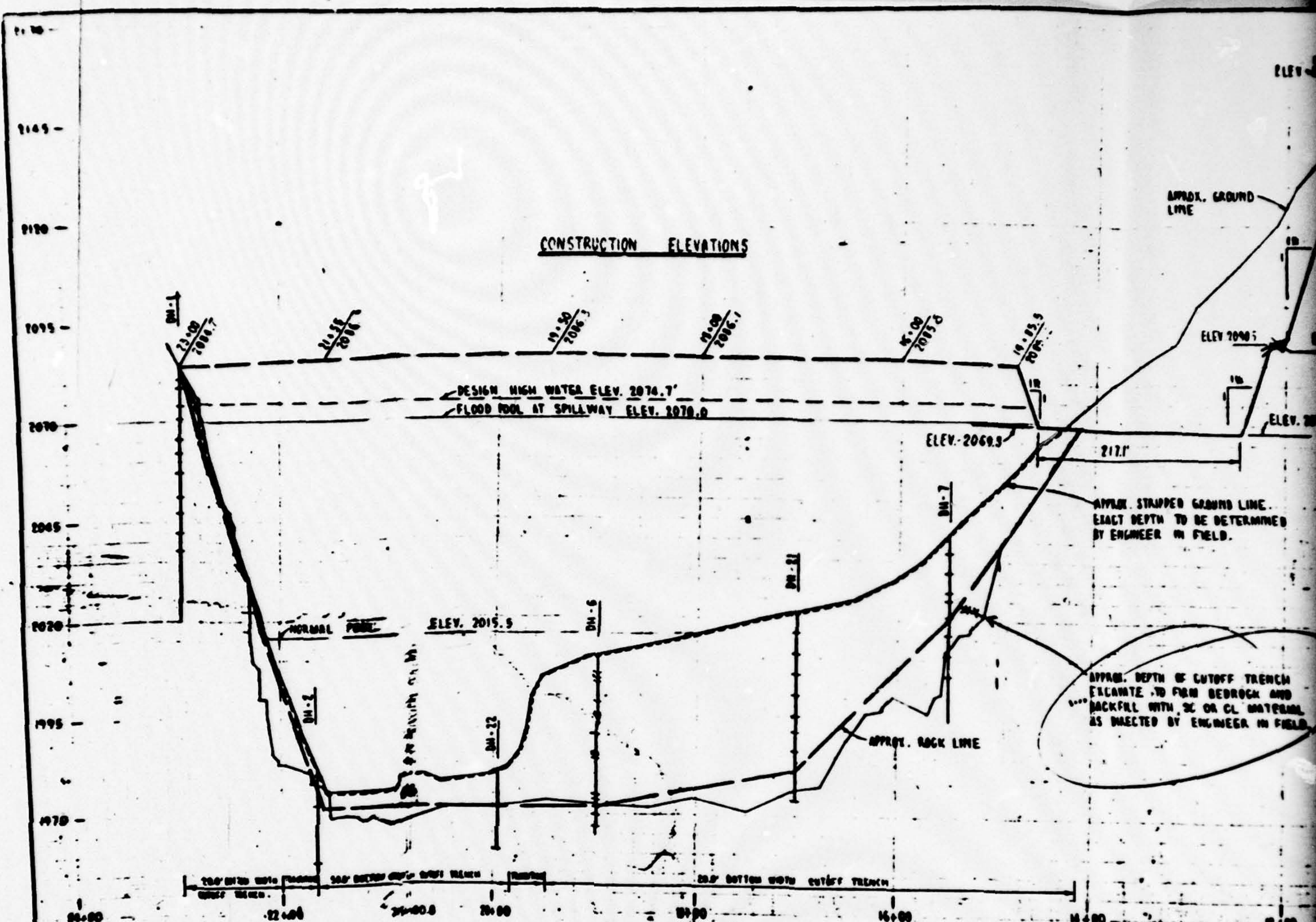
SM or GM Highly weathered flaggy ver, fine sandstone forms a SM or GM
GM or SM Weathered silty sandstone forms a GM or SM
All holes in spillway were dry and well drained.

NOTE. SOIL & ROCK DESCRIPTIONS DETERMINED BY VISUAL INSPECTION.
UNIFIED SOIL CLASSIFICATIONS BY VISUAL INSPECTION
GEOLOGICAL INVESTIGATION DATE: DEC 61 - JAN 62 - FEB 62

AS BUILT SHEET 4

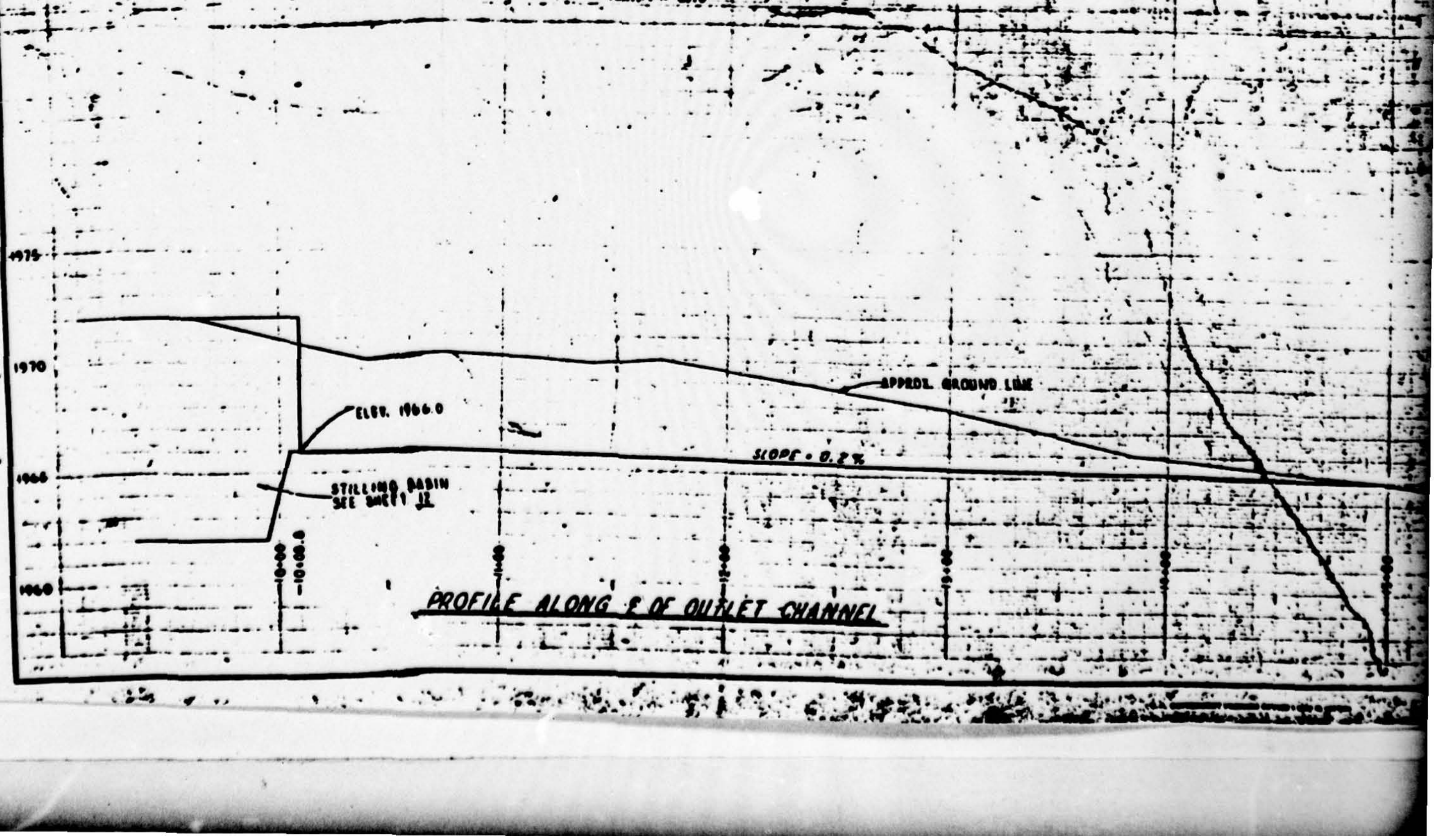
UPPER NORTH RIVER WATERSHED
OF THE POTOMAC RIVER WATERSHED PROJECT
MULTIPLE PURPOSE DAM NO. 76
AUGUSTA AND ROCKINGHAM COUNTIES VIRGINIA
SOILS INFORMATION

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

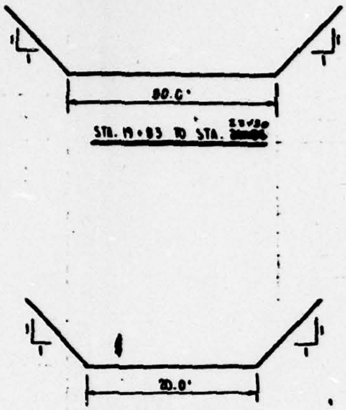


PROFILE ALONG ℄ OF DAM-LOOKING DOWNSTREAM

SCALE: HOR. 1" = 80.0'
VERT. 1" = 20.0'



PROFILE ALONG ℄ OF OUTLET CHANNEL

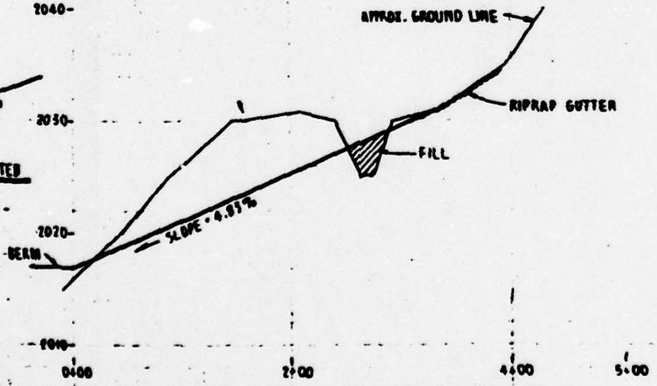


STA. 19+83 TO STA. 23+30

STA. 14+15 TO STA. 19+30
STA. 22+50 TO STA. 23+00

TYPICAL EXCAVATION SECTIONS OF CUTOFF TRENCH

CAL .EXCAVATION SECTION OF VEGETATED WATERWAY



PROFILE ALONG ℄ OF VEGETATED WATERWAY

SCALE: HOR. 1" = 40.0'
VERT. 1" = 8.0'

SHEET 5
AS BUILT

TYPICAL SECTION OF OUTLET CHANNE

UPPER NORTH RIVER WATERSHED
OF THE POTOMAC RIVER WATERSHED PROJECT
MULTIPLE PURPOSE DAM NO 76
AUGUSTA AND ROCKINGHAM COUNTIES, VIRGINIA
PROFILES

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

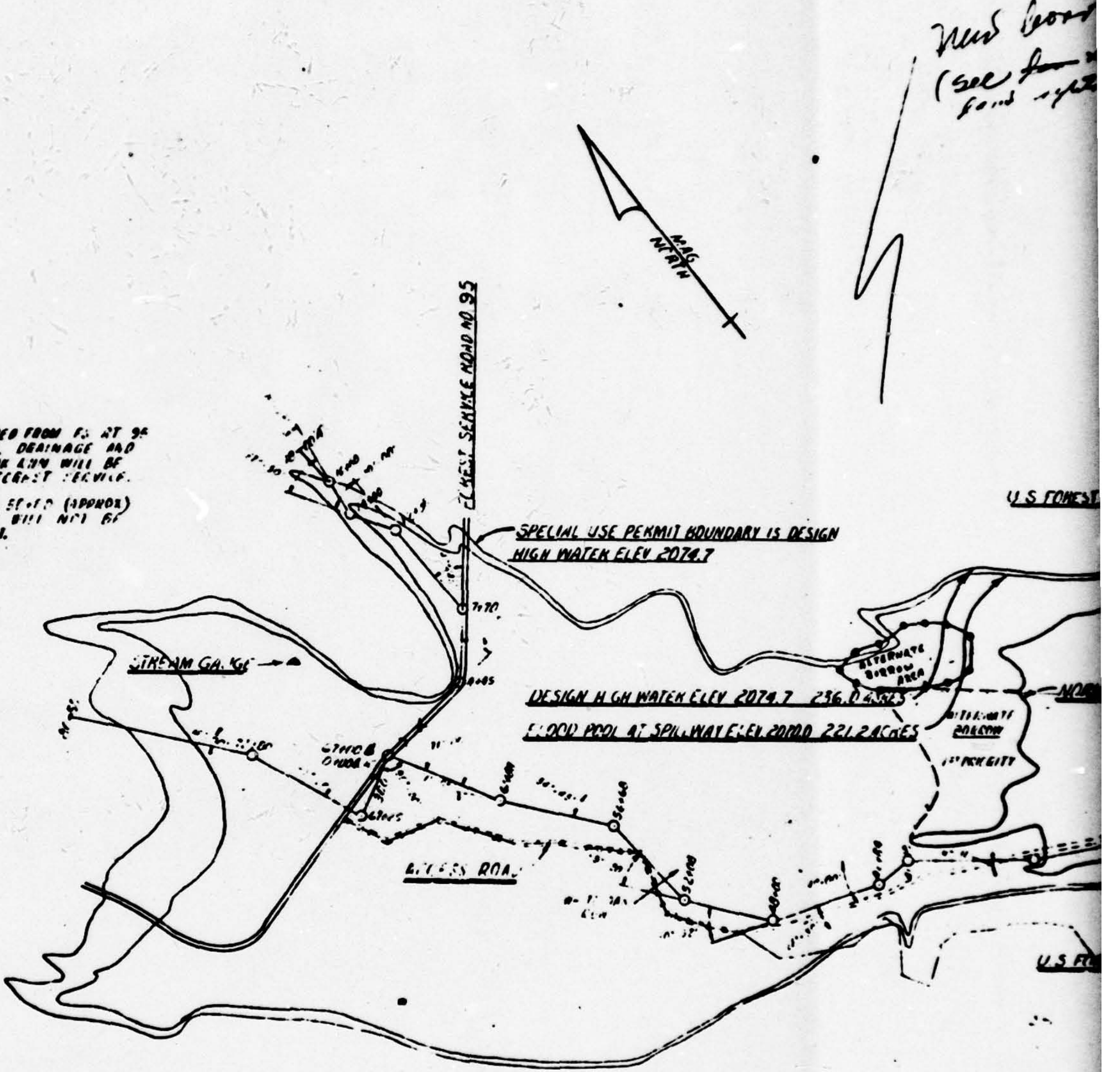
Designed N. WILSON - BARNES 6-62 Date	Approved by
Drawn L.S. COFFMAN AUG 62 W.H. MORGAN OCT 62	Title
Traced	Title
Checked Stanley E. Morris Nov. 65	Sheet No 9 of 19 · Drawing No VA-472-P

Form SCS-316 (November 1958)

NOTE:

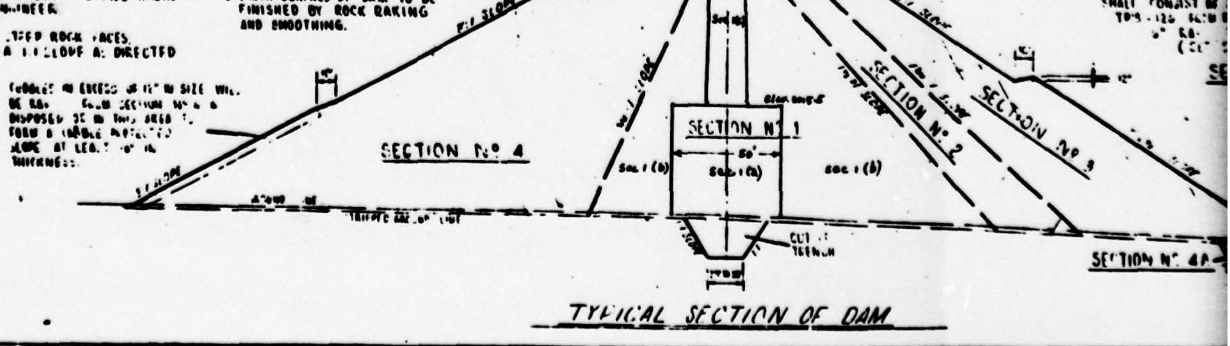
THE PRESCRIBED ACCESS ROAD WILL BE USED FROM F.S. RT 95 TO THE ELEVATION OF THE NORMAL POOL. DRAINAGE AND A LOW WATER CROSSING OVER WHITE OAK RUN WILL BE PROVIDED AS SPECIFIED BY THE U.S. FOREST SERVICE.

