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NATIONAL DAM SAFETY PROGRAM. GENERAL AMERICAN LIFE INSURANCE CO--ETC(U)

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UPPER MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

GENERAL AMERICAN LIFE INSURANCE CO. LAKE DAM

ST. LOUIS COUNTY, MISSOURI

MO 31390

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DTIC FILE COPY

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

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

FOR: STATE OF MISSOURI

DECEMBER 1980

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REPORT DOCUMENTATION PAGE

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9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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National Dam Safety Program. General American Life Insurance Co. Lake Dam (MO 31390), Upper Mississippi - Kaskaskia - St. Louis Basin, St. Louis County, Missouri. Phase I

18. SUPPLEMENTARY NOTES

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

Dam Safety, Lake, Dam Inspection, Private Dams

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

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

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UPPER MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

GENERAL AMERICAN LIFE INSURANCE CO. LAKE DAM

ST. LOUIS COUNTY, MISSOURI

MO 31390

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army Corps of Engineers

...Serving the Army
...Serving the Nation

St. Louis District

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

FOR: STATE OF MISSOURI

DECEMBER 1980

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: General American Lake Dam, MO 31390, Phase I Inspection Report

This report presents the results of field inspection and evaluation of the General American Lake Dam (MO 31390):

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 of the dam could result in failure of the dam.

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

SUBMITTED BY: SIGNED
Chief, Engineering Division

17 DEC 1980
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

18 DEC 1980
Date

GENERAL AMERICAN LAKE DAM

MISSOURI INVENTORY NO. 31390

ST. LOUIS COUNTY, MISSOURI

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

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

FOR:

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

CORPS OF ENGINEERS

DECEMBER 1980

HS-8011

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	General American Lake Dam
State Located:	Missouri
County Located:	St. Louis
Stream:	Tributary of Meramec River
Date of Inspection:	8 October 1980

The General American 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 these hydrologic/hydraulic investigations, the present general condition of the dam is considered to be satisfactory. However, several deficiencies were observed during the visual inspection which are considered to have an adverse effect on the overall safety and future operation of the dam. These deficiencies include such items as small trees, areas of high grass on the downstream face of the dam, minor erosion of the downstream face of the dam, erosion of the downstream embankment adjacent to and beneath the spillway outlet chute, as well as erosion of areas adjacent to the downstream toe of the dam, ineffective drainage of seepage in the vicinity of the downstream toe of the dam, and riprap slope protection considered too small to permanently resist forces produced by wave action.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the General American Lake Dam, which is classified as small in size and of high hazard potential, is specified to be a minimum of one-half the Probable Maximum Flood (PMF).

Considering the fact that numerous dwellings, including three apartment buildings, lie within the potential downstream flood damage zone should failure of the dam occur, it is recommended that the spillway for this dam be designed for the Probable Maximum Flood. 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. The PMF is ordinarily accepted as the inflow design flood for dams where failure of the structure would seriously increase the danger to human life.

Results of a hydrologic/hydraulic analysis indicated that the spillway is inadequate to pass lake outflow resulting from a storm of PMF magnitude without overtopping the dam. However, the spillway is capable of passing lake outflow resulting from the one percent chance (100-year frequency) flood and the lake outflow corresponding to about 41 percent of the PMF lake inflow, without overtopping the dam. 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 two miles. Accordingly, within the possible damage zone are numerous residential type dwellings, including three apartment buildings, State Highway 21, a golf course, and a county park.

Certain stability analyses were performed during the design of this dam. However, a review of available data indicated that these analyses do not conform precisely to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" in that not all of the prescribed conditions of loading were investigated. Therefore, it is recommended that these stability analyses be reviewed and that all conditions of loading, including earthquake, be considered. Any "as-built" deviations from the original plans should also be included when these investigations are made.

Although no indication was found that detailed seepage analyses were performed for this dam, details shown on the construction plans indicate that certain provisions, such as a seepage cutoff trench, a toe drain system, and blanketing of exposed bedrock in the original stream within the reservoir, were made in the design of the embankment in order to minimize the effects of seepage. Information obtained from the Owner's representative confirmed that the dam, including the anti-seepage provisions, was constructed in general compliance with the details shown on the plans. Observations made during the visual inspection indicated that no significant seepage problems existed. Therefore, the inspection team is of the opinion that detailed seepage analyses of this dam are unnecessary.

It is recommended that the Owner take the necessary action within a reasonable time to correct or control the deficiencies and safety defects reported herein. The provision of additional spillway capacity should be pursued on a high priority basis.

Harold B. Lockett

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

Albert B. Becker, Jr.

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

OVERVIEW GENERAL AMERICAN LAKE DAM

PHASE 1 INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

GENERAL AMERICAN LAKE DAM - MO 31390

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*By Hellmuth, Obata & Kassabaum, Inc., Issue Date October 16,1974.

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APPENDIX B - HYDROLOGIC AND HYDRAULIC ANALYSES

*By STS Engineers, Inc., July 1974.

PHASE I INSPECTION

NATIONAL DAM SAFETY PROGRAM

GENERAL AMERICAN LAKE DAM - MO 31390

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 General American 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 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 General American Lake Dam is an earthfill type embankment rising approximately 33 feet above the natural streambed at the downstream toe of the barrier. The embankment has an upstream slope above the waterline of approximately 1v on 3.1h, a crest width of about 10 feet, and a downstream slope which varies from approximately 1v on 3.5h at the dam crest to about 1v on 2.1h at the toe of the dam. The length of the dam is approximately 550 feet. A 3 foot wide walkway surfaced with pecan shells traverses the crest of the dam except at the spillway, where a timber footbridge about 4 feet wide and 40 feet long spans the outlet. A site plan of the General American Life Insurance Company's National Service Center including the lake and dam is shown on Plate 3 and a profile of the dam crest is shown on Plate 4. A cross-section of the dam at a location adjacent to the spillway outlet is also shown on Plate 4. An overview photograph of the dam is shown following the preface at the beginning of the report.

The spillway, a paved concrete trapezoidal section, is located about 50 feet left, looking downstream, of the center of the dam. A concrete weir is located within the spillway structure at a point approximately 16 feet upstream of the crest section. The weir spans the spillway channel and an opening approximately 1.0 foot high is provided between the underside of the weir and the invert of the spillway section. The spillway outlet consists of a concrete trapezoidal chute section which extends from the spillway structure across the downstream face of the dam to a point about 53 feet downstream of the toe of the dam. A trapezoidal channel section lined with concreted stone riprap extends about 60 feet beyond the end of the chute section. A profile of the spillway is shown on Plate 4, and cross-sections of the spillway structure are shown on Plate 5. Details of the spillway are also shown on Sheets 5-1 and 10-1 of the construction plans prepared by Hellmuth, Obata & Kassabaum, Inc. (HOK), reference Plates 9 and 10. Adjacent to the spillway structure, the dam had been landscaped with small trees and shrubs.

An 8-inch pipe controlled by a gate valve located within a concrete valve vault near the toe of the dam adjacent to the right side of the spillway chute is provided for lake drawdown. Details of the drawdown pipe are also shown on Sheet 5-1, reference Plate 9, of the construction plans prepared by HOK.

b. <u>Location</u>. The dam is located on an unnamed tributary of the Meramec River, on property owned by the General American Life Insurance Company and on which their National Service Center complex is located. The General American Life Insurance Company's National Service Center is located adjacent to the west side of State Highway 21, about 1.5 miles south of Interstate Highway 270, and about 2 miles southwest of Concord Village, Missouri, as shown on the Regional Vicinity Map, Plate 1. The dam is located in U. S. Survey 2992, approximately 1,900 feet northeast and 1,100 feet southeast of the southwest corner of Survey 2992, in Township 43 North, Range 6 East, within St. Louis County.

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

d. Hazard Classification. The General American 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 flood damage zone are numerous residential type dwellings, including three apartment buildings, a golf course, a county park and State Highway 21. Those features lying within the downstream damage zone reported by the Corps of Engineers, St. Louis District, were verified by the inspection team.

e. Ownership. The lake and dam are owned by the General American Life Insurance Company, 13045 Tesson Ferry Road, St. Louis, Missouri 63128. Mr. Edward J. Hogan, Director of St. Louis Properties, represented the Owner during the course of the investigation presented herein.

f. Purpose of Dam. The purpose of the dam is to provide stormwater detention as well as to enhance the aesthetic quality of the grounds surrounding the General American Life Insurance Company Building.

g. Design and Construction History. According to Edward J. Hogan, the Owner's representative, the dam was constructed in 1976 by the Rallo Contracting Company of St. Louis, Missouri, in conjunction with the construction of the National Service Center, a headquarters type building, for the General American Life Insurance Company. Plans for construction of the headquarters facility as well as the dam and reservoir were prepared in 1974 by the St. Louis architectural firm of Hellmuth, Obata, & Kassasbaum, Inc. (HOK). Copies of several of the HOK construction drawings pertinent to the investigation of the dam are included herein, reference Plates 7 through 10. Design of the embankment was by STS Engineers, Inc., under subcontract to HOK. However, the reservoir including the spillway outlet was designed by HOK, and as previously indicated, is intended to function as a stormwater detention basin.

h. Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the capacity of a concrete curb across a trapezoidal section, located near the center of the dam.

1.3 PERTINENT DATA

a. Drainage Area. Except at the north end of the reservoir, the land immediately adjacent to the lake is grass covered with park-like landscaping. The General American Life Insurance Company Building as well as its service roads and parking areas which are interspersed with turfed areas, occupies almost the entire watershed. The watershed above the dam is approximately 42 percent impervious and amounts to about 40 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

(1) Estimated known maximum flood at dam site ... 46 cfs* (W.S.Elev. 571.6)
(2) Spillway capacity ... 183 cfs.

c. Elevation (Ft. above MSL). Except where otherwise indicated, the following elevations were determined by survey and are based on the elevation of the spillway crest, which according to the Owner's representative, was constructed approximately 1.0 foot higher than the elevation of the spillway crest indicated on the plans prepared by Hellmuth, Obata & Kassabaum in 1974. Topographic data shown on the July, 1980 Aerial Survey by Surdex Corporation, reference Plate 3, provided by the Owner, appears to confirm this assumption.

*Based on an estimate of depth of flow at spillway as observed by Edward J. Hogan, the Owner's representative.

(1) Observed pool ... 570.3

(2) Normal pool ... 570.5

(3) Spillway crest ... 570.5

(4) Maximum experienced pool ... 571.6*

(5) Top of dam ... 572.9 (min.)

(6) Streambed at centerline of dam ... 537.5± (per construction plans)

(7) Maximum tailwater ... Unknown

(8) Observed tailwater ... None

d. Reservoir.

(1) Length at normal pool (Elev. 570.5) ... 670 ft.

(2) Length at maximum pool (Elev. 571.6) ... 670 ft. (lake abuts building)

e. Storage.

(1) Normal pool ... 30 ac. ft.

(2) Top of dam (incremental) ... 10 ac. ft.

f. Reservoir Surface.

(1) Normal pool ... 3.7 acres

(2) Top of dam (incremental) ... 0.7 acres

g. Dam. 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, modified homogeneous**

(2) Length ... 550 ft.

(3) Height ... 33 ft.

*Based on an estimate of depth of flow at spillway as observed by Edward J. Hogan, the Owner's representative.

**Per construction plans prepared by Hellmuth, Obata & Kassabaum, Inc., October 16, 1974.

(4) Top width ... 10 ft. (min.)

(5) Side slopes

a. Upstream ... 1v on 3.1h (above waterline)

b. Downstream ... Varies from 1v on 3.5h to 1v on 2.1h

(6) Cutoff ... Core trench*

(7) Slope protection

a. Upstream ... Grass and gravel riprap (2" max.)

b. Downstream ... Grass, landscaping

(8) Seepage control ... Toe drain with drainage blanket*

h. Spillway.

(1) Type ... Uncontrolled, concrete curb, trapezoidal section

(2) Location ... 50 feet left of dam center

(3) Crest ... Elevation 570.5

(4) Outlet channel ... Paved concrete chute, trapezoidal section to point 53 feet downstream of toe of dam; concreted riprap, trapezoidal section to point 60 feet beyond end of chute section.

i. Emergency Spillway. ... None

j. Lake Drawdown Facility.

(1) Type ... 8-Inch cast iron pipe*

(2) Control ... 8-Inch gate valve

(3) Elevation

a. Upstream ... 542.0*

b. Downstream ... 541.0*

(4) Valve location ... Right side of spillway at toe of dam

(5) Discharge ... To spillway outlet channel

*Per construction plans prepared by Hellmuth, Obata & Kassabaum, Inc., October 16, 1974.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

a. Dam. As previously indicated, the dam was designed by STS Engineers, Inc., under subcontract to Hellmuth, Obata & Kassabaum, Inc. (HOK). However, according to John A. deMonte, P.E., of STS, their involvement was limited to the design of the embankment and did not include determination of the spillway requirements. Mr. deMonte reported that subsurface investigations, test borings and test pits, were made at the location of the dam in order to determine the properties of the foundation soils as well as a suitable depth for the dam seepage cutoff trench. The locations of these test borings and test pits are shown on the Site Grading Plan, Sheet 1-1, reference Plate 7, prepared by HOK. Logs of these borings as detailed by STS are shown on Charts 2-1 through 2-4, and logs of the test pits are shown on Charts 2-5 through 2-9.

According to Mr. deMonte, based on laboratory testing of the material (silty clay) to be used in the embankment as well as experience and judgement, strength parameters were assigned the soil and stability analyses were performed. According to a report prepared by STS for design of the embankment and on file at the St. Louis County Department of Public Works, these analyses were performed by the stability number method. Mr. deMonte reported that these stability investigations included sudden drawdown and steady seepage conditions, and that in all cases, acceptable factors of safety existed. According to Mr. deMonte, the downstream toe drain system was provided in order to reduce pore pressures within the embankment and to provide drainage relief for lake seepage. Specifications for construction of the dam required that the fill material be compacted to a minimum density of 95 percent of maximum dry density per the Standard Proctor Test, ASTM 698. A statement in the STS report indicated that the subgrade profile and clay embankment are not subject to liquifaction under seismic forces. A cross-section of the dam indicating the cutoff trench and embankment proportions as well as the toe drain requirements, is shown on Sheet 10-1, reference Plate 10, of the construction plans prepared by HOK. Mr deMonte stated that they, STS Engineers, were not retained to inspect or test the actual construction of the embankment.

b. Spillway. According to Charles Danna, HOK Project Manager during design of the National Service Center facility, the reservoir including the spillway was designed as a stormwater detention basin in accordance with criteria specified by the St. Louis County Department of Public Works. A review of the design computations on file with the Department of Public Works indicated that in accordance with St. Louis County criteria, the design runoff was evaluated by the Rational Formula method using runoff factors for a 15-year frequency, 20 minute inlet time (duration), storm and, that the designated retention time was 30 minutes. According to the designer's notes, differential runoff from the site required detention of approximately 166,?35 cubic feet of water within the reservoir for the 30 minute period, and a design outflow of about 57.7 cfs. The spillway overflow structure as designed is shown on Sheet 10-1, reference Plate 10, of the HOK plans, with the exception that according to the designer's notes, the opening between the weir and the spillway crest was indicated to be 0.4 foot and not 0.8 foot as indicated by the elevation and section shown on the drawings, or 1.0 foot as determined by survey at the time of the inspection. Post construction additions by the Owner, i.e. the installation of a concrete curb across the spillway opening in order to raise the normal level of the lake, indicates the clearance between the top of the curb, or present spillway crest, and the weir to be 0.2 foot. The proportions and dimensions of the spillway as determined by survey during the inspection are shown on Plates 4 and 5.

2.2 CONSTRUCTION

As previously indicated, the dam was constructed in 1976 by the Rallo Contracting Company of St. Louis, Missouri. According to Edward J. Hogan, the Owner's representative who was present during the actual construction of the dam, a seepage cutoff trench was excavated to rock in accordance with the details shown on the plans prepared by Hellmuth, Obata & Kassabaum (HOK). Mr. Hogan reported that the material to build the dam was obtained from excavations for building foundations and from general site grading, and that the embankment material was compacted using a sheepsfoot roller.

Mr. Hogan indicated that the concrete curb section that governs the normal level of the lake was added following completion of the project when it was decided that the lake would be aesthetically more attractive if the normal waterline were 1 foot higher than originally planned. It appears that the footbridge that crosses the spillway structure was also added at a later date, since details of the bridge are not shown on the plans prepared by HOK. Mr. Hogan also mentioned that the 8-inch diameter riser pipe was extended and a screen was added to the end of the pipe after the lake had filled to a depth of about 10 feet and it was found that the amount of material being discharged through the outlet was excessive. Mr. Hogan was of the opinion that the material being discharged by the lake drain pipe was being scoured from the lake bottom by high intake velocities at the upstream end of the pipe, and not sediment that had accumulated within the reservoir. A detail of the lake drain shown on the HOK construction plans, see Plate 9, indicates a tee fitting was installed near the inlet end of the drain pipe and that a short section of pipe was attached to the horizontal leg of the tee on the lake bottom, and a section of pipe 2.0 feet long was connected to the vertical leg of the tee. Mr. Hogan reported that a diver connected the riser pipe and screen to the original vertical pipe section and that the drain has not been operated since the addition was made.

According to survey data and based on the premise that the normal level of the lake, as governed by the top of the concrete curb, see Plate 4, is 1.0 foot higher than the normal level shown on the construction plans, see Plate 10, the low point of the dam crest was found to be only 0.1 foot lower than the specified top of dam elevation shown on the construction plans. However, according to survey data obtained at the time of the inspection, at the section surveyed, the slope of the downstream face of the dam was found to be somewhat steeper than the 1v on 3h slope specified for the slope as indicated on the dam section shown on the plans, see Plate 10. Except for the post construction additions noted herein (curb, footbridge, and drawdown pipe screen) and the fact that the downstream slope of the dam was found to be somewhat steeper than specified, the dam and appurtenances were found to be essentially as shown on the construction plans prepared by HOK.

2.3 OPERATION

The lake level is uncontrolled and governed by the elevation of the spillway curb. No indication was found that the dam had been overtopped. According to Mr. E. J. Hogan, the Owner's representative, the dam has never been overtopped and the highest lake level experienced to date produced a depth of about 0.1 foot above the top of the spillway weir, which corresponds to a high water level of about elevation 571.6.

2.4 EVALUATION

a. Availability. The results of stability analyses for assessing the design of the dam were available. No indication was found that detailed seepage analyses had been performed. Calculations for determining the size of the spillway were available. The proportions of the dam and spillway as designed, except for the height of the opening between the spillway crest and the weir, are shown on the construction plans prepared by HOK, reference Plates 9 and 10.

b. Adequacy. It was found that certain stability analyses for design of this dam have been performed. Although these analyses do not conform precisely to the requirements of the specified guidelines, it may be that the results of these analyses are comparable to the results of the analyses specified by the guidelines, in so far as performed. Loading conditions investigated were limited to sudden drawdown and steady seepage with a full reservoir. No indication was found that partial pool or earthquake loading conditions were investigated. Therefore, it is recommended that these stability analyses be reviewed, and that the additional loading conditions, including earthquake (seismic loading) be considered. Deviations from the original design as shown on the plans, i.e., the steeper downstream slope of the dam and the 1.0 foot increase in the normal water elevation of the lake should also be evaluated.

Although no indication was found that detailed seepage analyses were performed for design of this dam, certain provisions were made in the design and construction of the embankment in order to minimize the effects of dam seepage. These provisions include a seepage cutoff trench, a toe drain system, and a blanket of compacted silty clay placed over exposed bedrock in the original stream channel. According to Mr. Edward J. Hogan, representative of the Owner, who was present during the time the dam was built, the dam was constructed essentially in agreement with the details shown on the plans prepared by Hellmuth, Obata & Kassabaum. Observations made during the inspection confirmed that the toe drains had been installed, and as far as could be determined, appeared to be functioning as intended. Therefore, the inspection team is of the opinion that detailed seepage analyses are unnecessary.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the General American 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 8 October 1980. An examination of the dam site was also made by an engineering geologist, Jerry D. Higgins, 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 General American Lake is located on an unnamed southward-flowing tributary of the Meramec River. The topography around the lake site is moderately rolling, and there is approximately 80 to 90 feet of relief between the lake and surrounding uplands. The area is included within the northeastern part of the Ozark Plateaus Physiographic Province, and the regional dip of the bedrock is eastward toward the Illinois Basin. The site is located approximately 4 miles to the east of a fault and/or monocline which affects the dip of the strata in the general area; however, the bedrock at the dam site still dips eastward. No faulting was observed at the site. The lake is located on the contact between the Mississippian-age limestones of the Salem and St. Louis formations.

The Salem and St. Louis formations consist of grey to light grey, medium-grained to lithographic limestones. Bedding thickness varies from a few inches to 3 or 4 feet. Chert is common in both formations. The limestones have undergone extensive solution weathering which has enlarged joints and bedding planes that usually form a very irregular bedrock surface. Sinks have probably formed; however, any surface expression would be masked by the residuum and loess deposits. As a result of the solution features, the bedrock is permeable, and will transmit water readily.

The soils in this area generally are divided into two zones, each with distinct engineering characteristics. The upper zone consists of residual clay mixed with loess (by natural processes) which ranges in thickness from 2 to 30 feet. These soils generally fall in the CL range of the Unified Soil Classification System, have low permeabilities, and form stable slopes. They are generally considered suitable for water impoundments, but due to the loess content are susceptible to erosion. The lower soil zone consists of residual, well-structured clay (CH) derived from weathering of the underlying limestones. The soil reportedly ranges from 5 to 40 feet in thickness in the general area. The permeability of the soil is relatively high and may cause considerable leakage from water impoundments. The reservoir is located on the upper zone soils, and, judging by the substantial amount of water in storage, a sufficient thickness of this soil is present to retard leakage to the permeable limestone.

