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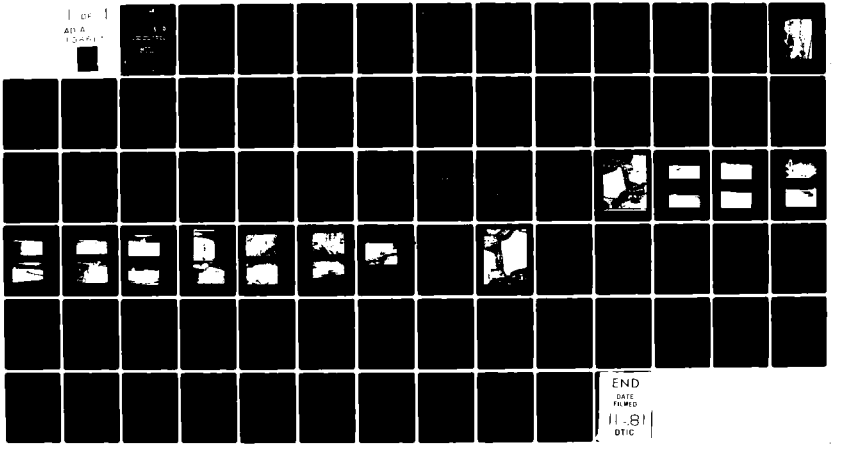

LEVEL II

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MISSISSIPPI - SALT - QUINCY BASIN

LAKE HANNIBAL ESTATES UPPER DAM

RALLS COUNTY, MO.

MO 11185

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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

St. Louis District

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

FOR: STATE OF MISSOURI

OCTOBER, 1980

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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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

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LAKE HANNIBAL ESTATES UPPER DAM

RALLS COUNTY, MISSOURI

MISSOURI INVENTORY NO. MO 11185

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

Lake Hannibal Estates Upper Dam (MO 11185),
Mississippi - Salt - Quincy Basin,
Ralls County, MO. Phase I Inspection Report.

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

UNDER DIRECTION OF

ST. LOUIS DISTRICT, CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

OCT [redacted] 1980

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Garold /Ulmer Harold P. /Hoskins

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

REPLY TO ATTENTION OF

SUBJECT: Lake Hannibal Estates Upper Dam Phase I Inspection Report

This report represents the results of field inspection and evaluation of the Lake Hannibal Estates Upper Dam (MO 11185).

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.

SUBMITTED BY: SIGNED — 5 JUN 1981
Chief, Engineering Division — Date

APPROVED BY: SIGNED — 8 JUN 1981
Colonel, CE, District Engineer — Date

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
ASSESSMENT SUMMARY

Name of Dam	Lake Hannibal Estates Upper Dam
State Located	Missouri
County Located	Ralls County
Stream	Big Creek
Date of Inspection	October 8, 1980

Lake Hannibal Estates Upper 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.

Lake Hannibal Estates Upper Dam has a height of nineteen (19) feet and a storage capacity at the minimum top elevation of the dam of one hundred ninety-four (194) acre-feet. In accordance with the guidelines, a small size dam has a height greater than or equal to twenty-five (25) feet but less than forty (40) feet and a storage capacity greater than or equal to fifty (50) acre-feet but less than one thousand (1,000) acre-feet. The size classification is determined by either the storage capacity or height, whichever gives the larger size category. Lake Hannibal Estates Upper Dam is classified as a small size dam.

In accordance with the guidelines and based on visual observation, the dam is classified as having a high hazard potential. Failure would threaten life and property. The estimated damage zone extends approximately three (3) miles downstream of the dam. Within the damage zone are another dam (MO 10061) at three-tenths of a mile downstream; Highway H at four-tenths of a mile downstream; several camp trailers, a barn and a house located between the lower dam and Highway H; a trailer home and a house under construction at one-half mile downstream; a house at two and nine-tenths miles downstream, and a garage and trailer home at three miles downstream.

Our inspection and evaluation indicates that the spillways do not meet the criteria set forth in the recommended guidelines for a small dam having a high hazard potential. Considering the small volume of water impounded and the reservoir and dam (MO 10061) immediately downstream, one half of the Probable Maximum Flood is the appropriate spillway design

flood. The hydraulic/hydrologic analyses based on the adjustable "gooseneck" type inlet being set at invert elevation of 97.0 indicate that the spillways will not pass the 100-year flood (1% probability flood - a flood having a one percent chance of being exceeded in any one year) without overtopping the dam. The spillway will pass 14% of the Probable Maximum Flood and the 10-year flood (a flood having a ten percent chance of being exceeded in any one year) without overtopping the dam. The Probable Maximum Flood is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonable possible in the region.

Rotation of the "gooseneck" type inlet to its highest invert elevation of 99.0 would result in the spillways not being able to pass the 10-year flood without overtopping the dam. Failure of the spillways to pass the 10-year flood would change the classification of the dam from Unsafe-Non-emergency to Unsafe-Emergency.

This dam appears to be in excellent structural condition. The deficiencies noted are inadequate spillway capacity, the lack of seepage and stability analyses as required by the guidelines for all dams having a high hazard potential, some erosion of the upstream slope and an open excavation along the left side of the principal spillway conduit. The adjustable "gooseneck" type inlet is also considered a deficiency since rotation of the invert upwards increases the possibility of overtopping of the dam.

Minimal design data were available for this dam. Based on the data available and on the observations made during the field inspection of the dam, the following remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams:

a. Alternatives.

(1) The emergency spillway size and/or the height of dam should be increased to pass 50% of the Probable Maximum Flood without overtopping. In either case the spillway should be protected to prevent erosion.

b. Operation and Maintenance Procedures.

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the design and construction of dams.

(2) Measures should be taken to repair present erosion and to stabilize the upstream slope.

(3) The excavation to uncover the valve on the 2-inch outlet pipe should be filled and stabilized. The outlet pipe should be maintained and operated periodically.

(4) Measures should be taken to assure that the elevation of the invert of the principal spillway inlet does not exceed 97.0.

(5) Maintenance of the vegetation on the embankment and emergency spillway is excellent and should be continued.

(6) A trash rack should be installed on the principal spillway inlet to help in keeping the spillway open.

(7) Periodic inspections of the dam should be made and recorded as part of this project file.

Rey S. Decker
E-3703

Gordon Jamison

Harold Ulmer
Garold Ulmer
E-19246

H. P. Hoskins
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
LAKE HANNIBAL ESTATES UPPER DAM - MO - 11185
RALLS 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 Lake Hannibal Estates Upper 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) Embankment. The dam is an earth fill structure approximately 600 feet in length and 19 feet in height with a maximum storage capacity at the minimum top elevation of dam of 194 acre-feet. The dam impounds recreational water for a housing development. Immediately downstream (approximately 1500 feet) is another dam (MO 10061). The impounded water in the lower reservoir encroaches upon the downstream toe of this dam. Both dams are owned by the same developer.

(2) Principal Spillway. The principal spillway was designed by SCS as a hood inlet type spillway with no control feature. During construction the hood was replaced with a "gooseneck" type corrugated metal pipe inlet which can be rotated in order to adjust the level of the water in the reservoir.

(a) Inlet Structure. The "gooseneck" type inlet is constructed of 24-inch diameter corrugated metal pipe and is attached to the inlet end of the conduit by a 24-inch length corrugated metal pipe band with manually tightened bolts. The effective invert elevation of the inlet can be raised by loosening the bolts and rotating the inlet. The "gooseneck" type inlet is shown in Photo No. 6.

(b) Conduit. The principal spillway conduit is 24-inch corrugated metal pipe having a length of 135 feet. The inlet invert elevation for the conduit is 97.0, and the outlet invert is at elevation 83.6. The SCS plan shows that the conduit is equipped with two anti-seep collars.

(c) Stilling Basin. The upper end of the lower reservoir (MO 10061) serves as a stilling basin.

(3) Emergency Spillway. The uncontrolled vegetated earth emergency spillway is cut through the right abutment. The bottom width is approximately 60 feet, and the side slopes vary. A road across the entrance channel serves as an outlet control. There is a training dike on the left side of the exit channel. The emergency spillway profile is shown on Plate C-2.

(4) Low-Level Outlet. The only low-level outlet is a 2-inch pipe through the dam with a valve at the downstream end.

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

b. Location. The dam is located within the corporate limits of Rensselaer in the north central part of Ralls County, Missouri, as shown on Plate A-2. The dam is shown on Plate A-1 in the NW 1/4 of Section 11, T56N, R6W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. This dam has a height of 19 feet, a storage capacity of 194 acre-feet and is classified as a small size dam. A small size dam has a height greater than or equal to 25 feet but less than 40 feet and a storage capacity greater than or equal to 50 acre-feet but less than 1,000 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 of dams and impoundments are presented in the guidelines as referenced in paragraph 1.1c above.

Aerial photographs of the downstream damage zone of this dam were taken in October, 1980. These photographs were used as reference in the field observations of the damage zone which were made during the inspection. Based on the field observations and on the referenced guidelines this dam is in the High Hazard Potential Classification. The estimated damage zone extends approximately three miles downstream of the dam. Within the damage zone are another dam (MO 10061) at three-tenths of a mile downstream; Highway H at four-tenths of a mile downstream; several camp trailers, a barn and a house located between the lower dam and Highway H; a trailer home and a house under construction at one-half mile downstream; a house at two and nine-tenths miles downstream, and a garage and trailer home at three miles downstream.

e. Ownership. The dam is owned by Lake Hannibal Estates, P.O. Box 430, Hannibal, Missouri 63401, c/o Tom Hulse.

f. Purpose of Dam. The dam was constructed to impound water for recreational purposes.

g. Design and Construction History. Rudimentary design assistance was provided by the Soil Conservation Service, New London, Missouri. One plan sheet prepared by SCS is included within this report as Plate C-3 in Appendix C. The dam was constructed in 1968.

h. Normal Operating Procedure. The pool level is controlled by rainfall, infiltration, evaporation, and the capacity of the uncontrolled spillways. The volume of water impounded can be increased by rotation of the "gooseneck" type inlet upward so that the invert elevation of the inlet is higher than the invert elevation of the conduit to which it is connected.

1.3 PERTINENT DATA

a. Drainage Area. 306 acres (0.478 square miles), from SCS Plans.

b. Discharge at Damsite.

(1) All discharges at the damsite are through the following:

(a) A 24-inch diameter principal spillway consisting of a corrugated metal pipe conduit equipped with a "gooseneck" type corrugated metal pipe inlet. The inlet can be manually rotated in order to impound water above the invert elevation of the conduit to which the inlet is connected. The spillway is uncontrolled after the invert elevation of the inlet has been set.

(b) An uncontrolled, vegetated earth channel emergency spillway.

(2) Estimated maximum flood at damsite -- unknown.

(3) The principal spillway capacity varies from 0 c.f.s. at elevation 97.0 feet to 14 c.f.s. at the crest of the emergency spillway (elevation 99.2 feet) to 36 c.f.s. at the minimum top of dam (elevation 100.2 feet).

(4) The emergency spillway capacity varies from 0 c.f.s. at its crest (elevation 99.2 feet) to 100 c.f.s. at the minimum top of dam (elevation 100.2 feet).

(5) Total spillway capacity at the minimum top of dam is 136 c.f.s. ±.

c. Elevations (feet - SCS Plans).

(1) Observed pool - 96.0

(2) Normal pool - 97.0

(3) Spillway crests

Principal - 97.0

Emergency - 99.2

(4) Maximum experienced pool - 99.7± (based on statement by Mr. Hulse that the spillway operated in 1973 with flow depth of 6 inches.)

(5) Top of dam (minimum) - 100.2

(6) Streambed - 81.5

(7) Maximum Tailwater - unknown

d. Reservoir. Length (feet) of pool

(1) At principal spillway crest - 2100±

(2) At emergency spillway crest - 2350±

(3) At top of dam (minimum) - 2450±

e. Storage (Acre-feet).

(1) Observed pool - 95±

(2) Normal pool - 115±

(3) Spillway crests

Principal - 115±

Emergency - 165±

(4) Maximum experienced pool - 180±

(5) Top of dam (minimum) - 194±

f. Reservoir Surface (Acres).

(1) Observed pool - 18±

(2) Normal pool - 20±

(3) Spillway crests

Principal - 20±

Emergency - 26±

(4) Maximum experienced pool - 28±

(5) Top of dam (minimum) - 31±

g. Dam.

(1) Type - Earth fill

(2) Length - 600 feet (plans & measured)

(3) Height - 19± feet

(4) Top Width - 14± feet

(5) Side slopes.

(a) Downstream - 1V on 5H (measured)

(b) Upstream - 1V on 5H (measured to water level)

(6) Zoning - Homogeneous

(7) Impervious core - Homogeneous

(8) Cutoff - Plans show 3 feet minimum depth, 10 feet bottom width and 1V on 1H side slopes. Mr. Hulse reported that the cutoff extended to about 10 feet in depth and was bottomed in clay.

(9) Grout curtain - None

(10) Wave protection - Vegetated earth

(11) Drains - None

h. Diversion Channel and Regulating Tunnel. None

i. Spillways.

(1) Principal

(a) Type. A 24-inch corrugated metal pipe conduit equipped with a "gooseneck" type corrugated metal pipe inlet. The invert elevation of the inlet can be adjusted by rotating the inlet.

(b) Crest (invert) elevation - 97.0 (Conduit invert elevation at juncture with inlet. Maximum rotation of inlet would result in an inlet invert elevation of 99.0±. 97.0 is used in the hydraulic/hydrologic analysis of this dam).

Outlet (invert)elevation - 83.6

(c) Length - 135 feet

(2) Emergency

(a) Type - An uncontrolled vegetated earth spillway excavated through the right abutment. Bottom width - approximately 60 feet. Side slopes vary. See Plate C-2 for inlet and exit slopes.

(b) Control section - Graveled road approximately 10-feet in width following the centerline of dam.

(c) Crest elevation - 99.2

(d) Upstream Channel - Open and clear - vegetated.

(e) Downstream Channel - Open and clear - vegetated. Discharges directly into lower reservoir approximately 400 feet downstream from centerline of this dam.

j. Regulating Outlets. None

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Rudimentary design assistance was provided by the Soil Conservation Service, New London, Missouri. One plan sheet prepared by SCS was obtained from the New London office and is included within this report as Plate C-3 in Appendix C. Differences between data shown on the plan sheet and actual construction are referred to throughout this report as well as on the typewritten insert which has been added in the preparation of Plate C-3.

2.2 CONSTRUCTION

No construction data were available. Mr. Hulse reported that the dam was constructed in 1968. He also reported that the embankment slopes were constructed flatter than shown on the plans and that the cutoff trench was about 10 feet in depth and bottomed in clay.

2.3 OPERATION

a. A 2-inch steel pipe passes through the dam along the principal spillway conduit. A control valve is located near the downstream toe of the dam. Flow from this pipe can be directed into the lower lake or into a pumping station located downstream from the left end of the dam for fire protection and other water uses. Mr. Hulse reported that the pump station was no longer needed or used since the water system had been completed for the development and that the pump station was to be removed.

b. The "gooseneck" type principal spillway inlet is an operating feature of this dam since it can be rotated in order to adjust the spillway invert elevation. At the date of inspection the invert elevation of the "gooseneck" inlet was lower than the invert elevation of the spillway conduit to which it is connected. Maximum rotation of the inlet upwards could raise the level of the water in the reservoir to the approximate level of the control section of the emergency spillway.

2.4 EVALUATION

a. Availability. All available data were readily provided by the Soil Conservation Service.

b. Adequacy. The field surveys, visual observations and plans presented herein are considered adequate to support the conclusions 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. Data that were available are considered to be valid, as modified during construction.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Lake Hannibal Estates Dam was made on October 8, 1980. Engineers from Hoskins-Western-Sonderegger, Inc., Lincoln, Nebraska, making the inspection were:

Rey S. Decker - Geotechnical
Garold G. Ulmer - Hydraulics and Hydrology
Gordon Jamison - Hydraulics and Hydrology

The owner was represented during the inspection by Mr. Tom Hulse.

b. Geology and Soils (abutment and embankment). This site is situated in the loess-till central Mississippi physiographic area. Upland soils in the area consist of the Menfro and Winfield series developed on loess and the Lindley developed on glacial till on the lower slopes. These loess and till materials mantle the Mississippian age Kinderhookian series of the Hannibal formation and the Chauteau group. These bedrock formations consist of fissile siltstones, shales, and undifferentiated limestone and dolomite.

The only significant structural feature in the area is the NW-SE trending Lincoln Fold, the axis of which is about one mile west of the site. No significant faulting has been recognized in the area.

The site is located in Seismic Zone 1 with minor probability of earthquake damage. The only reported earthquake within 25 miles is the August 8, 1930 quake of IV Modified Mercalli intensity.

Materials in the embankment and the abutments were sampled by hand auger and were field classified as CL loessial soils. Neither glacial till nor bedrock are exposed at this site. Limestone float rocks were observed on the lower slopes of the right (south) abutment of the lower dam (MO 10061) some 1500 feet downstream from this dam.

Catastrophic collapse due to solution cavitation in underlying carbonate bedrock is not reported in this vicinity. No evidence for this hazard was observed at the site or in the valley. Low yields in local wells are evidence of the low transmissivity and secondary porosity in the limestones and dolomites.

c. Dam.

(1) Upstream Slope. The upstream slope is well vegetated. No cracks or deformations were observed. Some erosional damage was observed on the slope extending 2 or 3 feet vertically above present lake level. Some of the eroded areas had been stabilized with small size riprap. One active erosional area was observed between stations 5+00 and 5+25. This area has cut into the face about 8 feet horizontally and has a vertical scarp about 2 feet deep. Mr. Hulse reported that he places riprap whenever the erosion becomes significant and that he plans to repair this area in the near future. The slope of the upstream embankment, as determined during the inspection, is 1V on 5H as compared to 1V on 3H as shown on Plate C-B. There was no evidence to indicate that an upstream berm was constructed. Photos 2 and 10 show the upstream face, and Photo No. 11 shows the active erosional area.

