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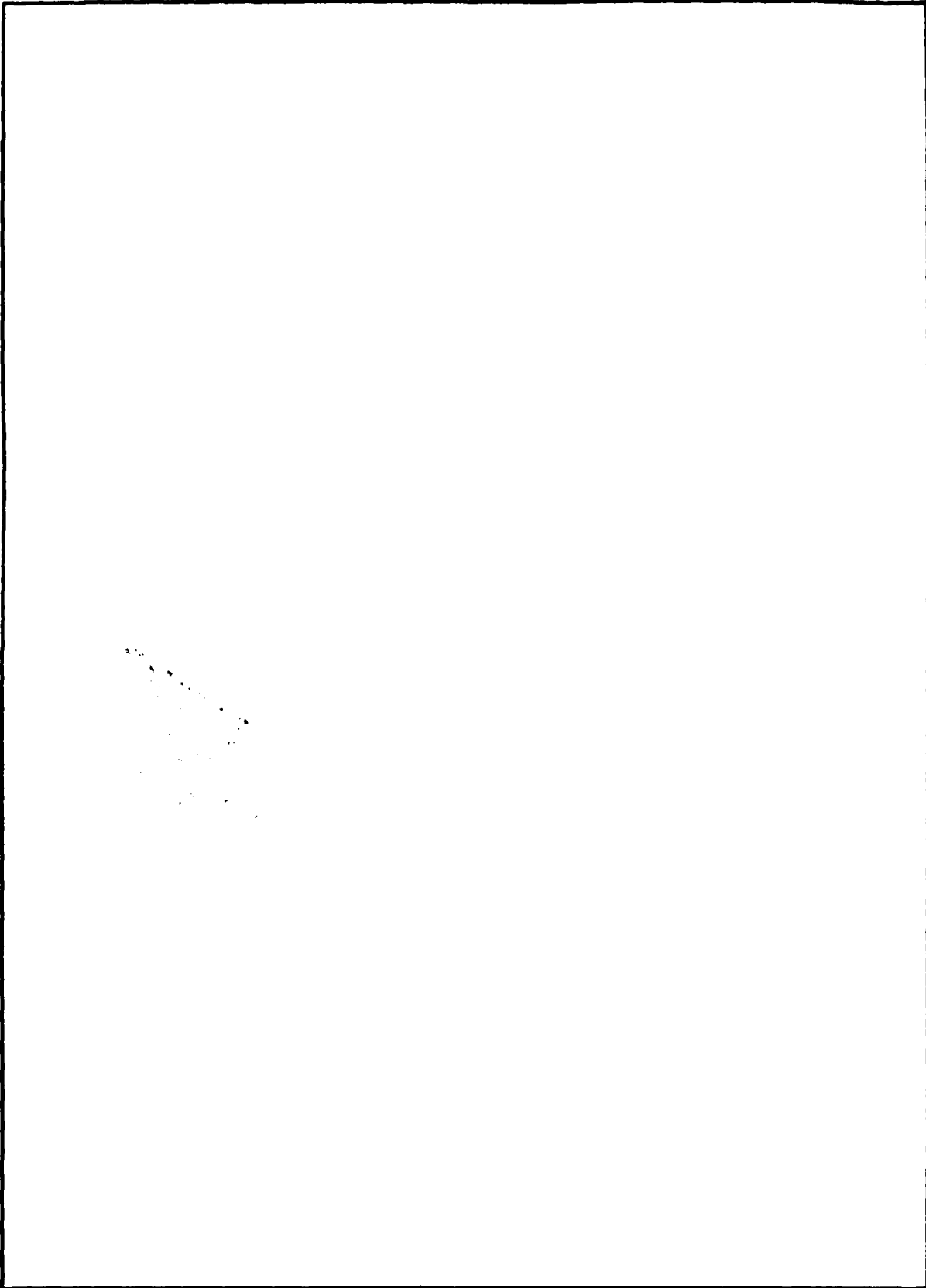
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MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

HICKORY HOLLOW LAKE DAM

PERRY COUNTY, MISSOURI

MO 31068

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

Hickory Hollow Lake Dam (MO-31068),
Mississippi - Kaskaskia - St. Louis Basin,
Perry County, Missouri. Phase 1 Inspection
Report.



United States Army
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DACW43-79-C-0047

(9) Final Rept.

11 Mar 80

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

FOR: STATE OF MISSOURI

MARCH 1980

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DEPARTMENT OF THE ARMY
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ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

LMSED-P

SUBJECT: Hickory Hollow Lake Dam (MO 31068) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Hickory Hollow Lake Dam:

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.

1. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.
2. Overtopping could result in dam failure.
3. Dam failure significantly increases the hazard to loss of life downstream.

SIGNED

Submitted By: _____
Chief, Engineering Division

9 APR 1980

Date

SIGNED

Approved By: _____
Colonel, CE, District Engineer

10 APR 1980

Date

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HICKORY HOLLOW LAKE DAM - MISSOURI INVENTORY NO. 31068

PERRY 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

MARCH 1980

HS-7925

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Hickory Hollow Lake Dam
State Located:	Missouri
County Located:	Perry
Stream:	Tributary Goose Creek
Date of Inspection:	18 October 1979

The Hickory Hollow Lake Dam 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 a hazard to human life or property.

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 somewhat less than satisfactory. The following deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam:

1. The upstream face of the dam has a grass cover to protect the slope from erosion. A grass covered slope is not considered adequate to prevent erosion by wave action or by fluctuations of the lake surface level.
2. A dense cover of small-to-medium size trees and brush that may contain animal burrows exists on the downstream face at the center and left sides of the dam. Several large willow trees are present within the reservoir area just upstream of the left side of the dam. Tree roots and animal burrows can provide

passageways for seepage that could develop into a piping condition (progressive internal erosion) that can lead to failure of the dam.

3. At the time of the inspection the turf cover on the upstream and downstream faces of the dam was approximately 3 feet high. Uncut grass on the dam is an indication of lack of regular maintenance.
4. Erosion, apparently due to storm water runoff, has created a small gulley approximately 3 feet deep and 8 feet wide at the intersection of the downstream side of the dam and the right abutment. A small slough approximately 1.5 feet high and 5 feet wide, also exists at the downstream face near the right side of the dam. Continued erosion and sloughing of the embankment could be detrimental to the stability of the dam.

According to the Owner, since construction of the dam, the lake has experienced problems with excessive leakage, as evidenced by the inability to maintain a stable lake surface level. At the time of the inspection, the lake level was about 30 feet below the spillway crest and appeared to be stable. Judging by waterline marks visible across the upstream face of the dam, it appeared that the lake has been at least 10 to 12 feet higher than the present level within the last year or so. An examination of the area immediately downstream of the dam and within the original stream channel for a distance of about 400 feet from the dam, did not disclose any evidence of seepage, although it is possible that, with a higher lake level, seepage not noticeable at the time of the inspection, may be evident. At this time, it does not appear that the leakage problem the lake is experiencing poses a hazard to the safety of the dam.

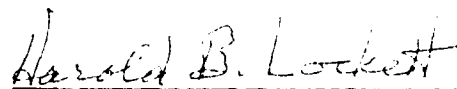
According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Hickory Hollow Lake Dam, which is classified as intermediate in size and of high hazard potential, is specified to be the Probable Maximum Flood (PMF). The

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.

Results of a hydrologic/hydraulic analysis indicated that the existing spillway is inadequate to pass lake outflow resulting from a storm of PMF magnitude. The spillway is adequate to pass lake outflow resulting from the 1 percent chance (100-year frequency) flood and lake outflow corresponding to about 10 percent of the PMF. 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 approximately six miles. Within the possible damage zone are State Highway N, five dwellings, and several other buildings.

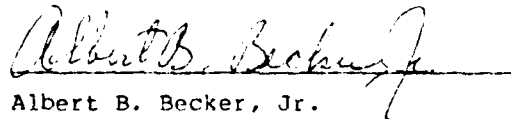
A review of available data did not disclose that seepage or stability analyses of the dam were performed. This is considered a deficiency and should be rectified.

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



Harold B. Lockett

P.E. Missouri E-4189



Albert B. Becker, Jr.

P.E. Missouri E-9168



OVERVIEW HICKORY HOLLOW LAKE DAM

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

HICKORY HOLLOW LAKE DAM - ID. NO. 31066

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2	Lake Watershed Map
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5	Spillway Profile
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2-1, 2-2

Engineering Geologic Report of Howard
Davis Lake Site, Perry County,
Missouri, by Thomas J. Dean, Geologist,
June 8, 1976.

APPENDIX A - INSPECTION PHOTOGRAPHS

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

HICKORY HOLLOW LAKE DAM - ID. NO. 31063

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 Hickory Hollow 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 dam poses a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams," Appendix D in "Report of 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 Hickory Hollow Lake Dam is an earthfill type embankment rising approximately 49 feet above the original stream bed. The embankment has an upstream slope (above the waterline) of 1v on 3.3h, a crest width of about 12 feet, and a downstream slope of 1v on 2.2h. The length of the dam including the

spillway section is approximately 760 feet. An unpaved road traverses the dam crest crossing the spillway channel just downstream of the centerline of the dam. A plan and profile of the dam is shown on Plate 3 and a cross-section of the dam is shown on Plate 4. At normal pool elevation the reservoir impounded by the dam occupies approximately 43 acres.

The spillway, a trapezoidal section founded on earth, is cut into the hillside at the right (south) abutment. The bottom width of the spillway channel varies from a minimum of about 4 feet at the dam where a wood bridge crosses the channel, to approximately 8 feet at a location just downstream of the bridge. A narrow, approximately 2.5-foot high earthen berm on the left side of the channel serves to confine spillway flow to the outlet section. The spillway crest, or high point of the channel invert, was found to be located approximately 200 feet east (downstream) of the dam centerline. Downstream of the spillway crest the channel maintains an eastwardly course for about another 200 feet, then by following the contour of the hillside, it turns to the southeast continuing for about another 300 feet before terminating at a small pond that lies in the adjacent valley. A profile of the spillway outlet channel beginning at the lake and extending 200 feet downstream of the crest is shown on Plate 5.

b. Location. The dam and lake are located on an unnamed tributary of Goose Creek, approximately 2 miles north-northwest of the Town of Silver Lake, Missouri, and 1 mile south of State Highway N, as shown on the Regional Vicinity Map, Plate 1. The dam is located in the NW 1/4 of the NW 1/4 of Section 25, Township 35 North, Range 9 East, in Perry County.

c. Size Classification. The size classification based on the height of the dam and storage capacity, is categorized as intermediate (Per Table 1, Recommended Guidelines for Safety Inspection of Dams).

d. Hazard Classification. The Hickory Hollow 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, extensive damages 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 approximately six miles downstream of the dam. Within the possible damage zone are State Highway N, five dwellings and several other buildings.

e. Ownership. The lake and dam are owned by Howard Davis. Mr. Davis's address is: 425 North Highway 61, Perryville, Missouri 63775.