The most significant geologic problem evident at the site is the high erodibility of the local soils. No other adverse geologic conditions were observed that would affect the stability or performance of the dam.

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. Erosion, apparently due to overflow of the concrete chute section of the spillway (see Photo 11), had created a hole approximately 1 foot deep and about 4 feet long in the embankment adjacent to the left (looking downstream) side of the chute at a location near the mid-height of the dam. Further, it appeared that at the hole a void extended beneath the chute and that the outlet section was undercut for some distance beginning at the eroded area next to the chute. The extent of the undercut section could not be determined. No cracking of the surface, sloughing of the embankment slopes, or undue settlement of the dam crest was noted. The upstream face of the dam was protected from erosion by grass and by gravel riprap up to about 2 inches in diameter and no significant erosion of the upstream slope was observed. The dam crest was also protected with grass, although a 3-foot wide walkway covered with pecan shells traverses the top of the dam. The grass on the upstream face and dam crest was about 3 inches high and uniformly covered both areas. Except for two areas adjacent to the spillway that are landscaped with shrubs and small trees, the grass on the downstream face of the dam was, in general, sparse and some surface erosion up to 1 foot deep and 1 foot wide was noticed. The grass on the downstream face, a combination of fescue, native grasses and weeds, was about 3 feet high at the time of the inspection. A 4-inch diameter willow tree and the remnants of what appeared to be an animal burrow were found on the upstream face of the dam near the left abutment. No other evidence of burrowing animals was noticed. 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 dam to be a yellow-brown, silty lean clay (CL) of low-to-medium plasticity.

Although attempts have been made to prevent erosion with concrete and asphalt, erosion that appeared to be due to overland drainage, has occurred adjacent to the downstream toe of the dam adjacent to these protective coverings. Below the left side of the dam a gully up to 1 foot deep and 2 feet wide existed and below the right side of the dam, a gully about 3 feet deep and 3 feet wide was found. These gullies may have developed from erosion of the 2-foot wide flat bottom ditches indicated on the construction plan, reference Plate 8, to be constructed along the toe of the dam. However, erosion of these ditch sections has negated their effectiveness as an outlet for the toe drain system of the dam. Some standing water, which was believed to be lake seepage emerging from the embankment drain systems (see Photos 7 and 10) at the toe of the dam, was observed within these gullies. No other seepage was observed in the immediate vicinity of the dam. A marshy area, approximately 50 feet wide by 75 feet long, with cattails, standing water and wet ground, was observed about 45 feet downstream of the left side of the dam in the vicinity of station 5+52. It could not be determined if this condition was a result of lake seepage or not. However, no water was observed flowing between the gully near the toe of the dam and the marshy area. According to E. J. Hogan, Director of St. Louis Properties for General American, at least two springs existed in this general area prior to construction of the dam.

The concrete spillway structure (see Photos 4 and 5) including the chute section downstream of the crest (see Photo 6), were examined and found to be in satisfactory condition without evidence of spalling or major cracking, although a transverse crack, that may have been an unsealed construction joint, up to one-half inch in width (see Photo 12) was found in the chute section at a location about 15 feet below the spillway crest. Downstream of the concrete chute, the channel is protected by concreted riprap and some minor erosion was noted adjacent to and downstream of the section.

The 8-inch cast-iron gate valve on the lake drawdown pipe (see Photo 9) as well as the concrete valve enclosure (see Photo 8) were examined and appeared to be in satisfactory condition, although the valve was not operated and some debris, i.e. boards and large rocks that could have been part of the toe drain system, was found within the enclosure about the valve.

d. Appurtenant Structures. Except for the footbridge crossing the spillway structure, no appurtenant structures were observed at this dam site.

e. Downstream Channel. Except at road and highway crossings, the channel downstream of the dam within the potential flood damage zone is unimproved. The channel section is irregular, of variable width, and for the most part, lined with trees. The stream joins the Meramec River at a point about 2 miles downstream of the dam.

f. Reservoir. Except where the lake abuts the building at the upstream end of the reservoir, the area surrounding the lake is covered with grass and well maintained. No significant erosion of the lake banks was noted. At the time of the inspection, the lake water was clear and about 0.2 foot below normal pool level. The amount of sediment within the lake could not be determined during the inspection; however, due to the fact that the drainage area consists of approximately 42 percent impervious area and the remaining area is maintained in a park-like condition, it is not expected to be significant.

3.2 EVALUATION

The deficiencies observed during this inspection and noted herein are not considered of significant importance to warrant immediate remedial action. Although no significant erosion of the upstream face of the dam was noted, the size of the gravel riprap slope protection, approximately 2 inches, is considered too small to permanently resist forces produced by lake wave action.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

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

4.2 MAINTENANCE OF DAM

According to Edward J. Hogan, Director of St. Louis Properties, the dam receives periodic routine maintenance such as mowing of the grass on the crest and upstream face of the dam, and removal of muskrats by trapping. Mr. Hogan also indicated that the Owner plans to replace the section of the concrete spillway chute that has been undercut by erosion sometime in the near future.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

With the exception of the lake drawdown valve, no outlet facilities requiring operation exist at this dam. There is no reservoir regulation plan.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The dam is routinely checked by the Owner's maintenance personnel. Mr. Hogan indicated that in the event of a threatened failure of the dam, the authorities, fire and police, would be notified.

4.5 EVALUATION

It is recommended that maintenance of the dam also include establishing and maintaining an adequate turf cover on the downstream face of the dam. Effective measures should be taken to prevent erosion along the abutments of the dam as well as to provide drainage of seepage emerging from the toe drain system. It is also 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.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Available hydraulic/hydrologic data pertinent to the design of the dam and spillway are discussed in Section 2, paragraph 2.1b.

b. Experience Data. The drainage area and lake surface area were determined from topographic data shown on a Surdex Corporation Aerial Survey Drawing dated July 1980 as provided by the Owner and supplemented by the 1969 USGS Maxville, Missouri, Quadrangle Map (photorevised 1968 and 1974). The proportions and dimensions of the spillway and dam were developed from surveys made during the inspection. Sizes and locations of storm sewers were obtained from construction plans prepared by Hellmuth, Obata & Kassabaum, issue date October 16, 1974. Records of rainfall, streamflow, or flood data for the watershed were not available.

Due to the fact that the watershed for this reservoir is small and since there is no history of excessive reservoir leakage that would adversely affect the normal operating 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 PMF 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.

c. Visual Observations.

(1) The spillway, a paved concrete, trapezoidal section, is located about 50 feet left of the centerline of the dam. A concrete curb section approximately 17.5 feet wide governs the normal level of the lake. A concrete trapezoidal chute section with a 6-foot wide bottom width conveys lake outflow down the downstream face of the dam and for about 53 feet down the valley floor downstream of the toe of the dam. A stone and concrete riprap trapezoidal section extends about 60 feet beyond the end of the chute section.

(2) A concrete weir that bridges the spillway section is located approximately 16 feet upstream of the crest section, and a timber footbridge crosses the spillway at a point about 6 feet upstream of the crest.

(3) Spillway releases within the capacity of the spillway section should not endanger the dam.

(4) Pipe storm sewer systems, installed in conjunction with the development of the site by the General American Life Insurance Company, which serve the parking lots and areas adjacent to the building, discharge into the lake. An 8-inch sanitary sewer serving the building crosses the upper reach of the lake and extends southwardly adjacent to the east side of the lake as a 10-inch sewer. A plan of the storm and sanitary sewers is shown on Plate 8. The storm sewer systems are also shown on Plate 3.

d. Overtopping Potential. The spillway is inadequate to pass the probable maximum flood, or 1/2 of the probable maximum flood, without overtopping the dam. The spillway is adequate, however, to pass the 1 percent probability (100-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. 572.9)	Duration of Overtopping of Dam (Hours)
0.50	254	573.2	0.3	0.4
1.00	787	573.8	0.9	1.0
1% Probability Flood	87	572.1	0.0	0.0

The lowest point in the dam crest was found to be elevation 572.9. The flow safely passing the spillway just prior to overtopping was determined to be approximately 183 cfs, which is the routed outflow corresponding to about 41 percent of the probable maximum flood inflow. During peak flow of the probable maximum flood, the greatest depth of flow over the dam is projected to be 0.9 foot and overtopping is estimated to extend across the central 455 feet of the dam.

e. Evaluation. Experience with embankments constructed of similar material (a silty lean clay of low-to-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 PMF when large lake outflow, accompanied by high flow velocities, occurs. Although, for the PMF condition, the depth of flow over the dam crest, a maximum of 0.9 foot, and the duration of flow over the dam, 1.0 hour, are relatively small, due to the erosive nature of this soil, damage to the crest and downstream face of the dam is expected. The extent of these damages is not predictable within the scope of these investigations; however, there is a possibility that they could result in failure by erosion of the dam. For the one-half PMF condition, since the maximum depth of flow over the dam is but 0.3 of a foot and the duration of flow over the dam is only 0.4 of an hour, it is unlikely that the extent of the damage to the embankment would result in failure of the dam.

f. References. Procedures and data for determining the probable maximum flood, the 1 percent probability (100-year frequency) flood and the discharge rating curve for flow passing the spillway are presented on pages B-1 through B-7 of the Appendix. Listings of the HEC-1 (Dam Safety Version) input data for both the probable maximum flood and the 1 percent probability (100-year frequency) flood are shown on pages B-8 through B-10. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-11 through B-14; tabulation of lake surface area, elevation and storage volume is shown on page B-15 and tabulations titled "Summary of Dam Safety Analysis" for the PMF and 1 percent probability (100-year frequency) flood are also shown on page B-15.

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. Design and construction data relating to the structural stability of the dam are discussed in Section 2, paragraphs 2.1a and 2.2.

c. Operating Records. With the exception of the valve on the lake drawdown pipe, no appurtenant structures or facilities requiring operation exist at this dam. According to Mr. Edward J. Hogan, Director of St. Louis Properties for the Owner, no records are kept of the lake level, spillway discharge, dam settlement, or seepage.

d. Post Construction Changes. According to Mr. Hogan, the concrete curb extending across the spillway structure was constructed in 1976 in order to raise the normal level of the lake approximately 1 foot. Mr. Hogan indicated that no other 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 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 earth 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 183 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 probable maximum flood magnitude, the recommended spillway design flood for this dam, the lake outflow would be about 787 cfs, and that for the 1 percent probability (100-year frequency) flood, the lake outflow would be about 87 cfs.

Several items were noticed during the inspection that could adversely affect the safety of the dam. These items include small trees, areas of high grass on the downstream face of the dam, erosion of the downstream face of the dam, erosion of the embankment adjacent to and beneath the spillway outlet chute, as well as erosion of areas adjacent to the downstream toe of the dam, and ineffective drainage of seepage in the vicinity of the downstream toe of the dam.

b. Adequacy of Information. Except as noted, the assessments regarding the general condition of the dam as reported herein were based largely 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.

Certain stability analyses were performed during the design of this dam. However, a review of available data indicated that these analyses do not conform precisely to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" in that not all of the prescribed conditions of loading were investigated. Therefore, it is recommended that these stability analyses be reviewed, and that all conditions of loading, including earthquake, be considered. Any "as-built" deviations from the original plans should also be included when these investigations are made.

Although no indication was found that detailed seepage analyses were performed for this dam, it was determined that certain provisions, such as a seepage cutoff trench, a toe drain system, and blanketing of exposed bedrock in the original stream within the reservoir, were made in the design and construction of the embankment in order to minimize the effects of seepage. Observations made during the visual inspection indicated that no significant seepage problems existed. Therefore, the inspection team is of the opinion that detailed seepage analyses of this dam are unnecessary.

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 in the near future. The item recommended in paragraph 7.2a concerning provision of additional spillway capacity should be pursued on a high priority basis.

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

e. Seismic Stability. The dam is located within a Zone II seismic probability area. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earth 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 probable maximum flood magnitude.

(2) Review and supplement as necessary the original stability analyses performed for the design of this dam. Stability analyses should be

performed for all operational conditions, including earthquake, and made a matter of record.

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

(1) Remove the trees from the dam. Maintain the grass on the dam at a height that will not conceal animal burrows or hinder inspection of the dam. Tree roots and animal burrows can provide passageways for lake seepage that could lead to a piping condition (progressive internal erosion) and possible failure of the dam.

(2) Restore the eroded areas of the downstream face of the dam and provide some type of grass cover that will prevent future erosion by overland drainage. Loss of embankment material by erosion can impair the structural stability of the dam.

(3) Seal all cracks and joints in the concrete spillway chute in order to prevent loss of subgrade material by spillway flows entering these openings and undercutting the slab. The eroded areas beneath the spillway chute should be restored. Lack of foundation support can result in failure by settlement of the spillway chute and, since the chute is founded on the embankment, loss of the subgrade material can also be detrimental to the structural stability of the dam.

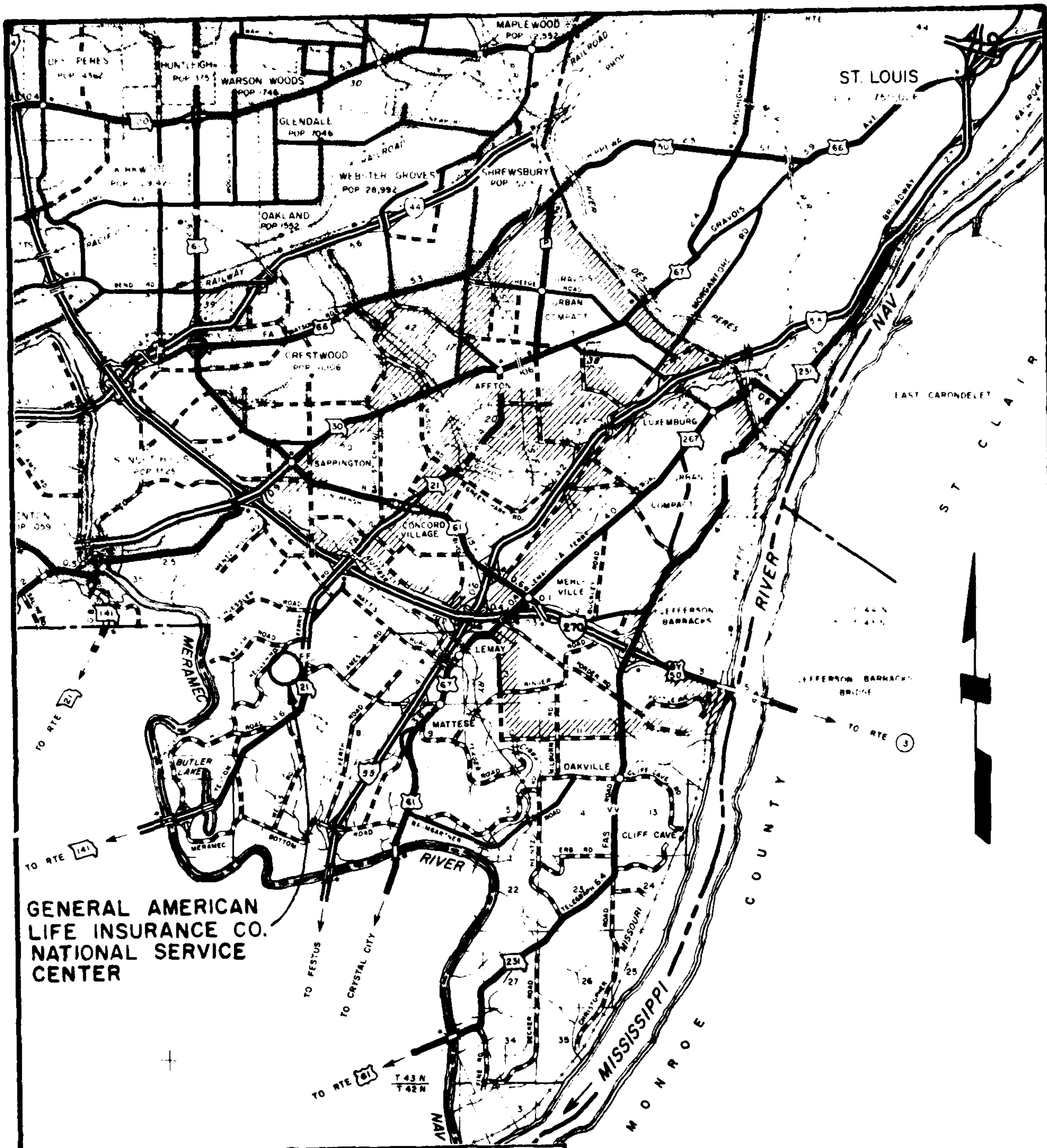
(4) Restore the eroded areas of the abutments adjacent to the downstream toe of the dam. Provide some type of slope protection and positive drainage system that will prevent future erosion of these areas as well as saturation of these areas by standing water. Loss of material and saturation of foundation areas adjacent to the dam are conditions considered to be unfavorable to the structural stability of the dam.

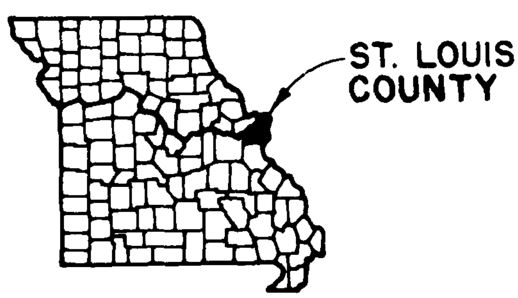
(5) The existing gravel riprap is considered too small to permanently resist the forces produced by wave action; however, it is suitable to prevent waves from washing out the underlying embankment material provided that it is covered by a larger size stone to insure its stability.

Therefore, cover the existing riprap with stone large enough to insure the stability of the gravel under adverse wave action conditions.

(6) 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.

(7) 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

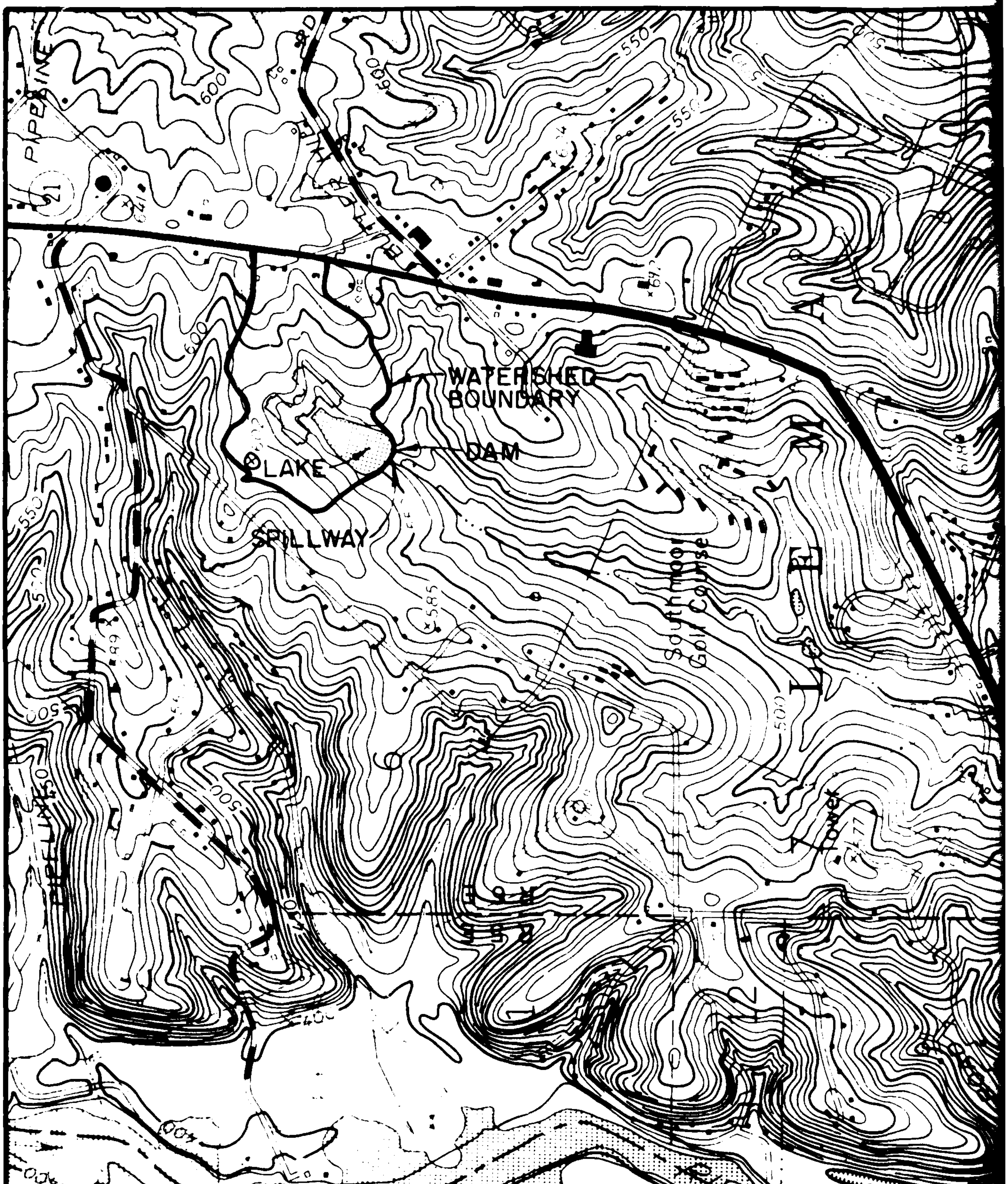
GENERAL AMERICAN LIFE
INSURANCE CO.

