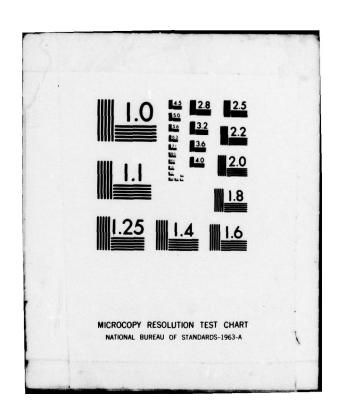
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NATIONAL DAM SAFETY PROGRAM. BROAD RUN DAM. INVENTORY NUMBER: V--ETC(U)
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Name Of Dam:

BROAD RUN DAM

Location:

PRINCE WILLIAM COUNTY

Inventory Number: VA. 15302

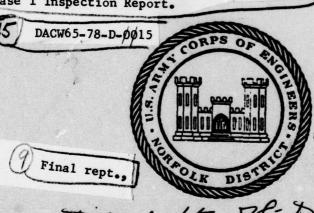


PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM.

AD A 0 73 627

Broad Run Dam. Inventory Number: VA-15302. Prince William County. Virginia. Phase I Inspection Report.



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James A. Walsh

DACW-65-98-5-0015

PREPARED FOR

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NORFOLK DISTRICT CORPS OF ENGINEERS

803 FRONT STREET NORFOLK, VIRGINIA 23510 12 86p.

BY

DEWARD M. MARTIN & ASSOCIATES

WILLIAMSBURG VIRGINIA

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VA 15302	OVT ACCESSION NO. 3. RECIPIENT'S CATALOG NUMBER
Phase I Inspection Report National Dam Safety Program Broad Run Dam	5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
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7. AUTHOR(4)	S. CONTRACT OR GRANT NUMBER(a)
Deward M. Martin & Associates	Deward - DACW 65-78-D-0015
PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
1. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE
U. S. Army Engineering District, Nor 803 Front Street	February 1979 13. NUMBER OF PAGES
14 PONTONING AGERGY NAME & ADDRESS(II different In	Controlling Office) 15. SECURITY CLASS. (of this report)
IN MONITORING AGENCY NAME & ADDRESS II GRAVEN II	Unclassified

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Dams - VA National Dam Safety Program Phase I Dam Safety

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20. Abstract

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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.

PHASE I INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

BROAD RUN DAM
PRINCE WILLIAM COUNTY, VIRGINIA
INVENTORY NO. VA 15302

20. Abstract

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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.

POTOMAC RIVER BASIN

Name of Dam:

Broad Run Dam

Location:

Prince William County, Virginia

Inventory Number: VA 15302

PHASE I INSPECTION REPORT

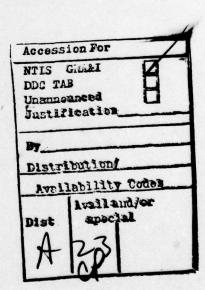
National Dam Safety Program

Prepared for

NORFOLK DISTRICT CORPS OF ENGINEERS 803 Front Street Norfolk, Virginia 23150

by

Deward M. Martin & Associates, Inc. January 1979



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.

PHASE I REPORT NATIONAL DAM SAFETY PROGRAM

Name of Dam

Broad Run Dam

State

Virginia

County

Prince William

Stream

Aquia Creek

Date of Inspection: December 6, 1979

Broad Run Dam is 1,250 feet long and 72 feet high from the top of the dam to the streambed. The concrete gravity section is 636 feet in length and the earth embankment is 614 feet in length. The ogee shaped principal spillway is 220 feet in length and 55 feet high from the crest to the streambed. The dam is located 10 miles west of Manassas, Virginia, 1 mile from Route 215 on Route 675. The lake is used as a source of water for the treatment plant, owned by the City of Manassas, which is located 300 feet below the dam.

The principal spillway will pass 100% of the PMF. The stability calculations of the gravity section of the principal spillway indicate the resultant in the middle third of the base. The Probable Maximum Flood indicated the resultant within 3 feet of the edge of the base. The original design calculations should be reviewed together with rock cores to provide a comprehensive examination of the gravity section stability under PMF conditions. A warning system procedure should be established to alert residents in case of an emergency. Annual inspections of the dam should be started. These recommendations should be completed within twelve (12) months from the date of the release of this report.

Deward M. Martin & Associates, Inc.

Submitted By:

Original signed by JAMES A., WALSH

JAMES A. WALSH, P.E. Chief, Design Branch

Recommended By:

Original signed by ZANE M., GOODWIN

ZANE M. GOODWIN, P.E. Chief, Engineering Division

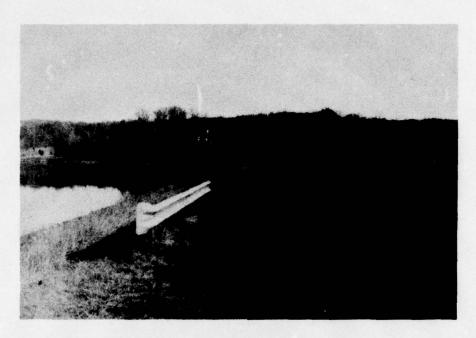
Approved By: Original signed by:

Douglas L. Haller DOUGLAS L. HALLER

Colonel, Corps of Engineers District Engineer

MAR

9 1979



Top of Dam



Front Face of Dam & Downstream Bridge

BROAD RUN DAM

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BROAD RUN DAM

SECTION 1. PROJECT INFORMATION

1.1 General:

- 1.1.1 Authority: Public Law 92-367, 8 Aug 72 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 (Appendix VI, Reference 1). 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: Broad Run Dam is 1,250 feet long and 55 feet high from the crest of the principal spillway at elevation 285 to the toe of the dam at elevation 230. The dam is a concrete gravity type for 636 feet of length and an earth embankment for 614 feet of length from concrete section to the right abutment. The maximum height of the embankment is 26 feet from the top of the dam at elevation 302 to existing ground at elevation 276. The principal spillway, located in the concrete portion of the dam, is an ogee section. There is a walkway along the top of the dam on both sides of the principal spillway. There are five manual controls for valves at the top of the dam to draw water from different levels for the treatment plant. There is a passageway or gallery located near the bottom of the gravity section. Riprap is showing along the lake side of the embankment. Flow from the selected level can be controlled by an electrically operated valve from inside the treatment plant. The required minimum discharge to the downstream channel is through a 48-inch diameter pipe.
- 1.2.2 Location: Broad Run Dam is located 10 miles west of Manassas, Virginia, 1 mile off of State Route 215, along State Route 675.
- 1.2.3 Size Classification: The dam is classified intermediate by height (72 feet).

- 1.2.4 Hazard Classification: The dam is located about 300 feet upstream from the Manassas Water Treatment Plant and there are about seven homes within 1,100 feet below the dam. It is therefore given a high hazard classification in accordance with guidelines contained in Section 2.1.2 of Recommended Guidelines for Safety Inspection of Dams, published by the Office of Chief of Engineers. The hazard classification used to categorize dams is a function of location only and is unrelated to the stability or probability of failure.
 - 1.2.5 Ownership: City of Manassas, Virginia
- 1.2.6 Purpose of Dam: The dam was built to create a water supply for the City of Manassas, Virginia.
- 1.2.7 Design and Construction History: The dam was designed by Hayes, Seay, Mattern & Mattern of Roanoke, Virginia in 1968. Contract plans and specifications and boring logs are on file with the Owner. Construction was completed near the end of 1970. Construction photographs required by the contract are on file with the designer. According to verbal comments by the designer, there were no problems or complications during the construction.
- 1.2.8 Normal Operating Procedures: Dam operations are generated by the water treatment plant operators. This consists of taking water from the lake for treatment, cleaning the trash racks, and maintaining the minimum flow required downstream. The dam is observed by the treatment plant operators in the course of their work each day.

1.3 Pertinent Data:

- 1.3.1 Drainage Area: The dam controls a drainage area of 60 square miles.
- 1.3.2 <u>Discharge at Dam Site</u>: The maximum discharge was the result of Tropical Storm Agnes in 1972, in which a flow of 16,800 cfs was recorded at the Buckland Storm gage located upstream which measures flow from 50.5 square miles.

The capacity of the principal spillway with water at the top of the dam is 60,000 cfs.

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

Table 1.1 DAM AND RESERVOIR DATA

	RESERVOIR							
ITEM	Elevation Ft., msl	Area Acres	Capac Acre Feet	Watershed Inches	Length Miles			
Top of Dam	302	1100	28000	8.70	7.7			
Crest of Principal Spillway	285	650	12000	3.80	5.8			
Streambed	230							

SECTION 2. ENGINEERING DATA

- 2.1 <u>Design</u>: The preliminary water supply study, for the City of Manassas, showed the need of Broad Run Dam. Design plans and specifications for the dam were prepared by Hayes, Seay, Mattern and Mattern, and are on file with the owner. The plans show site plan, hydrology and details of sections. The specifications show logs of borings taken for design. Design calculations were not available from the owner, but are of file with the designer. The Stability check was calculated with results shown in Appendix V.
- *2.1.1 Geological Investigation: A geological investigation was conducted by the design engineers, Hayes, Seay, Mattern & Mattern. A total of 27 soil tests borings and rock corings were performed. A detailed evaluation of the borings is not available. The original test borings for the dam revealed overburden soils consisting of silty clay and clayey silt, generally ranging in thickness from 2 feet to 8 feet. The upper 10 feet of the underlying bedrock was highly fractured, resulting in high water losses during drilling operations. Below the first 10 feet of rock, the rock was less fractured and small to negligible water losses were recorded during drilling. There was no mention in the geotechnical report of any pressure testing of the rock.

There were no faults encountered during the geotechnical investigation. Slickensides were found on some fractures but no evidence was detected during the geotechnical exploration to suggest substantial displacements.

2.1.2 Geologic Setting of the Dam Site:

- * 2.1.2.1 Regional: The general area of the dam lies within a geologic province known as the Triassic Fault Basin. The area is underlain by the Newark Formation.
- * 2.1.2.2 Specific Area of the Dam: The immediate dam area is underlain by quartz diorite, an intrusive igneous rock. The strike of the rock is generally N60°E to N80°E with a dip angle of 70 to 80 degrees to the southeast. Fracture planes in the rock are oriented approximately 90 degrees to the bedding plane.
- * 2.1.3 Foundation Treatment and Conditions: The foundation of the concrete gravity portion of the dam consists of hard quartz diorite. The earthfill portion of the dam (Stations 1+00 to 8+00) contains a cut-off trench with a minimum bottom width of 10 feet. A specification on the material type within the cut-off trench was not contained in the contract documents.

- *2.2 Construction: Compaction tests were reportedly performed during construction; however, records of these tests could not be located. A grouting program was also reportedly performed, but no records were available.
- 2.3 Operation: The City of Manassas does not employ regular operational procedure for the dam. The water treatment operator is responsible for the operational procedure involving raw water drawdown for treatment and maintaining required flow downstream. Inspection of the dam is done through observations by the water treatment operators, incidental to their daily activities. Auxiliary electrical power is provided by a gasoline driven genator. All valves can be manually operated if needed.
- *2.3 Evaluation: Geotechnical data in the form of boring logs is available. No laboratory data for the soil or rock was available. In addition, no construction records for quality control of the soil compaction or foundation grouting are available. In the absence of this geotechnical data, additional data as outlined in Section 6.3 should be collected.

Engineering data for Broad Run Dam is available through either the owner or the designer. The data should be gathered together in the files of the owner and carefully kept and updated as maintenance or improvements are accomplished throughout the history of the useful life of the dam structure.

