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NATIONAL DAM SAFETY PROGRAM. ROCKWOOD HILLS LAKE DAM (MO 30372)--ETC(U)
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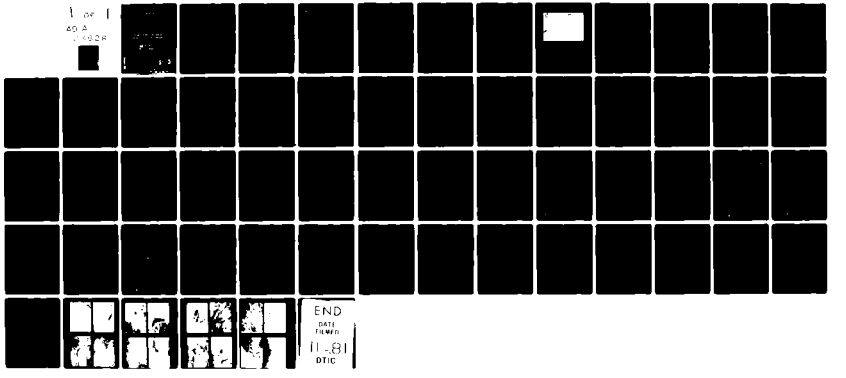

LEVEL II

WHITE RIVER BASIN

ROCKWOOD HILLS LAKE DAM

TANEY COUNTY, MISSOURI

MO 38372

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
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St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

JANUARY, 1981

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Rockwood Hills Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Rockwood Hills Lake Dam.

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, emergency by the St. Louis District because of the poor condition of the dam as a result of the following:

1) The slough areas along the crest of the dam and downstream face near the discharge of the east spillway.

2) The erosion at the toe of the downstream face immediately below a large slough area.

3) Steep downstream embankment slopes.

4) The inadequate spillway capacity and lack of erosion protection of the spillways.

SUBMITTED BY: SIGNED — 3 APR 1981
Chief, Engineering Division — Date

APPROVED BY: SIGNED — 7 APR 1981
Colonel, CE, District Engineer — Date

WHITE RIVER BASIN

ROCKWOOD HILLS LAKE DAM
TANEY COUNTY, MISSOURI
MISSOURI INVENTORY NO. 30372

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction of

St. Louis District, Corps of Engineers

For

Governor of Missouri

JANUARY, 1981

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam: Rockwood Hills Lake Dam
State Located: Missouri
County Located: Taney
Stream: Tributary of White River (Lake Taneycomo)
Date of Inspection: November 20, 1980

Rockwood Hills Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of this inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately three miles downstream of the dam. Located within this zone are one seasonal dwelling at 0.05 miles; one dwelling at 1.1 miles; U.S. Highway 65 at 1.35 miles; Highway F at 1.8 miles; nine dwellings at 2.2 miles.

The dam is in the small size classification, since it is approximately 25 ft high but less than 40 ft high, and the maximum storage capacity is greater than 50 ac-ft but less than 1,000 ac-ft.

Our inspection and evaluation indicate that the combined spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The combined spillways will pass 13 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering

the low height of the dam (25 ft), and the small storage capacity (56 Acre-ft), 50 percent of the PMF has been determined to be the appropriate spillway design flood. The 100-year flood (1 percent probability flood), will overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being exceeded in any given year. The 10 percent probability flood will not overtop the dam. The 10 percent probability flood is one that has a 10 percent chance of being exceeded in any given year.

The embankment was in poor condition. Deficiencies visually observed by the inspection team were: (1) Sloughing along crest of dam; (2) Large slough along toe near end of emergency spillway; (3) Erosion on upstream face, i.e., no wave protection; (4) Steep downstream side slopes; (5) Erosion of embankment by emergency spillway discharges; (6) Heavy brush and weed growth on embankment faces; (7) Animal burrows on front face; (8) Erosion between spillways and embankment; and (9) Undermining of ends of both spillway chutes.

Another deficiency was the lack of seepage and stability analysis records.

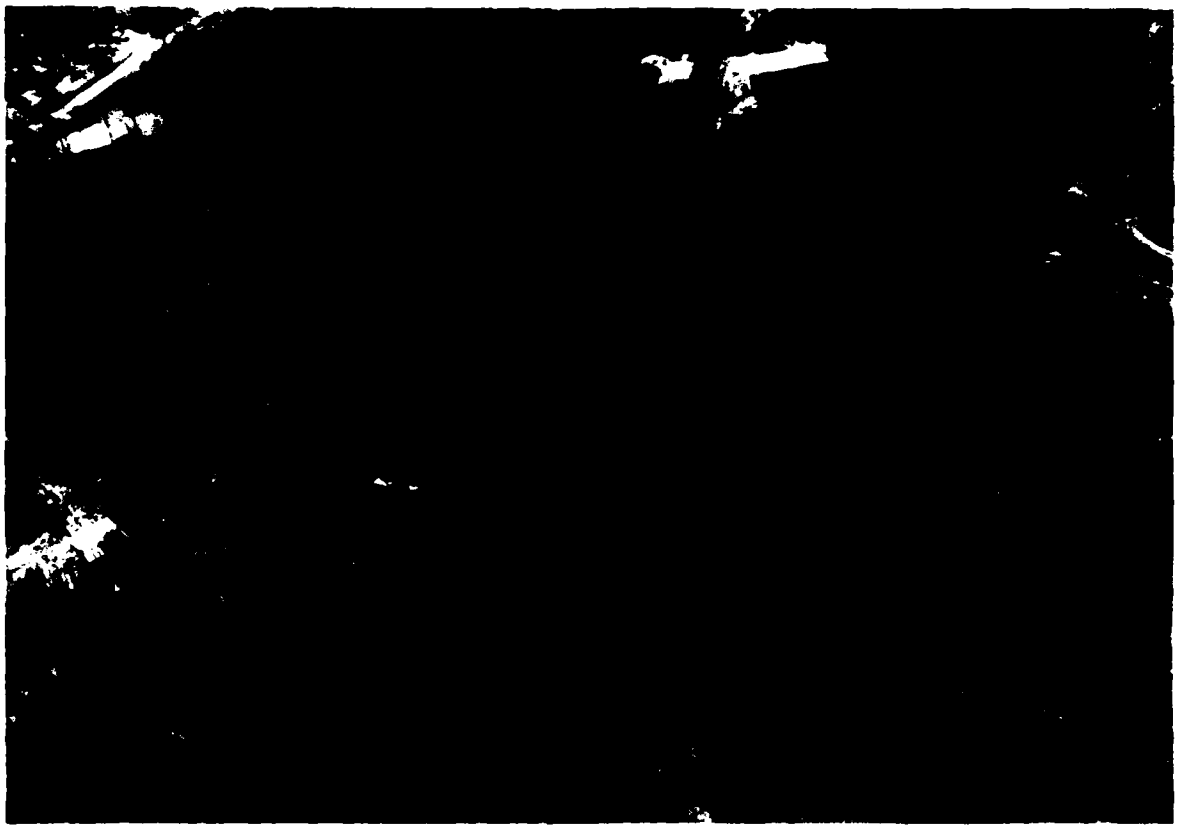
It is recommended that the owners take the necessary action immediately to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

Jack M. Healy, P.E.
Hanson Engineers, Inc.

Steven L. Brady, P.E.
Anderson Engineering, Inc.

Tom R. Beckley, P.E.
Anderson Engineering, Inc.

Nelson Morales, P.E.
Hanson Engineers, Inc.



AERIAL VIEW OF LAKE AND DAM

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
ROCKWOOD HILLS LAKE DAM
MISSOURI INVENTORY NO. 30372

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APPENDICES

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Rockwood Hills Lake Dam in Taney County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Rockwood Hills Lake Dam is an earth fill structure approximately 25 ft high and 260 ft long at the crest. The appurtenant work consists of a 9 ft wide concrete chute principal spillway at the west abutment and an 8 ft wide concrete emergency spillway at the east abutment.

Sheet 3 of Appendix A shows a plan, profile, and typical section of the embankments.

B. Location:

The dam is located along the western edge of Taney County, Missouri on a tributary of White River (Lake Taneycomo). The dam and lake are within the Branson, Missouri 7.5 minute quadrangle sheet (Section 30, T23N, R21W - latitude 36°40'06"; longitude 93°14'37"). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of approximately 25 ft and a maximum storage capacity of approximately 56 acre-ft, the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification. The estimated damage zone extends approximately three miles downstream of the dam. Located within this zone are one seasonal dwelling at 0.05 miles; one dwelling at 1.1 miles; U.S. Highway 65 at 1.35 miles; Highway F at 1.8 miles; and nine dwellings at 2.2 miles. The affected features located within the damage zone were field verified by the inspection team.

E. Ownership:

The dam is owned by Mr. Bob Patrick.
The owner's address is P. O. Box 44, Branson, MO 65616. The owner nor his representative was present during the inspection.

F. Purpose of Dam:

The dam was constructed primarily for use as a fishing pond.

G. Design and Construction History:

The following information was supplied by Mr. Ed Akers of Branson, Missouri, who was the owner of the dam when it was built.

No designs were prepared for the dam. The dam was constructed by the Waldo Nace Excavating Company of Branson, Missouri in August and September of 1972. Material for the embankment came from the lake area. No cut-off trench was used. However, the central part of the embankment was constructed with red clay. The outside portions of the embankment were finished with other soils found on the site. No spillways were built in this initial construction.

In November of 1972, heavy rains resulted in the central portion of the embankment being overtopped. The dam failed as a crevice 30 ft wide at the top and 10 ft wide at the bottom was eroded by the overflow.

The embankment was repaired by the same contractor in the Spring of 1973, and 2 concrete spillways were also added at that time.

Mr. Akers stated that the dam had not been overtopped since the concrete spillways had been installed.

H. Normal Operating Procedures:

Normal flows are passed by the uncontrolled principal spillway located at the west abutment and the uncontrolled emergency spillway located at the east abutment.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile, and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet, is approximately 190 acres.

B. Discharge at Dam Site:

(1) All discharge at the dam site is through uncontrolled spillways.

(2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 923.9): 264 cfs

(3) Estimated Capacity of Principal Spillway: 157 cfs

(4) Estimated Capacity of Emergency Spillway: 107 cfs

(5) Estimated Experienced Maximum Flood at Dam Site: Unknown

(6) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable

(7) Diversion Tunnel Outlet at Pool Elevation: Not Applicable

(8) Gated Spillway Capacity at Pool Elevation: Not Applicable

(9) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed mean sea level elevation of 924.0 for the top of the outside wall of the principal spillway (estimated from quadrangle map).

(1) Top of Dam: 923.9 ft, MSL (low point) 924.8 ft, MSL (high point)

(2) Principal Spillway Crest: 920.2 ft, MSL

(3) Emergency Spillway Crest: 920.8 ft, MSL

(4) Principal Spillway Invert at Outlet: 904.0 ft, MSL

(5) Streambed at Centerline of Dam: 900.0 ft, MSL

(6) Pool on Date of Inspection: 917.7 ft, MSL

(7) Apparent High Water Mark: 922.5 ft, MSL

(8) Maximum Tailwater: Not Applicable

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

(1) At Top of Dam: 950 ft

(2) At Emergency Spillway Crest: 825 ft

(3) At Principal Spillway Crest: 800 ft

E. Storage Capacities:

(1) At Top of Dam: 56 Acre-ft

(2) At Emergency Spillway Crest: 41 Acre-ft

(3) At Principal Spillway Crest: 40 Acre-ft

F. Reservoir Surface Areas:

(1) At Top of Dam: 5.5 Acres

(2) At Emergency Spillway Crest: 4.3 Acres

(3) At Principal Spillway Crest: 4.0 Acres

G. Dam:

(1) Type: Rolled Earth

(2) Length at Crest: 260 ft

(3) Height: 25 ft

(4) Top Width: 12 ft

(5) Side Slopes: Upstream 1.7:1; Downstream 2.0:1

(6) Zoning: Some zoning with red clay in center of dam and other soils on outside according to Mr. Akers

(7) Impervious Core: None

(8) Cutoff: None

(9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

(1) Type: Not Applicable

(2) Length: Not Applicable

(3) Closure: Not Applicable

(4) Access: Not Applicable

(5) Regulating Facilities: Not Applicable

I. Spillway:

I.1 Principal Spillway:

(1) Location: West abutment

(2) Type: 9 ft wide concrete chute with 4 ft high side walls

I.2 Emergency Spillway:

(1) Location: East abutment

(2) Type: 8 ft wide concrete chute with 4 ft high side walls

(3) Upstream Channel: Earth cut channel, grass and weed lined

(4) Downstream Channel: Grass and brush to wooded, earth channel with moderate to steep side slopes

J. Regulating Outlets:

No regulating outlets were found to be associated with this dam.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No engineering data exist for this dam. No construction inspection records or documented maintenance and operation data exist to our knowledge.

