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ANDERSON ENGINEERING INC SPRINGFIELD MO

NATIONAL DAM SAFETY PROGRAM, ELLIS LAKE DAM (MO 31067), MISSISS--ETC(U)

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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: Ellis Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Ellis Lake Dam (MO No. 31067).

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. Spillway 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.

SIGNED

24 JUN 1981

SUBMITTED BY:

Chief, Engineering Division

Date

SIGNED

APPROVED BY:

Colonel, CE, Commanding

30 JUN 1981

Date

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MISSISSIPPI-KASKASKIA-ST. LOUIS RIVER BASIN

ELLIS LAKE DAM

PERRY COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31067

PHASE 1 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 1 REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam: Ellis Lake Dam
State Located: Missouri
County Located: Perry
Stream: Tributary of Blue Spring Branch
Date of Inspection: 19 December 1980

Ellis 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 the 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.

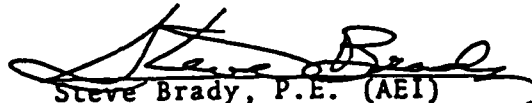
The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis 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 an 8 acre lake immediately downstream (MO I. D. No. 31066), the city of Lithium (eight dwellings), and a dwelling and two trailers (1 to 1.5 miles downstream). The existence of these downstream features was verified during the field inspection and at the time the aerial photographs were taken. 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 indicates 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 and the small storage capacity, 50 percent of the

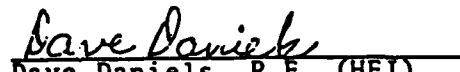
PMF has been determined to be the appropriate spillway design flood. The 1 percent probability flood will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being exceeded in any given year.

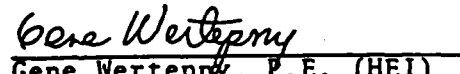
Deficiencies visually observed by the inspection team were: (1) a few small trees on the upstream face; (2) a lack of wave protection on the upstream face; (3) a few small animal holes on the upstream face; (4) erosion gullies on the downstream face and at the downstream dam-abutment contacts; and (5) erosion at the end of the emergency spillway channel. Another deficiency was the lack of seepage and stability analysis records.

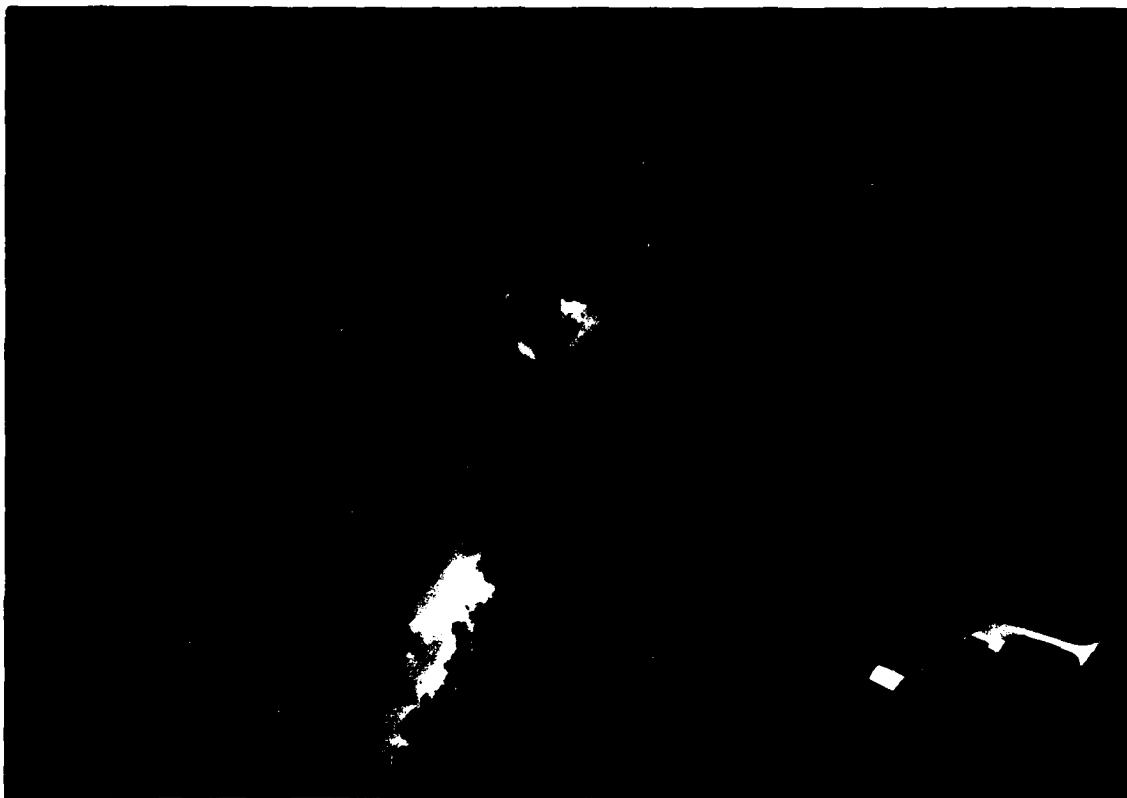
It is recommended that the owners take the necessary action promptly to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.


Steve Brady, P.E. (AEI)


Tom Beckley, P.E. (AEI)


Dave Daniels, P.E. (HEI)


Gene Wertepny, P.E. (HEI)



AERIAL VIEW OF LAKE AND DAM

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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 Ellis Lake Dam in Perry 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:

Ellis Lake Dam is an earth and rock fill structure approximately 28 ft high and 325 ft long at the crest. In this report, right and left orientation is based on looking in the downstream direction. The appurtenant works consist of an 8 1/2 in. diameter steel pipe through the dam at Station 2+00 (principal spillway) and an earth cut swale emergency spillway in the left abutment.

B. Location:

The dam is located in the northwest part of Perry County, Missouri on a tributary of Blue Spring Branch. The dam and lake are within the Lithium, Missouri 7.5 minute quadrangle sheet (Section 14, T36N,

R10E-latitude 37 deg. 49.4 min. , longitude 89 deg. 53.6 min.). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 28 ft and a maximum storage capacity of approximately 71 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 an 8 acre lake immediately downstream (MO I.D. No. 31066), the city of Lithium (eight dwellings - .5 miles), and a dwelling and two trailers (1 to 1.5 miles downstream). The existence of these downstream features was verified during the field inspection and at the time the aerial photographs were taken.

E. Ownership:

The dam is owned by Harold Ellis. The owner's address is Highway M, Lithium Missouri, 63775 (telephone:314-547-6814).

F. Purpose of Dam:

The dam was constructed primarily for recreation.

G. Design and Construction History:

The dam was built in 1973 by Dippold Construction Company of Perryville, Missouri. The Soil Conservation Service provided design assistance and had personnel on site periodically during construction. The owner indicated that borrow was obtained from the right upland area and from the lake area. He indicated that a cutoff was incorporated under the dam, which extended to bedrock. No modifications have been made to the dam.

In 1974, water from the lake leaked out through a sinkhole located in a small creek channel directly upstream of the northwest abutment of the dam (see Sheet 5 of Appendix A and Photo No. 16). An investigation was made by personnel of the Office of the State Geologist and a report with recommendations was written (see Sheet 6 of Appendix B. The owner indicated that the sinkhole was filled with about 2 cubic yards of concrete and did not leak after this was done.

H. Normal Operating Procedures:

Normal flows are discharged by uncontrolled spillways. There are no draindown facilities. The owner reported that the highest water level occurred in 1974 when the water level was 6 in. above the emergency spillway crest.

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 USGS quad sheet, is approximately 143 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. 432): 150 cfs
- (3) Estimated Capacity of Primary Spillway: 4 cfs
- (4) Estimated Experienced Maximum Flood at Dam Site: 20 cfs
- (5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable
- (6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable
- (7) Gated Spillway Capacity at Pool Elevation: Not Applicable
- (8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed mean sea level elevation of 427.8 for the top of the principal spillway pipe inlet (estimated from quadrangle map).

- (1) Top of Dam: 432
- (2) Principal Spillway Crest: 427

- (3) Emergency Spillway Crest: 430.2
- (4) Principal Outlet Pipe Invert: 408.8
- (5) Streambed at Centerline of Dam: 404.2
- (6) Pool on Date of Inspection: 426.2
- (7) Apparent High Water Mark: Not Evident
- (8) Maximum Tailwater: Unknown
- (9) Upstream Portal Invert Diversion Tunnel: Not Applicable
- (10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

- (1) At Principal Spillway Crest: 900 ft
- (2) At Top of Dam: 1,100 ft
- (3) At Emergency Spillway Crest: 1,020 ft

E. Storage Capacities:

- (1) At Principal Spillway Crest: 45 acre-ft
- (2) At Top of Dam: 71 acre-ft
- (3) At Emergency Spillway Crest: 59 acre-ft

F. Reservoir Surface Areas:

- (1) At Principal Spillway Crest: 4 acres
- (2) At Top of Dam: 7.3 acres
- (3) At Emergency Spillway Crest: 5.9

G. Dam:

- (1) Type: Earth
- (2) Length at Crest: 325 ft
- (3) Height: 28 ft

- (4) Top Width: 12 ft
- (5) Side Slopes: Upstream 3.4H:1V, Downstream 3.3H:1V (Avg)
- (6) Zoning: None
- (7) Impervious Core: None
- (8) Cutoff: To Bedrock
- (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: None

I. Spillway:

I.1 Principal Spillway:

- (1) Location: Station 2+00
- (2) Type: 8 1/2 in. diameter steel pipe

I.2 Emergency Spillway:

- (1) Location: Left Abutment
- (2) Type: Earth Cut Swale

J. Regulating Outlets:

There are no regulating outlets.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

Design information provided by the Soil Conservation Service included the drainage area, storage data above normal pool, a typical section of the dam and principal spillway, and a preliminary geologic report (Sheets 4 and 5 of Appendix B). A geological report regarding a sinkhole leakage problem was provided by the Office of the State Geologist (Sheet 6 of Appendix B).

A. Surveys:

Surveys were made by SCS previous to construction for the purpose of obtaining storage and embankment quantities. Sheet 3 of Appendix A presents a plan, profile, and cross section of the dam from survey data obtained during our site inspection. Sheet 4 of Appendix A shows a section and profile of the emergency spillway. The top of the entrance to the principal spillway pipe was used as a reference point to determine all other elevations. It is estimated that this site datum corresponds to mean sea level (MSL) elevation 427.8 (estimated from quad sheet).

B. Geology and Subsurface Materials:

The site is located in the east-central portion of the Ozarks geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus, and deep valleys. The most common bedrock types are dolomite, sandstone, and chert. The "Geologic Map of Missouri" indicates that the bedrock in the site area consists of the Joachim Formation. The Joachim is predominantly a yellowish-brown, argillaceous dolomite which contains limestone and shale in its lower part. As indicated by the SCS geologic report (Sheets 4 and 5 of Appendix B), there are numerous sinkholes in the area.

The "Geologic Map of Missouri" indicates several normal faults passing just north of the site in an east-west direction. It should also be noted that the site is located in seismic zone 2 (moderate damage zone) but is near the boundary of zone 3 (major damage zone - see Sheet 3 of Appendix B).

Soil overburden in the area of the dam would be expected to be at least 10 ft thick in upland areas. The soils are of the Memphis-Loring Soil Association and have developed from fairly thick loess deposits.

Auger probes in the embankment indicate the soils to be brown clayey silts (ML-CL).

C. Foundation and Embankment Design:

No foundation or embankment design information was available. Seepage and stability analyses required by the guidelines were not available. The owner indicated that borrow for the dam was obtained from the right abutment and upland area and from the lake area. He indicated that a cutoff was incorporated, and that it extended to bedrock.

D. Hydrology and Hydraulics:

Hydrology and hydraulics information as listed in Section 2.1 was obtained from SCS. This information was incorporated into our analyses. Based on this information, a field check of spillway dimensions and embankment elevations, and a check of the drainage area on the USGS quad sheet, hydrologic analyses using U.S. Army Corps of Engineers guidelines were performed and appear in Appendix C.

