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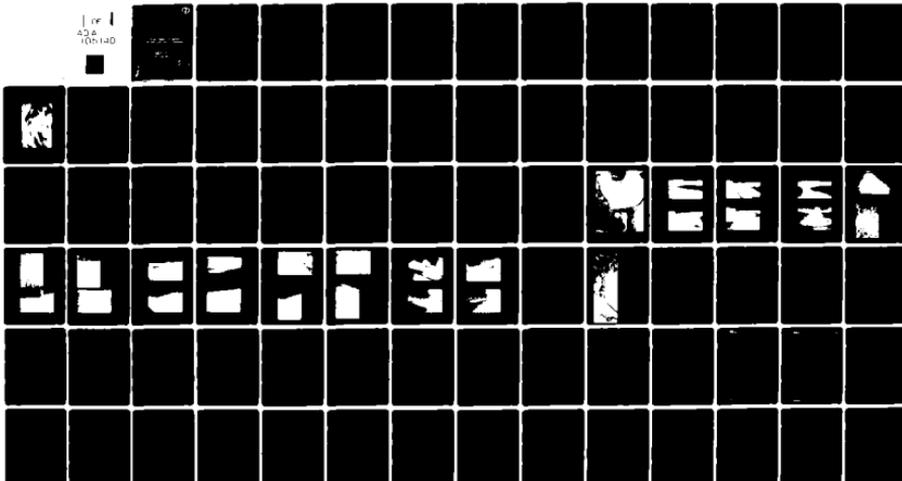
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MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

LEVEL II

BROWN LAKE DAM

CAPE GIRARDEAU COUNTY, MISSOURI

MO 31223

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PHASE 1 INSPECTION REPORT

6 NATIONAL DAM SAFETY PROGRAM.

Brown Lake Dam (MO 31223),
Mississippi - Kaskaskia - St. Louis Basin.
Cape Girardeau County, Missouri. Phase I
Inspection Report.



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

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OCTOBER, 1980

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

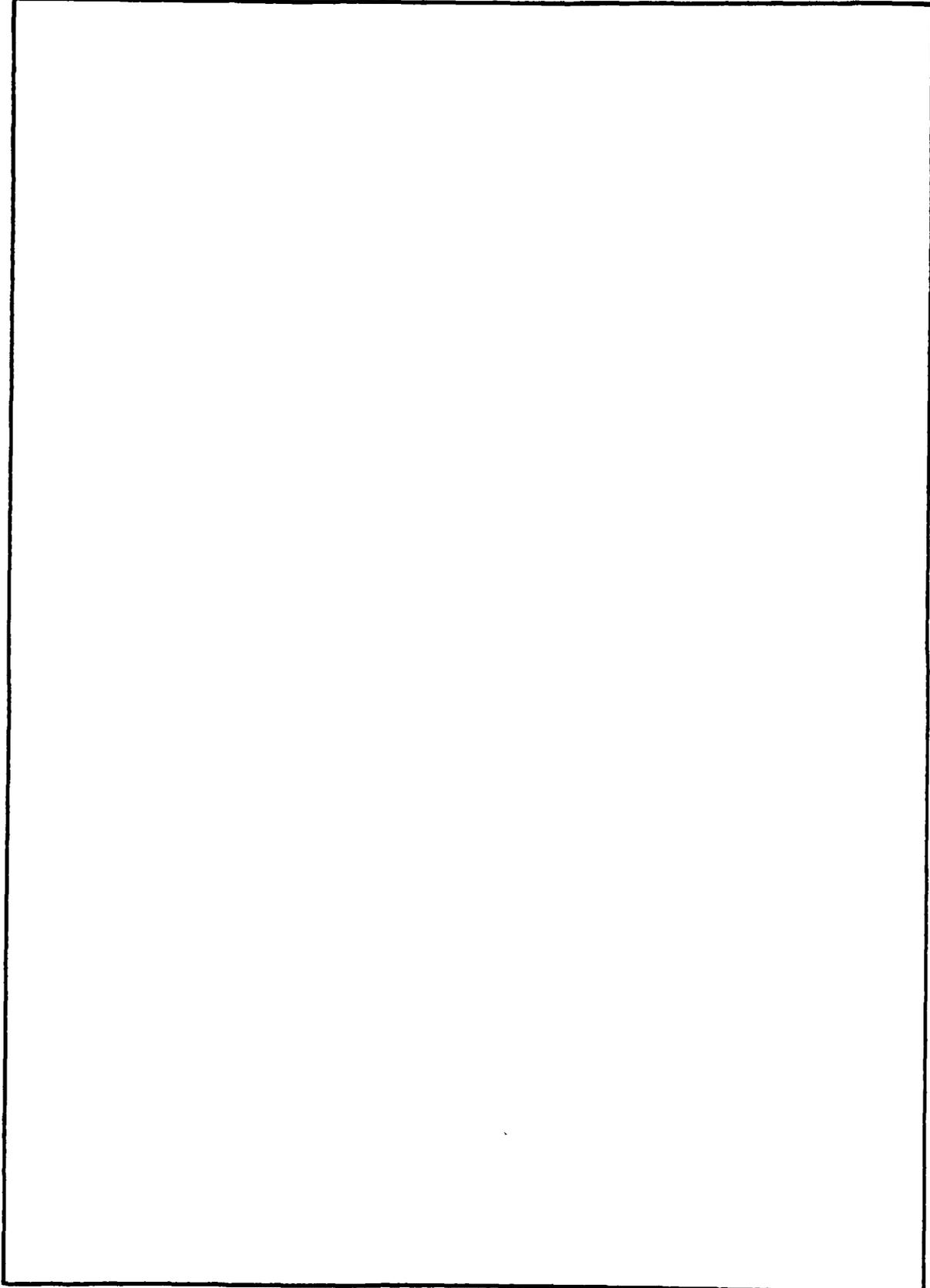
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BROWN LAKE DAM
CAPE GIRARDEAU COUNTY, MISSOURI
MISSOURI IDENTIFICATION NO. MO 31223

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
HOSKINS-WESTERN-SONDEREGGER, INC.
CONSULTING ENGINEERS
LINCOLN, NEBRASKA

UNDER DIRECTION OF
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

OCTOBER, 1980

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
ASSESSMENT SUMMARY

Name of Dam	Brown Lake Dam
State Located	Missouri
County Located	Cape Girardeau County
Stream	Tributary to Juden Creek
Date of Inspection	October 28, 1980

Brown Lake Dam was inspected by an interdisciplinary team of engineers from Hoskins-Western-Sonderegger, Inc. The purpose of the inspection was to make an assessment of the general conditions 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 developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers.

Brown Lake Dam has a height of thirty-three (33) feet and a storage capacity at the minimum top elevation of the dam of fifty-three (53) acre-feet. In accordance with the guidelines, a small size dam has a height greater than or equal to twenty-five (25) but less than forty (40) feet and a storage capacity greater than or equal to fifty (50) acre-feet but less than one thousand (1,000) acre-feet. The size classification is determined by either the storage capacity or height, whichever gives the larger size category. Brown Lake Dam is classified as a small size dam.

In accordance with the guidelines and based on visual observation, the dam is classified as having a high hazard potential. Failure would threaten life and property. The estimated damage zone extends approximately three (3) miles downstream of the dam. Within the damage zone are a dwelling, building and road at 0.55 mile; a barn at 0.7 mile; a church at 0.8 mile; a dwelling, building and road at 0.85 mile; 7 more or less dwellings and a road at 0.9 to 1.1 miles; 4 dwellings and an intersection at 1.2 miles; 3 dwellings at 1.3 miles; 4 dwellings and 3 buildings at 1.6 miles; 4 dwellings, church and cemetery at 1.7 to 1.9 miles; a dwelling at 1.95 miles; a dwelling at 2.05 miles; and a dwelling at 2.1 miles.

Our inspection and evaluation indicates that the spillways do not meet the criteria set forth in the recommended guidelines for a small dam having a high hazard potential. Considering the small volume of water impounded and the downstream channel from the dam, one-half of the Probable Maximum Flood is the appropriate spillway design flood. The spillways will pass the 100-year flood (1% probability flood - a flood having a one percent chance of being exceeded in any one year) without overtopping the dam. The spillways will pass 13% of the Probable Maximum Flood without overtopping the

dam. The Probable Maximum Flood (PMF) is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Brown Lake Dam is in excellent condition and is very well maintained. The only deficiencies noted are inadequate spillway capacity, the lack of seepage and stability analyses as required by the guidelines for all dams having a high hazard potential, and erosion in the left abutment trough.

Limited design data were available for this dam. Based on this data and on the analyses made during and subsequent to the field inspection, the following recommendations are made:

a. Alternatives.

- (1) An emergency spillway should be constructed and/or the height of dam should be increased in order to pass 50 percent of the probable maximum flood without overtopping the dam. Spillway design should include erosion control.

b. Operation and Maintenance Procedures.

- (1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the design and construction of dams.
- (2) Erosion in the left abutment trough should be corrected.
- (3) Present maintenance procedures should be continued.
- (4) A program of periodic inspection should be initiated, and the inspection reports made a part of this project file. Inspection items should include monitoring the possible seepage through the left abutment and seepage into the channel below the principal spillway, erosion of the slopes and abutment troughs, and future rodent activity.

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FOUNT 1

BINDING EDGE



PHOTO NO. 1 - OVERVIEW

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BROWN LAKE DAM - MO 31223
CAPE GIRARDEAU COUNTY, MISSOURI

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 of Brown Lake Dam be made.
- 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 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, in "Recommended Guidelines for Safety Inspection of Dams", Appendix D to "Report of the Chief of Engineers on the National Program of Inspection of Dams", dated May, 1975, and published by the Department of the Army, Office of the Chief of Engineers.

1.2 DESCRIPTION OF PROJECT

- a. Description of Dam and Appurtenances.
 - (1) Embankment. The embankment consists of an earthfill approximately 420 feet in length and 33 feet in height with a maximum storage capacity at the minimum top elevation of the dam of 53 acre-feet.
 - (2) Principal Spillway. The principal spillway is uncontrolled. It consists of a 24-inch diameter smooth iron pipe riser with trash rack and a 16-inch diameter smooth iron pipe conduit passing through the base of the dam at about Station 1+95.
 - (a) Inlet Structure. The inlet structure consists of a 24-inch diameter smooth iron pipe riser. The outlet pipe is located 21.3 feet below the top of the riser. The riser inlet is protected by a trash rack. There

is a 3-inch diameter smooth iron drawdown pipe with a gate valve on it located 3.0 feet below the crest of the riser. Photos 6 and 8 show the inlet of the principal spillway.

- (b) Conduit. The conduit consists of 123 feet of 16-inch diameter smooth iron pipe. The conduit has an inlet elevation of 426.7 feet m.s.l. and an outlet elevation of 421.0 feet m.s.l. Photos 9 and 10 show the outlet of the conduit.
 - (c) Stilling Basin. There is no structural stilling basin for the principal spillway. Spillway discharges drop approximately 1.4 feet to the bottom of a natural channel. Photos 7, 9, and 10 show the spillway outlet channel.
- (3) Auxiliary Spillway. The auxiliary spillway is an uncontrolled, 15-inch diameter corrugated metal pipe culvert passing through the embankment on the right end. The culvert has a length of 60 feet with the inlet located at Station 3+95 and the outlet located at Station 4+15. The culvert has an inlet elevation of 449.7 feet m.s.l. and an outlet elevation of 446.4 feet m.s.l. Photos 11, 12, and 13 show views of the auxiliary spillway.
- (4) Low-Level Outlet. The low-level outlet consists of a 3-inch diameter smooth iron pipe with a gate valve on it. The low-level outlet is connected to the principal spillway riser. The pipe invert elevation is 445.0 feet m.s.l. Photo No. 8 shows the low-level outlet.
- (5) Pertinent physical data are given in paragraph 1.3.
- b. Location. The dam is located in the east central portion of Cape Girardeau County, Missouri, as shown on Plate A-2. The dam is shown on Plate A-1 in the SE 1/4 of Section 17, T31N, R14E.
 - c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Brown Lake Dam has a height of 33 feet and a storage capacity of 53 acre-feet. This dam is classified as a small size dam. A small size dam has a height greater than or equal to 25 feet but less than 40 feet and a storage capacity greater than or equal to 50 acre-feet but less than 1,000 acre-feet. The size classification is determined by either the storage or height, whichever gives the larger size category.
 - d. Hazard Classification. Guidelines for determining hazard classification of dams and impoundments are presented in the guidelines as referenced in paragraph 1.1c above.

Aerial photographs of the downstream damage zone of this dam were taken in October, 1980. These photographs were used as reference in the field observations of the damage zone which were made during the inspection. Based on the field observations and on the referenced guidelines this dam is in the High Hazard Potential Classification. The estimated damage zone extends approximately three miles downstream of the dam. Within the damage zone are a dwelling, building and road at 0.55 mile; a barn at 0.7 mile; a church at 0.8 mile; a dwelling, building and road at 0.85 mile; 7 more or less dwellings and a road at 0.9 to 1.1 miles; 4 dwellings and an intersection at 1.2 miles; 3 dwellings at 1.3 miles; 4 dwellings and 3 buildings at 1.6 miles; 4 dwellings, church and cemetery at 1.7 to 1.9 miles; a dwelling at 1.95 miles; a dwelling at 2.05 miles; and a dwelling at 2.1 miles.

