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NATIONAL DAM SAFETY PROGRAM. SPRING LAKE DAM (MO 31180), MISSIS--ETC(U)
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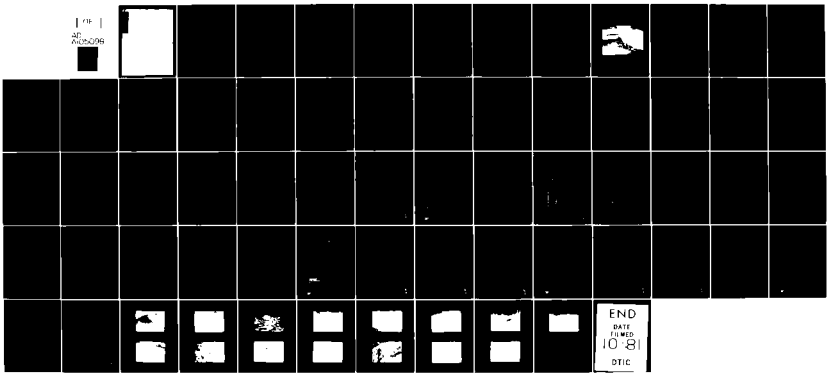

AD A105098

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO. AD-A105

3. RECIPIENT'S CATALOG NUMBER 098

4. TITLE (and Subtitle)
Phase I Dam Inspection Report
National Dam Safety Program
Spring Lake Dam (MO 31180)
Cape Girardeau County, Missouri

5. TYPE OF REPORT & PERIOD COVERED
Final Report

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Crawford, Murphy & Tilly, Inc.

8. CONTRACT OR GRANT NUMBER(s)
DACW43-81-C-0010

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

11. CONTROLLING OFFICE 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

12. REPORT DATE
March 1981

13. NUMBER OF PAGES
Approximately 60

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)
Nathan /Wilcoxon Guy /Freese
Timothy P. /Tappendorf

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

National Dam Safety Program. Spring Lake Dam (MO 31180), Mississippi - Kaskaskia - St. Louis Basin, Cape Girardeau County, Missouri. Phase I Inspection Report.

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

REPLY TO ATTENTION OF

SUBJECT: Spring Lake Dam Phase I Inspection Report
Cape Girardeau County, Missouri
Missouri Inventory No. 31180

This report presents the results of field inspection and evaluation of the Spring Lake Dam (MO 31180).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

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

SUBMITTED BY: SIGNED — 5 JUN 1981
Chief, Engineering Division — Date

APPROVED BY: SIGNED — 8 JUN 1981
Colonel, CE, District Engineer — Date

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MISSISSIPPI-KASKASKIA-ST. LOUIS BASIN

SPRING LAKE DAM
CAPE GIRARDEAU COUNTY MISSOURI
MISSOURI INVENTORY NO. 31180

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Crawford, Murphy & Tilly, Inc., Springfield, Illinois
A & H Engineering Corporation, Carbondale, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

MARCH, 1981

PREFACE

This report is prepared under guidance contained in Department of the Army, Office of the Chief of Engineers, Recommended Guidelines For Safety Inspection Of Dams, for a Phase I investigation. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigation, 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.

In reviewing this report, 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. Additional data or data furnished containing incorrect information could alter the findings of this report.

It is important to note that the condition of the 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 unsafe conditions be detected.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Spring Lake Dam
State Located:	Missouri
County Located:	Cape Girardeau
Stream:	Unnamed Tributary to Hubble Creek
Date of Inspection:	2 December 1980

BRIEF ASSESSMENT:

Spring Lake Dam was inspected and this report prepared by a team of engineers from Crawford, Murphy & Tilly, Inc. of Springfield, Illinois and A & H Engineering Corporation, Carbondale, Illinois. The purpose of this Phase I investigation was to make an assessment of the general condition of the dam with respect to safety, based upon available data, hydrologic and hydraulic studies, and a visual inspection in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment are contained in Department of the Army, Office of the Chief of Engineers, Recommended Guidelines for Safety Inspection of Dams for Phase I investigation. These guidelines were developed with the assistance of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. Within the estimated three mile downstream hazard zone are several dwellings, a sewage treatment plant, U. S. Highway 61, a motel, a public park, several commercial buildings and outbuildings.

Spring Lake Dam is an earthfill embankment constructed in 1969 or 1970 across an unnamed tributary to Hubble Creek. The dam is located in a residential subdivision entitled Spring Lake Estates and serves to provide recreation and enhancement to the residents of the subdivision.

The dam is in the small size category since the storage capacity is approximately 117 acre-feet and the embankment height is 21 feet.

Our inspection and evaluation indicates that the spillway has not met the criteria set forth in the guidelines for a small size dam in the high hazard potential category. This structure has the capability to hold and pass approximately 40 percent of the Probable Maximum Flood (PMF) before overtopping. The PMF is defined as 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 guidelines require that a

dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering the small drainage area (69.5 acres), the height of the dam (21 feet), the maximum storage capacity (117 acre-feet), the wide downstream floodway, and the fact that most residences along the downstream channel within a mile of the dam are approximately 10 feet above the streambed, 50% of the PMF has been determined to be the spillway design flood. The 100-year flood (1 percent probability flood) will not overtop the dam. The 1 percent probability flood (100-year flood) is one that has a 1 percent chance of being equalled or exceeded in any given year.

The dam appeared to be in fair condition. Deficiencies visually observed by the inspection team were: (1) a row of trees (approximately 8) along the upstream face of the dam; (2) a significant potential for restriction to flow into the principal spillway intake; (3) some minor erosion on the downstream face of the dam; (4) the emergency spillway channel is partially obstructed by six steel drums and a fence; and (5) minor seepage into the principal spillway conduit from within the embankment.

Another deficiency was the lack of records concerning the stability analysis and design information. Seepage and stability analyses should be made using appropriate loading conditions (including earthquake loads).

It is recommended that the owners take the necessary initiative in the near future to correct the deficiencies reported herein. A detailed discussion of the deficiencies is included in the following report.

Nathan Wilcoxon

Nathan Wilcoxon, P.E.
Crawford, Murphy & Tilly, Inc.

Guy Freese

Guy Freese, P.E.
A & H Engineering Corporation

Timothy P. Tappendorf

Timothy P. Tappendorf, E.I.T.
Crawford, Murphy & Tilly, Inc.

PHOTOGRAPH 1. OVERVIEW OF SPRING LAKE DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
SPRING LAKE DAM
MISSOURI INVENTORY NO. 31180

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, 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, District Engineer directed that a safety inspection be made of Spring Lake Dam in Cape Girardeau County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general conditions of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, Recommended Guidelines for Safety Inspection of Dams. 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 PROJECT:

A. Description of Dam and Appurtenances:

Spring Lake Dam is an earthfill structure approximately 21 feet high and 400 feet long at the crest. The appurtenant works consist of a drop-inlet pipe principal spillway and a trapezoidal channel cut into natural ground at the left abutment which acts as an emergency spillway.

A plan and typical cross section of the embankment is shown on plates 4 and 5 of Appendix A.

In this report right and left orientation are based on looking in the downstream direction.

B. Location:

The lake and dam are located just north of U. S. highway 61 approximately 0.6 miles south of Interstate Highway 55 in the center of Cape

Girardeau County, Missouri. Spring Lake Dam is within the Jackson, Missouri 7.5 minute qudrangle sheet (T 32 N, R 13 E - latitude 37° 25.3' longitude 89° 38.8'). Plate of of Appendix A shows the location and Plate 2 shows the general vicinity of the dam.

C. Size Classification:

Size classification may be determined by either storage or height, whichever gives the larger size category. Based on the embankment height of 21 feet and a maximum storage capacity of approximately 117 acre-feet, this dam is classified as small in size.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a potential high hazard dam. The estimated damage zone extends approximately 3 miles downstream of the dam. Within the 3 mile downstream hazard zone are several dwellings, a sewage treatment plant, U. S. Highway 61, a motel, a public park, several commercial buildings and outbuildings. Accordingly, the high hazard classification has been verified.

E. Ownership:

The dam and lake are owned by property owners within the Spring Lake Estates Subdivision. Each property owner has an undivided interest in the dam and lake. The developer and a property owner in the Spring Lake Subdivision is Dr. T. D. Wills whose address is: Michelle Drive, Spring Lake Estates, Jackson, Missouri 63755 (telephone 314-243-2443). Dr. Wills is the person responsible for operation and maintenance of the dam.

F. Purpose of Dam:

The dam was constructed to provide recreation and to enhance property within the Spring Lake Estates Subdivision development.

G. Design and Construction History:

Spring Lake Dam was constructed in 1969 or 1970 (as recalled by the developer). Design of the dam including the hydrology and hydraulics was provided by the local USDA Soils Conservation office at Jackson, Missouri. All design information and plans and specifications for the dam were destroyed by the SCS. The land developer (interviewed at his home during the inspection) also reported that he has no records of the dam.

At the time the dam was constructed, a gravel roadway over the crest and waste stabilization ponds (for treatment of domestic waste) near the downstream toe were also constructed. A sanitary sewer was constructed under the embankment near the right abutment and downstream face. (See Plate 4).

The developer reported that compaction of the embankment was accomplished with a sheepsfoot roller, and the fill material was obtained from the lake area just upstream from the dam. It was also indicated by the developer that after construction of the embankment, the downstream slope was flattened to allow easier access for mowing the slope. The dam was constructed by Calvin Phillips Construction Company, Highway 61 East, Jackson, Missouri.

H. Normal Operating Procedures:

The drop-inlet pipe spillway is uncontrolled and is equipped with a trash rack and anti-vortex plate. All flow will pass through the pipe spillway with water level elevations from 509.5 feet to 511.1 feet which is the crest of the emergency spillway. For water surface elevations above 511.1 both spillways will discharge flow. The developer indicated that since the dam was constructed, he has observed water as high as the emergency spillway crest (1.6 ft. above the crest of the principal spillway overflow).

The dam and appurtenances are maintained on an "as needed" basis by the owners.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works and reservoir are presented in the following paragraphs. Plates 4 and 5 of Appendix A present a plan and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the USGS quadrangle topographical map is approximately 69.5 acres (0.11 square miles).

B. Discharge at Dam Site:

Maximum known flood at damsite:

Just after construction the lake filled overnight and flood crest reached approximately 511 elevation.

Estimated principal spillway capacity at maximum pool (top of dam-elev. 513.3):	10 cfs
Estimated emergency spillway capacity at maximum pool:	257 cfs
Total spillway capacity at maximum pool:	267 cfs

C. Elevations (feet above MSL):

All elevations are consistent with an elevation of 576 feet taken from the USGS quadrangle map at the intersection of US Highway 61 and a "T" road to the east approximately 3,000 feet downstream from Spring Lake Dam.

Top of dam:	513.3
Principal spillway crest:	509.5
Emergency spillway crest:	511.1
Approximate high water:	511
Drawdown facility intake:	None
outlet:	None
Streambed at downstream toe:	490±
Maximum tailwater:	Not Applicable
Pool on date of inspection:	507.4 (2 Dec. 1980)

D. Reservoir Pool Lengths (Feet):

Maximum pool at top of dam:	1350
At emergency spillway crest:	1300
At principal spillway crest:	1150

E. Storage Capacities (Acre-Feet):

At top of dam:	117
At emergency spillway crest:	82.3
At principal spillway crest:	65.6

F. Reservoir Surface (Acres):

At top of dam:	11.2
At emergency spillway crest:	9.7
At principal spillway crest:	8.6

G. Dam:

Type:	Earthfill
Length at crest:	400 feet
Height:	21 feet
Top width:	18 feet
Side slopes (Horiz:Vert.):	
Upstream:	3:1
Downstream:	2.5:1
Zoning:	Apparently Homogeneous
Impervious core:	Unknown
Cutoff:	Unknown
Grout curtain:	None
Diversion tunnels:	None

H. Drawdown Facility:

Type:	None
Length:	Not Applicable
Access to closure:	Not Applicable

I. Spillways:

I.1 Principal Spillway:

Type:	Drop-inlet pipe with conduit through dam.
Location:	Approximately 180 feet from right abutment.
Length of weir:	18" diameter CMP riser
Crest elevation:	509.5 feet
Gates:	None
Other:	3' x 1'-8" anti-vortex plate at intake.

I.2 Emergency Spillway:

Type:	Excavated earth channel.

Location:	Immediately left of left abutment.
Length of weir:	25 feet (approximately)
Crest elevation:	511.1
Gates:	None
Other:	None
Channel U/S of control section:	22 foot long, -4.5% slope
Channel D/S of control section:	40 foot long, 3.4% slope

J. Regulating Outlets: None

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No engineering data or plans and specifications are known to exist for this dam. The USDA Soils Conservation Service provided assistance in designing the dam and prepared construction plans and specifications for the dam but these documents have been discarded. Likewise there are no construction inspection reports, laboratory results or maintenance records available.

A. Surveys:

No field surveying records are available for Spring Lake Dam.

B. Foundation and Embankment Design:

No design computations are available. Information concerning stability of the dam, seepage analysis or foundation preparation was not available. Also no subsurface exploration data are available.

C. Hydrology and Hydraulics:

No hydrologic or hydraulic design computations for this dam were available. The hydrologic and hydraulic designs were performed by the local USDA SCS office but records were discarded. Using field measurements, elevations and the USGS 7.5 minute quadrangle topographical map, hydrologic analyses were performed and the results appear in Appendix B.

D. Structures:

There are no design calculations or plans for the drop-inlet pipe spillway structure.

2.2 CONSTRUCTION:

No construction inspection, soil borings, or laboratory test data are available.

