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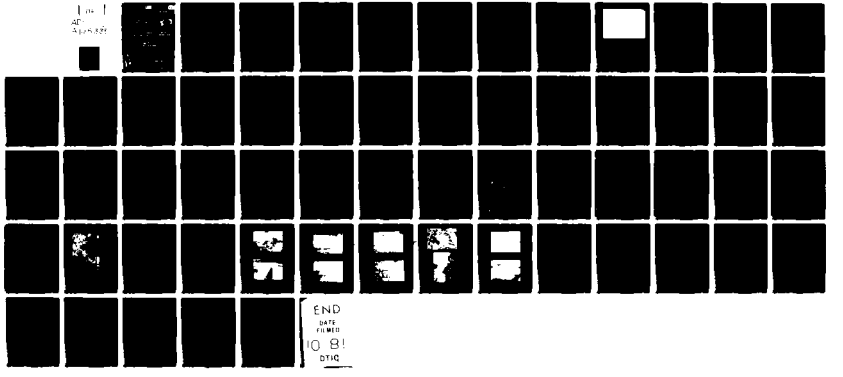

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HORNSEY BROTHERS DAM
WASHINGTON COUNTY, MISSOURI
MO 30101

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
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St. Louis District

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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 respec to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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

REPLY TO ATTENTION OF

SUBJECT: Hornsey Brothers Dam (MO 30101) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Hornsey Brothers Dam (MO 30101). It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY: SIGNED — Chief, Engineering Division — 4 MAR 1981 — Date

APPROVED BY: [illegible] — Colonel, CE, District Engineer — 5 MAR 1981 — Date

HORNSEY BROTHERS DAM

Washington County, Missouri

Missouri Inventory No. 30101

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

November 1980

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.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Hornsey Brothers Dam
State Located	Missouri
County Located	Washington
Stream	Swan Branch
Date of Inspection	15 August, 1980

Hornsey Brothers Dam, Missouri Inventory Number 30101, was inspected by Richard Berggreen (engineering geologist), Leonard Krazynski (geotechnical engineer), and Sean Tseng (hydrologist). The dam is an earth dam constructed to impound a reservoir for recreational purposes.

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 an expeditious identification of those dams which may pose hazard to human life and property, based on available data and visual inspection of the dam. In view of the limited nature of the study, no assurance can be given that all deficiencies have been identified.

The dam is classified as having a high hazard potential by the St Louis District, Corps of Engineers (SLD). The SLD estimated damage zone length extends approximately 10 mi downstream of the dam. Within the first two miles there are at least eight occupied dwellings, several farm buildings, and two state highways.

Hornsey Brothers Dam is classified intermediate size based on its approximate 50-ft height and storage capacity of 1250 ac-ft. Intermediate size dams classification criteria are: either a height between 40 and 100 ft, or a reservoir storage capacity between 1000 and 50,000 ac-ft.

The findings of the visual inspection and review of available data indicate the dam and appurtenant structures are in generally good condition. Evidence of soil creep was identified near the downstream toe of the dam, but did not appear to pose a safety hazard to the dam at this time. Minor seepage was noted near the toe of the maximum section

but water was not flowing at a measureable rate. Small trees and brush were noted on the crest and downstream face of the dam but did not obscure inspection. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available.

Hydrologic/hydraulic analyses indicate that overtopping and potential erosion of the auxiliary spillway will occur for floods greater than 66 percent of the Probable Maximum Flood (PMF). The main embankment will be overtopped by floods greater than 74 percent of the PMF. 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 main and auxiliary spillway discharge capacity with the reservoir surface at top of the dam is 3880 ft^3/sec. The main spillway alone will pass the one percent probability-of-occurrence event (100 year flood).

It is recommended that the following studies be made and the following actions be taken, under the guidance of an engineer experienced in the design and construction of earth dams:

a. Locate the surface trace of the Aptus fault in the vicinity of the dam and evaluate the potential for ground water solution activity in the foundation of the dam.

. Make seepage and stability analyses of the dam comparable to those recommended in the guidelines. These analyses should be made for the appropriate loading conditions, including earthquake loads.

c. An analysis should be made and appropriate measures should be taken to allow this dam to safety pass 100 percent of the PMF without overtopping the embankment, as required by the guidelines.

d. Evaluate the necessity of removing large trees from the dam embankment.

e. Evaluate the available options for a practical and reliable warning system to alert downstream residents and traffic in the event hazardous conditions develop at this facility during periods of flooding.

It is recommended that a program of periodic inspections and monitoring be initiated at this facility. This program should include:

a. Inspection of the embankment crest and slopes to identify evidence of instability such as cracking or slumping.

b. Inspection of the spillway, discharge channel and toe of dam for evidence of significant erosion following heavy precipitation events.

c. Inspection of the low level outlet to determine the operability of the outlet and required maintenance.

d. Monitoring seepage at the toe of the dam to identify changes in the volume of flow or turbidity in the seepage water.

It is recommended the owner take action on these remedial measures and recommendations as soon as practicable.

WOODWARD-CLYDE CONSULTANTS

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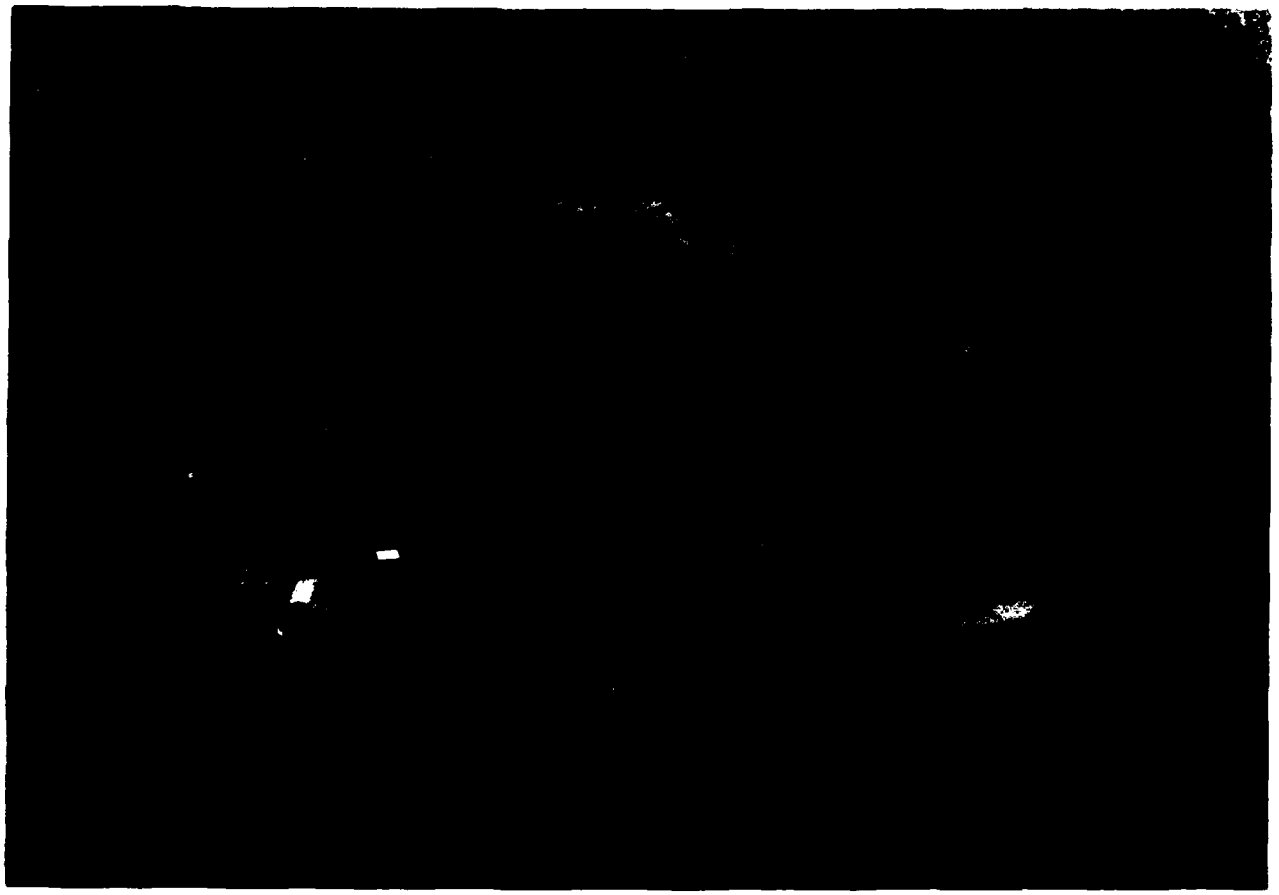
Registered Geologist

Leonard M. Krazynski, P. E.
Vice President



OVERVIEW
HORNSEY BROTHERS DAM

MISSOURI INVENTORY NUMBER 30101

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HORNSEY BROTHERS DAM, MISSOURI INVENTORY NO. 30101
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3A. Plan and Section of Dam
3B. Sections of Main Spillway and Downstream Channel
3C. Sections of Dam and Auxiliary Spillway
4. Regional Geologic Map

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A Figure A-1: Photo Location Sketch

Photographs

1. Spillway excavated in rock at right abutment. Looking north downstream.
2. Roadway and dam crest from right abutment. Looking northwest. Note vegetation on upstream and downstream slopes.
3. Downstream face of dam. Note vegetation on face of dam. Also note inclined fence posts near inspection team. Looking south.
4. Inclined fence posts at toe of dam, suggesting soil creep. Looking southeast along toe of dam.
5. Minor seepage at toe of dam. Seepage rate very slow, no apparent movement of water.
6. Discharge channel blasted in bedrock. Looking southwest, upstream.
7. Jointed bedrock in discharge channel.
8. Waterfall in discharge channel, approximately 200 ft downstream of spillway. Looking north toward original streambed.
9. Downstream hazards below dam. Looking east. Dam out of picture to lower right.
10. Downstream hazard zone. Looking east.

B Hydraulic/Hydrologic Data and Analyses

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HORNSEY BROTHERS DAM, MISSOURI INVENTORY NO. 30101

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 Hornsey Brothers Dam, Missouri Inventory Number 30101.

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, "National Program for Inspection of Non-Federal Dams", prepared 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, Corps of Engineers (SLD). 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.** Hornsey Brothers Dam is an earth dam (see Overview Photo) impounding a reservoir used for recreational purposes. The crest is typically 20 to 25 ft wide. The main spillway is a trapezoidal channel excavated in the native rock at the right abutment (as the observer faces downstream). The downstream slope is approximately 2.4(H) to 1(V) and the upstream slope was reported by the owner to be 3(H) to 1(V). Rock blasted to form the main spillway was placed as erosion protection on the dam adjacent to the spillway and on the upstream face of the dam.