A. Surveys:

No detailed surveys have been made of the dam to our knowledge. The bench mark used in the inspection survey was the top of the outside wall of the principal spillway. An elevation of 924.0 mean sea level was estimated for this point using U.S.G.S. quad sheets.

B. Geology and Subsurface Materials:

The site is located at the western edge of the Ozarks geologic region of Missouri. This region is characterized topographically by hills, plateaus and deep valleys. The bedrock underlying the site is a cherty dolomite and limestones. The Geologic Map of Missouri shows a fault running in a northwest-southeast direction approximately 5 miles southwest of the dam site. The Department of Natural Resources has said that the faults in this area are generally considered to be inactive.

Information from the Missouri Department of Natural Resources indicates that the bedrock in the area is the Jefferson City Dolomite, which is predominately a light brown, medium to finely crystalline dolomite. The publication "Caves of Missouri" lists three named caves in Taney County, and notes that they are several miles from the dam site.

Information from the United States Department of Agriculture Soil Conservation Service indicates that the soils in the immediate area of the dam and lake consist primarily of Clarksville Stony Silt Loam. The Clarksville series subsoil is a reddish-brown to red silty clay to heavy, stiff, tenacious, compact clay. These residual soils are derived from cherty and dolomitic limestones. Chert fragments are very common in the Clarksville soils. The loessial thickness map indicates that upland areas may have about 2.5 ft of loess cover.

C. Foundation and Embankment Design:

No design computations are available. Seepage and stability analyses apparently were not performed as required in the

guidelines. There is apparently some zoning of the embankment. However, no internal drainage features are known to exist.

D. Hydrology and Hydraulics:

No hydrologic or hydraulic design calculations for this dam were available. Based on a field check of spillway dimensions and embankment elevations, and a check of the drainage area on U.S.G.S. quad sheets, hydrologic analyses using U. S. Army Corps of Engineers guidelines were performed and appear in Appendix C, Sheets 1 through 10.

E. Structure:

The details of the principal and emergency spillway structures are included as Sheets 4 and 5 of Appendix A.

2.2 CONSTRUCTION:

No construction inspection data have been obtained.

2.3 OPERATION:

Normal flows are passed by the uncontrolled principal spillway and the uncontrolled emergency spillway.

2.4 EVALUATION:

A. Availability:

No engineering data, seepage or stability analyses, or construction test data was available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on November 20, 1980. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steven L. Brady - Anderson Engineering, Inc. - Civil Engineer
Tom R. Beckley - Anderson Engineering, Inc. - Civil Engineer
Jack M. Healy - Hanson Engineers, Inc. - Geotechnical Engineer
Nelson Morales - Hanson Engineers, Inc. - Hydrologic Engineer

Photographs of the dam, appurtenant structures, reservoir, and downstream features are presented in Appendix D.

B. Dam:

The dam appears to be in poor condition. Sloughing was noted along the crest of the dam. A large slough exists along the downstream face near the discharge of the east (emergency) spillway. There was also erosion on the front face of the dam. There was no rip-rap protection.

The downstream face had areas of steep slopes. Heavy wood and brush growth existed on both embankment faces. One large animal burrow was noted just below water level on the upstream face. The horizontal alignment of the dam appeared good.

The concrete spillways have no wingwalls, and there is some erosion between the walls and the dam and abutments. The concrete is in fairly good condition. However, some areas of honeycombing and cracking were noted. Some undermining has occurred at the discharge ends of both spillways.

The discharge of the east (emergency) spillway has eroded into the toe of the embankment immediately below the large slough area. One small discolored seepage spot was observed in the embankment below the large slough area. No flow was detected (See Photograph No. 14).

Sheet 6 of Appendix A presents a plan sketch of the dam showing observed features.

Auger probes in the crest of the dam indicated a yellowish-brown silty clay (ML-CL).

C. Appurtenant Structures:

C.1 Principal Spillway:

The principal spillway is a 9 ft wide concrete chute with 4 ft high walls located at the west abutment. The chute has no wingwalls and some erosion has occurred between the walls and the dam and abutment. The approach area is clear. The discharge area is fairly clear. Some trees exist below the discharge point. The discharge end of the concrete chute has been undermined. Discharges are away from the embankment (See Photograph No. 9).

C.2 Emergency Spillway:

The emergency spillway is an 8 ft wide concrete chute with 4 ft high walls located at the east abutment. The chute has no wingwalls and some erosion has occurred between the walls and the dam and abutment. The approach area is clear. The discharge end of the chute has been undermined and discharges are eroding into the embankment which is right below a large slough area.

D. Reservoir:

The watershed is partially wooded with a part occupied by a developed subdivision. The slopes are moderate to steep. No evidence of significant sedimentation was observed.

E. Downstream Channel:

The downstream channel is a narrow valley with steep wooded side slopes. The channel is also lined with trees and brush. A subdivision is being developed in the property below the dam.

3.2 EVALUATION:

The slough areas on the dam constitute a major hazard. The large slough near the east spillway will be aggravated by future emergency spillway releases and could possibly cause a failure of the dam.

The lack of wingwalls on the spillway entrances will result in further erosion around the concrete chute and the dam. Trees and brush on the dam constitute a potential seepage hazard and encourage animal burrowing. There is no wave protection provided on the upstream face of the embankment. Undermining of the ends of the spillways could worsen and affect the stability of the embankment.

The areas of sloughing should be immediately investigated by an engineer experienced in the design and construction of dams.

Photographs of the dam, appurtenant structures, and the reservoir are presented in Appendix D.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no operating facilities associated with this dam. The pool is normally controlled by rainfall, runoff, evaporation, the capacity of the uncontrolled spillway, and apparent leakage from the reservoir.

4.2 MAINTENANCE OF DAM:

The presence of tree and brush growth on the embankment indicates that little maintenance is done.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The sloughing areas are serious. Also the erosion at the toe of the embankment caused by the discharges from the emergency spillway is serious. Both of those conditions should be immediately investigated by an engineer experienced in the design and construction of dams.

The vegetation on the dam, animal holes, and lack of riprap and erosion around the spillway sections are additional deficiencies which could become serious if the lake were to hold water for a sustained period.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

No hydrologic or hydraulic design computations for this dam were available.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this lake and watershed.

C. Visual Observations:

The approaches to the principal and emergency spillways are clear. Considerable erosion has occurred at the outlet of both spillways. Both concrete chutes have been undermined at the end. Discharges from the emergency (east) spillway have eroded into the embankment because flows are not diverted away from the embankment. Erosion has also occurred along the sides of the concrete spillway sections because no wingwalls are present at the entrance to the spillways.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U. S. Army Corps of Engineers guidelines and the HEC-1 computer program) were based on: (1) a field survey of spillway dimensions and embankment elevations, and (2) an estimate of the reservoir storage and the pool and drainage areas from the Branson, and Garber, Missouri 7.5 Minute U.S.G.S. quad sheets.

Based on the hydrologic and hydraulic analysis presented in Appendix C, the combined spillways will pass 13 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the height of the dam (25 ft), and the maximum storage capacity (56 Acre-ft), 50 percent of the PMF has been determined to be the appropriate spillway design flood. The spillways will not pass a 1 percent probability flood without overtopping the dam.

Application of the probable maximum precipitation (PMP), minus losses, resulted in a flood hydrograph peak inflow of 4,090 cfs. For 50 percent of the PMF, the peak inflow was 2,045 cfs.

The routing of 50 percent of the PMF through the spillways and dam indicates that the dam will be overtopped by 1.8 ft at elevation 925.7. The duration of the overtopping will be 4.8 hours, and the maximum outflow will be 1,945 cfs. The maximum discharge capacity of the spillways is 264 cfs. The routing of the PMF indicates that the dam will be overtopped by 2.8 ft at elevation 926.7. The maximum outflow will be 3,965 cfs, and the duration of overtopping will be 6.6 hours. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

As a result of overtopping of the central portion of the dam and the related erosion, repair work was performed in the spring of 1973. Additionally, 2 concrete spillways were constructed at that time.

E. Seismic Stability:

The structure is located in seismic zone 1. Due to the poor condition of the embankment, it is recommended that the prescribed seismic loading for this zone be applied in stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is in poor condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) Sloughing along crest of dam; (2) Large slough along toe near end of emergency spillway; (3) Erosion on upstream face, i.e., no wave protection; (4) Steep downstream side slopes; (5) Erosion of embankment by emergency spillway discharges; (6) Heavy brush and weed growth on embankment faces; (7) Animal burrows on front face; (8) Erosion between spillways and embankment, and (9) Undermining of ends of both spillway chutes.

Another deficiency was the lack of seepage and stability analyses records.

The dam will be overtopped by flows in excess of 13 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on review of the information listed in Section 2.1, the performance history as related by others, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed

in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will continue to deteriorate and possibly could become serious in the future. The items recommended in paragraph 7.2A should be pursued immediately.

D. Necessity for Additional Inspection:

Based on the result of the Phase I inspection, no Phase II inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Alternatives:

(1) Spillway size and/or height of dam should be increased to pass 50 percent of the PMF. In either case, the spillway should be protected to prevent erosion.

B. O & M Procedures:

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.

(2) The sloughing areas at the crest and the downstream face near the end of the emergency spillway should be investigated by an engineer experienced in the design and construction of dams. Remedial measures will very likely be required.

(3) Protection should be provided for the embankment from emergency spillway releases. Further erosion below the large slough area could result in failure of the dam.

(4) Erosional areas should be repaired and seeded.

(5) Wave protection should be provided for the upstream face of the dam.

(6) Tree and brush growth should be removed from the faces of the embankment. Removal of trees should be under the supervision of an engineer experienced in the design and construction of dams. Indiscriminate clearing methods could jeopardize the safety of the dam.

(7) The vegetative growth on the dam should be cut periodically.

(8) Wingwalls should be constructed at the entrance to both spillways.

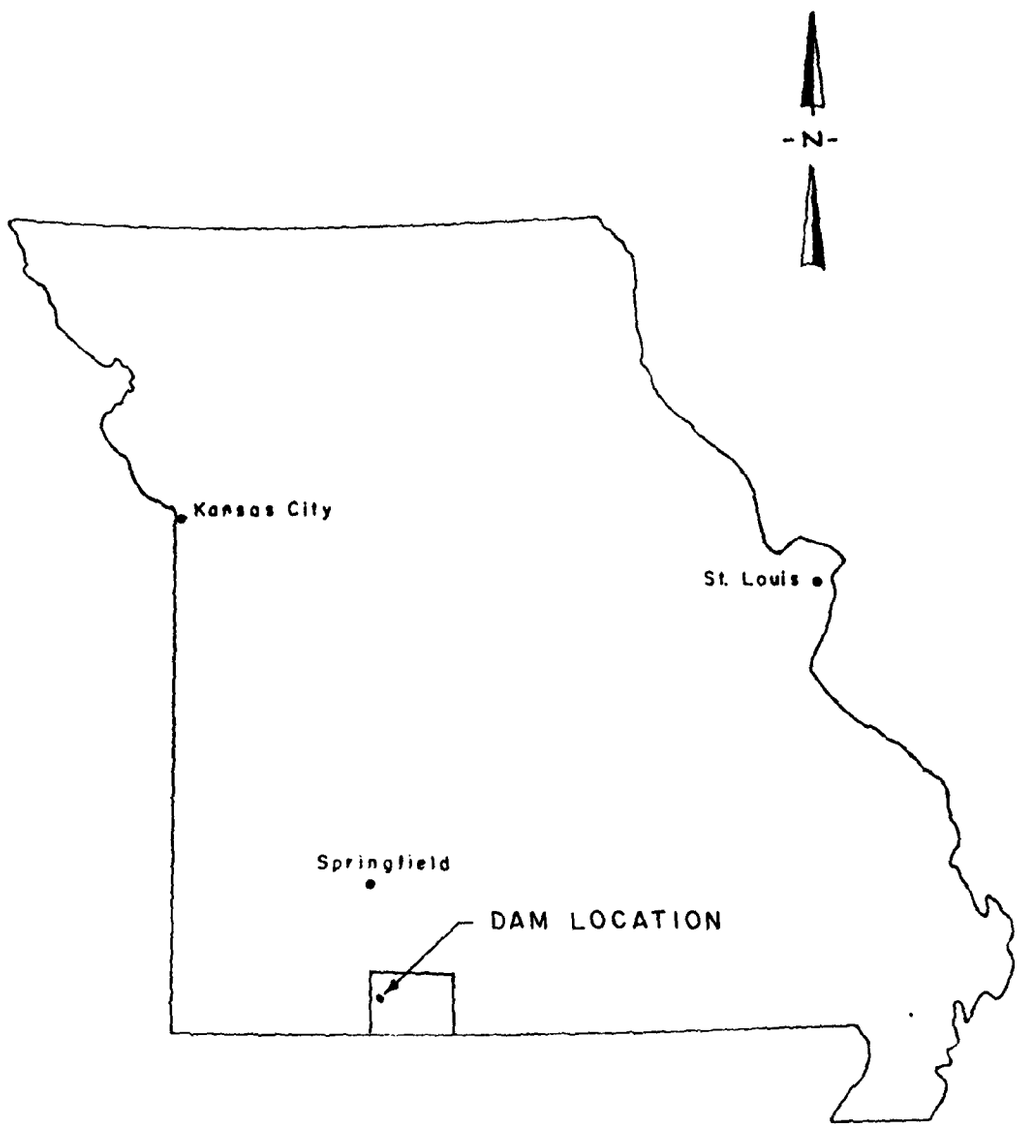
(9) Undermining of both spillway discharge ends should be corrected to prevent further deterioration of the concrete chutes.

