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NATIONAL DAM SAFETY PROGRAM. HILLIARD ESTATES LAKE DAM (MO 2047--ETC(U)
MAR 81 S BRADY, T R BECKLEY, J HEALY DACW43-81-C-0005

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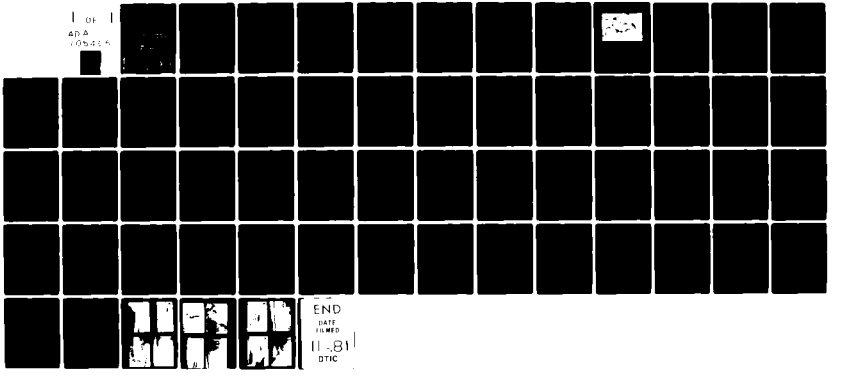

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OSAGE-GASCONADE RIVER BASIN

AD A105455

HILLIARD ESTATES LAKE DAM

GREENE COUNTY, MISSOURI

MO 20473

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

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

FOR: STATE OF MISSOURI

MARCH, 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.

4/12/84 JTC

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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: Hilliard Estates Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Hilliard Estates Lake Dam (MO No. 20473).

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

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. The combined spillway capacity will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED
Chief, Engineering Division — 29 MAY 1981 — Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer — 1 JUN 1981 — Date

OSAGE-GASCONADE RIVER BASIN

HILLIARD ESTATES LAKE DAM
GREENE COUNTY, MISSOURI
MISSOURI INVENTORY NO. 20473

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

MARCH, 1981

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam: Hilliard Estates Lake Dam
State Located: Missouri
County Located: Greene
Stream: Tributary of the Little Pomme de Terre
Date of Inspection: November 19, 1980

Hilliard Estates 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 two miles downstream of the dam. Located within this zone are a pond, a few out-buildings, and five dwellings.

The dam is in the small size classification, since it is greater than 25 ft high but less than 40 ft high, and the maximum storage capacity is greater than 50 acre-ft but less than 1,000 acre-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 20 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 small height of the dam and the low reservoir storage capacity,

50 percent of the PMF has been determined to be the appropriate spillway design flood. The 100-year flood (1 percent probability flood) will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being exceeded in any given year.

The embankment was in good condition. Deficiencies visually observed by the inspection team were: (1) Seepage at outlet of principal spillway pipe; (2) Erosion along north abutment-embankment contact; and (3) Lack of wave protection for upstream face of embankment.

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

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

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

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

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

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

AERIAL VIEW OF LAKE AND DAM

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HILLIARD ESTATES LAKE DAM
MISSOURI INVENTORY NO. 20473

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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 Hilliard Estates Lake Dam in Greene 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:

Hilliard Estates Lake Dam is an earth fill structure approximately 27 ft high and 320 ft long at the crest. The appurtenant work consists of a 4 in. diameter principal spillway pipe and an earthcut channel emergency spillway.

Sheet 3 of Appendix A shows a plan, profile, and typical section of the embankment. Sheet 4 of Appendix A shows a profile and section of the emergency spillway.

B. Location:

The dam is located in the northeastern part of Greene County, Missouri on a tributary of the Little Pomme de Terre River. The dam and lake are within the Strafford, Missouri 7.5 minute quadrangle sheet (Section 15, T30N, R20W - latitude 37°19.1'; longitude 93°07.3'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 27 ft and a maximum storage capacity of approximately 60 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 two miles downstream of the dam. Located within this zone are a pond, a few out-buildings, and five dwellings. The affected features located within the damage zone were field verified by the inspection team.

E. Ownership:

The dam is owned by Hilliard Estates Subdivision, c/o Mr. John Norman. The owner's address is Route 3, Box 282D Strafford, Missouri 65757.

F. Purpose of Dam:

The dam was constructed primarily for recreation.

G. Design and Construction History:

The dam was constructed in 1977 by the owner, Mr. John Norman. According to Mr. Norman, the Soil Conservation Service office did some preliminary survey and design work on the dam site. A request to SCS for available information resulted in their being unable to find any file information relative to this dam. Mr. Norman stated that the preliminary plan was used as a guide, but the dam was not constructed in accordance with the SCS preliminary design data. All information for the construction of the dam was obtained from Mr. Norman.

A core trench about 11 ft wide and 5 ft deep was excavated along the centerline of the dam. Select material from the lake bed was placed in the core and extended upward to the elevation of normal pool level (Elevation 1404.3 ft). The remainder of the fill material was also obtained from the lake bed.

The principal spillway pipe as initially installed included the vertical standpipe, a 4 in. gate valve installed at the bottom of the standpipe and an 8 in. steel pipe extending through the embankment. The pipe diameter was reduced to 4 inches about 20 ft from the pipe outlet. The remaining 20 ft of pipe was 4 in. PVC pipe.

As the lake was filling, Mr. Norman observed a leak in a welded joint of the spillway near the inlet. He removed the standpipe, inserted a 20 ft section of PVC pipe inside the 8 in. steel pipe and grouted between the two pipes. He stated that this procedure stopped the leak at the joint.

Mr. Norman stated that the dam had never been overtopped. The maximum water level obtained, to his knowledge, was at elevation 1406.0.

H. Normal Operating Procedures:

Normal flows are discharged through the uncontrolled principal and emergency spillways. The lake level can be lowered by use of the 4 in. gate valve into the principal spillway pipe. Mr. Norman stated that the pool level is normally maintained at the elevation of the principal spillway inlet pipe.

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 55 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. 1407.1): 150 cfs

(3) Estimated Capacity of Principal Spillway: Negligible

(4) Estimated Capacity of Emergency Spillway: 150 cfs

(5) Estimated Experience Maximum Flood at Dam Site: 35 cfs at Elevation 1406.0

(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 1384.0 MSL for northeast corner of downstream culvert headwall (estimated from quadrangle map).

(1) Top of Dam: 1407.1 ft, MSL

(2) Principal Spillway Crest: 1404.3 ft, MSL

(3) Emergency Spillway Crest: 1405.4 ft, MSL

(4) Principal Spillway Pipe Invert at Outlet: 1379.5 ft, MSL

(5) Streambed at Centerline of Dam: 1383.0 ft, MSL

(6) Pool on Date of Inspection: 1401.4 ft, MSL

(7) Apparent High Water Mark: 1404.3 ft, MSL (observed)

(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: 900 ft

(2) At Emergency Spillway Crest: 860 ft

(3) At Principal Spillway Crest: 830 ft

E. Storage Capacities:

(1) At Top of Dam: 60 Acre-ft

(2) At Emergency Spillway Crest: 52 Acre-ft

(3) At Principal Spillway Crest: 47 Acre-ft

F. Reservoir Surface Areas:

(1) At Top of Dam: 4.8 Acres

(2) At Emergency Spillway Crest: 4.6 Acres

(3) At Principal Spillway Crest: 4.3 Acres

G. Dam:

(1) Type: Rolled Earth

(2) Length at Crest: 320 ft

(3) Height: 27 ft

(4) Top Width: 12 ft

(5) Side Slopes: Upstream to water edge varies from 1V on 2.1H to 1V on 2.4H Downstream varies from 1V on 2.1H to 1V on 5.4H

(6) Zoning: Apparently Homogeneous

(7) Impervious Core: Clay core, 11 ft wide (information from owner)

(8) Cutoff: Key trench 5 ft deep (Information from owner)

(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: Station 1 + 30 centerline of dam

(2) Type: 4 in. diameter PVC pipe grouted inside an 8 in. diameter steel pipe

(3) Upstream Channel: Not Applicable

(4) Downstream Channel: Earth channel with gentle side slopes

I.2 Emergency Spillway:

(1) Location: North Abutment

(2) Type: Earth Channel

(3) Upstream Channel: Earthcut Channel

(4) Downstream Channel: Earth channel along embankment-abutment contact

J. Regulating Outlets:

There are no regulating outlets associated with this dam.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No engineering data is known to exist for this dam. Mr. Norman stated that SCS did some preliminary survey and design work on the dam. However, SCS does not have any file information on the dam. To our knowledge, no construction inspection records or documented maintenance and operation data exist.

A. Surveys:

No information regarding pre-construction survey data was available. Sheet 3 of Appendix A presents a plan, profile and cross-section of the dam and Sheet 4 of Appendix A presents a profile and section of the emergency spillway. The northeast headwall corner of the downstream culvert was used as a reference point to determine all other elevations. From the Strafford, Missouri 7.5 minute quad sheet a site datum of 1384.0 ft, MSL was estimated for the top of headwall elevation.

B. Geology and Subsurface Materials:

The topography around the site is gently rolling to hilly. This area is at the eastern edge of the Western Plains region of the state. Generally, the soils around the dam consist of deep, well drained, cherty, silty, clay soils. Those soils are residual from cherty Mississippian limestones. Typically, these soils have a brown, cherty, clayey silt surface layer followed by a reddish-brown, friable silty clay containing considerable chert rock fragments. The lower horizon is a red, dark red, crumbly, plastic, silty clay which has varying amounts of chert rock. Weathered ledge rock is often found near the surface in this area. The underlying rock is of the Burlington formation of the Osagean Series of the Mississippian Systems. The Burlington formation is a white to light buff, very coarsely crystalline, fossiliferous, crinoidal limestone. Layers of chert nodules are common in the upper portions of this formation. The bedrock has often weathered unevenly leaving pinnacles, mushroom-like knobs projecting from the rock surface. The crevices between these knobs are filled with the red, often highly plastic, silty clay.