(2) Crest. The crest is well graveled and serves as an access road for the development. No cracks or serious erosion were observed on the crest. The profile of the crest, shown on Plate C-2, Appendix C, shows a distinct hump in the crest with top elevation of 102.2 for a distance of 50 feet± either side of the principal spillway (comparable to settled elevation of 102 shown on Plate C-3). The remainder of the dam is below the settled top elevation shown on Plate C-3 with a low elevation of 100.3 at the extreme left (stations 0+00 to 0+50) and 100.2 at station 6+00 on the extreme right at the left edge of the emergency spillway. There was no evidence that would indicate that the dam has been overtopped. Photos 3, 8 and 9 show the crest.

(3) Downstream Slope. The downstream slope is very well vegetated with adapted grasses and is well mowed and maintained. No cracks, erosion, bulges, slides, deformations, tree growth or rodent activity were observed. No evidence of seepage was observed on the slope, in the abutment troughs or along the toe. The slope of the downstream embankment, as determined during the inspection, is 1V on 5H as compared to 1V on 4H as shown on Plate C-3. Photos 3, 4 and 8 show the downstream slope.

A wet spot with standing water was observed outside of the toe downstream from about station 2+50. Mr. Hulse reported that this is the pump station that is no longer used. It consists of a 1000-gallon tank equipped with a float valve system connected with the 2-inch pipe near the outlet of the principal spillway. Apparently the float valves are not operating effectively thus allowing the tank to overfill.

This water around the lift station does not appear to have any connection with seepage through the abutment. Mr. Hulse said that he plans to disconnect the inflow pipe at the valve near the principal spillway and to remove the storage tank and lift pump. Photo No. 17 shows the wet spot and the top of the storage tank. Photo No. 15 shows an excavated area just left of the spillway pipe where Mr. Hulse had uncovered the valve on the 2-inch pipe from the lake that supplies water to the lift station. Mr. Hulse plans to provide access for the valve and to refill this area.

d. Appurtenant Structures.

(1) Principal Spillway.

(a) Inlet Structure. The 24-inch corrugated metal pipe spillway was designed with a conventional uncontrolled hooded inlet (Plate C-3). A manually controlled "gooseneck" type inlet was added to the inlet end of the spillway in lieu of the hood inlet. This inlet can be manually rotated to provide control over the elevation of the normal pool. The inlet was open and free, and no deterioration of the metal structure was apparent. Photos 5 and 6 show the inlet of the principal spillway.

(b) Conduit. The conduit consists of about 135 feet of 24-inch diameter corrugated metal pipe. No deterioration of the metal was observed at the inlet or outlet ends of the pipe. Mr. Hulse reported that the pipe was double-dipped and coated. Photos 7, 14 and 15 show the outlet of the conduit.

(c) Stilling Basin. The principal spillway discharges directly into the lower reservoir as shown in Photos 7 and 15.

(2) Emergency Spillway. The emergency spillway is cut through the right abutment as opposed to the left abutment as shown on Plate C-3. The entire channel is well vegetated with adapted grasses. A retaining dike along the left side of the spillway exit channel diverts flows away from the embankment. The spillway discharges into the lower reservoir. Mr. Hulse reported that the emergency spillway operated in 1973 with a flow depth of about 6 inches.
The graveled access road passes across the spillway and serves as the control section. Photos No. 12 and 13 show the emergency spillway.

(3) Low-Level Outlet. The only low-level outlet consists of a 2-inch steel pipe through the dam located along the left side of the principal spillway. This outlet is controlled by a valve at the downstream end. Discharge from this pipe can be directed into the lower reservoir or into the pump station previously described. Photo No. 16 shows the excavation over the valve on this outlet pipe.

e. Reservoir Area. The shore line of the reservoir is well vegetated with grass. No significant erosion was noted around the reservoir. There was no evidence of abnormal siltation in the reservoir. Photo No. 5 shows a portion of the reservoir area.

f. Downstream Channel. The discharges from this reservoir flow directly into the lower reservoir (MO 10061).

3.2 EVALUATION

This structure appears to be in excellent structural condition with no apparent potential of failure. No seepage through the dam or abutments was observed, and the abnormally flat slopes should provide adequate safety against shear failures in a dam of this height and composition. A few minor deficiences in maintenance (erosion of the upstream face and open excavation along the left side of the principal spillway outlet) could ultimately impair the safety of the structure and should be corrected.

The source of water around the lift station downstream from station 2+50 is reported as leakage from the storage tank. This reported source should be verified and eliminated by repairing or removing the system.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool level is generally controlled by rainfall, infiltration, evaporation, and the capacity of the uncontrolled spillways. The only controlled outlet consists of a 2-inch steel pipe (with valve) through the embankment.

The "gooseneck" type inlet on the principal spillway presently keeps the normal pool level at the planned elevation of 97.0; however, it could be rotated upward to raise the normal pool elevation to a maximum elevation of 99.0±.

4.2 MAINTENANCE OF DAM

The dam is mowed regularly and is neat and clean in appearance. Maintenance of the upstream slope is reportedly done as needed. One eroded spot (station 5+00 - 5+25) needs to be repaired in the near future.

4.3 MAINTENANCE OF OPERATING FACILITIES

The 2-inch outlet system is operable but has not been used for a few years.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no warning system in effect for this dam.

4.5 EVALUATION

Maintenance of this structure is generally good. Prevention and/or repair of erosion on the upstream slope should be done on a regular basis rather than waiting until it becomes serious.

The "gooseneck" type inlet on the principal spillway should be removed or rivetted in place to prevent raising the normal pool level above elevation 97.0.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. One plan sheet containing design data was obtained from the New London, Missouri SCS office and is included as Plate C-3 in Appendix C of this report.

b. Experience Data. The drainage area, reservoir surface area, and elevation-storage data were developed from the USGS Rensselaer, 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. Hydrologic computations are attached as Appendix D of this report.

c. Visual Observations.

(1) The principal spillway conduit appears to be in excellent condition. No deterioration of the corrugated metal pipe was observed at either inlet or outlet end. The "gooseneck" type inlet which can be adjusted by rotation upward to increase the level of the water impounded behind the dam is a cause of concern for reasons as stated in paragraph 5.1d. below.

(2) The emergency spillway is well vegetated on both sides of the graveled road control section as shown in Photos 12 and 13. A retaining dike along the left side of the exit channel will divert flows away from the downstream toe of the dam. The downstream channel is unobstructed and is well maintained.

(3) Erosion damage on the upstream slope should be repaired and measures taken to stabilize the slope.

(4) The presence of bends in the principal spillway inlet and the absence of a trash rack may result in the blockage of the spillway by debris resulting in a reduced spillway capacity.

d. Overtopping Potential. The spillways are too small to pass 50% of the probable maximum flood without overtopping the dam. The spillways will pass 14% of the probable maximum flood and the 10% probability flood without overtopping. The spillways will not pass the 1% probability flood without minor overtopping (less than .3 foot for two hours). The hydraulic/hydrologic analyses of this dam is based on an invert elevation of 97.0 for the principal spillway (elevation of the principal spillway conduit at connection to the "gooseneck" type inlet). Rotation of the inlet upwards, resulting in the inlet invert elevation

being higher than the conduit invert elevation, will result in an increase in the volume of water impounded behind the dam and also a decrease in the amount of storm runoff that can be stored prior to flow occurring through the emergency spillway. The possibility of overtopping at both ends of the dam is enhanced by raising the elevation of the invert of the inlet. With the "gooseneck" type inlet raised to the highest position (invert at 99.0 ft) the spillway capacity would be lowered to 104 cfs, the spillways would pass 7% of the PMF, and the spillways would not pass the 10% probability flood without overtopping the dam. Overtopping of a dam should always be avoided. Overtopping would be dangerous because the flow of the water over the crest could erode the downstream face of the dam and, if continued long enough, could breach the dam with sudden release of all of the impounded water onto the downstream floodplain. It is recommended that the "gooseneck" type inlet be replaced with a hood inlet or that it be rivetted in place with its invert at elevation 97.0 or lower.

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 Dam Feet	Duration Over Top Hours
1%	1260	230	100.5	0.3	2
1/2 PMF	2090	1800	101.5	1.3	6
PMF	4180	3840	102.1	1.9	9
0.14 PMF	600	136	100.2	0	-

*Minimum top of dam elevation - 100.2 feet.

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 potential and a small size. Therefore, the 1/2 PMF to 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. Based on visual inspection this dam appears to be structurally stable. There is no evidence of slips, slides, cracking, seepage, rodent borrows or deformations. The abnormally flat slopes should provide adequate safety against shear failures.

b. Design and Construction Data. Design data as shown on Plate C-3 were available for this dam. 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. The small operating facility for this dam has not been used for several years.

d. Post Construction Changes. The inspection team is not aware of any post-construction changes. The embankment slopes were flattened, and the inlet to the principal spillway was modified during construction.

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. Based on visual inspection, this dam appears to be in excellent structural condition, and maintenance is generally good. There were no cracks, bulges, slides or abnormal deformations that would indicate structural stress. The dam is free of tree and brush, and no rodent activity was observed. There was no seepage along the toe of the dam or in either abutment trough. The crest is used as a road and is well graveled. The downstream slope and the emergency spillway are well vegetated, and there was no evidence of erosion in either. The upstream slope is also well vegetated. Some erosional damage was observed on the upstream slope which, if not repaired, could ultimately impair the safety of the dam. An open excavation along the left side of the outlet end of the principal spillway conduit should be repaired.

The water standing in the wet spot near the pump station downstream from the toe of the dam is apparently overflow water from the tank at the pump station. The pump station is no longer used and will be removed.

The approximate hydraulic/hydrologic analyses performed for this dam were based on the invert elevation of the adjustable "gooseneck" type inlet being set at the elevation of the principal spillway conduit at the point of connection with the inlet section (97.0). These analyses indicate that minor overtopping (0.3 foot for a period of 2 hours) could be expected for the 1% probability flood. 50% of the probable maximum flood would overtop the dam by 1.3 feet for a period of 6 hours. In accordance with the "Recommended Guidelines for Safety Inspection of Dams" the capacity of the spillways is inadequate for a small dam having a high hazard potential rating. Rotation of the "gooseneck" type inlet to its highest invert elevation (99.0) would result in the spillways not being able to pass the 10% probability flood without overtopping the dam. It is recommended that the "gooseneck" type inlet be replaced with a hood inlet or that it be rivetted in place with its invert at elevation 97.0 or lower.

The failure of this dam by overtopping could suddenly release the impounded water into the downstream reservoir placing an almost unbearable stress on the simultaneously heavily stressed downstream dam (MO 10061) and resulting in possible failure of that dam. 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. The design data furnished by the SCS and included as Plate C-3 of this report and the measurements and observations made during the inspection are considered adequate to support the conclusions and recommendations presented in 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.

c. Urgency. There does not appear to be an immediate urgency to accomplish the remedial measures recommended in paragraph 7.2.b. The item recommended in paragraph 7.2.a. should be pursued on a high priority basis.

d. Necessity for Further Investigations. Further investigations are not required.

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 emergency spillway size and/or the height of dam should be increased to pass 50% of the Probable Maximum Flood without overtopping. In either case, the spillway should be protected to prevent erosion.

b. Operation and Maintenance Procedures.

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the design and construction of dams.

(2) Measures should be taken to repair present erosion and to stabilize the upstream slope.

(3) The excavation to uncover the valve on the 2-inch outlet pipe should be filled and stabilized. The outlet pipe should be maintained and operated periodically.

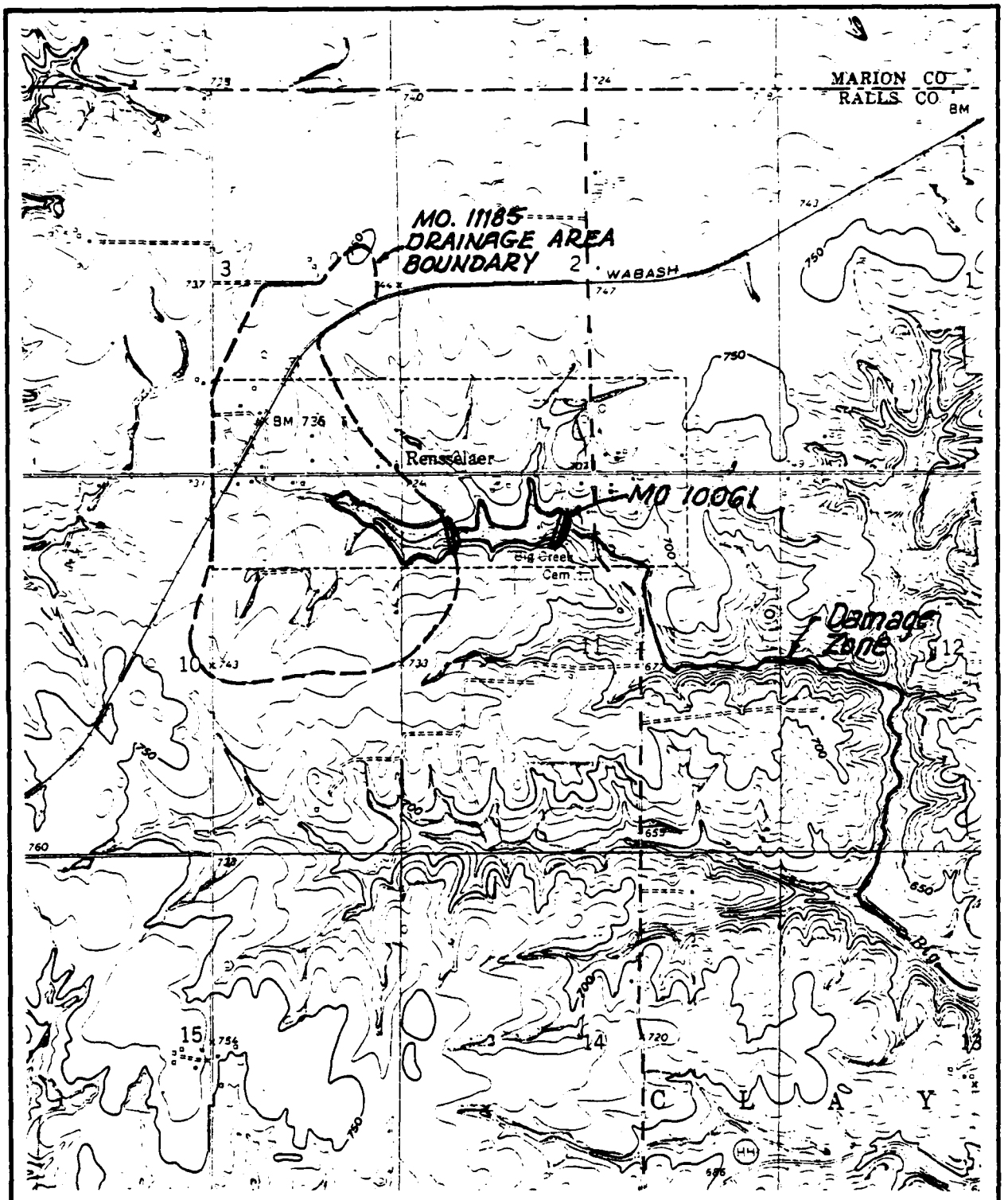
(4) Measures should be taken to assure that the elevation of the invert of the principal spillway inlet does not exceed 97.0.

(5) Maintenance of the vegetation on the embankment and emergency spillway is excellent and should be continued.

(6) A trash rack should be installed on the principal spillway inlet to help in keeping the spillway open.

(7) Periodic inspections of the dam should be made and recorded as part of this project file.

