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NATIONAL DAM SAFETY PROGRAM. FOREST LAKE DAM (MO 10128), GRAND --ETC(U)

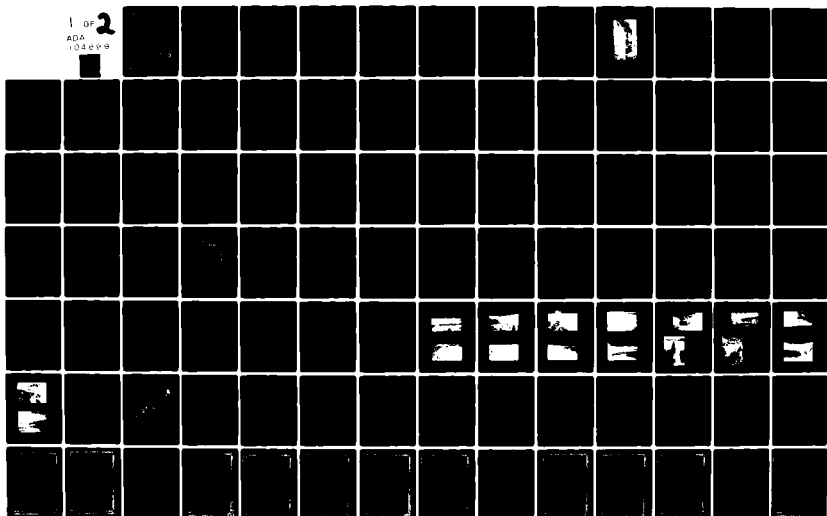
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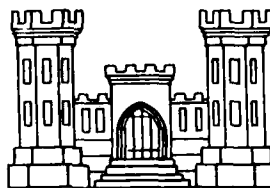
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GRAND CHARITON RIVER BASIN

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FOREST LAKE DAM
ADAIR COUNTY, MISSOURI
MO 10128

**PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM**



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

FOR: STATE OF MISSOURI

DECEMBER 1978

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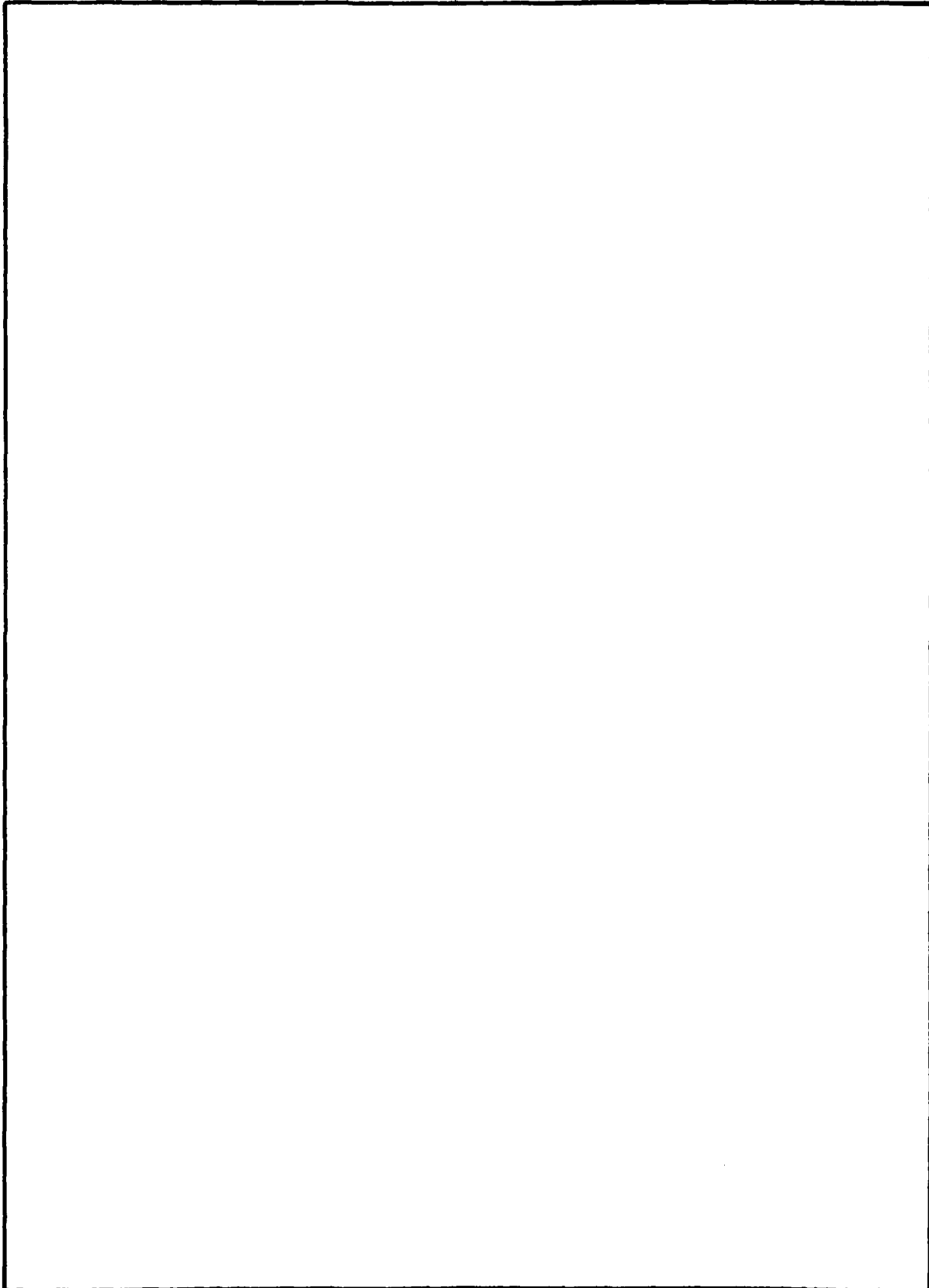
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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Forest Lake Dam (Mo. 10128), Phase I Inspection Report

This report presents the results of field inspection and evaluation of Forest Lake Dam (Mo. 10128).

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.
- 2) Overtopping could result in dam failure.
- 3) Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY:

SIGNED

Chief, Engineering Division

28 FEB 1979

(Date)

APPROVED BY:

SIGNED

Colonel, CE, District Engineer

28 FEB 1979

(Date)

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Forest Lake Dam, Missouri Inv. No. 10128
State Located: Missouri
County Located: Adair
Stream: Big Creek
Date of Inspection: September 29, and October 6, 1978

Forest Lake Dam No. Mo. 10128 was inspected using the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of Federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines are considered to represent a consensus of the engineering profession.

Based on the criteria in the guidelines, the dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur in the event of failure of the dam. Four farmhouses with associated farm buildings and two improved road crossings would be subjected to flooding, with possible damage and/or destruction, and possible loss of life. Forest Lake Dam is in the intermediate size classification since it is more than 40 feet, but less than 100 feet high, and impounds more than 1,000 acre-feet, but less than 50,000 acre-feet of water.

Our inspection and evaluation indicates that the spillway of Forest Lake Dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. Forest Lake Dam is an intermediate size dam with a high hazard potential required by the guidelines to pass the Probable Maximum Flood without overtopping. It was determined that the spillway will pass 25 percent of the Probable Maximum Flood without overtopping the dam. Our evaluation indicates that the spillway will pass the 100-year flood; that is, a flood having a 1 percent chance of being equalled or exceeded during any given year.

The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region.

Other deficiencies noted by the inspection team were a need for an annual inspection by a qualified professional engineer; lack of a maintenance schedule; extensive brush and tree growth on the embankment; seepage at the right side of the dam; rodent activity on the embankment; deteriorated concrete on the spillway crest and damage to the channel banks; vegetative growth in the spillway channel; and inoperable gate valves in the valve vault. The lack of stability and seepage analysis on record is also a deficiency that should be corrected.

It is recommended that the owner take action to correct or control the deficiencies described above.



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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Forest Lake Dam, I.D. No. 10128

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

FOREST LAKE DAM, Missouri Inv. No. 10128

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The Dam Inspection Act, Public Law 92-367 of August, 1972, authorizes the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspections. Inspection for the Forest Lake Dam was carried out under Contract DACW 43-78-C-0160 to the Department of the Army, St. Louis District, Corps of Engineers, by the engineering firms of Consoer, Townsend & Associates Ltd., and Engineering Consultants, Inc. (A Joint Venture), of St. Louis, Missouri.

b. Purpose of Inspection

The visual inspection of the Forest Lake Dam was made on September 29 and October 6, 1978. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

This report summarizes available pertinent data relating to the project; presents a summary of visual observations made during the field inspection; presents an evaluation of hydrologic and hydraulic conditions at the site; presents an evaluation as to the structural adequacy of the various project features; and assesses the general condition of the dam with respect to safety.

It should be noted that reference in this report to left or right abutments is as viewed looking downstream. Where left abutment or left side of the dam is used in this report, this also refers to south abutment or side, and right to the north abutment or side.

d. Evaluation Criteria

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams", Appendix D. These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of the Project

a. Description of Dam and Appurtenances

The dam embankment is a homogeneous earthfill structure. The crest of the embankment has a width of 20 feet and a length of approximately 1,500 feet. The crest elevation is set at 806.0 feet above MSL, and the maximum height of the embankment is 61 feet above the minimum streambed elevation along the centerline of the dam.

The upstream slope of the typical embankment section is constructed with a 1V to 3H slope from the crest to the toe. Two berms, one with a width of 6.3 feet, and one with a width of 20 feet, were constructed at elevations 793.0 and 765.0, respectively. The downstream slope was constructed with a 1V to 3H slope to elevation 771.0, where it flattens out to a 1V to 25H slope to the intersection with the ground surface.

An 18-inch thick layer of dumped rock riprap was placed on the upstream slope from elevation 793.0 to the crest of the dam. No gravel bedding was shown to have been placed under the riprap. The riprap was composed of hard, angular blocks of limestone up to 4 feet in diameter. Most of the blocks were 2 to 3 feet in diameter. The downstream slope of the embankment and the crest is provided with heavy vegetative cover.

A 6-foot wide sand filter was placed at the base of the embankment from a point near the downstream edge of the crest to the downstream toe. The horizontal sand filter was to extend the entire length of the embankment section, including the abutments.

The material to be used for the embankment was specified to be clay in the bid documents. Laboratory testing of the borrow pit material found the material to be silty clays and clayey silts with less than 10% sand. The material would be classified as CL-ML by the Unified Soil Classification System. The sand blanket was to be medium-fine sand for the top and bottom 1-1/2 feet, and medium coarse for the central section of the blanket. The downstream berm was to be constructed of waste materials from excavation of the spillway channel.

Bedrock at the site and within the vicinity is composed of Pennsylvania age, intercalated sandstones, shales and limestones. Meager natural outcrops and man-made excavations at the site expose the above rock types in a cyclic sequence. The soils of the area in which this dam is located are considered to be mixed glacial outwash modified with loessial deposits further modified by weathering.

The abutments and spillway for the dam are founded in the intercalated bedrock sequence. Bedrock bedding planes are near horizontal, and a joint plane was recorded as having an attitude of N29°E, 79°NW.

A cut-off trench with side slopes of 1H to 1V, and a base width of 12 feet, was excavated into the bedrock through the abutments and adjacent to the course of Big Creek. No cut-off trench was constructed below the embankment across the valley.

The spillway is located near the left abutment. The crest of the spillway is an uncontrolled concrete ogee overflow weir, with crest elevation at 800.0 MSL, and a crest length of 150-feet. A horizontal unlined discharge channel is

constructed at elevation 796.50, about 270 feet long, which connects the downstream toe of the crest section and the concrete spillway chute. The spillway chute slopes at 2H to 1V for about 120 feet into a conventional type stilling basin at elevation 743.0. The stilling basin width and length are 100 feet and 60 feet, respectively. On the stilling basin floor there are two rows of 2'-0" x 5'-0" baffle blocks and a 2-foot high end sill at the end of the basin floor. The stilling basin walls are 17 feet high. A cut-off wall and drain under the spillway was designed in 1969 by Larkin & Associates of Kansas City, Missouri, to help alleviate the problem of water seeping under the spillway structures. A complete set of plans of the cut-off wall and the spillway reconstruction has been made available from Larkin & Associates.

The approach channel to the spillway crest consists of the upstream face of the left end of the dam embankment with its stone protection, flanked on the left side by the abutment wall of the natural slope.

A 16-inch cast iron pipe has been installed in a 5' x 5' reinforced concrete conduit through the base of the dam embankment to serve the dual purpose of raw water supply pipe for the pumping plant and a reservoir drain outlet. The concrete conduit served for diversion during the dam construction.

The upstream inlet of the 16-inch pipe is at the base of the intake tower. The intake tower is fitted with seven 12-inch gate valves, each at different levels, so that water may be supplied from the level of best quality. Each gate valve may be operated from the top deck of the tower by a pedestal mounted handwheel connected to a valve stem exten-

sion. Each valve inlet and the inlet to the 16-inch pipe are protected with trash bars. The intake tower sits at the upstream toe of the dam, and its top deck is accessible only by boat.

At the downstream toe of the dam the 16-inch outlet pipe divides to two 16-inch branches for supply of raw water to the pumping plant; one branch to serve as a drain. A 16-inch gate valve is installed at the juncture of each branch with the upstream pipe. The valves are housed in a vault with its entrance opening at ground level. The branch leading to the pumping plant is buried, while the drain branch discharges directly into a 30-inch diameter concrete pressure pipe leading to the watercourse below the dam.

The reservoir at Forest Lake Dam impounds 21,000 acre-feet of water from a tributary area of 16.41 square miles in the Chariton River basin.

b. Location

The Forest Lake Dam is located on Big Creek which is a tributary of the Chariton River, Adair County, Missouri. The nearest downstream community is Youngstown, Missouri, population 25, which is approximately one mile downstream from the dam. Forest Lake is a part of, and surrounded by the Thousand Hills State Park. The reservoir and dam can be reached by travelling west out of Kirksville, Missouri, on State Road 6 for about 2.2 miles, and then south of State Road 157 for 2.5 miles to the sign for Thousand Hills State Park. To reach the dam, turn right on the gravel road just before the main sign, and keep to the left for about 2 miles. Then turn left on the dirt road next to the 6-foot cyclone fence and gate, for roughly 1 mile. The dam and reservoir is

shown on the Kirksville Quadrangle Sheet (15 minute series) in Section 14, Township 62 North, Range 15 West.

c. Size Classification

According to the "Recommended Guidelines for Safety Inspection of Dams", by the U.S. Department of the Army, Office of the Chief Engineer, the dam is classified in the dam size category as being "Intermediate" since its storage is more than 1,000 acre-feet, but less than 50,000 acre-feet. The dam is also classified as "Intermediate" in dam size category because its height is more than 40 feet, but less than 100 feet. The overall size classification is, accordingly, "Intermediate" in size.

d. Hazard Classification

The dam has been classified as having "High" hazard potential in the National Inventory of Dams, on the basis that in the event of failure of the dam or its appurtenances, excessive damage could occur to downstream property, together with the possibility of the loss of life. Our findings concur with the classification. The estimated damage zone extends 10 miles downstream of the dam. Within the damage zone are four farmhouses with associated farm buildings, and two improved roads. The floodplain is farmed.

e. Ownership

Forest Lake Dam is owned by the City of Kirksville, 201 South Franklin Street, Kirksville, Missouri 63501.

f. Purpose of Dam

The main purpose of the dam is to impound water for use in a water supply system operated by the City of Kirksville, Missouri. The impounded water is released by means of the bottom outlet. The lake is also for recreational use.

g. Design and Construction History

The original design for the Forest Lake Dam was done by J. W. Shikles & Company, of Kansas City, Missouri, in 1949 and 1950. Original construction was done by R. G. Albridge of Kansas City, Missouri. A cut-off wall and drain was designed in 1969, and the spillway reconstruction was designed in 1971, both by Larkin & Associates of Kansas City, Missouri.

The spillway reconstruction was done by L. G. Barcus of Kansas City, Missouri, and the cut-off wall and drain was built by Mhalovich Constructions, also of Kansas City, Missouri.

h. Normal Operational Procedures

The dam is used to impound water for use as water supply and for recreation. The reservoir level is controlled by rainfall, runoff, evaporation, and the water supply requirements of the City of Kirksville, Missouri. The reservoir is likely close to full at all times.

1.3

Pertinent Data

a. Drainage Area

b. Discharge at Damsite

All discharge at the dam-site is through an uncontrolled spillway and outlet pipe

Estimated experienced maximum flood:

Estimated ungated spillway capacity
at maximum pool elevation:

c. Elevation (Feet above MSL)

Top of dam:

Spillway crest:

Minimum streambed elevation at centerline of dam:

Maximum tailwater:

d. Reservoir

Length of maximum pool:

e. **Storage (Acre-Feet)**

Top of dam:

Spillway crest:

f. Reservoir Surface (Acres)

Top of dam:

Spillway crest:

g. Dam

Type:

Earth embankment

Length:

1,500 feet

Height (maximum):

61 feet

Top width:

20 feet

Side slopes:

Downstream	1V to 3H
Upstream	1V to 3H
Zoning:	None
Impervious core:	None
Cutoff:	Core trench with 12-foot bottom width and 1V to 1H side slopes
Grout curtain:	None

h. Diversion and Regulating Tunnel

Type:	5-foot by 5-foot reinforced concrete conduit
Length:	290 feet
Closure:	Blocked during construction, 16-inch C.I. pipe inside of conduit for water supply

i. Spillway

Type:	Ogee
Length of weir:	150 feet
Crest Elevation (MSL):	800.0 feet

j. Regulating Outlets

Type:	16-inch diameter cast iron pipe
Length:	285 feet
Closure:	16-inch diameter cast iron gate valve
Maximum Capacity:	36 cfs

SECTION 2: ENGINEERING DATA

2.1 Design

Original design drawings are available for the dam and appurtenant structures. These drawings were made in 1949 and 1950, and are given as plates in this report. Also available are as-built drawings of the spillway reconstruction performed in 1971.

Available design data also includes miscellaneous design calculations, a memorandum entitled "Comments on the Design of Kirksville Dam on Big Muddy Creek", written by the design engineer, and bore hole logs and testing results of sampling performed in the borrow areas and foundation during design. The above described data is available from city offices in the City of Kirksville, Missouri and/or from Larkin and Associates in Kansas City, Missouri.

2.2 Construction

The dam was constructed in 1950 by R. G. Albridge, of Kansas City, Missouri. Specifications for construction are available, however, no records of the construction period were found.

2.3 Operation

No operation records for Forest Lake Dam are available.

2.4

Evaluation

a. Availability

The availability of data is considered good for this project. Complete design drawings and specifications are available, along with some design calculations and soil testing results.

b. Adequacy

The engineering data available is adequate to aid in evaluating the adequacy of the hydraulic and hydrologic capabilities and stability of the dam for Phase I investigations.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams", Appendix D. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity

The dam and appurtenant structures appeared to be constructed in accordance with the design and reconstruction drawings, and all other engineering data appears to be valid.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

A visual inspection of Forest Lake Dam was made on September 29, and October 6, 1978. The following persons were present during the inspection:

<u>Name</u>	<u>Affiliation</u>	<u>Discipline</u>
Yin Au-Yeung	Engineering Consultants, Inc.	Project Engineer, Hydraulics and Hydrology
David Bramwell	Engineering Consultants, Inc.	Geology
Jon Diebel	Engineering Consultants, Inc.	Soils
John Ismert	Engineering Consultants, Inc.	Mechanical
Kevin Blume	Consoer, Townsend & Assoc., Ltd.	Civil & Structural

Specific observations are discussed below.

b. Dam

The crest of the dam has a heavy vegetative cover which adequately protects the embankment material. The grass appeared to have been recently cut. Some evidence of vehicular traffic can be seen on the crest, but does not appear to be extensive. Some small desiccation cracks were seen in the clay embankment material on the crest.

The upstream embankment slope is adequately protected by the large rock riprap. No degradation due to weathering of the blocks was seen. Many small trees were observed on the upstream slope. The majority of these trees were growing approximately 4 to 5 feet above the water surface, where the riprap was somewhat thinner.

The downstream embankment slope is heavily covered with brush and trees, making inspection difficult. Stumps of large trees which had been previously cut were numerous on the slope, with some of stumps up to 2 feet in diameter. Many smaller trees up to 6 inches in diameter are currently growing on the slope. Some rodent activity was observed on the downstream slope.

Seepage was noted in several areas on the downstream slope. One area was observed along the abutment contact at the right side of the dam approximately one-half way up the slope. This location is at the fill/bedrock contact, as limestone could be seen on the natural slope adjacent to the seepage. The seep was at a low rate without measurable flow. Other seepage areas were noted 50 to 100 feet upstream of the pump house, again along the fill/abutment contact. This area was approximately 20 feet in diameter, and was boggy with phreatophytes growing. No measurable flow could be seen. Just upstream and to the left (looking downstream) of this area an area 55 feet by 35 feet was observed, with similar characteristics to the above described area. An area 20-feet by 20-feet, exhibiting phreatophytes and ponding water, was observed approximately 500 feet north of the left abutment, and 50 feet west of the downstream toe of the dam.

