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NATIONAL DAM SAFETY PROGRAM. BENS BRANCH DAM (INVENTORY NUMBER --ETC(U)

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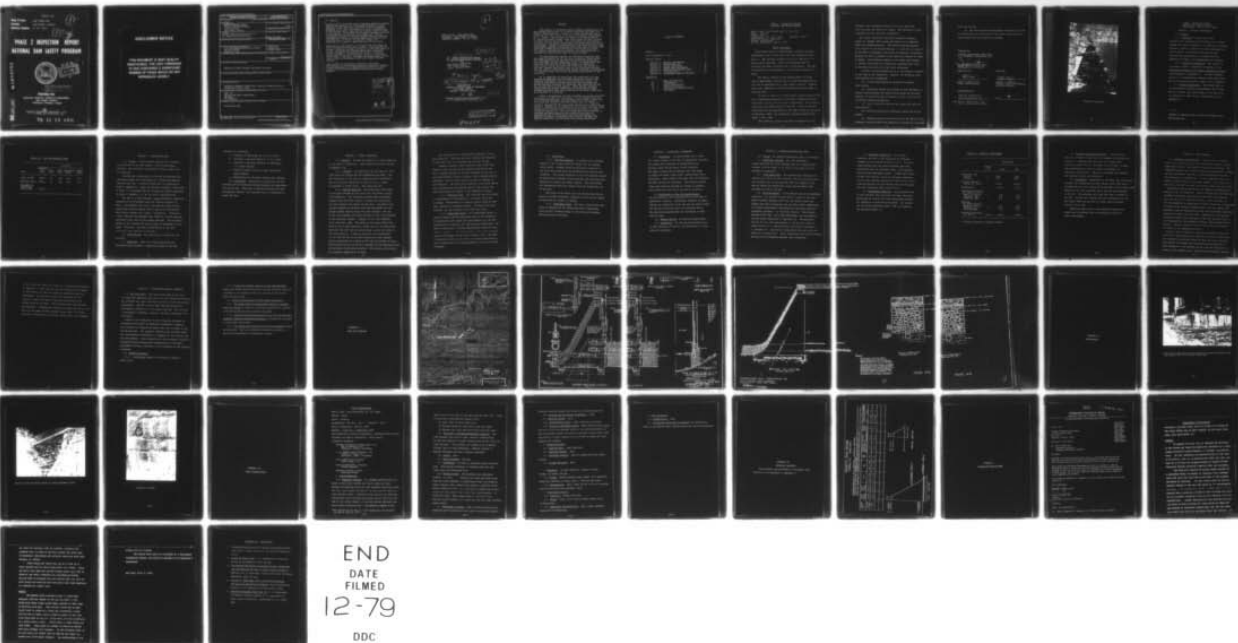
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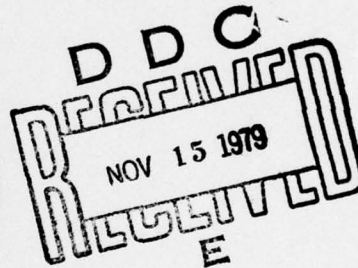
Name Of Dam: BENS BRANCH DAM
Location: WISE COUNTY, VIRGINIA
Inventory Number: VA. NO. 19509

LEVEL II

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

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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.

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20. Abstract

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

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

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

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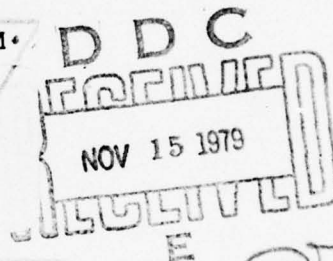
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NAME OF DAM: BENS BRANCH DAM
LOCATION: WISE COUNTY, VIRGINIA
INVENTORY NUMBER: VA. NO. 19509

Inventory Number

⑥ PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM.

Bens Branch Dam (VA-19509)
Wise County, Virginia.
Phase I Inspection Report.



⑨ Final Rept;

⑮ DACW 65-79-D-0004

⑫ 61

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

BY

⑩ James A. Walsh

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

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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 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 frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test 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

Preface.	i
Brief Assessment of Dam.	1
Overview Photo	4
Section 1: PROJECT INFORMATION.	5
Section 2: ENGINEERING DATA	9
Section 3: VISUAL INSPECTION.	11
Section 4: OPERATIONAL PROCEDURES	14
Section 5: HYDRAULIC/HYDROLOGIC DATA.	15
Section 6: DAM STABILITY.	19
Section 7: ASSESSMENT/REMEDIAL MEASURES	23

Appendices

I	-	Maps and Drawings
II	-	Photographs
III	-	Field Observations
IV	-	Stability Analysis
V	-	Construction Specifications
VI	-	References

PHASE I - INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Bens Branch Dam, Va. No. 19509
State: Virginia
County: Wise
Coordinates: Lat 36° - 54.1' Long 82° - 45.1'
USGS Quad Sheet: Appalachia
Stream: Bens Branch
Date of Inspection: May 23, 1979

BRIEF ASSESSMENT

Bens Branch Dam is a stone masonry, gravity structure approximately 266 ft long and 46 ft high (Elevation 2359.5 M.S.L.). The spillway consists of a 46 ft long by 0.4 ft deep overflow spillway. Water is discharged over the principal spillway and drops into a riprap basin. The dam was designed to be overtopped as the spillway capacity is minor.

The dam is located on Bens Branch about 1.4 miles east of Appalachia, Virginia and is owned and maintained by the Town of Appalachia as a water supply facility. Construction was completed in 1918 and modifications were made in 1920 and 1936.

The dam is rated as a "significant" hazard classification due to downstream proximity of the Town of Appalachia water filtration facility and the Town of Appalachia. The spillway will pass less than 5 percent of the PMF. Based on criteria established by the Department of the Army, Office of the Chief of Engineers (OCE), the appropriate spillway design flood (SDF) is the $\frac{1}{2}$ PMF.

The $\frac{1}{2}$ PMF will overtop the dam to a depth of 1.9 ft

maximum, with a maximum velocity of 6.4 fps, and water will flow over the dam for 6.2 hours. The spillway is rated inadequate but not seriously inadequate.

The visual inspection revealed no apparent problems except for leakage under coping and there are no immediate needs for remedial measures. The actual structure appears to be similar to the design drawings. A check of the stability was made in accordance with Corps of Engineers' guidelines, assuming the dam is founded on and keyed into bedrock as shown in design. The structure appears to be stable with respect to sliding resistance and overturning, assuming water level at the dam crest and at the PMF level calculated.

Overall, the dam appeared to be in satisfactory condition at the time of the inspection. However, the following remedial measures are recommended:

- (1) A staff gage should be installed to monitor water levels.
- (2) Protection should be provided at both abutments to prevent erosion during the floods which exceed the spillway capacity or provisions made to monitor erosion occurring due to extreme flooding conditions.
- (3) Repair should be made to the eroded area near the left abutment.

The following observation functions should also be performed:

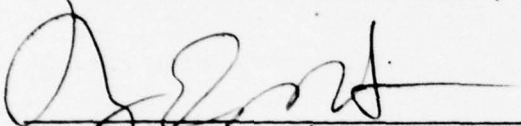
- (1) Seepage occurring along the toe of the dam and right guidewall should be monitored quarterly to detect any increased

flows and erosion.

(2) The thick woods and undergrowth should be cut from the downstream toe of the dam to facilitate observations in future monitoring and inspection programs.

Prepared By:

SCHNABEL ENGINEERING ASSOCIATES/
J. K. TIMMONS & ASSOCIATES, INC.



Ray E. Martin, Ph.D., P.E.
Commonwealth of Virginia

Submitted by:

Original signed by
JAMES A. WALSH

James A. Walsh, P.E.
Chief, Design Branch

Recommended by:

ORIGINAL SIGNED BY:
CARL S. ANDERSON, JR.