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

g. Design and Construction History. According to the Owner, Mr. Davis, who constructed the dam while doing business as the Howard Davis Construction Company, construction of the dam was started in 1963 and completed in 1964. Mr. Davis also reported that the dam was constructed without the benefit of any formal engineering design data, although Mr. Marion Clark, an agricultural engineer, formerly with the Agricultural Engineering Department, Extension Division, University of Missouri at Columbia, now retired, provided some assistance in the form of advice regarding the proportions of the embankment.

h. Normal Operational Procedure. The lake level is unregulated.

1.3 PERTINENT DATA

a. Drainage Area. The area tributary to the lake is essentially undeveloped and in a native state covered with timber. There are several dwellings and other buildings adjacent to the county road at the west side of the drainage area as well as a house trailer and several

buildings along the hillside just west of the lake. The watershed above the dam amounts to approximately 550 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

- (1) Estimated known maximum flood at damsite ... None*
- (2) Spillway capacity ... 92 cfs (W.S. = Elev. 638.9)

c. Elevation (Ft. above MSL). The following elevations were determined by survey and are based on topographic data shown on an advanced copy of the 1980 USGS Perryville NW, Missouri Quadrangle Map, 7.5 Minute Series.

- (1) Top of dam ... 638.9 (min.)
- (2) Top of spillway berm at dam ... 638.5
- (3) Normal pool (spillway crest) ... 636.3
- (4) Streambed at centerline of dam ... 590 $\pm$
- (5) Maximum tailwater ... Unknown

d. Reservoir.

- (1) Length at normal pool (elevation 636.3) ... 2,700 ft.
- (2) Length at maximum pool (elevation 638.9) ... 2,900 ft.

e. Storage.

- (1) Normal pool ... 712 ac. ft.
- (2) Top of dam (incremental) ... 118 ac. ft.

f. Reservoir Surface.

- (1) Normal pool ... 43 acres
- (2) Top of dam (incremental) ... 6 acres

g. Dam.

- (1) Type ... Earthfill, homogeneous**
- (2) Length ... 760 ft.

*According to the Owner, the level of the lake has never reached the spillway crest.

**Per Owner

- (3) Height ... 50 ft.
- (4) Top width ... 12 ft.
- (5) Side slopes
 - a. Upstream ... 1v on 3.3h
 - b. Downstream ... 1v on 2.2h
- (6) Cutoff ... Clay core*
 - a. Width ... 10-12 ft.
 - b. Depth ... 6-8 ft. (max.)
- (7) Slope protection
 - a. Upstream ... Grass
 - b. Downstream ... Grass

h. Principal Spillway.

- (1) Type ... Uncontrolled, broad-crested, trapezoidal section
- (2) Location ... Right abutment
- (3) Crest ... Elevation 636.3 (200 ft. downstream of dam centerline)
- (4) Approach channel ... Lake
- (5) Outlet channel ... Trapezoidal section, 8 ft. bottom width, 1v on 2h side slopes.

i. Emergency Spillway. ... None

j. Lake Drawdown Facility. ... None

* Per Owner.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No engineering data relating to the design of the dam are known to exist.

2.2 CONSTRUCTION

No formal records were maintained during construction of the dam. According to Mr. Davis, the Owner and builder of the dam, a core trench approximately 10 to 12 feet wide and 6 to 8 feet deep at the old stream bed, was excavated along the centerline of the dam across the valley. Mr. Davis reported that the trench was carried to solid rock and that the rock surface was swept clean prior to backfilling the trench. Material used to fill the trench and construct the embankment, approximately 124,000 cubic yards, was obtained from the hillside at the left abutment and from the area to be occupied by the lake, with about 75 percent of the fill being taken from the hill area. The Owner also mentioned that compaction of the fill was obtained by running the rubber-tired earth moving equipment over the fill, and that a single compaction test taken during construction of the embankment indicated the fill to be more dense than the adjacent undisturbed material. The Owner stated that the dam was closed at the location of the old streambed, and some minor settlement, on the order of 3 inches, of the dam crest has occurred at this location. The upstream and downstream sides of the dam were constructed to minimum slopes of 1v on 3h and 1v on 2h, respectively. Mr. Davis also reported that the spillway was originally intended to be 4 feet deep and 12 feet wide; however, it was not constructed as wide as planned.

2.3 OPERATION

According to the Owner, the lake has experienced severe leakage throughout its entire life. It was reported that in about 1965 an attempt was made to seal the lake by filling with concrete a crevice that existed in the lake bottom; however, this attempt was unsuccessful as the reservoir continued to leak uncontrollably. According to the Owner, the lake leaks so badly that the lake has never reached the spillway level.

An engineering geologic report on the lake site dated June 8, 1976, reference Charts 2-1 and 2-2, was prepared by Mr. Thomas J. Dean, Geologist, with the Missouri Department of Applied Engineering & Urban Geology. In the report Mr. Dean reviews the lake leakage problem and the efforts made by the Owner to seal the lake bottom as well as the results thereof.

The report points out that lineations on aerial photographs indicate a vertical joint running essentially east-west across the lake area, a sinkhole on the ridge east of the lake, and at least one additional joint line that trends southeast by northwest crossing the basin at approximately the area where the original collapse of the lake bottom occurred. The techniques used to find lineation (joints, cracks) as well as the likelihood of finding them are also discussed.

After mentioning that a compacted clay pad placed on the lake bottom would be only partially successful, Mr. Dean states that the leakage probably can only be remedied by uncovering the joints to determine their direction and then cutting off the flow of water above the lake waterline, and assuming that water leaving the lake through these joints could travel in several directions, a joint crossing the lake should be plugged on both sides of the lake.

In conclusion, recommendations are presented for implementing a method of uncovering the joints in the lake bottom and for sealing the joints once they are exposed. Mr. Dean maintains that the most practical

way of determining the location of the joints would be by using a bulldozer and that the joints, once found, could be sealed by grouting.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the dam and spillways 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 Hickory Hollow Lake Dam was made by Horner & Shifrin engineering personnel, H. B. Lockett, Civil Engineer and Hydrologist, T. K. Deedens, Geological Engineer, and A. B. Becker, Jr., Civil and Soils Engineer, on 18 October 1979. An examination of the dam site was also made by an engineering geologist, Jerry D. Higgins, a consultant retained by Horner & Shifrin for the purpose of assessing the area geology. Also examined at the time of the inspection, was the area 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. Area Geology. The dam site is located on the eastern flank of the Ozark Uplift on Ordovician-age sedimentary rock. In the area of the dam, the Jefferson City-Cotter formation is exposed at the surface and dips gently eastward. The formation is composed of light brown to brown, medium to finely crystalline dolomite and argillaceous dolomite. Some sandstone beds and chert nodules are present in the formation. The residuum is a tan to brown, cherty and silty clay. Bedrock is exposed along much of the shoreline, along a ditch on the upstream side of the left abutment, and at the right abutment. The bedrock is well bedded and contains solution-weathered open joints (open 1 to 2 inches in some cases). The most prominent joints trend N3°E and N80°E. The solution-weathered bedrock is exposed in the reservoir and appears to allow water to move out of the immediate vicinity along joints and bedding planes. It appears that the lake leaks to the extent that the water level is maintained several feet below the highest bedrock exposures in the reservoir.

The abutments are moderately sloping, composed of a thin veneer of clay residuum overlying dolomite and sandstone bedrock. The slopes appear stable, and no seepage was evident.

No severe erosion, seepage problems, or adverse geologic conditions that would be conducive to dam failure were observed. However, leakage of water along weathered joints and bedding planes in rock exposed in the reservoir has seriously influenced the water storage capacity and the performance of the facility.

c. Dam. The visible portions of the upstream and downstream faces of the dam (see Photos 1 and 3) appeared to be in sound condition, although a small slough approximately 1.5 feet deep and 5 feet wide was observed in the downstream face near the toe of slope at the right side of the dam. Erosion, apparently by stormwater runoff has created a small gulley approximately 3 feet deep and 8 feet wide at the junction of the downstream side of the dam and the right abutment. The upstream face of the dam had only turf cover to prevent erosion; however, none was noticed. A dense cover of small-to-medium size trees and brush covered the downstream face at the center and left side of the dam, and several large willow trees were observed within the reservoir area just upstream of the left side of the dam. No misalignment or cracking of the dam crest (see Photo 2) was evident. No signs of seepage was observed in the areas examined adjacent to the downstream toe of the dam or within the old streambed for a distance of about 400 feet below the dam.

A survey of the spillway channel indicated that the invert high point (crest) is located approximately 200 feet east (downstream) of the dam centerline, and that the channel is nearly level between the dam and the crest and for a distance of about 200 feet downstream of the crest. Along the alignment of the dam, a bridge made of timber (see Photo 4) crosses the spillway channel. At the bridge crossing the channel was found to be approximately 4 feet wide, whereas downstream of the bridge, the channel (see Photos 5 and 6) widens to about 8 feet. The left bank of the channel (see Photo 7) consists of a narrow earthen berm

approximately 2 to 2.5 feet high and about 5 feet wide at the top. The outlet channel appeared to be in satisfactory condition, although only a grass cover serves to protect the banks from erosion by lake outflow.

d. Downstream Channel. The channel downstream of the dam is unimproved and extends approximately 2.5 miles before joining Goose Creek. State Highway N crosses Goose Creek, at a point about 3 miles below the dam.

e. Reservoir. The area adjacent to the lake is for the most part in a natural state and wooded. Several dwellings and small buildings may be found on the hillside west of the lake. The lake water surface elevation at the time of the inspection was about 30 feet below normal pool, exposing numerous rock outcroppings on the east and west sides of the lake. As previously indicated, see paragraph 2.3, the lake has experienced problems with excessive leakage throughout its life time. The amount of sediment within the lake could not be determined at the time of the inspection, however it is believed not to be significant.

3.2 EVALUATION

The deficiencies observed during the inspection and noted herein, are not considered of significant importance to warrant immediate remedial action. It is advisable, however, that the Owner address the problem of trees and undergrowth on the upstream and downstream faces of the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillway is uncontrolled. The water surface level is governed by precipitation runoff, evaporation, seepage, leakage, and the capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

With the exception of the dense growth of brush and trees that exist on the downstream face at the center and left side of the dam and some erosion at the junction of the downstream slope and the right abutment, it appears that the structure is reasonably well maintained.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

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

4.5 EVALUATION

Regular maintenance of dam features is considered beneficial to the overall safety of a dam. It is recommended for future reference that records be kept of all maintenance work performed. Considering the remedial work performed in an attempt to seal the lake bottom, it would be desirable to have a record of the exact location or locations where repairs were made as well as an accurate description of the conditions encountered and the work performed.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design of Data. Design data are not available.

b. Experience Data. The drainage area and lake surface area were determined from an advanced copy of the 1980 USGS Perryville NW and 1959 USGS Parker Lake, Missouri, Quadrangle Maps. 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.

