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NATIONAL DAM SAFETY PROGRAM. SPRING LAKE DAM (MO 11122), MISSOURI-ETC(U)
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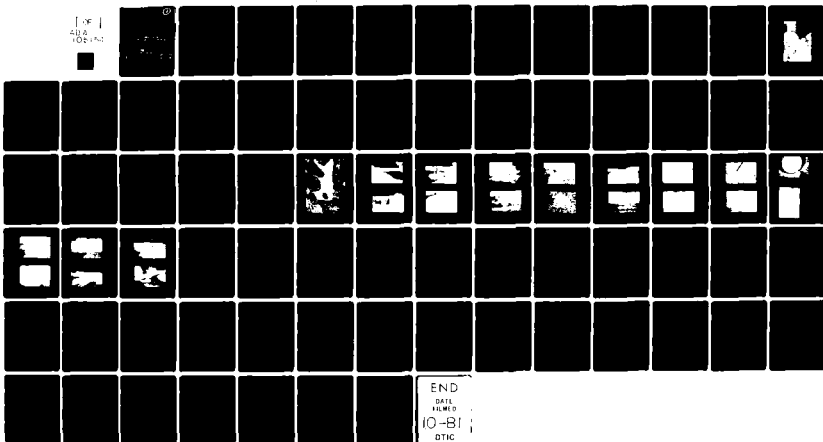
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AD A105154

SPRING LAKE DAM

CLINTON COUNTY, MISSOURI

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**PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM**

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**United States Army
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PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

JULY, 1980

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

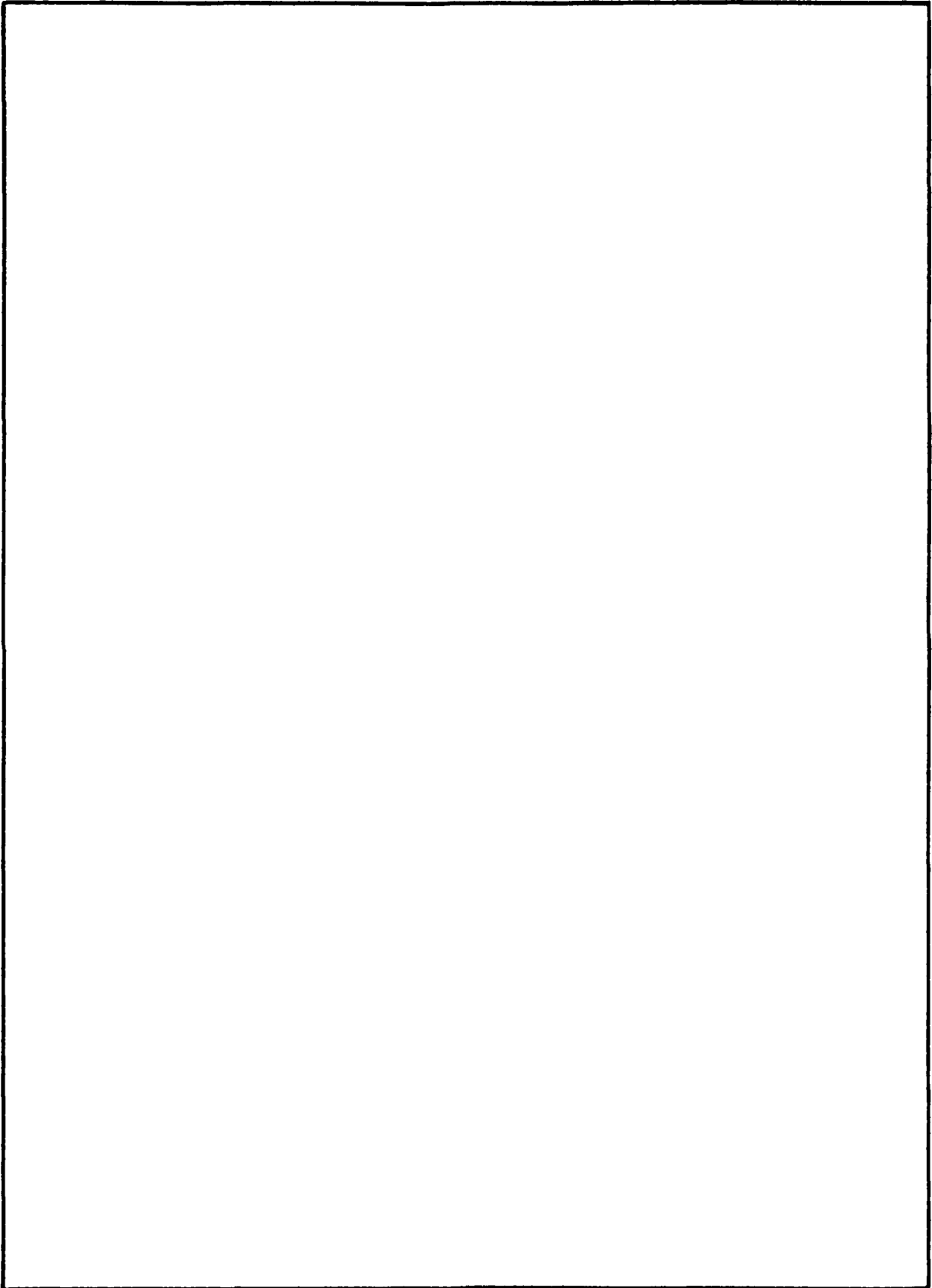
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SPRING LAKE DAM
CLINTON COUNTY, MISSOURI
MISSOURI INVENTORY NO. MO 11122

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
HOSKINS-WESTERN-SONDEREGGER, INC.
CONSULTING ENGINEERS
LINCOLN, NEBRASKA

UNDER DIRECTION OF
ST. LOUIS DISTRICT, CORPS OF ENGINEERS

FOR
GOVERNOR OF MISSOURI

JULY, 1980

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

SUBJECT: Spring Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Spring Lake Dam (MO 11122).

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:

- a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.
- b. Overtopping of the dam could result in failure of the dam.
- c. Dam failure significantly increases the hazard to loss of life downstream.

SIGNED		11 DEC 1980
SUBMITTED BY:	_____ Chief, Engineering Division	_____ Date
SIGNED		15 DEC 1980
APPROVED BY:	_____ Colonel, CE, District Engineer	_____ Date

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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Principal Spillway Rating Curve
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Computer Input and Output for Ratios of
PMF

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
ASSESSMENT SUMMARY

Name of Dam	Spring Lake Dam
State Located	Missouri
County Located	Clinton County
Stream	Tributary to Muddy Fork
Date of Inspection	July 2, 1980

Spring Lake Dam was inspected by an interdisciplinary team of engineers from Hoskins-Western-Sonderegger, Inc. The purpose of the inspection was to make an assessment of the general conditions 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 developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers.

Spring Lake Dam has a height of fifty (50) feet and a storage capacity at the minimum top elevation of the dam of three hundred thirty (330) acre-feet. In accordance with the guidelines, an intermediate size dam has a height greater than or equal to forty (40) feet but less than one hundred (100) feet and a storage capacity greater than or equal to one thousand (1,000) acre-feet but less than fifty thousand (50,000) acre-feet. The size classification is determined by either the storage capacity or height, whichever gives the larger size category. Spring Lake Dam is classified as an intermediate size dam.

In accordance with the guidelines and based on visual observation, the dam is classified as having a high potential for damage and loss of life. Failure would threaten life and property. The estimated damage zone extends approximately two (2) miles downstream of the dam. Within the damage zone are a dwelling (1.1 miles downstream), Highway PP and a bridge (1.4 miles downstream), a barn (1.6 miles downstream), and seven dwellings in the City of Holt (1.8 miles downstream).

Our inspection and evaluation indicate that the spillways do not meet the minimum criteria set forth in the recommended guidelines for an intermediate dam having a high hazard potential. The Probable Maximum Flood is the appropriate spillway design flood. The spillways will pass the 100-year flood (a flood having a 1 percent probability of being exceeded in any year) without overtopping the dam. The spillways will pass 22 percent of the Probable Maximum Flood without overtopping the dam. The Probable Maximum Flood (PMF) is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

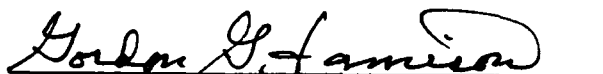
No design data were available for this dam. Based on the field inspection of the dam the following remedial measure should be implemented by the owner on a high priority basis:

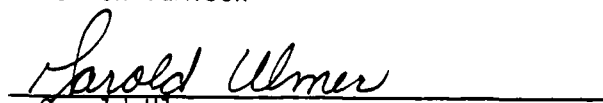
- a. The spillway size and/or the height of dam should be increased to pass the probable maximum flood without overtopping the dam.

The following operation and maintenance procedures are recommended and should be implemented by the owner in the near future:

- a. Seepage and stability analyses comparable to the recommendations of the recommended guidelines should be performed by an engineer experienced in the design and construction of dams.
- b. The volume and clarity of the seepage on the downstream side of the dam should be monitored by an engineer experienced in the design and construction of dams. The records of monitoring should be made a part of the project file.
- c. The erosional damage (piping) along the principal spillway culvert and through the control section of the emergency spillway should be repaired under the guidance of an engineer experienced in the design and construction of dams.
- d. The small willow trees growing at the entrance to the principal spillway and in the downstream channel should be removed. Measures should be taken to prevent recurrent growth.
- e. A program of regular maintenance and inspection should be initiated and records of these activities should be made a part of the project file.


Rey S. Decker
E-3703


Gordon Jamison


Garold Ulmer
E-19246

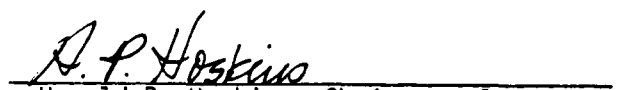

Harold P. Hoskins, Chairman of the Board
Hoskins-Western-Sonderegger, Inc.
E-8696



PHOTO NO. 1 - OVERVIEW

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
SPRING LAKE DAM - MO 11122
CLINTON COUNTY, MISSOURI

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 St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of Spring 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", Appendix D to "Report of the Chief of Engineers on the National Program of Inspection of Dams," dated May, 1975, and published by the Department of the Army, Office of the Chief of Engineers.

1.2 DESCRIPTION OF PROJECT

- a. Description of Dam and Appurtenances.
 - (1) The dam is an earth fill approximately 400 feet in length and 50 feet high. The maximum water storage at the minimum top elevation of the dam is 330+ acre-feet. It is located in the dissected till plains area within the Central Lowlands Physiographic Region about two miles northeast of Holt, Missouri.
 - (2) The principal spillway is uncontrolled and consists of two 24-inch corrugated metal pipe culverts. The culverts are set on bedrock and are located in the right abutment. The exit channel is cut into rock through the right abutment.
 - (3) An uncontrolled emergency spillway is also located in the right abutment and consists of a road embankment acting as a broad-crested weir. The embankment is constructed over the twin culvert principal spillway.
 - (4) Pertinent physical data are given in paragraph 1.3 below.

- b. Location. The dam is located in the southeast portion of Clinton County, Missouri, as shown on Plate A-2. The dam is shown on Plate A-1 in the NE 1/4 of Section 24, T54N, R31W.
- c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Spring Lake Dam has a height of 50 feet and a storage capacity of 330 acre-feet. This dam is classified as an intermediate size dam. An intermediate size dam has a height greater than or equal to 40 feet but less than 100 feet and a storage capacity greater than or equal to 1,000 acre-feet but less than 50,000 acre-feet. The size classification is determined by either the storage or height, whichever gives the larger size category.
- d. Hazard Classification. Guidelines for determining hazard classification are presented in the same guidelines as referenced in paragraph 1.1c above. Based on referenced guidelines, this dam is in the High Hazard Potential Classification. The estimated damage zone extends about two miles downstream of the dam. It was determined by visual observation that within the damage zone are a dwelling (1.1 miles downstream), Highway PP and a bridge (1.4 miles downstream), a barn (1.6 miles downstream), and seven dwellings in the City of Holt (1.8 miles downstream).
- e. Ownership. The dam is owned by the National Development Company, 2735 Villa Creek Drive, Suite 100, Dallas, Texas 75234. Attention: Mr. Dick Erkenbeck.
- f. Purpose of Dam. The dam impounds a recreational lake covering about 14 acres.
- g. Design and Construction History. It was reported by Mr. Dick Erkenbeck that the dam was constructed in 1974 for the National Development Company. Mr. Erkenbeck also reported that there was a set of design plans for the dam; however, the inspection team was not able to obtain a set. No other information was available on design or construction of the dam.
- h. Normal Operating Procedure. There are no operating facilities for this dam. The pool level is controlled by rainfall, infiltration, evaporation, and the capacity of the uncontrolled spillway.