- e. Ownership. The dam is owned by Mrs. Ruby Brown, Route 1, Box 47F, Cape Girardeau, Missouri 63701.
- f. Purpose of Dam. The dam impounds a recreational lake covering about 5 acres and containing about 33 acre-feet of water.
- g. Design and Construction History. The dam was constructed in 1971-72. The Soil Conservation Service, Jackson, Missouri, provided some assistance in the design of the dam.
- h. Normal Operating Procedure. There are no operating facilities for this dam except for the small drawdown pipe. The pool level is controlled by rainfall, infiltration, evaporation, and the capacity of the uncontrolled spillways.

1.3 PERTINENT DATA

- a. Drainage Area. 99 acres (0.155 square miles).
- b. Discharge at Damsite.
 - (1) All discharges at the damsite are through the following:
 - (a) A principal spillway consisting of an uncontrolled 24-inch diameter smooth iron pipe drop inlet with trash rack and a 16-inch smooth iron pipe conduit passing through the embankment. A 3-inch drawdown pipe with a gate valve is located on the spillway riser.
 - (b) An auxiliary spillway consisting of an uncontrolled, 15-inch corrugated metal pipe culvert passing through the embankment on the right side.
 - (2) Estimated maximum flood at damsite -- unknown.
 - (3) The principal spillway capacity varies from 0 c.f.s. at elevation 448.0 feet to 20 c.f.s. at the crest of the auxiliary spillway (elevation 449.7 feet) to 28 c.f.s. at the minimum top of dam (elevation 451.8 feet).

(4) The auxiliary spillway capacity varies from 0 c.f.s. at its crest (elevation 449.7 feet) to 6 c.f.s. at the minimum top of dam (elevation 451.8 feet).

(5) Total spillway capacity at the minimum top of dam is 34 c.f.s. \pm .

c. Elevations (feet above M.S.L.).

(1) Observed pool - 444.4 \pm

(2) Normal pool - 448.0 \pm

(3) Spillway crest

Principal - 448.0 \pm

Auxiliary - 449.7 \pm

(4) Maximum experienced pool - unknown

(5) Top of dam (minimum) - 451.8 \pm

(6) Streambed - 420 \pm

(7) Maximum tailwater - unknown

d. Reservoir. Length (feet) of pool.

(1) At principal spillway crest - 700 \pm

(2) At auxiliary spillway crest - 750 \pm

(3) At top of dam (minimum) - 800 \pm

e. Storage (acre-feet).

(1) Observed pool - 24 \pm

(2) Normal pool - 33 \pm

(3) Spillway crests

Principal - 33 \pm

Auxiliary - 42 \pm

(4) Maximum experienced pool - unknown

(5) Top of dam (minimum) - 53 \pm

f. Reservoir Surface (acres).

- (1) Observed pool - 4±
- (2) Normal pool - 5±
- (3) Spillway crests
Principal - 5±
Auxiliary - 6±
- (4) Maximum experienced pool - unknown
- (5) Top of dam (minimum) - 7±

g. Dam.

- (1) Type - earthfill
- (2) Length - 420 feet±
- (3) Height - 33±
- (4) Top Width - 18 feet (measured) 14' (plans)
- (5) Side slopes
 - (a) Downstream - 1V on 2H (measured) 1V on 2.5H (plans)
 - (b) Upstream - 1V on 3.5H (measured on exposed slope)
1V on 3H (plans)
- (6) Zoning - unknown
- (7) Impervious core - unknown
- (8) Cutoff - unknown (plans show core trench)
- (9) Grout curtain - none
- (10) Wave protection - small, cherty gravel (nominal size: 1 to 1½ inches, maximum size: 3 to 4 inches)
- (11) Drains - none

h. Diversion Channel and Regulating Tunnel. None

i. Spillways.

- (1) Principal
 - (a) Type - Uncontrolled drop inlet with a 24-inch diameter smooth iron pipe riser connected to a 16-inch diameter smooth iron pipe conduit passing through the embankment. A

trash rack is located over the inlet riser. A 3-inch drawdown pipe with a gate valve on it is located on the inlet riser.

(b) Crest (invert) elevation - 448.0

Outlet - 421.0

(c) Length - 123 feet ±

(d) Drawdown (invert) elevation - 445.0

(2) Auxiliary

(a) Type - Uncontrolled, 15-inch corrugated metal pipe culvert passing through the embankment on the right side.

(b) Inlet (invert) elevation - 449.7

(c) Outlet (invert) elevation - 446.4

(d) Length - 60 feet ±

(e) Upstream channel - Vegetated, clear stable

(f) Downstream channel - Vegetated, clear, exits into a sewage lagoon some 50± downstream.

j. Regulating Outlets. 3-inch diameter smooth iron pipe with gate valve connected to the principal spillway riser.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data for this dam were supplied by the Soil Conservation Service (SCS) and are included with this report in Appendix C.

2.2 CONSTRUCTION

No construction data were available. The dam was constructed in 1971-72.

2.3 OPERATION

No data were available on spillway operation.

2.4 EVALUATION

- a. Availability. The data included in Appendix C were readily available from the Soil Conservation Service.
- b. Adequacy. The data supplied by the Soil Conservation Service, the field surveys and the visual observations presented herein are considered adequate to support the conclusion of this report. 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. The data and analyses are considered valid and adequate.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

- a. General. A visual inspection of the Brown Lake Dam was made on October 28, 1980. Engineers from Hoskins-Western-Sonderegger, Inc., Lincoln, Nebraska, making the inspection were:

Rey S. Decker - Geotechnical
Garold G. Ulmer - Hydraulics and Hydrology
Gordon Jamison - Hydraulics and Hydrology

The owner, Mrs. Ruby Brown, was not present during the inspection.

- b. Dam.

- (1) Geology and Soils (abutment and embankment). The embankment is situated high in the dissected loess hills in the Ozark Physiographic Province of Southeastern Missouri. A thick clayey silt loess mantles the Plattin formation of the Ordovician system and provides parental material for the Grenada-Loring or Menfro-Winfield soil association. The primary structural feature of this region is the Jackson fault. Secondary structural features are the Cape Girardeau fault to the southeast and the Brooks Dome fault to the east-northeast. Groundwater movement at the embankment is controlled by the underlying colluvial-alluvial materials. These materials consist of sandy silts and a residual silty clay with cherty gravel.

The dam is located in Seismic Zone 3 as shown on Plate A-3. Earthquakes with Modified Mercalli intensities of V or greater have occurred in 1895, 1909, 1919 and 1977 within 25 radial miles of the damsite (Stover, Reagor and Algermissen, 1979).

Residual gravelly clays (GM, GC) and cherty gravels are exposed in the abutments downstream from the dam. Photos 20 and 21 show the cherty clay in the left abutment. These residual materials overlay the bedrock which was not exposed at the site. The bedrock formation is the Plattin formation, an evenly bedded, gray to dark gray limestone with chert nodules.

Materials in the embankment consist of ML-CL soils borrowed from the loess covered hills and slopes. Soil classification was done in the field from materials obtained by hand auger at depths of approximately 2 feet. Upland soils consist of ML and ML-CL developed on deep loess.

Karst topography was not evident. This absence coupled with low yield local wells and deep static water levels suggest

the low porosity of the formation. Solution cavitation was not evident in local outcrops. The loessial-colluvial mantle ranges from 5 to 10 feet in thickness. The valley alluvium consisting of silty clays ranges in thickness from 6 to 10 feet.

- (2) Upstream Slope. The upstream slope is well vegetated with adapted grasses. Part of the surface below normal pool elevation is covered with cherty gravel having nominal size of about 1 inch and maximum size of 3 to 4 inches. There is no significant erosion on the upstream face. No tree growth, cracks, or abnormal deformation were noted. There was no indication of rodent activity. Photos 3 and 4 show the upstream slope.
- (3) Crest. The crest is paved and serves as a roadway. The profile of the crest shows that both ends of the dam are about 1 foot lower than the center section. No cracks or abnormal deformations were noted. Photos 3 and 4 show the crest. The paved road section extends to the downstream crestline between Stations 0+65 and 1+00±. It would appear that this section might have been planned as an overflow spillway. However, it would discharge directly onto the downstream slope. Photos 4, 14, and 15 show the paved low section on the left end of the dam.
- (4) Downstream Slope. The downstream slope is well vegetated with adapted grasses. No cracks, slumps, slides or deformations were observed. There was no indication of significant erosion, tree growth or rodent activity on the slope. No seepage was observed along the toe of the dam. However, water was standing in the channel below the outlet of the principal spillway. This could be seepage under the dam or seepage from the sewage lagoon. There was no evidence that the principal spillway had operated for quite a time, nor was there evidence that the dam has ever been overtopped.

A change in vegetation (Bermuda grass instead of fescue and brome) was noted on the lower slope of the left side. It is not known whether or not this could indicate some seepage through the left abutment. There was no sign of surface water. Photo 5 shows the downstream slope with the Bermuda grass showing brown or tan. Surface erosion has undercut the paved gutter down the left abutment trough. Photos 18 and 19 show the erosion in the left abutment trough. A small sewage lagoon is located downstream from the toe of the dam in the right abutment trough. It has no apparent adverse effect upon the stability of the structure. Photo 13 shows the lagoon.

- (5) Miscellaneous. Maintenance of the structure appears to be excellent. All slopes had been recently mowed and it appeared that this was a regular practice.
- c. Appurtenant Structures.
- (1) Principal Spillway.
- (a) Inlet Structure. The inlet is uncontrolled. It consists of a 24-inch diameter smooth iron pipe riser which is about 21 feet high. A triangular welded steel mesh trash rack covers the inlet. The riser pipe and trash rack appear to be in good condition as shown in Photos 6 and 8.
- (b) Conduit. The conduit consists of about 123 feet of 16-inch diameter smooth iron pipe passing from the base of the riser through the base of the embankment. It appears to be in good condition as shown in Photos 9 and 10.
- (c) Stilling Basin. The stilling basin consists of an eroded scour hole about 1.5 to 2 feet in depth. No excessive erosion was observed around the plunge pool. It is shown in Photo 9.
- (2) Auxiliary Spillway. The auxiliary spillway consists of a 15-inch diameter corrugated metal pipe passing through the embankment at about Station 4+00 near the right abutment. The spillway outlets into the right abutment trough. The spillway pipe appears to be in fair condition as shown in Photos 12 and 13. The inlet end is somewhat out of shape. There was no evidence of any recent flows through the spillway.
- (3) Low-Level Outlet. The low-level outlet consists of a 3-inch diameter smooth iron pipe, controlled with a gate valve, passing into the 24-inch principal spillway riser pipe at an elevation about 3 feet below the crest of the riser. The drawdown facility appears to be in good condition. It is shown in Photo 9.
- d. Reservoir Area. The reservoir area is bounded by well vegetated banks. No significant erosion was noted around the reservoir, nor were there indications of siltation. A portion of the reservoir is shown in Photo 6.
- e. Downstream Channel. The channel downstream from the principal spillway is open and stable. It is bordered with trees and shrubs. Photo 7 shows the channel.

3.2 EVALUATION

This dam appears to be in excellent structural condition and is very well maintained. It is apparently safe against shear failures and does not have any apparent seepage problems. Erosional undercutting of the paved gutter in the left abutment trough could ultimately lead to more serious problems and should be remedied. The auxiliary spillway appears to be inadequate to handle a major storm.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no controlled outlet works for this dam except for the small drawdown pipe. The pool level is controlled by rainfall, infiltration, evaporation, and the capacity of the uncontrolled spillways.

4.2 MAINTENANCE OF DAM

Maintenance of this structure appears to be very good. The slopes have an excellent vegetative cover and are apparently mowed regularly. There is an erosional gully located in the left abutment trough that should be repaired.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities, except for the drawdown pipe, exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no warning system in effect for this dam.

4.5 EVALUATION

The deficiencies observed during the inspection can be corrected by improvement in maintenance.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

- a. Design Data. Plans for this dam were obtained from the owner and were prepared by the Soil Conservation Service. The plans and reports are included in Appendix C.
- b. Experience Data. The drainage area, reservoir surface area, and elevation-storage data were developed from the USGS Cape Girardeau, Missouri 7-1/2 minute topographic quadrangle map. The hydraulic computations for the spillway and dam overtopping discharge ratings were based on data collected in the field at the time of the field inspection. Hydrologic computations are attached as Appendix D of this report.
- c. Visual Observations.
 - (1) The drop inlet riser and outlet pipe appeared to be in good condition. The riser inlet was covered with an adequate trash rack. The inlet, as well as the entire upstream slope, was clear of debris.
 - (2) The auxiliary spillway appeared to be in good condition. A sewage lagoon is located directly downstream of the outlet. The lagoon probably would not be affected by normal spillway discharges but could be affected by overtopping of the dam.
 - (3) A drawdown pipe is located on the principal spillway riser and can lower the reservoir level approximately 3 feet below the crest of the principal spillway.
- d. Overtopping Potential. The spillways are too small to pass 50% of the probable maximum flood without overtopping the dam. The spillways will pass the 1% probability flood as well as 13% of the probable maximum flood without overtopping the dam. Overtopping is dangerous because the flow of water over the crest could erode the face of the dam and, if continued long enough, could breach the dam with sudden release of all of the impounded water into the downstream floodplain.

