LEVEL II

MISSOURI - OSAGE - GASCONADE BASIN

AD A106627

HENLEY LAKE DAM

COLE COUNTY, MISSOURI

MO 30322

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
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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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PHASE 1 INSPECTION REPORT
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PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

AUGUST 1981

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

REPLY TO
ATTENTION OF

LMSED-P

SUBJECT: Henley Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Henley Lake Dam (MO 30322):

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 — 10 AUG 1981 Date

APPROVED BY: SIGNED — Colonel, CE, Commanding — 20 AUG 1981 Date

HENLEY LAKE DAM

MISSOURI INVENTORY NO. 30322

COLE 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

AUGUST 1981

HS-8088

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Henley Lake Dam
State Located:	Missouri
County Located:	Cole
Stream:	Tributary of Little Tavern Creek
Date of Inspection:	9 June 1981

The Henley 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. 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 dam poses 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 on the visual inspection and the results of the hydrologic/hydraulic investigations, the present general condition of the dam is considered to be less than satisfactory. A number of 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 trees and undergrowth on both the upstream and downstream faces of the dam, seepage through the dam and at the contact of the embankment and the left abutment, a spillway wall that is badly deteriorated on the downstream side, a spillway outlet channel that, in the vicinity of the dam, is congested by small to medium size trees and brush, a wire-mesh fence that spans the spillway opening at the location of the reservoir outlet, and a dam crest, in areas that appear to be vehicular tracks, that is partially unprotected and subject to erosion.

The Henley Lake Dam is classified according to Table 1 of the recommended guidelines, as small in size. According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Henley Lake 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 a relatively small volume of water is impounded by the dam, that the downstream flood plain is fairly broad, and that there are but six dwellings within the potential flood damage zone, it is recommended that the spillway for this dam be designed for one-half the PMF.

Results of a hydrologic/hydraulic analysis indicated that the spillway is inadequate to pass lake outflow resulting from a storm of one-half PMF magnitude or the lake outflow resulting from the 1 percent chance (100-year frequency) flood without overtopping the dam. The spillway is capable of passing lake outflow corresponding to about 10 percent of the PMF lake inflow and the lake outflow resulting from the 10 percent chance (10-year frequency) flood. 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 six dwellings and a store.

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. Provision of additional spillway capacity should be assigned a high priority, since the existing spillway is considered to be seriously inadequate. The existing spillway, in its present condition, is also considered to be structurally unsafe.

Harold B. Lockett

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

Albert B. Becker, Jr.

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

CULVERT BENEATH LAKE DAM

PHASE 1 INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

HENLEY LAKE DAM - MO 30322

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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

HENLEY LAKE DAM - MO 30322

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 Henley 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 Henley Lake Dam is an earthfill type embankment rising approximately 28 feet above the natural streambed at the downstream toe of the barrier. At the surveyed cross-section, station 2+80, the embankment has an upstream slope (above the normal waterline) of approximately 1v on 2.4h, a crest width of about 12 feet, and a downstream slope on the order of 1v on 2.1h, although the slope becomes somewhat flatter as it approaches the toe of the dam. The upstream face of the dam is protected by stone riprap to a point about 1.5 feet above the normal waterline. The length of the dam is approximately 480 feet and an unsurfaced road traverses the dam crest. The alignment of the embankment is virtually straight with the spillway, a concrete and block wall, located within a rock cut at the right (looking downstream) abutment. The spillway forms a deflection angle of about 77 degrees with respect to the centerline of the dam. A plan and profile of the dam is shown on Plate 3 and a cross-section of the dam, at about the location of the original stream on which the dam was constructed, is shown on Plate 4. At normal pool level, the reservoir impounded by the dam occupies approximately 6.5 acres. An overview photo of the Henley Lake Dam is shown following the preface at the beginning of the report.

A 6-inch diameter cast-iron pipe is provided for lake drawdown. The pipe passes through the base of the dam at about station 2+21. A six foot square vault with 12-inch thick concrete walls and a one-quarter inch thick steel plate cover houses two valves located on the pipe just downstream of the toe of the dam. A tee type fitting allows flow to discharge just to the left of the vault near the original stream on which the dam was built, or to discharge to some point further downstream of the dam. This downstream outlet was not located during the inspection. Since the dam was built by the railroad company, it may be that the outlet is somewhere in the vicinity of the railroad tracks, or about one-half mile downstream of the dam.

As previously stated the spillway is located at the right abutment. The spillway, an overflow section consisting of a 2-foot thick wall of concrete with a single course of concrete block at the top, is approximately 5.8 feet high and about 41 feet long. The wall crosses a section between the dam and the excavated rock face of the abutment. The spillway outlet channel, a trapezoidal section of variable width, is cut into the hillside of the right abutment. The invert of the section is mostly rock covered with some sediment. The slope of the spillway channel is quite flat through the rock cut, but at a point about 120 feet downstream of the spillway wall, the channel encounters a series of rock falls which continue for approximately another 70 feet, before the channel arrives at the valley floor intersecting the drainage course of the adjoining watershed. This drainage course joins the original stream on which the dam was built at a point approximately 350 feet downstream of the centerline of the dam. The left bank of the spillway channel between the dam and the rock falls is protected by stone riprap. A profile of the spillway channel between the spillway wall and the rock falls and a cross-section of the channel at a point 40 feet downstream of the wall are presented on Plate 5. The elevation of the top of the spillway wall varies about 0.9 of a foot with the lowest point being at the end adjacent to the rock face of the abutment.

b. Location. The dam is located on an unnamed tributary of Little Tavern Creek about 0.4 mile due north of the Town of Henley, Missouri, and immediately west of State Route H. Henley is located about 18 miles south-southwest of Jefferson City, Missouri, as shown on the Regional Vicinity Map, Plate 1. The dam is located within the northeast one-quarter of Section 35 of Township 42 North, Range 13 West, in Cole 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 Henley 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 six dwellings and a store. 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 Mr. Earl Russell. Mr. Russell's address is: Post Office Box 36, Henley, Missouri 65040.

f. Purpose of Dam. The dam impounds water for recreational use.

g. Design and Construction History. According to Mr. Russell, the dam was constructed about 1909 by the Chicago Rock Island and Pacific Railroad Company. Mr. Russell reported that the property on which the dam is located was acquired in about 1964 by Al Helkenmeyer, deceased, who in turn sold the land to the Mr. Russell in 1974. Mr. Russell indicated that to his knowledge no design or construction data was available.

h. Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the capacity of a 2-foot wide concrete and block, wall type spillway.

1.3 PERTINENT DATA

a. Drainage Area. Except as indicated herein, the area tributary to the lake is about one-third meadowland and two-thirds woodland. A paved road, Route H, parallels the left side of the reservoir, and several mobile homes lie between the lake and the road. A second paved road closely parallels the drainage divide near the upstream end of the watershed. The watershed above the dam amounts to approximately 213 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

1. Estimated known maximum flood at damsite ... 39 cfs* (W.S. Elev. 630.7)
2. Spillway capacity ... 254 cfs (W.S. Elev. 631.9)

c. Elevation (Ft. above MSL). Except where noted, the following elevations were determined by survey and are based on topographic data shown on the 1948 USGS Eugene, Missouri, Quadrangle Map, 15 Minute Series.

1. Observed pool ... 630.0
2. Normal pool ... 630.0
3. Spillway crest ... 630.0
4. Maximum experienced pool ... 630.7*

*Based on an estimate of maximum depth of flow at spillway wall per Owner.

5. Top of dam ... 631.9 (Min.)
6. Streambed at centerline of dam ... 606± (Est.)
7. Maximum tailwater ... Unknown
8. Observed tailwater ... None

d. Reservoir.

1. Length at normal pool (Elev. 630.0) ... 950 ft.
2. Length of pool at top of dam (Elev. 631.9) ... 1,000 ft.

e. Storage.

1. Normal pool ... 50 ac. ft.
2. Top of dam ... 63 ac. ft.

f. Reservoir Surface Area.

1. Normal pool ... 6.5 acres
2. Top of dam ... 7.4 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 ... 480 ft.
3. Height ... 28 ft.
4. Top width ... 12 ft.
5. Side slopes
   a. Upstream ... lv on 2.4h (above normal waterline)
   b. Downstream ... lv on 2.1h (max.)
6. Cutoff ... Concrete core wall (per Owner)
7. Slope protection
   a. Upstream ... Stone riprap
   b. Downstream ... Vegetation

h. Principal Spillway.

1. Type ... Uncontrolled, 24-inch wide concrete and block wall
2. Location ... Right abutment
3. Crest ... Elevation 630.0 (low point, right side)
4. Length ... 41 ft.
5. Height ... 5.8 ft. (Max.)
6. Approach channel ... Lake
7. Outlet channel ... Trapezoidal section, rock invert

i. Emergency Spillway ... None

j. Lake Drawdown Facility .

1. Type ... 6-Inch diameter cast-iron pipe
2. Location ... Sta. 2+21, 68 ft. right (vault)
3. Control ... Gate valves at vault (two)
4. Pipe Invert ... Elevation 604.5 (outlet near dam)

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Data relating to the design of the dam were unavailable and, more than likely, do not exist.

2.2 CONSTRUCTION

As previously indicated, the dam was constructed in about 1909 by the Chicago Rock Island and Pacific Railroad. Mr. Russell, the Owner, reported that the dam was built with a concrete core wall, however, no other information or data regarding construction of the dam was available.

2.3 OPERATION

The level of the lake is uncontrolled and governed by the elevation of the crest of a concrete and block wall located at the right abutment. A 6-inch diameter pipe that passes through the dam near the location of the original stream on which the dam was built, is provided for lake drawdown. A tee fitting with gate valves just downstream of the fitting, allows flow to be discharged near the dam or to some point further downstream.

According to the Owner, and to the best of his knowledge, the dam has never been overtopped. No evidence of overtopping was noted during the inspection. It was reported by the Owner that the highest lake level observed produced a depth of flow at the spillway wall estimated to be about 0.7 foot.

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 Henley 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 9 June 1981. Neither the Owner or a representative of the Owner was present 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. The Henley Lake Dam is located on an unnamed tributary to Little Tavern Creek, approximately 2 miles upstream from the junction of Little Tavern Creek with the Osage River. The topography is moderately rugged, the valley sides are steeply sloping and there is approximately 200 feet of relief between the stream valley and the surrounding drainage divide. The area is situated near the northern boundary of the Salem Plateau Section of the Ozark Plateaus Physiographic Province. This region is underlain by Ordovician age sedimentary strata which dip gently to the northwest.

The bedrock formation which underlies the dam and reservoir is the Gasconade Dolomite. The Gasconade is composed primarily of a light brownish-grey, crystalline, cherty dolomite with a few irregular, thin sandstones included in the sequence. Cryptozoan, cellular and ropey cherts are common. The bedrock is often intensely weathered by solution activity.

The residual soils derived from the weathering of the Gasconade are reddish brown cherty, silty clays, sometimes with chert contents of up to fifty percent. They typically are classified, according to the Unified Soil Classification System, as stoney CL materials. Because of the steepness of the slopes surrounding the damsite and reservoir, the residual soils are quite thin and have a high concentration of chert fragments.

The right abutment is cut by the spillway and essentially horizontal beds of Gasconade Dolomite are exposed along the sides of the spillway and form the spillway floor. Some minor leakage appears to be occurring through the bedrock along bedding planes and solution enlarged joints.

There appears to be no significant geological conditions at the Henley Lake Dam that could affect the performance of the dam or reservoir.

c. Dam. 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 except as noted herein, found to be in sound condition. No cracking of the surface, sliding or sloughing of the slopes, erosion of the embankments, or undue settlement of the crest was noted. The upstream face of the dam was protected from erosion to an elevation about 1.5 feet above the normal waterline by limestone riprap up to about 10 inches in size.

Although apparently surfaced by riprap across the entire dam, the upstream face was also covered by vegetation consisting of tall grass, weeds, dense brush, clusters of elm trees up to 8 inches in diameter, and numerous sycamore trees up to 12 inches in diameter. In addition, two areas of cattails were observed at the water's edge; one about 6 feet long at station 1+70, and the other about 10 feet long at station 4+35. The downstream face of the dam was also heavily covered with brush and trees of various sizes and kinds. The dam crest was slightly rutted and without grass or other type of protection where it appeared to have been subject to vehicular traffic. No animal burrows were observed on the dam, but due to the presence of dense brush and high vegetation on the slopes it cannot be stated 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 a dark, grey-brown, slightly silty lean clay (CL) of medium plasticity.

