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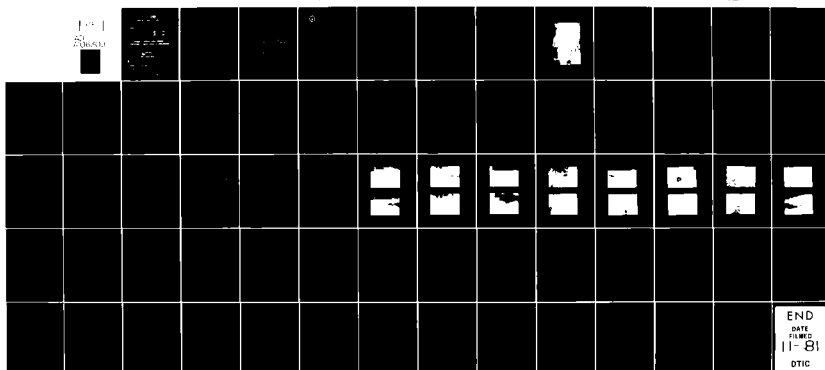
NATIONAL DAM SAFETY PROGRAM, BECKEMEYER LAKE DAM (MO 11227), MI--ETC(U)

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MISSOURI-KANSAS CITY BASIN

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BECKMEYER LAKE DAM

LAFAYETTE COUNTY, MISSOURI

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

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**United States Army
Corps of Engineers
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St. Louis District

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

FOR: STATE OF MISSOURI

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MISSOURI-KANSAS CITY BASIN

BECKEMEYER LAKE DAM

LAFAYETTE COUNTY, MISSOURI

MO 11227

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PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM



United States Army
Corps of Engineers
Serving the Army
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St. Louis District

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

FOR: STATE OF MISSOURI

MAY 1980



DEPARTMENT OF THE ARMY

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

FORM NO.
ATTACHED TO

LMSD-PD

SUBJECT: Beckemeyer Lake Dam, MO. I.D. No. 11227
Phase I Inspection Report

This report presents the results of field inspection and evaluation
of the Beckemeyer Lake Dam.

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

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

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

SUBMITTED BY:	SIGNED	24 SEP 1980
	Chief, Engineering Division	Date
APPROVED BY :	SIGNED	25 SEP 1980
	Colonel, CE, District Engineer	Date

BECKEMEYER LAKE DAM
LAFAYETTE COUNTY, MISSOURI
MISSOURI INVENTORY NO. 11227

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:
BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

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

MAY 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Beckemeyer Lake Dam
State Located	Missouri
County Located	Lafayette County
Stream	Tributary to Hicklin Branch
Date of Inspection	22 May 1980

Beckemeyer Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. 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. According to the St. Louis District, Corps of Engineers, failure would threaten lives and property. The estimated damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are four dwellings, two roads including U.S. Route 24, and two trailers. Contents of the estimated damage zone were verified by the inspection team.

Our inspection and evaluation indicates the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillways will not pass the probable maximum flood without overtopping but will pass 10 percent of the probable maximum flood. The spillways will not pass the estimated flood which has one percent chance of occurrence in any given year (100-year flood). The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the small volume of water impounded behind the dam, the valley below the dam and the hazard zone, the spillway design flood should be 50 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge which may be expected from the most severe combination of critical meteorologic and hydrologic conditions which are reasonably possible in the region.

Based on visual observations, this dam appears to be in fair condition. Deficiencies visually observed by the inspection team were seepage and erosion at the interface of the embankment and the left abutment, seepage downstream of the dam, erosion in the emergency spillway, and numerous animal burrows particularly on the upstream slope. Seepage and stability analyses required by the guidelines were not available.

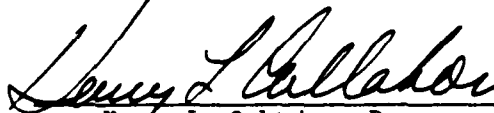
There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.



Paul R. Zeman, PE
Illinois 62-29261



Edwin R. Burton, PE
Missouri E-10137



Harry L. Calishan, Partner
Black & Veatch



OVERVIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BECKEMEYER LAKE DAM

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APPENDIX

Appendix A - Hydrologic and Hydraulic Analyses

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 District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Beckmever Lake Dam be made.

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

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." 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 structure located in the valley of a tributary to Hicklin Branch, a tributary of the Missouri River (Plate 1). The watershed is an area of low hills consisting of timber and crop land (Plate 2). The dam is approximately 375 feet long along the crest and 31 feet high. The dam crest is 16 feet wide. The downstream face of the dam has an irregular slope from the crest to the valley floor below.

(2) The primary spillway from the lake is an uncontrolled 15-inch beveled steel pipe with a canopy inlet installed in the embankment. Flow through the pipe discharges into the natural stream channel below. The emergency spillway consists of a notch cut in the abutment. Discharge through the emergency spillway flows around the east end of the dam to the natural stream channel.

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

b. Location. The dam is located in Lafayette County, Missouri. The location is shown on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Bates City, Missouri in Section 26 of T50N, R29W.

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, the dam and impoundment are in the small size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Beckemeyer Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Beckemeyer Lake Dam the estimated flood damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are four dwellings, two roads including U.S. Route 24 and two trailers. Contents of the estimated damage zone were verified by the inspection team.

e. Ownership. The dam is owned by Howard Beckemeyer, Route 1, Napoleon, Missouri 64074, Telephone 816-934-8254.

f. Purpose of Dam. The dam forms an 8-acre lake used for soil conservation and livestock water supply.

g. Design and Construction History. The Lafayette County Soil Conservation Service provided assistance in the design and construction of the dam. The dam was constructed in 1977.

h. Normal Operating Procedure. Normal rainfall, runoff, withdrawals (pumped) for water supply for livestock operation, transpiration, evaporation, and overflow through the uncontrolled outlet pipe all combine to maintain a relatively stable water surface elevation.

1.3 PERTINENT DATA

a. Drainage Area - 237 acres (includes 90 acres above an upstream impoundment).

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled 15-inch outlet pipe.

(2) Estimated experienced maximum flood at damsite - The owner Mr. Howard Beckemeier, stated that a rainfall of approximately 1.5 inches in 24 hours during September, 1977 did not overtop the dam. Prior to this time the lake was nearly empty.

(3) Estimated ungated spillway capacity at maximum pool elevation 1,050 cfs (50 percent Probable Maximum Flood Pool El. 756.1):

c. Elevation (feet above m.s.l.)

- (1) Top of dam - 753.9 (see Plate 3)
- (2) Emergency spillway crest - 752.6
- (3) Primary spillway pipe invert - 750.0
- (4) Streambed at toe of dam - 723.4
- (5) Maximum tailwater - Unknown

d. Reservoir

(1) Length of maximum pool - 2200 feet + (50 percent probable maximum flood pool level)

(2) Length of normal pool - 2000 feet + (Primary spillway pipe invert)

e. Storage (Acre-feet)

- (1) Top of dam - 122
- (2) Emergency spillway crest - 109
- (3) Primary spillway pipe invert - 86
- (4) Design surcharge - Not available

f. Reservoir Surface (Acres)

- (1) Top of dam - 11.0
- (2) Emergency spillway crest - 10.0

1. Primary spillway pipe invert - 8.1
2. Dam
 1. Type - Earth embankment
 2. Length - 570 feet
 3. Height - 51 feet
 4. Top width - 16 feet
 5. Side slopes - upstream face 1 G V on 4.2 H, downstream face varies between 1 G V on 2.8 H and 1 G V on 3.5 H (see Plate 4)
 6. Lining - Unknown
 7. Impervious core - Unknown
 8. Cutoff - Unknown
 9. Grout curtain - Unknown
3. Diversion and Regulating Tunnel - None
4. Primary Spillway
 1. Type - 45-inch beveled steel pipe with a canopy inlet
 2. Inlet invert elevation - 750.0 feet m.s.l.
 3. Outlet invert elevation - 723.7 feet m.s.l.
 4. Gates - None
 5. Upstream channel - Dead trees stand in the upper end of the lake. The channel is tree lined with another dam upstream
 6. Downstream channel - Natural open channel to streambed
5. Emergency Spillway
 1. Type - Grass open channel

- (c) Width of channel - 54 feet
- (d) Emergency spillway crest - 752.6
- (e) Gates - None
- (f) Upstream channel - Not applicable
- (g) Downstream channel - Natural open channel to a streambed
- (h) Regulating Outlets - Not observed

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design assistance was provided by the Lafayette County Soil Conservation Service. Design data were unavailable.

2.2 CONSTRUCTION

Construction records were unavailable, however, the dam was constructed in 1977.

2.3 OPERATION

Documentation of past floods was not available. The owner, Mr. Howard Beckemeyer, stated that a rainfall of 12 inches in a 24-hour period in September, 1977 did not overtop the dam but caused erosion in the unlined emergency spillway channel. It should be noted that the dam was just completed and that the lake was nearly empty when the storm occurred.

2.4 GEOLOGY

The site of the dam and reservoir is located in a deeply incised valley between two ridges. The dam impounds a small intermittent tributary of Nicklin Branch.

The soil of the dam and reservoir area consists of the Knox soil series. The Knox series consists of well-drained, loamy soils on ridges and hillsides. These soils formed under deciduous hardwoods in 10 to 90 feet or more of loess. Limestone, shale, or sandstone bedrock occurs beneath the loess. For engineering purposes these soils are classified as low-plastic silt (ML) or low-plastic clay (CL).

The bedrock in the area of the dam and reservoir consists of shale of the Pleasanton Group and interbedded shale, limestone, coal and sandstone of the Marmaton Group.

2.5 EVALUATION

a. Availability No engineering data could be obtained.

b. Adequacy Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate

loading conditions (including earthquake loads) and made a matter of record.

c. Validity. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Beckemeyer Lake Dam was made on 22 May 1980. The inspection team consisted of Ed Burton, team leader; Bob Pinker, geologist; C.L. Metzler, geotechnical engineer; Mark Snyder, hydraulic engineer; John Ruhl, hydraulic engineer; and Al Reif, structural engineer. Mr. Howard Beckemeyer, the dam owner, was at the site before and after the inspection. The dam is in fair condition. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following conditions at the dam. No cracking, sloughing, sliding, sinkholes, or other signs of settlement were observed. There is no evidence to indicate that the embankment has been overtopped. The embankment has no visible stability problems.

Seepage and resulting erosion was observed at the interface of the embankment and the left abutment. Seepage was also observed downstream of the embankment. The seepage was clear and nonflowing except at the left abutment where the flow was estimated to be 1 gpm. Some erosion has occurred on the downstream face. The material being eroded is a clayey silt (ML). No toe drains or relief wells were observed. The embankment has a good fescue grass cover on the upstream and downstream slopes. This grass has been effective in slowing erosion on the downstream slope but has not curbed erosion in the seepage areas. There are no trees on the embankment. Considerable animal burrowing activity was observed on the upstream slope which indicated the presence of several large colonies. Very few burrows were noted on the downstream slope with some observed on the dam crest.

c. Appurtenant Structures. The inspection team observed the following items pertaining to the appurtenant structures. The primary spillway consists of an uncontrolled 15-inch beveled steel pipe with a canopy inlet which runs through the embankment. About 10-12 feet of the interior of the steel pipe at the outlet end, about 4 feet of the exterior of the pipe at the outlet end, and 2 feet of the pipe at the inlet end were inspected. Minor rust was found on the inside surface. The pipe alignment was observed to follow a vertical curve. No evidence of leakage was noted into, out of or around the spillway pipe. There is some erosion near the outlet end of the primary spillway pipe.

