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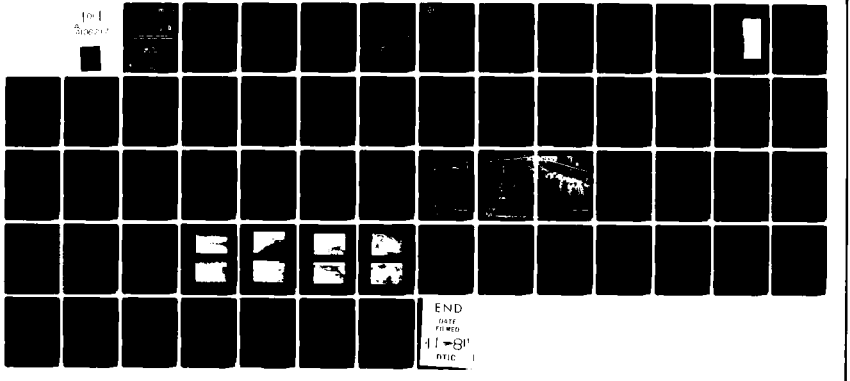

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UPPER MISSISSIPPI - SALT - QUINCY BASIN

CEDAR KNOLL FARM LAKE DAM
WARREN COUNTY, MISSOURI
MO 10782

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

SEPTEMBER 1980

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

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 - SALT - QUINCY BASIN

CEDAR KNOLL FARM LAKE DAM

WARREN COUNTY, MISSOURI

MO 10782

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

SEPTEMBER 1980

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: Cedar Knoll Farm Lake Dam, MO 10782, Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Cedar Knoll Farm Lake Dam (MO 10782):

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
24 SEP 1980
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer
24 SEP 1980
Date

CEDAR KNOLL FARM LAKE DAM

MISSOURI INVENTORY NO. 10782

WARREN 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

SEPTEMBER 1980

HS-8011

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Cedar Knoll Farm Lake Dam
State Located:	Missouri
County Located:	Warren
Stream:	Tributary of Peruque Creek
Date of Inspection:	9 June 1980

The Cedar Knoll Farm 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 these 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. A dense growth of brush and small trees exist on the entire downstream face of the dam. Areas of extensive development of cattails also exists along the shoreline of the upstream face. Tree roots can provide passagewavs for lake seepage which could develop into a piping condition (progressive internal erosion) that may result in failure of the dam. Brush and cattails can conceal animal burrows which could also provide passageways for lake seepage. A

hole that appeared to be an animal burrow existed in the dam crest at the upstream face near the left end of the dam.

2. A dense growth of brush and small trees that could impede the flow of water and reduce the carrying capacity of the channel, exists within the outlet channel for the principal spillway. A reduction in discharge capacity of the spillway outlet could result in flooding of the area just downstream of the dam, a condition considered detrimental to the stability of the embankment.

3. The dam, according to survey data obtained during the inspection, appears to have settled, perhaps as much as 0.6 foot, in the vicinity of the original stream crossing. As a result of this suspected settlement, the area at the left abutment intended to be an emergency spillway is virtually negated, and the only effective outlet for lake surcharge is the excavated earth, trapezoidal spillway section at the right abutment.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Cedar Knoll Farm 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). Considering the fact that the flood plain downstream of the dam is quite broad and the fact that the level of the living quarters of the two dwellings that lie just downstream of the dam are well above the elevation of the stream bank, and that the remaining two dwellings reported to be within the flood damage zone are located 2 and 3 miles respectively, downstream of the dam, it is recommended that the spillway for this dam be designed for one-half of the Probable Maximum Flood. 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.

Results of a hydrologic/hydraulic analysis indicated that the spillways (principal plus emergency) are inadequate to pass lake outflow resulting from a storm of one-half PMF magnitude or the outflow from the one percent

(100-year frequency) flood without overtopping the dam. The spillways are capable, however, of passing lake outflow resulting from the ten percent chance (10-year frequency) flood and the outflow corresponding to about 12 percent of the PMF without over-topping 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 five miles. Accordingly, within the possible damage zone are four dwellings, several farm buildings and State Highway F.

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

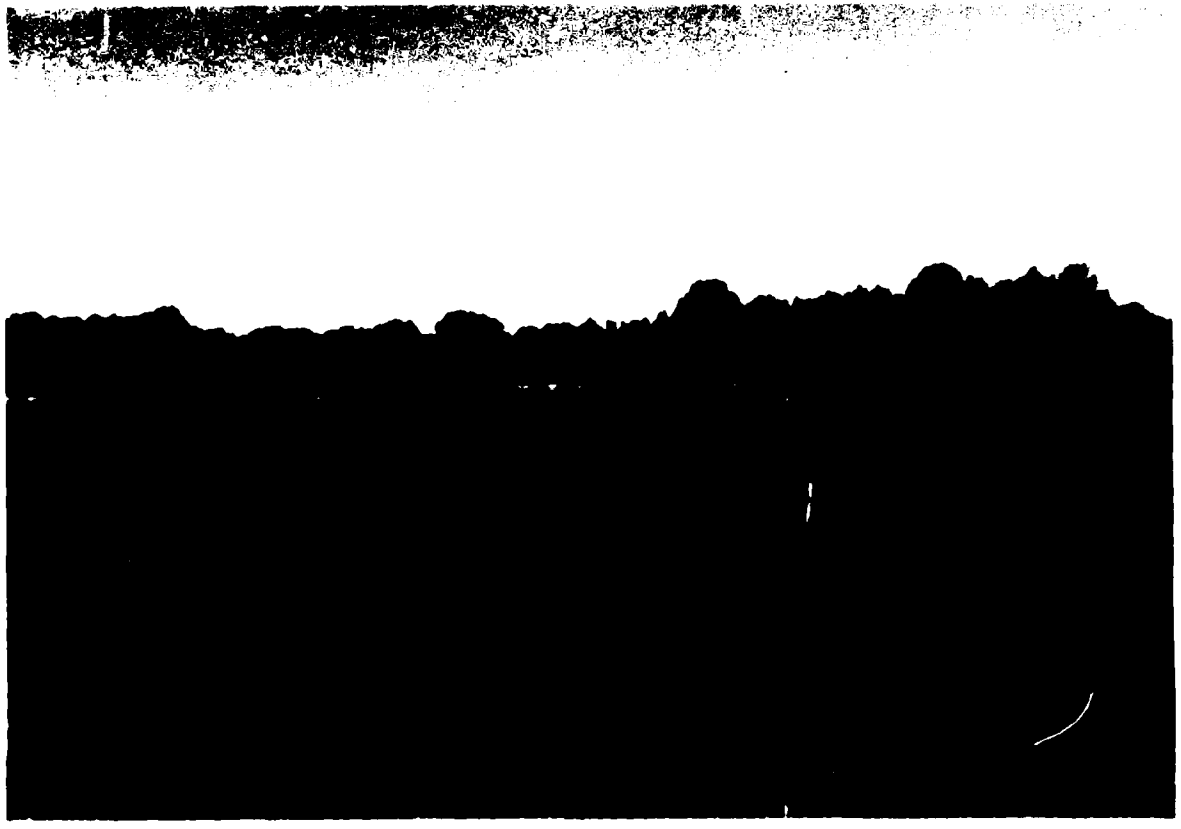
It is recommended that the Owner take the necessary action without undue delay to correct or control the deficiencies and safety defects reported herein. It is recommended, however, that priority be given to increasing spillway capacity, which is considered to be seriously inadequate.

Ralph E. Sauthoff

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

Albert B. Becker, Jr.

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



OVERVIEW CEDAR KNOLL FARM DAM

PHASE 1 INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

CEDAR KNOLL FARM LAKE DAM - MO 10782

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

CEDAR KNOLL FARM LAKE DAM - MO 10782

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 Cedar Knoll 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 above 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 Cedar Knoll Farm Lake Dam is an earthfill type embankment rising approximately 26 feet above the original streambed at the downstream toe of the barrier. The embankment has an upstream slope (above the waterline) of about 1v on 3.0h, a crest width of approximately 14 feet, and a downstream slope on the order of 1v on 2.1h. At

the original stream location, a fill approximately 15 feet in width is located at the downstream toe of the dam. Between abutments, the longitudinal axis of the dam contains two bends, each of which turn the dam convexly with respect to the lake. The upstream face of the dam is protected by stone riprap. The length of the dam is approximately 820 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 normal pool level, the reservoir impounded by the dam occupies approximately 15 acres. There is no lake drawdown facility to dewater the lake.

The dam has two spillways. The principal spillway, a grass-lined excavated earth trapezoidal section, is located at the right, or north, abutment. The spillway outlet, an unimproved V-section, swings to the south just downstream of the spillway crest and joins the original stream channel at a point about 175 feet downstream of the dam. The emergency spillway, a grass-lined excavated earth V-section, is located at the left, or south, abutment. Lake outflow passing the emergency spillway is unconfined by channel section; however, because of lower ground downstream of the embankment, flow should be conducted away from the dam. Cross-sections of the principal and emergency spillways are shown on Plate 5.

b. Location. The dam is located on an unnamed tributary of Peruque Creek, about 0.4 mile east of the junction of State Highways M and H; about 2.5 miles southwest of Wright City, as shown on the Regional Vicinity Map, Plate 1. The dam is located in the southwest quadrant of Section 29, Township 47 North, Range 1 West, within Warren 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 Cedar Knoll Farm 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 five miles downstream of the dam. Within the possible damage zone are four dwellings, several farm buildings and State Highway F. 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 Mrs. Ruth Sims. Mrs. Sims' address is: 14064 Calcutta, Chesterfield, Missouri, 63017.

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

g. Design and Construction History. According to the Owner's son, Mr. James E. Sims, the original owner of the property on which the dam was built was a Mr. Alex Wolff. Mr. Sims reported that his parents purchased the property from Mr. Wolff in about 1969. The present whereabouts or status of Mr. Wolff is unknown.

h. Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the combined capacities of two (principal and emergency) excavated earth type spillways.

1.3 PERTINENT DATA

a. Drainage Area. With the exception of a tree covered area near the upstream end of the watershed, the drainage area consists primarily of meadowland and farmland under cultivation. The watershed above the dam amounts to approximately 146 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite

(1) Estimated known maximum flood at damsite ... 90 cfs* (W.S. Elev. 789.1)
(2) Spillway capacity ... 109 cfs (principal plus emergency)

*Based on an estimate of lake level as observed by Mr. J. E. Sims.

c. Elevation (Ft. above MSL). The following elevations were determined by survey and are based on the elevation of the lake, assumed to be the normal pool level, as shown on the 1972 Wright City, Missouri, Quadrangle Map, 7.5 Minute Series.

(1) Observed pool ... 788.0
(2) Normal pool ... 788.0
(3) Spillway crest
    a. Principal ... 788.0
    b. Emergency ... 789.1
(4) Maximum experienced pool ... 789.1*
(5) Top of dam ... 789.2 (min.)
(6) Streambed at centerline of dam ... 767± (est.)
(7) Maximum tailwater ... Unknown
(8) Observed tailwater ... None

d. Reservoir

(1) Length at normal pool (Elev. 788.0) ... 1,800 ft.
(2) Length at maximum pool (Elev. 789.2) ... 2,000 ft.

e. Storage.

(1) Normal pool ... 118 ac. ft.
(2) Top of Dam (incremental) ... 19 ac. ft.

f. Reservoir Surface.

(1) Normal pool ... 15 acres
(2) Top of dam (incremental) ... 2 acres

*Based on an estimate of lake level as observed by Mr. J. E. Sims.

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 ... 820 ft.
(3) Height ... 26 ft.
(4) Top width ... 14 ft.

(5) Side slopes
  a. Upstream ... 1v on 3.0h (above waterline)
  b. Downstream ... 1v on 2.1h
(6) Cutoff ... Unknown
(7) Slope protection
  a. Upstream ... Stone riprap
  b. Downstream ... Grass

h. Principal Spillway.

(1) Type ... Uncontrolled, excavated earth, trapezoidal section
(2) Location ... Right abutment
(3) Crest ... Elevation 788.0
(4) Approach channel ... Lake
(5) Outlet channel ... Unimproved V-section

i. Emergency Spillway.