Seepage, as evidenced by a marshy area with cattails, soft wet ground, and running water estimated to be flowing at a rate of about 1-2 gpm (see Photo 10) was observed near the junction of the downstream toe of the dam and the left abutment. A similar marshy area with cattails and small pools of standing water was also noted just downstream of the dam at about the location of the original stream on which the dam was built. Through seepage, i.e., seepage emerging on the downstream face of the dam (see Photo 11) was also noted at station 2+80 at a point about 9 feet below the top of the dam. The quantity of seepage at this location appeared to be minor since no estimation of flow could be made, however, the ground at this location was wet and soft.

The concrete and block spillway wall (see Photos 4, 5, and 6) was inspected and found to be in poor condition with deterioration of the concrete of the downstream side of the wall extending across about three-quarters of the length of the wall. Erosion of the wall at one point (see Photo 12) reached a depth of about 9 inches and a height of 20 inches. However, the top of the wall where it appeared a course of grouted concrete block had been added to the original wall was found to be in good condition. A significant quantity of water, probably on the order of 10-to-15 gpm, was leaking from the lake through the tie-in at the dam end of the wall. Leakage was also observed at the abutment end of the wall, however, an estimate of the quantity could not be made due to the fact that the lake was overflowing the wall at this end. It also appeared that minor leakage of the wall was occuring at numerous points along the entire length of the wall. Two inch diameter fence posts at about 8-to-10 foot centers supported a 2-inch by 4-inch wire mesh fence about 1.5 feet high that spanned across the spillway opening along the upstream side of the wall. No debris was lodged on the fence at the time of the inspection.

The area of the spillway outlet channel between the wall and the rock falls was examined and found to be in reasonably good condition, although badly congested (see Photo 7) with small-to-medium size trees and areas of brush. The left bank of the spillway channel was well protected with stone riprap up to about 14 inches in diameter. The rock bluff of the right bank appeared to be structurally sound.

The concrete vault, housing the two valves on the 6-inch diameter cast-iron lake drawdown pipe (see Photo 8), was inspected and found to be in fair condition, although some minor cracking and deterioration of the walls due to weathering was evident. The steel cover was laying to one side of the structure and the interior of the structure was exposed to the elements. Approximately 6 inches of water was standing in the bottom of the vault. In addition, the structure was somewhat overgrown with weeds, vines, and other forms of vegetation. The valves and piping appeared to be in good condition. The valves were not operated as part of the inspection.

d. Appurtenant Structures. No appurtenant structures were observed at this dam site. A sewage lagoon (see Photo 9) that apparently serves the dwellings (mobile homes) along the left side of the reservoir was inspected. The lagoon measured approximately 50 feet wide by 80 feet long at the waterline and extended between about stations 4+50 and 5+00 with the lagoon surface located approximately 42 feet downstream of the center of the dam. At the time of the inspection the surface of the lagoon was approximately 9.3 feet lower than the lake surface. A small dam with about a 6-foot wide crest contained the lagoon on the low side of the hill and the grass on the crest appeared to have been recently cut. Elsewhere, the banks were unkept and some seepage from the lagoon was evident. However, the existence of the lagoon did not appear to endanger the dam.

e. Downstream Channel. Except at the railroad crossing and at the roadway crossings of the stream, the channel downstream of the dam is unimproved. Between the dam and the roadway just north of Little Tavern Creek the channel flows through farm pasture. The railroad crossing consists of a timber trestle type bridge and the roadway crossings, of which there are two, consist of low water, concrete slab type bridges. The channel section is irregular and for the most part lined with trees. The stream joins Little Tavern Creek about 0.6 mile downstream of the dam, and the creek, in turn, joins the Osage River about 2 miles downstream of the dam.

f. Reservior. The area west of the revervoir is unimproved, consisting of moderately steep, heavily wooded, hillside. Eight or nine mobile homes are located adjacent to the east side of the reservior between the lake and Route H. The improved area about the reservoir upstream of the dam appeared to be well maintained and no erosion of the lake banks at the shoreline was noticed. At the time of the inspection, the lake water was somewhat murky and the level was at the spillway crest, or normal pool. It was not feasible to determine the amount of sediment within the reservoir during the inspection. However, due to the fact that the Owner reported that sediment, about 2,000 truck loads, had been removed when the lake was drained in 1974, and since the drainage area is well covered with vegetation and no erosion of the lake banks was noticed during the inspection, the amount of sediment within the reservoir 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. However, it is recommended that, as soon as practical, the Owner repair or replace the spillway wall, since deterioration of the wall is extensive and the wall in its present condition is considered unsafe.

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.

4.2 MAINTENANCE OF DAM

According to the Owner, the trees on the dam have been cleared, the grass on the embankment is cut periodically during the growing season, and muskrats are removed by trapping during the winter. The Owner also reported that the lake level lowers to an elevation aproximately 1 foot below the spillway crest during the summer when the weather is hot and dry, such as was experienced during the summer of 1980.

The Owner reported that after purchasing the dam and lake property in 1974, the reservoir was drained and a considerable amount of sediment, as much as 2,000 truck loads of material, was removed from the lake bottom.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

With the exception of the two valves on the lake drawdown pipe, no outlet facilities requiring operation exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection did not reveal the existence of a dam failure warning system.

4.5 EVALUATION

Judging by the size and number of trees on the upstream and downstream faces of the dam as well as the dense brush on the dam slopes, it is evident that it has been some time since these areas have received the proper attention. The presence of seepage at the embankment contact with the left abutment, as well as the emergence of seepage high on the downstream face of the dam, indicates little concern for the problems, such as piping (progressive internal erosion), associated with seepage. In addition, the deteriorated condition of a significant portion of the downstream side of the spillway wall, as well as the overgrown condition, i.e., trees, brush, etc., of the spillway outlet channel just downstream of the wall, also indicates that maintenance of these areas has been overlooked. For the protection of the dam and to ensure proper maintenance procedures, 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 operations 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. Hydraulic and hydrologic design data were not available.

b. Experience Data. The drainage area and lake surface area were determined from the 1948 USGS Eugene, Missouri, Quadrangle Map. 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.

Due to the fact that the watershed for this reservoir is relatively small and since there is no history of excessive reservoir leakage that would severly affect the normal operational level of the lake, the lake level was assumed to be at normal pool as a result of antecedent storms prior to occurrence of the probable maximum flood and the probabilistic storm.

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. The Town of Henley lies about 0.4 mile downstream of the dam.

c. Visual Observations.

(1) The spillway consists of 2-foot thick concrete and block wall located within a rock cut at the right abutment. The wall is about 5.8 feet high, at its highest point, and approximately 41 feet long. A wire-mesh fence about 1.5 feet high spans the spillway opening at the location of the wall. No reduction in spillway capacity was assumed due to the presence of the fence.

(2) The spillway outlet channel, an excavated trapezoidal section with a rock invert, joins a series of rock falls at a point about 120 feet downstream of the dam. The right side of the channel is a rock bluff and the left side is protected by stone riprap. The channel joins the natural

drainage course of the adjacent watershed at a point about 190 feet downstream of the spillway wall. This waterway joins the stream on which the dam was constructed at a point about 350 feet downstream of the dam.

(3) Due to the fact that the spillway outlet directs flow away from the dam, lake outflow within the capacity of the spillway outlet should not endanger the dam.

(4) A 6-inch diameter pipe is provided for dewatering the reservoir. Valves for controlling the outlet are located in a vault that lies adjacent to the downstream toe of the dam.

d. Overtopping Potential. The spillway is inadequate to pass the probable maximum flood, 1/2 the probable maximum flood, or the 1 percent chance (100-year frequency) flood, without overtopping the dam. The spillway is adequate, however, to pass the 10 percent chance (10-year frequency) flood without overtopping the dam. The results of the dam overtopping analyses are as follows:

(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 over Dam (Elev. 631.9)	Duration of Overtopping of Dam (Hours)
0.50	2,060	633.3	1.4	5.1
1.00	4,322	634.1	2.2	6.8
1% Chance Flood	391	632.2	0.3	0.5
10% Chance Flood	120	631.3	0.0	0.0

Elevation 631.9 was found to be the lowest point in the dam crest. The flow safely passing the spillway just prior to dam overtopping was determined

to be approximately 254 cfs, which is the routed outflow corresponding to about 10 percent of the probable maximum flood inflow. This flow is less than the outflow resulting from the 1 percent chance (100-year frequency) flood, but greater than the outflow resulting from the 10 percent chance (10-year frequency) flood. During peak flow of the probable maximum flood, the greatest depth of the flow over the dam is projected to be 2.2 feet and overtopping will extend across the entire length of the dam. During peak flow of one-half the probable maximum flood, which is the recommended spillway design flood for this dam, the greatest depth of flow over the dam is projected to be 1.4 feet and overtopping will also extend across the entire length of the dam. During peak flow of the 1 percent chance flood the maximum depth of flow will be 0.3 foot and overtopping will extend across an area approximately 115 feet long between stations 0+85 and 2+00, and an area about 15 feet long between stations 3+90 and 4+05.

e. Evaluation. The results of the overtopping analysis indicate the existing spillway is inadequate to pass the lake outflow resulting from one-half the probable maximum flood event, which is the recommended spillway design flood. Experience with embankments constructed of similar material (a lean clay of medium plasticity) to that used to construct this dam has shown evidence that under certain conditions, such as high velocity flow, the material can be very erodible. Such a condition exists during the one-half PMF when large lake outflow, accompanied by high flow velocities, occurs. For this event where the depth of the flow over the dam crest, a maximum of 1.4 feet, and the duration of flow over the dam, 3.1 hours, are significant, damage by erosion to the crest and downstream face of the dam is expected. The extent of these damages is not predictable within the scope of this investigation; however, there is a possibility that they could result in failure by erosion of the dam.

f. References. Procedures and data for determining the probable maximum flood, the 100-year flood, the 10-year flood, and the discharge rating curve for flow passing the spillway and dam crest are presented on pages B-1 and B-2 of Appendix B. Listings of the HEC-1 (Dam Safety Version) input data for both the probable maximum flood, and the probabilistic floods, are shown on pages B-3 through B-7. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-8 through B-11; tabulation of lake surface area, elevation and storage volume is shown on page B-12; tabulations titled "Summary of Dam Safety Analysis" for the PMF, the 1 percent chance (100-year frequency) flood and the 10 percent chance (10-year frequency) flood are shown on pages B-12 and B-13. A rating curve for the spillway showing elevation - discharge relationships is shown on page B-14 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. No design or construction data relating to the structural stability of the dam are known to exist. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Operating Records. With the exception of the two valves on the lake drawdown pipe, no appurtenant structures or facilities requiring operation exist at this dam. According to the Owner, no records of lake level, spillway discharge, dam settlement, or lake seepage have been kept.

d. Post Construction Changes. According to the Owner 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. A possible exception may be the single course of 8-inch concrete block at the top of the concrete spillway wall, which appeared to be relatively new, and the deteriation of the wall itself.

e. Seismic Stability. The dam is located within a Zone I 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. A hydraulic analysis indicated that the spillway is capable of passing lake outflow of about 254 cfs without the level of the lake exceeding the low point in the top of the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicates that for storm runoff of one-half probable maximum flood magnitude, the lake outflow would be about 2,060 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 391 cfs. The existing spillway is inadequate to pass lake outflow resulting from a storm of one-half probable maximum flood magnitude (the recommended spillway design flood for this dam) and as a result of this inadequacy, overtopping of the dam is expected during this flood event. As indicated in Section 5, paragraph 5.1e, failure by erosion of the dam as a result of overtopping by the one-half probable maximum flood lake outflow, is a possibility.

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 trees and dense undergrowth on the upstream and downstream slopes of the embankment, seepage through the dam and at the contact of the embankment and the left abutment, a spillway wall that is badly deteriorated on the downstream side of the section, a spillway channel that is, in the vicinity of the dam, congested by small to medium size trees and brush, a wire-mesh fence that spans the spillway opening at the location of the reservoir outlet, and a dam crest that is partially, in areas that appear to be vehicular tracks, unprotected and subject to erosion.

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. Provision of additional spillway capacity should be assigned a high priority, since the existing spillway is considered to be seriously inadequate. Improvement of the existing spillway wall should also be assigned a high priority, since the wall in its present condition is considered to be structurally unsafe.

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 I 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 actions are recommended.

(1) Based upon criteria set forth in the recommended guidelines, spillway size and/or height of dam should be increased in order to pass lake outflow resulting from a storm of one-half probable maximum flood magnitude, the recommended spillway design flood for this dam. In either case, the spillway should be protected to prevent erosion.

(2) 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 trees and brush from the dam proper and the areas adjacent to the downstream toe of slope. The removal of trees should be performed under the direction and guidance of an engineer experienced in the design and construction of earthen dams, since indiscriminate clearing can jeopardize the safety of the dam. The existing turf cover should be restored if destroyed or missing. Maintain the turf cover at a height that will not hinder inspection of the embankment or provide cover for burrowing animals. Holes from tree roots can provide a pathway for lake seepage that could lead to a piping condition (progressive internal erosion) and failure of the dam.

