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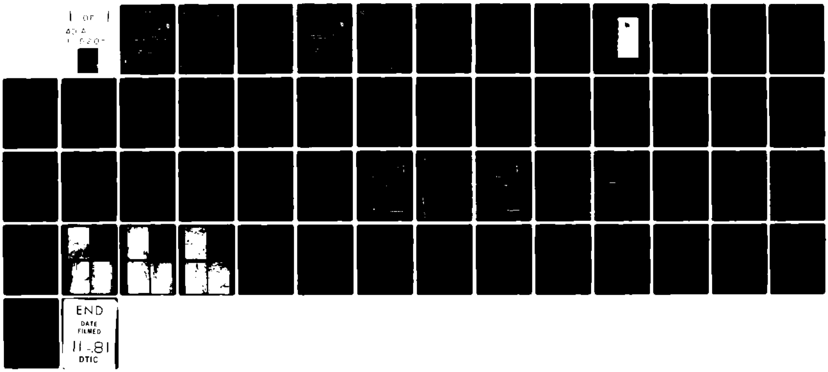

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UPPER MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

LAKE BONO DEL DAM

JEFFERSON COUNTY, MISSOURI

MO 30434

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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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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LAKE BONO DEL DAM

JEFFERSON COUNTY, MISSOURI

MO 30434

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
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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

LMSED-P

SUBJECT: Lake Bono Del Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Lake Bono Del Dam (MO 30434):

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:

1) Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

2) Overtopping of the dam could result in failure of the dam.

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

SUBMITTED BY: SIGNED — Chief, Engineering Division — 28 APR 1981 Date

APPROVED BY: SIGNED — Colonel, CE, District Engineer — 29 APR 1981 Date

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LAKE BONO DEL DAM

MISSOURI INVENTORY NO. 30434

JEFFERSON COUNTY, MISSOURI

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

APRIL 1981

HS-8088

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Lake Bono Del Dam
State Located:	Missouri
County Located:	Jefferson
Stream:	Tributary of Belew Creek
Date of Inspection:	25 November 1980

The Lake Bono Del Dam, which according to the St. Louis District, Corps of Engineers, is of high hazard potential, was visually inspected by engineering personnel of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of this inspection was to assess the general condition of the dam with respect to safety, and based upon this inspection and available data, determine if the dam poses an inordinate danger to human life or property. Evaluation of this dam was performed in accordance with the "Phase I" investigation procedures prescribed in "Recommended Guidelines for Safety Inspection of Dams" dated May 1975.

The following summarizes the findings of the visual inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team. Based on the visual inspection and the results of these hydrologic/hydraulic investigations, the present general condition of the dam is considered to be somewhat less than satisfactory. Several deficiencies were observed during the visual inspection which are considered to have an adverse effect on the overall safety and future operation of the dam. These deficiencies include such items as trees and brush on the downstream face of the dam, animal burrows in the upstream face of the dam, embankment erosion at the upstream face of the dam, and a fence extending across the spillway channel.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Lake Bono Del Dam, which, according to Table 1 of the guidelines, is classified as small in size and of high hazard potential, is specified, according to Table 3 of the guidelines for a dam of high hazard potential and small size, to be a minimum of one-half the Probable Maximum Flood (PMF). The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. Considering the fact that a relatively small volume of water is impounded by the dam, that the downstream flood plain is fairly broad, and that there are but six dwellings within the potential flood damage zone, it is recommended that the spillway for this dam be designed for one-half the Probable Maximum Flood.

Results of a hydrologic/hydraulic analysis indicated that the spillway is inadequate to pass lake outflow resulting from a storm of one-half PMF magnitude without overtopping the dam, which could cause failure. However, the spillway is capable of passing lake outflow resulting from the one percent chance (100-year frequency) flood and the lake outflow corresponding to about 30 percent of the PMF lake inflow, without overtopping the dam. According to the St. Louis District, Corps of Engineers, the length of the downstream damage zone, should failure of the dam occur, is estimated to be apprxoimately one mile. Within the possible damage zone are six dwellings, five of which are located about the upstream end of Lake Tishomingo, a privately owned lake of about 115 acres of surface area.

A review of available data did not disclose that seepage or stability analyses of the dam were performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action within the near future to correct or control the deficiencies and safety defects reported herein.

Ralph E. Sauthoff
P. E. Missouri E-19090

Albert B. Becker, Jr.
P. E. Missouri E-9168

OVERVIEW LAKE BONO DEL DAM

PHASE 1 INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

LAKE BONO DEL DAM - MO 30434

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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

LAKE BONO DEL DAM - MO 30434

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United Staes. Pursuant to the above, the St. Louis District, Corps of Engineers, directed that a safety inspection of the Lake Bono Del Dam be made.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of the dam with respect to safety and, based upon available data and this inspection, determine if the dam poses an inordinate danger to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance wth the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams", Appendix D to "Report to the Chief of Engineers on the National Program of Inspection of Non-Federal Dams", dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Lake Bono Del Dam is an earthfill type embankment rising approximately 27 feet above the natural streambed at the downstream toe of the barrier. The embankment has an upstream slope (above the waterline) of approximately 1v on 2.7h, a crest width of about 12 feet, and a downstream slope on the order of 1v on 2.2h. A section of chain-link fence fabric about 6 feet in width lies along the upstream face of the dam at about the normal waterline. The fabric serves to protect the dam from burrowing animals. The length of the dam is approximately 514 feet. A plan and profile of the dam is shown on Plate 3 and a cross-section of the dam, at about the location of the original stream on which the dam was constructed, is shown on Plate 4. At normal pool elevation, the reservoir impounded by the dam occupies approximately 4.0 acres. There is no lake drawdown facility to dewater the lake. An overview photo of the Lake Bono Del Dam is shown following the preface at the beginning of the report.

The spillway, an excavated earth trapezoidal section, is located at the right, or west abutment. The crest section and a portion of the exit section of the spillway are paved with concrete. Just downstream of the paved section, the channel invert is protected from erosion by stone riprap and pieces of broken concrete. Three 2-inch diameter steel pipes support a [illegible]-inch high wire mesh type fence that crosses the channel at the crest of the spillway. The spillway outlet channel, an irregular excavated earth trapezoidal section, joins the original stream on which the dam lies at a point about [illegible] feet downstream of the toe of the dam. A profile of the spillway and a cross-section of the channel at the crest location are shown on Plate 5.

b. Location. The dam is located on an unnamed tributary of Belew Creek about [illegible] mile south of the intersection of Eisenhauer Road and House Springs Hillsboro Road and approximately 5 miles southeast of the community of Cedar Hill, Missouri, as shown on the Regional Vicinity Map, Plate 1. The dam is located in the southeast one-quarter of Section 4, Township 41 North, Range 4 East, within Jefferson County.

c. Size Classification. The size classification based on the height of the dam and storage capacity, is categorized as small (per Table 1, Recommended Guidelines for Safety Inspection of Dams).

d. Hazard Classification. The Lake Bono Del Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that if the dam should fail, there may be loss of life, serious damage to homes, or extensive damage to agricultural, industrial and commerical facilities, important public utilities, main highways, or railroads. The estimated flood damage zone, should failure of the dam occur, as determined by the St. Louis

District, extends one mile downstream of the dam. Within the potential damage zone are six dwellings, five of which are located about the upstream end of Lake Tishomingo, a privately owned lake of about 115 acres of surface area. Those features lying within the downstream damage zone reported by the Corps of Engineers, St. Louis District, were verified by the inspection team.

e. Ownership. The lake and dam are owned by Lake Bono Del, Inc., a Missouri corporation. Mrs. Sylvia Allen is the current president of the corporation's Board of Trustees. Mrs. Allen's address is Route 4, Box 475, Hillsboro, Missouri 63050.

f. Purpose of Dam. The dam impounds water for recreational use.

g. Design and Construction History. According to Mr. Joseph E. Bouska, the son of the owners of the property at the time the dam was built, the dam was constructed about 1954 or 1955 by his parents, Mr. and Mrs. Joseph C. Bouska. Mr. Bouska, Sr. is deceased, and Mrs. Bouska was unavailable during the course of these investigations. Mr. Bouska reported that the dam was built by Hubard and Lucas, an excavating contractor from DeSoto, Missouri. The present status or whereabouts of Messrs. Hubard and Lucas are unknown. No records of the design or data relating to the construction of the dam were available. Mr. Bouska also reported that the property was sold to a Mr. and Mrs. Cletus J. Moll in 1960, and that they, in turn, sold the property to Mrs. Sylvia Allen in about 1972.

h. Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the capacity of a concrete paved, excavated earth type spillway.

1.3 PERTINENT DATA

a. Drainage Area. With the exception of the land adjacent to the lake, which is an established residential type development, the area tributary to the lake is essentialy meadowland. The watershed above the dam amounts to approximately 63 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

(1) Estimated known maximum flood at damsite ... 43 cfs* (W.S. Elev. 615.7)

(2) Spillway capacity ... 248 cfs (W.S. Elev. 617.1)

c. Elevation (Ft. above MSL). Unless otherwise indicated, the following elevations were determined by survey and are based on topographic data shown on the 1954 Belew Creek, Missouri, Quadrangle Map, 7.5 Minute Series, (photorevised 1968 and 1974).

(1) Observed pool ... 614.5

(2) Normal pool ... 615.0

(3) Spillway crest ... 615.0

(4) Maximum experienced pool ... 615.7 (per J. E. Bouska)

(5) Top of dam ... 617.2 (Min.)

(6) Effective top of dam ... 617.1**

(7) Streambed at centerline of dam ... 592± (Est.)

(8) Maximum tailwater ... Unknown

(9) Observed tailwater ... None

d. Reservoir.

(1) Length at normal pool (Elev. 615.0) ... 700 ft.

(2) Length at maximum pool (Elev. 617.2) ... 750 ft.

e. Storage.

(1) Normal pool ... 35 ac.ft.

(2) Top of dam ... 44 ac.ft.

*Based on an estimate of maximum lake level as reported by Mr. J. E. Bouska.
**Elevation of lake at which depth of flow in spillway exceeds elevation of dam erosion protection.

f. Reservoir Surface Area.

(1) Normal pool ... 4.0 acres

(2) Top of dam ... 4.6 acres

g. Dam. The height of the dam is defined to be the overall vertical distance from the lowest point of foundation surface at the downstream toe of the barrier to the top of the dam.

(1) Type ... Earthfill

(2) Length ... 514 ft.

(3) Height ... 27 ft.

(4) Top width ... 12 ft.

(5) Side slopes

a. Upstream ... 1v on 2.7h (above waterline)

b. Downstream ... 1v on 2.2h

(6) Cutoff ... Core trench (per J. E. Bouska)

(7) Slope protection

a. Upstream ... Grass and fence fabric

b. Downstream ... Grass

h. Principal Spillway.

(1) Type ... Uncontrolled, paved concrete, excavated earth, trapezoidal section

(2) Location ... Right abutment

(3) Crest elevation ... 615.0

(4) Width ... 20 ft.

(5) Approach channel ... Lake

(6) Outlet channel ... Excavated earth, irregular trapezoidal section

i. Emergency Spillway. ... None

j. Lake Drawdown Facility. ... None

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Data relating to the design of the dam were not available.

2.2 CONSTRUCTION

As previously indicated, the dam was constructed about 1954 by Hubard and Lucas, an excavating contractor from DeSoto, Missouri. According to information provided by Mr. Joseph F. Bouska, son of the original owners of the dam, a core section, excavated to bedrock and backfilled with clay, was constructed along the centerline of the dam. Mr. Bouska also reported that the material to build the dam was clay which was obtained primarily from the hillside on the right, or west, side of the dam, and that the material was compacted by the equipment used to haul the fill. According to Mr. Bouska, the concrete pavement and sill section were installed when the dam was built, and since then, there have been no changes or additions to the dam. Mr. Bouska did not recall seeing plans for construction of the dam, and no other information regarding construction of the structure was available.