THE SURVEY ROUTE INDICATED FROM STA. 55+00 (APPROX) TO THE EMERGENCY SPILLWAY ENTRANCE WILL NOT BE CONSTRUCTED OR USED IN THIS PROJECT.

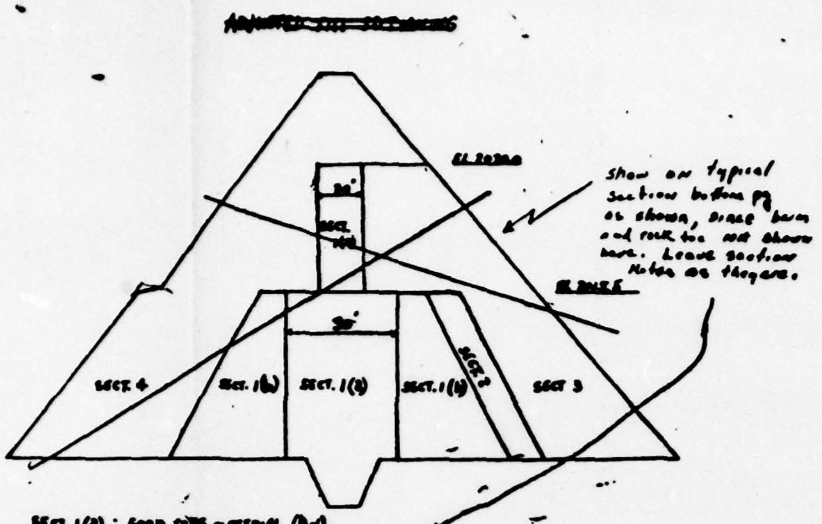


NOTE:

1. ALL ORGANIC MATERIAL, LOOSE SOIL AND BOULDERS SHALL BE REMOVED FROM UNDER THE FILL AREA AS DIRECTED BY THE ENGINEER.
2. ANY OVERHANGING LOOSE TALUS MATERIAL, SHALL BE REMOVED FROM UNDER THE FILL AREAS AS DIRECTED BY THE ENGINEER.
3. ALL STEEP SLOPES AND STEEP ROCK FACES SHALL BE CUT BACK TO A 1:1 SLOPE AS DIRECTED BY THE ENGINEER.
4. THE EMBANKMENT SIDE SLOPES SHOWN ARE SETTLED SLOPES. CONSTRUCTED SIDE SLOPES WILL BE ADJUSTED TO MEET THESE REQUIREMENTS.
5. EARTH SURFACE OF DAM TO BE FINISHED BY ROCK RAKING AND SMOOTHING.

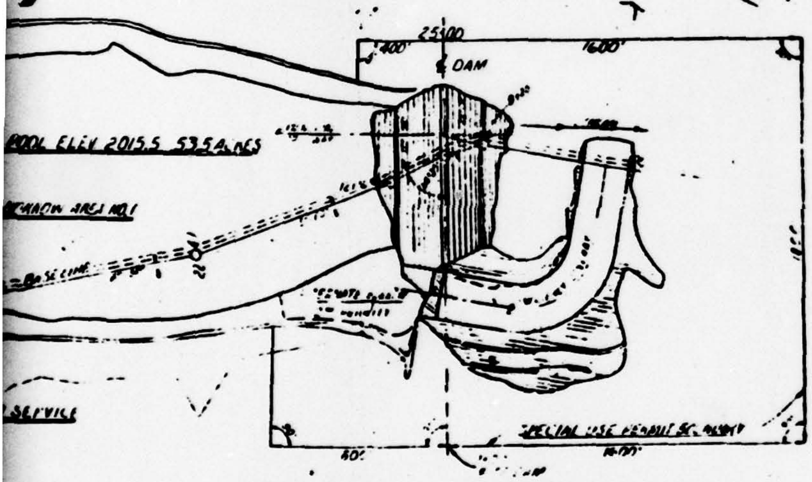


TYPICAL SECTION OF DAM



Show on typical section bottom pg as shown, since berm and rock toe not shown here. Leave section notes as they are.

SECT. 1(a) : GOOD CORE MATERIAL (B-1)
SECT. 1(b) : LESS DESIRABLE CORE MATERIAL (B-1)
SECT. 1(c) : GOOD TO ADEQUATE CORE MATERIAL (B-1)
SECT 2, 3, 4: SEE PLANS.



NOTE: ROCK EXCAVATED FROM THE EMERGENCY SPILLWAY THAT IS SUITABLE FOR EMBANKMENT MATERIAL, AS DETERMINED BY THE ENGINEER, WILL BE PLACED IN SECTION 3 OF THE DAM [illegible] THE EMERGENCY SPILLWAY [illegible] AND [illegible] FOR AS COMPACTED EARTH FILL. THE REMAINDER OF THE EXCAVATED ROCK [illegible] BE DISPOSED OF ON THE DOWNSTREAM TOE OF THE DAM AND ON THE UPSTREAM SLOPE OF THE DAM [illegible] AS SHOWN ON THE PLANS, AND IN THE AMOUNT DIRECTED BY THE ENGINEER. FOR [illegible] PAYMENT SHALL BE SUBSIDIARY TO ROCK EXCAVATION

R SANDCLAY (SC)

[illegible] CLAY (SC) [illegible] THE LOGS OF [illegible]
FROM 1 FT TO 12 FT
B-2 FILL)

RAVELLY (GM & GW)

[illegible] (GM AND GW) MATERIAL AS REPRESENTED BY THE LOGS OF [illegible] FROM 1 FT TO 6 FT MATERIAL LARGER THAN [illegible] THIS SECTION SHALL HAVE A MINIMUM HORIZONTAL THICKNESS OF 20 FT [illegible] "EARTH FILL" CLASS B-2 FILL)

ION N° 3

SHALL CONSIST OF COARSE MATERIAL (GW) FROM THE DESIGNATED BORROW AREAS AS REPRESENTED BY THE LOG OF TP-121 FROM 1 FT TO [illegible] TP-125 FROM 1 FT. TO 6 FT AND TP-130 FROM 1 FT TO 4 FT (SEE SPEC. 5-A "EARTH FILL", CLASS C FILL)

SECTION N° 4 AND 4A

SHALL CONSIST OF FINES [illegible] (GW) FROM THE DESIGNATED BORROW AREAS AS REPRESENTED BY THE LOG OF TP-126 FROM 1 FT TO 7 FT TP-[illegible] FROM 1 FT TO 7 FT AND TP-10C FROM 1 FT TO 1[illegible] FT. SEE SPEC 5-A "EARTH FILL" CLASS C FILL

ROCK TOE

MATERIAL GRADED IN SIZE FROM [illegible] TO 24-INCHES

42

AS BUILT SHEET 6

UPPER NORTH RIVER WATERSHED
OF THE POTOMAC RIVER WATERSHED PROJECT
MULTIPLE PURPOSE DAM NO. 76
AUGUSTA AND ROCKINGHAM COUNTIES, VIRGINIA
RESERVOIR AREA MAP

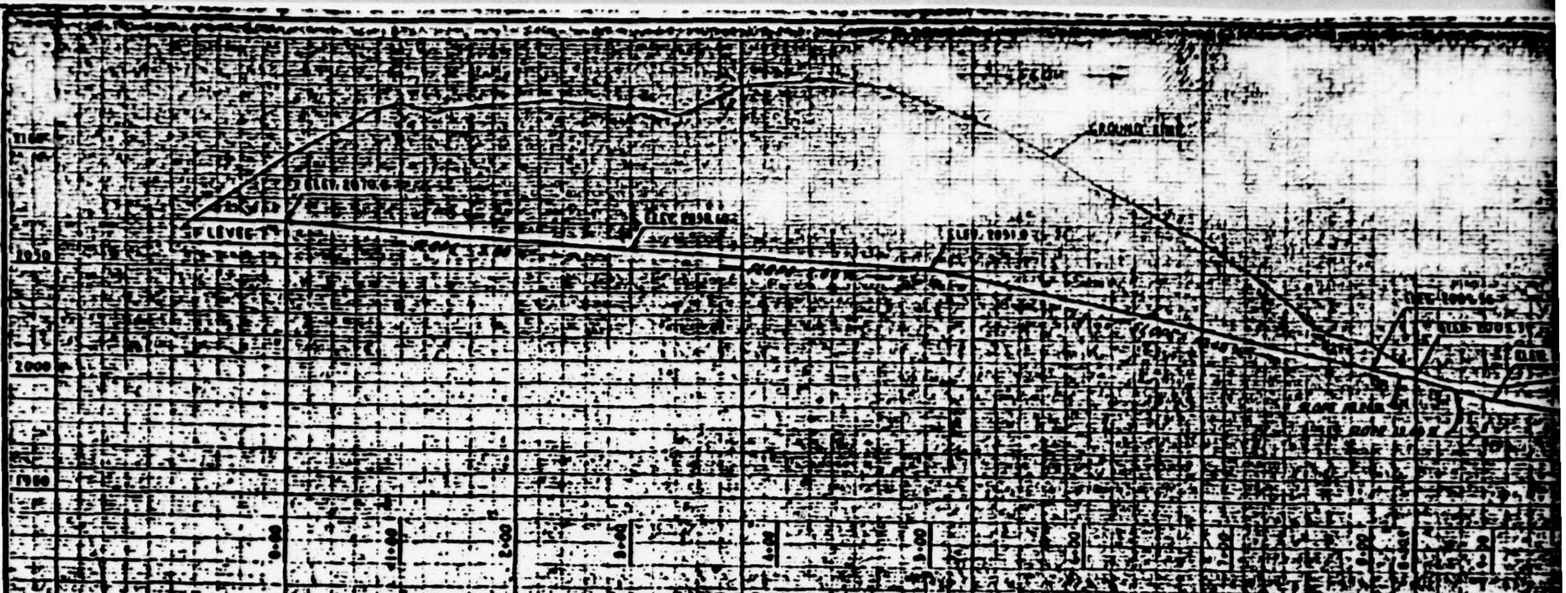
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

N. W. WILSON, R. C. BARNES JR 6-64
S. COFFMAN 9-64

2
19

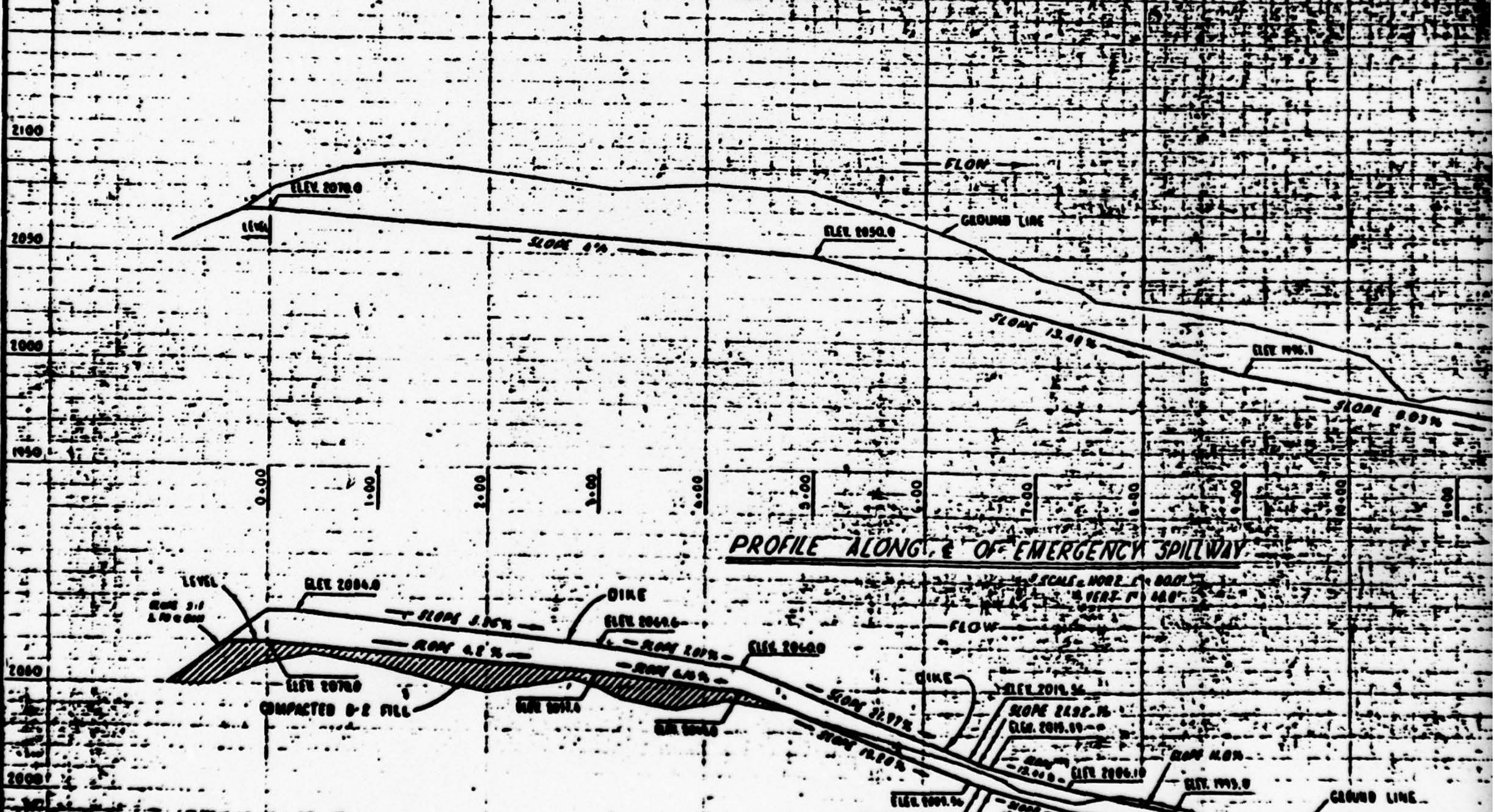
VA-472-P 2

SCS 313 November 1[illegible]