(1) Type ... Uncontrolled, excavated earth, V-section
(2) Location ... Left abutment
(3) Crest ... Elevation 789.1
(4) Approach channel ... Lake
(5) Exit channel ... Unconfined section

j. Lake Drawdown Facility ... None

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No data relative to the design of the dam is known to exist.

2.2 CONSTRUCTION

As previously stated, the owner of the property at the time the dam was constructed was Mr. Alex Wolff. Mr. Wolff's status is unknown, and no data relating to the construction of the dam are known to exist.

2.3 OPERATION

The lake level is uncontrolled and governed by the crest elevations of two overflow type spillways. An emergency spillway, with a crest elevation approximately 1.1 feet higher than the crest of the principal spillway and only about 0.1 foot lower than the top of the dam at its lowest point, is located at the left abutment. The principal spillway is located at the right abutment.

No indication was found that the dam has been overtopped. According to Mr. James E. Sims and to the best of his knowledge, the Sims family acquired possession of the dam in about 1969, the dam has never been overtopped, and the highest surface elevation observed occurred in April of 1979 when the lake reached a level just below the crest of the dam.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the dam and spillways 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 Cedar Knoll Farm Lake Dam was made by Horner & Shifrin engineering personnel, R. E. Sauthoff, Civil Engineer, and A. B. Becker, Jr., Civil and Soils Engineer, on 9 June 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-4 of Appendix A. The locations of the photographs taken during the inspection are indicated on Plate 3.

b. Site Geology. The dam site is located near the southern edge of the Dissected Till Plains Section of the Central Lowlands Physiographic Province and the northern edge of the Ozark Plateaus Physiographic Province. The topography is gently rolling with only about 40 feet of relief between the lake site and the surrounding drainage divides. No bedrock outcrops were noted at the site; however, well logs and outcrops in the general area indicate the bedrock to be Mississippian-age sedimentary strata of either the undifferentiated Chouteau group or the Osagean series. The bedrock of both the Chouteau and Osagean is predominantly limestone in this part of Missouri, and exhibits similar engineering characteristics. No faults were observed or are reported to be present in this area.

The undifferentiated Chouteau consists primarily of finely crystalline, thinly- to thickly-bedded limestones. The Osagean series in this part of the state consists primarily of the Burlington-Keokuk formations. The formations are light gray to buff colored, coarsely crystalline, fossiliferous, crinoidal limestones. The limestones are medium-bedded and contain abundant chert in the form of layers and nodules. The Chouteau and Osagean bedrock is susceptible to solution weathering and may exhibit solution-enlarged joints or bedding planes, sinkholes, etc. No evidence of these karst features was noted

in the vicinity of the reservoir. Glacial till and loess deposits reportedly reach 100 feet or greater in thickness in this general area. The thick sediment cover would mask the surface expression of these features, as well as minimize their effects on the performance of the reservoir and dam.

Thick, unconsolidated materials consisting of loess deposits overlying glacial till cover the Mississippian bedrock. The principal soils at the site are the Keswick series. These soils are deep, moderately well-drained materials formed from loessal deposits. They are dark grayish-brown silts near the surface and become more clayey with depth. According to the Unified Soil Classification System, the soils are classified CL or CL-ML materials, are low in permeability, and are susceptible to erosion. The silty soils of the Twomile, Hatton, and Calwoods series are also present at the site. These soils are formed from loessal deposits and exhibit engineering properties similar to the Keswick soils. Glacial till was not observed at the dam site; however, clay till has been reported in nearby drill holes. It is very probable that it overlies the bedrock at the site.

There appears to be no significant geotechnical problem at the dam site. No adverse geologic conditions were observed that would be conducive to severe reservoir leakage or embankment instability.

c. Dam. The visible portions of the upstream and downstream faces of the dam as well as the dam crest (see Photos 1 and 2) were inspected and, except as noted herein, appeared to be in sound condition. However, due to the presence of dense brush and small trees (see Photo 7), the downstream face could not be thoroughly examined. No sloughing of the embankment was noticed. No cracking of the dam crest was observed, although a hole, that appeared to be an animal burrow, (see Photo 8) was found in the dam crest adjacent to the upstream slope near station 7+00. An eroded area approximately 6 feet in length and 2 feet in depth that may, judging by the presence of new fill on the dam face, be under repair was also observed at about station 7+50. In several locations and particularly at the right side of the dam, dense patches of cattails prevented a detailed inspection of the entire upstream face. However, it was evident that for the most part the upstream face of the dam was protected by limestone riprap up to about 18 inches in size.

The area adjacent to the downstream toe of the dam was dry and no evidence of lake seepage was noticed. At the time of the inspection the turf cover on the dam crest and the area adjacent to the toe of the dam was about 3 inches high. An examination of a soil sample obtained from the downstream face of the dam indicated the material to be a brown, silty lean clay (CL) of low-to-medium plasticity.

The crest area of the excavated earth type principal spillway (see Photos 3 and 4) was examined and found to be in satisfactory conditon and well maintained. However, the spillway outlet channel beginning at a point just downstream of the crest (see Photo 5) was found to be overgrown with small trees and brush. Old fallen trees had also been placed in the channel, presumably to help control erosion.

The crest area of the excavated earth type emergency spillway (see Photo 6) was examined and was also found to be in good condition. There was no distinguishable outlet for flow passing the emergency spillway. It did appear because of lower ground downstream of the dam, that flow would be away from the dam.

It was evident from survey data obtained during the inspection that there was little difference (approximately 0.1) foot between the emergency spillway crest elevation and the elevation of the low point in the top of the dam. Also, survey data indicated that the lowest part of the dam crest is in the vicinity of the original stream crossing and that the dam crest in this location is approximately 0.6 foot lower than the remaining areas of the dam. A profile of the dam crest including both spillways is shown on Plate 3.

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

e. Downstream Channel. Except for several roads crossing the stream, the channel downstream of the dam is unimproved. The tributary on which the dam is constructed joins Peruque Creek at a point approximately one-quarter mile downstream of the dam. Peruque Creek is crossed by State Highway F at a point about 3 miles downstream of the dam and just south of Wright City.

f. Reservoir. The area immediately adjacent to the lake is for the most part meadow-like in appearance and well maintained. No significant erosion of the lake banks was noticeable. At the time of the inspection, the lake was at normal pool level and the water in the reservoir was clear. The amount of sediment within the lake could not be determined at the time of the inspection; however, due to the vegetation covering the surrounding area, it is not expected to be significant.

3.2 EVALUATION

The deficiencies observed during the inspection and noted herein are not considered of significant importance to warrant immediate remedial action. However, it is recommended that the trees and brush be removed from the embankment as soon as practical.

The limestone riprap on the upstream face of the dam appears to be adequate to prevent erosion of the slope by wave action or fluctuations of the lake level. However, it is recommended that the riprap be extended to protect the entire upstream face of the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillways are uncontrolled. The lake surface level is governed by precipitation runoff, evaporation, seepage, and the capacity of the uncontrolled principal and emergency spillways.

4.2 MAINTENANCE OF DAM

Judging by the growth of trees and brush on the downstream face and the extensive development of cattails along portions of the upstream face of the dam, as well as the trees and brush that exist within the spillway outlet channel, the inspection team is of the opinion that certain maintenance items have been neglected. Mr. J. E. Sims, the Owner's son, did report that the grass on the dam crest and the area adjacent to the downstream toe of the dam, is cut regularly, and that muskrats are removed from the lake area periodically. It was also reported that some effort to clear the downstream slope was undertaken this past winter.

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 SYSTEM IN EFFECT

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

4.5 EVALUATION

Lack of adequate maintenance is considered detrimental to the safety of the dam. It is recommended that maintenance of the dam be undertaken on a regular basis and that records be kept of all major items of maintenance work

performed. 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. The drainage area and lake surface area were determined from the 1972 USGS Wright City, 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.

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

c. Visual Observations.

(1) The dam has both a principal and an emergency spillway.

(2) The principal spillway, an excavated earth trapezoidal section, is located at the right abutment.

(3) The principal spillway outlet channel joins the original stream channel at a point approximately 175 feet downstream of the dam.

(4) The emergency spillway, an excavated earth V-section, is located at the left abutment.

(5) Emergency spillway releases are unconfined.

(6) The crest of the emergency spillway is only about 0.1 foot lower than the top of the dam at its lowest point.

(7) There is no lake drawdown facility.

d. Overtopping Potential. The spillways are inadequate to pass the probable maximum flood, 1/2 the probable maximum flood, or 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 Dam (Elev. 789.2)	Duration of Overtopping of Dam (Hours)
0.50	1,261	790.2	1.0	6.4
1.00	2,686	790.6	1.4	8.1

Elevation 789.2 was found to be the lowest point in the dam crest. The flow safely passing the spillway just prior to overtopping was determined to be approximately 109 cfs, which is the routed outflow corresponding to about 12 percent of the probable maximum flood inflow. During peak flow of the probable maximum flood, the greatest depth of flow over the dam is projected to be 1.4 feet and overtopping will extend across 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 conditon where the depth of flow over the dam crest, a maximum of 1.4 feet, and the duration of flow over the dam, 8.1 hours, are considerable, damage by erosion to the crest and downstream face of 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 condition, although not as severe, also exists for the 1/2 PMF condition.

f. References. Procedures and data for determining the probable maximum flood, the 100-year frequency flood, the 10-year flood and the discharge rating curve for flow passing the spillways and dam crest are presented on pages B-1 and B-2 of the Appendix. Listings of the HEC-1 (Dam Safety Version) input data for both the probable maximum flood, the 100-year frequency flood, and the 10-year frequency flood are shown on pages B-3 through B-7. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-8 through B-11; tabulation of lake surface area, elevation and storage volume is shown on page B-12; tabulations titled "Summary of Dam Safety Analysis" for the PMF and 1 percent chance (100-year frequency) flood are also shown on page B-12, and the "Summary of Dam Safety Analysis" for the 10 percent chance (10-year frequency) flood is shown on page B-13.

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 Mr. J. E. Sims, the Owner's son, no records are kept of lake level, spillway discharge, dam settlement, or seepage.

d. Post Construction Changes. Mr. Sims reported that to his knowledge no post construction changes have been made or have occurred which would affect the structural stability of the dam. A possible exception is the suspected settlement of the dam, approximately 0.6 foot, in the vicinity of the original stream crossing.

e. Seismic Stability. The dam is located in an area close to the boundary separating the Zone I and Zone II seismic probability areas. An earthquake of the magnitude that might occur in this area 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 be applied in any stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. A hydraulic analysis indicated that the spillways (principal plus emergency) are capable of passing lake outflow of about 109 cfs without the level of the lake exceeding the low point in the top of 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 lake outflow would be about 1,261 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 311 cfs. A similar analysis indicated that for the 10 percent (10-year frequency) flood, the lake outflow would be about 105 cfs.

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 trees and brush on the downstream face of the embankment, dense growths of cattails in several locations along the upstream face of the dam, a hole believed to be an animal burrow in the dam crest, a congested spillway outlet channel, and possible settlement of the dam 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 capacities of the spillways 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. It is recommended that priority be assigned to improving spillway capacity, which is considered to be seriously inadequate.

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 in an area close to the boundary separating the Zone I and Zone II seismic probability areas. An earthquake of the magnitude that might occur in this area 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 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, which is 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) Remove the trees and brush that may conceal animal burrows from the downstream face of the dam. Tree roots and animal burrows can provide passageways for lake seepage that could lead to a piping condition and subsequent failure of the dam. The cattails along the upstream face of the dam should likewise be removed, since they may also conceal animal burrows. Restore the dam at the location of the suspected animal burrow.

(2) Remove the trees, undergrowth, etc., from the spillway outlet channel. Obstructions within the channel reduce the capacity of the outlet which could result in flooding of the area adjacent to the downstream toe of the dam, a condition considered to be detrimental to the stability of the dam.

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

(4) 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.

