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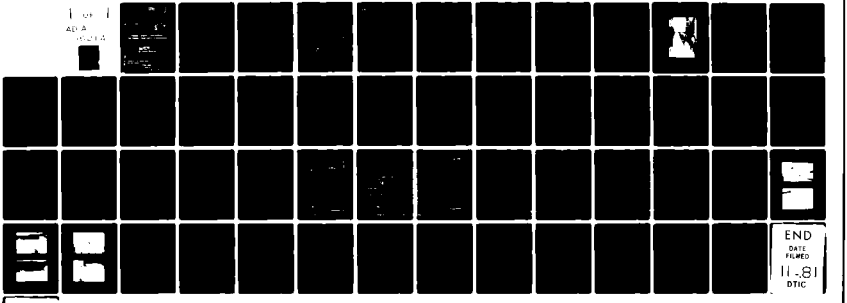

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MISSOURI - KANSAS CITY BASIN

STARK LAKE DAM

WARREN COUNTY, MISSOURI

MO 30516

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
St. Louis District

PREPARED BY U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
FOR STATE OF MISSOURI

OCTOBER 1980

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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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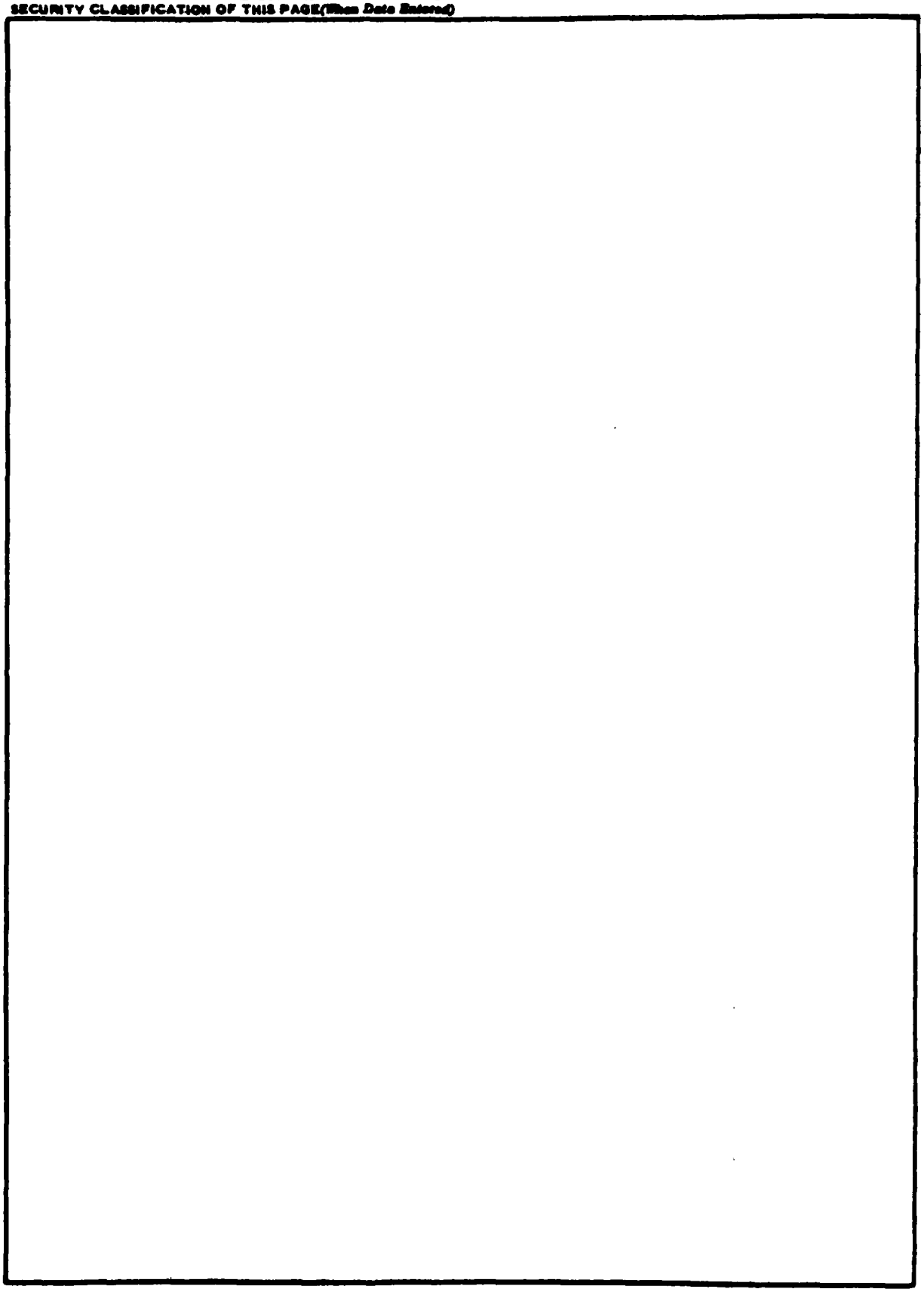

MISSOURI - KANSAS CITY BASIN

STARK LAKE DAM

WARREN COUNTY, MISSOURI

MO 30516

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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

St. Louis District

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

FOR: STATE OF MISSOURI

OCTOBER 1980

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: Stark Lake Dam, MO 30516, Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Stark Lake Dam (MO 30516):

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

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

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

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

SUBMITTED BY: SIGNED
Chief, Engineering Division

28 OCT 1980
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

28 OCT 1980
Date

STARK LAKE DAM

MISSOURI INVENTORY NO. 30516

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:	Stark Lake Dam
State Located:	Missouri
County Located:	Warren
Stream:	Tributary of the North Fork of Charrette Creek
Date of Inspection:	26 June 1980

Stark 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 satisfactory. ~~However, 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. Erosion of the grass covered upstream face of the dam apparently by wave action and/or fluctuations of the lake surface level has created a near vertical bank up to about 12 inches high above the normal waterline. A grass covered slope is not considered adequate protection to prevent erosion by wave action or fluctuations of the lake level. Loss of material due to erosion can impair the structural stability of the dam.

2. Wire mesh type fencing is located across the upstream end of the spillway pipes. The fencing could act as a barrier upon which lake carried debris can lodge and prevent lake outflow from entering the spillway pipes. Blockage of the spillway pipes may result in excessive flooding of the lake and possible overtopping of the dam.

3. Several holes believed to be old animal burrows exist along the upstream face of the dam. Animal burrows can provide passageways for seepage that could develop into a piping condition (progressive internal erosion) resulting in failure of the dam.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Stark Lake Dam, which is classified as intermediate in size and of high hazard potential, is specified to be the Probable Maximum Flood (PMF). The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Results of a hydrologic/hydraulic analysis indicated that the spillway is inadequate to pass lake outflow resulting from a storm of PMF magnitude without overtopping the dam. The spillway is capable, however, of passing lake outflow resulting from the one percent chance (100-year frequency) flood and the outflow corresponding to about 25 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 four miles. Accordingly, within the possible damage zone are a small lake and four dwellings.

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 in the near future to correct or control the deficiencies and safety defects reported herein. The provision of additional spillway capacity should be pursued on a high priority basis.

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 STARK LAKE DAM

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
STARK LAKE DAM - MO 30516

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

STARK LAKE DAM - MO 30516

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 safetv 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 Stark 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 Stark Lake Dam is an earthfill type embankment rising approximately 40 feet above the original streambed at the downstream toe of the barrier. The embankment has an upstream slope (above the waterline) of 1v on 5.0h, a crest width of about 11 feet, and a downstream slope on the order of 1v on 2.8h. The length of the dam is approximately 470 feet. A roadway covered with crushed stone traverses the dam crest. 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 8 acres.

The spillway, a culvert consisting of three 24-inch diameter corrugated metal pipes, is located at the right abutment. The pipes are uncontrolled. Concrete pavement serves to protect the surface above the pipes through the spillway area. It is likely that this section of the abutment protected by concrete pavement was intended to be an emergency outlet; however, survey data obtained during the inspection indicated the crest of the section above the pipes to be the same elevation as the low area of the dam, which negates its use as an outlet prior to dam overtopping. A profile of the spillway is shown on Plate 4.

b. Location. The dam is located on an unnamed tributary of the North Fork of Charrette Creek, about 2.5 miles south of the junction of Highway M and Schuetzen Ground Road; about 4.5 miles southeast of Warrenton, Missouri, as shown on the Regional Vicinity Map, Plate 1. The dam is located in the southwest quadrant of Section 1, Township 46 North, Range 2 West, within Warren County.

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

d. Hazard Classification. Stark 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 four miles downstream of the dam. Within the possible damage zone are a small lake and four dwellings. 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 Raymond Stark. Mr. Stark's address is: Route 3, Box 304A, Warrenton, Missouri 63383.

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

g. Design and Construction History. According to Mr. Alvin D. Vitt, the original dam owner, the dam was constructed in 1967 by the Hutchison Schaper Excavating Company of Wright City, Missouri. Mr. Vitt also reported that the U.S. Department of Agriculture, Agricultural Service Center (ASC) assisted during construction of the dam. However, Mr. Ray Ridder of the Warren County ASC reported that there are no longer any records available in their files regarding the design or construction of the dam. The extent of any engineering investigations is unknown.

h. Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the capacities of three 24-inch diameter pipes.

1.3 PERTINENT DATA

a. Drainage Area. The drainage area tributary to the lake is for the most part in a native state covered with timber. The watershed above the dam amounts to approximately 80 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

(1) Estimated known maximum flood at damsite ... 45 cfs* (W.S. Elev. 796.3)

(2) Spillway capacity ... 64 cfs (W.S. Elev. 797.4)

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.

*Based on an estimate of depth of flow at spillway as observed by the Owner.

(1) Observed pool ... 794.8

(2) Normal pool ... 795.0

(3) Spillway crest ... 795.0

(4) Maximum experienced pool ... 796.3*

(5) Top of dam ... 797.4 (min.)

(6) Streambed at centerline of dam ... 760 ± (Est.)

(7) Maximum tailwater ... Unknown

(8) Observed tailwater ... None

d. Reservoir.

