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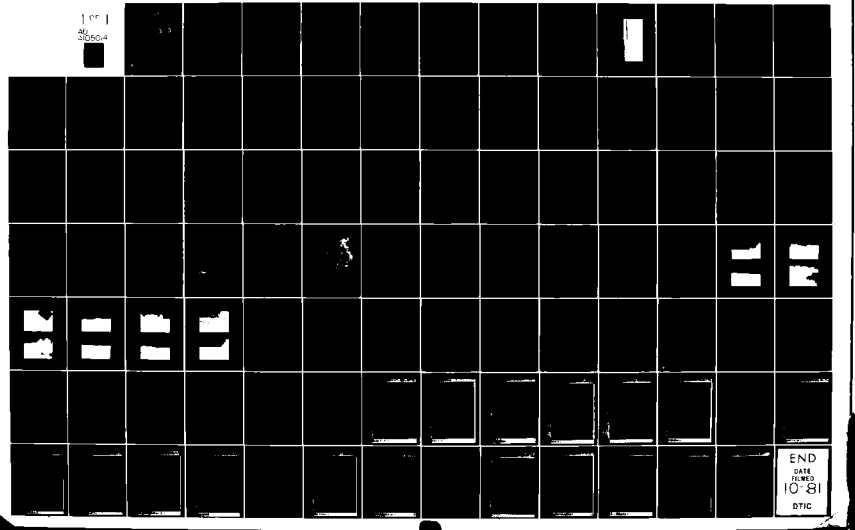

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AD A105014

ZANDER LAKE DAM
MONTGOMERY COUNTY, MISSOURI
MO. 10593

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Zander Lake Dam (MO 10593),
Missouri - Kansas City River Basin,
Montgomery County, Missouri. Phase I
Inspection Report.

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St. Louis District

(15) DACW43-80-C-0094

(11) Sep 80 (9) Final rept.,

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

FOR: STATE OF MISSOURI

SEPTEMBER, 1980

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
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4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Zander Lake Dam (MO 10593) Montgomery County, Missouri	5. TYPE OF REPORT & PERIOD COVERED Final Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Consoer, Townsend and Associates, Ltd.	8. CONTRACT OR GRANT NUMBER(s) DACW43-80-C-0094
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

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

REPLY TO ATTENTION OF

SUBJECT: Zander Lake Dam (Mo. 10593) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Zander Lake Dam (Mo. 10593).

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 — 15 OCT 1980 Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer — 15 OCT 1980 Date

ZANDER LAKE DAM
MONTGOMERY COUNTY, MISSOURI

MISSOURI INVENTORY NO. 10593

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
CONSOER, TOWNSEND AND ASSOCIATES, LTD.
ST. LOUIS, MISSOURI
AND
PRC ENGINEERING CONSULTANTS, INC.
ENGLEWOOD, COLORADO
A JOINT VENTURE

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

SEPTEMBER 1980

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Zander Lake Dam, Missouri Inv. No. 10593
State Located: Missouri
County Located: Montgomery
Stream: An unnamed tributary of the Scratchers Branch of the Little Loutre Creek
Date of Inspection: June 6, 1980

Assessment of General Condition

Zander Lake Dam was inspected by the engineering firms of Consoer, Townsend and Associates, Ltd. and PRC Engineering Consultants, Inc. (A Joint Venture) of St. Louis, Missouri according to the U. S. Army Corps of Engineers "Engineer Regulation No. 1110-2-106" and additional guidelines furnished by the St. Louis District of the Corps of Engineers. Based upon the criteria in the guidelines, the dam is in the high hazard potential classification, which means that loss of life and appreciable property damage could occur in the event of failure of the dam. Within the estimated damage zone of four miles downstream of the dam are four dwellings, and two sheds, which may be subjected to flooding, with possible damage and/or destruction, and possible loss of life. However, the hazard classification is questionable for this dam due to the fact that the dwellings mentioned above do exist along the estimated downstream damage zone but it is unknown whether the dwellings do indeed lay in the estimated damage zone. To determine the actual damage zone would require a combined breach and flood routing analysis which is beyond the scope of a Phase I inspection. Zander Lake Dam is in the small size classification since it is less than 40 feet in height and impounds less

than 1,000 acre-feet of water.

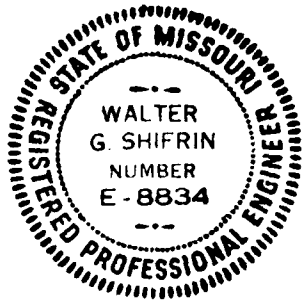
Our inspection and evaluation indicates that the spillway of Zander Lake Dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. Zander Lake Dam being a small size dam with a high hazard potential is required by the guidelines to be able to pass from one-half of the Probable Maximum Flood (PMF) to the Probable Maximum Flood without overtopping the dam. Considering the questionable downstream damage zone the one-half of the PMF is considered the appropriate spillway design flood for Zander Lake Dam. It was determined that the reservoir/spillway system can accommodate approximately 45 percent of the Probable Maximum Flood before overtopping of the dam occurs. Our evaluation also indicates that the reservoir/spillway system will accommodate the one-percent chance flood (100-year flood) without overtopping the dam.

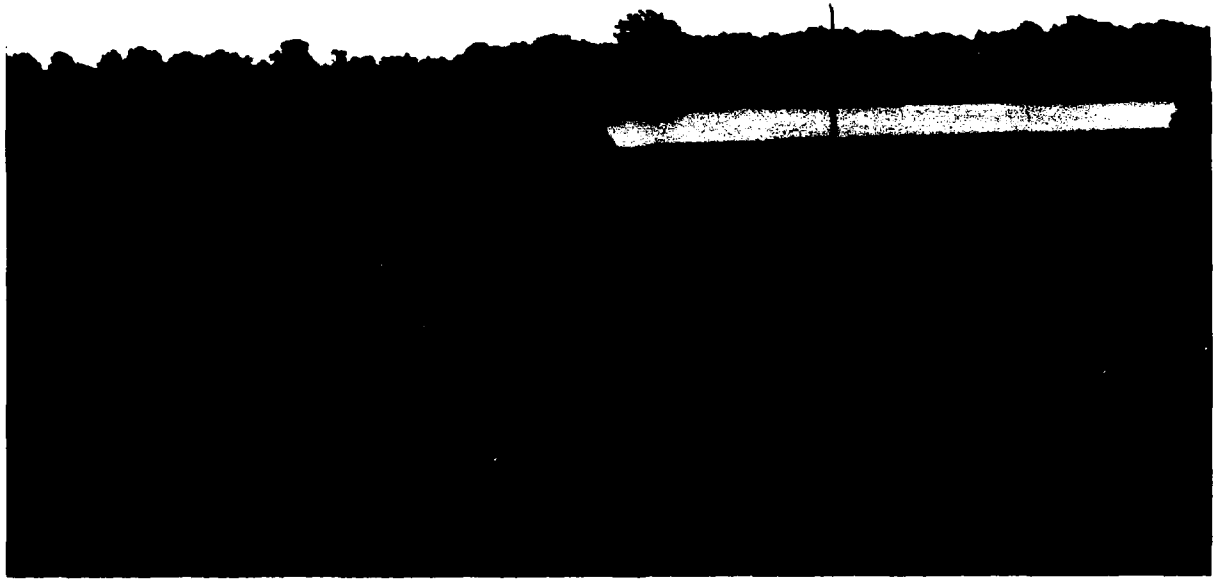
The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region.

Zander Lake Dam and its appurtenant structures appeared to be in fair condition. However, some deficiencies were noted by the inspection team which could affect the safety of the dam and appurtenant structures. These items are as follows: the wave erosion on the upstream slope; the evidence of the rodent activity on the embankment; the small saplings, bushes, and tall vegetation on the embankment; the piles of gravel, bales of hay, reeds, and unmaintained vegetation in the spillway discharge channel; a need for periodic inspection by a qualified engineer; and a lack of a maintenance schedule. The lack of seepage and stability analyses on record is also a deficiency that should be corrected.

It is recommended that the owner take action to correct or control the deficiencies described above.

Walter G. Shifrin, P.E.





Overview of Zander Lake Dam

NATIONAL DAM SAFETY PROGRAM

ZANDER LAKE DAM, I.D. No. 10593

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

ZANDER LAKE DAM, Missouri Inv. No. 10593

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The Dam Inspection Act, Public Law 92-367 of August, 1972, authorizes the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspections. Inspection for Zander Lake Dam was carried out under Contract DACW 43-80-C-0094 between the Department of the Army, St. Louis District, Corps of Engineers, and the engineering firms of Consoer, Townsend & Associates, Ltd., and PRC Engineering Consultants, Inc. (A Joint Venture), of St. Louis, Missouri.

b. Purpose of Inspection

The visual inspection of Zander Lake Dam was made on June 6, 1980. The purpose of the inspection was to make a general assessment regarding the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

This report summarizes available pertinent data relating to the project, provides a summary of visual observations made during the field inspection, gives an assessment of hydrologic and hydraulic conditions at the site, presents an evaluation of the

structural adequacy of the various project features and appraises the general condition of the dam with respect to safety.

Subsurface investigations, laboratory testing and detailed analyses were not within the scope of this study. No warranty as to the absolute safety of the project features is implied by the conclusions presented in this report.

It should be noted in this report that reference to left or right abutments is viewed as looking downstream. Where left abutment or left side of the dam is used in this report, this also refers to the west abutment or side, and right abutment or right side to the east abutment or side.

d. Evaluation Criteria

The inspection and evaluation of the dam is performed in accordance with the U.S. Army Corps of Engineers "Engineer Regulation No. 1110-2-106" and additional guidelines furnished by the St. Louis District office of the Corps of Engineers for Phase 1 Dam Inspections.

1.2 Description of the Project

a. Description of Dam and Appurtenances

The following description is based upon observations and measurements made during the visual inspection and conversations with Mr. Robert Starr, the contractor who designed and constructed the dam. No design drawings for the dam or appurtenant structures were available.

The dam is a homogeneous, rolled, earthfill structure with a straight alignment between earth abutments. Photos 1 through 3 show views of the embankment. The dam has an axis length of 560 feet between the spillway and the right abutment. The top width

varies from 7 to 10 feet. The top of dam varies in elevation. From the emergency spillway at the left side of the embankment, the top of dam slopes upward to a point approximately 160 feet to the right of the right edge of the spillway with an elevation gain of 1.1 feet. From this point, the top of dam is level for a distance of 280 feet to a point 120 feet from the right abutment; then for the last 120 feet the top of dam slopes upward to the right abutment with a rise in elevation of 1.0 foot (see Plate 2). The minimum elevation of the top of dam is approximately 770.4 feet above mean sea level (M.S.L.). The maximum structural height of the dam was measured to be 17.5 feet. The upstream slope above the water surface was measured as 1 vertical to 3 horizontal (1V to 3H). The downstream slope was also measured to be 1V to 3H. A 12- to 13-foot wide core trench was excavated parallel to the dam axis, according to Mr. Starr.

The dam was constructed with only one spillway which operates as an open channel. When measured at the axis of the dam, it is a trapezoidal channel with a 30-foot bottom width, an 88-foot top width, and side slopes of about 1V to 8H on the left and approximately 1V to 18H on the right. It is cut into the left abutment and its crest elevation is 768 feet above M.S.L. (assumed), which places it 2.4 feet lower than the minimum top of dam. After passing the crest, which is level for a distance of 14 feet, excess water flows into a discharge channel which has a slope of 5 to 6 percent and a cross section which is generally a wide swale (see Photo 7). The discharge channel directs flows away from the dam parallel to a county road before generally curving to the right and into the downstream channel. There is a 4-foot drop over which water flows from the discharge channel into the downstream channel. The discharge channel generally does not have any real definition to it; i.e., it seems that the flow would meander from the area of the crest to the downstream channel.

No low level outlets or outlet works were provided for this dam.

b. Location

Zander Lake Dam is located in Montgomery County of the State of Missouri on an unnamed tributary of the Scratchers Branch of the Little Loutre Creek. The dam is located approximately 3 miles northwest of Montgomery City in the northeast corner of Section 22 of Range 6 West, Township 49 North as shown on the Wellsville, Missouri Quadrangle (7.5 minute series) sheet.

c. Size Classification

Zander Lake Dam impounds less than 1000 acre-feet but more than 50 acre-feet which classifies it as a "small" dam. The maximum structural height is less than 25 feet which is the minimum height requirement for a structure to be classified as a dam. Nevertheless, the size classification is determined by either the storage or the height, whichever gives the larger size category. Therefore, the size classification is determined to fall within the "small" category according to the "Engineer Regulation No. 1110-2-106, Appendix D" by the U.S. Department of the Army, Office of the Chief Engineer.

d. Hazard Classification

The dam has been classified as having a "high" hazard potential in the National Inventory of Dams, on the basis that in the event of failure of the dam or its appurtenances, excessive damage could occur to downstream property, together with the possibility of the loss of life. Based upon a visual inspection of the downstream area there are four dwellings and two sheds located along the estimated damage zone, which extends approximately four miles downstream of the dam (see Photos 11 and 12). However, it is questionable whether or not the dwellings mentioned above do indeed

lay within the estimated damage zone. To determine the actual damage zone would require a combined breach and flooding routing analysis which is beyond the scope of a Phase I inspection.

e. Ownership

Zander Lake Dam is owned privately by Mr. Richard Zander. The mailing address is as follows: Mr. Richard A. Zander, 219 First Capital Plaza, St. Charles, Missouri, 63301.

f. Purpose of Dam

The purpose of the dam is to impound water for recreational use as a private lake.

g. Design and Construction History

Mr. Robert Starr of Montgomery City, Missouri designed and constructed Zander Lake Dam in 1968. Mr. Starr was the owner of the property when the dam was constructed. The dam was built without plans and specifications.

h. Normal Operational Procedures

Normal procedure is to allow the reservoir to remain as full as possible. The water level is controlled by rainfall, runoff, evaporation and the elevation of the spillway crest.

1.3 Pertinent Data

a. Drainage Area (square miles):. 0.18

b. Discharge at Damsite

Estimated experienced maximum flood (cfs): . . . . . Unknown

Estimated ungated spillway capacity with reservoir at minimum top of dam elevation (cfs): . . . 600

c. Elevation (Feet above MSL)

Top of dam (minimum):. 770.4

Spillway crest:. . . . . 768.0 (Assumed)

Normal Pool: 768.0

Maximum Experienced Pool:. . . . . Unknown

Observed Pool: 768.0

d. Reservoir

Length of pool with water surface at top of dam elevation (feet):. 1400

e. Storage (Acre-Feet)

Top of dam (minimum):. 81

Spillway crest:. 59

Normal Pool: 59

Maximum Experienced Pool:. . . . . Unknown

Observed Pool: 59

f. Reservoir Surfaces (Acres)

Top of dam (minimum):. 10

Spillway crest:. 8.5

Normal Pool: 8.5

Maximum Experienced Pool:. . . . . Unknown

Observed Pool: 8.5

g. Dam

Type:	Rolled, Earthfill
Length:	560 feet (excluding the spillway)
Structural Height:	17.5 feet
Hydraulic Height:	17.5 feet
Top width:	Varies 7 to 10 feet
Side slopes:	
Downstream	1V to 3H
Upstream	1V to 3H (Above the water surface)
Zoning:	Homogeneous
Impervious core:	NA
Cutoff:	A core trench with a bottom width of 12 to 13 feet (According to Mr. Starr)
Grout curtain:	None
Volume:	15,500 cu.yds. (estimated)

h. Diversion and Regulating Tunnel. . . . . None

i. Spillway

Type:	Earthcut channel, uncontrolled
Bottom width:	30 feet
Crest Elevation (feet above MSL):	768.0 feet

j. Regulating Outlets . . . None

SECTION 2: ENGINEERING DATA

2.1 Design

Design drawings and calculations are not available for this dam.

2.2 Construction

No data are available concerning the construction of the dam and appurtenant structures, other than the information obtained from Mr. Starr given below.

According to Mr. Starr, the compaction of the embankment was achieved by the activity of the earthmoving equipment across the embankment and no compaction control was employed. A core trench was excavated parallel to the dam axis but not to bedrock. The trench had a bottom width of 12 to 13 feet and near vertical side slopes. A dragline was used to remove saturated sand, which was encountered at the damsite, so that a suitable foundation for the embankment could be established. The depth of saturated sand varied in depth from 2 to 8 feet. The sand was stockpiled and mixed with the clay material used in the embankment. The clay used for the embankment was removed from the reservoir rim.

2.3 Operation

No operational records are available for Zander Lake Dam.

2.4 Evaluation

a. Availability

No design drawings, design computations, construction data, or operation data are available. The engineering data used in this report was obtained from the Soil Survey of Montgomery County conducted by the Soil Conservation Service, State Geological Maps, and U.S.G.S. Quadrangle Sheets.

b. Adequacy

The available engineering data was not sufficient for a definitive review and evaluation. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing and evaluating design, operation, and construction data, but is based primarily on visual inspection and past performance. 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

No valid engineering data pertaining to the design or construction of the dam and appurtenant structure were available.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

A visual inspection of the Zander Lake Dam was made on June 6, 1980. The following persons were present during the inspection:

Name	Affiliation	Disciplines
Mark Haynes, P.E.	PRC Engineering Consultants, Inc.	Project Engineer, Soils and Mechanical
Jerry Kenny	PRC Engineering Consultants, Inc.	Hydraulics and Hydrology
Robert McLaughlin, P.E.	PRC Engineering Consultants, Inc.	Civil
Razi Quraishi, R.P.G.	PRC Engineering Consultants, Inc.	Geology
John Lauth, P.E.	Consoer, Townsend & Assoc., Ltd.	Civil and Structural

Specific observations are discussed below.

b. Dam

The overall condition of the dam appears to be fair. Some items of concern were observed and are described below.

