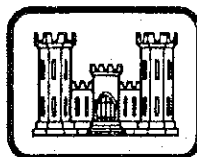


BLACK MOUNTAIN RESERVOIR DAM
BUNCOMBE COUNTY, NORTH CAROLINA
NATIONAL INVENTORY NO. - NC 1247
STATE INVENTORY NO. 11-007-H

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

FRONT COVER COLOR CODE:
Red - Urgent
Green - Other
BACK COVER COLOR CODE:
Black - High Hazard Category
Blue - Significant Hazard Category



**United States Army
Corps of Engineers**

*... Serving the Army
... Serving the Nation*

WILMINGTON DISTRICT

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

BLACK MOUNTAIN RESERVOIR DAM
BUNCOMBE COUNTY, NORTH CAROLINA
NATIONAL INVENTORY NO. - NC 1247
STATE INVENTORY NO. - 11-007-H

BY

GOLDER ASSOCIATES INC.

SEPTEMBER 1980

for

LAND QUALITY SECTION

DIVISION OF LAND RESOURCES

NORTH CAROLINA DEPARTMENT OF NATURAL RESOURCES

AND

COMMUNITY DEVELOPMENT

PREPARED FOR U.S. ARMY CORPS OF ENGINEERS

WILMINGTON DISTRICT

CONTRACT NO. DACW 54-78-C-0041

Cover Legend:

Green Front: Unsafe, Inadequate Spillway
Black Back: High Hazard

Golder Associates

This Phase I Inspection Report on Black Mountain Reservoir Dam has been reviewed by the undersigned panel members. In our opinion, the reported findings, conclusions, and recommendations are consistent with COE's Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice.

Mark H. Nelson
Review Panel, Soils Engineer

Bruce J. Maser, III
Review Panel, Structural Engineer

Henry L. Jerome
Review Panel, Hydraulics Engineer

John C. Holden, Jr.
Dam Safety Coordinator
Civil Engineer

D. L. Serin
Review Panel, Geologist

Edward H. Lamer
Chief, Design Branch
Civil Engineer

RECOMMEND APPROVAL:

APPROVED:

E. G. Long, Jr.
E. G. Long, Jr.
Chief, Engineering Division

Robert K. Hughes 10 Dec 80
ROBERT K. HUGHES
Colonel, Corps of Engineers
District Engineer
USAED Wilmington, North Carolina

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PREFACE

This report is prepared under guidance contained in Department of the Army, Office of the Chief of Engineers, Recommended Guidelines for Safety Inspection of Dams, for a Phase I Investigation. 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.

The analyses and recommendations included in this report are related to the hazard classification of the structure at the time of the report. Future changes in conditions downstream of the dam may change the classification of the structure from that presented herein. A change in hazard classification may also change the design flood on which the hydraulic and hydrologic analyses are based and may have a significant impact on the assessment of the safety 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 will be detected.

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

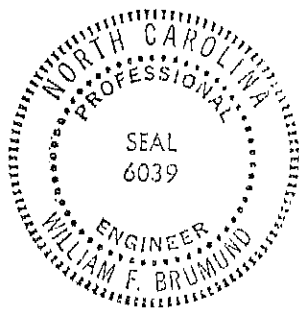
Name of Dam: Black Mountain Reservoir Dam
State Located: North Carolina
County Located: Buncombe
Stream: Tributary to Swannanoa River
Date of Inspection: July 15, 1980 and August 20, 1980

ASSESSMENT

Black Mountain Reservoir Dam is an earthfill structure with a maximum height of 45.5 ft. and maximum storage capacity of 55.9 ac-ft. The size classification is "medium" under State criteria and "intermediate" under Federal criteria. The hazard classification is "high" under both State and Federal criteria. The reservoir is owned and operated by the city of Black Mountain and was completed in 1935. Two lakes and three houses were noted downstream between the dam and Interstate 40. The nearest town is Black Mountain (population 3204), approximately 2 miles downstream.

The dam appeared reasonably maintained. However, the lower third of the embankment is wet with seepage. Some small springs were also noted downstream of the toe.

Based on the COE regional PMF equation the dam overtops by 2.8 ft. in the PMF (Federal SDF) and by 1.8 ft. in the $\frac{1}{2}$ PMF (State SDF). Therefore, the spillway capacity is considered to be seriously inadequate. Some localized slumping and slope movement was observed on the lower portion of the downstream slope. These movements are aggravated by the seepage through the dam. However, the embankment is not considered unstable at this time. Based on the spillway inadequacy, the dam is considered unsafe until remedial measures are implemented, or until further study proves otherwise. Further investigation is recommended to determine the required spillway modifications, the best method of controlling the seepage and the overall embankment stability.



GOLDER ASSOCIATES, INC.

WFB
William F. Brumund, P.E.

Principal

Registered, North Carolina #6039

PHASE I INSPECTION REPORT

BLACK MOUNTAIN RESERVOIR DAM

BUNCOMBE COUNTY

Principal Contributors

* William F. Brumund, P.E.	Principal
* J. Edmund Baker, Jr., P.E.	Hydrologist
* Leo K. Overmann	Geotechnical Engineer
* Jeffrey E. Fish	Engineering Technician
John F. Clerici, P.E.	Geotechnical Engineer
Richard M. Suever	Geotechnical Engineer
Hugh M. Gauntt, P.E.	Geotechnical Engineer

All of the above are with Golder Associates, Inc. and those denoted by (*) were participants in the field inspections.

BLACK MOUNTAIN RESERVOIR DAM

BUNCOMBE COUNTY

This report was reviewed for compliance with the National Guidelines and the State of North Carolina Dam Safety Program.

The following personnel were involved in inspection or review of the report:

<u>NAME</u>	<u>TITLE</u>
Charles H. Gardner, C.P.G., P.E.	Chief, Land Quality Section
William P. Weldon, P.E.	Chief Engineer
Richard A. Phillips, P.E.	Regional Engineer
William H. Allen	Assistant Regional Engineer
Richard D. Moore	Assistant Regional Engineer
Dennis G. Owenby	Engineering Technician
Donald C. Holebrooks	Engineering Technician
H. E. Withers, III., E.I.T.	Project Engineer

Submitted By: Chas H. Gardner

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

BLACK MOUNTAIN RESERVOIR DAM

NATIONAL INVENTORY NO. - NC 1247

STATE INVENTORY NO. - 11-007-H

SECTION I - PROJECT INFORMATION

1.1 General

a. Authority: Public Law 92-367

b. Purpose of Inspection:

To assess the general condition of the dam and its appurtenances, evaluate its hydraulic and hydrologic capacities, identify hazard to human life and property, and determine the need for additional study.

1.2 Description of Project

a. Description of Dam and Appurtenances.

The dam is an earthfill structure, 45.5 ft. high and impounds a maximum of 55.9 ac-ft. A 12 ft. wide weir on a concrete base serves as both principal and emergency spillway. The spillway flows into a lower lake, from which water can be pumped back into Black Mountain Reservoir. A chlorinator house is downstream of the dam.

b. Location.

Black Mountain Reservoir Dam is located on a small tributary to the Swannanoa River in Buncombe County, N.C. and is shown on the Black Mountain, North Carolina 7.5 minute USGS/TVA quadrangle at latitude 35°36'38"N, and longitude 82°17'14"W. The dam is approximately 2 miles upstream of the town of Black Mountain (pop. 3204). Figure 1 shows the location of the dam and a copy of a portion of the quadrangle is included in Appendix B.

c. Size Classification.

The size classification of the dam is "intermediate" under Federal criteria and is "medium" under State criteria (45.5 ft. high and 55.9 ac-ft. of storage).

d. Hazard Classification.

The dam is classified as "high" hazard under both State and Federal criteria.

e. Ownership.

Town of Black Mountain
225 W. State Street
Black Mountain, N.C. 28711
Attn: Mr. Earnest Hudgins, Town Manager

f. Purpose of Dam.

Water Supply

g. Design and Construction History.

According to a metal plaque located on the chlorinator house near the dam's toe, the dam was designed and constructed between 1933 and 1935 by the Emergency Relief Administration of North Carolina. However, no design or construction records were found. There was no SCS involvement in the design or construction of the dam.

h. Normal Operational Procedure(s).

Normal pool is maintained. Water is pumped from a lower lake as required to maintain maximum water supply storage.

1.3 Pertinent Data

a. Drainage Area.

281 acres

b. Discharge at Damsite.

Maximum known flood at damsite:

Undetermined

Normal flow at static pool level:

Approx. 1 cfs

Low stage spillway capacity:

350 cfs

Intermediate stage spillway capacity:	N/A
Emergency spillway capacity at maximum pool elevation:	Low stage spillway serves as emergency spillway
Gated spillway capacity at pool elevation:	N/A
Gated spillway capacity at maximum pool elevation:	N/A
Total spillway capacity at maximum pool elevation:	350 cfs

c. Elevation.

The normal pool elevation is approximately 2605 ft-MSL as determined from the Black Mountain 7.5' quadrangle. The elevations for this report are taken from an assumed datum of 100 feet. The assumed datum is not intended to be tied into any existing elevation.