The results of the routings through the dam are tabulated in regards to the following conditions:

<u>Frequency</u>	<u>Inflow Discharge c.f.s.</u>	<u>Outflow Discharge c.f.s.</u>	<u>Maximum Pool Elevation</u>	<u>*Maximum Depth Over Dam Feet</u>	<u>Duration Over Top Hours</u>
1%	250	23	450.2	0	0
1/2 PMF	960	890	453.4	1.6	6+
PMF	1910	1880	454.0	2.2	9+
0.13 PMF	250	33	451.7	0	0

* Minimum top of dam elevation - 451.8

According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, this dam is classified as having a high hazard potential and a small size. Therefore, the 1/2 PMF to PMF is the test for the adequacy of the dam and its spillway.

The estimated damage zone is described in paragraph 1.2d in this report.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

- a. Visual Observation. Based on visual observation this dam appears to be structurally stable against shear failures and normal seepage pressures. Signs of distress such as cracks, slides, settlement, erosion, tree growth and rodent burrows were not observed.
- b. Design and Construction Data. Minimal design data were supplied by the Soil Conservation Service, Jackson, Missouri. No construction data were available. 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.
- c. Operating Records. There are no controlled operating facilities for this dam.
- d. Post-Construction Changes. The inspection team is not aware of any post-construction changes.
- e. Seismic Stability. This dam is located in Seismic Zone 3. An earthquake of the magnitude predicted in this area could be expected to cause some damage to this dam. Stability analyses for this structure should include earthquake forces applicable to this area.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

- a. Safety. Based on visual observation this dam appears to be structurally stable from the standpoint of shear strength and seepage with no serious potential of failure. Approximate analyses performed for this report indicate that the spillways will pass the 1% probability flood without overtopping the dam. 50% of the Probable Maximum Flood will overtop the dam about 1.6 feet for about 6 hours. The effects of such overtopping on the stability of the dam are not known. In accordance with the "Recommended Guidelines for Safety Inspection of Dams" the capacity of the spillways is inadequate for a small dam having a high hazard potential rating. Erosion in the left abutment trough could ultimately lead to serious problems and should be corrected. 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.
- b. Adequacy of Information. The available design data and the field surveys and visual observations presented in this report, along with performance history, are considered adequate to support the conclusions of this report. 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.
- c. Urgency. The measures recommended in paragraph 7.2.b should be accomplished in the near future. The item recommended in paragraph 7.2.a should be pursued on a high priority basis.
- d. Necessity for Further Investigations. Further investigations are not required.
- e. Seismic Stability. This dam is located in Seismic Zone 3 as shown on Plate A-3. An earthquake of this magnitude could be hazardous to this dam. It is recommended that the prescribed seismic loading for Seismic Zone 3 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 registered professional engineer experienced in the design and construction of earth dams.

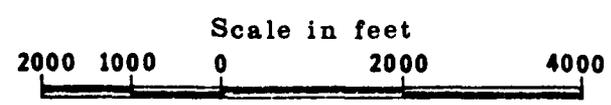
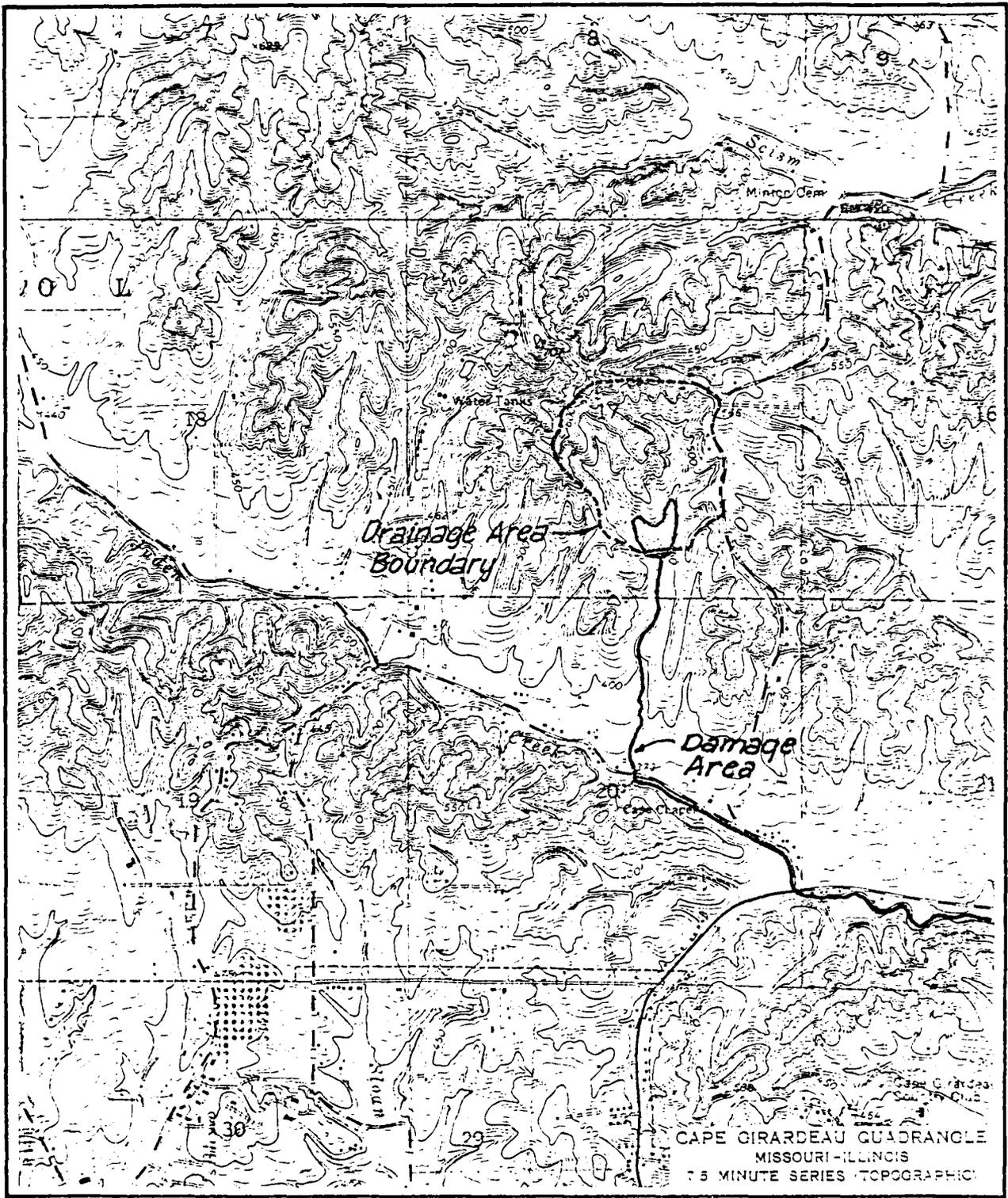
a. Alternatives.

- (1) An emergency spillway should be constructed and/or the height of dam should be increased in order to pass 50 percent of the probable maximum flood without overtopping the dam. Spillway design should include erosion control.

b. Operation and Maintenance Procedures.

- (1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the design and construction of dams.
- (2) Erosion in the left abutment trough should be corrected.
- (3) Present maintenance procedures should be continued.
- (4) A program of periodic inspection should be initiated, and the inspection reports made a part of this project file. Inspection items should include monitoring the possible seepage through the left abutment and seepage into the channel below the principal spillway, erosion of the slopes and abutment troughs, and future rodent activity.

APPENDIX A
MAPS



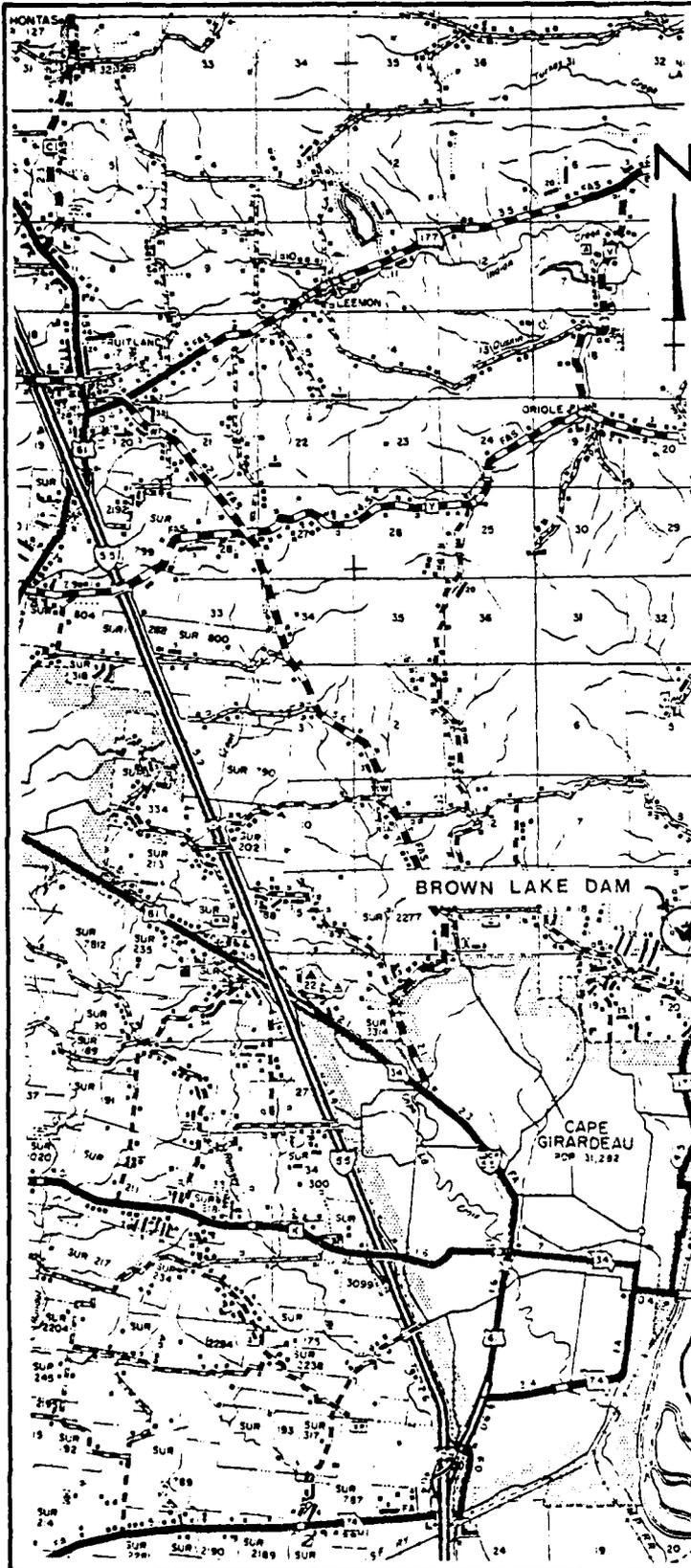
Contour Interval - 10'