Geologic mapping of Greene County, Missouri compiled by Mr. Kenneth C. Thomson of Southwest Missouri State University, shows one fault zone near the site. The Strafford fault lies approximately 1 mile south of the dam site. The Department of Natural

Resources has indicated that the faults in this area are generally considered to be inactive and have been for several hundred million years (rock associated with the Mississippian period is approximately 300 million years old). Additional mapping by Mr. Thomson indicates the nearest area of sinkhole features is approximately 5 miles southeast of the dam site. The nearest cave is approximately 3 miles west of the dam site.

C. Foundation and Embankment Design:

No foundation and embankment design information was available. Seepage and stability analyses apparently were not performed as required in the guidelines. No construction inspection test results have been obtained. No internal drainage features are known to exist.

D. Hydrology and Hydraulics:

No hydrologic or hydraulic design computations for this dam were available. Based on a field check of spillway dimensions, 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 9.

E. Structure:

There are no structural design computations available for this dam.

2.2 CONSTRUCTION:

No construction inspection data were available.

2.3 OPERATION:

Normal flows are passed by the uncontrolled principal spillway pipe and emergency spillway section at the north abutment. The flow through the principal spillway pipe, 4 in. diameter PVC pipe, is less than 1 cubic foot per second and is considered to be negligible in the analysis performed for this dam.

2.4 EVALUATION:

A. Availability:

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

B. Adequacy:

The engineering data available were indadequate to make a detailed assessment of the design, construction, and operaton 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 earthquate 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 19, 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, P.E. - Anderson Engineering, Inc. (Civil Engineer)
Tom R. Beckley, P.E. - Anderson Engineering, Inc. (Civil Engineer)
Jack Healy, P.E. - Hanson Engineers, Inc. (Geotechnical Engineer)
Nelson Morales, P.E. - Hanson Engineers, Inc. (Hydraulic Engineer)

The owner of the dam, Mr. John Norman, accompanied the inspection team during the visual inspection.

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

B. Dam:

The dam appeared to be in good condition. The upstream and downstream slopes of the embankment had good grass cover. No sloughing or other unusual movement of the embankment was noted. No animal burrows were observed.

The vertical alignment of the crest appeared good. A gentle slope downward in both directions from Station 2 + 00 was noted. The embankment was constructed with a gentle curve concave downstream.

The upstream slope of the embankment varied from 1V on 2.1H to 1V on 2.4H. A good grass cover was noted on the upstream slope. No rip rap was observed on the upstream slope. No significant erosion was noted.

Good grass cover was noted on the downstream slope of the embankment, except for the area adjacent to the embankment toe. The downstream slope of the embankment varied from 1V on 2.1H to 1V on 5.4H. No sloughing or significant erosion of the slope was noted.

An apparent seep area was observed at the outlet of the principal spillway pipe. No noticeable flow or soil particle suspension was observed.

The contact between the south abutment and the embankment was good. Erosion channels were noted at the north abutment and embankment contact. The erosion was due to to the emergency spillway discharges along the toe of embankment.

No instrumentation (monuments, piezometers, etc.) was observed.

Shallow auger probes into the embankment indicated the embankment to consist of a brown silty clay with some chert fragments (CL). The owner stated that the material for the embankment was obtained from the lake bed.

C. Appurtenant Structures:

C.1 Prinicpal Spillway:

The principal spillway inlet located within the lake, consisting of an 8 in. standpipe (See Photograph No. 6) and a 4 in. gate valve appeared to be in good condition. Mr. Norman stated that the gate valve had not been operated since it was installed. The outlet of the pipe (See Photograph No. 8) was clear. Standing water was noted at the outlet. The owner reported that this area remained wet independant of flow through the spillway pipe. Visual inspection did not reveal if the flow as through or around the spillway pipe. According to the owner, no anti-seep collars were installed on the spillway pipe.

C.2 Emergency Spillway:

The emergency spillway located at the north abutment is an earthcut channel with a concrete slab and fish screen installed on the bottom of the channel (See Photograph No. 9). The inlet channel is clear. No accumulation of trash or debris was noted on the fish screen. No grass cover of the channel or the side slopes of the control section was observed. The discharge channel of the emergency spillway is along the contact between the embankment and abutment. Erosion channels were observed along the embankment toe. Scattered grass cover of the channel at and downstream of the control section was noted.

D. Reservoir:

The watershed is generally wooded with moderate side slopes. No sloughing or erosion of the reservoir slopes was observed. No significant sedimentation of the lake was noted.

E. Downstream Channel:

Immediately downstream of the dam is a 5 ft high roadway embankment and concrete box culvert (See Photograph Nos. 10 and 12). During peak flows, discharge from the spillways will be retarded by the embankment and the culvert. The roadway embankment will overtop at elevation 1384.0, which is the toe of slope elevation. The back up of water due to the roadway embankment is not expected to cause serious damage to the dam embankment. Beyond the roadway, the channel is well defined with moderate slopes. The downstream channel is lightly wooded pastureland with good grass cover.

3.2 EVALUATION:

The dam is in good condition. The erosion along the embankment north abutment contact, could worsen with continued discharge through the emergency spillway and seriously affect the stability of the dam. Accumulation of trash or debris on the fish screen could result in additional erosion of the spillway and also seriously affect the stability of the dam. The seepage at the outlet of the principal spillway pipe and lack of wave protection for the upstream face are deficiencies which could also affect the stability of the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

The only operating facility for this dam is the 4 in. diameter PVC principal spillway pipe with associated 4 in. diameter gate valve, which carries negligible flows. The pool is normally controlled by rainfall, runoff, evaporation, and the capacity of the uncontrolled emergency spillway.

4.2 MAINTENANCE OF DAM:

The owner of the dam does not have an established maintenance program for the dam.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There is no regular maintenance of 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 seepage, erosion, and lack of wave protection are serious deficiencies which should be corrected. However, to avoid creating an unsafe condition, these deficiencies should be corrected under the direction of an engineer experienced in the design and construction of dams.

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. The owner reported that the maximum water level was about 6 in. over the emergency spillway and that the dam had never been overtopped. The owner stated that the lake level is usually maintained at normal pool level of 1404.3 ft, MSL (Elevation of principal spillway inlet).

C. Visual Observations:

The approach area to the spillway is clear. A concrete slab at the control section of the spillway was noted. The slab did not extend along the side slopes of the channel. The discharge of the spillway was carried along the embankment and abutment contact point. Erosion channels were observed at the contact point extending from the control section to the toe of the embankment. Ponding of water near the toe of the embankment would occur during periods of peak flow due to the 5 ft high embankment and limiting flow through the concrete box culvert immediately downstream of the embankment. Standing water was observed at the principal spillway outlet pipe. No noticeable flow or suspended soil particles were noted.

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 Strafford, Missouri 7.5 Minute U.S.G.S. quad sheet.

Based on the hydrologic and hydraulic analysis presented in Appendix C, the combined spillways will pass 20 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 small height of the dam and low reservoir storage capacity, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The spillways will 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 1,278 cfs. For 50 percent of the PMF, the peak inflow as 639 cfs. The results of flood routings are shown in Table 5, Sheet 7 of Appendix A.

The routing of 50 percent of the PMF through the spillways and dam indicates that the dam will be overtopped by 0.9 ft at elevation 1408.0. The duration of the overtopping will be 0.9 hours, and the maximum outflow will be 523 cfs. The maximum discharge capacity of the spillways is 150 cfs. The routing of the PMF indicates that the dam will be overtopped by 1.4 ft at elevation 1408.5. The maximum outflow will be 1,276 cfs. and the duration of overtopping will be 4.9 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:

The only reported post-construction was the placement of the 4 in. PVC pipe inside the 8 in. principal spillway pipe.

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.

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 was in good condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) Seepage at outlet of principal spillway pipe; (2) Erosion along north abutment and embankment contact; and (3) Lack of wave protection for upstream face of embankment.

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

The dam will be overtopped by flows in excess of 20 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 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 deteriorate and possibly could become serious in the future. The items recommended in paragraph 7.2A should be pursued in the near future.

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.

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 seepage at the principal spillway outlet pipe should be investigated by an engineer experienced in the design and construction of dams. Remedial measures may be required. As a minimum, this area should be inspected periodically in an effort to detect any increase in the quantity of seepage or any indication that soil particles are being carried by the water. In this event, an experienced engineer should be contacted immediately.

(3) The erosion channels along the north abutment-embankment contact should be repaired and maintained. Continued flows through the emergency spillway along the juncture point could seriously impair the structural stability of the embankment.

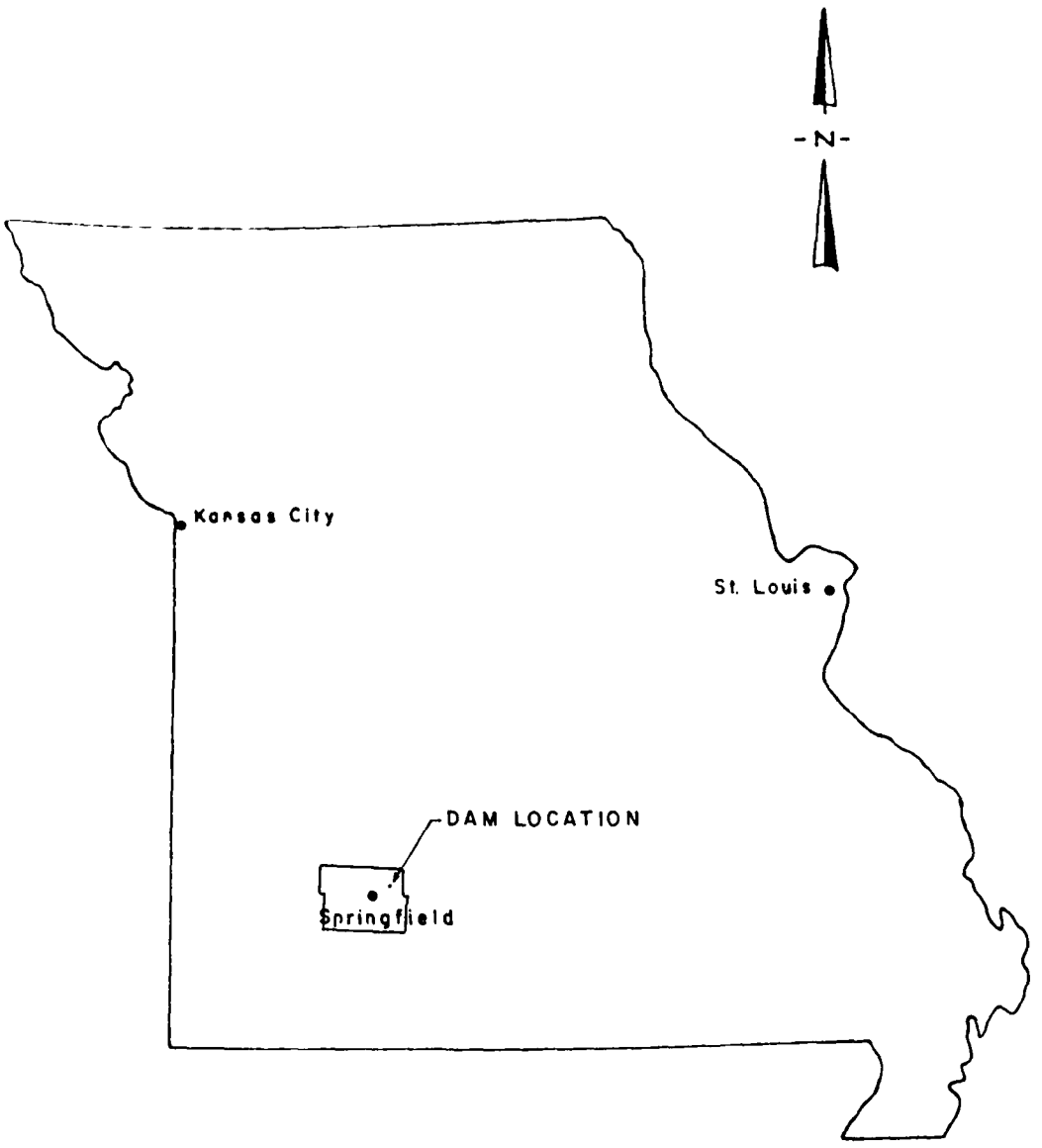
(4) Wave protection, such as rip rap, should be provided along the upstream slope of the embankment.

