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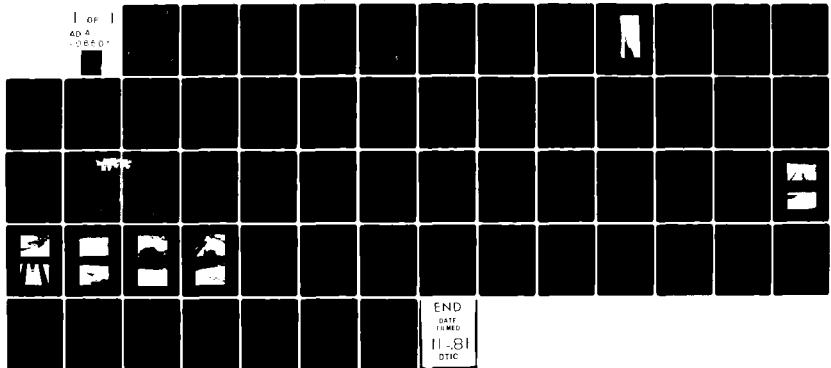
BLACK AND VEATCH KANSAS CITY MO  
NATIONAL DAM SAFETY PROGRAM, RAY COUNTY DAM NUMBER C-1 (MO 1023--ETC(U))  
MAY 79 P R ZAMAN, E R BURTON, H L CALLAHAN DACW43-79-C-0040

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**LEVEL II**

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**MISSOURI-KANSAS CITY BASIN**

**AD A106507**

**RAY COUNTY DAM NO. C-1**

**RAY COUNTY, MISSOURI**

**MO 10239**

**PHASE 1 INSPECTION REPORT  
NATIONAL DAM SAFETY INSPECTION**

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

**FOR: STATE OF MISSOURI**

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**MAY 1979**

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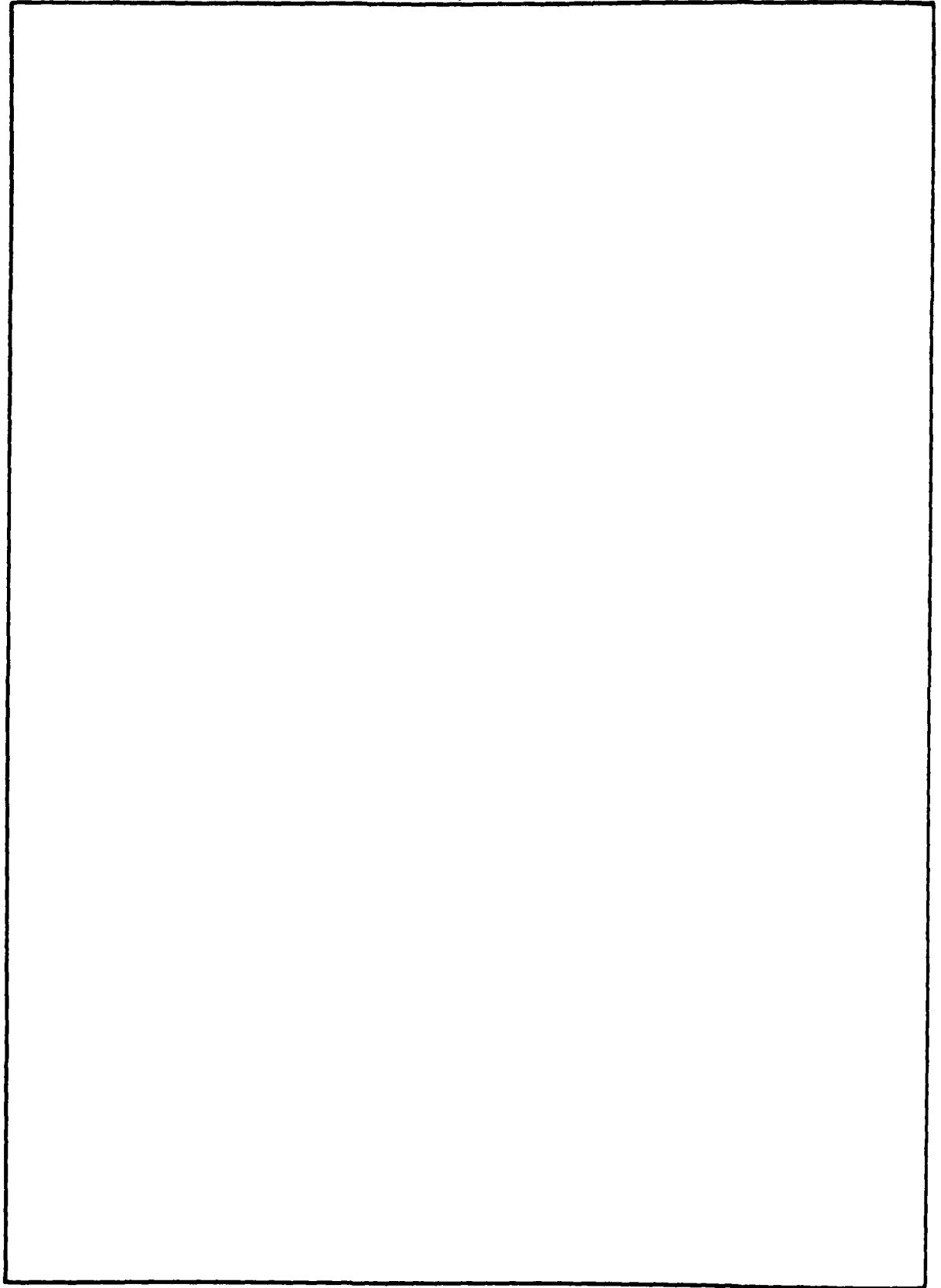
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)



SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

# MISSOURI-KANSAS CITY BASIN

RAY COUNTY DAM NO. C-1

RAY COUNTY, MISSOURI

MO 10239

## PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY INSPECTION



**United States Army  
Corps of Engineers**

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... Serving the Nation*

### **St. Louis District**

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

FOR: STATE OF MISSOURI

MAY 1979



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

REPLY TO  
 ATTENTION OF

SUBJECT: Ray County Dam No. C-1 No. I.D. No. 10239  
 Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Ray County Dam No. C-1:

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

14 JAN 1980  
 Date

APPROVED BY: SIGNED  
 Colonel, CE, District Engineer

14 JAN 1980  
 Date

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RAY COUNTY DAM NO. C-1

RAY COUNTY, MISSOURI

MISSOURI INVENTORY NO. 10239

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH  
CONSULTING ENGINEERS  
KANSAS CITY, MISSOURI

UNDER DIRECTION OF  
ST. LOUIS DISTRICT CORPS OF ENGINEERS  
FOR  
GOVERNOR OF MISSOURI

MAY 1979

PHASE I REPORT  
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Ray County Dam No. C-1
State Located	Missouri
County Located	Ray County
Stream	Tributary to Willow Creek
Date of Inspection	17 May 1979

Ray County Dam No. C-1 was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten the life and property of approximately six families downstream of the dam and would potentially cause damage to two roads and a water treatment plant within the estimated damage zone which extends approximately two miles downstream of the dam.

Our inspection and evaluation indicates the spillway meets the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will pass neither 50 nor 100 percent of the probable maximum flood without overtopping, but will pass 30 percent of the probable maximum flood and the 100-year flood. The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. Considering the volume of water impounded and the downstream hazard, the appropriate spillway design flood is 50 percent of the probable maximum flood.

Deficiencies visually observed by the inspection team were animal burrows in the embankment, damage to grass cover on dam by livestock paths and vehicular traffic, and erosion of emergency spillway. Seepage and stability analyses conforming to the guidelines were not available.



There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. A detailed report discussing each of these deficiencies is attached.

*Paul R. Zaman*

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Paul R. Zaman, PE  
Illinois 62-29261

*Edwin R. Burton*

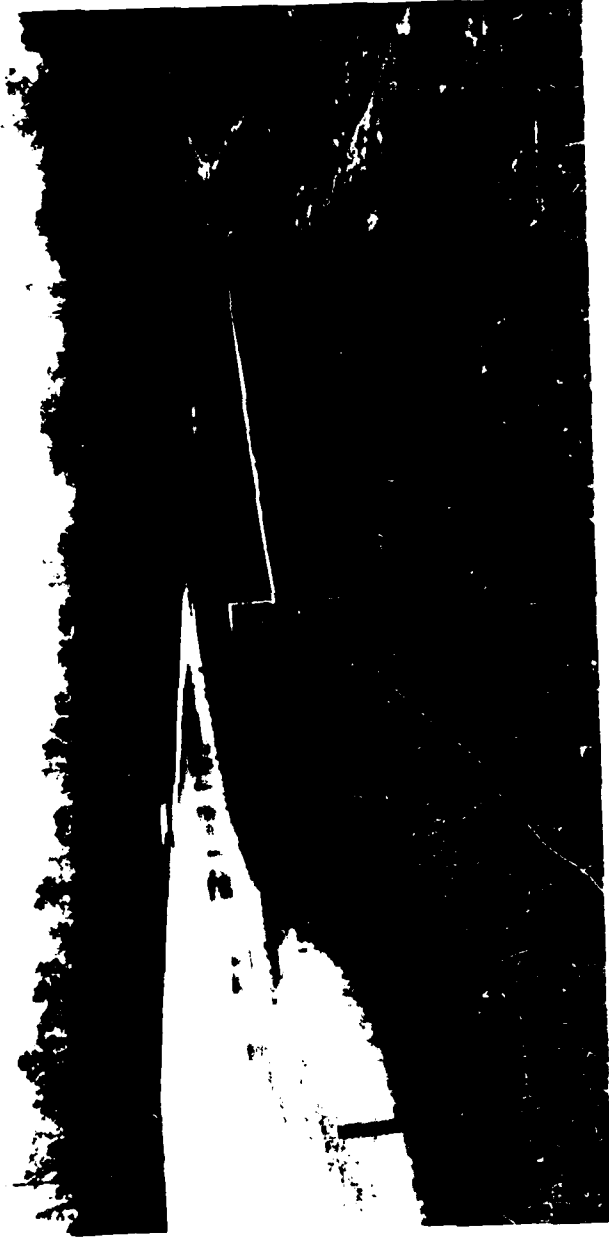
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Edwin R. Burton, PE  
Missouri E-10137

*Harry L. Callahan*

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Harry L. Callahan, Partner  
Black & Veatch



OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM  
RAY COUNTY DAM NO. C-1

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Appendix A - Hydrologic Computations

## 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 District Engineer of the St. Louis District, Corps of Engineers directed that a safety inspection of the Ray County Dam No. C-1 be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and 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, in "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.

(1) The Ray County Dam No. C-1, hereafter referred to in this report as Dam No. C-1, is a recently constructed earthen structure located in south-central Ray County, Missouri on a tributary to Willow Creek. This structure was designed by the Soil Conservation Service and was constructed under their supervision. The principal purpose for this dam is flood control. Dam No. C-1 is an integral part of the Willow Creek Watershed Plan and is located on property owned by Mr. Henry Hughes of Richmond, Missouri. The dam is 12 feet wide at the crest, 620 feet long and 26 feet high. The dam has an emergency spillway located at the right abutment, and a principal spillway with drawdown capabilities located near the right-center of the structure.