*Information provided by Law Engineering Associates of Virginia

SECTION 3. VISUAL INSPECTION

- 3.1 Findings: Appendix VI is a record of the field observations taken during the field inspection. Seepage was noted as follows:
 - On the right non-overflow section, there was a wet area on the wall halfway down the steps about 70 feet from end of concrete and about 25 feet from the top of dam. Other dry calcium stains are on this same wall beginning at elevation 275 and extending downward.
 - Stains were showing through the thin film of water going over the spillway. These stains are about 44 feet from the left end of the principal spillway and 10 to 15 feet below the crest.
 - The left wall has hairline cracks showing calcium deposits.
 The crack is located at about elevation 250 and about 10 feet left of the principal spillway.
 - 4. The gallery has moisture on the floor and wall, extending from the bottom of the incline from the left end of the dam, along the level section of the passageway for a distance of about 60 feet. The moisture is coming from a horizontal construction joint on the downstream side of the passageway at elevation 238. A deposit of calcium covers the wet wall and floor.
 - *3.1.1 During the time of the site inspection no seepage or signs of instability were observed in the earth-filled portions of the dam. The left abutment consisted of hard quartz diorite with only very minor seepage occurring along the fracture plane. Since the inspection was conducted on a day following rainstorms, it could not be ascertained whether the seepage was from the pool or from the adjacent small hillside. A small rock slide was observed approximately 150 feet downstream from the dam along the left abutment.
 - 3.2 Evaluation: The visual inspection indicated that the four items listed under seepage in paragraph 3.1 should be monitered on a scheduled basis and records kept of this inspection.

The abutments appear to be in generally good condition.

*Information provided by Law Engineering Associates of Virginia.

SECTION 4. OPERATIONAL PROCEDURES

- 4.1 Procedures and Maintenance: The water plant operators regulate the volume of water discharged downstream and remove debris from the trush rack periodically. No log of observations is maintained. The City of Manassas does not employ a person solely for operational procedure of the dam. The water treatment operator is responsible for the operational procedure involving water drawdown for treatment and maintaining required flow downstream. Inspection of the dam is done through observations by the water treatment operators, incidental to their daily activities. Electricity for lighting and operation of the control valve is supplied by the Prince William Electric Corporation. Auxiliary electrical power is provided by a gasoline driven generator. All valves can be manually operated.
- 4.2 Evaluation: The dam does not require extensive operational and maintenance procedure. Periodic inspections should be made and notes maintained on an annual basis. Any noted changes in conditions should be carefully monitored or if deemed necessary, maintenance repairs be made and noted in the next inspection report.

SECTION 5. HYDRAULICS/HYDROLOGY

- 5.1 Design: General hydraulic and hydrologic design data used for analysis is as follows:
 - a) Construction Plans from Hayes, Seay, Mattern & Mattern, dated June 1958 partial set.
 - Study of Town Council, Manassas Water Supply Study, undated.
 - c) "Optimization of Raw Water Interconnection for the Washington, D.C. Metropolitan Area - Phase I Hydrologic and Hydraulic Data" by GKY & Associates, Inc. for Department of the Army, Baltimore District Corps of Engineers, July 1978.
 - d) Gaging Station data from USGS 1 6565 Broad Run at Buckland, Virginia.
- 5.1.1 These data contained original hydrologic assumptions, spillway rating curve, and some details of construction.
- 5.2 Hydrologic Records: As mentioned in 5.1, gaging information from Broad Run at Buckland, Virginia was available. This data was used to compare theoretical hydrographs used to evaluate the performance of the system. Highest flood of record was 16,800 cfs and occured on June 21, 1972 (Agnes flood).
- 5.3 Flood Experience: No detailed flooding experience is available, however, the Agnes flood of 1972 was passed without damage to the structure. The maximum depth over the spillway was estimated at 6.5 feet, which corresponds to 13,300 cfs.
- 5.4 Flood Potential: General Assuming the pool elevation to be at the principal spillway crest, elevation 285 msl, the PMF and the 100 year flood were developed and routed through the reservoir and spillway.
- 5.4.1 The PMF, Probable Maximum Flood, was developed from data in Hydrometeorological Report 33 (Reference No. 1). The Probable Maximum Precipitation (PMP) for the Broad Run Dam area is 25 inches in 24 hours for a 200 square mile area. This value was modified for the Broad Run 60 square mile drainage area inputted to the HEC-I program, Flood Hydrograph Package, which synthesized an inflow hydrograph of the PMF. The ½ PMF inflow hydrograph was constructed by reducing each calculated PMF hydrograph ordinate by one-half.

The inflow hydrographs were constructed utilizing the unit hydrograph concept. The unit hydrograph was developed using a one-hour duration of excess precipitation and Synder's parameters (Reference No. 2). The HEC-I program then distributed excess precipitation in time and amount. The distribution thus derived was modified by revising the per cent hourly distribution within the maximum 6 hour precipitation to more closely conform to that used in TP 40 for the 100 year rainfall. Results of this analysis are presented in Table 5.1.

5.5 Reservoir Regulation: Broad Run Dam has an ogee-shaped uncontrolled spillway with a crest length of 220 feet and crest elevation of 285 msl.

Other outlets are integral to the dam and located at elevation 235.0, 265.0, 255.0 and 248 msl. These are for raw water intake to the treatment plant and are controlled by a 48-inch gate valve with a maximum capacity of 90 cfs with the reservoir water surface at elevation 300. As this amount is small relative to the ogee section, it was ignored during routing.

There is also a 48-inch pipe drain used to control outlet discharge. Using discharge curve as supplied by the designer, a discharge of 340 cfs at water surface elevation, 256 was noted. This amount was also ignored during routing.

- 5.5.1 Reservoir storage capacity above the spillway crest was calculated using contours from USGS maps, planimetering areas, and converting to volume in acre-feet. The spillway rating curve used was that given in the design data furnished. Routing was started assuming pool elevation at the principal spillway crest and inflow equal to outflow.
- 5.6 Overtopping Potential: The PMF, 1/2 PMF and 100 year flood inflow hydrographs were routed through the reservoir using the modified Puls method option of the HEC-I computer program with storage-outflow. Results of this routing are shown in Table 5.1.
- 5.6.1 A tailwater rating curve was not available for this dam. The tailwater elevation observed during field observation was approximately 234 msl with an assumed flow of 210 cfs. The 210 cfs was used as the starting base flow when routing the storms through the system.
- 5.7 Reservoir Emptying Potential: To empty the dam, there is a 48-inch outlet pipe with an invert elevation of 236 msl and a discharge capacity of 495 cfs at normal water surface elevation, 285 msl. The outlet flow curve was developed using the designer's discharge curve to elevation 256 msl and extending it to elevation 285 msl by use of a standard orifice equation.

- 5.7.1 The above information was inputted to the HEC-I program, with 60 cfs inflow and a developed storage vs. outflow curve. This analysis indicated that the dam can be emptied in 24 days.
- 5.7.2 This 48-inch outlet pipe was in operation at the time of inspection and therefore assumed functional.
- 5.8 Evaluation: Summarizing Table 5.1, the following data resulted from this study:
 - a) Spillway design flood is 50,000 cfs. This rate gives an elevation of 300 m.s.1. and leaves 2 feet of freeboard. It is the flood originally used for design.
 - b) Based on the high risk category of this dam, the spillway should be capable of passing the PMF which is an inflow of 56,399 cfs. with outflow of 53,996 cfs. With pool elevation at the crest of the dam, the outflow capacity is 60,000 cfs.
 - c) All hydrologic considerations presented in this report are based on present conditions and no allowances have been made for future development of the watershed.

TABLE 5.1 - RESERVOIR PERFORMANCE

			Hydrograph					
	Normal Flow	100 Yr. Storm	June '72 Flood*	⅓ PMF	PMF			
Dark Elm - 6-								
Peak Flow, cfs					4			
Inflow	210	15,546	17,000	28,199	56,399			
Outflow	210	12,709	13,300	25,093	53,996			
Maximum Elevation, ft. msl	285	291.3	291.5	294.5	300.5			
Ungated Spillway (285 msl)								
Depth of flow, ft. less	than 1	6.3	6.5	9.5	15.5			
Duration, hours		80	80	80	80			
Velocity, f.p.s.		9.2	. 9.3					
Percentage Peak outflow					-510			
Passed		100	100	100	100			
Non-Overflow Section (302 msl)								
Depth of flow, ft.		0	0	0	0			
Duration, hours		0	0	0	0			
Velocity, f.p.s.		0	0	0	Ö			
Tailwater Elevation, ft. msl	234	247	247.3	252	260			

^{*} Figures shown are approximate

SECTION 6. STRUCTURAL STABILITY

- *6.1 Dam Foundation: The concrete gravity portion of Broad Run Dam is founded on hard quartz diorite. The contract documents indicated a cement grouting program was to be conducted beneath the concrete grouting portion of the dam and beneath approximately 70 feet of the cut-off trench for the earth embankment. Since construction records are not available for the grouting program, an assessment cannot be made of the success of the program, other than the observation that no downstream leakage was observed.
- *6.2 Earth Embankment Stability: Stability calculations are not available and can therefore, not be checked. Although there were no signs of instability, there was no soil laboratory test data or sufficient soil description to allow a rough stability check.
- *6.3 Foundation Condition and Soil Stability: Due to the foundation of the concrete gravity portion of the dam being a competent rock, settlement is not a problem. Although there was a potential for leakage through the foundation, a grouting program was reportedly performed in the foundation rock. The success of the grouting program cannot be evaluated since there are no construction records for the grouting program. No leakage was observed downstream of the dam, however.
- 6.4 Concrete Gravity: The concrete gravity section at the principal spillway was checked for stability. When water is at the crest of the spillway, elevation 285, the resultant on the base is at the middle third point on the base. When the water is at the PMF level, elevation 300.5, the resultant is located at 3 feet back from the toe of the dam. The results of the stability analysis are shown in Appendix V.
- 6.5 Evaluation: There is insufficient data available with which to check the stability of the earth embankment section of the dam. Therefore, a geotechnical exploration is required to gather this required data. The exploration should consist of soil tests borings to verify the stratigraphy of the dam and to obtain undisturbed samples for laboratory strength testing and classification. After obtaining this data, the stability of the dam should be checked under both drained and undrained loading.

The evaluation of this condition is that the dam will not overturn but that review of the design assumption for leading and connection into the base rock is necessary to get a comprehensive understanding of the stability design and parameters used.