2.3 OPERATION

The lake level is uncontrolled and governed by the elevation of the paved concrete crest of the excavated earth spillway. There is no lake drawdown facility. No indication was found that the dam has been overtopped. According to both Mrs. Silvia Allen, the Owner's representative, and Mr. Joseph Bouska, the son of the original owners of the dam and a nearby resident, the dam has never been overtopped. Mr. Bouska reported that on several occasions, like after a heavy spring rainfall, the lake surface has been within 1.5 feet, or so, of the top of the dam. Information obtained from Mrs. Allen substantiated this judgement.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the dam and spillway were unavailable.

b. Adequacy. No data 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. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Lake Bono Del Dam was made by Horner & Shifrin engineering personnel, R. E. Sauthoff, Civil Engineer, H. B. Lockett, Hydrologist, and A. B. Becker, Jr., Civil and Soils Engineer, on 25 November 1980. The Owner's representative was not present during this inspection. An examination of the dam site was also made by an engineering geologist, Jerry D. Higgins, Ph.D., a consultant retained by Horner & Shifrin for the purpose of assessing the area geology. Also examined at the time of the inspection were the areas and features below the dam within the potential flood damage zone. Photographs of the dam taken at the time of the inspection are included on pages A-1 through A-3 of Appendix A. The locations of the photographs taken during the inspection are indicated on Plate 3.

b. Site Geology. The topography of the Lake Bono Del area is moderately to gently rolling, and there is a maximum of approximately 90 feet of relief between the reservoir and the surrounding drainage divide. The topography becomes more rugged toward the Big River Valley to the west, so that regionally there is about 350 feet of relief. The area is included within the northeastern part of the Ozark Plateaus Physiographic Province, and regionally the bedrock dips northeastward into the Illinois Basin.

The reservoir and dam are underlain by the Ordovician-age Jefferson City-Cotter formation. This is a light brown to gray, finely crystalline, argillaceous dolomite. It is generally thin- to medium-bedded and contains both nodular and bedded chert, as well as some thin sandstone layers. Solution weathering commonly causes enlargement of joints and bedding planes, and the contact between bedrock and overlying soils is generally very irregular as a result of the weathering. The solution features are commonly the cause of reservoir leakage when soil cover is thin. In recent years, a sinkhole reportedly opened up in a yard immediately west of the reservoir and has since been filled. Although sinkhole collapse in this area is very rare, it should be considered as a possibility. No faulting was noted or reported in the vicinity of the dam site.

The soils were derived from the weathering of the Jefferson City formation and the once-present overlying St. Peter formation. Some weathered sandstone fragments of the St. Peter formation are present in the residuum. These soils are brown to tan-colored, moderately plastic clays (CL, Unified Soil Classification System). They are usually mixed with silt on the uplands, and at the reservoir site contain a sand component.

The spillway channel has been eroded to bedrock, and has exposed dolomite and thin, weathered sandstone and shale layers. This erosion does not appear to endanger the embankment. The most significant geologic condition at the site is the presence of solution-weathered bedrock. The solution features could cause excessive water loss, although this does not appear to be a problem presently. Also, due to the proximity of the formation of a collapsed sink, the possibility of a similar incident under the dam does exist.

c. Dam. The visible portions of the upstream and downstream faces of the dam (see Photos 1 and 3), as well as the dam crest were inspected and except as noted herein, appeared to be in sound condition. However, due to the presence of dense brush and trees up to 8 inches in diameter, all areas of the downstream face of the dam could not be thoroughly examined. No cracking of the surface, sloughing or sliding of the embankment slopes, undue settlement of the dam, or misalignment of the strucutre was noted. The crest and the upper portion of the upstream face of the dam were covered with grass about 2 inches high, while grass and weeds up to 12 inches high were present on the upstream face of the dam, just above the waterline. Chain-link type fence fabric (see Photo 2) was found along the upstream slope extending from about the normal waterline to a level about 3 feet below the normal waterline, and several small holes which appeared to be animal burrows (see Photo 9) were present along the upstream face at about stations 0+75 and 2+58. In addition, erosion of the upstream face of the dam (see Photo 8), apparently by wave action, had created an almost vertical bank approximately 12 inches high above the normal waterline along most of the upstream face.

No seepage was noticed, although the area adjacent to the toe of the dam at about the location of the original stream was damp and the ground was slightly soft. Examination of a soil sample obtained from the downstream face of the embankment near the center of the dam indicated the surficial material to be a somewhat sandy, yellow-brown, silty lean clay (CL) of low-to-medium plasticity.

The excavated earth spillway (see Photos 4 and 5) including the concrete pavement at the spillway crest, were examined and found to be in reasonably good condition, although the concrete pavement just downstream of the crest was badly weathered and somewhat deteriorated with numerous small cracks and spalls evident in the surface. The spillway crest section was essentially clear of debris and foreign objects; however, a wire mesh (hardware cloth) type fence, about 12 inches high supported by three 2-inch diameter steel pipe posts at about 10-foot centers, spanned the opening and an 8-foot long railroad tie lay across the pavement at about the center of the invert. Dense brush and small trees (see Photo 6) were found on the left bank, or dam side, of the channel just downstream of the crest. The riprap protected invert section (see Photo 7) located just downstream of the paved concrete section was also inspected and, except for some minor erosion of the bottom and left bank, was found to be in good condition. Downstream of the protected section, the channel was eroded to bedrock and the banks were quite steep, but not excessively high.

d. Appurtenant Structures. No appurtenant structures were observed at this dam site.

e. Downstream Channel. The downstream channel joins Lake Tishomingo, a manmade reservoir with a surface area of approximately 115 acres, about 0.7 of a mile downstream of the Lake Bono Del Dam. The dam for Lake Tishomingo, which is not considered to be within the potential flood damage zone, lies about 2 miles downstream of Lake Bono Del. With the exception of one roadway crossing, the downstream channel within the potential flood damage zone is unimproved. The channel section is irregular and for the most part, lined with trees.

f. Reservoir. The area adjacent to the lake is a residential type development with large tree covered lots and well maintained lawns. As previously indicated, a sinkhole was reported to have developed in a yard adjacent to the lake. The sinkhole is believed to have been located just north of the carport of the first house north of the dam on the west side of the lake. According to Gene Brucker of Brucker & Associates, Consulting Engineers, St. Louis, Missouri, who supervised the remedial work, the subsided area was excavated to bedrock at a depth of about 20 feet and a concrete cap was constructed to seal an exposed fissure in the rock. The hole was then backfilled with compacted earth. Mr. Brucker also reported that two grout pipes were installed within the concrete cap in case it was found necessary at some time in the future to pressure grout the opening in the rock. The sinkhole was repaired in 1970 and since then, no further problems have developed.

No significant erosion of the lake banks was noted. At the time of the inspection, the lake was clear and about one-half foot below normal pool level. The amount of sediment within the lake could not be determined during the inspection; however, due to the fact that the drainage area is well covered with vegetation, it is not expected to be significant.

3.2 EVALUATION

The deficiencies observed during this inspection and noted herein are not considered of significant importance to warrant immediate remedial action.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillway is uncontrolled. The lake level is governed by precipitation runoff, evaporation, seepage, and the capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

According to Mrs. Silvia Allen, the Owner's representative, the grass on the dam crest is cut regularly during the growing season, and muskrats in the area of the dam are trapped during the winter. Mrs. Allen reported that muskrat burrows are filled with crushed stone and that the fence fabric along the upstream face of the dam was installed in an effort to prevent muskrats from burrowing into the dam, but that the plan has not been entirely successful since they, the muskrats, go under the fabric from the lake side. Mrs. Allen also indicated that the downstream face of the dam is periodically inspected for animal burrows and other abnormalities, and that the wire screen fence at the spillway crest is either cleaned or lifted out of the way during periods of appreciable lake outflow.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

No outlet facilities requiring operation exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

Mrs. Allen reported that telephone numbers of the local police and fire departments were readily available in the case of an emergency, such as the imminent failure of the dam. The inspection did not reveal the existence of any other type of dam failure warning system.

4.5 EVALUATION

It is recommended that maintenance of the dam also include the removal of brush and trees from the downstream face of the dam, restoration of the dam at eroded areas along the upstream face, as well as the provision of a suitable form of protection (not grass) along the upstream face of the dam in order to prevent erosion by wave action or by fluctuations of the lake level. It is also recommended that a detailed inspection of the dam be instituted on a regular basis by an engineer experienced in the design and construction of dams and that records be kept of all inspections made and remedial measures taken.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data were not available.

b. Experience Data. The drainage area and lake surface area were determined from the 1954 USGS Belew Creek, Missouri, Quadrangle Map (photorevised 1968 and 1974). The proportions and dimensions of the spillway and dam were developed from surveys made during the inspection. Records of rainfall, streamflow, or flood data for the watershed were not available.

Due to the fact that the watershed for this reservoir is small and since there is no history of excessive reservoir leakage that would adversely affect the normal operating level of the lake, the lake was assumed to be at normal pool as a result of antecedent storms prior to occurrence of the probable maximum flood and the probabilistic storm.

According to the St. Louis District, Corps of Engineers, the estimated flood damage zone, should failure of the dam occur, extends one mile downstream of the dam. The upstream end of Lake Tishomingo lies within the potential flood damage zone.

c. Visual Observations.

(1) The spillway, an excavated earth trapezoidal section, is located at the right, or east, abutment. The invert and a portion of the left side of the channel are protected by concrete pavement at the spillway crest.

(2) The spillway outlet channel joins the original stream channel at a point approximately 125 feet downstream of the toe of the dam. Portions of the spillway outlet channel have been eroded to bedrock.

(3) There is no lake drawdown facility.

(4) Spillway releases within the capacity of the protected portion of the spillway outlet should not endanger the dam.

d. Overtopping Potential. The spillway is inadequate to pass the probable maximum flood, or 1/2 the probable maximum flood, without overtopping the dam. The spillway is adequate, however, to pass the 1 percent chance (100-year frequency) flood without overtopping the dam. The results of the dam overtopping analyses are as follows:

(Note: The data appearing in the following table were extracted from the computer output data appearing in Appendix B. Decimal values have been rounded to the nearest one-tenth in order to prevent assumption of unwarranted accuracy.)

Ratio of PMF	Q-Peak Outflow (cfs)	Max. Lake W.S. Elev.	Max. Depth (Ft.) of Flow over Effective Top of Dam (Elev. 617.1)	Duration of Overtopping of Dam (Hours)
0.50	603	617.8	0.7	0.5
1.00	1,474	618.3	1.2	1.2
1% Chance Flood	203	616.9	0.0	0.0

Elevation 617.1 is the elevation of the lake at which the depth of flow in the spillway exceeds elevation 616.5, the top of the concrete pavement that serves to prevent erosion of the dam. For lake levels above elevation 617.1, it was found that the velocity of lake outflow within the spillway exceeded the assumed permissible non-erosive velocity of 5 feet per second. It should be noted that the low point of the dam crest was found to be elevation 617.2, or only 0.1 foot higher than the effective top of dam elevation. The flow safely passing the spillway just prior to exceeding the effective top of dam elevation was determined to be approximately 248 cfs, which is the routed outflow corresponding to about 30 percent of the probable maximum flood inflow. This flow is greater than the outflow from the 1 percent chance (100-year frequency) flood. During peak flow of the probable maximum flood, the greatest depth of flow over the dam is projected to be 1.2 feet and overtopping will extend across the entire length of the dam.

e. Evaluation. The results of the overtopping analyses indicate the existing spillway is inadequate to pass the lake outflow resulting from the PMF or from one-half the PMF, which is the recommended spillway design flood for this dam. With regard to these flood events, the following evaluation of dam overtopping is offered:

