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NATIONAL DAM SAFETY PROGRAM, CRANE STRUCTURE NUMBER 1 (MO 20509--ETC(U)

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WHITE RIVER BASIN

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CRANE STRUCTURE #1

STONE COUNTY, MISSOURI

MO 20509

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PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM



United States Army
Corps of Engineers

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St. Louis District

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

FOR: STATE OF MISSOURI

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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.		

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ATTENTION OF

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

SUBJECT: Crane Structure No. 1
Stone County, Missouri
Missouri Inventory No. 20509

This report presents the results of field inspection and evaluation of Crane Structure No. 1. It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY:

SIGNED

Chief, Engineering Division

30 OCT 1980

Date

APPROVED BY:

SIGNED

Colonel, CE, District Engineer

30 OCT 1980

Date

A 23

WHITE RIVER BASIN

CRANE STRUCTURE NO. 1
STONE COUNTY, MISSOURI
MISSOURI INVENTORY NO. 20509

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of
St. Louis District, Corps of Engineers

For
Governor of Missouri

AUGUST, 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam: Crane Structure No. 1
State Located: Missouri
County Located: Stone
Stream: Tributary of Crane Creek
Date of Inspection: July 17, 1980

Crane Structure No. 1 was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of this 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 they have been developed with the help 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. The estimated damage zone extends approximately one mile downstream of the dam. Located within this zone are 30 ⁺ dwellings and buildings, all located in the City of Crane.

The dam is in the small size classification, since it is greater than 25 ft high but less than 40 ft high, and the maximum storage capacity is greater than 50 ac-ft but less than 1,000 ac-ft.

Our inspection and evaluation indicates that the combined spillways do meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The combined spillways will pass 82 percent of the Probable Maximum Flood without overtopping. 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 guidelines require that a dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering

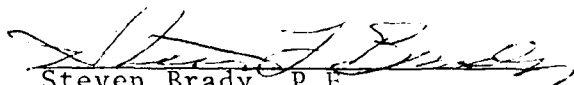
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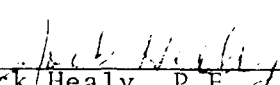
the maximum storage capacity (67 acre-feet) and the use of the structure as a floodwater detention dam with no permanent water storage, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The 100-year flood (1 percent probability flood) will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being exceeded in any given year.

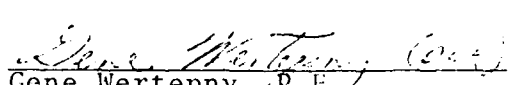
The structure and embankment appear to be in excellent condition. Deficiencies visually observed by the inspection team were: (1) scattered small trees and brush starting to grow in the emergency spillway channel; and (2) a few animal burrows in the embankment near the primary spillway inlet.

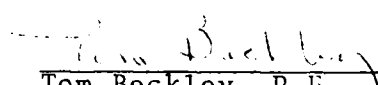
Another deficiency was the lack of seepage and stability analysis records.

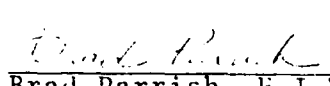
It is recommended that the owners take the necessary action without undue delay to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.


Steven Brady, P.E.
Anderson Engineering, Inc.


Jack Healy, P.E.
Hanson Engineers, Inc.


Gene Wertepny, P.E.
Hanson Engineers, Inc.


Tom Beckley, P.E.
Anderson Engineering, Inc.


Brad Parrish, E.I.T.
Anderson Engineering, Inc.



AERIAL VIEW OF LAKE AND DAM

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CRANE STRUCTURE NO. 1
MISSOURI INVENTORY NO. 20509

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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 Crane Structure No. 1 in Stone County, Missouri.

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 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, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Crane Structure No. 1 is an earth fill structure approximately 38 ft high and 375 ft long at the crest. The appurtenant works consist of a 30 inch diameter reinforced concrete primary spillway pipe with a reinforced concrete flow riser and an earth cut swale located at the west abutment.

Sheet 3 of Appendix A shows a plan, profile, and typical section of the embankments.

B. Location:

The dam is located in the northwestern part of Stone County, Missouri on a tributary of Crane Creek. The dam and lake are within the Crane, Missouri 7.5 minute quadrangle sheet (Section 33, T26N, R24W - latitude 36°54.5'; longitude 93°34.2'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 38 ft and a maximum storage capacity of approximately 67 acre-ft, the dam is in the small size category.

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 one mile downstream of the dam. Located within this zone are 30 ± dwellings and buildings, all located in the City of Crane. Aerial Photograph No. 1 in Appendix D shows a portion of the downstream hazard. The effected features within the estimated damage zone were field verified by the inspection team.

E. Ownership:

The dam is owned by the City of Crane, Attention: City Clerk. The owner's address is Crane, Missouri.

F. Purpose of Dam:

The dam was constructed primarily for floodwater detention.

G. Design and Construction History:

The dam was designed by the U. S. Department of Agriculture, Soil Conservation Service, Columbia, Missouri under the authority of a Resource Conservation and Development Act. A partial set of As Built Plans are included as Sheets 5 through 9 of Appendix A. A complete set of plans is available through the Columbia, Missouri office of the Soil Conservation Service.

Geologic investigations and analyses completed by the Soil Conservation Service are included as Sheets 3 through 18 of Appendix B. Sheets 19 through 21 of Appendix B are geologic reports written by the Missouri Geologic Survey, Rolla, Missouri.

Construction of the structure was started in the fall of 1972 and completed in July 1973. Don Stewart Construction Company, Joplin, Missouri was the contractor for the project. No pertinent information was available from the contractor concerning the construction history of the dam.

Inspection of the project was conducted under the control of Mr. Joe Green, Project Engineer, Soil Conservation Service Mount Vernon, Missouri. Results of the inspection and testing, including inspector's field notes, compaction, and concrete reports, are currently on file in the Columbia, Missouri, SCS office.

During excavation of the borrow area, a cavernous opening was encountered, according to Mr. Joe Green. The opening was stated to be approximately six (6) feet in diameter at the top. The cavern appeared to be intermittent with numerous openings throughout the area encountered. Mr. J. H. Williams of the Missouri Geologic Survey, Rolla, Missouri was consulted. His report is included as Sheets 20 and 21 of Appendix B. Remedial measures undertaken were the placement of large boulders into openings followed by successive layers of decreasing size of material. Mr. Green stated that subsequent to a 6 inch rain, he walked the downstream channel and did not observe any sign of the water surfacing after entry into the cavern.

Mr. Green was not aware of any additional modifications to the structure. He stated that the highest observed water level in the lake bed was to the base of the inlet structure.

II. Normal Operating Procedures.

The structure was designed for flood control purposes and permanent water storage capability was secondary. All flows will normally be passed by the restricted flow riser to the 30 inch spillway pipe and the uncontrolled earth cut emergency spillway.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile, and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet and the As Built Plans, is approximately 60 acres.

B. Discharge at Dam Site:

- (1) All discharge at the dam site is through an uncontrolled spillway.
- (2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 1217.1): 701 cfs
- (3) Estimated Capacity of Principal Spillway: 11 cfs (Elev. 1213.9)

- (4) Estimated Capacity of Emergency Spillway: 690 cfs
(Elev. 1217.1)
- (5) Estimated Experience Maximum Flood at Dam Site:
No flow through spillway
- (6) Diversion Tunnel Low Pool Outlet at Pool Elevation:
Not Applicable
- (7) Diversion Tunnel Outlet at Pool Elevation: Not Applicable
- (8) Gated Spillway Capacity at Pool Elevation: Not Applicable
- (9) Gated Spillway Capacity at Maximum Pool Elevation: Not
Applicable

C. Elevations:

All elevations are consistent with a mean sea level elevation of 1,231.04 for top of concrete monument at Station 4 + 99.94 centerline of dam as obtained from as built drawings (Sheet 5 of Appendix A).

- (1) Top of Dam: 1,217.1 feet, MSL (low point of crest)
- (2) Principal Spillway Crest: 1,194.6 feet, MSL
- (3) Emergency Spillway Crest: 1,212.8 feet, MSL
- (4) Principal Spillway Pipe Invert Elevation at Outlet:
1,180.1 feet, MSL
- (5) Streambed at Centerline of Dam: 1,180.0 feet, MSL
- (6) Pool on Date of Inspection: None
- (7) Apparent High Water Mark: None Visible
- (8) Maximum Tailwater: Not Applicable
- (9) Upstream Portal Invert Diversion Tunnel: Not Applicable
- (10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

- (1) At Top of Dam: 900 feet
- (2) At Emergency Spillway Crest: 800 feet
- (3) At Principal Spillway Crest: 350 feet

E. Storage Capacities:

- (1) At Top of Dam: 67 acre-feet
- (2) At Emergency Spillway Crest: 45 acre-feet
- (3) At Principal Spillway Crest: 32 acre-feet

F. Reservoir Surface Areas:

- (1) At Top of Dam: 5.6 acres
- (2) At Emergency Spillway Crest: 4.3 acres
- (3) At Principal Spillway Crest: 0.75 acres

G. Dam:

- (1) Type: Rolled Earth
- (2) Length at Crest: 375 feet
- (3) Height: 38 feet
- (4) Top Width: 16 feet (14 feet from as built plans)
- (5) Side Slopes: Upstream varies from 1V on 2.4H to 1V on 3H;
Downstream varies from 1V on 2.6H to 1V on 2.7H
- (6) Zoning: Apparently Homogeneous
- (7) Impervious Core: 12 feet wide
- (8) Cutoff: 6 to 20 feet below base of dam
- (9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

- (1) Type: Not Applicable
- (2) Length: Not Applicable
- (3) Closure: Not Applicable
- (4) Access: Not Applicable
- (5) Regulating Facilities: Not Applicable

I. Spillway:

I.1 Principal Spillway:

- (1) Location: Centerline of dam station 2 + 00
- (2) Type: Uncontrolled restricted flow riser and 30 inch diameter pipe

I.2 Emergency Spillway:

- (1) Location: West Abutment
- (2) Type: Earth Cut
- (3) Upstream Channel: Grass covered earth channel
- (4) Downstream Channel: Grass covered, gentle earth slopes changing to an asphalt parking lot and city streets

J. Regulating Outlets:

The only regulating outlet is the 8 inch diameter slide gate located at the bottom of the restricted flow riser.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

Design calculations and construction plans were prepared by and are currently on file with the Soil Conservation Service in Columbia, Missouri. A partial set of these plans is included as Sheets 5 through 9 of Appendix A. These plans were developed through the Resource Conservation and Development Act.

A. Surveys:

A topographic survey was conducted by the Soil Conservation Service for the structure area. This survey was tied to the sea level datum, and a temporary benchmark was located near the dam site. Concrete monuments were set at each end of the embankment by the Soil Conservation Service. A description of this benchmark is shown on Sheet 5 of Appendix A.

B. Geology and Subsurface Materials:

The site is located along the western border zone of the Ozarks geologic region of Missouri. This area is characterized topographically by rolling to hilly with oak and hickory forest areas. The sedimentary rock layers exposed in the Ozarks region dip downward away from the Ozarks region and the higher and younger sedimentary deposits become the surface ledges in southwest Missouri. The soils in this area region are residual from cherty limestones of the Osagean Series of the Mississippian formations. The bedrock is believed to be Burlington limestone formation of the Osagean series. This formation consists of white to light buff, very coarsely crystalline, fossiliferous, crinoidal limestone. The Burlington limestone is often weathered unevenly along its surface.

Soils on the site are residual cherty soils. A layer of soil on the valley floor is described as alluvial-colluvial and classified as GC in the "Detailed Geologic Investigation of Dam Sites" contained in Appendix B. Shallow probes in the embankment indicate the embankment to consist of cherty silty clays. The soils were identified by visual observation to be CL and GC of the Unified Soils groups.

The "Geologic Map of Missouri" indicates that several faults exist in this area of the State. The nearest fault lies approximately 5 miles north of the site and runs northwest to southeast. These faults are generally considered to be inactive and have been for several million years. The publication "Caves of Missouri" indicates there are sixteen caves in McDonald County and these are several miles from the dam site.

C. Foundation and Embankment Design:

Included as Sheets 3 and 4 of Appendix B are the "Geologic Investigation of Dam Site" for this structure. The profile at the centerline of the dam shows the location of the borings as obtained by the Soil Conservation Service. Sheets 5 through 18 of Appendix B are the detailed soils investigation with conclusion from the study. Sheets 19 through 21 are geologic reports written by the Missouri Geologic Survey, Rolla, Missouri.

Based upon the available information, the basic foundation soil appears to be cherty clays (CL). There is apparently no particular zoning of the embankment and no internal drainage features are known to exist.

D. Hydrology and Hydraulics:

The hydrologic and hydraulic design parameters of this dam are as shown on Sheet 9 of Appendix A. Based on the As Built Plans, a field check of the spillway dimensions and embankment elevations, and a check of the drainage area on U.S.G.S. quad sheets, hydrologic analyses using U.S. Army Corps of Engineers guidelines were performed. They appear as Appendix C, Sheets 1 through 10.

E. Structure:

The only structure associated with this dam is the uncontrolled restricted flow riser with 8 inch diameter slide gate. Details of this riser appear as Sheet 8 of Appendix A.

2.2 CONSTRUCTION:

Inspection during the construction of the dam was performed by the Soil Conservation Service Office, Mount Vernon, Missouri under the direction of Mr. Joe Green, Project Engineer. According to Mr. Green, construction inspection data for this structure were prepared by members of his staff. No construction inspection data were obtained for this project. The inspector's log and inspection tests, to include compaction and concrete testing, are currently on file at the Soil Conservation Office, Columbia, Missouri.

2.3 OPERATION:

Normal flows would be passed by the uncontrolled restricted flow riser to the 30 inch spillway pipe and the uncontrolled emergency spillway.

2.4 EVALUATION:

A. Availability:

The engineering data available are as listed in Section 2.1.

B. Adequacy:

The engineering data available were inadequate 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" 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.

C. Validity:

The As Built Plans and design data prepared by the Soil Conservation Service and included in Appendices A and B are valid engineering data on the design and construction of the dam.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on July 17, 1980. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steven Brady, P.E. - Anderson Engineering, Inc. (Civil Engineer)
Tom Beckley, P.E. - Anderson Engineering, Inc. (Civil Engineer)
Jack Healy, P.E. - Hanson Engineers, Inc. (Geotechnical Engineer)
Gene Wertepny, P.E. - Hanson Engineers, Inc. (Hydraulic Engineer)

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

B. Dam:

The dam appears to be in excellent condition. No sloughing or sliding of the embankment was noted. The juncture of the embankment and abutments was good. The horizontal and vertical alignments of the crest were good. No unusual movements of surface cracking were observed. The crest of the embankment was 16 feet wide, the low crest elevation was 1,217.1. The field survey data obtained compared favorably to the As Built Plans for the structure.

Shallow auger probes into the embankment indicated the fill to be reddish-brown cherty clay (CL). The embankment has an excellent grass cover, recently mowed, and appears to be in good condition. No sloughing of the embankment or seepage through the embankment was evident. Some animal burrows in the embankment near the spillway inlet structure were observed. No noticeable erosion was observed.

Due to the cavernous area encountered during construction, no permanent water storage is maintained. No riprap or other wave protection was noted on the upstream face. This does not present a problem, as a permanent water level is not maintained.

C. Appurtenant Structures:

C.1 Principal Spillway:

The principal spillway consisting of the 30 inch diameter reinforced concrete pipe and associated flow restrictor riser with 8 inch slide gate valve appeared to be in good condition. The normal flow, with permanent water storage, would be through the upper spillway orifice and the lower orifice if the gate valve

was opened. On the date of inspection the gate valve was approximately one-fourth open. No apparent high water marks were observed on the structure. The spillway pipe apparently has not carried any flows.

C.2 Emergency Spillway:

The emergency spillway, located at the west abutment, was an earth cut channel. The grass cover in the channel was excellent with no noticeable erosion. Some small tree growth was observed on the west slope of the spillway channel. The emergency spillway, according to Mr. Green, has not carried any flow.

The outlet channel is directed well away from the embankment. The inlet and outlet to the channel were clear.

D. Reservoir:

The slopes to the reservoir were generally steep with good grass cover. No serious erosion was observed. The reservoir banks appeared to be in good condition with no noticeable sedimentation. No noticeable point of water egress was observed in the lake bed.

E. Downstream Channel:

The downstream channel is not well defined. The slopes of the channel are gentle. The channel is grass-covered for approximately 200 feet. At and beyond the swimming pool the channel is asphalt or gravel-covered parking lot and city streets.

3.2 EVALUATION:

The embankment of the dam appears to be excellent with a well maintained grass cover. No noticeable erosion was observed. Some small tree growth was noted on the west slope of the spillway channel. A few animal burrows were observed on the embankment near the spillway inlet structure.

Photographs of the dam, appurtenant structures, and the reservoir are presented in Appendix D.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

The operation and maintenance of the dam are the responsibility of the Southwest Missouri Resource Conservation and Development Steering Committee, City of Crane, Missouri in conjunction with the Soil and Water Conservation District of Stone County. For the first three years following construction of the structure, a joint inspection was conducted by members of the Steering Committee and the Soil Conservation Service. After the three year time period, the responsibility was assumed by the Steering Committee. In addition to the required annual inspection, the dam is to be inspected after each severe flood and after the occurrence of any unusual condition which might adversely affect the structure.

The inspection is to include the condition of the primary spillway and its appurtenances, the emergency spillway, the earthfill and any other items installed as a part of the structure. Copies of the inspection report are forwarded to the Soil Conservation Service office in Springfield, Missouri. The last annual inspection of record was July 17, 1979. The results of this inspection are included as Sheet 10 of Appendix A.

4.2 MAINTENANCE OF DAM:

After the annual inspection of the dam, the Steering Committee determines the maintenance to be done. Monies for the required maintenance are derived from a tax levy imposed upon the residents of the water district.

4.3 MAINTENANCE OF OPERATING FACILITIES:

The maintenance required for the restricted flow riser is accomplished after the inspection by the Steering Committee.

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 general maintenance of the dam and associated items appeared to be in excellent condition. Some tree growth was noted on the west slope of the emergency spillway channel. A few animal burrows were observed on the embankment. The grass cover on the embankment and emergency spillway channel were good and well maintained.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

The hydrologic and hydraulic design data obtained for this dam are as shown on Sheet 9 of Appendix A.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this lake and watershed.

C. Visual Observations:

The approach channels to the spillway are clear. The emergency spillway is well separated from the embankment. Spillway releases would not be expected to endanger the dam. The spillway pipe and the earth cut channel do not appear to have carried any flows.

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 spillway dimensions and embankment elevations; (2) an estimate of the reservoir storage and pool and drainage areas from the Crane, Missouri 7.5 Minute U.S.G.S. quad sheet; and (3) data obtained from the As Built Plans prepared by the Soil Conservation Service.

Based on the hydrologic and hydraulic analyses presented in Appendix C, the combined spillways will pass 82 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. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the maximum storage capacity (67 acre-feet) and the use of the structure as a floodwater detention with no permanent water storage, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The spillways will pass the 1 percent probability flood without overtopping the dam.

Application of the probable maximum precipitation (PMP), minus losses, resulted in a flood hydrograph peak inflow of 1,430 cfs. For 50 percent of the PMF, the peak inflow was 715 cfs.

The routing of the PMF through the spillways and dam indicates that the dam will be overtopped by 0.5 ft at elevation 1,217.6. The duration of the overtopping will be 0.33 hours, and the maximum outflow will be 964 cfs. The maximum discharge capacity of the spillways, at elevation 1,217.1, is 701 cfs. The routing of 50 percent of the PMF indicates that the dam will not be overtopped. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

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 Sections 3.1B and 3.2.

B. Design and Construction Data:

Design data obtained are included in Appendix A. Analysis of the soil structure is included in Appendix B. Additional design data and construction notes and tests, not included in this report, are located at the Soil Conservation Service in Columbia, Missouri.

Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

To our knowledge, no post-construction changes have been made to the structure.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size.

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 excellent condition. A few items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are. (1) some small tree growth on the west slope of the emergency spillway channel, and (2) a few animal burrows on the embankment near the spillway inlet structure.

Another deficiency was the lack of seepage and stability analyses records.

The dam will be overtopped by flows in excess of 82 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on review of the information listed in Section 2.1, 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. If the deficiencies listed in paragraph B are not corrected, and if good maintenance is not provided, the embankment condition will deteriorate and possibly could become serious in the future.

D. Necessity for Additional Inspection:

Based on the result of the Phase I inspection, no additional inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size.