E. Structure:

The only appurtenant structure associated with this dam is the spillway pipe. There are no other structures.

2.2 CONSTRUCTION:

The owner indicated that SCS personnel were on site periodically during construction. However, no inspection data were available.

2.3 OPERATION:

Normal flows are passed by uncontrolled spillways. There are no operating facilities.

2.4 EVALUATION:

A. Availability:

The engineering data available are as listed in Section 2.1. No seepage or stability analyses or construction test data were 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 19 December 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:

Steve Brady - Anderson Engineering, Inc. (Civil Engineer)
Tom Beckley - Anderson Engineering, Inc. (Civil Engineer)
Gene Wertepny - Hanson Engineers, Inc. (Hydraulic Engineer)
Dave Daniels - Hanson Engineers, Inc. (Geotechnical Engineer)

The owner, Mr. Harold Ellis, also accompanied the inspection team. Photographs of the dam, appurtenant structures, reservoir, and downstream features are presented in Appendix D.

B. Dam:

The dam appears to be in fair condition. There are a few small trees on the upstream face, particularly on the left side of the dam. There is no wave protection, but no significant sloughing was observed. A few small animal holes were noted (see Photo No. 4).

The crest of the dam is clear and grass covered. It appeared fairly uniform both vertically and horizontally, and no cracking or unusual movement was observed (see Photo No. 3). The downstream face was fairly clear of trees and brush, except for a small patch of brush in the center near the toe. There was fairly significant erosion of the downstream face, but no sloughing or animal holes were noted (see Photo No. 5). Fairly significant erosion was noted at both downstream contacts of the dam and abutments. Erosion gullies were several feet deep and several feet wide (see Photo No. 6). A small area of marsh vegetation was noted near the toe at the center of the dam. The area was soft but no standing or flowing water was observed. This may just be an area of poor surface drainage and may not reflect seepage from the lake (see Photo No. 7).

C. Appurtenant Structures:

C.1 Principal Spillway:

The principal spillway is an 8 1/2 in. diameter steel pipe (through the dam) with a hooded inlet (see Photo No. 8). The SCS plans indicate that two 4 ft by 4 ft antiseep collars were to be placed at the upper end of the pipe. There was no trash rack on the inlet of the pipe. The spillway pipe outlets into a plunge pool at the headwaters of the downstream lake (see Photos 9 and 10). The pipe appeared to be in reasonably good condition. There are no draindown facilities for this dam.

C.2 Emergency Spillway:

The emergency spillway is a trapezoidal earth cut in the left abutment. There is no permanent control section for the spillway. The spillway is clear except for a few small trees in the approach area. Flows are directed by an earth berm on the right side. There is no significant erosion in the spillway channel except at the downstream end of the berm where discharges turn toward the dam (see Photos 11, 12, and 13).

D. Reservoir:

The watershed is approximately 78 percent pasture, 18 percent wooded, and 4 percent lake area. The topography is rolling with moderate slopes and sinkholes. The slopes adjacent to the lake are moderate, and no sloughing or serious erosion was noted. No significant sedimentation was observed.

E. Downstream Channel:

The spillways discharge into a downstream lake (MO I.D. No. 31066).

3.2 EVALUATION:

Trees and brush on the dam constitute a potential seepage hazard and encourage animal burrowing if the trees are allowed to get larger. Animal holes should be filled. There is no wave protection provided for the upstream face of the dam. Eroded areas on the dam and at the dam-abutment contacts should be repaired and maintained. It is recommended that the berm on the right side of the emergency spillway be lengthened so that flows are directed away from the toe of the dam and into the downstream lake. The area of marsh vegetation near the downstream toe should be monitored to be sure that this is not the result of seepage under the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

We are not aware of any operational procedures. The pool is normally controlled by rainfall, runoff, evaporation, and the capacity of the uncontrolled spillways.

4.2 MAINTENANCE OF DAM:

Some maintenance of the dam is apparently done. The dam is fairly clear of trees and brush.

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 small amount of brush and small trees on the dam, the animal holes, the lack of riprap, and the eroded areas are deficiencies which could become serious if not corrected. A program of regular maintenance of the dam should be established.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

The hydrologic and hydraulic design data for this dam were listed in Section 2.1. The Soil Conservation Service aided in the design. The principal spillway was originally designed for the 10 yr. frequency storm, and the emergency spillway was designed for the 25 yr. frequency storm.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this lake and watershed. The owner of the dam indicated that the highest water level occurred in 1974 when the water level was 6 in. above the crest of the emergency spillway.

C. Visual Observations:

The principal spillway pipe appears in good condition. The emergency spillway is fairly clear of trees and brush and has experienced little erosion except at the downstream end beyond the end of the earth berm. At this location, there is significant erosion where flows apparently turn toward the top of the dam. It is recommended that the berm be extended to direct flows away from the dam.

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 elevation, and (2) an estimate of the reservoir storage and the pool and drainage areas from the Lithium Missouri, 7.5 minute USGS quad sheet, and (3) storage and drainage area data provided by SCS.

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 small storage capacity and low height of the dam, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The spillways will pass the 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 3,180 cfs. For 50 percent of the PMP, the peak inflow was 1,590 cfs.

The routing of the PMF through the spillways and dam indicates that the dam will be overtopped by 2.4 ft at elevation 434.4. The duration of the overtopping will be 7.0 hours, and the maximum outflow will be 2,950 cfs. The maximum discharge capacity of the spillways is 150 cfs. The routing of 50 percent of the PMF indicates that the dam will be overtopped by 1.6 ft at elevation 433.6. The maximum outflow will be 1,330 cfs, and the duration of overtopping will be 5.3 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 3.1 B 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:

There have been no modifications to the dam.

E. Seismic Stability:

The structure is located in seismic zone 2. 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 generally in fair condition. Several items were noted during the visual inspection which should be investigated further, corrected, or controlled. These items are: (1) a few small trees on the upstream face; (2) a lack of wave protection on the upstream face; (3) a few small animal holes on the upstream face; (4) erosion gullies on the downstream face and at the downstream dam-abutment contacts; and (5) erosion at the end of the emergency spillway channel.

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 7.1.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 7.2.A should be pursued promptly.

D. Necessity for Additional Inspection:

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

E. Seismic Stability:

The structure is located in seismic zone 2. 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 and M Procedures:

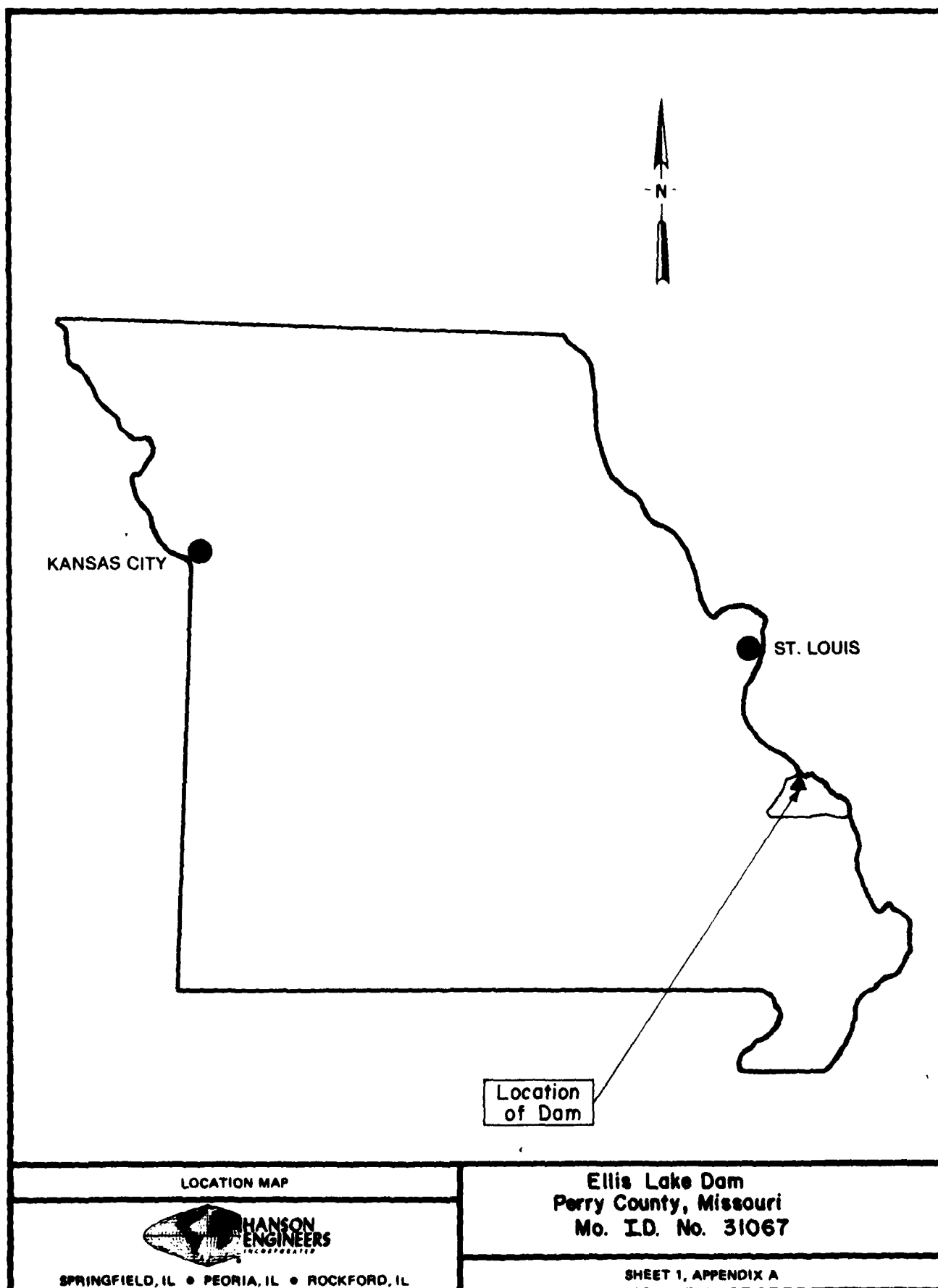
- (1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.
- (2) The minor tree and brush growth should be cut periodically.
- (3) Wave protection should be provided for the upstream face of the dam.
- (4) Animal holes on the upstream face should be filled.
- (5) Eroded areas on the dam and at the dam-abutment contacts should be repaired and maintained.
- (6) The marsh area at the downstream toe should be monitored to be sure this is not seepage under the dam.
- (7) It is recommended that the berm on the right side of the