(2) A grass-lined emergency spillway is located at the right abutment. It consists of a grass-lined approach channel and discharge channel. The spillway, approach and discharge channels have trapezoidal cross-sections. The spillway is separated from the dam structure by a protective berm.

(3) A principal spillway consisting of a drop inlet with trash rack, 30-inch discharge pipe, and a 10-inch valved drawdown pipe has been

provided at this dam. The outlet for the 30-inch pipe discharges into a natural scour plunge pool of the natural channel of the tributary of Willow Creek.

(4) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in south-central Ray County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Richmond, Missouri in Sections 5 and 6 of T51N, R27W and Sections 31 and 32 of T52N, R27W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Ray County Dam No. C-1 has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For Dam No. C-1 the flood damage zone extends approximately two miles downstream of the dam. Within the damage zone are six homes, farm buildings, two roads and a water treatment plant.

e. Ownership. The dam is owned and maintained by the Willow Creek Watershed Subdistrict, P.O.Box 380, Richmond, Missouri 64085. The structure is located on property owned by Mr. Henry Hughes, Route 2, Richmond, Missouri 64085.

f. Purpose of Dam. The dam forms a 13-acre flood control lake.

g. Design and Construction History. Data relating to the design and construction were made available by the Soil Conservation Service, Columbia, Missouri.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, and evaporation all combine to maintain a relatively stable water surface elevation.

i. Maintenance. The Willow Creek Watershed Subdistrict, Box 380, Richmond, Missouri 64085 is the group responsible for maintenance at this dam.

### 1.3 PERTINENT DATA

a. Drainage Area - 774 acres.

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled principal spillway.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated ungated spillway capacity at maximum pool elevation - 4,100 cfs at probable maximum flood pool El.751.9.

c. Elevation (Feet above m.s.l.).

(1) Top of dam - 749.0 (see Plate 3)

(2) Principal spillway crest - 738.0 (see Plate 5)

(3) Emergency spillway crest - 744.5 (see Plate 5)

(4) Streambed at toe of dam - 723.0 ± (from SCS design drawings)

(5) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 3,800 feet ± (provided by SCS)

(2) Length of normal pool - 2,300 feet ± (provided by SCS)

e. Storage (Acre-feet).

(1) Top of dam - 405 (from "As Built" drawings)

(2) Emergency spillway crest - 197 (from "As Built" drawings)

(3) Principal spillway crest - 65 (from "As Built" drawings)

f. Reservoir Surface (Acres).

(1) Top of dam - 44 (provided by SCS)

(2) Emergency spillway crest - 29.7 (provided by SCS)

(3) Principal spillway crest - 13 (provided by SCS)

- g. Dam.
- (1) Type - Earth embankment
  - (2) Length - 620 feet
  - (3) Height - 26 feet  $\pm$
  - (4) Top width - 12 feet
  - (5) Side slopes - upstream face 1 V on 2.8 H, downstream face varies from 1 V on 3 H to 1 V on 2.4 H (see Plate 4)
  - (6) Zoning - None.
  - (7) Impervious core - None.
  - (8) Cutoff - Core trench, earthfill.
  - (9) Grout curtain - None.
- h. Diversion and Regulating Tunnel - None.
- i. Emergency Spillway.
- (1) Type - Broad-crested weir with trapezoidal cross-section.
  - (2) Bottom width of channel - 60 feet (from "As-Built" drawings).
  - (3) Channel side slopes - 1.0 V on 3.0 H (from "As-Built" drawings).
  - (4) Crest elevation - 744.5 feet m.s.l.
  - (5) Gates - None.
  - (6) Upstream channel - Not applicable.
  - (7) Downstream channel - Grass-lined, bermed channel and pasture near the toe of the downstream embankment slope.
- j. Principal Spillway.
- (1) Type - concrete box drop inlet
  - (2) Crest elevation - 738.0
  - (3) Gates - None.



(4) Upstream channel - None.

(5) Discharge pipe - 30-inch diameter reinforced concrete pipe.

(6) Downstream channel - Open channel comprised of limestone, clays, and silt.

k. Regulating Outlets - A 10-inch diameter rising stem slide gate controls discharge through a 10-inch diameter asbestos cement pipe (Inv. El 730.6). The gate is located in the drop inlet structure. Discharge through the gate proceeds into the base of the drop inlet, then out the 30-inch diameter reinforced concrete pipe beneath the embankment.

## SECTION 2 - ENGINEERING DATA

### 2.1 DESIGN

Design data available from the Soil Conservation Service included a report of the detailed geologic investigation of the dam site, Project Engineer's Recommendations, and memorandum of laboratory test results.

### 2.2 CONSTRUCTION

"As-built" construction drawings dated 10-4-72 were provided by the SCS for the dam and spillways. The owner advised that the dam was constructed in 1971.

### 2.3 OPERATION

The maximum recorded loading on the dam is unknown.

### 2.4 GEOLOGY

The dam is located across a broad shallow valley that was formed by an intermittent tributary of Willow Creek. The soil of the dam and reservoir area consists of the Knox and Marshall Silt Loam soil series, respectively, consisting of clayey silt and silty clay developed from loess. Alluvial soil is present along the stream channels and consists of silty clay. For engineering purposes the soils are classified as clayey silt (ML) and silty clay (CL). The bedrock of the area consists of shale and limestone of the Marmaton Group of the Pennsylvanian System.

The foundation of the dam is on alluvial silty clay (CL) overlying shale bedrock. The depth to the bedrock is approximately 15 feet. According to the "as-built" drawings the silt soils (ML) were removed from the core trench area. Both the right and left abutments consist of silty clay (CL) soil derived from loess overlying shale bedrock. The emergency spillway is cut through clayey silts (ML) derived from loess overlying alluvial silty clay (CL) soils.

### 2.5 EVALUATION

a. Availability. Engineering data available for review included the summary report of the detailed geologic investigation of the dam site and classification tests performed on seven samples obtained from site borings. "As-built" construction drawings of the dam and spillways were also available.

b. Adequacy. Limited engineering data were available from which to make an assessment of the design of the dam.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions and made a matter of record.

The "as-built" construction drawings adequately described the construction details.

c. Validity. The summary report of the detailed geologic investigation of the dam site adequately represents site condition as observed during the inspection. The "as-built" construction drawings are valid for the dam and spillways.

## SECTION 3 - VISUAL INSPECTION

### 3.1 FINDINGS

a. General. A visual inspection of Dam No. C-1 was made on 17 May 1979. The inspection team included professional engineers with experience in dam design and construction, hydrology, hydraulic engineering, and geotechnical engineering. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following items at the dam. The embankment slopes are protected by a grass cover except where occasional livestock paths have developed. No erosion was observed on either the upstream or downstream slope. No erosion was evident at the water contact with embankment or reservoir shore areas. This structure does not have riprap protection.

The presence of silty clay soil in the surface of abutments and the embankment was confirmed by visual inspection. No outcrops of bedrock were observed in the area of the dam. Subsurface conditions were determined from "as-built" drawings of the dam.

A vehicular path was observed on the dam's crest. Some small animal burrows were found on the downstream face of the embankment. No evidence of settlement, sloughing, sinkholes, or cracking was observed.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The principal spillway inlet and discharge outlet were observed in good condition. No deterioration of the concrete nor underscouring of the outlet foundation were observed. An animal burrow was observed at the discharge culvert/embankment interface. A grass-lined emergency spillway that was constructed near the right abutment appears in good condition. The emergency spillway is acting as a broad-crested weir. The emergency spillway approach and discharge channels are adequately grass-lined with erosion observed on the approach channel. A protective dike constructed of CL materials is located along the left side of the emergency spillway channel to prevent erosion of the dam during spillway discharge.

d. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir.

e. Downstream Channel. The downstream channel is formed in alluvial silts and clays. No excessive erosion problems were observed in the channel.

### 3.2 EVALUATION

During the inspection there were observed four minor deficiencies which warrant attention. None of these deficiencies should be considered in an emergency category, although, in order to continue to maintain this dam in good to excellent condition they should be rectified.

a. Grazing of the dam by livestock has caused some paths to be developed. Although no erosion has presently developed along these livestock paths, it does provide a potential starting point for future erosion. Attention should be given to this possible problem area.

b. The crest has been used as a vehicle crossing and as such two paths have been formed. The paths are void of grass cover and are potential starting points for erosion. Careful monitoring of this condition is warranted.

c. Some small animal burrows were located on the downstream slope. Animal burrows can ultimately jeopardize the safety of an earthen structure if allowed to increase in number. Therefore, continual monitoring and repair is recommended at this time. In the event additional burrows are observed, a program designed to control burrowing animals should be implemented and corrective action taken for repairing damages.

d. A small erosion gully was observed in the approach channel of the emergency spillway.

## SECTION 4 - OPERATIONAL PROCEDURES

### 4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, evaporation, transpiration, and capacity of the uncontrolled principal spillway.

### 4.2 MAINTENANCE OF DAM

Under terms of the Soil Conservation Service Watershed program for Willow Creek, Ray County, Missouri maintenance for Dam No. C-1 is the responsibility of the Willow Creek Watershed Subdistrict, Richmond, Missouri.

Maintenance which may have been performed is unknown.

### 4.3 MAINTENANCE OF OPERATING FACILITIES

Maintenance performed on the slide gate is unknown. The gate appears to be in good condition.

### 4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing system or preplanned scheme for warning occupants of the hazard zone below this dam.

### 4.5 EVALUATION

Although the maintenance program is unknown, the facility is in good condition for a structure of this type. Corrective measures suggested elsewhere in this report should be implemented to keep this dam in its visibly good condition.

## SECTION 5 - HYDRAULIC/HYDROLOGIC

### 5.1 EVALUATION OF FEATURES

a. Design Data. Limited design data pertaining to hydrology and hydraulics were available from the Soil Conservation Service. Independent calculations were, however, performed for the report in accordance with the referenced guidelines.

b. Experience Data. The drainage area and lake surface area are developed from the USGS Richmond, Missouri Quadrangle Map. The spillway and dam layouts are from surveys made during the inspection and available design documents.

c. Visual Observations.

(1) The emergency and principal spillways are in generally good condition. Discharge channels for both spillways are also in good condition.

(2) Facilities are available that could serve to draw down the pool. A 10-inch diameter asbestos cement pipe (Inv. El. 730.6) with gate valve at the upstream portion of the drop inlet may be used to draw down the pool. The valve was locked and not operated at the time of inspection.

(3) An emergency spillway with a grass-lined discharge channel is located near the right abutment. Discharges from this appurtenance are unlikely to endanger the integrity of this dam. The dam is adequately protected from emergency discharges through the emergency spillway and channel by a grass-covered berm.

(4) A principal spillway with discharge pipe is located at center-right of the dam.

d. Overtopping Potential. The emergency and principal spillways discharging simultaneously will not pass the probable maximum flood, without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillways will pass 30 percent of the probable maximum flood and the 100-year flood without overtopping the dam. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the volume of water impounded and the characteristics of the downstream hazard zone 50 percent of the probable maximum flood is the appropriate spillway design flood. The portion of the estimated peak discharge of

the probable maximum flood overtopping the dam would be 4,200 cfs of the total discharge from the reservoir of 8,300 cfs. The estimated duration of overtopping is 4.5 hours with a maximum height of about 2.9 feet over the dam.