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. Alternatives:

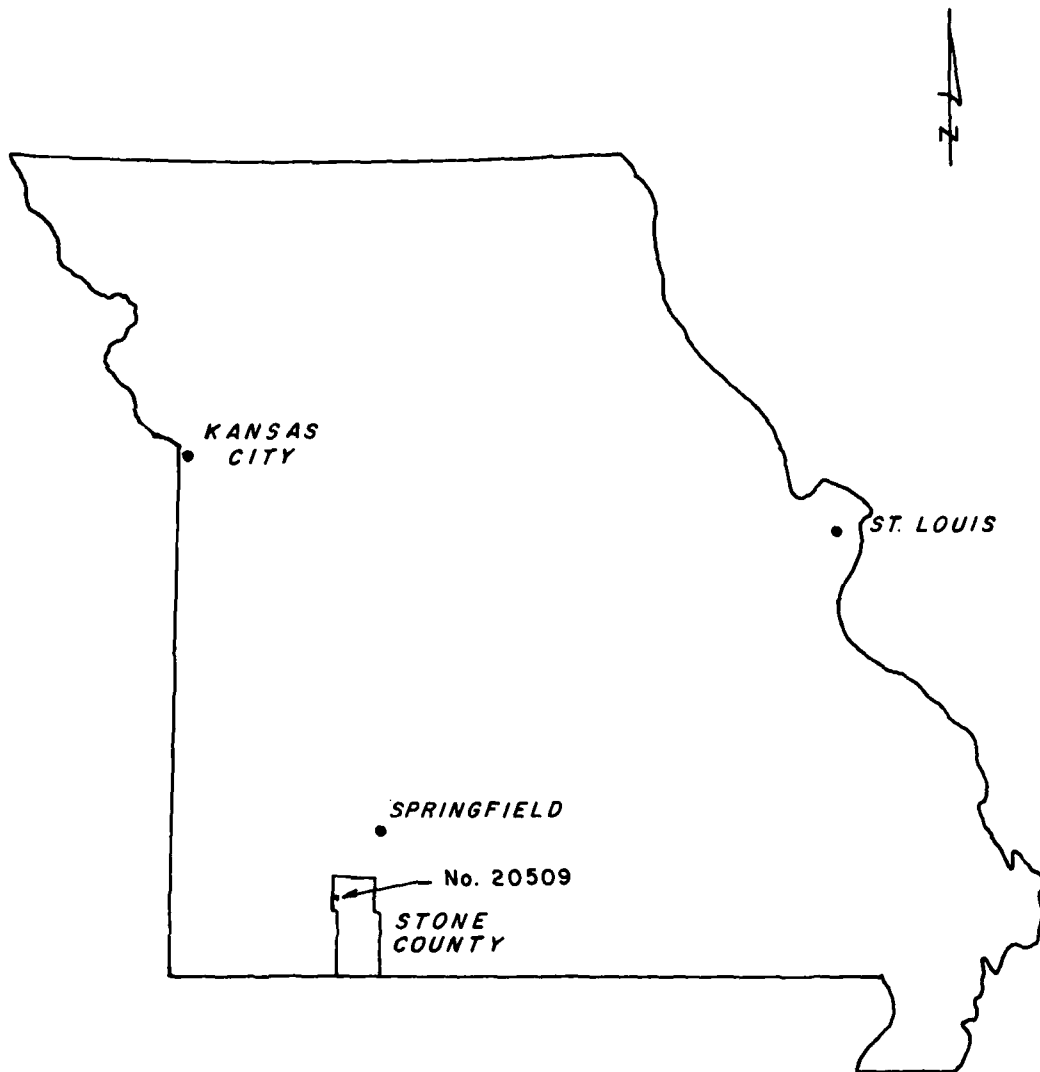
- (1) Not Applicable

B. O & M Procedures:

- (1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.
- (2) The small tree growth on the spillway channel slope should be removed.
- (3) The animal burrows should be repaired.
- (4) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

Dam Location and Plans



LOCATION MAP



VICINITY MAP



HANSON
ENGINEERS
INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Crane Structure #1
Stone County, Missouri
Mo. I.D. No. 20509

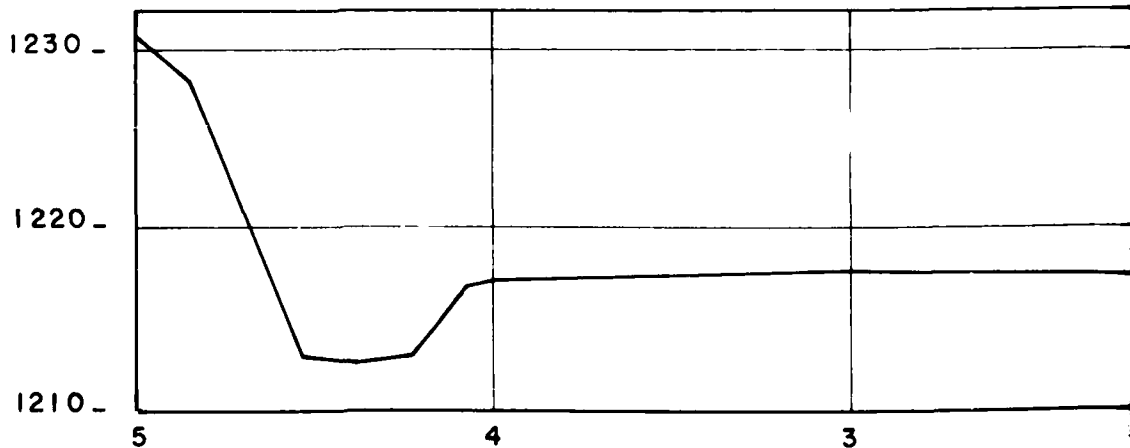
Sheet 2, Appendix A

BENCHMARK:
TOP OF CONCRETE MONUMENT
AT STA 4+99.94 CENTERLINE
OF DAM. ELEV. = 1231.04

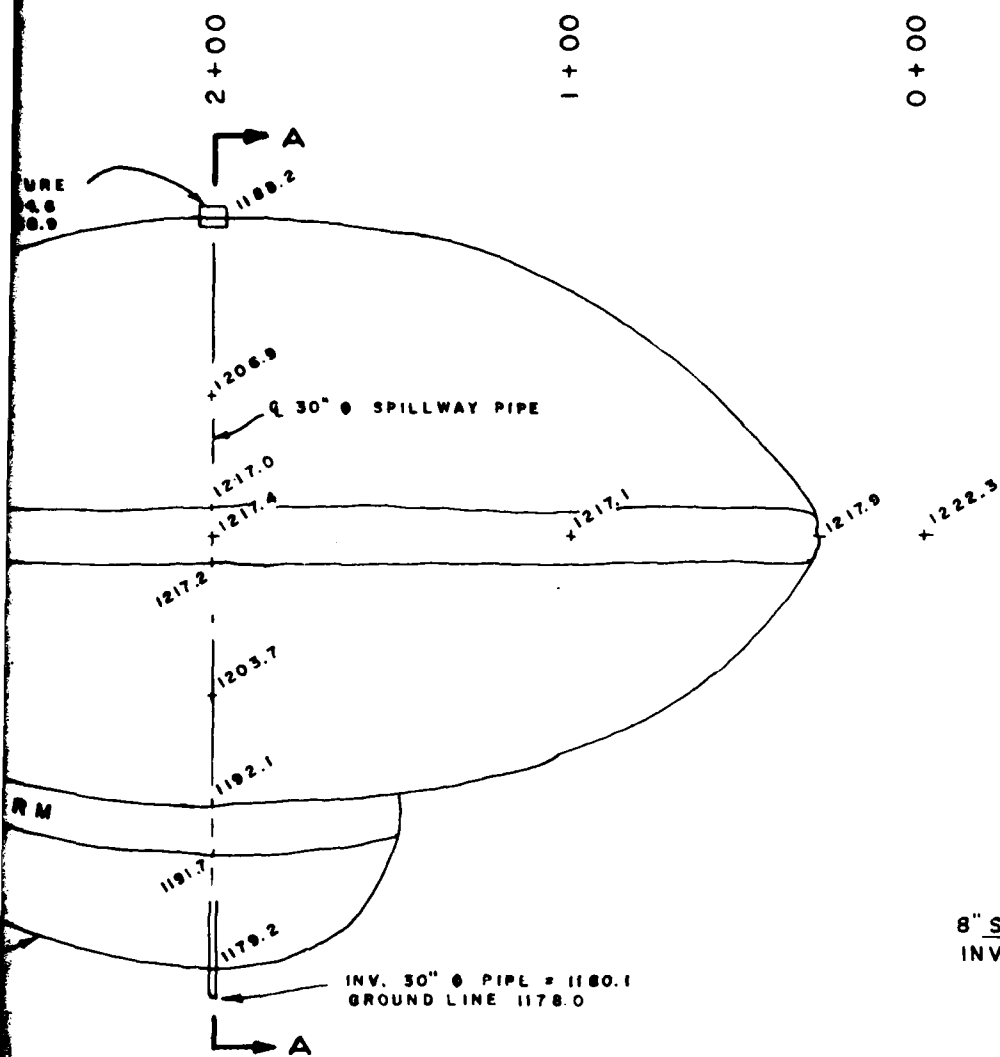
L A K E

INLET STRUCTURE
UPPER INV. 1194.6
LOWER INV. 1188.9

PLAN
SCALE

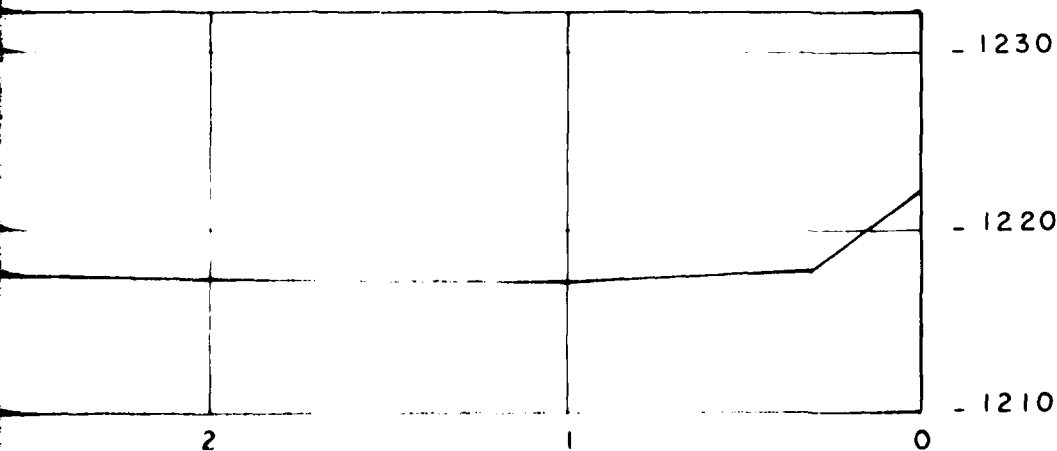
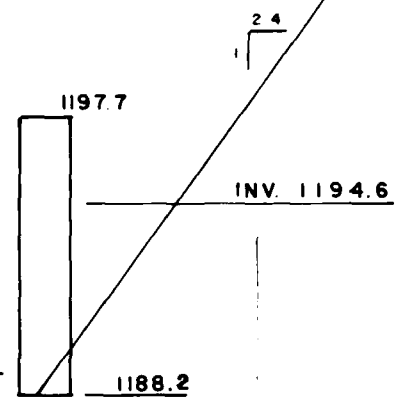


PROFILE

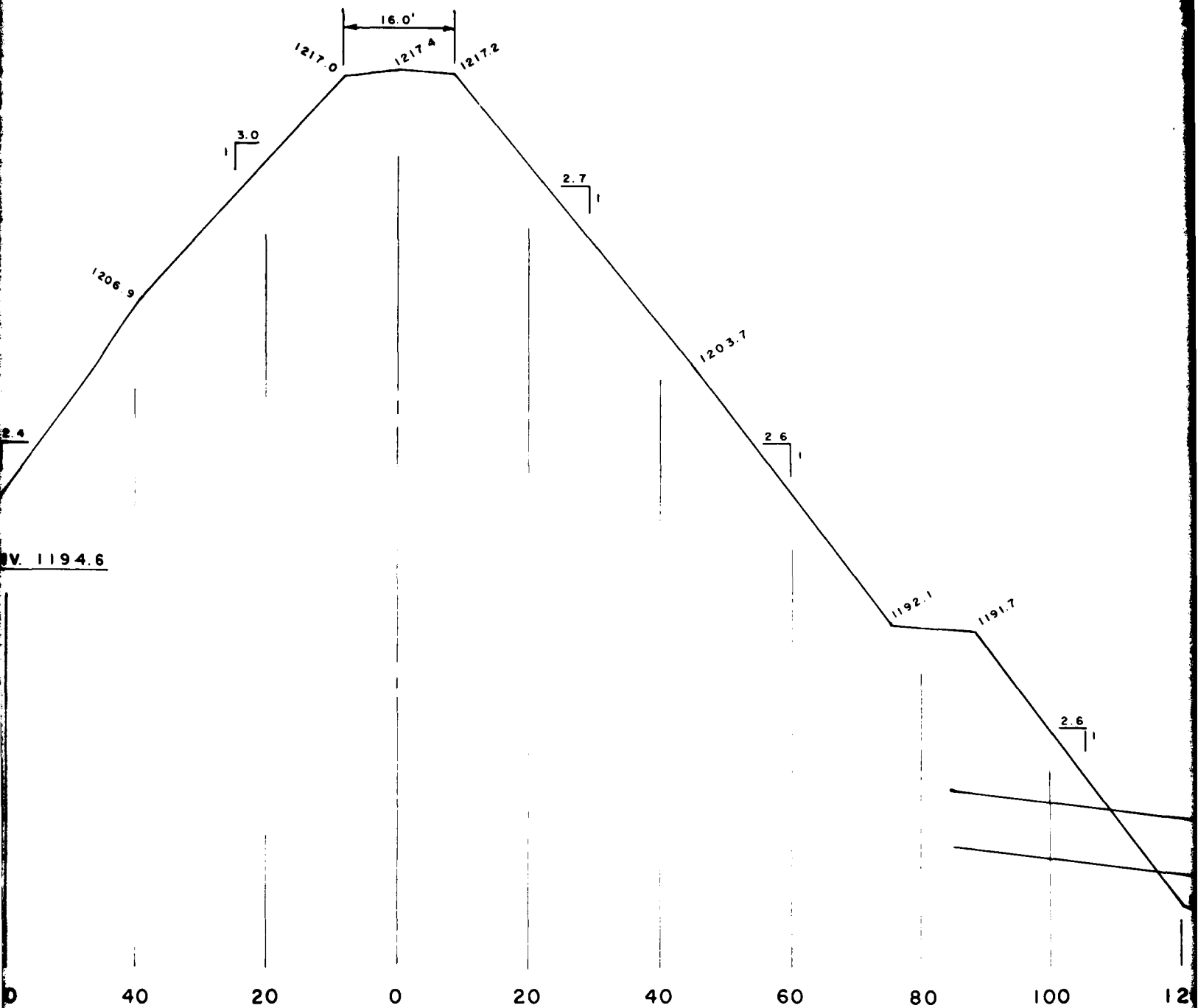


PLAN VIEW
SCALE: 1" = 50'

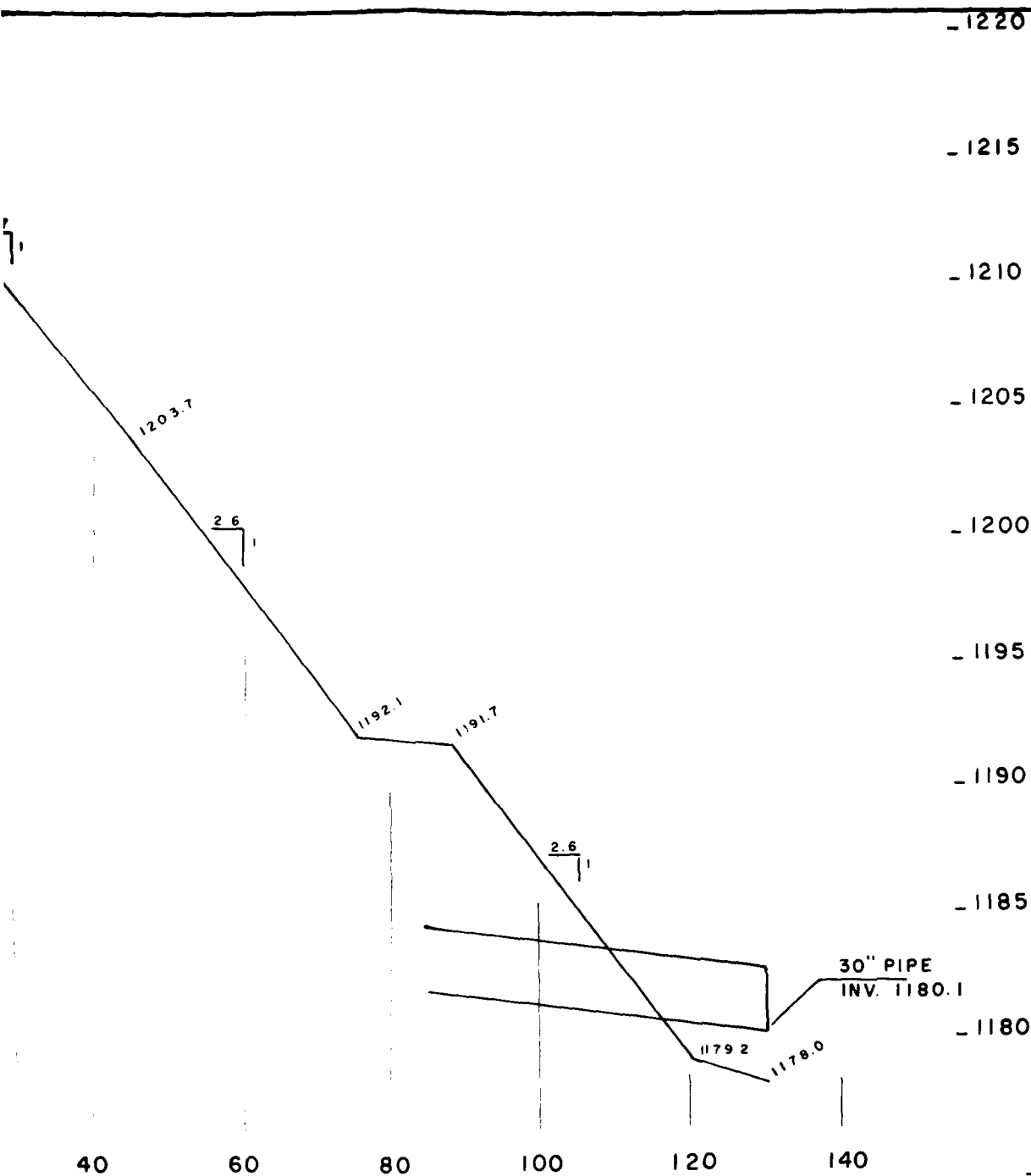
8" SLIDE GATE
INV. 1188.9



FILE



SECTION A-A STA 2+00



STA 2+00

SHEET 3 APPENDIX A

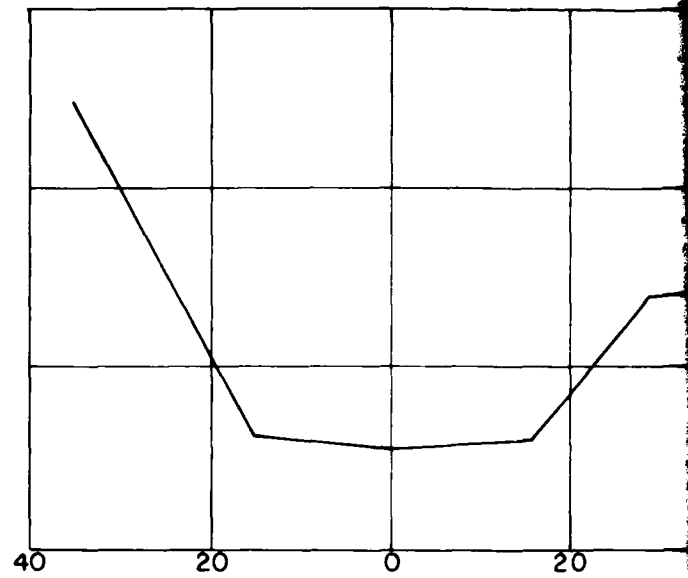
ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

CRANE STRUCTURE #1

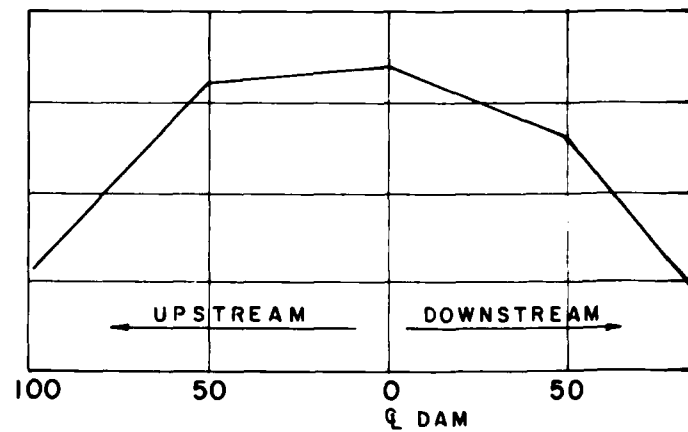
MO. No. 20509

PLAN & PROFILE

STONE COUNTY, MO.

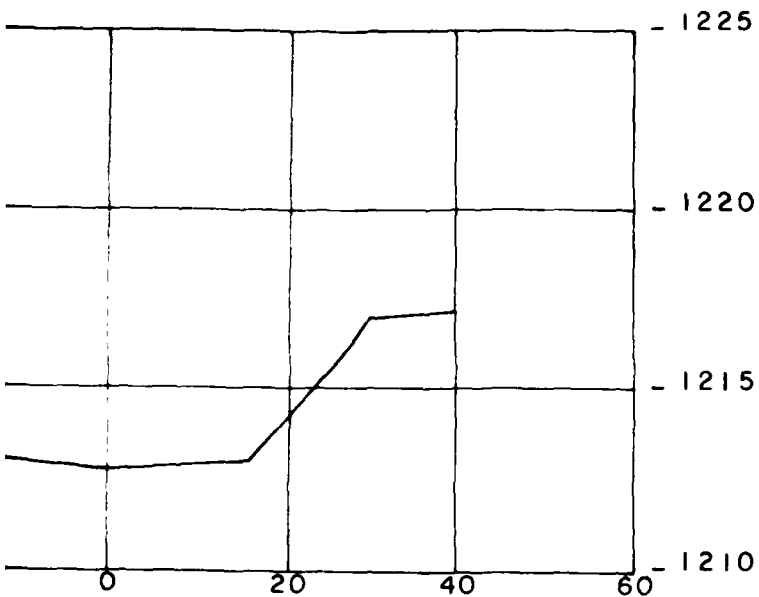


SPILLWAY SECTION C

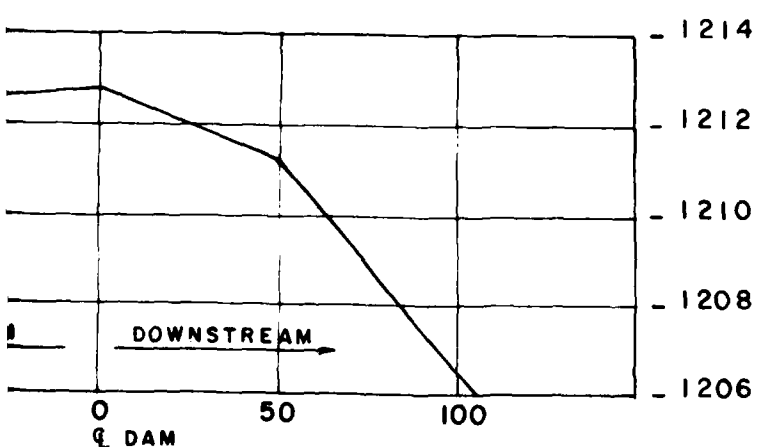


SPILLWAY PROFILE

1



SPILLWAY SECTION & DAM



SPILLWAY PROFILE

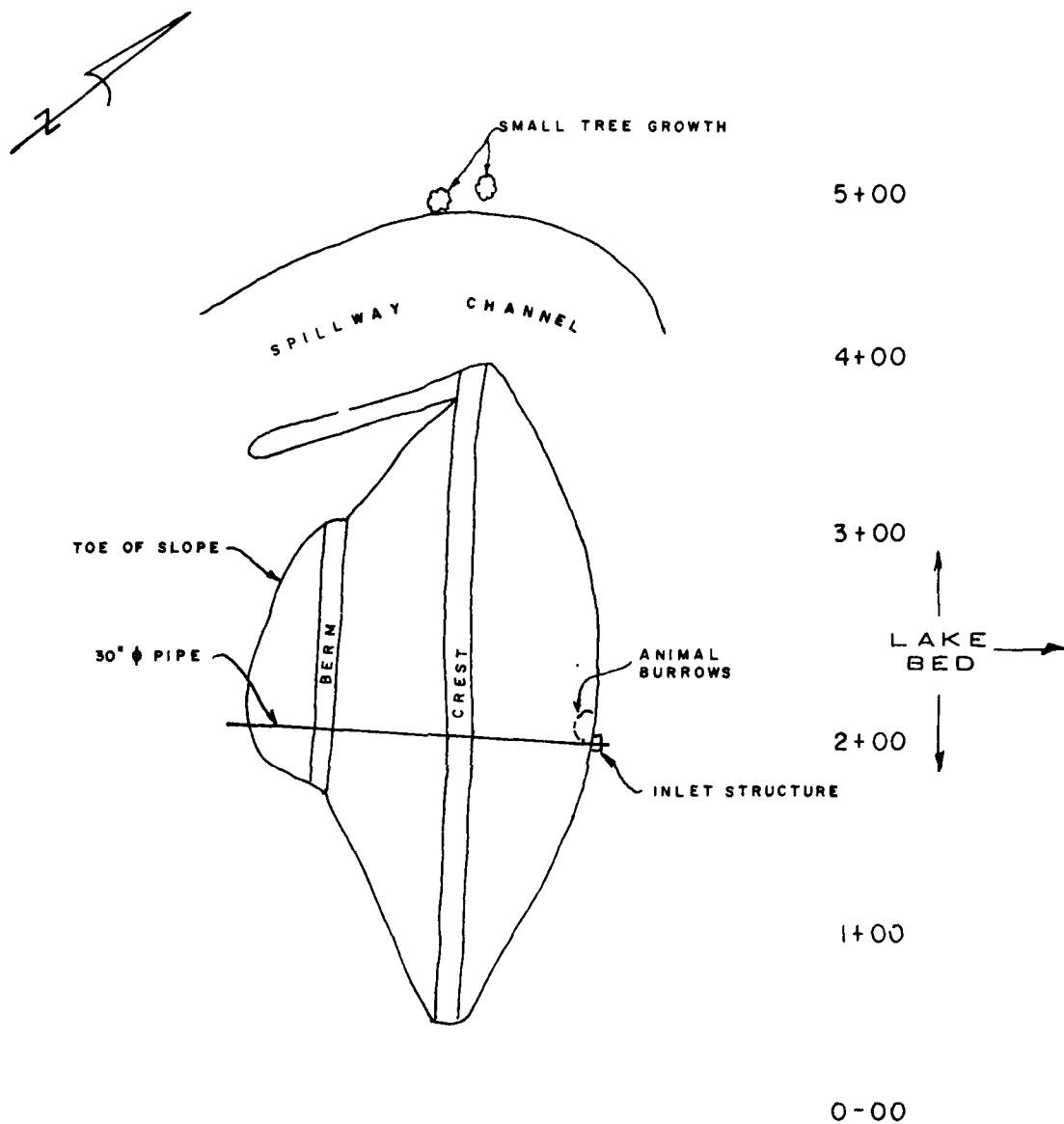
SHEET 3A APPENDIX A

ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

CRANE STRUCTURE #1

MO. No. 20509

SPILLWAY
SECTION & PROFILE
STONE COUNTY, MO.