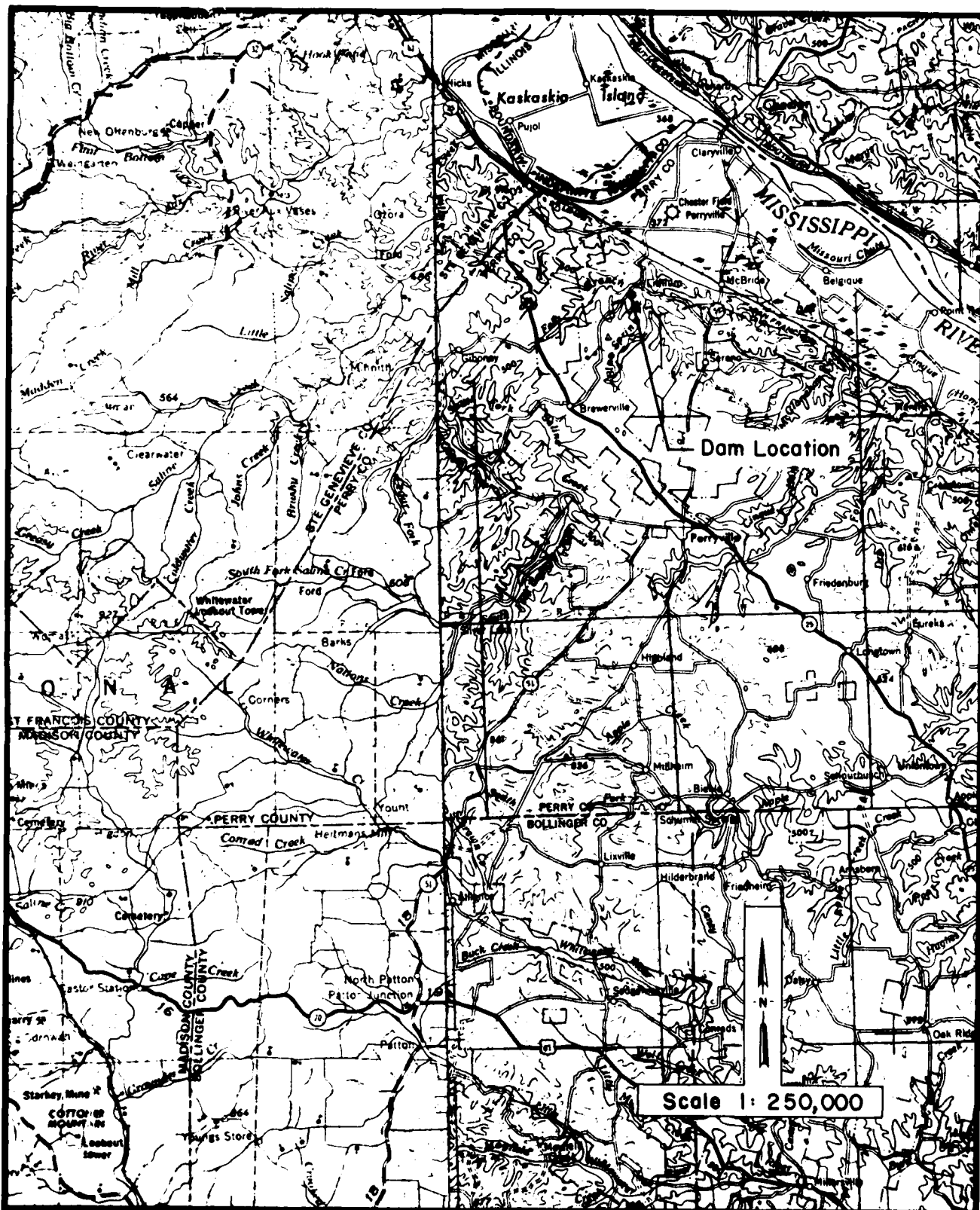
emergency spillway be extended downstream to direct flows away from the dam and into the downstream lake.

- (8) A program of regular maintenance of the dam should be established.
- (9) 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





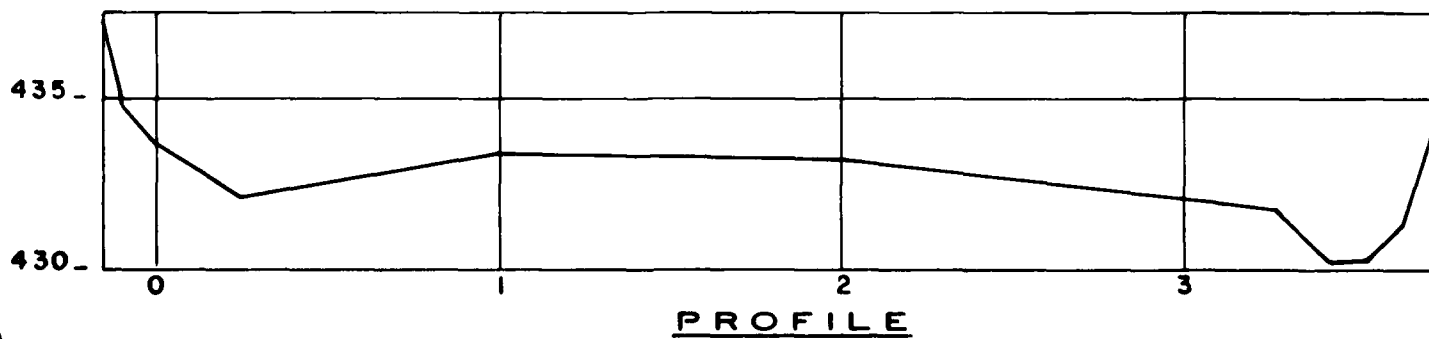
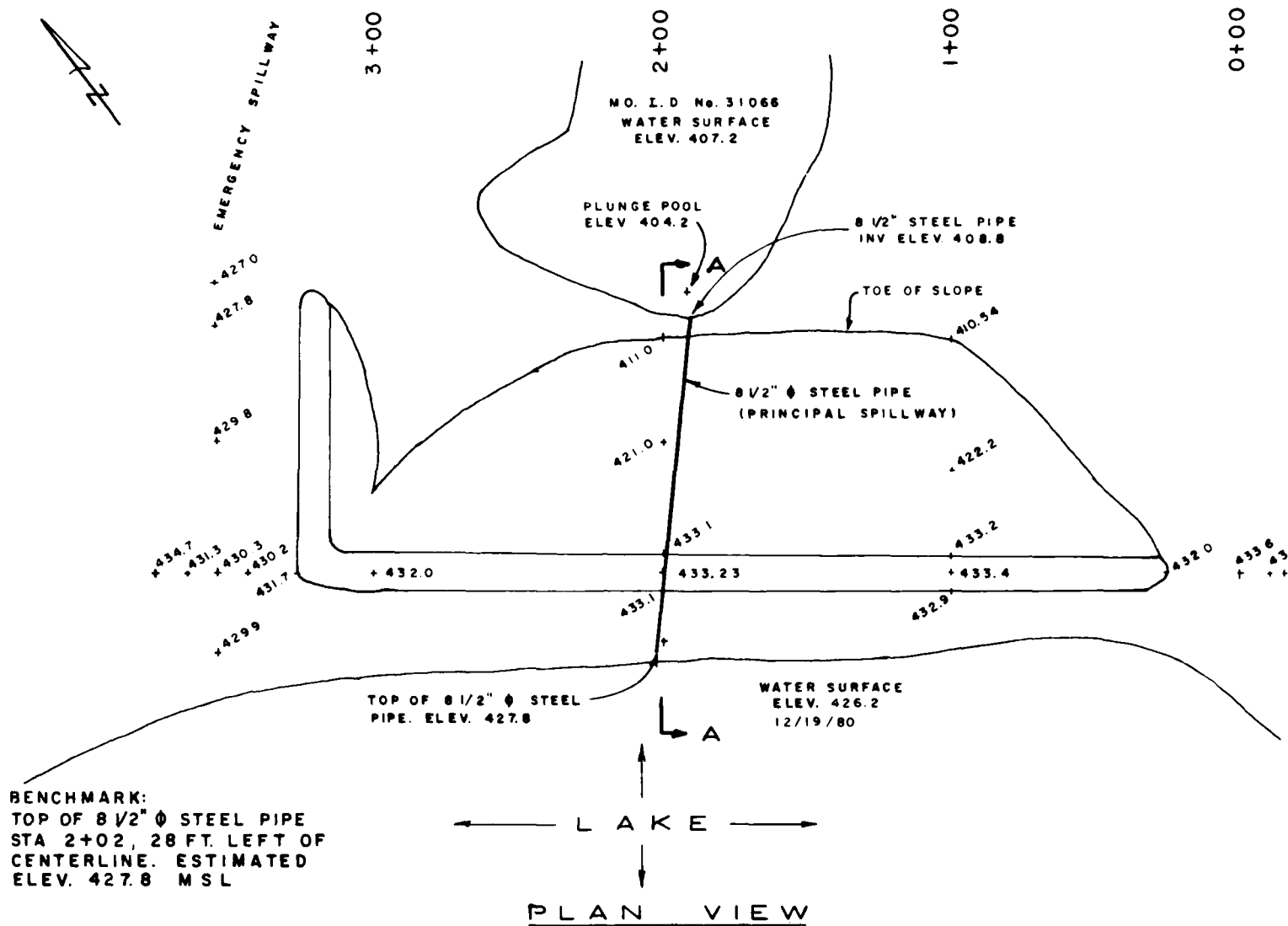
VICINITY MAP



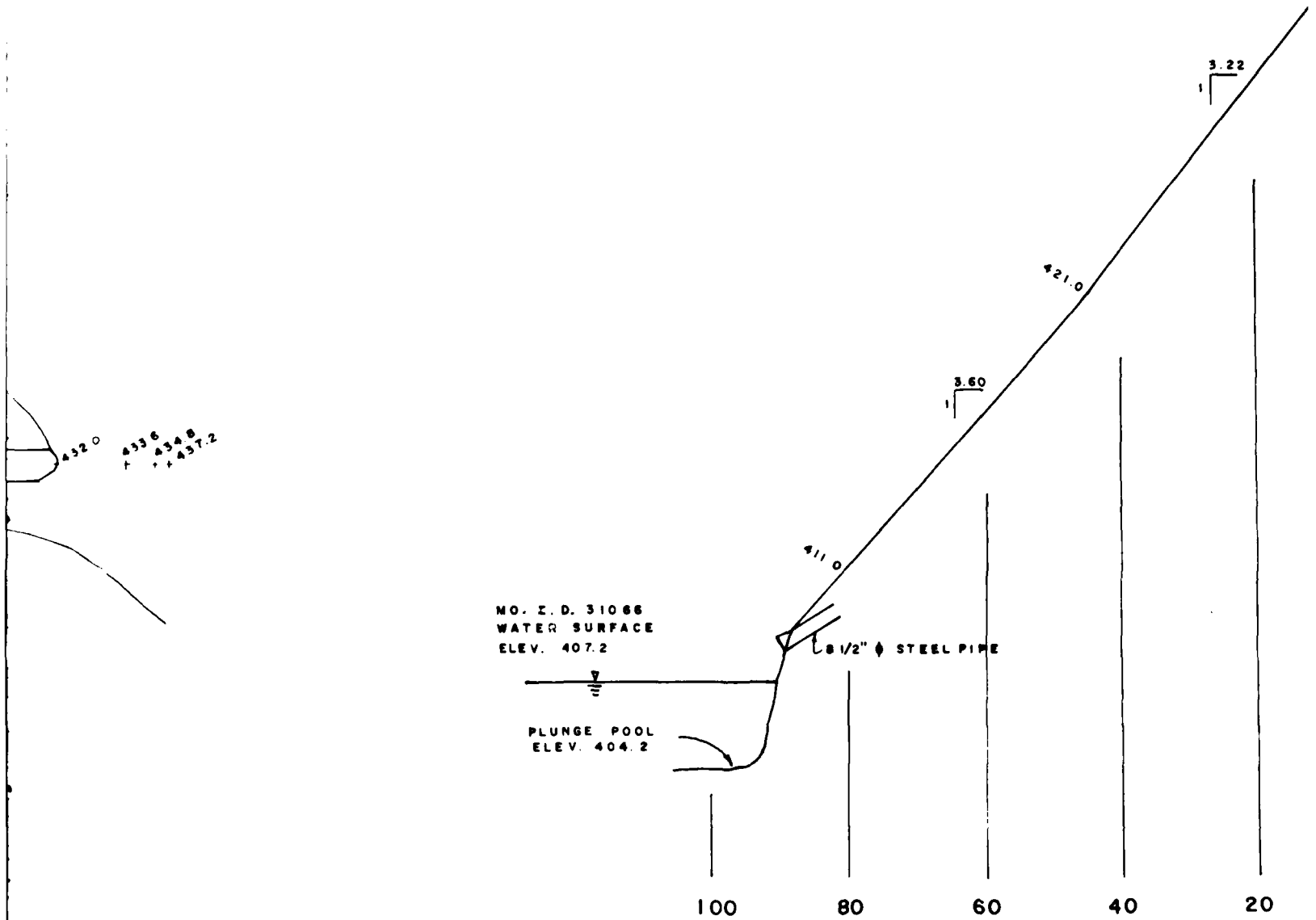
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Ellis Lake Dam
Perry County, Missouri
Mo. I.D. No. 31067

