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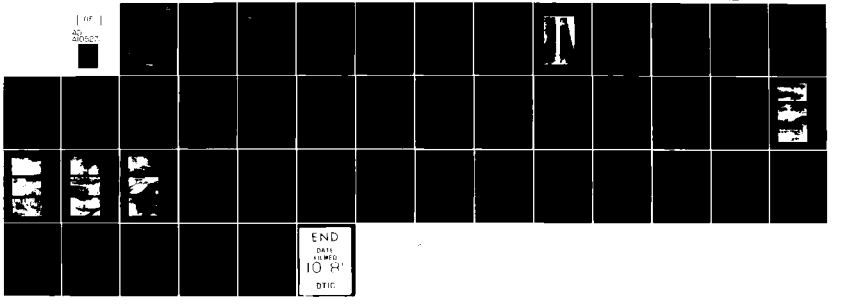

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MISSOURI-KANSAS CITY BASIN

HOUSTON LAKE DAM

PLATTE COUNTY, MISSOURI

MO 10002

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10 Harold P. /Hoskins

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM.

Houston Lake Dam (MO 10002),
Missouri - Kansas City Basin. Platte County,
Missouri. Phase I Inspection Report.

PREPARED BY: HOSKINS-WESTERN-SONDEREGGER, INC.

FOR: STATE OF MISSOURI

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Houston Lake Dam (MO 10002) Platte County, Missouri	5. TYPE OF REPORT & PERIOD COVERED Final Report
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Hoskins-Western-Sonderegger, Inc.	8. CONTRACT OR GRANT NUMBER(s) DACW43-78-C-0155 ✓
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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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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Houston Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Houston Lake dam:

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

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

1) Spillway will not pass 50 percent of the Probable Maximum Flood
2) Overtopping could result in dam failure.
3) Dam failure significantly increases the hazard to loss of life downstream

SUBMITTED BY: SIGNED — Chief, Engineering Division — 14 MAR 1979 — Date

APPROVED BY: SIGNED — Colonel, CE, District Engineer — 15 MAR 1979 — Date

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HOUSTON LAKE DAM
MO 10002

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PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Houston Lake Dam
State Located	Missouri
County Located	Platte County
Stream	Jumping Branch
Date of Inspection	September 22, 1978

Houston 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 condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. Failure would threaten life and property. The estimated damage zone extends two miles downstream of the dam. Within the damage zone are two drive-in theatres, two to three apartment buildings and a shopping center.

Our inspection and evaluation indicates that the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The recommended guidelines stipulate that the spillway of a small size dam with a high hazard rating shall be capable of passing one-half PMF to PMF. Due to the large volume of water impounded, the relatively steep and narrow floodplain downstream, the location of apartment houses, outdoor theatres and a shopping area in the damage zone, the PMF is the appropriate spillway design flood. The spillway will not pass the 100-year flood (flood having a one percent chance of being exceeded in any one year) without overtopping the dam. The spillway will pass 15% 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 reasonable possible in the region.

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 analyses should be obtained in the future.

Deficiencies visually observed by the inspection team were trees (up to 12" diameter) growing on the downstream slope, seepage at the toe of the dam at Station 3+30±, free water standing below the toe from Station 3+30± to the spillway, approximately 50 feet of the masonry wall of the spillway chute on the left side has been destroyed leaving bare soil exposed, the masonry wall on the right side of the inlet to the spillway is broken and in poor condition, cracked concrete in the downstream portion of the spillway allows water to penetrate and flow beneath concrete emerging downstream through a 6" x 2" hole in the concrete at the juncture with the apron to the box culvert crossing under I-635 and a welded steel railing along the crest of the spillway could act as a trash rack during spillway operation which would in effect increase the spillway elevation.

Several items of preventive maintenance need to be initiated by the owner. These are described in detail in the body of the report.

H. P. Hoskins

Harold P. Hoskins, P.E.
Hoskins-Western-Sonderegger, Inc.
Lincoln, Nebraska

PHOTOGRAPH NO. 1
OVERVIEW
LOOKING NORTHEAST
TO DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HOUSTON LAKE DAM - MO 10002
PLATTE 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 the Houston 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) This dam is an earth fill about 650 feet in length and 20 feet in height. Topography around the dam is rolling. Materials on the slopes consist of loess or reworked loess soils underlain by shales and limestones.

(2) The spillway consists of a broad-crested weir and a concrete-lined exit channel at the left abutment.

(3) It is reported by Frank G. Barnes, Mayor of Houston Lake, that a drawdown pipe passes through the base of the dam near the spillway, but that both the inlet and outlet have been destroyed.

(4) Pertinent physical data are given in Paragraph 1.3 below.

b. Location. The dam is located in the southeastern corner of Platte County, Missouri, as shown on Plate A-2. The dam is shown on Plate A-1 in the NW 1/4 of Section 33, T51N, R33W. The lake formed by the dam is shown in the NW 1/4 of Section 33 and the NE 1/4 of Section 32, T51N, R33W.

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

d. Hazard Classification. Guidelines for determining hazard classification are presented in the same guidelines as referenced in paragraph c above. Based on referenced guidelines, this dam is in the High Hazard Classification. The estimated damage zone extends two miles downstream of the dam. Within the damage zone are two drive-in theatres, two to three apartment buildings and a shopping area. The effect of the I-635 roadway embankment on the length of the estimated damage zone or on the hazard classification has not been assessed.

e. Ownership. This dam embankment is owned by the Venetian Gardens Homes Association, 5516 North Venetian Drive, Houston Lake, Missouri 64151, Attention: Frank E. Barnes. The bridge across the spillway and the road on the crest of the dam are owned by the City of Houston Lake, Missouri, of the same address, Attention: Frank E. Barnes, Mayor.

f. Purpose of Dam. The dam forms a 19 acre ± recreational lake.

g. Design and Construction History. No design or construction data were available. The dam was constructed in 1930 for Mr. Houston, a real estate developer. It was reported by Mr. Barnes that the core of the dam may be a limestone masonry wall.

h. Normal Operating Procedure. There are no controlled outlet works for this dam. No information was available on the fluctuation of the lake level. It was reported that the dam was overtopped or submerged in 1975 and again in 1976.

1.3 PERTINENT DATA

a. Drainage Area - 898 acres (1.40 square miles).

b. Discharge at Damsite.

(1) All discharge at the damsite is through an uncontrolled emergency spillway.

(2) Estimated maximum flood at damsite - unknown, but probably occurred in 1975 or 1976.

(3) The emergency spillway capacity varies from 0 c.f.s. at crest (809.9 feet) to 820 c.f.s. at maximum pool level (812.3 feet), low point on dam crest.

c. Elevation (Feet Above M.S.L.).

(1) Top of dam (low point) - 812.3.

(2) Emergency Spillway Crest - 809.9.

(3) Streambed at center line of dam - 790±.

(4) Maximum tailwater - unknown.

d. Reservoir. Length of maximum pool - 2000 feet ±.

e. Storage (Acre-Feet), above spillway crest.

(1) Top of dam (low point) - 56.

f. Reservoir Surface (Acres).

(1) Top of dam (low point) - 21±.

(2) Spillway Crest - 19±.

g. Dam.

(1) Type - earth embankment.

(2) Length - 650 feet ±.

(3) Height - 20 feet ±.

(4) Top width - 25 feet ±.

(5) Side slopes.

(a) Downstream - 1.6 to 3.3H on 1V (measured with hand level).

(b) Upstream - exposed slope - 1 1/2H on 1V.

(6) Zoning - unknown.

(7) Impervious core - possibly a limestone masonry wall, according to Frank E. Barnes, Mayor of Houston Lake.

(8) Cutoff - unknown.

(9) Grout curtain - unknown.

(10) Riprap - Upstream face is plated with limestone riprap generally less than 6 inches maximum dimension.

h. Diversion and Regulation - none.

i. Spillway.

(1) Emergency.

(a) Type - Broad crested weir divided by 5 stone and mortar piers. Vehicle bridge on top of piers.

(b) Net length of weir - 84 feet.

(c) Crest elevation - 809.9 feet.

(d) Downstream channel - clean and paved. Approximately 200 feet downstream channel is blocked by fill of Highway I-635. A 12' x 6' R/C box culvert, 600 feet long, serves as the outlet structure for the pool caused by backwater from the highway fill.

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, although it was reported by Frank E. Barnes, Mayor of Houston Lake, that the dam was built in 1930 and that it has a limestone masonry wall as a core.

2.3 OPERATION

There are no controlled discharge structures for this dam. It was reported by Mr. Barnes that the dam originally had a drawdown works, but that the inlet and outlet had both been destroyed. The crest was reported to have been under water on two occasions in recent years.

2.4 EVALUATION

a. Availability. There were no engineering data available for this dam.