The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 730 cfs of the total discharge from the reservoir of 3,300 cfs. The estimated duration of overtopping is 1.5 hours with a maximum height of about 1.2 feet over the dam.

There was no evidence observed during the inspection which would indicate that this structure has been overtopped. Soils typical of this structure's surfaces tend to erode. Should the embankment be subjected to prolonged overtopping it is believed that erosion would occur and could lead to failure.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately two miles downstream of the dam. There are six homes, farm buildings, and two road crossings downstream of the dam which could be severely damaged and lives could be lost should failure of the dam occur. A water treatment plant is located about 1.4 miles downstream of this structure which could conceivably be damaged in the event of a dam failure under the probable maximum precipitation flood conditions.



## SECTION 6 - STRUCTURAL STABILITY

### 6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.lb.

b. Design and Construction Data. Available design data included the Project Engineer's Recommendations, summary report of the geologic investigation and soil classification tests.

Available construction data included "as-built" construction drawings.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions and made a matter of record.

Based upon material classification and soil boring data, it is anticipated that the stability of the dam exceeds the suggested factors of safety as given in Table 4 of the Guidelines. The slopes of the dam are consistent with recommended slopes for small homogeneous earthfill dams on stable foundations as given in the USBR "Design of Small Dams".

c. Operating Records. No operational records were available for review by the inspection team.

d. Post Construction Changes. No known post construction changes exist.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone.

Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines. It is the opinion of the reviewers that an earthquake consistent with Seismic Zone 1 intensities will not cause serious structural damage to this dam.

## SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

### 7.1 DAM ASSESSMENT

a. Safety. Several items noted during the visual inspection by the inspection team which should be monitored or controlled are animal burrows in the embankment, destruction of grass cover on the embankment by vehicular traffic and livestock path development which could lead to future erosion, and erosion of the approach channel of the emergency spillway. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. The conclusions in this report are based on performance history, visual conditions, and the available engineering design data. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. It is the opinion of the inspection team that a program should be developed to implement remedial measures recommended in paragraph 7.2b. If the safety deficiencies listed in paragraph 7.1a are not corrected, they will continue to deteriorate and lead to a serious potential of failure.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam nor does it identify any serious dangers that would require a Phase II investigation.

e. Seismic Stability. This dam is located in Seismic Zone 1. Embankment and foundation strength parameters and stability analyses to assess the seismic stability of this embankment were not available. An assessment of the seismic stability should be included as part of the recommended stability analysis and made a matter of record.

It is the opinion of the reviewers that an earthquake consistent with Seismic Zone 1 intensities will not cause serious structural damage to this dam.

### 7.2 REMEDIAL MEASURES

a. Alternatives. The present spillway has the capacity to pass 30 percent of the probable maximum flood without overtopping the dam. In order to pass 50 to 100 percent of the probable maximum flood as required by the Recommended Guidelines, the spillway size and/or height of dam would need to be increased.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended:

(1) Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of dams.

(2) Measures should be implemented to maintain control of burrowing animals. Existing burrows should be excavated, filled, and compacted under the guidance of a qualified engineer.

(3) Livestock grazing should be controlled on this structure. Monitoring of path development should be initiated. In the event erosion becomes extensive in this area, the erosion should be repaired and livestock be kept off the dam.

(4) Measures should be taken to control the erosion of the approach channel to the emergency spillway through the excavation, filling, and compacting of eroded areas and establishment of grass cover where sparse or non-existent. These repairs should be completed under the direction of a qualified engineer.

(5) A detailed inspection of the dam should be made periodically by an engineer experienced in design and construction of dams. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increases.

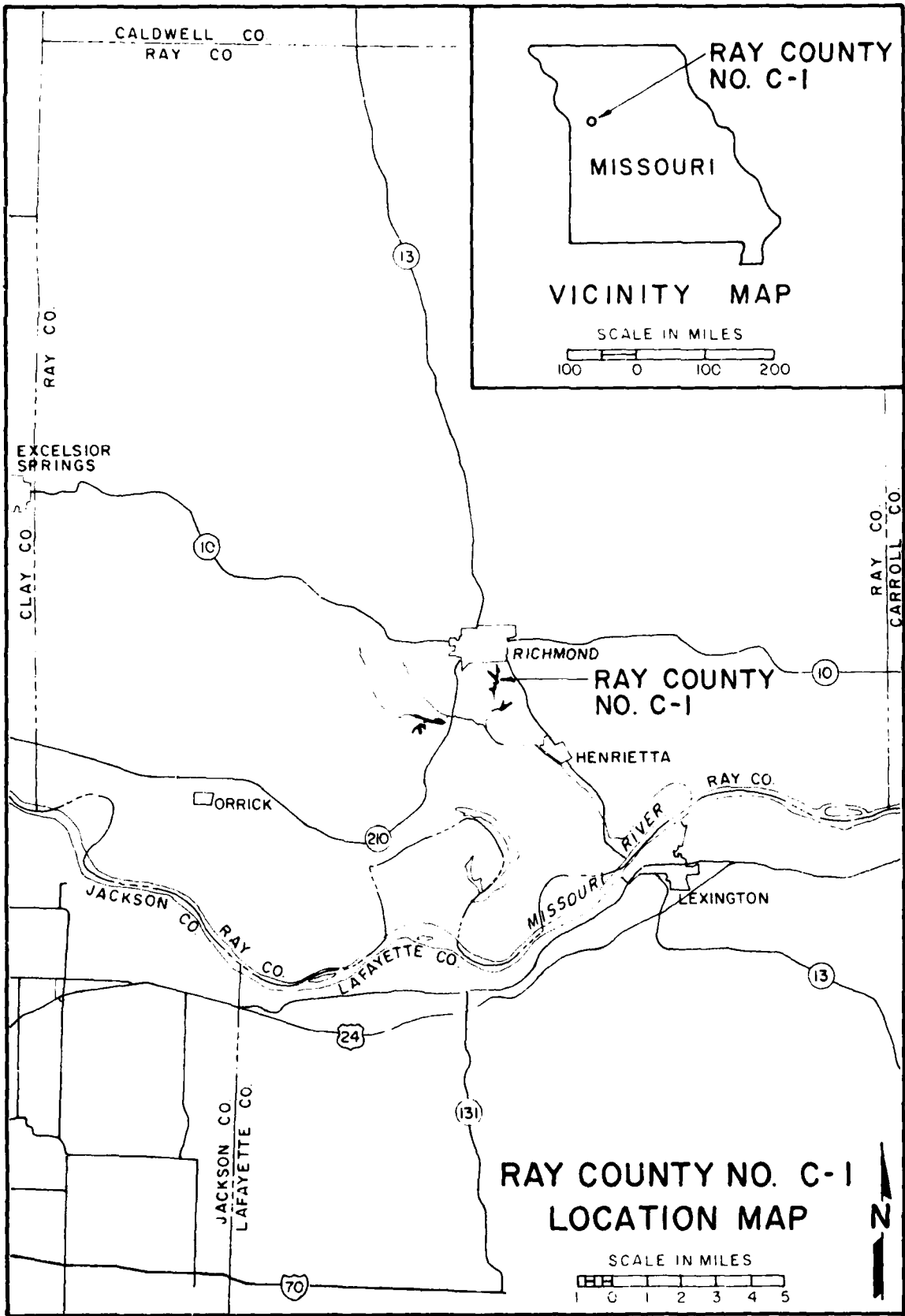
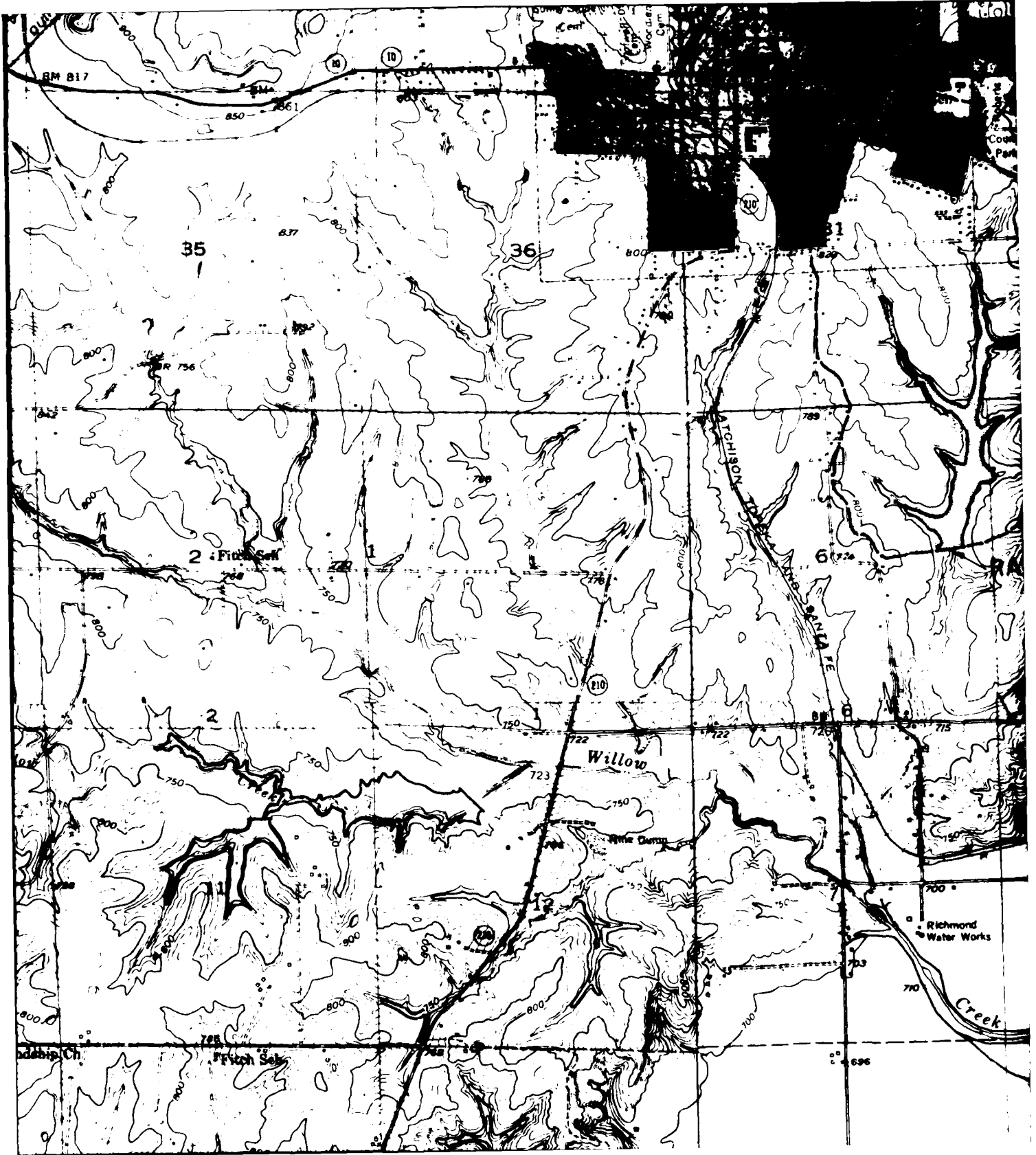
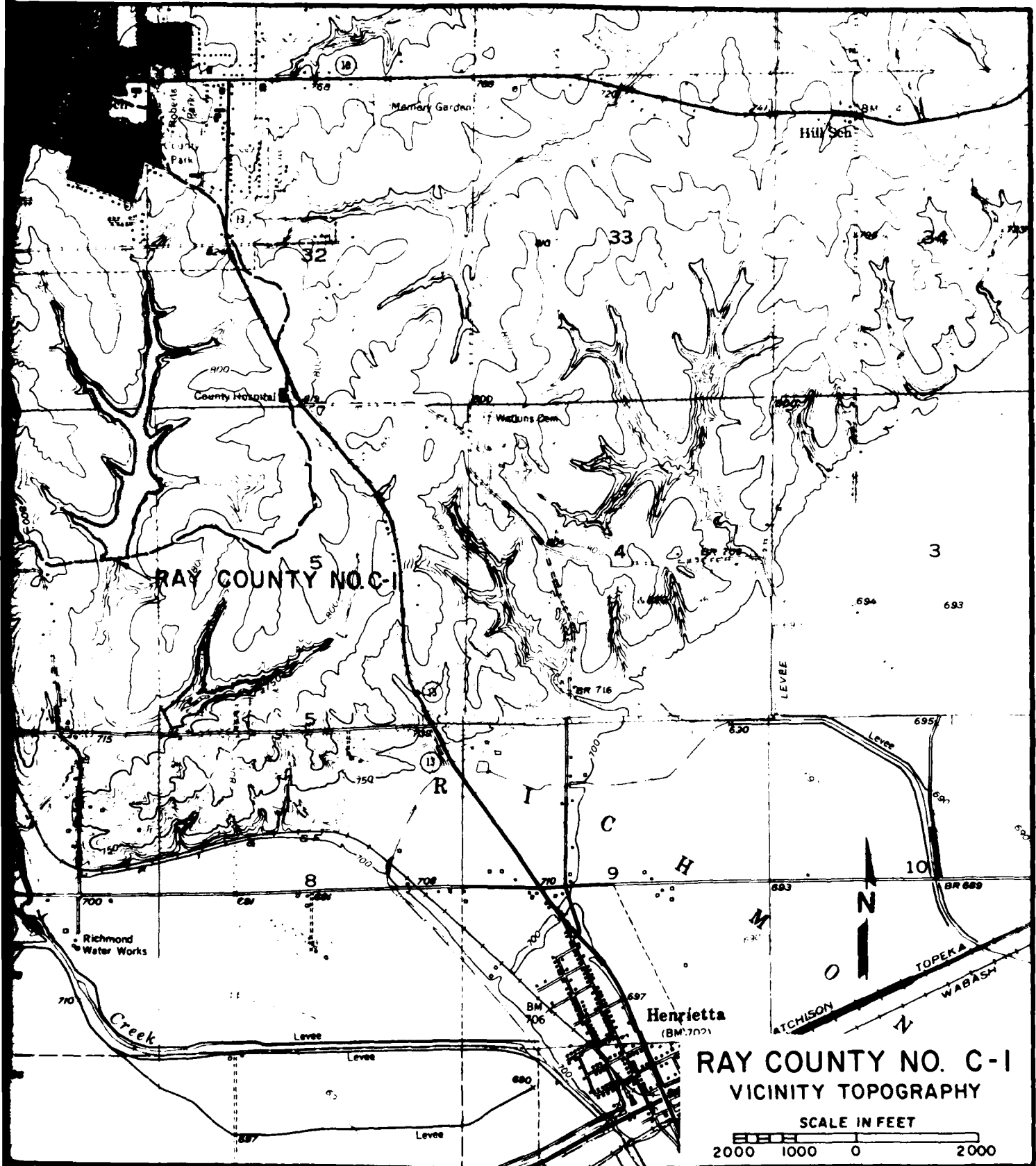