(1) Length at normal pool (Elev. 795.0) ... 1,000 ft.

(2) Length at maximum pool (Elev. 797.4) ... 1,100 ft.

e. Storage.

(1) Normal pool ... 89 ac. ft.

(2) Top of dam (incremental) ... 24 ac. ft.

f. Reservoir Surface.

(1) Normal pool ... 8 acres

(2) Top of dam (incremental) ... 5 acres

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

(1) Type ... Earthfill

(2) Length ... 470 ft.

(3) Height ... 40 ft.

(4) Top width ... 11 ft.

*Based on an estimate of depth of flow at spillway as observed by the Owner.

(5) Side slopes

a. Upstream ... 1v on 5.0h (above waterline)

b. Downstream ... 1v on 2.8h

(6) Cutoff ... Core trench*

(7) Slope protection

a. Upstream ... Railroad ties (below normal waterline) and grass

b. Downstream ... Grass

h. Spillway.

(1) Type ... Culvert, uncontrolled, three 24-inch diameter corrugated metal pipes

(2) Location ... Right abutment

(3) Crest ... Elevation 795.0

(4) Approach channel ... Lake

(5) Exit channel ... Earth cut, irregular trapezoidal section

i. Emergency Spillway ... Ineffective, crest elevation same as low point of top of dam

j. Lake Drawdown Facility ... None

*Per the Owner of the property when the dam was constructed.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

According to Mr. Alvin D. Vitt, the owner of the property at the time the dam was constructed, the Warren County Agricultural Service Center (ASC) provided some assistance, but the extent of the design work performed is unknown. Mr. Hutchison, the dam builder, recalled that plans had been prepared; however, plans or records of the design are no longer available from the ASC, the former owner, or the present owner.

2.2 CONSTRUCTION

No formal records were maintained during construction of the dam. As previously stated, Stark Lake was constructed in 1967 by the Hutchison Schaper Excavating Company of Wright City, Missouri. An interview with Mr. Hutchison indicated that a core trench 10 to 15 feet wide was excavated to rock, some of which was solid. He also reported that most of the fill for the dam was clay taken from the area north of the entrance road to the dam. According to Mr. Vitt, the fill for the core was compacted with a sheepsfoot roller.

2.3 OPERATION

The lake level is uncontrolled and governed by the elevation of the three spillway pipes which are located at the right abutment. No indication was found that the dam had been overtopped. The Owner of the dam, Mr. Raymond Stark, reported that the dam has never been overtopped and that the highest lake surface elevation he had observed occurred in April of 1979, when the spillway pipes were about two-thirds full, or about 1.3 feet above the normal pool elevation.

2.4 EVALUATION

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

b. Adequacy. No data available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Stark Lake Dam was made by Horner & Shifrin engineering personnel, R. E. Sauthoff, Civil Engineer, and A. B. Becker, Jr., Civil and Soils Engineer, on 26 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-3 of Appendix A. The locations of the photographs taken during the inspection are indicated on Plate 4.

b. Site Geology. Stark Lake Dam is located near the southern edge of the Dissected Till Plains Section of the Central Lowlands Physiographic Province. The topography is moderately sloping with 45 to 50 feet of relief between the lake site and the surrounding drainage divides. The bedrock formations consist of Mississippian-age limestones of the undifferentiated Chouteau group. The bedrock dips slightly to the north, and no faults were observed or are reported to be present in this area.

The Chouteau group consists of finely crystalline, sometimes argillaceous, thinly-to-thickly-bedded limestones. The limestones are susceptible to solution weathering and may exhibit solution-enlarged joints or bedding planes, sinkholes, and a highly irregular bedrock surface, all of which may contribute to reservoir leakage. The only bedrock exposures noted at the site were highly weathered remnants in the stream channel below the dam. Although any surface expression of karst development is masked by residuum and glacial deposits, these exposures indicate a great deal of solution weathering, and karst features should be expected.

The unconsolidated surficial materials of the area consist of residual clays, glacial till, and loess. The valley floor in the dam and reservoir

area is covered with the Goss series soils. This series consists of deep, well-drained soils formed in material weathered from cherty limestone. The soil typically ranges from a dark grayish-brown to brown, very cherty, silty clay at the surface to a yellowish-brown, firm, very cherty clay at depth. According to the Unified Soil Classification System, the soil ranges from a GM to GC material, is moderately permeable, and compressible. Seepage from water impoundments is common in these soils. The valley walls are covered with soils of the Keswick series. These soils are deep, moderately well-drained materials formed in glacial deposits. They are dark grayish-brown silts near the surface and become more clayey with depth. These soils are mixed with loessal deposits of the Hatton series which are predominant on the ridges. The soils are classified CL or CL-ML materials, are low in permeability, and may be susceptible to erosion.

There appears to be no significant geotechnical problem at the site. No adverse geologic conditions were observed that would be considered to severely affect the performance of the reservoir or the stability of the embankment.

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 examined and except as indicated herein appeared to be in sound condition. No settlement, horizontal misalignment or cracking of the dam was noticed, nor was any seepage evident. However, erosion along the upstream face of the dam, apparently by wave action, has created a near vertical bank which extends about 12 inches above the normal waterline. Railroad ties that were placed in a sawtooth pattern (see Photo 6) just below the normal waterline on what appeared to be a wave berm, extended along the upstream face of the dam. There was also evidence of old animal burrows at several locations along the upstream face of the dam. An examination of the surficial material of the dam indicated it to be a silty lean clay (CL) of medium plasticity.

Both the upstream and downstream faces of the dam were covered with a fescue type grass which was about 30 inches tall at the time of the inspection. No trees were noted on the embankment proper. The crushed stone road that extends the length of the dam was found to be in good condition without potholes or ruts. Two power poles were observed on the downstream slope of the dam near the crest.

The three 24-inch diameter corrugated metal spillway pipes (see Photos 3 and 4) as well as the concrete headwalls at the pipe ends and the concrete pavement above the pipes appeared to be in sound condition. No major cracks or spalling of the surface of the concrete was noticed. The upstream ends of the spillway pipes were covered with a length of wire mesh type fencing material. Openings in the mesh were about 1 inch across. Some minor debris was found near the upstream end of the spillway pipes. The earthen discharge channel (see Photo 5), an irregular trapezoidal section in satisfactory condition, joins the original stream approximately 200 feet downstream of the centerline of the dam. The course of the spillway outlet channel was away from the embankment.

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

e. Downstream Channel. A dam extends across the channel at a location approximately 2000 feet downstream of the Stark Lake Dam and impounds a lake with a surface area of about 1 acre. The remainder of the downstream channel is unimproved.

f. Reservoir. With the exception of a grass covered area with two dwellings and a maintenance building that lies just northeast of the dam, the hillsides surrounding the lake are in a native state covered with timber. At the time of the inspection, the lake water surface elevation was about 0.2 foot below normal pool and the water within the reservoir was essentially clear. The amount of sediment within the lake at the time of inspection could not be determined; however, due to the vegetation covering the surrounding area, it is believed to be insignificant.

3.2 EVALUATION

The wave berm and railroad ties along the upstream face of the dam did not appear to provide adequate protection of the upstream face from erosion by wave action and/or fluctuations of the lake surface above the normal waterline.

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

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

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

4.2 MAINTENANCE OF DAM

The inspection team is of the opinion that the dam is well maintained. According to the Owner, the grass on the embankment is cut periodically and muskrats are removed from the dam when found.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist at this dam, and there is no reservoir regulating 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

It is recommended that maintenance of the dam include more frequent cutting of grass on the slopes during the growing season. Measures should be taken to prevent further erosion of the upstream face at the normal waterline and to prevent burrowing animals from damaging the dam. It is also recommended that a detailed inspection of the dam be instituted on a regular basis by an engineer experienced in the design and construction of dams and that records be kept of all inspections made and remedial measures taken.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data were not available.

b. Experience Data. The drainage area and lake surface area were developed from the 1972 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.

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 occurrence of the PMF and the probabilistic storm.

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

c. Visual Observations.

(1) The spillway consists of three 24-inch diameter corrugated metal pipes about 31 feet long. The spillway, a culvert type structure, passes through the abutment at the right side of the dam.

(2) The concrete paved section above the spillway pipes appeared to be constructed as an emergency spillway, but survey data obtained during the inspection indicated that the elevation of the pavement was the same as that of the low area of the dam.

(3) The spillway outlet channel directs flow away from the embankment and joins the original stream channel about 200 feet downstream of the dam. Spillway releases within the capacity of the spillway pipes will not endanger the dam.

d. Overtopping Potential. The spillway is inadequate to pass the probable maximum flood, or 1/2 the probable maximum flood, without overtopping the dam. The 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. 797.4)	Duration of Overtopping of Dam (Hrs.)
0.50	675	798.2	0.8	4.3
1.00	1,464	798.6	1.2	7.0

Elevation 797.4 was found to be the elevation of the low area of the dam crest. The flow safety passing the spillway just prior to overtopping amounts to approximately 64 cfs, which is the routed outflow corresponding to about 25 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 1.2 feet and, except for a 20-foot long section just to the left of the spillway pipes, overtopping will extend across the entire length of the dam.

e. Evaluation. Experience with embankments constructed of similar material (a silty lean clay of medium plasticity) to that used to construct this dam have shown evidence that the material under certain 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 1.2 feet, and the duration of flow over the dam, 7.0 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 within the scope of these investigations; 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 spillway 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 and the 100-year frequency flood are shown on pages B-3 and B-5. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-6 through B-9; tabulation of lake surface area, elevation and storage volume is shown on page B-10 and tabulation titled "Summary of Dam Safety Analysis" for the PMF and 1 percent chance (100-year frequency) flood are also shown on page B-10.

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 the Owner, no records are kept of the lake level, spillway discharge, dam settlement, or seepage.

d. Post Construction Changes. Information available indicated that no post construction changes have been made or have occurred which would affect the structural stability of the dam.

e. Seismic Stability. The dam is located 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 spillway is capable of passing lake outflow of about 64 cfs without the level of the lake exceeding the low area in the top of the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicated that for storm runoff of probable maximum flood magnitude, the lake outflow would be on the order of 1,464 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 52 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 old animal burrows on the upstream face of the dam, erosion of the upstream face, and the mesh type fencing material across the upstream end of the spillway outlet pipes.

