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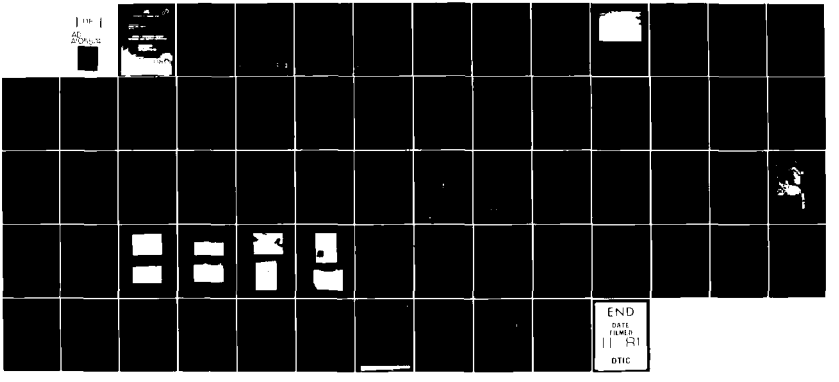

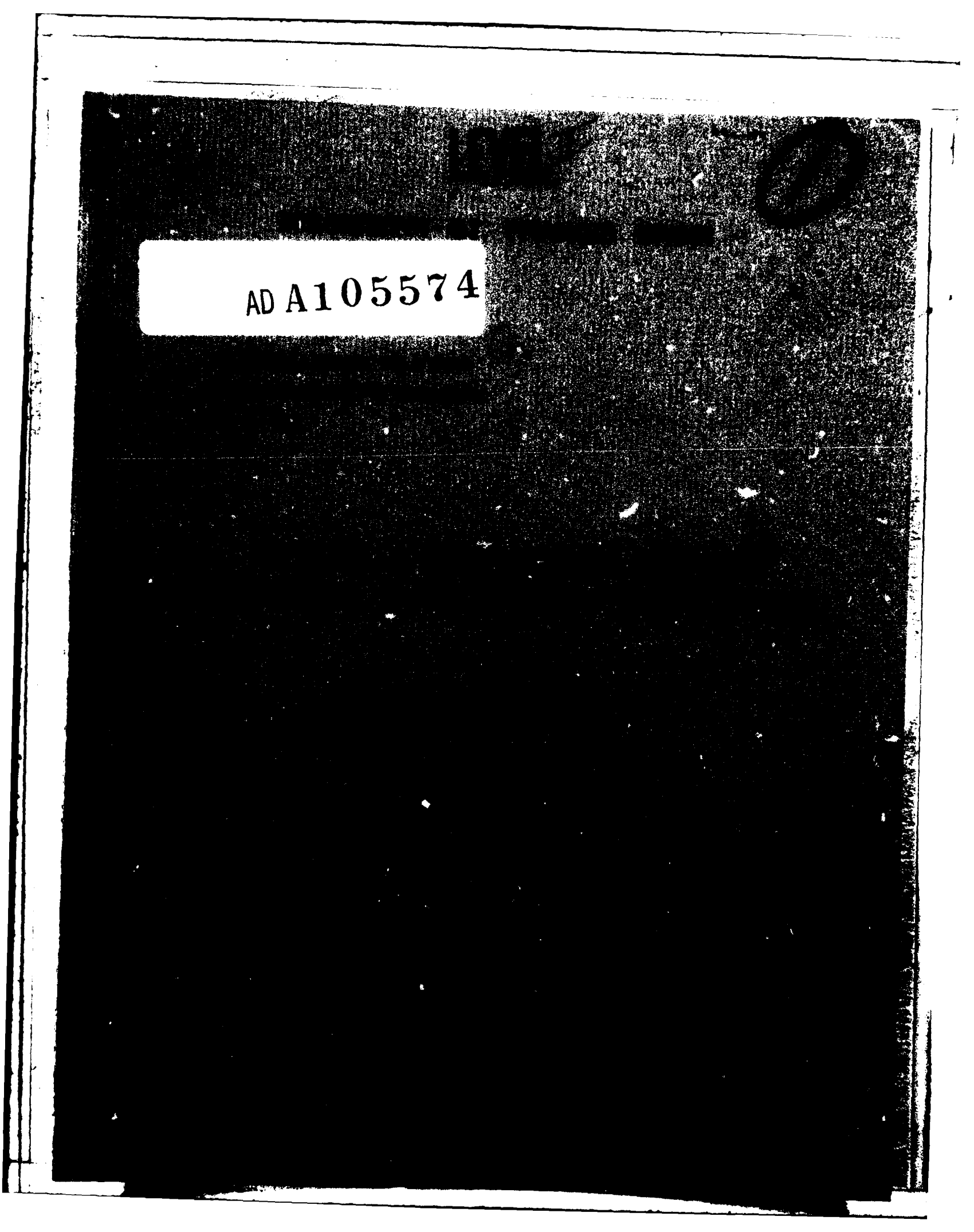

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This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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

REPLY TO ATTENTION OF

SUBJECT: John Bollinger No. 2 Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the John Bollinger No. 2 Dam (MO 31433).

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

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

a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED
Chief, Engineering Division
28 APR 1981
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer
29 APR 1981
Date

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JOHN BOLLINGER NO. 2 DAM

Madison County, Missouri

Missouri Inventory No. 31433

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.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	John Bollinger No. 2 Dam
State Located	Missouri
County Located	Madison
Stream	Unnamed Tributary of Saline Creek
Date of Inspection	13 November 1980

John Bollinger No. 2 Dam, Missouri Inventory Number 31433, 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 of those dams which may pose hazards to human life or property based on available data and a visual inspection. 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. Approximately eight occupied dwellings, assorted outbuildings, and Missouri Highways 72 and Z are located in this damage zone, which extends to the outskirts of the town of Fredericktown. The contents of the damage zone were verified by aerial reconnaissance. Loss of life and property could take place in the event of overtopping and failure of the dam.

The dam is classified as small, based on its 19 ft height and storage capacity of 54 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 the dam is in generally good condition. No evidence of significant erosion, slumps, or unexpected settlement was noted on this dam. No animal burrows were noted.

Some erosion may occur during flood flows in the auxiliary spillway and in the discharge channel downstream of the dam.

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

Hydraulic/hydrologic analyses indicate the 1 percent probability-of-occurrence event (100 year flood) will be passed without overtopping the dam. These analyses also indicate a storm greater than 40 percent of the 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 small impounded volume of water, the small drainage basin, the broad flow area downstream of this dam, and the distance to the nearest residences, it is recommended that 50 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 without undue delay for the facilities at John Bollinger No. 2 Dam:

1. Design and construct appropriate facilities to enable the dam to pass at least 50 percent of the PMF without overtopping.

2. Evaluate options for erosion protection or relocation of the downstream channel below the auxiliary spillway. Considerations should also be given to the erodible nature of the embankment and the downstream channel. Additional planting of appropriate grasses should be considered to provide a more uniform vegetative cover and minimize erosion.

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

4. Construction of an appropriate trash rack at the inlet of the main spillway to prevent blockage and obstruction of flood discharge.

A program of periodic inspections is recommended to be implemented as soon as practical, and should include but not be limited to the following:

1. Inspection of seepage areas to detect increases in rate of flow or turbidity (soil) in the seepage water;

2. Inspection of slopes for evidence of instability such as cracking or deformations of the embankment;

3. Inspection of the discharge channel, toe of dam and auxiliary spillway to identify any evidence of erosion that could adversely influence the stability of the dam.

4. Inspection of the trash rack, which should be constructed at the inlet to 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.

An evaluation should be made of a practical and effective warning system to alert downstream traffic and residents should hazardous conditions develop at this dam.

WOODWARD-CLYDE CONSULTANTS

Richard G. Berggreen
Registered Geologist

Leonard M. Krazynski, P.E.
Vice President

OVERVIEW
JOHN BOLLINGER NO.2 DAM

MISSOURI INVENTORY NUMBER 31433

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
JOHN BOLLINGER NO. 2 DAM, MISSOURI INVENTORY NO. 31433

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
JOHN BOLLINGER NO. 2 DAM, MISSOURI INVENTORY NO. 31433

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 John Bollinger No. 2 Dam, Missouri Inventory Number 31433.

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," and Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design 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 (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.** John Bollinger No. 2 Dam is an earth dam constructed to impound a small lake for irrigation. The dam was designed by the US Soil Conservation Service. The dam appears to be constructed in accordance with the design, with some modifications. Design plans are presented in Appendix C.

The normal operating pool outlet, or main spillway, consists of a 12-in. dia asbestos-concrete pipe through the center of the dam. The outlet of this pipe is near the toe of the maximum section. No valve was noted on the pipe during the field inspection.

An auxiliary spillway is located at the left abutment (as the observer faces downstream). This auxiliary spillway consists of a broad low area subject to overtopping during flood events. The area considered as the auxiliary spillway is approximately 150 ft wide at an elevation of 824.0 ft (the minimum top of dam at the right abutment). There are no control structures for regulating flows through this spillway.

b. **Location.** The dam is located in Madison County, Missouri, approximately two miles northeast of Fredericktown, along Shulte Road, in Survey Number 3323, T33N, R7E (Fig 1). The dam is on an unnamed tributary of Saline Creek on the USGS Fredericktown, Missouri, 7.5-minute quadrangle map (1980).

c. **Size classification.** The dam is classified as small on the basis of its storage volume of 54 ac-ft and height of 19 ft. A small dam is one that impounds 50 to 1000 ac-ft, or is 25 to 40 ft high.

d. **Hazard classification.** 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. Within this damage zone, which extends to the outskirts of the town of Fredericktown, are approximately eight occupied dwellings, assorted buildings, and two Missouri Highways. The contents of the hazard zone were verified by aerial reconnaissance. There exists a potential for loss of life and property in the event of overtopping and failure of this dam.

e. **Ownership.** The dam is reportedly owned by Mr John Bollinger, Route 1, Fredericktown, Missouri, 63645. Correspondence should be addressed to Mr Bollinger.

f. **Purpose of dam.** The dam was constructed to impound a small lake to be used for irrigation of crops.

g. **Design and construction history.** The dam was constructed in 1978. Soil Conservation Service design notes for the dam and outlet pipe spillway were supplied by Mr K. G. McManus of the Soil Conservation Service. Our visual inspection and survey indicate the dam was constructed with some deviations from the design documents. The main deviations are that the main spillway is a 12-in. diameter concrete-asbestos pipe instead of a 6-in. diameter iron pipe and that the auxiliary spillway is at the left abutment instead of the right. It is not known whether the antiseep collars called for in the SCS design were actually installed with the pipe. The design notes are included as Appendix C.

h. **Normal operating procedures.** No operating records were found. Normal operating outflow would pass through the main spillway outlet pipe, or over the auxiliary spillway at the left abutment. The field inspection found evidence (soil erosion at the discharge end of pipe) indicating overflow through the pipe had occurred. No evidence was found of overflow at the auxiliary spillway.

1.3 Pertinent Data

a. **Drainage area.** Approximately 0.09 mi^2

b. **Discharge at damsite.**

Maximum known flood at damsite	Unknown
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	220 ft^3/sec
Total spillway capacity at maximum pool elevation	220 ft^3/sec

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

Top of dam	824.0 to 825.5
Maximum pool-design surcharge	N/A
Full flood control pool	N/A
Recreation pool	N/A
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 at maximum section	806.5

d. **Reservoir.**

Length of maximum pool	700 ft
Length of recreation pool	N/A
Length of flood control pool	N/A

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

Recreation pool	22 (at el 819.1)
Flood control pool	N/A
Design surcharge	N/A
Top of dam	54

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

Top of dam	8.3
Maximum pool	8.3
Flood control pool	N/A
Recreation pool	N/A
Spillway crest	4.8

g. **Dam.**

Type	Compacted earth
Length	805 ft
Height	19 ft
Top width	12 ft
Side slopes	Upstream; 4.2(H) to 4.6(H): 1(V) Downstream; 2.3(H): 1(V)
Zoning	None
Impervious core	None
Cutoff	10 ft wide trench, depth not specified
Grout curtain	None

h. **Diversion and regulating tunnel.**

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

i. **Spillway.**

Type	Main: 12-in. diameter ungated, asbestos-concrete pipe through maximum section of dam. Auxiliary: uncontrolled, unlined weir at left abutment.