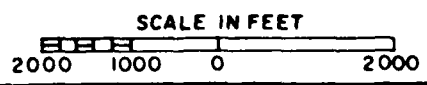
PLATE I





RAY COUNTY NO. C-1

RAY COUNTY NO. C-1  
VICINITY TOPOGRAPHY



6-27  
EL 749.9

5-00  
EL 752.3

4-00  
EL 753.6

3-00  
EL 750.1

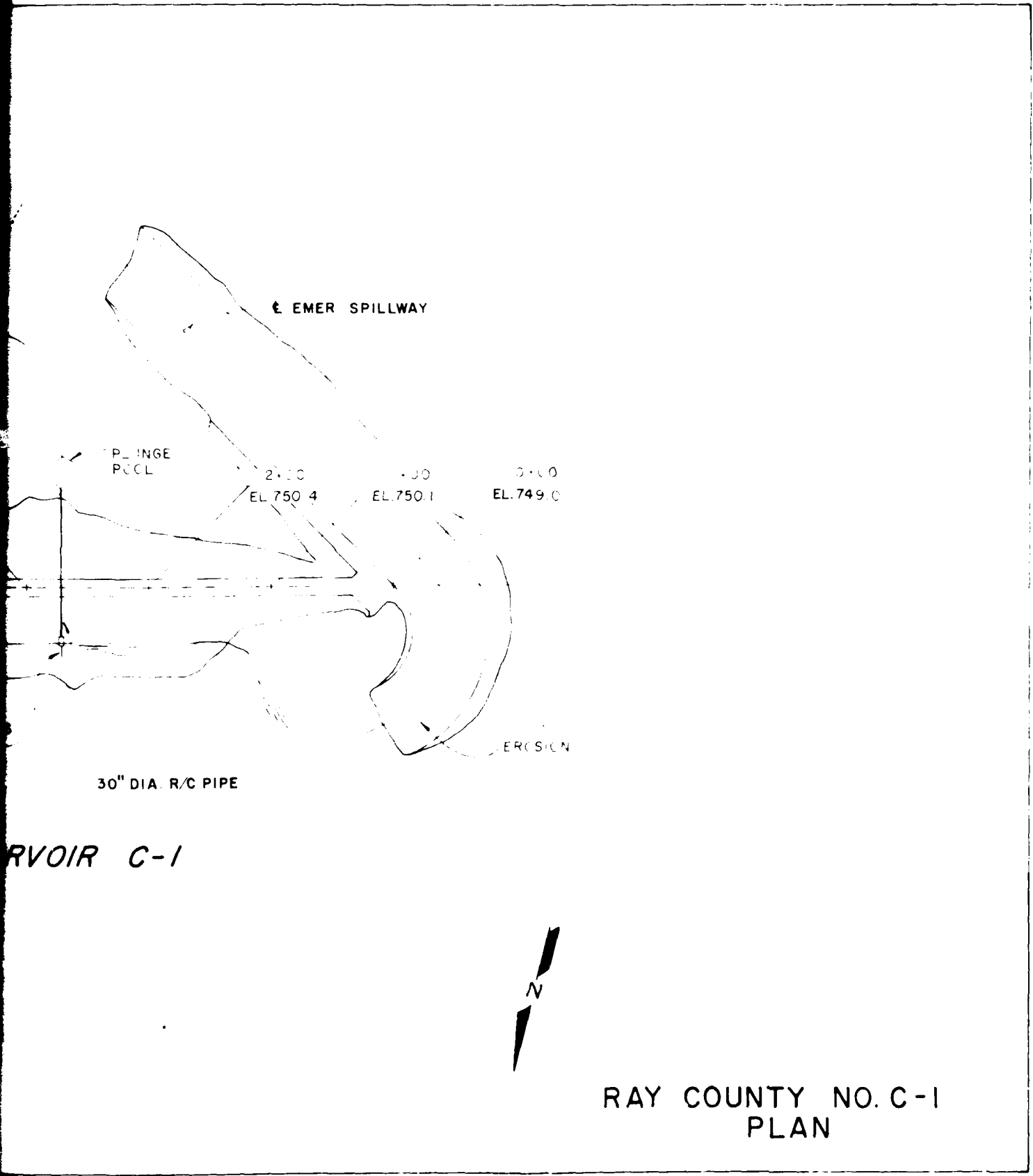
PLUNGE  
POOL

DAM

10" DIA ASBESTOS  
CEMENT PIPE

30" DIA R/C

RESERVOIR C-1



EMER SPILLWAY

PLUNGE  
PCCL

2+00  
EL. 750.4

4+00  
EL. 750.1

6+00  
EL. 749.0

EROSION

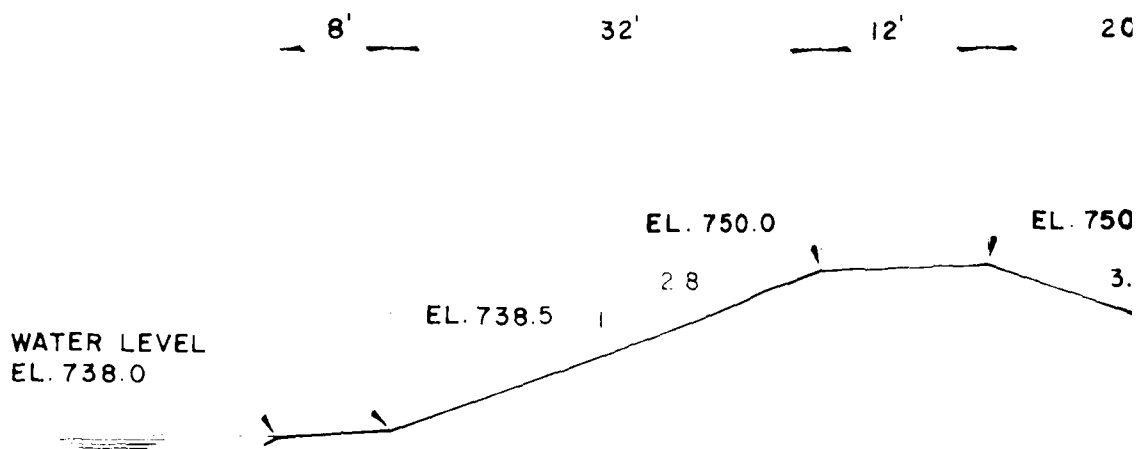
30" DIA. R/C PIPE

RESERVOIR C-1



RAY COUNTY NO. C-1  
PLAN





EMBANKMENT CROSS-SECTION TAKEN AT APPRO

12'      20'      20'      21'