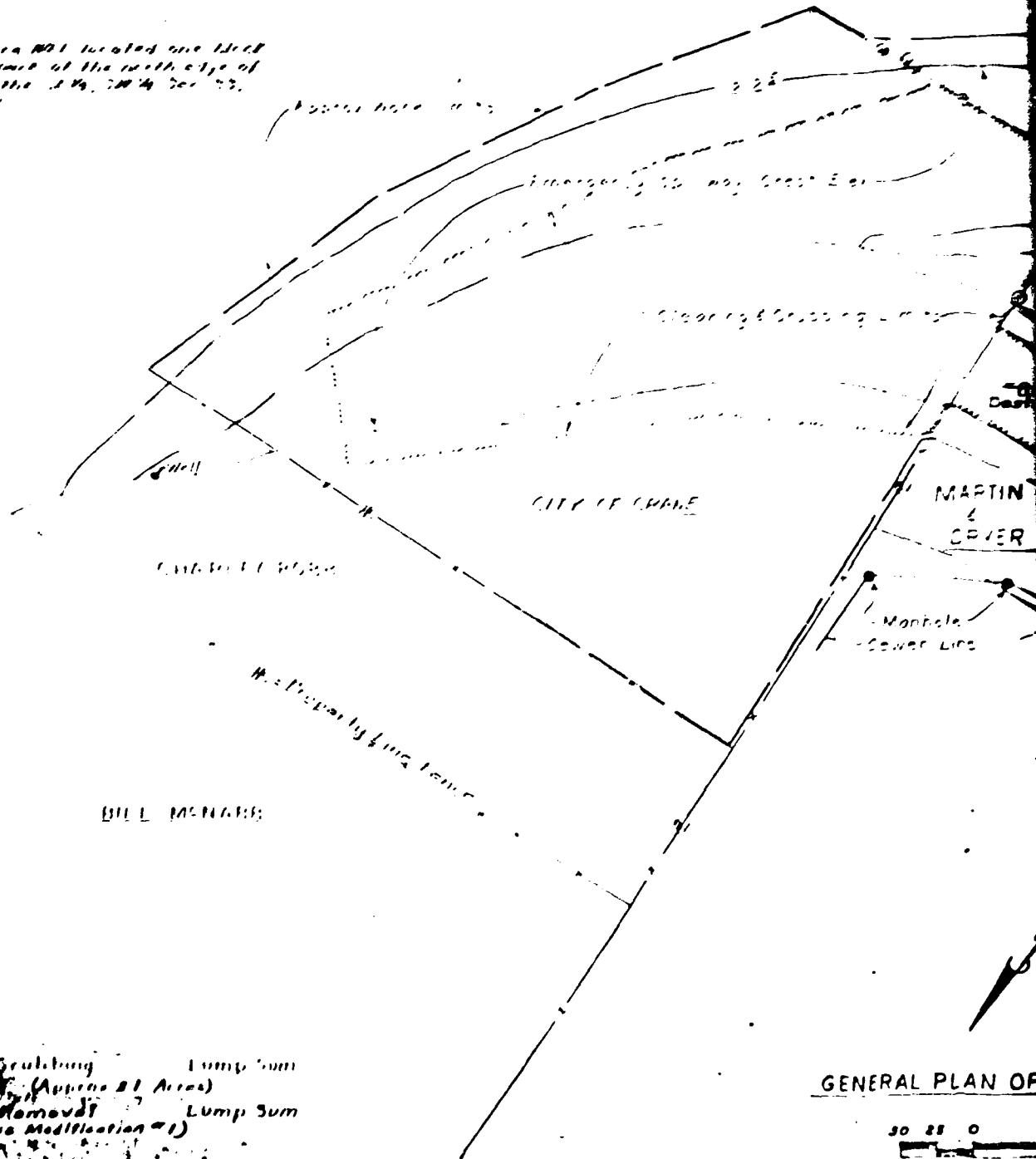
PLAN SKETCH OF DAM
 CRANE STRUCTURE No. 1
 MO. No. 20509

DATA TABLE

Side-slope Area, Acres	65
Segment Slope, Area Feet	12
Segment Slope, Area Feet	455
Segment Area, Acres	0.75
Segment Area, Acres	4.15

General Structure No. 1 located one block north of city limit at the north edge of Section No. 1 in the 1/4, 2nd 1/4 Sec 23, T 25 N, R 10 W

LEGEND
 Clearing and Grubbing
 Existing Fence
 Fence to be removed
 Existing Sewer Line with Manhole
 Sewer Line to be abandoned
 Egress - Egress Route
 Egress to be reserved by chart
 BIA #2 E12 1223 63
 Located Concrete Monument at Sta 0+00 & Dam.



QUANTITIES

Clearing and Grubbing	Lump Sum
(Appendix A1 Area)	
Segment Slope Removal	Lump Sum
(See Modification #1)	

GENERAL PLAN OF

30 25 0

Scale in

LEGEND

and Grubbing _____ C.C.C.

Fence _____

to Abandoned _____ ● ●

over L. 76 with Marhole _____ ●

to be Abandoned _____

Press Route _____

to be removed by C.C.C. _____

Elev. 1223.63

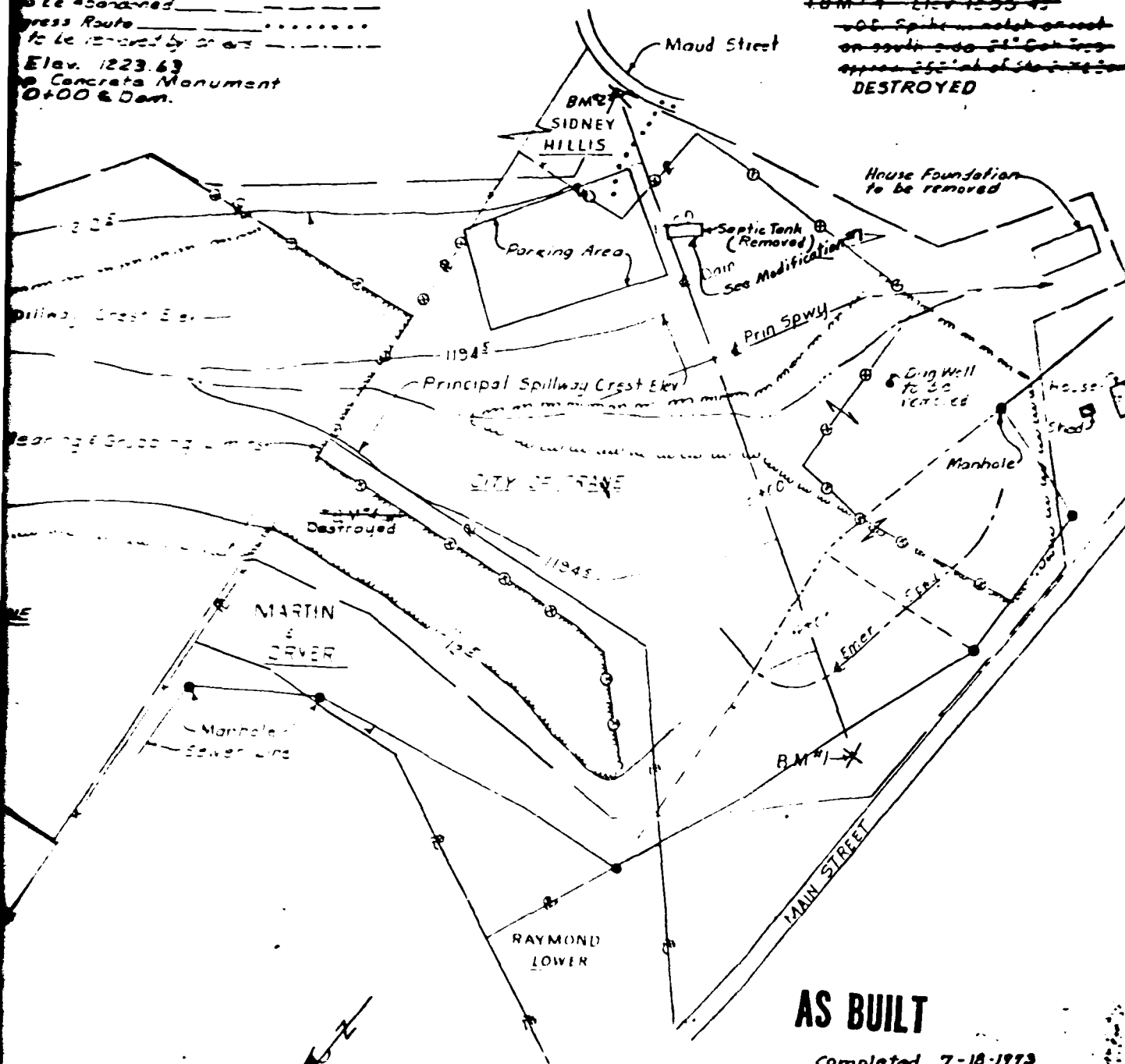
Concrete Monument

O+O & Dam.

B M #1 Elev. 1231.04
X on top Concrete Monument
at Sta. 4+99.28 & Dam.

~~FROM 4-15-55~~

DESTROYED



AS BUILT

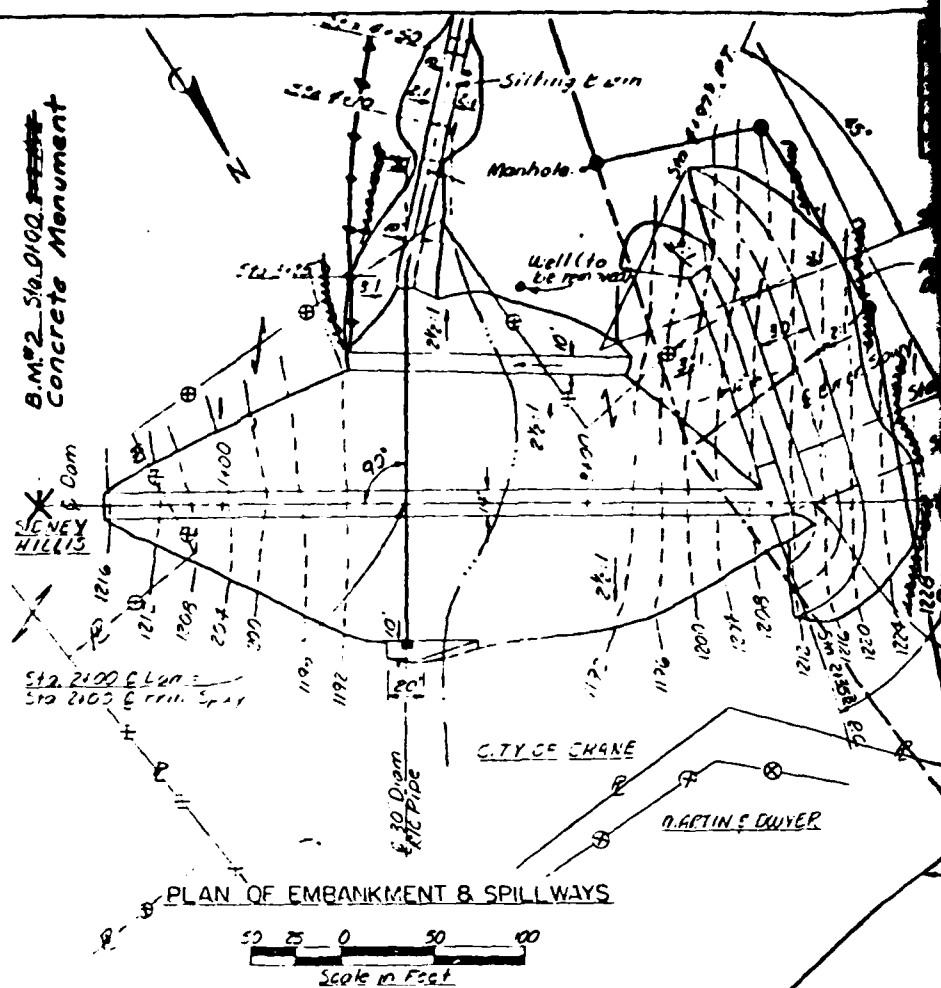
Completed 7-18-1973

GENERAL PLAN OF RESERVOIR

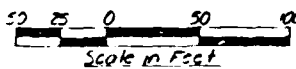


CRANE STRUCTURE NO. 1
SOUTHWEST MISSOURI RCBD PROJECT
STONE COUNTY, MISSOURI
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Sheet 5 of Appendix



PLAN OF EMBANKMENT & SPILLWAYS



NOTES

Protective Dike

Protective dikes to be constructed at the approx. locations shown. Dimensions shall be: 12' effective height, 3:1 side slopes, minimum base width 9'.

Topsoil

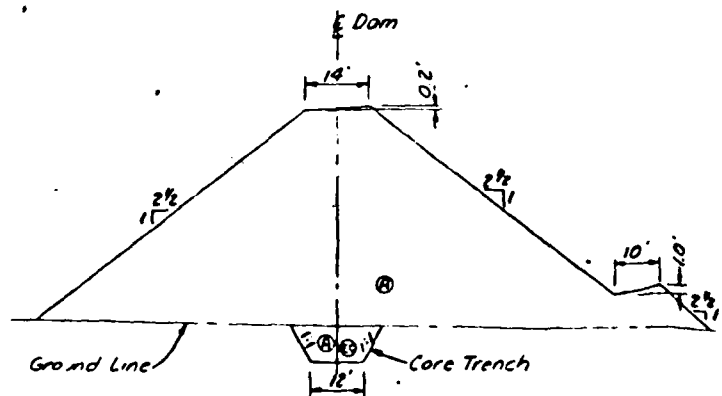
A minimum of six (6) inches topsoil to be placed on all compacted earth fill slopes and in the emergency spillway.

Waste Area

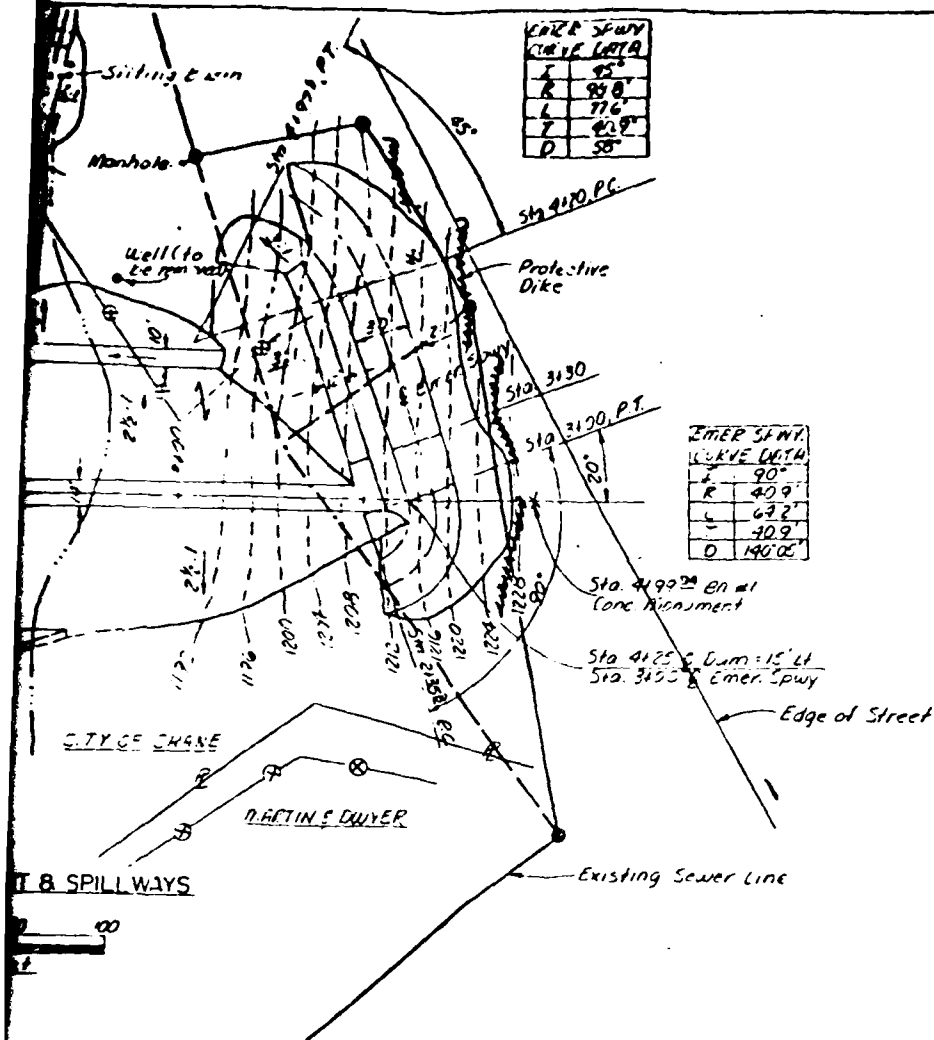
Waste area will be as shown or as directed by the Engineer.

Downstream Berm

Grade of downstream berm from approx. Sta. 1470 to 3130 +0.01. Control elevations at Sta. 2100 on Sheet 4.

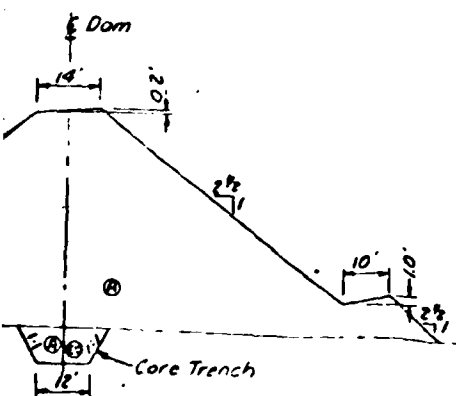


TYPICAL SECTION OF EMBANKMENT



EMER. SPWY. CURVE DATA	
I	25°
R	85.8'
L	77.6'
T	42.9'
D	58°

EMER. SPWY. CURVE DATA	
I	90°
R	40.9'
L	69.2'
T	40.9'
D	140°05'



CROSS SECTION OF EMBANKMENT

QUANTITIES		
Excavation, Common to:		
Sitting Easim.	247	Cu Yds.
Core Trench	3,058	Cu Yds.
Structure	152	Cu Yds.
Outlet Channel	187	Cu Yds.
Total	3,624	Cu Yds.
Earth Fill	31,320	Cu Yds.
Topsoil	1,767	Sq Yds.
Excavation Rock	03	Cu Yds.
(See Modification #2 & 3)		

AS BUILT

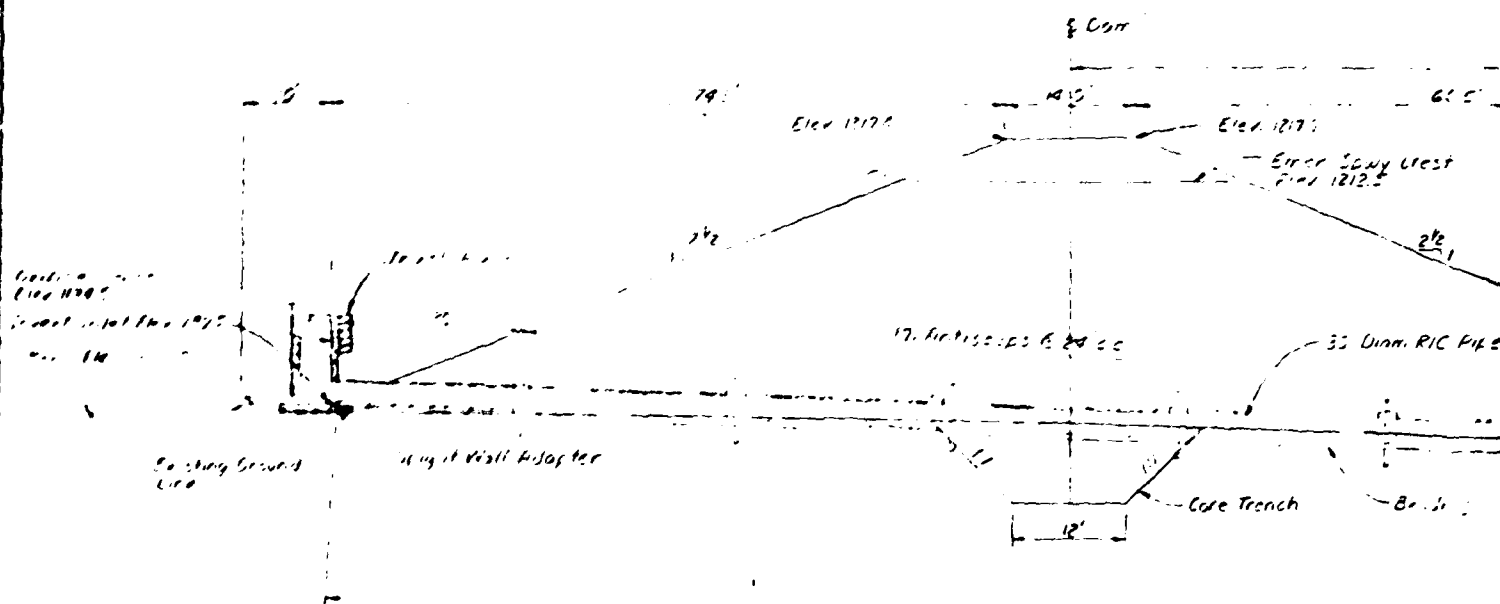
Completed 7-18-1973.