Experience with embankments constructed of similar material (a silty lean clay of low-to-medium plasticity) to that used to construct this dam has shown evidence that under certain conditions, such as high velocity flow, the material can be very erodible. An example of such erosion is evident at the spillway outlet channel. Such a condition exists during the PMF when large lake outflow, accompanied by high flow velocities, occurs. For the PMF condition where the depth of the flow over the dam crest, a maximum of 1.2 feet, and the duration of flow over the dam, 1.2 hours, are appreciable, damage by erosion to the crest and downstream face of the dam is expected. The extent of these damages is not predictable within the scope of this investigation; however, there is a possibiity that they could result in failure by erosion of the dam. A similar condition, but not as severe, also exists during occurrence of one-half the PMF.

f. References. Procedures and data for determining the probable maximum flood, the 100-year flood, and the discharge rating curve for flow passing the spillway and dam crest are presented on pages B-1 and B-2 of Appendix B. Listings of the HEC-1 (Dam Safety Version) input data for both the probable maximum flood, and the probabilistic flood, are shown on pages B-3 through B-5. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-6 through B-9; tabulation of lake surface area, elevation and storage volume is shown on page B-10; tabulations titled "Summary of Dam Safety Analysis" for the PMF and the 1 percent chance (100-year frequency) flood are also shown on page B-10 of Appendix B.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which adversely affect the structural stability of the dam are discussed in Section 3, paragraph 3.1c.

b. Design and Construction Data. No design or construction data relating to the structural stability of the dam are known to exist. 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. Operating Records. No appurtenant structures or facilities requiring operation exist at this dam. According to Mrs. Silvia Allen, the Owner's representative, records of the lake level, spillway discharge, dam settlement, or lake seepage are not maintained.

d. Post Construction Changes. According to Mr. Joseph Bouska, who lives nearby and is familiar with the dam since its inception, no post construction changes have been made or have occurred which would affect the structural stability of the dam.

e. Seismic Stability. The dam is located within a Zone II seismic probability area. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earthen dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. A hydraul' analysis indicated that the spillway is capable of passing lake outflow of about 248 cfs without the level of the lake exceeding the top of the concrete pavement provided at the spillway in order to prevent erosion of the dam. It should be noted that the actual low point of the dam is only 0.1 foot higher than the top of the concrete slope protection at the dam, which was considered to be the effective top of dam. Therefore, for all practical purposes, the actual top of dam and the effective top of dam are the same. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicates that for storm runoff of one-half probable maximum flood magnitude, the lake outflow would be about 603 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 203 cfs. The existing spillway is inadequate to pass lake outflow resulting from a storm of one-half probable maximum flood magnitude (the recommended spillway design flood for this dam) and as a result of this inadequacy, overtopping of the dam is expected during this flood event. Overtopping by the one-half probable maximum flood lake outflow could result in failure of the dam. A description of the features within the potential flood damage zone should failure of the dam occur is presented in Section 1, paragraph 1.2d.

Seepage and stability analyses of the dam were not available for review, and therefore, no judgment could be made with respect to the structural stability of the dam.

Several items were noticed during the inspection that could adversely affect the safety of the dam. These items include trees and brush on the downstream slope of the embankment, animal burrows on the upstream face of the dam, erosion of the upstream face of the dam, and a fence extending across the spillway channel at the crest.

b. Adequacy of Information. Due to lack of design and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The assessments of the hydrology of the watershed and capacity of the spillway were based on a hydrologic/ hydraulic study as indicated in Section 5. Seepage and stability analyses comparable to the requirements of "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 for the items concerning the safety of the dam noted in paragraph 7.1a should be accomplished within the near future.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. The dam is located within a Zone II seismic probability area. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earthen dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

a. Recommendations. The following actions are recommended.

(1) Based upon criteria set forth in the recommended guidelines, spillway size and/or height of dam should be increased in order to pass lake outflow resulting from a storm of one-half probable maximum flood magnitude, the recommended spillway design flood for this dam.

(2) Obtain the necessary soil data and perform dam seepage and stability analyses in order to determine the structural stability of the dam for all operational conditions. Seepage and stability analyses should be performed by a qualified professional engineer experienced in the design and construction of earthen dams.

b. Operations and Maintenance (O & M) Procedures. The following O & M. Procedures are recommended:

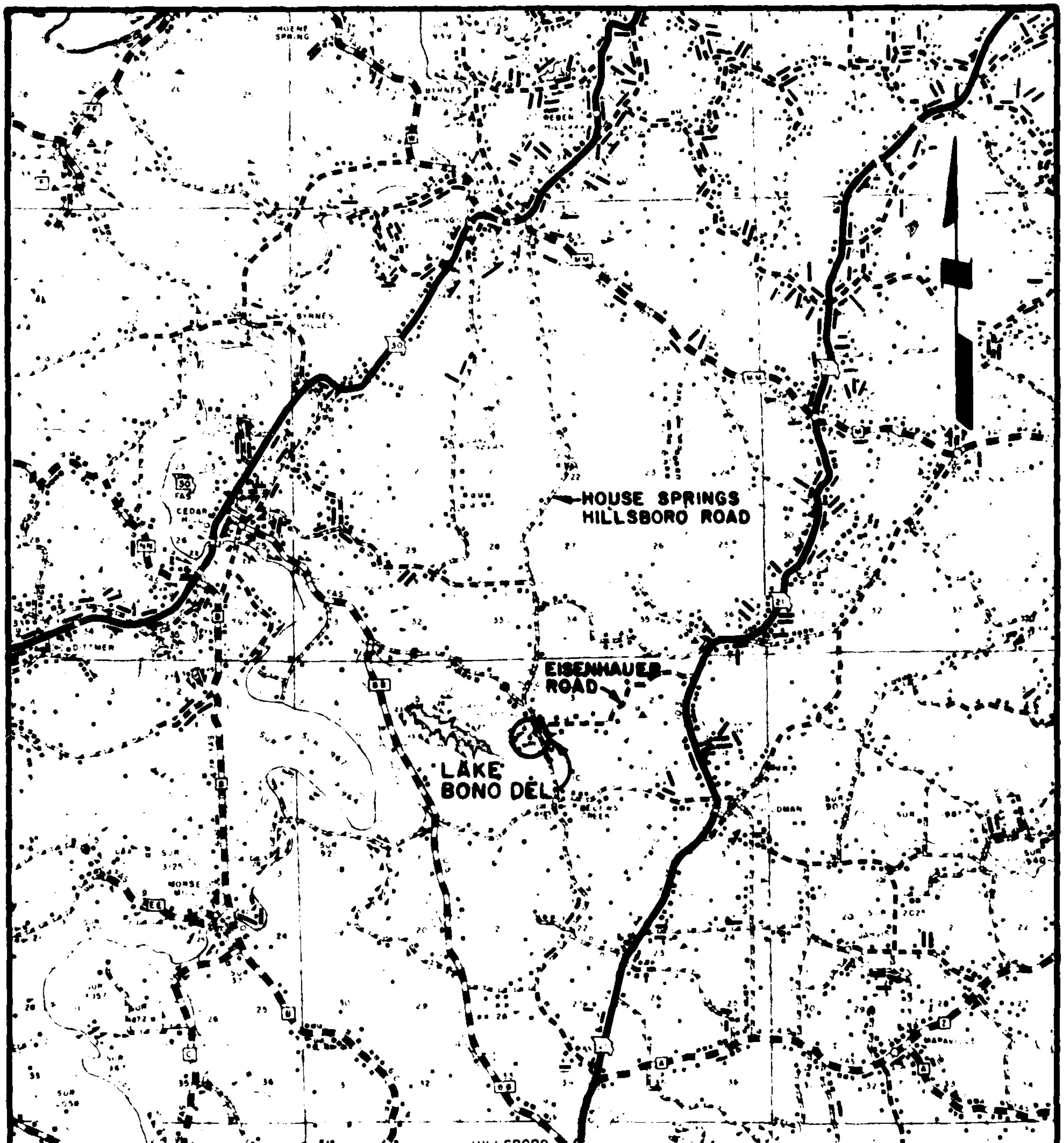
(1) Remove the trees and brush from the downstream face of the dam including the area adjacent to the spillway. The removal of trees should be performed under the direction and guidance of an engineer experienced in the design and construction of earthen dams, since indiscriminate clearing can jeopardize the safety of the dam. All holes should be filled with compacted impervious material (clay) and the existing turf cover should be restored if destroyed or missing. Maintain the turf cover at a height that will not hinder inspection of the embankment or provide cover for burrowing animals. Restore the areas of the upstream face of the dam that have been damaged by burrowing animals. Holes from tree roots and voids created by burrowing animals can provide passageways for lake seepage that could lead to a piping condition (progressive internal erosion) and potential failure of the dam.

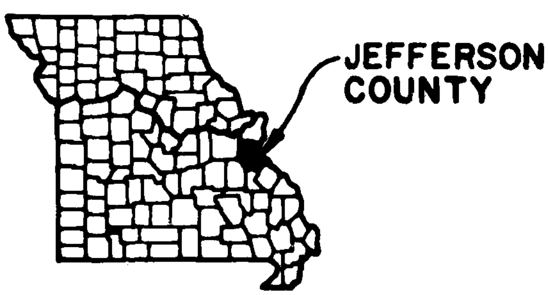
(2) Restore the upstream face of the dam and provide some form of protection other than grass (or fence fabric) at and above the normal waterline in order to prevent erosion. A grass covered slope is not considered adequate protection to prevent erosion by wave action or by a fluctuating lake level. Loss of embankment material due to erosion can impair the structural stability of the dam.

(3) Remove the fence that crosses the spillway opening. Lake carried debris can lodge upon the fence resulting in a reduction of spillway capacity and the possibility of dam overtopping by lake surcharge.

(4) Provide maintenance of all areas of the dam and spillway on a regularly scheduled basis in order to insure these features of being in satisfactory operational condition.

(5) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended that records be kept for future reference of all inspections made and remedial measures taken.