APPENDIX A
MAPS



Scale in feet

2000 1000 0 2000 4000

Contour Interval – 10′

N

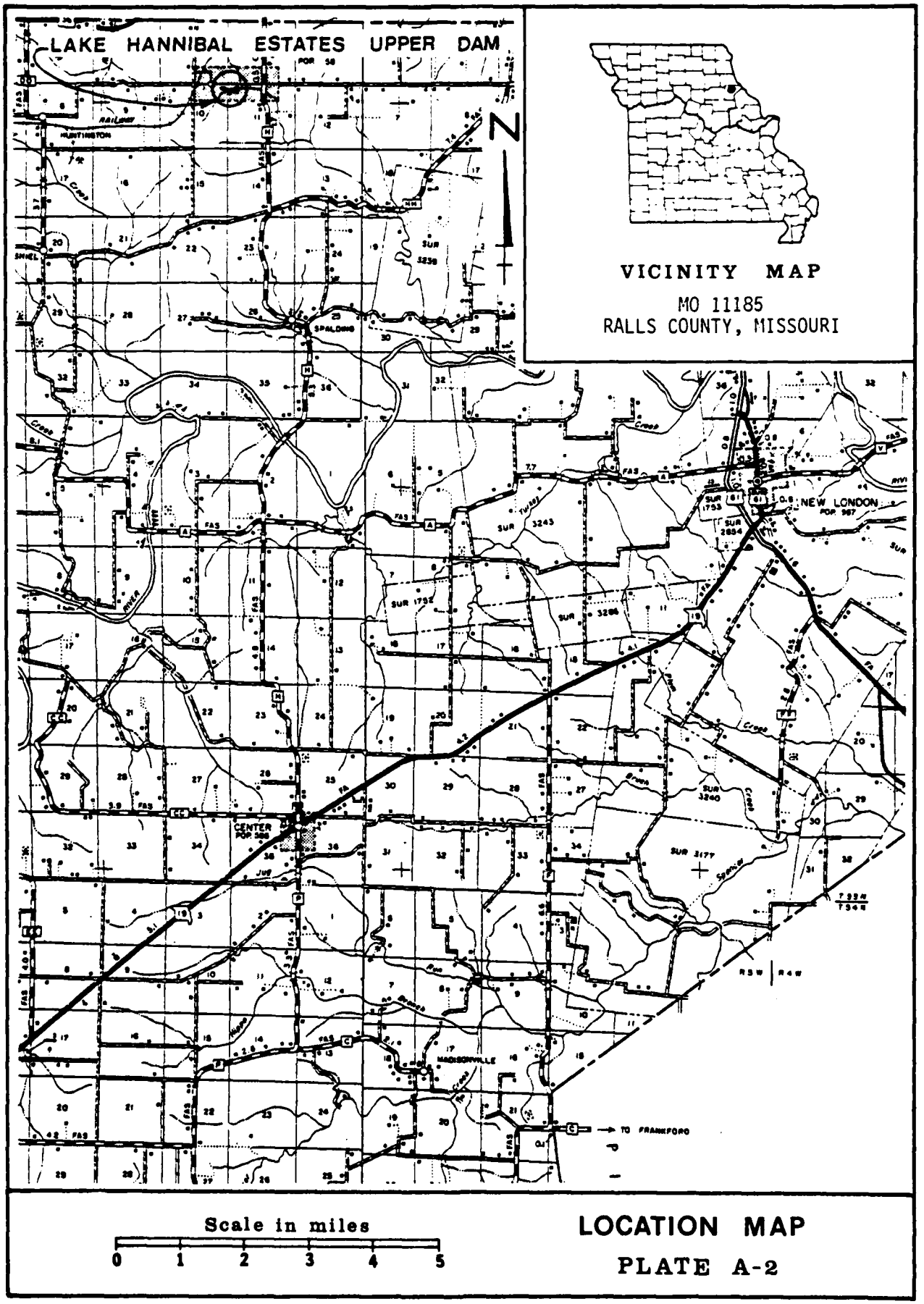
VICINITY TOPOGRAPHY

LAKE HANNIBAL ESTATES UPPER DAM

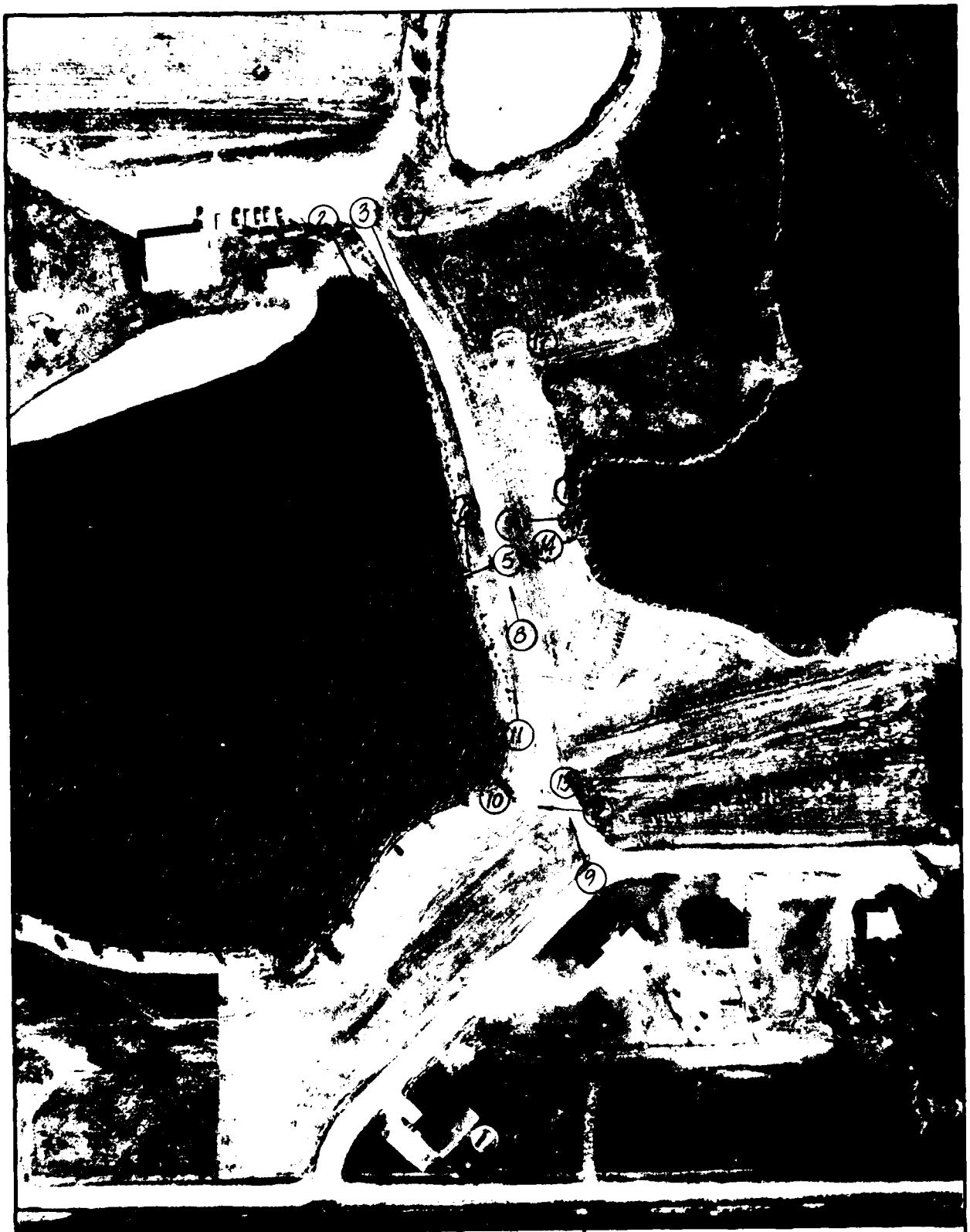
RALLS COUNTY, MO.

MO 11185

PLATE A-1


LAKE HANNIBAL ESTATES UPPER DAM
N
VICINITY MAP
MO 11185
RALLS COUNTY, MISSOURI
NEW LONDON
POP. 967
CENTER
POP. 388
MADISONVILLE
TO FRANKFORD
R3W
R4W
Scale in miles
0 1 2 3 4 5
LOCATION MAP
PLATE A-2

APPENDIX B
PHOTOGRAPHS



LAKE HANNIBAL ESTATES UPPER DAM

RALLS COUNTY, MO.

MO 11185

PHOTO INDEX

PLATE B-1

PHOTO NO. 2 - UPSTREAM FACE FROM LEFT END.

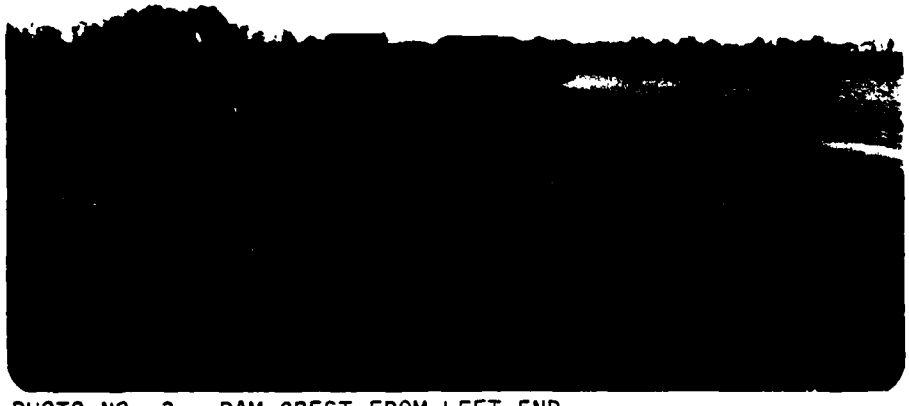


PHOTO NO. 3 - DAM CREST FROM LEFT END.

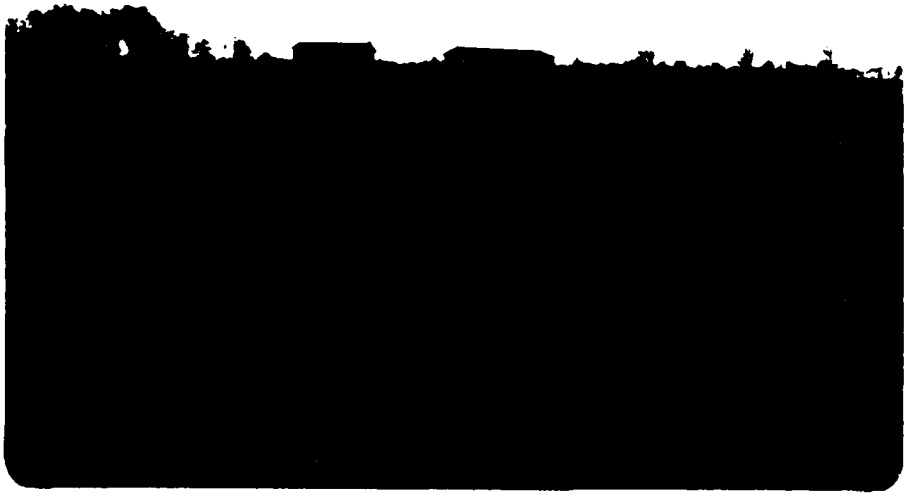


PHOTO NO. 4 - DOWNSTREAM SLOPE FROM LEFT END.

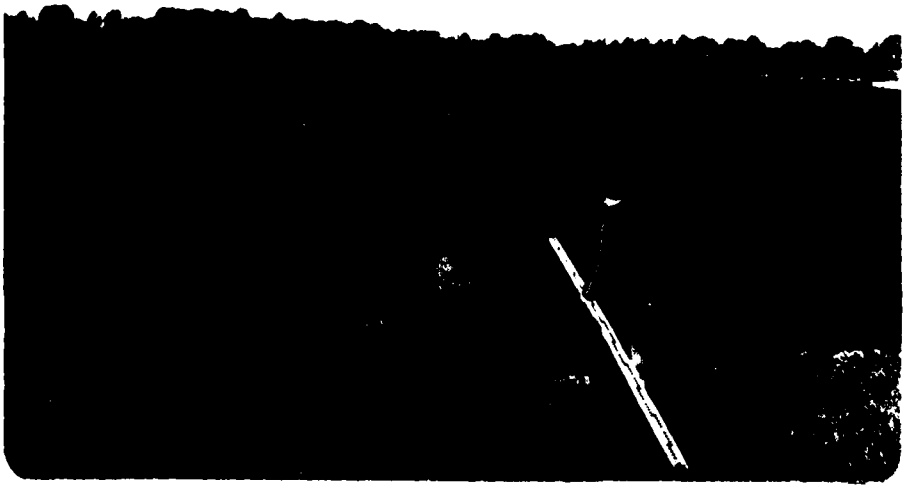


PHOTO NO. 5 - PRINCIPAL SPILLWAY INLET FROM CREST.

PHOTO NO. 6 - PRINCIPAL SPILLWAY INLET WITH ADJUSTABLE HOOD.

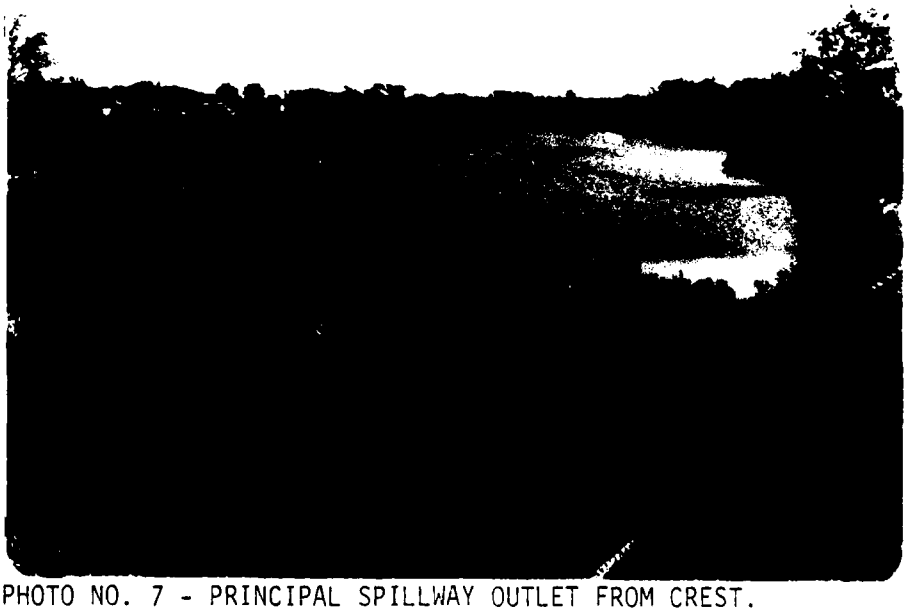


PHOTO NO. 7 - PRINCIPAL SPILLWAY OUTLET FROM CREST.

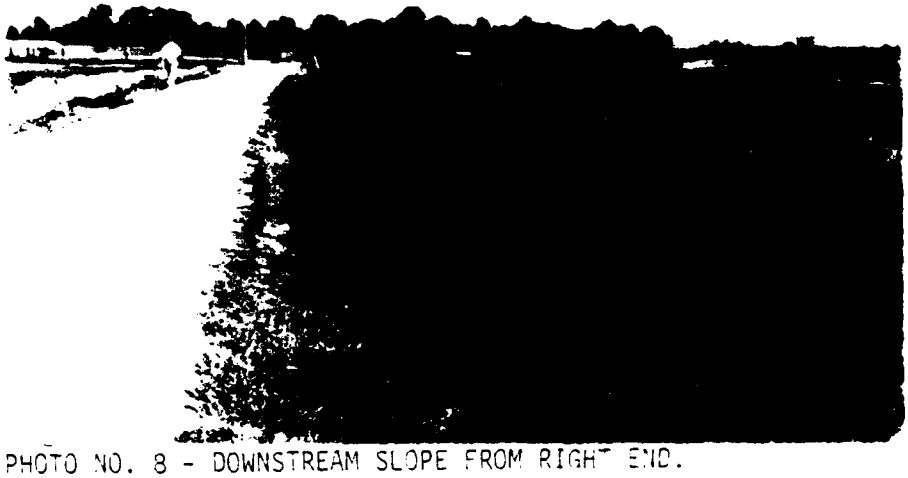


PHOTO NO. 8 - DOWNSTREAM SLOPE FROM RIGHT END.

PHOTO NO. 9 - CREST FROM RIGHT END.

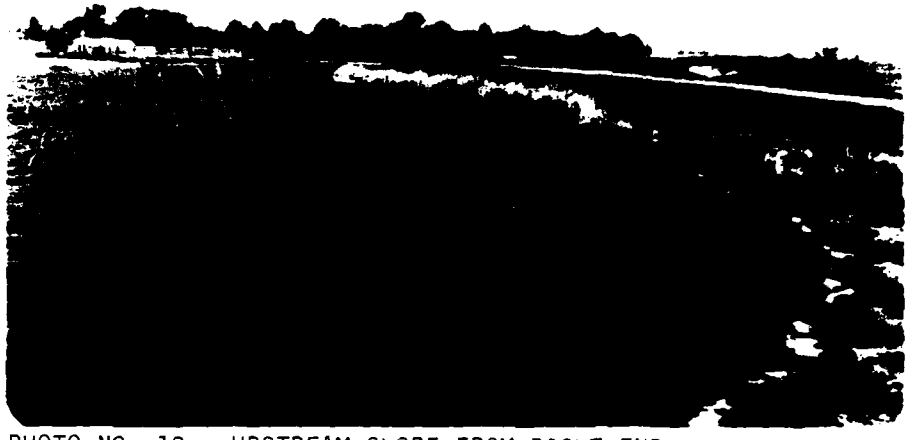


PHOTO NO. 10 - UPSTREAM SLOPE FROM RIGHT END.

PHOTO NO. 11 - EROSION AREA ON RIGHT UPSTREAM FACE.

PHOTO NO. 12 - LOOKING UPSTREAM IN EMERGENCY SPILLWAY CHANNEL.

PHOTO NO. 13 - LOOKING DOWNSTREAM IN EMERGENCY SPILLWAY CHANNEL.

PHOTO NO. - 14 LOOKING DOWNSTREAM AT PRINCIPAL SPILLWAY OUTLET PIPE.

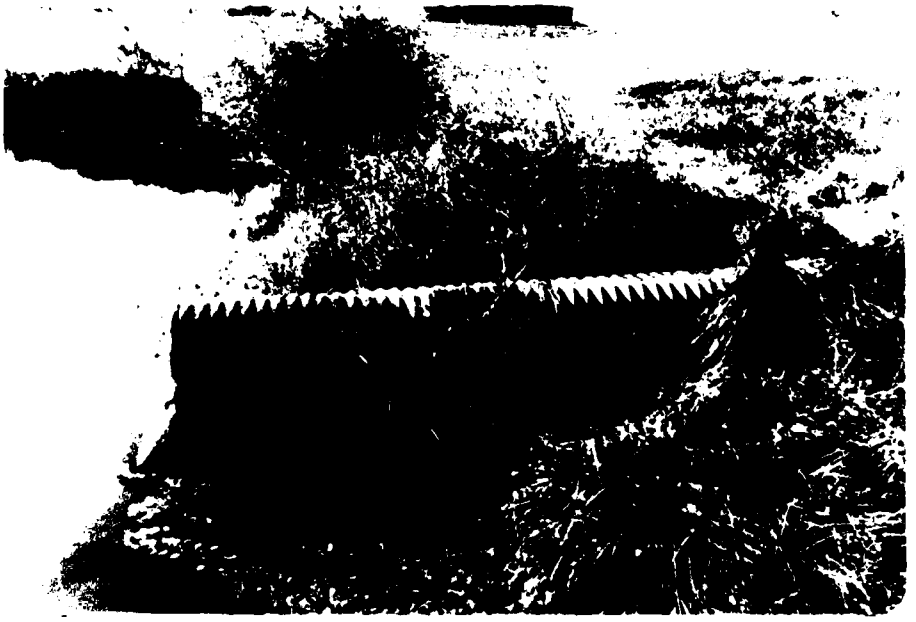


PHOTO NO. 15 - LOOKING FROM LEFT TO RIGHT AT PRINCIPAL SPILLWAY OUTLET PIPE.

PHOTO NO. 16 - EXCAVATED DITCH AT LEFT SIDE OF PRINCIPAL SPILLWAY OUTLET PIPE.