0 1 2 3 4

SCALE (MILES)

REGIONAL VICINITY MAP

PLATE I



WATERSHED BOUNDARY
DAM
LAKE
SPILLWAY
PIPELINE
Southmoor Golf Course
MERAMEC RIVER
A=APPROXIMATE EXTENT OF DOWNSTREAM FLOOD DAMAGE ZONE

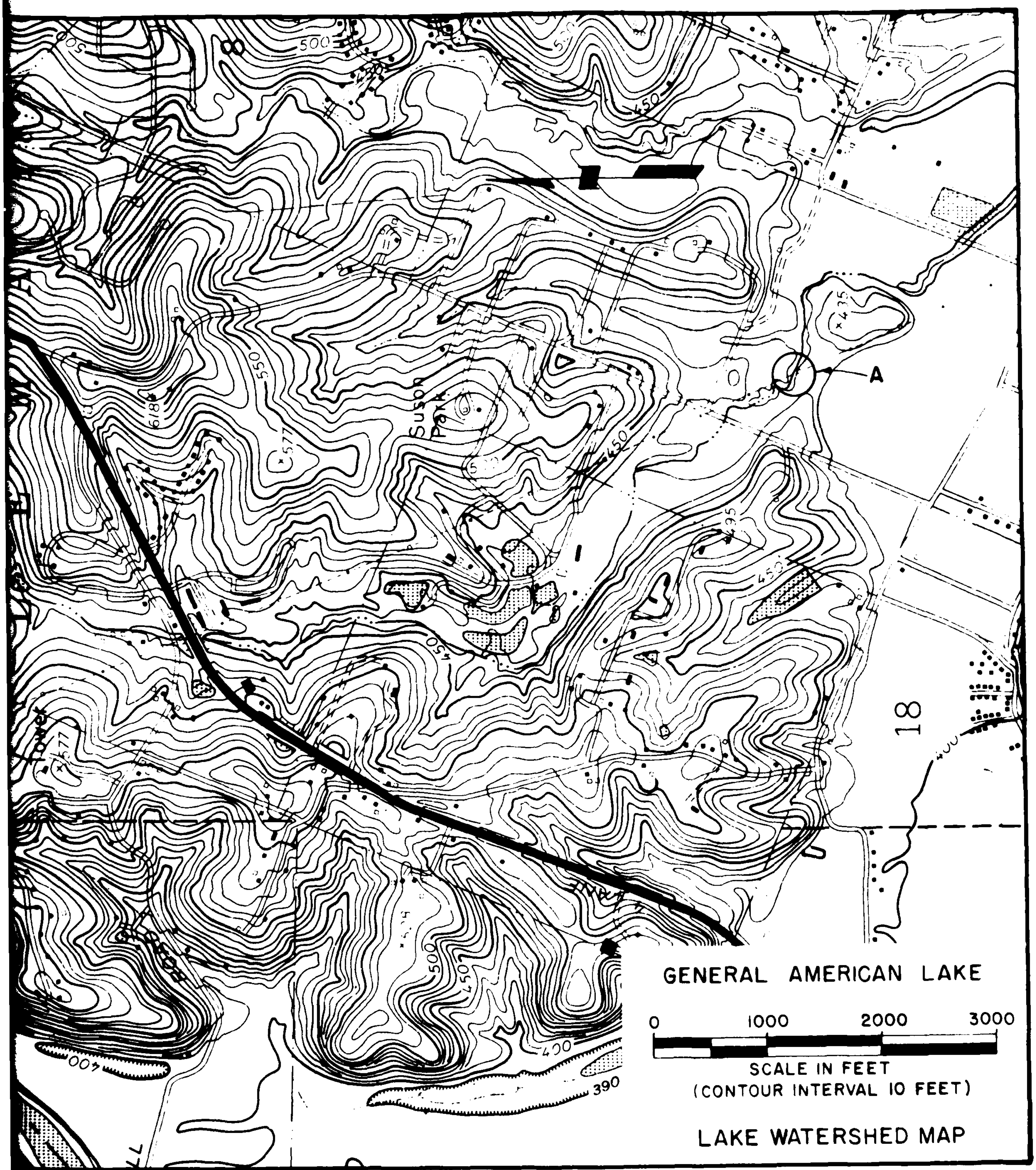
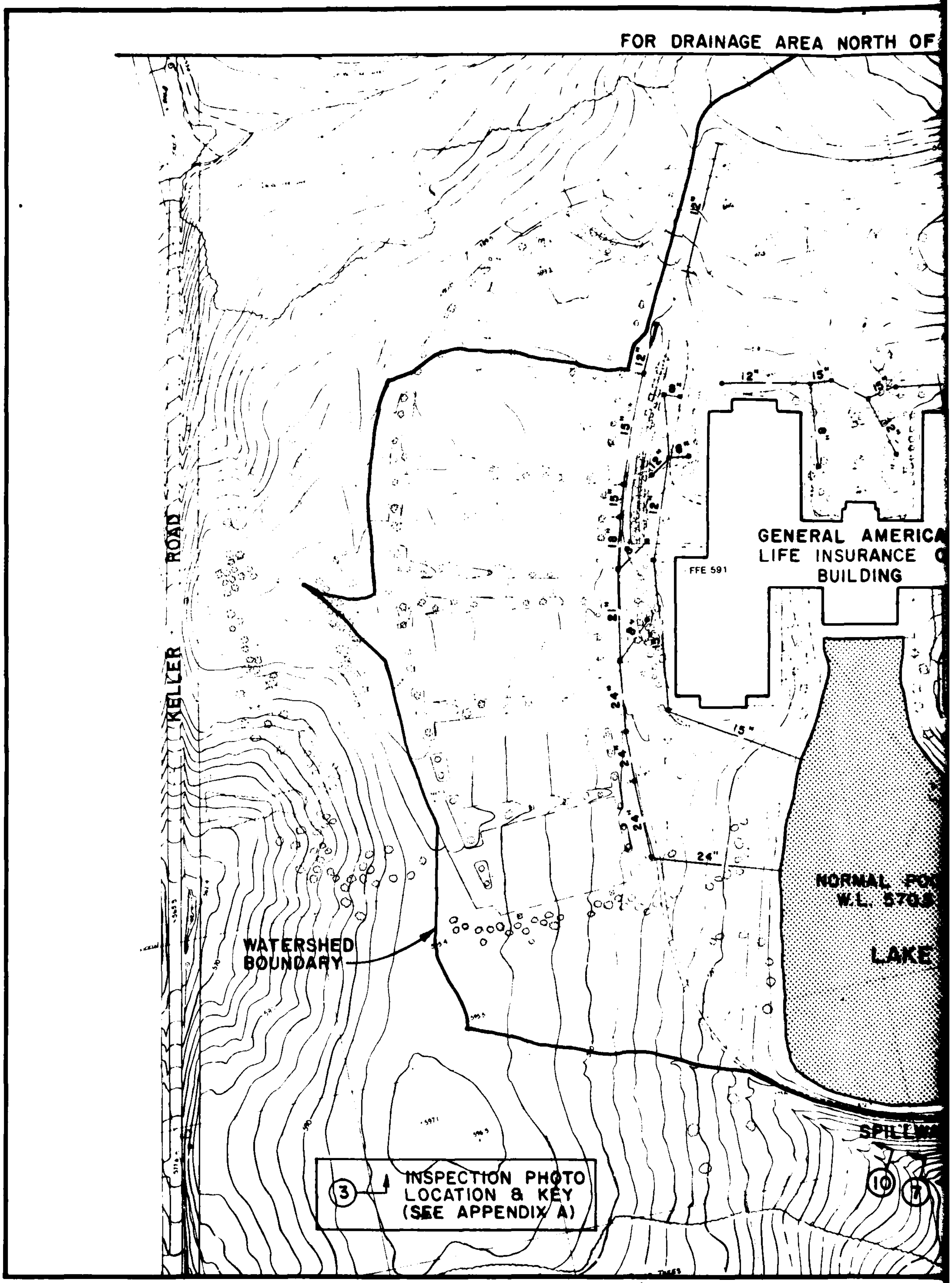
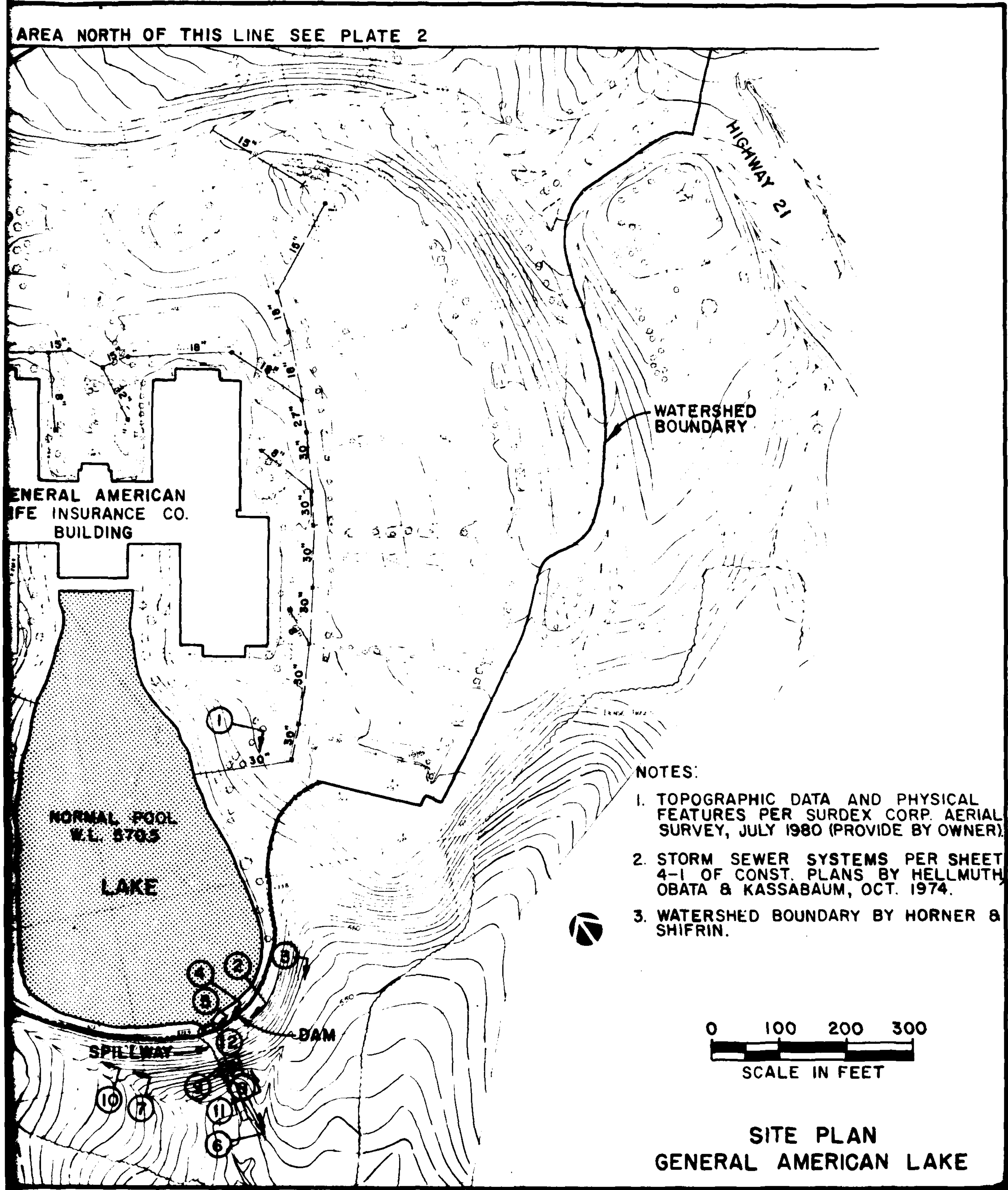

A
18
GENERAL AMERICAN LAKE
0
1000
2000
3000
SCALE IN FEET
(CONTOUR INTERVAL 10 FEET)
LAKE WATERSHED MAP

PLATE 2

2



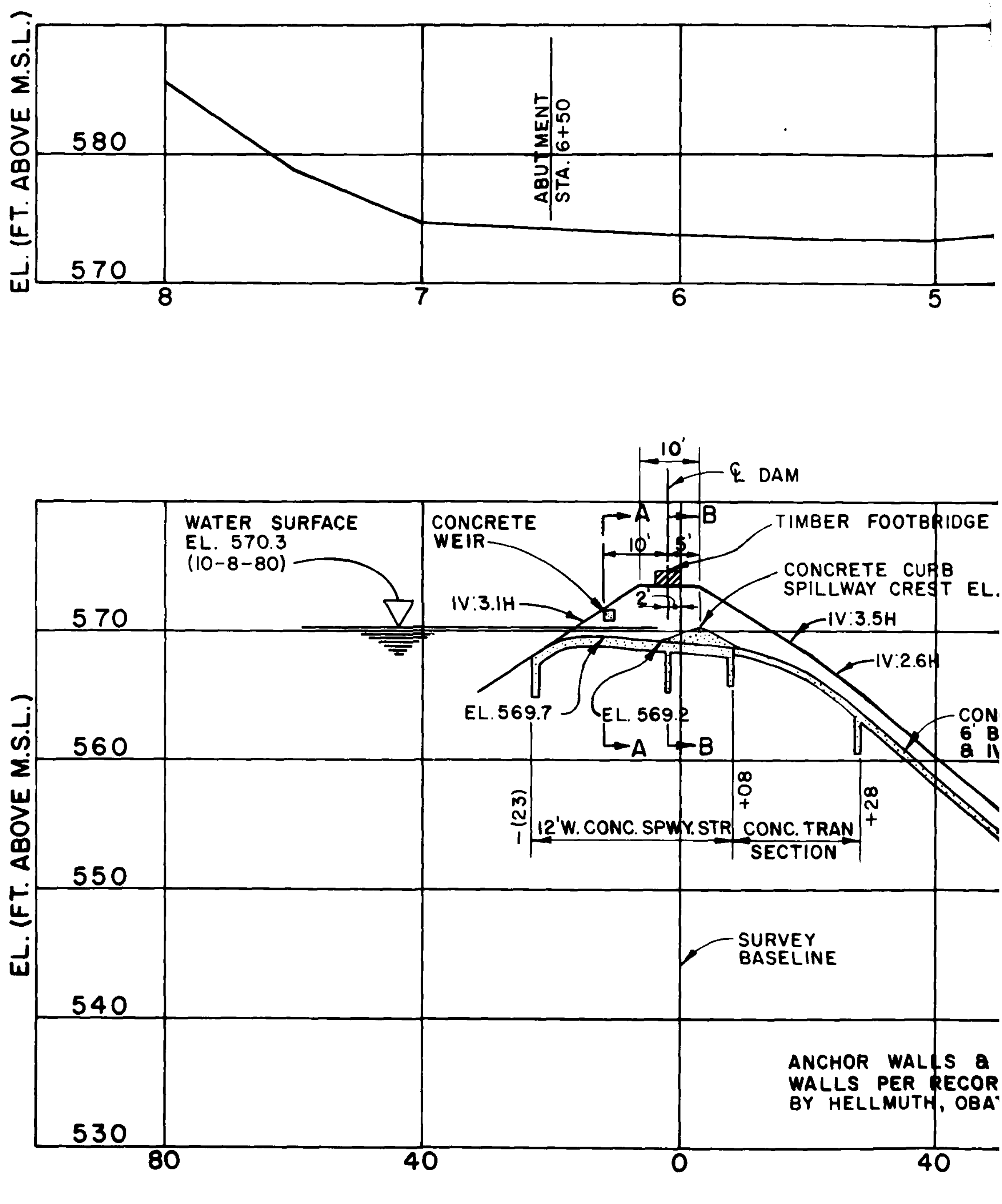
FOR DRAINAGE AREA NORTH OF
KELLER ROAD
GENERAL AMERICA
LIFE INSURANCE C
BUILDING
FFE 591
NORMAL PO
W.L. 570.
LAKE
SPILLW
WATERSHED BOUNDARY
INSPECTION PHOTO LOCATION & KEY (SEE APPENDIX A)



SITE PLAN
GENERAL AMERICAN LAKE

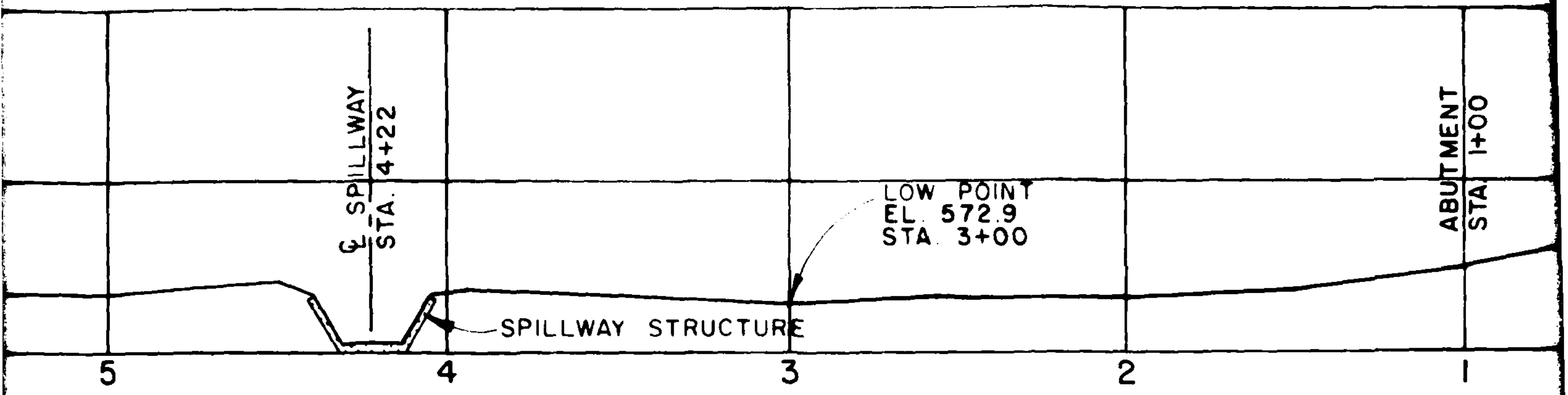
2

PLATE 3

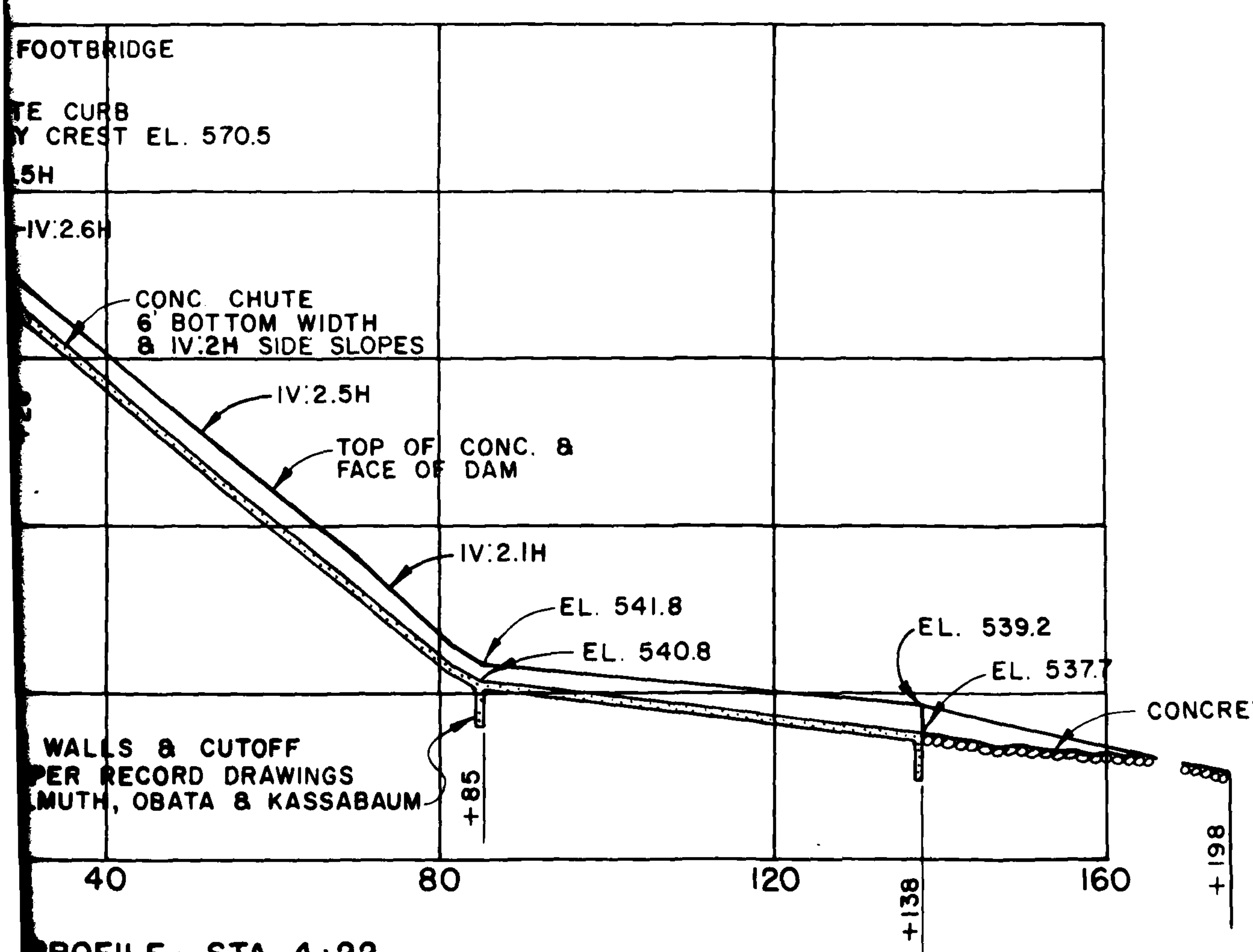


SPILLWAY PROFILE -

SCALE: 1"=10'V., 1"=



PROFILE DAM CREST
SCALE: 1"=10'V., 1"=50'H.