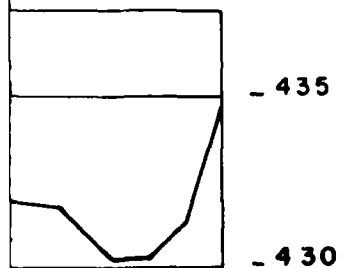
Sheet 2, Appendix A



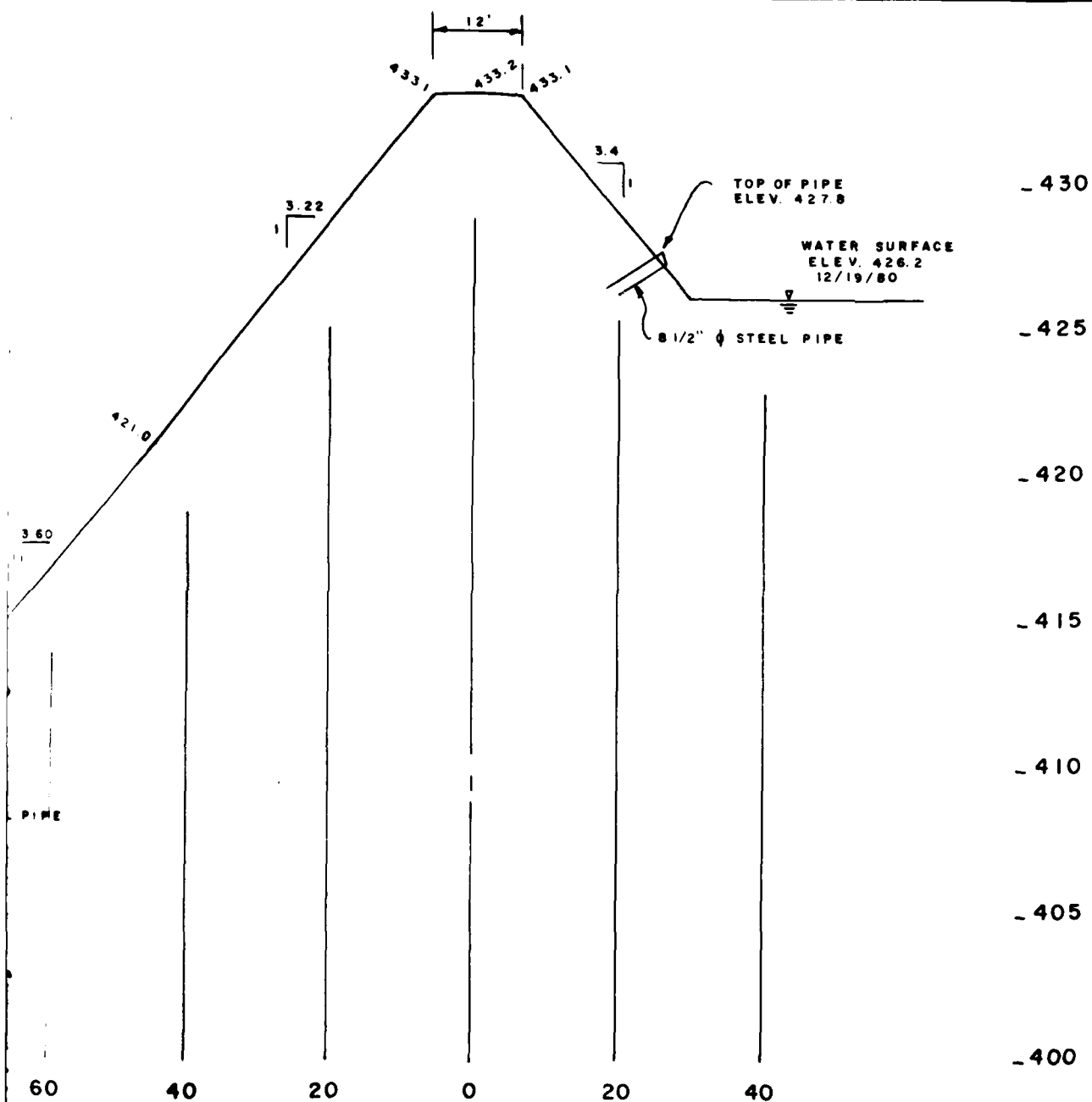
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SECTION A -



2



SECTION A-A STA 2+00

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ELLIS LAKE DAM

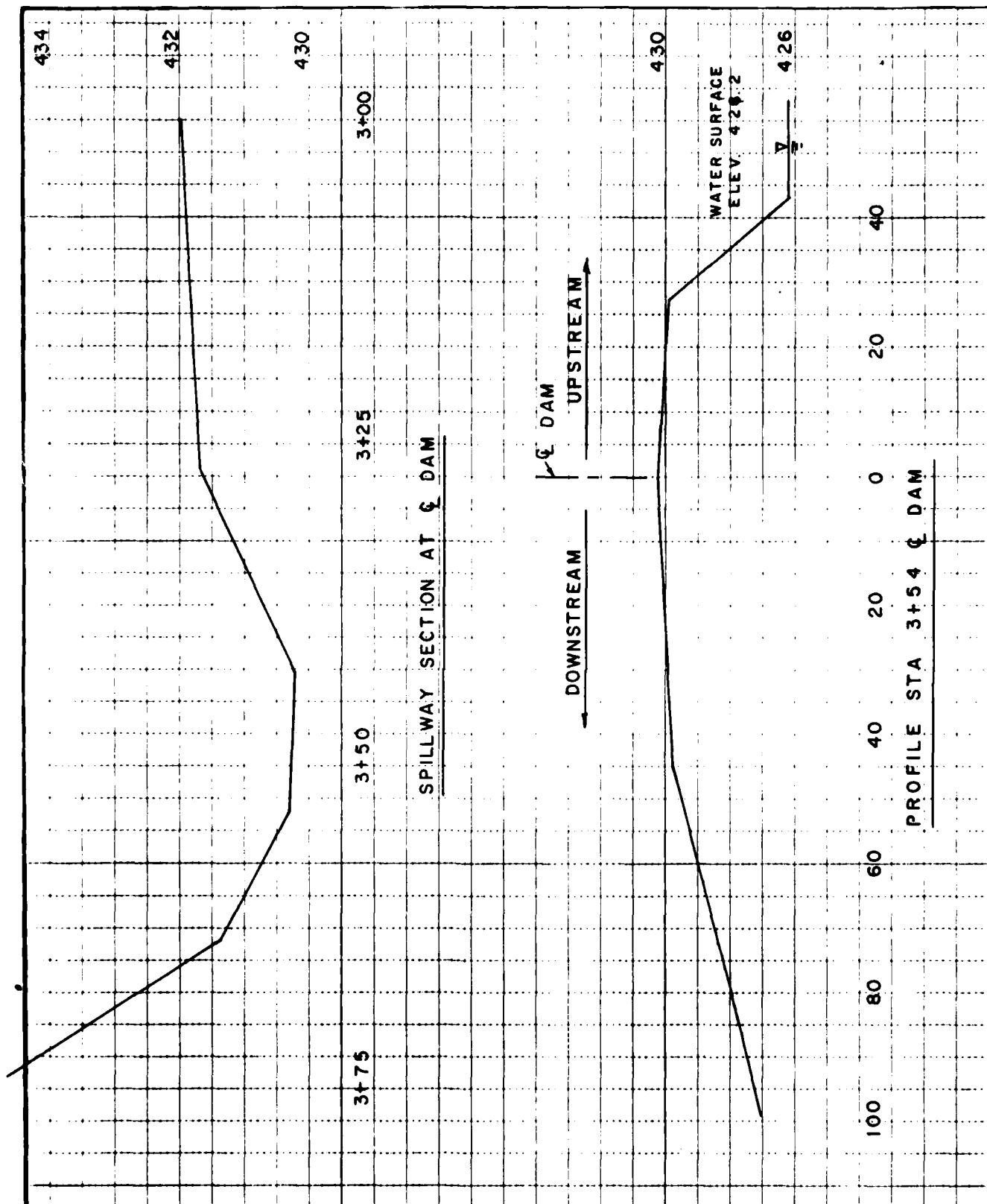
MO. No. 31067

PLAN, PROFILE & SECTION

PERRY COUNTY, MO.

SHEET 3, APPENDIX A

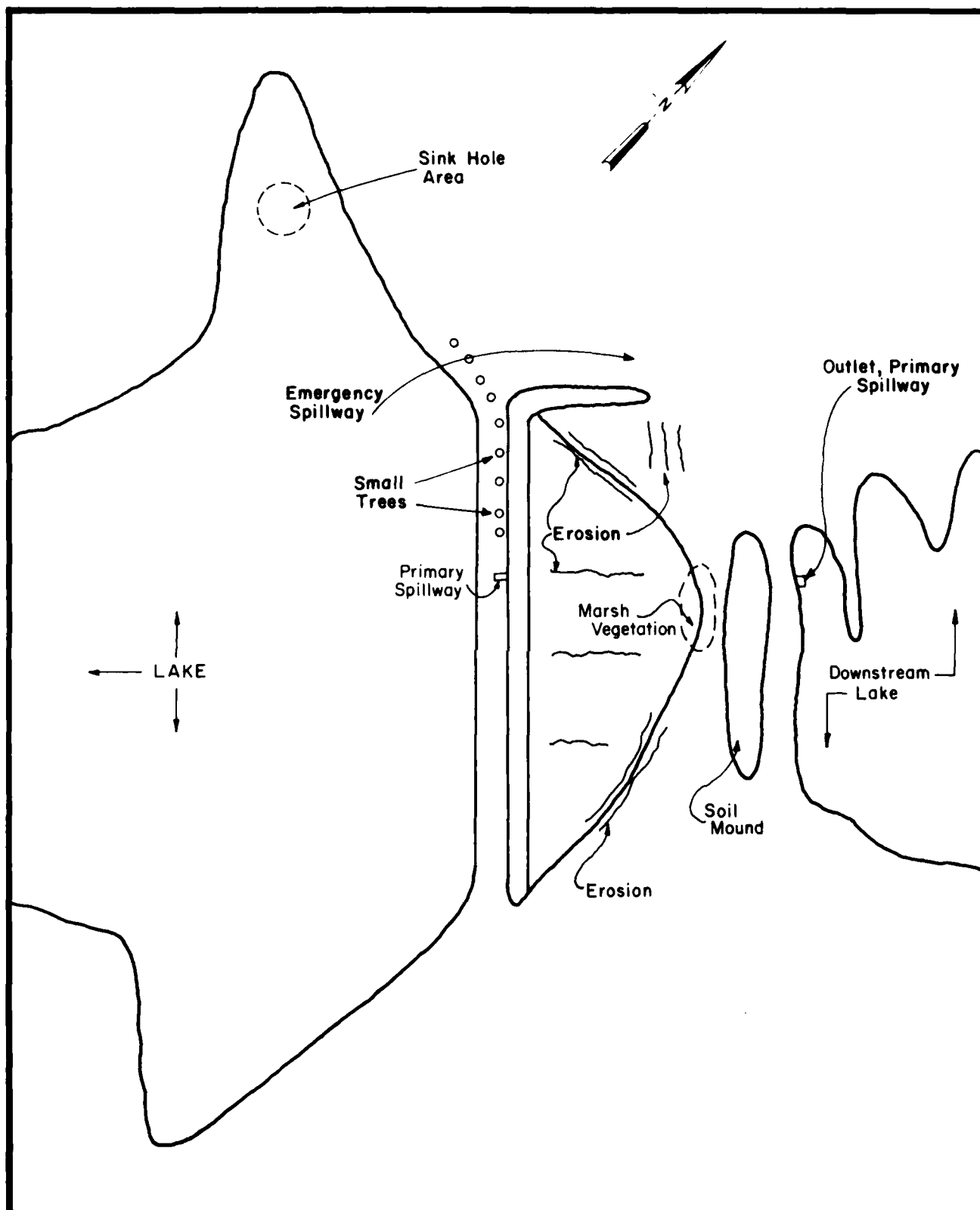
3



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ELLIS LAKE DAM
PERRY COUNTY, MISSOURI
MO. I. D. No. 30563
EMERGENCY SPILLWAY
SECTION AND PROFILE