	Length of weir	Main: N/A Auxiliary: 150 ft at elevation of top of dam (824 ft).
	Crest elevation	Main: 819.1 ft (MSL) Auxiliary: 822.9 ft (MSL)
	Gates	None
	Downstream channel	Main spillway: culvert under Shulte Road. Auxiliary spillway; unlined ditch at toe of dam; runs along toe of dam to junction with the main spillway downstream channel near the discharge end of the 12-in. diameter asbestos-concrete pipe near the maximum section of the dam.
j.	**Regulating outlets.**	None

SECTION 2
ENGINEERING DATA

2.1 Design

Design notes for John Bollinger No. 2 Dam were supplied by Mr K. G. McManus, State Conservationist, Soil Conservation Service. These included survey notes, design computations, drawings and survey check-out notes. Of principal use in the evaluation and the visual inspection was the diagram of the cross section through the maximum section and spillway pipe. This is included in Appendix C.

The field inspection and survey of the dam identified some minor variances from the design drawings. The spillway pipe was designed as a 6-in. diameter pipe. The dam was constructed using a 12-in. diameter pipe. The auxiliary spillway was designed to be 1.5 ft higher than the inlet elevation for the spillway pipe. It was surveyed as 3.8 ft higher. The auxiliary spillway is at the left abutment instead of at the right abutment, as designed.

The design drawings show an anticipated settlement of the dam fill of 2.3 ft. As the survey check-out notes were not referenced to Mean Sea Level Datum, the actual settlement of the fill cannot be accurately determined. The relative settlement cannot be determined from the survey notes because the points that were surveyed are not clearly defined.

Other features of the design such as placement of seepage collars and cutoff trench dimensions could not be inspected.

2.2 Construction

No records were available of compaction tests on the embankment materials. The embankment fill was described as class IV (SCS). No other records of construction were available.

2.3 Operation

There are no operating facilities at this dam. Water levels are controlled by flow through the ungated spillway pipe and the auxiliary spillway at the left abutment.

2.4 Evaluation

a. **Availability.** The only engineering data obtained for evaluation of this dam were from the Soil Conservation Service design notes included in Appendix C.

b. **Adequacy.** The available data are insufficient to evaluate the adequacy of design of this dam. Stability and seepage analyses comparable to the "Recommended Guidelines for Safety Inspections of Dams" are not on record, which is considered a deficiency. These stability and seepage 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 the Soil Conservation Service appear to generally reflect the present condition of the dam, with the exception of the items mentioned in Section 2.1.

2.5 Project Geology

The dam site is located just north of the center of the Ozark structural dome. Bedrock in the area is mapped on the Geologic Map of Missouri (1979) as Cambrian age Elvins Group and Bonneterre Formation (Fig 4). The site appears to be located near the base of this section and is likely underlain by Bonneterre Formation. The Bonneterre Formation is typically a light grey, medium- to fine-grained dolomite with glauconitic or shaley partings and beds.

A residual clay soil profile developed on the carbonate bedrock is present over most of the site. This soil (CL-CH) is apparently the material used in the dam construction. The soil is mapped on the Missouri General Soil Map (1979) as Peridge-Cantwell-Gasconade Association.

A branch of the Simms Mountain Fault System is mapped on the Structural Features Map of Missouri approximately two miles northeast of the dam. The Simms Mountain System is a complex network of faults approximately 42 mi long, with displacement on the faults typically up to the southwest. The fault appears to be limited to Precambrian and lower Paleozoic formations. The dam site is not considered to be in a seismically active area and the fault system does not appear to pose a significant hazard to the dam.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** A visual inspection was conducted of John Bollinger No. 2 Dam on 13 November 1980, without the owner's representative present. This inspection indicated the dam embankment was in generally good condition. The lake water surface was quite low due to a dry period prior to the inspection. Deficiencies pertaining to the inadequate spillway capacity and the lack of a trash rack at the main spillway are discussed in this report.

b. **Dam.** The dam is constructed of compacted earth, primarily a stiff light gray and brown silty clay (CL-CH). Some minor amounts of gravel are present. The soil appears to be a residual clay developed on the carbonate bedrock in the area.

The vertical and horizontal alignment of the dam appears undisrupted (Photo 2). No animal burrows were noted. Numerous shrinkage cracks were noted on the surface of the dam (Photo 7). No evidence of slumping or slope instability was noted during the inspection. Some minor erosion rills were noted on both the upstream and downstream slopes of the dam.

There is no riprap or other erosion protection on the upstream slope but due to the short fetch of the reservoir, none is probably needed.

Very minor seepage was noted along the toe of the dam. Cattail vegetation was growing in soggy ground near the toe of the dam (Photo 8). The seepage quantity could not be estimated as there was no discernable flow.

c. **Appurtenant Structures.**

1. Main spillway. The main spillway consists of a 12-in. dia asbestos-concrete pipe extending through the dam embankment. There is no trash rack or canopy at the upstream end of the pipe. However, the drainage basin is

used exclusively for agriculture and opportunity for developing obstructions sufficient to block the pipe is comparatively limited. However, a trash rack should be constructed to avoid blocking the pipe with such objects as discarded plastic bags, etc. No valves or controls were noted on the pipe. The outlet exits near the toe of the dam near the maximum section (Photos 6 and 8).

2. Auxiliary spillway. The auxiliary spillway is a broad low area at the left abutment. It will serve as an overflow during heavy flooding. The overflow area is ill-defined with no distinct margins. The minimum top of dam elevation considered for the overtopping analysis (Section 5) is 824.0 ft, where overflow would begin over the right abutment.

The embankment materials appear moderately erodible and significant overtopping for extended periods of time could cause erosion in the auxiliary spillway.

d. **Reservoir area.** The reservoir area consists entirely of cropland. The slopes surrounding the reservoir are quite flat, less than about 8(H) to 1(V). Vegetation was limited to the corn crop and weeds along the lake shore. No evidence of slope instability was noted in the slopes surrounding the reservoir. Apparently, the rate of siltation has not been measured or calculated.

e. **Downstream channel.** The channel below the main spillway pipe flows by the farm seen in Photo 1 and under Shulte Road. The channel from the auxiliary spillway flows along the toe of the dam and into the downstream channel of the main spillway. During significant storms, flow through the auxiliary spillway would likely erode the toe of the dam to an unknown degree, and probably overflow Shulte Road, thereby disrupting traffic.

3.2 Evaluation

The visual inspection indicates the dam embankment is in generally good condition. Shrinkage cracks were noted on the dam embankment and propagation of these cracks into erosion gullies should be monitored and prevented by maintenance. Planting of appropriate grasses on the embankment is recommended to fill-in the moderately erodible bare spots and to provide a more uniform vegetative cover.

No evidence of unexpected settlement, slumps, animal burrows or disrupted horizontal or vertical alignment was noted. Seepage was too small to measure, but soggy ground at the toe of the dam was noted.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

So far as could be determined there are no written operational procedures for this dam. The water level in the reservoir is controlled by the crest of the ungated spillway pipe and auxiliary spillway.

4.2 Maintenance of Dam

No records of maintenance on this facility were available.

4.3 Maintenance of Operating Facilities

There are no facilities requiring operation at this dam.

4.4 Description of Any Warning System in Effect

The inspection did not identify any warning system in effect at this facility.

4.5 Evaluation

There is apparently no maintenance program in effect at this facility. In view of the potential erosion along the discharge channel, and the potentially adverse effect this could have on the stability of the dam, it is recommended a maintenance program be established for this dam and appurtenant facilities. The feasibility of a practical warning system should be evaluated to alert downstream residents, should potentially hazardous conditions develop during periods of heavy precipitation.

SECTION 5
HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. **Design data.** The dam was designed by the Soil Conservation Service (SCS) and a limited amount of hydrologic and hydraulic design data were available. However, the dam, as constructed, did not entirely comply with all the SCS design specifications according to the field inspection. Pertinent dimensions of the dam and reservoir were surveyed for this report on 12 December, 1980, measured during the field inspection or estimated from topographic maps. The survey was performed by James F. McCaul, III and Associates of Potosi, Missouri. The map used in the analysis was the USGS Fredericktown SE 7.5-minute quadrangle (1980).

b. **Experience data.** No recorded history of rainfall, runoff, discharge or pool stage data were available for this reservoir or watershed.

c. **Visual observation.**

1. Watershed. The watershed is rural and cultivated cropland. The area of the reservoir is about 14 percent of the total watershed area of 0.09 mi^2.

2. Spillways. The main spillway consists of a 12-in. diameter asbestos-concrete pipe located in the main body of the dam. The auxiliary spillway is a broad area at the left (northeast) abutment, approximately triangular in shape. It is grass-lined and ungated. The configuration of this spillway at Section C-C, Fig. 3-B, indicates that it acts as the control section for discharge from the reservoir. Together these spillways are capable of passing approximately 220 ft^3/sec, with the water level at the dam crest elevation (el 824.0 ft).

3. Seepage. The amount of seepage noted at this dam was negligible. The reservoir surface elevation was low as a result of a dry period preceeding the inspection.

d. **Overtopping potential.** One of the important considerations in the evaluation of John Bollinger No. 2 Dam is the assessment of the potential for overtopping and possible consequent failure by erosion of the embankment. The lowest portion of the dam for overtopping analyses is at the southwest end of the embankment and is mostly on the compacted dam embankment (Fig 3-A). Hydrologic and hydraulic computations indicate that a flood greater than 40 percent of the Probable Maximum Flood (PMF) will overtop this lowest portion of 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 dam will pass the one percent probability-of-occurrence event (100 year flood) without overtopping the dam.

The following data are computed for various flood events, assuming no erosion of the auxiliary spillway or the embankment:

Precipitation Event	Maximum Outflow, ft^3/sec	Maximum Lake Elevation, ft	Maximum Depth of Overtopping, ft	Duration of Overtopping, hrs
1% Prob	15	821.9	0	0
40% PMF	220	824.0	0	0
50% PMF	370	824.2	0.2	0.6
100% PMF	870	824.7	0.7	2.2

The maximum auxiliary spillway mean channel discharge velocity was calculated as 5.3 ft/sec. This is expected to cause some erosion of the spillway. The maximum flow velocity for the overtopped portion of the embankment was calculated as 3 ft/sec. This is not expected to cause significant erosion at the right abutment. It is felt however, that due to the turbulent flow that would occur in the discharge channel along the toe of the dam, significant erosion could occur near the toe of the dam during overtopping and would require subsequent repair. Due to the relatively short duration of overtopping, it is not felt that the dam embankment would be likely to fail due to the erosion at the toe of the dam.

John Bollinger No. 2 Dam has a small drainage area (0.09 mi^2) and impounds a volume of water (54 ac-ft) which is only slightly above the criterion necessary to classify this facility as a small dam (50 ac-ft). There is a broad flow area downstream of this dam and the distance to the nearest structures is about 1800 ft. In the event of overtopping at the right (southwest) abutment the likelihood of failure of the main dam embankment is judged to be small. Based on these considerations it is recommended that the spillways for this facility be designed for a minimum flow equivalent to 50 percent of the PMF.

Input data and output summaries for the hydrologic and hydraulic analyses are summaried in the attached Appendix B.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual inspection.** The visual inspection of John Bollinger No. 2 Dam identified no evidence of instability in the embankment. Numerous shrinkage cracks were noted on the surface of the dam. These cracks should be filled in or graded and grass should be planted to avoid propagation of these cracks into erosion rills and gullies as noted on John Bollinger No. 1 Dam (MO 31417). Other measures to mitigate this erosion should be considered.

Settlement of the dam crest has apparently occurred as anticipated by the SCS design. This evaluation is based on survey check-out notes obtained as part of the SCS design. This settlement does not presently pose a safety hazard to the dam.

The downstream channel below the auxiliary spillway flows along the toe of the dam and could erode the toe during periods of heavy overflow runoff. The dam was built in 1978 and there is only a short history of performance. No records of overtopping were located.

b. **Design data.** Standard design notes used for the design of John Bollinger No. 2 Dam were obtained from the Soil Conservation Service in Columbia, Missouri. The dam appears to be built generally in accordance with the available information except as noted in Section 2.1.