VICINITY TOPOGRAPHY

BROWN LAKE DAM
 CAPE GIRARDEAU COUNTY, MISSOURI
 MO 31223

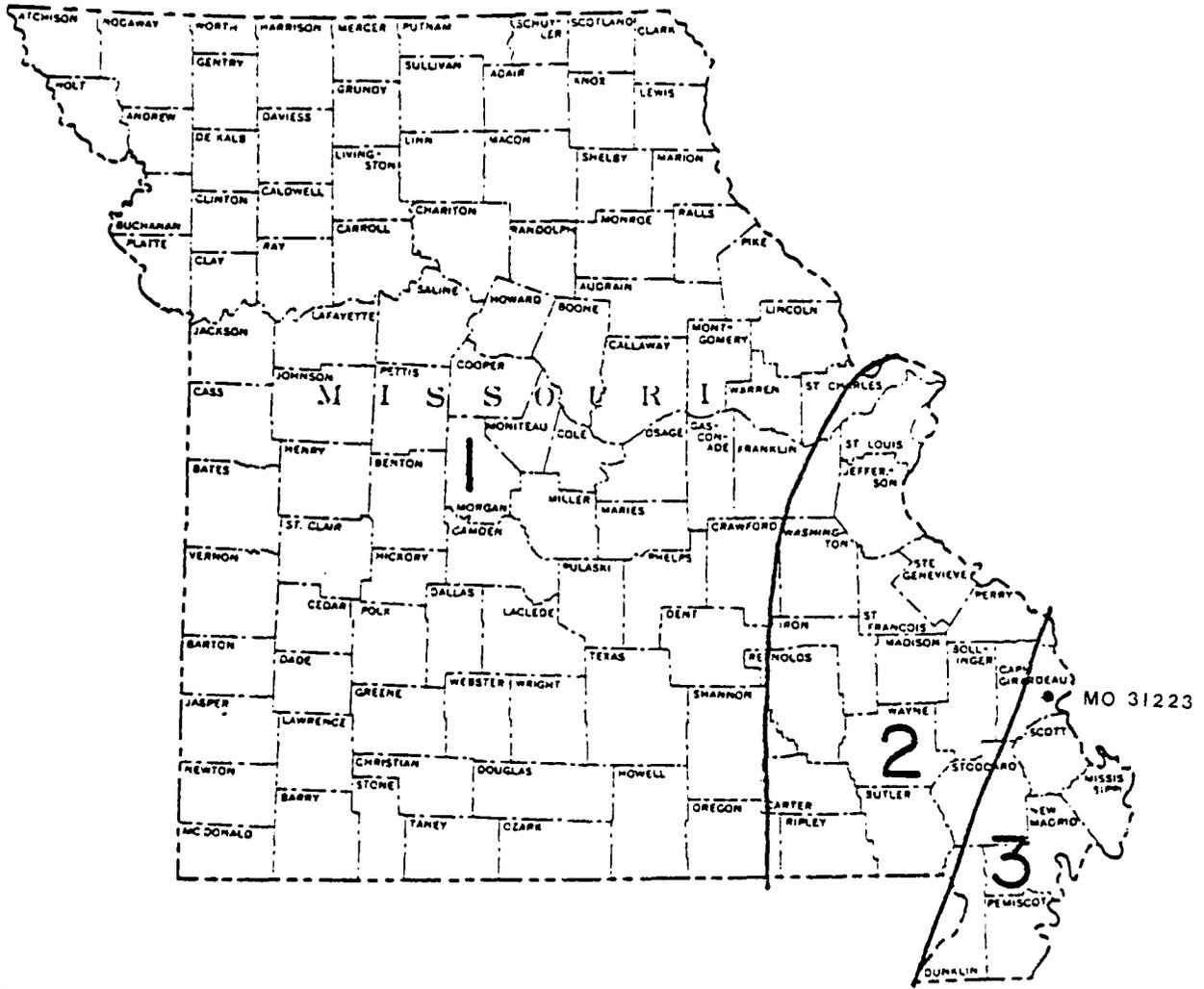
PLATE A-1



VICINITY MAP
 MO 31223
 CAPE GIRARDEAU COUNTY, MO.



LOCATION MAP
 PLATE A-2



MISSOURI
SEISMIC ZONE MAP

APPENDIX B
PHOTOGRAPHS



*BROWN LAKE DAM
CAPE GIRARDEAU COUNTY, MISSOURI
MO. 31223*

PHOTO INDEX

PLATE B-1

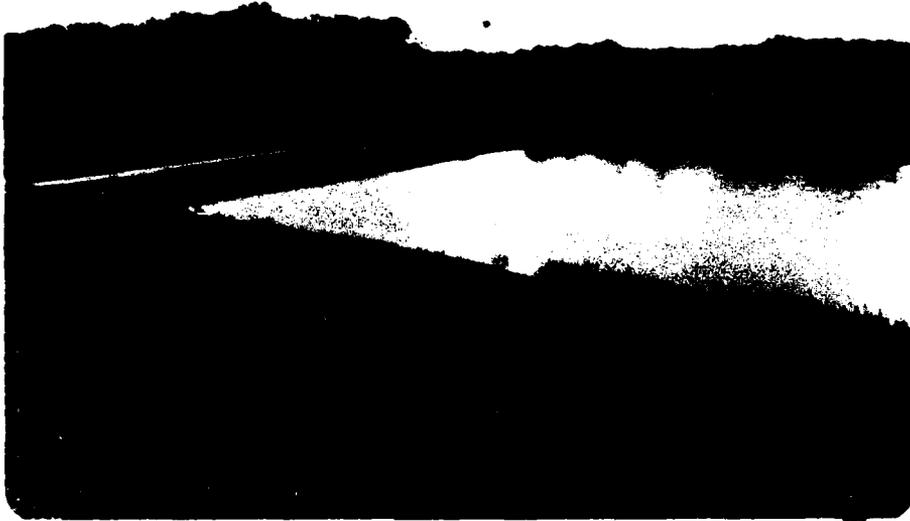


PHOTO NO. 2 - OVERVIEW FROM THE LEFT SIDE.



PHOTO NO. 3 - UPSTREAM SLOPE FROM THE LEFT SIDE.



PHOTO NO. 4 - CREST FROM THE LEFT SIDE.



PHOTO NO. 5 - DOWNSTREAM SLOPE FROM THE LEFT SIDE.

100000

100000



PHOTO NO. 6 - LOOKING UPSTREAM OVER THE PIPE SPILLWAY.



PHOTO NO. 7 - LOOKING DOWNSTREAM AT THE PRINCIPAL SPILLWAY OUTLET.



PHOTO NO. 8 - INLET OF THE PRINCIPAL SPILLWAY. THERE IS ALSO A 3-INCH DRAWDOWN PIPE WITH A GATE VALVE ON IT.



PHOTO NO. 9 - OUTLET OF THE PRINCIPAL SPILLWAY PIPE - 16-INCH DIAMETER STEEL PIPE.

FORM 13, BACK



PHOTO NO. 10 - END OF
THE PRINCIPAL SPILLWAY
OUTLET LOOKING DOWN-
STREAM INTO THE CHANNEL.



PHOTO NO. 11 - INLET OF THE AUXILIARY SPILLWAY ON THE
RIGHT SIDE. IT IS A 15-INCH C.M.P.

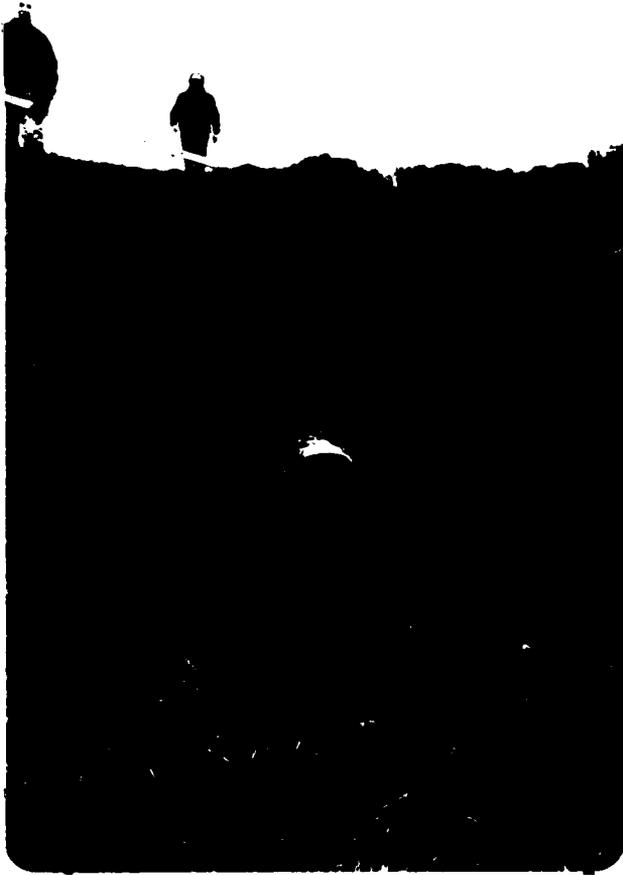


PHOTO NO. 12 - OUTLET OF
THE AUXILIARY SPILLWAY.



PHOTO NO. 13 - OUTLET OF THE AUXILIARY SPILLWAY. SEWAGE
LAGOON AT THE TOE OF THE DAM AT THE RIGHT
ABUTMENT SHOWS IN THE BACKGROUND.



PHOTO NO. 14 - LOOKING UPSTREAM AT LOW SPOT ON CREST ON THE LEFT END.



PHOTO NO. 15 - LOW SPOT ON CREST ON LEFT TAKEN FROM UPSTREAM.



PHOTO NO. 16 - DOWNSTREAM SLOPE OF THE DAM SHOWING
BERMUDA GRASS AND OUTLET CHANNEL.

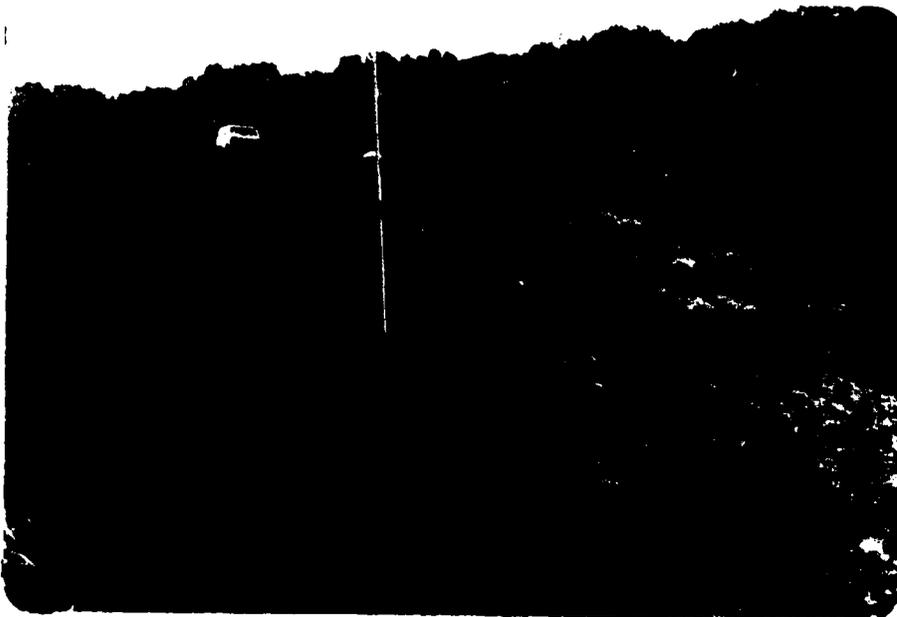


PHOTO NO. 17 - BERMUDA GRASS ON THE DOWNSTREAM SLOPE ABOUT
ONE-THIRD OF THE WAY UP THE SLOPE. COULD IN-
DICATE SEEPAGE ALONG THE TOE.

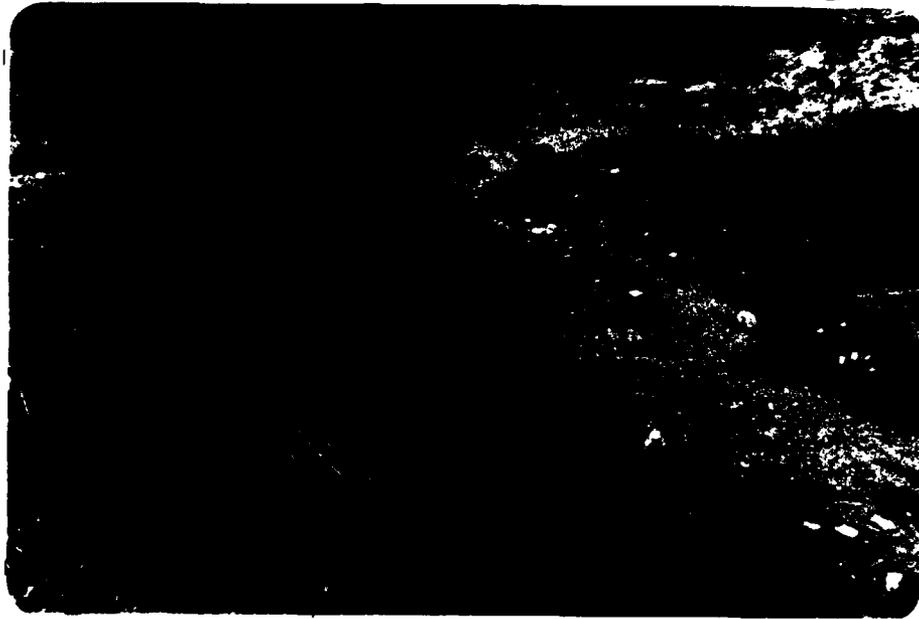


PHOTO NO. 18 - PAVED GUTTER DOWN THE LEFT ABUTMENT TROUGH.
ERODED ALONG THE SIDE.



PHOTO NO. 19 - ANOTHER
VIEW LOOKING UP THE ABUT-
MENT TROUGH AT EROSION
ALONG THE GUTTER. APPROX.
TWO TO THREE FEET WIDE
AND TWO FEET+ DEEP.