*Information provided by Law Engineering Associates of Virginia

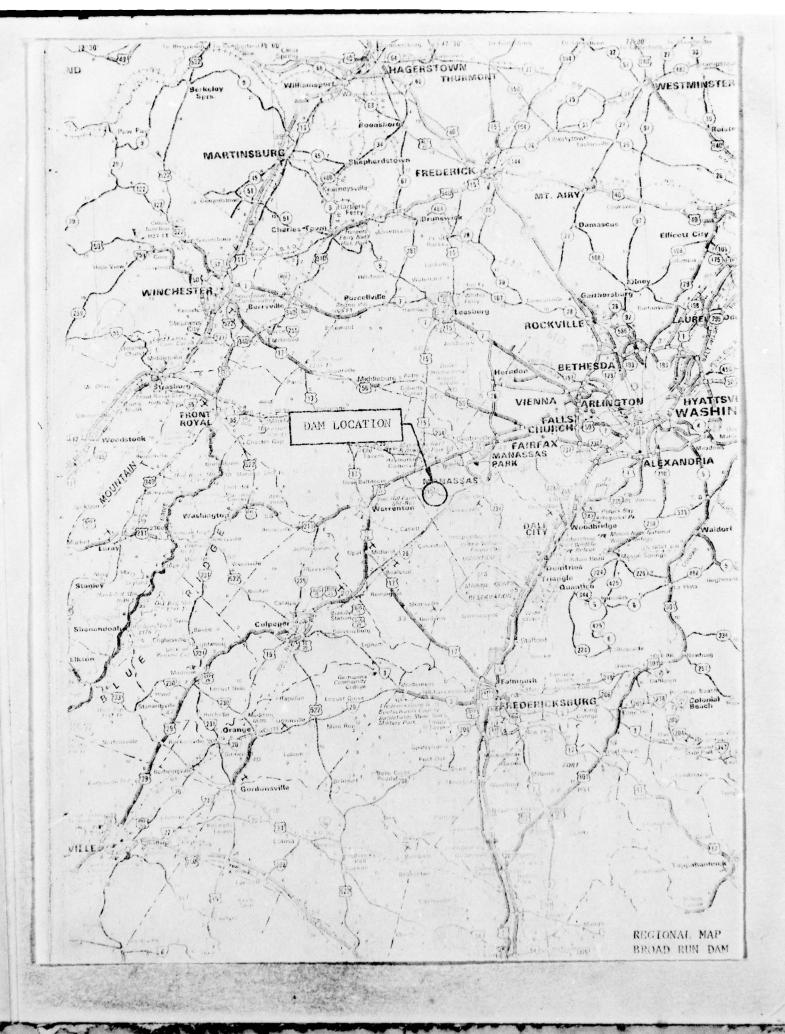
SECTION 7. ASSESSMENT AND REMEDIAL MEASURES/RECOMMENDATIONS

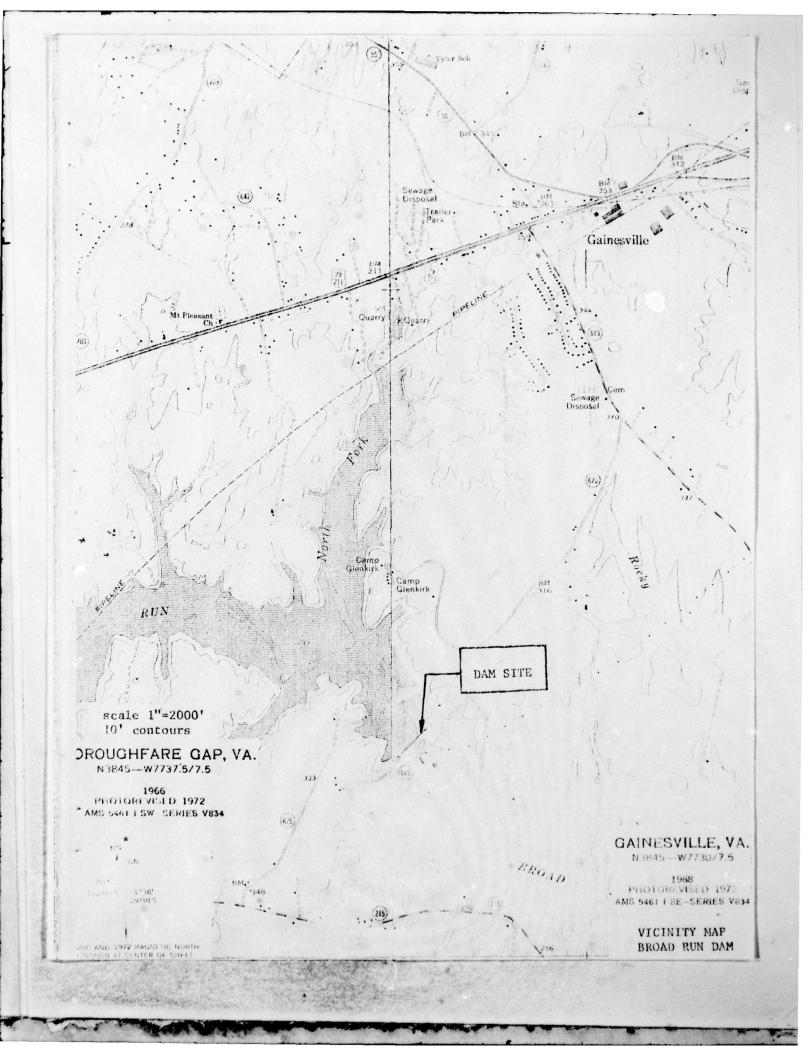
7.1 Dam Assessment:

- 7.1.1 The engineering data available through the owner are site plans, section of the dam and specifications. The specifications have boring logs of holes drilled for the design. The plans and specifications were professionally prepared. Design calculations were not available.
- 7.1.2 The dam has no obvious misalignments or settlements that could be noted from visual inspection. The gallery shows seepage and calcium deposits on the wall with moisture on the wall and floor, which has apparently been in progress for several years. There are also seepage stains on the abutment walls along the joint lines.
- 7.1.3 Monitoring records of the observations of the condition of the dam are not maintained.
 - 7.1.4 The spillway will pass 100% of the PMF.
- 7.1.5 The stability of the gravity section is within the criteria for water at the crest of the spillway. However, with the water level of elevation 300.5 for the PMF, the results of the stability analysis shows 16% of the base in conpression and a sliding factor of safety of 6.0.
 - 7.1.6 There is no warning procedure established.
 - 7.2 Remedial Measures/Recommendations: The stability and geological information should be checked for loadings with water levels above the spillway crest to the PMF elevation of 300.5. The seepage in the gallery should be monitered and records kept of observations. A warning system procedure should be established to alert residents in case of an emergency. Annyal inspection reports should be prepared by a professional engineer.