Some surface erosion was occurring along each abutment contact. This condition had not progressed to a significant stage at the time of inspection.

No signs of past or present instability were seen on the embankment or in the foundation at any location.

c. Appurtenant Structures

(1) Spillway

The top of the ogee spillway crest is seriously eroded. The crest is fairly level, and no variations were detected. Minor horizontal and vertical cracking was visible on the downstream face. There is some local spalling of concrete on the spillway chute slab, and minor vertical cracks on the stilling basin walls. The horizontal spillway channel between the crest structure and the spillway chute is covered with heavy vegetative growth for the entire length. There is a 3' x 3' hole on the right wall of the spillway channel approximately 30 feet upstream of the spillway chute.

(2) Outlet Works

The decks of the intake tower with the valve operators was reached by boat. The concrete and operators were found to be weathered, but in satisfactory condition.

The conduit under the dam was entered through the valve vault and inspected throughout its length. The conduit, as well as the 16-inch pipe, were dry and in good condition.

Attempted operation of the two gate valves in the valve vault was unsuccessful. Both valves were stuck. The valve in the line to the pump station was open, and the drain valve was closed. The maintenance man advised that they had not been operated in 4 or 5 years.

The outlet of the 30-inch concrete drain pipe from the valve vault was inspected. The pipe terminates in a concrete headwall structure which is in satisfactory condition, but partially covered with vegetation. An 8-inch pipe drain from the pumping plant also terminates in the headwall. The lower one-third of the 30-inch drain pipe was submerged under the water standing in the outlet ditch.

d. Reservoir Area

The water surface elevation was 799.5 feet above MSL at the time of inspection.

No wave wash, excessive erosion, or slides were observed along the reservoir rim. The reservoir rim is generally gentle to moderately sloping, with trees and woods at the left shore and relatively more grass and brush at the right shore.

e. Downstream Channel

The channel is trapezoidal in shape and well-defined with a rock streambed, a bottom width of approximately 15 feet, and side slopes of 1V to 3H. There is no sign of erosion or undercutting of banks downstream of the stilling basin.

3.2 Evaluation

The visual inspection did not exhibit any items which are sufficiently significant to indicate a need for immediate remedial action.

The following problems were observed which could affect the safety of the dam, or which will require maintenance within a reasonable period of time.

1. Heavy brush and trees on the upstream and downstream embankment slope.
2. Rodent activity on the downstream embankment slope.
3. The seepage occurring at the right abutment contact and downstream of the toe of the embankment 500 feet north of the left abutment.
4. Concrete erosion on the ogee spillway crest.
5. A 3-foot by 3-foot hole on the right wall of the spillway channel 30 feet upstream of the spillway chute.
6. Vegetation in the spillway channel between the ogee and the spillway chute.
7. Inability to operate the two 16-inch gate valves in the valve vault.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

The dam is used to impound water from Big Creek for water supply and recreation. The only operating facility at the dam is the water supply intake and appurtenant piping. The intake is supplied with 7 gate valves at various levels to provide water with the best quality. Each gate valve is operated from the top deck of the tower by a pedestal mounted handwheel connected to a stem extension.

Both valves for controlling the flow into the two branch lines of the outlet pipe are manually operated, the valve to the pumping plant normally being kept open, and the valve to the drain normally being kept closed. The drain valve would be opened to draw down the reservoir for dam or spillway maintenance, or in event of an emergency situation.

Operation and maintenance records are not available.

4.2 Maintenance of Dam

The dam is maintained by the City of Kirksville, Missouri. The large amount of brush on the downstream embankment slope, and trees on the upstream and downstream embankment slope demonstrates a need for more regular maintenance. Other maintenance problems observed with the dam or appurtenant structures include rodent activity on the embankment slopes, concrete erosion on the spillway crest, and minor problems with the spillway discharge channel.

4.3 Maintenance of Operating Facilities

The two 16-inch gate valves in the water supply piping are apparently inoperable, with one being stuck open, and the other closed. These should be repaired in the near future for use in case problems develop with the dam or appurtenant structures.

4.4 Description of Any Warning System in Effect

The inspection team is not aware of any existing warning system in effect.

4.5 Evaluation

The observations described above indicate a need for further maintenance at the damsite. The operation procedures appear to be satisfactory.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

Forest Lake Dam has a watershed of approximately 10,500 acres, mostly covered with dense wooded forest. Land gradients are fairly steep, ranging from 7 to 10 percent. Forest Lake (formerly Big Creek Reservoir) is located on Big Creek, which is a tributary of the Chariton River.

Elevations within the watershed range from approximately 800 feet above MSL at the damsite to over 980 feet above MSL in the upper portion of the watershed.

A drainage map showing the watershed area is included in Appendix B.

Evaluation of the hydraulic and hydrologic features of Forest Lake Dam was based on criteria set forth in the Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams, and additional guidance provided by the St. Louis District of the Corps of Engineers. The Probable Maximum Flood (PMF) was calculated from the Probable Maximum Precipitation (PMP) using the methods outlined in the U.S. Weather Bureau Publication, Hydrometeorological Report No. 33. The probable maximum storm duration was set at 48 hours, and storm rainfall distribution was based on criteria given in EM 1110-2-1411 (Standard Project Storm). The SCS triangular hydrograph, transformed to a curvilinear hydrograph, was adopted for developing the unit hydrograph. A

time interval of 10 minutes was used in the unit hydrograph. The derived unit hydrograph is presented in Appendix B.

Initial and infiltration loss rates were applied to the PMF to obtain rainfall excesses. The rainfall excesses were then applied to the unit hydrograph to obtain the PMF hydrograph, utilizing the Corps of Engineers' computer program HEC-1, (Dam Safety Version), which was prepared specifically for dam safety analysis. The computed peak discharge of the PMF and one-half of the PMF are 97,422 cfs and 48,711 cfs, respectively.

Both the PMF and one-half of the PMF inflow hydrographs were routed through the reservoir by the Modified Puls Method, also utilizing the HEC-1 (Dam Safety Version) computer program. The peak outflow discharges for the PMF and one-half of the PMF are 75,603 cfs and 31,555 cfs, respectively. Both the PMF and one-half of the PMF, when routed through the reservoir, resulted in overtopping of the dam. The hydraulic capacity of the spillway is 8,840 cfs before overtopping of the dam.

The stage-outflow relation for the spillway was prepared from field notes, sketches and limited construction drawings. The reservoir stage-capacity data were based on the U.S.G.S. Kirksville Quadrangle topographic maps (15 minute series) in combination with data given in the National Dam Safety Inventory Table. Reservoir storage capacity included surcharge levels exceeding the top of the dam, and the spillway overtop rating curve assumed that the dam remains intact during routing. In the routing computations, the discharge through the outlet facilities was excluded due to its insignificant magnitude as compared to the spillway discharge and the PMF. The spillway overtop rating curve and the reservoir capacity curve are also presented in Appendix B.

From the standpoint of dam safety, the hydrologic design of a dam aims at avoiding overtopping. Overtopping is especially dangerous for an earth dam because the downrush of waters over the crest will erode the dam face and, if continued long enough, will breach the dam embankment and release all the stored water suddenly into the downstream floodplain. The safe hydrologic design of a dam calls for a spillway discharge capability, in combination with an embankment crest height that can handle a very large and exceedingly rare flood without overtopping.

b. Experience Data

No records of reservoir stage or spillway discharge are maintained for this site. However, according to interviews with local residents, the maximum reservoir level was never higher than the crest of the embankment.

c. Visual Observations

The spillway approach channel is in good condition. However, the spillway crest structure, spillway discharge channel, stilling basin and exit channel are well-defined, but inadequately maintained. Concrete in the ogee section is in a deteriorated condition, exhibiting severely eroded concrete at the crest. The spillway discharge channel floor and banks contain vegetation and tree growth. Some spalling of the concrete was observed on the spillway chute slabs. Minor vertical cracks also appear on the stilling basin walls. Some debris and sediment have accumulated in the stilling basin. The downstream channel is also well-defined, but with some tree growth and vegetative cover.

d. Overtopping Potential

As indicated in Section 5.1-a., both the Probable Maximum Flood and one-half of the Probable Maximum Flood, when routed through the reservoir, resulted in overtopping of the dam. The Probable Maximum Flood (PMF) is defined as the flood discharge that may be expected from the most severe combination of critical meteorological and hydrological conditions that are reasonably possible in the region. The PMF and one-half of the PMF overtopped the dam crest by 5.39 feet and 2.48 feet, respectively. The total duration of embankment overflow is 7.00 hours during the PMF, and 4.33 hours during one-half of the PMF. The spillway for Forest Lake Dam is capable of passing a flood equal to approximately 25 percent of the PMF just before overtopping the dam.

The computed one percent chance flood using 100-year, 24 hour rainfall data was routed through the reservoir, and is given in the last section in Appendix B. The routing results indicate the spillway will pass the 100-year flood with a freeboard of 1.03 feet.

The effect from rupture of the dam could extend approximately 10 miles downstream of the dam. There are four farmhouses with associated farm buildings, and two improved roads within this ten miles of floodplain area. The floodplain is farmed.

Without extensive field surveys and downstream hydraulic routings, the impact on the town of Youngstown that failure of Forest Lake Dam would have cannot be ascertained. Youngstown, Missouri is located on the west bank of the Chariton River, while Forest Lake Dam is located on a tributary approximately 1.5 miles east of the Chariton River.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There were no signs of settlement or distress observed on the embankment or foundation during the visual inspection. The upstream slope, crest, and downstream slope are well protected by either riprap or vegetation.

The seepage observed at its current condition is not felt to be sufficiently serious to indicate an unsafe condition. However, the seepage should be monitored and any changes in quantity, location or color should be reported and investigated.

The upstream slope, crest, and downstream slope are well protected by either riprap or vegetation. However, the trees and large brush growing on the slopes could eventually pose a hazard to the embankment. Surface erosion is not yet a problem for the embankment section.

Concrete in the ogee crest section shows signs of deterioration due to severe erosion. This condition should be corrected as soon as possible before the condition progresses further. The spillway channel banks are in good condition, except for a damaged portion at the grouted blocks on the right bank near the spillway chute. This damaged portion of the channel bank should be repaired. Spalling of concrete in the spillway chute slab and minor vertical cracking in the stilling basin walls do not pose any danger to the structural integrity of the spillway or the embankment.

The gate valves on the water supply piping should be made operable in case emergency operation of the valves is required.

b. Design and Construction Data

Design calculations found included computations for the stability of the dam foundation. Also found were gradations and Atterberg limits for the foundation soils and borrow pit material. No design data relating to seepage and stability analysis are known to exist.

c. Operating Records

No operating records are available relating to the stability of the dam. Water level on the day of inspection was 6 inches below the spillway crest, and it is assumed that the reservoir remains close to full at all times. The only operating facility at the dam is the intake for the water supply, pump house, and appurtenant piping.

d. Post Construction Changes

A cut-off wall and drain under the spillway was designed in 1969 by Larkin & Associates of Kansas City, Missouri, to alleviate the problem of water seeping under the spillway structure.

Spillway reconstruction, which indicated under-drains, a cut-off wall extension, and reconstruction of parts of the stilling basin and retaining walls, was designed and performed in 1971.

The reconstruction work was performed by L. G. Barcus of Kansas City, Missouri, and the cut-off wall and drain was built by Mhalovic Constructions, also of Kansas City, Missouri.

e. Seismic Stability

In general, projects located in Seismic Zones 0, 1 and 2 may be assumed to present no hazard from earthquake, provided the static stability conditions are satisfactory and conventional safety margins exist. Forest Lake Dam is located in Seismic Zone 1. A detailed seismic analysis is not felt to be necessary for this embankment.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

It should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team.

It is also important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that an unsafe condition could be detected.

a. Safety

The dam appears to be in generally good condition, with a spillway that will pass only 24 percent of the PMF without overtopping of the dam.

The heavy brush and trees on the embankment slope pose a potential hazard to the dam. The extensive tree growth is considered unsatisfactory in terms of dam safety for several reasons: First, trees toppled by wind expose holes

that invite rapid erosion, and second, decay of large existing root systems could form channels for eventual piping. Rodent activity also should be eliminated on the embankment.

The seepage observed at the abutment contact and downstream of the toe of the dam is not felt to indicate an unsafe condition at its current extent. This seepage should be monitored for changes indicating a potential hazard.

Other observations made during the visual inspection, although not jeopardizing the safety of the dam, should be repaired within a reasonable period of time.

b. Adequacy of Information

Information concerning operation and maintenance of the dam and appurtenant structures is somewhat lacking. It is recommended that the following programs be initiated to help alleviate this problem:

1. Annual inspection of the dam by a professional engineer experienced in the design and construction of earthen dams should be made and this inspection report made a matter of record.
2. Set up a maintenance schedule and log all visits to the dam for operation, repairs and maintenance.
3. Perform seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams".

The engineering data, together with performance history and visual inspection findings is felt to be adequate information to support the conclusions presented in this report.

c. Urgency

The remedial measures recommended in Paragraph 7.2 should be accomplished within a reasonable period of time.

Increasing the spillway capacity is certainly of a more urgent nature than the other recommended actions.

d. Necessity for Phase II Inspection

Based on results of the Phase I inspection, a Phase II inspection is not felt to be necessary.

7.2 Remedial Measures

a. Alternatives

Possible alternatives for increasing the spillway capacity of the dam include:

1. Lowering the ogee crest of the spillway.
2. Raising the height of the dam crest.
3. Widening the spillway crest length.

4. A combination of the above items.

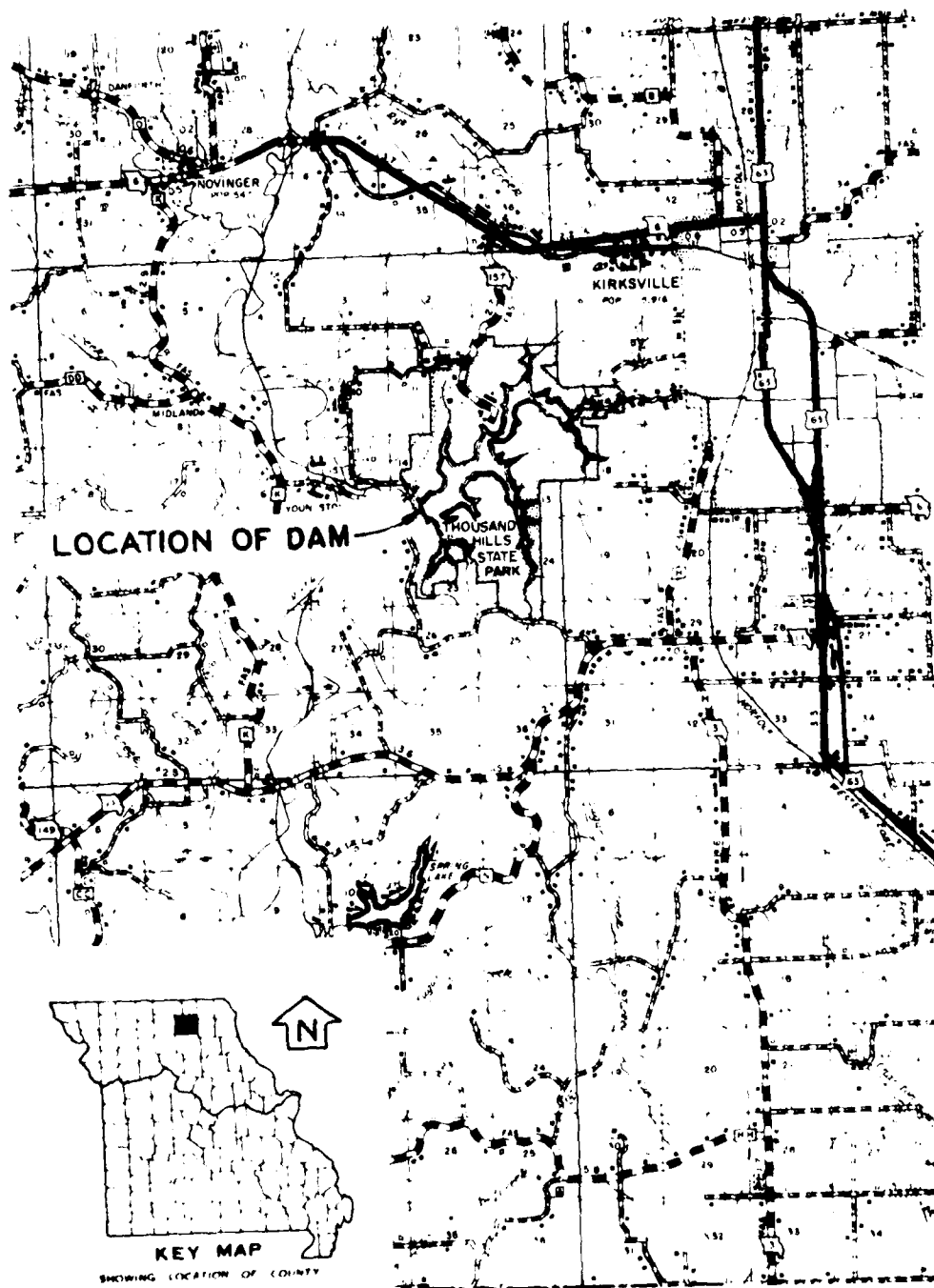
b. O & M Maintenance Procedures

The owner should initiate the following programs:

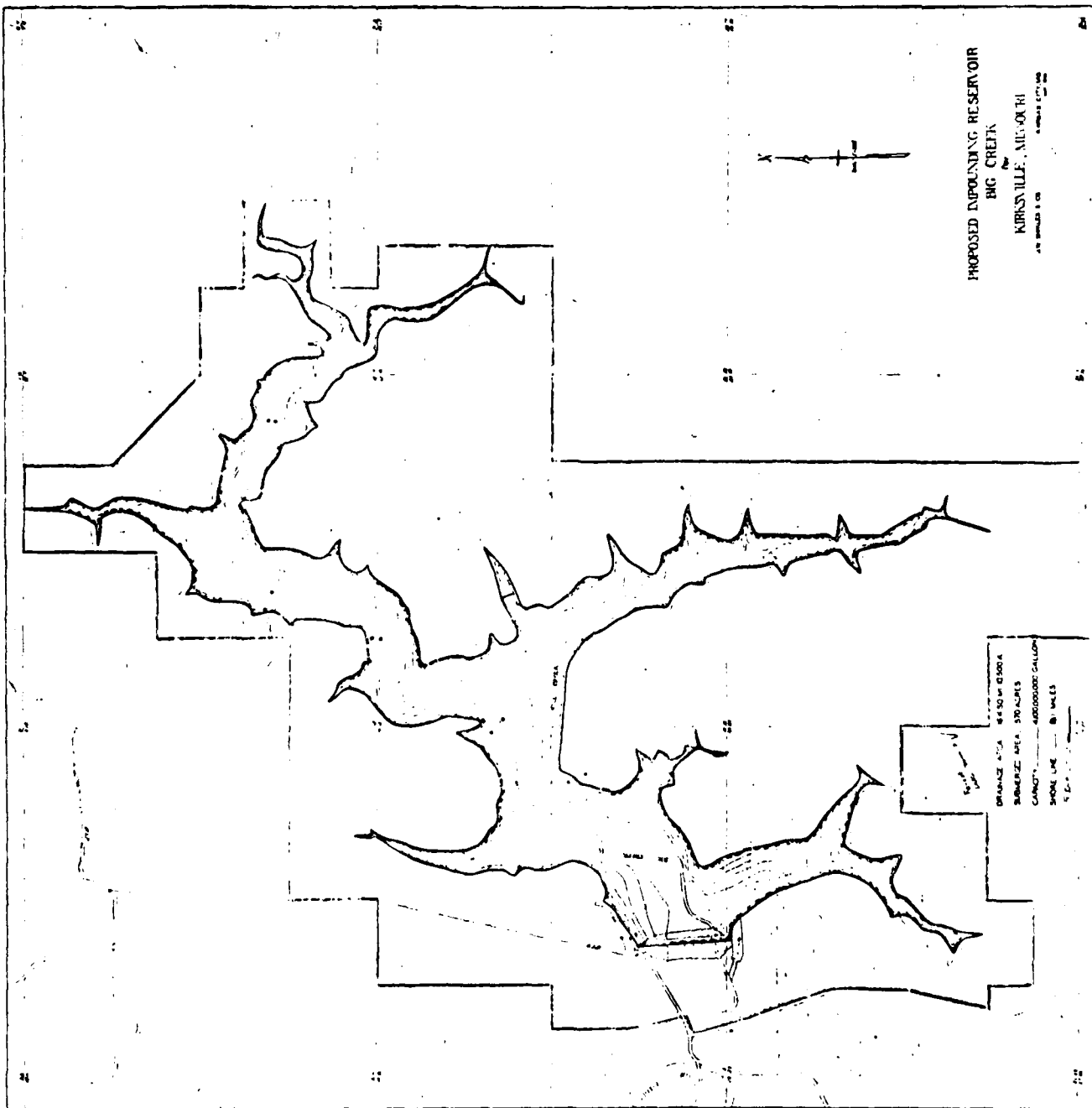
1. Annual inspection of the dam by a professional engineer experienced in the design and construction of earthen dams.
2. Set up a maintenance schedule and log all visits to the dam for operation, repairs and maintenance.
3. Clear the upstream and downstream embankment slope of all trees and large brush. Future growth should be prevented following original clearing.
4. Monitor seepage at the right abutment contact and downstream of the toe of the dam for changes in quantity, location or color of the seepage. Any changes should be reported.
5. Patch concrete on the ogee spillway crest.
6. Repair the hole on the right side of the spillway channel.
7. Clean off all vegetation and tree growth in the spillway channel between the ogee crest and the spillway chute.