(5) A detailed study of the long term ponding effects of the downstream roadway embankment should be investgated by an engineer experienced in the design and construction of dams. Remedial measures may be required.

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

APPENDIX A

Dam Location and Plans



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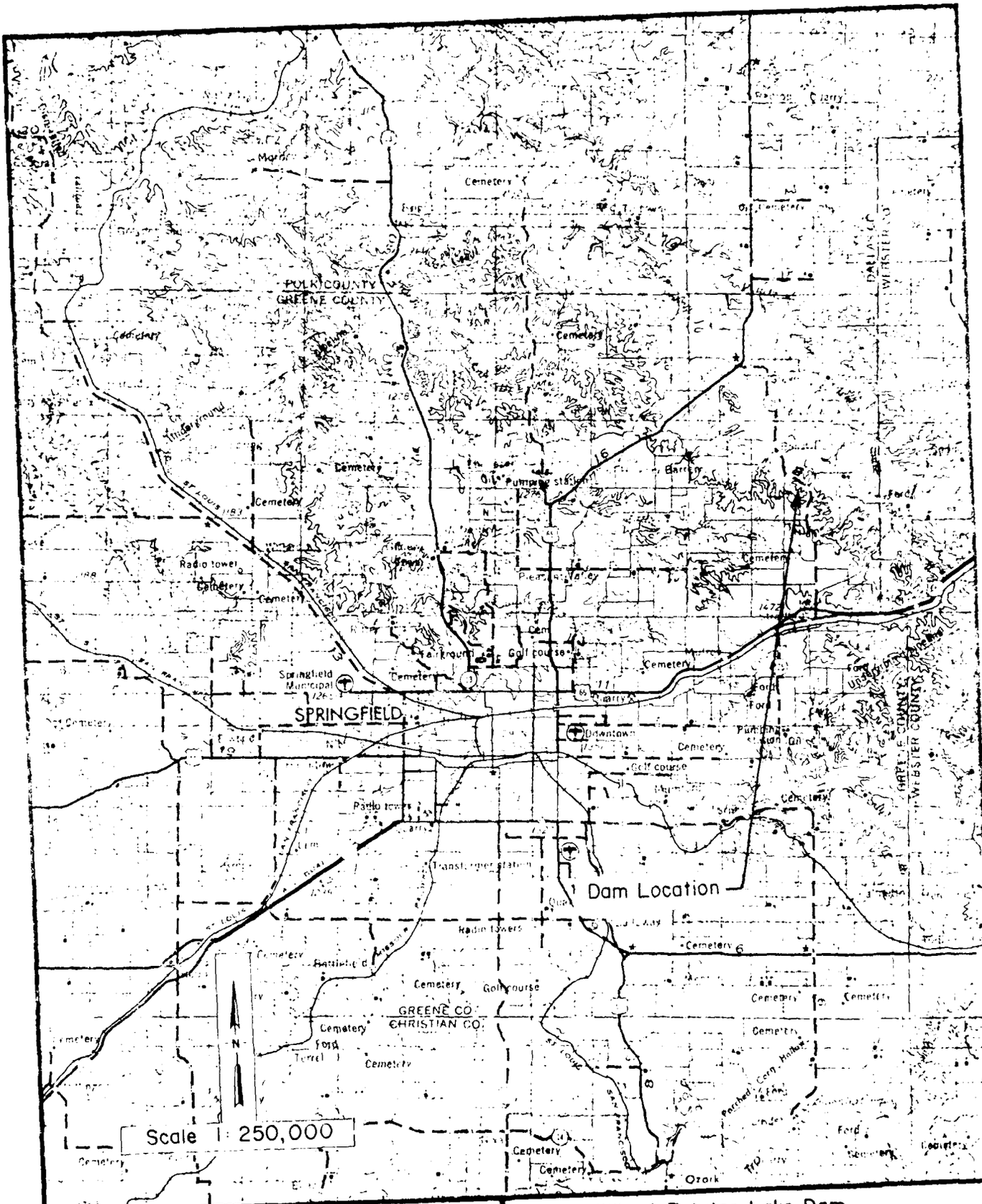
LOCATION MAP

HILLIARD ESTATES LAKE
GREENE COUNTY, MISSOURI
MO. I. D. No. 20473

SHEET 1, APPENDIX A



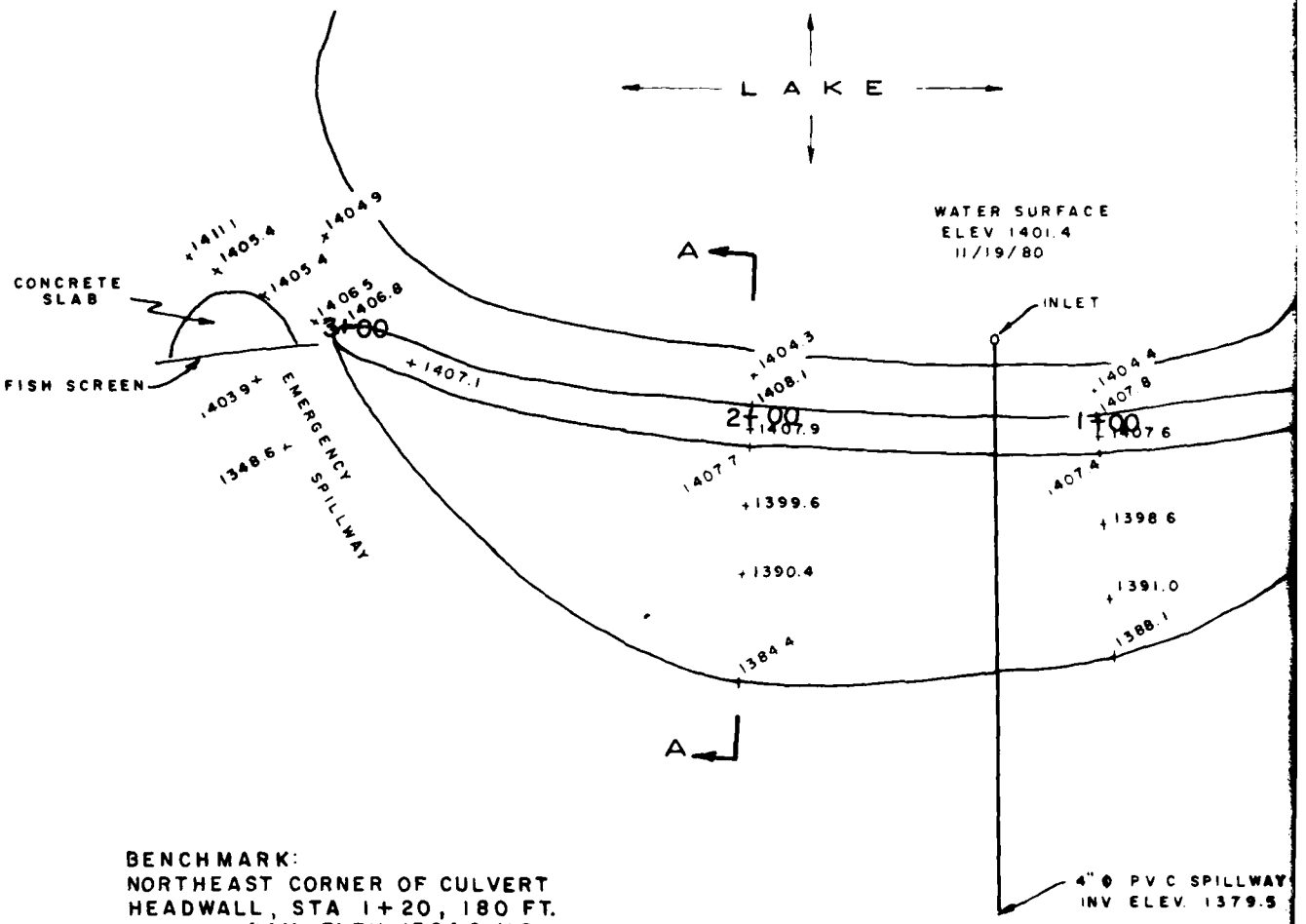
VICINITY MAP

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

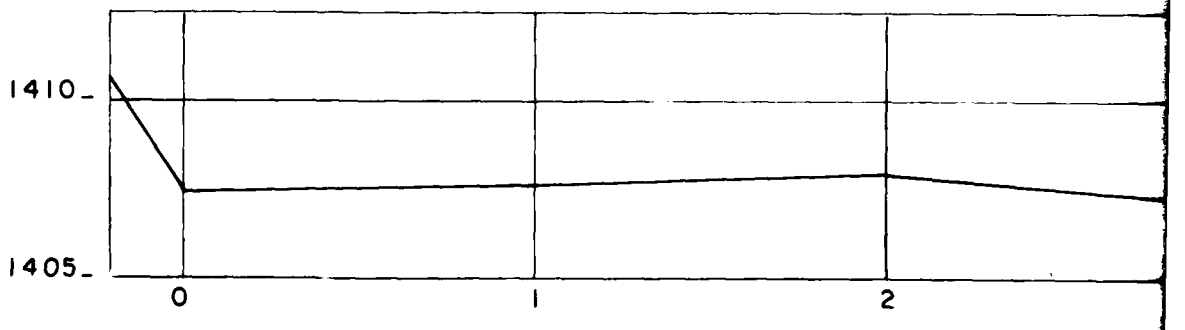
Hilliard Estates Lake Dam
Greene County, Missouri
Mo. I.D. No. 20473