The grass-lined emergency spillway channel was observed to be eroded down the middle. This erosion occurred during the September 1977 flood, prior to establishment of the grass cover, according to the owner, Mr. Howard Beckemeyer. The eroded material is a clayey silt (ML). The emergency spillway contains no obstructions to flow.

d. Geology. The soil in the area of the dam and reservoir is formed in loess of unknown thickness. The soils are classified as low-plastic silt (ML) for engineering purposes. The depth to rock is anticipated to be greater than 10 feet.

One outcrop of bedrock was observed approximately 100 yards downstream of the dam. The rock consisted of weathered shale of the Pleasanton Group. No other outcrops were observed.

Samples of the embankment were taken near the center of the upstream crest using an Oakfield sampler. The materials in the samples were classified as clayey silt (ML) in accordance with ASTM D-2488-69. Based on the samples and visual observation, it is anticipated that the embankment consists of clayey silt (ML).

The abutments and foundation of the dam are anticipated to be clayey silt overlying shale bedrock.

e. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir. The lake is fairly clear with no noticeable siltation.

f. Downstream Channel. The channel downstream of the spillway outlet pipe is a natural open channel to the original streambed.

3.2 EVALUATION

The various deficiencies observed at the time of the inspection are not believed to represent an immediate safety hazard. They do, however, warrant monitoring and control. The most serious seepage is at the left abutment interface. Seepage can cause internal erosion creating cavities and underground channels, thereby weakening the embankment. The most serious erosion is in the emergency spillway channel and near the seepage at the left abutment. Burrowing animals will continue to damage the embankment if the present animal control program is not expanded sufficiently to eliminate them. Piping failure of the embankment has resulted in similar small earth dams due to burrowing animal damage.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, withdrawals (pumped) for water supply for livestock operation, evaporation, transpiration, and capacity of the uncontrolled primary spillway outlet pipe.

4.2 MAINTENANCE OF DAM

The existing maintenance program includes occasional mowing of the slopes, reseeding the eroded areas and trapping muskrats in the winter.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities were observed.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing warning system or preplanned scheme for alerting downstream residents for this dam.

4.5 EVALUATION

The maintenance program should be expanded to include more frequent mowing of the grass cover on the embankment in order to discourage animal burrowing. The animal control program should be expanded to eliminate the burrowing animals. More extensive measures than reseeding of the eroded areas should be undertaken. The areas of erosion should be repaired prior to reseeding and the seeded areas should be protected until grass cover is established. The areas of seepage should be monitored periodically and, if flows increase significantly or if seepage flows become muddy, a qualified engineer should be consulted.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data pertaining to hydrology and hydraulics were unavailable

b. Experience Data. The drainage area and lake surface area are developed from USGS Bates City Quadrangle Map. The dam layout is from a survey made during the inspection. All elevations are based on an assumed elevation of 750.0 at the primary spillway inlet invert.

c. Visual Observations.

(1) The primary spillway appears to be in good condition. The lake level at the time of the inspection was at the inlet level and there was some flow through the pipe. About 10-12 feet of the interior of the steel pipe at the outlet end, about 4 feet of the exterior of the steel pipe at the outlet end, and 2 feet of the pipe at the inlet end were observed. The spillway pipe discharges with a free outfall into a natural channel. There were no obstructions to flow in the downstream channel.

(2) The emergency spillway channel is eroded.

(3) Emergency spillway discharges can erode the embankment.

d. Overtopping Potential. The spillways were analyzed using the hydrologic and hydraulic methods described in Appendix A. The spillways will not pass the probable maximum 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 meteorologic and hydrologic conditions that are reasonably possible in the region. The spillways will pass 10 percent of the probable maximum flood without overtopping the dam. The spillways will not pass the one percent probability flood estimated to have a peak outflow of 212 cfs developed by a 24-hour, one percent probability rainfall. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the small volume of water impounded by the dam, the valley below the dam and the downstream hazard, the appropriate spillway design flood should be 50 percent of the probable maximum flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 2,600 cfs of the total discharge from the reservoir of 4,300 cfs. The estimated duration of overtopping is 8.2 hours with a maximum height of 3.2 feet. The

portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 850 cfs of the total discharge from the reservoir of 1,900 cfs. The estimated duration of overtopping is 5.8 hours with a maximum height of 2.2 feet. Overtopping of the embankment for these periods of time could jeopardize the embankment.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately two miles downstream of the dam. Four dwellings, two roads including U.S. Route 24 and two trailers could be severely damaged and lives could be lost should failure of the dam occur. Contents of the estimated downstream damage zone were verified by the inspection team. There does not appear to be any flood plain regulations or other constraints in force to limit future downstream development.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

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

c. Operating Records. No operational records exist.

d. Postconstruction Changes. No changes have been made since completion of the dam.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservation should pose no serious stability problems during earthquakes in this zone. The seismic stability of an earth dam is dependent upon a number of factors: embankment and foundation material classifications and shear strengths; abutment materials, conditions, and strengths; embankment zoning, and embankment geometry. Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the visual inspection by the inspection team should be monitored and/or controlled. These are seepage and the resulting erosion at the interface of the embankment and the left abutment; erosion in the emergency spillway channel; seepage downstream of the dam; and numerous animal burrows, especially on the upstream slope of the dam.

b. Adequacy of Information. Due to the lack of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. A program should be developed as soon as possible to monitor at regular intervals the deficiencies described in this report. The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. The item recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam nor does it identify any serious dangers which would require a Phase II investigation. However, the additional analyses noted in paragraph 2.5b are necessary for compliance with the guidelines.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment was not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. The emergency spillway size and/or height of dam would need to be increased or the lake level would need to be lowered to increase available flood storage in order to pass the spillway design flood. The emergency spillway should be protected to prevent erosion.

1. Operation and Maintenance Procedures. The following operation and maintenance procedures should be carried out under the direction of an engineer experienced in the design, construction, and inspection of dams.

1.1. The seepage areas noted in section 3.1.b. as a result of the visual inspection should be closely monitored and documented as to quantity of flow.

1.2. The animal burrows in the embankment should be repaired since they can lead to piping. Control measures should be implemented to discourage increased animal activity in the area.

1.3. The areas of erosion noted in Sections 3.1.b and 3.1.c should be repaired.

1.4. An improved maintenance program should be developed. Grass cover on the embankment should be cut more frequently. Frequent observations of the upstream slope should be made to note any evidence of erosion, sloughing, or sliding of embankment material. Should conditions of progressive deterioration be noted, measures should be undertaken to evaluate the adequacy of upstream slope protection and/or the stability of the embankment.

(5) Seepage and stability analyses should be performed.

(6) A detailed inspection of the dam should be made periodically. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increase.