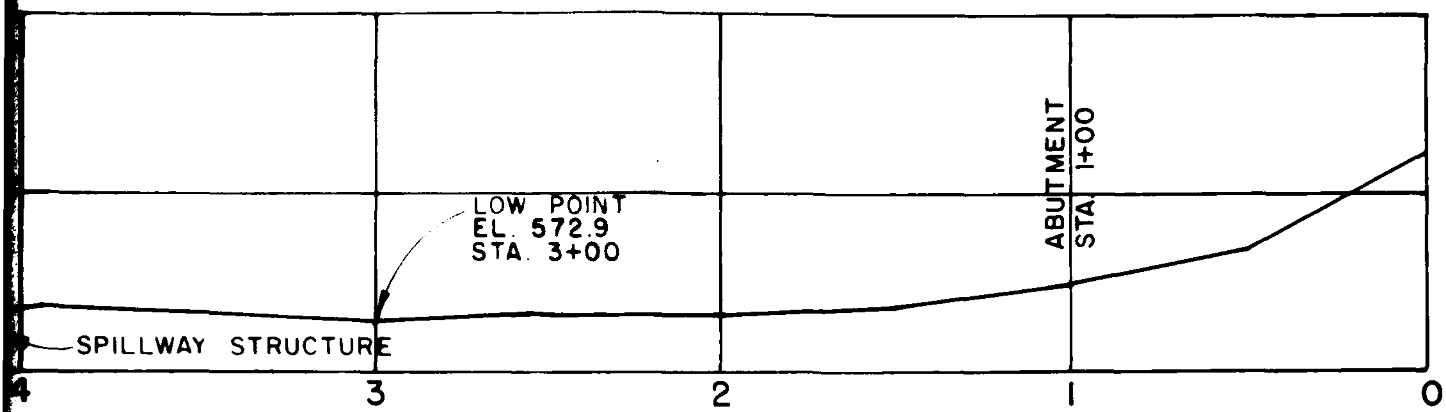


PROFILE – STA. 4+22
1"=10'V., 1"=20'H.

GENERAL A
DAM CRE
SPILLWA
Horner & Shifrin,

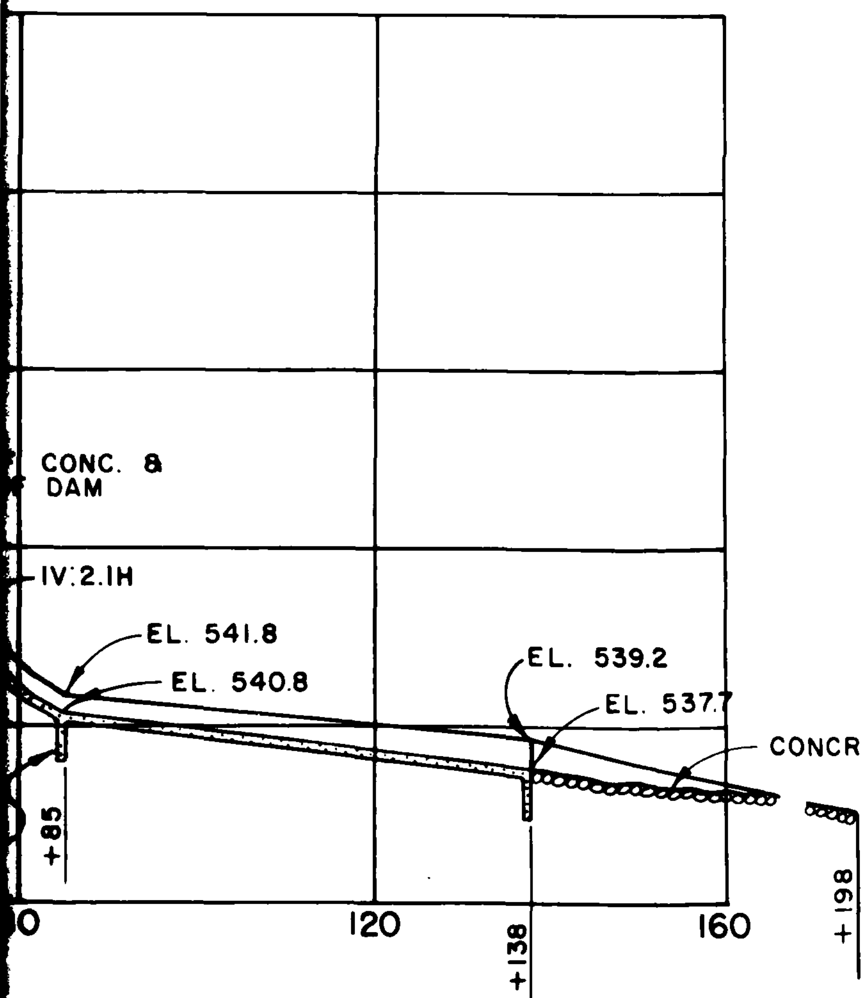
1

2



DAM CREST

V., 1" = 50' H.



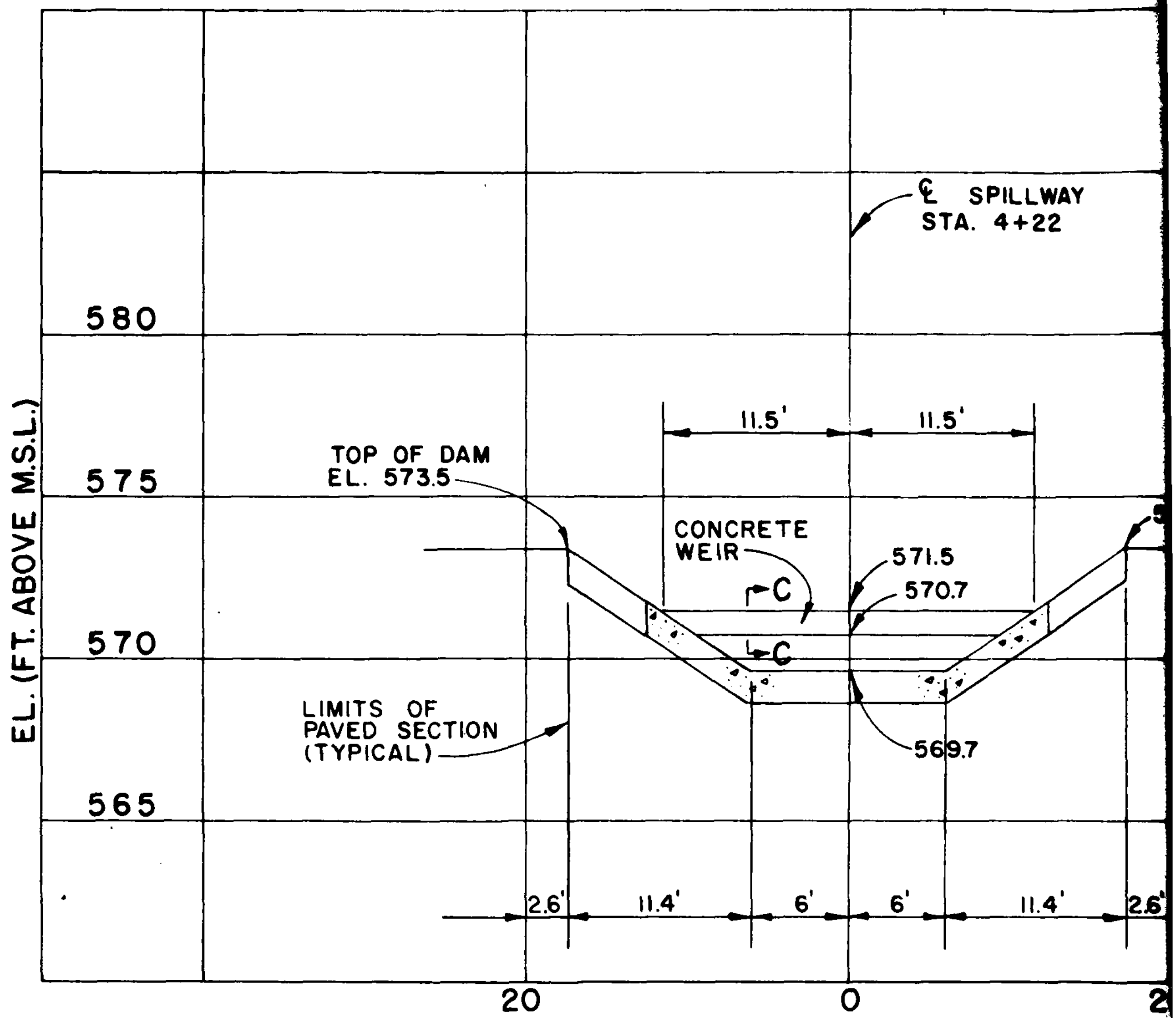
GENERAL AMERICAN LAKE
DAM CREST PROFILE
SPILLWAY PROFILE

Horner & Shifrin, Inc. Oct. 1980

2

PLATE 4

3

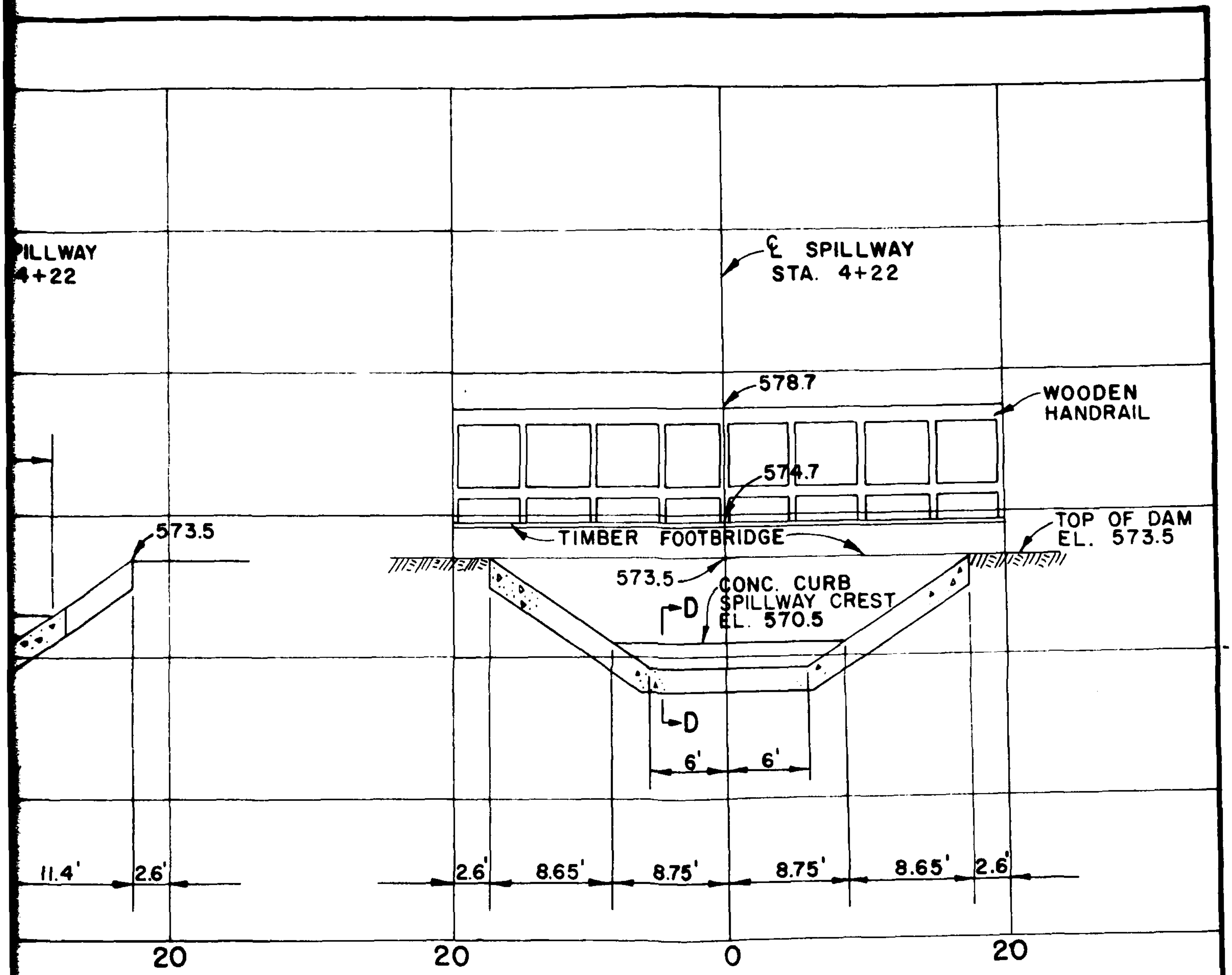


SPILLWAY SECTION A

SCALES: 1" = 5' V., 1" = 10' H.

SECTION C-C

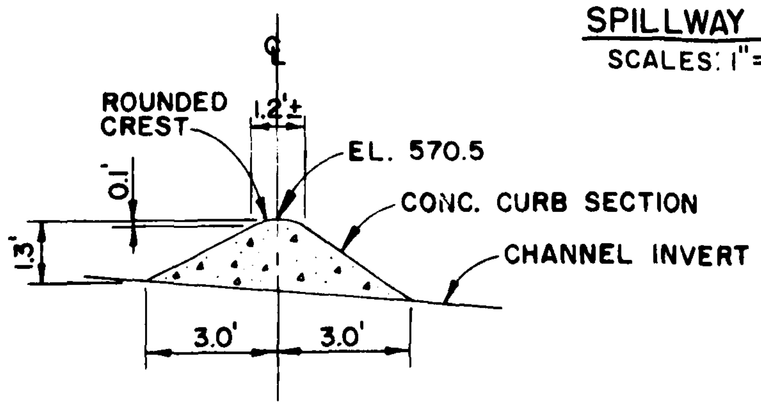
SCALE: 1" = 4'



A

SPILLWAY SECTION B

SCALES: 1"=5' V., 1"=10' H.



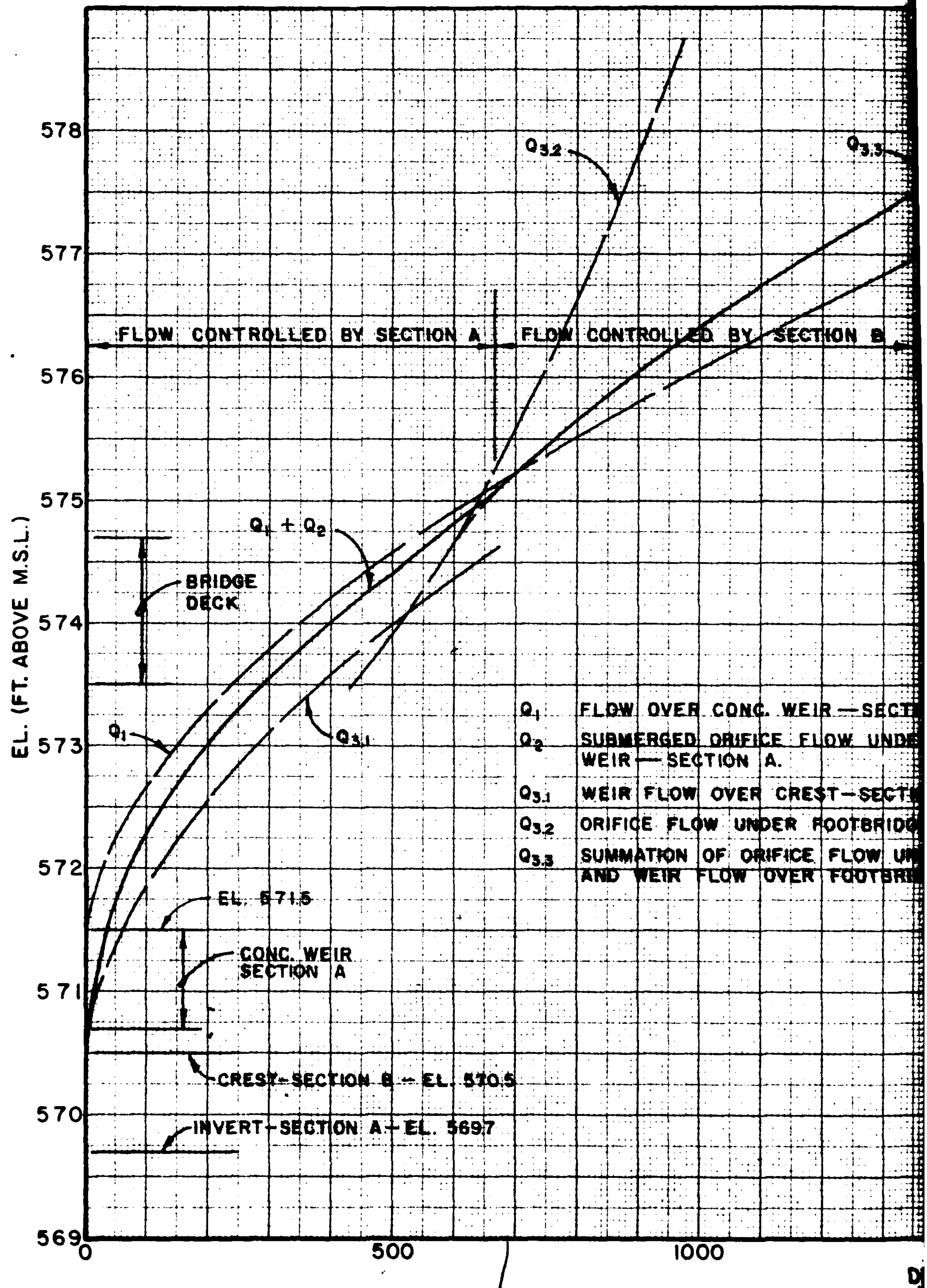
SECTION D-D

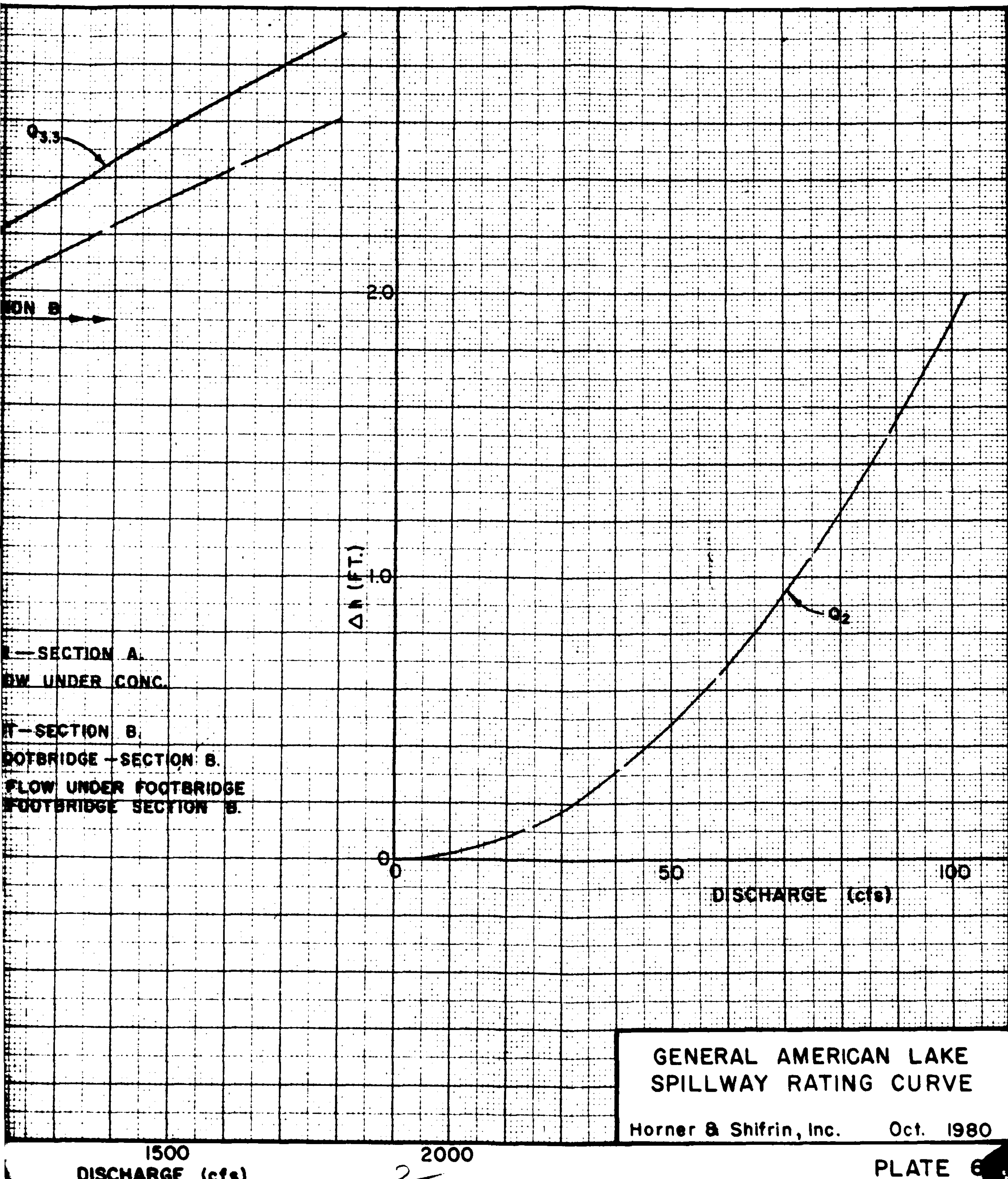
SCALE: 1"=4'