(10) The animal burrows should be repaired and maintained.

(11) A detailed inspection of the dam should be made periodically by an engineer experienced in the construction of dams.

APPENDIX A

Dam Location and Plans



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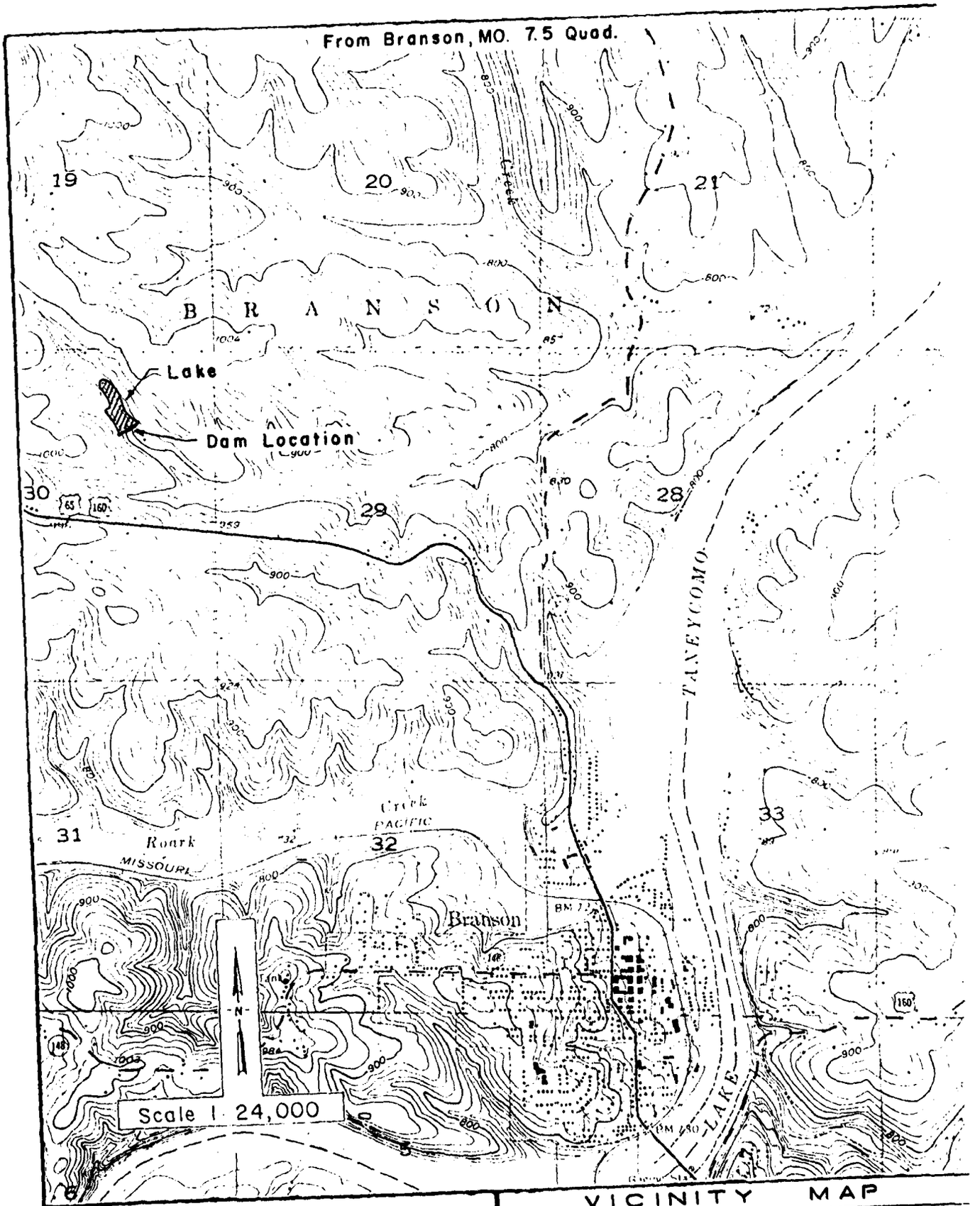
LOCATION MAP

ROCKWOOD HILLS LAKE DAM
TANEY COUNTY, MISSOURI
MO. I. D. No. 30372

SHEET 1, APPENDIX A



VICINITY MAP

ROCKWOOD HILLS LAKE DAM
TANEY COUNTY, MISSOURI
MO. I.D. No. 30372

SHEET 2, APPENDIX A

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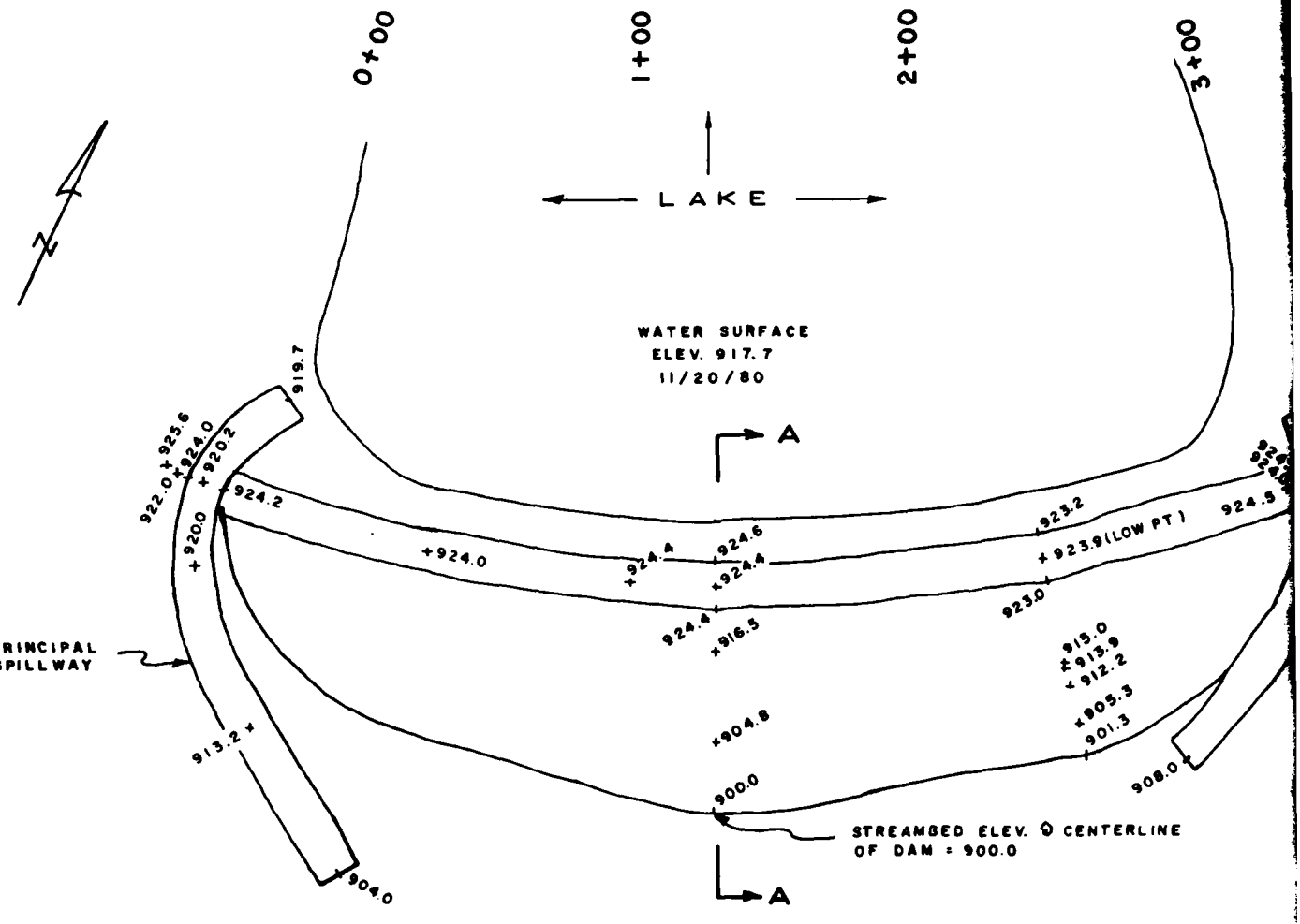
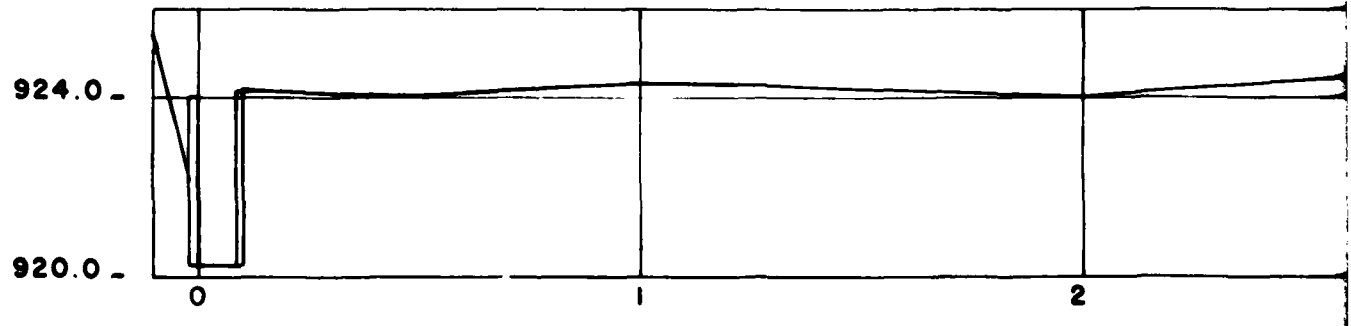