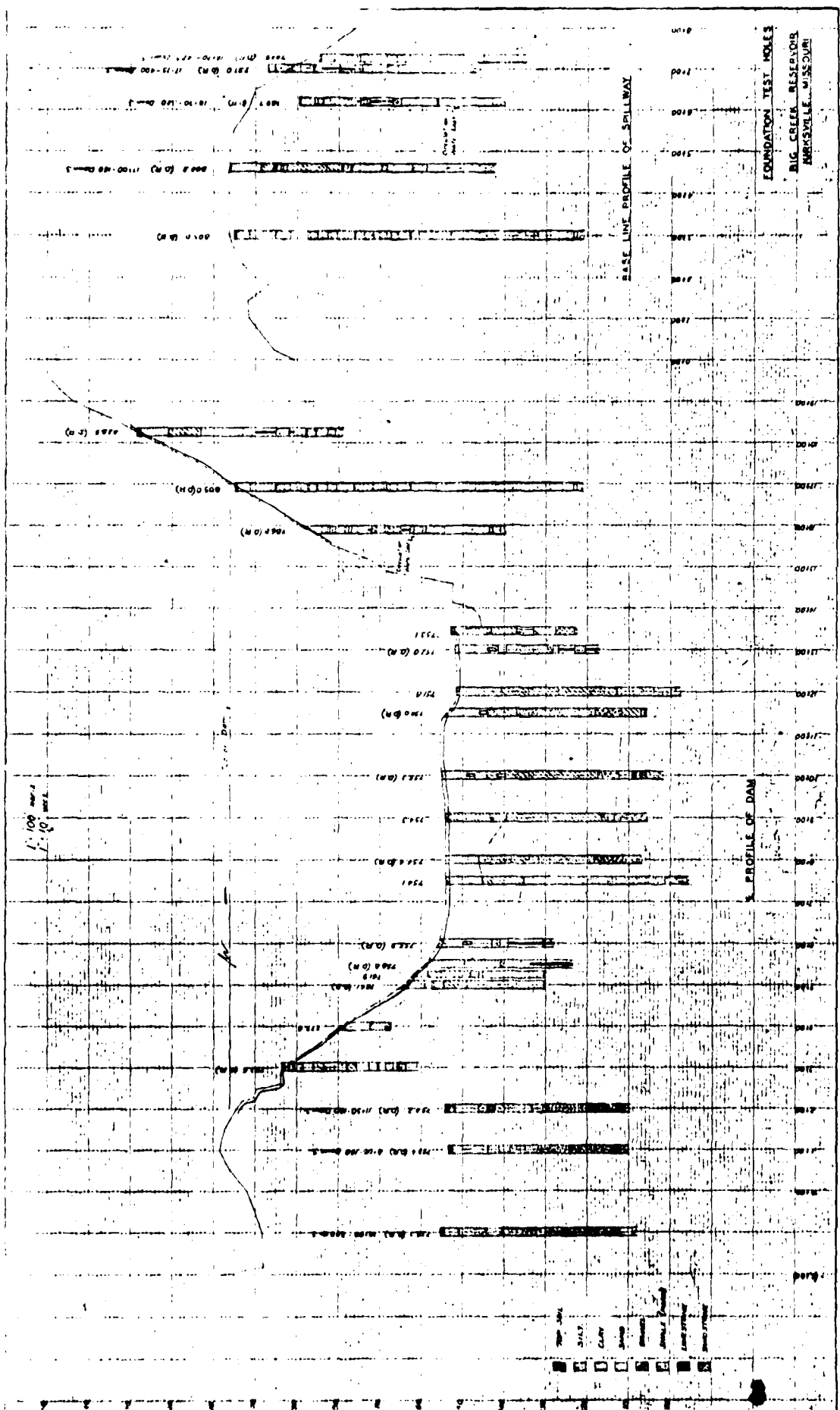
8. Repair the gate valves for the water supply pipe located in the valve vault.
9. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of dams.

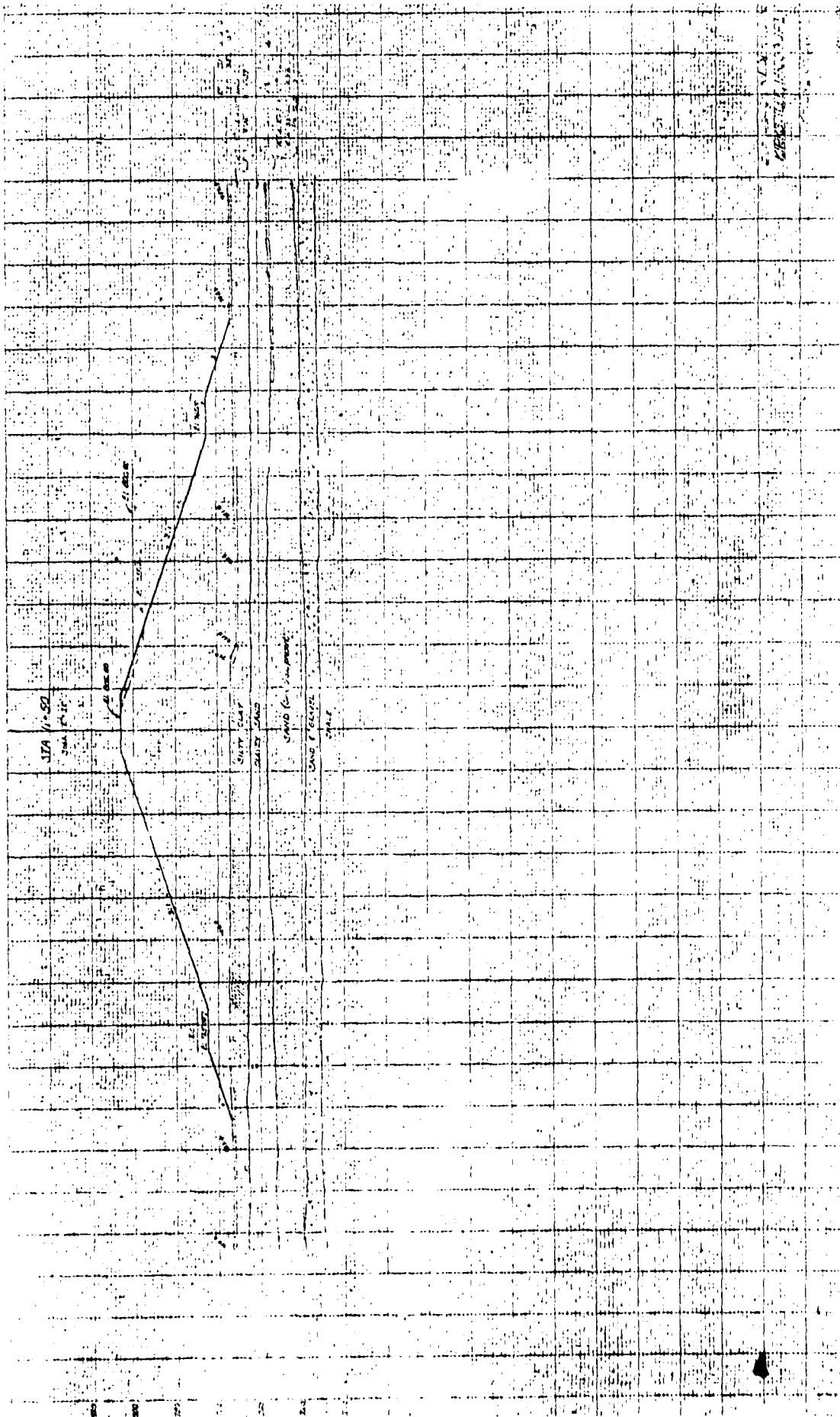
PLATES



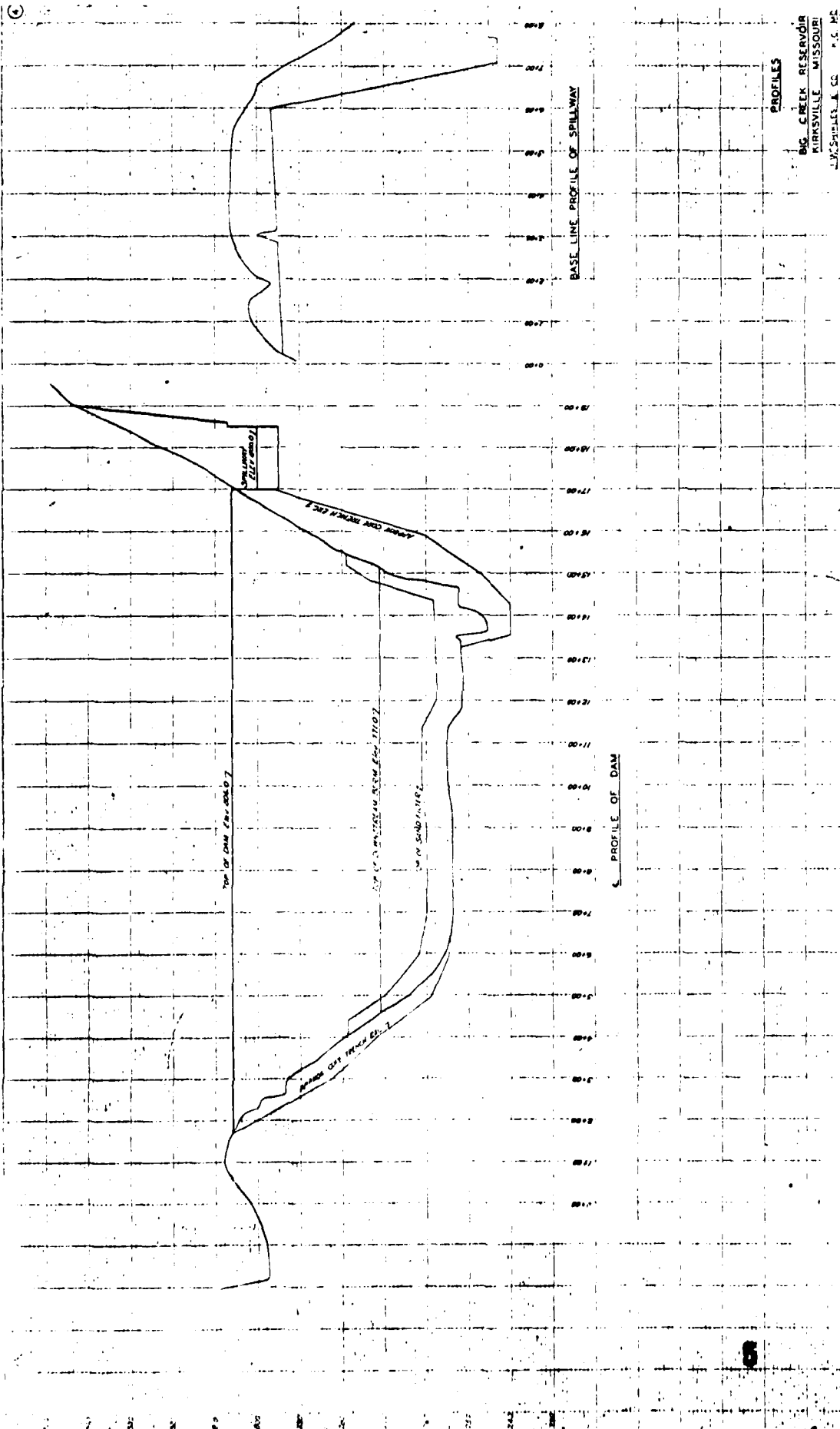
LOCATION MAP
FOREST LAKE DAM
ADAIR COUNTY, MISSOURI

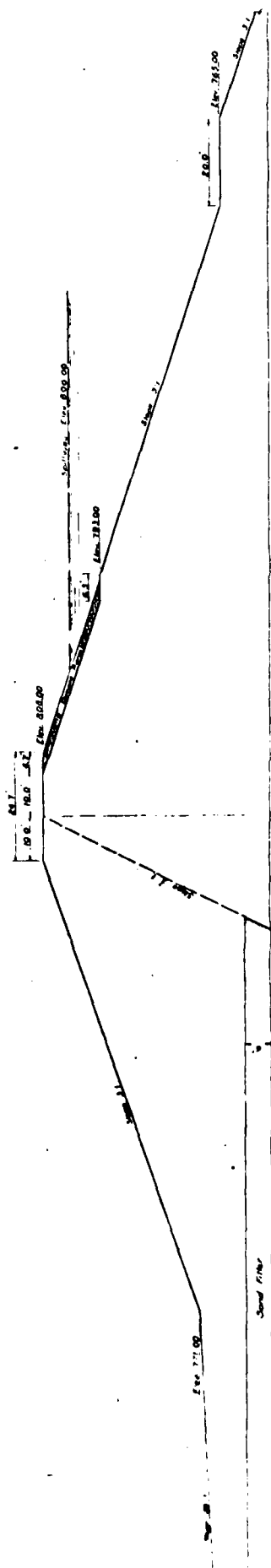




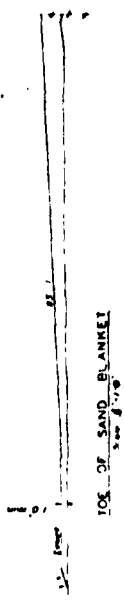


6

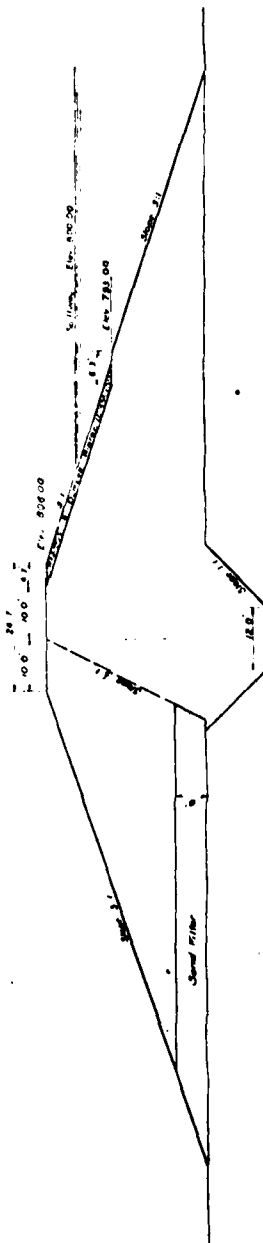




TYPICAL VALLEY SECTION
Scale 1:10'



TOG OF SAND BLANKET 200 ft.



