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NATIONAL DAM SAFETY PROGRAM. DEMARCO LAKE DAM (MO 31555), MISSO--ETC(U)
JUL 80 P R ZAMAN, E R BURTON, H L CALLAHAN DACW43-80-C-0074

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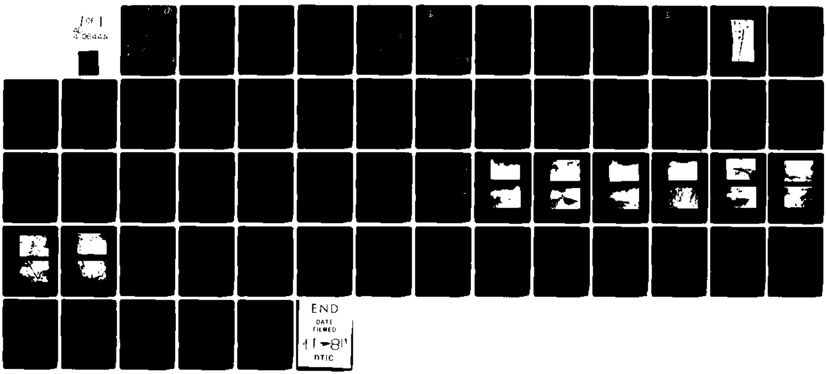

LEVEL II

MISSOURI-KANSAS CITY BASIN

AD A106444

DEMARCO LAKE DAM

BOONE COUNTY, MISSOURI

MO 31555

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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

St. Louis District

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

FOR: STATE OF MISSOURI

JULY 1980

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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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MISSOURI-KANSAS CITY BASIN

DEMARCO LAKE DAM

BOONE COUNTY, MISSOURI

MO 31555

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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

St. Louis District

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

FOR: STATE OF MISSOURI

JULY 1980

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

REPLY TO
ATTENTION OF

LMSED-PD

SUBJECT: DeMarco Lake Dam, MO. I.D. No. 31555
Phase I Inspection Report

This report presents the results of field inspection and evaluation of the DeMarco 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 — Chief, Engineering Division — 09 OCT 1980 Date

APPROVED BY : SIGNED — Colonel, CE, District Engineer — 10 OCT 1980 Date

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DEMARCO LAKE DAM

BOONE COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31555

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

JULY 1980

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	DeMarco Lake Dam
State Located	Missouri
County Located	Boone County
Stream	A minor tributary to the Missouri River
Date of Inspection	2 July 1980

DeMarco Lake 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 three dwellings, a building, a trailer, a barn, and a railroad embankment. Contents of the estimated downstream hazard 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 spillway will not pass 50 percent of the probable maximum flood without overtopping but will pass 15 percent of the probable maximum flood. The spillway will not pass the flood which has a one percent chance of occurrence in any given year (the 100-year flood). The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the volume of water impounded behind 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 satisfactory condition. Deficiencies visually observed by the inspection team were extremely dense grass, tree, and brush cover, some cracks on the crest and downstream slope, one small seepage area at the toe of the embankment, erosion gullies at both the left and right abutment interface with the downstream face of the embankment, erosion holes on the upstream slope, which were initially animal burrows, enlarged by wave action, vegetation in the spillway approach, and erosion of the spillway channel and sideslopes. The dam was difficult to inspect due to the high grass and trees. 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. Zaman, PE
Illinois 62-29261

Edwin R. Burton, PE
Missouri E-10137

Harry L. Callahan, Partner
Black & Veatch

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

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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: ______________________________ __________
Chief, Engineering Division Date

APPROVED BY : ______________________________ __________
Colonel, CE, District Engineer Date

OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DEMARCO LAKE DAM

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APPENDIX

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 Demarco 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 minor tributary to the Missouri River (see Plate 1). The watershed is an area of low hills with fairly steep slopes consisting of about 50% timber and heavy brush and 50% grassland (see Plate 2). The dam is approximately 350 feet long along the crest and 31 feet high. The dam crest is 15 feet wide. The downstream face of the dam has a fairly uniform slope from the crest to the valley floor below.

(2) The principal spillway is an unlined channel cut through the left abutment, eroded to bedrock and discharging away from the downstream toe of the embankment. The trapezoidal channel has a 7-foot bottom width and is about 4 feet deep. There is no emergency spillway for this dam.

(3) A 1-inch plastic water supply pipe is controlled by a valve just downstream of the toe on the left side of the dam. No data could be obtained on the intake for this water supply pipe.

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

b. Location. The dam is located in southern Boone County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle maps for Jefferson City Northwest, Missouri and Hartsburg, Missouri in Section 14 of T45N, R12W.

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 DeMarco 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 DeMarco Lake Dam the estimated flood damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are three dwellings, a building, a trailer, a barn, and a railroad embankment. Contents of the estimated downstream hazard zone were verified by the inspection team.

e. Ownership. The dam is owned by Mr. Guy P. DeMarco, Route 1, Hartsburg, Missouri 65039.

f. Purpose of Dam. The dam forms a 2.8-acre lake used for recreation and as a water supply for livestock.

g. Design and Construction History. Data relating to the design and construction were not available.

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

1.3 PERTINENT DATA

a. Drainage Area - 42 acres

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled unlined trapezoidal spillway channel.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated ungated spillway capacity at maximum pool elevation 160 cfs (50 Percent Probable Maximum Flood Pool El.658.6).

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

(1) Top of dam - 657.6 (see Plate 3)

(2) Spillway crest - 655.8

(3) Streambed at toe of dam - 626.3

(4) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 500 feet ± (50 Percent probable maximum flood pool level)

(2) Length of normal pool - 300 feet ± (Spillway crest)

e. Storage (Acre-feet).

(1) Top of dam - 31

(2) Spillway crest - 26

(3) *Design surcharge - Not available.*

f. Reservoir Surface (Acres).

(1) Top of dam - 3.0

(2) Spillway crest - 2.8

g. Dam.

(1) Type - Earth embankment

(2) Length - 350 feet

(3) Height - 31 feet ±

(4) Top width - 15 feet

(5) Side slopes - upstream face 1.0 V on 3.6 H, downstream face varies between 1.0 V on 2.2 H and 1.0 V on 2.4 H (see Plate 4).

(6) Zoning - Unknown.

(7) Impervious core - Unknown.

(8) Cutoff - Unknown.

(9) Grout curtain - Unknown.

h. Diversion and Regulating Tunnel - None.

i. Principal Spillway.

(1) Type - Unlined trapezoidal channel cut to bedrock with a 7-foot bottom width.

(2) Spillway crest elevation - 655.8

(3) Gates - None.

(4) Upstream channel - The spillway approach is grown up with cattails and one small tree. The channel upstream of the lake is characterized by heavy brush and tree cover.

(5) Downstream channel - Natural stream below the dam through pasture and woods.

j. Emergency Spillway - None

k. Regulating Outlets.

(1) Type - 1-inch plastic pipe.

(2) Pipe invert elevation - Unknown.

(3) Valve - downstream of embankment toe near the left abutment.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data were not available.

2.2 CONSTRUCTION

Construction records were unavailable.

2.3 OPERATION

No records of operation or of past floods were available.

2.4 GEOLOGY

The site of the dam and reservoir is located in a deeply incised steep-sided valley. The dam impounds a minor tributary to the Missouri River.

The soils of the area consist of the Winfield soil series. The Winfield soils are located along the ridges and valley slopes around the reservoir and are formed in loess. They are classified for engineering purposes as low-plastic clayey silt (ML). Also present in the valley is steep stony land consisting of stony and rocky areas along the larger creeks. It has formed either from loess or residuum from limestone. The soils vary in thickness from a few inches to several feet and contain large fragments of chert.

The bedrock in the area of the reservoir consists of the Burlington and Keokuk formations of the Osage series of the Mississippian System. Both of these formations consist of limestone with chert layers and nodules.

2.5 EVALUATION

a. Availability. No engineering data were available.

b. Adequacy. No engineering data were available. Thus, an assessment of the design, construction, and operation could not be made. 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 DeMarco Lake Dam was made on 2 July 1980. The inspection team included professional engineers with experience in dam design and construction, hydrology, hydraulic engineering, and geotechnical engineering. The inspection team consisted of Edwin Burton, hydrologist/hydraulic engineer and team leader; Robert Pinker, geologist; Gary Van Riessen, geotechnical engineer; and Andrew Dywan, civil engineer. The inspection team was accompanied by Mike DeMarco, the owner's son. The dam appears to be in satisfactory 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. The dam was difficult to inspect due to high grass and trees.

b. Dam. The inspection team observed the following conditions at the dam. Some cracks were observed along the crest and downstream slope about 1/2 inch wide and 6 inches deep. The cracking may be due to the recent very hot, dry weather. It should be noted that the temperature was 90° F plus on the day of the inspection and a record 110° F on the previous day. There is no evidence of sliding, sloughing or sinkholes. The embankment has no visible stability problems. No instruments to measure the performance of the dam were located.

A small seepage area was observed on the downstream slope on the left side of the embankment about two feet downstream of the water supply valve. The ground is wet but there is no visible flow. No toe drains or relief wells were observed.