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 assessment of the hydrology of the watershed and capacity of the spillway were based on a hydrologic/hydraulic study as indicated in Section 5. Seepage and stability analyses comparable to the requirements of the "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 sometime in the near future. The item recommended in paragraph 7.2a concerning spillway capacity should be pursued on a high priority basis.

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 to pass lake outflow resulting from a storm of probable maximum flood magnitude, which is the recommended spillway design flood for this dam.

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

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

(1) Restore the eroded areas and the locations damaged by burrowing animals along the upstream face of the dam. Provide some form of protection other than grass at and above the normal waterline to prevent erosion. A grass covered slope is not considered adequate protection to prevent erosion by wave action or by a fluctuating lake level.

(2) Remove the wire mesh fencing material from the upstream ends of the spillway pipes in order to prevent clogging of the pipes and/or restriction of flow into the pipes. A reduction in spillway capacity could result in unwarranted flooding of the lake and possible overtopping of the dam.

(3) 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.

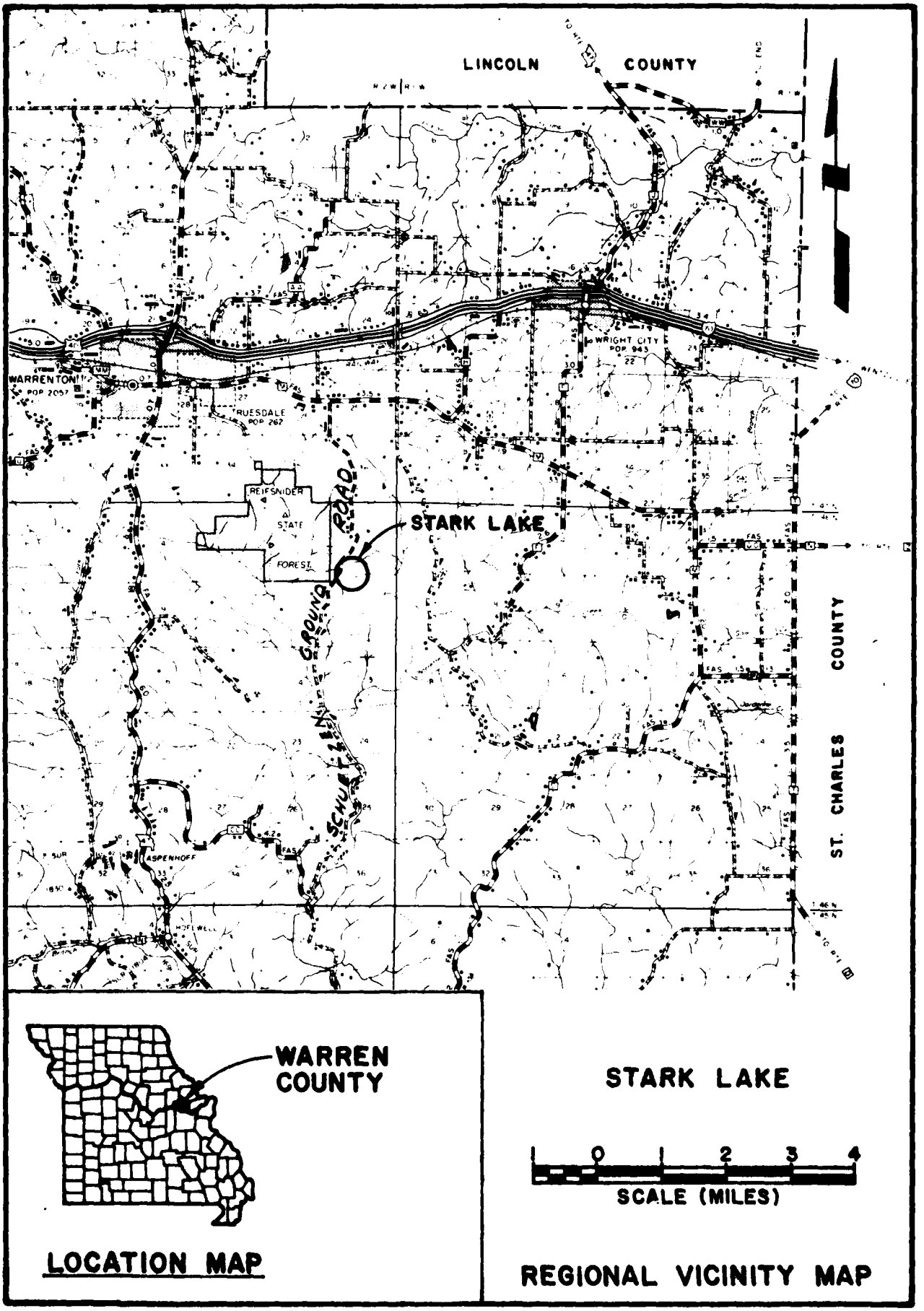
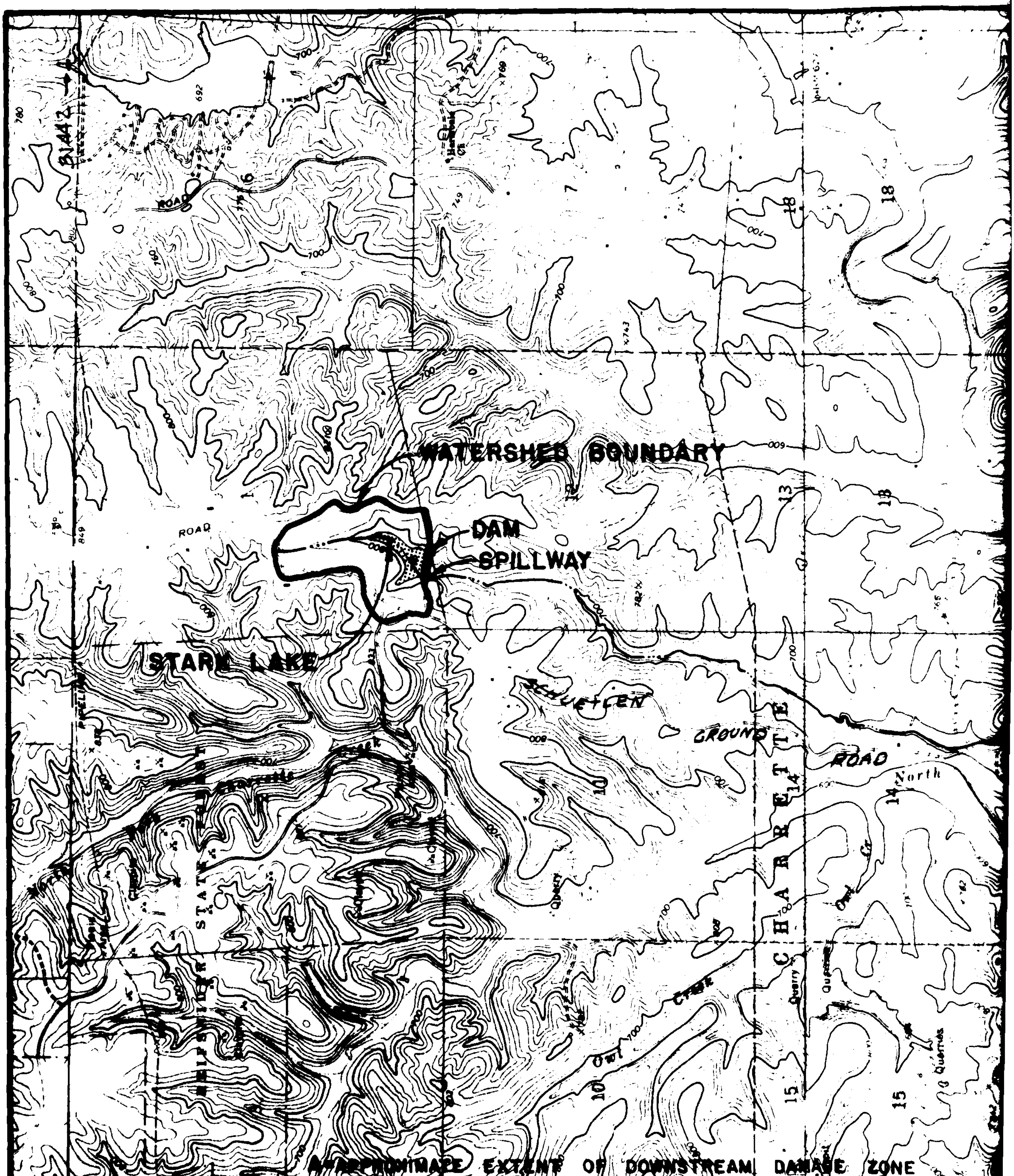

LINCOLN COUNTY
WARRENTON
POP 2057
TRUESDALE
POP 262
WRIGHT CITY
POP 943
REIFSNIDER
STATE
FOREST
STARK LAKE
GROUND
ROAD
SCHUETZEN
ASPENHOFF
HOFFWELL
ST. CHARLES COUNTY
WARREN
COUNTY
LOCATION MAP
STARK LAKE
0 2 3 4
SCALE (MILES)
REGIONAL VICINITY MAP

PLATE 1



WATERSHED BOUNDARY
DAM
SPILLWAY
STARK LAKE
ROAD
SCHUETZEN
GROUND
ROAD
CHARRETTE
North
Owl
Creek
APPROXIMATE EXTENT OF DOWNSTREAM DAMAGE ZONE