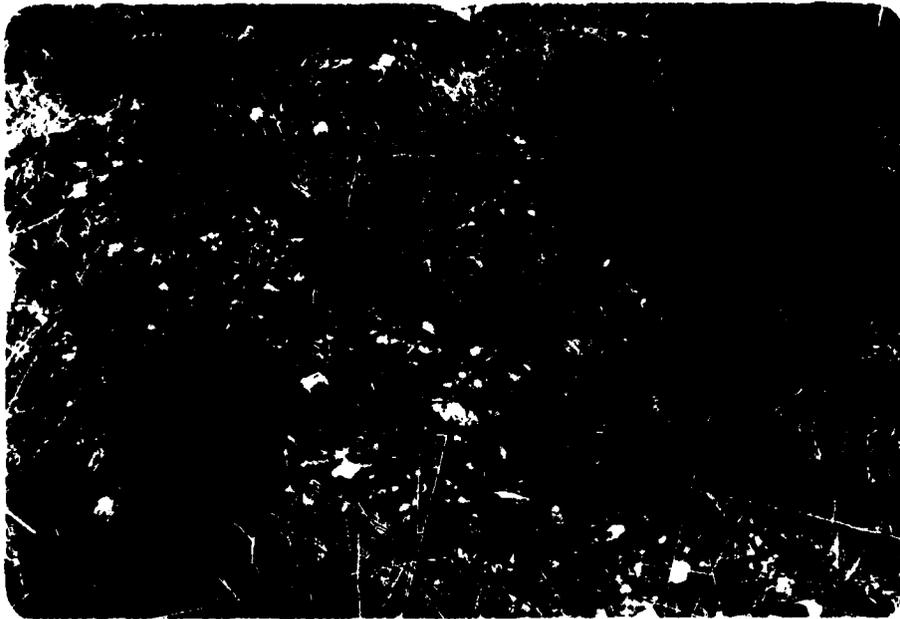


PHOTO NO. 20 - CHERTY CLAY EXPOSED IN THE LOWER PORTION
OF THE LEFT ABUTMENT TROUGH.



PHOTO NO. 21 - CHERTY GRAV-
EL EXPOSED AT THE TOP OF
DAM ELEVATION IN THE LEFT
ABUTMENT.

PLATE B-11



PHOTO NO. 22 - TRAILER LOCATED APPROX. 0.5 MILES DOWN-
STREAM OF THE DAM. HOUSE IN THE BACK-
GROUND.



PHOTO NO. 23 - LOOKING NORTHEAST AT HOUSE BEHIND THE
TRAILER IN PHOTO NO. 22.



PHOTO NO. 24 - CHURCH LOCATED 0.8 MILES DOWNSTREAM OF DAM.



PHOTO NO. 25 - HOUSES EAST OF THE CHURCH LOCATED ABOUT ONE MILE DOWNSTREAM OF DAM.

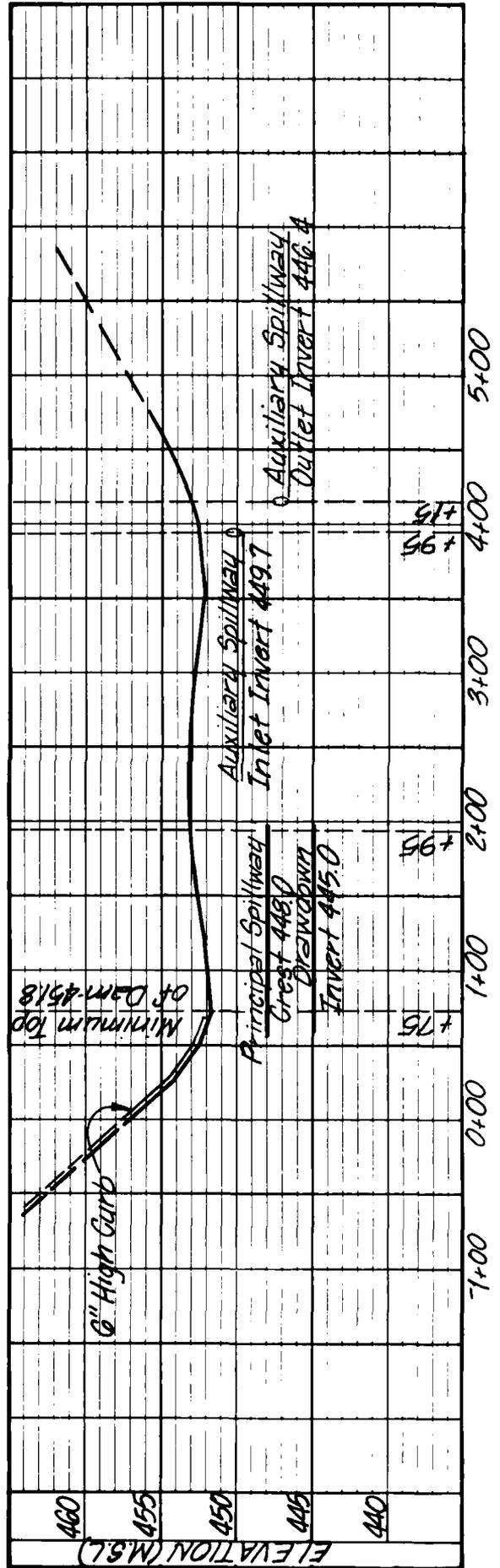
GROUP 1

FORM 2

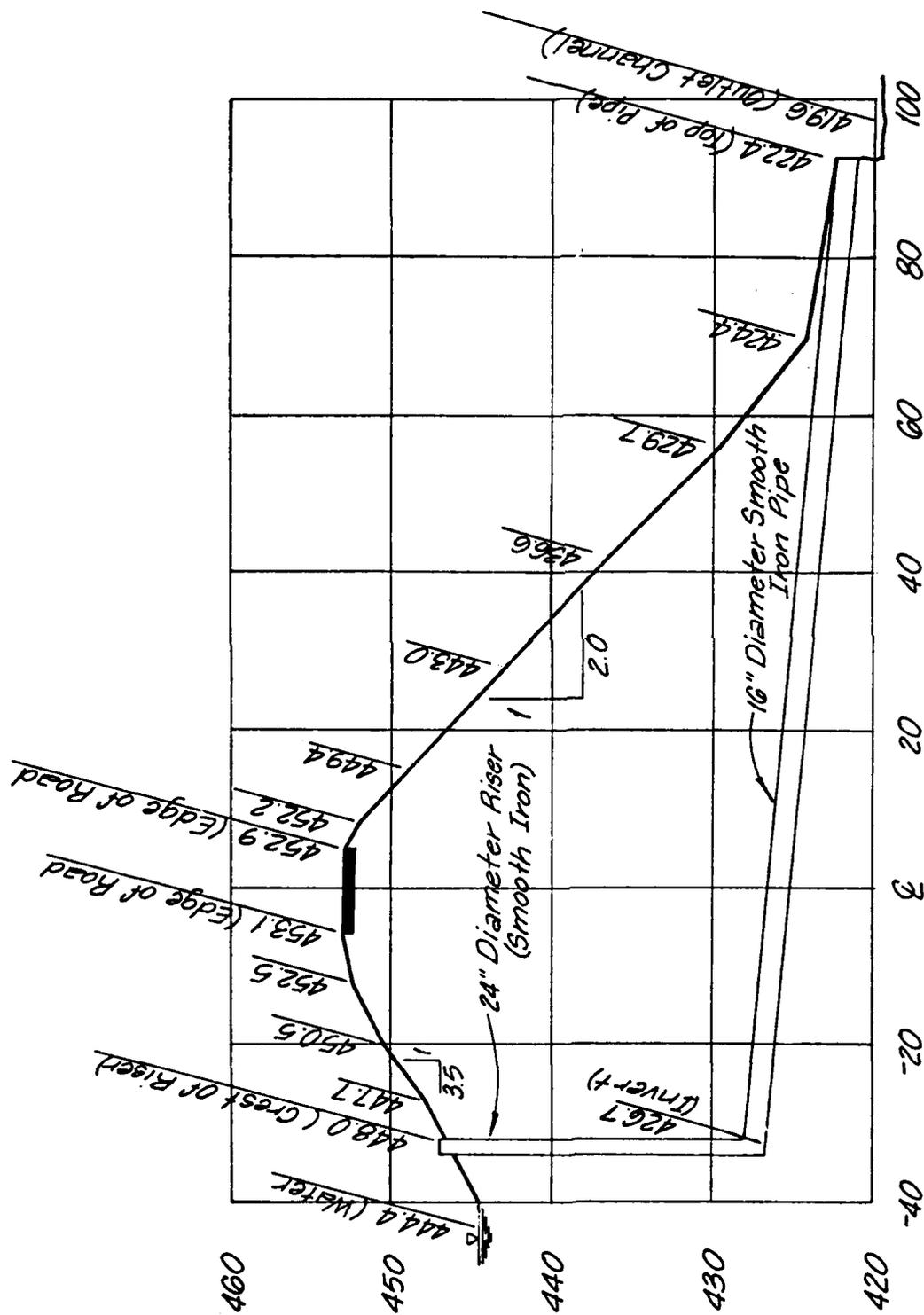
APPENDIX C
PROJECT PLATES



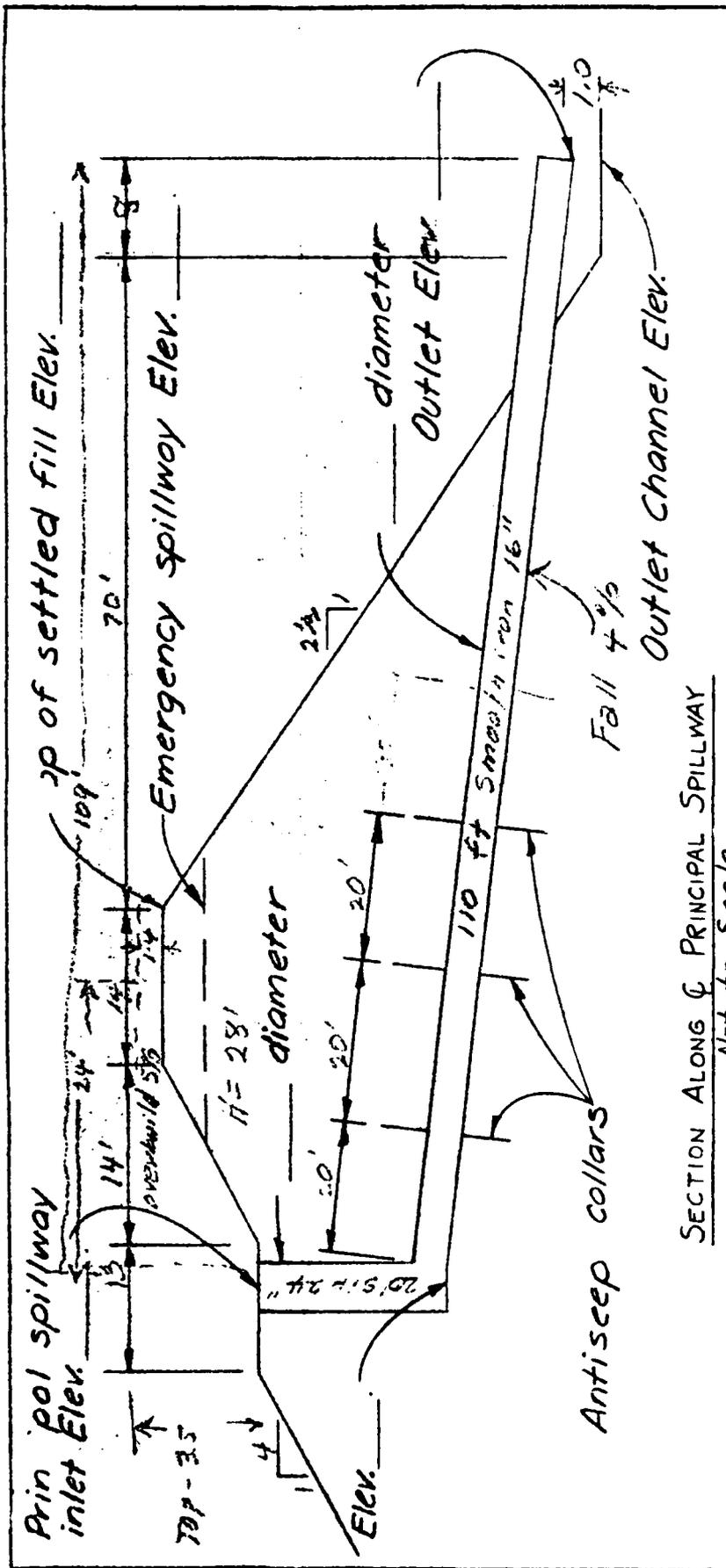
PLAN OF DAM
Scale: 1"=100'



CENTERLINE PROFILE OF DAM
Scale As Shown



MAXIMUM CROSS-SECTION OF DAM AT STA. 1+95
SCALE: 1" = 20' H.
1" = 10' V.