1.3 PERTINENT DATA

- a. Drainage Area. 148.6 acres (0.232 square miles).
- b. Discharge at Damsite.
 - (1) All discharges at the damsite are through an uncontrolled principal spillway (twin 24-inch corrugated metal pipe culverts) and an uncontrolled emergency spillway (low road section constructed over the 24-inch corrugated metal pipe culverts).

- (2) Estimated maximum flood at damsite - Unknown.
- (3) The principal spillway capacity varies from 0 c.f.s. at elevation 960.3 feet to 37 c.f.s. at the crest of the emergency spillway (elevation 963.4 feet) to 43 c.f.s. at the minimum top of dam (elevation 964.1 feet).
- (4) The emergency spillway capacity varies from 0 c.f.s. at its crest (elevation 963.4 feet) to 53 c.f.s. at the minimum top of dam (elevation 964.1 feet).
- (5) Total spillway capacity at the minimum top of dam is 96 c.f.s.±.

c. Elevations (feet above M.S.L.).

- (1) Observed pool - 960.0
- (2) Normal pool - 960.3
- (3) Spillway crest (s)
 - Principal - 960.3
 - Emergency - 963.4
- (4) Maximum experienced pool - Unknown
- (5) Top of dam (minimum) - 964.1
- (6) Maximum Tailwater - Unknown
- (7) Streambed at Centerline - 910.4

d. Reservoir.

- (1) Length (feet) of pool at top of dam - 1600±.
- (2) Length (feet) of pool at principal spillway crest - 1600±.
- (3) Length (feet) of pool at emergency spillway crest - 1600±.

e. Storage (Acre-feet).

- (1) Observed pool - 194±
- (2) Normal pool - 194±
- (3) Spillway crest (s)
 - Principal - 194±
 - Emergency - 250±

(4) Maximum experienced pool - Unknown

(5) Top of dam (minimum) - 330₊

f. Reservoir Surface (Acres).

(1) Observed pool - 14₊

(2) Normal pool - 14₊

(3) Spillway crest (s).

Principal - 14₊

Emergency - 16₊

(4) Maximum experienced pool - Unknown

(5) Top of dam (minimum) - 17₊

g. Dam.

(1) Type - Homogeneous earth fill

(2) Length - 400 feet

(3) Height - 50 feet ₊ (maximum)

(4) Top width - 18 feet

(5) Side slopes.

(a) Downstream 1V on 3.2H (measured - overall)

(b) Upstream 1V on 2.4H (measured on exposed slope)

(6) Zoning - Unknown

(7) Impervious core - Unknown

(8) Cutoff - Unknown

(9) Grout curtain - Unknown

(10) Wave protection - Riprap (size ranging from 1" to 10")

(11) Drains - None

h. Diversion Channel and Regulating Tunnel. None

i. Spillway.

(1) Principal

(a) Type - Uncontrolled, twin 24-inch corrugated metal pipe culverts.

(b) Inlet (invert) elevation - 960.3 (left culvert); 960.4 (right culvert).

Outlet (invert) elevation - 959.7 (right and left culvert)

(c) Length - 42 ft. (right and left culvert).

(2) Emergency

(a) Type - An uncontrolled earth road embankment constructed over the twin culverts acting as a broad-crested weir.

(b) Control section - The road embankment which consists of a 20-foot crest width with a 1V on 5.6H upstream slope and a 1V on 2.9H downstream slope. The section is parabolic in shape.

(c) Crest elevation - 963.4 (minimum)

(d) Upstream Channel - Water level at invert elevation of principal spillway culverts. No observable upstream channel.

(e) Downstream Channel - A trapezoidal section with an approximate bottom width of 10' cut into bedrock. It is open and stable with an 8.6% grade for approximately 80 ft. where it drops off into a headcut.

j. Regulating Outlets. None

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design data were available for this dam.

2.2 CONSTRUCTION

No construction data were available. It was reported by Mr. Dick Erkenbeck that the dam was constructed in 1974.

2.3 OPERATION

No data were available on spillway operation. It was reported by Mr. King, the caretaker, that the spillway operates every year. The maximum flow through the spillway was reported by Mr. King to be about one-half the capacity of the culverts. It is not known when this occurred. There was no evidence to indicate that the dam has been overtopped.

2.4 EVALUATION

- a. Availability. No data were available.
- b. Adequacy. The field surveys and visual observation presented herein are considered adequate to support the conclusion of this report. 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. Not applicable.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

- a. General. A visual inspection of the Spring Lake Dam was made on July 2, 1980. Engineers from Hoskins-Western-Sonderegger, Inc., Lincoln, Nebraska making the inspection were: R. S. Decker, Geotechnical; Garold Ulmer and Gordon Jamison, Hydrology and Hydraulics. Mr. and Mrs. King, caretaker and manager, were interviewed prior to the inspection.

b. Dam.

- (1) Geology and Soils (abutment and embankment). Spring Lake Dam is located in the dissected till plains area within the Central Lowlands Physiographic Region. The dam site is in a region where the stratigraphic sequence consists of 8 to 16 feet of loess overlying Kansan-age glacial till of undetermined thickness and character, which in turn overlies bedrock of the Kansas City Group, Missourian Series, Pennsylvanian System. Strata of this group consist of interlayered sequences of shales, limestones, and sandstones.

The dam lies in a narrow, steeply-sided valley with 1 to 3 feet of soil mantling bedrock. Limestone bedrock is exposed in most of the left abutment trough. Limestone is also exposed in the excavated spillway cut through the right abutment.

Materials in the valley consist of a thin cover of alluvium (CL) with sand, gravel, and cobbles. Materials in the dam consist of CL soils borrowed from the loess hill tops and till from the abutments.

Upland soils consist of the Sharpsburg-Grundy-Adair-Shelby soil association developed on moderately deep loess and glacial till.

- (2) Upstream Slope. The upstream slope is well covered with durable limestone riprap having a maximum size of 8 to 10 inches and a nominal size of 1 to 1.5 inches. No deterioration of the riprap was noted. No slumps or deformations were observed. Photo No. 4 shows the upstream slope.
- (3) Crest. The crest serves as a roadway and is well covered with limestone gravel. Measurements along the crest, shown on Plate C-1, indicate that it is quite uniform in elevation with a maximum variation of one-half foot. No cracks, slumps or deformations were observed. Photo No. 3 shows the crest.

- (4) Downstream Slope. The downstream slope is very well vegetated with adapted grasses. No cracks, slumps, slides or other deformations were noted. The irregularities of the measured section (Plate C-2) are apparently the result of construction. Soils in the downstream slope are CL's. Seepage outcrops in the left abutment trough at about elevation 943, some 20 feet down from the crest. This seepy area extends down the trough to the toe of the dam where discharge was estimated at less than 0.5 g.p.m. Another seep area occurs at the lower end of the right abutment trough. Water was standing in the cat-tails in this area with little or no flow observed. All seep was clear and no boils were observed. The limestone bedrock is undoubtedly the source of seepage in both abutments. Photo No. 5 shows the downstream slope. Photos 12, 13, 18 and 19 show the seepy areas at the toe and in both abutment troughs.

A manhole and valve are located below the downstream toe in the valley near the maximum section. This waterline has no apparent connection with the dam and reservoir.

- (5) Miscellaneous. This dam is in excellent condition. The vegetative cover and nature of the materials in the dam indicate that it could withstand considerable overtopping without serious damage.

c. Appurtenant Structures.

- (1) The uncontrolled principal spillway consists of two 24-inch diameter corrugated metal pipe culverts placed in a rock cut through the right abutment. The pipe appears to be in good condition. Some small willow trees are growing near the entrance of the spillway pipes, as shown in Photo No. 6. There is a large erosional (piping) channel that extends along the left pipe from the upstream shoulder to the downstream shoulder of the roadway crossing the spillway culverts. The entrance and exit of the piping channel are shown in Photos 8 and 9. The principal spillway exits into the emergency spillway channel which is cut through rock. The exit channel is shown in Photo 7.
- (2) The uncontrolled emergency spillway consists of a cut through rock in the right abutment at the same location as the principal spillway. The control section consists of a gravelled roadway covering the principal spillway culverts. The entrance channel is partially blocked by willow trees. The exit channel is cut in rock and is stable. Small willows are growing in the exit channel. It outlets into a gully head cut about 100 feet downstream from the control section. Due to the presence of bedrock in the exit channel, this gully cannot progress to the reservoir. Photos 6 and 7 show the combined

spillways. Photo No. 3 shows the roadway over the culvert pipes. The tree on the left is located near the entrance of the culverts. The exit channel shows to the rear of the truck.

(3) Drawdown facilities - There are no drawdown facilities for this dam.

- d. Reservoir Area. The area around the reservoir is well grassed. No significant erosion nor slides were observed. Mr. King, manager, reported that a small silt basin just above the reservoir kept most of the sediment out of the lake. A portion of the reservoir is shown in Photo No. 10. Photo No. 1 shows the small silt basin.
- e. Downstream Channel. A number of trees are growing in the channel downstream from the spillway. However, they are located much lower in elevation than the spillway exit and should not affect spillway operation. Photo No. 11 shows part of the downstream channel.

3.2 EVALUATION

This dam appears to be in excellent condition. It would appear that seepage in the abutment troughs and along the toe is carried through limestone bedrock and should not endanger the safety of the dam. The few minor deficiencies in maintenance that were observed (trees in entrance of spillway, erosion along principal spillway pipe), should be corrected.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no controlled outlet works for this dam. The pool level is controlled by rainfall, evaporation, infiltration, and the capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

Maintenance seems to be reasonably good. Trees in the spillway entrance and erosion along the spillway culvert pipe should be corrected.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no warning system in effect for this dam.

4.5 EVALUATION

An improvement in maintenance procedures would eliminate the deficiencies observed during the inspection.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

- a. Design Data. No design data were found for this dam. Plans were requested from the owner, but were never received.
- b. Experience Data. The drainage area, reservoir surface area, and elevation-storage data were developed from the USGS Holt, Missouri 7 1/2 minute topographic quadrangle map. The hydraulic computations for the spillway and dam overtopping discharge ratings were based on data collected in the field at the time of the field inspection.
- c. Visual Observations.
 - (1) The riprap on the upstream face of the dam appears to be in good condition although it is rather small in size. There were no signs of erosion or deformation. The downstream slope is well vegetated with adapted grasses. The road on top of the dam has a fair gravel cover with evidence of a few shallow potholes but no cracks of significance.
 - (2) The twin 24-inch corrugated metal pipe culverts are in excellent condition and are setting on bedrock. However, there is a large piping hole evident that extends from the upstream shoulder to the downstream shoulder of the road crossing the culverts. It would appear that this piping hole could develop quickly into a washout from heavy rains and especially any kind of high spillway use. It is recommended that this deficiency gets immediate attention.
 - (3) The spillway exit channel is in rock, and the headcut approximately 100 feet downstream poses no threat at this time.
- d. Overtopping Potential. The spillways are too small to pass 50% of the probable maximum flood without overtopping. The spillways will pass the 1% probability flood and will pass 22% of the PMF without overtopping. Overtopping of the dam could cause erosion of the crest and embankments and subsequent failure. The results of the routings through the dam are tabulated in regards to the following conditions:

Frequency	Inflow Discharge c.f.s.	Outflow Discharge c.f.s.	Maximum Pool Elevation	*Maximum Depth Over Top Feet	Duration Over Top Hours
1/2 PMF	1230	1010	965.1	1.0	4
PMF	2460	2200	965.6	1.5	6
0.22 PMF	540	96	964.1	0	---

* Minimum Top of Dam Elevation = 964.1

According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, this dam is classified as having a high hazard rating and an intermediate size. Therefore, the PMF is the test for the adequacy of the dam and its spillway.