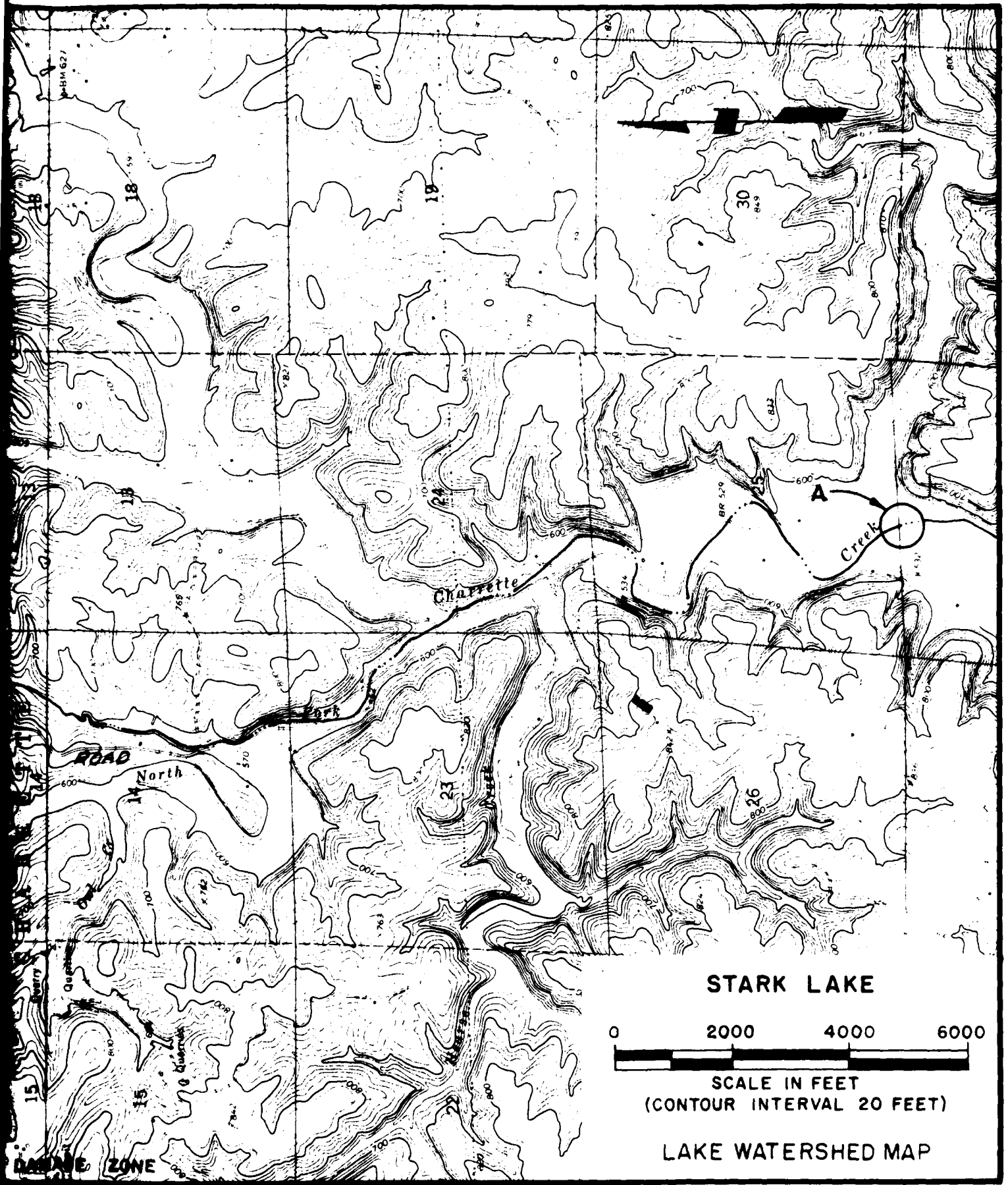
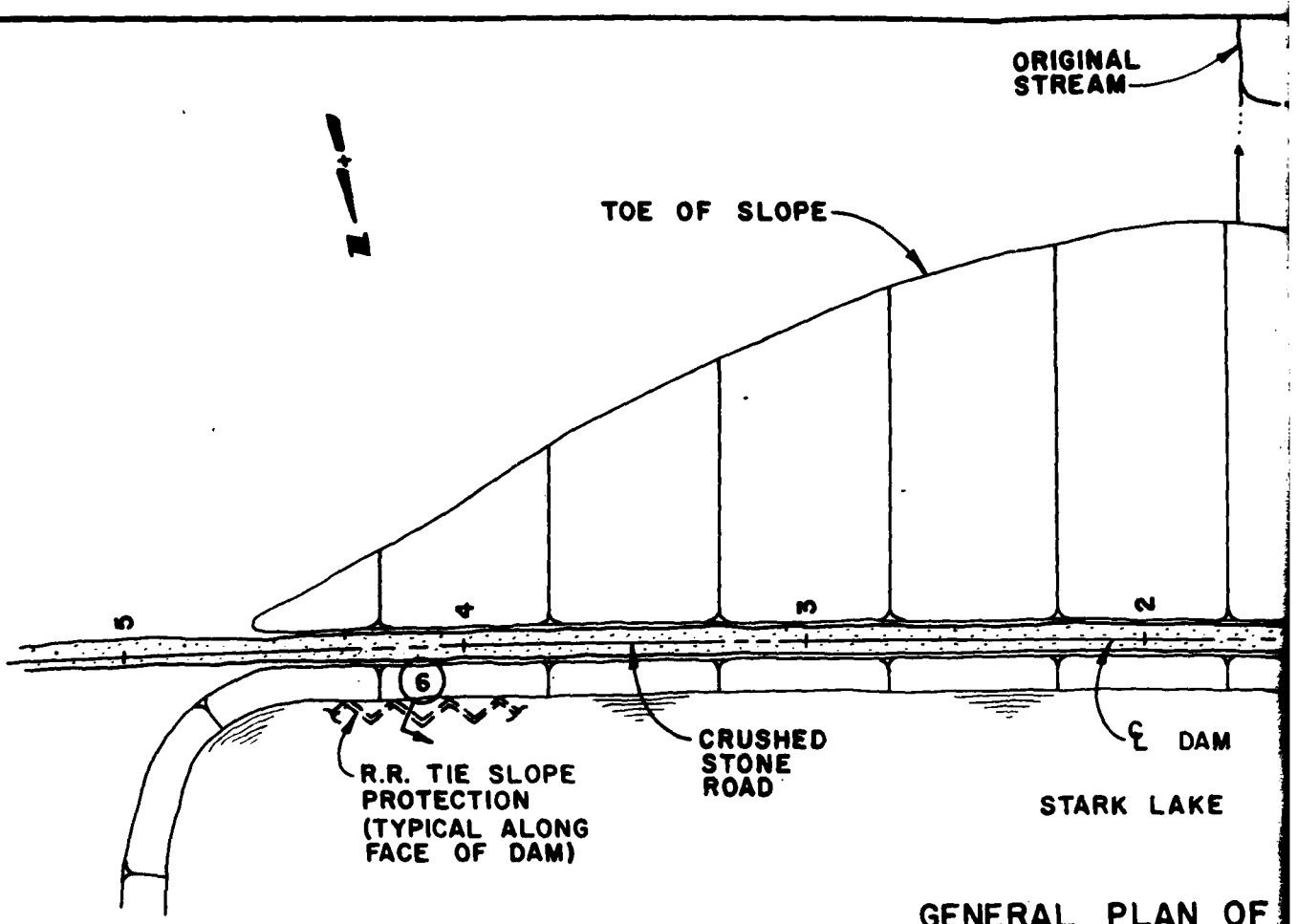
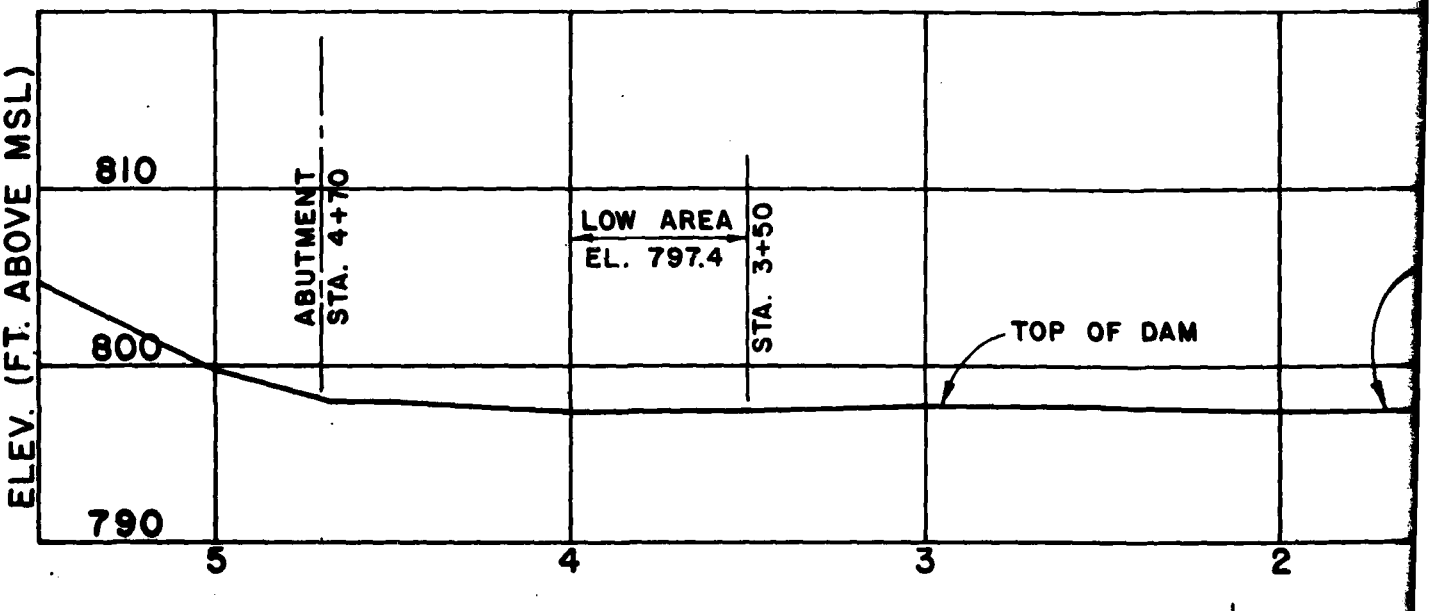

