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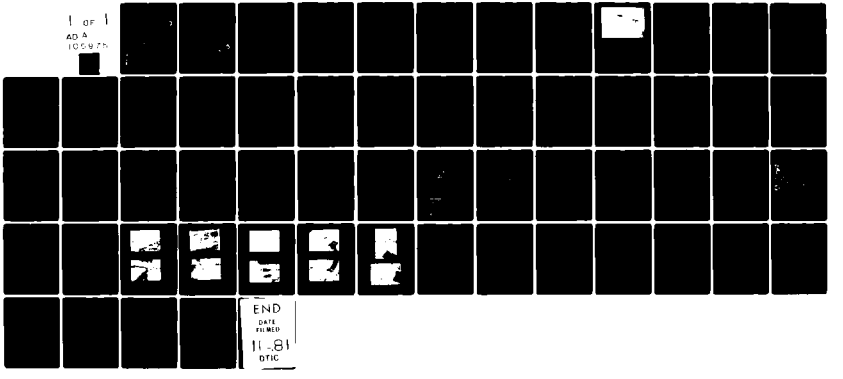

LEVEL II

MISSISSIPPI-KASKASKIA-ST. LOUIS BASIN

WALNUT HOLLOW LAKE DAM
IRON COUNTY, MISSOURI
MO 30619

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

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

JANUARY 1981

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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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WALNUT HOLLOW LAKE DAM

Iron County, Missouri

Missouri Inventory No. 30619

Phase I Inspection Report

National Dam Safety Program

Prepared by

Woodward-Clyde Consultants

Chicago, Illinois

Under Direction of

St Louis District, Corps of Engineers

for

Governor of Missouri

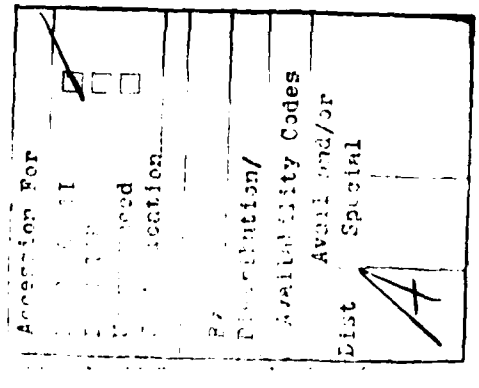
January 1981

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.



DRAFT
PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Walnut Hollow Lake Dam
State Located	Missouri
County Located	Iron
Stream	Unnamed Tributary of Big Creek
Date of Inspection	11 November 1980

Walnut Hollow Lake Dam, Missouri Inventory Number 30619, was inspected by Richard Berggreen (engineering geologist), Leonard Krazynski (geotechnical engineer), and Sean Tseng (hydrologist).

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. These guidelines are intended to provide for an expeditious identification, based on available data and a visual inspection, of those dams which may pose hazards to human life or property. In view of the limited nature of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District (SLD), Corps of Engineers has classified this dam as having a high hazard potential. The SLD estimated damage zone length extends approximately two miles downstream of the dam. Several occupied dwellings, assorted out-buildings, and Missouri Highway 40 are located in this damage zone. The contents of the damage zone were verified by aerial reconnaissance. The loss of life and property could be significant in the event of overtopping and sudden failure of the dam.

The dam is classified as small, based on its 35 ft height and storage capacity of 87 ac-ft. The small dam classification includes dams 25 to 40 ft in height, or having storage capacities of 50 to 1000 ac-ft.

Our inspection and evaluation indicate that the dam embankment is in generally good condition. No evidence of significant erosion, sliding, cracking, slope deformation or excessive settlement was noted on this dam. No animal burrows were noted.

Seepage and stability analyses comparable to the guidelines are not on record which is considered a deficiency.

Inadequate spillway capacity is the item of primary concern for this facility. Hydraulic/hydrologic analyses indicate the 1 percent probability-of-occurrence event (100 year flood) will be passed without overtopping the dam. The 1 percent probability-of-occurrence event is defined as the flood that has 1 percent chance of occurring in any one year, or occurs on the average of once every 100 years. These analyses also indicate any storm greater than 30 percent of the Probable Maximum Flood (PMF) will overtop the embankment. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Based on the apparent elevation of the occupied dwellings in the hazard zone below this dam, it is recommended that 100 percent of the PMF be considered as the spillway design flood.

It is recommended the following remedial measures be implemented and additional studies be made for the facilities at Walnut Hollow Lake Dam:

1. Design and construct appropriate spillway facilities to enable the dam to pass 100 percent of the PMF without overtopping the embankment. The spillway system should be protected from erosion.

2. Seepage and stability analyses comparable to the requirement for the "Recommended Guidelines for Safety Inspection of Dams" should be performed.

3. A trash rack should be constructed at the inlet to the main spillway (18-in. diameter corrugated pipe).

4. An evaluation should be made of the feasibility of implementing a practical and effective warning system to alert the downstream residents, should potentially hazardous conditions develop at the dam during periods of heavy precipitation.

The owner should take action on these recommendations without undue delay.

As soon as practical, it is recommended that a program of periodic inspections be implemented to:

1. Inspect seepage areas to identify increases in volume of seepage water or turbidity (soil) in the seepage water;

2. Inspect slopes for evidence of instability such as cracks or slumping;

3. Inspect the trash rack at the inlet of the main spillway to detect any conditions that might lead to spillway blockage.

Records should be kept of all inspections and any required maintenance. All remedial measures should be performed under the guidance of an engineer experienced in the design and construction of earth dams.

WOODWARD-CLYDE CONSULTANTS

Richard Berggreen
Registered Geologist

Leonard M. Krazynski, P.E.
Vice President

OVERVIEW
WALNUT HOLLOW LAKE DAM

MISSOURI INVENTORY NUMBER 30619

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
WALNUT HOLLOW LAKE DAM, MISSOURI INVENTORY NO. 30619

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
WALNUT HOLLOW LAKE DAM, MISSOURI INVENTORY NO. 30619

SECTION 1
PROJECT INFORMATION

1.1 General

a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of the Walnut Hollow Lake Dam, Missouri Inventory Number 30619.

b. **Purpose of Inspection.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted" (Chapter 3, "Recommended Guidelines for Safety Inspection of Dams").

c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams," Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams," developed by the Office of Chief of Engineers, Department of the Army, and "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams," prepared by the St Louis District (SLD), Corps of Engineers. 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.** Walnut Hollow Lake Dam is an earth dam impounding a lake used for recreational purposes. The dam was constructed in an arc, convex in a downstream direction, and crosses two small drainages separated by a small hill. The result is a rise in the elevation of the base of the dam near the center of the embankment (Fig 3-A; and Fig A-1, Appendix A).

There are two spillways at this dam, both located near the right abutment (as the observer faces downstream). The lower elevation spillway, hereafter termed the main spillway, consists of an uncontrolled culvert drop structure and outlet pipe constructed of 18-in. diameter corrugated galvanized pipe through the right end of the embankment. The top of the inlet end of the pipe is at elevation 773.9 ft (MSL). The higher elevation spillway is an uncontrolled notch cut into the hillside beyond the right end of the dam. This spillway carries a road from the lake to the downhill side of the dam, and the roadway acts as the spillway weir and downstream channel. The low elevation on the embankment crest is 775.8 ft (MSL), while the low point in the spillway is at elevation 774.8 (MSL).

There is a low-level outlet at the base of the right half of the dam. The outlet consists of a 6-in. diameter welded steel pipe. It is controlled by a hand-operated wheel at the downstream end of the pipe. This control wheel could not be operated during the field inspection.

b. **Location.** The dam is located on an unnamed tributary of Big Creek, approximately two miles northeast of Annapolis in Iron County, Missouri (Fig 1). The dam is in Section 12, T31N, R3E, on the USGS Glover, Missouri (1968) 7.5-minute quadrangle map. The area is called Walnut Hollow by the local residents, according to Mr Ed Glick, caretaker of the dam and adjacent property.

c. **Size classification.** The dam is classified small based on its height of 35 ft and its storage capacity of 87 ac-ft. The small size classification is based on a 25 to 40 ft height or 50 to 1000 ac-ft storage volume.

d. **Hazard classification.** The St Louis District (SLD), Corps of Engineers has classified this dam as having a high hazard potential; we concur with this classification. The SLD estimated damage zone length extends approximately two miles downstream. Aerial reconnaissance of the downstream hazard zone identified several vacation and permanent dwellings and Missouri State Highway 40 in the estimated damage zone (Photo 1).

e. **Ownership.** The dam is reportedly owned by the Education Employees Credit Union, 10326 Old Olive Road, St Louis, Missouri, 63141. Correspondence should be sent to the attention of Mr Ed Glick, caretaker for the facility.

f. **Purpose of dam.** The reservoir impounded by the dam is used for recreational purposes.

g. **Design and construction history.** No design or construction reports were found for this dam. Information was obtained from Mr Glick, caretaker for the property. Mr Glick reported the dam was built about 5 years ago (1974 - 1975) by Buxton Brothers of Ellington, Missouri. We were unable to contact Buxton Brothers to ask for design specifications or construction reports.

Mr Glick reported the dam was keyed to bedrock, the trench being about one dozer blade wide. The reservoir area covers two small drainages formerly separated by a small hill. The hill within the area of the present reservoir was used as borrow to construct the dam embankment. A portion of the hill projects through the dam alignment, partially separating the dam embankment into two halves (Fig 3-A; and Fig A-1, Appendix A).

h. **Normal operating procedures.** No operating records or procedures were found for this facility. Flood flows pass through the uncontrolled culvert spillway or over the uncontrolled auxiliary spillway.

1.3 Pertinent Data

a. **Drainage area.** 0.06 mi^2

b. **Discharge at damsite.**

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	N/A (not applicable)
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	80 ft^3/sec
Total spillway capacity at maximum pool elevation	80 ft^3/sec

c. **Elevations (ft above MSL).**

Top of dam	775.8
Maximum pool - design surcharge	N/A
Full flood control pool	N/A
Recreation pool	773.9
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Maximum tailwater	Unknown
Toe of dam at maximum section	741.7

d. **Reservoir.**

Length of maximum pool	Approximately 650 ft
Length of recreation pool	Approximately 600 ft
Length of flood control pool	N/A

e. **Storage (acre-feet).**

Recreation pool	74
Flood control pool	N/A
Design surcharge	N/A
Top of dam	87

f. **Reservoir surface (acres).**

Top of dam	7.1
Maximum pool	7.1
Flood control pool	N/A
Recreation pool	6.7
Spillway crest	6.7

g. **Dam.**

Type	Compacted stoney soil
Length	625 ft
Height	35 ft
Top width	15 ft (typical)
Side slopes	Upstream unknown; Downstream 2(H) to 1(V)
Zoning	Unknown, probably homogeneous embankment
Impervious core	Unknown, probably homogeneous embankment
Cutoff	Dozer cut trench to bedrock (information from Mr Glick)
Grout curtain	Unknown, probably none

h. **Diversion and regulating tunnel.**

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating facilities	N/A

i. **Spillway.**

	Main	Auxiliary
Type	Uncontrolled 18-in. diameter corrugated, galvanized pipe with vertical	Uncontrolled, unlined, trapezoidal notch at right abutment.

	drop pipe to horizontal discharge pipe, through embankment near right abutment.	
Length of weir	N/A	100 ft
Crest elevation	773.9 ft (MSL)	774.9 ft (MSL)
Gates	None	None
Downstream channel	Broad swale through trees beyond toe of dam.	Along gravel road running from lake across spillway and down broad hillside which forms right abutment.

j. **Regulating outlets.** 6" diameter welded steel pipe. Valve could not be operated at time of inspection.

