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MISSOURI-GRAND-CHARITON BASIN

AD A105647

BETHANY CITY RESERVOIR
HARRISON COUNTY, MISSOURI
MO 10051

15 DACW43-78-C-0155 (9) Final rept.
10 Harold P. /Hoskins

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

Bethany City Reservoir Dam (MO 10051),
Missouri - Grand - Chariton Basin,
Harrison County, Missouri. Phase I Inspection
Report.

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PREPARED BY: HOSKINS-WESTERN-SONDEREGGER, INC.
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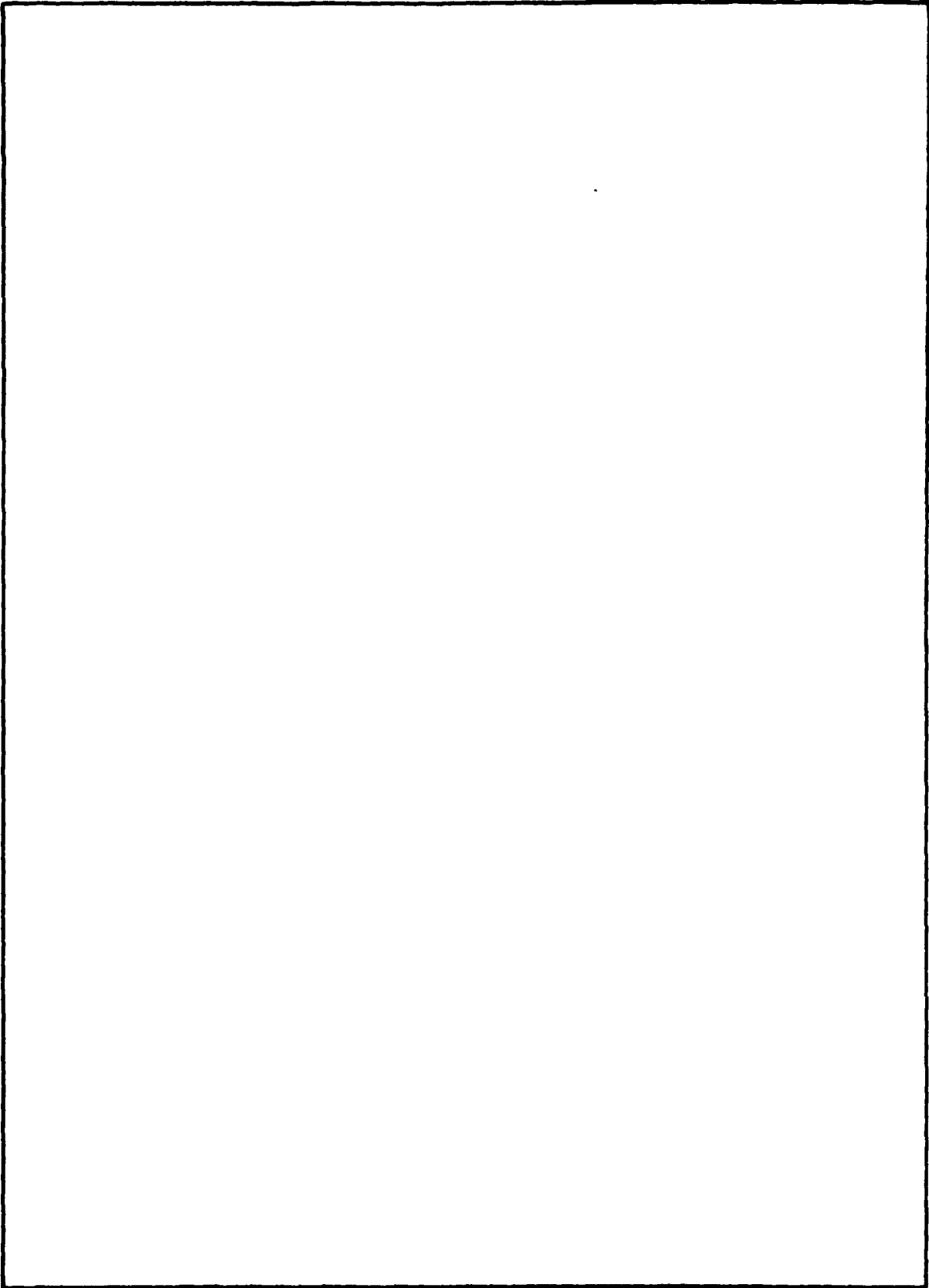
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DEPARTMENT OF THE ARMY
 ST. LOUIS DISTRICT, CORPS OF ENGINEERS
 210 NORTH 12TH STREET
 ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Bethany City Reservoir Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Bethany City Reservoir 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

26 SEP 1978

Date

APPROVED BY: SIGNED
 Colonel, CE, District Engineer

26 SEP 1978

Date

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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Bethany City Reservoir Dam
State Located	Missouri
County Located	Harrison County
Stream	Tributary to East Fork of Big Creek
Date of Inspection	July 20, 1978

Bethany City Reservoir 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 3.5 miles downstream of the dam. The damage zone runs along the edge of the town of Bethany, Missouri (population 2,900) which is about one mile downstream of the dam. Within the damage zone area are four homes with farm buildings and two improved road bridges. The flood plain is farmed.

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 spillway will pass 25% of the Probable Maximum Flood without overtopping the dam. The Probable Maximum Flood (PMF) is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. Additional deficiencies, in accordance with the guidelines, are the lack of seepage and stability analysis. These analyses should be obtained in the future.

Other deficiencies visually observed by the inspection team were many small trees and brush growing on both embankment slopes, rodent holes and burrows on the downstream slope, a small crack parallel to and downstream from the centerline of the dam, a bulged area in the embankment downstream from the crack, a boil adjacent to the pumphouse caused by a broken water main and spalling of the concrete in the cap on the spillway.

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Additional engineering investigations, at the owner's expense, are recommended as stated in the report.

Several items of preventive maintenance need to be initiated by the owner. These are described in detail in the body of the report. Copies of the report have been furnished the dam owner and the Governor of Missouri.

H. P. Hoskins E 8696
Harold P. Hoskins, P.E.
Hoskins-Western-Sonderregger, Inc.
Lincoln, Nebraska

SUBMITTED BY	SIGNED	26 SEP 1978
	Chief, Engineering Division	Date
APPROVED BY	SIGNED	26 SEP 1978
	Colonel, CE, District Engineer	Date



PHOTOGRAPH NO. 1
OVERVIEW OF LAKE AND DAM
TAKEN FROM NORTH. DAM
LOCATED IN RIGHT CENTER
OF PHOTOGRAPH.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BETHANY CITY RESERVOIR DAM - MO 10051

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of the Bethany City Reservoir Dam be made.

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

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

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth fill in a narrow valley. Topography around the dam and reservoir is gently rolling. Soils on the slopes consist of colluvium or residual materials over limestone bedrock. The dam is located parallel with and almost adjacent to U.S. Highway 69.

(2) The spillway consists of an uncontrolled concrete morning glory inlet 20.5 feet in diameter outletting into a concrete conduit six feet in diameter (see Appendix C).

(3) The controlled outlet works consist of a concrete gate tower and inlet connected with a 12-inch diameter cast iron pipe line which passes under the dam and into a pump station located at the downstream toe of the dam.

