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STURMFELS LAKE DAM

ST. LOUIS COUNTY, MISSOURI

MO 30849

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army Corps of Engineers
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St. Louis District

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

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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

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UPPER MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

STURMFELS LAKE DAM

ST. LOUIS COUNTY, MISSOURI

MO 30849

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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

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

FOR: STATE OF MISSOURI

SEPTEMBER 1981

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

REPLY TO
ATTENTION OF

SUBJECT: Sturmfels Lake Dam, MO 30849

This report presents the results of field inspection and evaluation of the Sturmfels Lake Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY: SIGNED — Chief, Engineering Division — 24 SEP 1981 Date

APPROVED BY: SIGNED — Colonel, CE, District Engineer — 24 SEP 1981 Date

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STURMFELS LAKE DAM

MISSOURI INVENTORY NO. 30849

ST. LOUIS COUNTY, MISSOURI

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

SEPTEMBER 1981

HS-8088

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Sturmfels Lake Dam
State Located:	Missouri
County Located:	St. Louis
Stream:	Tributary of Glaize Creek
Date of Inspection:	18 August 1981

The Sturmfels Lake Dam, which according to the St. Louis District, Corps of Engineers, is of high hazard potential, was visually inspected by engineering personnel of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri on 18 August 1981. The purpose of this inspection was to assess the general condition of the dam with respect to safety and, based upon this inspection and available data, determine if the presence of the dam creates an inordinate danger to human life or property. Evaluation of this dam was performed in accordance with the "Phase I" investigation procedures prescribed in "Recommended Guidelines for Safety Inspection of Dams", dated May 1975.

The following summarizes the findings of the visual inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team. Based primarily on the visual inspection, the present general condition of the dam is considered to be somewhat less than satisfactory. Several items were noticed during the inspection which are considered to have an adverse effect on the overall safety and future operation of the dam. These items include small trees and dense undergrowth on the crest and upstream and downstream faces of the dam; a leaking pump suction line that has resulted in, or is contributing to, some minor erosion of the downstream side of the embankment at the junction of the dam and right (looking downstream) abutment; a marshy area, approximately 50 feet wide by 125 feet long, that lies just downstream of the right side of the dam; and, the lack of a suitable form of protection, such as riprap, to prevent erosion of the upstream face of the dam and the exit section of the spillway outlet channel.

The Sturmfels Lake Dam is classified, according to Table 1 of the recommended guidelines, as small in size. And according to the criteria set forth in the guidelines, the magnitude of the spillway design flood for a small size dam is specified to be a minimum of one-half the Probable Maximum Flood (PMF) and can be, depending upon the degree of risk involved, the full Probable Maximum Flood (PMF). The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. Considering the fact that there are numerous dwellings within the potential flood damage zone, it is recommended that the spillway for this dam be designed for the full PMF.

Results of a hydrologic/hydraulic analysis indicated that the spillway is adequate to pass lake outflow resulting from a storm of PMF magnitude without overtopping the dam. Also, the reservoir was found to be capable of storing the runoff from the 1 percent chance (100-year frequency) flood without the level of the lake exceeding the spillway crest.

Sturmfels Lake is located within a rapidly developing area of west St. Louis County. Within the downstream damage zone of the dam are a number of residential subdivisions and an area designated for commercial development.

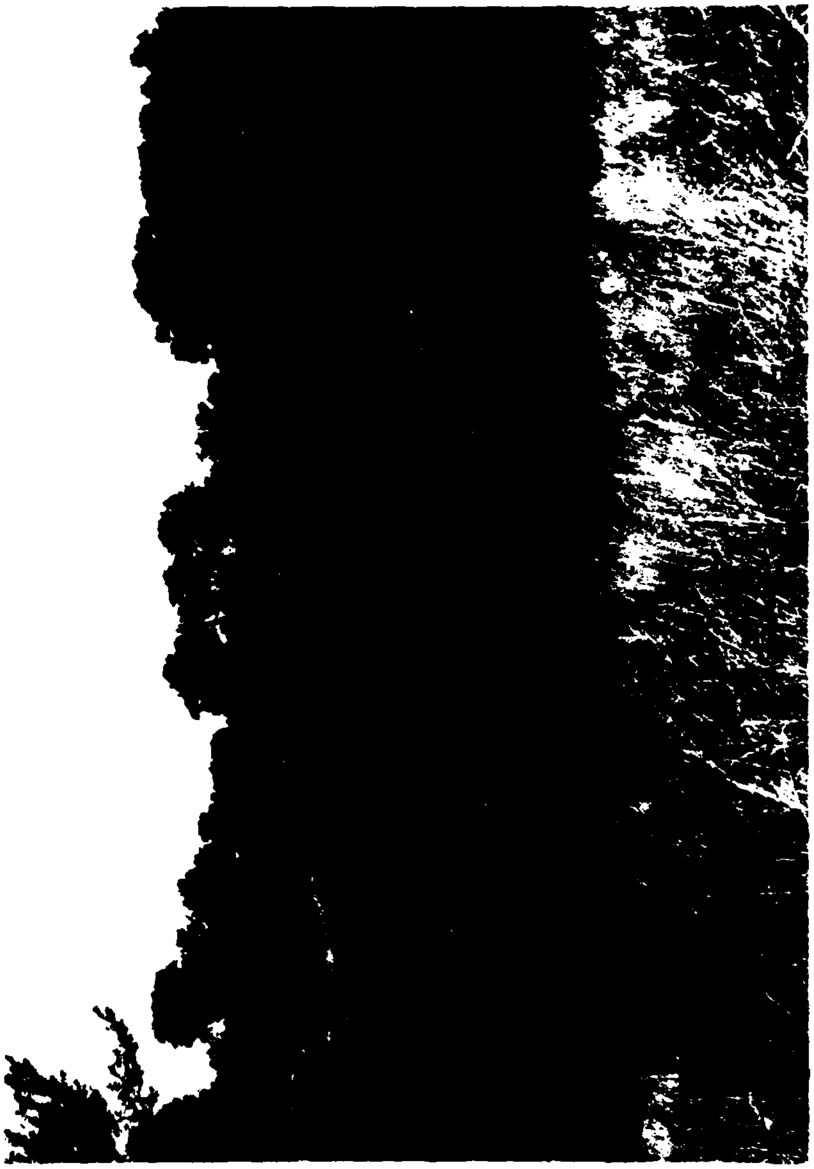
According to the St. Louis District, Corps of Engineers, the length of the downstream damage zone, should failure of the dam occur, is estimated to be two miles. Within the possible damage zone are approximately forty dwellings, a Junior Achievement Training Center, and several commercial buildings.

Seepage or stability analyses of the dam were not available. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action within the near future to correct or control the deficiencies and safety defects reported herein.

Harold B. Lockett
Harold B. Lockett
P. E. Missouri E-4189

Albert B. Becker, Jr.
Albert B. Becker, Jr.
P. E. Missouri E-9168



PHASE 1 INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

STURMFELS LAKE DAM - MO 30849

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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

STURMFELS LAKE DAM - MO 30849

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, directed that a safety inspection of the Sturmfels Lake Dam be made.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of the dam with respect to safety and, based upon available data and this inspection, determine if the presence of the dam creates an inordinate danger to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in the "Recommended Guidelines for Safety Inspection of Dams", Appendix D to "Report to the Chief of Engineers on the National Program of Inspection of Non-Federal Dams", dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Strumfels Lake Dam is an earthfill type embankment rising approximately 38 feet above the natural streambed at the downstream toe of the barrier. At the surveyed cross-section, station 2+15, which is about the location of the original stream on which the dam was constructed, the crest of the dam is approximately 20 feet wide. The upstream slope (above the waterline) of the embankment varies, but is steepest, approximately 1v on 1.5h, near the dam crest. The downstream slope also varies and, again, the steepest section, about 1v on 1.7h, is near the top of the dam. The length of the dam, excluding the spillway, is on the order of 603 feet. The alignment of the dam between abutments is virtually straight, although the spillway, which is located at the right (looking downstream) end (abutment) of the dam, is slightly skew to the centerline of the dam. At the elevation of the spillway crest, the reservoir impounded by the dam occupies approximately 3.6 acres. A general plan of the dam along with a profile of the dam crest extending through the spillway section is shown on Plate 3. A cross-section of the dam, at about the location of the original stream on which the dam was built, is shown on Plate 4. An overview photo of the dam is shown following the preface at the beginning of the report.

The spillway, an excavated earth irregular section, is located, as previously stated, at the right end of the dam. The bottom of the spillway opening is about 12 feet wide and the side slopes of the section are on the order of 1v on 2.0h. The spillway outlet channel, through the crest section where the channel slope is quite flat, follows the countour of the right abutment hillside for approximately 350 feet. The channel is a trapezoidal section with a bottom width of about 10 feet. The side slopes of the channel are somewhat variable, but appear to be as steep as 1v on 2.0h. A low bank on the downhill, or left side of the channel, serves to confine flow to the section. At a point approximately 285 feet downstream of the spillway crest, a V-shaped opening in the left bank of the channel allows flow in the channel to spill down the hillside where it joins the original stream channel at a point approximately 300 feet downstream of the toe of the dam. A profile of the spillway channel and a cross-section of the outlet are shown on Plate 5.

A 4-inch diameter pipe is provided for lake drawdown. The outlet end of the pipe is located approximately 112 feet downstream of the dam at about station 2+20. A valve located about 17 feet from the end of the pipe serves to control flow. The valve operating nut is located within a 6-inch diameter clay pipe riser and a 24-inch diameter concrete pipe encloses and protects the valve.

A pump house is located on the downstream side of the embankment at about station 0+65. The house contains a small cetrifigal type pump, a compressor, and a storage tank capable of being pressurized. The pump is no longer used and the electrical service to the pump house has been disconnected.

b. Location. The dam is located on an unnamed tributary of Glaize Creek about 2 miles due north of the City of Manchester, Missouri, and just east of State Route 141, as shown on the Regional Vicinity Map, Plate 1. The dam is located within U.S. Survey No. 936, approximately 1,800 feet southeast and 1,900 feet northeast of the northwest corner of the tract, Township 45 North, Range 5 East, in St. Louis County.

c. Size Classification. The size classification based on the height of the dam and storage capacity, is categorized as small (per Table 1, Recommended Guidelines for Safety Inspection of Dams). A small size dam is classified, according to the guidelines, as having a height less than 40 feet, but greater than or equal to 25 feet and/or a storage capacity less than 1,000 acre-feet, but greater than or equal to 50 acre-feet.

d. Hazard Classification. The Sturmfels Lake Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that if the dam should fail, there may be loss of life, serious damage to homes, or extensive damage to agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. The estimated flood damage zone, should failure of the dam occur, as determined by the St. Louis District, extends two miles downstream of the dam. Within the possible damage zone are approximately forty dwellings, a Junior Achievement Training Center, and several commercial buildings. Those features lying within the downstream damage zone as reported by the St. Louis District, Corps of Engineers, were verified by the inspection team.

e. Ownership. The dam owner is Mrs. W.G. Sturmfels. Mrs. Sturmfels' address is 878 Woods Mill Road, Manchester, Missouri 63011.

f. Purpose of Dam. The dam presently impounds water for recreational use. The original purpose of the reservoir was to supply water for domestic use.

g. Design and Construction History. According to the Owner's son, W.G. Sturmfels, Jr. (Mr. Sturmfels served as a spokesman for his mother during the course of these investigations.) the dam was constructed for his father (deceased) and was completed about 1959, having taken approxmately two years to complete. Mr. Sturmfels could not recall the name of the contractor that built the dam and records of the dam design or construction were unavailable.

h. Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the capacity of an excavated earth type spillway.

1.3 PERTINENT DATA

a. Drainage Area. The area tributary to the lake is almost entirely meadowland. The watershed above the dam amounts to approximately 23 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

1. Estimated known maximum flood at damsite ... Unknown*
2. Spillway capacity ... 340 cfs (W.S. Elev. 608.5)**

c. Elevation (Ft. above MSL). Except where noted, the following elevations were determined by survey and are based on topographic data shown on the 1954 USGS Manchester, Missouri, Quadrangle Map, 7.5 minute series, photorevised 1968 and 1974.

1. Observed pool ... 600.9
2. Normal pool ... Unknown
3. Mean annual high water ... 601.0 (assumed)
4. Spillway crest ... 605.0
5. Maximum experienced pool ... Unknown*

*According to Mr. Sturmfels, the lake surface has never reached the level of the spillway crest.
**Elevation at which velocity of flow at spillway crest equals 7.5 feet per second.

6. Top of dam ... 611.9 (at original stream crossing, station 2+15)
7. Streambed at centerline of dam ... 579± (Est.)
8. Maximum tailwater ... Unknown
9. Observed tailwater ... None

d. Reservoir.

1. Length at spillway crest (Elev. 605.0) ... 400 ft.
2. Length of pool at top of dam (Elev. 611.9) ... 500 ft.

e. Storage.

1. Spillway crest ... 30 ac. ft.
2. Top of dam ... 60 ac. ft.

f. Reservoir Surface Area.

1. Spillway crest ... 3.6 acres
2. Top of dam ... 5.0 acres

g. Dam. According to the guidelines, the height of the dam is defined to be the overall vertical distance from the lowest point of foundation surface at the downstream toe of the barrier, to the top of the dam.

1. Type ... Earthfill
2. Length ... 603 ft. (between abutments)
3. Height ... 38 ft. (max.)
4. Top width ... 20 ft. (station 2+15)
5. Side slopes
   a. Upstream ... Variable, 1v on 1.5h (max., above waterline)
   b. Downstream ... Variable, 1v on 1.7h (max.)
6. Cutoff ... Unknown
7. Slope protection
   a. Upstream ... Vegetation
   b. Downstream ... Vegetation

h. Principal Spillway.