2.3 OPERATION:

When the lake is full, flows are discharged from the lake through the uncontrolled principal drop-inlet spillway and through the uncontrolled emergency spillway channel. No operating facilities exist.

2.4 EVALUATION:

A. Availability:

No engineering data, plans, laboratory test data, boring logs, or seepage or stability analyses are available.

B. Adequacy:

The engineering and related data available were insufficient to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the Recommended Guidelines for Safety Inspection of Dams are not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

No valid engineering or related data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on 2 December, 1980. The inspection team consisted of persons from Crawford, Murphy & Tilly, Inc. of Springfield, Illinois and A & H Engineering Corporation, Carbondale, Illinois. The team members were:

Nathan Wilcoxon, P.E. - Crawford, Murphy & Tilly, Inc.
(Mgr. Hydraulics & Hydrology Dept.)

Timothy Tappendorf, E.I.T. - Crawford, Murphy & Tilly, Inc.
(Civil Engineer)

Guy Freese, P.E. - A & H Engineering Corporation
(Geotechnical Engineer)

Photographs of the dam, appurtenant structures, reservoir, and downstream features are presented in Appendix C.

B. Regional and Project Geology:

The general southeastern Missouri area is underlain wholly or partially by Coastal Plain sediments. The Ozark Escarpment, which is the northwestern boundary, divides the lowland area (the Mississippi embayment) from the Ozark Province. This is an irregular boundary which trends northeast by southwest from the southern sections of Cape Girardeau County through Bollinger County, Wayne County, Butler County and into Arkansas. The Mississippi embayment is a broad arm of the Gulf Coastal Plain which extends up the Mississippi River Valley from the Gulf of Mexico.

The southern edge of Cape Girardeau County lies within the advance lowlands (the embayment areas), in the southeast sections of the county. The central, northern and all of the western sections of this county are included in the Ozark Province. Ordovician bedrock belonging to the (Canadian) Roubidoux formation and the Kimmswick-Dutchtown formations, make up most of the subsurface deposits in the area.

The dam site is located in the central part of the county. The area around the dam site consists of Ordovician bedrock overlain by loess deposits, residual soils and occasional stream alluvials. This exposed Paleozoic bedrock ranges from the older Canadian Series in the west through the Champlainian Series to the Cincinnatian Series in the east. These formations blend into Silurian-Devonian bedrock which overlies the Ordovician bedrock east of this area.

The soil cover at the site of the dam is a yellow-brown modified loess which generally ranges in thickness from 10 to 20 feet. Although not visible in the immediate dam site, a layer of residual soils underlie the modified loess. These soils are formed by the weathering of the limestone bedrock. Typically, the residual soils are red silty clays with variable permeabilities. They have moderate to high structural strength when they are dry, but can be somewhat unstable when wet.

Bedrock outcrops were not observed in the dam area. However, the Ordivician bedrock in the dam site area is Kimmswick limestone. The Kimmswick formation is usually coarsely crystalline, white to light gray, medium bedded to massive limestone. This formation ranges from 50 to 150 feet thick and is free from chert except in a zone about 8 feet thick near the middle of the formation. Because it is subject to the effects of groundwater solutioning, the surface bedrock profile is pinnacled. Bedrock is also permeable with significant leakage along enlarged joints and bedding planes. The Kimmswick is a firm rock formation although leakage is a common problem, it is not subject in this area to bedrock failure as a result of sinkhole collapse. The Kimmswick is underlain by a thin shaley limestone unit, the Decorah formation.

The Decorah formation consists of green to brown shales with numerous thin, interbedded limestone layers in the lower part, grading upward to medium to thinly bedded fossiliferous limestone layers. This formation ranges from 25 to 40 feet thick. The Decorah is relatively impermeable and can form a relatively water tight bedrock formation when considered for a small lake.

The Jackson Fault lies in the central Cape Girardeau County, approximately 3 miles south of the dam site. Maximum displacements along the fault line are in the order of 200 feet. There are a number of other smaller faults in the area of the dam but most of these are most likely a part of the Jackson Fault system. It appears that the faults in the immediate vicinity of the dam are seismically inactive. However, the site is approximately 30 miles north of the New Madrid area which is seismically active at this time.

C. Dam:

The dam is an earthfill embankment constructed from borrow taken from the reservoir area just upstream from the dam. The dam was constructed to form Spring Lake as a part of the Spring Lake Estates residential subdivision development. A plan view of the dam and appurtenant works is shown on Plate 4 and a typical cross-section is shown on Plate 5.

The embankment appears to be in fair condition. The horizontal alignment of the embankment (though curved) is good. The vertical alignment is erratic (see Exhibit 3 of Appendix C). It is believed this irregularity was primarily the result of grading for the roadway which extends across the crest of the dam. (See Photo 2 of Appendix C).

No apparent seepage through or under the dam was observed. However, a wet area near the toe of the downstream face of the right side of the embankment (see Plate 4 and Photo 6) was observed. This wet area was apparently the result of an overflowing sanitary sewer manhole (see Photo 7) and not related to underseepage.

The upstream and downstream slopes of the dam are shown on Photos 3 and 4. From these views it can be observed that the slopes are fairly uniform. Very little erosion from runoff or wave action was noted on the upstream slope which is protected with riprap. Some minor erosion from runoff was noted on the downstream slope near the toe. No sloughing was apparent on either the upstream or downstream slopes. At the time of the inspection, the upstream slope protection appeared to be adequate.

No instrumentation (monuments, piezometer gages, etc.) was observed.

D. Appurtenant Structures:

D.1 Principal Spillway:

The drop-inlet pipe spillway structure consists of an 18" vertical CMP approximately 18.7 feet in length and a 15" CMP outlet conduit under the embankment. The 15" CMP is reported by Dr. Wills to be equipped with anti-seep collars. The outlet conduit is extended under the dividing levee between the two cells of the waste stabilization pond where it outlets to the downstream channel. Those portions of the pipe spillway that could be observed appeared to be in good condition.

The spillway intake riser is equipped with an anti-vortex plate and a trash rack (see Photo 5). The trash rack was free of debris at the time of the inspection, but a fine screen covering the intake would severely restrict flow during a flood.

During the inspection the water was not overflowing the spillway intake structure. However, there was a small quantity of flow in the pipe observed at the concrete box (see Photo 4) at the downstream toe of the embankment. This indicates that there is some seepage entering the spillway conduit. The purpose of the concrete box located over the spillway outlet pipe is not known, but may have been provided to allow access to the conduit for cleaning.

D.2 Emergency Spillway:

The emergency spillway consists of a trapezoidal grass lined channel located to the left of the left abutment. A cross-section and profile of the emergency spillway are shown on Exhibits 3 and 4. Photo 8 is a view of the emergency spillway crest and the downstream part of the channel. Photo 9 shows the emergency spillway approach channel. The channel is obstructed by several steel drums and a wire fence. The emergency spillway is lined with a good vegetal (grass) cover.

E. Reservoir:

The watershed is generally grass covered with steep slopes. A portion of the drainage area consists of residential lots while the rest is primarily pastureland (see Photo 16) with only a small portion of it being cultivated. Sedimentation into the lake does not appear to be significant. The shoreline erosion also has been fairly minor (see Photo 9) and has not contributed significantly to the sediment load.

F. Downstream Channel:

Immediately downstream from the dam is a wastewater stabilization pond which receives sanitary sewage from the Spring Lake Estates Subdivision. The spillway outlet was extended to the downstream side of this waste facility and is located in the dividing levee shown in the center of Photo 10. Photo 11 is a view of the outlet end of the principal spillway. Photo 13 is a view of the downstream channel which leads to Hubble Creek shown in Photo 14. The downstream channel is grass covered and not significantly obstructed.

3.2 EVALUATION:

There is a row of approximately 8 trees growing along the top edge of the riprap on the upstream face of the embankment. These should be removed since as the trees continue to grow, the root system could go laterally through the embankment and provide seepage paths. Also if trees are blown over during a storm, large sections of the embankment can be weakened. It would be desirable to cut the trees, remove the stumps, fill the holes, compact and restore the vegetation on the disturbed areas.

No animal holes were observed in the embankment, but during the inspection several muskrats were removed by a trapper from the waste stabilization ponds and from several areas along the shoreline of the lake. This practice should be encouraged to continue since such animals can cause severe damage to the embankment.

Vegetal cover on the embankment was good over most areas. The embankment slopes were mowed and kept free of brush which allows for a good inspection of the surface of the dam. Some areas where minor erosion is occurring should be monitored and, if necessary, corrective measures should be initiated.

The principal spillway intake structure under flooding conditions would not operate properly since the fine screen around the trash rack would quickly clog and seriously restrict flows. The screen should be removed and, if necessary, a more suitable trash rack provided.

The emergency spillway which now is partially obstructed by a fence and steel drums should be kept free to allow unobstructed release of flood flows.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no operating facilities associated with this dam. The pool is controlled by the uncontrolled spillway overflow, rainfall, runoff and evaporation.

4.2 MAINTENANCE OF THE DAM:

The dam appeared to be well maintained at the time of inspection. Slopes were mown, riprap was uniform, the roadway over the crest was smooth and the reservoir free of floating debris. The developer and property owners assume the responsibility to maintain the dam although there is no regular maintenance program established. Maintenance is performed on the dam on an "as needed" basis.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities for this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The obstructions to flow in both the principal and emergency spillways, trees on the upstream face of the embankment, and minor erosion on the downstream face of the embankment, are deficiencies which should be corrected. Remedial measures should be investigated by an engineer experienced in the design and construction of dams. Subsequently, these items should be inspected periodically to insure the safety of the dam.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

No hydrologic or hydraulic computations for this dam were available.

The significant dimensions of the dam principal and emergency spillway, and reservoir were measured or surveyed during the inspection or estimated from USGS topographical mapping. Soil information is available from the local Soil Conservation Office.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data are available for this lake and watershed. Information from Dr. T. D. Wills (developer) indicates that the maximum stage in the lake was at the emergency spillway crest, (elevation 511). A hydrologic and hydraulic analyses appears in Appendix B.

C. Visual Observations:

Both the principal and emergency spillways have flow restrictions. The principal spillway is restricted by a fine screen around the trash rack and the emergency spillway by several steel drums in the center of the channel. The principal spillway discharge is well beyond the toe of the dam and affords no potential to erosion of the embankment. The emergency spillway located in undisturbed earth at the left abutment is erodable but does not discharge near the embankment and thus poses no potential to effect the dam.

A description of the downstream channel is given in Paragraph 3.1 F. The downstream hazard zone extends approximately 3 miles downstream from the dam to Jackson, Missouri and includes a waste stabilization pond, U.S. Highway 61, dwellings, commercial establishments, a motel, and a public park.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U.S. Army, Corps of Engineers guidelines and the HEC-1 computer program) were based on: (1) A field survey of the principal and emergency spillway dimensions and elevations; (2) Embankment cross-section and elevations; and (3) An estimate of the reservoir storage and the pool and drainage areas from the Jackson, Missouri 7.5 minute USGS quadrangle map.

Based on the hydrologic and hydraulic analyses presented in Appendix B, the structure will hold and pass approximately 40% of the PMF. The PMF is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydraulic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, requires that this structure (small size with high downstream hazard potential) pass from 50 percent to 100 percent of the PMF, without overtopping. Considering the small drainage area (69.5 acres), the height of the dam (21 feet), the maximum storage capacity (117 acre-feet), the relatively wide downstream floodway, and the fact that most residences along the downstream channel within one mile of the dam are approximately 10 feet above the streambed, 50% of the PMF has been determined to be the appropriate spillway design flood. The structure will pass a 1 percent flood without overtopping the dam.

Data from the 40, 50, and 100 percent PMF is presented in the table below.

Percent PMF	Starting Pool Elevation (MSL)	Peak Inflow To Lake (cfs)	Maximum Pool Elevation (MSL)	Maximum Depth Over Dam (feet)	Peak Discharge (cfs)	Overtopping Duration (hour)
40	509.5	592	513.35	0.05	288	0.2
50	509.5	741	513.6	0.3	427	0.6
100	509.5	1481	514.4	1.1	1198	1.9

The maximum capacity of the principal spillway is 10 cfs and the maximum capacity of the emergency spillway is 257 cfs when the lake level is at the top of the dam. The principal spillway capacity may be severely restricted during a flood event due to the fine screen around the intake structure (see Photo 5). In the hydrologic and hydraulic analysis of the dam it is assumed that the principal spillway capacity would be reduced by approximately 70 percent.

The starting pool elevation shown was found by assuming the lake level was at the crest of the principal spillway and then applying an appropriate antecedent storm to the watershed 4 days prior to the storm being analyzed. The antecedent storm was 20% of the PMF for the 40% PMF, 25% PMF for the 50% PMF, and 50% PMF for the 100% PMF. In each case the pool elevation will return to the principal spillway crest prior to the design storm.

It is noted that less intense flood events (approximately 10% PMF and above) will cause the pool elevation to reach the emergency spillway crest. This will cause more frequent use of the emergency spillway and erosion in the spillway channel may become pronounced. There was no evidence at the time of the inspection that there has been flow through the emergency spillway or over the top of the dam.

Overtopping the embankment could cause serious erosion and may lead to a breach of dam. Flood discharges resulting from a failure of Spring Lake Dam could be expected to produce substantial economic losses and loss of life.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Section 3 of this report.

B. Design and Construction Data:

It was understood from conversations with Dr. Wills that the Soil Conservation Service had prepared the design plans for the dam. The local Soil Conservation Service Office no longer has on file the design data for this dam and design data from other sources were unavailable.