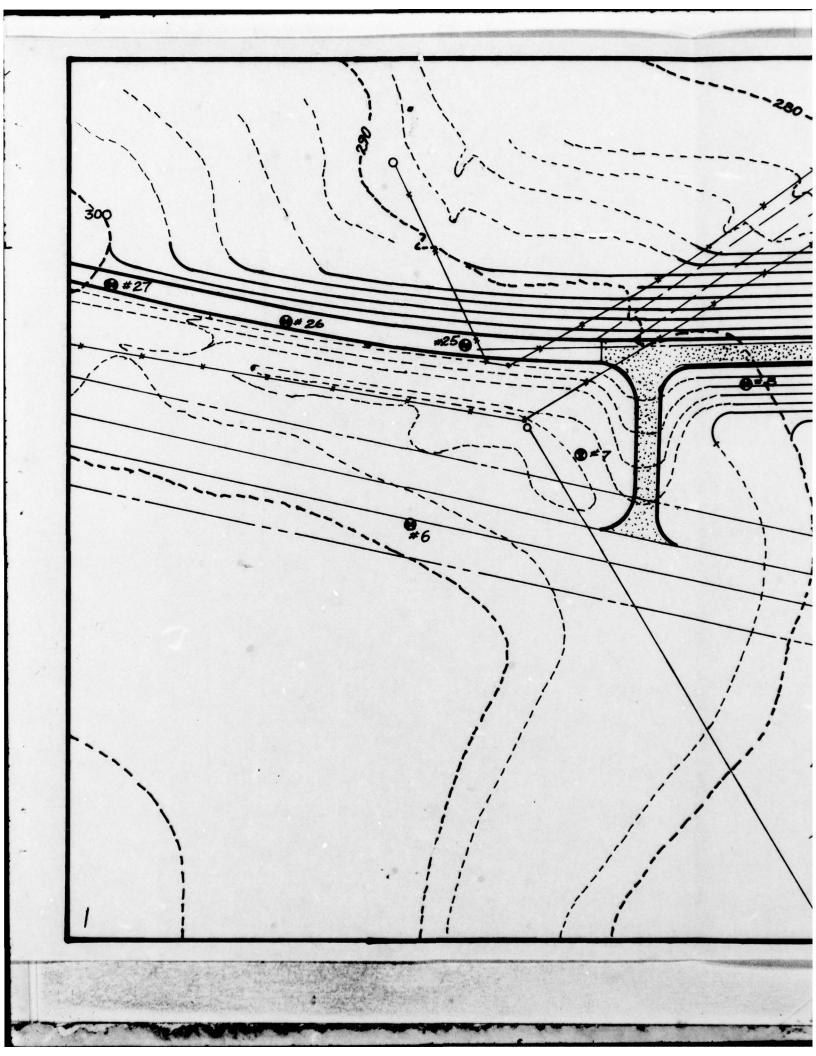
APPENDIX I

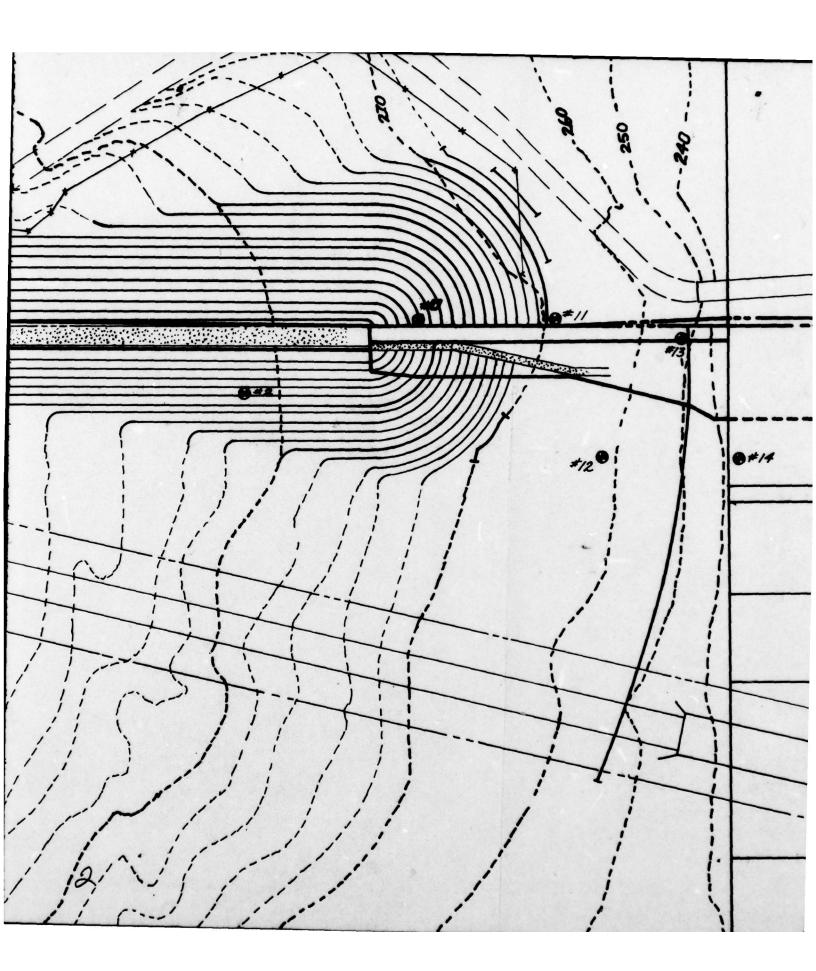
MAPS

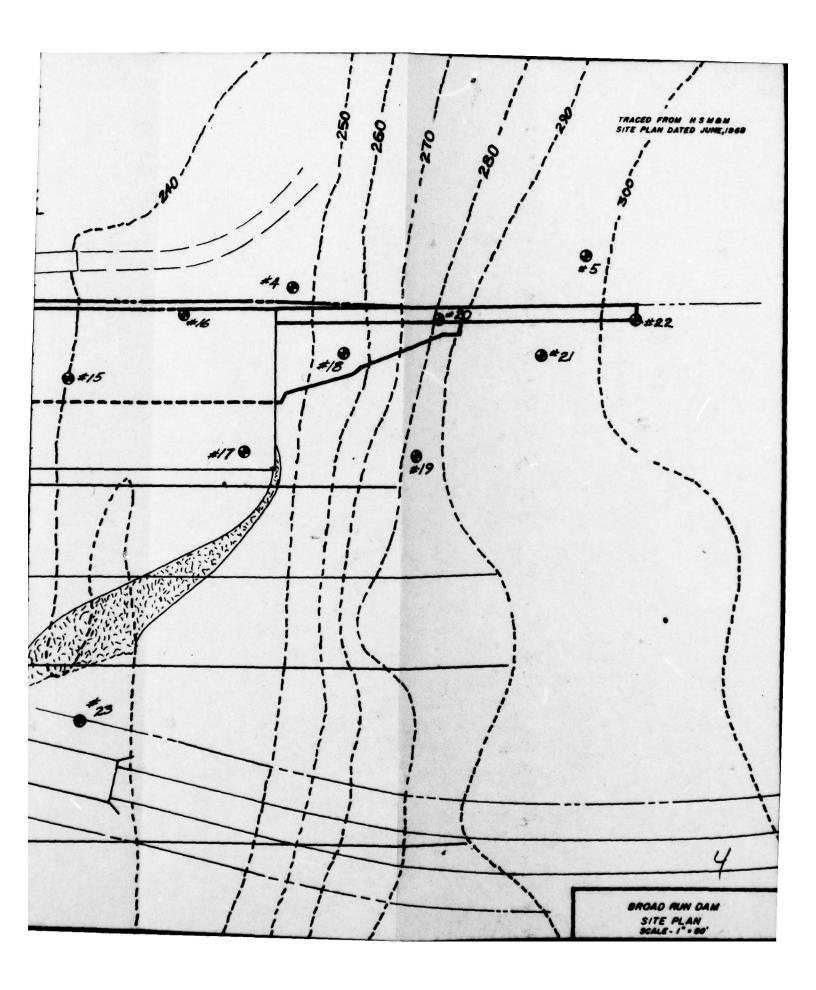


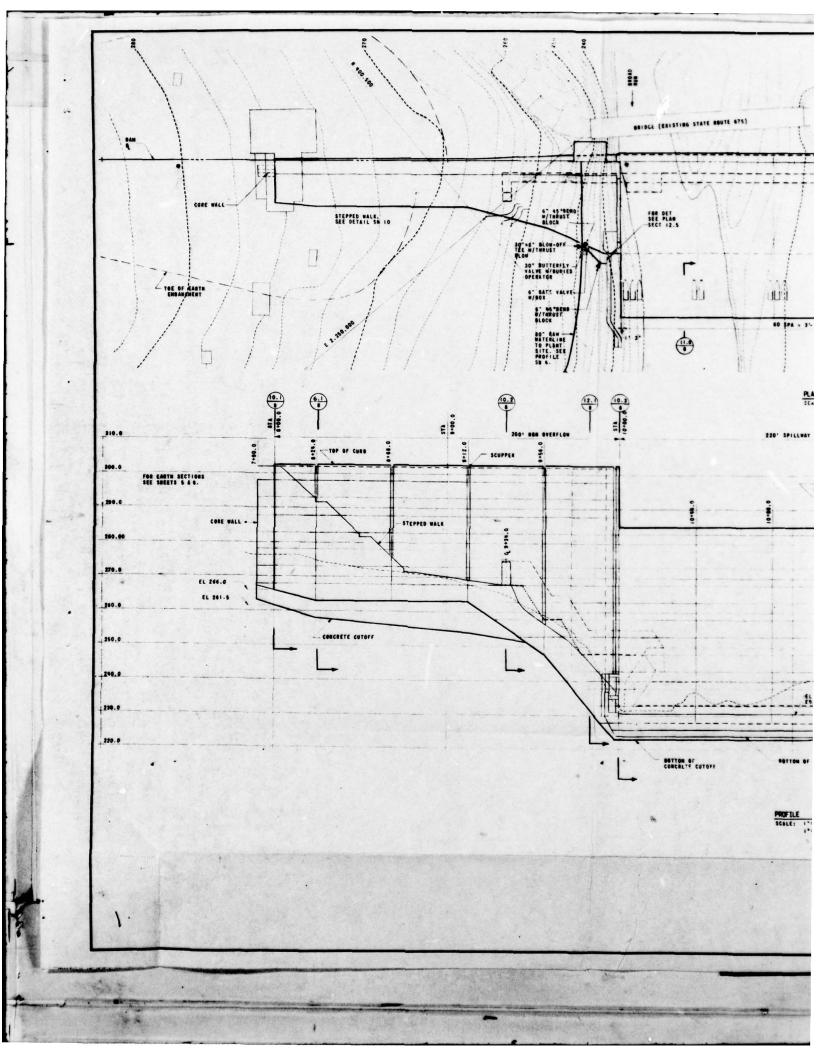


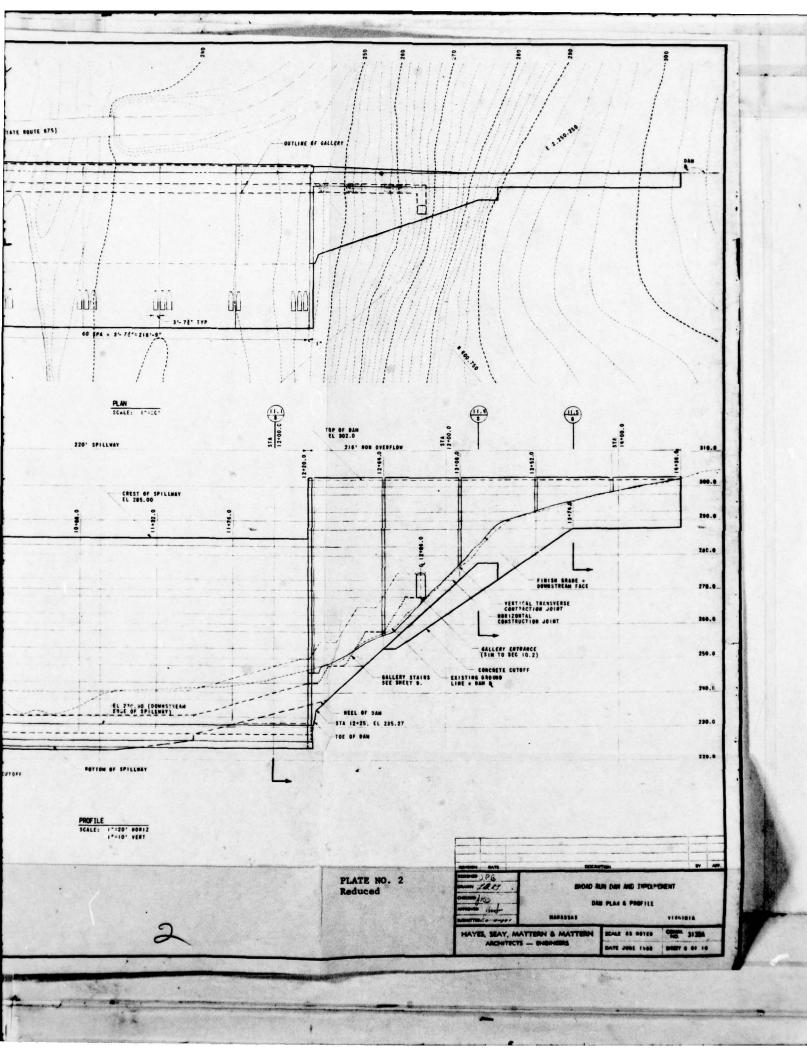
APPENDIX II
PLANS

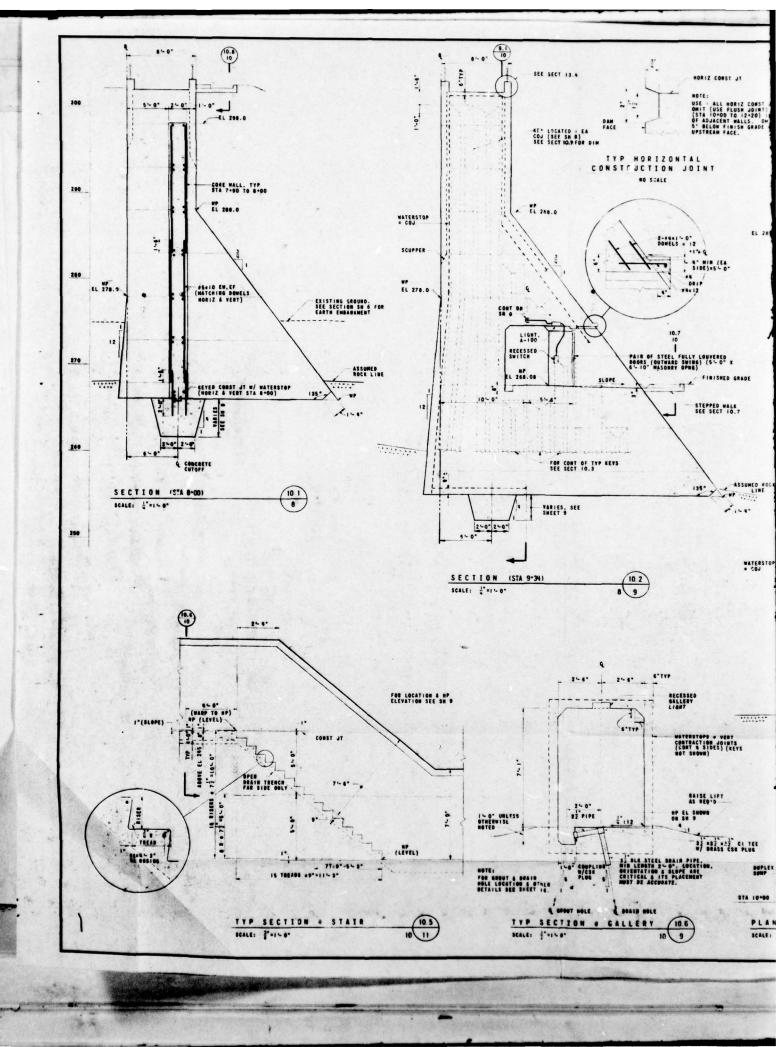


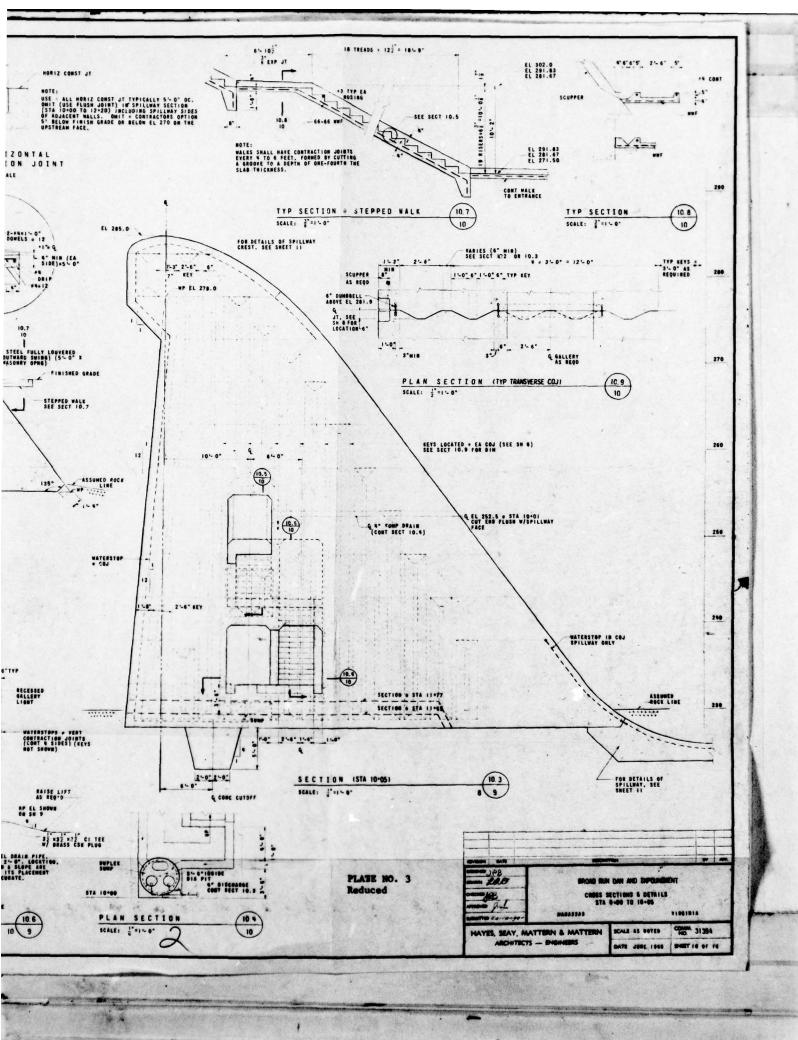












APPENDIX III

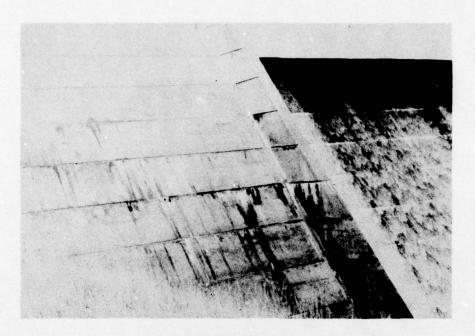
PHOTOGRAPHS



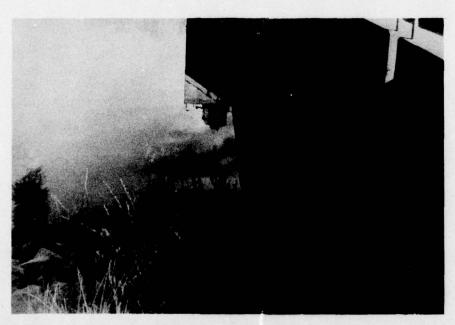
PHOTOGRAPH NO. 1
Back Face of Dam & Emergency Spillway