The dam crest and the upstream and downstream slopes were observed to have a dense, unmowed grass cover (1-2 feet tall), with thick brush and trees up to 6 inches in diameter. This dense protective cover is noted to be quite effective in preventing erosion on the downstream slope, but severe erosion gullies measuring 2 to 3 feet deep and up to 2 feet wide were observed at both the left and right abutment interfaces with the downstream slope of the embankment. Also, some erosion holes, 1-1/2 to 2 feet wide and up to 1 foot deep, were observed in the silt on the upstream slope. They were initially animal burrows which have been enlarged by wave action. No evidence was found to indicate that the embankment had ever been overtopped. The owner also stated that the dam had never been overtopped.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The spillway consists of an uncontrolled notch or trapezoidal channel cut through the left abutment. Some erosion of the unlined channel and side slopes was observed. This erosion exposed the bedrock which was noted to be limestone overlaying thin layers (2 inches ±) of sandstone and shale. There was no evidence of erosion upstream or downstream of the spillway. The short approach channel to the spillway was observed to be overgrown with cattails and one small tree, but would not be considered to be an obstruction to large flows. An abnormally large spillway discharge would probably not damage the embankment. There was no development in the spillway area which could suffer damage due to flow through the spillway.

d. Geology. The soil on the ridges and side slopes around the reservoir is developed in loess. The thickness of the soils could not be determined. The soils downstream of the embankment consist of thin rocky soils developed in colluvium and residuum from limestone. Numerous fragments of chert are present in the soils.

Limestone outcrops were observed at several places downstream of the embankment and along the downstream valley. The limestone was horizontal and massive with closed bedding planes and no observable joints. The spillway channel was cut into shale and siltstone overlying limestone. The shale and siltstone were bluish gray and highly weathered. They were less than one foot thick.

Samples of the embankment were taken at the downstream crest approximately 100 feet from the left abutment using an Oakfield sampler. The auger penetrated a 2-inch void approximately 2 inches below the surface. The upper foot of material consisted of low-plastic clayey silt (ML). The material from 1 to 2 feet consisted of a low-plastic silty clay (CL). Based on these samples and visual observations, it is anticipated that the embankment consists of low-plastic silty clay (CL) overlain by approximately one foot of low-plastic clayey silt (ML).

The abutments of the dam are anticipated to be limestone overlain by loess or residual soils classified as low plastic clayey silt (ML) or silty clay (CL). The foundation of the dam is anticipated to be limestone covered with a very thin layer of alluvial or residual low-plastic silty clay soil (CL).

e. Reservoir Area. No slumping or slides at the reservoir banks were observed. The upstream channel to the lake contains heavy brush and many trees. The lake has a minor amount of siltation noted by the growth of cattails and aquatic weeds around the edge of the lake.

f. Downstream Channel. Natural channel through pasture and woods.

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 erosion gullies at the left and right abutment interfaces with the downstream slope of the embankment should be repaired.

Animal burrows on the upstream slope of the dam have precipitated wave action erosion. If not corrected, wave action will continue to erode the embankment and could lead to slope stability problems. Burrowing animals will continue to damage the embankment if no program is undertaken to eliminate them. Piping failure of the embankment has resulted in similar small earth dams due to burrowing animal damage.

The growth of trees and brush and the uncut grass, if allowed to go unchecked, could cause deterioration of the embankment. The roots of trees can loosen the embankment material and also can leave voids through which water can pass. Brush on the dam prevents inspection of the embankment and kills the smaller grasses whose roots are more effective in protecting the surface soil of the slope from erosion. The brush and tall uncut grass provides habitat for burrowing animals which can damage the embankment.

The area of seepage at the downstream slope near the left abutment which was observed should be monitored regularly for quality and quantity. Seepage can cause internal erosion creating cavities and underground channels, thereby weakening the embankment and/or abutments.

The cracks on the crest and downstream slope are a problem. The potential for sloughing and sliding of slope segments will increase as additional water enters the cracks.

The erosion of the spillway channel and side slopes should be curtailed. If allowed to continue, the crest of the spillway may erode causing the lake level to drop or the side slopes may collapse causing obstruction of the spillway discharges.

The growth of cattails and one tree at the approach to the spillway will impede low flow discharges from the spillway. However, high flow discharges should cause the vegetation to be matted down, thus not having a significant effect on spillway discharges at high flows.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, evaporation, transpiration, withdrawals for livestock water supply, and overflow through the low spot in the dam near the left abutment.

4.2 MAINTENANCE OF DAM

No maintenance was evident.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist, except for a valved 1-inch plastic pipe used as a water supply for livestock. The pipe is broken about two feet downstream of the valve.

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

A maintenance program should be initiated which would include mowing the grass cover on the embankment in order to discourage animal burrowing. A program should be undertaken to eliminate the burrowing animals. The brush and trees on the embankment should be removed. The area of seepage should be monitored periodically and, if flow increases significantly or if seepage flow becomes muddy, a qualified engineer should be consulted.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. No design data were available.

b. Experience Data. The drainage area and lake surface area are developed from USGS Jefferson City Northwest and Hartsburg, Missouri Quadrangle Maps. The dam layout is from a survey made during the inspection.

c. Visual Observations.

(1) The spillway appears to be in adequate condition. The lake level at the time of the inspection (El.655.4) was below the crest elevation. The spillway consists of an uncontrolled channel cut through the left abutment and eroded to rock. The rock is limestone overlaying sandstone and shale. The approach is overgrown with cattails and one small tree, but these obstructions would not prevent large flows from discharging.

(2) The water supply valve was closed at the time of the inspection.

(3) Spillway discharges do not endanger the integrity of the dam.

d. Overtopping Potential. The spillway 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 spillway will pass 15 percent of the probable maximum flood without overtopping the dam. The spillway will not pass the one percent chance flood estimated to have a peak outflow of 102 cfs developed by a 24-hour, one percent chance 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 volume of water impounded by 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 50 percent of the probable maximum flood overtopping the dam would be 290 cfs of the total discharge from the reservoir of 450 cfs. The estimated duration of overtopping is 1.8 hours with a maximum height of 1.0 feet. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 700 cfs of the total discharge from the reservoir of 950 cfs. The estimated duration of overtopping is 5.7 hours with a maximum height of 1.5 feet. The embankment could be jeopardized should overtopping occur for these periods of time.

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. Three dwellings, a trailer, a building, a barn, and a railroad embankment could be severely damaged and lives could be lost should failure of the dam occur. Contents of the estimated downstream hazard zone were verified by the inspection team.

There are no floodplain 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. It is not known whether any post-construction changes have been made. The owner stated that he plans to install a 24-inch pipe and gate in the embankment.

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 conservatism 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 shear 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 erosion at both abutment/embankment interfaces, erosion holes on the upstream slope, a seepage area on the downstream slope, the dense growth of grass, brush and trees on the embankment, cracking along the crest and downstream slope, vegetation in the spillway approach, and erosion of the spillway channel and side slopes. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. Due to the absence 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 7.2b 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 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 recommended stability analysis.

7.2 REMEDIAL MEASURES

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

b. Operation and Maintenance Procedures. The following operation and maintenance procedures should be implemented under the direction of a professional engineer experienced in the design, construction, and inspection of dams:

(1) The erosion holes on the upstream face of the dam should be repaired using a suitable compacted backfill material. Slope protection should be provided to protect the repaired areas. Control measures should be implemented to discourage increased animal activity in the area.

(2) The seepage area noted during the visual inspection should be closely monitored and documented as to quantity of flow. Any significant changes should be evaluated.

(3) The cracking along the crest and downstream slope of the dam should be repaired.

(4) The erosion gullies on the downstream slope at the interface of the embankment and the right and left abutments should be backfilled with suitable compacted material. Paved ditches or other slope protection may be required to control the concentrated surface runoff.

(5) An improved maintenance program to remove and control the growth of brush and trees on the embankment should be developed. Grass cover on the embankment should be cut periodically.

(6) The spillway entrance channel should be cleaned of restrictive vegetation and should be maintained in an unrestricted condition. The spillway should be protected to prevent erosion.

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

(8) 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.