TYPICAL ABUTMENT SECTION
Scale 1:10

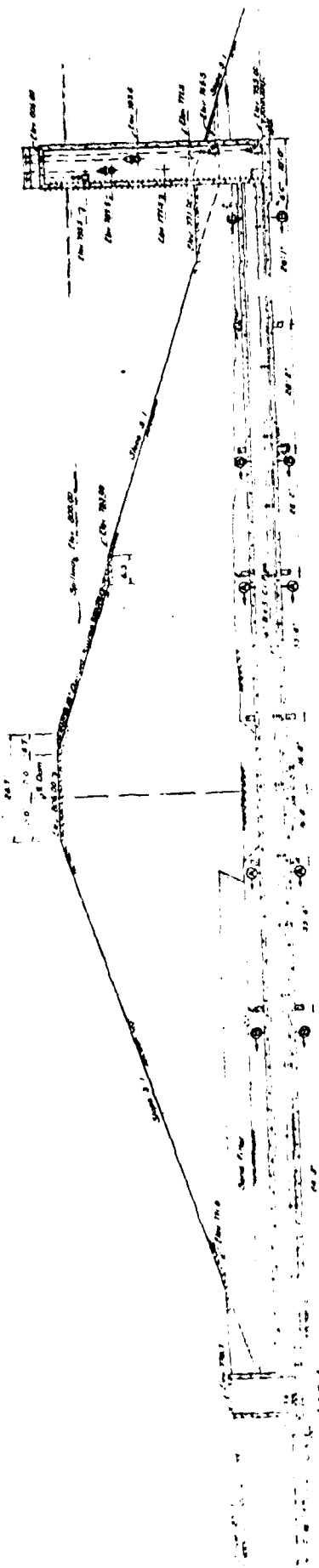
TYPICAL CROSS SECTIONS
OF DAM

BIG CREEK RESERVOIR
KIRKSVILLE, MISSOURI

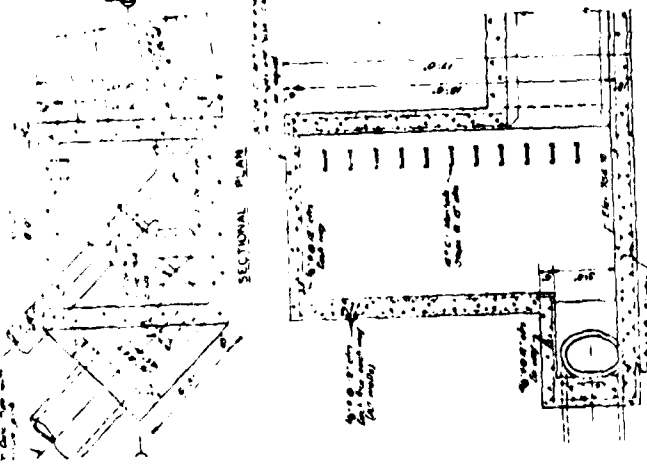
J.W. SHUMLER & CO

P.C. 300
10

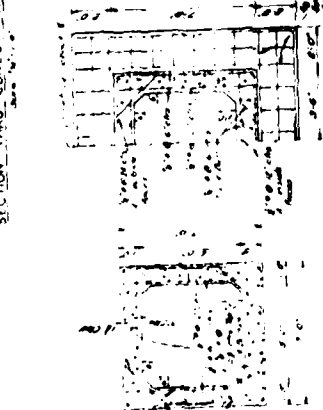
①



SECTION THRU CONDUIT AND TOWER

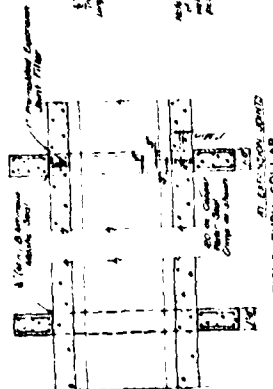


SECTIONAL PLAN

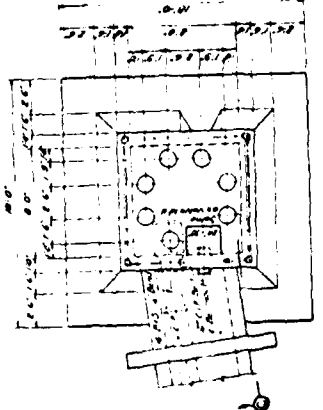


SECTION A-A

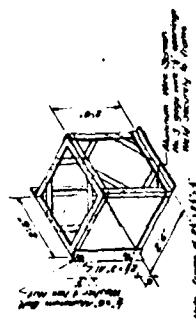
HALF ELEVATION OF CUT-OFF COLLAR



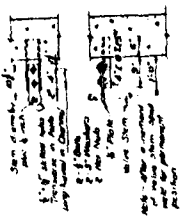
DETAILS OF CONDUIT AND CUT-OFF COLLAR



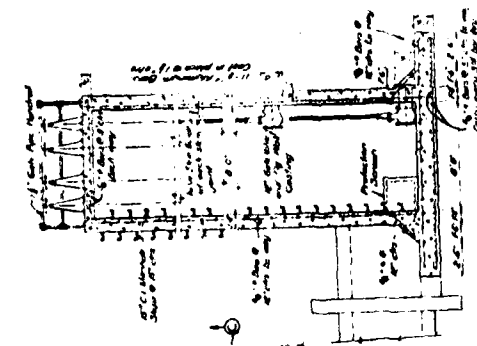
PLAN OF TOWER



PROTECTION SCREEN



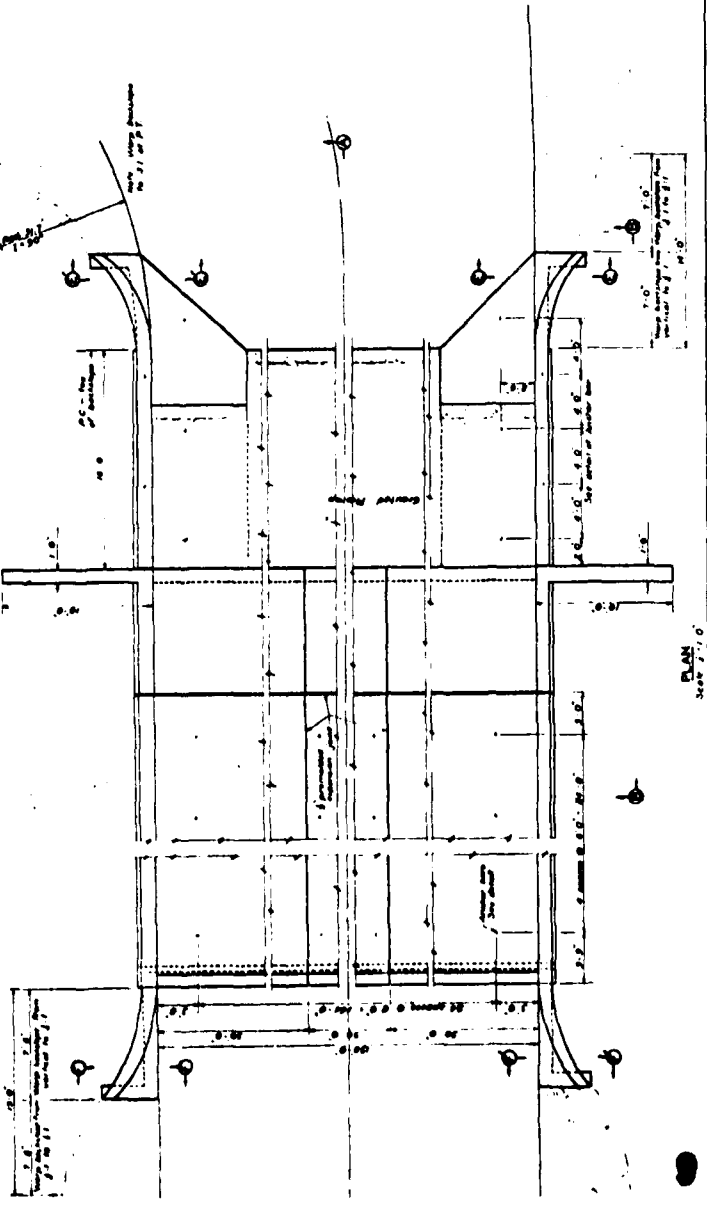
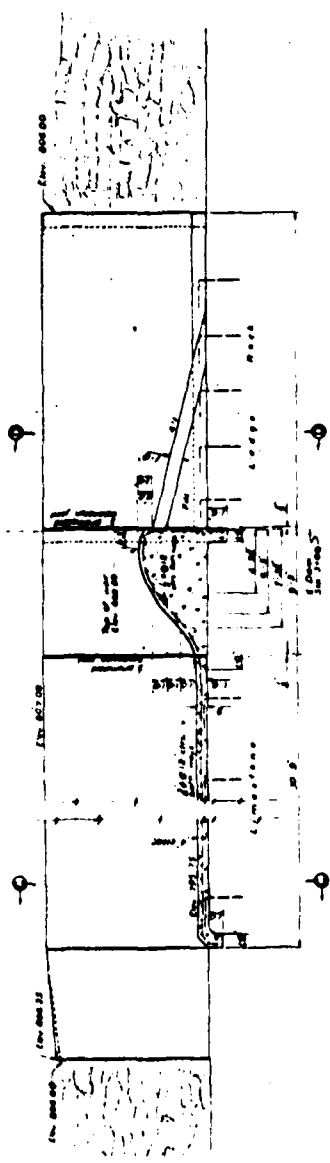
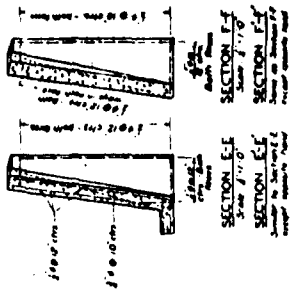
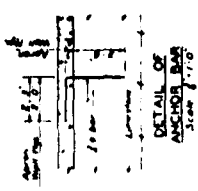
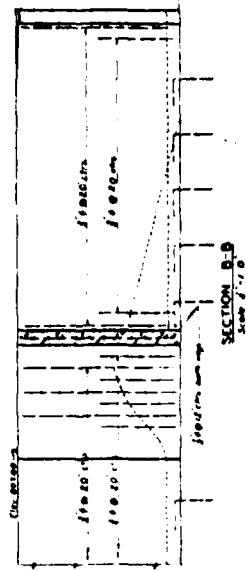
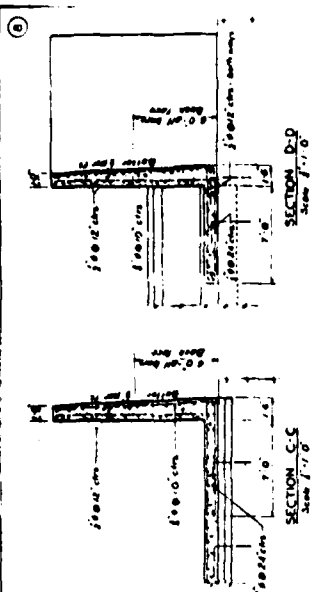
VALVE STEM GUIDE



SECTION C-C

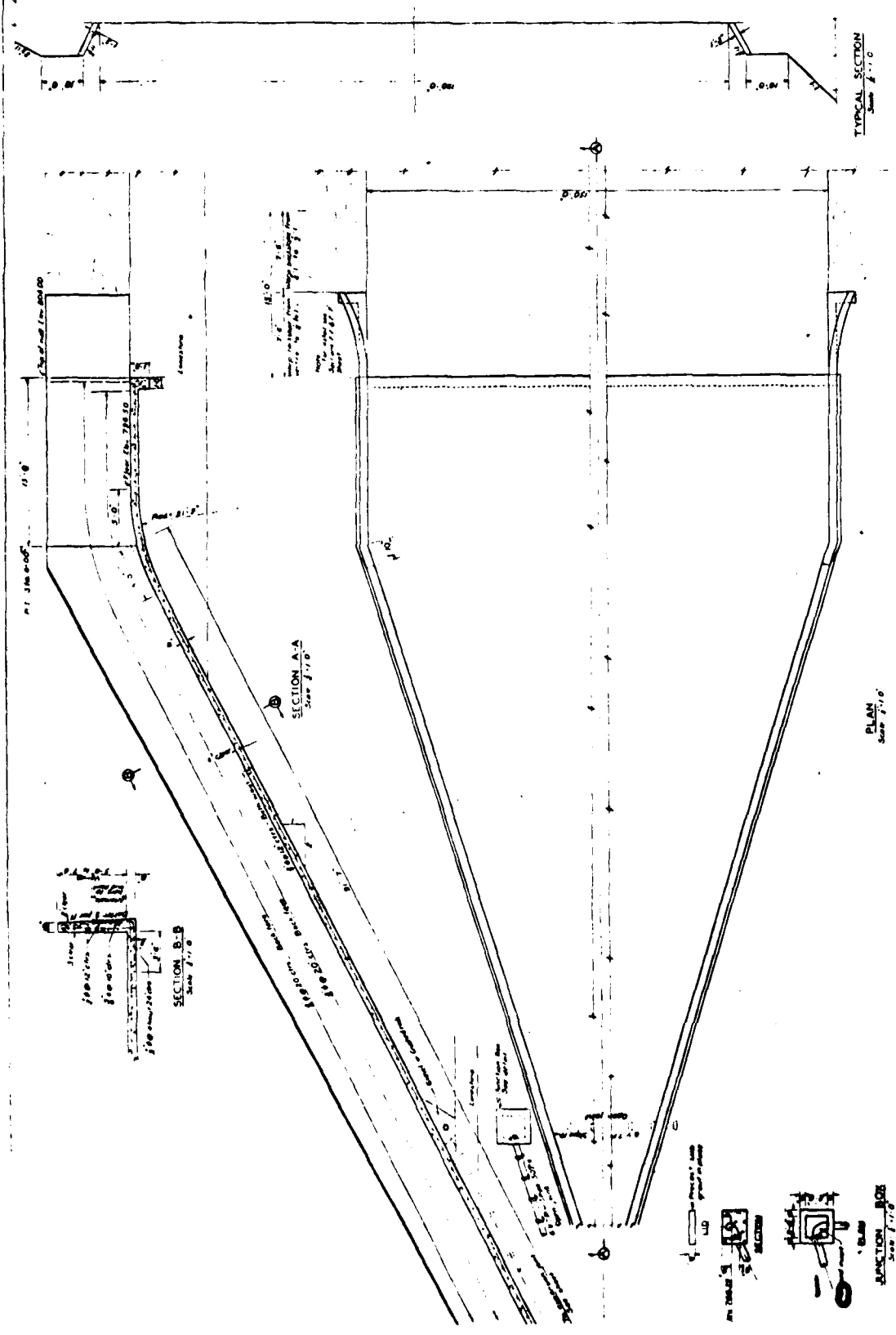
DIVISION-INTAKE CONDUIT
AND INTAKE TOWER
BIG CREEK RESERVOIR
KIRKSVILLE MISSOURI
JAN 20 - 1911

SECTION D-D
DETAILS OF VALVE MANHOLE



SPILLWAY CHANNEL
AND OGLE WEIR
BIG CREEK RESERVOIR
KIRKSVILLE, MISSOURI
J. B. SPANGLER & CO. P. C. NO. 10

9



SPILLWAY CHANNEL
BIG CREEK RESERVOIR
KIRKSVILLE, MISSOURI
J.M. SHAW & CO. E.C. MO
A-1 112

TYPICAL SECTION
Scale 1" = 10'

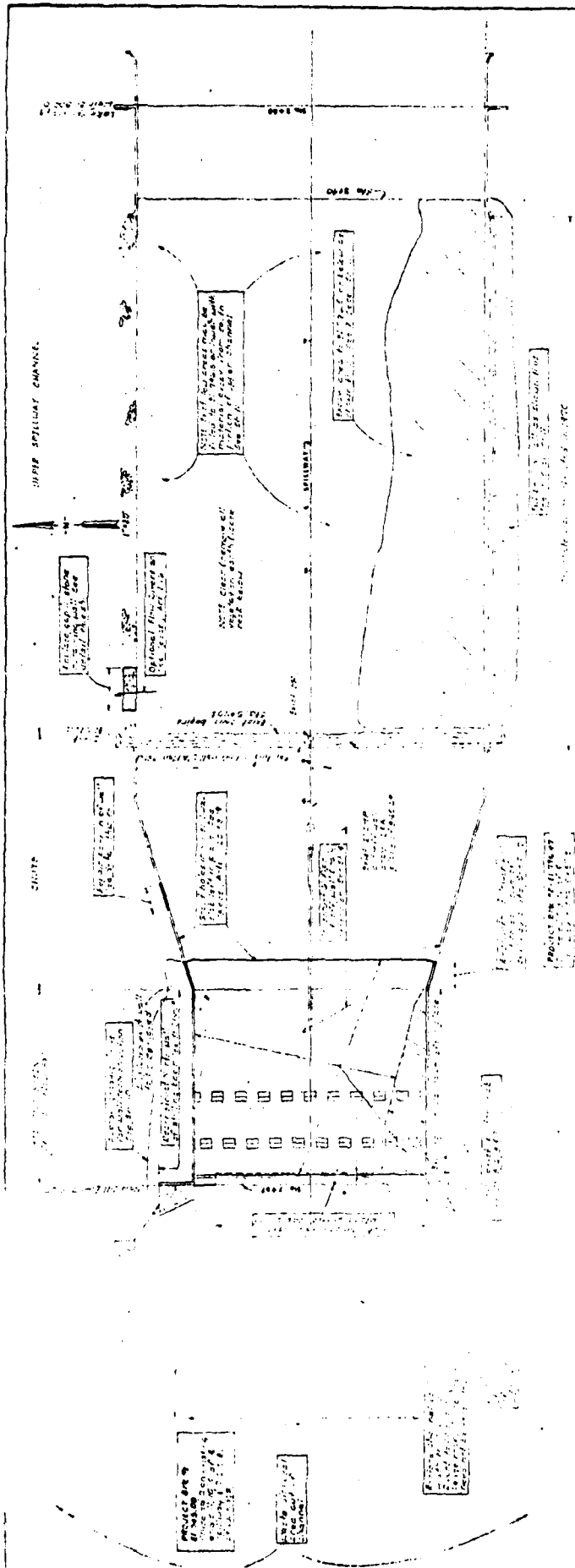
PLAN
Scale 1" = 100'

SECTION B-B
Scale 1" = 10'

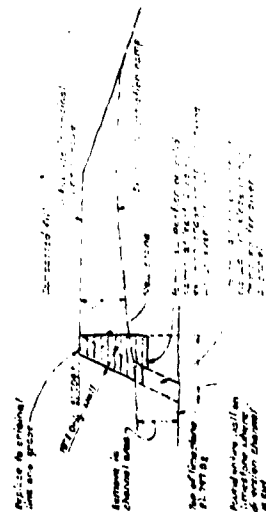
SECTION A-A
Scale 1" = 10'

SECTION B-B
Scale 1" = 10'

SECTION A-A
Scale 1" = 10'



GENERAL LAYOUT



DETAIL OF SECTION OF NORTH SPILLWAY WALL



DETAIL OF SECTION OF NORTH SPILLWAY WALL

FOREST LAKE SPILLWAY RECONSTRUCTION	
KIRKSVILLE, MISSOURI	
GENERAL LAYOUT	
LARKIN & ASSOCIATES Consulting Engineers	
No. 100-1000	

ENGINEERING CONSULTANTS, INC.

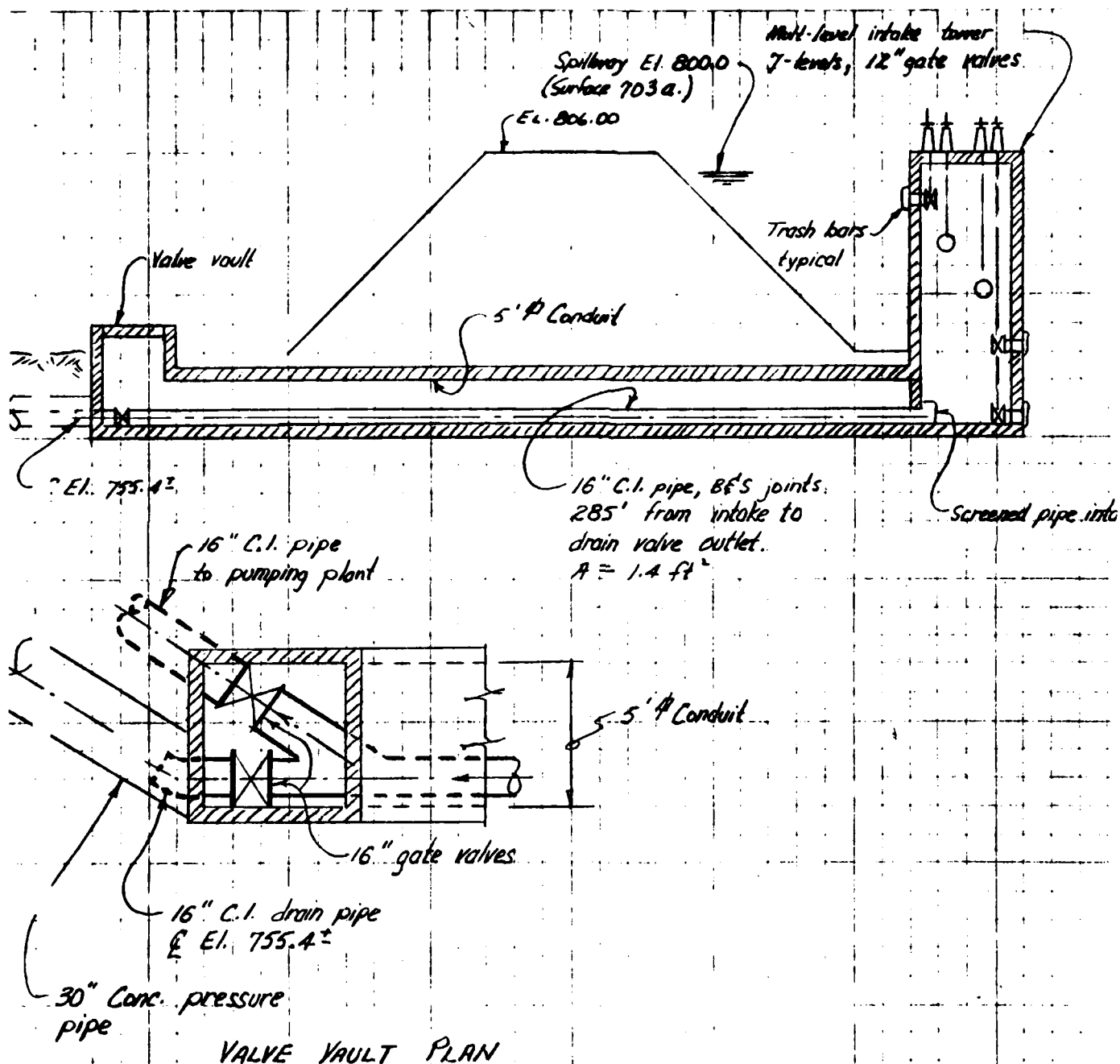
FOREST LAKE (BIG CREEK RESERVOIR) - MISSOURI

SHEET NO. 1 OF

JOB NO. 1223

RATING CURVE FOR DRAIN OUTLET

BY JCE DATE 10/11/78



Significant losses are pipe entrance loss, pipe friction, exit velocity head.

At higher reservoir levels all gate valves in intake tower can be opened, therefore losses into tower will be small.

Pipe friction

From Hyd. Institute Tables $F \approx 1.15$ where $h_f = F \frac{V^3}{29}$ per 100'Increase about 15% for ageing $F = 1.15 \times 1.15 \times \frac{285}{100} = 3.77$

$$h_f = 3.8 \frac{V^3}{29}$$

Entrance Loss

Bellmouth type $K \approx 0.2$

$$h_f = 0.2 \frac{V^3}{29}$$

$$\text{Exit Vel Head} = 1.0 \frac{V^3}{29}$$

Total

$$\begin{array}{r} 3.8 \frac{V^3}{29} \\ 0.2 \\ \hline 1.0 \\ \hline 5.0 \frac{V^3}{29} \end{array}$$

$$H_{\text{total}} = 5.0 \frac{V^3}{29} = \frac{5 Q^2}{A^2 (29)} = \frac{5 Q^2}{(1.4)^2 (29)}$$

$$Q = 1.4 \sqrt{\frac{29(H)}{5}} = 5.02 \sqrt{H} \text{ CFS}$$

Drawdown rate at design pool elevation

Surface area = 703 a

time to drawdown one foot

$$= \frac{703 \text{ a} \times 43,560 \text{ ft}^2/\text{a}}{33.7 \text{ ft}^3/\text{s} \times 60 \times 60 \times 24}$$

$$= 10.5 \text{ days}$$

About 9 days if pumping plant
starts in ... (2600 gpm)

EL - Ft	H - Ft	Q - CFS
764.4	9	15.06
771.4	16	20.08
780.4	25	25.10
791.4	36	30.12
804.4	49	35.14
819.4	64	40.16

ECI-4

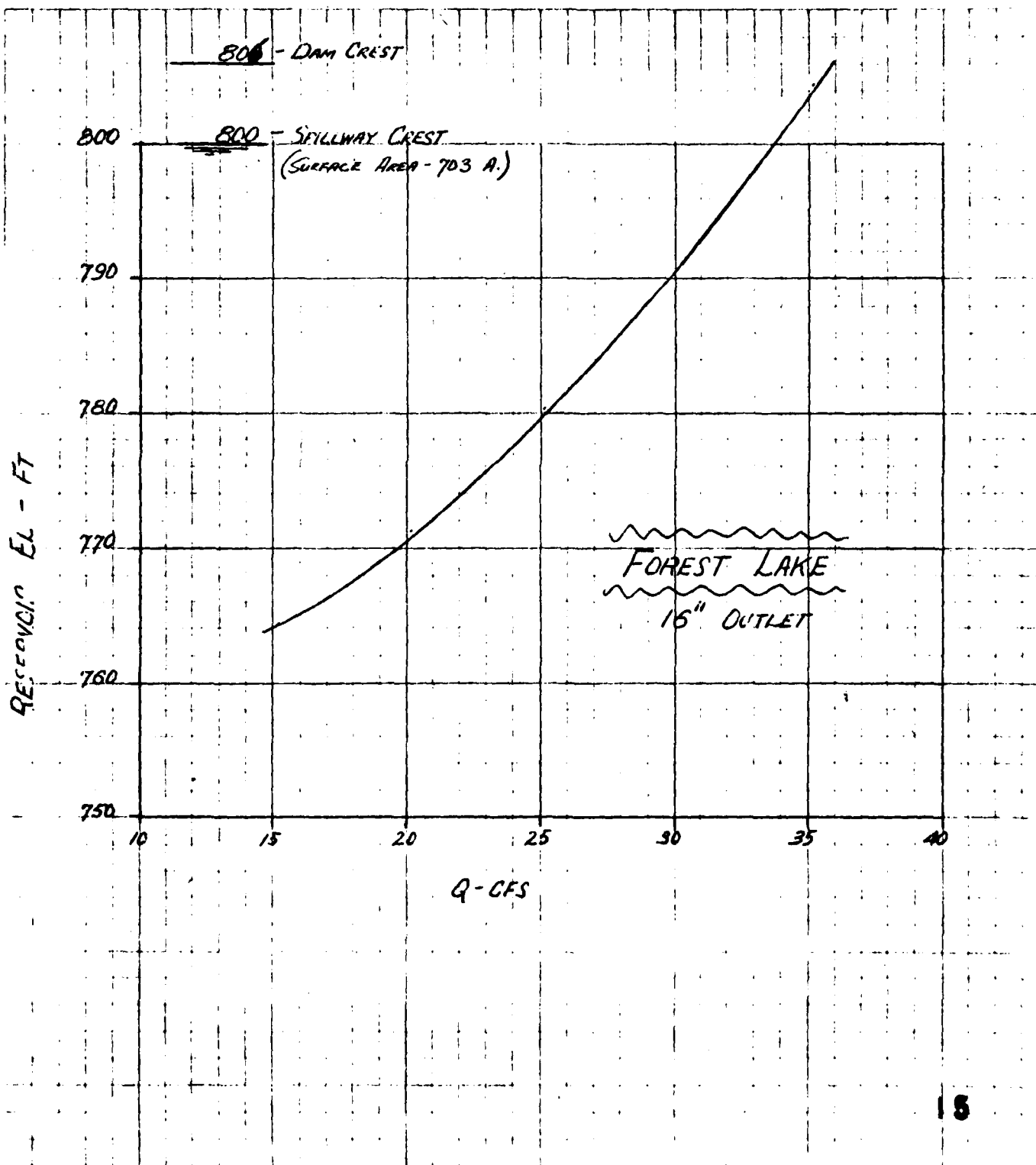
ENGINEERING CONSULTANTS, INC.