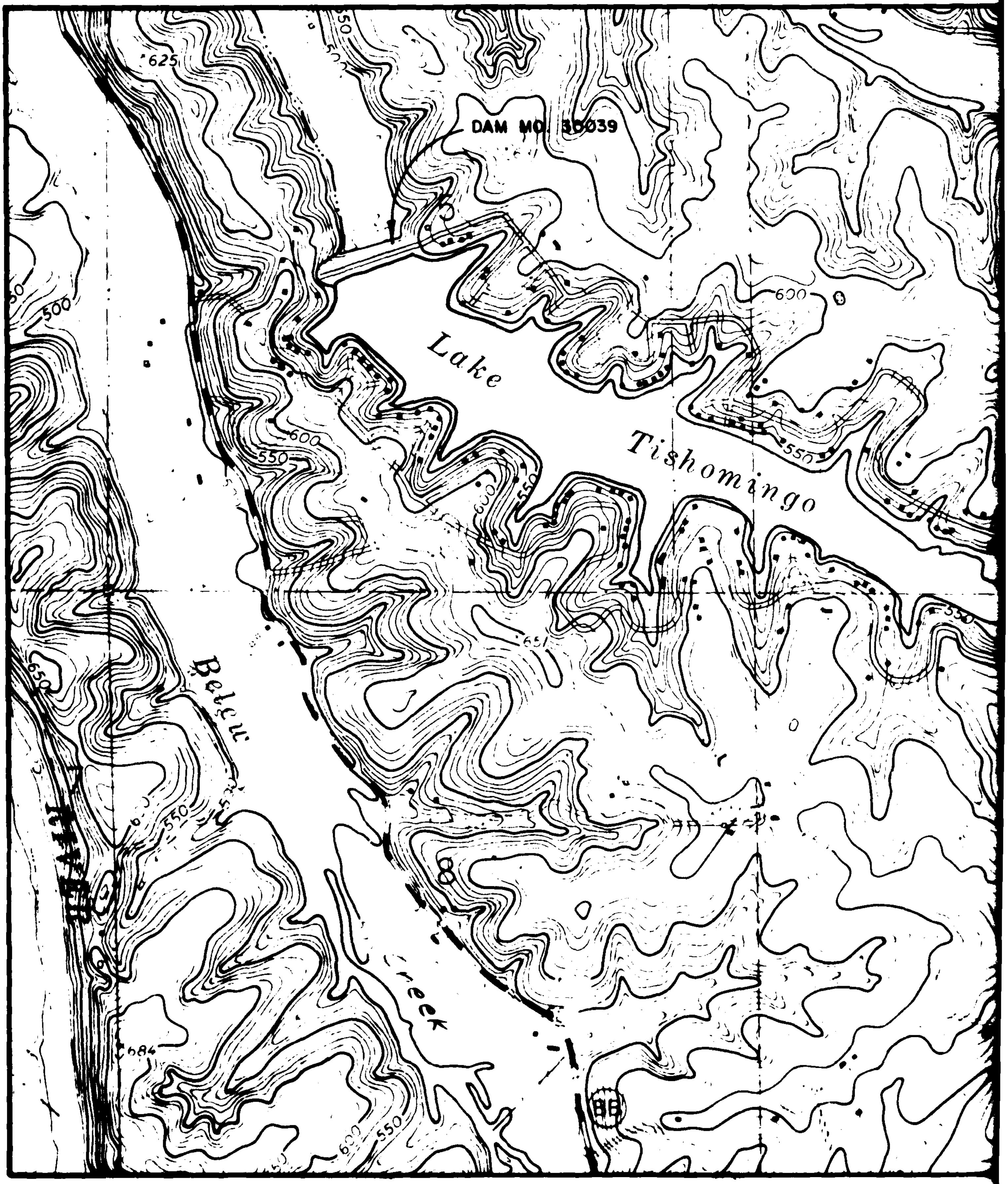
LOCATION MAP

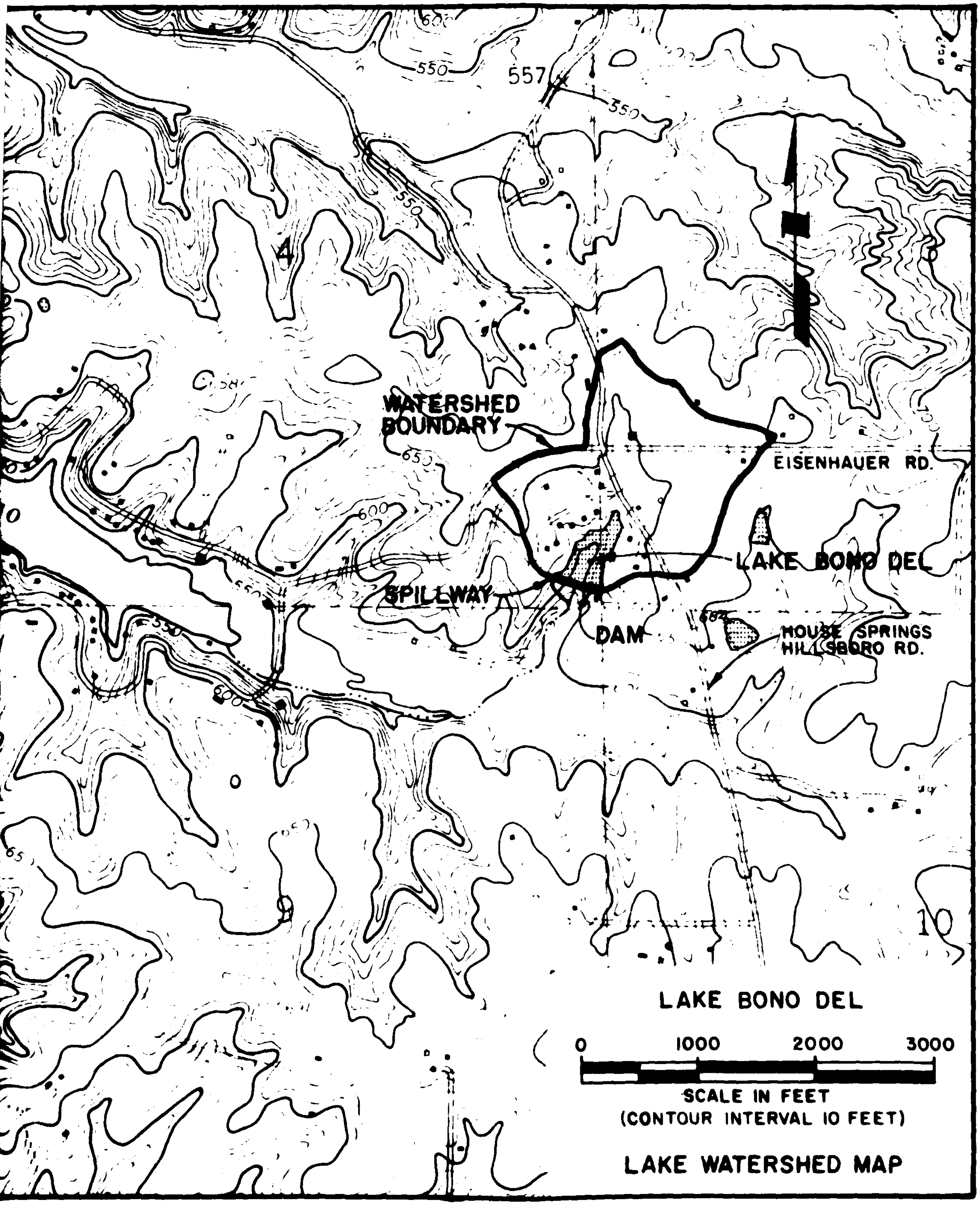
LAKE BONO DEL

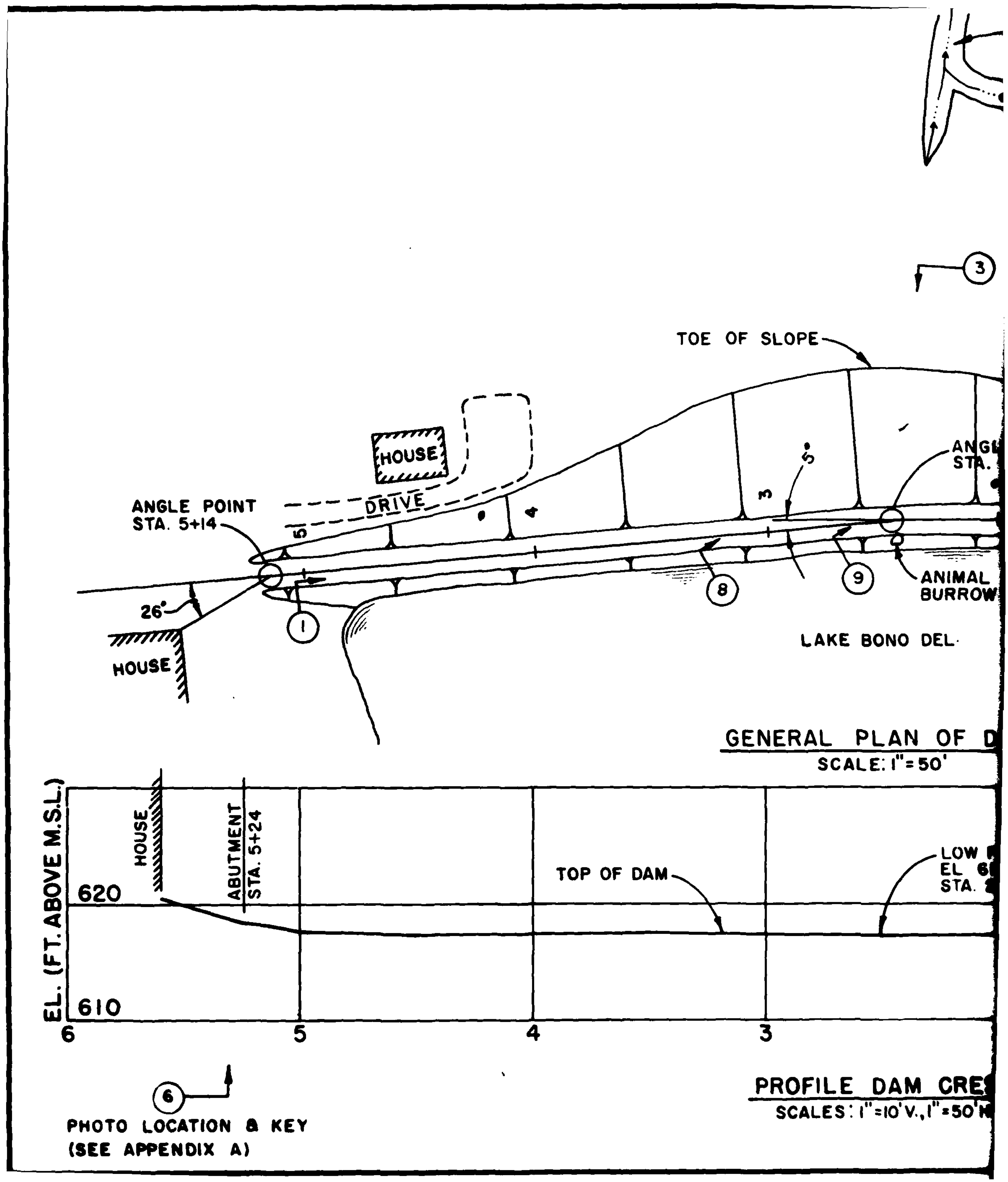
SCALE (MILES)

REGIONAL VICINITY MAP

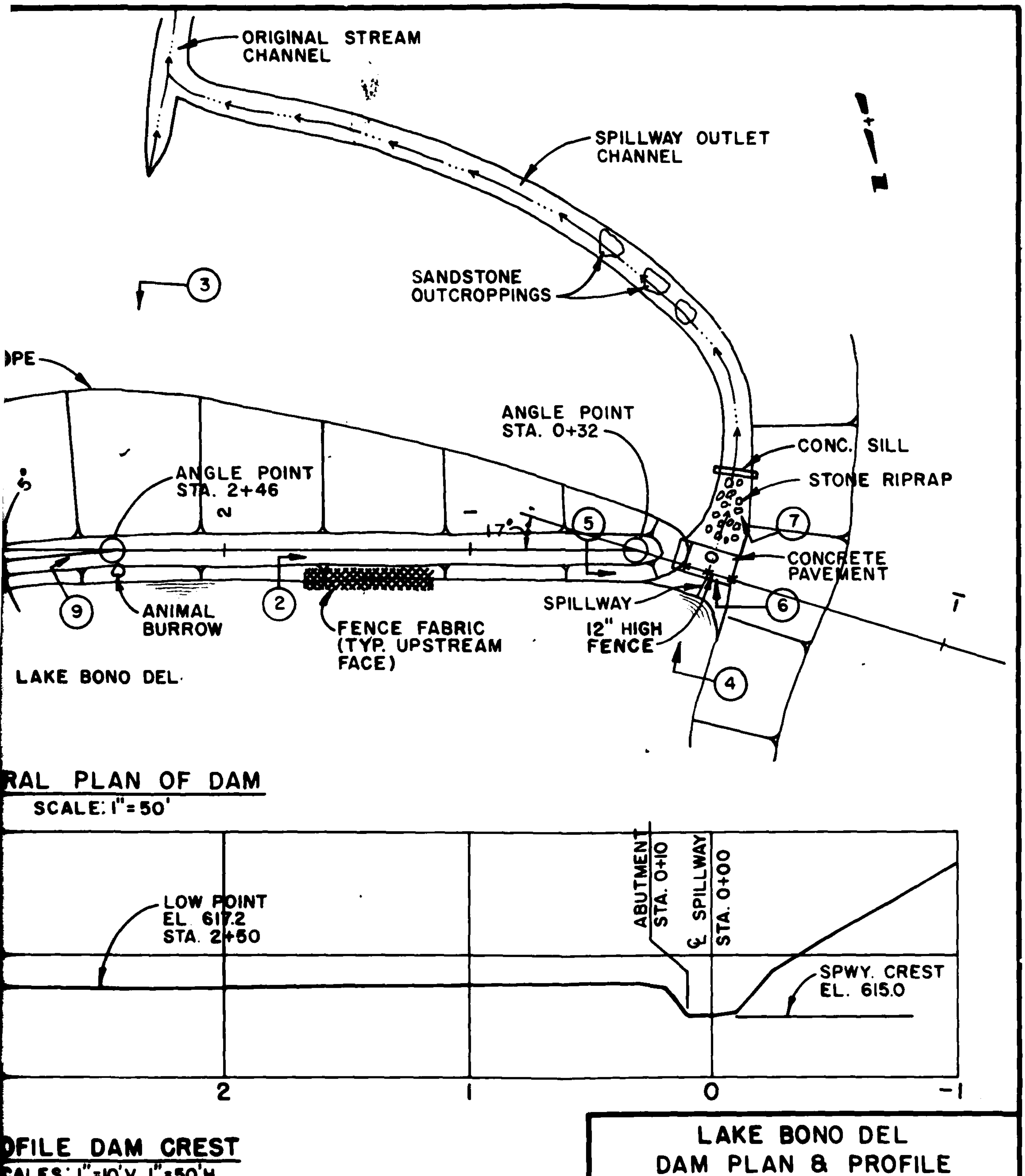
PLATE I


DAM MO 30039
Lake
Tishomingo
Belew
Creek
625
500
600
550
651
684
88


WATERSHED BOUNDARY
EISENHAUER RD.
LAKE BONO DEL
SPILLWAY
DAM
HOUSE SPRINGS HILLSBORO RD.
LAKE BONO DEL
0
1000
2000
3000
SCALE IN FEET
(CONTOUR INTERVAL 10 FEET)
LAKE WATERSHED MAP