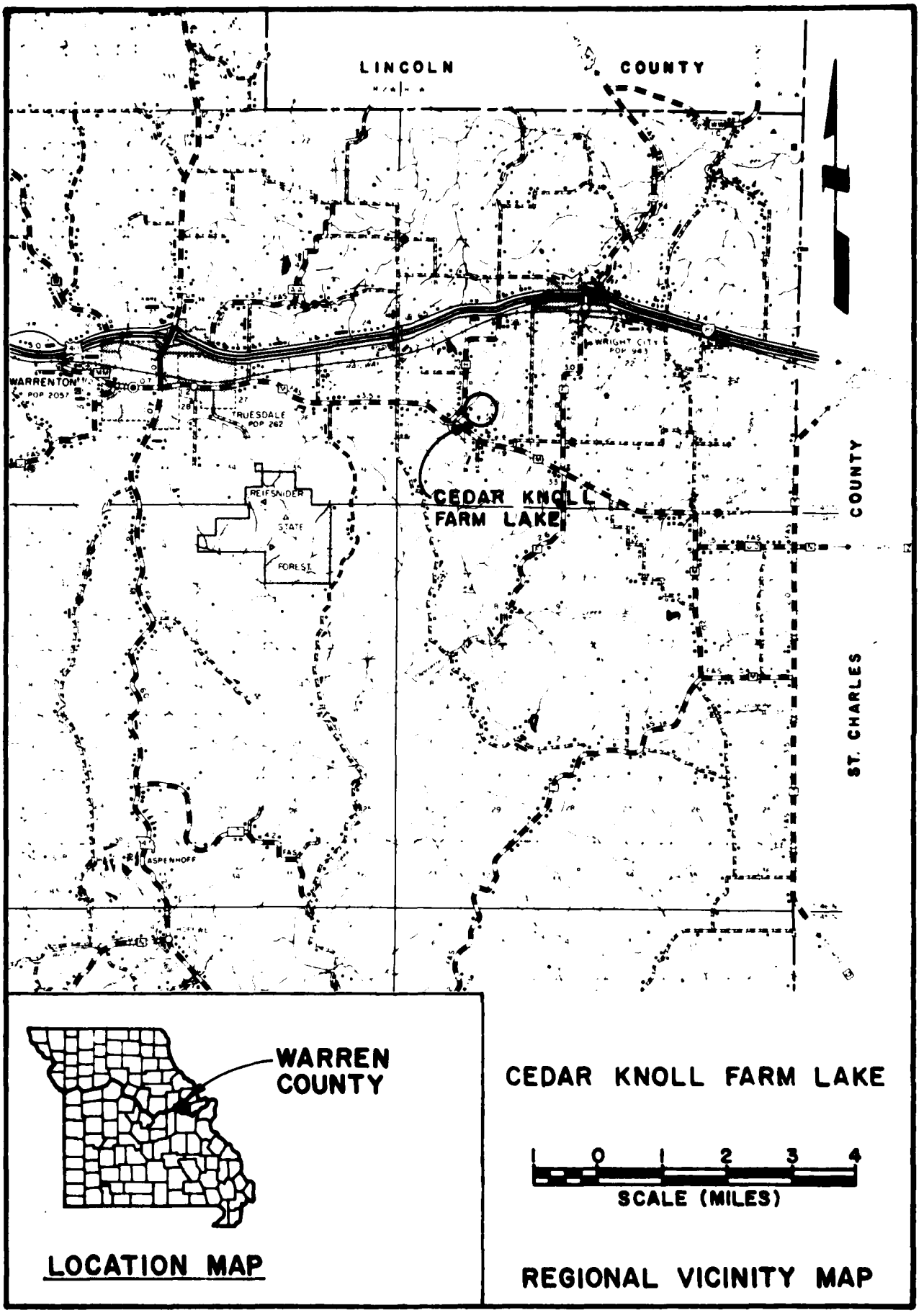
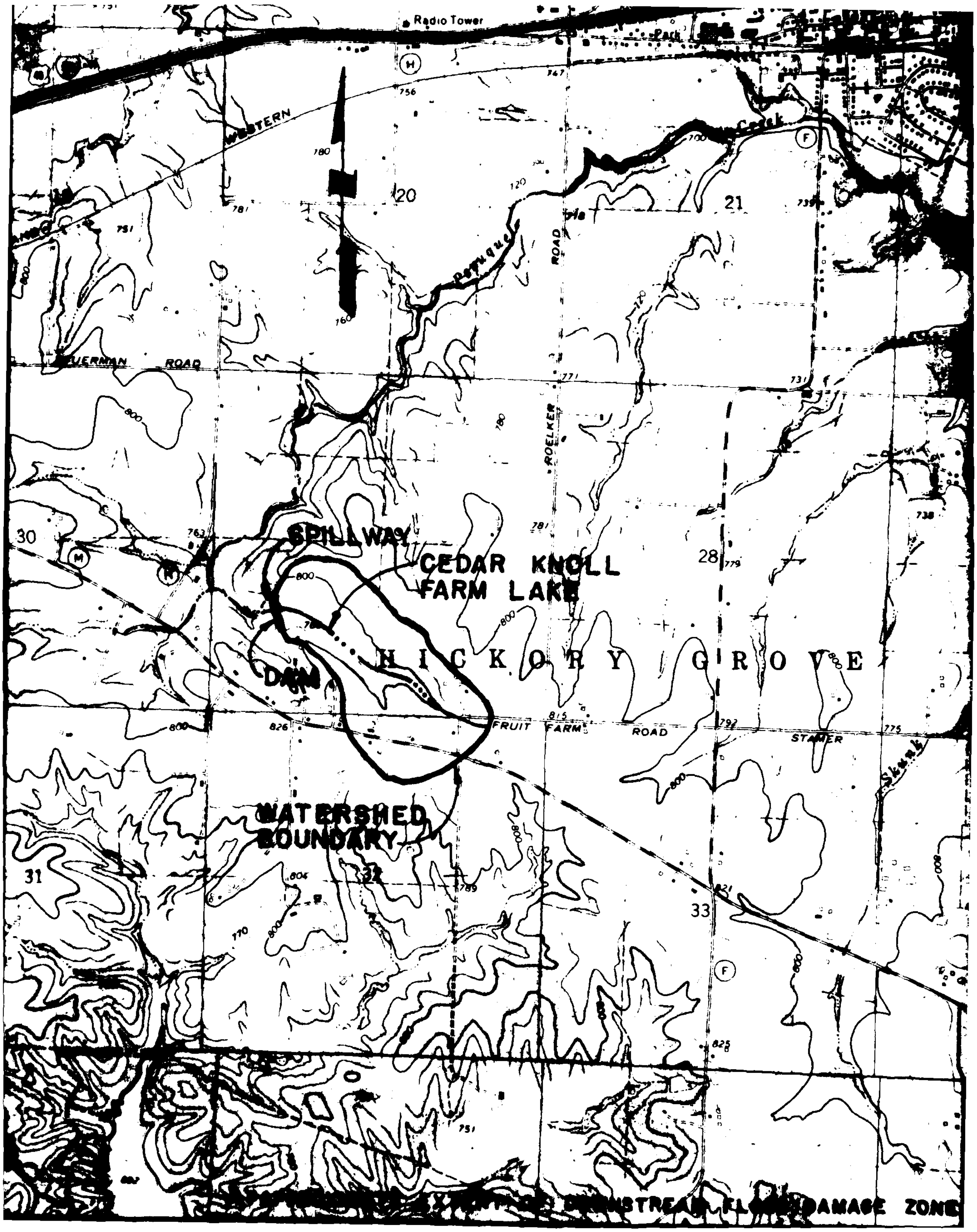

LINCOLN
COUNTY
WARRENTON
POP 2057
TRUESDALE
POP 262
WRIGHT CITY
POP 983
REIFSNIDER
STATE
FOREST
CEDAR KNOLL
FARM LAKE
ST. CHARLES
COUNTY
ASPENHOFF
WARREN
COUNTY
LOCATION MAP
CEDAR KNOLL FARM LAKE
0 1 2 3 4
SCALE (MILES)
REGIONAL VICINITY MAP

PLATE 1



Radio Tower
WESTERN
Creek
ROAD
ROELKER
SPILLWAY
CEDAR KNOLL
FARM LAKE
DAM
HICKORY GROVE
FRUIT FARM ROAD
STAMER
WATERSHED
BOUNDARY
BUERMAN ROAD
20
21
28
30
31
32
33
DAMAGE ZONE

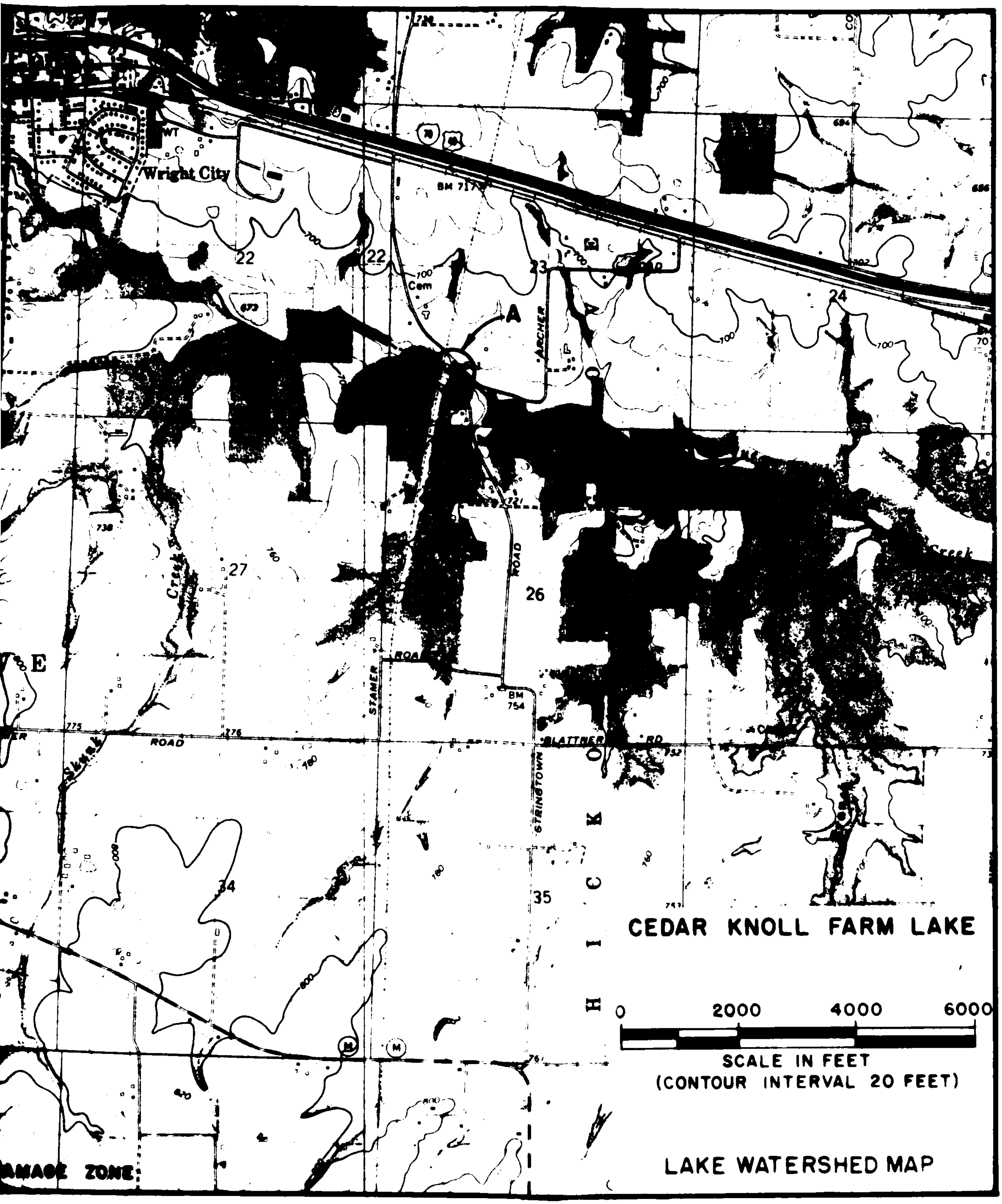
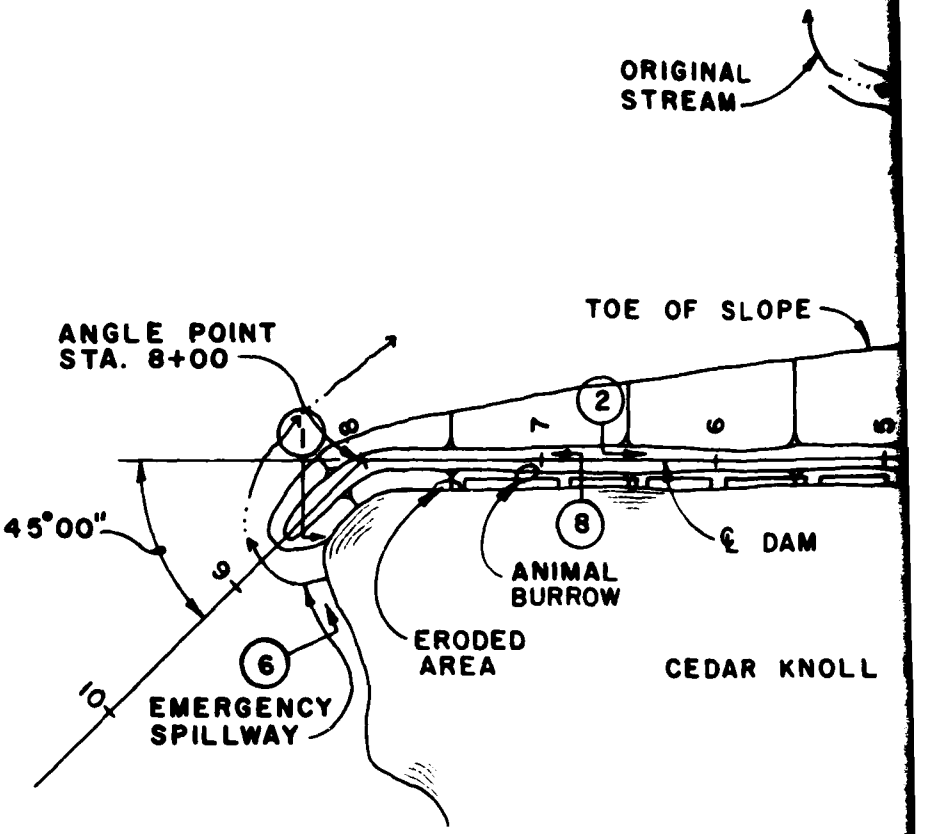
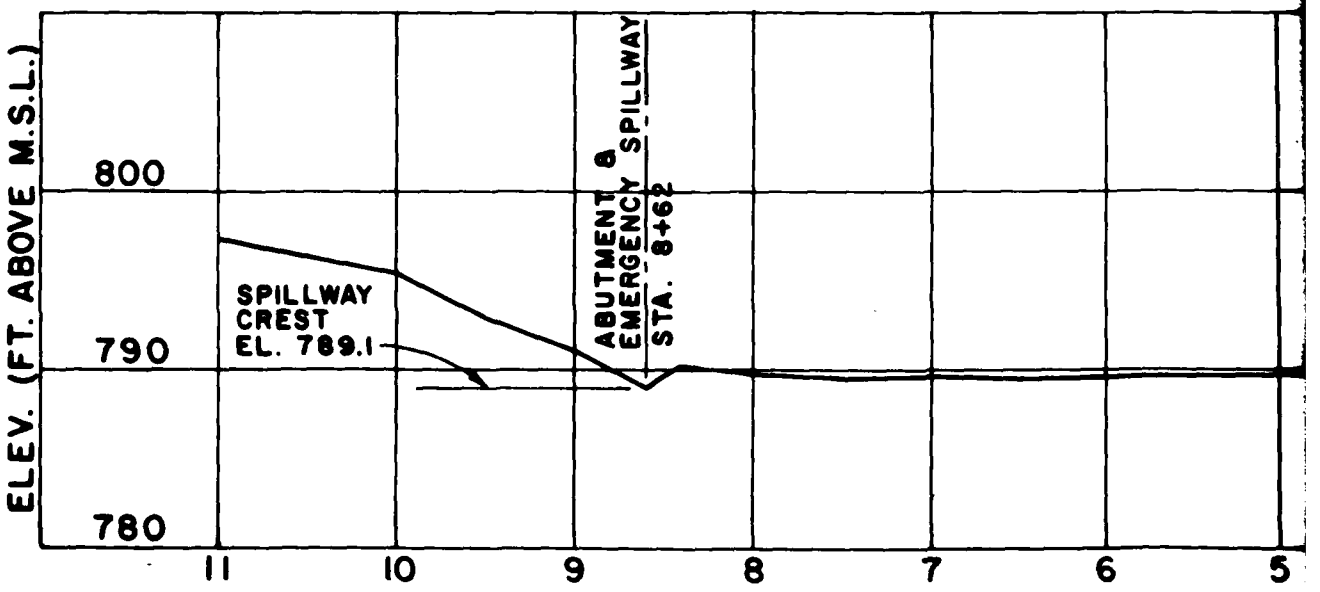