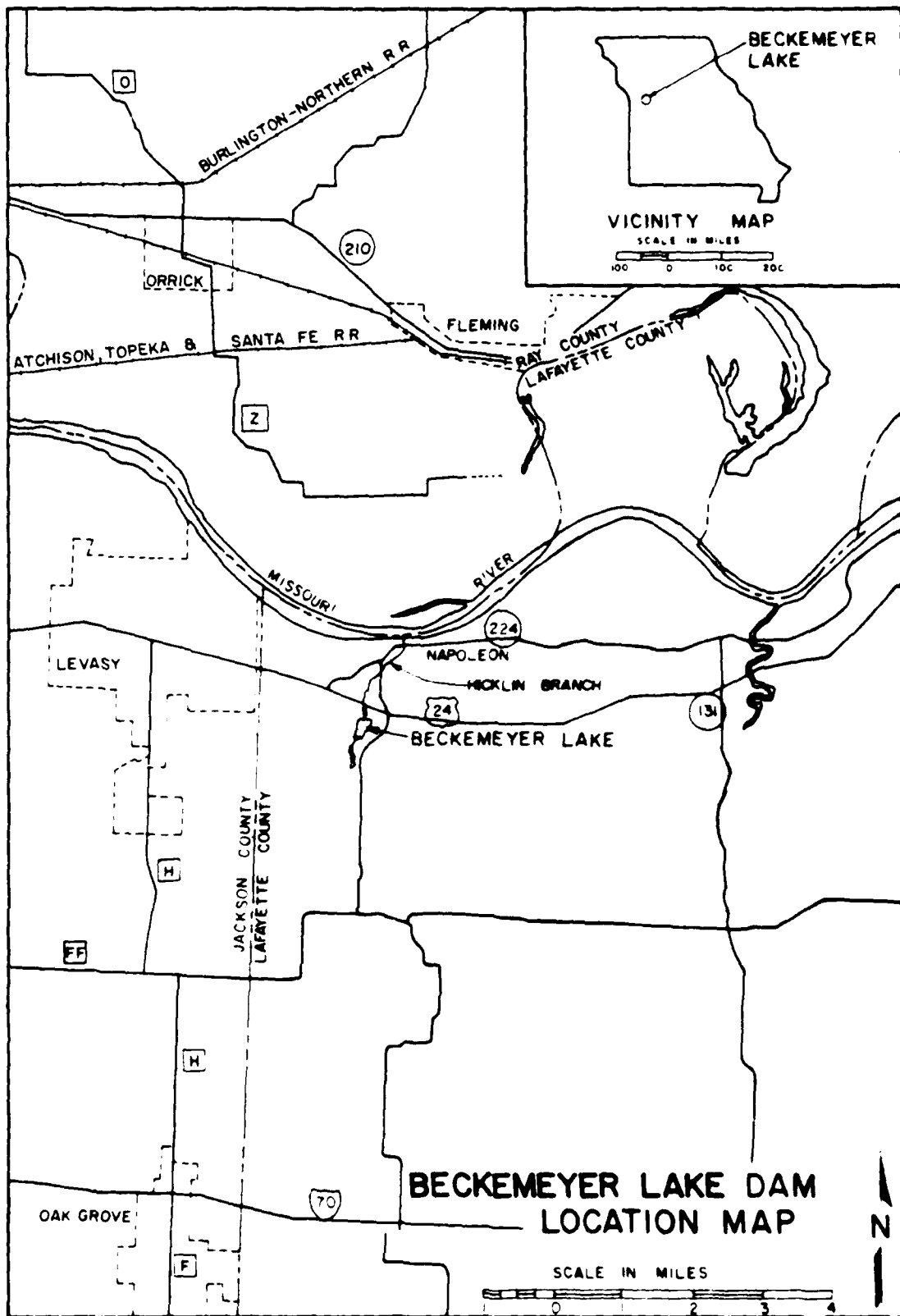


PLATE I

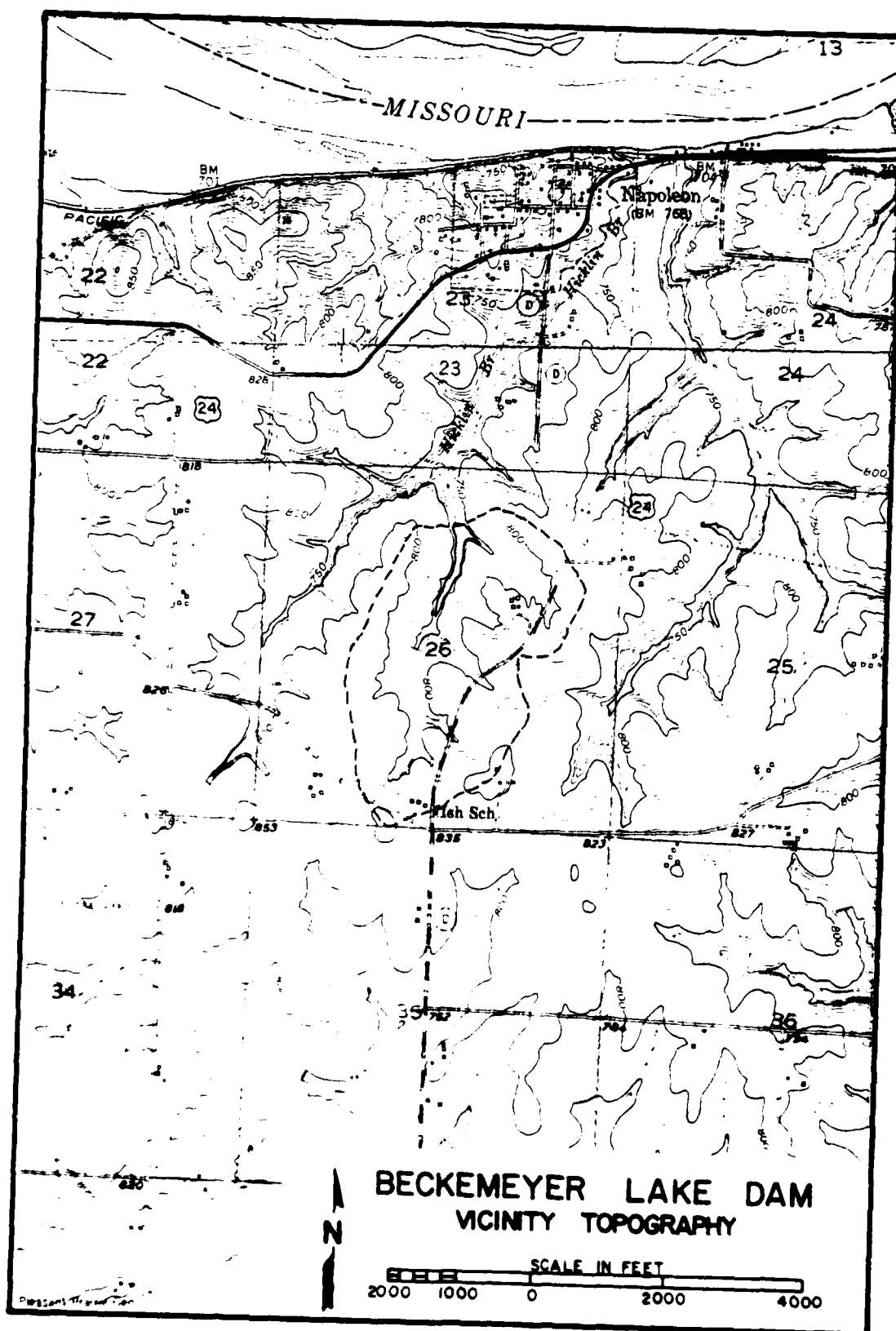
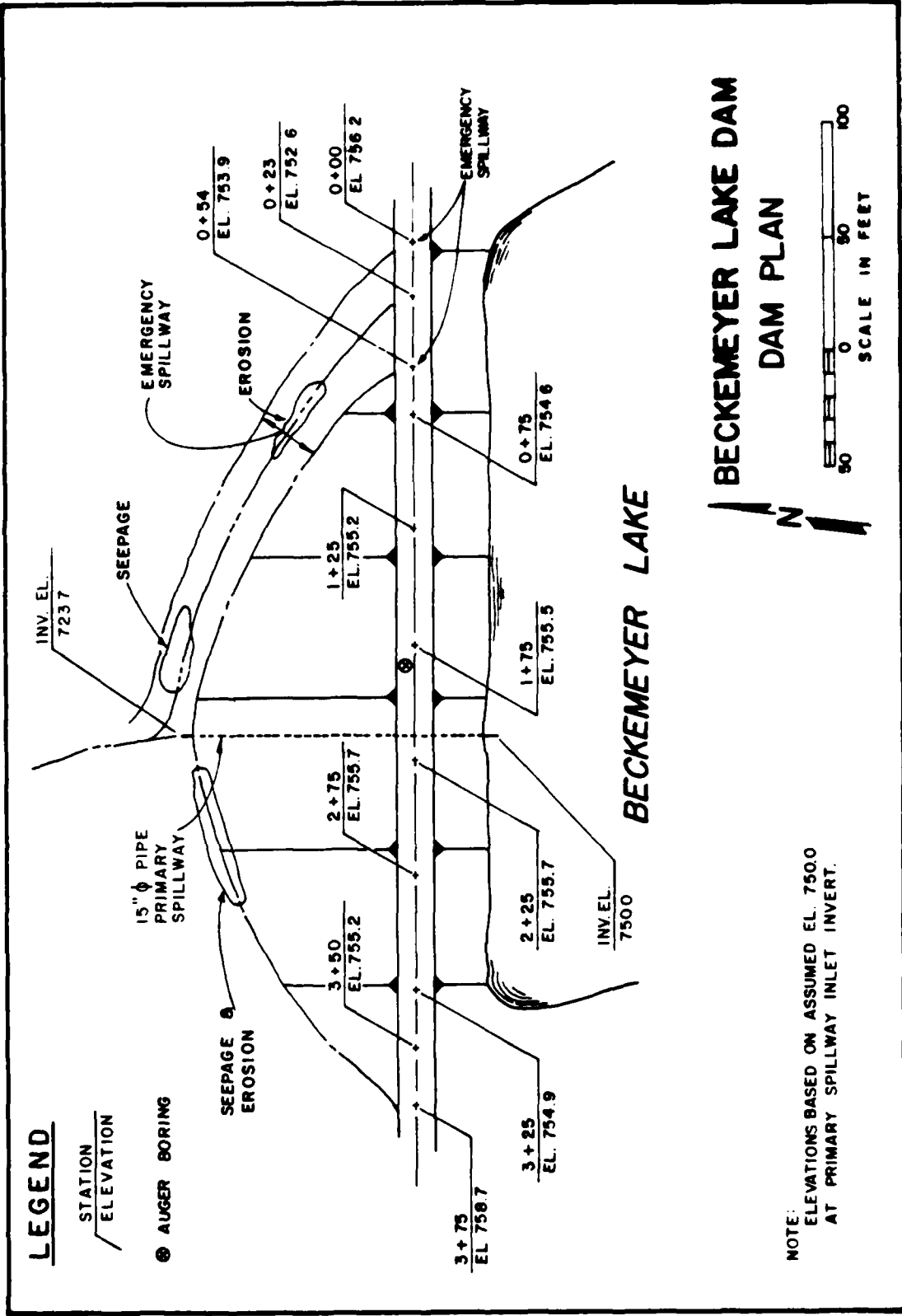
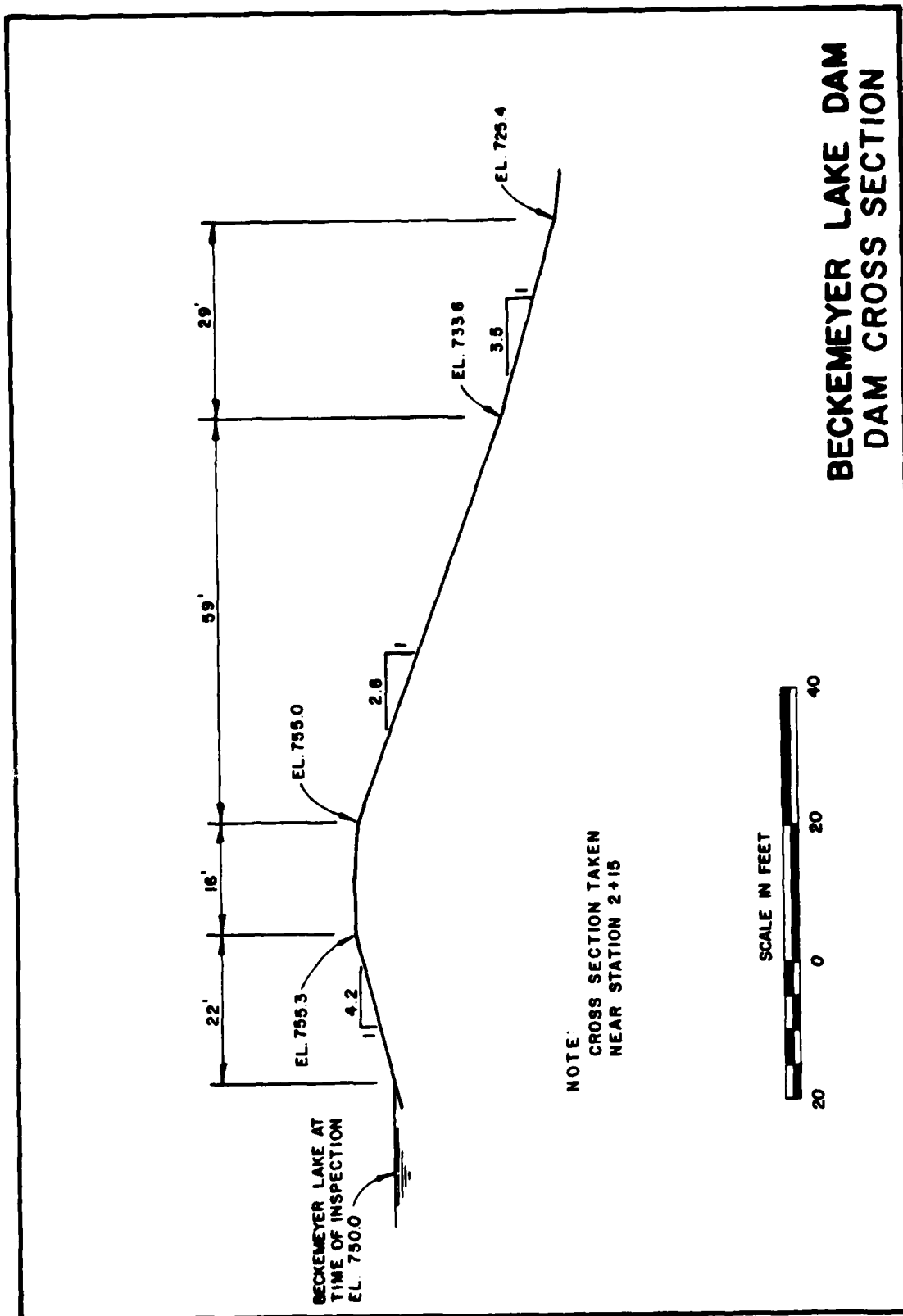
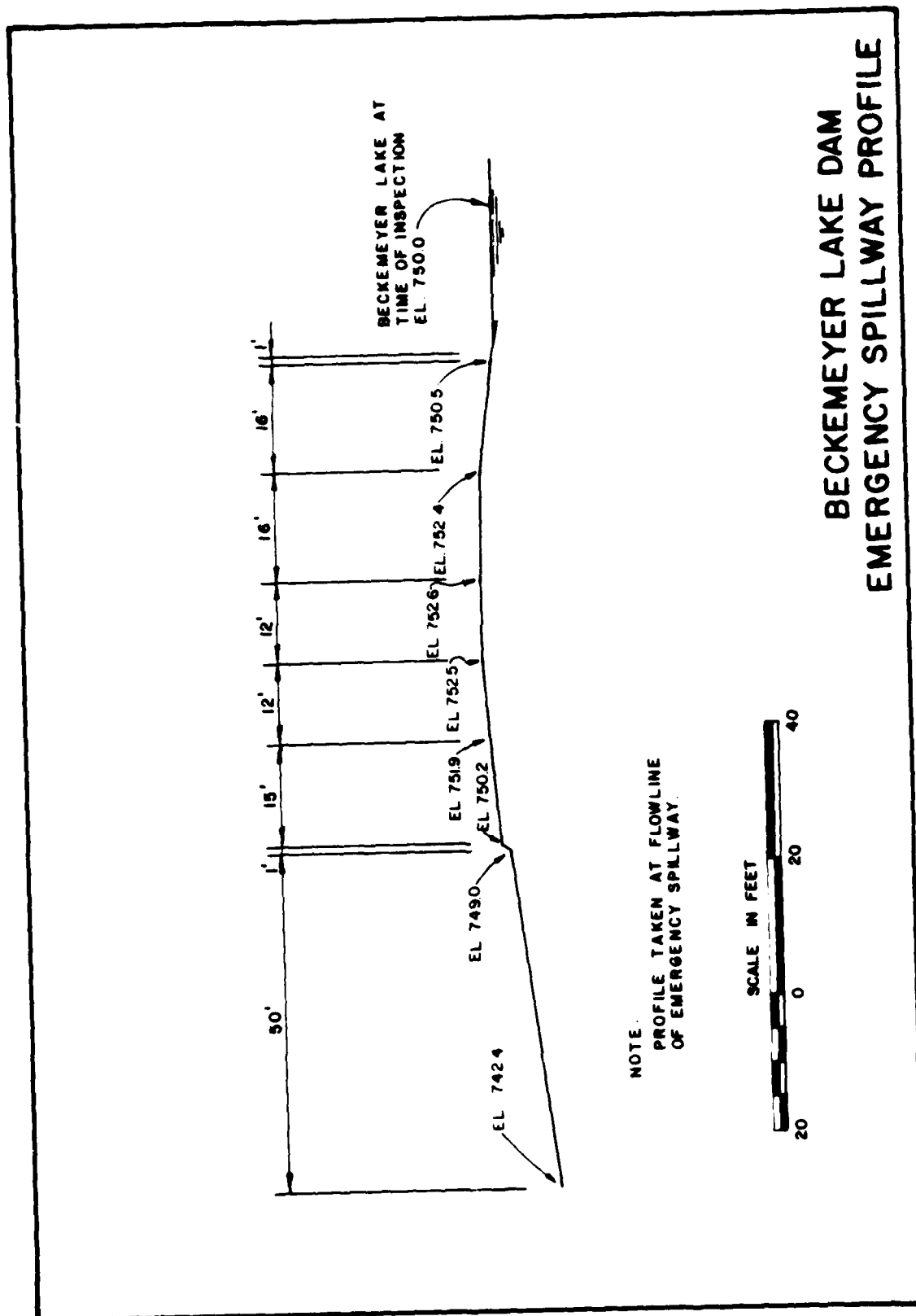