SECTION 2
ENGINEERING DATA

2.1 Design

No design drawings or reports have been found for the dam or the appurtenant structures.

2.2 Construction

No construction reports were available for this facility. Mr Glick who was on site when the dam was built reported the dam was constructed about 5 years ago (1974 or 1975) by Buxton Brothers of Ellington, Missouri. We were unable to contact Buxton Brothers to determine if design documents or construction records are on file.

Mr Glick reported the dam was constructed of stoney soil borrowed from the small hill that formerly occupied the center of the reservoir area. A cutoff trench was made to shallow bedrock, and was about one dozer blade wide. The embankment fill was compacted with the traffic of the construction equipment.

No other records of construction were available.

2.3 Operation

The only structure requiring operation at this facility is the low-level outlet at the toe of the right half of the dam. No records were available that indicated the outlet had been operated since installation. This outlet is controlled by a hand-operated wheel at the downstream end of the outlet. An attempt was made by Mr Glick to operate this control wheel during the visual inspection, but it could not be moved. It is considered inoperative in its present condition.

2.4 Evaluation

a. **Availability.** Information on the design and construction was limited to that obtained through interviews with Mr Ed Glick, property caretaker.

b. **Adequacy.** The available information on design and construction is insufficient to evaluate the design of the Walnut Hollow Lake Dam.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" are not on record. This is a deficiency which should be rectified. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be made by a professional engineer experienced in the design and construction of earth dams.

c. **Validity.** The information obtained from Mr Glick appears valid and does not disagree with findings of the visual inspection. However, the information was quite incomplete.

2.5 Project Geology

The dam is located on the south flank of the Ozark structural dome. The regional dip is to the south, although significant local dip variations occur around buried and exposed Precambrian basement highlands. One such highland is immediately east of the dam, probably influencing the dip of the formations to the west.

The bedrock formations in the vicinity of the dam site are mapped on the Geologic Map of Missouri (1979) as Cambrian age Potosi Formation and Elvins Group (Fig 4). The area is on or very near the contact between these two units. The Potosi Formation is a medium- to fine-grained, light gray dolomite, which typically contains an abundance of quartz druse characteristic of chert-bearing formations. The underlying unit, the Elvins Group, consists of interbedded silty glauconite shale and thin-bedded dolomite. The bedrock at the damsite is deeply weathered and the actual bedrock formation cannot be unequivocally determined from the visual inspection.

The soil at the site is a light tan to reddish brown very rocky to silty clay (CL), apparently a residual soil developed on the dolomite bedrock formations. The stoney fraction includes chert and quartz druse, probably derived from the Potosi Formation, some dolomite fragments, and volcanic rock fragments, probably derived from the adjacent Precambrian highland to the east. This soil and weathered rock appears to be the material used in the dam construction. The soil is mapped on the General Soils Map of Missouri (1979) as Captina-Clarksville-Doniphan Soil Association.

Several bedrock faults have been mapped in this part of the Ozarks. The nearest fault to the site is the Black Fault, approximately 22 mi long, trending northwest-southeast. The southeast end of the fault is about 7 mi northwest of the site. The fault is mapped on the Geologic Map of Missouri as having variable displacement along its length, but is labeled on the Structural Features Map of Missouri (1971) as northeast side up.

The Grenville Fault is located about 21 mi southeast of the site. It has a mapped length of 43 mi, trends northeast-southwest, and is mapped as northwest side up. These faults, like most others in the Ozark region, are not considered to be seismically active, and are not considered to pose a significant hazard to the dam.

The dam is located about 76 miles northeast of the line of epicenters for the very large New Madrid earthquakes which occurred in 1811 and 1812. A recurrence of an earthquake of the magnitude of the New Madrid events could possibly cause damage at the dam, but a study of this aspect of risk was beyond the scope of this Phase I investigation.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** A field inspection was made of the Walnut Hollow Lake Dam on 11 November, 1980. Mr Ed Glick, caretaker for the property, accompanied the inspection team throughout the inspection. The inspection indicated the dam embankment is in generally good condition; however, the spillways are substantially inadequate for the potential flood conditions at the site.

b. **Dam.** The dam is constructed of a gravelly, silty clay soil, with some angular gravel (quartz druse). The soil is a tan to red-brown, moderately plastic residual clay (CL). The dam has a moderate to low erosion potential due to its good cohesion and vegetative cover. The upstream face has had the fine soil particles washed out by wave action, leaving the gravel-sized portion (Photo 2).

The dam crest did not exhibit any lateral spreading, deformation, or excessive vertical settling (Photo 2 and Overview). No evidence of any sinkhole development or animal burrows was observed during the inspection.

The downstream face was vegetated with some berry bushes and a sparse cover of grass. The slopes did not appear to have undergone any movement. Some irregularities and bumps observed on the slopes are probably due to the construction methods and not due to slope movement.

Slow seepage was observed in several locations along the toe of both high portions of the dam embankment (Fig A-1 and Photos 9 and 10). The seepage was slow and was estimated at about 1 to 2 gpm in each location with the total flow of about 10 gpm. Substantial algae growth was observed at the points of seepage at the time of inspection. Seepage did not appear to be transporting any soil particles. The reservoir surface was about 6 ft below the spillway crest at the time of inspection.

The soil comprising both the upstream and downstream slopes contains a high percentage of gravel and is judged to be only moderately erodible by moving water. There were no signs of significant wave erosion on the upstream slope (Photo 2).

c. **Appurtenant structures.** The main spillway consists of an uncontrolled, 18-in. diameter corrugated galvanized pipe; the configuration is shown in Fig 3-A. The inlet is not protected by a trash rack (Photo 4) and the outlet discharges near the toe of the embankment into a wooded area (Photo 5). There is some evidence of limited prior flow through the main spillway. Both inlet and outlet are located near the right abutment.

The auxiliary spillway is a trapezoidal, unlined notch cut into the native gravelly soil at the right abutment (Photo 6). This spillway is noticably shallow and was surveyed to be only 0.6 ft below the adjacent compacted embankment (Fig 3-B). There is no evidence of any prior flow over the auxiliary spillway.

There is a low-level outlet located near the center of the right portion of the earth embankment. It consists of a 6-in. diameter welded steel pipe with a valve on the downstream end. The valve was inoperative at the time of our inspection (Photos 7 and 8).

d. **Reservoir area.** The slopes surrounding the reservoir are heavily vegetated, with grasses and trees (see Overview Photo). The slopes are approximately 3(H) to 1(V) or flatter. No evidence of instability was noted during the visual inspection. The beach face of the reservoir has been only slightly eroded by wave action. There have been no major changes in the drainage basin, such as road or building construction, that would increase sedimentation in the reservoir. Sedimentation records were not available, but indications are that the siltation of the reservoir is slight.

e. **Downstream channel.** The discharge channels for both spillways traverse a wooded area for about 200 ft. The flow will then enter a broad valley clear of vegetation other than grass. No erosion or need for maintenance has been noted, and there was very little evidence of substantial spillway flow in the

five-year history of this dam. Potential obstruction to flow due to fallen trees does not seem to be a concern in this case, as a very wide area is available for the flow and flood waters have ample opportunity to find an unobstructed route away from the dam embankment.

3.2 Evaluation

Our visual inspection and evaluation identified only one significant item of concern, specifically the inadequate capacity of the spillways. This item will be further addressed in Section 5.

The dam embankment appeared stable and was apparently constructed of good materials with a high percentage of gravel. The slopes did not exhibit any signs of detectable deformation and were relatively free of significant erosion.

Two additional items which require future attention are: construction of a trash rack at the intake into the main pipe spillway and the continued monitoring of the seepage areas.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

No formal operating procedures were found for this facility. Water level in the reservoir is controlled by two ungated spillways. Normal operating procedure is to allow natural drainage through the spillways. The valve for the 6-in. diameter outlet was inoperative at the time of inspection.

4.2 Maintenance of Dam

No records of maintenance were identified for this dam. The only identifiable maintenance performed on the dam was the cutting of grass on the dam crest.

4.3 Maintenance of Operating Facilities

No records of maintenance on the 6-in. diameter outlet pipe were found. The valve for the outlet was inoperative at the time of our inspection.

4.4 Description of Any Warning System in Effect

A warning system was not identified in the inspection.

4.5 Evaluation

There is no formal maintenance program in effect for this dam. Some of the small trees should be removed from the downstream slope before they become well established. The spillway and spillway discharge channel will probably require future maintenance after appropriate redesign and enlargement. The development of a maintenance program and an evaluation of a practical and effective warning system are recommended for this facility.

SECTION 5
HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. **Design data.** No hydrologic or hydraulic design data were available for evaluation of this dam or reservoir; however, dimensions and elevations of the dam and appurtenant structures were field surveyed 12 December, 1980 or measured during the field inspection. Other relevant data were measured during the visual inspection or estimated from topographic mapping. The maps used in the analyses were the USGS Glover and Des Arc, Missouri 7.5-minute quadrangle maps (1968).

b. **Experience data.** No recorded rainfall, runoff, discharge or pool stage historical data were found for this reservoir.

c. **Visual inspection.**

1. Watershed. The watershed is natural woodland, forested with mixed hardwoods and softwoods. The area of the reservoir is approximately 17 percent of the total drainage area of 0.06 mi^2.

2. Reservoir. The reservoir and dam are best described by the maps and photographs enclosed herewith. The primary use of this impoundment is for recreation.

3. Spillway. The main spillway consists of an uncontrolled, 18-in. diameter corrugated pipe with an entrance at elevation 773.9. The auxiliary spillway is a trapezoidal, unlined notch cut into the native gravelly soil at the right abutment. The auxiliary spillway crest is at elevation 774.9 and the top of the adjacent compacted embankment is at elevation 775.5.

