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NATIONAL DAM SAFETY PROGRAM. FOREST LAKE DAM (MO 10113), UPPER --ETC(U)

SEP 80 R E SAUTHOFF, A B BECKER DACW43-80-C-0063

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UPPER MISSISSIPPI - SALT - QUINCY BASIN

FOREST LAKE DAM

WARREN COUNTY, MISSOURI

MO 10113

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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UPPER MISSISSIPPI - SALT - QUINCY BASIN

FOREST LAKE DAM

WARREN COUNTY, MISSOURI

MO 10113

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
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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: Forest Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Forest Lake Dam (MO 10113):

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.

SIGNED

17 SEP 1980

SUBMITTED BY: ______________________ ____________
Chief, Engineering Division — Date

SIGNED

18 SEP 1980

APPROVED BY: ______________________ ____________
Colonel, CE, District Engineer — Date

FOREST LAKE DAM

MISSOURI INVENTORY NO. 10113

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

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Forest Lake Dam
State Located:	Missouri
County Located:	Warren
Stream:	Tributary of Indian Camp Creek
Date of Inspection:	30 May 1980

The Forest 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-to-medium size trees were present on the downstream face of the dam. Small trees and brush were also found near the waterline on the upstream face of the dam. Tree roots can provide a passageway for lake seepage which could lead to a piping condition (progressive internal erosion) that can result in failure of the dam. Brush may conceal animal burrows which could also provide passageways for lake seepage.

2. Erosion of the embankment has created a near vertical bank about 10 feet high at the downstream end of the spillway outlet pipe and about 9 feet of spillway pipe is exposed and unsupported. In addition, scouring by falling spillway pipe discharges has created a depression in the ground surface and a pool of water approximately 40 feet long by 30 feet wide and 4 feet deep exists adjacent to the downstream toe of the dam. Loss of foundation material at and adjacent to the toe of the dam can be detrimental to the stability of the embankment. Saturation of the soil adjacent to the dam by standing water can weaken the strength of the material and reduce its capacity to provide foundation support.

3. Seepage, as evidenced by a marshy area with cattails and wet soft ground, was observed in a location approximately 50 feet north of the downstream toe of the dam and 250 feet west of the centerline of the emergency spillway. Uncontrolled seepage can develop into a piping condition that could result in failure of the dam.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Forest 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 several dwellings lie within the possible flood damage zone, it is recommended that the spillway for this dam be designed for the 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. The PMF is ordinarily accepted as the inflow design flood for dams where failure of the structure would increase the danger to human life.

Results of a hydrologic/hydraulic analysis indicated that both spillways, principal plus emergency, are inadequate to pass lake outflow resulting from a storm of PMF magnitude. The spillways are capable of passing lake outflow resulting from the one percent chance (100-year frequency) flood and the outflow corresponding to about 18 percent of the PMF. 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 approximately six dwellings and State Highway J.

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 in the near future to correct or control the deficiencies and safety defects reported herein.

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 FOREST LAKE DAM

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

FOREST LAKE DAM - ID. NO. 10113

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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

FOREST LAKE DAM - I. D. NO. 10113

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 Forest 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 the "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 Forest Lake Dam is an earthfill type embankment rising approximately 38 feet above the natural streambed at the downstream toe of the barrier. The embankment has an upstream slope (above the waterline) of approximately 1v on 2.1h, a crest width of about 11 feet, and a downstream slope on the order of 1v on 2.1h that flattens to about 1v on 4.0h at a point approximately 20 feet below the dam crest. The length of the dam is approximately 285 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 elevation, the reservoir impounded by the dam occupies approximately 30 acres. The inspection did not reveal the presence of a lake drawdown facility.

The dam has both a principal and an emergency spillway. The principal spillway, which is located near the center of the dam, consists of a 38-inch diameter concrete drop inlet with a 24-inch diameter steel outlet pipe. A steel grate across the top of the inlet serves as a trash screen to prevent clogging of the inlet. The spillway outlet pipe discharges to the original stream channel at a point about 10 feet above the toe of the dam. At the outlet end approximately 9 feet of the spillway pipe is unsupported and projects beyond the face of the embankment.

The emergency spillway is located at the right, or east, abutment. The spillway outlet channel, an excavated earthen trapezoidal section is cut into the hillside with an earth bank constructed on the left, or west, side to confine flow to the channel. The channel extends approximately 350 feet from the centerline of the dam at which point spillway releases leave the improved section and follow the hillside slope joining the original stream course at a point about 700 feet downstream of the dam. A profile of the emergency spillway channel is shown on Plate 4 and a cross-section of the channel is shown on Plate 5.

b. Location. The dam is located on an unnamed tributary of Indian Camp Creek about 1,500 feet east of State Highway J and 3,000 feet north of the intersection of Highway J and Interstate Highway 70; about 0.8 of a mile northeast of Wright City, Missouri, as shown on the Regional Vicinity Map, Plate 1. The dam is located in Section 15, 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 Forest Lake Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that if the dam should fail, there mav 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 six dwellings, several buildings, and State Highway J. Those features lying within the downstream damage zone as reported by the St. Louis District, Corps of Engineers, were verified by the inspection team.

e. Ownership. The lake and dam are owned by the Forest Lake Development Corporation of which Mr. Earl J. Wipfler is the president. Mr. Wipfler's address is 311 Violet Avenue, Webster Groves, Misouri, 63119.

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

g. Design and Construction History. According to Mrs. Catherine Fredrick, the wife of the original owner of the dam, (Mr. Fredrick is deceased), the dam was constructed in 1957 by Paul Crowley, an earth moving contractor from Chesterfield, Missouri. Mrs. Fredrick reported that the contractor was assisted by an engineer; however, his name could not be recalled, and the extent of the engineering investigations and services performed are unknown. Although Mrs. Fredrick believed that construction drawings of the dam were prepared and were filed with the Recorder's Office in the Warren County Courthouse, no record of the plans could be found. According to Mr. Wipfler, the Forest Lake Development Corporation acquired the property in 1959.

h. Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the capacities of the drop inlet type spillway and the excavated earth type emergency spillway.

1.3 PERTINENT DATA

a. Drainage Area. The area tributary to the lake is for the most part covered with timber. Interstate Highway 70, tracks belonging to the Norfolk & Western Railroad Company, a trailer park, and portions of the community of Wright City are located along the southern limits of the drainage area. The watershed above the dam amounts to approximately 524 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

1. Estimated known maximum flood at damsite ... 54 cfs* (W.S.Elev. 632.0)
2. Spillway capacity
   a. Principal ... 21 cfs (W.S.Elev. 631.7)
   b. Principal + emergency ... 714 cfs (W.S.Elev. 634.0)

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 ... 631.0
2. Normal pool ... 631.0
3. Spillway crest
   a. Principal ... 631.0
   b. Emergency ... 631.7
4. Maximum experienced pool ... 632.0
5. Top of dam ... 634.0 (min.)
6. Streambed at centerline of dam ... 597± (est.)
7. Maximum tailwater ... Unknown
8. Observed tailwater ... 596.4

* Based on an estimate of lake level as observed by Mrs. Catherine Fredrick.

d. Reservoir.

1. Length at normal pool (Elev. 631.0) ... 2,100 ft.
2. Length at maximum pool (Elev. 634.0) ... 2,500 ft.

e. Storage.

1. Normal pool ... 341 ac. ft.
2. Top of dam (incremental) ... 99 ac. ft.

f. Reservoir Surface.

1. Normal pool ... 30 acres
2. Top of dam (incremental) ... 7 acres

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

1. Type ... Earthfill, homogeneous*
2. Length ... 985 ft.
3. Height ... 38 ft.
4. Top width ... 11 ft.
5. Side slopes
    a. Upstream ... 1v on 2.1h (above waterline)
    b. Downstream ... 1v on 2.1h to 1v on 4.0h
6. Cutoff ... Core trench*
7. Slope protection
    a. Upstream ... Limestone riprap
    b. Downstream ... Grass

* Per Mrs. Catherine Fredrick.

h. Principal Spillway.

1. Type ... Uncontrolled, drop inlet, 38-inch diameter concrete riser
2. Location ... Center of dam at lake
3. Top elevation ... 631.0
4. Outlet ... 24-inch diameter corrugated metal pipe

i. Emergency Spillway.

1. Type ... Uncontrolled, excavated earth, trapezoidal section
2. Location ... Right abutment
3. Crest ... Elevation 631.7
4. Approach channel ... Lake
5. Outlet channel ... Trapezoidal earth section, 350 feet long (improved section)

j. Lake Drawdown Facility ... None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

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

2.2 CONSTRUCTION

As previously stated, the dam was constructed in 1958 by Paul Crowley, an earth moving contractor from Chesterfield, Missouri. The present whereabouts and status of Mr. Crowley are unknown and no records of the dam construction were available. According to Mrs. Catherine Fredrick, one of the original owners of the dam, a core trench was excavated along the alignment of the dam; however, the width and depth of the trench could not be recalled. Mrs. Fredrick reported that the material to build the dam was obtained from the hillside to the right of the dam and to some extent, from the area to be occupied by the lake. Mrs. Fredrick also believed that the fill material was compacted using a sheepsfoot roller.

2.3 OPERATION

The lake level is uncontrolled and governed by the elevation of the crest of the principal, drop inlet type spillway. An emergency spillway, with a crest elevation approximately 0.7 foot higher than the crest of the principal spillway and 2.3 feet lower than the top of the dam at its lowest point, is located at the right abutment. Mrs. Fredrick, who resides nearby the lake and is familiar with the reservoir's operation since its inception, reported that the dam has never been overtopped and that the highest lake level observed is believed to have occurred in April of 1979 when the lake surface reached an elevation approximately 1 foot above the crest of the drop inlet spillway.

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 Forest Lake Dam was made by Horner & Shifrin engineering personnel, R. E. Sauthoff, Civil Engineer, and A. B. Becker, Jr., Civil and Soils Engineer, on 30 May 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-5 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 border of the Dissected Till Plains Section of the Central Lowlands Physiographic Province and the northern edge of the Ozark Plateaus Physiographic Province. The topography of the reservoir area is moderately sloping with approximately 100 feet of relief between the reservoir and the surrounding drainage divide. The area is underlain by loess and glacial till deposits with no bedrock exposures evident at the site. Reportedly the bedrock consists of gently northward-dipping Mississippian-age sedimentary strata of the Osagean series. Residual cherty clays exposed in the spillway indicate the underlying bedrock to most probably be the Burlington-Keokuk formations. These formations consist of light gray to buff colored, coarsely crystalline, fossiliferous, crinoidal limestone. Chert is common in the form of layers and nodules. The Burlington-Keokuk formations are well known in Missouri for their solution-weathered features. Sinkholes, caves, losing streams, solution-enlarged joints or bedding planes, and a very irregular bedrock surface are common. No evidence of these karst features was noted in the dam or reservoir area. The thick soil cover would tend to mask these features, as well as minimize their effects on the performance of the reservoir. No faults were observed or are reported to be present in this area.