SECTION ALONG & PRINCIPAL SPILLWAY
 Not to Scale

QUAN	UNIT	ITEM
16	LI	20' x 17' x 24" (Riser)
26	FT	1" x 24" (Riser)
3	CR	Anti-seep collars 38" x 60" x 60"

COOPERATOR _____ MEC _____ T. _____ R _____
 COOPERATING WITH _____ STATE _____
 COUNTY _____ SURVEYED _____ DATE _____
 DROP INLET SPILLWAY

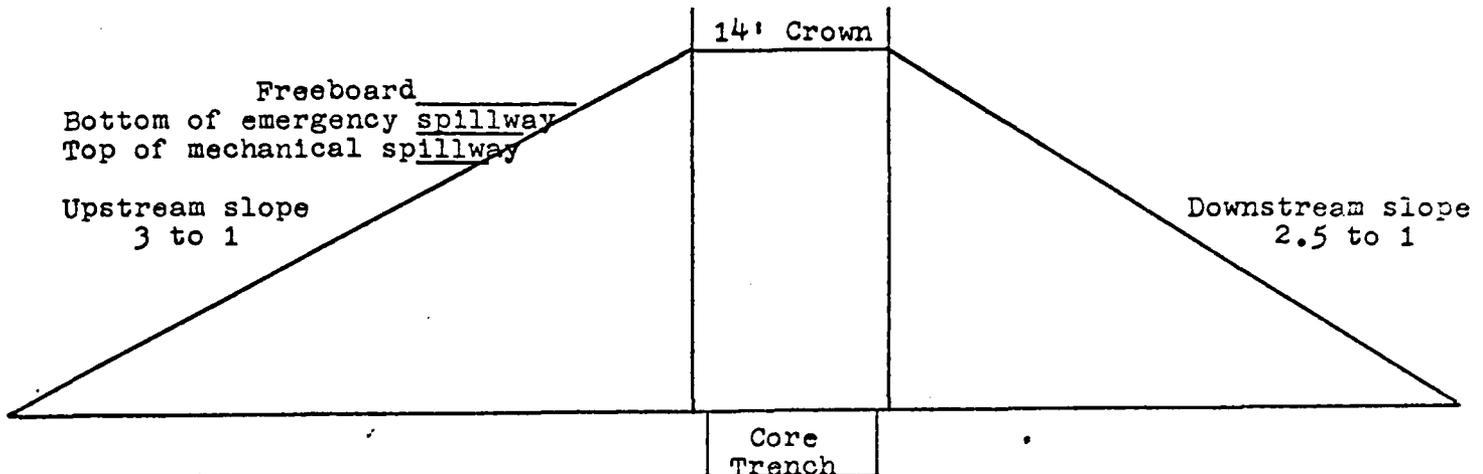
U. S. DEPARTMENT OF AGRICULTURE
 SOIL CONSERVATION SERVICE

Designed by _____
 Checked by _____
 Date _____

Cape GMC Pontiac Proposed Lake
T31N - R14E - S17
755 South Kingshighway
Cape Girardeau, Missouri

July 7, 1971

CROSS SECTION THRU THE LAKE DAM



1. All dams over 20' high should have a wider crown, therefore, I'm recommending a 14' crown. This will also make a better road since the crown is to be used for this purpose.
2. The freeboard should be 3 feet, this means the bottom of the emergency spillway should be 3 feet below the top of the dam.
3. The top of the mechanical spillway should be one (1) foot below the bottom of the emergency spillway or four (4) feet below the top of the dam. This would give acre feet of storage.
4. The core trench should be at least 8 feet wide. The depth of the core trench depends on the soil type, gravel, rocks, etc.. Make sure no gravel deposits are underneath. The length of the core trench should be under the entire length of the dam. Naturally, the core trench will be deeper in the bottom of the valley. The core trench should be re-filled with good clay earth.
5. "Very Important" - Before the lake has been started test holes should be dug at different places on the line of the dam to make sure we have good clay earth and that no rocks nor gravel is present.
6. The entire area that the dam will set on should be scrapped off, the vegetation removed. This could be pushed to the lower part of the dam and used for fill. All trees and stumps should be removed in the dam site.
7. The mechanical spillway, the location, size of the pipe, seep collars, and the emergency spillway can be worked out later. Assistance will be gotten from the Soil Conservation Service as to the drainage ratio and necessary pipe size.

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Box 215, New Madrid, Missouri 63869

SUBJECT: Soils - Investigation of lake site - GMC Motor Co. September 28, 1971
TO: Keith Little, D.C., SCS, Jackson, Missouri

Just for the record let me jot down our finding at the lake site we investigated this AM.

Two pits were dug at the dam site with a back hoe. The soil material was as following: five to six feet of the surface accumulation is grayish brown gravelly silt loam, a mixture of alluvial silts and cherty residuum washed from the adjacent uplands. The surface two feet contained an estimate 30 to 50 percent chert while the lower part increased up to 75 percent or more of chert. In other words, the soil material is increasingly cherty with depth. The 4 to 6 feet depth layer has a noticeable amount of voids and was very porous. Below 6 feet is yellowish brown cherty clay loam or light clay. The chert content is estimated to be 20 to 40 percent. The material is sticky, plastic and contained some grayish mottles. Thickness is more than 2 feet thick.

It is reasonable to assume from the properties exhibited that the yellowish brown clayey material has a slow permeability and seepage rate but the upper six feet of gravelly silt loam has a rather rapid permeability and seepage rate. Therefore, it is necessary to cut a core trench approximately 8 feet deep and sufficiently wide (probably 12 or 14 feet) and back fill and compact a suitable material.

A third pit was dug in the upper part of the proposed reservoir area. The soil profile there is similar to the others differing mainly in having thinner layers. It was also underlain by the yellowish brown cherty clay at about five feet. The presence of grayish mottles, the texture and consistence indicate that this clayey layer is suitable for water impoundment. Permeability is estimated to be slow.

The grayish brown gravelly silt loam in the upper 4 to 6 feet of the alluvial plain is not a suitable fill material - it has poor compaction characteristics and only fair to poor stability. Two or three feet of this material will however probably affect the seepage rate of the reservoir area only slightly.


Burton L. Brown, Soil Scientist
New Madrid, Missouri

MO-ENG-110
12/70
(File Code ENG-13)

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DESIGN SHEET FOR CLASS II III IV * DETENTION STORAGE STRUCTURE
WITH DROP INLET SPILLWAY -- HOOD INLET SPILLWAY -- CANOPY INLET SPILLWAY *

Landowner _____ Location _____

Design by _____ Date _____ Checked by _____ Date _____

Drainage area = 100 ac. Height X storage = _____ X _____ = _____

WATERSHED CONDITIONS AND FACTORS

Location factor: L = _____
Infiltration factor: (above)(average)(below) * I = _____
Topographic factor: _____% average slope T = _____
Shape factor: runoff distance = _____ ft. S = _____
Cover factor: cropland _____%, pasture _____%, timber _____% V = _____
Contouring factor: C = _____
Storage factor: _____% terraced P = _____

PEAK RATE OF RUNOFF AND VOLUME OF RUNOFF

Product of factors = L X I X T X S X V X C X P = 0.8 $Q_{10} = \underline{196}$ c.f.s.

V X I = _____ X _____ = 0.8

For Principal Spillway Design:

- 25-year peak rate of runoff = $Q_{ip} = \underline{1.3} \times \underline{196}$ c.f.s. = 255 c.f.s.

Rate of volume of runoff = 0.16 ac.ft./ac. (Table 1, 1519)

Total volume of runoff = $V_{rp} = (\text{drainage area}) \times (\text{rate of volume of runoff}) \times L =$
100 ac. X 0.16 ac.ft./ac. X 1.0 = 16 ac.ft.

For Both Spillways (total structure):

25-year peak rate of runoff = $Q_i = \underline{1.3} \times \underline{196}$ c.f.s. = 255 c.f.s.

Rate of volume of runoff = 0.16 ac.ft./ac.

Total volume of runoff = $V_r = \underline{100}$ ac. X 0.16 ac.ft./ac. X 1.0 = 16 ac.ft.

*Mark out those items that do not apply.

Instructions for use of form: Make one pencil copy for applicable structure. File with other worksheets and structure plan in cooperator's or landowner's folder in work unit office.

	Stage	Stage
	A.Ft.	Ac.Ft.
Perm surf.	3.0	2.0
Surft 2.0-4	9.0	17.0

PRINCIPAL SPILLWAY DESIGN

Available storage at stage of 2.0 ft. = $V_{sp} =$ 16 ac.ft. (See map)

$V_{sp}/V_{rp} =$ 17 ac.ft. / 16 ac.ft. = 1.1. $Q_{op}/Q_{ip} =$ _____ (Table 2, 1519)

$Q_{op} = Q_{ip} \times$ 0.01 = 255 c.f.s. \times 0.01 = 2.5 c.f.s. *store total runoff*

Conduit:

Type SMOOTH IRON Length = 110 ft. Total head on conduit = 24 ft.

Diameter = 16 in. Discharge capacity = 25 c.f.s. (1520)

Minimum entrance head = _____ ft. (1510 or 1511)

Riser: **

Type _____ Height = _____ ft. Diameter = _____ in. (1511)

EMERGENCY SPILLWAY DESIGN

Control Section:

Depth of flow = _____ ft. V_s at this depth = _____ ac.ft. (See map)

$V_s/V_r =$ _____ ac.ft. / _____ ac.ft. = _____

$Q_{op}/Q_i =$ _____ c.f.s. / _____ c.f.s. = _____ $Q_{oe}/Q_i =$ _____ (Table 3, 1519)

$Q_{oe} = Q_i \times$ _____ = _____ c.f.s. \times _____ = _____ c.f.s.

Width = _____ ft. Total depth = depth of flow + freeboard = _____ ft. + 1.0 =

_____ ft. Use _____ ft. (Table 4, 1517)

Exit Section:

Slope = _____ % Quality of vegetation: (fair)(good)(excellent) *

(Less)(More) * erosive soils. Permissible velocity = _____ f.p.s. (1517)

Depth = _____ ft. Design velocity = _____ f.p.s. Width = _____ ft. (1517 or 1505)

Use width of _____ ft.

ANTI-SEEP COLLARS

Length of saturated zone = $L =$ _____ ft. Collar addition = _____ ft. (1515)

Number = $n = (L \times \text{_____}) / V = (\text{_____} \times \text{_____}) / \text{_____} = \text{_____}$. Use _____ collars.

Mark out those items that do not apply.

* Applies only to Drop Inlet Spillways.

Cape GMC Pontiac Proposed Lake
T31N - R14E - S17
755 South Kingshighway
Cape Girardeau, Missouri

July 7, 1971

Estimated size in surface area-----	9.8 acres
Length of dam-----	420.0 feet
Maximum height of dam-----	25.0 feet
Crown width of dam-----	14.0 feet
Base of dam in width-----	152.0 feet
Drainage area in acres*-----	??.
Drainage ratio-----	??.
Estimated cubic yards for construction----- Does not include digging core trench	19,250

APPENDIX D
HYDRAULIC AND HYDROLOGIC DATA

HYDROLOGIC COMPUTATIONS

1. The SCS dimensionless unit hydrograph and the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Corps of Engineers, Davis, California, were used to develop the inflow hydrographs (see this Appendix).
 - a. Twenty-four, one percent probabilistic rainfall for the dam location was taken from the data for the rainfall station at Cape Girardeau, Missouri, as supplied by the St. Louis District, Corps of Engineers per their letter dated December 5, 1980. The twenty-four hour probable maximum precipitation was taken from the curves of Hydrometeorological Report No. 33 and current Corps of Engineers and St. Louis policy and guidance for hydraulics and hydrology.
 - b. Drainage area = 0.155 square miles (99 acres).
 - c. Time of concentration of runoff = 10 minutes (computed from the "Kirpich" formula and verified using the equation from the California Culverts Practice, California Highways and Public Works Department).
 - d. The antecedent storm conditions for the probable maximum precipitation were heavy rainfall and low temperatures which occurred on the previous 5 days (SCS AMC III). The antecedent storm conditions for the one percent probabilistic precipitation were an average of the conditions which have preceded the occurrence of the maximum annual flood on numerous watersheds (SCS AMC II). The initial pool elevation was assumed at the invert of the principal spillway.
 - e. The total twenty-four hour storm duration losses for the one percent probabilistic storm were 4.52 inches. The total losses for the PMF storm were 3.35 inches. These data are based on SCS runoff curve No. 59 and No. 77 for antecedent moisture conditions SCS AMC II and AMC III respectively. The watershed is composed of primarily SCS soil groups Menfro and Winfield (hydrologic soil group "B"). Heavy, thick woods cover the majority of the watershed area.
 - f. Average soil loss rates = 0.14 inch per hour approximately (for PMF storm, AMC III).
2. The combined discharge rating consisted of three components: the flow through the principal spillway, the flow through the auxiliary spillway and the flow going over the top of the dam.