4. Seepage. The magnitude of seepage through this dam is very small and not hydrologically significant to the overtopping potential.

d. **Overtopping potential.** One of the primary considerations in the evaluation of Walnut Hollow Lake Dam is the assessment of the potential for overtopping and possible consequent failure by erosion of the embankment. The lowest portion of the dam considered to be the top of dam for the purpose of determining the overtopping potential was near the ridge near the center of the dam (Fig 3-A). The 18-in. diameter pipe spillway was assumed operating for this evaluation. The 6-in. diameter low-level outlet was assumed to be inoperative for this analysis.

Hydrologic analysis of this dam for the 1 and 10 percent probability-of-occurrence and Probable Maximum Floods (PMF) were all based on initial water surface elevations equal to the main spillway crest elevation. This is supported by the field survey which established that the high water elevation is slightly below that of the spillway crest. The results of the analysis indicate that a flood of greater than 30 percent of the PMF will overtop the dam. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The analysis also indicates that the spillway will pass the 1 percent probability-of-occurrence flood (100-yr flood) without overtopping the dam. The total (combined main and auxiliary) spillway capacity at maximum pool elevation (top of dam) is 80 ft^3/sec.

The following overtopping data for the various precipitation events were computed for the dam:

Precipitation Event	Maximum Reservoir W.S. Elev., ft, (MSL)	Maximum Depth Over Dam, ft	Maximum Outflow, ft^3/sec	Duration Overtopping, hrs
30% PMF	775.9	0	80	0
50% PMF	776.3	0.4	250	2.3
100% PMF	776.6	0.7	600	5.2

Based on the apparent elevation of the occupied dwellings in the downstream hazard zone, it is recommended that 100 percent of the PMF be considered as the spillway design flood.

It should be noted that at 100 percent of the PMF the depth of overtopping will reach 0.7 feet and the dam will be overtopped for 5.2 hours. During this time, significant erosion would very likely take place at the low elevation point in approximately the center of the embankment. With the available data the total effect on the dam's safety cannot be properly evaluated. It is felt, however, overtopping for nearly 5.2 hours could develop into an effective dam breach.

The input data and output summaries for the hydrologic analyses are presented in Appendix B.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual observations.** The visual inspection of Walnut Hollow Lake Dam revealed that the dam embankment is structurally in generally fair condition. There was no evidence of lateral spreading or horizontal displacement of the dam crest. No evidence of sinkholes near the dam or in the surrounding area was noted. No cracking on the dam or in the visible area beyond the dam toe was identified. There were no slumps noted on the downstream slope of the dam. No animal burrows were noted in the embankment.

The slow seepage which was noted in several locations at the toe of the dam did not appear to be transporting soil particles. This seepage should be monitored and the amount of flow and turbidity of the seepage should be checked periodically.

The main spillway, consisting of an 18-in. diameter corrugated galvanized pipe, appears to be in good condition, but has no trash rack at the inlet. The auxiliary spillway is also in good condition at present. It is excavated in gravelly native soil. The erosion potential is judged to be moderate. At the present time the spillway depression is very shallow.

Neither spillway has a well-defined discharge channel, but the areas downstream of both spillways appear adequate for safe passage of the flood flows. Erosion in these areas is not expected to represent a safety hazard to the dam.

b. **Design and construction data.** No design or construction data records were available for this dam. Limited information on the construction of the dam was obtained through Mr Ed Glick, caretaker for the dam, and is recorded in Section 1.2g of this report. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available.

c. **Operating records.** No operating records or water level records are maintained for this facility.

d. **Post construction changes.** There have been no identifiable post construction changes on this dam since its construction approximately five years ago.

e. **Seismic stability.** The dam is in Seismic Zone 2, to which the guidelines assign a moderate seismic damage potential. During a seismic event, liquefaction of the gravelly, silty clay dam material is unlikely. However, without knowledge of the soil properties of the embankment materials the seismic stability of the dam cannot be evaluated.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on the visual inspection, the dam embankment appears to be in generally fair condition. Seepage and stability analyses comparable to the requirements in the guidelines are not on record, which is a deficiency. Inadequate spillway capacity is the item of primary concern for this facility. The hydraulic/hydrologic analyses of the spillway, dam, and the reservoir storage indicate that the dam will pass only 30 percent of the PMF without overtopping. The apparent elevation of the occupied dwellings in the hazard zone below the dam indicates that 100 percent of the PMF should be used as the spillway design flood.

b. **Adequacy of information.** The visual inspection and survey data obtained for this evaluation provided sufficient information to support the recommendations presented in this Phase I investigation. The lack of design documents such as static and seismic stability analyses and seepage analysis comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" precludes an evaluation of the static and seismic stability of the dam. This is a deficiency which should be corrected.

c. **Urgency.** The deficiencies described in this report could affect the safety of the dam. Those remedial measures that should be initiated without undue delay are described in Section 7.2b. The inspection program described in Section 7.2c should be initiated as soon as practical.

d. **Necessity for Phase II.** In accordance with the "Recommended Guidelines for Safety Inspections of Dams," the subject investigation was a minimum study. This study revealed that additional, in-depth investigations are needed to complete the assessment of the safety of the dam. Those investigations which should be performed without undue delay are described in Section 7.2b. It is our understanding from discussions with the SLD that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

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

1. Remove the dam, or breach it to prevent storage of water.

2. Increase the height of dam and/or spillway size to pass the PMF without overtopping the dam.

3. Purchase downstream land that would be adversely impacted by dam failure, and restrict human occupancy.

4. Provide a highly reliable flood warning system (generally does not prevent damage but diminishes chances for loss of life).

b. **Recommendations.** Based on our inspection of the Walnut Hollow Lake Dam, it is recommended that the following actions be taken without undue delay:

1. Prepare a more detailed hydraulic/hydrologic analysis and design a spillway system capable of passing 100 percent of the PMF without overtopping the embankment. The spillway should be protected to prevent erosion.

2. Prepare seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams".

3. Construct a trash rack at the inlet to the main spillway (18-in. diameter corrugated pipe).

4. Investigate the feasibility of a warning system to alert downstream residents should potentially hazardous conditions develop at the dam during periods of heavy precipitation.

All remedial measures should be performed under the guidance of an engineer experienced in the design and construction of earth dams.

c. **O & M procedures.** It is recommended that a program of periodic inspections and maintenance be developed and implemented as soon as practical. This program should identify, as a minimum, evidence of instability such as cracking or deformations on the embankment, and monitor seepage at the toe of the dam. Changes in conditions such as increased seepage volume or turbidity in the seepage water should be evaluated. The recommended trash rack should be inspected to detect any condition that might lead to spillway blockage. Records of the inspections and maintenance should be kept.

All inspections and maintenance should be evaluated and/or performed by an engineer experienced in the design and construction of earth dams.

REFERENCES

Allgood, Ferris P., and Persinger, Ivan, D., 1979, "Missouri General Soil Map and Soil Association Descriptions," US Department of Agriculture, Soil Conservation Service and Missouri Agricultural Experiment Station.

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Hydrologic Engineering Center, US Army Corps of Engineers, 1978, "Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations."

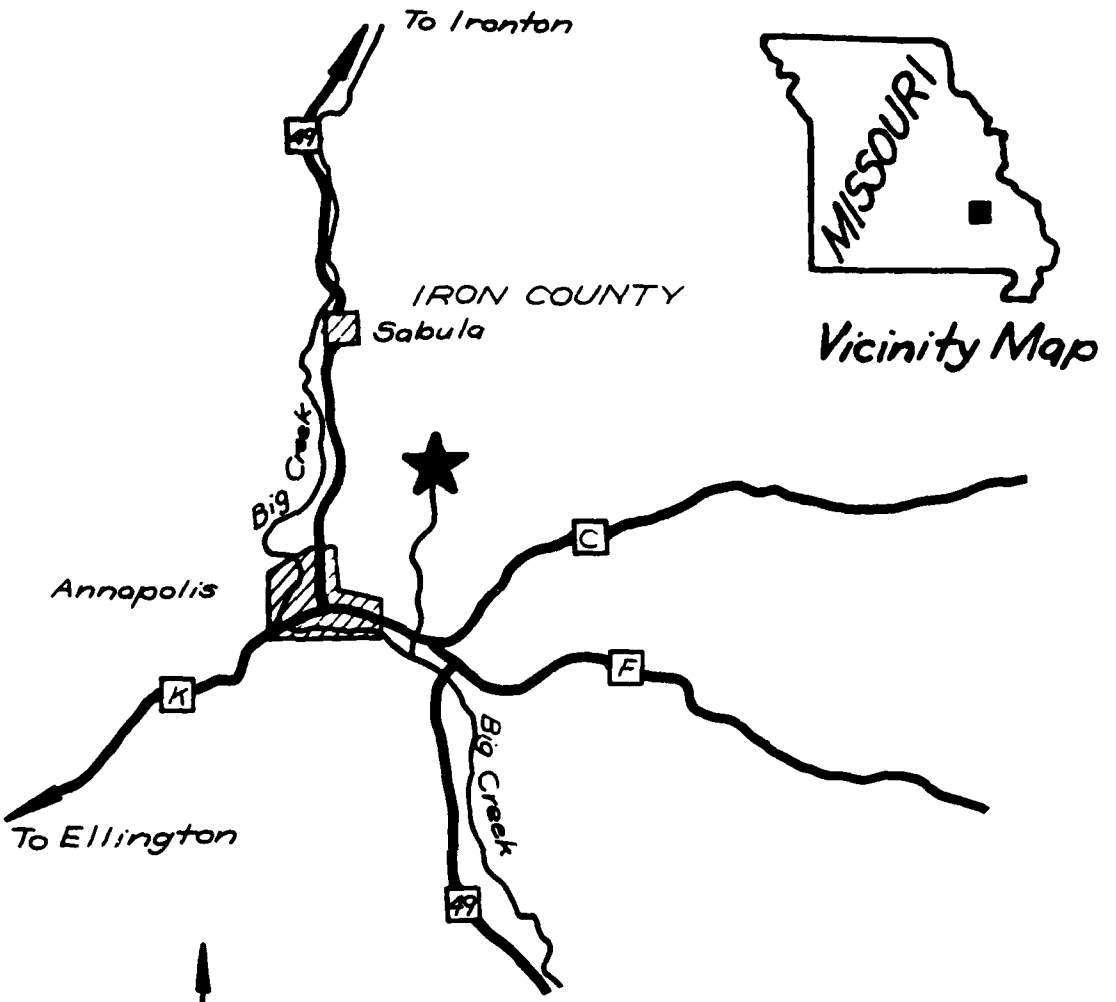
McCracken, Mary H., 1971, Structural Features Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

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

US Department of Commerce, US Weather Bureau, 1956, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours," Hydrometeorological Report No. 33.

US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.