PHOTOGRAPH NO. 2 Principal Spillway Crest



PHOTOGRAPH NO. 3
Spillway & adjacent Wall



PHOTOGRAPH NG. 4 Riprap Upstream Face of Dam



PHOTOGRAPH NO. 5 Downstream Channel



PHOTOGRAPH NO. 6 Waterworks below Dam

APPENDIX IV

GEOLOGICAL INVESTIGATION DATA

FOUNDATION DRILLING AND GROUTING

7-01 GENERAL:

- a. Scene of work: The work includes drilling grout holes, exploratory holes and drain holes; installing and making grout connections; furnishing, handling, transporting, storing, mixing and injecting the grout materials; patching the finished grout holes; care and disposal of drill cuttings, waste water and waste grout; clean-up of the areas upon completion of the work and all such other operations as are incidental to the drilling and the grouting.
- b. Program: The work consists of the construction of a grout curtain as indicated. The approximate locations, limits, and details are indicated on the contract drawings. The program shown on the drawings and described herein is tentative and is presented for the purpose of canvassing bids. The amount of drilling and grouting which actually will be required is unknown and will be governed by conditions encountered as the work progresses. Any increase or decrease of the quantities shown will be computed at the applicable unit prices bid which shall be the basis for adjustment of the contract price.
- c. Procedures: Grouting mixes, pressures, the pumping rate and the sequence in which the holes are drilled and grouted will be determined in the field and shall be as directed by the Architect-Engineer.

7-02 EQUIPMENT:

- a. General: All drilling and grouting equipment used shall be of a type, capacity and mechanical condition suitable for doing the work as determined by the Architect-Engineer.
- b. Drilling equipment: Standard drilling equipment of the rotary type shall be used to perform the drilling as specified herein.
- c. Grouting equipment: The grout plant shall be capable of supplying, mixing, stirring and pumping the grout to the satisfaction of the Architect-Engineer. The plant shall be capable of injecting grout at a pressure up to 100 psi. It shall be maintained in first-class operating condition at all times and any grout hole that is lost or damaged due to mechanical failure of equipment or inadequacy of grout supply shall be replaced by another hole, drilled by the Contractor at his expense.

7-03 GROUTING MATERIALS:

- a. Composition: Grout will be composed of water and cement. The grout mixes will be specified by the Architect-Engineer and will be varied to meet the characteristics of each hole as determined by conditions encountered.
- b. Water: The water used in the grout shall be fresh, clean, and free from injurious amounts of sewage, oil, acid, alkali, salts or organic matter.
- c. Cement: Cement used in the grout shall conform to the requirements of Federal Specification SS-C-192g, Type I or Type II. Storage of cement shall be in accordance with the requirements of Section "Concrete Work". The use of bulk cement will be permitted provided the Contractor employs methods of handling, transporting, and storage that are satisfactory to the Architect-Engineer; otherwise, only cement furnished in cloth or paper bags will be acceptable. A sufficient quantity of cement shall be stored at or near the site to insure that grouting operations will not be delayed by shortage of cement. In the event the cement is found to contain lumps or foreign matter of any nature and in amounts which, in the opinion of the Architect-Engineer, may be deleterious to the grouting operations, screening through a standard 100 mesh screen may be required. No payment will be made for such screening.

7-04 EXPLORATORY AND GROUT HOLES:

a. General: All holes drilled and grouted from the gallery shall be at 10-foot intervals and are referred to as primary holes. Secondary holes are within the area covered by the concrete portion of the dam exclusive of the galleried area. Tertiary holes embrace the area of the earthful embankment. Quatenery holes, the last to be drilled and grouted, are to ded in the east abutment area. Hole groupings are to be drilled in the sequence outlined above. The number of grout holes shall be increased, progressively, by the split spacing method as deemed necessary by the Architect-Engineer until the amount of grout taken indicates that the foundation is tight. The use of grease, "rod dope", or other lubricant on rotary drill rods will not be permitted. Each hole drilled shall be protected from clogging or obstructions by means of a cap or other suitable device; any hole that becomes clogged or obstructed before completion of operations shall be cleaned out in a manner satisfactory to the Architect-Engineer or another hole provided by and at the expense of the Contractor.

- Grout hole drilling: Grout holes shall be drilled with standard rotary drilling equipment. No core recovery will be required and the type bit used shall be optional with the Contractor. The diameter of hole shall be not less than 1-1/2 inches at the point of maximum penetration. No grout hole will be drilled at an angle greater than 45 degrees measured from the vertical nor to a depth greater than 85 feet measured from the gallery or the indicated construction lift. If, as the work progresses, it is determined that holes to depths greater than indicated in the bid schedule are necessary, drilling to such greater depth will be ordered in writing, and the drilling to depths in excess of 85 feet will be paid for at a negotiated unit price. Whenever a void or artesian flow is encountered, the drilling operations shall be stopped and the hole grouted before drilling operations are resumed in such hole. The grout so injected remaining in a partially completed hole shall be removed therefrom by washing or other methods before it has set sufficiently to require redrilling. Redrilling required because of the Contractor's failure to clean out a hole before the grout has set shall be performed at the Contractor's expense except that where the grout has been allowed to set by direction of the Architect-Engineer, the redrilling will be paid for at the rate of 50 percent of the schedule price for drilling the grout hole.
- Exploratory hole drilling: The Contractor shall perform such exploratory drilling as may be required to determine the condition of the rock prior to grouting or the effectiveness of the grouting operations after grouting. All exploratory drilling shall be performed with rotary drilling equipment using coring type bits. Since the maximum recovery of unpredictable soft or friable materials is of prime importance, the Contractor shall, when such materials are encountered or when directed, use a standard ball bearing, swivel type, double tube core barrel equipped with diamond set core bits and standard core lifters, similar in construction and equal in performance to the Sprague and Henwood "M" series. The amount of, and the requirement for, exploratory drilling will be as directed. The NX holes may be required to be drilled to varying depths, with a maximum depth of 125 feet. Special care shall be exercised to obtain cores in good condition. The Contractor shall keep, in a manner satisfactory to the Architect-Engineer, and furnish to the Architect-Engineer an accurate driller's log of all exploratory holes drilled. The log shall include a non-technical description of all materials encountered in the drilling, their location in the holes and the location of special features such as seams, open cracks, soft or broken rock, points where abnormal loss or gain of drill water occurred, and any other items of interest in connection with the purpose for which the exploratory drilling is required. Wooden core boxes will be furnished by the Contractor, and the Contractor shall place the cores in the boxes in the correct sequence, separated accurately by wooden blocks, according to the measured distances

in the holes. No box shall contain cores from more than one hole. The covers shall be fastened securely to the core boxes and the boxes shall be delivered to the office of the Architect-Engineer in Roanoke, Virginia. Exploratory holes may be grouted under pressure, if conditions so indicate, but in all such cases the holes shall be grouted to full depth in one operation and the Contractor will not be required to remove the grout from any part of the hole.

7-05 DRAIN HOLES:

- a. Drain holes shall be drilled with standard rotary drilling equipment. Drilling of drain holes shall not commence until all grouting operations have been completed. No core recovery will be required and the type bit used shall be optional with the Contractor. The diameter of the hole shall be not less than 3 inches.
- b. The location, depth, and angle of drain holes are shown on the contract drawings. All drain holes shall be drilled from the gallery.
- c. Black steel pipe employed for guiding drain hole drilling shall be carefully placed at the proper location and slope required. The pipe shall be suitably tied or braced to prevent movement during pouring of the surrounding concrete. Care shall be exercised to see that plugs required in the drain hole piping are readily accessible and easily removable.

7-06 PRESSURE GROUTING:

Washing and pressure testing grout holes: Immediately before the pressure grouting of any hole is begun, the hole shall be thoroughly washed under pressure and pressure tested. All intersected rock seams and crevices containing clay or other washable materials shall be washed with water and air under pressure to remove as much of these materials as possible. If practicable, as determined by the Architect-Engineer, such material shall be ejected from one or more holes by introducing water and air under pressure into an adjacent hole. In no case shall such pressure exceed the maximum grouting pressure as directed. All grout holes shall be tested with clean water under continuous pressure up to the required grouting pressure as directed. All holes sufficiently tight to build up the maximum required pressure shall be washed at such pressure and the washing shall continue as long as there is any increase in the rate at which water is taken, such increase indicating that fractures are being opened by the washing operation. Open holes in which no pressure can be built up shall be washed for a period of five minutes, with the pump operating at full capacity, or for such period of time as fracture-filling

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is being removed, as evidenced by the escape of muddy water through surface openings or other grout holes.

- b. Grouting pressures to be used in the work will vary with conditions encountered in the respective holes and pressures used shall be as directed. It is anticipated that pressures will range from 0 psi to 80 psi, but in no event will pressures in excess of 100 psi be required.
- c. Grouting: All pressure grouting operations shall be performed in the presence of the Architect-Engineer, and shall be in accordance with the following general procedures.
- (1) Grout mixes: Mixes shall be in the proportions directed by the Architect-Engineer who will, from time to time, direct changes to suit the conditions found to exist in the particular grout hole. The water-cement ratio by volume will be varied to meet the characteristics of each hole as revealed by the grouting operation and will range between 3.0 and 0.6; the greater part of the grout probably being placed at a ratio of about 1.0. Grout shall consist of portland cement and water.
- (2) Grout injection: Grouting connections shall be packers or nipples at the Contractor's option. In general, if pressure tests indicate a tight hole, grouting shall be started with a thin mix. If an open hole condition exists, as determined by loss of drill water or inability to build up pressure during washing operations, then grouting shall be started with a thicker mix and with the grout pump operating as nearly as practicable at constant speed at all times; the ratio will be decreased, if necessary, until the required pressure has been reached. When the pressure tends to rise too high, the water-cement ratio shall be increased as may be required to produce the desired results. If necessary to relieve premature stoppage, periodic applications of water under pressure shall be made. Under no conditions shall the pressure or rate of pumping be increased suddenly as either may produce a water-hammer effect which may promote stoppage. The grouting of any hole shall not be considered complete until that hole refuses to take any grout whatever at three-fourths of the maximum pressure required for the respective hole. Should grout leaks develop, the Contractor shall calk such leaks when and as directed, the cost thereof being included in the contract price. In the event surface leaks or "breakouts" occur that cannot be effectively stopped by calking, the hole shall be grouted by the "packer grouting" method described herein. The hole and leaking fissure shall be filled with thick grout, the pumping discontinued and the grout allowed to set sufficiently to require drilling to clean the hole. The hole shall then be drilled to the next depth and washed and cleaned in the normal manner. A packer shall then be inserted in the hole and scated

near the bottom of the previously grouted section. The grout shall then be injected into the lower portion of the hole through the packer. After grouting to the final depth the packer shall be withdrawn and full pressure applied to the pipe connection located at the collar of the hole. The packer used shall be a type approved by the Architect-Engineer which shall provide a positive seal against the bypass of grout. If, due to size and continuity of fracture, it is found impossible to reach the required pressure after pumping a reasonable volume of grout at the minimum workable water-cement ratio, the speed of the pumping shall be reduced or pumping shall be stopped temporarily and intermittent grouting shall be performed, allowing sufficient time between grout injections for the grout to stiffen. Following such reduction in pumping speed, if the desired result is not obtained, grouting in the hole shall be discontinued when directed. In such event, the hole shall be cleaned, the grout allowed to set, and additional drilling and grouting shall then be done in this hole or in the adjacent area as directed, until the desired resistance is built up. After the grouting of any stage of a hole is finished, the pressure shall be maintained by means of a stop-cock or other suitable device until the grout has set to the extent that it will be retained in the hole. Grout that cannot be placed, for any reason, within two hours after mixing shall be wasted. If such grout is mixed at the direction of the Architect-Engineer, such wasted grout except as specified in paragraph "Measurement and Payment" will be paid for at the contract unit prices for the materials contained therein.