(2) Provide some means of controlling seepage evident in the area adjacent to the downstream toe at the left abutment and the seepage emerging on the face of the embankment near the center of the dam. Uncontrolled seepage can lead to a piping condition that can result in failure of the dam. Drainage of the areas affected by seepage including elimination of the wet area just downstream of the dam should be one of the objectives of the seepage control measures since saturation of the soil weakens the foundation which could impair the structural stability of the dam.

(3) Repair the deteriorated areas of the spillway wall, or replace the entire wall if deemed necessary, in order to prevent failure of the wall which in its present condition is considered to be unsafe. Failure of the wall could produce a sudden release of flow which could jeopardize the safety of people and property within the downstream damage zone.

(4) Remove the trees, brush, debris, etc., from the spillway outlet channel through the section between the wall and the rock falls. Items such as trees and brush within the channel serve to congest the waterway area which could result in a decrease of flow capacity. It is also recommended that the

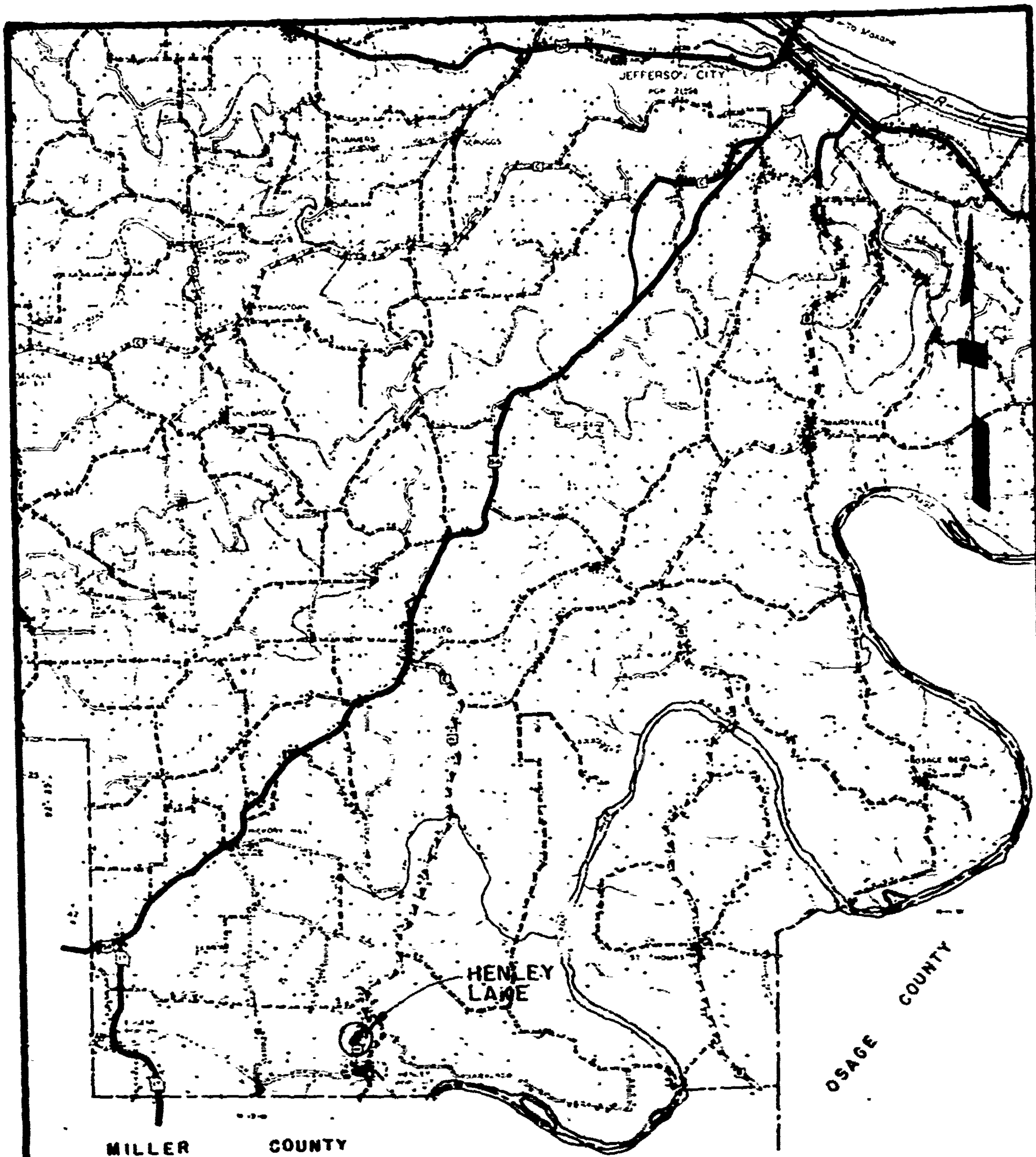
wire-mesh fence that spans the spillway opening at the top of the wall be removed since lake carried debris could lodge on the fence and block the outlet which could result in flooding of the reservoir and overtopping of the dam.

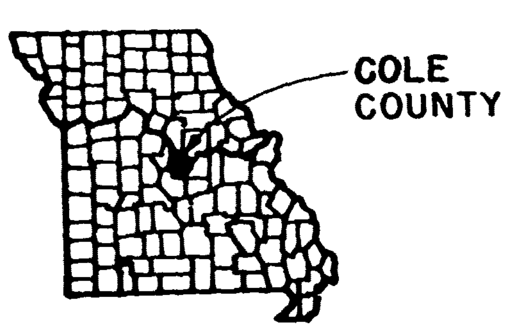
(5) Provide some form of protection, grass or crushed stone, in order to prevent erosion of the dam crest by vehicles or overland drainage. Erosion of the dam crest will lower the top of the embankment which can result in overtopping.

(6) The lake drawdown facility should be periodically inspected and operated in order to maintain the system in proper working condition.

(7) 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.

(8) 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.





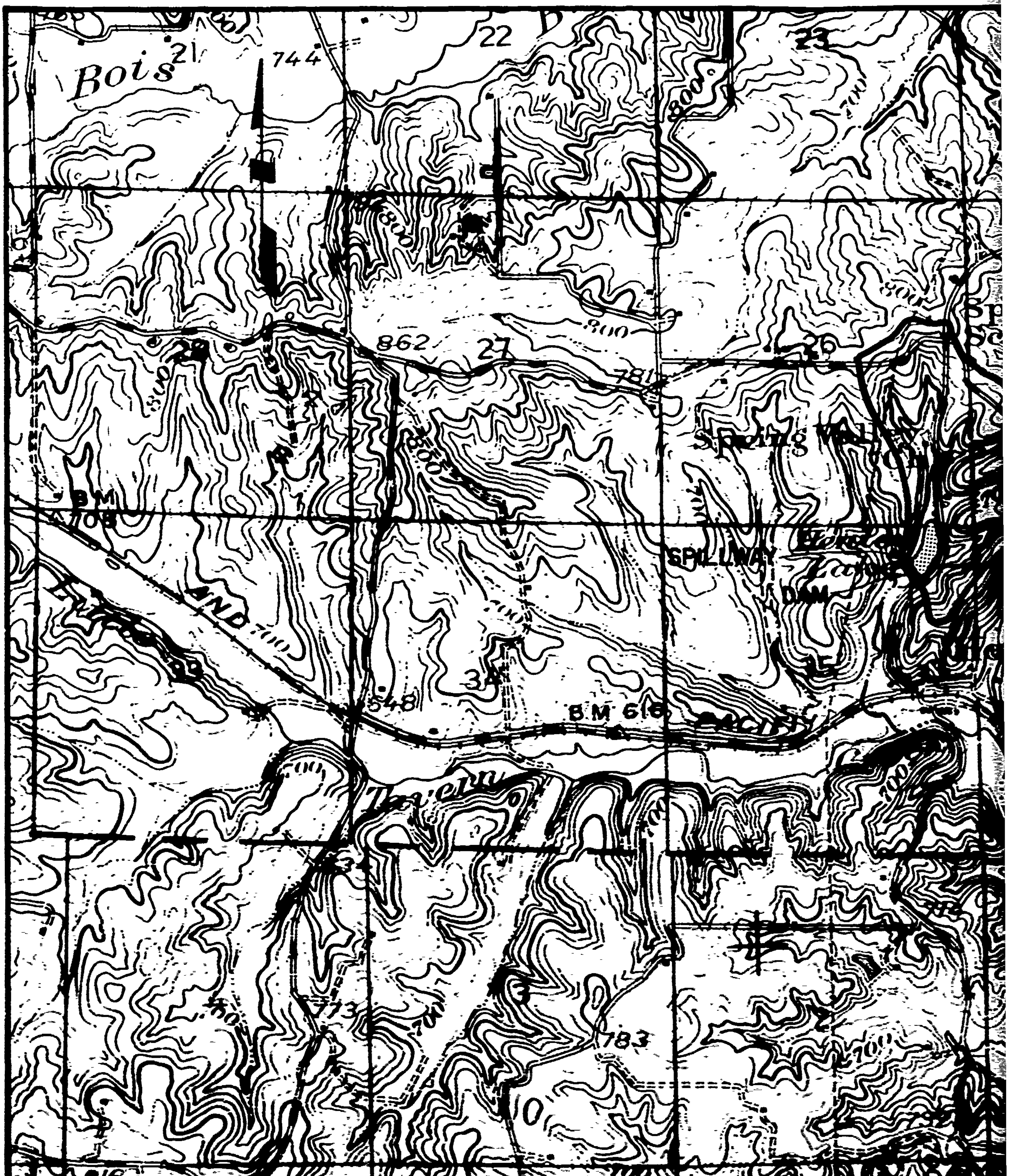
LOCATION MAP

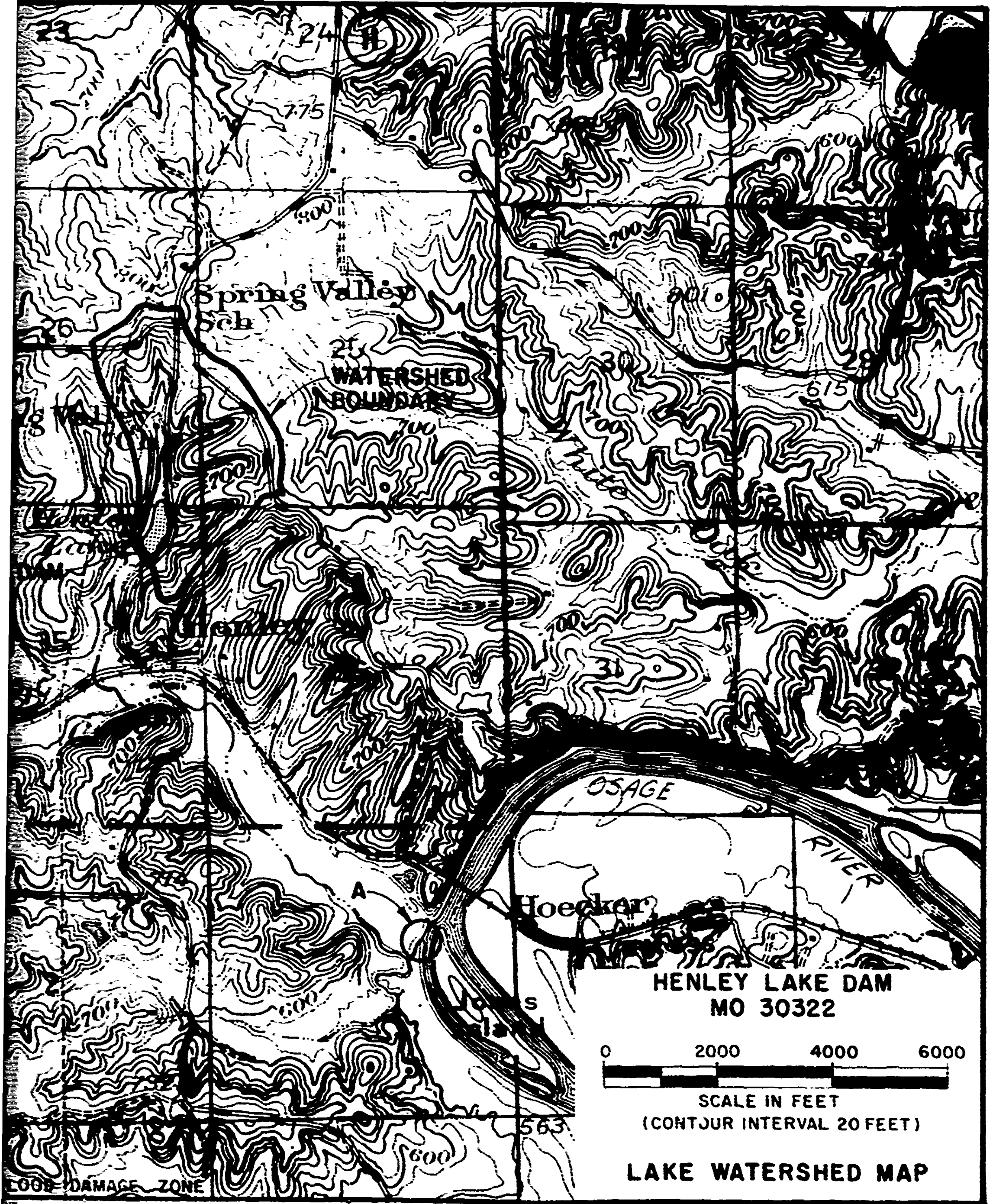
HENLEY LAKE DAM
MO 30322

1 0 1 2 3 4
SCALE (MILES)

