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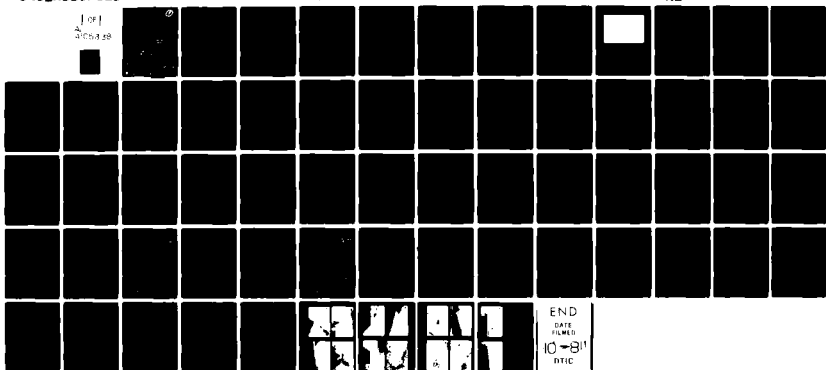
ANDERSON ENGINEERING INC SPRINGFIELD MO
NATIONAL DAM SAFETY PROGRAM. DUCK CREEK STATE WILDLIFE REFUGE ---ETC(U)
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LEVEL II



MISSISSIPPI-ST. FRANCIS RIVER BASIN

AD A105338

**DUCK CREEK STATE WILDLIFE
REFUGE — POND #2
STODDARD COUNTY, MISSOURI
MO 48893**

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



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

St. Louis District

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

FOR: STATE OF MISSOURI

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DECEMBER, 1980

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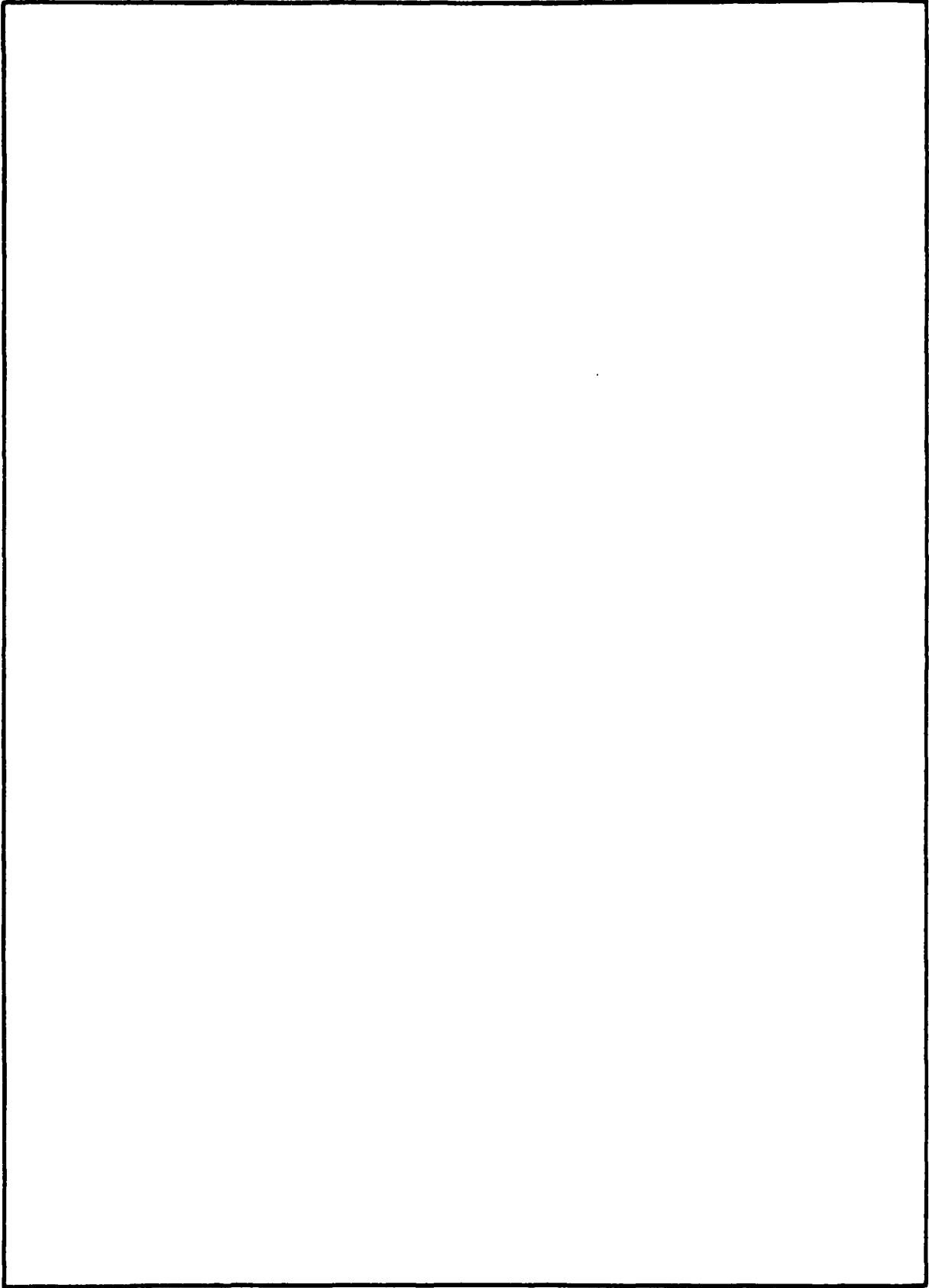
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7. AUTHOR(s) Anderson Engineering, Inc.		8. CONTRACT OR GRANT NUMBER(s)
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
This report was prepared under the National 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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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