SHEET 4 , APPENDIX A



PLAN SKETCH OF FEATURES



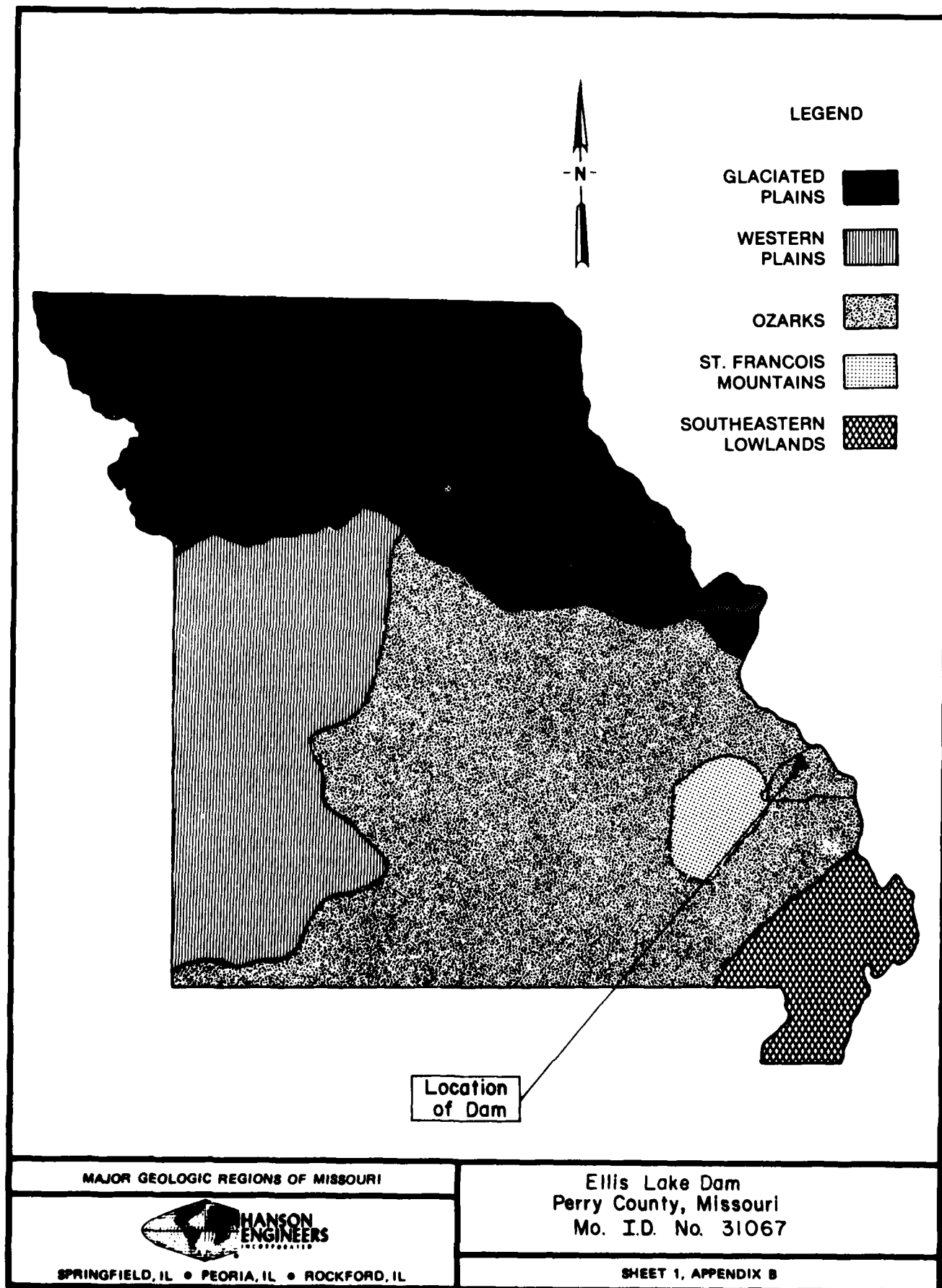
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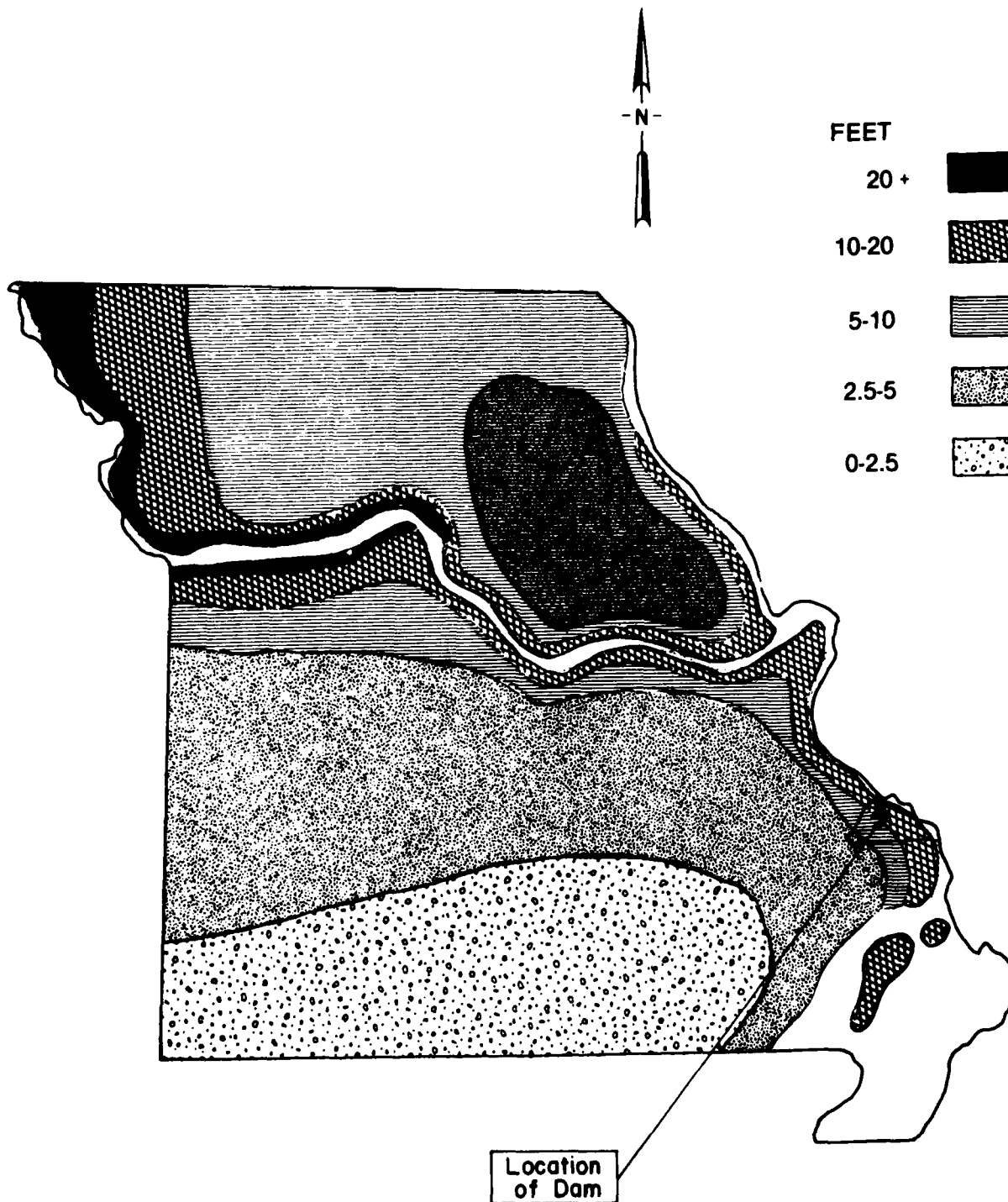
Ellis Lake Dam
Perry County, Missouri
Mo. I.D. No. 31067

Sheet 5, Appendix A

APPENDIX B

Geology and Soils





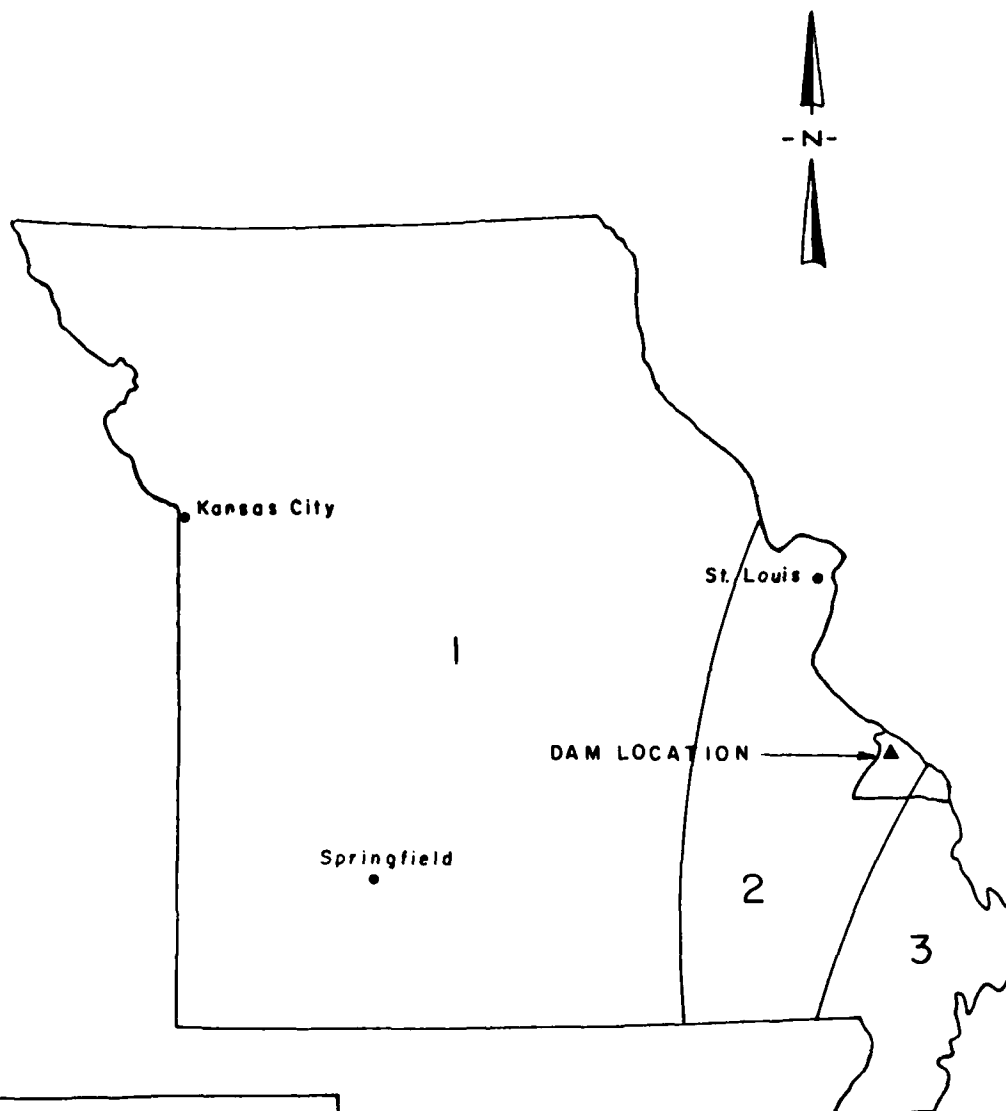
THICKNESS OF LOESSIAL DEPOSITS



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Ellis Lake Dam
Perry County, Missouri
Mo. I.D. No. 31067

SHEET 2, APPENDIX B



SEISMIC PROBABILITY	
ZONE	DAMAGE
1	MINOR
2	MODERATE
3	MAJOR

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SEISMIC ZONE MAP

ELLIS LAKE DAM
PERRY COUNTY, MISSOURI
MO. I. D. No. 31067

SHEET 3 , APPENDIX B

PRELIMINARY GEOLOGIC INVESTIGATION
OF DAM SITES

Watershed _____ Subwatershed _____ Site no. _____ County Perry State Missouri
Location NE 1/4, SE 1/4, Sec 14, 36 N, 10 E Site group III Structure class a Fund class 01
Nearest post office Perryville, Missouri Landowner/operator H. Ellis
Drainage area: _____ sq. mi. 120 acres. Purpose(s) of structure Farm Pond
Embankment: Length 200 ft. Height 25 ft. Cubic yards 400 Est. storage capacity 20 ac. ft.
This investigation made by: Inspection of surface XXX Hand auger _____ Test pits _____ Other(specify) _____
Investigated by: Michael J. Johnson, Geologist 1/18/72
Signature and Title Date

GENERAL GEOLOGY

Physiographic description Mississippi Valley Wooded Slopes Geologic formation(s) Joachim
Dolomite Attitude: Strike _____ Dip _____
Direction of valley axis (downstream) NE Steepness of abutments: Left _____ percent, Right _____ percent
Material of abutment and valley walls Shallow residium on the lower slopes with loess covered
upper slopes and ridges.
Surficial deposits Alluvium on the valley floor.
Faults, folds, joints, caverns and slide areas (describe briefly): Sinkholes are numerous in the drainage area,
some on the valley floor near the proposed dam site, solution enlargement of
joints and bedding planes.
Depths to and kind of rock in foundation Rock outcrops in the channel not determined on the abutments.
Depth to groundwater _____ Date measured _____
Leakage problems See narrative.