GENERAL AMERICAN LAKE
SPILLWAY SECTIONS

Horner & Shifrin, Inc. Oct. 1980

PLATE 5


EL. (FT. ABOVE M.S.L.)
578
577
576
575
574
573
572
571
570
569
0
500
1000
D
FLOW CONTROLLED BY SECTION A
FLOW CONTROLLED BY SECTION B
$Q_{3.2}$
$Q_{3.3}$
$Q_1 + Q_2$
BRIDGE DECK
Q_1
$Q_{3.1}$
Q_1 FLOW OVER CONC. WEIR — SECT
Q_2 SUBMERGED ORIFICE FLOW UNDE WEIR — SECTION A.
$Q_{3.1}$ WEIR FLOW OVER CREST — SECTI
$Q_{3.2}$ ORIFICE FLOW UNDER FOOTBRIDG
$Q_{3.3}$ SUMMATION OF ORIFICE FLOW UN AND WEIR FLOW OVER FOOTBRI
EL. 571.5
CONC. WEIR SECTION A
CREST-SECTION B — EL. 570.5
INVERT-SECTION A — EL. 569.7

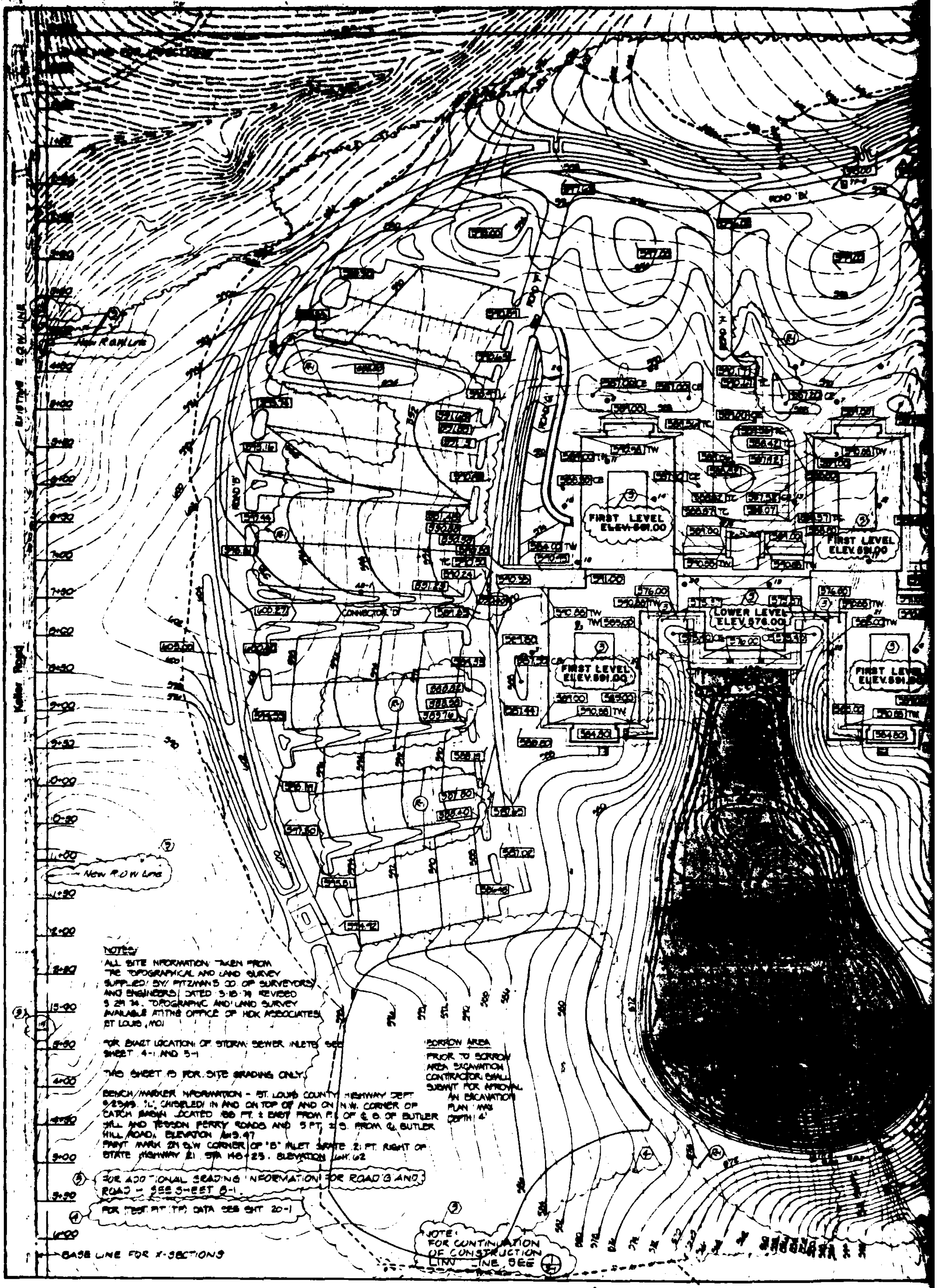


GENERAL AMERICAN LAKE
SPILLWAY RATING CURVE

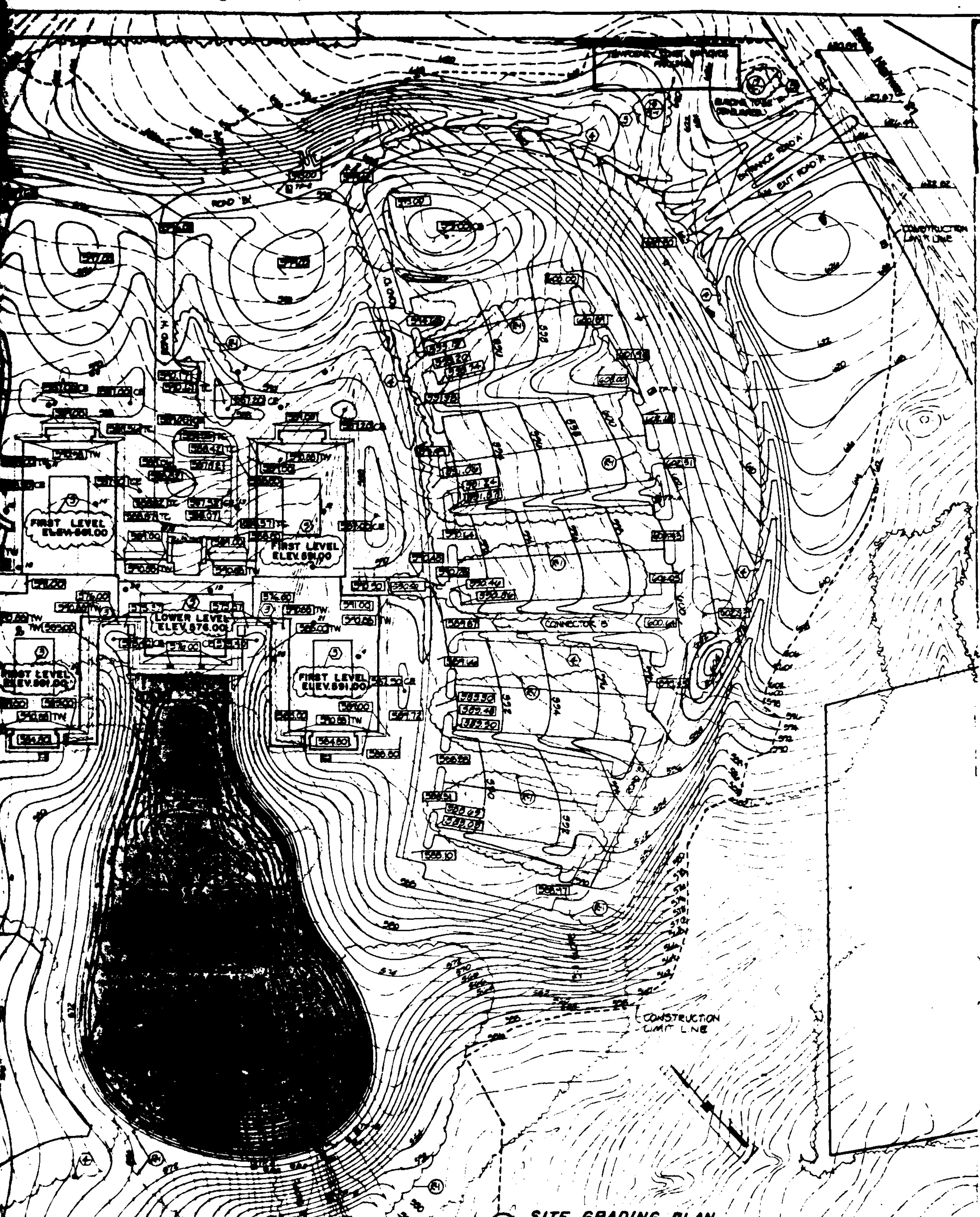
Horner & Shifrin, Inc. Oct. 1980

2

PLATE 6



Keller Road
EXISTING R.O.W. LINE
New R.O.W. Line
New R.O.W. Line
ROAD 'B'
CONNECTOR 'D'
FIRST LEVEL ELEV. 591.00
FIRST LEVEL ELEV. 591.00
FIRST LEVEL ELEV. 591.00
LOWER LEVEL ELEV. 576.00
NOTES:
ALL SITE INFORMATION TAKEN FROM THE TOPOGRAPHICAL AND LAND SURVEY SUPPLIED BY PITZMAN'S CO. OF SURVEYORS AND ENGINEERS, DATED 5-18-74 REVISED 5-29-74. TOPOGRAPHIC AND LAND SURVEY AVAILABLE AT THE OFFICE OF HOK ASSOCIATES, ST LOUIS, MO.
FOR EXACT LOCATION OF STORM SEWER INLETS SEE SHEET 4-1 AND 5-1
THIS SHEET IS FOR SITE GRADING ONLY.
BENCH MARKER INFORMATION - ST. LOUIS COUNTY HIGHWAY DEPT. "L" CHISELED IN AND ON TOP OF AND ON N.W. CORNER OF CATCH BASIN LOCATED 186 FT. ± EAST FROM P.I. OF ℄ OF BUTLER HILL AND TESSON FERRY ROADS AND 5 FT. ± S. FROM ℄ BUTLER HILL ROAD, ELEVATION 619.47
PAINT MARK ON S.W. CORNER OF "B" INLET GRATE 2 FT. RIGHT OF STATE HIGHWAY 21 STA 146+25, ELEVATION 614.62
BORROW AREA
PRIOR TO BORROW AREA EXCAVATION CONTRACTOR SHALL SUBMIT FOR APPROVAL AN EXCAVATION PLAN. MAX. DEPTH 4'
FOR ADDITIONAL GRADING INFORMATION FOR ROAD 'G' AND ROAD - SEE SHEET 6-1.
FOR TEST PIT (TP) DATA SEE SHT 20-1
NOTE: FOR CONTINUATION OF CONSTRUCTION LIMIT LINE SEE
BASE LINE FOR X-SECTIONS



SITE GRADING PLAN

REVISIONS

NO.	DATE
1	[illegible]
2	[illegible]
3	[illegible]
4	[illegible]

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JACK D. GILLUM & ASSOCIATES, ST. LOUIS, MO. — STRUCT. ENGINEERS
SVERDRUP & PARCEL AND ASSOC., INC., ST. LOUIS, MO. — MECH/ELEC. ENGINEERS
HOK ASSOCIATES, ST. LOUIS, MO. — CIVIL ENGINEERS/LANDSCAPE ARCHITECTS
FLAMBERT & FLAMBERT, INC., S.F., CALIF. — FOOD SERVICE CONSULTANTS

NATIONAL SERVICE CENTER

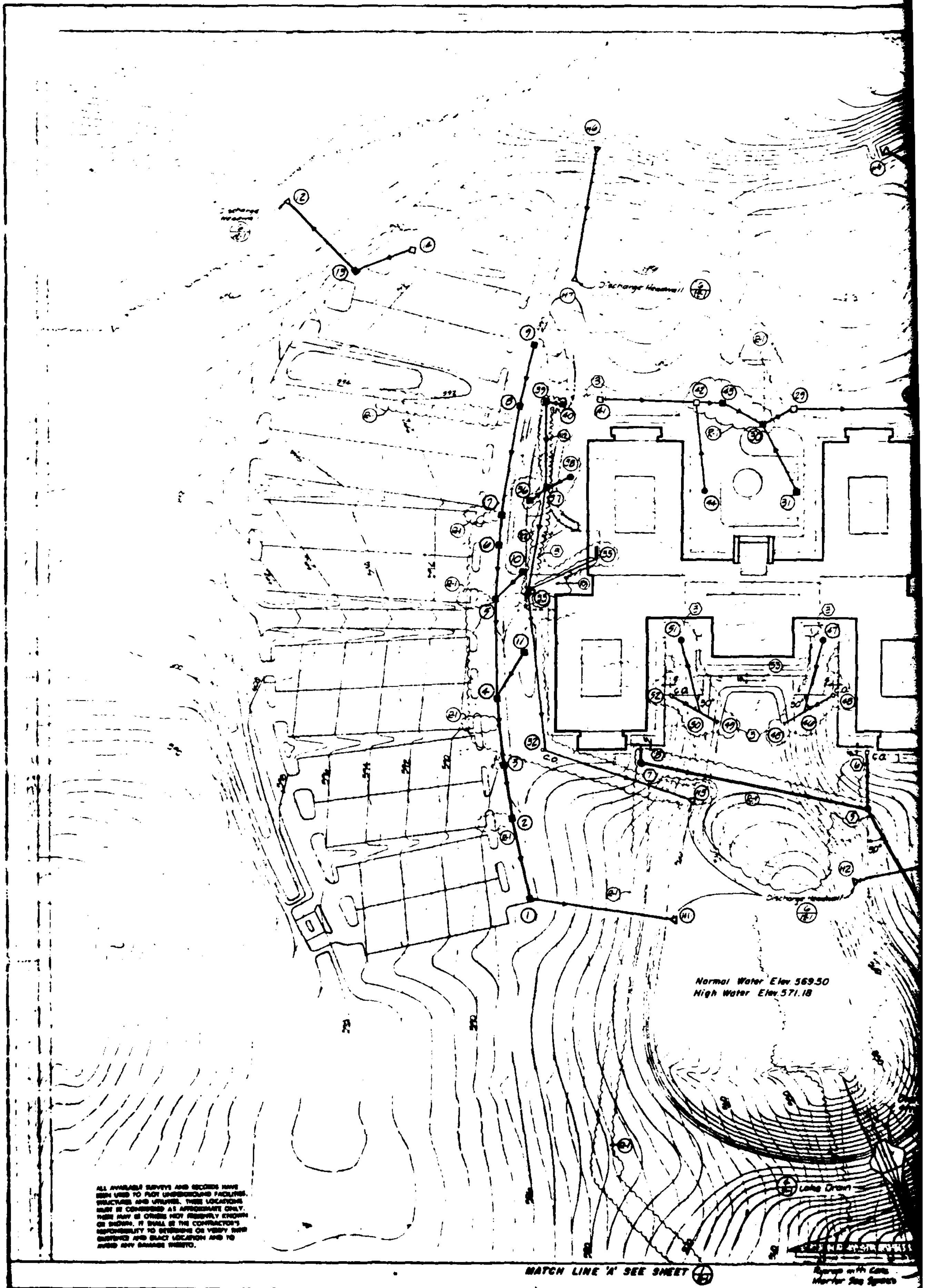
GENERAL AMERICAN LIFE INSURANCE COMPANY — ST. LOUIS

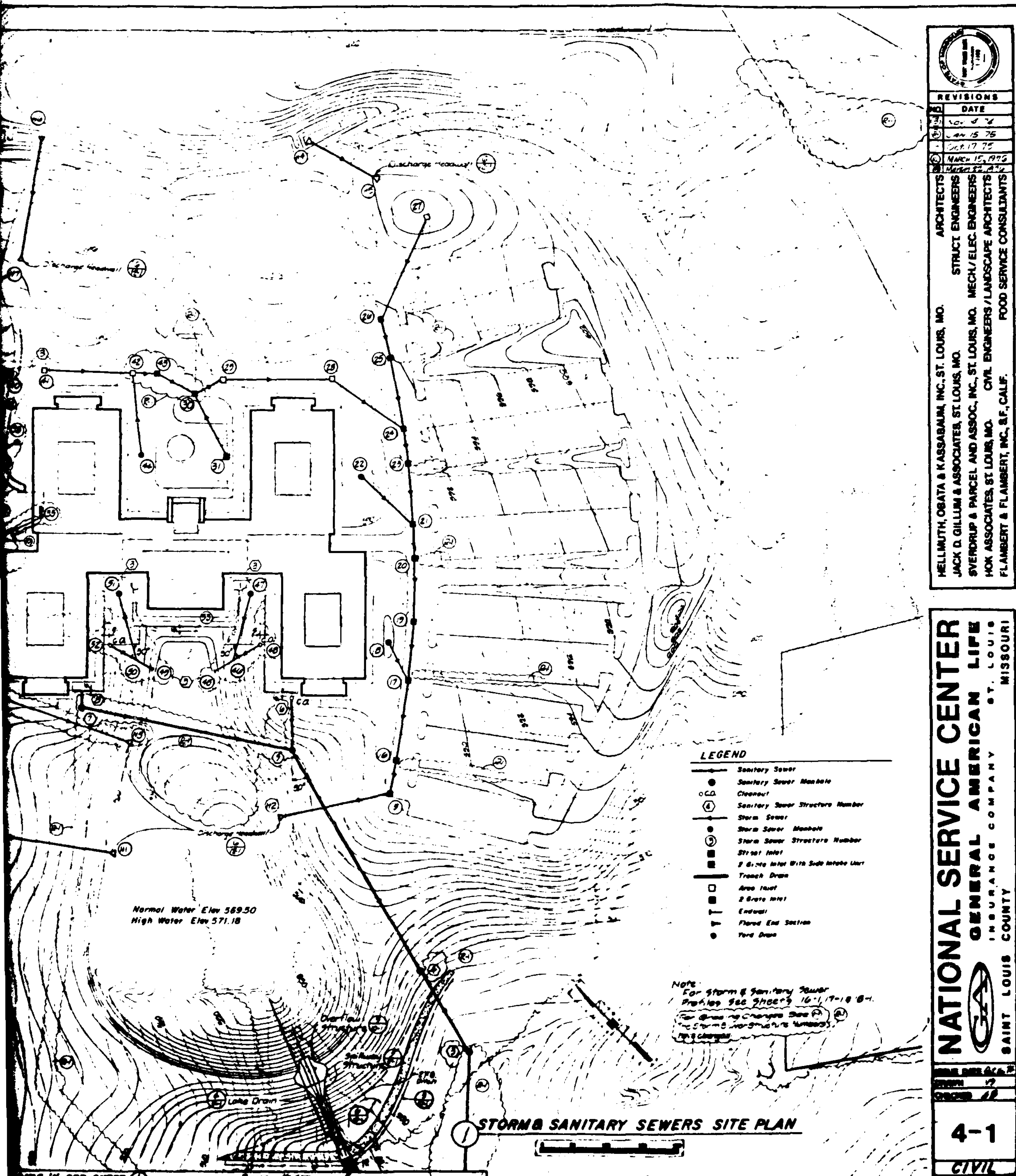
SAINT LOUIS COUNTY — MISSOURI

ISSUE DATE [illegible]
DRAWN [illegible]
CHECKED [illegible]