CRAVE STRUCTURE NO. 1
SOUTHWEST MISSOURI R.C.B.D. PROJECT
STONE COUNTY, MISSOURI

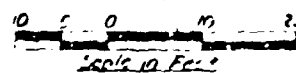
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed JAG, B.B.S.	5-71	Approved by	
Drawn MDH	5-71	Checked by	
Reviewed R.W.K., B.N.H.	5-71	Project No.	S.E.-28913

Sheet 6 of Appendix A



SECTION ON CENTERLINE

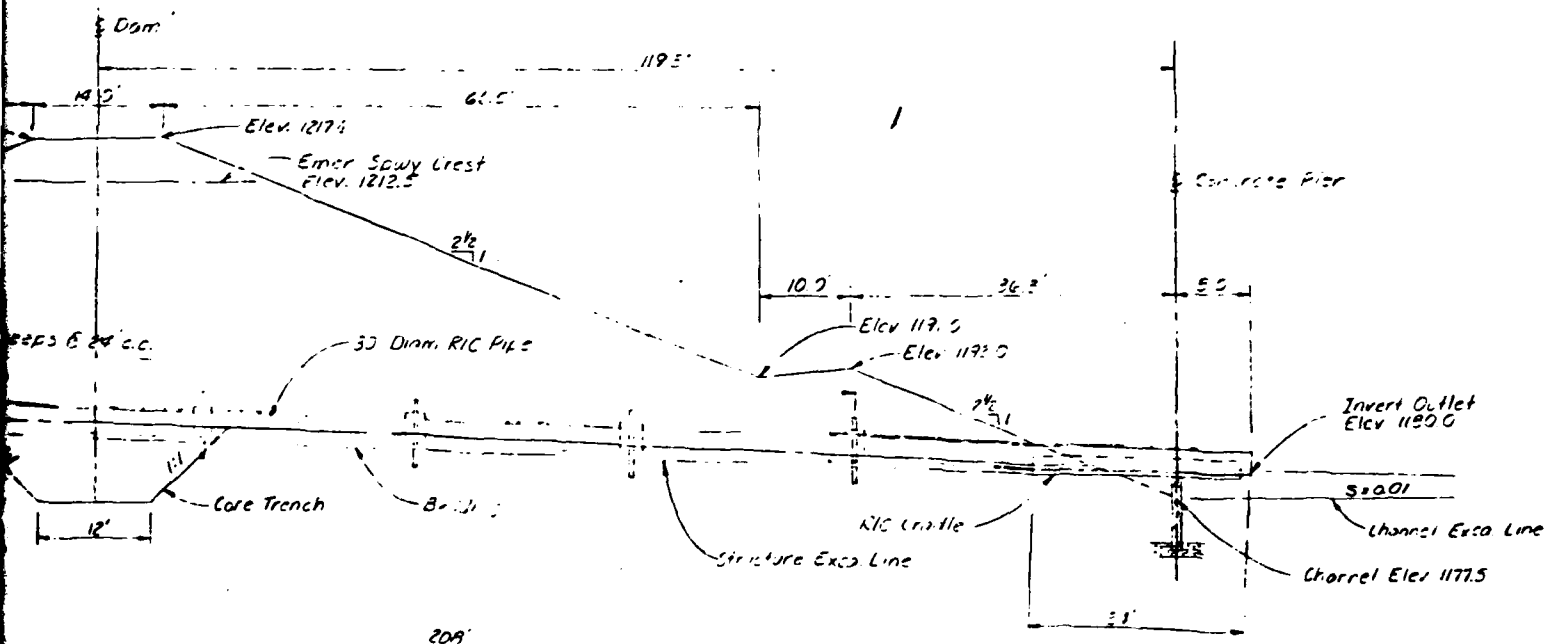


MATERIALS

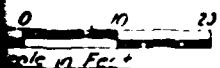
Concrete, Class 4000
 Steel Bar Reinforcement
 Pipe - Reinforced Concrete (Pressure), 30" Diam, Steel Ring Type Joint and Rubbs
 Aluminum Trash Rack
 Slide Gate - 8" Diam
 16 to 24 Gage Galvanized Metal, Pipe Joint Covering Strips
 (See Modification # 4)

NOTES:

- Conduit elevations other than those shown will be furnished by the Engineer, when required.
- Antiseep collars shall not be placed closer than two (2) feet to a pipe joint.



ON CENTERLINE



AS BUILT

Completed 7-18-1973
CRANE STRUCTURE NO. 1

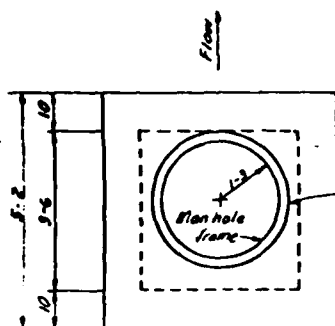
RESTRICTED FLOW INLET FOR 30" DIAM PIPE
GENERAL LAYOUT
SOUTHWEST MISSOURI R.C.B.D. PROJECT
STONE COUNTY, MISSOURI

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	RWK & BES	Date	5-71
Drawn	MDH	Date	5-71
Checked	RWK & NHR	Date	5-71
Approved		Date	5-71
Project	S.E.-23,919		

MATERIALS

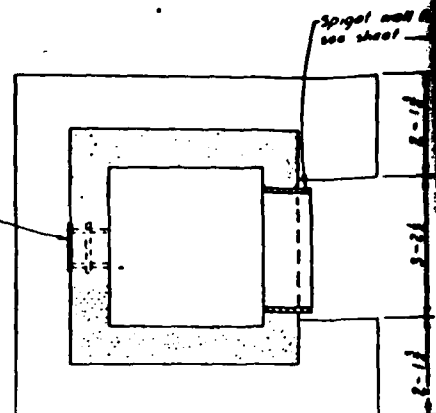
rel. 30' Diam. Steel Ring Type Joint and Rubber Gasket	44.3 Cu. Yds.
	2,925 Pounds
	208 Lin. Ft.
	Lump Sum
Steel Pipe Joint Covering Strips	1 Each
Modification # 4)	Lump Sum



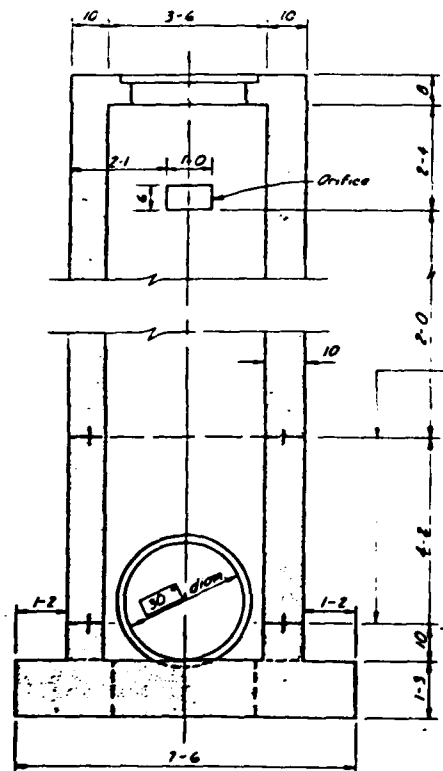
TOP PLAN

Medium duty cast iron or steel manhole frame and solid lid. The removable lid shall be attached to the frame by bolts or locking device.

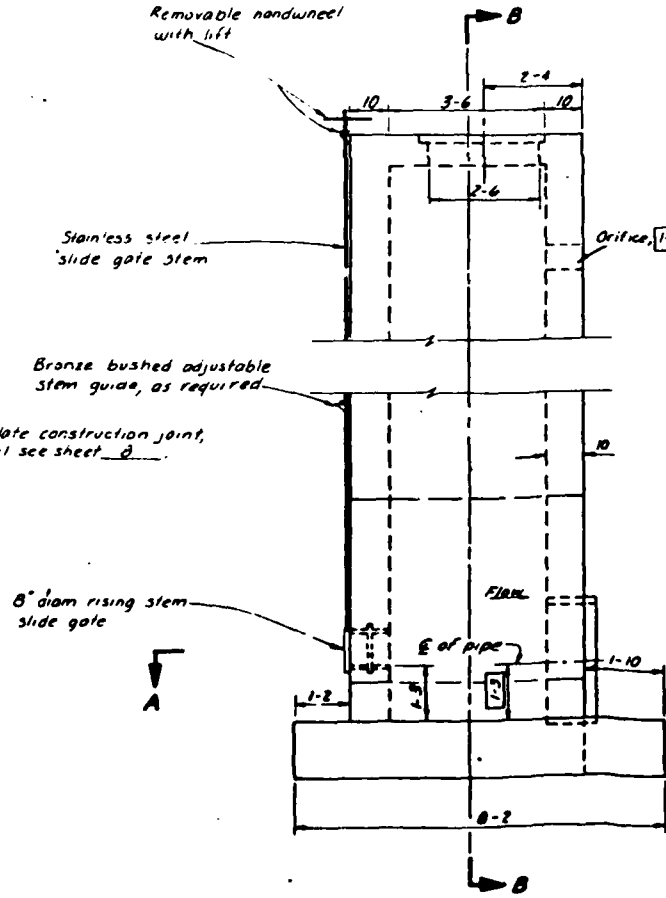
F type wall thimble, 8" diam, 10" long



SECTION A-A

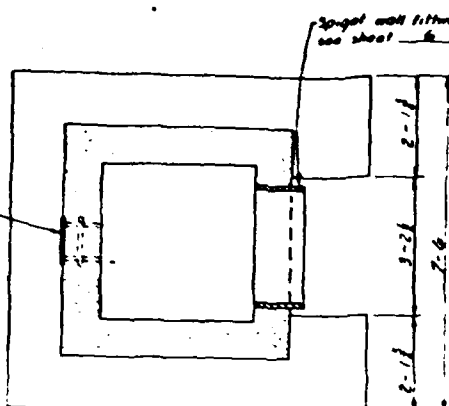


SECTION B-B



SIDEWALL ELEVATION

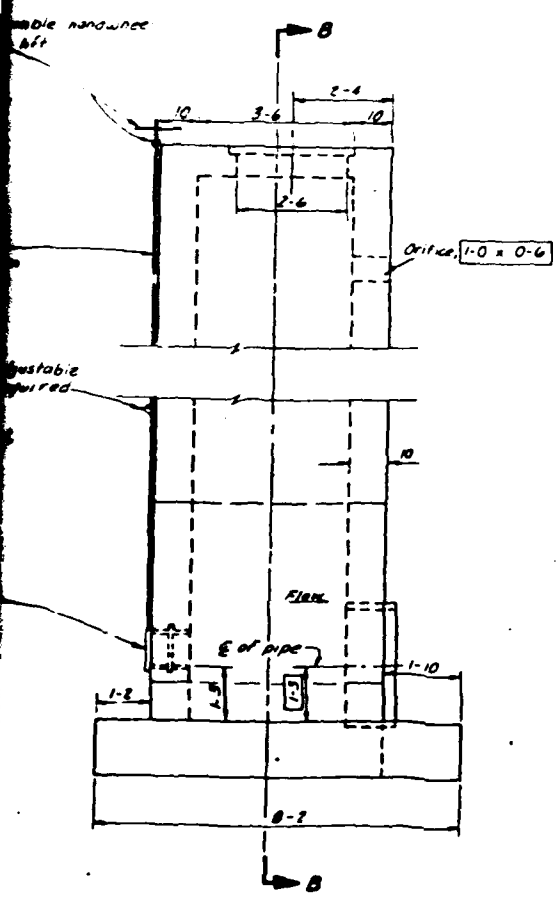
E B W P LINT - DESIGN SECTION LINCOLN, NEBRASKA
DRAWING NO. SE-0,000,225
DATE APPROVED JAN 6, 1970 REV 0-71
SHEET 1 OF 3



SECTION A-A

Note: Modify bedding shown on sheet 6, as required to fit between riser footing. Bedding and riser footing shall be separated by 1/4" bituminous type preformed expansion joint filler.

Notes:
1. Chamfer all exposed concrete edges 1/4".
2. For trash rack details, see sheet 10.



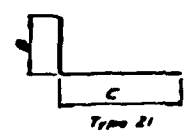
SIDEWALL ELEVATION

QUANTITIES

STEEL	
#4 BARS - 1030'-0" FT. - 888 LBS.	
#6 BARS - 381'-0" FT. - 377 LBS.	
#8 BARS - 56'-0" FT. - 84 LBS.	
TOTAL	1,400 LBS.
CONCRETE	8.0 CU. YDS.

BAR BENDS

Straight
Type 1



STEEL SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C
B1	5	8	7'-0"	56'-0"	1		
B2	5	8	7'-0"	56'-0"	1		
B3	5	6	7'-0"	42'-0"	1		
B4	5	5	6'-0"	30'-0"	1		
B5	6	7	7'-0"	49'-0"	1		
B6	6	8	1'-0"	7'-0"	1		
B7	5	6	7'-0"	42'-0"	1		
B8	5	5	6'-0"	30'-0"	1		
B9	8	12	10'-0"	120'-0"	21	3-5	7-C
B10	8	8	7'-0"	56'-0"	21	C-9	7-C
B11	8	3	5'-0"	15'-0"	1		
B12	8	16	7'-0"	112'-0"	21	C-9	6-B
B13	8	1	2'-3"	2'-3"	21	C-9	1-6
B14	8	3	6'-0"	18'-0"	1		
B15	8	2	5'-0"	10'-0"	21	C-9	3-3
B16	8	18	6'-0"	108'-0"	21	3-2	3-2
B17	8	20	6'-0"	120'-0"	1		
B18	8	8	6'-0"	48'-0"	21	1-3	3-3
B19	4	1	2'-6"	2'-6"	21	C-9	1-9
B20	4	1	4'-0"	4'-0"	1		
B21	4	1	4'-0"	4'-0"	1		
B22	4	2	1'-0"	2'-0"	1		
T1	4	32	6'-0"	192'-0"	21	3-3	3-3
T2	4	2	5'-0"	10'-0"	21	1-9	3-3
T3	5	10	8'-0"	80'-0"	21	3-3	4-9
T4	5	2	6'-0"	12'-0"	21	1-3	4-9
T5	5	4	5'-0"	20'-0"	21	C-9	4-9
T6	5	2	5'-0"	10'-0"	21	C-9	4-9
T7	5	1	2'-0"	2'-0"	21	C-9	2-3
T8	5	2	6'-0"	12'-0"	21	1-3	4-9
T9	5	1	5'-0"	5'-0"	21	1-0	4-9
T10	4	24	4'-3"	102'-0"	1		
T11	4	19	4'-9"	90'-3"	1		
T12	4	1	2'-0"	2'-0"	1		
T13	4	1	1'-0"	1'-0"	1		
T14	4	1	1'-0"	1'-0"	1		
T15	4	6	4'-3"	25'-0"	1		
T16	4	3	0'-6"	1'-6"	1		
T17	4	4	0'-9"	3'-0"	1		
T18	4	2	1'-3"	2'-6"	1		
T19	4	3	1'-0"	3'-0"	1		

AS BUILT

Scale in feet
Completed 7-18-1973
CRANE STRUCTURE NO. 1

R/C RESTRICTED FLOW RISER
FOR 30" DIAM. R/C PIPE
SOUTHWEST MISSOURI R.C.B.D. PROJECT
STONE COUNTY, MISSOURI

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed: B.E.S.	U-71	Approved by:	
Drawn: M.D.H.	11-71	Checked:	
Revised:		Revised:	
Checked: R.W.K. & N.H.R.	11-71	Revised:	

STRUCTURE DATA

Class of Structure "C" Floodwater Retarding

Drainage Area (total) 60 Ac. .094 Sq.Mi.

(uncontrolled) 60 Ac. .094 Sq.Mi.

Time of Concentration 0.20 Hours

Soil Cover Complex Number 70 For A.M.C. II

*Sediment Capacity Available 3.2 Ac.Ft. below Elev. 1194.5

Total Sediment Capacity Available 3.2 Ac.Ft.

Capacity Equivalents (Vol.) 0.64 In.

Retarding Capacity Provided 40.0 Ac.Ft.

Capacity Equivalents (Vol.) 8.00 In.

Water Supply Provided None Ac.Ft.-Identify Uses

* 100 yr. Sediment Elev.

Principal Spillway:

Maximum Capacity (low stage) 10 c.f.s.

~~Maximum Capacity (high stage) _____ c.f.s.~~

10 Day Drawdown Elev. 1194.5

Emergency Spillway:

Percent Chance Use 1 Storm Duration 6 Hrs.

Type Veg. Earth "n" Value Used 0.04

Emergency Spillway Hydrograph for Class C Structures

Rainfall 11.90 in.

Runoff 7.95 in.

Peak Inflow 381 c.f.s.

Maximum Discharge - Emergency Spillway 0 c.f.s.

Maximum Water Surface Elev. 1211.49

Velocity of Flow (Ve) _____ f.p.s.

Supplementary Data and Special Design Features:

Principal Spillway Crest Elev. 1194.5

Emergency Spillway Crest Elev. 1212.5

Settled Top of Dam Elev. 1216.5

Emergency Spillway Bottom Width 30'

Freeboard

Rainfa

Runoff

Peak I

Maximu

Maximu

1220

Elevations

1210

1200

1190

1180

Supplement

Special De

Height x St

STRUCTURE DATA

Freeboard Hydrograph for Class C Structures

Rainfall 28.7 in.

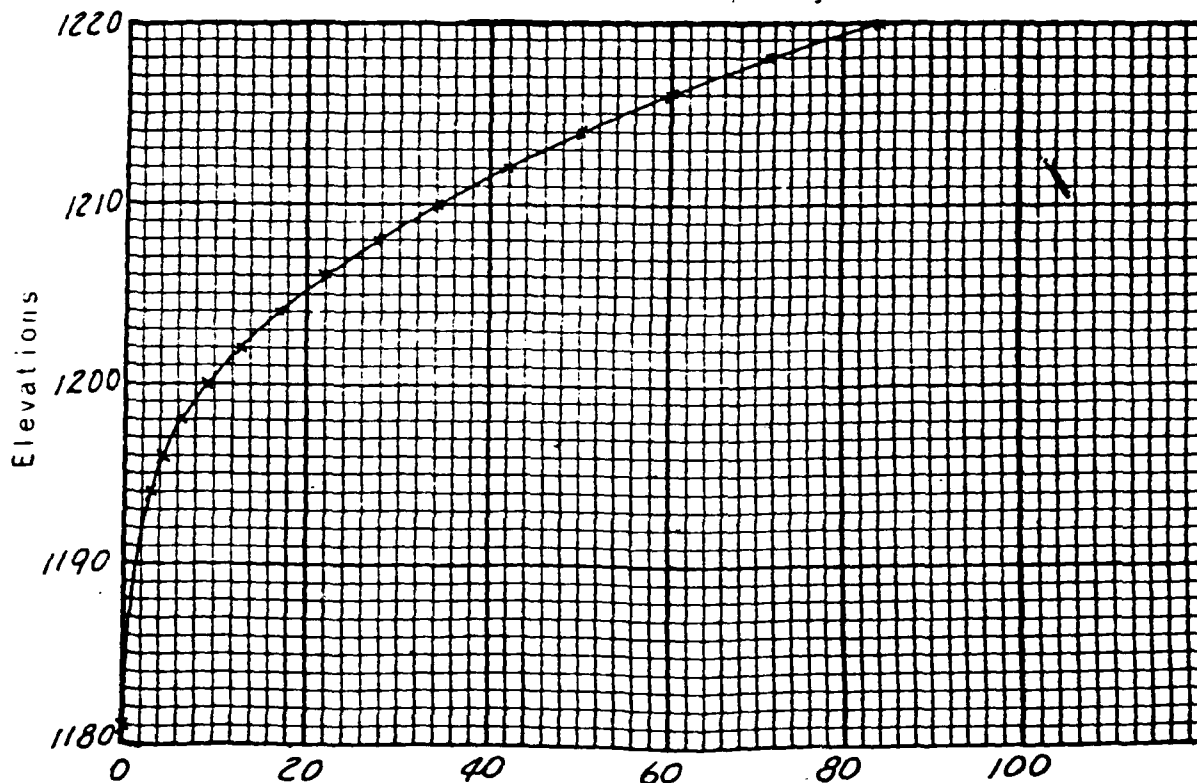
Runoff 24.12 in.

Peak Inflow 1,115 c.f.s.

Maximum Discharge - Emergency Spillway 556 c.f.s.

Maximum Water Surface Elev. 1216.14

Reservoir Capacity



Total Storage - Ac.Ft.