The estimated damage zone is described in Paragraph 1.2d in this report.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

- a. Visual Observation. This dam appears to be structurally stable. No evidence of sliding or deterioration was observed. Seepage is considered to be passing through limestone bedrock without significant effects on stability.
- b. Design and Construction Data. No design or construction data were available at the time of inspection. 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. Operating Records. There are no controlled operating facilities for this dam.
- d. Post Construction Changes. The inspection team is not aware of any post-construction changes.
- e. Seismic Stability. This dam is located in Seismic Zone 1. An earthquake of the magnitude predicted in this area is not expected to cause structural failure of this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

- a. Safety. This dam is considered to be in excellent condition and to be structurally stable. The approximate hydrologic analyses presented in Section 5 of this report indicate that the spillways will pass the one percent probability flood but not the probable maximum flood which is the recommended spillway design flood for an intermediate size dam having a high hazard potential. The spillway capacity is inadequate.

Seepage and stability analyses comparable to the requirements of the guidelines were not available which is considered a deficiency.

The small willow trees growing in the spillway entrance section should be removed and the erosion (piping) along the principal spillway pipe should be eliminated.

- b. Adequacy of Information. Due to the lack of engineering data, the conclusions in this report are based upon performance history and visual observations. 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 measures recommended in paragraph 7.2b 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 Further Investigations. The additional studies and analyses recommended in paragraph 7.2b should be accomplished by the owner in the near future.
- e. Seismic Stability. This dam is located in Seismic Zone 1. An earthquake of this magnitude is not expected to be hazardous to this dam. It is recommended, however, that the prescribed seismic loading for Seismic Zone 1 be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a registered professional engineer experienced in the design and construction of earth dams.

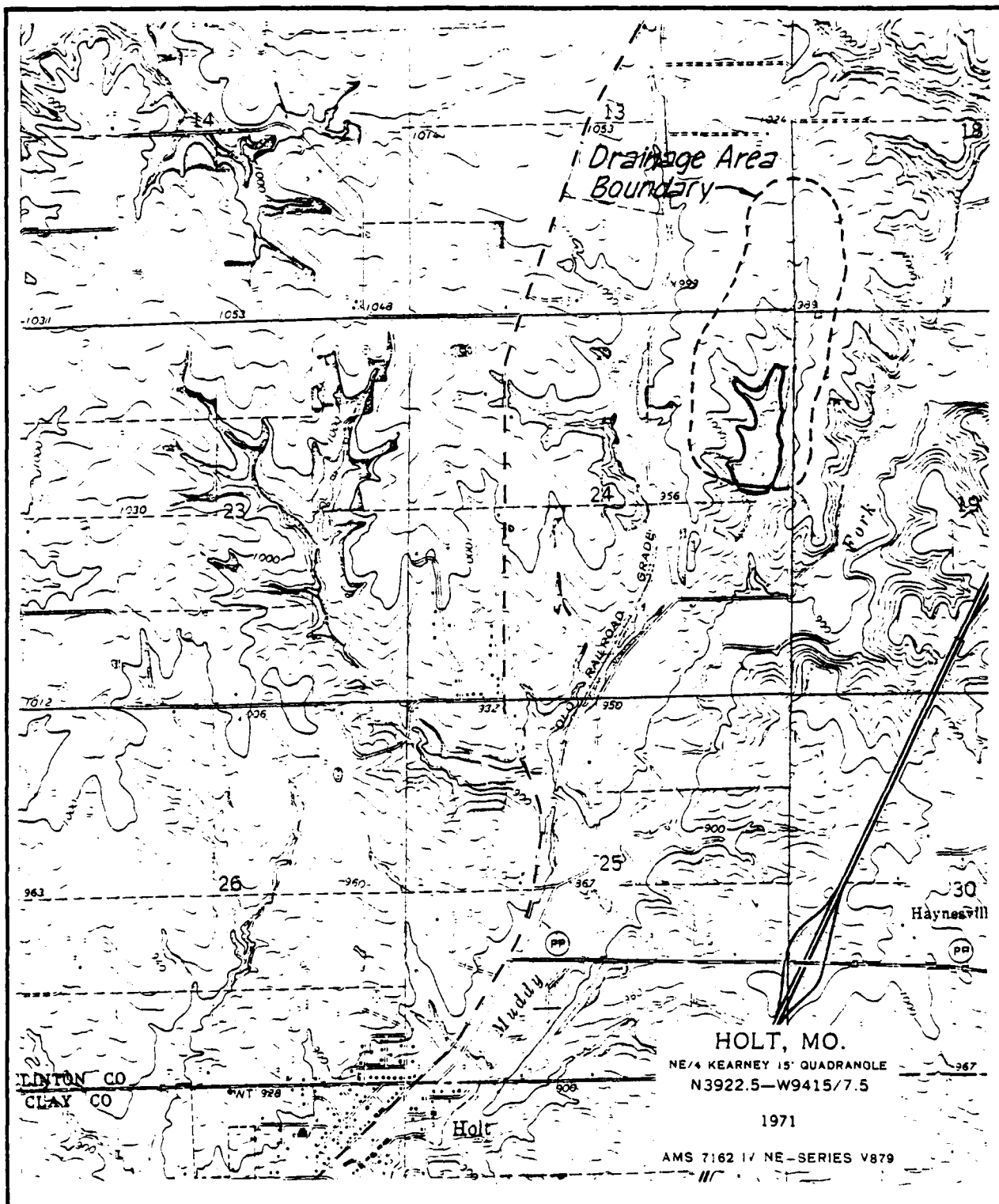
- a. Alternatives.

- (1) The spillway size and/or the height of dam should be increased to pass the probable maximum flood without overtopping the dam.

b. Operation and Maintenance Procedures.

- (1) Seepage and stability analyses comparable to the requirements of the guidelines should be performed by an engineer experienced in the design and construction of dams.
- (2) The volume and clarity of the seepage on the downstream side of the dam should be monitored by an engineer experienced in the design and construction of dams. The records of monitoring should be made a part of the project file.
- (3) The erosional damage (piping) along the principal spillway culvert and through the control section of the emergency spillway should be repaired under the guidance of an engineer experienced in the design and construction of dams.
- (4) The small willow trees growing at the entrance to the principal spillway and in the downstream channel should be removed. Measures should be taken to prevent recurrent growth.
- (5) A program of regular maintenance and inspection should be initiated and records of these activities should be made a part of the project file.

APPENDIX A
MAPS



Scale in feet

2000 1000 0 2000 4000

Contour Interval - 20'



VICINITY TOPOGRAPHY

SPRING LAKE DAM

CLINTON COUNTY, MISSOURI

MO. III22

PLATE A-1

APPENDIX B
PHOTOGRAPHS



SPRING LAKE DAM
CLINTON COUNTY, MISSOURI
MO 11122

PHOTO INDEX

PLATE B-1



PHOTO NO. 2 - OVERVIEW FROM RIGHT UPSTREAM BANK.



PHOTO NO. 3 - CREST FROM RIGHT ABUTMENT.



PHOTO NO. 4 - UPSTREAM FACE OF DAM FROM RIGHT ABUTMENT.



PHOTO NO. 5 - DOWNSTREAM SLOPE FROM RIGHT END.



PHOTO NO. 6 - VIEW UPSTREAM AT DOUBLE CULVERT PRINCIPAL
SPILLWAY.



PHOTO NO. 7 - VIEW DOWNSTREAM AT DOUBLE CULVERT PRINCIPAL
SPILLWAY.



PHOTO NO. 8 - VIEW OF PIPING HOLE ABOVE CULVERT AT DOWNSTREAM SHOULDER OF ROAD.

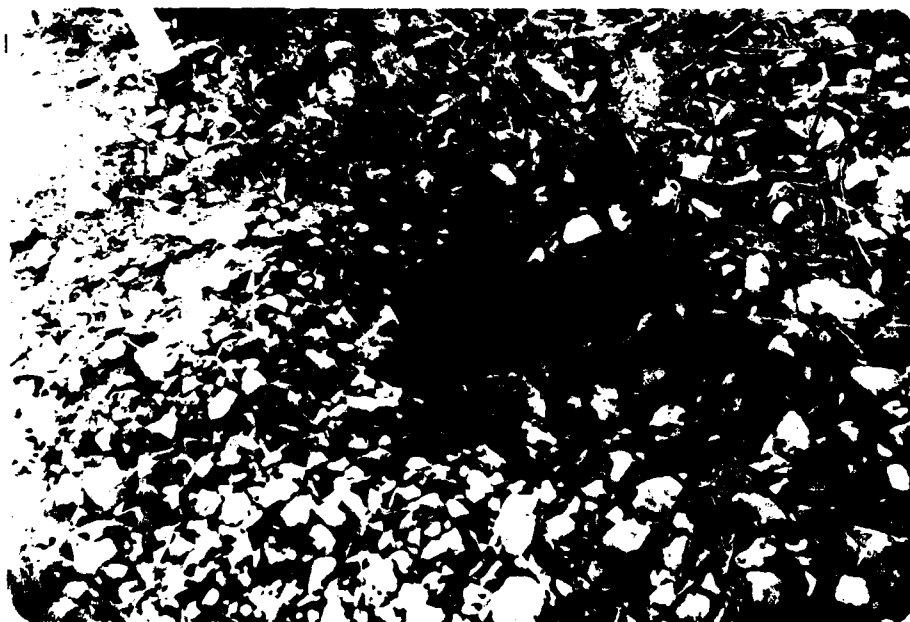


PHOTO NO. 9 - VIEW OF PIPING HOLE ABOVE CULVERT AT UPSTREAM SHOULDER OF ROAD.

REVIEW

PLATE 7



PHOTO NO. 10 - VIEW LOOKING UPSTREAM FROM NEAR CENTER OF DAM.



PHOTO NO. 11 - VIEW LOOKING DOWNSTREAM FROM NEAR CENTER OF DAM.



PHOTO NO. 12 - SEEPAGE SPOT IN LEFT ABUTMENT TROUGH.

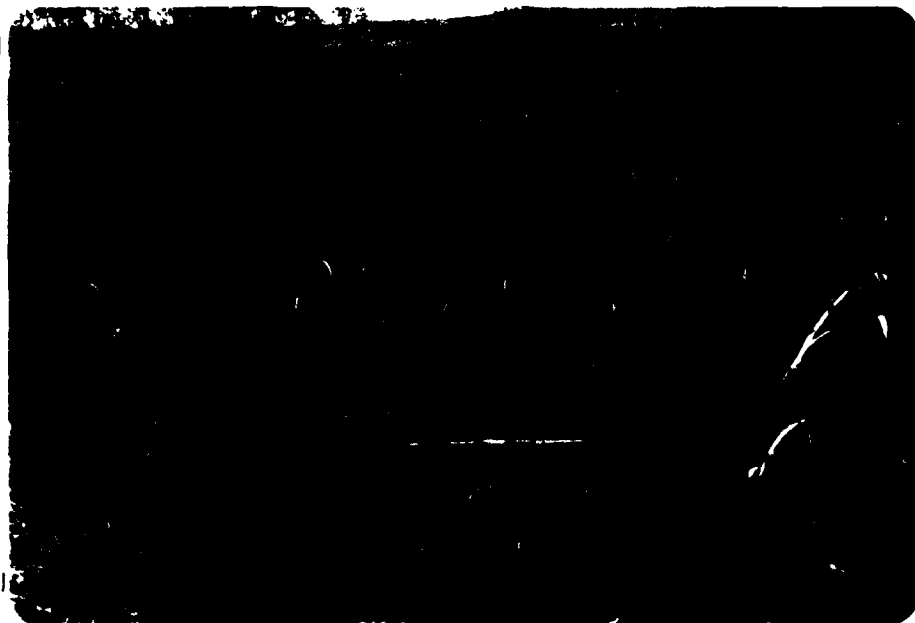


PHOTO NO. 13 - SEEPAGE SPOT NEAR LEFT ABUTMENT TROUGH.