Legend

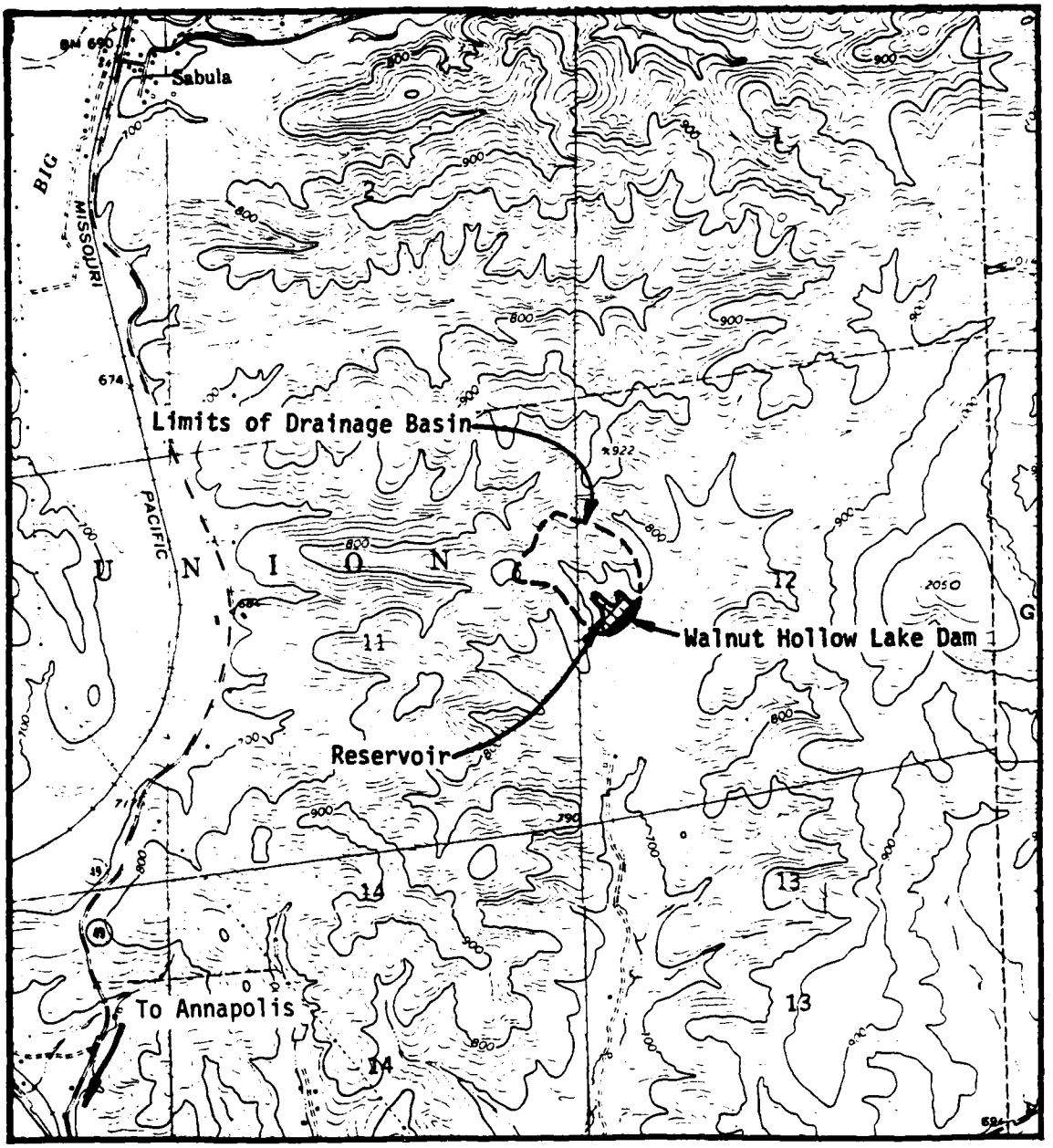
State highway and Route No.