A low-level outlet was described as being located beneath the dam in the former stream channel. The control is in a locked structure at the downstream toe of the dam. The outlet is described as a 12-in. diameter welded steel pipe with the upstream end covered by a screen having 3/4-in. circular holes. Coarse rock, gravel and sand were reportedly placed over the screen. The outlet was not operated during the field visit.

b. **Location.** The dam is located on Swan Branch, about 1/2 mi south of Missouri Highway AA, Section 6, T37N, R2E, about 4-1/2 miles west-northwest of Potosi, Missouri, on the USGS Potosi 7.5-minute quadrangle map (Fig. 1).

c. **Size classification.** The dam is classified as intermediate size based on its approximate 50 ft height and 1250 ac-ft storage capacity. Intermediate size dams classification criteria are: either a height between 40 and 100 ft, or a storage capacity between 1000 and 50,000 ac-ft.

d. **Hazard classification.** The dam is classified as having a high hazard potential by the St Louis District, Corps of Engineers; we concur with this classification. The downstream damage zone length estimated by the St Louis District extends approximately 10 mi downstream of the dam. Within the first two miles downstream there are at least eight occupied dwellings, assorted farm buildings, and two state highways (Photos 9 and 10).

e. **Ownership.** We understand the dam is owned by Mr Walter Hornsey. Correspondence should be addressed to him at Hornsey Brothers Mining Company, Potosi, Missouri 63664.

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

g. **Design and construction history.** No design drawings or construction reports were available for this dam. All design and construction data were obtained from interviews with Mr Walter Hornsey.

The dam was built by Hornsey Brothers in 1960. A 20-ft wide trench was excavated to bedrock and backfilled with compacted clay, taken from the area occupied by the reservoir. Compacted clay (CL-CH) forms the majority of the embankment to within 3 ft of the dam crest. Gravelly mine waste was placed on the dam crest. Blasted rock riprap from the main spillway excavation was placed on the upstream slope and on the end of the dam adjacent to the spillway to act as erosion protection.

The main spillway (Photo 1) was excavated, by blasting, in the right abutment (as the observer faces downstream). No significant erosion is anticipated in this spillway or its downstream discharge channel. Maximum historical depth of flow through the main spillway to date was reported to be about 1-1/2 ft deep.

An auxiliary spillway located at the left abutment (Overview Photo) consists of a low berm adjacent to the west end of the dam embankment, approximately 4 ft above the level of the main spillway and about 3 ft lower than the main embankment of the dam. Discharge from this spillway would flow near the toe of the dam, but would not be confined by any existing channel. The valley sides slope down toward this auxiliary spillway, and do not allow for unrestricted flow over the entire length of this low berm. Detailed surveying and backwater hydrologic analysis are beyond the scope of this Phase I study. However, four cross-sections perpendicular to the axis of the low berm have been surveyed and an approximate profile of the effective auxiliary spillway has been constructed and is shown in Fig. 3-C. There is no record of flow over the auxiliary spillway to date.

h. **Normal operating procedures.** No operating records or procedures were found for this facility. Flood flows pass over the uncontrolled main spillway at the right abutment.

1.3 Pertinent Data

a. **Drainage area.** 1.48 mi^2

b. **Discharge at damsite.**

Maximum known flood at damsite	Approximately 1.5 ft depth in main spillway
Warm water outlet at pool elevation	N/A
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	3880 ft^3/sec
Total spillway capacity at maximum pool elevation	3880 ft^3/sec

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

Top of dam	898.1 to 899.2
Maximum pool-design surcharge	N/A
Full flood control pool	N/A
Recreation pool	891.4
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	N/A
Toe of dam of maximum section	Approximately 848.0

d. **Reservoir.**

Length of maximum pool	3200 ft (estimated from topographic map)
Length of recreation pool	2800 ft (estimated from topographic map)
Length of flood control pool	N/A

e. **Storage (ac-ft).**

Recreation pool	840
Flood control pool	N/A
Design surcharge	N/A
Top of dam	1250

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

Top of dam	77
Maximum pool	77
Flood control pool	N/A
Recreation pool	60
Spillway crest	60

g. **Dam.**

Type	Compacted earth
Length	782 ft
Height	50 ft
Top width	22 ft (typical)
Side slopes	Upstream approximately 3(H) to 1(V) (from lake level to crest of dam) Downstream 2.4(H) to 1(V)
Zoning	Compacted clay with gravel crest and riprap on upstream slope
Impervious core	Probably homogeneous embankment
Cutoff	20-ft wide trench to bedrock backfilled with clay (reported by dam owner)
Grout curtain	None

h. **Diversion and regulating tunnel.** None.

i. **Spillway.**

Main spillway

Type	Unlined trapezoidal channel in rock
Length of weir	49 ft at bottom; 110 ft at el 898.1 ft (top of dam)
Crest elevation	891.4 ft
Gates	None
Upstream channel	None
Downstream channel	Rock-lined gorge

Auxiliary spillway

Type	Low soil berm at left abutment
Length of weir	Approximately 120 ft
Crest elevation	895 ft
Gates	None
Upstream channel	None
Downstream channel	No channel. Slope of valley side toward auxiliary spillway does not allow unrestricted flow over entire length of low earth berm at left abutment.

j. **Regulating outlets.** Reported to be a 12-in. diameter welded steel pipe at base of dam, with upstream end covered by screen with 3/4-in. circular holes, covered with rock, gravel, and sand. Control is in locked structure at downstream end. Outlet has not been operated since dam was constructed in 1960 (report by owner).

SECTION 2
ENGINEERING DATA

2.1 Design

No design drawings or other data were available for this dam.

2.2 Construction

No construction reports or records were found for this dam. The dam was constructed by the owner in 1960, as described in Section 1.2.g.

2.3 Operation

The low level outlet through the base of the dam is the only facility identified at this dam which could be considered an operable item. The control is at the downstream end of the outlet in a locked structure. It was not operated during the visual inspection. Mr Hornsey indicated this outlet has not been operated since the dam was built.

2.4 Evaluation

a. **Availability.** Engineering data was limited to information obtained through interviews with Mr Hornsey, the owner.

b. **Adequacy.** The available information is insufficient to evaluate the design of the Hornsey Brothers Dam. Seepage and stability analyses comparable to the guidelines were not available. This is a deficiency which should be rectified. Such seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be performed by an engineer experienced in the design and construction of earth dams.

c. **Validity.** The engineering data obtained from Mr Hornsey appears to be valid and factual, however it was not confirmed by another source and is incomplete. The information obtained appeared to be in good general agreement with the conditions observed in the field during our inspection.

2.5 Project Geology

The dam is located on the northern flank of the Ozark structural dome. The bedrock in the area is mapped on the Geologic Map of Missouri (1979) as Potosi and Eminence dolomite formations (Fig. 4). The Potosi Formation consists of siliceous dolomite and typically contains an abundance of quartz druse characteristic of chert bearing formations. The Eminence Formation conformably overlies the Potosi, and is similar in appearance but contains less chert and quartz. Some large springs and caves have been noted in the Eminence Formation; however, no evidence of springs or solution activity was noted during the visual inspection of the dam site.

The soil in the vicinity of the dam site is a dark red-brown to tan, plastic residual clay (CL-CH) characteristically developed on the Potosi Formation. The soil also contains abundant quartz druse gravel typical of soils overlying the Potosi Formation. This residual soil is locally overlain by a thin (2 to 5 ft) loess profile of clay (CL) and silt (ML). The soils in this area are mapped on the Missouri General Soils Map as Union-Goss-Gasconade-Peridge Association.

The Aptus Fault is mapped on the Geologic Map of Missouri (1979) as less than ½ mile northeast of the dam (Fig. 4). However, the scale of the map (1 in. equals 8 mi) does not allow for precise location of the fault trace. No evidence of the fault was noted during the field inspection. The fault is approximately 15 miles long, trending northwest-southeast, and is mapped as northeast side up.

This fault, like others in the Ozark region, appears confined to the Paleozoic bedrock and is likely Paleozoic in age. The area is not considered seismically active. However, the possible presence of a fault in the immediate vicinity of the dam suggests further study is advisable to accurately locate the fault and evaluate the potential for possible groundwater solutioning along the fault in the foundation of the dam.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** A field inspection was made of the Hornsey Brothers Dam on 15 August 1980, accompanied part of the time by Mr Walter Hornsey, the owner.

b. **Dam.** The Hornsey Brothers dam is an earth dam, approximately 780 ft long, and 50 ft high. The crest width is about 20 to 25 ft. There is a gravel road along the crest (Photo 2).

The soil used in the dam construction is a gravelly to sandy, plastic, dark red residual clay (CL-CH). The clay appears somewhat less plastic than noted in other dams in the vicinity. The upper 2 to 3 ft on the crest of the dam are composed of crushed rock and chat (gravel-size mine tailings). The embankment is likely to be moderately susceptible to erosion if overtopped.

Trees and brushy vegetation were noted on both the upstream and downstream faces of the dam. The vegetation is not dense enough at present to obscure the face of the dam from inspection (Photo 3).

No significant erosion was noted on the dam. No evidence was found of sinkhole development, cracking, animal burrows, or disruption of the vertical or horizontal alignment of the dam crest.

Some evidence of soil creep was noted on the downstream slope of the dam during the visual inspection. A fence line near the toe of the dam showed inclined posts in one area (Photo 4) suggesting some slope creep movements. No scarp was identified, and the trees in this area did not appear disrupted.

The slope movement does not appear to be deep-seated and was not judged by the inspection team to be indicative of potential slope failure in the embankment. It appears to be the result of shrink-swell cycles in the clay material on a steep slope. The area should be inspected periodically, but does not appear at present to constitute a safety hazard to the dam.

Minor seepage was noted near the toe of the maximum section (Photo 5), but the water was not flowing at a measurable rate. The water surface in the impounded lake was about 7 ft below the bottom of the spillway at the time of inspection.

c. **Appurtenant structures.**

1. Main spillway. The main spillway at the dam is a trapezoidal notch, excavated in rock (by blasting) at the right abutment (Photo 1). The very hard nature of the rock indicates the erosion potential for the probable flows is very low.

There is approximately 7 ft elevation difference between most of the dam crest and the spillway crest. The difference in elevation between the lowest point on the dam crest and the spillway is about 6½ ft. The owner reports the maximum observed flood flow through the spillway to date was about 1.5 ft deep.

No features were noted that could result in obstructing the spillway during flood flows.

2. Auxiliary spillway. An auxiliary spillway has been constructed at the left abutment (see Overview Photo). It consists of a low soil berm at the end of the dam, approximately 4 ft higher than the main spillway crest elevation, and about 3 ft lower than the main embankment of the dam. This soil berm is likely moderately erodible if overtopped. However, erosion of this auxiliary spillway is not expected to pose a safety hazard to the dam due to the distance from the main dam section and relatively shallow depth to bedrock.