Notwithstanding the fact that the reservoir leaks severely or that the lake level has never reached the spillway crest (according to the Owner), the analyses of dam overtopping reported herein are based on a starting lake surface level at normal pool. It is noted that in the report prepared by Mr. Dean, reference Charts 2-1 and 2-2, a statement is made that "during wet weather, the lake backs up beyond its normal pool level with a rapid lowering of the water level to a relatively stable condition."

c. Visual Observations.

(1) The spillway consists of a trapezoidal section cut into the hillside at the right abutment.

(2) A small timber bridge crosses the spillway channel at the dam. At the bridge location, the spillway channel has a bottom width of about 4 feet, downstream of the bridge the bottom width is about 8 feet.

(3) The channel invert is nearly flat with the high point (crest) occurring at a location approximately 200 feet downstream of the center of the dam.

(4) A narrow berm approximately 2.5 feet high serves to confine flow to the channel and protect the dam.

(5) No emergency spillway or lake drawdown facilities are provided.

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

<u>Ratio of PMF</u>	<u>Q-Peak Outflow (cfs)</u>	<u>Max Lake W.S. Elev.</u>	<u>Max. Depth of Flow over Dam (Elev. 638.9)</u>	<u>Duration of Overtopping of Dam (Hours)</u>
0.10*	95	638.92	0.02	1.0
0.50	4,317	640.8	1.9	11.1
1.00	9,073	641.8	2.9	13.0
100-Yr. Flood	69	638.7	0.0	0.0

Elevation 638.9 was found to be the lowest point in the dam crest. The flow safely passing the spillway just prior to overtopping was determined to be approximately 92 cfs, which amounts to about 10 percent of the probable maximum flood inflow. This flow is greater than the outflow from the 1 percent chance (100-year frequency) flood. During peak flow of the probable maximum flood, the greatest depth of flow over the dam is projected to be 2.9 feet and overtopping will extend along the entire length of the dam.

e. Evaluation of Overtopping Effect. Experience indicates that the soil used to build the dam, a cherty, brown silty clay, can, under certain conditions, such as high velocity flow, be very erodible. For the PMF condition, when large lake outflow with corresponding high velocities occur both at the spillway and over the top of the dam; and since the depth of flow overtopping the dam, (2.9 feet maximum) and the

*To nearest one-hundredth.

duration of flow over the dam (13.0 hours), are substantial; serious damage by erosion due to overtopping of the dam is likely. The extent of these damages is not predictable, however, there is the possibility that they could result in failure of the dam.

f. References. Procedures and data for determining the probable maximum flood, the 100-year frequency flood, and the discharge rating curve for flow passing the spillway and dam crest are presented on Pages B-1 and B-2 of the Appendix. Listings of the HEC-1 (Dam Safety Version) input data for both the probable maximum flood and the 100-year frequency flood are shown on Pages B-3 and B-4 of the Appendix. A copy of the computer output table entitled "Summary of Dam Safety Analysis" is presented on Page B-5 and the inflow and outflow hydrographs for the probable maximum flood are shown on Page B-6 of the Appendix. A rating curve of the spillway is presented on Plate 6 and area-storage curves for the reservoir are shown on Plate 7.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which adversely affect the structural stability of the dam 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. No appurtenant structures or facilities requiring operation exist at this dam. The Owner did report that the lake level has never reached the spillway crest and that the dam crest has settled approximately 3 inches at the location of the old streambed.

d. Post Construction Changes. The Owner also reported that no post construction changes have been made or have occurred which would affect the structural stability of the dam.

e. Seismic Stability. The dam is located within a Zone II seismic area. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. 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 92 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, indicated that for storm runoff of probable maximum flood magnitude, the lake outflow would be on the order of 9,073 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 69 cfs.

Items noticed during the inspection that could adversely affect the safety of the dam include lack of adequate erosion protection at the spillway and along the upstream face of the dam as well as the dense cover of brush and trees that exist on the downstream face near the center and left side of 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.

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 assessment 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 the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. Except as noted herein, the items concerning the safety of the dam noted in paragraph 7.1a and the remedial measures recommended in paragraph 7.2 should be accomplished in the near future. The item in paragraph 7.2 regarding additional spillway capacity should be pursued without undue delay.

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 area. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. 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 to pass lake outflow resulting from a storm of probable maximum flood magnitude. 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 dams.

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

(1) Provide some means of preventing excessive leakage from the lake basin.

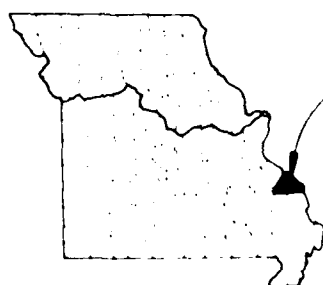
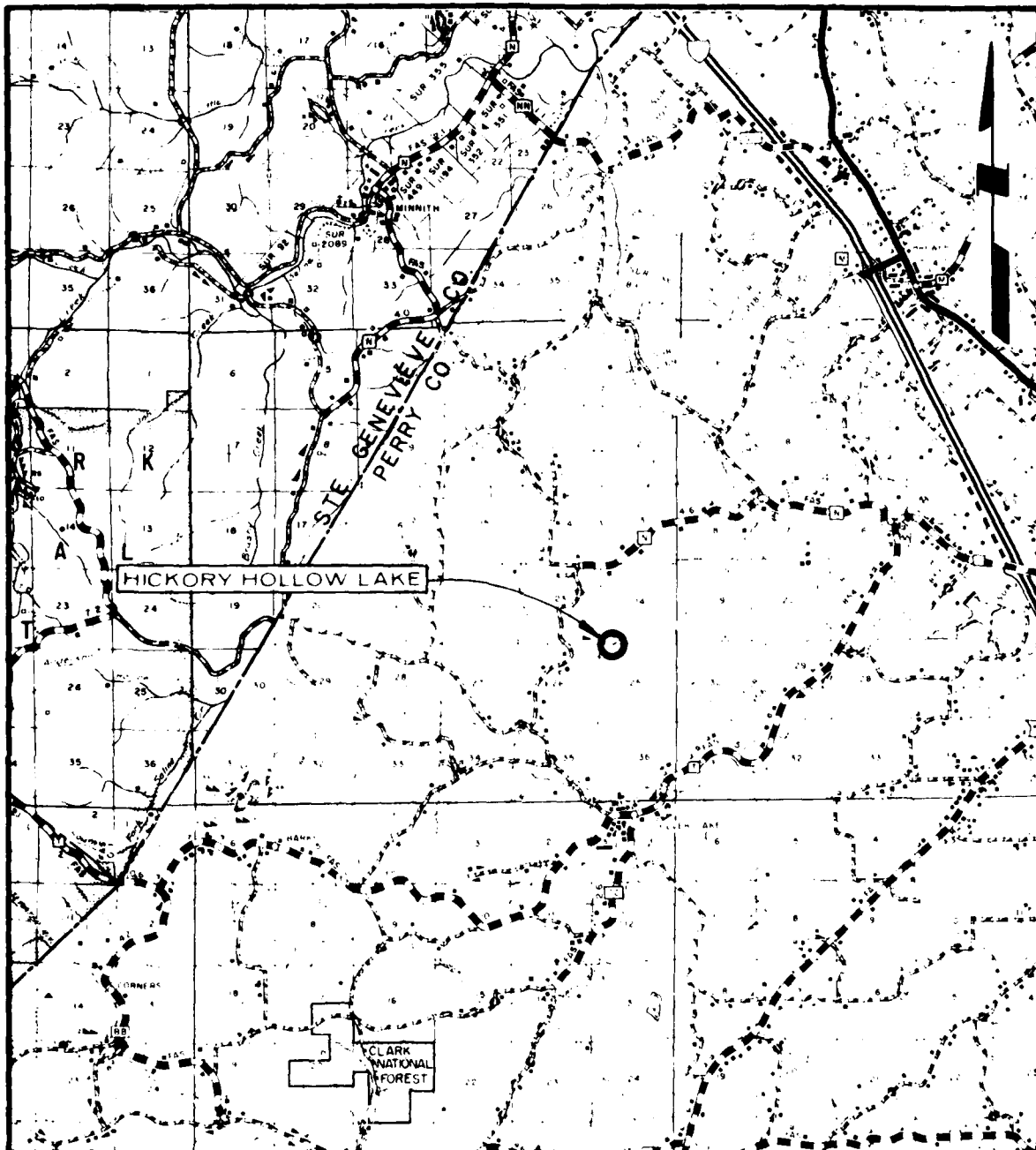
(2) Provide some form of protection particularly along the left bank (dam side) of the outlet channel in order to prevent erosion by lake outflow.

(3) Provide some form of protection other than grass for the upstream face of the dam at and above the normal waterline in order to prevent erosion. A grass covered slope is not considered adequate protection to prevent erosion by wave action or by a fluctuating lake level.

(4) Remove the trees and brush that may conceal animal burrows from the downstream face of the dam. Tree roots and animal burrows can provide a passageway for lake seepage that could lead to a piping condition (progressive internal erosion) and subsequent failure of the dam. The removal of trees should be performed under the direction of an engineer experienced in the design and construction of earth 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 on the slopes at a height that will not hinder inspection of the slope or provide cover for burrowing animals.

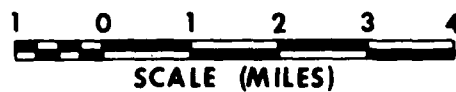
(5) Provide maintenance of all areas of the dam and spillway on a regularly scheduled basis in order to insure these features of being in satisfactory operational condition.

(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.