EL. 750.1

3.0

EL. 743.4

2.4

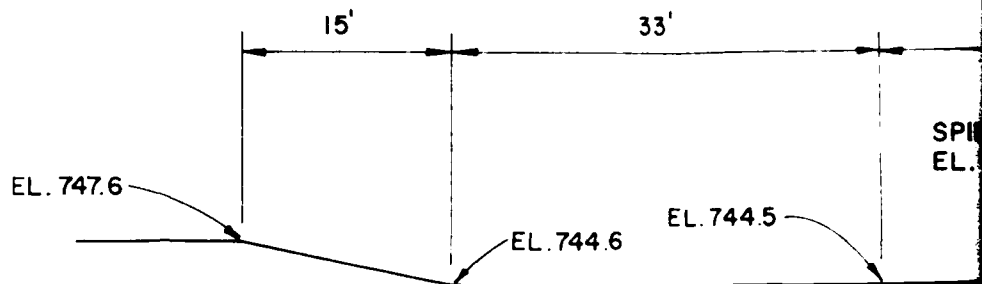
EL. 735.2

3.3

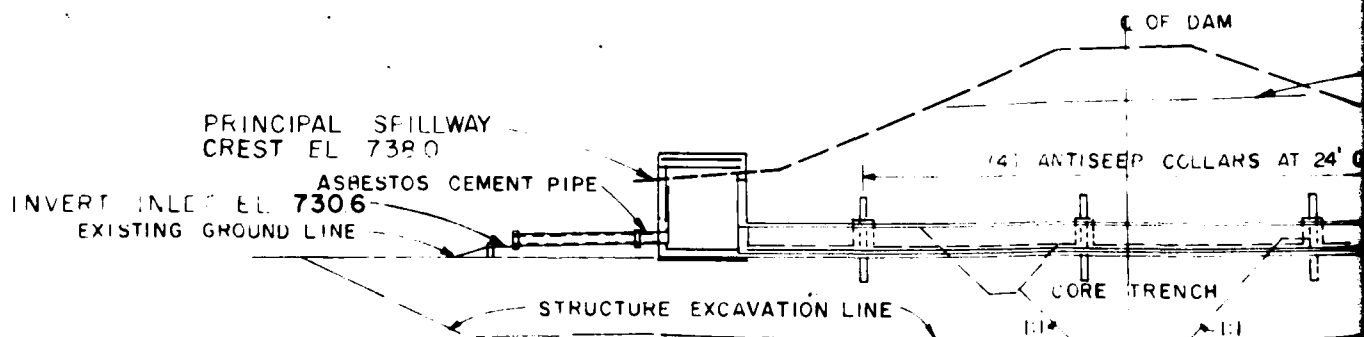
EL. 728.8

TAKEN AT APPROX STATION 3+20

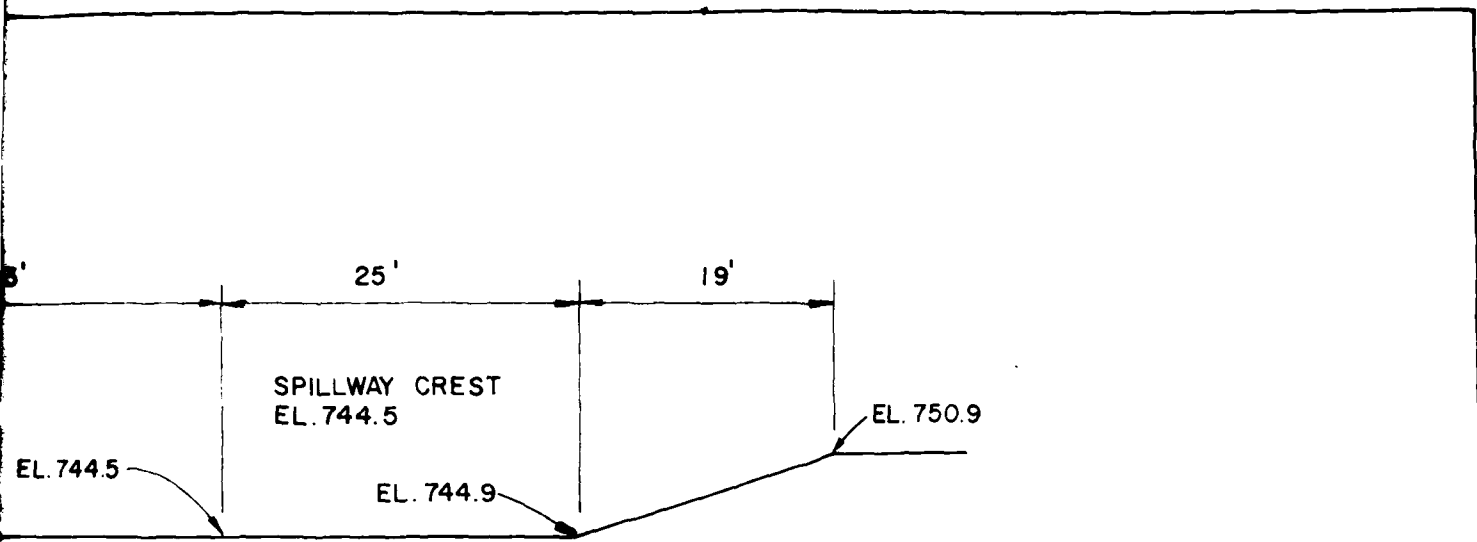
RAY COUNTY NO. C-1  
TYPICAL SECTION



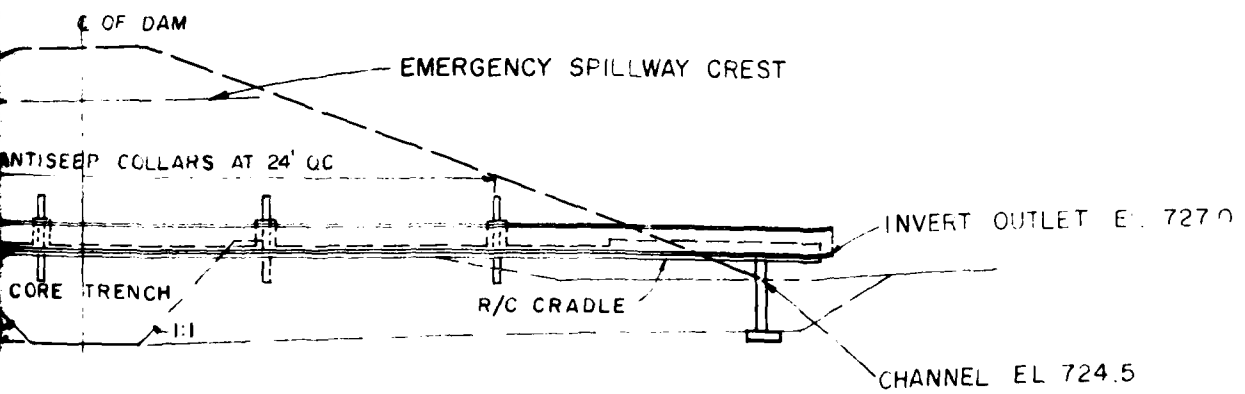
EMERGENCY SPILLWAY  
 SECTION TAKEN LOOKING DOWN  
 LONGITUDINAL CENTER LINE OF



PRINCIPAL SPILLWAY SECT  
 FROM AS BUILT DRAWINGS



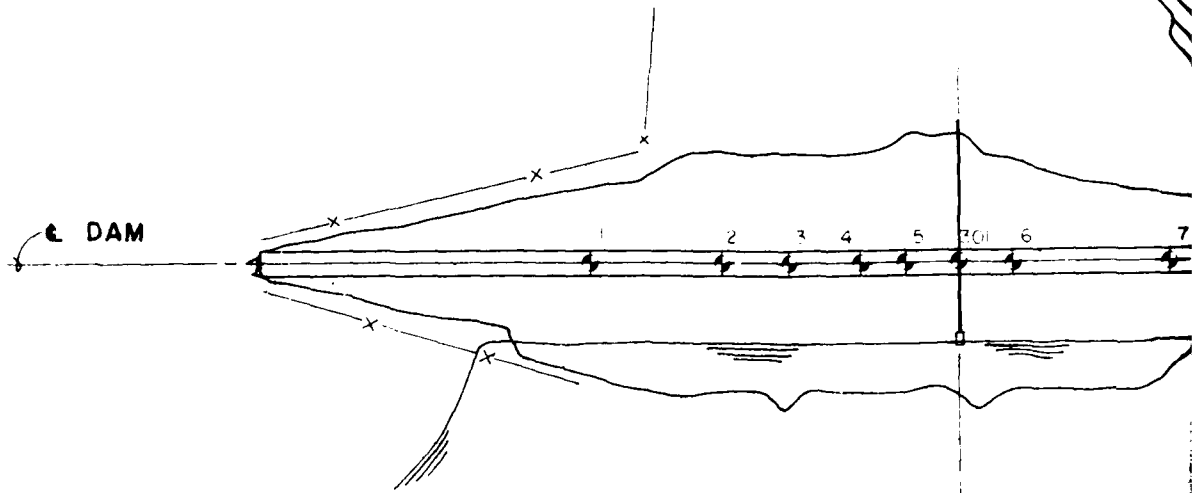
EMERGENCY SPILLWAY  
TAKEN LOOKING DOWNSTREAM NEAR  
ORIGINAL CENTER LINE OF DAM