Seepage and stability analysis comparable to the requirement of the inspection guidelines were also not available. This situation constitutes a deficiency which should be corrected.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

Dr. Wills reported that after the dam was constructed, additional fill was added to the downstream portion of the embankment to flatten the slope allowing for better access to mow the slope. He also reported that some repairs to the riprap have been made since construction.

E. Seismic Stability:

This dam is located in Seismic Zone 3, as shown on Plate 3 of Appendix A. Zone 3 delineates areas in which major damage would result from the expected seismic activity in this area. An accurate slope stability analysis with seismic loading cannot be made because of the lack of original design data and soil strength parameters. It should be noted that due to the relatively steep embankment slopes in the event of potential seismic loading, the slopes may become unstable and suffer some damage. The extent of damage would depend upon the intensity and duration of the seismic occurrence. It is recommended that stability analyses be made for the dam and spillway structures using the appropriate seismic loadings.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in fair condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) a row of trees (approximately 8) along the upstream face of the dam; (2) there is a significant restriction to flow to the principal spillway intake structure; (3) there is minor erosion near the toe of the downstream face of the embankment; (4) the emergency spillway channel is partially obstructed by 6 steel drums and a fence; (5) there is minor seepage into the principal spillway conduit under the embankment; and (6) the frequency of use of the emergency spillway could occur often enough to cause erosion. Also the lack of seepage and stability analyses records constitutes a deficiency.

The dam will be overtopped by flood flows in excess of 40 percent of the Probable Maximum Flood. Overtopping the embankment could cause serious erosion and may lead to a breach of the dam.

B. Adequacy of Information:

The conclusions in this report were based on the performance history as related by others, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the Recommended Guidelines for Safety Inspection of Dams were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in Paragraph 7.2 should be accomplished in the near future. The item recommended in Paragraph 7.2.A.1 should be pursued on a high priority basis. If these deficiencies listed in Paragraph A above are not corrected, and if good maintenance is not provided, serious consequences could eventually result.

D. Necessity for Additional Inspection:

Based on the results of the Phase I inspection, additional periodic inspections are recommended.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Recommendations:

1. Spillway capacity and/or height of dam should be increased to pass 50 percent of the PMF.

2. Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the design and construction of dams.

3. The frequency of use and erosion potential from flooding of the emergency spillway should be investigated to determine if serious erosion could result.

B. Operation and Maintenance Procedures:

1. Under the guidance of an engineer experienced in the design and construction of earth dams, remove the trees from the shoreline of the dam. Stumps and roots should also be removed. Disturbed areas should be refilled, and compacted.

2. The erosion areas on the downstream face of the embankment should be repaired and a good vegetal cover established. Consideration should be given to controlling runoff to avoid future erosion.

3. The fine screen around the principal spillway should be removed and if necessary, the trash rack replaced to provide adequate protection against the spillway clogging.

4. Insofar as practical all obstructions should be removed from the emergency spillway. (The fence is not considered to be a significant deterrent to flow and need not be removed but should be maintained free of debris).

5. Seepage into the principal spillway conduit should be monitored. This should be done by an engineer experienced in the design and construction of dams. (Significant increase in this flow or murky appearance would indicate remedial action should be initiated).

6. A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

PHASE I INSPECTION REPORT

APPENDIX A

MAPS AND GENERAL DRAWINGS

APPENDIX A

MAPS AND GENERAL DRAWINGS

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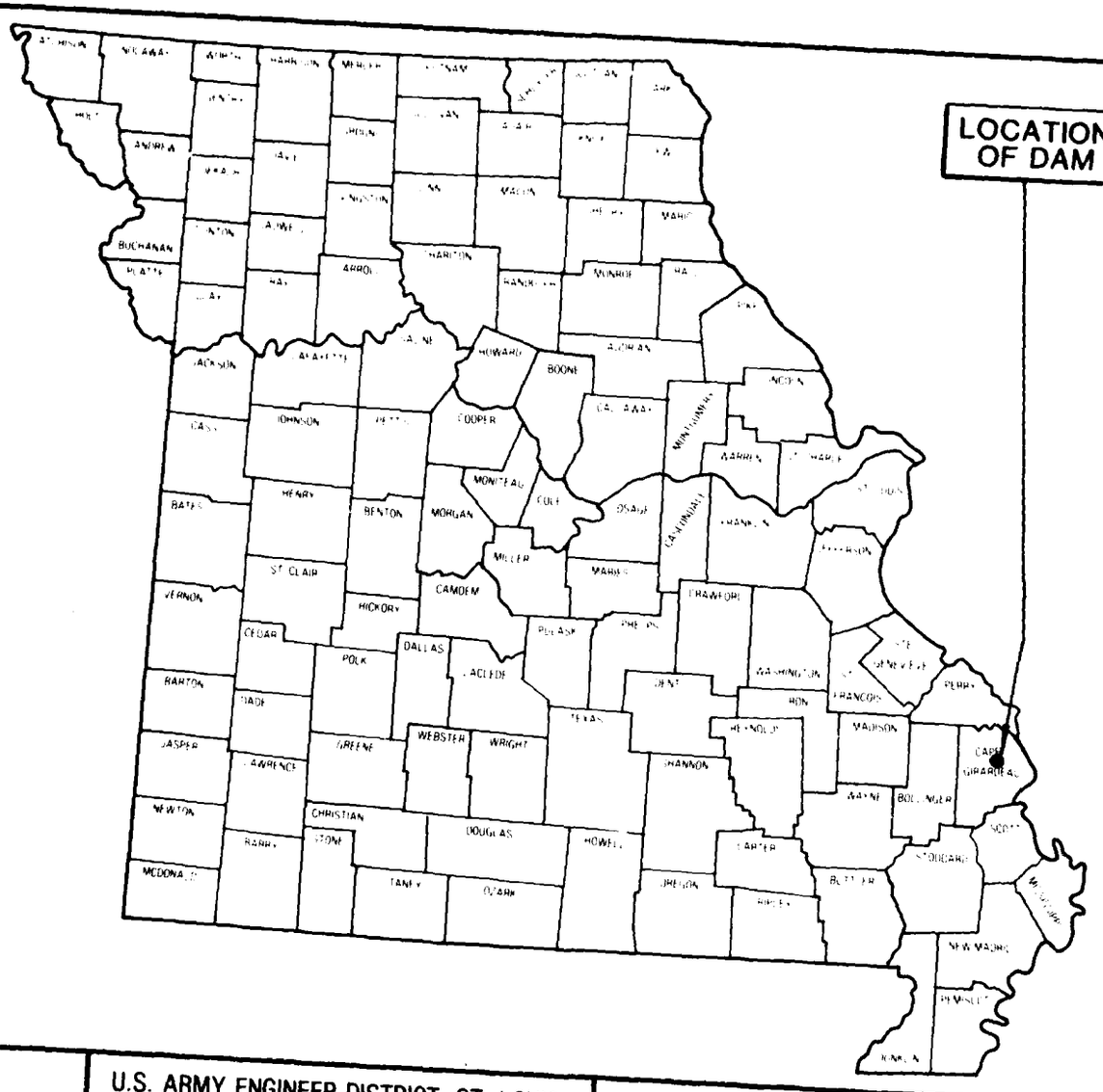
3	Seismic Zone Map
4	Plan of Dam and Spillway
5	Cross Section of Dam



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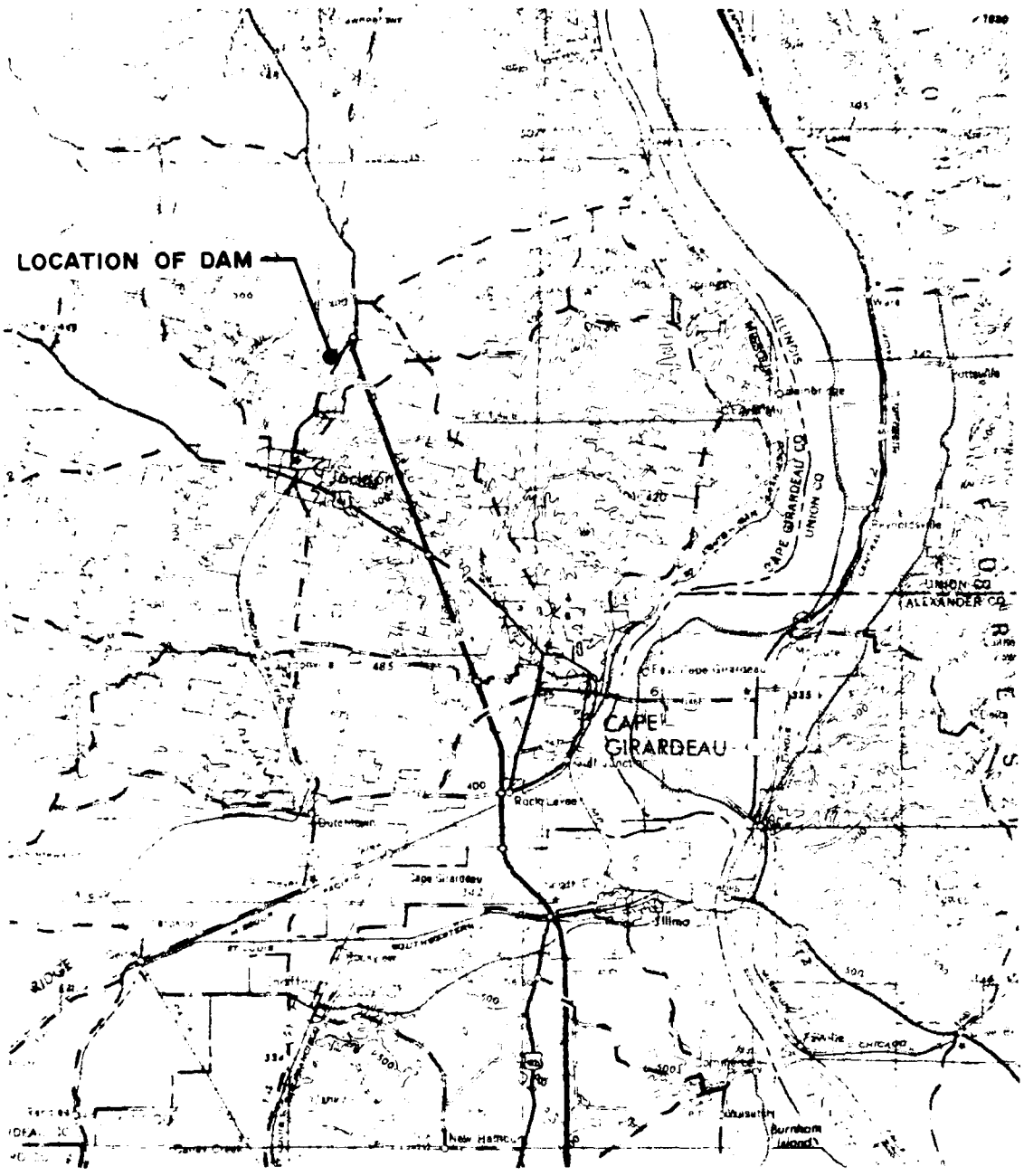
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

LOCATION MAP
SPRING LAKE DAM MO 31180

PLATE I

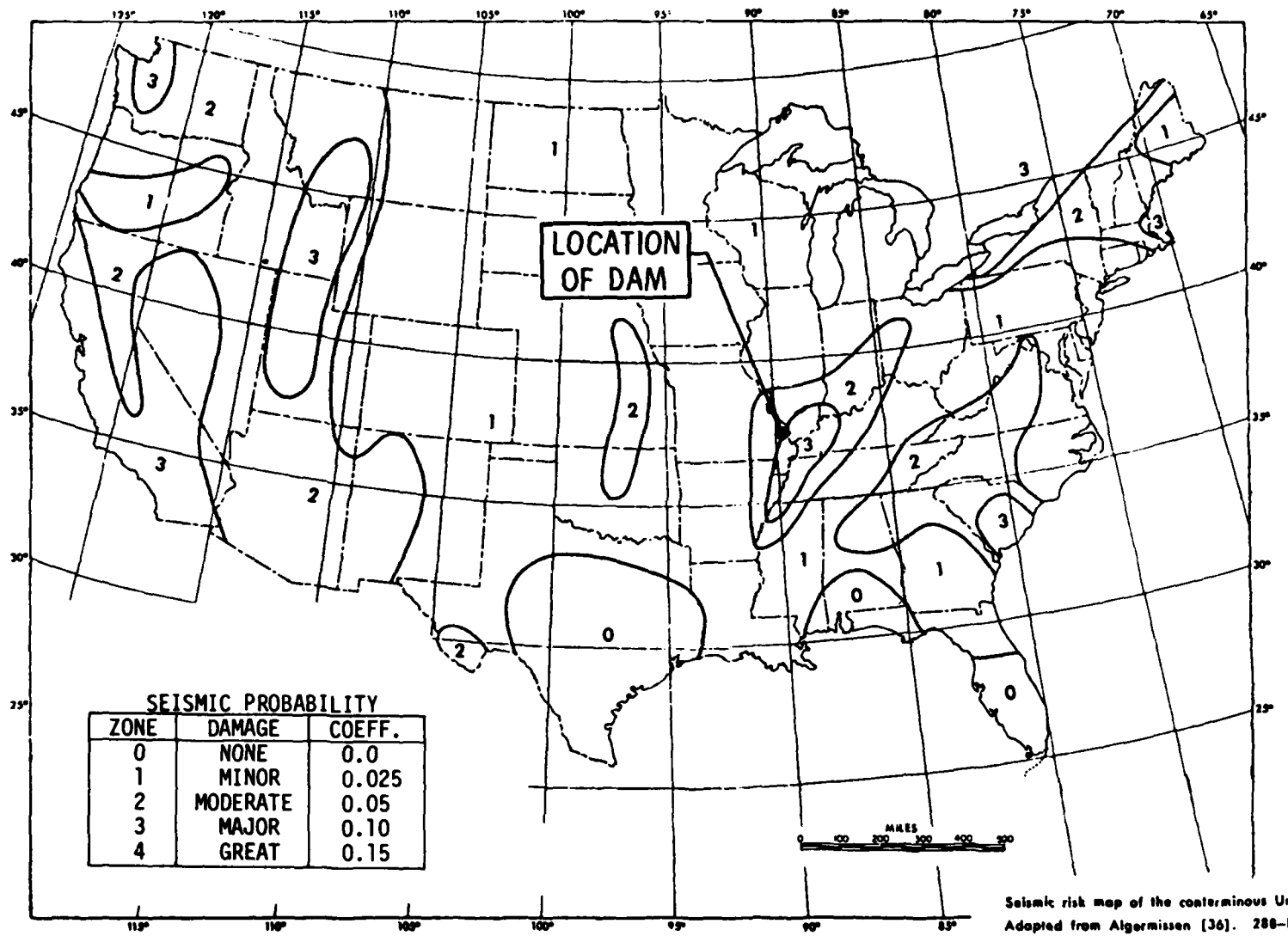


N

SCALE
1:250,000

CMST	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	VICINITY MAP SPRING LAKE DAM MO31180

PLATE 2



SEISMIC PROBABILITY

ZONE	DAMAGE	COEFF.
0	NONE	0.0
1	MINOR	0.025
2	MODERATE	0.05
3	MAJOR	0.10
4	GREAT	0.15

Seismic risk map of the conterminous United States. Adapted from Algermissen [36]. 288-D-2786.