REGIONAL VICINITY MAP

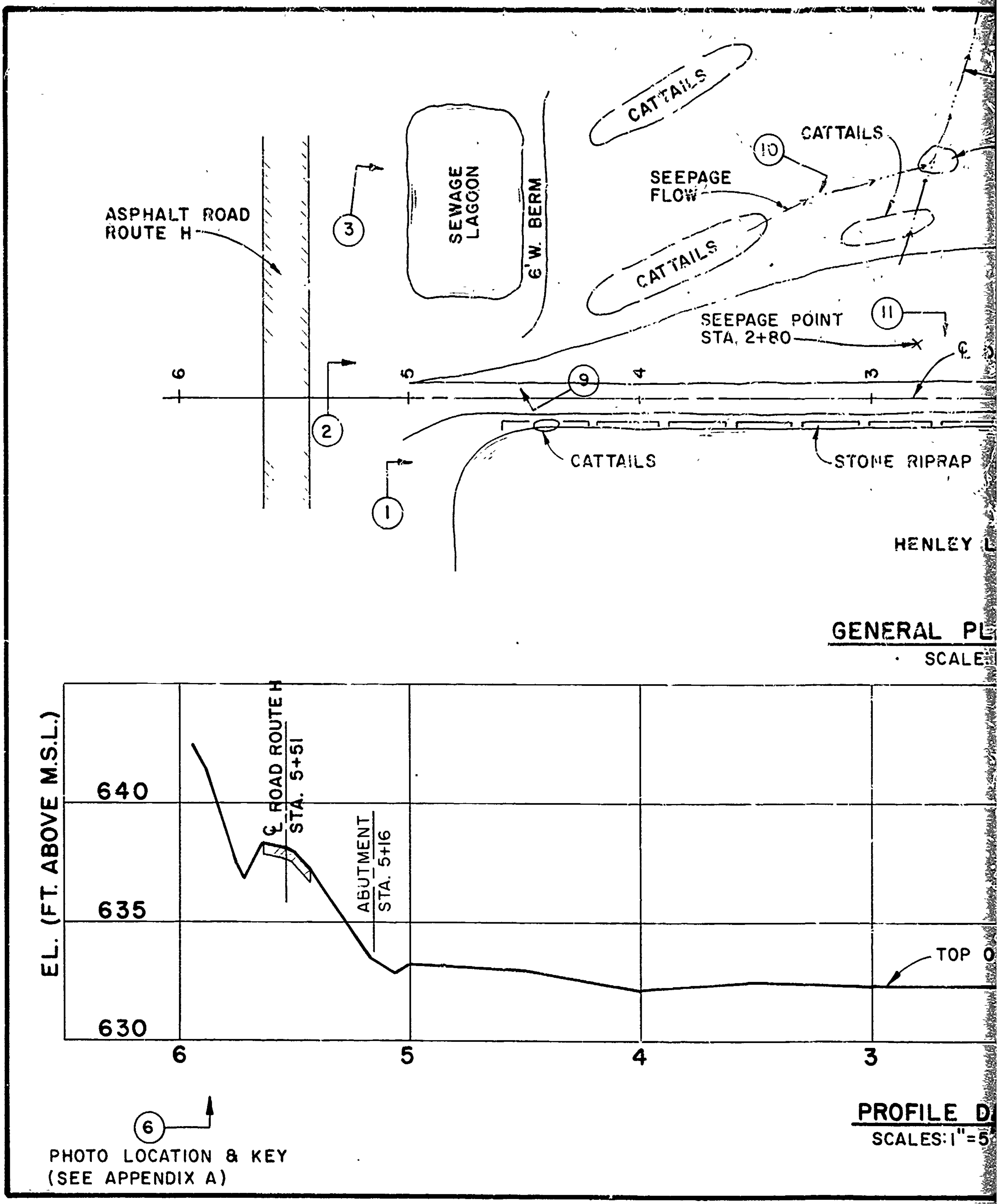
PLATE 1


Bois
21
744
22
23
800
862
27
26
781
800
Spring Valley
B M
708
AND
700
SPILLWAY
Lake
DAM
34
548
B M 616
PACIFIC
Tavern
773
783
APPROXIMATE EXTENT OF DOWNSTREAM FLOOD DAMAGE ZONE

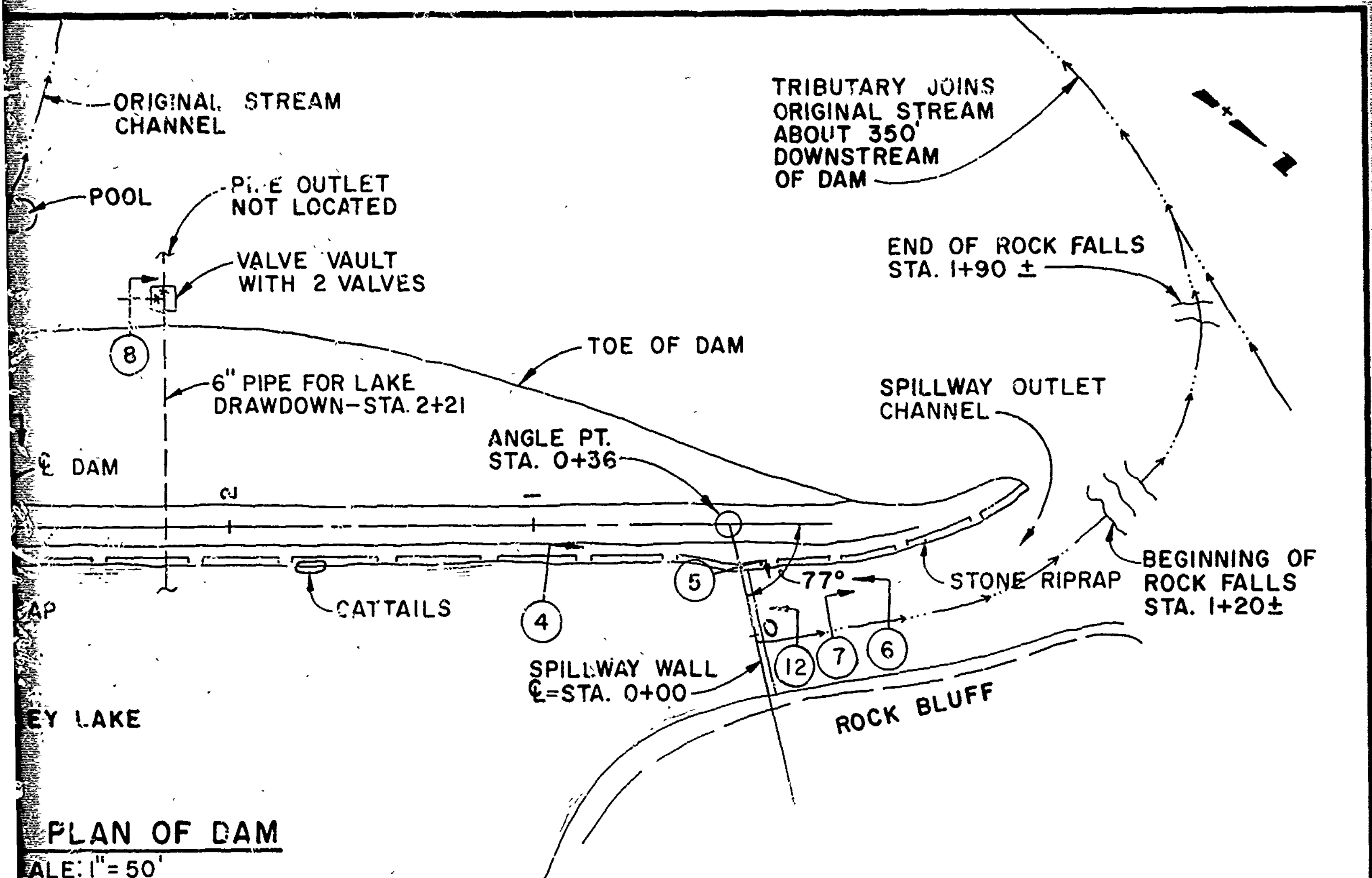

Spring Valley Sch
WATERSHED BOUNDARY
OSAGE
RIVER
Hoecker
HENLEY LAKE DAM
MO 30322
0 2000 4000 6000
SCALE IN FEET
(CONTOUR INTERVAL 20 FEET)
LAKE WATERSHED MAP
FLOOD DAMAGE ZONE

2

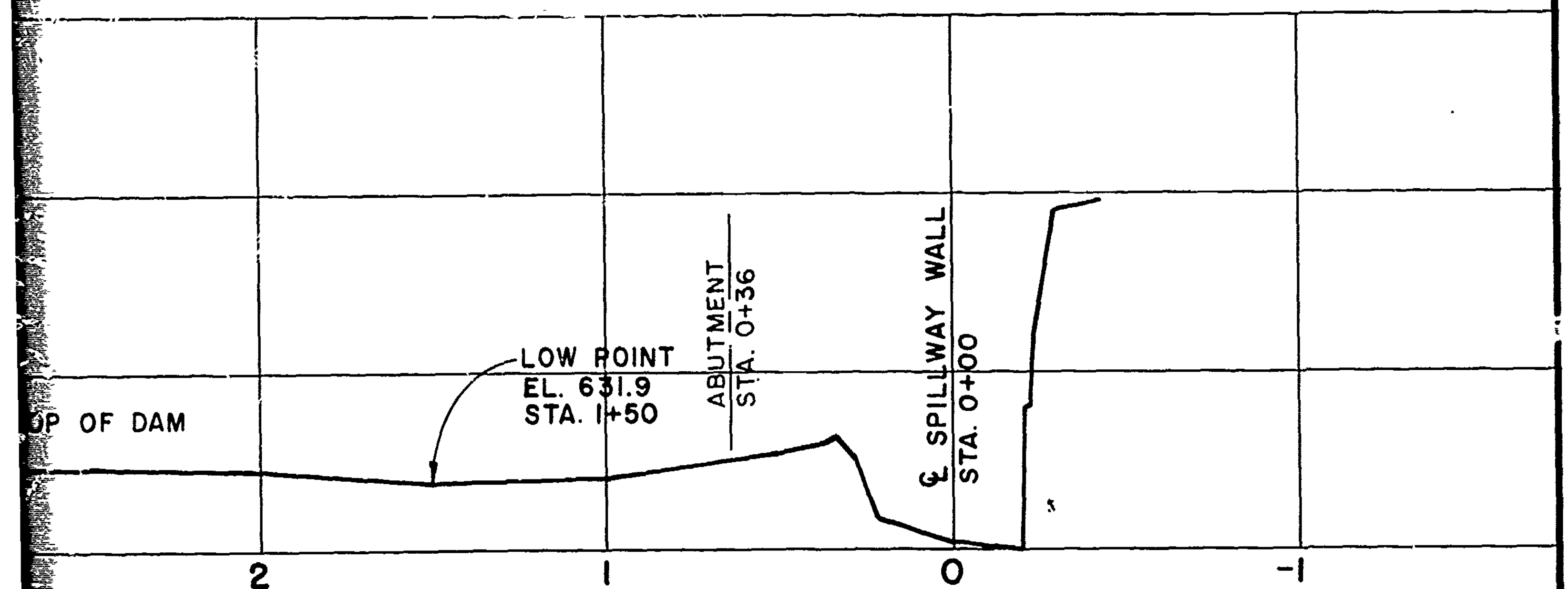
PLATE 2



CATTAILS
CATTAILS
CATTAILS
CATTAILS
SEWAGE LAGOON
6' W. BERM
ASPHALT ROAD ROUTE H
SEEPAGE FLOW
SEEPAGE POINT STA. 2+80
STONE RIPRAP
HENLEY L
6
5
4
3
1
2
3
9
10
11
GENERAL PL
SCALE
EL. (FT. ABOVE M.S.L.)
640
635
630
℄ ROAD ROUTE H STA. 5+51
ABUTMENT STA. 5+16
TOP O
6
5
4
3
PROFILE D
SCALES: 1"=5
6
PHOTO LOCATION & KEY
(SEE APPENDIX A)