The top of dam is adequately protected against surface erosion by an unmaintained vegetative cover (see Photo 2). A comprehensive inspection of the top of dam was hampered due to the vegetative cover. No depressions or cracks indicative of an instability of the embankment were apparent. The difference in elevation along the top of dam did not appear to be due to an instability of the embankment. The dam was most likely constructed in this manner. No misalignments in either the vertical or horizontal direction, other than the difference in elevation along the axis, were apparent. Piles of cobbles were observed on the top of dam in a few places. No evidence indicating that the dam has ever been overtopped was observed.

The upstream slope has no riprap protection and consequently, considerable damage to the slope has occurred due to wave action (see Photos 1 and 4). Erosional scarps, undercutting, and areas with small tension cracks, where sloughing is likely to take place in the future, were observed along the slope (see Photo 4). Cattails were observed growing along the shoreline in some areas. The cattails actually appear to provide some protection against wave erosion for the slope. The upper portion of the slope appeared to be adequately protected against surface erosion by an unmaintained grass cover. A comprehensive inspection of the slope was hampered due to the height of the vegetative cover. Evidence of burrowing animals was observed on the slope. No depressions, bulges or cracks indicative of major slope or foundation movement were apparent. One small sapling was found growing on the slope near the spillway.

The downstream slope is adequately protected against surface erosion by an unmaintained vegetative cover (see Photo 3). A comprehensive inspection of the slope was hampered due to the height of the vegetation. No depressions, bulges or cracks indicative of major slope or foundation movement were apparent. No seepage on the embankment or at the toe was observed. Small animal holes up to 1 inch in diameter were observed on the slope and near the toe of the slope (see Photo 5). One small sapling and some small bushes were observed on the slope.

Both abutments slope gently upward from the crest. No instabilities, seepage or erosion were observed on either abutment.

c. Project Geology and Soils

(1) Project Geology

The damsite is located on an unnamed tributary of the Scratchers Branch of the Little Loutre Creek in the Dissected Till Plains Section of the central Lowland Physiographic Province. Loess-mantled Kansas drift covers the surface of most of the Dissected Till Plains Section. This section is distinguished from the Young Drift Section to the north and from the Till Plains on the east by the stage it has reached in the post-glacial erosion cycle. Broadly generalized, this section is a nearly flat till plain submature to mature in its erosional cycle.

The topography at the damsite is flat to rolling on the east, and hilly on the west with V-shaped valleys. Elevation of the ground surface ranges from 780 feet above M.S.L. at the damsite to 849 feet above M.S.L. nearly 2.5 miles northeast of the damsite. The reservoir slopes are in the range of 5^{o} to 10^{o} from the horizontal. The area near the damsite is covered with slope wash deposits of glacial-fluvial and loess origins consisting of reddish brown, silty clay.

The regional bedrock geology beneath the glacial outwash deposits in the damsite area, as shown on Geologic Map of Missouri (1979) (see Plate 4), consists of the Pennsylvanian Marmaton-Cherokee Group (cyclic deposits of shale limestone and sandstone), the Mississippian age Burlington Limestone (cherty, grayish brown, sandy limestone), the Mississippian Chouteau Group, the Devonian Sulphur Springs Group (Bushberg Sandstone, Glen Park Limestone, Grassy Creek Shale), and the Ordovician rocks consisting of Maqouketa Shale, Kimmswick Limestone, Cape Limestone, Joachim Dolomite, St. Peter Sandstone, Smithville Formation and Powell Dolomite.

No outcropping of rock was noticeable at the damsite. The predominent bedrock near the site vicinity underlying the glacial-fluvial deposits are the Pennsylvanian Marmaton-Cherokee Group (cyclic deposits of shale, limestone and sandstone) and Mississippian Burlington Limestone. Inlet and outlet areas of this unnamed tributary of the Scratchers Branch exhibit quaternary alluvium.

No faults have been identified in the vicinity of the damsite. The closest trace of a fault in the vicinity of the damsite is the Mineola Fault nearly 10 miles southeast of the damsite. The Mineola Fault had its last movement in post-Early Ordovician time. Thus, the fault has no effect on the damsite.

Zander Lake Dam consists of a homogeneous earthfill embankment, and a spillway located at the left abutment end of the embankment.

No boring logs or construction reports were available which would indicate foundation conditions encountered during the construction. Based on the visual inspection, the embankment probably rests on glacial-fluvial deposits (reddish brown, silty clay). The spillway was cut into the left abutment, which consists of glacial-fluvial deposits (reddish brown, silty clay).

(2) Project Soils

According to the "Soil Survey of Montgomery and Warren Counties, Missouri" published by the Soil Conservation Service in 1978, the common soils in the general area of the dam belong to the Mexico-Armster-Putnam association. The soil at the damsite consists of the Armster loam, the Mexico silt loam and the Sharon silt loam. These soils are basically formed from glacial till, alluvium, and loess.

Materials removed from the upstream and downstream slopes of the embankment appeared to be a light brown, silty clay with traces of fine to medium sand. Based upon the Unified Soil Classification System, the soil would probably be classified as a CL. This is an impervious soil type which generally has the following characteristics: a coefficient of permeability less than 1.0 foot per year, medium shear strength, and a high resistance to piping.

d. Appurtenant Structures

(1) Spillway

According to Mr. Starr, areas of saturated sand were encountered at the damsite during the construction of the dam. This may be a contributing factor to the standing water found in the discharge channel (see Photo 8), which created sort of a marshy condition. There are also bales of hay and piles of gravel in the vicinity of the standing water and elsewhere in the discharge channel which were placed there to provide erosion protection. The entrance to the spillway has a growth of reeds which fairly well covers the entire width of the approach to the inlet (see Photo 6). Also, it was observed that a stand of grass 2 to 3 feet high covers most of the discharge channel area (see Photos 6 and 7). Then when the discharge channel intersects the downstream channel, it does so at an unfavorable angle of 90 degrees.

(2) Outlet Works

No low level outlets or outlet works were provided for this dam.

e. Reservoir Area

The reservoir water surface elevation at the time of the inspection was 768.0 feet above M.S.L.

The surface area of the reservoir at normal water level is about 8.5 acres. The rim appears to be stable with no severe erosional problems observed. Minor wave erosion and localized erosional scarps were observed along the shoreline. The land around the reservoir slopes gently to the rim and is grass and tree covered (see Photo 10). One home is built in close proximity to the reservoir.

f. Downstream Channel

The downstream channel is a well defined meandering channel. It is fairly narrow and shallow and is partially obstructed with trees. A fairly wide floodplain exists outside of the channel (see Photo 9). The hydraulic efficiency of the channel will be slightly affected by the trees.

3.2 Evaluation

The visual inspection uncovered nothing of a consequential nature which would require immediate remedial action. However, some conditions were observed which could adversely affect the dam and the spillway in the near future.

1. The wave erosion on the upstream slope does not appear to affect the stability of the dam in its present condition. Nevertheless, continual erosion of the slope which appears to be evident can only be detrimental to the stability of the dam.

2. The small animal activity observed on the embankment and near the toe could jeopardize the safety of the dam. The holes created by the animals make avenues for possible piping.

3. The small saplings and bushes on the embankment do not pose a danger to the safety of the dam at this time. Nevertheless, if the saplings are allowed to grow, they pose a potential danger to the safety of the dam. Depending upon the extent of the root systems of large trees, the roots could provide paths for piping through the embankment.

4. The present vegetation on the embankment should be properly maintained. A heavy growth of vegetation on the embankment hinders a comprehensive inspection of the dam and potential problems could go undetected.

5. The marshy condition does not appear to be detrimental to the flow characteristics of the spillway discharge channel. However, the hay bales and gravel piles would cause a certain amount of turbulence and the high grass would contribute to a reduced flow velocity in the discharge channel. The reeds growing at the entrance to the inlet would tend to retard the flow of excess reservoir water from the reservoir to the crest. The four foot drop at the end of the discharge channel is an earthen drop and, as such, is subject to erosion; however, this doesn't appear to pose a dangerous condition for the dam.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

No specific operational procedures are in effect for the dam. The water level below the spillway crest is allowed to remain as high as possible. The water level is controlled by rainfall, runoff, evaporation and unregulated spillway releases.

4.2 Maintenance of Dam

The dam is maintained by the owner, Mr. Richard Zander. The dam embankment appears to have received very little maintenance and upkeep. The entire embankment is covered with a dense growth of vegetation and a few saplings and small bushes were observed on the upstream and downstream slopes. Dumped rock and bales of hay were placed in the spillway several years ago to prevent erosion of the spillway. There have been no major repairs done to the dam itself since its original construction.

4.3 Maintenance of Operating Facilities

There are no operating facilities associated with Zander Lake Dam.

4.4 Description of Any Warning System in Effect

The inspection team is not aware of any existing warning system consisting of any electrical warning systems or manual warning notification plans in effect for this dam.

4.5 Evaluation

Operational procedures are nonexistent, and the maintenance at Zander Lake Dam appears to be inadequate at this time. The remedial measures described in Section 7 should be undertaken to improve the condition of the dam.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

The watershed area of the Zander Lake Dam upstream from the dam axis consists of approximately 113 acres. The watershed is pasture and range land with some wooded areas. Land gradients in the watershed average roughly 3 percent. The Zander Lake Dam is located on an unnamed tributary of the Scratchers Branch of the Little Loutre Creek. The reservoir behind the dam is about 0.5 miles upstream from the confluence of the unnamed tributary and the Scratchers Branch. The watershed at its longest arm is approximately 0.6 miles long. A drainage map showing the watershed and the downstream hazard zone is presented as Plate 1 in Appendix B.

Evaluation of the hydraulic and hydrologic features of Zander Lake Dam was based on criteria set forth in the Corps of Engineers' "Engineer Regulation No. 1110-2-106" and additional guidance provided by the St. Louis District of the Corps of Engineers. The Probable Maximum Flood (PMF) was calculated from the Probable Maximum Precipitation (PMP) using the methods outlined in the U.S. Weather Bureau Publication, Hydrometeorological Report No. 33. The probable maximum storm duration was set at 24 hours, and storm rainfall distribution was based on criteria given in the Corps of Engineers' EM 1110-2-1411 (Standard Project Storm). The Soil Conservation Service (SCS) method was used for deriving the unit hydrograph, utilizing the Corps of Engineers' computer program HEC-1 (Dam Safety Version). The unit hydrograph parameters are presented in Appendix B. The SCS method was also used for determining the loss rate. The hydrologic soil group of the watershed was determined by the use of published soil maps. The hydrologic soil group of the watershed and the SCS curve number are presented in Appendix

B. The curve number, the unit hydrograph parameters, the PMP index rainfall and the percentages for various durations were direct input to the HEC-1 (Dam Safety Version) computer program to obtain the PMF hydrograph. The computed peak inflow discharges of the PMF and the one-half PMF are 2,212 cfs and 1,106 cfs, respectively.

Both the PMF and the one-half PMF inflow hydrographs were routed through the reservoir by the Modified Puls Method also utilizing the HEC-1 (Dam Safety Version) computer program. An antecedent storm of 50 percent of the PMF preceded the PMF and the an antecedent storm of 25 percent of the PMF preceded the one-half PMF, each by four days. The starting elevation for routing antecedent floods was assumed to be equal to the mean annual high water level in the reservoir. The mean annual high water level for Zander Lake Dam reservoir was estimated to be at the crest of the spillway. The water level in the reservoir at the end of the four day routing period was at the same elevation as the crest of the spillway. The reservoir was assumed at this level at the start of the routing computation for the PMF and the one-half PMF. The peak outflow discharges for the PMF and the one-half PMF are 1,722 and 710 cfs, respectively. Both the PMF and the the one-half PMF when routed through the reservoir resulted in overtopping of the dam.

The sizes of physical features utilized to develop the stage-outflow relation for the spillway and overtopping of the dam were taken from field notes and sketches, prepared during the field inspection. The reservoir stage-capacity data were based on the U.S.G.S. Wellsville, Missouri Quadrangle topographic map (7.5 minute series). The reservoir elevation-area curve and the spillway and overtop rating curve are presented in Plates 2 and 3, respectively, in Appendix B.

From the standpoint of dam safety, the hydrologic design of a dam must aim at avoiding overtopping. Overtopping is especially dangerous for an earth dam because of its erosive characteristics. The safe hydrologic design of an embankment dam requires a

spillway discharge capability combined with an embankment height that can handle a very large and exceedingly rare flood without overtopping the dam.

The Corps of Engineers designs dams to safely pass the Probable Maximum Flood that could be generated from the dam's watershed. This is the generally accepted criterion for major dams throughout the world, and is the standard for dam safety where overtopping would pose any threat to human life. However, since the high hazard classification for the downstream hazard zone is questionable, the hydrologic requirement for safety for this dam is the capability to pass one-half of the Probable Maximum Flood without overtopping the dam.

b. Experience Data

It is believed that records of reservoir stage or spillway discharge are not maintained for this site. Nevertheless, there was no evidence of the dam ever having been overtopped.

c. Visual Observations

Observations made of the spillway during the visual inspection are discussed in Section 3.1d and evaluated in Section 3.2.

d. Overtopping Potential

As indicated in Section 5.1.a, both the Probable Maximum Flood and the one-half Probable Maximum Flood when routed through the reservoir, resulted in overtopping of the dam. The peak outflow discharges for the PMF and the one-half PMF are 1,722 and 710 cfs, respectively. The capacity of the spillway is 600 cfs. The PMF overtopped the top of dam by 1.27 feet and one-half of the PMF overtopped the dam by 0.21 feet. The total duration of flow over the top of dam is 0.83 hours during the PMF and 0.33 hours during

the one-half PMF. The spillway and downstream slope of the embankment may be susceptible to erosion due to the high velocity of flow during overtopping of the dam. The spillway/reservoir system of Zander Lake Dam is capable of accommodating a flood equal to approximately 45 percent of the PMF just before overtopping the dam. The reservoir/spillway system of Zander Lake Dam will accommodate the one-percent chance flood (100-year flood) without overtopping the dam.

The failure of the dam could cause extensive damage to the property downstream of the dam and possible loss of life. The estimated damage zone extends approximately four miles downstream of the dam. There are four dwellings and two sheds which are probably located within the damage zone.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There were no major signs of settlement or distress observed on the embankment or foundation during the visual inspection. The erosion due to wave action on the upstream slope does not endanger the structural integrity of the embankment in its present condition. Nevertheless, if the erosion continues, it can only have an adverse effect on the stability of the embankment. In the absence of seepage and stability analyses, no quantitative evaluation of the structural stability can be made.

The structural stability of the crest and discharge channel of the spillway appeared to be adequate on the day of the inspection.

b. Design and Construction Data

No design computations pertaining to the embankment or appurtenant structure were uncovered. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available. No embankment or foundation soil parameters were available for carrying out a conventional stability analysis on the embankment. No construction data or specifications relating to the degree of embankment compaction were available for use in a stability analysis.

c. Operating Records

No operating records are available relating to the stability of the dam or appurtenant structure. The water level on the day of inspection was at the crest of the spillway, and it is assumed that the reservoir remains close to full at all times. No regulated outlet works or low level outlets were provided for this dam.

d. Post Construction Changes

No post construction changes to the embankment are known to exist which will affect the structural stability of the dam.

e. Seismic Stability

The dam is located in Seismic Zone 1 (see Plate 6), as defined in "Recommended Guidelines for Safety Inspection of Dams" prepared by the Corps of Engineers, and will not require a seismic stability analysis. An earthquake of the magnitude which would be expected in Seismic Zone 1 will not cause significant distress to a well designed and constructed earth dam. Available literature indicates that no active faults exist near the vicinity of the damsite.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation, however, the investigation is intended to identify any need for such studies.

It should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team.

It is also important to realize that the condition of a dam depends upon numerous and constantly changing internal and external factors, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be an assurance that an unsafe condition could be detected.

a. Safety

The spillway capacity of Zander Lake Dam is found to be "Inadequate". The spillway/reservoir system will accommodate about 45 percent of the PMF without overtopping the dam. The safety of the embankment will be in jeopardy if the dam is overtopped. The embankment itself would be susceptible to erosion due to the high velocity of flow on its downstream slope which could lead to an eventual failure of the dam.

The dam and appurtenant structures appeared to be in fair condition. However, no quantitative evaluation of the safety of the embankment can be made in view of the absence of seepage and stability analyses. The present embankment and appurtenant structure, however, appear to have performed satisfactorily since their construction without failure or evidence of instability. There was no evidence of the dam ever having been overtopped.

The safety of the dam can be improved if the deficiencies described in Sections 3 and 6.1a and below are properly corrected as described in Section 7.2b. The burrowing animals observed on the embankment could jeopardize the safety of the dam. The holes created by the animals make avenues for possible piping. The small saplings and bushes on the embankment do not affect the safety of the dam in their present condition, however, they could have an adverse effect on the dam if allowed to grow.

b. Adequacy of Information

Information relating to the design and construction of the dam is completely lacking. The conclusions presented in this report are based upon field measurement, past performance and present condition of the dam. Information on the design hydrology, hydraulic design, and the operation and maintenance of the dam were not 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. Urgency

The remedial measures recommended in Paragraph 7.2 should be accomplished in the near future. The items recommended in Paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II Inspection

Based upon results of the Phase I inspection, and assuming that the remedial measures recommended in Paragraph 7.2 are undertaken, a Phase II inspection is not felt to be necessary.

7.2 Remedial Measures

a. Alternatives

There are several general options which may be considered to reduce the possibility of dam failure or to diminish the harmful aspects of such a failure. Some of these options are:

1. Increase the spillway capacity to pass the PMF without overtopping.

2. Increase the height of the dam enough to pass the PMF without overtopping the dam; an investigation should be done which also includes studying the effects on the structural stability of the existing emankment. The overtopping depth during the occurrence of the PMF, stated in Section 5.1d, is not the required or recommended increase in the height of the dam.