The unconsolidated surficial materials in the vicinity of the reservoir are composed principally of soils derived from glacial till, bedrock residuum, and loess deposits. The dam site and reservoir are underlain by soils of the Sharon and Lindley series. Hatton series soils cap the surrounding uplands. The Sharon soils, which make up the valley floor, consist of deep, moderately well-drained silty alluvium. According to the Unified Soil Classification System, the soil ranges from ML to CL material, is moderately permeable, and is susceptible to erosion and piping. The valley walls are primarily covered with Lindley series soils. These are deep, well-drained soils formed on glacial till. The soil typically ranges from a silty clay at the surface, becoming more clayey with depth. Chert fragments, from the reworked residual soils, are common. The soils are classified as CL-ML to CL materials, exhibit moderately low permeability, and are generally considered favorable for impoundments and embankments. The surrounding uplands are covered with soils of the Hatton series. These are moderately well-drained clays and silty clays formed from loess and the underlying glacial sediment. These soils are only present well above the reservoir and dam site.

There appear to be no significant geologic problems at the Forest Lake site. No adverse geologic conditions were observed that would be considered conducive to severe reservoir leakage or embankment instability.

c. Dam. The visible portions of the upstream face and crest of the dam (see Photos 1 and 2) were examined and appeared to be in sound condition. No surface cracks or unusual misalignment of the crest of the dam was noticed. However, at the time of the inspection, the grass on the dam crest was about 30 inches high. And, according to survey data, a low point in the dam crest exists at the crossing of the spillway outlet pipe, and the possibility of dam settlement at this location cannot be discounted. The elevation of the dam crest at station 5+89, the location of the spillway outlet pipe, was found to be approximately 1 foot lower than the elevations of the top of the dam at stations 5+00 and 7+00.

At and above the normal waterline, the upstream face of the dam was protected against erosion by limestone riprap up to about 18 inches in size. Brush and small trees up to about 6 inches in diameter were also present along the upstream face of the dam. Due to the presence of dense brush and trees, (trees as large as 8 inches in diameter were common and several as large as 12 inches were noticed), the downstream face (see Photo 7) of the dam could not be thoroughly inspected. An examination of the surficial material of the dam indicated it to be a silty lean clay (CL) of low-to-medium plasticity.

A marshy area approximately 80 feet wide and 125 feet long with cattails and wet, soft ground (see Photo 8) existed at a location about 250 feet west of the emergency spillway and 50 feet north of the toe of the dam. Seepage flow was not seen; however, due to the presence of dense brush, a detailed examination of the area could not be made.

The drop inlet spillway structure (see Photo 3) was examined and except for a light coating of rust on the steel, bar grate type trash screen, was found to be in satisfactory condition. It could not be determined if the two steel angles that projected from the top of the inlet were intended to support an anti-vortex plate or served some other purpose. However, a plate was not installed at the time of the inspection. At the downstream end of the 24-inch spillway outlet pipe (see Photo 4), erosion of the embankment that appeared to be a result of falling pipe discharges, had created a near vertical bank approximately 10 feet high above the normal toe of the dam and about 9 feet of the pipe end section was projecting unsupported from the face of the embankment. Judging by the condition of the end of the pipe, a galvanized corrugated steel section, the outlet except for being unsupported, appeared to be in satisfactory structural condition. The eroded embankment section extended for about 15 feet on either side of the outlet pipe at the toe of the dam. Scouring by falling spillway discharges had eroded a depression in the ground and a pool approximately 30 feet wide by 40 feet long and 4 feet deep existed adjacent to the toe of the dam at the location of the outlet pipe.

The emergency spillway, an excavated trapezoidal section (see Photos 5 and 6), was inspected and found to be in satisfactory condition, although the bank on the left side of the channel had a fairly dense growth of brush and small trees that prevented a close examination of the bank area. The riprap that protects the upstream face of the dam did not extend across the lake side of the emergency spillway; however, no significant erosion of the section at the lake was noticed. Dense brush and trees prevented a detailed inspection of the channel downstream of the improved section.

d. Downstream Channel. The channel downstream of the dam is unimproved. The stream crosses Highway J at a point approximately 0.5 mile downstream of the dam and again about 1.0 mile beyond the dam. The tributary joins Indian Camp Creek at a point nearly 1.5 miles downstream of the dam.

e. Reservoir. The hillsides surrounding the lake are for the most part covered with forest. Except for the upstream end of the lake the shoreline is tree-lined. At the time of the inspection the lake was at normal pool level and the water within 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 significant to warrant immediate remedial action. However, it is recommended that, as soon as practical, the trees and brush be removed from the embankment as indicated in paragraph 7.2b(1), and that the entire downstream slope be re-examined after it is cleared for signs of seepage, erosion, sloughing, and other defects that could impair the safety of the dams. It is also recommended that the bar type trash screen on the top of the drop inlet be replaced with a type of trash screen that is less susceptible to clogging by lake carried debris. A trash screen (rack) of the kind recommended by Soil Conservation Service for drop inlets should be considered. The stone riprap on the upstream face of the dam appears to be adequate to prevent erosion of the slope by wave action or by fluctuations of the lake level.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

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

4.2 MAINTENANCE OF DAM

Judging by the dense growth of brush and trees on the downstream face of the dam, as well as the embankment erosion that was observed at the downstream end of the spillway outlet pipe, the inspection team is of the opinion that maintenance of the dam proper has been somewhat neglected. According to Mr. E. [illegible] Whipfler, the drop inlet spillway grate is cleared of debris three or four times a year and the grass on the dam crest is cut periodically. Mr. Whipfler also reported that the concrete encasement at the drop inlet was installed several years ago in order to seal a leak that had developed in the structure. Mr. Whipfler also stated that a caretaker had been employed prior to 1979, but that at present, there is none.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

No outlet operating facilities exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEMS IN EFFECT

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

4.5 EVALUATION

Lack of or inadequate maintenance is considered detrimental to the safety of a dam. It is recommended that maintenance of the dam and spillways 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 - HYDROLOGIC/HYDRAULIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data are not available.

b. Experience Data. The drainage area and lake surface area were developed from the 1972 USGS Wright City and Foristell, Missouri, Quadrangle Maps. The proportions and dimensions of the spillways and dam were developed from surveys made during the inspection. Records of rainfall, streamflow or flood data for the watershed are not available.

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 principal spillway, a 38-inch diameter concrete encased corrugated metal drop inlet, is located just to the left of the center of the dam. The drop inlet is about 8 feet deep. Steel grating over the top of the inlet serves as a trash screen.

2. A 24-inch corrugated metal pipe extends from the drop inlet to a point about 10 feet above the toe of the dam at the downstream channel. The outlet pipe extends about 9 feet beyond the ground surface at the outlet end, and an erosion pool has formed below the end of the pipe at the toe of the dam.

3. The emergency spillway, a shallow broad-crested trapezoidal section, is located in the hillside of the right (east) abutment.

4. The emergency spillway outlet channel, a trapezoidal earth section, is excavated into the hillside at the right abutment and joins the original stream channel about 700 feet downstream of the dam.

d. Overtopping Potential. The spillways (principal and emergency) are inadequate to pass the probable maximum flood, or 1/2 the probable maximum flood, without overtopping the dam. The results of the dam overtopping analysis are as follows:

(Note: The data appearing in the following table have been 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. 634.0)	Duration of Overtopping of Dam (Hrs.)
0.50	3,757	635.8	1.8	4.0
1.00	8,586	636.7	2.7	6.6

Elevation 634.0 was found to be the lowest point in the dam crest. The flow safely passing the spillway just prior to overtopping amounts of approximately 714 cfs, which is the routed outflow corresponding to about 18 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 2.7 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 have shown evidence that the material under cetain conditions such as high velocity flow, 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 dam crest, a maximum of 2.7 feet, and the duration of flow over the dam, 6.6 hours, are substantial, 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.

f. Reference. Procedures and data for determining the probable maximum flood, the 100-year frequency flood, and the discharge rating curve for flow passing the spillways and dam crest are presented on Pages B-1 through B-3 of the Appendix. Listings of t HEC-1 (Dam Safety Version) input data for both the probable maximum flood and the 100-year frequency flood are shown on pages B-4 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 PMF and 1 percent chance (100-year frequency) flood are also shown on page B-11.

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. E. J. Whipfler, a representative of the Owner, no records are kept of the lake level, spillway discharge, dam settlement, or seepage.

d. Post Construction Changes. According to Mrs. Fredrick, the original owner, and Mr. Whipfler, no post construction changes have been made which would affect the structural stability of the dam. However, it is probable that the erosion that has occurred at the downstream toe of the dam in the vicinity of the spillway outlet pipe is detrimental to the dam's stability.

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 emeregency) are capable of passing lake outflow of about 714 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 probable maximum flood magnitude, the lake outflow would be about 8,586 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 571 cfs.

Several items were noticed during the inspection that could adversely affect the safety of the dam. These items include trees and brush on the dam slopes, seepage, and the areas of erosion at the downstream toe of the dam in the vicinity of the spillway outlet pipe.

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.

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 items concerning the safety of the dam noted in paragraph 7.1a and the remedial measures recommended in paragraph 7.2 should be accomplished in the near future. The item recommended in paragraph 7.2a regarding the provision of additional spillway capacity should be pursued on a high priority basis. It is also recommended that, as soon as practical, the trees and brush be removed from the embankment as indicated in paragraphs 7.2b(1), and that the entire downstream slope be re-examined as stated after it is cleared.

d. Necessity for Phase II. Based on the results cr 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 probable maximum flood magnitude; in any event the spillway(s) shall 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. The presence of the pool at the toe of the dam should be taken into consideration when stability analyses of the dam are performed or provisions should be made to drain the pool and prevent formation by scour of a like condition. In any event, provisions should be undertaken to restore the eroded embankment at the downstream end of the spillway outlet pipe and provide adequate support for the pipe at this location. It is also recommended that the pipe end be reconfigured to prevent free fall of spillway discharge.