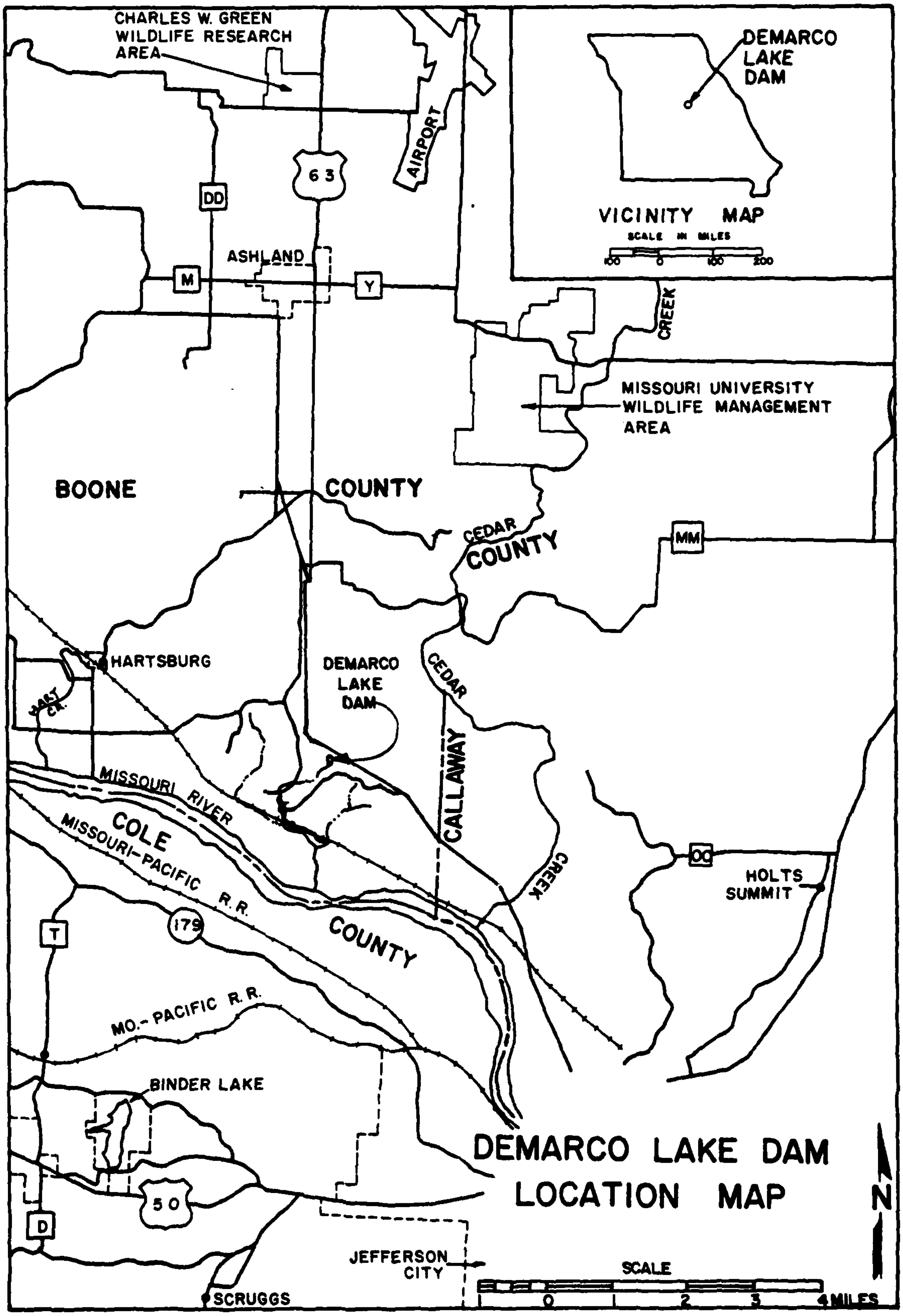

CHARLES W. GREEN
WILDLIFE RESEARCH
AREA
AIRPORT
63
DD
DEMARCO
LAKE
DAM
VICINITY MAP
ASHLAND
M
Y
CREEK
MISSOURI UNIVERSITY
WILDLIFE MANAGEMENT
AREA
BOONE
COUNTY
CEDAR
COUNTY
MM
HARTSBURG
DEMARCO
LAKE
DAM
CEDAR
CALLAWAY
MISSOURI RIVER
COLE
MISSOURI-PACIFIC R.R.
CREEK
OO
HOLTS
SUMMIT
T
179
COUNTY
MO.-PACIFIC R.R.
BINDER LAKE
DEMARCO LAKE DAM
LOCATION MAP
50
N
D
JEFFERSON
CITY
SCALE
0 1 2 3 4 MILES
SCRUGGS

PLATE I

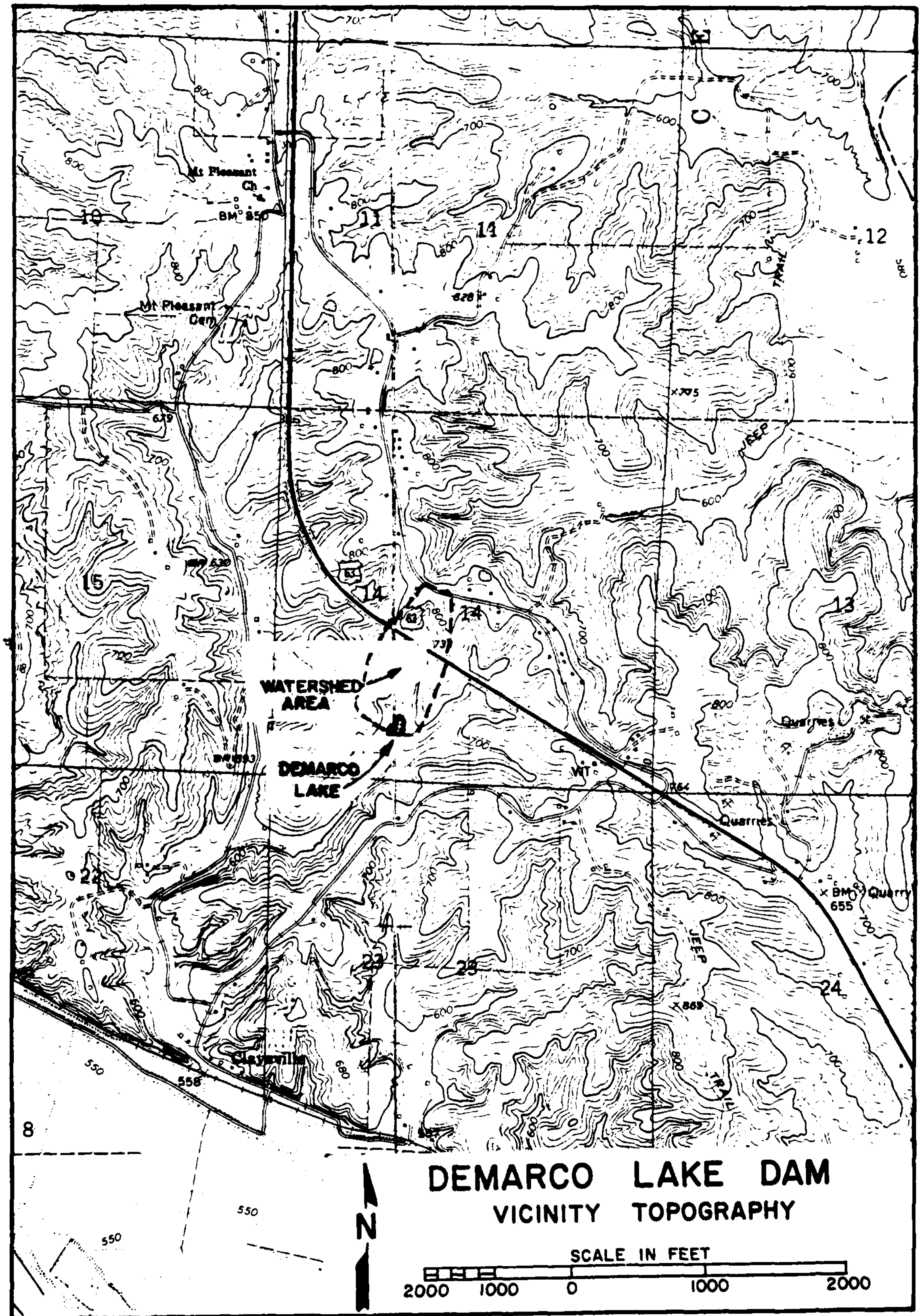

Mt Pleasant Ch
Mt Pleasant Cem
WATERSHED AREA
DEMARCO LAKE
Quarries
Claysville
JEEP TRAIL
DEMARCO LAKE DAM
VICINITY TOPOGRAPHY
SCALE IN FEET
2000 1000 0 1000 2000
N