Top of Dam:	99.2 ft. (low point)
Maximum pool-design surcharge:	99.2 ft.
Full flood control pool:	N/A
Recreation Pool:	96.5 ft.
Emergency spillway crest (ungated):	N/A
Upstream invert low stage spillway:	96.5 ft.
Downstream invert low stage spillway:	N/A
Lowest natural elevation at downstream toe of dam:	53.7 ft.
Maximum tailwater:	Unknown

d. Reservoir.

Length of maximum pool:	Approximately 450+ ft.
Length of recreation pool:	Approximately 450 ft.

	Length of flood control pool:	N/A
e.	<u>Storage.</u>	
	Recreation pool:	47.9 ac-ft.
	Flood control pool:	N/A
	Design surcharge:	8.0 ac-ft.
	Top of dam:	55.9 ac-ft.
f.	<u>Reservoir Surface.</u>	
	Top of dam:	3.1 acres
	Maximum pool:	3.1 acres
	Flood-control pool:	N/A
	Recreation pool:	2.8 acres
	Spillway crest:	2.8 acres
g.	<u>Dam.</u>	
	Type:	Earthfill
	Length:	350 ft.
	Structural Height:	45.5 ft.
	Hydraulic Height:	42.8 ft.
	Top Width:	11 ft.
	Side Slopes:	Upstream and downstream: 2.0 hor: 1.0 ver. (locally slightly steeper)
	Volume of Dam:	44,000 cu. yds. (estimated)
	Zoning:	Unknown
	Impervious Core:	Unknown

- | | |
|----------------|---------------------|
| Cutoff: | Unknown |
| Grout curtain: | Unknown |
| Foundation: | Assumed to be Earth |
- h. Diversion and Regulating Tunnel.
None
- i. Spillway System.
Type(s): Wooden weir board on concrete base
Length of weir: 12 ft.
Size of Pipe or Box: N/A
Width of Channel: 15 to 20 ft.
Crest Elevation: 96.5 ft.
Low Stage: 96.5 ft.
High Stage: N/A
- j. Bottom drain.
Water supply intake serves as bottom drain and is operational.
- k. Miscellaneous.
There are no locks or power generating facilities associated with the dam.

SECTION 2

ENGINEERING DATA

2.1 Design

The dam was designed by the Emergency Relief Administration of North Carolina between 1933 and 1935. Discussions with Mr. White, a city employee associated with the dam since about 1950 and Mr. Hudgins, Town Manager, produced no design nor information. The SCS was not involved in the design of the dam.

2.2 Construction

The dam was built by the Emergency Relief Administration of North Carolina. The SCS was not involved in the construction of the dam and no construction records are available.

2.3 Operation

The reservoir is operated by city employees in conjunction with a lower lake for water supplies to the city of Black Mountain.

2.4 Evaluation

a. Availability.

Not available

b. Adequacy.

Unknown

c. Validity.

Unknown

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General.

Golder personnel were met at the gate to the site by Mr. White, an employee of the city of Black Mountain. We interviewed Mr. White, surveyed the dam, took several photographs and thoroughly inspected the dam and reservoir area on July 15, and August 20, 1980. The downstream area was inspected and development noted. Figures 2 through 6 are plan, profile and cross-section drawings from the visual inspection.

b. Dam.

The following points were noted:

1. The dam is reasonably maintained with no undesirable growth (see Photos 2 and 3).
2. An access roadway crosses the crest and a fence is located on the downstream shoulder of the dam (see Photo 1).
3. Several stones (max. 1 ft. dia.) were noted on the downstream slope, mostly on lower portion.
4. Heavy seepage across lower third of the downstream slope and at the toe was noted (see Photo 6). Total seepage flow is about 3 to 5 gpm. Rust colored floc was noted but no materials migration was observed.
5. Several small "springs" were noted about 100 ft. downstream of the toe. Total flow was about 1 gpm.
6. A 15 ft. wide area near the right abutment appears to have slumped. The area is wet around the slump, aggravating the condition. This slump appears to be the result of prolonged movement.
7. Several other portions of the lower third of the downstream slope show some signs of minor movement and excessive seepage. The surficial soils in these areas were soft, wet and spongy.

c. Appurtenant Structures.

The spillway weir board and concrete base were in good condition (see Photo 4). A cast iron pipe empties into the lake from lower lake pumpage (see Photo 5). A pipe handrail runs from the crest of the dam under water to the intake pipe opening on the upstream slope of the embankment.

d. Reservoir Area.

The valley walls are steep but no instabilities were noted.

e. Downstream Channel.

The downstream channel is moderately steep, rocky, and heavily vegetated. Two other small lakes are downstream, one is owned by the city of Black Mountain, the other is not city owned.

f. Erosion Protection

The upstream face of the dam has no riprap but the slope does not appear eroded. Both slopes and the crest appear adequately vegetated. The spillway weir board is on a concrete base with a 3.5 ft. wide downstream apron. The spillway channel is natural rock and boulders. A wooden splash apron protects the outfall area of the lower lake inflow pipe from erosion.

g. Hazard Evidence.

Two small lakes are downstream of the dam and both would probably fail in the event of a failure of Black Mountain Reservoir Dam. Further downstream there are 3 houses, a railroad track and Interstate 40 (see Photo 7). There is the potential for loss of life in the event of a failure of Black Mountain Reservoir Dam. The nearest downstream town, Black Mountain, North Carolina (pop. 3204) is approximately 2 miles below the dam.

h. Foundation.

Appears to be founded on earth.

3.2 Evaluation

The dam is reasonably maintained, however, it has heavy seepage and may have minor toe stability problems. The total seepage flow is estimated to be about 3-5 gpm. Rust colored floc was present but no material migration was noted. There appears to be a hazard to loss of life in the event of a failure of the dam.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedures

The dam is kept at full normal pool for water supply as much as possible. Pumpage from the lower lake is used as required to maintain full pool.

4.2 Maintenance of Dam

The dam is maintained by the city of Black Mountain. This maintenance includes regular mowing and inspection of the embankment.

4.3 Maintenance of Operating Facilities

The operating facilities are maintained by the city of Black Mountain. All facilities appeared operational and are regularly inspected.

4.4 Description of Any Warning System in Effect

There are no known warning systems in effect.

4.5 Evaluation

The operational procedures should include monitoring of seepage flow rate and movement of the slump near the right abutment. Other procedures appear adequate.

SECTION 5
HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design data.

No hydraulic/hydrologic design data was found.

b. Experience data.

According to Mr. White, a Black Mountain city employee, the dam has never been known to overtop.

c. Visual observations.

There was no visual evidence of overtopping of the dam.

d. Overtopping Potential.

The appropriate spillway design flood (SDF) based on Federal criteria is the PMF and based on State criteria is the 1/2 PMF. The results of the hydraulic/hydrologic analysis based on the COE regional PMF equations and SCS emergency spillway design procedures (NEH-4) are listed below. Supporting figures, calculations and curves are included in Appendix B. A copy of a portion of the USGS quadrangle is also included in Appendix B.

OVERTOPPING POTENTIAL

Flood	PEAK		OVERTOPPING	
	Inflow (cfs)	Elevation* (ft-TBM)	Depth** (ft)	Velocity (fps)
COE PMF	4945	102.0	2.8	8.8
COE 1/2 PMF	2472	101.0	1.8	7.0
SCS PMF	3777	101.6	2.4	8.1
SCS 1/2 PMF	1499	100.6	1.4	6.2

*Assume top of dam at 99.6 ft-TBM for rating calculations.

**Low point of crest (99.2 ft-TMB) used for overtopping calculations.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations.

There appeared to be a 15 ft. wide slump on the downstream slope near the right abutment. The surrounding area was quite wet, aggravating the condition. The movement appears to be gradual and is not considered significant at this time. Other minor signs of slope distress were observed along the downstream slope.

b. Design and Construction Data.

Unknown.

c. Operating Records.

Normal pool maintained. Water use and lake level records are kept by the city of Black Mountain.

d. Post Construction Changes.

There are no known post construction changes.

e. Seismic Stability.

The dam is in Seismic Risk Zone 2, indicating a moderate probability of damage from earthquake forces.

SECTION 7

ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety.

Minor slope distress is present on the downstream face of the dam but this is not considered to present a threat to the overall integrity of the structure at this time. The seepage observed on the downstream slope contributes to this slope distress and should be controlled. These factors are not considered a hazard to the stability of the dam at this time.

Based on the COE regional PMF equation the dam overtops by 2.8 ft. in the PMF (Federal SDF) and by 1.8 ft. in the $\frac{1}{2}$ PMF (State SDF). It is judged that the dam would fail under these overtopping depths, presenting an increased hazard to loss of life over that which would exist prior to the failure of the dam. Therefore, the spillway capacity is considered to be seriously inadequate and the dam is considered unsafe until corrective measures are taken or further investigation proves otherwise.

b. Adequacy of Information.

This study was based on data obtained from interviews, field survey, topographic maps and generalized hydrologic information.

c. Urgency.

Further investigation addressing enlarging the spillway, controlling seepage and improving embankment stability should proceed as soon as possible upon approval of this report.

d. Necessity for Additional Study.

Additional study is needed to determine the required spillway modifications. The seepage springs and slope movement should be investigated further to assess their effect on the overall stability of the dam.

7.2 Remedial Measures

a. Alternatives.

The spillway capacity should be increased to an acceptable level and possibly a toe drain installed. State dam safety laws dictate that if the needed repairs are not implemented the lake should be drained and the dam breached.

b. Operation and Maintenance Procedures.