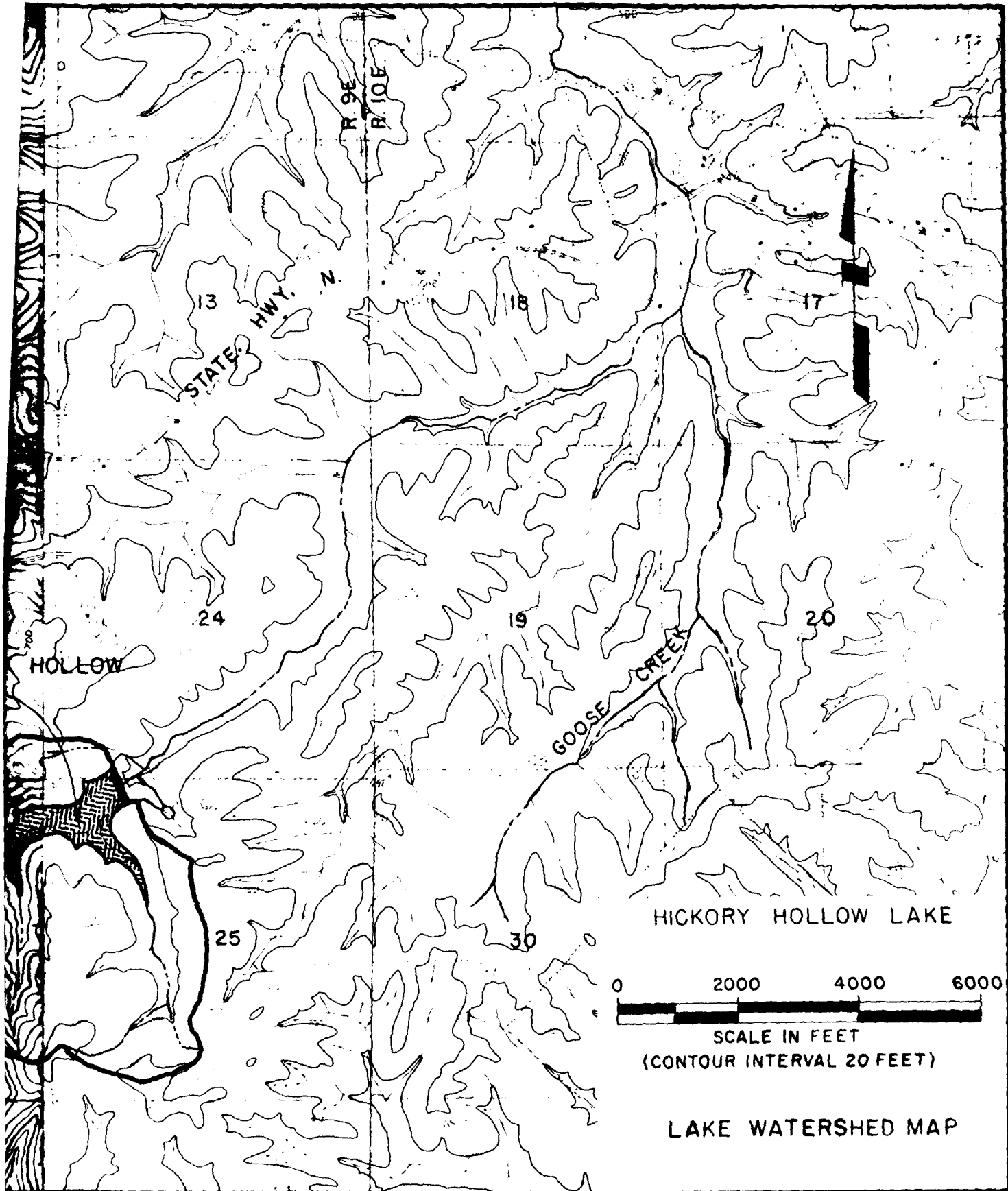
LOCATION MAP

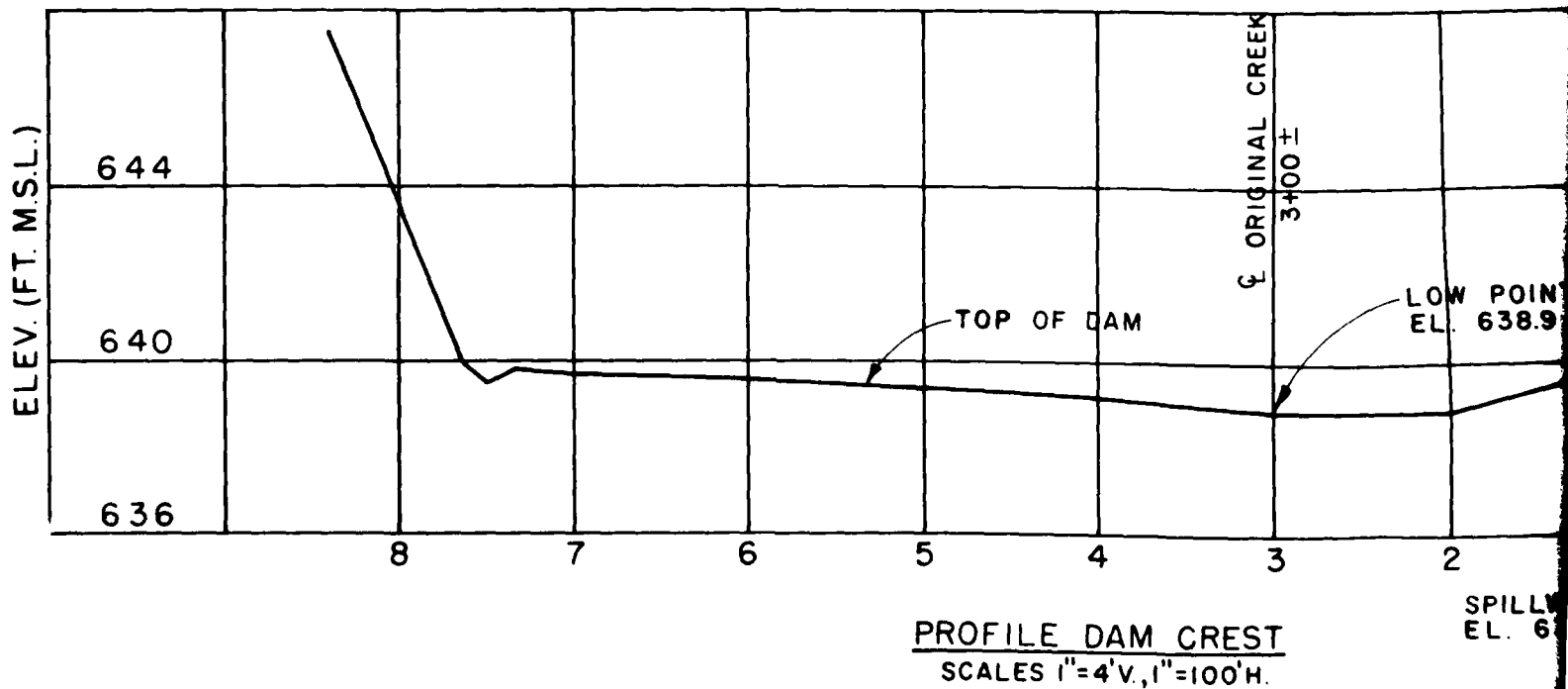
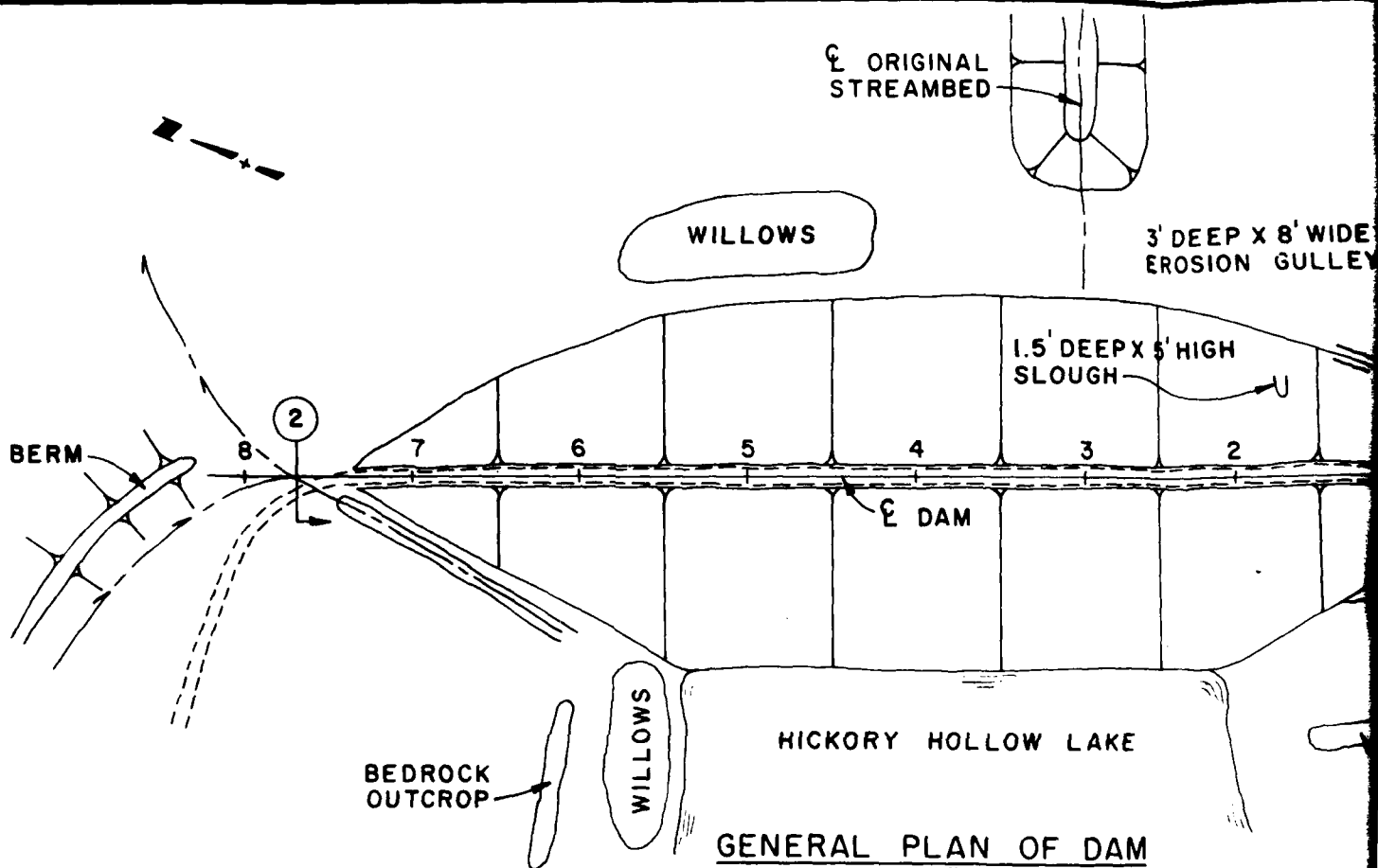
HICKORY HOLLOW LAKE