PLATE 2

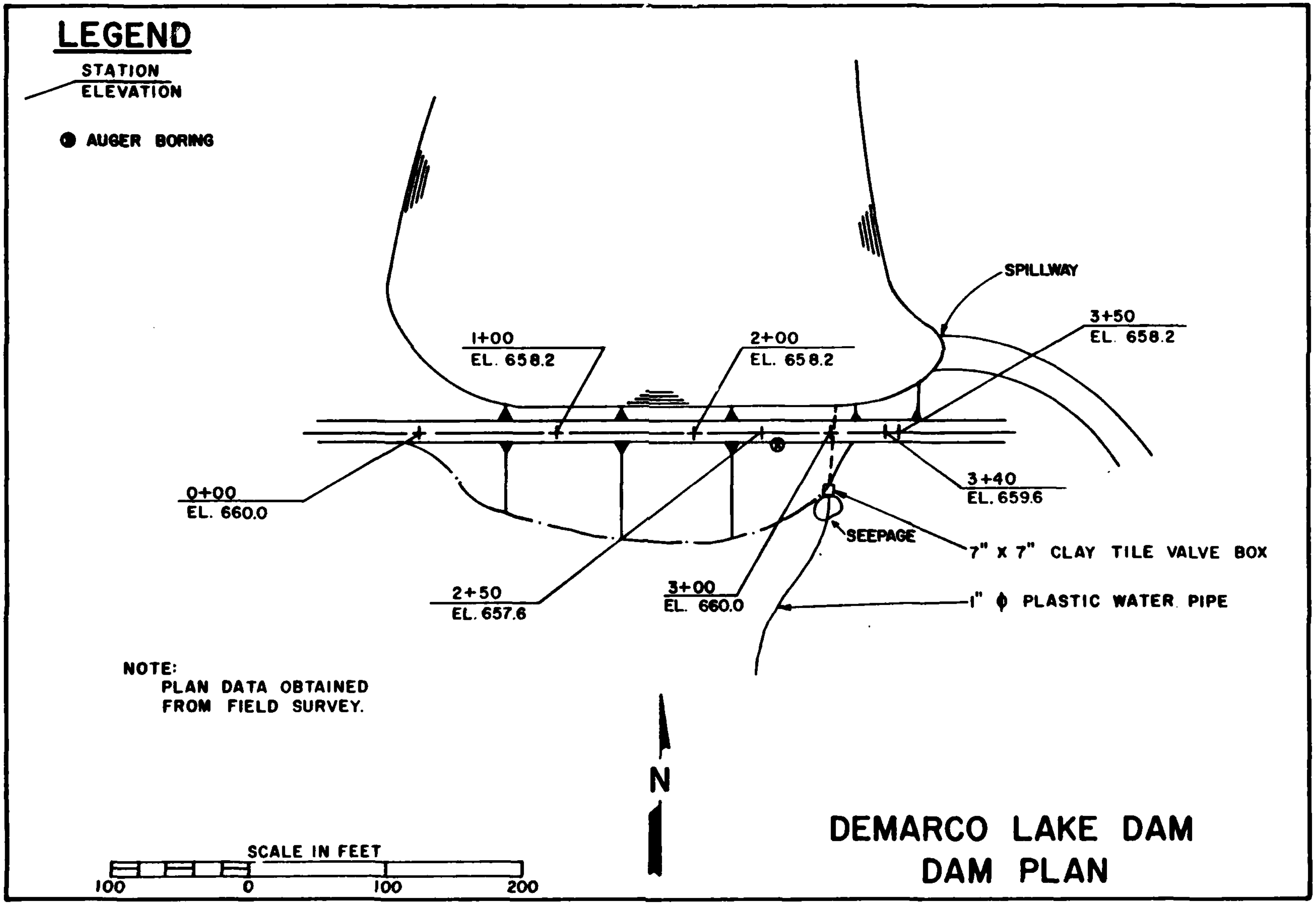
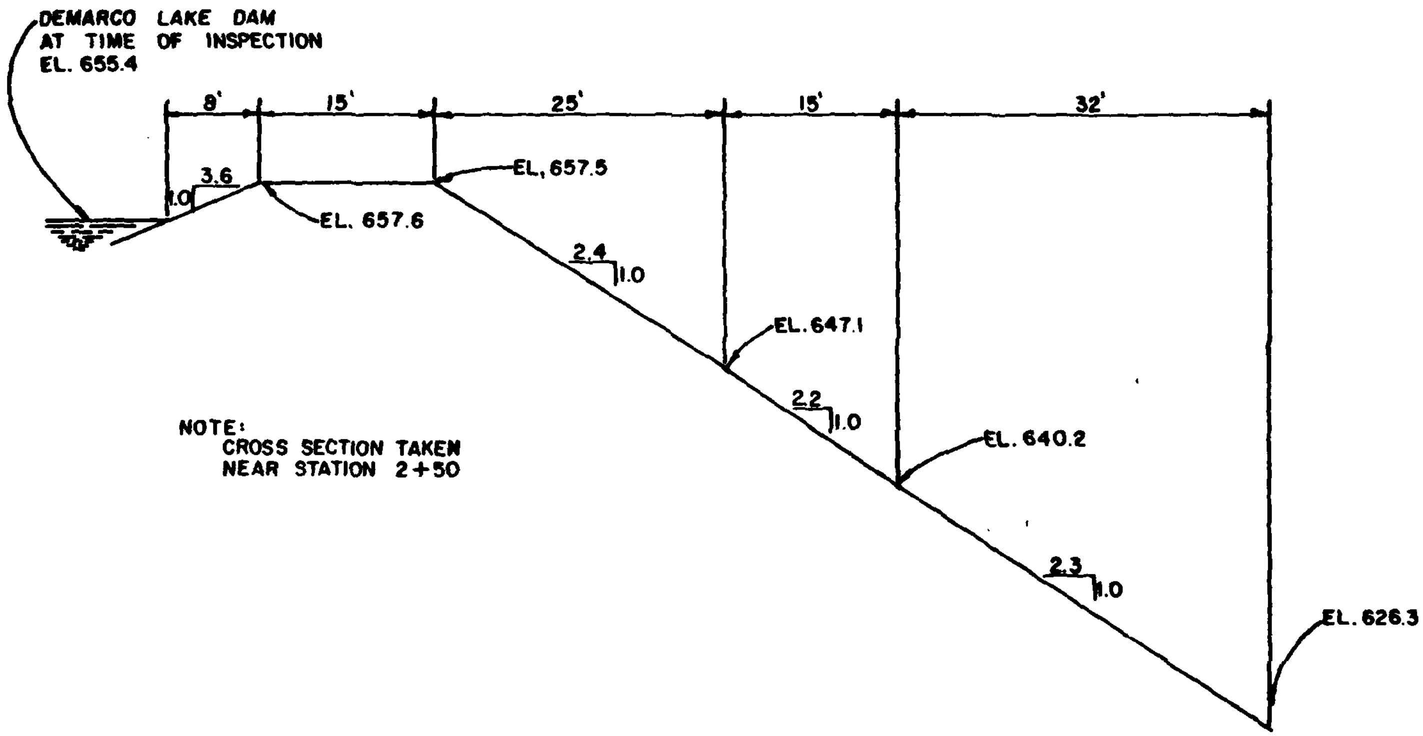

LEGEND
STATION
ELEVATION
AUGER BORING
SPILLWAY
3+50
EL. 658.2
1+00
EL. 658.2
2+00
EL. 658.2
0+00
EL. 660.0
3+40
EL. 659.6
SEEPAGE
7" x 7" CLAY TILE VALVE BOX
2+50
EL. 657.6
3+00
EL. 660.0
1" ϕ PLASTIC WATER PIPE
NOTE:
PLAN DATA OBTAINED
FROM FIELD SURVEY.
N
SCALE IN FEET
100
0
100
200
DEMARCO LAKE DAM
DAM PLAN