Discharge through the auxiliary spillway would apparently flow near the toe of the dam, but would not be confined to any existing channel and could spread onto the grass-covered fields at the toe of the dam. From the point of view of safety of the embankment, it is not expected that significant erosion of the toe would result from short-duration overtopping of the auxiliary spillway.

The valley sides adjacent to the auxiliary spillway slope toward the spillway, and do not allow for unrestricted flow over the entire length of this low berm. Sufficient data was obtained in this area to permit a preliminary evaluation of the hydrologic characteristics of the auxiliary spillway. Detailed surveying of this slope and preparation of a detailed backwater analysis of flow through this area are beyond the scope of this Phase I study.

3. Low level outlet. A low level outlet beneath the dam was described by the owner. It is reported to consist of a 12-in. diameter welded steel pipe, placed in the alignment of the former stream channel. The upstream end of the pipe is covered by a screen with 3/4-in. circular holes, which is in turn covered by rock, gravel and sand. The downstream end of the outlet is in a locked structure at the toe of the dam. The control is also at the downstream end. This outlet was not operated during the field inspection, nor at any time since the completion of the dam in 1960.

d. **Reservoir area.** The slopes surrounding the reservoir consist of pastureland adjacent to the reservoir, and heavy forest. Slopes are typically moderate to gently sloping, generally less than 4(H) to 1(V). No evidence of unstable slopes was noted during the visual inspection.

e. **Downstream channel.** The downstream channel below the main spillway is a blasted, rock-lined channel (Photo 6). It has very low erosion potential. The rock is jointed (Photo 7), but the joints appear tight and are not likely to be eroded by relatively short-duration flood flows. There is a steep scarp in the rock channel caused by headward erosion and can be described appropriately as a dry waterfall; it is approximately 15 ft high, and is located about 200 ft downstream of the spillway crest (Photo 8). Below this waterfall, the channel flows in the original streambed of Swan Creek.

The downstream discharge channel for the auxiliary spillway is ill-defined. Overflow would flow near the toe of the dam, but would not be confined to any existing channel and could spread across the pastureland at the toe of the dam. No evidence of prior flow from the auxiliary spillway in this area was noted in the visual inspection. Short duration storm flows over the auxiliary spillway should not result in downstream conditions which would represent a safety hazard to the main dam embankment.

3.2 Evaluation

The visual inspection identified no major deficiencies at the Hornsey Brothers Dam. The soil creep on the face of the dam should be periodically inspected, but does not appear to constitute a safety hazard to the dam at present. Seepage at the toe of the dam was not measurable. The lake level at the time of inspection was relatively low and seepage should be inspected when the lake is near the spillway elevation.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

There were no operating procedures on record for this dam. The only facility requiring operation is the low level outlet described in Section 3.1.c.3. This outlet is located in a locked structure at the toe of the dam and was not operated during the field inspection. Reservoir level is normally controlled by overflow at the main spillway.

4.2 Maintenance of the Dam

No records of maintenance were identified at this dam. The gravel road on the dam crest appears to be well maintained. The riprap on the upstream slope appeared to be in a well maintained condition. There did not appear to be any effort to control vegetation on the dam embankment and this condition should be evaluated.

4.3 Maintenance of Operating Facilities

The only operating facility at this dam is the low level outlet beneath the dam. No maintenance has been performed on this outlet since the dam was built in 1960. The outlet has not been operated since the dam was built. It was not operated during the visual inspection.

4.4 Description of Any Warning System in Effect

No warning system was identified at this facility during our visual inspection.

4.5 Evaluation

There is no formal maintenance program in effect for this dam. However, the dam and spillway appear to be in satisfactory condition. Consideration should be given to controlling the growth of large trees on the downstream face of the embankment, as roots could provide piping paths through the embankment, and excessive growth

may interfere with proper inspection of the dam. Removal of large trees should be done under the guidance of personnel experienced in the construction and maintenance of dams. Indiscriminate clearing of trees could jeopardize the safety of the dam. An evaluation should be made of a practical and effective warning system for this facility.

The outlet control should be examined for operability and be properly maintained. It is good practice to operate the valve periodically in order to verify the outlet is in good operating order. The pipe should be checked for corrosion.

It is also considered good engineering practice to have the control valve for a low level outlet located at the upstream end of the pipe. This prevents a constant pressure from being maintained in the portion of the pipe under the dam. Corrosion or deterioration of the pipe could allow leakage from the pipe under full reservoir head. Periodic inspection of the outlet portion of the pipe should include examining the pipe for signs of leakage beneath the dam.

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, the owner (Mr Walter Hornsey), informed the field inspection team that the dam was constructed in 1960, has a full pool maximum depth of about 42 ft and surface area of approximately 50 to 60 acres. The maximum depth of flow in the main spillway to date had been approximately 1.5 ft. The dam was constructed of impervious clay to reduce seepage through the dam. Other relevent data such as the dimensions of the dam and main spillway and storage capacity were field surveyed and/or estimated from topographic mapping. The dimensions and elevations are shown in Figs. 3A, 3B and 3C. The embankment Section A-A in Fig. 3A was not surveyed at the maximum section. The height of dam at the maximum section is estimated to be 50 ft. The maps used in the analyses were the 7.5-minute USGS quadrangle maps for Shirley, Missouri (1958) and Potosi, Missouri (1958).

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

c. **Visual inspection.**

1. Watershed. The entire watershed is rural, consisting of forest, with the exception of approximately 20 acres of pasture. The area of the reservoir is approximately 6 percent of the total drainage area of 1.48 square miles.

2. Reservoir. The reservoir and dam are illustrated by maps and photographs enclosed herewith. The primary purpose of this impoundment is for recreation.

3. Spillway. The ungated main spillway is located on the right abutment of the dam. The spillway and discharge channel were constructed by blasting the natural rock formation. The spillway shape is approximately trapezoidal. Because of the steepness of the discharge channel, cross-section B-B of the main spillway (Fig. 3B) acts as the control section for discharge.

An auxiliary spillway is located in the left abutment as shown in the overview photograph. The width of the auxiliary spillway is about 120 ft. Water discharging over the auxiliary spillway may cause some erosion of this shallow dike depending on the depth and duration of flow. Downstream of the auxiliary spillway flow would take place over a sloping grass-covered field to the valley downstream of the dam.

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

d. **Overtopping potential.** An important consideration in the hydrologic evaluation of Hornsey Brothers Dam is the assessment of the potential for overtopping and consequent failure by erosion of the embankment. Since the main spillway of this dam is in rock, excessive erosion due to high velocity discharges is not expected. The lowest portion of the dam near the auxiliary spillway, as well as the auxiliary spillway dike, are likely to have some erosion in the event flow velocity exceeds about 6 ft./sec.

Hydrologic analyses of this reservoir for all flood events were based on a starting water surface at elevation 891.4, which is the main spillway crest elevation, and on the assumption that no erosion of the auxiliary spillway or dam will take place in the event of overflow.

The results of the analyses show that this reservoir and main spillway alone are capable of passing the flood with one percent probability-of-occurrence (100 year flood). However, a flood of greater than 74 percent of the Probable Maximum Flood (PMF) would result in overtopping of the dam at the low point in the main embankment (Elevation 898.1, see Fig. 3A). At that time the flow in the auxiliary spillway would have a maximum depth of about 3 ft and a discharge of about 700 ft^3/sec out of the total discharge of about 3880 cfs. The maximum flow velocity in the auxiliary spillway area at that time would be the order of 6 ft./sec. At 100 percent of the PMF the velocity is indicated to be of the order of 7½ ft./sec.

The following results were computed for various flood events:

Precipitation Event	Maximum Reservoir Elevation, ft	Maximum Depth Over Dam, ft	Maximum Outflow, ft^3/sec	Duration of Overtopping, hrs
50% PMF	897.0	0	2460	0
74% PMF	898.1	0	3880	0
100% PMF	898.9	0.8	5540	2.3

The depth of overtopping calculated by these analyses indicates the area of overtopping would extend over a substantial portion of the main dam embankment. The hydrologic analyses were made using the data and procedures presented and described in Appendix B, Hydraulic/Hydrologic Data and Analyses. The analyses are based on the low point on the dam crest as surveyed at el 898.1. An assumption was made that there would be no erosion of the auxiliary spillway area as overtopping by the 100 percent PMF progressed.

It should be noted that the guidelines require that all dams of intermediate size classification safety pass 100 percent PMF event without overtopping the embankment.

Input data and output summaries are included in Appendix B. Complete printouts for these analyses are available in the project files.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual observations.** The visual inspection of the Hornsey Brothers Dam indicated the dam embankment is in generally good condition. There is no evidence of cracking, settling, displacement of the vertical or horizontal alignment of the crest, or sinkhole development.

Some evidence was found of soil creep on the downstream face of the dam (Photos 3, 4). This creep appears to be shallow, as no scarp was noted and the larger trees in the area appeared unaffected. The creep is likely due to cyclic shrink-swell action in the clay embankment materials. This creep does not appear to pose a safety hazard to the dam at this time, but should be inspected periodically.

Minor seepage was noted at the toe of the dam. However, it was not carrying soil, and was of such a small volume that a flow rate could not be estimated. This seepage does not appear to pose a present hazard to the dam, but should be monitored periodically to check for potential changes in the volume of flow or turbidity in the seepage water. As was discussed in Section 3 of this report, the seepage should be re-inspected when the lake level is near the spillway elevation.

The main spillway discharge channel is in rock and appears to be in good condition.

b. **Design and construction data.** No design or construction records were available for this dam. All information on the construction of the dam was obtained through conversations with Mr Walter Hornsey, owner and builder of the dam, and is recorded in Section 1.2.g. of this report. Seepage and stability

analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available. This is a deficiency which should be corrected.

c. **Operating records.** No operating records or water level records are maintained for this facility. The low level outlet has not been operated since the dam was constructed, according to Mr Hornsey.

d. **Post construction changes.** There have been no post construction changes on this dam other than the uncontrolled growth of trees, grass and bushes on the downstream and upstream dam faces.

e. **Seismic stability.** The dam is located in Seismic Zone 2 to which the guidelines assign a moderate 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 appears to be in generally good condition. No significant deficiencies were identified at this facility. 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. Hydraulic/hydrologic analyses indicate the main and auxiliary spillways will pass 74 percent of the PMF. The auxiliary spillway may suffer some erosion during periods of heavy flow. With present conditions overtopping of the dam is indicated at 100 percent of the PMF for a depth of about 0.8 ft and a period of about 2.3 hours.

b. **Adequacy of information.** The visual inspection provided a reasonable base of information to support the conclusions and recommendations presented in this Phase I report. The lack of design documents such as static and seismic stability analyses and seepage analysis 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 long term stability of the dam. Remedial measures should be initiated as soon as practicable.

d. **Necessity for Phase II.** In accordance with the "Recommended Guidelines for Safety Inspection 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 are recommended for this dam are described in Section 7.2.b. It is our understanding from discussions with the St Louis District, Corps of Engineers 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 appropriate design flood 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 Hornsey Brothers Dam, it is recommended that the following topics be studied and evaluated as soon as practical:

1. Location of the Aptus Fault, discussed in Section 2.5, and potential for solution activity in foundation.

2. Seepage and stability analyses comparable to the recommended guidelines should be performed for this dam for appropriate loading conditions (including seismic) and made a matter of record.