PHOTO NO. 14 - CLOSE-UP VIEW OF SEEPAGE SPOT.

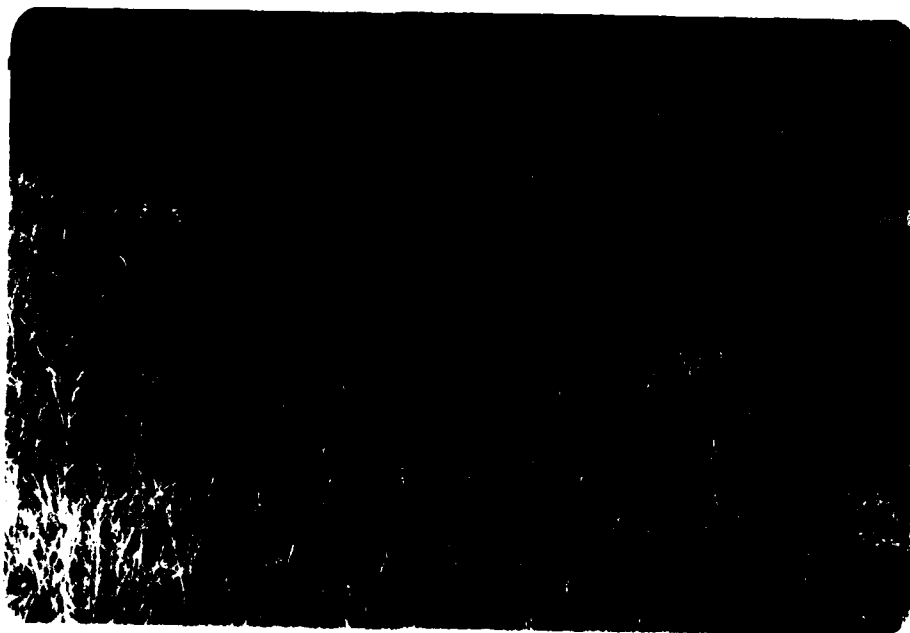


PHOTO NO. 15 - SEEPAGE AREA ALONG TOE OF DAM.



PHOTO NO. 16 - MANHOLE & VALVE AT TOE OF DAM NEAR MAXIMUM SECTION.

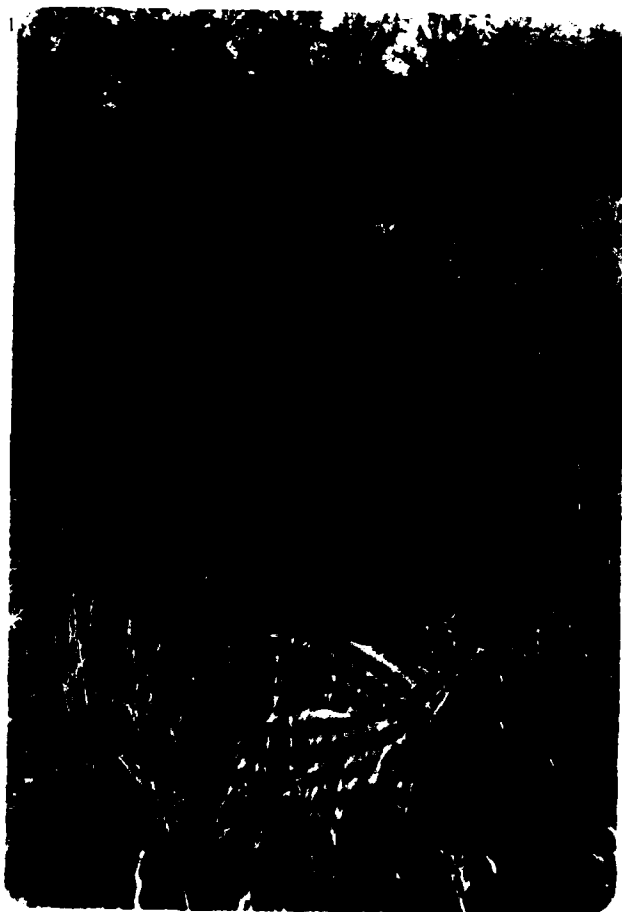


PHOTO NO. 17 - MANHOLE AND
SEEP AREA AT TOE OF DAM
NEAR MAXIMUM SECTION.

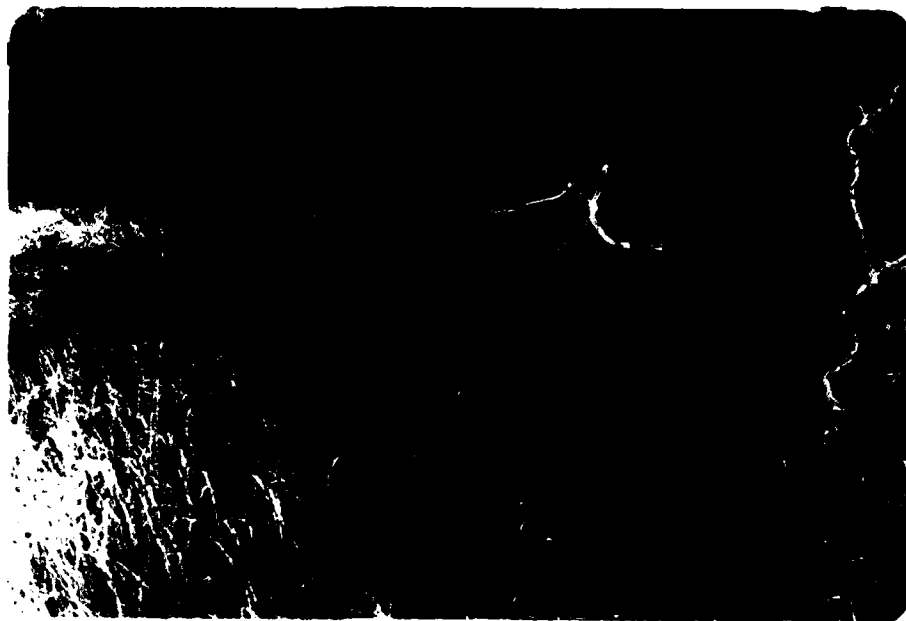


PHOTO NO. 18 - SEEP AREA AT TOE OF DAM NEAR MAXIMUM SECTION.

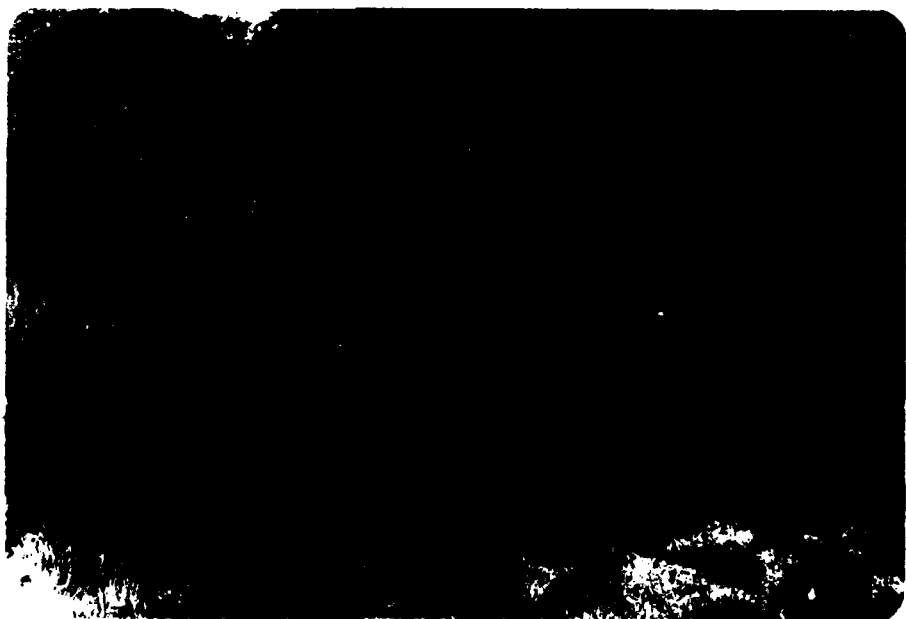


PHOTO NO. 19 - SEEP AREA DOWNSTREAM FROM RIGHT ABUTMENT TROUGH.



PHOTO NO. 20 - VIEW OF HOUSE JUST BELOW DAM.



PHOTO NO. 21 - HAZARDS APPROXIMATELY 1 MILE DOWNSTREAM AND BELOW CONFLUENCE OF OUTLET OF MUCH LARGER RESERVOIR.



PHOTO NO. 22 - DOWNSTREAM HAZARD. COMMERCIAL BUILDING AT
INTERSECTION OF HIGHWAYS PP & 33.



PHOTO NO. 23 - DOWNSTREAM HAZARDS. BUILDINGS IN TOWN OF HOLT.