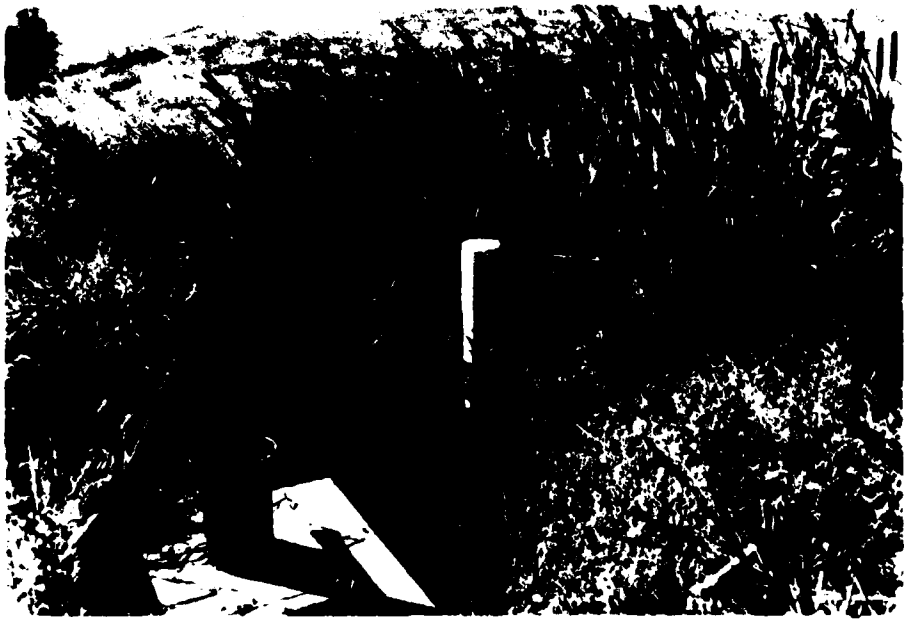


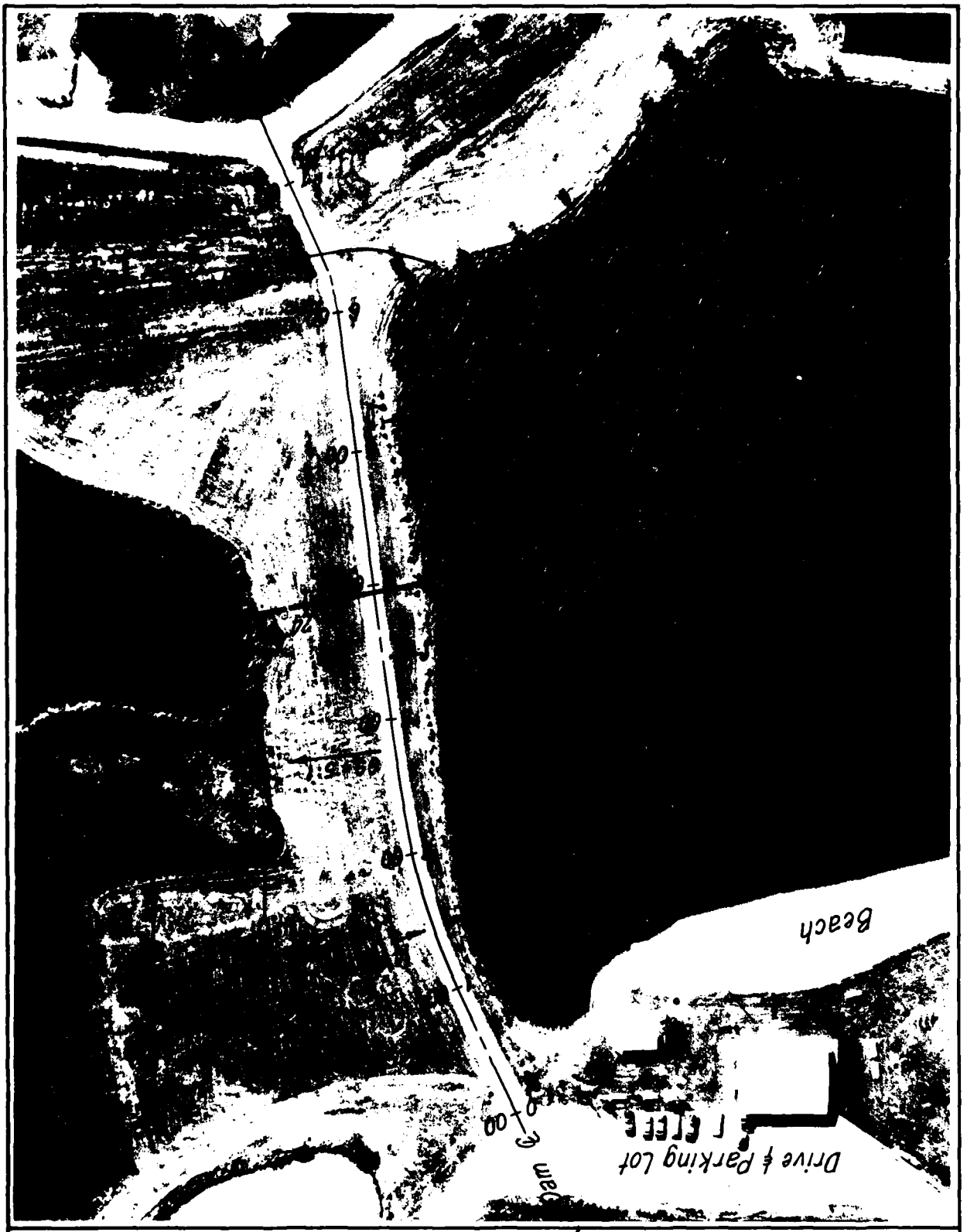
PHOTO NO. 17 - CATTAIL AREA AROUND EMERGENCY LIFT PUMP.

PHOTO NO. 18 - DOWNSTREAM HAZARDS. CAMPING TRAILERS IN PARK JUST DOWNSTREAM FROM LOWER RESERVOIR.

PHOTO NO. 19 - DOWNSTREAM HAZARDS. TRAILER HOME, SMALL HOUSE, AND NEW CONSTRUCTION ON RIGHT BANK APPROXIMATELY ¼ MILE BELOW LOWER RESERVOIR.

PHOTO NO. 20 - DOWNSTREAM HAZARD. HOME ON HIGH LEFT BANK APPROXIMATELY TWO MILES DOWNSTREAM. PROBABLY NOT IN DANGER.

APPENDIX C
PROJECT PLATES



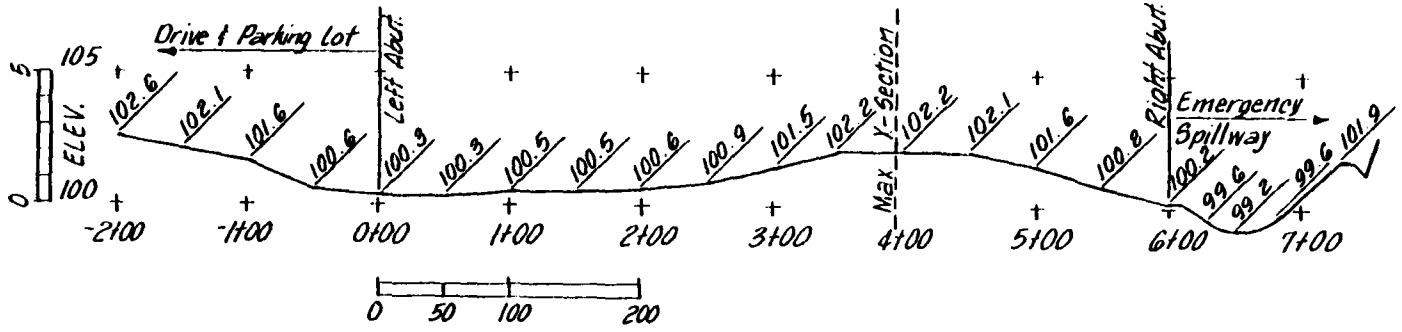
LAKE HANNIBAL ESTATES UPPER DAM

RALLS, COUNTY, MO.

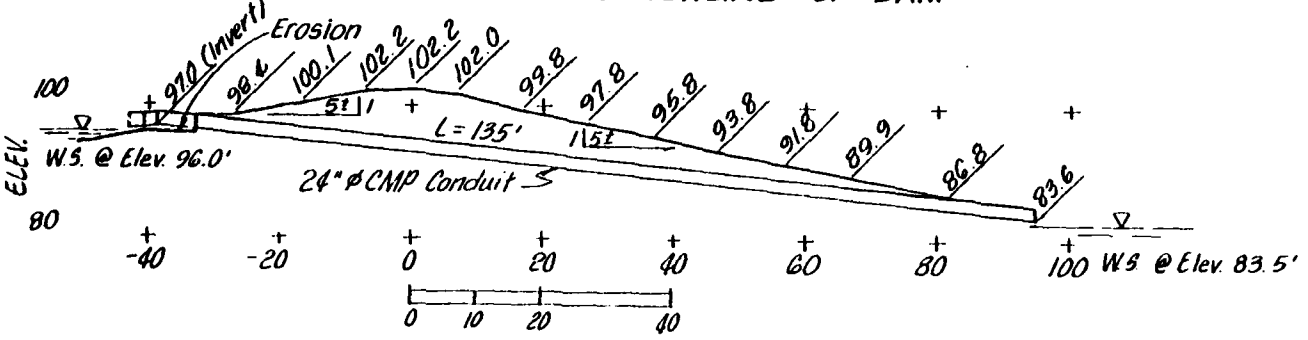
MO 11185

PLAN OF DAM

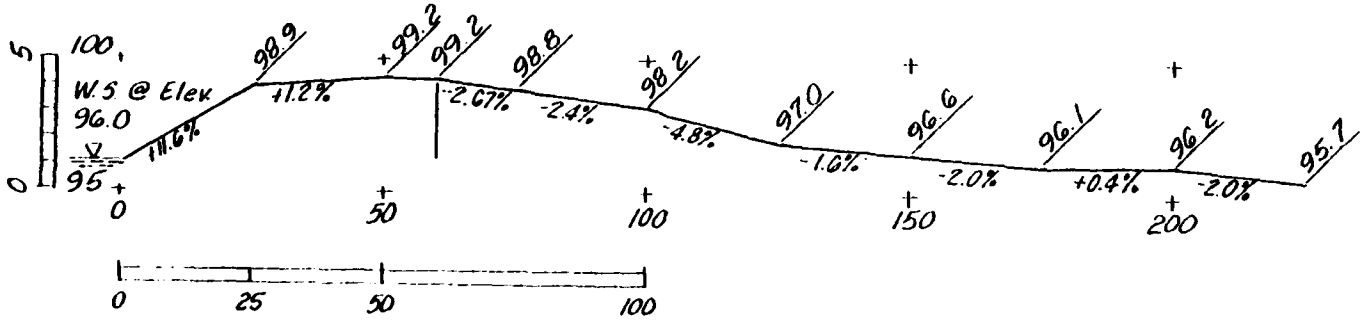
PLATE C-1



PROFILE ALONG CENTERLINE OF DAM

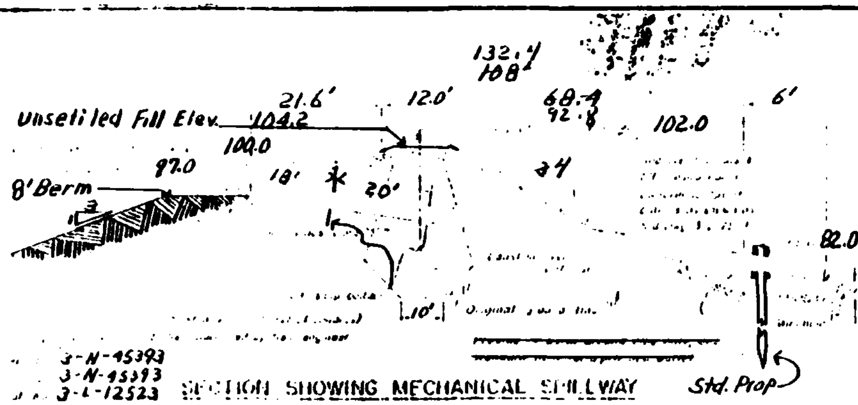


MAXIMUM CROSS-SECTION OF DAM AT STA. 3+95



PROFILE ALONG CENTERLINE OF EMERGENCY SPILLWAY

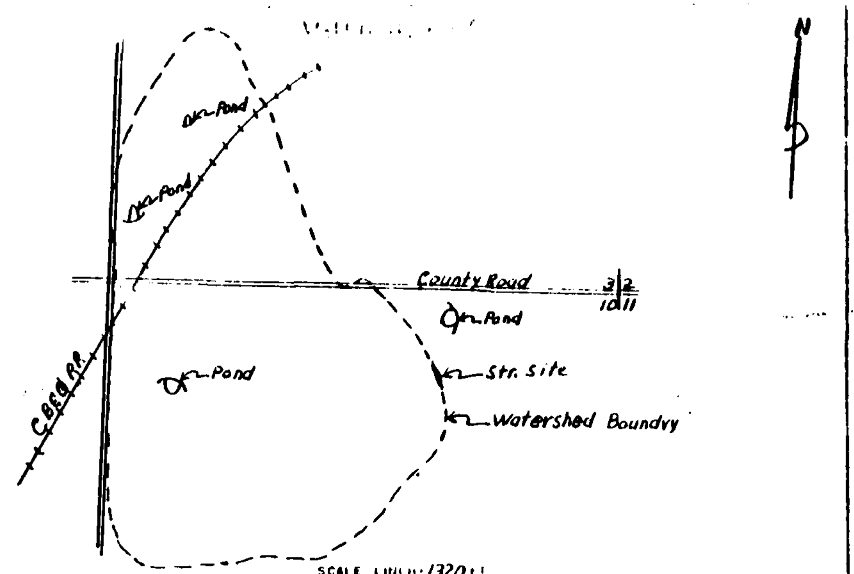
PLATE C-2



SECTION SHOWING MECHANICAL SPILLWAY

LAYOUT PLAN

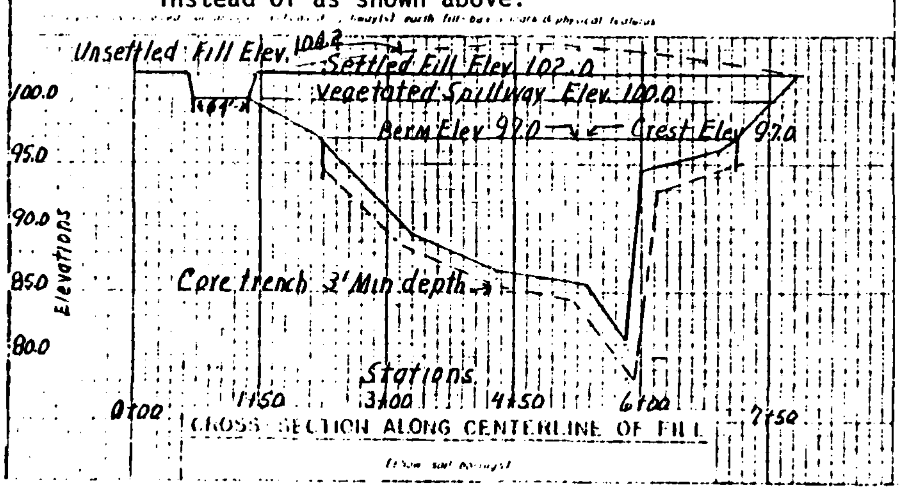
See Sheet No. 2



SCALE 1 INCH = 1320 FT

PHASE I INSPECTION:

1) Hood Inlet replaced with "gooseneck" type adjustable inlet during construction.
2) Watershed Map shows dam in Sec. 10 instead of Sec. 11.
3) Spillway modified to accommodate vehicular traffic.
4) Spillway shown on left side on plan. Constructed on right side.
5) Upstream and downstream slopes are 1V on 5H instead of as shown above.



CROSS SECTION ALONG CENTERLINE OF FILL

DESIGN DATA

DRAINAGE AREA 306 AC
Rainfall: 17 (VC) 14 (SS) 9 - 48
Q (P) 520 ... 1.0 ... 71 - 368 CFS
SURFACE AREA PERM. POOL - 14.7 ACS
HOUR RAINFALL - 3.7 IN RUNOFF CURVE 82
DESIGN RUNOFF - 2.36 IN
VOL. FLOOD RUNOFF (VI) 306/12 2.36 (DA) - 60.2 AC FT
PIPE FLOW
... (3/4) ... (1.0) ... 42 ...
H (TO EMER. SPILLWAY) - 17.0 FT
Q/Q ... .11 K - .83 (FROM 3-L-45245)
MAXIMUM STAGE 3.0 FT
VOL. FLOOD STORAGE REQ'D (Vs) - K x Vr - .83 x 60.2 - 50.0 AC FT
HOOD INLET
STAGE INLET INVERT TO EMERG. SPILLWAY - 3.0 FT
EMERGENCY SPILLWAY (Q = 2.75 LH^3/2)
DESIGN Q - 40 % OF Q 25 - 172 CFS
WIDTH (L) 64 FT DEPTH OF FLOW (H) - 1.0 FT
FREEBOARD REQUIRED - 1.0 FT

ESTIMATED QUANTITIES

136 ft	ft	24" CM Pipe Alumn. 14 ga. w/Coll. Seams
2	ea.	72"X72" diaphram 14 ga.
1	ea.	36"X36" Baffle
5	ea.	24"X24" Watertight Bands
1	ea.	Standard Prop
14,627 13,896		(4:1 & 3:1)
725	cy.	Core Trench (Estimated)

COOPERATOR Hulse, Tommy
COOPERATING WITH Ralls
STATE Missouri ... 10 ... 56N 6W
SURVEYED Minor, Rice & Wybrant DATE 12-6-67

HOOD INLET PIPE SPILLWAY

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Rice 12-67
Minor 12-67
John F. Rice
Area Engineer

1/2

PLATE C-3

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 Appendix).

    a. Twenty-four hour, one percent probabilistic rainfall for the dam location was taken from the data for the rainfall station at Kirksville, 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 = 0.478 square miles (306 acres).

    c. Time of concentration of runoff = 32 minutes (computed from the "Kirpich" formula. This compares to 32 minutes based on Calif. Hwys & P.W. 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.

    e. The total twenty-four hour storm duration losses for the one percent probabilistic storm were 1.52 inches. The total losses for the PMF storm were 0.62 inches. These data are based on SCS runoff curve No. 87 (SCS Plans) and No. 95 for antecedent moisture conditions SCS AMC II and AMC III respectively. The watershed is composed entirely of SCS soil group D (Leonard-Mexico-Putnam Soil Association). Land use is equally divided between the usual farm cultivated crops, grassland, and farmstead areas.

    f. Average soil loss rates = 0.03 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 the methods and formulas found in SCS TR No. 3, "Hood Inlets for Culvert Spillways".

b. The emergency spillway rating curve was developed using the Corps of Engineers, Water Surface Profile HEC-2 computer program. The slope-area method was used assuming an estimated energy slope of 0.016 ft/ft.

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 Appendix.