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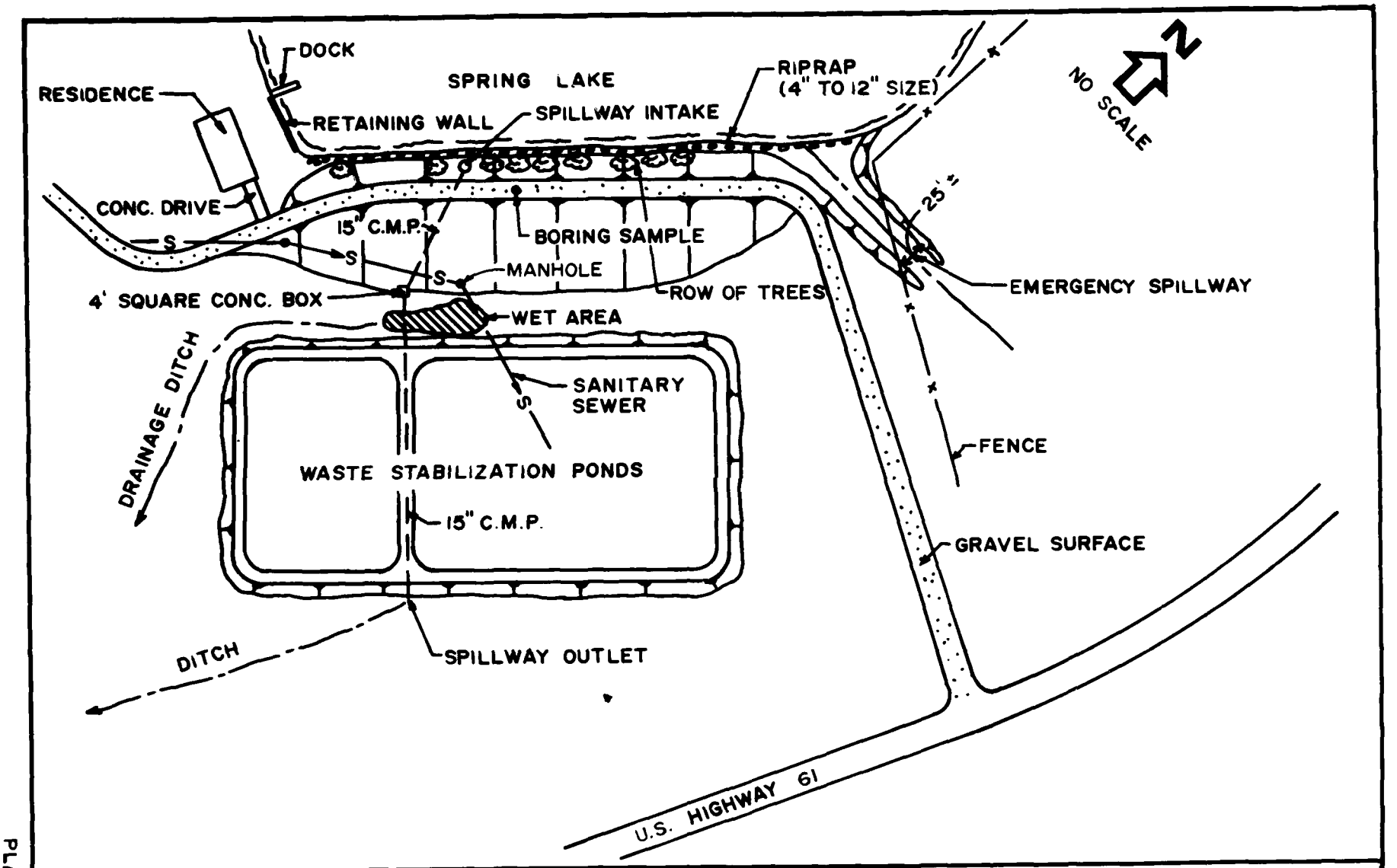
SEISMIC ZONE MAP OF CONTIGUOUS STATES
SPRING LAKE DAM MO 31180

PLATE 3



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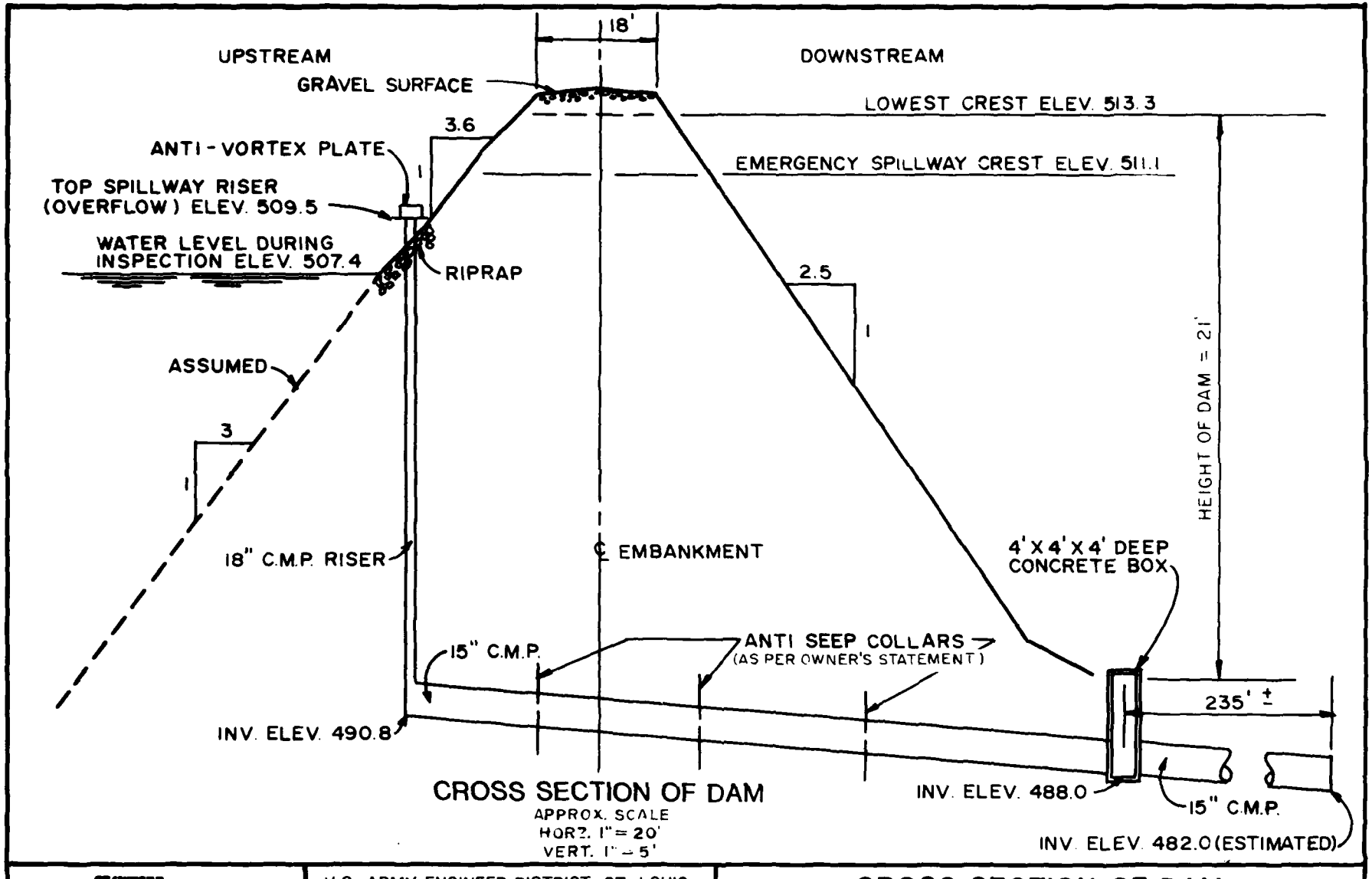
PLAN OF DAM AND SPILLWAY
SPRING LAKE DAM MO31180

PLATE 4



CROSS SECTION OF DAM
APPROX. SCALE
HORZ. 1" = 20'
VERT. 1" = 5'

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PHASE I INSPECTION REPORT

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSIS

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSIS

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2	Elevation-Area-Capacity Relation
3	Profile Along Crest of Dam
4	Centerline Profile - Emergency Spillway
5	HEC-1 Input Data
6	Inflow & Outflow Hydrographs - 40% PMF
7	Inflow & Outflow Hydrographs - 50% PMF
8	Inflow & Outflow Hydrographs - 100% PMF
9	Summary Table

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSIS

A. PURPOSE

The purpose of this Appendix is to present the methodology used and the results of the hydrologic and hydraulic analysis. The analysis was done according to criteria presented in the Recommended Guidelines for Safety Inspection of Dams and in the St. Louis District Hydrologic/Hydraulic Standards for Phase I Safety Inspection of Non-Federal Dams dated 22 August 1980. The purpose of the analysis is to determine the overtopping potential for Spring Lake Dam.

B. HYDROLOGIC AND HYDRAULIC ANALYSIS:

The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for a reservoir routing. Data for determination of the unit hydrograph was obtained from the U.S. Geological Survey 7.5 minute quadrangle map for Jackson, Missouri, dated 1966 and photo revised in 1978 and from the field inspection. A lake and watershed map is shown on Exhibit 1. There is a small farm pond in the drainage area upstream from Spring Lake (see Photo 15). The size of the pond is very small and its effect on the determination of the unit hydrograph was neglected in the analyses. The parameters used in the development of the unit hydrograph are presented in Table 1.

TABLE 1

UNIT HYDROGRAPH PARAMETERS

Drainage Area (A)	69.5	acres
Length of watercourse (L)	3000	feet
Watershed difference in elevation (H)	105	feet
Time of Concentration (Tc)	13	minutes
Duration (smallest HEC-1 allows)	5	minutes
Peak Flow	335	cfs
Snyder's Lag (tp)	0.16	hours
Snyder's Peaking Coefficient (Cp)	0.66	hours

Unit Hydrograph from the Computer Output

Time (Minutes)	Discharge (cfs)
0	0
5	92
10	264
15	275
20	141
25	51
30	18
35	7

Formula Used:

$$Tc = 0.0078 \frac{L^{3/2}}{H^{1/2}} \quad 0.770$$

From equation by P. Z. Kirpich (Verified using overland plus channel flow times)

$$tp = \frac{D}{2} + 0.6\ Tc$$

$$Qp = \frac{484\ A\ Q}{tp}$$

Q = Excess runoff = 1 inch

$$Cp = \frac{0.6\ Qp\ Tc}{640A}$$

The hypothetical storm that is applied to the unit hydrograph is the Probable Maximum Precipitation (PMP). It is derived and determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." No reduction factors have been applied to the PMP. A 1 percent probability storm was also analyzed. A 24-hour storm duration is assumed with total depth distributed over 6-hour periods in accordance with procedures outlined in EM 1110-2-1411 (SPF determination). The maximum 6-hour rainfall period is then distributed to hourly increments by the same criteria. Within-the-hour distribution is based upon NOAA Technical Memorandum NWS HYDRO-35. The non-peak 6-hour rainfall periods are distributed uniformly. All distributed values are arranged in a critical sequence by the SPF. The final inflow hydrograph is produced by deduction of infiltration losses appropriate to the soil, land use, and antecedent moisture conditions. Soil information was obtained from mapping available from the Cape Girardeau Soil Conservation Service. Land use and slopes were determined from the field inspection and available mapping. Antecedent Moisture Condition II (AMC II) was used for the analysis of the 1 percent probability storm and AMC III was used for the analysis of the PMP percentage storms. The rainfall applied, the perameters used to determine infiltration losses and the resulting runoffs are presented in Table 2.

TABLE 2

RAINFALL-RUNOFF PARAMETERS

Selected Storm Event	Storm Duration (hours)	Rainfall (inches)	Runoff (inches)	Losses (inches)
PMP	24	34.45	33.15	1.30
1% Probability Storm	24	7.0	4.1	2.9

Additional Data:

1) Soil Conservation Service Runoff Curve Number CN = 90 (AMC III) for the PMF and 50% PMF.