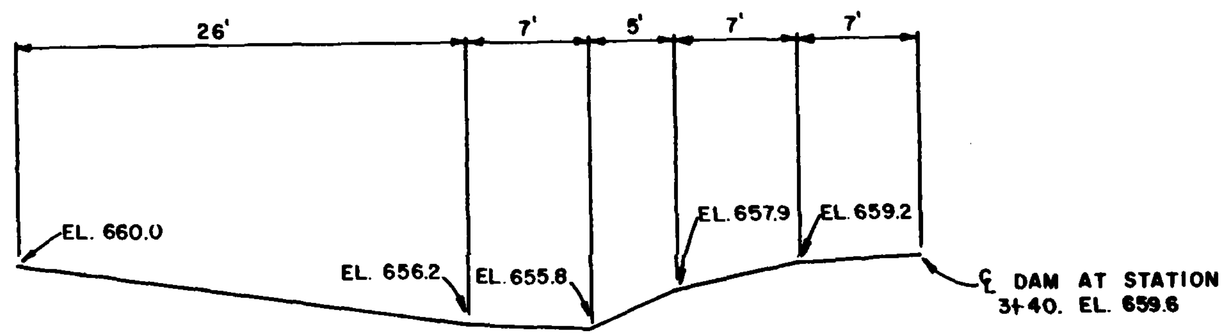
PLATE 3



NOTE:
CROSS SECTION TAKEN
NEAR STATION 2+50

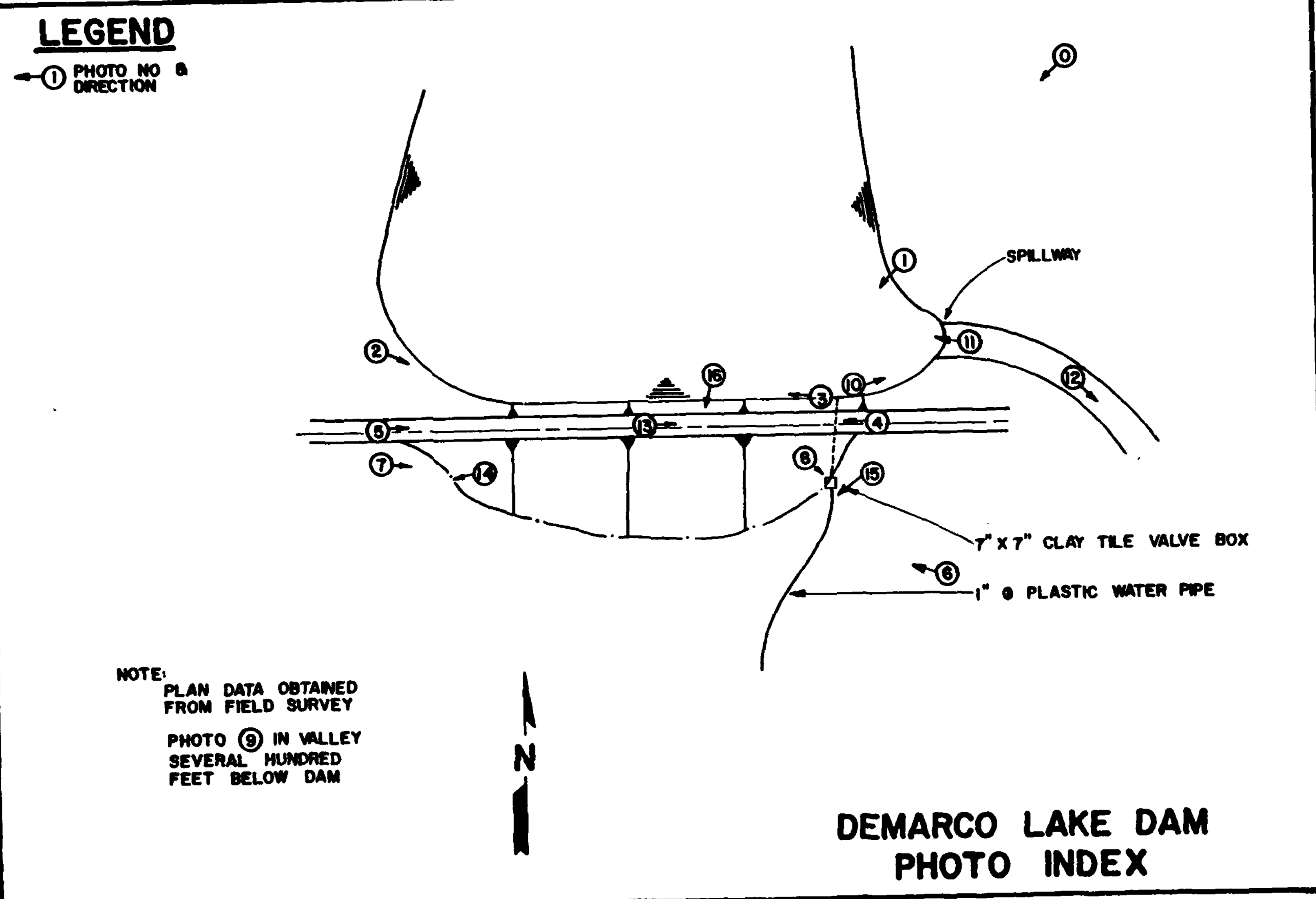
DEMARCO LAKE DAM
DAM CROSS SECTION

PLATE 4



DEMARCO LAKE DAM
SPILLWAY CROSS SECTION

DEMARCO LAKE DAM PHOTO INDEX



NOTE:
PLAN DATA OBTAINED FROM FIELD SURVEY

PHOTO ⑨ IN VALLEY SEVERAL HUNDRED FEET BELOW DAM

PHOTO 1: UPSTREAM FACE OF DAM VIEWED FROM LEFT BANK

PHOTO 2: UPSTREAM FACE OF DAM VIEWED FROM RIGHT BANK

PHOTO 3: UPSTREAM FACE OF DAM AT WATERLINE

PHOTO 4: CREST OF DAM FROM LEFT END

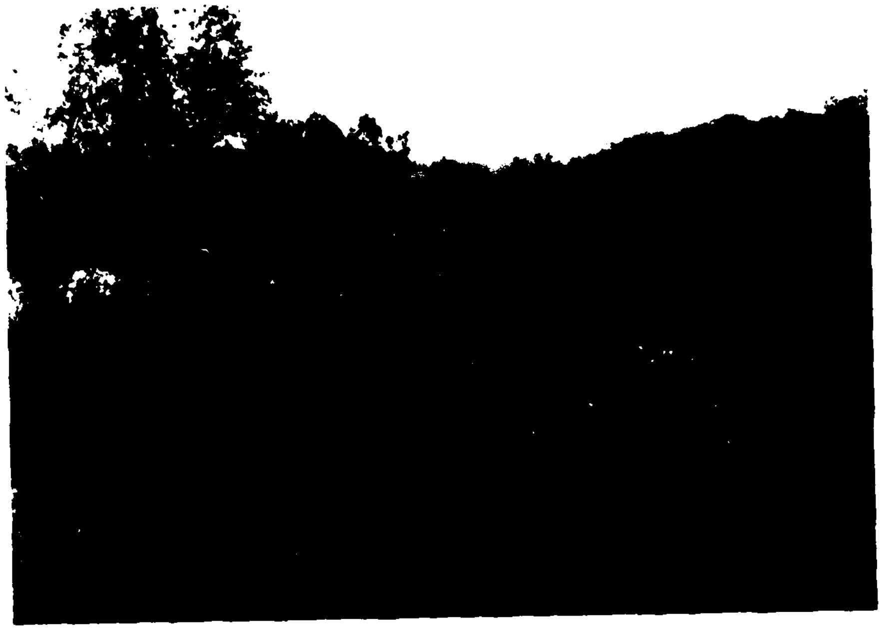


PHOTO 5: CREST OF DAM FROM RIGHT END

PHOTO 6: DOWNSTREAM SLOPE OF DAM FROM BELOW

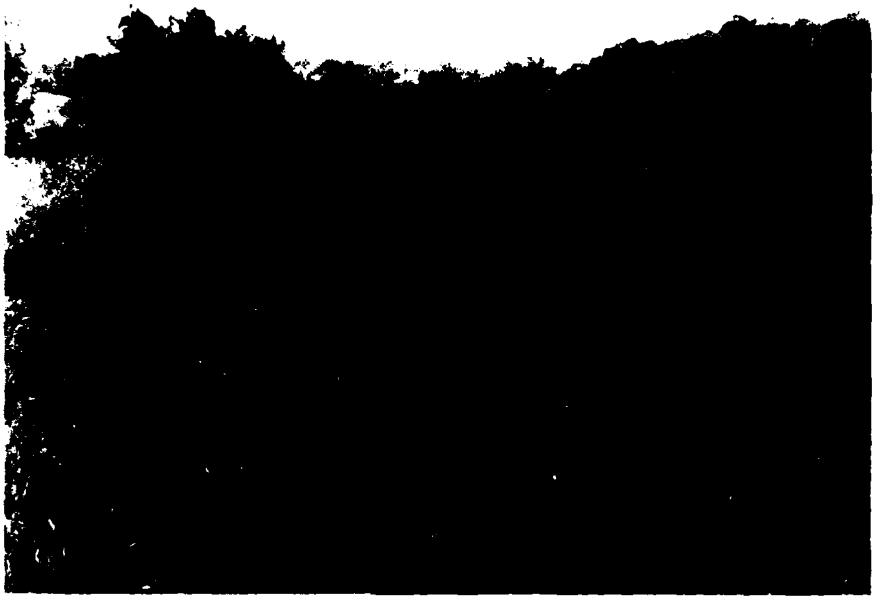


PHOTO 7: DOWNSTREAM SLOPE OF DAM FROM RIGHT ABUTMENT

PHOTO 8: VALVE BOX TO PLASTIC WATERLINE

PHOTO 9: CHANNEL BELOW DAM AT PLASTIC PIPE OUTLET

PHOTO 10: APPROACH TO SPILLWAY CHANNEL

PHOTO 11: SPILLWAY CHANNEL LOOKING UPSTREAM

PHOTO 12: SPILLWAY CHANNEL LOOKING DOWNSTREAM

PHOTO 13: CRACK IN CREST OF DAM

PHOTO 14: EROSION AT RIGHT ABUTMENT/ DOWNSTREAM SLOPE INTERFACE

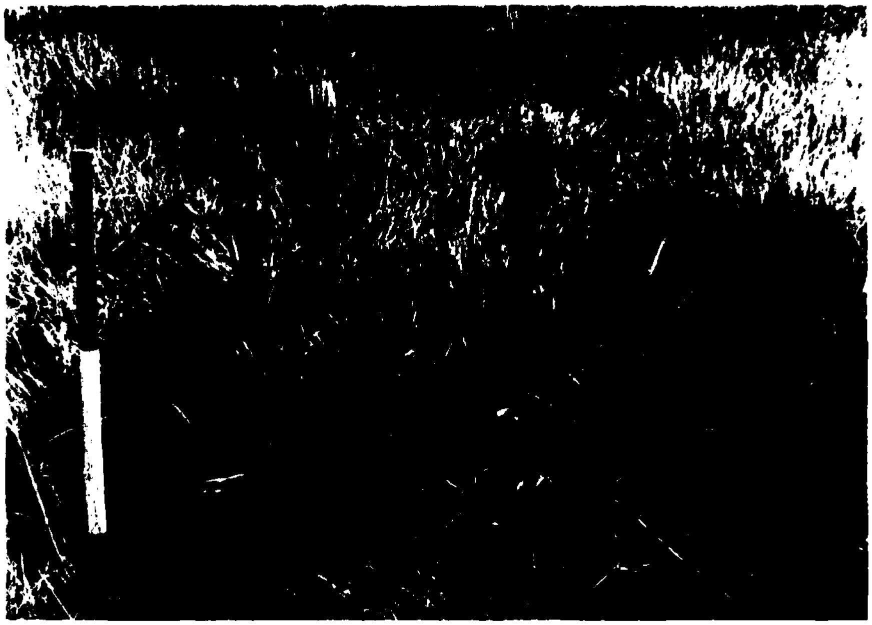


PHOTO 15: SEEPAGE AREA NEAR VALVE BOX

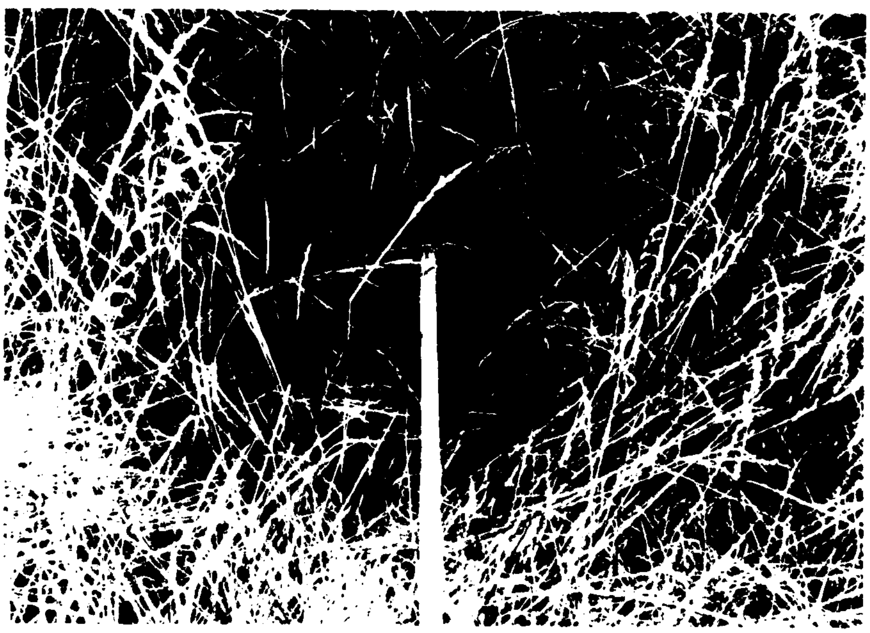


PHOTO 16: EROSION ON UPSTREAM FACE OF DAM

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC ANALYSES

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was 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 Jefferson 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 reservoir and spillway.

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

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

The reservoir routing was performed using the Modified Puls Method. The initial reservoir pool elevation for the routing of each storm was determined to be equivalent to the crest elevation of the spillway at elevation 655.8 feet m.s.l. 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 (2). The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation, surface area, storage, and discharge relationships shown in Table 3.

The flow over the crest of the dam and through the spillway 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 result of the routing analyses indicates that 15 percent of the PMF will not overtop the dam.

A summary of the routing analysis for different ratios of the PMF is shown in Table 4.