LAKE HANNIBAL ESTATES
UPPER DAM
MO. ID. NO. 11185
PRINCIPAL SPILLWAY
RATING CURVE

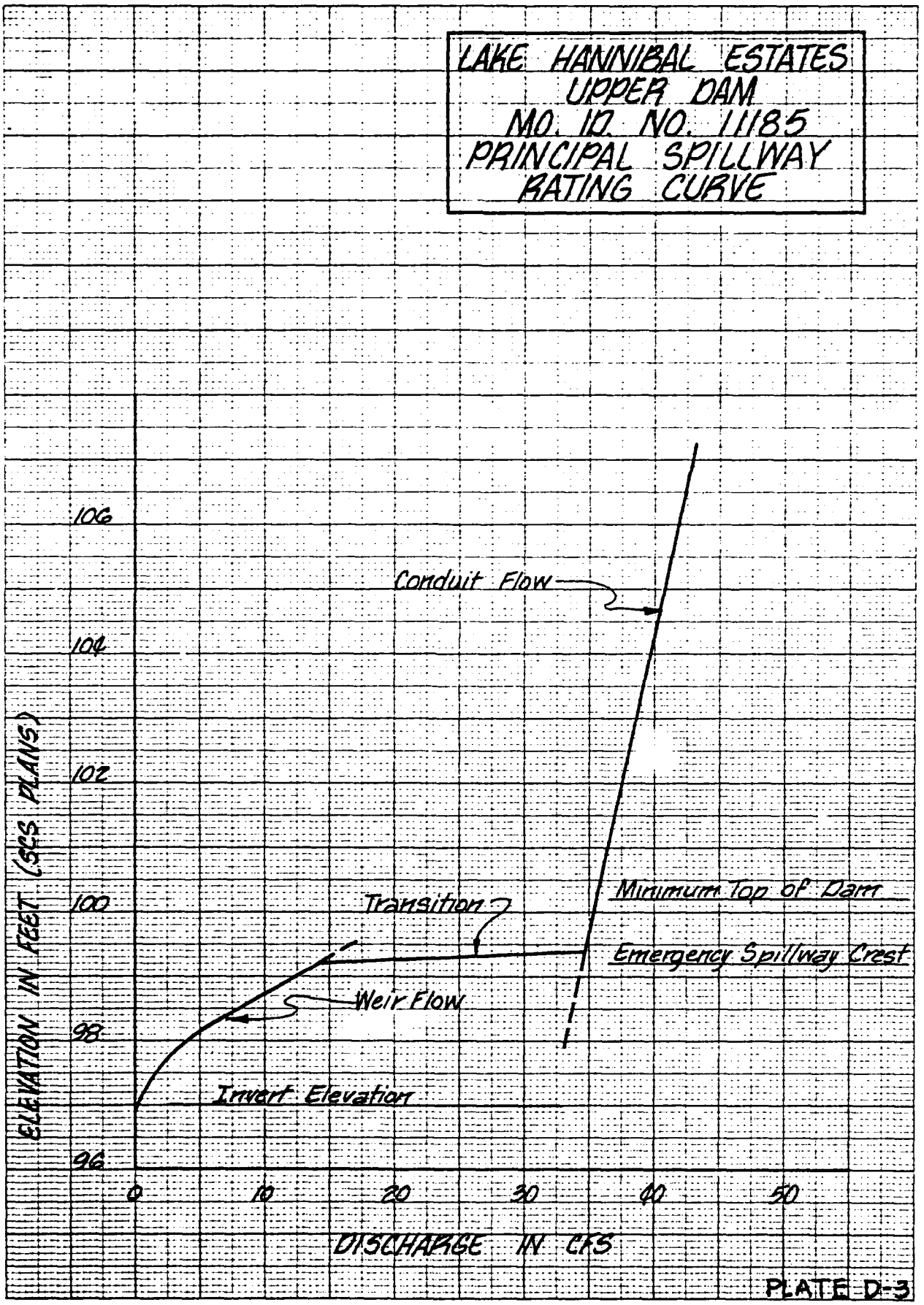


PLATE D-3

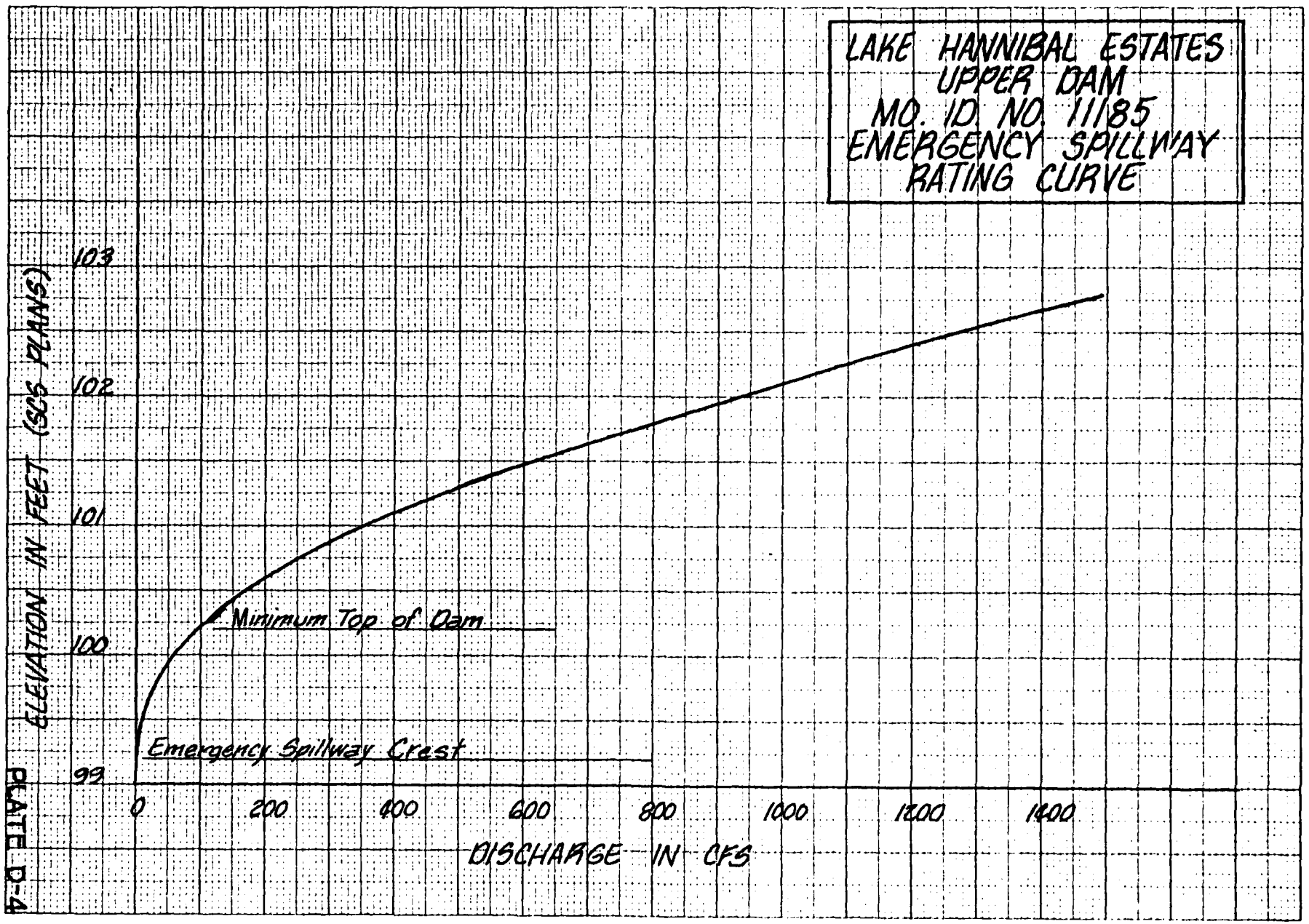
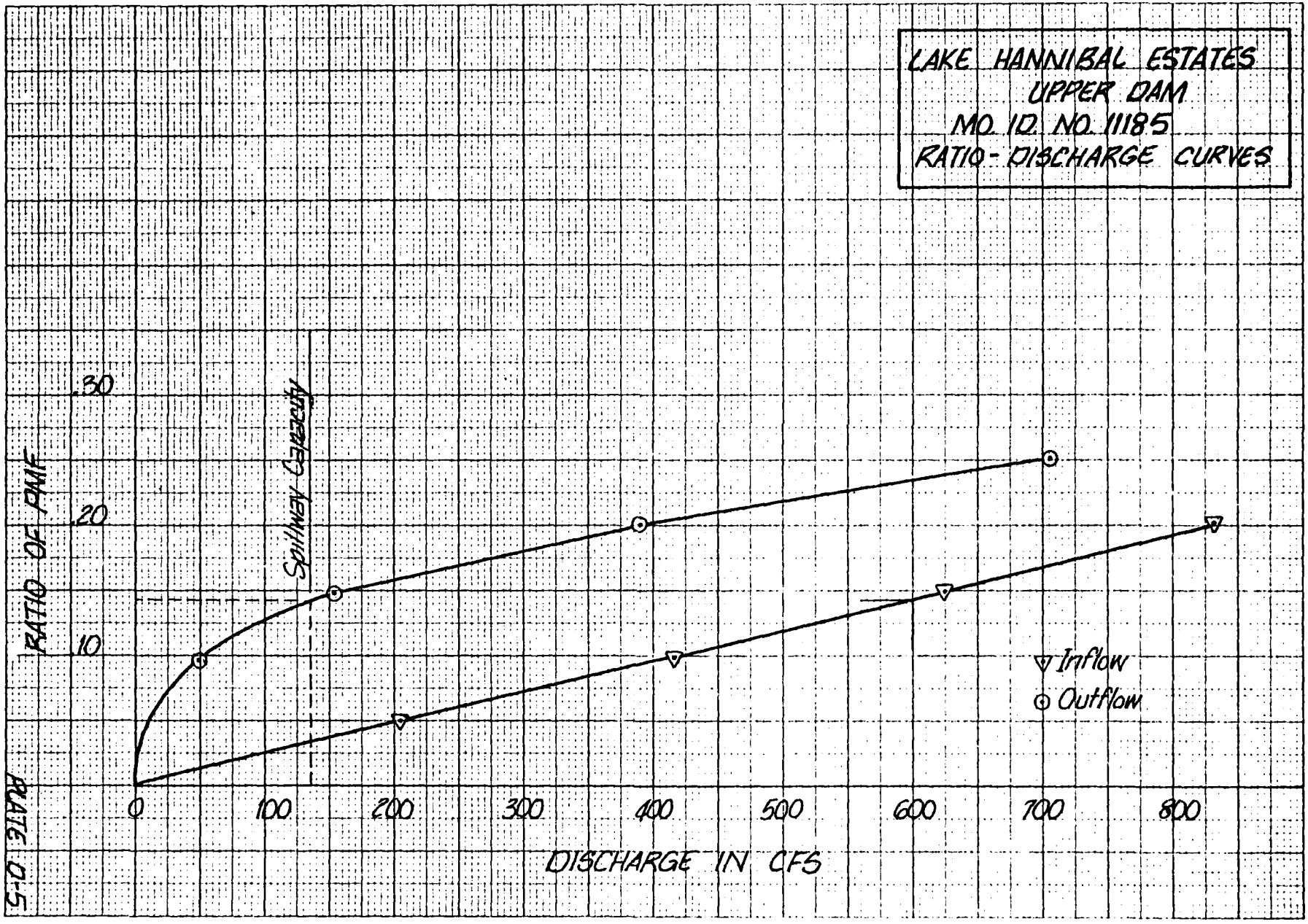


PLATE D-4



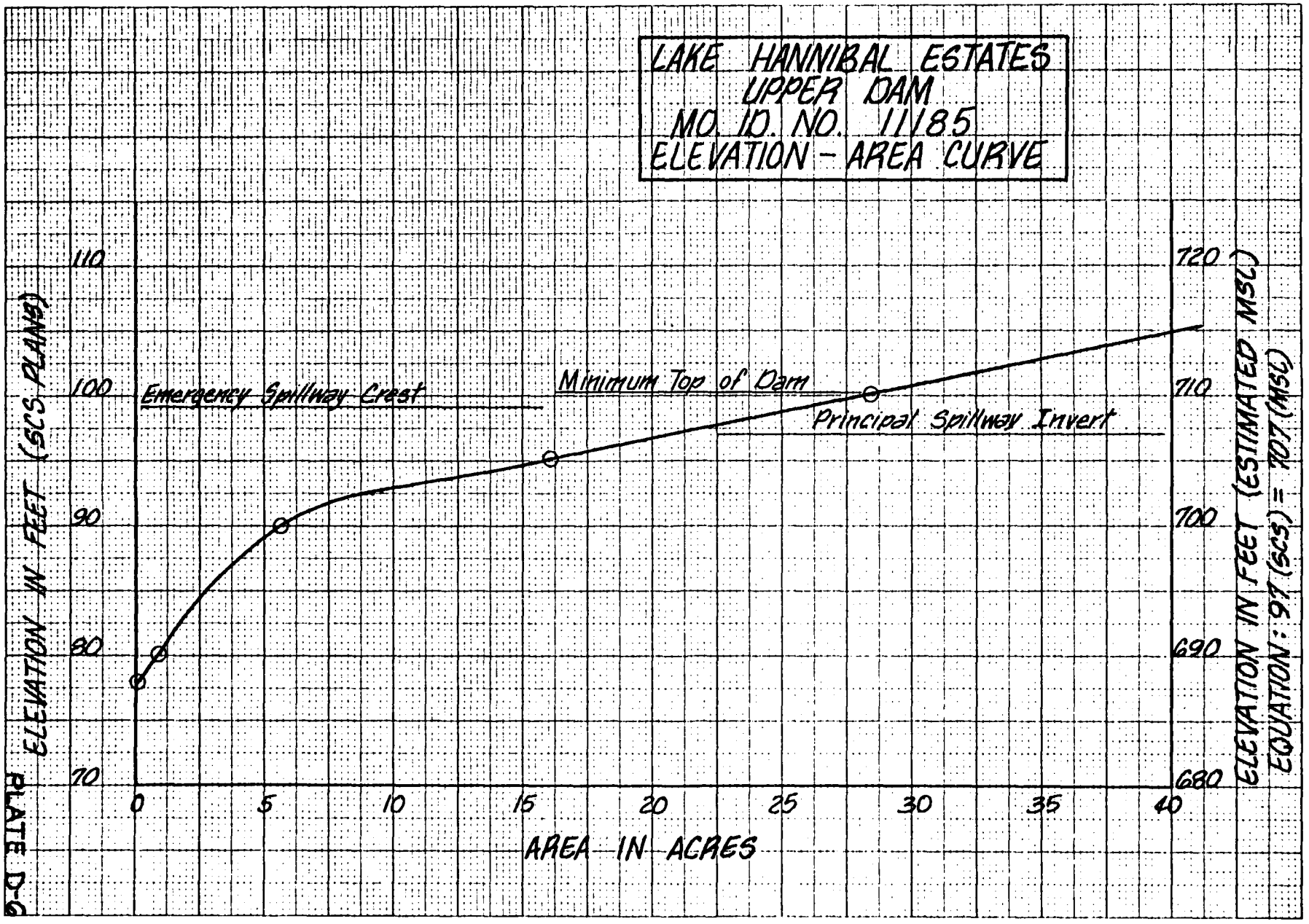


PLATE D-2

```
A1                    LAKE HANNIBAL ESTATES UPPER DAM / MO. ID. NO. 11185
A2       SAFETY ANALYSIS OF DAM OVERTOPPING USING ASSIGNED FLOOD FREQUENCIES
A3                H & H ANALYSIS BY ROUTING PMF RATIOS THRU THE RESERVOIR
B     28800000000000000005                                  000000000000000000000003
B1       5
J        10000000800000001
J1    .0500000.1000000.1500000.2000000.2500000.3500000.50000001.0
K        000000001                  000000000000000000000001
K1       CALCULATION OF INFLO HYDRO TO UPPER RESERVOIR
M        1000000020000.478          0000.424000001.0                    00000001
P        0000024.200000102000001210000130
T                                                              -1.0    -95.0
W2       0000.316
X        0     -.0100000001
K        100000002                  000000020000000000000001
K1       ROUTED FLOWS THRU UPPER DAM
Y                        000000010000000 1
Y1       1                                                     -97.0       -1
Y4  97.0000097.4000097.8000098.2000098.6000099.0000099.2000099.4000099.7000100.0
Y4 100.2000100.6000101.3000101.8000102.1000102.4000102.8
Y5       0000000.9000002.6000005.0000008.8000000120000001400000040000000500000085
Y5    13600000236000005370000083700001038000012380000153 8
$A       0000000.9000002.7000005.6000008.0000016.1000020.7000028.5000041.0
$E     78000000800000008500000090000000920000009500000097000001000000010 5
$$   97.0
$D  100.2000002.8000001.500000800
$L       000000010000000600000016500000210000003400000048900000710000007600000080 0
$V  100.2000100.3000100.3000100.5000100.5000100.8000101.5000102.2000102.2000102.6
K       99
A
A
A
A
A
```