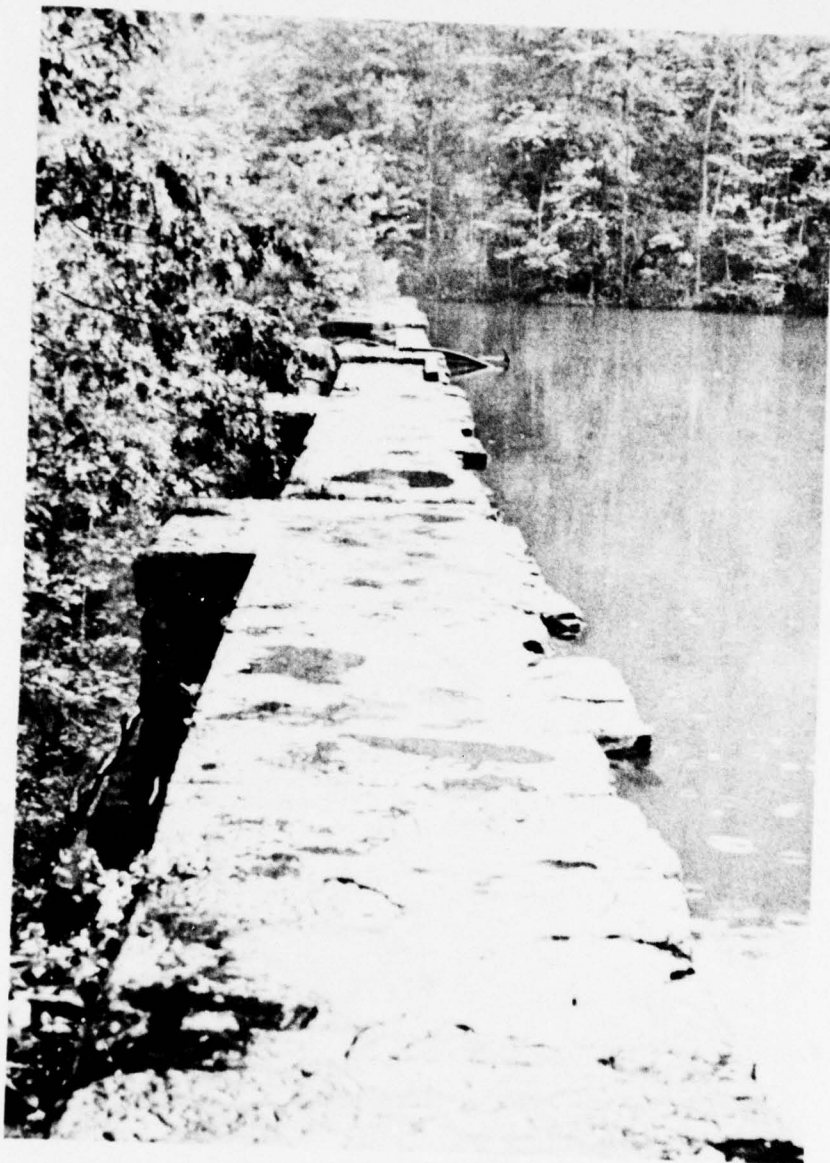
for Jack G. Starr, P.E., R.A.
Chief, Engineering Division

Approved:

Original signed by:
Douglas L. Haller

Douglas L. Haller
Colonel, Corps of Engineers
District Engineer

Date: SEP 1 1963



OVERVIEW PHOTOGRAPH

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BENS BRANCH DAM VA. NO. 19509

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 responsi-
bility is to expeditiously identify those dams which
may be a potential hazard to human life or property.

1.2 Project Description: Bens Branch Dam is
a stone masonry structure approximately 266 ft long
and 46 ft high*. The crest width is 6 ft and is at
an elevation of 2359.5 M.S.L. (See Plates 2 and 3,
Appendix I).

*Height is measured from the top of the dam to the
downstream toe.

The spillway is 46 ft long with a crest elevation of 2359.1 M.S.L. There is a 24-inch diameter pipe inlet at elevation 2313.4 M.S.L. (invert), which may be used to drain the lake, and two 12-inch water intakes located at elevation 2323.5[±] and 2320.5[±] M.S.L. (inverts).

1.2.2 Location: Bens Branch Dam is located on the Bens Branch, 1.4 miles east of Appalachia, Virginia, (See Plate 1, Appendix I).

1.2.3 Size Classification: The dam is classified as an "intermediate" size structure because of height.

1.2.4 Hazard Classification: The dam is located in a rural area; however, based upon the downstream proximity of the Town of Appalachia and its water filtration plant (Photo No. 1, Appendix II), the dam is assigned a "significant" hazard classification. The hazard classification used to categorize a dam is a function of location only and has nothing to do with its stability or probability of failure.

1.2.5 Ownership: The Town of Appalachia owns and operates the dam.

1.2.6 Purpose: Water supply for the Town of Appalachia.

1.2.7 Design and Construction History: The dam was constructed in 1918 and was designed and constructed under the supervision of a consulting engineer, 60 Wall Street, New York, New York, for the Virginia Coal and Iron Company.

Modifications made to the dam since initial construction are as follows:

a) Increase in dam height by 2.5 ft.

- b) Decrease in spillway depth (increase in elevation) by 2.1 ft.
- c) Pressure grouting of dam
- d) Modification of raw water intake

1.2.8 Normal Operational Procedures: The spillway is ungated; therefore, water rising above the crest is automatically discharged downstream.

1.3 Pertinent Data:

1.3.1 Drainage Areas: The drainage area is 0.53 square miles.

1.3.2 Discharge at Dam Site: Maximum known flood at the dam site occurred in April 1977; however, the pool elevation was not observed.

Spillway Discharge:

Pool at Crest of Dam (El 2359.5 M.S.L.) 44 CFS

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

Table 1.1 DAM AND RESERVOIR DATA

Item	Reservoir				
	Elevation Feet M.S.L.	Area Acres	Acre Feet	Watershed Inches	Length Miles
Crest of Dam	2359.5	18	403	14.2	0.4
Spillway Crest	2359.1	18	396	14.0	0.4
Streambed at Downstream Toe of Dam	2313.5	-	-	-	-

SECTION 2 - ENGINEERING DATA

2.1 Design: Partial design drawings are available at the Office of the Town Manager, Town of Appalachia, Virginia. The hydrologic and hydraulic design report was not available.

The dam was constructed in 1918 and was designed and constructed under the supervision of a consulting engineer from New York City. Original design data is presented on Plate 2, Appendix I. Since the dam was originally constructed in 1918, it is assumed that the "section at center" presented on Plate 3, Appendix I is an "as built" representation.

The dam is a stone masonry, gravity structure, apparently designed to be overtopped since the spillway capacity is minor. As designed, the core of the dam was "made of very heavy stone laid on natural beds in matrix of hard placed small stone grouted in 8" layers - horizontal". Plates No. 2 and 3 show the dam embedded into "hard" or "solid" bedrock with both a heel and toe key trench provided. The horizontal extent of the trenches and actual depth of embedment are not known. Plate No. 2 provides a description of the gate valves and other details as designed.

2.2 Construction: The construction records are not available.

2.3 Operation: There is no known operation and instrumentation procedure. Operation records of the dam

indicate the following:

- a. Increase in dam height by 2.5 ft in 1920.
- b. Decrease in spillway depth by 1 ft in 1920.
- c. Decrease in spillway depth by an additional 1 ft (date unknown).
- d. Pressure gravity of dam in 1936 (extent and depth unknown).
- e. Modification of raw water intake (date unknown).

2.4 Evaluation: Engineering calculations are not available but the available design drawings are representative of the dam. There are no records available for dam performance; however, the available data is sufficient to assess the dam.

SECTION 3 - VISUAL INSPECTION

3.1 Findings: The dam was generally in good condition at the time of inspection. Field observations are outlined in Appendix III.

3.1.1 General: An inspection was made May 23, 1979; light rain was falling and the temperature was 65°F. The pool elevation at the time of inspection was 2359.9±M.S.L. and the tailwater elevation was 2313.5± M.S.L., which corresponds to normal flows. The ground was wet.