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

b. Location. The dam is located in the central portion of Harrison County, Missouri, as shown on Plate 2. The reservoir formed by the dam is shown on Plate 1 in the E 1/2 Sec. 2, T63N, R28W. The reservoir is also shown on the Bethany SE Orthophotograph (Plate 3).

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 3.5 miles downstream of the dam. The damage zone runs along the edge of the town of Bethany, Missouri (population 2,900) which is about the one mile downstream of the dam. Within the damage zone area are four homes with farm buildings and two improved road bridges. The floodplain is farmed.

e. Ownership. The dam is owned by the City of Bethany, Missouri, c/o Mike Roscoe, City Administrator, Bethany, Missouri 64424.

f. Purpose of Dam. The dam forms a 18± acre city water supply reservoir.

g. Design and Construction History. The dam was constructed in 1936. It was designed by the Kansas City firm of Burns and McDonnell. The plans show a proposed crest width of 10 feet with an additional 10 feet added to form a 20-foot wide roadway across the dam. The plans also show the spillway crest elevation at 128 feet.

A notation of elevation 130 is also shown on Sheet 4 on the elevation view of the spillway (see Appendix C). It is the opinion of the inspection team that this is the as-built elevation of the spillway instead of the 128 as originally designed. At some later date, the crest of the spillway was raised another two feet ± by the addition of a vertical sided concrete cap which covers the original lip of the spillway. (See Photo No. 3, Appendix B.)

h. Normal Operating Procedure. The controlled operational features of this dam make up a part of the city's water supply system. The water supply consists of this reservoir and the Bethany New City Reservoir located some 1.75 miles north of this reservoir. The supply lines from the two reservoirs are interconnected. Prior to construction of the Bethany New City Reservoir Dam, water was pumped from the East Branch of Big Creek into this reservoir. This procedure is not in operation at the present time, but it was reported that it is to be used in the future.

1.3 PERTINENT DATA

a. Drainage Area - 213 acres (0.333 square miles).

b. Discharge at Damsite.

(1) All flood discharge at the damsite is through an uncontrolled reinforced concrete glory-hole type drop inlet which is connected to a 72 inch diameter reinforced concrete pipe spillway.

(2) Estimated maximum flood at damsite - unknown.

(3) The emergency spillway capacity varies from 0 c.f.s. (at elevation 132 feet) to 800 c.f.s. (at elevation 134.5 feet) when the pipe spillway discharge becomes the controlling factor.

c. Elevation (Feet - Assumed Project Datum).

(1) Top of dam - 134 feet (Burns & McDonnell plans) - 133.5 feet (minimum elevation by survey of 20 July 1978).

(2) Emergency spillway crest - 128 feet (Burns & McDonnell plans) - 132 feet (survey of 20 July 1978), based on water surface elevations measured at the gate tower and observed on the spillway (see paragraph 3.1c).

(3) Streambed at centerline of dam - 100±.

(4) Maximum tailwater - unknown.

d. Reservoir. Length of maximum pool - 1100 feet ±.

e. Storage (Acre-feet). Top of dam - 222.

f. Reservoir Surface (Acres).

(1) Top of dam - 19.3 ±.

(2) Spillway crest - 17.6 ±.

g. Dam.

(1) Type - earth embankment.

(2) Length - 700 feet ±.

(3) Height - 33 feet ±.

(4) Top width - 16 feet (measured).

- (5) Side Slopes -
 - (a) Downstream - 2H on 1V (measured with abney hand level).
 - (b) Upstream (Exposed) - 3H on 1V (measured) plans show 2.5H on 1V.
- (6) Zoning - unknown.
- (7) Impervious Core - unknown.
- (8) Cutoff - Plans show concrete cutoff walls cut into clay or shale from Station 0+10 to Station 1+40 and from Station 3+85 to Station 6+75. Cutoff wall is not shown between Station 1+40 and Station 3+85 (see Sheet 2 - Appendix C).
- (9) Grout Curtain - unknown.
- (10) Wave Protection - Riprap on upstream face.
- h. Diversion and Regulating Tunnel. None.
- i. Spillway.
 - (1) Type - concrete morning glory drop inlet and 72 inch diameter reinforced concrete conduit.
 - (2) Length of weir - 64.4 feet.
 - (3) Diameter - 20.5 feet.
 - (4) Crest elevation - 132± feet.
 - (5) Conduit - Length: 232± feet.
Drop: 16 feet.
 - (6) Downstream channel - blocked with trees and brush which could affect tailwater conditions on spillway discharge.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data available are shown in Appendix C. Stability or seepage analyses were not available at the owner's office. Plan sheets in Appendix C are from copies made of plans in owner's office.

2.2 CONSTRUCTION

The dam was constructed in 1936. No other construction data were available.

2.3 OPERATION

The maximum loading or lake level that has occurred is not known. The water surface was approximately 3 feet below the crest of the spillway at the time of the inspection.

2.4 EVALUATION

- a. Availability. Construction plans are available from Burns & McDonnell, Kansas City, Missouri. It is not known whether design data relating to soil and foundation conditions, hydrology and hydraulics are available from Burns & McDonnell.
- b. Adequacy. The data available at the owner's office were not adequate to make a detailed assessment of design and construction.
- c. Validity. The available data are considered to be valid.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Bethany City Reservoir Dam was made on July 20, 1978. Members of the inspection team were: Rey Decker and Steve Nickel, geology and soil engineering; Garold Ulmer, Civil Engineer and Richard Walker, hydrology. All of the team are from Hoskins-Western-Sonderegger, Inc., Lincoln, Nebraska. Local information on the project was supplied by Mike Roscoe, Bethany City Administrator and Mrs. Premer, City Clerk. Specific observations are discussed below.

b. Dam. Many small trees and bushes are growing on the upstream slope. The face of the upstream slope is rippapped with durable limestone which looked good. No erosion or slides were evident on the upstream slope. The downstream slope is covered with tall grass, shrubs, and a few small trees. Material on the surface of the dam is lean to fat clay (CL or CH). A few fairly large rodent holes and burrows were noted on the downstream slope.

A small crack was observed parallel to and just downstream from the centerline of the dam in the area between \bar{Q} stations 4+00 and 4+30. The upper one-half of downstream slope is slightly bulged in this area (see measured sections shown in Appendix C).

Seepage was existing along the north section of the downstream toe of the dam from about centerline stations 3+00 to 5+00 (see photo 12). The seepage discharge was clear and estimated at about 0.25 gal/min. No seepage was observed along the toe south of the pumphouse in the area where the concrete cutoff had been installed. A boil adjacent to the pumphouse was discharging an estimated 2 gal/min (see photo 6). The effluent was clear. It was reported by Mr. Roscoe that this boil results from a broken water line entering the pump station. There was no evidence of other boils or piping on the downstream slope or toe.

Fractured limestone bedrock was exposed in the north abutment above the crest elevation of the dam. The south abutment was mantled with CL soil.

c. Appurtenant Structures. The plans show the design crest elevation of the spillway at 128 feet. Field measurements were based on the elevation of 134 feet indicated on the plans as being the top of the gate tower. Measurement from the top of the gate tower indicated a water surface elevation of 128.9 feet or 0.9 feet above the design spillway crest. Photo No. 3 shows no water flowing into the spillway. The inspection team estimated that the water surface was $3\pm$ feet below the crest of the

spillway which added to the water surface elevation of 128.9 feet would place the crest of the spillway at 132 feet \pm . It is the opinion of the inspection team that the spillway crest elevation was changed from 128 feet to 130 feet during construction and that at some later date, a two foot depth vertical sided concrete cap was added to increase the crest elevation from 130 feet to 132 feet (see paragraph 1.2g). The addition of the concrete cap resulted in a cold joint, and the area above the joint was spalled. The concrete in the gate tower appeared to be in good shape. However, the access bridge was in poor condition.

