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SPRINGDALE LAKE DAM
CASS COUNTY, MISSOURI
MO 20238

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PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

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St. Louis District

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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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SPRINGDALE LAKE DAM
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PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM



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St. Louis District

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

FOR: STATE OF MISSOURI

MAY 1980



DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
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IN REPLY REFER TO

LMSD-PD

SUBJECT: Springdale Lake Dam, Mo. ID No. 20238
Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Springdale Lake Dam.

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

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

a. Spillway will not pass a 10-year frequency flood without overtopping of the dam. The spillway is, therefore, considered to be unusually small and seriously inadequate.

b. Overtopping could result in dam failure.

c. Dam failure significantly increases the hazard to life and property downstream.

SIGNED

Submitted By:

Chief, Engineering Division

4 SEP 1980

Date

SIGNED

Approved By:

Colonel, CE, District Engineer

4 SEP 1980

Date

SPRINGDALE LAKE DAM
CASS COUNTY, MISSOURI

MISSOURI INVENTORY NO. 20238

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF
ST. LOUIS DISTRICT CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

MAY 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Springdale Lake Dam
State Located	Missouri
County Located	Cass County
Stream	Oil Creek
Date of Inspection	6 May 1980

Springdale Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

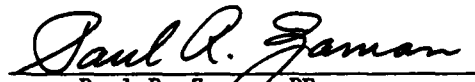
The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and were developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten lives and property. The estimated damage zone extends approximately three miles downstream of the dam. Over fifteen homes are located between one-half and one mile below the dam. Contents of the estimated hazard zone were verified by the inspection team.

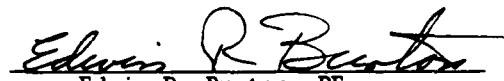
Our inspection and evaluation indicates the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillways will not pass the probable maximum flood without overtopping but will pass 4 percent of the probable maximum flood. The spillways will not pass the 10 percent probability flood flow. The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the hazard zone downstream of the dam, the spillway design flood should be 100 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge which may be expected from the most severe combination of critical meteorologic and hydrologic conditions which are reasonably possible in the region.


Based on visual observations, this dam appears to be in good condition. Deficiencies visually observed by the inspection team were an

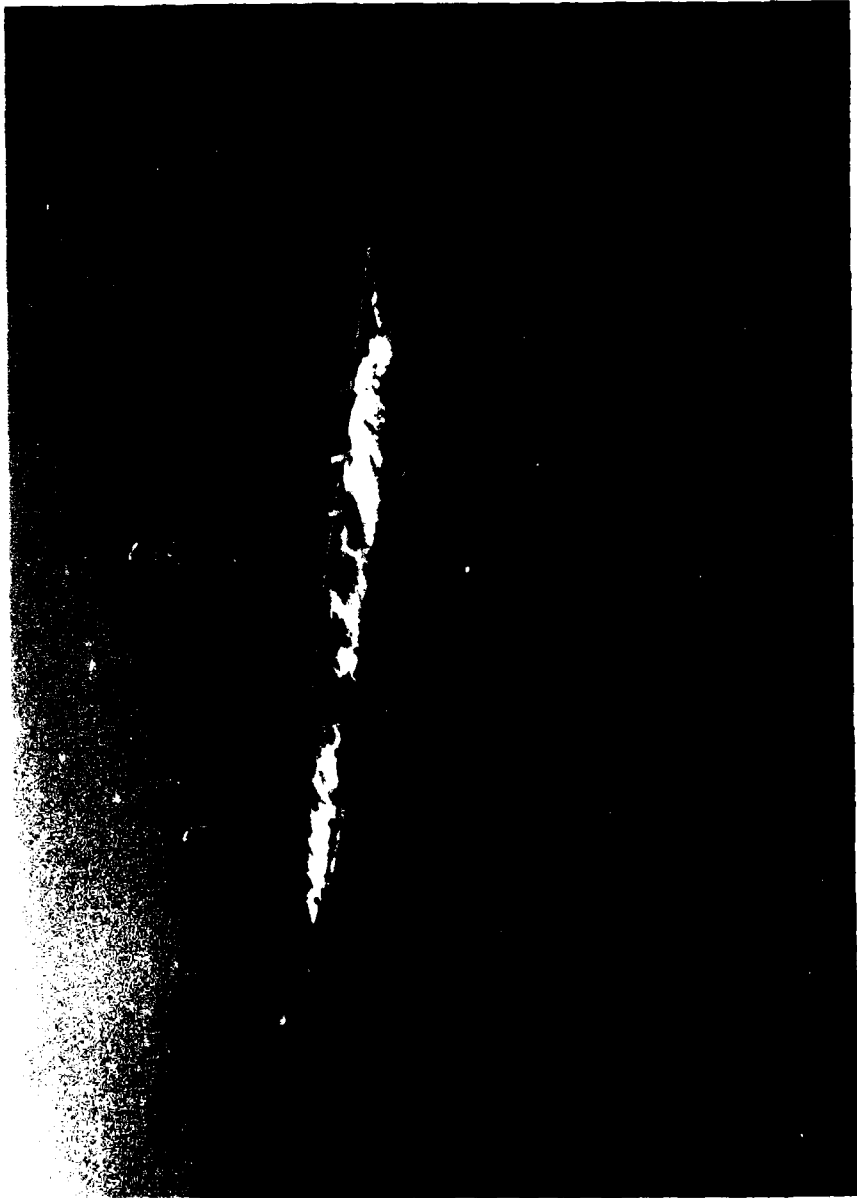
area of possible seepage downstream of the dam, erosion on the upstream slope and around the principal spillway, trees growing on the embankment, a few small animal burrows and the uncovered principal spillway drop inlet. Seepage and stability analyses required by the guidelines were not available.

There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.


Paul R. Zagan, PE
Illinois 62-29261


Edwin R. Burton, PE
Missouri E-10137


Harry L. Callahan, Partner
Black & Veatch



OVERVIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
SPRINGDALE LAKE DAM

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, 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 District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Springdale Lake Dam be made.

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

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth structure with an asphalt road on the crest. It is located in the valley of Oil Creek (Plate 1). The watershed consists of cropland, grassland, and urban areas (Plate 2) in hilly terrain. The watershed is presently undergoing commercial development particularly near U.S. 71 highway. The dam is approximately 600 feet long along the crest and 17 feet high. The dam crest is 27 feet wide. The downstream face of the dam slopes uniformly from the crest to the valley floor below.

(2) The primary spillway from the lake consists of a 30-inch corrugated-metal drop inlet without a grate covering the top and a 24-inch corrugated-metal pipe through the dam. The drop inlet is 8 feet deep. Flow through the pipe discharges into the natural stream channel below. The emergency spillway appears to be a low area in the natural material of the right abutment. A chain link fence approximately three feet high acts as a trash screen at the upstream crest of the embankment. The downstream channel is grass-lined with a low dike along the right side to direct the flow toward the natural stream channel.

(3) The facilities for water-supply withdrawal were not observed.

(4) Two 8-inch corrugated-metal pipes lie underneath the pavement in the emergency spillway.

(5) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in Northwestern Cass County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Belton, Missouri in Section 7 of T46N, R32W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Springdale Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Springdale Lake Dam the estimated flood damage zone extends approximately three miles downstream of the dam. Within the first one mile downstream are over fifteen residences. Contents of the estimated hazard zone were verified by the inspection team.

e. Ownership. The dam is owned by the Springdale Management, Inc., 222 W. Gregory Blvd., Suite #204, Kansas City, Missouri 64113, Telephone 816-444-7810.

f. Purpose of Dam. The dam forms a 9-acre lake used for recreation and domestic water supply. About 30,000 gallons per day are drawn for water supply.

g. Design and Construction History. No information on the design was available. The dam was constructed in approximately 1954.

h. Normal Operating Procedure. Normal rainfall, runoff, inflow from springs, transpiration, evaporation, outflow through the water-supply pipe, and overflow through the uncontrolled outlet pipe all combine to maintain a relatively stable water surface elevation.

1.3 PERTINENT DATA

a. Drainage Area - 580 acres

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled 30-inch drop inlet and a 24-inch outlet pipe through the embankment.

(2) Estimated experienced maximum flood at damsite - Unknown, however a rainfall of approximately 6 inches in a 36-hour period occurred in the general vicinity of the dam watershed on September 12-13, 1977. The manager, Mr. Francis Pace, stated that the dam was overtopped at that time.

(3) Estimated ungated spillway capacity at maximum pool elevation 1,300 cfs (Probable Maximum Flood Pool El.1035.0).

c. Elevation (Feet above m.s.l.).

(1) Top of dam - 1031.8 (see Plate 3)

(2) Emergency spillway crest - 1031.2

(3) Primary spillway crest - 1029.0

(4) Streambed at toe of dam - 1015 ±

(5) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 2,000 feet ± (Probable maximum flood pool level)

(2) Length of normal pool - 1,300 feet ± (Primary spillway crest)

e. Storage (Acre-feet).

(1) Top of dam - 101

(2) Emergency spillway crest - 93

- (3) Primary spillway crest - 63
- (4) Design surcharge - Not available.

f. Reservoir Surface (Acres).

- (1) Top of dam - 16.3
- (2) Emergency spillway crest - 15.1
- (3) Primary spillway crest - 9.0

g. Dam.

- (1) Type - Earth embankment
- (2) Length - 600 feet
- (3) Height - 17 feet ±
- (4) Top width - 27 feet
- (5) Side slopes - upstream face 1.0 V on 2.2 H, downstream face varies between 1.0 V on 2.7 H and 1.0 V on 4.9 H (see Plate 4)
- (6) Zoning - Unknown.
- (7) Impervious core - Unknown.
- (8) Cutoff - Unknown.
- (9) Grout curtain - Unknown.

h. Diversion and Regulating Tunnel - None.

i. Primary Spillway.

- (1) Type - 30-inch corrugated metal drop inlet with a 24-inch outlet pipe.
- (2) Inlet crest elevation - 1029.0 feet m.s.l.
- (3) Outlet invert elevation 1018.6 feet m.s.l.