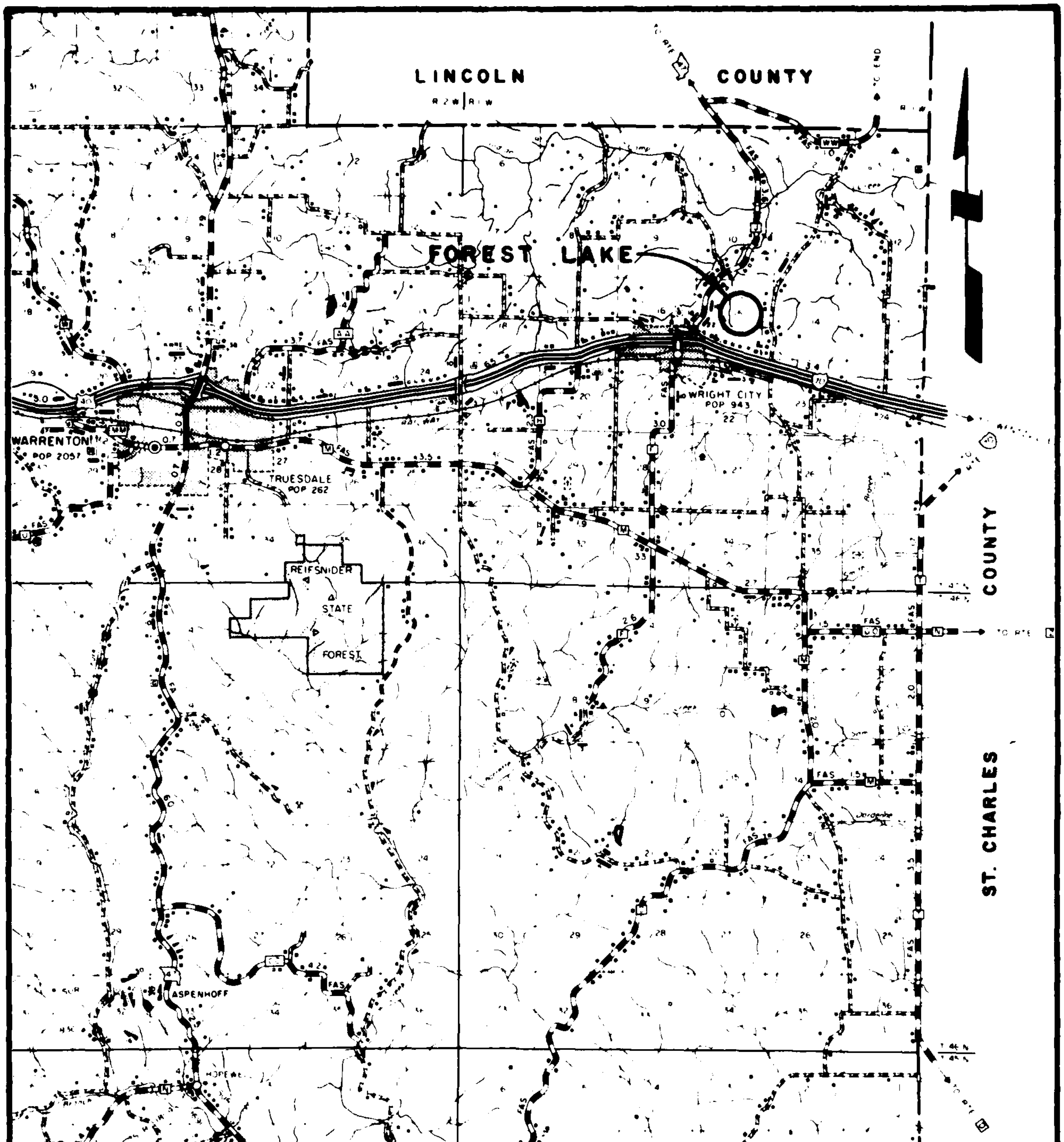
b. Operations and Maintenance (O & M) Procedures. The following O & M Procedures are recommended:

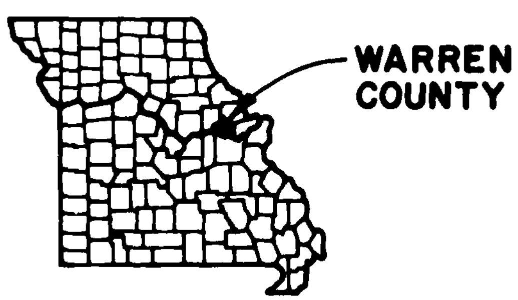
1. Remove the trees and brush from the dam proper and the areas adjacent to the downstream toe of slope. The removal of trees should be performed under the direction and guidance of an engineer experienced in the design and construction of earthen dams, since indiscriminate clearing can jeopardize the safety of the dam. Once the dam and adjacent downstream area are cleared of trees and brush, they should be thoroughly examined by an engineer for animal burrows, seepage, erosion, sloughing and other signs of instability. The existing turf cover should be restored if destroyed or missing. Maintain the turf cover at a height that will not hinder inspection of the embankment or provide cover for burrowing animals. Holes from trees, roots and voids created by burrowing animals can provide a pathway for lake seepage that could lead to a piping condition (progressive internal erosion) and potential failure of the dam.

2. Provide some means of controlling seepage evident in the area adjacent to the downstream toe near the right side of the dam. Uncontrolled seepage can lead to a piping condition which could result in the failure of the dam. Drainage of the areas affected by seepage including elimination of the marshy area just downstream of the dam 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. 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.