3. A combination of 1 and 2 above.

b. O & M Procedures

1. The erosion due to wave action on the upstream slope should be properly repaired and protected from further damage.

2. Determine the extent of damage done to the embankment by burrowing animals, if any, and make corrective repairs as required. All burrowing animals should be eliminated from the embankment and their burrows properly backfilled and compacted.

3. The small saplings and bushes should be removed from the embankment and prevented from regrowth.

4. The vegetation on the embankment should be maintained periodically and large vegetation, such as bushes and trees, should be prevented from growing on the slope.

5. The hay bales and piles of gravel in the spillway discharge channel should be either removed or spread around the adjacent areas within the channel.

6. The reeds in front of the spillway inlet area should be removed and maintained in such condition. Also, the grass within the spillway and discharge channel generally should be cut and maintained at a one foot maximum height.

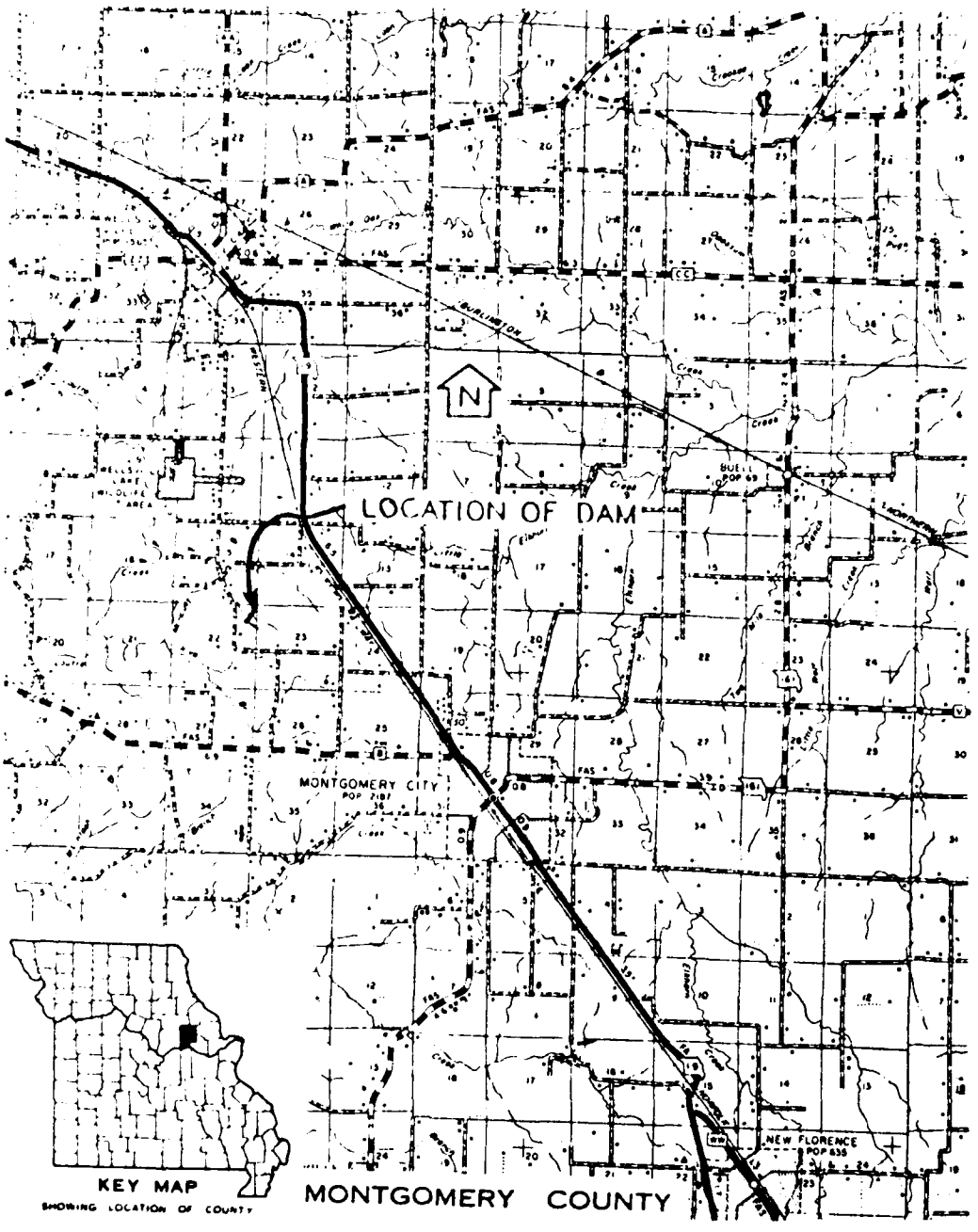
7. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of earth dams.

8. The owner should initiate the following programs:

(a) Periodic inspection of the dam by a professional engineer experienced in the design and construction of earth dams.

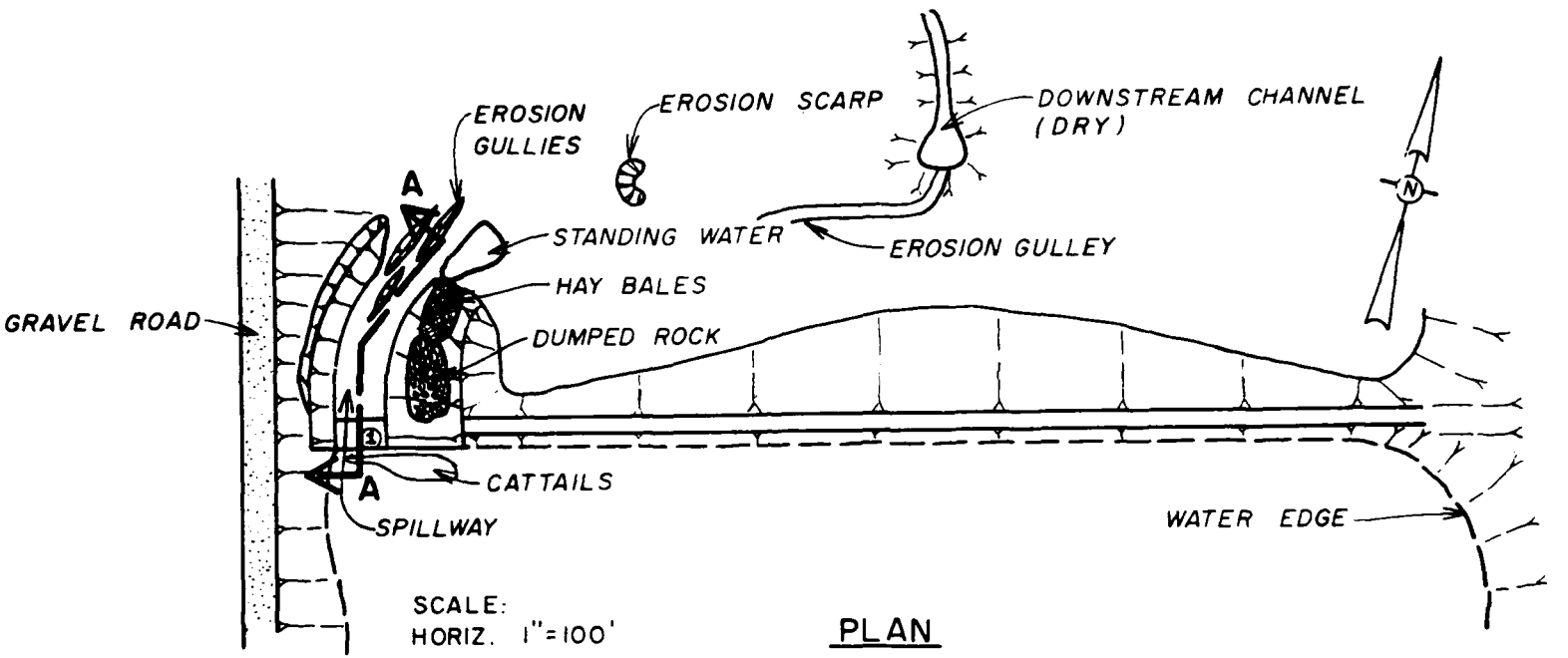
(b) Set up a maintenance schedule and log all visits to the dam for operation, repairs and maintenance.

PLATES

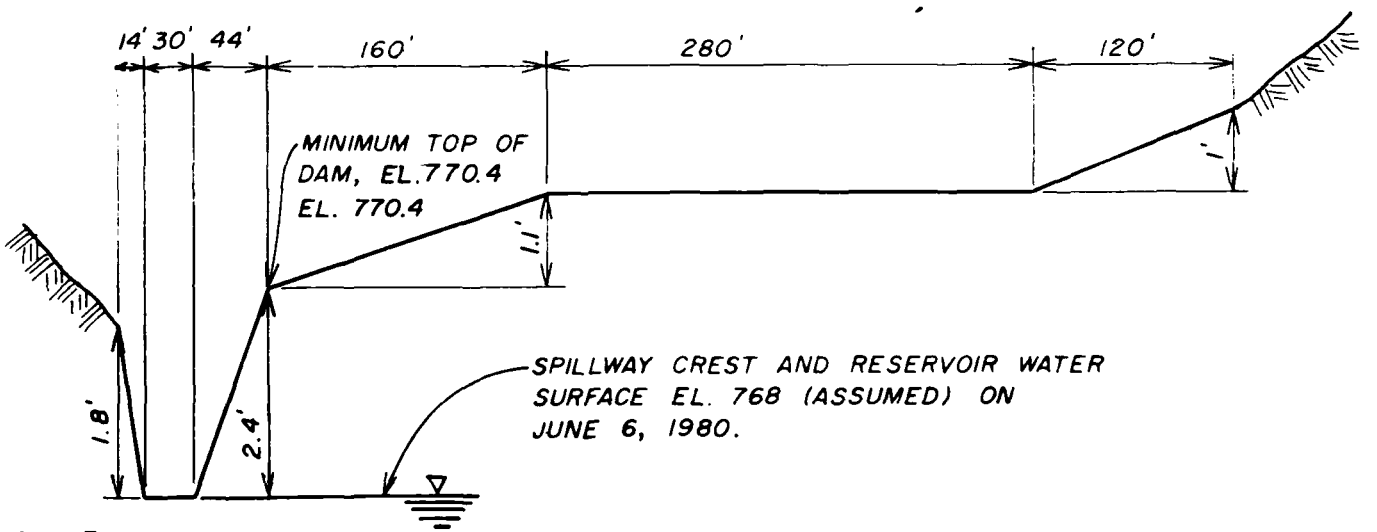


LOCATION MAP — ZANDER LAKE DAM

MO. 10593



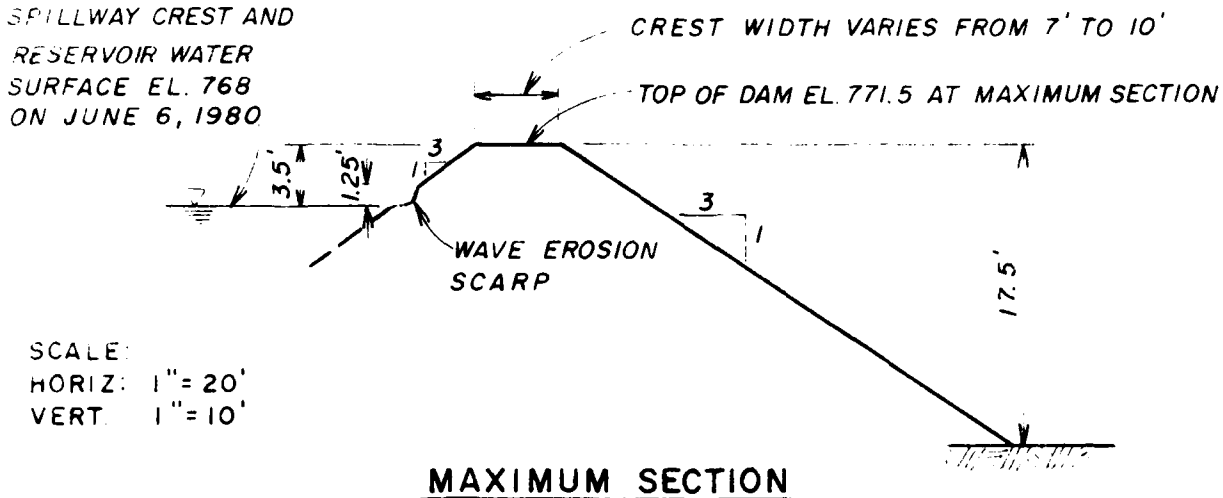
PLAN



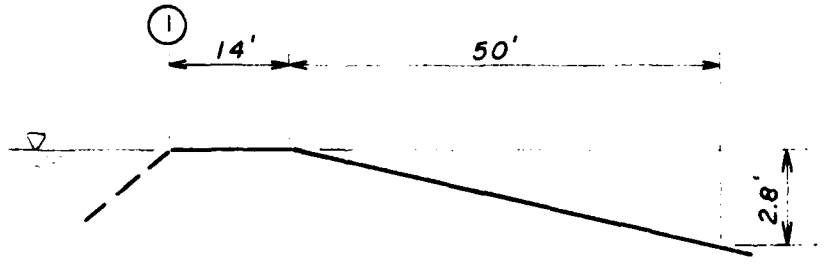
ELEVATION

ZANDER LAKE DAM (MO. 10593)
PLAN AND ELEVATION
(SHEET 1 OF 2)

PLATE 2



MAXIMUM SECTION



SECTION A-A
SPILLWAY PROFILE

① *REFERENCE POINT, SEE SHEET 1 OF 2*

ZANDER LAKE DAM (MO. 10593)
MAXIMUM SECTION OF EMBANKMENT AND SPILLWAY PROFILE
(SHEET 2 OF 2)

PLATE 4

SCALE

0 10 20 30 40 Miles

⊕ LOCATION OF DAM

NOTE: LEGEND OF THIS DAM IS ON PLATE 5

REFERENCE:

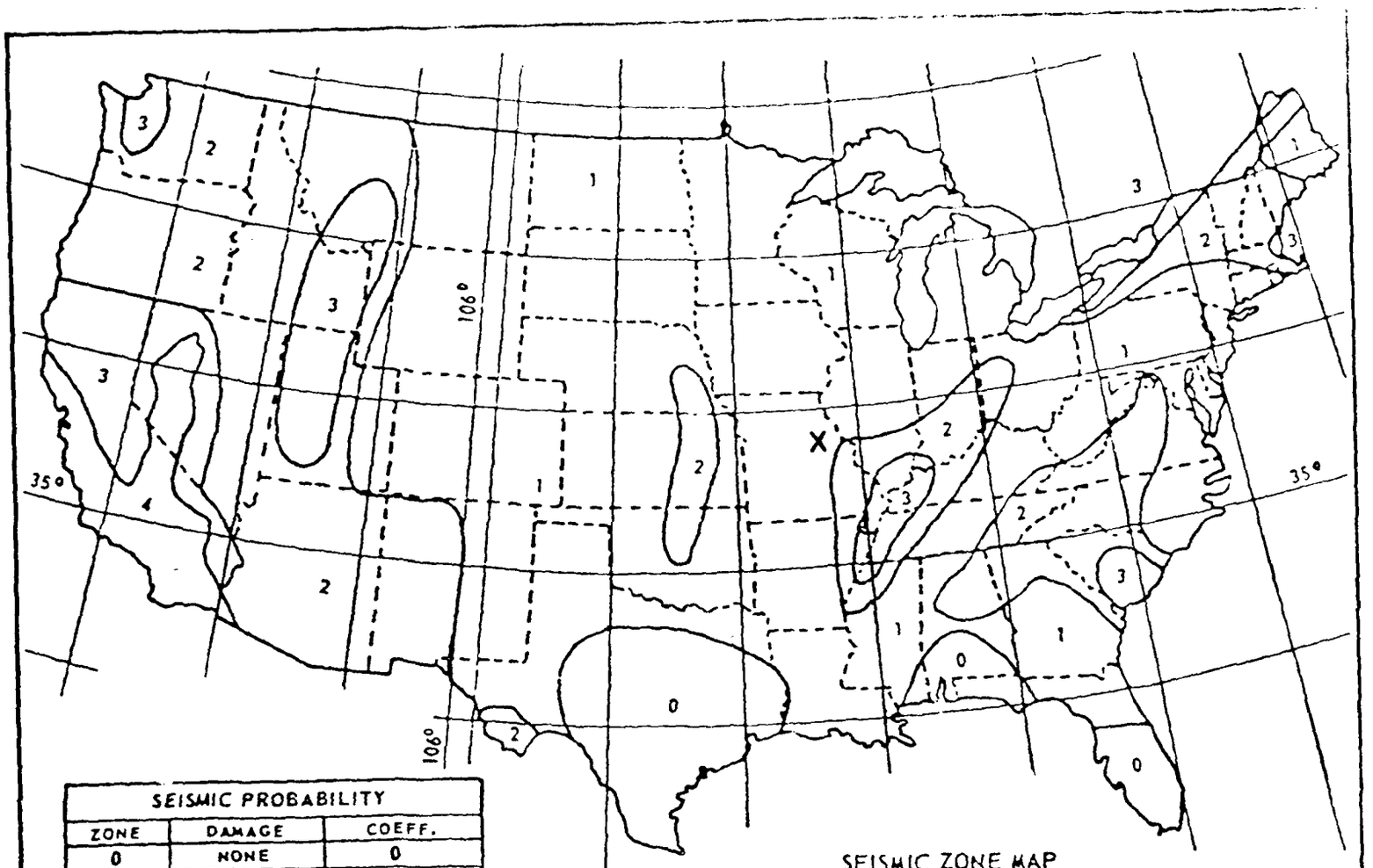
GEOLOGIC MAP OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
MISSOURI GEOLOGICAL SURVEY
KENNETH H. ANDERSON, 1979