- of the grouting equipment shall be such as to provide a continuous circulation of grout throughout the system and to permit accurate pressure control by operation of a valve on the grout return line, regardless of how small the grout take may be. The equipment and lines shall be prevented from becoming fouled by the constant circulation of grout and by the periodic flushing out of the system with water. Flushing shall be done with the grout intake valve closed, the water supply valve open, and the pump running at full speed.
- d. Protection to work and cleanup: During grouting operations the Contractor shall take such precautions as may be necessary to prevent drill cuttings, equipment exhaust oil, wash water, and grout, from defacing or damaging the permanent structure. The Contractor will be required to furnish such pumps as may be necessary to care for waste water and grout from his operations. The Contractor shall, upon completion of his operations, clean up all waste resulting from his operations that is unsightly or would interfere with the efficient operation of the project as anticipated by the original design.

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e. Records: The Architect-Engineer will keep records of all grouting operations, such as a log of the grout holes, results of washing and pressure testing operations, time of each change of grouting operation, pressure, rate of pumping, amount of cement for each change in water-cement ratio, and other data as deemed by him to be necessary. The Contractor shall furnish all necessary assistance and cooperation to this end.

7-07 MEASUREMENT AND PAYMENT:

- a. General: The contract prices for the various items of work and materials shall constitute full compensation for mobilizing, demobilizing and furnishing all equipment necessary to perform the drilling and grouting of the structure in accordance with these specifications; all drilling, washing and pressure testing of grout holes; care and disposal of waste water and waste grout; clean-up of the site; furnishings, handling, transporting and storing of grout materials; and furnishing all labor and supplies incidental to the work. No payment will be made for grout, or the material constituents thereof, wasted due to improper anchorage of grout pipe or connections, or which is wasted due to negligence on the part of the Contractor, nor for grout which is rejected by the Architect-Engineer because of improper mixing. Payment will be made at the applicable contract unit prices for materials contained in grout which are wasted, where the wasting is not due to negligence on the part of the Contractor.
- b. Mobilization and demobilization: The cost of assembling all plant and equipment at the site preparatory to initiating the work, and for removing it therefrom when the drilling and grouting program has been completed, will be made at the lump sum price bid for "Mobilization and Demobilization of Grouting Equipment".
- c. Drilling grout holes: Drilling of grout holes will be measured for payment on the basis of the linear feet of holes actually drilled in rock or concrete as shown on the drawings or as directed, including all intermediate holes. Payment for drilling grout holes will be made at the unit price per linear foot bid for "Drilling Grout Holes".
- d. Drilling exploratory holes: Drilling of exploratory holes will be measured for payment on the basis of the linear feet of holes actually drilled in rock or concrete, as directed by the Architect-Engineer. Payment for drilling exploratory holes will be made at the unit price per linear foot bid for "Drilling Exploratory Holes".
- e. Drilling drain holes: Drilling of drain holes will be measured for payment on the basis of the linear feet of holes actually drilled in

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 7-7

concrete and rock as shown on the drawings or as directed. Payment for drilling drain holes will be made at the unit price per linear foot bid for "Drilling Drain Holes".

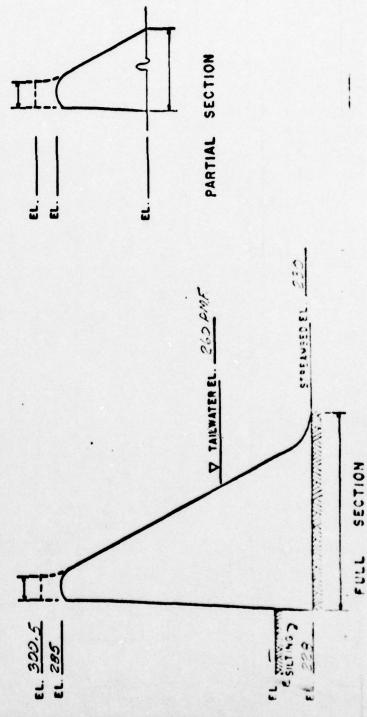
- f. Grouting connections: Payment for connections to grout holes found necessary for the purpose of injecting grout, as determined necessary by the Architect-Engineer, will be paid for at the unit price per connection for "Grouting Connections". Payment for each such connection will be made, regardless of the amount of grout actually injected, at the established unit price per connection.
- g. Foundation grouting: The operation of furnishing and placing grout will be measured for payment on the basis of the number of cubic feet of material, exclusive of water and regardless of the proportions of the mixes, satisfactorily placed. Payment for furnishing and placing grout in grout and exploratory holes will be made at the unit price per cubic foot bid for "Foundation Grouting", which price shall constitute full compensation for proportioning the mix as directed, and mixing and injecting the grout, all as specified herein or as may be directed.

APPENDIX V
STABILITY ANALYSIS

GRAVITY DAM DESIGN STABILITY ANALYSIS

ANALYSIS DONE ON FULL SECTION PARTIAL SECTION DEN DEN LOCATION OF SECTION STA. 10+00 FENCIAL SPICIAL SECTION ANALYSIS PREPARED BY DOWNEY MINISTER & ASSOCIATION

	FLEV	V3 13				LOCATION % BASE	% BASE	FACTOR	FOUNDATIC	FACTOR FOUNDATION FRESSURE
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A										
PME	32.5 260	260	125.7 ^k	124.7 3.99 3.1	2.99	3.1	165%	0.00	165% 6.00 26.7%	•



			BORING LA Structure Geologist Engineer	-D	am G	_ Sh Bo	eet / of _ 2. pring No 3 ste 2 Nov. 1965
Real	ificat	ion	Description of Materials	Sam or Sp	pler		Misc. Data Lnth of hole 50.0
Elevation	Depth	Legend	(Type, color & Consistency)	Blows	Penetration	Sample No.	Rock 47.0 Wt of hammer /10" Av fall of ham 50" El of grd, water 2324 REMARKS
		8~	TON CLOYAY SILTIW FIND TO COOKS & SAND PEBBLE COBBLESELOCK FLOGMENT	5			W.T. C.O.4-29Hrs. Alluvium CORERECOVERY
	5.0		TOPWEATHEREDROCK				CORE RECOVERY 2.5'-3.5'-70% CORE RECOVERY 3.5'-5.0'-73%
		\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\					CORFRECOVERY 5.0:-8.7:-94%
:::8 :	10.0			,			CORETIZCOVERY 8.7'-11.4'-89%
_		NI IV	3.7.2.6.6.7.5.2.				
_	15.0	3%	sides on some froctures Esome Alteration along froctures				
	20.0	(),() \\;\\ \\;\\					CORFREÇOVERY. 11.9'-18.0-98%
<u>·</u>	250	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\					CORE RECOVERY 18.0-25.5-70%
_	-	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\					CORE RECOVERY
28	300	(///					25.5-30.0-974/2

Lo	cation	Mc	BORING L Structure Geologist Engineer	De	am G.	- Sh	omm. No. 3/39A eet 2 of . 2 oring No. 3 ate 3 Nov. 1765
Stra	tificat	ion	Description of Materials	Sam or Sp	-		Misc. Data Lnth of hole 50.0
SCON Elevation	Depth	Legend	(Type, color & Consistency)	Blows	Penetration	Sample No.	Rock 47.0' Wt of hammer 140 Av fall of ham 30' El of grd. water 232. REMARKS
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	35.0	11/11/					
		175.54	Fractured to highly fractured porphyr- Itic QUARTI DIORITE				
228	10.0		IW stickansidas on Soma flacturas and soma oltarat- Ion Olong flacturas				CORE RECOVER 30.0'-90.0'-997
	45.0						CORERECOVE
	,						CORERECOVER 40.0'-95.5'-9917
32.8	520	淡淡	Bottom of Hola				CORE RI-COVERY 15.5'-50.0'-857 0.3'-0.4' Cora Vart in hola
							Hole Complet 12:30 pm 1 3NOV. 1965
							40-31/2 Flush Joint Cosing
-							