1. Type ... Excavated earth, irregular section
2. Location ... Right abutment
3. Crest ... Elevation 605.0
4. Bottom width ... 12 ft.
5. Side slopes ... Irregular, 1v on 2±h
6. Erosion protection ... Vegetation
7. Approach channel ... Lake
8. Outlet channel ... Trapezoidal section, earth bottom, variable side slopes

i. Emergency Spillway ... None

j. Lake Drawdown Facility.

1. Type ... 4-Inch diameter pipe
2. Outlet location ... Sta. 2+20, 112 ft. right
3. Control ... Gate valve (station 2+15, 95 ft. right)
4. Outlet pipe invert ... Elevation 573.2

k. Appurtenant Structure.

1. Feature ... Pump house
2. Location ... Sta. 0+65, 25 ft. right (center)
3. Floor ... Elevation 597.9
4. Construction ... Concrete walls, wood roof
5. Size ... 8.5 ft. wide by 12.0 ft. long by 7.0 ft. high

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Data relating to the design of the dam were unavailable.

2.2 CONSTRUCTION

As previously stated, construction of the dam was completed in about 1959. With the exception of indicating that the equipment operators had mentioned that they were experienced in building levees for the Government, Mr. Sturmfels reported that he had no other factual knowledge of the construction of the dam. However, Mr. Sturmfels believed that it was likely that a keyway, or core trench, was constructed, since it was good practice to do so and the people that built the dam appeared to be experienced in this type of construction.

2.3 OPERATION

The level of the lake is uncontrolled, and would be, under normal conditions, governed by the crest of the excavated earth spillway located at the right end, or abutment, of the dam. According to Mr. Sturmfels, the lake surface has never reached the level of the spillway crest, although at one time, it was fairly close. No estimate of the highest lake level observed was offered. No evidence of dam overtopping was observed and none was reported.

Mr. Sturmfels reported that because of all the rain the area has experienced this year, the lake level observed at the time of the inspection was about 2 feet higher than normal for this time of the year. Judging by the new weed growth about the perimeter of the lake as observed during the inspection, it would appear that the lake level had been one-to-two feet higher than the observed level sometime fairly recently.

A 4-inch diameter pipe, that passes through the dam near the location of the original stream on which the dam was built, is available for lake drawdown. A valve located near the outlet end of the pipe is provided for control of flow. At one time the reservoir was used as a source of water supply and water was pumped from the lake to the Owner's residence. Mr. Sturmfels reported that the pump suction line is connected to the drain line at some point beneath the dam and that the pipe extends into the center of the lake with the inlet end turned upward. As previously stated, the pump is no longer in service.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the dam and spillway were unavailable.

b. Adequacy. No data available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Sturmfels Lake Dam was made by Horner & Shifrin engineering personnel, R. E. Sauthoff, Civil Engineer, H. B. Lockett, Hydrologist, and A. B. Becker, Jr., Civil and Soils Engineer, on 18 August 1981. A neighbor, Mrs. Fredricks, was present during the inspection, but did not accompany the team during the inspection. An examination of the dam site was also made by an engineering geologist, John D. Rockaway, Ph.D., a consultant retained by Horner & Shifrin for the purpose of assessing the area geology. Also examined at the time of the inspection were the areas and features below the dam within the potential flood damage zone. Photographs of the dam taken at the time of the inspection are included on pages A-1 through A-4 of Appendix A. The locations of the photographs taken during the inspection are indicated on Plate 3.

b. Site Geology. Sturmfels Lake is located near the head of an unnamed tributary to Glaize Creek. The topography is rolling and there is about 50 feet of relief between the crest to the dam and the surrounding drainage divide. The site is at the northern edge of the Salem Plateau Section of the Ozark Uplift Physiographic Province, near its border with the Dissected Till Plains Section of the Central Lowland Province. The bedrock formations consist of gently northward dipping Mississippian age sedimentary strata. No bedrock outcrops were noted at the site, however, the area is underlain by the St. Louis Limestone Formation. No faults were observed or are reported to be present in the area.

The St. Louis Limestone is a light colored, dense, crystalline limestone that is usually thickly or massively bedded. The bedrock is highly susceptible to solution and sinkholes, caves and solution enlarged bedding planes frequently occur. The contact between the bedrock and the overlying surfacial material usually is irregular and bedrock remnants in the residual material are common.

The bedrock surface is ovelain by thick deposits of loessal material. These soils are comprised of silts and clays deposited by wind on the ridgetops and hillsides adjacent to the Missouri River Valley. The soils are dark yellowish-brown, friable silts (ML) in the upper layers, becoming darker and more clayey (CL) with depth. They are relatively permeable materials which are susceptible to erosion, but are generally suitable for use in embankments and for reservoir impoundments. Although not observed, these soils usually overlie a red, blocky residual clay formed as residuum from the weathering of limestone bedrock.

There appear to be no significant geotechnical problems at this site. It is very probable that significant seepage is occurring through the solution features in the limestone bedrock. This is suggested by the fact that the reservoir has never reached its full capacity. A small spring in an adjacent ravine (the spring predates the dam) also suggests solution features in the limestone bedrock.

c. <u>Dam</u>. The visible portions of the upstream and downstream faces of the dam, as well as the dam crest (see Photos 1, 2 and 3) were examined, and, so far as could be determined, appeared to be in sound condition. Due to the presence of dense vegetation consisting of lespedeza (sericea), up to 4 feet tall, and weeds, up to 6 feet tall, a thorough inspection of the dam surface could not be made. However, no cracking of the dam surface, sloughing or erosion of the embankment and abutment slopes, or undue settlement of the crest, was observed. And, although the upstream face of the dam was not protected by riprap, no significant erosion was noticed. A few small trees, up to about 3 inches in diameter, were found on the upstream and downstream slopes. No animal burrows were seen, but due to the dense undergrowth on the dam, it cannot be reported that none exist. Examination of a soil sample obtained from the downstream face of the embankment near the center of the dam, indicated the surficial material of the embankment to be yellow-brown, lean clay (CL) of medium plasticity.

The excavated earth spillway section (see Photo 4) and outlet channel (see Photo 5) were examined and found to be in good condition. Both the spillway opening and the crest section of the outlet channel were well protected from erosion by a dense cover of fescue grass along with several varieties of native grasses and weeds. The exit section of the channel (see Photo 6) was unimproved. However, the course of flow down the hillside was distinguishable due to the fact that erosion, presumably by overland drainage since it was reported that the level of the lake has never reached the spillway crest, had produced a gulley up to 3 feet deep throughout most of the section. This erosion does not appear to endanger the dam since the location of the exit section is appxoximately 250 feet from the nearest point of the dam.

The visible portions of the 4-inch diameter lake drawdown pipe were inspected. The valve on the line could not be examined due to the fact that it was below ground level and the 6-inch diameter clay tile riser about the valve was filled with water to a level about 4-to-6 inches above the operating nut. A vertical section of 24-inch diameter concrete pipe (see Photo 7) enclosed the valve. No other form of protection, such as straw to prevent freezing of the valve, was noticed. The outlet end of the pipe (see Photo 8) was below the ground surface and covered by about 6 inches of earth. The pipe end was uncovered, but due to the presence of water and earth it could not be thoroughly examined. However, the pipe appeared to be of cast iron.

d. Appurtenant Structures. The pump house (see Photo 9) and appurtenances located near the right end of the dam, was inspected. The concrete walls of the pump house appeared to be in good condition, since no structural defects were evident, and the roof, a wood deck, appeared to be adequate for the intended purpose. It was apparent, however, from the condition of the piping, valves, pump, and other items within the structure that the facility had not been used for quite some time. One of the valves on the 2-inch diameter pump suction line was leaking at a rate estimated to be 2-to-3 gpm and other small leaks in the piping system accounted for about another 1 gpm. According to elevations obtained by survey at the time of the inspection, the head on the pump suction line was about 1.8 feet. The leakage from the system collected on the floor of the structure and flowed out the front, or east side, of the building, where at a point approximately 15 feet beyond the structure the flow entered a hole (see Photo 10) in the embankment surface. The hole which was about 4 inches in diameter, may have been an abandoned animal burrow. At a point 15 feet, or so, beyond the hole, the flow emerged on the surface and continued along the junction of the embankment and abutment hillside until reaching the marshy area (see Photo 11) located adjacent to the dam between stations 1+00 ± and 1+50 ±. A small berm, on the order of 3 feet high and 5 feet wide, served to confine the flow, as well as any overland drainage, to this area. Cattails and a pool of standing water (see Photo 12) up to about 8 inches deep, were noticed within the area which was estimated to be approximately 50 feet wide by 125 feet long. Except for the pump house, no other appurtenant structures were noted.

e. Downstream Channel. Except at road crossings, there are a total of five, the channel downstream of the dam within the potential flood damage zone, is unimproved although some straightening of the channel may have been done through the commercial area adjacent to Highway 100 (Manchester Road). The channel is irregular and, for the most part, lined with trees. The stream joins Grand Glaize Creek at a point about 2 miles downstream of the dam.

Some flow, on the order of 2-to-3 gpm, was observed in the channel just downstream of the dam. The source of this flow could not be determined, however, it is likely that it is a combination of seepage from the reservoir and/or from the marshy area that lies adjacent to the right side of the dam.

f. Reservoir. Except at the two drainage courses that are tributary to the lake, the area surrounding the reservoir is meadowland and the hillside slopes about the lake are moderately steep. At the time of the inspection, the lake level was about 4.1 feet below the spillway crest, and the water was fairly clear, although some algae was present on the surface about the perimeter of the reservoir. No estimate of the actual amount of sediment within the reservoir was made, but due to the fact that the drainage area is well covered with vegetation, it is not expected to be hydrologically significant.

3.2 EVALUATION

The deficiencies observed during this inspection, and noted herein, are not considered of significant importance to warrant immediate remedial action.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillway is uncontrolled. The lake surface level is governed by precipitation runoff, evaporation, seepage, and the capacity of the uncontrolled spillway. There is no emergency spillway. There is a lake drawdown, or drain, facility. At one time, the reservoir was used to impound water for domestic purposes being pumped from the lake to the Owner's home. However, this procedure was discontinued some time ago.

4.2 MAINTENANCE OF DAM

According to Mr. Sturmfels, the dam is periodically inspected for defects; the grass on the dam is mowed one or two times a year, if not too wet to safely operate the mowing equipment; trees are removed before they become well established; and, although muskrats have been observed and removed from the reservoir, none have been noticed on the dam proper.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

As previously indicated, the reservoir was once used to provide water for domestic use. However, the facility for pumping water from the lake is no longer in operation and the equipment has been allowed to fall into a condition of disorder.

Mr. Sturmfels reported that the valve on the lake drawdown pipe is operated regularly to check its capability.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

According to Mr. Sturmfels, the telephone number of the St. Louis County Police is readily available in the case of an emergency, such as the imminent failure of the dam. No other form of dam failure warning system was reported or observed.

4.5 EVALUATION

Judging by the extent of the growth of the vegetation on the dam crest and slopes, it is evident that these areas could use more frequent attention. In addition, the pipes and valves within the pump house should be removed and the line plugged, or serviced to prevent leaks, and the marshy area adjacent to the dam where the drainage is allowed to pond should be eliminated. For the safety of the dam, it is recommended that a detailed inspection of the dam be instituted on a regular basis by an engineer experienced in the design and construction of dams and that records be kept of all inspections made and remedial measures taken. Additional recommendations regarding the operation and maintenance procedures of the dam are contained in Section 7, paragraph 7.2b.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data were not available.

b. Experience Data.

(1) The drainage area and lake surface area were determined from the 1954 Manchester, Missouri, Quadrangle Map (photorevised 1968 and 1974). The proportions and dimensions of the spillway and dam were developed from surveys made during the inspection. Records of rainfall, streamflow, or flood data for the watershed were not available.

(2) The lake level prior to the beginning of all antecedent storms was assumed to be at elevation 601.0 with storage equivalent to 17.0 acre-feet. This elevation was assumed to be the mean annual high lake level. According to Mr. Sturmfels, the present level is about 2 feet higher than the normal level of the lake for this time of the year, and the maximum lake level experienced to date approached, but did not quite reach, the level of the spillway crest (elevation 605.0). The observed level at the time of the inspection was about 4.1 feet below the spillway crest.

(3) In accordance with criteria established by the St. Louis District, Corps of Engineers, for the one percent chance (100-year frequency) storm, the 24-hour runoff from the rainfall distribution for the 24 hours preceding the maximum 24 hours was evaluated and found to be 0.40 inch, and the computed volume of runoff for the antecedent storm amounted to 0.8 acre-feet, resulting in accumulated storage equal to 17.8 acre-feet at elevation 601.3 at the beginning of the one percent chance (100-year frequency storm).

(4) In accordance with the hydrologic/hydraulic standards of the St. Louis District, Corps of Engineers, for all PMF ratio storms, an antecedent storm equal to one-half the PMF ratio event was assumed to precede the PMF

ratio storm by four days. This PMF ratio antecedent storm was then routed through the reservoir. For the 50 percent PMF storm, an antecedent storm of 25 percent PMF magnitude was assumed to precede the 50 percent PMF storm by four days. This storm was routed through the lake, and it was found that elevation 605.0, the spillway crest, was exceeded by about 0.4 feet, and that the lake level receded to the elevation of the spillway crest by the end of the second day. It is evident, therefore, that a similar analysis for the 100 percent PMF ratio storm, using an antecedent storm of 50 percent PMF magnitude, would also result in the level of the lake exceeding the crest of the spillway with the lake level receding to the elevation of the spillway crest within two days. The lake surface at the beginning of the 50 percent and 100 percent PMF ratio storms was therefore taken as the level of the spillway crest, elevation 605.0.

(5) In the determination of spillway capacity it was assumed that the spillway outlet channel could pass 32 cfs before overtopping of the left bank of the channel would occur. It was also assumed that once overtopping occurred the confining bank would be eroded, resulting in a free discharge with control shifting to the spillway crest section. Under free discharge, flow would spill down the hillside near the toe of the dam and some erosion of the embankment may take place.