3.1.2 Dam and Spillway: The structure is believed to have been founded on rock since the area shows a solid rock foundation. The structure surface shows no apparent seepage along the face; however, leakage was noted along the joint between the coping and dam face. Scattered iron-stained seepage was observed along the downstream toe and natural ground contact along the right abutment, the top of the left abutment and along the base of the left guidewall of the discharge channel. Seepage in all areas appeared to be less than 1 gpm. The grout in the stone surface was found to be in good condition, except that on the downstream face near the left side of the spillway a crack was noted in the stone masonry. A surface crack was also noted about 4.5 ft from the top on the face toward the right abutment. Erosion consisting of a gully 10 ft[±] long and several ft deep exists below the top of the left abutment on the downstream side. No structural cracks were observed. The vertical and horizontal alignment appeared to be good.

The concrete weir on the spillway appears to be in good condition. Floating raw water intakes were observed. It was noted that the structure had no drain system.

Numerous outcrops exist along the road to the dam; however, only one outcrop was actually observed at the site. Bedrock exposed in the left abutment at the top of the road consists of gray to brown, fine to medium grained sandstone. Rock at this location strikes 63 degrees to the 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.

3.1.3 Reservoir Area: The reservoir has side slopes of approximately 2 horizontal to 1 vertical (2:1) and is wooded. Measurements at numerous points along the dam face indicated no sediment buildup. No debris was noted upstream and the reservoir water was very clear.

3.1.4 Downstream Areas: The downstream channel is heavily wooded from the downstream face of the structure. The downstream side slopes are approximately 1:1 and the stream width is constant for some distance downstream. The Town of Appalachia is located approximately 8000 ft[±] downstream along the Powell River. This river produced severe flood damage to the Town in April, 1977. The Town of Appalachia water filter plant is located approximately 800 ft downstream and is approximately 8 ft to 10 ft above streambed.

3.2 Evaluation:

3.2.1 Dam and Abutments: In general the structure appears to be in good condition except for the leakage along coping. Seepage should be monitored quarterly in the areas described along the downstream toe and the left guidewall. The erosion adjacent to the left abutment should be backfilled to prevent future problems and then monitored quarterly to detect any future erosion. The thick woods and undergrowth should be removed from the downstream toe of the dam.

The crack in the mortar joint on the dam face did not appear to affect structural integrity of the dam but should be monitored for growth or seepage.

3.2.2 Downstream Areas: The water filter plant that would be damaged and the downstream Town of Appalachia could receive flooding damage if this dam were breached during periods of flooding.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures: The Bens Branch Dam is used for a water supply to the Town of Appalachia, Virginia. The normal pool elevation is maintained by the spillway crest and raw water intake structure. The water is drawn off by several cast iron pipes to supply the water filter plant located some 800 ft downstream. Above normal flows pass over the spillway and down the face of structure. The overall picture shows that once the spillway is filled to capacity, water flows over the top of the entire structure.

4.2 Maintenance of Dam and Appurtenances: The maintenance is the responsibility of the Town of Appalachia, Virginia. Maintenance consists of debris removal and inspection of the dam and raw water intake. The dam and filtration plant are inspected daily. The operating appurtenances are reportedly in good working order.

4.3 Warning System: No warning system exists.

4.4 Evaluation: The dam and appurtenances are in good operating condition, and maintenance is being routinely performed.

SECTION 5 - HYDRAULICS/HYDROLOGIC DATA

5.1 Design: No hydraulic-hydrologic data is available.

5.2 Hydrologic Records: The only hydrologic record available for this drainage area is a rainfall measurement of 8.38 inches in 24 hours in the April of 1977, measured at Appalachia.

5.3 Flood Experience: The maximum pool elevation observed was in April of 1977; however, the pool elevation was not recorded, but it was observed that the roadway to the dam was washed out during this flood and the water level exceeded the top of the dam.

5.4 Flood potential: 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. The Probable Maximum Flood (PMF) and $\frac{1}{2}$ PMF hydrographs were developed by the SCS method (Reference 4, Appendix VI). Precipitation amounts for the flood hydrographs of the PMF and $\frac{1}{2}$ PMF are taken from the U. S. Weather Bureau Information (Reference 5, Appendix VI). Appropriate adjustments for basin size and shape were accounted for. These hydrographs were routed through the reservoir to determine maximum pool elevations.

5.5 Reservoir Regulation: For routing purposes, the pool at the beginning of flood was assumed to be at elevation 2359.1 M.S.L. Reservoir stage-storage data and stage-discharge data were determined from the available plans, field measurement and USGS quadrangle sheets. Floods were routed through the reservoir using the spillway discharge up to a pool storage elevation of 2359.5 M.S.L. and a combined spillway and non-overflow section discharge for pool elevations above 2359.5 M.S.L.

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 flood conditions (PMF, $\frac{1}{2}$ PMF) are shown in the following Table 5.1.

TABLE 5.1 RESERVOIR PERFORMANCE

		Hydrograph	
		Normal Flow	
			$\frac{1}{2}$ PMF
			PMF
Peak Flow, CFS			
Inflow	1	2504	5008
Outflow	1	2247	4492
Maximum Pool Elevation ft, M.S.L.		2361.4	2362.5
Freeboard, Ft		(-1.9)	(-3.0)
Non-Overflow Section (El 2359.5 M.S.L.)			
Depth of Flow, ft	-	1.9	3.0
Duration, hrs	-	6.2	6.2
Velocity, fps*	-	6.4	8.0
Spillway (El 2359.1 M.S.L.)			
Depth of Flow, ft	-	2.3	3.4
Duration, hrs	-	12.0	12.0
Velocity, fps*	-	7.4	9.0
Tailwater Elevation Ft, M.S.L.	2313.5	2317.4	2318.6

* Critical Velocity at Control Section

5.7 Reservoir Emptying Potential: A 24-inch pipe drain at elevation 2313.4 M.S.L. is capable of draining the reservoir. Assuming that the lake is at normal pool elevation (2359.1 M.S.L.) and there is no inflow, it would take approximately 2 days to lower the reservoir to elevation 2313.4 M.S.L. There are no methods for lowering the reservoir below this elevation.

5.8 Evaluation: Department of the Army, COE, guidelines indicate the appropriate spillway design flood (SDF) for an intermediate size and significant hazard dam is the $\frac{1}{2}$ PMF to PMF. Because of the risk involved, the $\frac{1}{2}$ PMF has been selected as the SDF. The spillway will pass less than 5 percent of the PMF. The SDF will overtop the dam a maximum of 1.9 ft, and remain above the dam for 6.2 hours with a critical velocity of 6.4 fps.

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

SECTION 6 - DAM STABILITY

6.1 Foundation and Abutments: The dam site is located within the southeast edge of the Appalachian Plateau (locally Cumberland Plateau) Physiographic Province of Virginia. The Cumberland Plateau is a stream dissected plateau which is underlain by sedimentary rocks up to lower Pennsylvanian in age (See Reference 3, Appendix VI). In the Appalachia area, the surface of the country is extremely rugged. Flat lands even a few acres in extent are rare, and valley slopes are very steep.

Bens Branch Dam is believed to be founded on sandstones or shales of the Lee Formation. Design drawings show the dam being founded on hard rock and actually keyed into rock along the heel and toe of the structure (Plates 2 and 3, Appendix I). The Lee Formation is approximately 1500 ft thick and is comprised of three thick, massive sandstone beds which are usually conglomeratic and are separated by shale and thin-bedded sandstones containing several thin coal beds. Bedrock near the dam site generally strikes from northeast to due east and dips from 25 to 50 degrees[±] to the northwest; however, dip reversals occur locally. Geologic maps of the area do not show the presence of faults in the immediate vicinity.

Plates 2 and 3, Appendix I shows the overburden soils and "soft rock" excavated and the structure resting on "hard rock". Key trenches are provided along the heel and toe of the dam. This method of founding the structure would provide for a good foundation. The drawings do not give any indication of design in the abutment area. Based upon the outcrops exposed

in the left abutment and the presence of only very minor erosion along the contacts, it would appear that the dam is keyed into rock in the abutments.

A stability analysis was apparently made since Plate 3, Appendix I includes a "Resultant of All Forces/Factor 2.780." It is not known whether this refers to the as built structure or to the modified structure. Details are not available.