PLATE 2





BECKEMEYER LAKE DAM DAM CROSS SECTION



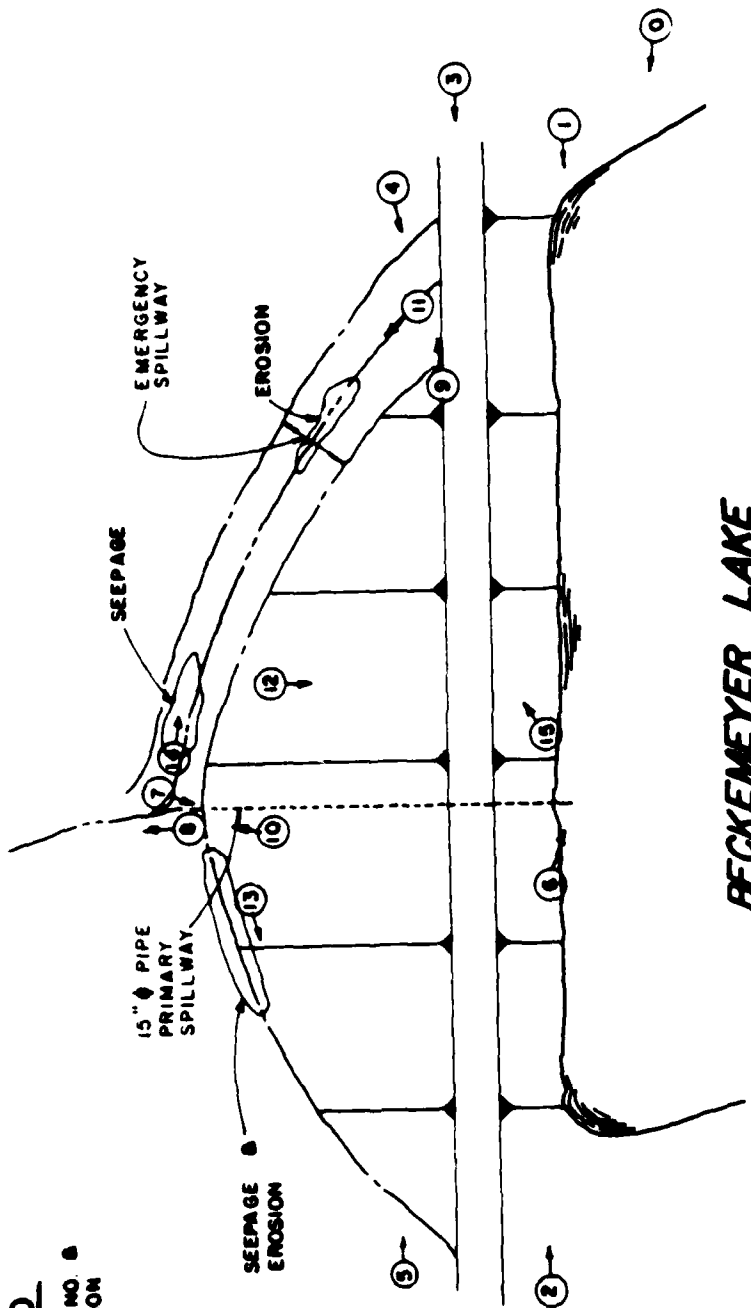
NOTE:
 PROFILE TAKEN AT FLOWLINE
 OF EMERGENCY SPILLWAY.



BECKEMEYER LAKE DAM EMERGENCY SPILLWAY PROFILE

LEGEND

PHOTO NO. 8
DIRECTION



BECKEMEYER LAKE

NOTE: PHOTO 16 IS LOCATED
UPSTREAM OF BECKEMEYER
LAKE.