EMERGENCY SPILLWAY

Best location: Left abutment _____ Right abutment _____ Other _____
Estimated excavation: Volume _____ yds.; Percent rock _____; Suitable for fill? _____ Type _____
Erodibility of control section _____ Erodibility of exit channel _____
(high, medium, low or very low) (high, medium, low or very low)

STREAM OR OUTLET CHANNEL

Description: width _____ ft.; Depth _____ ft.; Bed material _____ *D _____ Size of bed material _____ in.
Channel: Scouring _____ Aggrading _____ Stable _____; Banks: Eroding _____ Stable _____

* Insert 50 or 75

(continued on reverse side)

Summary of Findings, Interpretations & Conclusions

Bedrock outcrops in the channel and is expected to occur at shallow depths on the steeper right abutment. Bedrock across the valley floor to the left of the channel should be about the same elevation as the bedrock in the channel. The left abutment is covered with clay over burden 10 feet or more in depth. There is a small spring upstream which is believed to be within the pool area.

The presence of extensive sinkhole development in this area, within the drainage area and at the site makes this setting appear extremely hazardous for water impoundment. However, there is a successful lake just down stream. The geologic setting is similar except the higher ground water levels at the lower site due to the influence in the alluvium from Blue Spring Branch and Falls Creek. If this site is considered further, the following precautions should be taken.

1. Move the dam site upstream from the area where sinkholes are now present. Engineering aspects will determine the exact location.
2. If bedrock is encountered in the core trench excavations on the right abutment, careful evaluation should be made at the time and remedial measures taken to prevent leakage and protect the embankment. These might include setting the core into bedrock, use of dental grout or cement slurry, etc.
3. Pad the channel and any other rock exposed on the right slope, or uncovered in clearing, etc.
4. Borrow may be taken from the left slope but care should be taken to leave an adequate pad over rock.

It should be emphasized that if failure should occur it will be through the opening of solution enlarged joints or sinkholes in the bedrock. Correcting will be expensive, difficult, or impossible.

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GEOLOGICAL REPORT ON THE ELLIS LAKE SITE

Perry County, Missouri

LOCATION: SW $\frac{1}{4}$, NE $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 14, T.36N., R.10E., Lithium Quadrangle

This lake was already constructed at the time of this inspection. Personnel from the Soil Conservation Service in Perryville accompanied me on the inspection.

The water level had dropped several feet before inspection was made. An open hole was noticed in the small creek channel directly upstream of the northwest abutment of the dam. The hole, about 12 inches in diameter, looks like the remnants of an old sink. Bedrock exposed near the sink consists of weathered limestone. This same limestone is exposed in the bottom of the small creek upstream of the opening. The limestone contained clay filled joints that were at least 16 inches in width. The extensive weathering of the bedrock around the hole would indicate that the opening is a sink.

The water level of the lake is at approximately the same level as the sink opening. It appeared that the lake water ran into the opening until the level dropped to the same elevation as that of the opening and is not flowing into the opening now.

RECOMMENDATIONS:

1) The lake water level should be observed for at least a week to see if it maintains its present level. If there are other openings within the lake basin, the water level will continue to drop. If the sink is the only opening where there is water loss, the level should become fairly stable.

2) A tractor-mounted backhoe should be obtained and the sink opening cleaned out as far as the backhoe can reach.

3) The tunnel through which water moves within the sink should not be blocked. The tunnel should be left open so water can move through it and the sink throat filled with gravel. The gravel should vary in size from coarse gravel at the base and gradually be brought up to fine gravel. The top 3 to 4 feet of the sink should be covered with compacted clay to prevent further leakage.

The enclosed article illustrates the sealing of the sink.

Cpy: SCS, Perryville, Mo.

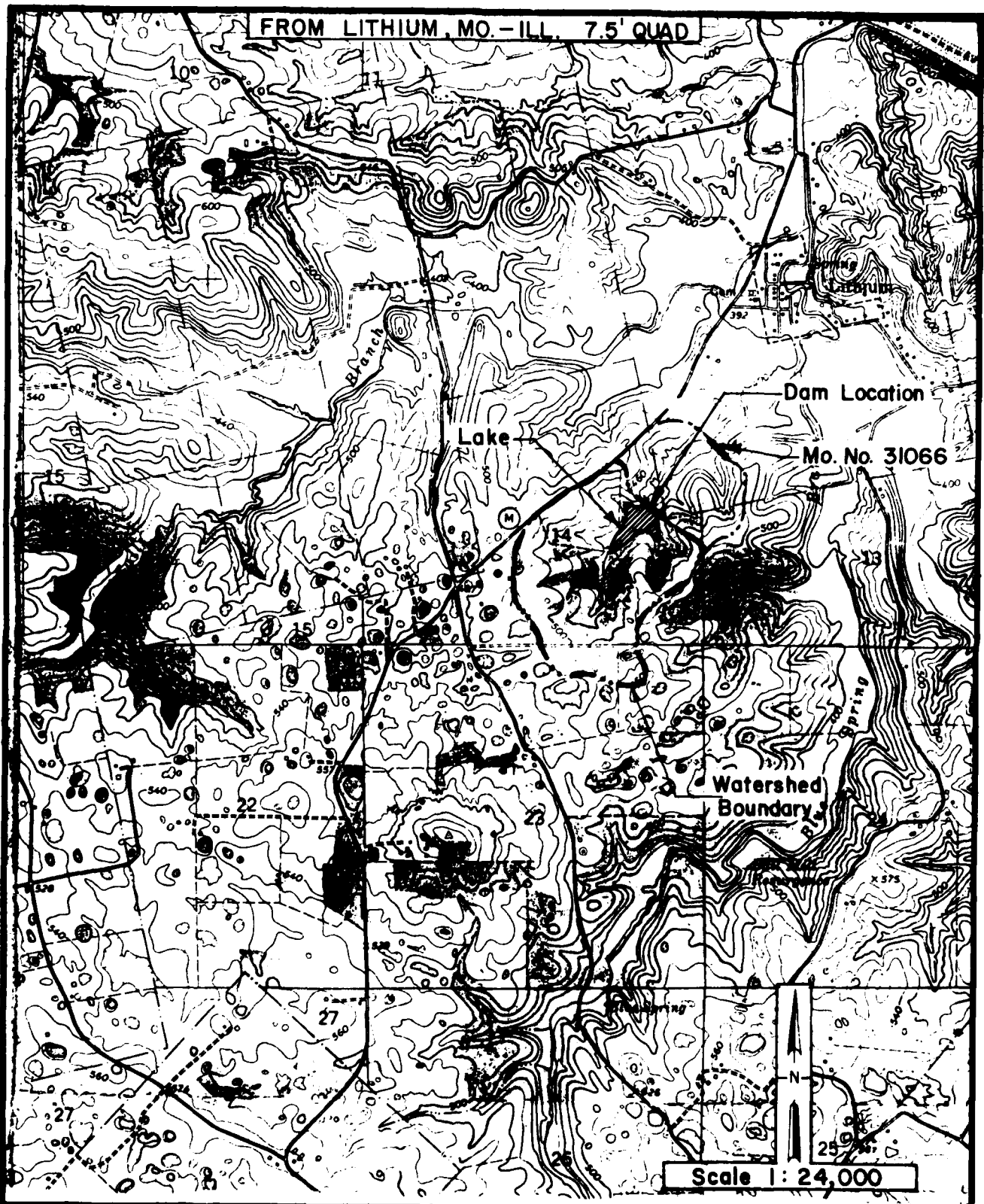
John W. Whitfield, Geologist
Applied Engineering & Urban Geology
Office of the State Geologist
September 30, 1974

Sheet 6 App. B

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APPENDIX C

Overtopping Analysis



LAKE AND WATERSHED MAP



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Ellis Lake Dam
Perry County, Missouri
Mo. ID. No. 31067

Sheet I, 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. St. Genevieve, 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). To account for the sinkholes existing in the watershed, the time of concentration was increased about 50 percent and the drainage area reduced 10 percent.

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used for the antecedent moisture conditions (AMC), 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. It was assumed that the mean annual high water elevation corresponds with the normal pool elevation. The hydraulic capacity of the spillway 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 orifice flow for the principal spillway and critical flow conditions on a broad-crested weir with trapezoidal cross section for the emergency spillway.

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)	0.22 sq miles
Length of Watercourse (L)	0.40 miles
Difference in elevation (H)	73 ft
Time of concentration (Tc)	0.17 hrs
Lag Time (Lg)	0.10 hrs
Time to peak (Tp)	0.14 hrs
Peak Discharge (Qp)	760 cfs
Duration (D)	5 min.

<u>Time (Min.)(*)</u>	<u>Discharge (cfs)(*)</u>
0	0
5	481
10	713
15	313
20	122
25	46
30	18
35	7
40	2

(*) From the computer output

FORMULA USED:

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

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

$$L_g = 0.6 T_c$$

$$T_p = \frac{D}{2} + L_g$$

$$Q_p = \frac{484 A \cdot Q}{T_p}$$

$$Q = \text{Excess Runoff} = 1 \text{ inch}$$

TABLE 2
RAINFALL-RUNOFF VALUES

<u>Selected Storm Event</u>	<u>Storm Duration (Hours)</u>	<u>Rainfall (Inches)</u>	<u>Runoff (Inches)</u>	<u>Loss (Inches)</u>
PMP	24	34.1	31.0	3.1
1% Prob. Flood	24	7.1	2.8	4.3

Additional Data:

- 1) Soil Conservation Service Soil Group B
- 2) Soil Conservation Service Runoff Curve CN = 78 (AMC III) for the PMF
- 3) Soil Conservation Service Runoff Curve CN = 60 (AMC II) for the
1 percent probability flood
- 4) Percentage of Drainage Basin Impervious 3 percent

TABLE 3
ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

<u>Elevation (feet-MSL)</u>	<u>Lake Surface Area (acres)</u>	<u>Lake Storage (acre-ft)</u>	<u>Spillway Discharge (cfs)</u>
406.0	0	0	-
420.0	3.0	21	-
*427.0	4.0	45	0
**430.2	5.9	59	3
***432.0	7.3	71	150
435.0	9.6	97	-
440.0	13.5	-	-

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

The above relationships were developed using data from the USGS
 Lithium, MO-IL 7.5 minute quadrangle map with a 20 ft contour
 interval, and the field measurements.