7-18-1973
AS BUILT

Supplementary Data and
Special Design Features:

Height x Storage = $31.1 \times 43.2 = 1,344$

CRANE STRUCTURE NO. 1			
SOUTHWEST MISSOURI RC&D PROJECT			
STONE COUNTY, MISSOURI			
U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE			
Designed	JAG & B.E.S.	Date	1971
Drawn	B.E.S.	Date	5-71
Traced		Date	
Checked	R.W.K. & N.H.P. 6-71	Date	5, E-29, 919-H

Sheet 9 of Appendix A

RC&D

PROJECT SOUTHWEST MISSOURI RC&D

COUNTY STONE

CRANE FLOOD PREVENTION (Site 1)

DATE WORK COMPLETED: 1973

[illegible]

Carl Wehner

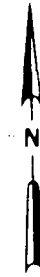
17-11-75

Yours Obedient

Original and 2 copies to AC - 1 copy in Field Office File
AC send original to SAO and retain 1 copy

APPENDIX B

Geology and Soils



LEGEND

GLACIATED
PLAINS



WESTERN
PLAINS



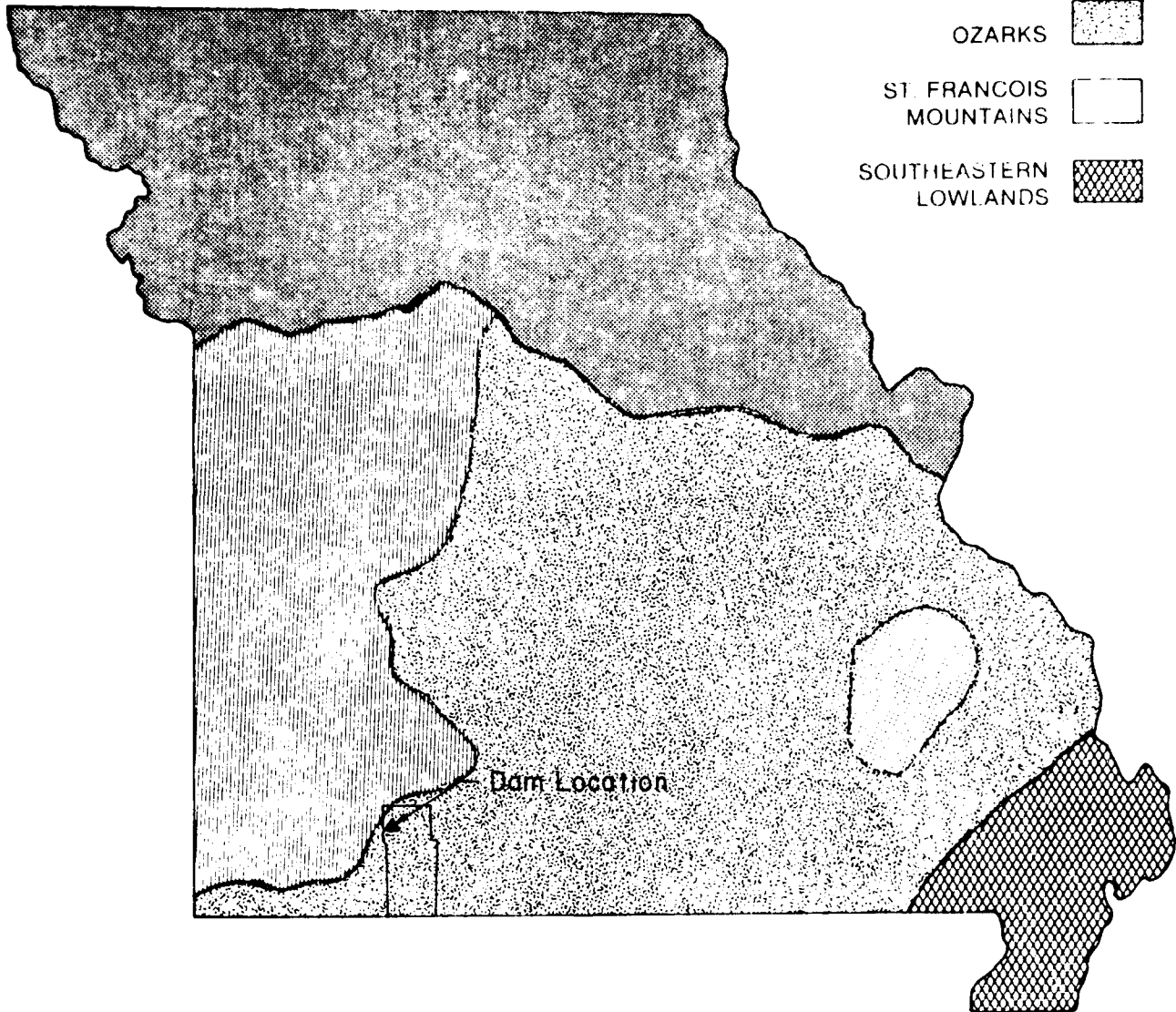
OZARKS



ST. FRANCOIS
MOUNTAINS



SOUTHEASTERN
LOWLANDS



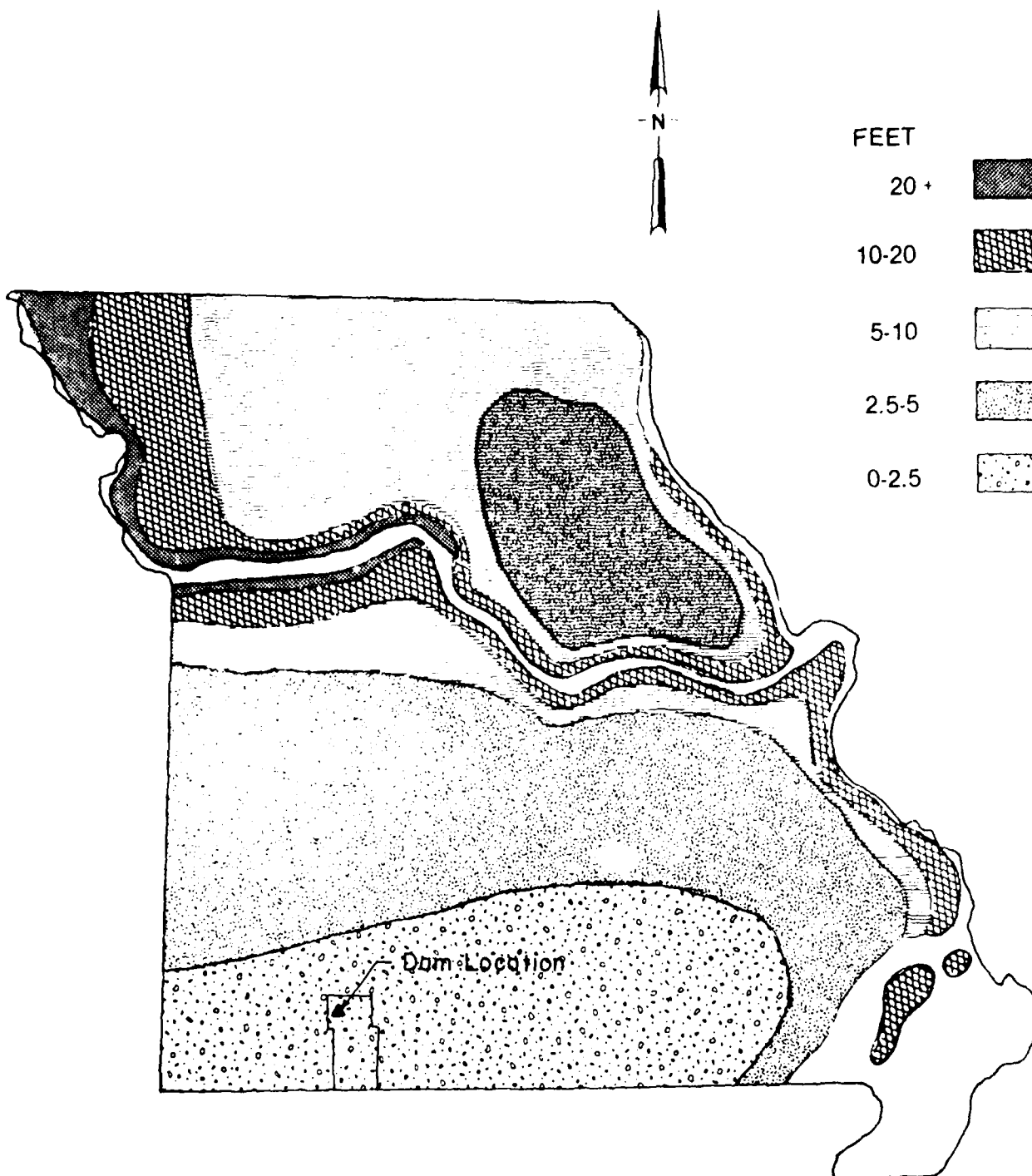
MAJOR GEOLOGIC REGIONS OF MISSOURI



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Crane Structure #1
Stone County, Missouri
Mo. I.D. No. 20509

SHEET 1, APPENDIX B



THICKNESS OF LOESSIAL DEPOSITS



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Crane Structure #1
Stone County, Missouri
Mo. I.D. No. 20509

SHEET 2, APPENDIX B

3. ~~on top of bronze cap on Concrete Monument~~
~~set flush with ground at Sta 4+50 ²⁰ ± Dam.~~

Destroyed

Structure #1 located 2 blocks north of the city park
at the north edge of Crane, Mo. in the
S. E. $\frac{1}{4}$ of the S.W. $\frac{1}{4}$ of Section 33,
T. 25 N., R. 24 W.

NOTE:

Borrow shall not be taken within 50 feet of the toe of fill slopes. All borrow slopes shall be 2:1 unless otherwise specified.

Principal southern Crest Elev.

Emergency Spillway Crest Elev.

PLAN OF DAM EMERGENCY SPILLWAY AND BORROW AREA (S)

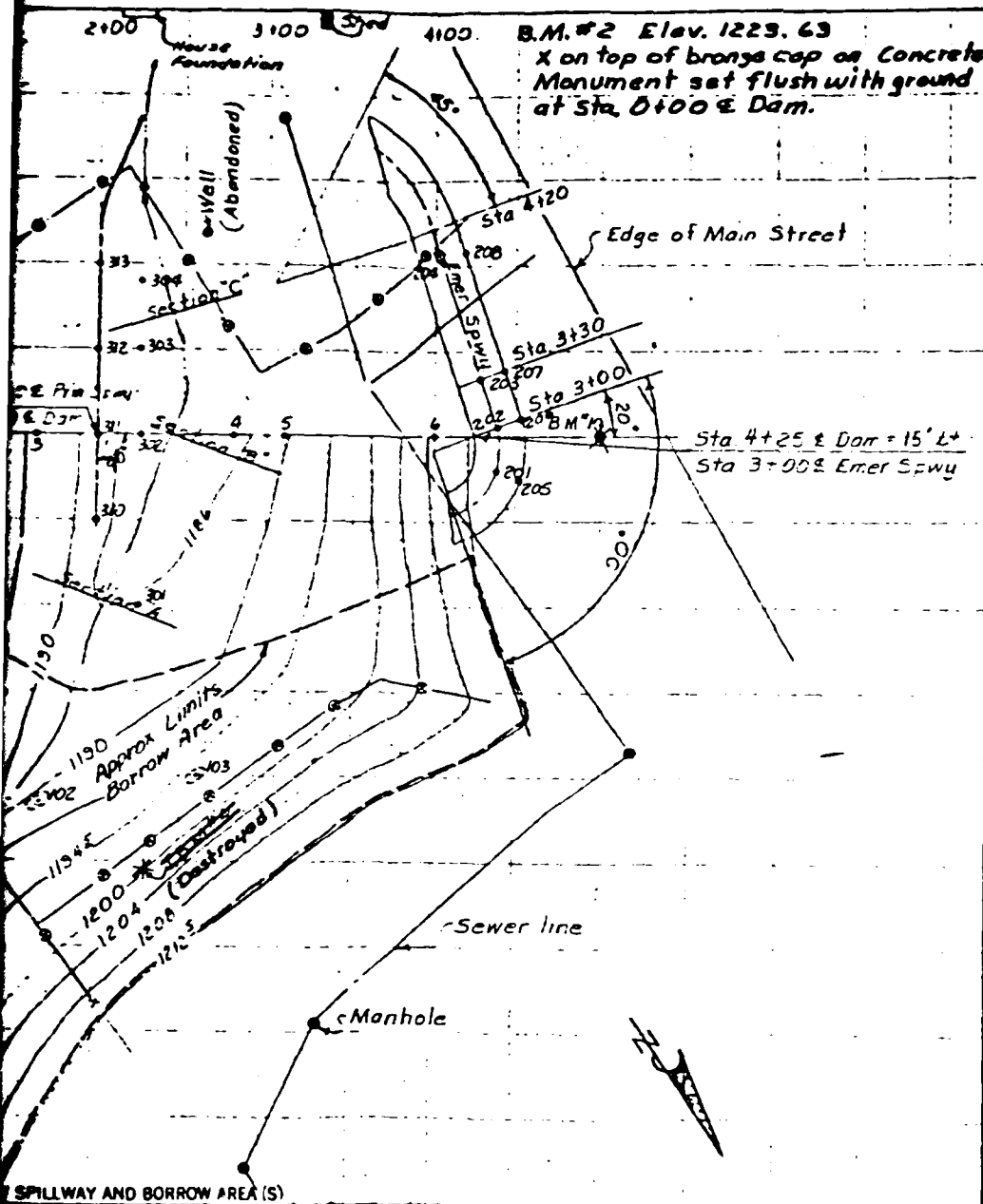
**-Approx. Limits
Borrow Area-**

Sta. 2160
Grid B100

103
66
2

Note: The Soil Class made by the
cases, agree
mechanics
for further

GEOLOGIC CROSS SECTIONS OF BORROW AREA (S)



LEGEND

SYMBOLS

UNCONSOLIDATED MATERIAL

Gravel, sand, silt, clay, etc.

CONSOLIDATED MATERIAL

Sedimentary Rocks

Conglomerate, sandstone, shale, limestone, etc.

Metamorphic Rocks

Gneiss, schist, marble, etc.

Igneous Rocks

Granite, diorite, etc.

Other Symbols

● hole logged only
○ hole sampled
— strike and dip
— pit or trench

ABBREVIATIONS

ang. angular	lam. laminated	G. gravel, gravelly
bd. boulders (> 12")	loam. loam	S. sand, sandy
calc. calcareous	med. medium	M. silt, silty
cal. caliche	mic. micaceous	C. clay, clayey
cml. cemented	mod. moderately	O. organic
cls. coarse	n.r. no recovery	W. well graded
clb. cobbles (3"-12")	per. permeable	P. poorly graded
cpt. compact	po. poorly	
con. concretions	rd. rounded	
cr. crystalline	sl. slightly	
ds. dense	st. soft	
dp. dipping	st. some	
d.s. downstream	st. slowly	
fm. fine	st. stiff	
fr. fractured	tb. thin-bedded	
frg. fragments	tu. tuffaceous	
fr. friable	u.s. upstream	
gr. grain	var. variable	
gsp. gypsiferous	v. very	
hd. hard	w. with	
h. highly	we. weathered	
	w.l. (date) static water level	

TEST HOLE NUMBERING SYSTEM

Centerline of dam	1 - 99	Stream channel	401 - 499
Borrow area	101 - 199	Relief walls	501 - 599
Emergency spillway	201 - 299		601 - 699
Centerline of outlet structure	301 - 399		701 - 799

UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOLS

GW	Well graded gravels, gravel-sand mixtures
GP	Poorly graded gravels
GM	Silty gravels, gravel sand-silt mixtures
GC	Clayey gravels, gravel sand-clay mixtures
SW	Well graded sands, sand-gravel mixtures
SP	Poorly graded sands
SM	Silty sand
SC	Clayey sands, sand-clay mixtures
ML	Silts with liquid limit of 50 or less
MH	Silts with liquid limit above 50
CL	Clays with liquid limit of 50 or less
CH	Clays with liquid limit above 50
OL	Organic silts and clays with liquid limit of 50 or less
OH	Organic silts and clays with liquid limit above 50