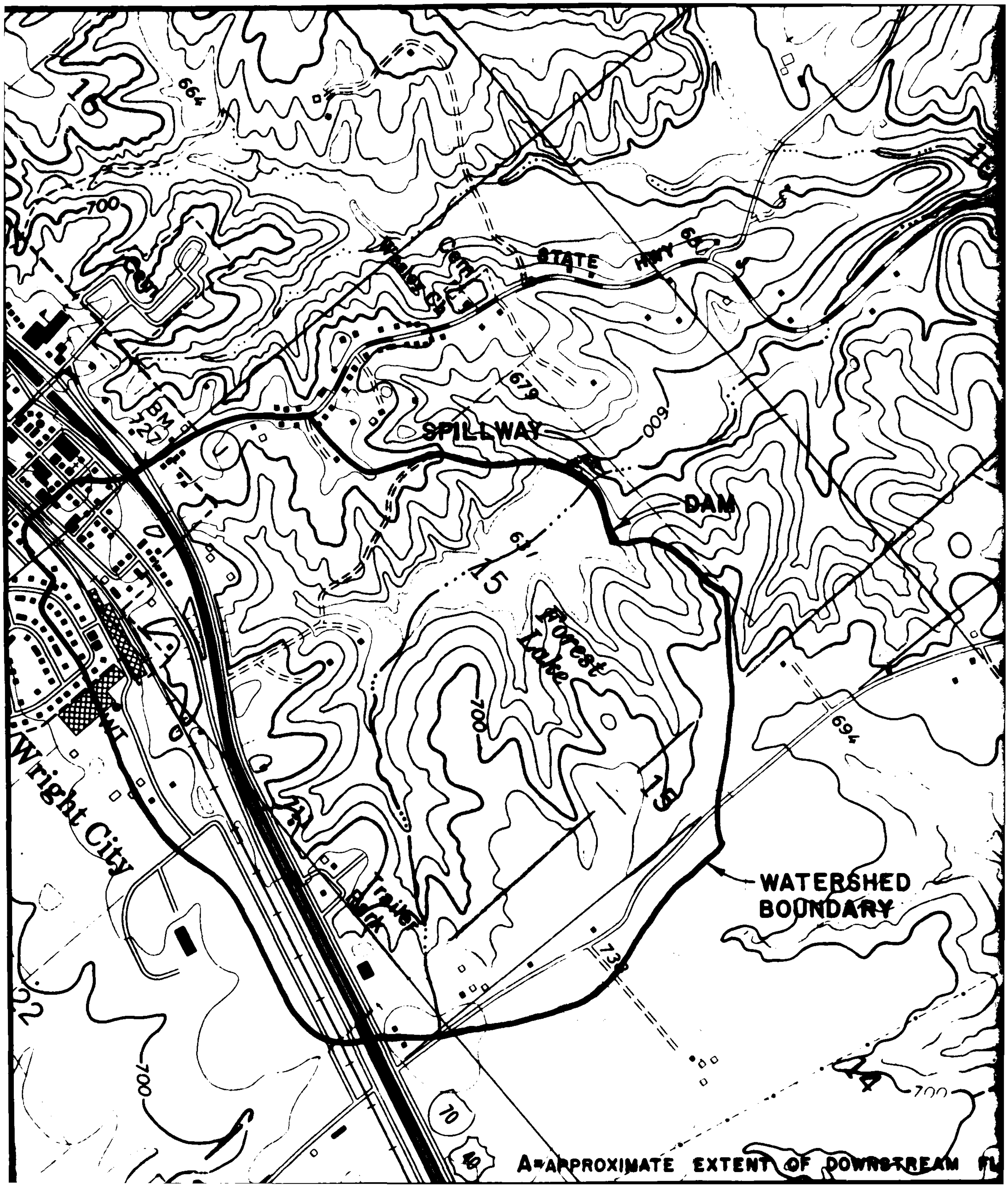
LOCATION MAP

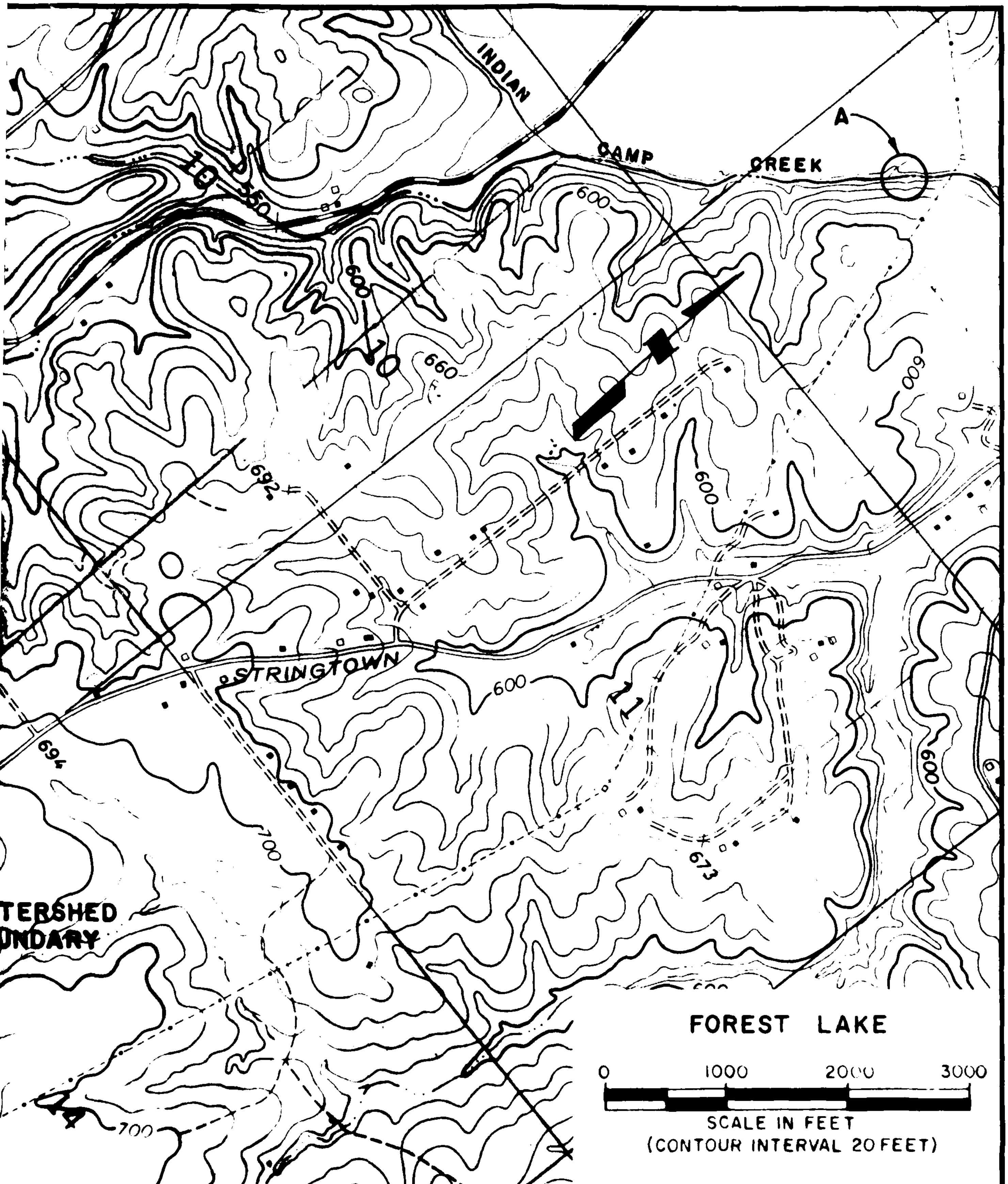
FOREST LAKE

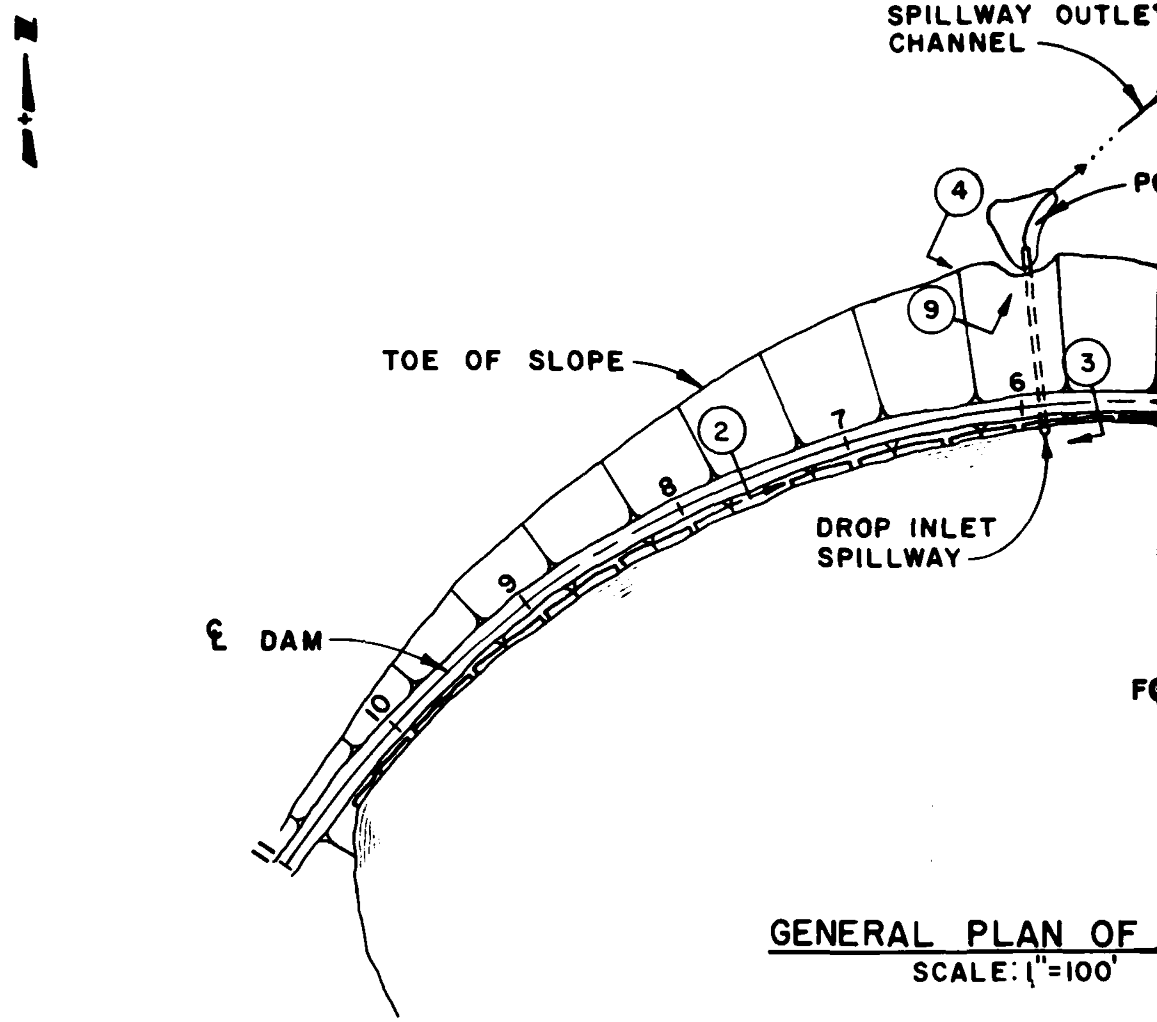
0 1 2 3 4

SCALE (MILES)

REGIONAL VICINITY MAP


SPILLWAY
DAM
STATE HWY
Forest Lake
Wright City
WATERSHED BOUNDARY
Trailer Park
A=APPROXIMATE EXTENT OF DOWNSTREAM


INDIAN
CAMP
CREEK
A
600
660
692
694
700
600
600
673
600
STRINGTOWN
TERSHED
UNDARY
DOWNSTREAM FLOOD DAMAGE ZONE
FOREST LAKE
0
1000
2000
3000
SCALE IN FEET
(CONTOUR INTERVAL 20 FEET)
LAKE WATERSHED MAP



GENERAL PLAN OF

SCALE: 1"=100'

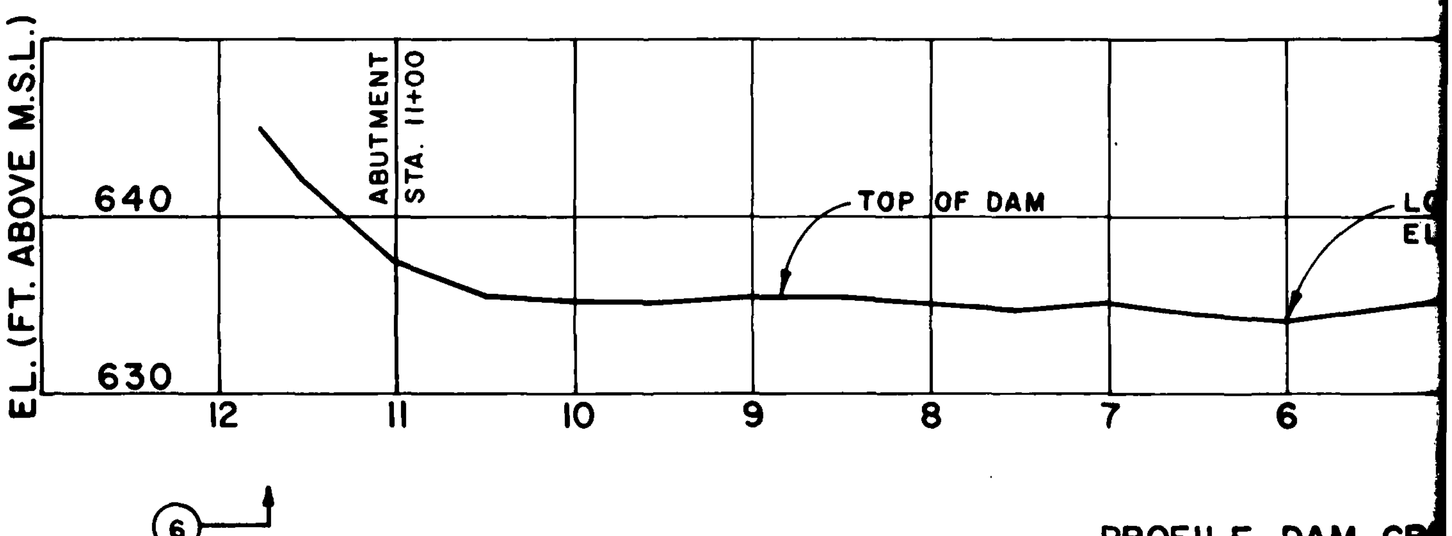
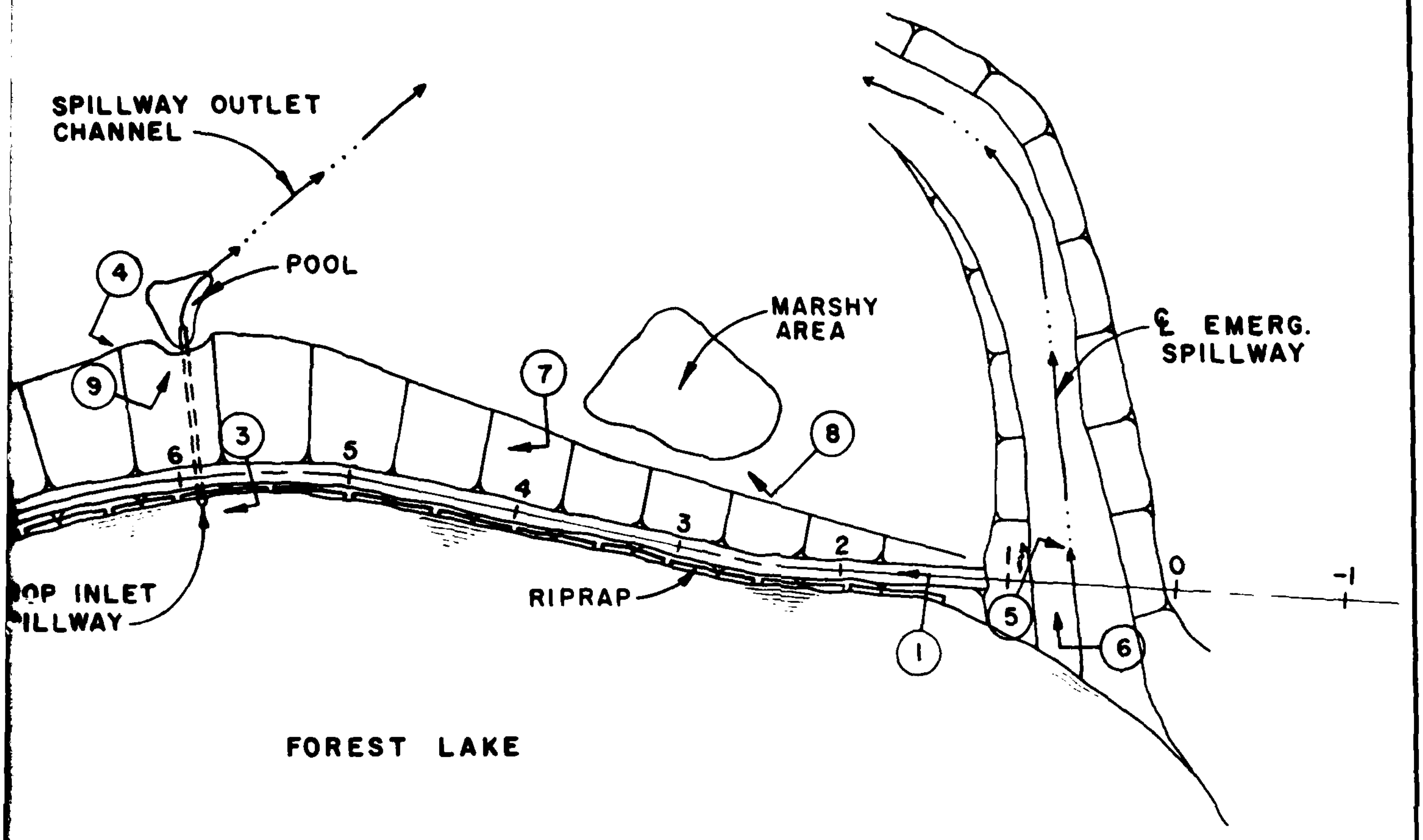


