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NATIONAL DAM SAFETY PROGRAM. BROWN LAKE DAM (MO 31251), UPPER M--ETC(U)
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UPPER MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

BROWN LAKE DAM

FRANKLIN COUNTY, MISSOURI

MO 31251

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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

St. Louis District

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

FOR: STATE OF MISSOURI

OCTOBER 1980

UNCLASSIFIED

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READ INSTRUCTIONS BEFORE COMPLETING FORM

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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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UPPER MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

BROWN LAKE DAM

FRANKLIN COUNTY, MISSOURI

MO 31251

PHASE 1 INSPECTION REPORT
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PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

OCTOBER 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT. CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 6310

REPLY TO
ATTENTION OF

LMSED-P

SUBJECT: Brown Lake Dam, MO 31251, Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Brown Lake Dam (MO 31251):

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: ______________________ 12 ________
Chief, Engineering Division — Date

APPROVED BY: SIGNED ______________________ 14 JAN ________
Colonel, CE, District Engineer — Date

BROWN LAKE DAM

MISSOURI INVENTORY NO. 31251

FRANKLIN 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

OCTOBER 1980

HS-8011

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Brown Lake Dam
State Located:	Missouri
County Located:	Franklin
Stream:	Subtributary of Pin Oak Creek
Date of Inspection:	28 August 1980

The Brown Lake Dam 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 a hazard to human life or property.

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 the hydrologic/hydraulic investigations, the present general condition of the dam is considered to be less than satisfactory. The following deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam:

1. Much of the embankment had been recently plowed, including the upstream face to within about 3 feet of the waterline, the crest, and about two-thirds of the downstream face of the dam, leaving the slopes unprotected and subject to erosion by stormwater runoff. With the exception of the vegetative cover near the waterline, the upstream face of the dam was unprotected, and erosion, apparently by wave action and/or by fluctuations of the lake surface level, has created a near vertical bank approximately 15 inches high at the normal waterline. Vegetative cover is not considered adequate protection to prevent erosion by wave action or fluctuations of the

lake level. Loss of embankment material by erosion can be detrimental to the structural stability of the dam.

2. Seepage, as characterized by wet, soft ground and cattails was observed at the toe of the downstream slope in an area which extended about 150 feet from the original stream channel toward the left abutment. Uncontrolled seepage could develop into a piping condition (progressive internal erosion) that can lead to failure of the dam. Saturation of the soil adjacent to the dam can weaken the foundation and impair the stability of the dam.

3. The dam, according to survey data obtained during the inspection and information obtained from the Owner's representative, appears to have settled, perhaps as much as 1.7 feet, in the vicinity of the original stream crossing. Low areas in the dam crest reduce dam freeboard and penalize spillway capacity.

4. Numerous small trees were present at the normal waterline on the upstream face of the dam. Tree roots can provide passageways for lake seepage which could lead to a piping condition resulting in failure of the dam.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Brown Lake Dam, which is classified as small in size and of high hazard potential, is specified 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 small volume of water is impounded by the dam, that the flood plain downstream of the dam is fairly broad, and that the level of the dwellings, including the mobile homes, within the estimated flood damage zone are at elevations appreciably above the bank of the downstream channel, it is recommended that the spillway for this dam be designed for one-half the Probable Maximum Flood.

According to Mr. Nelson Porter, the Owner's representative, since completion of the dam in 1972, the lake level has never reached the elevation of the spillway. At the time of the inspection, the lake level was about 5.2 feet below the spillway crest. Judging by an eroded wave terrace on the upstream face of the dam, the lake had been for some period of time approximately one foot higher than the observed level. Mr. Porter indicated that the highest lake level experienced to date was probably about 2.5 feet below the spillway crest or approximately 2.7 feet higher than the level at the time of inspection. For the purpose of the hydraulic/hydrologic investigations performed for this dam, the level of the lake just prior to the beginning of the assumed antecedent storms for the Probable Maximum Flood and the one percent chance (100-year frequency) flood, was assumed to be the elevation of the eroded wave terrace on the upstream face of the dam, or four feet below the spillway crest.

According to survey data obtained during the inspection, the minimum elevation of the dam crest near the left end of the dam was found to be approximately 0.1 foot higher than the crest of the spillway, and the elevation of the top of the dam near the center of the structure was found to be only 0.3 foot higher than the spillway crest. Considering the obvious erosion potential of the dam (the entire dam surface including the spillway area had recently been plowed) and the fact that very little difference exists between the top of dam elevation and the spillway crest elevation, the effective elevation of the top of dam was considered to be the elevation of the spillway crest, or elevation 660.0.

Results of a hydrologic/hydraulic analysis indicated that the reservoir is not capable of storing the runoff resulting from a storm of one-half PMF magnitude without overtopping the dam. The reservoir is capable of storing, above the level of the assumed antecedent storm, the runoff corresponding to a storm of about 9 percent of the PMF without overtopping the dam, and for all practical purposes, the runoff from the 1 percent chance (100-year frequency) flood. 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 two miles. Accordingly, within the possible damage zone are five dwellings, nine mobile homes, and three buildings.

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 without undue delay to correct or control the deficiencies and safety defects reported herein. Priority should be given to increasing the height of the dam and/or the size of the spillway.

Harold B. Lockett

Harold B. Lockett
P. E. Missouri E-4189

Albert B. Becker, Jr.

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

OVERVIEW BROWN LAKE DAM

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

BROWN LAKE DAM - [illegible]

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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

BROWN LAKE DAM - MO 312[illegible]

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 States. Pursuant to the above, the St. Louis District, Corps of Engineers, directed that a safety inspection of the Brown Lake 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 a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with 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 Brown Lake Dam is an earthfill type embankment rising approximately 31 feet above the natural streambed at the downstream toe of the barrier. The embankment has an upstream slope of approximately 1v on 4h, a crest width of about 18 feet, and a downstream slope on the order of 1v on 3.1h. The length of the dam is approximately 545 feet. A plan and profile of the dam are shown on Plate 3, and a cross-section of the dam is shown on Plate 4. At spillway crest elevation, the reservoir impounded by the dam occupies approximately 3 acres.

There is no drawdown facility to dewater the lake. An overview photograph of the dam is shown at the rear of the preface at the front of the report.

The spillway, a shallow earthen V-section, is located at the right, or west, abutment. The spillway outlet channel joins a natural swale located downstream of the dam at a point about 200 feet from the crest of the dam. The swale, in turn, joins the original stream channel about 300 feet beyond the toe of the dam. Apparent settlement of the dam has lowered the dam crest to a point where there is virtually no difference in elevation between the top of the dam and the spillway crest. A profile and cross-section of the spillway are shown on Plate 5.

b. Location. The dam is located on an unnamed subtributary of Pin Oak Creek, about 0.4 mile southwest of the intersection of St. Louis Rock Road and State Highway M and approximately 0.5 mile north of the town of Villa Ridge, Missouri, as shown on the Regional Vicinity Map, Plate 1. The dam is located in Section 10, Township 43 North, Range 1 East, within Franklin 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 Brown Lake 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 commercial 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 two miles downstream of the dam. Within the possible damage zone are five dwellings, nine mobile homes, and three buildings. 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 Brown Quarries, Inc., Box 250, Washington, Missouri 63090. Mr. Richard E. Brown is the President of Brown Quarries.

f. Purpose of Dam. The property on which the dam and reservoir are located is operated as a horse ranch. The reservoir impounded by the dam is used for stock watering.

g. Design and Construction History. According to Mr. Richard Brown, the dam was constructed in 1972 by Mr. Nelson Porter, Farm Manager for the Owner. According to Mr. Porter, the dam was constructed without the benefit of any formal design or engineering data.

h. Normal Operational Procedure. The lake level is unregulated. Since the existing spillway has been negated by apparent dam settlement, there is no effective outlet for runoff in excess of the storage capacity of the reservoir.

1.3 PERTINENT DATA

a. Drainage Area. The area tributary to the lake is for the most part pastureland. The watershed above the dam amounts to approximately 30 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

(1) Estimated known maximum discharge at damsite ... None 1/

(2) Spillway capacity ... None

c. Elevation (Ft. above MSL). Unless otherwise indicated, the following elevations were determined by survey and are based on the topographic data as shown on the 1969 Moselle, Missouri, Quadrangle Map, 7.5 Minute Series.

(1) Observed pool ... 654.8

(2) Normal pool ... Unknown

(3) Mean annual high water ... 656.0 (per high water mark)

(4) Spillway crest ... 660.0

1/ According to Mr. Porter, the level of the lake has never reached the elevation of the spillway crest.

(5) Maximum experienced pool ... 657.5 1/

(6) Top of dam ... 660.1 (Min.)

(7) Effective top of dam ... 660.0

(8) Streambed at centerline of dam ... 632± (Est.)

(9) Maximum tailwater ... Unknown

(10) Observed tailwater ... None

d. Reservoir.

(1) Length at spillway crest (Elev. 660.0) ... 600 ft.

(2) Length at maximum pool (Elev. 660.0) ... 600 ft.

e. Storage.

(1) Spillway crest ... 29 ac. ft.

(2) Top of dam (incremental) ... None

f. Reservoir Surface.

(1) Spillway crest ... 3.4 acres

(2) Top of dam (incremental) ... None

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, homogeneous 2/

(2) Length ... 545 ft.

(3) Height ... 31 ft.

(4) Top width ... 18 ft.

1/ Based on an estimate of lake level as observed by Mr. Nelson Porter, Farm Manager for the Owner.

2/ Per Mr. Nelson Porter.

(5) Side slopes

a. Upstream ... 1v on 4h (above waterline)

b. Downstream ... 1v on 3.1h

(6) Cutoff ... Core trench 1/

(7) Slope protection

a. Upstream ... Vegetation to 3 feet above waterline, remainder - no protection (under cultivation)

b. Downstream ... 35% - Vegetation
65% - None (under cultivation)

h. Spillway.

(1) Type ... Uncontrolled, excavated earth, V-section

(2) Location ... Right abutment

(3) Crest ... Elevation 660.0

(4) Approach channel ... Lake

(5) Exit channel ... Unconfined, earth (unimproved)

i. Emergency Spillway ... None

j. Lake Drawdown Facility ... None

1/ Per Mr. Nelson Porter.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No engineering data relating to the design of the dam are known to exist.

2.2 CONSTRUCTION

No formal records were maintained during construction of the dam. As previously stated, Brown Lake Dam was constructed in 1972 by Mr. Nelson Porter, Farm Manager for the Owner. An interview with Mr. Porter indicated that a core trench approximately 40 feet wide was excavated about 4 feet deep along the alignment of the dam. Mr. Porter indicated that a seam of gravel was encountered near the left abutment and that the core trench was excavated to bedrock just below the gravel. Mr. Porter reported that fill for the dam was obtained from the area now occupied by the lake, and was compacted with the equipment used to construct the dam. According to Mr. Porter, the elevation of the top at the center of the dam was about two feet higher than at the abutments at the time the dam was completed.