AS BUILT Completed 7-18-1973

CROSS SECTIONS PLAN AND PROFILES FOR GEOLOGIC INVESTIGATIONS

CRANE STRUCTURE NO. 1

SOUTHWEST MISSOURI ROAD PROJECT

STONE COUNTY MISSOURI

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

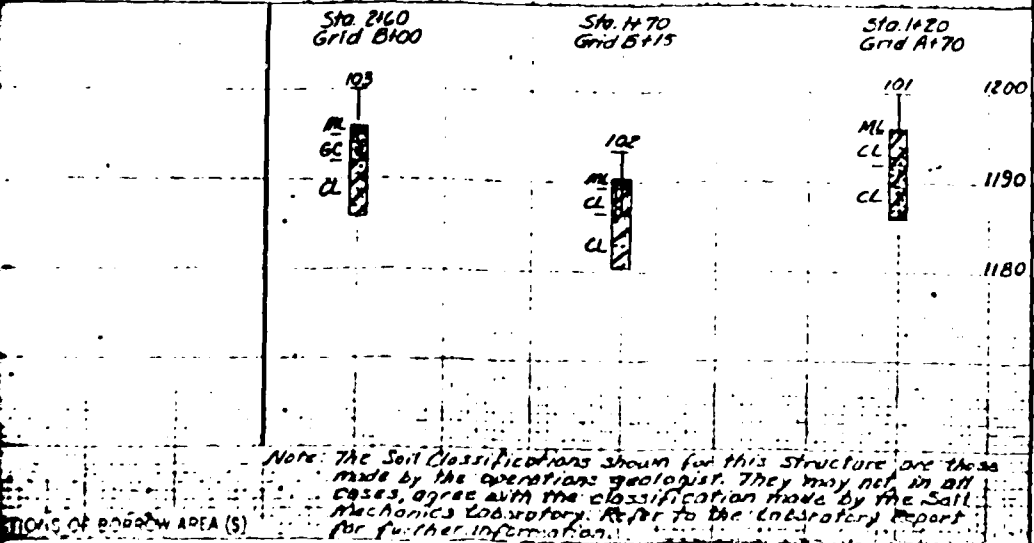
Investigated by: N.F. Edmonds 4-71

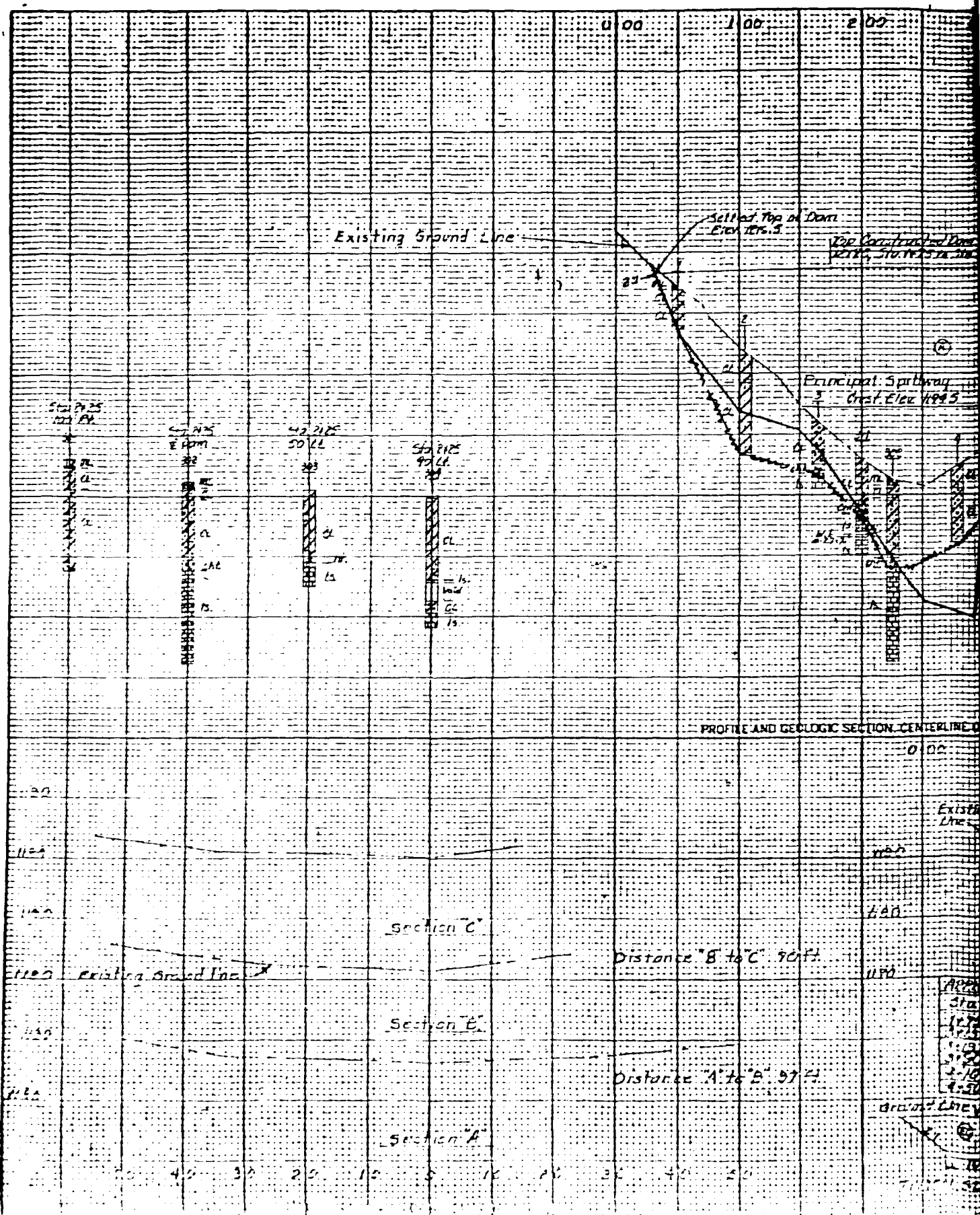
Checked by: B.W. B.N.H.R. 6-71

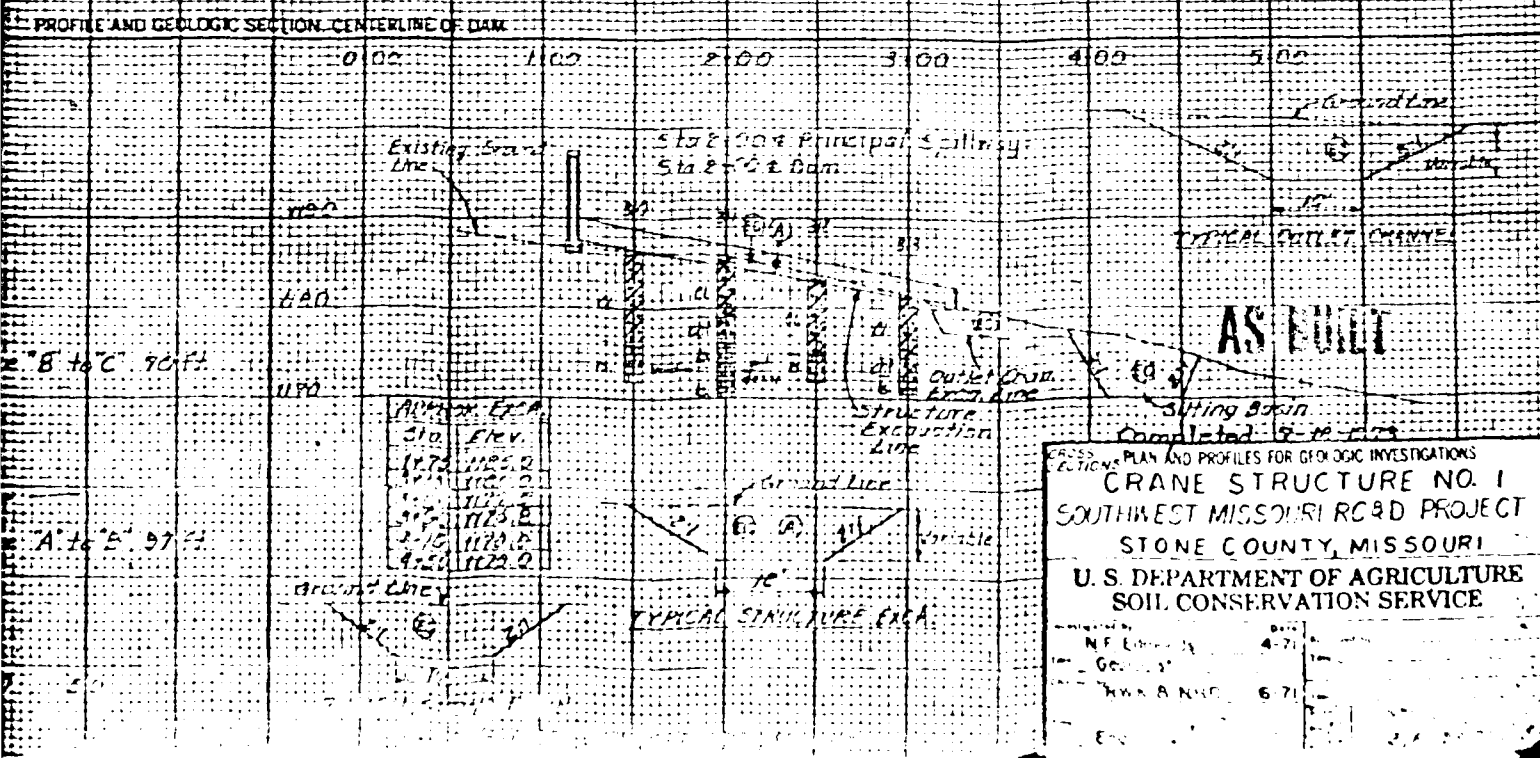
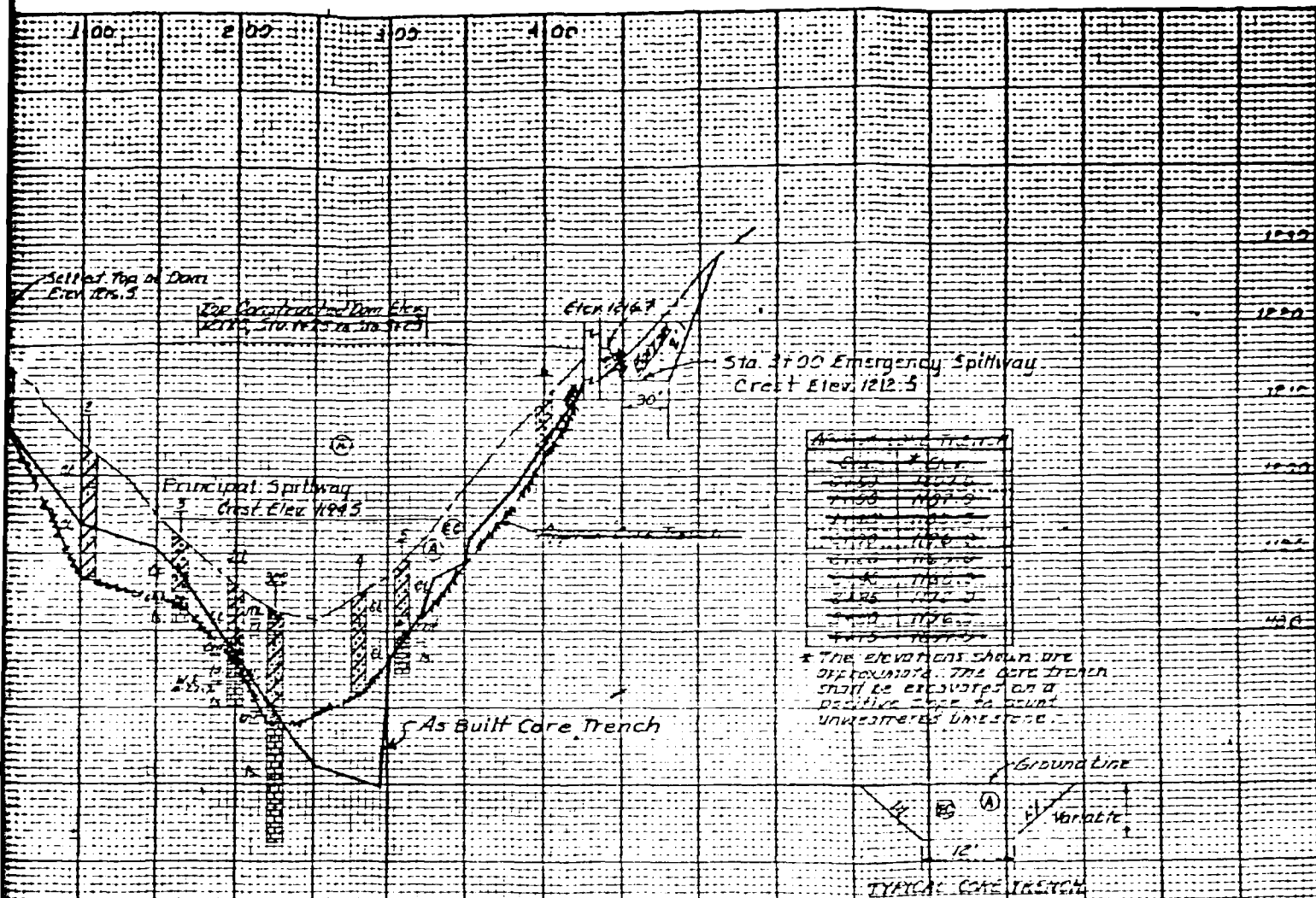
Engineer: 12-71

Approved: 5,8-29,5,9

Note: The Soil Classifications shown for this structure are those made by the operations geologist. They may not in all cases, agree with the classification made by the Soil Mechanics Laboratory. Refer to the Laboratory Report for further information.







CROSS SECTIONS PLAN AND PROFILES FOR GEOLOGIC INVESTIGATIONS
 CRANE STRUCTURE NO. 1
 SOUTHWEST MISSOURI RCD PROJECT
 STONE COUNTY, MISSOURI
 U. S. DEPARTMENT OF AGRICULTURE
 SOIL CONSERVATION SERVICE

Investigated by
 NF L... 4-71
 G...
 HWA AND 6-71

10-59

DETAILED GEOLOGIC INVESTIGATION OF DAM SITES

GENERAL

State Missouri County Stone SE $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 33 T. 25N R. 24W Watershed SW RC&D
Subwatershed _____ Fund class 6002 Site number Crane Site group I Structure class C
(FP-2, WP-1, etc.)
Investigated by [Signature] Equipment used Falling 1500 Date 4/28/71
(signature and title) (Type, size, make, model, etc.)

SITE DATA

Drainage area size _____ sq. mi. 60 acres. Type of structure 30" RC DI Purpose Flood Prevention
Direction of valley trend (downstream) S Maximum height of fill 35 feet. Length of fill 390 feet.
Estimated volume of compacted fill required 27,000 yards

STORAGE ALLOCATION

	Volume (ac. ft.)	Surface Area (acres)	Depth at Dam (feet)
Sediment	<u>1.3</u>	<u>.75</u>	<u>13</u>
Floodwater	<u>40</u>	<u>4.1</u>	<u>31</u>

SURFACE GEOLOGY AND PHYSIOGRAPHY

Physiographic description Ozark Highland Topography Rolling Attitude of beds: Dip -- Strike --
Slopes of abutments: Left 20 percent; Right 23 percent. Width of floodplain at centerline of dam 0 feet
General geology of site: The site is located in National Soil Resource Area 116, The Ozark Highlands. Shallow cherty residual permeable overburden overlies the Burlington limestones of the Mississippian System.

DETAILED GEOLOGIC INVESTIGATION OF DAM SITES

FEATURE E Dam, Principal Spillway, Emergency Spillway, Borrow Area

(CENTERLINE OF DAM, PRINCIPAL SPILLWAY, EMERGENCY SPILLWAY, THE STREAM CHANNEL, INVESTIGATIONS FOR DRAINAGE OF STRUCTURE, BORROW AREA, RESERVOIR BASIN, ETC.)

DRILLING PROGRAM

NUMBER OF SAMPLES TAKEN

EQUIPMENT USED	NUMBER OF HOLES		UNDISTURBED (STATE TYPE)	DISTURBED	
	EXPLORATION	SAMPLING		LARGE	SMALL
FA - 5' Flight Auger	13				
Rb - Tricone rock bit	9				
Backhoe		3		7 bags	
TOTAL	22	3		7	

SUMMARY OF FINDINGS
(INCLUDE ONLY FACTUAL DATA)

The overburden of the abutments is cherty residual clay classified as gravelly CL. The chert fragments occur throughout the soil material and range in size from gravel to cobbles. The depth to sound bedrock ranges from 7 to 17 feet on the left abutment and from 7 to 10.5 feet on the right abutment. The overburden of the valley floor is gravelly alluvium over the cherty residuum. Bedrock occurs at 13 to 14.5 feet. The overburden in the foundation area is permeable. There was no groundwater level at the time of the investigation.

The principal spillway location at station 2+00 centerline dam has a relatively uniform bedrock surface profile occurring at depths of 7 to 10 feet beneath residual clay overburden.

The emergency spillway cuts are shallow and will be in the residual overburden except at the locations of test holes 201, 205, and 208 where refusal occurred on bedrock one to two feet above the proposed finished gradeline.

Borrow material available is the residual cherty clay and the gravelly clay alluvium. Samples taken are representative of the material available at the site.

DETAILED GEOLOGIC INVESTIGATION OF DAM SITES

WATERSHED Crane		SUBWATERSHED		COUNTY St. Louis	STATE Missouri
SITE NO. 1	SITE GROUP 2	STRUCTURE CLASS C		INVESTIGATED BY: (SIGNATURE OF GEOLOGIST)	DATE

INTERPRETATIONS AND CONCLUSIONS

Foundation

The overburden of the valley floor and lower slopes is permeable. In test holes advanced with a tricone roller bit, some water loss occurred at depths of 3 to 5 feet. Recovery was easy with the use of bentonite. In the zone just above what is indicated as the firm bedrock surface, water loss was instant and exceeded the pump capacity of an estimated 80 to 90 gallons per minute. This zone is believed to be weathered limestone and/or chert with clay except in test holes 304 and 311 where voids, as indicated by bit drops, occurred below what was believed to be sound limestone. In test hole 302 there was no water loss into the bedrock with pressures applied which were equivalent to the head at the emergency spillway crest elevation. Other test holes were advanced 2 to 4 feet into the sound rock. Representative foundation samples could not be obtained with equipment available. Borrow samples obtained with the backhoe are believed to be representative of the material which occurs in the foundation area. There is no groundwater level in the soil material at the site.

Principal Spillway

Further investigation was made to relocate the principal spillway after the void was encountered in the test hole for the pier on the original spillway location at station 2+25 centerline of the dam. The location of station 2+00 has a relatively uniform bedrock surface profile and the overburden consists of the cherty residual clay. This material is slightly moist to moist and stiff in place. Strength and consolidation is not questionable. The permeable zone just above sound bedrock is expected to occur along the foundation area of this location.

Emergency Spillway

The tricone roller bit was used to determine the type of rock encountered in test hole 207. All other refusals with the auger are believed to be sound rock.

Borrow Material

Borrow samples submitted are believed to be representative of the residual cherty clay and the gravelly textured alluvium which overlies the residuum of the valley floor. There is approximately .5 to 1 foot of topsoil which is classified as a gravelly ML in the foundation and borrow areas. The chert fragments range in size from gravel to cobbles. They are weathered and brittle and are expected to break down during borrowing operations and placement.

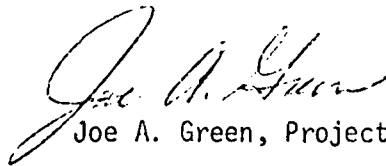
Channel

The channel is slight to non-existent throughout the drainage area. No channel deposits as such are present.

ENGINEER'S REPORT

SITE NO. 1 CRANE

1. STREAM CHANNEL - Stripping and foundation preparation should eliminate all the stream channel cleanout needed.
2. DEPTH OF CORE - Due to class of structure it is recommended the core be cut to firm bedrock the entire length of the dam to emergency crest elevation with 2:1 approaches above emergency spillway elevation. Core trench excavation with 10 ft. bottom width and 1:1 side slopes will be approximately 3,600 cubic yards.
3. UNDESIRABLE MATERIAL - There appears to be no undesirable material in the foundation area that needs to be removed other than normal stripping removal.
4. MATERIALS - Excavations from core trench and emergency spillway can be used as fill material. Excavation of bedrock in emergency spillway is considered insignificant. Borrow material should be obtained from below the 1204 contour. Approximately 30,000 cubic yards can be obtained by excavating 10 ft. deep with 2:1 side slopes below the 1204 contour.
5. CONDUIT - Due to class structure conduit will be reinforced 30 inch concrete pipe. To obtain more uniform bedrock location the structure was relocated to station 2+00 centerline dam.
6. DRAINAGE - If core trench is excavated to sound bedrock, no drainage conditions should exist that would need special treatment.



Joe A. Green, Project Engineer

Date: April 28, 1971

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE - Soil Mechanics Laboratory

XXXXXXXXXXXXXXXXXXXX 800 "J" Street, Lincoln, Nebraska 68508

SUBJECT: ENG 22-5, Missouri RC&D, Crane Structure No. 1 DATE: June 28, 1971
(Stone County)

TO: James M. Dale, State Conservation Engineer
SCS, Columbia, Missouri

ATTACHMENTS

1. Form SCS-354, Soil Mechanics Laboratory Data, 1 sheet.
2. Form SCS-352, Compaction and Penetration Resistance, 5 sheets.

INTRODUCTION

The proposed 35-foot high, Class C hazard flood prevention dam is in the Ozark Highland physiographic area of southwest Missouri. Ten to fifteen feet of permeable cherty CL residuum blanket the limestone bedrock of the Burlington formation in the abutments. The soil materials generally disperse readily in water.

DISCUSSION

FOUNDATION

- A. Classification. Gravelly clay alluvium blankets the cherty residual clay in the flood plain to depths up to 5 feet. Limestone bedrock underlies the residual clay of the flood plain at depths of 13 to 14.5 feet.

Voids near the surface of the limestone bedrock were reported in the flood plain test holes Nos. 304 and 311.

No ground water was encountered during the site investigation. Water circulation loss was reported at the bedrock contact in several holes. A pressure test in the bedrock from the 15 to 30-foot depths showed no water loss. The cherty residual and alluvial soils were reported to be permeable.

- B. Shear Strength. The shear strength of the gravelly alluvium and cherty residual soils is expected to be adequate for the proposed 35-foot high embankment.
- C. Consolidation. The consolidation potential of the flood plain soils under the proposed 35-foot high dam is expected to be low.



EMBANKMENT

- A. Classification. The borrow materials will consist of residual cherty clay and gravelly clay alluvium. Five borrow samples were submitted to the laboratory for testing. The 2 shallow gravelly samples from the surface 4 feet of the flood pool borrow area were GC-GM materials with 48% and 38% gravel and low-plasticity fines. Liquid limits of the minus No. 10 material were 23 and 26 and the plasticity indices were 4 and 6.

Two samples underlying the shallow GC-GM samples at depths of 4 to 8 feet are CL materials with 29% and 40% gravel. One has low-plasticity fines and the other has high-plasticity fines.

The fifth sample of borrow material is a high-plasticity MH material with a liquid limit of 66 and a plasticity index of 32.

The Atterberg limits (43, 22) indicate the high-plasticity CL sample 102.2 (71-O-182) will have a shrinkage limit of approximately 15%, which is 10% lower than the optimum moisture content of 25% for Standard Proctor compaction (ASTM D-698, Method A). The Atterberg limits (66, 32) of the MH sample 103.2 (71-O-183) indicate a shrinkage limit of approximately 22%, which is 13% less than optimum moisture of 35% for Standard compaction.

The 3 low-plasticity samples are expected to have shrinkage limits at or below optimum moisture content for Standard Proctor compaction.

The high-plasticity CL and the MH materials are quite stable when submerged in water. The three borrow samples with low-plasticity fines are not water stable and disperse readily when placed in water.

- B. Compacted Dry Density. Standard Proctor compaction tests (ASTM D-698, Method A) were made on all 5 borrow samples submitted. Maximum dry densities for the minus No. 4 fractions of the 3 samples with low-plasticity fines varied from 105.0 pcf to 108.5 pcf. The high-plasticity samples yielded considerably lower densities. The CL sample 102.2 (71-O-182) had a maximum dry density of 93.5 pcf, and the MH sample 103.2 (71-O-183) had a maximum dry density of 81.0 pcf.
- C. Permeability. The compacted borrow materials at 95% of Standard density are expected to be fairly permeable.
- D. Shear Strength. The borrow materials at 95% of Standard density are expected to have adequate strength for the proposed 35-foot high dam.

CONCLUSIONS AND RECOMMENDATIONS

- A. General. Permeability and susceptibility to erosion and drying cracks appear to be the major problems at this site. The solution for one problem makes another problem worse. Covering the plastic materials with the erodible low-plasticity materials to avoid drying cracks creates slope erosion problems. Placing the erosion-resistant plastic materials on the slopes for erosion control may result in drying cracks and possible internal seepage problems. An upstream impervious zone of plastic CL and MH material (placed at or above optimum to obtain low permeability) covered with a scraper width of the GC-CM (to protect from drying cracks) appears to be a satisfactory compromise to control seepage, to avoid deep rilling or jugging of the slope, and to prevent drying cracks.
- B. Cutoff. An upstream cutoff extending down to firm bedrock is recommended below the emergency spillway elevation to control seepage through the foundation soil materials and to provide an inspection trench to determine the nature of the bedrock surface. A 15-foot bottom width is suggested across the floodplain to provide adequate working room for dental grouting of any fractures encountered. A bottom width of 10 feet is sufficient at the emergency spillway elevation. Side slopes of 1:1 or flatter are recommended. Backfill with the plastic borrow materials.
- C. Drainage. Foundation drainage is not considered necessary if the cutoff extends to sound bedrock and any fractures encountered are dental grouted. The natural permeability of the soil materials is considered sufficient to dissipate any seepage through the impervious section of the dam.
- D. Embankment Design. The following are recommended:
1. Selectively place the plastic CL and MH materials in an upstream impervious zone. Place wet of optimum to obtain the lowest permeability. Drying cracks between lifts of the high shrink-swell materials will be a big hazard, so careful scarifying techniques should be used to break up potential seepage paths at the interfaces.
 2. Provide an upstream slope cover (scraper width) of the gravelly alluvial borrow material like the GC-CM material 102.1 (71-C-18a) to protect the plastic impervious zone materials from cracking due to drying in prolonged drouth periods.
 3. Place the low-plasticity materials in the remainder of the embankment.
 4. Control fill density on the minus No. 4 fraction at 95% of Standard (ASTM D-698, Method A).

James M. Dale

4

Subj: Missouri RC&D, Crane Structure No. 1

5. Provide $2\frac{1}{2}$:1 or flatter embankment slopes both upstream and downstream.
6. Provide an overfill of 1.0 foot across the flood plain to compensate for residual foundation and embankment settlement after construction is complete.

Prepared by:

Edgar F. Steele
Edgar F. Steele

Reviewed and Approved by:

Lorn P. Dunnigan
Lorn P. Dunnigan
Head
Soil Mechanics Laboratory

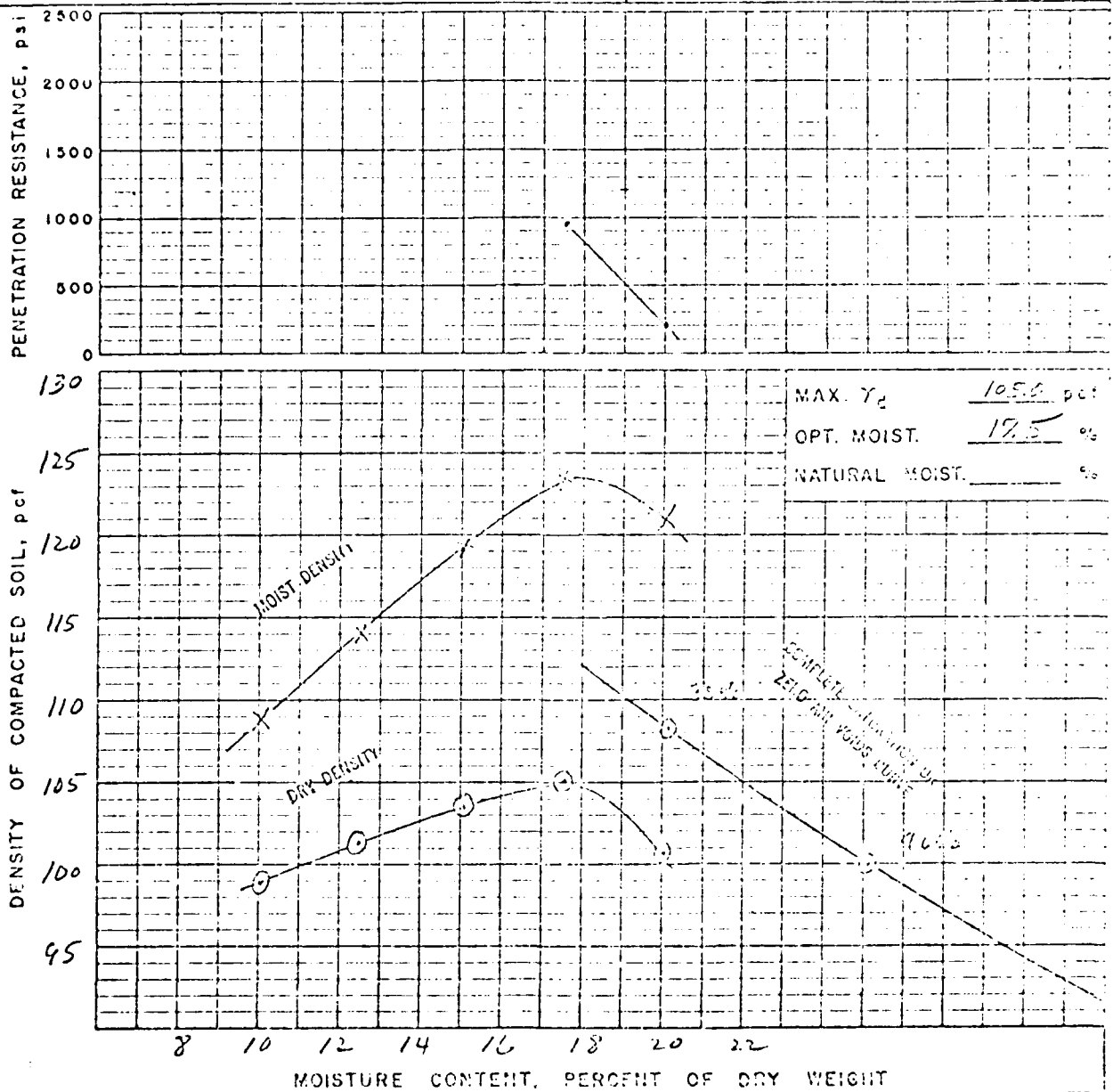
Attachments

cc:

Joe A. Green, Project Engineer, Mt. Vernon, Mo. (2)
Kenneth M. Kent, Lincoln, Nebraska