- (4) Gates - None.
- (5) Upstream channel - Not applicable.
- (6) Downstream channel - Natural open channel to streambed.
- j. Emergency Spillway.
 - (1) Type - Grass open channel.
 - (2) Width of channel - 63 feet.
 - (3) Emergency spillway crest - 1031.2.
 - (4) Gates - None.
 - (5) Upstream channel - Not applicable.
 - (6) Downstream channel - Natural open channel to streambed.
- k. Regulating Outlets - Not observed.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design data were available.

2.2 CONSTRUCTION

Construction records were unavailable, however, according to the owner, the dam was constructed in approximately 1954.

2.3 OPERATION

Documentation of past floods was not available.

2.4 GEOLOGY

The dam is constructed across a broad shallow valley at the headwaters of the Little Blue River. The soils of the drainage area consist of the Macksburg, Martin, Snead, Sampsel, Oska and Blackoar soil series. The Sampsel series consists of deep, somewhat poorly drained soils formed in residuum weathered from shale. It is classified for engineering purposes as a low or high plastic clay. The depth to rock varies from forty to seventy inches. The Snead series consists of moderately deep, moderately well drained soils on the hillsides. The soil is formed in residuum weathered from calcareous clayey shales and thin interbedded limestones. The soil is classified as a low or high plastic clay for engineering purposes. Rock is generally 15-30 inches below the surface of the Snead series. The Blackoar series consists of deep, poorly drained soil located on floodplains. It is formed in alluvial deposits and is classified as a low plastic silt or clay for engineering purposes. Rock is generally greater than five feet below the surface of the Blackoar series.

2.5 EVALUATION

a. Availability. No engineering data were available.

b. Adequacy. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Springdale Lake Dam was made on 6 May 1980. The inspection team consisted of Ed Burton, team leader; Bob Pinker, geologist; Gary Van Riessen, geotechnical engineer; John Ruhl, hydrologist; Mark Snyder, hydrologist; and Alan Reif, structural engineer. The dam is in generally good condition. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following conditions at the dam. The upstream face of the dam is covered with crushed limestone gravel approximately 1 to 1-1/2 inches in size. The downstream face is grass covered. One small tree is located on the upstream face and a row of trees stands at the top of the downstream embankment. Trees also exist at the toe of the embankment near the primary spillway outlet. Guard posts have been placed along each side of the road. The posts on the upstream embankment are leaning toward the slope. The upstream face of the dam is fairly steep which is possibly the result of foot traffic. Minor erosion was observed on the upstream face of the embankment. One horizontal hole at the left end measured three feet in depth. The material being eroded is silty clay (CL). The only possible area of seepage observed was below the dam to the left of the primary spillway outlet pipe. This area of ponded water is more likely caused by poor drainage. A few small animal burrows exist in the downstream embankment. No cracking, sliding, sloughing, settlement, or sinkholes were observed. There are no toe drains or relief wells.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The inside of the drop inlet and about two feet of the outlet end of the primary spillway pipe were observed. The pipe appeared to be in good condition. Trash and debris have collected in the bottom of the riser pipe. Observation of the pipe from the downstream end revealed a slight horizontal curve to the left but no pipe distortion. The soil underneath the concrete splash pad at the primary spillway is being eroded. There is no evidence of erosion of the silty clay (CL) material making up the emergency spillway. Concrete has been dumped on the upstream face at the left end of the emergency spillway possibly because of erosion.

d. Geology. The surrounding terrain is gently rolling with moderately wide and gentle interstream divides. The area is not glaciated although varying amounts of loess are present throughout the area. The

soils at the location of the dam are of the Sampsel and Snead series along the sides of the reservoir and of the Blackoar series downstream of the dam.

The subsoil geology in the vicinity of the dam consists of the Lane formation and the Frisbie, Quindaro and Argentine members of the Wyandotte formation. The Lane consists of a gray, silty, micaceous shale ranging in thickness from seven to forty-two feet. The Frisbie is a massive limestone, four to five feet thick. The Quindaro consists of a black fissile and yellowish-gray limey shale or shale-like limestone. The Argentine is a limestone 20 to 40 feet thick. It is thin and wavy bedded with open bedding planes and closely spaced vertical joints (1-2 ft). It contains secondary porosity due to solutioning along bedding planes and joints.

No outcrops were observed at the dam itself. However, an outcrop at the upper end of the reservoir of Argentine limestone was observed extending from below the water level to near the crest of the hill where it was covered with soil. It is anticipated that the abutments of the dam are in the Argentine limestone and possibly the Frisbie and the Quindaro. The foundation of the dam is probably the Lane shale covered by the Blackoar soil, if it was not removed during construction. The area around the dam is known for springs, and the reservoir is said by the caretaker to be springfed. One spring was observed at the outcrop of the Argentine at the upper end of the reservoir. Flow was estimated at less than 5 gpm.

e. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir. Although there was no noticeable lake siltation, the manager, Mr. Francis Pace, stated that considerable silt was washed in during construction of U.S. 71 highway. He also stated that the lake is about 12 feet deep.

f. Downstream Channel. The channel downstream of the spillway outlet pipe is a natural open channel to the original streambed. The soil is a silty clay (CL).

3.2 EVALUATION

The various deficiencies observed at the time of the inspection are not believed to represent an immediate safety hazard. They do, however, warrant monitoring and control. The area of ponded water below the dam should be monitored to determine whether it is caused by seepage or poor drainage. Seepage can cause internal erosion creating cavities and underground channels, thereby weakening the embankment. The erosion at the outlet end of the primary spillway pipe may eventually erosion

failure of the splash pad and increase erosion of the channel. Some minor erosion has taken place on the upstream face due to wave action in areas without riprap. The growth of trees could cause deterioration of the embankment, if allowed to go unchecked. The roots of trees can loosen the embankment material and also can leave voids through which water can pass. Although the animal burrows are small, additional animal burrowing could damage the embankment. The open drop inlet which is close to the upstream embankment poses a hazardous situation.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, inflow from springs, evaporation, transpiration, outflow through the water-supply pipe and capacity of the uncontrolled primary spillway outlet pipe.

4.2 MAINTENANCE OF DAM

The existing maintenance program consists of periodic mowing of the downstream face of the embankment and the addition of rock and soil to the embankment. The owner monitors the condition of the dam and remedies any evidence of deterioration.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing warning system or preplanned scheme for alerting downstream residents for this dam.

4.5 EVALUATION

The dam is well-maintained, however the maintenance program should be expanded to provide for tree removal.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data pertaining to hydrology and hydraulics were unavailable.

b. Experience Data. The drainage area and lake surface area are developed from USGS Belton and Raymore Quadrangle Maps. The dam layout is from a survey made during the inspection.

c. Visual Observations.

(1) The primary spillway appears to be in good condition. The lake level at the time of the inspection was at the inlet level and there was some flow through the pipe. Only the inside of the drop inlet and about two feet of the outlet end were observable. The spillway pipe discharges with a free outfall onto a splash pad and then into a natural channel. There were no obstructions to flow in the downstream channel.

(2) The emergency spillway channel is in good condition with no evidence of erosion at the time of the inspection.

(3) Spillway discharges do not endanger the integrity of the dam.

d. Overtopping Potential. The spillways will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillways will pass 4 percent of the probable maximum flood without overtopping the dam. The spillways will not pass the 10 percent probability flood flow estimated to have a peak outflow of 1,100 cfs developed by a 24-hour, 10 percent probability rainfall. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the hazard zone downstream of the dam, the appropriate spillway design flood should be 100 percent of the probable maximum flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 4,600 cfs of the total discharge from the reservoir of 5,900 cfs. The estimated duration of overtopping is 17.0 hours with a maximum height of 3.2 feet. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 2,100 cfs of the total discharge from the reservoir of 2,900 cfs. The estimated duration of overtopping is 15.6 hours with a maximum height of 2.3 feet. Over-

topping for these periods of time could jeopardize the embankment. The manager, Mr. Francis Pace, stated that the dam was overtopped by eight inches in about 1973 and was also overtopped in September, 1977.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately three miles downstream of the dam. Over fifteen homes are located between one-half mile and one mile below the dam. Should failure of the dam occur these homes could be severely damaged and lives could be lost. Contents of the estimated hazard zone were verified by the inspection team.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

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

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Detailed seepage and stability analyses as required by the guidelines are not available, which is considered a deficiency.

c. Operating Records. No operational records exist.

d. Post Construction Changes. The year of any rehabilitation is unknown. Fill concrete has been placed near the emergency spillway, between the dam crest and waterline. This was possibly an attempt to repair some erosion on the upstream face.

e. Seismic Stability. The dam is located in Seismic Zone 1, a zone which is considered to be of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservation should pose no serious stability problems during earthquakes in this zone. The seismic stability of an earth dam is dependent upon a number of factors: embankment and foundation material classifications and shear strengths; abutment materials, conditions, and strengths; embankment zoning; and embankment geometry. Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available, and therefore, no inference will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analyses required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the visual inspection by the inspection team should be monitored and/or controlled. These are the possible areas of seepage below the dam, the erosion at the outlet end of the primary spillway and on the front face of the embankment, the trees growing on the embankment, the animal burrows, and the open drop inlet near the embankment. 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.

b. Adequacy of Information. Due to the lack of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. 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. A program should be developed as soon as possible to monitor at regular intervals the deficiencies described in this report. The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. The item recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam nor does it identify any serious dangers which would require a Phase II investigation. However, the additional analyses noted in paragraph 2.5.b. are necessary for compliance with the guidelines.