BECKEMEYER LAKE DAM
PHOTO INDEX

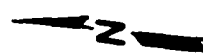




PHOTO 1: UPSTREAM FACE OF DAM

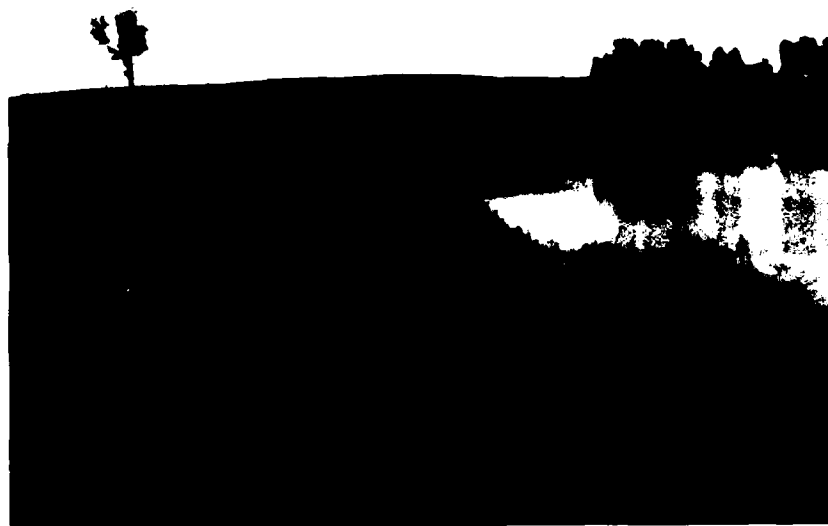


PHOTO 2: UPSTREAM FACE OF DAM LOOKING EAST



PHOTO 3: CREST OF DAM LOOKING WEST



PHOTO 4: DOWNSTREAM SLOPE OF DAM LOOKING WEST



PHOTO 5: DOWNSTREAM SLOPE OF DAM LOOKING EAST



PHOTO 6: PRIMARY SPILLWAY INLET



PHOTO 7: PRIMARY SPILLWAY OUTLET

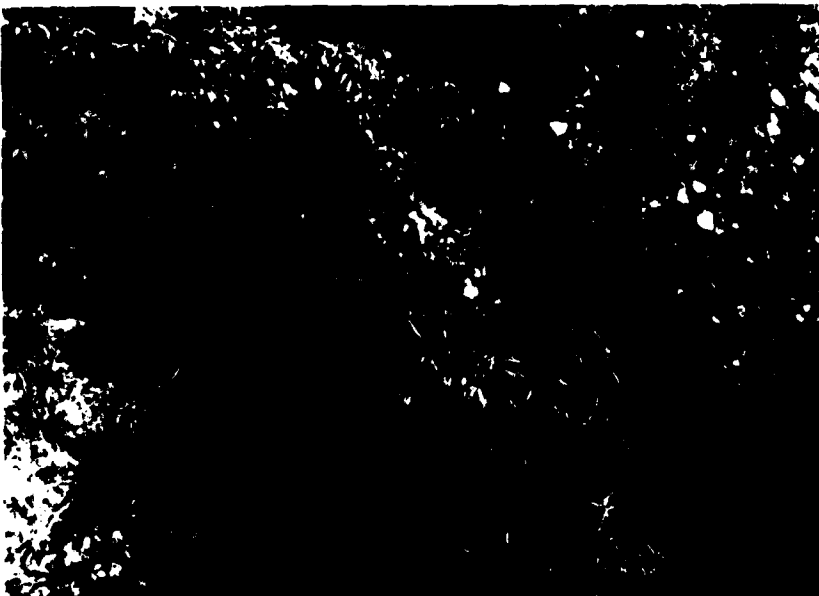


PHOTO 8: CHANNEL BELOW PRIMARY SPILLWAY



PHOTO 9: EMERGENCY SPILLWAY



PHOTO 10: EROSION ALONG PRIMARY SPILLWAY PIPE

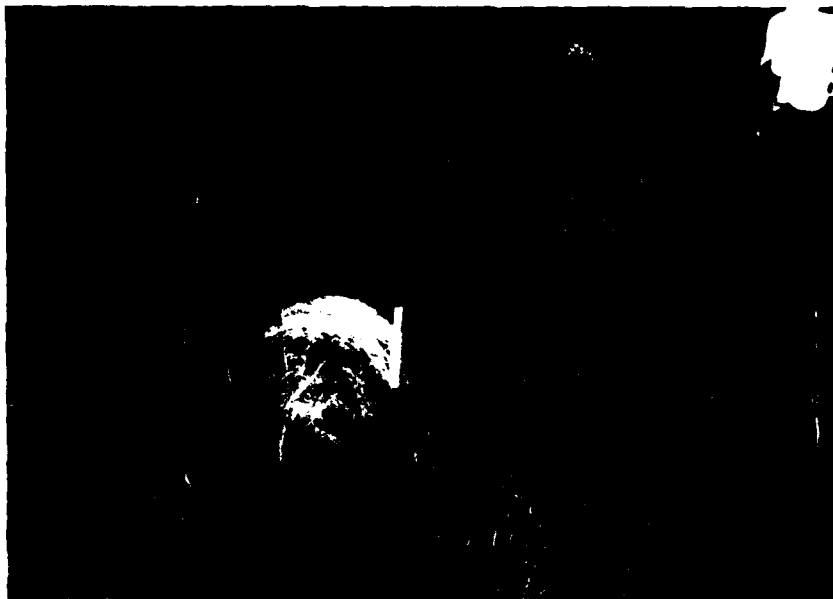


PHOTO 11: EROSION IN EMERGENCY SPILLWAY

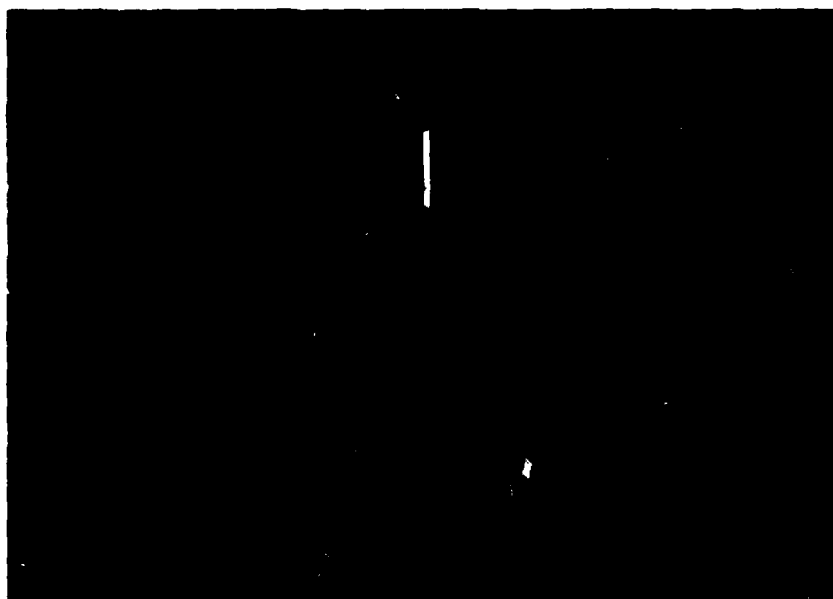


PHOTO 12: EROSION ON DOWNSTREAM SLOPE OF DAM



PHOTO 13: SEEPAGE AT LEFT ABUTMENT/EMBANKMENT INTERFACE



PHOTO 14: SEEPAGE BELOW TOE OF DAM



PHOTO 15: ANIMAL BURROWS ON FACE OF DAM



PHOTO 16: UPSTREAM DAM

APPENDIX A
HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC ANALYSES

To determine the overtopping potential of Beckemeyer Lake Dam, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to synthetic unit hydrographs to develop inflow hydrographs for Beckemeyer Lake and its upstream reservoir. The inflow hydrographs were then routed through the reservoirs and spillways. The overtopping analyses were determined using the computer program HEC-1 (Dam Safety Version) (1).

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33" (HMR-33). Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm was determined according to the procedures outlined in HMR-33 and EM 1110-2-1411. The Kansas City, Missouri rainfall distribution (5 min. interval - 24 hours duration), as provided by the St. Louis District, Corp of Engineers, was used when the one percent chance probability flood was routed through the reservoirs and spillways.

The synthetic unit hydrographs for the watershed were developed by the computer program using the Soil Conservation Service (SCS) method. The parameters for the unit hydrographs are shown in Table 1.

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationships. The CN values used, and the result from the computer output, are shown in Table 2.

Storms were routed through Beckemeyer Lake and the lake upstream of Beckemeyer Lake (see Plate 2) which shall be referenced as "Upstream Lake" through the remainder of this appendix.

Routing through the reservoirs was performed using the Modified Puls Method. The initial reservoir pool elevations for the routing of each storm were determined to be equivalent to the primary spillway crest elevations in accordance with antecedent storm conditions preceding the one percent probability and probable maximum storms outlined by the U.S. Army Corps of Engineers, St. Louis District (5). The hydraulic capacity of the spillways and the storage capacity of the reservoirs were defined by the elevation, surface area, storage, and discharge relationships shown in Table 3.

The rating curves for the spillways are shown in Table 4. The flow over the crest of each of the dams was determined using the nonlevel dam crest option (\$L and \$V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir. The flow through the primary spillways was determined from the orifice flow equation, the weir flow equation, and from Hydraulic Charts for The Selection of Highway Culverts. (7) The flow over the Upstream Lake Dam emergency

spillway was determined from the weir equation. The flow over the Beckemeyer Lake Dam emergency spillway was determined from backwater analysis.

Where routing through the upstream reservoir resulted in overtopping breach, analyses were performed using HEC-1. The breaching parameters are noted in Table 5.

The result of the routing and breach analyses indicates that 10 percent of the PMF will not overtop the Beckemeyer Lake dam.

A summary of the routing analysis for different ratios of the PMF is shown in Table 6.

The computer input data and a summary of the output data are presented at the back of this appendix.

TABLE 1
SYNTHETIC UNIT HYDROGRAPH

<u>Parameters:</u>	<u>Upstream Lake</u>	<u>Beckemeyer Lake</u>
Drainage Area (A)	90 acres	237 acres*
Hydraulic Length of Watercourse (L)	0.22 miles	0.42 miles
Difference in Elevation (H)	85 feet	100 feet
Lag Time (L_g)	0.05 hours	0.1 hours
Time of Concentration (T_c)	0.08 hours	0.16 hours
Duration (D)	1 minute (use 5 minutes in both cases)	1 minute

*Includes the drainage area of Upstream Lake

TABLE 1
(Continued)

Unit Hydrograph Coordinates

Time (Min)	Discharge (cfs)*	
	<u>Upstream-Lake</u>	<u>Beckemeyer Lake</u>
0	0	0
5	724	503
10	277	745
15	64	327
20	15	127
25	3	49
30		19
35		8
40		2

*From HEC-1 computer output

FORMULAS USED:

$$T_c = [(11.9 \times L^3)/H]^{0.385}$$

$$L_g = 0.6 T_c$$

$$D = 0.133 T_c$$

TABLE 2
RAINFALL-RUNOFF VALUES

<u>Selected Storm Event</u>	<u>Storm Duration (Hours)</u>	<u>Rainfall (Inches)</u>	<u>Runoff (Inches)</u>	<u>Loss (Inches)</u>
PMF				
Upstream Lake	24	31.98	30.40	1.58
Beckemeyer Lake	24	31.98	30.40	1.58
50% PMF				
Upstream Lake	24	16.73	15.20	1.53
Beckemeyer Lake	24	16.73	15.20	1.53
1% Probability				
Upstream Lake	24	7.59	4.68	2.92
Beckemeyer Lake	24	7.59	4.56	3.03

Additional Data:

- 1) The soil associations in this watershed are Marshall, Knox, and Higginsville (3).
98 percent of total drainage area in hydrologic soil group B.
2 percent of total drainage area in hydrologic soil group C.
92 percent of the land use was cropland.
8 percent of the land use was timberland (2 and 4).
- 2) SCS Runoff Curve CN (AMC III) for ratios of the PMF:
88 - Upstream Lake
88 - Beckemeyer Lake
- 3) SCS Runoff Curve CN (AMC II) for the one percent probability flood:
75 - Upstream Lake
74 - Beckemeyer Lake

TABLE 3

ELEVATION, SURFACE AREA, STORAGE, AND DISCHARGE RELATIONSHIPS

<u>Elevation</u> <u>(feet-MSL)</u>	<u>Lake Surface</u> <u>Area (acres)</u>	<u>Lake Storage</u> <u>(acre-ft)</u>	<u>Spillway</u> <u>Discharge (cfs)</u>
Upstream Lake			
*769.1	4.3	40	0
**771.0	4.8	49	74
***773.2	5.4	60	314
Beckemeyer Lake			
*750.0	8.1	86	0
**752.6	10.0	109	9
***753.9	11.0	122	154

*Primary spillway crest elevation

**Emergency spillway crest elevation

***Top of dam elevation

The relationships in Table 3 were developed from the Bates City, Missouri 7.5 minute quadrangle map and the field measurements.