REGIONAL GEOLOGICAL MAP OF ZANDER LAKE DAM

ZANDER LAKE DAM
PLATE 5

LEGEND

PERIOD	SYMBOL	DESCRIPTION
QUATERNARY	Qal	ALLUVIUM: SAND, SILT, GRAVEL
PENNSYLVANIAN	Pm	MARMATON GROUP: CYCLIC DEPOSITS OF SHALE, LIMESTONE AND SANDSTONE
	Pcc	CHEROKEE GROUP: CYCLIC DEPOSITS OF SHALE, LIMESTONE AND SANDSTONE
MISSISSIPPIAN	Mo	KEOKUK-BURLINGTON FORMATION: CHERTY GRAYISH BROWN SANDY LIMESTONE
	Mk	CHOUTEAU GROUP: BACHELOR, AND HANNIBAL FORMATION (LIMESTONE AND SHALE)
DEVONIAN	D	SULPHUR SPRING GROUP: BUSHBERG SANDSTONE, GLEN PARK LIMESTONE, GRASSY CREEK SHALE
ORDOVICIAN	Ou	MAQUOKETA SHALE, KIMMSWICK LIMESTONE
	Omk	CAPE LIMESTONE
	Ojd	JOACHIM DOLOMITE
	Osp	ST PETER SANDSTONE
	Ojc	SMITHVILLE FORMATION, POWELL DOLOMITE



SEISMIC PROBABILITY		
ZONE	DAMAGE	COEFF.
0	NONE	0
1	MINOR	0.025
2	MODERATE	0.05
3	MAJOR	0.10
4	GREAT	0.15

X – APPROXIMATE LOCATION OF ZANDER LAKE DAM

SEISMIC ZONE MAP
of
CONTIGUOUS STATES

PLATE 6

APPENDIX A

PHOTOGRAPHS TAKEN DURING INSPECTION

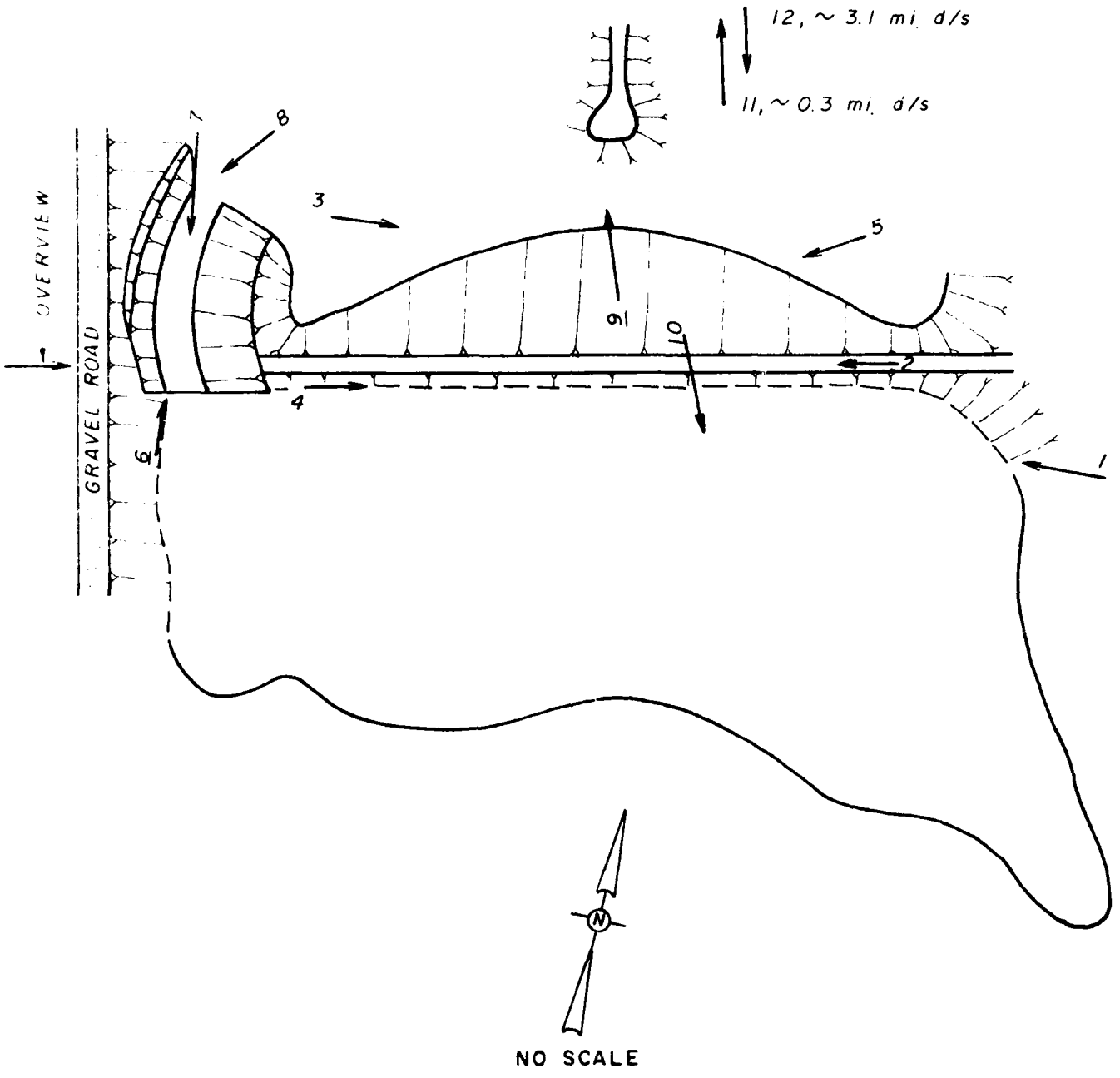


PHOTO INDEX FOR ZANDER LAKE DAM

Zander Lake Dam

Photographs

Photo 1 - View of the upstream slope showing the wave erosion and cattails along the shoreline.

Photo 2 - View of the top of dam showing the tall unmaintained vegetative cover.

Photo 3 - View of the downstream slope.

Photo 4 - Close-up view of the wave erosion, undercutting and cattails on the upstream slope.

Photo 5 - View of a small animal burrow near the toe of the embankment.

Photo 6 - Downstream view of the control section of the spillway showing cattails at the entrance, and small tree and tall grass in and near the crest and discharge channel area.

Photo 7 - View of the spillway discharge channel looking towards the reservoir, showing tall grass and small tree.

Photo 8 - View of the standing water (possibly due to quick condition) in the discharge channel of the spillway. Hay bales in the channel are seen in the background.

Photo 9 - View of the downstream channel from the top of dam.

Photo 10 - View of the reservoir and rim.

Photo 11 - View of dwelling approximately 0.3 miles downstream of the dam taken from the downstream channel.

Photo 12 - View of dwelling and 2 sheds approximately 3.1 miles downstream of the dam showing the downstream channel (Little Loutre Creek) on the left side of the photo.

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

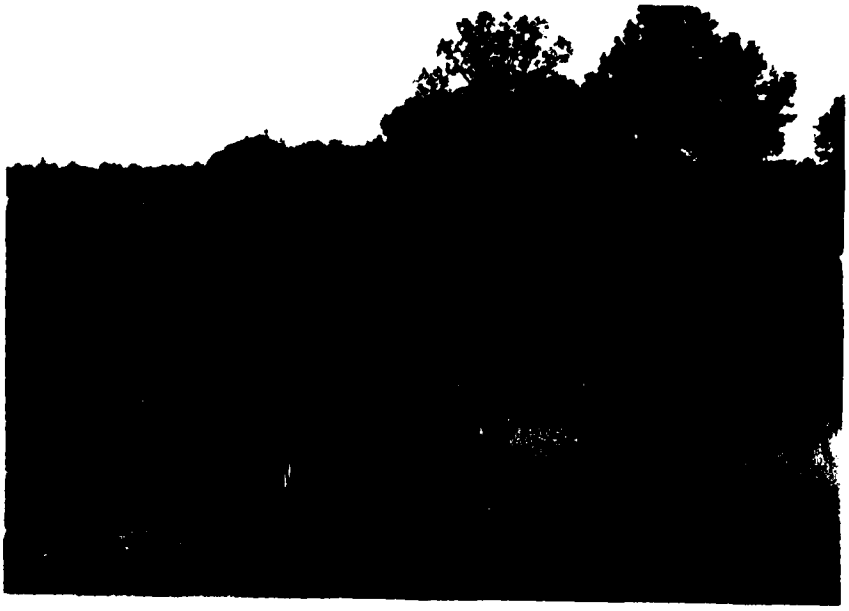


Photo 6

Photo 7

Photo 8

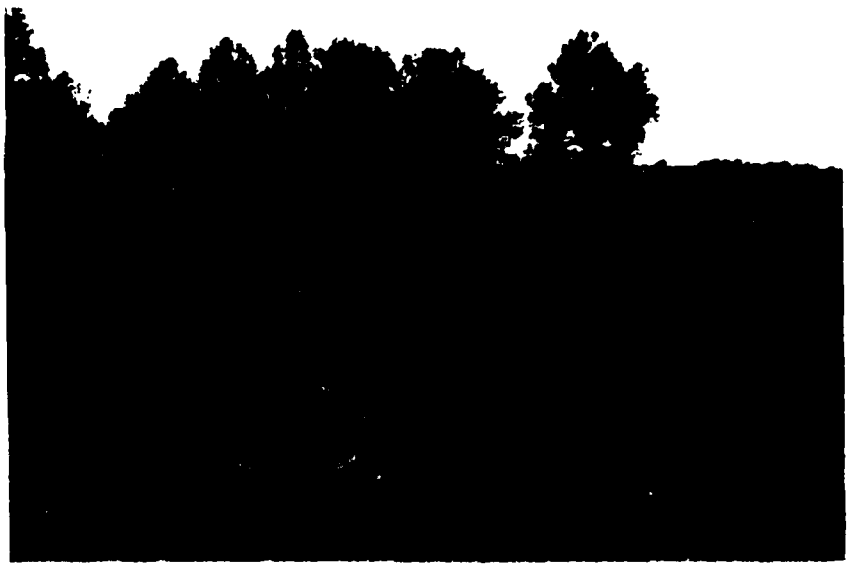


Photo 9

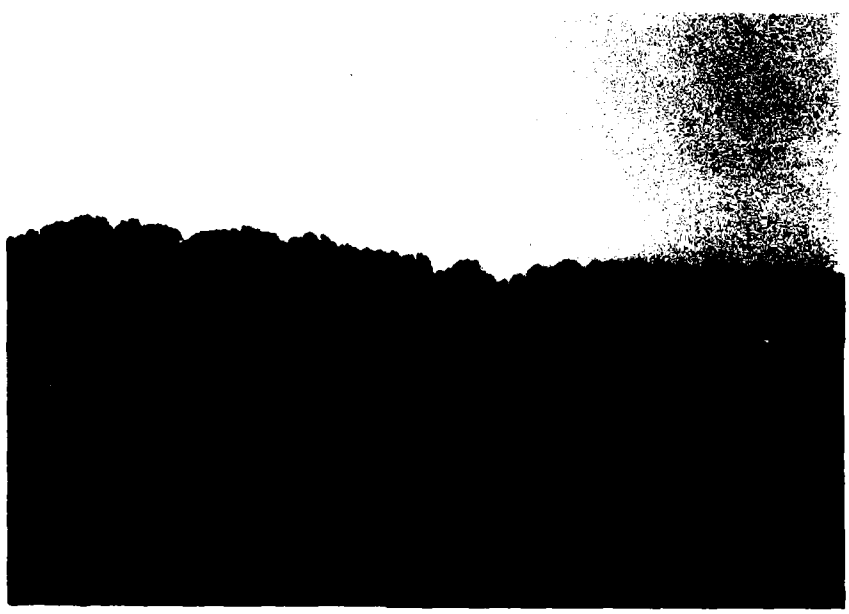


Photo 10

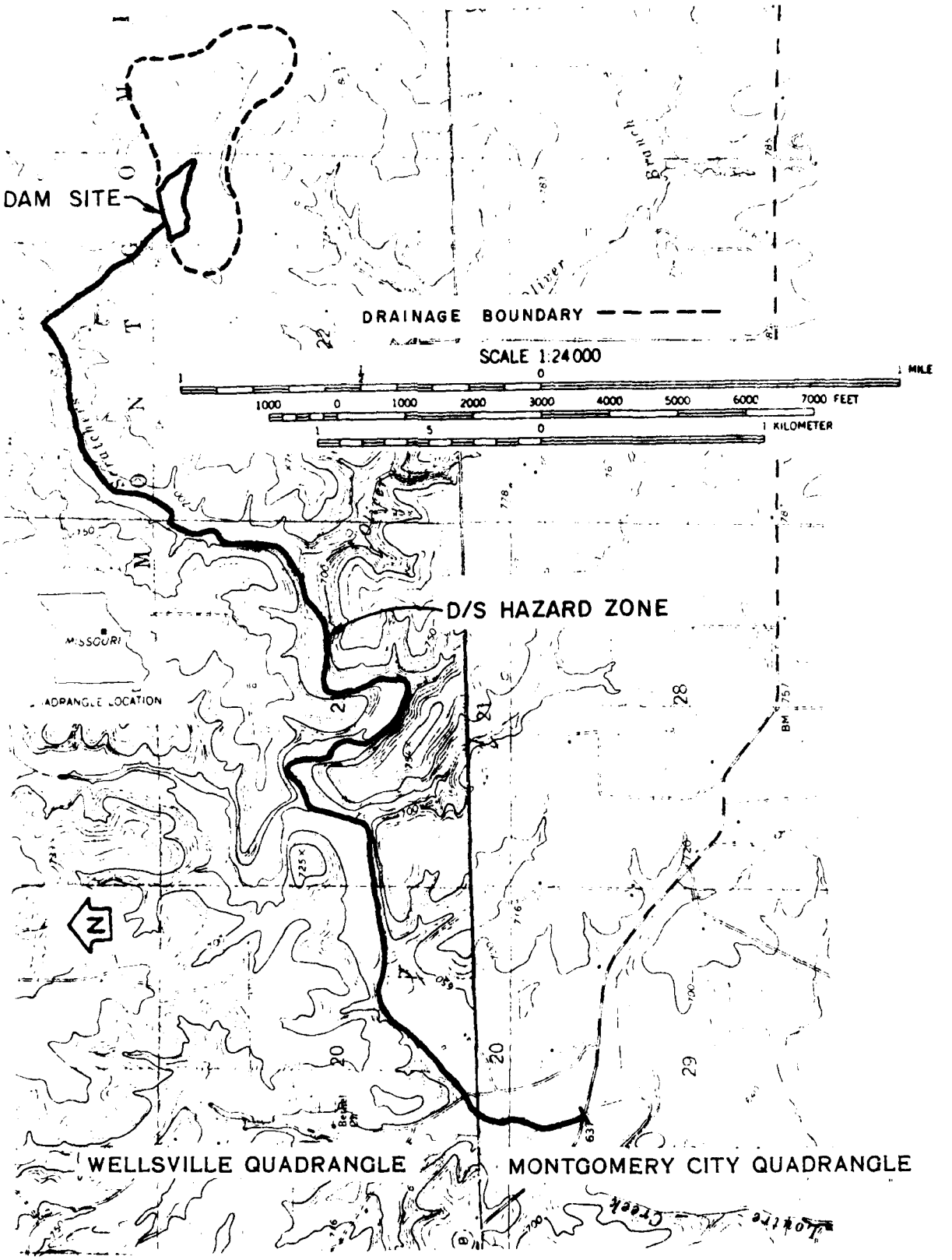
Photo 11

Photo 12

APPENDIX B

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

PLATE 1, APPENDIX B



ZANDER LAKE DAM (MO. 10593)
DRAINAGE BASIN AND
DOWNSTREAM HAZARD ZONE

PSC ENGINEERING CONSULTANTS, INC.