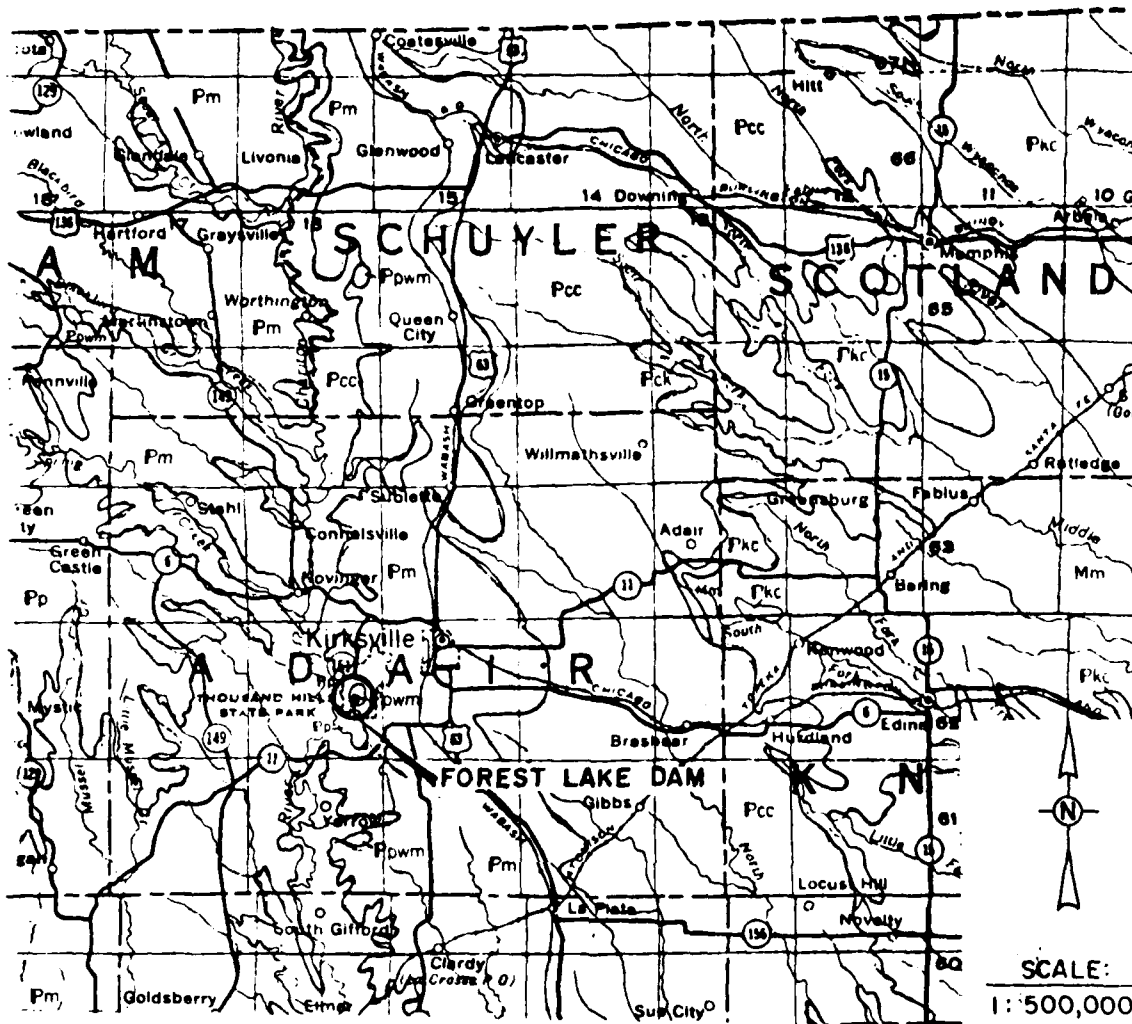
FOREST LAKE (BIG CREEK RESERVOIR) - MISSOURI

SHEET NO. 3 OF

JOB NO. 1223

BY JCE DATE 10/11/78





Explanation

Pennsylvanian System

- P_{kc} - Kansas City group: cyclic deposits with numerous limestones.
- P_{pwm} - Pleasanton group: sandstone channel member.
- P_m - Marmaton group: cyclic deposits with limestones.
- P_{cc} - Cherokee group: cyclic deposits, predominately shale, sandstone and coal beds.

Mississippian System

- M_m - sandy, oolitic, fossiliferous, lithographic, or cherty limestones.
- M_o - cherty, crinoidal limestone, with some shale.
- M_k - intercalated limestones and shales.

Reference: Geologic Map of Missouri, 1961, Division of Geological Survey and Water Resources, State of Missouri.

APPENDIX A

PHOTOGRAPHS TAKEN DURING INSPECTION

FOREST LAKE DAM

- Photo 1 - View across spillway and of downstream slope of dam taken at left abutment.
- Photo 2 - View along downstream slope of dam taken at left of dam near spillway.
- Photo 3 - Picture of downstream slope of dam taken downstream of dam at left side.
- Photo 4 - View along crest of dam taken at left side of dam.
- Photo 5 - Picture of typical condition of upstream slope showing riprap and vegetation.
- Photo 6 - Picture of intake structure for outlet works.
- Photo 7 - Picture of pump house taken from dam crest near right abutment.
- Photo 8 - View of spillway channel taken from upstream.
- Photo 9 - View of spillway channel taken from downstream.
- Photo 10 - Picture of concrete ogee crest section of spillway. Note erosion of concrete.
- Photo 11 - Picture of vegetation in spillway channel downstream of ogee section.
- Photo 12 - Hole in grouted block wall on right side of spillway channel downstream of ogee section.
- Photo 13 - Picture of stilling basin with baffle blocks at base of concrete chute.
- Photo 14 - Concrete wall of spillway at right side of stilling basin.
- Photo 15 - Seepage in spillway channel about half-way down slope on right side. Seepage is occurring in bedrock slope cut.
- Photo 16 - View of discharge channel downstream of spillway.

Forest Lake Dam



Photo 1 - View across spillway and of downstream slope of dam taken at left abutment.



Photo 2 - View along downstream slope of dam taken at left of dam near spillway.

Forest Lake Dam



Photo 3 - Picture of downstream slope of dam taken downstream of dam at left side.



Photo 4 - View along crest of dam taken at left side of dam.

Forest Lake Dam



Photo 5 - Picture of typical condition of upstream slope showing riprap and vegetation.



Photo 6 - Picture of intake structure for outlet works.

Forest Lake Dam

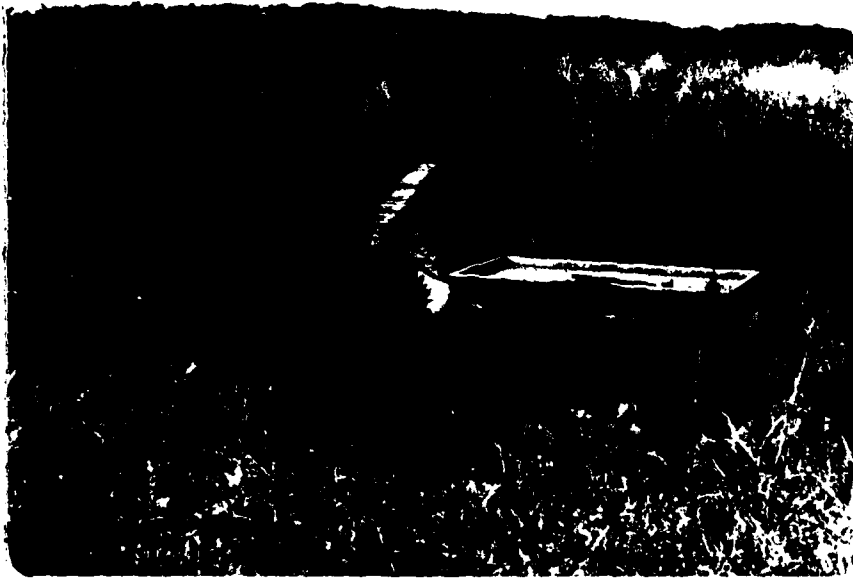


Photo 7 - Picture of pump house taken from dam crest near right abutment.



Photo 8 - View of spillway channel taken from upstream.



Photo 9 - View of spillway channel taken from downstream.



Photo 10 - Picture of concrete ogee crest section of spillway. Note spalling of concrete.

Forest Lake Dam



Photo 11 - Picture of vegetation in spillway channel downstream of ogee section.



Photo 12 - Hole in grouted block wall on right side of spillway channel downstream of ogee section.

Forest Lake Dam



Photo 13 - Picture of stilling basin with baffle blocks at base of concrete chute.



Photo 14 - Concrete wall of spillway at right side of stilling basin.



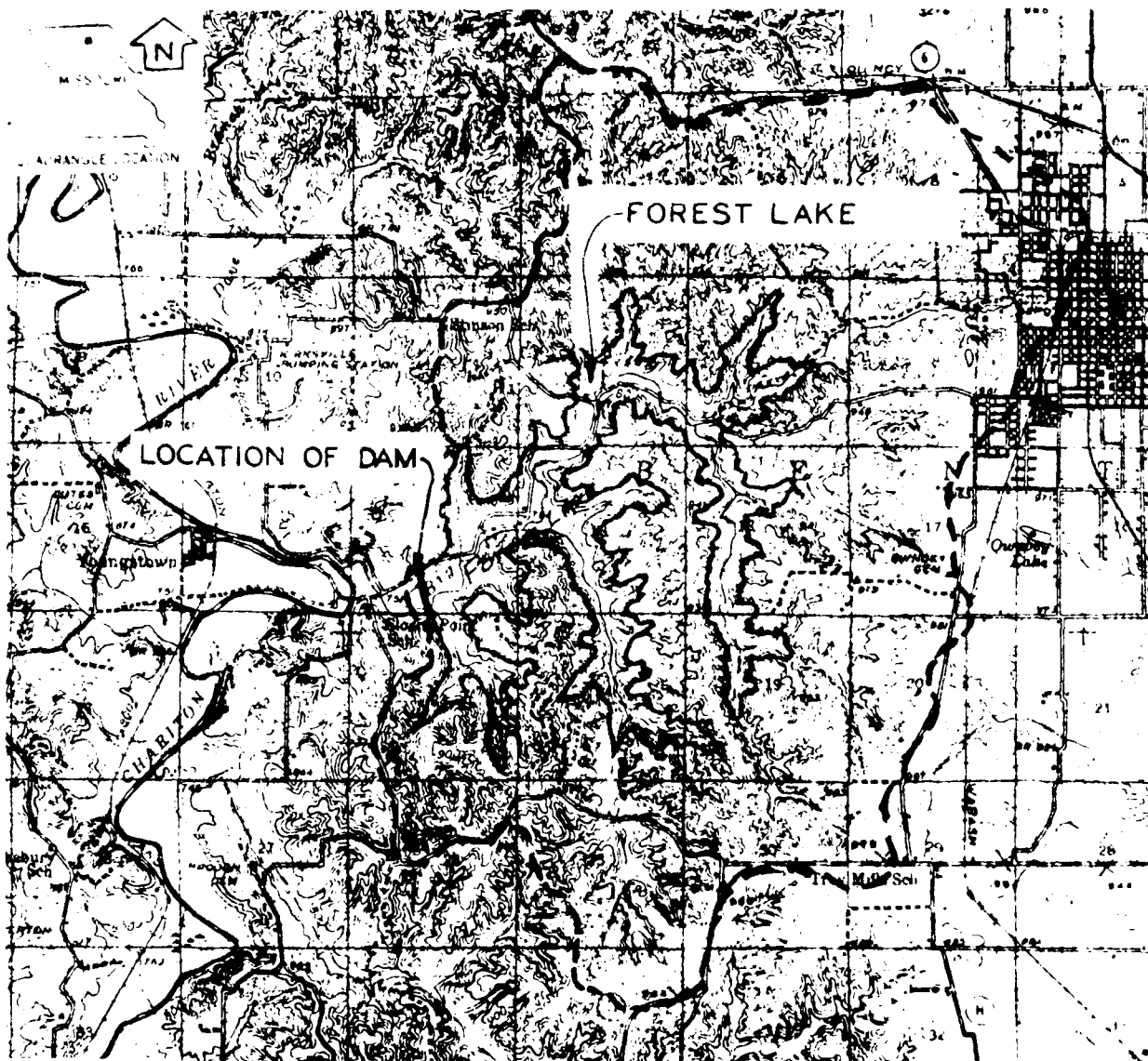
Photo 15 - Seepage in spillway channel about half-way down slope on right side. Seepage is occurring in bed-rock slope cut.



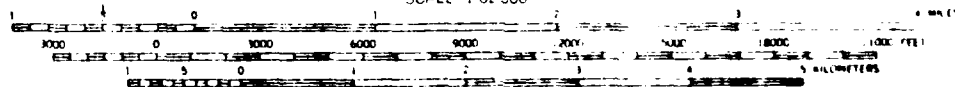
Photo 16 - View of discharge channel downstream of spillway.

APPENDIX B

HYDROLOGIC COMPUTATIONS

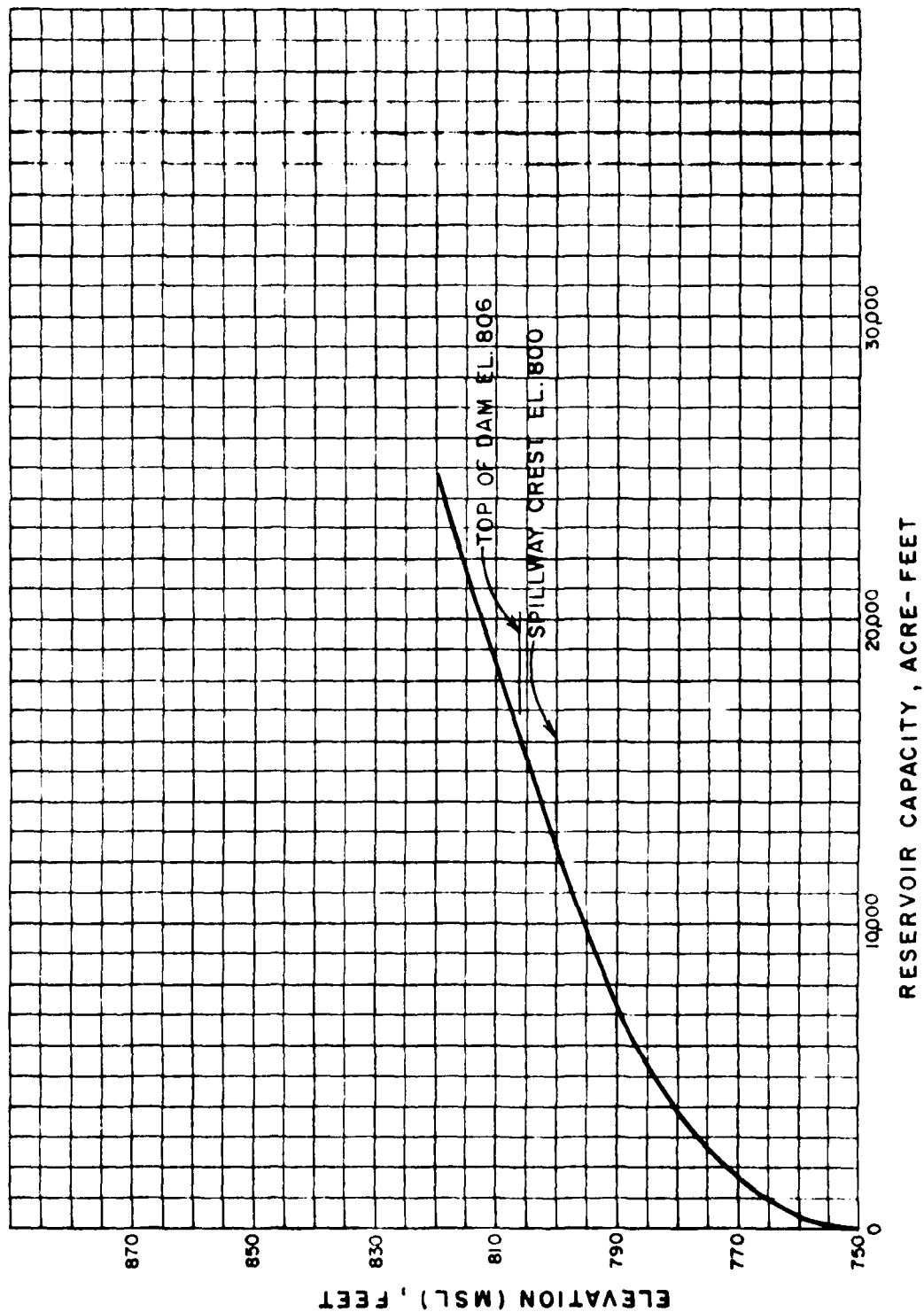


SCALE 1:62,500

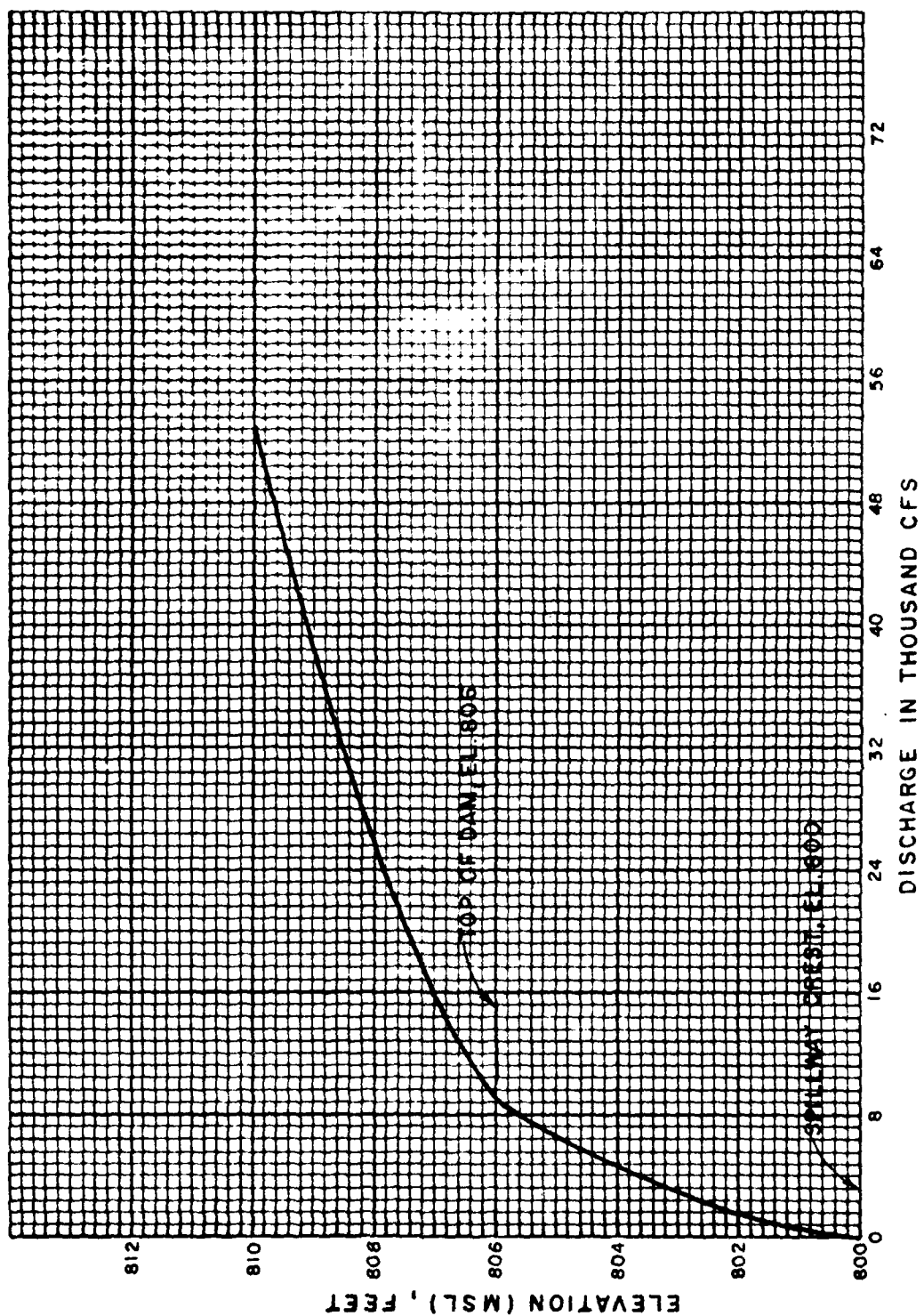


Contour interval 20 feet
 10 foot contours added in dashed lines
 NATIONAL GEODETIC VERTICAL DATUM OF 1929
 DRAINAGE BOUNDARY — — — — —

FOREST LAKE DAM
 DRAINAGE BASIN



FOREST LAKE DAM
RESERVOIR CAPACITY CURVE



FOREST LAKE DAM
SPILLWAY & OVERTOP RATING CURVE

DAM SAFETY INSPECTION - MISSOURI

SHEET NO. 1 OF

FOREST LAKE DAM

JOB NO. 1223-POL-1

RESERVOIR AREA CAPACITY

BY KLB

DATE 10-16-78

FOREST LAKE DAM

AREA - CAPACITY DATA

DATA FROM CURVE PRESENTED WITH PLANS

ELEV (FT)	SURFACE AREA (ACRES)	STORAGE MILLION GALLONS	STORAGE (MG-FT)	REMARKS
750	0	0	0	INVERT
760	72	140	430	
770	174	540	1657	
780	290	1290	3759	
790	420	2440	7489	
800	562	4050	12431	SPILLWAY CREST
806	646	5200	15961	TOP OF DAM
810	700	6080	18662	
820	835	8100	24861	EXTRAPOLATED POINT

DATA WAS BASED ON USGS KANSASVILLE & INDIANAPOLIS
(15 minute series) in combination with data given in the National
Dam Safety Engineering Guide.