TOE OF SLOPE
HOUSE
DRIVE
ANGLE POINT
STA. 5+14
26°
HOUSE
1
8
9
3
ANIMAL
BURROW
LAKE BONO DEL
GENERAL PLAN OF D
SCALE: 1"=50'
EL. (FT. ABOVE M.S.L.)
HOUSE
ABUTMENT
STA. 5+24
TOP OF DAM
LOW
EL
STA.
620
610
6
5
4
3
PROFILE DAM CRE
SCALES: 1"=10'V., 1"=50'H
6
PHOTO LOCATION & KEY
(SEE APPENDIX A)

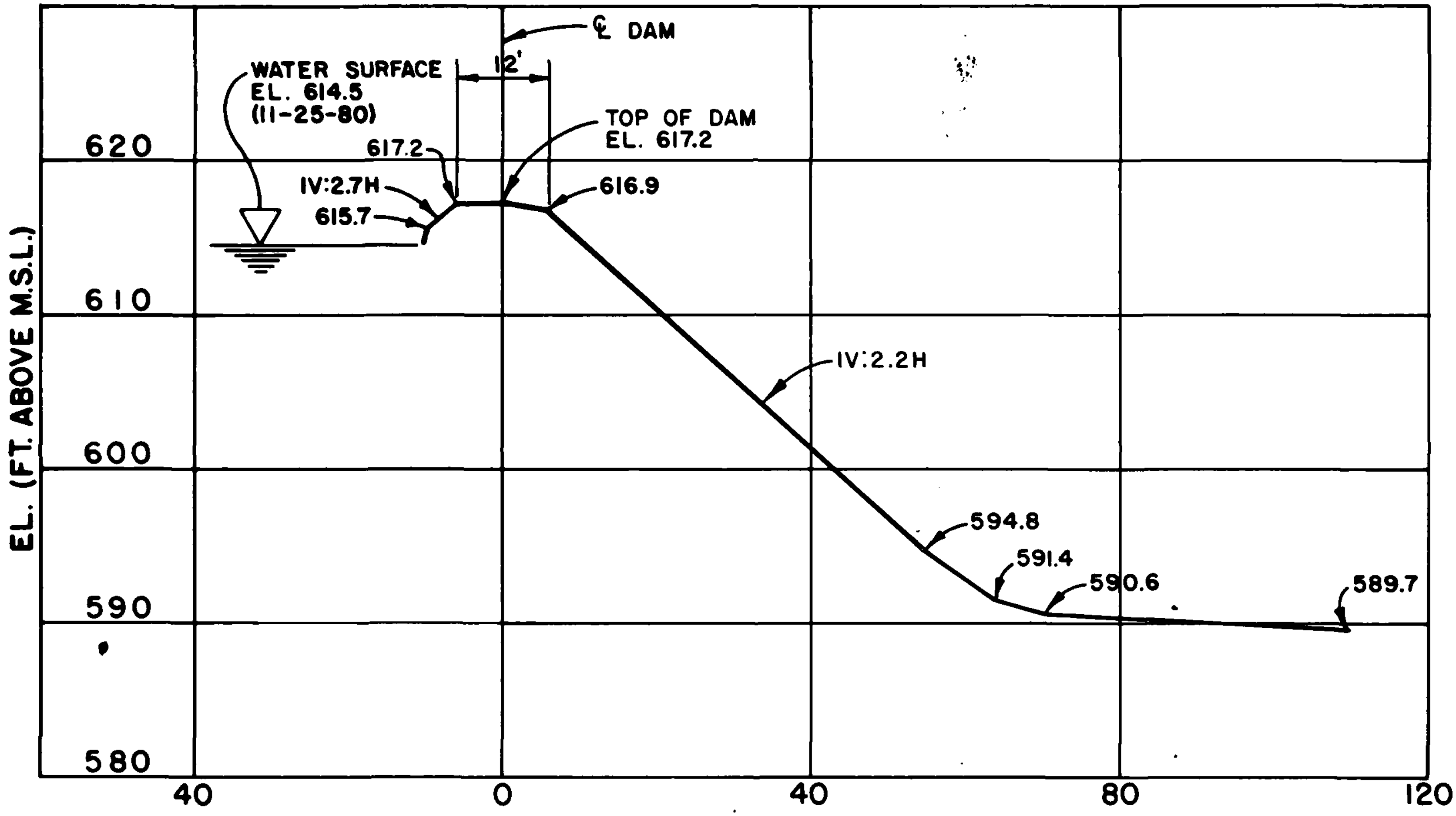


LAKE BONO DEL
DAM PLAN & PROFILE

Horner & Shifrin, Inc. Feb. 1981

PLATE 3

2

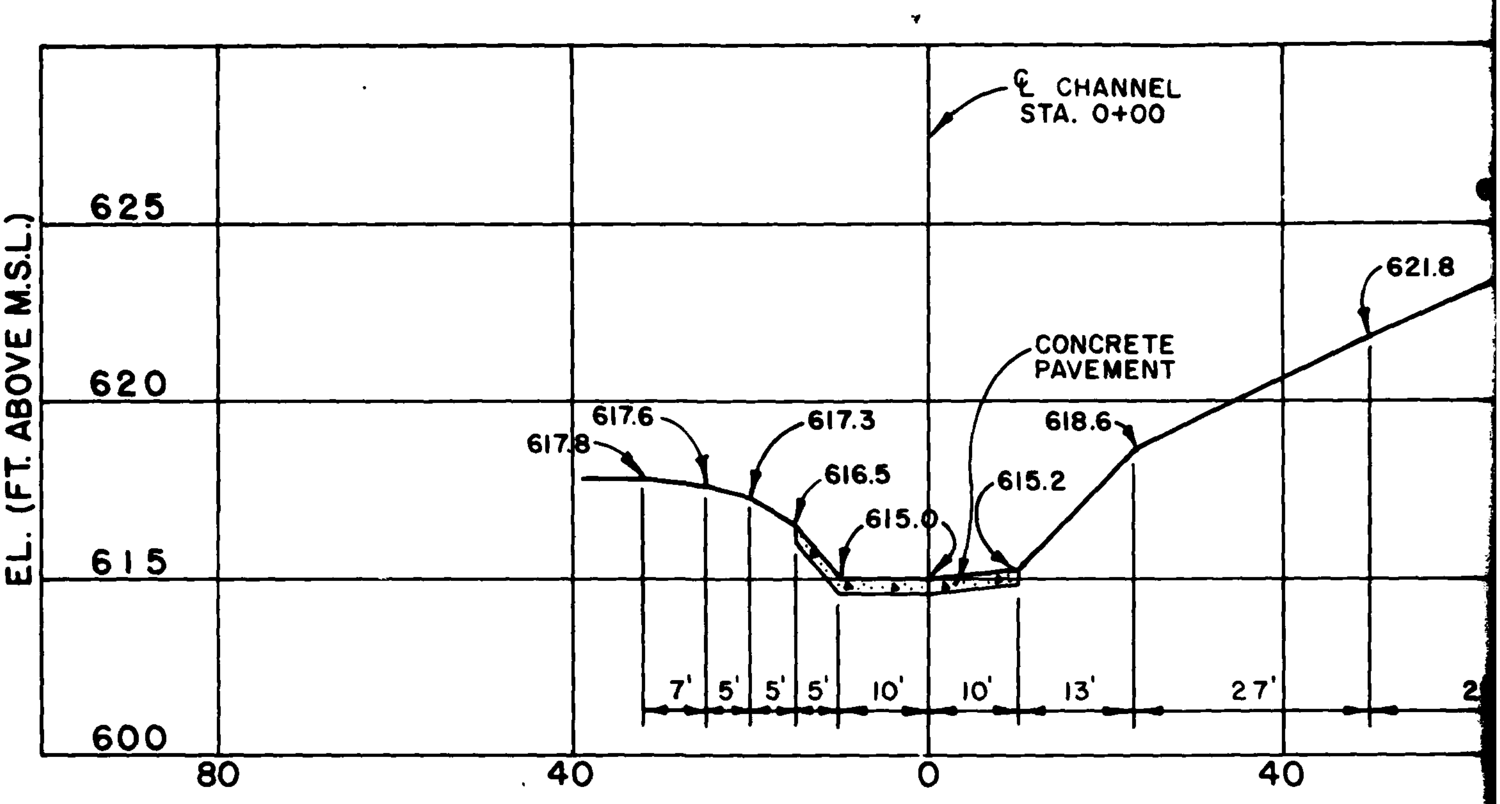


DAM CROSS-SECTION STA. 2+46

SCALE: 1"=10'V., 1"=20'H.