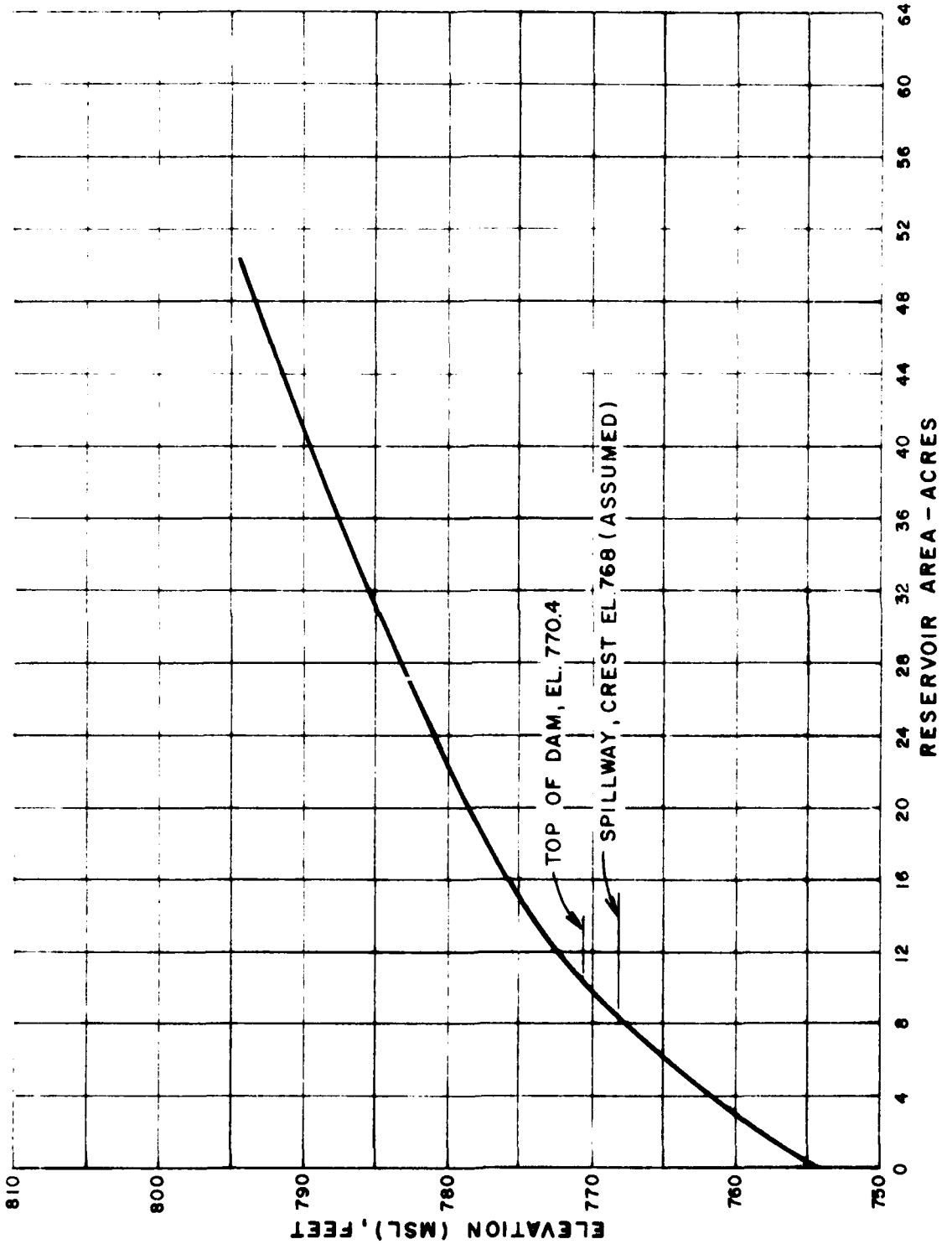
SAFETY INSPECTION - MISSOURI SHEET NO. ____ OF ____

DAM NAME: ZANDER LAKE DAM / ID NO.: 10593 JOB NO. 1263

RESERVOIR ELEVATION - AREA DATA BY FZ DATE JUL 80

ELEV. (M.S.L.) (Ft.)	RESERVOIR SURFACE AREA (Acres)	REMARKS
754	0	RESERVOIR STREAM BED
760	4.5	Interpolated
765	6.5	"
768	8.5	Spillway crest (Assumed)
770.4	10	Top of dam
775	15.0	Interpolated
780	22.0	USGS Quad. reading
785	31	Interpolated.

PLATE 2, APPENDIX B



ZANDER LAKE DAM (MO. 10593)
RESERVOIR ELEV.- AREA CURVE

PRC ENGINEERING CONSULTANTS, INC.

[illegible] INSPECTION / MISSOURI — SHEET NO. 1 OF 1

DAM NAME: [illegible] (MO 10593) — JOB NO. 1263

UNIT HYDROGRAPH PARAMETERS — BY BN KLB DATE 6/30

1) DRAINAGE AREA, A = .177 sq. mi = (113 acres)

2) LENGTH OF STREAM, L = (1.2" × 2000' = 2400') = .455 mi.

3) ELEVATION AT DRAINAGE DIVIDE ALONG THE LONGEST STREAM,

$H_1 = 815$

4) ELEVATION OF RESERVOIR AT SPILLWAY CREST, $H_2 = 768$

5) ELEVATION OF CHANNEL BED AT 0.85L, $E_{85} = 807$

6) ELEVATION OF CHANNEL BED AT 0.10L, $E_{10} = 770$

7) AVERAGE SLOPE OF THE CHANNEL, $S_{AVG} = (E_{85} - E_{10})/0.75L = \frac{807-770}{0.75 \times 2400} = 0.02$

8) TIME OF CONCENTRATION:

A) BY KIRPICH'S EQUATION,

$t_c = [(11.9 \times L^3)/(H_1 - H_2)]^{0.385} = \left(\frac{11.9 \times 0.455^3}{815-768}\right)^{0.385} = 0.237$ hr

B) BY VELOCITY ESTIMATE,

SLOPE = 2% ⟹ AVG. VELOCITY = 2.5 fps

$t_c = L/V = \frac{2400}{2.5} \times \frac{1}{3600} = 0.27$ hr

USE $t_c = 0.237$

9) LAG TIME, $t_l = 0.6\, t_c = 0.142$

10) UNIT DURATION, $D \leq t_l/3 = 0.047$ < 0.083 hr.

USE D = .083

11) TIME TO PEAK, $T_p = D/2 + t_l = 0.184$

12) PEAK DISCHARGE,

$q_p = (484 \times A)/T_p = 466$ cfs

PRC ENGINEERING CONSULTANTS, INC.

SAFETY INSPECTION / MISSOURI - 1980 SHEET NO. 1 OF 1

DAM NAME: FINDLEY LAKE DAM (MO 10593 JOB NO. 1263

CURVE NUMBER DETERMINATION BY RPM KLB DATE 6/30

I) SOIL GROUP

WATERSHED SOILS IN THE BASIN CONSIST OF:

PUTNAM, MEXICO
(GR. D) (GR. D)

GROUP D SOILS SEEM TO PREDOMINATE THE BASIN. THEREFORE, ASSUME GROUP D SOILS FOR THE ENTIRE WATERSHED FOR HYDROLOGIC PURPOSES.

II) COVER COMPLEX

ASSUMED LAND USE	ASSUMED HYDROLOGIC CONDITION	PER CENT AREA	CN (AMC II)
FOREST	FAIR	10%	79
RANGE	FAIR	90%	84

III) CURVE NUMBER

WEIGHTED AVERAGE CN = 84 FOR AMC II

CURVE NUMBER = 93 FOR AMC III

PRC ENGINEERING CONSULTANTS, INC.

SAFETY INSPECTION / MISSOURI SHEET NO. ____ OF ____

DAM NAME: HADER LAKE DAM (MO 10593) JOB NO. 1263

PROBABLE MAXIMUM PRECIPITATION BY KLB DATE 6/30

DETERMINATION OF PMP

1) Determine drainage area of the basin

D.A. = 113 Ac = 0.177 Sq mi.

2) Determine PMP Index Rainfall (for D.A. = 200 sq. mi. & 24 hr. duration)

Location of centroid of basin,

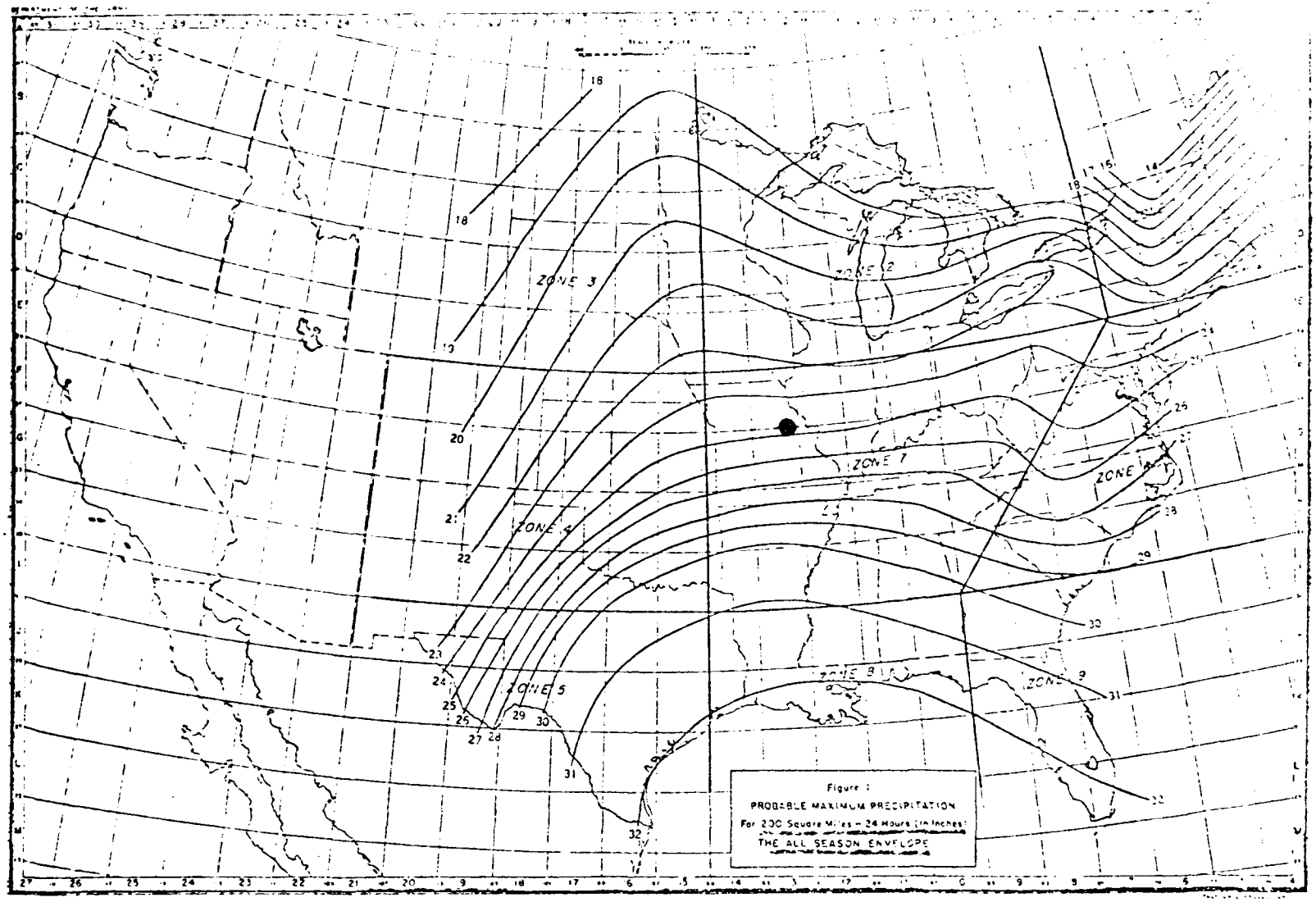
Long. = 91° 33' 27" Lat. = 39° 0' 48"

PMP = 24.8 (from Fig. 1, HMR 33)

Zone = 7

3) Determine basin rainfall in terms of percentage of PMP Index Rainfall for various durations. (from Fig. 2, HMR 33)

Duration (Hrs.)	Percent of Index Rainfall (%)	Total Rainfall (Inches)	Rainfall Increments (Inches)	Duration of Increment (Hrs.)
6	100	24.8	24.8	6
12	120	29.8	5.0	6
24	130	32.2	2.4	12



⊕ Location of Basin Centroid

Zander Lake Dam (MO. 10593)

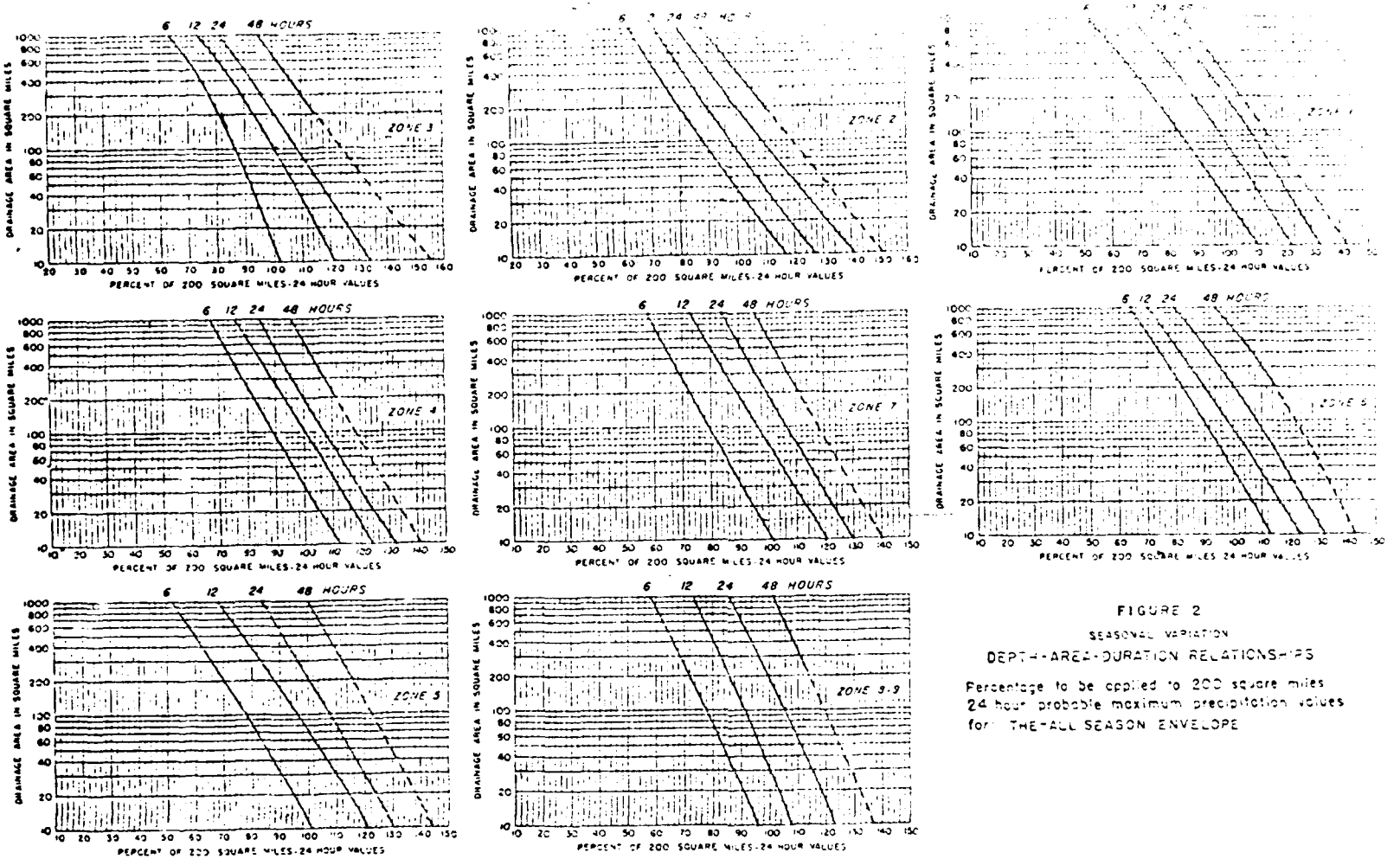
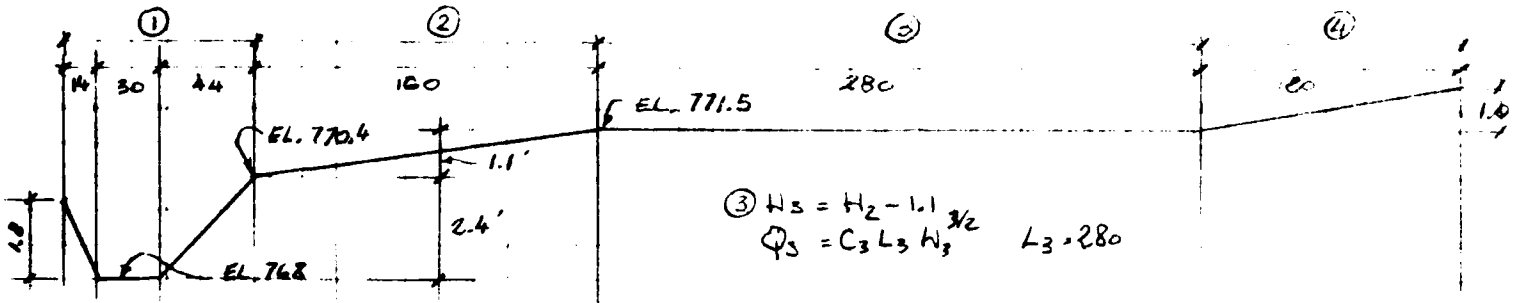


FIGURE 2

SEASONAL VARIATION

DEPTH-AREA-DURATION RELATIONSHIPS

Percentage to be applied to 200 square miles 24 hour probable maximum precipitation values for THE-ALL SEASON ENVELOPE



③ $H_3 = H_2 - 1.1$
$Q_3 = C_3 L_3 H_3^{3/2}$ $L_3 = 280$

①							WSEL	②					③			④				
y_{c_1}	A_1	T_1	V_1	Q_1	$\frac{V_1^2}{2g}$	H_1	$H_1=768$	H_2	y_{c_2}	A_2	T_2	Q_2	H_3	C_3	Q_3	H_4	y_{c_4}	A_4	T_4	Q_4
0.0							768.00													
0.5	18.3	43.1	5.7	67.5	0.21	0.71	768.71													
1.0	43.1	56.1	5.0	214.0	0.38	1.38	769.38													
1.5	73.4	69.2	5.9	437.6	0.54	2.04	770.04													
1.7	88.7	74.4	6.2	549.9	0.60	2.30	770.30													
1.9	104.1	78.8	6.5	678.7	0.66	2.56	770.56	0.16	0.13	1.2	18.6	1.7								
2.2	128.6	84.3	7.0	900.8	0.76	2.96	770.96	0.56	0.45	14.6	65.2	39.2								
2.6	163.4	88	7.7	1263.5	0.93	3.53	771.53	1.13	0.90	58.4	131.5	226.7	0.03	2.86	4.2	0.03	0.02	0.03	2.9	0.0
2.7	178.2	"	7.9	1366.9	0.98	3.68	771.68	1.28	1.02	76.3	149.0	309.6	0.18	2.96	63.3	0.18	0.14	1.84	17.3	1.9
2.9	189.8	"	8.3	1581.7	1.08	3.98	771.98	1.58	1.24	109.9	160	516.6	0.48	3.02	281.2	0.48	0.38	8.9	46.1	22.0
3.1	207.4	"	8.7	1806.8	1.18	4.28	772.28	1.88	1.44	141.9	"	758.0	0.78	3.03	584.3	0.78	0.62	23.4	76.9	74.1
3.4	233.8	"	9.3	2162.5	1.33	4.73	772.73	2.33	1.74	189.9	"	1173.7	1.23	3.04	1160.4	1.23	0.98	58.1	118.1	231.2
4.0	286.6	"	10.2	2885.0	1.63	5.63	773.63	3.23	2.34	285.9	"	2168.3	2.13	3.07	2076.3	2.13	1.59	180.4	120	771.4

① $y_{c_1} < 1.8 \Rightarrow A_1 = \frac{4}{5}(4 y_{c_1} \cdot 13.66 + 30)$
$T_1 = 26.3 y_{c_1} + 30$

$1.8 < y_{c_1} < 2.4 \Rightarrow A_1 = y_{c_1}(T + 9.2 y_{c_1}) - 12.6$
$T = 44 + 18.3 y_{c_1}$

$y_{c_1} > 2.4 \Rightarrow A_1 = T y_{c_1} - 65.4$
$T_1 = 88$

$V = \sqrt{\frac{A g}{T}}$ $Q = VA$ $H_1 = y_{c_1} + \frac{V^2}{2g}$

② $H_2 = H_1 - 2.4$

$y_{c_2} < 1.1 \Rightarrow y_{c_2} = \frac{4}{5} H$
$A_2 = 72.7 y_{c_2}^2$
$T_2 = 145.5 y_{c_2}$

$y_{c_2} > 1.1$ $y_{c_2} = \frac{2}{3}(H_2 + 0.28)$
$A = 160(y_{c_2} - 0.55)$
$T = 160$

④ $H_4 = H_3$

$y_{c_4} < 1 \Rightarrow y_{c_4} = \frac{4}{5} H_4$ $A_4 = 60 y_{c_4}^2$
$T_4 = 120 y_{c_4}$

$y_{c_4} > 1 \Rightarrow y_{c_4} = \frac{2}{3}(H_4 + \frac{1}{4})$

$A_4 = 120(y_{c_4} - 0.5)$
$T_4 = 120$

PRC ENGINEERING CONSULTANTS, INC.