Seepage and stability analysis comparable to the requirements of the "Recommended Guidelines for Safety Inspections of Dams" are not on record. This is a deficiency which should be rectified. These analyses should be performed under 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. **Operating records.** No operating records or water level records are maintained at this facility.

d. **Post construction changes.** No post construction changes in the dam could be identified.

e. **Seismic stability.** The dam is in Seismic Zone 2, to which the guidelines assign a moderate damage potential. In view of the gravelly clay used in the construction of the dam, liquefaction of the embankment is unlikely during a seismic event. However, since static stability analysis and soil property data are not available for review, the seismic stability cannot be evaluated.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on the visual inspection and evaluation of the available data, John Bollinger No. 2 Dam is judged to be in generally good condition.

This judgment is based on the lack of signs of instability or significant erosion on the dam at this time. The potential for erosion at the toe, and the short history of performance indicate the need for periodic inspections to maintain the facility in good condition. Seepage and stability analyses comparable to the recommended guidelines are not on record, which is considered a deficiency.

The spillways will pass 40 percent of the PMF without overtopping the dam. The combined spillway discharge capacity was calculated as 220 ft^3/sec.

b. **Adequacy of information.** The visual inspection provided a reasonable base of information for the conclusions and recommendations in this Phase I report.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These analyses should be conducted under the direction of an engineer experienced in the construction of earth dams.

c. **Urgency.** The deficiencies described in this report could affect the long term safety of the dam. Corrective actions described in Section 7.2b should be taken without undue delay. The inspection and maintenance program described in Section 7.2c should be implemented 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 St Louis District 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 50 percent of the Probable Maximum 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 minimizes the potential for loss of life).

b. **Recommendations.** Based on our inspection of John Bollinger No. 2 Dam, it is recommended that further studies be conducted without undue delay, to evaluate as a minimum:

1. Design and construction of appropriate facilities to enable the dam to pass at least 50 percent of the PMF without overtopping.

2. Options for erosion protection or relocation of downstream channel below the auxiliary spillway. Consideration should also be given to the erodible nature of embankment, discharge channel and the auxiliary spillway. Additional planting of appropriate grasses should be considered to provide a more uniform vegetative cover and minimize the erosion.

3. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams."

4. Construction of an appropriate trash rack at the inlet of the main spillway to prevent blockage by any object foreseeable for this drainage area.

These studies should be conducted under the guidance of an engineer experienced in design and construction of dams.

c. **Operation and maintenance procedures.** A program of periodic inspections is recommended for the John Bollinger No. 2 Dam. This program should include, but not be limited to:

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

2. Inspection of slopes to identify evidence of slope instability such as cracking or deformations of the embankment.

3. Inspection of the discharge channel, toe of the dam and auxiliary spillway to identify any evidence of erosion that could adversely influence the stability of the dam.

4. Inspection of the trash rack, which should be constructed at the inlet to the main spillway, to detect any conditions that might lead to spillway blockage.

Records should be kept of the 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.

An evaluation should be made of a practical and effective warning system to alert downstream traffic and residents should hazardous conditions develop at this dam.

REFERENCES

Allgood, F. P., and Persinger, I., D., 1979, Missouri General Soil Map and Soil Association Descriptions: US Department of Agriculture, Soil Conservation Service and Missouri Agricultural Experiment Station.

Department of the Army, Office of the Chief of Engineers, 1977, EC 1110-2-188, Engineering and Design National Program of Inspection of Non-Federal Dams.

Department of the Army, Office of the Chief of Engineers, 1979, ER 1110-2-106, Engineering and Design National Program of Inspection of Non-Federal Dams.

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

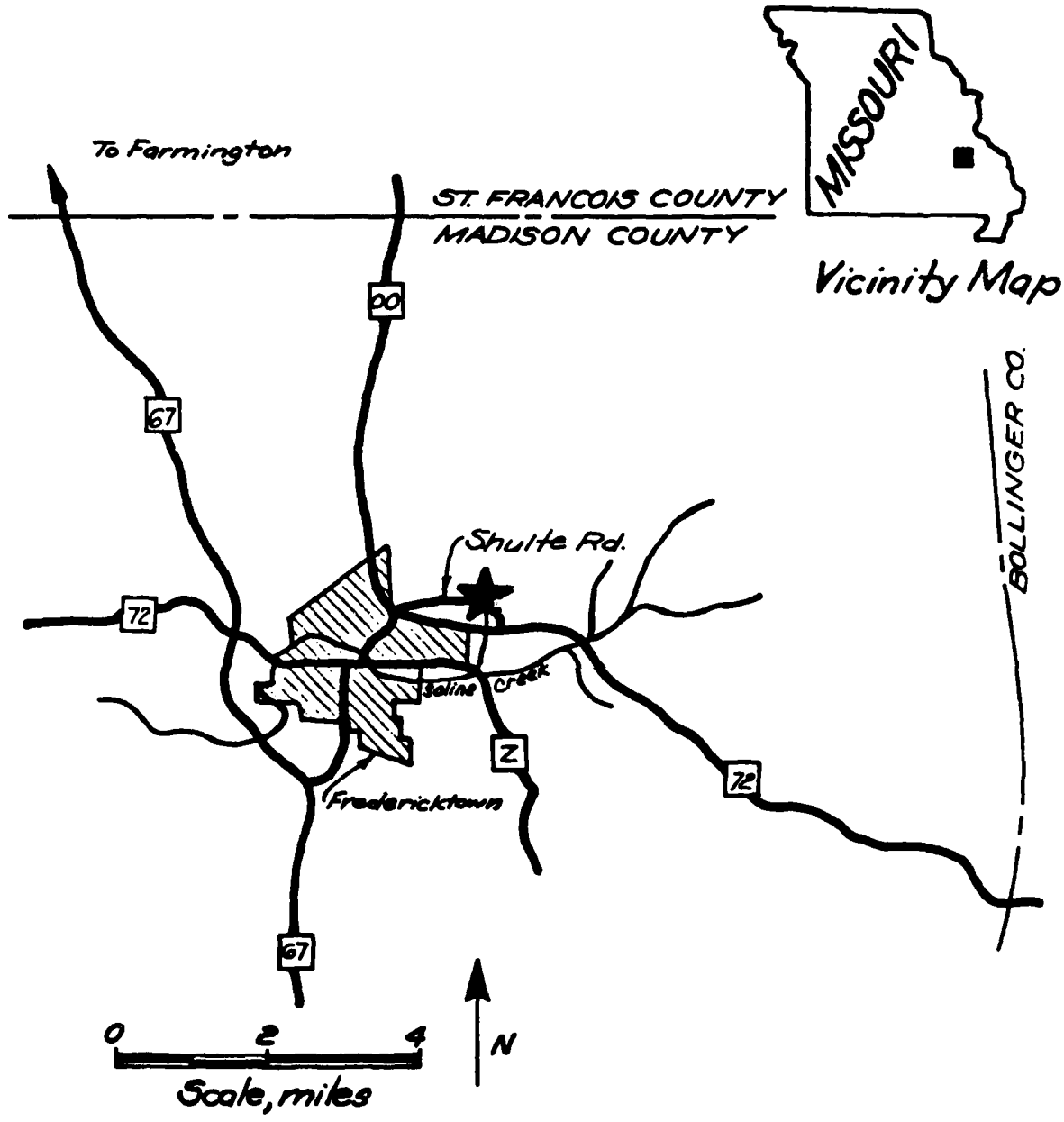
McCracken, M. H., 1971, Structural Features Map of Missouri: Missouri Geological Survey, scale 1:500,000.

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 Agriculture, Soil Conservation Service, 1971, Hydrology: National Engineering Handbook, Section 4.

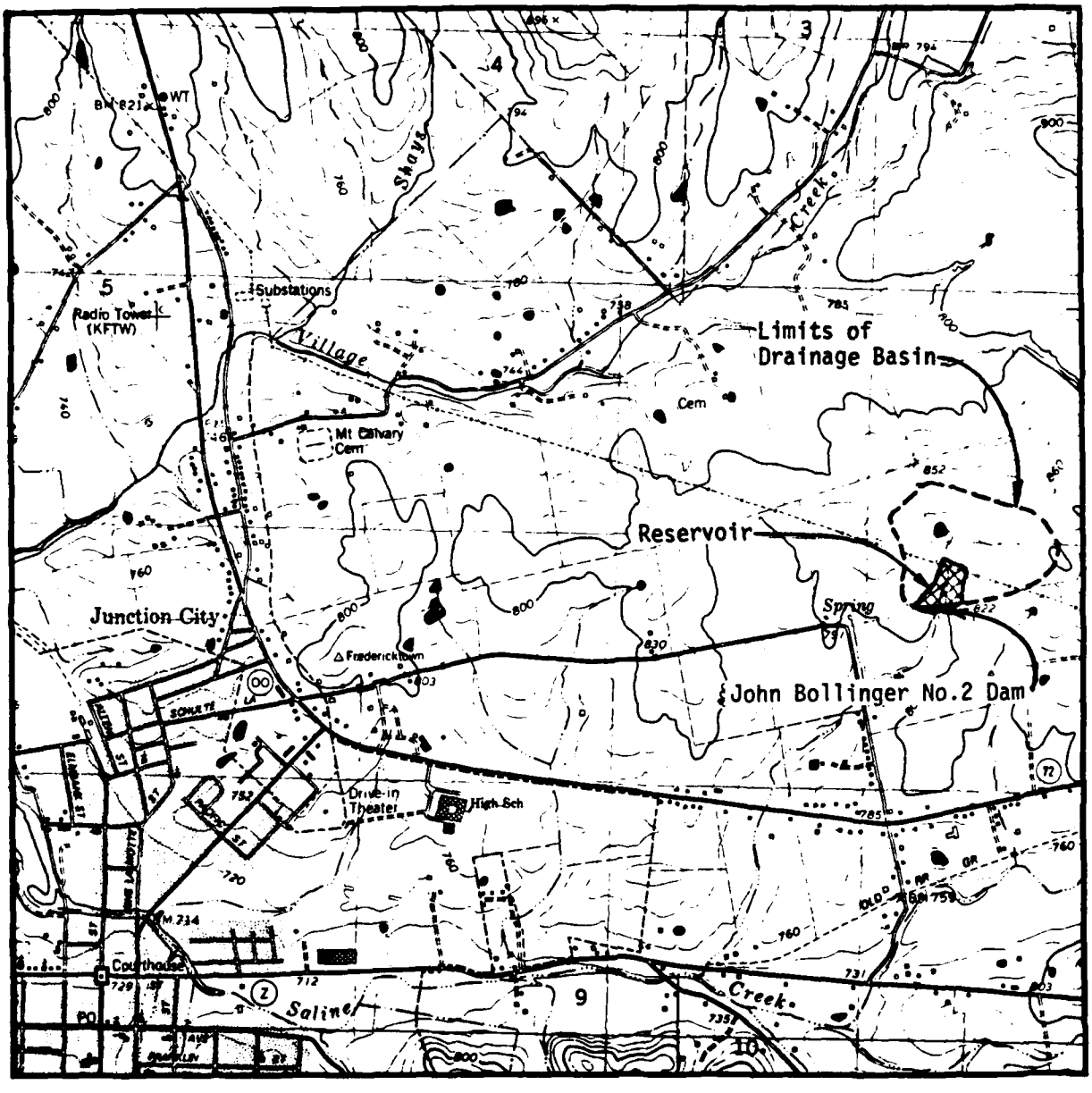
US Department of Commerce, US Weather Bureau, 1956, Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours, Hydrometeorological Report No. 33.