A
Creek
Charrette
ROAD
North
STARK LAKE
0 2000 4000 6000
SCALE IN FEET
(CONTOUR INTERVAL 20 FEET)
LAKE WATERSHED MAP

PLATE 2

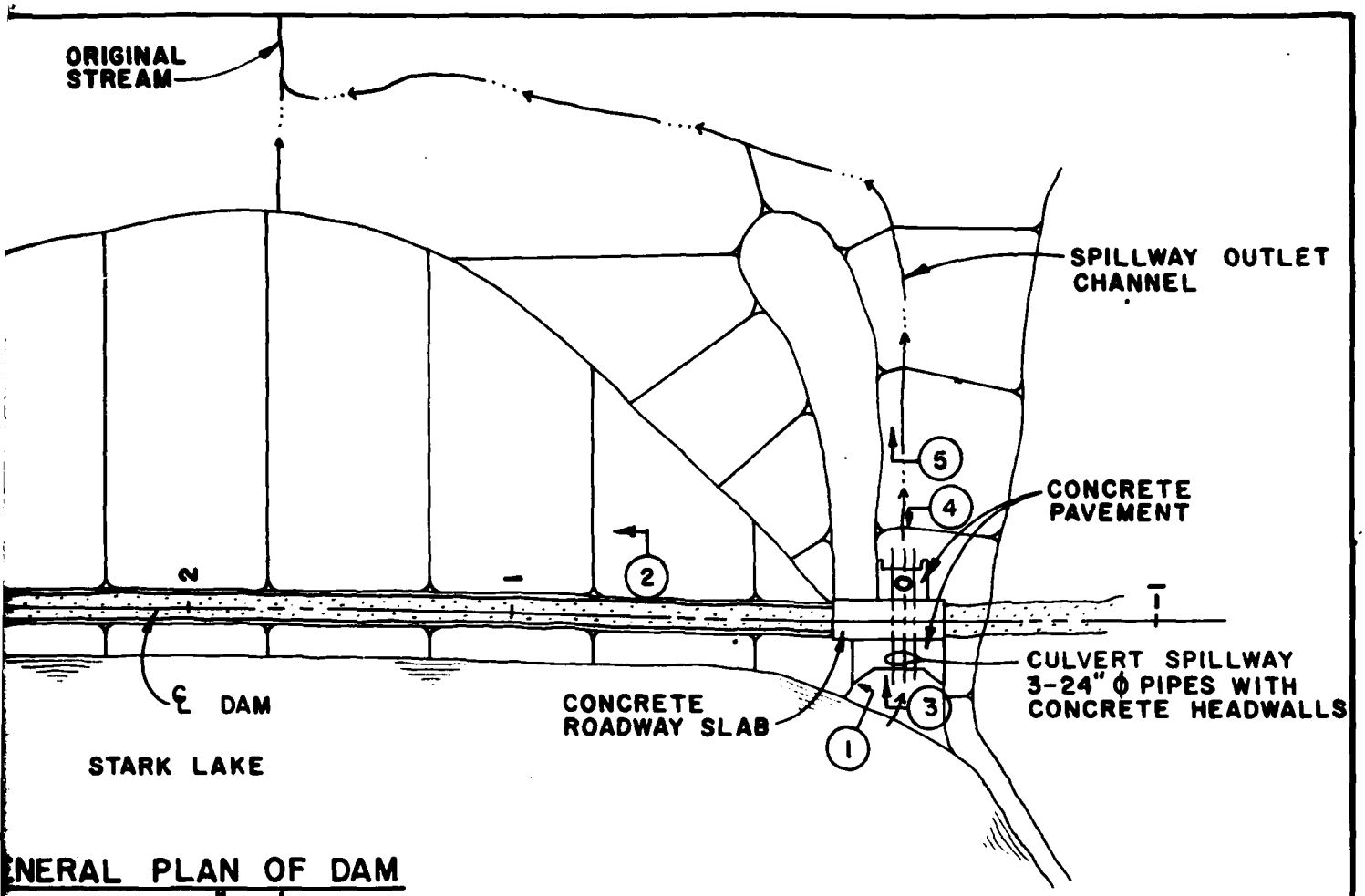


GENERAL PLAN OF
SCALE: 1"=50'

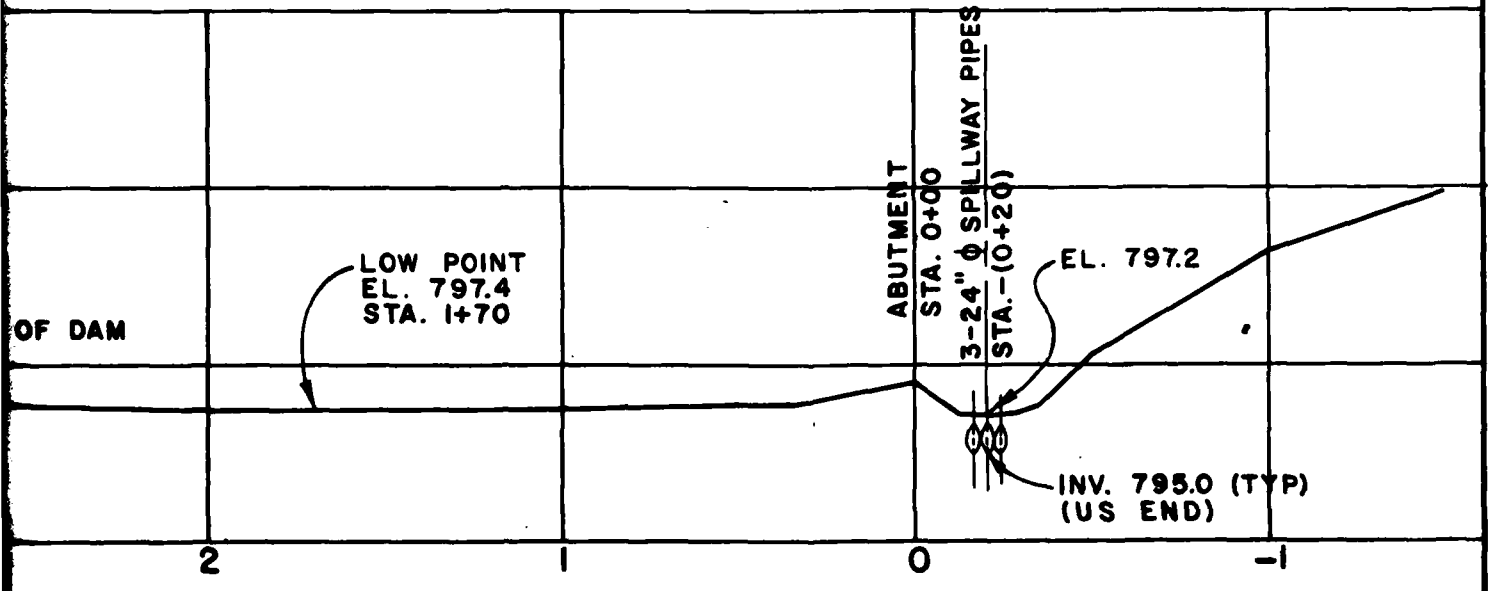


PROFILE DAM C
SCALES: 1"=10'V., 1"=5

6
PHOTO LOCATION & KEY
(SEE APPENDIX A)



ENERAL PLAN OF DAM
SCALE: 1"=50'



PROFILE DAM CREST
SCALES: 1"=10'V., 1"=50' H.

STARK LAKE
DAM PLAN & PROFILE

Horner & Shifrin, Inc. August 1980

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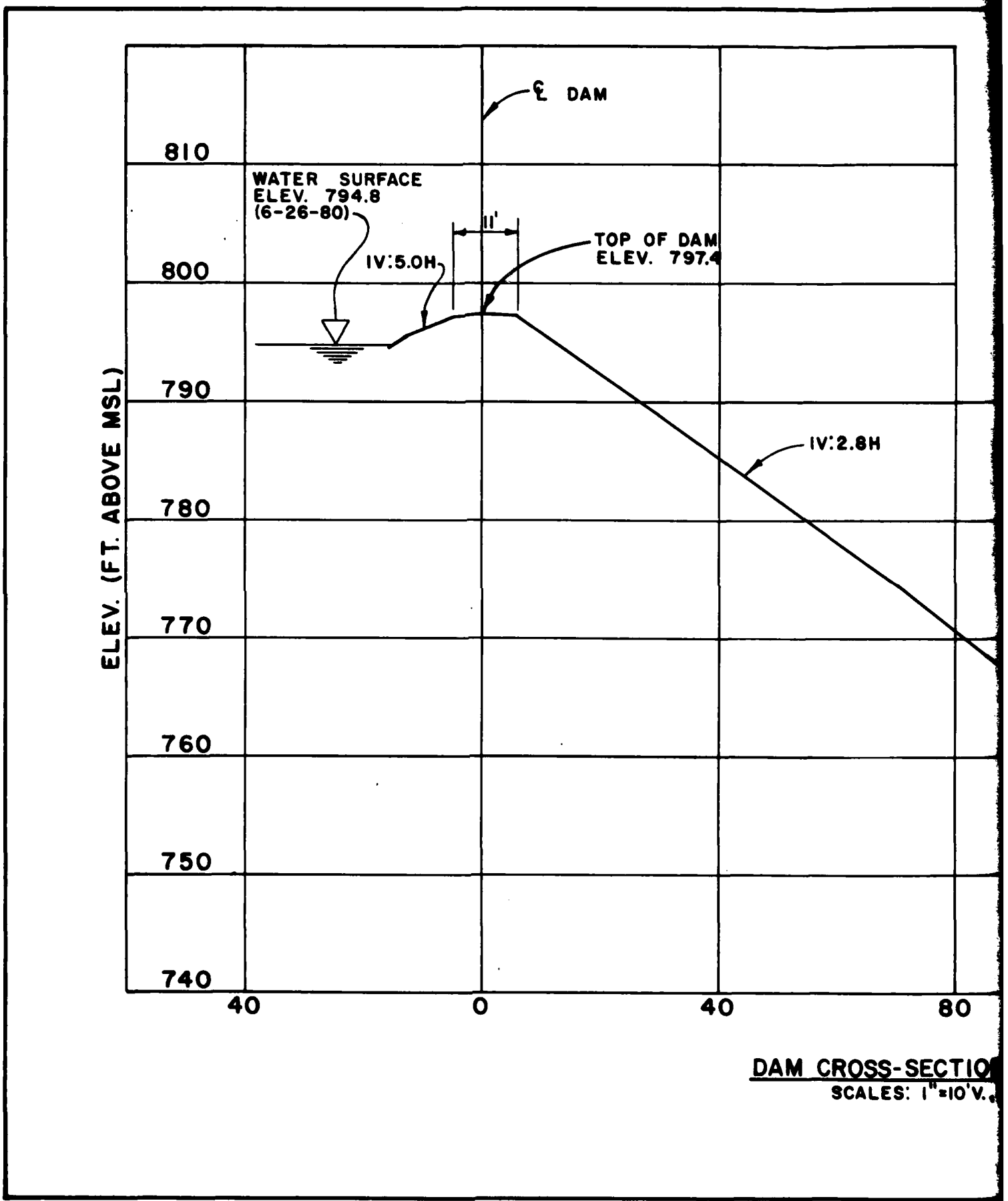
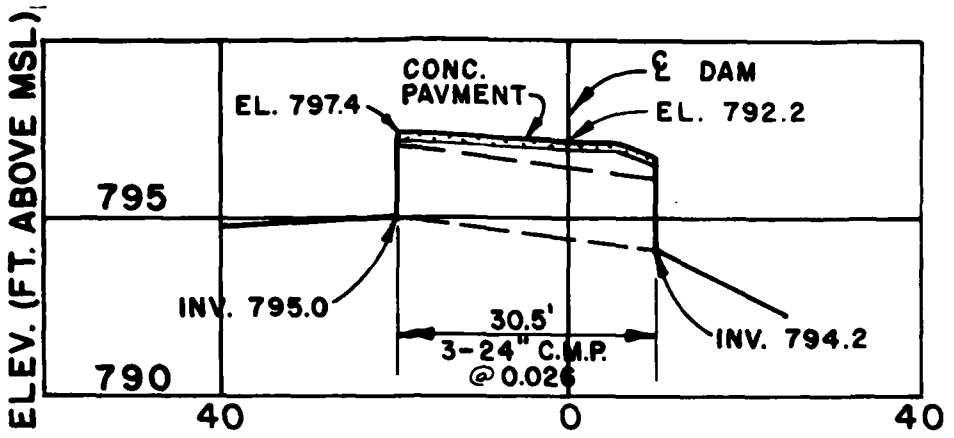
PLATE 3