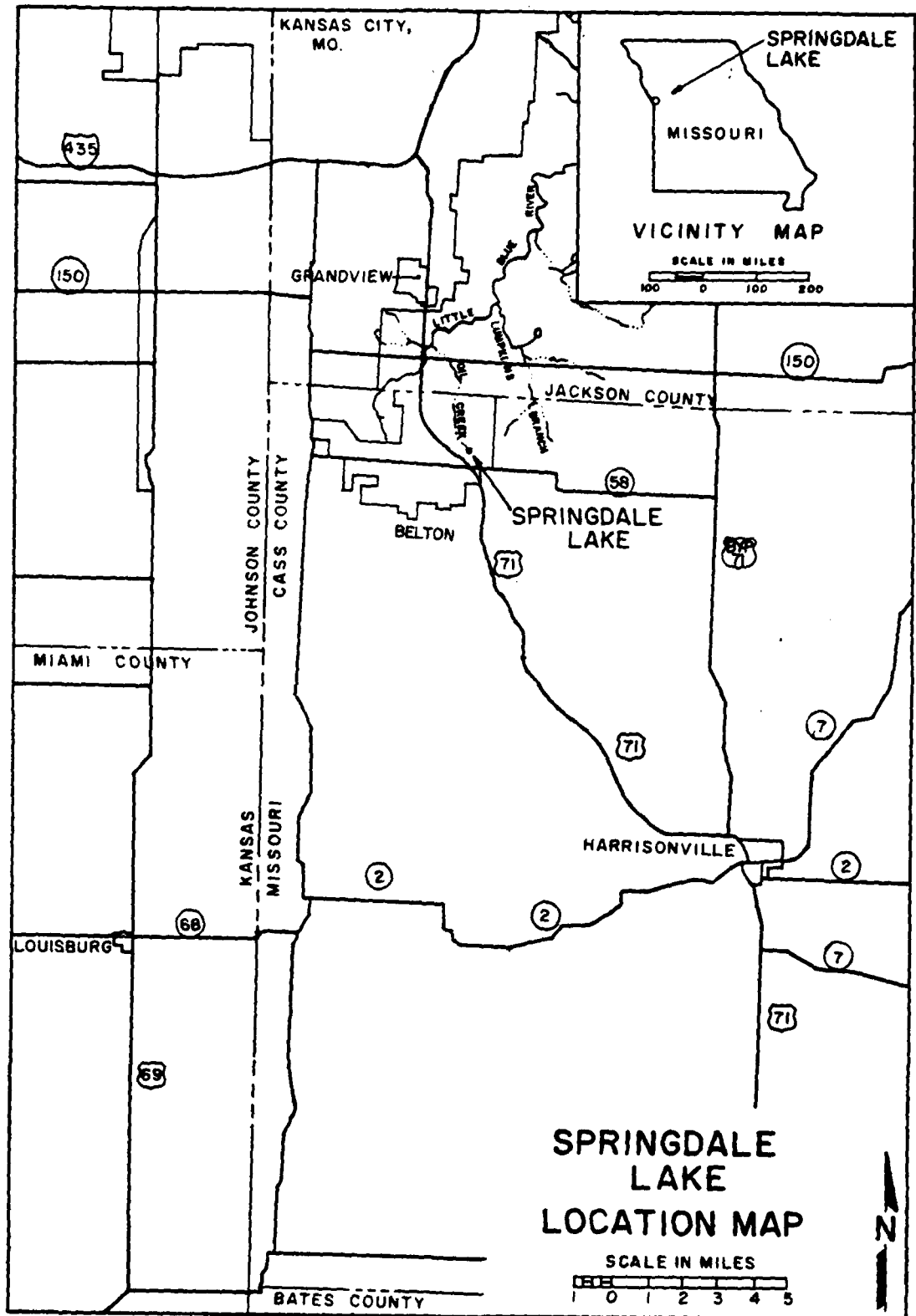
e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. The emergency spillway size and/or height of dam would need to be increased or the lake level would need to be lowered to increase available flood storage in order to pass the spillway design flood. The emergency spillway should be protected to prevent erosion.

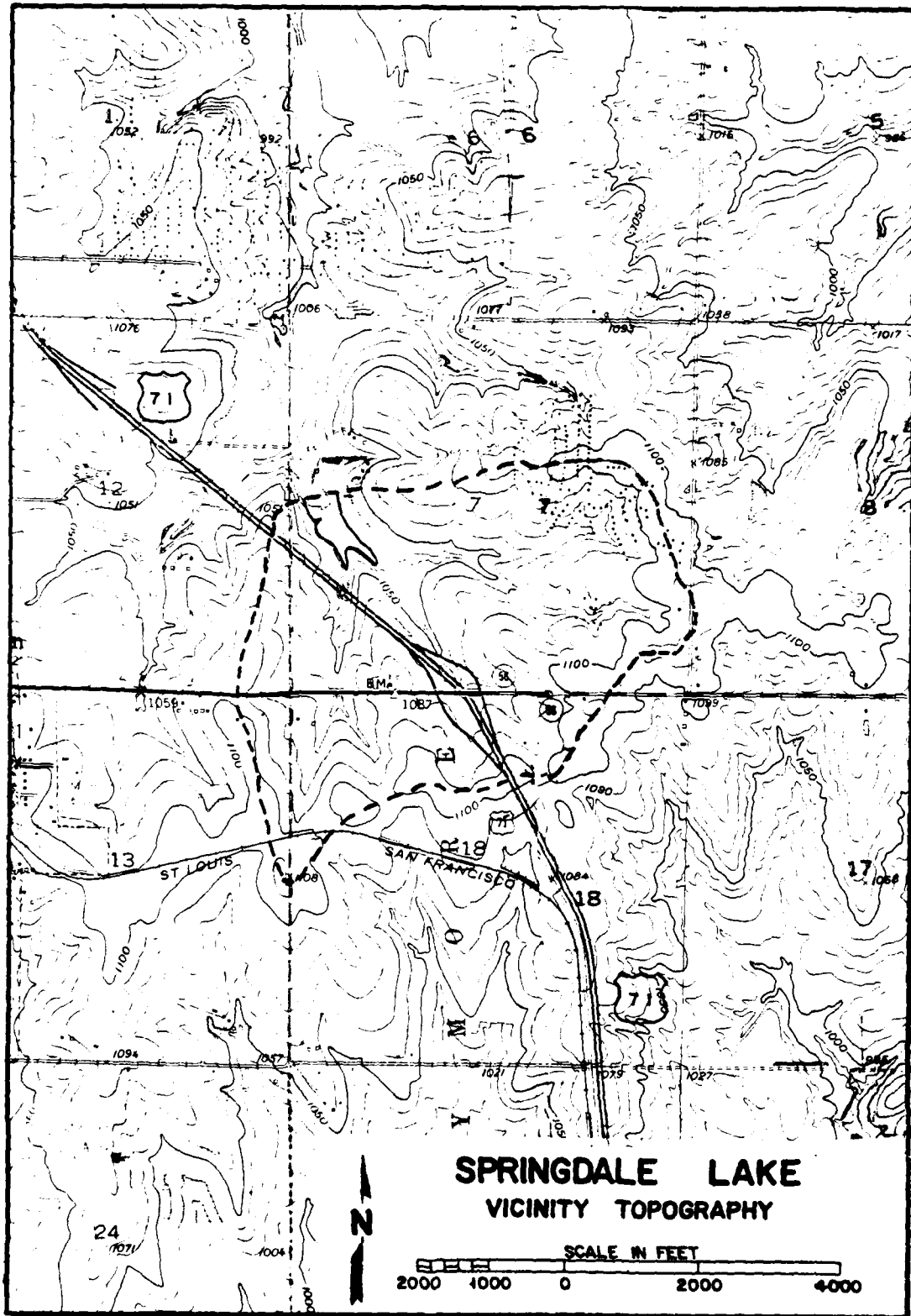
b. Operation and Maintenance Procedures. The following operation and maintenance procedures should be carried out under the direction of an engineer experienced in the design, construction, and inspection of dams:

- (1) Riprap should be added as necessary on the upstream face of the dam to prevent erosion of the embankment material.
- (2) The possible seepage area noted during the visual inspection should be monitored. Any significant changes should be evaluated.
- (3) The animal burrows in the embankment should be corrected since they can lead to piping. Control measures should be implemented to discourage increased animal activity in the area. The embankment slope should be monitored during this repair.
- (4) A grate or protective covering should be placed over the drop inlet to the primary spillway. The grate should be cleaned regularly to prevent the accumulation of trash.
- (5) The existing maintenance program should be expanded to include tree removal.
- (6) Seepage and stability analysis should be performed.
- (7) A detailed inspection of the dam should be made periodically. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increase.