Hwy No.	MISSOURI LOCATION AND DESCRIPTION	Grade Site: 1	Depth ft	FIELD CLASS- ification	GRAIN SIZE DISTRIBUTION EXPRESSED AS PERCENT FINER BY DRY WEIGHT																UNITED STATES CLASS- ification	DRY DENSITY g/cm ³	DRY DENSITY lb/ft ³	MOISTURE CONTENT %	FLUIDITY CLASS	REMARKS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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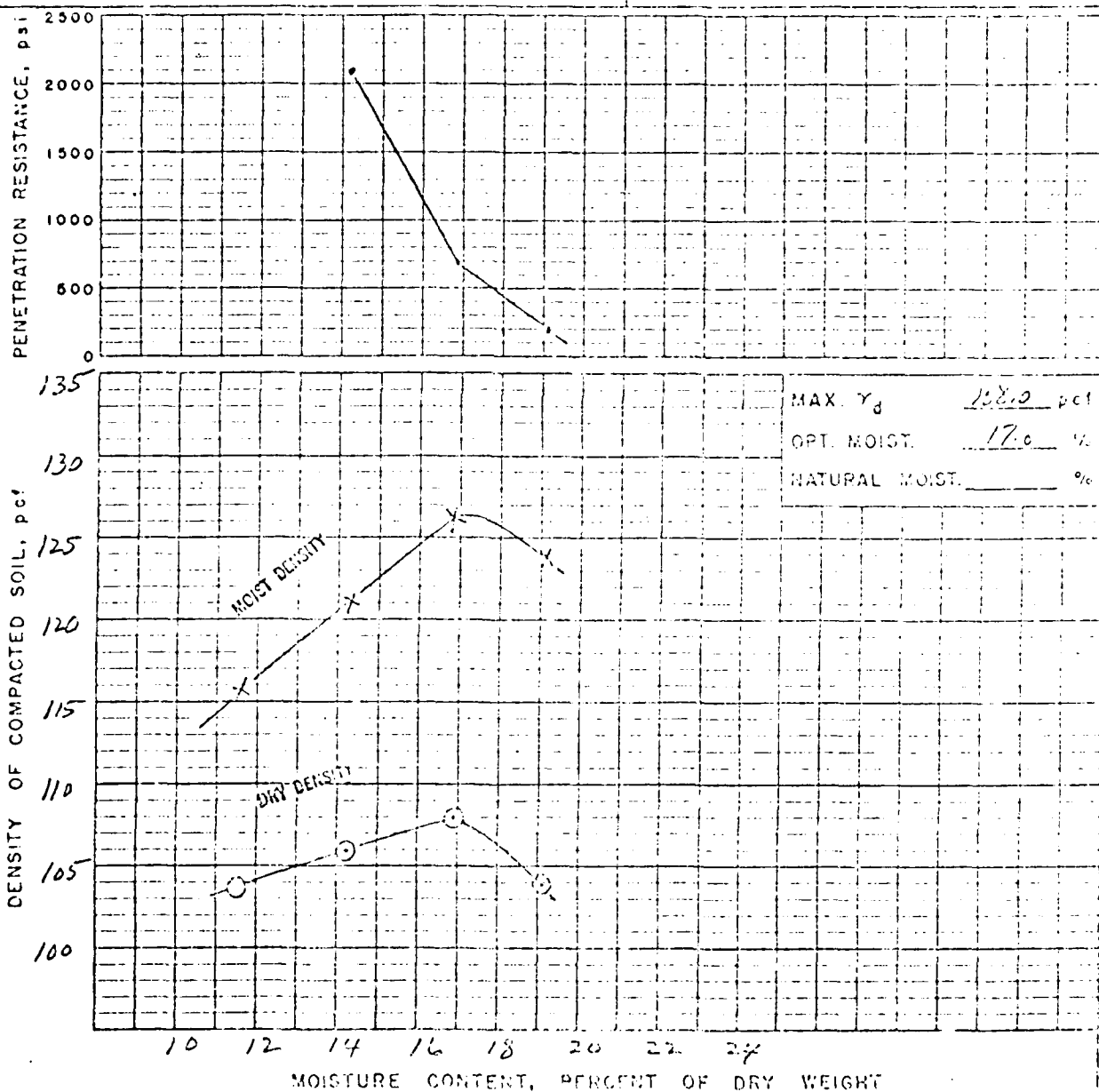
MATERIALS TESTING REPORT		U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE		COMPACTION AND PENETRATION RESISTANCE	
PROJECT OR STATE <u>Crane #1, RC + D Project, Missouri</u>					
FIELD SAMPLE NO. <u>101.1</u>		LOCATION <u>Borrow, A + 70, 1 + 20</u>			DEPTH <u>1-4'</u>
GEOLOGIC ORIGIN		TESTED AT <u>SML-LINCOLN</u>		APPROVED BY <u>Egg F. Steale</u>	DATE <u>6/22/71</u>
CLASSIFICATION <u>EC-GM</u> LL <u>23</u> PI <u>4</u>				CURVE NO. <u>1</u> OF <u>5</u>	
MAX. PARTICLE SIZE INCLUDED IN TEST <u>< #4</u> "				STD. (ASTM D-698) ☒ METHOD <u>A</u>	
SPECIFIC GRAVITY (G_s) { MINUS NO. 4 <u>2.66</u>				MOD. (ASTM D-1557) ☐ METHOD _____	
				OTHER TEST ☐ (SEE REMARKS)	
				PLUS NO. 4 <u>2.38</u>	



REMARKS

CURVE IS FOR THE MINUS NO. 4 FRACTION SHEET 14 of Appendix B
GRADATION OF TOTAL SAMPLE
< NO. 200 37 %; < NO. 4 52 %; < 3 IN. 100 %

MATERIALS TESTING REPORT		U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE		COMPACTION AND PENETRATION RESISTANCE	
PROJECT AND STATE <u>Grave #1, R.C.D. Project, Missouri</u>					
FIELD SAMPLE NO. <u>1062</u>		LOCATION <u>Borrow, A+70, 1+20.</u>			DEPTH <u>4-7'</u>
GEOLOGIC ORIGIN		TESTED AT <u>SML-LINCOLN</u>	APPROVED BY <u>Edgar F. Stebbins</u>		DATE <u>6/22/71</u>
CLASSIFICATION <u>CL</u> LL <u>27</u> PI <u>8</u>		CURVE NO. <u>2</u> OF <u>5</u>			
MAX. PARTICLE SIZE INCLUDED IN TEST <u>< #4</u>		STD. (ASTM D-698) ☒ METHOD <u>A</u>			
SPECIFIC GRAVITY (G _s) { MINUS NO. 4 _____ PLUS NO. 4 _____		MOD. (ASTM D-1557) ☐ METHOD _____			
		OTHER TEST ☐ (SEE REMARKS)			



REMARKS

CURVE IS FOR THE MINUS NO. 4 FINE
GRADATION OF TOTAL SAMPLE

Sheet 15 of Appendix B

< NO. 20 54, 20, < NO. 4 11, < 3 140

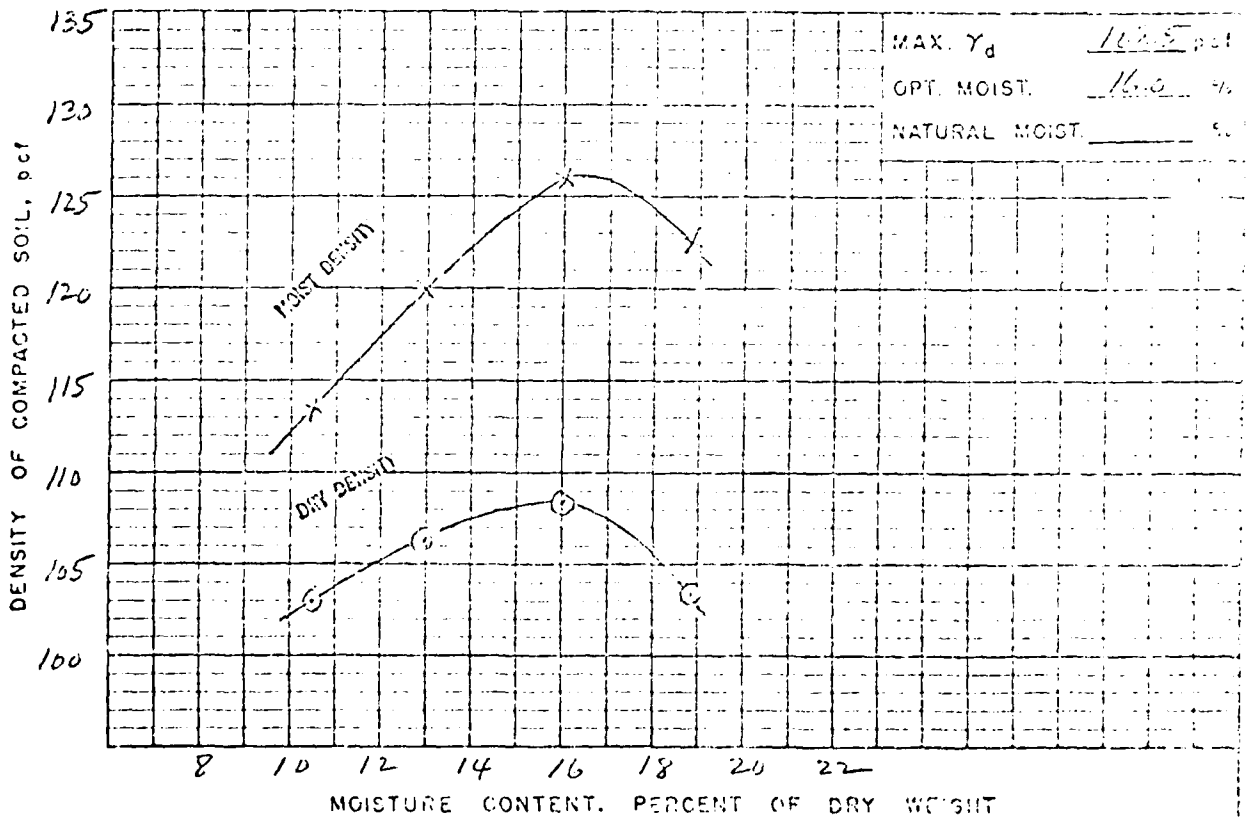
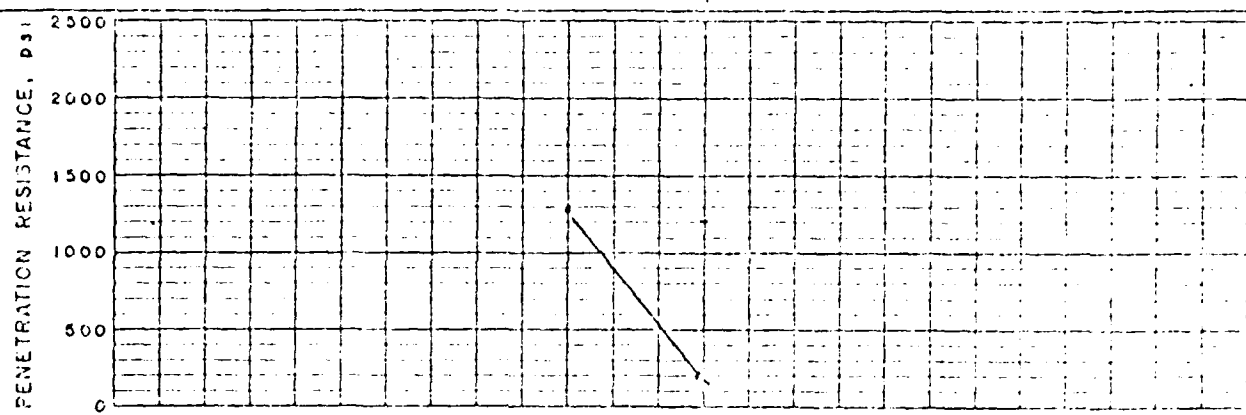
MATERIALS TESTING REPORT	U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	COMPACTION AND PENETRATION RESISTANCE
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PROJECT OR STATE CDR #1, RCD Project, Missouri,

FIELD SAMPLE NO. <u>102.1</u>	LOCATION <u>Borrow, B+15, L+70</u>	DEPTH <u>1-4'</u>
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TESTED AT <u>SIGL-LINCOLN</u>	APPROVED BY <u>Edgar L. Sigl</u>	DATE <u>6/22/71</u>
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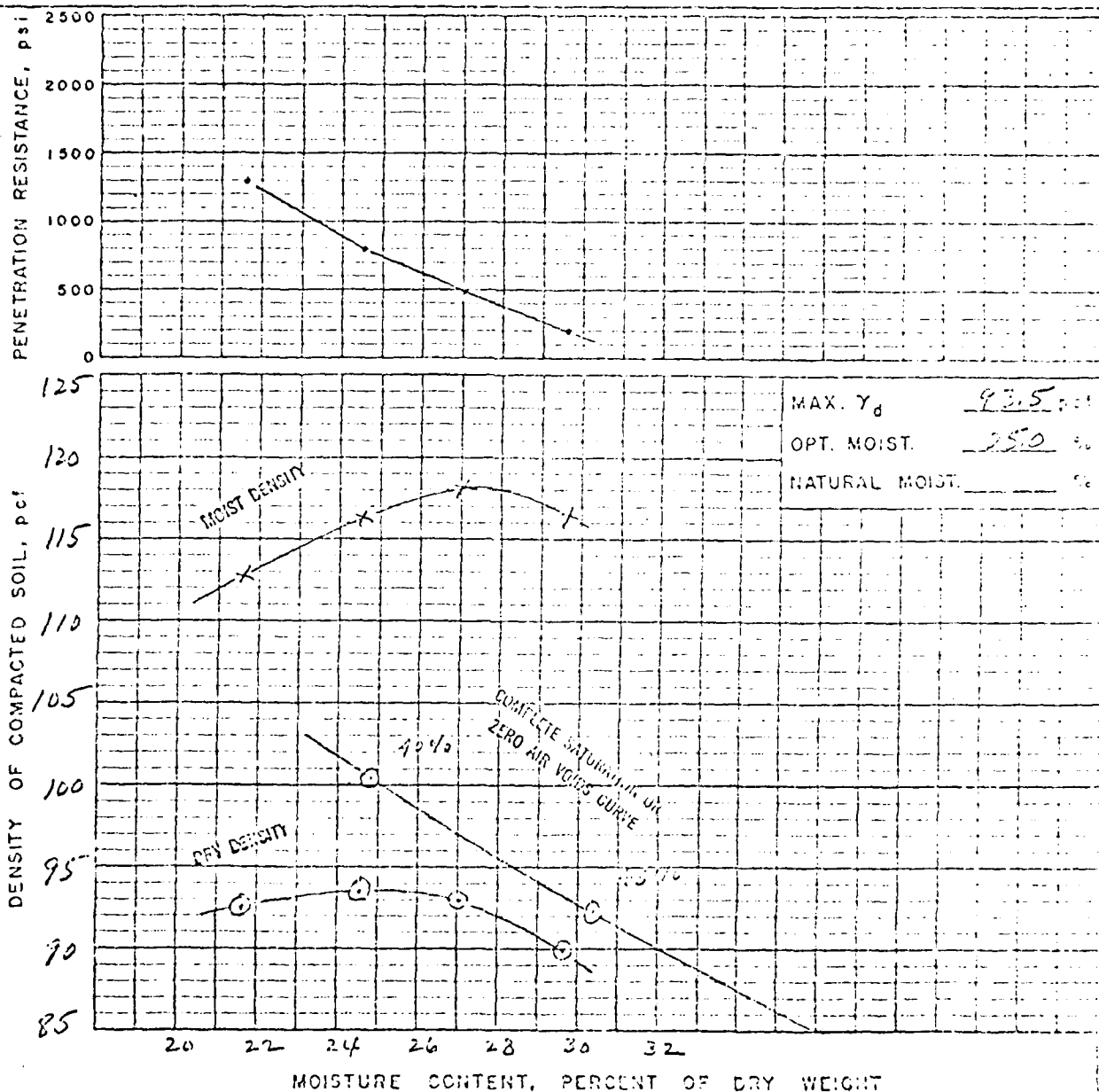
CLASSIFICATION <u>GC-GM LL 26 PI 6</u>	CURVE NO. <u>3</u> OF <u>5</u>
MAX. PARTICLE SIZE INCLUDED IN TEST <u>< #4 "</u>	STD (ASTM D-698) [X]; METHOD <u>h</u>
SPECIFIC GRAVITY (G _s) { MINUS NO. 4 _____ PLUS NO. 4 _____	MOD (ASTM D-1557) []; METHOD _____
OTHER TEST ☐ (SEE REMARKS)	



MAX. γ_d 10.5 pcf
OPT. MOIST. 16.0 %
NATURAL MOIST. _____ %

REMARKS: CURVE IS FOR THE MINUS NO. 4 FRACTION
GRADATION OF TOTAL SAMPLE
Sheet 16 of Appendix B
< NO. 200 119 % < NO. 4 62 % < 3 in. 100 %

MATERIALS TESTING REPORT		U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE		COMPACTION AND PENETRATION RESISTANCE	
PROJECT AND STATE <u>Crane #1 RCD Project, Missouri.</u>					
FIELD SAMPLE NO. <u>102.2</u>		LOCATION <u>Borrow, B+15, 1+70.</u>			DEPTH <u>4-8'</u>
GEOLOGIC ORIGIN		TESTED AT <u>SML-LINCOLN</u>		APPROVED BY <u>E. F. Siple</u>	DATE <u>9/22/71</u>
CLASSIFICATION <u>CL</u> LL <u>43</u> PI <u>22</u>				CURVE NO. <u>4</u> OF <u>5</u>	
MAX. PARTICLE SIZE INCLUDED IN TEST <u><#4</u> "				STD. (ASTM D-698) ☒ METHOD <u>A</u>	
SPECIFIC GRAVITY (G _s) { MINUS NO. 4 <u>2.68</u>				MOD. (ASTM D-1557) ☐ METHOD <u> </u>	
				PLUS NO. 4 <u>2.42</u>	
				OTHER TEST ☐ (SEE REMARKS)	



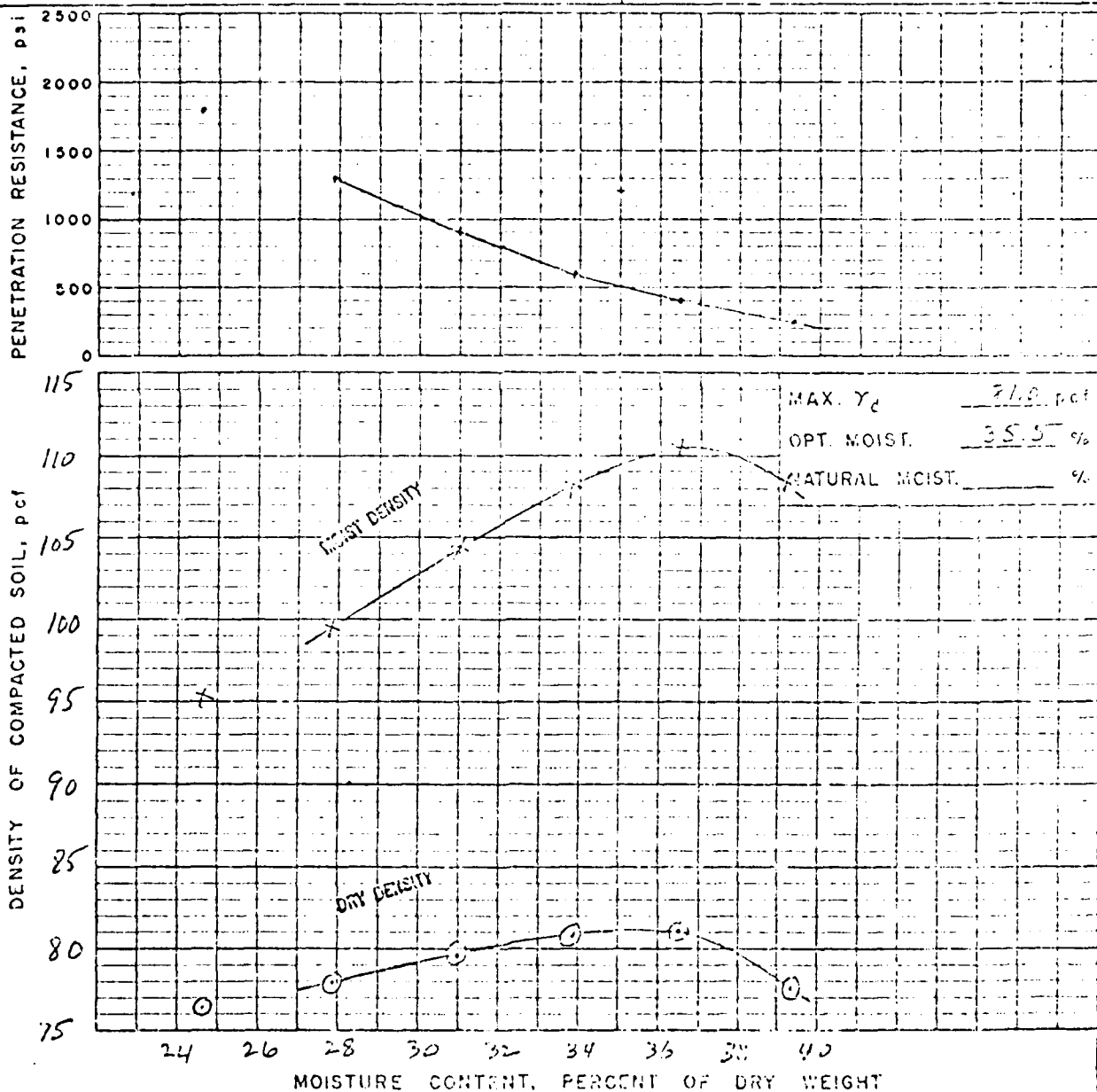
REMARKS

CURVE IS FOR THE MINUS NO. 4 FRACTION
GRADATION OF TOTAL SAMPLE

Sheet 17 of Appendix B

<10.100 54 10.100 1.00 9.10.100.2

MATERIALS TESTING REPORT		U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE		COMPACTION AND PENETRATION RESISTANCE	
PROJECT AND STATE <u>Crane #1, RCD Project, Missouri</u>					
FIELD SAMPLE NO. <u>103.2</u>		LOCATION <u>Borrow, B+00, 2+60.</u>			DEPTH <u>4-7'</u>
GEOLOGIC ORIGIN		TESTED AT <u>SML-LINCOLN</u>	APPROVED BY <u>F. J. Smith</u>		DATE <u>6/22/71</u>
CLASSIFICATION <u>MH</u> <u>LL 66</u> <u>PI 32</u>		CURVE NO. <u>5</u> OF <u>5</u>			
MAX. PARTICLE SIZE INCLUDED IN TEST <u>2#4</u> "		STD. (ASTM D-698) ☒ ; METHOD <u>A</u>			
SPECIFIC GRAVITY (G_s)		MOD. (ASTM D-1557) ☐ ; METHOD			
{ MINUS NO. 4		OTHER TEST ☐ (SEE REMARKS)			
{ PLUS NO. 4					



REMARKS

CURVE IS FOR THE MINUS NO. 4 FRACTION
COMBINATION OF TOTAL SAMPLE

Sheet 18 of Appendix B

< NO. 200 68 % - NO. 4 70 % - 3 % - 100 %

ENGINEERING GEOLOGY OF THE CRANE LAKE SITES, BARRY COUNTY

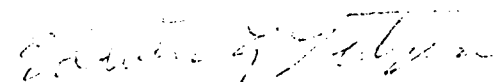
LOCATION: S $\frac{1}{2}$ sec. 33, T.26 N., R.24 W. (Aurora Quad.)

GEOLOGIC SETTING:

The geologic setting for both of the proposed lake sites for the village of Crane are identical. The sites are located in very steep sided high gradient valleys which would normally have rapid runoff. The bedrock if encountered in this area would consist of the Elsey or Reed Springs Formations which are identified by thin alternating bands of chert and limestone. The residual soil on these formations is characterized by very stony "cherty" soil. The chert fragments frequently account for more than 50% of the total volume of the soil, giving this soil a highly permeable nature. The bedrock due to the alternating bands of limestone and chert and numerous vertical joints transmits large amounts of water. Without very extensive and expensive remedial measures it is not possible to construct a dam at these sites that would be guaranteed to maintain a stable water level.

RECOMMENDATIONS:

Due consideration to the construction of flood retention dams should be given. The soils and bedrock in this area is suitable for this type of structures. There are certain remedial measures such as grouting, construction a core trench to bedrock, borrowing all the embankment fill from the ridge tops where better soil is found, and treating the lake bottom with bentonite that would aid in sealing the ponds. However, the city officials should be warned that if any or all of these remedial measures are accomplished that these dams could not be guaranteed to hold water. If flood retention structures are designed they should be similar to the design of Southwest City.