(6) According to the St. Louis District, Corps of Engineers, the estimated flood damage zone, should failure of the dam occur, extends two miles downstream of the dam.

c. Visual Observations.

(1) The spillway, a broad-crested, irregular shaped excavated earth section, is located at the right abutment. The spillway crest and outlet channel have a vegetative type of cover to prevent erosion.

(2) The spillway outlet channel, a shallow trapezoidal section, extends along the contour of the right abutment hillside for about 350 feet. A low bank on the left, or downhill, side of the channel serves to confine

flow to the section. Approximately 285 feet downstream of the spillway crest, a V-shaped opening in the left bank of the channel allows flow in the channel to spill down the hillside where it joins the original stream channel at point about 300 feet downstream of the toe of the dam.

(3) There is no emergency spillway. A 4-inch diameter pipe is provided for lake drawdown.

d. Overtopping Potential. The spillway is adequate to pass one-half the probable maximum flood and the probable maximum flood without overtopping the dam. Under the assumed antecedent conditions and with the initial level of the lake at elevation 601.3 prior to the one percent chance storm, the reservoir will contain the runoff from the one percent chance (100-year frequency storm) and no lake outflow is expected.

(Note: The data appearing in the following table were extracted from the computer output data appearing in Appendix B. Decimal values have been rounded to the nearest one-tenth in order to prevent assumption of unwarranted accuracy.)

Ratio of PMF	Q-Peak Outflow (cfs)	Max. Lake W.S. Elev.	Max. Depth (Ft.) of Flow Above Top of Dam (Elev. 611.9)	Duration of Overtopping of Dam (Hours)
0.50	145	607.3	0.0	0.0
1.00	307	608.3	0.0	0.0
1% Chance Flood	0	603.2	0.0	0.0

During the probable maximum flood and with the level of the lake at elevation 608.3, the depth of flow within the spillway was determined to be about 3.3 feet and the velocity of flow passing the spillway crest is expected to be approximately 7.3 feet per second. At the time of maximum outflow and with a velocity of flow of 7.3 feet per second, some damage by erosion to the embankment adjacent to the spillway crest is likely. However, since the time when these somewhat excessive velocities occur is rather brief, approximately 18 minutes, the amount of damage to the dam is not expected to be significant.

f. References. Procedures and data for determining the probable maximum flood, the 100-year flood, and the discharge rating curve for flow passing the spillway and dam crest are presented on pages B-1 through B-3 of Appendix B. Listings of the HEC-1 (Dam Safety Version) input data for ratios of the probable maximum flood and the one percent chance (100-year frequency) flood are shown on pages B-4 through B-6. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-7 through B-10; tabulation of lake surface area, elevation and storage volume is shown on page B-11; tabulations titled "Summary of Dam Safety Analysis" for the 50 and 100 percent PMF, and the 1 percent chance (100-year frequency) flood are also shown on page B-11. A rating curve for the spillway showing elevation - discharge relationships is shown on page B-12 of Appendix B.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which adversely affect the strucutral stability of the dam and spillway are discussed in Section 3, paragraph 3.1c.

b. Design and Construction Data. Design or construction data relating to the structural stability of the dam were unavavailable. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were also unavailable, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Operating Records. According to Mr. Sturmfels, no records were kept of pumpage from the lake, and no records of lake level are maintained, although it was reported that the lake has never reached the level of the spillway crest.

d. Post Construction Changes. According to the Mr. Sturmfels, and to the best of his knowledge, no post construction changes have been made or have occurred which would affect the structural stability or safety of the dam.

e. Seismic Stability. The dam is located within a Zone II seismic probability area. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earthen dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Results of a hydrologic/hydraulic analysis indicated that the spillway is adequate to pass the probable maximum flood, the recommended spillway design flood, without overtopping the dam.

Seepage and stability analyses of the dam were not available for review, and therefore, no judgment could be made with respect to the structural stability of the dam.

Several items were noticed during the inspection that could adversely affect the safety of the dam. These items include small trees and dense undergrowth on the crest and upstream and downstream slopes of the embankment, a leaking pump suction line that has resulted in, or is contributing to, some minor erosion of the downstream side of the embankment at the junction of the dam and right abutment; a marshy area, approximately 50 feet wide by 125 feet long, that lies just downstream of the right side of the dam; and the lack of a suitable form of protection, such as riprap, to prevent erosion of the upstream face of the dam and the exit section of the spillway outlet channel.

b. Adequacy of Information. Due to lack of design and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The assessments of the hydrology of the watershed and capacity of the spillway were based on a hydrologic/hydraulic study as indicated in Section 5. Seepage and stability analyses comparable to the requirements of "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. The remedial measures recommended in paragraph 7.2 for the items concerning the safety of the dam noted in paragraph 7.1a should be accomplished within the near future.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. The dam is located within a Zone II seismic probability area. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earthen dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

a. Recommendations. The following action is recommended.

Obtain the necessary soil data and perform dam seepage and stability analyses in order to determine the structural stability of the dam for all operational conditions. Seepage and stability analyses should be performed by a qualified professional engineer experienced in the design and construction of earthen dams.

b. Operations and Maintenance (O & M) Procedures. The following O & M Procedures are recommended:

(1) Remove the undergrowth that may conceal animal burrows and the small trees from the dam. Holes produced by tree roots or animal burrows can provide pathways for lake seepage that could result in a piping condition (progressive internal erosion) and failure of the dam. Maintain the turf cover on the embankment at a height that will not hinder inspection of the dam or provide cover for burrowing animals.

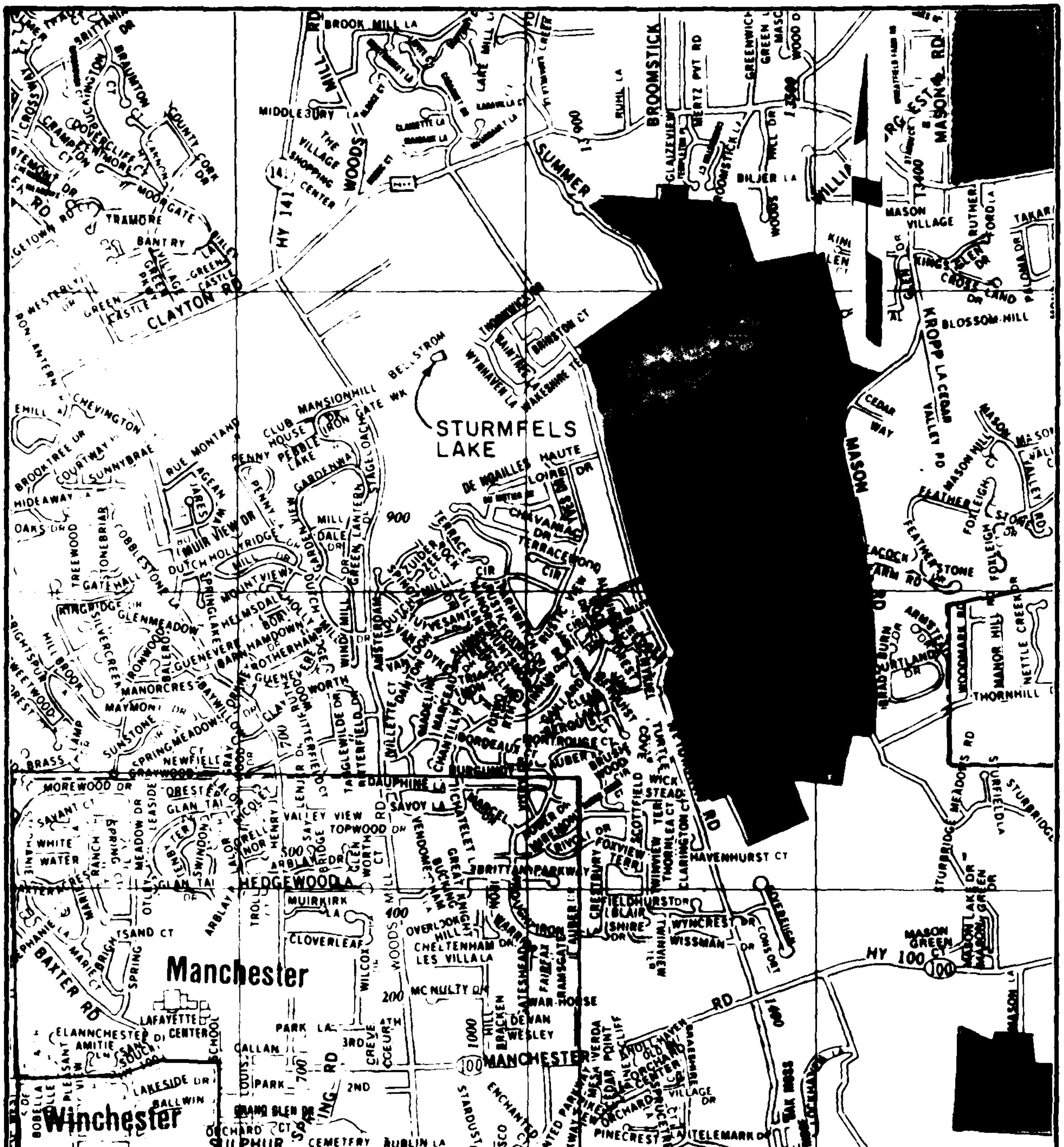
(2) Prevent the leakage of the pump suction line that has resulted in, or is contributing to, erosion of the embankment. Restore the embankment at the location of the erosion. Loss of embankment due to erosion can impair the stability of the dam.

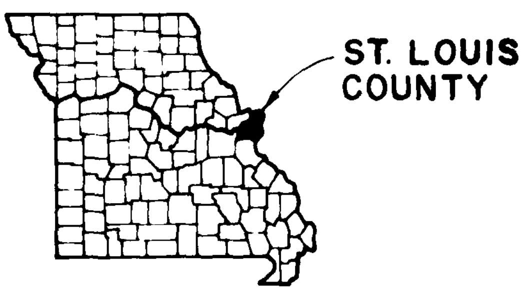
(3) Eliminate the marshy area adjacent to the right side of the dam. Saturation of the soil can reduce the strength of the material and lessen its effectiveness to provide adequate support for the dam.

(4) Provide some form of protection, other than grass, across the upstream face of the dam at the normal waterline. A grass covered slope is not considered adequate protection in order to prevent erosion of the embankment by wave action or by fluctuations of the lake level.

(5) Provide maintenance of all areas of the dam and spillway on a regularly scheduled basis in order to insure features of being in satisfactory operational condition.

(6) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended, for future reference, that records be kept of all inspections made and remedial measures taken.



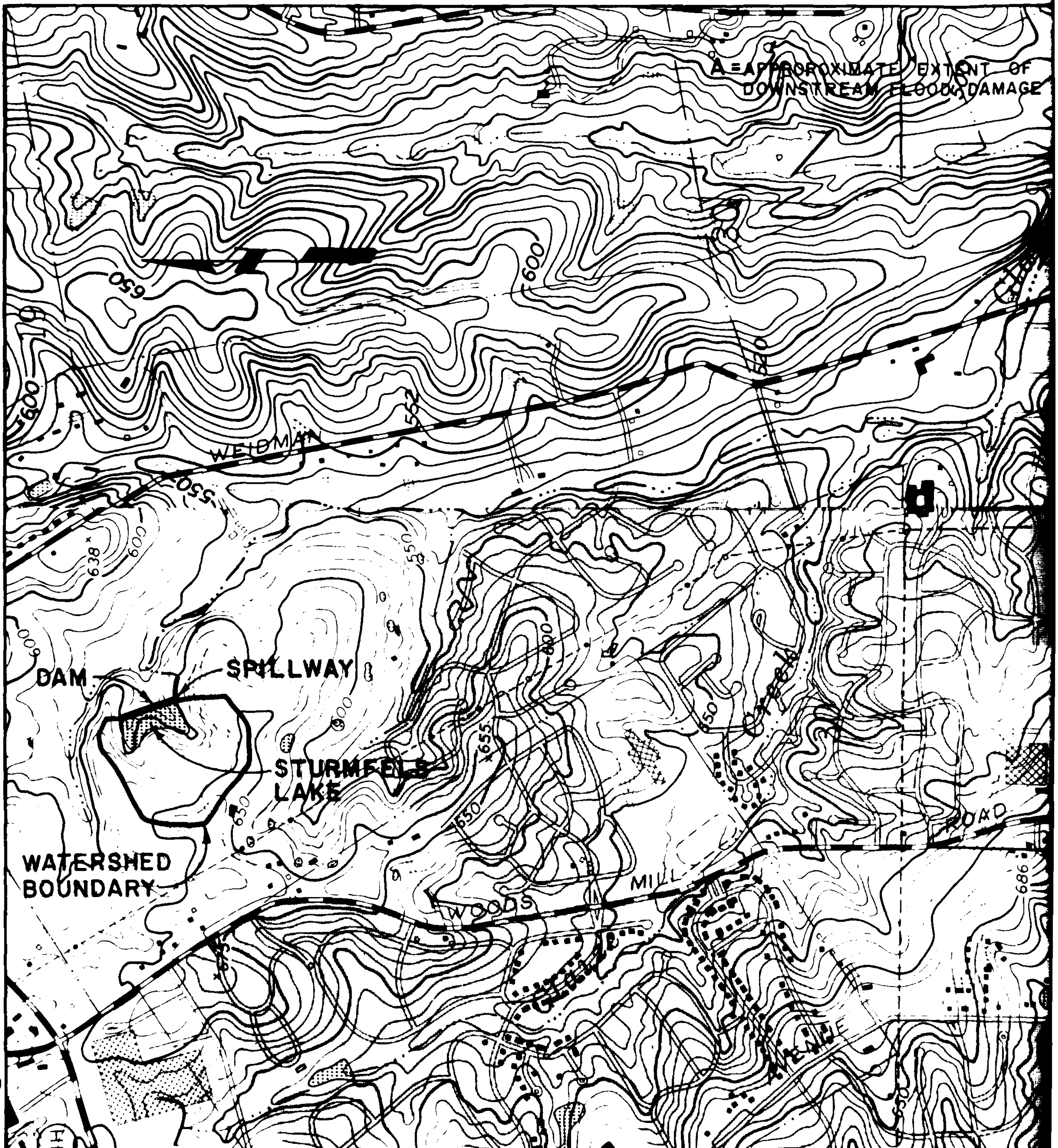


LOCATION MAP

STURMFELS LAKE DAM
MO 30849

SCALE (1,000 FT)