SHEET NO. ____ OF ____

DAM SAFETY INSPECTION — JOB NO. 1263

ZANDER LAKE DAM — BY FZ DATE JUL 80

VERIFICATION OF CRITICAL DEPTH ASSUMPTION

y_c	Q	y_N*
1.0	214	0.69
2.2	901	1.49
2.9	1582	1.97
3.4	2163	2.29

$Q = \frac{1.49}{n} S^{1/2} \frac{A^{5/3}}{P^{2/3}}$

$y_n < y_c$

Supercritical ⇒ O.K.

$S = 2.8/50 = 0.056$

$n = 0.03$

* NORMAL DEPTH CALCULATED FROM GIVEN CROSS SECTION DATA BY PROGRAMMABLE CALCULATOR

DEC ENGINEERING CONSULTANTS, INC.

SHEET NO. ____ OF ____

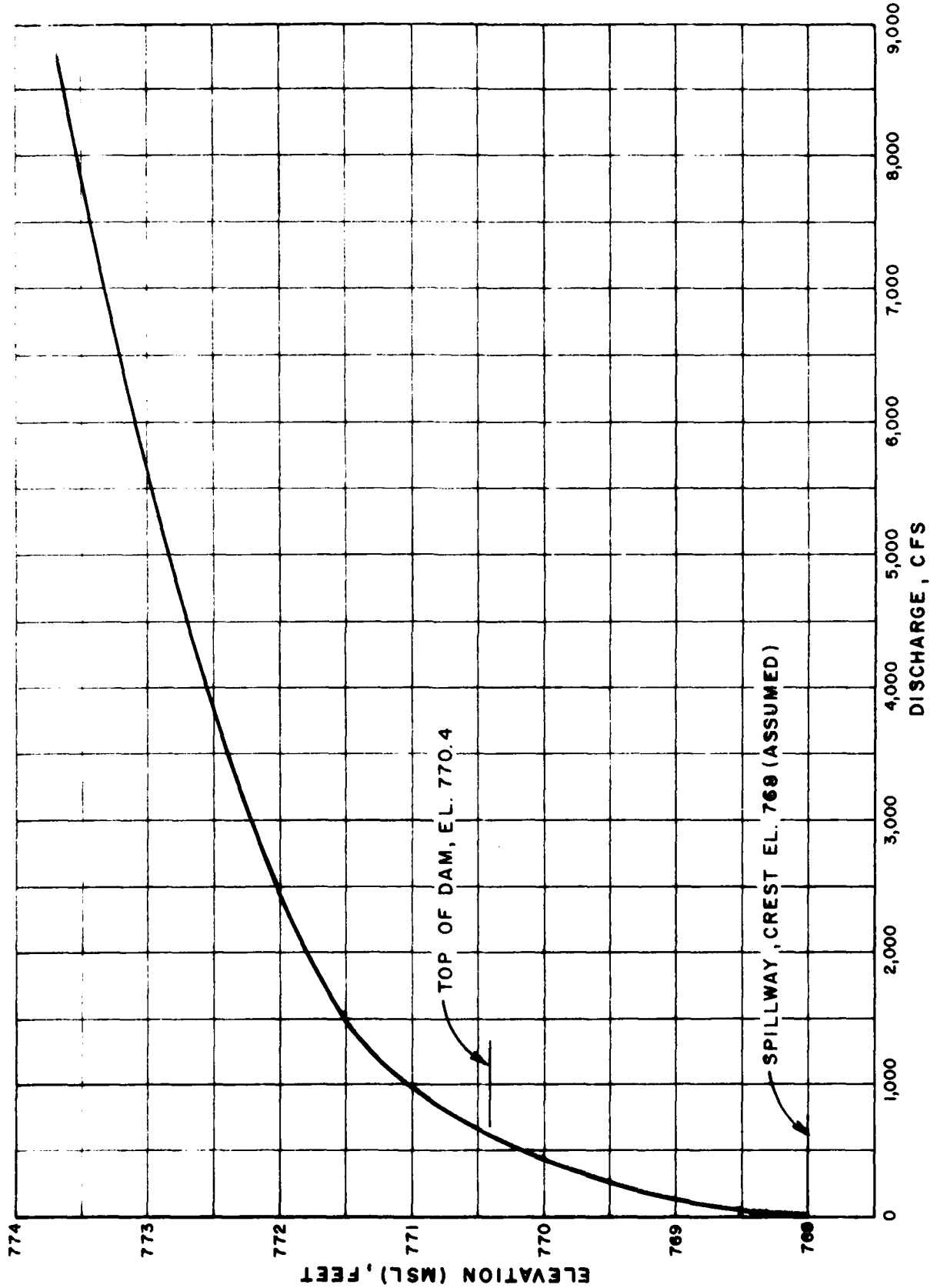
SAFETY INSPECTION — JOB NO. 1263

ZANDER LAKE DAM # 10599 — BY FZ KLS DATE JUL 80

Spillway and Overtop Rating Curve

WSEL	Total Q
768.00	0
768.71	68
769.38	214
770.04	438
770.30	550
770.56	680
770.96	940
771.53	1494
771.68	1742
771.98	2402
772.28	3223
772.73	4728
773.63	8550

PLATE 3, APPENDIX B



ZANDER LAKE DAM (MO. 10593)
SPILLWAY & OVERTOP RATING CURVE

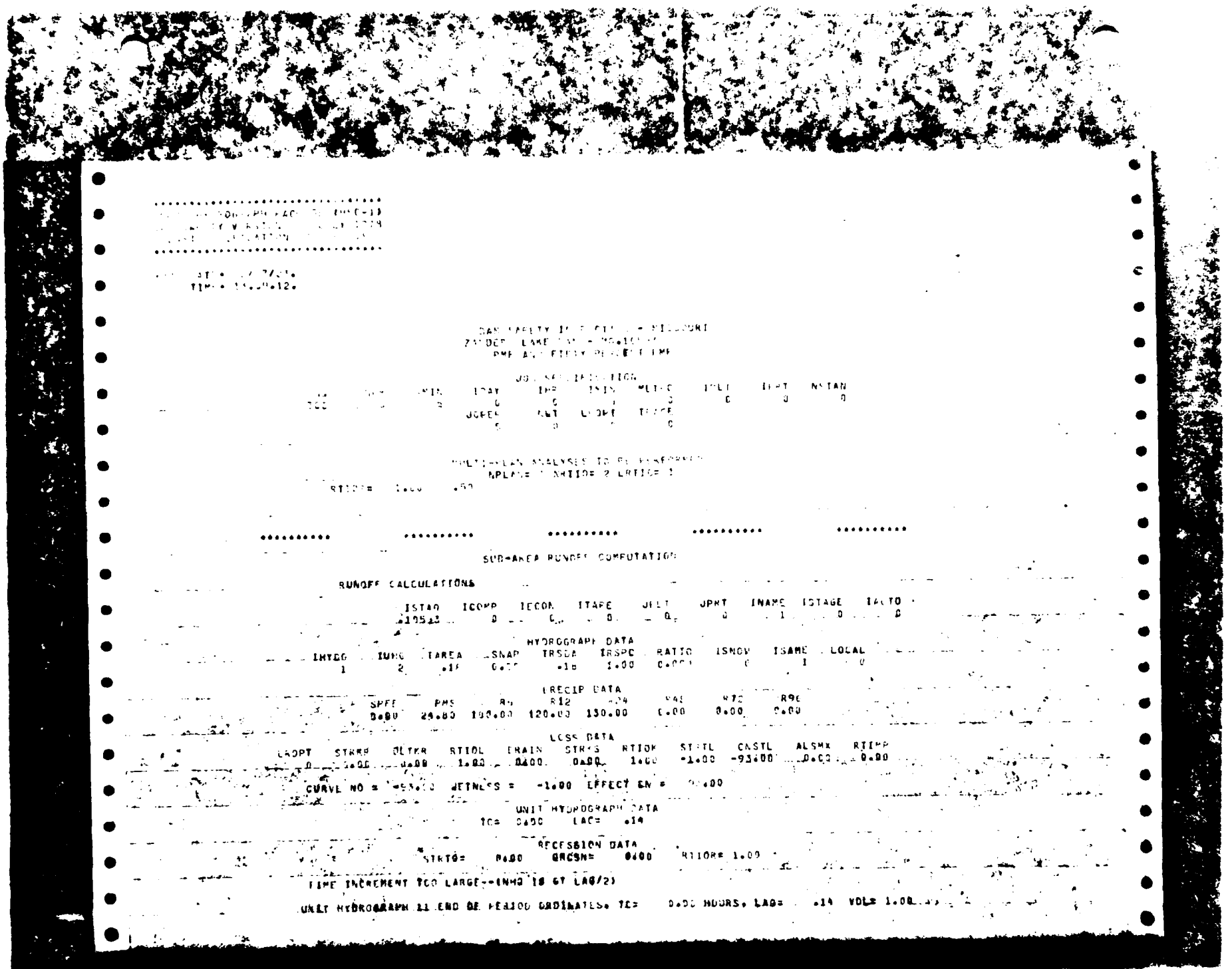
HEC1DB INPUT DATA

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

DAM SAFETY INSPECTION - MISSOURI
ZANDER LAKE DAM - MO.10593
PMF AND FIFTY PERCENT PMF

```
     1 A1
     2 A2
     3 A3
     4 B     300       0       5       0       0       0       0       0       0       0
     5       1       5
     6 J       1       2       1
     7 J1      1      .5                                               1
     8 K       MO.10593
     9 K1      RUNOFF CALCULATIONS                                                     1
    10 M       1       2    .177               .177       1
    11 E             24.5     100     .120      130                    -1      -.5
    12 T
    13 A2            .142
    14 Y                      1/                                       1
    15 K      1MO.10593
    16 K1     ROUTE HYDROGRAPH THROUGH DAM
    17 Y                                        1       1
    19 Y1     1                                                      -.98      -1
    18 Y4    768   768.71  769.38  770.04  770.30  770.56  770.96  771.53  771.68  771.98
    20 Y4772.28  772.73  773.63
    21 Y5       0      68     214     438     550     680     940    1494    1742    2402
    22 Y5    3223    4728    8550
    23 YA       0     4.5     6.5     8.5      10      15      22      31      41
    24 IE     754     760     765     768   770.4     775     780     785     790
    25 IS     768
    26 SD   770.4
    27 K       99
```

INFLOW PMF AND ONE-HALF PMF HYDROGRAPHS



DAM SAFETY IN [illegible] - MISSOURI
ZADOR LAKE [illegible] - 750.10
PMF AND FIFTY PERCENT PMF

JOB SPECIFICATION

NPS	NDAY	IHR	MIN	IMIT	PMS	IDAY	IPRT	NSTAN
300	0	0	0	1	0	0	0	0

JOPER	NWT	LROPT	TRACE
0	0		0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 2 LRTIO= 1

RTIO= 1.00 .50

SUB-AREA RUNOFF COMPUTATION

RUNOFF CALCULATIONS

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
19513	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.19	0.00	.19	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	24.80	100.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	1.00	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 EN = 0.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .14

RECESSION DATA
STRTQ= 0.00 QRCSN= 0.00 RTIOR= 1.00

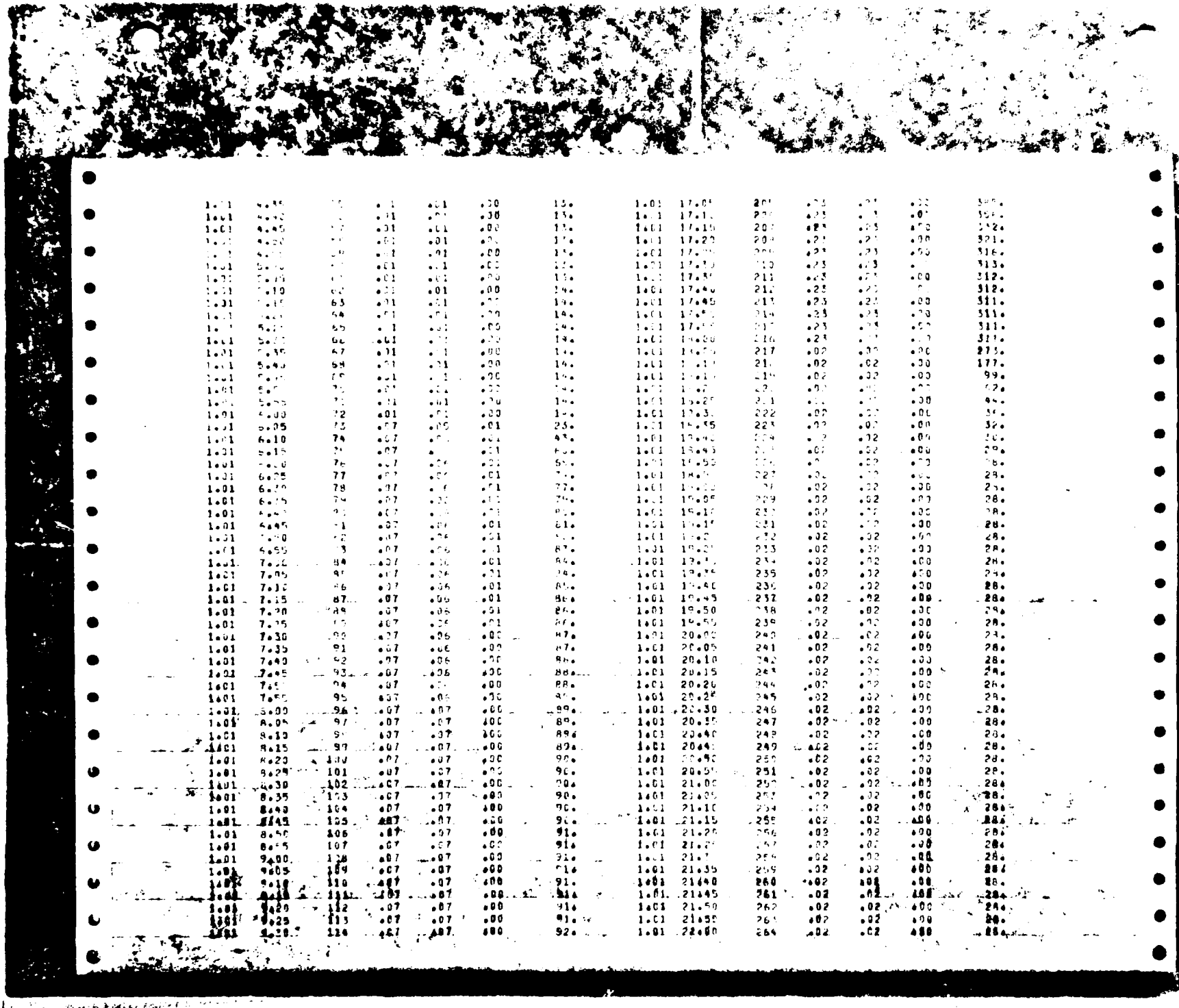
TIME INCREMENT TOO LARGE--(NHR IS GT LAG/2)

UNIT HYDROGRAPH 11 END OF PERIOD ORDINATES, TE= 0.00 HOURS, LAG= .14 VOL= 1.00

1.	4[illegible]3.	679.	178.	67.	51.	20.	9.	5.	2.