6.2 Evaluation:

6.2.1 Foundation and Abutments: The entire dam rests 1 to 2 ft below the designated "line of hard rock" at elevation 2307.0. This represents a 38^{\pm} ft wide cut from abutment to abutment, which extends into bedrock approximately 4 ft. A 7^{\pm} ft wide and 2^{\pm} ft deep trench was then excavated along the toe of the dam while a 2^{\pm} wide and 2^{\pm} deep trench was provided along the heel of the dam. Based upon the outcrops exposed in the surrounding area and the foundation design, excessive settlement of the dam does not appear to be a problem since outcrops in the immediate area consist of fairly competent, slightly to moderately weathered bedrock. Measured attitudes indicate there are probably no adversely oriented weak planes within the foundation rock that would act as a potential sliding plane. The heel and toe key trenches increase the sliding resistance of the structure and also serve as cutoffs for any potential seepage through the foundation rock. Only minor seepage would be expected through bedrock joints.

The steep slopes which form both abutments consist of weathered bedrock and a thin soil cover. These slopes were considered safe and stable at the time of inspection.

According to Mr. Stewart Stidham, formerly with the Cumberland Water Company (previous owner of the dam) the dam was pressure grouted along the downstream face in 1936 in attempt to plug all visible seepage paths through the structure. The actual extent and depth of the grouting is not known. The existing mortar appears to be performing satisfactorily except in areas where leakage runs along the coping.

A surface crack was also noted in the dam about 4.5 ft from the top of the face toward the right abutment. This appears to be only surficial and is not believed to be detrimental to the structural integrity of the dam.

6.2.2 Stability Analysis: A check of the stability of the dam was made in accordance with Section 4.4 of Reference 1, Appendix V. Assuming the structure resting upon a horizontal bedrock surface, the stability was evaluated with respect to sliding resistance and overturning assuming water at the dam crest, and 1.9 ft over the crest which corresponds to the $\frac{1}{2}$ PMF. Calculations are included in Appendix IV. Factors of safety of 9.3 and 9.2 were obtained for the sliding condition for the two pool level conditions. These factors of safety are substantially

greater than the factor of safety of 3 required by Reference 1, Appendix V. The stability of the structure with respect to overturning for the two reservoir conditions was also determined. At both pool levels the resultant of all forces is within the base of the dam but not within the middle third of the base. This analysis does not consider end restraint. Although the factors of safety are low at 1.20 and 1.13 for water at the spillway crest, and 1.9 ft over the crest, respectively, we do not believe this is a problem.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment: The Bens Branch Dam at the time of inspection appeared sound and in a safe operating condition. The spillway will pass less than 5 percent of the PMF without overtopping. The SDF is the $\frac{1}{2}$ PMF, and the dam will be overtopped a maximum of 1.9 ft during the SDF. The spillway is considered inadequate, however, the dam is designed to be overtopped.

A check of the stability of this structure was made in accordance with Corps' of Engineers guidelines, assuming the structure is founded and keyed into rock as shown in the design drawings. The analysis indicates the structure meets the requirements of Reference 1, Appendix VI for sliding, but not for movement. Upon inspection of the structure, review of available design drawings and consideration of the dam's performance history, stability of the structure is not believed a problem.

7.2 Remedial Measures:

7.2.1: A staff gage should be installed to monitor water levels.

7.2.2 Protection against erosion of the dam abutments during the floods which exceed the spillway capacity should be provided or the abutments should be monitored for erosion after extreme floods.

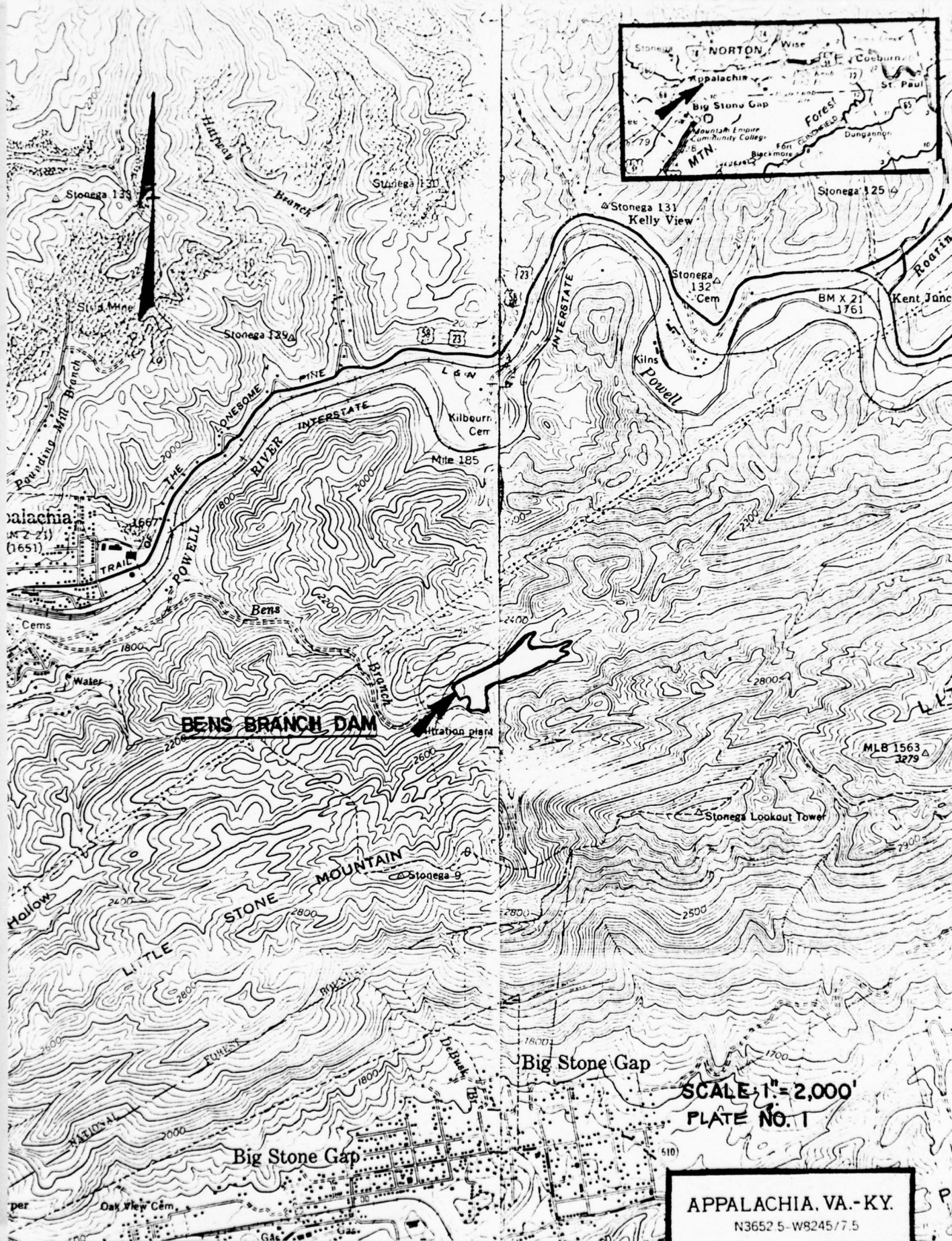
7.3 Required Maintenance and Monitoring Procedures:

7.3.1 The thick woods and undergrowth should be removed from toe of dam in order to facilitate observations required in future monitoring and inspection programs.

7.3.2 Seepage occurring along the toe of the dam and right guidewall should be monitored quarterly to detect any increase in flow rates and erosion.

7.3.3 The eroded area existing in the left abutment should be corrected. This area should be monitored quarterly to detect the development of additional erosion.

APPENDIX I
MAPS AND DRAWINGS



NOTE:

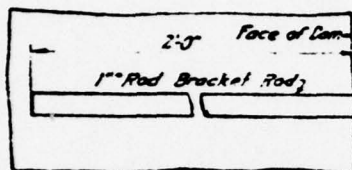
Gate Rods should come in about 10 ft. length with standard screw ends.