APPENDIX C
PROJECT PLATES

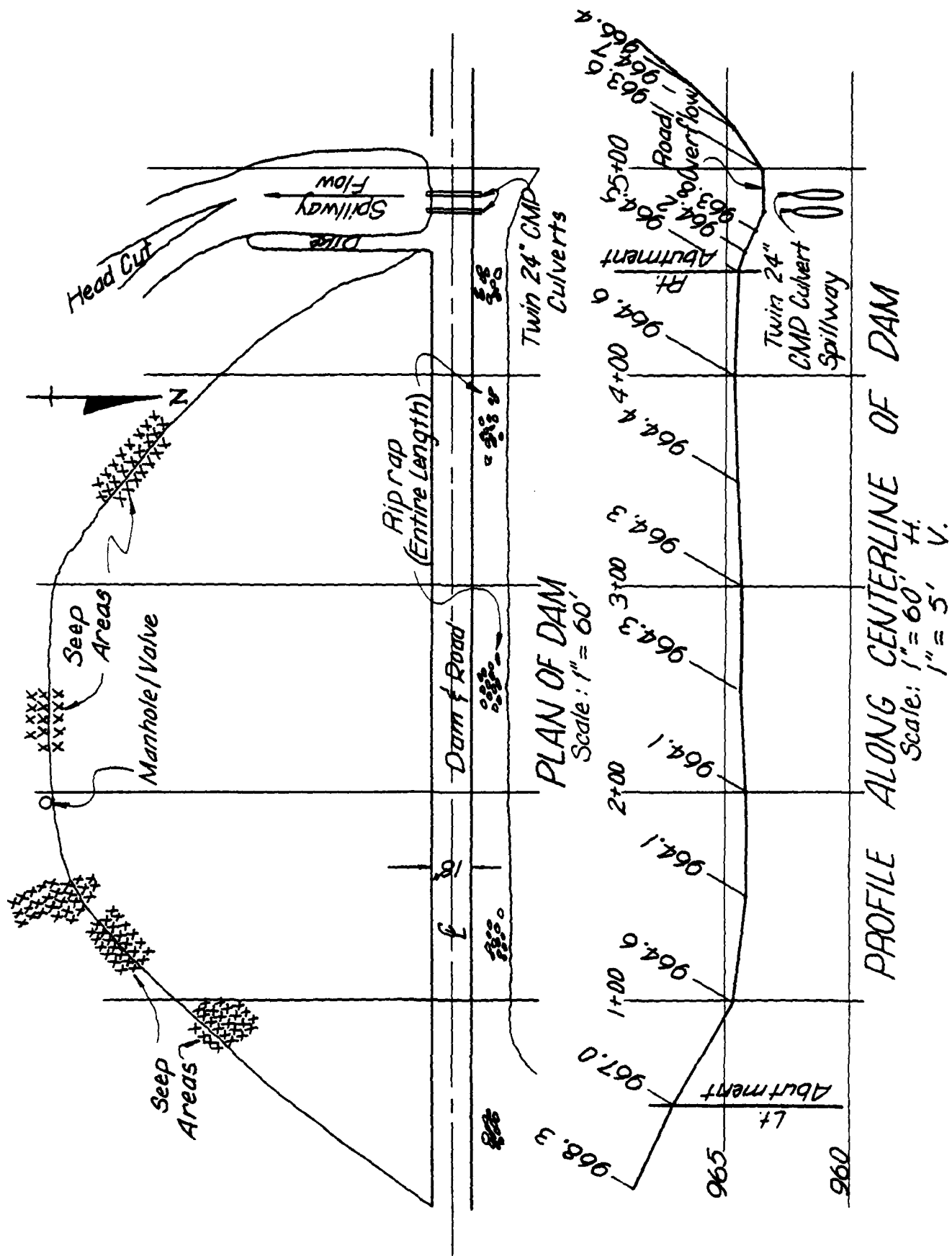
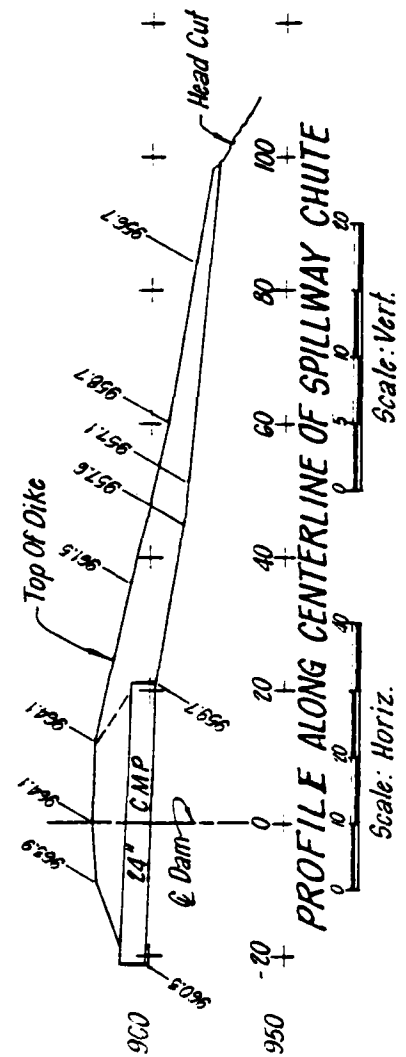
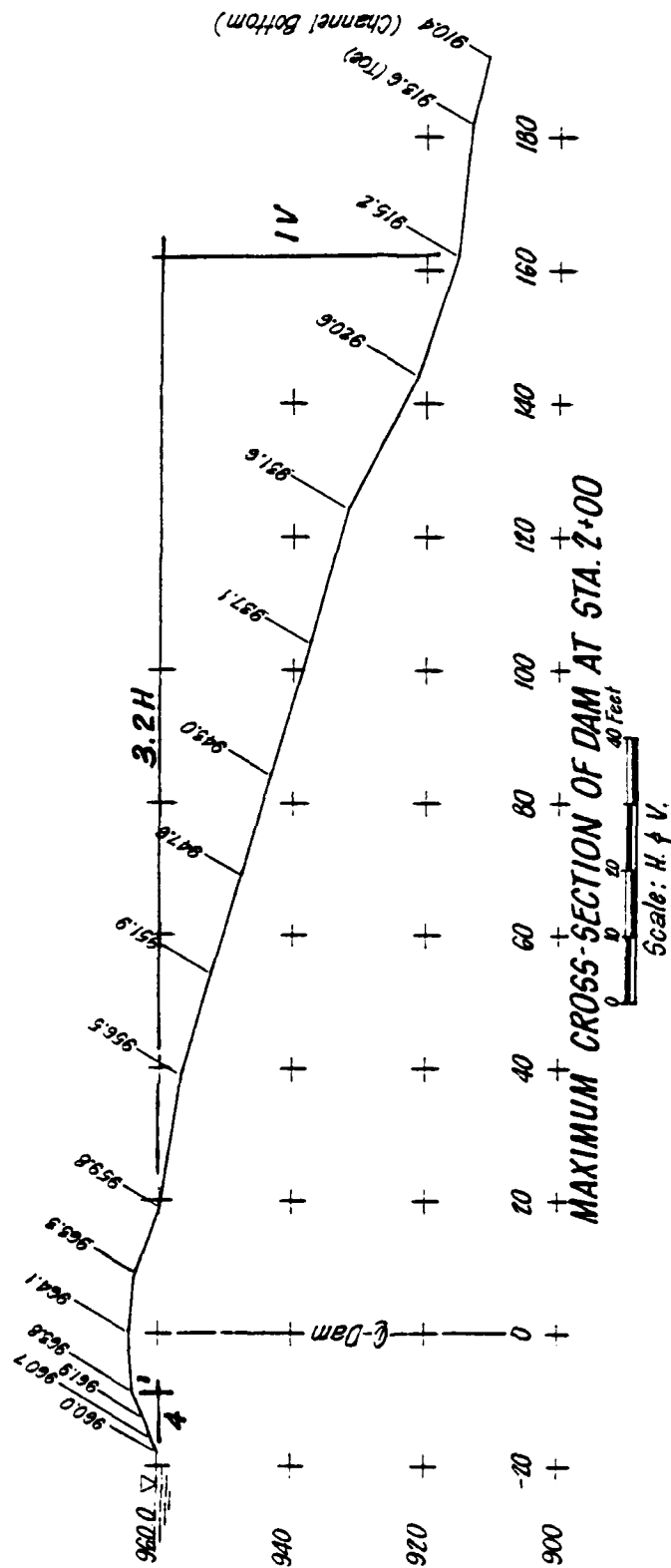