3. An analysis should be made and appropriate measures taken to allow this dam to pass 100 percent of the PMF without overtopping the embankment, as required by the guidelines.

4. Necessity of removing trees from dam embankment.

5. Evaluate the available options for a practical and reliable warning system to alert downstream residents and traffic in the event hazardous conditions develop at this facility during periods of flooding.

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 be established for this facility. This program should include, as a minimum:

1. Inspection of the embankment crest and slopes to identify evidence of instability such a cracking or slumping.

2. Inspection of the spillway, discharge channel and toe of dam for evidence of significant erosion following heavy precipitation events.

3. Inspection of the low level outlet to determine operability of the outlet and required maintenance.

4. Monitoring seepage at the toe of the dam to identify changes in the volume of flow or turbidity in the seepage water.

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

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

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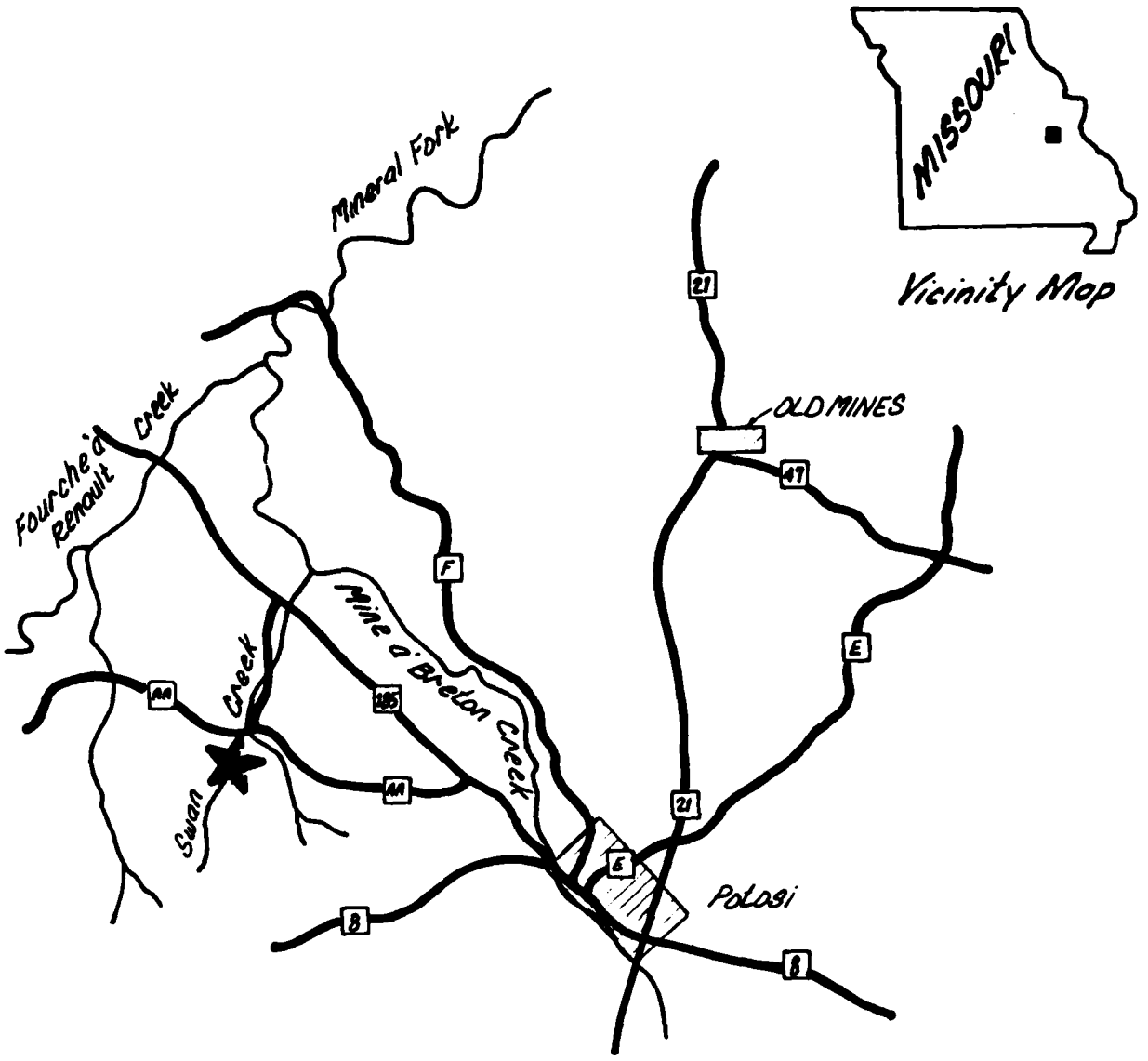
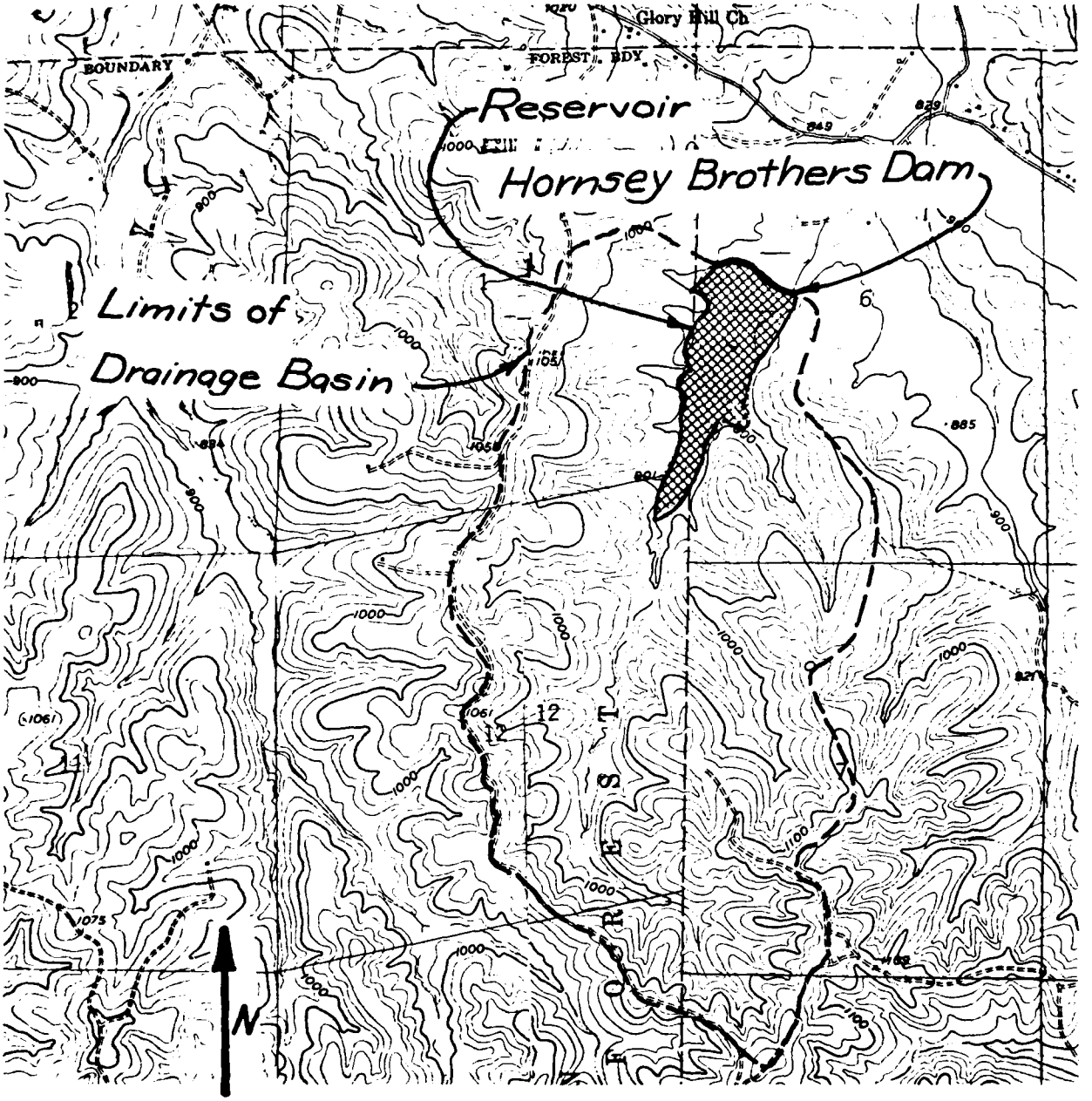
US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.