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

TABLE 1

SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	42 acres
Length of Longest Watercourse (L)	0.35 miles
Elevation Differences in Watershed (H)	170 feet
Wave Velocity (V)	22.7 feet per second
Length of Reservoir (L_w)	300 feet
Lag Time (L_g)	0.07 hours
Time of concentration (T_c)	0.11 hours
Duration (D)	1 min. (use 5 minutes)

Time (Min.) *	Discharge (cfs) *
0	0
5	258
10	178
15	49
20	14
25	4
30	1

* From HEC-1 computer output

FORMULAS USED:

$$T_c = (11.9 \times L^3/H)^{0.385} + V/L_w \quad (3 \text{ and } 4)$$

$$L_g = 0.6\ T_c$$

$$D = 0.133\ T_c$$

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	24	32.50	31.06	1.44
1% Probability	24	7.44	4.63	2.79

Additional Data:

1) The soil association in this watershed is Winfield (5).
   75 percent of drainage area in hydrologic soil group C.
   25 percent of drainage area in hydrologic soil group D.
   50 percent of the land use was timber.
   50 percent of the land use was grassland.
2) SCS Runoff Curve CN = 89 (AMC III) for the PMF.
3) SCS Runoff Curve CN = 76 (AMC II) for the one percent probability flood (4).

TABLE 3

ELEVATION, SURFACE AREA, STORAGE, AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
*655.8	2.8	26	0
**657.6	3.0	31	77

*Spillway crest elevation
**Top of dam elevation

The relationships in Table 3 were developed from the Jefferson City Northwest, Missouri and Hartsburg, Missouri 7.5 minute quadrangle maps and the field measurements.

METHOD USED:

Discharge rates for the spillway were determined by HEC-1 (1) given data describing the embankment crest.

Discharges through the spillway for the probable maximum flood and 50 percent of the probable maximum flood were determined by the equations for flow over a nonlevel crest.

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

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

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

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/sec^2 = acceleration due to gravity.

TABLE 4

RESULTS OF FLOOD ROUTINGS

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	*655.8	26	0	-
0.15	153	657.5	31	64	0
0.50	511	658.6	34	447	1.0
1.00	1,022	659.1	36	944	1.5

* Spillway crest elevation

BIBLIOGRAPHY

(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. Army Corps of Engineers, St. Louis District, Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams, 12 December 1979.

(3) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.

(4) U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, August 1972.

(5) U.S. Department of Agriculture, Soil Conservation Service, Soil Survey for Boone County, Missouri.

(6) U.S. Department of Agriculture, Soil Conservation Service, Soil Survey Interpretations and Field Maps, 1980.

(7) Mary H. McCracken, Missouri Division of Geological Survey, Geologic Map of Missouri, 1961.

```
*****************************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  06 FEB 80
*****************************************
     1                A1MISSOURI DAM INSPECTION PROGRAM
     2                A2ST. LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
     3                A3DEMARCO LAKE DAM - PMF
     4                B    288       0       5       0       0       0       0       0       0       0
     5                B1     5
     6                J      1       9       1
     7                J1   .15      .2     .25      .3     .35      .4     .45      .5     1.0
     8                K      0       1                               3       1
     9                K1    DEMAPCO LAKE (24 HR. PROBABLE MAXIMUM RUNOFF)
    10                M      1       2    .065                       1
    11                P           25.0     101     120     130
    12                T                                                      -1     -89
    13                WZ          .366
    14                X                      1
    15                K      1       2                                       1
    16                K1    ROUTE THROUGH SPILLWAY
    17                Y                              1       1
    18                Y1     1                                   -655.80
    19                SA0.0    2.8     3.3     7.0
    20                SE629.0 655.4  660.0   680.0
    21                SS655.80
    22                SD657.6
    23                SLC.     8.     22.     56.    190.    244.    279.    322.    354.    391.
    24                SV655.8G656.2  657.6   657.9   658.2   658.8   659.2   659.6   659.8   660.
    25                K     99
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***********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  06 FEB 80
***********************************
                         MISSOURI DAM INSPECTION PROGRAM
                         ST. LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
                         DEMARCO LAKE DAM - PMF

                                              JOB SPECIFICATION
                          NO      NHR      NMIN     IDAY      IHR      IMIN    METRC     IPLT     IPRT    NSTAN
                         288        0         5        0        0         0        0        0        0        0
                                                   JOPER      NWT     LROPT    TRACE
                                                       5        0         0        0

                                         MULTI-PLAN ANALYSES TO BE PERFORMED
                                              NPLAN= 1 NRTIO= 9 LRTIO= 1
                         RTIOS=    .15     .20     .25     .30     .35     .40     .45     .50    1.00

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

                                            SUB-AREA RUNOFF COMPUTATION

                         DEMARCO LAKE (24 HR. PROBABLE MAXIMUM RUNOFF)

                                      ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                                          1       0       0       0       0       3       1       0       0

                                                    HYDROGRAPH DATA
                         IHYDG   IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
                             1      2     .07     .00     .07    1.00    .000       0       0       0

                                                      PRECIP DATA
                                   SPFE     PMS      R6     R12     R24     R48     R72     R96
                                    .00   25.00  101.00  120.00  130.00     .00     .00     .00

                                                       LOSS DATA
                  LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
                      0     .00     .00    1.00     .00     .00    1.00   -1.00  -89.00     .00     .00

                         CURVE NO = -89.00  WETNESS =   -1.00  EFFECT CN =  89.00

                                                 UNIT HYDROGRAPH DATA
                                            TC=    .00     LAG=    .07

                                                    RECESSION DATA
                                     STRTQ=     .06   QRCSN=     .00   RTIOR= 1.00

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

                         UNIT HYDROGRAPH  6 END OF PERIOD ORDINATES, TC=     .00 HOURS, LAG=    .07  VOL= 1.00
                      258.      178.       49.       14.        4.        1.
```

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

UNIT HYDROGRAPH 6 END OF PERIOD ORDINATES, TC= .00 HOURS, LAG= .07 VOL= 1.00
256. 178. 49. 14. 4. 1.

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.00	.01	0.	1.01	12.05	145	.21	.20	.01	68.
1.01	.10	2	.01	.00	.01	0.	1.01	12.10	146	.21	.20	.01	93.
1.01	.15	3	.01	.00	.01	0.	1.01	12.15	147	.21	.20	.01	100.
1.01	.20	4	.01	.00	.01	0.	1.01	12.20	148	.21	.20	.01	102.
1.01	.25	5	.01	.00	.01	0.	1.01	12.25	149	.21	.20	.01	103.
1.01	.30	6	.01	.00	.01	0.	1.01	12.30	150	.21	.21	.01	103.
1.01	.35	7	.01	.00	.01	0.	1.01	12.35	151	.21	.21	.00	103.
1.01	.40	8	.01	.00	.01	0.	1.01	12.40	152	.21	.21	.00	103.
1.01	.45	9	.01	.00	.01	0.	1.01	12.45	153	.21	.21	.00	104.
1.01	.50	10	.01	.00	.01	0.	1.01	12.50	154	.21	.21	.00	104.
1.01	.55	11	.01	.00	.01	0.	1.01	12.55	155	.21	.21	.00	104.
1.01	1.00	12	.01	.00	.01	0.	1.01	13.00	156	.21	.21	.00	104.
1.01	1.05	13	.01	.00	.01	0.	1.01	13.05	157	.25	.25	.00	115.
1.01	1.10	14	.01	.00	.01	0.	1.01	13.10	158	.25	.25	.00	122.
1.01	1.15	15	.01	.00	.01	0.	1.01	13.15	159	.25	.25	.00	124.
1.01	1.20	16	.01	.00	.01	0.	1.01	13.20	160	.25	.25	.00	125.
1.01	1.25	17	.01	.00	.01	0.	1.01	13.25	161	.25	.25	.00	125.
1.01	1.30	18	.01	.00	.01	0.	1.01	13.30	162	.25	.25	.00	125.
1.01	1.35	19	.01	.00	.01	0.	1.01	13.35	163	.25	.25	.00	125.
1.01	1.40	20	.01	.00	.01	0.	1.01	13.40	164	.25	.25	.00	125.
1.01	1.45	21	.01	.00	.01	0.	1.01	13.45	165	.25	.25	.00	125.
1.01	1.50	22	.01	.00	.01	0.	1.01	13.50	166	.25	.25	.00	126.
1.01	1.55	23	.01	.00	.01	1.	1.01	13.55	167	.25	.25	.00	126.
1.01	2.00	24	.01	.00	.01	1.	1.01	14.00	168	.25	.25	.00	126.
1.01	2.05	25	.01	.00	.01	1.	1.01	14.05	169	.32	.31	.00	142.
1.01	2.10	26	.01	.00	.01	1.	1.01	14.10	170	.32	.31	.00	153.
1.01	2.15	27	.01	.00	.01	1.	1.01	14.15	171	.32	.31	.00	156.
1.01	2.20	28	.01	.00	.01	1.	1.01	14.20	172	.32	.31	.00	157.
1.01	2.25	29	.01	.00	.01	1.	1.01	14.25	173	.32	.31	.00	157.
1.01	2.30	30	.01	.00	.01	1.	1.01	14.30	174	.32	.31	.00	158.
1.01	2.35	31	.01	.00	.01	2.	1.01	14.35	175	.32	.31	.00	158.
1.01	2.40	32	.01	.00	.01	2.	1.01	14.40	176	.32	.31	.00	158.
1.01	2.45	33	.01	.00	.01	2.	1.01	14.45	177	.32	.31	.00	158.
1.01	2.50	34	.01	.00	.01	2.	1.01	14.50	178	.32	.31	.00	158.
1.01	2.55	35	.01	.00	.01	2.	1.01	14.55	179	.32	.31	.00	158.
1.01	3.00	36	.01	.00	.01	2.	1.01	15.00	180	.32	.31	.00	158.
1.01	3.05	37	.01	.00	.01	2.	1.01	15.05	181	.19	.19	.00	126.
1.01	3.10	38	.01	.00	.01	2.	1.01	15.10	182	.38	.38	.00	153.
1.01	3.15	39	.01	.00	.01	2.	1.01	15.15	183	.38	.38	.00	161.
1.01	3.20	40	.01	.00	.01	2.	1.01	15.20	184	.58	.57	.00	238.
1.01	3.25	41	.01	.01	.01	2.	1.01	15.25	185	.67	.67	.00	299.
1.01	3.30	42	.01	.01	.01	3.	1.01	15.30	186	1.63	1.62	.01	573.
1.01	3.35	43	.01	.01	.01	3.	1.01	15.35	187	2.69	2.68	.01	1022.
1.01	3.40	44	.01	.01	.01	3.	1.01	15.40	188	1.06	1.05	.00	839.
1.01	3.45	45	.01	.01	.01	3.	1.01	15.45	189	.67	.67	.00	516.
1.01	3.50	46	.01	.01	.01	3.	1.01	15.50	190	.58	.57	.00	362.
1.01	3.55	47	.01	.01	.01	3.	1.01	15.55	191	.38	.38	.00	260.
1.01	4.00	48	.01	.01	.01	3.	1.01	16.00	192	.38	.38	.00	211.
1.01	4.05	49	.01	.01	.01	3.	1.01	16.05	193	.29	.29	.00	174.
1.01	4.10	50	.01	.01	.01	3.	1.01	16.10	194	.29	.29	.00	155.
1.01	4.15	51	.01	.01	.01	3.	1.01	16.15	195	.29	.29	.00	150.
1.01	4.20	52	.01	.01	.01	3.	1.01	16.20	196	.29	.29	.00	148.
1.01	4.25	53	.01	.01	.01	3.	1.01	16.25	197	.29	.29	.00	148.