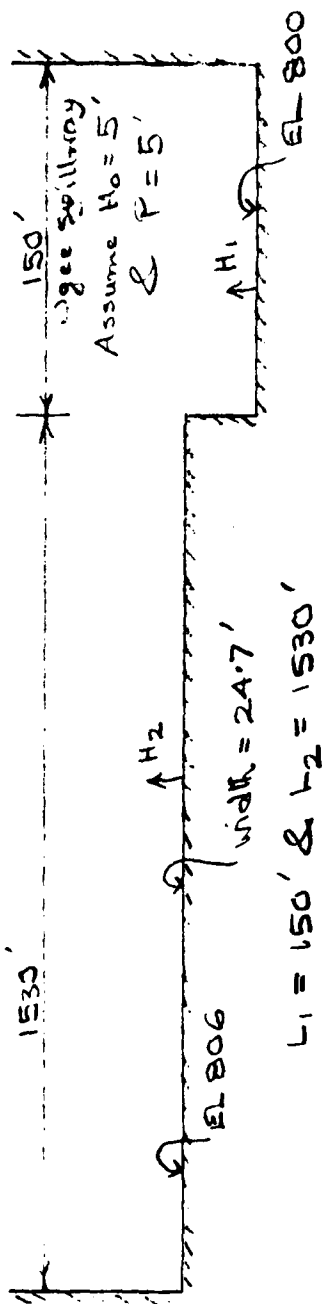
DAM SAFETY INSPECTION / MISFORD

SHEET NO. 1 OF

FOREST LAKE DAM

JOB NO. 1223-001

SPILLWAY & OVERTOP DISCHARGE CAPACITY BY MAS DATE 10-16-78



Upstream W.E. Elev (ft)	H_1	C_o	C/C_o	C_1	H_2	C_2	$Q_T = C_1 L_1 H_1^{1.5} + C_2 L_2 H_2^{1.5}$
800	1	3.89	0.85	3.31			0
801	2	"	0.90	3.50			497
802	3	"	0.94	3.66			1485
803	4	"	0.97	3.77			2853
804	5	"	1.00	3.89			4524
805	6	"	1.03	4.01			6524
806	7	"	1.05	4.08			8840
807	8	"	1.07	4.16	1	2.63	$11334 + 4024 = 15358$
808	9	"	1.10	4.28	2	2.63	$14120 + 11381 = 25501$
809	10	"	1.10	4.28	3	2.63	$17334 + 20999 = 38333$
810	12	"	1.10	4.28	4	2.63	$20302 + 32191 = 52493$
812	15	"	1.10	4.28	6	2.63	$26687 + 59139 = 85826$
815	20	"	1.10	4.28	9	2.63	$37297 + 108445 = 145742$
820			1.10	4.28	14	2.63	$57422 + 210784 = 268206$

ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION - MISSOURI

FOREST LAKE DAM

UNIT HYDROGRAPH PARAMETERS

SHEET NO. 1 OF 3

JOB NO. 1223-001-1

BY KLB DATE 12-18-78

1. DRAINAGE = 10500 AC = 16.41 SQ. MI.

2. LENGTH OF STREAM = L = 2.27 MI

3. DIFFERENCE IN ELEVATION : ΔH

$$\Delta H = 980 - 520 = 160 \text{ Ft.}$$

4. TIME OF CONCENTRATION, T_c

$$T_c = \left(\frac{11.9 \times L^3}{\Delta H} \right)^{0.385}$$

$$T_c = \left(\frac{11.9 \times 2.27^3}{160} \right)^{0.385}$$

$$T_c = \underline{0.95 \text{ HR.}}$$

5. LAG TIME $L_t = 0.6 \times T_c$

$$L_t = 0.6 \times 0.95 = \underline{0.57 \text{ HR}}$$

6. RAINFALL UNIT DURATION, D

$$\text{USE } D = 10 \text{ MIN.} = 0.166 \text{ HR}$$

(MINIMUM ALLOWABLE FOR 48 HR PMP CALCULATIONS USING HEC10B)

7. TIME TO PEAK, T_p

$$T_p = \frac{D}{2} + 0.6 \times T_c$$

$$T_p = \frac{0.166}{2} + 0.6 \times 0.95 = \underline{0.65 \text{ HR}}$$

8. $q_p = \frac{484 \times A}{T_p} = \frac{484 \times 16.41}{0.65} = \underline{12219 \text{ CFS}}$

DAM SAFETY INSPECTION - MISSOURI

SHEET NO. 2 OF

FOREST LAKE DAM

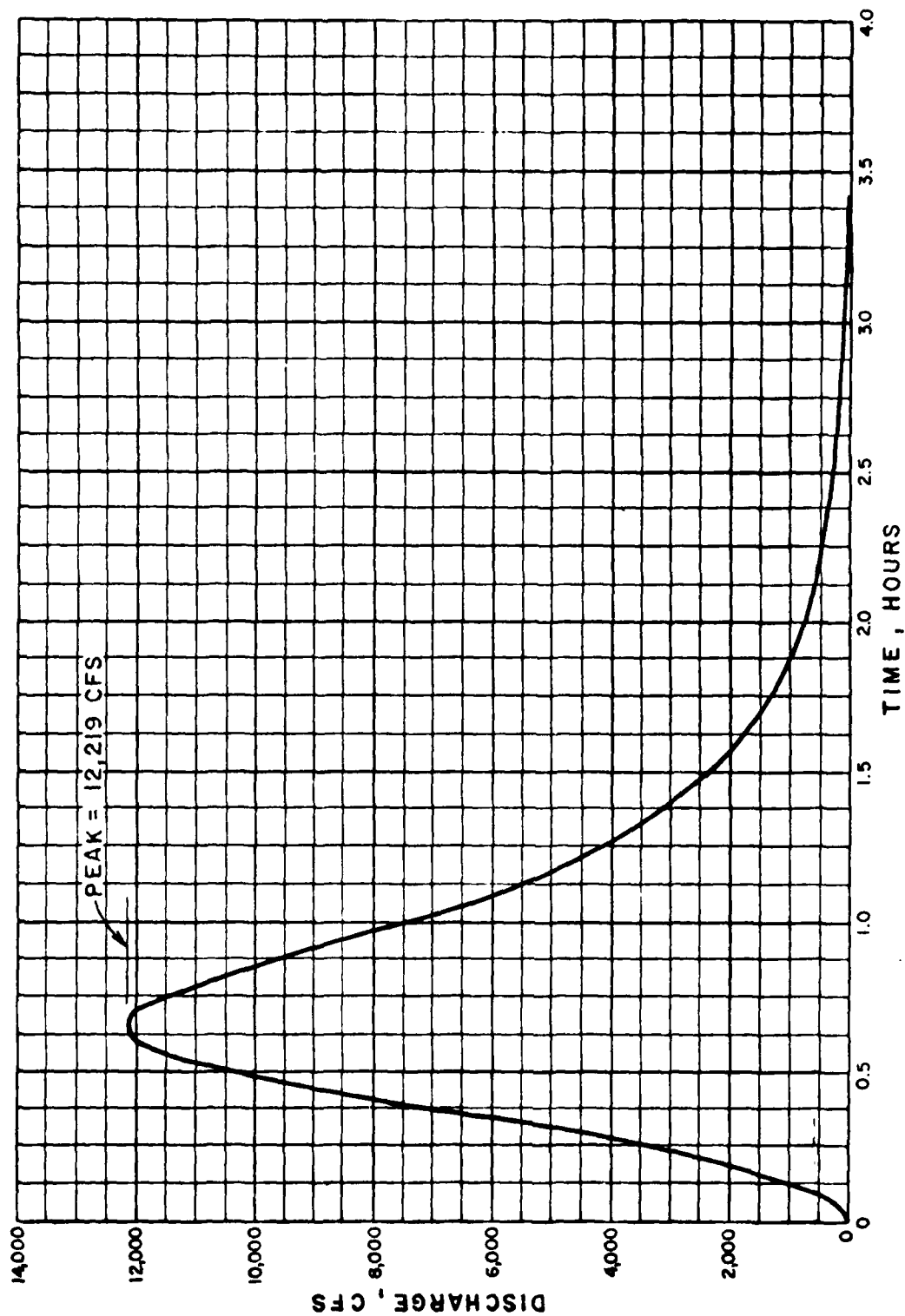
JOB NO. 1223-001-1

SCS UNIT HYDROGRAPH DERIVATION

BY KLB DATE 12-18-78

9) CURVILINEAR UNIT HYDROGRAPH

TIME T/Tp	DISCHARGE RATIO q/q _p	UNIT HYDROGRAPH	
		TIME, T (HRS)	DISCHARGE (CFS)
0.0	0.000	0.00	0.000
0.1	0.015	0.07	183.29
0.2	0.075	0.13	916.44
0.3	0.16	0.20	1995.06
0.4	0.28	0.26	3421.36
0.5	0.45	0.33	5498.61
0.6	0.60	0.39	7331.18
0.7	0.71	0.46	8675.59
0.8	0.87	0.52	10630.65
0.9	0.97	0.59	11852.56
1.0	1.00	0.65	12219.14
1.1	0.98	0.72	11974.76
1.2	0.92	0.78	11241.61
1.3	0.84	0.85	10264.08
1.4	0.75	0.91	9164.35
1.5	0.66	0.98	8064.63
1.6	0.56	1.04	6842.72
1.8	0.42	1.17	5132.04
2.0	0.32	1.30	3910.12
2.2	0.24	1.43	2932.59
2.4	0.18	1.56	2199.44
2.6	0.13	1.69	1588.49
2.8	0.098	1.82	1197.48
3.0	0.075	1.95	916.44
3.5	0.036	2.28	439.89
4.0	0.018	2.60	219.94
4.5	0.007	2.93	109.97
5.0	0.004	3.25	48.88



FOREST LAKE DAM
10 MINUTE UNIT HYDROGRAPH

FOREST LAKE DAMDETERMINATION OF PMS

1. Determine drainage area of the basin

$$D.A. = 10,500 \text{ acres} = 16.41 \text{ sq. mi}$$

2. Determine PMP Index rainfall:

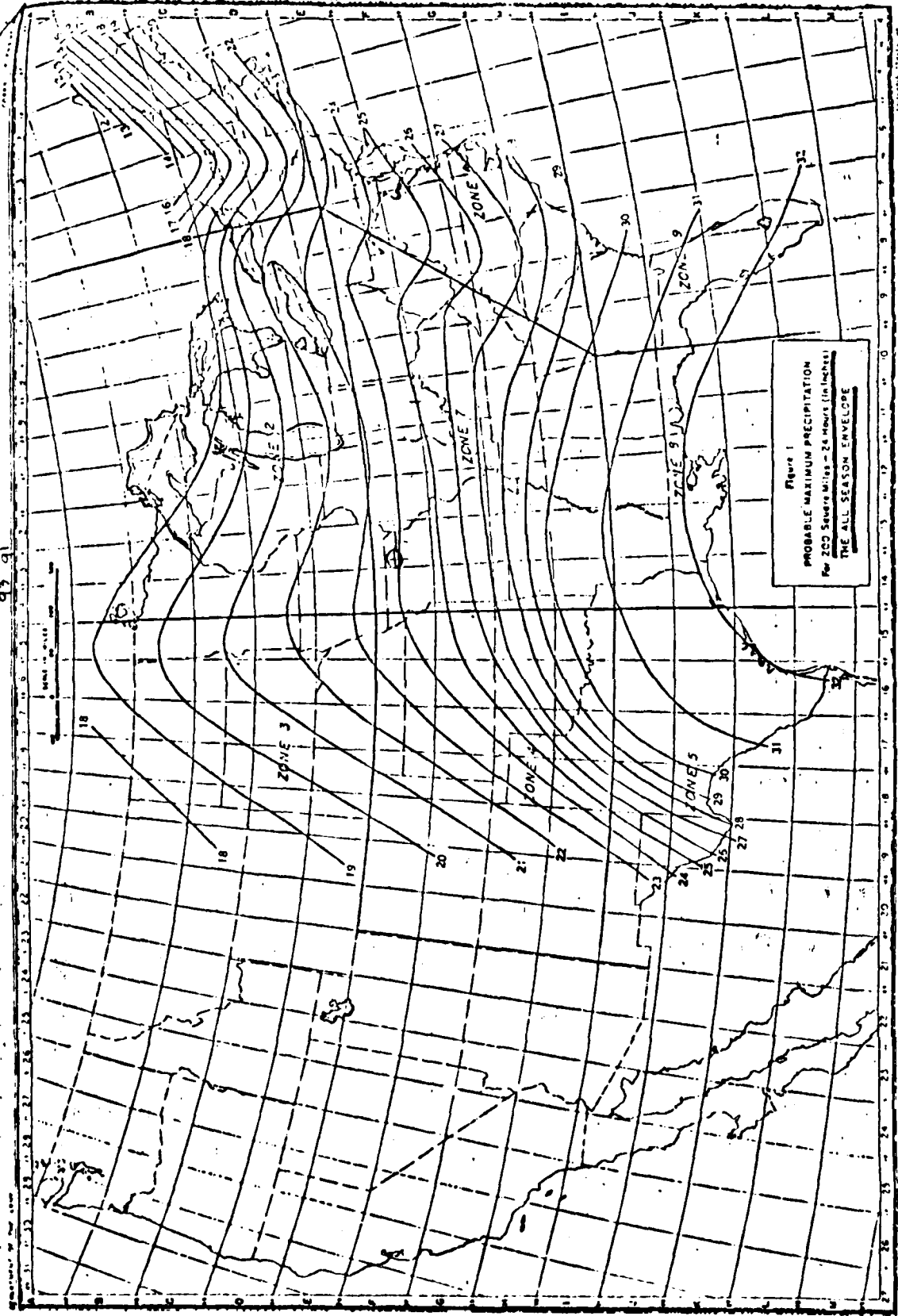
Location of Centroid of basin:

Long. $92^{\circ}63'$; Lat. $40^{\circ}18'$
 $\rightarrow$ PMP for 200 sq. mi. & 24 hrs duration
 $= 23.9''$ (from Fig 1, HMR NO 33)

3. Determine basin rainfall in terms of percentage of PMP Index rainfall for various durations:

Location: Long. $92^{\circ}63'$; Lat. $40^{\circ}18'$ $\Rightarrow$ Zone-7

Duration (Hrs.)	Percent of Index rainfall (%)	Total rainfall (Inches)	Rainfall increments (Inches)	Duration of incre- ment (Hrs.)
6	90	23.4	23.4	6
12	116	27.7	4.3	6
24	126	30.1	2.4	12
48	140	33.5	3.4	<u>24</u>



DAM SAFETY INSPECTION / MISSOURI

SHEET NO. 1 OF 1

FOREST LAKE DAM

JOB NO. 1223-001

100-YEAR FLOOD BY REGRESSION EQ.

BY MAS DATE 10-17-78

FOREST LAKE DAM100-YEAR FLOOD BY REGRESSION EQ.

Regression equation for 100-year flood for
Missouri: -

$$Q_{100} = 85.1 A^{0.934} S^{0.576}$$

where A = drainage area in sq. mi.

S = main channel slope ft./mi.
(Avg. slope between 0.70 & 0.85)

For Forest Lake Dam:

$$A = 10,500 \text{ acres} = 16.41 \text{ sq. mi.}$$

$$S = 99 \text{ ft.} / 1.70 \text{ mi} = 58.24 \text{ ft./mi.}$$

$$\begin{aligned} Q_{100} &= (85.1) (16.41)^{0.934} (58.24)^{0.576} \\ &= \underline{\underline{10,468 \text{ cfs}}} \end{aligned}$$

HEC1DB INPUT DATA

DAM SAFETY INSPECTION - MISSOURI									
FOREST LAKE DAM									
PMP AND 50 PERCENT PMP DETERMINATION AND ROUTING									
	0	10	0	0	0	0	0	0	0
A	1	2	1						
B	1	0.5							
C	1	1.0							
D	1	0.5							
E	1	1.0							
F	1	0.5							
G	1	1.0							
H	1	0.5							
I	1	1.0							
J	1	0.5							
K	1	1.0							
L	1	0.5							
M	1	1.0							
N	1	0.5							
O	1	1.0							
P	1	0.5							
Q	1	1.0							
R	1	0.5							
S	1	1.0							
T	1	0.5							
U	1	1.0							
V	1	0.5							
W	1	1.0							
X	1	0.5							
Y	1	1.0							
Z	1	0.5							
AA	1	1.0							
AB	1	0.5							
AC	1	1.0							
AD	1	0.5							
AE	1	1.0							
AF	1	0.5							
AG	1	1.0							
AH	1	0.5							
AI	1	1.0							
AJ	1	0.5							
AK	1	1.0							
AL	1	0.5							
AM	1	1.0							
AN	1	0.5							
AO	1	1.0							
AP	1	0.5							
AQ	1	1.0							
AR	1	0.5							
AS	1	1.0							
AT	1	0.5							
AU	1	1.0							
AV	1	0.5							
AW	1	1.0							
AX	1	0.5							
AY	1	1.0							
AZ	1	0.5							
BA	1	1.0							
BB	1	0.5							
BC	1	1.0							
BD	1	0.5							
BE	1	1.0							
BF	1	0.5							
BG	1	1.0							
BH	1	0.5							
BI	1	1.0							

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

HUNTER HYDROGRAPH AT
BRIDGE HYDROGRAPH TO
END OF NETWORK

• 2

END OF NETWORK

INFLOW PMF AND ONE-HALF PMF HYDROGRAPHS

 01000 HYDROGRAPH PACKAGE (HEC-2)
 DAM SAFETY VERSION JULY 1980
 LAST MODIFICATION 21 AUG 78

RUN DATE 78/12/18
 TIME 14.03.56

DAM SAFETY INSPECTION - MISSOURI
 FOREST LAKE DAM
 PHF AND 50 PERCENT PHF DETERMINATION AND ROUTING

JHB SPECIFICATION									
NR	MR	MTN	IRAY	IMR	IMIN	METRC	IPLT	IPRT	INSTAN
300	0	10	0	0	0	0	0	0	0
JOPER 5 0 0 0 0 0 0 0 0 0									

MULTI-PLAN ANALYSES TO BE PERFORMED
 NPLANS 1 NPLANS 2 LRTIME 1

RTIOS 1.00 .50

***** SUB-AREA RUNOFF COMPUTATION *****
 INPUT OF MR PHF INDEX PRECIPITATION, INPUT 0 = 10 MIN. SCS
 INSTAL ICOMP ITCOM ITAPE JPLY JPRY INAME ISTAGE IAUFD
 2 0 0 0 0 0 1 0 0

HYDROGRAPH DATA									
INVOG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	01	16.01	0.00	16.01	1.00	0.000	0	0	0