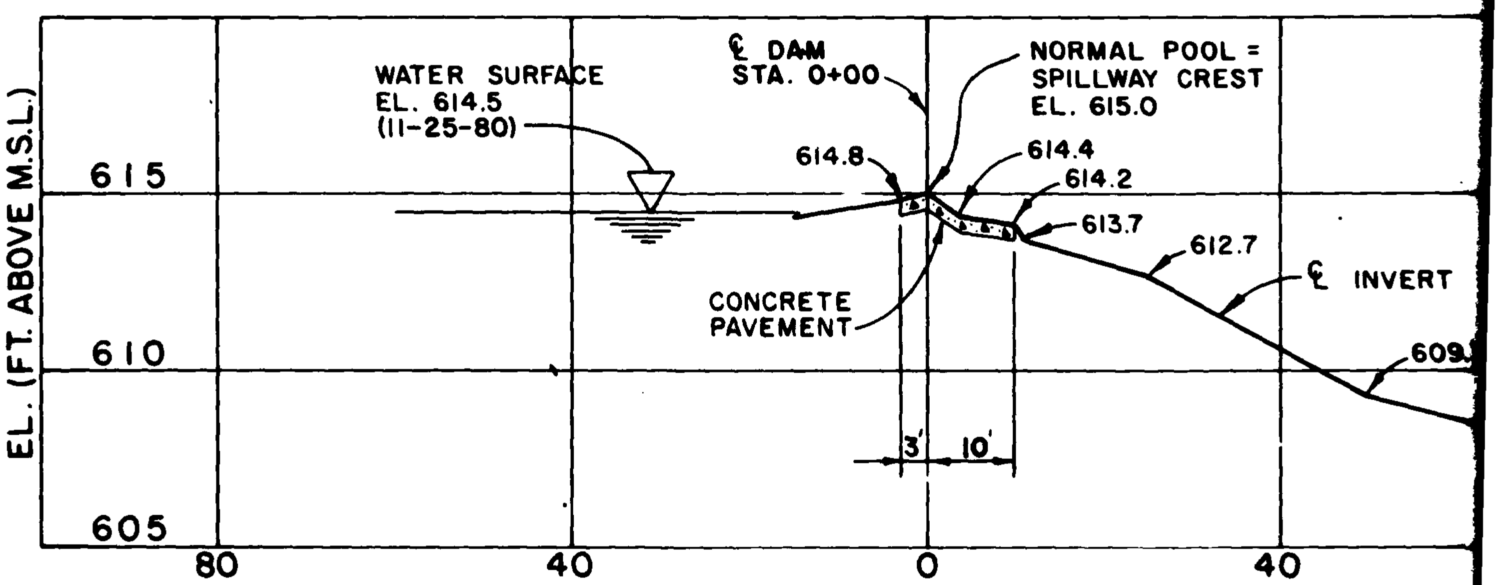
LAKE BONO DEL
DAM CROSS-SECTION

Horner & Shifrin, Inc. Feb. 1981



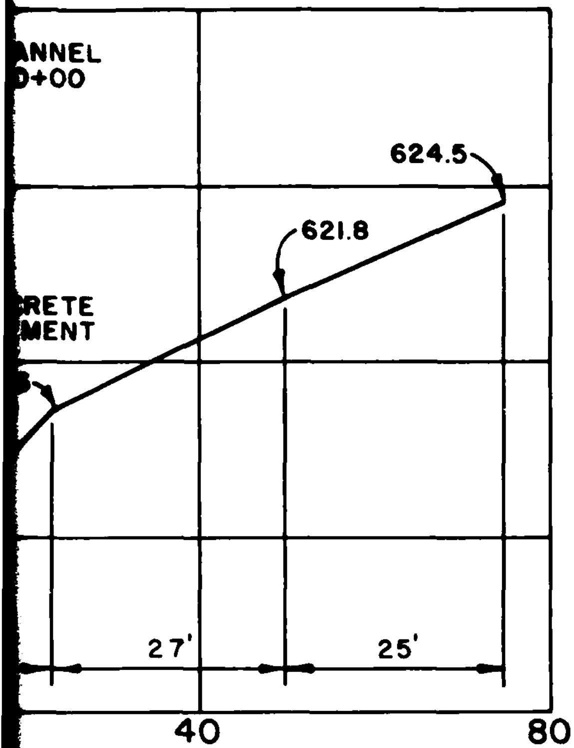
CROSS-SECTION SPILLWAY CHANNEL—℄ DAM

SCALE: 1" = 5' V., 1" = 20' H.

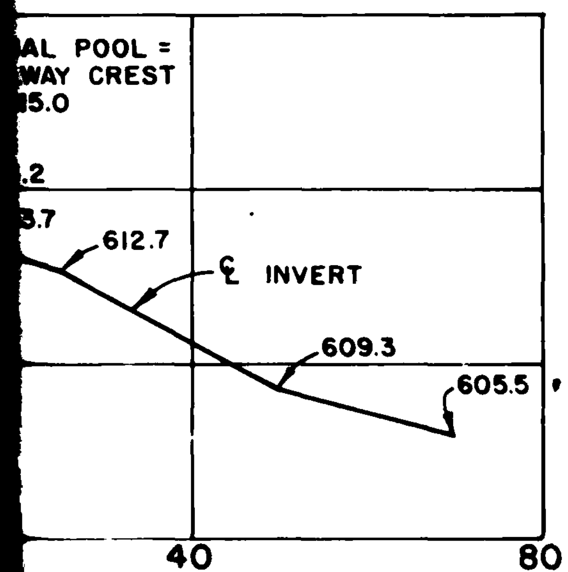


PROFILE SPILLWAY CHANNEL

SCALE: 1" = 5' V., 1" = 20' H.



NEL — ℄ DAM



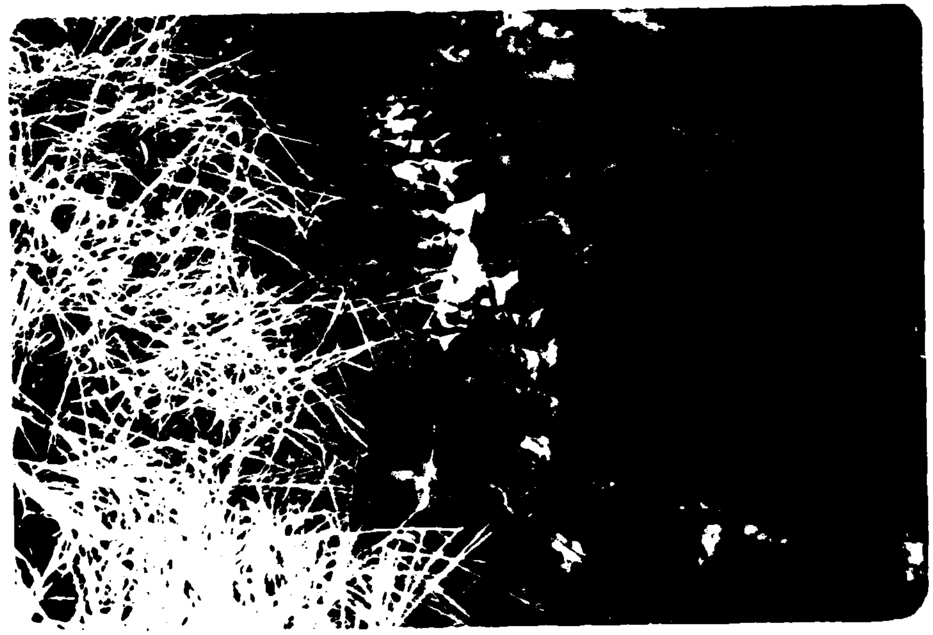
NNEL

LAKE BONO DEL
SPILLWAY CROSS-SECTION
& PROFILE

Horner & Shifrin, Inc. Feb. 1981

APPENDIX A

INSPECTION PHOTOGRAPHS



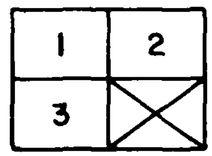


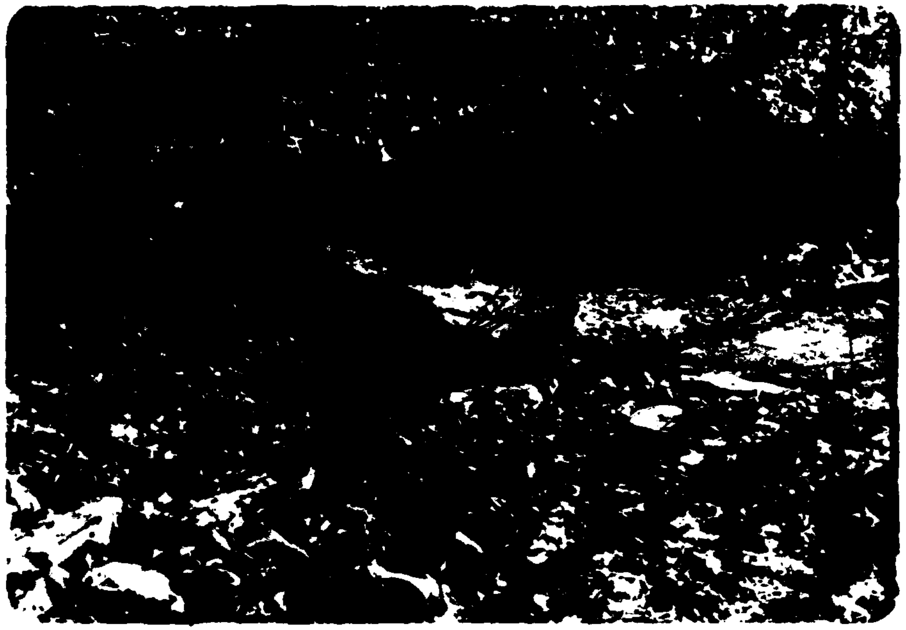
PHOTO KEY

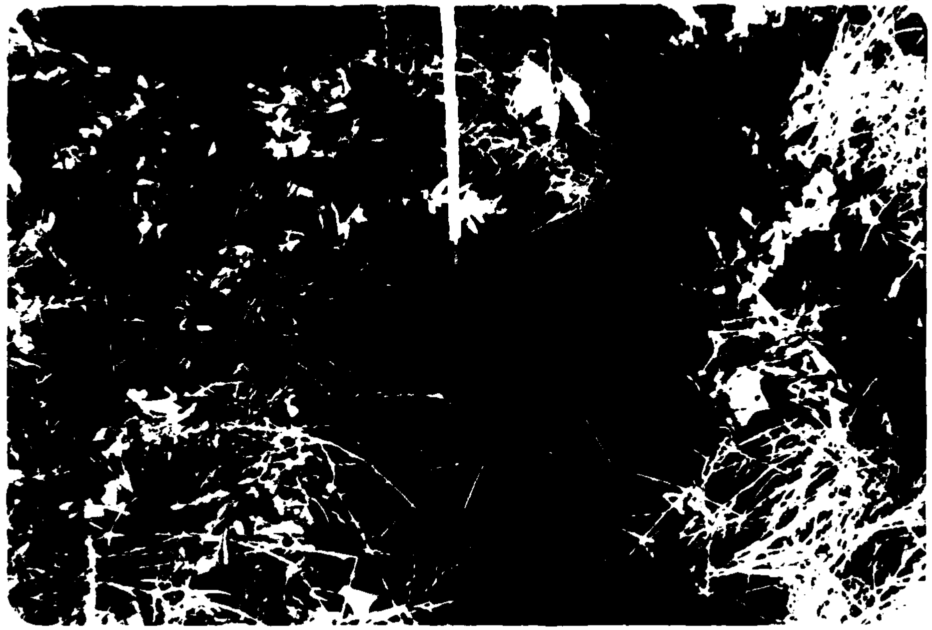
NO.	DESCRIPTION
1	Upstream Face of Dam
2	Fence Fabric Along Upstream Face of Dam
3	Downstream Face of Dam

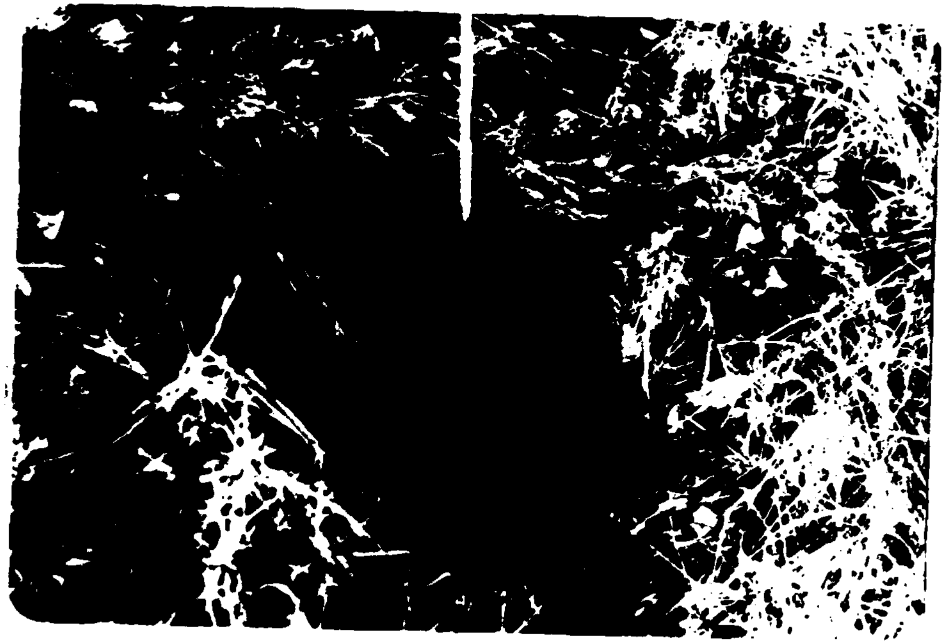
4	5
6	X

PHOTO KEY

NO.	DESCRIPTION
4	Spillway
5	Spillway Crest
6	Spillway Outlet Channel - Looking Downstream from Crest







7	8
9	☒

PHOTO KEY

NO.	DESCRIPTION
7	Erosion Protection Within Spillway Outlet Channel
8	Embankment Erosion at Upstream Face of Dam
9	Animal Burrow in Upstream Face of Dam

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. miles, 24-hour value equals 25.5 inces) from Hydrometerological Report No. 33. The precipitation data used in the analysis of the 1 percent chance (100-year frequency) flood was provided by the St. Louis District, Corps of Engineers.

b. Storm duration = 24 hours, unit hydrograph duration = 5 minutes.

c. Drainage area = 0.098 square miles = 63 acres.

d. SCS parameters:

Time of Concentration (Tc) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$ = 0.099 hours

Where: T_c = Travel time of water from hydraulically most distant point to point of interest, hours.
L = Length of longest watercourse = 0.284 miles.
H = Elevation difference = 85 feet.