2) Soil Conservation Service Runoff Curve Number CN = 74 (AMC II) for the 1% probability storm.

The reservoir routing is accomplished by using the Modified Puls routing technique where in the flood hydrograph is routed through lake storage. The hydraulic capacity in the principal and emergency spillways and the crest of the dam are used as outlet controls in the routing. Storage in the pool area is defined by an elevation-storage capacity curve. The hydraulic capacity of the spillway and top of the dam are defined by elevation-discharge curves.

The elevation-storage capacity curve was developed by determining the lake surface area at various elevations using available mapping and then inputting this information to the HEC-1 computer program. The computer program then developed an elevation-storage capacity curve using the conic method. An elevation-area-capacity curve is shown on Exhibit 2.

The flow over the crest of the dam during overtopping was determined using the non-level crest option ($L and $V cards) of the HEC-1 program. The program assumes critical flow over a broad crested weir. The coefficient C was selected to be 2.6 as found in Handbook of Hydraulics by Horace Williams King and Ernest F. Brater. The minimum elevation was determined in the field by simple survey. A profile of the dam crest is shown on Exhibit 3. The minimum elevation of the embankment was used in the hydrologic and hydraulic analyses since it is lower than the lake elevation at which outflow velocities exceed the suggested maximum permissible mean velocities in the emergency spillway channel.

The hydraulic capacity for the drop-inlet principal spillway was determined assuming weir flow (for a circular pipe) for the riser and entrance control for the horizontal pipe conduit. The formula used for weir flow is $Q = 7.7DH^{3/2}$ where D is the diameter of the riser in feet and the formula used for the pipe conduit is $Q = Ca\ (2gh)^{0.5}$ where C was computed as 0.18. Due to the fine screen around the approach to the principal spillway entrance, a 70 percent reduction in capacity was assumed.

The hydraulic capacity of the emergency spillway was determined using methods found in the U.S. Department of Agriculture Soil Conservation Service Technical Release No. 2, "Earth Spillways," dated October 1, 1956. The profile of the emergency spillway flow line and a cross-section of the spillway channel as surveyed in the field were used in this determination and they are shown on Exhibits 3 and 4. The elevation-spillway capacity input to the computer is shown in Table 3.

TABLE 3

LAKE ELEVATION VS. SPILLWAY CAPACITY

Lake Elevation (MSL)	Spillway Capacity: Principal Spillway cfs	Spillway Capacity: Emergency Spillway cfs	Spillway Capacity: Total Capacity cfs
509.5[a]	0	0	0
511.1[b]	6.5	0	6.5
511.5	9.8	5	15
512.0	10.0	18	28
512.5	10.1	75	85
513.3[c]	10.2	257	267
514.0	10.3	485	495
515.0	10.5	930	940

a. Principal spillway crest elevation.
b. Emergency spillway crest elevation.
c. Top of dam elevation.

The dam overtopping analysis has been conducted by hydrologic methods for this dam and lake. This analysis determines the percentage of the PMF hydrograph that the reservoir can contain without the dam being effectively overtopped. According to Hydrologic/Hydraulic Standards developed by the Corps of Engineers, St. Louis District, an antecedent storm should be applied to the watershed before analysis of the PMF. The antecedent storm precedes the storm being analyzed by 4 days and the starting elevation at the beginning of the antecedent storm is the mean annual high water mark. No mean annual high water mark could be determined for Spring Lake Dam and therefore the principal spillway crest (elevation 509.5) was used as the starting elevation

at the beginning of the antecedent storms. The antecedent storm for the analysis of the PMF ratio storms is one-half the storm being analyzed. The analysis for the starting elevation of the spillway design flood includes an allowance for the trash accumulation and the resulting flow restriction at the principal spillway intake. The starting elevations, antecedent storms, and storms analyzed are given in Table 4.

TABLE 4

ANTECEDENT STORMS AND STARTING ELEVATIONS

Starting Elevation Before Antecedent Storm	Antecedent Storm Used	Elevation At Start of Storm Being Analyzed	Storm Being Analyzed
509.5	20% PMF	509.5	40% PMF
509.5	25% PMF	509.5	50% PMF
509.5	50% PMF	509.5	100% PMF

The percentage of the PMF that will reach the top of the dam is 40%.

The above methodology has been accomplished for this report using the systematized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The numeric parameters estimated for this site for the input to the program are listed on Exhibit 5. Definitions of these variables are contained in the "User's Manual" for the computer program.

The inflow and outflow hydrographs, obtained from the computer output, for the 40%, 50% and 100% PMF storms are shown on Exhibits 6, 7, and 8. A summary table for the overtopping analysis is presented on Exhibit 9.

C. REFERENCES:

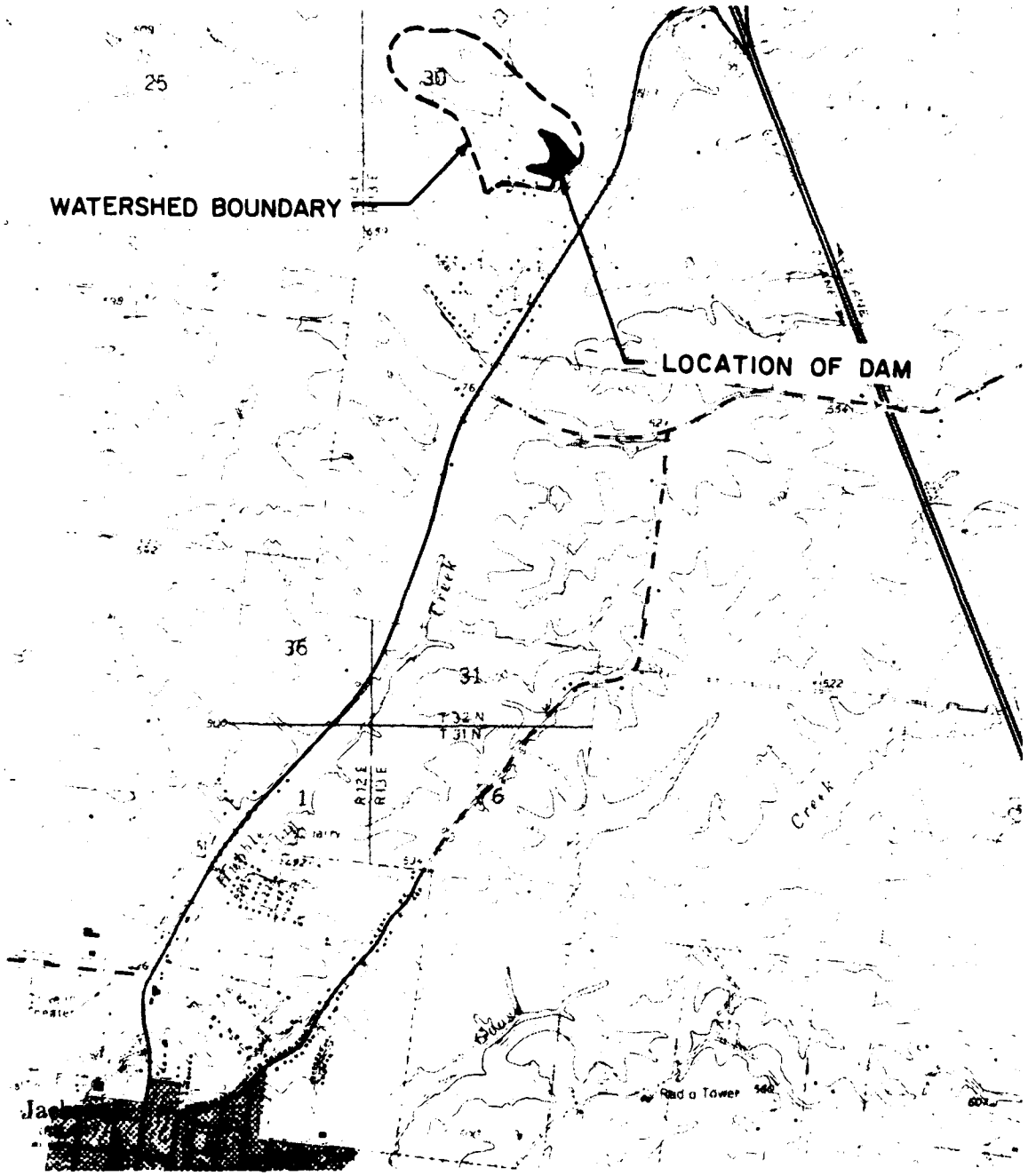
a. Earth Spillways, Technical Release No. 2, Soil Conservation Service, United States Department of Agriculture, Engineering Division, October, 1956.

b. Flood Hydrograph Package (HEC-1), Users Manual for Dam Safety Investigations, The Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California, September, 1978.

c. King, Horace Williams and Brater, Ernest F., Handbook of Hydraulics, Fifth Edition, 1963.

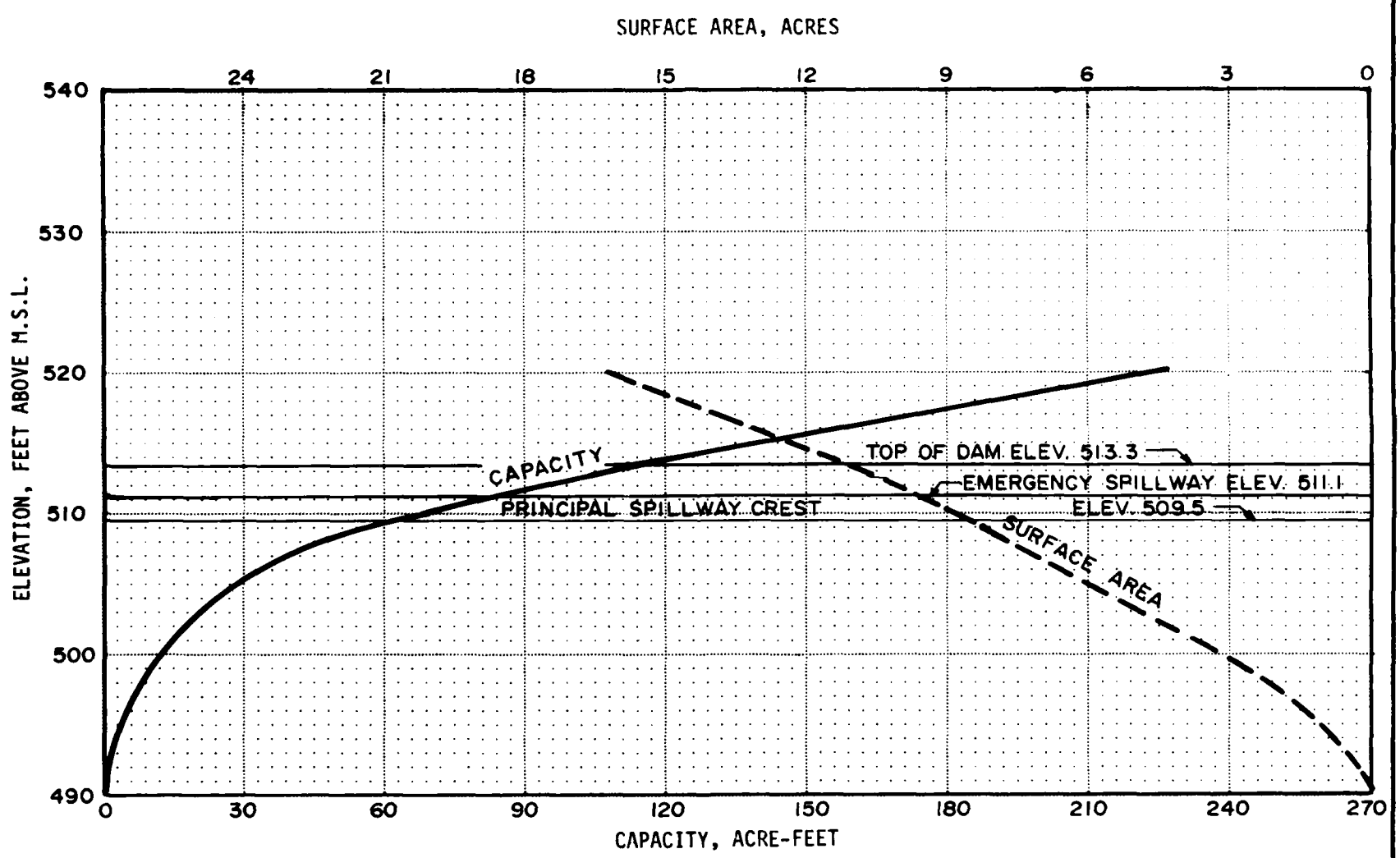
d. National Engineering Handbook, Sec. 4 Hydrology, Supplement A; Soil Conservation Service, United States Department of Agriculture, 1957.

e. Riedel, J. T., Appleby, J. F., and Schloemer, R. W., Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1000 Square Miles and Durations of 6, 12, 24 and 48 Hours, Hydrometeorological Report No. 33, U. S. Department of Commerce, Weather Bureau, April 1956.