PLATE C-1

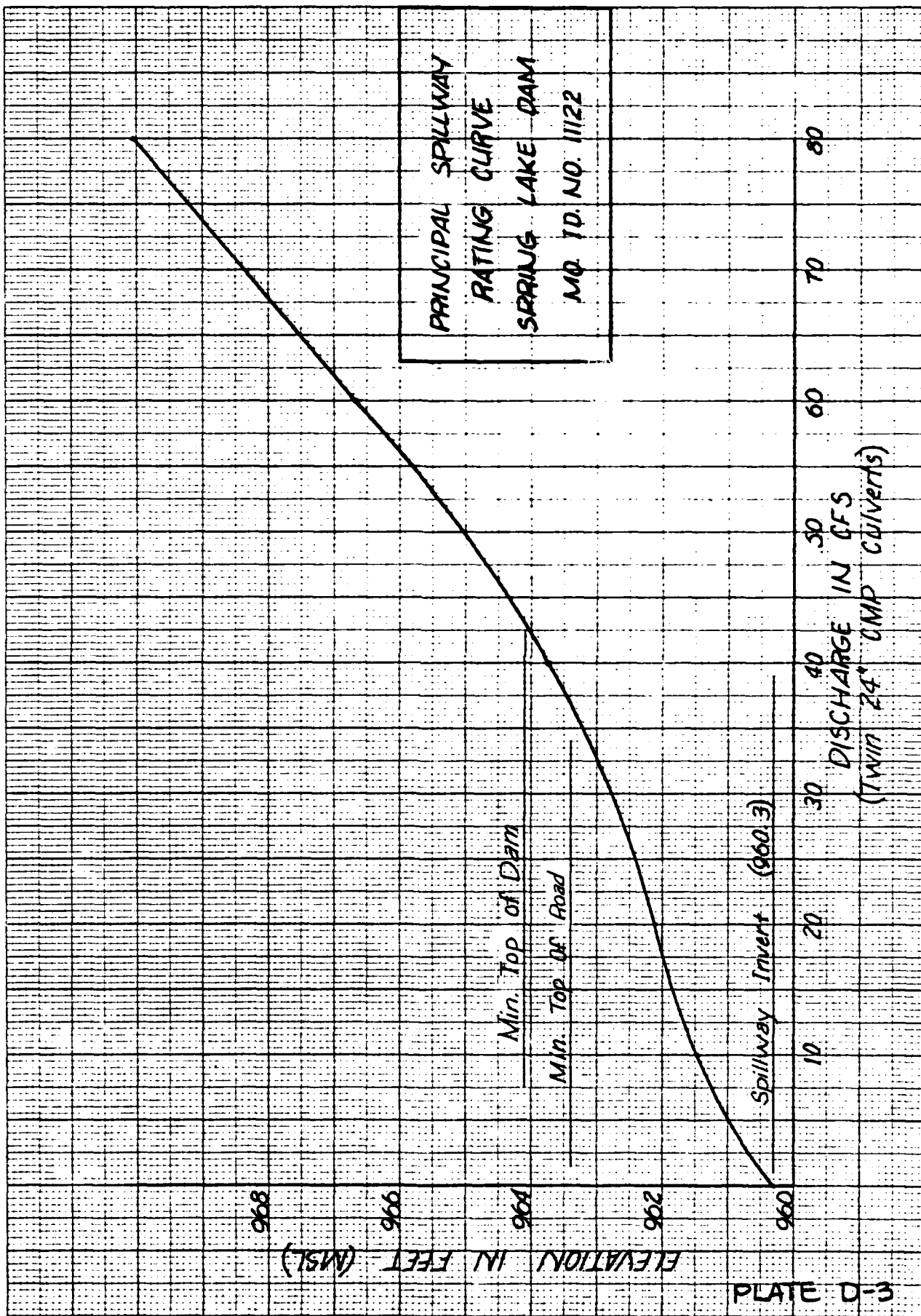


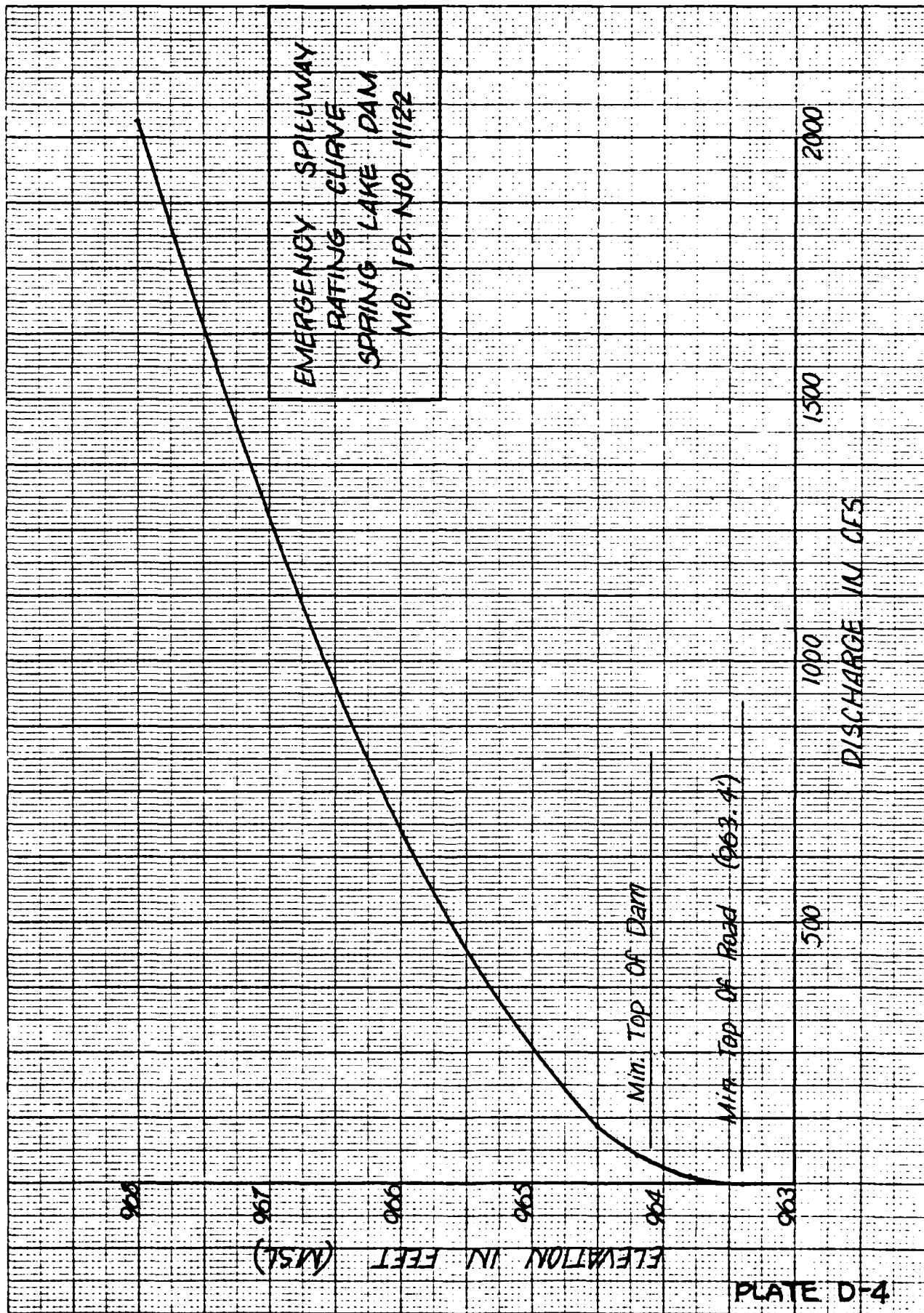
APPENDIX D
HYDRAULIC AND HYDROLOGIC DATA

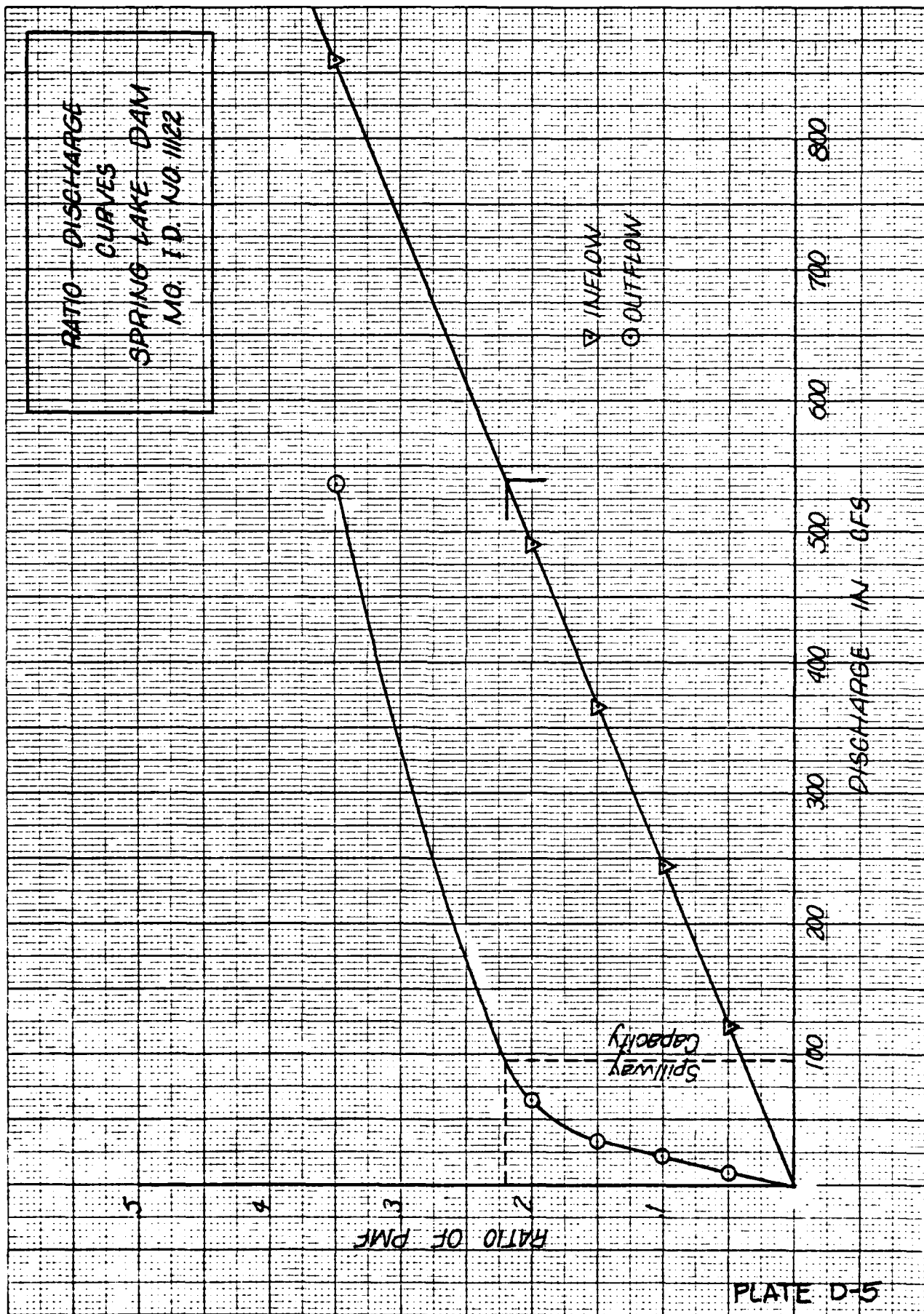
HYDROLOGIC COMPUTATIONS

1. The SCS dimensionless unit hydrograph and the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Corps of Engineers, Davis, California, were used to develop the inflow hydrographs (See this Section).
 - a. Twenty-four, one percent probabilistic rainfall for the dam location was taken from the data for the rainfall station at Kansas City, MO. as supplied by the St. Louis District, Corps of Engineers per their letter dated 4 March 1980. The twenty-four hour probable maximum precipitation was taken from the curves of Hydrometeorological Report No. 33 and current Corps of Engineers and St. Louis policy and guidance for hydraulics and hydrology.
 - b. Drainage area = 0.232 square miles (148.6 acres).
 - c. Time of concentration of runoff = 21 minutes (computed from the "Kirpich" formula).
 - d. The antecedent storm conditions for the probable maximum precipitation were heavy rainfall and low temperatures which occurred on the previous 5 days (SCS AMC III). The antecedent storm conditions for the one percent probabilistic precipitation were an average of the conditions which have preceded the occurrence of the maximum annual flood on numerous watersheds (SCS AMC II). The initial pool elevation was assumed at the invert of the principal spillway (twin 24" CMF culverts).
 - e. The total twenty-four hour storm duration losses for the one percent probabilistic storm were 2.69 inches. The total losses for the PMF storm were 1.44 inches. These data are based on SCS runoff curve No. 77 and No. 89 for antecedent moisture conditions SCS AMC II and AMC III respectively. The watershed is composed of primarily SCS soil groups B & C (Lagonda-Grundy-Clinton-Ladoga soils). 14% of the area was assumed in reservoir and road surface and the remainder in undeveloped urban area.
 - f. Average soil loss rates = 0.05 inch per hour approximately (For PMF storm, AMC III).
2. The combined discharge rating consisted of three components: the flow through the principal spillway, the flow through the emergency spillway and the flow going over the top of the dam.
 - a. The principal spillway rating was developed by using culvert flow tables for CMP culverts with inlet control as found in FHA-BPR HEC Cinc. No. 5.

- b. The emergency spillway rating was developed by computing flow over highway embankments with methods and coefficients found in USGS TWRI, Bk. 3, Ch. A5 "Measurement of Peak Discharge at Dams by Indirect Methods".
 - c. The flows over the dam were determined by using the dam overtopping analyses (irregular top of dam) within the HEC-1 (Dam Safety Version) program.
3. Floods were routed through the reservoir using the HEC-1 (Dam Safety Version) program to determine the capabilities of the spillway and dam embankment crest. The input, output and plotted hydrographs are attached in this Section.







[illegible]

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

RUN DATE# 00/07/79.
 TIME# 15.32.46.

SPRING LAKE DAM-MO ID NO 11122
 SAFETY ANALYSIS OF DAM OVERTOPPING USING ASSIGNED FLOOD FREQUENCIES
 H & H ANALYSIS BY ROUTING PMF RATIOS THRU THE RESERVOIR

JOB SPECIFICATION									
NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
208	0	5	0	0	0	0	0	3	0
			JUPLR	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED

RTIOS= .05 .10 .15 .20 .35 .50 .75 1.00
 NPLAN= 1 RTIO= 8 LRTIO= 1

SUB-AREA RUNOFF COMPUTATION

CALCULATION OF INFLOW HYDRO TO SPRING LAKE

ISTAQ	ICOMP	IECUN	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
000001	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

INHYG	IUHG	TAREA	SWAP	IRSDA	IRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.23	0.00	.23	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	24.30	102.00	121.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STKRK	ULTRK	RTIOL	ERAIN	STKRS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-89.00	0.00	0.00

CURVE NO = -89.00 WEYNES = -1.00 EFFECT CN = 89.00

UNIT HYDROGRAPH DATA

IC= 0.00 LAG= .21

RECESSION DATA

STRTQ= 0.00 GRCSN= -.01 RTIOK= 1.00

UNIT HYDROGRAPH 15 END OF PERIOD ORDINATES, IC= 0.00 HOURS, LAG= .21 VOL= 1.00
 99. 333. 442. 576. 229. 130. 78. 46. 26. 16.