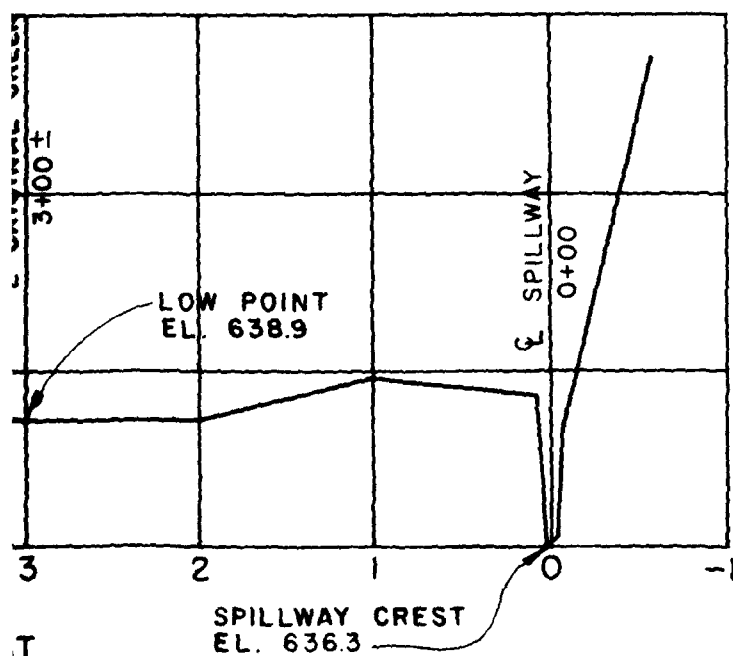
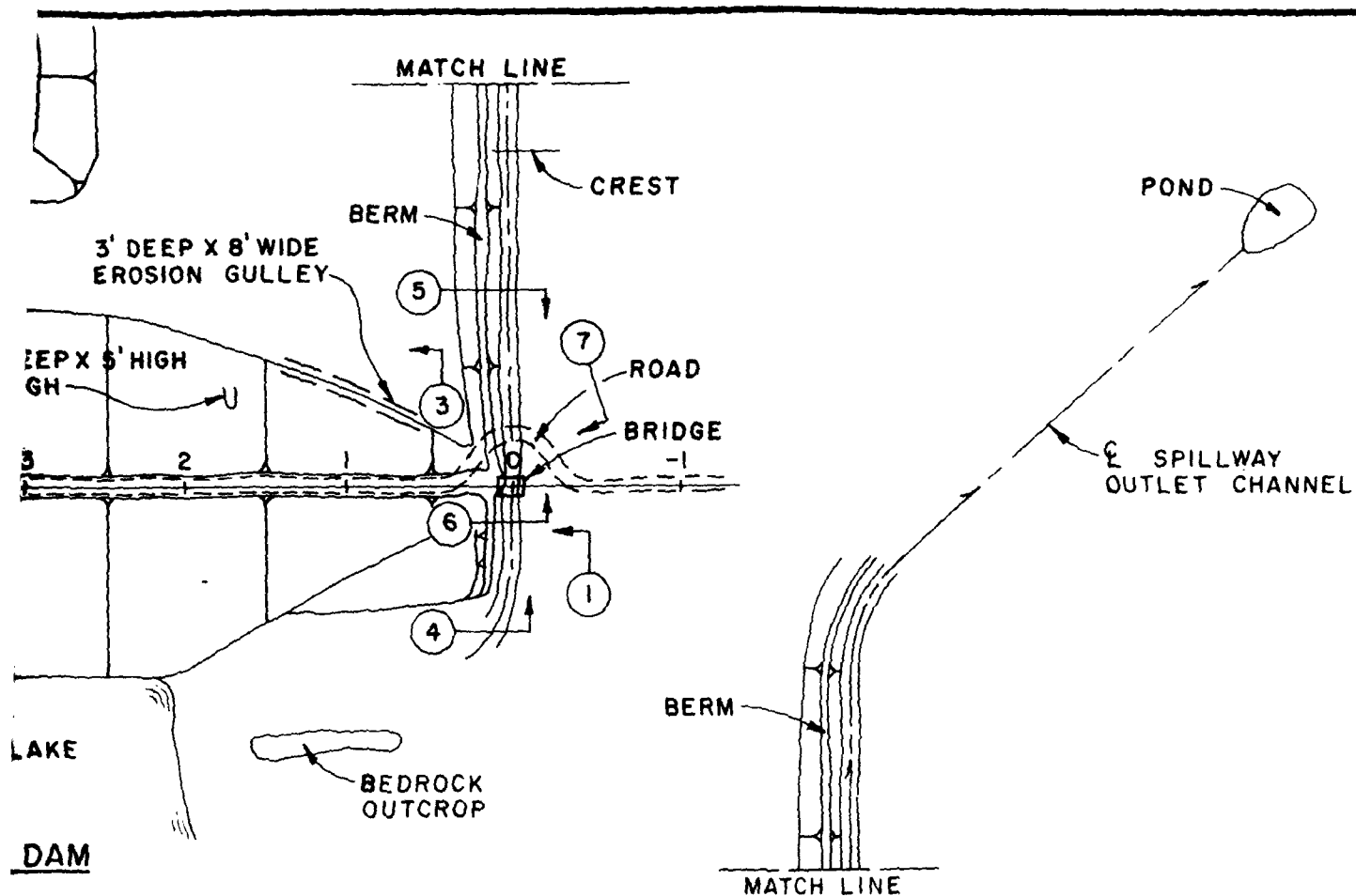


REGIONAL VICINITY MAP









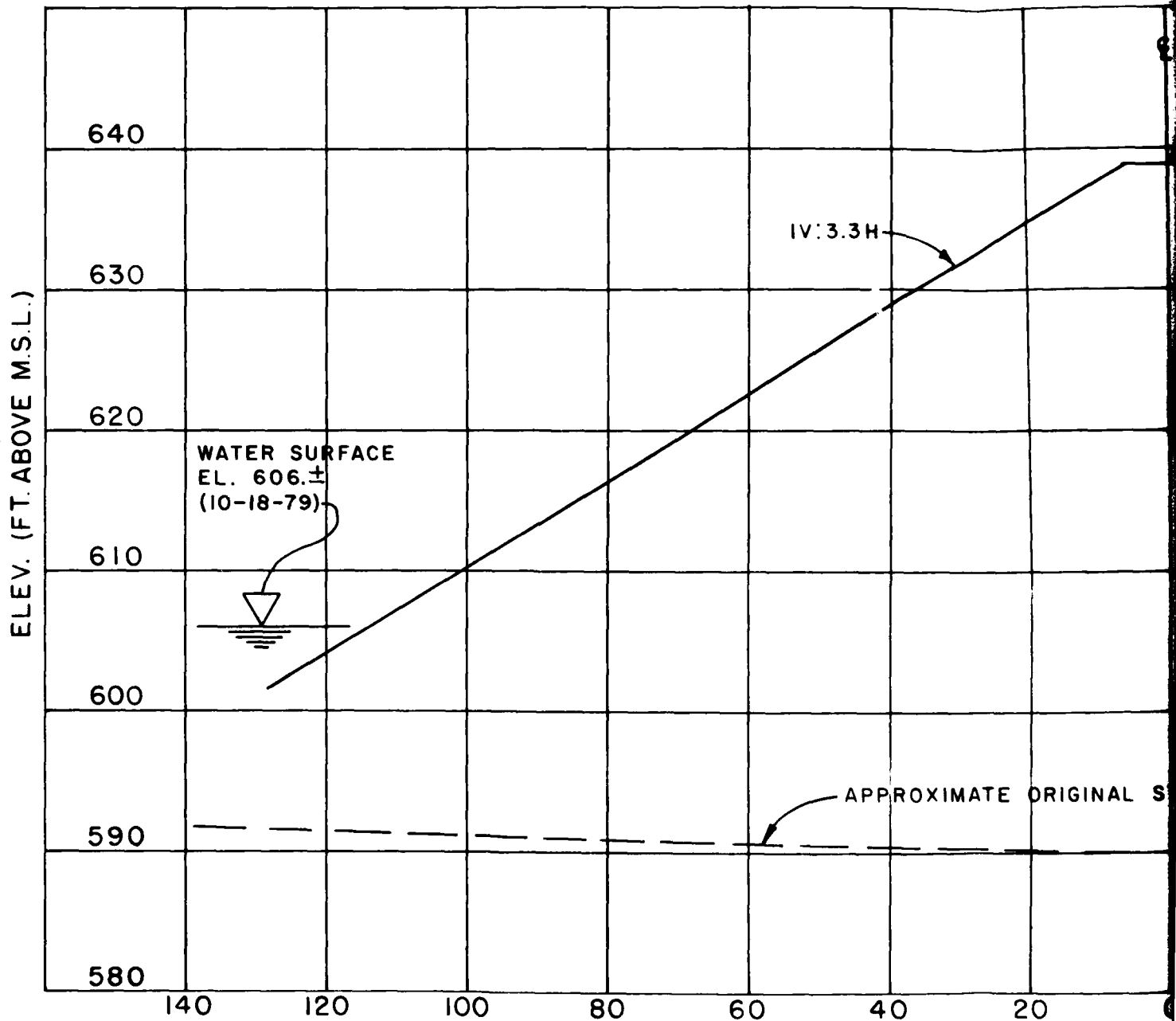
6
PHOTO LOCATION & KEY
(SEE APPENDIX A)

HICKORY HOLLOW LAKE DAM PLAN & PROFILE

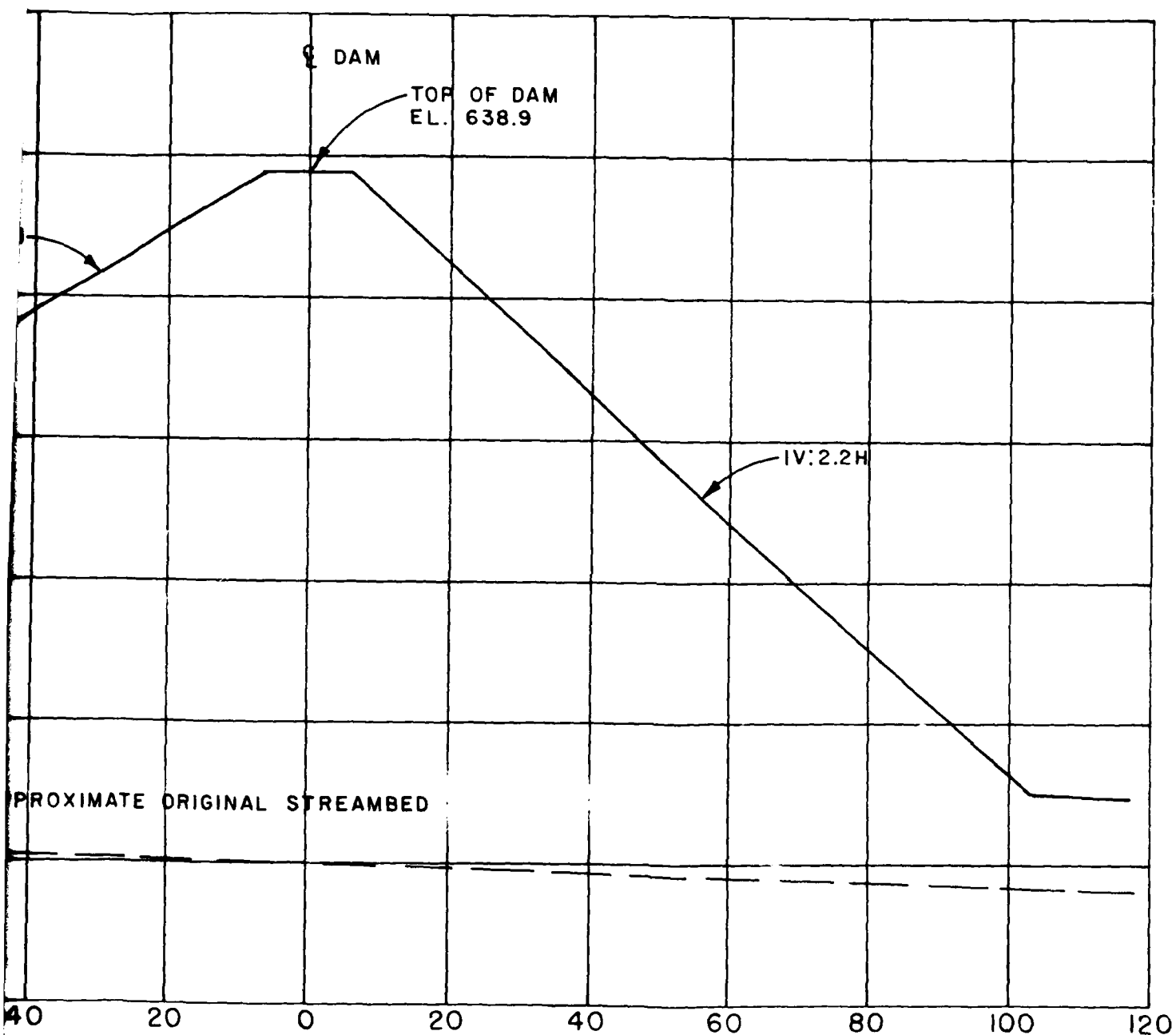
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PLATE 3



DAM CROSS-SECTION STA.
SCALES 1"=10' V., 1"=20' H.