PROFILE ALONG OUTER EDGE OF EMERGENCY SPILLWAY

CENTERLINE STATIONS



PROFILE ALONG ℄ OF EMERGENCY SPILLWAY

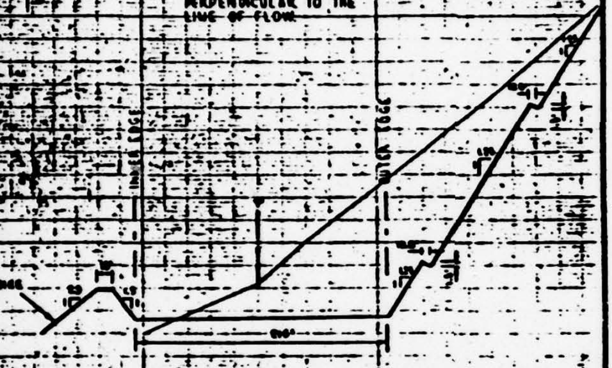
PROFILE ALONG INNER EDGE OF EMERGENCY SPILLWAY

CENTERLINE STATIONS

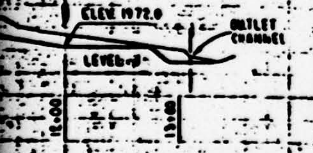
SCALE HORZ. 1" = 200'
VERT. 1" = 40'

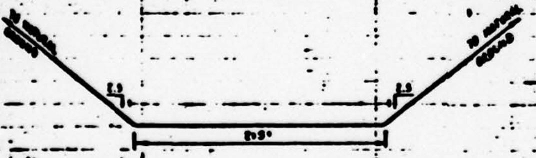
TYPICAL SECTION OF EMERGENCY SPILLWAY WHERE SIDES ARE RIPRAPPED

NOTE:
RIPRAP SHALL BE WELL
GRADED FROM A MAX.
SIZE OF 18" TO A MIN.
SIZE OF 6" PLACED
WITH THE LONG DIMENSION
PERPENDICULAR TO THE
LINE OF FLOW



TYPICAL SECTION OF EMERGENCY SPILLWAY @ DIKE LOOKING DOWNSTREAM





TYPICAL SECTION OF EMERGENCY SPILLWAY

OUTLET CHANNEL
SEE SHEET 2

AS BUILT SHEET 7

UPPER NORTH RIVER WATERSHED
OF THE POTOMAC RIVER WATERSHED PROJECT
MULTIPLE PURPOSE DAM NO. 76
AUGUSTA AND ROCKINGHAM COUNTIES, VIRGINIA
PROFILES

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed WILSON · BARNES JUNE 62
Drawn L.S. COFFMAN AUG 62
H.T. BROWNING JR. OCT. '62
Traced
Approved by

VA-472-

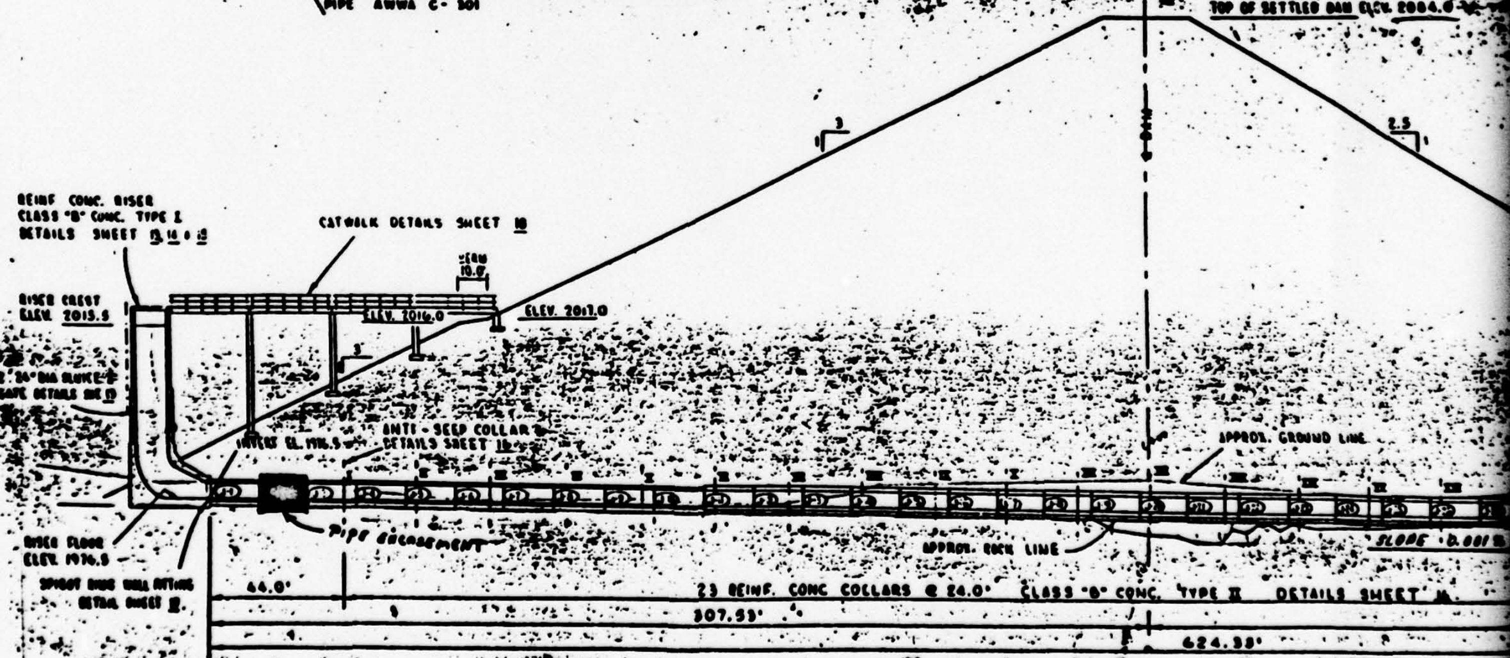
PLAN

SCALE 1" = 30.0'

42" I.D. REINF. CONC. WATER PIPE
78 16'-0" SECTIONS
2 SIPGOT RING WALL FITTING
TOTAL - - 1250.67

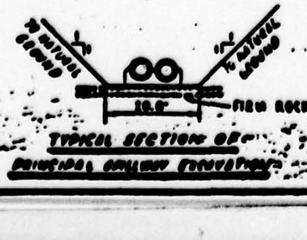
44 SECTIONS J-1 THRU J-10 AND J-27 THRU OUTLET
PRESSURE HEAD = 103'
LOAD = 65,700 LBS. PER LIN FT BASED ON O.D. OF 53"
MIN 3 EDGE BEARING STRENGTH FOR 0.001" CRACK
EQUALS 13,700 LBS. PER LIN. FT. FOR PRESTRESSED
PIPE AWWA C-301

34 SECTIONS J-10 THRU J-27
PRESSURE HEAD = 103'
LOAD = 122,320 LBS. PER LIN FT BASED ON O.D. OF 58"
MIN 3 EDGE BEARING STRENGTH FOR 0.001" CRACK
EQUAL 24,400 LBS. PER LIN FT. FOR PRESTRESSED
PIPE AWWA C-301

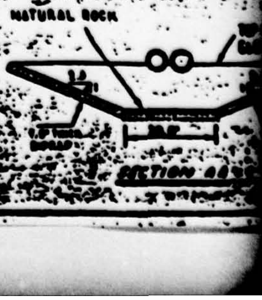


PROFILE ALONG ℄ OF PRINCIPAL SPILL

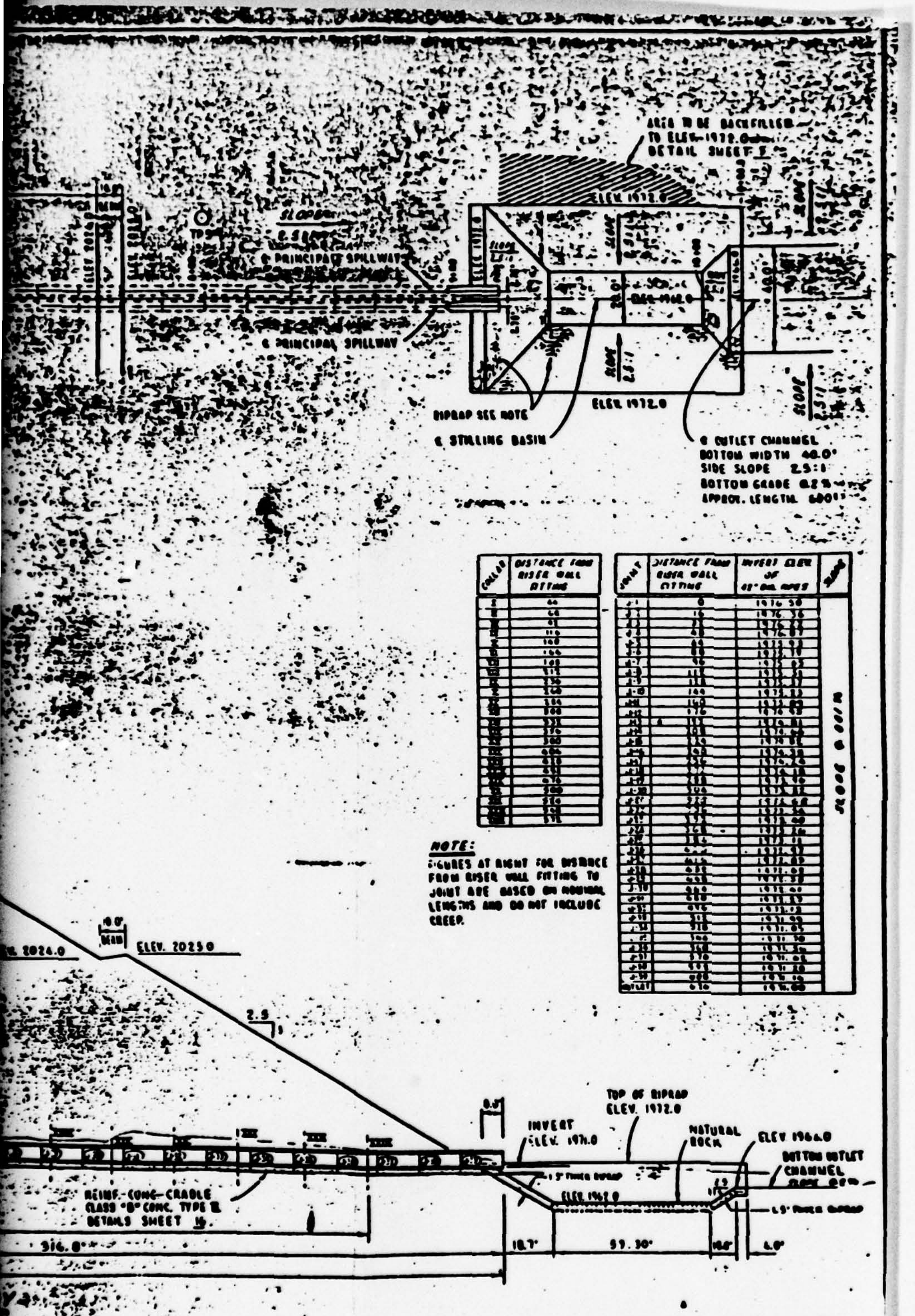
SCALE HORZ 1" = 30.0' - VERT. 1" = 20.0'



TYPICAL SECTION OF PRINCIPAL SPILLWAY EXCAVATION



SECTION



COLLAR	DISTANCE FROM RISER WALL FITTING
I	44
II	68
[illegible]	92
[illegible]	116
[illegible]	140
[illegible]	164
[illegible]	188
[illegible]	212
[illegible]	236
[illegible]	260
[illegible]	284
[illegible]	308
[illegible]	332
[illegible]	356
[illegible]	380
[illegible]	404
[illegible]	428
[illegible]	452
[illegible]	476
[illegible]	500
[illegible]	524
[illegible]	548
[illegible]	572

JOINT	DISTANCE FROM RISER WALL FITTING	INVERT ELEV. OF 42" DIA. PIPE	SLOPE
J-1	0	1976.50	SLOPE @ [illegible]
J-2	16	1976.36	
J-3	[illegible]	[illegible]	
J-4	[illegible]	[illegible]	
J-5	[illegible]	[illegible]	
J-6	[illegible]	[illegible]	
J-7	96	[illegible]	
J-8	[illegible]	[illegible]	
J-9	[illegible]	[illegible]	
J-10	144	[illegible]	
J-11	[illegible]	[illegible]	
J-12	176	[illegible]	
J-13	[illegible]	[illegible]	
J-14	[illegible]	[illegible]	
J-15	[illegible]	[illegible]	
J-16	[illegible]	[illegible]	
J-17	[illegible]	[illegible]	
J-18	[illegible]	[illegible]	
J-19	[illegible]	[illegible]	
J-20	[illegible]	[illegible]	
J-21	[illegible]	[illegible]	
J-22	[illegible]	[illegible]	
J-23	[illegible]	[illegible]	
J-24	[illegible]	[illegible]	
J-25	[illegible]	[illegible]	
J-26	[illegible]	[illegible]	
J-27	[illegible]	[illegible]	
J-28	[illegible]	1972.08	
J-29	[illegible]	[illegible]	
J-30	[illegible]	[illegible]	
J-31	[illegible]	[illegible]	
J-32	[illegible]	[illegible]	
J-33	[illegible]	[illegible]	
J-34	[illegible]	1971.85	
J-35	[illegible]	[illegible]	
J-36	[illegible]	[illegible]	
J-37	[illegible]	[illegible]	
J-38	[illegible]	[illegible]	
J-39	[illegible]	[illegible]	
OUTLET	616	[illegible]	

NOTE:
FIGURES AT RIGHT FOR DISTANCE FROM RISER WALL FITTING TO JOINT ARE BASED ON NOMINAL LENGTHS AND DO NOT INCLUDE CREEP.