				BORING LO			Co	mm. No. 3/394
Lo	cation	Ma	nossas Va	Structure		m	Sh	eet / of
				Geologist		5	_ Bo	ring No. 4
Co	ntract	or	C.C.D	Engineer	_=		_ Da	te 3Nov. 1965
					Sam	pler		Misc, Data
Stra	tificat	ion	Description of M	aterials	or Sp			Lnth of hole 60.0'
			(Type, color & Con					Rock 57.5
tio		9	(17,71, 11111111111111111111111111111111			tio	No.	Wt of hammer /10"
\$ >	슢	Legend			5	tra	ple	Av fall of ham 30"
Elevation	Depth	Le			Blows	Penetration	Sample	El of grd. water 239.7
248.5	0.0				M	ů,	Ŝ	REMARKS
2476	0.9	3.7.17	TOPSOIL ROOTS ORGANICS	5 E				W.T. C8.8'-166His
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		55.						
		30						
	5.0	0~	Brown, Sand Some Clay, M Jock Hadme	45127/W				
	3.0		rock fradma	nts É				
		~~~	large brocks	,				
		20	,					
240.0	8.5	<u>R</u> -2	TOPWEATHERE	DROCK				
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		17,5%						CONT RECOVER 10.2'-20.2'-977
		( <u>)</u>						CORERECOVER
		(\)						20.2'-22.2'-9747
		X . X						CORE RECOVER
-		17,14						22.2-24.0-95%
	25.0	公公						
-		1317						
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48.5	300	DV-V						
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Lo	cation	M	, 2005505 Va.	Structure		2	Co	enm. No. 3/37A
			C.C.D	Geologist Engineer	H.		_ Bo	ring No. 4. ste 4 Nov. 1765
Stra	tificat	ion	Description of Ma	iterials	Samp or Sp			Misc. Data Lnth of hole 60,0
S Elevation	O Depth	Legend	(Type, color & Con	sistency)	Blows	Penetration	Sample No.	Rock 5/,5' Wt of hammer //O" Av fall of ham JO" El of grd, water 2327 REMARKS
		然						CORERECOVERY 24.0'-31.5'-96%
	35.0	公公						
			Blue-groy fre porphyritic G	CTURA				
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			distintion of					
	15.0							
		经						
18.5	50.0							25-42-12-12-12-12-12-12-12-12-12-12-12-12-12
_								CORE RECOVERY 41.0'-51.2'-99+7.
_								
	55.0	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\						9.0'-31/2" Flush
								CORERECOVERY
38.5	600	, ,;	Bottom of I	Hole				5/2'-600-991/2 Hole Completed 5:00 pm 4 Nov 1965

Lo	cation	M	massas Va	BORING LO		ממו	Co	omm. No. 3/37/A
		or_	CCD	Geologist Engineer	Ho		Bo	oring No. 13 ate 28 Nov. 1966
Strat	ificat	ion	Description of M	aterials	Samp or Sp			Misc. Data Lnth of hole 70.0'
Elevation	O Depth	Legend	(Type, color & Co	nsistency)	Blows	Penetration	Sample No.	Rock SS.// Wt of hammer ///OF Av fall of ham 30" El of grd. water REMARKS
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							,	CORERECOVERY 1.7'-3.5'-89%
	5.0	<b>XX</b>					1.6'	CORE RECOVERY 3.5'-5.0'-99+%
		XX						Noticed dill Woll 135 uing from frocterias c Cran
24/./	10.0	公公						Lost Wosh Wota C8.0'
			Blue-glayfi QUARTZ DIOR Salpantina	ITE/W			4.6'	5.0-10.0-92%
		火公	fibetules					
	15.0	XXXX					6.6	CORF RECOVER 10.0'-16.5 -1714
31.1	200							
		*** *** ***						
-	25,0	XXX					10.1	CORFRECOVERY 16.5-26.5-47+7 PORPHYVILIC 28.
21.1	30.0							Porphyritic 28. -29.5-lphanocry to up to I"long.

Loc	ation	Me	massas, Va.	Structure	Do	am	Sh	ect 2 of . 3
Cor	ntract	or	C.C.D	Geologist Engineer		-		ring No. 13 te 29 Nov. 1766
Strat	ificat	ion	Description of l	Materials	Sam; or Sp	oon		Misc. Data  Lnth of hole 70.0'  Rock 88./'
Elevation	O Depth	Legend	(Type, color & Co	onsistency)	Blows	Penetration	Sample No.	Wt of hammer 140# Av fall of ham 30" El of grd. water REMARKS
		XX, XX, XX,						
	35.0	XXXX XXXX XXXX XXXX					10.0	CORFREGOVERY 26.5-36.5-77%
271.1	40.0	XXXX XXXX	Blua-gray	floctura PITE/W Clong	1			
	45.0	V. V.					9.9	COLLEXICOVERY GG.S-4G.S-47%
34.1	50.0	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\						
	55.0	77.77 77.77 77.77					27	CO.C.T. C.ECOVERY
3/./	60.0	\$\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\						76.3-263-7776

				BORING LO			Co	mm. No.3/39A
Lo	cation	140	mossas, Va.	Structure		m	Sh	eet Joi. J
			C.C.D	Geologist Engineer		G_		ring No. 13
Col	itracti	·	<u>C.C.D</u>	Engineer			Da	te 30 Nov. 1966
					Sam	pler		Misc. Data
Strat	ificat	ion	Description of Ma	terials	or Sp			Lath of hole 90.0'
-			(Type, color & Con					Rock 88/
tio		7	(-,,-			tio	No.	Wt of hammer /40#
Elevation	Depth	gend				Penetration	Sample	Av fall of ham 30"
Ele	Del	Leg			Blows	ne	Ę	El of grd. water -
71.1	60.0				18	Pe	လိ	REMARKS
		XX						Highlytractured
		VIV					1	62.0'4066.5'
		71.1						
		兴兴						
		VV						
	65.0	777					90	CARERENTE
		111					1.7	CORF RECOVERY 56.5'-665'-99%
		100						,,,,
		1/11/						
		Will						
3/1	70.0	1/1/	Blin-grayti	actura	/_			
		111	QUARTZ DION	PITEIW			5.0	CORERECOVERY
		V.V.	Expenting of	110119				CORERECOVERY 66.5'-71.5'-99%
		公公						
		1/11/						
	750	20						
	73.0	N'A'						
		MIN						
		1/1/						
		1111.						
7//	800	XX						
· ·		17/1/						
1		11.1					9.8	CORE RECOVERY
		1114						11.5 -01.5 - 7078
		公公						h.
		XX;						19'-31/2 Flush
	85.0	Wil.						Joint Cosing
		1	Cala harra	hlas Va				
		11/1/	Cora borrel	ired			7.0	COREKECOVERY
-		WY	83.0"-90.0"					815-895-99%
		0.3					1.4	CORERECOVER
11	900	111	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,					58.5'-90.0-777
			Bottom of	17012				Hola Completed
1	<u></u>							1DIC. 1766

			BORING LO  2005505 Vo. Structure Geologist C.C.D Engineer		am G	— She	mm. No. 3/37A  eet \( \sigma \text{ of . 2} \)  ring No. \( \sigma \frac{4}{5} \)  te \( 25 \sigma \frac{1966}{5} \)
Strat	ificat	lon	Description of Materials	Sam; or Sp	oon		Misc, Data  Lnth of hole 50./'  Rock 44.7'
Elevation	Depth	Legend	(Type, color & Consistency)	Blows	Penetration	Sample No.	Wt of hammer / 10#  Av fall of ham 30"  El of grd. water 233.4  REMARKS
135.1	1.0		TOPSOIL EROOTMAT	10		767	W.T.C 2.7-6Jon.6
		40	Blown SILT IN foots, Pieces of Wood & lock fragments.	10	/	191)	Drova Sompla. bat waen two
230.7	5.0	VV	TOP BEDROCK				
		\$3 \$3 \$3 \$3 \$3 \$3 \$3 \$3 \$3 \$3 \$3 \$3 \$3 \$					Highly floctured
126.1	10.0		Blue-gloy froctured QUARTZ DIORITE IVY DESPARTING, Glong				CORF RECOVERY 5.4'-10.5'-94%
		X	tracturas Eslickati-				- 4.
	15.0		Quartz Vain-0.08' thick C 15.8'				
16.1	20.0						GOPF RESOVERY 10.51-20.5-777%
-	250				*		
206.1	30.0	**** ***					CORE RECOVERY 20.5'-30.5-477

			c.C.D	BORING L Structure Geologist Engineer	Do H.	am G	_ Bo	omm. No <u>3/39A</u> eet <u>2</u> of . <u>2</u> pring No. <u>/4</u> ste <u>25 Nov./9</u> 66
Strat	ificat	ion	Description of M		Sam or Sp	oon		Misc. Data Luth of hole 50./ Rock 44.7
Elevation	Depth 200	Legend	(Type, color & Co	nsistency)	Blows	Penetration	Sample No.	Wt of hammer /40# Av fall of ham 30" El of grd. water 233.4 REMARKS
		XX						·
	35.0			,				CORERECOVERY 30.5-35.5-77%
·	10.0		Blua-gloy fi Superty Clori Sarpaptina Frocturas	ractura e	/			Highly Flockwad 41.0'-544.0'
_	450							CORF RECOVERY 35.5'-44.0'-97%
	<u>50.0</u> 30.1		Bottom of	Hola				CORE RESOVERY 44.0'-50.1'-77%
								Hola.Complatão 12:00 Noon 28 Nov. 1966
								Coint Casing
_								· ·

		BORING LOG	Comm. No 3/39A
Location M	anassas Va	Structure Dam	Sheet / of . 2
		Geologist H.G	Boring No. 15
Contractor	C.C.D	Engineer	Date / DCC. 1966

Strat	ificat	ion	Description of Materials	Sam; or Sp			Misc. Data Lnth of hole 50.3'
Elevation	Depth	Legend	(Type, color & Consistency)	Blows	enetration	Sample No.	Rock 38.3' Wt of hammer 140# Av fall of ham 30" El of grd. water 238.9
90.1	0.0	11.61	10/150/1 //2076 6	-	4	03	REMARKS, W.T.C.1.7'-6Jong
138.6	1.5	0.0	TOPSOIL, HOOTS E LEAVES Brown SILT IW faw Smoll rock fragments E roots-troce of Sano	10	1'	Ø/	SAMPLE 1.5'-2.5'
	5.0	-0 -0	ÉOCCOSIONOT COBBIE	40	/'	18/	SAMPLE 5.0'-6.0
	10.0 12.0	0.7.	Increase in Cophles 940/tzita Ediorita e TOP ROCK	66	<i>)</i> *	/3V/	SAMPLE 10.05-71.
	15.0			,			
20.1	20.c		Blue-gray fractured QUARTZ DIORITE IN Sarpantine along Fractures IW Some Stick ansides along fractures.				CORERECOVIER 12.0'-22.0'-9970' Highly Fracture 22.0'-24.0'
•	25.0	1111					
:'0./	30.0	XX			,		

6. Feb. 100

Loc	ation	Me	C.C.D	SORING LO Structure Geologist	00	m	— Sh	enm. No <u>3/32A</u> cet <u>2</u> of <u>2</u> cring No. <u>15</u>
Con	ntract	or	C.C.D	Engineer		-/-	_ Da	te 2 Dac. 1766
Strat	ificat	ion	Description of Ma		Sam; or Sp	oon		Misc. Data Luth of hole 50.3' Rock 58.3'
Elevation	O Depth	Legend	(Type, color & Con	sistency)	Blows	Penetration	Sample No.	Wt of hammer /40"  Av fall of ham 30"  El of grd, water 2389  REMARKS
		XXXX						CORE RECOVERY
	35.0							
200.1	10.0	(*\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	Blua-groy fre QUARTZ BIOR Sarpantina G	nctura ITE IW Iong	/		-(%-	GERFYER VIEW
	45.0							
30.1 39.8	50.0 50.3	**************************************	Bottom of	Hola				CORF RECOVERY 42.0-50,3-47%
								Hola Complata 11:300ml 2 Dac, 1966
*								Joint Cosing

Loc	cation		BORING LA  Structure  Geologist  Engineer	0	am G	Bo	mm. No. 3/39/A eet / of . 3 ering No. /4. te 28 Nov. 1964
Strat	ificati	ion	Description of Materials	Sam or Sp	oon		Minc. Data Lnth of hole 83./ Rock 72./
Elevation	O Depth	Legend	(Type, color & Consistency)	Blows	Penetration	Sample No.	Rock Wt of hammer / fo# Av fall of ham 30" El of grd, water — REMARKS
41.2			TOPSOIL, ROOTS & LEAVES  RIOWN Clayay SILT  NV Small rock Flog- mants & Occasional	10	1'	TO)	W.TCO.1-6Jan.67 SAMPLE1.5-2.5
K.8	5.0	11 3 6 2 5 11 8 1 5 2 5	Mixad COLLUVIUM É ALLUVIUM including Cobble Size piaces Of quartz dioxite				
	10.0	5230 5286	Valnguartz graan- stona égubetzitain a Silt-cloy motrix				
130.8	15.0		TOPBEDROCK				CORE RECOVERY 11.0'-14.2'-91%
		** ** **	Blue - gray fractural	/			
121.8	200		Saipenfine glong finctures Eslicken sides				Highly fractur-
•	250						CORFRECOVERY 14.2'-24.2'-771-76
11.8	300	公公					

Loc	ation	M	200550516	Structure	_	200	Co	mm. No. 3/37A
			C.C.D	Geologist	H		Bo	eet 2 of . 3 ring No. 76.
Cor	ntract	or	C.C.D	Engineer			_ Da	te 29 Nov. 1766
Strat	ificat	ion	Description of Ma		Sam; or Sp	oon		Lnth of hole ST/
ion		-	(Type, color & Con	sistency)		Penetration	No.	Wt of hammer /10#
Elevation	Depth	Legend				tra		Av fall of ham 30"
					Blows	ene	Sample	El of grd. water
211.8	30.0	VIV			-	Д,	<u> </u>	REMARKS
		7.71						
		///	đ					
		次次						CORERECOVERY
	35.0	汉公						24.2'-34.2'-9676
		1/1/			4			
		XX						
talo	1	WW	01	. ,				
201.6	100	1/1/	Blue-gloy f	COCTURA VITE /W	4			
			sarpantine	dong				CORE RECOVERY
		1111	FIOCIONOS					CORF RECOVERY 34.2-42.9-99%
		汉汉						
	45.0	XX						
		11.11						
		1/1/						
7/8	50.0							
	20.0	1						
		11/1						CORFRECOVERY 12.9-52.8-99%
		兴兴						42.9-52.9-99%
		1111						
	55.0	11.17						
-		<b>***</b>						
***		1/1/						1
		22						
3/8	60.0	11/11						

			c.c.D	ORING LOST CONTROL OF COLORS CONTROL OF COLORS COLO	DO H.		Sh	omm. No. 3/39A eet 3 of . 3 oring No. 16 ate 30 Nov. 1766
Strat	ificat	ion	Description of Ma	terials	Sam; or Sp			Misc. Data Luth of hole 83/