Sheet 2, Appendix A

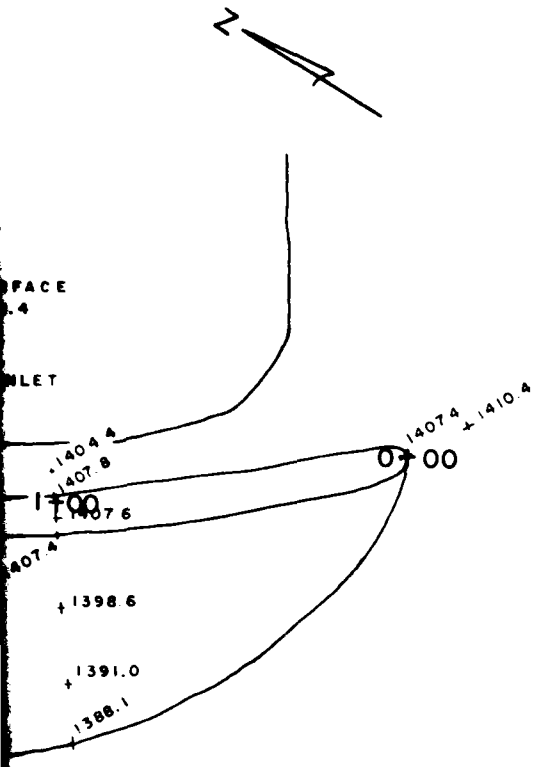


BENCHMARK:
NORTHEAST CORNER OF CULVERT
HEADWALL, STA 1+20, 180 FT.
LEFT ℄ DAM. ELEV. 1384.0 MSL.

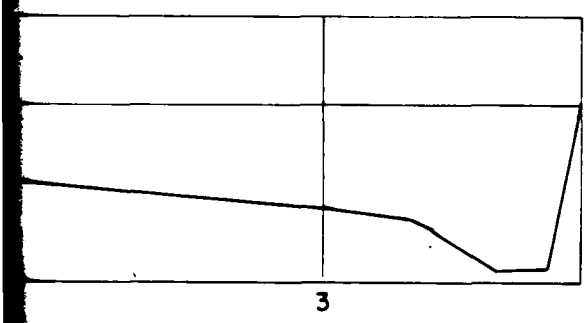
PLAN VIEW
SCALE: 1" = 50'

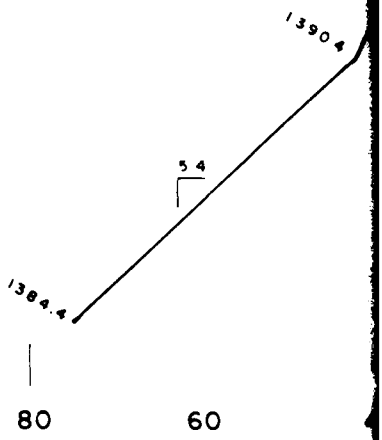


PROFILE
SCALE: HORZ. 1" = 50'
VERT. 1" = 5'



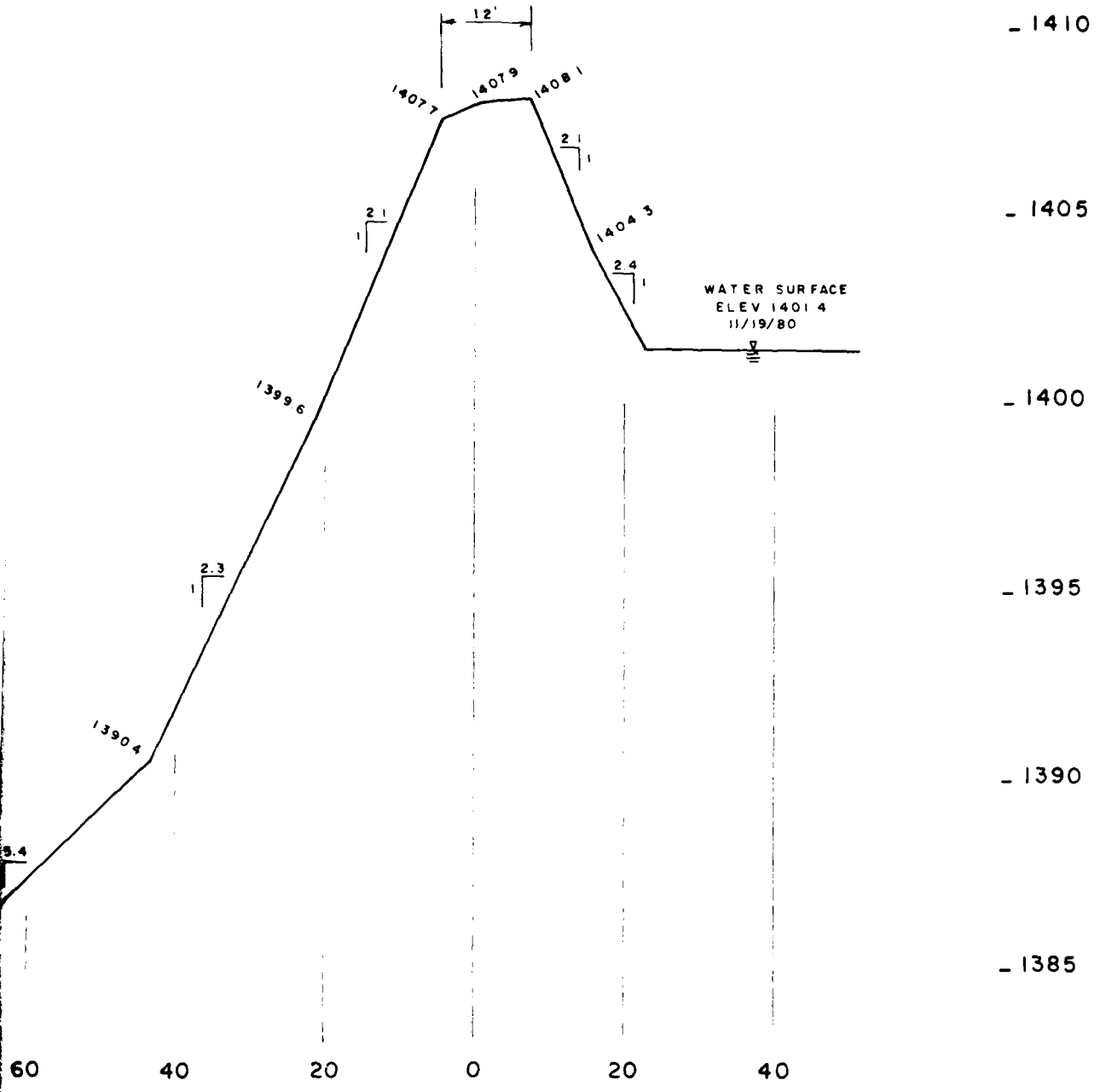
4" Ø PVC SPILLWAY PIPE
INV. ELEV. 1379.5





SE

0'
5'



SECTION A-A STA 2+00

SCALE HORZ 1" = 20'
VERT. 1" = 4'

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HILLIARD ESTATES LAKE DAM

MO. No. 20473

PLAN & PROFILE

GREENE COUNTY, MO.