The existing operation and maintenance procedures are adequate but the seepage flow rate and movement of the downstream slope should be monitored.

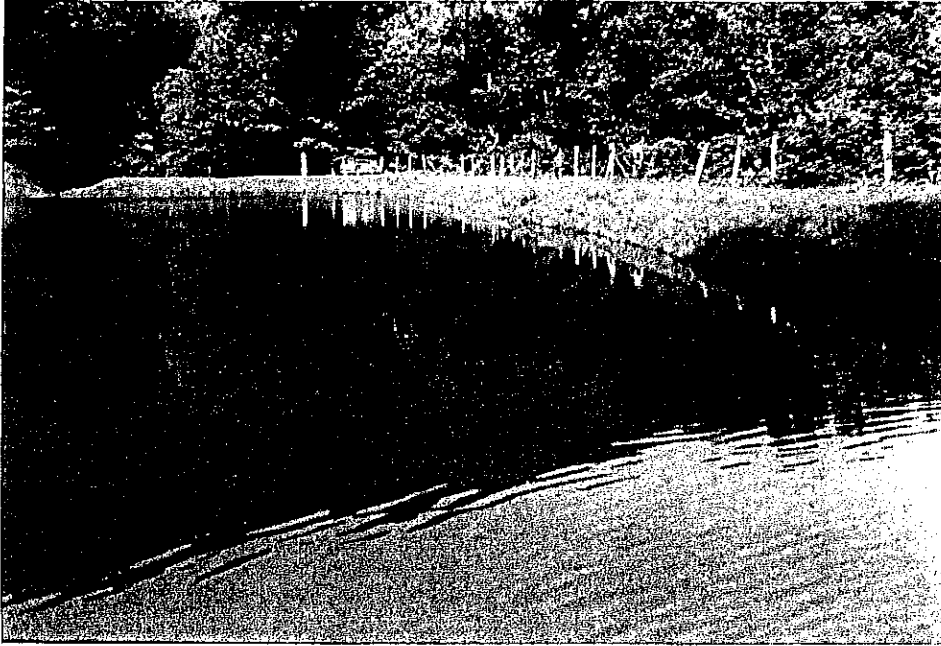
APPENDIX A
Pictures and Drawings



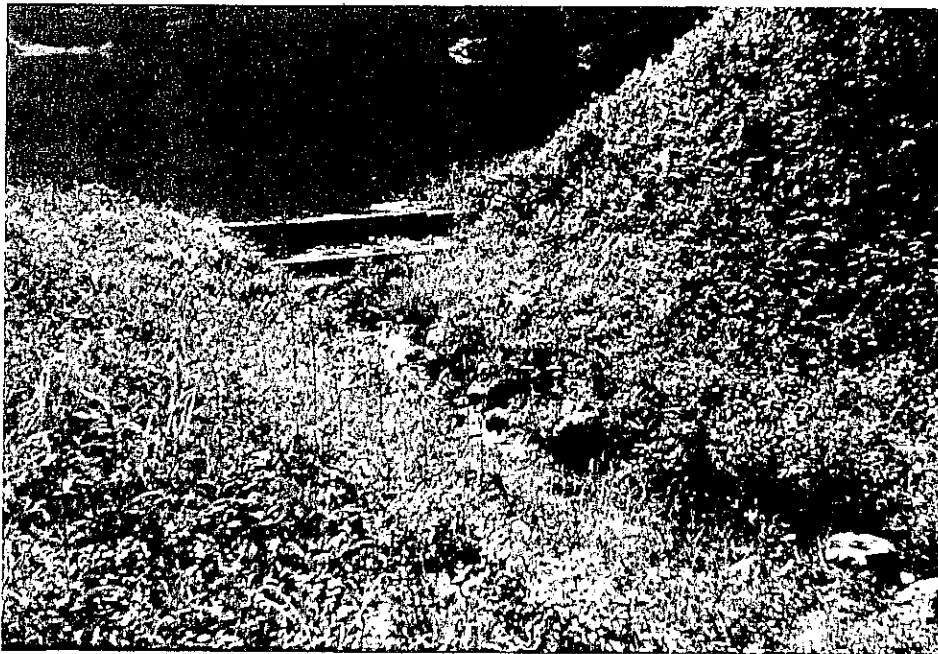
1. Black Mountain Reservoir and Dam



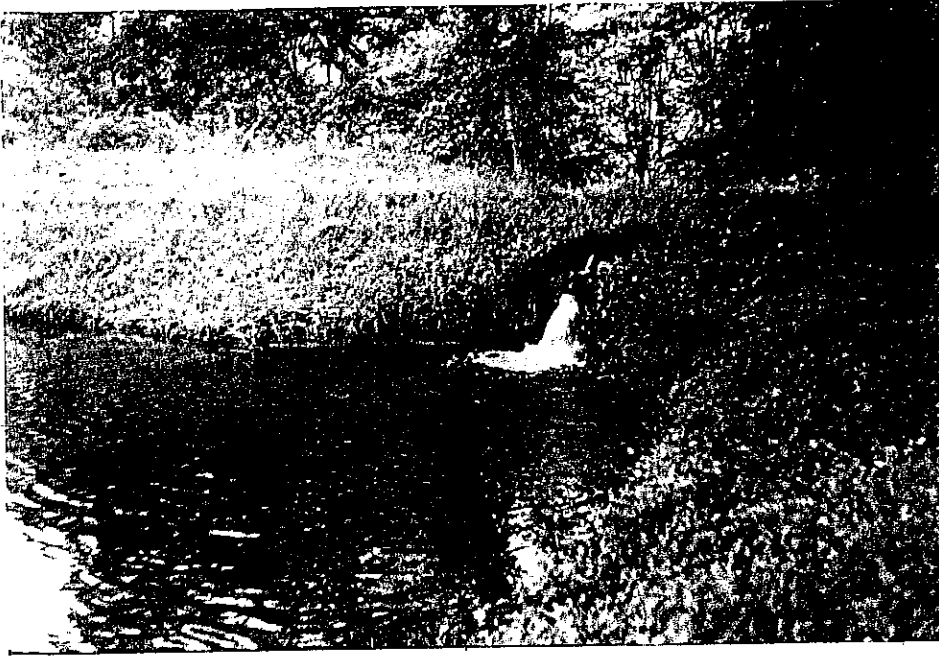
2. Downstream Slope of Dam



3. Upstream Slope of Dam