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

c. Validity. Not applicable.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Houston Lake Dam was made on September 22, 1978. Engineers from the firm of Hoskins-Western-Sonderegger, Inc. making the inspection were: Stephen Nickel, Geology and Soil Mechanics; Gordon Jamison, Hydrology and Hydraulics; Garold Ulmer, Civil Engineer; and Richard Walker, Hydrology. Specific observations are discussed below.

b. Dam. The upstream slope has a covering of light riprap, through which weeds and grasses are growing. Neither slides nor serious erosion were noted. The crest consisted of a bituminous-surfaced roadway and a ridge of earth fill, higher than the roadway, which extends the length of the embankment immediately downstream from the roadway. The soil forming the ridge appeared to be poorly compacted or uncompacted. The soil on the downstream slope appeared to be poorly compacted. A number of trees, up to approximately 12 inches in diameter, are growing on the downstream slope. The remainder of the vegetation on the downstream slope consists of weeds, brush, and cattails. An active seep was found at the downstream toe near center line station 3+30. Free water was found along the property fence about 10 feet below the downstream toe from station 3+30 to the spillway. No boils were noted and all seepage was clear. A flow rate was not able to be estimated. The soil exposed on the surface of the embankment is a low to medium plasticity silty clay. No animal burrows were noted.

The abutments apparently consist of soils similar to those in the embankments. These soils are known to overlie alternating beds of shales and limestones, however no outcrops were seen. No sliding or seepage was noted in the abutments.

c. Appurtenant Structures. The spillway consists of a broad crested weir and chute section that drops irregularly from its crest at the permanent pool elevation. The floor of the chute is broomed concrete and the sidewalls are limestone masonry. A section of wall on the left side of the chute has been destroyed, and soil is exposed for a length of approximately 50 feet. There are limestone masonry walls on both sides on the inlet to the spillway. The inlet wall on the right (embankment) side of the spillway is broken and is in poor condition. This uncontrolled spillway is the only structure to control pool levels at this dam.

d. Reservoir Area. No wave wash, excessive erosion, or slides were observed along the shore of the reservoir.

e. Downstream Channel. The downstream channel is a continuation of the chute spillway to the property line, 30 to 50 feet downstream from the toe of the embankment. Beyond that point the channel is defined by the reinforced concrete apron and wingwalls of a box culvert beneath Highway I-635. The I-635 embankment is higher than Houston Lake Dam and acts effectively as a dry dam. At the time of the inspection, less than 1 gallon per minute was flowing over the spillway. At a point approximately 20 feet upstream from the box culvert apron, the spillway flow disappeared into a transverse crack in the broomed concrete channel bottom. At the joint between the broomed concrete and the apron, clear water was flowing from a hole, roughly 6 inches by 2 inches, at a rate estimated to be 3 gallons per minute. The water boiled up about 1 inch as it discharged, indicating a sizeable pressure head. There is a welded steel railing along the crest of the spillway. This railing could act as a trash rack during spillway operation and increase the effective spillway elevation.

f. Downstream Hazards. Located approximately 200 feet downstream from the dam is the I-635 roadway embankment, which is higher than the dam. No attempt has been made to determine the effect of this embankment on the length of the estimated damage zone or on the hazard classification.

3.2 EVALUATION

The trees on the downstream slope of the dam, if left uncontrolled, could cause potential failure of the dam. The railing along the crest of the spillway should be removed to allow the spillway to function as intended. The limestone masonry wall to the right of the spillway inlet should be repaired or replaced. The missing section of the limestone masonry wall on the left of the exit channel should be repaired. Cracks in the broomed concrete exit channel bottom should be sealed to prevent the infiltration of water to reduce the possibility of failure of the channel bottom during spillway operation. The seepage near the downstream toe of the dam and at the end of the exit channel should be investigated. The seepage appears serious enough to require remedial action in the near future to eliminate the potential of failure of the exit channel and the embankment.

Located approximately 200 feet downstream from the dam is the I-635 roadway embankment. No attempt has been made to determine the effect of this embankment, whether beneficial or adverse, on the Houston Lake Dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no controlled outlet works for this dam and no regulating proccdures exist.

4.2 MAINTENANCE OF DAM

The amount of brush and the size of the trees on the downstream slope indicate that it has been several years since any vegetative control measures have been performed. The roadway on the dam crest has a new bituminous surface. The relatively uncompacted fill in the ridge on the dam crest and on the downstream slope may have been placed to repair damage caused by the dam reportedly being under water in 1975 and 1976.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist at this dam.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

The inspection team is not aware of any warning system at this dam.

4.5 EVALUATION

Trees and brush growing on the downstream slope could lead to the potential of failure if not controlled. Roots penetrating partially or completely through the dam provide avenues for seepage. The effect of concentrated seepage in root holes could cause failure of the dam by piping.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design data. No design plans were found for this dam.

b. Experience. The drainage area, reservoir surface area, and elevation-storage data were developed from the U.S.G.S. North Kansas City, Missouri-Kansas and Parkville, Missouri-Kansas 7½ minute topographic quadrangle maps. The hydraulic computations for the spillway and dam overtopping discharge ratings were made from field measurements obtained at the time of the field inspections.

c. Visual Observations.

(1) The weir portion of the spillway, including the bridge piers, appears to be in good condition. The wall on the right side of the spillway inlet is in a deteriorated condition. A section of wall on the right side of the exit channel is missing, and there are open cracks in the concrete bottom of the exit channel which admit water.

(2) Spillway use could endanger the soundness of the dam. High spillway flows would endanger the right spillway inlet wall. Failure of this wall would expose possibly erosive soil to high velocity flow and could lead to the breaching of the dam. In addition, spillway flow impinging on the missing section of exit channel wall could cause extensive erosion of the downstream slope of the dam since the exit channel is carried on the embankment at that location.

(3) The ridge of earth material which forms the crest of the dam for most of its length along the downstream edge of the bituminous road does not appear to have been compacted and would be subject to erosion or cutting in case of dam overtopping.

d. Overtopping Potential. The spillway is too small to pass the 1/2 probable maximum flood or the 100-year flood without overtopping. The spillway will pass 15% of the PMF without overtopping the dam. The results of the routing through the reservoir are tabulated in regard to the following conditions.

Frequency	Peak Inflow Discharge c.f.s.	Peak Outflow Discharge c.f.s.	Maximum Pool Elevation	Freeboard Top of Dam Min. Elev. 812.3	Time Dam Overtopping Hrs.
100-Yr.	1690	1540	813.2	-0.9	1.8
1/2 PMF	3910	3860	814.4	-2.1	5.3
PMF	7930	7890	815.5	-3.2	6.7
0.15 PMF	1030	840	812.3	0	-

Backwater from the I-365 highway fill and 12' x 6' box culvert will reach the spillway crest elevation during an approximate 0.27 PMF.

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 small size. The recommended guidelines stipulate that the spillway of a small size dam with a high hazard rating shall be capable of passing one-half PMF to PMF. Due to the large volume of water impounded, the relatively steep and narrow floodplain downstream the location of apartment houses, outdoor theatres and a shopping area in the damage zone, the PMF is the appropriate spillway design flood.

The St. Louis District, Corps of Engineers in a letter dated 11 August, 1978 has estimated the damage zone as extending two miles downstream of the dam. Within the damage zone are two drive-in theaters, two to three apartment buildings, and a shopping area. The I-635 roadway embankment, which is approximately 200 feet downstream from the dam, is also included in the damage zone. No attempt has been made to determine the effect of this embankment, whether beneficial or adverse, on the Houston Lake Dam.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of items which adversely affect the stability of the dam are discussed in Section 3. These include the following features: brush and trees on the downstream slope, the railing along the crest of the spillway, the condition of the limestone masonry wall at the right side of the spillway inlet, a missing section of limestone masonry wall along the left side of the spillway exit channel, open cracks in the broomed concrete exit channel bottom, and seepage near the downstream toe of the embankment and at the end of the exit channel.

b. Design and Construction Data. No design or construction data were available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Operating Records. There are no operating structures at this dam.

d. Post-Construction Changes. Increasing the crest height with the ridge of uncompacted soil and possibly adding soil to the downstream slope could have affected the structural stability of the dam. Additional investigation and analysis would be required to evaluate these effects.

e. Seismic Stability. This dam is in Seismic Zone 1. An earthquake of the magnitude used for design in this zone is not expected to cause structural failure of this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several items were noted during the visual inspection which could seriously threaten the safety of the dam if not remedied or controlled. These items include uncontrolled vegetation on the downstream slope of the dam, the deteriorated condition of the wall on the right side of the spillway inlet, a missing section of wall on the left side of the exit channel, the railing along the spillway crest, open cracks in the concrete on the bottom of the exit channel, and seepage from the embankment near the toe of the dam and from the joint at the end of the exit channel. The Probable Maximum Flood will overtop the dam. The 100-year flood will overtop the dam. The spillway will pass 15% of the PMF before the dam is overtopped. The dam will be (and reportedly has been) submerged due to temporary impoundment of flood waters by the Highway I-635 embankment approximately 200 ft. downstream.

b. Adequacy of Information. Since no engineering or construction data were available, the conclusions of this report are based upon performance history and visual observations. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. This is a deficiency which should be corrected in the near future. Additional studies would be required to evaluate downstream hazards from possible overtopping or failure of this dam since the Highway I-635 embankment, just downstream from this dam, is higher than the dam.

c. Urgency. The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. Top priority should be given to the alternatives and recommendations of paragraph 7.2.a.

d. Necessity for Phase II. A Phase II investigation is not called for. However, additional engineering data and analyses should be obtained at the owner's expense, to evaluate and design recommended remedial measures.

e. Seismic Stability. The dam is located in Seismic Zone 1. An earthquake of the magnitude used for design in this seismic zone is not expected to be hazardous to this dam.