PLAN OF DAM
ALE: 1"= 50'



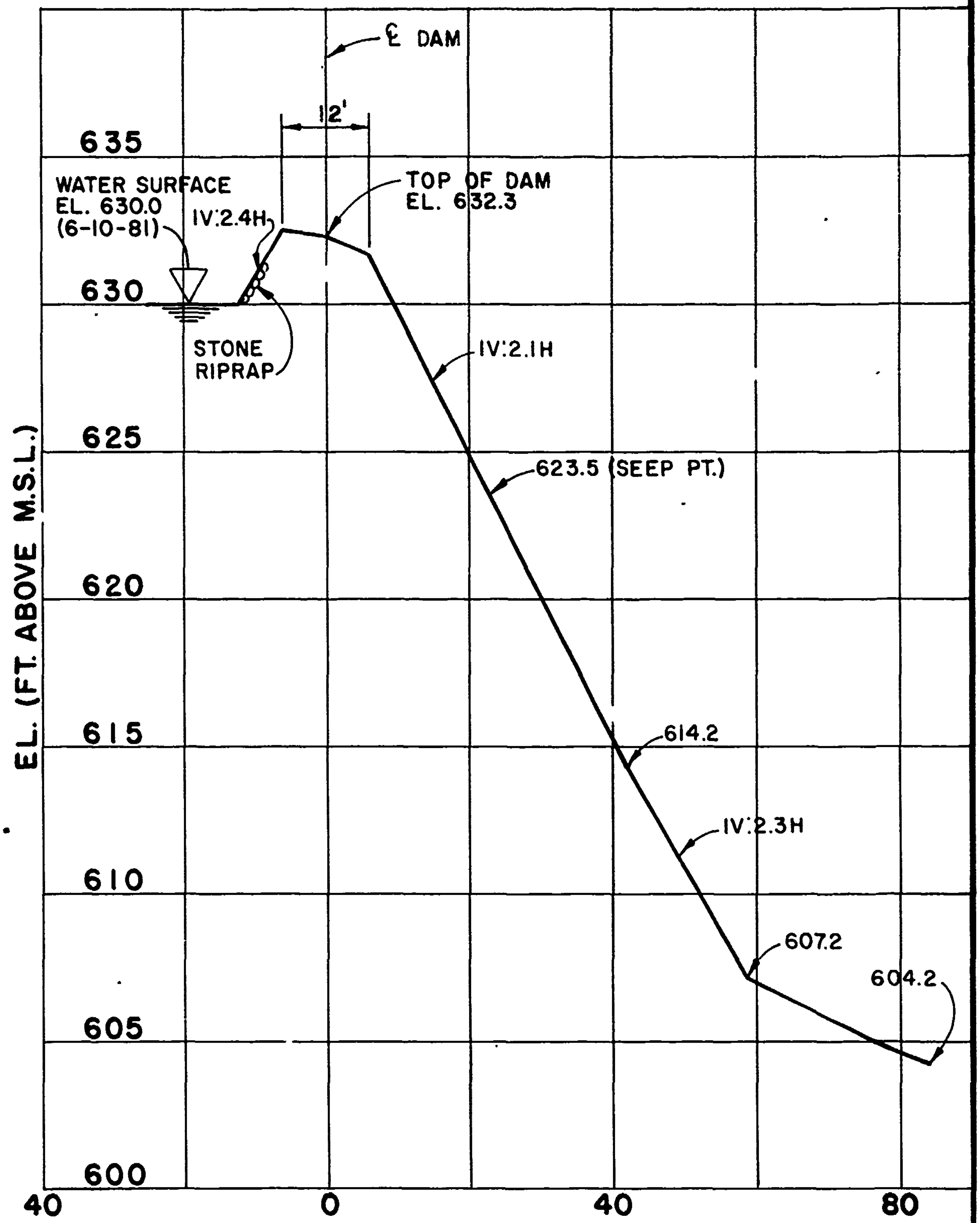
DAM CREST
1"=5'V., 1"= 50'H.

HENLEY LAKE DAM-MO 30322
DAM PLAN & PROFILE

Horner & Shifrin, Inc. June 1981

PLATE 3

1 2



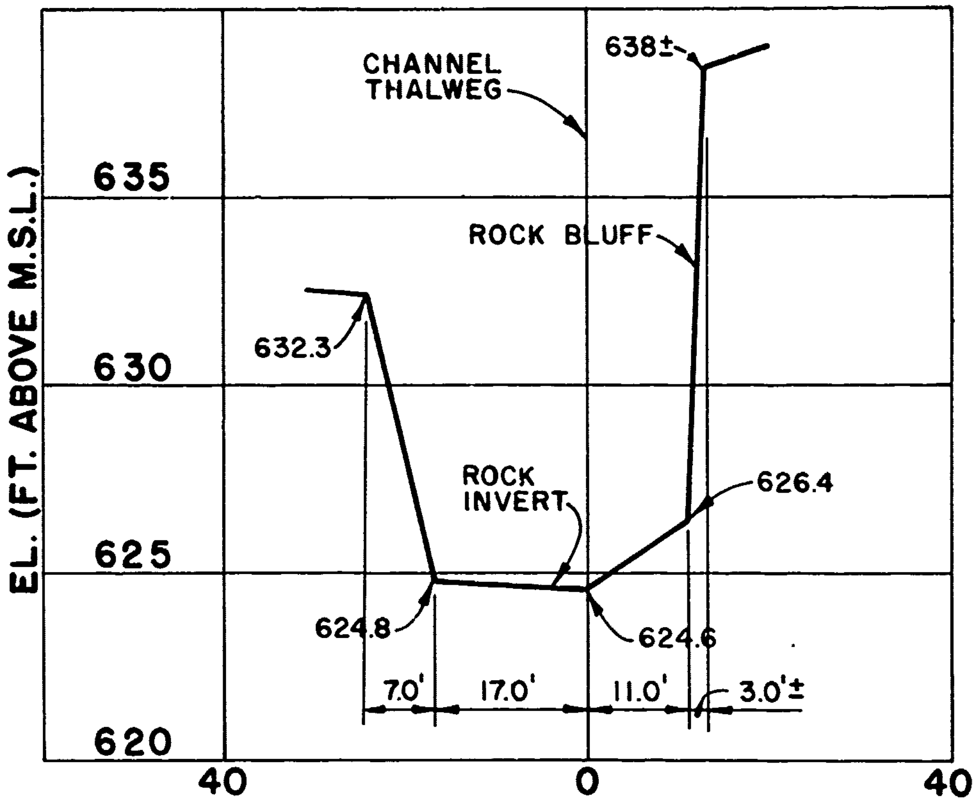
CROSS-SECTION STA. 2+80

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

HENLEY LAKE DAM-MO 30322
DAM CROSS-SECTION

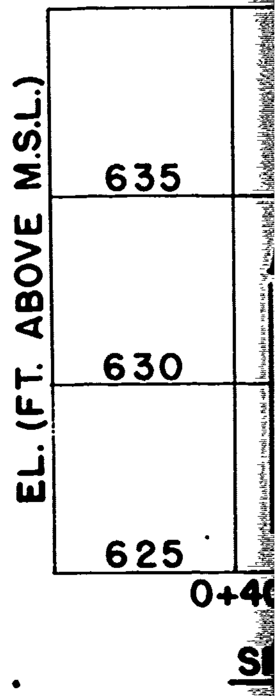
Horner & Shifrin, Inc. June 1981

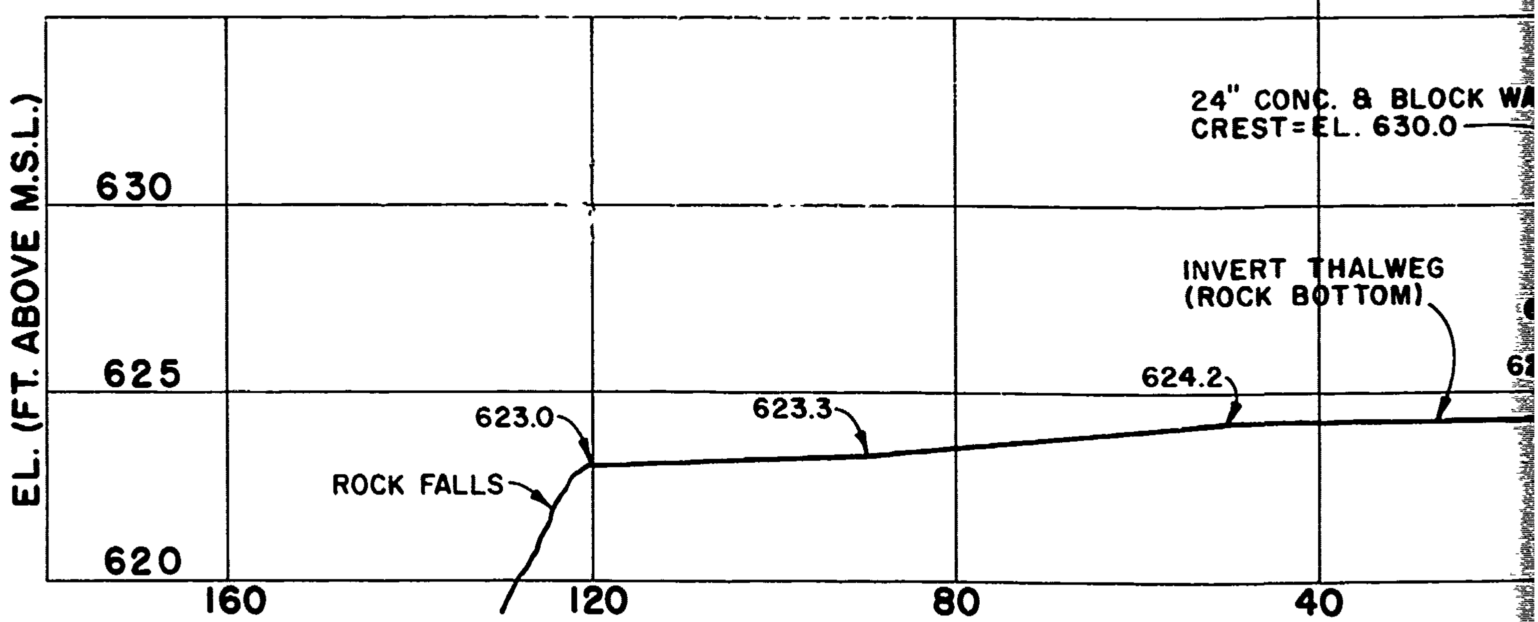
PLATE 4



CHANNEL CROSS-SECTION STA. 0+40

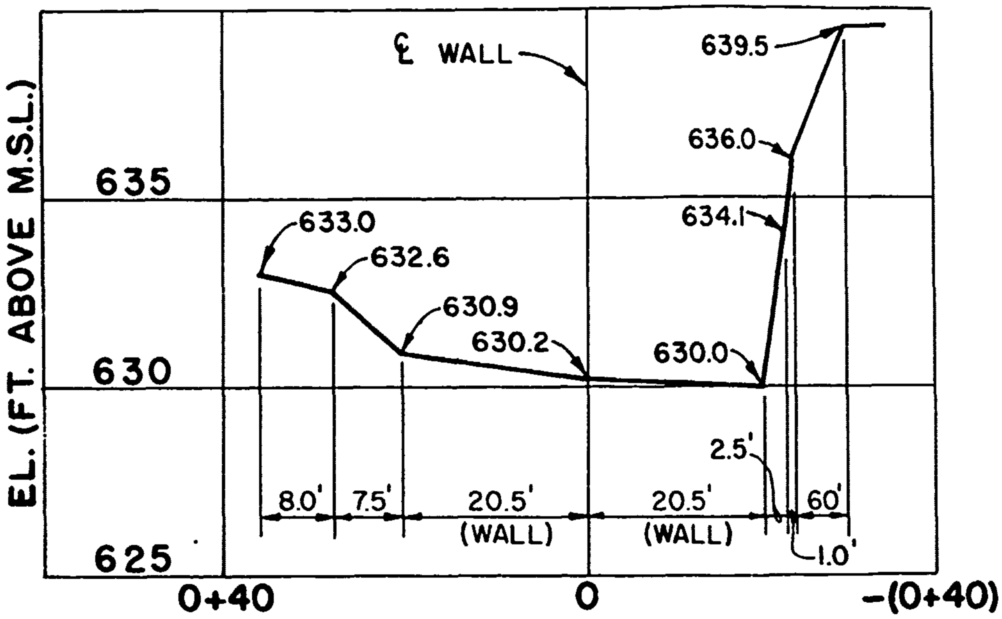
SCALE: 1"=5'V., 1"=20'H.