Legend

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

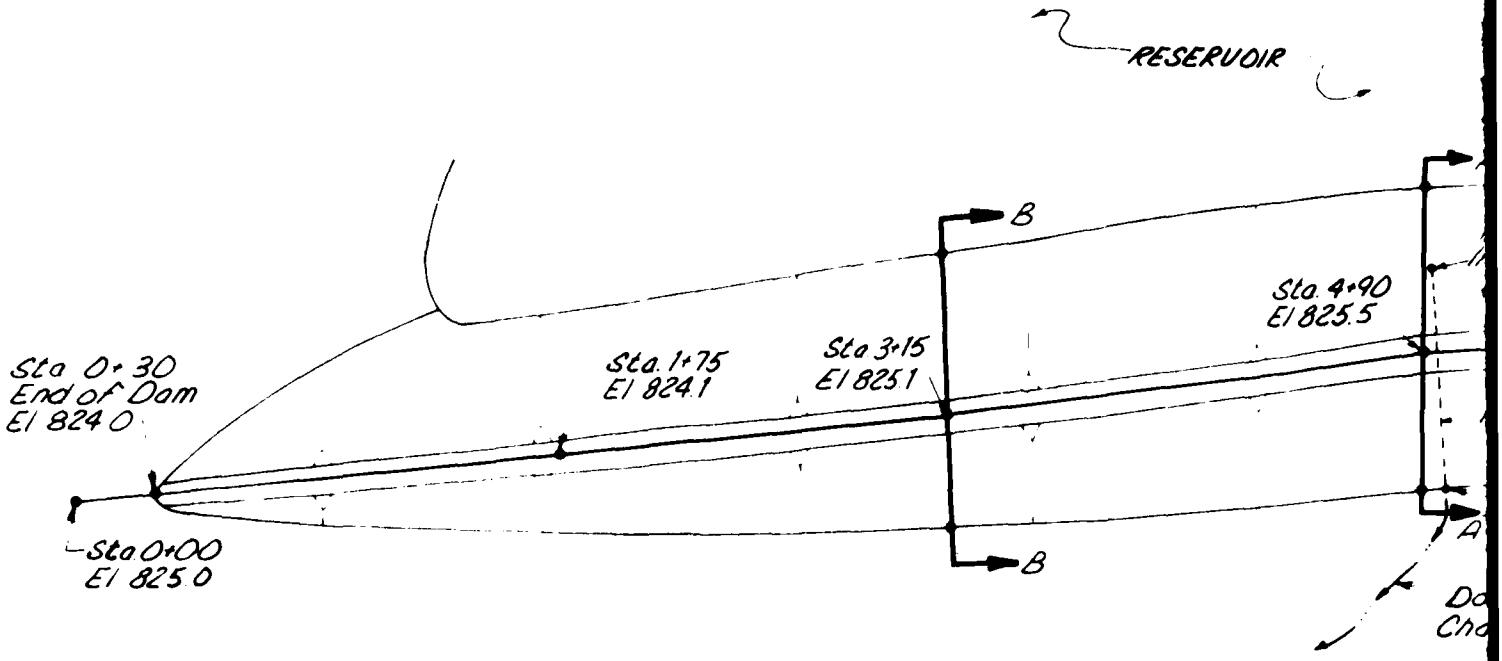
SITE LOCATION MAP	
JOHN BOLLINGER NO. 2 DAM	
MO. 31433	Fig. 1



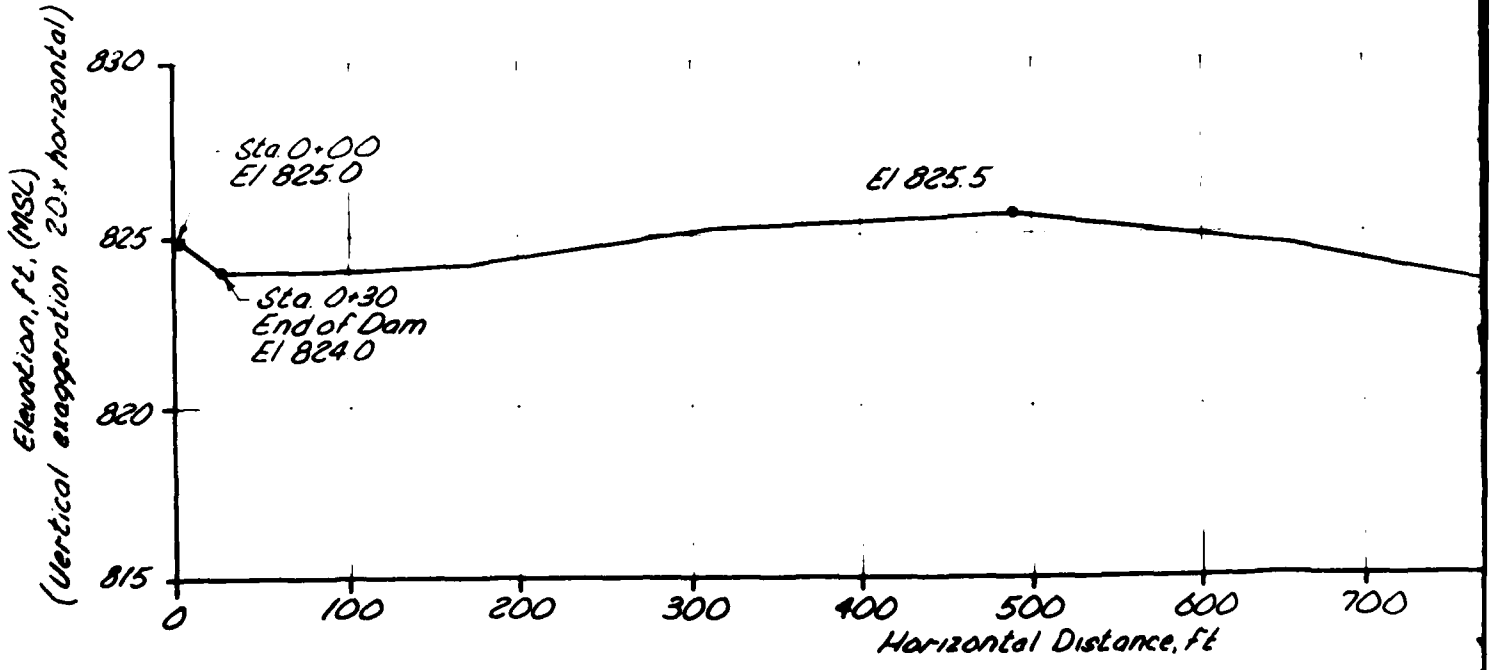
Note:
Topography from USGS
Fredericktown SE
7.5-minute quadrangle
map. (1980)

DRAINAGE BASIN AND SITE TOPOGRAPHY

JOHN BOLLINGER NO.2 DAM	
MO 31433	Fig. 2

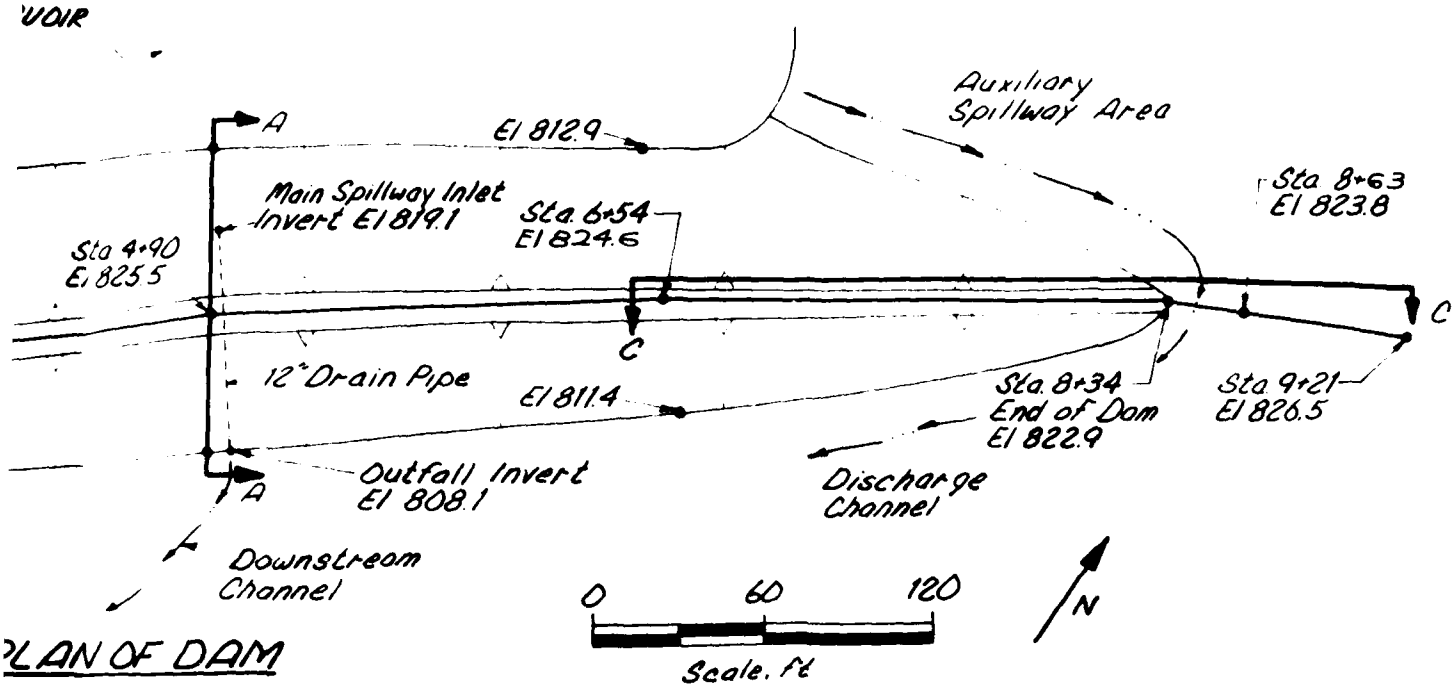


PLAN OF DAM

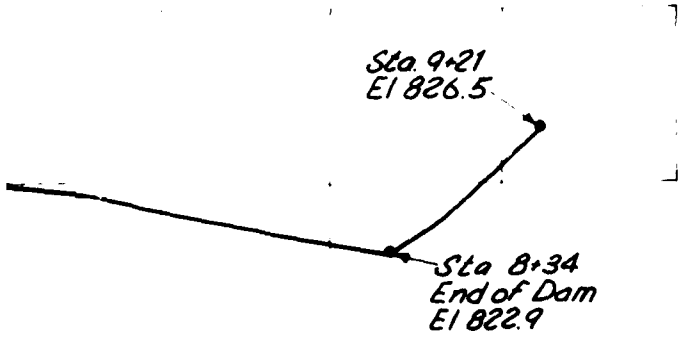


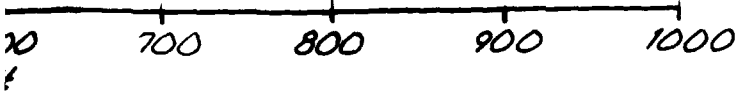
DAM CREST PROFILE

'VOIR



'LAN OF DAM

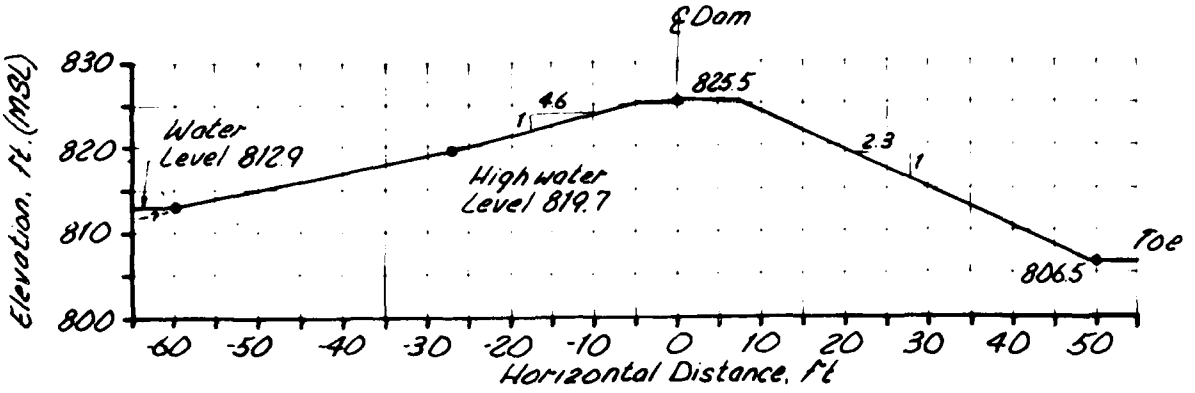




'LE

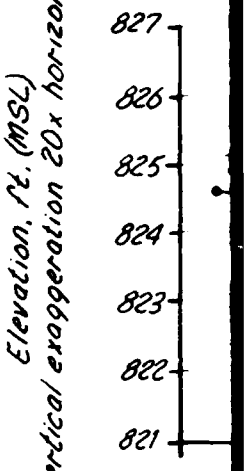
Note:
1 Survey data supplied by James F. McCaul, III and Associates Consulting Engineers / Land Surveyors Potosi, Mo. 63664