1-1

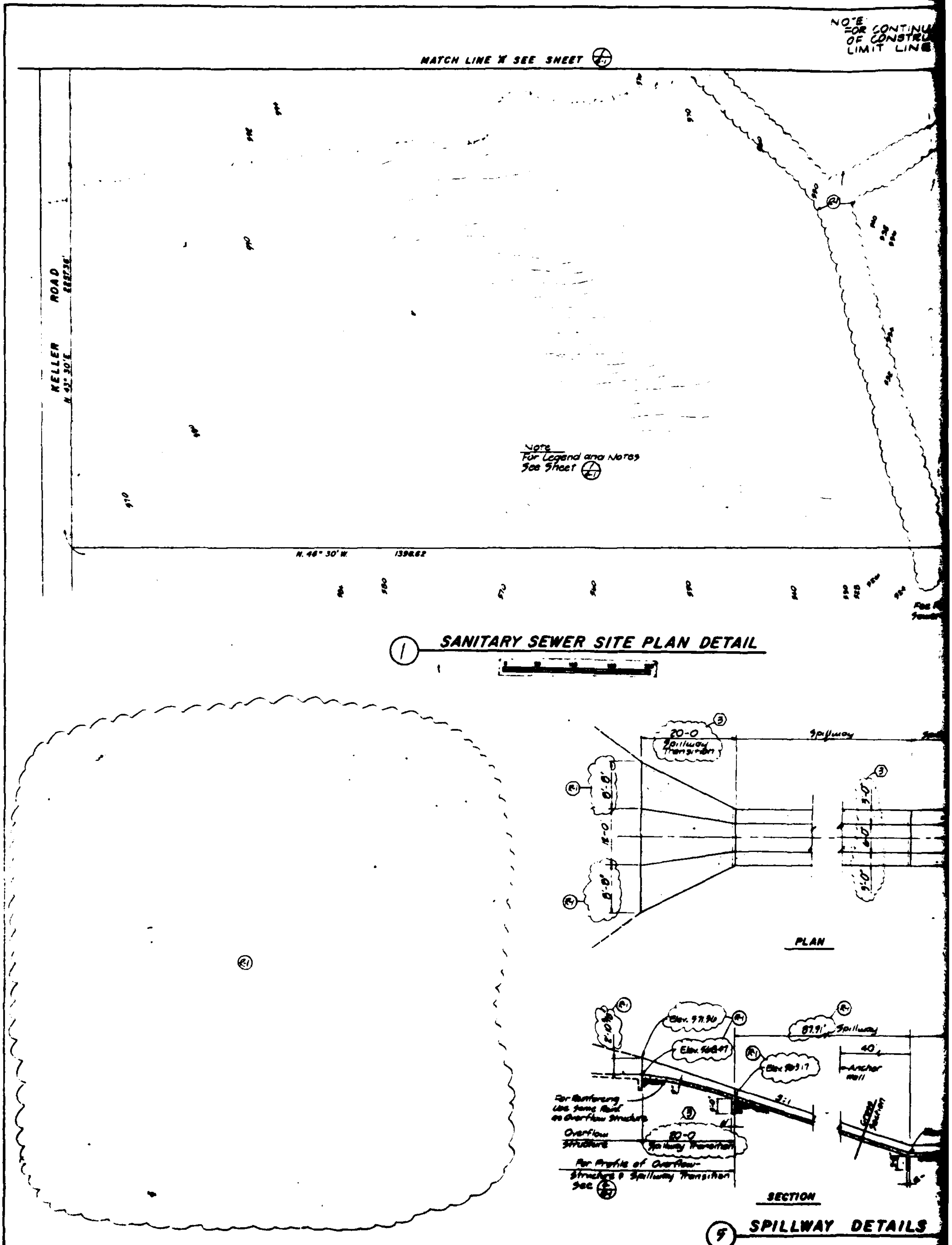
CIVIL

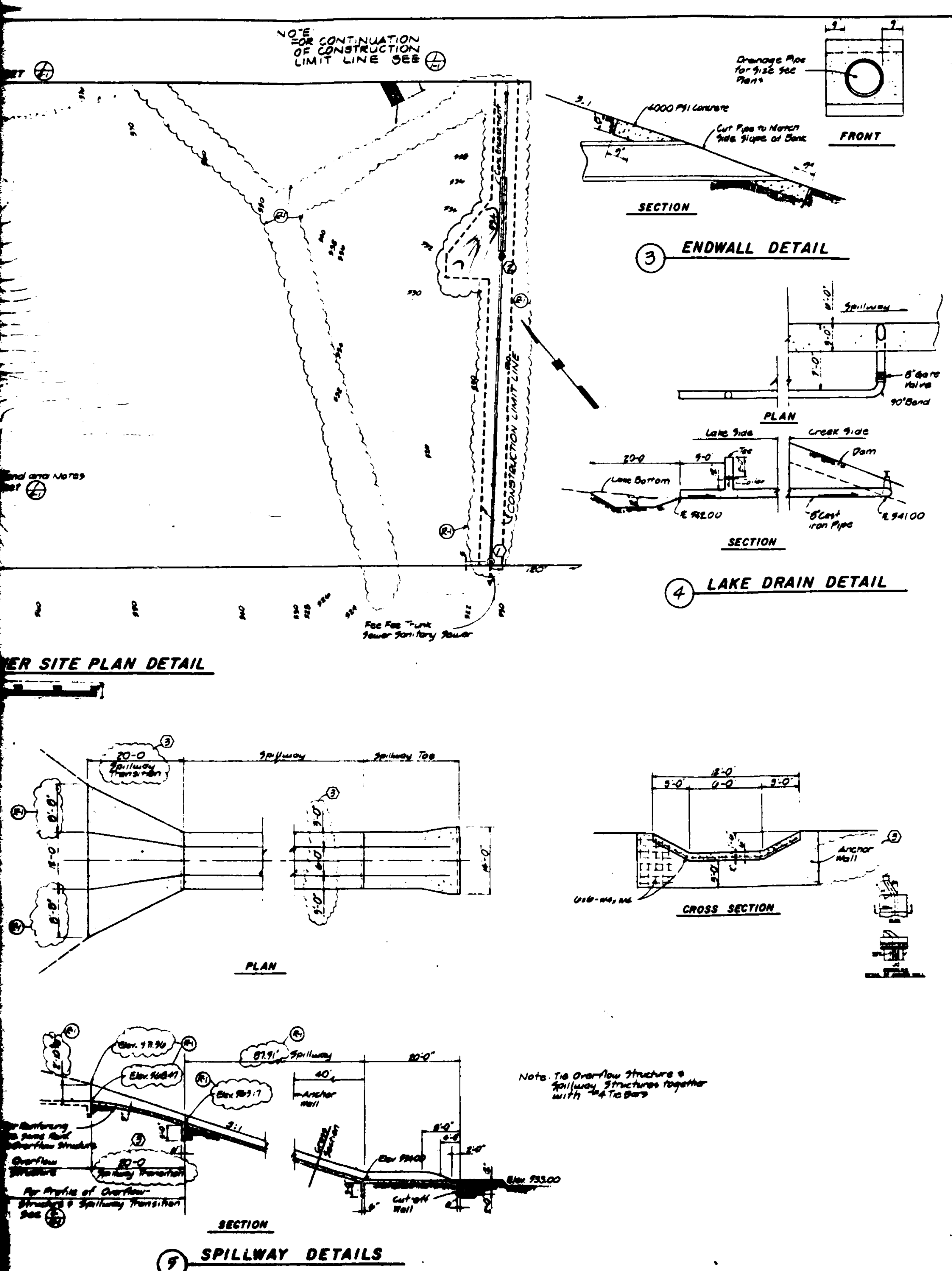

Discharge Headwall
Normal Water Elev. 569.50
High Water Elev. 571.18
Lake Drain
ALL AVAILABLE SURVEYS AND RECORDS HAVE BEEN USED TO PLOT UNDERGROUND FACILITIES, STRUCTURES AND UTILITIES. THESE LOCATIONS MUST BE CONSIDERED AS APPROXIMATE ONLY. THERE MAY BE OTHERS NOT PRESENTLY KNOWN OR SHOWN. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO DETERMINE OR VERIFY THEIR EXISTENCE AND EXACT LOCATION AND TO AVOID ANY DAMAGE THERETO.
MATCH LINE 'A' SEE SHEET



Discharge Headwall
Normal Water Elev 569.50
High Water Elev 571.18
Overflow Structure
Spillway Structure
Lake Drain
LEGEND
Sanitary Sewer
Sanitary Sewer Manhole
Cleanout
Sanitary Sewer Structure Number
Storm Sewer
Storm Sewer Manhole
Storm Sewer Structure Number
Street Inlet
2 Grate Inlet With Side Intake Unit
Trench Drain
Area Inlet
2 Grate Inlet
Endwall
Flared End Section
Yard Drain
Note
For Storm & Sanitary Sewer Profiles See Sheets 16-1, 17-1 & 18-1.
STORM & SANITARY SEWERS SITE PLAN
REVISIONS
NO. DATE
March 15, 1976
HELLMUTH, OBATA & KASSABAUM, INC., ST. LOUIS, MO. ARCHITECTS
JACK D. GILLUM & ASSOCIATES, ST. LOUIS, MO. STRUCT. ENGINEERS
SVERDRUP & PARCEL AND ASSOC., INC., ST. LOUIS, MO. MECH./ELEC. ENGINEERS
HOK ASSOCIATES, ST. LOUIS, MO. CIVIL ENGINEERS / LANDSCAPE ARCHITECTS
FLAMBERT & FLAMBERT, INC., S.F., CALIF. FOOD SERVICE CONSULTANTS
NATIONAL SERVICE CENTER
GENERAL AMERICAN LIFE INSURANCE COMPANY ST. LOUIS
SAINT LOUIS COUNTY MISSOURI
4-1
CIVIL

PLATE 8


NOTE: FOR CONTINU
OF CONSTRU
LIMIT LINE
MATCH LINE X SEE SHEET
KELLER ROAD
N 43° 30' E
Note
For Legend and Notes
See Sheet
N. 46° 30' W.
1398.62
SANITARY SEWER SITE PLAN DETAIL
20-0
Spillway Transition
Spillway
PLAN
Elev. 97.96
Elev. 968.47
Elev. 965.17
87.91' Spillway
40'
Anchor Wall
For Reinforcing Use Same Reinf. as Overflow Structure
Overflow Structure
20-0
Spillway Transition
For Profile of Overflow Structure & Spillway Transition See
2:1
SECTION
SPILLWAY DETAILS



REVISIONS

NO.	DATE
2	Nov 4 '76
3	Jan 15 '75

HELLMUTH, OBATA & KASSABAUM, INC., ST. LOUIS, MO. — ARCHITECTS
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NATIONAL SERVICE CENTER

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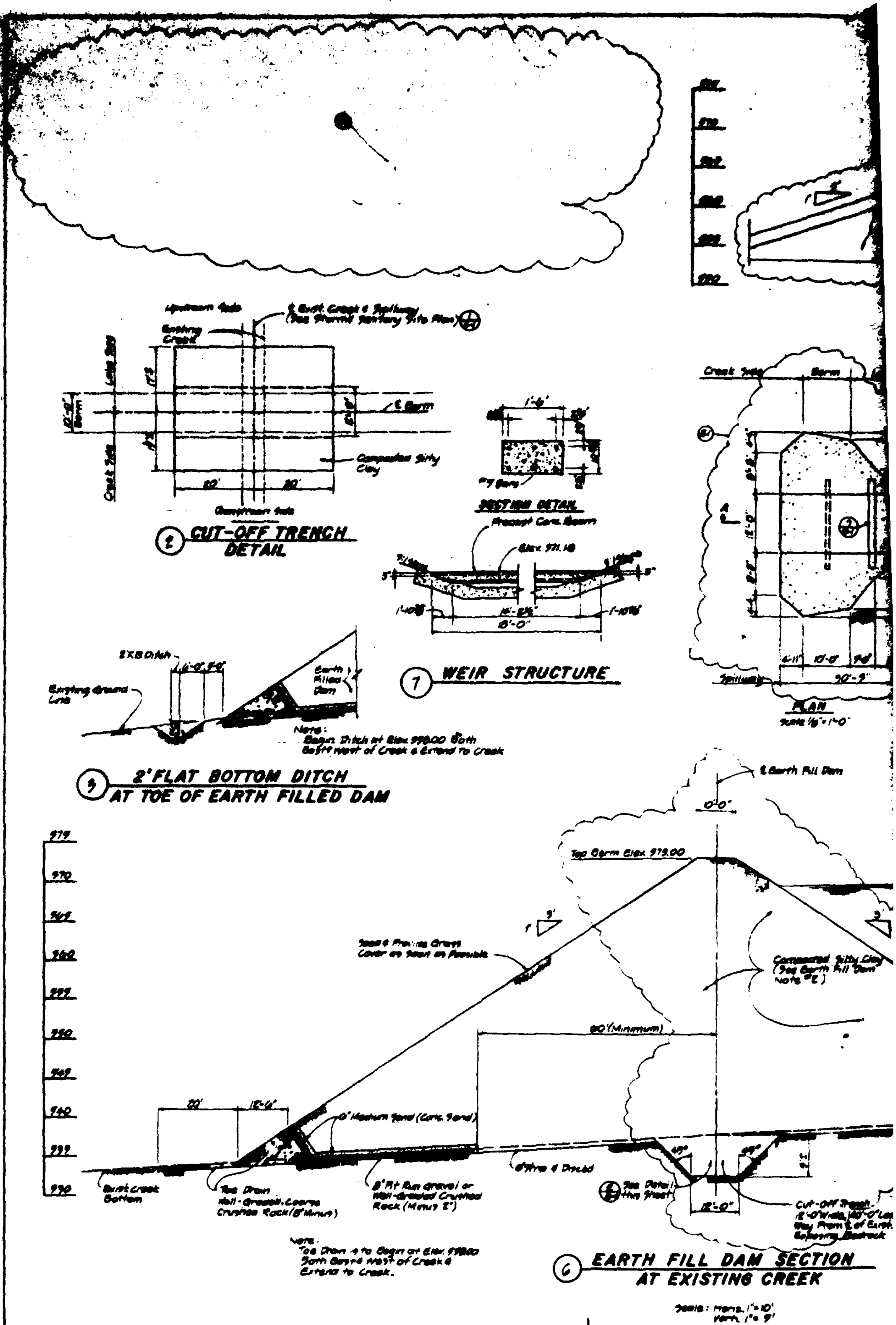
INSURANCE COMPANY — ST. LOUIS

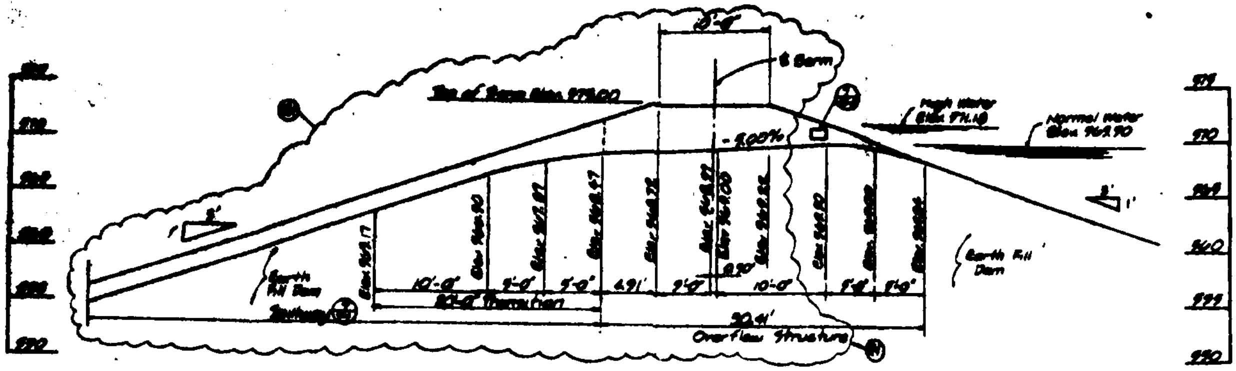
SAINT LOUIS COUNTY — MISSOURI

5-1

CIVIL

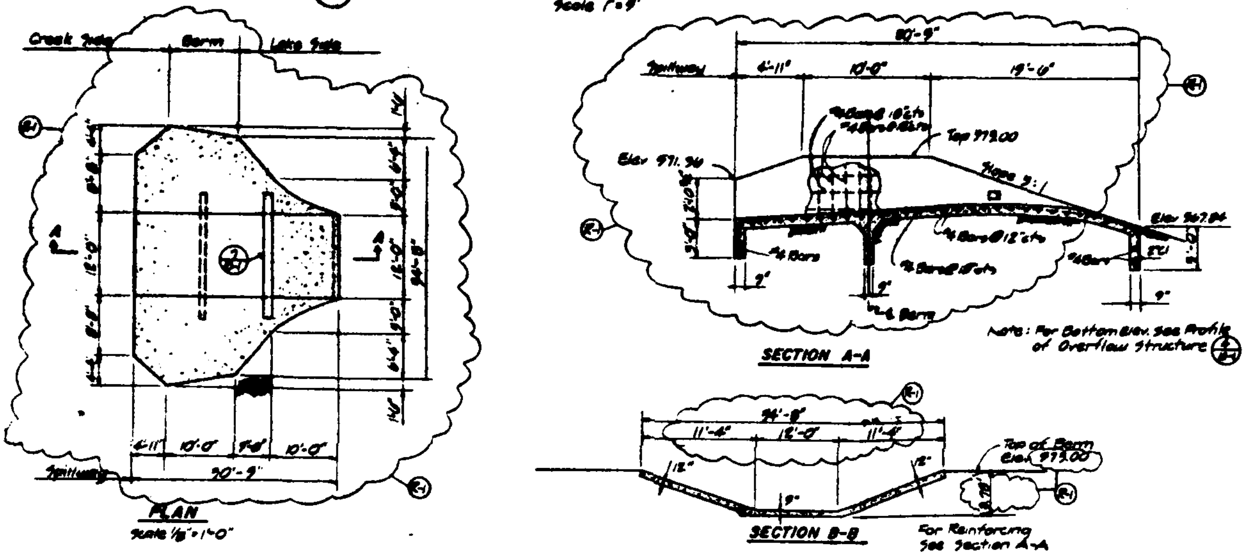
PLATE 9


Upstream Side
℄ Exist. Creek & Spillway (See Storm Sanitary Site Plan)
Existing Creek
Lake Side
Creek Side
℄ Berm
Compacted Silty Clay
20'
20'
Downstream Side
CUT-OFF TRENCH DETAIL
1'-6"
#7 Bars
SECTION DETAIL
Precast Conc. Beam
Elev. 971.10
10'-0"
WEIR STRUCTURE
Creek Side
Berm
12'-0"
6'-11"
10'-0"
30'-9"
Spillway
PLAN
Scale 1/8"=1'-0"
2'x8 Ditch
Existing Ground Line
Earth Filled Dam
Note:
Begin Ditch at Elev. 998.00 Both East & West of Creek & Extend to Creek
2' FLAT BOTTOM DITCH AT TOE OF EARTH FILLED DAM
℄ Earth Fill Dam
10'-0"
Top Berm Elev. 975.00
Seed & Provide Grass Cover as Soon as Possible
Compacted Silty Clay (See Earth Fill Dam Note #2)
80' (Minimum)
20'
12'-6"
6" Medium Sand (Conc. Sand)
Exist. Creek Bottom
Toe Drain Well-Graded Coarse Crushed Rock (8" Minus)
8" Pit Run Gravel or Well-Graded Crushed Rock (Minus 2")
Strip & Discard
45°
45°
12'-0"
See Detail This Sheet
Cut-Off Trench
Note:
Toe Drain is to Begin at Elev. 998.00 Both East & West of Creek & Extend to Creek.
EARTH FILL DAM SECTION AT EXISTING CREEK
Scale: Horiz. 1"=10' Vert. 1"=5'

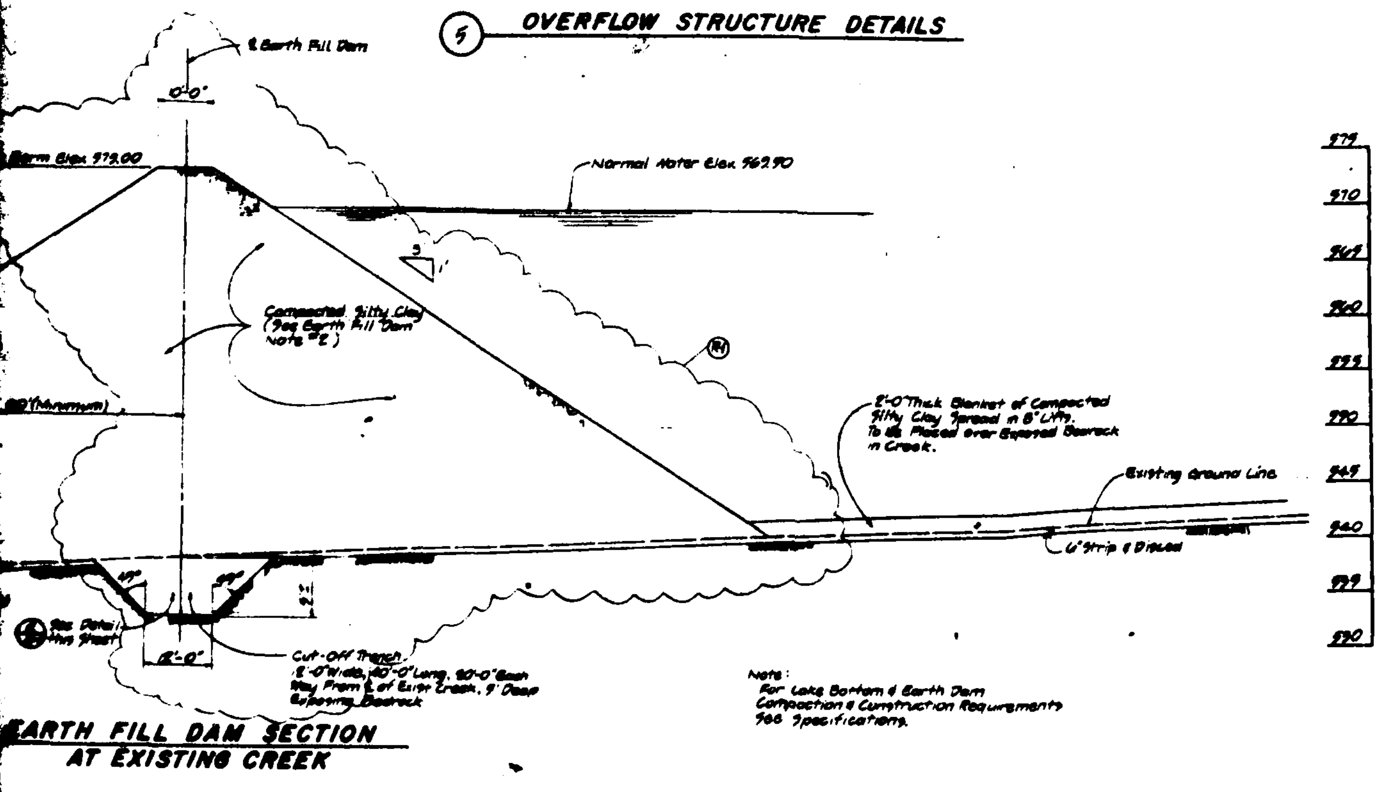


④ PROFILE OF OVERFLOW STRUCTURE & SPILLWAY

Scale 1"=9'



⑤ OVERFLOW STRUCTURE DETAILS



Note: For Lake Bottom & Earth Dam Compaction & Construction Requirements See Specifications.