DETAIL OF 12 WASHER
Scale: 3"=1'-0"



DETAILS

Standard screw end
Standard Hex bolt for 1" Rod
2-1/2 Washers to act as shoulder for bracket



GATE HANDLE & BRACKET
Scale: 3"=1'-0"

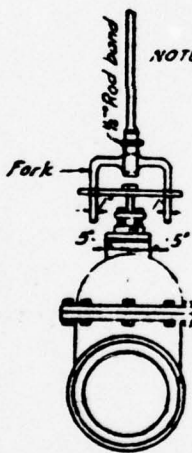
EL 23570 Crest
Fiasboard Channels
Storm Spill EL 23550
Normal Spill EL 23530

NOTES:

This Dwg. supplied for information of Nov. 1, 1912

NOTE:

Care should be taken to see that key does not rest on Gate



GATE & GATE KEY
Scale: 1"=1'-0"

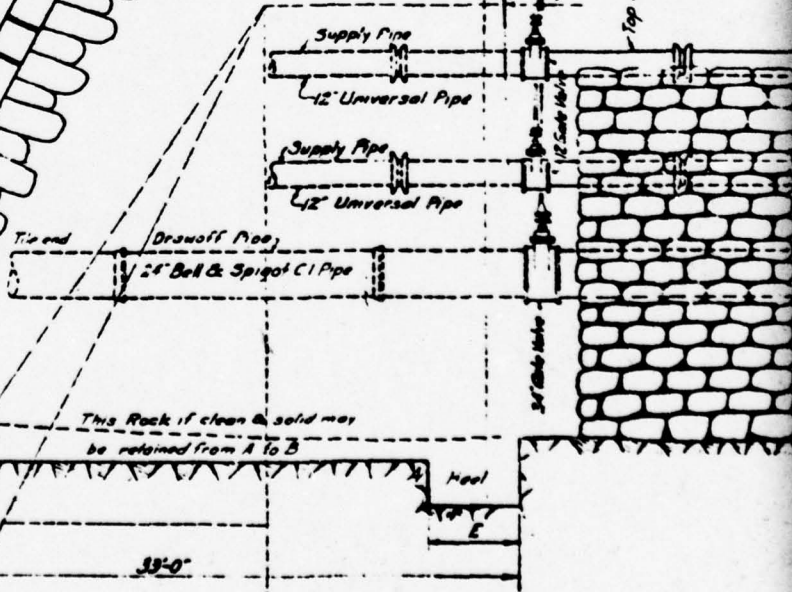
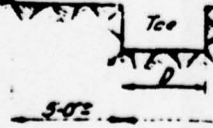
Core to be made of very heavy stone laid on natural beds in matrix of hand placed small stone grouted in 8" layers - horizontal

Vertical Better 18" in 30'-0"

Top of 14" 12" Pipe EL 23845

To be stopped Earth

Rock



This Rock if clean & solid may be retained from A to B

NOTES:

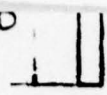
Depths of A B & C & width of D & E to be given by Engineer on ground

CROSS SECTION OF DAM
Scale: 1/2"=1'-0"

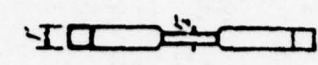
ASHER
20"



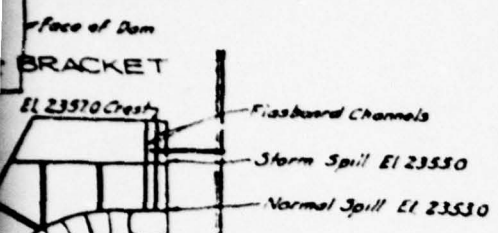
DETAILS OF 1" ROD BAND
Scale 5"=1'-0"



DETAILS OF FORK HANDLE
Scale 3"=1'-0"

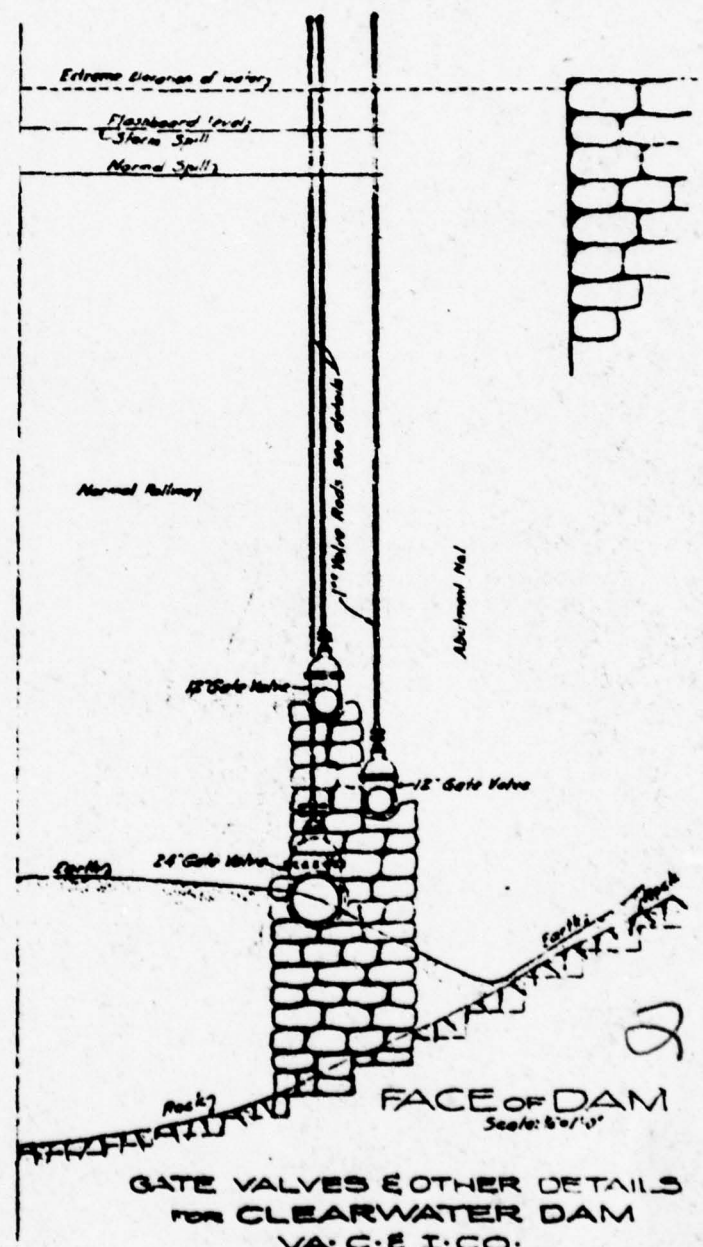
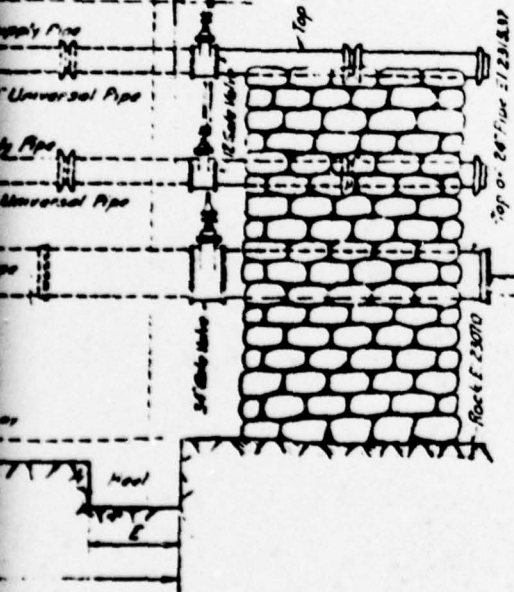


DETAILS OF FORK
Scale 3"=1'-0"



NOTES:
This Dwg supplements Dwg of Nov 1, 1917
For information not given here see Dwg
of Nov 1, 1917

be made of
very stone laid
out beds in masonry
of black and small
rounded in 8"
horizontal