[illegible]-PERIOD FLOW

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	12.35	151	.21	.20	.00	275.
1.01	.10	[illegible]	.01	0.00	.01	0.	1.01	12.40	152	.21	.20	.00	279.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.45	153	.21	.20	.00	280.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.50	154	.21	.21	.00	2[illegible]1.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.55	155	.21	.21	.00	281.
1.01	.30	[illegible]	.01	0.00	.01	[illegible]	1.01	13.00	156	.21	.21	.00	[illegible]31.
1.01	.35	7	.01	0.00	.01	0.	1.01	13.05	157	.25	.25	.00	[illegible]8[illegible].
1.01	.40	8	.01	0.00	.01	0.	1.01	13.10	158	.25	.25	.00	30[illegible].
1.01	.45	9	.01	0.00	.01	0.	1.01	13.15	159	.25	.25	.00	323.
1.01	.50	10	.01	0.00	.01	0.	1.01	13.20	160	.25	.25	.00	331.
1.01	.55	11	.01	[illegible]	.01	0.	1.01	13.25	161	.25	.25	.00	335.
1.01	1.00	12	.01	.00	.01	0.	1.01	13.30	162	.25	.25	.00	3[illegible].
1.01	1.05	13	.01	.00	.01	[illegible]	1.01	13.35	163	.25	.25	.00	337.
1.01	1.10	14	.01	.00	.01	1.	1.01	13.40	164	.25	.25	.00	338.
1.01	1.15	15	.01	.00	.01	1.	1.01	13.45	165	.25	.25	.00	3[illegible].
1.01	1.20	16	.01	.00	.01	[illegible]	1.01	13.50	166	.25	.25	.00	33[illegible].
1.01	1.25	17	.01	.00	.01	[illegible]	1.01	13.55	167	.25	.25	.00	338.
1.01	1.30	18	.01	.00	.01	3.	1.01	14.00	168	.25	[illegible]	.00	339.
1.01	1.35	19	.01	.00	.01	3.	1.01	14.05	169	.31	.31	.00	350.
1.01	1.40	20	.01	.00	.01	4.	1.01	14.10	170	.31	.31	.00	378.
1.01	1.45	21	.01	.00	.01	4.	1.01	14.15	171	.31	.31	.00	402.
1.01	1.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.01	14.20	172	.31	.31	.00	41[illegible].
1.01	1.55	23	.01	.00	.01	5.	1.01	14.25	173	.31	.31	.00	418.
1.01	2.00	24	.01	.00	.01	6.	1.01	14.30	174	.31	.31	.00	421.
1.01	2.05	25	.01	.00	.01	6.	1.01	14.35	175	.31	.31	.00	428.
1.01	2.10	26	.01	.01	.01	6.	1.01	14.40	176	.31	.31	.00	423.
1.01	2.15	27	.01	.01	.01	7.	1.01	14.45	177	.31	.31	.00	423.
1.01	2.20	28	.01	.01	.01	7.	1.01	14.50	178	.31	.31	.00	424.
1.01	2.25	29	.01	.01	.01	7.	1.01	14.55	179	.31	.31	.00	424.
1.01	2.30	30	.01	.01	.01	8.	1.01	15.00	180	.31	.31	.00	424.
1.01	2.35	31	.01	.01	.01	8.	1.01	15.05	181	.19	.19	.00	[illegible]1.
1.01	2.40	32	.01	.01	.01	8.	1.01	15.10	182	.38	.38	.00	380.
1.01	2.45	33	.01	.01	.01	9.	1.01	15.15	183	.38	.38	.00	421.
1.01	2.50	34	.01	.01	.01	9.	1.01	15.20	184	.57	.56	.00	506.
1.01	2.55	35	.01	.01	.01	9.	1.01	15.25	185	.65	.65	.00	633.
1.01	3.00	36	.01	.01	.01	9.	1.01	15.30	186	1.60	1.60	.00	934.
1.01	3.05	37	.01	.01	.01	10.	1.01	15.35	187	2.64	2.64	.00	1636.
1.01	3.10	38	.01	.01	.01	10.	1.01	15.40	188	1.04	1.04	.00	2212.
1.01	3.15	39	.01	.01	.01	10.	1.01	15.45	189	.65	.66	.00	1973.
1.01	3.20	40	.01	.01	.01	10.	1.01	15.50	190	.57	.56	.00	1455.
1.01	3.25	41	.01	.01	.01	11.	1.01	15.55	191	.38	.39	.00	1082.
1.01	3.30	42	.01	.01	.01	11.	1.01	16.00	192	.38	.38	.00	816.
1.01	3.35	43	.01	.01	.01	11.	1.01	16.05	193	.29	.29	.00	643.
1.01	3.40	44	.01	.01	.01	11.	1.01	16.10	194	.29	.29	.00	528.
1.01	3.45	45	.01	.01	.01	11.	1.01	16.15	195	.29	.29	.00	459.
1.01	3.50	46	.01	.01	.01	11.	1.01	16.20	196	.29	.29	.00	425.
1.01	3.55	47	.01	.01	.01	12.	1.01	16.25	197	.29	.29	.00	407.
1.01	4.00	48	.01	.01	.00	12.	1.01	16.30	198	.29	.29	.00	401.
1.01	4.05	49	.01	.01	.00	12.	1.01	16.35	199	.29	.29	.00	399.
1.01	4.10	50	.01	.01	.00	12.	1.01	16.40	200	.29	.29	.00	397.
1.01	4.15	51	.01	.01	.00	12.	1.01	16.45	201	.29	.29	.00	[illegible]
1.01	4.20	52	.01	.01	.00	12.	1.01	16.50	202	.29	.29	.00	396.
1.01	4.25	53	.01	.01	.00	13.	1.01	16.55	203	.29	.29	.00	395.
1.01	4.30	54	.01	.01	.00	13.	1.01	17.00	204	.29	.29	.00	39[illegible].



1.01	9.35	115	.07	.07	.00	92.	1.01	22.05	265	.02	.02	.0	[illegible]
1.01	9.40	116	.07	.07	.00	92.	1.01	22.10	266	.02	.02	.00	[illegible]
1.01	9.45	117	.07	.07	.00	92.	1.01	22.15	267	.02	.02	.00	28.
1.01	9.50	118	.07	.07	.00	92.	1.01	22.20	268	.02	.02	.00	28.
1.01	9.55	119	.07	.07	.00	92.	1.01	22.25	269	.02	.02	.00	28.
1.01	10.00	120	.07	.07	.00	92.	1.01	22.30	270	.02	.02	.00	28.
1.01	10.05	121	.07	.07	.00	92.	1.01	22.35	271	.02	.02	.00	28.
1.01	10.10	122	.07	.07	.00	92.	1.01	22.40	272	.02	.02	.00	28.
1.01	10.15	123	.07	.07	.00	92.	1.01	22.45	273	.02	.02	.00	28.
1.01	10.20	124	.07	.07	.00	92.	1.01	22.50	274	.02	.02	.00	28.
1.01	10.25	125	.07	.07	.00	92.	1.01	22.55	275	.02	.02	.00	28.
1.01	10.30	126	.07	.07	.00	92.	1.01	23.00	276	.02	.02	.00	28.
1.01	10.35	127	.07	.07	.00	92.	1.01	23.05	277	.02	.02	.00	28.
1.01	10.40	128	.07	.07	.00	92.	1.01	23.10	278	.02	.02	.00	28.
1.01	10.45	129	.07	.07	.00	93.	1.01	23.15	279	.02	.02	.00	28.
1.01	10.50	130	.07	.07	.00	93.	1.01	23.20	280	.02	.02	.00	28.
1.01	10.55	131	.07	.07	.00	93.	1.01	23.25	281	.02	.02	.00	28.
1.01	11.00	132	.07	.07	.00	93.	1.01	23.30	282	.02	.02	.00	28.
1.01	11.05	133	.07	.07	.00	93.	1.01	23.35	283	.02	.02	.00	28.
1.01	11.10	134	.07	.07	.00	93.	1.01	23.40	284	.02	.02	.00	28.
1.01	11.15	135	.07	.07	.00	93.	1.01	23.45	285	.02	.02	.00	28.
1.01	11.20	136	.07	.07	.00	93.	1.01	23.50	286	.02	.02	.00	28.
1.01	11.25	137	.07	.07	.00	93.	1.01	23.55	287	.02	.02	.00	28.
1.01	11.30	138	.07	.07	.00	93.	1.02	0.00	288	.02	.02	.00	28.
1.01	11.35	139	.07	.07	.00	93.	1.02	.05	289	0.00	0.00	0.00	24.
1.01	11.40	140	.07	.07	.00	93.	1.02	.10	290	0.00	0.00	0.00	15.
1.01	11.45	141	.07	.07	.00	93.	1.02	.15	291	0.00	0.00	0.00	7.
1.01	11.50	142	.07	.07	.00	93.	1.02	.20	292	0.00	0.00	0.00	3.
1.01	11.55	143	.07	.07	.00	93.	1.02	.25	293	0.00	0.00	0.00	2.
1.01	12.00	144	.07	.07	.00	95.	1.02	.30	294	0.00	0.00	0.00	1.
1.01	12.05	145	.21	.20	.00	118.	1.02	.35	295	0.00	0.00	0.00	0.
1.01	12.10	146	.21	.20	.00	181.	1.02	.40	296	0.00	0.00	0.00	0.
1.01	12.15	147	.21	.20	.00	[illegible]	1.02	.45	297	0.00	0.00	0.00	0.
1.01	12.20	148	.21	.20	.00	257.	1.02	.50	298	0.00	0.00	0.00	0.
1.01	12.25	149	.21	.20	.00	269.	1.02	.55	299	0.00	0.00	0.00	0.
1.01	12.30	150	.21	.20	.00	275.	1.02	1.00	300	0.00	0.00	0.00	0.

SUM 32.24 31.35 .89 42928.
(819.)(796.)(23.)(1216.59)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2210.	467.	149.	149.	42924.
CMS	63.	13.	4.	4.	1216.
INCHES		24.55	31.35	31.35	31.35
MM		623.44	796.39	796.39	796.39
AC-FT		232.	296.	296.	296.
THOUS CU M		286.	365.	365.	365.

HYDROGRAPH AT STA.10593.00 PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	1.	1.	2.	2.	3.	3.	4.
4.	5.	6.	6.	6.	6.	7.	7.	7.	8.
8.	8.	9.	9.	9.	9.	10.	10.	10.	10.
11.	11.	11.	11.	11.	11.	12.	12.	12.	12.
12.	12.	13.	13.	13.	13.	13.	13.	13.	13.
13.	14.	14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	23.	43.	60.	69.	74.	77.	79.	80.
81.	82.	83.	84.	84.	85.	86.	86.	86.	87.

87.	[illegible]	[illegible]	88.	[illegible]	[illegible]	[illegible]	89.	[illegible]	90.
90.	91.	[illegible]	90.	90.	91.	91.	91.	91.	91.
91.	91.	91.	[illegible]	[illegible]	92.	92.	92.	92.	92.
[illegible]	[illegible]	[illegible]	92.	92.	92.	92.	[illegible]	[illegible]	93.
[illegible]	[illegible]	[illegible]	[illegible]	93.	[illegible]	[illegible]	93.	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	237.	257.	[illegible]	275.
[illegible]	279.	[illegible]	291.	[illegible]	[illegible]	[illegible]	[illegible]	323.	331.
[illegible]	336.	337.	339.	338.	338.	338.	378.	[illegible]	378.
[illegible]	413.	[illegible]	421.	422.	422.	423.	424.	424.	424.
401.	480.	421.	[illegible]	[illegible]	[illegible]	[illegible]	2212.	[illegible]	1455.
[illegible]	516.	[illegible]	[illegible]	[illegible]	[illegible]	407.	461.	[illegible]	397.
376.	336.	396.	395.	[illegible]	356.	[illegible]	321.	316.	313.
312.	312.	[illegible]	311.	[illegible]	[illegible]	273.	177.	[illegible]	62.
44.	36.	32.	[illegible]	29.	[illegible]	[illegible]	28.	28.	28.
28.	28.	29.	29.	29.	28.	[illegible]	28.	29.	29.
29.	29.	29.	[illegible]	[illegible]	[illegible]	[illegible]	28.	28.	28.
28.	29.	[illegible]	29.	[illegible]	[illegible]	[illegible]	[illegible]	29.	29.
28.	28.	[illegible]	[illegible]	[illegible]	[illegible]	28.	28.	[illegible]	28.
[illegible]	[illegible]	29.	[illegible]	28.	[illegible]	[illegible]	28.	[illegible]	28.
28.	28.	28.	29.	26.	[illegible]	[illegible]	24.	24.	15.
7.	[illegible]	2.	1.	0.	[illegible]	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2112.	461.	149.	142.	42954.
CMS	63.	13.	4.	4.	1216.
INCHES		[illegible]	31.39	[illegible]	31.39
MM		623.45	796.39	[illegible]	796.39
AC-FT		[illegible]	[illegible]	296.	296.
THOUS CU M		[illegible]	365.	365.	365.

HYDROGRAPH AT STA.10593 FOR PLAN 1, RTIO 2

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	1.	1.	1.	1.	2.	2.
2.	2.	3.	3.	3.	3.	3.	4.	4.	4.
4.	4.	4.	4.	5.	5.	5.	5.	5.	5.
5.	5.	5.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	7.	7.	7.	7.
7.	7.	7.	7.	7.	7.	7.	7.	7.	7.
7.	7.	11.	22.	[illegible]	35.	37.	39.	39.	40.
41.	41.	42.	42.	42.	43.	43.	43.	43.	43.
44.	44.	44.	44.	44.	44.	44.	45.	45.	45.
45.	45.	45.	45.	45.	45.	45.	45.	45.	46.
46.	46.	46.	46.	46.	46.	46.	46.	46.	46.
46.	46.	46.	46.	46.	46.	46.	46.	46.	46.
46.	46.	46.	46.	46.	46.	46.	46.	46.	46.
46.	47.	47.	47.	59.	91.	117.	129.	135.	138.
139.	140.	140.	140.	140.	140.	144.	154.	162.	165.
167.	168.	169.	169.	169.	169.	169.	169.	175.	189.
201.	207.	209.	211.	211.	211.	212.	212.	212.	212.
201.	199.	211.	253.	317.	467.	819.	1106.	999.	728.
541.	409.	321.	264.	229.	212.	204.	200.	199.	198.
198.	198.	198.	196.	192.	178.	166.	161.	156.	157.
156.	156.	156.	156.	156.	156.	137.	89.	50.	31.
22.	18.	16.	15.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	[illegible]	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.	14.	14.

PMF AND ONE-HALF PMF ROUTING

1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.	0.	1.	0.	0.	0.	0.	0.	0.	0.

	PEAK	MAX	24-HR	72-HR	TOTAL VOL
CFS	11.6	230.	7.	7.	1477.
CMS	.33	7.	.2	.2	42.
INCHES		12.07	1.06	1.06	1.06
MM		307.34	26.92	26.92	26.92
AC-FT		110.	14.	14.	148.
THOUS CU M		14.	1.	1.	1.

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HYDROGRAPH ROUTING

ROUTE HYDROGRAPH THROUGH DAM

INAME	ISTAGE	IAUTO
1	0	0

ROUTING DATA

CLOSS	CLOSS	AVG	IRES	ISAME	ICON	IPRT	LSTR
1.0	0.040	0.00	1	1	0	5	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.033	0.000	0.00	0.	-1

STAGE	768.00	768.71	769.71	770.04	770.30	770.56	770.96	771.53	771.68	771.98
	772.28	772.72	773.65							
FLOW	0.00	68.00	214.00	430.00	550.00	660.00	850.00	1494.00	1742.00	2402.00
	3223.00	4728.00	8550.00							
SURFACE AREA=	0.	5.	7.	9.	10.	15.	22.	31.	41.	
CAPACITY=	0.	9.	56.	59.	81.	134.	230.	362.	941.	
ELEVATION=	754.	764.	765.	766.	770.	775.	780.	785.	790.	