PRINCIPAL SPILLWAY SECTION  
AS BUILT DRAWINGS

RAY COUNTY NO. C-1  
PRINCIPAL AND EMERGENCY SPILLWAY SECTIONS

12

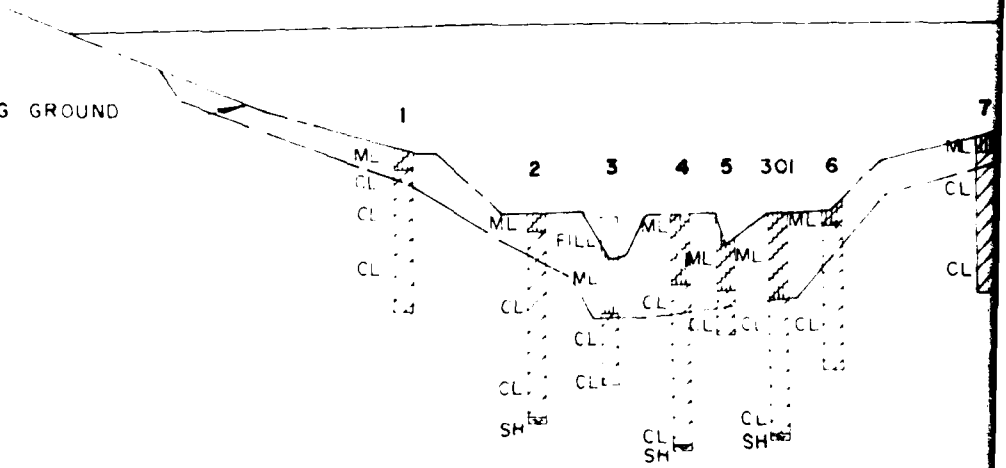


30" DIA. R/C PIPE

RESERVOIR C-1

STA 0+90

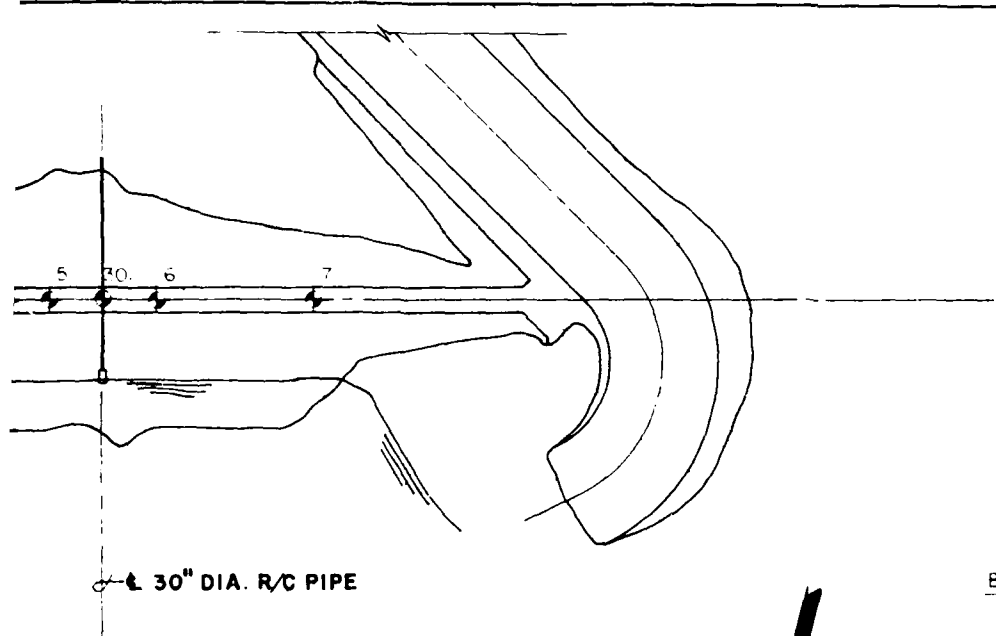
EXISTING GROUND LINE



LEGEND

✦ BORING HOLE LOCATION

BORING DATA FROM SGS "AS BUILT" DRAWINGS



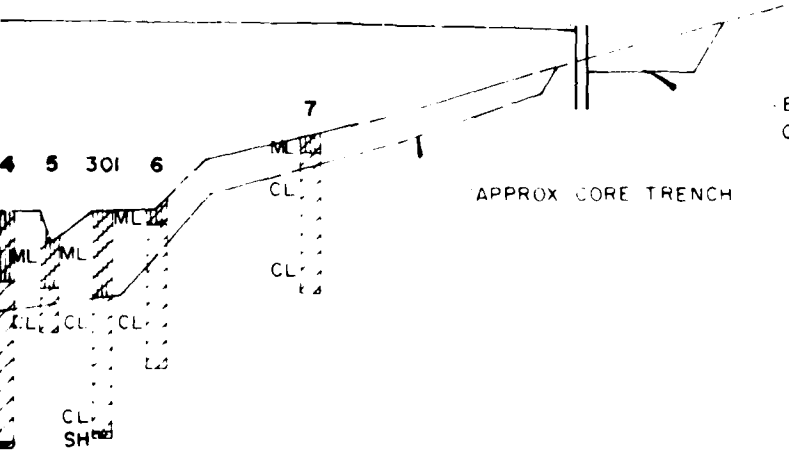
30" DIA. R/C PIPE

RESERVOIR C-1



STA 7+55

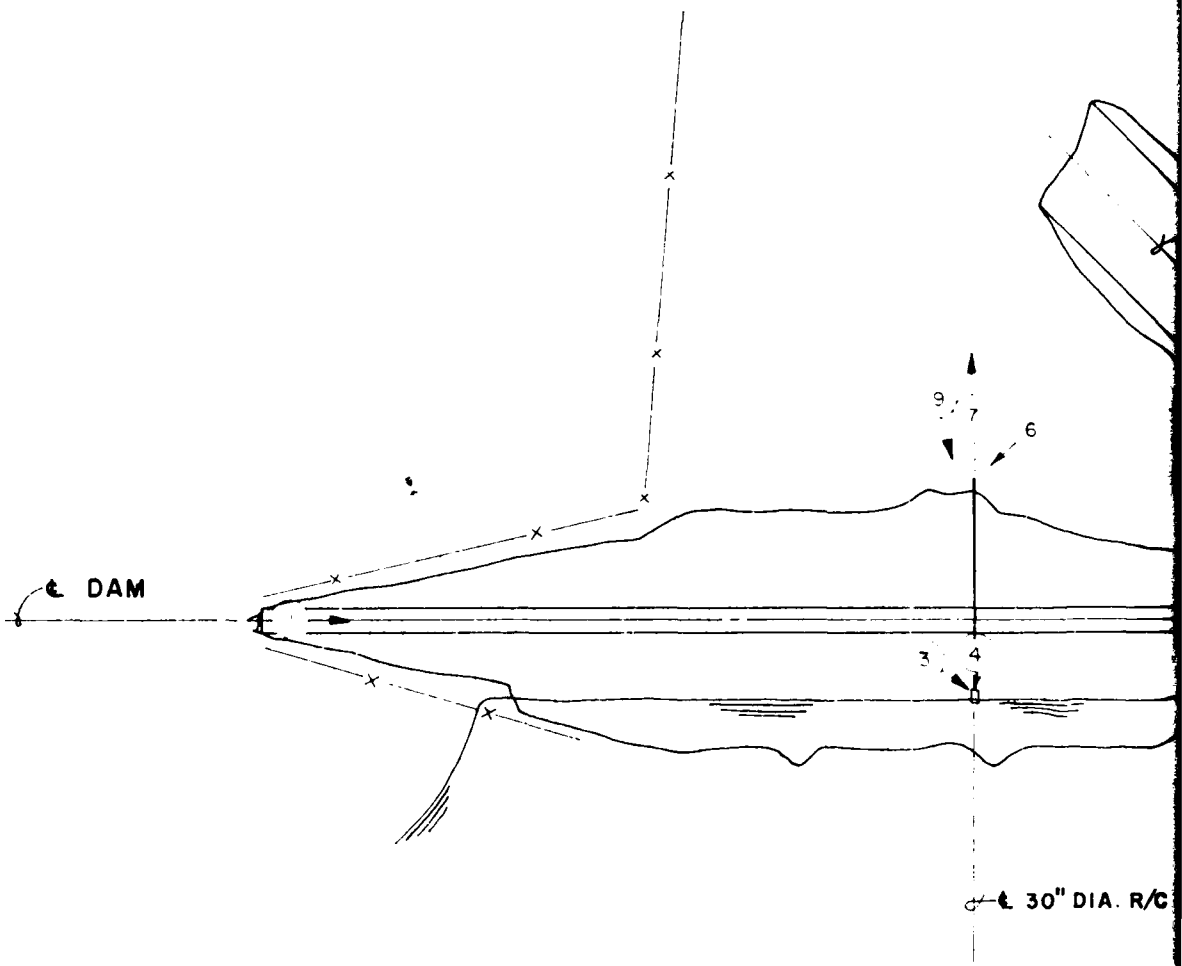
BORING NO.	STATION
1	2+75
2	3+50
3	3+95
4	4+35
5	4+70
301	4+90
6	5+20
7	6+5



EMERGENCY SPILLWAY  
CREST EL. 744.5

APPROX CORE TRENCH

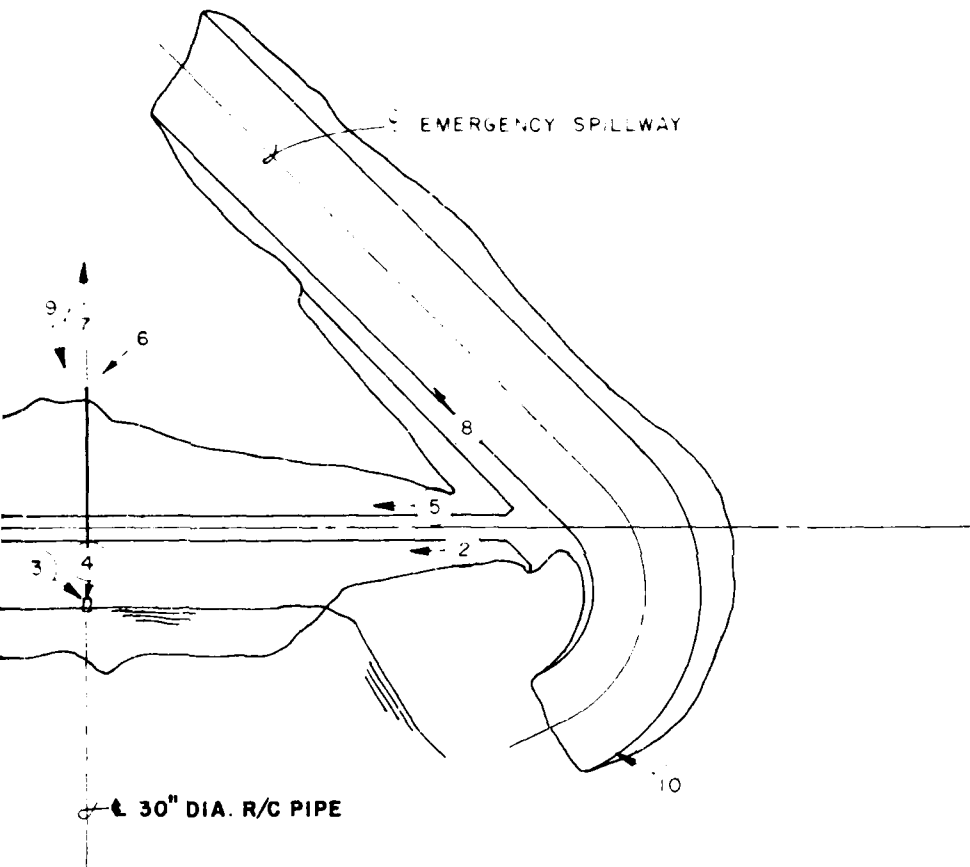
# RAY COUNTY NO. C-1 BORING PLAN



RESERVOIR C-1

LEGEND

→ PHOTO NUMBER AND DIRECTION



RESERVOIR C-1



RAY COUNTY NO. C-1  
PHOTO INDEX

1 12





PHOTO 1: CREST OF DAM (LOOKING WEST)



PHOTO 2: UPSTREAM EMBANKMENT (LOOKING EAST)