Edwin E. Lutzen
Engineering Geologist
Missouri Geological Survey
February 27, 1969

E. Edmunds *mmk*

ENGINEERING GEOLOGIC REPORT ON CRANE FLOOD
RETARDATION STRUCTURE

Stone County, Missouri

LOCATION: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 33, T. 26 N., R. 24 W., (Aurora Quadrangle)

GEOLOGIC SETTING:

The site is underlain by massive pinnacled limestone, the Burlington Formation, with an overlying soil consisting of stoney red clay. The setting is typical of southwestern Missouri where a variable thickness of soil cover exists over cavernous limestone. A shallow cavern development, typical of this region, occurs at the limestone-soil contact. This contact, of course, is extremely irregular because of the pinnacled characteristics of the bedrock. In addition, the cavern development is equally irregular. Most of the actual opening that is maintained for any period of time exists in the limestone portion of the cavern. However, the roof usually consists of stoney red clay so that collapse into the underlying limestone cavern is relatively common. These collapses may occur naturally or may be caused by change in surface water characteristics, excavation procedures, vibration, etc. In major stream valleys and areas of large caves, these collapses are significant and serious in both size and lateral continuity. However, on upland tributaries, such as at the Crane dam site, and in regions where cavern development has not been extensive, the affect of collapse is less dramatic.

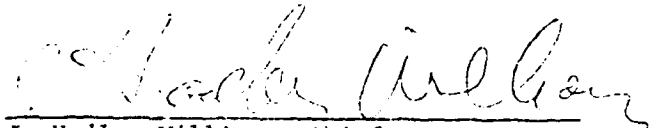
RECOMMENDATIONS:

Because the location is on an upland tributary area, with collapse limited to a shallow soil cover over limestone and remote from known extensive cavern and cave development, there is no apparent hazard to groundwater pollution that would be caused by loss of surface flow. The most obvious point of resurgence of water loss is downstream in the adjoining valley with water moving along the limestone-soil contact. Consequently, recommendations from the geologic aspect would be aimed more toward stabilizing the foundation of the lake floor subsequent to completion of the structure rather than concern about contaminates entering the groundwater system.

Procedures for stabilizing openings developed by collapse into caves developed in the soil and bedrock profile consist of stabilization with large boulders overlain by decreasing smaller size material all of which

is well graded.

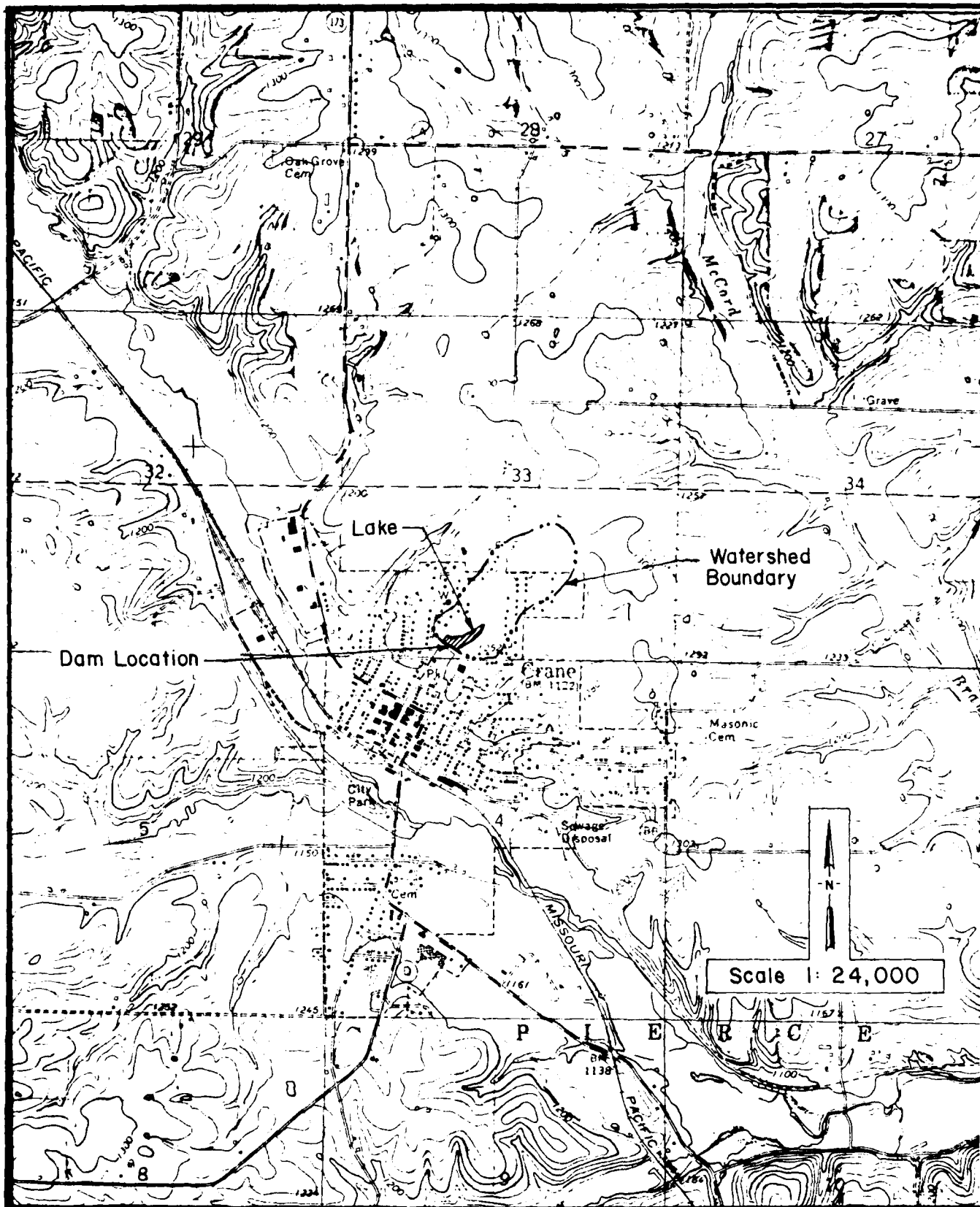
It is anticipated that the rate of water loss will gradually diminish as the residual soil roof of the caves gradually collapse. The debris will continue to fill the small cavern passageways developed in the uppermost portion of the limestone. While the change in the typical valley regime will undoubtedly cause more rapid removal of the fine textured materials when water is impounded by the flood retardation structure, the large fragments will continue to accumulate and remain in the cavern areas. Thus, over a long period of time the rate of water loss will gradually diminish as the voids fill with chert or rock fragments.



J. Hadley Williams, Chief
Applied Engineering & Urban Geology Section
Missouri Geological Survey
November 9, 1972

APPENDIX C

Overtopping Analysis



LAKE AND WATERSHED MAP



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Crane Structure #1
Stone County, Missouri
Mo. I.D. No. 20509

Sheet 1, Appendix C

APPENDIX C

HYDROLOGIC AND HYDRAULIC ANALYSIS

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was accomplished using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination).

The synthetic unit hydrograph for the watershed was developed by the computer program using the SCS method. The parameters for the unit hydrograph are shown in Table 1 (Sheet 4, Appendix C).

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2 (Sheet 5, Appendix C).

The reservoir routing was accomplished by using the Modified Puls Method. The hydraulic capacity of the spillway was used as an outlet control in the routing. The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation-surface area--storage-discharge relationships shown in Table 3 (Sheet 5, Appendix C.)

This dam has been designed for flood control purposes, and the water surface elevation is maintained below the principal spillway invert elevation. To consider the effect of the reservoir storage, an antecedent storm of 25 percent and 50 percent of the PMF was considered (assuming the reservoir at the sedimentation pool elevation 1,194.6) to determine the starting reservoir elevation for the routing of 50 percent and 100 percent of the PMF respectively. The antecedent storms were assumed to occur four days prior to their corresponding storm. The 25 percent PMF reached elevation 1,211.07. The 50 percent PMF will fill the reservoir (1,215.07) beyond the emergency spillway level. At the end of the four days, the reservoir will reduce to the sedimentation pool level since the principal spillway is unregulated. Thus, the final routing analysis was accomplished considering the starting reservoir level at the principal spillway invert elevation 1,194.6 (sedimentation pool).

The result of the routings of the PMF ratios indicate that the dam will pass the 1 percent probability flood without overtopping the dam.

The rating curve for the spillways (see Table 4, Sheet 6, Appendix C) was determined assuming orifice flow for the principal spillway and channel flow for the emergency spillway.

The flow over the crest of the dam during overtopping was determined using the non-level dam option (\$L and \$V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5 (Sheet 7, Appendix C).

The computer input data, a summary of the output data, and a plot of the inflow-outflow hydrograph for the PMF are presented on Sheets 8, 9 and 10 of Appendix C.

TABLE 1
SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	0.094 sq miles
Length of Watercourse (L)	0.50 miles
Difference in elevation (H)	105.0 ft
Time of concentration (Tc)	0.20 hrs
Lag Time (Lg)	0.12 hrs
Time to peak (Tp)	0.16 hrs
Peak Discharge (Qp)	284 cfs
Duration (D)	5 min.

<u>Time (Min.) (*)</u>	<u>Discharge (cfs) (*)</u>
0	0
5	141
10	282
15	177
20	73
25	32
30	14
35	6
40	3
45	1

(*) From the computer output

FORMULA USED:

$$T_c = \left(\frac{11.9 L^3}{H} \right)^{0.385} \quad \text{From California Culverts Practice, California Highways and Public Works, September, 1942.}$$

$$L_g = 0.6 T_c$$

$$T_p = \frac{D}{2} + L_g$$

$$Q_p = \frac{484 A \cdot Q}{T_p} \quad Q = \text{Excess Runoff} = 1 \text{ inch}$$

TABLE 2
RAINFALL-RUNOFF VALUES

<u>Selected Storm Event</u>	<u>Storm Duration (Hours)</u>	<u>Rainfall (Inches)</u>	<u>Runoff (Inches)</u>	<u>Loss (Inches)</u>
PMP	24	36.4	34.6	1.8

Additional Data:

- 1) Soil Conservation Service Soil Group B
- 2) Soil Conservation Service Runoff Curve CN = 85 (AMC III) for the PMF
- 3) Soil Conservation Service Runoff Curve CN = 70 (AMC II) for the
1 percent chance flood
- 4) Percentage of Drainage Basin Impervious 10 percent

TABLE 3
ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

<u>Elevation (feet-MSL)</u>	<u>Lake Surface Area (acres)</u>	<u>Lake Storage (acre-ft)</u>	<u>Spillway Discharge (cfs)</u>
1,188.0	0	0	-
*1,194.6	0.8	3.2	0
1,200.0	1.5	9.4	6
1,212.5	4.1	43.2	10
**1,212.8	4.3	45.0	10
1,215.0	4.8	55.0	211
***1,217.1	5.6	67.0	701
1,220.0	6.4	84.0	1,707

* Principal spillway crest elevation

**Emergency Spillway crest elevation

***Top of dam elevation

The above relationships were developed using data from the SCS plans, the USGS CRANE, MO 7.5 minute quadrangle map and the field measurement.

TABLE 4

SPILLWAY RATING CURVE

<u>Reservoir Elevation</u> (MSL)	<u>Principal Spillway</u> (cfs)	<u>Emergency Spillway</u> (cfs)	<u>Total Discharge</u> (cfs)
1,194.6	0	-	0
1,198.0	5	-	5
1,205.0	8	-	8
*1,212.8	10	0	10
1,213.4	10	17	27
1,213.9	11	58	69
1,214.4	11	118	129
1,214.9	11	192	203
1,216.0	11	411	422
**1,217.1	11	690	701
1,218.0	12	960	972
1,219.0	12	1,305	1,317
1,220.0	12	1,695	1,707

*Emergency spillway crest elevation

**Top of dam elevation

METHOD USED:

- 1) Principal spillway: Assuming orifice flow

$$Q = C.A. (2 g.h)^{1/2}$$

Q = Discharge in cfs

C = Discharge coefficient = 0.60

A = Opening area in ft² (0.5 x 1.0)

g = Acceleration of gravity = 32.2 ft/sec²

h = Head from reservoir elevation to the center of the opening (in ft)

- 2) Emergency spillway: Assuming open channel flow. Using charts from "UD Method of Reservoir Flood Routing", SCS Technical Release No. 35, February 1967.

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (cfs)	Peak Lake Elevation (ft, MSL)	Total Storage (acre-ft)	Peak Outflow (cfs)	Depth (ft.) Over Top of Dam
-	0	*1,194.6	3	0	-
0.20	286	1,208.2	32	9	-
0.25	357	1,211.1	40	10	-
0.30	429	1,213.3	47	23	-
0.50	715	1,215.1	55	237	-
0.70	1,001	1,216.6	64	575	-
0.80	1,144	1,217.0	67	685	-
0.82	1,173	**1,217.1	67	701	0
0.90	1,287	1,217.4	69	812	0.3
0.95	1,358	1,217.5	69	889	0.4
1.00	1,430	1,217.6	70	964	0.5

The percentage of the PMF that will reach the top of the dam is 82 percent.

*Principal spillway crest elevation

**Top of dam elevation

Sheet 8, Appendix 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 MILES (SQUARE KILOMETERS)

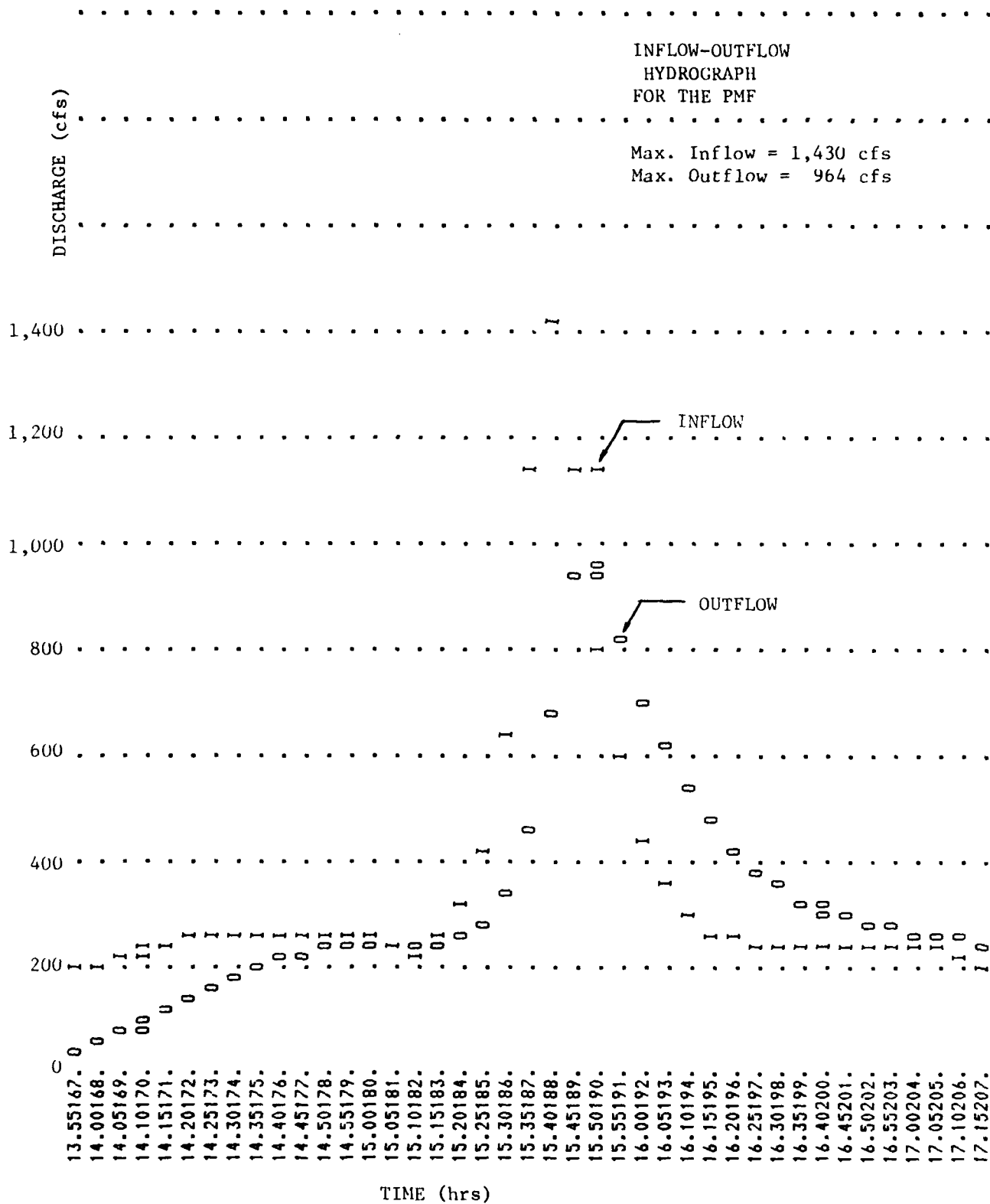
OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS								
				RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
HYDROGRAPH AT	1	0.09	1	286.	357.	429.	715.	1001.	1144.	1287.	1358.	1430.
	(	0.24)	(	8.10)	(	10.12)	(	12.14)	(	20.24)	(	28.34)
ROUTED TO	2	0.09	1	9.	10.	23.	237.	575.	685.	812.	889.	964.
	(	0.24)	(	0.25)	(	0.27)	(	0.64)	(	16.28)	(	19.41)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1			INITIAL VALUE		SPILLWAY CREST		TOP OF DAM	
ELEVATION			1194.60		1194.60		1217.10	
STORAGE			3.		3.		67.	
OUTFLOW			0.		0.		701.	

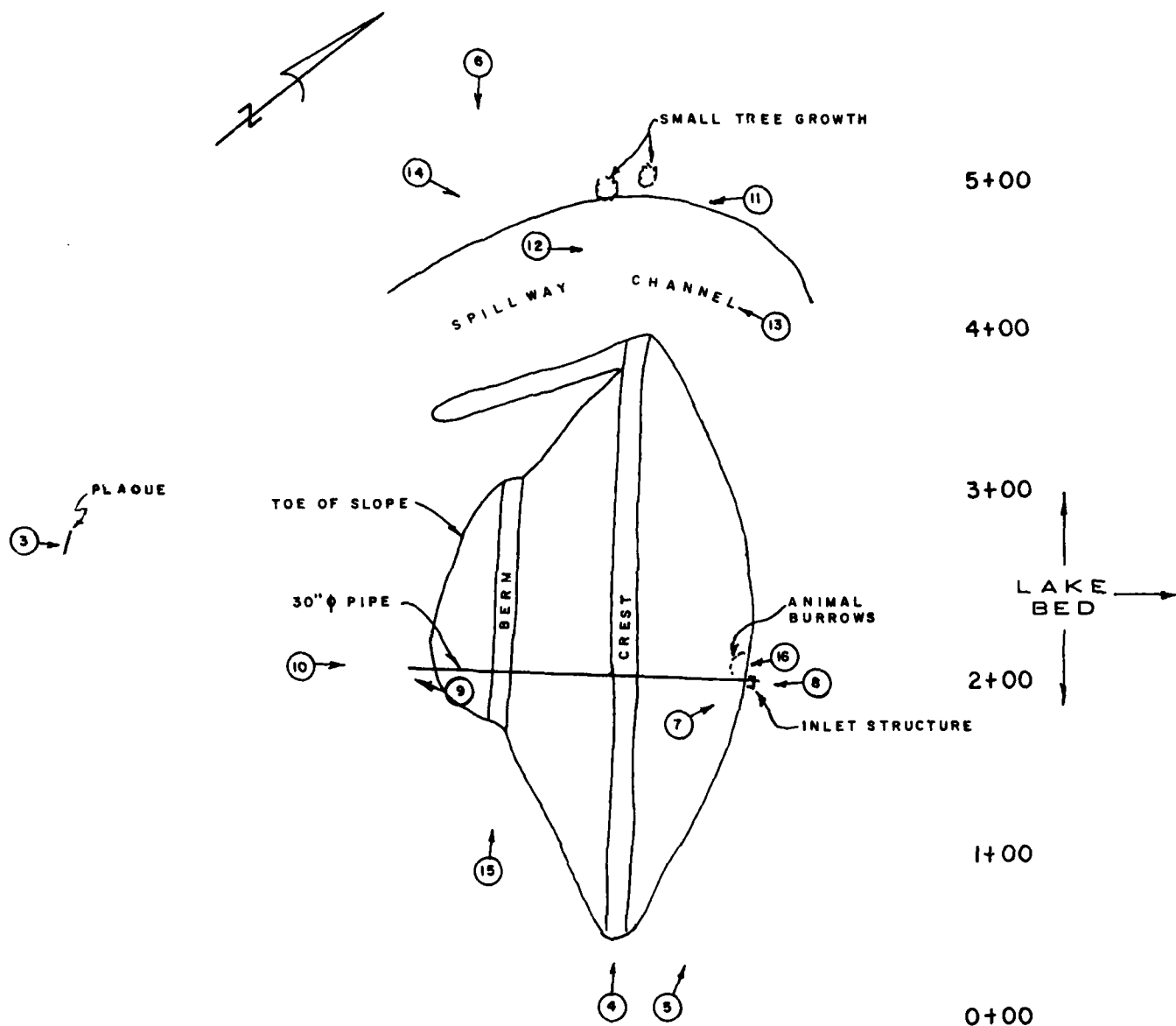
RATIO OF PMF	MAXIMUM RESERVOIR U.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.20	1208.18	0.00	32.	9.	0.00	19.50	0.00
0.25	1211.07	0.00	40.	10.	0.00	19.67	0.00
0.30	1213.25	0.00	47.	23.	0.00	18.83	0.00
0.50	1215.07	0.00	55.	237.	0.00	16.00	0.00
0.70	1216.60	0.00	64.	575.	0.00	15.83	0.00
0.80	1217.04	0.00	67.	685.	0.00	15.83	0.00
0.90	1217.38	0.28	69.	812.	0.25	15.83	0.00
0.95	1217.51	0.41	69.	889.	0.25	15.83	0.00
1.00	1217.60	0.51	70.	964.	0.33	15.83	0.00

PMF RATIOS
OUTPUT DATA



APPENDIX D

Photographs



PHOTOGRAPH INDEX

CRANE STRUCTURE No. 1
MO. No 20509

LIST OF PHOTOGRAPHS

<u>PHOTO NO.</u>	<u>DESCRIPTION</u>
1	Aerial View of Embankment (Looking South)
2	Aerial View of Embankment
3	View of On-Site Plaque
4	Crest of Dam (Looking West)
5	Upstream Slope of Dam (Looking West)
6	Downstream Slope of Dam (Looking East)
7	Inlet Structure (Looking Northwest)
8	View of Slide Gate Valve on Inlet Structure (Looking South)
9	Spillway Pipe Outlet (Looking Southwest)
10	Spillway Pipe Outlet (Looking North)
11	Emergency Spillway (Looking South)
12	Emergency Spillway (Looking North)
13	Emergency Spillway (Looking Southwest)
14	View of Lake Bed (Looking Northeast)
15	Downstream Slope and Berm (Looking West)
16	Animal Burrow at Inlet Structure (Looking South)