REGIONAL VICINITY MAP


A = APPROXIMATE EXTENT OF DOWNSTREAM FLOOD DAMAGE
WEIDMAN
ROAD
DAM
SPILLWAY
STURMFELS LAKE
WATERSHED BOUNDARY
WOODS MILL
650
600
550
638
655
686

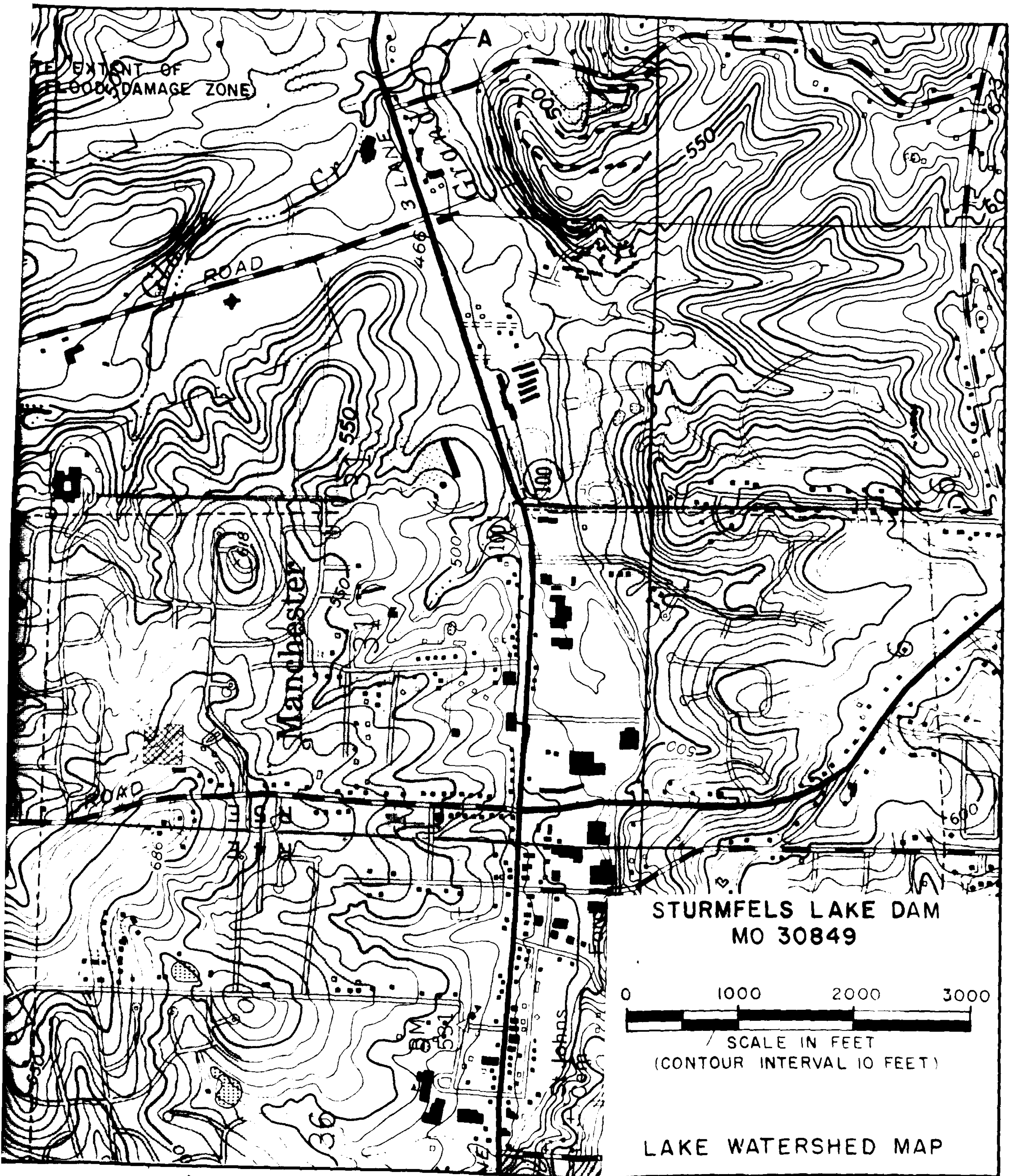
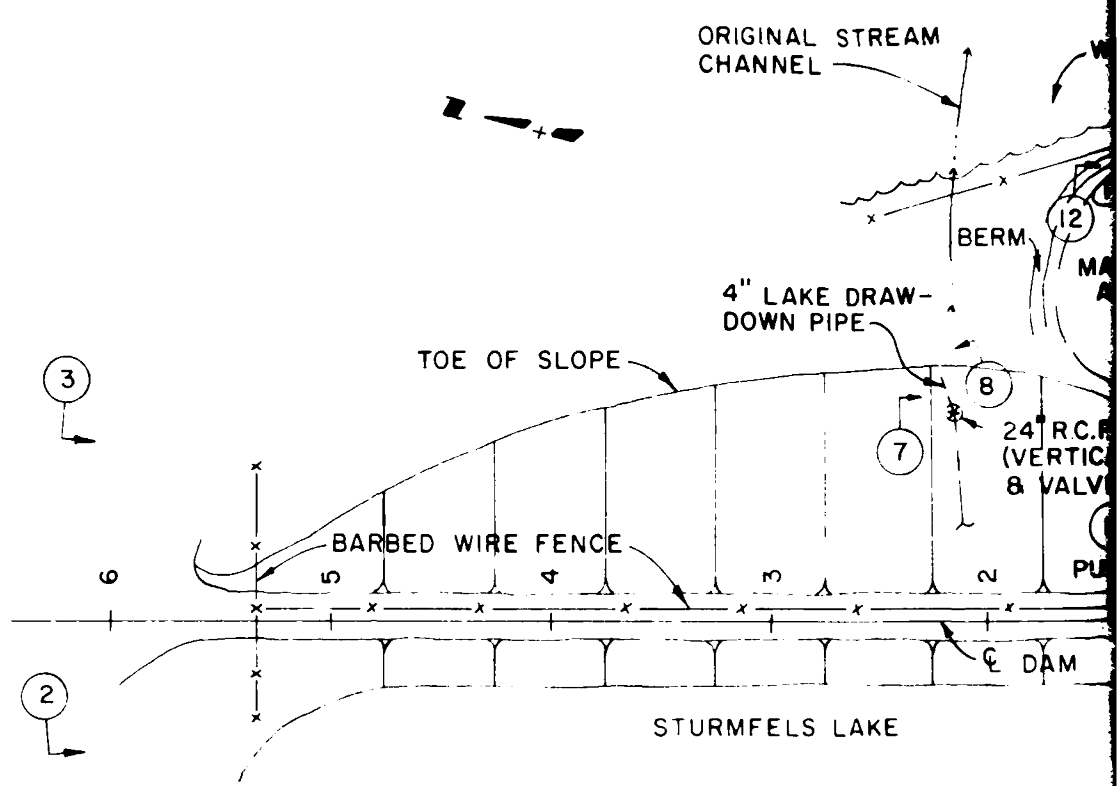
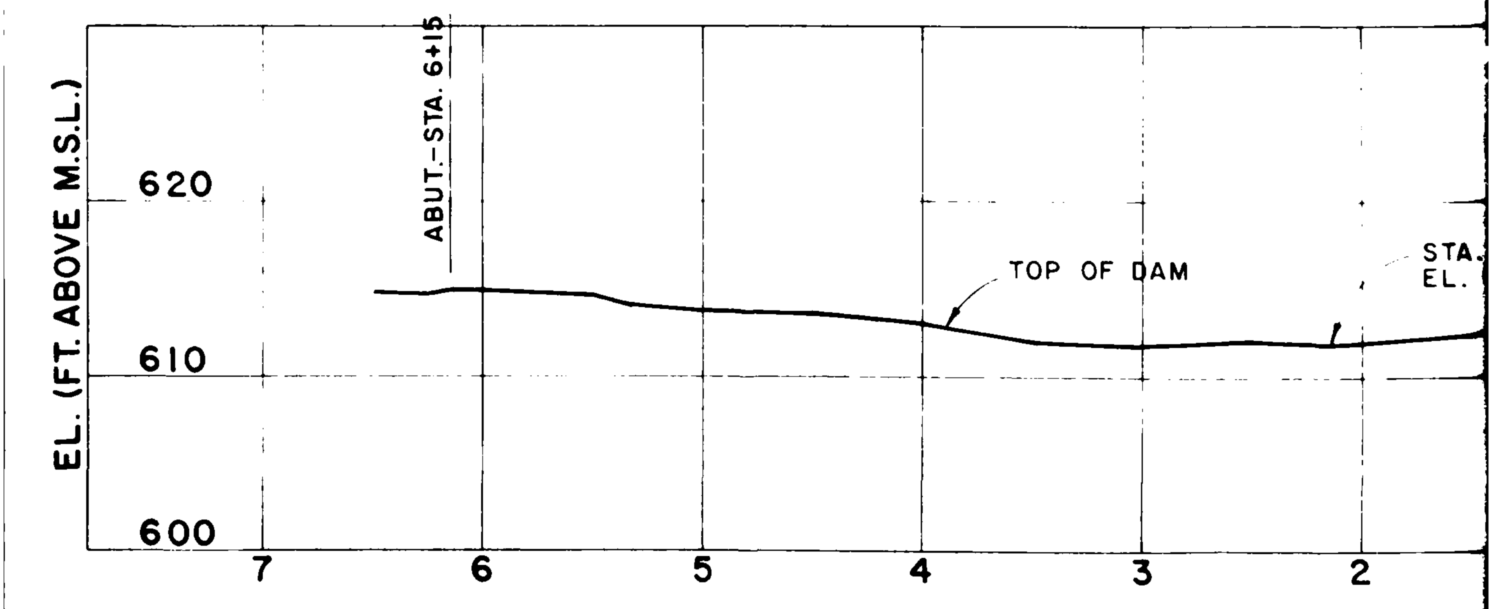

EXTENT OF
FLOOD DAMAGE ZONE
A
ROAD
550
500
Manchester
ROAD
STURMFELS LAKE DAM
MO 30849
0
1000
2000
3000
SCALE IN FEET
(CONTOUR INTERVAL 10 FEET)
LAKE WATERSHED MAP

PLATE 2



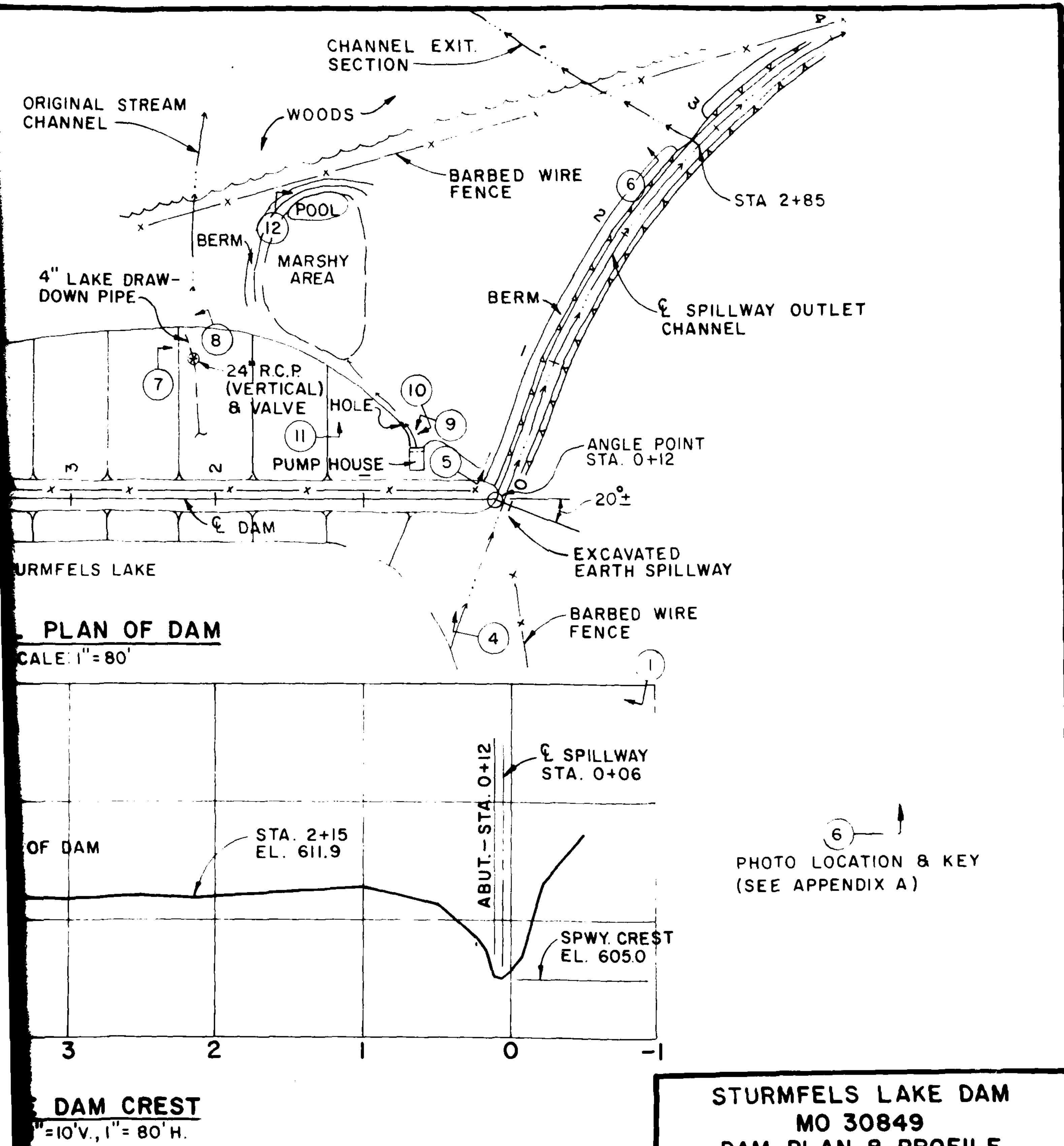
GENERAL PLAN OF DAM

SCALE: 1" = 80'