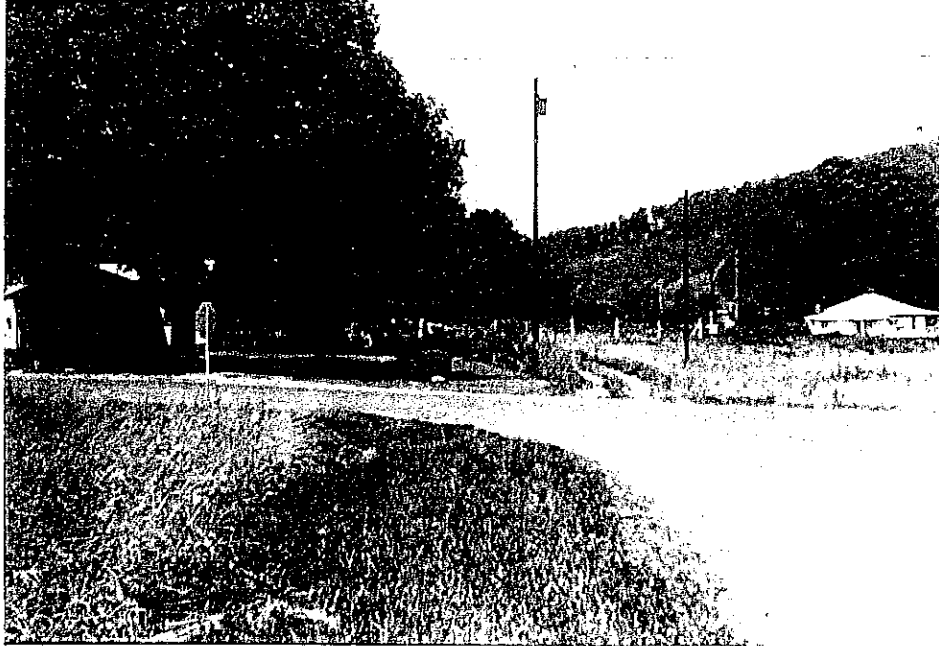
4. Spillway Weir Board



5. Pump Outlet from Lower Lake



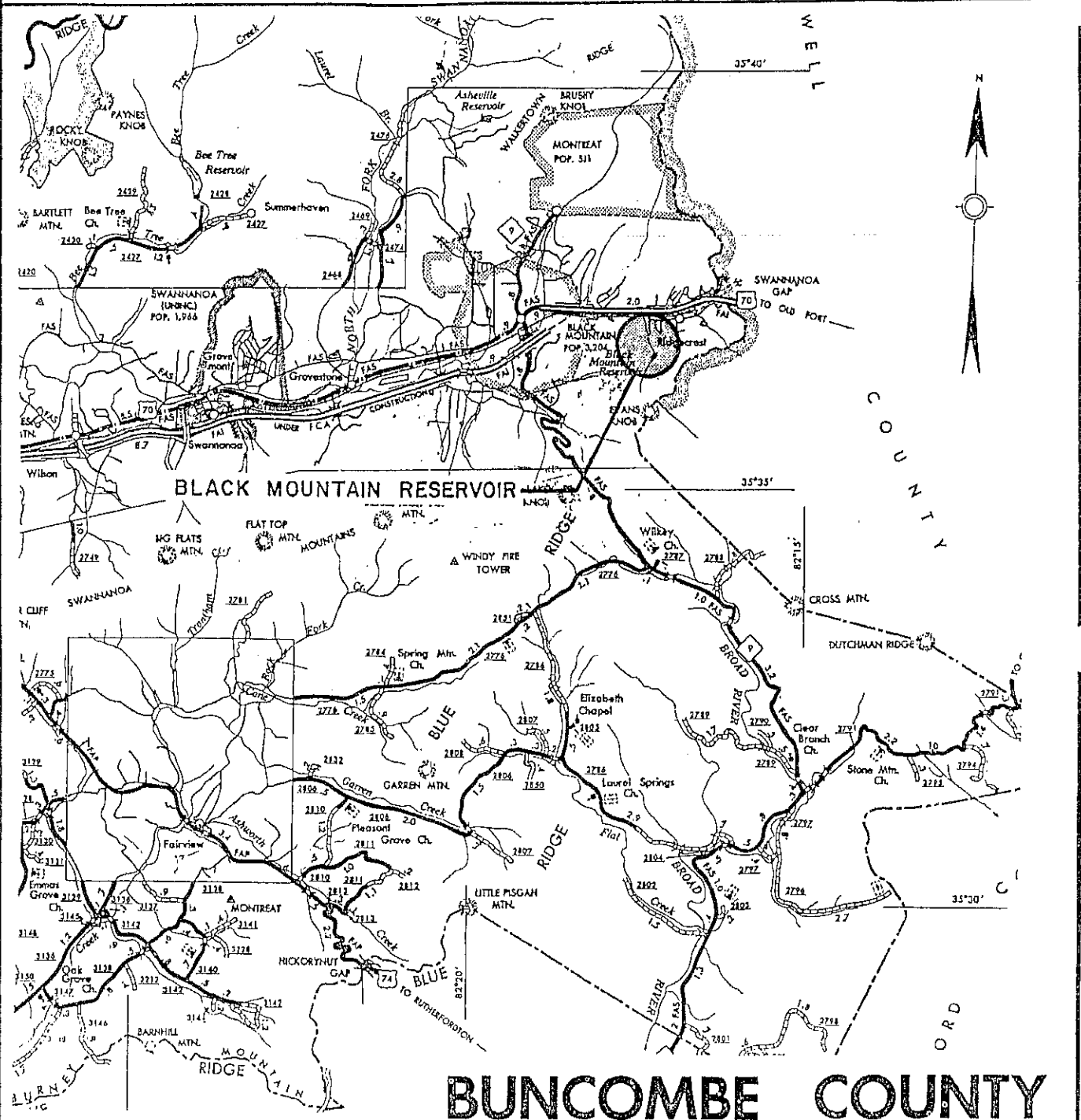
6. Seepage Near Toe of Dam



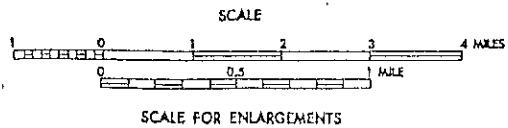
7. Houses Downstream of Dam

REGIONAL VICINITY MAP
BLACK MOUNTAIN RESERVOIR

FIGURE /



BUNCOMBE COUNTY
NORTH CAROLINA



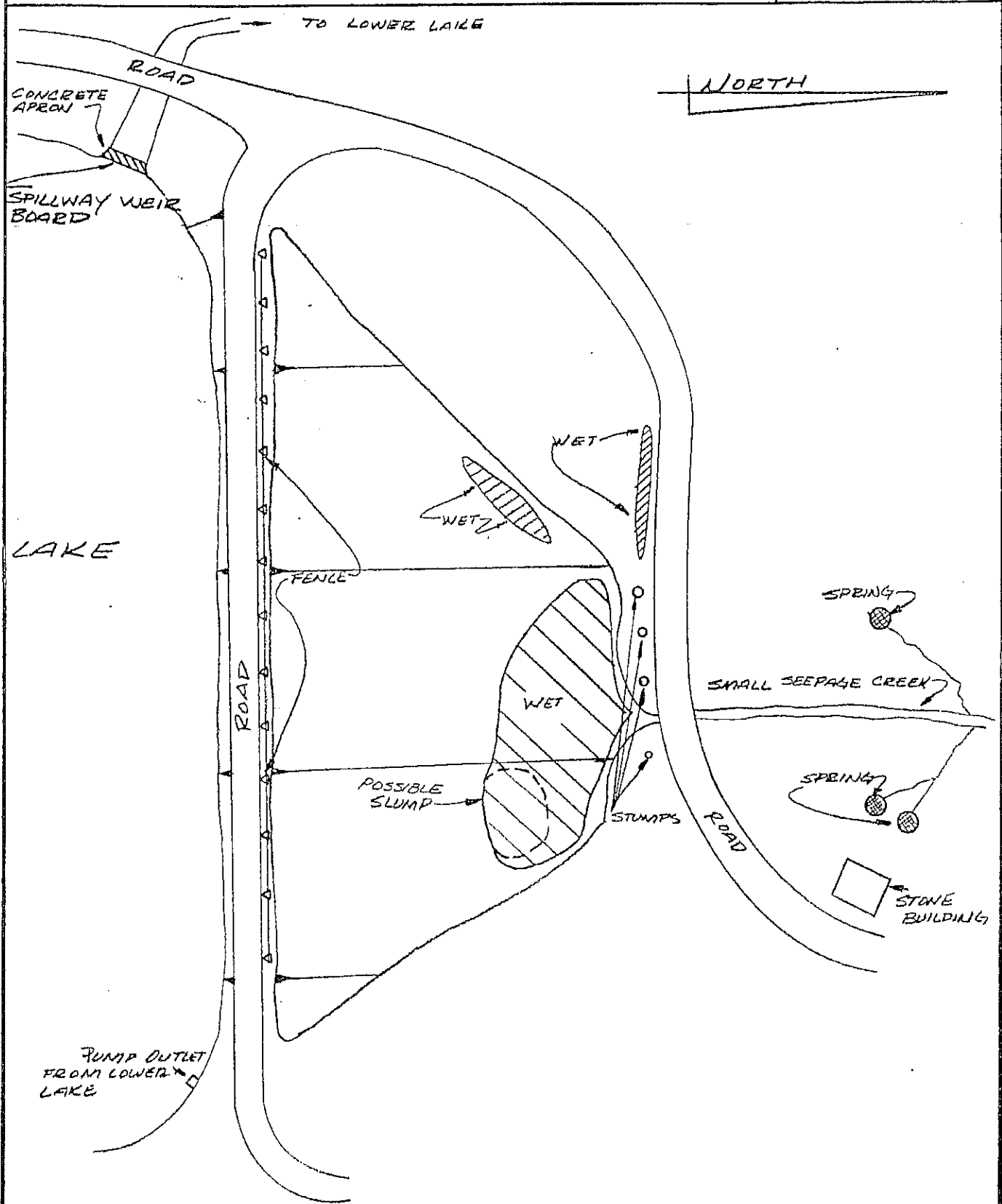
Scale AS SHOWN
Date 7-31-80
Job No. 804-1167