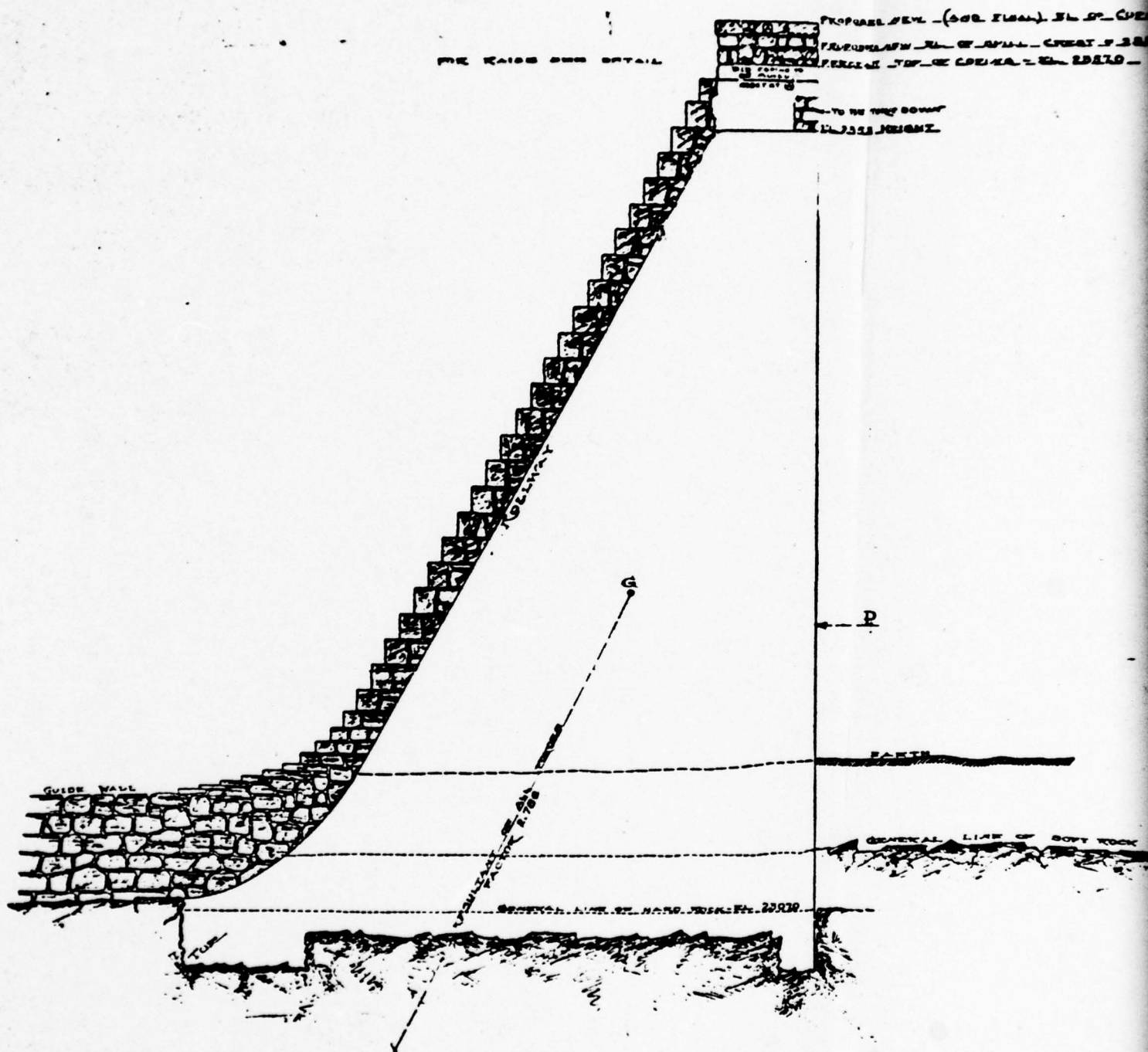


GATE VALVES & OTHER DETAILS
FOR CLEARWATER DAM
VA. C. & I. CO.

APPALACHIA VA.
SIGNED: AS SHOWN DATE: DEC 10, 1917
CONSULTING ENGINEER
60 WALL ST. NEW YORK CITY
KINGSPORT TENN

PLATE NO 2

ON OF DAM



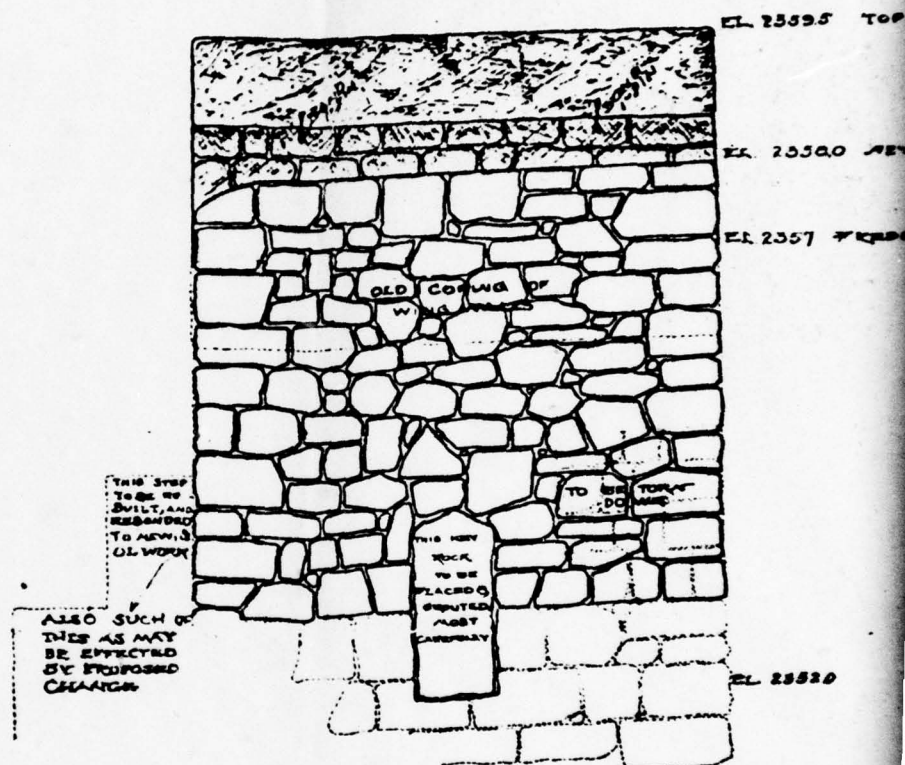
CLEARWATER DAM, APPALACHIA, VA.

SHOWING PROPOSED RAISING IN ELEVATION

APPALACHIA, VA—MCH.—30TH 1920—

H. A. Miles CONSULTING ENGR.
N.Y. CITY.

STATION EL. 25525
 WALL - GREAT S. BASIN (7144) -
 EL. 25520 -



ALSO SUCH OF THIS AS MAY BE EFFECTED BY PROPOSED CHANGE

DETAIL SECTION
 SCALE 1" = 1'0"

NOTES!