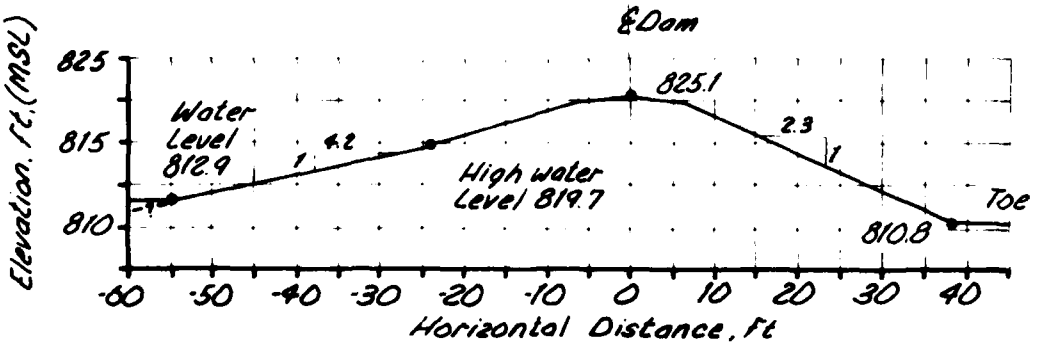
'PLAN OF DAM AND PROFILE OF DAM CREST	
JOHN BOLLINGER NO.2 DAM	
MO 31433	Fig. 3-A



SECTION A-A

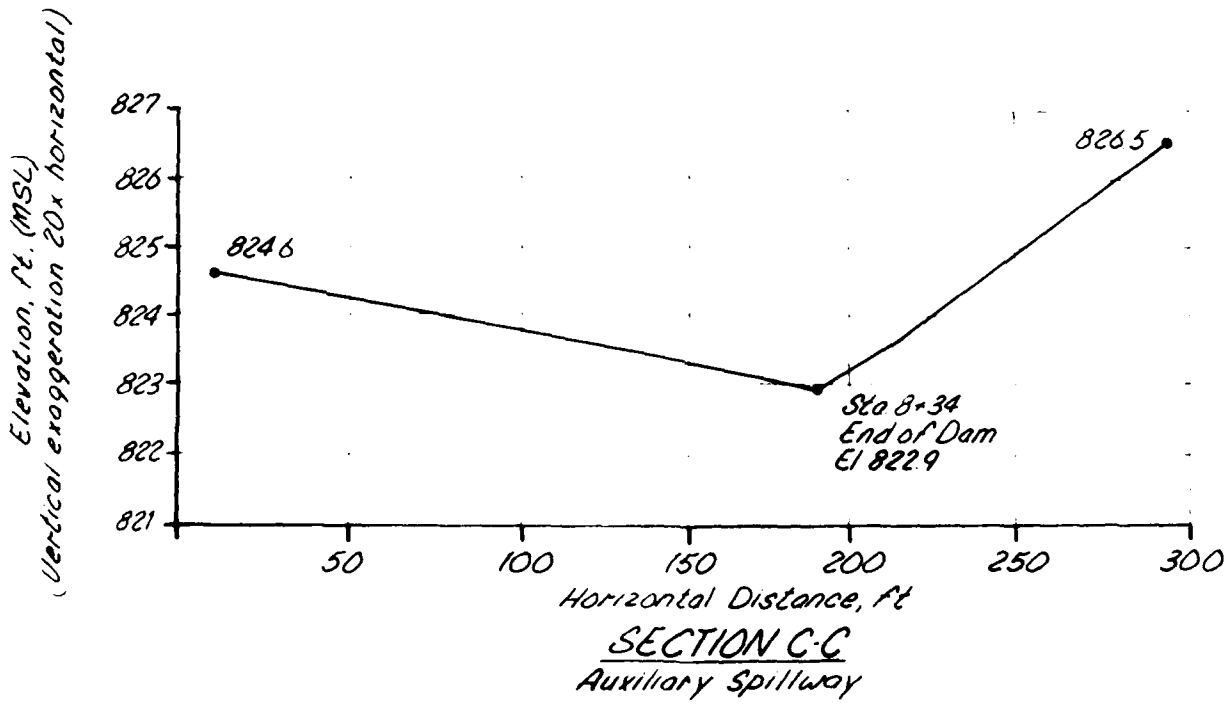
Maximum Dam Section





SECTION B-B

Dam Section



SECTION C-C
Auxiliary Spillway

SECTIONS OF DAM AND SPILLWAY	
JOHN BOLLINGER NO.2 DAM	
MO 31433	Fig. 3-B

2

0 10 20

Scale, mile

Legend

Olc — Smithville Formation, Powell Dolomite, Cotter Dolomite, Jefferson City Dolomite

Or — Roubidoux Formation

Gasconade Dolomite
Gunter Sandstone Member

Cep — Eminence Dolomite

Potosi Dolomite

Derby-Doerun Dolomite

Davis Formation

Bonneterre Formation
Whetstone Creek Member
Sullivan Siltstone Member

Reagan Sandstone

Lamotte Sandstone

Diabase (dikes and sills)

St. Francois Mountains Intrusive Suite

St. Francois Mountains Volcanic Supergroup

REGIONAL GEOLOGIC MAP

JOHN BOLLINGER NO.2 DAM

MO 31433 | **Fig. 4**

APPENDIX A

Photographs

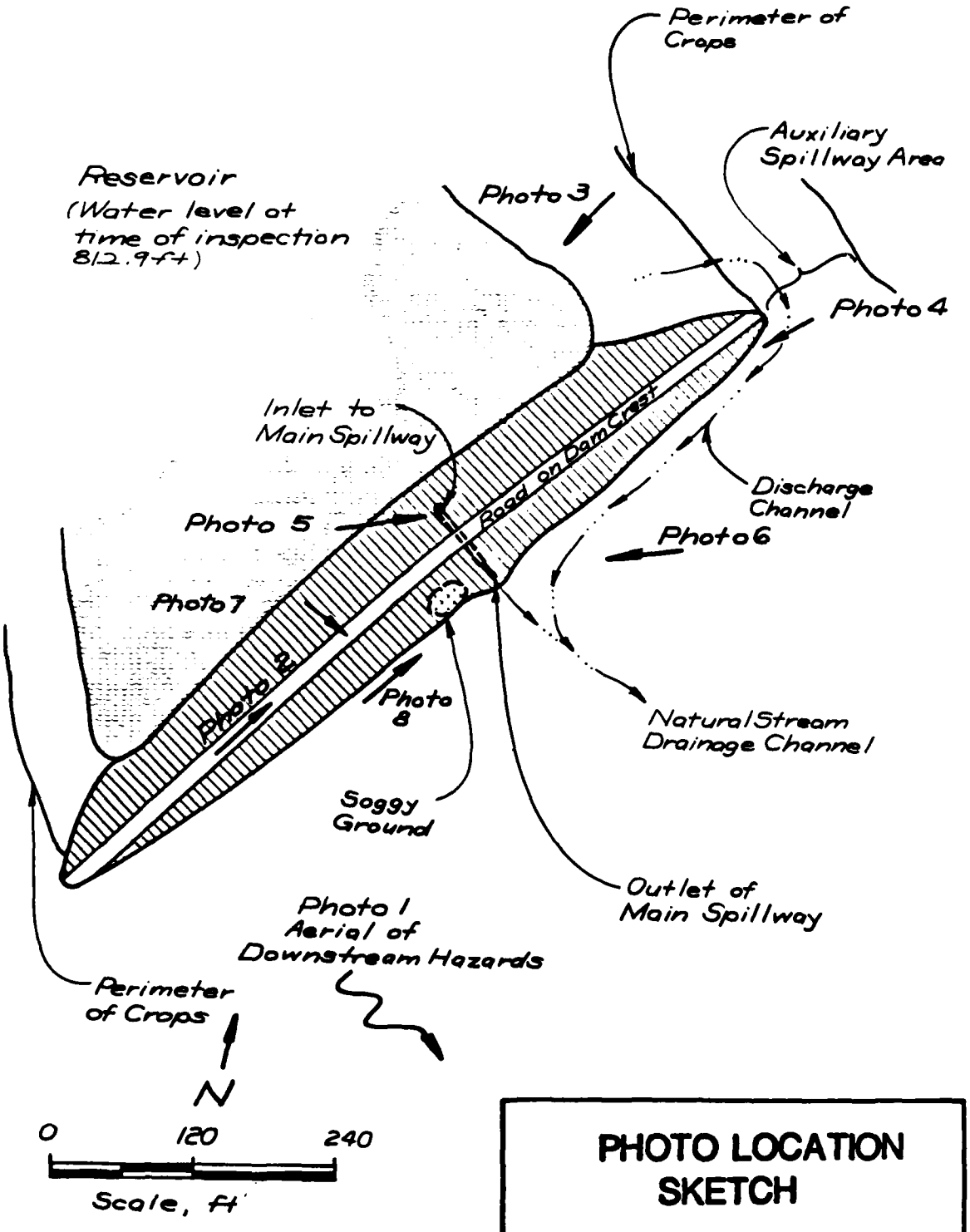


PHOTO LOCATION SKETCH

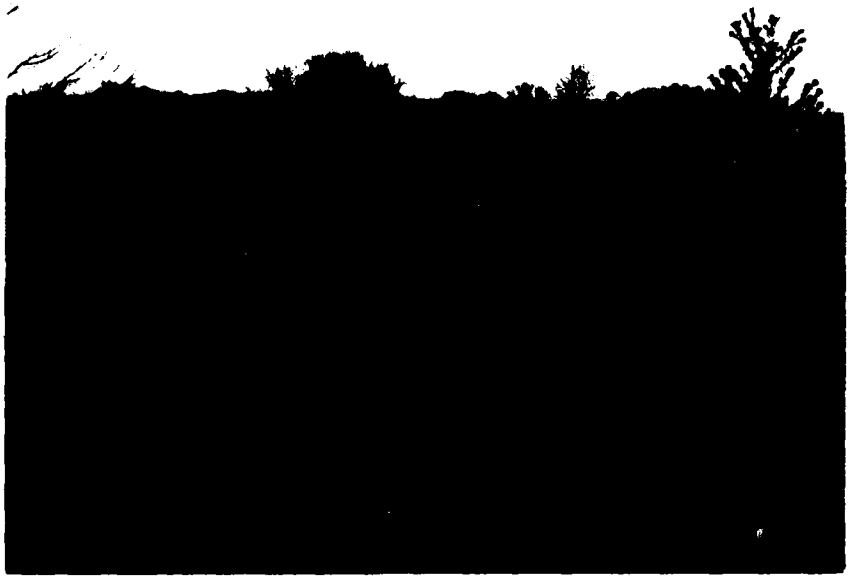
JOHN BOLLINGER NO.2 DAM

MO 31433 | Fig. A-1

1. Hazard downstream of John Bollinger No.2 Dam. Dam out of picture to the right, approximately 1600 feet upstream. Looking west.