CMT	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	LAKE AND WATERSHED MAP SPRING LAKE DAM MO31180

EXHIBIT 1



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CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

ELEVATION - AREA - CAPACITY RELATION
SPRING LAKE DAM MO31180

EXHIBIT 2

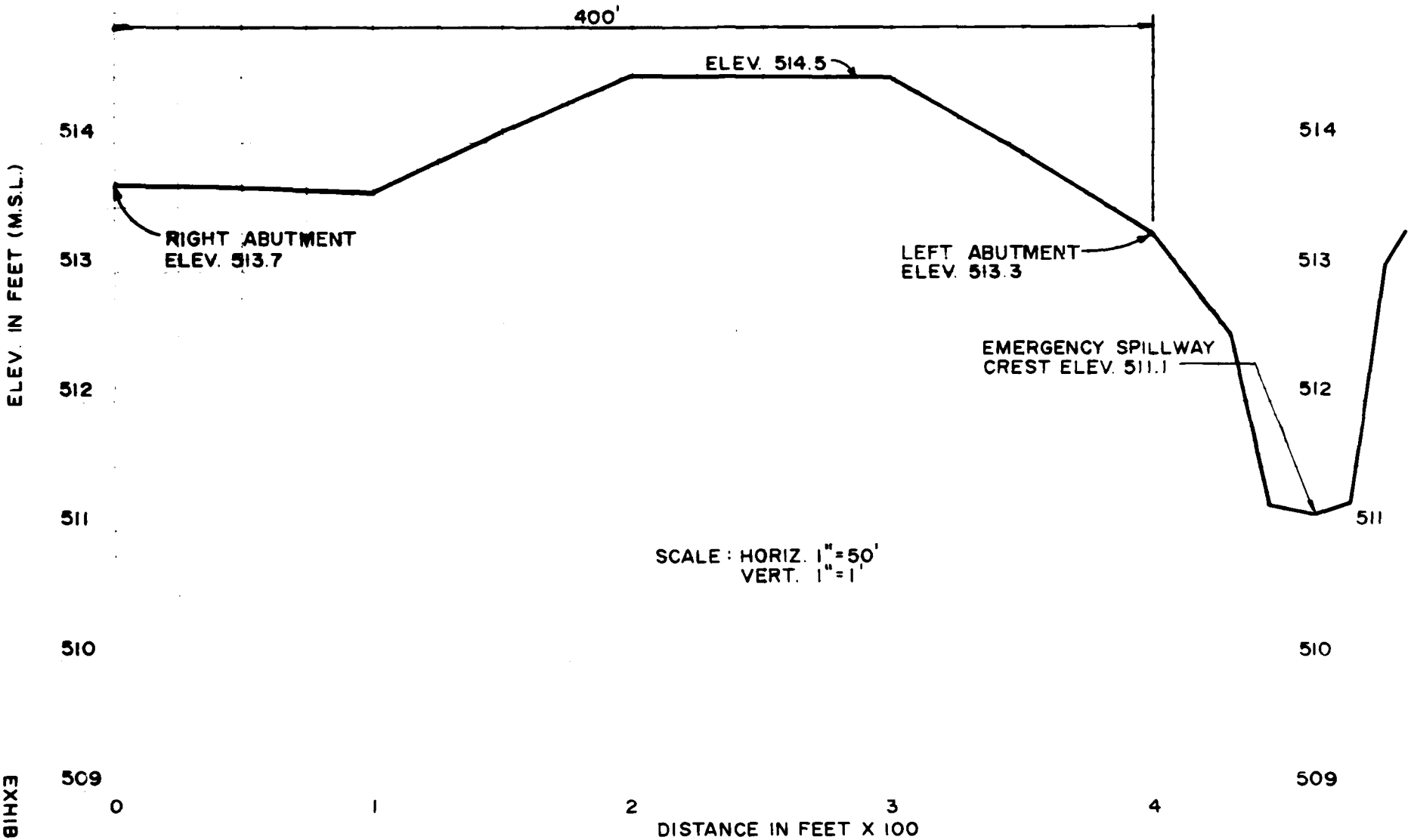
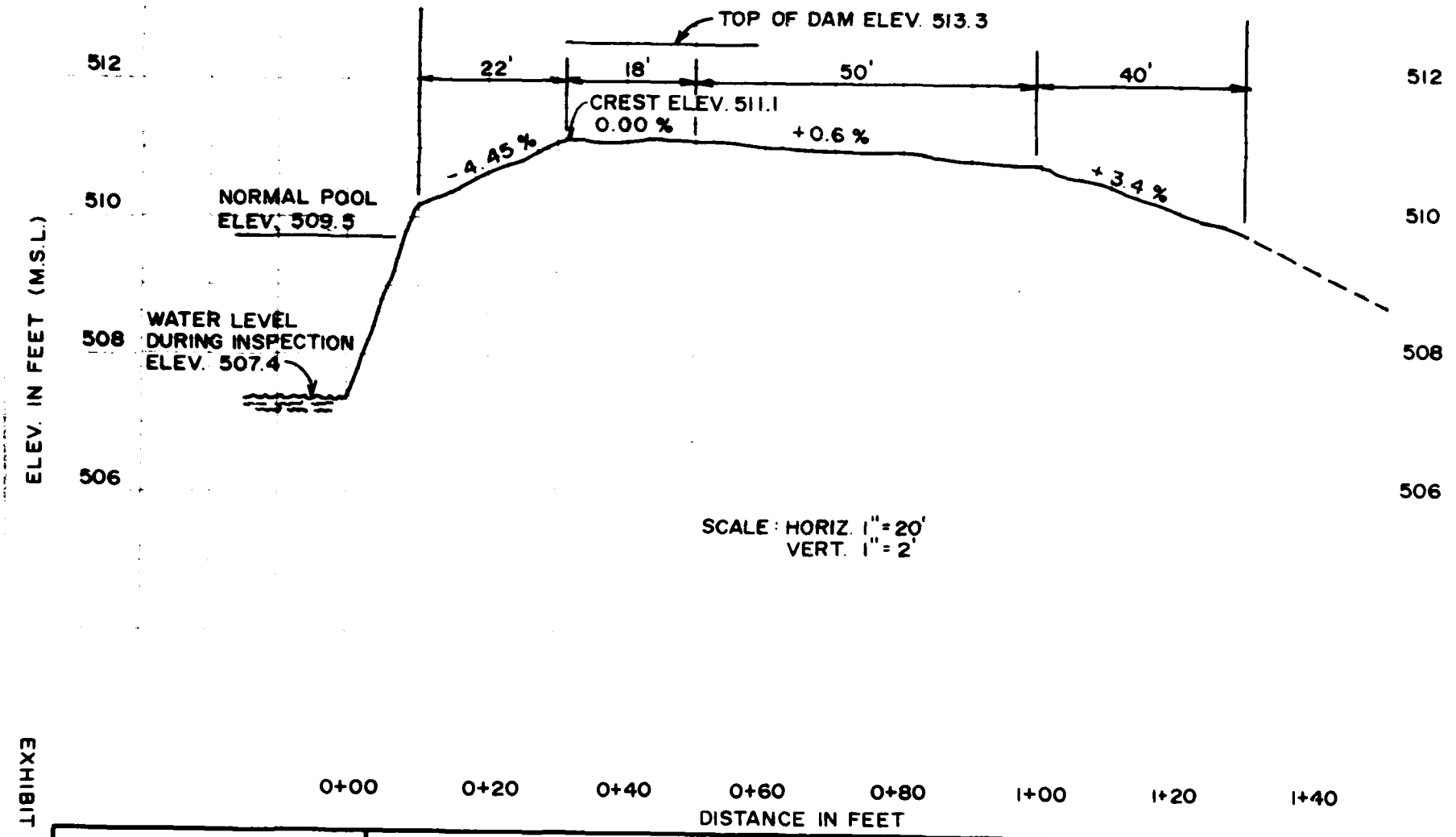


EXHIBIT 3

CRAWFORD, MURPHY & TILLY, Inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	PROFILE ALONG CREST OF DAM SPRING LAKE DAM MO31180



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CRAWFORD, MURPHY & TILLY, Inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	℄ PROFILE – EMERGENCY SPILLWAY SPRING LAKE DAM MO31180

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100A1 HYDROLOGIC AND HYDRAULIC ANALYSIS  SPRING LAKE (MO 31180), CAPE GIRARDEAU CO.
110A2 NATIONAL DAM SAFETY PROGRAM    CORPS OF ENGINEERS, ST. LOUIS DISTRICT
120A3 CMWT JOB NO.
130B    288       0       5                                                  2
140R1     5
150J      1       9       1
160J1   .10     .20     .25     .30     .35     .40     .50     .75     1.0
170K      0  INFLOW
180K1 INFLOW HYDROGRAPH COMPUTATION
190M      1       1     .11                       1                         1
200P      0    26.5     102     120    -130
210T                                                   -1     -90
220W   .157     .66
230X      0      .1    1.75
240R      1    LAKE
250K1 RESERVOIR ROUTING BY MODIFIED PULS METHOD
260Y                                1       1
270Y1     1                                          -509.5       1
280Y4 509.5   511.1   511.5   512.0   512.5   513.3   514.0   515.0
290Y5     0     6.5      15      28      85     267     595     940
300$A     0     3.3     8.6     9.7    10.2    11.2    11.8    12.3    16.2
310$L   490     500   509.5   511.1     512   513.3     514     515     520
320$$ 509.5
330$D 513.3     2.6     1.5     400
340$L     0      25     143     200     241     400
350$V 513.3   513.6   513.7     514   514.2   514.5
360K     99
370A
380
390
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U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

HEC-1 INPUT DATA
SPRING LAKE DAM MO31180

EXHIBIT 5

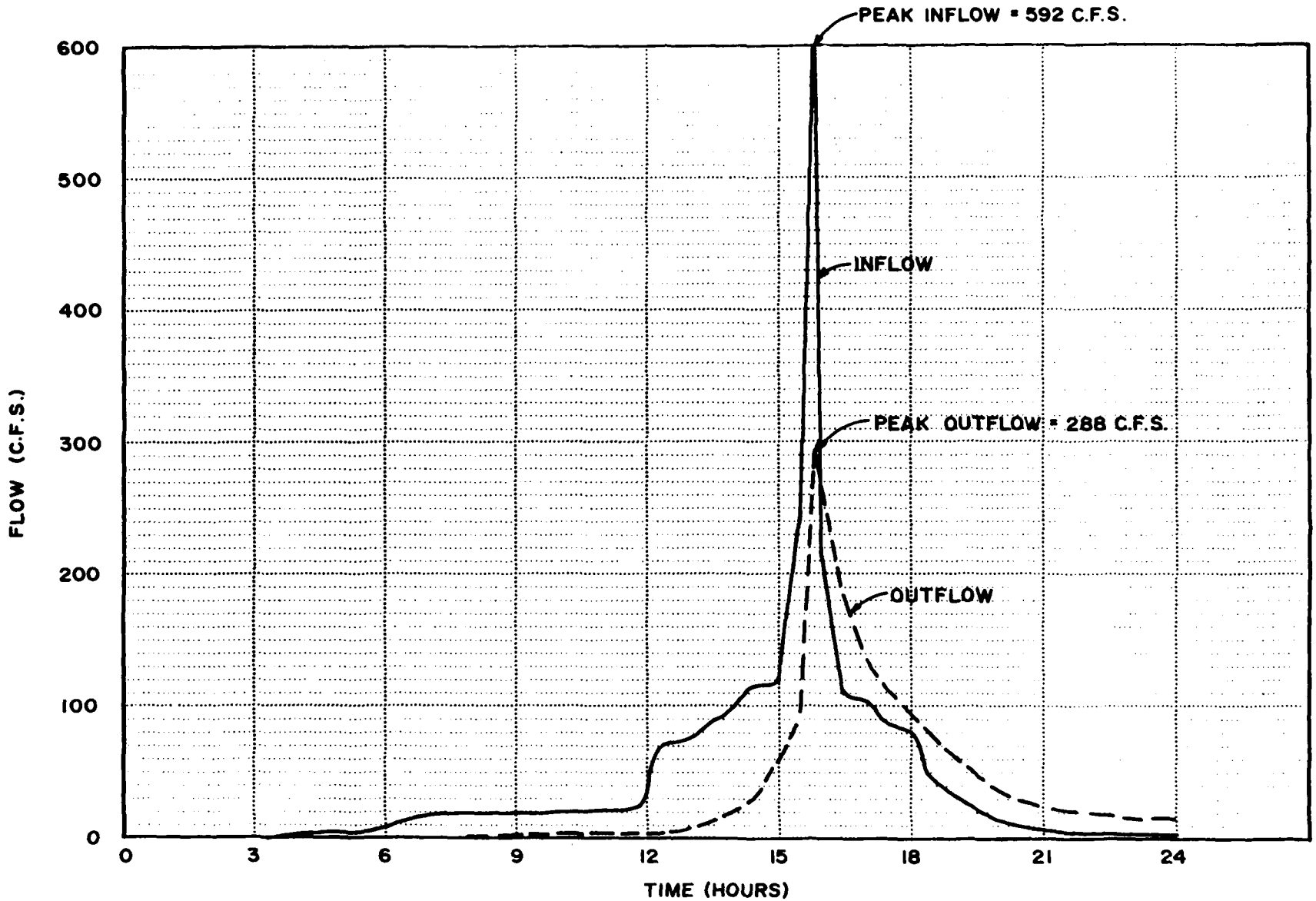
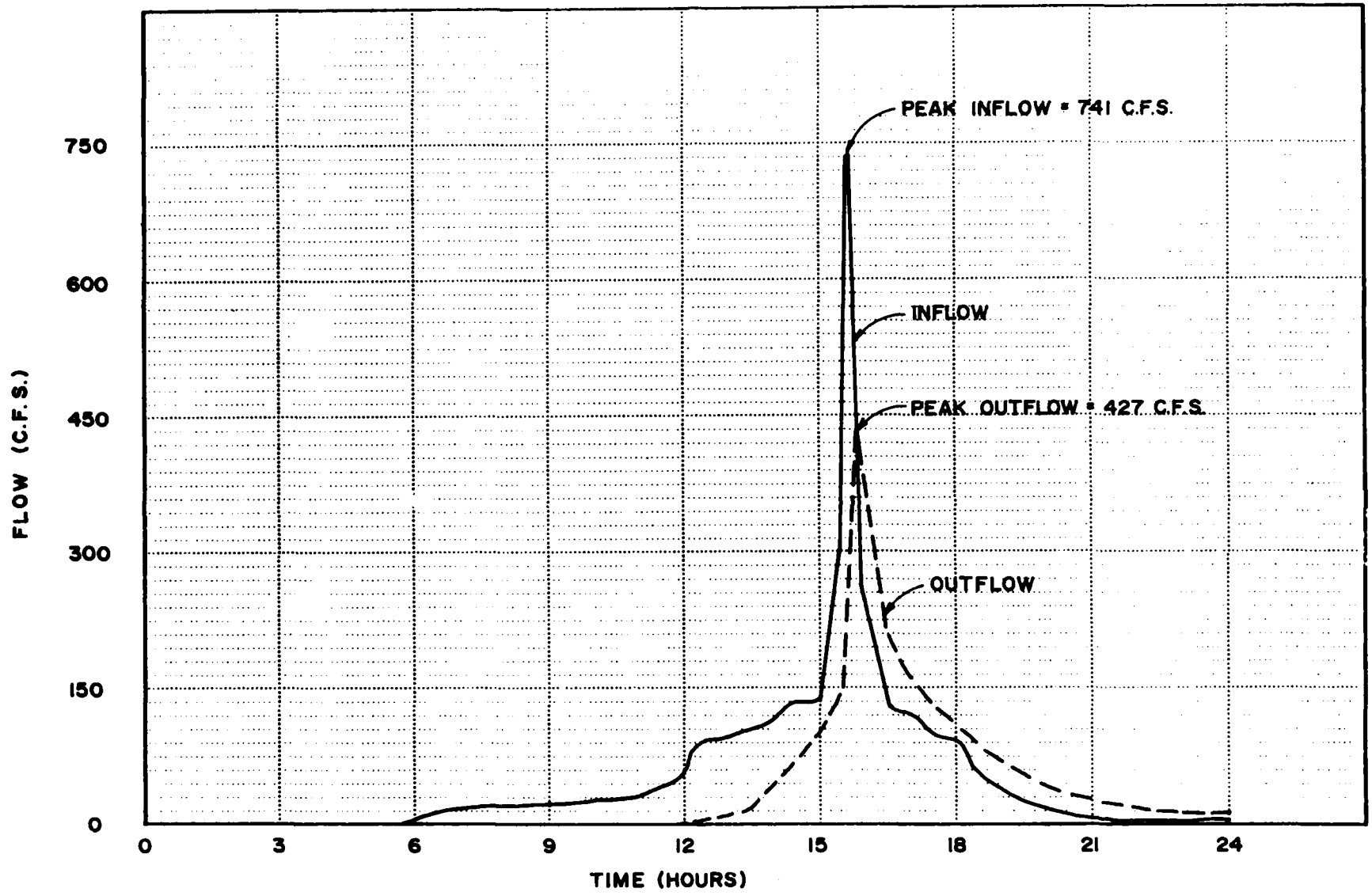