WALLS MUST BE SPILL AND WINGS, TO
 CARRY THROUGH AT ELEVATIONS SHOWN
 FOR EACH, RESPECTIVELY - AND TO BE MOST
 GRADUALLY KEYS INTO SOLID ROCK AT INTERSECTION
 THROUGH AT EXTREME ENDS - I.E. MOUNTAIN SIDES -
 NOT LESS THAN 1 FT DEEP IN ABSOLUTELY SOLID ROCK

STONE WORK TO BE OF SAME CHARACTER AS PRESENT
 STRUCTURE - BOND STONE TO BE SET OVER EVERY
 JOINT, AND TO BE DOUBLE IN LENGTH THE WIDTH
 OF STRETCHERS - ALL ROCK TO BE CLEAN & SOUND,
 AND TO BE SET IN FULL BEDS OF MORTAR -
 MORTAR TO BE COMPOSED OF 1 ONE PART BEST
 AM. PORTLAND CEMENT TO 2 TWO PARTS SAND
 SAND USED IN MAIN STRUCTURE

NEW WORK TO BE INSPECTED, AND APPROVED
 BY CONSULTING ENGINEER BEFORE ACCEPTANCE

PLATE N° 3

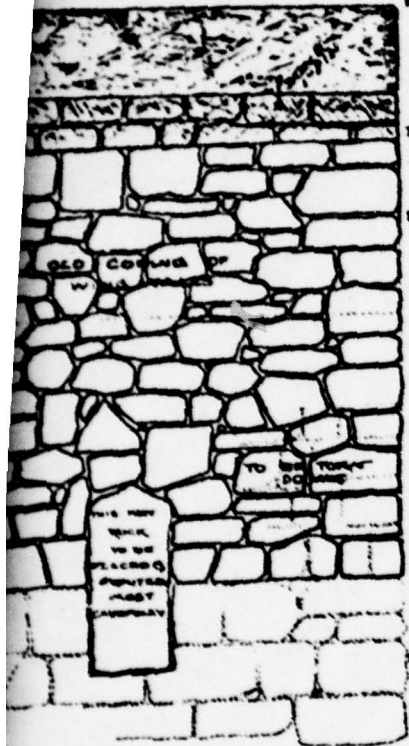
2

EL 25395 TOP OF COPING (APPROXIMATE)

EL 25300 NEW SPILL CREST

EL 2557 PRESENT TOP OF COPING

EL 25520



TAIL SECTION
SCALE 1" = 1.0'

PLATE N°3

3

APPENDIX II
PHOTOGRAPHS



PHOTO TAKEN FROM CREEK BED OF THE BACK OF WATER TREATMENT PLANT
(EYE LEVEL SIGHT IS 5'4" ABOVE CREEK BED)



VIEW OF HEAVY WOODS IN DOWNSTREAM CHANNEL



VIEW SHOWING GOOD CONDITION OF RUBBLE FACE
(NOTE DATE BLOCK - ARROW)



PHOTO OF FACE AND WATER INTAKE TO WATER TREATMENT PLANT



CLOSE-UP OF CRACK

II-5

APPENDIX III
FIELD OBSERVATIONS

FIELD OBSERVATIONS

Name of Dam: Bens Branch Dam, Va. No. 19509

County: Henry

State: Virginia

Coordinates: Lat 36° - 54.1' Long 82° - 45.1'

Date of Inspection: May 23, 1979

Weather: Light rain, temperature 65°F

Pool Elevation at Time of Inspection: Elevation 2359.9 M.S.L.

Tailwater at Time of Inspection: 2313.5 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
Hugh Gildea, P.E.

Town of Appalachia, Virginia
Robert Reynolds

Dewberry, Nealon & Davis
Lawrence Phipps

1 Concrete/Masonry:

1.1 Seepage or Leakage: All seepage observed was estimated at less than 1 gallon per minute (gpm) per seep.

Seepage was observed along the left abutment crest down along the side slope toward the base of the dam and also near the right abutment crest. Scattered iron-staining was observed. Considerable iron-staining and seepage exists along the left side of the outlet channel in the area beside and below the stone rubble retaining wall. Considerable seepage or wet

*Not present during May 23, 1979 inspection, but visited the dam on June 13, 1979.

spots exist on the face of the dam along the top 6 ft[±]. Areas of particular concentration appear to be:

- (1) Just right of first right pier.
- (2) Between second of third piers from the right.
- (3) Between the fifth and sixth piers from the right.

1.2 Structure to Abutment/Foundation Junction: The right abutment ties into a steep, natural, wooded slope. No rock was observed. A narrow unpaved road exists along the right abutment. The adjacent cut exposes fine to medium grained, gray to brown sandstone. Bedrock strikes 63 degrees northeast and dips 5 degrees southeast.

1.3 Drains: None

1.4 Water Passages: Spillway

1.5 Foundation: The dam is reportedly keyed into bedrock. Fine grained sandstone is exposed along the left slope along the downstream face.

1.6 Surface Cracks: The structure was reportedly grouted in 1936[±]. Between the fifth and sixth piers from the right abutment, a discontinuous crack was observed along a mortar joint, which also crosses a sandstone block. Entire length is 6 ft[±]. A 7 inch void in mortar was visible along the right side of the first pier, approximately 4 ft below the crest. Most cracks occur in the top 4.5 ft. Distinct crack located 4.5 ft from top near the right abutment, below coping.

1.7 Structural Cracking: Some cracking observed along retaining wall bounding the left side of the outlet channel.

Scattered surface cracks were noted on the downstream face.

1.8 Vertical and Horizontal Alignments: Good.

1.9 Monolith Joints: None

1.10 Construction Joints: Good condition in general.

1.11 Erosion of Abutment Slopes: Some erosion exists along the top of the left abutment slope at the contact between the dam and natural ground. The erosion includes a gully 10ft[±] long and several ft deep. Appears to be related to runoff but some seepage also present.

2 Ungated Spillway:

2.1 Concrete Weir: Good condition.

2.2 Approach Channel: None

2.3 Discharge Channel: Heavily wooded and thick undergrowth.

2.4 Bridge and Piers: None

3 Reservoir: In good condition, slight to steep slopes, no debris noticed.

3.1 Slopes: Heavily wooded steep slopes (2:1) generally bound the reservoir to water level. The area was clean.

3.2 Sedimentation: None, depth was 44 ft at the upstream face and the water was extremely clear.

4 Downstream Channel:

4.1 Condition: Wooded and rocky.

4.2 Slopes: Steep (1:1) heavily wooded slopes occur on both sides.

4.3 Population and Facilities: None, water treatment plant 800 ft[±] downstream.

5 Instrumentation:

5.1 Monumentation: None.

5.2 Observation Wells and Piezometers: No observation wells or piezometers were located during our field observations.

APPENDIX IV

STABILITY ANALYSIS

This analysis was performed in accordance with
Section 4.4 of Reference 1, Appendix V.

GRAVITY DAM DESIGN

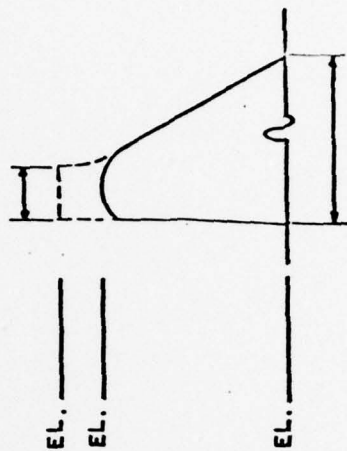
STABILITY ANALYSIS

ANALYSIS DONE ON X. FULL SECTION — PARTIAL SECTION

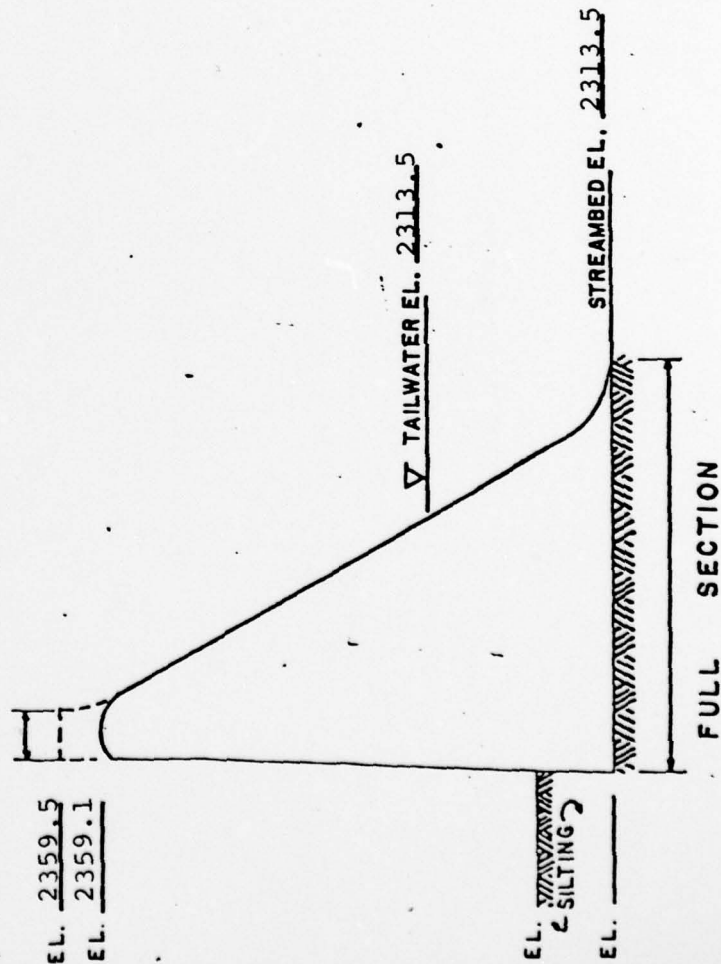
LOCATION OF SECTION Center of Dam

ANALYSIS PREPARED BY Schnabel Engineering Associates, P.C.