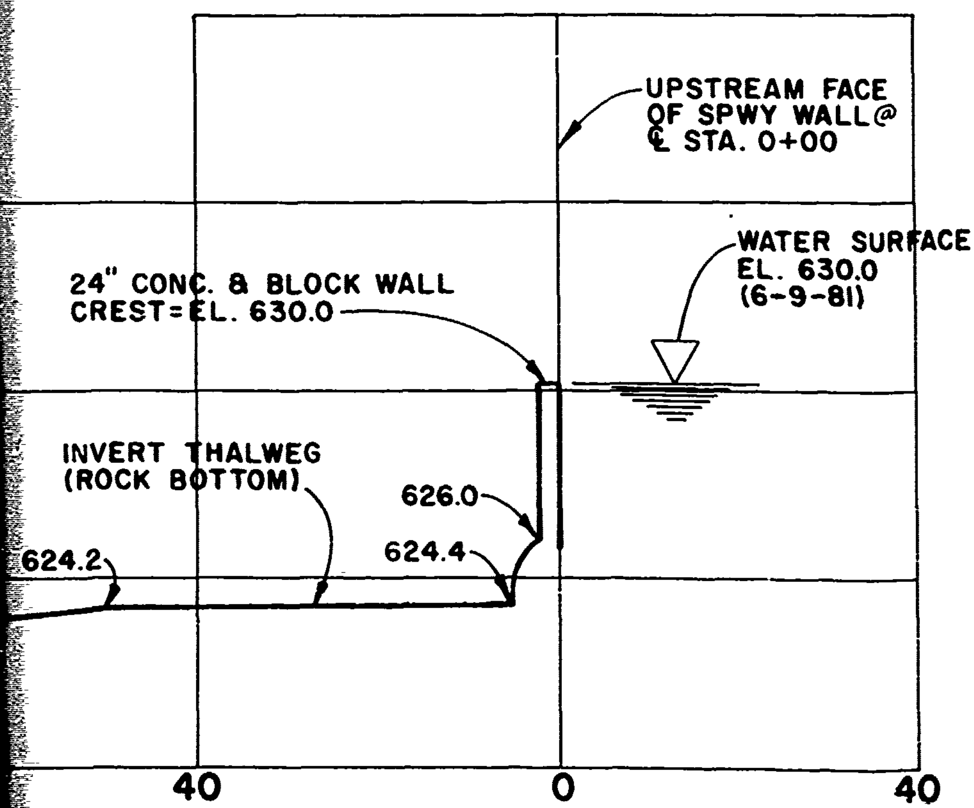
OUTLET CHANNEL PROFILE

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



SPILLWAY CROSS-SECTION STA. 0+00

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



NEL PROFILE

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

HENLEY LAKE DAM-MO 30322
OUTLET CHANNEL PROFILE
& CROSS-SECTION.

Horner & Shifrin, Inc. June 1981

PLATE 5

, 2

APPENDIX A

INSPECTION PHOTOGRAPHS

1	2
3	

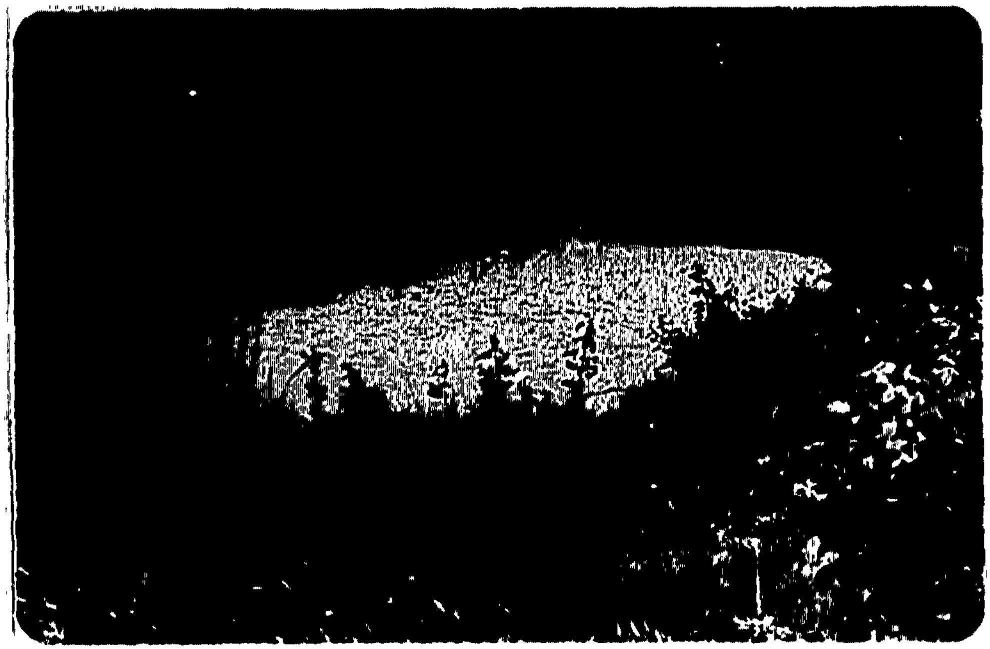
PHOTO KEY

NO.	DESCRIPTION
1	Upstream Face of Dam
2	Dam Crest
3	Downstrean Face of Dam (Note Surveyor on Dam Crest)

4	5
6	

PHOTO KEY

NO.	DESCRIPTION
4	Spillway Approach
5	Spillway Wall
6	Downstream Side of Spillway Wall



7	8
9	

PHOTO KEY

NO.	DESCRIPTION
7	Spillway Channel Downstream of Wall
8	Valve Vault Piping
9	Sewage Lagoon

10	11
12	

PHOTO KEY

NO.	DESCRIPTION
10	Seepage at Left Abutment
11	Through Seepage at Station 2+80
12	Deterioration of Spillway Wall

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 25.5 inches) from Hydrometerological Report No. 33. The precipitation data used in the analysis of the 1 percent chance (100-year frequency) flood and the 10 percent chance (10-year frequency) flood was provided by the St. Louis District, Corps of Engineers.

b. Storm duration = 24 hours, unit hydrograph duration = 5 minutes

c. Drainage area = 213 acres = 0.333 square miles.

d. SCS parameters:

Time of Concentration (Tc) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$ = 0.194 hours

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

L = Length of longest watercourse = 0.61 miles.

H = Elevation difference = 190 feet.

The time of concentration (Tc) 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 = 0.117 hours (0.60 Tc)

Hydrologic Soil Group = 100% B (Lebanon-Goss-Bardley-Peridge Series with 2/3 wooded hillsides and 1/3 meadow per SCS Missouri General Soil Map and field inspection)

Soil type CN = 63 (AMC II, 100-yr and 10-yr flood conditions)
= 80 (AMC III, PMF condition)

2. The spillway consists of a 2-foot thick concrete and block wall overflow section with a variable crest elevation for which conventional weir formulas are not considered applicable. Spillway release rates were determined as follows:

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 Q_c was computed as $Q_c = (\frac{a^3 g}{t})^{0.5}$ 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.

d. The spillway discharges for corresponding elevations were entered on the Y4 and Y5 cards.

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.

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

A1	ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF									
A2	HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF HENLEY LAKE DAM									
A3	RATIOS OF PMF ROUTED THROUGH RESERVOIR									
B	288	0	5	0	0	0	0	0	0	0
B1	5									
J	1	4	1							
J1	0.10	0.11	0.50	1.00						
K	0	INFLOW					1			
K1	INFLOW HYDROGRAPH									
M	1	2	0.333			1.0			1	
P	0	25.5	102	120	130					
T							-1	-80		
W2		0.117								
X	-1.0	-.10	2.0							
K	1	DAM					1			
K1	RESERVOIR ROUTING BY MODIFIED PULS									
Y				1	1					
Y1	1						-630.	-1		
Y4	630.0	630.25	630.80	631.19	631.92	632.49	633.06	633.63	634.01	634.39
Y4	634.99	635.59	635.69	636.28	637.02	637.76	638.50	639.21	639.92	
Y5	0	4	45	102	258	417	602	813	973	1151
Y5	1451	1773	1826	2179	2648	3151	3679	4216	4785	
$A	0	6.5	11.9	19.3	27.5					
$E	607	630	640	650	660					
$$	630.0									
$D	631.9									
$L	0	67	90	358	414	477	505	528	544	554
$V	631.9	632.0	632.1	632.5	633.0	633.2	636.8	638.0	638.3	641.5
K	99									

A1	ANALYSIS OF DAM OVERTOPPING USING 1% CHANCE FLOOD									
A2	HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF HENLEY LAKE DAM									
A3	1% CHANCE FLOOD ROUTED THROUGH RESERVOIR									
B	288	0	5	0	0	0	0	0	0	0
B1	5									
J	1	1	1							
J1	1.00									
K	0	INFLOW					1			
K1	INFLOW HYDROGRAPH									
M	0	2	0.333			1.0			1	
O	288	7.224								
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.014	.014	.014	.014	.014	.014	.014	.014
01	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
01	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
01	.014	.014	.014	.014	.014	.014	.014	.014	.022	.022
01	.022	.022	.022	.022	.022	.022	.022	.022	.022	.022
01	.022	.022	.022	.022	.022	.022	.031	.031	.031	.031
01	.031	.031	.061	.061	.061	.061	.061	.061	.132	.132
01	.132	.252	.252	.552	.826	.384	.252	.132	.132	.132
01	.061	.061	.061	.061	.061	.061	.031	.031	.031	.031
01	.031	.031	.022	.022	.022	.022	.022	.022	.022	.022
01	.022	.022	.022	.022	.022	.022	.022	.022	.022	.022

1% CHANCE FLOOD (Cont'd)

01	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
01	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
01	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
01	.014	.014	.014	.014	.014	.014	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
01	.007	.007	.007	.007	.007	.007	.007	.007		
T							-1	-55		
W2		0.117								
X	-1.0	-.10	2.0							
K	1	DAM					1			
K1	RESERVOIR ROUTING BY MODIFIED PULS									
Y				1	1					
Y1	1						-630.	-1		
Y4	630.0	630.25	630.80	631.19	631.92	632.49	633.06	633.63	634.01	634.39
Y4	634.99	635.59	635.69	636.28	637.02	637.76	638.50	639.21	639.92	
Y5	0	4	45	102	258	417	602	813	973	1151
Y5	1451	1773	1826	2179	2648	3151	3679	4216	4785	
$A	0	6.5	11.9	19.3	27.5					
$E	607	630	640	650	660					
$$	630.0									
$D	631.9									
$L	0	67	90	358	414	477	505	528	544	554
$V	631.9	632.0	632.1	632.5	633.0	633.2	636.8	638.0	638.3	641.5
K	99									