7.2 REMEDIAL MEASURES

a. Alternatives. If overtopping of this dam will endanger property downstream beyond the highway embankment, the size of the spillway and/or the height of the dam should be increased and/or the permanent pool elevation should be lowered so that the Probable Maximum Flood can be passed without overtopping the dam.

Regardless of which of these alternatives is chosen, additional investigations and analyses should be conducted to determine the structural characteristics and stability of the present embankment. These analyses should include a seepage analysis to determine the source of the seepage near the downstream toe and at the end of the spillway exit channel. The services of an engineer experienced in the design of dams should be obtained to perform the investigations and analyses of the present dam and to design the appropriate modifications and remedial measures.

b. O & M Maintenance and Procedures. The following O & M maintenance and procedures are recommended.

(1) Trees and brush should be removed from the dam and a program initiated to control vegetation on the structure.

(2) The wall on the right side of the spillway inlet should be repaired or replaced.

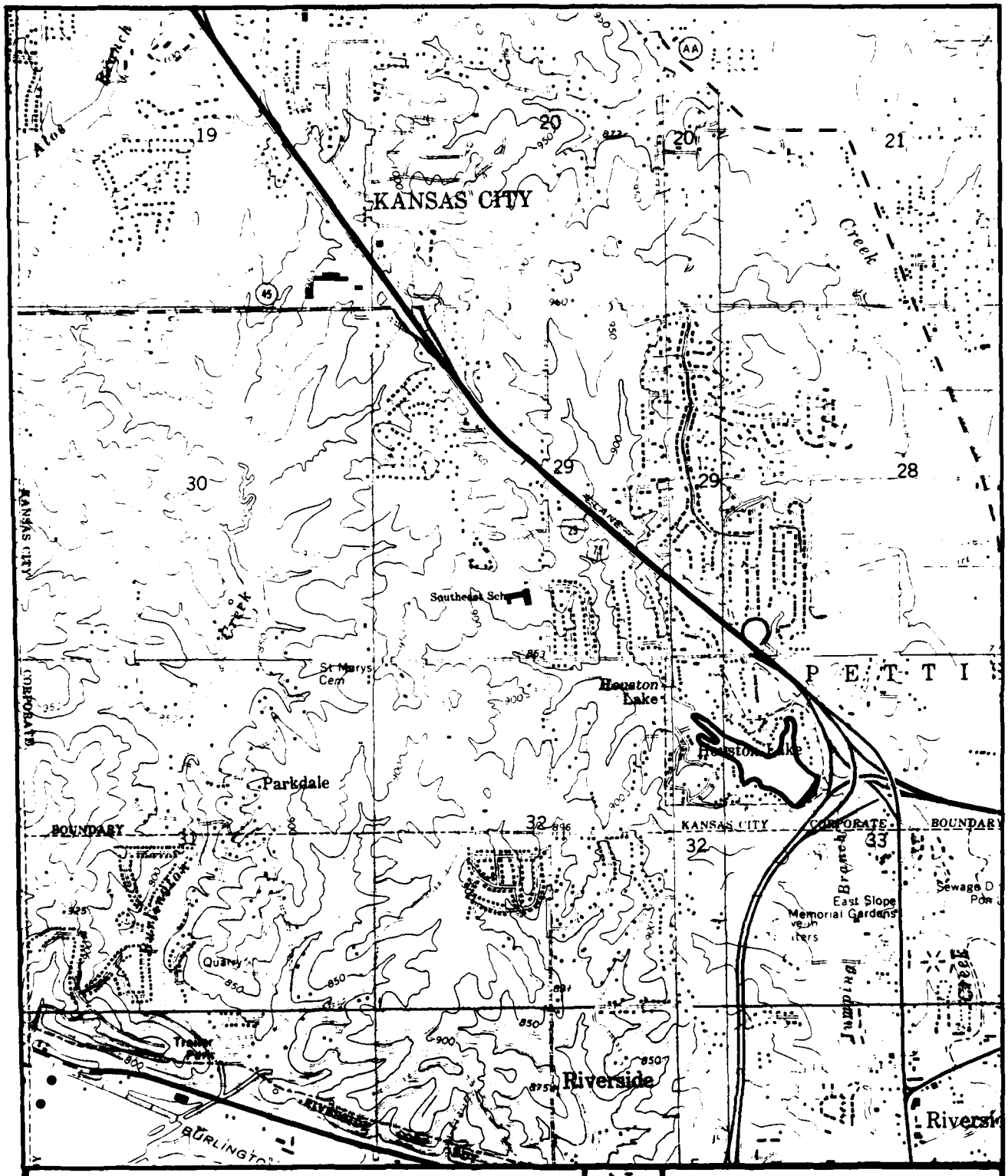
(3) The missing section of wall along the left side of the spillway exit channel should be replaced.

(4) The railing along the crest of the spillway should be removed.

(5) All open cracks in the concrete bottom of the exit channel should be sealed with a joint sealing compound.

(6) The dam should be inspected regularly by qualified personnel to determine the presence of seepage on the downstream slope in the abutments, below the downstream toe, or in the exit channel, to determine the presence of slides in the downstream slope, to observe the upstream slope for any erosional damage, and to observe the structural stability of the spillway and exit channel.

APPENDIX A
MAPS


KANSAS CITY
Parkdale
Riverside
Houston Lake
Houston Lake
Southeast Sch
St Marys Cem
Quarry
Trailer Park
East Slope Memorial Gardens
Sewage D
Pon
P E T T I
BOUNDARY
CORPORATE
KANSAS CITY
BURLINGTON
19
20
21
28
29
30
32
33
SCALE IN FEET
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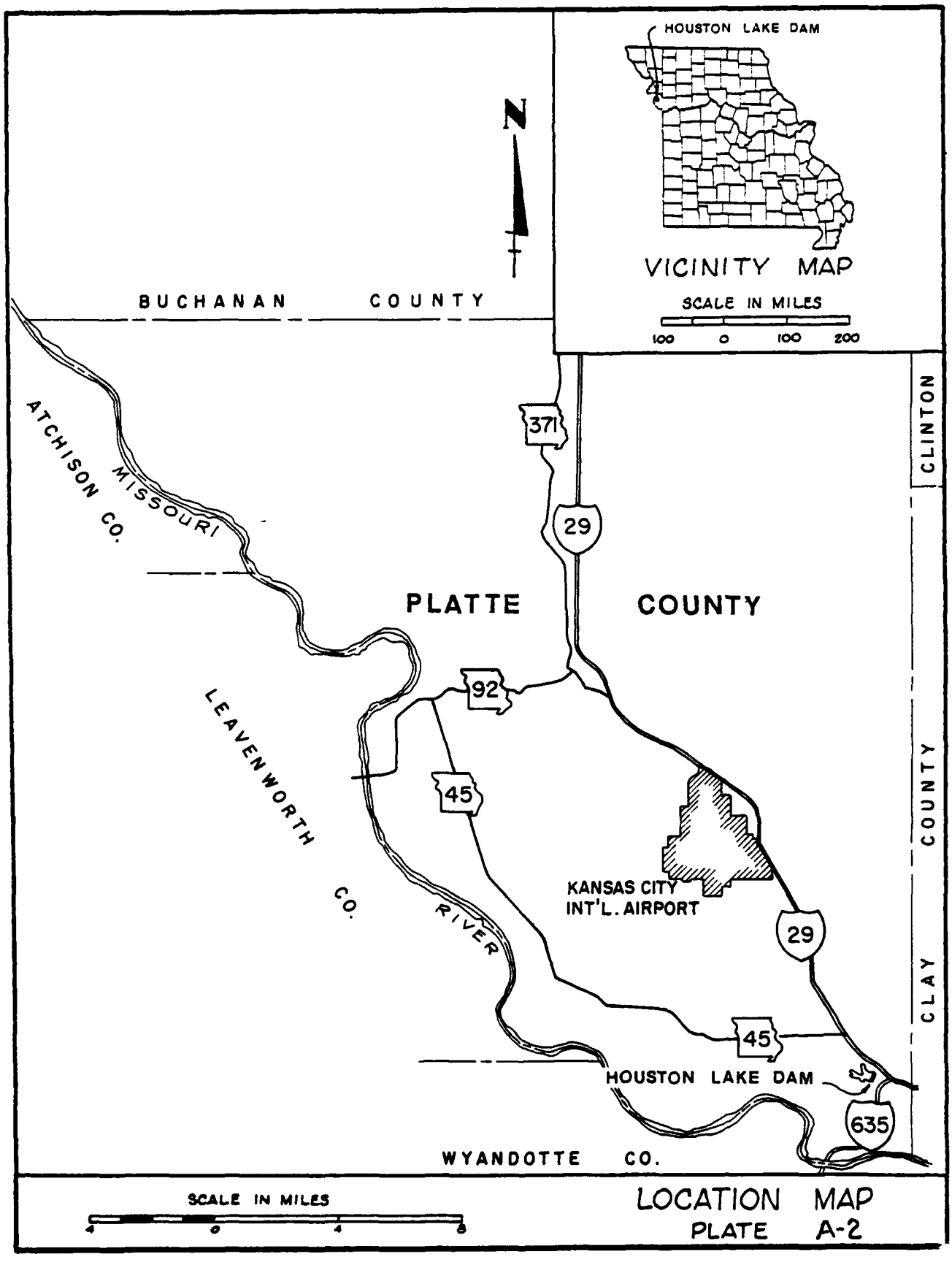
SCALE IN METERS
N
HOUSTON LAKE DAM
VICINITY TOPOGRAPHY
PLATE A-1