Legend

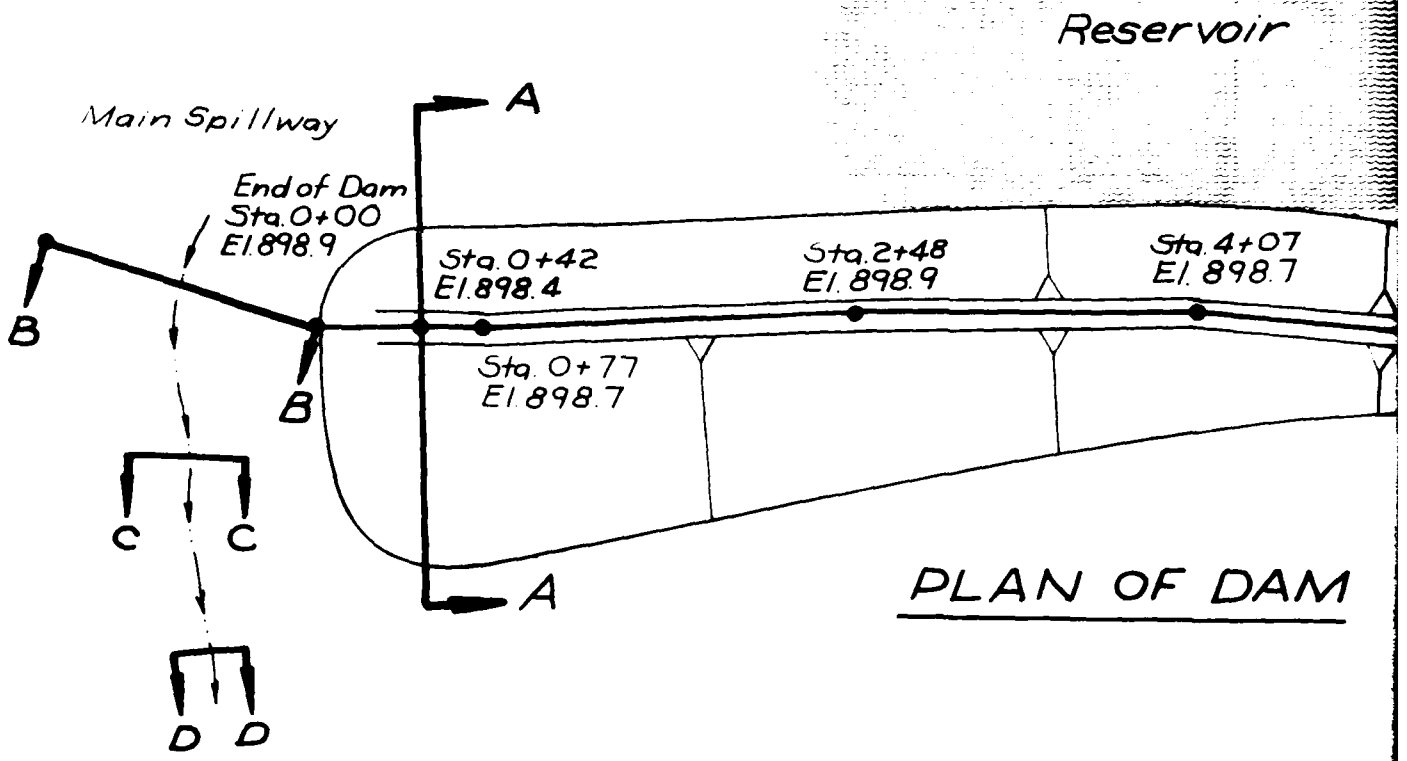
- State highway and Route No.
- River or Creek
- City or Town
- Project location

SITE LOCATION MAP	
HORNSEY BROTHERS DAM	
MO 30101	Fig. 1

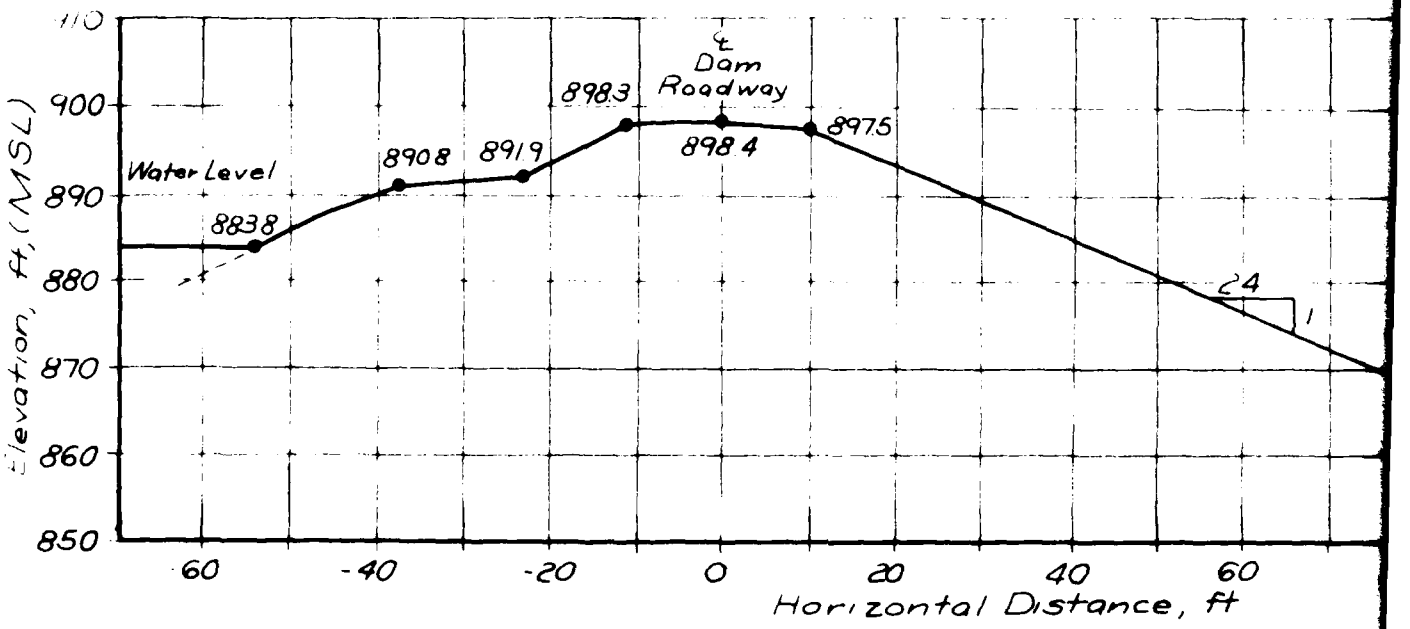


1. Topography from USGS Potosi (1958) and Shirley (1958) 7.5-minute quadrangle map.

DRAINAGE BASIN AND SITE TOPOGRAPHY	
HORNSEY BROTHERS DAM	
MO 30101	Fig. 2



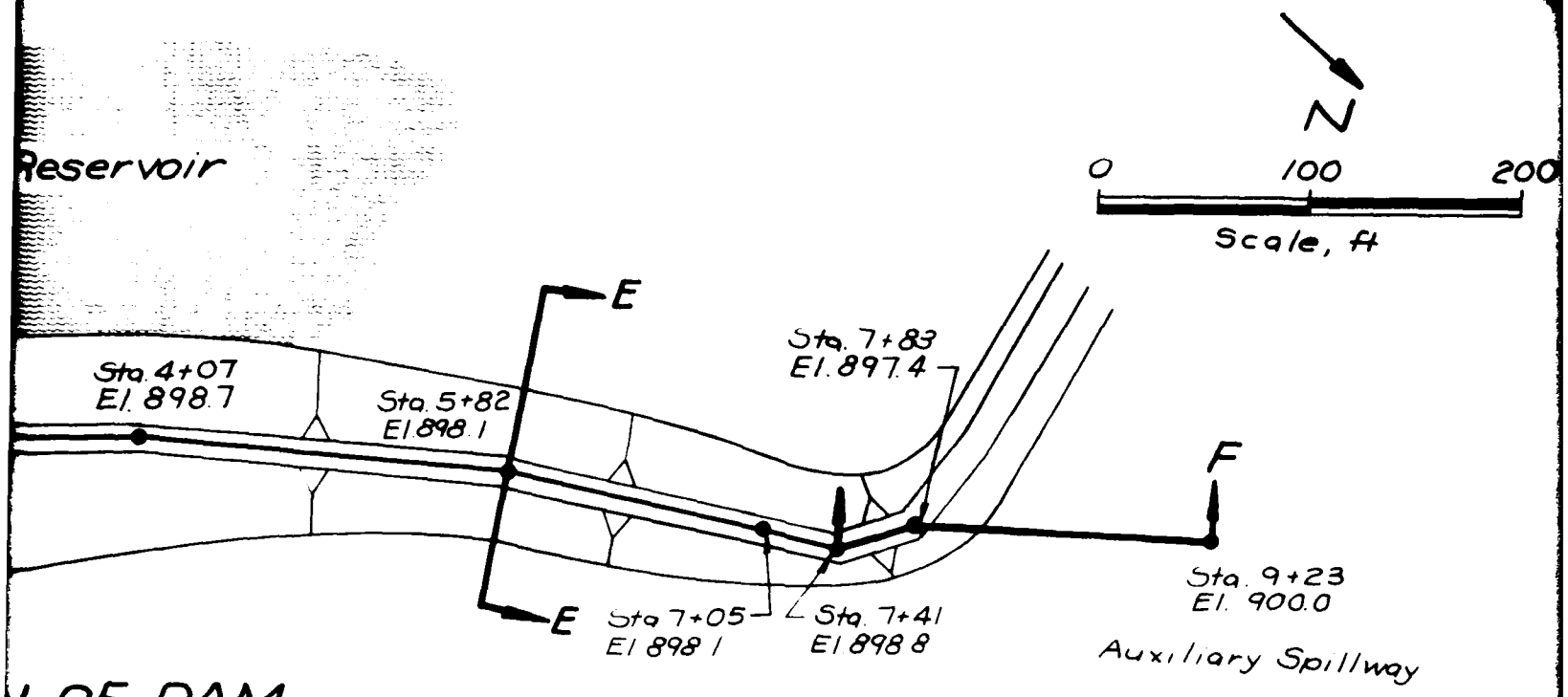
PLAN OF DAM



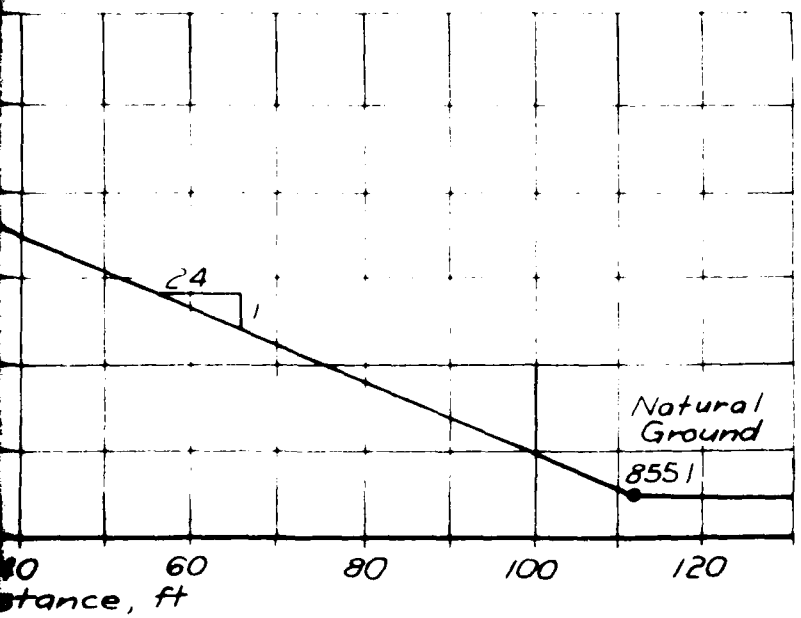
SECTION A-A

Dam Section

(Not at Maximum Section)