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.05	145	.21	.20	.01	124.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.21	.20	.01	170.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.21	.20	.01	231.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.21	.20	.01	283.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.21	.20	.01	315.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.21	.20	.01	334.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.21	.20	.01	345.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.21	.20	.00	352.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.21	.20	.00	356.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.21	.20	.00	359.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.21	.20	.00	361.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.21	.20	.00	362.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.25	.24	.00	367.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.25	.24	.00	381.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.25	.24	.00	399.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.25	.24	.00	415.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.25	.24	.00	424.
1.01	1.30	18	.01	0.00	.01	0.	1.01	13.30	162	.25	.24	.00	430.
1.01	1.35	19	.01	0.00	.01	0.	1.01	13.35	163	.25	.24	.00	434.
1.01	1.40	20	.01	0.00	.01	0.	1.01	13.40	164	.25	.24	.00	436.
1.01	1.45	21	.01	0.00	.01	0.	1.01	13.45	165	.25	.24	.00	437.
1.01	1.50	22	.01	0.00	.01	0.	1.01	13.50	166	.25	.24	.00	438.
1.01	1.55	23	.01	0.00	.01	0.	1.01	13.55	167	.25	.25	.00	439.
1.01	2.00	24	.01	0.00	.01	0.	1.01	14.00	168	.31	.31	.00	439.
1.01	2.05	25	.01	0.00	.01	1.	1.01	14.05	169	.31	.31	.00	446.
1.01	2.10	26	.01	0.00	.01	1.	1.01	14.10	170	.31	.31	.00	466.
1.01	2.15	27	.01	0.00	.01	1.	1.01	14.15	171	.31	.31	.00	494.
1.01	2.20	28	.01	0.00	.01	2.	1.01	14.20	172	.31	.31	.00	517.
1.01	2.25	29	.01	0.00	.01	2.	1.01	14.25	173	.31	.31	.00	531.
1.01	2.30	30	.01	0.00	.01	2.	1.01	14.30	174	.31	.31	.00	540.
1.01	2.35	31	.01	0.00	.01	3.	1.01	14.35	175	.31	.31	.00	545.
1.01	2.40	32	.01	0.00	.01	3.	1.01	14.40	176	.31	.31	.00	548.
1.01	2.45	33	.01	0.00	.01	3.	1.01	14.45	177	.31	.31	.00	550.
1.01	2.50	34	.01	0.00	.01	4.	1.01	14.50	178	.31	.31	.00	551.
1.01	2.55	35	.01	0.00	.01	4.	1.01	14.55	179	.31	.31	.00	551.
1.01	3.00	36	.01	0.00	.01	4.	1.01	15.00	180	.31	.31	.00	552.
1.01	3.05	37	.01	0.00	.01	5.	1.01	15.05	181	.19	.19	.00	540.
1.01	3.10	38	.01	0.00	.01	5.	1.01	15.10	182	.38	.37	.00	519.
1.01	3.15	39	.01	0.00	.01	5.	1.01	15.15	183	.38	.37	.00	520.
1.01	3.20	40	.01	0.00	.01	6.	1.01	15.20	184	.57	.56	.00	504.
1.01	3.25	41	.01	0.00	.01	6.	1.01	15.25	185	.66	.66	.00	699.
1.01	3.30	42	.01	0.00	.01	6.	1.01	15.30	186	1.60	1.59	.01	933.
1.01	3.35	43	.01	0.00	.01	6.	1.01	15.35	187	2.64	2.63	.01	1475.
1.01	3.40	44	.01	0.00	.01	7.	1.01	15.40	188	1.04	1.03	.00	2163.
1.01	3.45	45	.01	0.00	.01	7.	1.01	15.45	189	.66	.66	.00	2456.
1.01	3.50	46	.01	0.00	.01	7.	1.01	15.50	190	.57	.56	.00	2250.
1.01	3.55	47	.01	0.00	.01	7.	1.01	15.55	191	.38	.38	.00	1812.
1.01	4.00	48	.01	0.00	.01	8.	1.01	16.00	192	.38	.38	.00	1420.
1.01	4.05	49	.01	0.00	.01	8.	1.01	16.05	193	.29	.29	.00	1129.
1.01	4.10	50	.01	0.00	.01	8.	1.01	16.10	194	.29	.29	.00	909.
1.01	4.15	51	.01	0.00	.01	8.	1.01	16.15	195	.29	.29	.00	757.
1.01	4.20	52	.01	0.01	.01	8.	1.01	16.20	196	.29	.29	.00	659.
1.01	4.25	53	.01	0.01	.01	9.	1.01	16.25	197	.29	.29	.00	600.
1.01	4.30	54	.01	0.01	.01	9.	1.01	16.30	198	.29	.29	.00	567.
1.01	4.35	55	.01	0.01	.01	9.	1.01	16.35	199	.29	.29	.00	547.
1.01	4.40	56	.01	0.01	.01	9.	1.01	16.40	200	.29	.29	.00	533.
1.01	4.45	57	.01	0.01	.01	9.	1.01	16.45	201	.29	.29	.00	525.
1.01	4.50	58	.01	0.01	.01	10.	1.01	16.50	202	.29	.29	.00	521.
1.01	4.55	59	.01	0.01	.01	10.	1.01	16.55	203	.29	.29	.00	520.
1.01	5.00	60	.01	0.01	.01	10.	1.01	17.00	204	.29	.29	.00	519.

1.01	5.05	61	.01	.01	.01	10.	1.01	17.05	205	.23	.23	.00	512.
1.01	5.10	62	.01	.01	.01	10.	1.01	17.10	206	.23	.23	.00	492.
1.01	5.15	63	.01	.01	.01	10.	1.01	17.15	207	.23	.23	.00	464.
1.01	5.20	64	.01	.01	.01	11.	1.01	17.20	208	.23	.23	.00	441.
1.01	5.25	65	.01	.01	.01	11.	1.01	17.25	209	.23	.23	.00	427.
1.01	5.30	66	.01	.01	.01	11.	1.01	17.30	210	.23	.23	.00	419.
1.01	5.35	67	.01	.01	.01	11.	1.01	17.35	211	.23	.23	.00	414.
1.01	5.40	68	.01	.01	.01	11.	1.01	17.40	212	.23	.23	.00	411.
1.01	5.45	69	.01	.01	.01	11.	1.01	17.45	213	.23	.23	.00	409.
1.01	5.50	70	.01	.01	.01	11.	1.01	17.50	214	.23	.23	.00	409.
1.01	5.55	71	.01	.01	.01	12.	1.01	17.55	215	.23	.23	.00	408.
1.01	6.00	72	.01	.01	.01	12.	1.01	18.00	216	.23	.23	.00	400.
1.01	6.05	73	.06	.04	.03	15.	1.01	18.05	217	.02	.02	.00	307.
1.01	6.10	74	.06	.04	.03	25.	1.01	18.10	218	.02	.02	.00	317.
1.01	6.15	75	.06	.04	.02	39.	1.01	18.15	219	.02	.02	.00	225.
1.01	6.20	76	.06	.04	.02	52.	1.01	18.20	220	.02	.02	.00	147.
1.01	6.25	77	.06	.04	.02	61.	1.01	18.25	221	.02	.02	.00	99.
1.01	6.30	78	.06	.04	.02	67.	1.01	18.30	222	.02	.02	.00	72.
1.01	6.35	79	.06	.05	.02	72.	1.01	18.35	223	.02	.02	.00	55.
1.01	6.40	80	.06	.05	.02	75.	1.01	18.40	224	.02	.02	.00	46.
1.01	6.45	81	.06	.05	.02	78.	1.01	18.45	225	.02	.02	.00	40.
1.01	6.50	82	.06	.05	.02	81.	1.01	18.50	226	.02	.02	.00	37.
1.01	6.55	83	.06	.05	.02	83.	1.01	18.55	227	.02	.02	.00	35.
1.01	7.00	84	.06	.05	.01	84.	1.01	19.00	228	.02	.02	.00	34.
1.01	7.05	85	.06	.05	.01	86.	1.01	19.05	229	.02	.02	.00	33.
1.01	7.10	86	.06	.05	.01	88.	1.01	19.10	230	.02	.02	.00	33.
1.01	7.15	87	.06	.05	.01	89.	1.01	19.15	231	.02	.02	.00	33.
1.01	7.20	88	.06	.05	.01	90.	1.01	19.20	232	.02	.02	.00	33.
1.01	7.25	89	.06	.05	.01	91.	1.01	19.25	233	.02	.02	.00	33.
1.01	7.30	90	.06	.05	.01	93.	1.01	19.30	234	.02	.02	.00	33.
1.01	7.35	91	.06	.05	.01	94.	1.01	19.35	235	.02	.02	.00	33.
1.01	7.40	92	.06	.05	.01	94.	1.01	19.40	236	.02	.02	.00	33.
1.01	7.45	93	.06	.05	.01	95.	1.01	19.45	237	.02	.02	.00	33.
1.01	7.50	94	.06	.05	.01	96.	1.01	19.50	238	.02	.02	.00	33.
1.01	7.55	95	.06	.06	.01	97.	1.01	19.55	239	.02	.02	.00	33.
1.01	8.00	96	.06	.06	.01	98.	1.01	20.00	240	.02	.02	.00	33.
1.01	8.05	97	.06	.06	.01	98.	1.01	20.05	241	.02	.02	.00	33.
1.01	8.10	98	.06	.06	.01	99.	1.01	20.10	242	.02	.02	.00	33.
1.01	8.15	99	.06	.06	.01	100.	1.01	20.15	243	.02	.02	.00	33.
1.01	8.20	100	.06	.06	.01	100.	1.01	20.20	244	.02	.02	.00	33.
1.01	8.25	101	.06	.06	.01	101.	1.01	20.25	245	.02	.02	.00	33.
1.01	8.30	102	.06	.06	.01	101.	1.01	20.30	246	.02	.02	.00	33.
1.01	8.35	103	.06	.06	.01	102.	1.01	20.35	247	.02	.02	.00	33.
1.01	8.40	104	.06	.06	.01	102.	1.01	20.40	248	.02	.02	.00	33.
1.01	8.45	105	.06	.06	.01	103.	1.01	20.45	249	.02	.02	.00	33.
1.01	8.50	106	.06	.06	.01	103.	1.01	20.50	250	.02	.02	.00	33.
1.01	8.55	107	.06	.06	.01	103.	1.01	20.55	251	.02	.02	.00	33.
1.01	9.00	108	.06	.06	.01	104.	1.01	21.00	252	.02	.02	.00	33.
1.01	9.05	109	.06	.06	.01	104.	1.01	21.05	253	.02	.02	.00	33.
1.01	9.10	110	.06	.06	.01	105.	1.01	21.10	254	.02	.02	.00	33.
1.01	9.15	111	.06	.06	.01	105.	1.01	21.15	255	.02	.02	.00	33.
1.01	9.20	112	.06	.06	.01	105.	1.01	21.20	256	.02	.02	.00	33.
1.01	9.25	113	.06	.06	.00	105.	1.01	21.25	257	.02	.02	.00	33.
1.01	9.30	114	.06	.06	.00	106.	1.01	21.30	258	.02	.02	.00	33.
1.01	9.35	115	.06	.06	.00	106.	1.01	21.35	259	.02	.02	.00	33.
1.01	9.40	116	.06	.06	.00	106.	1.01	21.40	260	.02	.02	.00	33.
1.01	9.45	117	.06	.06	.00	107.	1.01	21.45	261	.02	.02	.00	33.
1.01	9.50	118	.06	.06	.00	107.	1.01	21.50	262	.02	.02	.00	33.
1.01	9.55	119	.06	.06	.00	107.	1.01	21.55	263	.02	.02	.00	33.
1.01	10.00	120	.06	.06	.00	107.	1.01	22.00	264	.02	.02	.00	33.
1.01	10.05	121	.06	.06	.00	107.	1.01	22.05	265	.02	.02	.00	33.
1.01	10.10	122	.06	.06	.00	108.	1.01	22.10	266	.02	.02	.00	33.

1.01	10.15	123	.06	.06	.00	100.	1.01	22.15	267	.02	.02	.00	33.
1.01	10.20	124	.06	.06	.00	100.	1.01	22.20	260	.02	.02	.00	33.
1.01	10.25	125	.06	.06	.00	108.	1.01	22.25	269	.02	.02	.00	33.
1.01	10.30	126	.06	.06	.00	108.	1.01	22.30	270	.02	.02	.00	33.
1.01	10.35	127	.06	.06	.00	109.	1.01	22.35	271	.02	.02	.00	33.
1.01	10.40	128	.06	.06	.00	109.	1.01	22.40	272	.02	.02	.00	33.
1.01	10.45	129	.06	.06	.00	109.	1.01	22.45	273	.02	.02	.00	33.
1.01	10.50	130	.06	.06	.00	109.	1.01	22.50	274	.02	.02	.00	33.
1.01	10.55	131	.06	.06	.00	109.	1.01	22.55	275	.02	.02	.00	33.
1.01	11.00	132	.06	.06	.00	109.	1.01	23.00	276	.02	.02	.00	33.
1.01	11.05	133	.06	.06	.00	109.	1.01	23.05	277	.02	.02	.00	33.
1.01	11.10	134	.06	.06	.00	110.	1.01	23.10	278	.02	.02	.00	33.
1.01	11.15	135	.06	.06	.00	110.	1.01	23.15	279	.02	.02	.00	33.
1.01	11.20	136	.06	.06	.00	110.	1.01	23.20	280	.02	.02	.00	33.
1.01	11.25	137	.06	.06	.00	110.	1.01	23.25	281	.02	.02	.00	33.
1.01	11.30	138	.06	.06	.00	110.	1.01	23.30	282	.02	.02	.00	33.
1.01	11.35	139	.06	.06	.00	110.	1.01	23.35	283	.02	.02	.00	33.
1.01	11.40	140	.06	.06	.00	110.	1.01	23.40	284	.02	.02	.00	33.
1.01	11.45	141	.06	.06	.00	110.	1.01	23.45	285	.02	.02	.00	33.
1.01	11.50	142	.06	.06	.00	110.	1.01	23.50	286	.02	.02	.00	33.
1.01	11.55	143	.06	.06	.00	111.	1.01	23.55	287	.02	.02	.00	33.
1.01	12.00	144	.06	.06	.00	111.	1.02	0.00	288	.02	.02	.00	33.
SUM 31.59 30.15 1.44 54069.										(802.1(766.)(36.)(1531.06)			