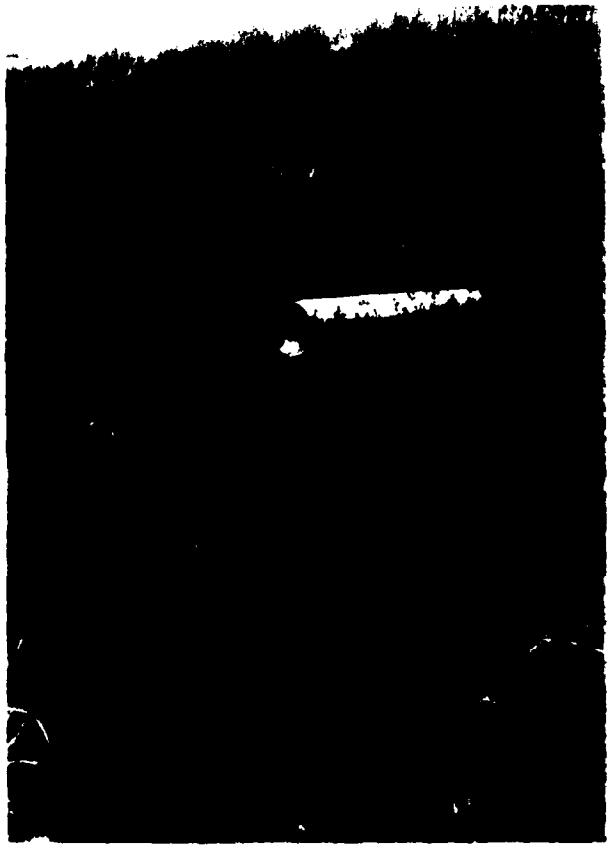
2. Crest of dam looking northeast. Note type of vegetation.

3. Upstream face of dam. Note approximate high water mark, lack of wave erosion protection and terrace at about mid-height of dam. Looking southwest.



4. Downstream face of dam. Note type and size of vegetation.

5. Inlet to 12-in. dia main spillway. Note the lack of a canopy and trash rack.



6. Outlet of main spillway. Note the damaged end and height of water fall. Looking west.

7. Examples of numerous shrinkage cracks found on dam embankment.

8. Cattails growing in area of soggy ground at downstream toe of dam. Looking northeast.

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 = 1950
$s = \frac{1000}{CN} - 10 = 2.82$

CN = hydrologic soil curve number as indicated in Section B.2e.
Y = average watershed land slope in percent = 5

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

The value of T_c was checked using the time of travel method.

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 inlet elevation, 819.1 ft.

(2) Probable Maximum Storm - main spillway inlet elevation, 819.1 ft.

These starting elevations were used because the main spillway was found to be capable of discharging the antecedent storm storage within 4 days.

f. Spillway Rating Curve. The HEC-2 computer program was used to compute the auxiliary spillway rating curve using the spillway section and conveyance characteristics. The capacity of the main spillway was calculated and manually added to the auxiliary spillway rating curve.

B.2 Pertinent Data

a. Drainage area. 0.09 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. 0.25 hr

d. Hydrologic soil group. C

e. SCS curve numbers.

1. For PMF: AMC III - Curve Number 90
2. For 1 and 10 percent probability-of-occurrence events: AMC II - Curve Number 78

f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Fredericktown SE, Missouri (1980) 7.5-minute quadrangle map. 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 developed from the cross section data of the spillway and the downstream channel, using the HEC-2 backwater program. The results of the above were added to the main spillway discharge 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 819.1 ft, the main spillway inlet elevation. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was also 819.1 ft, the main spillway inlet 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.

```
**********
*FLOOD HYDROGRAPH PACKAGE (HEC-1)
*DAM SAFETY VERSION      JULY 1978
*LAST MODIFICATION  26 FEB 79
**********
....1.....A1    JOHN BOLLINGER #2, DAM NO. 31433, MADISON COUNTY, MISSOURI.
    2     A2    *GOODWARD-CLYDE CONSULTANTS, PROJECTION JOB 80C224.
    3     A3    PROBABLE MAXIMUM FLOODS.
    4     B   288       0       5       0       0       0       0       0       0       0
    5     B1    9
    6     J     1       2       1
    7     J1  .50    1.00
    8     K     0  INFLOW                                                 1
    9     K1    JOHN BOLLINGER LAKE PMF INFLOW COMPUTATIONS.
   10     M     1       2    0.09                              1.0
   11     P     0      26     102     120     130
   12     1                                                   -1     -90            0.14
   13     J2          0.26
   14     K    -1    -.09       9
   15     K     1     DAM                                      1
   16     K1    FLOOD ROUTING AND OVERTOPPING ANALYSES
   17     T                                     1       1
   18     V1    1                                                -819.1      -1
   19     V4 819.1   822.9   823.2   823.5   823.7   824.0   824.5   824.9   825.3   825.6
   20     V4 826.0
   21     V5    0      20      30      70     120     220     520     820    1220    1920
   22     V5 2620
   23     S   0.     1.6     2.6     3.5     4.8     5.4     6.1     7.      7.7     8.3
   24     SA  8.9    9.7    10.     12.
   25     SE 808.    813.    815.    817.    819.    820.    821.    822.    823.    824.
   26     SE 829.    826.    827.    830.
   27     SS 819.1
   28     SD 824.0    2.8     1.5
   29     SL   0.    260.    430.    735.    790.
   30     SV 824.0   824.5   825.0   825.5   826.0
   31     K    99
```

Input Data
Various PMF Events
John Bollinger No. 2 Dam
MO 31433

B4

HEC-1 FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST REVISION 28 FEB 79

RUN DATE 07/01/07.
TIME 09.19.09.

JOHN BOLLINGER #2, DAM NO. 31433, MADISON COUNTY, MISSOURI.
WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 80C224.
PROBABLE MAXIMUM FLOODS.

JOB SPECIFICATION

NO	NMIN	IDAY	IHR	IPIN	METRC	IPLT	IPRT	NSTAN
200	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

JOHN BOLLINGER 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	.04	0.00	.09	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	-90.00	0.00	.14

CURVE NO = -90.00 WETNESS = -1.00 EFFECT CN = 90.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .26

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

UNIT HYDROGRAPH 18 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .26 VOL= 1.00

24.	82.	136.	142.	114.	72.	45.	29.	19.	12.
7.	5.	3.	2.	1.	1.	0.	0.		