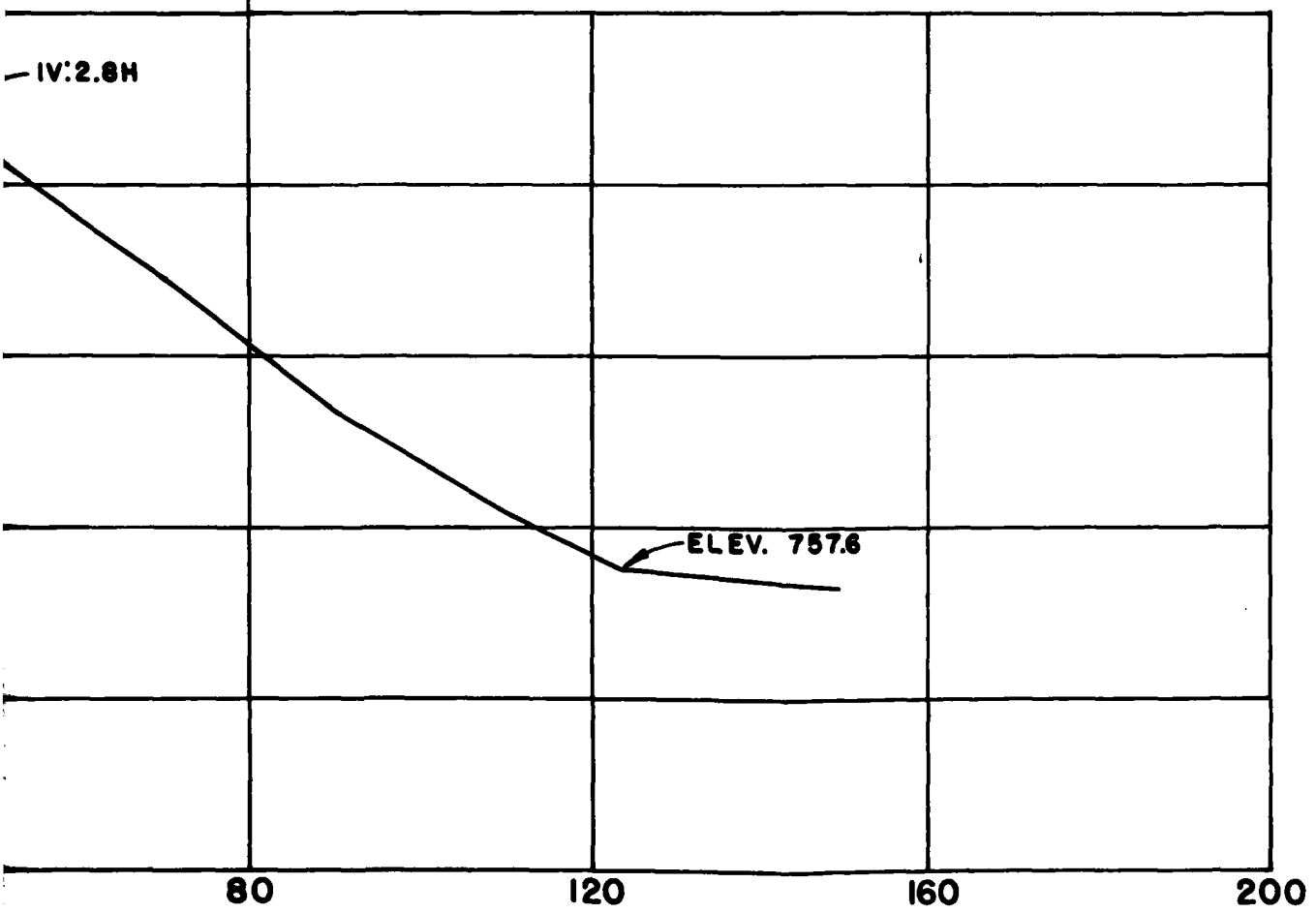
DAM CROSS-SECTION

SCALES: 1"=10'V.



PROFILE SPILLWAY ℄

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



M CROSS-SECTION STA. 1+70

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

STARK LAKE
DAM CROSS-SECTION &
SPILLWAY PROFILE

Horner & Shifrin, Inc. August 1980

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PLATE 4

APPENDIX A

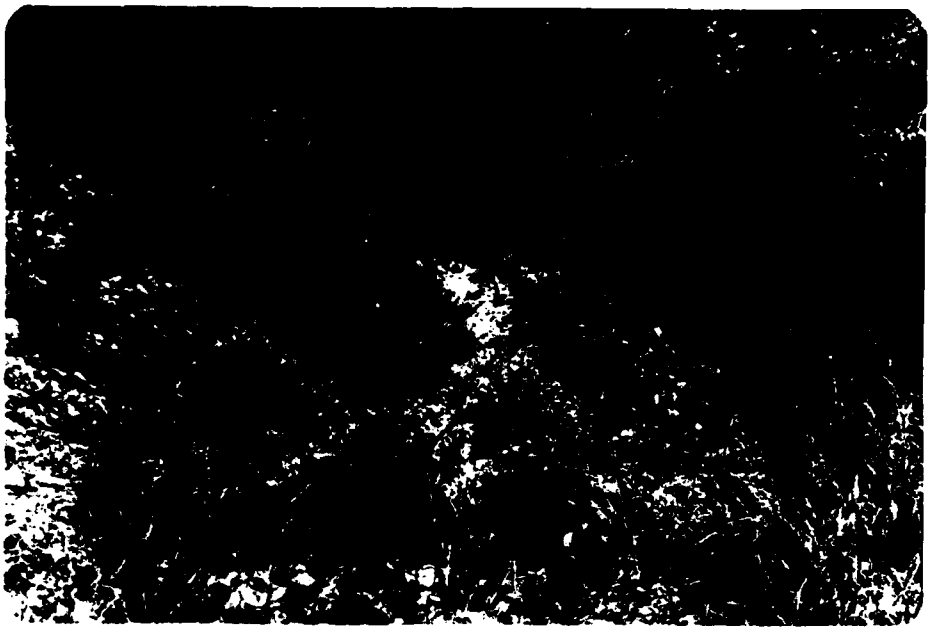
INSPECTION PHOTOGRAPHS

NO. 1: UPSTREAM FACE OF DAM

NO. 2: DOWNSTREAM FACE OF DAM

NO. 3: UPSTREAM END OF SPILLWAY

NO. 4: DOWNSTREAM END OF SPILLWAY



NO. 5: SPILLWAY OUTLET CHANNEL - LOOKING DOWNSTREAM FROM SPILLWAY

NO. 6: RAILROAD TIE SLOPE PROTECTION

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.

b. Drainage area = 0.125 square miles = 80 acres.

c. SCS parameters:

$$\text{Time of Concentration } (T_c) = \left(\frac{11.9L^3}{H}\right)^{0.385} = 0.169 \text{ hours}$$

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

L = Length of longest watercourse = 0.322 miles

H = Elevation difference = 40 feet

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

Lag Time = 0.102 hours (0.60 Tc)

Hydrologic soil group = 10% C (Hatton series) + 90% D (Keswick series) per SCS County Soil Report

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

= 91 (AMC III, PMF condition)

2. Flow through the three 24-inch diameter corrugated metal spillway pipes was computed using Bernoulli's equation for pressure flow in pipes. A pipe friction factor (n) of 0.021 was used. Losses, including entrance, pipe and exit losses totaled 2.1 velocity heads. Reference "Handbook of Hydraulics", Fifth Edition, by King and Brater, pages 8-5 and 8-6.