THOUS	CU M	AC-FT	MM	INCHES	CMS	CFS	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
							2456.	607.	188.	188.	54034.
							70.	17.	5.	5.	1530.
								24.34	30.09	30.09	30.09
								618.24	764.32	764.32	764.32
								501.	372.	372.	372.
								371.	459.	459.	459.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 1

THOUS	CU M	AC-FT	MM	INCHES	CMS	CFS	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
							123.	30.	9.	9.	2702.
							3.	1.	0.	0.	77.
								1.22	1.50	1.50	1.50
								30.91	30.22	30.22	30.22
								15.	19.	19.	19.
								19.	23.	23.	23.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 2

THOUS	CU M	AC-FT	MM	INCHES	CMS	CFS	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
							246.	61.	19.	19.	5403.
							7.	2.	1.	1.	153.
								2.43	3.01	3.01	3.01
								61.02	76.43	76.43	76.43
								30.	37.	37.	37.
								37.	46.	46.	46.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 3

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	368.	91.	28.	28.	8105.
CMS	10.	3.	1.	1.	230.
INCHES		3.65	4.51	4.51	4.51
MM		92.74	114.65	114.65	114.65
AC-FT		45.	56.	56.	56.
THOUS CU M		56.	69.	69.	69.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 4

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	491.	121.	38.	38.	10807.
CMS	14.	3.	1.	1.	306.
INCHES		4.87	6.02	6.02	6.02
MM		123.65	152.86	152.86	152.86
AC-FT		60.	74.	74.	74.
THOUS CU M		74.	92.	92.	92.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 5

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	860.	212.	66.	66.	18912.
CMS	24.	6.	2.	2.	536.
INCHES		8.52	10.53	10.53	10.53
MM		216.38	267.51	267.51	267.51
AC-FT		105.	130.	130.	130.
THOUS CU M		130.	161.	161.	161.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 6 $\frac{1}{2}$ PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1228.	304.	94.	94.	27017.
CMS	35.	9.	3.	3.	765.
INCHES		12.17	15.05	15.05	15.05
MM		309.12	382.16	382.16	382.16
AC-FT		151.	186.	186.	186.
THOUS CU M		186.	230.	230.	230.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 7

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1842.	455.	141.	141.	40526.
CMS	52.	13.	4.	4.	1148.
INCHES		18.26	22.57	22.57	22.57
MM		463.68	573.24	573.24	573.24
AC-FT		226.	279.	279.	279.
THOUS CU M		278.	344.	344.	344.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 8 $\frac{1}{2}$ PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2456.	607.	188.	188.	54039.

[illegible]

ROUTED FLOWS THRU SPRING LAKE DAM

DAM DATA			
TOPEL	COQU	EXPD	DAMWID
964.1	2.8	1.5	430.

STAT (W-000002, PLAN-1, RATIO-1)

-----END-OF-PERIOD-HYDROGRAPH ORDINATES

OUTFLOW

[illegible]

1/2 PMF

STATION 000002, PLAN 1, RATIO 6

END-OF-PERIOD HYDROGRAPH ORIGINATES

[illegible][illegible]

250. 250. 250. 249. 249. 249. 248.
 248. 247. 247. 247. 247. 247. 246.
 246. 245. 245. 245. 245. 245. 245.
 244. 244. 244. 244. 244. 244. 244.
 243. 243. 243. 242. 242. 242. 243.

960.3 960.3 960.3 960.3 960.3 960.3 960.3
 960.3 960.3 960.3 960.3 960.3 960.3 960.3
 960.3 960.3 960.3 960.3 960.3 960.3 960.3
 960.3 960.3 960.3 960.3 960.3 960.3 960.3
 960.3 960.3 960.3 960.3 960.3 960.3 960.3
 960.4 960.4 960.4 960.4 960.4 960.4 960.4
 960.4 960.4 960.4 960.4 960.4 960.4 960.4
 960.5 960.5 960.5 960.5 960.5 960.5 960.5
 960.7 960.7 960.7 960.7 960.7 960.7 960.7
 960.9 960.9 960.9 960.9 960.9 960.9 960.9
 961.1 961.2 961.2 961.2 961.2 961.2 961.1
 961.3 961.4 961.4 961.4 961.4 961.4 961.3
 961.6 961.6 961.6 961.6 961.6 961.6 961.5
 961.7 961.8 961.8 961.8 961.8 961.8 961.7
 962.1 962.2 962.2 962.2 962.2 962.2 962.1
 962.9 962.9 962.9 962.9 962.9 962.9 962.8
 963.7 963.7 963.7 963.7 963.7 963.7 963.6
 964.4 964.4 964.4 964.4 964.4 964.4 964.3
 965.1 965.0 964.9 964.8 964.7 964.6 964.5
 964.5 964.5 964.5 964.5 964.5 964.5 964.4
 964.4 964.4 964.4 964.4 964.4 964.4 964.3
 964.3 964.2 964.2 964.2 964.2 964.2 964.0
 963.8 963.7 963.7 963.7 963.7 963.7 963.6
 963.6 963.6 963.6 963.6 963.6 963.6 963.5
 963.5 963.5 963.5 963.5 963.5 963.5 963.4
 963.4 963.4 963.4 963.4 963.4 963.4 963.3
 963.3 963.3 963.3 963.3 963.3 963.3 963.3

PEAK OUTFLOW IS 1013. AT TIME 15.92 HOURS

CFS	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
INCHES	1013.	244.	72.	72.	20712.
MM	29.	7.	2.	2.	586.
AC-FT		9.80	11.53	11.53	11.53
THOUS CU M		248.96	292.97	292.97	292.97
		121.	143.	143.	143.
		150.	176.	176.	176.

•OVF•

STATION0000002

	0.	200.	400.	600.	800.	1000.	1200.	1400.	0.	0.	0.	0.	0.	0.
.05 11	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.10 21	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.15 31	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.20 41	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.25 51	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.30 61	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.35 71	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.40 81	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.45 91	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.50 101	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.55 111	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.00 121	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.05 131	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.10 141	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.15 151	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.20 161	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.25 171	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.30 181	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.35 191	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.40 201	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.45 211	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.50 221	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.55 231	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.00 241	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.05 251	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.10 261	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.15 271	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.20 281	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.25 291	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.30 301	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.35 311	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.40 321	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.45 331	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.50 341	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.55 351	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.00 361	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.05 371	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.10 381	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.15 391	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.20 401	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.25 411	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.30 421	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.35 431	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.40 441	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.45 451	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.50 461	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.55 471	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.00 481	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.05 491	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.10 501	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.15 511	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.20 521	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.25 531	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.30 541	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.35 551	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.40 561	.	.	.	.	.	.	.	.	.	.	.	.	.	.

PLATE D-18

END-OF-PERIOD HYDROGRAPH ORDINATES

[illegible][illegible]

253. 252. 252. 252. 251. 251. 251. 251.
 251. 250. 250. 250. 249. 249. 249. 249.
 249. 249. 249. 249. 248. 248. 248. 248.
 247. 247. 247. 247. 247. 247. 247. 247.

960.3 960.3 960.3 960.3 960.3 960.3 960.3 960.3
 960.3 960.3 960.3 960.3 960.3 960.3 960.3 960.3
 960.3 960.3 960.3 960.3 960.3 960.3 960.3 960.3
 960.4 960.4 960.4 960.4 960.4 960.4 960.4 960.4
 960.4 960.4 960.4 960.4 960.4 960.4 960.4 960.4
 960.5 960.5 960.5 960.5 960.5 960.5 960.5 960.5
 960.7 960.7 960.7 960.7 960.7 960.7 960.7 960.7
 961.1 961.1 961.1 961.1 961.1 961.1 961.1 961.1
 961.5 961.5 961.5 961.5 961.5 961.5 961.5 961.5
 961.9 961.9 961.9 961.9 961.9 961.9 961.9 961.9
 962.3 962.3 962.3 962.3 962.3 962.3 962.3 962.3
 962.7 962.7 962.7 962.7 962.7 962.7 962.7 962.7
 963.0 963.0 963.0 963.0 963.0 963.0 963.0 963.0
 963.7 963.7 963.7 963.7 963.7 963.7 963.7 963.7
 964.6 964.6 964.6 964.6 964.6 964.6 964.6 964.6
 964.7 964.7 964.7 964.7 964.7 964.7 964.7 964.7
 964.7 964.7 964.7 964.7 964.7 964.7 964.7 964.7
 965.6 965.6 965.6 965.6 965.6 965.6 965.6 965.6
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 964.5 964.5 964.5 964.5 964.5 964.5 964.5 964.5
 964.1 964.1 964.1 964.1 964.1 964.1 964.1 964.1
 963.9 963.9 963.9 963.9 963.9 963.9 963.9 963.9
 963.8 963.8 963.8 963.8 963.8 963.8 963.8 963.8
 963.7 963.7 963.7 963.7 963.7 963.7 963.7 963.7
 963.6 963.6 963.6 963.6 963.6 963.6 963.6 963.6
 963.5 963.5 963.5 963.5 963.5 963.5 963.5 963.5

STAGE

PLAK OUTFLOW IS 2196. AT TIME 15.83 HOURS

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
2196.	580.	164.	164.	47110.
62.	16.	5.	5.	1334.
	23.26	26.23	26.23	26.23
	590.88	666.37	666.37	666.37
	208.	324.	324.	324.
	355.	400.	400.	400.

CFS
 CMS
 INCHES
 MM
 AC-FT
 THOUS CU M

•DVF•

STATION0000002

	0.	400.	800.	1200.	1600.	2000.	2400.	2000.	0.	0.	0.	0.	0.	0.	0.
.05	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.10	21	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.15	31	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.20	41	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.25	51	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.30	61	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.35	71	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.40	81	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.45	91	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.50	101	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.55	111	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.00	121	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.05	131	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.10	141	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.15	151	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.20	161	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.25	171	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.30	181	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.35	191	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.40	201	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.45	211	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.50	221	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1.55	231	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.00	241	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.05	251	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.10	261	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.15	271	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.20	281	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.25	291	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.30	301	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.35	311	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.40	321	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.45	331	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.50	341	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.55	351	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.00	361	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.05	371	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.10	381	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.15	391	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.20	401	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.25	411	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.30	421	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.35	431	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.40	441	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.45	451	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.50	461	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.55	471	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.00	481	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.05	491	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.10	501	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.15	511	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.20	521	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.25	531	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.30	541	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.35	551	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.40	561	.	.	.	.	.	.	.	.	.	.	.	.	.	.

PLATE D-23

PLATE D-25

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC 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	RATIO 7	RATIO 8
				.05	.10	.15	.20	.35	.50	.75	1.00
HYDROGRAPH A)	000001	.23 (.60)	1 (	123. (3.48)	246. (6.95)	368. (10.43)	491. (13.91)	860. (24.34)	1228. (34.77)	1842. (52.16)	2456. (69.55)
	000002	.23 (.60)	1 (	10. (.27)	22. (.63)	34. (.98)	66. (1.87)	530. (15.24)	1013. (28.69)	1612. (45.65)	2196. (62.18)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1							
	ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM			
	STORAGE	960.30	960.30	964.10			
	OUTFLOW	198.	198.	256.			
		0.	0.	96.			
RATIO	MAXIMUM	MAXIMUM	MAXIMUM	DURATION	TIME OF	TIME OF	
OF	RESERVOIR	DEPTH	STORAGE	OVER TOP	MAX OUTFLOW	FAILURE	
PMF	W.S.ELEV	OVER DAM	AC-FT	HOURS	HOURS	HOURS	
.05	961.35	0.00	213.	0.00	18.25	0.00	
.10	962.30	0.00	227.	0.00	18.25	0.00	
.15	963.20	0.00	241.	0.00	18.25	0.00	
.20	963.90	0.00	253.	0.00	18.17	0.00	
.35	964.74	.64	267.	3.00	16.00	0.00	
.50	965.06	.96	272.	4.08	15.52	0.00	
.75	965.37	1.27	277.	5.42	15.83	0.00	
1.00	965.63	1.53	282.	6.25	15.83	0.00	

**DAT
FILM**