CROSS-SECTION STA. 3+00

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

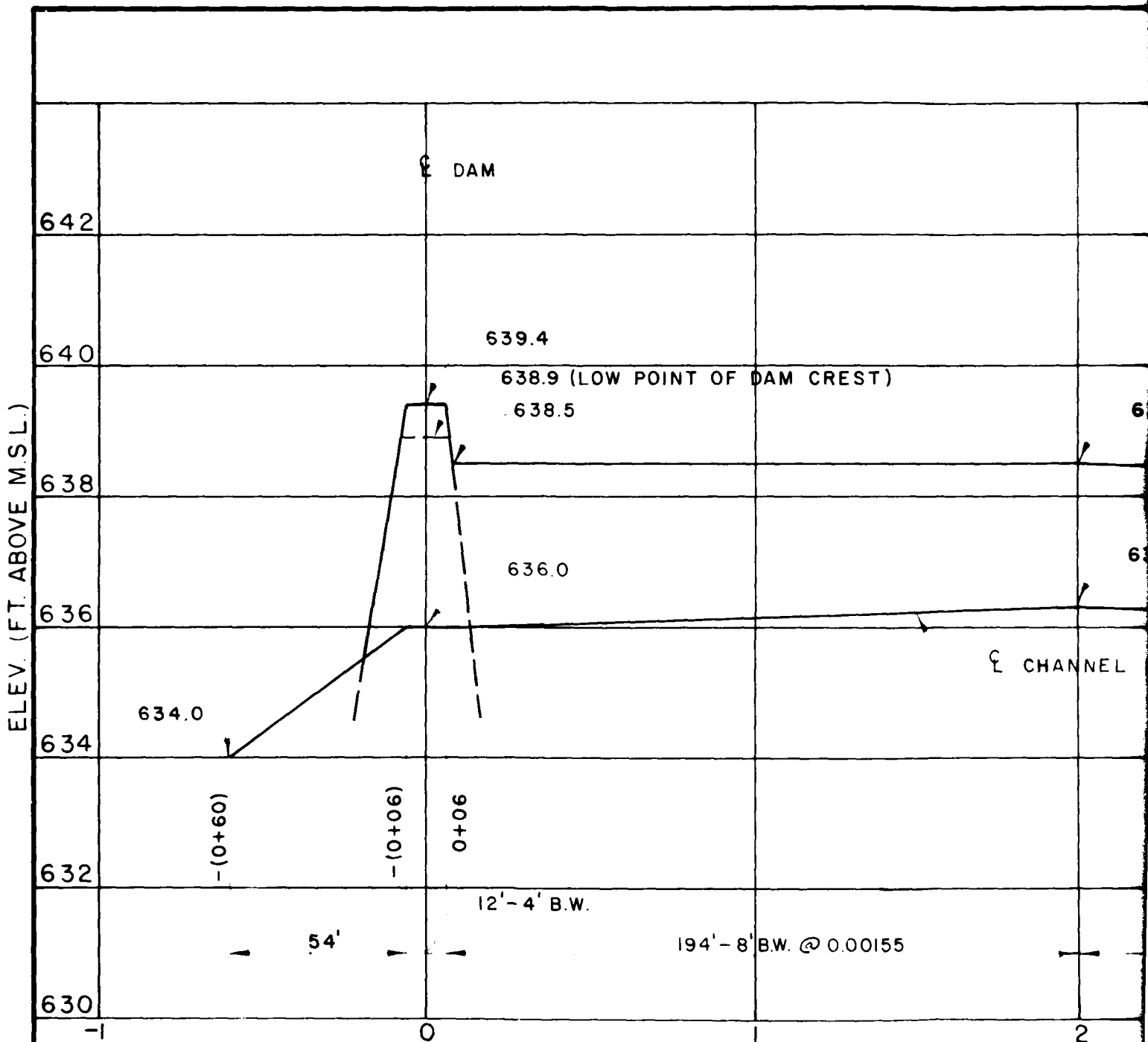
HICKORY HOLLOW LAKE
DAM CROSS-SECTION

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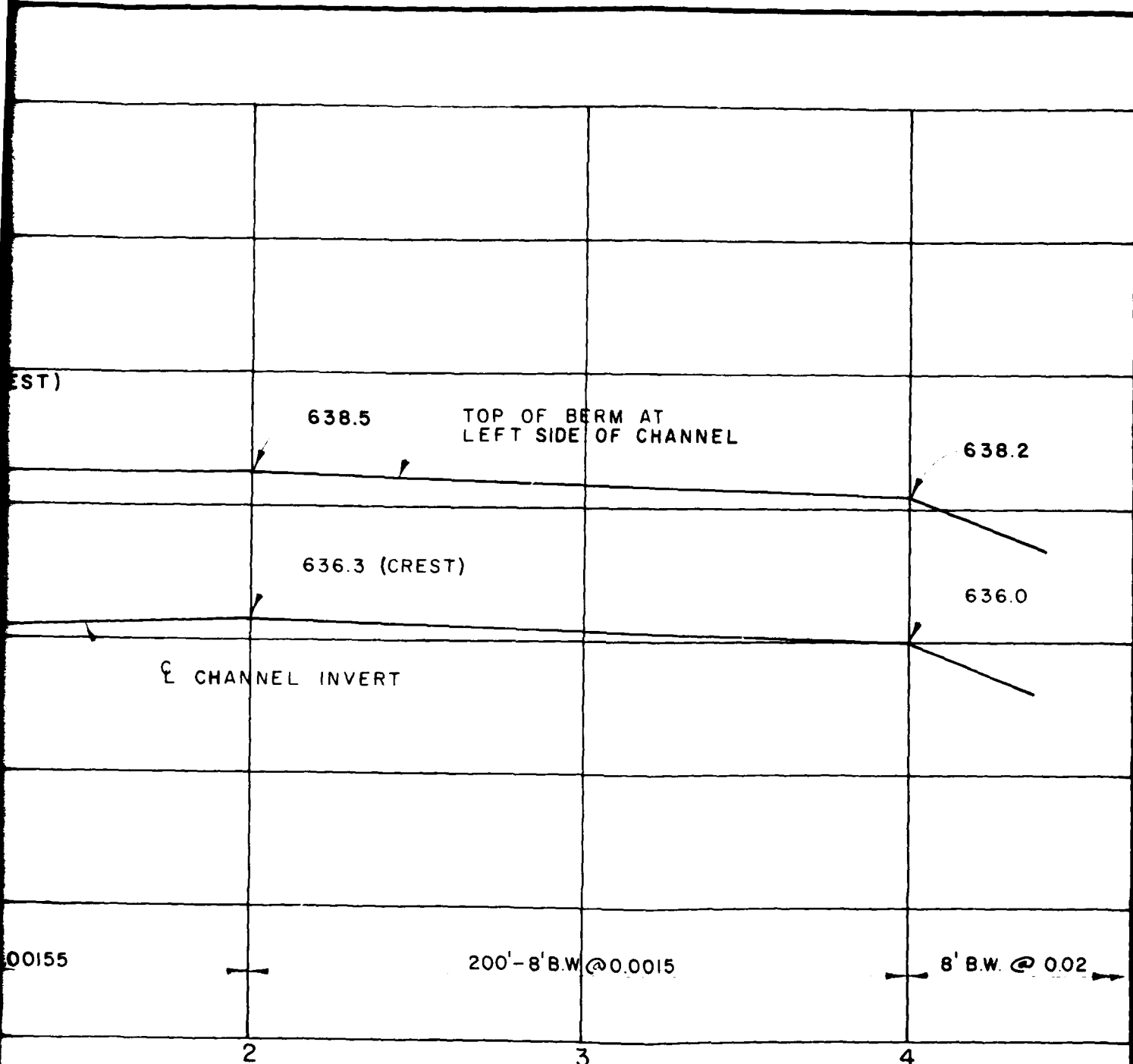
PLATE 4

12



NOTE: CHANNEL SIDE SLOPES
APPROX. 1V:2H

PROFILE SPILLWAY @
SCALES: 1"=2' V., 1"=40' H.



PROFILE SPILLWAY @
SCALES: 1" = 2' V., 1" = 40' H.