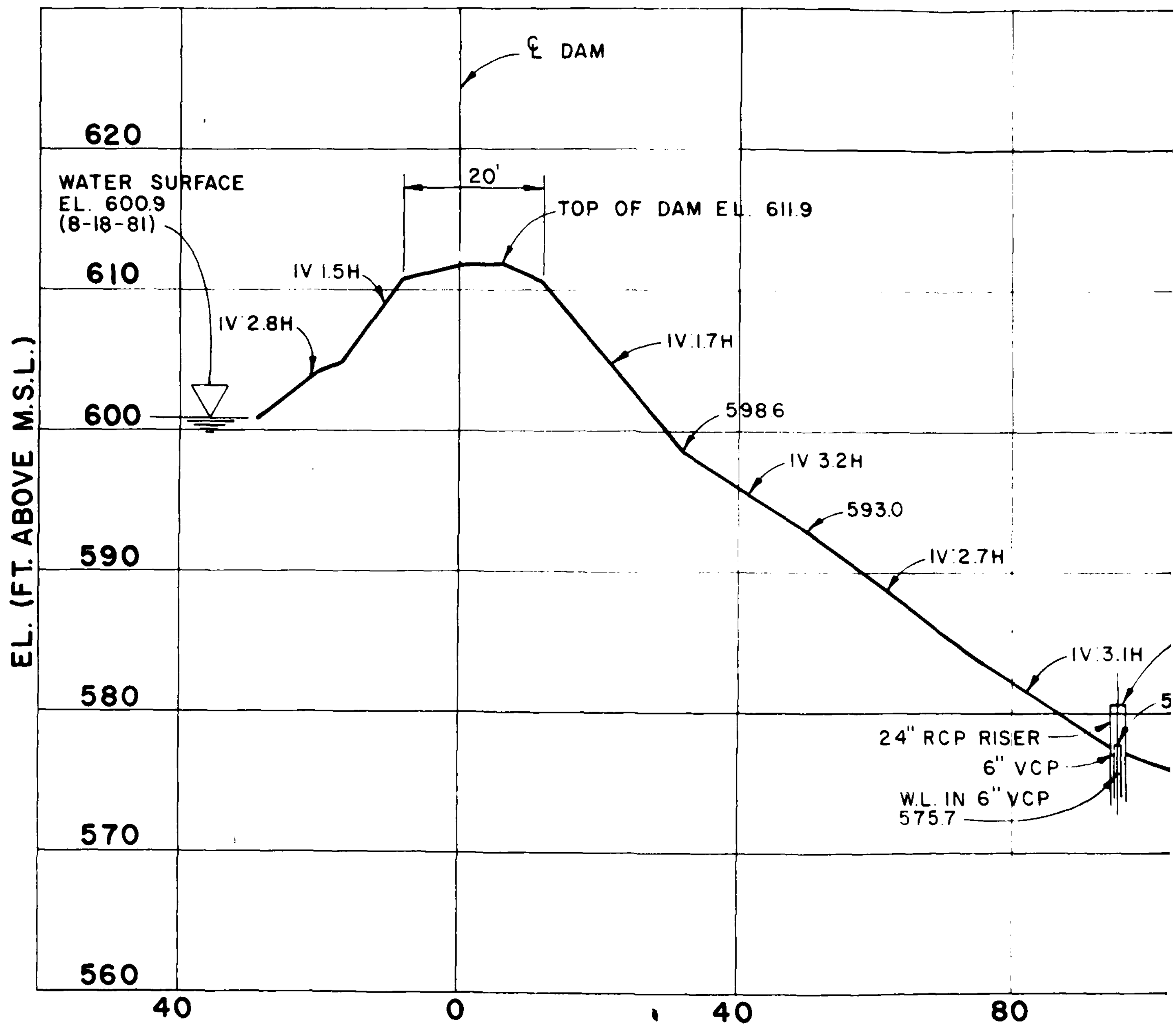
PROFILE DAM CREST

SCALES: 1" = 10' V., 1" = 80' H.



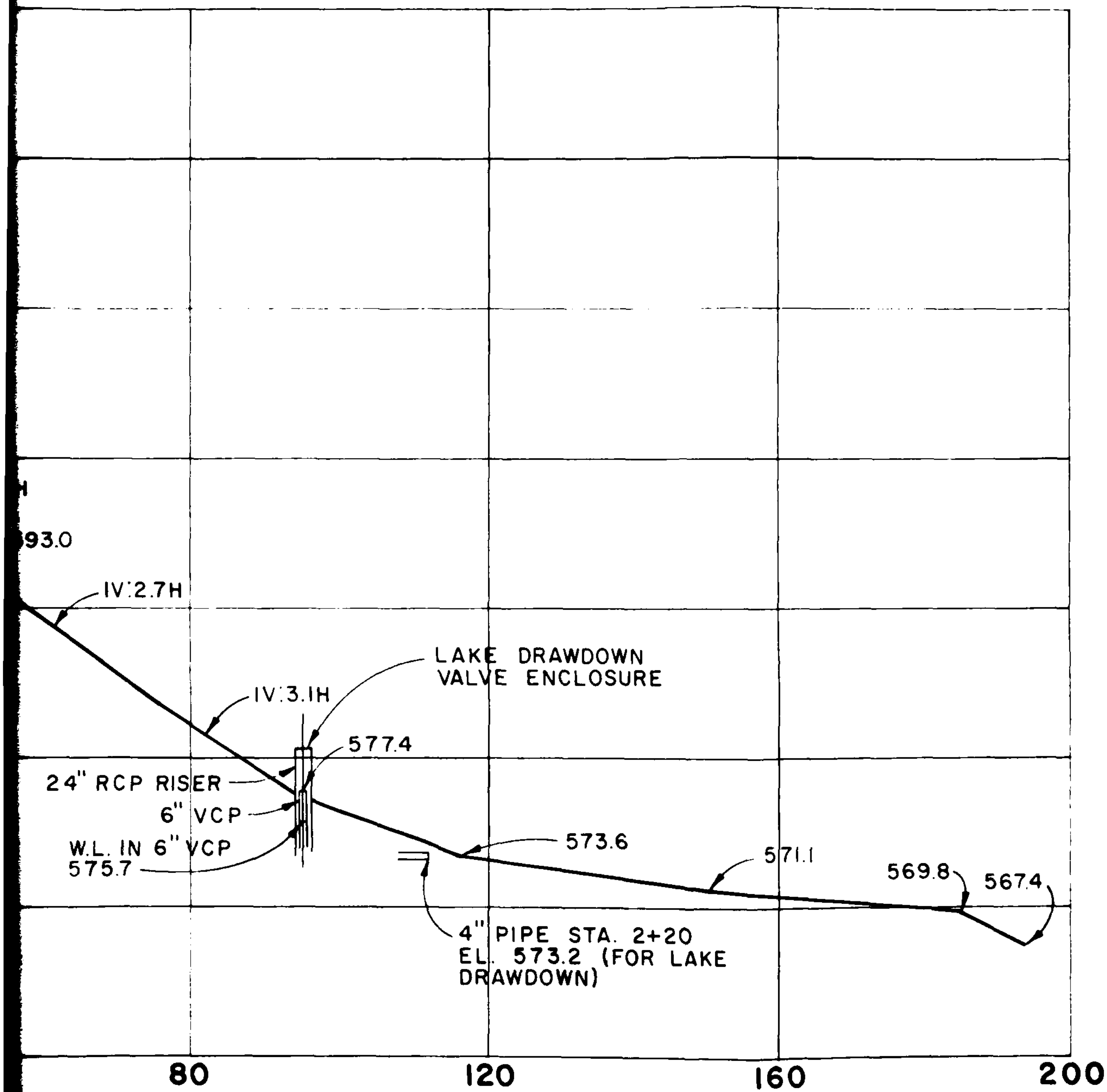
STURMFELS LAKE DAM
MO 30849
DAM PLAN & PROFILE
Horner & Shifrin, Inc. Sept. 1981

PLATE 3



DAM CROSS-SECTION STA.

SCALES: 1"=10'V., 1"=20'H.

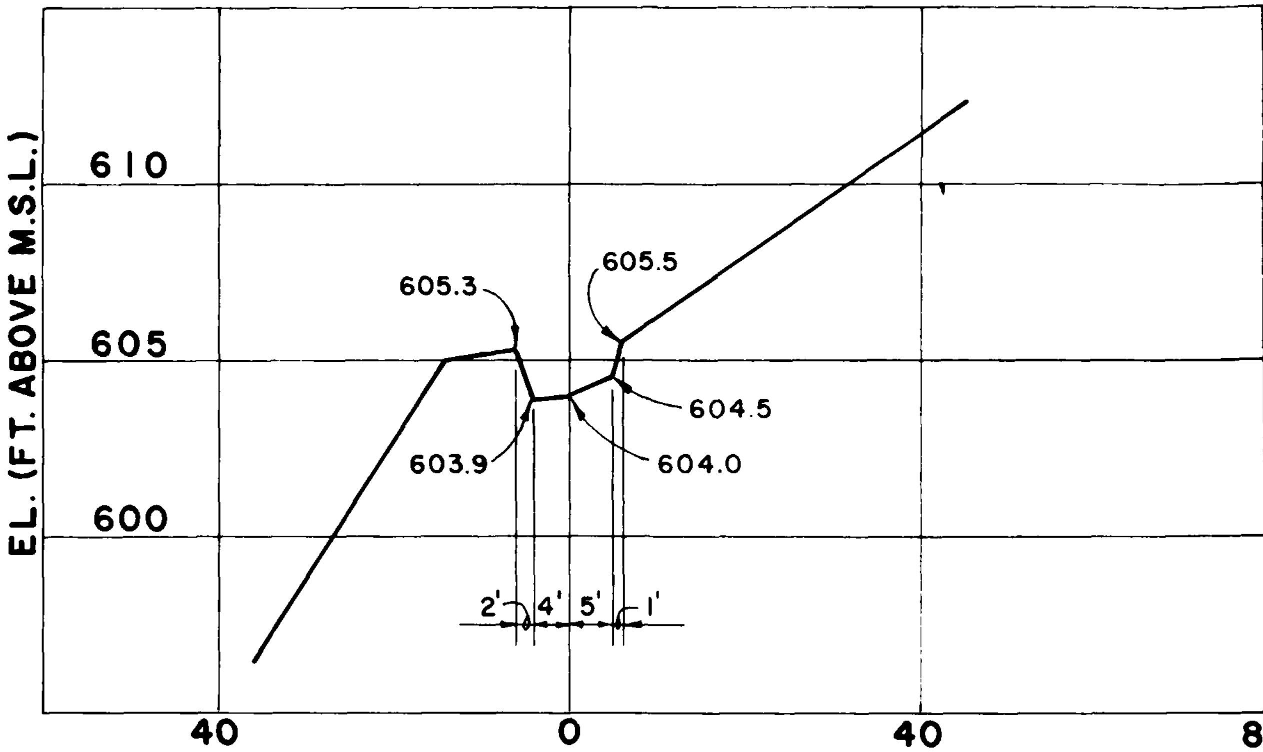


CROSS-SECTION STA. 2+15

SCALES: 1"=10'V., 1"=20'H.