River or Creek

City or Town

Project location

SITE LOCATION MAP	
WALNUT HOLLOW LAKE DAM	
MO 30619	Fig. 1

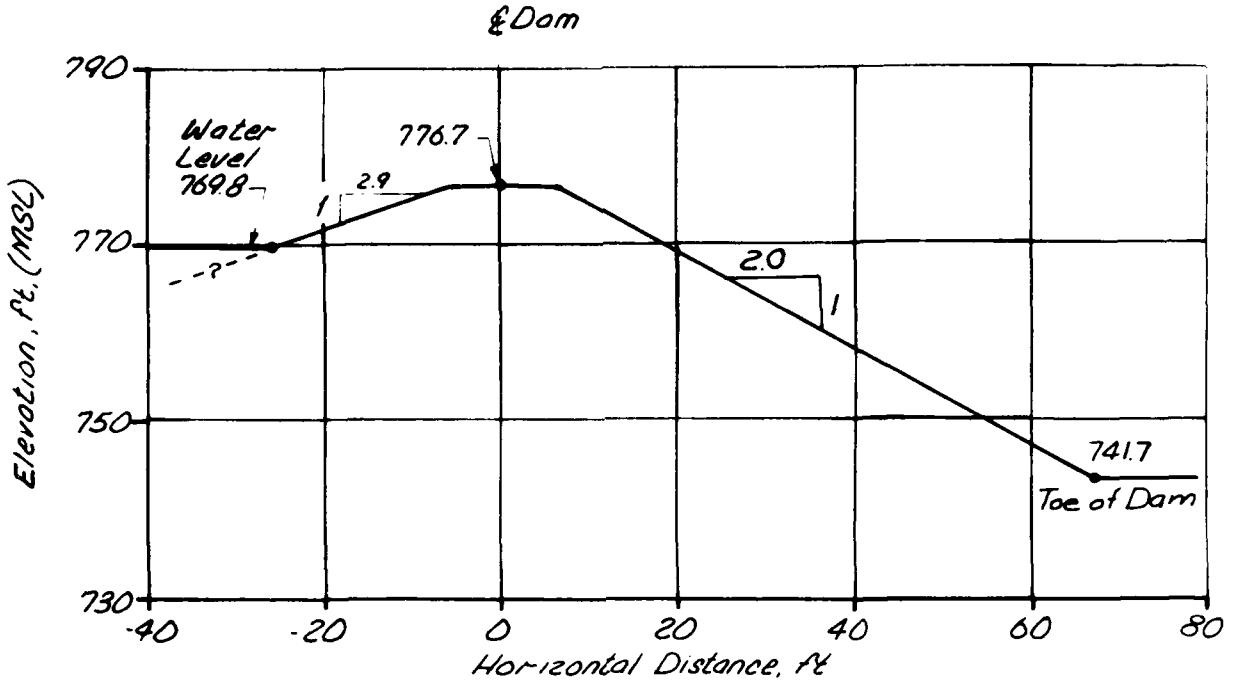


1. Topography from USGS Glover,MO (1968) and Des Arc,MO (1968) 7.5 minute quadrangle maps

DRAINAGE BASIN AND SITE TOPOGRAPHY

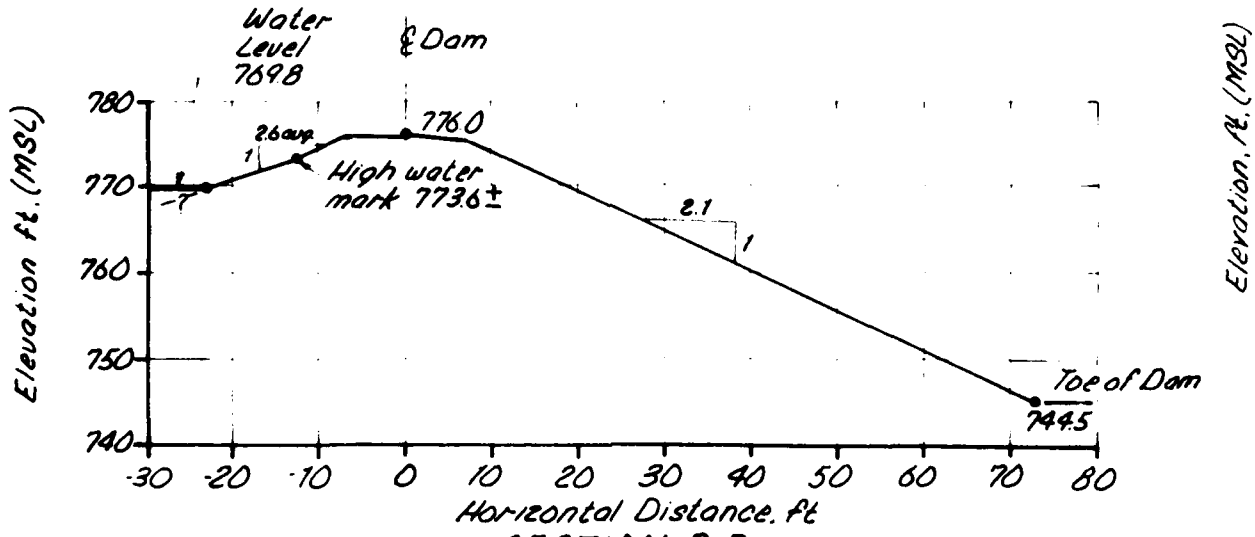
WALNUT HOLLOW LAKE DAM

MO 30619 | Fig. 2



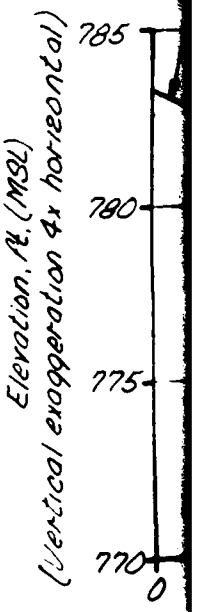
SECTION A-A

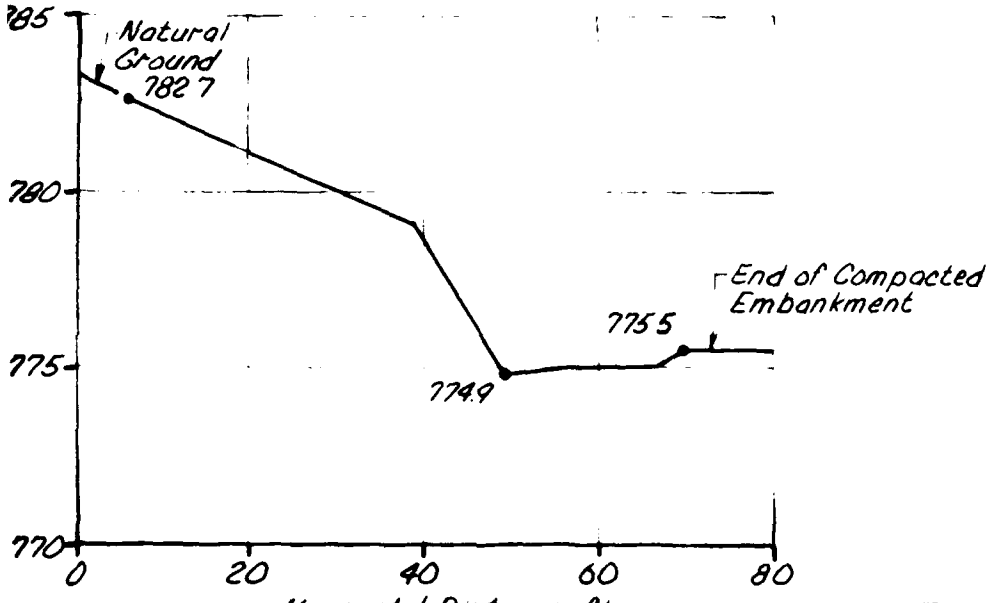
Maximum Dam Section



SECTION B-B

Dam Section

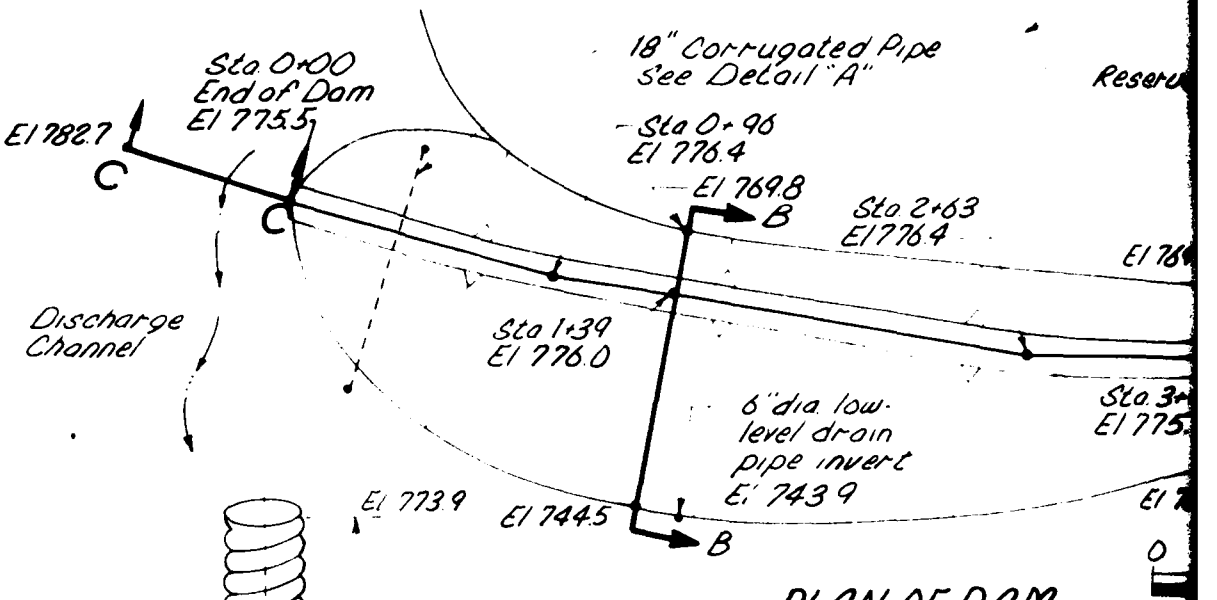




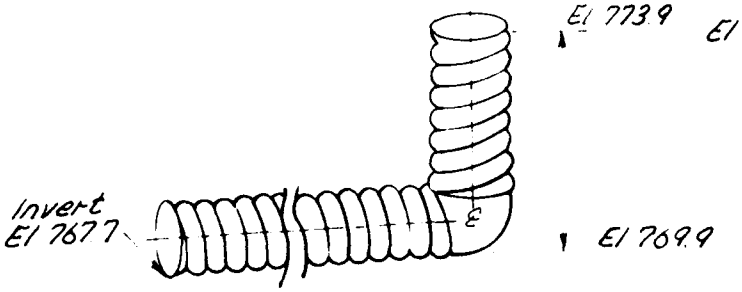
SECTION C-C

Auxiliary Spillway

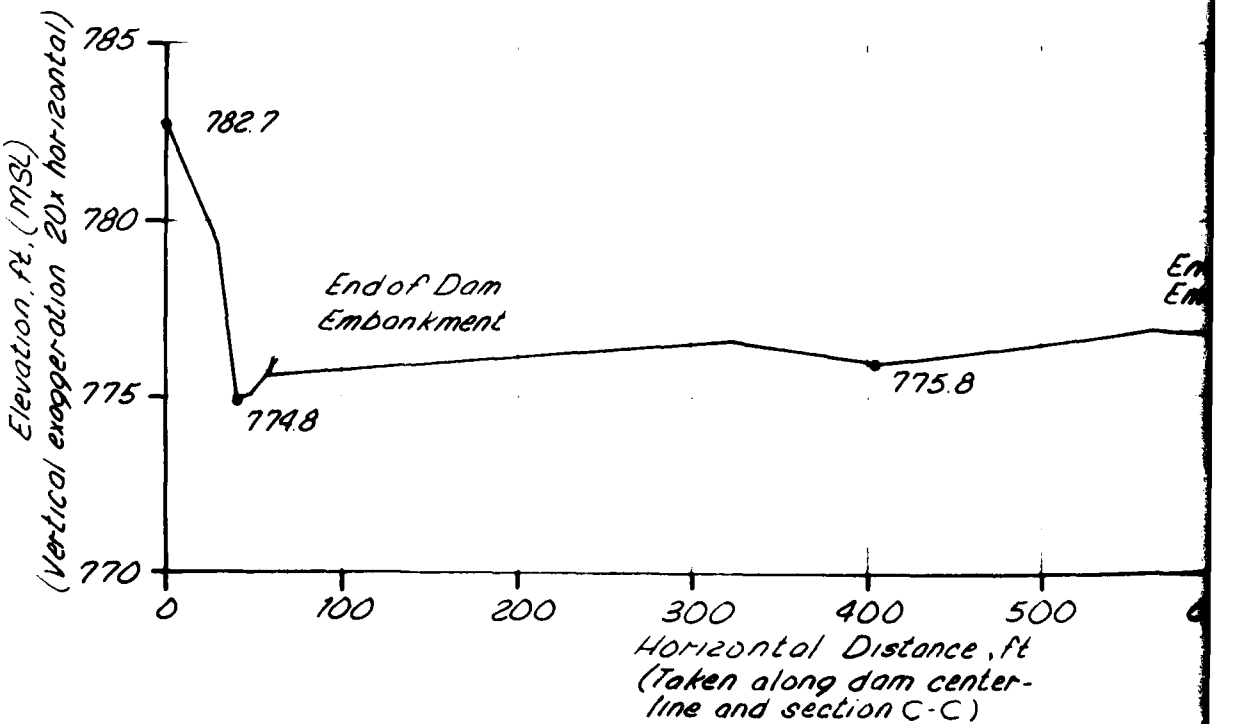
SECTIONS OF DAM AND SPILLWAY	
WALNUT HOLLOW LAKE DAM	
MO 30619	Fig. 3-B



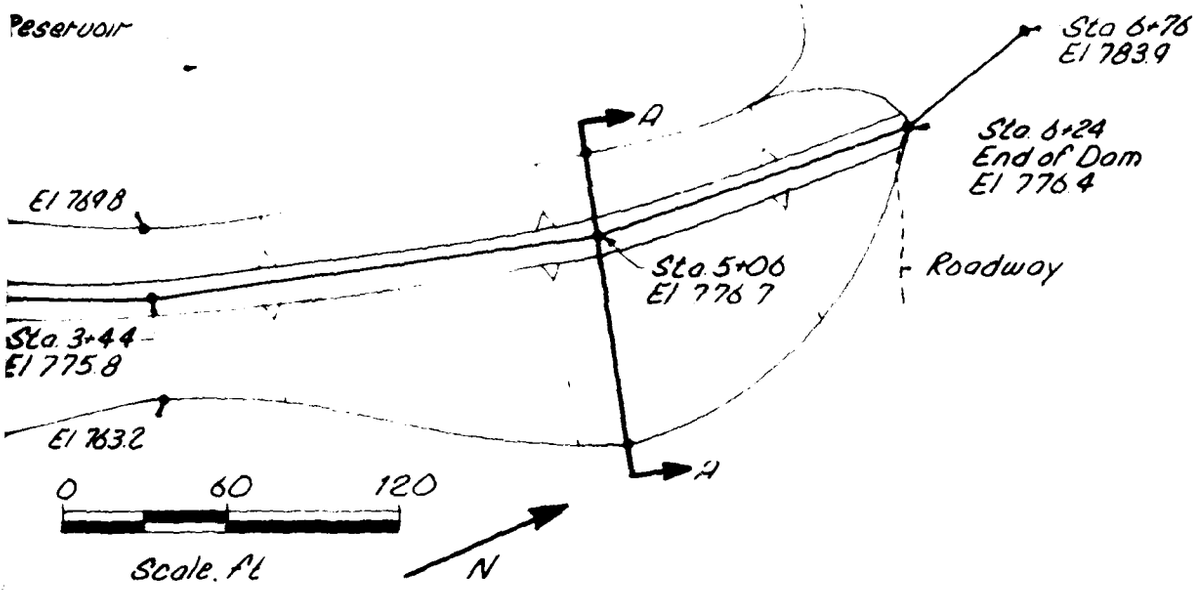
PLAN OF DAM

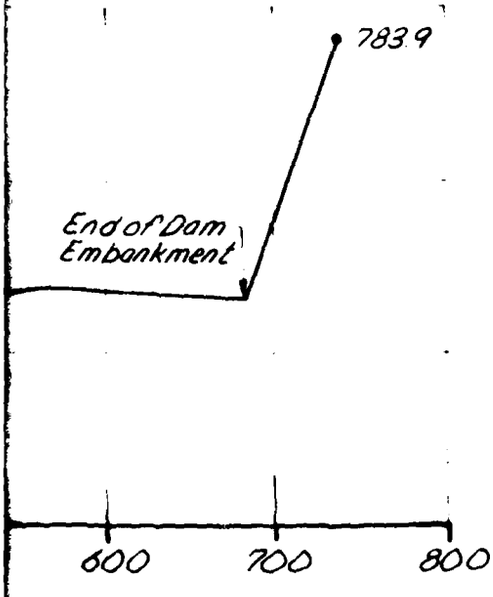


DETAIL "A"
(Not to scale)