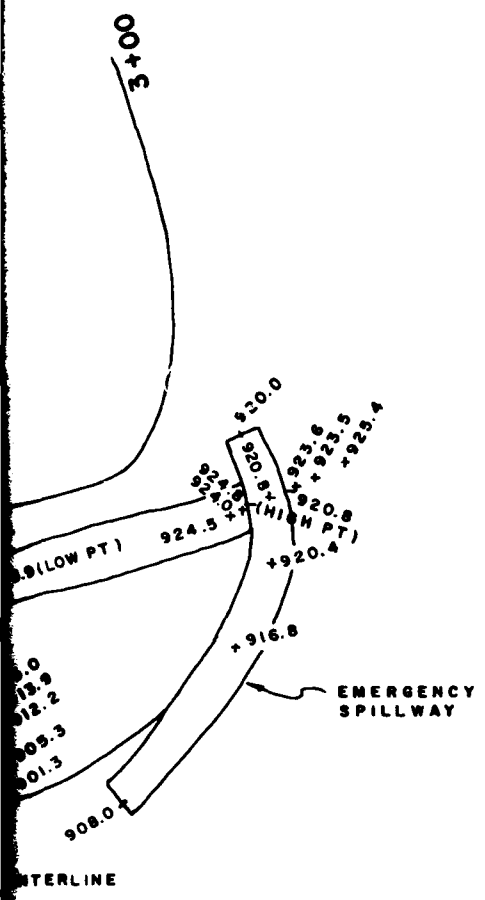
PLAN VIEW

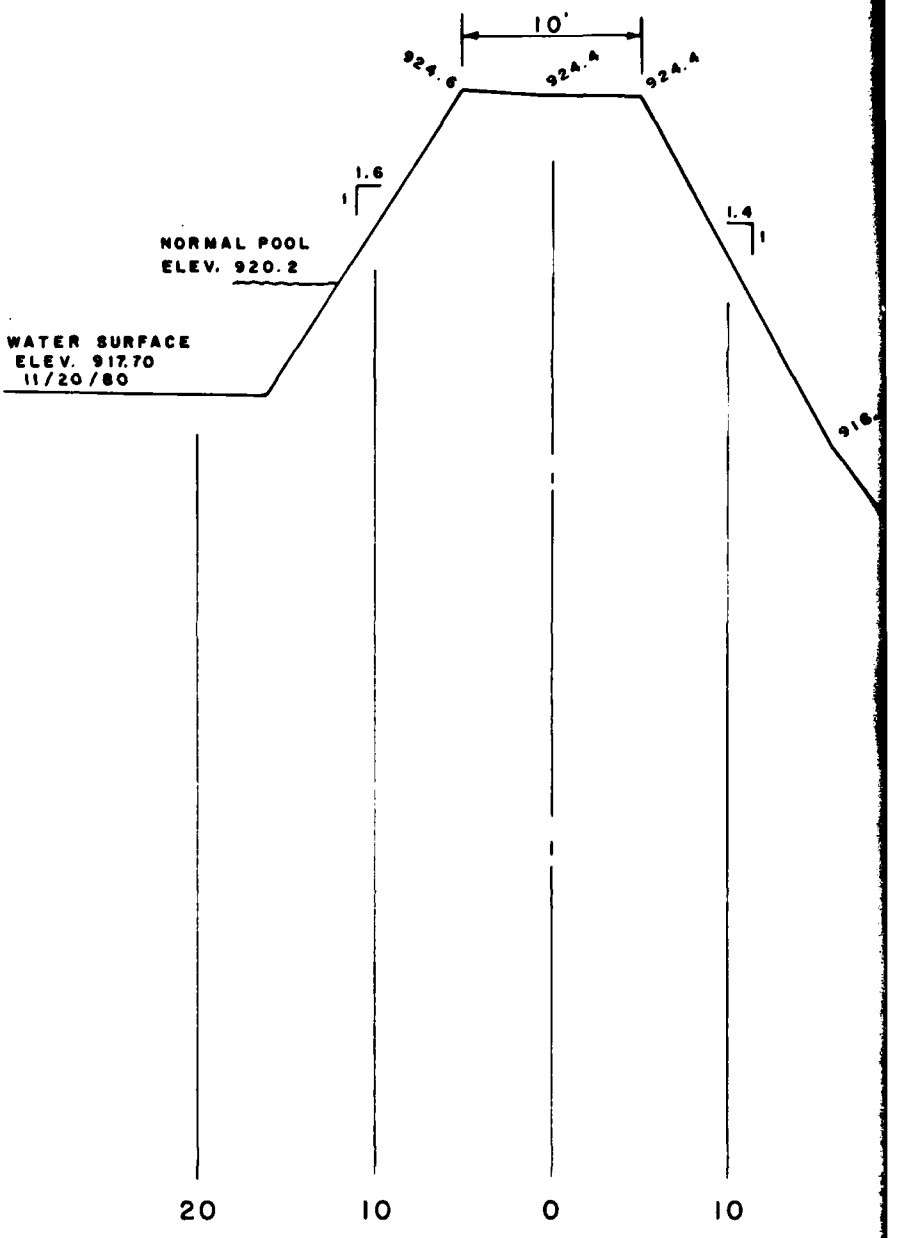
SCALE 1" = 50'

BENCHMARK:
TOP OF SOUTH WALL OF
SOUTH SPILLWAY WALL
STA. 0+00 ℄ DAM
ELEV. = 924.0

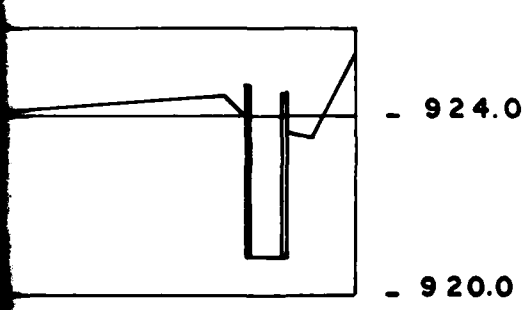


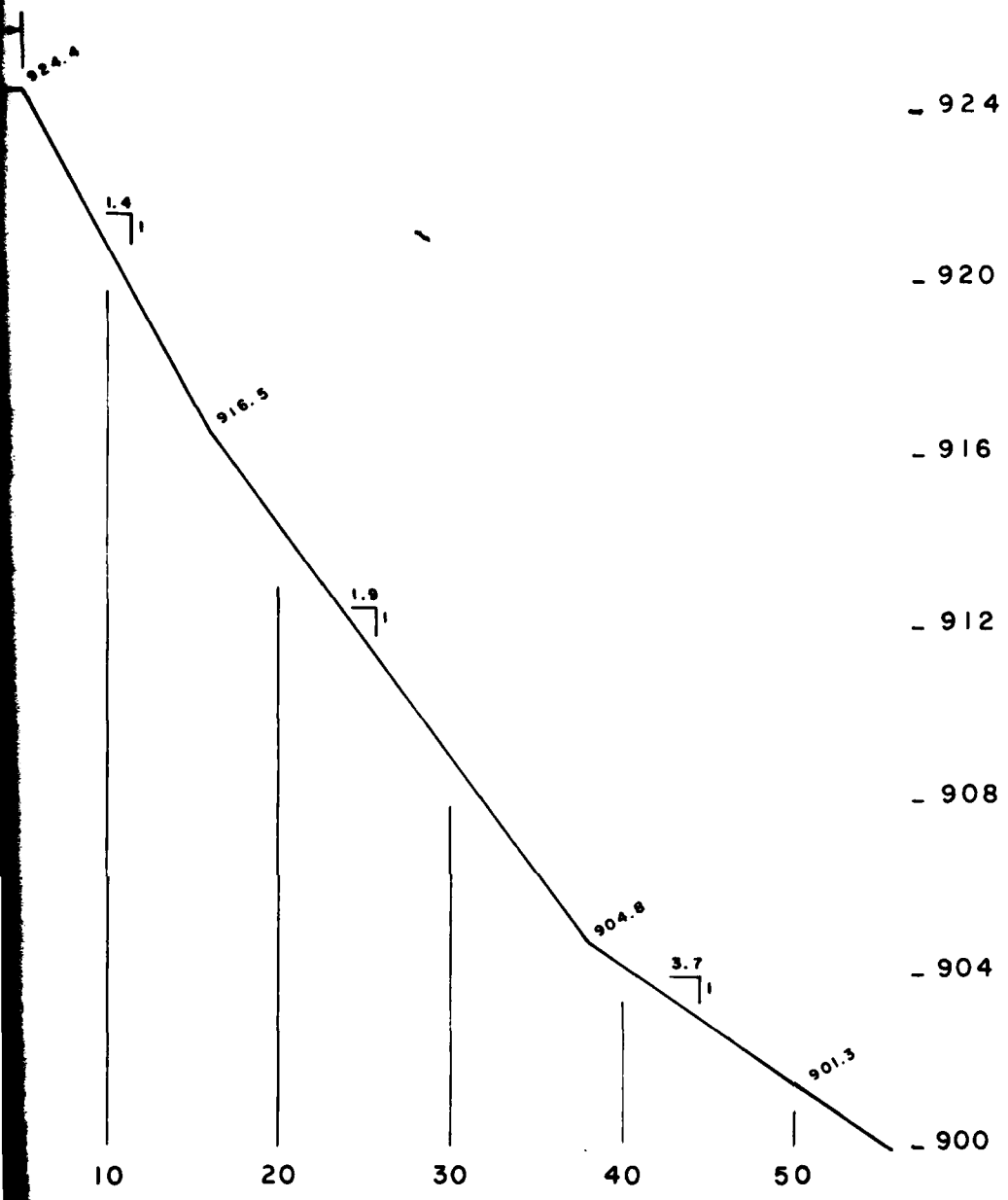
PROFILE





SECTION A-A STA 1





A STA 1+20

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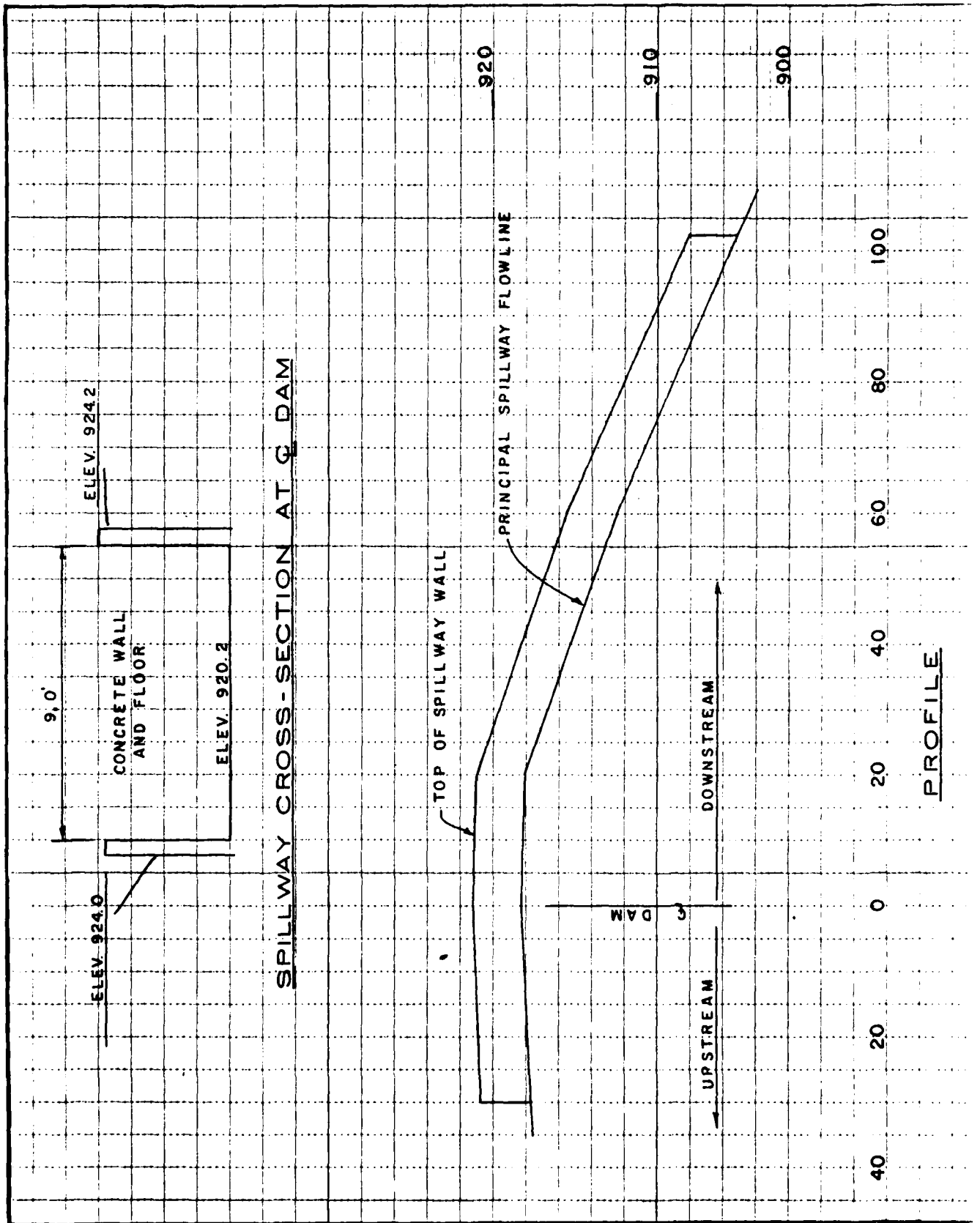
ROCKWOOD HILLS LAKE DAM

MO. No. 30372

PLAN & PROFILE

TANEY COUNTY, MO.