SHEET 3, APPENDIX A

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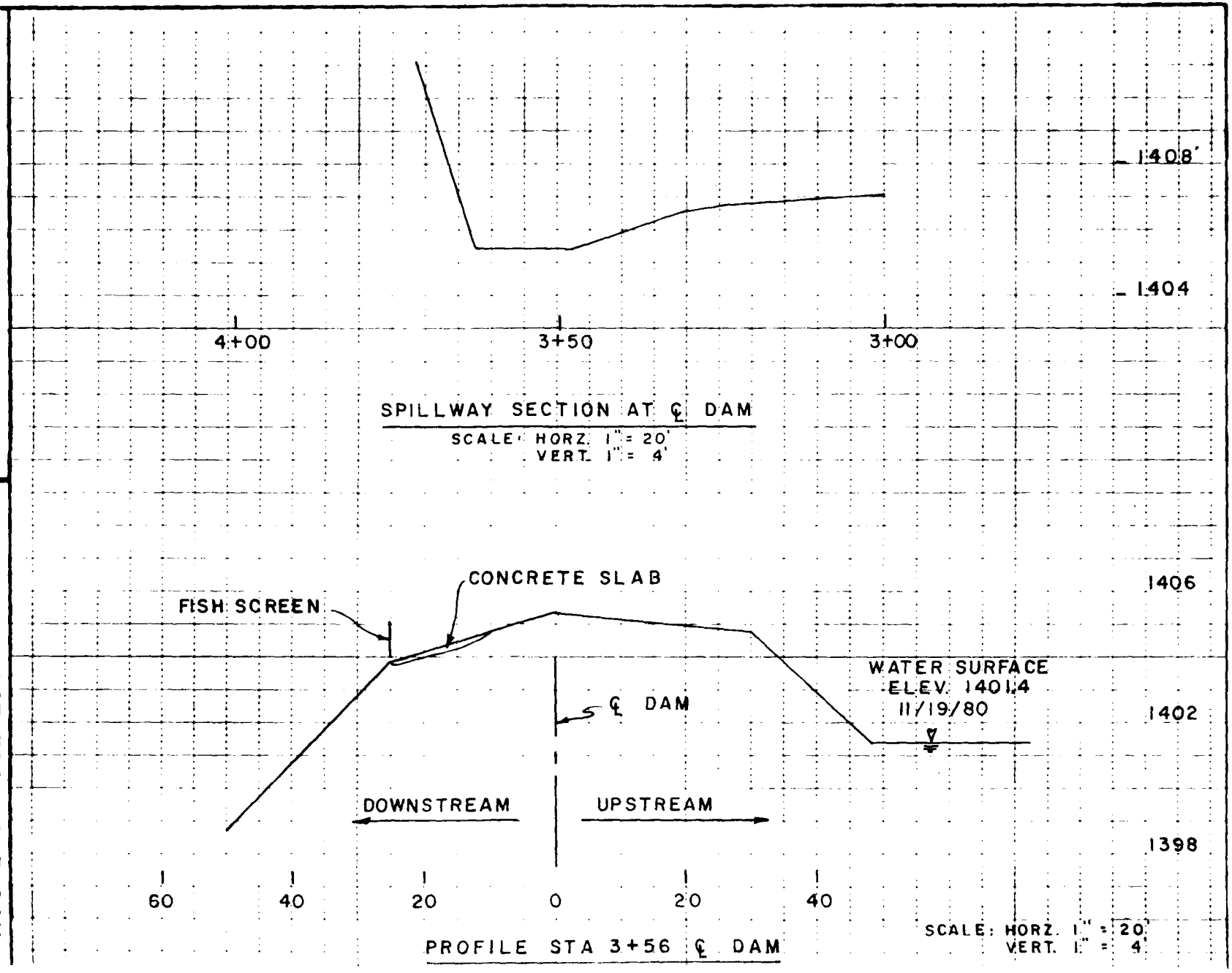
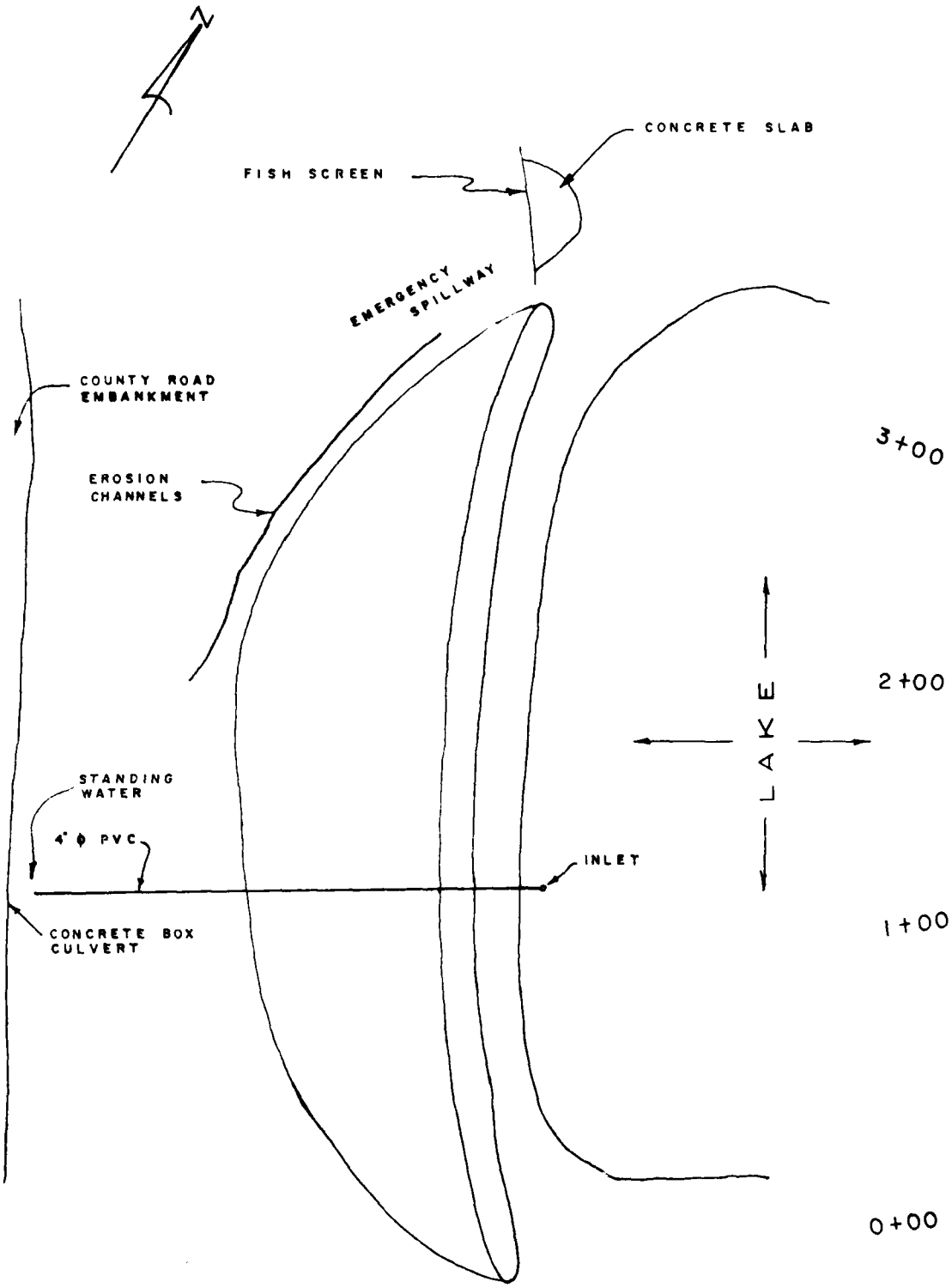
HILLIARD ESTATES LAKE DAM
GREENE COUNTY, MISSOURI
MO. I. D. No. 20473
EMERGENCY SPILLWAY
SECTION & PROFILE

SHEET 4, APPENDIX A

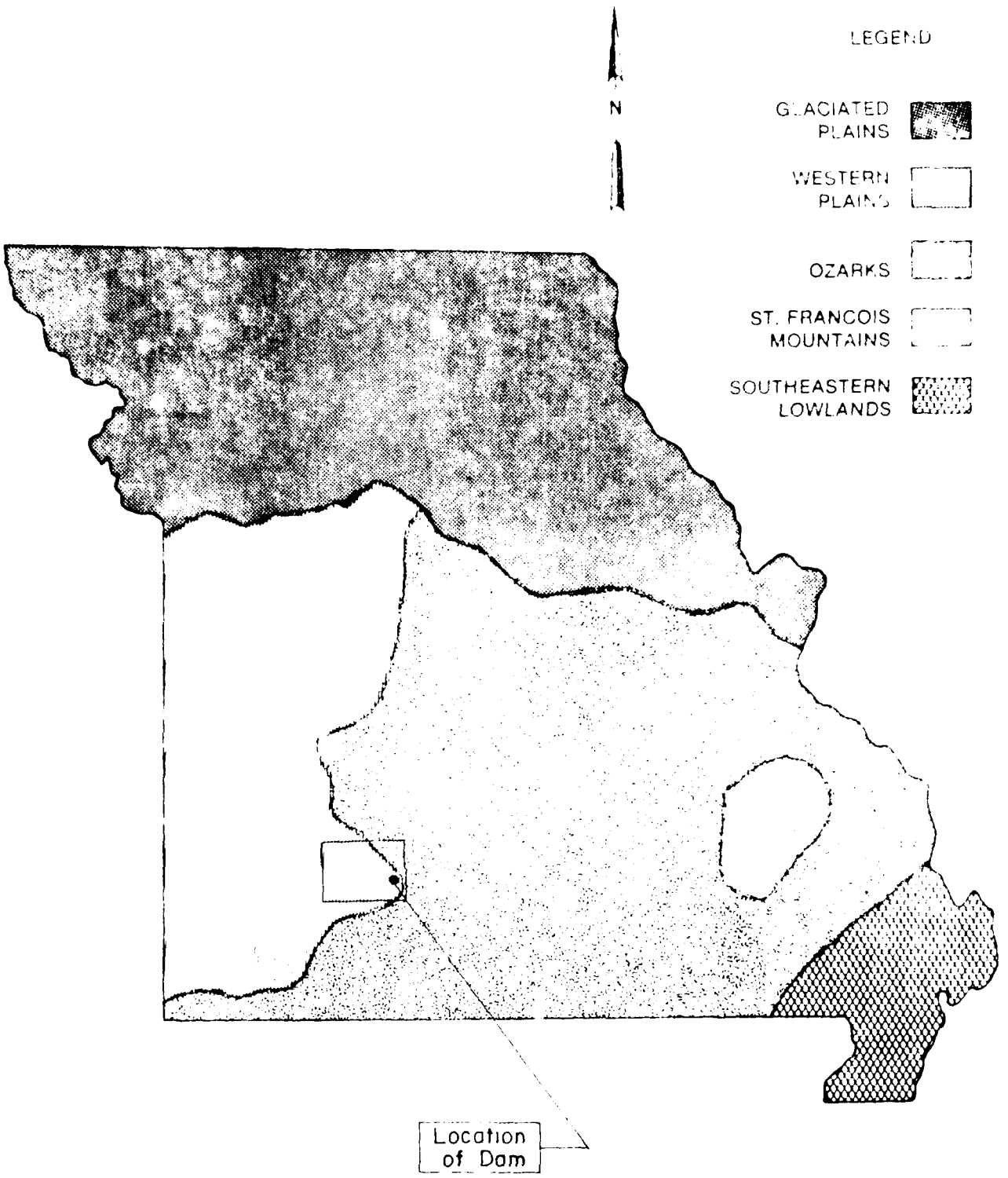




A/E ANDERSON ENGINEERING, INC. 730 N. BENTON AVE • SPRINGFIELD, MO 65802	PLAN SKETCH OF DAM HILLIARD ESTATES LAKE DAM GREENE COUNTY, MISSOURI MO. I. D. No. 20473 SHEET 5 , APPENDIX A