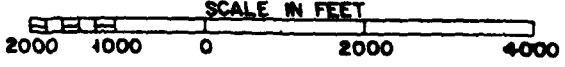


**SPRINGDALE
LAKE
LOCATION MAP**

PLATE I



**SPRINGDALE LAKE
VICINITY TOPOGRAPHY**



LEGEND

STATION
/ ELEVATION

⊙ AUGER BORING

OUTLET INV. EL. 1018.6

OIL CREEK

24" Ø CORRUGATED
METAL OUTLET PIPE

EMERGENCY
SPILLWAY

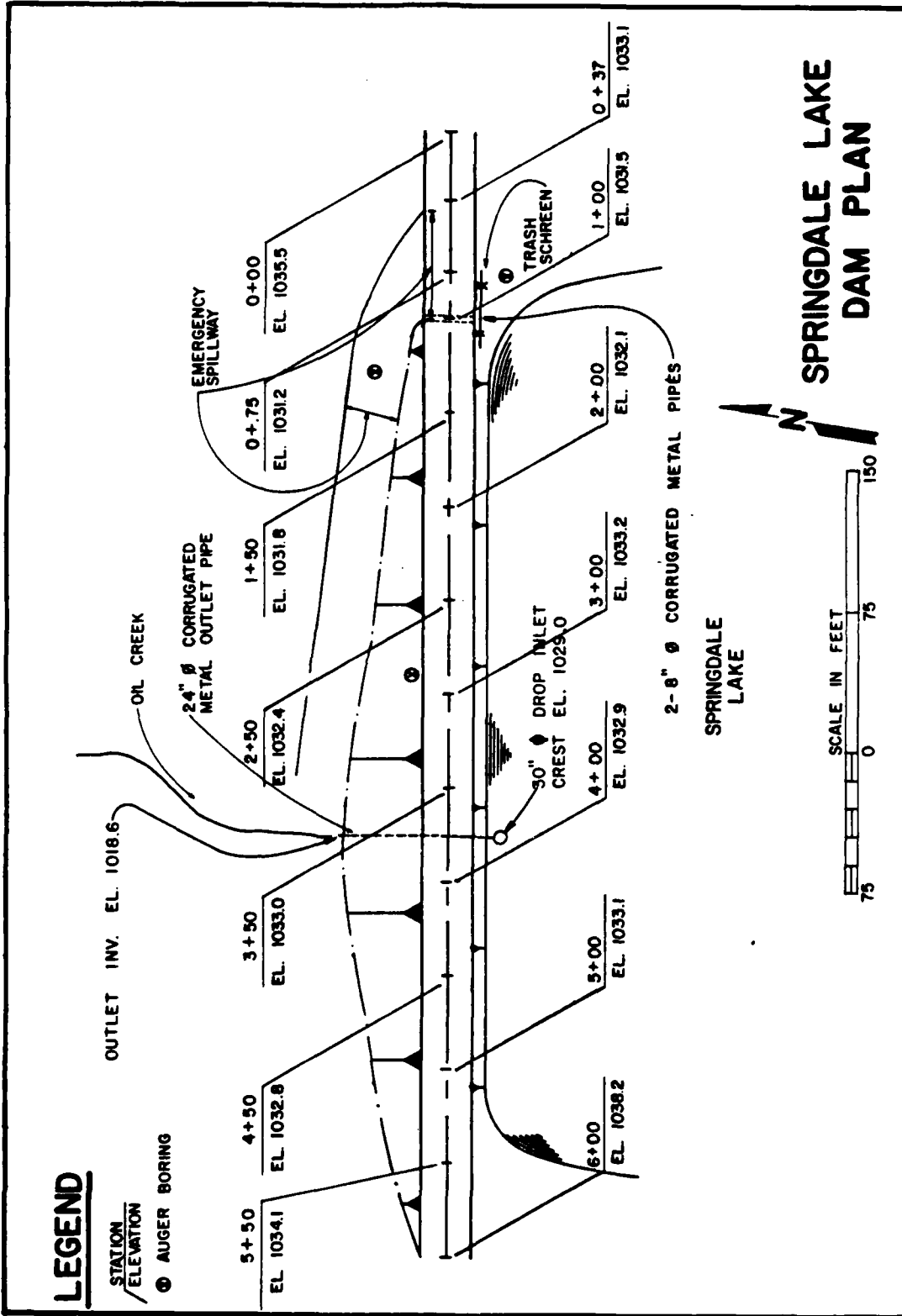
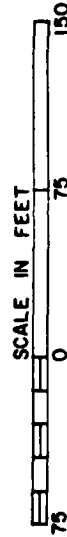
50" DROP INLET
CREST EL. 1029.0