SUBJECT: Duck Creek State Wildlife Refuge - Pond 2
Stoddard County, Missouri
Missouri Inventory No. 40093

This report presents the results of field inspection and evaluation of the Duck Creek State Wildlife Refuge - Pond 2. It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY: **SIGNED**
Chief, Engineering Division

01 APR 1981
Date

APPROVED BY: **SIGNED**
Colonel, CE, District Engineer

03 APR 1981
Date

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DUCK CREEK STATE WILDLIFE REFUGE - POND 2
STODDARD COUNTY, MISSOURI
MISSOURI INVENTORY NO. 40093

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

December, 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam: Duck Creek State Wildlife Refuge - Pond 2
State Located: Missouri
County Located: Stoddard
Stream: None
Date of Inspection: October 9, 1980

↓
Duck Creek State Wildlife Refuge - Pond 2 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 significant hazard potential classification, which means that some 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 the town of Kinder (few dwellings) and Highway 51.

↓
The dam is in the intermediate size classification, since the storage capacity is greater than 1,000 Acre-ft.

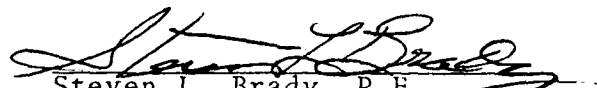
Our inspection and evaluation indicates that the spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillways will pass 40 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood 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 intermediate size with a significant downstream hazard potential pass 50 to 100 percent of the PMF. Considering the small height of the dam, the low storage capacity, and the short duration of permanent water impoundment, 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 embankment was in good condition. A deficiency visually observed by the inspection team was: The thick growth of trees on the embankment slopes.

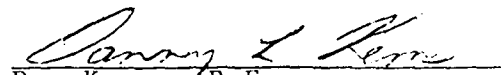
Another deficiency was the lack of seepage and stability analysis records.

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


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


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


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


Dan Kerns, P.E.
Hanson Engineers, Inc.



AERIAL VIEW OF LAKE AND DAM
(Looking West)

Note: Pond 1 in background and South embankment at left
side of photo

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DUCK CREEK STATE WILDLIFE REFUGE - POND 2
STODDARD COUNTY, MISSOURI
MISSOURI INVENTORY NO. 40093

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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 Duck Creek State Wildlife Refuge - Pond 2 in Stoddard 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:

Duck Creek State Wildlife Refuge - Pond 2 is an earth fill structure approximately 8 ft high and 24,738 ft long at the crest. The pond was constructed on a relatively flat plain, Mingo Swamp, with the pool area completely enclosed within the embankment. The appurtenant work consists of a 36 in. diameter corrugated metal inlet pipe with gate and a 36 in. and two 24 in. diameter corrugated metal outlet pipes with gates.

Sheets 3 through 10 of Appendix A show a plan, profile, and typical sections of the embankment.

B. Location:

The dam is located in the northwestern part of Stoddard County, Missouri in the Duck Creek State Wildlife Refuge. The dam and lake are within the Sturdivant, Missouri 7.5 minute quadrangle sheet (Section 4, T27N, R9E - latitude 37°01.3; longitude 90°05.5). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 8 ft and a maximum storage capacity of approximately 1,290 acre-ft, the dam is in the intermediate size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has determined that this dam is in the significant hazard potential classification. The estimated damage zone extends approximately one mile downstream of the dam. Located within this zone are the town of Kinder (few dwellings) and Highway 51. The affected features located within the potential damage zone were field verified by the inspection team.