As discussed in paragraph 3.1a, above, a water supply line entering the pump house is broken and discharging water at the rate of about 2 gal/min.

d. Reservoir Area. Wave erosion was evident along a section of the shoreline (300 to 400 feet) on the southeast side of the lake. The remainder of the shoreline looked good. Limestone bedrock is exposed along a portion of the north shore of the lake.

e. Downstream Channel. Spillway discharge flows into a covered concrete box which outlets through a concrete culvert under U.S. Highway 69. The culvert appears to have adequate capacity to pass the maximum spillway discharge. The outlet channel downstream from the highway culvert is not well defined and is lined with trees and brush (see photo 21).

3.2 EVALUATION

The conditions observed that require immediate remedial action and additional investigations are the broken water line which is discharging very near the toe of the dam, and the apparent shear failure (slide) on the downstream slope. The possibility exists that the centerline crack (Sta. 4+00 \pm to 4+30 \pm), the embankment bulge (Sta. 4+00 \pm to Sta. 4+30 \pm) and the seepage (Sta. 3+00 \pm to Sta. 5+00 \pm) are related, and could indicate a serious embankment problem. This problem warrants an investigation in the near future by an engineer who is experienced and competent in soil mechanics and earth dam design. Vegetation on the upstream and downstream slopes could lead to potential of failure if left uncontrolled. The trees and brush growing on the embankment slopes should be removed. Continued spalling of the spillway cap could ultimately lead to deterioration of the top of the spillway. Seepage along the right side of the downstream toe does not appear to seriously affect the integrity of the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The only operating procedures existing at this dam are those relating to the maintenance of the water supply to the water tower for the City of Bethany.

4.2 MAINTENANCE OF DAM

Maintenance of the dam seems to be reasonably good. The trees and brush on the upstream and downstream slopes should be removed. (See paragraph 3.2.) Maintenance of the concrete spillway has been neglected.

4.3 MAINTENANCE OF OPERATING FACILITIES

Maintenance of one of the water lines entering the pump house has been neglected. Other operating facilities are apparently in satisfactory condition.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

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

4.5 EVALUATION

Vegetation left uncontrolled on the upstream and downstream faces and flow from the leaky pipeline, if not eliminated, could lead to potential of failure. (See paragraph 3.2.)

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Pertinent hydraulic and hydrologic data which were taken from as-built plans furnished by Burns and McDonnell, consulting Engineers, are tabulated in Appendix D on Hydrologic Computations. The supporting computations are attached.

b. Experience. The drainage area and lake surface data are developed from U.S.G.S. Bethany, Missouri fifteen minute topographic maps and/or orthophoto sheets. The spillway and dam layout are from as-built plans and surveys made during inspections. One major discrepancy was found in the hydraulic structural component of the spillway. An approximate 2 foot + lift had been added to the morning glory spillway. In addition a 2 foot+ unexplained difference exists between what appears to be the top of the original spillway crest and that elevation as shown on the original as-built plans. (See paragraphs 1.2g and 3.1.c.)

c. Visual Observations

(1) Spillway appears in fair condition except as noted. Some spalling off and cracking was noted in the construction joint for the additional lift.

(2) Concrete in gate tower looks good.

d. Overtopping Potential. The spillway is too small to pass the 1/2 PMF and the PMF. The spillway will just pass the 100-yr. frequency flood without overtopping. The spillway will pass the 25% PMF without overtopping. The results of the routings through the reservoir are tabulated in regards to the following conditions.

<u>Frequency</u>	<u>Peak Inflow Discharge c.f.s.</u>	<u>Peak Outflow Discharge c.f.s.</u>	<u>Maximum Pool Elevation</u>	<u>Freeboard Top of Dam Min. Elev. 133.5</u>	<u>Dam Time Overtopping Hours</u>
100-Yr.	400	300	133.4	+0.1	-
1/2 PMF	1000	1000	134.1	-0.6	2.25
PMF	2100	2000	134.6	-1.1	5.55
25% PMF	500	400	133.5	0	-

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 a small size. Therefore, the PMF is the test for the adequacy of the dam and its spillways.

The St. Louis District, Corps of Engineers in a letter dated 13 July 1978 has estimated the damage zone as extending 3.5 miles downstream from the dam. The damage zone runs along the edge of the town of Bethany, Missouri, (population 2,900) which is about one mile downstream from the dam. Within the damage zone area are four homes with farm buildings, five improved road bridges, and one railroad bridge. These facts were verified by field inspection.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations which adversely affect the stability of this dam have been discussed in Sections 3 and 4.

b. Design and Construction Data. Design and Construction data available were not sufficient to make a detailed evaluation of the structural stability of the dam.

c. Operating Records. The only operational records are those pertaining to the supply and demand for water by the City of Bethany. These records were not examined.

d. Post Construction Changes. A two foot+ depth vertical-sided concrete cap has been constructed on the morning glory spillway. Raising the crest of the spillway affects the hazards of overtopping the dam. (See paragraphs 1.2g., 3.1c. and 7.1a.)

e. Seismic Stability. This dam is located in Seismic Zone 1. An earthquake of this magnitude is not expected to affect the structural stability of this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Items noted during the visual inspection that should be corrected or controlled are: trees on the upstream slope, spalling below the crest of the concrete spillway and the leak in the waterline which apparently causes the boil at the downstream toe. The extent of seepage under the dam could be better assessed after the leak in the waterline has been eliminated.

Additional investigations are necessary to determine the structural stability of the downstream slope.

With the spillway crest elevation at 128 feet, as originally planned, the spillway would pass the one-half probable maximum flood with $2.7' \pm$ freeboard. The PMF would overtop by approximately 1 foot. The suspected change during construction which raised the elevation of the spillway crest to 130 feet resulted in the following: The spillway would pass the one-half PMF with approximately 0.9 foot freeboard. The PMF would overtop by approximately 1.1 feet. The subsequent addition of the $2' \pm$ vertical-sided concrete cap to the spillway resulted in the following: The spillway would pass the 100 year frequency with $0.1 \text{ foot} \pm$ freeboard. The one-half PMF would overtop by approximately 0.64 foot and the PMF would overtop by approximately 1.13 feet. (See paragraph 5.1d.)

b. Adequacy of Information. The only engineering data available on design and construction are shown in Appendix C. These data along with visual observations are considered sufficient to support the conclusions given in this report. Seepage and stability analyses were not found which is a deficiency that should be corrected in the future.

d. Necessity for Phase II. Phase II investigations are not being called for. Additional engineering investigations should be made in the near future at the owner's expense to determine the properties and conditions of the present embankment and foundation materials. The results of test borings and soil mechanics tests should be used to analyze the stability of the downstream slope from the standpoint of shear strength and seepage pressures.

In addition surveys should be conducted to determine accurately the elevation of the crest of the dam in relation to the evaluation of the spillway crest. Evidence from hand level survey and visual observation indicates a maximum of $1.5 \text{ feet} \pm$ freeboard when water rises to spillway crest elevation.