2.3 OPERATION

The lake level is uncontrolled. The level of the lake is intended to be governed by the elevation of the crest of the spillway. However, apparent settlement of the dam has lowered the dam crest to a point where there is virtually no difference in elevation between the top of the dam and the spillway crest. No indication was found that the dam has been overtopped. Mr. Nelson Porter reported that the dam has never been overtopped and that the highest lake level observed was approximately 2.5 feet lower than the crest of the spillway.

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.

c. Validity. Considering the watershed to lake ratio, approximately 9 to 1, the fact that the observed seepage was relatively minor, and that the dam is about 8 years old, it is unclear why the reservoir has not filled to spillway level. A possible explanation is the underlying geologic conditions which, as indicated in Section 3.1b, can be a source of reservoir leakage if the soil cover is relatively thin.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Brown Lake 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 28 August 1980. An examination of the dam area was also made by an engineering geologist, Jerry D. Higgins, Ph.D., a consultant retained by Horner & Shifrin for the purpose of assessing the site 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. Brown Lake Dam is located within the Salem Plateau Section of the Ozark Plateaus Physiographic Province near the border with the Dissected Till Plains Section of the Central Lowlands Province. The topography is rolling, with a maximum of approximately 90 feet of relief between the reservoir and the surrounding drainage divides. No outcrops were found on the site; however, nearby borings indicate the bedrock consists of gently northward-dipping Ordovician-age sedimentary strata of the Jefferson City-Cotter formation. No faults were observed or have been reported in the vicinity of the site. The Jefferson City-Cotter is a light brown, medium to finely crystalline dolomite. It is thin- to medium-bedded, often argillaceous, and cherty. Solution-enlargement of joints and bedding planes frequently occurs in the dolomite, and the contact between bedrock and the overlying surficial materials is usually an irregular surface. These solution features are often the source of reservoir leakage if the soil cover is relatively thin.

The unconsolidated surficial materials are composed primarily of residual clays overlain by loessal soils. The residual soils, formed from in-place weathering of bedrock, consist of stony, blocky, silty clays which are somewhat permeable and often cause seepage from reservoirs. The loessal soils consist of deep, moderately well-drained silts and silty clays. In general, these soils grade from light brown silts near the surface to a friable silty clay with depth. The soils are classified ML or ML-CL materials and are generally low in permeability but susceptible to erosion, especially on slopes. If the residual clays and the loessal soils are not too thin and protected from erosion, they are generally suitable for small water impoundments.

No significant geologic problems were observed that would be considered to adversely affect the stability of the dam embankment.

c. Dam. The visible portions of the upstream and downstream faces of the dam (see Photos 1 and 2) were examined and appeared to be in sound condition. No cracking or sloughing of the embankment was noticed. The crest, as well as most of both the upstream and downstream faces of the dam, had been recently plowed, and were clear of vegetation. Although there was no evidence of erosion in the areas that had been plowed, it appeared that the soils would be easily eroded by stormwater runoff. An examination of the surficial material obtained from the downstream face of the dam indicated it to be a yellow-brown, silty lean clay (CL) of low-to-medium plasticity. Along the upstream face, the area from the waterline to about 3 feet above the lake level was covered with grass about 3 feet high, and numerous small willow trees. No riprap was present on the upstream face, and erosion of the upstream face of the dam, apparently due to wave action, had created an almost vertical bank (see Photo 6) up to about 15 inches in height at the high water level.

According to Mr. Nelson Porter, Farm Manager for the Owner and builder of the dam, the dam was constructed about 2 feet higher at the center than at the abutments. However, based on survey data obtained during the inspection, the dam at the center was found to be only 0.2 foot higher than the top of the dam at the left abutment, and only 0.3 foot higher than the crest of the spillway at the right abutment. Since the low point in the top of the dam was found to be near the location of the original stream on which the dam was constructed, it is possible that the dam has settled, perhaps as much as 1.7 feet, in the vicinity of the original stream crossing.

The portion of the downstream face of the dam which had not been plowed, about one-third of the area of the slope, was located in the vicinity of the left abutment. The slope in this area was covered with grass which was about 3 feet high at the time of inspection. A marshy area (see Photo 5), with wet, soft ground and cattails, was observed at the toe of the downstream slope extending about 150 feet from the original stream channel toward the left abutment. No water was observed flowing from the area at the time of inspection and, therefore, an estimate of seepage quantity could not be made.

The spillway (see Photo 3) was inspected and appeared to be in sound condition; however, the spillway crest and channel had also been plowed recently, and were unprotected from erosion. There was no outlet channel apparent (see Photo 4), and it appeared that spillway discharges would follow the hillside slope away from the embankment toward a natural swale located approximately 200 feet downstream of the dam.

d. <u>Appurtenant Structures</u>. No appurtenant structures were observed at this dam.

e. <u>Downstream Channel</u>. The downstream channel is dish-shaped and grass-covered to a point about 400 feet downstream of the dam. At the time of the inspection, the slopes adjacent to this section of the channel had been recently plowed. Except at the road and rail crossings, the remainder of the channel between the dam and the Bourbeuse River is unimproved, the section is irregular, and the slopes adjacent to the banks are primarily grass-covered.

f. <u>Reservoir</u>. At the time of the inspection, the slopes adjacent to the reservoir had been recently plowed and the water within the reservoir was cloudy. The lake level was about 5.2 feet below the crest of the spillway. The amount of sediment within the lake could not be determined at the time of inspection; however, the depth of sediment at the upstream end of the lake, near the waterline, was measured, and the maximum depth was found to be approximately 8 inches. It is not expected that the sediment within the lake significantly affects the storage capacity of the reservoir since, according to Mr. Richard Brown, the slopes are normally covered with grass for use as pasture.

3.2 EVALUATION

The deficiencies observed during this inspection and noted herein are not considered of significant importance to warrant immediate remedial action. Considering the fact that the elevation of the spillway crest and the low point of the dam crest are virtually the same, it is evident that lake outflow would overtop the dam at approximately the elevation of the spillway crest.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The reservoir has no effective spillway. The lake surface level is governed by precipitation runoff, reservoir storage evaporation, and seepage.

4.2 MAINTENANCE OF DAM

According to Mr. Nelson Porter, Farm Manager, the grass on the dam slopes and crest are mowed two or three times each year, and these areas are plowed and cultivated every three years.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

No outlet facilities requiring operation exist at this dam, and there is no reservoir regulation plan.

4.4 DESCRIPTION OF ANY WARNING SYSTEMS IN EFFECT

The inspection did not reveal the existence of a dam failure warning system.

4.5 EVALUATION

The turf cover on the dam should be maintained at a height that will not hinder inspection of the dam or conceal animal burrows. However, plowing of the dam crest and slopes leaves the structure unprotected from erosion by stormwater runoff and spillway releases. Regular maintenance of dam features is considered beneficial to the overall safety of a dam. It is recommended that the practice of cultivating the dam proper be discontinued, since the dam is left without turf cover during the re-establishment period and is subject to erosion which can impair the stability of the structure.

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 are not available.

b. Experience Data.

(1) The drainage area and lake surface area were determined from the 1969 Moselle, Missouri, Quadrangle Map. 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.

(2) The lake level prior to the beginning of all antecedent storms was assumed to be at elevation 656.0 with storage equal to 17.33 acre-feet. This elevation was established during the inspection as the mean annual high lake level, as determined by the location of the eroded wave terrace, on the upstream face of the dam. Mr. Nelson Porter, Farm Manager for the Owner, stated that the maximum lake level experienced to date was about 2.5 feet below the spillway crest, or approximately elevation 657.5.

As specified by the St. Louis District, Corps of Engineers, for the one percent chance (100-year frequency) storm, the antecedent 24-hour runoff was assumed to be 0.40 inch. The computed volume of runoff for the antecedent storm amounted to 0.99 acre-feet, resulting in accumulated storage equal to 18.32 acre-feet at elevation 656.3 at the beginning of the one percent chance (100-year frequency) storm.

In accordance with the hydrologic/hydraulic standards of the St. Louis District, Corps of Engineers, for the PMF ratio storms, an antecedent storm equal to one-half the PMF ratio event was assumed to precede the PMF ratio storm by four days. This PMF ratio antecedent storm was then routed through the reservoir. The antecedent storm, which when combined with the PMF ratio storm fills the reservoir to the point of overtopping, corresponds to about 4.5 percent of the PMF lake inflow. As a result of this antecedent storm, the level of the lake at the beginning of the 9 percent PMF ratio storm was determined to be elevation 657.4.

For the 50 percent PMF storm, an antecedent storm of 25 percent PMF magnitude was assumed. This storm was routed through the lake and it was found that the dam was overtopped by 0.5 feet, and that the lake level receded to the assumed top of dam level, elevation 660.0 by the end of the second day. Experience indicates that a similar analysis for the 100 percent PMF storm, using an antecedent storm of 50 percent PMF magnitude would also result in dam overtopping with the level of the lake receding to the elevation of the assumed top of dam within two days. The lake surface at the beginning of the 50 percent and 100 percent PMF storm events was therefore taken as the level of the assumed top of dam, elevation 660.0. Failure of the dam due to overtopping by the 25 percent or 50 percent antecedent storms was not assumed to occur in these investigations of overtopping by the 50 percent PMF and 100 percent PMF events.

(3) According to the St. Louis District, Corps of Engineers, the estimated flood damage zone, should failure of the dam occur, extends two miles downstream of the dam.

c. Visual Observations.

(1) The spillway, a shallow, broad-crested, V-shaped excavated earth section, is located at the right abutment. The elevation of the spillway crest was found to be only 0.1 foot lower than the top of the dam near the left end of the structure and 0.3 foot lower than the dam crest near the center of the barrier.

(2) No lake drawdown facility is provided.

(3) Mr. Nelson Porter, Farm Manager for the Owner, stated that the dam and surrounding areas are cultivated for pasture approximately every three years. At the time of the inspection, the dam proper including the spillway and areas surrounding the reservoir had recently been plowed.

d. Overtopping Potential. The reservoir is not capable of storing the runoff resulting from the probable maximum flood, or one-half the probable maximum flood without overtopping the dam (lake surface at spillway crest elevation 660.0 at beginning of 50 percent PMF and PMF storms). The reservoir is adequate, however, to contain the runoff from the one percent chance (100-year frequency) storm without overtopping the dam (lake suface at elevation 656.3 at beginning of the one percent chance storm).