PLATE D-7

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

RUN  DATE= 81/01/20.
     TIME= 15.33.51.
```

LAKE HANNIBAL ESTATES UPPER DAM / MO. ID. NO. 11185
SAFETY ANALYSIS OF DAM OVERTOPPING USING ASSIGNED FLOOD FREQUENCIES
H & H ANALYSIS BY ROUTING PMF RATIOS THRU THE RESERVOIR

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	5	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 8 LRTIO= 1

RTIOS= .05 .10 .15 .20 .25 .35 .50 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

CALCULATION OF INFLO HYDRO TO UPPER RESERVOIR

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

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.48	0.00	.42	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	24.20	102.00	121.00	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	-95.00	0.00	0.00

CURVE NO = -95.00 WETNESS = -1.00 EFFECT CN = 95.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .32

RECESSION DATA
STRTQ= 0.00 QRCSN= -.01 RTIOR= 1.00

UNIT HYDROGRAPH 21 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .32 VOL= 1.00

84. 260. 528. 640. 613. 504. 341. 227. 158. 108.
74. 50. 34. 24. 16. 11. 8. 6. 4. 2.
1.

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	.00	246.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.21	.20	.00	284.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.21	.20	.00	320.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.21	.20	.00	448.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.21	.20	.00	535.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.21	.20	.00	606.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.21	.20	.00	654.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.21	.20	.00	686.
1.01	.45	9	.01	.00	.01	0.	1.01	12.45	153	.21	.20	.00	709.
1.01	.50	10	.01	.00	.01	0.	1.01	12.50	154	.21	.20	.00	724.
1.01	.55	11	.01	.00	.01	0.	1.01	12.55	155	.21	.20	.00	735.
1.01	1.00	12	.01	.00	.01	1.	1.01	13.00	156	.21	.20	.00	742.
1.01	1.05	13	.01	.00	.01	1.	1.01	13.05	157	.25	.25	.00	751.
1.01	1.10	14	.01	.00	.01	2.	1.01	13.10	158	.25	.25	.00	765.
1.01	1.15	15	.01	.00	.01	4.	1.01	13.15	159	.25	.25	.00	789.
1.01	1.20	16	.01	.00	.01	5.	1.01	13.20	160	.25	.25	.00	817.
1.01	1.25	17	.01	.00	.01	6.	1.01	13.25	161	.25	.25	.00	844.
1.01	1.30	18	.01	.00	.01	8.	1.01	13.30	162	.25	.25	.00	865.
1.01	1.35	19	.01	.00	.01	9.	1.01	13.35	163	.25	.25	.00	880.

PLATE D-8

PLATE D-9

1.01	9.00	108	.06	.06	.00	230.	1.01	21.00	252	.02	.02	.00	67.
1.01	9.05	109	.06	.06	.00	230.	1.01	21.05	253	.02	.02	.00	67.
1.01	9.10	110	.06	.06	.00	231.	1.01	21.10	254	.02	.02	.00	67.
1.01	9.15	111	.06	.06	.00	231.	1.01	21.15	255	.02	.02	.00	67.
1.01	9.20	112	.06	.06	.00	231.	1.01	21.20	256	.02	.02	.00	67.
1.01	9.25	113	.06	.06	.00	231.	1.01	21.25	257	.02	.02	.00	67.
1.01	9.30	114	.06	.06	.00	231.	1.01	21.30	258	.02	.02	.00	67.
1.01	9.35	115	.06	.06	.00	231.	1.01	21.35	259	.02	.02	.00	67.
1.01	9.40	116	.06	.06	.00	232.	1.01	21.40	260	.02	.02	.00	67.
1.01	9.45	117	.06	.06	.00	232.	1.01	21.45	261	.02	.02	.00	67.
1.01	9.50	118	.06	.06	.00	232.	1.01	21.50	262	.02	.02	.00	67.
1.01	9.55	119	.06	.06	.00	232.	1.01	21.55	263	.02	.02	.00	67.
1.01	10.00	120	.06	.06	.00	232.	1.01	22.00	264	.02	.02	.00	67.
1.01	10.05	121	.06	.06	.00	232.	1.01	22.05	265	.02	.02	.00	67.
1.01	10.10	122	.06	.06	.00	232.	1.01	22.10	266	.02	.02	.00	67.
1.01	10.15	123	.06	.06	.00	233.	1.01	22.15	267	.02	.02	.00	67.
1.01	10.20	124	.06	.06	.00	233.	1.01	22.20	268	.02	.02	.00	67.
1.01	10.25	125	.06	.06	.00	233.	1.01	22.25	269	.02	.02	.00	67.
1.01	10.30	126	.06	.06	.00	233.	1.01	22.30	270	.02	.02	.00	67.
1.01	10.35	127	.06	.06	.00	233.	1.01	22.35	271	.02	.02	.00	67.
1.01	10.40	128	.06	.06	.00	233.	1.01	22.40	272	.02	.02	.00	67.
1.01	10.45	129	.06	.06	.00	233.	1.01	22.45	273	.02	.02	.00	67.
1.01	10.50	130	.06	.06	.00	233.	1.01	22.50	274	.02	.02	.00	67.
1.01	10.55	131	.06	.06	.00	233.	1.01	22.55	275	.02	.02	.00	67.
1.01	11.00	132	.06	.06	.00	233.	1.01	23.00	276	.02	.02	.00	67.
1.01	11.05	133	.06	.06	.00	233.	1.01	23.05	277	.02	.02	.00	67.
1.01	11.10	134	.06	.06	.00	234.	1.01	23.10	278	.02	.02	.00	67.
1.01	11.15	135	.06	.06	.00	234.	1.01	23.15	279	.02	.02	.00	67.
1.01	11.20	136	.06	.06	.00	234.	1.01	23.20	280	.02	.02	.00	67.
1.01	11.25	137	.06	.06	.00	234.	1.01	23.25	281	.02	.02	.00	67.
1.01	11.30	138	.06	.06	.00	234.	1.01	23.30	282	.02	.02	.00	67.
1.01	11.35	139	.06	.06	.00	234.	1.01	23.35	283	.02	.02	.00	67.
1.01	11.40	140	.06	.06	.00	234.	1.01	23.40	284	.02	.02	.00	67.
1.01	11.45	141	.06	.06	.00	234.	1.01	23.45	285	.02	.02	.00	67.
1.01	11.50	142	.06	.06	.00	234.	1.01	23.50	286	.02	.02	.00	67.
1.01	11.55	143	.06	.06	.00	234.	1.01	23.55	287	.02	.02	.00	67.
1.01	12.00	144	.06	.06	.00	234.	1.02	0.00	288	.02	.02	.00	67.
									SUM	31.46	30.84	.62	113773.
										(799.)(	783.)(	16.)(	3221.69)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4182.	1248.	395.	395.	113750.
CMS	118.	35.	11.	11.	3221.
INCHES		24.28	30.75	30.75	30.75
MM		616.69	780.94	780.94	780.94
AC-FT		619.	783.	783.	783.
THOUS CU M		763.	966.	966.	966.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	209.	62.	20.	20.	5687.
CMS	6.	2.	1.	1.	161.
INCHES		1.21	1.54	1.54	1.54
MM		30.85	39.05	39.05	39.05
AC-FT		31.	39.	39.	39.
THOUS CU M		38.	48.	48.	48.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 2

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	418.	125.	39.	39.	11375.
CMS	12.	4.	1.	1.	322.
INCHES		2.43	3.07	3.07	3.07
MM		61.67	78.09	78.09	78.09
AC-FT		62.	78.	78.	78.
THOUS CU M		76.	97.	97.	97.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 3

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	627.	187.	59.	59.	17062.
CMS	18.	5.	2.	2.	483.
INCHES		3.64	4.61	4.61	4.61
MM		92.50	117.14	117.14	117.14
AC-FT		93.	118.	118.	118.
THOUS CU M		114.	145.	145.	145.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 4

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	836.	250.	79.	79.	22750.
CMS	24.	7.	2.	2.	644.
INCHES		4.86	6.15	6.15	6.15
MM		123.34	156.19	156.19	156.19
AC-FT		124.	157.	157.	157.
THOUS CU M		153.	193.	193.	193.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 5

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1046.	312.	99.	99.	28437.
CMS	30.	9.	3.	3.	805.
INCHES		6.07	7.69	7.69	7.69
MM		154.17	195.23	195.23	195.23
AC-FT		155.	196.	196.	196.
THOUS CU M		191.	242.	242.	242.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 6