NOTE:
RIPRAP SHALL BE WELL GRADED FROM A MIN. SIZE OF 6" TO A MAX. SIZE OF 18". IT SHALL BE PLACED WITH THE LONGEST DIMENSION PERPENDICULAR TO THE LINE OF FLOW.

AS BUILT SHEET 8

UPPER NORTH RIVER WATERSHED
OF THE POTOMAC RIVER WATERSHED PROJECT
MULTIPLE PURPOSE DAM NO. 76
AUGUSTA AND ROCKINGHAM COUNTIES, VIRGINIA
PLAN-PROFILE OF PRINCIPAL SPILLWAY

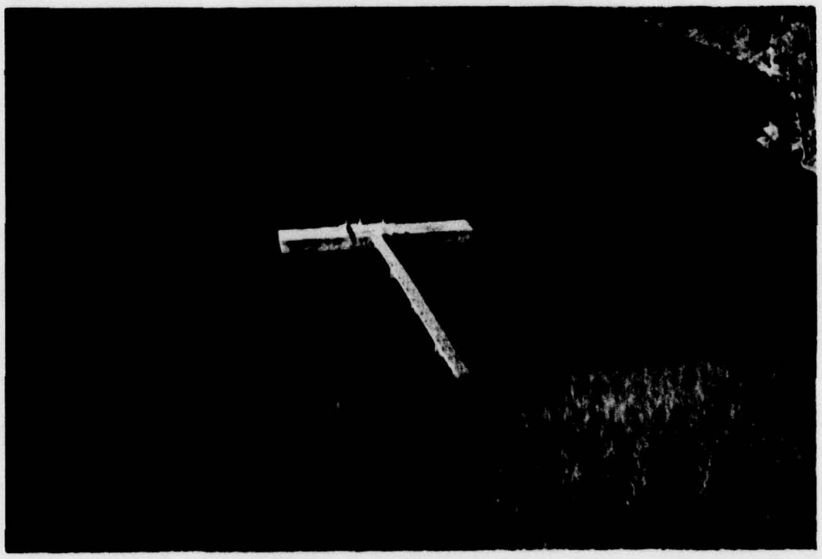
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed WILSON D. BARNES
Drawn
M.T. BROWNING JR.
Checked
Approved by
Title
Sheet [illegible] of [illegible]
Drawing No. VA-472 8P

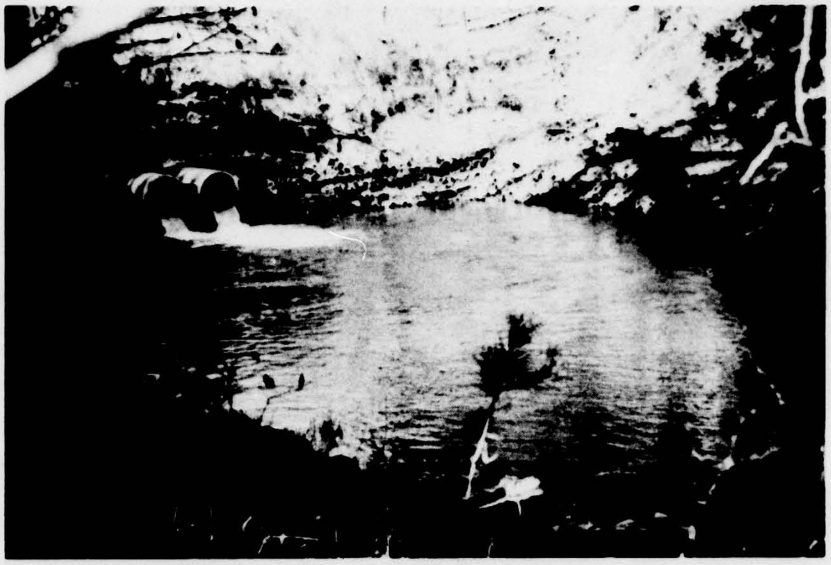
APPENDIX II

PHOTOGRAPHS

TOP OF EARTHEN BERM
VIEW FROM NORTHEAST
Photo #1

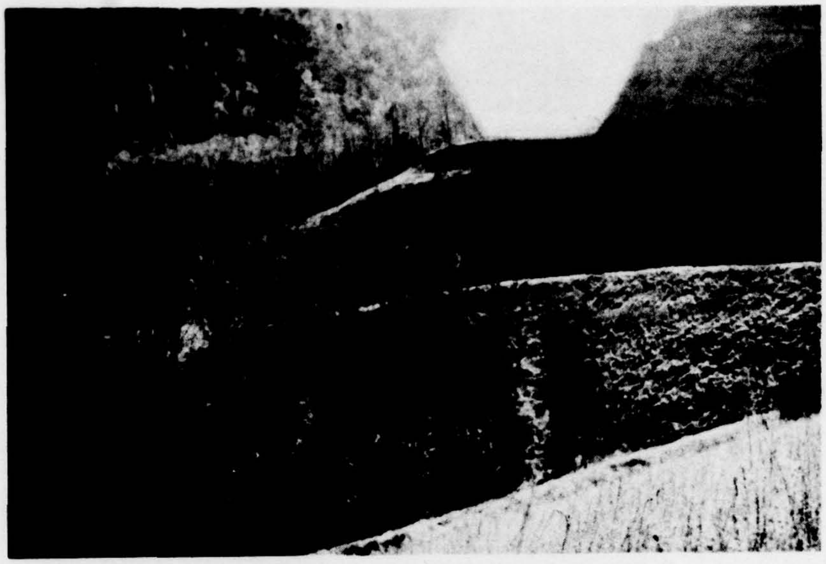


PRINCIPAL SPILLWAY STRUCTURE
(GOOD CONDITION)
Photo #2



STILLING BASIN AND OUTLET PIPE
(NOTE RIP RAP AND STILL WATER SURFACE)
Photo #3

DOWNSTREAM CHANNEL
(GOOD CONDITION)
Photo #4



EMERGENCY SPILLWAY
(NOTE CUT IN BACKGROUND)
Photo #5

LOWER END EMERGENCY SPILLWAY
(NOTE BROAD FLAT AREA)
Photo #6

APPENDIX III

FIELD OBSERVATIONS

FIELD OBSERVATIONS

Name of Dam: Upper North River No. 76 (Elkhorn Lake Dam)

County: Augusta

State: Virginia

Coordinates: Lat 38° - 19.6' Long 79° - 13.25'

Date of Inspection: December 13, 1978

Weather: Fair, temperature 45°

Pool Elevation at Time of Inspection: 2015.75 M.S.L.

Tailwater at Time of Inspection: 1966.5 M.S.L.

Inspection Personnel:

Schnabel Engineering Associates, P. C.
    Ray E. Martin, P.E.
    Stephen G. Werner (recorder)

J. K. Timmons and Associates, Inc.
    Robert G. Roop, P.E.
    William A. Johns (recorder)

State Water Control Board
    John Hyden

1 Embankment:

1.1 Surface Cracks: The slopes, crest, emergency spillway, and abutment contacts were inspected and no cracks were noted. The embankment portion of the dam and spillway were covered with 3 to 4 ft high, light vegetation, making observations difficult. Small (1 to 2" diameter) trees were growing along the embankment at the north abutment contact and also on the downstream slope near the center of the embankment.

1.2 Unusual Movement: No unusual movements were noted on the dam or downstream beyond the embankment toe.

1.3 Sloughing or Erosion: No sloughing was noted, however, minor erosion was noted along the south and north abutment contacts. The erosion consisted of approximately 6-inch deep gullies.

1.4 Alignment: The vertical and horizontal alignment of the dam was visually observed to be in accordance with "as built" drawings.

1.5 Riprap: Showed no displacement or washing and appeared to be in proper alignment.

1.6 Junctions: Conditions appear good at the junction of the embankment and the abutments. Numerous sandstone outcrops are exposed throughout the steep ridge which forms the north abutment. The sandstone is brown to gray, fine-grained and is thinly to massively bedded. Crossbeds occur locally. Bedrock strikes 65°NE± and dips 18°SE±. Wedge-shaped or subrectangular joint sets were also measured: N25W, 90 and N85E, 85SE. The emergency spillway is in cut along the south abutment, which includes steep cut slopes (75-100'± high) with benches. Slopes are not vegetated and the spillway is cut primarily in sandstone. Scattered shale interbeds near the middle of the slopes are capped with red shale. Bedrock strikes 65°NE± and dips 10°SE±.

1.7 Seepage: One damp spot was noted about 20 ft right of the left abutment and about 50 ft downstream of the midslope drainage berm. We believe this wet area at about EL 2005 is the result of surface water seeping from the drainage berm above.

1.8 Staff Gage: None found.

1.9 Drains: The embankment contains a downstream rock toe drain which extends to about EL 2023 along the north abutment and along the toe of the embankment and a portion of the emergency spillway. This elevation along the left abutment corresponds with the outfall elevation of the downstream drainage berm at the left abutment. No discharge outlets were noted, however, the drain terminates on each side of the principal spillway pipe and is presumed to discharge into the downstream channel at this point. The midslope drainage berm contained a few wet spots which coincided with low areas and these are believed to be trapped surface water from rains which occurred just prior to the inspection. The approximate locations of these wet areas are illustrated on Sheet 2 in Appendix I.

2 Reservoir:

2.1 Slopes: The upstream end of the reservoir is occupied by the river floodplain. Steep natural rock slopes with numerous sandstone outcrops bound the left side of the reservoir. The right side of the reservoir is graded locally but consists primarily of moderate to steep natural rock slopes, with sandstone and shale outcrops. No slide areas were noted around the perimeter of the reservoir. Sloughing was observed along the toe of the cut slope at the east end of the spillway.

2.2 Sedimentation: Slight sedimentation at stream inflow (alluvial fan of rock and sand). No evidence of any bottom sediment buildup. Water was very clear.

3 Downstream Channel:

3.1 Condition: Good. Channel has rock bottom.

3.2 Slopes: Downstream, steep natural slopes with sandstone and shale outcrops occur along the left and right sides of the stream. The stream valley narrows considerably, below the dam. No slope failures were noted in the valley adjacent to the toe of the dam.

3.3 Population and Facilities: None. Staunton Lake is 9,000' downstream.

4 Principal Spillway:

4.1 Intake Structure: The structure was in good condition. Gates were well greased, however, the lower gate is inoperable. Catwalk was in good condition. Concrete on the structure visually was in good condition.

4.2 Outlet Structure: Was in good condition. This was viewed from the downstream end and pictures of this can be seen in Appendix II.

5 Emergency Spillway:

5.1 Channel Section: Was found to be in uniform shape with exception of one section adjacent to Handkney Mountain, which showed sloughing of side slope. The bottom and side adjacent to berm was well vegetated and found to be in design configuration. The rip side slope was in good condition. The lower end was a broad flat area in uniform design configuration.

6 Instrumentation:

6.1 Monumentation: None

6.2 Observation Wells and Piezometers: No observation wells or piezometers were noted in the field.

APPENDIX IV

STABILITY ANALYSIS

OFFICE MEMORANDUM -- UNITED STATES GOVERNMENT

TO : R. C. Barnes, State Conservation Engineer, DATE: June 8, 1962
SCS, Richmond, Virginia

FROM : Rey S. Decker, Head, Soil Mechanics Laboratory,
SCS, Lincoln, Nebraska

SUBJECT: Virginia FP-2, Upper North River, Site No. 76

ATTACHMENTS

1. Form SCS 354, Soil Mechanics Laboratory Data, 4 sheets.
2. Form SCS 352, Compaction and Penetration Resistance Report, 15 sheets.
3. Figures 1 and 2, Void-Ratio and Percent Consolidation vs. Load Curves, 2 sheets.
4. Form SCS 355, Triaxial Shear Test Data, 6 sheets.
5. Form SCS 353, Figure 3, Gradation of Large Diameter Shear Specimens, 1 sheet.
6. Form SCS 347, Figure 4, Summary of Soil Engineering Properties on South Fork Watershed, West Virginia, 1 sheet.
7. Form SCS 357, Summary - Slope Stability Analysis, 3 sheets.
8. Figure 5, Estimate of Construction Pore Pressure, 1 sheet.
9. Figure 6, Estimate of Seepage through the Bedrockin the Flood Plain Section, 1 sheet.
10. Form SCS 353, Figure 7, Grain Size Distribution Graph, 1 sheet.
11. Figure 8, Percent Consolidation vs. Load for the Embankment Core, 1 sheet.
12. Form SCS 372, Embankment Placement Recommendations, 2 sheets.
13. Geological Plans and Profiles.

DISCUSSION

FOUNDATION:

A. Classification: The bedrock at this site consists of alternating beds or stratum of very fine sandstone and siltstone or mudstone. The bedrock in the valley is described as extremely hard.

Bedrock is exposed on the relatively steep left abutment and in the channel section. The bedrock in the flood plain and terrace level to the right of the channel is mantled with gravelly and cobbley material. The thickness of the mantle through these sections ranges from about 8 feet to 40 feet. Samples of the mantle from the vicinity of the toe drain indicate that the material in the flood plain is very coarse (27% finer than No. 4); whereas, the surface material in the terrace is considerably finer with about 55% finer than the No. 4 size and 8% cobbles.

The bedrock in the right abutment is mantled with residual silty sands to depths of about 20 feet.

B. Shear Strength: Standard penetration tests were made in the alluvial and colluvial gravels. The blow count was high; it is questionable, however, whether blow count can be related to shear strength in a cobbley material such as this. A triaxial shear test was made on material from the flood plain borrow area. The shear data obtained is discussed under the embankment section of this report. Based on the shear tests made, it appears that $\phi = 36°$ would be a conservative design value for the gravelly and cobbley foundation material.

C. Permeability: Field permeability tests were made in two locations in the terrace material. Computed permeability rates based on the field permeability test data in the geologic report are in the range of 3 to 6 feet per day in the tighter material and from 37 to 86 feet per day in the somewhat looser (lower blow count zone) material. The computed rate/ for each field test ~~is~~ are shown on the attached ℄ profile. The rates were computed from the equation and data given in the open end permeability test procedure in the Bureau of Reclamation's, "Earth Manual". There is a small error involved since the head was not constant. The rates were computed to show ranges of permeability and are believed to be satisfactory for this purpose.