(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 Dam (Elev. 660.0)	Duration of Overtopping of Dam (Hours)
0.50	351	661.0	1.0	24.0
1.00	750	661.2	1.2	24.0
1% Chance	0	660.0	0.0	0.0

Due to the obvious erosion potential of the dam and the fact that very little difference exists between the top of dam elevation and the spillway crest elevation, the effective elevation of the top of dam was considered to be the elevation of the spillway crest, elevation 660.0. The reservoir was found capable of storing, above the level of the assumed antecedent storm, the runoff corresponding to a storm of about 9 percent of the probable maximum flood inflow without overtopping the dam. During peak flow of one-half the probable maximum flood, the recommended spillway design flood, the greatest depth of flow over the dam is projected to be 1.0 foot and overtopping will extend over almost the entire length of the dam.

e. Evaluation. 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. 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 flow over the effective top of dam, a maximum of 1.2 feet, and the duration of flow over the dam, a minimum of 24 hours, are considerable, damage by erosion to the dam is expected. The extent of these damages is not predictable; however, there is a possibility that they could result in failure by erosion of the dam. A similar and nearly as severe condition also exists during one-half the PMF event.

f. Reference. Procedures and data for determining the probable maximum flood, the 100-year frequency flood, and the flow passing over the 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 the 9 percent probable maximum flood, the probable maximum flood, and the one percent chance (100-year frequency) flood are shown on pages B-3 through B-6. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-7 through B-10; tabulation of lake surface area, elevation and storage volume is shown on page B-11 and tabulations titled "Summary of Dam Safety Analysis" for the 9 percent PMF, the 50 and 100 percent PMF, and the one percent chance (100-year frequency) flood are shown on pages B-11 and B-12.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observation. 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 Mr. Nelson Porter, Farm Manager for the Owner, no records are kept of the lake level, spillway discharge, dam settlement, or seepage. Mr. Porter did report that the highest level experienced by the lake was about 2.5 feet below the elevation of the spillway crest.

d. Post Construction Changes. Mr. Porter reported that no post construction changes have been made or have occurred that would affect the structural stability of the dam. A possible exception is the suspected settlement of the dam that has occurred in the vicinity of the original stream crossing.

e. Seismic Stability. The dam is located within a Zone II seismic probability area. An earthquake of this magnitude would not be expected to cause structural damage to a well constructed earth 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. As previously indicated, the existing spillway was considered to be ineffective and not capable of safely passing lake outflow without overtopping the dam. As a result of this assumption, only the runoff corresponding to the available storage within the reservoir at the time of the storm event under consideration, can be safely tolerated. Flood events in excess of the available storage were assumed to overtop the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicates that for storm runoff of one-half the probable maximum flood magnitude (the recommended spillway design flood), the dam would be overtopped. A similar analysis indicated that the reservoir is capable of containing the runoff from a storm of about 9 percent of the probable maximum flood inflow, and for all practical purposes, the runoff resulting from the 1 percent (100-year frequency) flood without overtopping the dam.

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 visual inspection that could adversely affect the safety of the dam. These items include the lack of protection from erosion on the crest and slopes of the dam, settlement, seepage, and small trees on the upstream face of the dam.

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 reservoir 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 without undue delay. Priority should be given to increasing the height of the dam and/or spillway capacity.

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 this magnitude would not be expected to cause structural damage to a well constructed earth 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 the probable maximum flood magnitude, the recommended spillway design flood for this dam. In either case, the spillway should be protected to prevent erosion.

(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.

(3) Restore the dam crest to a uniform elevation and monitor the top of the dam through the area of suspected settlement in order to determine the extent of possible future settlement and the remedial work required to compensate for such settlement. In any event, the crest of the dam should be uniform throughout without low areas that reduce dam freeboard and penalize spillway capacity.

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

(1) Restore and maintain a grass cover on the dam crest and slopes to prevent erosion by stormwater runoff. Also restore the eroded material along the upstream face of the dam and provide some form of protection other than grass at and above the normal waterline in order to prevent erosion by wave action or by fluctuations of the lake level. 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 by erosion can be detrimental to the structural stability of the dam.

(2) Provide some means of controlling seepage evident in the area adjacent to the downstream toe between the left abutment and the original stream channel. Uncontrolled seepage can lead to a piping condition (progressive internal erosion) which could result in the failure of the dam. Drainage of the areas affected by seepage should be one of the objectives of the seepage control measures since saturation of the soil weakens the foundation which could impair the stability of the dam.

(3) Remove the trees from the upstream face of the dam. Tree roots can provide passageways for lake seepage which could lead to a piping condition and subsequent failure of the dam.

(4) Provide maintenance of all areas of the dam and spillway on a regularly scheduled basis in order to insure 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, for future reference, that records be kept of all inspections made and remedial measures taken.

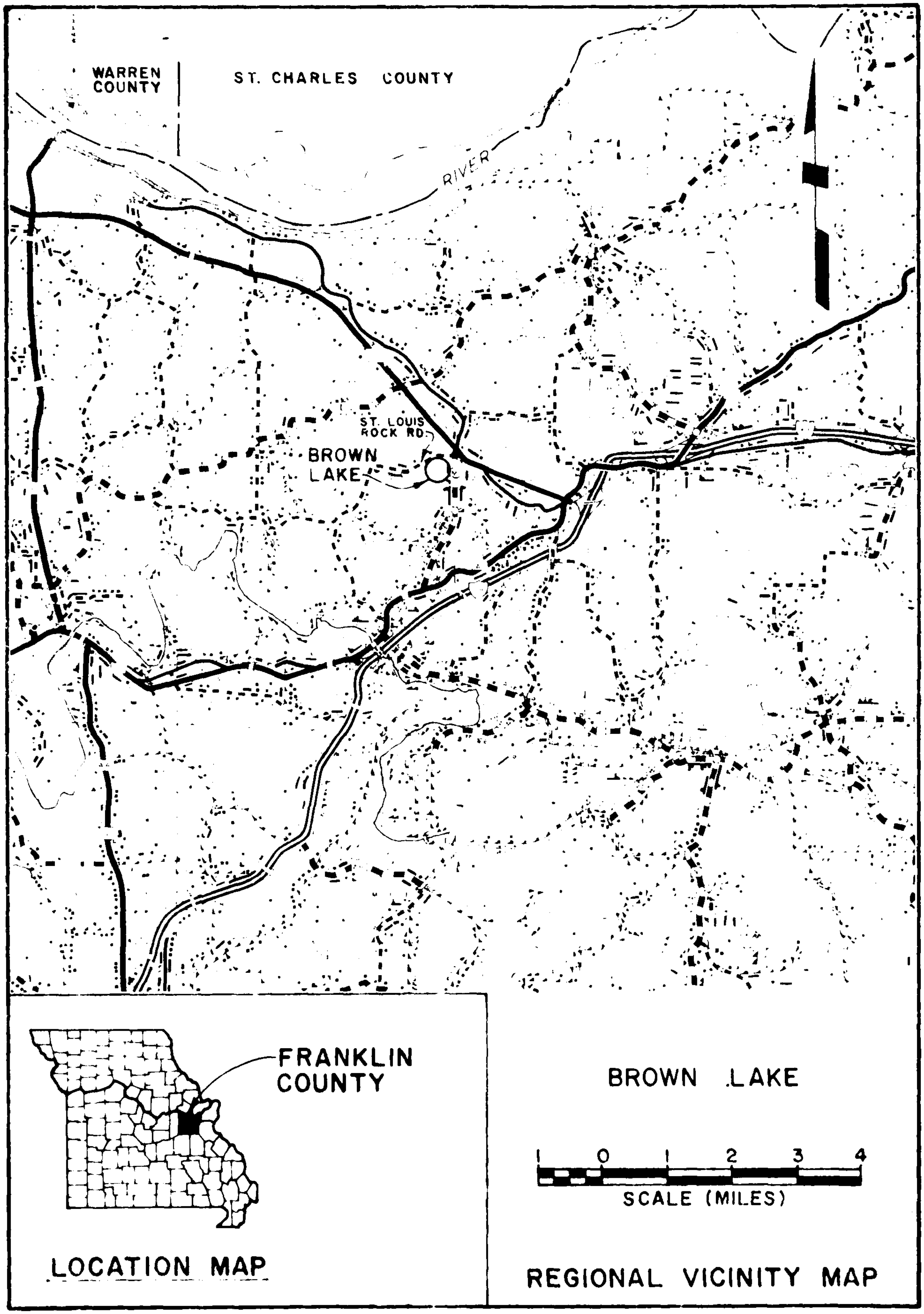
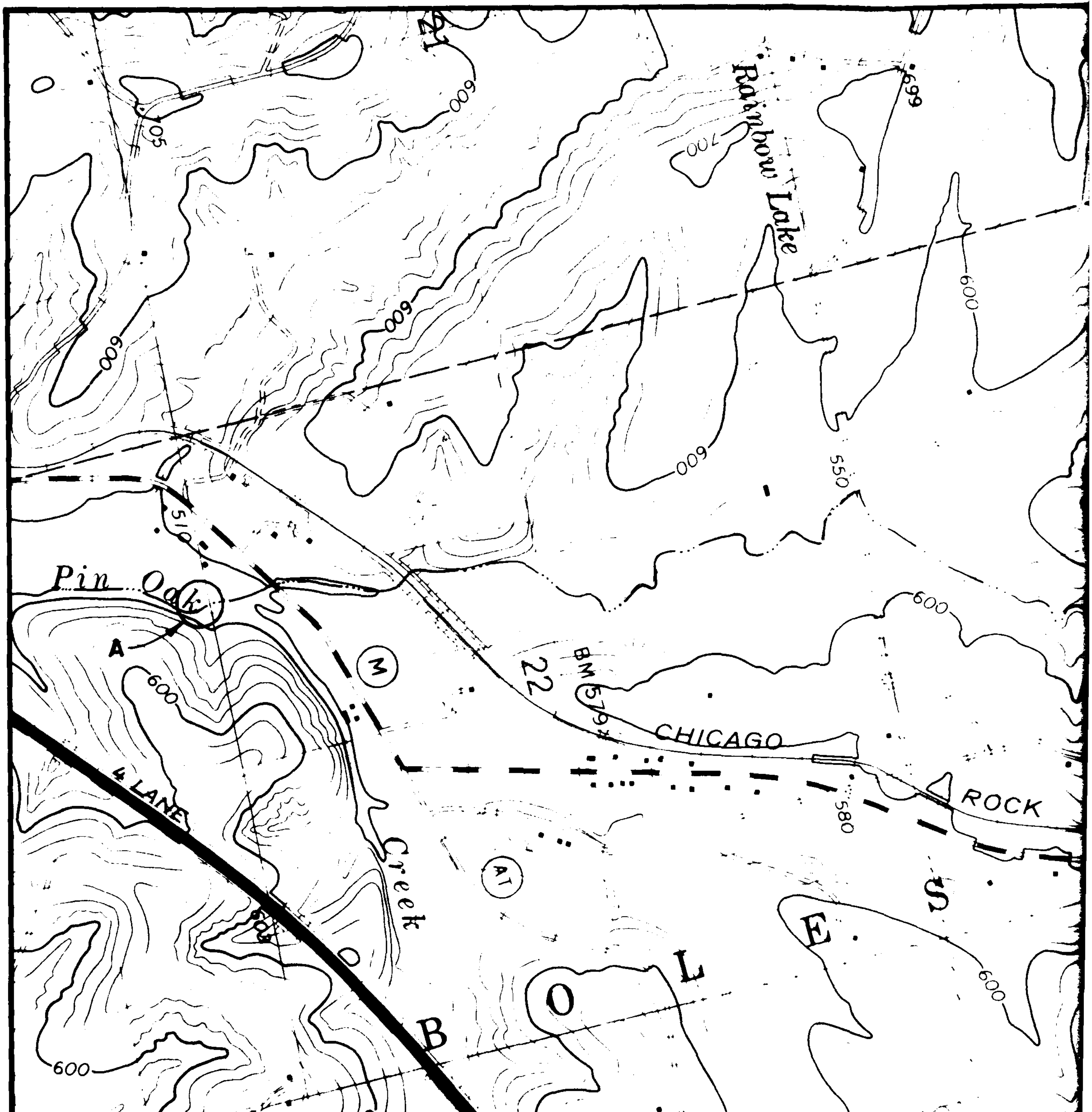