N OF DAM



A-A

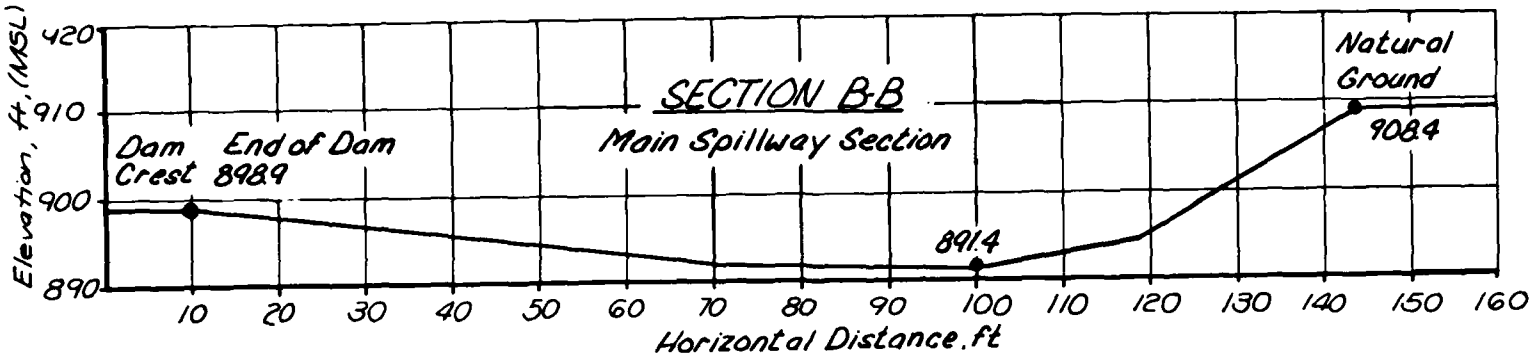
ion

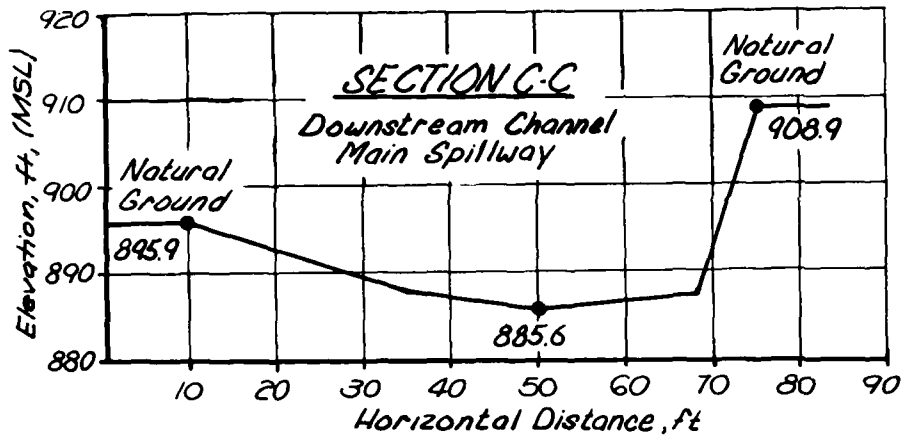
um Section)

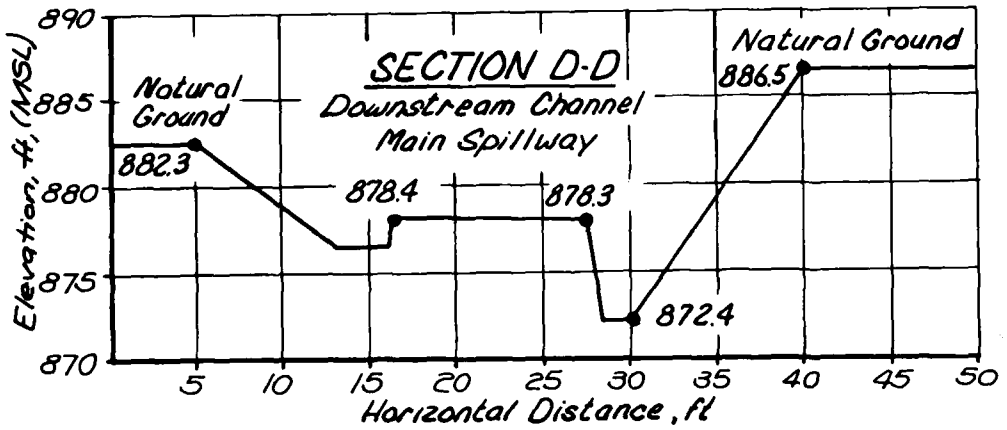
Note

Surveyed 8-4-80 and 12-4-80.
James F McCaul and Associates,
Potosi, Missouri

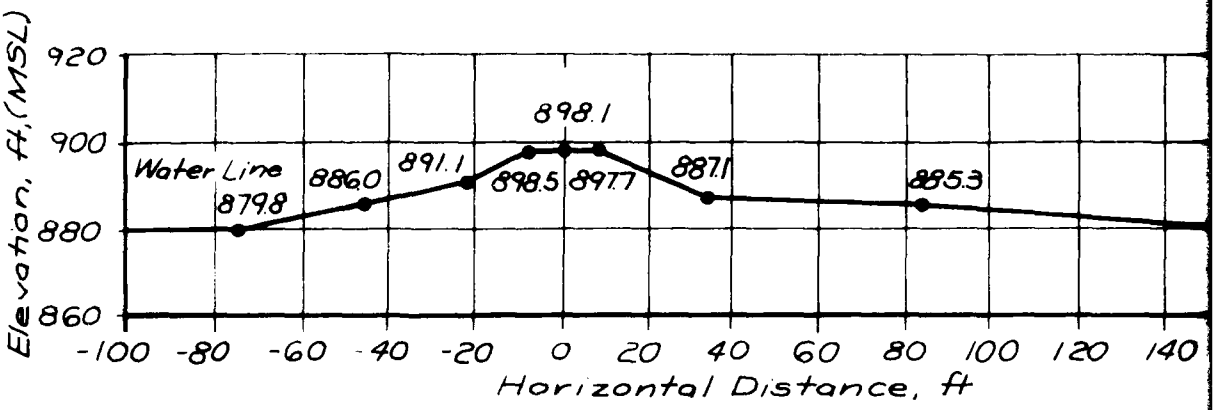
PLAN AND SECTION OF DAM	
HORNSEY BROTHERS DAM	
MO 30101	Fig. 3-A





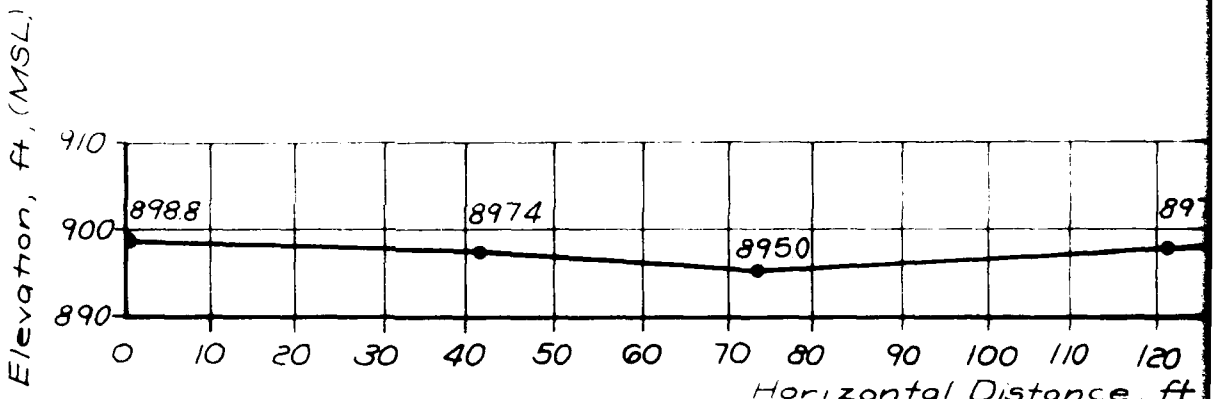


SECTIONS OF MAIN SPILLWAY AND DOWNSTREAM CHANNEL	
HORNSEY BROTHERS DAM	
MO 30101	Fig. 3-B



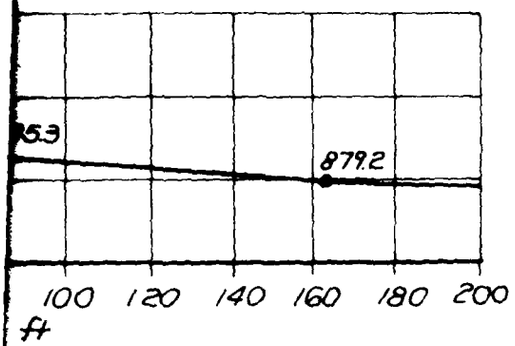
SECTION E-E

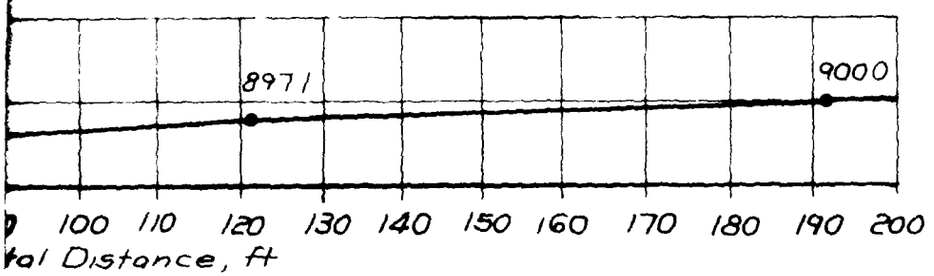
Dam Section
(Near Auxiliary Spillway)



SECTION F-F

Auxiliary Spillway





TION F-F

ry Spillway

SECTIONS OF DAM AND AUXILIARY SPILLWAY	
HORNSEY BROTHERS DAM	
MO 30101	Fig. 3-C

Legend

- Roubidoux Formation
- Gasconade Dolomite
  - Gunter Sandstone Member
- Eminence Dolomite
- Potosi Dolomite
- Derby-Doerun Dolomite
- 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