Pressure tests were conducted in the bedrock at several location. The results of the tests are included in the geology report. Permeability rates were computed from this data in accordance with the equation $k = C_p \frac{Q}{H}$ given in the Packer test procedure in the Bureau of Reclamation's "Earth Manual". H was considered as the distance from the ground surface to the midpoint of the test zone. No water table was considered, except in test hole # 2 where the water table was considered at 22.5 feet. The diameter of the test hole was considered as NX.

The computed permeability rates are shown on the attached Form SCS 35D.

EMBANKMENT:

A. Classification: The borrow materials fall into two general categories consisting of (1) weathered sandstone and siltstone from the emergency spillway and the abutment downstream from the spillway and (2) the flood plain material.

Samples of the weathered sandstone ranged from CL-ML to GC-GM. The general range of material appears SC-SM, however, with the percent of fines ranging 28 on the GC-GM to 53 on the CL-ML. The percent of gravel ranged from 15 to 45 percent.

The flood plain gravels can be divided into two general groups, based on the amount of gravel or cobbles larger than 3.0 inches. Samples 62F1108, 62F1109, 62F1110 and 62F1112 contained from 24 to 36 percent material finer than 3.0 inches in diameter. Samples 62F1111, 62F1113 and 62F1114 contain from 53 to 63 percent finer than 3.0 inches in diameter.

B. Permeability: Estimated permeability rates of the embankment materials are shown in the following table:

Type of Material	Lab. Sample No.	k Ft./Day	Size Range Considered
Residual Silty			
Sandstone	62F1097	0.007	Minus No. 4
(Embankment Core)	62F1103	0.009	Minus No. 4
Coarse Flood Plain			
Borrow	62F1108	18.0	Field Gradation
(Shell Section)		0.03	Fraction Finer Than 6.0"
	62F1109	200+	Field Gradation
		25.0	Fraction Finer Than 6.0"
	62F1110	180	Field Gradation
		17.0	Fraction Finer Than 6.0"
	62F1112	200+	Field Gradation
		3.0	Fraction Finer Than 6.0"
Finer Flood	62F1111	6.0	Fraction Finer Than 6.0"
Plain and Terrace	62F1113	0.5	Fraction Finer Than 6.0"
Borrow (Shell Section)	62F1114	1.5	Fraction Finer Than 6.0"

The permeability rates shown for the core section were measured rates on the consolidation test specimens. The rates shown for the shell materials were estimated from Hazen's Formula, $k = 2 (D_{10})^2$, where the D_{10} size is in mm. and k is in feet/minute. The computed rates are reported in feet/day and were reduced one order of magnitude, according to the approximate correlation of D_{10} to D_5 size as contained in the preliminary report by Moran, Proctor, Mueser and Rutledge on the "Study of Effective Use of Coarse Grained Soils in Construction of Earth Fill Dams".

C. Compacted Density: Standard Proctor compaction tests were made on the minus No. 4 size fraction on 15 of the borrow samples submitted. The test data is shown on the attached Forms SCS 352. Corrected density for material larger than No. 4 size is also shown.

The borrow samples were submitted in moisture-proof bags. In order to obtain additional information on the compaction characteristics as well as the field moisture content, a small portion of the moist sample finer than 1 1/2 inches in diameter was compacted in a 1/30 cubic foot mold and also in a 1/13.3 cubic foot mold using Standard Proctor effort. The 1/30 cubic foot mold has a 4.0" diameter and the 1/13.3 cubic foot mold has a 6.0 inch diameter.

After compaction in this manner, the gradation was determined from the material in the 1/30 cubic foot mold. With percent of material larger than No. 4 known, it was then possible to compute the density and moisture content of the minus No. 4 fraction.

The Standard USBR equations for correcting the compacted density and moisture content based on the percent material larger than No. 4 size were used. The density and moisture content of the soil and rock mixture ~~are~~ were known. Therefore, the equations were solved for the density and the moisture content of the minus No. 4 fraction. The computed density and moisture content of the minus No. 4 fraction is shown on the compaction reports with relation to the Standard compaction curve.

You will note that there is pretty good agreement between the Standard Proctor curve and the computed densities. It is, therefore, considered that the "rock correction" as normally used by the Laboratory is reasonable for density control of these materials.

62F1097

D. Consolidation: Consolidation tests were made on two samples that represent the core section of the embankment. The tests were made on the minus No. 4 fraction from Samples 62F1079 and 62F1103. The test samples were compacted to 95 percent of Standard Proctor density. The void-ratio versus load and the percent consolidation of the Laboratory samples are attached, Figures 1 and 2.

E. Shear Strength: Triaxial shear tests were made on Samples 62F1097, 62F1103 and 62F1107 to represent the center section of the embankment. Shear tests were made on a mixture of 62F1108, 62F1111, 62F1113 and 62F1114 to represent the shell sections. A total of three tests were made on this material, consisting of two tests using 4.0 inch diameter test specimens with a maximum particle diameter of 1.0 inch and one test using 6.0 inch diameter test specimens with a maximum particle diameter of 1 1/2 inch. The shear data obtained are summarized as follows:

Sample No.	Emb. Sec. Represented	Diameter of Test Specimen (Inches)	Density (p.c.f.)	% of Standard Proctor	Degree of Saturation (%)	ϕ	c (p.s.f.)
62F1097	Center	1.4	105.5	95.4	98+	23.5°	500
62F1103	Center	1.4	103.6	94.8	95+	23°	350
62F1107	Center	1.4	110.5	95.2	97+	26°	850
62F1108	Shell	4.0	127	95	82-88	36°	0
1111	Shell	4.0	132.5	100	91-97	36°	575
1113	Shell	6.0	138.5	102	100	43°	1.000
1114							

Pore pressure was measured during the test on Sample 62F1103 and the effective stress values are recorded on the triaxial shear test data sheet.

The gradation used for tests on the shell material is shown on the attached Form SCS 353, Figure 1. The test samples were regraded as shown. Some trouble was encountered with consolidation and glycerine leaks on these large diameter test specimens. The data is believed to be quite consistent, however, in that the strength increased with density as would be expected. The c value obtained is believed to be due primarily to the increased density of the fines. You will note that c was 0 at 95% of Standard, 575 p.s.f. at 100% of Standard and 1000 p.s.f. at 102% of Standard Proctor. The increase in ∅ between the 4.0 inch diameter tests and the 6.0 inch diameter test is due, in part, to the increase in gravel percentage from 44 to 56%, respectively.

The shear data obtained on these gravelly materials are in pretty good agreement with data previously obtained on granular material from the South Fork Watershed in West Virginia. A summary of the average values from the South Fork Watershed is attached for comparison, Figure 4.

SLOPE STABILITY:

The stability of the proposed embankment was checked with a Modified Swedish Circle Method of analysis. Two sections were analyzed -- one at the channel section where the bedrock occurs at a very shallow depth and one on the terrace section where from 30 to 40 feet of gravelly material overlies bedrock.

The analysis considered a zoned embankment with a phreatic line from emergency spillway elevation (2064) to a drain at c/b = 0.6. The shear strength of Sample 62F1097 (∅ = 23.5°, c = 500 p.s.f.) from the emergency spillway was used to represent the core. The shell material was considered to be represented by Samples 62F1108, 62F1111, 62F1113 and 62F1114. The shell was considered at 100% of Standard Proctor with shear strength of ∅ = 36°, c = 575 p.s.f. At the maximum section the analysis considered the embankment only. Satisfactory factors of safety (greater than 1.5) were obtained on a 2 1/2:1 upstream slope when the central core was limited to 3/4:1 (Trial No. 1 and Trial No. 1A). Trial No. 1B shows that a 3:1 slope is required to obtain a factor of safety of 1.50 on the upstream slope when the upstream slope of the central core is 1 1/2:1.

The analysis showed a factor of safety of 1.82 for a 2 1/2:1 downstream slope with the slope of the central core at 1 1/2:1. This factor of safety would be increased somewhat if the shell section, with selective placement, effectively drains the central core.

The analysis on terrace section assumed that the shear strength of the gravelly foundation was ∅ = 36°, c = 0. The central core and the shell were considered the same as at the maximum section. This analysis shows that the proposed 2 1/2:1 upstream slope requires modification to obtain a factor of safety of 1.50. This could be accomplished by wide stabilizing berms as shown by Trial Circles 4A and 5A or by flattening the upstream slope to 3:1 (Trial Circle No. 6). The analysis at this embankment section considered a slope of 3/4:1 on the central core. A flatter slope such as 1:1 or 1 1/2:1 could be used, however, with very little change in the factor of safety, since the trial failure arc was restricted to the central core.

A 3:1 upstream slope was checked for safety against drawdown with an infinite slope analysis. For this purpose, shear strength of $\phi = 36°$, $c = 0$ was used. A factor of safety of 1.15 was obtained when horizontal seepage forces were considered. The factor of safety obtained is considered adequate.

The water forces considered in this analysis are more severe than will result from construction pore pressure if the center section material is placed with a moisture content less than 3 to 4 percent wet of optimum. The construction pore pressure was estimated according to Hilf's Method based on the laboratory consolidation curves. A plot of the construction pore pressure versus total stress is attached (Figure 5). The plot shows construction pore pressure for placement moisture contents of 17 percent, 19 percent and 21 percent, which covers the range from about optimum to 4 percent over optimum.

Trial Circle No. 7 on the attached slope stability summary shows the factor of safety obtained ($F_s = 2.2$) when estimated construction pore pressure was based on a placement moisture content of 21 percent.

RECOMMENDATIONS

A. Site Preparation: Any overhangs or loose talus material that may be present should be removed from the relatively steep left abutment.

B. Centerline Cutoff: We recommend a cutoff to bedrock at this site. This will involve relatively deep excavation through the moderate to highly permeable terrace gravels.

A minimum trench bottom width of 30 feet is recommended for the flood plain section and a minimum trench bottom width of 20 feet is recommended through the terrace section. Normal foundation preparation will probably remove most of the material overlying bedrock in the channel section; if not, the trench bottom width should be about 10 feet.

The formula $w = h - d$ taken from the Bureau of Reclamation's, "Design of Small Dams", was used as a basis for the suggested trench bottom widths. The reservoir head (h) was considered from normal pool level.

Based on the pressure tests made, it is apparent that seepage may be expected through the bedrock. In order to get some idea of the amount of seepage, the conditions shown on the attached Figure 6 were assumed. The estimated seepage loss through the flood plain section is 0.05 c.f.s. with the conditions assumed. Considering losses through the abutments, this figure may double. This estimate is conservative if the permeability of the bedrock is in the range of 2.5 ft./day or less.

The cutoff trench should be backfilled with SC or CL material and compacted to a minimum of 95 percent of Standard Proctor with the moisture content controlled to near optimum.

C. Principal Spillway: We recommend that the principal spillway be placed on bedrock. It appears that the amount of trench excavation could be reduced by shifting the conduit to the left of the proposed location shown on the attached Form SCS 35D.

D. Drain: Drainage is required for embankment stability and also to provide a safe outlet for seepage that by-passes the cutoff trench through the bedrock. We recommend selective placement of the flood plain borrow in the downstream shell to control the phreatic line in the embankment. This may be accomplished by placing the coarse flood plain material in the outer shell of the downstream section with a transition zone of the finer flood plain material like Samples 62F1113 and 62F1114 between the core and the outer shell. The suggested placement for drainage purposes is shown on the attached Form SCS 372. The relation of the gradation of each of the embankment zones and the foundation material is shown on the attached Form SCS 353, Figure 7.

In addition to selective placement of the embankment, we recommend a rock toe drain to provide a safe outlet for seepage through the bedrock. The toe drain should bottom on bedrock through the flood plain and penetrate the terrace material to about an 8.0 foot depth. The coarse flood plain material like Sample 62F1109 should be used as a transition filter between the foundation and the rock toe.

A D_{15} size of about 3 inches is suggested for the rock toe drain.

E. Settlement: The estimated settlement of the central core is 2 percent or 2 feet at the maximum section. The consolidation tests of the minus No. 4 fraction were used as a basis for this estimate. The percent consolidation versus load obtained on laboratory tests was reduced in proportion to the percentage of material larger than the No. 4 size. An average of 30% gravel was considered. The corrected consolidation curve is shown on the attached Figure 8.

F. Selection of Material: A zoned fill is recommended. Suggested placement of material, minimum density and placement moisture ranges are shown on the attached Form SCS 372. The minimum placement density suggested for the minus No. 4 fraction is 95% of Standard Proctor for the core and 100% of Standard Proctor for the shell.

G. Slopes: The results of the stability analysis are summarized as follows:

Section	Slope of the Outside Shells		Slope of the Core		F_s	Berm Width
	Upstream	Downstream	Upstream	Downstream		
Maximum	2 1/2:1		1 1/2:1		1.35	10'
℄ Station 21+25		2 1/2:1		1 1/2:1	1.82	Normal 10'
	2 1/2:1		3/4:1		1.63	10'
	3:1		1 1/2:1		1.55	10'
Terrace	2 1/2:1		3/4:1		1.33	10'
Section	2 1/2:1		3/4:1		1.50	55'
℄ Station 19+50	3:1		3/4:1		1.50	10'

We suggest embankment slopes of 3:1 upstream and 2 1/2:1 downstream with the 10 foot berms as originally proposed. The slope of the central core can be as flat as 1 1/2:1, depending on availability of material.