TABLE 4

SPILLWAY RATING CURVE

<u>Reservoir Elevation (ft-msl)</u>	<u>Primary Spillway Discharge (cfs)</u>	<u>Emergency Spillway Discharge (cfs)</u>	<u>Total Spillway Discharges (cfs)</u>
Upstream Lake			
769.0	0	0	0
770.0	26	0	26
*771.0	74	0	74
772.0	108	26	134
773.0	112	142	254
**773.2	114	200	314
774.0	120	431	551
775.0	122	783	905
Beckemeyer Lake			
750.0	0	0	0
751.0	3	0	3
752.0	7	0	7
*752.6	9	0	9
753.0	10	20	30
754.0	12	156	168
755.0	14	470	484
757.0	17	1,600	***1,620
760.0	21	4,130	***4,150

*Emergency Spillway Crest Elevation

**Top of Dam Elevation

***Values rounded off

METHOD USED

Upstream Lake

Primary spillway releases were calculated using the weir and orifice equations. The weir equation for the drop inlet is:

$$Q = CLH^{3/2}$$

where:

C = 3.3 = coefficient of discharge; inlet acts as a sharp-crested weir,
L = 7.85 ft. = length of the weir = circumference of pipe
H = head in feet

Orifice equation (6):

$$Q = C_a [2gH]^{1/2}$$

where

C = 0.6 = coefficient of discharge
a = 4.9 sq. ft. = area of orifice
g = 32.2 ft/sec² = acceleration due to gravity
H = difference between the energy gradient elevation upstream and the downstream tailwater elevation

Emergency spillway releases were computed using the equations for flow over nonlevel crests:

$$d_c = 2/3 (H_m + 1/4 \Delta Y)$$

$$A = 1/2 T (2d_c - \Delta Y)$$

$$Q = (A^3 g/T)^{0.5}$$

where:

d_c = critical depth (feet)
H_m = available specific energy which is taken to be the height of the water surface in the reservoir above the bottom of the section (feet)
ΔY = change in elevation across the section (feet)
A = flow area (sq. ft.)
T = top width (feet)
Q = flow (cfs)
g = 32.2 ft/sec² = acceleration due to gravity.

Beckemeyer Lake

Primary spillway releases were determined by nomographs for steel pipe (7).

Emergency spillway releases were determined from backwater analysis of the spillway channel.

TABLE 5

BREACHING PARAMETERS

	<u>Upstream Lake</u>
Bottom Width of Breach (BRWID)	10 feet
Side Slope of Breach (z) (In feet horizontal to 1.0 feet vertical)	0.5
Elevation of Breach Bottom at Maximum Size of Breach (ELBM)	757.0 ft. m.s.l.
Time for Breach to Develop to Maximum Size (TFAIL)	1.0 hour
Elevation of Water Surface Which Will Cause Dam to Fail (FAILEL)	773.2 ft. m.s.l.

TABLE 6

RESULTS OF FLOOD ROUTINGS - BECKEMEYER LAKE

Ratio of PMF	Peak Inflow (CFS)	Peak Lake Elevation (ft.-MSL)	Total Storage (AC.-FT.)	Peak Outflow (CFS)	Depth (ft.) Over Top of Dam
-	0	*750.0	86	0	-
0.10	556	753.5	118	99	0
0.50	2,327	756.1	147	1,903	2.2
1.00	4,796	757.1	161	4,303	3.2

* Primary spillway crest elevation.

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- (1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.
- (2) U.S. Department of Agriculture, Soil Conservation Service, Technical Release No. 55, Urban Hydrology for Small Watersheds, January, 1975.
- (3) U.S. Department of Agriculture, Soil Conservation Service, Preliminary Soils Report for Lafayette County, Missouri.
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- (5) U.S. Army Corps of Engineers, St. Louis District, Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams, 12 December 1979.
- (6) Horace W. King and Ernest F. Brater, Handbook of Hydraulics, Sixth Edition, McGraw Hill Book Company, 1976.
- (7) U.S. Department of Commerce, Bureau of Public Roads, Hydraulic Engineering Circular No. 5, Hydraulic Charts for the Selection of Highway Culverts, December, 1965.
- (8) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.
- (9) U.S. Department of Agriculture, Soil Conservation Service, Soil Survey Interpretations and Field Maps, 1980.
- (10) Mary H. McCracken, Missouri Division of Geological Survey, Geologic Map of Missouri, 1961.

P L A C E V I A Y C M PROJECT 9165 DATE 27 JUL 80 PAGE
FOLLOW W/ 1/0-QU TIME 9:12:00 CASE

[illegible]

BUNCE HYDROGRAPH AT
 BOUTE HYDROGRAPH TO
 BOUTE HYDROGRAPH AT
 CONE 2 1/2 MILES AT
 11 MILES FROM
 BOUTE HYDROGRAPH
 BOUTE HYDROGRAPH
 BOUTE HYDROGRAPH

TIME 1:00 PM 100 LARGE--COW IS AT 100/21

UNIT HYDROGRAPH 5 END OF PERIOD OPTIMIZED, 100
726. 15. 5.

NO HOURS, LAG= .05 VOL= 1.00

PROJECT 9166. DATE 27 AUG 80 PAGE 3
PROGRAM M2102-00 TIME 19:22:06 CASE

NO. 04		MR. 04	PERIOD	RAIN	EXCS	LOSS	END-OF-FERTIL FLOW COMP. W	NO. 04	MR. 04	PERIOD	PAIN	EXCS	LOSS	COMP. L
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1.01	4.10	72	.01	.01	.01	.01	.01	.01	.01	1.01	18.25	221	.29	.29	.00	.00	313.
1.01	4.10	73	.01	.01	.01	.01	.01	.01	.01	1.01	18.30	222	.29	.29	.00	.00	313.
1.01	4.10	74	.01	.01	.01	.01	.01	.01	.01	1.01	18.35	223	.29	.29	.00	.00	313.
1.01	4.10	75	.01	.01	.01	.01	.01	.01	.01	1.01	18.40	224	.29	.29	.00	.00	313.
1.01	4.10	76	.01	.01	.01	.01	.01	.01	.01	1.01	18.45	225	.29	.29	.00	.00	313.
1.01	4.10	77	.01	.01	.01	.01	.01	.01	.01	1.01	18.50	226	.29	.29	.00	.00	313.
1.01	4.10	78	.01	.01	.01	.01	.01	.01	.01	1.01	18.55	227	.29	.29	.00	.00	313.
1.01	4.10	79	.01	.01	.01	.01	.01	.01	.01	1.01	19.00	228	.29	.29	.00	.00	313.
1.01	4.10	80	.01	.01	.01	.01	.01	.01	.01	1.01	19.05	229	.29	.29	.00	.00	313.
1.01	4.10	81	.01	.01	.01	.01	.01	.01	.01	1.01	19.10	230	.29	.29	.00	.00	313.
1.01	4.10	82	.01	.01	.01	.01	.01	.01	.01	1.01	19.15	231	.29	.29	.00	.00	313.
1.01	4.10	83	.01	.01	.01	.01	.01	.01	.01	1.01	19.20	232	.29	.29	.00	.00	313.
1.01	4.10	84	.01	.01	.01	.01	.01	.01	.01	1.01	19.25	233	.29	.29	.00	.00	313.
1.01	4.10	85	.01	.01	.01	.01	.01	.01	.01	1.01	19.30	234	.29	.29	.00	.00	313.
1.01	4.10	86	.01	.01	.01	.01	.01	.01	.01	1.01	19.35	235	.29	.29	.00	.00	313.
1.01	4.10	87	.01	.01	.01	.01	.01	.01	.01	1.01	19.40	236	.29	.29	.00	.00	313.
1.01	4.10	88	.01	.01	.01	.01	.01	.01	.01	1.01	19.45	237	.29	.29	.00	.00	313.
1.01	4.10	89	.01	.01	.01	.01	.01	.01	.01	1.01	19.50	238	.29	.29	.00	.00	313.
1.01	4.10	90	.01	.01	.01	.01	.01	.01	.01	1.01	19.55	239	.29	.29	.00	.00	313.
1.01	4.10	91	.01	.01	.01	.01	.01	.01	.01	1.01	20.00	240	.29	.29	.00	.00	313.
1.01	4.10	92	.01	.01	.01	.01	.01	.01	.01	1.01	20.05	241	.29	.29	.00	.00	313.
1.01	4.10	93	.01	.01	.01	.01	.01	.01	.01	1.01	20.10	242	.29	.29	.00	.00	313.
1.01	4.10	94	.01	.01	.01	.01	.01	.01	.01	1.01	20.15	243	.29	.29	.00	.00	313.
1.01	4.10	95	.01	.01	.01	.01	.01	.01	.01	1.01	20.20	244	.29	.29	.00	.00	313.
1.01	4.10	96	.01	.01	.01	.01	.01	.01	.01	1.01	20.25	245	.29	.29	.00	.00	313.
1.01	4.10	97	.01	.01	.01	.01	.01	.01	.01	1.01	20.30	246	.29	.29	.00	.00	313.
1.01	4.10	98	.01	.01	.01	.01	.01	.01	.01	1.01	20.35	247	.29	.29	.00	.00	313.
1.01	4.10	99	.01	.01	.01	.01	.01	.01	.01	1.01	20.40	248	.29	.29	.00	.00	313.
1.01	4.10	100	.01	.01	.01	.01	.01	.01	.01	1.01	20.45	249	.29	.29	.00	.00	313.
1.01	4.10	101	.01	.01	.01	.01	.01	.01	.01	1.01	20.50	250	.29	.29	.00	.00	313.
1.01	4.10	102	.01	.01	.01	.01	.01	.01	.01	1.01	20.55	251	.29	.29	.00	.00	313.
1.01	4.10	103	.01	.01	.01	.01	.01	.01	.01	1.01	21.00	252	.29	.29	.00	.00	313.
1.01	4.10	104	.01	.01	.01	.01	.01	.01	.01	1.01	21.05	253	.29	.29	.00	.00	313.

F L A C K R V A T C M								
F_GOD HYDROGRAPH PACKAGE - HFC-1								
1.01	9.10	119	.06	.01	.64	1.01	21.10	254
1.01	9.11	119	.06	.01	.64	1.01	21.15	255
1.01	9.12	112	.06	.01	.64	1.01	21.20	256
1.01	9.13	115	.06	.01	.64	1.01	21.25	257
1.01	9.14	116	.06	.01	.64	1.01	21.30	258
1.01	9.15	115	.06	.01	.64	1.01	21.35	259
1.01	9.16	116	.06	.01	.64	1.01	21.40	260
1.01	9.17	117	.06	.01	.64	1.01	21.45	261
1.01	9.18	118	.06	.01	.64	1.01	21.50	262
1.01	9.19	119	.06	.01	.64	1.01	21.55	263
1.01	10.01	123	.06	.01	.64	1.01	22.00	264
1.01	10.02	123	.06	.01	.64	1.01	22.05	265
1.01	10.03	123	.06	.01	.64	1.01	22.10	266
1.01	10.04	123	.06	.01	.64	1.01	22.15	267
1.01	10.05	124	.06	.01	.64	1.01	22.20	268
1.01	10.06	125	.06	.01	.64	1.01	22.25	269
1.01	10.07	124	.06	.01	.64	1.01	22.30	270
1.01	10.08	124	.06	.01	.64	1.01	22.35	271
1.01	10.09	124	.06	.01	.64	1.01	22.40	272
1.01	10.10	124	.06	.01	.64	1.01	22.45	273
1.01	10.11	130	.06	.01	.64	1.01	22.50	274
1.01	10.12	131	.06	.01	.64	1.01	22.55	275
1.01	11.00	132	.06	.01	.64	1.01	23.00	276
1.01	11.01	135	.06	.01	.64	1.01	23.05	277
1.01	11.02	134	.06	.01	.64	1.01	23.10	278
1.01	11.03	135	.06	.01	.64	1.01	23.15	279
1.01	11.04	134	.06	.01	.64	1.01	23.20	280
1.01	11.05	137	.06	.01	.64	1.01	23.25	281
1.01	11.06	126	.06	.01	.64	1.01	23.30	282
1.01	11.07	139	.06	.01	.64	1.01	23.35	283
1.01	11.08	140	.06	.01	.64	1.01	23.40	284
1.01	11.09	141	.06	.01	.64	1.01	23.45	285
1.01	11.10	142	.06	.01	.64	1.01	23.50	286
1.01	11.11	143	.06	.01	.64	1.01	23.55	287
1.01	12.00	144	.06	.01	.64	1.01	24.00	288