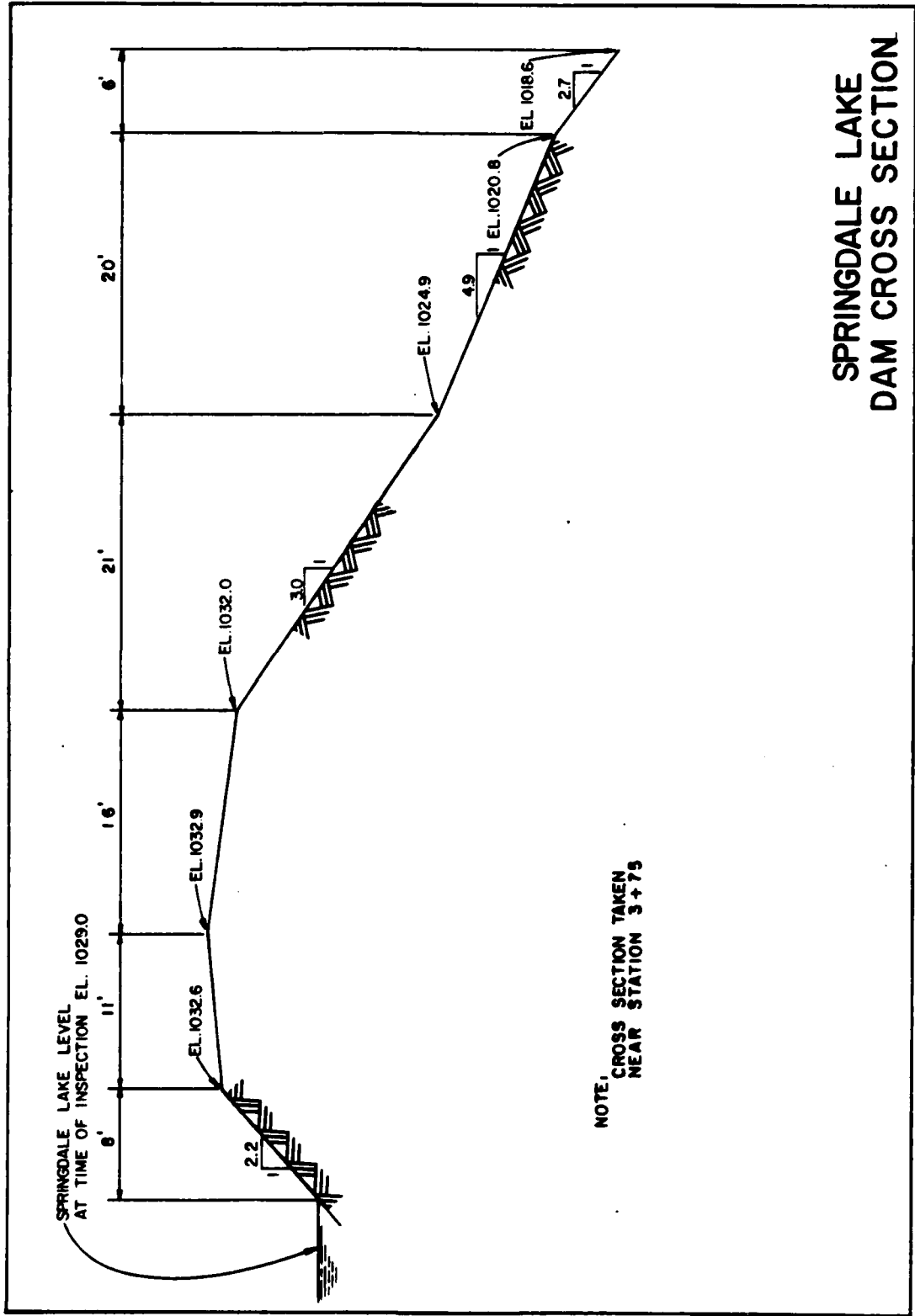
TRASH
SCREEN

2-8" Ø CORRUGATED METAL PIPES

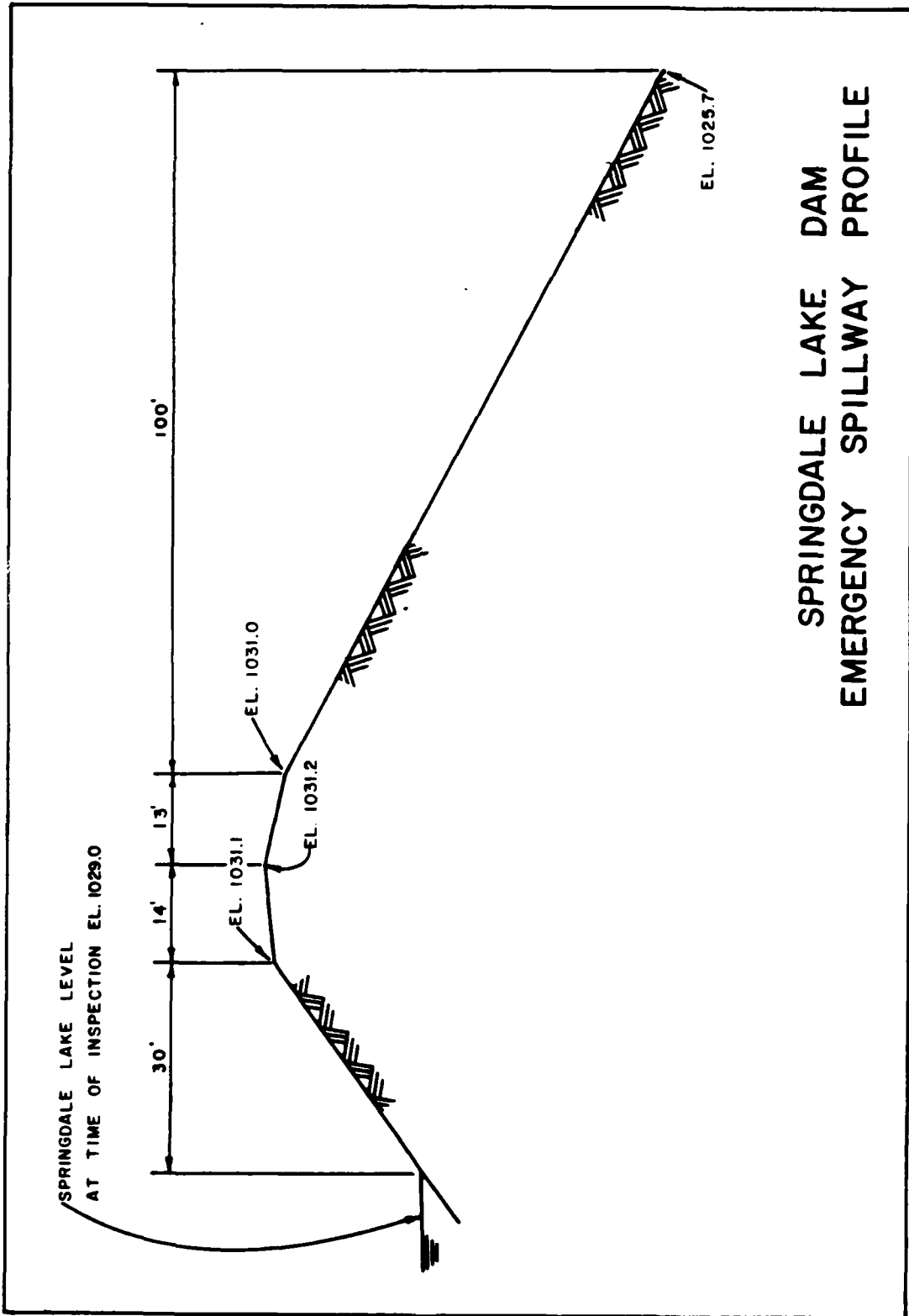
SPRINGDALE
LAKE

**SPRINGDALE LAKE
DAM PLAN**





SPRINGDALE LAKE
DAM CROSS SECTION



SPRINGDALE LAKE DAM
 EMERGENCY SPILLWAY PROFILE

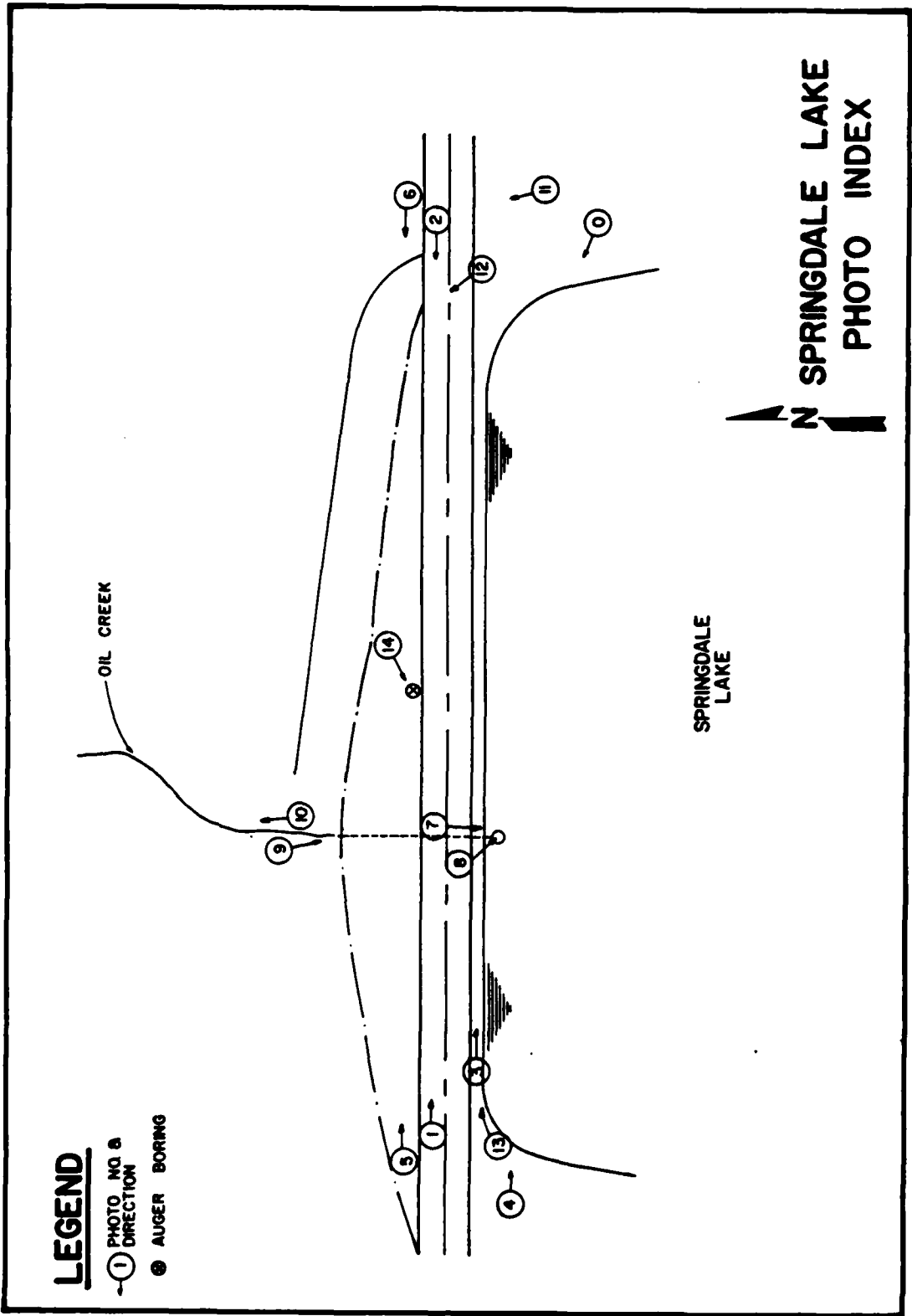


PLATE 6



PHOTO 1: CREST OF DAM LOOKING EAST



PHOTO 2: CREST OF DAM LOOKING WEST



PHOTO 3: FACE OF DAM LOOKING ALONG UPSTREAM EDGE OF CREST



PHOTO 4: FACE OF DAM LOOKING EAST



PHOTO 5: DOWNSTREAM SLOPE OF DAM LOOKING EAST



PHOTO 6: DOWNSTREAM SLOPE OF DAM LOOKING WEST

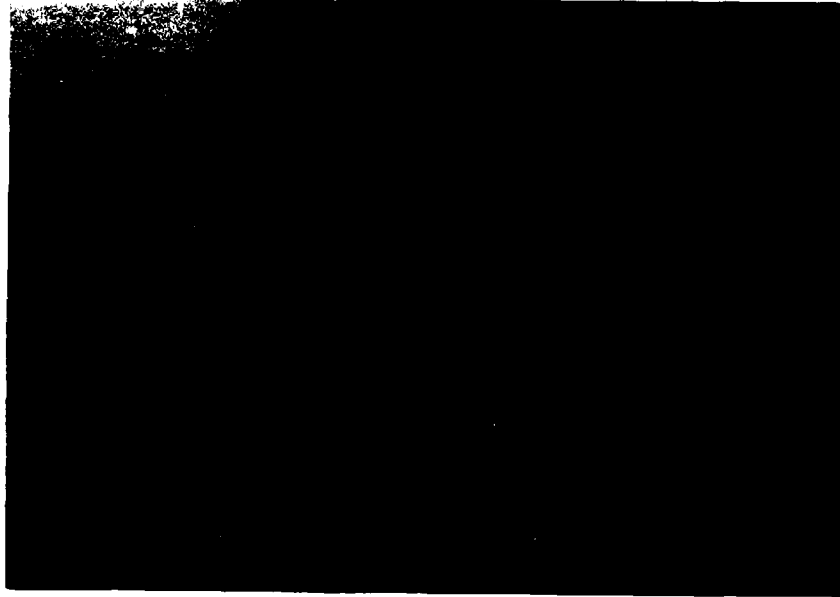


PHOTO 7: PRIMARY SPILLWAY DROP INLET



PHOTO 8: LOOKING INTO DROP INLET



PHOTO 9: PRIMARY SPILLWAY OUTLET AND SPLASH PAD



PHOTO 10: CHANNEL DOWNSTREAM FROM SPILLWAY



PHOTO 11: EMERGENCY SPILLWAY AND TRASH SCREEN

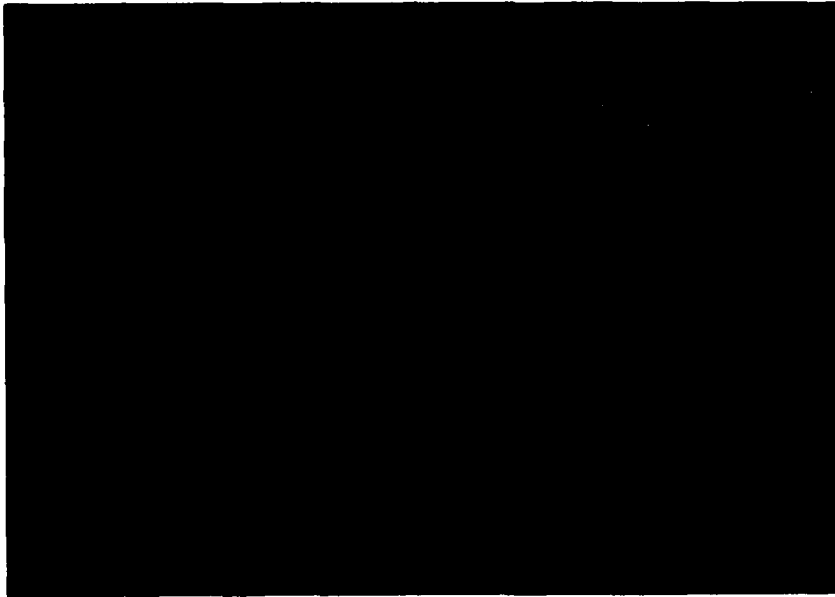


PHOTO 12: EMERGENCY SPILLWAY CHANNEL LOOKING DOWNSTREAM

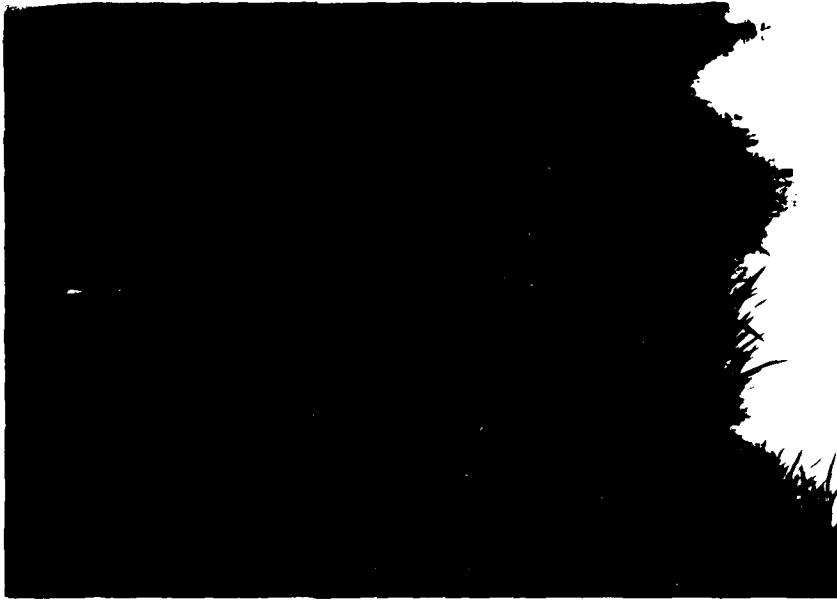


PHOTO 13: EROSION HOLE IN FACE OF DAM



PHOTO 14: SAMPLE OF EMBANKMENT MATERIAL

APPENDIX A
HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph and HEC-1 (1) were used to develop the inflow hydrographs and hydrologic inputs as follows:

a. Twenty-four hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33.