The investigations and evaluation of data should be by an engineer who is competent and knowledgeable in soil mechanics and earth dam design. (See paragraph 3.2.)

e. Seismic Stability. The stability of this structure is not expected to be adversely affected by the magnitude of an earthquake in Seismic Zone 1.

7.2 REMEDIAL MEASURES

a. Alternatives.

(1) Remove the 2'± vertical sided concrete cap from the morning glory spillway and construct a vegetated earth emergency spillway which will supplement the existing spillway and permit the passage of the Probable Maximum Flood without overtopping.

(2) If the 2'± concrete cap is not removed increase the height of the dam and construct a vegetated earth emergency spillway as stated above.

(3) Stabilize the downstream slope by means of flatter slopes, berms and/or toe drains should the additional engineering investigations indicate the need.

(4) The alternative measures above should be done from plans prepared by an engineer who is experienced and competent in earth dam design.

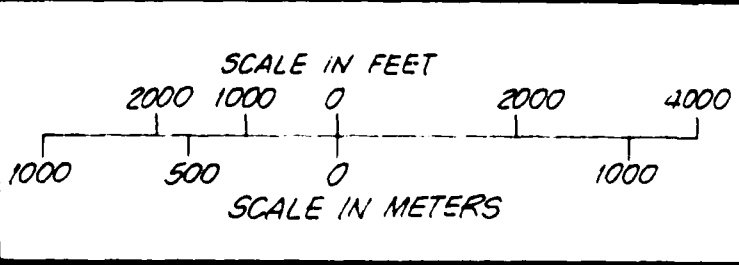
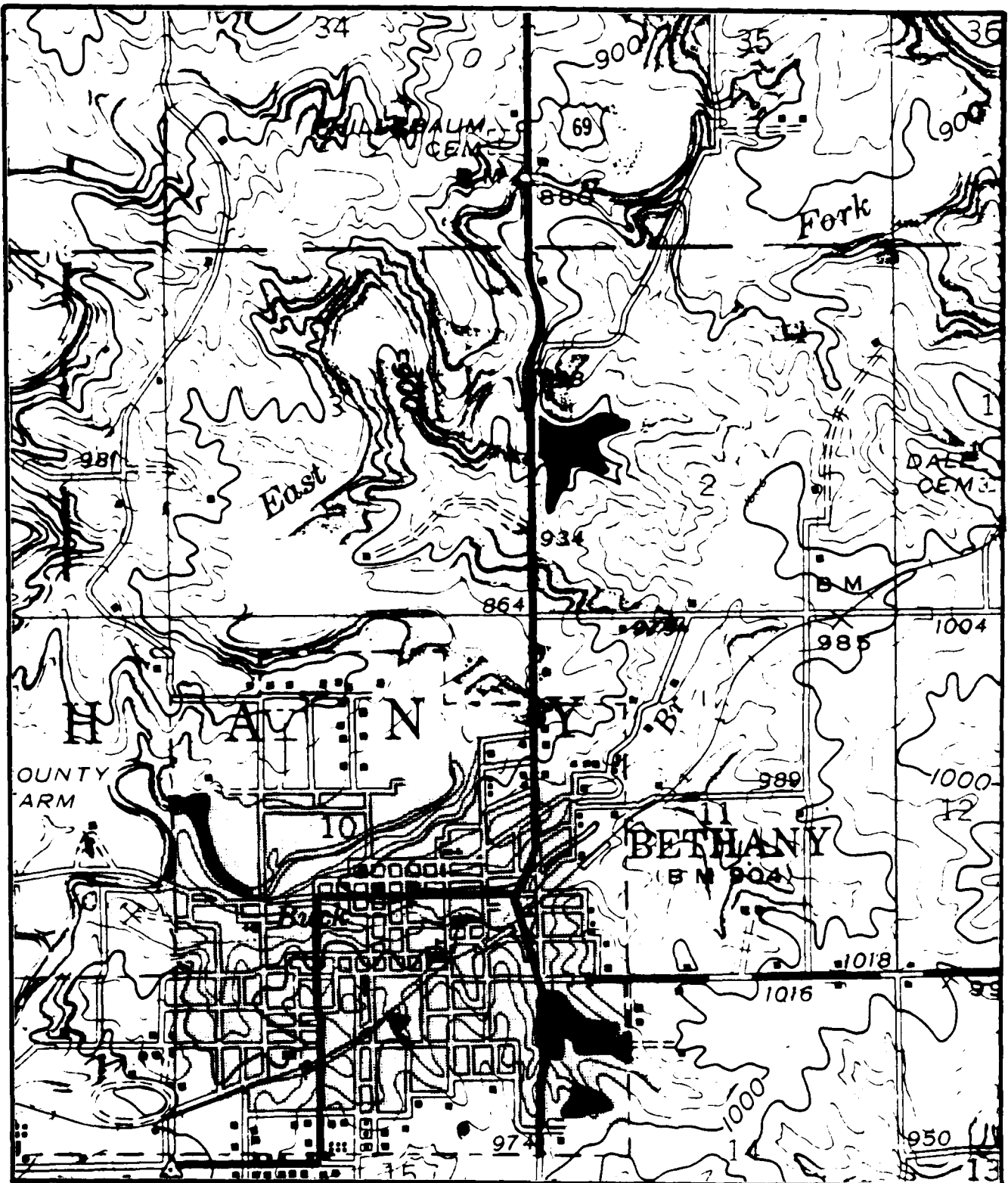
b. O & M Maintenance and Procedures.

(1) The trees (all relatively small) and/or brush on the upstream and downstream slopes should be removed and measures initiated to prevent their recurrence. If left uncontrolled, this vegetation could lead to potential of failure. (See paragraph 3.2.)