E. Ownership:

The dam is owned by the Missouri Department of Conservation. The owner's address is P. O. Box 180, Jefferson City, Missouri 65102. A district office, Duck Creek Wildlife Management Area, is located adjacent to the pond area. Mr. Dave Shaffer is the Area Manager of the office.

F. Purpose of Dam:

The dam was constructed primarily for a state-operated wildlife refuge area.

G. Design and Construction History:

The dam was designed by the Missouri Department of Conservation in 1951 and 1952. The plans included details for Pond 1, Pond 2, and Pond 3. The details provided for Pond 2 consisted of typical outlet pipes with gate valves. Information regarding the embankment section and profile was not available. Design and construction data were obtained from conversations with the Area Manager, Mr. Dave Shaffer. The dam was constructed in 1953 by the work force of the Missouri Department of Conservation. The borrow material was obtained from the levee system constructed

adjacent to the lake. The levee system encompasses the embankment area except for the northeastern part of the lake. The levee system consist of an embankment and drainage ditch along the northern boundary, along the western boundary between Pond 1 and Pond 2, and along the eastern and southern boundary of Pond 2. The levee embankment height varies from equal elevation with Pond 2 embankment on the east, to a maximum of 4 ft above the Pond 2 embankment elevation on the west. The levees were designed to carry upland flow and directional outflow from Ponds 1, 2, and 3.

No design data regarding the embankment were available. The slopes of the downstream and upstream are generally 1 vertical on 2 horizontal.

H. Normal Operating Procedures:

Normal rainfall, evaporation, the inlet pipe from Pond 1, and the gate controlled outlet pipes are used to control the water surface. The pond is normally filled from Pond 1 starting in September or October of each year, dependant upon the water level of Pond 1. The normal pool elevation 341.5 is maintained until the end of December when the gates are opened and the pond allowed to drain.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheets 3 through 10 of Appendix A present 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, is approximately 712 acres (enclosed within the embankment area).

B. Discharge at Dam Site:

- (1) All discharge at the dam site is through the controlled spillway outlet pipes.
- (2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 342.4): 124 cfs
- (3) Estimated Capacity of Principal Spillways: 124 cfs
- (4) Estimated Capacity of Emergency Spillway: Not Applicable

- (5) Estimated Experience Maximum Flood at Dam Site: Unknown
- (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 an assumed mean sea level elevation of 347.2 for top of concrete structure for the inlet pipe at Station 0 + 00. (Elevation obtained from plans for Pond 1 and the Phase I Inspection Report for Pond 1 dated March 1980.)

- (1) Top of Dam: 342.4 MSL (low point of dam and adjacent levee embankment)
- (2) Principal Spillway Outlet Pipes (Inverts at Inlets):
24 in. Pipe - Station 12 + 20, Elevation 337.2
24 in. Pipe - Station 66 + 00, Elevation 333.8
36 in. Pipe - Station 213 + 38, Elevation 336.2
- (3) Emergency Spillway Crest: Not Applicable
- (4) Principal Spillway Outlet Pipes (Inverts at Outlets):
24 in. Pipe - Station 12 + 20, Elevation 336.5
24 in. Pipe - Station 66 + 00, Elevation 333.0
36 in. Pipe - Station 213 + 38, Elevation 335.3
- (5) Plain Elevation at Centerline of Dam: 334.0 MSL
- (6) Pool on Date of Inspection: 339.9 MSL Normal Pool 341.5 MSL
- (7) Apparent High Water Mark: Unknown
- (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: 8,010 ft
- (2) At Emergency Spillway Crest: Not Applicable

(3) At Normal Pool Elevation: 8,000 ft

E. Storage Capacities:

(1) At Top of Dam: 1,290 Acre-ft

(2) At Emergency Spillway Crest: Not Applicable

(3) At Normal Pool Elevation: 650 Acre-ft

F. Reservoir Surface Areas:

(1) At Top of Dam: 712 Acres

(2) At Emergency Spillway Crest: Not Applicable

(3) At Normal Pool Elevation: 709 Acres

G. Dam:

(1) Type: Rolled Earth

(2) Length at Crest: 24,738 ft

(3) Height: 8 ft

(4) Top Width: 13 ft

(5) Side Slopes: Upstream 1V on 2H
Downstream 1V on 2H

(6) Zoning: Apparently Homogeneous

(7) Impervious Core: None

(8) Cutoff: Unknown

(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 (Outlet Pipes):

- (1) Location: Station 12 + 20, Station 66 + 00, and Station 213 + 38
- (2) Type: Two 24 in. corrugated metal pipes (CMP) and one 36 in. corrugated metal pipe with gates
- (3) Upstream Channel: CMP extending into lake area
- (4) Downstream Channel: Earth cut channel to adjacent drainage ditch paralleling embankment.