200 square mile, 24 hour rainfall inches	- 24.75
10 square mile, 6 hour percent of 24 hour 200 square mile rainfall	- 101%
10 square mile, 12 hour percent of 24 hour 200 square mile rainfall	- 120%
10 square mile, 24 hour percent of 24 hour 200 square mile rainfall	- 130%

b. Drainage area = 580 acres (175 acres are upstream of U.S. 71 highway).

c. Lag: $L = \frac{[\ell^{0.8} \times (S+1)^{0.7}]}{1,900 \times Y^{0.5}} = 0.34 \text{ hours} = 21 \text{ minutes}$ for the area upstream of U.S. 71 highway for antecedent moisture condition III

where:

$\ell = 4,020 \text{ feet} = \text{hydraulic length of watershed in feet}$

$S = 1,000/\text{CN}' - 10$ where $\text{CN}' = 97 = \text{hydrologic soil cover complex number}$; and

$Y = 1.99\% = \text{average watershed land slope in percent}$.

$L = 0.46 \text{ hours} = 28 \text{ minutes}$ for the area upstream of U.S. 71 highway for antecedent moisture condition II where:

$\ell = 4,020 \text{ feet}$

$S = 1,000/\text{CN}' - 10$ where $\text{CN}' = 91$ and

$Y = 1.99\%$.

L = 0.46 hours = 28 minutes for the area downstream of
 U.S. 71 highway for antecedent moisture condition III
 where:
 $l = 5,100$ feet;
 $S = 1,000/CN' - 10$ where $CN' = 97$
 $Y = 1.59\%$.

L = 0.62 hours = 38 minutes for the area downstream of
 U.S. 71 highway for antecedent moisture condition II
 where:
 $l = 5,100$ feet
 $S = 1,000/CN' - 10$ where $CN' = 91$
 $Y = 1.59\%$ (2)

d. The soil associations in this watershed were Macksburg, Martin, Snead, Sampsel, and Oska (3).

e. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 97 for antecedent moisture condition III and a curve number of 91 for antecedent moisture condition II. Approximately 68% of the drainage area was hydrologic soil group C; 24% of the drainage area was hydrologic soil Group D; and 8% of the drainage area was hydrologic soil group B. The land uses in the watershed were projected to be 70% urban, 20% cropland, and 10% grassland (2 and 4).

2. Primary spillway release rates were based on the minimum of the discharge calculated for flow into the drop inlet using the weir equation and the discharge calculated for flow through the pipe using the orifice equation.

Weir equation:

$$Q = C_o [2\pi R_s] H_o^{3/2}$$

where:

C_o ranges from 1.0 to 3.7 = weir coefficient for drop-inlet spillways

$R_s = 1.5$ feet = radius of the drop inlet

$H_o^s =$ head above the crest of the weir (5)

Orifice equation:

$$Q = Ca[2gH]^{1/2}$$

where:

C = 0.45 = coefficient of discharge

a = 3.14 sq. ft. = net area of the orifice in square feet

g = gravitational acceleration

H = difference between the energy gradient elevation upstream and the tailwater elevation downstream (6)

Discharge rates for the emergency spillway and over the top of the dam were determined by HEC-1 (1) given data describing the embankment crest. Discharge through the emergency spillway for the probable maximum flood and 50 percent of the probable maximum flood was determined by the unlevel weir equation:

$$Q = \frac{2Cb}{5(h_b - h_a)} (h_b^{2.5} - h_a^{2.5})$$

where:

C = 2.60 = weir coefficient

b = the length of flow normal to the weir in feet

h_b = the head on the low end of the weir in feet

h_a = the head on the high end of the weir in feet (7)

Discharge rates through the U.S. 71 highway embankment were determined by nomographs for box culverts with inlet and outlet control. (8)

3. The relationship between elevation and storage volume for the reservoir was determined from a contour map of the reservoir area. A planimeter measurement was made of the area enclosed by each contour line. The storage below the principal spillway was computed by multiplying the average of the areas at the embankment toe and the lake surface by the elevation difference. The storage above this level was computed by HEC-1 (1) given area-elevation data.

4. Floods were routed through the spillway using HEC-1, modified Puls to determine the capability of the spillway.

- (1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.
- (2) U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, August 1972.

- (3) U.S. Department of Agriculture, Soil Conservation Service, Preliminary Soils Report for Cass County, Missouri.
- (4) U.S. Department of Agriculture, Soil Conservation Service, Technical Release No. 55, Urban Hydrology for Small Watersheds, January, 1975.
- (5) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.
- (6) Horace W. King and Ernest F. Brater, Handbook of Hydraulics, Sixth Edition, McGraw Hill Book Company, 1976.
- (7) U.S. Department of the Interior, Geological Survey, Techniques of Water-Resources Investigations, Book 3, Chapter A5, Measurement of Peak Discharge at Dams by Indirect Methods, by Harry Hulsing, 1967.
- (8) U.S. Department of Commerce, Bureau of Public Roads, Hydraulic Engineering Circular No. 5, Hydraulic Charts for the Selection of Highway Culverts, December, 1965.
- (9) U.S. Department of Agriculture, Soil Conservation Service, Soil Survey Interpretations and Field Maps, 1980.
- (10) Mary H. McCracken, Missouri Division of Geological Survey, Geologic Map of Missouri, 1961.

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 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 26 FEB 79

MISSOURI DAM INSPECTION PROGRAM									
2ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS									
3 SPRINGDALE LAKE DAM									
	B	0	5	0	0	0	0	0	0
4	288	0	5	0	0	0	0	0	0
5	01	5							
6	J	1	6	1					
7	J1	.05	.1	.15	.2	.5	1.		
8	K	0	1				3	1	
9	K1	SPRINGDALE LAKE UPSTREAM OF 71 HWY (24 HR. PROBABLE MAXIMUM RUNOFF)							
10	M	1	2	.273			1		
11	P	1	24.75	.191	120	130			
12	T							-1	-97
13	M2		.344						
14	X		1						
15	K	1	2				1		
16	K1	ROUTING THRU HWY 71 BOX CULVERT							
17	Y		1						
18	Y1	1						-1033.2	-1
19	Y1033.21035.3	1035.7	1036.7	1037.7	1038.7	1039.7	1040.7	1041.7	1042.7
20	Y1043.71044.7	1045.7	1046.7	1047.7	1048.7	1049.7			
21	Y50.3	70.	95.	156.	226.	310.	390.	460.	512.
22	Y5615.	651.	698.	737.	770.	800.	800.	1206.	568.
23	SA0.6	1.8	9.04	23.1					
24	SE1033.21040.	1050.	1060.						
25	SE1033.2								
26	SD1049.1								
27	K	3					3		
28	K1	SPRINGDALE LAKE DAM (24 HR. PROBABLE MAXIMUM RUNOFF)							
29	M	1	2	0.633			1		
30	P	1	24.75	101	120	130			
31	T							-1	-97
32	M2		.366						
33	X		1						
34	K	2	4				1		
35	K1	COMBINE HYDROGRAPHS - TOTAL INFLOW HYDROGRAPH TO SPRINGDALE LAKE (24 HR. DMF)							
36	K	1	5				1		
37	K1	ROUTING THROUGH SPRINGDALE LAKE							
38	Y	1							
39	Y1	1						-1029.0	-1
40	Y1029.01030.0	1031.0	1032.0	1033.0	1034.0	1035.0	1036.0	1037.0	1038.
41	Y50.	27.	36.	40.	41.	43.	44.	46.	47.
42	Y49.0	13.6	28.9	49.7					
43	SE1029.1030.	1040.	1050.						
44	SE1029.								
45	SD1031.8								
46	SL0.	43.	151.	217.	417.	500.	530.	545.	575.
47	SE1031.21031.7	1032.2	1032.7	1033.2	1033.7	1034.2	1034.7	1035.2	1035.7
48	K	99							

.....
 LAST MODIFICAT 26 FEB 79

RUN DATE 06/18/80
 TIME 19.06.38.

MISSOURI DAM INSPECTION PROGRAM
 ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
 SPRINGDALE LAKE DAM

NO NHR NMIN IDAY IHR IMIN METRC IPLT IPRT NSTAN
 28R 0 5 JOPER 0 0 0 0 0 0
 5 JOPER 0 0 0 0 0 0

JOB SPECIFICATION

MULTI-PLAN ANALYSES TO BE PERFORMED

RTIOS= .05 .10 .15 .20 .25 .50 1.00
 NPLAN= 1 NRTIO= 6 LRTIO= 1

.....

SUB-AREA RUNOFF COMPUTATION

SPRINGDALE LAKE UPSTREAM OF 71 HWY (24 HR. PROBABLE MAXIMUM RUNOFF)

ISTAG ICOMP IECON ITAPE IJPLT JPRT INAME ISTAGE IAUTO
 1 0 0 0 0 0 3 1 0 0

HYDROGRAPH DATA

IHYDC IUNG TAREA SNAP TRSDA TRSPC RATIO ISNOW ISAKE LOCAL
 1 2 .27 0.00 .27 1.00 0.000 0 0 0

PRECIP DATA

SPFE PMS R6 R12 R24 R48 R72 R96
 0.00 24.75 101.00 120.00 130.00 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 -97.00 0.00 0.00

CURVE NO = -97.00 WETNESS = -1.00 EFFECT CN = 97.00

UNIT HYDROGRAPH DATA

TC= 0.00 LAG= .34

RECESSION DATA

STRIG= 0.00 GRCSN= 0.00 RTIOE= 1.00

UNIT HYDROGRAPH 23 END OF PERIOD ORIGINATES: IC= 0.00 HOURS LAG= .34 VOL= 1.00
 39. 124. 252. 331. 339. 295. 227. 150. 105. 76.
 53. 37. 26. 13. 9. 6. 5. 3. 2.
 2. 1. 0.