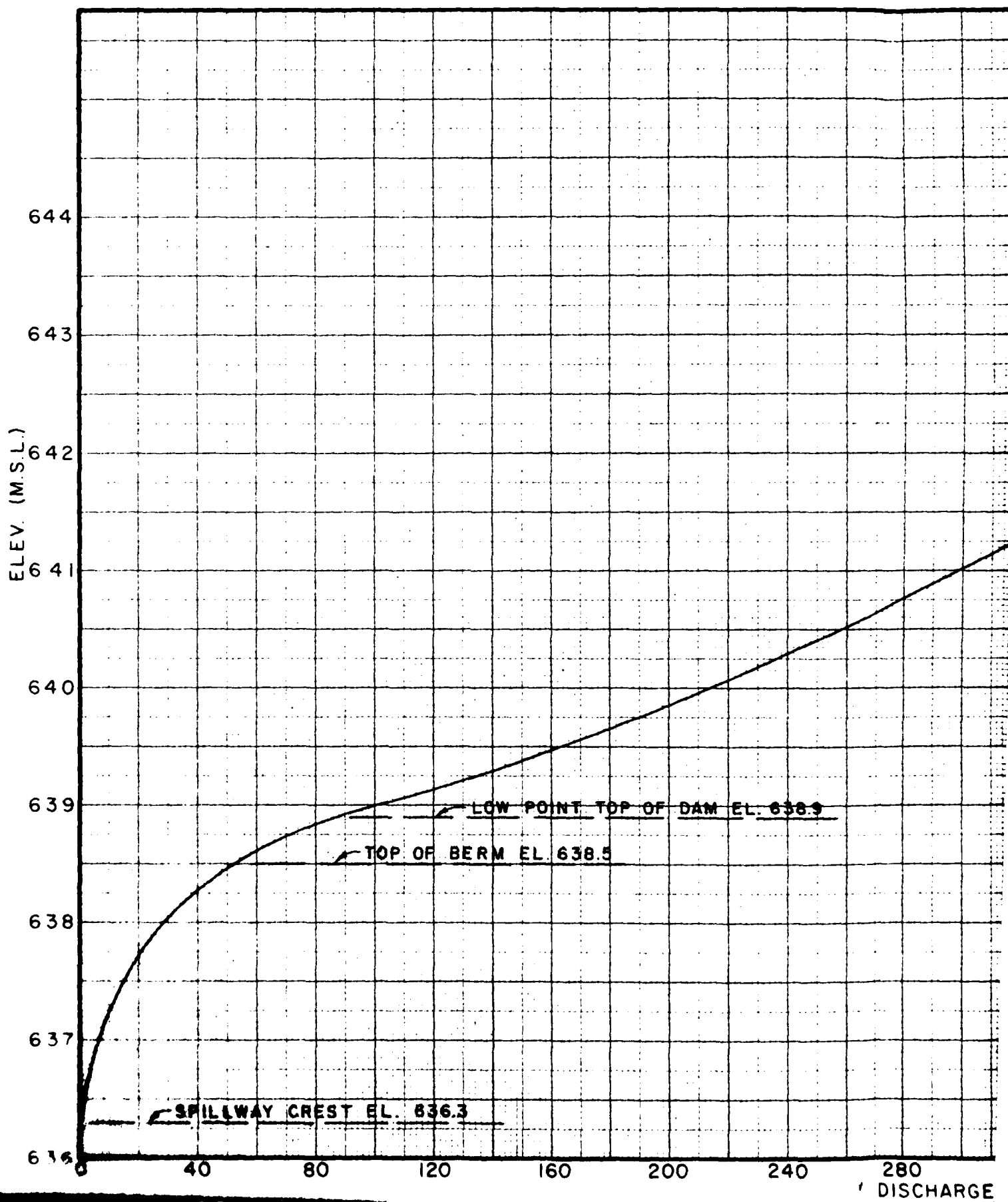
HICKORY HOLLOW LAKE
SPILLWAY PROFILE

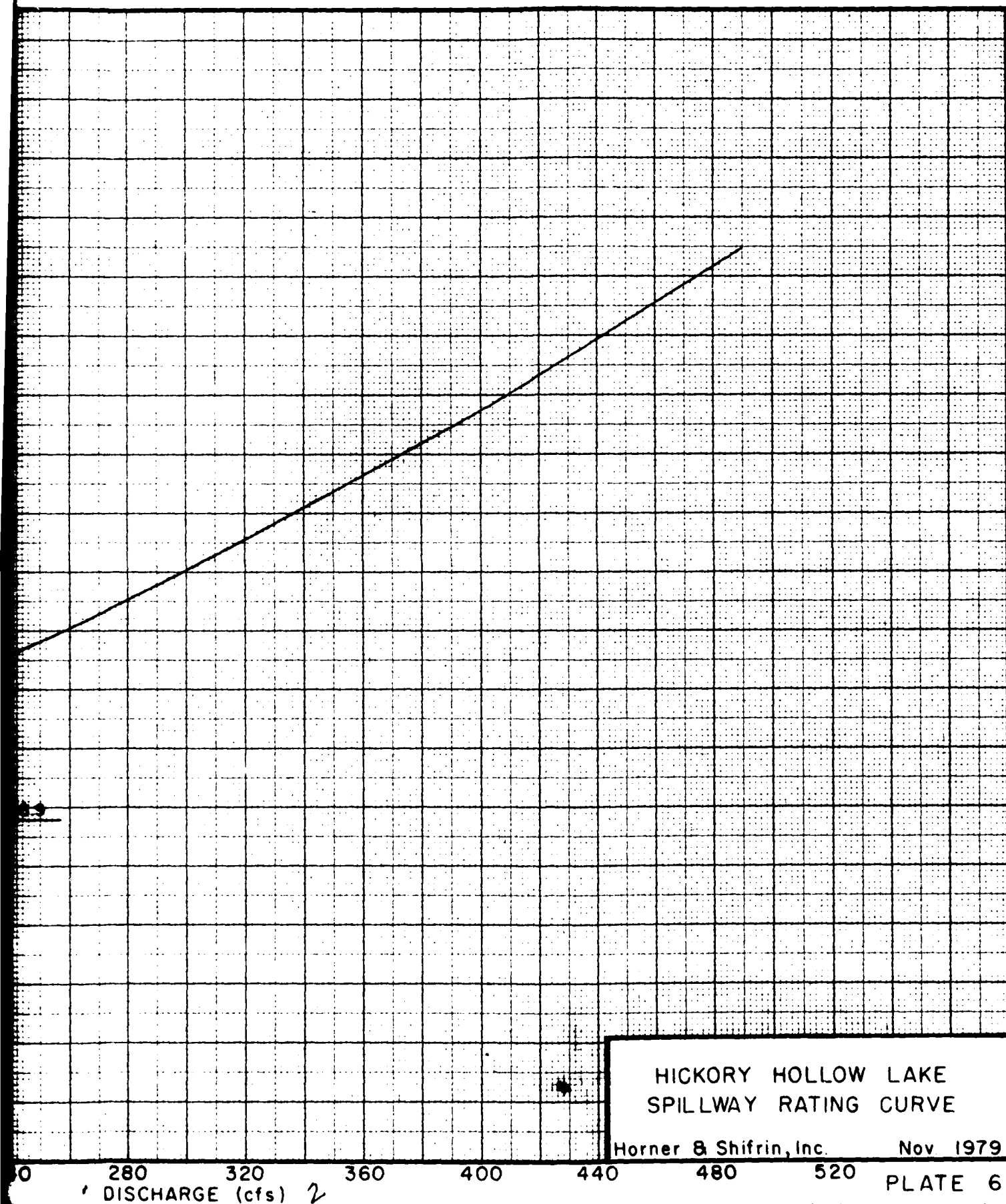
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PLATE 5

12





HICKORY HOLLOW LAKE
SPILLWAY RATING CURVE

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PLATE 6

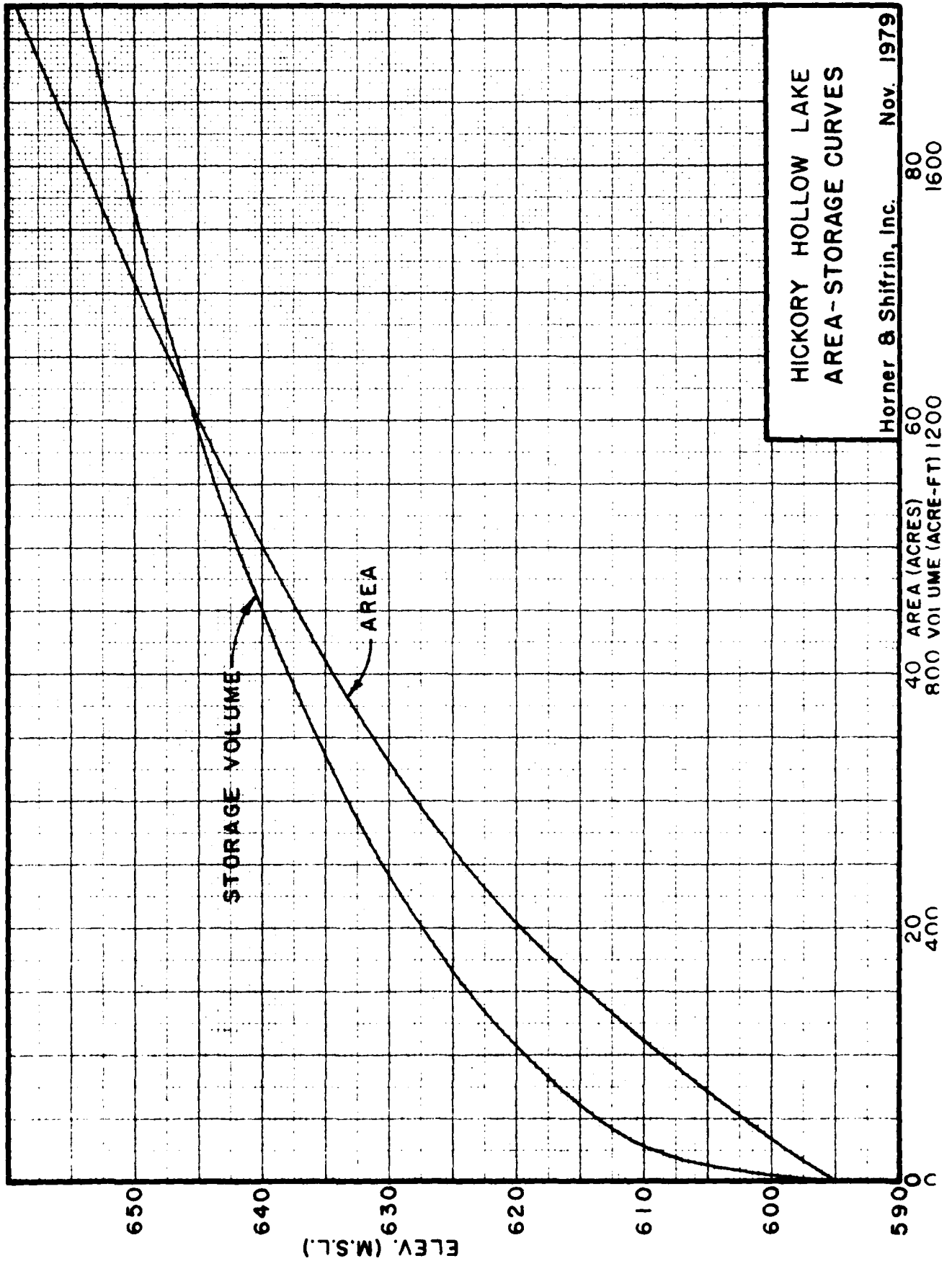


PLATE 7

HICKORY HOLLOW LAKE
AREA-STORAGE CURVES

Horner & Shifrin, Inc. Nov. 1979

Perry County
BB

ENGINEERING GEOLOGIC REPORT OF THE HOWARD DAVIS LAKE SITE

PERRY COUNTY, MISSOURI

LOCATION: NE $\frac{1}{4}$, NE $\frac{1}{4}$, NE $\frac{1}{4}$, Section 26, T. 35 N., R. 9 E., Parker Lake Quadrangle.