REGIONAL GEOLOGIC MAP

HORNSEY BROTHERS DAM

MO 30101 | **Fig. 4**

APPENDIX A

Photographs

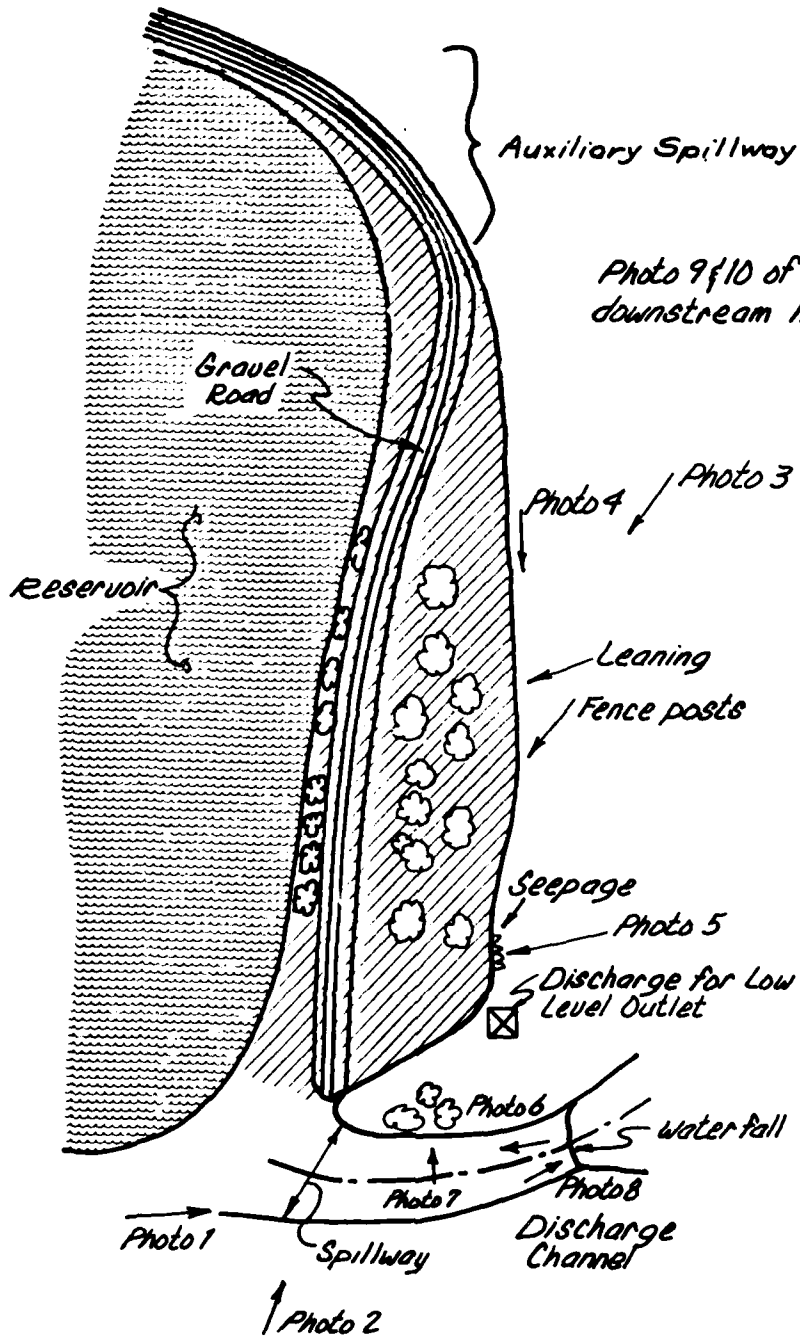


PHOTO LOCATION SKETCH	
HORNSEY BROTHERS DAM	
MO. 30101	Fig. A-1

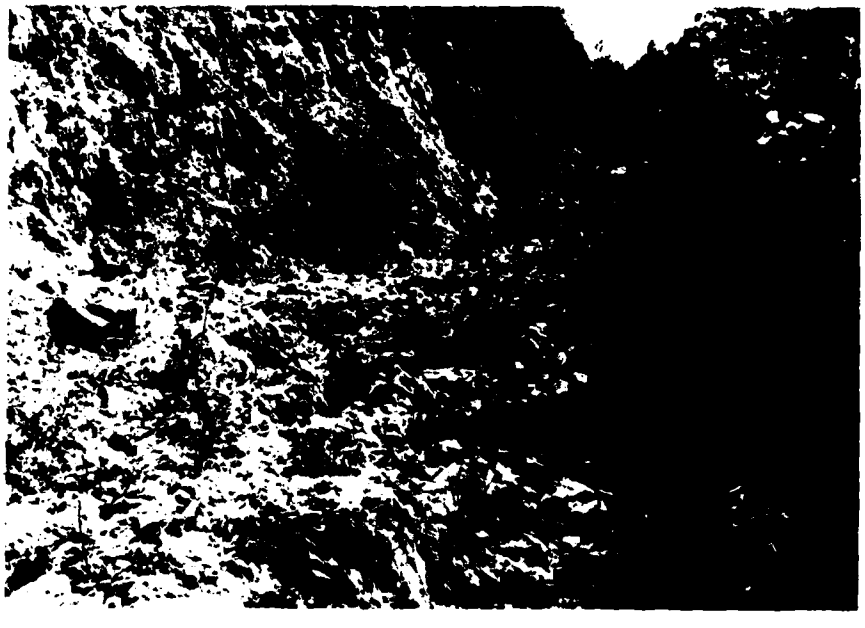
1. Spillway excavated in rock at right abutment. Looking north downstream.

2. Roadway and dam crest from right abutment. Looking northwest. Note vegetation on upstream and downstream slopes.

3. Downstream face of dam. Note vegetation on face of dam. Also note inclined fence posts near inspection team. Looking south.

4. Inclined fence posts at toe of dam, suggesting soil creep. Looking southeast along toe of dam.

5. Minor seepage at toe of dam. Seepage rate very slow, no apparent movement of water.



6. Discharge channel blasted in bedrock. Looking southwest, upstream.

7. Jointed bedrock in discharge channel.

8. Waterfall in discharge channel, approximately 200ft downstream of spillway. Looking north toward original streambed.

9. Downstream hazards below dam. Looking east. Dam out of picture to lower right.

10. Downstream hazard zone. Looking east.

APPENDIX B

Hydraulic/Hydrologic 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
$s = \frac{1000}{CN} - 10$ where CN = hydrologic soil curve number
Y = average watershed land slope in percent

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 15 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 - spillway crest elevation

(2) Probable Maximum Storm - spillway crest elevation

Because the low level outlet pipe is of small diameter, it was assumed to be either blocked or inoperable and will not pass any amount of the flood.

f. Spillway Rating Curve. The spillway rating curves for the main and auxiliary spillways were calculated individually and then added together. These capacities were entered on the Y4 and Y5 cards to the HEC-1 program.

B.2 Pertinent Data

a. Drainage area. 1.48 mi^2

b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 48 hours duration was divided into 15 minute intervals in order to develop the inflow hydrograph.

c. Lag time. 1.72 hrs

d. Hydrologic soil group. C

e. SCS curve numbers.

1. For PMF- AMC III - Curve Number 86
2. For 1 and 10 percent probability-of-occurrence events-AMC II - Curve Number 72

f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Shirley, MO (1958) and Potosi, MO (1958) 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 rating curves for the main and auxiliary spillways were individually computed by using the HEC-2 program. These two curves were subsequently combined into a single rating curve which was then entered on the Y4 and Y5 cards.

i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 891.4 ft, the main spillway crest elevation. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was also 891.4 ft, the main spillway crest 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.

NO 30101
HORNSEY BROS.
PMF
Detailed Output

```
**********   **********
HMR6 HYG   RAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
 LAST MODIFICATION  01 APR 80
**********
....1 ... .. .... A1 ..  DAM NO. 30101 - HORNSEY BROTHERS DAM, WASHINGTON COUNTY, MISSOURI.
    2          A2       WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 79CH009.
    3          A3       PROBABLE MAXIMUM FLOODS (PMF) ANALYSIS.
    4          B   144        0      20      -0      -0      -0      -0      -0      -0      -0
    5          B1   5
    6          J     1        2       1
    7          J1  .50     1.00
    8          K     0      0-IN                                      1
    9          K1  HORNSEY BROTHERS DAM INFLOW COMPUTATION, PMF RATIO FLOODS.
   10          M     1        2    1.48                      1.0
   11          P     0      26.     102     120     130     140
   12          T                                                    -1     -86             0.06
   13          M2          1.72
   14          K    -1     -.05       9
   15          K     1      DAM                                     1
   16          K1  HORNSEY BROTHERS DAM PMF FLOOD ROUTINGS.
   17          Y                                      1       1
   18          Y1    1                                                -891.4     -1
   19          Y4 891.4   891.9   892.3   892.7   893.1   894.1   894.8   895.5    896.    896.5
   20          Y4  897.    897.5   898.    898.5   899.    899.5   900.
   21          Y5   0.     10.     50.     100.    200.    500.    800.    1160.   1535.   1930.
   22          Y5 2430.   3010.   3740.   4450.   5470.   6500.   7650.
   23          SA   0.     4.7    13.5    32.4    55.4    60.     77.     85.
   24          SE  850.    860.    870.    880.    890.    891.4   897.4   900.
   25          SS 891.4    74.     2.9     1.5
   26          SD 898.1    2.8     1.5
   27          SL   0.    145.    685.    705.
   28          SV 898.1   898.5   899.    899.2
   29          K    99
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Input Data
Various PMF Events
Hornsey Brothers Dam
MO 30101

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**********  /**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION  JULY 1978
LAST MODIFICATION  01 APR 80
**********
RUN DATE= 30 JAN 81
TIME= 12.37.20
```

DAM NO. 30101 - HORNSEY BROTHERS DAM. WASHINGTON COUNTY. MISSOURI.
WOODWARD-CLYDE CONSULTANTS. HOUSTON JOB 79CH009.
PROBABLE MAXIMUM FLOODS (PMF) ANALYSIS.

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
144	0	20	-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

HORNSEY BROTHERS DAM INFLOW COMPUTATION. PMF RATIO FLOODS.

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
Q-IN	0	-0	-0	-0	-0	1	-0	-0

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	1.48	-0.	1.48	1.00	-0.	-0	-0	-0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.	26.00	102.00	120.00	130.00	140.00	-0.	-0.

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
-0	-0.	-0.	1.00	-0.	-0.	1.00	-1.00	-86.00	-0.	.06

CURVE NO = -86.00 WETNESS = -1.00 EFFECT CN = 86.00

UNIT HYDROGRAPH DATA
TC= -0. LAG= 1.72

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

UNIT HYDROGRAPH 20 END OF PERIOD ORDINATES. TC= -0. HOURS. LAG= 1.72 VOL= 1.00

32.	96.	200.	313.	371.	376.	342.	290.	217.	156.
117.	89.	67.	50.	38.	28.	21.	16.	12.	9.
7.	5.	4.	3.	2.	2.	1.	0.		

END-OF-PERIOD FLOW

Output Summary
Various PMF Events
Hornsey Brothers Dam
MO 30101

RECESSION DATA

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

UNIT HYDROGRAPH 20 END OF PERIOD ORDINATES, TC= -0. HOURS, LAG= 1.72 VOL= 1.00

32.	96.	200.	313.	371.	376.	342.	290.	217.	156.
117.	89.	67.	50.	38.	28.	21.	16.	12.	9.
7.	5.	4.	3.	2.	2.	1.	0.		