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A1        ANALYSIS OF DAM OVERTOPPING USING 10% CHANCE FLOOD
A2        HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF HENLEY LAKE DAM
A3        10% CHANCE FLOOD ROUTED THROUGH RESERVOIR
B      288       0       5       0       0       0       0       0       0       0
B1       5
J        1       1       1
J1    1.00
K        0  INFLOW                                       1
K1        INFLOW HYDROGRAPH
M        0       2   0.333                   1.0                             1
O      288   5.114
O1    .005    .005    .005    .005    .005    .005    .005    .005    .005    .005
O1    .005    .005    .005    .005    .005    .005    .005    .005    .005    .005
O1    .005    .005    .005    .005    .005    .005    .005    .005    .005    .005
O1    .005    .005    .005    .005    .005    .005    .005    .005    .005    .005
O1    .005    .005    .005    .005    .005    .005    .005    .005    .005    .005
O1    .005    .005    .005    .005    .005    .005    .005    .005    .005    .005
O1    .005    .005    .005    .005    .005    .005    .005    .005    .005    .005
O1    .005    .005    .010    .010    .010    .010    .010    .010    .010    .010
O1    .010    .010    .010    .010    .010    .010    .010    .010    .010    .010
O1    .010    .010    .010    .010    .010    .010    .010    .010    .010    .010
O1    .010    .010    .010    .010    .010    .010    .010    .010    .015    .015
O1    .015    .015    .015    .015    .015    .015    .015    .015    .015    .015
O1    .015    .015    .015    .015    .015    .015    .031    .031    .031    .031
O1    .031    .031    .049    .049    .049    .049    .049    .049    .086    .086
O1    .086    .164    .164    .377    .587    .262    .164    .086    .086    .086
O1    .049    .049    .049    .049    .049    .049    .031    .031    .031    .031
O1    .031    .031    .015    .015    .015    .015    .015    .015    .015    .015
O1    .015    .015    .015    .015    .015    .015    .015    .015    .015    .015
```

10% CHANCE FLOOD (Cont'd)

01	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010
01	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010
01	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010
01	.010	.010	.010	.010	.010	.010	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
01	.005	.005	.005	.005	.005	.005	.005	.005		
T							-1	-63		
W2		0.117								
X	-1.0	-.10	2.0							
K	1	DAM					1			
K1	RESERVOIR ROUTING BY MODIFIED PULS									
Y				1	1					
Y1	1						-630.	-1		
Y4	630.0	630.25	630.80	631.19	631.92	632.49	633.06	633.63	634.01	634.39
Y4	634.99	635.59	635.69	636.28	637.02	637.76	638.50	639.21	639.92	
Y5	0	4	45	102	258	417	602	813	973	1151
Y5	1451	1773	1826	2179	2648	3151	3679	4216	4785	
$A	0	6.5	11.9	19.3	27.5					
$E	607	630	640	650	660					
$$	630.0									
$D	631.9									
$L	0	67	90	358	414	477	505	528	544	554
$V	631.9	632.0	632.1	632.5	633.0	633.2	636.8	638.0	638.3	641.5
K	99									

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF HENLEY 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= 4 LRTIO= 1
RTIOS= .10 .11 .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	.33	0.00	.33	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.50	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	-80.00	0.00	0.00

CURVE NO = -80.00 WETNESS = -1.00 EFFECT CN = 80.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .12

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

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

UNIT HYDROGRAPH 9 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .12 VOL= 1.00
529. 1017. 602. 249. 105. 45. 19. 9. 3.

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	.22	.19	.02	219.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.22	.20	.02	359.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.22	.20	.02	444.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.22	.20	.02	480.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.22	.20	.02	497.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.22	.20	.02	506.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.22	.20	.02	511.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.22	.20	.02	514.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.22	.20	.02	517.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.22	.20	.01	519.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.22	.20	.01	520.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.22	.20	.01	522.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.26	.24	.02	545.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.26	.25	.01	583.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.26	.25	.01	615.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.26	.25	.01	627.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.26	.25	.01	633.
1.01	1.30	18	.01	0.00	.01	0.	1.01	13.30	162	.26	.25	.01	636.
1.01	1.35	19	.01	0.00	.01	0.	1.01	13.35	163	.26	.25	.01	638.
1.01	1.40	20	.01	0.00	.01	0.	1.01	13.40	164	.26	.25	.01	640.
1.01	1.45	21	.01	0.00	.01	0.	1.01	13.45	165	.26	.25	.01	641.
1.01	1.50	22	.01	0.00	.01	0.	1.01	13.50	166	.26	.25	.01	643.
1.01	1.55	23	.01	0.00	.01	0.	1.01	13.55	167	.26	.25	.01	644.
1.01	2.00	24	.01	0.00	.01	0.	1.01	14.00	168	.26	.25	.01	645.
1.01	2.05	25	.01	0.00	.01	0.	1.01	14.05	169	.33	.31	.01	679.
1.01	2.10	26	.01	0.00	.01	0.	1.01	14.10	170	.33	.31	.01	744.
1.01	2.15	27	.01	0.00	.01	0.	1.01	14.15	171	.33	.31	.01	783.
1.01	2.20	28	.01	0.00	.01	0.	1.01	14.20	172	.33	.32	.01	800.
1.01	2.25	29	.01	0.00	.01	0.	1.01	14.25	173	.33	.32	.01	808.
1.01	2.30	30	.01	0.00	.01	0.	1.01	14.30	174	.33	.32	.01	812.
1.01	2.35	31	.01	0.00	.01	0.	1.01	14.35	175	.33	.32	.01	814.
1.01	2.40	32	.01	0.00	.01	0.	1.01	14.40	176	.33	.32	.01	815.
1.01	2.45	33	.01	0.00	.01	0.	1.01	14.45	177	.33	.32	.01	816.
1.01	2.50	34	.01	0.00	.01	0.	1.01	14.50	178	.33	.32	.01	817.
1.01	2.55	35	.01	0.00	.01	0.	1.01	14.55	179	.33	.32	.01	818.
1.01	3.00	36	.01	.00	.01	0.	1.01	15.00	180	.33	.32	.01	819.
1.01	3.05	37	.01	.00	.01	0.	1.01	15.05	181	.20	.19	.00	754.
1.01	3.10	38	.01	.00	.01	0.	1.01	15.10	182	.40	.39	.01	730.
1.01	3.15	39	.01	.00	.01	1.	1.01	15.15	183	.40	.39	.01	852.
1.01	3.20	40	.01	.00	.01	1.	1.01	15.20	184	.59	.58	.01	1041.
1.01	3.25	41	.01	.00	.01	2.	1.01	15.25	185	.69	.68	.01	1326.
1.01	3.30	42	.01	.00	.01	2.	1.01	15.30	186	1.69	1.65	.03	2074.
1.01	3.35	43	.01	.00	.01	2.	1.01	15.35	187	2.77	2.73	.03	3749.
1.01	3.40	44	.01	.00	.01	3.	1.01	15.40	188	1.09	1.08	.01	4603.
1.01	3.45	45	.01	.00	.01	3.	1.01	15.45	189	.69	.69	.01	3623.
1.01	3.50	46	.01	.00	.01	3.	1.01	15.50	190	.59	.59	.01	2555.
1.01	3.55	47	.01	.00	.01	4.	1.01	15.55	191	.40	.39	.00	1866.
1.01	4.00	48	.01	.00	.01	4.	1.01	16.00	192	.40	.39	.00	1404.
1.01	4.05	49	.01	.00	.01	4.	1.01	16.05	193	.30	.30	.00	1129.
1.01	4.10	50	.01	.00	.01	5.	1.01	16.10	194	.30	.30	.00	940.
1.01	4.15	51	.01	.00	.01	5.	1.01	16.15	195	.30	.30	.00	842.

END-OF-PERIOD FLOW (Cont'd)

1.01	4.20	52	.01	.00	.01	5.	1.01	16.20	196	.30	.30	.00	800.
1.01	4.25	53	.01	.00	.01	6.	1.01	16.25	197	.30	.30	.00	785.
1.01	4.30	54	.01	.00	.01	6.	1.01	16.30	198	.30	.30	.00	779.