DAM CREST PROFILE



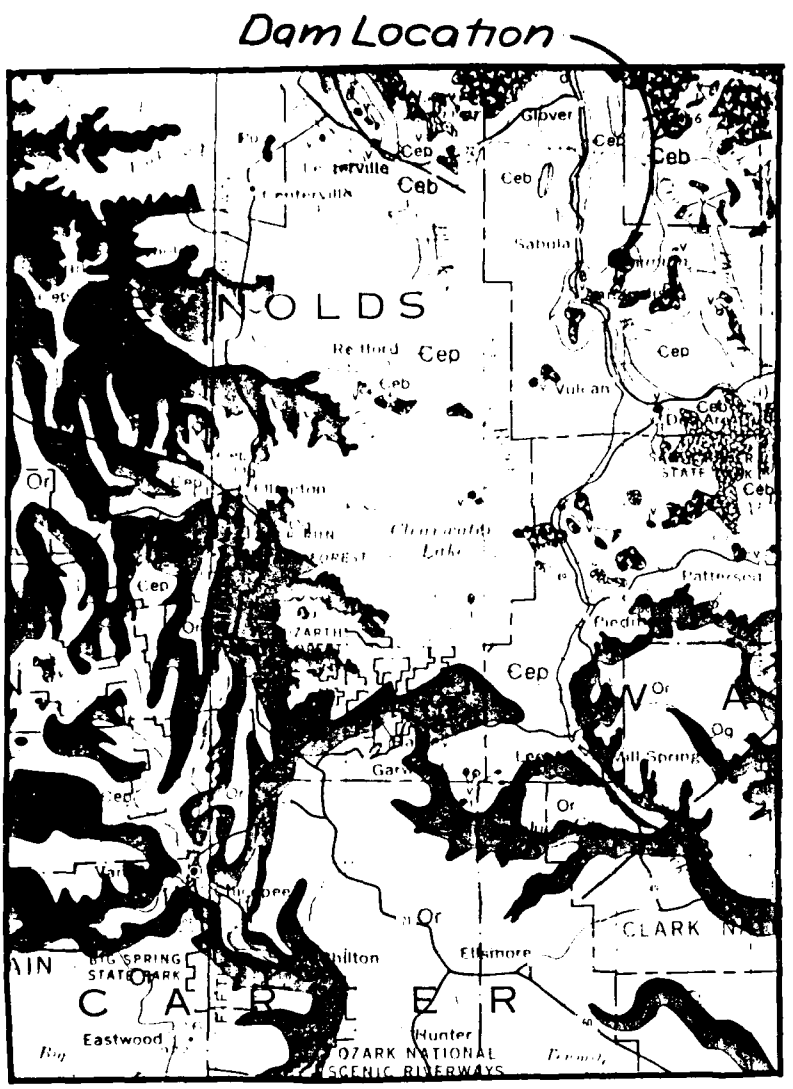


Note

Survey data supplied by James F. McCaul, III and Associates. Consulting Engineers/Land Surveyors Potosi, Mo 63664

PLAN OF DAM AND DAM CREST PROFILE	
WALNUT HOLLOW LAKE DAM	
MO 30619	Fig.3-A

12



Legend

- Or — Roubidoux Formation
- Og — Gasconade Dolomite
  - Gunter Sandstone Member
- Cep — Eminence Dolomite
- Potosi Dolomite
- Derby-Doerun Dolomite
- Ceb — Davis Formation
- Bonneterre Formation
  - Whetstone Creek Member
  - Sullivan Siltstone Member
- Reagan Sandstone (subsurface, western Missouri)
- Lamotte Sandstone
- Diabase (dikes and sills)
- St. Francois Mountains Intrusive Suite
- St. Francois Mountains Volcanic Supergroup

0 10 20

Scale, mile

N

REGIONAL GEOLOGIC MAP

WALNUT HOLLOW LAKE DAM

MO 30619 | Fig. 4

APPENDIX A

Photographs

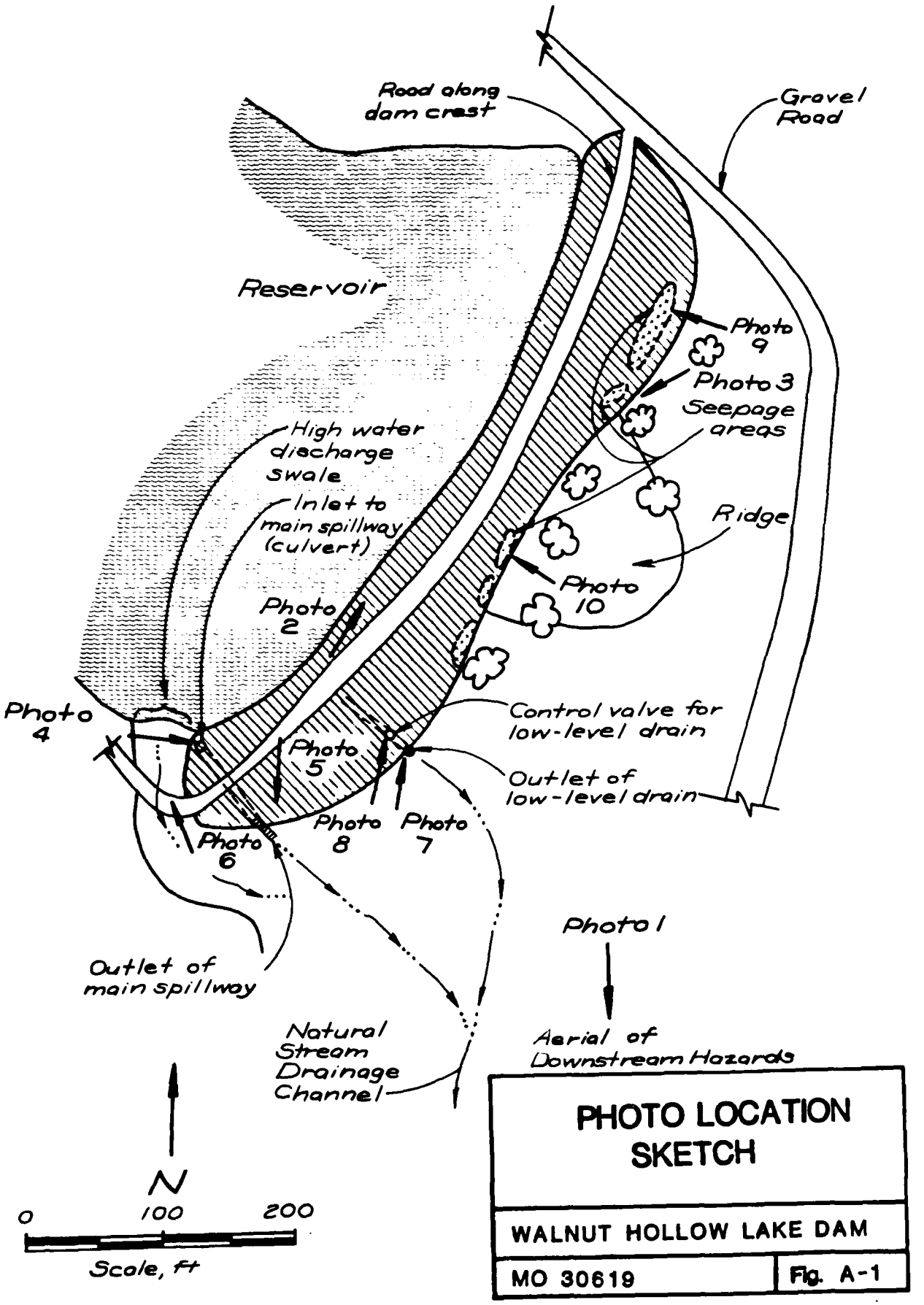


PHOTO LOCATION SKETCH

WALNUT HOLLOW LAKE DAM

MO 30619 | Fig. A-1

1. Hazards downstream of Walnut Hollow Dam.

2. Upstream face of dam. Note gravel that protects against wave erosion. Looking northeast.

3. Downstream face of dam. Looking southwest.

4. Inlet to 18-in. dia culvert which is the main spillway. Looking east.

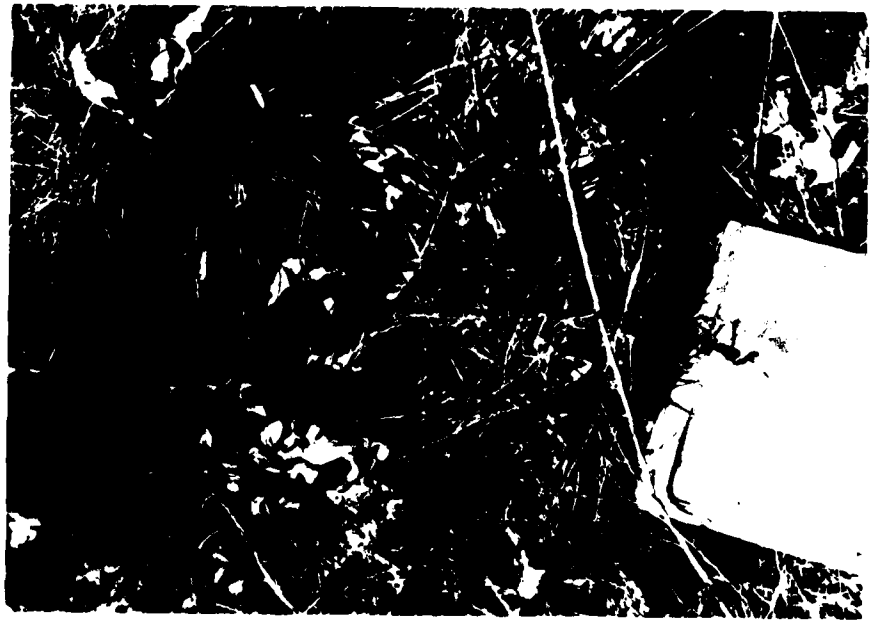
5. Outlet and drainage way of main spillway near right abutment. Looking south.

6. Auxiliary spillway at right (southwest) abutment. Note gravel surface and lack of erosion rills or gullies. Note ridge in center of reservoir that was excavated for dam construction. Looking northwest.

7. Outlet to 6-in. dia low-level drain of reservoir. Note lack of evidence of previous significant flow.

8. Valve control box for 6-in. dia low-level drain. Located at the downstream end of drainpipe.

9. Seepage from left half of embankment near the toe of dam.



10. Seepage on ridge at lower part of the downstream face of the dam

APPENDIX B

Hydraulic/Hyrologic Data and Analyses

APPENDIX B
Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.

b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956).

c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (National Engineering Handbook, Section 4, Hydrology, 1971) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi^2, and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{\ell^{0.8}\,(s+1)^{0.7}}{1900\,Y^{0.5}} \qquad \text{(Equation 15-4)}$$

where: L = lag in hours
ℓ = hydraulic length of the watershed in feet = 1900
$s = \frac{1000}{CN} - 10 = 3.699$
CN = hydrologic soil curve number as indicated in Section B.2e.
Y = average watershed land slope in percent = 9.0.