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1464.	437.	138.	138.	39812.
CMS	41.	12.	4.	4.	1127.
INCHES		8.50	10.76	10.76	10.76
MM		215.84	273.33	273.33	273.33
AC-FT		217.	274.	274.	274.
THOUS CU M		267.	338.	338.	338.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 7 [1/2 PMF]

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2091.	624.	197.	197.	56875.
CMS	59.	18.	6.	6.	1611.
INCHES		12.14	15.37	15.37	15.37
MM		308.34	390.47	390.47	390.47
AC-FT		309.	392.	392.	392.
THOUS CU M		382.	483.	483.	483.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 8 [PMF]

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4182.	1248.	395.	395.	113750.
CMS	118.	35.	11.	11.	3221.
INCHES		24.28	30.75	30.75	30.75
MM		616.69	780.94	780.94	780.94
AC-FT		619.	783.	783.	783.
THOUS CU M		763.	966.	966.	966.

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTED FLOWS THRU UPPER DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
000002	1	0	0	2	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.0	0.000	0.00	1	1	0	0		0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-97.	-1

STAGE	97.00	97.40	97.80	98.20	98.60	99.00	99.20	99.40	99.70	100.00	
	100.20	100.60	101.30	101.80	102.10	102.40	102.80				
FLOW	0.00	.90	2.60	5.00	8.80	12.00	14.00	40.00	55.00	85.00	
	136.00	236.00	537.00	837.00	1038.00	1238.00	1538.00				
SURFACE AREA=	0.	1.	3.	6.	8.	16.	21.	29.	41.		
CAPACITY=	0.	1.	9.	30.	43.	78.	115.	189.	361.		
ELEVATION=	78.	80.	85.	90.	92.	95.	97.	100.	105.		

PLATE D-11

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
97.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

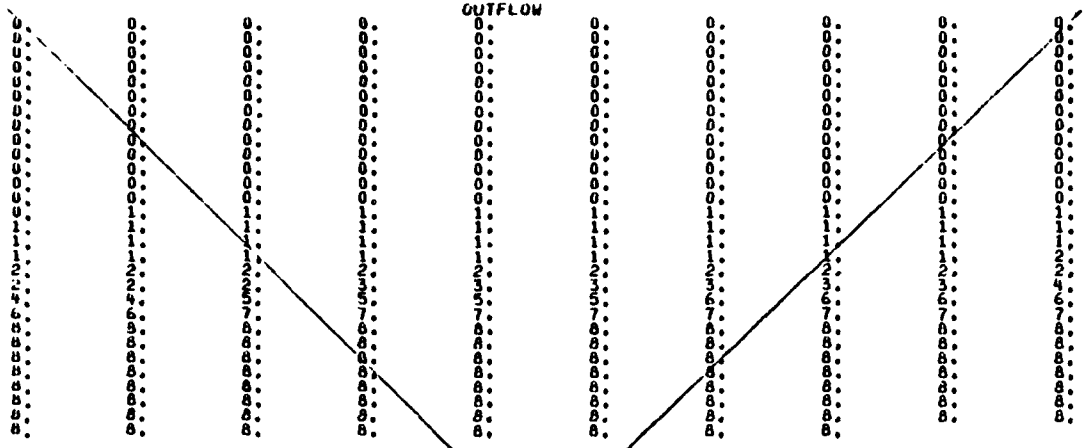
TOPEL	COQD	EXPD	DAMWID
100.2	2.8	1.5	800.

CREST LENGTH AT OR BELOW ELEVATION	0.	10.	60.	165.	210.	340.	489.	710.	760.	800.
	100.2	100.3	100.3	100.5	100.5	100.8	101.5	102.2	102.2	102.6

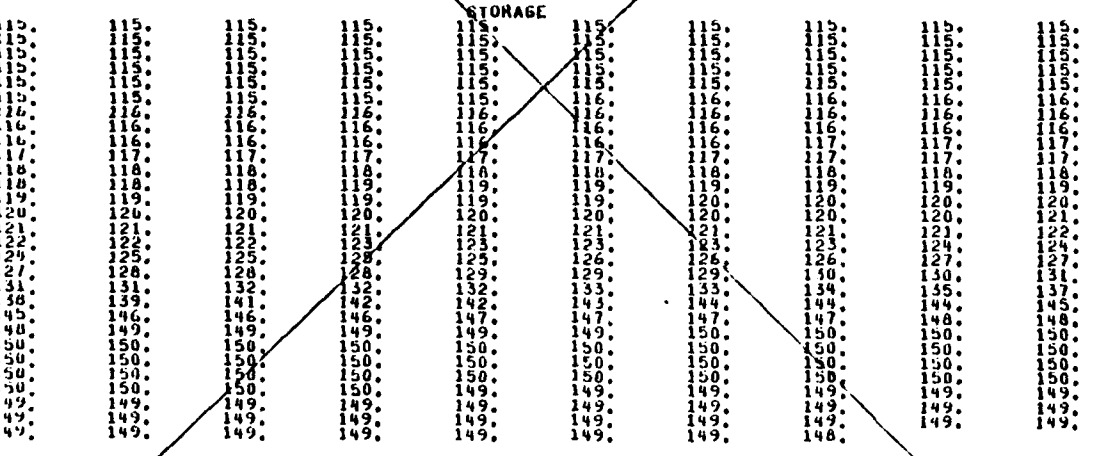
STATION 000002, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW



STORAGE



STAGE

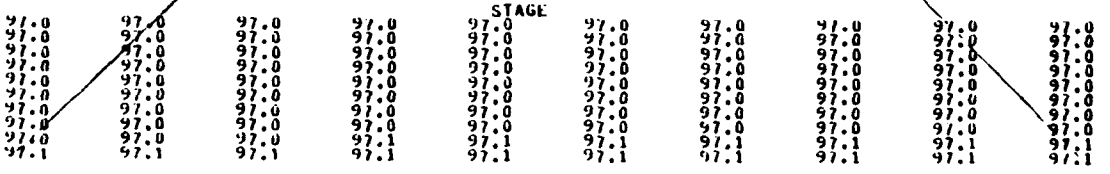


PLATE D-12

•OVN•

STATION 000002, PLAN 1, RATIO 7 [½ PMF]

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	2.	2.	2.	2.	2.
2.	2.	3.	3.	3.	3.	3.	4.	4.	4.
4.	4.	5.	5.	5.	5.	5.	6.	6.	6.
7.	7.	7.	8.	8.	8.	8.	9.	9.	9.
9.	10.	10.	10.	10.	11.	11.	11.	11.	11.
12.	12.	12.	12.	13.	13.	13.	14.	14.	15.
18.	22.	26.	28.	31.	35.	39.	42.	44.	47.
51.	54.	60.	68.	75.	82.	95.	111.	128.	144.
160.	178.	200.	223.	248.	274.	300.	328.	353.	376.
396.	417.	438.	459.	479.	496.	511.	523.	533.	541.
547.	550.	551.	553.	563.	595.	676.	843.	1112.	1430.
1693.	1802.	1758.	1617.	1441.	1274.	1128.	1003.	901.	819.
755.	705.	666.	636.	612.	592.	573.	554.	534.	516.
499.	484.	472.	461.	453.	446.	439.	430.	413.	388.
355.	318.	287.	260.	238.	220.	204.	190.	179.	169.
160.	153.	146.	140.	134.	128.	123.	117.	112.	108.
103.	99.	95.	92.	88.	85.	84.	83.	81.	80.
79.	78.	77.	76.	75.	74.	73.	72.	71.	70.
69.	69.	68.	67.	66.	65.	65.	64.	63.	62.
62.	61.	60.	60.	59.	58.	58.	57.	57.	56.
55.	55.	55.	54.	54.	54.	54.	53.		

STORAGE

115.	115.	115.	115.	115.	115.	115.	115.	115.	115.
115.	115.	115.	115.	115.	115.	115.	115.	115.	115.
115.	115.	115.	116.	116.	116.	116.	116.	116.	116.
116.	116.	116.	116.	116.	116.	116.	117.	117.	117.
117.	117.	117.	117.	117.	117.	117.	117.	118.	118.
118.	118.	118.	118.	118.	118.	118.	119.	119.	119.
119.	119.	119.	119.	119.	120.	120.	120.	120.	120.
120.	120.	120.	121.	121.	121.	121.	122.	122.	123.
124.	124.	125.	126.	127.	127.	128.	129.	129.	130.
131.	132.	132.	133.	134.	135.	135.	136.	137.	138.
138.	139.	140.	141.	141.	142.	143.	144.	144.	145.
146.	147.	147.	148.	149.	150.	150.	151.	152.	153.
153.	154.	155.	156.	156.	157.	158.	158.	159.	160.
161.	161.	162.	163.	164.	164.	165.	166.	166.	167.
168.	168.	169.	170.	170.	171.	172.	173.	174.	176.
178.	180.	182.	184.	186.	188.	190.	192.	194.	195.
197.	199.	201.	202.	204.	205.	206.	207.	208.	208.
209.	210.	210.	211.	211.	212.	212.	212.	213.	213.
213.	213.	213.	213.	213.	214.	216.	219.	224.	229.
232.	234.	233.	231.	229.	226.	224.	222.	220.	219.
217.	216.	216.	215.	214.	214.	213.	213.	213.	212.
212.	211.	211.	211.	211.	210.	210.	210.	210.	209.
208.	207.	206.	204.	203.	202.	201.	200.	199.	198.
197.	196.	196.	195.	194.	194.	193.	192.	192.	191.
191.	190.	190.	189.	189.	189.	188.	188.	188.	187.
187.	187.	186.	186.	186.	186.	185.	185.	185.	185.
184.	184.	184.	184.	184.	183.	183.	183.	182.	182.
182.	182.	182.	182.	181.	181.	181.	181.	181.	181.
180.	180.	180.	180.	180.	180.	180.	179.		

STAGE

97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0
97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0
97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0
97.0	97.0	97.0	97.0	97.1	97.1	97.1	97.1	97.1	97.1
97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1
97.1	97.1	97.1	97.1	97.1	97.2	97.2	97.2	97.2	97.2
97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2
97.2	97.2	97.2	97.3	97.3	97.3	97.3	97.3	97.3	97.4
97.4	97.4	97.5	97.5	97.5	97.6	97.6	97.6	97.7	97.7
97.7	97.8	97.8	97.8	97.9	97.9	97.9	98.0	98.0	98.0
98.1	98.1	98.1	98.2	98.2	98.2	98.3	98.3	98.3	98.3
98.4	98.4	98.4	98.5	98.5	98.5	98.6	98.6	98.6	98.6
98.7	98.7	98.7	98.8	98.8	98.8	98.9	98.9	98.9	98.9
99.0	99.0	99.0	99.0	99.1	99.1	99.1	99.2	99.2	99.2
99.3	99.3	99.3	99.3	99.3	99.4	99.4	99.4	99.5	99.5

PLATE D-13

100.3	100.4	100.4	100.5	100.5	100.6	100.6	100.6	100.7	100.7
100.7	100.7	100.7	100.8	100.8	100.8	100.8	100.8	100.8	100.8
100.8	100.8	100.8	100.8	100.8	100.9	100.9	101.0	101.2	101.3
101.4	101.5	101.5	101.4	101.3	101.3	101.2	101.1	101.1	101.0
101.0	100.9	100.9	100.9	100.9	100.9	100.8	100.8	100.8	100.8
100.8	100.8	100.8	100.8	100.7	100.7	100.7	100.7	100.7	100.7
100.7	100.6	100.6	100.5	100.5	100.5	100.4	100.4	100.4	100.3
100.3	100.3	100.2	100.2	100.2	100.2	100.1	100.1	100.1	100.1
100.1	100.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9
99.8	99.8	99.8	99.8	99.8	99.8	99.8	99.8	99.8	99.8
99.8	99.8	99.8	99.7	99.7	99.7	99.7	99.7	99.7	99.7
99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7		

PEAK OUTFLOW IS 1802. AT TIME 16.00 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1802.	578.	165.	165.	47576.
CMS	51.	16.	5.	5.	1347.
INCHES		11.26	12.86	12.86	12.86
MM		285.89	326.63	326.63	326.63
AC-FT		287.	328.	328.	328.
THOUS CU M		354.	404.	404.	404.

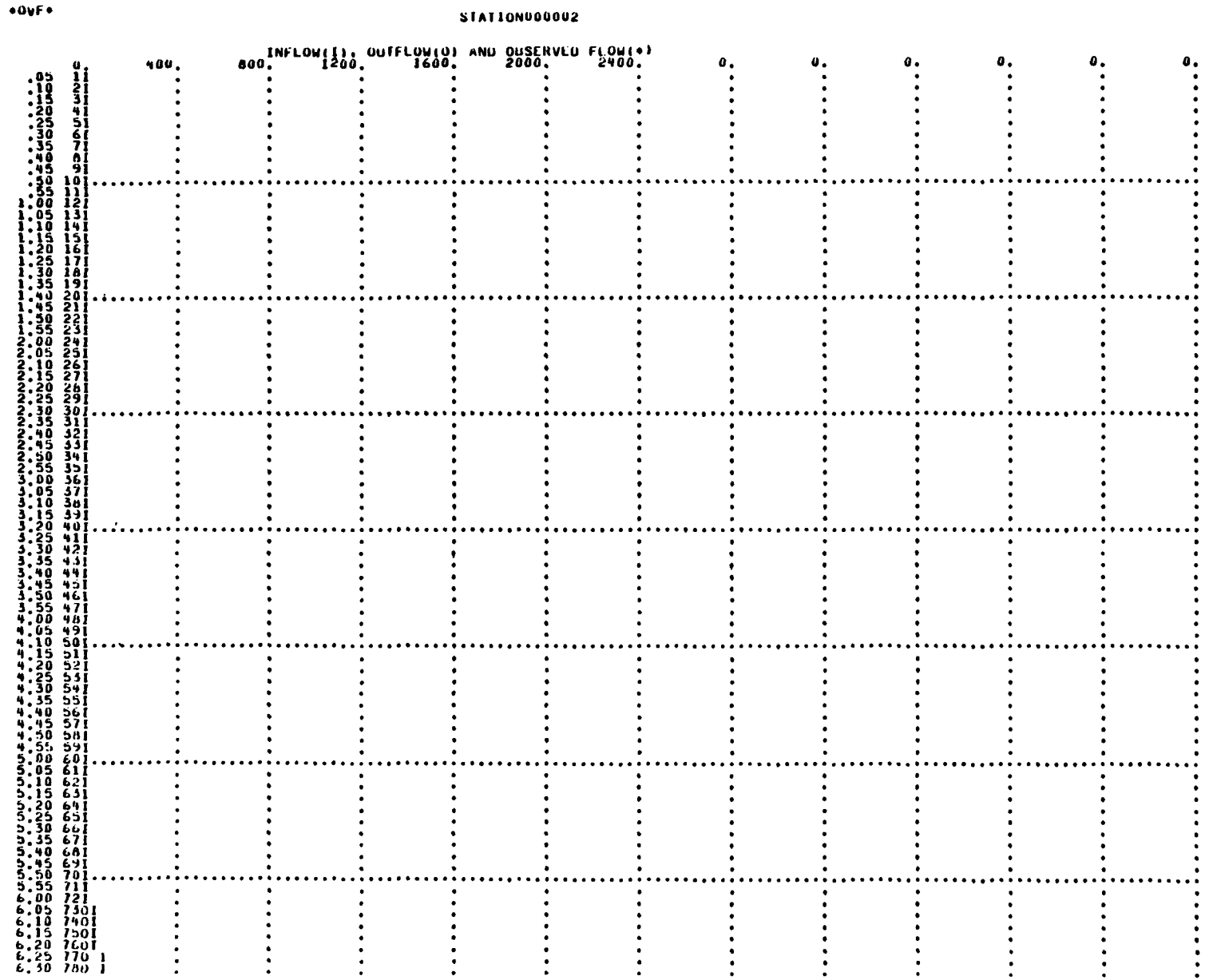

OVF
STATION000002
INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)