MO. DA HR. MN PERIOD RAIN EXCS LOSS COMP 0 MO. DA HR. MN PERIOD RAIN EXCS LOSS COMP 0

END-OF-PERIOD FLOW

NO. DA	HR. MN	PERIOD	RAIN	EXCS	LOSS	COMP O	NO. DA	HR. MN	PERIOD	RAIN	EXCS	LOSS	COMP O
1.01	0.05	1	.01	0.00	.01	0.	1.01	12.05	145	.21	.21	.00	143.
1.01	0.10	2	.01	0.00	.01	0.	1.01	12.10	147	.21	.21	.00	161.
1.01	0.15	3	.01	0.00	.01	0.	1.01	12.15	147	.21	.21	.00	157.
1.01	0.20	4	.01	0.00	.01	0.	1.01	12.20	148	.21	.21	.00	244.
1.01	0.25	5	.01	0.00	.01	0.	1.01	12.25	149	.21	.21	.00	292.
1.01	0.30	6	.01	0.00	.01	0.	1.01	12.30	150	.21	.21	.00	334.
1.01	0.35	7	.01	0.00	.01	0.	1.01	12.35	151	.21	.21	.00	367.
1.01	0.40	8	.01	0.00	.01	1.	1.01	12.40	152	.21	.21	.00	388.
1.01	0.45	9	.01	0.00	.01	1.	1.01	12.45	153	.21	.21	.00	403.
1.01	0.50	10	.01	0.00	.01	3.	1.01	12.50	154	.21	.21	.00	414.
1.01	0.55	11	.01	0.01	.01	4.	1.01	12.55	155	.21	.21	.00	422.
1.01	1.00	12	.01	0.01	.01	5.	1.01	13.00	156	.21	.21	.00	427.
1.01	1.05	13	.01	0.01	.01	7.	1.01	13.05	157	.25	.25	.00	433.
1.01	1.10	14	.01	0.01	.01	8.	1.01	13.10	158	.25	.25	.00	440.
1.01	1.15	15	.01	0.01	.01	9.	1.01	13.15	159	.25	.25	.00	453.
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1.01	1.25	17	.01	0.01	.01	12.	1.01	13.25	161	.25	.25	.00	483.
1.01	1.30	18	.01	0.01	.01	13.	1.01	13.30	162	.25	.25	.00	486.
1.01	1.35	19	.01	0.01	.01	14.	1.01	13.35	163	.25	.25	.00	506.
1.01	1.40	20	.01	0.01	.01	15.	1.01	13.40	164	.25	.25	.00	512.
1.01	1.45	21	.01	0.01	.01	16.	1.01	13.45	165	.25	.25	.00	517.
1.01	1.50	22	.01	0.01	.00	16.	1.01	13.50	166	.25	.25	.00	520.
1.01	1.55	23	.01	0.01	.01	17.	1.01	13.55	167	.25	.25	.00	523.
1.01	2.00	24	.01	0.01	.00	18.	1.01	14.00	168	.25	.25	.00	524.
1.01	2.05	25	.01	0.01	.00	18.	1.01	14.05	169	.31	.31	.00	528.
1.01	2.10	26	.01	0.01	.01	19.	1.01	14.10	170	.31	.31	.00	536.
1.01	2.15	27	.01	0.01	.00	19.	1.01	14.15	171	.31	.31	.00	552.
1.01	2.20	28	.01	0.01	.00	20.	1.01	14.20	172	.31	.31	.00	574.
1.01	2.25	29	.01	0.01	.00	20.	1.01	14.25	173	.31	.31	.00	595.
1.01	2.30	30	.01	0.01	.00	21.	1.01	14.30	174	.31	.31	.00	614.
1.01	2.35	31	.01	0.01	.00	21.	1.01	14.35	175	.31	.31	.00	628.
1.01	2.40	32	.01	0.01	.00	22.	1.01	14.40	176	.31	.31	.00	637.
1.01	2.45	33	.01	0.01	.00	22.	1.01	14.45	177	.31	.31	.00	644.
1.01	2.50	34	.01	0.01	.00	22.	1.01	14.50	178	.31	.31	.00	649.
1.01	2.55	35	.01	0.01	.00	22.	1.01	14.55	179	.31	.31	.00	652.
1.01	3.00	36	.01	0.01	.00	23.	1.01	15.00	180	.31	.31	.00	655.
1.01	3.05	37	.01	0.01	.00	23.	1.01	15.05	181	.19	.19	.00	651.
1.01	3.10	38	.01	0.01	.00	23.	1.01	15.10	182	.38	.38	.00	645.
1.01	3.15	39	.01	0.01	.00	23.	1.01	15.15	183	.38	.38	.00	638.
1.01	3.20	40	.01	0.01	.00	24.	1.01	15.20	184	.57	.57	.00	634.
1.01	3.25	41	.01	0.01	.00	24.	1.01	15.25	185	.66	.66	.00	703.
1.01	3.30	42	.01	0.01	.00	24.	1.01	15.30	186	1.61	1.61	.00	828.
1.01	3.35	43	.01	0.01	.00	24.	1.01	15.35	187	2.66	2.66	.00	1101.
1.01	3.40	44	.01	0.01	.00	24.	1.01	15.40	188	1.04	1.04	.00	1521.
1.01	3.45	45	.01	0.01	.00	25.	1.01	15.45	189	.66	.66	.00	1974.
1.01	3.50	46	.01	0.01	.00	25.	1.01	15.50	190	.57	.57	.00	2287.
1.01	3.55	47	.01	0.01	.00	25.	1.01	15.55	191	.38	.38	.00	2330.
1.01	4.00	48	.01	0.01	.00	25.	1.01	16.00	192	.38	.38	.00	2177.
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1.01	4.10	50	.01	0.01	.00	25.	1.01	16.10	194	.29	.29	.00	1586.
1.01	4.15	51	.01	0.01	.00	25.	1.01	16.15	195	.29	.29	.00	1338.
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1.01	4.25	53	.01	0.01	.00	26.	1.01	16.25	197	.29	.29	.00	993.
1.01	4.30	54	.01	0.01	.00	26.	1.01	16.30	198	.29	.29	.00	840.
1.01	4.35	55	.01	0.01	.00	26.	1.01	16.35	199	.29	.29	.00	871.
1.01	4.40	56	.01	0.01	.00	26.	1.01	16.40	200	.29	.29	.00	741.