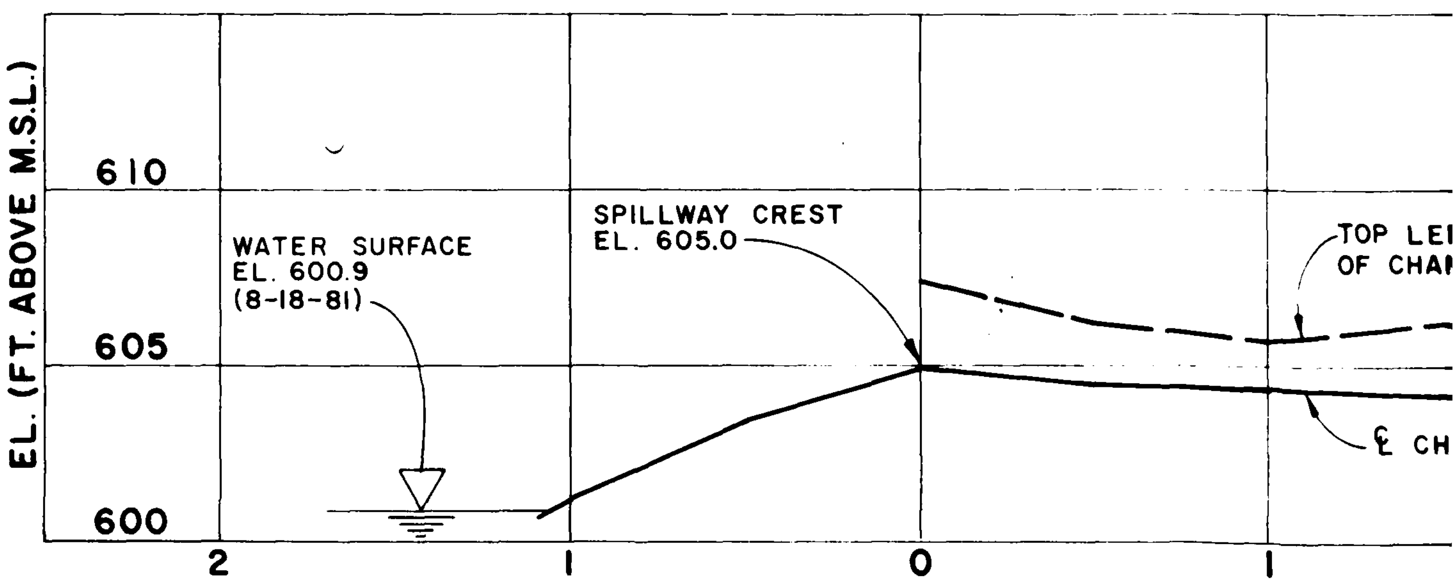
STURMFELS LAKE DAM
MO 30849
DAM CROSS-SECTION
Horner & Shifrin, Inc. Sept. 1981

PLATE 4



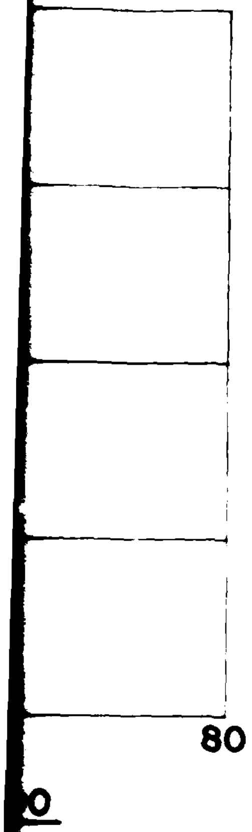
CHANNEL CROSS-SECTION STA. 2+00

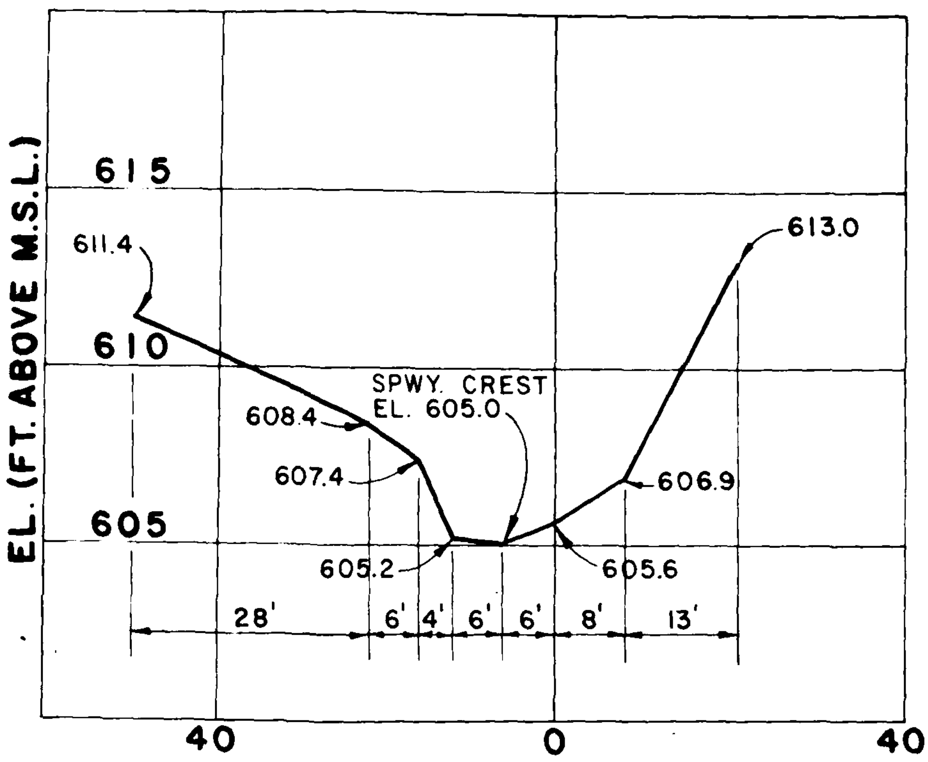
SCALE: 1"=5' V., 1"=20' H.



OUTLET CHANNEL PROI

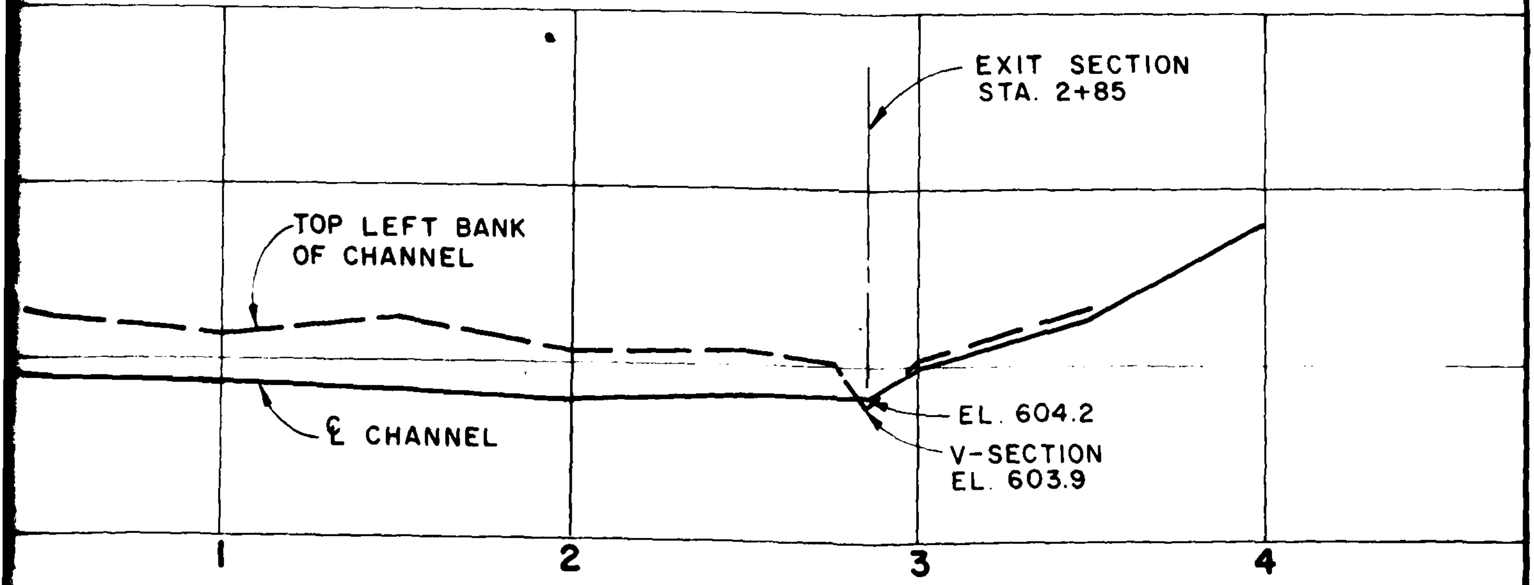
SCALE: 1"=5' V., 1"=20' H.





SPILLWAY CROSS-SECTION STA. 0+00

SCALES: 1"=5'V., 1"=20'H.



TLET CHANNEL PROFILE

SCALE: 1"=5'V., 1"=20'H.

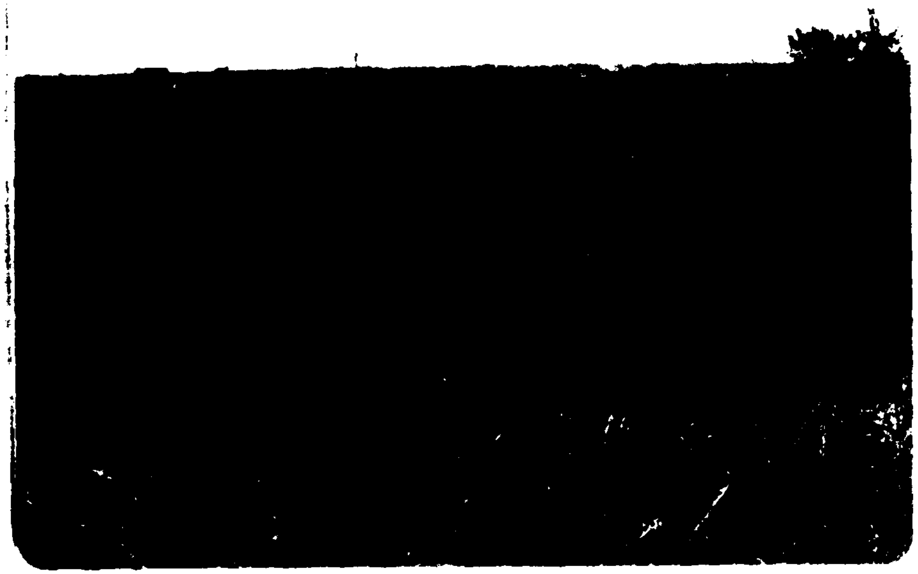
STURMFELS LAKE DAM
MO 30849
SPILLWAY DETAILS

Horner & Shifrin, Inc. Sept. 1981

PLATE 5

APPENDIX A

INSPECTION PHOTOGRAPHS



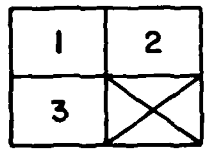


PHOTO KEY

NO.	DESCRIPTION
1	Dam Overview
2	Upstream Face of Dam
3	Downstream Face of Dam

4	5
6	

PHOTO KEY

NO.	DESCRIPTION
4	Excavated Earth Spillway
5	Spillway Outlet Channel, Crest Section
6	Spillway Outlet Channel, Exit Section

7	8
9	

PHOTO KEY

NO.	DESCRIPTION
7	Enclosure for Lake Drawdown Valve
8	Outlet End of Lake Drawdown Pipe
9	Pump House

10	11
12	

PHOTO KEY

NO.	DESCRIPTION
10	Hole Where Water Enters Ground
11	Marshy Area
12	Standing Water in Marsh

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 1 April 1980) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. miles, 24-hour value equals 25.2 inches) from Hydrometerological Report No. 33. The precipitation data used in the analysis of the 1 percent chance (100-year frequency) flood was provided by the St. Louis District, Corps of Engineers.

b. Drainage area = 0.036 square miles = 23 acres.

c. SCS parameters:

Time of Concentration (T_C) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$ = 0.069 hours

Where: T_C = Travel time of water from hydraulically most distant point to point of interest, hours.

L = Length of longest watercourse = 0.170 miles.

H = Elevation difference = 61 feet.

The time of concentration (T_C) was obtained using method C as described in Fig. 30, "Design of Samll Dams", by the United States Department of the Interior, Bureau of Reclamation, and was verified using average channel velocity estimates and watercourse lengths.

Lag time = 0.041 hours (0.60 T_C)

Hydrologic Soil Group = 50% B (Menfro Series) and 50% C (Winfield Series) per SCS Missouri General Soil Map.

Soil type CN = 64 (AMC II, 100-yr flood condition)
= 81 (AMC III, PMF condition)

2. Spillway release rates were determined as follows:

A. Flows less than 32 cfs. The spillway outlet channel was determined to have a capacity of about 32 cfs at a depth of 1.4 feet before overtopping of the left bank of the outlet channel would occur. The channel capacity was computed using Mannings formula:

$$Q = \frac{1.486}{n} A\ r^{2/3}\ S^{1/2}$$

With n = 0.030, A = 12.37 sq. ft., r = 0.983, and an average slope(s) of 0.0028.

B. Flows greater than 32 cfs. For flows greater than 32 cfs, it was assumed that the confining left bank of the outlet channel would be overtopped and eroded, with flow control shifting to the spillway crest section proper. The spillway section consists of an irregular shaped broad-crested section for which conventional weir formulas do not apply.

a. Spillway crest section properties (areas, "a", and top width, "t") were computed for various depths, "d".

b. It was assumed that flow over the spillway crest would occur at critical depth. Flow at critical depth was computed as

$Q_c = \left(\frac{a^3 g}{t}\right)^{0.5}$ for the various depths, "d". Corresponding velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas.* Reference "Handbook of Hydraulics", Fifth Edition, by King & Brater, page 8-7.

c. Static lake levels corresponding to the various flow values passing the spillway were computed as critical depths plus critical velocity heads ($d_c + H_{vc}$), and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignificant friction losses across the length of the spillway.

* $v_c = \frac{Qc}{a}$; $Hvc = \frac{{v_c}^2}{2g}$

C. The spillway discharges for corresponding elevations were entered on the Y4 and Y5 cards. The spillway rating curve is shown on page B-12.

3. The profile of the dam crest is irregular and flow over the dam cannot be determined by application of conventional weir formulas. Crest length and elevation data for the dam crest proper were entered into the HEC-1 Program on the $L and $V cards. The program assumes that flow over the dam crest occurs at critical depth and computes internally the flow passing the dam crest and adds this flow to the flow passing the spillway as entered on the Y4 and Y5 cards.