SHEET 3, APPENDIX A



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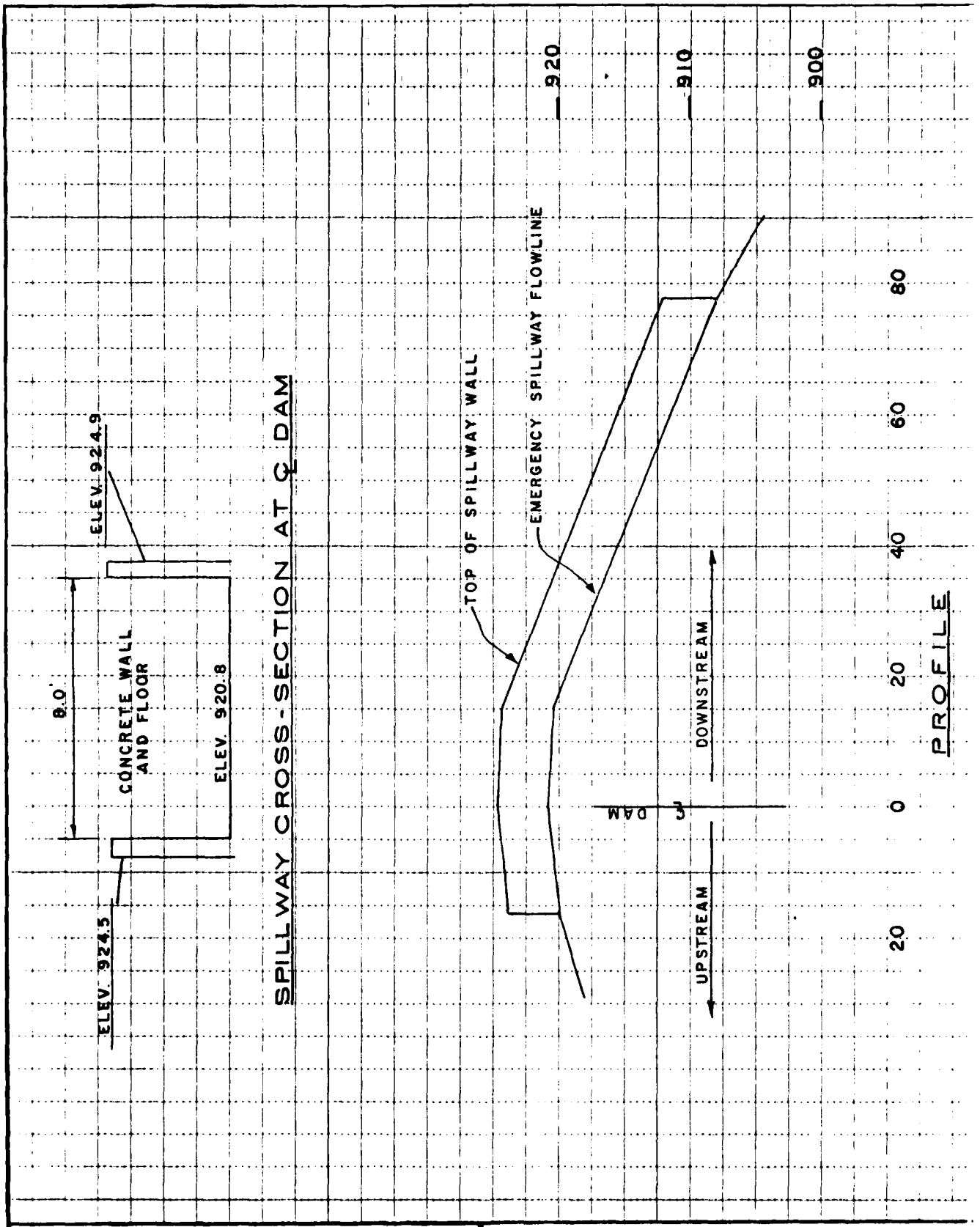
ROCKWOOD HILLS LAKE DAM
TANEY COUNTY, MISSOURI
MO. I. D. No. 30372
PRINCIPAL SPILLWAY

SHEET 4 , APPENDIX A



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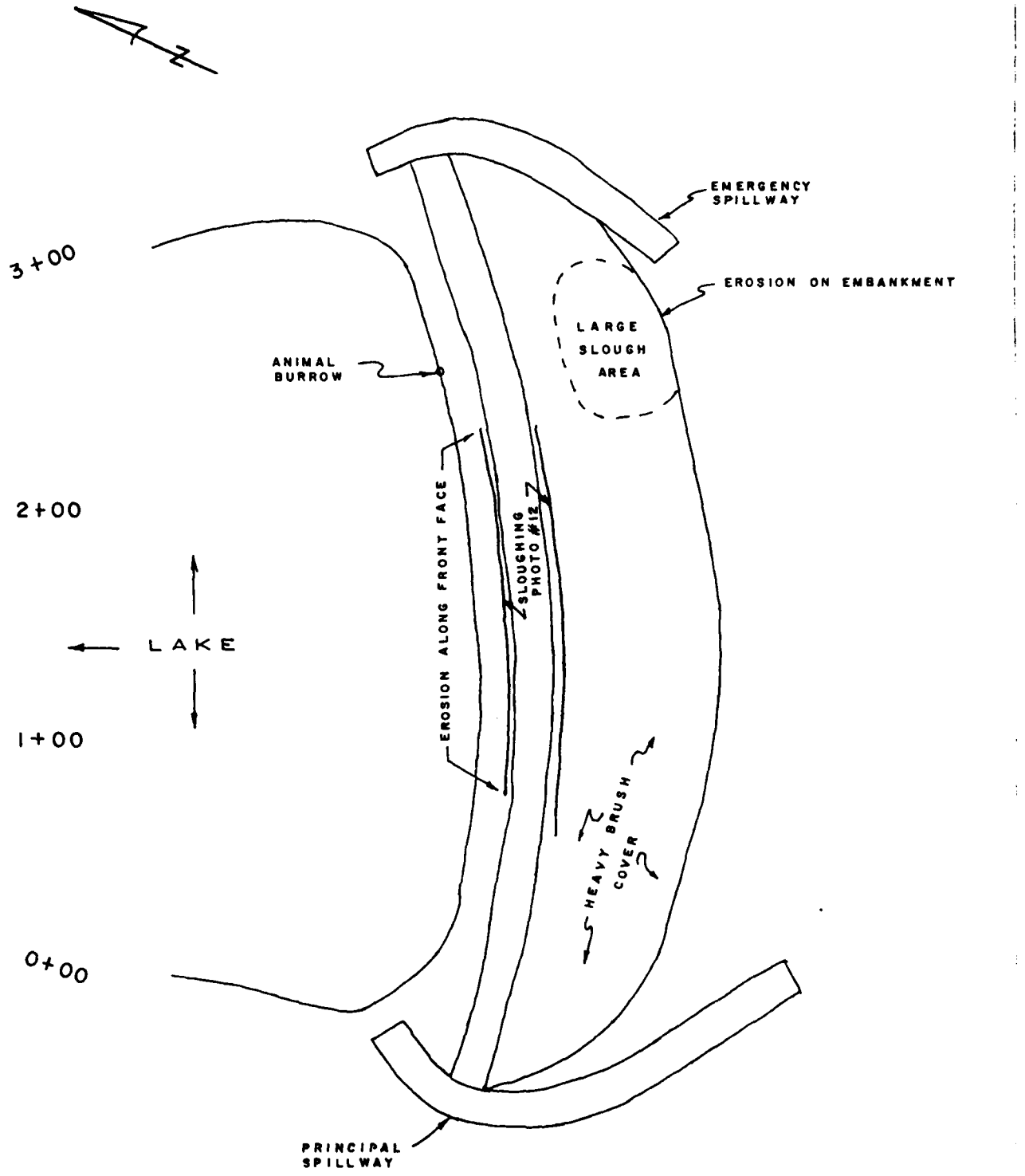
ROCKWOOD HILLS LAKE DAM
TANEY COUNTY, MISSOURI
MO. I. D. No. 30372
EMERGENCY SPILLWAY

SHEET 5, APPENDIX A



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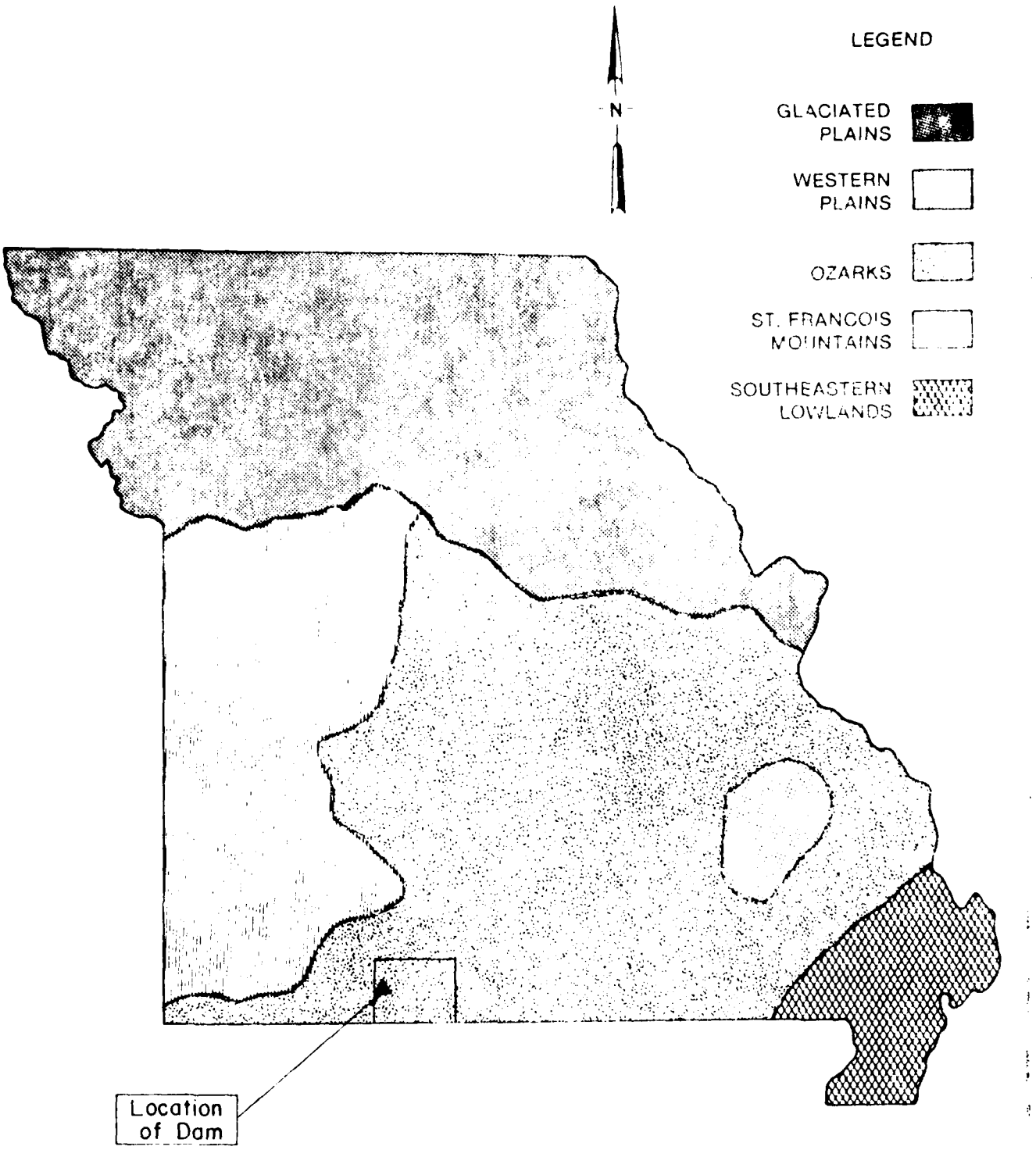
PLAN SKETCH OF DAM