APPENDIX B

Geology and Soils



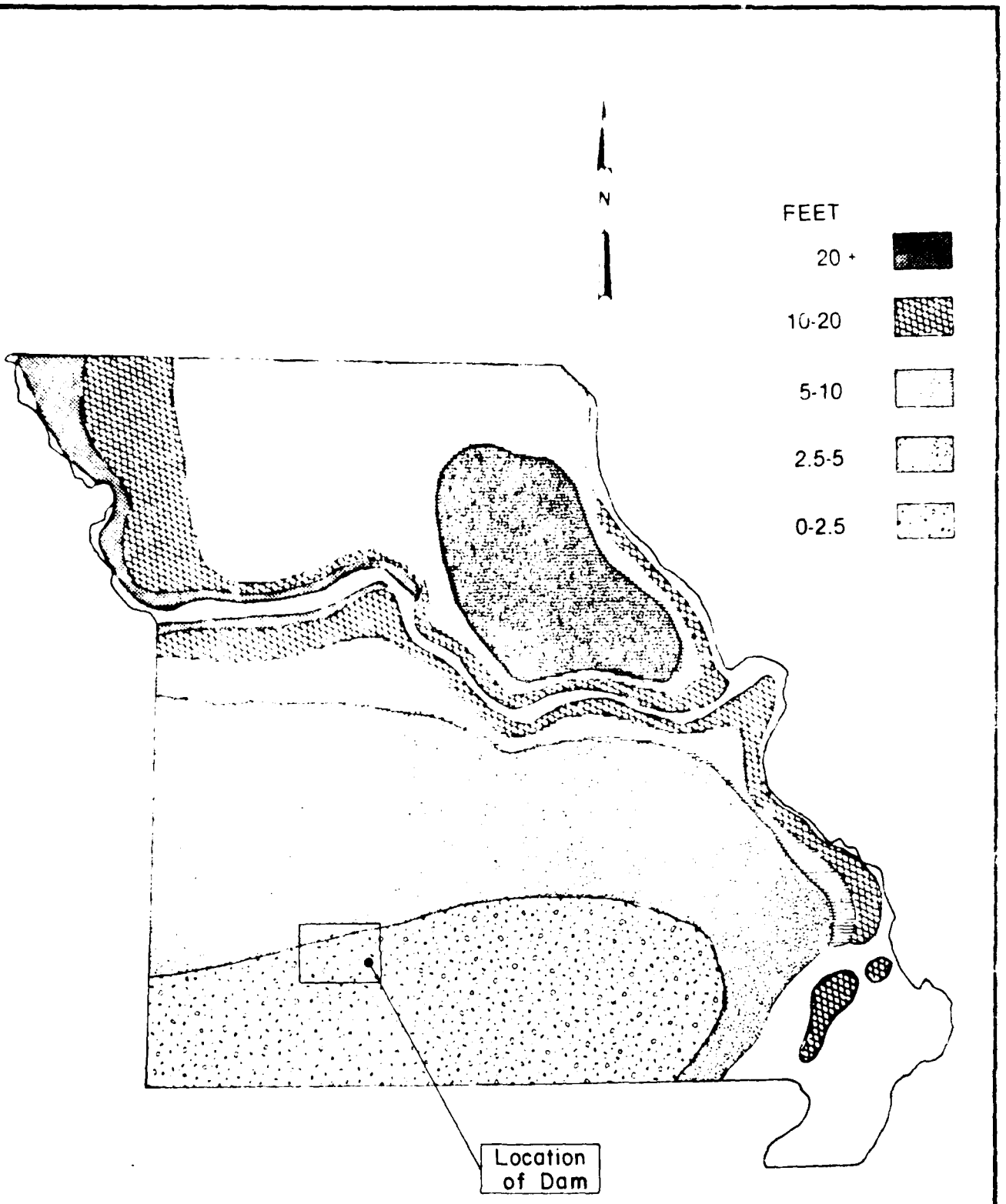
MAJOR GEOLOGIC REGIONS OF MISSOURI

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Hilliard Estates Lake Dam
Greene County, Missouri
Mo. I.D. No. 20473

SHEET 1, APPENDIX B



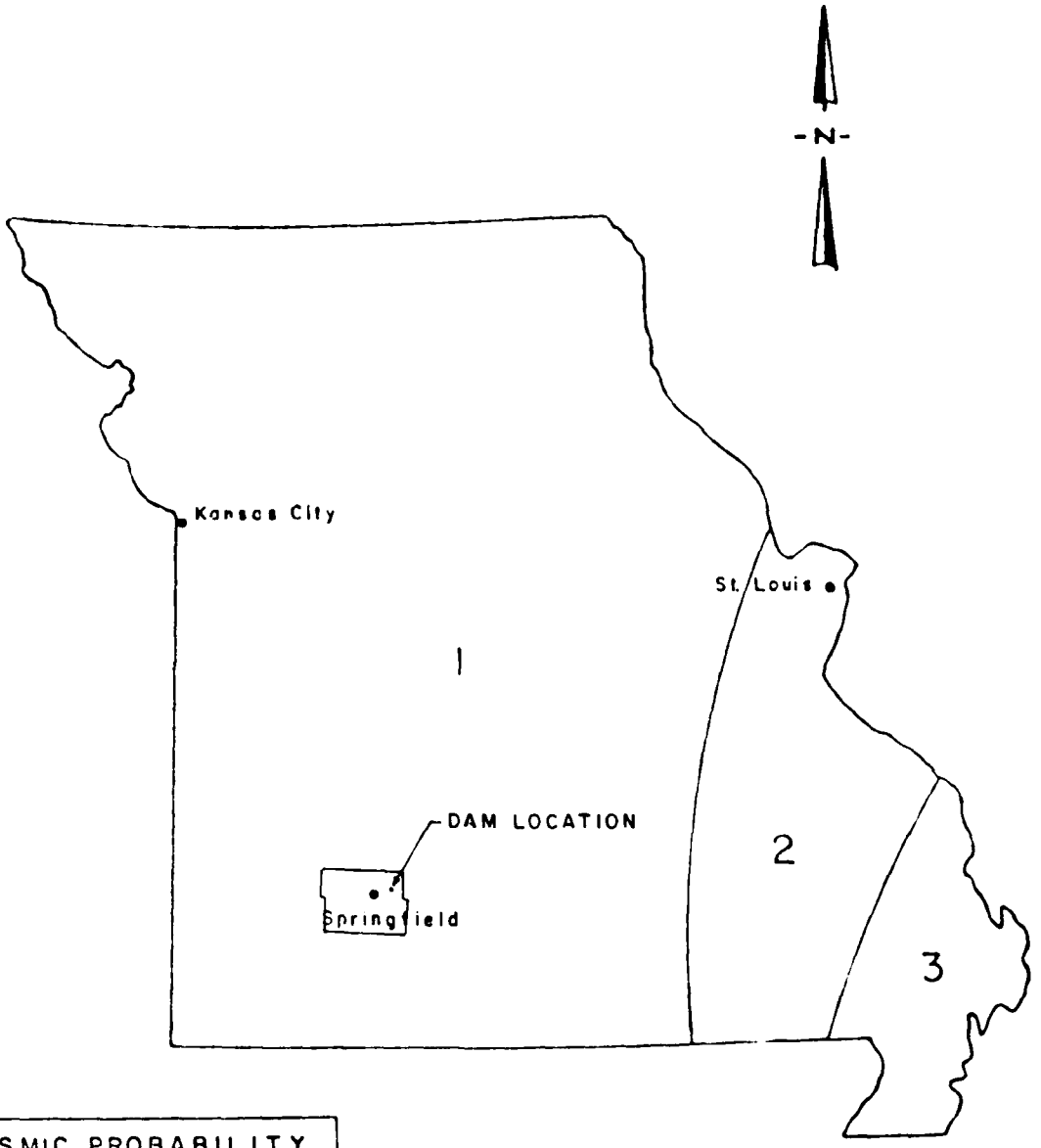
THICKNESS OF [illegible] DEPOSITS

HANSON ENGINEERS

SPRINGFIELD, IL • [illegible] IL • ROCKFORD, IL

Hilliard Estates Lake Dam
Greene County, Missouri
Mo. I.D. No. 20473

SHEET 2, APPENDIX B



SEISMIC PROBABILITY	
ZONE	DAMAGE
1	MINOR
2	MODERATE
3	MAJOR

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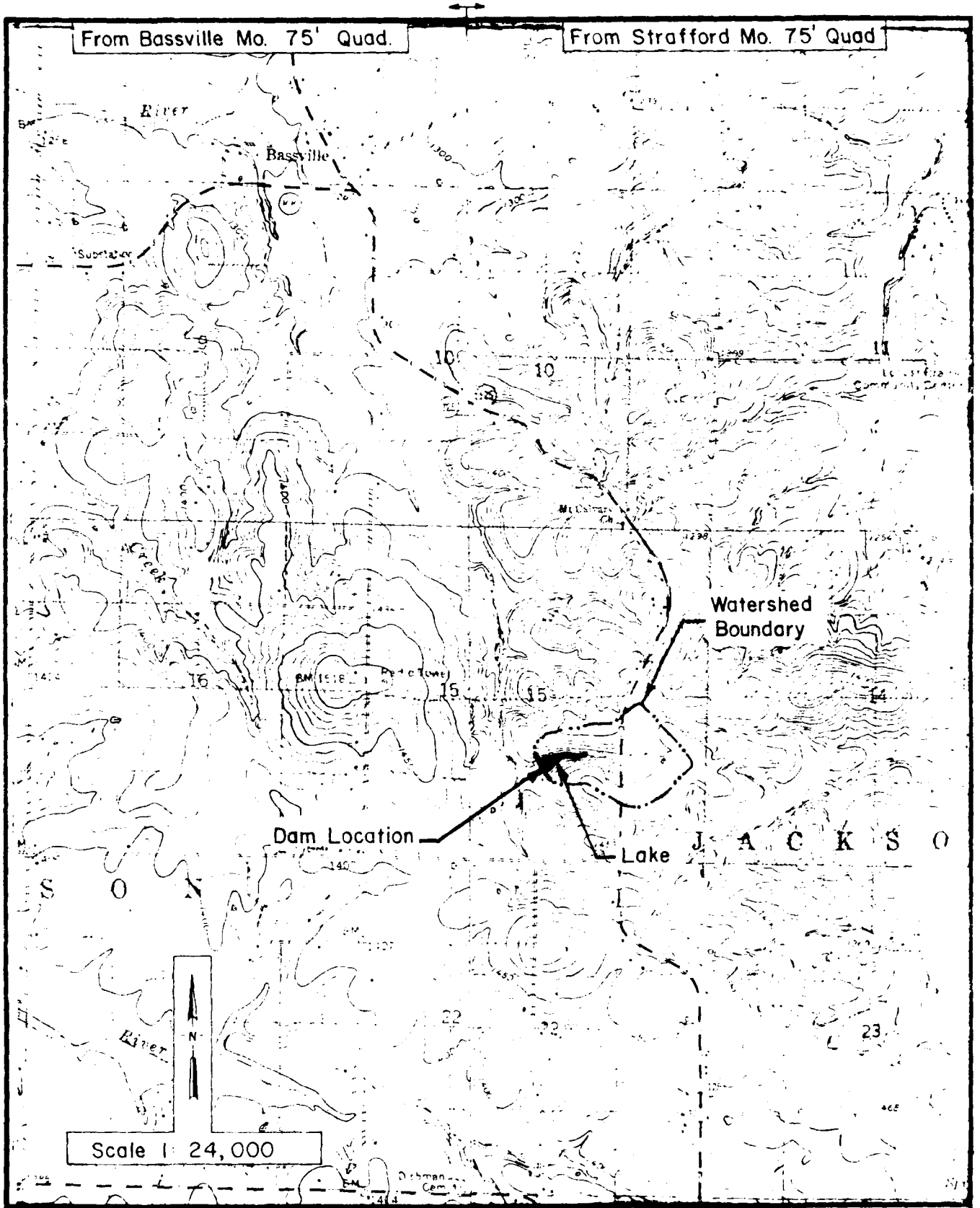
SEISMIC ZONE MAP