Wright City
22
22
23
24
A
Cem
ARCHER
BM 717
27
26
ROAD
STAMER
ROAD
BM 754
ROAD
BLATTNER
RD
STRINGTOWN
Creek
Creek
34
35
HICKO
DAMAGE ZONE
CEDAR KNOLL FARM LAKE
0
2000
4000
6000
SCALE IN FEET
(CONTOUR INTERVAL 20 FEET)
LAKE WATERSHED MAP

PLATE 2

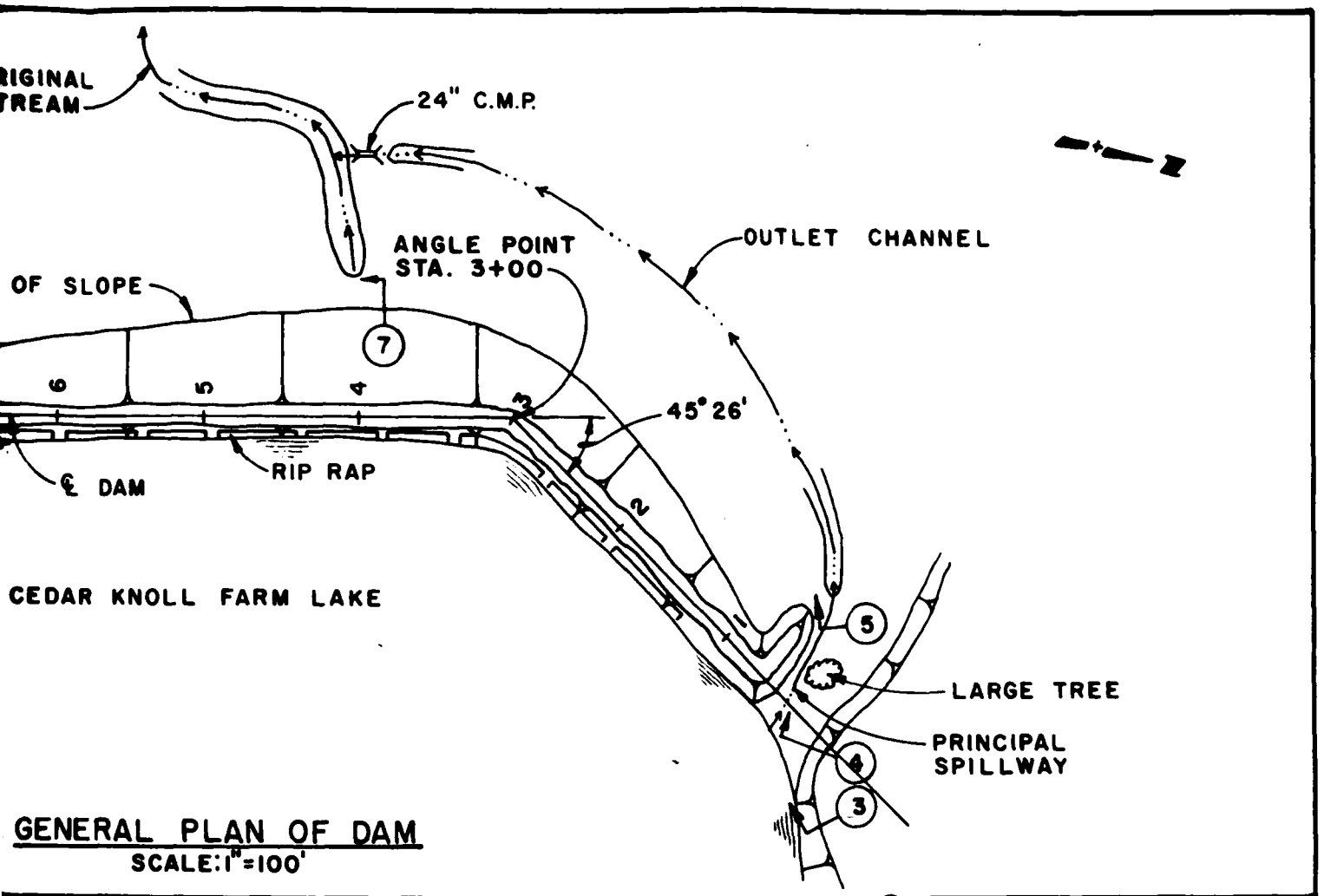


GENERAL PL
SCALE:

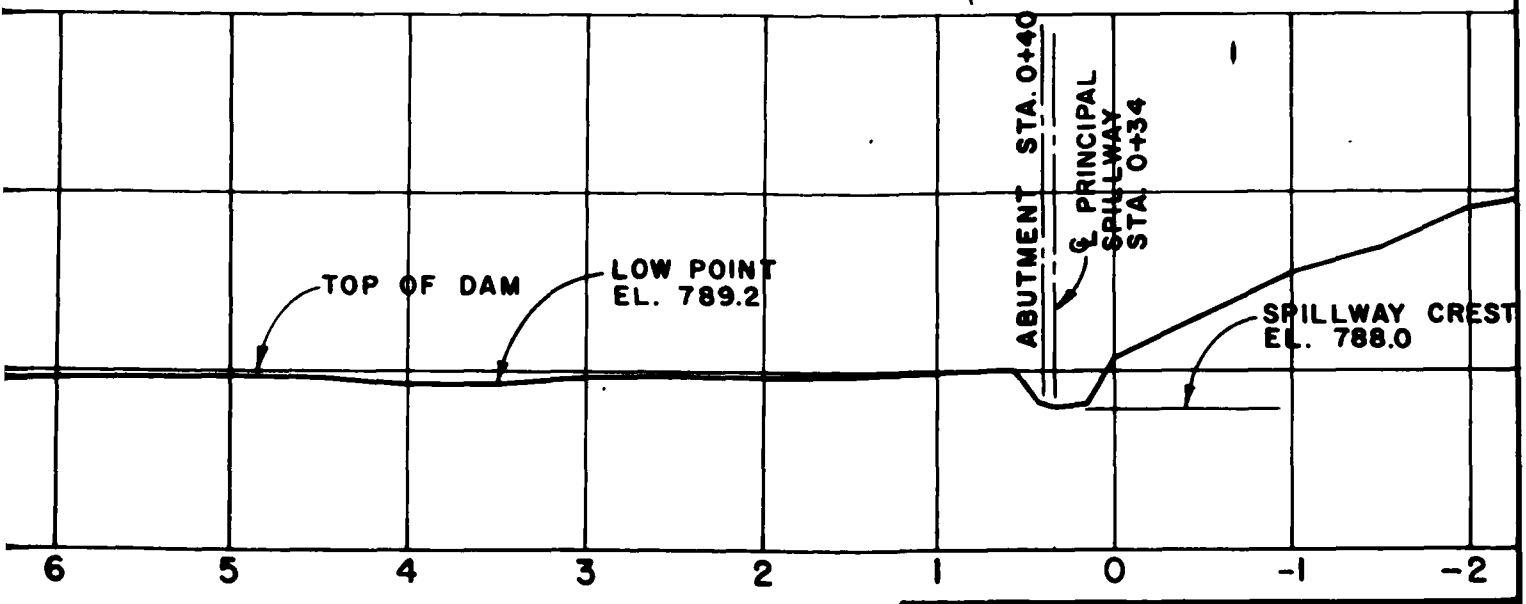


PROFILE D
SCALES: 1"=

6
PHOTO LOCATION & KEY
(SEE APPENDIX A)



GENERAL PLAN OF DAM
SCALE: 1"=100'