EARTH FILL DAM SECTION AT EXISTING CREEK

Scale: Horiz. 1"=10' Vert. 1"=9'

REVISIONS

NO	DATE
1	JAN. 9, 79

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SVERDRUP & PARCEL AND ASSOC., INC., ST. LOUIS, MO. MECH./ELEC. ENGINEERS
HOK ASSOCIATES, ST. LOUIS, MO. CIVIL ENGINEERS/LANDSCAPE ARCHITECTS
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NATIONAL SERVICE CENTER
GENERAL AMERICAN LIFE INSURANCE COMPANY
ST. LOUIS
SAINT LOUIS COUNTY MISSOURI

DRAWN VY
CHECKED GY

10-1

CIVIL

PLATE 10

SHEET 1 OF 1

PROJECT NAME Earth Dam - General American Life Ins. Co.

PROJECT NO. 60196

DATE 7-24-74

B-1

PROJECT LOCATION National Serv. Ctr.(Hwy. 21)

RIG Hand auger

GEOLOGIST RTF   DRILLER FW

WATER ENTERS @ 2'

SURFACE ELEVATION 540+   ELEVATION DATUM MSL

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0				Firm to stiff, red-brown, highly plastic clay with sand and gravel	CH	Boring advanced with hand auger
	ST	2.0		Same - stiff		
	ST	.8		Stiff, grey, highly plastic clay with rock fragments - auger refusal	CH	Bottom of boring 3'
5						

FIGURE NO.

Chart 2-1

SHEET 1 OF 1

PROJECT NAME Earth Dam - General American Life Ins. Co.

PROJECT NO. 60196

DATE 7-25-74

B-2

PROJECT LOCATION National Serv. Ctr.(Hwy. 21)

RIG Hand auger

GEOLOGIST RTF DRILLER FW

WATER ENTERS None at time of drilling

SURFACE ELEVATION 543+ ELEVATION DATUM MSL

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	USC	SPECIAL NOTES AND FIELD OBSERVATIONS
0	ST	2.0		Very stiff, brown and grey, clayey silt, trace sand and roots (desiccated)	ML	Boring advanced with hand auger QP 3.0
	ST	.9		Stiff brown & grey highly plastic clay with limestome frag., ST refusal	CH	Bottom of boring 3'
5						

FIGURE NO

Chart 2-2

SHEET 1 OF 1

ROJECT NAME Earth Dam - General American Life Ins. Co.

PROJECT NO. 60196

DATE 7-25-74

B-3

PROJECT LOCATION National Serv. Ctr.(Hwy.21)

RIG Hand auger

GEOLOGIST RTF DRILLER FW

WATER ENTERS None

URFACE ELEVATION 546± ELEVATION DATUM MSL

EPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS	
0				Hard brown clay with sand & roots	CH	Boring advanced with hand auger	0
	ST	1.8		Very stiff, brown, highly plastic clay (desiccated)	CH	Upper 1' desiccated	
	ST	1.5		Same			
	ST	1.2		Same with small rock fragments			
5							5
	ST	1.3		Stiff, brown and grey, highly plastic clay with rock fragments, auger refusal on rock	CH		
						Bottom of boring 6.5'	
10							10

FIGURE NO.

Chart 2-3

SHEET 1 OF 1

PROJECT NAME Earth Dam - General American Life Ins. Co.

PROJECT NO. 60196

DATE 7-25-74

B-4

PROJECT LOCATION National Serv. Ctr.(Hwy.21)

RIG Hand auger

GEOLOGIST RTF DRILLER FW

WATER ENTERS None at time of drilling

SURFACE ELEVATION 548+ ELEVATION DATUM MSL

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0						Boring advanced with hand auger (Loessial)
	ST	2.0		Hard, desiccated, brown, silty clay with roots	CL	QP 4.5+
	ST	1.5		Same		
						QP 4.5+
	ST	1.1		Same		
5						Bottom of boring 5'

FIGURE NO.

Chart 2-4

SHEET 1 OF 1

PROJECT NAME Earth Dam - General American Life Ins. Co.

PROJECT NO. 60196

DATE 7-29-74

TP-1

PROJECT LOCATION Natl. Serv. Ctr. (Hwy. 21)

RIG Backhoe

GEOLOGIST RTF DRILLER MM

WATER ENTERS Trace @ 2'

SURFACE ELEVATION 540± ELEVATION DATUM MSL

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	BAG			Red-brown, silty clay with rock fragments and gravel		Boring advanced with backhoe
				Firm, red-brown, silty clay with small gravel	CL	15-20% rock fragments
						3' rock
	BAG			Stiff, brown and grey, highly plastic clay with small to medium rock fragments	CH	15-20% rock fragments
5				Refusal on large rock or bedrock		Bottom of boring 5'

FIGURE NO

Chart 2-5

SHEET 1 OF 1

PROJECT NAME Earth Dam - General American Life Ins. Co.

PROJECT NO. 60196

DATE 7-29-74

TP-2

PROJECT LOCATION Natl. Serv. Ctr. (Hwy. 21)

RIG Backhoe

GEOLOGIST RTF DRILLER MM

WATER ENTERS None

SURFACE ELEVATION 539+ ELEVATION DATUM MSL

DEPTH	SAMPLE TYPE	REC	RESIST	DESCRIPTION	USC	SPECIAL NOTES AND FIELD OBSERVATIONS
0	BAG			Firm to stiff, red-brown clay with small to large rock fragments	CH	Boring advanced with backhoe
						2' rock
				Refusal on large rock or bedrock		3-5% rock fragments
						Bottom of boring 3'
5						

FIGURE NO.

Chart C-6

BORING LOG

SHEET 1 OF 1

PROJECT NAME Earth Dam - General American Life Ins. Co.

PROJECT NO. 60196

DATE 7-29-74

TP-3

PROJECT LOCATION Natl. Serv. Ctr. (Hwy. 21)

RIG Backhoe

GEOLOGIST RTF DRILLER MM

WATER ENTERS None detected

SURFACE ELEVATION 548+ ELEVATION DATUM MSL

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0						Boring advanced with backhoe
	C	.3		Very stiff, red-brown, silty clay and roots	CL	QP 2.5
5	C	.3		Same	CL	QP 2.5
				Stiff, red, highly plastic clay with small limestone fragments	CH	25-35% fragments
				Refusal on rock or bedrock		Bottom of boring 9'
10						

FIGURE NO
Chart 3-7

SHEET 1 OF 1

PROJECT NAME Earth Dam - General American Life Ins. Co.

PROJECT NO. 60196

DATE 7-29-74

TP-4

PROJECT LOCATION Natl. Serv. Ctr. (Hwy. 21)

RIG Backhoe

GEOLOGIST RTF DRILLER MM

WATER ENTERS None detected

SURFACE ELEVATION 546± ELEVATION DATUM MSL

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	USC	SPECIAL NOTES AND FIELD OBSERVATIONS
0				Very stiff, brown silty clay, trace sand	CL	Boring advanced with backhoe
	C	.3		Same		QP 3.5
5						
	C	.3		Very stiff, red-brown clay	CH	QP 3.5
	BAG			Stiff, red-brown clay with limestone fragments Refusal on large rock or bedrock		35% estimated rock fragments
10						Bottom of boring 10'

FIGURE NO

Chart 2-3

SHEET 1 OF 1

ROJECT NAME Earth Dam - General American Life Ins. Co.

PROJECT NO. 60196

DATE 7-29-74

TP-5

PROJECT LOCATION Natl. Serv. Ctr. (Hwy. 21)

RIG Backhoe

GEOLOGIST RTF DRILLER MM

WATER ENTERS None detected

URFACE ELEVATION 550± ELEVATION DATUM MSL

DEPTH	SAMPLE TYPE	REC	RESIST	DESCRIPTION	USC	SPECIAL NOTES AND FIELD OBSERVATIONS	
0				Hard, brown, silty clay, trace roots (desiccated)	CL	Boring advanced with backhoe	0
	C	.3		Same	CL	QP 4.0	
5							5
	C	.3		Same	CL	QP 4.0	
	BAG			Stiff, red-brown, highly plastic clay with rock fragments (up to 1')	CL	estimate 15-25% fragments	
10							10
						Bottom of boring 11'	
15							15

FIGURE NO. ____

Chart 2-9

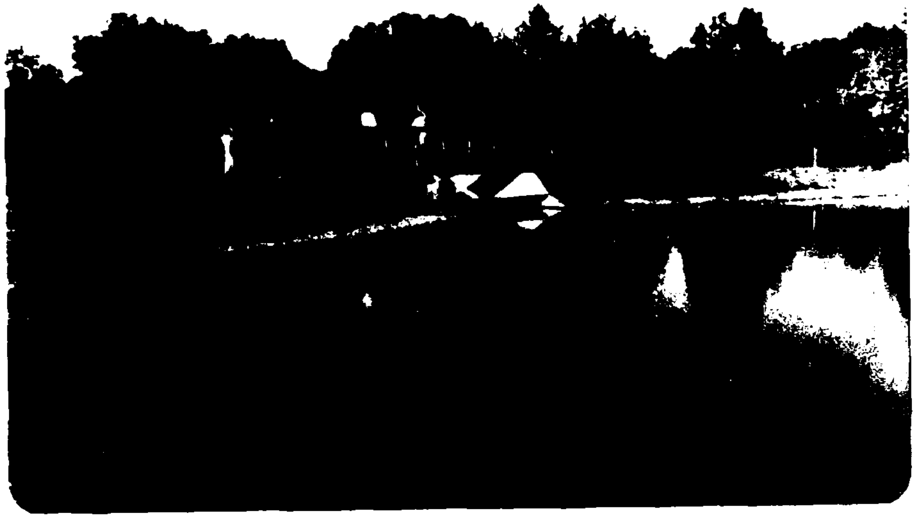
APPENDIX A

INSPECTION PHOTOGRAPHS

1	2
3	

PHOTO KEY

NO.	DESCRIPTION
1	DAM OVERVIEW
2	UPSTREAM FACE OF DAM
3	DOWNSTREAM FACE OF DAM



4	5
6	

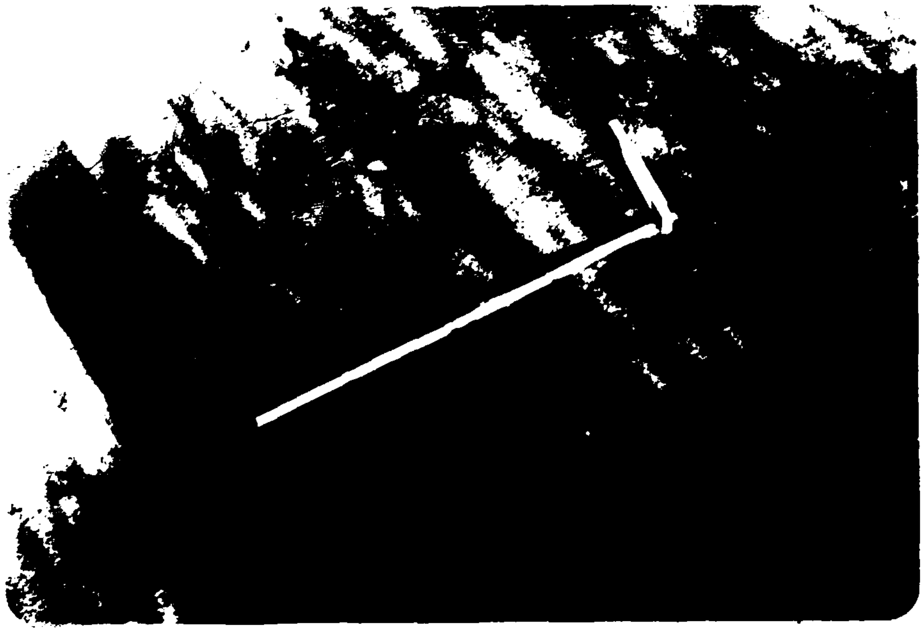
PHOTO KEY

NO.	DESCRIPTION
4	SPILLWAY OVERFLOW STRUCTURE
5	UPSTREAM END OF OVERFLOW STRUCTURE
6	SPILLWAY OUTLET CHUTE

7	8
9	

PHOTO KEY

NO.	DESCRIPTION
7	TOE DRAIN
8	DRAIN VALVE ENCLOSURE
9	DRAIN VALVE



10	11
12	

PHOTO KEY

NO.	DESCRIPTION
10	SEEPAGE AREA
11	EROSION ADJACENT TO SPILLWAY CHUTE
12	OPEN JOINT (CRACK) IN CHUTE

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

b. Drainage area = 0.063 square miles = 40 acres.

c. SCS parameters:

Time of Concentration (T_C) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$ = 0.221 hours

Where: T_C = Travel time of water from hydraulically most distant point to point of interest, hours
L = Length of longest watercourse = 0.47 miles
H = Elevation difference = 62 feet

Although a pipe storm sewer system is provided for the parking lots and areas adjacent to the building, the system was apparently designed for a 15-year frequency storm (the St. Louis County standard design storm), the sewer system would be surcharged during occurrence of the PMF and 1 percent chance events with the majority of the storm flow taking place over the ground surface; therefore, ditch and gutter flow velocities were used in developing the time of concentration.

The time of concentration (T_C) was obtained using Method C as described in Figure 30, "Design of Small Dams", by the United States

Department of the Interior, Bureau of Reclamation, and was verified using average ditch and gutter velocity estimates and watercourse lengths.

Lag time = 0.133 hours (0.60 T_c)

Hydrologic Soil Group = 100% D (Gasconade Series per Missouri General Soil Map and field investigation; 42% impervious)

Soil type CN = 78 (AMC II, 1 percent probability flood condition)
= 90 (AMC III, PMF condition)

2. The concrete spillway is characterized by two control sections; the upstream control section (shown as Section A on Plates 4 and 5) is trapezoidal shaped with a rectangular reinforced concrete weir 0.8 foot high located transverse to the section 1.0 foot above the invert of the section. The downstream control section (Section B on Plates 4 and 5) consists of a trapezoidal channel with an inverted trapezoidal shaped concrete curb projecting 1.3 feet above the channel invert. The concrete curb has a slightly rounded crest. According Mr. E. J. Hogan, Director of St. Louis Properties for General American, the curb section was added subsequent to construction of the spillway to raise the level of the lake surface approximately 1.0 foot. A timber footbridge with wooden handrails crosses the spillway section five feet upstream of control Section B; the bridge and handrails will form an obstruction to higher flows through the spillway section, and, in order to simplify the hydraulic calculations, were projected into the plane of the curb control Section B. The relative invert elevations and configurations of the two control sections are such that flow passing these sections will take place in several stages:

a. For small flows with the lake level at or just above the crest elevation of Section B, flow at Section A will take place beneath the concrete weir as submerged weir flow with Section B performing as a trapezoidal weir.

b. For somewhat higher flows, with the lake level above the crest elevation of Section B, flow at Section A will occur as orifice flow below the concrete weir.

c. For yet higher flows, with the lake level above the crest elevation of Section B, flow at Section A will be a combination of broad-crested trapezoidal weir flow over the top of the concrete weir and submerged orifice flow beneath the concrete weir, with the driving head on the orifice equal to the total head differential (d + hv) upstream of Sections A and B respectively.

d. For still higher flows, flow conditions at Section A will remain as described in (c), while flow past Section B will be progressively:

(1) Trapezoidal weir flow over crest B up to the elevation of the underside of the footbridge,

(2) Orifice flow under the bridge opening up to the elevation of the top of the footbridge deck, and

(3) A combination of orifice flow under the bridge and broad-crested weir flow over the bridge deck.

3. Flow Computations.

a. At Section A:

(1) Submerged weir flow (Elev. 570.5 to 570.7). The flow quantities involved (0 to 8$\pm$ cfs) are so small that the head losses across the weir are insignificant, and the outflow is controlled by the characteristics of the weir flow over Section B (see 3.b.(1) following).

(2) Orifice flow under concrete weir (Elev. 570.7 to 571.5). Flows in this range were computed as:

$$Q = c\ a\ (2\ g \Delta h)^{0.5}$$

where c is a coefficient, taken as 0.6, a is the area beneath the concrete weir, equal to 15.05 sf, h is the total differential head between the upstream and downstream faces of the concrete weir, and g is the acceleration due to gravity. Reference, "Handbook of Hydraulics", by King & Brater, page 4-9.

(3) Combination flow (above Elev. 571.5). Flow over the broad-crested weir section above the top of the concrete weir was computed as follows:

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

II. It was assumed that flow over the section would occur at critical depth. Flow at critical depth was computed as

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

III. Static lake levels upstream of the section corresponding to the various flow values passing the crest were computed as critical depths plus critical velocity heads (d_c+H_{vc}), thus obtaining the relationship between lake level and flow over the top of the section.

Flow passing the submerged orifice under the concrete weir was determined as described in 3.a.(2) above.

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

b. **At Section B:**

(1) Trapezoidal weir flow (Elev. 570.5 to 573.5, the underside of the footbridge). Flows in this range were assumed to occur at critical depth, and were computed as described in 3.a.(3)I through III above.

(2) Orifice flow below top of footbridge deck (Elev. 573.5 to 574.7). Flow in this range was computed as

$$Q = c\ a\ (2\ g\ h)^{0.5}$$

where c is a coefficient, used as 0.6, a is the area below the underside of the bridge deck (78.86 sf), and h is the head, measured from the water surface upstream of the bridge to the centroid of the area, a (the centroid of the area is located 1.67 feet above the crest). Reference, ibid., page 4-3.

(3) Weir flow above the top of the footbridge deck (above Elev. 574.7). Flow above the top of the deck was computed as flow over a broad crested weir:

$$Q = C\ L\ H^{1.5}$$

where c is a coefficient selected to reflect the flow obstructions represented by the bridge handrails (taken as 2.5), L is the weir length (40 feet), and H is the head from the water surface to the top of the bridge deck. Reference, "Application of the HEC-2 Bridge Routines",the Hydrologic Engineering Center, Corps of Engineers, U. S. Army, pages 34-35.

The total flow at Section B in this range was taken as the sum of the weir and orifice flows for corresponding elevations.

4. <u>Determination of Governing Control Section</u>. To determine the static lake level for flows passing the two control sections, the following trial and error procedure was used.

a. A flow quantity over the crest of the concrete weir at Section A (Q_1) was assumed, and the corresponding static lake level (Ea) was determined.

b. **A trial flow quantity over the weir crest at Section B (Q_3) was selected, and the corresponding static level (Eb) was determined.**

c. The driving head, $h = Ea - Eb$, for the submerged orifice at Section B was computed, and the flow through the orifice (Q_2) was determined.

d. The sum $Q_1 + Q_2$ past Section A was compared with the trial flow quantity Q_3 over Section B, and the procedure repeated until balance was achieved.

5. The results of the flow balance determinations, together with the curves representing flow over control Sections A and B for the several stages are shown on Plate 6. It is evident that Section A controls spillway discharge from the crest elevation 570.5 up to about Elev. 575; above Elev. 575, Section B controls the spillway discharge.

Controlling elevations and corresponding discharges for the spillway were entered on the Y4 and Y5 cards for use in the HEC-1 Program.

6. The flow and head relationships for flow over the concrete curb, Section B, was checked using the following approximate trapezoidal broad-crested weir formula:

$$Q_H = C_1 L H_1^{1.5} + \left[\frac{(\text{[illegible]}_{H2})^3 \, (32.2\text{[illegible]})}{T_{H2}} \right]^{.5}$$

where H_1 is the head on the retangular portion of the weir and C_1 is a coefficient for the rectangular portion of the weir with the following range of values:

H_1	C_1*
$0 < H < 1.0$	2.8
$1.0 < H < 2.0$	3.0
$H > 2.0$	3.2

*Per Tables 5-9 and 5-10, Handbook of Hydraulics, Fifth Edition, King & Brater.

and A_{H2} and T_{H2} are the area and top width of the triangular portion of the weir for H_2, the head on the triangular portion of the weir.

No significant difference was found when the results of the two methods, i.e., critical depth and weir formula solution, were compared.