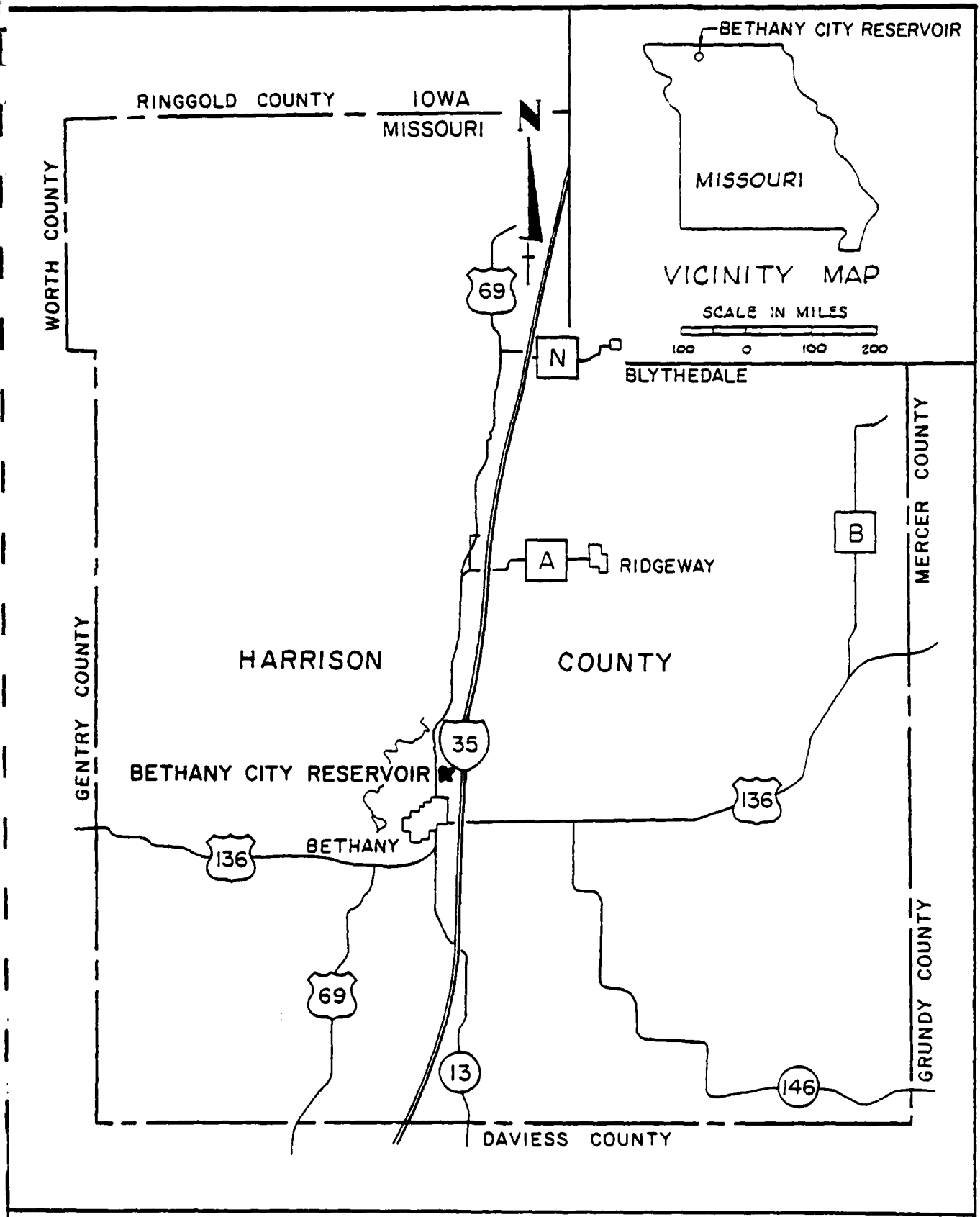
(2) The leak in the water supply line near the toe of the dam should be repaired in the near future. This leaky pipeline could lead to serious potential of failure of the dam. Regular inspections of the water supply system should be scheduled to assure the integrity of the system.

(3) If the concrete cap on the spillway is to remain the areas where spalling is occurring should be repaired.

APPENDIX A
MAPS



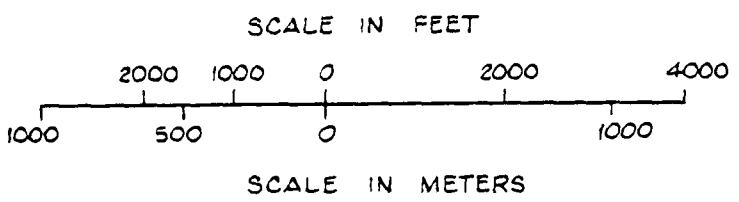
BETHANY
 CITY RESERVOIR
 VICINITY TOPOGRAPHY
 PLATE 1



LOCATION MAP
PLATE 2



BETHANY



BETHANY
CITY RESERVOIR
ORTHOGRAPH
PLATE 3

APPENDIX B
PHOTOGRAPHS



PHOTO. NO. 2
GATE TOWER
TAKEN FROM DAM.

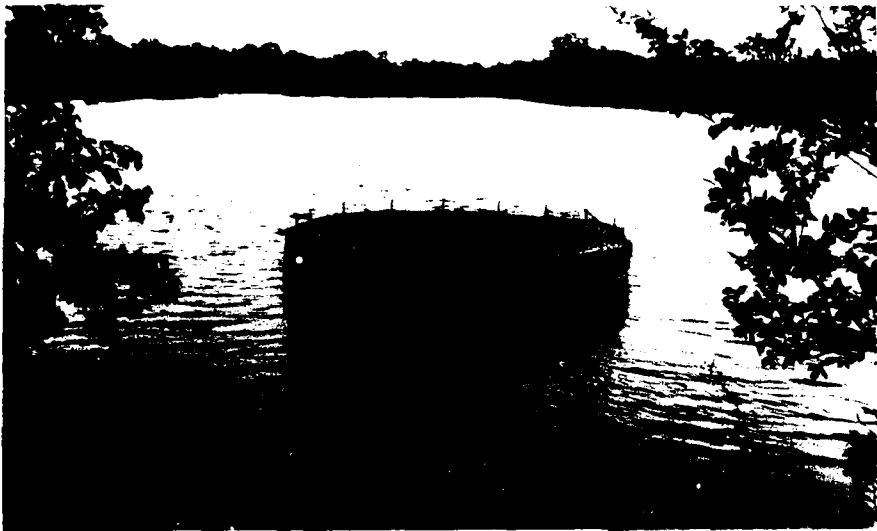


PHOTO. NO. 3
SPILLWAY TAKEN
FROM DAM LOOKING
NORTHEAST.



PHOTO. NO. 4
TAKEN FROM SOUTH
LOOKING ALONG
CENTERLINE.



PHOTO. NO. 5
UPSTREAM SLOPE
TAKEN FROM
SOUTH LOOPING
NORTH.



PHOTO. NO. 6
POND AND BOIL
UNDER PUMPHOUSE
STEP. DOWNSTREAM
FROM C STA. 4+20±.



PHOTO. NO. 7
FLOW FROM BOIL
AT PUMPHOUSE.

PHOTO. NO. 8
DOWNSTREAM
SLOPE OF DAM.



PHOTO. NO. 9
GLORY HOLE
SPILLWAY.



PHOTO. NO. 10
SHORE EROSION
ON EAST SIDE.





PHOTO. NO. 11
PUMPHOUSE FROM
CENTERLINE STA.
4+20.



PHOTO. NO. 12
SEEP BELOW
CENTERLINE
STATION 4+50.



PHOTO. NO. 13
CATTAIL GROWTH
AT TOE OF DAM AT
STA. 5+00. LOOKING
NORTH FROM HIGHWAY.



PHOTO. NO. 14
ONE-HALF INCH WIDE
CRACK IN CREST
PARALLEL WITH
CENTERLINE. STA
4+00 TO STA. 4+30.



PHOTO. NO. 15
LIMESTONE ON
NORTH ABUTMENT.
STA. 6+90⁺.



PHOTO. NO. 16
VIEW OF WATERSHED.
TAKEN FROM GOLF
COURSE CLUBHOUSE
NORTH OF LAKE
LOOKING NORTHEAST.



PHOTO. NO. 17
VIEW OF WATERSHED
TAKEN FROM GOLF
COURSE CLUBHOUSE
NORTH OF LAKE
LOOKING EAST.



PHOTO. NO. 18
VIEW OF WATERSHED
TAKEN FROM GOLF
COURSE CLUBHOUSE
NORTH OF LAKE
LOOKING SOUTHEAST.



PHOTO. NO. 19
VIEW OF WATERSHED
TAKEN FROM GOLF
COURSE CLUBHOUSE
NORTH OF LAKE
LOOKING SOUTH.