The time of concentration (Tc) was obtained using method C as described in Fig. 30, "Design of Samll Dams", by the United States Department of the Interior, Bureau of Reclamation, and was verified using average channel velocity estimates and watercourse lengths.

Lag time = 0.59 hours (0.60 Tc)

Hydrologic Soil Group = 100% D (Gasconade Series primarily meadowland per SCS Missouri General Soil Map and field investigation; 15% impervious)

Soil type CN = 80 (AMC II, 100-yr flood)
= 91 (AMC III, PMF condition)

2. The spillway consists of a paved concrete, broad-crested trapezoidal section, for which conventional weir formulas do not apply. The following procedure was used to determine spillway release rates:

a. Spillway crest section properties (areas, "a", and top width, "t") were computed for various depths, "d".

b. It was assumed that flow over the spillway crest would occur at critical depth. Flow at critical depth Q_c was computed as

$Q_c = \left(\frac{a^3 g}{t}\right)^{0.5}$ for the various depths, "d". Corresponding

velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas.* Reference "Handbook of Hydraulics", Fifth Edition, by King & Brater, page 8-7.

c. Static lake levels corresponding to the various flow values passing the spillway were computed as critical depths plus critical velocity heads ($d_c + H_{vc}$), and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignificant friction losses across the length of the spillway.

d. The spillway discharges for corresponding elevations were entered on the Y4 and Y5 cards.

3. The profile of the dam crest is irregular and flow over the dam cannot be determined by application of conventional weir formulas. Crest length and elevation data for the dam crest proper were entered into the HEC-1 Program on the $L and $V cards. The program assumes that flow over the dam crest occurs at critical depth and computes internally the flow passing the dam crest and adds this flow to the flow passing the spillway as entered on the Y4 and Y5 cards.

* $v_c = \frac{Qc}{a}$; $Hvc = \frac{v_c^2}{2g}$

```
A1      ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2      HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF LAKE BONO DEL DAM
A3      RATIOS OF PMF ROUTED THROUGH RESERVOIR
B      288       0       5                                       0
B1      .5
J        1       4       1
J1     .30     .35     .50     1.0
K        0  INFLOW                                       1
K1      INFLOW HYDROGRAPH
M        1       2   0.098                     1.0                       1
P        0    25.5     102     120     130
T                                                       -1     -91              0.15
W2           0.059
X     -1.0    -.10     2.0
K        1     DAM                                       1
K1      RESERVOIR ROUTING BY MODIFIED PULS
Y                                1       1
Y1       1                                           -615.      -1
Y4     615  615.35  615.75  616.55   617.5  618.25   618.9  619.65   620.5
Y5       0      10      50     150     305     405     610     850    1200
$A       0     1.5     4.0    5.74   11.71   19.05
$E     592     604     615     620     630     640
$$     615
$D   617.1
$L       0      18      22     141     366     434     470     488     509     537
$V   616.5   617.2   617.2   617.4   617.6   617.7   617.8   617.8   618.4     620
K       99
```

```
A1       ANALYSIS OF DAM OVERTOPPING USING 1% CHANCE FLOOD
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF LAKE RONO DEL DAM
A3       1% CHANCE FLOOD ROUTED THROUGH RESERVOIR
B     288       0       5                                               4
B1      5
J       1       1       1
J1     1.
K       0  INFLOW                                       1
K1       INFLOW HYDROGRAPH
M       0       2   0.098                       1.0                     1
O     288   7.224
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .014    .014    .014    .014    .014    .014    .014    .014
01   .014    .014    .014    .014    .014    .014    .014    .014    .014    .014
01   .014    .014    .014    .014    .014    .014    .014    .014    .014    .014
01   .014    .014    .014    .014    .014    .014    .014    .014    .022    .022
01   .022    .022    .022    .022    .022    .022    .022    .022    .022    .022
01   .022    .022    .022    .022    .022    .022    .031    .031    .031    .031
01   .031    .031    .061    .061    .061    .061    .061    .061    .132    .132
01   .132    .252    .252    .552    .826    .384    .252    .132    .132    .132
01   .061    .061    .061    .061    .061    .061    .031    .031    .031    .031
01   .031    .031    .022    .022    .022    .022    .022    .022    .022    .022
```

1% CHANCE FLOOD (Cont'd)

```
O1  .022    .022    .022    .022    .022    .022    .022    .022    .022    .022
O1  .014    .014    .014    .014    .014    .014    .014    .014    .014    .014
O1  .014    .014    .014    .014    .014    .014    .014    .014    .014    .014
O1  .014    .014    .014    .014    .014    .014    .014    .014    .014    .014
O1  .014    .014    .014    .014    .014    .014    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007
T                                                     -1     -80             0.15
W2          0.059
X   -1.0    -.10     2.0
K      1     DAM                                       1
K1     RESERVOIR ROUTING BY MODIFIED PULS
Y                                1       1
Y1     1                                           -615.      -1
Y4   615  615.35  615.75  616.55   617.5  618.25   618.9  619.65   620.5
5      0      10      50     150     305     405     610     850    1200
$A     0     1.5     4.0    5.74   11.71   19.05
$E   592     604     615     620     630     640
$$   615
$D 617.1
$L     0      18      22     141     366     434     470     488     509     537
$V 616.5   617.2   617.2   617.4   617.6   617.7   617.8   617.8   618.4     620
K     99
```

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF LAKE BONO DEL DAM
RATIOS OF PMF ROUTED THROUGH RESERVOIR

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1
RTIOS= .30 .35 .50 1.00

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

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
INFLOW	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.10	0.00	.10	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.50	102.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-91.00	0.00	.15

CURVE NO = -91.00 WETNESS = -1.00 EFFECT CN = 91.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .06

RECESSION DATA
STRTQ= -1.00 QRCSN= -.10 RTIOR= 2.00

TIME INCREMENT TOO LARGE--(NMQ IS GT LAG/2)

UNIT HYDROGRAPH 6 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .06 VOL= 1.00
442. 235. 61. 16. 4. 0.

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.00	.01	1.
1.01	.10	2	.01	.00	.01	2.
1.01	.15	3	.01	.00	.01	2.
1.01	.20	4	.01	.00	.01	2.
1.01	.25	5	.01	.00	.01	2.
1.01	.30	6	.01	.00	.01	2.
1.01	.35	7	.01	.00	.01	2.
1.01	.40	8	.01	.00	.01	2.
1.01	.45	9	.01	.00	.01	2.
1.01	.50	10	.01	.00	.01	2.
1.01	.55	11	.01	.00	.01	2.
1.01	1.00	12	.01	.00	.01	2.
1.01	1.05	13	.01	.00	.01	2.
1.01	1.10	14	.01	.00	.01	2.
1.01	1.15	15	.01	.00	.01	2.
1.01	1.20	16	.01	.00	.01	2.
1.01	1.25	17	.01	.00	.01	2.
1.01	1.30	18	.01	.00	.01	2.
1.01	1.35	19	.01	.00	.01	3.
1.01	1.40	20	.01	.00	.01	3.
1.01	1.45	21	.01	.00	.01	3.
1.01	1.50	22	.01	.00	.01	3.
1.01	1.55	23	.01	.00	.01	3.
1.01	2.00	24	.01	.00	.01	4.
1.01	2.05	25	.01	.01	.01	4.
1.01	2.10	26	.01	.01	.01	4.
1.01	2.15	27	.01	.01	.01	4.
1.01	2.20	28	.01	.01	.01	4.
1.01	2.25	29	.01	.01	.01	4.
1.01	2.30	30	.01	.01	.01	5.
1.01	2.35	31	.01	.01	.01	5.
1.01	2.40	32	.01	.01	.01	5.
1.01	2.45	33	.01	.01	.01	5.
1.01	2.50	34	.01	.01	.01	5.
1.01	2.55	35	.01	.01	.01	5.
1.01	3.00	36	.01	.01	.01	5.
1.01	3.05	37	.01	.01	.01	5.
1.01	3.10	38	.01	.01	.01	6.
1.01	3.15	39	.01	.01	.01	6.
1.01	3.20	40	.01	.01	.01	6.
1.01	3.25	41	.01	.01	.01	6.
1.01	3.30	42	.01	.01	.01	6.
1.01	3.35	43	.01	.01	.01	6.
1.01	3.40	44	.01	.01	.01	6.
1.01	3.45	45	.01	.01	.01	6.
1.01	3.50	46	.01	.01	.01	6.
1.01	3.55	47	.01	.01	.01	6.
1.01	4.00	48	.01	.01	.01	7.
1.01	4.05	49	.01	.01	.01	7.
1.01	4.10	50	.01	.01	.01	7.
1.01	4.15	51	.01	.01	.01	7.

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	12.05	145	.22	.21	.00	114.
1.01	12.10	146	.22	.21	.00	149.
1.01	12.15	147	.22	.21	.00	158.
1.01	12.20	148	.22	.21	.00	161.
1.01	12.25	149	.22	.21	.00	162.
1.01	12.30	150	.22	.21	.00	162.
1.01	12.35	151	.22	.21	.00	162.
1.01	12.40	152	.22	.21	.00	162.
1.01	12.45	153	.22	.21	.00	162.
1.01	12.50	154	.22	.21	.00	162.
1.01	12.55	155	.22	.21	.00	163.
1.01	13.00	156	.22	.21	.00	163.
1.01	13.05	157	.26	.26	.00	182.
1.01	13.10	158	.26	.26	.00	192.
1.01	13.15	159	.26	.26	.00	195.
1.01	13.20	160	.26	.26	.00	195.
1.01	13.25	161	.26	.26	.00	196.
1.01	13.30	162	.26	.26	.00	196.
1.01	13.35	163	.26	.26	.00	196.
1.01	13.40	164	.26	.26	.00	196.
1.01	13.45	165	.26	.26	.00	196.
1.01	13.50	166	.26	.26	.00	196.
1.01	13.55	167	.26	.26	.00	196.
1.01	14.00	168	.26	.26	.00	196.
1.01	14.05	169	.33	.32	.00	225.
1.01	14.10	170	.33	.32	.00	240.
1.01	14.15	171	.33	.32	.00	244.
1.01	14.20	172	.33	.32	.00	245.
1.01	14.25	173	.33	.32	.00	245.
1.01	14.30	174	.33	.32	.00	246.
1.01	14.35	175	.33	.32	.00	246.
1.01	14.40	176	.33	.32	.00	246.
1.01	14.45	177	.33	.32	.00	246.
1.01	14.50	178	.33	.32	.00	246.
1.01	14.55	179	.33	.32	.00	246.
1.01	15.00	180	.33	.32	.00	246.
1.01	15.05	181	.20	.20	.00	190.
1.01	15.10	182	.40	.39	.00	247.
1.01	15.15	183	.40	.39	.00	286.
1.01	15.20	184	.59	.59	.00	333.
1.01	15.25	185	.69	.69	.00	475.
1.01	15.30	186	1.68	1.68	.00	947.
1.01	15.35	187	2.77	2.76	.01	1669.
1.01	15.40	188	1.09	1.09	.00	1246.
1.01	15.45	189	.69	.69	.00	759.
1.01	15.50	190	.59	.59	.00	542.
1.01	15.55	191	.40	.39	.00	385.
1.01	16.00	192	.40	.39	.00	320.
1.01	16.05	193	.30	.30	.00	263.
1.01	16.10	194	.30	.30	.00	238.
1.01	16.15	195	.30	.30	.00	232.