1.01	6.10	50	.01	.01	.00	25.	1.01	16.10	154	.29	.29	.00	1.06.
1.01	6.10	51	.01	.01	.00	25.	1.01	16.15	195	.29	.29	.00	330.
1.01	6.10	52	.01	.01	.00	25.	1.01	16.20	196	.29	.29	.00	.143.
1.01	6.25	53	.01	.01	.00	26.	1.01	16.25	197	.29	.29	.00	.990.
1.01	6.30	54	.01	.01	.00	26.	1.01	16.30	198	.29	.29	.00	860.
1.01	6.35	55	.01	.01	.00	26.	1.01	16.35	199	.29	.29	.00	801.
1.01	6.40	56	.01	.01	.00	26.	1.01	16.40	200	.29	.29	.00	746.
1.01	6.45	57	.01	.01	.00	26.	1.01	16.45	201	.29	.29	.00	708.
1.01	6.50	58	.01	.01	.00	26.	1.01	16.50	202	.29	.29	.00	661.
1.01	6.55	59	.01	.01	.00	26.	1.01	16.55	203	.29	.29	.00	662.
1.01	5.00	60	.01	.01	.00	26.	1.01	17.00	204	.29	.29	.00	648.
1.01	5.05	61	.01	.01	.00	26.	1.01	17.05	205	.23	.23	.00	637.
1.01	5.10	62	.01	.01	.00	26.	1.01	17.10	206	.23	.23	.00	622.
1.01	5.15	63	.01	.01	.00	26.	1.01	17.15	207	.23	.23	.00	601.
1.01	5.20	64	.01	.01	.00	27.	1.01	17.20	208	.23	.23	.00	576.
1.01	5.25	65	.01	.01	.00	27.	1.01	17.25	209	.23	.23	.00	551.
1.01	5.30	66	.01	.01	.00	27.	1.01	17.30	210	.23	.23	.00	531.
1.01	5.35	67	.01	.01	.00	27.	1.01	17.35	211	.23	.23	.00	516.
1.01	5.40	68	.01	.01	.00	27.	1.01	17.40	212	.23	.23	.00	507.
1.01	5.45	69	.01	.01	.00	27.	1.01	17.45	213	.23	.23	.00	500.
1.01	5.50	70	.01	.01	.00	27.	1.01	17.50	214	.23	.23	.00	495.
1.01	5.55	71	.01	.01	.00	27.	1.01	17.55	215	.23	.23	.00	492.
1.01	6.00	72	.01	.01	.00	27.	1.01	18.00	216	.23	.23	.00	489.
1.01	6.05	73	.07	.06	.00	29.	1.01	18.05	217	.02	.02	.00	480.
1.01	6.10	74	.07	.06	.00	35.	1.01	18.10	218	.02	.02	.00	453.
1.01	6.15	75	.07	.06	.00	47.	1.01	18.15	219	.02	.02	.00	399.
1.01	6.20	76	.07	.06	.00	64.	1.01	18.20	220	.02	.02	.00	339.
1.01	6.25	77	.07	.06	.00	80.	1.01	18.25	221	.02	.02	.00	259.
1.01	6.30	78	.07	.06	.00	95.	1.01	18.30	222	.02	.02	.00	157.
1.01	6.35	79	.07	.06	.00	106.	1.01	18.35	223	.02	.02	.00	149.
1.01	6.40	80	.07	.06	.00	114.	1.01	18.40	224	.02	.02	.00	118.
1.01	6.45	81	.07	.06	.00	120.	1.01	18.45	225	.02	.02	.00	96.
1.01	6.50	82	.07	.06	.00	124.	1.01	18.50	226	.02	.02	.00	80.
1.01	6.55	83	.07	.06	.00	127.	1.01	18.55	227	.02	.02	.00	69.
1.01	7.00	84	.07	.06	.00	129.	1.01	19.00	228	.02	.02	.00	61.
1.01	7.05	85	.07	.06	.00	131.	1.01	19.05	229	.02	.02	.00	56.
1.01	7.10	86	.07	.06	.00	132.	1.01	19.10	230	.02	.02	.00	52.
1.01	7.15	87	.07	.06	.00	133.	1.01	19.15	231	.02	.02	.00	49.
1.01	7.20	88	.07	.06	.00	133.	1.01	19.20	232	.02	.02	.00	46.
1.01	7.25	89	.07	.06	.00	134.	1.01	19.25	233	.02	.02	.00	46.
1.01	7.30	90	.07	.06	.00	134.	1.01	19.30	234	.02	.02	.00	45.
1.01	7.35	91	.07	.06	.00	135.	1.01	19.35	235	.02	.02	.00	45.
1.01	7.40	92	.07	.06	.00	135.	1.01	19.40	236	.02	.02	.00	44.
1.01	7.45	93	.07	.06	.00	135.	1.01	19.45	237	.02	.02	.00	44.
1.01	7.50	94	.07	.06	.00	135.	1.01	19.50	238	.02	.02	.00	44.
1.01	7.55	95	.07	.06	.00	136.	1.01	19.55	239	.02	.02	.00	44.
1.01	8.00	96	.07	.06	.00	136.	1.01	20.00	240	.02	.02	.00	44.
1.01	8.05	97	.07	.06	.00	136.	1.01	20.05	241	.02	.02	.00	44.
1.01	8.10	98	.07	.06	.00	136.	1.01	20.10	242	.02	.02	.00	44.
1.01	8.15	99	.07	.06	.00	136.	1.01	20.15	243	.02	.02	.00	44.
1.01	8.20	100	.07	.06	.00	136.	1.01	20.20	244	.02	.02	.00	44.
1.01	8.25	101	.07	.06	.00	136.	1.01	20.25	245	.02	.02	.00	44.
1.01	8.30	102	.07	.06	.00	136.	1.01	20.30	246	.02	.02	.00	44.
1.01	8.35	103	.07	.06	.00	136.	1.01	20.35	247	.02	.02	.00	44.
1.01	8.40	104	.07	.06	.00	136.	1.01	20.40	248	.02	.02	.00	44.
1.01	8.45	105	.07	.06	.00	137.	1.01	20.45	249	.02	.02	.00	44.
1.01	8.50	106	.07	.06	.00	137.	1.01	20.50	250	.02	.02	.00	44.
1.01	8.55	107	.07	.06	.00	137.	1.01	20.55	251	.02	.02	.00	44.
1.01	9.00	108	.07	.06	.00	137.	1.01	21.00	252	.02	.02	.00	44.
1.01	9.05	109	.07	.06	.00	137.	1.01	21.05	253	.02	.02	.00	44.
1.01	9.10	110	.07	.06	.00	137.	1.01	21.10	254	.02	.02	.00	44.
1.01	9.15	111	.07	.06	.00	137.	1.01	21.15	255	.02	.02	.00	44.

1.01	8.55	1.7	.07	.06	.00	137.	1.01	20.55	251	.02	.00	44.
1.01	9.00	1.08	.07	.06	.00	137.	1.01	21.00	252	.02	.00	44.
1.01	9.05	1.09	.07	.06	.00	137.	1.01	21.05	253	.02	.00	44.
1.01	9.10	1.10	.07	.06	.00	137.	1.01	21.10	254	.02	.00	44.
1.01	9.15	1.11	.07	.06	.00	137.	1.01	21.15	255	.02	.00	44.
1.01	9.20	1.12	.07	.06	.00	137.	1.01	21.20	256	.02	.00	44.
1.01	9.25	1.13	.07	.06	.00	137.	1.01	21.25	257	.02	.00	44.
1.01	9.30	1.14	.07	.06	.00	137.	1.01	21.30	258	.02	.00	44.
1.01	9.35	1.15	.07	.06	.00	137.	1.01	21.35	259	.02	.00	44.
1.01	9.40	1.16	.07	.06	.00	137.	1.01	21.40	260	.02	.00	44.
1.01	9.45	1.17	.07	.06	.00	137.	1.01	21.45	261	.02	.00	44.
1.01	9.50	1.18	.07	.06	.00	137.	1.01	21.50	262	.02	.00	44.
1.01	9.55	1.19	.07	.06	.00	137.	1.01	21.55	263	.02	.00	44.
1.01	10.00	1.20	.07	.06	.00	137.	1.01	22.00	264	.02	.00	44.
1.01	10.05	1.21	.07	.06	.00	137.	1.01	22.05	265	.02	.00	44.
1.01	10.10	1.22	.07	.06	.00	137.	1.01	22.10	266	.02	.00	44.
1.01	10.15	1.23	.07	.07	.00	137.	1.01	22.15	267	.02	.00	44.
1.01	10.20	1.24	.07	.07	.00	137.	1.01	22.20	268	.02	.00	44.
1.01	10.25	1.25	.07	.07	.00	137.	1.01	22.25	269	.02	.00	44.
1.01	10.30	1.26	.07	.07	.00	137.	1.01	22.30	270	.02	.00	44.
1.01	10.35	1.27	.07	.07	.00	137.	1.01	22.35	271	.02	.00	44.
1.01	10.40	1.28	.07	.07	.00	137.	1.01	22.40	272	.02	.00	44.
1.01	10.45	1.29	.07	.07	.00	137.	1.01	22.45	273	.02	.00	44.
1.01	10.50	1.30	.07	.07	.00	137.	1.01	22.50	274	.02	.00	44.
1.01	10.55	1.31	.07	.07	.00	137.	1.01	22.55	275	.02	.00	44.
1.01	11.00	1.32	.07	.07	.00	137.	1.01	23.00	276	.02	.00	44.
1.01	11.05	1.33	.07	.07	.00	137.	1.01	23.05	277	.02	.00	44.
1.01	11.10	1.34	.07	.07	.00	137.	1.01	23.10	278	.02	.00	44.
1.01	11.15	1.35	.07	.07	.00	137.	1.01	23.15	279	.02	.00	44.
1.01	11.20	1.36	.07	.07	.00	137.	1.01	23.20	280	.02	.00	44.
1.01	11.25	1.37	.07	.07	.00	138.	1.01	23.25	281	.02	.00	44.
1.01	11.30	1.38	.07	.07	.00	138.	1.01	23.30	282	.02	.00	44.
1.01	11.35	1.39	.07	.07	.00	138.	1.01	23.35	283	.02	.00	44.
1.01	11.40	1.40	.07	.07	.00	138.	1.01	23.40	284	.02	.00	44.
1.01	11.45	1.41	.07	.07	.00	138.	1.01	23.45	285	.02	.00	44.
1.01	11.50	1.42	.07	.07	.00	138.	1.01	23.50	286	.02	.00	44.
1.01	11.55	1.43	.07	.07	.00	138.	1.01	23.55	287	.02	.00	44.
1.01	12.00	1.44	.07	.07	.00	138.	1.02	0.00	288	.02	.00	44.

SUM 32.17 31.81 .37 67012.
(.817.36 808.36) 9.36 1897.57)

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
2358.	722.	233.	233.	66970.
CFS	20.	7.	7.	1896.
66.	24.59	31.69	31.69	31.69
CMS	624.54	805.02	805.02	805.02
INCHES	358.	461.	461.	461.
MM	441.	569.	569.	569.
AC-FT				
THOUS CU M				

HYDROGRAPH AT STA 1 FOR PLAN 1, RATIO 1

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
116.	36.	12.	12.	3348.
CFS	1.	0.	0.	95.
3.	1.23	1.58	1.58	1.58
CMS	31.23	40.25	40.25	40.25
INCHES	18.	23.	23.	23.
MM	22.	28.	28.	28.
AC-FT				
THOUS CU M				

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO (CONGRUIC COMPUTATIONS)
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS					
				RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6
				.05	.10	.15	.20	.50	1.00
HYDROGRAPH AT	1	.27 (.71)	1 (3.30)	116. (3.30)	233. (6.60)	349. (9.90)	466. (13.19)	1165. (32.99)	2330. (65.97)
ROUTED TO	2	.27 (.71)	1 (2.75)	97. (2.75)	197. (5.59)	296. (8.39)	388. (10.98)	692. (19.58)	1526. (43.22)
HYDROGRAPH AT	3	.63 (1.64)	1 (6.59)	233. (6.59)	466. (13.19)	598. (19.78)	931. (26.37)	2328. (65.93)	4657. (131.86)
2 COMBINED	4	.91 (2.35)	1 (9.28)	328. (9.28)	660. (18.70)	990. (28.05)	1312. (37.14)	2981. (84.42)	6047. (171.23)
ROUTED TO	5	.91 (2.35)	1 (2.95)	104. (2.95)	549. (15.52)	986. (25.00)	1228. (34.65)	2900. (82.11)	5921. (167.67)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1

ELEVATION STORAGE
 1033.20
 0.
 0.
 935.

INITIAL VALUE
 1033.20
 0.
 0.

SPILLWAY CREST
 1033.20
 0.
 0.

TOP OF DAM
 1049.10
 50.
 935.

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
.05	1035.74	0.00	2.	97.	0.00	16.08	0.00
.10	1037.29	0.00	4.	197.	0.00	16.08	0.00
.15	1038.54	0.00	5.	296.	0.00	16.08	0.00
.20	1039.67	0.00	7.	388.	0.00	16.08	0.00
.50	1045.56	0.00	26.	692.	0.00	16.25	0.00
1.00	1050.85	1.75	65.	1526.	.92	16.17	0.00

END

DATE
FILMED

12-81

DTIC