PRECIP DATA					
SPEE	PMS	RA	R12	R24	R48
0.00	23.90	98.00	116.00	125.00	140.00

LOSS DATA					
LEHFF	STHR	DLTK	RTIO	FRAIN	STKRS
0	0.00	0.00	1.00	0.00	1.00

GIVEN UNIT GRAPH, NUMBOS 23					
00	1250	4000	10000	12219	10700
1250	800	400	400	250	175
25	0	0	0	0	0

UNIT GRAPH TOTALS 63064, CFS OR 1.00 INCHES OVER THE AREA

***** REVISION DATA *****

RTIOS 0.00 ORCONS 0.00 RTIOFF 1.00

MD,DA	MR,MM	PERIOD	RAIN	ENCS	LOSS	CONC B
MD,DA	MR,MM	PERIOD	RAIN	ENCS	LOSS	CONC B

1.01	1.10	1.00	1.02	1.10	151	.02	.01	1779.
1.01	1.20	1.02	1.02	1.20	152	.02	.01	1779.
1.01	1.30	1.02	1.02	1.30	153	.02	.01	1779.
1.01	1.40	1.02	1.02	1.40	154	.02	.01	1779.
1.01	1.50	1.02	1.02	1.50	155	.02	.01	1779.
1.01	1.60	1.02	1.02	1.60	156	.02	.01	1779.
1.01	1.70	1.02	1.02	1.70	157	.02	.01	1779.
1.01	1.80	1.02	1.02	1.80	158	.02	.01	1779.
1.01	1.90	1.02	1.02	1.90	159	.02	.01	1779.
1.01	2.00	1.02	1.02	2.00	160	.02	.01	1779.
1.01	2.10	1.02	1.02	2.10	161	.02	.01	1779.
1.01	2.20	1.02	1.02	2.20	162	.02	.01	1779.
1.01	2.30	1.02	1.02	2.30	163	.02	.01	1779.
1.01	2.40	1.02	1.02	2.40	164	.02	.01	1779.
1.01	2.50	1.02	1.02	2.50	165	.02	.01	1779.
1.01	2.60	1.02	1.02	2.60	166	.02	.01	1779.
1.01	2.70	1.02	1.02	2.70	167	.02	.01	1779.
1.01	2.80	1.02	1.02	2.80	168	.02	.01	1779.
1.01	2.90	1.02	1.02	2.90	169	.02	.01	1779.
1.01	3.00	1.02	1.02	3.00	170	.02	.01	1779.
1.01	3.10	1.02	1.02	3.10	171	.02	.01	1779.
1.01	3.20	1.02	1.02	3.20	172	.02	.01	1779.
1.01	3.30	1.02	1.02	3.30	173	.02	.01	1779.
1.01	3.40	1.02	1.02	3.40	174	.02	.01	1779.
1.01	3.50	1.02	1.02	3.50	175	.02	.01	1779.
1.01	3.60	1.02	1.02	3.60	176	.02	.01	1779.
1.01	3.70	1.02	1.02	3.70	177	.02	.01	1779.
1.01	3.80	1.02	1.02	3.80	178	.02	.01	1779.
1.01	3.90	1.02	1.02	3.90	179	.02	.01	1779.
1.01	4.00	1.02	1.02	4.00	180	.02	.01	1779.
1.01	4.10	1.02	1.02	4.10	181	.12	.01	1779.
1.01	4.20	1.02	1.02	4.20	182	.12	.01	1779.
1.01	4.30	1.02	1.02	4.30	183	.12	.01	1779.
1.01	4.40	1.02	1.02	4.40	184	.12	.01	1779.
1.01	4.50	1.02	1.02	4.50	185	.12	.01	1779.
1.01	4.60	1.02	1.02	4.60	186	.12	.01	1779.
1.01	4.70	1.02	1.02	4.70	187	.12	.01	1779.
1.01	4.80	1.02	1.02	4.80	188	.12	.01	1779.
1.01	4.90	1.02	1.02	4.90	189	.12	.01	1779.
1.01	5.00	1.02	1.02	5.00	190	.12	.01	1779.
1.01	5.10	1.02	1.02	5.10	191	.12	.01	1779.
1.01	5.20	1.02	1.02	5.20	192	.12	.01	1779.
1.01	5.30	1.02	1.02	5.30	193	.12	.01	1779.
1.01	5.40	1.02	1.02	5.40	194	.12	.01	1779.
1.01	5.50	1.02	1.02	5.50	195	.12	.01	1779.
1.01	5.60	1.02	1.02	5.60	196	.12	.01	1779.
1.01	5.70	1.02	1.02	5.70	197	.12	.01	1779.
1.01	5.80	1.02	1.02	5.80	198	.12	.01	1779.
1.01	5.90	1.02	1.02	5.90	199	.12	.01	1779.
1.01	6.00	1.02	1.02	6.00	200	.12	.01	1779.
1.01	6.10	1.02	1.02	6.10	201	.12	.01	1779.
1.01	6.20	1.02	1.02	6.20	202	.12	.01	1779.
1.01	6.30	1.02	1.02	6.30	203	.12	.01	1779.
1.01	6.40	1.02	1.02	6.40	204	.12	.01	1779.
1.01	6.50	1.02	1.02	6.50	205	.12	.01	1779.
1.01	6.60	1.02	1.02	6.60	206	.12	.01	1779.
1.01	6.70	1.02	1.02	6.70	207	.12	.01	1779.
1.01	6.80	1.02	1.02	6.80	208	.12	.01	1779.
1.01	6.90	1.02	1.02	6.90	209	.12	.01	1779.
1.01	7.00	1.02	1.02	7.00	210	.12	.01	1779.

PMF FLOOD ROUTING

END 1170. 5378 170 41 2420
 INCHES 11.12 15.25 1525
 284.10 350.30 887.74
 9764 12330 15330
 12000 15233 16452

***** HYDROGRAPH ROUTING *****

ROUTE HYDROGRAPH THROUGH FOREST LAKE DAM

ISTAT ICOMP IFCON ITAPE JPLY JPDY INAME ISTAT IAUFD
 1 0 0 2 0 1 0 0

ROUTING DATA
 IYES ITIME IIMP ISTR

0.0 0.000 0.00 1 1 0 0

NSTPS NSTOL LAG ANSKK X TSK STCHA ISPRAT
 1 0 0 0.000 0.000 0.000 -870. -1

STAGE 800.0 801.0 802.0 803.0 804.0 805.0 806.0 807.0 808.0 809.0

810.0 812.0 815.0 820.0

FLOW 0. 407. 1405. 2853. 4525. 6520. 8940. 13358. 25501. 38283.

CAPACITY 0. 410. 1657. 3959. 7489. 12431. 15961. 18462. 20861.

ELEVATIONS 750. 760. 770. 780. 790. 800. 806. 810. 820.

CPFL SPMD CQUM EXPD ELEV EXPD DAMDID
 800.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

DAM DATA
 TPEL CQUD EXPD DAMDID
 806.0 0.0 0.0 0.

STATION 1. PLAN 1. PATT 1

END-OF-PERIOD HYDROGRAPH UPDATES

0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

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0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

ONE-HALF PMF FLOOD ROUTING

87-14734

[illegible]

AD-A104 899

PRC CONSOER TOWNSEND INC ST LOUIS MO

F/8 13/13

NATIONAL DAM SAFETY PROGRAM. FOREST LAKE DAM (MO 10128), GRAND --ETC(U)

DEC 78

DACW43-78-C-0160

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SUMMARY OF PMF AND ONE-HALF PMF FLOOD ROUTING

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 PLUMS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO PLUMS

OPERATION	STATION	AREA	PLAN	RATIO	1	RATIO	2
					1.00		.50
HYDROGRAPH AT	2	16.41 (42.50)	1	97422.	48711. (2758.69)	1379.34	(
ROUTED TO	1	16.41 (42.50)	1	75603.	31555. (2100.83)	693.53	(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1							
ELEVATION STORAGE OUTFLOW		INITIAL VALUE 800.00 12631. 0.		SPILLWAY CREST 800.00 12431. 0.		TOP OF DAM 806.00 12661. 8840.	
RATIO OF DHF	MAXIMUM PERCENTAGE 4.5% ELEV	MAXIMUM DEPTH CUM DAM	MAXIMUM STORAGE ACFT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAY OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	811.39	5.10	19522.	75603.	7.00	40.67	0.00
.90	804.42	5.44	17632.	31545.	4.33	40.83	0.00

PERCENT OF PMF FLOOD ROUTING
EQUAL TO SPILLWAY CAPACITY

REVIEW OF SEQUENCE BY STREAM NETWORK CALCULATIONS

WUPP HYDROGRAPH AT
ROUTE HYDROGRAPH IN
END OF NETWORK

 FLOOD HYDROGRAPH PACKAGE (MFC-1)
 DAM SAFETY VERSION JULY 1974
 LAST MODIFICATION 21 JUL 74

RUN DATE: 78/12/10
 TIME: 04.32.25

DAM SAFETY INSPECTION - MISSOURI
 FCHST LAKE DAM
 PERCENT OF PMS DETERMINATION AND ROUTING

NO	QMR	NMIN	INAY	IMR	IMIN	METC	IPLY	IPRI	MTAN
100	0	10	0	0	0	0	0	1	0
	JOHR					TRACE			
	0								

ROUTING APPLIES TO ME PERFORMED
 RELEASE TIME: 0.100000

RTIME	.20	.21	.22	.23	.24	.25	.26	.27	.28

***** SURFACE RUNOFF COMPUTATION *****

IMP-1 JR MD PMS INDEX PRECIPITATION, INPUT D = 10 MIN. SCS
 TSTAO TCOMP TCON ITAPE JPLY JORT INAME INSTAG IADIC

IMYOS	ITUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISKOW	ISAME	LOCAL
1	-1	16.41	0.00	16.41	1.00	0.000	0	0	0

HYDROGRAPH DATA

SPFF	PMS	CO	R12	R24	R48	R72	R96
0.00	23.90	28.00	110.00	125.00	140.00	0.00	0.00

PRECIP DATA

LEHPP	STRAH	PLTTP	MTJOL	EQAIN	STRKS	MTJOK	MTJYL	CNSTL	ALSHX	MTJMP
0	0.00	0.00	1.00	0.00	0.00	1.00	.85	.07	0.00	0.00

LOSS DATA

STRTOS	0.00	ORCSNA	0.00	RTIORS	1.00

FNO-M-PEPTON FLOW

MO,DA	HR,MIN	PERIOD	RAIN	EYES	LOSS	COMP D	MO,DA	HR,MIN	PERIOD	RAIN	EYES	LOSS	COMP S

SUM 33.26 30.41 3.05 19360791
 (850.1) 772.10 (49.164888.51)

HYDROGRAPH ROUTING

ROUTE HYDROGRAPH THROUGH FOREST LAKE DAM									
STAG	ICOMP	IFCON	ITAPE	JULY	JPMI	INAME	ISTAG	IAUTO	
1	1	0	0	0	0	1	0	0	
ROUTING DATA									
QLOSS	CLOSS	AVC	INCS	ISAME	ISPT	TPMP	LSTR		
0.0	0.000	0.00	1	1	0	0	0		
MSTPS									
LAG	4SKK	X	TSM	STODA	ISPRAT				
0	0.000	0.000	0.000	0.000	0.000				
STAGE	800.0	801.0	802.0	803.0	804.0	805.0	806.0	807.0	808.0
	810.0	812.0	815.0	820.0					809.0
FLOW	0	407.	1485.	2853.	4524.	6524.	8840.	15350.	25501.
	52493.	45826.	145942.	268206.					30243.
CAPACITY	0.	410.	1657.	3059.	7400.	12431.	15961.	14662.	20861.
ELEVATIONS	750.	760.	770.	780.	790.	800.	806.	810.	820.
CREL									
SP-10	EXP-10	EXP-10	EXP-10	EXP-10	EXP-10	EXP-10	EXP-10	EXP-10	EXP-10
800.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TYPEL	CUON	EXPO	DAM-10
800.0	0.0	0.0	0.

PEAK OUTFLOW IS	6885. AT TIME 42.00 HOURS
PEAK OUTFLOW IS	6939. AT TIME 41.83 HOURS
PEAK OUTFLOW IS	7393. AT TIME 41.83 HOURS
PEAK OUTFLOW IS	7880. AT TIME 41.83 HOURS
PEAK OUTFLOW IS	8285. AT TIME 41.83 HOURS
PEAK OUTFLOW IS	8727. AT TIME 41.83 HOURS
PEAK OUTFLOW IS	9530. AT TIME 41.67 HOURS
PEAK OUTFLOW IS	10388. AT TIME 41.67 HOURS
PEAK OUTFLOW IS	11102. AT TIME 41.50 HOURS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIOS APPLIED TO FLOWS						
						RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
HYDROGRAPH AT	2	16.41 (42.50)	1	14884	20450	21433	22407	23381	24356	25330	26304	27278
				(551.74)	(579.32)	(606.91)	(634.50)	(662.08)	(689.67)	(717.26)	(744.85)	(772.43)
ROUTED TO	1	16.41 (42.50)	1	6085	6939	7793	7840	8285	8727	9530	10340	11162
				(185.60)	(196.00)	(209.34)	(222.00)	(230.60)	(247.18)	(269.87)	(293.02)	(316.08)

PLAN 1

DATE	ELEVATION STORAGE OUTFLOW	INITIAL VALUE 400.00 12431. 0.	SPILLWAY CREST 800.00 12431. 0.	TOP OF DAM 900.00 15061. PMIC.	TIME OF MAX OUTFLOW HOURS	TIME OF PAULIPE HOURS
01	MAXIMUM PERFORMING W.S. LEVEL	MAXIMUM DEPTH 100% DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION DOWN TOP HOURS	
02	804.94	0.70	15361.	6485.	3.00	42.00
03	805.14	0.63	15074.	6039.	0.00	41.43
04	805.34	0.57	15593.	7303.	0.00	41.43
05	805.57	0.50	15707.	7640.	0.00	41.43
06	805.76	0.40	15820.	8285.	0.00	41.43
07	805.95	0.30	15912.	8727.	0.00	41.43
08	806.11	0.23	16033.	9530.	1.33	41.67
09	806.11	0.17	16107.	10348.	1.43	41.67
10	806.23	0.13	16172.	11162.	2.17	41.50
11	806.36	0.10				0.00

FOREST LAKE DAM

100 YEAR FLOOD DETERMINATION AND ROUTING
FROM PRECIPITATION DATA

PREVIEW OF REFINEMENT OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT

ROUTE HYDROGRAPH IN

END OF NETWORK

2

1

1.01	2.30	85	.03	0.00	.03	0.	1.02	8.30	195	0.00	0.00	0.00
1.01	7.40	46	.03	0.00	.03	0.	1.02	8.40	196	0.00	0.00	0.00
1.01	7.50	47	.03	0.00	.03	0.	1.02	9.50	197	0.00	0.00	0.00
1.01	8.00	48	.03	0.00	.03	0.	1.02	9.00	198	0.00	0.00	0.00
1.01	8.10	49	.03	0.00	.03	0.	1.02	9.10	199	0.00	0.00	0.00
1.01	8.20	50	.03	0.00	.03	0.	1.02	9.20	200	0.00	0.00	0.00
1.01	8.30	51	.03	0.00	.03	0.	1.02	9.30	201	0.00	0.00	0.00
1.01	8.40	52	.03	0.00	.03	0.	1.02	9.40	202	0.00	0.00	0.00
1.01	8.50	53	.03	.01	.01	17.	1.02	9.50	203	0.00	0.00	0.00
1.01	9.00	54	.03	.01	.01	79.	1.02	10.00	204	0.00	0.00	0.00
1.01	9.10	55	.05	.04	.01	244	1.02	10.10	205	0.00	0.00	0.00
1.01	9.20	56	.05	.04	.01	518.	1.02	10.20	206	0.00	0.00	0.00
1.01	9.30	57	.05	.04	.01	843.	1.02	10.30	207	0.00	0.00	0.00
1.01	9.40	58	.05	.04	.01	1276.	1.02	10.40	208	0.00	0.00	0.00
1.01	9.50	59	.05	.04	.01	1591.	1.02	10.50	209	0.00	0.00	0.00
1.01	10.00	60	.05	.04	.01	1814.	1.02	11.00	210	0.00	0.00	0.00
1.01	10.10	61	.05	.04	.01	1976.	1.02	11.10	211	0.00	0.00	0.00
1.01	10.20	62	.05	.04	.01	2049.	1.02	11.20	212	0.00	0.00	0.00
1.01	10.30	63	.05	.04	.01	2179.	1.02	11.30	213	0.00	0.00	0.00
1.01	10.40	64	.06	.05	.01	2268.	1.02	11.40	214	0.00	0.00	0.00
1.01	10.50	65	.06	.05	.01	2391.	1.02	11.50	215	0.00	0.00	0.00
1.01	11.00	66	.07	.05	.01	2575.	1.02	12.00	216	0.00	0.00	0.00
1.01	11.10	67	.14	.13	.01	2874.	1.02	12.10	217	0.00	0.00	0.00
1.01	11.20	68	.14	.13	.01	3394.	1.02	12.20	218	0.00	0.00	0.00
1.01	11.30	69	.14	.13	.01	4263.	1.02	12.30	219	0.00	0.00	0.00
1.01	11.40	70	.26	.24	.01	5610.	1.02	12.40	220	0.00	0.00	0.00
1.01	11.50	71	.35	.34	.01	6967.	1.02	12.50	221	0.00	0.00	0.00
1.01	12.00	72	.69	.68	.01	9461.	1.02	13.00	222	0.00	0.00	0.00
1.01	12.10	73	1.07	1.05	.01	10499.	1.02	13.10	223	0.00	0.00	0.00
1.01	12.20	74	.35	.34	.01	21420.	1.02	13.20	224	0.00	0.00	0.00
1.01	12.30	75	.27	.26	.01	28040.	1.02	13.30	225	0.00	0.00	0.00
1.01	12.40	76	.14	.13	.01	30053.	1.02	13.40	226	0.00	0.00	0.00
1.01	12.50	77	.14	.13	.01	23599.	1.02	13.50	227	0.00	0.00	0.00
1.01	13.00	78	.14	.13	.01	23124.	1.02	14.00	228	0.00	0.00	0.00
1.01	13.10	79	.07	.05	.01	14773.	1.02	14.10	229	0.00	0.00	0.00
1.01	13.20	80	.07	.05	.01	15191.	1.02	14.20	230	0.00	0.00	0.00
1.01	13.30	81	.06	.05	.01	12040.	1.02	14.30	231	0.00	0.00	0.00
1.01	13.40	82	.05	.04	.01	9527.	1.02	14.40	232	0.00	0.00	0.00
1.01	13.50	83	.05	.04	.01	7569.	1.02	14.50	233	0.00	0.00	0.00
1.01	14.00	84	.05	.04	.01	6077.	1.02	15.00	234	0.00	0.00	0.00
1.01	14.10	85	.05	.04	.01	5010.	1.02	15.10	235	0.00	0.00	0.00
1.01	14.20	86	.05	.04	.01	4182.	1.02	15.20	236	0.00	0.00	0.00
1.01	14.30	87	.05	.04	.01	3592.	1.02	15.30	237	0.00	0.00	0.00
1.01	14.40	88	.05	.04	.01	3193.	1.02	15.40	238	0.00	0.00	0.00
1.01	14.50	89	.05	.04	.01	2911.	1.02	15.50	239	0.00	0.00	0.00
1.01	15.00	90	.05	.04	.01	2713.	1.02	16.00	240	0.00	0.00	0.00
1.01	15.10	91	.03	.01	.01	2542.	1.02	16.10	241	0.00	0.00	0.00
1.01	15.20	92	.03	.01	.01	2347.	1.02	16.20	242	0.00	0.00	0.00
1.01	15.30	93	.03	.01	.01	2051.	1.02	16.30	243	0.00	0.00	0.00
1.01	15.40	94	.03	.01	.01	2051.	1.02	16.40	244	0.00	0.00	0.00
1.01	15.50	95	.03	.01	.01	1747.	1.02	16.50	245	0.00	0.00	0.00
1.01	16.00	96	.03	.01	.01	1480.	1.02	17.00	246	0.00	0.00	0.00
1.01	16.10	97	.03	.01	.01	1394.	1.02	17.10	247	0.00	0.00	0.00
1.01	16.20	98	.03	.01	.01	1181.	1.02	17.20	248	0.00	0.00	0.00
1.01	16.30	99	.03	.01	.01	1049.	1.02	17.30	249	0.00	0.00	0.00
1.01	16.40	100	.03	.01	.01	1035.	1.02	17.40	250	0.00	0.00	0.00
1.01	16.50	101	.03	.01	.01	990.	1.02	17.50	251	0.00	0.00	0.00
1.01	17.00	102	.03	.01	.01	963.	1.02	18.00	252	0.00	0.00	0.00
1.01	17.10	103	.03	.01	.01	931.	1.02	18.10	253	0.00	0.00	0.00
1.01	17.20	104	.03	.01	.01	931.	1.02	18.20	254	0.00	0.00	0.00

FLOW 0. 407. 1484. 2853. 6524. 19350. 25981. 30243.