HILLIARD ESTATES LAKE
GREENE COUNTY, MISSOURI
MO. I. D. No. 20473

APPENDIX C

Overtopping Analysis



LAKE AND WATERSHED MAP

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Hilliard Estates Lake Dam
Greene County, Missouri
Mo. I.D. No. 20473

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 probability flood was routed through the reservoir and spillway. Springfield, Missouri rainfall distribution (5 min. interval - 24 hours duration), as provided by the St. Louis District, Corps of Engineers, was used in this case.

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 considered in this case. The hydraulic capacity of the spillway was used as an outlet control in the routing. The hydraulic capacity of the spillway 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 spillway (see Table 4 Sheet 6, Appendix C) was determined assuming critical flow conditions at the control section and, approach channel losses equal to 30 percent of the critical velocity head at the control section.

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 spillway will pass the 1 percent probability flood without overtopping 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)	0.086	sq miles
Length of Watercourse (L)	0.32	miles
Difference in elevation (H)	60	ft
Time of concentration (Tc)	0.15	hrs
Lag Time (Lg)	0.09	hrs
Time to peak (Tp)	0.13	hrs
Peak Discharge (Qp)	320	cfs
Duration (D)	5	min

Time (Min.)(*)	Discharge (cfs)(*)
0	0
5	225
10	279
15	104
20	38
25	13
30	5
35	2

(*) 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	34.7	32.9	1.8
1% Prob. Flood	24	8.0	4.9	3.1

Additional Data:

1) Soil Conservation Service Soil Group B
2) Soil Conservation Service Runoff Curve CN = 85 (AMC III) for the PMF
3) Soil Conservation Service Runoff Curve CN = 70 (AMC II) for the 1 percent probability flood
4) Percentage of Drainage Basin Impervious 12 percent

TABLE 3

ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
1383.0	0	0	-
1390.0	1.2	4	-
1400.0	3.8	29	-
*1404.3	4.5	47	0
**1405.4	4.6	52	0
***1407.1	4.8	60	150
1410.0	5.0	74	-
1420.0	7.5	-	-

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

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

TABLE 4

SPILLWAYS RATING CURVE

Reservoir Elevation (MSL)	Principal Spillway(1) (cfs)	Emergency Spillway (cfs)	Total Discharge (cfs)
*1404.3	0	-	0
**1405.3	0	0	0
1406.3	0	47	47
1407.0	0	135	135
***1407.1	0	150	150
1407.7	0	270	270
1408.5	0	470	470
1409.2	0	710	710
1409.5	0	860	860

(1) The discharge capacity is too small. Neglected

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

Method Used: (Emergency Spillway)

Assuming:

a) Critical flow condition at the control section.
b) Approach channel losses equal to 30 percent of the critical velocity head at the control section.

FORMULA:

$\frac{Q^2}{g} = \frac{A^3}{T}$ Design of Small Dams, 1974 Edition, Page 553, Water and Power Resources Service (Formerly USBR).

Q = Discharge in cubic feet per second
A = Cross sectional area in square feet
T = Water surface width in feet
g = Acceleration of gravity in ft/sec

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	*1404.3	47	0	-
0.10	128	1406.2	56	40	-
0.15	192	1406.6	58	81	-
0.20	256	**1407.1	60	150	0
0.25	320	1407.2	60	170	0.1
0.30	384	1407.4	61	217	0.3
0.40	511	1407.8	63	360	0.7
0.50	639	1408.0	64	523	0.9
0.75	959	1408.3	66	930	1.2
1.00	1,278	1408.5	67	1,276	1.4

The percentage of the PMF that will reach the top of the dam is 20 percent.