HOUSTON LAKE DAM
VICINITY MAP
SCALE IN MILES
100 0 100 200
N
BUCHANAN COUNTY
ATCHISON CO.
MISSOURI
371
29
CLINTON
PLATTE COUNTY
92
45
LEAVENWORTH CO.
RIVER
KANSAS CITY
INT'L. AIRPORT
29
CLAY COUNTY
45
HOUSTON LAKE DAM
635
WYANDOTTE CO.
SCALE IN MILES
4 0 4 8
LOCATION MAP
PLATE A-2

APPENDIX B
PHOTOGRAPHS

PHOTO NO. 2
UPSTREAM SLOPE
FROM RIGHT
ABUTMENT

PHOTO NO. 3
SPILLWAY INLET
AND UPSTREAM SLOPE
FROM LEFT ABUTMENT

PHOTO NO. 4
CREST OF DAM
FROM RIGHT
ABUTMENT

PLATE B-1

PHOTO NO. 5
DOWNSTREAM SLOPE
LOOKING NORTH FROM
STA. 4+00. SEEP
AT DOWNSTREAM TOE

PHOTO NO. 6
DOWNSTREAM SLOPE
LOOKING SOUTH FROM
RIGHT SIDE OF
EXIT CHANNEL

PHOTO NO. 7
FREE WATER IN
CATTAILS AT DOWN-
STREAM TOE STA. 3+50

PHOTO NO. 8
DETERIORATED WALL
AT RIGHT SIDE OF
SPILLWAY INLET

PHOTO NO. 9
WALL AT LEFT
SIDE OF SPILLWAY
INLET

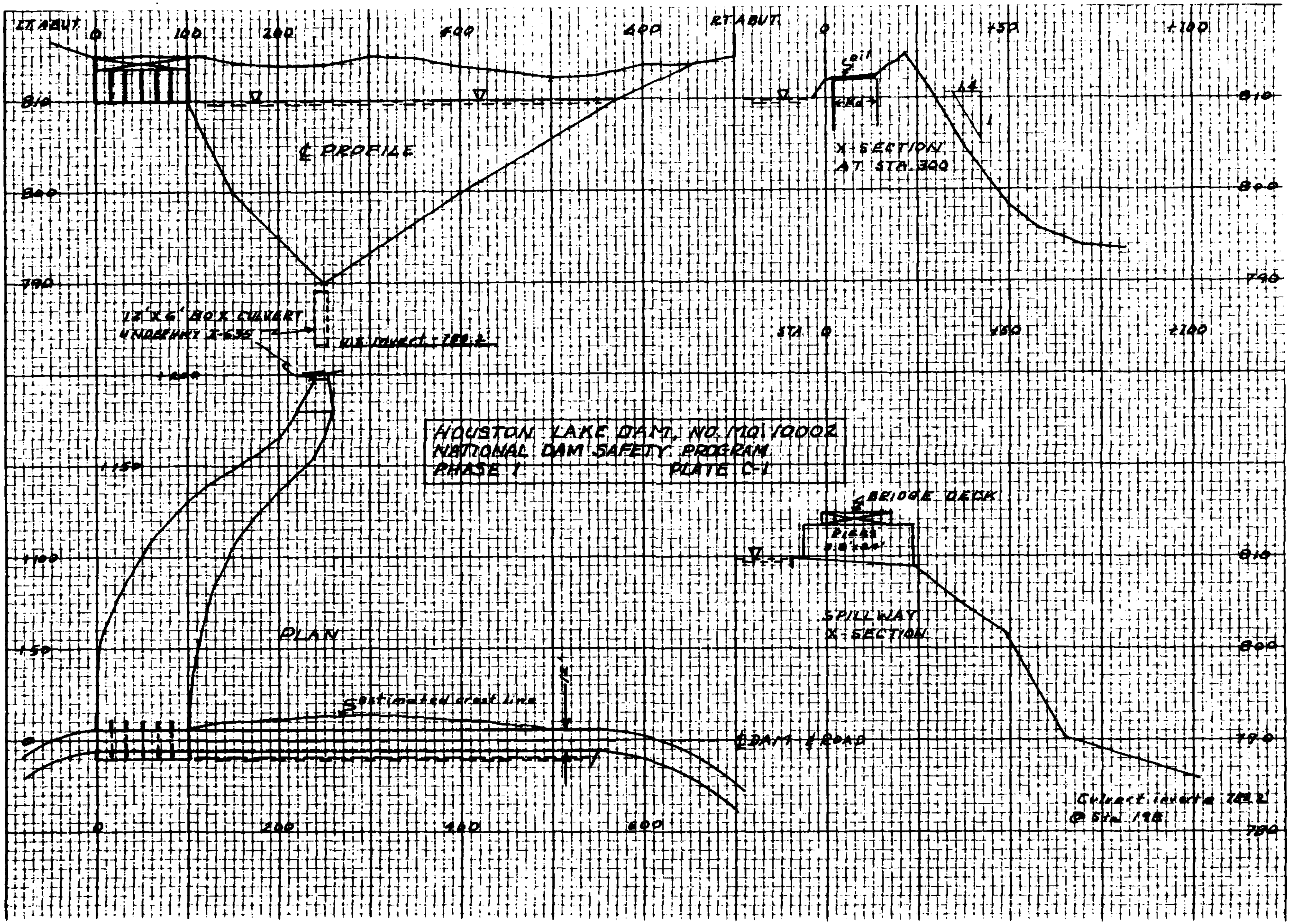
PHOTO NO. 10
SPILLWAY EXIT
CHANNEL LOOKING
DOWNSTREAM

PHOTO NO. 11
LEFT SIDE OF EXIT
CHANNEL

PHOTO NO. 12
LOOKING UPSTREAM
FROM EXIT CHANNEL

PHOTO NO. 13
SEEPAGE FROM JOINT
BETWEEN EXIT CHANNEL
AND CONCRETE APRON

APPENDIX C
PLANS, PROFILE AND SECTIONS


LT. ABUT.
RT. ABUT.
℄ PROFILE
X-SECTION
AT STA. 300
12' X 6' BOX CULVERT
UNDERHWY Z-635
U.S. Invert - 788.2
HOUSTON LAKE DAM, NO. MO 10002
NATIONAL DAM SAFETY PROGRAM
PHASE I
PLATE C-1
℄ BRIDGE DECK
SPILLWAY
X-SECTION
PLAN
Estimated crest line
℄ DAM ℄ ROAD
STA. 0
Culvert invert = 788.2
@ Sta. 198

APPENDIX D
HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Mockes dimensionless standard curvalinear unit hydrograph and the SCS TR-20 program were used to develop the inflow hydrographs (see Plate D1). The inflow hydrograph for the 100-year flood was generated by the consultant using the TR-20 program.

   a. Six-hour, twelve-hour, and twenty-four hour 100-year rainfall for the dam location was taken from NOAA Technical Paper 40. The 24-hour probable maximum precipitation was taken from the curves of Hydrometeorological Report No. 33 and current Corps of Engineers and St. Louis District policy and guidance for hydraulics and hydrology.

   b. Drainage area = 1.40 square miles (898 acres).

   c. Time of concentration of runoff = 45 minutes (computed from "Kirpich" formula). 1/

   d. The antecedent storm conditions were heavy rainfall and low temperatures which occurred on the previous 5 days (SCS AMCIII). The initial pool elevation was assumed at the crest of the emergency spillway.

   e. The total 24-hour storm duration losses for the 100-year storm were 1.57 inches. The total losses for the 24-hour duration 1/2 PMF storm were 1.72 inches. The total losses for the PMF storm were 1.78 inches. These data are based on SCS runoff curve No. 87 and antecedent moisture conditions from SCS AMCIII.

   f. Average soil loss rates = 0.05 inch per hour approximately.

2. The emergency spillway discharge rating was developed using the broad-crested weir equations $Q = CLH^{3/2}$, where H is the head on the weir. The coefficient C varies with the head and was adjusted for the contractions caused by the abutments and piers. The flows over the dam crest were based on the broad-crested weir equation $Q = CLH^{3/2}$, where H is the head on the dam crest and the coefficient C varies with head on the dam.