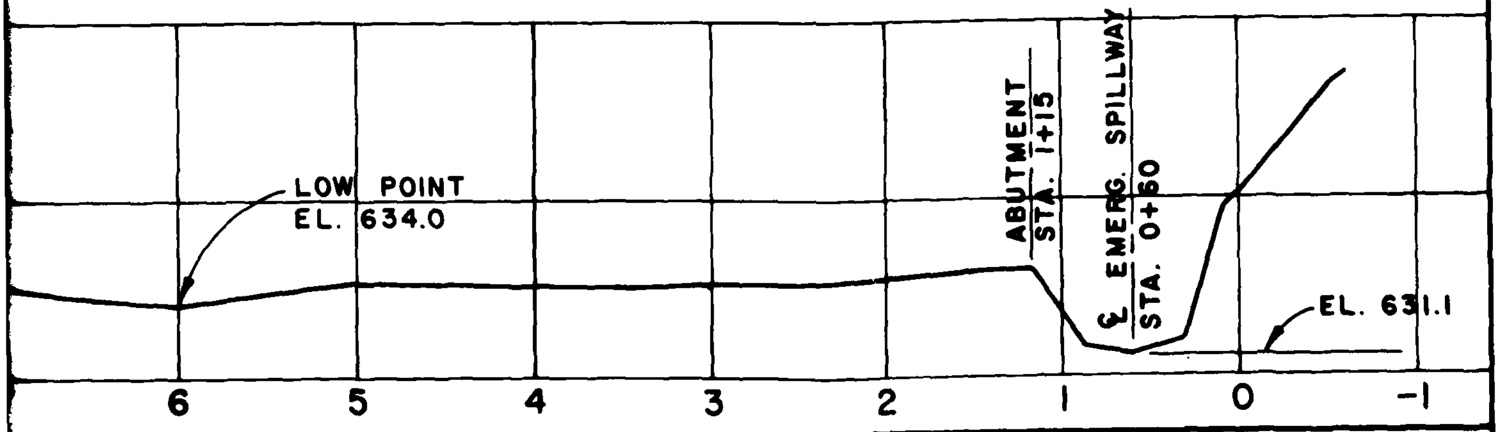
PHOTO LOCATION & KEY
(SEE APPENDIX A)

PROFILE DAM CR

SCALES: 1"=10'V., 1"=100



ERAL PLAN OF DAM
SCALE: 1"=100'



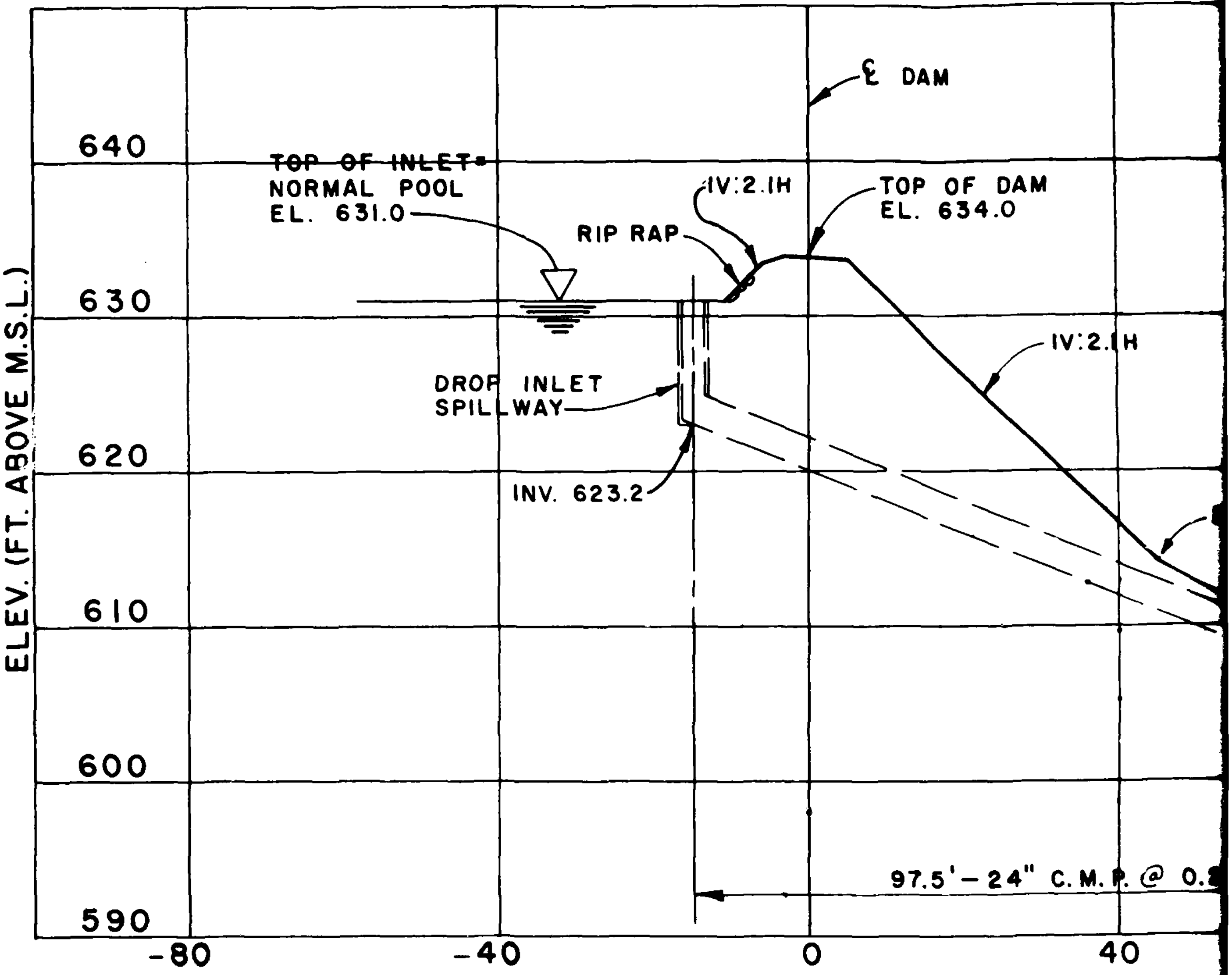
ROFILE DAM CREST
SCALES: 1"=10'V., 1"=100'H.

FOREST LAKE
DAM PLAN & PROFILE

Horner & Shifrin, Inc. July 1980

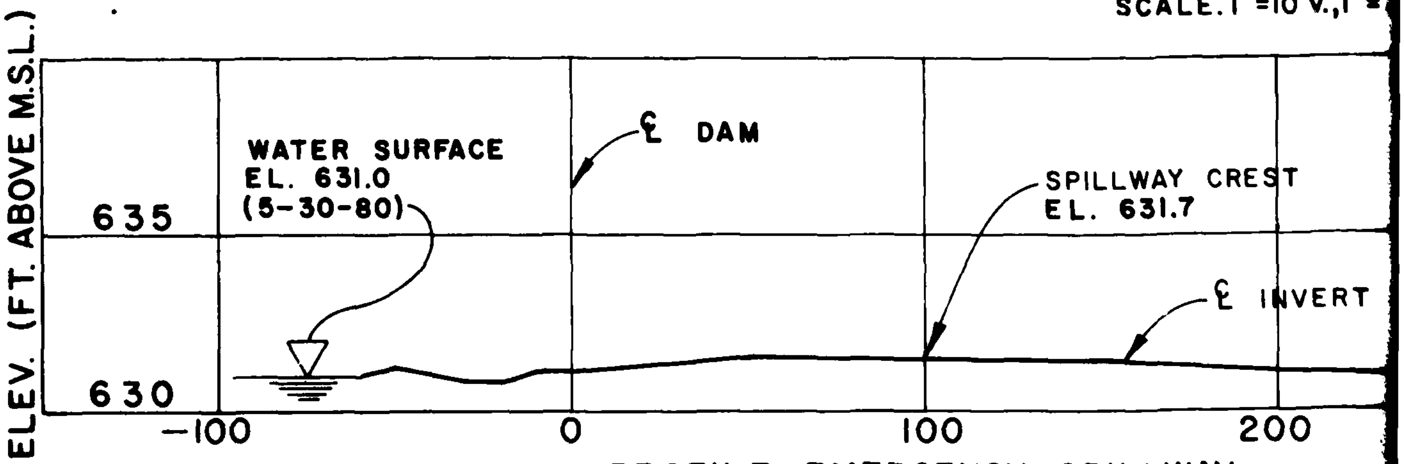
PLATE 3

12



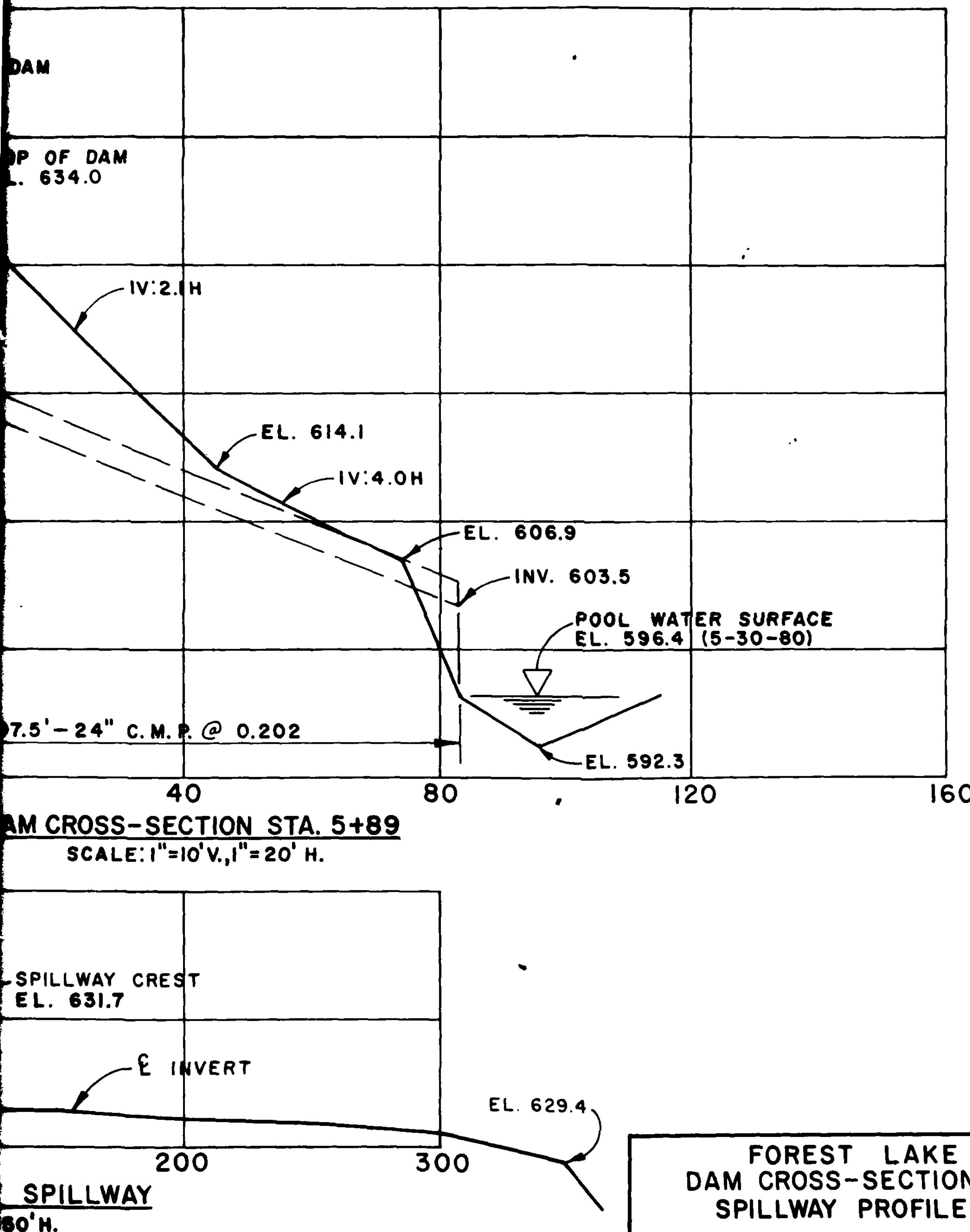
DAM CROSS-SECTION

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



PROFILE EMERGENCY SPILLWAY

SCALE: 1"=5' V., 1"=50' H.