*Principal spillway crest elevation
**Top of dam elevation

```
A       OVERTOPPING ANALYSIS FOR HILLIARD ESTATES LAKE DAM ( # 9 )
A       STATE ID NO. 20473  COUNTY NAME : GREENE
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   0.086           0.086       1                       1
P      0     26.7     102     120     130
T                                                       -1     -85             0.12
W2  0.15     0.09
X      0     -.1        2
K      1        2                        0       4       1
K1       RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                  1       1
Y1     1                                                47      -1
Y41404.3  1405.4  1406.3  1407.0  1407.1  1407.7  1408.5  1409.2  1409.5
Y5     0        0      47     135     150     270     470     710     860
$S     0        4      29      47      52      60      74     137
$E1383.0  1390.0  1400.0  1404.3  1405.4  1407.1  1410.0  1420.0
$$1404.3
$D1407.1
$L     0        5      20     180     325     330     335     340
$V1407.0  1407.1  1407.4  1407.7  1407.9  1408.5  1409.0  1410.0
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	0.09	1	128.	192.	256.	320.	384.	511.	639.	959.	1278.
	(	0.22)	(	3.62)(	5.43)(	7.24)(	9.05)(	10.86)(	14.48)(	18.10)(	27.15)(	36.20)
ROUTED TO	2	0.09	1	40.	81.	123.	170.	217.	360.	523.	930.	1276.
	(	0.22)	(	1.14)(	2.31)(	3.50)(	4.81)(	6.14)(	10.19)(	14.81)(	26.33)(	36.13)

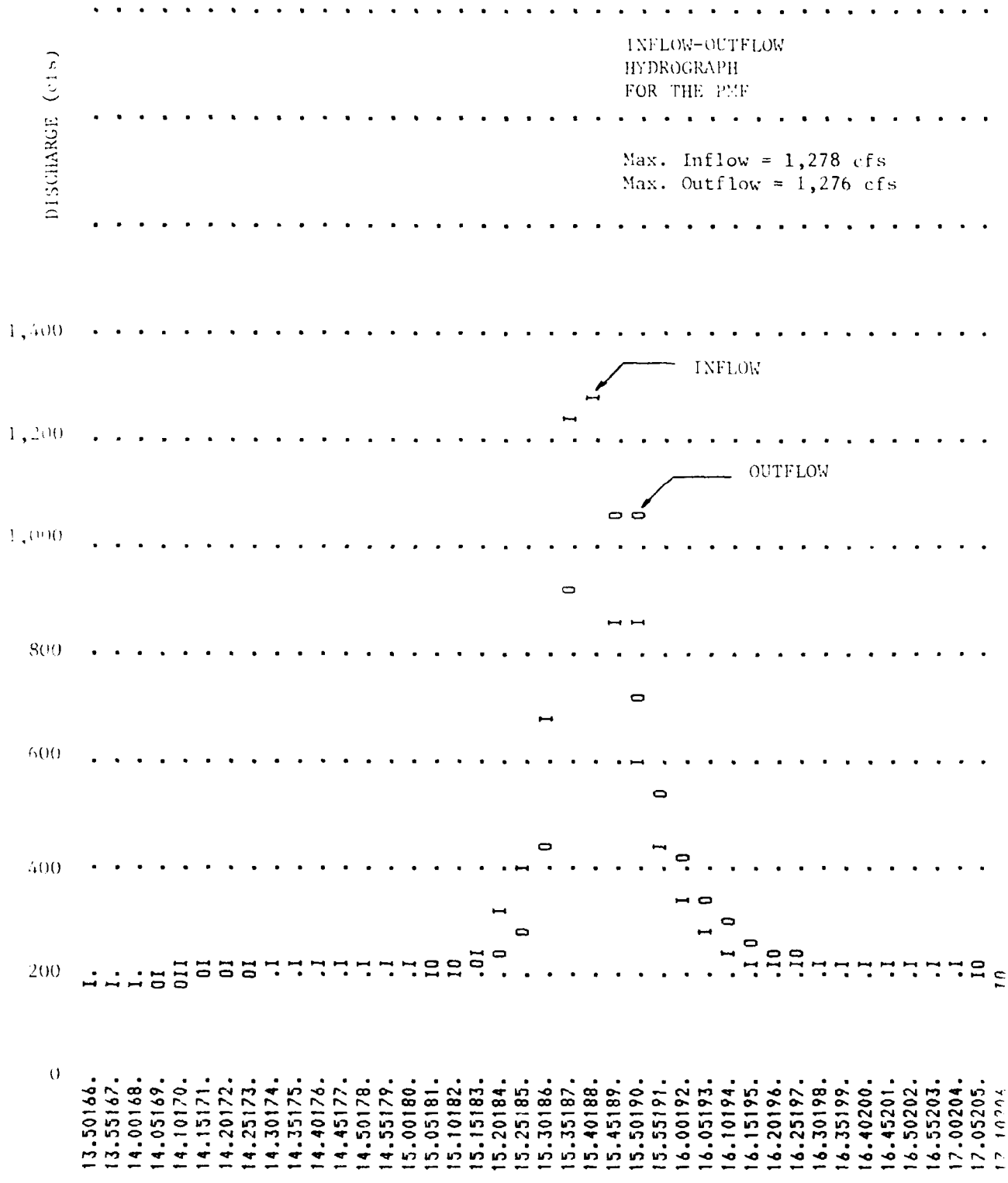
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1404.30	1404.30	1407.10
STORAGE	47.	47.	60.
OUTFLOW	0.	0.	150.

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	1406.17	0.00	56.	40.	0.00	15.92	0.00
0.15	1406.57	0.00	58.	81.	0.00	15.83	0.00
0.20	1406.91	0.00	59.	123.	0.00	15.83	0.00
0.25	1407.19	0.09	60.	170.	0.25	15.83	0.00
0.30	1407.40	0.30	61.	217.	0.50	15.83	0.00
0.40	1407.76	0.66	63.	360.	0.67	15.75	0.00
0.50	1407.95	0.85	64.	523.	0.92	15.75	0.00
0.75	1408.27	1.17	66.	930.	2.75	15.67	0.00
1.00	1408.49	1.40	67.	1276.	4.92	15.67	0.00

PMF RATIOS
OUTPUT DATA


INFLOW-OUTFLOW
HYDROGRAPH
FOR THE PMF
Max. Inflow = 1,278 cfs
Max. Outflow = 1,276 cfs
DISCHARGE (cfs)
1,400
1,200
1,000
800
600
400
200
0
INFLOW
OUTFLOW
TIME (hrs)

LIST OF PHOTOGRAPHS

NO.	DESCRIPTION
1	Aerial View (Looking North)
2	View of reservoir and watershed (Looking East)
3	Crest and upstream face of embankment (Looking North)
4	Crest and upstream face of embankment with emergency spillway in foreground (Looking South)
5	Downstream slope of embankment (Looking Southeast)
6	Principal spillway inlet structure (Looking East)
7	Upstream face and principal spillway inlet structure (Looking North)
8	Principal spillway outlet pipe, note standing water (Looking East)
9	Emergency spillway and spillway inlet channel (Looking East)
10	Emergency spillway and downstream spillway channel, note erosion channels along abutment-embankment contact (Looking Southwest)
11	Emergency spillway downstream channel, note erosion and location of channel adjacent to embankment (Looking North)
12	Roadway embankment and box culvert immediately downstream of dam. Area of standing water is the location of the principal spillway outlet pipe (Looking West)

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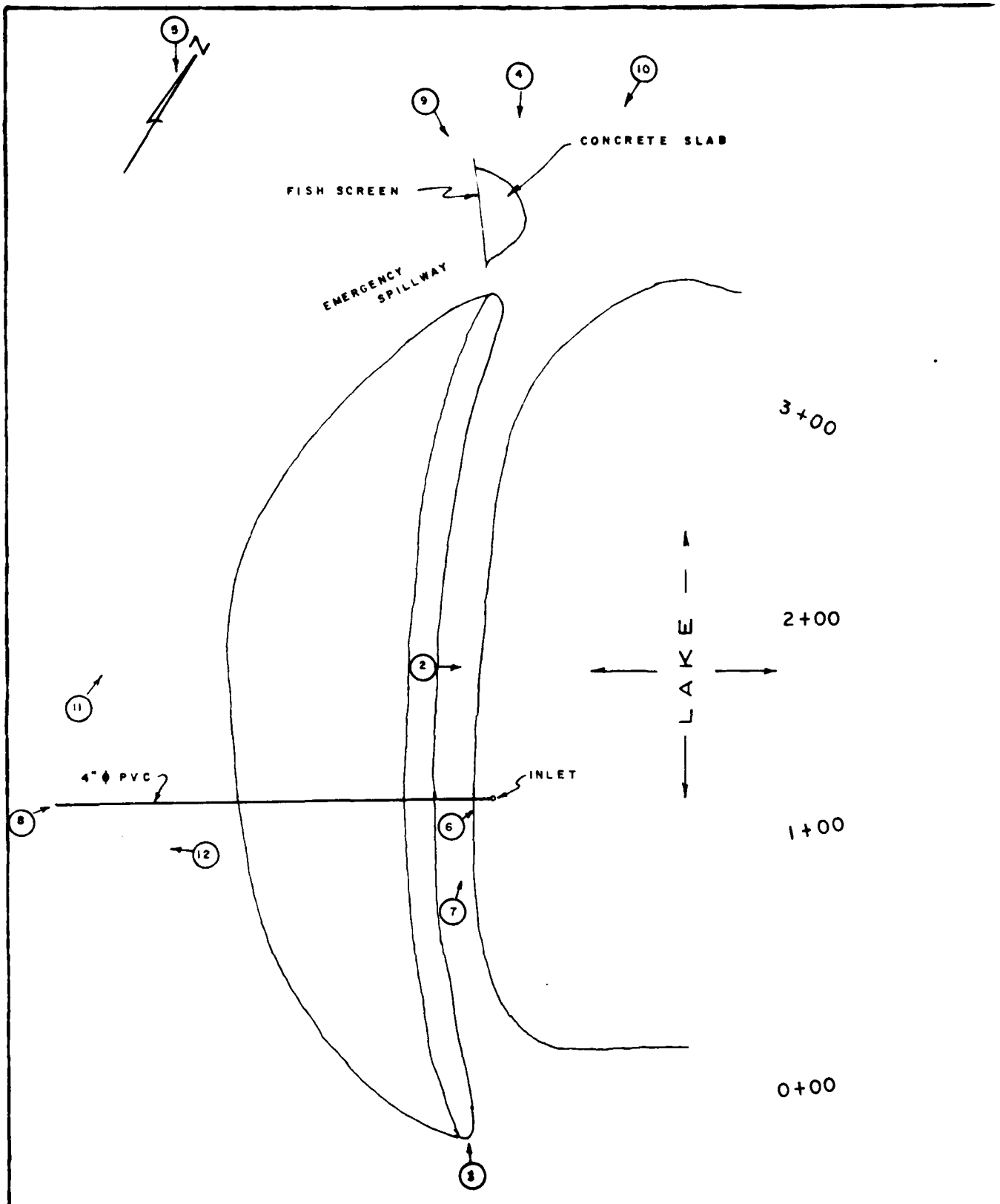


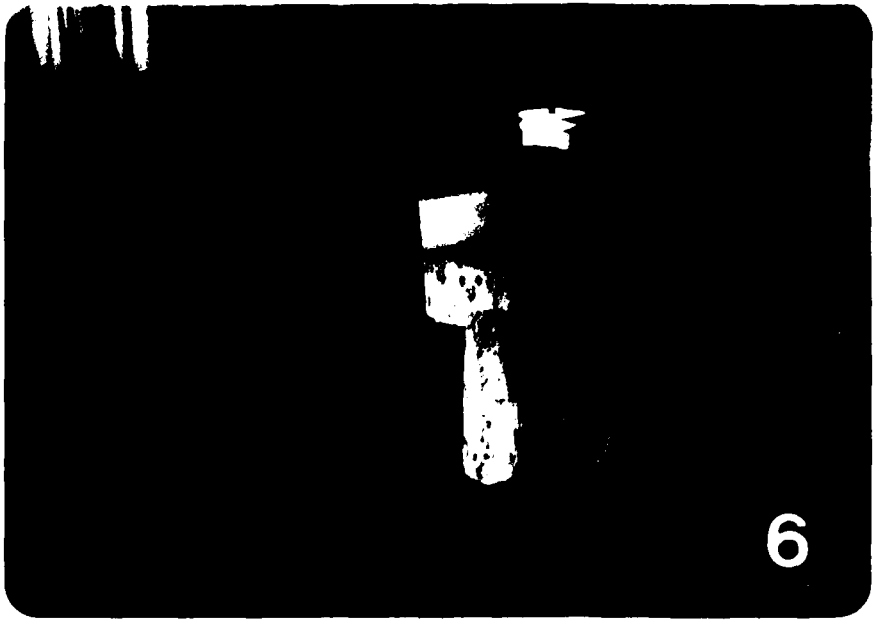
A/E ANDERSON ENGINEERING, INC. 730 N. BENTON AVE. • SPRINGFIELD, MO. 65802	PHOTOGRAPH INDEX HILLIARD ESTATES LAKE DAM GREENE COUNTY, MISSOURI MO. I. D. No. 20473 SHEET 2 , APPENDIX D


2


3


4


5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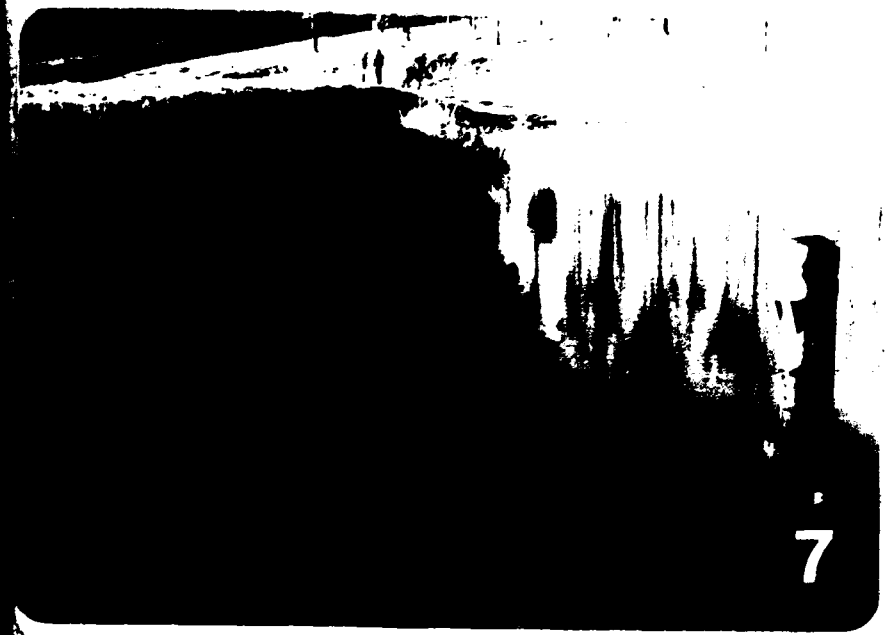
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