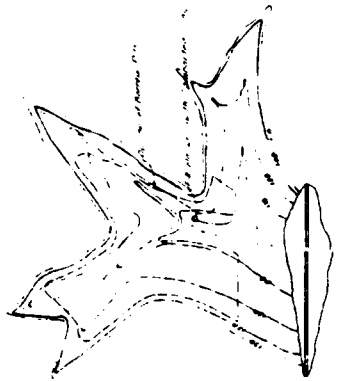


PHOTO. NO. 20
SPILLWAY OUTLET
UNDER HIGHWAY.
LOOKING UPSTREAM.
DAM IN BACKGROUND.

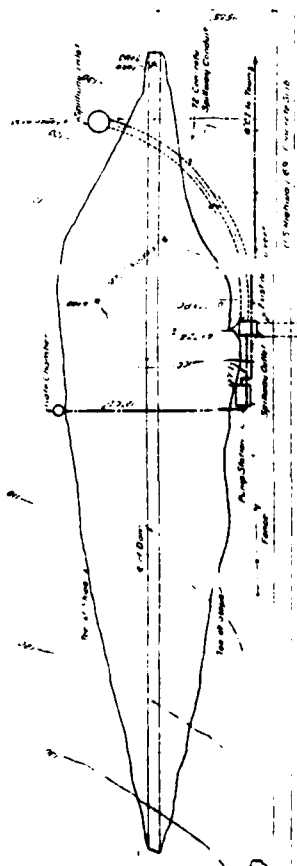


PHOTO. NO. 21
OUTLET CHANNEL
FROM HIGHWAY
LOOKING DOWNSTREAM.

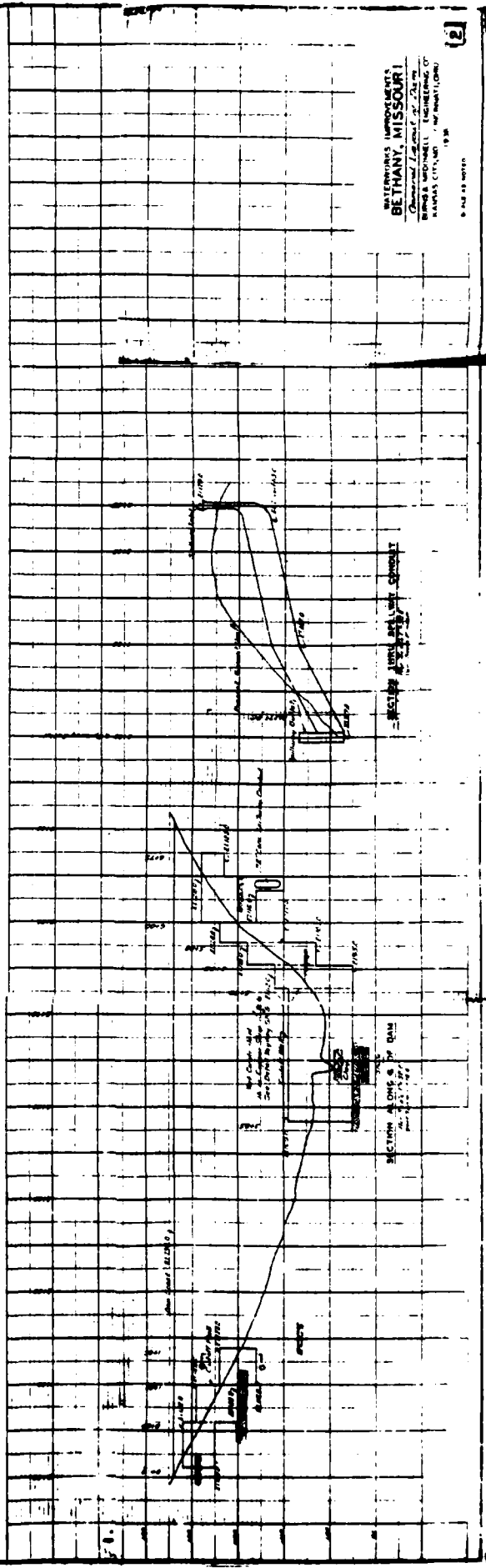
APPENDIX C
PLANS AND REPORTS



MAP OF RESERVOIR SITE
Scale 1:2000



GENERAL LAYOUT OF DAM
Scale 1:1000



ENGINEERING IMPROVEMENTS
BETHANY, MISSOURI
Designed by
BRADY & WOODRUFF, ENGINEERS OF
BETHANY, MISSOURI

1
2

3113

3100

3150

3200

3150

3100

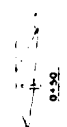
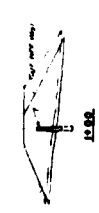
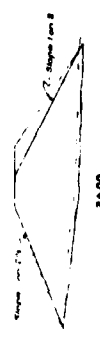
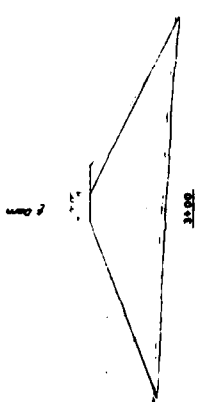
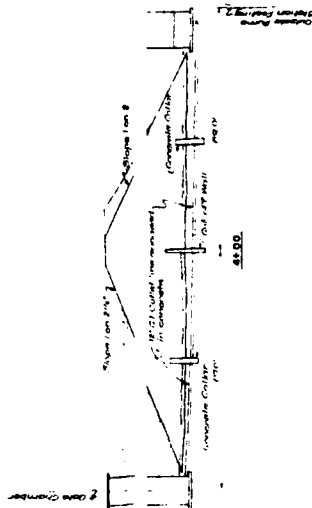
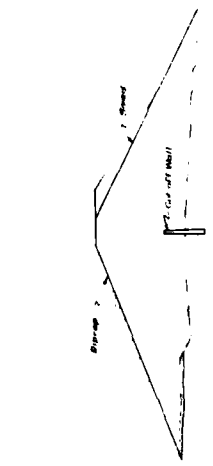
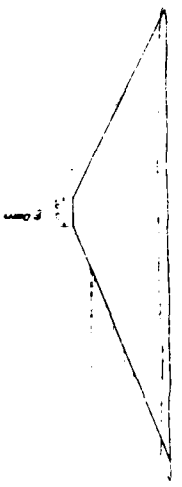
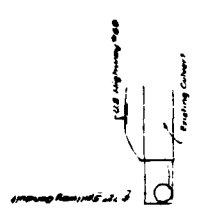
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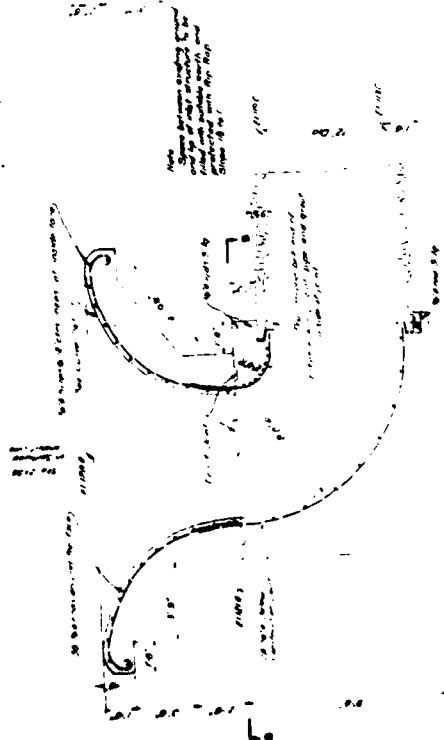
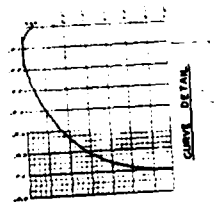
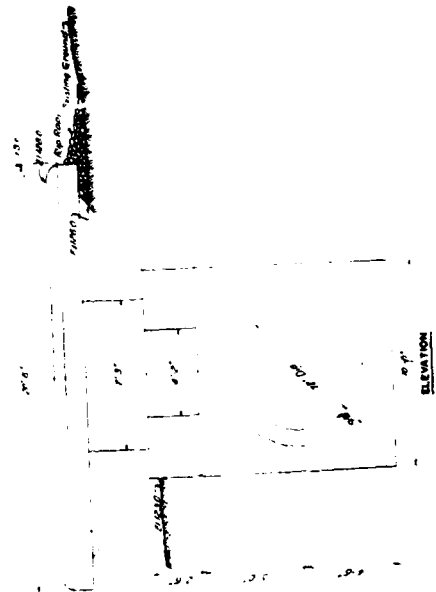
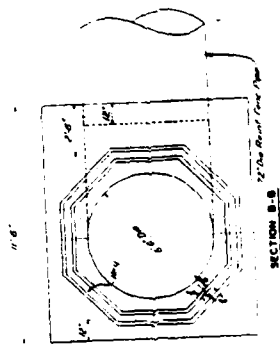