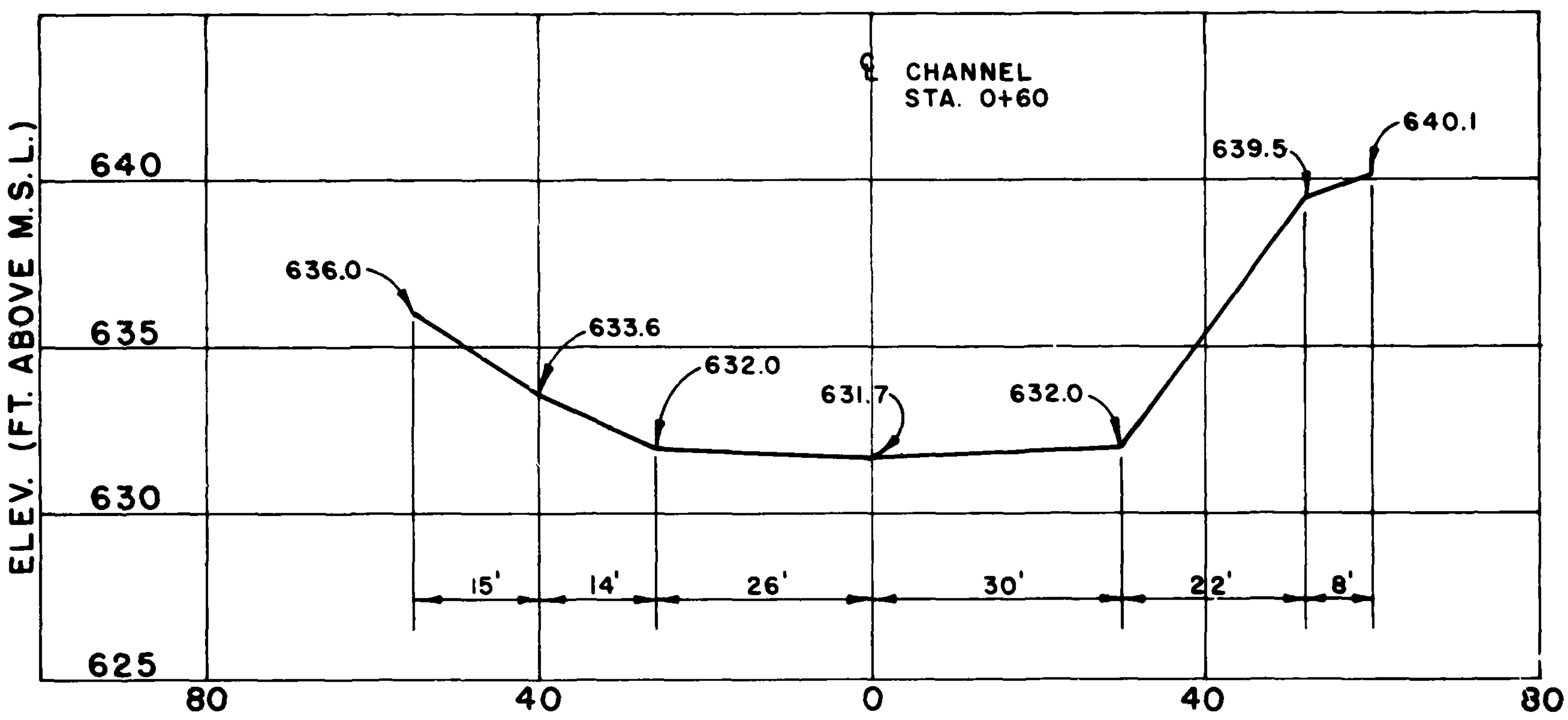


FOREST LAKE
DAM CROSS-SECTION &
SPILLWAY PROFILES

Horner & Shifrin, Inc. July 1980

1 2

PLATE 4



CROSS-SECTION AT CREST

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

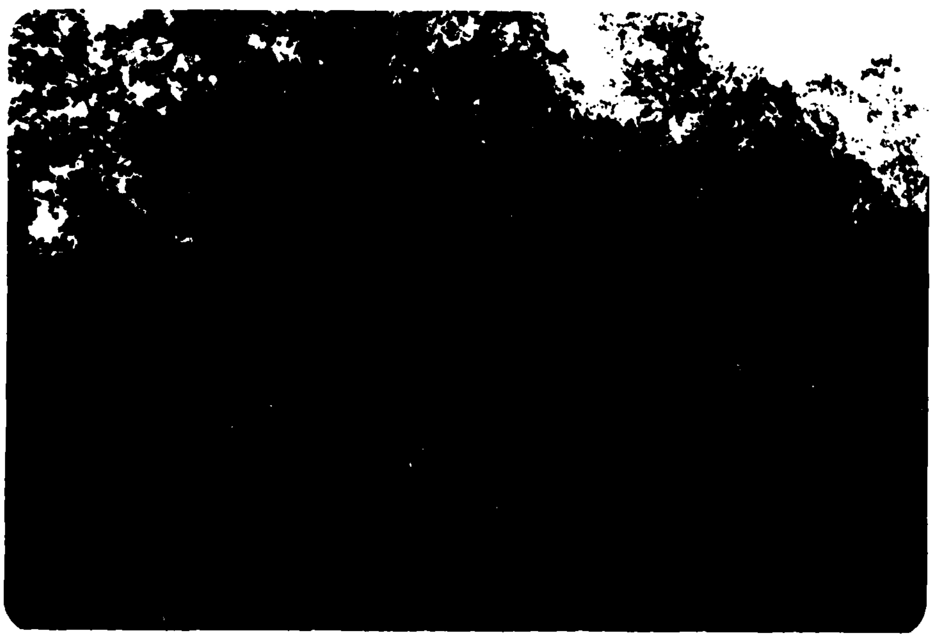
FOREST LAKE
EMERGENCY SPILLWAY
CROSS-SECTION

Horner & Shifrin, Inc. August 1980

APPENDIX A

INSPECTION PHOTOGRAPHS

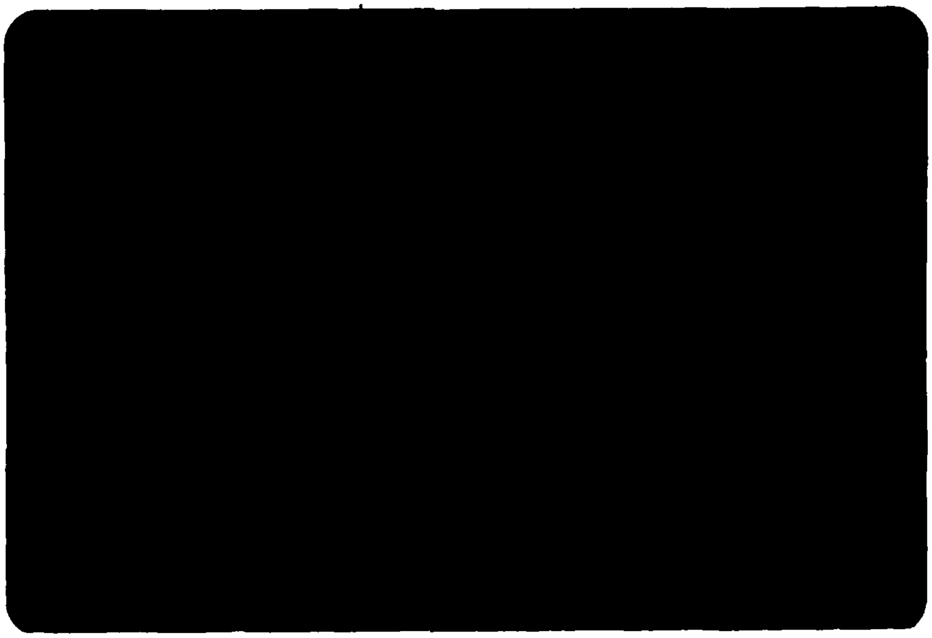
NO. 1: UPSTREAM FACE OF DAM



NO. 2: CREST AND DOWNSTREAM FACE OF DAM

NO. 3: DROP INLET SPILLWAY

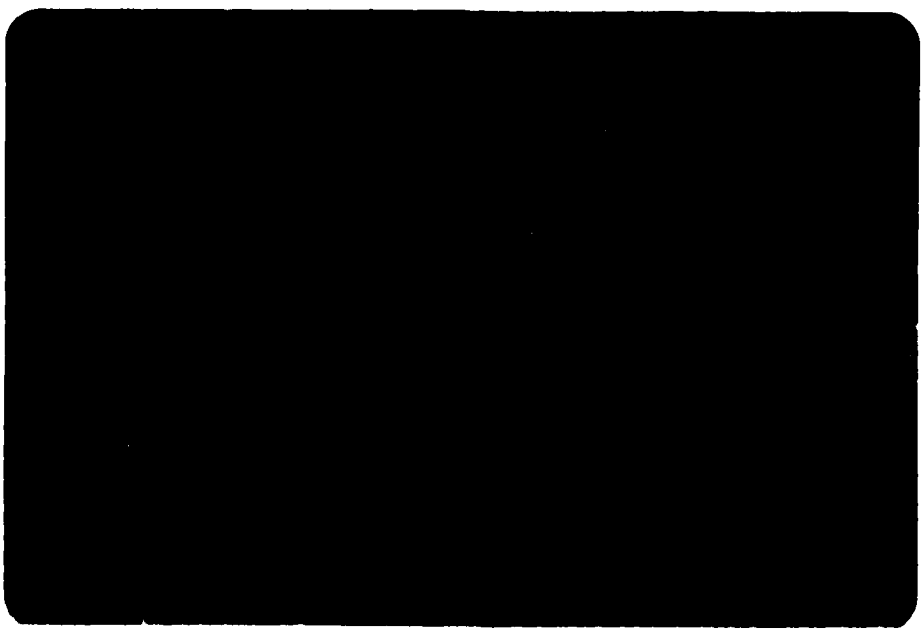
NO. 4: 24-INCH SPILLWAY OUTLET PIPE



NO. 5: CREST OF EMERGENCY SPILLWAY

NO. 6: EMERGENCY SPILLWAY OUTLET CHANNEL - LOOKING DOWNSTREAM FROM CREST

NO. 7: TREES AND BRUSH ON DOWNSTREAM FACE OF DAM



NO. 8: MARSHY AREA NEAR TOE OF DAM

NO. 9: POOL ADJACENT TO DAM AT SPILLWAY OUTLET PIPE

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 frequency) flood was provided by the St. Louis District, Corps of Engineers. Due to the fact that the watershed for this lake 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 storm(s).

b. Drainage area = 0.819 square miles = 524 acres.

c. SCS parameters:

Time of Concentration (T_c) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$ = 0.276 hours

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

L = Length of longest watercourse = 0.686 miles

H = Elevation difference = 109 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 = 0.166 hours (0.60 Tc)

Hydrologic Soil Group = C (Primarily Hatton Series, per SCS Soil Survey Report)

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

2. Spillway releases for the drop inlet spillway were computed utilizing equations and nomographs presented in "Design of Small Dams" by the U. S. Department of the Interior (USDI) for drop inlet type spillways. The rise of the nappe above the elevation of the crest lip was conidered negligible. The following equation was used for crest control:

$$Q = C_o (2 \pi R_s) H_o^{3/2}$$

where "C_o" is a coefficient obtained from Figure 283 of the above reference, expressed in terms of H_o/R_s, "R_s" is the radius of the spillway crest, 1.58 feet, and "H_o" is the depth of flow over the crest.