Elevation	O Depth	Legend	(Type, color & Con	sistency)	Blows	Penetration	Sample No.	Rock  Wt of hammer / 40"  Av fall of ham 30"  El of grd, water  REMARKS
								CORE RECOVERY 52.9:-63.1'-99%
	65.0							Highly alterad 69.814070.7
<u>.                                    </u>	70.0		Blue-gray fr QUARTZ DIORI Sarpantina C fracturas	TEIN				CORERECOVERY 63.1-73.1-7676 Highly floctural 72.84074.5'
	75.0							
48	<u> 80.c</u>							CORE RECOVERY
387	83.1	<u> </u>	Bottomot	Hola.				CORF RECOVERY 13.1'-83.1'-7776 Hola Completed 3:30pm 30 Nov. 1966
-								12.5'-3'/2 Flush

Loc	ation	Mo	nossos Va	Structure Geologist	De	am	Co Sh Bo	eet / of //	
Cor	tract	or	C.C.D	Engineer			_ Da	te 25 Nov. 1166	
Strat	ificat	ion	Description of M		Sam or Sp			Misc. Data Lnth of hole 47.4' Rock 35.7'	
Elevation	O Depth	Legend	(Type, color & Co		Blows	Penetration	Sample No.	Wt of hammer/40° Av fall of ham 50° El of grd. water 24/, REMARKS	Z
14.3	0.5	(公) (公) (公) (公)	Ougetz dion	cita .				W.T.C3.7-6Jan.	67
		(S) (S)	Quartz dior COLLUVIUMI Slay between	WSilf E					
	5.0	\$1.60 \$2.60 \$2.60							
34.8	10.0	350							
		(V)2							
31.3	13.5	<b>辺</b> る ※	TOP BEDROC	K				Highly fractu	1
	15.0	<u> </u>							_
		XX						CORERECOVER 13.5'-17.7'-93%	24
318	20.0		Blua-glayfi QUARTZ DIO SALBEFILLOS	COCHURA	/_				
			Salbaptines.	along					+
Section (Section )	25.0	()() ()()							-
		17.7						CORERECOVER	
-		// // ///						177-277-9676 Highly Fracture 28.2-30.2	1
18	30.0	7.4						28.2 - 30.2	-
					1				

Comm. No 3/39/4 Structure Dom Location Manassas Va Sheet 2 of . 2 Geologist H.G Boring No. 17 Contractor C.C.D Date 25 Nov. 1966 Engineer Misc. Data Sampler Stratification Lath of hole 1277 Description of Materials or Spoon Rock 3.7.9" (Type, color & Consistency) No. Penetration Elevation Wt of hammer / 10# Depth Av fall of ham Jo" El of grd. water 7/1/ REMARKS CORERECOVERY 27.7'-31.7'-95% 35.0 1.1 Blue-groy Hactured MOUARTZ DIORITE IW Dispanting along CORERECOVERY 1 Frocturas 45.0 154 194 175 39.2-49.4-97% Bottom of Holo 4de Completad 10:00 Ont 28Nov.1966 Joint Cosing

BORING LOG

APPENDIX VI FIELD OBSERVATIONS

Lake Manassas Ref. Inv. Dams Pg 714 Report 1/12/74 VA 15302 NAD VA 153-08

50,000 cfs Broad Run MANASSAS H. CREST: 1185 STREAM: DISCH: OWNER:

Visual Inspection Check List Fhase 1

Hayes, Seay, Mattern & Matte

Gainsville & Thoroughfare Gap

ENG. BY: Hayes, S CONSTRUCTED BY: Jackson QUAD: Gainsvil

State Virginia

County Prince William

Name Dam Broad Run Dam

Coordinators Lat. 3845.8 Long. 7737.3

Date(s) Inspection 12/6/78

Weather clear

Temperature 60°

Pool Elevation at Time of Inspection 285

Tailwater at Time of Inspection 234

Inspection Personnel:

Forest Fister , DMNSA, Hydrology

Tim Perry , SWCB, Regional Office

John S. Jones, Law Engineering, Geo. & Solls

Treatment Plant

Bill Swartz, Manassas Water

Wade Whetzel, Manassas Water Ireatment Plant

Don Echols, Manassas Water Works Dept.

Recorder Paul Seiler, DMV&A, Civil Engr.

## CONCRETE/PASONRY DAMS

IEE PAGE ON LEAKAGE No.	OBSERVATIONS	NEWARKS OR RECOMMENDATIONS
	None visible through spillway. Wet area on wall at right abutment halfway down steps to Passageway.	
TEUCTURE TO SUTHENT/EMBANGMENT . No	No visible seepage at junction of wall and embankment right abutment and left abutment.	
JRA INS	None visible.	
Se	See note on walkway passage-gallery.	
No No No No No	Not visible. No crack in spillway structure.	

## CONCRETE/NASONRY DAYS

REMARKS OR ECCONDENDATIONS					
VISUAL EXECTIVATION OF OBERSVATIONS	SUCRCE CRACKS CONCRETE STRFACES Hairline crack 5' vertical approximately 10' left of left of left end of spillway in concrete wall shows white deposits.	STRUCTURAL CRACKING None visible.	ALIGNENT ALIGNENT  ALIGNENT  Owner representative reported that water goes over crest of principal spillway at right end of spillway before covering the entire length of spillway crest. See Photo No. 2. This could indicate settlement at left end of spillway, or crest was not level when	NONCELTH JOINTS No visible seepage.	44 ft. right from left end of spillway, about 5 feet below crest, was wet for a length of 60 feet and showed calcium deposits. Owner reported this was happening for several years. The water enters at a horizontal construction joint on the downstream side of passageway.

### EMBANCHENT

VISUAL EXAMINATION OF	CBSERVATIONS	REMAIKS OR RECOMMENDATIONS
SUDENCE CRACKS	None visible.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	No visible movement of toe, cracks or seepage.	
SICUSHING OR EROSION OF EMELINITENT AND ABUTHENT SIGPES	None visible.	
VERTICAL AND HORIZONFAL ALINEDRY OF THE CREST	0.K.	
RIPRAF FAILURES	None Ribrap lake side is 18 feet up side of embankment.	

## ENBANCENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR NECOMENDATIONS
JUNCTION OF EMBANCENT AND ABUTHENT, SPILLWAY AND DAM	No Crack.	
ANY NOTICEABLE SEEPAGE	No visible seepage.	
SIATT CAGE AND RECORDER	None at dam. Waterworks reads downstream gage to maintain minimum required discharge for downstream use.	
DRATINS	None visible	

- 4	
. ;	
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	NEWATKS OR RECONCIDENTIONS				- appears to be from water treatment plant lagoon appears to be from drain field.
OUT! ET WORKS	OBSERVATIONS	None visible.	Not visible.	Concrete spillway Ogee type (See ungated.) Lake drain pipe - valve controlled - by waterworks. (48" diameter). Discharging at time of inspection, pipe cast in concrete of dam.	Rock debris in channel from bridge pier protection, bridge is located about 200 feet downstream from dam. Channel downstream from debris is clear, has earth banks 4 to 5 feet high.  1,000 feet downstream from dam, near back filter lagoon, there was a wet spot about 100 feet to the right from the channel.  1,200 feet downstream from dam, there is a wet spot in field about 200 feet right from channel.
	VISUAL EXAMINATION OF	CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	INTAKE STRUCTURE	OUTLET STRUCTURE	OUTLET CHANNEL

	UNGATED SPILLWAY	
VISUAL EXAMINATION OF	OBSENTATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR		
	Ogee principal spillway.	
APPROACH CHANNEL	Not visible.	
DISCHARGE CHANNEL	Concrete spillway, ogee type to riprap channel. See outlet works outlet channel.	
BRIDGE AND PIERS	3-span 2-lane structure 200' downstream from dam. With stood 1972 flood. Washed rip-rap away from bridge piers.	

•		
	GATED SPILLWAY	
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECONSIENDATIONS
CONCRETE SILL	No visible cracks.	
APPROACH CHANNEL	Forested.	
DISCHARGE CHANNEL	See outlet channel outlet works.	
BRIDGE AND PIERS	None.	
CATES AND OPERATION EQUIPMENT	Valves are operational and used by water works personnel each day. Operation is manual to select each of 5 levels to draw down water from lake. There is a valve in the plant to control flow of water into plant. Discharge to downstream	is by manual control.

•		
	INSTACTENTATION	
VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
CESERVATION WELLS		
	None.	
LEIRS		
	None.	
PIEZOMETERS		
	None.	
CTHER		

•		REMAINS OR RECOMMENDATIONS					
	riservoir	OBSERVATIONS	Steep to moderate slopes to shoreline.	available.			
		VISIAL EXAMINATION OF	SLOFES Steep to moderate slope 75% pasture land, stabl	SEDEMINIATION No information available.			

CHECK LIST ENGINEERING DATA DESIGN, CONSTAUCTION, OPERATION

REVARK

AN OF DAM

GIONAL VICINITY HAP

INSTRUCTION RISTORY

PICAL SECTIONS OF DAM See plans.

YDROLOGIC/HYDRAULIC DAIA See plans.

JTLETS - PLAN

- DETAILS

-DISCILLINGE RATIN

LINGALL/RESERVOIR RECORDS

None at reservoir.

Incl

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VICTOR!	
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VISUAL EXAMINATION OF	OBSERVATIONS	REMAINS OR RECOMMENDATIONS
CCNDITION (OSSIRUCTIONS, DEBRIS, ETC.)	Bridge 200-300 ft. below dam. Channel has riprap washed from bridge piers.	
STOPES	Narrow channel at bridge 150' wide, 4'-6' deep. Wide flood plains.	
APPROXIMATE NO. OF HOMES AND POFULATION	Water Treatment Plant 400' downstream, approximately 7 farm homes in 1,200 ft. below dam. Manassas airport approximately 9 miles downstream.	

ESIGN REPORTS

Water supply study Cityof Manassas, Va. Bid specs in owner files.

Design plans on file with owner.

EOLOGY REPORTS

See bid Specs on file with owner, for borings.

Not on file with Owner. ESIGN COMPUTATIONS

YDROLOGY & HYDRAULICS AM STABILITY

EEPAGE STUDIES

None to date.

AATERIALS INVESTIGATIONS

ORING RECORDS ABORATORY

IELD

See bid specs.

OST-CONSTRUCTION SURVEYS OF DAM

None taken,

ORROW SOURCES.

None known.

PILLTAY PLAN

SECTIONS See plans.
DETAILS

PERCING EQUIPMENT LANS & DETAILS

ITEM

MONITORING SYSTEMS None.

MODIFICATIONS

None.

HIGH POOL RECORDS None.

POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS

None.

PRIOR ACCIDENTS OR FALURE OF DAM DESCRIPTION None.

MAINTENANCE OPERATION RECORDS

No existing system, water employees daily are on dam because of valves to treatment plant. Their observations not logged.

## CHECK LIST HYDROLOGIC AND HYDRAULIC DATA ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Wooded/Argicultural, 60 sq. mi.
ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 285 12000 Ac. ft.
ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): Same as above
RLEVATION MAXIMUM DESIGN POOL: Elev. 302
ELEVATION TOP DAM: Elev. 302
CREST: Principle spillway
a. Elevation 285 feet  b. Type O-gee  c. Width 220 feet  d. Length  e. Location Spillover North of mid-point of Dam  f. Number and Type of Gates None.
OUTLET WORKS:
a. Type Valved pipe. b. Location South end of Spillway.
b. Location South end of Spillway.
c. Entrance inverts
d. Exit invertse. Emergency draindown facilities 48" pipe.
HYDROMETEOROLOGICAL GAGES:
n. Type
b. Location
c. Records
MAX DIUM NON-DAMAGING DISCHARGE: 53038 cfs.

APPENDIX VII

REFERENCES

## REFERENCES

- Reference No. 1: Riedel, J.T.; Appleby, J.F.; and Schloemer, R.W.; Hydrometeorological Report No. 33, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 200 to 100 Square Miles and Durations of 6, 12, 24, and 48 hours"; U.S. Department of Commerce, Weather Bureau, Hydrologic Services Division, 1956.
- Reference No. 2: Synder, "F.F. Synthetic Unit-graphs", <u>Transactions of the American Geophys. Union</u>, Vol. 19, pp 497-545, 1938.

## BROAD RUN DAM

List of Data Available

Furnished by:

Town of Manassas, Virginia

- 1. Report of Water Supply Study of 1966.
- Plans Broad Run Dam and Impoundment, Town of Manassas, prepared by Hayes, Seay, Mattern & Mattern, Roanoke, Virginia.
- 3. Specifications Contract documents for Broad Run Dam.
- 4. Hydrologic and Hydraulic Data Optimization of Raw Water Interconnections, Washington D.C. area for the Corps of Engineers, Norfolk, Prepared by GKY & Associates, Inc., Alexandria, Virginia.