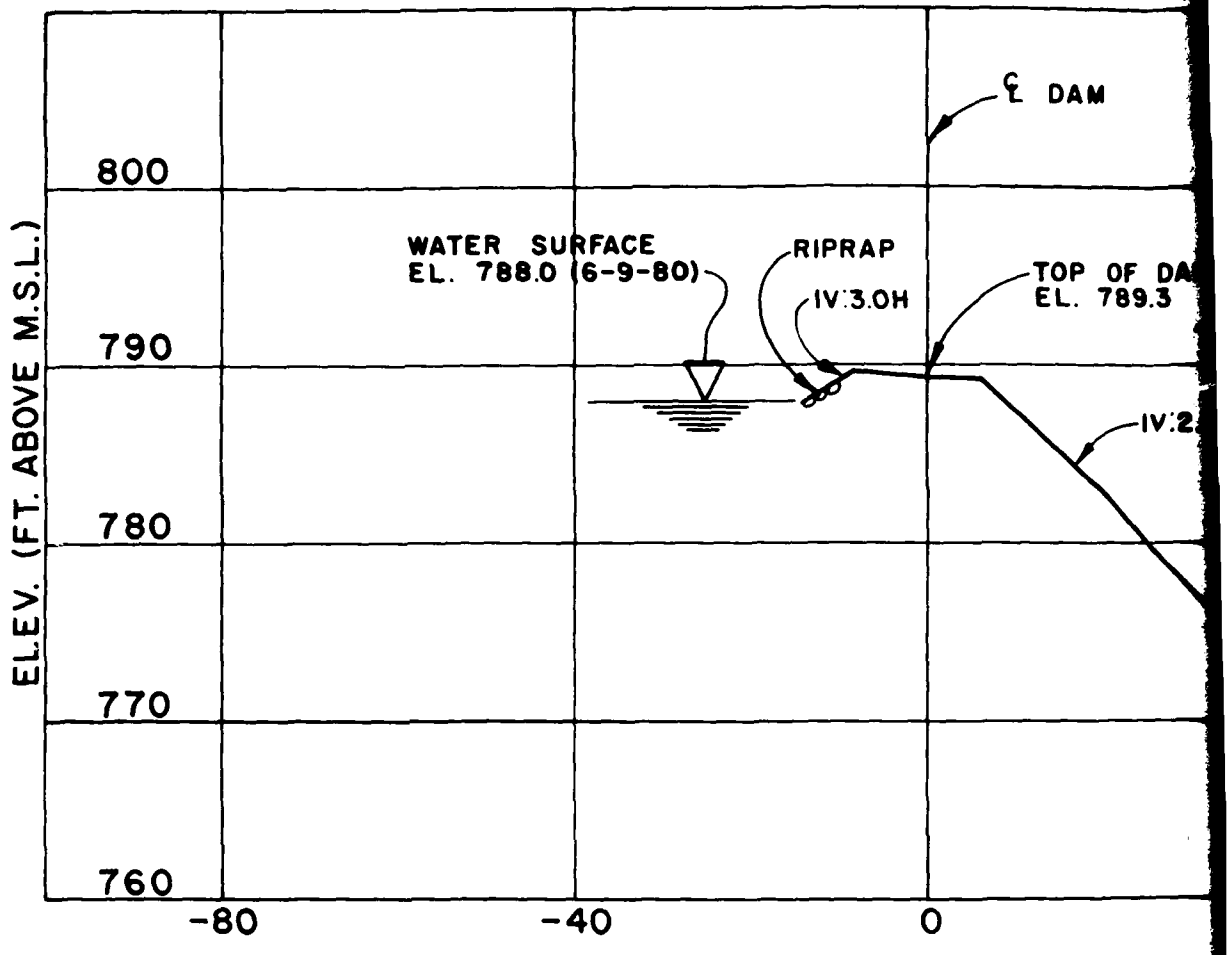
PROFILE DAM CREST
SCALES: 1"=10'V., 1"=100'H.

CEDAR KNOLL FARM LAKE
DAM PLAN & PROFILE

Horner & Shifrin, Inc. July 1980

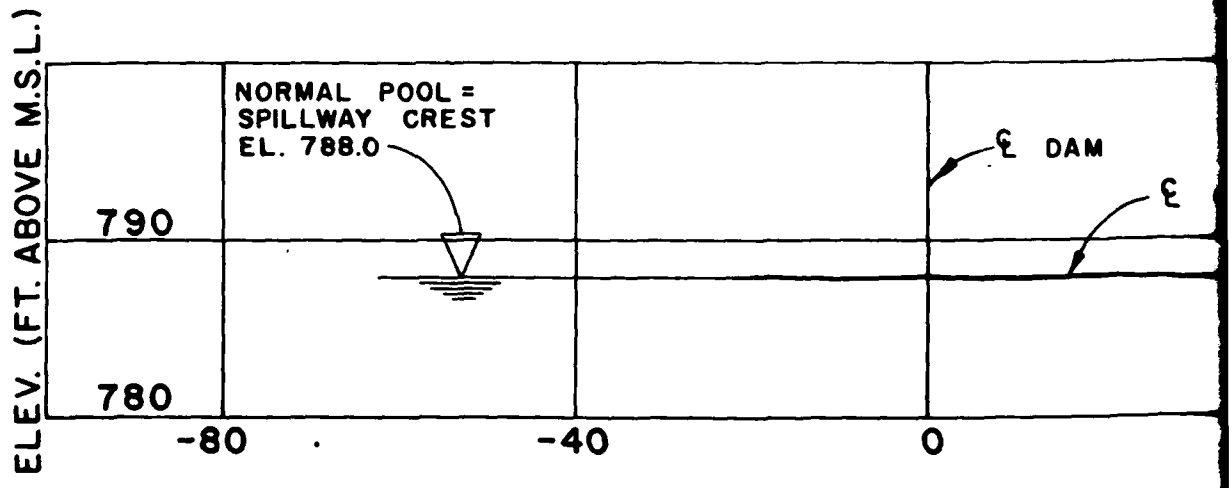
1 2

PLATE 3



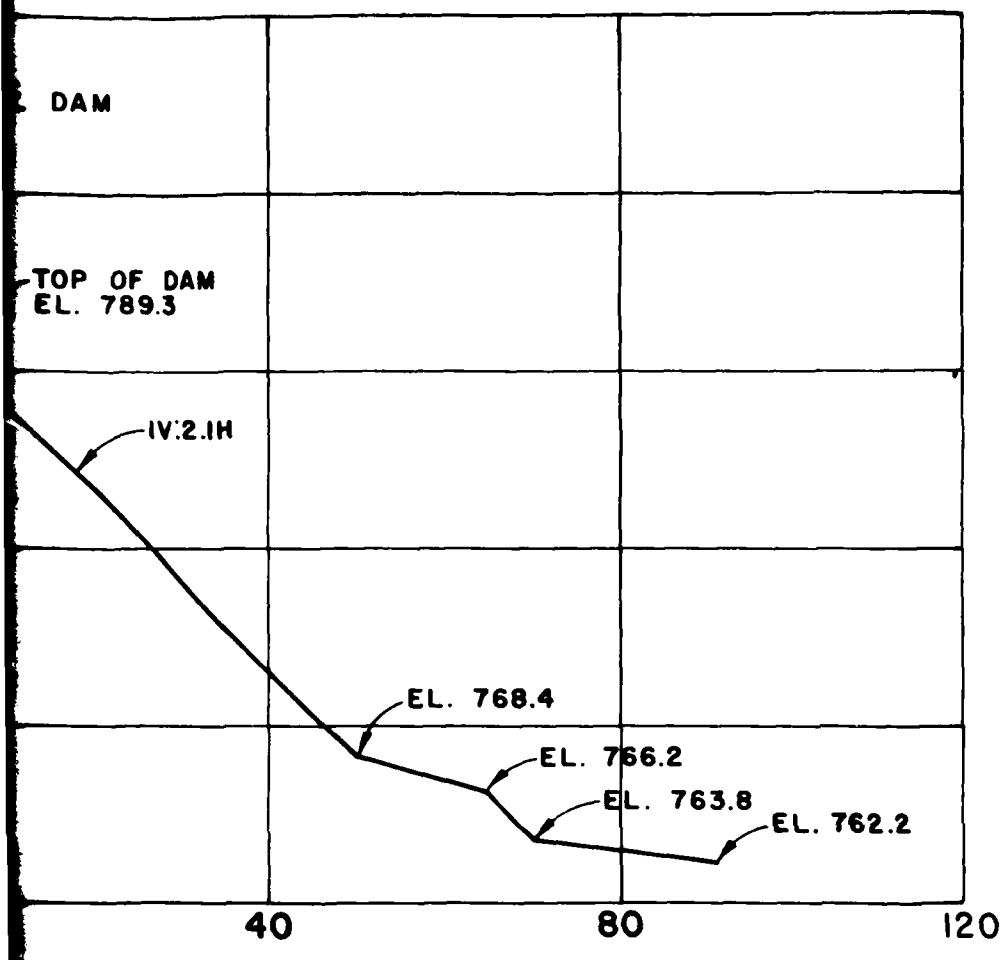
DAM CROSS-SECTION STA.

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

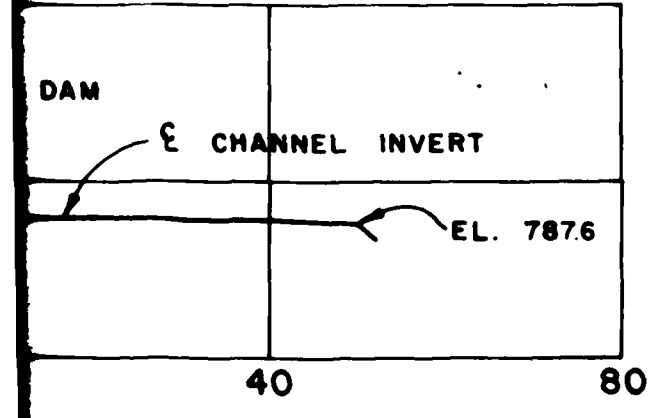


PROFILE PRINCIPAL SPILL

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



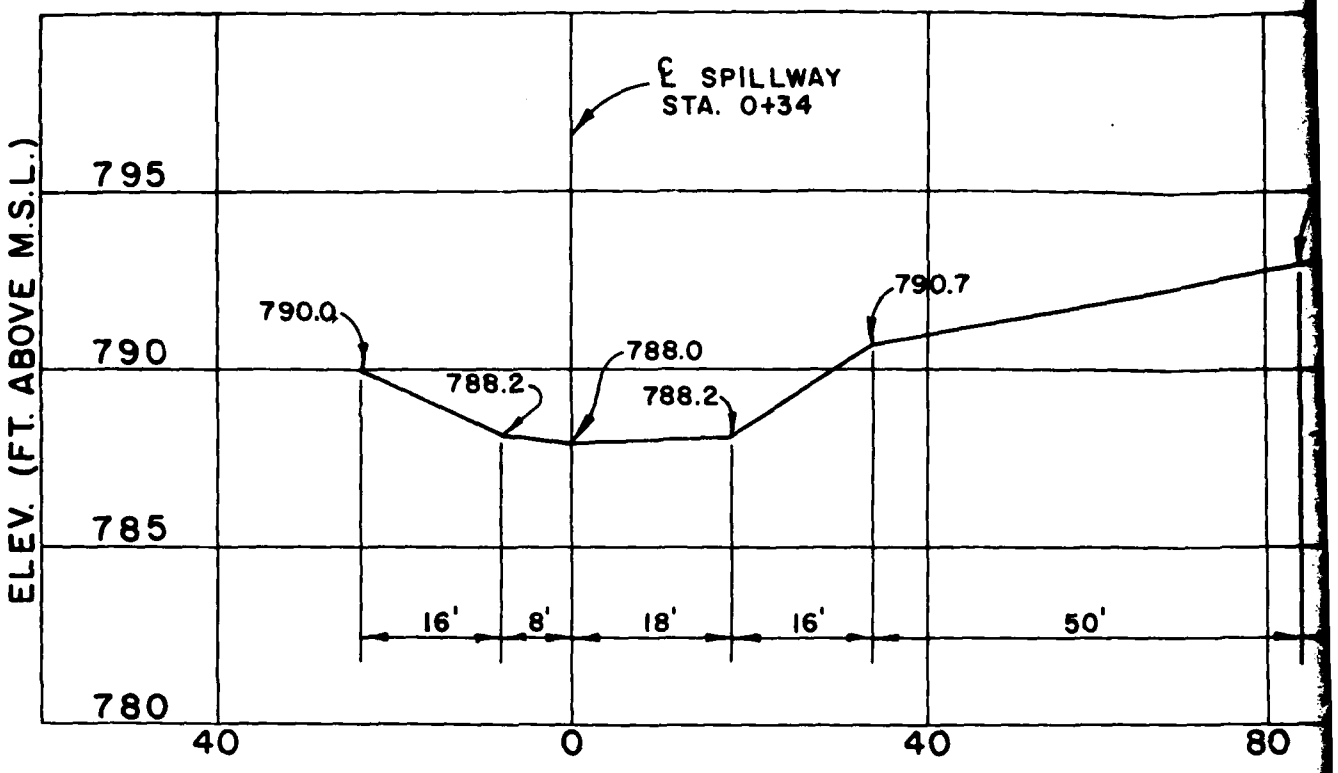
ON STA. 4+00
0' V., 1" = 20' H.