WARREN COUNTY
ST. CHARLES COUNTY
RIVER
ST. LOUIS ROCK RD.
BROWN LAKE
FRANKLIN COUNTY
LOCATION MAP
BROWN LAKE
0 1 2 3 4
SCALE (MILES)
REGIONAL VICINITY MAP

PLATE I


Rainbow Lake
Pin Oak
Creek
A
M
AT
22
BM 579
CHICAGO
ROCK
4 LANE
B O L E S
700
600
550
580
A=APPROXIMATE EXTENT OF DOWNSTREA

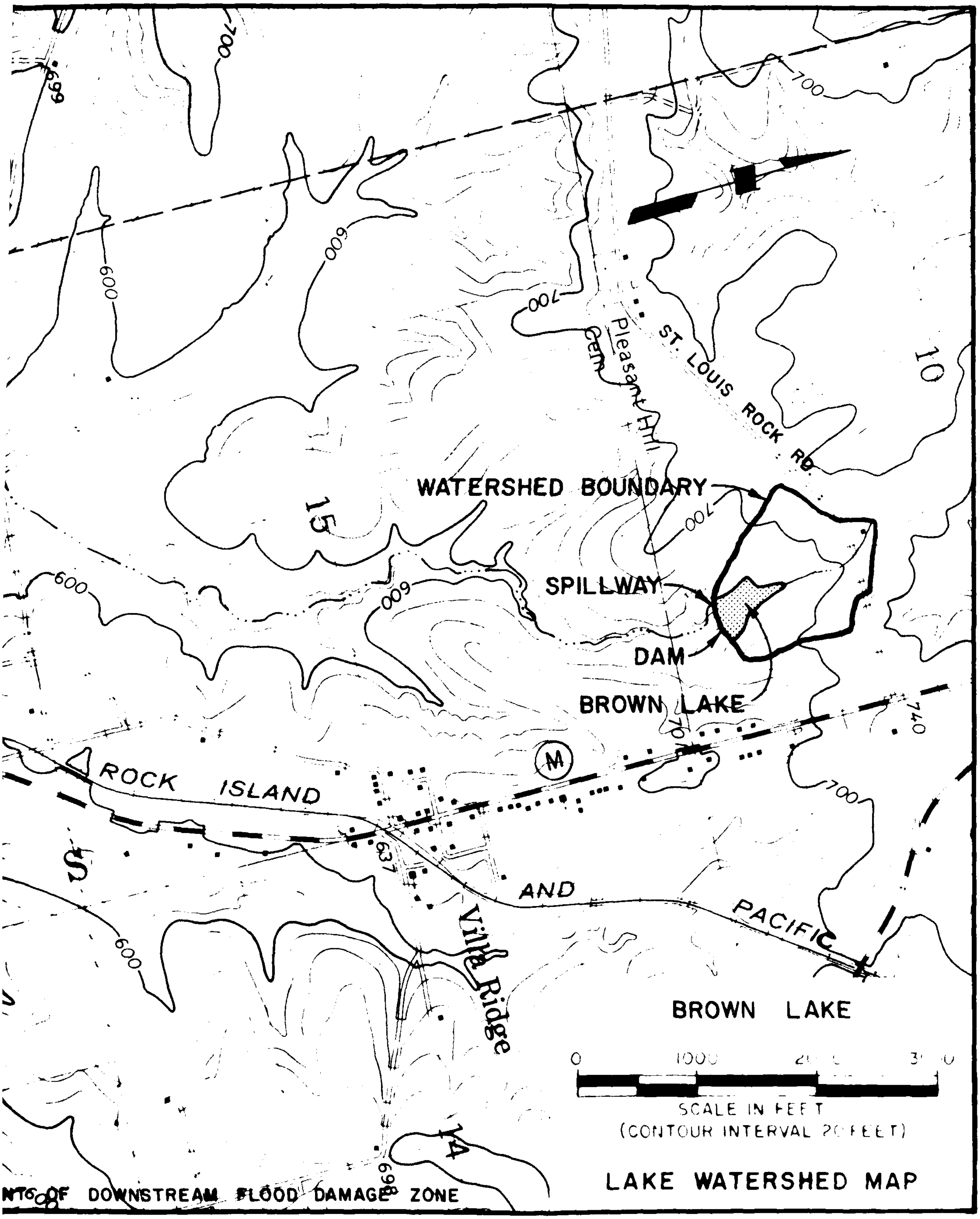
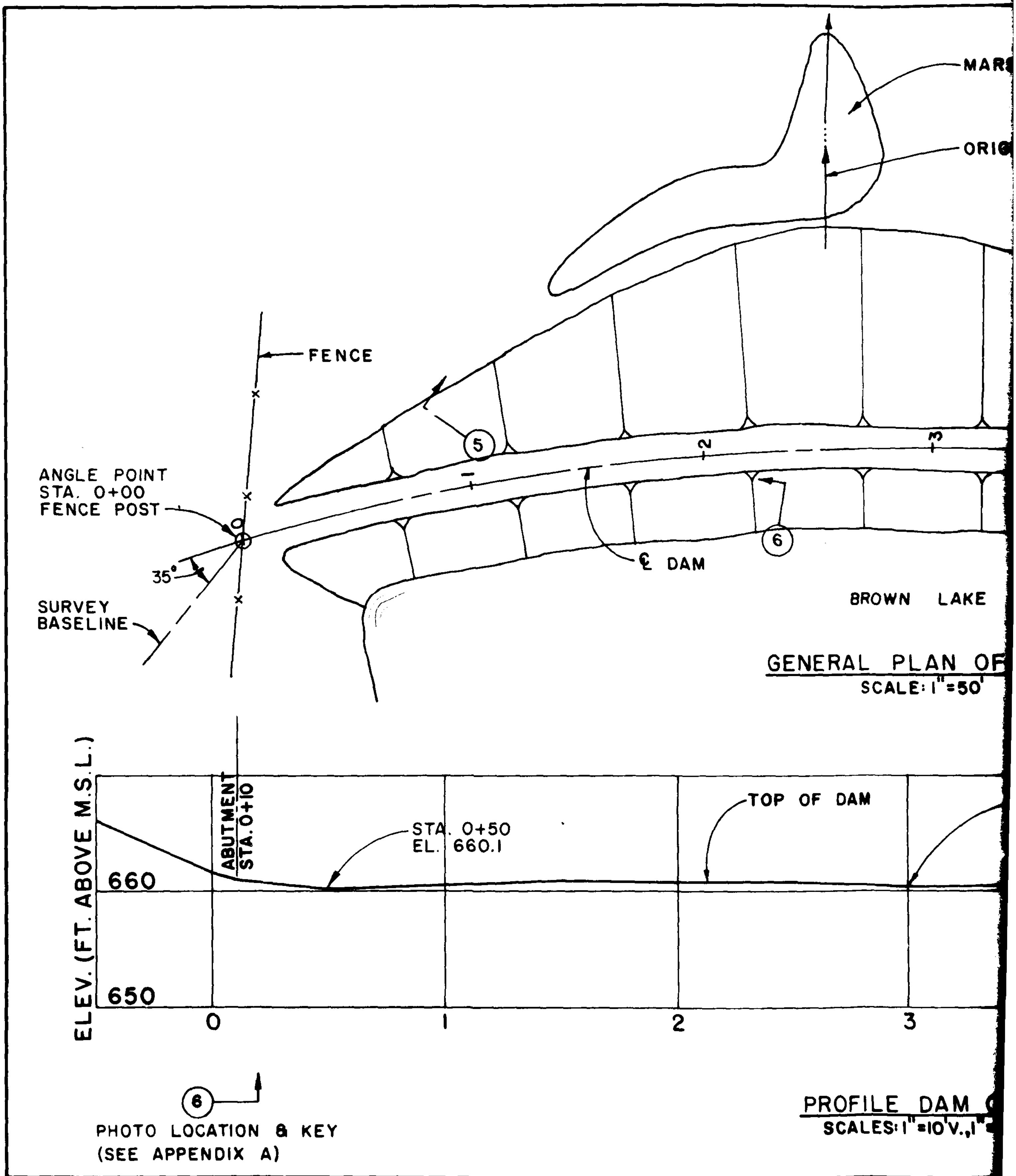
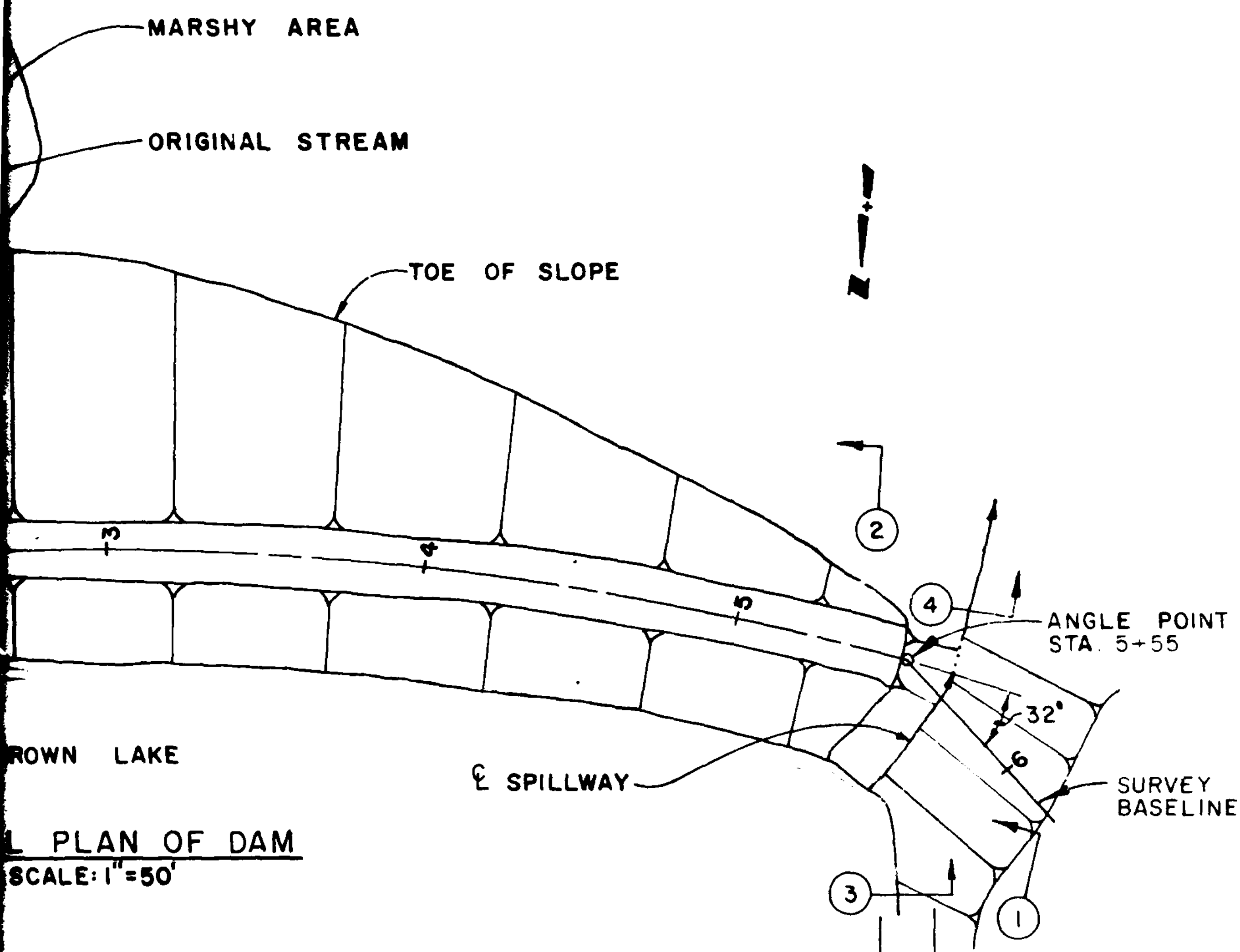
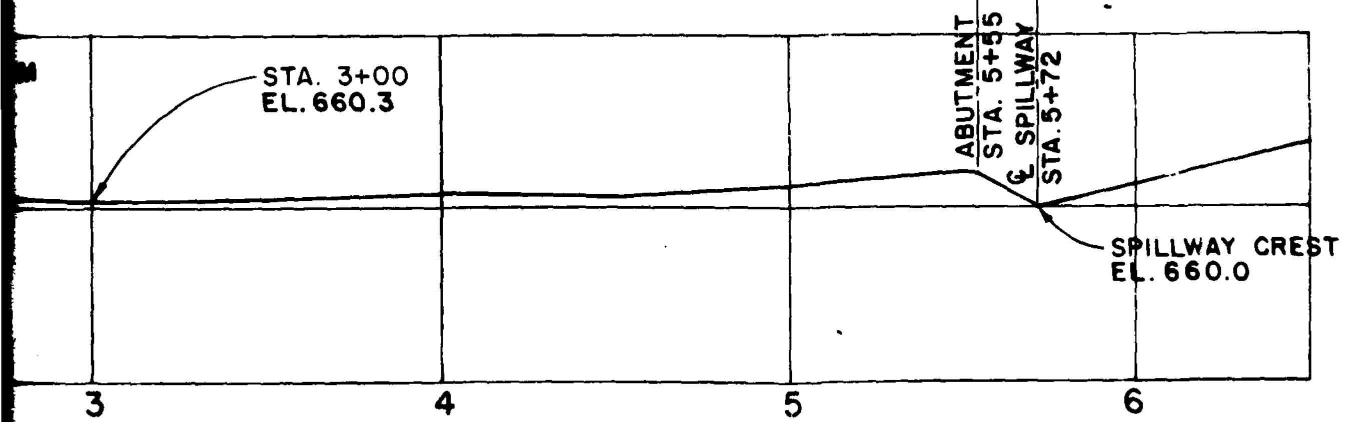