Prepared by:

Lorn P. Dunnigan

Reviewed and Approved by:

Roland B. Phillips

Attachments

cc: R. C. Barnes (6 Four are being forwarded now and two the first of next week)
H. M. Kautz, Upper Darby, Pennsylvania (2)
G. W. Grubb, Upper Darby, Pennsylvania

FORM SCS-357
10-58

Sheet 1 of 3

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY
SUMMARY - SLOPE STABILITY ANALYSIS

State Virginia Project Upper North River [illegible]

Date 5-16-62 Analysis Made By Thompson Checked By Cole

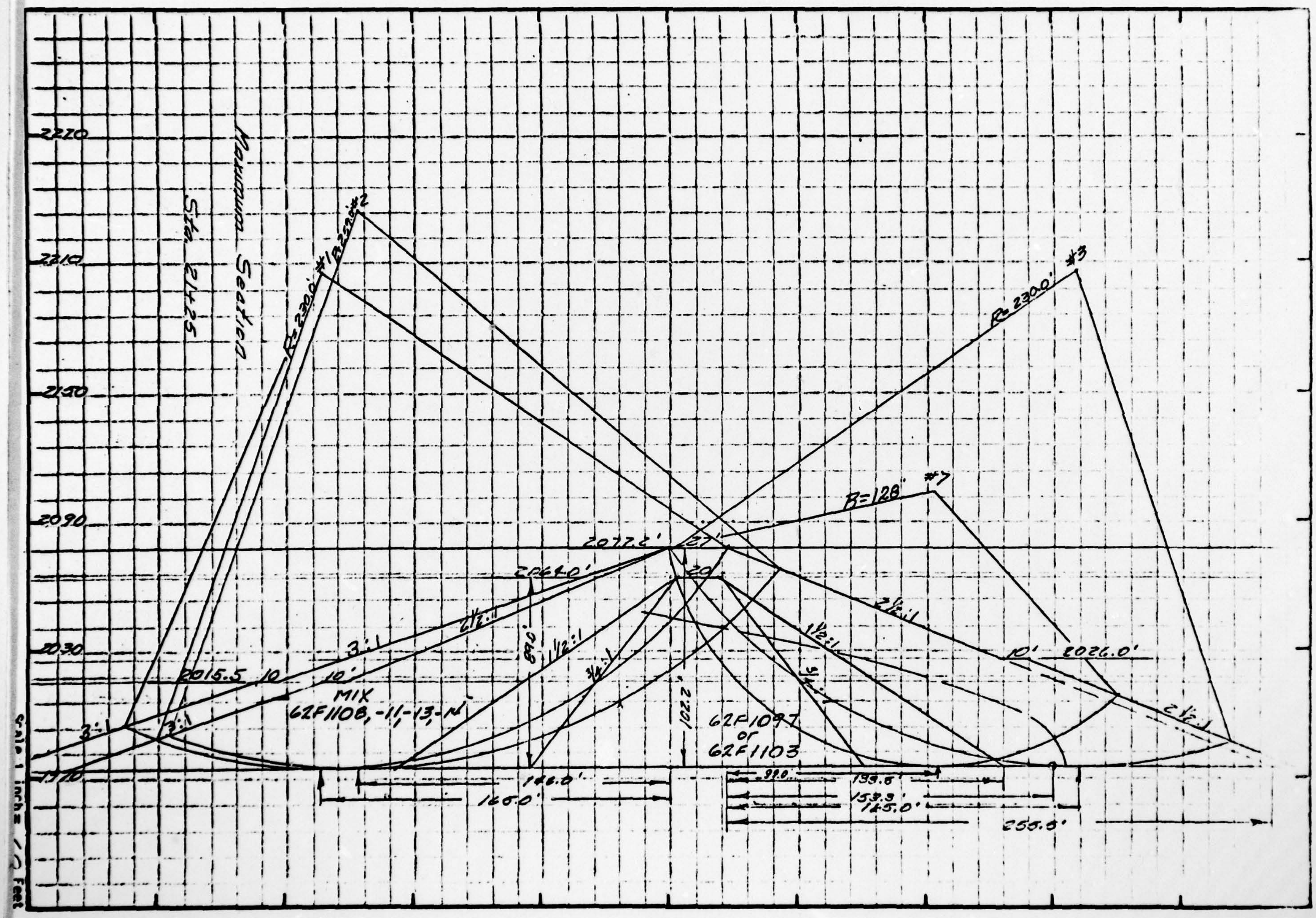
Method of Analysis Swedish Circle

Location of Material			Core Emb. 95% std SC		Emb 95% std SC		Emb. 98% std		Shell Emb 100% std	
Sample No.			62F 1097		62F 1103		62F 1107		62F 1108, 1111 1113, 1116	
γ_d			113.0		103.5		116.5		122.5	
γ_m			130.0		121.5		135.5		144.5	
γ_s			133.0		126.0		131.5		146.0	
γ_b			70.5							
Condition	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.
ϕ				23.5°	ϕ'=	31.5 29	(FROM TEST DATA SHEET—[illegible])	26		34
Tan ϕ				0.435		0.532	↓	0.488		[illegible]
K										
C				500	C'=	350 250	(")	950		575

UPSTREAM SLOPE			
Trial	Slope	Conditions	Fs
#1	2½:1/3:1	Full drawdown - 16' berm @ elev 2015.5'-	
		Arc cut from opp. shoulder thru zoned	
		emb. with 3½:1 slope on core. Sat.	
		shear values only.	1.63
#1A	2½:1/3:1	Same as No.1 but with 1½:1 slope on core	1.35
#2	2½:1/3:1	Full drawdown - 16' berm @ elev 2015.5'-	
		Arc cut from opp. slope @ 0.1 H thru	
		zoned emb with 3½:1 slope on core	
		Sat. shear values only.	1.73
#2A	2½:1/3:1	Same as No. 2 but with 1½:1 slope on core	1.44
#1B	3:1	Same as No1A but with 3:1 slope on Shell	1.55

DOWNSTREAM SLOPE			
Trial	Slope	Conditions	Fs
#3	2½:1	Drain @ C/b = 0.6 - 10.0' berm @ elev. 2026.0'-	
		Arc cut from opp. shoulder thru zoned	
		emb with 1½:1 slope on core. Sat.	
		shear values only	1.52
# -			
#7	2½:1	Factor of Safety Against Construction	2.2
		Failure - Estimated Pore Pressure Based	
		on Placement Moisture Content of 21%	
		Note: Zoned Emb.;	
		Shell of 62F 1108, 1111 1113, 1116	
		Core of 62F 1097	

To be used to report to field offices data used for slope stability analyses and the results of the analyses. The right side of the form will be used for a sketch of the embankment on which the analyses have been made.



Scale 1 inch= 10 Feet

FORM SCS-357
10-58

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL MECHANICS LABORATORY

Sheet 2 of 3

SUMMARY - SLOPE STABILITY ANALYSIS

State VIRGINIA Project UPPER NORTH RIVER SITE #76

Date 6-4-62 Analysis Made By GLM Checked By G.N.G

Method of Analysis SWEDISH CIRCLE

Location of Material	Found				Emb 95% Std SC		Emb 100% Std			
Sample No.	Assumed				62F1097		62F1113, 1114 1108, 1111,			
γ_d					113.0		132.5			
γ_m					130.0		144.5			
γ_s	146.0				133.0		146.0			
γ_b					70.5		83.5			
Condition	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.
ϕ		36°				23.5°		36°		
Tan ϕ		0.727				0.435		0.727		
K										
C		0				500		575		

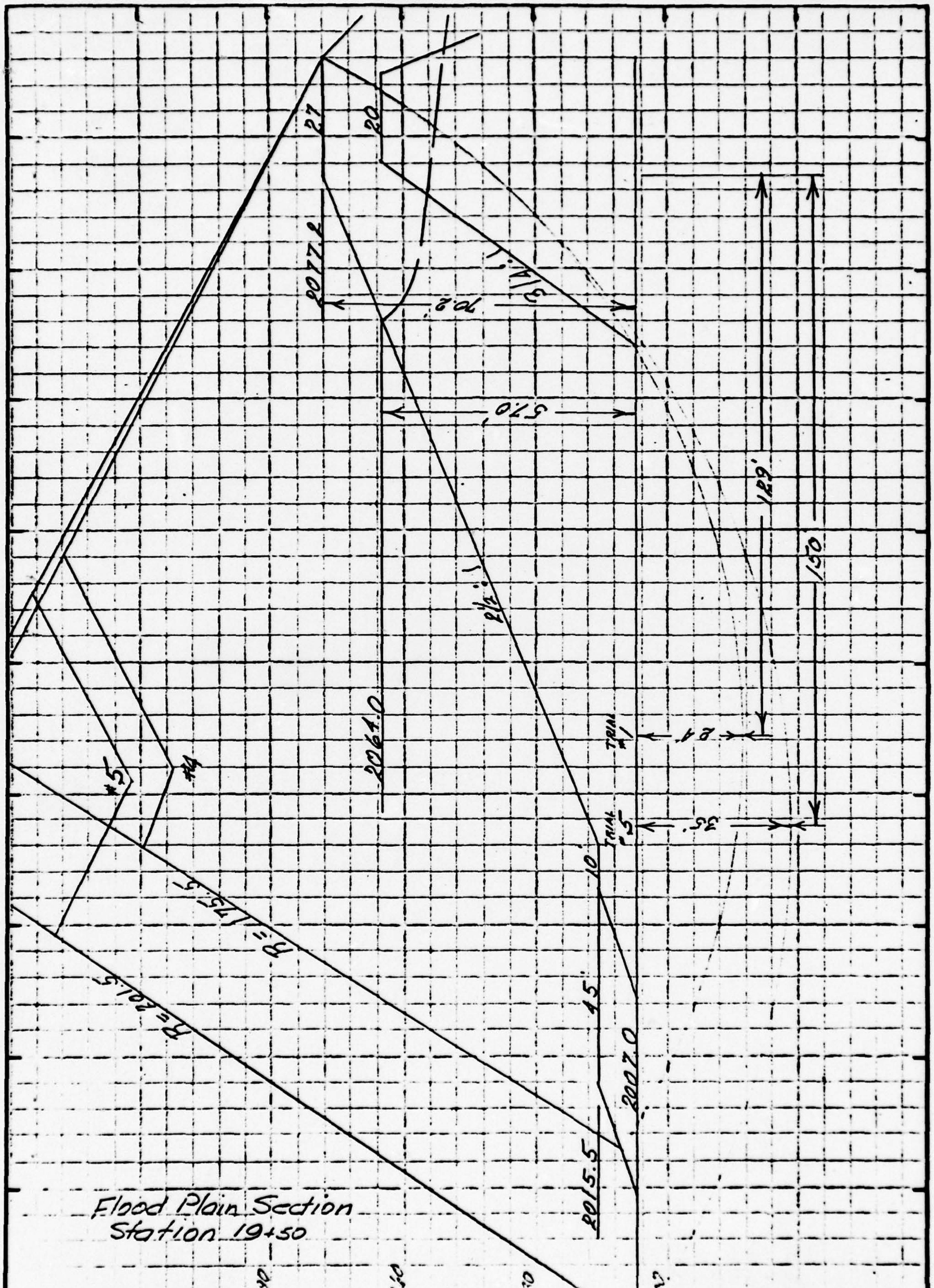
UPSTREAM SLOPE

Trial	Slope	Conditions	Fs
4	2½:1/3:1	Full drawdown; 10' berm @ el 2015.5; Arc cut from opp shoulder thru zoned emb & 24' into found.	1.33
4A	2½:1/3:1	Same as #4 except with 55' berm @ el. 2015.5.	1.50
5	2½:1/3:1	Full drawdown; 10' berm @ el. 2015.5; Arc cut from opp shoulder thru zoned emb & 35' into found.	1.43
5A	2½:1/3:1	Same as #5 except with 40' berm @ el. 2015.5.	1.50

DOWNSTREAM SLOPE

Trial	Slope	Conditions	Fs
		NOTE:	
		Sat. shear values on all trials	
		Zoned emb:	
		Core - 23.5° - 500	
		Shell - 36° - 575	

To be used to report to field offices data used for slope stability analyses and the results of the analyses. The right side of the form will be used for a sketch of the embankment on which the analyses have been made.



Flood Plain Section
Station 19+50

FORM SCS-357
10-58

Sheet 3 of 3

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOIL MECHANICS LABORATORY

SUMMARY - SLOPE STABILITY ANALYSIS

State VIRGINIA Project UPPER NORTH RIVER SITE #76

Date 6-4-62 Analysis Made By GLM Checked By G.N.G.

Method of Analysis SWEDISH CIRCLE

Location of Material	Found				Emb 95% Std SC		Emb 100% Std			
Sample No.	Assumed				62F 1097		1108, 1111, 62F 1113. 1114			
γ_d					113.0		132.5			
γ_m					130.0		144.5			
γ_s	146.0				133.0		146.0			
γ_b					70.5		83.5			
Condition	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.
ϕ		36°				23.5°		36°		
Tan ϕ		0.727				0.435		0.727		
K										
C		0				500		575		

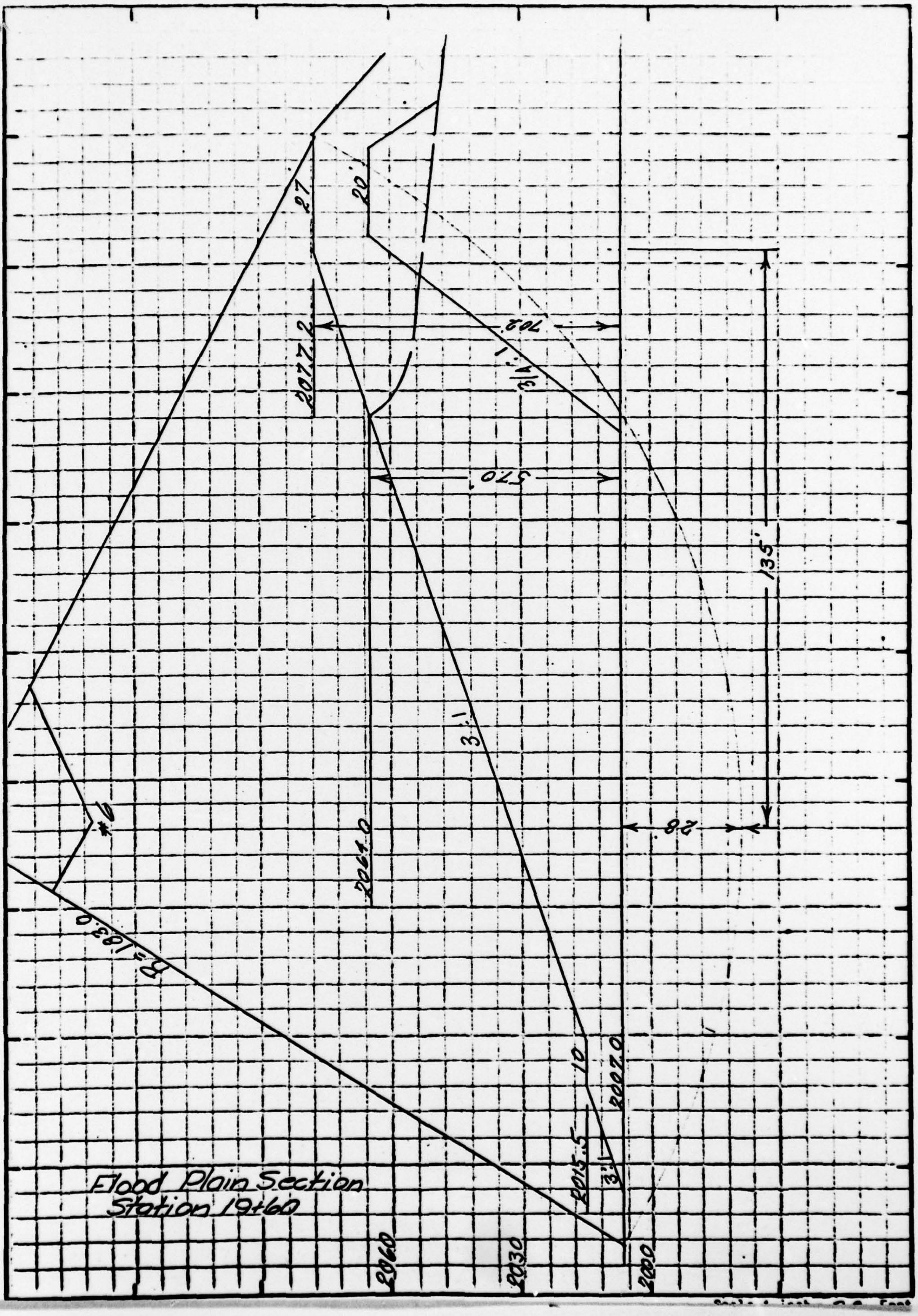
UPSTREAM SLOPE

Trial	Slope	Conditions	Fs
6	3:1	Full drawdown; 10' berm @ el. 2015.5; Arc cut from opp shoulder thru zoned emb & 28' into found. Sat shear values only.	1.50
		Note: Zoned Emb.	
		Shell - 36° - 575	
		Core - 23.5° - 500	

DOWNSTREAM SLOPE

Trial	Slope	Conditions	Fs

To be used to report to field offices data used for slope stability analyses and the results of the analyses. The right side of the form will be used for a sketch of the embankment on which the analyses have been made.