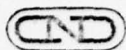
LOADING CASE	ELEV. HEAD WATER	ELEV. TAIL WATER	ΣV	ΣH	$\frac{\Sigma H}{\Sigma V}$	LOCATION RESULTANT FROM TOE	% BASE COMPRESSION IN	FACTOR SAFETY SLIDING	FOUNDATION PRESSURE	
									TOE	HEEL
Normal Pool	2359.1	2313.5	94.3 kip	80.0 kip	.85	7.8'	61.6	9.3	8.1 ksf	0
$\frac{1}{2}$ PMF	2361.4	2317.4	92.7 kip	81.1 kip	.87	5.5'	43.4	9.2	11.3 ksf	0



PARTIAL SECTION



APPENDIX V
CONSTRUCTION SPECIFICATIONS



RECEIVED JUL 9 1979

DEWBERRY, NEALON & DAVIS
ENGINEERS • ARCHITECTS • PLANNERS • SURVEYORS

8411 ARLINGTON BOULEVARD FAIRFAX, VIRGINIA 22031 (703) 560-1100

July 5, 1979

Schnabel Engineering Associates
11 South Twelfth Street
Suite 300
Richmond, Virginia 23219

Attention: Steve Werner

Re: Ben's Branch Dam
Appalachia, Virginia
Original Construction Documents

SIDNEY O. DEWBERRY
RICHARD N. DAVIS
HAROLD WILLIAMS
VERNON R. GINGELL
ERNEST M. JENNELLE
PAUL J. TEMPLES
ROBERT J. DIAISO
WILLIAM H. EDWARDS
DOUGLAS R. FAHL*
WILLIAM G. FRY
CARL E. KEISLER*
JOHN T. MONAGHAN
ROBERT E. POEHNER*
ARCHIE L. WHISONANT*
THOMAS L. WILEY
WARREN H. ZIMMERMAN*
*NON-REGISTERED PROFESSIONALS

Gentlemen:

Attached is one [1] copy each of the two [2] plan sheets and the five [5] specification pages of the construction documents for the Ben's Branch Dam. This represents both the original construction and the later modification.

These copies were produced photographically from the originals. While we did make an effort to assure that all the information was transferred from the original to the copy, we do not assume any responsibility for the completeness of these copies. If you wish to view the originals, these will be available in the Appalachia Town Office.

If you have any questions or comments, or if you require any information, please contact us.

Very truly yours,

DEWBERRY, NEALON & DAVIS

Joseph J. Doane, P.E.
Director
Structural Engineering Department

JJD:oa-m

Encs: As indicated above

xc: Town of Appalachia - Attention: E.E. Brooks (w/encs & original)

MEMORANDUM SPECIFICATION

covering a proposed final raise in height of Spillway of the large Rubble Dam on Ben's Branch, on Big Stone Mountain, near Appalachia, Va.

GENERAL

In general the work will be executed by employees of the owners and under the immediate direction of a thoroughly competent Superintendent, or Foreman, supplied by them. He will understand the responsibility of the work of following plans and specifications falls upon him, and that he is to make no changes therein of moment without obtaining written authority therefor from his employers.

The work will consist of laying rubble masonry of a character which, as nearly as possible, will resemble that with which the top five or six feet of the present structure is finished. The new rubble shall be laid to exactly conform to the new work shown on the accompanying drawings. The intent is to build a solid wall of rubble masonry from present top of dam on both spillway and wings to the proposed elevation shown on said drawings for both, respectively. Before starting said new work the old coping stone on both spillway and wings shall be taken off and stacked at convenient nearby spot, and the raw stone work under same shall be carefully swept and cleaned. A-

ter such cleaning, a line of stone, about as shown on accompanying section, will be pried out so as to form a continuous channel from end to end of wings and from end to end of spillway. This channel need not be anything like as large as that shown in the drawings, nor need it be a continuous straight line; it should, however, not be less than six (6) inches deep, and wide, as a minimum, nor should it deviate from a general straight line more than one (1) foot on either side of a general centre line.

In channel so made shall be set in full bed of mortar, and surrounded by some good, jagged but eminently solid rock extending up as teeth for a height of not less than six (6) inches over the general plane of the starting elevation, said stone to act as key, or bond stone between the old and proposed new masonry.

After said bond stones are strongly set (for a period of not less than 48 hours) the rough top of old work from which coping has been removed will be thoroughly cleaned, all deep crevices, or interstices grouted full, and the new work started from a thoroughly cleansed and drenched surface, and diligently prosecuted to its finished height, all as shown on said drawings.

All the above work may be done in sections, if found more practicable, but in such event the new wall will be stepped off roughly at end to insure a complete and adequate

bond with the ensuing and adjacent piece.

The old coping stone will be re-used, being reset at new elevation as shown on the drawings. They will be set in very full beds of very freshly mixed mortar and will each be provided with at least one dowel pin of at least one (1) inch iron, extending down into wall four (4) inches, and up into underside of coping at least two (2) inches. After being set the coping stone shall not bear any weights or be walked on for at least forty-eight (48) hours. (This can be very easily arranged for by building from far side, and completing as wall progresses across.)

MASONRY

The rock used in new work shall be as nearly like those used in old work as possible, both as to size, color, etc. They shall be built into a rubble masonry exactly like the old work, except that they shall furnish more headers. These headers shall alternate with stretchers and shall head back in wall at least one-half the width of the adjacent stretcher. All masonry shall be laid in good heavy beds of freshly mixed mortar and shall be completely surrounded by same. Absolutely no two stones shall be allowed under any circumstances to touch each other at any possible point. All interstices must be completely filled with mortar, although the use of spalls for shimming.

and even for filling, will be allowed, providing the greatest care is used to see that mortar (by grout only if necessary) absolutely and entirely envelopes each such shifter, or filler.

After being set stone will not be walked on or carry weights for at least forty-eight (48) hours. Where one day's work ends and another begins great care will be taken to see that a complete and satisfactory broken stepped bond is arranged for and carried out, and that before laying new work all old work shall have been thoroughly cleansed and washed down.

MORTAR

The mortar shall consist of one (1) part best American Portland Cement to two and one-half ($2 \frac{1}{2}$) parts good sharp clean quartz sand, similar to that used in building main dam. This mortar (which may be hand mixed) must be mixed in a clean and workmanlike manner and carried in clean pails or hods to point of use, and there deposited on top of a clean rock, or very preferably on a small mortar board. Mortar must be mixed fresh and used fresh. None shall be allowed to remain on boards more than fifteen (15) minutes. At end of day's work, or at noon hour, all mortar must be used up and mixer, or mixing box (if by hand) cleaned. No re-tempering of old

mortar will be allowed.

The entire work shall be completed in a thoroughly workmanlike manner, and shall be subject to the Engineer's acceptance.

New York, April 7, 1920.

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. The Geology and Mineral Resources of Wise County and the Coal-Bearing Portion of Scott County, Virginia, Bulletin 24, J. Brian Eby, Virginia Division of Mineral Resources, 1923, 617 pp.
4. Section 4, Hydrology, Part 1 Watershed Planning, SCS National Engineering Handbook, Soil Conservation Service, U. S. Department of Agriculture, 1964.
5. Hydrometeorological Report No. 33, U. S. Department of Commerce, Weather Bureau, U. S. Department of Army, Corps of Engineers, Washington, D. C., April 1956.