Golder Associates

Drawn JEF
Checked _____
Approved _____

BLACK MOUNTAIN RESERVOIR DAM PLAN VIEW

FIGURE 2



Scale NOT TO SCALE

Date 7-28-80

Job No. 804-1167

Golder Associates

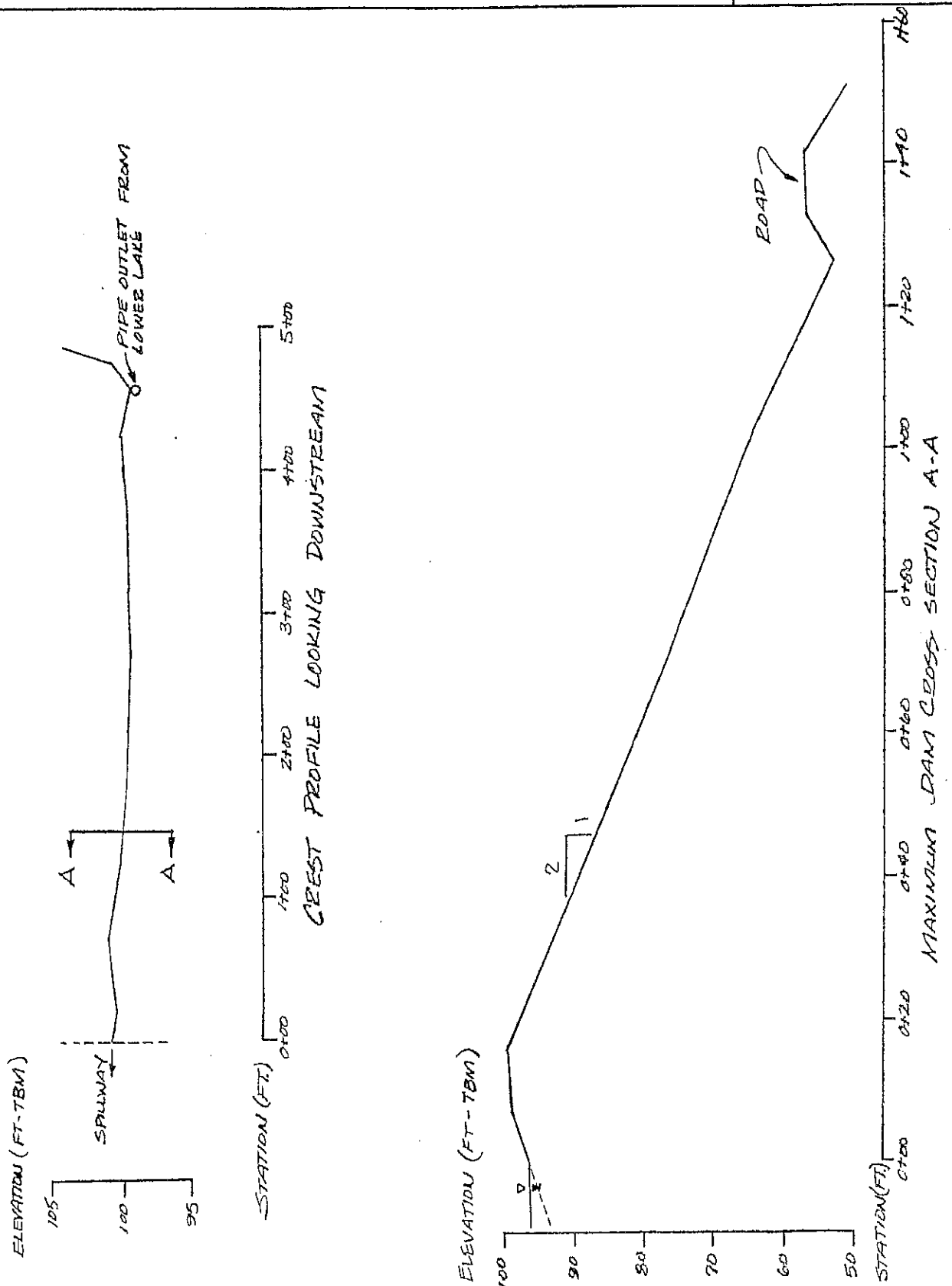
Drawn C.A.B

Checked J.E.B

Approved _____

BLACK MOUNTAIN RESERVOIR DAM CREST PROFILE AND CROSS-SECTION

FIGURE 3



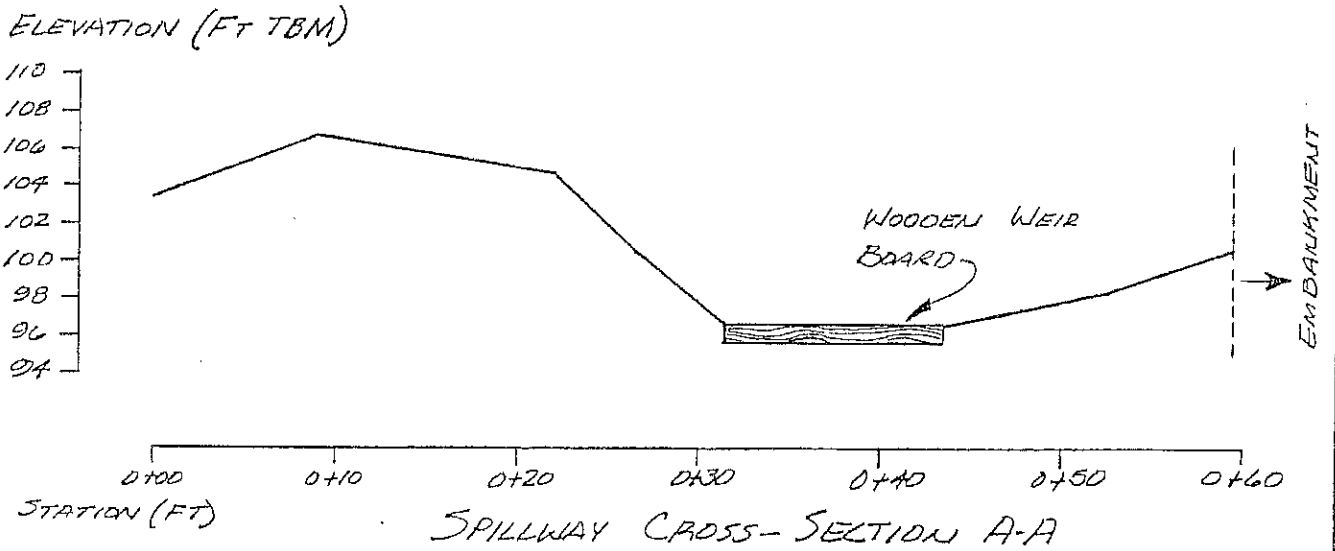
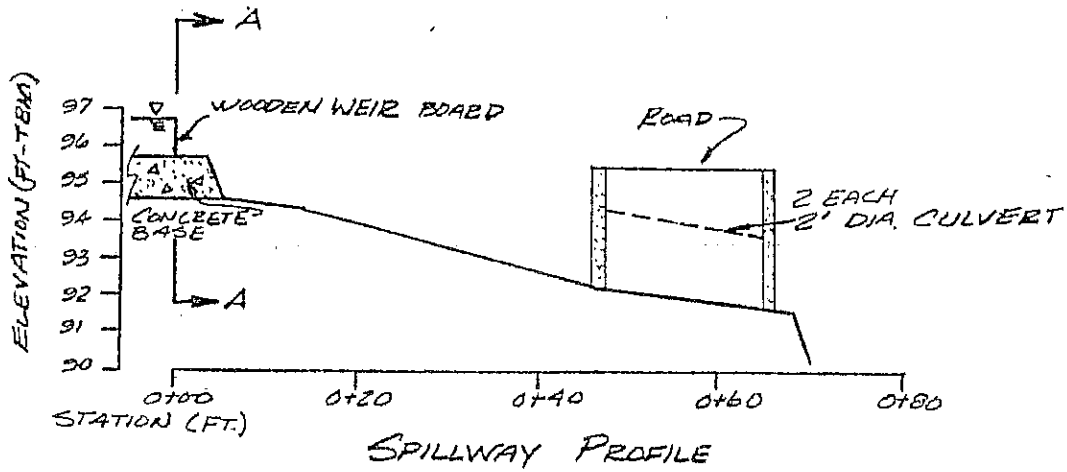
Scale AS SHOWN
 Date 7-24-80
 Job No. 804-1167

Golder Associates

Drawn CAB
 Checked JEB
 Approved _____

BLACK MOUNTAIN RESERVOIR DAM
 SPILLWAY PROFILE AND CROSS SECTION

FIGURE 4



Scale AS SHOWN
 Date 7-24-80
 Job No. 804-1167

Golder Associates

Drawn C.A.B
 Checked J.E.B
 Approved _____

APPENDIX B

Hydraulic and Hydrologic Analysis

APPENDIX B

HYDRAULIC/HYDROLOGIC ANALYSIS

The hydraulic/hydrologic analysis performed in this study consists of the following 4 tasks; (1) determine appropriate spillway design flood's (SDFs), (2) compute the peak inflow rates based on the COE regional PMF equations, (3) compare the COE PMF inflows to those computed using SCS methods, (4) determine crest overtopping depths and velocities (if overtopped) for each peak inflow rate. The methods used to perform each task are outlined below.

The appropriate SDFs are selected based on the height of the dam and its storage capacity. The height is defined as the difference between the low point of the crest and the lowest natural elevation at the downstream toe of the dam. The storage capacity is computed to the crest of the dam. Both State and Federal criteria are used to set the appropriate SDF based on the largest of the height and volume size classifications and the hazard class of the dam.

The COE regional PMF equations yield a peak inflow rate for a given drainage area and are regionalized to the geologic areas of the State. The equations used are those received by Mr. Charles Gardner from the Wilmington District COE on May 23, 1978. As defined by the Wilmington District HES, a partial PMF (i.e. $\frac{1}{2}$ PMF) is computed by multiplying the peak PMF inflow rate by the desired fraction.

SCS peak inflows were computed using the procedures outlined in the SCS National Engineering Handbook, Section 4 (NEH-4), Chapter 21. This method requires as input the drainage area, time of concentration and runoff curve number of the watershed. The design storm is assumed to have a duration of 6 hours (unless the time of concentration of the watershed is longer than 6 hours) and a total depth of rainfall equal to the PMP values given in NEH-4 Figure 21.5, corrected for drainage area based on Figure 21.2 of NEH-4. Partial PMFs were computed by multiplying the PMP rainfall depth by the appropriate fraction prior to performing the SCS computations.

Overtopping depths and velocities were determined based on detailed hydraulic computations. A total outflow/elevation rating curve was computed for the spillway(s) and the crest itself. This rating curve was used to compute peak water surface elevations for each SDF peak flow rate. The overtopping depths were determined by subtracting the low point of the crest from the peak water surface elevation. Overtopping velocities were then computed assuming critical flow over the crest of the dam at a depth equal to $\frac{2}{3}$ of the overtopping depth.