7. 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 section occurs at critical depth and computes internally the flow over the dam crest and adds this flow to the flow over the spillway as entered on the Y4 and Y5 cards.

```
A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF GENERAL AMERICAN LIFE INS. CO. LAKE DAM
A3       RATIOS OF PMF ROUTED THROUGH RESERVOIR
B     288       0       5                                               0
B1      5
J       1       4       1
J1   0.41    0.42    0.50    1.00
K       0   INFLOW                                      1
K1       INFLOW HYDROGRAPH
M       1       2   0.043                       1.0                     1
P       0    25.4     102     120     130
T                                               1      90           0.42
W2          0.133
X     1.0   -0.10     2.0
K       1     DAM                                       1
K1       RESERVOIR ROUTING BY MODIFIED PULS
Y                               1       1
Y1      1                                           30.22      -1
Y4 570.5   571.0   571.5  572.27  573.02  573.56  574.01  574.40  574.75  575.07
Y4575.25  575.70  576.70  577.70  578.70  579.70  580.70
Y5      0      17      38      77     199     299     398     497     582     664
Y5    800     913    1020    1412    1770    2160    2570
$A      0     3.7     4.2     4.6     5.1     5.4     5.9     6.3
$E    546   570.5     572     574     576     578     580     582
$$ 570.5
$D 572.9
$L      0     160     231     361     479     548     584     636     677     734
$V 572.9   573.3   573.4   573.7   574.2   574.7   575.0   576.9   578.9   582.2
K      99
```

```
1A1       ANALYSIS OF DAM OVERTOPPING USING 1 PERCENT CHANCE FLOOD
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF GENERAL AMERICAN LIFE INS. CO. LAKE DAM
A3       1 PERCENT CHANCE FLOOD ROUTED THROUGH RESERVOIR
B     288       0       5                                                   4
B1      5
J       1       1       1
J1   1.00
K       0   INFLOW                                  1
K1      INFLOW HYDROGRAPH
M       0       2   0.063                 1.0                               1
O     288   6.974
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    .012    .012    .012    .012    .012    .012    .012    .012
01   .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
01   .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
01   .012    .012    .012    .012    .012    .012    .012    .012    .023    .023
01   .023    .023    .023    .023    .023    .023    .023    .023    .023    .023
01   .023    .023    .023    .023    .023    .023    .030    .030    .030    .030
01   .030    .030    .048    .048    .048    .049    [illegible]  .049    .134    .134
01   .134    .255    .255    .547    [illegible]  [illegible]  [illegible]  .134    .134    .134
01   .049    .049    .049    .048    .048    [illegible]  .030    .030    .030    .030
01   .030    .030    .023    .023    .023    .023    .023    .023    .023    .023
01   .023    .023    .023    .023    .023    .023    .023    .023    .023    .023
```

1 PERCENT CHANCE FLOOD (Cont'd)

```
01   .012     .012     .012     .012     .012     .012     .012     .012     .012     .012
01   .012     .012     .012     .012     .012     .012     .012     .012     .012     .012
01   .012     .012     .012     .012     .012     .012     .012     .012     .012     .012
01   .012     .012     .012     .012     .012     .012     .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      -78              0.42
W2            0.133
X     -1.0     -.10      2.0
K        1      DAM                                         1
K1       RESERVOIR ROUTING BY MODIFIED PULS
Y                                   1        1
Y1       1                                              30.22       -1
Y4 570.5    571.0    571.5   572.27  [illegible] [illegible]  574.01   574.40   574.75   575.07
Y4575.20   575.70   576.70   577.70  [illegible] [illegible] [illegible]
Y5       0       17       38       97 [illegible] [illegible] [illegible]      497      582      664
Y6 [illegible]   810     1000  [illegible] [illegible] [illegible] [illegible]
$A       0      3.7      4.2  [illegible] [illegible]  [illegible] [illegible]     6.3
$E     546    570.5      572      574 [illegible] [illegible] [illegible] [illegible]
$$ 570.5
$D 572.?
$L       0      140 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
$V 572.? 573.3 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
K       99
```

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF GENERAL AMERICAN LIFE INS. CO
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= .41 .42 .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	.06	0.00	.06	1.00	0.000	[illegible]	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.40	102.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-90.00	0.00	.42

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

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .10

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

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

UNIT HYDROGRAPH 10 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .10 VOL= 1.00

76.	175.	131.	57.	[illegible]	[illegible]	[illegible]	3.	1.	0.

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.01	.01	1.	1.01	12.05	145	.22	.21	.00	42.
1.01	.10	2	.01	.01	.01	2.	1.01	12.10	146	.22	.21	.00	65.
1.01	.15	3	.01	.01	.01	2.	1.01	12.15	147	.22	.21	.00	83.
1.01	.20	4	.01	.01	.01	3.	1.01	12.20	148	.22	.21	.00	96.
1.01	.25	5	.01	.01	.01	3.	1.01	12.25	149	.22	.21	.00	100.
1.01	.30	6	.01	.01	.01	3.	1.01	12.30	150	.22	.21	.00	102.
1.01	.35	7	.01	.01	.01	3.	1.01	12.35	151	.22	.21	.00	103.
1.01	.40	8	.01	.01	.01	3.	1.01	12.40	152	.22	.21	.00	104.
1.01	.45	9	.01	.01	.01	3.	1.01	12.45	153	.22	.21	.00	104.
1.01	.50	10	.01	.01	.01	3.	1.01	12.50	154	.22	.21	.00	104.
1.01	.55	11	.01	.01	.01	3.	1.01	12.55	155	.22	.21	.00	104.
1.01	1.00	12	.01	.01	.01	3.	1.01	13.00	156	.22	.21	.00	104.
1.01	1.05	13	.01	.01	.01	3.	1.01	13.05	157	.26	.25	.00	108.
1.01	1.10	14	.01	.01	.01	3.	1.01	13.10	158	.26	.26	.00	115.
1.01	1.15	15	.01	.01	.01	3.	1.01	13.15	159	.26	.25	.00	121.
1.01	1.20	16	.01	.01	.01	3.	1.01	13.20	160	.26	.25	.00	123.
1.01	1.25	17	.01	.01	.01	3.	1.01	13.25	161	.26	.25	.00	124.
1.01	1.30	18	.01	.01	.01	3.	1.01	13.30	162	.26	.25	.00	125.
1.01	1.35	19	.01	.01	.01	3.	1.01	13.35	163	.26	.25	.00	125.
1.01	1.40	20	.01	.01	.01	3.	1.01	13.40	164	.26	.25	.00	125.
1.01	1.45	21	.01	.01	.01	3.	1.01	13.45	165	.26	.25	.00	[illegible]
1.01	1.50	22	.01	.01	.01	3.	1.01	13.50	166	.26	.25	.00	126.
1.01	1.55	23	.01	.01	.01	3.	1.01	13.55	167	.26	.25	.00	126.
1.01	2.00	24	.01	.01	.01	3.	1.01	14.00	168	.26	.26	.00	128.
1.01	2.05	25	.01	.01	.01	4.	1.01	14.05	169	.32	.32	.00	131.
1.01	2.10	26	.01	.01	.01	4.	1.01	14.10	170	.32	.32	.00	142.
1.01	2.15	27	.01	.01	.01	4.	1.01	14.15	171	.32	.32	.00	[illegible]
1.01	2.20	28	.01	.01	.01	4.	1.01	14.20	172	.32	.32	.00	154.
1.01	2.25	29	.01	.01	.01	4.	1.01	14.25	173	.32	.32	.00	156.
1.01	2.30	30	.01	.01	.01	4.	1.01	14.30	174	.32	.32	.00	157.
1.01	2.35	31	.01	.01	.01	4.	1.01	14.35	175	.32	.32	.00	157.
1.01	2.40	32	.01	.01	.01	4.	1.01	14.40	176	.32	.32	.00	157.
1.01	2.45	33	.01	.01	.01	4.	1.01	14.45	177	.32	.32	.00	157.
1.01	2.50	34	.01	.01	.01	4.	1.01	14.50	178	.32	.32	.00	157.
1.01	2.55	35	.01	.01	.01	4.	1.01	14.55	179	.32	.32	.00	157.
1.01	3.00	36	.01	.01	.01	4.	1.01	15.00	180	.32	.32	.00	157.
1.01	3.05	37	.01	.01	.01	4.	1.01	15.05	181	.20	.20	.00	148.
1.01	3.10	38	.01	.01	.01	4.	1.01	15.10	182	.39	.39	.00	141.
1.01	3.15	39	.01	.01	.00	4.	1.01	15.15	183	.39	.39	.00	153.
1.01	3.20	40	.01	.01	.00	4.	1.01	15.20	184	.59	.59	.00	192.
1.01	3.25	41	.01	.01	.00	4.	1.01	15.25	185	.69	.69	.00	241.
1.01	3.30	42	.01	.01	.00	5.	1.01	15.30	186	1.67	1.67	.00	363.
1.01	3.35	43	.01	.01	.00	5.	1.01	15.35	187	2.76	2.75	.00	642.
1.01	3.40	44	.01	.01	.00	5.	1.01	15.40	188	1.08	1.08	.00	845.
1.01	3.45	45	.01	.01	.00	5.	1.01	15.45	189	.69	.69	.00	727.
1.01	3.50	46	.01	.01	.00	5.	1.01	15.50	190	.59	.59	.00	522.
1.01	3.55	47	.01	.01	.00	5.	1.01	15.55	191	.39	.39	.00	365.
1.01	4.00	48	.01	.01	.00	5.	1.01	16.00	192	.39	.39	.00	290.
1.01	4.05	49	.01	.01	.00	5.	1.01	16.05	193	.30	.30	.00	[illegible]

END-OF-PERIOD FLOW (Cont'd)

1.01	4.10	50	.01	.01	.00	5.
1.01	4.15	51	.01	.01	.00	5.
1.01	4.20	52	.01	.01	.00	5.
1.01	4.25	53	.01	.01	.00	5.
1.01	4.30	54	.01	.01	.00	5.
1.01	4.35	55	.01	.01	.00	5.
1.01	4.40	56	.01	.01	.00	5.
1.01	4.45	57	.01	.01	.00	5.
1.01	4.50	58	.01	.01	.00	5.
1.01	4.55	59	.01	.01	.00	5.
1.01	5.00	60	.01	.01	.00	5.
1.01	5.05	61	.01	.01	.00	5.
1.01	5.10	62	.01	.01	.00	5.
1.01	5.15	63	.01	.01	.00	5.
1.01	5.20	64	.01	.01	.00	5.
1.01	5.25	65	.01	.01	.00	5.
1.01	5.30	66	.01	.01	.00	5.
1.01	5.35	67	.01	.01	.00	5.
1.01	5.40	68	.01	.01	.00	5.
1.01	5.45	69	.01	.01	[illegible]	5.
1.01	5.50	70	.01	.01	.00	5.
1.01	5.55	71	.01	.01	.00	5.
1.01	6.00	72	.01	.01	.00	5.
1.01	6.05	73	.06	.05	.01	[illegible]
1.01	6.10	74	.06	.05	.01	[illegible]
1.01	6.15	75	.06	.05	.01	21.
1.01	6.20	76	.06	.05	.01	24.
1.01	6.25	77	.06	.05	.01	25.
1.01	6.30	78	.06	.05	.01	[illegible]
1.01	6.35	79	.06	.06	.01	[illegible]
1.01	6.40	80	.06	.06	.01	27.
1.01	6.45	81	.06	.06	.01	27.
1.01	6.50	82	.06	.06	.01	27.
1.01	6.55	83	.06	.06	.01	27.
1.01	7.00	84	.06	.06	.01	27.
1.01	7.05	85	.06	.06	.01	[illegible]
1.01	7.10	86	.06	.06	.01	[illegible]
1.01	7.15	87	.06	.06	.01	[illegible]
1.01	7.20	88	.06	.06	.01	28.
1.01	7.25	89	.06	.06	.01	[illegible]
1.01	7.30	90	.06	.06	.00	28.
1.01	7.35	91	.06	.06	.00	25.
1.01	7.40	92	.06	.06	.00	27.
1.01	7.45	93	.06	.06	.00	[illegible]
1.01	7.50	94	.06	.06	.00	[illegible]
1.01	7.55	95	.06	.06	.00	[illegible]
1.01	8.00	96	.06	.06	.00	[illegible]
1.01	8.05	97	.06	.06	.00	[illegible]
1.01	8.10	98	.06	.06	.00	29.
1.01	8.15	99	.06	.06	.00	[illegible]
1.01	8.20	100	.06	.06	.00	[illegible]
1.01	8.25	101	.06	.06	.00	[illegible]
1.01	8.30	102	.06	.06	[illegible]	[illegible]

1.01	16.10	194	.30	.30	.00	190.
1.01	16.15	195	.30	.30	.00	[illegible]
1.01	16.20	196	.30	.30	.00	155.
1.01	16.25	197	.30	.30	.00	150.
1.01	16.30	198	.30	.30	.00	[illegible]
1.01	16.35	199	.30	.30	.00	143.
1.01	16.40	200	.30	.30	.00	147.
1.01	16.45	201	.30	.30	.00	147.
1.01	16.50	202	.30	.30	.00	147.
1.01	16.55	203	.30	.30	.00	147.
1.01	17.00	204	.30	.30	.00	147.
1.01	17.05	205	.24	.24	.00	142.
1.01	17.10	206	.24	.24	.00	131.
1.01	17.15	207	.24	.24	.00	122.
1.01	17.20	208	.24	.24	.00	[illegible]
1.01	17.25	209	.24	.24	.00	117.
1.01	17.30	210	.24	.24	.00	[illegible]
1.01	17.35	211	.24	.24	[illegible]	[illegible]
1.01	17.40	212	.24	.24	[illegible]	[illegible]
1.01	17.45	213	.24	.24	[illegible]	[illegible]
1.01	17.50	214	.24	.24	.00	116.
1.01	17.55	215	.24	.24	.00	116.
1.01	18.00	216	.24	.24	.00	116.
1.01	18.05	217	.02	.02	.00	[illegible]
1.01	18.10	218	.02	.02	.00	81.
1.01	18.15	219	.02	.02	.00	76.
1.01	18.20	220	.02	.02	.00	71.
1.01	18.25	221	.02	.02	.00	66.
1.01	18.30	222	.02	.02	.00	61.
1.01	18.35	223	.02	.02	.00	57.
1.01	18.40	224	.02	.02	.00	53.
1.01	18.45	225	.02	.02	.00	50.
1.01	18.50	226	.02	.02	.00	47.
1.01	18.55	227	.02	.02	.00	43.
1.01	19.00	228	.02	.02	.00	41.
1.01	19.05	229	.02	.02	.00	38.
1.01	19.10	230	.02	.02	.00	35
1.01	19.15	231	.02	.02	.00	33.
1.01	19.20	232	.02	.02	.00	31.
1.01	19.25	233	.02	.02	.00	29.
1.01	19.30	234	.02	.02	.00	27.
1.01	19.35	235	.02	.02	.00	25.
1.01	19.40	236	.02	.02	.00	23.
1.01	19.45	237	.02	.02	.00	22.
1.01	19.50	238	.02	.02	.00	20.
1.01	19.55	239	.02	.02	.00	19.
1.01	20.00	240	.02	.02	.00	18.
1.01	20.05	241	.02	.02	.00	16.
1.01	20.10	242	.02	.02	.00	15.
1.01	20.15	243	.02	.02	.00	14.
1.01	20.20	244	.02	.02	.00	13.
1.01	20.25	245	.02	.02	.00	12.
1.01	20.30	246	.02	.02	.00	12.

END-OF-PERIOD FLOW (Cont'd)

1.01	8.35	103	.06	.06	.00	29.	1.01	20.35	247	.02	.02	.00	11.
1.01	8.40	104	.06	.06	.00	29.	1.01	20.40	248	.02	.02	.00	10.
1.01	8.45	105	.06	.06	.00	29.	1.01	20.45	249	.02	.02	.00	10.
1.01	8.50	106	.06	.06	.00	30.	1.01	20.50	250	.02	.02	.00	10.
1.01	8.55	107	.06	.06	.00	30.	1.01	20.55	251	.02	.02	.00	10.
1.01	9.00	108	.06	.06	.00	30.	1.01	21.00	252	.02	.02	.00	10.
1.01	9.05	109	.06	.06	.00	30.	1.01	21.05	253	.02	.02	.00	10.
1.01	9.10	110	.06	.06	.00	30.	1.01	21.10	254	.02	.02	.00	10.
1.01	9.15	111	.06	.06	.00	30.	1.01	21.15	255	.02	.02	.00	10.
1.01	9.20	112	.06	.06	.00	30.	1.01	21.20	256	.02	.02	.00	10.
1.01	9.25	113	.06	.06	.00	30.	1.01	21.25	257	.02	.02	.00	10.
1.01	9.30	114	.06	.06	.00	30.	1.01	21.30	258	.02	.02	.00	10.
1.01	9.35	115	.06	.06	.00	30.	1.01	21.35	259	[illegible]	[illegible]	.00	10.
1.01	9.40	116	.06	.06	.00	30.	1.01	21.40	260	.02	.02	.00	10.
1.01	9.45	117	.06	.06	.00	30.	1.01	21.45	261	.02	.02	.00	10.
1.01	9.50	118	.06	.06	.00	30.	1.01	21.50	262	.02	.02	.00	10.
1.01	9.55	119	.06	.06	.00	30.	1.01	21.55	263	.02	[illegible]	.00	10.
1.01	10.00	120	.06	.06	.00	30.	1.01	22.00	264	[illegible]	[illegible]	[illegible]	10.
1.01	10.05	121	.06	.06	.00	30.	1.01	22.05	265	[illegible]	[illegible]	[illegible]	[illegible]
1.01	10.10	122	.06	.06	.00	30.	1.01	22.10	266	.02	[illegible]	[illegible]	10.
1.01	10.15	123	.06	.06	.00	30.	1.01	22.15	267	.02	.02	.00	10.
1.01	10.20	124	.06	.06	.00	30.	1.01	[illegible]	268	.02	.02	.00	10.
1.01	10.25	125	.06	.06	.06	30.	1.01	22.25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1.01	10.30	126	.06	.06	.00	30.	1.01	[illegible]	[illegible]	.02	[illegible]	[illegible]	[illegible]
1.01	10.35	127	.06	.06	.00	30.	1.01	22.35	[illegible]	.02	[illegible]	[illegible]	[illegible]
1.01	10.40	128	.06	.06	.00	30.	1.01	22.40	[illegible]	[illegible]	[illegible]	.00	10.
1.01	10.45	129	.06	.06	.00	30.	1.01	22.45	[illegible]	[illegible]	.02	[illegible]	10.
1.01	10.50	130	.06	.06	.00	30.	1.01	22.50	274	.02	.02	[illegible]	10.
1.01	10.55	131	.06	.06	.00	30.	1.01	22.55	275	[illegible]	[illegible]	.00	10.
1.01	11.00	132	.06	.06	.00	30.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.
1.01	11.05	133	.06	.06	.00	30.	1.01	23.05	277	.02	.02	.00	10.
1.01	11.10	134	.06	.06	.00	30.	1.01	[illegible]	[illegible]	[illegible]	.02	.00	10.
1.01	11.15	135	.06	.06	.00	30.	1.01	23.15	279	[illegible]	.02	.00	10.
1.01	11.20	136	.06	.06	.00	30.	1.01	23.20	280	.02	.02	.00	10.
1.01	11.25	137	.06	.06	.00	30.	1.01	23.25	281	.02	.02	.00	10.
1.01	11.30	138	.06	.06	.00	30.	1.01	23.30	282	.02	.02	.00	10.
1.01	11.35	139	.06	.06	.00	30.	1.01	23.35	283	.02	.02	.00	10.
1.01	11.40	140	.06	.06	.00	30.	1.01	23.40	284	.02	.02	.00	10.
1.01	11.45	141	.06	.06	.00	30.	1.01	23.45	285	.02	.02	.00	10.
1.01	11.50	142	.06	.06	.00	30.	1.01	23.50	286	.02	.02	.00	10.
1.01	11.55	143	.06	.06	.00	30.	1.01	23.55	287	.02	.02	.00	10.
1.01	12.00	144	.06	.06	.00	30.	1.02	0.00	288	.02	.02	.00	10.

SUM 33.02 32.27 .75 16354.
(839.)(820.)(19.)(463.09)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	345.	174.	57.	57.	16348.
CMS	24.	5.	2.	2.	464.
INCHES		25.65	33.57	33.57	33.57
MM		651.50	852.63	852.63	[illegible]
AC-FT		86.	[illegible]	[illegible]	[illegible]
THOUS CU M		106.	[illegible]	[illegible]	[illegible]

SURFACE AREA=	0.	4.	4.	5.	5.	5.	6.	6.
CAPACITY=	0.	30.	36.	45.	55.	65.	76.	89.
ELEVATION=	546.	571.	572.	574.	576.	578.	580.	582.

SUMMARY OF DAM SAFETY ANALYSIS

PMF

....		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	570.50	570.50	572.90
	STORAGE	30.	30.	40.
	OUTFLOW	0.	0.	183.

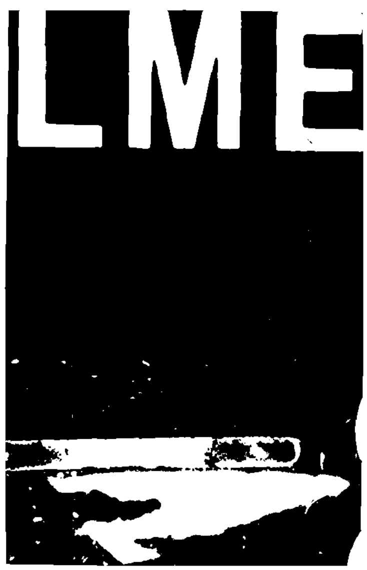
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.41	572.89	0.00	40.	181.	0.00	15.92	0.00
.42	572.93	.03	40.	187.	.17	15.92	0.00
.50	573.20	.30	41.	254.	.42	15.83	0.00
1.00	573.82	.92	44.	[illegible]	1.00	15.75	0.00

SUMMARY OF DAM SAFETY ANALYSIS

1 PERCENT CHANCE FLOOD

....		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	570.50	570.50	572.90
	STORAGE	30.	30.	40.
	OUTFLOW	0.	0.	183.

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	[illegible]	0.00	[illegible]	[illegible]	0.00	[illegible]	0.00


LME