1.01	4.10	50	.01	.01	.01	3.	1.01	16.10	194	.29	.29	.00	[illegible]
[illegible]	4.15	51	.01	.01	.01	3.	1.01	16.15	195	.29	.29	.00	150.
1.01	4.20	52	.01	.01	.01	3.	1.01	16.20	196	.29	.29	.00	148.
1.01	4.25	53	.01	.01	.01	3.	1.01	16.25	197	.29	.29	.00	148.

1.01	4.30	54	.01	.01	.01	3.	1.01	16.30	198	.29	.29	.00	148.
1.01	4.35	55	.01	.01	.01	3.	1.01	16.35	199	.29	.29	.00	148.
1.01	4.40	56	.01	.01	.01	4.	1.01	16.40	200	.29	.29	.00	148.
1.01	4.45	57	.01	.01	.01	4.	1.01	16.45	201	.29	.29	.00	148.
1.01	4.50	58	.01	.01	.01	4.	1.01	16.50	202	.29	.29	.00	148.
1.01	4.55	59	.01	.01	.01	4.	1.01	16.55	203	.29	.29	.00	148.
1.01	5.00	60	.01	.01	.01	4.	1.01	17.00	204	.29	.29	.00	148.
1.01	5.05	61	.01	.01	.01	4.	1.01	17.05	205	.23	.23	.00	132.
1.01	5.10	62	.01	.01	.01	4.	1.01	17.10	206	.23	.23	.00	120.
1.01	5.15	63	.01	.01	.01	4.	1.01	17.15	207	.23	.23	.00	117.
1.01	5.20	64	.01	.01	.01	4.	1.01	17.20	208	.23	.23	.00	117.
1.01	5.25	65	.01	.01	.01	4.	1.01	17.25	209	.23	.23	.00	116.
1.01	5.30	66	.01	.01	.01	4.	1.01	17.30	210	.23	.23	.00	116.
1.01	5.35	67	.01	.01	.01	4.	1.01	17.35	211	.23	.23	.00	116.
1.01	5.40	68	.01	.01	.01	4.	1.01	17.40	212	.23	.23	.00	116.
1.01	5.45	69	.01	.01	.01	4.	1.01	17.45	213	.23	.23	.00	116.
1.01	5.50	70	.01	.01	.01	4.	1.01	17.50	214	.23	.23	.00	116.
1.01	5.55	71	.01	.01	.01	4.	1.01	17.55	215	.23	.23	.00	116.
1.01	6.00	72	.01	.01	.01	4.	1.01	18.00	216	.23	.23	.00	116.
1.01	6.05	73	.07	.04	.02	13.	1.01	18.05	217	.02	.02	.00	62.
1.01	6.10	74	.07	.04	.02	19.	1.01	18.10	218	.02	.02	.00	25.
1.01	6.15	75	.07	.04	.02	21.	1.01	18.15	219	.02	.02	.00	14.
1.01	6.20	76	.07	.05	.02	22.	1.01	18.20	220	.02	.02	.00	11.
1.01	6.25	77	.07	.05	.02	23.	1.01	18.25	221	.02	.02	.00	11.
1.01	6.30	78	.07	.05	.02	24.	1.01	18.30	222	.02	.02	.00	10.
1.01	6.35	79	.07	.05	.02	24.	1.01	18.35	223	.02	.02	.00	10.
1.01	6.40	80	.07	.05	.02	25.	1.01	18.40	224	.02	.02	.00	10.
1.01	6.45	81	.07	.05	.02	25.	1.01	18.45	225	.02	.02	.00	10.
1.01	6.50	82	.07	.05	.01	26.	1.01	18.50	226	.02	.02	.00	10.
1.01	6.55	83	.07	.05	.01	26.	1.01	18.55	227	.02	.02	.00	10.
1.01	7.00	84	.07	.05	.01	26.	1.01	19.00	228	.02	.02	.00	10.
1.01	7.05	85	.07	.05	.01	27.	1.01	19.05	229	.02	.02	.00	10.
1.01	7.10	86	.07	.05	.01	27.	1.01	19.10	230	.02	.02	.00	10.
1.01	7.15	87	.07	.05	.01	27.	1.01	19.15	231	.02	.02	.00	10.
1.01	7.20	88	.07	.05	.01	27.	1.01	19.20	232	.02	.02	.00	10.
1.01	7.25	89	.07	.06	.01	28.	1.01	19.25	233	.02	.02	.00	10.
1.01	7.30	90	.07	.06	.01	28.	1.01	19.30	234	.02	.02	.00	10.
1.01	7.35	91	.07	.06	.01	28.	1.01	19.35	235	.02	.02	.00	10.
1.01	7.40	92	.07	.06	.01	28.	1.01	19.40	236	.02	.02	.00	10.
1.01	7.45	93	.07	.06	.01	29.	1.01	19.45	237	.02	.02	.00	10.
1.01	7.50	94	.07	.06	.01	29.	1.01	19.50	238	.02	.02	.00	10.
1.01	7.55	95	.07	.06	.01	29.	1.01	19.55	239	.02	.02	.00	10.
1.01	8.00	96	.07	.06	.01	29.	1.01	20.00	240	.02	.02	.00	10.
1.01	8.05	97	.07	.06	.01	29.	1.01	20.05	241	.02	.02	.00	10.
1.01	8.10	98	.07	.06	.01	29.	1.01	20.10	242	.02	.02	.00	10.
1.01	8.15	99	.07	.06	.01	29.	1.01	20.15	243	.02	.02	.00	10.
1.01	8.20	100	.07	.06	.01	30.	1.01	20.20	244	.02	.02	.00	10.
1.01	8.25	101	.07	.06	.01	30.	1.01	20.25	245	.02	.02	.00	10.
1.01	8.30	102	.07	.06	.01	30.	1.01	20.30	246	.02	.02	.00	10.
1.01	8.35	103	.07	.06	.01	30.	1.01	20.35	247	.02	.02	.00	10.
1.01	8.40	104	.07	.06	.01	30.	1.01	20.40	248	.02	.02	.00	10.
1.01	8.45	105	.07	.06	.01	30.	1.01	20.45	249	.02	.02	.00	10.
1.01	8.50	106	.07	.06	.01	30.	1.01	20.50	250	.02	.02	.00	10.
1.01	8.55	107	.07	.06	.01	30.	1.01	20.55	251	.02	.02	.00	10.
1.01	9.00	108	.07	.06	.01	30.	1.01	21.00	252	.02	.02	.00	10.
1.01	9.05	109	.07	.06	.01	31.	1.01	21.05	253	.02	.02	.00	10.

.01	8.50	106	.07	.06	.01	30.	1.01	20.50	250	.02	.02	.00	10.
.01	8.55	107	.07	.06	.01	30.	1.01	20.55	251	.02	.02	.00	10.
1.01	9.00	108	.07	.06	.01	30.	1.01	21.00	252	.02	.02	.00	10.
1.01	9.05	109	.07	.06	.01	31.	1.01	21.05	253	.02	.02	.00	10.