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A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF STURMFELS LAKE DAM
A3       RATIOS OF PMF ROUTED THROUGH RESERVOIR
B     288       0       5                                                     0
B1      5
J       1       2       1
J1   0.50    1.00
K       0   INFLOW                                          1
K1       INFLOW HYDROGRAPH
M       1       2   0.036                           1.0                       1
P       0    25.2     102     120     130
T                                                          -1     -.1
W2          0.041
X    -1.0    -.10     2.0
K       1     DAM                                           1
K1       RESERVOIR ROUTING BY MODIFIED PULS
Y                               1       1
Y1      1                                               -605.      -1
Y4  605.0  605.75  606.40  606.88  607.51  608.20  608.92  609.62  610.32  611.02
Y4  611.7  612.39  613.07  613.75  614.42  615.09  615.89
Y5      0      10      32      96     177     280     429     588     767     966
Y5   1181    1414    1667    1936    2223    2531    2922
$A      0     2.8     4.6     6.7     9.4
$E    583   600.9     610     620     630
$$  605.0
$D  611.9
$L      0       6      34      52     222     360     534     634     684     734

$V  607.4   608.4   611.4   611.9   612.1   612.8   614.7   614.9   616.1   618.7
K      99
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A1 ANALYSIS OF DAM OVERTOPPING USING 1 PERCENT CHANCE FLOOD
A2 HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF STUMMELS LAKE DAM
A3 1 PERCENT CHANCE FLOOD ROUTED THROUGH RESERVOIR

B	288	[illegible]	5							4
B1	5									
J	1	1	1							
J1	1.00									
K	0	INFLOW							1	
K1	INFLOW HYDROGRAPH									
M	[illegible]	2	[illegible]			1.				1
O	388	[illegible] 4								
O1	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
O1	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
O1	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
O1	.007	.007	.007	[illegible]	.007	.007	.007	.007	.007	.007
O1	.007	.007	.007	.007	.007	[illegible]	.007	.007	[illegible]	.007
O1	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
O1	.007	.007	.007	.007	.007	[illegible]	.007	.007	.007	.007
O1	[illegible]	[illegible]	.012	.012	.012	.011	[illegible]	[illegible]	.012	.012
O1	.012	.012	.012	.012	.012	.011	.012	.011	.012	.012
O1	.012	.012	.012	.012	.012	.012	.012	.011	.012	.012
O1	.012	.012	.012	.012	.012	.012	.012	.012	.023	.023
O1	.023	[illegible]	[illegible]	[illegible]	.023	[illegible]	[illegible]	.023	.023	.023
O1	[illegible]	.023	.023	[illegible]	.023	.023	.030	[illegible]	.030	.030
O1	[illegible]	.030	.048	.048	.048	.047	.049	.049	.134	.134
O1	.134	[illegible]	.155	[illegible]	.047	[illegible]	.155	.134	.134	.134
O1	.047	.047	.047	.046	.048	.042	.030	.030	.030	.030
O1	[illegible]	[illegible]	.077	.023	.023	.017	.017	.017	.023	.023
O1	[illegible]	.023	.023	.023	.023	.023	.023	.023	.023	.023

1% CHANCE FLOOD (CONT'D)

```
O1  .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1  .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1  .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1  .012    .012    .012    .012    .012    .012    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007
T                                                    -1     -64
W2          0.041
X   -1.[illegible]  -.16   2.0
[illegible]    1    DAM                                  1
[illegible]     RESERVOIR ROUTING BY MODIFIED PULS
                                1       1
Y1     1                                         -601.[illegible]   -1
Y4  [illegible]  605.75  606.4[illegible]  606.86  607.51  608.20  [illegible]  [illegible]  [illegible]  611.02
Y4  611.[illegible]  612.[illegible]  613.07  613.75  614.42  615.0[illegible]  615.[illegible]
Y5     0      10      32     [illegible]    177     289     4[illegible]     5[illegible]     [illegible]     966
Y5  1181    1414    1667    1936    2223    2531    2922
$A     0    [illegible].8     4.6    [illegible].7     9.4
$E   587   600.[illegible]     610     620     630
$$ 305.0
$D 611.[illegible]
$L     0       [illegible]      14      52     222     389     534     [illegible]     684     734
$V 607.4  608.4   611.4   611.9   612.1   612.8   614.7   614.9   616.1   616.7
K      99
```

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF STURMFELS LAKE DAM
RATIOS OF PMF ROUTED THROUGH RESERVOIR

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 2 LRTIO= 1
RTIOS= .50 1.00

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

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

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	.04	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.20	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	-31.00	0.00	0.00

CURVE NO = -31.00 WETNESS = -1.00 EFFECT CN = 31.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .04

RECESSION DATA
STRTQ= -1.00 QRCSN= -.10 RTIOR= 2.00

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

UNIT HYDROGRAPH 5 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .04 VOL= 1.00
207. 58. 11. 2. 0.

Q

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.05	145	.21	.19	.02	44.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.21	.19	.02	52.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.21	.20	.02	54.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.21	.20	.02	55.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.21	.20	.02	55.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.21	.20	.02	55.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.21	.20	.02	55.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.21	.20	.01	56.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.21	.20	.01	56.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.21	.20	.01	56.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.21	.20	.01	56.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.21	.20	.01	56.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.26	.24	.01	65.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.26	.24	.01	67.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.26	.24	.01	68.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.26	.25	.01	68.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.26	.25	.01	68.
1.01	1.30	18	.01	0.00	.01	0.	1.01	13.30	162	.26	.25	.01	69.
1.01	1.35	19	.01	0.00	.01	0.	1.01	13.35	163	.26	.25	.01	69.
1.01	1.40	20	.01	0.00	.01	0.	1.01	13.40	164	.26	.25	.01	69.
1.01	1.45	21	.01	0.00	.01	0.	1.01	13.45	165	.26	.25	.01	69.
1.01	1.50	22	.01	0.00	.01	0.	1.01	13.50	166	.26	.25	.01	69.
1.01	1.55	23	.01	0.00	.01	0.	1.01	13.55	167	.26	.25	.01	69.
1.01	2.00	24	.01	0.00	.01	0.	1.01	14.00	168	.26	.25	.01	69.
1.01	2.05	25	.01	0.00	.01	0.	1.01	14.05	169	.32	.31	.01	82.
1.01	2.10	26	.01	0.00	.01	0.	1.01	14.10	170	.32	.31	.01	86.
1.01	2.15	27	.01	0.00	.01	0.	1.01	14.15	171	.32	.31	.01	87.
1.01	2.20	28	.01	0.00	.01	0.	1.01	14.20	172	.32	.31	.01	87.
1.01	2.25	29	.01	0.00	.01	0.	1.01	14.25	173	.32	.31	.01	87.
1.01	2.30	30	.01	0.00	.01	0.	1.01	14.30	174	.32	.31	.01	87.
1.01	2.35	31	.01	0.00	.01	0.	1.01	14.35	175	.32	.31	.01	87.
1.01	2.40	32	.01	0.00	.01	0.	1.01	14.40	176	.32	.31	.01	87.
1.01	2.45	33	.01	0.00	.01	0.	1.01	14.45	177	.32	.31	.01	88.
1.01	2.50	34	.01	.00	.01	0.	1.01	14.50	178	.32	.31	.01	88.
1.01	2.55	35	.01	.00	.01	0.	1.01	14.55	179	.32	.31	.01	88.
1.01	3.00	36	.01	.00	.01	0.	1.01	15.00	180	.32	.32	.01	88.
1.01	3.05	37	.01	.00	.01	0.	1.01	15.05	181	.20	.19	.00	62.
1.01	3.10	38	.01	.00	.01	0.	1.01	15.10	182	.39	.38	.01	95.
1.01	3.15	39	.01	.00	.01	0.	1.01	15.15	183	.39	.38	.01	105.
1.01	3.20	40	.01	.00	.01	0.	1.01	15.20	184	.59	.58	.01	146.
1.01	3.25	41	.01	.00	.01	0.	1.01	15.25	185	.68	.67	.01	178.
1.01	3.30	42	.01	.00	.01	0.	1.01	15.30	186	1.66	1.64	.02	335.
1.01	3.35	43	.01	.00	.01	0.	1.01	15.35	187	2.73	2.70	.03	664.
1.01	3.40	44	.01	.00	.01	0.	1.01	15.40	188	1.07	1.06	.01	597.
1.01	3.45	45	.01	.00	.01	0.	1.01	15.45	189	.68	.68	.01	237.
1.01	3.50	46	.01	.00	.01	0.	1.01	15.50	190	.59	.58	.00	178.
1.01	3.55	47	.01	.00	.01	1.	1.01	15.55	191	.39	.39	.00	124.
1.01	4.00	48	.01	.00	.01	1.	1.01	16.00	192	.39	.39	.00	111.
1.01	4.05	49	.01	.00	.01	1.	1.01	16.05	193	.30	.30	.00	90.

End-of-Period Flow (Cont'd)

1.01	4.10	50	.01	.00	.01	1.	1.01	16.10	194	.30	.30	.00	84.
1.01	4.15	51	.01	.00	.01	1.	1.01	16.15	195	.30	.30	.00	83.
1.01	4.20	52	.01	.00	.01	1.	1.01	16.20	196	.30	.30	.00	83.
1.01	4.25	53	.01	.00	.01	1.	1.01	16.25	197	.30	.30	.00	83.
1.01	4.30	54	.01	.00	.01	1.	1.01	16.30	198	.30	.30	.00	83.
1.01	4.35	55	.01	.00	.01	1.	1.01	16.35	199	.30	.30	.00	83.
1.01	4.40	56	.01	.00	.01	1.	1.01	16.40	200	.30	.30	.00	83.
1.01	4.45	57	.01	.00	.01	1.	1.01	16.45	201	.30	.30	.00	83.
1.01	4.50	58	.01	.00	.01	1.	1.01	16.50	202	.30	.30	.00	83.
1.01	4.55	59	.01	.00	.01	1.	1.01	16.55	203	.30	.30	.00	83.
1.01	5.00	60	.01	.00	.01	1.	1.01	17.00	204	.30	.30	.00	83.
1.01	5.05	61	.01	.00	.01	1.	1.01	17.05	205	.24	.23	.00	70.
1.01	5.10	62	.01	.00	.01	1.	1.01	17.10	206	.24	.23	.00	66.
1.01	5.15	63	.01	.00	.01	1.	1.01	17.15	207	.24	.23	.00	65.
1.01	5.20	64	.01	.00	.01	1.	1.01	17.20	208	.24	.23	.00	65.
1.01	5.25	65	.01	.00	.01	1.	1.01	17.25	209	.24	.23	.00	65.
1.01	5.30	66	.01	.00	.01	1.	1.01	17.30	210	.24	.23	.00	65.
1.01	5.35	67	.01	.00	.01	1.	1.01	17.35	211	.24	.23	.00	65.
1.01	5.40	68	.01	.00	.01	1.	1.01	17.40	212	.24	.23	.00	65.
1.01	5.45	69	.01	.00	.01	1.	1.01	17.45	213	.24	.23	.00	65.
1.01	5.50	70	.01	.00	.01	1.	1.01	17.50	214	.24	.23	.00	65.
1.01	5.55	71	.01	.00	.01	1.	1.01	17.55	215	.24	.23	.00	65.
1.01	6.00	72	.01	.00	.01	1.	1.01	18.00	216	.24	.23	.00	65.
1.01	6.05	73	.06	.02	.04	5.	1.01	18.05	217	.02	.02	.00	61.
1.01	6.10	74	.06	.02	.04	6.	1.01	18.10	218	.02	.02	.00	57.
1.01	6.15	75	.06	.03	.04	7.	1.01	18.15	219	.02	.02	.00	53.
1.01	6.20	76	.06	.03	.04	7.	1.01	18.20	220	.02	.02	.00	50.
1.01	6.25	77	.06	.03	.03	8.	1.01	18.25	221	.02	.02	.00	46.
1.01	6.30	78	.06	.03	.03	8.	1.01	18.30	222	.02	.02	.00	43.
1.01	6.35	79	.06	.03	.03	9.	1.01	18.35	223	[illegible]	[illegible]	[illegible]	[illegible]
1.01	6.40	80	.06	.03	.03	9.	1.01	18.40	224	[illegible]	[illegible]	[illegible]	[illegible]
1.01	6.45	81	.06	.03	.03	9.	1.01	18.45	225	[illegible]	[illegible]	[illegible]	[illegible]
1.01	6.50	82	.06	.03	.03	9.	1.01	18.50	226	[illegible]	[illegible]	[illegible]	[illegible]
1.01	6.55	83	.06	.04	.03	10.	1.01	18.55	227	.02	.02	.00	30.
1.01	7.00	84	.06	.04	.03	10.	1.01	19.00	228	.02	.02	.00	28.
1.01	7.05	85	.06	.04	.03	10.	1.01	19.05	229	.02	.02	.00	27.
1.01	7.10	86	.06	.04	.02	11.	1.01	19.10	230	.02	.02	.00	25.
1.01	7.15	87	.06	.04	.02	11.	1.01	19.15	231	.02	.02	.00	24.
1.01	7.20	88	.06	.04	.02	11.	1.01	19.20	232	.02	.02	.00	22.
1.01	7.25	89	.06	.04	.02	11.	1.01	19.25	233	.02	.02	.00	20.
1.01	7.30	90	.06	.04	.02	11.	1.01	19.30	234	.02	.02	.00	19.
1.01	7.35	91	.06	.04	.02	12.	1.01	19.35	235	.02	.02	.00	18.
1.01	7.40	92	.06	.04	.02	12.	1.01	19.40	236	.02	.02	.00	16.
1.01	7.45	93	.06	.04	.02	12.	1.01	19.45	237	.02	.02	.00	15.
1.01	7.50	94	.06	.04	.02	12.	1.01	19.50	238	.02	.02	.00	14.
1.01	7.55	95	.06	.04	.02	12.	1.01	19.55	239	.02	.02	.00	13.
1.01	8.00	96	.06	.04	.02	12.	1.01	20.00	240	.02	.02	.00	12.
1.01	8.05	97	.06	.05	.02	13.	1.01	20.05	241	.02	.02	.00	12.
1.01	8.10	98	.06	.05	.02	13.	1.01	20.10	242	.02	.02	.00	11.
1.01	8.15	99	.06	.05	.02	13.	1.01	20.15	243	.02	.02	.00	10.
1.01	8.20	100	.06	.05	.02	13.	1.01	20.20	244	.02	.02	.00	9.
1.01	8.25	101	.06	.05	.02	13.	1.01	20.25	245	.02	.02	.00	9.
1.01	8.30	102	.06	.05	.02	13.	1.01	20.30	246	.02	.02	.00	8.
1.01	8.35	103	.06	.05	.02	13.	1.01	20.35	247	.02	.02	.00	8.