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \qquad \text{(Equation 15-3)}$$

where: T_c = time of concentration in hours

L = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133 T_c \qquad \text{(Equation 16-12)}$$

where: ΔD = duration of unit excess rainfall
T_c = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 5 minutes was used.

d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF events and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:

(1) 1 and 10 percent probability events - main spillway pipe elevation, 773.9;

(2) Probable Maximum Storm - main spillway pipe elevation, 773.9.

Because the 6-in. diameter low-level outlet pipe was inoperative at the time of the inspection, it was assumed inoperative during flooding and did not pass any amount of the flood.

f. Spillway Rating Curve. The spillway rating curve was calculated using spillway cross sections and assuming critical depth over the spillway. The flow through 18-in. diameter pipe was calculated separately and combined with auxiliary spillway rating curve and entered on the Y4 and Y5 cards to the HEC-1 program.

B.2 Pertinent Data

a. Drainage area. 0.06 mi^2.

b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 24 hours duration was divided into 5 minute intervals in order to develop the inflow hydrograph.

c. Lag time. 0.27 hr.

d. Hydrologic soil group. C.

e. SCS curve numbers.

1. For PMF: AMC III - Curve Number 87
2. For 1 and 10 percent probability-of-occurrence events: AMC II - Curve Number 73.

f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Glover, and Des Arc, Missouri (1968) 7.5-minute quadrangle maps. The data were entered on the $A and $E cards so that the HEC-1 program could compute storage volumes.

g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the $D, $L, and $V cards.

h. Outflow capacity. The spillway rating curve was calculated from the cross section data of the auxiliary spillway assuming critical depth in the spillway. The results of the above were combined with the main spillway rating curve and entered on the Y4 and Y5 cards of the HEC-1 program.

i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 773.9 ft, the main spillway pipe elevation. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was also 773.9 ft, the main spillway pipe elevation.

B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.

```
**********    **********
FEQOO HYD  GRAPH PACKAGE (PEC-1)
DAM SAFETY VERSION      JULY 1978
 LAST MODIFICATION  26 FEB 79
**********
    1              A1       WALNUT HOLLOW, DAM NO. 30619, IRON COUNTY, MISSOURI.
    2              A2       WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 80C224.
    3              A3       PROBABLE MAXIMUM FLOODS.
    4              B    288       0       5       0       0       0       0       0       0       0
    5              B1     5
    6              J      1       2       1
    7              J1   .50    1.00
    8              K      0  INFLOW                                          1
    9              K1       WALNUT HOLLOW LAKE PMF INFLOW COMPUTATIONS.
   10              P      1       2    .062                          1.0
   11              P     0.      26.     102.    120.    130.
   12              T                                                  -1     -87                    .16
   13              W2           0.27
   14              X     -1    -.05       5
   15              K      1     DAM                                     1
   16              K1       FLOOD ROUTING AND OVERTOPPING ANALYSES
   17              Y                                       1       1
   18              Y1                                                -779.9     -1
   19              Y4  773.9   774.9   775.3   775.9   776.4   777.1   778.3   779.2   780.
   20              Y5    0.    20.0    30.0    70.0    125.    225.    425.    625.    825.
   21              YA    0.     2.8     5.5     6.6     7.1     8.3
   22              YE  750.0   760.0   770.0   773.9   775.8   780.0
   23              YS  773.9
   24              YO  775.8     2.8     1.5
   25              YL    0.    70.0   450.0   625.0   635.0   640.0
   26              YV  775.5   776.0   776.5   777.0   778.0   779.0
   27              K     99
```

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

RUN  DATE= 81/01/12.
     TIME= 11.37.40.


                    WALNUT HOLLOW, DAM NO. 30619, IRON COUNTY, MISSOURI.
                    MCCOWARD-CLYDE CONSULTANTS, HOUSTON JOB 80C224.
                    PROBABLE MAXIMUM FLOODS.

                                   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= 2 LRTIO= 1
                        RTIOS=     .50    1.00


                                 SUB-AREA RUNOFF COMPUTATION

                    WALNUT HOLLOW LAKE PMF INFLOW COMPUTATIONS.

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

                                      HYDROGRAPH DATA
                    IHYDG    IUHG    TAREA    SNAP    TRSDA    TRSPC    RATIO    ISNOW    ISAME    LOCAL
                        1       2      .06    0.00      .06     1.00    0.000        0        0        0

                                        PRECIP DATA
                          SPFE      PMS       R6      R12      R24      R48      R72      R96
                          0.00    26.00   102.00   120.00   130.00     0.00     0.00     0.00

                                        LOSS DATA
                    LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
                        0    0.00    0.00    1.00    0.00    0.00    1.00   -1.00  -87.00    0.00     .16

                    CURVE NO =  -87.00  WETNESS =   -1.00  EFFECT CN =   87.00

                                    UNIT HYDROGRAPH DATA
                                  TC=    0.00    LAG=    .27

                                    RECESSION DATA
                              STRTQ=   -1.00    QRCSN=    -.05    RTIOR= 5.00

                    UNIT HYDROGRAPH 18 END OF PERIOD ORDINATES, TC=    0.00 HOURS, LAG=    .27  VOL= 1.00
                      15.      52.      89.      95.      80.      53.      33.      22.      14.       9.
                       6.       4.       2.       2.       1.       1.       0.       0.