ROCKWOOD HILLS LAKE DAM
TANEY COUNTY, MISSOURI
MO. I.D. No. 30372

SHEET 6 , APPENDIX A

APPENDIX B

Geology and Soils



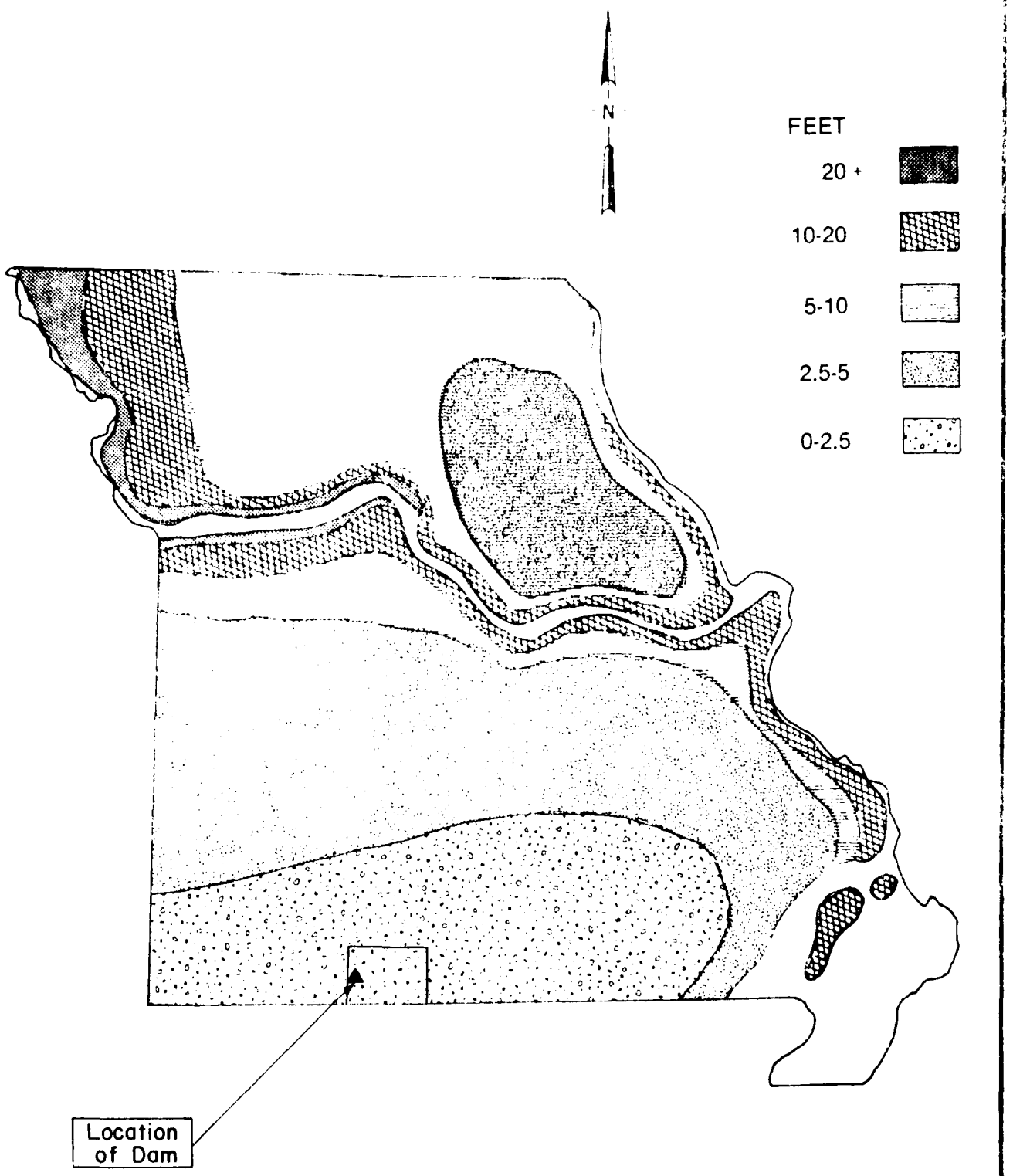
MAJOR GEOLOGIC REGIONS OF MISSOURI

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Rockwood Hills Lake Dam
Taney County, Missouri
Mo. I.D. No. 30372

SHEET 1, APPENDIX B



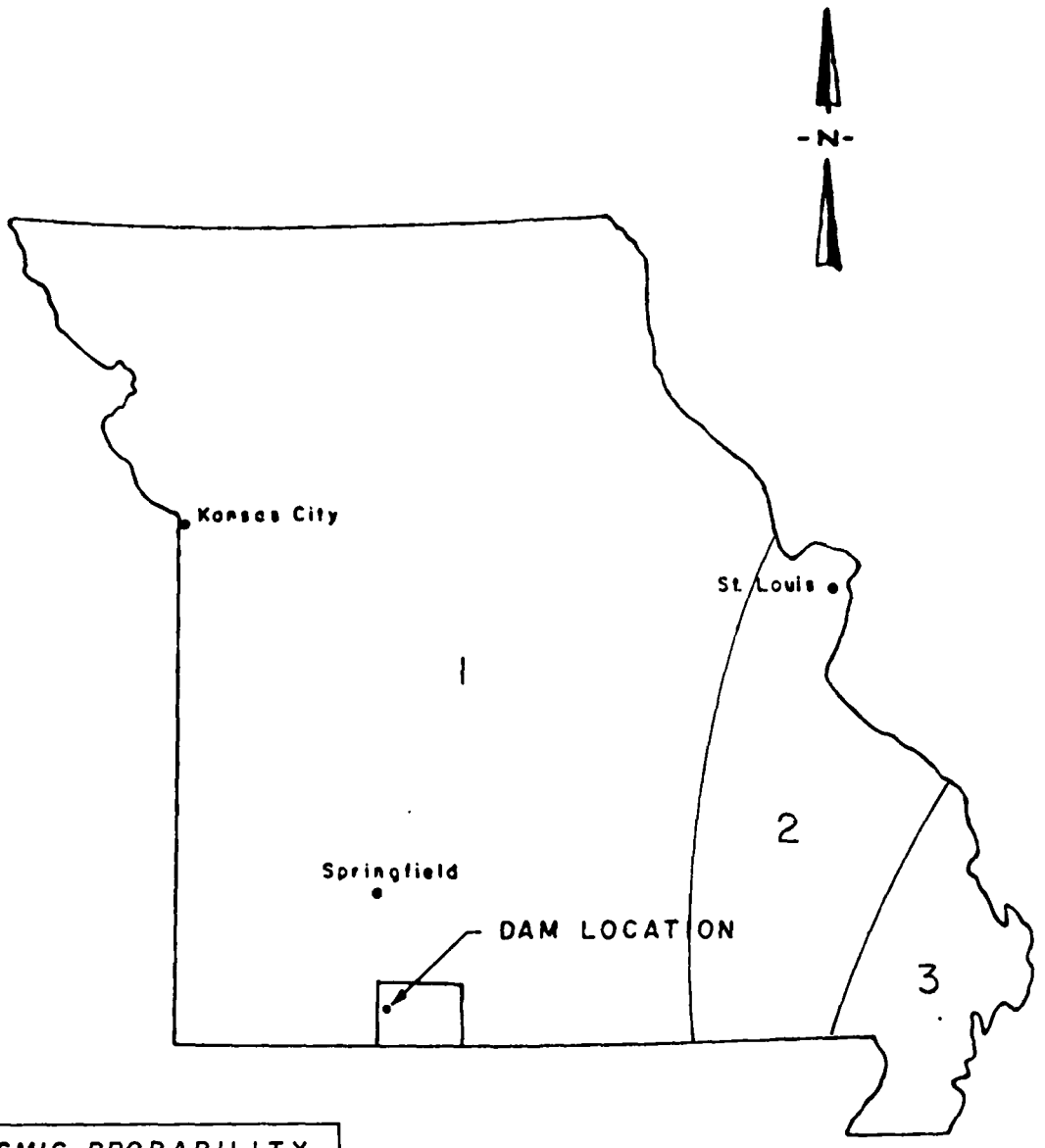
THICKNESS OF LOESSIAL DEPOSITS

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Rockwood Hills Lake Dam
Taney County, Missouri
Mo. I.D. No. 30372

SHEET 2, APPENDIX B



SEISMIC PROBABILITY	
ZONE	DAMAGE
1	MINOR
2	MODERATE
3	MAJOR

A/E ANDERSON ENGINEERING, INC.
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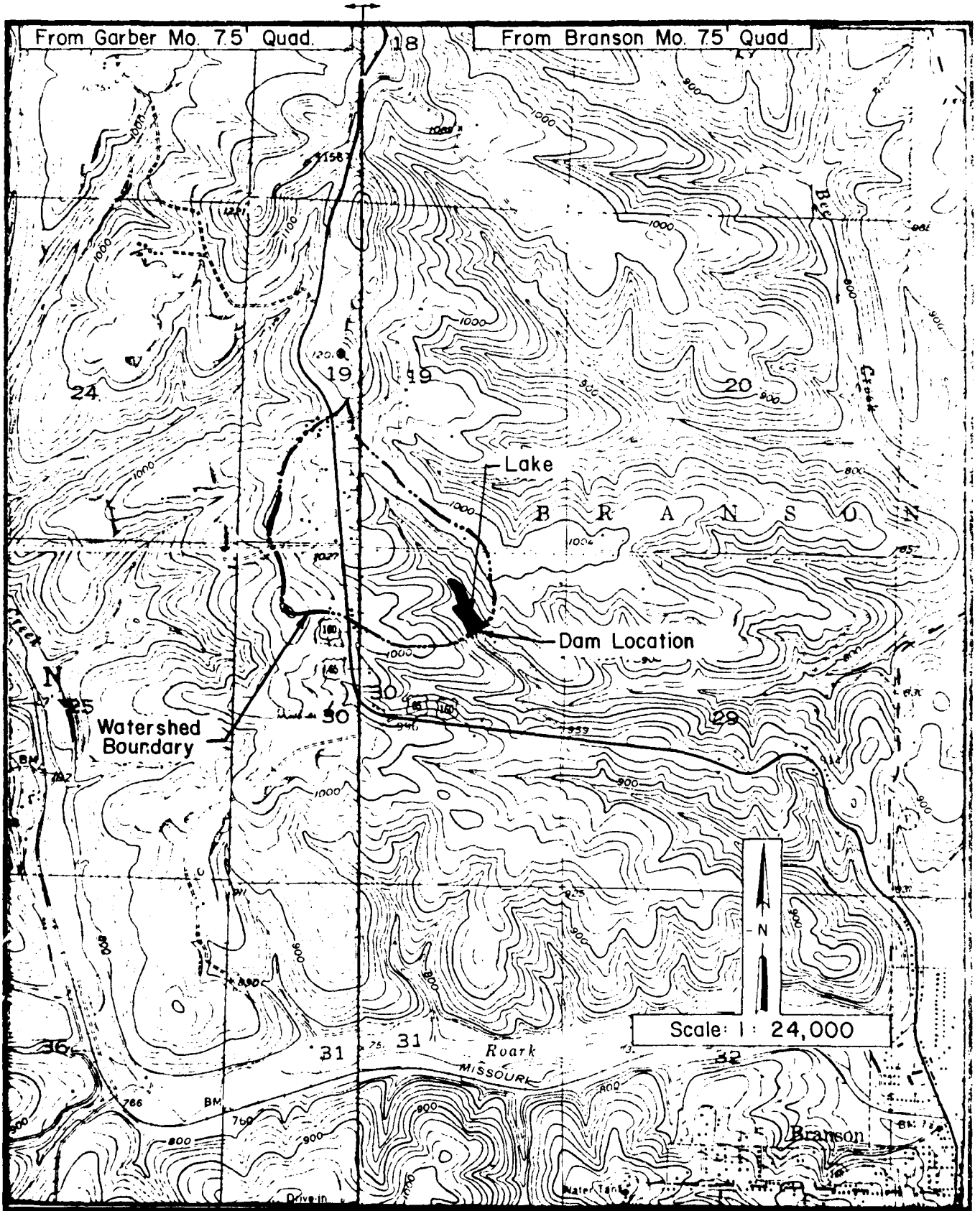
SEISMIC ZONE MAP

ROCKWOOD HILLS LAKE DAM
TANEY COUNTY, MISSOURI
MO. I.D. No. 30372

APPENDIX C

Overtopping Analysis



LAKE AND WATERSHED MAP

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Rockwood Hills Lake Dam
Taney County, Missouri
Mo. I.D. No. 30372

Sheet 1, Appendix C

APPENDIX C

HYDROLOGIC AND HYDRAULIC ANALYSIS

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was accomplished using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination). Also, the 1 percent chance and the 10 percent chance probability floods were routed through the reservoir and spillways. Springfield, Missouri rainfall distributions (5 min. interval - 24 hours duration), as provided by the St. Louis District, Corps of Engineers, were used in these cases.

The synthetic unit hydrograph for the watershed was developed by the computer program using the SCS method. The time of concentration was estimated using the Kirpich formula. This formula and the parameters for the unit hydrograph are shown in Table 1 (Sheet 4, Appendix C). The time of concentration was also verified from velocity estimates for the average slopes of the watershed and the main channel (Design of Small Dams, page 70, 1974 Edition).

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2 (Sheet 5, Appendix C).

The reservoir routing was accomplished by using the Modified Puls Method assuming the starting lake elevation at normal pool. No antecedent storm was routed in order to determine the starting elevation. The hydraulic capacity of the spillways was used as an outlet control in the routing. The hydraulic capacity of the spillways and the storage capacity of the reservoir were defined by the elevation-surface area--storage-discharge relationships shown in Table 3 (Sheet 5, Appendix C).

The rating curve for the spillways (see Table 4 Sheet 6, Appendix C) was determined assuming critical flow conditions on a rectangular broad-crested weir, and approach and friction losses equal to 50 percent of the critical velocity head.

The flow over the crest of the dam during overtopping was determined using the non-level dam option ($L and $V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir. The lowest elevation of the crest of the dam, obtained from survey measurements, was assumed as top of dam elevation.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5 (Sheet 7, Appendix C). The result of the routings indicates that the spillways will pass the 10 percent probability flood without overtopping the dam. The 1 percent probability flood will cause overtopping of the dam.