Flood Plain Section
Station 19+60

Scale 1 inch = [illegible] Feet

Sheet 1 of 2

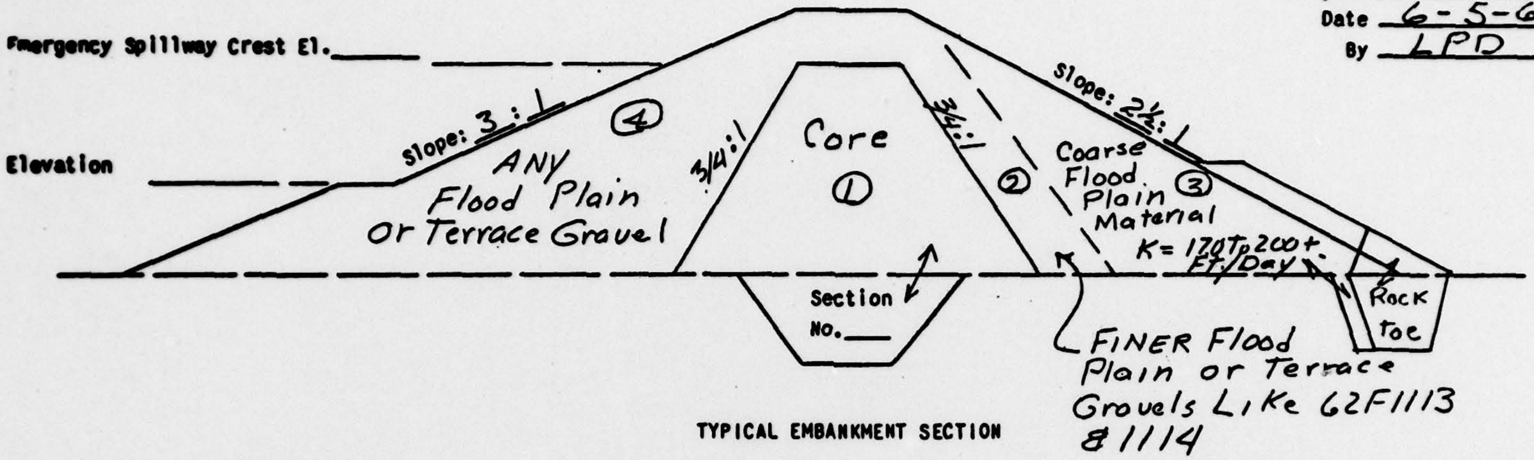
SCS-372
(3/59)

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

RECOMMENDED USE OF EXCAVATED MATERIAL

☐ Formal Zoning Plan ☑ Selective Placement Plan

State VIRGINIA
Project UPPER NORTH RIVER "
Date 6-5-62
By LPD



TYPICAL EMBANKMENT SECTION

Embankment Section		Source of Fill Material			Lab. Sample No.	Lab Test		Lab. Curve No.	Compaction Requirements Class of Fill E-2	
Sec. No.	Description	Location	Ave. Depth			Standard			Minimum Density	Moisture Range	
			From	To	62F	Max. Den.	Optm. Moist.		Lbs. per Cu.Ft.	Percent From	To
1.	Cutoff Trench & Core	Emer Spwy.	1	12	1097	111.0	17	3	105.0	16.0	19.0
.	" " "	" "	1	12	1098	113.0	16.5	4	107.0	15.0	18.0
	" " "	" "	1	12	1099	105.5	19.5	5	100.5	18.0	21.5
	" " "	" "	1	12	1100	112.0	16.0	6	106.0	14.0	17.5
	" " "	" "	1	12	1101	113.5	15.0	7	108.0	14.0	17.0
	" " "	Borrow Area	1	12	1163	109.5	17.0	9	104.0	16.0	19.0
	" " "	" "	1	12	1164	109.5	17.0	10	104.0	15.0	19.0
.	" " "	" "	1	12	1105	115.0	14.5	11	109.0	13.0	16.0
.	" " "	" "	1	12	1167	116.0	13.5	13	110.0	12.0	16.0
.											
.	Densities Shown are For The Minus No 4 Fraction										
.											

USDA-SCS-LINCOLN NEBR. 1959

5,L-15,731

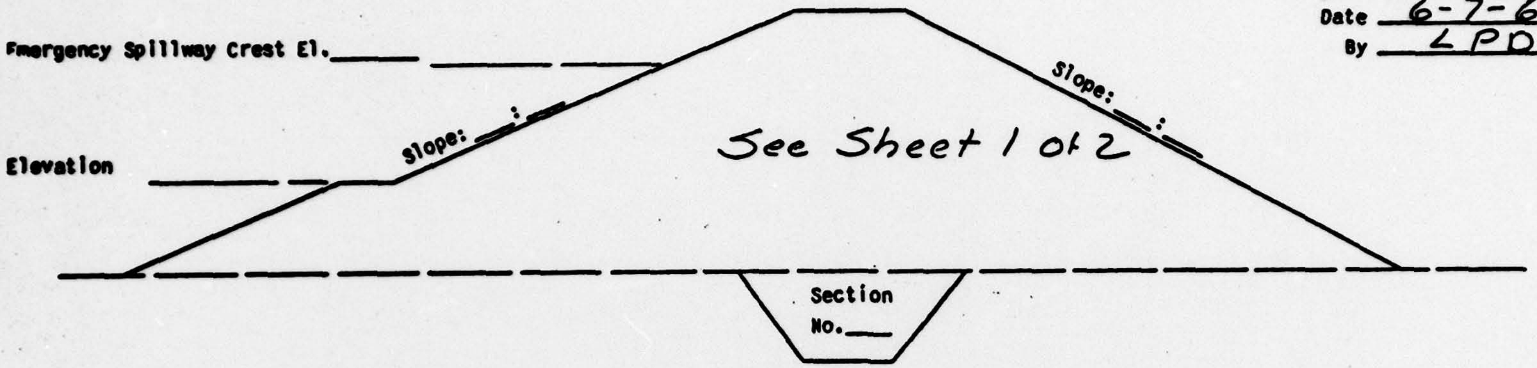
SCS-372
(3/59)

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

RECOMMENDED USE OF EXCAVATED MATERIAL

☐ Formal Zoning Plan ☐ Selective Placement Plan

State VIRGINIA
Project UPPER NORTH RIVER #7
Date 6-7-62
By LPD



TYPICAL EMBANKMENT SECTION

Embankment Section		Source of Fill Material			Lab. Sample No.	Lab Test		Lab. Curve No.	Compaction Requirements Class of Fill B-1-		
Sec. No.	Description	Location	Ave. Depth			Standard			Minimum Density	Moisture Range	
			From	To	62F	Max. Den.	Optm. Moist.		Lbs. per Cu.Ft.	Percent From	To
2or	4-Transition or Upstream–	Flood Plain & Terrace	1	7	1113	1235	12.0	19	123.5		
	" " "	" " "	1	6	1114	126.0	9.5	20	126.0		
3	Downstream–Outer Shell–	Flood Plain	1	7	1109				111.5		
	" " "	" "	1	6	1110				111.5		
	" " "	" "	1	4	1112	111.5	13.5	18	111.5		
4	Upstream Shell	Flood Plain	1	7	1111	118.0	12.0	17	118.5		
	" "	Flood Plain	1	7	1108	117.0	13.0	13	117.0		
	" "	alluvial & Colluvial	1	12	1102	113.5	14.5	8	113.5		
	Densities Shown are	For	the		Minus 4		Fraction				

R. C. Barnes, State Conservation Engineer,
SCS, Richmond, Virginia

August 22, 1962

Roy S. Decker, Head, Soil Mechanics Laboratory,
SCS, Lincoln, Nebraska

Virginia FPP - Upper North River, Site No. 76

We have reviewed placement recommendations for coarse materials on the subject site, as requested by telephone call from Mr. Oman.

Original shear tests on coarse material for this site were run on a composite of Samples 62F1108, 1111, 1113 and 1114 as representing flood plain material with the most fines.

Test densities for shear tests were based upon assumption that all material 6 inches and over would be raked from the mass of the fill to the outside shells. With this assumption, the composite would have about 47% larger than #4 with an average density on - #4 of 119 p.c.f.

The shear tests were run on material finer than 1 inch. The test specimens were re-graded in the sand and gravel size range as shown in the original report. There was 44 percent plus No. 4 material in the 4.0 inch diameter test specimens and 56 percent plus No. 4 material in the 6.0 inch shear specimens.

With the minus No. 4 material at 95% of Standard Proctor (113 p.c.f.), the corrected density with 44 percent gravel included in the sample would be 128 p.c.f. With the minus No. 4 material at 100% of Standard Proctor, the corrected density with 44 percent gravel in the sample would be 132 p.c.f.

The 6.0 inch diameter test specimens contained 56 percent gravel. Maximum Standard density, considering this percentage of gravel, would be 137 p.c.f.

The first shear tests were set up at about 127 p.c.f. which would represent about 95% of the Standard Proctor density for the gradation used. These specimens slumped before testing and it was deemed necessary to test at higher densities. The second and third tests were run at densities of 132 p.c.f. and 138.5 p.c.f. which would represent about 100% of Standard Proctor density for the gradation used.

Strength values used in the stability analyses were for γ_d = 132 p.c.f.

After reviewing the data on gradation of field samples which show that the above composite would have about 70% larger than No. 4 and about 30% larger than 6", we concur in the idea that removing all 6" and larger material would not be practical.

Since our report of June 8, 1962 on this site, we have had opportunity to review the Rutledge report on coarse material. Data in that report based upon U.S.B.R. tests on - 3" material show that material tested at 125 p.c.f. on the - 3" fraction gave ϕ values of 38° to 42°.

We have re-analyzed the designs proposed in our report of June 8 using upstream slopes of 3:1 for the outside shell and 3/4:1 for the interior core with berm at 2015.5 and embankment values of γ_d = 125 p.c.f., ϕ = 38°, c = 0. This analysis produced f_s = 1.52. (Trial circle 1C on the attached slope stability summary.)

Further review of the volumes of borrow material show that Samples 62F1111 and 1114 represent some 240,000 cubic yards. These materials show only 13% larger than 6" and 0% larger than 12".

We recommend modification of original report as follows:

1. Embankment design: Upstream slope = 3:1 outside; downstream slope = 2 1/2:1; center core 3/4:1; with berms as originally proposed.
2. Placement of material represented by 62F1111 and 1114 adjacent to core section with + 6" material raked to outside shell. This material should be placed at not less than 125 p.c.f. dry density of the - 3" fraction. Four or five passes with D-7 or equivalent track type tractor should effect this density but it is suggested that a few density tests be made to assure this weight. Assuming an average of 40% larger than 3", the required density of the - 6" fraction would be about 137 p.c.f.
3. Coarser material placed in the outside shells could be specified as Class C fill.

Prepared by:

Attachment

Roy S. Decker

and

Lorn P. Dunnigan

cc: H. M. Kautz - Upper Darby, Pa.

RSD:LPD:vmo

FORM SCS-357
10-58

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY

SUMMARY - SLOPE STABILITY ANALYSIS

State VIRGINIA Project UPPER NORTH RIVER SITE #76

Date 5-16-62 Analysis Made By GLM Checked By TCH

Method of Analysis SWEDISH CIRCLE

Location of Material	Found						Emb 95% Std SC		Emb 100% Std	
Sample No.	Assumed						62F 1097		62F 1108.1111 1113.1114	
γ_d							113.0		125.0	
γ_m							130.0		136.0	
γ_s	146.0						133.0		140.0	
γ_b							70.5		77.5	
Condition	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.	Opt.	Sat.
ϕ		36°						23.5°		38.7°
Tan ϕ		0.727						0.435		0.800
K										
C		0						500		0