WATERSHED BOUNDARY
SPILLWAY
DAM
BROWN LAKE
ST. LOUIS ROCK RD.
Pleasant Hill
Cem
ROCK ISLAND AND PACIFIC
Villa Ridge
700
600
15
10
14
BROWN LAKE
0 1000
SCALE IN FEET
(CONTOUR INTERVAL 20 FEET)
LAKE WATERSHED MAP
OF DOWNSTREAM FLOOD DAMAGE ZONE

PLATE 2


MARS
ORIG
FENCE
ANGLE POINT
STA. 0+00
FENCE POST
35°
SURVEY
BASELINE
5
6
1
2
3
℄ DAM
BROWN LAKE
GENERAL PLAN OF
SCALE: 1"=50'
ELEV. (FT. ABOVE M.S.L.)
ABUTMENT
STA. 0+10
STA. 0+50
EL. 660.1
TOP OF DAM
660
650
0
1
2
3
6
PHOTO LOCATION & KEY
(SEE APPENDIX A)
PROFILE DAM
SCALES: 1"=10'V., 1"



L PLAN OF DAM
SCALE: 1" = 50'



FILE DAM CREST
LES: 1" = 10' V., 1" = 50' H.

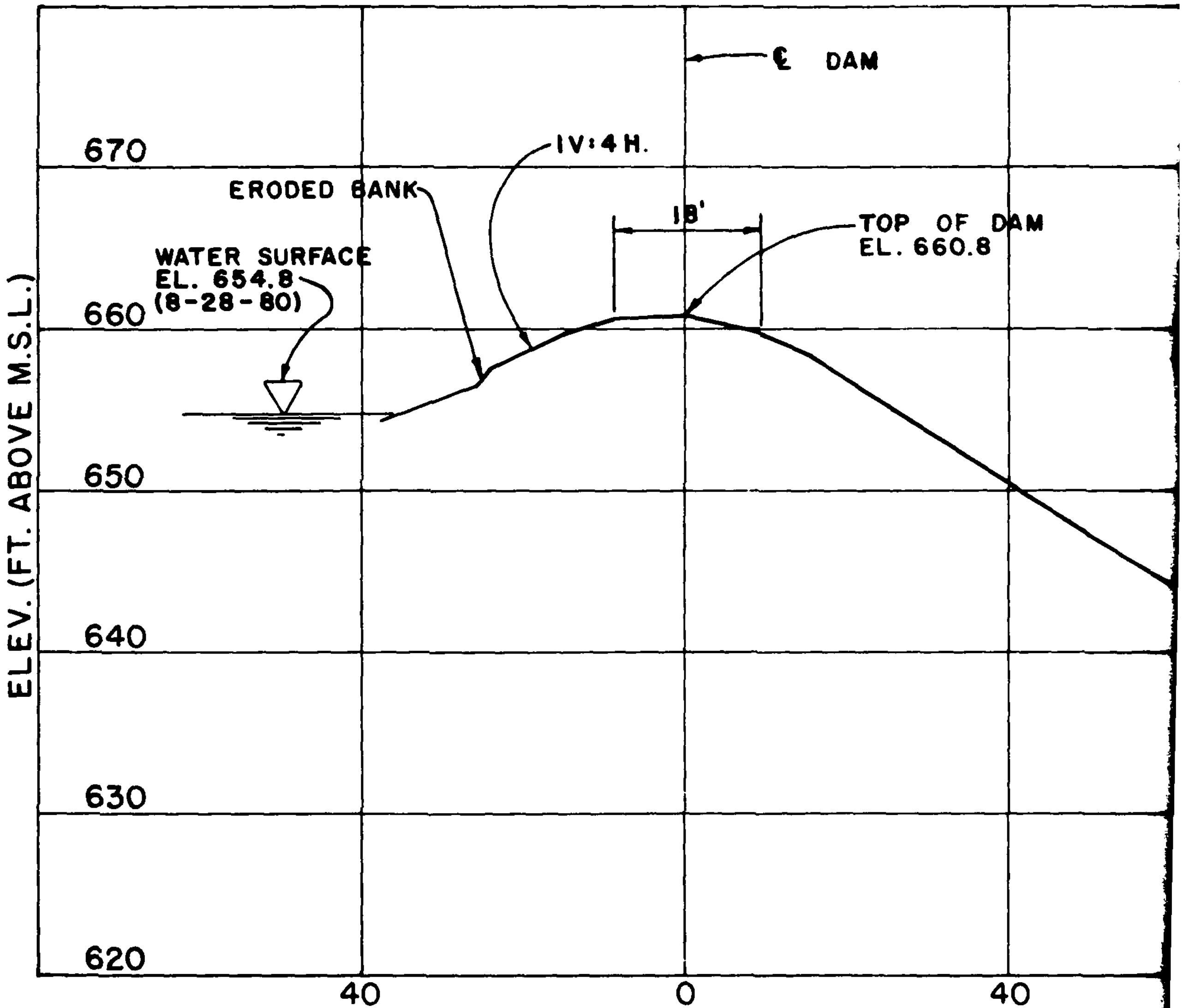