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Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100																																																																																																																										
1990	749.00	753.00	770.00	771.00	772.00	773.00	774.00	775.00	776.00	777.00	778.00	779.00	780.00	781.00	782.00	783.00	784.00	785.00	786.00	787.00	788.00	789.00	790.00	791.00	792.00	793.00	794.00	795.00	796.00	797.00	798.00	799.00	800.00	801.00	802.00	803.00	804.00	805.00	806.00	807.00	808.00	809.00	810.00	811.00	812.00	813.00	814.00	815.00	816.00	817.00	818.00	819.00	820.00	821.00	822.00	823.00	824.00	825.00	826.00	827.00	828.00	829.00	830.00	831.00	832.00	833.00	834.00	835.00	836.00	837.00	838.00	839.00	840.00	841.00	842.00	843.00	844.00	845.00	846.00	847.00	848.00	849.00	850.00	851.00	852.00	853.00	854.00	855.00	856.00	857.00	858.00	859.00	860.00	861.00	862.00	863.00	864.00	865.00	866.00	867.00	868.00	869.00	870.00	871.00	872.00	873.00	874.00	875.00	876.00	877.00	878.00	879.00	880.00	881.00	882.00	883.00	884.00	885.00	886.00	887.00	888.00	889.00	890.00	891.00	892.00	893.00	894.00	895.00	896.00	897.00	898.00	899.00	900.00	901.00	902.00	903.00	904.00	905.00	906.00	907.00	908.00	909.00	910.00	911.00	912.00	913.00	914.00	915.00	916.00	917.00	918.00	919.00	920.00	921.00	922.00	923.00	924.00	925.00	926.00	927.00	928.00	929.00	930.00	931.00	932.00	933.00	934.00	935.00	936.00	937.00	938.00	939.00	940.00	941.00	942.00	943.00	944.00	945.00	946.00	947.00	948.00	949.00	950.00	951.00	952.00	953.00	954.00	955.00	956.00	957.00	958.00	959.00	960.00	961.00	962.00	963.00	964.00	965.00	966.00	967.00	968.00	969.00	970.00	971.00	972.00	973.00	974.00	975.00	976.00	977.00	978.00	979.00	980.00	981.00	982.00	983.00	984.00	985.00	986.00	987.00	988.00	989.00	990.00	991.00	992.00	993.00	994.00	995.00	996.00	997.00	998.00	999.00	1000.00

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Case No.	Case Name	Case Type	Case Status	Case Date
1001	John Doe	Case 1	Open	10/10/2023
1002	Jane Smith	Case 2	Closed	10/10/2023
1003	Bob Johnson	Case 3	Open	10/10/2023
1004	Alice Brown	Case 4	Closed	10/10/2023
1005	Charlie Davis	Case 5	Open	10/10/2023
1006	Eve White	Case 6	Closed	10/10/2023
1007	Frank Green	Case 7	Open	10/10/2023
1008	Grace Black	Case 8	Closed	10/10/2023
1009	Henry Blue	Case 9	Open	10/10/2023
1010	Ivy Red	Case 10	Closed	10/10/2023

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10011 10012 10013 10014 10015 10016 10017 10018 10019 10020 10021 10022 10023 10024 10025 10026 10027 10028 10029 10030 10031 10032 10033 10034 10035 10036 10037 10038 10039 10040 10041 10042 10043 10044 10045 10046 10047 10048 10049 10050 10051 10052 10053 10054 10055 10056 10057 10058 10059 10060 10061 10062 10063 10064 10065 10066 10067 10068 10069 10070 10071 10072 10073 10074 10075 10076 10077 10078 10079 10080 10081 10082 10083 10084 10085 10086 10087 10088 10089 10090 10091 10092 10093 10094 10095 10096 10097 10098 10099 10100 10101 10102 10103 10104 10105 10106 10107 10108 10109 10110 10111 10112 10113 10114 10115 10116 10117 10118 10119 10120 10121 10122 10123 10124 10125 10126 10127 10128 10129 10130 10131 10132 10133 10134 10135 10136 10137 10138 10139 10140 10141 10142 10143 10144 10145 10146 10147 10148 10149 10150 10151 10152 10153 10154 10155 10156 10157 10158 10159 10160 10161 10162 10163 10164 10165 10166 10167 10168 10169 10170 10171 10172 10173 10174 10175 10176 10177 10178 10179 10180 10181 10182 10183 10184 10185 10186 10187 10188 10189 10190 10191 10192 10193 10194 10195 10196 10197 10198 10199 10200 10201 10202 10203 10204 10205 10206 10207 10208 10209 10210 10211 10212 10213 10214 10215 10216 10217 10218 10219 10220 10221 10222 10223 10224 10225 10226 10227 10228 10229 10230 10231 10232 10233 10234 10235 10236 10237 10238 10239 10240 10241 10242 10243 10244 10245 10246 10247 10248 10249 10250 10251 10252 10253 10254 10255 10256 10257 10258 10259 10260 10261 10262 10263 10264 10265 10266 10267 10268 10269 10270 10271 10272 10273 10274 10275 10276 10277 10278 10279 10280 10281 10282 10283 10284 10285 10286 10287 10288 10289 10290 10291 10292 10293 10294 10295 10296 10297 10298 10299 10300 10301 10302 10303 10304 10305 10306 10307 10308 10309 10310 10311 10312 10313 10314 10315 10316 10317 10318 10319 10320 10321 10322 10323 10324 10325 10326 10327 10328 10329 10330 10331 10332 10333 10334 10335 10336 10337 10338 10339 10340 10341 10342 10343 10344 10345 10346 10347 10348 10349 10350 10351 10352 10353 10354 10355 10356 10357 10358 10359 10360 10361 10362 10363 10364 10365 10366 10367 10368 10369 10370 10371 10372 10373 10374 10375 10376 10377 10378 10379 10380 10381 10382 10383 10384 10385 10386 10387 10388 10389 10390 10391 10392 10393 10394 10395 10396 10397 10398 10399 10400 10401 10402 10403 10404 10405 10406 10407 10408 10409 10410 10411 10412 10413 10414 10415 10416 10417 10418 10419 10420 10421 10422 10423 10424 10425 10426 10427 10428 10429 10430 10431 10432 10433 10434 10435 10436 10437 10438 10439 10440 10441 10442 10443 10444 10445 10446 10447 10448 10449 10450 10451 10452 10453 10454 10455 10456 10457 10458 10459 10460 10461 10462 10463 10464 10465 10466 10467 10468 10469 10470 10471 10472 10473 10474 10475 10476 10477 10478 10479 10480 10481 10482 10483 10484 10485 10486 10487 10488 10489 10490 10491 10492 10493 10494 10495 10496 10497 10498 10499 10500 10501 10502 10503 10504 10505 10506 10507 10508 10509 10510 10511 10512 10513 10514 10515 10516 10517 10518 10519 10520 10521 10522 10523 10524 10525 10526 10527 10528 10529 10530 10531 10532 10533 10534 10535 10536 10537 10538 10539 10540 10541 10542 10543 10544 10545 10546 10547 10548 10549 10550 10551 10552 10553 10554 10555 10556 10557 10558 10559 10560 10561 10562 10563 10564 10565 10566 10567 10568 10569 10570 10571 10572 10573 10574 10575 10576 10577 10578 10579 10580 10581 10582 10583 10584 10585 10586 10587 10588 10589 10590 10591 10592 10593 10594 10595 10596 10597 10598 10599 10600 10601 10602 10603 10604 10605 10606 10607 10608 10609 10610 10611 10612 10613 10614 10615 10616 10617 10618 10619 10620 10621 10622 10623 10624 10625 10626 10627 10628 10629 10630 10631 10632 10633 10634 10635 10636 10637 10638 10639 10640 10641 10642 10643 10644 10645 10646 10647 10648 10649 10650 10651 10652 10653 10654 10655 10656 10657 10658 10659 10660 10661 10662 10663 10664 10665 10666 10667 10668 10669 10670 10671 10672 10673 10674 10675 10676 10677 10678 10679 10680 10681 10682 10683 10684 10685 10686 10687 10688 10689 10690 10691 10692 10

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二、三、四、五、六、七、八、九、十、十一、十二、十三、十四、十五、十六、十七、十八、十九、二十、二十一、二十二、二十三、二十四、二十五、二十六、二十七、二十八、二十九、三十、三十一、三十二、三十三、三十四、三十五、三十六、三十七、三十八、三十九、四十、四十一、四十二、四十三、四十四、四十五、四十六、四十七、四十八、四十九、五十、五十一、五十二、五十三、五十四、五十五、五十六、五十七、五十八、五十九、六十、六十一、六十二、六十三、六十四、六十五、六十六、六十七、六十八、六十九、七十、七十一、七十二、七十三、七十四、七十五、七十六、七十七、七十八、七十九、八十、八十一、八十二、八十三、八十四、八十五、八十六、八十七、八十八、八十九、九十、九十一、九十二、九十三、九十四、九十五、九十六、九十七、九十八、九十九、一百。

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SUB-AREA RUNOFF COMPUTATION
 LOCAL RUNOFF INTO BECKMEYER LAKE
 ISTAR IECOM ISTAR JPLY JPAT INARE ISTAR IAURO
 0 0 0 0 0 0 0 0

HYDROGRAPH DATA
 INTRG IUNG IAREA SNAP IASDA ISPEC RATIO ISROW ISALE LOCAL
 1 2 .25 .00 .25 1.00 .000 0 0 0
 SALT PMS 44
 24.00 101.00 120.00 110.00 .00
 PRECIP DATA
 44
 24.00 101.00 120.00 110.00 .00

LOSS DATA
 ISTAR ISTAR ISTAR ISTAR ISTAR ISTAR ISTAR ISTAR ISTAR ISTAR
 0 0 0 0 0 0 0 0 0 0
 CURVE NO. 100.00 100.00 100.00 100.00 100.00 100.00 100.00 100.00 100.00 100.00

UNIT HYDROGRAPH DATA
 IECOM IECOM IECOM IECOM IECOM IECOM IECOM IECOM IECOM IECOM
 0 0 0 0 0 0 0 0 0 0
 STATION .00 RECUSION DATA .00 STATION 1.00