1.01	9.10	110	.07	.06	.01	31.	1.01	21.10	254	.02	.02	.00	10.
1.01	9.15	111	.07	.06	.00	31.	1.01	21.15	255	.02	.02	.00	10.
1.01	9.20	112	.07	.06	.00	31.	1.01	21.20	256	.02	.02	.00	10.
1.01	9.25	113	.07	.06	.00	31.	1.01	21.25	257	.02	.02	.00	10.
1.01	9.30	114	.07	.06	.00	31.	1.01	21.30	258	.02	.02	.00	10.
1.01	9.35	115	.07	.06	.00	31.	1.01	21.35	259	.02	.02	.00	10.
1.01	9.40	116	.07	.06	.00	31.	1.01	21.40	260	.02	.02	.00	10.
1.01	9.45	117	.07	.06	.00	31.	1.01	21.45	261	.02	.02	.00	10.
1.01	9.50	118	.07	.06	.00	31.	1.01	21.50	262	.02	.02	.00	10.
1.01	9.55	119	.07	.06	.00	31.	1.01	21.55	263	.02	.02	.00	10.
1.01	10.00	120	.07	.06	.00	31.	1.01	22.00	264	.02	.02	.00	10.
1.01	10.05	121	.07	.05	.00	31.	1.01	22.05	265	.02	.02	.00	10.
1.01	10.10	122	.07	.06	.00	31.	1.01	22.10	266	.02	.02	.00	10.
1.01	10.15	123	.07	.06	.00	31.	1.01	22.15	267	.02	.02	.00	10.
1.01	10.20	124	.07	.06	.00	31.	1.01	22.20	268	.02	.02	.00	10.
1.01	10.25	125	.07	.06	.00	31.	1.01	22.25	269	.02	.02	.00	10.
1.01	10.30	126	.07	.06	.00	31.	1.01	22.30	270	.02	.02	.00	10.
1.01	10.35	127	.07	.06	.00	32.	1.01	22.35	271	.02	.02	.00	10.
1.01	10.40	128	.07	.06	.00	32.	1.01	22.40	272	.02	.02	.00	10.
1.01	10.45	129	.07	.06	.00	32.	1.01	22.45	273	.02	.02	.00	10.
1.01	10.50	130	.07	.06	.00	32.	1.01	22.50	274	.02	.02	.00	10.
1.01	10.55	131	.07	.06	.00	32.	1.01	22.55	275	.02	.02	.00	10.
1.01	11.00	132	.07	.06	.00	32.	1.01	23.00	276	.02	.02	.00	10.
1.01	11.05	133	.07	.06	.00	32.	1.01	23.05	277	.02	.02	.00	10.
1.01	11.10	134	.07	.06	.00	32.	1.01	23.10	278	.02	.02	.00	10.
1.01	11.15	135	.07	.06	.00	32.	1.01	23.15	279	.02	.02	.00	10.
1.01	11.20	136	.07	.06	.00	32.	1.01	23.20	280	.02	.02	.00	10.
1.01	11.25	137	.07	.06	.00	32.	1.01	23.25	281	.02	.02	.00	10.
1.01	11.30	138	.07	.05	.00	32.	1.01	23.30	282	.02	.02	.00	10.
1.01	11.35	139	.07	.06	.00	32.	1.01	23.35	283	.02	.02	.00	10.
1.01	11.40	140	.07	.06	.00	32.	1.01	23.40	284	.02	.02	.00	10.
1.01	11.45	141	.07	.06	.00	32.	1.01	23.45	285	.02	.02	.00	10.
1.01	11.50	142	.07	.06	.00	32.	1.01	23.50	286	.02	.02	.00	10.
1.01	11.55	143	.07	.06	.00	32.	1.01	23.55	287	.02	.02	.00	10.
1.01	12.00	144	.07	.06	.00	32.	1.02	.00	288	.02	.02	.00	10.
									SUM	32.50	31.06	1.44	15590.
										(825.)(	789.)(	37.)(	441.46)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1022.	174.	54.	54.	15615.
CMS	29.	5.	2.	2.	442.
INCHES		24.95	31.04	31.04	31.04
MM		633.80	788.37	788.37	788.37
AC-FT		86.	108.	108.	108.
THOUS CU M		107.	133.	133.	133.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	153.	26.	9.	9.	2342.
CMS	4.	1.	0.	0.	66.
INCHES		3.74	4.66	4.66	4.66
MM		95.07	118.26	118.26	118.26

CFS	153.	26.	8.	8.	2342.
CMS	4.	1.	0.	0.	66.
INCHES		3.74	4.66	4.66	4.66
MM		95.07	118.26	118.26	118.26

AC-FT		13.	16.	16.	16.
THOUS CU M		16.	20.	20.	20.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 2

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	204.	35.	11.	11.	3123.
CMS	6.	1.	0.	0.	88.
INCHES		4.99	6.21	6.21	6.21
MM		126.76	157.67	157.67	157.67
AC-FT		17.	22.	22.	22.
THOUS CU M		21.	27.	27.	27.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 3

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	255.	44.	14.	14.	3904.
CMS	7.	1.	0.	0.	111.
INCHES		6.24	7.76	7.76	7.76
MM		158.45	197.09	197.09	197.09
AC-FT		22.	27.	27.	27.
THOUS CU M		27.	33.	33.	33.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 4

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	306.	52.	16.	16.	4685.
CMS	9.	1.	0.	0.	133.
INCHES		7.49	9.31	9.31	9.31
MM		190.14	236.51	236.51	236.51
AC-FT		26.	32.	32.	32.
THOUS CU M		32.	40.	40.	40.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 5

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	358.	61.	19.	19.	5465.
CMS	10.	2.	1.	1.	155.
INCHES		8.73	10.86	10.86	10.86
MM		221.83	275.93	275.93	275.93
AC-FT		30.	38.	38.	38.
THOUS CU M		37.	46.	46.	46.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 6

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 6

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	469.	70.	22.	22.	6246.
CMS	12.	2.	1.	1.	177.
INCHES		9.98	12.42	12.42	12.42
MM		253.52	315.35	315.35	315.35
AC-FT		35.	43.	43.	43.
THOUS CU M		43.	53.	53.	53.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 7

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	469.	78.	24.	24.	7027.
CMS	13.	2.	1.	1.	199.
INCHES		11.23	13.97	13.97	13.97
MM		285.21	354.77	354.77	354.77
AC-FT		39.	48.	48.	48.
THOUS CU M		48.	60.	60.	60.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 8

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	511.	87.	27.	27.	7808.
CMS	14.	2.	1.	1.	221.
INCHES		12.48	15.52	15.52	15.52
MM		316.90	394.18	394.18	394.18
AC-FT		43.	54.	54.	54.
THOUS CU M		53.	66.	66.	66.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 9

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1022.	174.	54.	54.	15615.
CMS	29.	5.	2.	2.	442.
INCHES		24.95	31.04	31.04	31.04
MM		633.80	788.37	788.37	788.37
AC-FT		86.	108.	108.	108.
THOUS CU M		107.	133.	133.	133.

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HYDROGRAPH ROUTING

ROUTE THROUGH SPILLWAY

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

ROUTING DATA

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

ROUTING DATA

BLACK & VEATCH PROJECT 9166. DATE 6 AUG 80 PAGE 26

FLOOD HYDROGRAPH PACKAGE - HEC-1 PROGRAM H21/02-0U TIME 13:06:52 CASE 100

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
.0	.000	.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	.000	.000	.000	-656.	0

SURFACE AREA=	0.	3.	3.	7.
CAPACITY=	0.	25.	39.	139.
ELEVATION=	629.	655.	660.	680.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
655.8	.0	.0	.0	.0	.0	.0	.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
657.6	.0	.0	0.

CREST LENGTH AT OR BELOW	0.	8.	22.	56.	190.	244.	279.	322.	354.	391.
ELEVATION	655.8	656.2	657.6	657.9	658.2	658.8	659.2	659.6	659.8	660.0

STATION 2, 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.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	[illegible]	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	4.	4.	4.	4.	4.	4.
4.	4.	4.	4.	4.	5.	5.	6.	6.	7.
7.	8.	8.	9.	9.	10.	10.	11.	11.	12.
12.	13.	13.	14.	14.	15.	15.	15.	16.	16.
17.	17.	18.	19.	19.	20.	20.	20.	21.	21.
21.	21.	21.	22.	24.	29.	41.	56.	64.	64.
61.	57.	52.	48.	44.	41.	38.	36.	34.	33.
32.	30.	29.	24.	26.	27.	26.	25.	24.	23.
23.	22.	22.	21.	21.	21.	20.	19.	17.	16.
15.	13.	12.	12.	11.	10.	10.	9.	9.	8.
8.	7.	7.	7.	6.	5.	6.	6.	5.	5.
5.	5.	5.	4.	4.	4.	4.	4.	4.	4.
4.	4.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	2.	2.	2.	2.	2.	2.	2.	2.	2.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

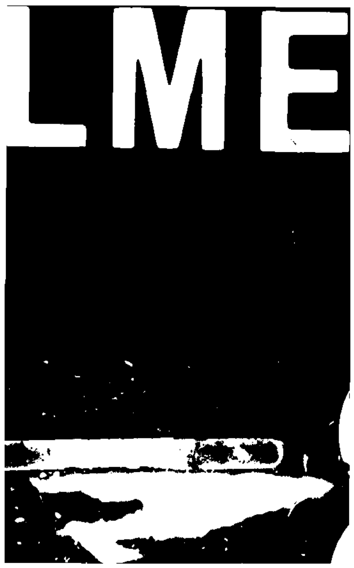
				RATIOS APPLIED TO FLOWS								
OPERATION	STATION	AREA	PLAN	RATIO 1 .15	RATIO 2 .20	RATIO 3 .25	RATIO 4 .30	RATIO 5 .35	RATIO 6 .40	RATIO 7 .45	RATIO 8 .50	RATIO 9 1.00
HYDROGRAPH AT	1	.07	1	153.	204.	255.	306.	358.	409.	460.	511.	1022.
	(	.17)	(	4.34)(	5.79)(	7.23)(	8.68)(	10.13)(	11.57)(	13.02)(	14.46)(	28.93)
ROUTED TO	2	.07	1	64.	95.	139.	193.	254.	326.	390.	447.	944.
	(	.17)	(	1.82)(	2.70)(	3.94)(	5.48)(	7.18)(	9.24)(	11.05)(	12.66)(	26.74)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	655.80	655.80	657.60
STORAGE	26.	26.	31.
OUTFLOW	0.	0.	77.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.15	657.46	.00	31.	64.	.00	15.83	.00
.20	657.77	.17	32.	95.	.42	15.75	.00
.25	656.02	.42	32.	139.	.58	15.75	.00
.30	658.18	.58	33.	193.	.67	15.75	.00
.35	658.30	.70	33.	256.	.83	15.67	.00
.40	655.42	.82	34.	326.	1.00	15.67	.00
.45	658.51	.91	34.	390.	1.25	15.67	.00
.50	658.58	.98	34.	447.	1.75	15.67	.00
1.00	659.08	1.48	36.	944.	5.67	15.67	.00


LME