The results of the above outlined procedure are given in the table below. Supporting hand calculations, curves and maps are included in this Appendix.

OVERTOPPING POTENTIAL

Flood	PEAK		OVERTOPPING	
	Inflow (cfs)	Elevation* (ft-TBM)	Depth** (ft)	Velocity (fps)
COE PMF	4945	102.0	2.8	8.8
COE 1/2 PMF	2472	101.0	1.8	7.0
SCS PMF	3777	101.6	2.4	8.1
SCS 1/2 PMF	1499	100.6	1.4	6.2

*Assume top of dam at 99.6 ft-TBM for rating calculations.

**Low point of crest (99.2 ft-TMB) used for overtopping calculations.

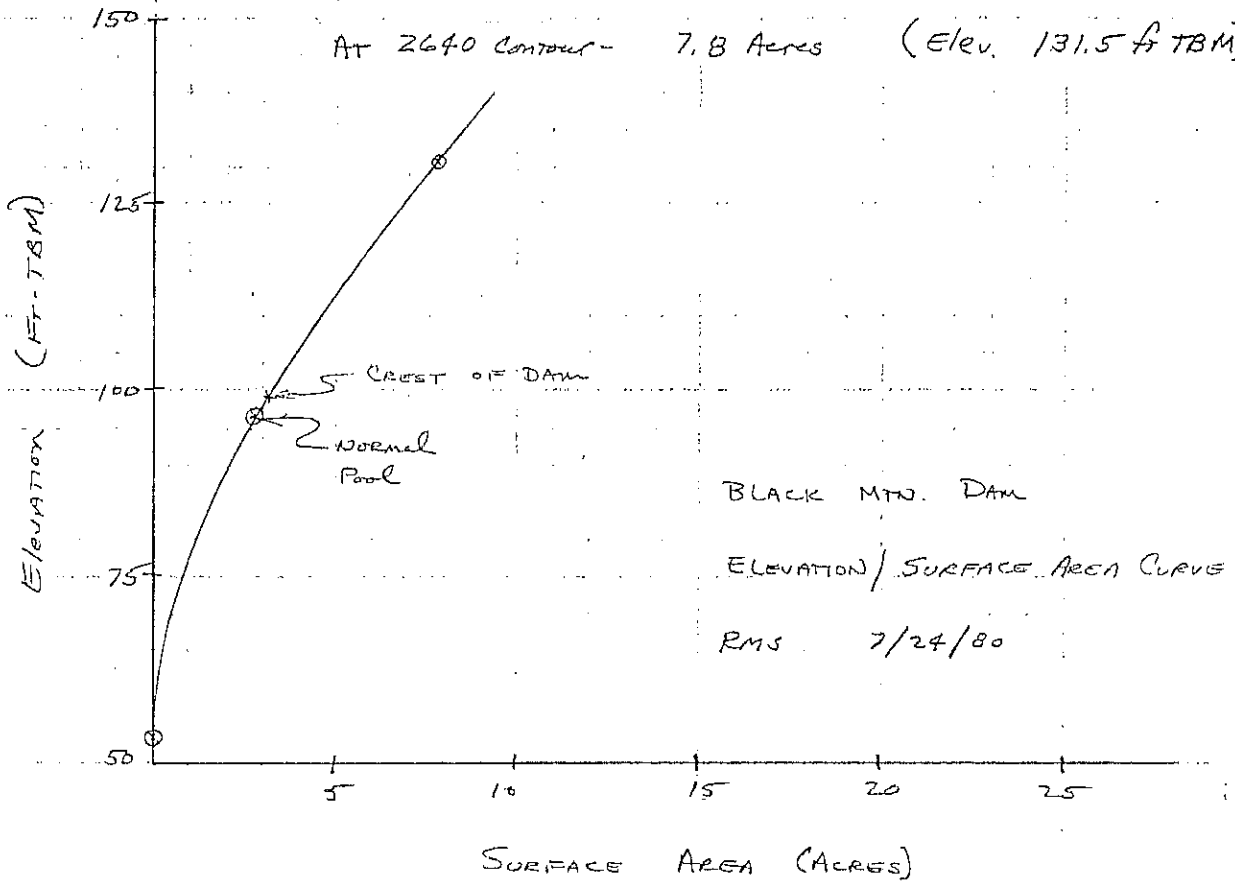
The storage between normal pool and the top of the dam is 8.0 ac-ft. The runoff hydrographs from the PMF and 1/2 PMF contain 491.8 ac-ft. and 210.8 ac-ft. respectively. This is equivalent to 21.0 in. and 9.0 in. of runoff for the PMF and 1/2 PMF respectively. The reservoir can therefore detain 1.6% of the PMF runoff and 3.8% of the 1/2 PMF runoff.

Golder Associates

By RMS Job N.C. DAMS
 Chkd. JEB Subject BLACK MTD DAM
 Appd. JEO STORAGE VOL.

Sheet 1 of 1
 Job No. 804-1167
 Date 24 July 1980

SURFACE AREA: Normal Pool - 2.8 Acres (Elev 96.5 ft TBM)
 Bottom - 0 Acres (Elev 53.7 ft TBM)
 At 2640 contour - 7.8 Acres (Elev. 131.5 ft TBM)



From the above curve - Top of DAM - 3.1 Acres (Elev. 99.2 ft-TBM)

STORAGE VOLUMES

Normal Pool $Vol = (2.8)(42.8)(0.4) = 47.9 \text{ Ac. ft}$

Surcharge $\left(\frac{2.8+3.1}{2}\right)(99.2-96.5) = 8.0 \text{ Ac. ft}$

Maximum pool = $47.9 + 8.0 = 55.9 \text{ Ac. ft}$

**Golder
Associates**

By RMS Job N.C. DAMS
Chkd. JEB Subject BLACK MTN. DAM
Appd. JEB SIZE CLASSIFICATION

Sheet 1 of 1
Job No. 804-1167
Date 24 July 1980

Height & Volume

Height - Crest - 99.2 (ft TBM)
Toe - 53.7 "

Height 45.5 ft

Volume: Top of Dam = 55.9 Ac. Ft.

SIZE CLASSIFICATION

FEDERAL:

Height - INTERMEDIATE
Volume - SMALL

STATE:

Height - MEDIUM
Volume - SMALL

SPILLWAY DESIGN FLOOD

FEDERAL - PMF

STATE - 1/2 PMF

Goldier Associates

By RMS Job N.C. Dam Sheet 1 of 1
Chkd. JEB Subject CALCULATION OF Job No. 804-1167
Appd. JEB SPILLWAY DESIGN FLOODS Date 7/28/80

COE EQUATIONS

BLACK MOUNTAIN DAM

From the equation taken from a letter dated 23 MAY 1978 to Mr. Charles GARNER:

$$g_p = 8800 A^{-.3}$$

where A = drainage Area in mi^2

$$A = 281.0 \text{ Acres} \times \frac{43,560 \text{ ft}^2}{1 \text{ Acre}} \times \frac{1 \text{ mi}^2}{2.79 \times 10^7 \text{ ft}^2} = .439 \text{ mi}^2$$

$$\therefore g_p = 8800 (.439)^{-.3} \\ = 11,265 \text{ ft}^3/\text{sec} / \text{mi}^2$$

$$Q = g_p \times A \\ = (11,265) (.439) \\ = 4945 \text{ cfs}$$

Spillway Design Flood

Federal - 4945 cfs (PMF)

State - $\frac{1}{2} (4945) = \underline{2472 \text{ cfs}}$ ($\frac{1}{2}$ PMF)

~~SCS Emergency Spillway Design Procedure -
(from FORM, JFC 7/28/80)~~

SEE RMS 9/9/80
for SCS Proc.

~~PMF = 4300 cfs~~

~~Per COE, Wilmington District; HES -~~

~~$\frac{1}{2}$ PMF = $\frac{4300}{2} = 2150 \text{ cfs}$~~

Golder Associates

By FMS
 Chkd. JEB
 Appd. JEB

Job N.R. DAMS
 Subject DETERMINATION of T_c
BLACK MOUNTAIN DAM

Sheet 1 of 2
 Job No. EOL-1167
 Date 9 Sep - 1977

Average Watershed Land Slope			
Point No.	Δh (ft)	length (ft)	Slope (%)
1	160	250	64.0
2	80	100	80.0
3	200	500	40.0
4	195	775	25.2
5	195	1000	19.5
6	200	725	27.6
7	200	300	66.7
8	200	750	26.7
9	400	1000	40.0
10	195	900	21.7
			<u>41.1 % Avg</u>

DETERMINATION OF Time of Concentration (NEH 4. SCS)

$L = 0.6 T_c$ (15.3) pg 15-6

$L = \frac{l^{0.8} (S+1)^{0.7}}{1900 (Y)^{0.5}}$ (15.4) pg 15-7

where $S = \frac{1000}{CN} - 10$

Known: $CN = 55$ ∴ $S = \frac{1000}{55} - 10 = 8.18$
 $l = 4500$
 $Y = 41.1\%$

Flow across LAKE $Q = 400 \text{ cfs}$

$V_w = \sqrt{g D_m}$ (15.5) pg 15-11

where $D_m = 22.7 \text{ ft}$

$V_w = \sqrt{32.2 (22.7)}$

$= 27.0 \text{ fps}$

time of travel = $\frac{400 \text{ ft}}{27 \text{ fps}} = 14.8 \text{ sec} = .004 \text{ hr}$