CAPACITY 0. 430. 1457. 3950. 7400. 12431. 15961. 14602. 24001.

ELEVATION 750. 760. 770. 780. 790. 800. 810. 820.

FEEL SPHID CLOW FPM ELEV COOL CAKEA EXPL
R00.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

DAM DATA
TYPEL CLOW EXPN DAMMID
R00.0 0.0 0.0 0.

STATION 1. PLAN 1, MATIN 1

END-OF-PEAK HYDROGRAPH COORDINATES

TIME	PERIOD	INFL	OUTFL	STAGE
1.01	1.10	1	17	12431.
1.01	2.20	2	33	12431.
1.01	3.30	3	50	12431.
1.01	4.40	4	67	12431.
1.01	5.50	5	83	12431.
1.01	6.60	6	100	12431.
1.01	7.70	7	117	12431.
1.01	8.80	8	133	12431.
1.01	9.90	9	150	12431.
1.01	11.00	10	167	12431.
1.01	12.10	11	183	12431.
1.01	13.20	12	200	12431.
1.01	14.30	13	217	12431.
1.01	15.40	14	233	12431.
1.01	16.50	15	250	12431.
1.01	17.60	16	267	12431.
1.01	18.70	17	283	12431.
1.01	19.80	18	300	12431.
1.01	20.90	19	317	12431.
1.01	22.00	20	333	12431.
1.01	23.10	21	350	12431.
1.01	24.20	22	367	12431.
1.01	25.30	23	383	12431.
1.01	26.40	24	400	12431.
1.01	27.50	25	417	12431.
1.01	28.60	26	433	12431.
1.01	29.70	27	450	12431.
1.01	30.80	28	467	12431.
1.01	31.90	29	483	12431.
1.01	33.00	30	500	12431.
1.01	34.10	31	517	12431.
1.01	35.20	32	533	12431.
1.01	36.30	33	550	12431.
1.01	37.40	34	567	12431.
1.01	38.50	35	583	12431.
1.01	39.60	36	600	12431.
1.01	40.70	37	617	12431.
1.01	41.80	38	633	12431.
1.01	42.90	39	650	12431.
1.01	44.00	40	667	12431.

1.01	6.50	21	6.43	0.0	12431.	800.0
1.01	7.00	42	7.19	0.0	12431.	800.0
1.01	7.10	43	7.33	0.0	12431.	800.0
1.01	7.20	44	7.47	0.0	12431.	800.0
1.01	7.30	45	7.50	0.0	12431.	800.0
1.01	7.40	46	7.67	0.0	12431.	800.0
1.01	7.50	47	7.83	0.0	12431.	800.0
1.01	8.00	48	8.00	0.0	12431.	800.0
1.01	8.10	49	8.17	0.0	12431.	800.0
1.01	8.20	50	8.33	0.0	12431.	800.0
1.01	8.30	51	8.50	0.0	12431.	800.0
1.01	8.40	52	8.67	0.0	12431.	800.0
1.01	8.50	53	8.83	0.0	12431.	800.0
1.01	9.00	54	9.00	17.	12431.	800.0
1.01	9.10	55	9.17	79.	12432.	800.0
1.01	9.20	56	9.33	244.	12434.	800.0
1.01	9.30	57	9.50	518.	12439.	800.0
1.01	9.40	58	9.67	893.	12440.	800.0
1.01	9.50	59	9.83	1274.	12463.	800.1
1.01	10.00	60	10.00	1591.	12483.	800.1
1.01	10.10	61	10.17	1818.	12505.	800.1
1.01	10.20	62	10.33	1976.	12530.	800.2
1.01	10.30	63	10.50	2089.	12551.	800.2
1.01	10.40	64	10.67	2179.	12585.	800.3
1.01	10.50	65	10.83	2268.	12618.	800.3
1.01	11.00	66	11.00	2391.	12643.	800.4
1.01	11.10	67	11.17	2575.	12675.	800.4
1.01	11.20	68	11.33	2874.	12706.	800.5
1.01	11.30	69	11.50	3394.	12749.	800.5
1.01	11.40	70	11.67	4243.	12798.	800.6
1.01	11.50	71	11.83	5419.	12840.	800.9
1.01	12.00	72	12.00	6967.	12940.	800.9
1.01	12.10	73	12.17	9661.	13048.	801.0
1.01	12.20	74	12.33	12499.	13205.	801.3
1.01	12.30	75	12.50	16420.	13438.	801.7
1.01	12.40	76	12.67	21420.	13758.	802.3
1.01	12.50	77	12.83	28040.	14127.	802.9
1.01	13.00	78	13.00	37053.	14800.	803.5
1.01	13.10	79	13.17	49599.	14773.	804.0
1.01	13.20	80	13.33	67773.	14995.	804.4
1.01	13.30	81	13.50	95191.	15153.	804.6
1.01	13.40	82	13.67	12090.	15259.	804.8
1.01	13.50	83	13.83	15229.	15322.	804.9
1.01	14.00	84	14.00	19566.	15351.	805.0
1.01	14.10	85	14.17	25077.	15350.	805.0
1.01	14.20	86	14.33	31810.	15348.	805.0
1.01	14.30	87	14.50	40182.	15319.	804.9
1.01	14.40	88	14.67	50992.	15286.	804.9
1.01	14.50	89	14.83	64803.	15248.	804.8
1.01	15.00	90	15.00	82911.	15207.	804.9
1.01	15.10	91	15.17	106713.	15164.	804.6
1.01	15.20	92	15.33	138443.	15122.	804.6
1.01	15.30	93	15.50	180523.	15078.	804.6
1.01	15.40	94	15.67	237497.	15033.	804.6
1.01	15.50	95	15.83	315493.	14987.	804.3
1.01	16.00	96	16.00	430000.	14938.	804.3
1.01	16.10	97	16.17	586889.	14889.	804.2
1.01	16.20	98	16.33	808114.	14840.	804.1
1.01	16.30	99	16.50	111990.	14792.	804.0
1.01	16.40	100	16.67	153513.	14745.	803.9

1.01	14.50	17	19.85	96.	4282.	14599.	801.9
1.01	17.00	182	17.00	989.	4135.	14555.	801.9
1.01	17.10	103	17.10	931.	4033.	14511.	801.7
1.01	17.20	104	17.33	937.	3914.	14570.	803.6
1.01	17.30	105	17.50	929.	3800.	14529.	803.6
1.01	17.40	106	17.67	921.	3698.	14491.	803.9
1.01	17.50	107	17.83	919.	3583.	14453.	803.9
1.01	18.00	108	18.00	919.	3481.	14417.	803.9
1.01	18.10	109	18.17	919.	3383.	14382.	803.9
1.01	18.20	110	18.33	919.	3288.	14349.	803.9
1.01	18.30	111	18.50	914.	3195.	14316.	803.9
1.01	18.40	112	18.67	914.	3101.	14283.	803.9
1.01	18.50	113	18.83	914.	3008.	14250.	803.9
1.01	19.00	114	19.00	914.	2987.	14215.	803.9
1.01	19.10	115	19.17	914.	2816.	14180.	803.9
1.01	19.20	116	19.33	914.	2734.	14145.	802.9
1.01	19.30	117	19.50	914.	2633.	14110.	802.9
1.01	19.40	118	19.67	97.	2531.	14076.	802.9
1.01	19.50	119	19.83	97.	2429.	14042.	802.9
1.01	20.00	120	20.00	96.	2348.	14009.	802.9
1.01	20.10	121	20.17	95.	2271.	13977.	802.9
1.01	20.20	122	20.33	37.	2200.	13946.	802.9
1.01	20.30	123	20.50	31.	2132.	13915.	802.5
1.01	20.40	124	20.67	24.	2065.	13886.	802.5
1.01	20.50	125	20.83	24.	2001.	13857.	802.4
1.01	21.00	126	21.00	24.	1939.	13830.	802.4
1.01	21.10	127	21.17	22.	1878.	13803.	802.3
1.01	21.20	128	21.33	22.	1820.	13777.	802.3
1.01	21.30	129	21.50	21.	1763.	13752.	802.2
1.01	21.40	130	21.67	21.	1708.	13727.	802.2
1.01	21.50	131	21.83	21.	1655.	13704.	802.2
1.01	22.00	132	22.00	21.	1604.	13681.	802.1
1.01	22.10	133	22.17	21.	1554.	13659.	802.1
1.01	22.20	134	22.33	21.	1505.	13637.	802.1
1.01	22.30	135	22.50	21.	1455.	13616.	802.0
1.01	22.40	136	22.67	21.	1406.	13596.	802.0
1.01	22.50	137	22.83	21.	1357.	13574.	801.9
1.01	23.00	138	23.00	21.	1309.	13557.	801.9
1.01	23.10	139	23.17	21.	1262.	13539.	801.9
1.01	23.20	140	23.33	21.	1216.	13520.	801.9
1.01	23.30	141	23.50	21.	1171.	13502.	801.8
1.01	23.40	142	23.67	21.	1127.	13485.	801.8
1.01	23.50	143	23.83	21.	1084.	13468.	801.8
1.02	0.00	144	24.00	21.	1041.	13451.	801.7
1.02	0.10	145	24.17	21.	1000.	13435.	801.7
1.02	0.20	146	24.33	21.	958.	13419.	801.7
1.02	0.30	147	24.50	19.	917.	13403.	801.7
1.02	0.40	148	24.67	16.	876.	13388.	801.6
1.02	0.50	149	24.83	12.	835.	13373.	801.6
1.02	1.00	150	25.00	6.	794.	13358.	801.6
1.02	1.10	151	25.17	4.	753.	13344.	801.6
1.02	1.20	152	25.33	3.	712.	13329.	801.5
1.02	1.30	153	25.50	3.	671.	13316.	801.5
1.02	1.40	154	25.67	2.	630.	13302.	801.5
1.02	1.50	155	25.83	1.	589.	13289.	801.5
1.02	2.00	156	26.00	1.	548.	13276.	801.4
1.02	2.10	157	26.17	1.	507.	13263.	801.4
1.02	2.20	158	26.33	0.	466.	13251.	801.4
1.02	2.30	159	26.50	0.	425.	13239.	801.4
1.02	2.40	160	26.67	0.	384.	13227.	801.4

1.02	2.58	161	24.43	0.	927.	13216.	801.3
1.02	3.00	162	27.08	0.	804.	13204.	801.3
1.02	3.16	163	27.17	0.	784.	13193.	801.3
1.02	3.20	164	27.33	0.	771.	13183.	801.3
1.02	3.30	165	27.50	0.	754.	13172.	801.3
1.02	3.40	166	27.67	0.	736.	13162.	801.2
1.02	3.50	167	27.83	0.	720.	13152.	801.3
1.02	4.00	168	28.00	0.	703.	13142.	801.2
1.02	4.10	169	28.17	0.	687.	13132.	801.3
1.02	4.20	170	28.33	0.	671.	13123.	801.2
1.02	4.30	171	28.50	0.	656.	13114.	801.2
1.02	4.40	172	28.67	0.	641.	13105.	801.1
1.02	4.50	173	28.83	0.	626.	13096.	801.1
1.02	5.00	174	29.00	0.	612.	13088.	801.1
1.02	5.10	175	29.17	0.	598.	13079.	801.1
1.02	5.20	176	29.33	0.	584.	13071.	801.1
1.02	5.30	177	29.50	0.	571.	13063.	801.1
1.02	5.40	178	29.67	0.	558.	13056.	801.1
1.02	5.50	179	29.83	0.	545.	13048.	801.0
1.02	6.00	180	30.00	0.	533.	13041.	801.0
1.02	6.10	181	30.17	0.	520.	13033.	801.0
1.02	6.20	182	30.33	0.	509.	13026.	801.0
1.02	6.30	183	30.50	0.	497.	13019.	801.0
1.02	6.40	184	30.67	0.	491.	13012.	801.0
1.02	6.50	185	30.83	0.	486.	13006.	801.0
1.02	7.00	186	31.00	0.	480.	12999.	801.0
1.02	7.10	187	31.17	0.	474.	12993.	801.0
1.02	7.20	188	31.33	0.	469.	12986.	800.9
1.02	7.30	189	31.50	0.	463.	12980.	800.9
1.02	7.40	190	31.67	0.	458.	12973.	800.9
1.02	7.50	191	31.83	0.	453.	12967.	800.9
1.02	8.00	192	32.00	0.	448.	12961.	800.9
1.02	8.10	193	32.17	0.	442.	12955.	800.9
1.02	8.20	194	32.33	0.	437.	12949.	800.9
1.02	8.30	195	32.50	0.	432.	12943.	800.9
1.02	8.40	196	32.67	0.	427.	12937.	800.9
1.02	8.50	197	32.83	0.	422.	12931.	800.8
1.02	9.00	198	33.00	0.	417.	12925.	800.8
1.02	9.10	199	33.17	0.	413.	12919.	800.8
1.02	9.20	200	33.33	0.	408.	12914.	800.8
1.02	9.30	201	33.50	0.	403.	12908.	800.8
1.02	9.40	202	33.67	0.	398.	12903.	800.8
1.02	9.50	203	33.83	0.	394.	12897.	800.8
1.02	10.00	204	34.00	0.	389.	12892.	800.8
1.02	10.10	205	34.17	0.	385.	12886.	800.8
1.02	10.20	206	34.33	0.	380.	12881.	800.8
1.02	10.30	207	34.50	0.	376.	12876.	800.8
1.02	10.40	208	34.67	0.	372.	12871.	800.7
1.02	10.50	209	34.83	0.	367.	12866.	800.7
1.02	11.00	210	35.00	0.	363.	12861.	800.7
1.02	11.10	211	35.17	0.	359.	12856.	800.7
1.02	11.20	212	35.33	0.	355.	12851.	800.7
1.02	11.30	213	35.50	0.	351.	12846.	800.7
1.02	11.40	214	35.67	0.	346.	12841.	800.7
1.02	11.50	215	35.83	0.	342.	12836.	800.7
1.02	12.00	216	36.00	0.	339.	12832.	800.7
1.02	12.10	217	36.17	0.	335.	12827.	800.7
1.02	12.20	218	36.33	0.	331.	12823.	800.7
1.02	12.30	219	36.50	0.	327.	12818.	800.7
1.02	12.40	220	36.67	0.	323.	12813.	800.7

1.02	12.50	221	30.93	0.	119.	12809.	800.9
1.02	13.00	222	37.00	0.	316.	12805.	800.6
1.02	13.10	223	37.11	0.	312.	12800.	800.6
1.02	13.20	224	37.11	0.	308.	12796.	800.6
1.02	13.30	225	37.39	0.	305.	12792.	800.6
1.02	13.40	226	37.67	0.	301.	12788.	800.6
1.02	13.50	227	37.83	0.	298.	12784.	800.6
1.02	14.00	228	38.00	0.	294.	12779.	800.6
1.02	14.10	229	38.17	0.	291.	12775.	800.6
1.02	14.20	230	38.33	0.	288.	12771.	800.6
1.02	14.30	231	38.50	0.	284.	12768.	800.6
1.02	14.40	232	38.67	0.	281.	12764.	800.6
1.02	14.50	233	38.83	0.	278.	12760.	800.6
1.02	15.00	234	39.00	0.	275.	12756.	800.6
1.02	15.10	235	39.17	0.	271.	12752.	800.6
1.02	15.20	236	39.33	0.	268.	12749.	800.5
1.02	15.30	237	39.50	0.	265.	12745.	800.5
1.02	15.40	238	39.67	0.	262.	12741.	800.5
1.02	15.50	239	39.83	0.	259.	12738.	800.5
1.02	16.00	240	40.00	0.	256.	12734.	800.5
1.02	16.10	241	40.17	0.	253.	12731.	800.5
1.02	16.20	242	40.33	0.	250.	12727.	800.5
1.02	16.30	243	40.50	0.	247.	12724.	800.5
1.02	16.40	244	40.67	0.	244.	12720.	800.5
1.02	16.50	245	40.83	0.	242.	12717.	800.5
1.02	17.00	246	41.00	0.	239.	12714.	800.5
1.02	17.10	247	41.17	0.	236.	12710.	800.5
1.02	17.20	248	41.33	0.	233.	12707.	800.5
1.02	17.30	249	41.50	0.	231.	12704.	800.5
1.02	17.40	250	41.67	0.	228.	12701.	800.5
1.02	17.50	251	41.83	0.	225.	12698.	800.5
1.02	18.00	252	42.00	0.	223.	12695.	800.4
1.02	18.10	253	42.17	0.	220.	12692.	800.4
1.02	18.20	254	42.33	0.	218.	12689.	800.4
1.02	18.30	255	42.50	0.	215.	12686.	800.4
1.02	18.40	256	42.67	0.	213.	12683.	800.4
1.02	18.50	257	42.83	0.	210.	12680.	800.4
1.02	19.00	258	43.00	0.	208.	12677.	800.4
1.02	19.10	259	43.17	0.	205.	12674.	800.4
1.02	19.20	260	43.33	0.	203.	12671.	800.4
1.02	19.30	261	43.50	0.	201.	12668.	800.4
1.02	19.40	262	43.67	0.	198.	12666.	800.4
1.02	19.50	263	43.83	0.	196.	12663.	800.4
1.02	20.00	264	44.00	0.	194.	12660.	800.4
1.02	20.10	265	44.17	0.	191.	12658.	800.4
1.02	20.20	266	44.33	0.	189.	12655.	800.4
1.02	20.30	267	44.50	0.	187.	12652.	800.4
1.02	20.40	268	44.67	0.	185.	12650.	800.4
1.02	20.50	269	44.83	0.	183.	12647.	800.4
1.02	21.00	270	45.00	0.	181.	12645.	800.4
1.02	21.10	271	45.17	0.	179.	12642.	800.4
1.02	21.20	272	45.33	0.	176.	12640.	800.4
1.02	21.30	273	45.50	0.	174.	12637.	800.4
1.02	21.40	274	45.67	0.	172.	12635.	800.3
1.02	21.50	275	45.83	0.	170.	12633.	800.3
1.02	22.00	276	46.00	0.	168.	12630.	800.3
1.02	22.10	277	46.17	0.	166.	12628.	800.3
1.02	22.20	278	46.33	0.	165.	12626.	800.3
1.02	22.30	279	46.50	0.	163.	12624.	800.3
1.02	22.40	280	46.67	0.	161.	12621.	800.3

1.02	22.50	281	40.83	0.	159.	12619.	800.3
1.02	23.00	282	41.00	0.	147.	12617.	800.3
1.02	23.10	283	41.17	0.	155.	12615.	800.3
1.02	23.20	284	41.33	0.	153.	12613.	800.3
1.02	23.30	285	41.50	0.	152.	12611.	800.3
1.02	23.40	286	41.67	0.	150.	12608.	800.3
1.02	23.50	287	41.83	0.	148.	12606.	800.3
1.02	23.60	288	42.00	0.	146.	12604.	800.3
1.02	23.70	289	42.17	0.	145.	12602.	800.3
1.02	23.80	290	42.33	0.	143.	12600.	800.3
1.02	23.90	291	42.50	0.	141.	12598.	800.3
1.02	24.00	292	42.67	0.	140.	12596.	800.3
1.02	24.10	293	42.83	0.	138.	12593.	800.3
1.02	24.20	294	43.00	0.	137.	12591.	800.3
1.02	24.30	295	43.17	0.	135.	12589.	800.3
1.02	24.40	296	43.33	0.	133.	12587.	800.3
1.02	24.50	297	43.50	0.	132.	12585.	800.3
1.02	24.60	298	43.67	0.	130.	12583.	800.3
1.02	24.70	299	43.83	0.	129.	12582.	800.3
1.02	24.80	300	44.00	0.	127.	12580.	800.3

PEAK OUTFLOW IS ADOR. AT TIME 14.17 HOURS

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
6000.	4822.	1977.	1017.	305153.
143.	137.	56.	29.	8641.
INCHES	2.73	4.49	4.41	4.41
FEET	69.42	113.85	122.05	122.05
AC-FT	2391.	3921.	4203.	4203.
THOUS CU YD	2000.	4836.	5185.	5185.

PEAK FLOW AND STORAGE (END OF DESIGN) SUMMARY FOR MULTIPLE BLANKETTED SCHEMATIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUMULATIVE FEET PER SECOND)
 AREA IN SQUARE FEET (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO	1
					1.00
HYDROGRAPH AT	2	16.41	1	3053.	
	(	42.50)	(	851.011)	
ROUTED TO	1	16.41	1	644.	
	(	42.50)	(	143.15)	

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1

ELEVATION STORAGE OUTFLOW	INITIAL VALUE 800.00 12431. 0.	SPILLWAY CREST 800.00 12431. 0.	TOP OF DAM 800.00 15961. 8000.
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RATIO OF 100-5% FLOOD 1.00	MAXIMUM RESERVOIR IN W.S. ELEV 804.07	MAXIMUM DEPTH OVER DAM 0.00	MAXIMUM STORAGE AC-FIT 15356.	MAXIMUM OUTFLOW CFS 6468.	DURATION OVER TOP HOURS 0.00	TIME OF MAX OUTFLOW HOURS 14.17	TIME OF FAILURE HOURS 0.00
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