1.01	4.35	55	.01	.00	.01	6.	1.01	16.35	199	.30	.30	.00	777.
1.01	4.40	56	.01	.00	.01	7.	1.01	16.40	200	.30	.30	.00	777.
1.01	4.45	57	.01	.00	.01	7.	1.01	16.45	201	.30	.30	.00	776.
1.01	4.50	58	.01	.00	.01	7.	1.01	16.50	202	.30	.30	.00	777.
1.01	4.55	59	.01	.00	.01	8.	1.01	16.55	203	.30	.30	.00	777.
1.01	5.00	60	.01	.00	.01	8.	1.01	17.00	204	.30	.30	.00	777.
1.01	5.05	61	.01	.00	.01	8.	1.01	17.05	205	.24	.24	.00	743.
1.01	5.10	62	.01	.00	.01	8.	1.01	17.10	206	.24	.24	.00	677.
1.01	5.15	63	.01	.00	.01	9.	1.01	17.15	207	.24	.24	.00	638.
1.01	5.20	64	.01	.00	.01	9.	1.01	17.20	208	.24	.24	.00	622.
1.01	5.25	65	.01	.00	.01	9.	1.01	17.25	209	.24	.24	.00	616.
1.01	5.30	66	.01	.00	.01	10.	1.01	17.30	210	.24	.24	.00	613.
1.01	5.35	67	.01	.00	.01	10.	1.01	17.35	211	.24	.24	.00	612.
1.01	5.40	68	.01	.00	.01	10.	1.01	17.40	212	.24	.24	.00	611.
1.01	5.45	69	.01	.00	.01	10.	1.01	17.45	213	.24	.24	.00	611.
1.01	5.50	70	.01	.00	.01	11.	1.01	17.50	214	.24	.24	.00	611.
1.01	5.55	71	.01	.00	.01	11.	1.01	17.55	215	.24	.24	.00	611.
1.01	6.00	72	.01	.00	.01	11.	1.01	18.00	216	.24	.24	.00	611.
1.01	6.05	73	.06	.02	.04	20.	1.01	18.05	217	.02	.02	.00	497.
1.01	6.10	74	.06	.02	.04	38.	1.01	18.10	218	.02	.02	.00	435.
1.01	6.15	75	.06	.02	.04	50.	1.01	18.15	219	.02	.02	.00	405.
1.01	6.20	76	.06	.03	.04	58.	1.01	18.20	220	.02	.02	.00	378.
1.01	6.25	77	.06	.03	.04	64.	1.01	18.25	221	.02	.02	.00	353.
1.01	6.30	78	.06	.03	.04	68.	1.01	18.30	222	.02	.02	.00	329.
1.01	6.35	79	.06	.03	.03	72.	1.01	18.35	223	.02	.02	.00	307.
1.01	6.40	80	.06	.03	.03	75.	1.01	18.40	224	.02	.02	.00	287.
1.01	6.45	81	.06	.03	.03	79.	1.01	18.45	225	.02	.02	.00	268.
1.01	6.50	82	.06	.03	.03	82.	1.01	18.50	226	.02	.02	.00	250.
1.01	6.55	83	.06	.03	.03	85.	1.01	18.55	227	.02	.02	.00	233.
1.01	7.00	84	.06	.04	.03	87.	1.01	19.00	228	.02	.02	.00	217.
1.01	7.05	85	.06	.04	.03	90.	1.01	19.05	229	.02	.02	.00	203.
1.01	7.10	86	.06	.04	.03	93.	1.01	19.10	230	.02	.02	.00	189.
1.01	7.15	87	.06	.04	.03	95.	1.01	19.15	231	.02	.02	.00	176.
1.01	7.20	88	.06	.04	.02	97.	1.01	19.20	232	.02	.02	.00	165.
1.01	7.25	89	.06	.04	.02	99.	1.01	19.25	233	.02	.02	.00	154.
1.01	7.30	90	.06	.04	.02	101.	1.01	19.30	234	.02	.02	.00	143.
1.01	7.35	91	.06	.04	.02	103.	1.01	19.35	235	.02	.02	.00	134.
1.01	7.40	92	.06	.04	.02	105.	1.01	19.40	236	.02	.02	.00	125.
1.01	7.45	93	.06	.04	.02	107.	1.01	19.45	237	.02	.02	.00	116.
1.01	7.50	94	.06	.04	.02	109.	1.01	19.50	238	.02	.02	.00	109.
1.01	7.55	95	.06	.04	.02	110.	1.01	19.55	239	.02	.02	.00	101.
1.01	8.00	96	.06	.04	.02	112.	1.01	20.00	240	.02	.02	.00	95.
1.01	8.05	97	.06	.04	.02	113.	1.01	20.05	241	.02	.02	.00	88.
1.01	8.10	98	.06	.05	.02	115.	1.01	20.10	242	.02	.02	.00	82.
1.01	8.15	99	.06	.05	.02	116.	1.01	20.15	243	.02	.02	.00	77.
1.01	8.20	100	.06	.05	.02	117.	1.01	20.20	244	.02	.02	.00	72.
1.01	8.25	101	.06	.05	.02	119.	1.01	20.25	245	.02	.02	.00	67.
1.01	8.30	102	.06	.05	.02	120.	1.01	20.30	246	.02	.02	.00	62.
1.01	8.35	103	.06	.05	.02	121.	1.01	20.35	247	.02	.02	.00	58.
1.01	8.40	104	.06	.05	.02	122.	1.01	20.40	248	.02	.02	.00	54.
1.01	8.45	105	.06	.05	.02	123.	1.01	20.45	249	.02	.02	.00	54.

END-OF-PERIOD FLOW (Cont'd)

1.01	8.50	106	.06	.05	.01	124.
1.01	8.55	107	.06	.05	.01	125.
1.01	9.00	108	.06	.05	.01	126.
1.01	9.05	109	.06	.05	.01	127.
1.01	9.10	110	.06	.05	.01	128.
1.01	9.15	111	.06	.05	.01	129.
1.01	9.20	112	.06	.05	.01	130.
1.01	9.25	113	.06	.05	.01	130.
1.01	9.30	114	.06	.05	.01	131.
1.01	9.35	115	.06	.05	.01	132.
1.01	9.40	116	.06	.05	.01	133.
1.01	9.45	117	.06	.05	.01	133.
1.01	9.50	118	.06	.05	.01	134.
1.01	9.55	119	.06	.05	.01	135.
1.01	10.00	120	.06	.05	.01	135.
1.01	10.05	121	.06	.05	.01	136.
1.01	10.10	122	.06	.05	.01	137.
1.01	10.15	123	.06	.05	.01	137.
1.01	10.20	124	.06	.05	.01	138.
1.01	10.25	125	.06	.05	.01	138.
1.01	10.30	126	.06	.05	.01	139.
1.01	10.35	127	.06	.05	.01	139.
1.01	10.40	128	.06	.05	.01	140.
1.01	10.45	129	.06	.05	.01	140.
1.01	10.50	130	.06	.05	.01	141.
1.01	10.55	131	.06	.06	.01	141.
1.01	11.00	132	.06	.06	.01	142.
1.01	11.05	133	.06	.06	.01	142.
1.01	11.10	134	.06	.06	.01	142.
1.01	11.15	135	.06	.06	.01	143.
1.01	11.20	136	.06	.06	.01	143.
1.01	11.25	137	.06	.06	.01	144.
1.01	11.30	138	.06	.06	.01	144.
1.01	11.35	139	.06	.06	.01	144.
1.01	11.40	140	.06	.06	.01	145.
1.01	11.45	141	.06	.06	.01	145.
1.01	11.50	142	.06	.06	.01	145.
1.01	11.55	143	.06	.06	.01	146.
1.01	12.00	144	.06	.06	.01	146.

1.01	20.50	250	.02	.02	.00	54.
1.01	20.55	251	.02	.02	.00	54.
1.01	21.00	252	.02	.02	.00	54.
1.01	21.05	253	.02	.02	.00	54.
1.01	21.10	254	.02	.02	.00	54.
1.01	21.15	255	.02	.02	.00	54.
1.01	21.20	256	.02	.02	.00	54.
1.01	21.25	257	.02	.02	.00	54.
1.01	21.30	258	.02	.02	.00	54.
1.01	21.35	259	.02	.02	.00	54.
1.01	21.40	260	.02	.02	.00	54.
1.01	21.45	261	.02	.02	.00	54.
1.01	21.50	262	.02	.02	.00	54.
1.01	21.55	263	.02	.02	.00	54.
1.01	22.00	264	.02	.02	.00	54.
1.01	22.05	265	.02	.02	.00	54.
1.01	22.10	266	.02	.02	.00	54.
1.01	22.15	267	.02	.02	.00	54.
1.01	22.20	268	.02	.02	.00	54.
1.01	22.25	269	.02	.02	.00	54.
1.01	22.30	270	.02	.02	.00	54.
1.01	22.35	271	.02	.02	.00	54.
1.01	22.40	272	.02	.02	.00	54.
1.01	22.45	273	.02	.02	.00	54.
1.01	22.50	274	.02	.02	.00	54.
1.01	22.55	275	.02	.02	.00	54.
1.01	23.00	276	.02	.02	.00	54.
1.01	23.05	277	.02	.02	.00	54.
1.01	23.10	278	.02	.02	.00	54.
1.01	23.15	279	.02	.02	.00	54.
1.01	23.20	280	.02	.02	.00	54.
1.01	23.25	281	.02	.02	.00	54.
1.01	23.30	282	.02	.02	.00	54.
1.01	23.35	283	.02	.02	.00	54.
1.01	23.40	284	.02	.02	.00	54.
1.01	23.45	285	.02	.02	.00	54.
1.01	23.50	286	.02	.02	.00	54.
1.01	23.55	287	.02	.02	.00	54.
1.02	0.00	288	.02	.02	.00	54.
		SUM	33.15	30.33	2.82	81735.
			(842.)	(770.)	(72.)	(2314.48)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4603.	903.	284.	284.	81728.
CMS	130.	26.	8.	8.	2314.
INCHES		25.24	31.71	31.71	31.71
MM		641.04	805.41	805.41	805.41
AC-FT		448.	563.	563.	563.
THOUS CU M		553.	694.	694.	694.

SURFACE AREA=	0.	7.	12.	19.	28.
CAPACITY=	0.	50.	140.	295.	518.
ELEVATION=	607.	630.	640.	650.	660.

SUMMARY OF DAM SAFETY ANALYSIS

PMF

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	630.00	630.00	631.90
STORAGE	50.	50.	63.
OUTFLOW	0.	0.	254.

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
.10	631.84	0.00	63.	240.	0.00	15.83	0.00
.11	631.96	.06	63.	268.	.17	15.83	0.00
.50	633.31	1.41	74.	2060.	5.08	15.67	0.00
1.00	634.09	2.19	80.	4322.	6.83	15.67	0.00

SUMMARY OF DAM SAFETY ANALYSIS

1% CHANCE FLOOD

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	630.00	630.00	631.90
STORAGE	50.	50.	63.
OUTFLOW	0.	0.	254.

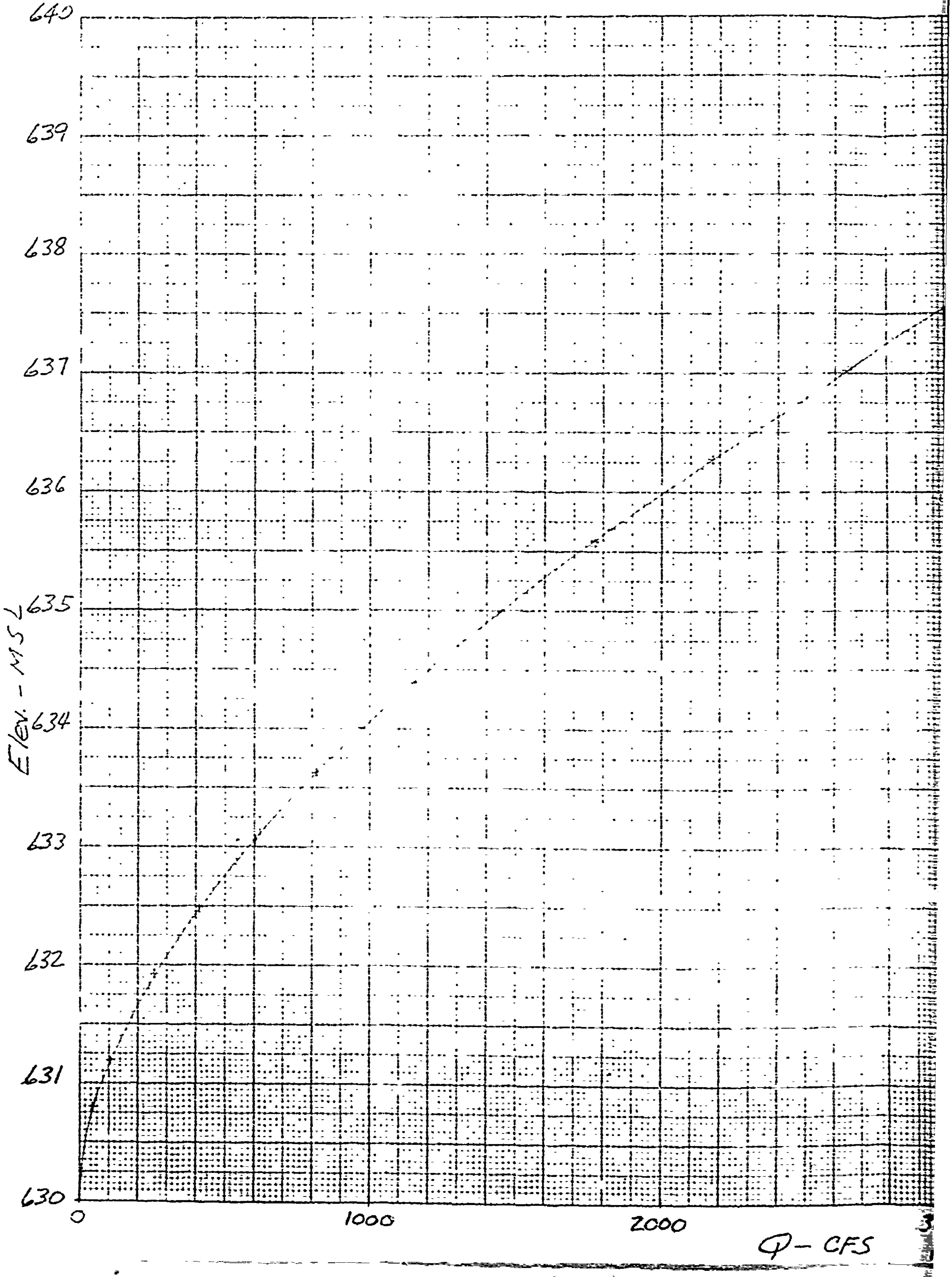
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	632.24	.34	66.	[illegible]	.50	12.47	0.00

SUMMARY OF DAM SAFETY ANALYSIS

10% CHANCE FLOOD

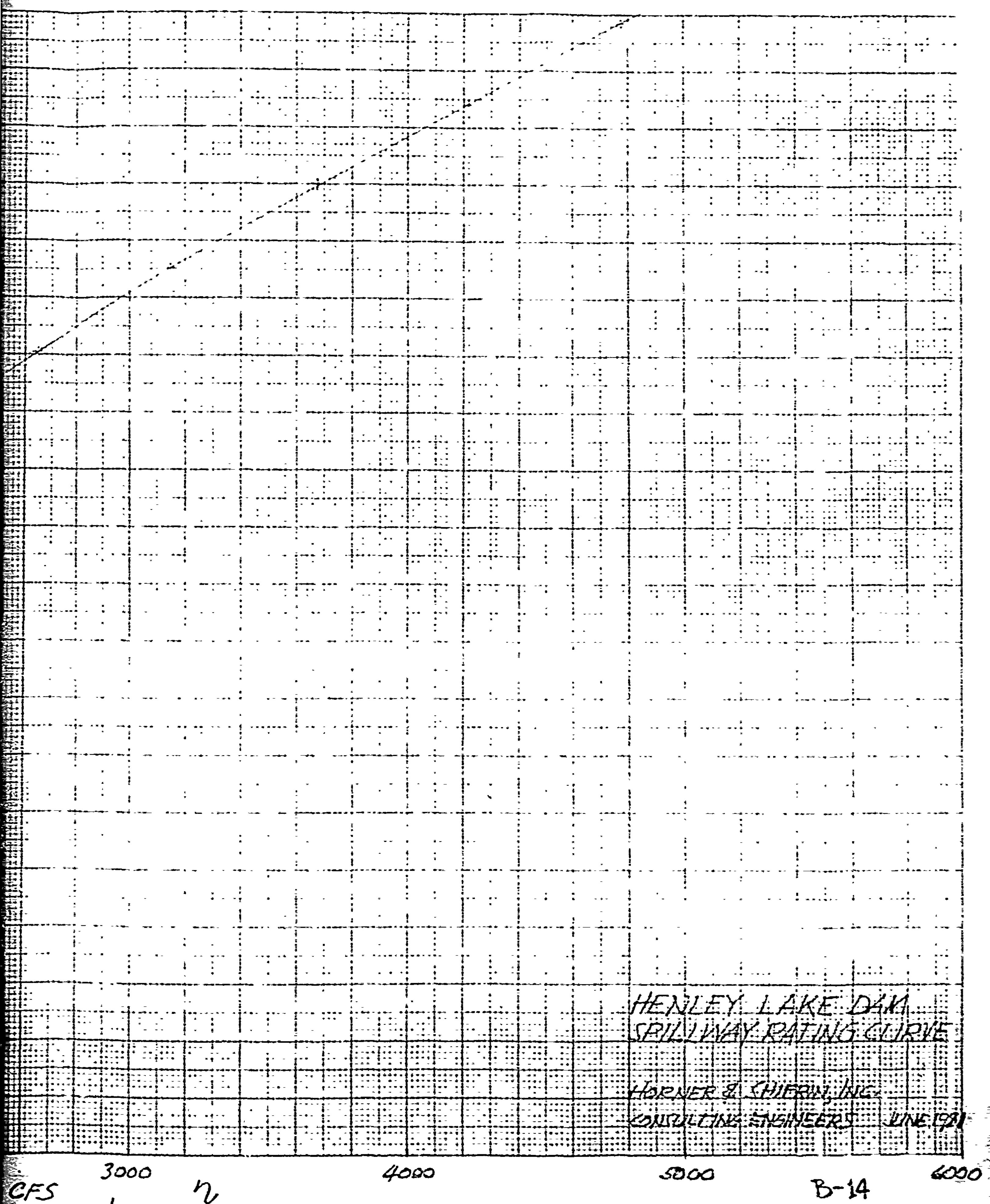
	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	630.00	630.00	631.90
STORAGE	50.	50.	63.
OUTFLOW	0.	0.	254.

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	631.28	0.00	59.	120.	0.00	12.58	0.00



640
639
638
637
636
635
634
633
632
631
630
Elev. - MSL
0
1000
2000
Q - CFS

1


HENLEY LAKE DAM
SPILLWAY RATING CURVE
HORNER & SHIFRIN, INC.
CONSULTING ENGINEERS JUNE 1981
3000
4000
5000
6000
CFS