AL SPILLWAY
, 1" = 20' H.

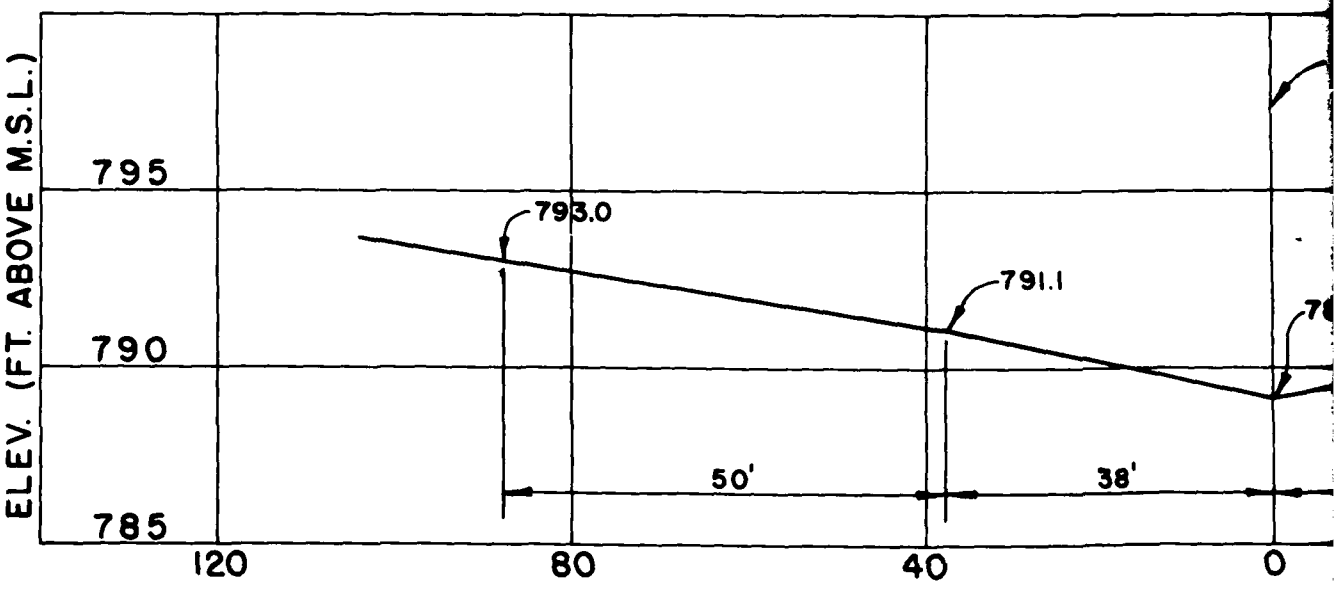
CEDAR KNOLL FARM LAKE
DAM CROSS-SECTION &
SPILLWAY PROFILE
Horner & Shifrin, Inc. July 1980

PLATE 4



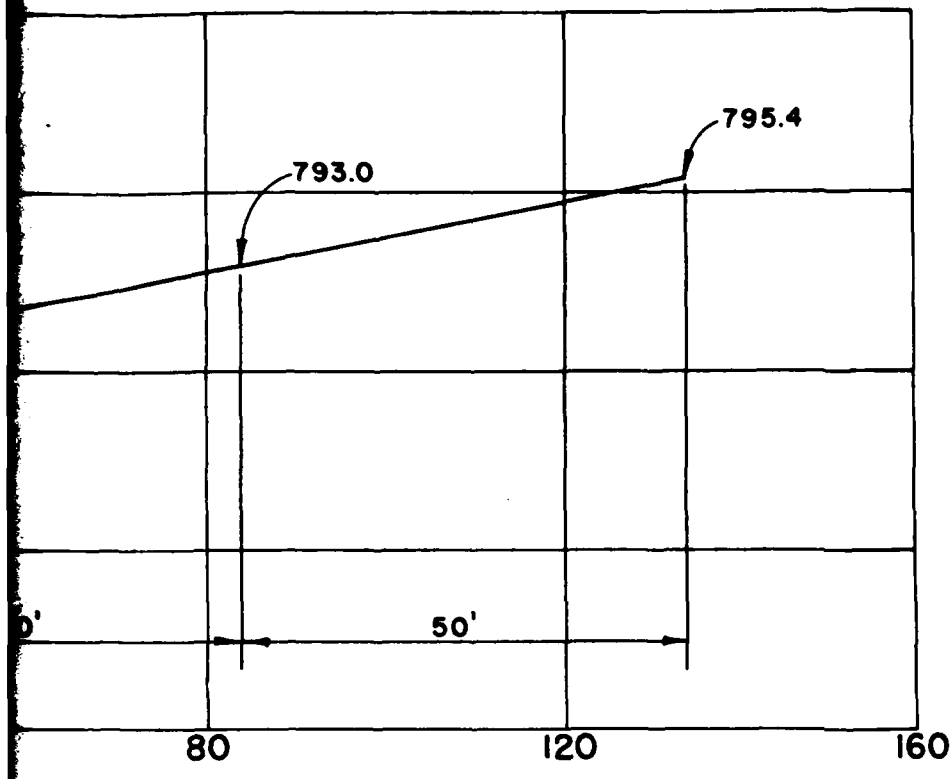
PRINCIPAL SPILLWAY CROSS-SECTION—

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



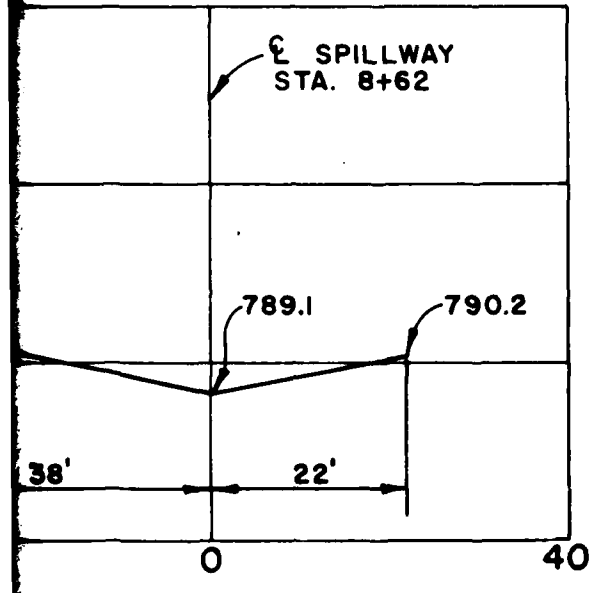
EMERGENCY SPILLWAY CROSS-SECTION—℄ DAM

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



S-SECTION - ℄ DAM

=20' H.



N - ℄ DAM

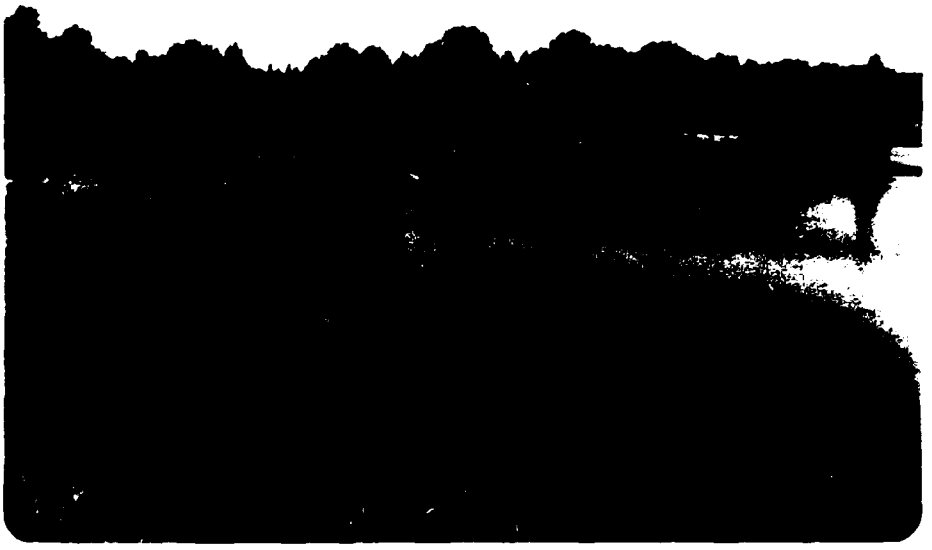
CEDAR KNOLL FARM LAKE
SPILLWAY CROSS-SECTIONS

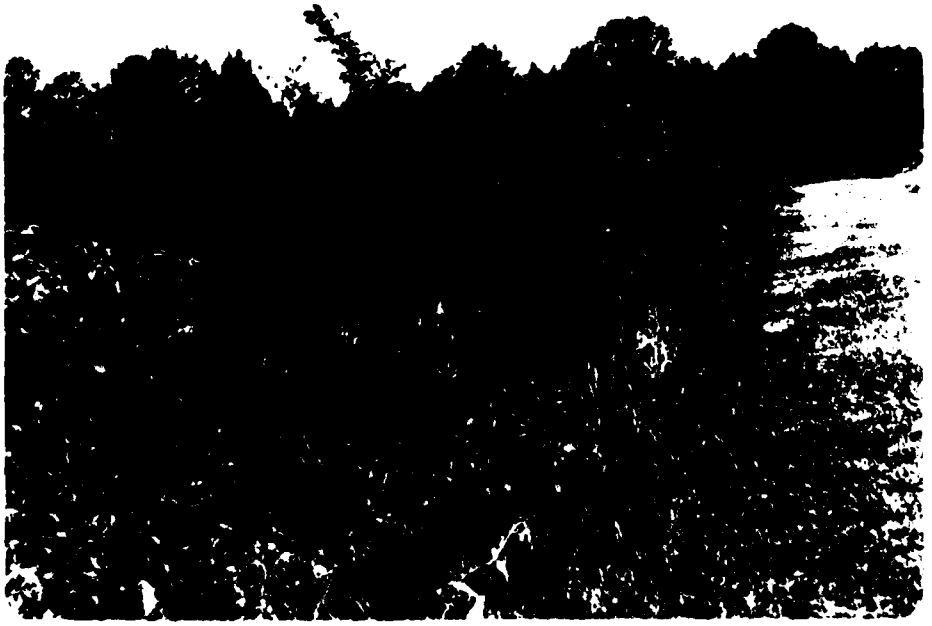
Horner & Shifrin, Inc. Sept. 1980

PLATE 5

APPENDIX A

INSPECTION PHOTOGRAPHS





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 25.0 inches) from Hydrometeorological Report No. 33. The precipitation data used in the analysis of the 1 percent (100-year flood) and the 10 percent (10-year flood) were provided by the St. Louis District, Corps of Engineers. Due to the fact that the watershed for this reservoir is small, the lake level was assumed to be at normal pool as a result of antecedent storms prior to the occurrence of the PMF and probabilistic storms.

b. Drainage area = 0.228 square miles = 146 acres.

c. SCS parameters:

Time of Concentration (Tc) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$ = 0.234 hours

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

L = Length of longest watercourse = 0.407 miles.

H = Elevation difference = 35 feet.

The time of concentration (Tc) was obtained using method C as described in Fig. 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 = 0.140 hours (0.60 Tc)

Hydrologic Soil Group = 5% C (Hatton Series) and 95% D (Keswick and Calwoods Series) per SCS County Soil Report

Soil type CN = 84 (AMC II, 10-yr & 100-yr flood condition)
= 93 (AMC III, PMF condition)

2. The principal spillway section consists of a broad-crested, trapezoidal section and the emergency spillway consists of a broad-crested, V-section, either for which conventional weir formulas do not apply.