Input Data
Various PMF Events
John Bollinger No. 2 Dam
MO 31433

B5

B5

Output Summary
Various PMF Events
John Bollinger No. 2 Dam
MO 31433

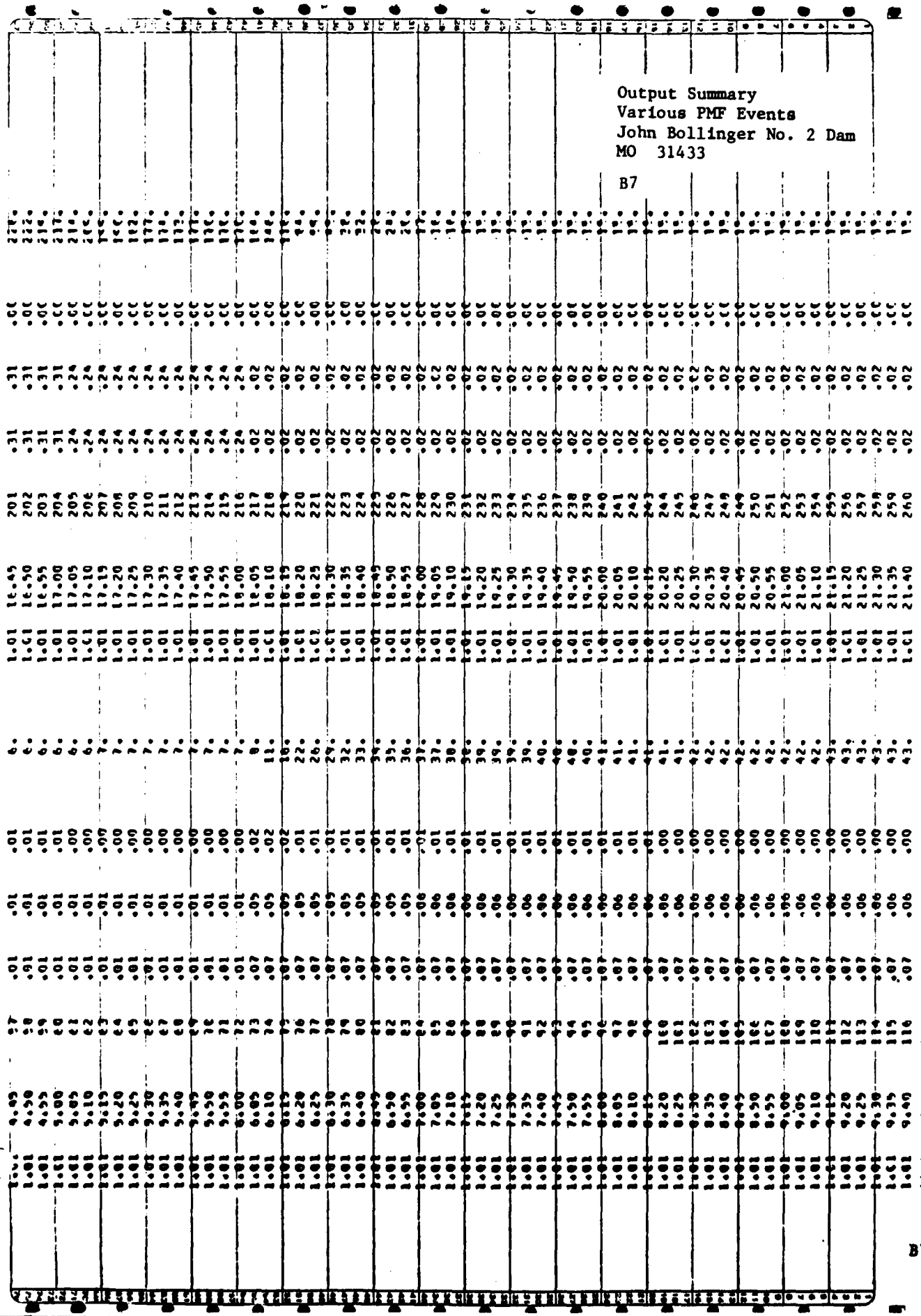
B6

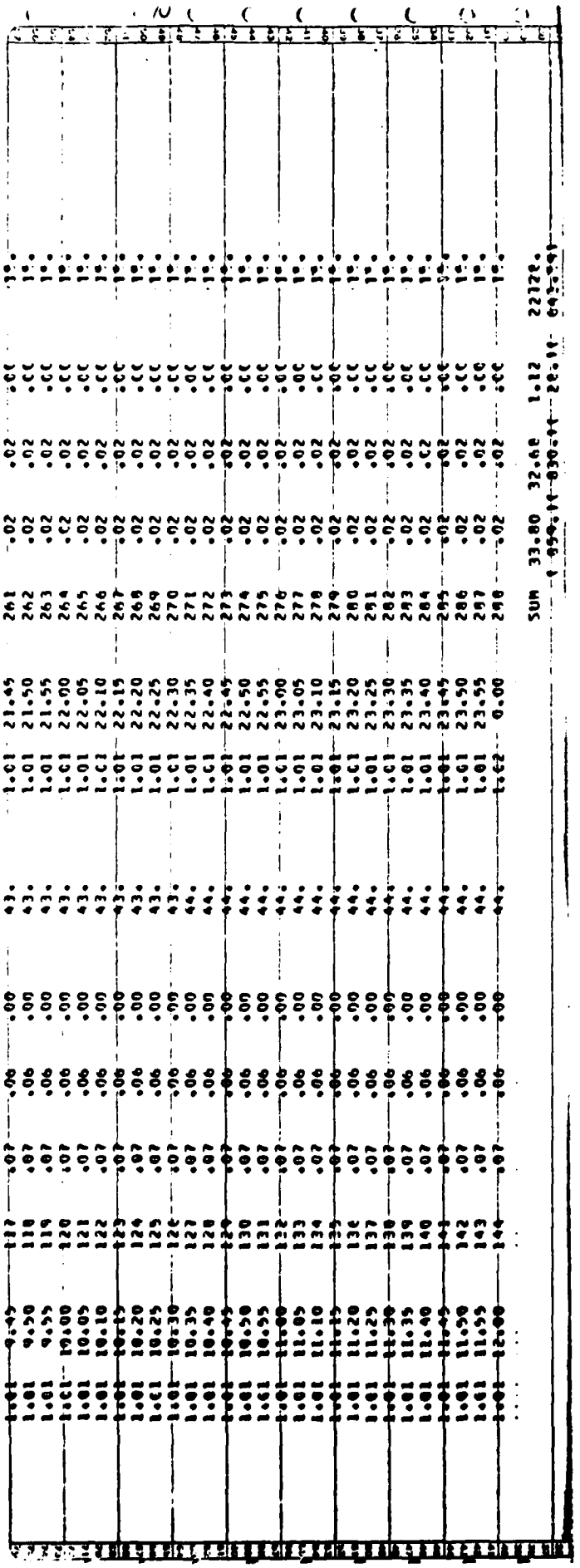
END-OF-PERIOD FLOW

MN.C	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	PO.OB	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.00	.01	0.	1.01	12.05	145	.22	.22	.01	46.
1.01	.10	2	.01	.00	.01	0.	1.01	12.10	146	.22	.22	.00	46.
1.01	.15	3	.01	.00	.01	1.	1.01	12.15	147	.22	.22	.00	91.
1.01	.20	4	.01	.00	.01	1.	1.01	12.20	148	.22	.22	.00	137.
1.01	.25	5	.01	.00	.01	1.	1.01	12.25	149	.22	.22	.00	137.
1.01	.30	6	.01	.00	.01	1.	1.01	12.30	150	.22	.22	.00	137.
1.01	.35	7	.01	.00	.01	1.	1.01	12.35	151	.22	.22	.00	137.
1.01	.40	8	.01	.00	.01	1.	1.01	12.40	152	.22	.22	.00	137.
1.01	.45	9	.01	.00	.01	1.	1.01	12.45	153	.22	.22	.00	137.
1.01	.50	10	.01	.00	.01	1.	1.01	12.50	154	.22	.22	.00	137.
1.01	.55	11	.01	.00	.01	1.	1.01	12.55	155	.22	.22	.00	137.
1.01	1.00	12	.01	.00	.01	1.	1.01	13.00	156	.22	.22	.00	137.
1.01	1.05	13	.01	.00	.01	1.	1.01	13.05	157	.27	.26	.00	137.
1.01	1.10	14	.01	.00	.01	1.	1.01	13.10	158	.27	.26	.00	137.
1.01	1.15	15	.01	.00	.01	1.	1.01	13.15	159	.27	.26	.00	137.
1.01	1.20	16	.01	.00	.01	1.	1.01	13.20	160	.27	.26	.00	137.
1.01	1.25	17	.01	.00	.01	1.	1.01	13.25	161	.27	.26	.00	137.
1.01	1.30	18	.01	.00	.01	1.	1.01	13.30	162	.27	.26	.00	137.
1.01	1.35	19	.01	.00	.01	2.	1.01	13.35	163	.27	.26	.00	137.
1.01	1.40	20	.01	.00	.01	2.	1.01	13.40	164	.27	.26	.00	137.
1.01	1.45	21	.01	.00	.01	2.	1.01	13.45	165	.27	.26	.00	137.
1.01	1.50	22	.01	.00	.01	2.	1.01	13.50	166	.27	.26	.00	137.
1.01	1.55	23	.01	.00	.01	2.	1.01	13.55	167	.27	.26	.00	137.
1.01	2.00	24	.01	.00	.01	2.	1.01	14.00	168	.27	.26	.00	137.
1.01	2.05	25	.01	.00	.01	3.	1.01	14.05	169	.33	.33	.00	137.
1.01	2.10	26	.01	.00	.01	3.	1.01	14.10	170	.33	.33	.00	137.
1.01	2.15	27	.01	.00	.01	3.	1.01	14.15	171	.33	.33	.00	137.
1.01	2.20	28	.01	.01	.01	3.	1.01	14.20	172	.33	.33	.00	137.
1.01	2.25	29	.01	.01	.01	3.	1.01	14.25	173	.33	.33	.00	137.
1.01	2.30	30	.01	.01	.01	3.	1.01	14.30	174	.33	.33	.00	137.
1.01	2.35	31	.01	.01	.01	3.	1.01	14.35	175	.33	.33	.00	137.
1.01	2.40	32	.01	.01	.01	4.	1.01	14.40	176	.33	.33	.00	137.
1.01	2.45	33	.01	.01	.01	4.	1.01	14.45	177	.33	.33	.00	137.
1.01	2.50	34	.01	.01	.01	4.	1.01	14.50	178	.33	.33	.00	137.
1.01	2.55	35	.01	.01	.01	4.	1.01	14.55	179	.33	.33	.00	137.
1.01	3.00	36	.01	.01	.01	4.	1.01	15.00	180	.33	.20	.00	137.
1.01	3.05	37	.01	.01	.01	4.	1.01	15.05	181	.20	.40	.00	137.
1.01	3.10	38	.01	.01	.01	4.	1.01	15.10	182	.40	.40	.00	137.
1.01	3.15	39	.01	.01	.01	5.	1.01	15.15	183	.40	.40	.00	137.
1.01	3.20	40	.01	.01	.01	5.	1.01	15.20	184	.60	.60	.00	137.
1.01	3.25	41	.01	.01	.01	5.	1.01	15.25	185	.71	.70	.00	137.
1.01	3.30	42	.01	.01	.01	5.	1.01	15.30	186	1.71	1.71	.01	137.
1.01	3.35	43	.01	.01	.01	5.	1.01	15.35	187	2.82	2.82	.01	137.
1.01	3.40	44	.01	.01	.01	5.	1.01	15.40	188	1.11	1.11	.00	137.
1.01	3.45	45	.01	.01	.01	5.	1.01	15.45	189	.71	.70	.00	137.
1.01	3.50	46	.01	.01	.01	5.	1.01	15.50	190	.60	.60	.00	137.
1.01	3.55	47	.01	.01	.01	5.	1.01	15.55	191	.40	.40	.00	137.
1.01	4.00	48	.01	.01	.01	6.	1.01	16.00	192	.40	.40	.00	137.
1.01	4.05	49	.01	.01	.01	6.	1.01	16.05	193	.31	.31	.00	137.
1.01	4.10	50	.01	.01	.01	6.	1.01	16.10	194	.31	.31	.00	137.
1.01	4.15	51	.01	.01	.01	6.	1.01	16.15	195	.31	.31	.00	137.
1.01	4.20	52	.01	.01	.01	6.	1.01	16.20	196	.31	.31	.00	137.
1.01	4.25	53	.01	.01	.01	6.	1.01	16.25	197	.31	.31	.00	137.
1.01	4.30	54	.01	.01	.01	6.	1.01	16.30	198	.31	.31	.00	137.
1.01	4.35	55	.01	.01	.01	6.	1.01	16.35	199	.31	.31	.00	137.
1.01	4.40	56	.01	.01	.01	6.	1.01	16.40	200	.31	.31	.00	137.

Output Summary
Various PMF Events
John Bollinger No. 2 Dam
MO 31433

B7





Output Summary
Various PMF Events
John Bollinger No. 2 Dam
MO 31433

B8

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	.09	1	463.	929.
		(.23)		(13.10)(	(26.20)(
ROUTED TO	DAM	.09	1	370.	869.
		(.23)		(10.47)(	(24.61)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	819.10	819.10	824.00
	STORAGE	22.	22.	54.
	OUTFLOW	0.	0.	220.

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	824.23	.23	96.	370.	.58	16.00	0.00
1.00	824.67	.67	60.	869.	2.17	15.92	0.00

Output Summary
Various PMF Events
John Bollinger No. 2 Dam
MO 31433

B9

Output Summary
Various PMF Events
John Bollinger No. 2 Dam
MO 31433

B10

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 .40	RATIO 2 .41	RATIO 3 .42	RATIO 4 .43
				RATIOS APPLIED TO FLOWS			
HYDROGRAPH AT	INFLOW	.09	1	370.	379.	389.	398.
	(	.23)	(	10.48)(	10.74)(	11.00)(	11.27)(
ROUTED TO	DAM	.09	1	215.	233.	250.	268.
	(	.23)	(	6.09)(	6.59)(	7.09)(	7.60)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	819.10	819.10	824.00
STORAGE	22.	22.	54.
OUTFLOW	0.	0.	220.

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
.40	823.99	0.00	54.	215.	0.00	16.08	0.00
.41	824.02	.02	54.	233.	.25	16.08	0.00
.42	824.05	.05	54.	250.	.25	16.08	0.00
.43	824.08	.08	55.	268.	.33	16.00	0.00

APPENDIX C

Soil Conservation Service
Design Data

John Bollinger No. 2 Dam
MO 31433

MO-ENG-40
12/70
(File Code ENG-13)

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DESIGN SHEET FOR CLASS II, III, IV * DETENTION STORAGE STRUCTURE WITH DROP INLET SPILLWAY -- HOOD INLET SPILLWAY -- CANOPY INLET SPILLWAY

Landowner John T. Langan Location _____

Design by [illegible] Date 11-2-77 Checked by [illegible] Date 11-77

Drainage area = 65 ac. Height x storage = 21 x 588 = 1235

WATERSHED CONDITIONS AND FACTORS

Location factor: L = 1.07

Infiltration factor: ~~(above)~~ (average) ~~(below)~~* I = 1.00

Topographic factor: 9 % average slope T = 1.04

Shape factor: runoff distance = 2500 ft. S = 1.00

Cover factor: cropland 100 %, pasture — %, timber — % V = 1.00

Contouring factor: C = 0.97

Storage factor: 100 % terraced P = 0.98

PEAK RATE OF RUNOFF AND VOLUME OF RUNOFF

Product of factors = L X I X T X S X V X C X P = 1.0 Q_{10} = 175 c.f.s.

V X I = 1.0 X 1.0 = 1.0

For Principal Spillway Design:

5-year peak rate of runoff = Q_{ip} = 0.8 X 175 c.f.s. = 140 c.f.s.

Rate of volume of runoff = .12 ac.ft./ac. (Table 1, 1519)

Total volume of runoff = V_{rp} = (drainage area)X(rate of volume of runoff)X L =

65 ac. X .12 ac.ft./ac. X 1.0 = 7.8 ac.ft.

For Both Spillways (total structure):

25-year peak rate of runoff = Q_1 = 1.3 X 175 c.f.s. = 228 c.f.s.

Rate of volume of runoff = .20 ac.ft./ac.

Total volume of runoff = V_r = 65 ac. X .20 ac.ft./ac. X 1.0 = 13.0 ac.ft.

*Mark out those items that do not apply.

Instructions for use of form: Make one pencil copy for applicable structure. File with other worksheets and structure plan in cooperator's or landowner's folder in work unit office.

PRINCIPAL SPILLWAY DESIGN

Available storage at stage of 1.5 ft. = V_{sp} = 9.4 ac.ft. (See map)

V_{sp}/V_{rp} = 9.4 ac.ft. / 7.8 ac.ft. = Stored Q_{op}/Q_{ip} = _____ (Table 2, 1519)

$Q_{cp} = Q_{ip}$ X _____ = _____ c.f.s. X _____ = _____ c.f.s.

Conduit:

Type SIP Length = 91 ft. Total head on conduit = 2[illegible] ft.

Diameter = _____ in. Discharge capacity = 2.3 c.f.s. (1520)

Minimum entrance head = _____ ft. (1510 or 1511)

Riser: **

Type _____ Height = _____ ft. Diameter = _____ in. (1511)

EMERGENCY SPILLWAY DESIGN

Control Section:

Depth of flow = 1.0 ft. V_s at this depth = 16.2 ac. ft. (See map)

V_s/V_r = 16.2 ac.ft. / 13.0 ac.ft. = stored

Q_{op}/Q_i = _____ c.f.s. / _____ c.f.s. = _____ Q_{oe}/Q_i = _____ (Table 3, 1519)

$Q_{oe} = Q_i$ X _____ = _____ c.f.s. X _____ X _____ c.f.s.

Width = 10 ft. Total depth = depth of flow + freeboard = 0.5 ft. + 1.0 =

1.5 ft. Use 1.5 ft. (Table 4, 1517)

Exit Section: No Problem

Slope = _____ % Quality of vegetation: (fair) (good) (excellent) *

(Less) (More) * erosive soils. Permissible velocity = _____ f.p.s. (1517)

Depth = _____ ft. Design velocity = _____ f.p.s. Width = _____ ft. (1517 or 1505

Use width of _____ ft.