Discharge quantities, determined by the method described herein, were plotted versus corresponding lake water elevations to determine the discharge rating curve for the spillway pipes. These discharge values along with their corresponding lake elevations were entered on the Y4 and Y5 cards.

3. The profile of the dam crest is irregular and flow over the dam cannot be determined by application of conventional weir formulas. Crest length and elevation data for the dam crest including the paved section above the three 24-inch diameter spillway pipes 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 over the dam crest and adds this flow to the flow over the spillway as entered on the Y4 and Y5 cards.

```
A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF STARK LAKE DAM
A3       RATIOS OF PMF ROUTED THROUGH RESERVOIR
B     288        0        5        0        0        0        0        0        0        0
B1      5
J       1        4        1
J1   0.25     0.26     0.50     1.00                                                    
K       0   INFLOW                                                   1
K1        INFLOW HYDROGRAPH
M       1        2    0.125                                  1.0                      1
P       0     25.0      102      120      130
T                                                                  -1      -91
W2            0.102
X    -1.0     -.10      2.0
K       1      DAM                                                   1
K1        RESERVOIR ROUTING BY MODIFIED PULS
Y                                          1        1
Y1      1                                                    88.53       -1
Y4    795      796      797      798      799      800      801      802      803      804
Y4    805      806
Y5      0       38       58       72       84       94      103      112      120      127
Y5    134      141
$A      0      8.3     17.4     27.4     34.0
$E    763      795      800      810      820
$$ 795.0
$D 797.4
$L     69      192      307      389      409      460      529      546      557
$V 797.4    797.5    797.7    797.8    797.9    798.0    799.1    799.8    800.5
K      99
```

```
1A1       ANALYSIS OF DAM OVERTOPPING USING 100-YR FLOOD
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF STARK 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    0.125                      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     .247     .247     .546     .826     .380     .247     .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
```

100-YR. FLOOD (Cont'd)

```
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
T                                                     -1      -80
W2           0.102
X   -1.0     -.10    2.0
K      1     DAM                                      1
```



```
K1        RESERVOIR ROUTING BY MODIFIED PULS
Y                                    1       1
Y1     1                                             88.53      -1
Y4   795     796     797     798     799     800     801     802     803     804
Y4   805     806
Y5     0      38      58      72      84      94     103     112     120     127
Y5   134     141
$A     0     8.3    17.4    27.4    34.0
$E   763     795     800     810     820
$$ 795.0
$D 797.4
$L    69     192     307     389     409     460     529     546     557
$V 797.4   797.5   797.7   797.8   797.9   798.0   799.1   799.8   800.5
K     99
```

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

JOB SPECIFICATION

NQ	NMR	NMIN	JDAY	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= .25 .26 .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	.13	0.00	.13	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	-91.00	0.00	0.00

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

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .10

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

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

UNIT HYDROGRAPH 8 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .10 VOL= 1.00
263. 404. 183. 72. 28. 11. 4. 2.

O MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW 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	.01	98.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.21	.21	.00	157.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.21	.21	.00	184.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.21	.21	.00	195.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.21	.21	.00	199.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.21	.21	.00	201.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.21	.21	.00	202.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.21	.21	.00	202.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.21	.21	.00	202.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.21	.21	.00	202.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.21	.21	.00	203.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.21	.21	.00	203.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.26	.25	.00	214.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.26	.25	.00	231.
1.01	1.15	15	.01	.00	.01	0.	1.01	13.15	159	.26	.25	.00	239.
1.01	1.20	16	.01	.00	.01	0.	1.01	13.20	160	.26	.25	.00	242.
1.01	1.25	17	.01	.00	.01	0.	1.01	13.25	161	.26	.25	.00	243.
1.01	1.30	18	.01	.00	.01	1.	1.01	13.30	162	.26	.25	.00	244.
1.01	1.35	19	.01	.00	.01	1.	1.01	13.35	163	.26	.25	.00	244.
1.01	1.40	20	.01	.00	.01	1.	1.01	13.40	164	.26	.25	.00	244.
1.01	1.45	21	.01	.00	.01	2.	1.01	13.45	165	.26	.25	.00	245.
1.01	1.50	22	.01	.00	.01	2.	1.01	13.50	166	.26	.25	.00	245.
1.01	1.55	23	.01	.00	.01	2.	1.01	13.55	167	.26	.25	.00	245.
1.01	2.00	24	.01	.00	.01	3.	1.01	14.00	168	.26	.25	.00	245.
1.01	2.05	25	.01	.00	.01	3.	1.01	14.05	169	.32	.32	.00	262.
1.01	2.10	26	.01	.00	.01	3.	1.01	14.10	170	.32	.32	.00	287.
1.01	2.15	27	.01	.00	.01	3.	1.01	14.15	171	.32	.32	.00	299.
1.01	2.20	28	.01	.00	.01	4.	1.01	14.20	172	.32	.32	.00	304.
1.01	2.25	29	.01	.00	.01	4.	1.01	14.25	173	.32	.32	.00	306.
1.01	2.30	30	.01	.00	.01	4.	1.01	14.30	174	.32	.32	.00	306.
1.01	2.35	31	.01	.00	.01	4.	1.01	14.35	175	.32	.32	.00	307.
1.01	2.40	32	.01	.00	.01	4.	1.01	14.40	176	.32	.32	.00	307.
1.01	2.45	33	.01	.01	.01	5.	1.01	14.45	177	.32	.32	.00	307.
1.01	2.50	34	.01	.01	.01	5.	1.01	14.50	178	.32	.32	.00	307.
1.01	2.55	35	.01	.01	.01	5.	1.01	14.55	179	.32	.32	.00	307.
1.01	3.00	36	.01	.01	.01	5.	1.01	15.00	180	.32	.32	.00	307.
1.01	3.05	37	.01	.01	.01	5.	1.01	15.05	181	.19	.19	.00	274.
1.01	3.10	38	.01	.01	.01	6.	1.01	15.10	182	.39	.39	.00	275.
1.01	3.15	39	.01	.01	.01	6.	1.01	15.15	183	.39	.39	.00	330.
1.01	3.20	40	.01	.01	.01	6.	1.01	15.20	184	.58	.58	.00	407.
1.01	3.25	41	.01	.01	.01	6.	1.01	15.25	185	.68	.68	.00	522.
1.01	3.30	42	.01	.01	.01	6.	1.01	15.30	186	1.65	1.64	.00	855.
1.01	3.35	43	.01	.01	.01	6.	1.01	15.35	187	2.71	2.71	.01	1539.
1.01	3.40	44	.01	.01	.01	7.	1.01	15.40	188	1.07	1.06	.00	1746.
1.01	3.45	45	.01	.01	.01	7.	1.01	15.45	189	.68	.68	.00	1250.
1.01	3.50	46	.01	.01	.01	7.	1.01	15.50	190	.58	.58	.00	873.
1.01	3.55	47	.01	.01	.01	7.	1.01	15.55	191	.39	.39	.00	635.
1.01	4.00	48	.01	.01	.01	7.	1.01	16.00	192	.39	.39	.00	481.
1.01	4.05	49	.01	.01	.01	7.	1.01	16.05	193	.30	.30	.00	392.
1.01	4.10	50	.01	.01	.01	7.	1.01	16.10	194	.30	.30	.00	329.