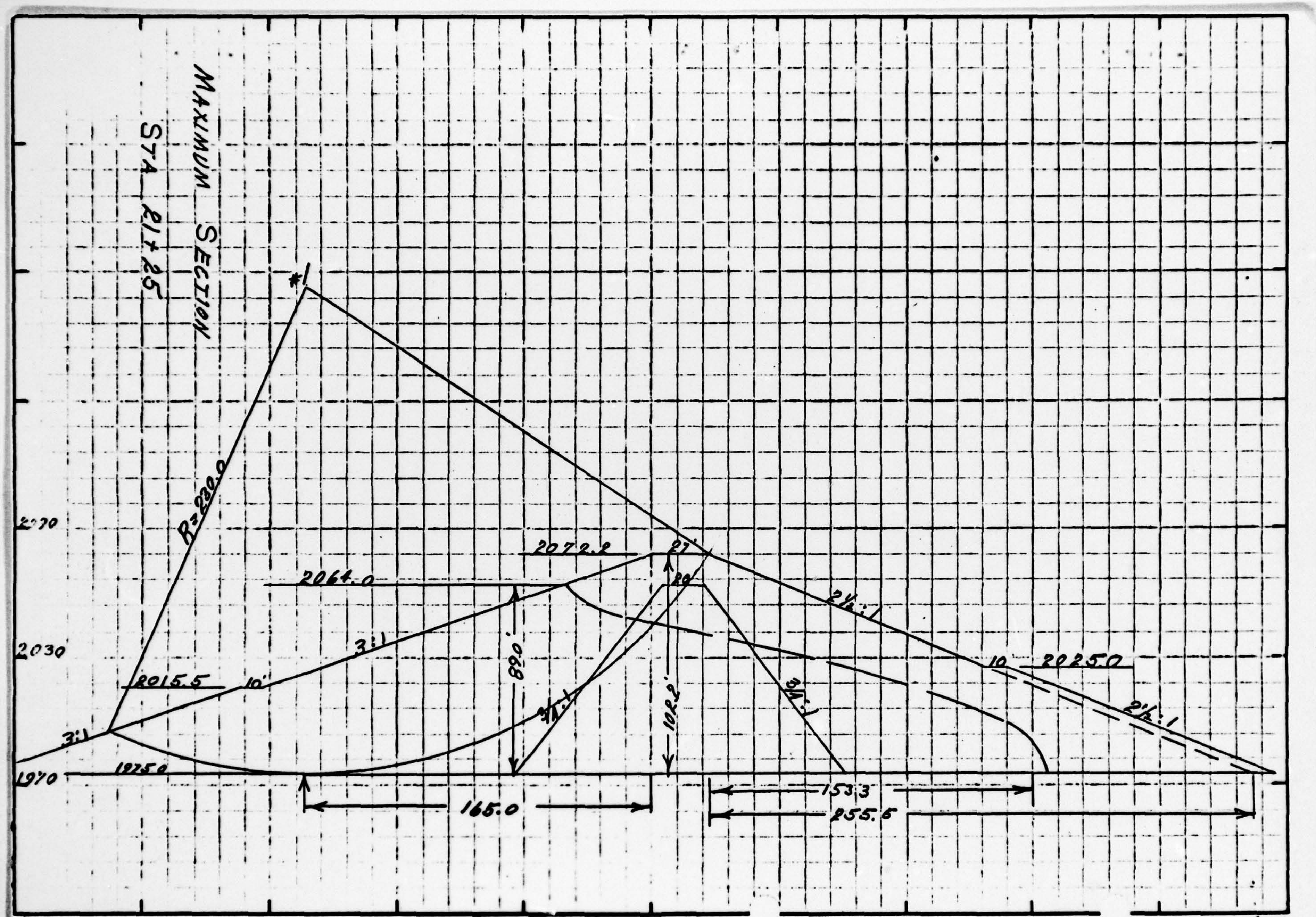
UPSTREAM SLOPE

Trial	Slope	Conditions	Fs
1C	3:1	Full drawdown; 10' berm @ elev 2015.5;	
		Arc cut from opp shoulder thru	
		zoned emb only. - 3/4:1 slope	
		on core. Sat shear values only.	1.52
		Note:	
		Zoned emb - Shell (38.7° - 0)	
		Core (23.5° - 500)	

DOWNSTREAM SLOPE

Trial	Slope	Conditions	Fs

USDA SCS LINCOLN NEBR 1960



MAXIMUM SECTION

STA 21+25

APPENDIX V

DESIGN REPORT

DESIGN REPORT

UPPER NORTH RIVER WATERSHED
SITE NO. 76
AUGUSTA COUNTY, VIRGINIA

This multiple-purpose structure is located in Augusta County, Virginia, approximately 15 miles north-northwest of Staunton. The transparent overlay (sheet 4 of this report) together with the Parnassus quadrangle published by the U.S. Geological Survey, may be used to locate the structure.

This dam is a class (c) structure (Engineering Memorandum SCS-27) and is designed in accordance with SCS criteria.

It is an earthfill structure having a cutoff trench to firm bedrock. The embankment materials are placed in a manner to afford foundation and embankment drainage through a rock toe drain.

The purpose of this dam is to reduce downstream flooding by providing temporary storage for the runoff from 17,370 acres of watershed. This temporary storage is released gradually through the principal spillway. This structure impounds 616 acre-feet of water for the city of Staunton which has its present water supply reservoir about a mile downstream from this dam. The 55-acre reservoir created by the permanent pool will afford limited recreational facilities which will be managed by the U.S. Forest Service.

The principal spillway consists of twin 42-inch diameter reinforced concrete water pipes. Discharge into the conduits is provided by a 9.0' x 10.5' reinforced concrete riser. There are three heavy duty gates attached to this riser for dewatering the reservoir and to permit utilization of the municipal water supplies.

There is a large emergency spillway cut through the right abutment. The 4.85 inches of floodwater storage below the crest of the emergency spillway, plus flow through principal spillway, will contain the maximum runoff produced by a storm in excess of 100-year frequency.

The inflow hydrographs used in the design of this structure were developed by the method described in Chapter 3.21 of Section 4, Hydrology, National Engineering Handbook.

The flood routing procedure used in the design is given in Section 5, Hydraulics, of the National Engineering Handbook.

The following table gives the results of the hydrologic and hydraulic determinations:

REFERENCE:	U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING & WATERSHED PLANNING UNIT UPPER DARBY, PENNSYLVANIA	DRAWING NO. VA-472-R SHEET 1 OF 5 DATE 3/22/63

DESIGN REPORT

Factor Which Determines Stage	Surface Area Acres	Runoff in Inches	Peak Inflow c.f.s.	Peak Outflow c.f.s.	Elev. of Maximum Stage	Storage in Ac.-Ft.	Element of Structure Determined by Maximum Stage
50-year sediment accumulation	20[1]	-	-	-	1978.0	168	Invert of riser dewatering gate
Water supply	55	-	-	-	2015.5	616	Crest of riser
100-year frequency storm moisture condition II	186	-	-	-	2060.5	5066	Below crest of emergency spillway
Greater than 100-yr. frequency storm moisture condition II[2]	221	-	-	-	2070.0	7020	Crest of emergency spillway
1.0x9-hour point rainfall moisture condition II	227	7.65	15,659	6600	2074.7	8090	Design high water
2.50x9-hour point rainfall moisture condition II	274	24.17	46,370	45,000	2084.7[3]	10,500	Check top of dam

[1] Borrow excavation in reservoir provides 248 acre-feet of storage.
[2] To reduce velocities in emergency spillway.
[3] Top of dam set at elevation 2084.00.

The time to empty the pool from the crest of the emergency spillway to the crest of the orifice is 6.10 days.

The geology report and Soil Mechanics Laboratory report were used to determine the adequacy of the design. Copies of these reports are attached.

The following publications were used in the design of this dam:

REFERENCE:	U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING & WATERSHED PLANNING UNIT UPPER DARBY, PENNSYLVANIA	DRAWING NO. VA-472-R SHEET 2 OF 5 DATE 3/22/63

DESIGN REPORT

NE Handbook No. 5, Hydraulics
NE Handbook No. 4, Hydrology
NE Handbook No. 6, Structural Design
Technical Releases Nos. 2, 5 and 10

Copies of these publications may be obtained from Mr. Tom F. McGourin, State Conservationist, USDA, Soil Conservation Service, Richmond, Virginia.

Concurred:

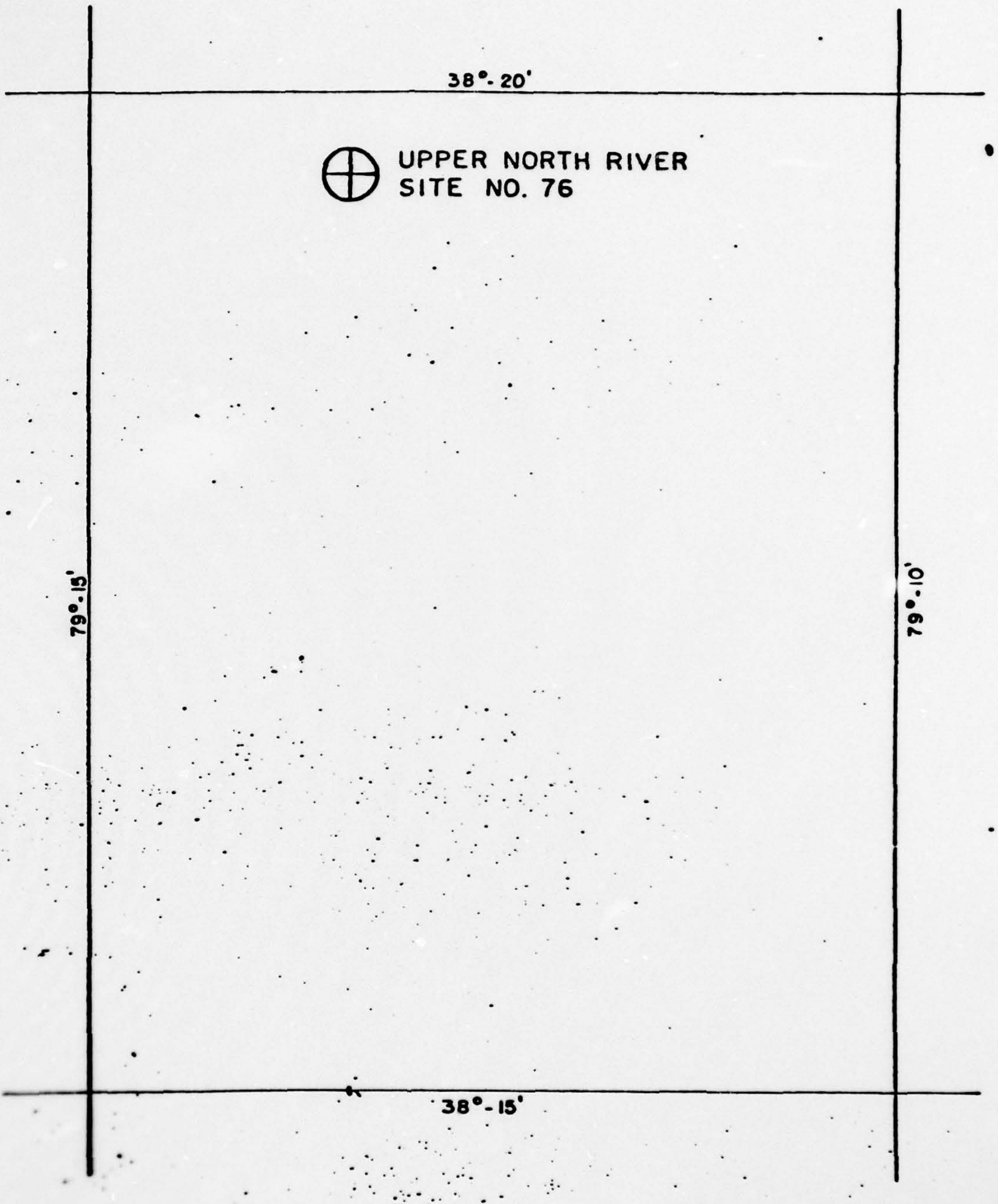
Gerald E. Oman
Design Engineer

R. C. Barnes, Jr.
State Conservation Engineer

Vincent McKeever
Hydrologist

Robert F. Fonner
Geologist

DESIGN REPORT



REFERENCE:
[illegible] QUADRANGLE,
[illegible], [illegible]

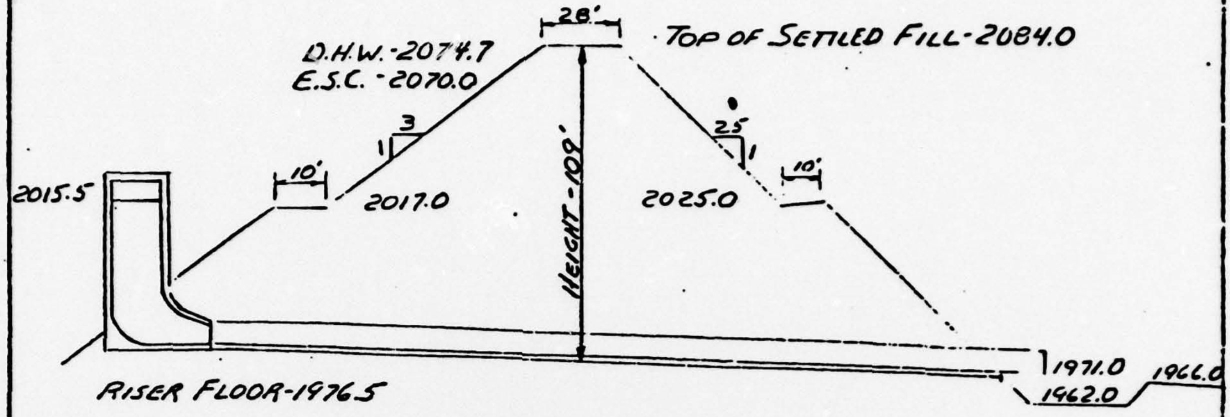
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING & WATERSHED PLANNING UNIT
UPPER DARBY, PENNSYLVANIA

DRAWING NO.

SHEET 4 OF 5

DESIGN REPORT

Summary Sheet



Typical X-Section

I. Watershed data
  - A. Structure class (c)
  - B. Drainage area 17,370 Ac.
  - C. Time of concentration - T_c 8.6 Hrs.
  - D. Hydrologic curve number - C_n
    - 1. Moisture condition II 71
    - 2. Moisture condition III 88

II. Principal spillway
  - A. Conduit
    - 1. Size (I.D.) twin 42- In.
    - 2. Length 625.3 Ft.
  - B. Riser
    - 1. Size 10.5x9.0 Ft.
    - 2. Height 39.0 Ft.
  - C. Weir length 21.0 Ft.
  - D. Orifice size - In.
  - E. Pond drain size 36 In.

III. Emergency spillway
  - A. Width 215 Ft.
  - B. Side slopes variable 1.25 to 2.50
  - C. Length of level section 40 Ft.
  - D. Exit slope 0.04 Ft/Ft.
  - E. Maximum velocity at control section (D.H.W.) 9.4 Ft/Sec.
  - F. Duration of flow (D.H.W.) through emergency spillway 16.4 Hrs.
  - G. Frequency of use Less frequent than 100 year

REFERENCE:

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING & WATERSHED PLANNING UNIT
UPPER DARBY, PENNSYLVANIA

DRAWING NO. VA-472-R
SHEET 5 OF 5
DATE 3/22/63

APPENDIX VI - REFERENCES

1. Recommended Guidelines for Safety Inspection of Dams, Department of Army, Office of the Chief of Engineers, 46 pp.
2. Design of Small Dams, U. S. Department of Interior, Bureau of Reclamation, 1974, 816 pp.
3. Geology of the Stokesville and Parnassus Quadrangles, Virginia, Reports of Investigations No. 19, E.K. Rader, Virginia Division of Mineral Resources, 1969, 30 pp.
4. Section 4, Hydrology, Part 1, Watershed Planning, SCS National Engineering Handbook, Soil Conservation Service, U. S. Department of Agriculture,1964.
5. Hydrometerological Report No. 33, U. S. Department of Commerce, Weather Bureau, U. S. Department of Army, Corps of Engineers, Washington, D. C., April 1956.
6. Technical Paper No. 40, U. S. Department of Commerce, Weather Bureau, Washington, D. C., May 1961.