BROWN LAKE

DAM PLAN & PROFILE

Horner & Shifrin, Inc. Sept. 1980

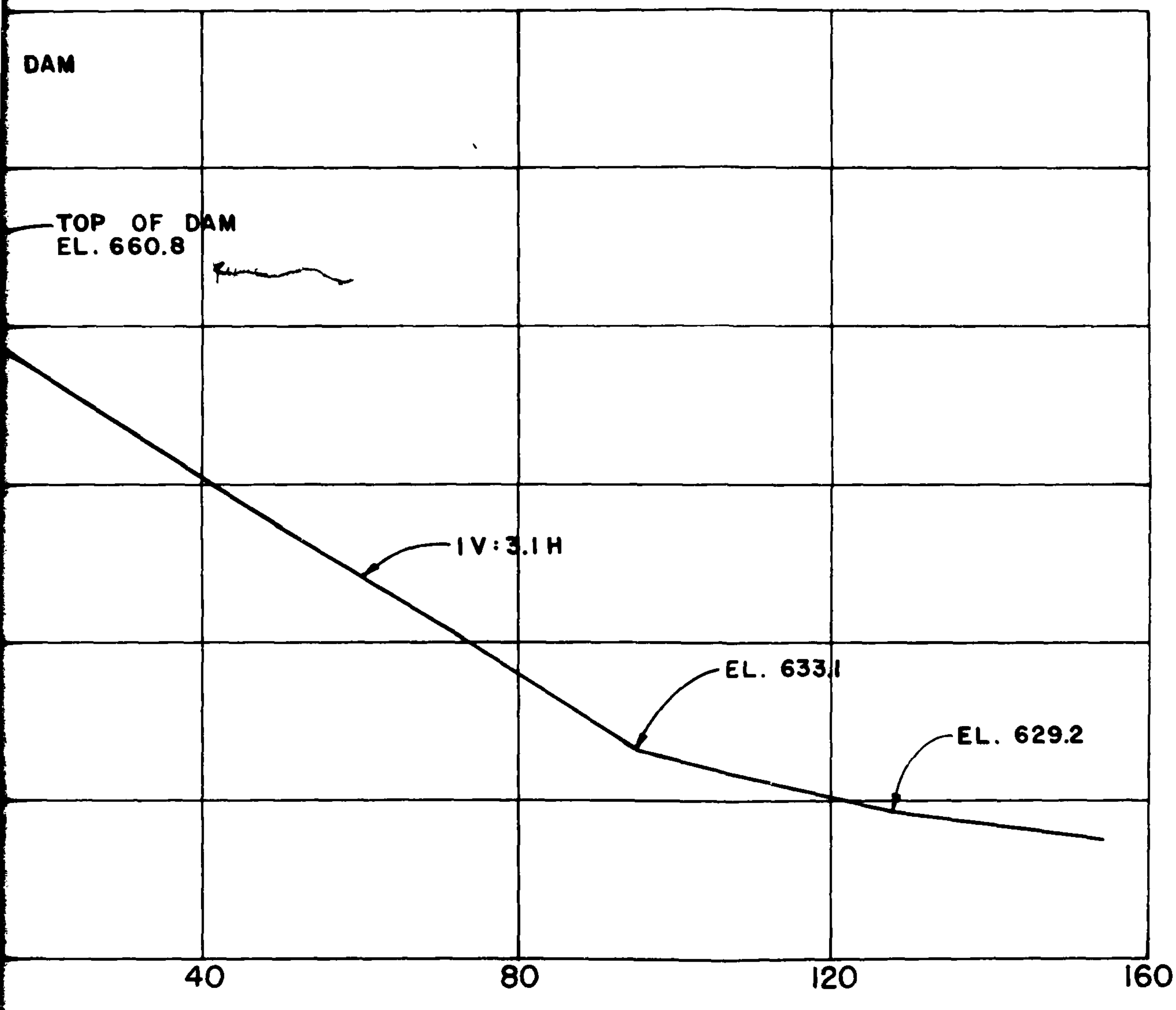
7

PLATE 3



CROSS-SECTION STA.

SCALES: 1"=10'V., 1"=20'



ROSS-SECTION STA. 2+50

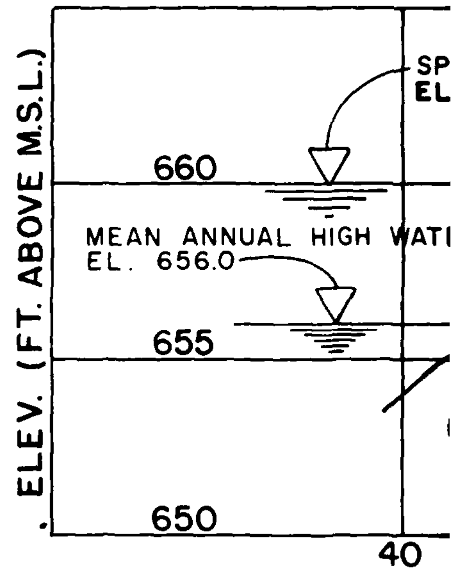
SCALES: 1"=10' V., 1"=20' H.

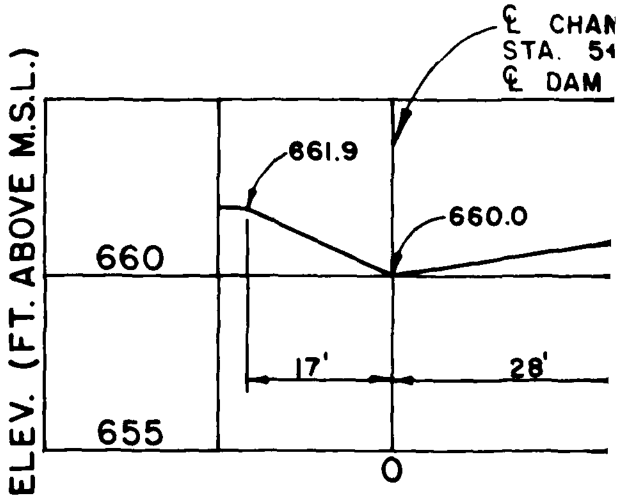
BROWN LAKE

DAM CROSS-SECTION

Horner & Shifrin, Inc. Sept. 1980

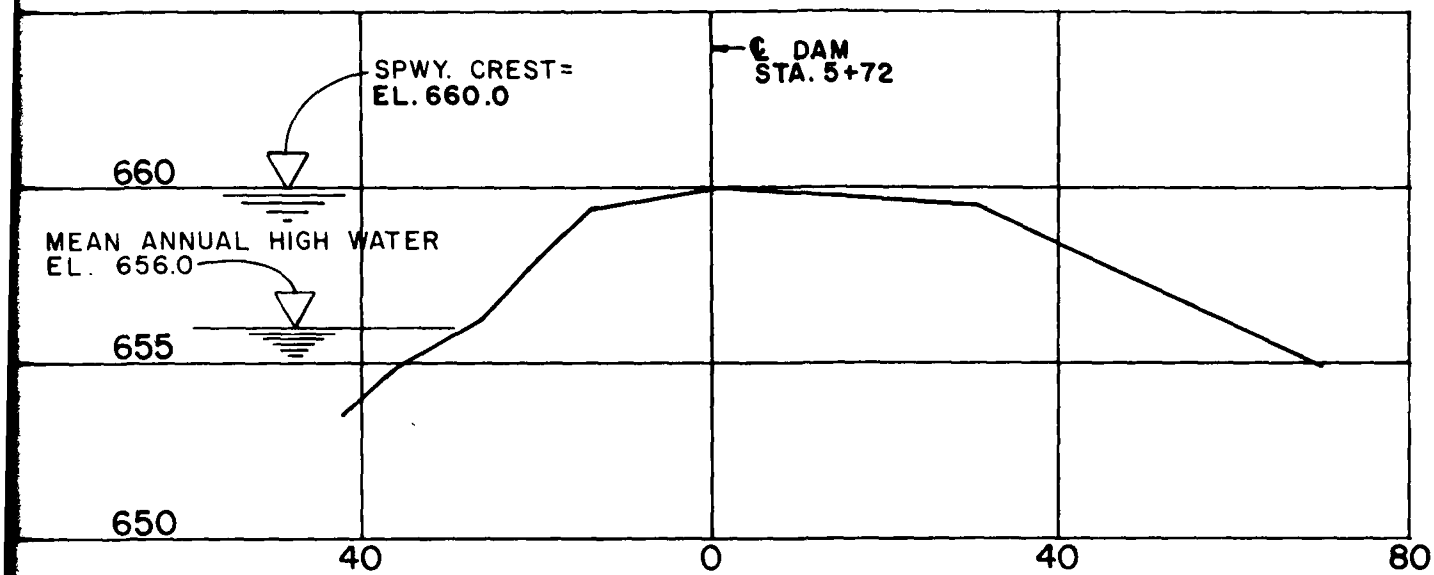
PLATE 4





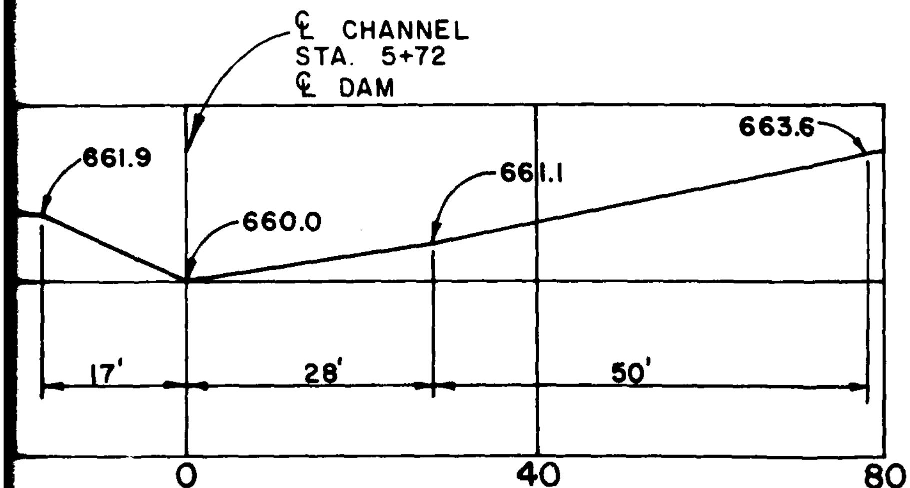
SPILLWAY CRO

SCALE: 1" = 5'V.



SPILLWAY PROFILE

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



SPILLWAY CROSS-SECTION

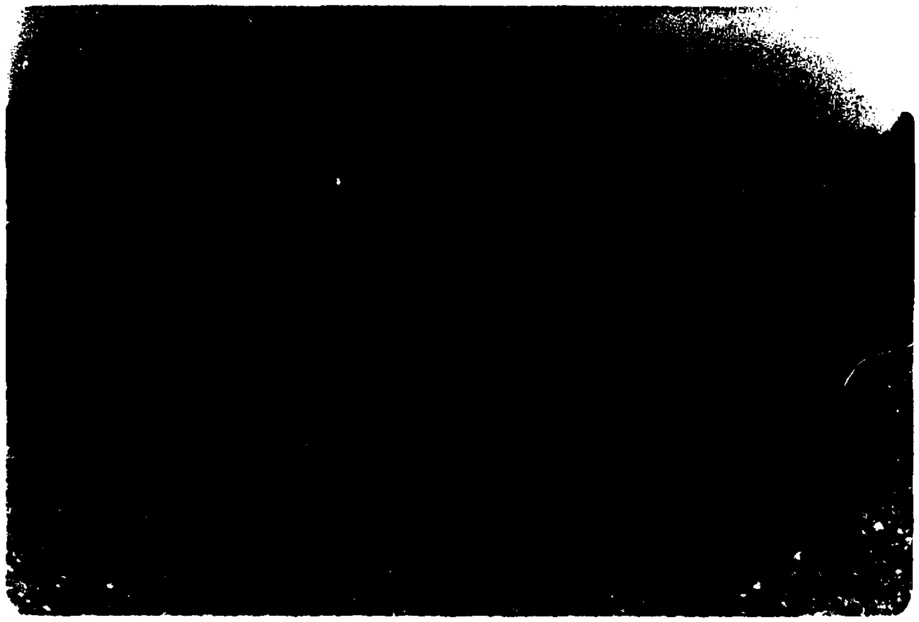
SCALE: 1" = 5' V., 1" = 20' H.