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	.20	1	.00	.00	.00	1.	1.02	.20	73	.06	.05	.01	19.
1.01	.40	2	.00	.00	.00	1.	1.02	.40	74	.06	.05	.01	23.
1.01	1.00	3	.00	.00	.00	1.	1.02	1.00	75	.06	.05	.01	31.
1.01	1.20	4	.00	.00	.00	1.	1.02	1.20	76	.06	.05	.01	44.
1.01	1.40	5	.00	.00	.00	1.	1.02	1.40	77	.06	.05	.01	60.
1.01	2.00	6	.00	.00	.00	1.	1.02	2.00	78	.06	.05	.01	76.
1.01	2.20	7	.00	.00	.00	1.	1.02	2.20	79	.06	.05	.01	91.
1.01	2.40	8	.00	.00	.00	1.	1.02	2.40	80	.06	.05	.01	104.
1.01	3.00	9	.00	.00	.00	1.	1.02	3.00	81	.06	.05	.01	114.
1.01	3.20	10	.00	.00	.00	1.	1.02	3.20	82	.06	.05	.01	121.
1.01	3.40	11	.00	.00	.00	1.	1.02	3.40	83	.06	.05	.01	127.
1.01	4.00	12	.00	.00	.00	1.	1.02	4.00	84	.06	.05	.01	131.
1.01	4.20	13	.00	.00	.00	1.	1.02	4.20	85	.06	.05	.01	134.
1.01	4.40	14	.00	.00	.00	1.	1.02	4.40	86	.06	.05	.01	137.
1.01	5.00	15	.00	.00	.00	1.	1.02	5.00	87	.06	.05	.01	139.
1.01	5.20	16	.00	.00	.00	1.	1.02	5.20	88	.06	.05	.01	141.
1.01	5.40	17	.00	.00	.00	1.	1.02	5.40	89	.06	.05	.01	142.
1.01	6.00	18	.00	.00	.00	1.	1.02	6.00	90	.06	.05	.01	144.
1.01	6.20	19	.02	.00	.02	1.	1.02	6.20	91	.26	.23	.03	150.
1.01	6.40	20	.02	.00	.02	1.	1.02	6.40	92	.26	.24	.02	169.
1.01	7.00	21	.02	.00	.02	1.	1.02	7.00	93	.26	.24	.02	206.
1.01	7.20	22	.02	.00	.02	1.	1.02	7.20	94	.26	.24	.02	269.
1.01	7.40	23	.02	.00	.02	2.	1.02	7.40	95	.26	.24	.02	339.
1.01	8.00	24	.02	.00	.02	2.	1.02	8.00	96	.26	.24	.02	406.
1.01	8.20	25	.02	.00	.02	2.	1.02	8.20	97	.26	.25	.01	472.
1.01	8.40	26	.02	.00	.02	3.	1.02	8.40	98	.26	.25	.01	526.
1.01	9.00	27	.02	.00	.02	3.	1.02	9.00	99	.26	.25	.01	571.
1.01	9.20	28	.02	.00	.02	3.	1.02	9.20	100	.26	.25	.01	604.
1.01	9.40	29	.02	.00	.02	3.	1.02	9.40	101	.26	.25	.01	629.
1.01	10.00	30	.02	.00	.02	3.	1.02	10.00	102	.26	.25	.01	648.
1.01	10.20	31	.02	.00	.02	3.	1.02	10.20	103	.26	.25	.01	664.
1.01	10.40	32	.02	.00	.02	3.	1.02	10.40	104	.26	.25	.01	676.
1.01	11.00	33	.02	.00	.02	3.	1.02	11.00	105	.26	.25	.01	686.
1.01	11.20	34	.02	.00	.02	4.	1.02	11.20	106	.26	.25	.01	694.
1.01	11.40	35	.02	.00	.02	4.	1.02	11.40	107	.26	.25	.01	700.
1.01	12.00	36	.02	.00	.02	4.	1.02	12.00	108	.26	.25	.01	705.
1.01	12.20	37	.07	.01	.05	5.	1.02	12.20	109	.88	.86	.02	720.
1.01	12.40	38	.07	.02	.05	7.	1.02	12.40	110	.88	.87	.02	790.
1.01	13.00	39	.07	.02	.05	11.	1.02	13.00	111	.88	.87	.02	915.
1.01	13.20	40	.08	.03	.05	16.	1.02	13.20	112	1.06	1.04	.02	1119.
1.01	13.40	41	.08	.03	.05	24.	1.02	13.40	113	1.06	1.05	.01	1361.
1.01	14.00	42	.08	.04	.04	33.	1.02	14.00	114	1.06	1.05	.01	1630.
1.01	14.20	43	.10	.05	.05	44.	1.02	14.20	115	1.33	1.31	.01	1906.
1.01	14.40	44	.10	.06	.05	57.	1.02	14.40	116	1.33	1.32	.01	2178.
1.01	15.00	45	.10	.06	.04	71.	1.02	15.00	117	1.33	1.32	.01	2433.
1.01	15.20	46	.18	.11	.07	87.	1.02	15.20	118	2.32	2.30	.01	2707.
1.01	15.40	47	.49	.34	.14	115.	1.02	15.40	119	6.35	6.32	.03	3193.
1.01	16.00	48	.11	.08	.03	153.	1.02	16.00	120	1.41	1.41	.00	3777.
1.01	16.20	49	.10	.07	.02	203.	1.02	16.20	121	1.24	1.23	.00	4572.
1.01	16.40	50	.10	.07	.02	253.	1.02	16.40	122	1.24	1.23	.00	5330.
1.01	17.00	51	.10	.08	.02	284.	1.02	17.00	123	1.24	1.23	.00	5716.
1.01	17.20	52	.07	.06	.01	295.	1.02	17.20	124	.97	.97	.00	5752.
1.01	17.40	53	.07	.06	.01	292.	1.02	17.40	125	.97	.97	.00	5529.

Output Summary
Various PMF Events
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1.	14.40	44	.10	.06	.05	57.	1.02	14.40	116	1.33	1.32	.01	2178.
1	15.00	45	.10	.06	.04	71.	1.02	15.00	117	1.33	1.32	.01	2433.
1..	15.20	46	.18	.11	.07	87.	1.02	15.20	118	2.32	2.30	.01	2707.
1.01	15.40	47	.49	.34	.14	115.	1.02	15.40	119	6.35	6.32	.03	3193.
1.01	16.00	48	.11	.08	.03	153.	1.02	16.00	120	1.41	1.41	.00	3777.
1.01	16.20	49	.10	.07	.02	203.	1.02	16.20	121	1.24	1.23	.00	4572.
1.01	16.40	50	.10	.07	.02	253.	1.02	16.40	122	1.24	1.23	.00	5330.
1.01	17.00	51	.10	.08	.02	284.	1.02	17.00	123	1.24	1.23	.00	5716.
1.01	17.20	52	.07	.06	.01	295.	1.02	17.20	124	.97	.97	.00	5752.
1.01	17.40	53	.07	.06	.01	292.	1.02	17.40	125	.97	.97	.00	5529.
1.01	18.00	54	.07	.06	.01	279.	1.02	18.00	126	.97	.97	.00	5149.
1.01	18.20	55	.01	.01	.00	255.	1.02	18.20	127	.09	.09	.00	4608.
1.01	18.40	56	.01	.01	.00	230.	1.02	18.40	128	.09	.09	.00	4077.
1.01	19.00	57	.01	.01	.00	205.	1.02	19.00	129	.09	.09	.00	3570.
1.01	19.20	58	.01	.01	.00	176.	1.02	19.20	130	.09	.09	.00	3040.
1.01	19.40	59	.01	.01	.00	147.	1.02	19.40	131	.09	.09	.00	2508.
1.01	20.00	60	.01	.01	.00	119.	1.02	20.00	132	.09	.09	.00	2015.
1.01	20.20	61	.01	.01	.00	94.	1.02	20.20	133	.09	.09	.00	1568.
1.01	20.40	62	.01	.01	.00	74.	1.02	20.40	134	.09	.09	.00	1254.
1.01	21.00	63	.01	.01	.00	59.	1.02	21.00	135	.09	.09	.00	996.
1.01	21.20	64	.01	.01	.00	49.	1.02	21.20	136	.09	.09	.00	810.
1.01	21.40	65	.01	.01	.00	41.	1.02	21.40	137	.09	.09	.00	677.
1.01	22.00	66	.01	.01	.00	34.	1.02	22.00	138	.09	.09	.00	565.
1.01	22.20	67	.01	.01	.00	30.	1.02	22.20	139	.09	.09	.00	484.
1.01	22.40	68	.01	.01	.00	26.	1.02	22.40	140	.09	.09	.00	424.
1.01	23.00	69	.01	.01	.00	24.	1.02	23.00	141	.09	.09	.00	380.
1.01	23.20	70	.01	.01	.00	22.	1.02	23.20	142	.09	.09	.00	347.
1.01	23.40	71	.01	.01	.00	20.	1.02	23.40	143	.09	.09	.00	321.
1.02	0.	72	.01	.01	.00	19.	1.03	0.	144	.09	.09	.00	301.
									SUM	36.40	34.63	1.77	97511.
										925.11	880.11	45.11	2761.20

Output Summary
Various PMF Events
Hornsey Brothers Dam
MO 30101

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	RATIO APPLIED TO FLOWS RATIO 1 .50	RATIO 2 1.00
HYDROGRAPH AT	G-IN	1.48	1	2876.	5752.
		(3.83)	(	81.44)(	162.89)(
ROUTED TO	DAM	1.48	1	2460.	5540.
		(3.83)	(	69.65)(	156.87)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	891.40	891.40	898.10
	STORAGE	840.	840.	1305.
	OUTFLOW	0.	0.	3682.

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	897.03	0.	1222.	2460.	0.	42.00	0.
1.00	898.88	.78	1368.	5540.	2.33	41.67	0.

Output Summary
Various PMF Events
Hornsey Brothers Dam
MO 30101

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	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6
				.70	.72	.74	.75	.76	.78
HYDROGRAPH AT	D-IN	1.48	1	4027.	4142.	4257.	4314.	4372.	4487.
		(3.831)	(	114.021(	117.281(	120.541(	122.171(	123.801(	127.051(
ROUTED TO	DAM	1.48	1	3653.	3767.	3876.	3931.	3986.	4098.
		(3.831)	(	103.441(	106.661(	109.751(	111.311(	112.871(	116.041(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	891.40	891.40	898.10
STORAGE	840.	840.	1305.
OUTFLOW	0.	0.	3882.

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
.70	897.94	0.	1292.	3653.	0.	42.00	0.
.72	898.02	0.	1298.	3767.	0.	42.00	0.
.74	898.10	0.	1304.	3876.	0.	42.00	0.
.75	898.13	.03	1308.	3931.	.67	42.00	0.
.76	898.17	.07	1311.	3986.	.67	42.00	0.
.78	898.25	.15	1317.	4098.	1.00	42.00	0.

Output Summary
Various PMF Events
Hornsey Brothers Dam
MO 30101

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