EXHIBIT 6

CRAWFORD, MURPHY & TILLY, Inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	INFLOW AND OUTFLOW HYDROGRAPHS--40% PMF SPRING LAKE DAM MO31180



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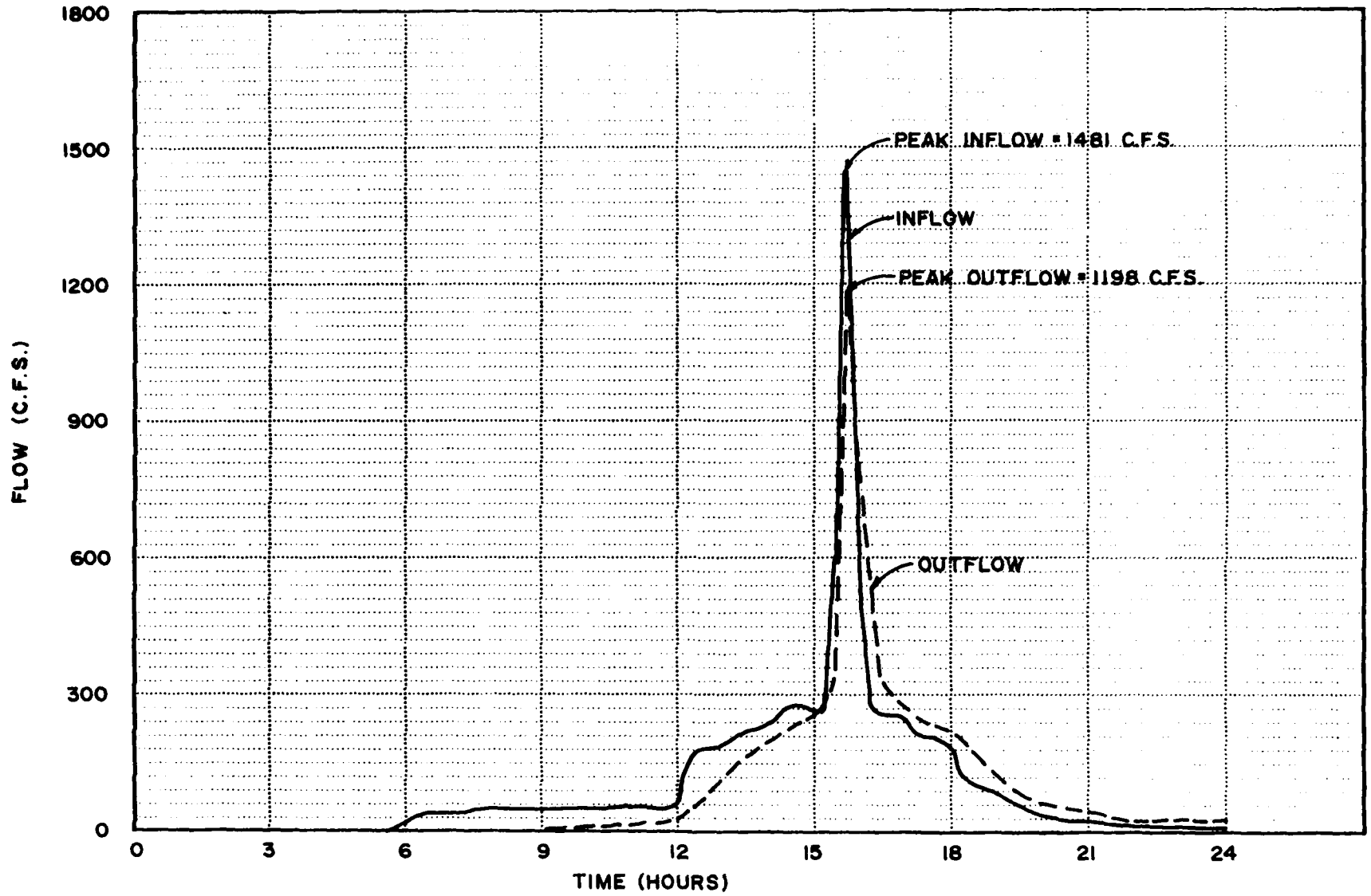
INFLOW AND OUTFLOW HYDROGRAPHS--50%PMF
SPRING LAKE DAM MO31180

EXHIBIT 7



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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 .10	RATIO 2 .20	RATIO 3 .25	RATIO 4 .30	RATIO 5 .35	RATIO 6 .40	RATIO 7 .50	RATIO 8 .75	RATIO 9 1.00
				RATIOS APPLIED TO FLOWS								
HYDROGRAPH AT	INFLOW	.11	1	148.	296.	370.	444.	518.	592.	741.	1111.	1481.
		(.28)	(	4.19)(	8.39)(	10.48)(	12.58)(	14.68)(	16.78)(	20.97)(	31.45)(	41.94)
ROUTED TO	LAKE	.11	1	10.	51.	100.	170.	228.	288.	427.	812.	1198.
		(.28)	(	.27)(	1.44)(	2.82)(	4.81)(	6.45)(	8.16)(	12.09)(	22.98)(	33.92)

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	509.50	509.50	513.30
STORAGE	66.	66.	103.
OUTFLOW	0.	0.	267.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	511.24	0.00	82.	10.	0.00	18.83	0.00
.20	512.20	0.00	91.	51.	0.00	17.08	0.00
.25	512.56	0.00	95.	100.	0.00	16.08	0.00
.30	512.87	0.00	98.	170.	0.00	16.00	0.00
.35	513.13	0.00	101.	228.	0.00	15.92	0.00
.40	513.35	.05	104.	288.	.17	15.92	0.00
.50	513.63	.33	107.	427.	.58	15.92	0.00
.75	514.11	.81	112.	812.	1.00	15.83	0.00
1.00	514.44	1.14	116.	1198.	1.92	15.83	0.00

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
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NATIONAL DAM SAFETY PROGRAM

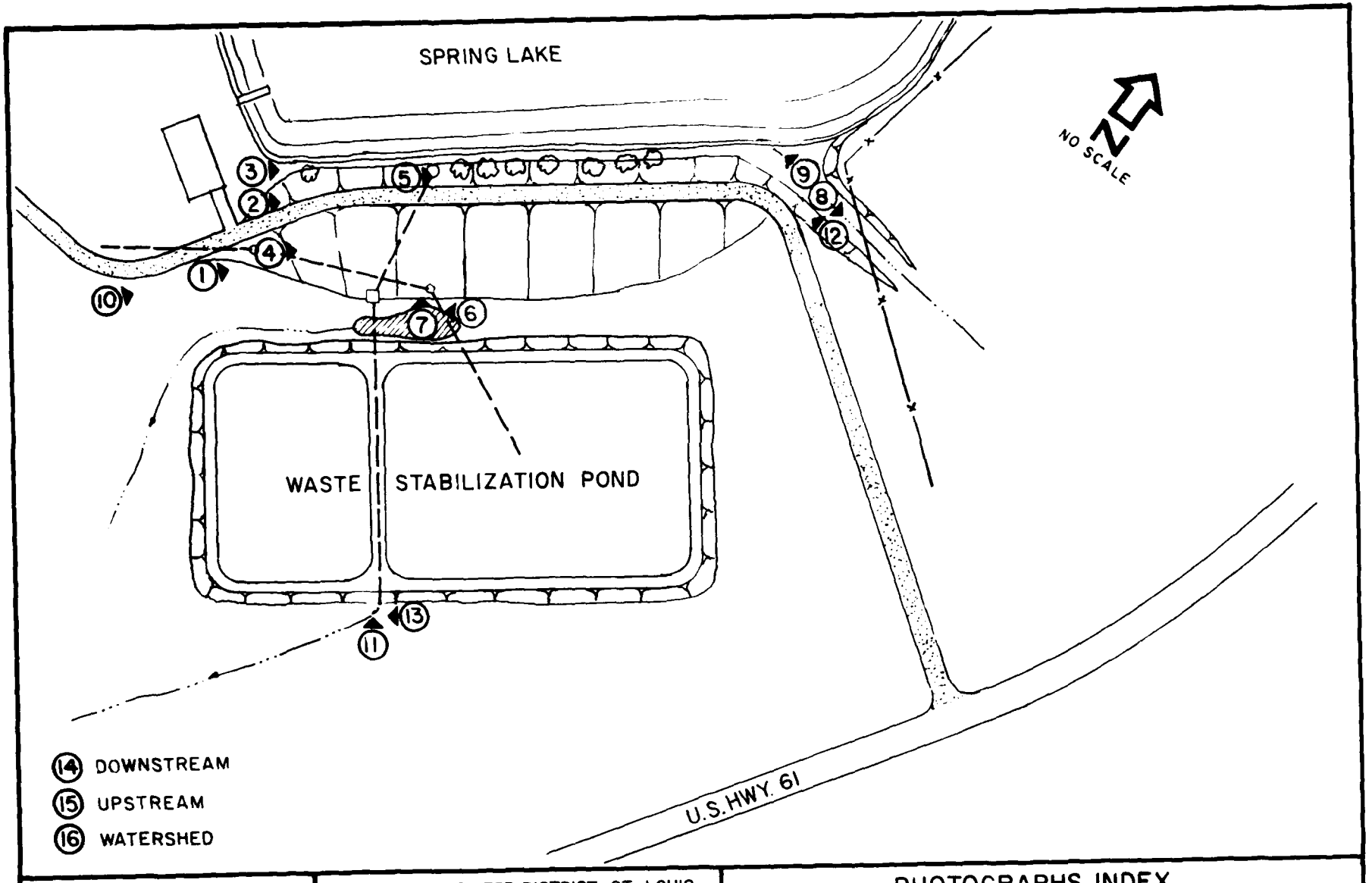
SUMMARY TABLE
SPRING LAKE DAM MO31180

EXHIBIT 9

PHASE I INSPECTION REPORT

APPENDIX C

PHOTOGRAPHS



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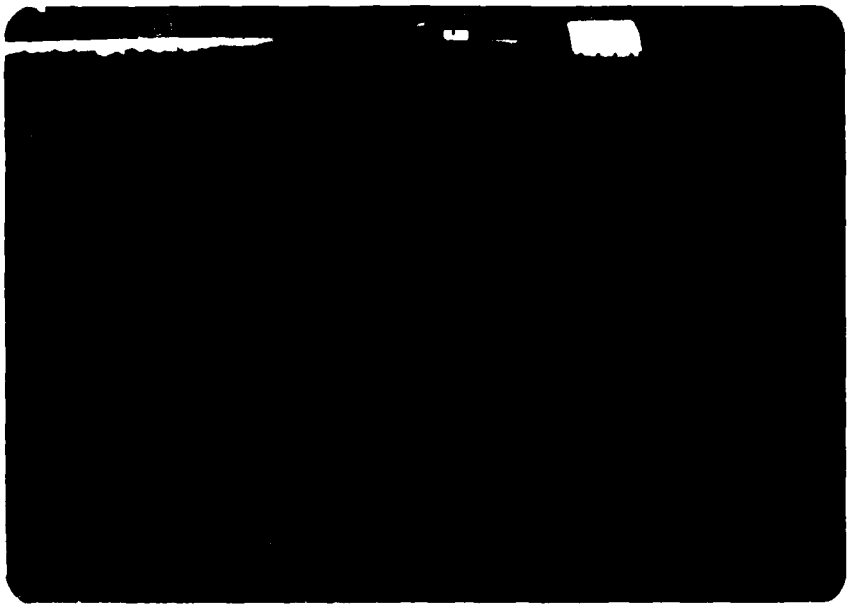
PHOTOGRAPHS INDEX
SPRING LAKE DAM MO 31180

Photograph 2. Crest of dam viewed from right abutment.