   The ridge of earth material which formed the dam crest (Station 103 to 500) was assumed to be at 0.5 feet lower elevation for the flow over dam crest computations which would make allowance for expected erosion and cutting action.

   The coefficients C in the formulas above were taken from the U.S.G.S. publication "TWRI, Book 3 Chapter 5, Measurement of Peak Discharge at Dams by Indirect Methods".

1/ The computation interval for the runoff hydrograph is automatically adjusted to 0.17 Tc by the TR-20 computer program.

3. Floods were routed through the reservoir using the TR-20 program to determine the capabilities of the spillways and dam embankment crest. The storm rainfall patterns, inflow hydrographs, and routed outflow hydrographs are shown on Plate D-3.

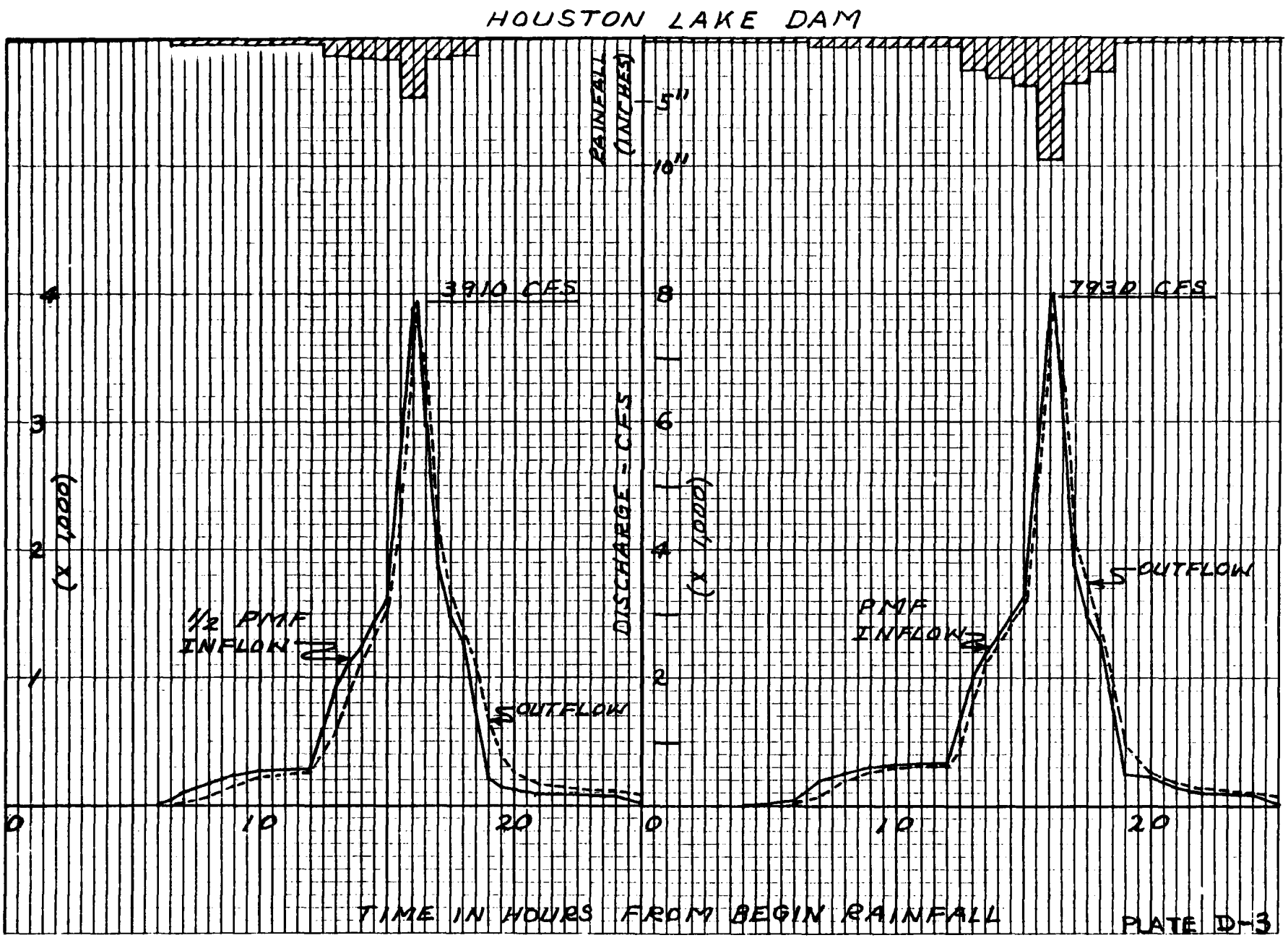


PLATE D-3

HASKINS-WESTERN-SONDEREGGER

COMPUTED BY GGJ DATE 10/26/78 SHEET NO. ____ OF ____

CHECKED BY ____ DATE ____ JOB NUMBER 78/3095

PROJECT Mo Dam Insp. # 10002

CALCULATIONS FOR COMBINED BRIDGE & DAM RATING

HOUSTON LAKE

ELEV	UNDER BRIDGE	OVER DAM	TOTAL
809.9	0	—	0
810.1	21	—	21
810.5	100	—	100
811.0	260	—	260
811.5	450	—	450
812.0	670	—	670
812.3	820	0	820
812.6	980	16	996
813.0	1200	140	1340
813.5	1480	440	1920
814.0	1720	1060	2780
814.5	1930	2100	4030
815.0	2130	3570	5700
815.5	2310	5500	7810