TABLE 4

SPILLWAYS RATING CURVE

<u>Reservoir Elevation (MSL)</u>	<u>Principal Spillway (cfs)</u>	<u>Emergency Spillway (cfs)</u>	<u>Total Discharge (cfs)</u>
*427.0	0	-	0
428.0	2	-	2
429.0	3	-	3
**430.2	3	0	3
431.0	4	30	34
431.5	4	75	79
***432.0	4	146	150
432.5	4	240	244
433.0	5	350	355
433.5	5	480	485
434.0	5	630	635
434.5	5	820	825

*Principal spillway crest elevation

**Emergency spillway crest elevation

***Top of dam elevation

Method Used:

- 1) Principal Spillway: Assuming orifice flow.

Formula Used: $Q = c.A.(2gh)^{1/2}$ King-Brater Handbook of Hydraulics

Q = Discharge in cubic feet per second

C = coefficient of discharge (0.6 assumed)

A = Orifice area in square feet (0.40)

g = Acceleration of gravity in ft/sec² (32.2)

h = head in ft (depth of water above center of orifice)

- 2) Emergency Spillway: Assuming critical flow condition at the control section and approach channel losses equal to 30 percent of the velocity head at the control section.

Formula Used:

$$\frac{Q^2}{g} = \frac{A^3}{T}$$

Design of Small Dams, Water and Power Resources
Service (Formerly USBR), page 553, 1974 Edition.

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/sec²

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	*427.0	45	0	-
0.05	159	430.4	60	11	-
0.10	318	431.5	67	76	-
0.13	414	**432.0	71	155	0
0.15	478	432.2	73	215	0.2
0.20	637	432.6	76	364	0.6
0.25	796	432.9	78	523	0.9
0.30	955	433.1	80	689	1.1
0.50	1,590	433.6	85	1,330	1.6
0.75	2,388	434.0	89	2,117	2.0
1.00	3,180	434.4	92	2,950	2.4

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 ELLIS LAKE DAM (# 5)									
A	STATE ID NO. 31067 COUNTY NAME : PERRY									
A	HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 80S3001									
B	288	5								
B1	5									
J	1	9	1							
J1	.05	.10	.15	.20	.25	.30	.50	.75	1.0	
K	0	1	1			3	1			
K1	INFLOW HYDROGRAPH COMPUTATION FOR ELLIS LAKE DAM									
M	1	2	.22		.22	1			1	
P	0	26.2	102	120	130					
T							-1	-78		0.03
W2	0.17	0.10								
X	0	-.1	2							
K	1	2			0	4	1			
K1	RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE (ELLIS LAKE DAM)									
Y			1	1						
Y1	1						45	-1		
Y4	427.0	428.0	429.0	430.2	431.0	431.5	432.0	432.5	433.0	433.5
Y4	434.0	434.5								
Y5	0	2	3	3	34	79	150	244	355	485
Y5	635	825								
\$S	0	21	45	59	71	97				
\$E	406.0	420.0	427.0	430.2	432.0	435.0				
\$S	427.0									
\$D	432.0									
\$L	0	27	100	180	210	324	327	330	337	
\$V	431.7	432.0	432.5	433.0	433.2	433.4	433.6	434.0	434.8	
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
HYDROGRAPH AT	1	0.22	1	0.05	0.10	0.15	0.20	0.25	0.30	0.50	0.75	1.00
	(	0.57)	(	4.51)	(	9.01)	(	13.52)	(	18.03)	(	27.04)
ROUTED TO	2	0.22	1	11.	76.	215.	364.	523.	689.	1333.	2117.	2946.
	(	0.57)	(	0.32)	(	2.16)	(	6.08)	(	10.32)	(	14.80)

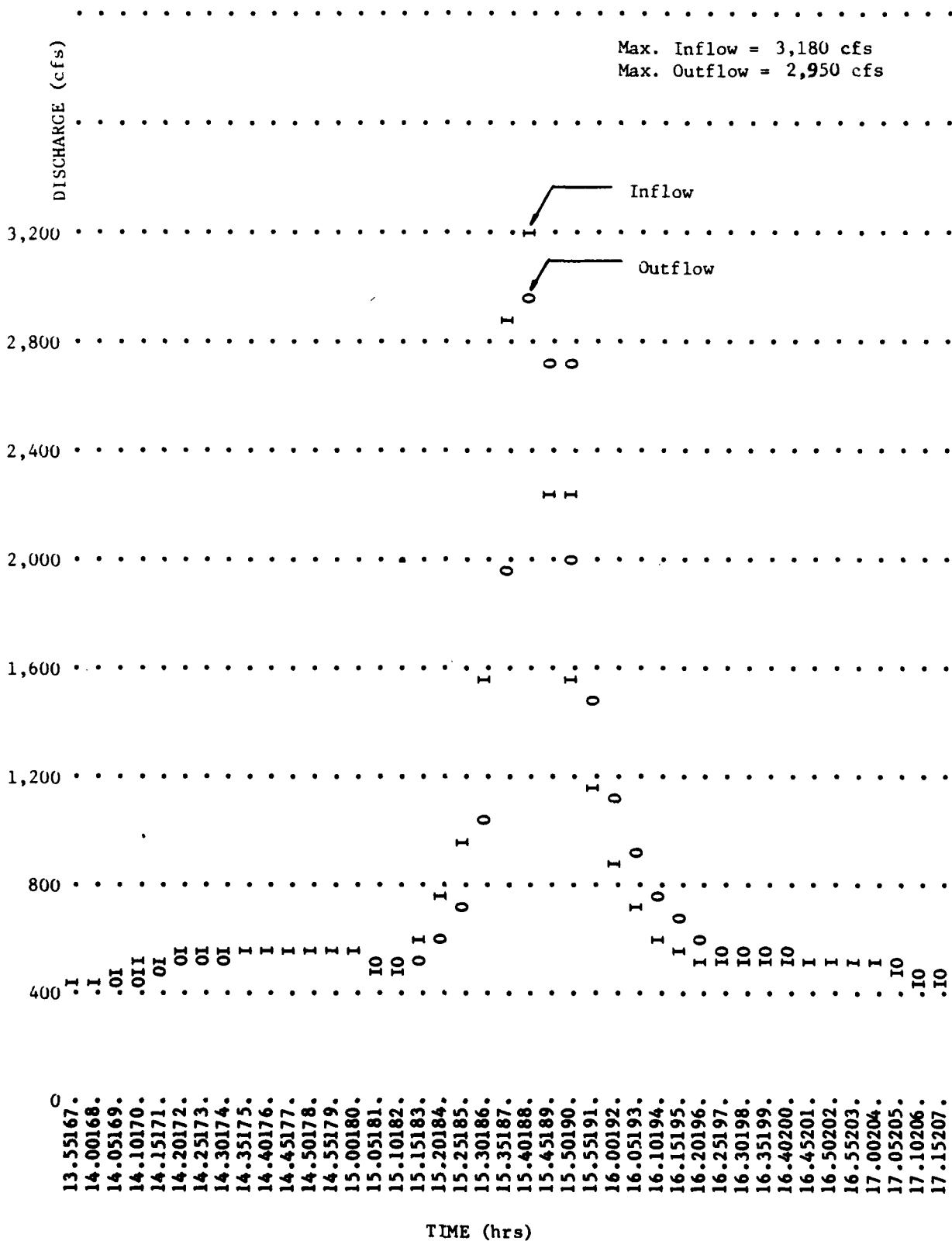
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1

ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
STORAGE	427.00	427.00	432.00
OUTFLOW	45.	45.	71.
	0.	0.	155.

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
0.05	430.41	0.00	60.	11.	0.00	18.50	0.00
0.10	431.47	0.00	67.	76.	0.00	16.08	0.00
0.15	432.22	0.22	73.	215.	0.50	15.83	0.00
0.20	432.59	0.59	76.	364.	1.00	15.83	0.00
0.25	432.85	0.85	78.	523.	1.42	15.75	0.00
0.30	433.06	1.06	80.	689.	2.00	15.75	0.00
0.50	433.59	1.59	85.	1333.	5.25	15.75	0.00
0.75	434.03	2.03	89.	2117.	6.50	15.67	0.00
1.00	434.41	2.41	92.	2946.	7.08	15.67	0.00

PMF RATIOS
 OUTPUT DATA



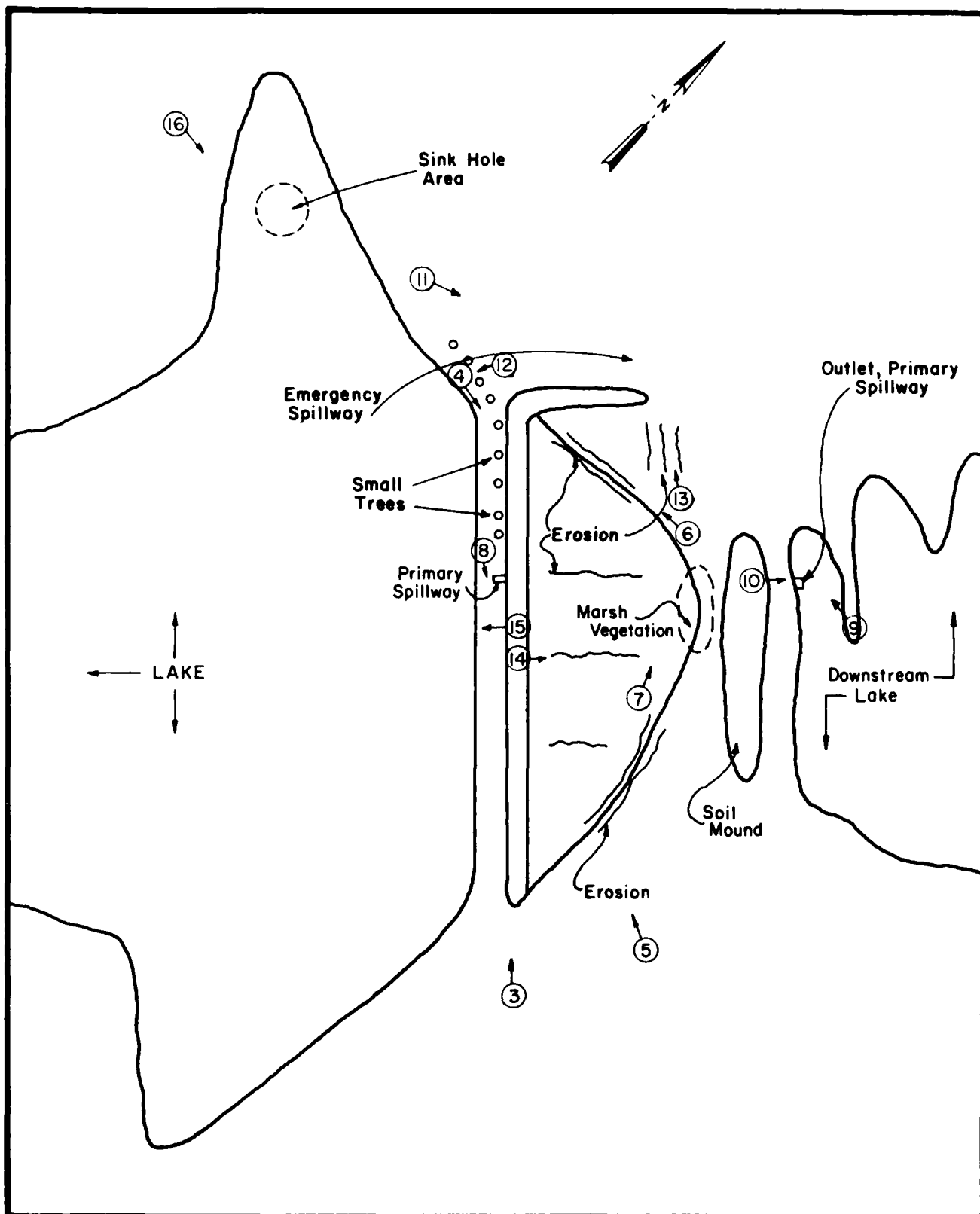
INFLOW-OUTFLOW HYDROGRAPH
FOR THE PMF

APPENDIX D

Photographs

LIST OF PHOTOGRAPHS

<u>Photo No.</u>	<u>Description</u>
1.	Aerial view of dams 31067 and 31066 looking northeast (city of Lithium in upper left).
2.	Aerial view of dam looking northwest.
3.	Crest of dam looking northwest from right abutment.
4.	Upstream face of dam looking east from left abutment - Note small trees and lack of riprap.
5.	Downstream face of dam looking northwest from right abutment.
6.	Left abutment-dam downstream contact area - Note erosion gully.
7.	Area of marsh vegetation near toe of dam.
8.	Principal spillway pipe inlet.
9.	Principal spillway pipe outlet.
10.	Plunge pool and downstream lake at end of principal spillway pipe looking downstream.
11.	Emergency spillway looking downstream, berm on right of photograph.
12.	Emergency spillway looking upstream.
13.	Erosion at end of emergency spillway.
14.	Upper reaches of downstream lake looking downstream from crest of dam.
15.	View of lake from crest of dam.
16.	Sinkhole area looking east; upstream face of dam in background; Note pipe in left foreground marking approximate location of concrete plugged sinkhole.