Golder Associates

By RMS

Job N.C. DAMS

Sheet 2 of 2

Chkd. JEB

Subject Determination of Tc

Job No. 809-1167

Appd. JEB

Black Mountain

Date 9 Sept 1960

Watershed excluding lake

$$L = 4500 \text{ ft} - 400 \text{ ft} = 4100 \text{ ft}$$

$$L = \frac{(4100)^{0.8} (9.18)^{0.7}}{1900 (41.1)^{0.5}}$$

$$= .30 \text{ hrs}$$

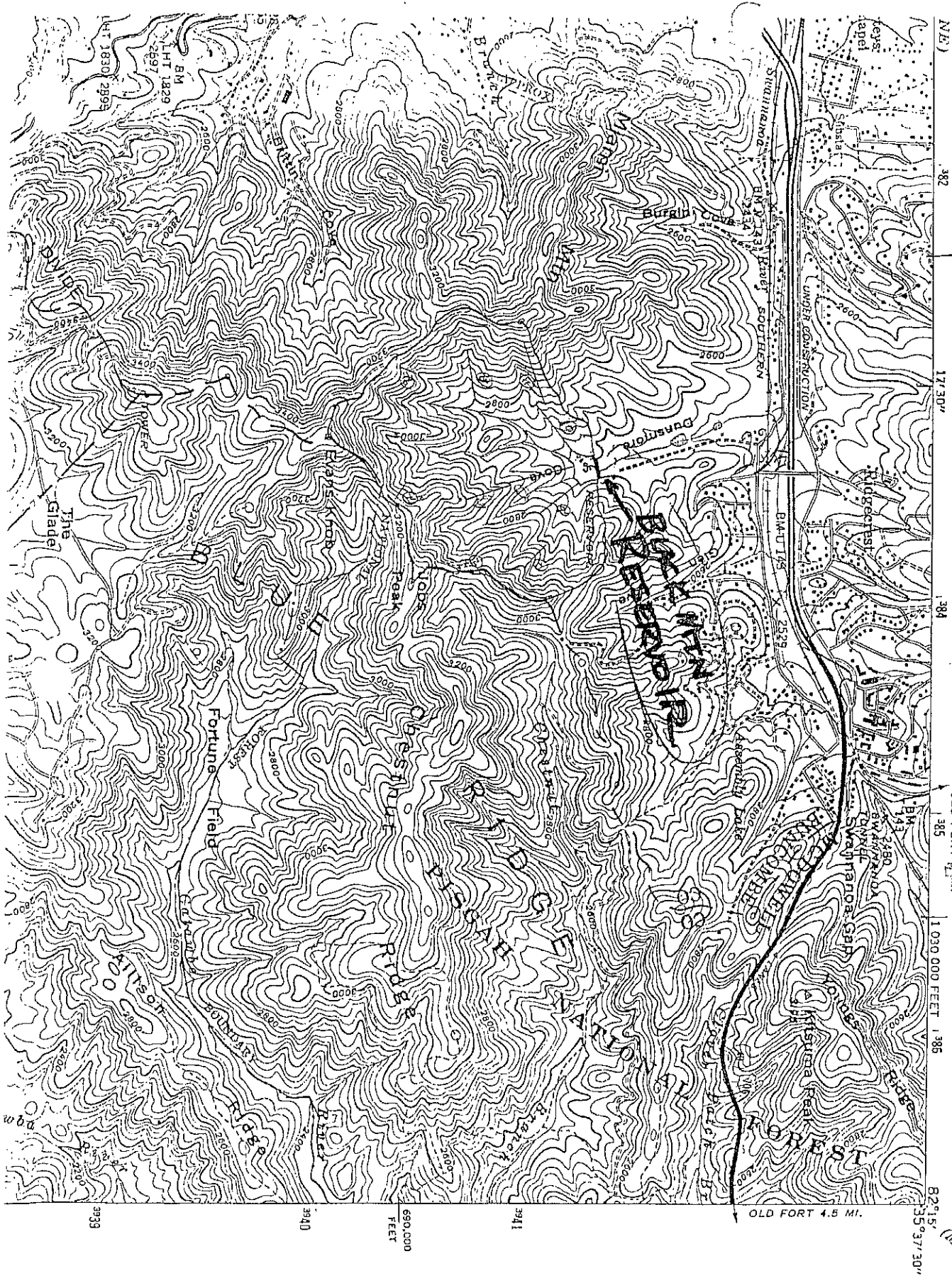
$$L = 0.6 T_c$$

$$T_c = \frac{.30 \text{ hrs} + .004 \text{ hrs}}{.6} = \frac{.304}{.6}$$

$$= \underline{\underline{.51 \text{ hrs}}}$$

ATES
AUTHORITY
S BRANCH

BLACK MOUNTAIN QUADRANGLE
NORTH CAROLINA
7.5 MINUTE SERIES (TOPOGRAPHIC) 201-SE
OLD FORT 4.5 MI.



11 1985
1:62,500
(Morton)

HYDROGRAPH COMPUTATION
For SCS-ENG-319
Rev. 1-70

TABLE B-1

$\frac{1}{2}$ PMP HYDROLOGIC ANALYSIS

WATERSHED OR PROJECT STATE	$t = (t/T_p) \text{REV. } T_p$	$q = (q_c/q_p)(Q)(q_p)$	$Q_c = (Q_c/Q)Q$
	t HOURS	q CFS	Q INCHES
N.C. DAMS	0	0	0
Black Mtn. DAM			
DR. AREA 0.44 SQ.MI. STRUCTURE CLASS -	1.06	1,499	
T_c 0.57 HR. STORM DURATION 6.0 HR.			
POINT RAINFALL 14.5 IN.			
ADJUSTED RAINFALL:			
AREAL FACTOR - IN. -			
DURATION FACTOR - IN. -			
RUNOFF CURVE NO. 55			
Q 9.00 IN.			
HYDROGRAPH FAMILY NO. 3			
COMPUTED T_p 0.357 HR. $T_p = 0.7 T_c$			
T_0 4.70 HR.			
(T_0/T_p) :			
COMPUTED 13.17 ; USED 16			
REVISED T_p 0.294			
$q_p = \frac{484A}{\text{REV. } T_p} = \frac{724.4}{\text{REV. } T_p}$ CFS.			
$(Q)(q_p) = 6,520$ CFS.			
t (COLUMN) = $(t/T_p) \text{REV. } T_p$			
q (COLUMN) = $(q_c/q_p)(Q)(q_p)$			
Q (COLUMN) = $(Q_c/Q)Q$			

Date 9 Sept 1980
Job No. 804-1167

Golder Associates

Calc. By Rms
Checked JEB
Approved _____

HYDROGRAPH COMPUTATION
For SCS-ENG-319
Rev. 1-70

TABLE B-2

PMP Hydrologic Analysis

WATERSHED OR PROJECT <u>N.C. DAMS</u>	$t = (t/T_p) \text{REV. } T_p$	$q = (q_c/q_p)(Q)(q_p)$	$Q_c = (Q_c/Q)Q$
	<u>t</u> HOURS	<u>q</u> CFS	<u>Q</u> INCHES
STATE <u>N.C.</u>	1	0	0
STRUCTURE SITE OR SUBAREA <u>Black Mtn. DAM</u>	2		
DR. AREA <u>0.44</u> SQ.MI. STRUCTURE CLASS <u>-</u>	3		
T_c <u>0.51</u> HR. STORM DURATION <u>6.0</u> HR.	4		
POINT RAINFALL <u>29.0</u> IN.	5		
ADJUSTED RAINFALL:	6		
AREAL FACTOR <u>-</u> IN. <u>-</u>	7	1.77	3,777
DURATION FACTOR <u>-</u> IN. <u>-</u>	8		
RUNOFF CURVE NO. <u>55</u>	9		
Q <u>21.0</u> IN.	10		
HYDROGRAPH FAMILY NO. <u>2</u>	11		
COMPUTED T_p <u>0.352</u> HR. $T_p = 0.7 T_c$	12		
T_0 <u>5.25</u> HR.	13		
(T_0/T_p) :	14		
COMPUTED <u>14.71</u> ; USED <u>16</u>	15		
REVISED T_p <u>0.328</u>	16		
$q_p = \frac{484A}{\text{REV. } T_p} = \frac{649.3}{\text{REV. } T_p}$ CFS.	17		
$(Q)(q_p) = \underline{13,635}$ CFS.	18		
t (COLUMN) = $(t/T_p) \text{REV. } T_p$	19		
q (COLUMN) = $(q_c/q_p)(Q)(q_p)$	20		
Q (COLUMN) = $(Q_c/Q)Q$	21		
	22		
	23		
	24		
	25		
	26		
	27		
	28		
	29		
	30		
	31		
	32		
	33		
	34		

Rate Spillway and dam Crest using broad-crested trapezoidal weir formula:

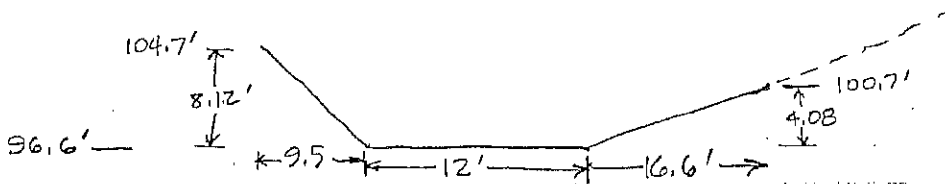
$$Q = C_1 L H_1^{3/2} + C_2 H_2^{5/2} \frac{\tan \theta}{2} + \dots$$

Where Q = total flow (cfs) summed for all component
 C_1, C_2, \dots = Weir coefficient for each component of dam profile
 H = Head over each weir component (ft)
 $\theta_1, \theta_2, \dots$ = Angle (in degrees) from vertical for each component of dam.
 L = length of crest of dam - (ft)

Crest Length = 350', assume @ Elev 99.7' TBM

Crest weir coefficient = 3.2 (from King & Brater Handbook of Hydraulics, Table 5-13, p 5-50)

Spillway sections:



Weir board Coeff = 3.5 From Brater & King, Table 5-11, P5-50
 Side Bank Coeff = 3.2 " " Table 5-13 " "

Crest Flow:

$$Q = 3.2(350)(E - 99.7)^{3/2}$$

Spillway Flow:

$$Q = 3.5(12)(E - 96.6)^{3/2} + 3.2(E - 96.6)^{5/2} \left(\frac{16.6}{4.08} + \frac{9.5}{8.12} \right) 0.5$$

Tabulate Computations -

Golder Associates

By JEB
 Chkd. JFC
 Appd. JEB

Job N.C. DAMS
 Subject BLACK MTN. RES.
OUTFLOW RATINGS

Sheet 2 of 3
 Job No. 8041149
 Date 7/27/80

<u>Elev.</u> (FT-TBM)	<u>CREST</u> <u>Head</u> (FT)	<u>SPILL</u> <u>Head</u> (FT)	<u>Q_{crest}</u> (cfs)	<u>Q_{spill}</u> (cfs)	<u>Q_{TOTAL}</u> (cfs)
96.6	—	0	—	0	0
97.0	—	0.4	—	11.5	12
97.5	—	0.9	—	42.3	42
98.0	—	1.4	—	89.0	89
99.0	—	2.4	—	231	231
99.6	0	3.0	0	349	349
100.0	0.3	3.4	184	442	626
100.5	0.8	3.9	801	575	1376
101.0	1.3	4.4	1660	728	2388
102.0	2.3	5.4	3907	1095	5002
104.0	4.3	7.4	9987	2094	12080
106.0	6.3	9.4	17710	3481	21191

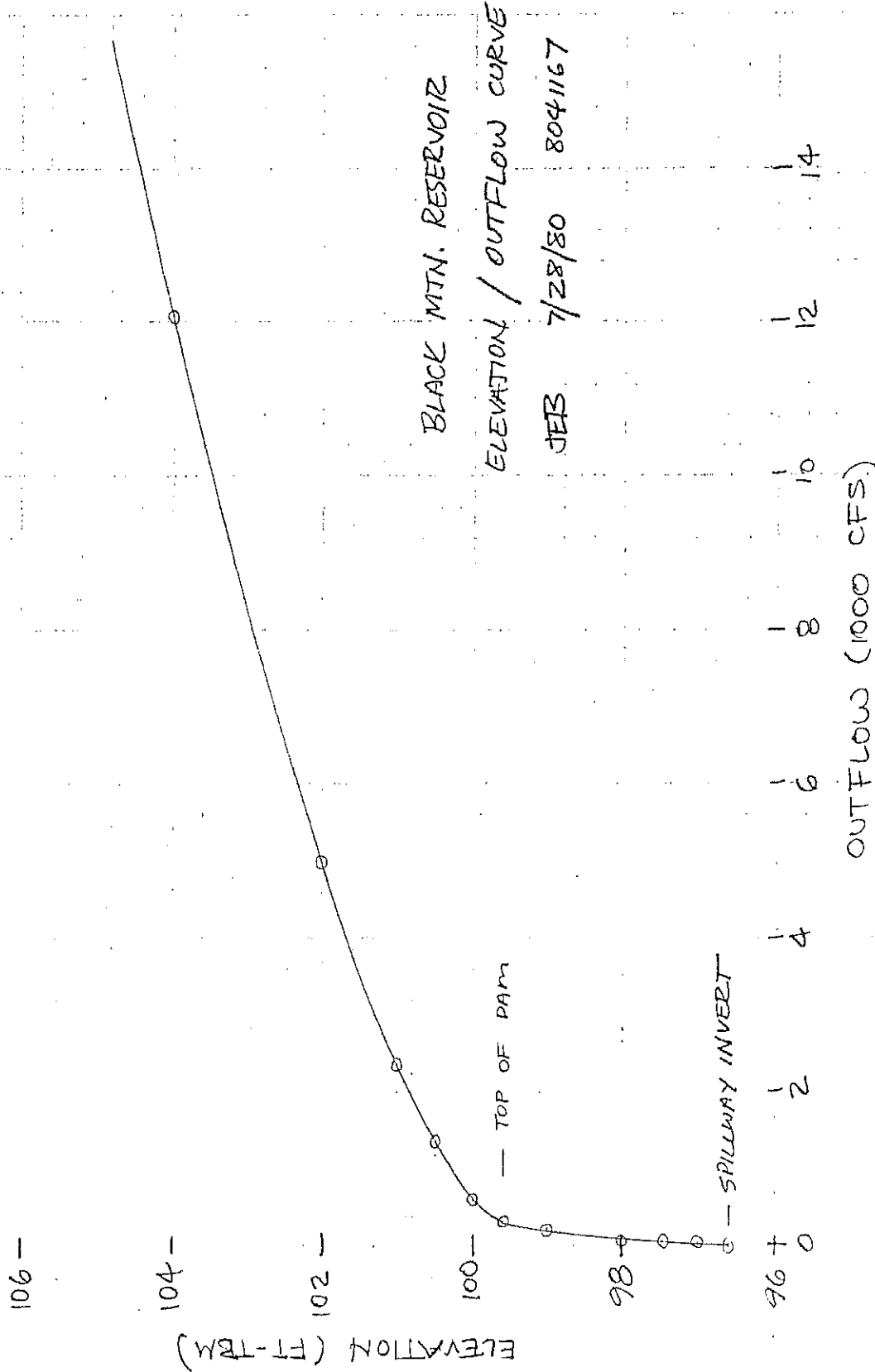
Plot outflow rating curve on next sheet.

Golder Associates

By JEB
 Chkd. JFC
 Appd. JEB

Job N.C. Dams
 Subject BLACK MTN. DAM
OUTFLOW RATING

Sheet 3 of 3
 Job No. 8041149
 Date 7/28/80



Golder Associates

By RMS Job N.C DAMS Sheet 1 of 1
 Chkd. JEB Subject DETERMINATION OF T_c Job No. 804-1167
 Appd. JEB BLACK MOUNTAIN DAM Date 9 Sept 1980

Top of Dam - Assume to 99.6' TBM for rating calculations
 - Low Point is 99.2' TBM for overtopping calculations

Crest Velocity - Assume critical flow over crest & critical flow is $\frac{2}{3}$ the approach depth
 $V = 1.5 C H^{1/2}$; $C = 3.5$

FLOOD	PEAK INFLOW (cfs)	PEAK ELEVATION* (ft-TBM)	OVERTOPPING DEPTH** (ft)	OVERTOPPING VELOCITY (fps)
COE PMF	4945	102.0	2.8	8.8
COE $\frac{1}{2}$ PMF	2472	101.0	1.8	7.0
SCS PMF	3777	101.6	2.4	8.1
SCS $\frac{1}{2}$ PMF	1499	100.6	1.4	6.2

* Based on 99.6 ft TBM (approximated crest)
 ** Based on 99.2 ft TBM (crest low point)

Storage Considerations

Design Storage: 8.0 Ac ft
 PMF Hydrograph (SCS) = 21.0 in. : 491.8 Ac ft
 $\frac{1}{2}$ PMF Hydrograph (SCS) = 9.0 in. : 210.8 Ac ft

Percent Storage

(PMF) = $\frac{8.0}{491.8} = 1.6\%$
 $(\frac{1}{2} PMF) = \frac{8.0}{210.8} = 3.8\%$

APPENDIX C
Dam Inventory Forms

FORM APPROVED
 OMB NO. 49-RO-421
 REQUIREMENTS CONTROL SYMBOL
 DAEN-CWE-17

STATI		IDENTITY NUMBER				
1	2	3	4	5	6	7
N	C		1	2	4	7

[41] [42] [43] [44] [45]

STATIS	VIGATION LOCKS															BLANK						
	WIDTH (I)			LENGTH (I)			WIDTH (I)			LENGTH (I)			WIDTH (I)									
	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73		74	75	76	77	78	79
																						5

[48]

MISC. DA	CONSTRUCTION BY																							
	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80		
	R	G	.	R	E	L	I	E	F	A	D	M	I	N	O	F	N	C	6					

[52]

MISC. DA (Continue)	MAINTENANCE																						
	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	
				N	C	D	N	R	C	D													7

[55]

MISC. DA (Continue)	AUTHORITY FOR INSPECTION																						
	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	
																							8

REMARK																							
	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	
																							9