                                    END-OF-PERIOD FLOW
 0
MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS    COMP Q       MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS    COMP Q
```

Output Summary
Various PMF Events
Walnut Hollow Lake Dam
MO 30619

B5

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	.22	.21	.01	32.
1.01	.10	2	.01	.00	.01	0.	1.01	12.10	146	.22	.21	.01	46.
1.01	.15	3	.01	.00	.01	0.	1.01	12.15	147	.22	.21	.01	59.
1.01	.20	4	.01	.00	.01	1.	1.01	12.20	148	.22	.21	.01	68.
1.01	.25	5	.01	.00	.01	1.	1.01	12.25	149	.22	.21	.01	80.
1.01	.30	6	.01	.00	.01	1.	1.01	12.30	150	.22	.21	.01	88.
1.01	.35	7	.01	.00	.01	1.	1.01	12.35	151	.22	.22	.01	93.
1.01	.40	8	.01	.00	.01	1.	1.01	12.40	152	.22	.22	.01	97.
1.01	.45	9	.01	.00	.01	1.	1.01	12.45	153	.22	.22	.01	99.
1.01	.50	10	.01	.00	.01	1.	1.01	12.50	154	.22	.22	.01	101.
1.01	.55	11	.01	.00	.01	1.	1.01	12.55	155	.22	.22	.00	102.
1.01	1.00	12	.01	.00	.01	1.	1.01	13.00	156	.22	.22	.00	102.
1.01	1.05	13	.01	.00	.01	1.	1.01	13.05	157	.27	.26	.01	104.
1.01	1.10	14	.01	.00	.01	1.	1.01	13.10	158	.27	.26	.01	106.
1.01	1.15	15	.01	.00	.01	1.	1.01	13.15	159	.27	.26	.00	110.
1.01	1.20	16	.01	.00	.01	1.	1.01	13.20	160	.27	.26	.00	113.
1.01	1.25	17	.01	.00	.01	1.	1.01	13.25	161	.27	.26	.00	116.
1.01	1.30	18	.01	.00	.01	1.	1.01	13.30	162	.27	.26	.00	121.
1.01	1.35	19	.01	.00	.01	1.	1.01	13.35	163	.27	.26	.00	122.
1.01	1.40	20	.01	.00	.01	1.	1.01	13.40	164	.27	.26	.00	123.
1.01	1.45	21	.01	.00	.01	1.	1.01	13.45	165	.27	.26	.00	124.
1.01	1.50	22	.01	.00	.01	1.	1.01	13.50	166	.27	.26	.00	125.
1.01	1.55	23	.01	.00	.01	1.	1.01	13.55	167	.27	.26	.00	125.
1.01	2.00	24	.01	.00	.01	1.	1.01	14.00	168	.27	.26	.00	125.
1.01	2.05	25	.01	.00	.01	1.	1.01	14.05	169	.33	.33	.00	126.
1.01	2.10	26	.01	.00	.01	1.	1.01	14.10	170	.33	.33	.00	126.
1.01	2.15	27	.01	.00	.01	1.	1.01	14.15	171	.33	.33	.00	126.
1.01	2.20	28	.01	.00	.01	1.	1.01	14.20	172	.33	.33	.00	127.
1.01	2.25	29	.01	.00	.01	2.	1.01	14.25	173	.33	.33	.00	128.
1.01	2.30	30	.01	.00	.01	2.	1.01	14.30	174	.33	.33	.00	131.
1.01	2.35	31	.01	.00	.01	2.	1.01	14.35	175	.33	.33	.00	133.
1.01	2.40	32	.01	.00	.01	2.	1.01	14.40	176	.33	.33	.00	135.
1.01	2.45	33	.01	.00	.01	2.	1.01	14.45	177	.33	.33	.00	136.
1.01	2.50	34	.01	.00	.01	2.	1.01	14.50	178	.33	.33	.00	137.
1.01	2.55	35	.01	.01	.01	2.	1.01	14.55	179	.33	.33	.00	137.
1.01	3.00	36	.01	.01	.01	2.	1.01	15.00	180	.33	.33	.00	137.
1.01	3.05	37	.01	.01	.01	2.	1.01	15.05	181	.20	.20	.00	138.
1.01	3.10	38	.01	.01	.01	2.	1.01	15.10	182	.40	.40	.00	139.
1.01	3.15	39	.01	.01	.01	2.	1.01	15.15	183	.40	.40	.00	141.
1.01	3.20	40	.01	.01	.01	2.	1.01	15.20	184	.60	.60	.00	144.
1.01	3.25	41	.01	.01	.01	3.	1.01	15.25	185	.71	.70	.00	151.
1.01	3.30	42	.01	.01	.01	3.	1.01	15.30	186	1.71	1.71	.01	228.
1.01	3.35	43	.01	.01	.01	3.	1.01	15.35	187	2.82	2.81	.01	332.
1.01	3.40	44	.01	.01	.01	3.	1.01	15.40	188	1.11	1.10	.00	402.
1.01	3.45	45	.01	.01	.01	3.	1.01	15.45	189	.71	.70	.00	443.
1.01	3.50	46	.01	.01	.01	3.	1.01	15.50	190	.60	.60	.00	464.
1.01	3.55	47	.01	.01	.01	3.	1.01	15.55	191	.40	.40	.00	472.
1.01	4.00	48	.01	.01	.01	3.	1.01	16.00	192	.40	.40	.00	478.
1.01	4.05	49	.01	.01	.01	3.	1.01	16.05	193	.31	.31	.00	480.
1.01	4.10	50	.01	.01	.01	3.	1.01	16.10	194	.31	.31	.00	312.
1.01	4.15	51	.01	.01	.01	3.	1.01	16.15	195	.31	.31	.00	269.
1.01	4.20	52	.01	.01	.01	3.	1.01	16.20	196	.31	.31	.00	234.
1.01	4.25	53	.01	.01	.01	3.	1.01	16.25	197	.31	.31	.00	197.
1.01	4.30	54	.01	.01	.01	3.	1.01	16.30	198	.31	.31	.00	188.
1.01	4.35	55	.01	.01	.01	3.	1.01	16.35	199	.31	.31	.00	169.
1.01	4.40	56	.01	.01	.01	3.	1.01	16.40	200	.31	.31	.00	161.
1.01	4.45	57	.01	.01	.01	4.	1.01	16.45	201	.31	.31	.00	157.
1.01	4.50	58	.01	.01	.01	4.	1.01	16.50	202	.31	.31	.00	154.
1.01	4.55	59	.01	.01	.01	4.	1.01	16.55	203	.31	.31	.00	152.
1.01	5.00	60	.01	.01	.01	4.	1.01	17.00	204	.31	.31	.00	150.
1.01	5.05	61	.01	.01	.01	4.	1.01	17.05	205	.24	.24	.00	148.

Output Summary
Various PMF Events
Walnut Hollow Lake Dam
MO 30619

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Output Summary
Various PMF Events
Walnut Hollow Lake Dam
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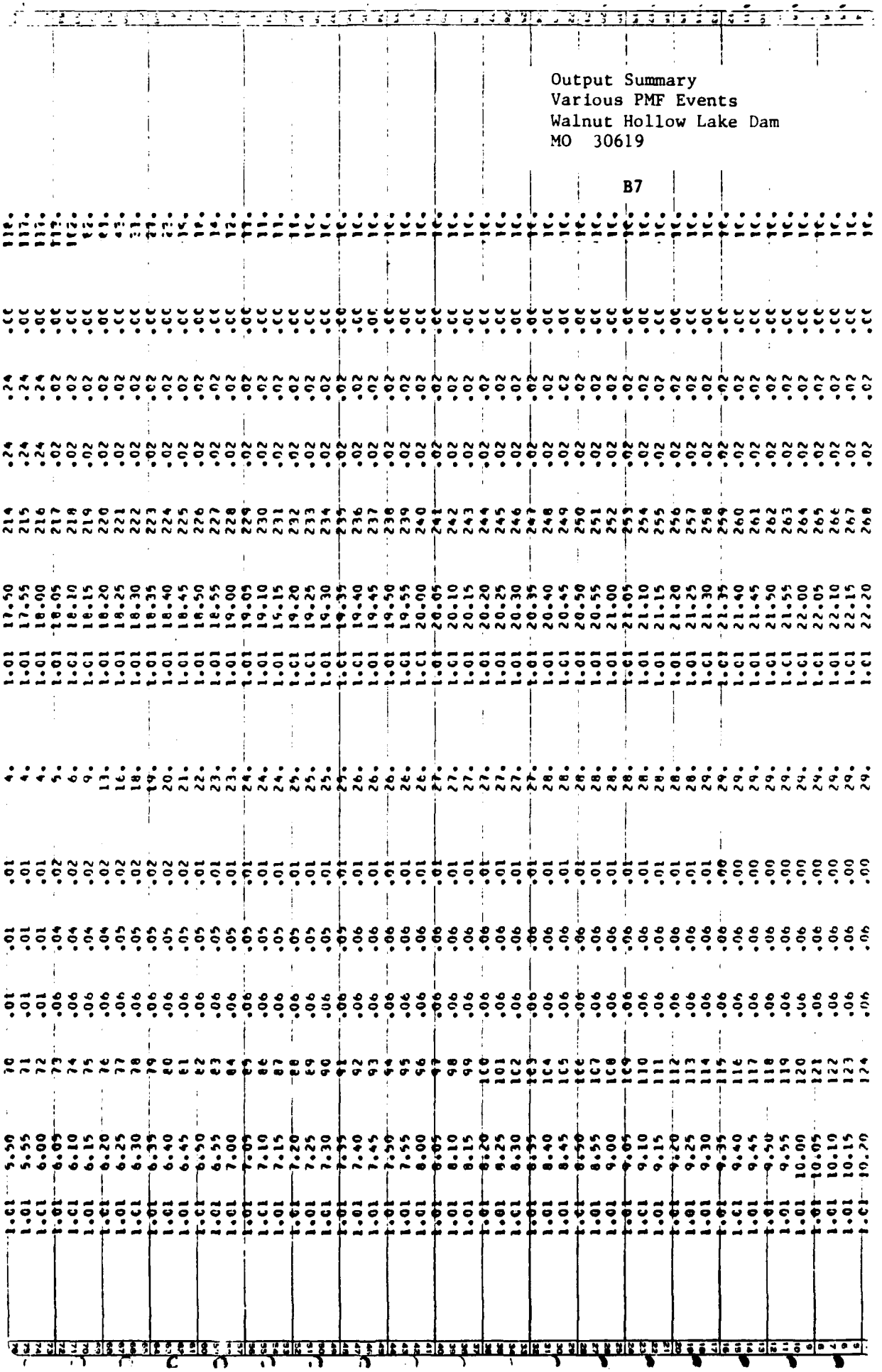

1	10.00	120	.06	.06	.00	29.	1.01	22.00	264	.02	.02	.00	1C.
1.01	10.05	121	.06	.06	.00	29.	1.01	22.05	265	.02	.02	.00	1C.
1.01	10.10	122	.06	.06	.00	29.	1.01	22.10	266	.02	.02	.00	1C.
1.01	10.15	123	.06	.06	.00	29.	1.01	22.15	267	.02	.02	.00	1C.
1.01	10.20	124	.06	.06	.00	29.	1.01	22.20	268	.02	.02	.00	1C.
1.01	10.25	125	.06	.06	.00	29.	1.01	22.25	269	.02	.02	.00	1C.
1.01	10.30	126	.06	.06	.00	29.	1.01	22.30	270	.02	.02	.00	1C.
1.01	10.35	127	.06	.06	.00	29.	1.01	22.35	271	.02	.02	.00	1C.
1.01	10.40	128	.06	.06	.00	29.	1.01	22.40	272	.02	.02	.00	1C.
1.01	10.45	129	.06	.06	.00	29.	1.01	22.45	273	.02	.02	.00	1C.
1.01	10.50	130	.06	.06	.00	29.	1.01	22.50	274	.02	.02	.00	1C.
1.01	10.55	131	.06	.06	.00	29.	1.01	22.55	275	.02	.02	.00	1C.
1.01	11.00	132	.06	.06	.00	29.	1.01	23.00	276	.02	.02	.00	1C.
1.01	11.05	133	.06	.06	.00	30.	1.01	23.05	277	.02	.02	.00	1C.
1.01	11.10	134	.06	.06	.00	30.	1.01	23.10	278	.02	.02	.00	1C.
1.01	11.15	135	.06	.06	.00	30.	1.01	23.15	279	.02	.02	.00	1C.
1.01	11.20	136	.06	.06	.00	30.	1.01	23.20	280	.02	.02	.00	1C.
1.01	11.25	137	.06	.06	.00	30.	1.01	23.25	281	.02	.02	.00	1C.
1.01	11.30	138	.06	.06	.00	30.	1.01	23.30	282	.02	.02	.00	1C.
1.01	11.35	139	.06	.06	.00	30.	1.01	23.35	283	.02	.02	.00	1C.
1.01	11.40	140	.06	.06	.00	30.	1.01	23.40	284	.02	.02	.00	1C.
1.01	11.45	141	.06	.06	.00	30.	1.01	23.45	285	.02	.02	.00	1C.
1.01	11.50	142	.06	.06	.00	30.	1.01	23.50	286	.02	.02	.00	1C.
1.01	11.55	143	.06	.06	.00	30.	1.01	23.55	287	.02	.02	.00	1C.
1.01	12.00	144	.06	.06	.00	30.	1.02	0.00	288	.02	.02	.00	1C.
									SUM	33.80	32.35	1.45	15477.
										(859.1(	822.1(	37.1(	438.2(

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	628.	173.	54.	54.	15492.
CMS	18.	5.	2.	2.	439.
INCHES		25.96	32.28	32.28	32.28
MM		659.44	819.99	819.99	819.99
AC-FT		86.	107.	107.	107.
THOUS CU M		106.	132.	132.	132.

HYDROGRAPH AT STAINFLOW FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	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.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	3.	5.	6.	8.	9.	10.	10.
11.	11.	11.	12.	12.	12.	12.	12.	12.	13.
13.	13.	13.	13.	13.	13.	13.	13.	13.	14.
14.	14.	14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.	14.	14.
14.	15.	15.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	16.	20.	27.	34.	40.	44.
47.	48.	50.	50.	51.	51.	52.	53.	55.	57.
59.	60.	61.	62.	62.	62.	62.	63.	63.	65.
68.	71.	74.	76.	77.	77.	78.	78.	79.	79.
78.	78.	78.	80.	90.	114.	166.	241.	302.	314.
286.	238.	193.	158.	131.	112.	99.	90.	84.	81.
78.	77.	76.	75.	74.	72.	69.	66.	63.	61.
60.	60.	59.	59.	59.	58.	57.	51.	41.	30.
22.	16.	13.	11.	10.	8.	7.	6.	6.	5.
5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
4.	4.	4.	4.	4.	4.	4.	4.	4.	4.

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)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1	RATIO 2
				.50	1.00
HYDROGRAPH AT	INFLOW	.06	1	314.	628.
		(.16)		(8.89)(	17.78)(
ROUTED TO	DAM	.06	1	252.	597.
		(.16)		(7.14)(	16.90)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	773.90	773.90	775.80
STORAGE	74.	74.	87.
OUTFLOW	0.	0.	71.

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
.50	776.31	.51	90.	252.	2.25	16.00	0.00
1.00	776.62	.82	93.	597.	5.17	15.92	0.00

Output Summary
Various PMF Events
Walnut Hollow Lake Dam
MO 30619

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)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1	RATIO 2	RATIO 3	RATIO 4
				.20	.25	.30	.35
HYDROGRAPH AT	INFLOW	.06	1	126.	157.	188.	220.
	(	.16)	(	3.56)(	4.44)(	5.33)(	6.22)(
ROUTED TO	DAM	.06	1	34.	53.	80.	119.
	(	.16)	(	.95)(	1.50)(	2.27)(	3.36)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	773.90	773.90	775.90
STORAGE	74.	74.	87.
OUTFLOW	0.	0.	71.

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
.20	775.35	0.00	84.	34.	0.00	16.58	0.00
.25	775.63	0.00	85.	53.	0.00	16.33	0.00
.30	775.86	.06	87.	80.	.58	16.25	0.00
.35	776.03	.29	88.	119.	1.08	16.17	0.00

Output Summary
Various PMF Events
Walnut Hollow Lake Dam
MO 30619

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