1.01	4.15	51	.01	.01	.01	7.	1.01	16.15	195	.30	.30	.00	302.
1.01	4.20	52	.01	.01	.01	8.	1.01	16.20	196	.30	.30	.00	293.
1.01	4.25	53	.01	.01	.01	8.	1.01	16.25	197	.30	.30	.00	289.
1.01	4.30	54	.01	.01	.01	8.	1.01	16.30	198	.30	.30	.00	288.
1.01	4.35	55	.01	.01	.01	8.	1.01	16.35	199	.30	.30	.00	288.
1.01	4.40	56	.01	.01	.01	8.	1.01	16.40	200	.30	.30	.00	287.
1.01	4.45	57	.01	.01	.01	8.	1.01	16.45	201	.30	.30	.00	287.
1.01	4.50	58	.01	.01	.01	8.	1.01	16.50	202	.30	.30	.00	287.
1.01	4.55	59	.01	.01	.01	8.	1.01	16.55	203	.30	.30	.00	287.
1.01	5.00	60	.01	.01	.01	8.	1.01	17.00	204	.30	.30	.00	287.
1.01	5.05	61	.01	.01	.01	8.	1.01	17.05	205	.23	.23	.00	271.
1.01	5.10	62	.01	.01	.01	8.	1.01	17.10	206	.23	.23	.00	245.
1.01	5.15	63	.01	.01	.00	9.	1.01	17.15	207	.23	.23	.00	233.
1.01	5.20	64	.01	.01	.00	9.	1.01	17.20	208	.23	.23	.00	227.
1.01	5.25	65	.01	.01	.00	9.	1.01	17.25	209	.23	.23	.00	227.
1.01	5.30	66	.01	.01	.00	9.	1.01	17.30	210	.23	.23	.00	226.
1.01	5.35	67	.01	.01	.00	9.	1.01	17.35	211	.23	.23	.00	226.
1.01	5.40	68	.01	.01	.00	9.	1.01	17.40	212	.23	.23	.00	226.
1.01	5.45	69	.01	.01	.00	9.	1.01	17.45	213	.23	.23	.00	226.
1.01	5.50	70	.01	.01	.00	9.	1.01	17.50	214	.23	.23	.00	226.
1.01	5.55	71	.01	.01	.00	9.	1.01	17.55	215	.23	.23	.00	226.
1.01	6.00	72	.01	.01	.00	9.	1.01	18.00	216	.23	.23	.00	226.
1.01	6.05	73	.06	.04	.02	18.	1.01	18.05	217	.02	.02	.00	174.
1.01	6.10	74	.06	.05	.02	33.	1.01	18.10	218	.02	.02	.00	162.
1.01	6.15	75	.06	.05	.02	40.	1.01	18.15	219	.02	.02	.00	151.
1.01	6.20	76	.06	.05	.02	43.	1.01	18.20	220	.02	.02	.00	141.
1.01	6.25	77	.06	.05	.01	45.	1.01	18.25	221	.02	.02	.00	132.
1.01	6.30	78	.06	.05	.01	46.	1.01	18.30	222	.02	.02	.00	123.
1.01	6.35	79	.06	.05	.01	47.	1.01	18.35	223	.02	.02	.00	115.
1.01	6.40	80	.06	.05	.01	48.	1.01	18.40	224	.02	.02	.00	107.
1.01	6.45	81	.06	.05	.01	49.	1.01	18.45	225	.02	.02	.00	100.
1.01	6.50	82	.06	.05	.01	49.	1.01	18.50	226	.02	.02	.00	93.
1.01	6.55	83	.06	.05	.01	50.	1.01	18.55	227	.02	.02	.00	87.
1.01	7.00	84	.06	.05	.01	50.	1.01	19.00	228	.02	.02	.00	81.
1.01	7.05	85	.06	.05	.01	51.	1.01	19.05	229	.02	.02	.00	76.
1.01	7.10	86	.06	.05	.01	51.	1.01	19.10	230	.02	.02	.00	71.
1.01	7.15	87	.06	.05	.01	52.	1.01	19.15	231	.02	.02	.00	66.
1.01	7.20	88	.06	.05	.01	52.	1.01	19.20	232	.02	.02	.00	61.
1.01	7.25	89	.06	.05	.01	53.	1.01	19.25	233	.02	.02	.00	57.
1.01	7.30	90	.06	.06	.01	53.	1.01	19.30	234	.02	.02	.00	53.
1.01	7.35	91	.06	.06	.01	53.	1.01	19.35	235	.02	.02	.00	50.
1.01	7.40	92	.06	.06	.01	54.	1.01	19.40	236	.02	.02	.00	47.
1.01	7.45	93	.06	.06	.01	54.	1.01	19.45	237	.02	.02	.00	43.
1.01	7.50	94	.06	.06	.01	54.	1.01	19.50	238	.02	.02	.00	40.
1.01	7.55	95	.06	.06	.01	54.	1.01	19.55	239	.02	.02	.00	38.
1.01	8.00	96	.06	.06	.01	55.	1.01	20.00	240	.02	.02	.00	35.
1.01	8.05	97	.06	.06	.01	55.	1.01	20.05	241	.02	.02	.00	33.
1.01	8.10	98	.06	.06	.01	55.	1.01	20.10	242	.02	.02	.00	31.
1.01	8.15	99	.06	.06	.01	55.	1.01	20.15	243	.02	.02	.00	29.
1.01	8.20	100	.06	.06	.00	55.	1.01	20.20	244	.02	.02	.00	27.
1.01	8.25	101	.06	.06	.00	56.	1.01	20.25	245	.02	.02	.00	25.
1.01	8.30	102	.06	.06	.00	56.	1.01	20.30	246	.02	.02	.00	23.
1.01	8.35	103	.06	.06	.00	56.	1.01	20.35	247	.02	.02	.00	22.

1.01	8.40	104	.06	.06	.00	56.
1.01	8.45	105	.06	.06	.00	56.
1.01	8.50	106	.06	.06	.00	56.
1.01	8.55	107	.06	.06	.00	57.
1.01	9.00	108	.06	.06	.00	57.
1.01	9.05	109	.06	.06	.00	57.
1.01	9.10	110	.06	.06	.00	57.
1.01	9.15	111	.06	.06	.00	57.
1.01	9.20	112	.06	.06	.00	57.
1.01	9.25	113	.06	.06	.00	57.
1.01	9.30	114	.06	.06	.00	57.
1.01	9.35	115	.06	.06	.00	57.
1.01	9.40	116	.06	.06	.00	57.
1.01	9.45	117	.06	.06	.00	58.
1.01	9.50	118	.06	.06	.00	58.
1.01	9.55	119	.06	.06	.00	58.
1.01	10.00	120	.06	.06	.00	58.
1.01	10.05	121	.06	.06	.00	58.
1.01	10.10	122	.06	.06	.00	58.
1.01	10.15	123	.06	.06	.00	58.
1.01	10.20	124	.06	.06	.00	58.
1.01	10.25	125	.06	.06	.00	58.
1.01	10.30	126	.06	.06	.00	58.
1.01	10.35	127	.06	.06	.00	58.
1.01	10.40	128	.06	.06	.00	58.
1.01	10.45	129	.06	.06	.00	58.
1.01	10.50	130	.06	.06	.00	58.
1.01	10.55	131	.06	.06	.00	58.
1.01	11.00	132	.06	.06	.00	58.
1.01	11.05	133	.06	.06	.00	59.
1.01	11.10	134	.06	.06	.00	59.
1.01	11.15	135	.06	.06	.00	59.
1.01	11.20	136	.06	.06	.00	59.
1.01	11.25	137	.06	.06	.00	59.
1.01	11.30	138	.06	.06	.00	59.
1.01	11.35	139	.06	.06	.00	59.
1.01	11.40	140	.06	.06	.00	59.
1.01	11.45	141	.06	.06	.00	59.
1.01	11.50	142	.06	.06	.00	59.
1.01	11.55	143	.06	.06	.00	59.
1.01	12.00	144	.06	.06	.00	59.
1.01	20.40	248	.02	.02	.00	20.
1.01	20.45	249	.02	.02	.00	20.
1.01	20.50	250	.02	.02	.00	20.
1.01	20.55	251	.02	.02	.00	20.
1.01	21.00	252	.02	.02	.00	20.
1.01	21.05	253	.02	.02	.00	20.
1.01	21.10	254	.02	.02	.00	20.
1.01	21.15	255	.02	.02	.00	20.
1.01	21.20	256	.02	.02	.00	20.
1.01	21.25	257	.02	.02	.00	20.
1.01	21.30	258	.02	.02	.00	20.
1.01	21.35	259	.02	.02	.00	20.
1.01	21.40	260	.02	.02	.00	20.
1.01	21.45	261	.02	.02	.00	20.
1.01	21.50	262	.02	.02	.00	20.
1.01	21.55	263	.02	.02	.00	20.
1.01	22.00	264	.02	.02	.00	20.
1.01	22.05	265	.02	.02	.00	20.
1.01	22.10	266	.02	.02	.00	20.
1.01	22.15	267	.02	.02	.00	20.
1.01	22.20	268	.02	.02	.00	20.
1.01	22.25	269	.02	.02	.00	20.
1.01	22.30	270	.02	.02	.00	20.
1.01	22.35	271	.02	.02	.00	20.
1.01	22.40	272	.02	.02	.00	20.
1.01	22.45	273	.02	.02	.00	20.
1.01	22.50	274	.02	.02	.00	20.
1.01	22.55	275	.02	.02	.00	20.
1.01	23.00	276	.02	.02	.00	20.
1.01	23.05	277	.02	.02	.00	20.
1.01	23.10	278	.02	.02	.00	20.
1.01	23.15	279	.02	.02	.00	20.
1.01	23.20	280	.02	.02	.00	20.
1.01	23.25	281	.02	.02	.00	20.
1.01	23.30	282	.02	.02	.00	20.
1.01	23.35	283	.02	.02	.00	20.
1.01	23.40	284	.02	.02	.00	20.
1.01	23.45	285	.02	.02	.00	20.
1.01	23.50	286	.02	.02	.00	20.
1.01	23.55	287	.02	.02	.00	20.
1.02	0.00	288	.02	.02	.00	20.
			SUM	32.50	31.34	1.16	31710.
				(825.)	(796.)	(29.)	(897.93)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1746.	339.	110.	110.	31703.
CMS	49.	10.	3.	3.	898.
INCHES		25.24	32.77	32.77	32.77
MM		641.20	832.32	832.32	832.32
AC-FT		168.	218.	218.	218.
THOUS CU M		207.	269.	269.	269.

SURFACE AREA=	0.	8.	17.	27.	34.
CAPACITY=	0.	89.	151.	374.	680.
ELEVATION=	763.	795.	800.	810.	820.

SUMMARY OF DAM SAFETY ANALYSIS

PMF

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	795.00	795.00	797.40
STORAGE	89.	89.	113.
OUTFLOW	0.	0.	64.

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
.25	797.33	0.00	112.	63.	0.00	17.17	0.00
.26	797.43	.03	113.	65.	1.25	17.17	0.00
.50	798.15	.75	123.	675.	4.25	15.75	0.00
1.00	798.57	1.17	129.	1464.	7.00	15.75	0.00

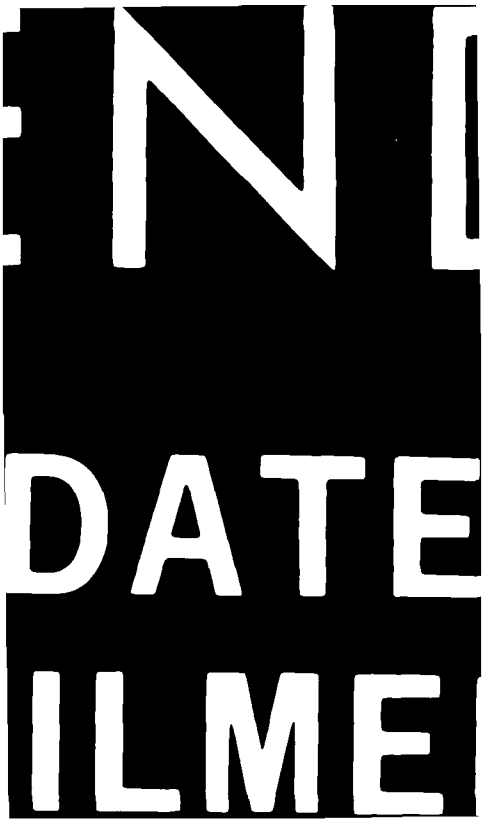
SUMMARY OF DAM SAFETY ANALYSIS

100-YR. FLOOD

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	795.00	795.00	797.40
STORAGE	89.	89.	113.
OUTFLOW	0.	0.	64.

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	796.71	0.00	105.	52.	0.00	13.00	0.00


DATE
ILME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DATE
ILME