The computer input data, a summary of the output data, and a plot of the inflow-outflow hydrograph for the PMF are presented on Sheets 8, 9, and 10 of Appendix C.

TABLE 1

SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	0.297	sq miles
Length of Watercourse (L)	0.75	miles
Difference in elevation (H)	180	ft
Time of concentration (Tc)	0.25	hrs
Lag Time (Lg)	0.15	hrs
Time to peak (Tp)	0.19	hrs
Peak Discharge (Qp)	750	cfs
Duration (D)	5	min.

Time (Min.)(*)	Discharge (cfs)(*)
0	0
5	276
10	733
15	646
20	326
25	163
30	80
35	39
40	20
45	10
50	5

(*) From the computer output

FORMULA USED:

$$Tc = \left(\frac{11.9\ L^3}{H}\right)^{0.385}$$

Kirpich Formula.
From California Culverts Practice, California Highways and Public Works, September, 1942.

$$Lg = 0.6\ Tc$$

$$Tp = \frac{D}{2} + Lg$$

$$Qp = \frac{484\ A.Q}{Tp}$$

Q = Excess Runoff = 1 inch

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	24	35.9	34.5	1.4
1% Prob. Flood	24	8.0	5.3	2.7
10% Prob. Flood	24	5.6	3.2	2.4

Additional Data:

1) Soil Conservation Service Soil Group C
2) Soil Conservation Service Runoff Curve CN = 88 (AMC III) for the PMF
3) Soil Conservation Service Runoff Curve CN = 75 (AMC II) for the 1 percent probability flood
4) Percentage of Drainage Basin Impervious 10 percent

TABLE 3

ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillways Discharge (cfs)
900.0	0	0	-
920.0	3.9	39	-
*920.2	4.0	40	0
**920.8	4.3	41	10
***923.9	5.5	56	264
925.0	6.0	62	401
927.0	6.8	75	694
940.0	12.0	-	-

*Principal spillway crest elevation
**Emergency spillway crest elevation
***Top of dam elevation

The above relationships were developed using data from the USGS Branson, Missouri 7.5 minute quadrangle map and the field measurements.

TABLE 4

SPILLWAYS RATING CURVE

Reservoir Elevation (MSL)	Principal Spillway (cfs)	Emergency Spillway (cfs)	Total Discharge (cfs)
*920.2	0	-	0
**920.8	10	0	10
921.5	33	15	48
922.2	62	32	94
923.0	103	64	167
***923.9	157	107	264
924.5	197	139	336
925.0	232	169	401
926.0	308	232	540
927.0	391	303	694

*Principal spillway crest elevation
**Emergency spillway crest elevation
***Top of dam elevation

Method Used: Assuming critical flow conditions on a rectangular broad-crested weir, and approach and friction losses equal to 50 percent of the critical velocity head.

Formula: $Q = 3.087\ L\ (H)^{1.5}$ Handbook of Hydraulics, King and Brater, page 5-53, Fifth Edition.

Q = Discharge in cubic feet per second.
L = Weir length in feet
H = Energy head in feet

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (cfs)	Peak Lake Elevation (ft, MSL)	Total Storage (acre-ft)	Peak Outflow (cfs)	Depth (ft) Over Top of Dam
-	0	*920.2	40	-	-
0.10	409	923.2	53	192	-
0.13	532	**923.9	56	264	0
0.15	614	924.2	58	331	0.3
0.20	818	924.7	60	626	0.8
0.25	1,023	924.9	62	888	1.0
0.30	1,227	925.1	63	1,128	1.2
0.40	1,636	925.4	65	1,540	1.5
0.50	2,045	925.7	66	1,945	1.8
0.75	3,068	926.2	70	2,958	2.3
1.00	4,090	926.7	73	3,965	2.8

The percentage of the PMF that will reach the top of the dam is 13 percent.

*Principal spillway crest elevation
**Top of dam elevation

```
A       OVERTOPPING ANALYSIS FOR ROCKWOOD HILLS DAM ( # 11 )
A       STATE ID NO. 30372  COUNTY NAME : TANEY
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 80S3001
B    300                5
B1     5
J      1        9        1
J1   .10      .15      .20      .25      .30      .40      .50      .75      1.0
K      0        1                                  3        1
K1      INFLOW HYDROGRAPH COMPUTATION **
M      1        2    0.297             0.297        1                          1
P      0     27.6      102      120      130
T                                                              -1      -88              0.10
W2  0.25     0.15
X      0     -.1        2
K      1        2                             0        4        1
K1      RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                     1        1
Y1     1                                                      40       -1
Y4 920.2    920.8    921.5    922.2    923.0    923.9    924.5    925.0    926.0    927.0
Y5     0       10       48       94      167      264      336      401      540      694
$S     0       39       40       41       56       62       75
$E 900.0    920.0    920.2    920.8    923.9    925.0    927.0
$$ 920.2
$D 923.9
$L     0       30      130      220      240      250      255      280      290
$V 923.9    924.0    924.2    924.4    924.4    924.5    924.6    925.5    927.0
K     99
```

PMF RATIOS
INPUT DATA

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
				0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.75	1.00
HYDROGRAPH AT	1	0.30	1	409.	614.	818.	1023.	1227.	1636.	2045.	3068.	4090.
	(	0.77)	(	11.58)(	17.37)(	23.17)(	28.96)(	34.75)(	46.33)(	57.91)(	86.87)(	115.83)
ROUTED TO	2	0.30	1	192.	331.	626.	888.	1128.	1540.	1945.	2958.	3965.
	(	0.77)	(	5.45)(	9.36)(	17.71)(	25.16)(	31.93)(	43.60)(	55.07)(	83.76)(	112.28)

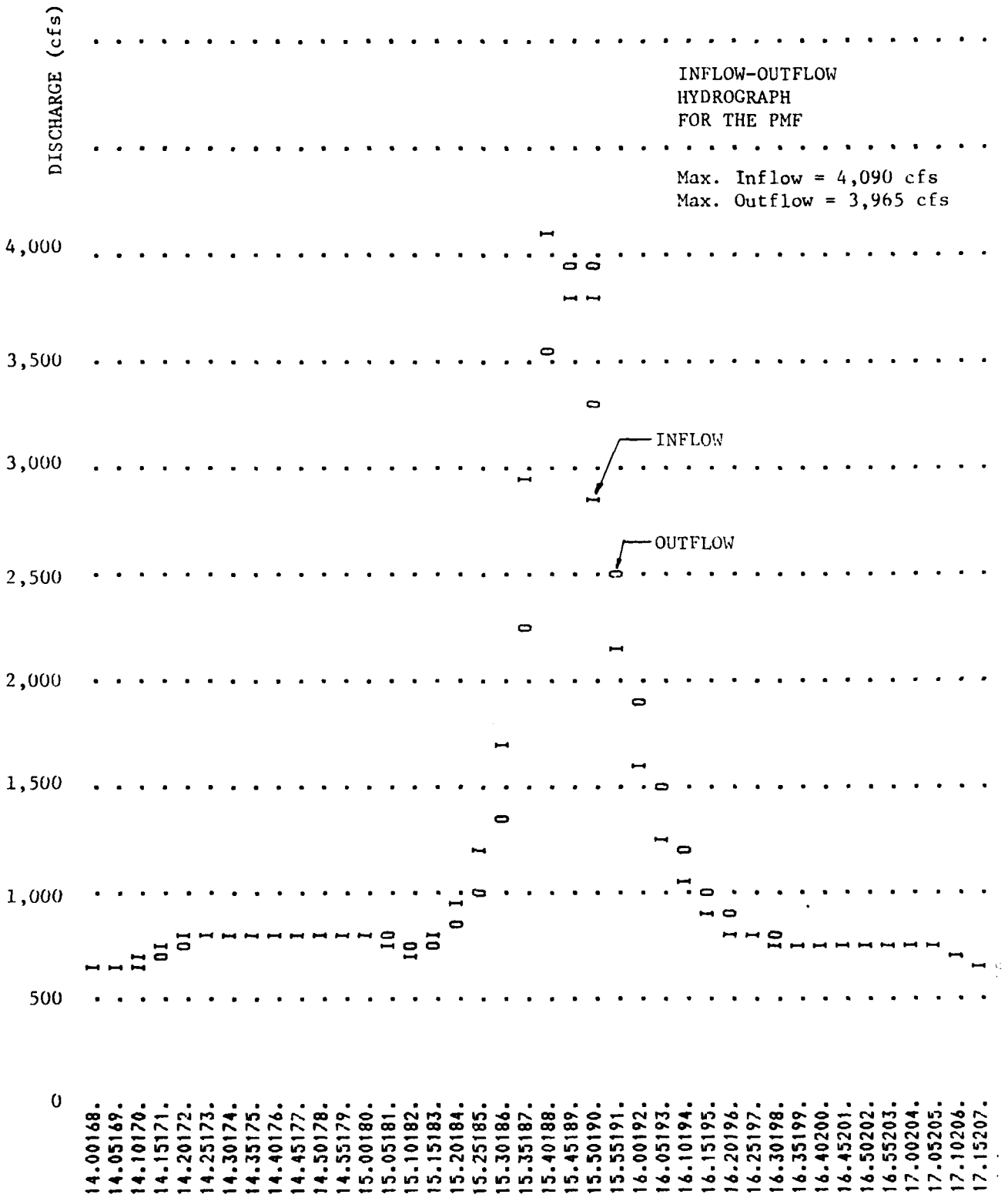
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	920.20	920.20	923.90
STORAGE	40.	40.	56.
OUTFLOW	0.	0.	264.

PMF RATIOS OUTPUT DATA

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.10	923.24	0.00	53.	192.	0.00	15.92	0.00
0.15	924.23	0.33	58.	331.	0.42	15.92	0.00
0.20	924.67	0.77	60.	626.	0.75	15.83	0.00
0.25	924.93	1.03	62.	888.	0.92	15.75	0.00
0.30	925.12	1.22	63.	1128.	1.25	15.75	0.00
0.40	925.41	1.51	65.	1540.	3.25	15.75	0.00
0.50	925.67	1.77	66.	1945.	4.83	15.75	0.00
0.75	926.23	2.33	70.	2958.	6.00	15.75	0.00
1.00	926.71	2.81	73.	3965.	6.58	15.75	0.00