End-of-Period Flow (Cont'd)

1.01	8.40	104	.06	.05	.01	13.	1.01	20.40	248	.02	.02	.00	7.
1.01	8.45	105	.06	.05	.01	14.	1.01	20.45	249	.02	.02	.00	7.
1.01	8.50	106	.06	.05	.01	14.	1.01	20.50	250	.02	.02	.00	6.
1.01	8.55	107	.06	.05	.01	14.	1.01	20.55	251	.02	.02	.00	6.
1.01	9.00	108	.06	.05	.01	14.	1.01	21.00	252	.02	.02	.00	6.
1.01	9.05	109	.06	.05	.01	14.	1.01	21.05	253	.02	.02	.00	6.
1.01	9.10	110	.06	.05	.01	14.	1.01	21.10	254	.02	.02	.00	6.
1.01	9.15	111	.06	.05	.01	14.	1.01	21.15	255	.02	.02	.00	6.
1.01	9.20	112	.06	.05	.01	14.	1.01	21.20	256	.02	.02	.00	6.
1.01	9.25	113	.06	.05	.01	14.	1.01	21.25	257	.02	.02	.00	6.
1.01	9.30	114	.06	.05	.01	14.	1.01	21.30	258	.02	.02	.00	6.
1.01	9.35	115	.06	.05	.01	14.	1.01	21.35	259	.02	.02	.00	6.
1.01	9.40	116	.06	.05	.01	14.	1.01	21.40	260	.02	.02	.00	6.
1.01	9.45	117	.06	.05	.01	15.	1.01	21.45	261	.02	.02	.00	6.
1.01	9.50	118	.06	.05	.01	15.	1.01	21.50	262	.02	.02	.00	6.
1.01	9.55	119	.06	.05	.01	15.	1.01	21.55	263	.02	.02	.00	6.
1.01	10.00	120	.06	.05	.01	15.	1.01	22.00	264	.02	.02	.00	6.
1.01	10.05	121	.06	.05	.01	15.	1.01	22.05	265	.02	.02	.00	6.
1.01	10.10	122	.06	.05	.01	15.	1.01	22.10	266	.02	.02	.00	6.
1.01	10.15	123	.06	.05	.01	15.	1.01	22.15	267	.02	.02	.00	6.
1.01	10.20	124	.06	.05	.01	15.	1.01	22.20	268	.02	.02	.00	6.
1.01	10.25	125	.06	.05	.01	15.	1.01	22.25	269	.02	.02	.00	6.
1.01	10.30	126	.06	.05	.01	15.	1.01	22.30	270	.02	.02	.00	6.
1.01	10.35	127	.06	.05	.01	15.	1.01	22.35	271	.02	.02	.00	6.
1.01	10.40	128	.06	.05	.01	15.	1.01	22.40	272	.02	.02	.00	6.
1.01	10.45	129	.06	.05	.01	15.	1.01	22.45	273	.02	.02	.00	6.
1.01	10.50	130	.06	.05	.01	15.	1.01	22.50	274	.02	.02	.00	6.
1.01	10.55	131	.06	.05	.01	15.	1.01	22.55	275	.02	.02	.00	6.
1.01	11.00	132	.06	.06	.01	15.	1.01	23.00	276	.02	.02	.00	6.
1.01	11.05	133	.06	.06	.01	15.	1.01	23.05	277	.02	.02	.00	6.
1.01	11.10	134	.06	.06	.01	15.	1.01	23.10	278	.02	.02	.00	6.
1.01	11.15	135	.06	.06	.01	15.	1.01	23.15	279	.02	.02	.00	6.
1.01	11.20	136	.06	.06	.01	16.	1.01	23.20	280	.02	.02	.00	6.
1.01	11.25	137	.06	.06	.01	16.	1.01	23.25	281	.02	.02	.00	6.
1.01	11.30	138	.06	.06	.01	16.	1.01	23.30	282	.02	.02	.00	6.
1.01	11.35	139	.06	.06	.01	16.	1.01	23.35	283	.02	.02	.00	6.
1.01	11.40	140	.06	.06	.01	16.	1.01	23.40	284	.02	.02	.00	6.
1.01	11.45	141	.06	.06	.01	16.	1.01	23.45	285	.02	.02	.00	6.
1.01	11.50	142	.06	.06	.01	16.	1.01	23.50	286	.02	.02	.00	6.
1.01	11.55	143	.06	.06	.01	16.	1.01	23.55	287	.02	.02	.00	6.
1.01	12.00	144	.06	.06	.01	16.	1.02	0.00	288	.02	.02	.00	6.
									SUM	32.76	30.10	2.66	8997.
										(832.)	(765.)	(67.)	(254.77)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	664.	97.	31.	31.	8991.
CMS	19.	3.	1.	1.	255.
INCHES		25.15	32.27	32.27	32.27
MM		638.76	819.61	819.61	819.61
AC-FT		48.	62.	62.	62.
THOUS CU M		60.	76.	76.	76.

SURFACE AREA=	0.	3.	5.	7.	9.
CAPACITY=	0.	17.	50.	106.	186.
ELEVATION=	583.	601.	610.	620.	630.

SUMMARY OF DAM SAFETY ANALYSIS

PMF

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	[illegible]	605.00	611.90
STORAGE	[illegible]	30.	59.
OUTFLOW	[illegible]	0.	1450.

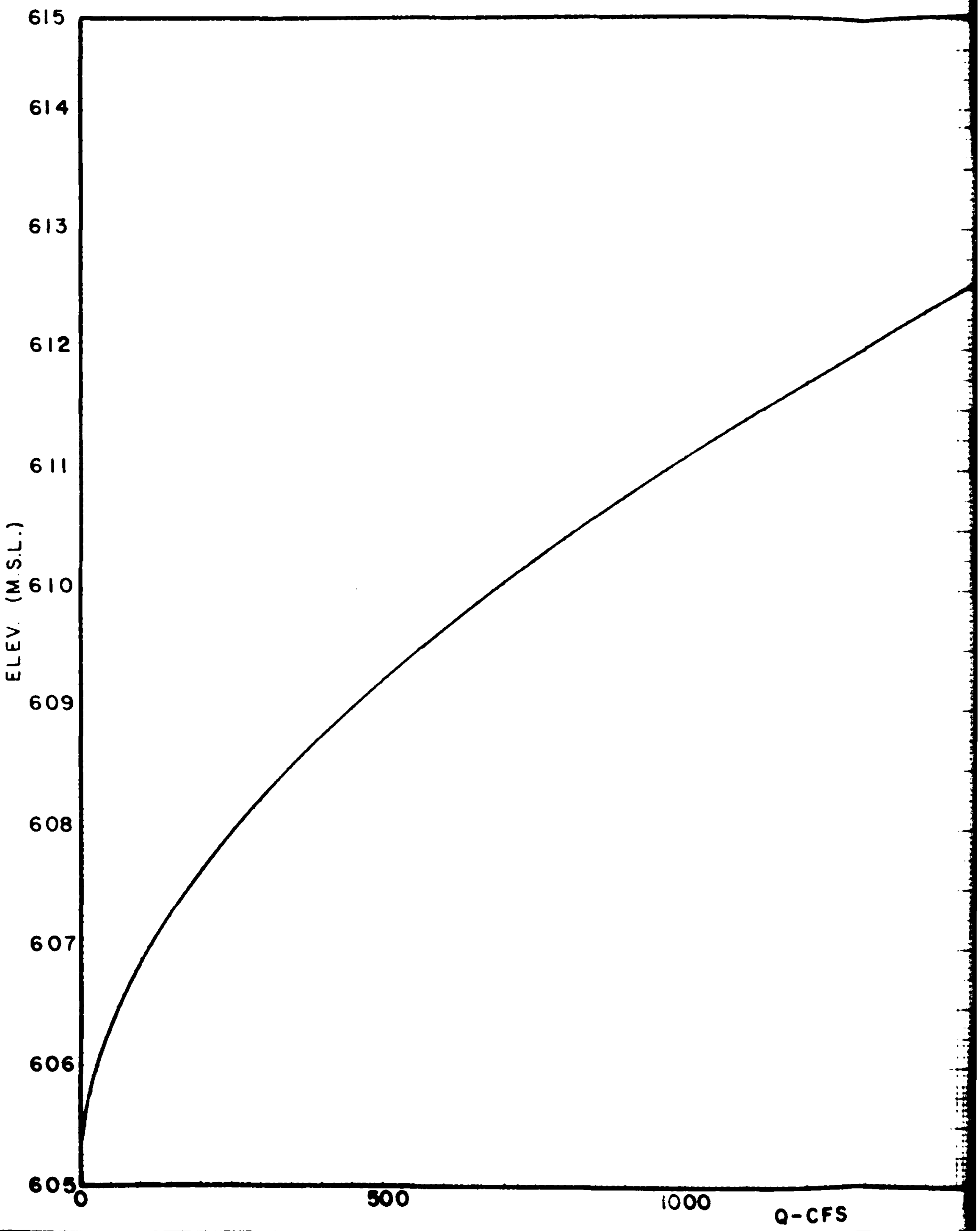
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
[illegible]	[illegible]	[illegible]	3[illegible].	145.	0.00	15.[illegible]	0.00
[illegible]	[illegible]	[illegible]	[illegible]	307.	0.00	15.[illegible]	0.00

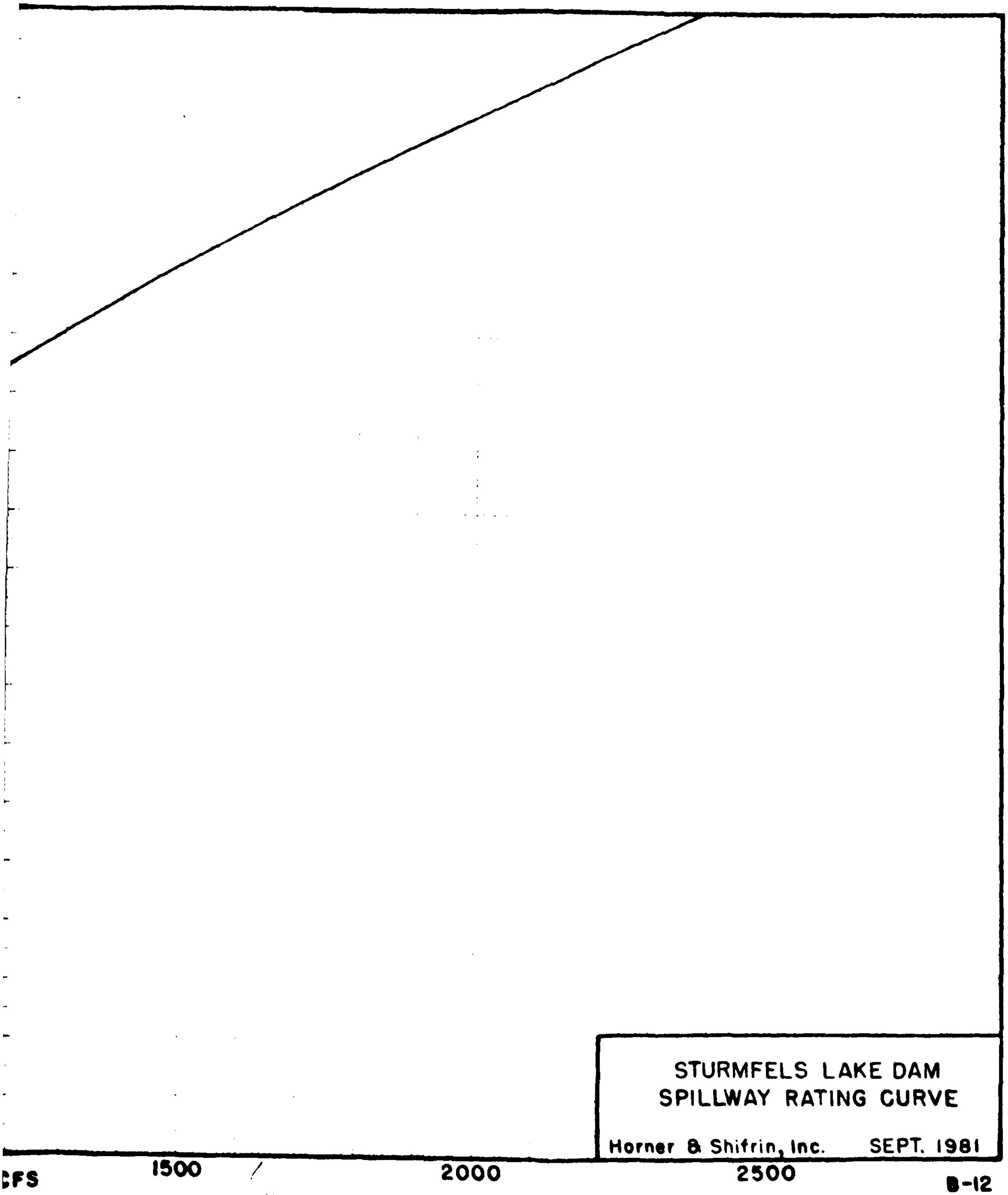
SUMMARY OF DAM SAFETY ANALYSIS

1% CHANCE FLOOD

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	601.30	605.00	611.90
STORAGE	18.	30.	59.
OUTFLOW	0.	0.	1650.

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
1.00	603.21	0.00	24.	0.	0.00	0.00	0.00


615
614
613
612
611
610
609
608
607
606
605
ELEV. (M.S.L.)
0
500
1000
Q-CFS



STURMFELS LAKE DAM
SPILLWAY RATING CURVE

Horner & Shifrin, Inc. SEPT. 1981