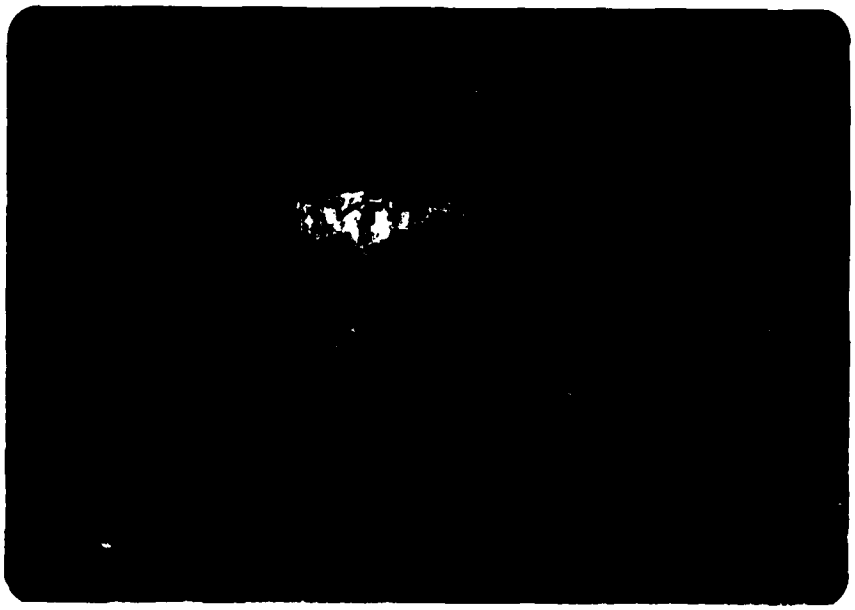
Photograph 3. Upstream face of dam viewed from right abutment.



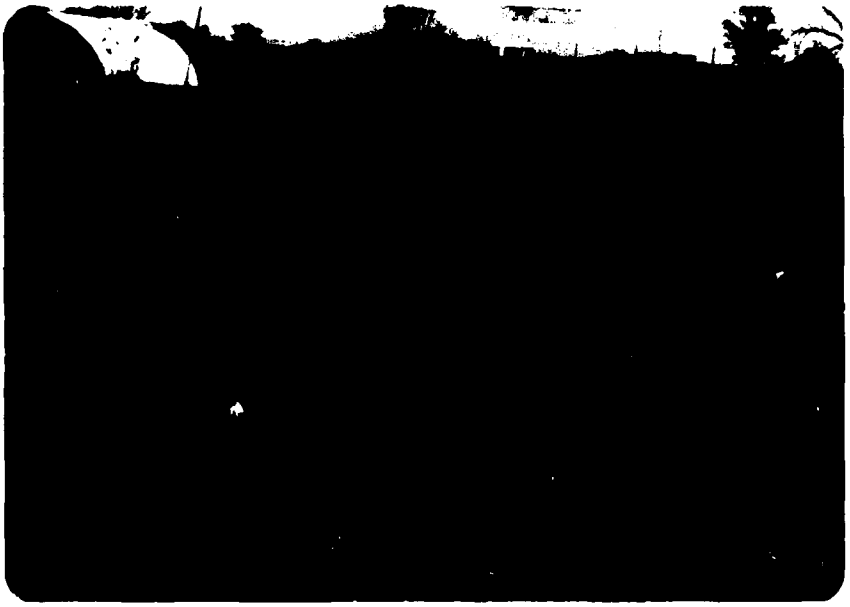
Photograph 4. Downstream face of dam viewed from right abutment.

Photograph 5. View of principal spillway intake structure.

Photograph 6. View of wet area and concrete box over principal spillway discharge conduit at toe of dam.

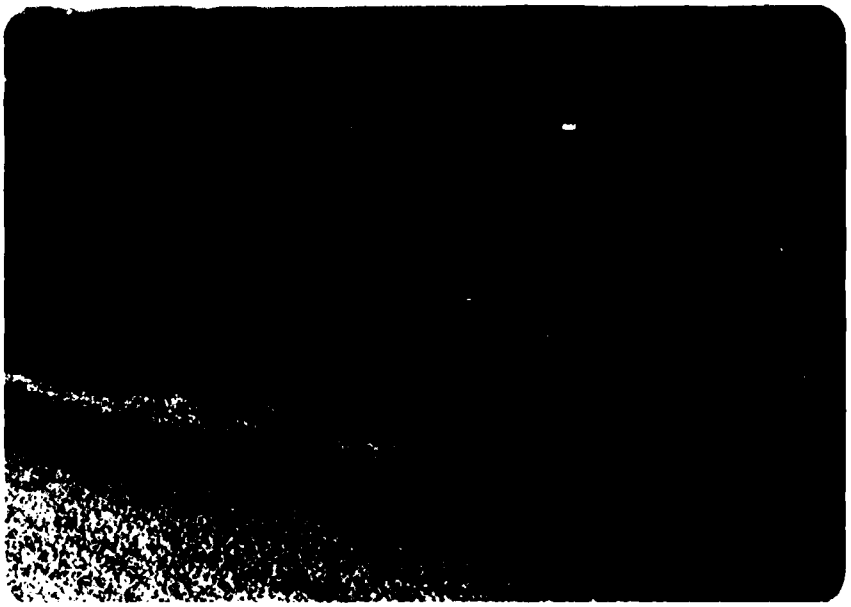


Photograph 7. View of sanitary sewer manhole near toe of dam (note evidence of overflow).



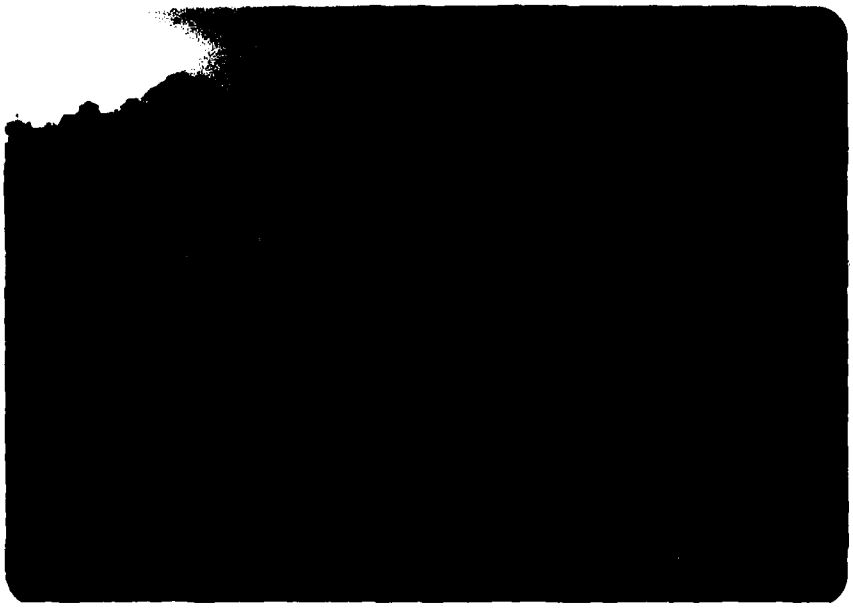
Photograph 8. Crest and downstream channel of emergency spillway viewed from approach channel.

Photograph 9. Approach channel to emergency spillway viewed from crest.

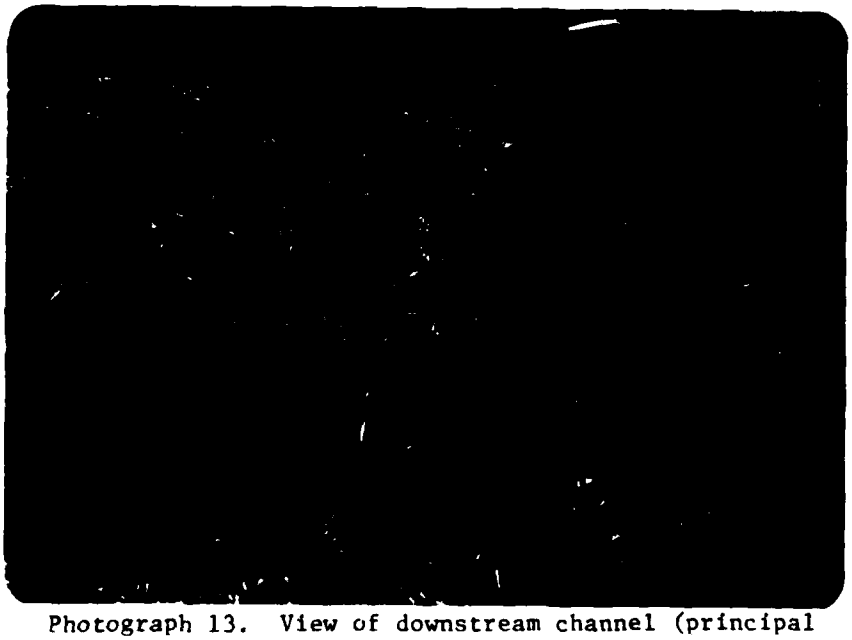


Photograph 10. Waste stabilization (sewage) ponds near downstream toe of dam viewed from right abutment.

Photograph 11. View of outlet end of principal spillway pipe (downstream of sewage ponds).

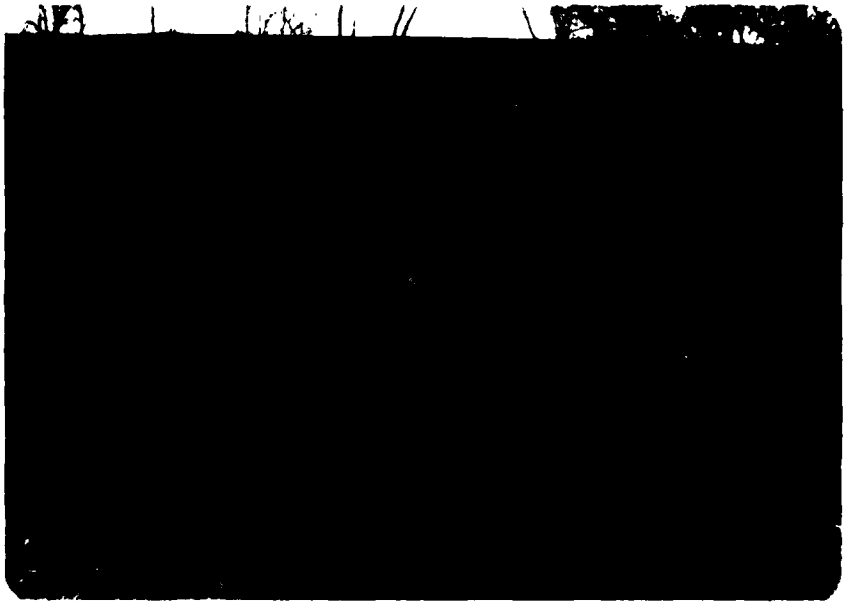


Photograph 12. View of lake from left abutment.

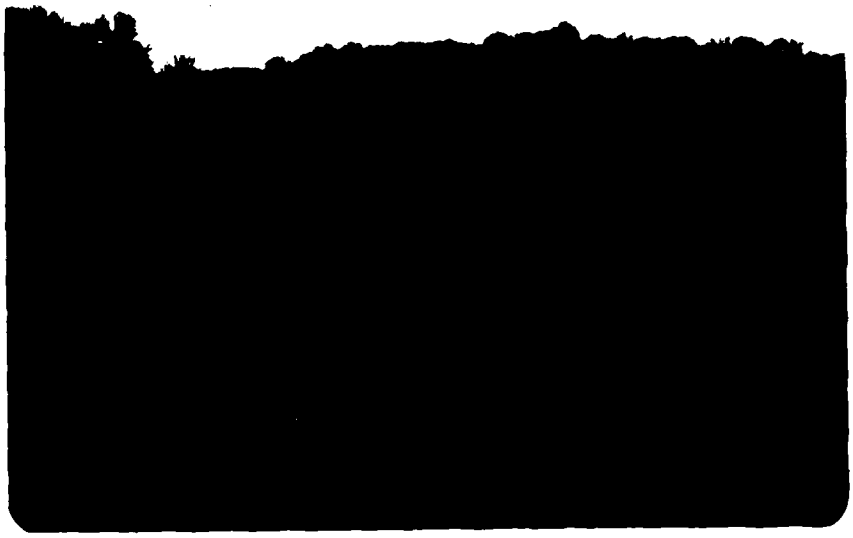


Photograph 13. View of downstream channel (principal spillway outlet is in lower right corner).

Photograph 14. Downstream channel showing residences near bank of stream.



Photograph 15. Small farm pond located in watershed upstream of dam.



Photograph 16. Typical view of watershed area.

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