The discharge rating for the principal spillway was developed using equations for orifice, weir, and full conduit flow. They are as follows:

- a. Orifice flow equation ($Q = CA\sqrt{2gH}$)
 where C = orifice coefficient = 0.6
 A = area of opening, ft² = 3.14
 H = total head, ft. = pool elev. - 448.0
- b. Weir flow equation ($Q_w = CLH^{1.5}$)
 where C = weir coefficient = 3.1 (from SCS Engr. Memo 50)
 L = length of weir, ft. = 6.28
 H = total head, ft. = pool elev. - 448.0
- c. Full conduit flow equation

$$Q = a \sqrt{\frac{2gH}{1 + K_e + K_p L + K_b}}$$

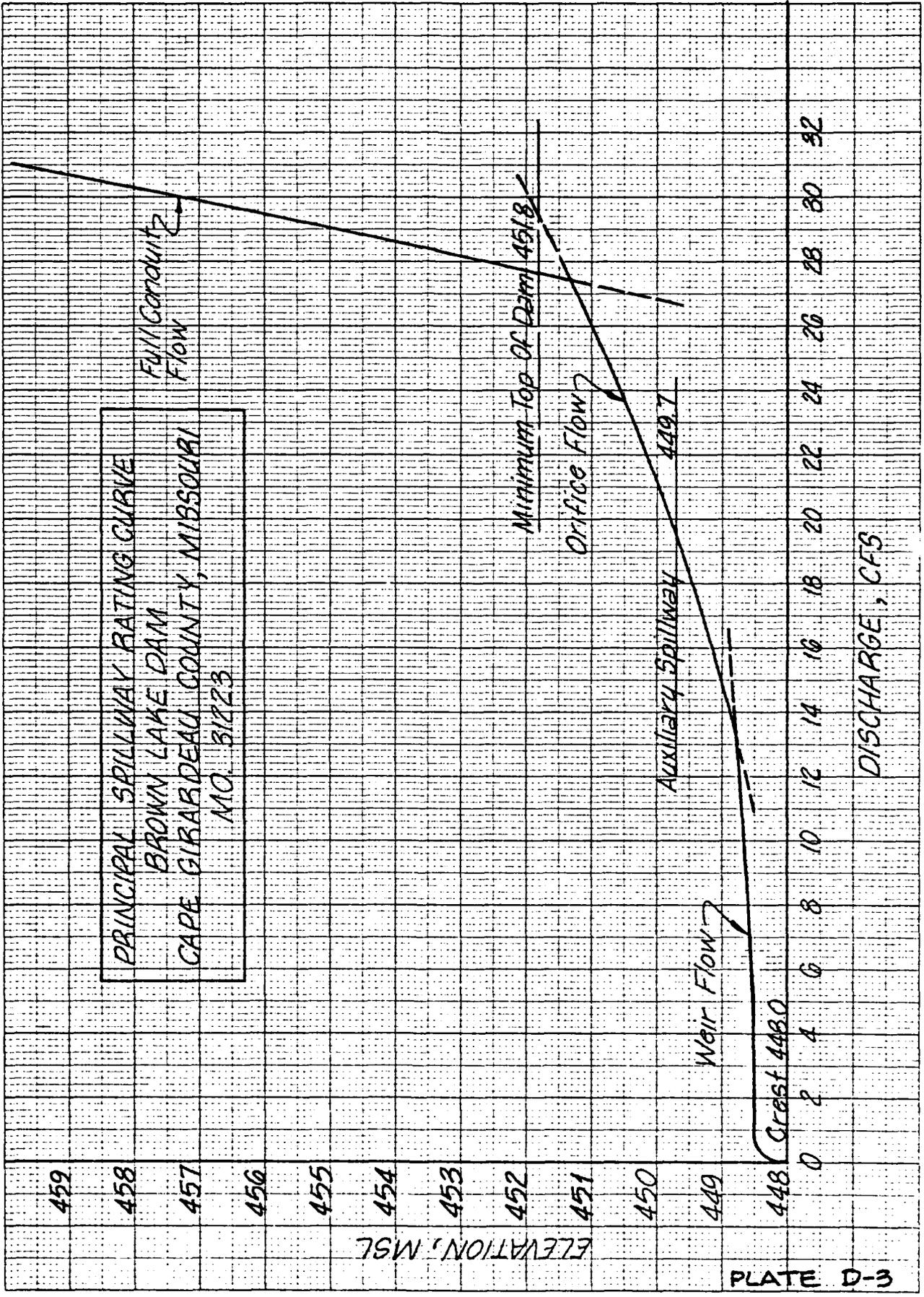
- where a = cross-sectional area of pipe, ft² = 1.4
 H = total head, ft. = pool elev. - 421.8
 K_p = coefficient for pipe friction loss = 0.0247
 (assuming n = 0.014, ES-42, SCS NEH, Section 5)
 K_e = coefficient for entrance loss = 0.5 (Chow, Vente Handbook of Applied Hydrology, New York: McGraw-Hill Book Co., Inc., pp. 21-62 to 21-64)
 K_b = coefficient for bend loss = 0.42 (Chow, Vente Handbook of Applied Hydrology, New York: McGraw-Hill Book Co., Inc., pp. 21-62 to 21-64)
 L = Length of pipe, ft. = 123

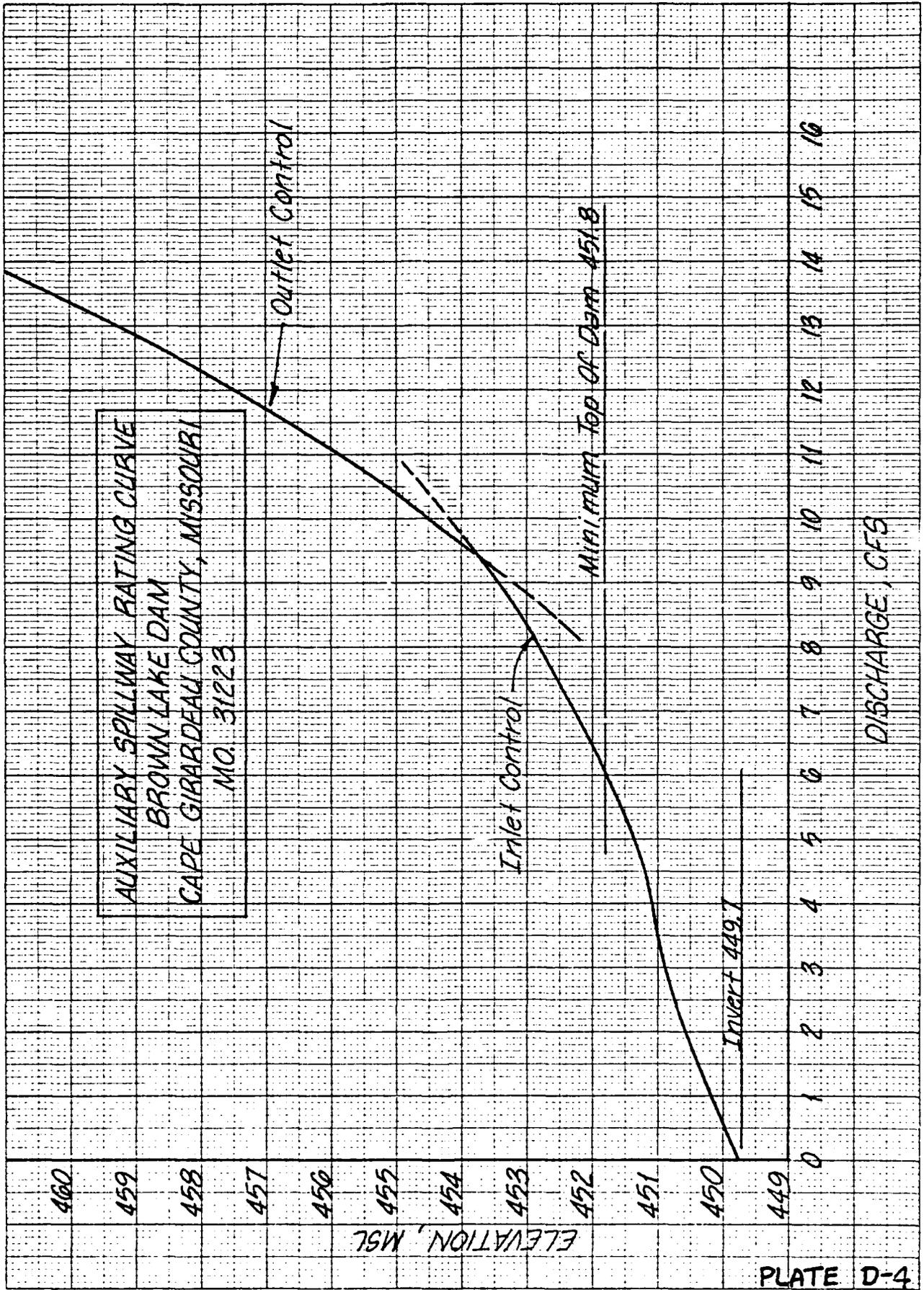
The auxiliary spillway rating was developed by using culvert flow tables for CMP culverts with inlet control and outlet control as found in FHA-BPR HEC Circ. No. 5.

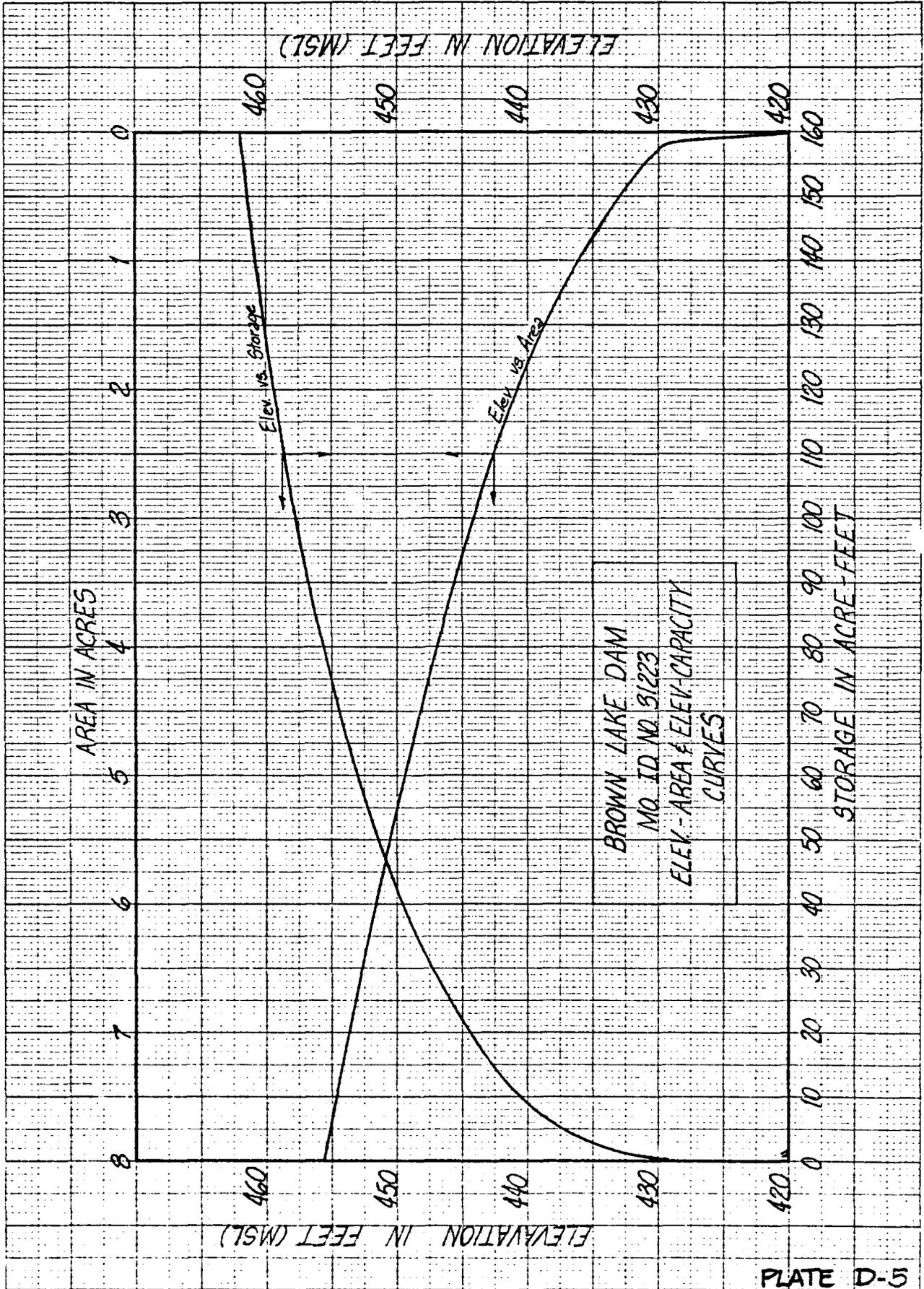
The flows over the dam crest were developed using the HEC-1 (Dam Safety Version) program using the irregular top of dam option.

3. Floods were routed through the reservoir using the HEC-1 (Dam Safety Version) program to determine the capabilities of the spillway and dam embankment crest. The output and plotted hydrographs are shown in this Appendix.

PRINCIPAL SPILLWAY RATING CURVE
 BROWN LAKE DAM
 CAPE GIRARDEAU COUNTY, MISSOURI
 MO. 31223







BROWN LAKE DAM.
MO. ID. NO. 91223
ELEV.-AREA & ELEV.-CAPACITY
CURVES

 FLOOD HYD. MAP PACKAGE (MFC-1)
 LAG UNIT. CURSORS JULY 1978
 LAST MODIFICATION 26 FEB 79

RDY DATE 01/09/80.
 TIME 17.00.42.