The lake, built more than ten years ago, impounds only several acres of water because of leakage in the center portion of the lake basin. The dam, approximately 50 feet high, reportedly filled to approximately $\frac{1}{2}$ of its intended volume before rapid leakage through the bottom of the lake began to take place. Uncovering of portions of the lake bottom revealed a vertical opening in the bedrock (joint) that accepted large quantities of water. An attempt was made to bulkhead off the joints and otherwise fill them with concrete. The attempt was at least partially a failure.

During wet weather, the lake backs up beyond its normal pool level with a rapid lowering of the water level to a relatively stable condition.

Lineations on aerial photography indicate a vertical joint running essentially east-west from a point at the trailer house directly east into the valley wall on the east side of the lake. A sinkhole is present on the ridge directly east of the lake on the same linament. The photography indicates at least one more linament coming from the southeast trending northwest through the bottom of the basin at approximately the area where the original collapse took place. These linaments cannot be seen out of the lake basin to the northwest or west.

Water from the lake is reported to emerge at a spring in the northeast part of Section 10, T. 34 N., R. 9 E., to the north of this area approximately 4 or 5 miles. Aerial photography is not available for the area to the north or to the east so additional delineation of the linaments is not possible.

Various techniques are known to find lineations in thin soil areas by the use of radar imagery, thermal imagery, etc. Where the soil becomes thicker, such as out of the lake area, these techniques would probably not be useful. Probing with drilling equipment to try and find the direction of the large cracks or joints would be time consuming and expensive. For the most part, the joints would have a rock cap of varying thickness and the joint itself would normally be only several feet in width decreasing with depth. Probing with drilling equipment could miss these vertical features readily.

Padding with compacted clay would only be partially successful as water coming down the valley can easily get underneath the pad or the pad can easily collapse into narrow voids that may now be present. The leakage probably can only be remedied by uncovering the joints to determine their direction and then cutting off the flow of water above the water line of the lake. The point of water emergence such as the spring to the north is not necessarily an indication of direction of water movement out of the lake basin. The water is thought to move to the west of the lake for some distance. The water then moves into the system recharging springs to the north and as such probably does not represent a travel direction from the lake. A high head of water such as 40 to 50 feet (if the lake were full) would probably allow water to move in several directions rather than in one direction under the low head now present. For this reason, the joints would need to be plugged on either side of the lake assuming the joint crosses the lake.

RECOMMENDATIONS:

1. It is recommended that during a period of low water in the lake that a bulldozer be employed to remove the dirt material from the lake bottom in the vicinity of the collapses to uncover the joint to a point where a direction of the joint or joints can be determined. The dirt could be pushed from south to the north to create a temporary dam between the joint system and the existing lake body and/or the water of the lake could be drawn down 5 to 10 feet to where only a small pool exists. When the bedrock has been exposed and the joints or other openings identified as to location, then a drilling and grouting program could be set up to cut off the water flow. The flow is initially vertical but probably rapidly changes to a lateral water movement of shallow depth (20 - 30 feet).

SUMMARY:

In summary, no known practical means of pinpointing the joint pattern in the lake basin is known. Uncovering of the joint with a bulldozer or other equipment would in all probability be the most practical method of determining where the joints are and at what point they move out of the lake basin. A grouting program could then be employed to intercept the horizontal movement of water.

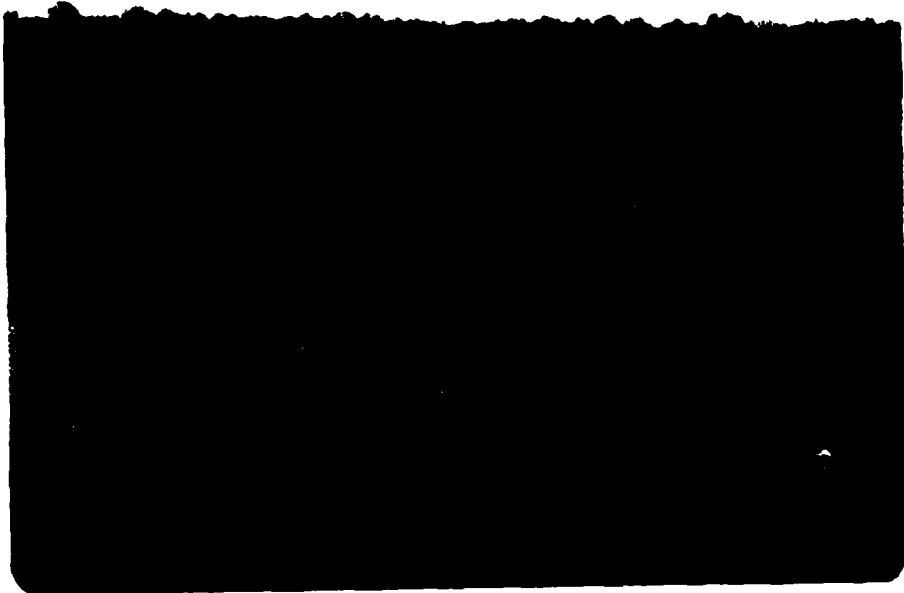
Thomas J. Dean, Geologist
Applied Engineering & Urban Geology
Geology & Land Survey
June 8, 1976

TJD:bh

cc: Howard Davis, 425 N. Highway 61, Perryville, MO 63775
Soil Conservation Service, 10 S. Main St., POB 323, Perryville, MO 63775

APPENDIX A

INSPECTION PHOTOGRAPHS



NO. 1: UPSTREAM FACE OF DAM



NO. 2: CREST OF DAM FROM LEFT ABUTMENT



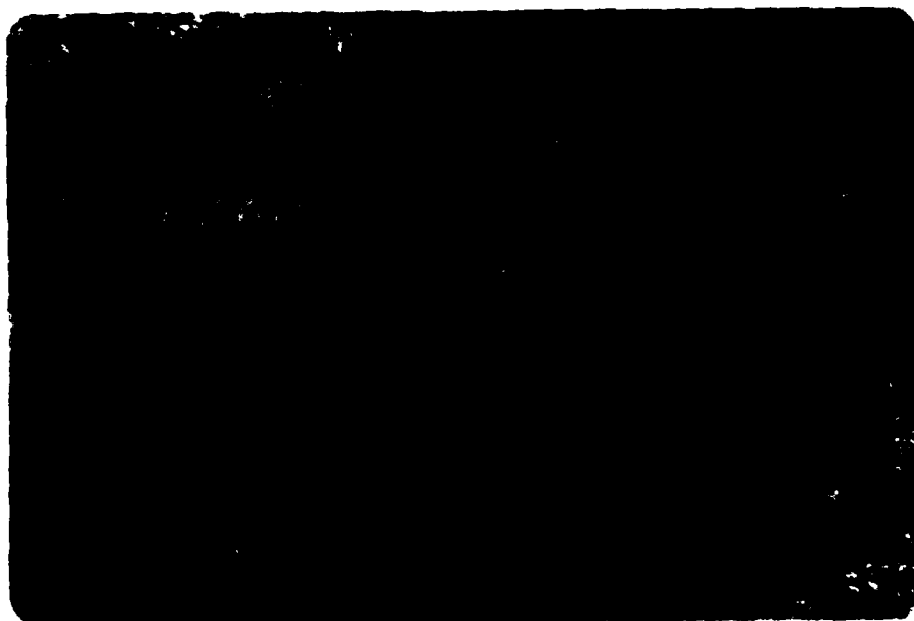
NO. 3: DOWNSTREAM FACE OF DAM



NO. 4: BRIDGE ACROSS SPILLWAY APPROACH CHANNEL



NO. 5: SPILLWAY CHANNEL LOOKING UPSTREAM FROM CREST



NO. 6: SPILLWAY CHANNEL LOOKING DOWNSTREAM FROM BRIDGE



NO. 7: JUNCTION OF DAM CREST AND BARGE AT LEFT SIDE OF CHANNEL

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. mile, 24-hour value equals 26.5 inches) from Hydrometeorological Report No. 33. The precipitation data used in the analysis of the 1 percent (100-year frequency) flood was provided by the St. Louis District, Corps of Engineers.

b. Drainage area = 0.86 square miles = 550 acres.

c. SCS parameters:

Soil Group B = 100 percent

Soil type CN = 80 (AMC III, PMF condition)

= 63 (AMC II, 100-yr condition)

Lag Time = 0.60 (T_C) = 0.15 hours

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

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

L = Length of longest watercourse, miles

H = Elevation difference, feet

2. As indicated on the spillway channel profile on Plate 5, the crest of the spillway (elevation 636.3) was found to be located approximately 200 feet downstream of the centerline of the dam. The critical section for determination of flow in the spillway channel was assumed to be located approximately 200 feet downstream of the crest. The left bank of the outlet channel adjacent to the dam was found to be approximately 2.2 feet higher than the spillway crest. Spillway releases

greater than 52 cfs were found to overtop the channel bank at the dam. For lake outflow greater than 52 cfs, spillway releases were assumed to be equivalent to the flow passing the outlet channel plus the flow overtopping the channel bank. Flow overtopping the channel bank was determined for various depths corresponding to flows in the channel with depths greater than the top of bank level.

Spillway release rates were determined as follows:

- a. Spillway section properties (area, "a" and top width, "t") were computed for various depths, "d."
- b. It was assumed that flow passing the spillway 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." The water surface profile corresponding to the critical depth value was determined by computer using conventional backwater profile techniques.
- c. Static lake levels corresponding to the various flow values passing the spillway and over the bank were computed as the depth of flow in the channel at the dam (d) plus critical velocity head ($d + H_{vc}$), 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 channel bank.
- d. Spillway discharge values for equal elevations were selected for entry on the Y4 and Y5 cards.

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

[illegible][illegible]

SUMMARY OF DAM SAFETY ANALYSIS

RATIOS OF PMF

ELEVATION		INITIAL VALUE		SPILLWAY CREST		TOP OF DAM			
STORAGE		636.30		636.30		638.90			
OUTFLOW		712.0		712.0		830.0			
RATIO OF PMF	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS			
	0.00	821.0	74.0	0.00	18.50				
	.10	831.0	95.0	1.00	18.33				
	.50	838.0	140.0	3.25	18.17				
	1.00	840.80	4317.0	11.08	15.83				
0.00	2.67	974.0	5073.0	13.00	15.83	0.00	0.00		
0.00	0.00	712.0	0.00	0.00	0.00	0.00	0.00		

SUMMARY OF DAM SAFETY ANALYSIS

100-YR. FLOOD

ELEVATION		INITIAL VALUE		SPILLWAY CREST		TOP OF DAM			
STORAGE		636.30		636.30		638.00			
OUTFLOW		712.0		712.0		830.0			
RATIO OF PMF	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS			
	0.00	820.0	69.0	0.00	18.58	0.00			
	1.00	0.00	0.00	0.00	0.00	0.00			

HICKORY HOLLOW LAKE PMF INFLOW & OUTFLOW HYDROGRAPHS

Horner & Shifrin, Inc.

Nov. 1979