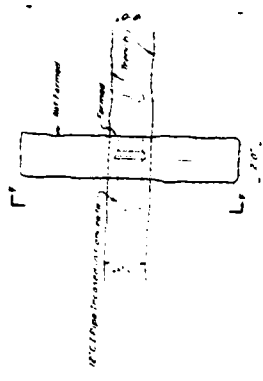
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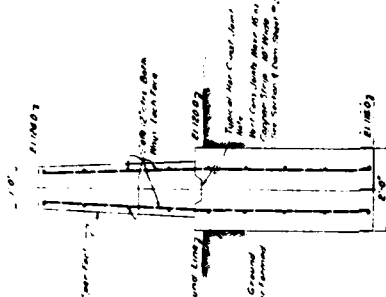
WATERWORKS IMPROVEMENTS
BETHANY, MISSOURI
 BERRY & MCGHEE, ENGINEERS, LTD.
 KANSAS CITY, MO.
 1918

MISSOURI ARCHITECTS
 BETTANY MISSOURI
 312 WEST 10TH STREET
 KANSAS CITY, MO. 64105

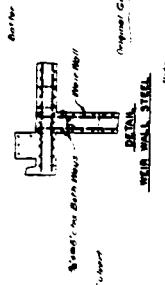




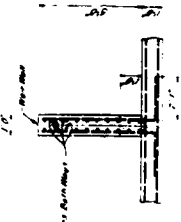
SECTIONAL PLAN OF OUTLET PIPE COLLAR
Scale 1/2" = 1'-0"



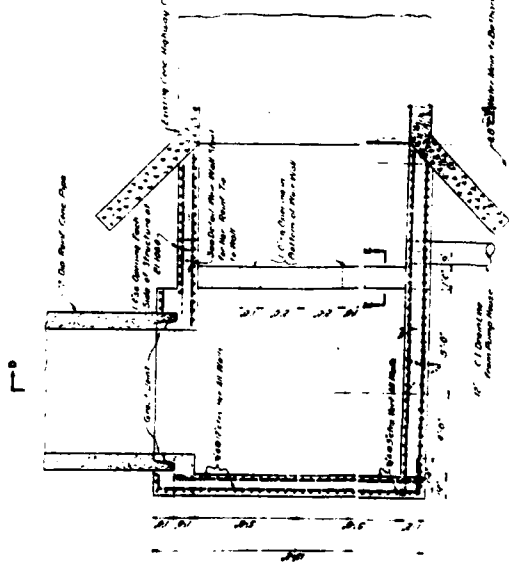
DETAIL OF CONCRETE CUT OFF WALL
TYPICAL SECTION G-B
Scale 1/2" = 1'-0"