0. 400. 800. 1200. 1600. 2000. 2400. 0. 0. 0. 0. 0. 0.
.05 11
.10 21
.15 31
.20 41
.25 51
.30 61
.35 71
.40 81
.45 91
.50 101
.55 111
1.00 121
1.05 131
1.10 141
1.15 151
1.20 161
1.25 171
1.30 181
1.35 191
1.40 201
1.45 211
1.50 221
1.55 231
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
4.45 571
4.50 581
4.55 591
5.00 601
5.05 611
5.10 621
5.15 631
5.20 641
5.25 651
5.30 661
5.35 671
5.40 681
5.45 691
5.50 701
5.55 711
6.00 721
6.05 730
6.10 740
6.15 750
6.20 760
6.25 770
6.30 780

PLATE D-15

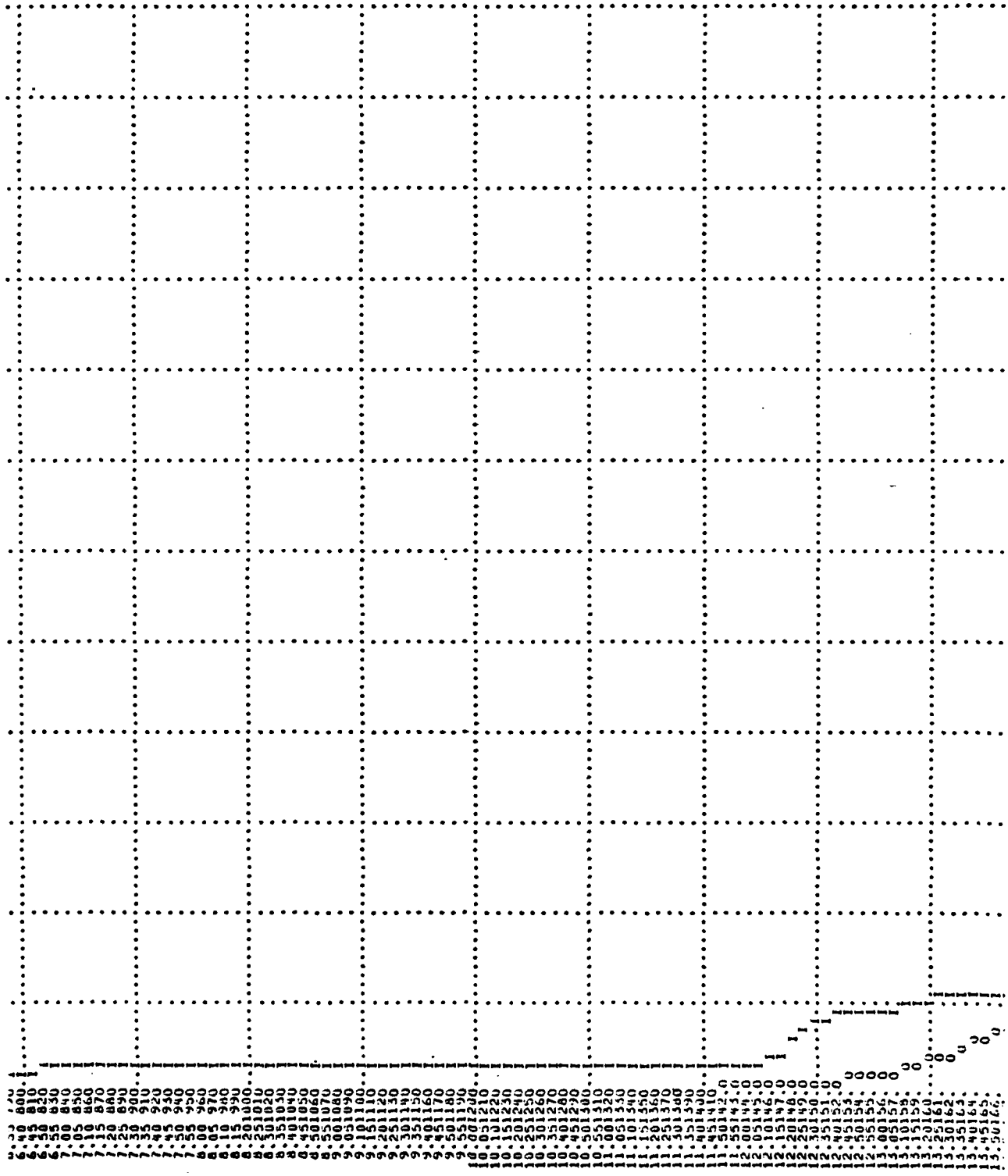


PLATE D-16

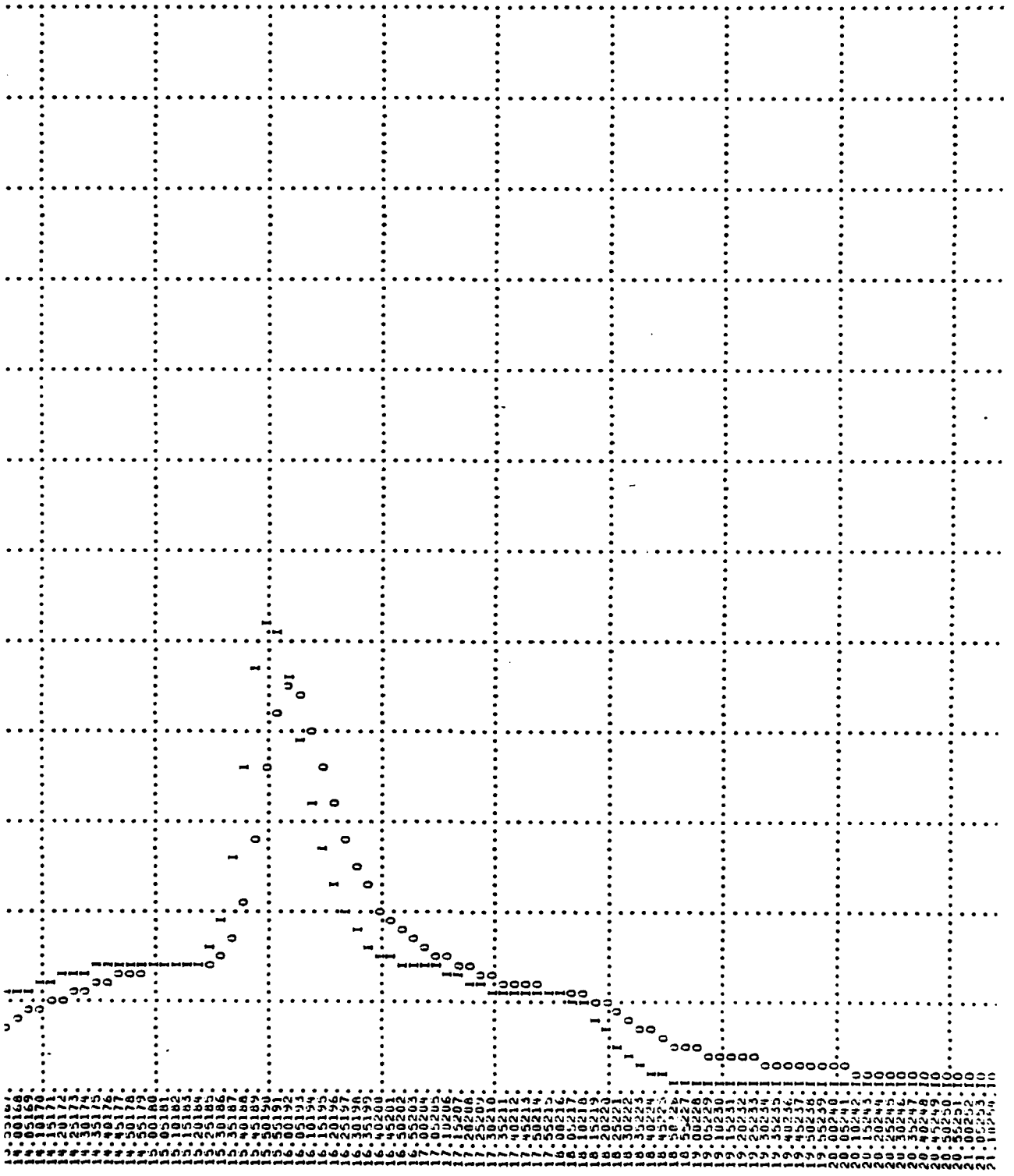


PLATE D-17

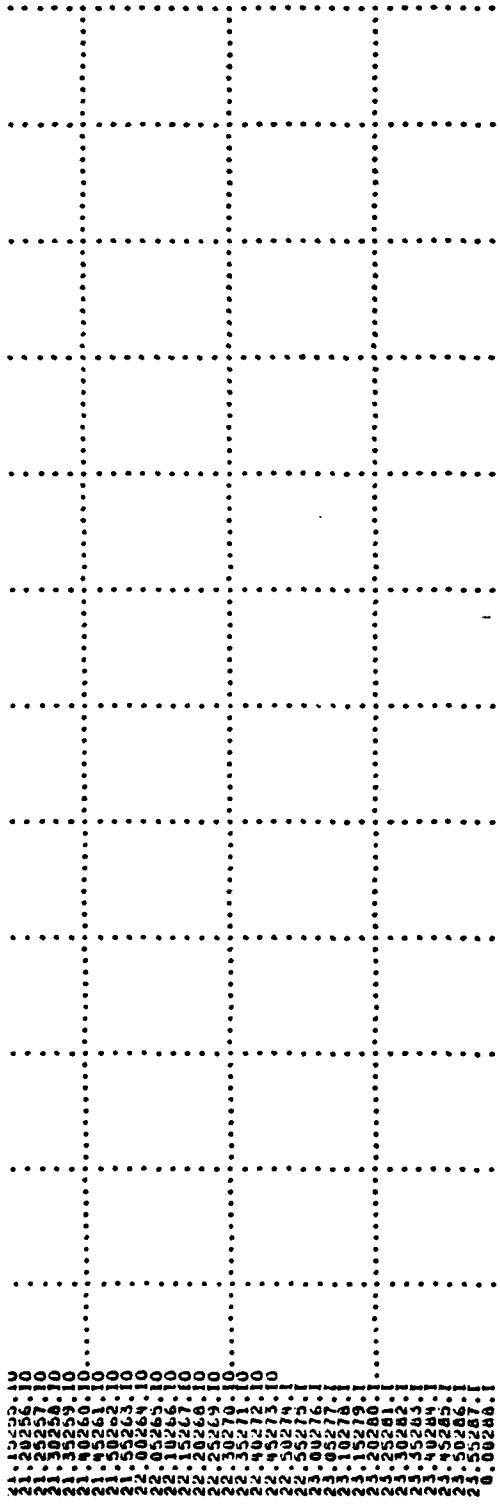


PLATE D-18

•OVIN•

STATION 000002, PLAN 1, RATIO 8 PMF

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	2.	2.	2.	2.	2.
3.	3.	3.	4.	4.	4.	5.	6.	6.	6.
7.	7.	8.	9.	9.	10.	10.	11.	11.	11.
12.	13.	13.	14.	17.	24.	31.	37.	41.	44.
46.	48.	51.	53.	55.	60.	64.	68.	72.	76.
79.	83.	89.	97.	105.	113.	120.	126.	133.	138.
144.	149.	154.	158.	163.	168.	172.	177.	181.	185.
189.	193.	196.	200.	203.	209.	220.	239.	271.	319.
383.	447.	506.	559.	603.	640.	669.	694.	718.	743.
768.	794.	817.	838.	855.	868.	879.	887.	894.	903.
917.	938.	965.	995.	1024.	1050.	1071.	1088.	1101.	1112.
1118.	1110.	1113.	1114.	1139.	1218.	1426.	1864.	2539.	3275.
3753.	3837.	3592.	3184.	2762.	2390.	2079.	1831.	1637.	1469.
1378.	1299.	1240.	1196.	1161.	1130.	1099.	1065.	1029.	993.
961.	933.	911.	893.	879.	869.	858.	839.	800.	730.
656.	572.	491.	422.	364.	316.	282.	257.	237.	220.
206.	194.	184.	175.	168.	161.	156.	151.	146.	141.
137.	133.	129.	126.	122.	119.	116.	113.	110.	108.
106.	103.	101.	99.	97.	95.	94.	92.	91.	89.
88.	87.	86.	85.	84.	84.	84.	83.	83.	82.
82.	82.	81.	81.	81.	80.	80.	80.	79.	79.
79.	79.	78.	78.	78.	78.	77.	77.		

STORAGE

115.	115.	115.	115.	115.	115.	115.	115.	115.	115.
115.	115.	115.	115.	115.	115.	115.	115.	115.	115.
116.	116.	116.	116.	116.	116.	116.	116.	116.	117.
117.	117.	117.	117.	117.	118.	118.	118.	118.	118.
118.	119.	119.	119.	119.	119.	120.	120.	120.	120.
120.	121.	121.	121.	121.	122.	122.	122.	122.	122.
123.	123.	123.	123.	124.	124.	124.	124.	125.	125.
125.	125.	126.	126.	126.	127.	128.	129.	130.	131.
132.	134.	135.	136.	138.	139.	141.	142.	144.	145.
147.	148.	150.	151.	153.	154.	155.	157.	158.	160.
161.	163.	164.	166.	167.	169.	170.	172.	173.	174.
175.	177.	178.	179.	180.	182.	183.	184.	185.	186.
187.	188.	189.	190.	191.	192.	193.	195.	194.	195.
195.	196.	196.	197.	198.	198.	198.	199.	199.	200.
200.	200.	200.	201.	201.	201.	202.	203.	205.	207.
209.	210.	212.	213.	214.	215.	216.	216.	217.	217.
218.	218.	219.	219.	219.	220.	220.	220.	220.	220.
220.	221.	221.	222.	222.	223.	223.	223.	224.	224.
224.	224.	224.	224.	224.	226.	229.	234.	242.	250.
254.	253.	253.	249.	245.	241.	237.	234.	232.	230.
226.	227.	226.	225.	225.	224.	224.	223.	222.	222.
221.	221.	220.	220.	220.	220.	219.	219.	218.	217.
215.	213.	212.	210.	208.	207.	205.	204.	203.	202.
201.	200.	199.	199.	198.	197.	197.	196.	196.	195.
193.	194.	194.	193.	193.	193.	192.	192.	192.	191.
191.	191.	190.	190.	190.	190.	190.	189.	189.	189.
189.	189.	189.	189.	189.	188.	188.	188.	188.	188.
188.	188.	188.	188.	187.	187.	187.	187.	187.	187.
187.	187.	187.	187.	187.	187.	186.	186.		

STAGE

97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0
97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0
97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.1	97.1	97.1
97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1
97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2
97.2	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3
97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.5
97.5	97.5	97.5	97.5	97.5	97.5	97.6	97.6	97.7	97.7
97.8	97.8	97.9	98.0	98.0	98.1	98.2	98.2	98.3	98.3
98.4	98.5	98.5	98.6	98.6	98.7	98.8	98.8	98.9	98.9
99.0	99.1	99.1	99.2	99.2	99.3	99.3	99.4	99.4	99.5
99.5	99.6	99.6	99.7	99.7	99.7	99.8	99.8	99.9	99.9
99.9	100.0	100.0	100.0	100.1	100.1	100.1	100.2	100.2	100.2
100.2	100.3	100.3	100.3	100.3	100.3	100.3	100.4	100.4	100.4
100.4	100.4	100.4	100.4	100.4	100.4	100.5	100.5	100.6	100.6

PLATE D-19

101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.1	101.1
101.1	101.1	101.1	101.1	101.1	101.1	101.2	101.2	101.2	101.2
101.2	101.2	101.2	101.2	101.2	101.2	101.3	101.3	101.3	101.3
102.1	102.1	102.1	102.0	101.8	101.7	101.6	101.5	101.4	101.4
101.3	101.3	101.2	101.2	101.2	101.2	101.2	101.2	101.1	101.1
101.1	101.1	101.1	101.1	101.0	101.0	101.0	101.0	101.0	101.0
100.9	100.8	100.8	100.7	100.7	100.6	100.6	100.5	100.5	100.5
100.4	100.4	100.4	100.3	100.3	100.3	100.3	100.3	100.2	100.2
100.2	100.2	100.2	100.2	100.1	100.1	100.1	100.1	100.1	100.1
100.1	100.1	100.1	100.1	100.0	100.0	100.0	100.0	100.0	100.0
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.9	99.9
99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9		

PEAK OUTFLOW IS 3837. AT TIME 16.00 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3837.	1233.	359.	359.	103382.
CMS	109.	35.	10.	10.	2927.
INCHES		24.00	27.94	27.94	27.94
MM		609.67	709.76	709.76	709.76
AC-FT		612.	712.	712.	712.
THOUS CU M		754.	878.	878.	878.

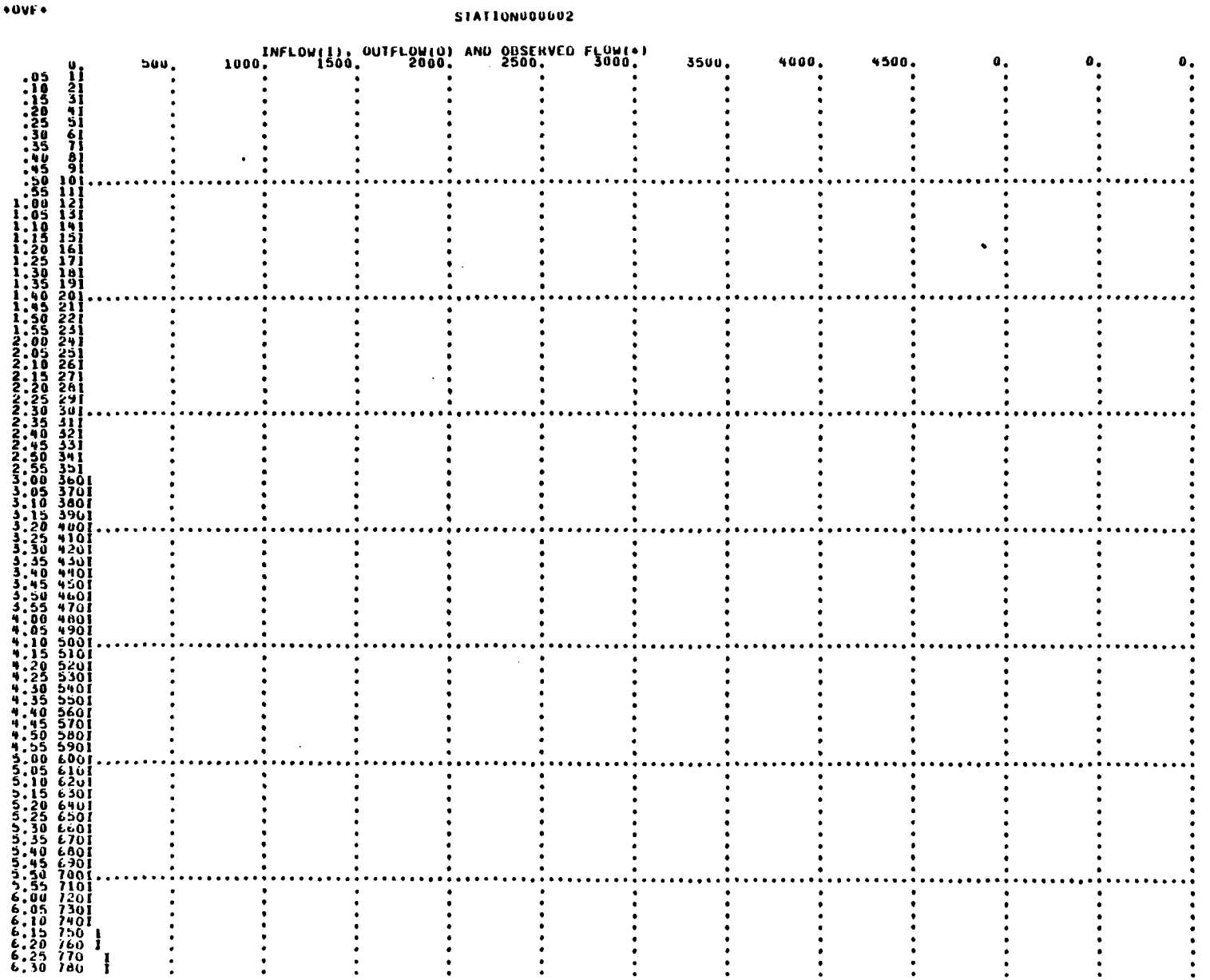

OVF
STATION000002
INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)
0. 500. 1000. 1500. 2000. 2500. 3000. 3500. 4000. 4500. 0. 0. 0.

PLATE D-21

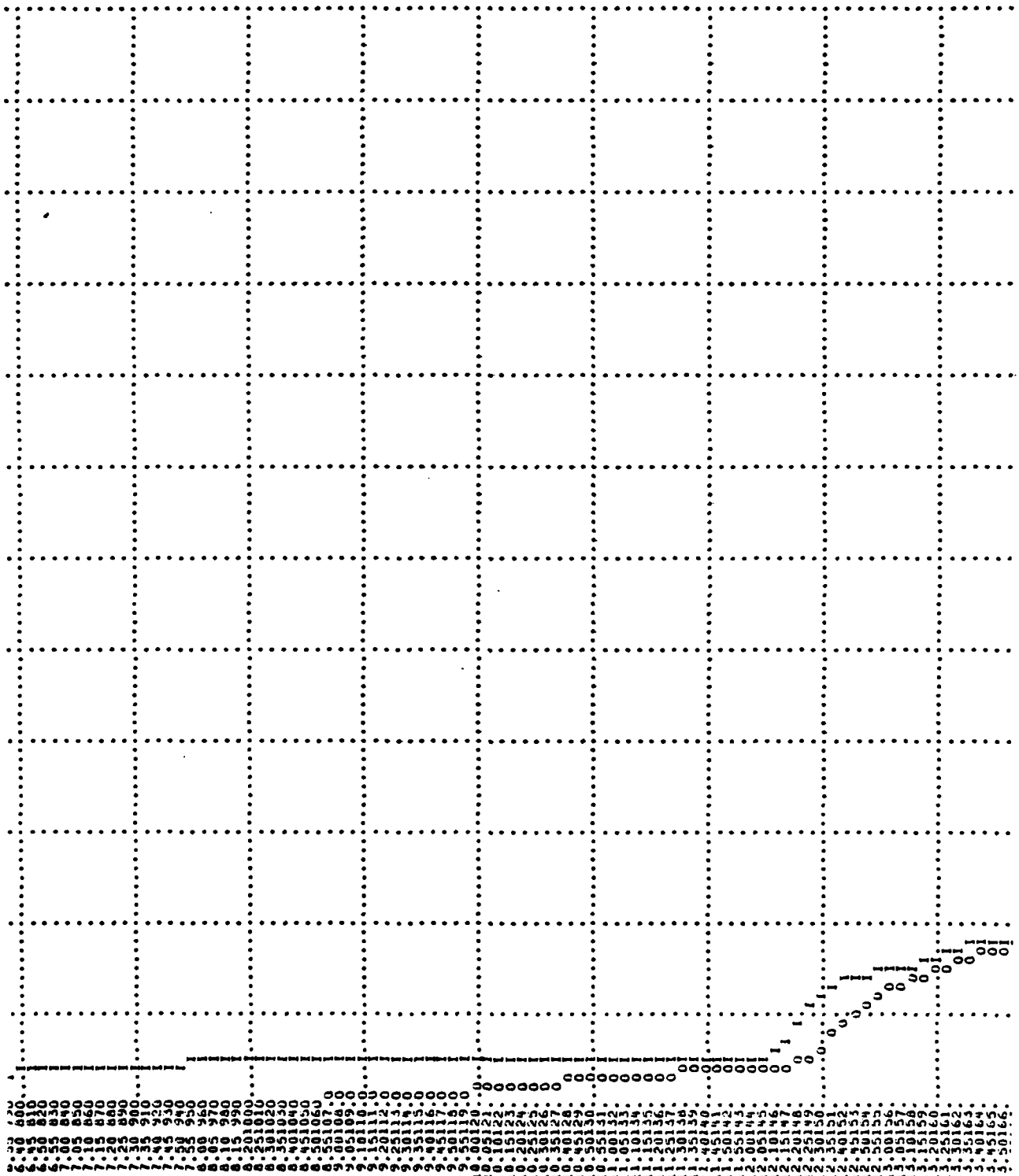


PLATE D-22

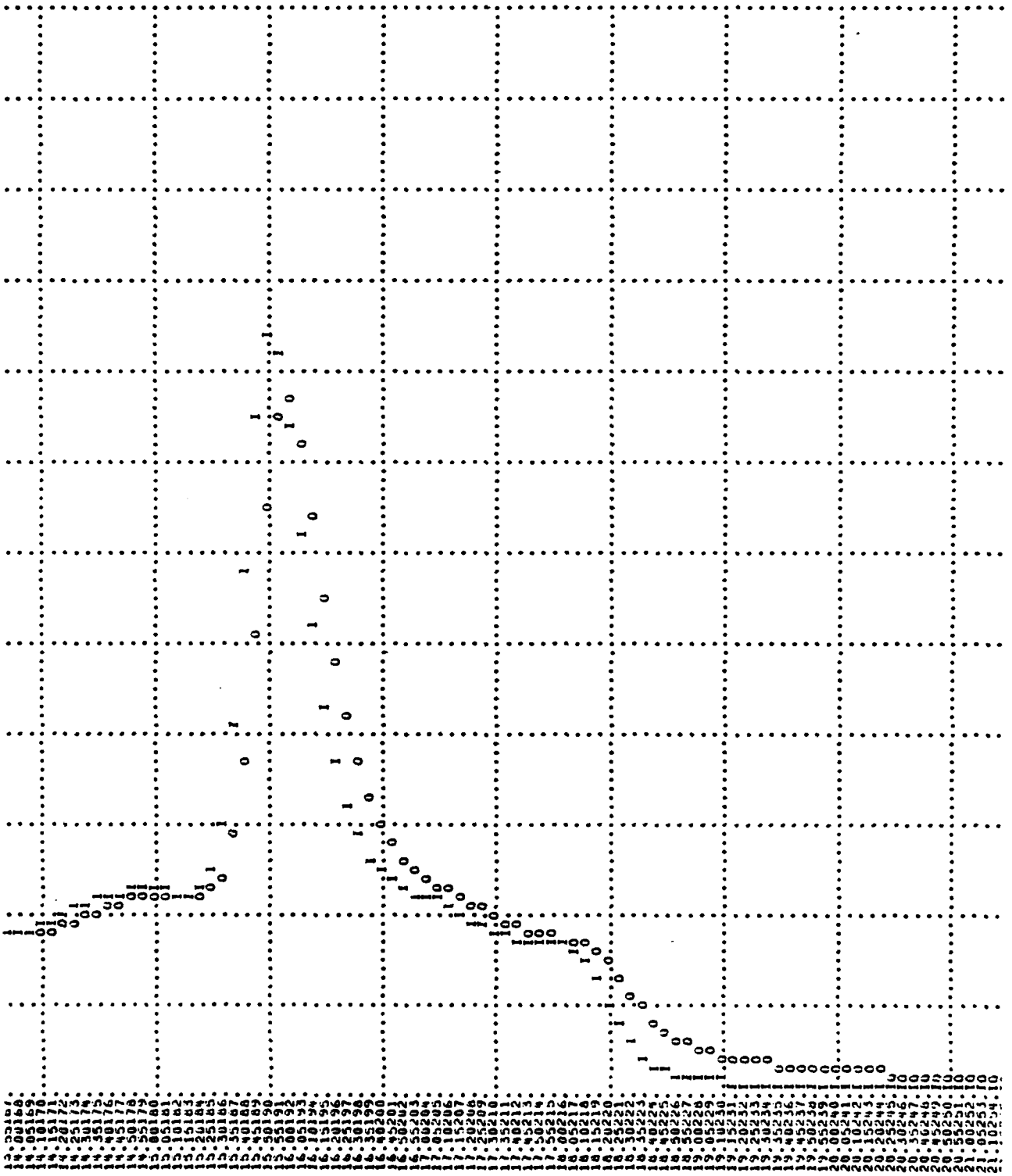
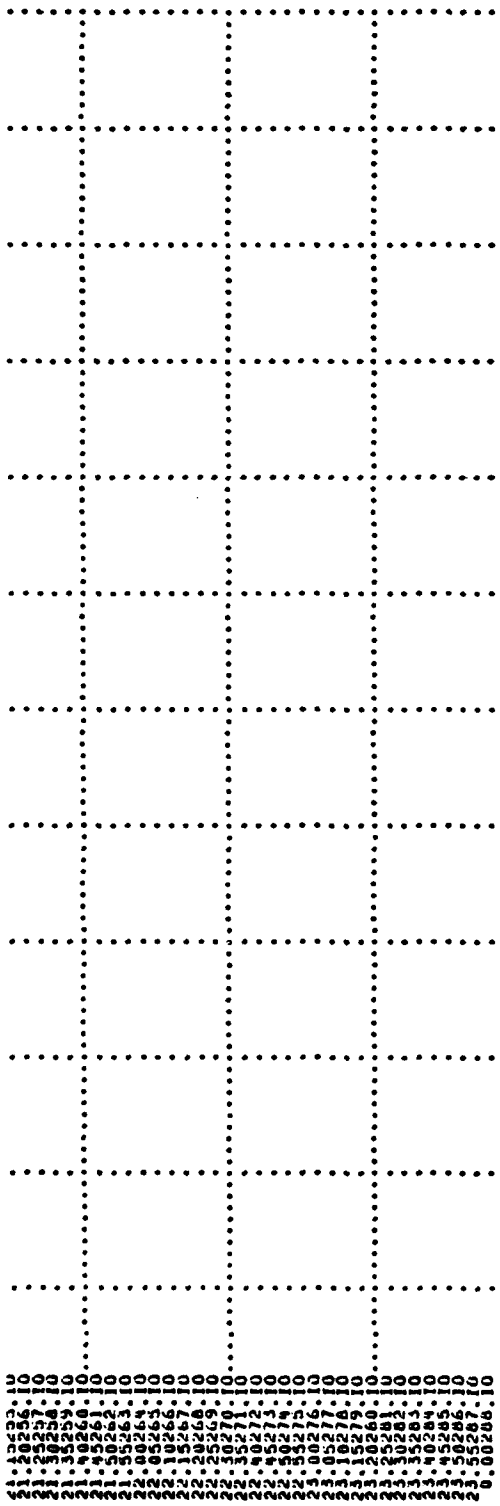


PLATE D-23



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 .05	RATIO 2 .10	RATIO 3 .15	RATIO 4 .20	RATIO 5 .25	RATIO 6 .35	RATIO 7 .50	RATIO 8 1.00
HYDROGRAPH AT	000001	.48 (1.24)	1	209. (5.92)	418. (11.84)	627. (17.76)	836. (23.69)	1046. (29.61)	1464. (41.45)	2091. (59.21)	4182. (118.43)
ROUTED TO	000002	.48 (1.24)	1	8. (.24)	53. (1.50)	155. (4.38)	392. (11.09)	709. (20.07)	1186. (33.59)	1802. (51.01)	3837. (108.66)

PLATE D-25

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	97.00	97.00	100.20
STORAGE	115.	115.	194.
OUTFLOW	0.	0.	136.

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	98.56	0.00	150.	0.	0.00	18.67	0.00
.10	99.66	0.00	179.	53.	0.00	18.33	0.00
.15	100.27	.07	197.	155.	2.00	17.25	0.00
.20	100.69	.49	209.	392.	3.08	16.33	0.00
.25	100.94	.74	216.	709.	3.67	16.17	0.00
.35	101.22	1.02	225.	1186.	4.92	16.08	0.00
.50	101.49	1.29	234.	1802.	6.25	16.00	0.00
1.00	102.13	1.93	255.	3837.	9.33	16.00	0.00