When the ratio H_o/R_s reached a value of 1.00, inflow was determined by assuming flow was over a sharp edge submerged orifice. The following equation was used: $Q = Ca (2gh)^{0.5}$, where "C" is a coefficient assumed to be 0.6, "a" is the area of the orifice, 7.89 sf, "h" is the height of flow above the orifice, and "g" is acceleration due to gravity. Reference "Handbook of Hydraulics", Fifth Edition, by King & Brater, page 4-3.

Flow through the 24-inch diameter outlet pipe was determined using Bernoulli's equation for pressure flow in pipes. Losses, including throat, entrance, pipe and exit losses totaled 4.96 velocity heads. Reference "Handbook of Hydraulics", Fifth Edition, by King & Brater, pages 8-5 and 8-6.

Discharge quantities, determined by the methods described herein were plotted versus corresponding lake water surface elevations to determine the discharge rating curve for the drop inlet spillway.

3. The emergency spillway section consists of a broad-crested, trapezoidal section for which conventional weir formulas do not apply.

Spillway release rates were determined as follows:

a. Spillway crest section properties (area, "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 was computed as

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

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

d. The discharges for the principal and emergency spillways for equal elevations were summated for entry on the Y4 and Y5 cards.

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

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

```
A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF FOREST LAKE DAM
A3       RATIOS OF PMF ROUTED THROUGH RESERVOIR
B     288       0       5               0       0       0       0       0       0
B1      5
J       1       4       1
J1   0.18    0.19    0.50    1.00
K       0  INFLOW                                       1
K1       INFLOW HYDROGRAPH
M       1       2   0.819                   1.0                         1
P       0    25.0     102     120     130
T                                                      -1     -88
W2           0.164
X    -1.0    -.10     2.0
K       1     DAM                                       1
K1       RESERVOIR ROUTING BY MODIFIED PULS
Y                               1       1
Y1      1                                          341.13      -1
Y4  631.0   631.7   632.1   632.8   633.6   634.4   635.0   635.6   636.3   637.0
Y4  637.7   638.4   639.1   639.8
Y5      0      21      65     247     511     916    1238    1668    2217    2801
Y5   3446    4204    5016    5881
$A      0    30.1    41.7    60.4    88.2
$E  577.0   631.0     640     650     660
$$  631.0
$D  634.0
$L      0     102     250     367     502     833     913     951     985    1035
$V  634.0   634.6   635.0   635.1   635.2   635.4   635.9   636.0   637.3   641.[illegible]
K      99
```

```
1A1      ANALYSIS OF DAM OVERTOPPING USING 100 YR FLOOD
A2      HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF FOREST LAKE DAM
A3      100-YR FLOOD ROUTED THROUGH RESERVOIR
B      240       0       6                                               4
B1       5
J        1       1       1
J1    1.00
K        0   INFLOW                                     1
K1         INFLOW HYDROGRAPH
M        0       2   0.819                     1.0                       1
O      240   7.088
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1    .017    .017    .017    .017    .017    .017    .017    .017    .017    .017
O1    .017    .017    .017    .017    .017    .017    .017    .017    .017    .017
O1    .017    .017    .017    .017    .017    .017    .017    .017    .017    .017
O1    .028    .028    .028    .028    .028    .028    .028    .028    .028    .028
O1    .028    .028    .028    .028    .028    .035    .035    .035    .035    .035
O1    .072    .072    .072    .072    .072    .155    .156    .156    .295    .586
O1    .932    .375    .295    .156    .156    .072    .072    .072    .072    .072
O1    .035    .035    .035    .035    .035    .028    .028    .028    .028    .028
O1    .028    .028    .028    .028    .028    .028    .028    .028    .028    .028
```

100-YR. FLOOD (Con't.)

01	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017
01	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017
01	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
T							-1	-75		
W2		0.166								
X	-1.0	-.10	2.0							
K	1	DAM					1			
K1	RESERVOIR ROUTING BY MODIFIED PULS									
Y				1	1					
Y1	1						341.13	-1		
Y4	631.0	631.7	632.1	632.8	633.6	634.4	635.0	635.6	636.3	637.0
Y4	637.7	638.4	639.1	639.8						
Y5	0	21	65	247	511	916	1238	1668	2217	2801
Y5	3446	4204	5016	5891						
$A	0	30.1	48.7	68.4	80.2					
$E	597.0	631.0	640	650	660					
$$	631.0									
$D	634.0									
$L	0	102	253	347	582	833	913	951	985	1035
$V	634.0	634.6	635.0	635.1	635.2	635.4	635.9	636.0	637.3	641.9
K	99									

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF FOREST 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= .18 .19 .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	.82	0.00	.82	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	-88.00	0.00	0.00

CURVE NO = -88.00 WETNESS = -1.00 EFFECT CN = 88.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .17

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

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

UNIT HYDROGRAPH 12 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .17 VOL= 1.00

599. 1787. 1779. 1065. 533. 279. 146. 76. 40. 21.
12. 4.

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	1.	1.01	12.05	145	.21	.20	.01	465.
1.01	.10	2	.01	0.00	.01	1.	1.01	12.10	146	.21	.20	.01	722.
1.01	.15	3	.01	0.00	.01	1.	1.01	12.15	147	.21	.20	.01	980.

END-OF-PERIOD FLOW (Con't.)

1.01	.20	4	.01	0.00	.01	1.	1.01	12.20	148	.21	.21	.01	1135.
1.01	.25	5	.01	0.00	.01	1.	1.01	12.25	149	.21	.21	.01	1214.
1.01	.30	6	.01	0.00	.01	1.	1.01	12.30	150	.21	.21	.01	1257.
1.01	.35	7	.01	0.00	.01	1.	1.01	12.35	151	.21	.21	.01	1281.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.21	.21	.01	1294.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.21	.21	.01	1302.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.21	.21	.01	1307.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.21	.21	.01	1310.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.21	.21	.00	1313.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.26	.25	.01	1339.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.26	.25	.01	1415.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.26	.25	.00	1491.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.25	.25	.00	1537.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.26	.25	.00	1561.
1.01	1.30	18	.01	0.00	.01	0.	1.01	13.30	162	.26	.25	.00	1574.
1.01	1.35	19	.01	0.00	.01	0.	1.01	13.35	163	.26	.25	.00	1581.
1.01	1.40	20	.01	.00	.01	0.	1.01	13.40	164	.26	.25	.00	1586.
1.01	1.45	21	.01	.00	.01	0.	1.01	13.45	165	.26	.25	.00	1589.
1.01	1.50	22	.01	.00	.01	1.	1.01	13.50	166	.26	.25	.00	1591.
1.01	1.55	23	.01	.00	.01	2.	1.01	13.55	167	.26	.25	.00	1592.
1.01	2.00	24	.01	.00	.01	3.	1.01	14.00	168	.26	.25	.00	1594.
1.01	2.05	25	.01	.00	.01	5.	1.01	14.75	169	.31	.31	.00	1652.
1.01	2.10	26	.01	.00	.01	6.	1.01	14.10	170	.32	.32	.00	1746.
1.01	2.15	27	.01	.00	.01	8.	1.01	14.15	171	.32	.32	.00	1059.
1.01	2.20	28	.01	.00	.01	9.	1.01	14.20	172	.32	.32	.00	1927.
1.01	2.25	29	.01	.00	.01	11.	1.01	14.25	173	.32	.32	.00	1962.
1.01	2.30	30	.01	.00	.01	12.	1.01	14.30	174	.32	.32	.00	1980.
1.01	2.35	31	.01	.00	.01	14.	1.01	14.35	175	.32	.32	.00	1991.
1.01	2.40	32	.01	.00	.01	15.	1.01	14.40	176	.32	.32	.00	1996.
1.01	2.45	33	.01	.00	.01	16.	1.01	14.45	177	.32	.32	.00	2000.
1.01	2.50	34	.01	.00	.01	18.	1.01	14.50	178	.32	.32	.00	2002.
1.01	2.55	35	.01	.00	.01	19.	1.01	14.55	179	.32	.32	.00	2003.
1.01	3.00	36	.01	.00	.01	20.	1.01	15.00	180	.32	.32	.00	2004.
1.01	3.05	37	.01	.00	.01	21.	1.01	15.05	181	.19	.19	.00	1931.
1.01	3.10	38	.01	.00	.01	23.	1.01	15.10	182	.39	.38	.00	1825.
1.01	3.15	39	.01	.00	.01	24.	1.01	15.15	183	.39	.39	.00	1948.
1.01	3.20	40	.01	.00	.01	25.	1.01	15.20	184	.58	.58	.00	2275.
1.01	3.25	41	.01	.00	.01	26.	1.01	15.25	185	.68	.67	.00	2816.
1.01	3.30	42	.01	.00	.01	27.	1.01	15.30	186	1.65	1.64	.01	3977.
1.01	3.35	43	.01	.00	.01	28.	1.01	15.35	187	2.71	2.70	.01	6751.
1.01	3.40	44	.01	.00	.01	29.	1.01	15.40	188	1.07	1.06	.00	9605.
1.01	3.45	45	.01	.01	.01	30.	1.01	15.45	189	.68	.68	.00	9431.
1.01	3.50	46	.01	.01	.01	31.	1.01	15.50	190	.58	.58	.00	7521.
1.01	3.55	47	.01	.01	.01	32.	1.01	15.55	191	.39	.39	.00	5667.
1.01	4.00	48	.01	.01	.01	33.	1.01	16.00	192	.39	.39	.00	4319.
1.01	4.05	49	.01	.01	.01	34.	1.01	16.05	193	.30	.30	.00	3393.
1.01	4.10	50	.01	.01	.01	34.	1.01	16.10	194	.30	.30	.00	2751.
1.01	4.15	51	.01	.01	.01	35.	1.01	16.15	195	.30	.30	.00	2345.
1.01	4.20	52	.01	.01	.01	36.	1.01	16.20	196	.30	.30	.00	2121.

END-OF-PERIOD FLOW (Con't.)