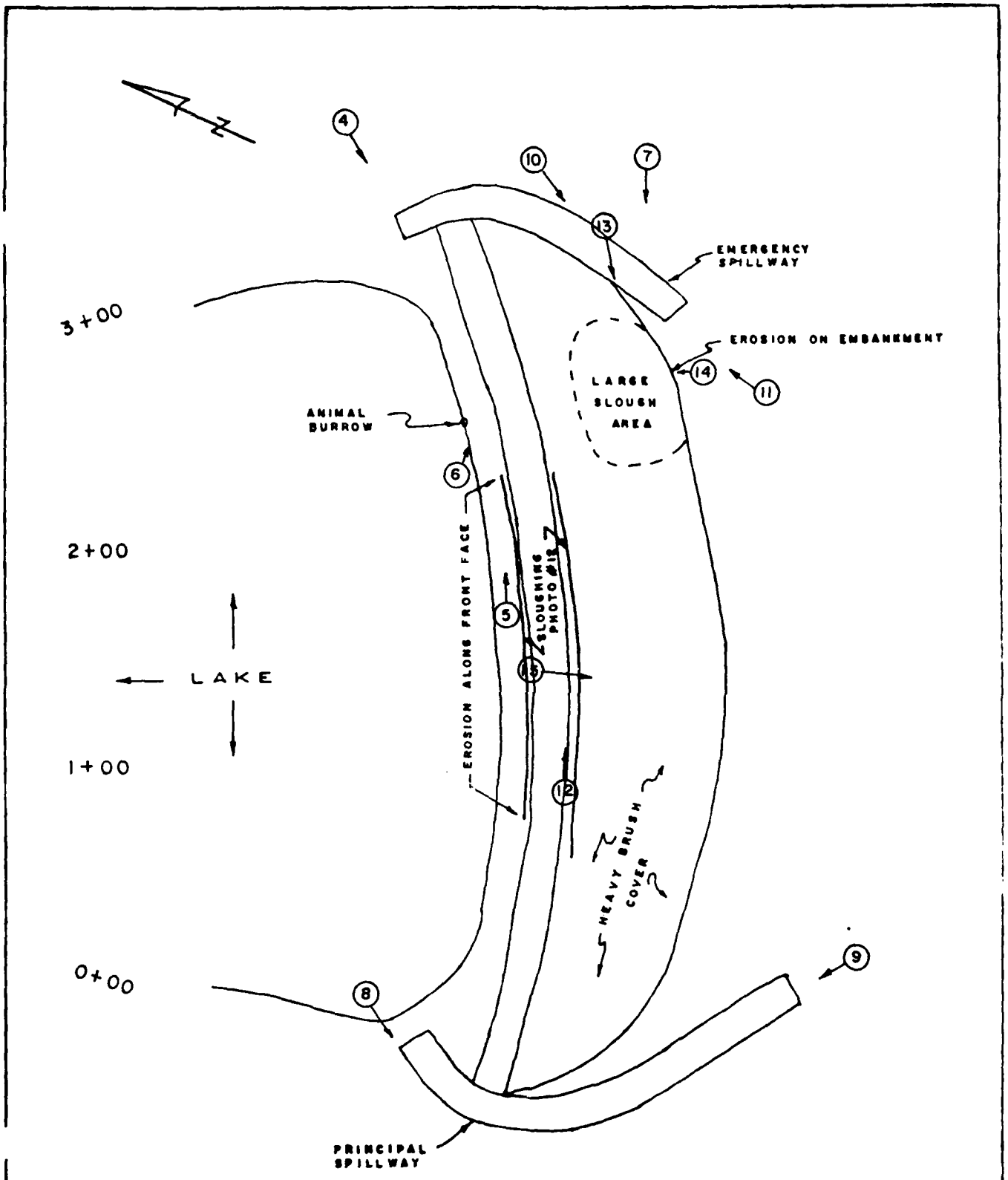

DISCHARGE (cfs)
INFLOW-OUTFLOW
HYDROGRAPH
FOR THE PMF
Max. Inflow = 4,090 cfs
Max. Outflow = 3,965 cfs
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
INFLOW
OUTFLOW
14.00168.
14.05169.
14.10170.
14.15171.
14.20172.
14.25173.
14.30174.
14.35175.
14.40176.
14.45177.
14.50178.
14.55179.
15.00180.
15.05181.
15.10182.
15.15183.
15.20184.
15.25185.
15.30186.
15.35187.
15.40188.
15.45189.
15.50190.
15.55191.
16.00192.
16.05193.
16.10194.
16.15195.
16.20196.
16.25197.
16.30198.
16.35199.
16.40200.
16.45201.
16.50202.
16.55203.
17.00204.
17.05205.
17.10206.
17.15207.
TIME (hrs)

APPENDIX D

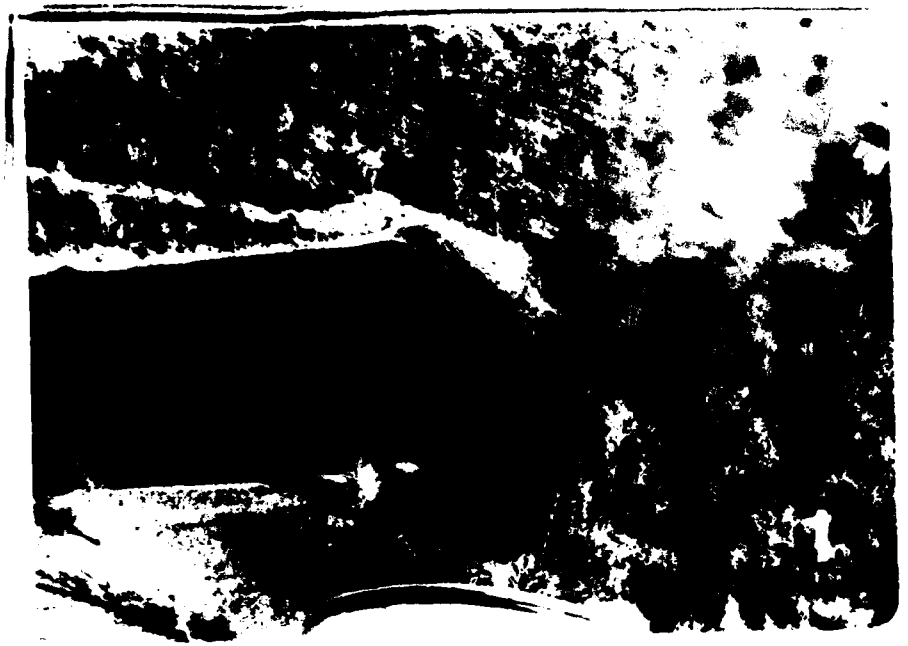
Photographs

LIST OF PHOTOGRAPHS

PHOTO NO.	DESCRIPTION
1	Aerial view of dam (Looking East)
2	Aerial view of dam (Looking West)
3	Aerial view of reservoir (Looking North)
4	Crest of dam, emergency spillway in foreground
5	Upstream face of embankment (Looking East)
6	Animal burrow on front face
7	Downstream face of embankment (Looking Southwest)
8	Entrance to principal spillway
9	Principal spillway outlet
10	Emergency spillway discharge channel
11	Emergency spillway outlet
12	Sloughing along edge of crest (Looking East)
13	Emergency spillway discharge channel (Note erosion of embankment)
14	Small seepage spot at toe of embankment near discharge point of emergency spillway
15	Downstream view from top of dam
16	Aerial view of downstream hazard features (Highway 65 in background)



A/E ANDERSON ENGINEERING, INC. 730 N. BENTON AVE. • SPRINGFIELD, MO. 65802	PHOTOGRAPHIC INDEX ROCKWOOD HILLS LAKE DAM TANEY COUNTY, MISSOURI MO. I.D. No. 30372 SHEET 2, APPENDIX D




2


4

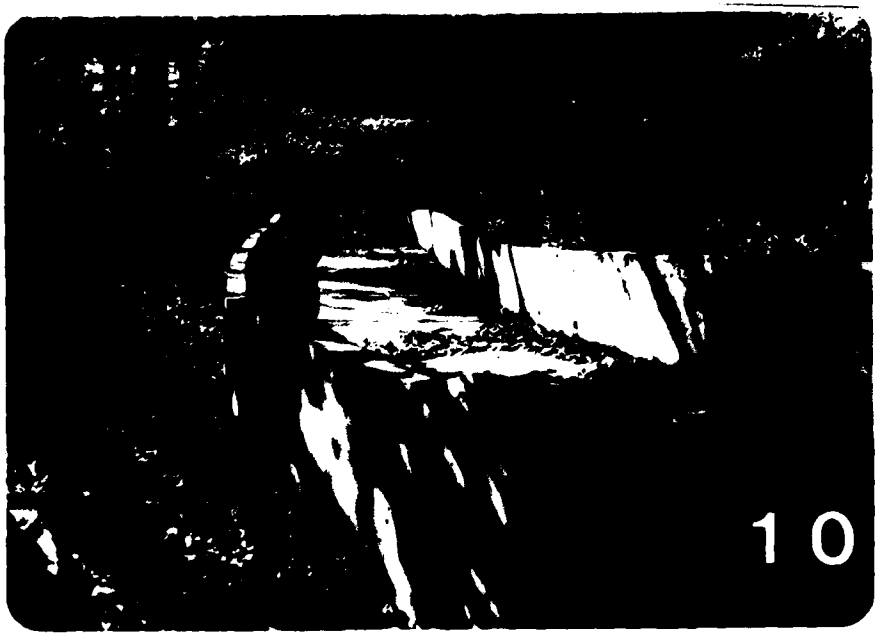

5


6


7


8


9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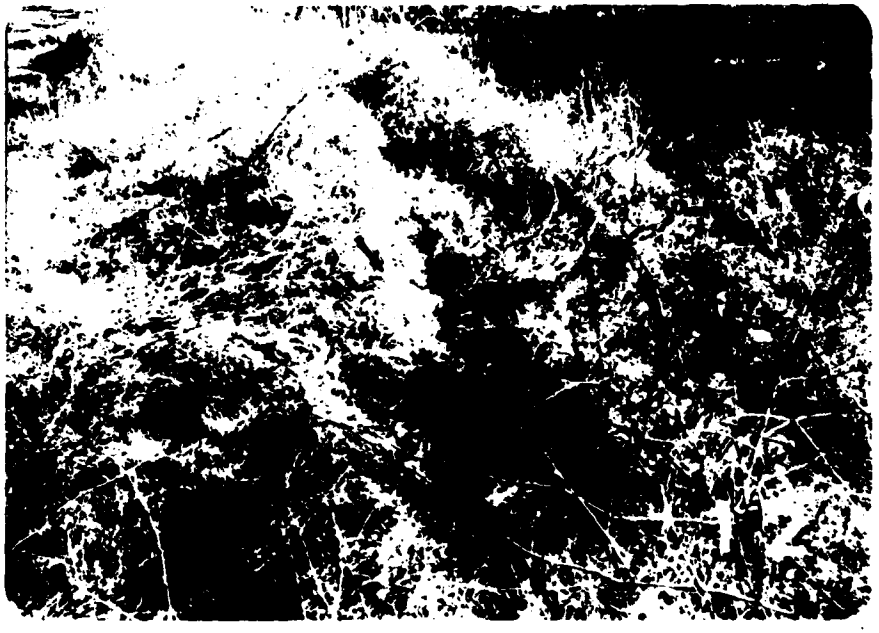
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13


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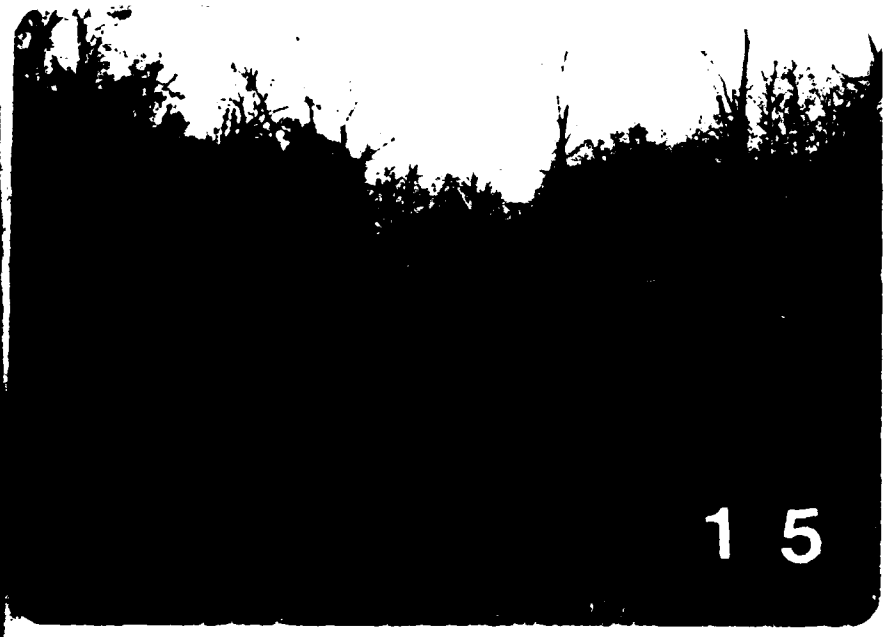
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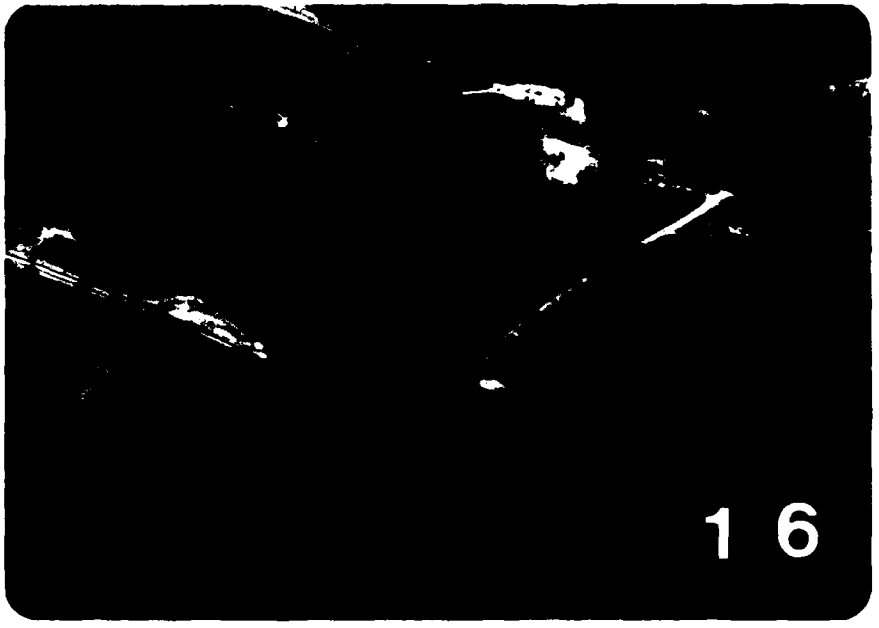
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