ANTI-SEEP COLLARS

Length of saturated zone = L = _____ ft. Collar addition = _____ ft. (1515)

Number = n = (L X _____)/V = (_____ X _____)/_____ = _____. Use _____ collars.

* Mark out those items that do not apply.
** Applies only to Drop Inlet Spillways.

storage available for detention 24 acre feet at el. 101.1

" " " " " " 36 acre feet at el. 103.1

BY VAN WIN

ELEV	SURFACE ACS	TOTAL STORAGE AC FEET	
95.1	1.6	2.8	
96.1	2.1	5.9	
97.1	2.6	8.5	
98.1	3.0	11.5	
99.1	3.5	15.0	
100.1	4.15	19.15	
→ 101.1	4.8	23.95	Pipe
102.1	5.45	27.4	
103.1	6.1	35.5	Pipe
104.1	6.75		

103.1

103.1

MO-ENG-15
Rev. 11/72
File Code: ENG-13

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

EARTHWORK COMPUTATION SHEET FOR EARTH DAM

Landowner or Watershed [illegible] Location or Sub-watershed [illegible]

Top of Fill: Width 12 feet; Elev. 106.4. Side Slopes: Downstream 2:1; Upstream 4:1

Upstream Berm: Width ____ feet; Elev. ____. Downstream Berm: Width ____ feet; Elev. ____

Computed by [illegible] Date 11/3/77 Checked by [illegible] Date ____

Station	Ground Elev. Ft.	Main Fill		Upstream Berm		Downstream Berm		Total Fill Quantity Cu. Yd. Per ft.	Sum of Fill Quantity Cu. Yd. Per ft.	Distance Between Stations Ft.	Double Fill Quantity Cu. Yd.
		Fill Height Ft.	Fill Quantity Cu. Yd. Per ft.	Fill Height Ft.	Fill Quantity Cu. Yd. Per ft.	Fill Height Ft.	Fill Quantity Cu. Yd. Per ft.				
0+40		00	00						XXXXXXXXX	XXXXXXXXX	XXXXXXXXX
1+		3.5	3.0						3.0	60	180
1+50		6.4	7.5						10.5	50	525
2+		9.7	14.8						22.3	50	1115
2+50		12.4	22.6						37.4	50	1870
2+80		14.9	31.3						53.9	30	1617
3+20		16.4	37.2						68.5	40	2740
3+73		17.8	43.1						80.3	53	4256
3+80		22.0	63.6						106.7	7	747
3+82		21.8	62.6						126.2	2	252
3+92		17.5	41.8						104.4	10	1044
4+82		17.5	41.8						83.6	30	2508
4+52		16.6	38.0						79.8	30	2394
5+		14.9	31.3						69.3	50	3465
5+52		12.8	23.9						55.2	50	2760
[illegible]		10.8	17.7						41.6	50	2080
[illegible]		9.2	13.5						31.2	45	1404
[illegible]		7.2	9.0						22.5	40	900
7+27		7.1	8.8						17.8	40	712
7+67		4.4	4.2						13.0	40	520
7+87		3.5	3.0						7.2	10	72
[illegible]		2.0	1.3						4.3	34	146
									XXXXXXXXXXXXXXX	XXXXXXXXXXXXXXX	
								Total Double Fill Quantity			31307
								Fill Quantity			15654

[illegible] 300' x 10' x 2' ⟶

Allow ___ % for Settlement. . . . . —

Side Spillway Fill (Including Dikes). . —

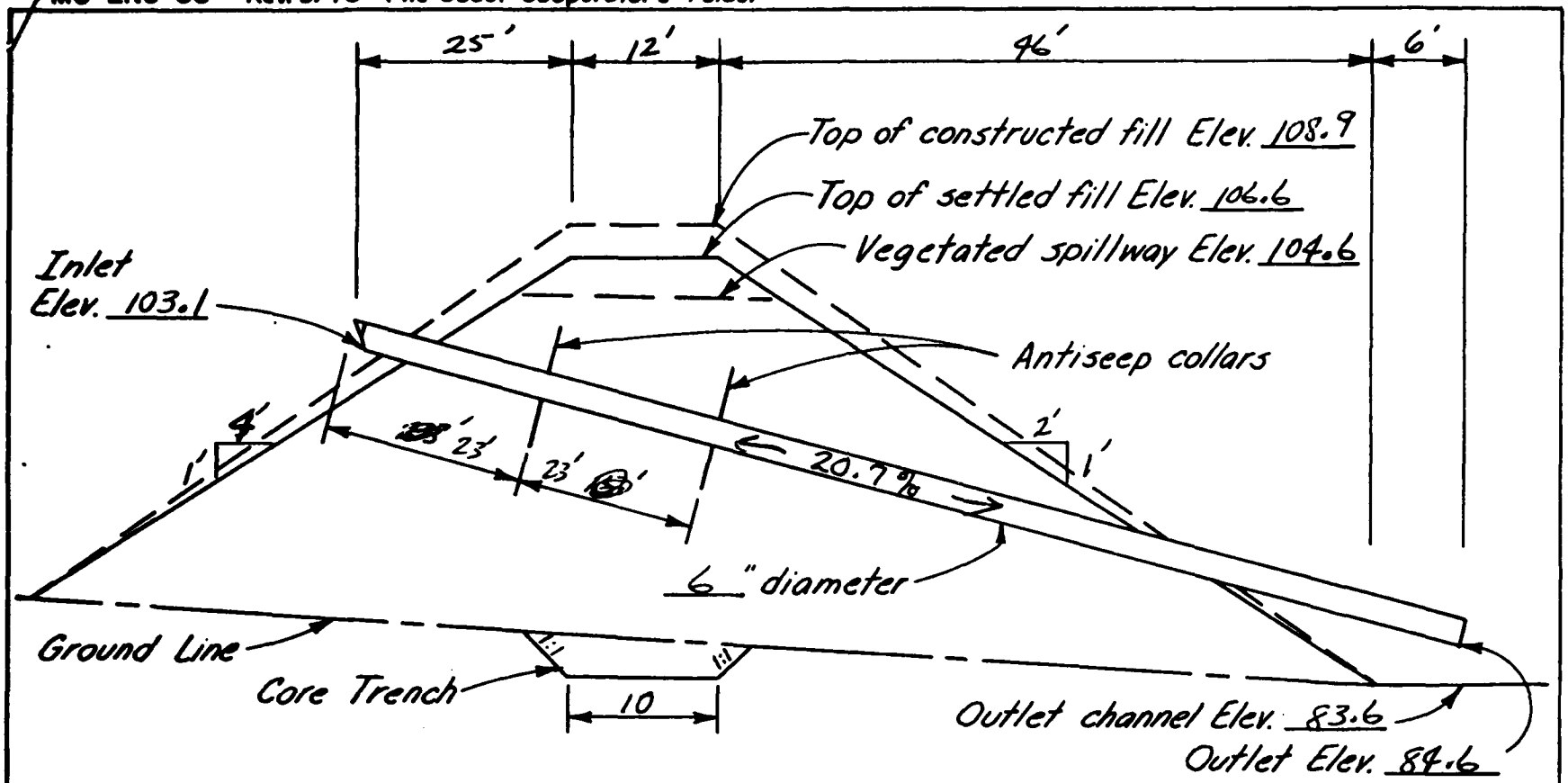
Backfill for Core Trench Excavation . . 652

Backfill for Structure Excavation . . . —

Backfill for Stripping. . . . . —

Total Fill Quantity (Class III) . . . 16306

MO-ENG-66 Rev. 9/75 File Code: Cooperator's Folder



SECTION ALONG ℄ PRINCIPAL SPILLWAY

Not to Scale

ESTIMATED QUANTITIES

QUAN.	UNIT	ITEM
91	ft.	6" smooth Iron Pipe
2	ea.	45"x45" Anti-Seep Collars
1	ea.	trash guard
15,654	cu.yds.	Settled Earth Fill
652	cu.yds.	Core Trench Backfill

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

~~FLOOD~~ or CANOPY

INLET SPILLWAY

Londowner John Bollinger

Madison County, Missouri

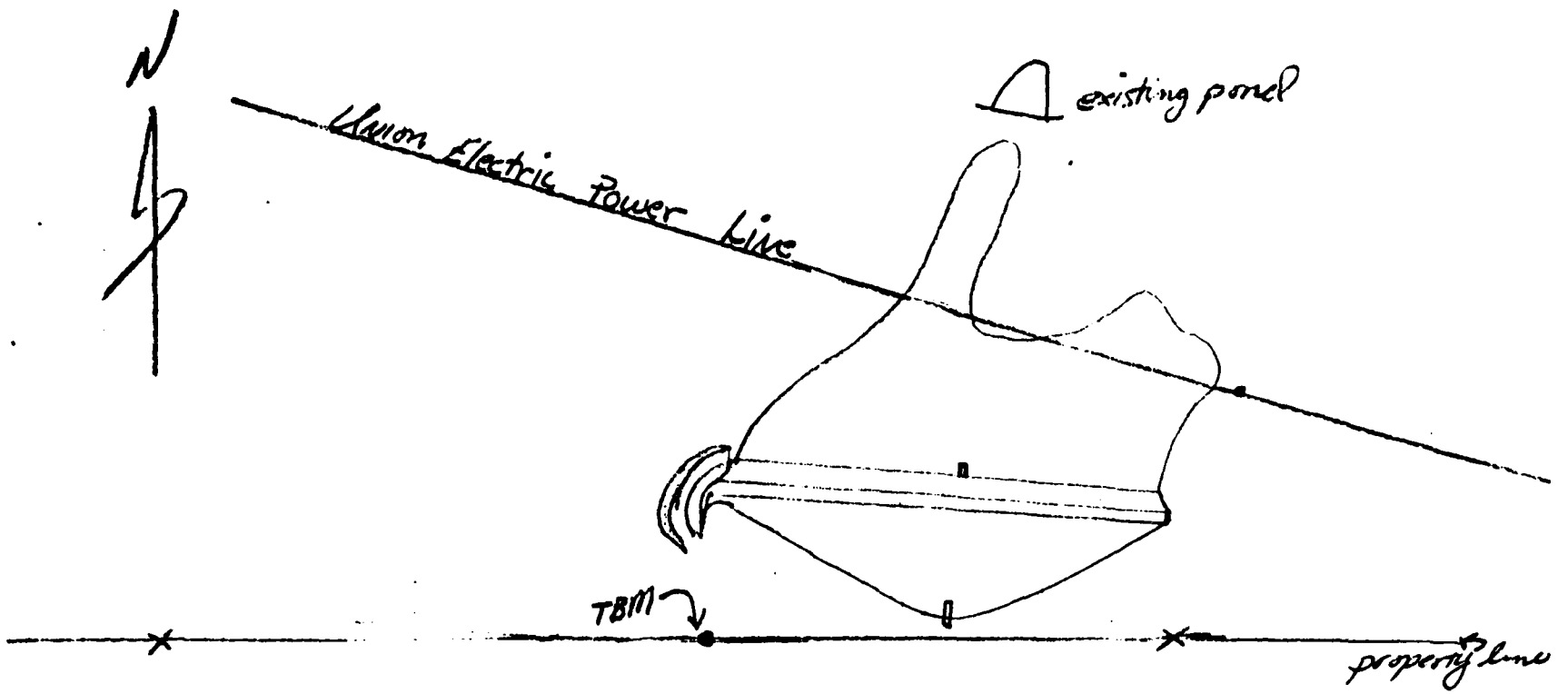
Designed by Don Winkler Date 11/9/77

Checked by Date

Approved by MVW Date 11-9-77

Sheet of

MO-ENG-63
2/71
File Code ENG-13



PLAN VIEW - SKETCH OF DAM AND SPILLWAYS

Not to scale

Approximate surface area 6.1 acres.
Permanent pool elevation 1236.
TBM No. 1 Elev. 100.0 Description
Tip on top front post aprox 70 ft. south lower spillway.

TBM No. Elev. Description

Sheet 1 of 1

UNITED STATES DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	
Landowner Tipp Bollinger	
Morgan County, Missouri	
Designed by [illegible]	Date 11/7/77
Checked by [illegible]	Date 11/9/77
Approved by	Date

S.L.-28,922

END

DATE
FILMED

11-81

DTIC