BROWN LAKE
SPILLWAY CROSS-SECTION
& PROFILE
Horner & Shifrin, Inc. Sept. 1980

1 12

APPENDIX A

INSPECTION PHOTOGRAPHS



NO. 1: UPSTREAM FACE OF DAM

NO. 2: DOWNSTREAM FACE OF DAM

NO. 3: SPILLWAY CREST AREA

NO. 4: SPILLWAY OUTLET AREA

NO. 5: MARSHY AREA NEAR DOWNSTREAM TOE OF DAM

NO. 6: EMBANKMENT EROSION AT 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. mile, 24-hour value equals 25.4 inches) from Hydrometeorological Report No. 33. The precipitation data used in the analysis of the 1 percent (100-year flood) was provided by the St. Louis District, Corps of Engineers.

b. Drainage area = 0.047 square miles = 30 acres.

c. SCS parameters:

Time of Concentration (T_C) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$ = 0.073 hours

Where: T_c = Travel time of water from hydraulically most distant point to point of interest, hours.

L = Length of longest watercourse = 0.180 miles.

H = Elevation difference = 62 feet.

The time of concentration (T_c) was obtained using Method C as described in Figure 30, "Design of Small 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 = 0.044 hours (0.60 T_c)

Hydrologic soil group = 40% Menfro (B) and 60% Bucklick (C) per unpublished SCS County Soil Report

Soil type CN = 75 (AMC II, 100-yr flood condition)
88 (AMC III, PMF condition)

2. For all practical purposes, there is no spillway.

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, including the intended spillway section, were entered into the HEC-1 Program on the $L and $V cards. The program assumes that flow over the dam crest section occurs at critical depth and computes internally the flow over the dam crest.

A1 ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2 HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF BROWN LAKE DAM
A3 [illegible]

[illegible]

$$ [illegible] 657.39 [illegible]
SA [illegible] 9.4 13.6
SE [illegible] 670 680 690

SL [illegible] 417 538 564 [illegible]
SV [illegible] 681.1 [illegible] 687.0 [illegible]

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1A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2        HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF BROWN LAKE DAM
A3        RATIOS OF PMF ROUTED THROUGH RESERVOIR
[illegible]
J1   0.50      1.00
     0   INFLOW                                                  1
[illegible]
```

A1 ANALYSIS OF DAM OVERTOPPING USING 1 PERCENT CHANCE FLOOD
A2 HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF BROWN LAKE DAM
A3 1 PERCENT CHANCE FLOOD ROUTED THROUGH RESERVOIR

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1 PERCENT CHANCE FLOOD (CONT'D)

[illegible]	.031	.031	.022	.022	.022	.022	.022	.022	.022	.022
[illegible]	.022	.022	.022	.022	.022	.022	.022	.022	.022	.022
[illegible]	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
[illegible]	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
[illegible]	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
[illegible]	.014	.014	.014	.014	.014	.014	.007	.007	.007	.007
[illegible]	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
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ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF BROWN LAKE 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= 3 LRTIO= 1
   RTIOS=    .05    .50   1.00

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

                    SUB-AREA RUNOFF COMPUTATION

   INFLOW HYDROGRAPH

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

                         HYDROGRAPH DATA
  IHYDG   IUHG  TAREA   SNAP  TRSDA  TRSPC  RATIO  ISNOW  ISAME  LOCAL
      1      1    .05   0.00    .05   1.00  0.000      0      1      0

                           PRECIP DATA
              SPFE    PMS     R6    R12    R24    R48    R72    R96
              0.00  25.40 102.00 120.00 130.00   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  80.00   0.00   0.00

    CURVE NO =  -80.00  WETNESS =  -1.00  EFFECT CN =  80.00

                        UNIT HYDROGRAPH DATA
                     TC=  0.00   LAG=   .04

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

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

   UNIT HYDROGRAPH  5 END OF PERIOD ORDINATES, TC=   0.00 HOURS, LAG=    .04  VOL= 1.00
 262.      81.      17.      3.      0.
```

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	[illegible]	145	[illegible]	[illegible]	[illegible]	61.
1.01	.10	2	.01	0.00	.01	0.	1.01	[illegible]	146	[illegible]	[illegible]	.01	72.
1.01	.15	3	.01	0.00	.01	0.	[illegible]	[illegible]	147	[illegible]	[illegible]	[illegible]	75.
[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1.01	[illegible]	[illegible]	.01	[illegible]	[illegible]	0.	[illegible]	[illegible]	150	[illegible]	[illegible]	[illegible]	[illegible]
1.01	.35	7	.01	0.00	[illegible]	0.	1.01	12.35	151	.21	.21	.01	[illegible]
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.22	.21	.01	[illegible]
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.22	.21	.01	[illegible]
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.22	.21	.01	[illegible]
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.22	.21	.01	[illegible]
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.22	.21	[illegible]	[illegible]
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	[illegible]	.25	[illegible]	[illegible]
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.26	.25	[illegible]	[illegible]
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.26	.25	[illegible]	52.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.26	.25	[illegible]	93.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.26	.25	[illegible]	93.
1.01	1.30	18	.01	0.00	.01	0.	1.01	13.30	162	.26	.25	.01	[illegible]
1.01	1.35	19	.01	0.00	.01	0.	1.01	13.35	163	.26	.26	[illegible]	[illegible]
1.01	1.40	20	.01	[illegible]	.01	0.	1.01	13.40	164	[illegible]	.26	[illegible]	[illegible]
1.01	1.45	21	.01	.00	.01	0.	1.01	13.45	165	[illegible]	.25	[illegible]	[illegible]
1.01	1.50	22	.01	.00	.01	0.	1.01	13.50	166	[illegible]	[illegible]	[illegible]	[illegible]
1.01	1.55	23	.01	.00	.01	0.	1.01	13.55	167	[illegible]	[illegible]	[illegible]	[illegible]
1.01	2.00	24	.01	.00	.01	0.	1.01	14.00	168	[illegible]	[illegible]	[illegible]	[illegible]
1.01	2.05	25	.01	.00	[illegible]	[illegible]	[illegible]	14.05	169	[illegible]	[illegible]	[illegible]	[illegible]
1.01	2.10	26	.01	.00	.01	1.	[illegible]	14.10	170	[illegible]	[illegible]	[illegible]	115.
1.01	2.15	27	.01	.00	.01	1.	1.01	14.15	171	.32	.32	[illegible]	[illegible]
1.01	2.20	28	.01	.00	.01	1.	1.01	14.20	172	.32	[illegible]	[illegible]	[illegible]
1.01	2.25	29	.01	.00	.01	1.	1.01	14.25	173	.32	.32	[illegible]	[illegible]
1.01	2.30	30	.01	.00	.01	1.	1.01	14.30	174	.32	.32	.00	117.
1.01	2.35	31	.01	.00	.01	1.	1.01	14.35	175	.32	[illegible]	[illegible]	[illegible]
1.01	2.40	32	.01	.00	.01	1.	1.01	14.40	176	.32	.32	[illegible]	117.
1.01	2.45	33	.01	.00	.01	1.	1.01	14.45	177	.32	.32	.00	117.
1.01	2.50	34	.01	.00	.01	1.	1.01	14.50	178	.32	.32	.00	117.
1.01	2.55	35	.01	.00	.01	1.	1.01	14.55	179	.32	.32	.00	[illegible]
1.01	3.00	36	.01	.00	.01	1.	1.01	15.00	180	[illegible]	[illegible]	[illegible]	117.
1.01	3.05	37	.01	.00	.01	1.	[illegible]	15.05	181	[illegible]	[illegible]	[illegible]	[illegible]
1.01	3.10	38	.01	.00	.01	1.	[illegible]	15.10	182	[illegible]	[illegible]	[illegible]	[illegible]
1.01	3.15	39	.01	.00	.01	2.	1.01	15.15	183	[illegible]	[illegible]	[illegible]	[illegible]
1.01	3.20	40	.01	.00	.01	[illegible]	1.01	15.20	184	.59	[illegible]	.00	193.
1.01	3.25	41	.01	.00	.01	2.	1.01	15.25	185	[illegible]	[illegible]	.00	235.
1.01	3.30	42	.01	.00	.01	2.	1.01	15.30	186	1.67	[illegible]	.01	504.
1.01	3.35	43	.01	.00	.01	2.	1.01	15.35	187	[illegible]	[illegible]	.01	[illegible]
1.01	3.40	44	.01	.01	.01	2.	[illegible]	15.40	188	1.06	1.06	.00	[illegible]
1.01	3.45	45	.01	.01	.01	2.	1.01	15.45	189	.69	.69	.00	320.
1.01	3.50	46	.01	.01	.01	2.	1.01	15.50	190	.59	.59	.00	236.
1.01	3.55	47	.01	.01	.01	2.	1.01	15.55	191	.39	.39	.00	167.
1.01	4.00	48	.01	.01	.01	2.	1.01	16.00	192	.39	.39	.00	147.
1.01	4.05	49	.01	.01	.01	2.	1.01	16.05	193	.30	.30	.00	120.
1.01	4.10	50	.01	.01	.01	2.	1.01	16.10	194	.30	.30	.00	112.