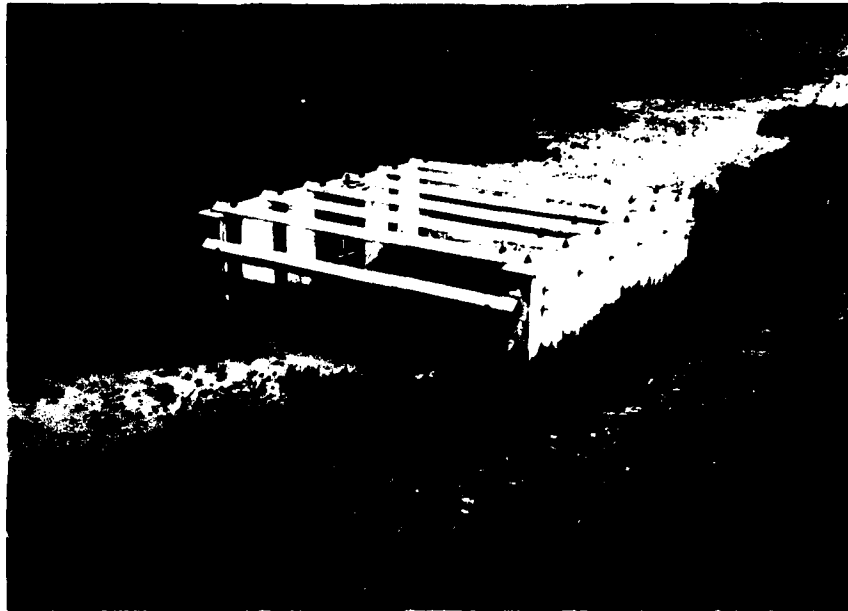


PHOTO 3: PRINCIPAL SPILLWAY WITH RACK

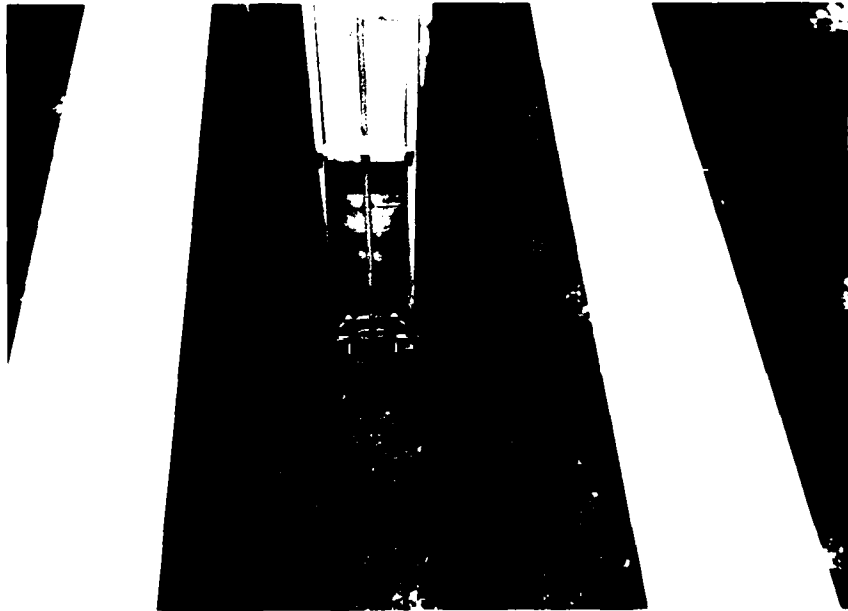


PHOTO 4: PRINCIPAL SPILLWAY STRUCTURE - SLUCE GATE AND MECHANISM FOR 10-INCH DRAWDOWN PIPE

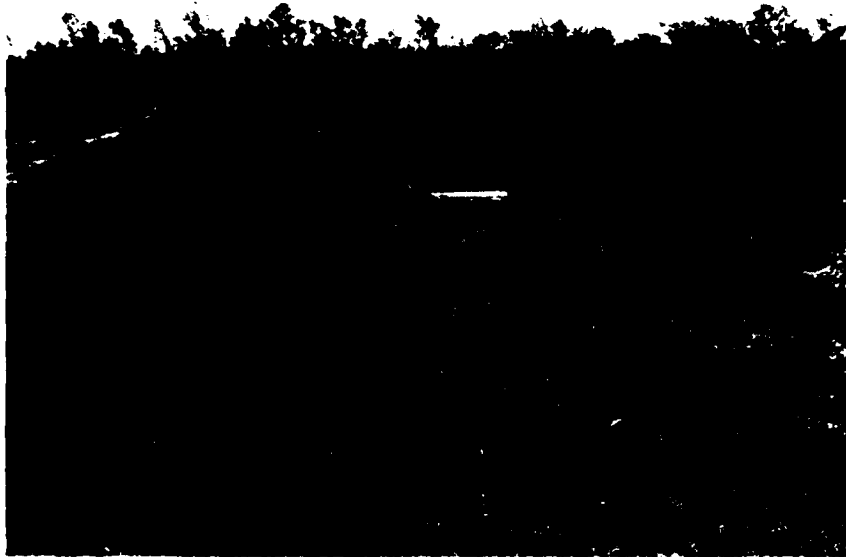


PHOTO 5: DOWNSTREAM EMBANKMENT (LOOKING EAST)

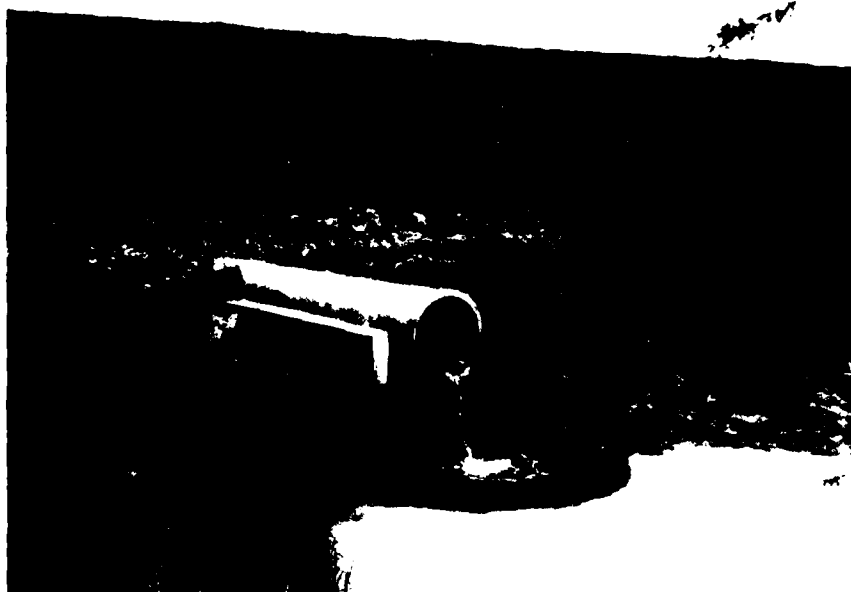


PHOTO 6: PRINCIPAL SPILLWAY DISCHARGE PIPE



PHOTO 7: DISCHARGE CHANNEL (LOOKING DOWNSTREAM)



PHOTO 8: EMERGENCY SPILLWAY (LOOKING DOWNSTREAM)



PHOTO 9: ANIMAL BURROW UNDER SPILLWAY DISCHARGE PIPE



PHOTO 10: EROSION OF EMERGENCY SPILLWAY

APPENDIX A  
HYDROLOGIC COMPUTATIONS

## HYDROLOGIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph and HEC-1 (1) were used to develop the inflow hydrographs, and hydrologic inputs are as follows:

a. Twenty-four hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33.

200 square mile, 24 hour rainfall inches	- 24.5
10 square mile, 6 hour percent of 24 hour 200 square mile rainfall	- 101%
10 square mile, 12 hour percent of 24 hour 200 square mile rainfall	- 120%
10 square mile, 24 hour percent of 24 hour 200 square mile, rainfall	- 130%

b. Drainage area = 774 acres.

c. Time of concentration:

$$T_c = (1.67) L$$

$$L = \frac{\ell^{0.8} (S+1)^{0.7}}{1,900Y^{0.5}}$$

L = lag in hours

$\ell$  = hydraulic length of watershed in feet

S =  $\frac{1,000}{CN} - 10$  (where CN is the retardance factor and is equivalent to the runoff curve number)

Y = average watershed slope in percent

$$T_c = 0.68 \text{ hours (2).}$$

d. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 84 and antecedent moisture condition III(2). The hydrologic soil group in the basin is B.

e. The soil association in this watershed is mainly Marshall Silt Loam. The land use is characterized by pasture or range. The hydrologic condition is considered fair.

2. Principal spillway release rates are based on the weir and pipe flow equations (4).

Weir equation:

$$Q = CLH^{1.5} \quad (C = \text{varies from } 2.75 \text{ to } 3.32, L = 15.0 \text{ feet, } H \text{ is the head on weir}).$$

Pipe-flow equation:

$$Q = CA(2gh)^{0.5} \quad (C = 0.63, A = 3.14 \text{ ft}^2, g = 32.2 \text{ ft/sec}^2, h = \text{difference in reservoir surface elevation and downstream culvert discharge outlet}).$$

3. Emergency spillway releases are based upon calculations of critical depths of flow at the crest. Reservoir elevations corresponding to given spillway release rates were calculated by adding to the critical depth,  $d_c$ , the velocity head,  $v^2/2g$ ; and the friction head,  $h_f$  (5).

Discharge rates over the top of the dam are based on the nonlevel weir equation:

Nonlevel weir equation:

$$Q = \frac{2Cb}{5(h_b - h_a)} (h_b^{2.5} - h_a^{2.5})$$

( $C = 2.6$ ,  $b =$  integral length of weir normal to flow in feet,  $h_a =$  head on the high end of the weir in feet,  $h_b =$  head on the low end of the weir in feet (6)).

4. The elevation-storage relationship above normal pool elevation was taken from "As Built" drawings provided by the SCS.

5. Floods are routed through the spillway using HEC-1, modified Puls to determine the capability of the spillway.

6. Routing of the probable maximum flood began with a water surface elevation at the principal spillway crest of 738.0.

- (1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.
- (2) U.S. Department of Agriculture, Soil Conservation Service, SCS National Engineering Handbook, Section 4, Hydrology, August, 1975.



- (3) Soil and Water Conservation District of Ray County, Watershed Work Plan, Willow Creek Watershed, Ray County, Missouri, November 1, 1965.
- (4) Horace W. King and Ernest F. Brater, Handbook of Hydraulics, Sixth Edition, McGraw Hill Book Company, 1976.
- (5) U.S. Department of Agriculture, Soil Conservation Service, Engineering Division, Hydraulics of Broad-Crested Spillways, Technical Release No. 39, Design Unit, May, 1968.
- (6) Techniques of Water-Resources Investigations of the United States Geological Survey, Measurement of Peak Discharge at Dams by Indirect Methods, by Harry Hulsing, United States GPO, Washington, D.C., 1967.



51  
52  
53  
54

31738.  
54 734.  
30748.99  
K 99

740. 742.3 744.4 747. 749. 750. 751. 753.

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
201.	176.	37.	7.	2.07%
4.	1.	1.	1.	1.01%
10000	1.27	1.14	2.14	1.14%
10000	54.76	54.46	54.46	54.46%
AC-FT	176.	176.	176.	176.
THOUS CU M	171.	171.	171.	171.

\*\*\*\*\*

RUNOFF SUMMARY: AVERAGE FLOW IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)  
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

HYDROGRAPH AT	PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
1	1697.	447.	1.1.	131.	1.21
(	47.19)(	12.66)(	3.71)(	3.71)(	3.13)
ROUTED TO	2	256.	178.	70.	1.21
(	5.85)(	5.04)(	1.97)(	1.97)(	3.13)

\*\*\*\*\*  
 FLOOD HYDROGRAPH PACKAGE (HEC-1)  
 DAM SAFETY VERSION JULY 1978  
 LAST MODIFICATION 26 FEB 75  
 \*\*\*\*\*

1	MISSOURI DAM INSPECTION PROGRAM									
2	DIST. LOUIS DISTRICT US ARMY CORPS OF ENGR									
3	ASC-1 LAKE NO. 1239									
4	R	288	C	5	0	C	0	0	0	0
5	R1	5	C	1	0	C	0	0	0	0
6	J	1	C	1	0	C	0	0	0	0
7	U1	.05	C	.10	.15	.20	.25	.30	.35	.50
8	K	9	C	1	0	C	3	3	3	1.0
9	K1	24 HR PMF INFLOW								
10	M	1	C	2	1.21					
11	P	1	C	24.5	101	120	130	1		
12	T	1							-1	-84
13	L	1		.41						
14	X	1								
15	K	1	C	2						1
16	K1	ROUTE THROUGH SPILLWAY								
17	Y	1	C	1						
18	V1	1	C	1					-738	-1
19	V4	778.	C	735.	741.	743.	744.5	745.53	746.38	747.56
20	V4753.09		C							749.42
21	V5	0	C	47.	85.	92.	56.	220.	452.	1117.
22	V516732.		C							2031.
23	S	65.	C	95.	148.	197.	280.	360.	405.	455.
24	S738.		C	745.	742.3	744.5	747.	749.	750.	751.
25	S	73M.	C							752.
26	S748.99		C							
27	K	99	C							

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 FEET (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS								
				RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
				.05	.10	.15	.20	.25	.30	.35	.50	1.00
HYDROGRAPH AT	1	1.21	1	463.	927.	1390.	1853.	2310.	2780.	3243.	4633.	9265.
	(	3.13)	(	13.12)	26.24)	39.35)	52.47)	65.59)	78.71)	91.83)	131.10)	262.36)
ROUTED TO	2	1.21	1	85.	96.	317.	651.	1018.	1425.	1752.	3325.	6312.
	(	3.13)	(	2.41)	2.71)	8.97)	18.42)	28.84)	40.34)	51.02)	94.22)	235.38)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....  
 ELEVATION  
 STORAGE  
 OUTFLOW

INITIAL VALUE  
 738.00  
 65.  
 0.