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
 WITH ANALYSIS OF SAFETY OF BROWN LAKE 31223
 RATIOS OF PMF ROUTED THROUGH THE RESERVOIR

RDY 000001
 NDAY 5
 JOPER 5
 NMTM 5
 IDAY 0
 JOPER 5
 IWK 0
 LRPT 0
 IWK 0
 LRPT 0
 METRC 0
 TRACE 0
 IPLT 0
 IPRT 3
 NSTAN 0

MULTI-PLAN ANALYSES TO BE PERFORMED
 NPLAN= 1 RATIO= 9 LRTRIO= 1

KFIOS= .10 .15 .20 .25 .30 .35 .40 .50 .50 1.00

***** SUB-AREA RUNOFF COMPUTATION *****

CALCULATION OF INFLOW HYDROGRAPH TO RESERVOIR 51223

ISTAQ 000001
 ICOMP 0
 ITAPE 0
 JPLT 0
 INAME 1
 ISTAGE 0
 IAUTO 0

IHYDG 1
 IUNG 2
 TANEA .16
 SWAP 0.00
 HYDROGRAPH DATA
 TRSDA TRSPC
 .16 1.00
 RATIO 0.000
 ISNOW 0
 ISAME 1
 LOCAL 0

SPFL 0.00
 PMS 27.00
 R6 102.00
 R12 121.00
 R24 130.00
 R48 0.00
 R72 0.00
 R96 0.00

LRPT 0
 STRKH 0.00
 DLTKH 0.00
 RTIOL 1.00
 ERAIN 0.00
 STRKS 0.00
 RTIOK 1.00
 SIRTL -1.00
 CMSTL -77.00
 ALSMX 0.00
 RTIMP 0.00

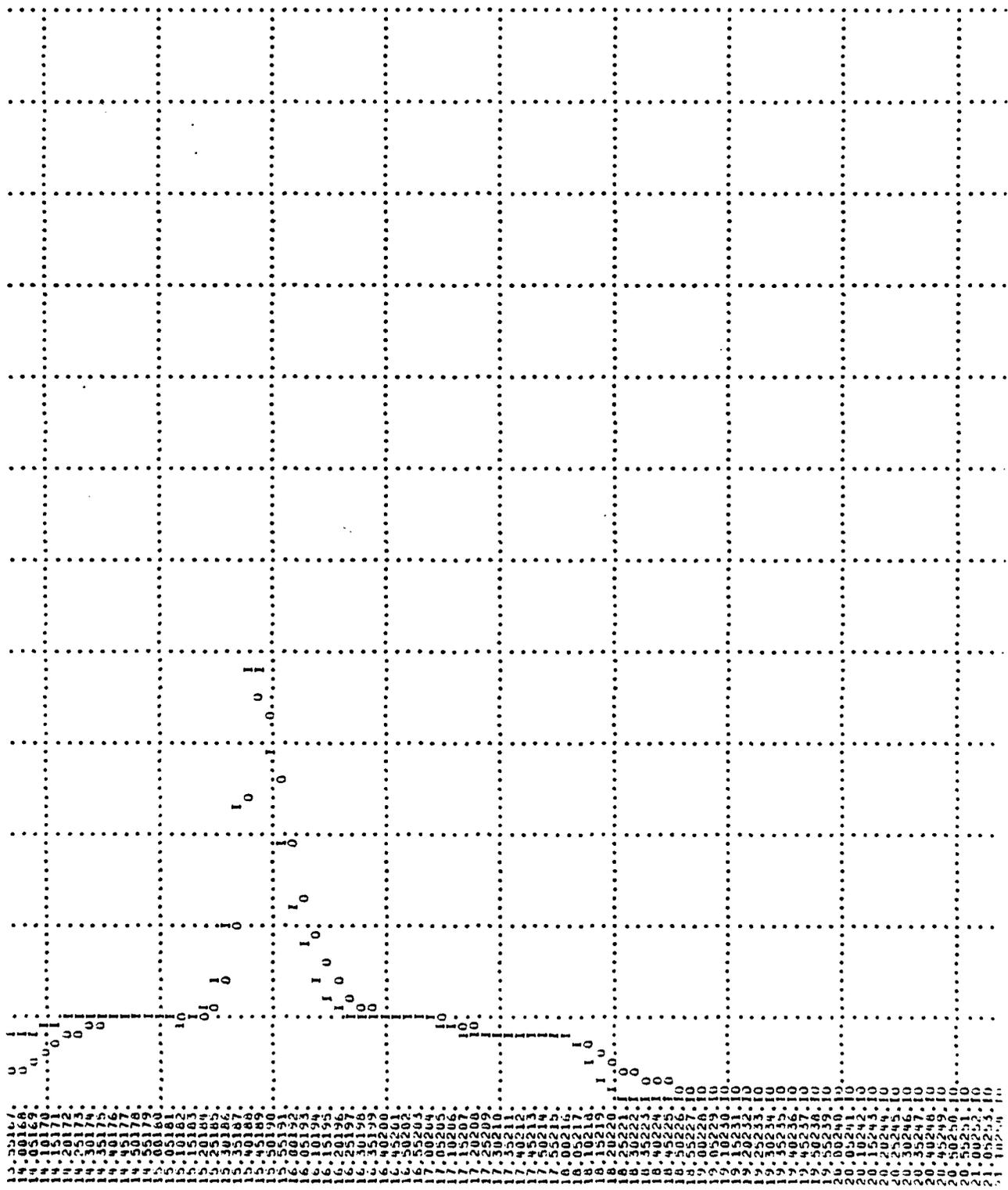
CURVE NO = -77.00 WETNESS = -1.00 EFFECT CN = 77.00

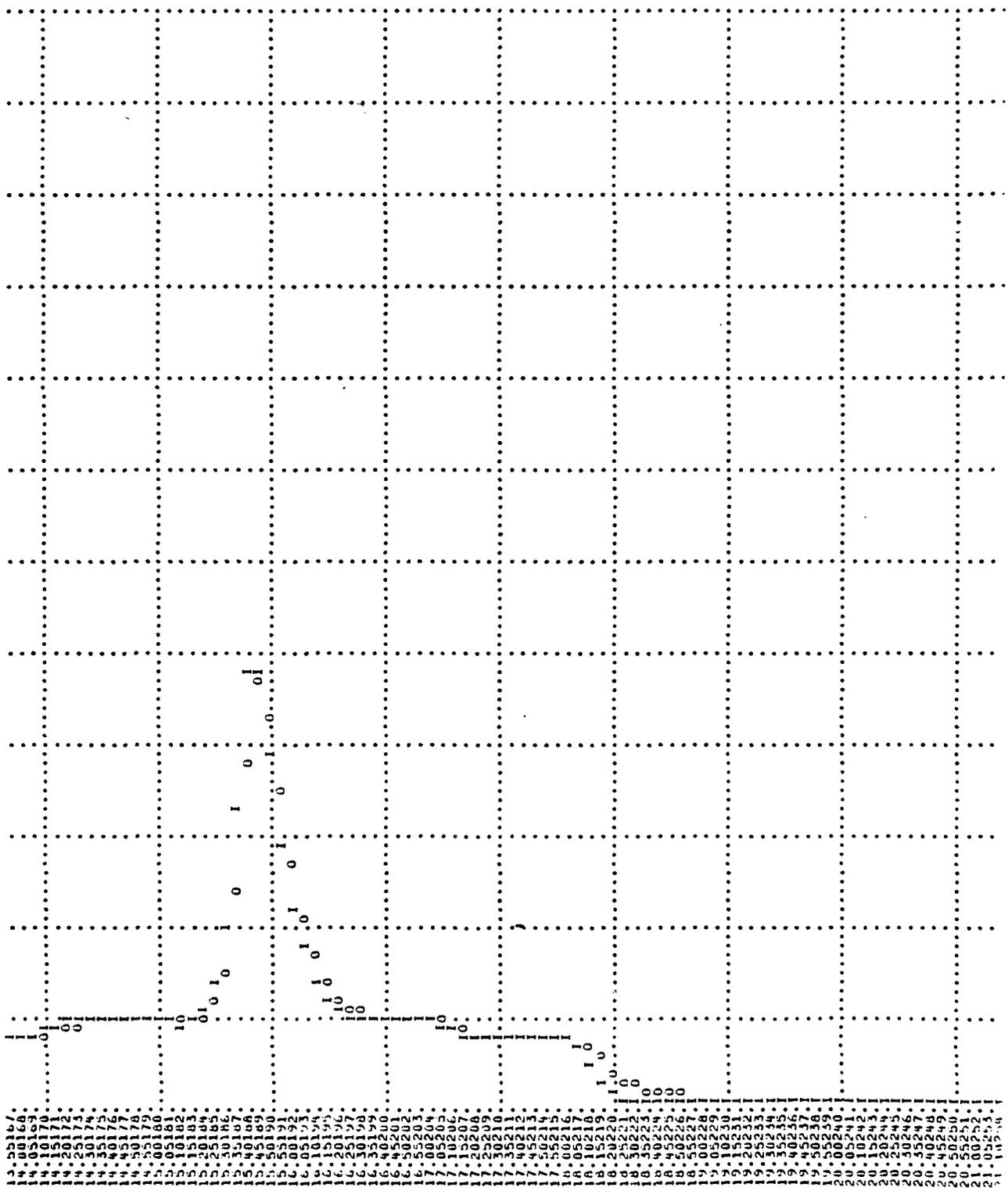
UNIT HYDROGRAPH DATA
 TC= 0.00 LAG= .17

SIRTO= 0.00 RECESION DATA
 ORCSM= -.01 RTIYR= 1.00

107. UNIT HYDROGRAPH 323.
 2. LHD OF PERIOD ORIGINATES, TC= 56. 0.00 HOURS, LAG= 30. .17 VOL= 1.00 4.
 354. 210. 105. 30. 8.

MO.DA	HR.MN	PERIOD	RATN	EXCS	LOSS	LMD-OF-PERIOD FLOW	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP U
1.01	0.05	1	.01	0.00	.01	1.01	12.05	145	.23	.20	.03	.03	.90
1.01	1.15	2	.01	0.00	.01	1.01	12.15	146	.23	.20	.03	.03	135.
1.01	2.25	3	.01	0.00	.01	1.01	12.20	147	.23	.20	.03	.03	183.
1.01	3.35	4	.01	0.00	.01	1.01	12.25	149	.23	.21	.02	.02	2213.
1.01	4.45	5	.01	0.00	.01	1.01	12.30	150	.23	.21	.02	.02	2229.
1.01	5.55	6	.01	0.00	.01	1.01	12.35	151	.23	.21	.02	.02	2238.
1.01	6.65	7	.01	0.00	.01	1.01	12.40	152	.23	.21	.02	.02	2247.
1.01	7.75	8	.01	0.00	.01	1.01	12.45	153	.23	.21	.02	.02	2247.
1.01	8.85	9	.01	0.00	.01	1.01	12.50	154	.23	.21	.02	.02	2251.
1.01	9.95	10	.01	0.00	.01	1.01	12.55	154	.23	.21	.02	.02	2252.
1.01	11.05	11	.01	0.00	.01	1.01	13.00	155	.23	.21	.02	.02	2253.
1.01	12.15	12	.01	0.00	.01	1.01	13.05	157	.20	.26	.02	.02	2259.
1.01	13.25	13	.01	0.00	.01	1.01	13.10	159	.20	.26	.02	.02	274.
1.01	14.35	14	.01	0.00	.01	1.01	13.15	159	.28	.26	.02	.02	289.
1.01	15.45	15	.01	0.00	.01	1.01	13.20	160	.28	.26	.02	.02	289.
1.01	16.55	16	.01	0.00	.01	1.01	13.25	161	.28	.26	.02	.02	304.
1.01	17.65	17	.01	0.00	.01	1.01	13.30	162	.28	.26	.02	.02	308.
1.01	18.75	18	.01	0.00	.01	1.01	13.35	162	.28	.26	.02	.02	308.
1.01	19.85	19	.01	0.00	.01	1.01	13.40	163	.28	.26	.02	.02	310.
1.01	20.95	20	.01	0.00	.01	1.01	13.45	164	.28	.26	.02	.02	311.





PLAN FLOW AND STORAGE (LHD 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	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
RATIOS APPLIED TO FLOWS												
.10 .15 .20 .25 .30 .35 .40 .50												
HYDROGRAPH AT	000001	.16	1	191	287	382	478	573	669	765	861	956
		.40		5.41	8.12	10.83	13.53	16.24	18.95	21.65	24.36	27.07
ROUTE TO	000002	.16	1	28	45	61	78	94	111	128	145	162
		.40		.80	1.29	1.78	2.27	2.76	3.25	3.74	4.23	4.72

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	ELEVATION STORAGE OUTFLOW	INITIAL VALUE	SPILLWAY CHEST	TOP OF DAM	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
		448.00	448.00	451.80		
		33.	33.	53.		
		0.	0.	34.		
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
.10	450.81	0.00	47.	28.	0.90	18.08
.15	452.10	.20	55.	45.	2.83	17.58
.20	453.55	.75	58.	151.	3.50	16.08
.25	454.87	1.07	60.	331.	3.92	16.92
.30	456.06	1.26	62.	494.	4.40	15.83
.35	457.23	1.43	63.	586.	5.00	15.83
.40	458.23	1.55	64.	687.	5.50	15.83
.45	459.23	1.71	64.	821.	6.23	15.72
1.00	459.99	2.15	68.	1850.	8.32	15.72

DATE
ILME