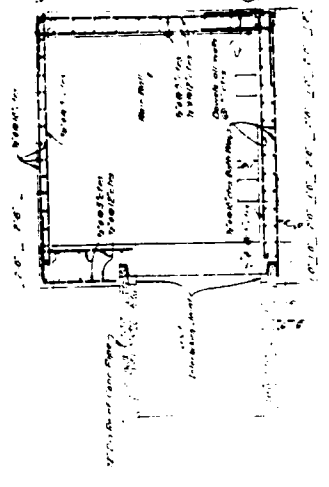
DETAIL OF REINFORCING STEEL



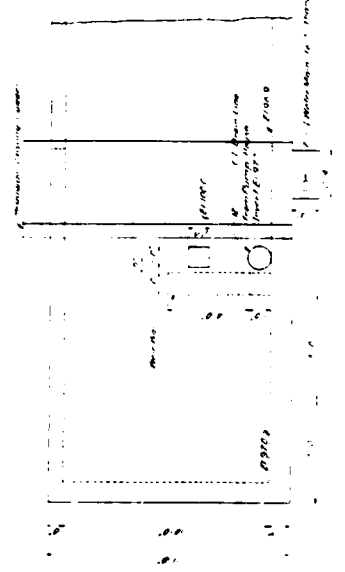
SECTION E-E



SECTIONAL PLAN E-C



SECTION D-D

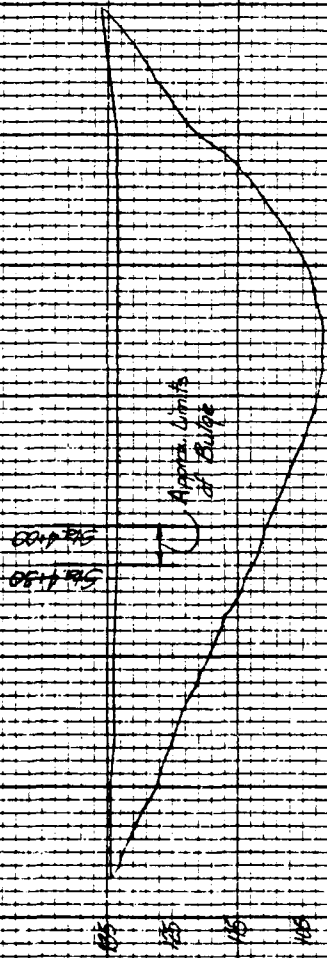


SECTION F-F

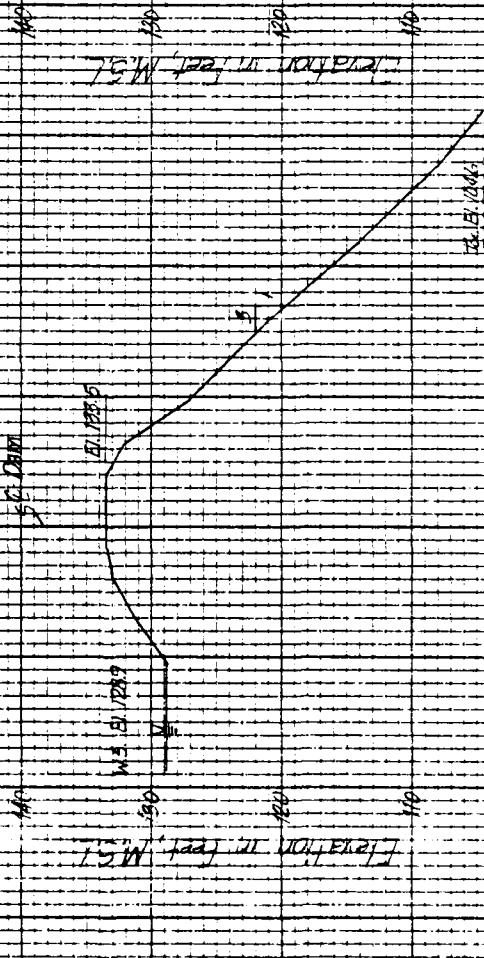
WATERWORKS IMPROVEMENTS
BETHANY, MISSOURI
DESIGNED BY
ENGINEER
BANKS & WATSON, L. ENGINEERING CO.
BETHANY, MISSOURI
DATE: 10-1-1910

BETHANY CITY RESERVOIR DAM
National Dam Safety Program

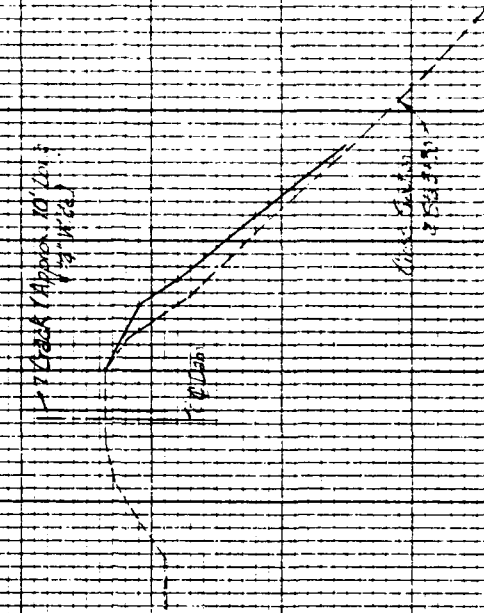
PHASE I



Profile



Cross Section @ Sta 5+30.30



Cross Section @ Sta 5+42.0

APPENDIX D
HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Mockes dimensionless standard curvilinear 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, 12-hour, and 24-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 Hydro-meteorological Report No. 33 and current OCE directives furnished 3 August 1978.

b. Drainage area = 0.333 square miles.

c. Time of concentration of runoff = 16 minutes.

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 principal spillway.

e. The total 24-hour storm duration losses for the 100-year storm were 1.82 inches. The 100-year storm is a 0.23 PMF storm. The total losses for the 24-hour duration 1/2 PMF storm were 2.05 inches. The total losses for the PMF storm were 2.15 inches. These data are based on SCS runoff curve No. 84 and antecedent moisture conditions from SCS AMCIII.

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

2. The flows over the spillway and the dam crest are based on the broad crested weir equation ($Q = CLH^{3/2}$), where H is the head on the dam crest; the coefficient C, which varies with head, is taken from the USGS publication "Measurement of Peak Discharge at Dams by Indirect Methods: Book 3, Chapter 5, TWRI".

3. Floods were routed through the spillway using the TR-20 program to determine capability of the spillway and dam embankment crest. The storm rainfall patterns, inflow hydrographs and routed outflow hydrographs are given on Plate D1.

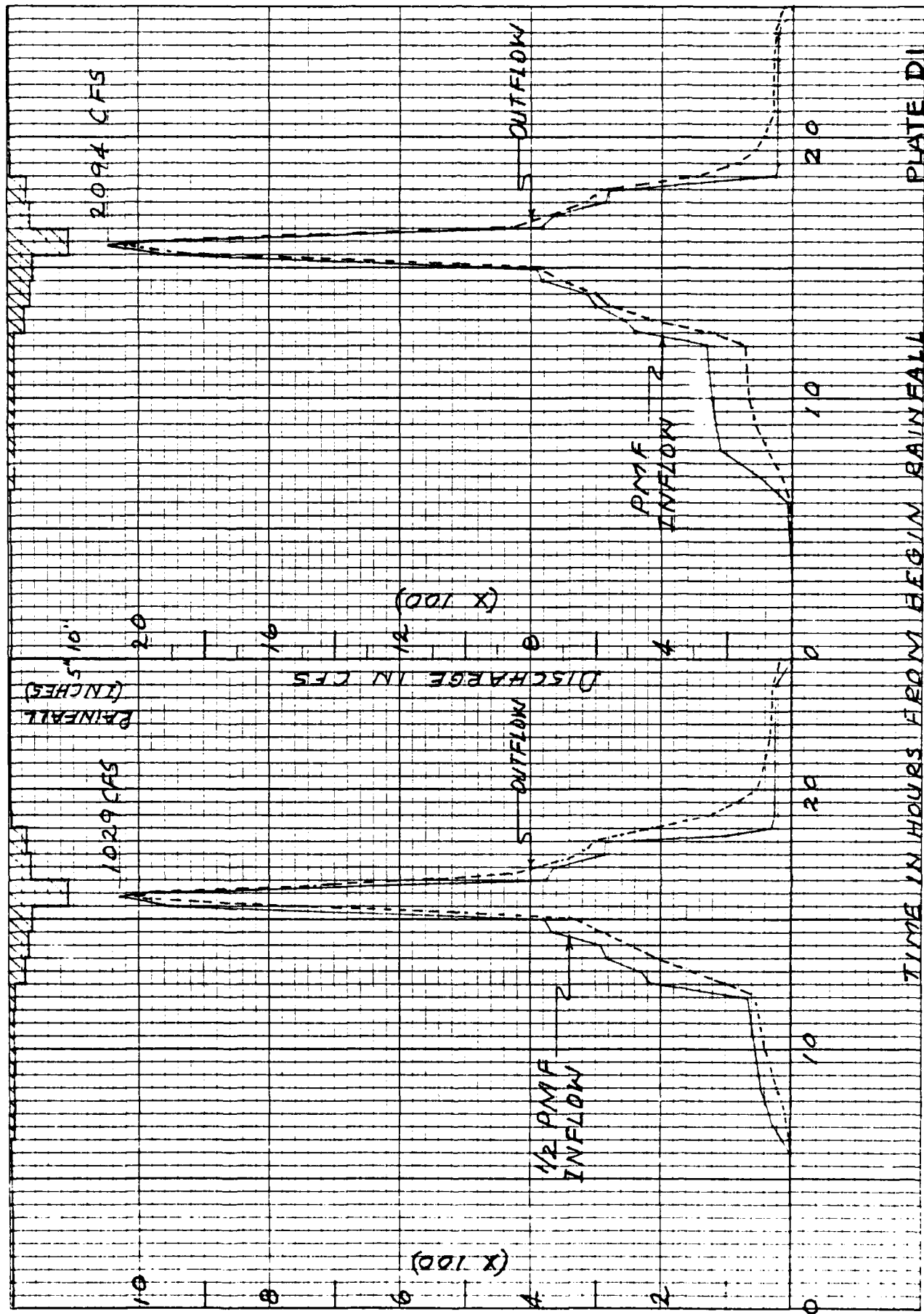


PLATE DI