PLATE D-4

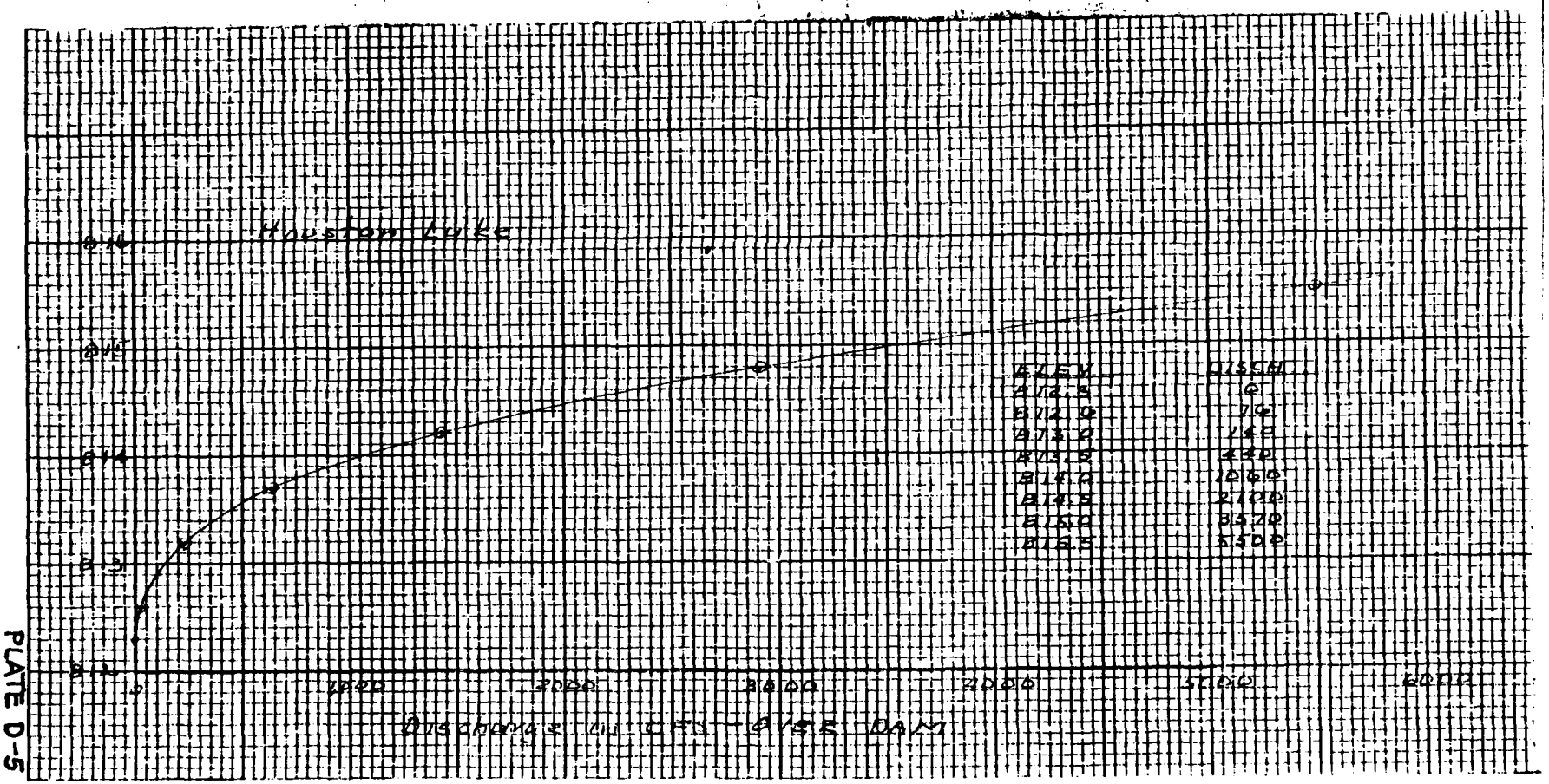
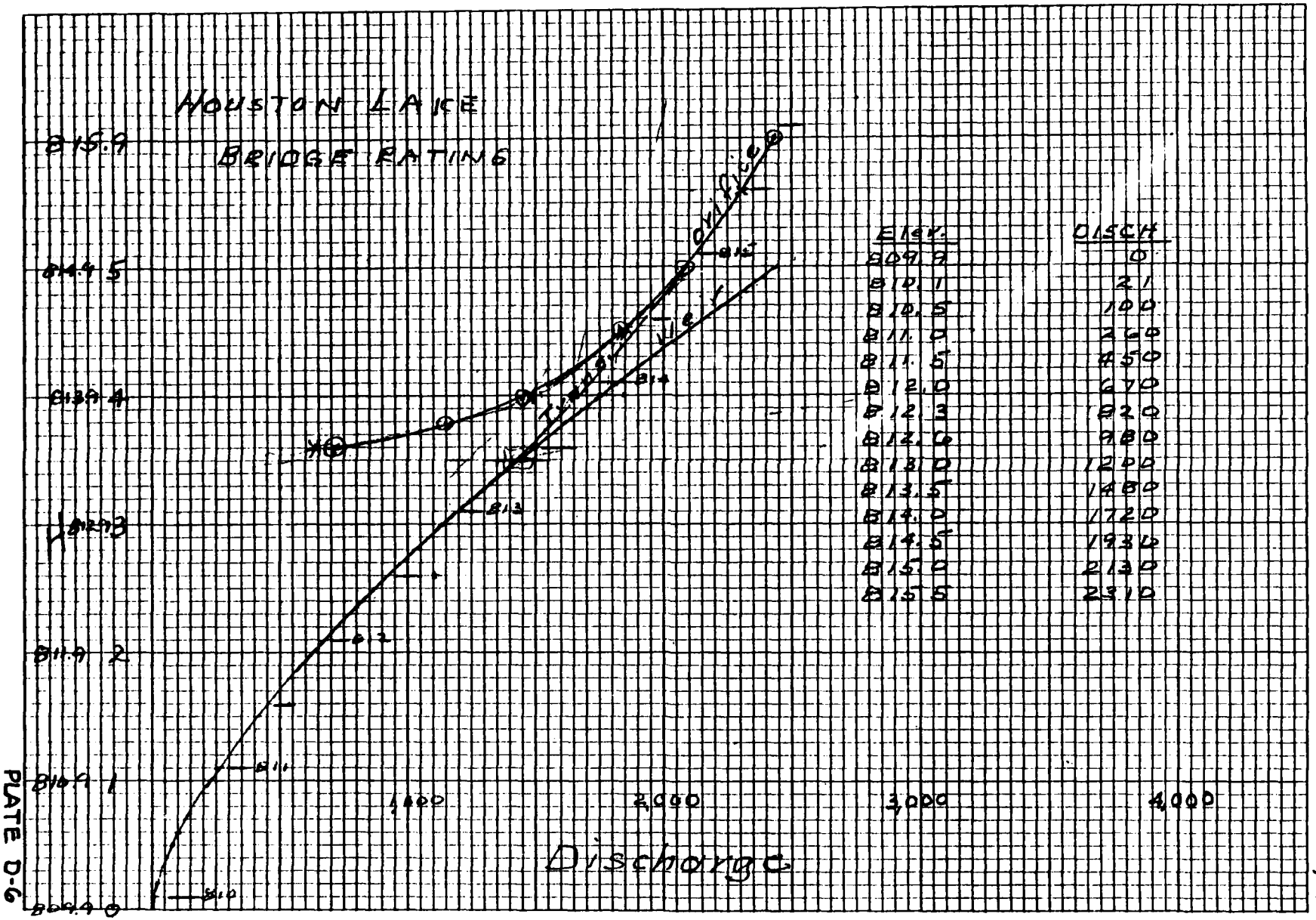


PLATE D-5



Elev.	Disch
209.9	0
210.1	21
210.5	100
211.0	240
211.5	450
212.0	670
212.3	820
212.6	980
213.0	1200
213.5	1480
214.0	1720
214.5	1934
215.0	2130
215.5	2310

2/3

HYDROLOGY PROGRAM FOR IBM 1130 - DATED JULY, 1968

MO DAM INSP-HOUSTON LAKE TR-20 ROUTING.

EXECUTIVE CONTROL CARD OPERATION LIST

MO DAM INSP-HOUSTON LAKE

C TABLE VELOCITY INCREMENT = 0.200

8	0.0000	0.0800	0.1800	0.2500	0.3200
8	0.3700	0.4100	0.4500	0.4900	0.5100
8	0.5400	0.5700	0.5900	0.6100	0.6300
8	0.6500	0.6600	0.6700	0.6900	0.7000
8	0.7100	0.7200	0.7300	0.7400	0.7500
8	0.7600	0.7700	0.7700	0.7800	0.7900
8	0.7900	0.8000	0.8100	0.8100	0.8200
8	0.8200	0.8300	0.8300	0.8400	0.8400
8	0.8400	0.8500	0.8500	0.8600	0.8600
8	0.8600	0.8600	0.8700	0.8700	0.8700
8	0.8800	0.8800	0.8800	0.8900	0.8900
8	0.8900	0.8900	0.8900	0.8900	0.9000
8	0.9000	0.9000	0.9000	0.9000	0.9100
8	0.9100	0.9100	0.9100	0.9100	0.9100
8	0.9200	0.9200	0.9200	0.9200	0.9200
8	0.9200	0.9200	0.9200	0.9300	0.9300
9 ENDTBL					

STRUCTURE NO. 1

	ELEVATION	DISCHARGE	STORAGE
8	809.9000	0.0000	0.0000
9 ENDTBL			

DIMENSIONLESS HYDROGRAPH - DELTA T =484.00

8	0.0000	0.0300	0.1000	0.1900	0.3100
8	0.4700	0.6600	0.8200	0.9300	0.9900
8	1.0000	0.9900	0.9300	0.8600	0.7800
8	0.6800	0.5600	0.4600	0.3900	0.3300
8	0.2800	0.2410	0.2070	0.1740	0.1470
8	0.1260	0.1070	0.0910	0.0770	0.0660
8	0.0550	0.0470	0.0400	0.0340	0.0290
8	0.0250	0.0210	0.0180	0.0150	0.0130
8	0.0110	0.0090	0.0080	0.0070	0.0060
8	0.0050	0.0040	0.0030	0.0020	0.0010
8	0.0000	0.0000	0.0000	0.0000	0.0000
9 ENDTBL					

RAINFALL TABLE NO. 1 TIME INCREMENT = 0.50

8	0.0000	0.0080	0.0170	0.0260	0.0350
8	0.0450	0.0550	0.0650	0.0760	0.0870
8	0.0990	0.1120	0.1250	0.1400	0.1560
8	0.1740	0.1940	0.2190	0.2540	0.3030
8	0.5150	0.5830	0.6240	0.6540	0.6820
8	0.7050	0.7270	0.7480	0.7670	0.7840
8	0.8000	0.8160	0.8300	0.8440	0.8570
8	0.8700	0.8820	0.8930	0.9050	0.9160
8	0.9260	0.9360	0.9460	0.9550	0.9650
8	0.9740	0.9830	0.9920	1.0000	1.0000
9 ENDTBL					

RAINFALL TABLE NO. 2 TIME INCREMENT = 0.02

8	0.0000	0.0100	0.0200	0.0200	0.0300
8	0.0400	0.0500	0.0600	0.0700	0.0800
8	0.1000	0.1100	0.1300	0.1400	0.1700
8	0.1900	0.2200	0.2700	0.3500	0.4400
8	0.5200	0.6000	0.6300	0.6600	0.6800
8	0.7000	0.7200	0.7400	0.7600	0.7700
8	0.7900	0.8000	0.8200	0.8300	0.8400
8	0.8500	0.8700	0.8800	0.8900	0.9000
8	0.9100	0.9200	0.9300	0.9400	0.9500
8	0.9567	0.9633	0.9700	0.9800	0.9900
8	1.0000	1.0000	1.0000	1.0000	1.0000
9 ENDTBL					

RAINFALL TABLE NO. 3 TIME INCREMENT = 0.50

8	0.0000	0.0700	0.1400	0.2100	0.2800

PLATE D-7

8	0.3500	0.4300	0.5000	0.5800	0.6500
8	0.7300	0.8000	0.8800	1.2700	1.6600
8	2.0500	2.4400	2.8300	3.2200	3.6100
8	4.0000	4.3900	4.7800	5.1700	5.5600
8	6.8100	8.0700	9.5700	11.0800	12.9600
8	14.8400	19.6100	24.3600	26.1300	27.8900
8	29.2700	30.6500	30.7600	30.8800	30.9900
8	31.1000	31.2100	31.3200	31.4300	31.5400
8	31.6500	31.7600	31.8700	31.9800	31.9800
9	ENDTBL				