SPILLWAY CREST  
 738.00  
 65.  
 0.

TOP OF DAM  
 748.99  
 66.  
 1782.

RATIO OF PMF	MAXIMUM RESERVOIR W.C. LEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME TO MAX OUTFLOW TO BEG	TIME TO FAILURE HOURS
.05	741.64	0.00	119.	83.	0.00	18.33	0.00
.10	744.36	0.00	194.	96.	0.00	18.58	0.00
.15	745.89	0.00	243.	317.	0.00	18.94	0.00
.20	746.85	0.00	275.	651.	0.00	16.34	0.00
.25	747.73	0.00	576.	1118.	0.00	14.58	0.00
.30	748.45	0.00	334.	1425.	0.00	15.42	0.00
.35	749.05	0.06	362.	1802.	.25	16.42	0.00
.50	750.16	1.17	413.	3329.	1.50	16.25	0.00
1.00	751.86	2.87	500.	8312.	4.50	16.08	0.00

UNITED STATES GOVERNMENT

## Memorandum

U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICETO : James M. Dale, State Conservation Engineer,  
SCS, Columbia, Missouri

DATE: September 18, 1969

FROM : Lorn P. Dunnigan, Head, Soil Mechanics Laboratory,  
SCS, Lincoln, Nebraska

SUBJECT: ENG 22-5, Missouri WP-08, Willow Creek, Site No. C-1 (Ray County)

The attached Form SCS-354 provides results of the classification tests performed as requested on the seven samples submitted to the Laboratory.

Charges are based on current rates for testing services only.

*Lorn P. Dunnigan*

Attachment:  
Form SCS-354, Soil Mechanics Laboratory Data, 1 sheet

cc:  
James M. Dale (2)

## Consolidation - Hole 201

B/c 4 to 5	0-10'	@ 0.04 =	0.4	(See sample 2-1 site)
Firm	10-13	@ 0.025 =	0.08	
B/c 8	13-21	} very small	—	
Firm to stiff	21-24		—	
Shale	24'	0	—	
			0.48	use 0.5'

Fill

21' @ 0.015 = 0.32

Total = 0.8' use 1.0' because of lack of test in formation.



973/9

116. 25.71  
18,800 cu yd

Missouri  
Willow Creek Site: C-1  
Flood Water Retaining

U.S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

LABORATORY SAMPLE NUMBER	FIELD NUMBER	LOCATION AND DESCRIPTION	DEPTH	FIELD CLASSIFICATION	MECHANICAL ANALYSIS														WATER LOSS PLOT	WATER LOSS PLOT
					SAND				FINE SAND				CLAY				LUMEN			
					20-75 %	40 %	60 %	100 %	47.5 %	20 %	8.5 %	0.75 %	0.075 %	0.0075 %	47.5 %	20 %	8.5 %	0.75 %		
70W																				
436	4.1	Willow Creek Dam 4+35	4-5'	ML	95	100	100	100	100	100	100	100	100	100	100	100	100	31	6	ML
437	4.2	" "	10-11'	CL	94	100	100	100	100	100	100	100	100	100	100	100	100	32	7	ML
438	4.3	" "	15-16'	CL	85	100	100	100	100	100	100	100	100	100	100	100	100	32	9	ML
439	301.1	4+90 Dam	4-5'	ML	93	100	100	100	100	100	100	100	100	100	100	100	100	32	7	ML
440	301.2	" "	9-10'	ML	95	100	100	100	100	100	100	100	100	100	100	100	100	32	7	ML
441	301.3	" "	14-15'	CL	100	100	100	100	100	100	100	100	100	100	100	100	100	41	13	CL
442	301.4	" "	19-20'	CL	100	100	100	100	100	100	100	100	100	100	100	100	100	44	22	CL

PROJECT ENGINEER'S RECOMMENDATIONS

WILLOW CREEK

STRUCTURE C-1

1. FOUNDATION

General Statement-- There are no serious foundation problems on this site. At 16 feet in hole #4 there is a small area of 3 blow count material with thin lens of fine sand and numerous iron concretions. This layer is only two feet thick and is located deep under the stream channel. It is not considered a problem.

The two areas of sand and gravel in hole #4 are pockets of material and are not considered a problem. Drains are not needed.

The only request for lab work will be for classification of all samples except borrow. There is enough available borrow of the heavy XX CL material to eliminate the need for lab classification. Compaction (density) Proctors will be completed by the field office.

- 1.1 Core--The following core grade elevations are intended to extend into the firm CL material, as field classified. These grades will remove the two channel fill areas. More or less excavation can be done after inspection during construction.

<u>Hole</u>	<u>Station</u>	<u>Elevation</u>
1	2+75	734
2	3+50	726
3	3+95	717
5	4+60	720
301	4+90	724
6	5+20	727
7	6+05	735

- 1.2 Channel Cleanout-- See Cross Sections on: SCS-35B

- 1.3 Structure excavation-- See SCS-35B. Channel cleanout and backfill create differential settlement conditions under the structure. Excavation as shown on the Principal Profile SCS-35B will eliminate uneven settlement under the pipe.

2. Borrow

Needed-  $19,000 \times 1.3 = 24,700$  cy

Available- Topsoil 15,000

CL material 20,000-- Includes area above waterline in the 102 hole vicinity. Cut off the point between the forks. Below Emergency Spillway elevation.

Emergency Spillway 3,700 cy  
Total available borrow 38,700 cy

3. Channel outlet-- None required. The left channel of the two old ones below the dam may be used as a waste area.

DETAILED GEOLOGIC INVESTIGATION OF DAM SITES

GENERAL

State Missouri County Ray ; \_\_\_\_\_ 1/4, \_\_\_\_\_ 1/4, Sec. \_\_\_\_\_, T. \_\_\_\_\_ R. \_\_\_\_\_ ; Watershed Willow Creek  
 Subwatershed \_\_\_\_\_ Fund class WP-08-12 Site number C-1 Site group II Structure class a  
 (FP-2, WP-1, etc.)  
 Investigated by Nuel J. Edwards Equipment used Failing 1500 Date 7-3-69  
 (signature and title) (Type, size, make, model, etc.)  
Geologist

SITE DATA

Drainage area size \_\_\_\_\_ sq. mi., 774 acres. Type of structure D.I. 30" R/C Purpose FWR  
 Direction of valley trend (downstream) S Maximum height of fill 25.7 feet. Length of fill 665 feet.  
 Estimated volume of compacted fill required 18,800 yards

STORAGE ALLOCATION

	Volume (ac. ft.)	Surface Area (acres)	Depth at Dam (feet)
Sediment	<u>59.0</u>	<u>12.4</u>	<u>14.1</u>
Floodwater	<u>138.0</u>	<u>29.7</u>	<u>21.0</u>

SURFACE GEOLOGY AND PHYSIOGRAPHY

Physiographic description River Hill Loess Topography Rolling Attitude of beds: Dip \_\_\_\_\_ Strike \_\_\_\_\_  
 Steepness of abutments: Left 7 percent; Right 6 percent. Width of floodplain at centerline of dam 190 feet  
 General geology of site: The site is located in National Soil Resource Area 107, The Iowa & Missouri Deep Loess Hills. The loess is modified by weathering and is classified as CL. The clay content decreases below depth of 12 to 15 feet, however materials classified as ML are rare. The underlying bedrock is the Marmaton Group, Desmoinesian Series, Pennsylvanian System which is described as cyclic Deposits of shale and limestone with lesser amounts of sandstone and some coal beds.

DETAILED GEOLOGIC INVESTIGATION OF DAM SITES

FEATURE 2 Dams, Prin. Spillway, Emerg. Spillway, channel, Borrow Area  
(CENTERLINE OF DAM, PRINCIPAL SPILLWAY, EMERGENCY SPILLWAY, THE STREAM CHANNEL, INVESTIGATIONS FOR DRAINAGE OF STRUCTURE, BORROW AREA, RESERVOIR BASIN, ETC.)

DRILLING PROGRAM

EQUIPMENT USED	NUMBER OF HOLES		NUMBER OF SAMPLES TAKEN		
	EXPLORATION	SAMPLING	UNDISTURBED (STATE TYPE)	DISTURBED	
				LARGE	SMALL
<u>5 1/2" Flight Auger</u>	<u>8</u>	<u>4</u>		<u>8</u> Bags	
<u>Std. Split Tube</u>		<u>2</u>			<u>7</u> Jar
TOTAL	<u>8</u>	<u>6</u>		<u>8</u>	<u>7</u>

SUMMARY OF FINDINGS  
(INCLUDE ONLY FACTUAL DATA)

The gently sloping abutments are modified loess classified as firm to stiff clay. The upper alluvium is a clayey silt overlying firm to stiff alluvial clays. Test holes through the alluvium were bottomed in shale. The alluvium forms the foundation of the principal spillway and is generally uniform in depth, texture, consistency and thickness of the strata. The emergency spillway cuts are shallow and will be in the soil formed from loess. There are two channels through the foundation area. Channel deposits of soft silts (with other debris) are from 4 to 6 feet deep. Alluvium from the valley floor & loess soil from the slopes are the sources of borrow. Sufficient quantities are available within 600 feet of the centerline. Water levels were high in the alluvium at the time of the investigation due to the season and unusually heavy & frequent rains.

DETAILED GEOLOGIC INVESTIGATION OF DAM SITES

WATERSHED <i>Willow Creek</i>		SUBWATERSHED		COUNTY <i>Rau</i>	STATE <i>Missouri</i>
TE. NO. <i>C-1</i>	SITE GROUP <i>II</i>	STRUCTURE CLASS <i>a</i>	INVESTIGATED BY: (SIGNATURE OF GEOLOGIST) <i>Dwight L. ...</i>		DATE <i>7-3-69</i>

INTERPRETATIONS AND CONCLUSIONS

The abutments and emergency spillway present no apparent geologic problems. Penetration test were unusually high in the alluvium. Blow counts from 4 to 8 were obtained in the foundation of the principal spillway and the materials are generally uniform in texture and thickness. Foundation strength was considered adequate for the proposed height of fill and undisturbed samples were not taken. Borings at the centerline stations 3+95 and 4+60 are on channel sections B and B<sub>1</sub>. Test hole #302 is on the right of channel section C. The depth of the channel deposits at the other channel sections was estimated.

END

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