TIME INCREMENT 100 LARGEST-100-15 GT LAUGA
 UNIT HYDROGRAPH DATA
 IECOM IECOM IECOM IECOM IECOM IECOM IECOM IECOM IECOM IECOM
 0 0 0 0 0 0 0 0 0 0

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|------|------|----|-----|-----|-----|------|-------|-----|-----|-----|-----|------|
| 1.01 | 1.01 | 1 | .01 | .00 | .01 | 1.01 | 12.05 | 145 | .21 | .20 | .01 | 180. |
| 1.01 | 1.01 | 2 | .01 | .00 | .01 | 1.01 | 12.10 | 146 | .21 | .20 | .01 | 242. |
| 1.01 | 1.01 | 3 | .01 | .00 | .01 | 1.01 | 12.15 | 147 | .21 | .20 | .01 | 222. |
| 1.01 | 1.01 | 4 | .01 | .00 | .01 | 1.01 | 12.20 | 148 | .21 | .20 | .01 | 345. |
| 1.01 | 1.01 | 5 | .01 | .00 | .01 | 1.01 | 12.25 | 149 | .21 | .20 | .01 | 151. |
| 1.01 | 1.01 | 6 | .01 | .00 | .01 | 1.01 | 12.30 | 150 | .21 | .20 | .01 | 151. |
| 1.01 | 1.01 | 7 | .01 | .00 | .01 | 1.01 | 12.35 | 151 | .21 | .20 | .01 | 151. |
| 1.01 | 1.01 | 8 | .01 | .00 | .01 | 1.01 | 12.40 | 152 | .21 | .20 | .01 | 151. |
| 1.01 | 1.01 | 9 | .01 | .00 | .01 | 1.01 | 12.45 | 153 | .21 | .20 | .01 | 151. |
| 1.01 | 1.01 | 10 | .01 | .00 | .01 | 1.01 | 12.50 | 154 | .21 | .20 | .01 | 151. |
| 1.01 | 1.01 | 11 | .01 | .00 | .01 | 1.01 | 12.55 | 155 | .21 | .20 | .01 | 151. |
| 1.01 | 1.01 | 12 | .01 | .00 | .01 | 1.01 | 13.00 | 156 | .21 | .20 | .01 | 151. |
| 1.01 | 1.01 | 13 | .01 | .00 | .01 | 1.01 | 13.05 | 157 | .21 | .20 | .01 | 151. |
| 1.01 | 1.01 | 14 | .01 | .00 | .01 | 1.01 | 13.10 | 158 | .21 | .20 | .01 | 151. |
| 1.01 | 1.01 | 15 | .01 | .00 | .01 | 1.01 | 13.15 | 159 | .21 | .20 | .01 | 151. |

PROJECT 9100. DATE 27 AUG 80 PAGE 10
PROGRAM M1/C2-00 TIME 18:22:16 CASE

PLATE 6 VIBRATION
FACED MHC-CURVE PACKAGE - HEC-1

| | | | | | | | | | | | | | | | |
|------|------|----|-----|-----|-----|----|------|-------|-----|-----|-----|-----|-----|-----|-----|
| 1.01 | 1.21 | 16 | .01 | .00 | .01 | 0. | 1.01 | 13.20 | 180 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.25 | 17 | .01 | .00 | .01 | 0. | 1.01 | 13.25 | 181 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.30 | 18 | .01 | .00 | .01 | 0. | 1.01 | 13.30 | 182 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.35 | 19 | .01 | .00 | .01 | 0. | 1.01 | 13.35 | 183 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.40 | 20 | .01 | .00 | .01 | 0. | 1.01 | 13.40 | 184 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.45 | 21 | .01 | .00 | .01 | 0. | 1.01 | 13.45 | 185 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.50 | 22 | .01 | .00 | .01 | 0. | 1.01 | 13.50 | 186 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.55 | 23 | .01 | .00 | .01 | 0. | 1.01 | 13.55 | 187 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.60 | 24 | .01 | .00 | .01 | 0. | 1.01 | 14.00 | 188 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.65 | 25 | .01 | .00 | .01 | 0. | 1.01 | 14.05 | 189 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.70 | 26 | .01 | .00 | .01 | 0. | 1.01 | 14.10 | 190 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.75 | 27 | .01 | .00 | .01 | 0. | 1.01 | 14.15 | 191 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.80 | 28 | .01 | .00 | .01 | 0. | 1.01 | 14.20 | 192 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.85 | 29 | .01 | .00 | .01 | 0. | 1.01 | 14.25 | 193 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.90 | 30 | .01 | .00 | .01 | 0. | 1.01 | 14.30 | 194 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 1.95 | 31 | .01 | .00 | .01 | 0. | 1.01 | 14.35 | 195 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.00 | 32 | .01 | .00 | .01 | 0. | 1.01 | 14.40 | 196 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.05 | 33 | .01 | .00 | .01 | 0. | 1.01 | 14.45 | 197 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.10 | 34 | .01 | .00 | .01 | 0. | 1.01 | 14.50 | 198 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.15 | 35 | .01 | .00 | .01 | 0. | 1.01 | 14.55 | 199 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.20 | 36 | .01 | .00 | .01 | 0. | 1.01 | 15.00 | 200 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.25 | 37 | .01 | .00 | .01 | 0. | 1.01 | 15.05 | 201 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.30 | 38 | .01 | .00 | .01 | 0. | 1.01 | 15.10 | 202 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.35 | 39 | .01 | .00 | .01 | 0. | 1.01 | 15.15 | 203 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.40 | 40 | .01 | .00 | .01 | 0. | 1.01 | 15.20 | 204 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.45 | 41 | .01 | .00 | .01 | 0. | 1.01 | 15.25 | 205 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.50 | 42 | .01 | .00 | .01 | 0. | 1.01 | 15.30 | 206 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.55 | 43 | .01 | .00 | .01 | 0. | 1.01 | 15.35 | 207 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.60 | 44 | .01 | .00 | .01 | 0. | 1.01 | 15.40 | 208 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.65 | 45 | .01 | .00 | .01 | 0. | 1.01 | 15.45 | 209 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.70 | 46 | .01 | .00 | .01 | 0. | 1.01 | 15.50 | 210 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.75 | 47 | .01 | .00 | .01 | 0. | 1.01 | 15.55 | 211 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.80 | 48 | .01 | .00 | .01 | 0. | 1.01 | 15.60 | 212 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.85 | 49 | .01 | .00 | .01 | 0. | 1.01 | 15.65 | 213 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.90 | 50 | .01 | .00 | .01 | 0. | 1.01 | 15.70 | 214 | .25 | .24 | .00 | .00 | .00 | .00 |
| 1.01 | 2.95 | 51 | .01 | .00 | .01 | 0. | 1.01 | 15.75 | 215 | .25 | .24 | .00 | .00 | .00 | .00 |

YEAR FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAY-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUMULATIVE METERS PER SECOND)
 DATA IN SQUARE FEET (CUMULATIVE KILOMETERS)

| OPERATION | STATION | AREA | YEAR | RATIOS APPLIED TO FLOWS | | | |
|---------------------|---------|------|------|-------------------------|---------|---------|---------|
| | | | | RATIO 1 | RATIO 2 | RATIO 3 | RATIO 4 |
| | | | | .10 | .15 | .20 | 1.00 |
| HYDROGRAPH AT URBAN | (| 112 | 1 | 240. | 350. | 440. | 1200. |
| |) | 270 | | 6.233E | 10.233E | 13.603E | 33.003E |
| HYDROGRAPH AT RURAL | (| 274 | 1 | 41. | 90. | 137. | 585. |
| |) | 275 | | 1.723E | 2.753E | 3.873E | 27.003E |
| HYDROGRAPH AT DAM | (| 273 | 1 | 413. | 640. | 825. | 1545. |
| |) | 274 | | 8.853E | 11.223E | 17.713E | 44.223E |
| COMBINED | (| 277 | 1 | 367. | 530. | 747. | 2327. |
| |) | 275 | | 10.233E | 15.273E | 21.163E | 65.923E |
| TOTAL FLOW | (| 277 | 1 | 99. | 457. | 675. | 1905. |
| |) | 275 | | 2.793E | 7.233E | 11.753E | 52.823E |

PLANK 8 V E A T C M
 FLOOD HYDROGRAPH PACKAGE - HEC-1

SUMMARY OF DAM SAFETY ANALYSIS

| PLAN 1 | ELEVATION
SPILLWAY
OUTFLOW | INITIAL VALUE
765.10
60.
3. | SPILLWAY CREST
765.10
60.
3. | TOP OF DAM
771.20
60.
116. | | | |
|--------------------|----------------------------------|--------------------------------------|---------------------------------------|-------------------------------------|-------------------------------|---------------------------------|-----------------------------|
| | | | | | | | |
| RATIO
OF
F-1 | MAXIMUM
RESIDUAL
ELEVATION | MAXIMUM
DEPTH
UNDER DAM | MAXIMUM
STORAGE
AL-FT | MAXIMUM
OUTFLOW
CFS | DURATION
OVER TOP
HOURS | TIME OF
MAX OUTFLOW
HOURS | TIME OF
FAILURE
HOURS |
| .10 | 770.76 | .00 | 47. | 61. | .00 | 15.83 | .00 |
| .15 | 771.61 | .00 | 51. | 92. | .00 | 15.83 | .00 |
| .20 | 772.04 | .00 | 54. | 137. | .00 | 15.83 | .00 |
| .25 | 772.06 | .46 | 66. | 987. | .52 | 16.52 | 15.58 |
| 1.0 | 772.22 | .02 | 65. | 1070. | .57 | 15.67 | 16.42 |

SUMMARY OF TAP SAFETY ANALYSIS

| | | | | | | | | | |
|--------------|--|---------------|--|-----------------|--|------------|--|-------------|--|
| PLAN 1 | | | | | | | | | |
| ELEVATION | | INITIAL VALUE | | SPILLWAY CRUISE | | TOP OF DAM | | | |
| START OF | | 750.00 | | 750.00 | | 751.00 | | | |
| CULVERT | | 66 | | 66 | | 122 | | | |
| | | 66 | | 70 | | 124 | | | |
| MAXIMUM | | MAXIMUM | | MAXIMUM | | DURATION | | TIME OF | |
| DISCHARGE | | STORAGE | | OUTFLOW | | OVER TOP | | PAR OUTFLOW | |
| 148 | | AL-13 | | FS | | HOURS | | HOURS | |
| 150 | | 751.50 | | 118 | | 99 | | 16.75 | |
| 15 | | 756.25 | | 125 | | 67 | | 15.92 | |
| 20 | | 756.57 | | 131 | | 45 | | 15.83 | |
| 25 | | 757.13 | | 147 | | 1935 | | 15.75 | |
| 30 | | 757.14 | | 151 | | 4335 | | 15.67 | |
| 1500 | | 757.14 | | 151 | | 4335 | | 15.67 | |

END

DATE
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