RAINFALL TABLE NO. 4 TIME INCREMENT = 0.50

8	0.0000	0.0300	0.0600	0.0900	0.1200
8	0.1500	0.1800	0.2100	0.2400	0.2700
8	0.3000	0.3300	0.3600	0.4500	0.5400
8	0.6300	0.7200	0.8100	0.9000	0.9900
8	1.0800	1.1700	1.2700	1.3600	1.4600
8	1.7400	2.0300	2.3700	2.7100	3.1300
8	3.5600	4.6400	5.7300	6.1300	6.5300
8	6.8400	7.1600	7.2000	7.2500	7.2900
8	7.3400	7.3800	7.4300	7.4700	7.5200
8	7.5600	7.6100	7.6500	7.7000	7.7000
9	ENDTBL				

PLATE D-8

STANDARD CONTROL INSTRUCTIONS

SUBRTN	XSECTN	STRCT	HYDROGRAPHS IN1	IN2	OUT	DATA NO. 1	DATA NO. 2	DATA NO. 3	OUTPUT OPTIONS PK	H	E	V	PH	SM
RUNOFF	0	1	0	6	6	1.400	73.000	0.750	1	1	0	1	0	0
RESVOR	0	1	6	0	7	809.900	0.000	0.000	1	1	1	1	0	0
ENDATA														

END OF LISTING

PLATE D-9

ADDITIONS TO TABULAR DATA FOLLOW

STRUCTURE NO. 1

8	809.9000	0.0000	0.0000
8	810.1000	21.0000	5.0000
8	810.5001	100.0000	14.0000
8	811.0001	260.0000	26.0000
8	811.5001	450.0000	37.0000
8	812.0001	670.0001	49.0000
8	812.3000	820.0001	56.0000
8	812.6000	1000.0001	62.0000
8	813.0001	1340.0002	72.0000
8	813.5001	1920.0002	84.0000
8	814.0001	2780.0004	96.0000
8	814.5001	4030.0004	108.0000
8	815.0001	5700.0009	120.0000
8	815.5001	7810.0009	132.0000

EXECUTIVE CONTROL CARD OPERATION INCREM. MAIN TIME INCREMENT= 0.25
EXECUTIVE CONTROL CARD OPERATION COMPUT. FROM XSECTN/STRUCT 0/ 1 TO XSECTN/STRUCT 0/ 1
STARTING TIME= 0.00 RAIN DEPTH= 1.00 RAIN DURATION= 1.00 RAIN TABLE NO.= 3 SOIL CONDITION= 3
ALTERNATE NO.= 1 STORM NO.= 1

PMF

SUBROUTINE RUNOFF STRUCTURE 1
AREA= 1.40 INPUT RUNOFF CURVE= 73.0 TIME OF CONCENTRATION= 0.75
COMPUTED CURVE NO. = 86.8

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
16.05	7931.032	(RUNOFF)
23.62	198.319	(RUNOFF)

HYDROGRAPH, TZERO= 2.50 DELTA T= 0.25 DRAINAGE AREA= 1.40

TIME											
2.50	DISCHG	0.00	2.86	7.273	12.50	17.17	21.87	27.524	32.69	35.92	39.25
5.00	DISCHG	44.405	48.81	50.75	53.05	59.296	98.79	202.32	313.34	391.297	445.14
7.50	DISCHG	484.66	514.94	538.948	558.43	574.46	587.80	599.179	608.93	617.38	624.75
10.00	DISCHG	631.2210	636.92	641.98	646.49	650.53//	654.16	657.43	660.39	672.022	850.06
12.50	DISCHG	1326.98	1771.40	2005.5513	2165.68	2362.33	2519.06	2604.7214	2724.65	2963.13	3169.24
15.00	DISCHG	3304.4915	3974.83	5641.29	7165.20	7906.0716	7605.21	6050.89	4543.22	3779.8717	3364.03
17.50	DISCHG	2989.00	2716.18	2585.3118	2273.93	1480.82	798.67	475.7819	329.47	258.84	224.43
20.00	DISCHG	208.4520	201.11	198.55	198.35	198.2621	198.22	198.20	198.20	198.2022	198.20
22.50	DISCHG	198.21	198.21	198.2123	198.21	198.21	198.21	197.0224	173.25	110.47	52.83
25.00	DISCHG	23.6325	10.55	4.64	1.97	0.7426	0.19	0.00			

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 30.2041 CFS-HRS= 27289.95 ACRE-FT= 2255.24

SUBROUTINE RESVOR STRUCTURE 1
SURFACE ELEVATION= 809.90

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
16.12	7889.204	815.51

HYDROGRAPH, TZERO= 2.50 DELTA T= 0.25 DRAINAGE AREA= 1.40

TIME											
2.50	DISCHG	0.00	0.11	0.533	1.30	2.43	3.85	5.584	7.62	9.84	12.15
2.50	ELEV	809.90	809.90	809.903	809.91	809.92	809.93	809.954	809.97	809.99	810.01
5.00	DISCHG	14.625	17.28	19.98	24.28	29.586	37.80	56.55	90.02	148.987	214.17
5.00	ELEV	810.035	810.06	810.09	810.11	810.146	810.18	810.28	810.44	810.657	810.85
7.50	DISCHG	278.61	345.60	400.528	445.39	483.70	514.73	539.819	560.27	577.11	591.11
7.50	ELEV	811.04	811.22	811.368	811.48	811.57	811.64	811.709	811.75	811.78	811.82
10.00	DISCHG	602.8510	612.79	621.28	628.60	634.9411	640.48	645.36	649.67	654.9412	691.32
10.00	ELEV	811.8410	811.87	811.88	811.90	811.92	811.93	811.94	811.95	811.96	812.04
12.50	DISCHG	(839.97	1192.89	1614.8213	1930.73	2214.28	2406.92	2538.7714	2645.90	2821.86	3075.14
12.50	ELEV	812.33	812.82	813.2513	813.50	813.67	813.78	813.85	813.92	814.01	814.11
15.00	DISCHG	3242.8015	3654.21	4963.43	6751.72	7762.8716	7753.54	6559.75	4996.79	4013.8117	3555.75
15.00	ELEV	814.1815	814.34	814.77	815.24	815.48	815.48	815.20	814.78	814.4917	814.31
17.50	DISCHG	3162.61	2841.22	2668.1818	2465.21	1965.07	1405.57	992.4719	738.31	588.56	478.08
17.50	ELEV	814.15	814.02	813.9318	813.81	813.52	813.05	812.5819	812.13	811.81	811.56
20.00	DISCHG	397.4620	339.11	296.33	267.11	249.0221	236.73	227.40	220.33	214.9722	210.91
20.00	ELEV	811.3620	811.20	811.09	811.01	810.96	810.92	810.89	810.87	810.8522	810.84
22.50	DISCHG	207.8316	205.50	203.74	202.40	201.38	200.61	199.8923	196.32	183.13	158.56

PLATE D-10

22.50	ELEV	810.83	810.82	810.82	810.82	810.81	810.81	810.81	810.80	810.75	810.68
25.00	DISCHG	129.42	102.23	85.79	72.08	60.32	50.36	42.00	35.02	29.20	24.34
25.00	ELEV	810.59	810.50	810.42	810.35	810.29	810.24	810.20	810.17	810.14	810.11

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 30.1389 CFS-HRS= 27231.08 ACRE-FT= 2250.37

ENDCMP 1

PLATE D-11

EXECUTIVE CONTROL CARD OPERATION COMPUT. FROM XSECTN/STRUCT 0/ 1 TO XSECTN/STRUCT 0/ 1
STARTING TIME= 0.00 RAIN DEPTH= 0.50 RAIN DURATION= 1.00 RAIN TABLE NO.= 3 SOIL CONDITION= 3
ALTERNATE NO.= 1 STORM NO.= 4

SUBROUTINE RUNOFF STRUCTURE 1
AREA= 1.40 INPUT RUNOFF CURVE= 73.0 TIME OF CONCENTRATION= 0.75
COMPUTED CURVE NO. = 86.8

½ PMF

PEAK TIMES 16.05 23.62 PEAK DISCHARGES 3908.242 98.500 PEAK ELEVATIONS (RUNOFF) (RUNOFF)

HYDROGRAPH, TZERO= 4.75 DELTA T= 0.25 DRAINAGE AREA= 1.40

TIME											
4.75	DISCHG	0.00	1.735	3.12	4.39	5.72	7.636	16.09	39.97	71.23	100.05 7
7.25	DISCHG	125.08	146.77	165.60	181.998	196.33	208.92	220.02	229.879	238.64	246.50
9.75	DISCHG	253.57	259.9510	265.73	270.98	275.77	280.141	284.15	287.83	291.23	298.40 12
12.25	DISCHG	380.99	600.91	809.73	925.3513	1008.33	1109.26	1191.58	1239.9714	1304.56	1426.18
14.75	DISCHG	1532.12	1603.6715	1937.35	2761.33	3519.17	3894.3016	3754.13	2991.02	2248.27	1872.44 17
17.25	DISCHG	1667.80	1482.78	1348.11	1283.6718	1129.38	735.56	396.74	236.3719	163.70	128.62
19.75	DISCHG	111.52	103.5920	99.94	98.67	98.58	98.5421	98.51	98.51	98.51	98.51 22
22.25	DISCHG	98.51	98.52	98.52	98.5223	98.52	98.53	98.53	97.9424	86.15	54.91
24.75	DISCHG	26.26	11.7425	5.24	2.30	0.98	0.3726	0.09	0.00		