END-OF-PERIOD FLOW (CONT'D)

1.01	4.15	51	.01	.01	.01	2.	1.01	16.15	195	.30	.30	.00	110.
1.01	4.20	52	.01	.01	.01	2.	1.01	16.20	196	.30	.30	.00	110.
1.01	4.25	53	.01	.01	.01	2.	1.01	16.25	197	.30	.30	.00	110.
1.01	4.30	54	.01	.01	.01	2.	1.01	16.30	198	.30	.30	.00	110.
1.01	4.35	55	.01	.01	.01	2.	1.01	16.35	199	.30	.30	.00	110.
1.01	4.40	56	.01	.01	.01	2.	1.01	16.40	200	.30	.30	.00	110.
1.01	4.45	57	.01	.01	.01	2.	1.01	16.45	201	.30	.30	.00	110.
1.01	4.50	58	.01	.01	.01	2.	1.01	16.50	202	.30	.30	.00	110.
1.01	4.55	59	.01	.01	.01	3.	1.01	16.55	203	.30	.30	.00	110.
1.01	5.00	60	.01	.01	.01	3.	1.01	17.00	204	.30	.30	.00	110.
1.01	5.05	61	.01	.01	.01	3.	1.01	17.05	205	.24	.24	.00	86.
1.01	5.10	62	.01	.01	.01	3.	1.01	17.10	206	.24	.24	.00	86.
1.01	5.15	63	.01	.01	.01	3.	1.01	17.15	207	.24	.24	.00	86.
1.01	5.20	64	.01	.01	.01	3.	1.01	17.20	208	.24	.24	.00	86.
1.01	5.25	65	.01	.01	.01	3.	1.01	17.25	209	.24	.24	.00	86.
1.01	5.30	66	.01	.01	.01	3.	1.01	17.30	210	.24	.24	.00	86.
1.01	5.35	67	.01	.01	.01	3.	1.01	17.35	211	.24	.24	.00	86.
1.01	5.40	68	.01	.01	.01	3.	1.01	17.40	212	.24	.24	.00	86.
1.01	5.45	69	.01	.01	.01	3.	1.01	17.45	213	.24	.24	.00	86.
1.01	5.50	70	.01	.01	.01	3.	1.01	17.50	214	.24	.24	.00	86.
1.01	5.55	71	.01	.01	.01	3.	1.01	17.55	215	.24	.24	.00	86.
1.01	6.00	72	.01	.01	.01	3.	1.01	18.00	216	.24	.24	.00	86.
1.01	6.05	73	.06	.04	.03	11.	1.01	18.05	217	.02	.02	.00	[illegible]
1.01	6.10	74	.06	.04	.02	13.	1.01	18.10	218	.02	.02	.00	75.
1.01	6.15	75	.06	.04	.02	14.	1.01	18.15	219	.02	.02	.00	71.
1.01	6.20	76	.06	.04	.02	15.	1.01	18.20	220	.02	.02	.00	[illegible]
1.01	6.25	77	.06	.04	.02	15.	1.01	18.25	221	.02	.02	.00	[illegible]
1.01	6.30	78	.06	.04	.02	16.	1.01	18.30	222	.02	.02	.00	57.
1.01	6.35	79	.06	.04	.02	16.	1.01	18.35	223	.02	.02	.00	[illegible]
1.01	6.40	80	.06	.05	.02	17.	1.01	18.40	224	.02	.02	.00	[illegible]
1.01	6.45	81	.06	.05	.02	17.	1.01	18.45	225	.02	.02	.00	46.
1.01	6.50	82	.06	.05	.02	17.	1.01	18.50	226	.02	.02	.00	[illegible]
1.01	6.55	83	.06	.05	.02	17.	1.01	18.55	227	.02	.02	.00	[illegible]
1.01	7.00	84	.06	.05	.01	18.	1.01	19.00	228	.02	.02	.00	38.
1.01	7.05	85	.06	.05	.01	18.	1.01	19.05	229	.02	.02	.00	35.
1.01	7.10	86	.06	.05	.01	18.	1.01	19.10	230	.02	.02	.00	33.
1.01	7.15	87	.06	.05	.01	18.	1.01	19.15	231	.02	.02	.00	30.
1.01	7.20	88	.06	.05	.01	19.	1.01	19.20	232	.02	.02	.00	[illegible]
1.01	7.25	89	.06	.05	.01	19.	1.01	19.25	233	.02	.02	.00	[illegible]
1.01	7.30	90	.06	.05	.01	19.	1.01	19.30	234	.02	.02	.00	25.
1.01	7.35	91	.06	.05	.01	19.	1.01	19.35	235	.02	.02	.00	23.
1.01	7.40	92	.06	.05	.01	19.	1.01	19.40	236	.02	.02	.00	22.
1.01	7.45	93	.06	.05	.01	19.	1.01	19.45	237	.02	.02	.00	21.
1.01	7.50	94	.06	.05	.01	19.	1.01	19.50	238	.02	.02	.00	[illegible]
1.01	7.55	95	.06	.05	.01	[illegible]	1.01	19.55	239	.02	.02	.00	16.
1.01	8.00	96	.06	.05	.01	20.	1.01	20.00	240	.02	.02	.00	16.
1.01	8.05	97	.06	.05	.01	20.	1.01	20.05	241	.02	.02	.00	15.
1.01	8.10	98	.06	.05	.01	20.	1.01	20.10	242	.02	.02	.00	14.
1.01	8.15	99	.06	.05	.01	20.	1.01	20.15	243	.02	.02	.00	13.
1.01	8.20	100	.06	.05	.01	20.	1.01	20.20	244	.02	.02	.00	12.
1.01	8.25	101	.06	.05	.01	20.	1.01	20.25	245	.02	.02	.00	12.
1.01	8.30	102	.06	.06	.01	20.	1.01	20.30	246	.02	.02	.00	11.
1.01	8.35	103	.06	.06	.01	20.	1.01	20.35	247	.02	.02	.00	10.

END-OF-PERIOD FLOW (CONT'D)

1.01	8.40	104	.06	.06	.01	21.	1.01	20.40	248	[illegible]	[illegible]	[illegible]	[illegible]
1.01	8.45	105	.06	.06	.01	21.	1.01	20.45	249	[illegible]	[illegible]	[illegible]	8.
1.01	8.50	106	.06	.06	.01	21.	1.01	20.50	250	[illegible]	[illegible]	[illegible]	[illegible]
1.01	8.55	107	.06	.06	.01	21.	1.01	20.55	251	.02	[illegible]	[illegible]	[illegible]
1.01	9.00	108	.06	.06	.01	21.	1.01	21.00	252	.02	[illegible]	.00	8.
1.01	9.05	109	.06	.06	.01	21.	1.01	21.05	253	[illegible]	[illegible]	.00	8.
1.01	9.10	110	.06	.06	.01	21.	1.01	21.10	254	.02	.02	.00	8.
1.01	9.15	111	.06	.06	.01	21.	1.01	21.15	255	.02	.02	.00	8.
1.01	9.20	112	.06	.06	.01	21.	1.01	21.20	256	.02	.02	.00	8.
1.01	9.25	113	.06	.06	.01	21.	1.01	21.25	257	.02	[illegible]	.00	8.
1.01	9.30	114	.06	.06	.01	21.	1.01	21.30	258	.02	.02	.00	8.
1.01	9.35	115	.06	.06	.01	21.	1.01	21.35	259	.02	.02	.00	8.
1.01	9.40	116	.06	.06	.00	21.	1.01	21.40	260	.02	.02	.00	8.
1.01	9.45	117	.06	.06	.00	21.	1.01	21.45	261	.02	.02	.00	8.
1.01	9.50	118	.06	.06	.00	21.	1.01	21.50	262	.02	.02	.00	8.
1.01	9.55	119	.06	.06	.00	21.	1.01	21.55	263	.02	.02	.00	8.
1.01	10.00	120	.06	.06	.00	21.	1.01	22.00	264	.02	.02	.00	8.
1.01	10.05	121	.06	.06	.00	21.	1.01	22.05	265	.02	.02	.00	8.
1.01	10.10	122	.06	.06	.00	22.	1.01	22.10	266	.02	.02	.00	8.
1.01	10.15	123	.06	.06	.00	22.	1.01	22.15	267	.02	.02	.00	8.
1.01	10.20	124	.06	.06	[illegible]	22.	1.01	22.20	268	.02	.02	.00	8.
1.01	10.25	125	.06	.06	.00	22.	1.01	22.25	269	.02	.02	.00	8.
1.01	10.30	126	.06	.06	.00	22.	1.01	22.30	270	.02	.02	.00	8.
1.01	10.35	127	.06	.06	.00	22.	1.01	22.35	271	.02	.02	.00	8.
1.01	10.40	128	.06	.06	.00	22.	1.01	22.40	272	.02	.02	.00	8.
1.01	10.45	129	.06	.06	.00	22.	1.01	22.45	273	.02	.02	.00	8.
1.01	10.50	130	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	274	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11.00	[illegible]	.06	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1.01	11.05	133	.06	.06	[illegible]	22.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1.01	11.10	134	.06	.06	.00	22.	1.01	23.10	278	.02	.02	[illegible]	8.
1.01	11.15	135	.06	.06	.00	22.	1.01	23.15	279	.02	.02	.00	8.
1.01	11.20	136	.06	.06	.00	22.	1.01	23.20	280	.02	.02	.00	8.
1.01	11.25	137	.06	.06	.00	22.	1.01	23.25	281	.02	.02	.00	8.
1.01	11.30	138	.06	.06	.00	22.	1.01	23.30	282	.02	.02	.00	8.
1.01	11.35	139	.06	.06	.00	22.	1.01	23.35	283	.02	.02	.00	8.
1.01	11.40	140	.06	.06	.00	22.	1.01	23.40	284	.02	.02	.00	8.
1.01	11.45	141	.06	.06	.00	22.	1.01	23.45	285	.02	.02	.00	8.
1.01	11.50	142	.06	.06	.00	22.	1.01	23.50	286	.02	.02	.00	8.
1.01	11.55	143	.06	.06	.00	22.	1.01	23.55	287	.02	.02	.00	8.
1.01	12.00	144	.06	.06	.00	22.	1.02	0.00	288	.02	.02	.00	8.
									SUM	33.02	31.44	1.58	12149.
										(839.)(	799.)(	40.)(	344.03)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	880.	130.	42.	42.	12139.
CMS	25.	4.	1.	1.	344.
INCHES		15.04	33.02	33.02	33.02
MM		152.37	253.91	253.91	253.91
AC-FT		64.	84.	84.	84.
THOUS CU M		79.	104.	104.	104.

SURFACE AREA=	0.	3.	5.	6.	9.	14.
CAPACITY=	0.	17.	29.	76.	152.	286.
ELEVATION=	[illegible]	[illegible]	660.	670.	680.	[illegible]

SUMMARY OF DAM SAFETY ANALYSIS

0.09 PMF

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	657.[illegible]	660.00	660.00
STORAGE	21.	29.	29.
OUTFLOW	0.	0.	0.

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
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SUMMARY OF DAM SAFETY ANALYSIS
0.50 & 1.0 PMF

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	[illegible]	[illegible]	[illegible]
STORAGE	[illegible]	[illegible]	[illegible]
OUTFLOW	[illegible]	[illegible]	[illegible]

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
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1% CHANCE FLOOD

	INITIAL VALUE	[illegible]	TOP OF DAM
ELEVATION	[illegible]	[illegible]	[illegible]
STORAGE	18.	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]	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
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

DATE

FILMED