1.01	4.25	53	.01	.01	.01	37.
1.01	4.30	54	.01	.01	.01	38.
1.01	4.35	55	.01	.01	.01	38.
1.01	4.40	56	.01	.01	.01	39.
1.01	4.45	57	.01	.01	.01	40.
1.01	4.50	58	.01	.01	.01	41.
1.01	4.55	59	.01	.01	.01	41.
1.01	5.00	60	.01	.01	.01	42.
1.01	5.05	61	.01	.01	.01	43.
1.01	5.10	62	.01	.01	.01	43.
1.01	5.15	63	.01	.01	.01	44.
1.01	5.20	64	.01	.01	.01	45.
1.01	5.25	65	.01	.01	.01	45.
1.01	5.30	66	.01	.01	.01	46.
1.01	5.35	67	.01	.01	.01	46.
1.01	5.40	68	.01	.01	.01	47.
1.01	5.45.	69	.01	.01	.01	48.
1.01	5.50	70	.01	.01	.01	48.
1.01	5.55	71	.01	.01	.01	49.
1.01	6.00	72	.01	.01	.01	49.
1.01	6.05		.06	.04	.03	67.
1.01	6.10	74	.06	.04	.02	119.
1.01	6.15	75	.06	.04	.02	174.
1.01	6.20	76	.06	.04	.02	211.
1.01	6.25	77	.06	.04	.02	233.
1.01	6.30	78	.06	.04	.02	248.
1.01	6.35	79	.06	.04	.02	259.
1.01	6.40	80	.06	.04	.02	268.
1.01	6.45	81	.06	.05	.02	275.
1.01	6.50	82	.06	.05	.02	281.
1.01	6.55	83	.06	.05	.02	287.
1.01	7.00	84	.06	.05	.01	292.
1.01	7.05	85	.06	.05	.01	297.
1.01	7.10	86	.06	.05	.01	301.
1.01	7.15	87	.06	.05	.01	305.
1.01	7.20	88	.06	.05	.01	309.
1.01	7.25	89	.06	.05	.01	313.
1.01	7.30	90	.06	.05	.01	316.
1.01	7.35	91	.06	.05	.01	320.
1.01	7.40	92	.06	.05	.01	323.
1.01	7.45	93	.06	.05	.01	325.
1.01	7.50	94	.06	.05	.01	328.
1.01	7.55	95	.06	.05	.01	331.
1.01	8.00	96	.06	.05	.01	333.
1.01	8.05	97	.06	.05	.01	335.
1.01	8.10	98	.06	.05	.01	337.
1.01	8.15	99	.06	.05	.01	339.
1.01	8.20	100	.06	.05	.01	341.
1.01	16.25	197	.30	.30	.00	2004.
1.01	16.30	198	.30	.30	.00	1937.
1.01	16.35	199	.30	.30	.00	1904.
1.01	16.40	200	.30	.30	.00	1891.
1.01	16.45	201	.30	.30	.00	1885.
1.01	16.50	202	.30	.30	.00	1883.
1.01	16.55	203	.30	.30	.00	1882.
1.01	17.00	204	.30	.30	.00	1882.
1.01	17.05	205	.23	.23	.00	1844.
1.01	17.10	206	.23	.23	.00	1730.
1.01	17.15	207	.23	.23	.00	1617.
1.01	17.20	208	.23	.23	.00	1549.
1.01	17.25	209	.23	.23	.00	1515.
1.01	17.30	210	.23	.23	.00	1498.
1.01	17.35	211	.23	.23	.00	1488.
1.01	17.40	212	.23	.23	.00	1484.
1.01	17.45	213	.23	.23	.00	1481.
1.01	17.50	214	.23	.23	.00	1480.
1.01	17.55	215	.23	.23	.00	1479.
1.01	18.00	216	.23	.23	.00	1479.
1.01	18.05	217	.02	.02	.00	1351.
1.01	18.10	218	.02	.02	.00	972.
1.01	18.15	219	.02	.02	.00	873.
1.01	18.20	220	.02	.02	.00	[illegible]
1.01	18.25	221	.02	.02	.00	[illegible]
1.01	18.30	222	.02	.02	.00	[illegible]
1.01	18.35	223	.02	.02	.00	681.
1.01	18.40	224	.02	.02	.00	[illegible]
1.01	18.45	225	.02	.02	.00	553.
1.01	18.50	226	.02	.02	.00	551.
1.01	18.55	227	.02	.02	.00	516.
1.01	19.00	228	.02	.02	.00	481.
1.01	19.05	229	.02	.02	.00	449.
1.01	19.10	230	.02	.02	.00	419.
1.01	19.15	231	.02	.02	.00	391.
1.01	19.20	232	.02	.02	.00	365.
1.01	19.25	233	.02	.02	.00	340.
1.01	19.30	234	.02	.02	.00	318.
1.01	19.35	235	.02	.02	.00	296.
1.01	19.40	236	.02	.02	.00	277.
1.01	19.45	237	.02	.02	.00	258.
1.01	19.50	238	.02	.02	.00	241.
1.01	19.55	239	.02	.02	.00	225.
1.01	20.00	240	.02	.02	.00	210.
1.01	20.05	241	.02	.02	.00	196.
1.01	20.10	242	.02	.02	.00	182.
1.01	20.15	243	.02	.02	.00	170.
1.01	20.20	244	.02	.02	.00	159.

END-OF-PERIOD FLOW (Con't.)

1.01	8.25	101	.06	.05	.01	343.	1.01	20.25	245	.02	.02	.00	149.
1.01	8.30	102	.06	.05	.01	345.	1.01	20.30	246	.02	.02	.00	136.
1.01	8.35	103	.06	.06	.01	347.	1.01	20.35	247	.02	.02	.00	132.
1.01	8.40	104	.06	.06	.01	348.	1.01	20.40	248	.02	.02	.00	132.
1.01	8.45	105	.06	.06	.01	350.	1.01	20.45	249	.02	.02	.00	132.
1.01	8.50	106	.06	.06	.01	351.	1.01	20.50	250	.02	.02	.00	132.
1.01	8.55	107	.06	.06	.01	352.	1.01	20.55	251	.02	.02	.00	132.
1.01	9.00	108	.06	.06	.01	354.	1.01	21.00	252	.02	.02	.00	132.
1.01	9.05	109	.06	.05	.01	355.	1.01	21.05	253	.02	.02	.00	132.
1.01	9.10	110	.06	.06	.01	356.	1.01	21.10	254	.02	.02	.00	132.
1.01	9.15	111	.06	.06	.01	357.	1.01	21.15	255	.02	.02	.00	132.
1.01	9.20	112	.06	.06	.01	358.	1.01	21.20	256	.02	.02	.00	132.
1.01	9.25	113	.06	.06	.01	359.	1.01	21.25	257	.02	.02	.00	132.
1.01	9.30	114	.06	.06	.01	360.	1.01	21.30	258	.02	.02	.00	132.
1.01	9.35	115	.06	.06	.01	361.	1.01	21.35	259	.02	.02	.00	132.
1.01	9.40	116	.06	.06	.01	362.	1.01	21.40	260	.02	.02	.00	132.
1.01	9.45	117	.06	.06	.00	363.	1.01	21.45	261	.02	.02	.00	132.
1.01	9.50	118	.06	.06	.00	364.	1.01	21.50	262	.02	.02	.00	132.
1.01	9.55	119	.06	.06	.00	365.	1.01	21.55	263	.02	.02	.00	132.
1.01	10.00	120	.06	.06	.00	366.	1.01	22.00	264	.02	.02	.00	132.
1.01	10.05	121	.06	.06	.00	366.	1.01	22.05	265	.02	.02	.00	132.
1.01	10.10	122	.06	.06	.00	367.	1.01	22.10	266	.02	.02	.00	132.
1.01	10.15	123	.06	.06	.00	368.	1.01	22.15	267	.02	.02	.00	132.
1.01	10.20	124	.06	.06	.00	369.	1.01	22.20	268	.02	.02	.00	132.
1.01	10.25	125	.06	.06	.00	369.	1.01	22.25	269	.02	.02	.00	132.
1.01	10.30	126	.06	.06	[illegible]	370.	1.01	22.30	270	.02	.02	.00	132.
1.01	10.35	127	.06	[illegible]	[illegible]	370.	1.01	22.35	271	.02	.02	.00	132.
1.01	10.40	128	.06	[illegible]	[illegible]	371.	1.01	22.40	272	.02	.02	.00	132.
1.01	10.45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.01	22.45	273	.02	.02	.00	132.
1.01	10.50	130	.06	.06	.00	372.	1.01	22.50	274	.02	.02	.00	132.
1.01	10.55	131	.06	.06	.00	373.	1.01	22.55	275	.02	.02	.00	132.
1.01	11.00	132	.06	.06	.00	373.	1.01	23.00	276	.02	.02	.00	132.
1.01	11.05	133	.06	.06	.00	374.	1.01	23.05	277	.02	.02	.00	132.
1.01	11.10	134	.06	.06	.00	374.	1.01	23.10	278	.02	.02	.00	132.
1.01	11.15	135	.06	.06	.00	375.	1.01	23.15	279	.02	.02	.00	132.
1.01	11.20	136	.06	.06	.00	375.	1.01	23.20	280	.02	.02	.00	132.
1.01	11.25	137	.06	.06	.00	376.	1.01	23.25	281	.02	.02	.00	132.
1.01	11.30	138	.06	.06	.00	376.	1.01	23.30	282	.02	.02	.00	132.
1.01	11.35	139	.06	.06	.00	376.	1.01	23.35	283	.02	.02	.00	132.
1.01	11.40	140	.06	.06	.00	377.	1.01	23.40	284	.02	.02	.00	132.
1.01	11.45	141	.06	.06	.00	377.	1.01	23.45	285	.02	.02	.00	132.
1.01	11.50	142	.06	.06	.00	378.	1.01	23.50	286	.02	.02	.00	132.
1.01	11.55	143	.06	.06	.00	378.	1.01	23.55	287	.02	.02	.00	132.
1.01	12.00	144	.06	.06	.00	378.	1.02	0.00	288	.02	.02	.00	132.
									SUM	32.50	30.92	1.58	202572.
										(825.)	(785.)	(40.)	(5736.20)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	9609.	2206.	703.	703.	202504.
CMS	272.	62.	20.	20.	5734.
INCHES		25.06	31.95	31.95	31.95
MM		636.57	811.42	811.42	811.42
AC-FT		1094.	1395.	1395.	1395.
THOUS CU M		1350.	1720.	1720.	1720.

SURFACE AREA=	0.	30.	49.	68.	88.
CAPACITY=	0.	341.	792.	1275.	2056.
ELEVATION=	597.	631.	640.	650.	660.

SUMMARY OF DAM SAFETY ANALYSIS
PMF

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	631.00	631.00	634.00
STORAGE	341.	341.	440.
OUTFLOW	0.	0.	714.

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
.18	633.94	0.00	430.	[illegible]	0.00	16.08	0.00
.19	634.04	.04	441.	732.	.25	16.08	0.00
.50	635.80	1.80	508.	[illegible]	4.00	15.83	0.00
1.00	636.70	2.70	544.	[illegible]	6.58	15.75	0.00

SUMMARY OF DAM SAFETY ANALYSIS

100-YR. FLOOD

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	631.00	631.00	634.00
STORAGE	341.	341.	440.
OUTFLOW	0.	0.	714.

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	[illegible]	0.00	[illegible]	[illegible]	0.00	12.70	0.00