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 14.2884 CFS-HRS= 12909.83 ACRE-FT= 1066.86

SUBROUTINE RESVOR STRUCTURE 1
SURFACE ELEVATION= 809.90

PEAK TIMES 16.16 PEAK DISCHARGES 3857.391 PEAK ELEVATIONS 814.43

HYDROGRAPH, TZERO= 4.75 DELTA T= 0.25 DRAINAGE AREA= 1.40

TIME											
4.75	DISCHG	0.00	0.07	0.26	0.55	0.93	1.41	2.28	4.42	8.68	15.08 7
4.75	FLEV	809.90	809.905	809.90	809.90	809.90	809.916	809.92	809.94	809.98	810.04
7.25	DISCHG	25.37	43.75	62.45	80.968	98.95	123.58	145.59	164.809	181.62	196.38
7.25	FLEV	810.12	810.21	810.30	810.40	810.49	810.57	810.64	810.707	810.75	810.80
9.75	DISCHG	209.37	220.8410	231.01	240.05	248.12	255.35	262.30	269.47	275.55	281.38 12
9.75	FLEV	810.84	810.87	810.90	810.93	810.96	810.98	811.00	811.02	811.04	811.05
12.25	DISCHG	299.04	357.16	463.24	592.0013	717.10	(847.36	990.77	1106.8314	1192.84	1282.53
12.25	FLEV	811.10	811.25	811.53	811.82	812.09	(812.34	812.58	812.72	812.82	812.93
14.75	DISCHG	1397.34	1510.9415	1683.82	2184.54	3045.22	3730.9816	3827.63	3355.89	2626.24	2144.7817
14.75	FLEV	813.04	813.14	813.29	813.65	814.10	814.38	814.41	814.25	813.91	813.63
17.25	DISCHG	1846.42	1665.83	1499.06	1377.0618	1280.27	1099.45	838.17	647.8919	505.26	393.80
17.25	FLEV	813.43	813.28	813.13	813.03	812.92	812.71	812.33	811.94	811.62	811.35
19.75	DISCHG	310.90	251.4620	215.22	187.15	165.72	149.4521	137.12	127.77	120.69	115.32 22
19.75	FLEV	811.13	810.97	810.86	810.77	810.70	810.65	810.61	810.58	810.56	810.54
22.25	DISCHG	111.25	108.16	105.83	104.0623	102.72	101.70	100.93	100.2824	98.82	94.11
22.25	FLEV	810.53	810.52	810.51	810.51	810.50	810.50	810.50	810.50	810.49	810.47
24.75	DISCHG	85.21	74.2025	63.28	53.38	44.78	37.4426	31.26	26.07	21.73	19.56 27
24.75	FLEV	810.42	810.36	810.31	810.26	810.22	810.18	810.15	810.12	810.10	810.08
27.25	DISCHG	17.93	16.44	15.07	13.8228	12.67	11.61	10.65	9.7629	8.95	8.20
27.25	FLEV	810.07	810.05	810.04	810.03	810.02	810.01	810.00	809.99	809.98	809.97

1.599
TOTAL WATER, IN INCHES ON DRAINAGE AREA= 14.2880 CFS-HRS= 12891.39 ACRE-FT= 1065.34
1.72

ENDCMP 1

PLATE D-12

EXECUTIVE CONTROL CARD OPERATION COMPUT, FROM XSECTN/STRUCT 0/ 1 TO XSECTN/STRUCT 0/ 1
STARTING TIME= 0.00 RAIN DEPTH= 1.00 RAIN DURATION= 1.00 RAIN TABLE NO.= 4 SOIL CONDITION= 3
ALTERNATE NO.= 1 STORM NO.= 1

SUBROUTINE RUNOFF STRUCTURE 1
AREA= 1.40 INPUT RUNOFF CURVE= 73.0 TIME OF CONCENTRATION= 0.75
COMPUTED CURVE NO. = 86.8

100-Yr.

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
16.07	1690.226	(RUNOFF)
20.16	81.958	(RUNOFF)
21.32	81.459	(RUNOFF)
22.21	81.705	(RUNOFF)
23.21	81.804	(RUNOFF)
23.95	79.216	(RUNOFF)

HYDROGRAPH, TZERO= 5.75 DELTA T= 0.25 DRAINAGE AREA= 1.40

TIME											
5.75	DISCHG	0.00	1.60	3.75	9.08	16.42	23.89	31.00	37.67	43.89	49.67
8.25	DISCHG	55.05	60.06	64.72	69.07	73.13	76.93	80.49	83.84	86.99	90.01
10.75	DISCHG	94.11	100.22	104.76	105.49	106.72	113.72	144.56	222.17	298.59	347.24
13.25	DISCHG	385.52	429.40	465.90	489.20	510.99	571.66	620.57	659.88	809.64	1166.32
15.75	DISCHG	1501.01	1679.59	1633.45	1308.44	987.18	823.87	733.99	651.28	592.72	569.81
18.25	DISCHG	508.42	341.66	198.73	134.71	106.10	88.85	80.58	81.03	81.74	78.06
20.75	DISCHG	76.06	79.34	81.41	78.07	75.95	79.47	81.73	78.02	75.75	79.54
23.25	DISCHG	81.76	78.18	76.08	79.07	72.72	47.10	22.58	10.10	4.51	1.98
25.75	DISCHG	0.85	0.33	0.08	0.00						

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 7.76 / 6.1293 CFS-HRS= 5538.00 ACRE-FT= 457.66
1.57

SUBROUTINE RESVOR STRUCTURE 1
SURFACE ELEVATION= 809.90

PEAK TIMES	PEAK DISCHARGES	PEAK ELEVATIONS
16.33	1544.929	813.17

HYDROGRAPH, TZERO= 5.75 DELTA T= 0.25 DRAINAGE AREA= 1.40

TIME											
5.75	DISCHG	0.00	0.06	0.26	0.79	1.78	3.31	5.32	7.73	10.48	13.50
5.75	ELEV	809.90	809.90	809.90	809.90	809.91	809.93	809.95	809.97	809.99	810.02
8.25	DISCHG	16.73	20.13	26.29	33.04	39.37	45.30	50.85	56.06	60.94	65.52
8.25	ELEV	810.05	810.09	810.12	810.16	810.19	810.22	810.25	810.27	810.30	810.32
10.75	DISCHG	69.94	74.46	79.12	83.45	87.21	90.96	97.22	116.82	151.58	193.06
10.75	ELEV	810.34	810.37	810.39	810.41	810.43	810.45	810.48	810.55	810.66	810.79
13.25	DISCHG	235.03	280.99	331.46	375.70	414.58	454.39	499.53	544.33	604.98	734.83
13.25	ELEV	810.92	811.05	811.18	811.30	811.40	811.51	811.61	811.71	811.85	812.12
15.75	DISCHG	992.18	1302.36	1527.67	1489.89	1279.15	1084.91	952.50	819.23	747.74	687.39
15.75	ELEV	812.58	812.95	813.16	813.12	812.92	812.69	812.48	812.29	812.15	812.03
18.25	DISCHG	638.06	570.22	474.67	380.20	301.52	243.79	205.28	175.14	152.44	134.87
18.25	ELEV	811.92	811.77	811.55	811.31	811.10	810.94	810.82	810.73	810.66	810.60
20.75	DISCHG	120.87	110.42	103.15	98.27	94.73	91.90	90.02	88.34	86.43	84.97
20.75	ELEV	810.56	810.53	810.50	810.49	810.47	810.45	810.44	810.44	810.43	810.42
23.25	DISCHG	84.25	83.54	82.47	81.66	80.70	77.24	70.19	61.24	52.27	44.12
23.25	ELEV	810.42	810.41	810.41	810.40	810.40	810.38	810.34	810.30	810.25	810.21
25.75	DISCHG	37.02	30.96	25.85	21.55	19.48	17.86	16.38	15.01	13.76	12.62
25.75	ELEV	810.18	810.15	810.12	810.10	810.08	810.07	810.05	810.04	810.03	810.02
28.25	DISCHG	11.57	10.61	9.72	8.91	8.17	7.49	6.87	6.30	5.77	5.29
28.25	ELEV	810.01	810.00	809.99	809.98	809.97	809.97	809.96	809.95	809.95	809.95

TOTAL WATER, IN INCHES ON DRAINAGE AREA= 6.1114 CFS-HRS= 5521.76 ACRE-FT= 456.31

ENDCMP 1

END OF JOB TR20 GGJ
BATCH JOB

JOB NUMBER 78/3095 PHASE 0

PLATE D-19

END

DATE
FILMED
10-81

DTIC