Spillway release rates for each of these sections were determined as follows:

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 $Q_c = (\frac{a^3 g}{t})^{0.5}$ 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 and Brater, page 8-7.

c. Static lake levels corresponding to the various 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 insignifcant friction losses across the length of the 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 proper were entered into the HEC-1 Program on the $L and the $V cards. The program assumes that flow over the dam crest occurs at critical depth and computes internally the flow over the dam crest and adds this flow to the flow passing over the spillways 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 CEDAR KNOLL FARM LAKE DAM
A3        RATIOS OF PMF ROUTED THROUGH RESERVOIR
B    2[illegible]       0       5       0       0       0       0       0       0       0
B1      5
J       1       4       1
J1   0.1[illegible]    0.13    0.50    1.00
K               INFLOW                                          1
K1        INFLOW HYDROGRAPH
M       1       2       0.228                   1.[illegible]                   1
P       0       25.[illegible]    102     120     13[illegible]
T
W2              0.140                                   -1      -93
X       1.0     -.10    2.0
K       1       DAM                                             1
K1        RESERVOIR ROUTING BY MODIFIED PULS
Y                               1       1
Y1      1                                               [illegible]
Y4   [illegible]    [illegible]    7[illegible].1    789.4    790.0    7[illegible]    [illegible]    7[illegible]1.7    7[illegible].0    7[illegible]2.6
Y5   [illegible]    [illegible]    754.4    785.0
$A              [illegible]8    90      147     315     64[illegible]    1[illegible]25    1340    16[illegible]5    2260
$E   [illegible]    4[illegible]10    5135    6400
$$      [illegible]    14.7    18.5    41.3    65.9    [illegible]1.8
$E   [illegible]4.0    [illegible]    7[illegible]0     800     810     820
$$   [illegible].0
$D   7[illegible].2
$L      0       60      105     203     367     4[illegible]0    [illegible]55    782     78[illegible]
$V   789.2    789.3    789.5    789.6    789.7    789.8    790.0    790.2    796.0
K       99
```

A1	ANALYSIS OF DAM OVERTOPPING USING 100-YR FLOOD									
A2	HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF CEDAR KNOLL FARM LAKE DAM									
A3	100-YR FLOOD ROUTED THROUGH RESERVOIR									
B	288	0	5						4	
B1	5									
J	1	1	1							
J1	1.00									
K	0	INFLOW					1			
K1		INFLOW HYDROGRAPH								
M	0	2	0.228			1.0			1	
O	288	7.094								
O1	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
O1	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
O1	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
O1	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
O1	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
O1	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
O1	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
O1	.006	.006	.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	.014	.014	.024	.024
O1	.024	.024	.024	.024	.024	.024	.024	.024	.024	.024
O1	.024	.024	.024	.024	.024	.024	.029	.029	.029	.029
O1	.029	.029	.060	.060	.060	.060	.060	.060	.129	.129
O1	.130	.147	.147	.546	.776	.380	.147	.130	.130	.129
O1	.060	.060	.060	.060	.060	.060	.029	.029	.029	.029
O1	.029	.029	.024	.024	.024	.024	.024	.024	.024	.024
O1	.024	.024	.024	.024	.024	.024	.024	.024	.024	.024
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	.006	.006	.006	.006
O1	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
O1	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
O1	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
O1	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
O1	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
O1	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
O1	.006	.006	.006	.006	.006	.006	.006	.006		
T							-1	-84		
W2		0.140								
X	1.0	-.10	2.0							
K	1	DAM					1			

100-YR. FLOOD (Cont'd)

```
K1          RESERVOIR ROUTING BY MODIFIED PULS
Y                                  1      1             117.60          -1
Y1     1
Y4  788.0   788.7   789.1   789.4   790.0   790.7   791.3   791.7   792.0   792.4
Y4  793.2   793.8   794.4   795.0
Y5      0      38      90     147     315     640    1025    1340    1625    2260
Y5   3000    4010    5135    6400
$A      0    14.7    18.5    41.3    65.[illegible]    71.8
$E  764.0   780.0     790     800     810     820
$$  723.0
$D  789.2
$[illegible]      0      60     105     200     347     433     755     782     783
$V  789.2   789.3   789.5   789.6   789.7   789.8   790.0   790.2   796.0
K      99
```

1A1	ANALYSIS OF DAM OVERTOPPING USING 10-YR FLOOD									
A2	HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF CEDAR KNOLL FARM LAKE DAM									
A3	10-YR FLOOD ROUTED THROUGH RESERVOIR									
B	288	0	5						4	
B1	5									
J	1	1	1							
J1	1.00									
K	0	INFLOW					1			
K1	INFLOW HYDROGRAPH									
M	0	2	0.228			1.0			1	
O	288	5.045								
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.010	.010	.010	.010	.010	.010	.010	.010
01	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010
01	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010
01	.010	.010	.010	.010	.010	.010	.010	.010	.015	.015
01	.015	.015	.015	.015	.015	.015	.015	.015	.015	[illegible]
01	.015	.015	.015	.015	.015	.015	.031	.031	.031	[illegible]
01	.031	.031	[illegible]	[illegible]	[illegible]	[illegible]	.140	[illegible]	[illegible]	[illegible]
01	.080	.150	.150	[illegible]	[illegible]	[illegible]	.150	[illegible]	.080	[illegible]
01	.048	.048	[illegible]	[illegible]	[illegible]	[illegible]	.031	.031	.031	[illegible]
01	.031	.031	.015	[illegible]	.015	.015	.015	.015	.015	.015
01	.015	.015	.015	[illegible]	.015	.015	.015	.015	.015	[illegible]
01	.010	.010	.010	[illegible]	.010	.010	.010	.010	.010	[illegible]
01	.010	.010	.010	[illegible]	[illegible]	[illegible]	.010	.010	.010	.010
01	.010	.010	.010	.010	.010	.010	.010	.010	.010	[illegible]
01	.010	.010	[illegible]	.010	.010	.010	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005		
T							-1	-84		
W2		0.140								
X	-1.0	-.10	2.0							
K	1	DAM					1			

10-YR. FLOOD (Cont'd)

```
K1          RESERVOIR ROUTING BY MODIFIED PULS
Y                                          1         1
Y1       1                                                   117.60        -1
Y4  788.0     788.7     789.1     789.4     790.0     790.7     791.3     791.7     792.0     792.6
Y4  793.2     793.8     794.4     795.0
Y5       0        38        90       147       315       640      1025      1340      1625      2260
Y5    3060      4010      5105      6400
$A       0      14.7      18.5      41.3      65.9      71.8
$E  764.0     788.0       790       800       810       820
$$  788.0
$D  793.2
$L       0  [illegible]    105       203       367       573       755       782       789
$V  789.2     789.3     789.5     789.6     789.7     789.8     790.0     790.2     796.0
K       99
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ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF CEDAR KNOLL FARM 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= 4 LRTIO= 1
RTIOS= .12 .13 .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	.23	0.00	.23	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.00	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	-93.00	0.00	0.00

CURVE NO = -93.00 WETNESS = -1.00 EFFECT CN = 93.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .14

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

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

UNIT HYDROGRAPH 10 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .14 VOL= 1.00

246.	604.	486.	225.	109.	51.	24.	12.	6.	3.

						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	12.05	145	.21	.21	.00	145.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.21	.21	.00	234.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.21	.21	.00	306.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.21	.21	.00	340.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.21	.21	.00	356.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.21	.21	.00	364.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.21	.21	.00	368.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.21	.21	.00	370.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.21	.21	.00	371.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.21	.21	.00	371.
1.01	.55	11	.01	.00	.01	0.	1.01	12.55	155	.21	.21	.00	372.
1.01	1.00	12	.01	.00	.01	0.	1.01	13.00	156	.21	.21	.00	372.
1.01	1.05	13	.01	.00	.01	0.	1.01	13.05	157	.26	.25	.00	382.
1.01	1.10	14	.01	.00	.01	1.	1.01	13.10	158	.26	.25	.00	408.
1.01	1.15	15	.01	.00	.01	2.	1.01	13.15	159	.26	.25	.00	429.
1.01	1.20	16	.01	.00	.01	2.	1.01	13.20	160	.26	.25	.00	438.
1.01	1.25	17	.01	.00	.01	3.	1.01	13.25	161	.26	.25	.00	443.
1.01	1.30	98'	.01	.00	.01	4.	1.01	13.30	162	.26	.25	.00	445.
1.01	1.35	19	.01	.00	.01	5.	1.01	13.35	163	.26	.25	.00	447.
1.01	1.40	20	.01	.00	.01	5.	1.01	13.40	164	.26	.25	.00	447.
1.01	1.45	21	.01	.00	.01	6.	1.01	13.45	165	.26	.25	.00	448.
1.01	1.50	22	.01	.00	.01	6.	1.01	13.50	166	.26	.25	.00	448.
1.01	1.55	23	.01	.00	.01	7.	1.01	13.55	167	.26	.25	.00	448.
1.01	2.00	24	.01	.00	.01	7.	1.01	14.00	168	.26	.25	.00	448.
1.01	2.05	25	.01	.01	.01	8.	1.01	14.05	169	.32	.32	.00	464.
1.01	2.10	26	.01	.01	.01	8.	1.01	14.10	170	.32	.32	.00	502.
1.01	2.15	27	.01	.01	.01	9.	1.01	14.15	171	.32	.32	.00	533.
1.01	2.20	28	.01	.01	.01	9.	1.01	14.20	172	.32	.32	.00	547.
1.01	2.25	29	.01	.01	.01	10.	1.01	14.25	173	.32	.32	.00	554.
1.01	2.30	30	.01	.01	.01	10.	1.01	14.30	174	.32	.32	.00	558.
1.01	2.35	31	.01	.01	.01	11.	1.01	14.35	175	.32	.32	.00	559.
1.01	2.40	32	.01	.01	.01	11.	1.01	14.40	176	.32	.32	.00	560.
1.01	2.45	33	.01	.01	.01	11.	1.01	14.45	177	.32	.32	.00	561.
1.01	2.50	34	.01	.01	.01	12.	1.01	14.50	178	.32	.32	.00	561.
1.01	2.55	35	.01	.01	.01	12.	1.01	14.55	179	.32	.32	.00	561.
1.01	3.00	36	.01	.01	.01	12.	1.01	15.00	180	.32	.32	.00	561.
1.01	3.05	37	.01	.01	.01	13.	1.01	15.05	181	.19	.19	.00	530.
1.01	3.10	38	.01	.01	.01	13.	1.01	15.10	182	.39	.39	.00	503.
1.01	3.15	39	.01	.01	.01	13.	1.01	15.15	183	.39	.39	.00	559.
1.01	3.20	40	.01	.01	.01	14.	1.01	15.20	184	.58	.58	.00	673.
1.01	3.25	41	.01	.01	.01	14.	1.01	15.25	185	.68	.68	.00	843.
1.01	3.30	42	.01	.01	.01	14.	1.01	15.30	186	1.65	1.64	.00	1248.
1.01	3.35	43	.01	.01	.01	14.	1.01	15.35	187	2.71	2.71	.00	2192.
1.01	3.40	44	.01	.01	.01	15.	1.01	15.40	188	1.07	1.06	.00	2947.
1.01	3.45	45	.01	.01	.01	15.	1.01	15.45	189	.68	.68	.00	2616.
1.01	3.50	46	.01	.01	.01	15.	1.01	15.50	190	.58	.58	.00	1914.
1.01	3.55	47	.01	.01	.01	15.	1.01	15.55	191	.39	.39	.00	1420.
1.01	4.00	48	.01	.01	.00	15.	1.01	16.00	192	.39	.39	.00	1070.
1.01	4.05	49	.01	.01	.00	16.	1.01	16.05	193	.30	.30	.00	843.
1.01	4.10	50	.01	.01	.00	16.	1.01	16.10	194	.30	.30	.00	694.