END-OF-PERIOD FLOW (Cont'd)

1.01	4.20	52	.01	.01	.01	7.	1.01	16.20	196	.30	.30	.00	230.
1.01	4.25	53	.01	.01	.00	7.	1.01	16.25	197	.30	.30	.00	230.
1.01	4.30	54	.01	.01	.00	7.	1.01	16.30	198	.30	.30	.00	230.
1.01	4.35	55	.01	.01	.00	7.	1.01	16.35	199	.30	.30	.00	230.
1.01	4.40	56	.01	.01	.00	7.	1.01	16.40	200	.30	.30	.00	230.
1.01	4.45	57	.01	.01	.00	7.	1.01	16.45	201	.30	.30	.00	230.
1.01	4.50	58	.01	.01	.00	7.	1.01	16.50	202	.30	.30	.00	230.
1.01	4.55	59	.01	.01	.00	7.	1.01	16.55	203	.30	.30	.00	230.
1.01	5.00	60	.01	.01	.00	7.	1.01	17.00	204	.30	.30	.00	230.
1.01	5.05	61	.01	.01	.00	7.	1.01	17.05	205	.24	.24	.00	201.
1.01	5.10	62	.01	.01	.00	7.	1.01	17.10	206	.24	.24	.00	186.
1.01	5.15	63	.01	.01	.00	8.	1.01	17.15	207	.24	.24	.00	182.
1.01	5.20	64	.01	.01	.00	8.	1.01	17.20	208	.24	.24	.00	181.
1.01	5.25	65	.01	.01	.00	8.	1.01	17.25	209	.24	.24	.00	181.
1.01	5.30	66	.01	.01	.00	8.	1.01	17.30	210	.24	.24	.00	181.
1.01	5.35	67	.01	.01	.00	8.	1.01	17.35	211	.24	.24	.00	181.
1.01	5.40	68	.01	.01	.00	8.	1.01	17.40	212	.24	.24	.00	181.
1.01	5.45	69	.01	.01	.00	8.	1.01	17.45	213	.24	.24	.00	181.
1.01	5.50	70	.01	.01	.00	8.	1.01	17.50	214	.24	.24	.00	181.
1.01	5.55	71	.01	.01	.00	8.	1.01	17.55	215	.24	.24	.00	181.
1.01	6.00	72	.01	.01	.00	8.	1.01	18.00	216	.24	.24	.00	181.
1.01	6.05	73	.06	.05	.02	25.	1.01	18.05	217	.02	.02	.00	157.
1.01	6.10	74	.06	.05	.01	34.	1.01	18.10	218	.02	.02	.00	147.
1.01	6.15	75	.06	.05	.01	37.	1.01	18.15	219	.02	.02	.00	137.
1.01	6.20	76	.06	.05	.01	38.	1.01	18.20	220	.02	.02	.00	128.
1.01	6.25	77	.06	.05	.01	39.	1.01	18.25	221	.02	.02	.00	119.
1.01	6.30	78	.06	.05	.01	39.	1.01	18.30	222	.02	.02	.00	111.
1.01	6.35	79	.06	.05	.01	40.	1.01	18.35	223	.02	.02	.00	104.
1.01	6.40	80	.06	.05	.01	40.	1.01	18.40	224	.02	.02	.00	97.
1.01	6.45	81	.06	.05	.01	41.	1.01	18.45	225	.02	.02	.00	90.
1.01	6.50	82	.06	.05	.01	41.	1.01	18.50	226	.02	.02	.00	84.
1.01	6.55	83	.06	.06	.01	42.	1.01	18.55	227	.02	.02	.00	79.
1.01	7.00	84	.06	.06	.01	42.	1.01	19.00	228	.02	.02	.00	73.
1.01	7.05	85	.06	.06	.01	42.	1.01	19.05	229	.02	.02	.00	68.
1.01	7.10	86	.06	.06	.01	43.	1.01	19.10	230	.02	.02	.00	64.
1.01	7.15	87	.06	.06	.01	43.	1.01	19.15	231	.02	.02	.00	60.
1.01	7.20	88	.06	.06	.01	43.	1.01	19.20	232	.02	.02	.00	56.
1.01	7.25	89	.06	.06	.01	43.	1.01	19.25	233	.02	.02	.00	52.
1.01	7.30	90	.06	.06	.01	44.	1.01	19.30	234	.02	.02	.00	48.
1.01	7.35	91	.06	.06	.01	44.	1.01	19.35	235	.02	.02	.00	45.
1.01	7.40	92	.06	.06	.01	44.	1.01	19.40	236	.02	.02	.00	42.
1.01	7.45	93	.06	.06	.01	44.	1.01	19.45	237	.02	.02	.00	39.
1.01	7.50	94	.06	.06	.01	44.	1.01	19.50	238	.02	.02	.00	37.
1.01	7.55	95	.06	.06	.01	44.	1.01	19.55	239	.02	.02	.00	34.
1.01	8.00	96	.06	.06	.00	45.	1.01	20.00	240	.02	.02	.00	32.
1.01	8.05	97	.06	.06	.00	45.	1.01	20.05	241	.02	.02	.00	30.
1.01	8.10	98	.06	.06	.00	45.	1.01	20.10	242	.02	.02	.00	28.
1.01	8.15	99	.06	.06	.00	45.	1.01	20.15	243	.02	.02	.00	26.
1.01	8.20	100	.06	.06	.00	45.	1.01	20.20	244	.02	.02	.00	24.
1.01	8.25	101	.06	.06	.00	45.	1.01	20.25	245	.02	.02	.00	23.
1.01	8.30	102	.06	.06	.00	45.	1.01	20.30	246	.02	.02	.00	21.
1.01	8.35	103	.06	.06	.00	45.	1.01	20.35	247	.02	.02	.00	20.

END-OF-PERIOD FLOW (Cont'd)

1.01	8.40	104	.06	.06	.00	46.	1.01	20.40	248	.02	.02	.00	18.
1.01	8.45	105	.06	.06	.00	46.	1.01	20.45	249	.02	.02	.00	17.
1.01	8.50	106	.06	.06	.00	46.	1.01	20.50	250	.02	.02	.00	16.
1.01	8.55	107	.06	.06	.00	46.	1.01	20.55	251	.02	.02	.00	16.
1.01	9.00	108	.06	.06	.00	46.	1.01	21.00	252	.02	.02	.00	16.
1.01	9.05	109	.06	.06	.00	46.	1.01	21.05	253	.02	.02	.00	16.
1.01	9.10	110	.06	.06	.00	46.	1.01	21.10	254	.02	.02	.00	16.
1.01	9.15	111	.06	.06	.00	46.	1.01	21.15	255	.02	.02	.00	16.
1.01	9.20	112	.06	.06	.00	46.	1.01	21.20	256	.02	.02	.00	16.
1.01	9.25	113	.06	.06	.00	46.	1.01	21.25	257	.02	.02	.00	16.
1.01	9.30	114	.06	.06	.00	46.	1.01	21.30	258	.02	.02	.00	16.
1.01	9.35	115	.06	.06	.00	46.	1.01	21.35	259	.02	.02	.00	16.
1.01	9.40	116	.06	.06	.00	46.	1.01	21.40	260	.02	.02	.00	16.
1.01	9.45	117	.06	.06	.00	46.	1.01	21.45	261	.02	.02	.00	16.
1.01	9.50	118	.06	.06	.00	47.	1.01	21.50	262	.02	.02	.00	16.
1.01	9.55	119	.06	.06	.00	47.	1.01	21.55	263	.02	.02	.00	16.
1.01	10.00	120	.06	.06	.00	47.	1.01	22.00	264	.02	.02	.00	16.
1.01	10.05	121	.06	.06	.00	47.	1.01	22.05	265	.02	.02	.00	16.
1.01	10.10	122	.06	.06	.00	47.	1.01	22.10	266	.02	.02	.00	16.
1.01	10.15	123	.06	.06	.00	47.	1.01	22.15	267	.02	.02	.00	16.
1.01	10.20	124	.06	.06	.00	47.	1.01	22.20	268	.02	.02	.00	16.
1.01	10.25	125	.06	.06	.00	47.	1.01	22.25	269	.02	.02	.00	16.
1.01	10.30	126	.06	.06	.00	47.	1.01	22.30	270	.02	.02	.00	16.
1.01	10.35	127	.06	.06	.00	47.	1.01	22.35	271	.02	.02	.00	16.
1.01	10.40	128	.06	.06	.00	47.	1.01	22.40	272	.02	.02	.00	16.
1.01	10.45	129	.06	.06	.00	47.	1.01	22.45	273	.02	.02	.00	16.
1.01	10.50	130	.06	.06	.00	47.	1.01	22.50	274	.02	.02	.00	16.
1.01	10.55	131	.06	.06	.00	47.	1.01	22.55	275	.02	.02	.00	16.
1.01	11.00	132	.06	.06	.00	47.	1.01	23.00	276	.02	.02	.00	16.
1.01	11.05	133	.06	.06	.00	47.	1.01	23.05	277	.02	.02	.00	16.
1.01	11.10	134	.06	.06	.00	47.	1.01	23.10	278	.02	.02	.00	16.
1.01	11.15	135	.06	.06	.00	47.	1.01	23.15	279	.02	.02	.00	16.
1.01	11.20	136	.06	.06	.00	47.	1.01	23.20	280	.02	.02	.00	16.
1.01	11.25	137	.06	.06	.00	47.	1.01	23.25	281	.02	.02	.00	16.
1.01	11.30	138	.06	.06	.00	47.	1.01	23.30	282	.02	.02	.00	16.
1.01	11.35	139	.06	.06	.00	47.	1.01	23.35	283	.02	.02	.00	16.
1.01	11.40	140	.06	.06	.00	47.	1.01	23.40	284	.02	.02	.00	16.
1.01	11.45	141	.06	.06	.00	47.	1.01	23.45	285	.02	.02	.00	16.
1.01	11.50	142	.06	.06	.00	47.	1.01	23.50	286	.02	.02	.00	16.
1.01	11.55	143	.06	.06	.00	47.	1.01	23.55	287	.02	.02	.00	16.
1.01	12.00	144	.06	.06	.00	47.	1.02	0.00	288	.02	.02	.00	16.
									SUM	33.15	32.17	.98	25885.
										(842.)	(817.)	(25.)	(732.98)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1669.	272.	90.	90.	25869.
CMS	47.	8.	3.	3.	733.
INCHES		25.86	34.10	34.10	34.10
MM		656.94	866.27	866.27	866.27
AC-FT		135.	178.	178.	178.
THOUS CU M		167.	220.	220.	220.

SURFACE AREA=	0.	2.	4.	6.	12.	19.
CAPACITY=	0.	6.	35.	59.	145.	297.
ELEVATION=	592.	604.	615.	620.	630.	640.

SUMMARY OF DAM SAFETY ANALYSIS

PMF

....	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	615.00	615.00	617.10
STORAGE	35.	35.	44.
OUTFLOW	0.	0.	248.

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
.30	617.08	0.00	44.	244.	0.00	15.75	0.00
.35	617.32	.22	45.	297.	.25	15.75	0.00
.50	617.76	.66	47.	603.	.50	15.67	0.00
1.00	618.26	1.16	50.	1474.	1.25	15.67	0.00

SUMMARY OF DAM SAFETY ANALYSIS

1% CHANCE FLOOD

....	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	615.00	615.00	617.10
STORAGE	35.	35.	44.
OUTFLOW	0.	0.	248.

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
1.00	616.86	0.00	43.	203.	0.00	12.25	0.00

END

DATE

ILME