SPREL	SPWID	COOW	EXPW	ELEVL	COOL	CARLA	EXPL
768.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

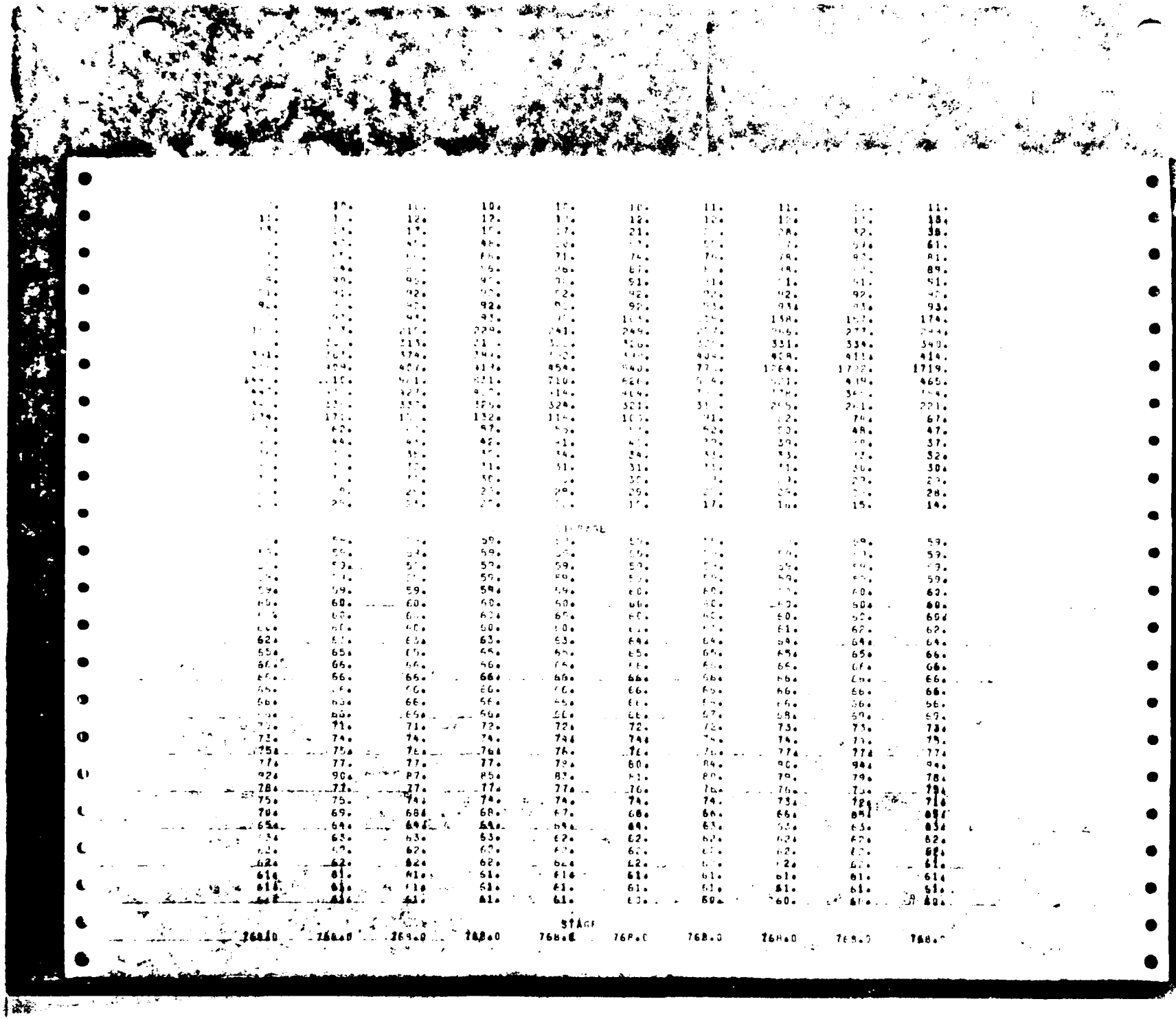
DAM DATA

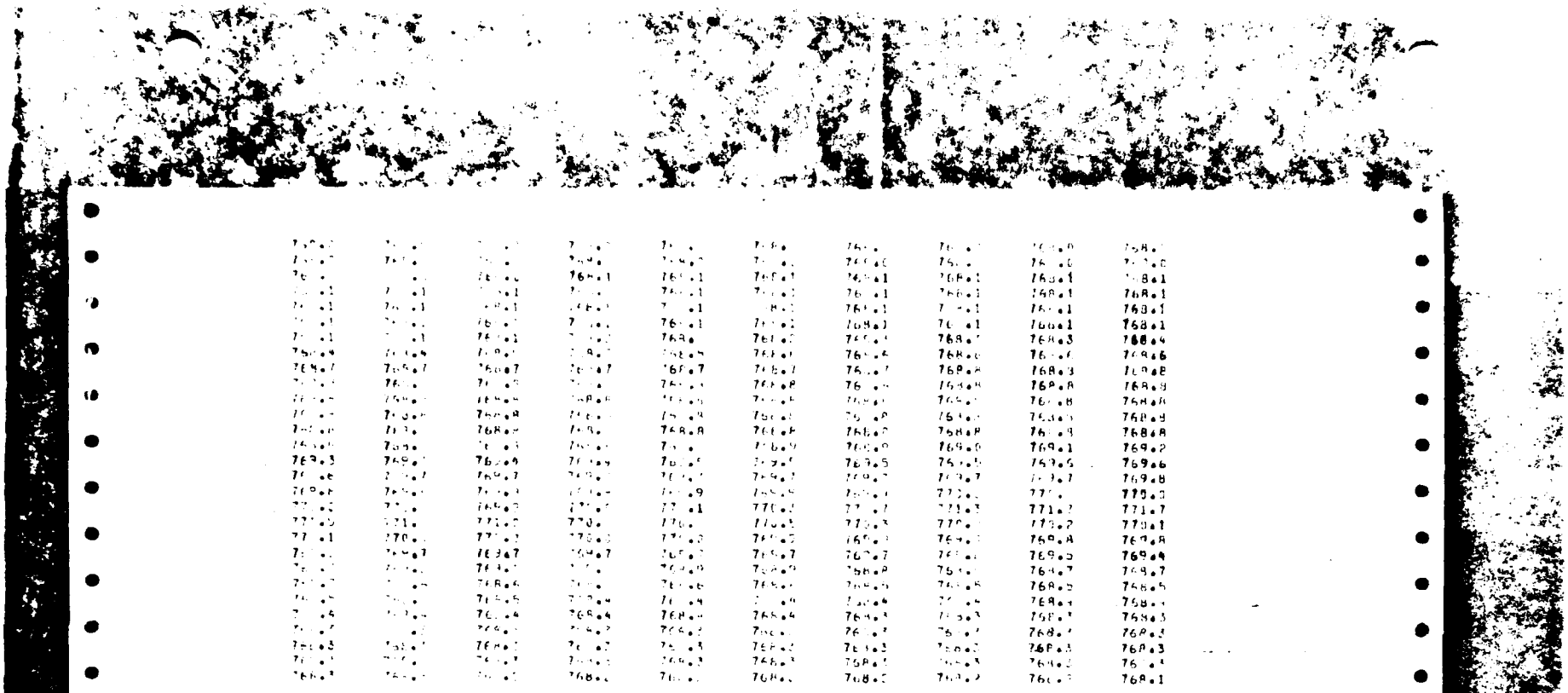
TOPEL	COQD	EXPD	DAMWID
770.4	0.0	0.0	0.

STATION a10591a PLAN 1. RATIO 1

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.	1.	1.	1.
1.	1.	2.	2.	2.	3.	3.	3.	3.	4.	
4.	4.	5.	5.	5.	6.	6.	6.	6.	7.	
7.	7.	8.	8.	8.	8.	9.	9.	9.	9.	





PEAK OUTFLOW IS [illegible] AT TIME 1.75 HOURS

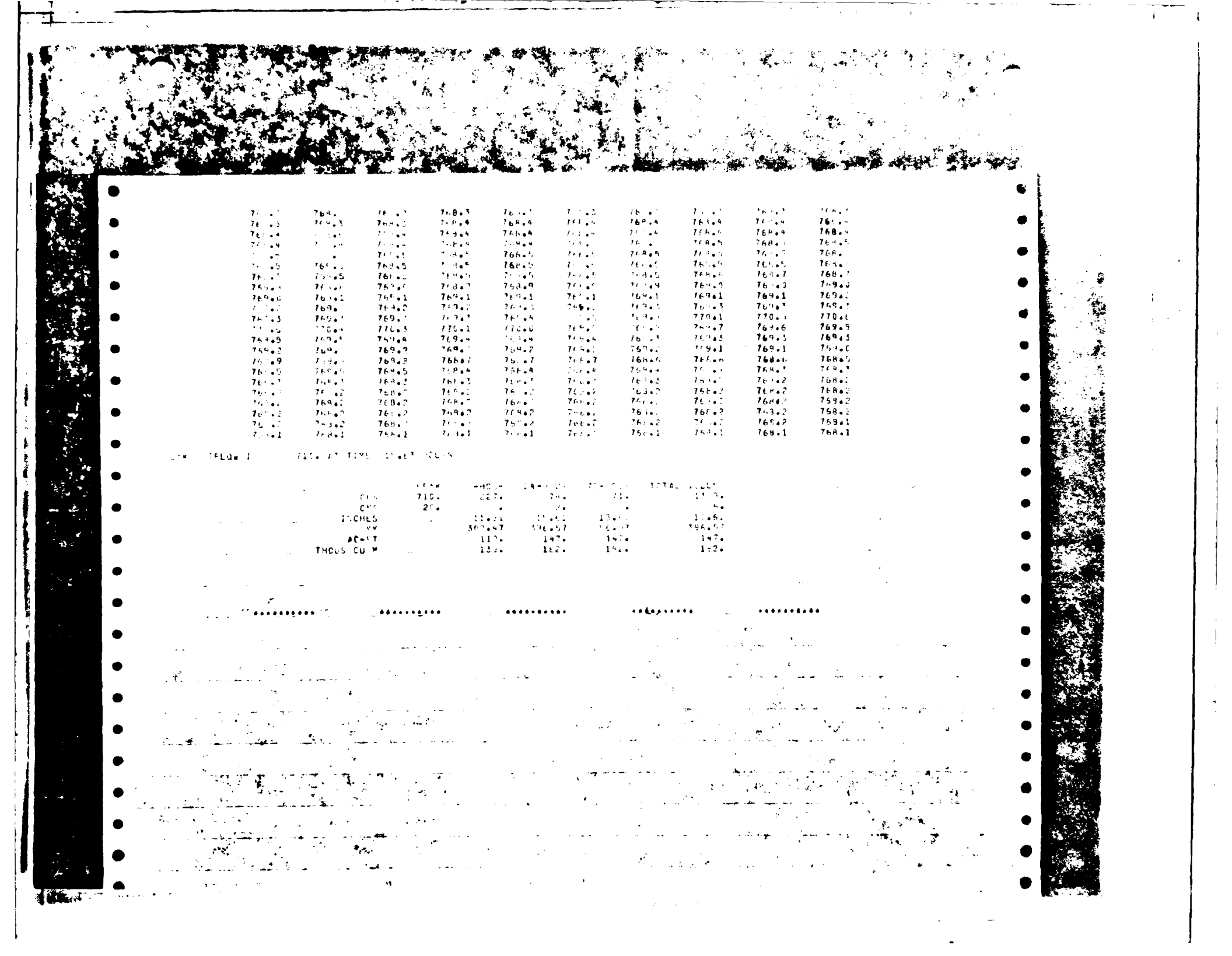
	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1722.	458.	149.	147.	42775.
CMS	49.	13.	4.	4.	1211.
INCHES		.0607	31.22	31.22	31.22
MM		1.6A	793.07	793.07	793.07
AC-FT		227.	295.	295.	295.
THOUS CU M		28.	363.	363.	363.

STATION [illegible] PLAN 1. RATIO 2

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.
1.	1.	1.	1.	1.	1.	1.	2.	2.	2.
2.	2.	2.	3.	3.	3.	3.	3.	3.	3.
4.	4.	4.	4.	4.	4.	4.	4.	5.	5.
5.	5.	5.	5.	5.	5.	5.	5.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	7.	7.	9.	11.	13.	14.	16.	18.
19.	21.	23.	24.	25.	27.	28.	29.	30.	31.
32.	33.	35.	34.	35.	36.	36.	37.	37.	38.
37.	39.	39.	40.	40.	41.	41.	41.	42.	42.
42.	42.	42.	43.	43.	43.	43.	44.	44.	44.



SUMMARY OF PMF AND ONE-HALF PMF FLOOD ROUTING

MEAN FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR HYDROLOGIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PEAK	RATIO 1 1.00	RATIO 2 .00
HYDROGRAPH AT	.13594	.18	1	221.	110.
		.46)		62.69)	31.27)
ROUTED TO	.13595	.18	1	172.	71.
		.46)		48.75)	20.10)

SUMMARY OF DAM SAFETY ANALYSIS

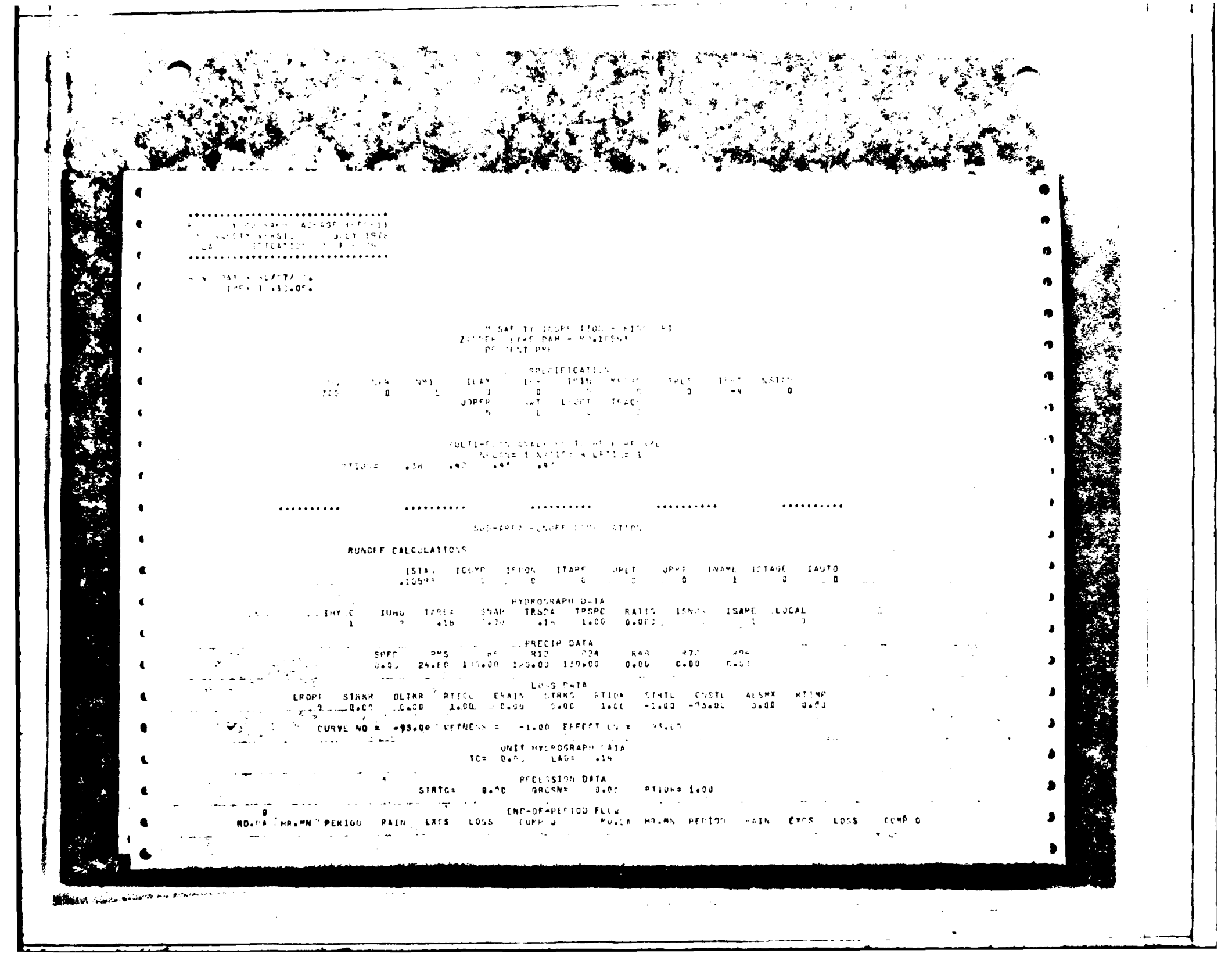
[illegible]		[illegible] VALUE	[illegible] RELEASE REST	TOP OF DAM	
		7[illegible]	7[illegible]	77.43	
		[illegible]	[illegible]	FT.	
	OUTFLOW	0.	0.	600.	

RATIO OF [illegible]	MINIMUM RESERVOIR [illegible] ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE [illegible]	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	771.67	1.07	94.	1721.	.7	15.75	0.00
.50	770.41	.21	93.	713.	.59	15.83	0.00

PERCENT OF PMF FLOOD ROUTING
EQUAL TO SPILLWAY CAPACITY

PREVIEW OF [illegible] OF STREAMFLOW FOR CALCULATIONS

RUNOFF HYDROGRAPH AT [illegible]
ROUTE HYDROGRAPH TO [illegible]
END OF SESSION



SUM 32.29 31.[illegible] .83 829.3
(817.3) 795.[illegible] .25[illegible] 12[illegible]5.59)

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MICROCOMPUTER ROUTING

ROUTE HYDROGRAPH THROUGH DAM

ITAB	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
105	1	0	0	0	0	1	0	0

ROUTING DATA

RSVR	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
.0	0.	0.0	1	1	0	0	0

NSTPS	NSTPL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.0000	0.000	0.000	768.	1

ELEV	770.00	770.27	770.53	770.94	771.03	771.06	770.96	771.53	771.69	771.95
	770.00	770.27	770.53							
FLOW	.00	27.00	91.20	439.03	.00	.00	960.00	1494.00	1742.00	2012.00
	0.00	47.00	161.00							
STOR	0.	1.	7.	0.	1.	11.	19.	51.	81.	
CAPACITY	0.	1.	36.	19.	41.	179.	230.	362.	541.	
ELEVATIONS	769.	770.	770.	770.	770.	771.	770.	785.	790.	

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
770.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
779.0	0.0	0.0	0.

PEAK OUTFLOW IS [illegible] AT TIME 15.83 HOURS

PEAK OUTFLOW IS 565. AT TIME 15.83 HOURS

PEAK OUTFLOW IS 5[illegible]. AT TIME 15.83 HOURS

PEAK OUTFLOW IS [illegible] AT TIME 15.83 HOURS

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[illegible] COMPUTATION
[illegible]
[illegible] (CUBIC METER PER SECOND) AND (CUBIC METER PER SECOND)
AT A IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PEAK	TIME OF PEAK	RATIOS APPLIED TO FLOWS			
					.3	.4	.43	.47
HYDROGRAPH AT	[illegible]	.19	1	795.	570.	754.	1174.
	1	.493	1	22.53	16.13	21.35	33.25
ROUTED TO	[illegible]	.19	1	837.	771.	974.	1004.
	1	.493	1	23.70	21.83	27.58	28.43

[illegible] DAM SAFETY ANALYSIS

[illegible]

	ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	[illegible]	7[illegible].00	768.	77[illegible]
	[illegible]	[illegible].	[illegible].	[illegible].
	[illegible]	0.	0.	[illegible].

RATIO OF PMF	FLOW THROUGH SPILLWAY CFS	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.[illegible]	[illegible].	0.00	[illegible].	[illegible].	0.[illegible]	15.83	0.00
.4	[illegible].	0.00	[illegible].	[illegible].	[illegible].00	15.83	0.00
.[illegible]	[illegible].	[illegible]	[illegible].	[illegible].	0.0	15.83	0.00
.[illegible]	[illegible].	.[illegible]	[illegible].	[illegible].	.17	15.83	0.00

END

DATE
FILMED
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