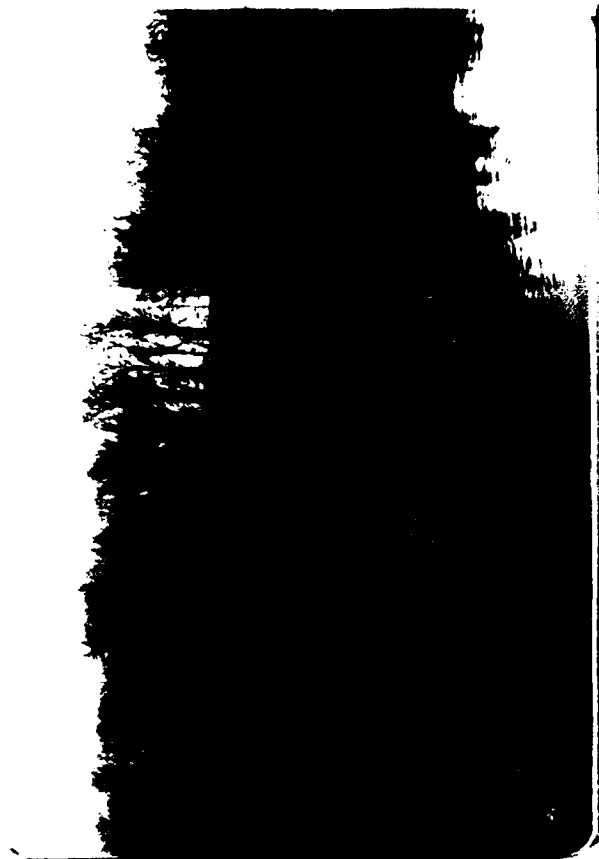
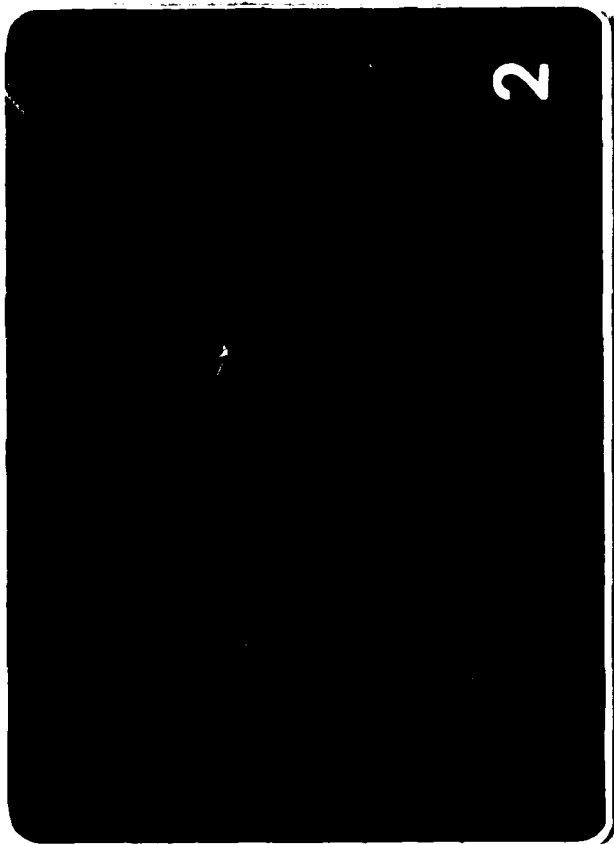
PHOTOGRAPH LOCATIONS

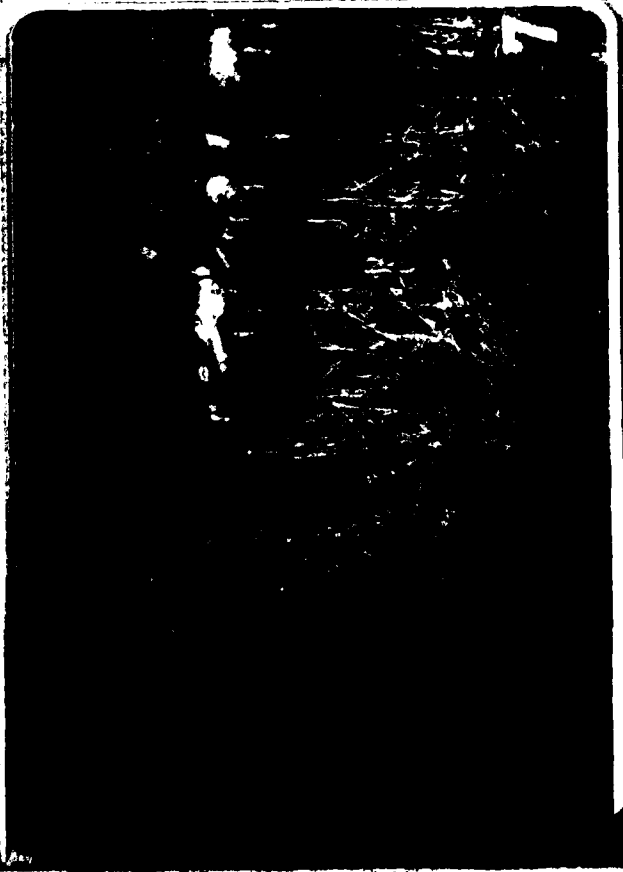


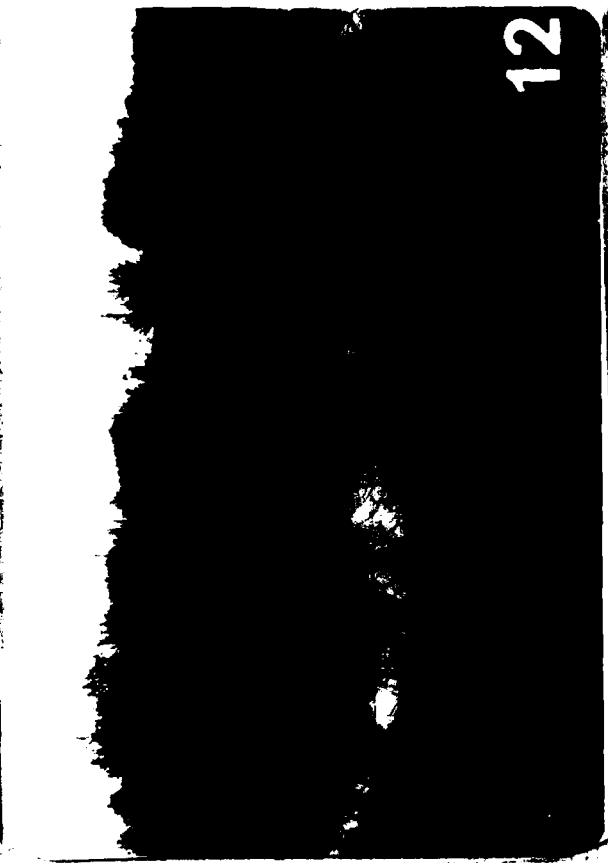
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

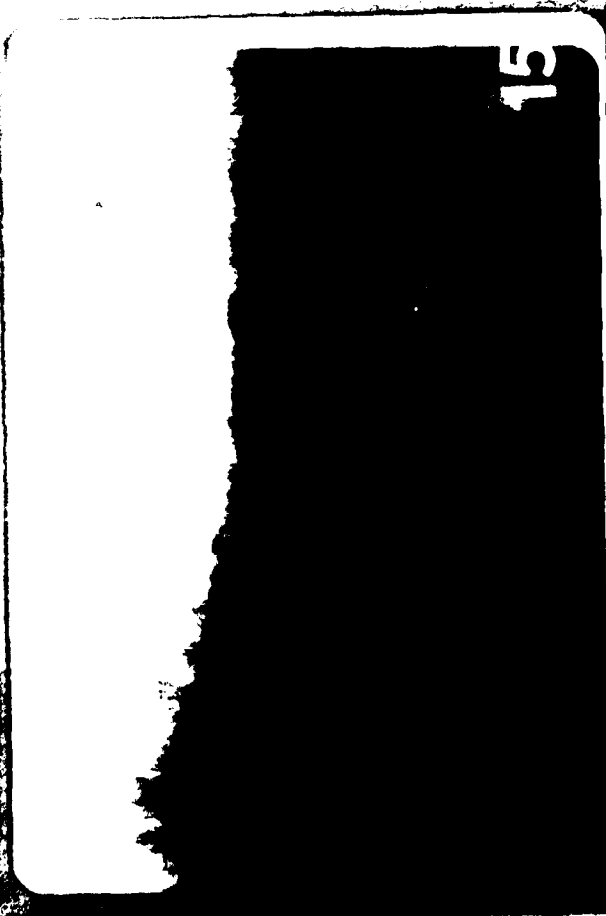
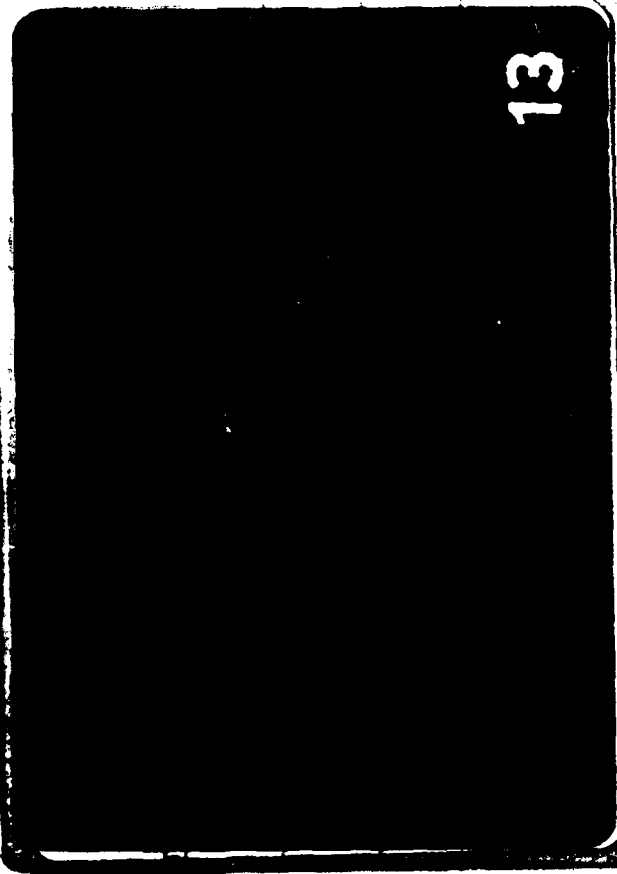
Ellis Lake Dam
Perry County, Missouri
Mo. I.D. No. 31067

Sheet 2, Appendix D









END

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11-81

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