END-OF-PERIOD FLOW (Cont'd)

1.01	4.15	51	.01	.01	.00	16.	1.01	16.15	195	.30	.30	.00	604.
1.01	4.20	52	.01	.01	.00	16.	1.01	16.20	196	.30	.30	.00	561.
1.01	4.25	53	.01	.01	.00	16.	1.01	16.25	197	.30	.30	.00	539.
1.01	4.30	54	.01	.01	.00	17.	1.01	16.30	198	.30	.30	.00	530.
1.01	4.35	55	.01	.01	.00	17.	1.01	16.35	199	.30	.30	.00	527.
1.01	4.40	56	.01	.01	.00	17.	1.01	16.40	200	.30	.30	.00	525.
1.01	4.45	57	.01	.01	.00	17.	1.01	16.45	201	.30	.30	.00	525.
1.01	4.50	58	.01	.01	.00	17.	1.01	16.50	202	.30	.30	.00	525.
1.01	4.55	59	.01	.01	.00	17.	1.01	16.55	203	.30	.30	.00	525.
1.01	5.00	60	.01	.01	.00	17.	1.01	17.00	204	.30	.30	.00	525.
1.01	5.05	61	.01	.01	.00	18.	1.01	17.05	205	.23	.23	.00	509.
1.01	5.10	62	.01	.01	.00	18.	1.01	17.10	206	.23	.23	.00	471.
1.01	5.15	63	.01	.01	.00	18.	1.01	17.15	207	.23	.23	.00	440.
1.01	5.20	64	.01	.01	.00	18.	1.01	17.20	208	.23	.23	.00	425.
1.01	5.25	65	.01	.01	.00	18.	1.01	17.25	209	.23	.23	.00	418.
1.01	5.30	66	.01	.01	.00	18.	1.01	17.30	210	.23	.23	.00	415.
1.01	5.35	67	.01	.01	.00	18.	1.01	17.35	211	.23	.23	.00	414.
1.01	5.40	68	.01	.01	.00	18.	1.01	17.40	212	.23	.23	.00	413.
1.01	5.45	69	.01	.01	.00	19.	1.01	17.45	213	.23	.23	.00	412.
1.01	5.50	70	.01	.01	.00	19.	1.01	17.50	214	.23	.23	.00	412.
1.01	5.55	71	.01	.01	.00	19.	1.01	17.55	215	.23	.23	.00	412.
1.01	6.00	72	.01	.01	.00	19.	1.01	18.00	216	.23	.23	.00	412.
1.01	6.05	73	.06	.05	.01	28.	1.01	18.05	217	.02	.02	.00	360.
1.01	6.10	74	.06	.05	.01	52.	1.01	18.10	218	.02	.02	.00	285.
1.01	6.15	75	.06	.05	.01	71.	1.01	18.15	219	.02	.02	.00	266.
1.01	6.20	76	.06	.05	.01	81.	1.01	18.20	220	.02	.02	.00	248.
1.01	6.25	77	.06	.05	.01	87.	1.01	18.25	221	.02	.02	.00	231.
1.01	6.30	78	.06	.05	.01	90.	1.01	18.30	222	.02	.02	.00	216.
1.01	6.35	79	.06	.05	.01	92.	1.01	18.35	223	.02	.02	.00	202.
1.01	6.40	80	.06	.05	.01	94.	1.01	18.40	224	.02	.02	.00	188.
1.01	6.45	81	.06	.05	.01	95.	1.01	18.45	225	.02	.02	.00	175.
1.01	6.50	82	.06	.06	.01	96.	1.01	18.50	226	.02	.02	.00	164.
1.01	6.55	83	.06	.06	.01	97.	1.01	18.55	227	.02	.02	.00	153.
1.01	7.00	84	.06	.06	.01	97.	1.01	19.00	228	.02	.02	.00	142.
1.01	7.05	85	.06	.06	.01	98.	1.01	19.05	229	.02	.02	.00	133.
1.01	7.10	86	.06	.06	.01	99.	1.01	19.10	230	.02	.02	.00	124.
1.01	7.15	87	.06	.06	.01	99.	1.01	19.15	231	.02	.02	.00	116.
1.01	7.20	88	.06	.06	.01	100.	1.01	19.20	232	.02	.02	.00	108.
1.01	7.25	89	.06	.06	.01	100.	1.01	19.25	233	.02	.02	.00	101.
1.01	7.30	90	.06	.06	.00	101.	1.01	19.30	234	.02	.02	.00	94.
1.01	7.35	91	.06	.06	.00	101.	1.01	19.35	235	.02	.02	.00	88.
1.01	7.40	92	.06	.06	.00	102.	1.01	19.40	236	.02	.02	.00	82.
1.01	7.45	93	.06	.06	.00	102.	1.01	19.45	237	.02	.02	.00	76.
1.01	7.50	94	.06	.06	.00	102.	1.01	19.50	238	.02	.02	.00	71.
1.01	7.55	95	.06	.06	.00	103.	1.01	19.55	239	.02	.02	.00	66.
1.01	8.00	96	.06	.06	.00	103.	1.01	20.00	240	.02	.02	.00	62.
1.01	8.05	97	.06	.06	.00	103.	1.01	20.05	241	.02	.02	.00	58.
1.01	8.10	98	.06	.06	.00	104.	1.01	20.10	242	.02	.02	.00	54.
1.01	8.15	99	.06	.06	.00	104.	1.01	20.15	243	.02	.02	.00	50.
1.01	8.20	100	.06	.06	.00	104.	1.01	20.20	244	.02	.02	.00	47.
1.01	8.25	101	.06	.06	.00	104.	1.01	20.25	245	.02	.02	.00	44.
1.01	8.30	102	.06	.06	.00	105.	1.01	20.30	246	.02	.02	.00	41.

END-OF-PERIOD FLOW (Cont'd)

1.01	8.35	103	.06	.06	.00	105.	1.01	20.35	247	.02	.02	.00	38.
1.01	8.40	104	.06	.06	.00	105.	1.01	20.40	248	.02	.02	.00	37.
1.01	8.45	105	.06	.06	.00	105.	1.01	20.45	249	.02	.02	.00	37.
1.01	8.50	106	.06	.06	.00	105.	1.01	20.50	250	.02	.02	.00	37.
1.01	8.55	107	.06	.06	.00	106.	1.01	20.55	251	.02	.02	.00	37.
1.01	9.00	108	.06	.06	.00	106.	1.01	21.00	252	.02	.02	.00	37.
1.01	9.05	109	.06	.06	.00	106.	1.01	21.05	253	.02	.02	.00	37.
1.01	9.10	110	.06	.06	.00	106.	1.01	21.10	254	.02	.02	.00	37.
1.01	9.15	111	.06	.06	.00	106.	1.01	21.15	255	.02	.02	.00	37.
1.01	9.20	112	.06	.06	.00	106.	1.01	21.20	256	.02	.02	.00	37.
1.01	9.25	113	.06	.06	.00	106.	1.01	21.25	257	.02	.02	.00	37.
1.01	9.30	114	.06	.06	.00	107.	1.01	21.30	258	.02	.02	.00	37.
1.01	9.35	115	.06	.06	.00	107.	1.01	21.35	259	.02	.02	.00	37.
1.01	9.40	116	.06	.06	.00	107.	1.01	21.40	260	.02	.02	.00	37.
1.01	9.45	117	.06	.06	.00	107.	1.01	21.45	261	.02	.02	.00	37.
1.01	9.50	118	.06	.06	.00	107.	1.01	21.50	262	.02	.02	.00	37.
1.01	9.55	119	.06	.06	.00	107.	1.01	21.55	263	.02	.02	.00	37.
1.01	10.00	120	.06	.06	.00	107.	1.01	22.00	264	.02	.02	.00	37.
1.01	10.05	121	.06	.06	.00	107.	1.01	22.05	265	.02	.02	.00	37.
1.01	10.10	122	.06	.06	.00	107.	1.01	22.10	266	.02	.02	.00	37.
1.01	10.15	123	.06	.06	.00	107.	1.01	22.15	267	.02	.02	.00	37.
1.01	10.20	124	.06	.06	.00	107.	1.01	22.20	268	.02	.02	.00	37.
1.01	10.25	125	.06	.06	.00	108.	1.01	22.25	269	.02	.02	.00	37.
1.01	10.30	126	.06	.06	.00	108.	1.01	22.30	270	.02	.02	.00	37.
1.01	10.35	127	.06	.06	.00	108.	1.01	22.35	271	.02	.02	.00	37.
1.01	10.40	128	.06	.06	.00	108.	1.01	22.40	272	.02	.02	.00	37.
1.01	10.45	129	.06	.06	.00	108.	1.01	22.45	273	.02	.02	.00	37.
1.01	10.50	130	.06	.06	.00	108.	1.01	22.50	274	.02	.02	.00	37.
1.01	10.55	131	.06	.06	.00	108.	1.01	22.55	275	.02	.02	.00	37.
1.01	11.00	132	.06	.06	.00	108.	1.01	23.00	276	.02	.02	.00	37.
1.01	11.05	133	.06	.06	.00	108.	1.01	23.05	277	.02	.02	.00	37.
1.01	11.10	134	.06	.06	.00	108.	1.01	23.10	278	.02	.02	.00	37.
1.01	11.15	135	.06	.06	.00	108.	1.01	23.15	279	.02	.02	.00	37.
1.01	11.20	136	.06	.06	.00	108.	1.01	23.20	280	.02	.02	.00	37.
1.01	11.25	137	.06	.06	.00	108.	1.01	23.25	281	.02	.02	.00	37.
1.01	11.30	138	.06	.06	.00	108.	1.01	23.30	282	.02	.02	.00	37.
1.01	11.35	139	.06	.06	.00	108.	1.01	23.35	283	.02	.02	.00	37.
1.01	11.40	140	.06	.06	.00	108.	1.01	23.40	284	.02	.02	.00	37.
1.01	11.45	141	.06	.06	.00	108.	1.01	23.45	285	.02	.02	.00	37.
1.01	11.50	142	.06	.06	.00	108.	1.01	23.50	286	.02	.02	.00	37.
1.01	11.55	143	.06	.06	.00	108.	1.01	23.55	287	.02	.02	.00	37.
1.01	12.00	144	.06	.06	.00	109.	1.02	0.00	288	.02	.02	.00	37.

SUM	32.50	31.61	.89	57986.
	(825.)	(803.)	(23.)	(1641.98)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2947.	619.	201.	201.	57963.
CMS	83.	18.	6.	6.	1641.
INCHES		25.25	32.85	32.85	32.85
MM		641.32	834.27	834.27	834.27
AC-FT		307.	399.	399.	399.
THOUS CU M		379.	492.	492.	492.

SURFACE AREA=	0.	15.	19.	41.	46.	92.
CAPACITY=	0.	118.	151.	442.	973.	1758.
ELEVATION=	764.	788.	790.	800.	810.	820.

SUMMARY OF DAM SAFETY ANALYSIS

PMF

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
	788.18	0.00	126.	106.	0.00	14.00	0.00
	788.47	.47	145.	311.	1.58	15.00	0.00
	788.57	.57	154.	424.	2.00	15.00	0.00
	788.68	1.38	167.	2000.	2.00	14.00	0.00

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	788.00	788.00	788.00
STORAGE	118.	118.	137.
OUTFLOW	0.	0.	109.

SUMMARY OF DAM SAFETY ANALYSIS

100-YR. FLOOD

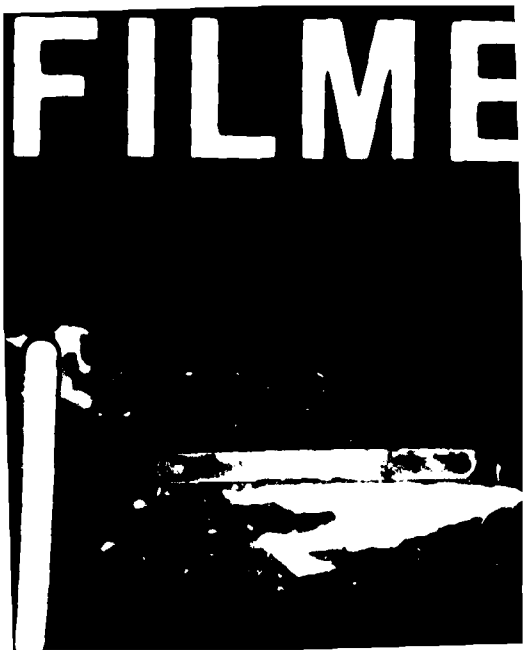
INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
788.00	788.00	788.00
118.	118.	137.
0.	0.	109.

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	788.47	.47	145.	311.	1.58	15.00	0.00

SUMMARY OF DAM SAFETY ANALYSIS

10-YR. FLOOD

ELEVATION	INITIAL VALUE
	708.00
	118.
	0.


FILME