I.2 Emergency Spillway:

- (1) Location: Not Applicable
- (2) Type: Not Applicable
- (3) Upstream Channel: Not Applicable
- (4) Downstream Channel: Not Applicable

J. Regulating Outlets:

The regulating outlets associated with this dam are the slide gates for the two 24 in. CMP's and for the one 36 in. CMP.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

The engineering design data consist of a set of plans and drawings for the entire Duck Creek Wildlife Refuge. The plans obtained from the Missouri Conservation Department were primarily for the construction of Pond 1 and the levee system for the refuge. Reference was made to Pond 2, but no design drawings were present in the plans. No design computations or reports are available.

A. Surveys:

The most recent survey conducted in the area was for the preparation of the Phase I Safety Inspection for Pond 1, report dated March 1980. Sheets 3 through 10 of Appendix A present a plan, profile, and cross section of the dam from survey data obtained during our site inspection. A site benchmark elevation of 347.2 for the top of the concrete structure at the inlet gate pipe, Station 0 + 00 was used. The elevation of the structure was obtained from the Phase I inspection of Pond 1.

B. Geology and Subsurface Materials:

The Duck Creek State Wildlife Refuge - Pond 2 Dam is located near the western edge of the Southeastern Lowlands geologic region of Missouri. The area is characterized topographically by its flatness. The dam is located on the braided stream terrace deposits of the Pleistocene. The underlying sand is the alluvium of the Mississippi-Ohio River complex, while the loessial sand, sandy clay, and clay are the McNary formation of the Cretaceous. The thickness of the Cretaceous system in southeastern Missouri ranges from 100 to 250 ft. Braided stream deposits consist of material eroded from the uplands to the east of the dam site. The material has been dissected by small streams in the area which generally flow in a parallel direction.

The Duck Creek State Wildlife Refuge - Pond 2 Dam is a rectangular shaped structure which was erected on a flat plain. The embankments were constructed by using on-site material which consisted of sands, silts, and clays. The surface material of the site is underlain by sand which in turn is underlain by non-marine sand and sandy clay.

The publication "Caves of Missouri" lists three caves known to exist in Stoddard County. The closest cave is approximately 5 miles east of the site. The dam is located in seismic zone 3.

C. Foundation and Embankment Design:

No foundation and embankment design information was available. Seepage and stability analyses apparently were not performed as required in the guidelines. There is apparently no particular zoning of the embankment, and no internal drainage features are known to exist.

D. Hydrology and Hydraulics:

No hydrologic and hydraulic design computations for this dam were available. The two 24 in. and one 36 in. diameter gated CMPs were considered to act as the principal spillway. No emergency spillway section was provided for the dam. Based on a check of the CMP spillway pipes 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 and appear in Appendix C, Sheets 1 to 11.

E. Structure:

The structures associated with this dam include the gated 36 in. inlet pipe structure and the principal spillway outlet pipes. The slide gates for the three outlet pipes are located in a concrete structure on the lake side of the embankment.

2.2 CONSTRUCTION:

No construction inspection data have been obtained.

2.3 OPERATION:

The normal pool elevation of 341.5 is maintained only during the fall of the year. Usually in September of each year the inlet gate from Pond 1, located at Station 0 + 00, is opened to fill the lake to elevation 341.5. The level is maintained until after the duck hunting season, latter part of December, when the lake level is lowered by the three gated spillway pipes.

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 (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available. The engineering data available were principally for the construction of Pond 1 and the surrounding levee system.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on October 9, 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 L. Brady - Anderson Engineering, Inc. - Civil Engineer
Tom R. Beckley - Anderson Engineering, Inc. - Civil Engineer
Gene Wertepny - Hanson Engineers, Inc. - Hydraulic Engineer
Dan Kerns - Hanson Engineers, Inc. - Geotechnical Engineer

The Area Manager, Mr. Dave Shaffer, was to accompany the inspection team. However, his services were required elsewhere within the area and no replacement personnel were available during the course of the inspection.

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

B. Dam:

Pond 2 is a unique dam and lake as the impounded water is completely enclosed inside the embankment. On the date of inspection the pool level was at elevation 339.9, approximately 1.6 ft below desired elevation. The inlet gate from Pond 1 was opened the middle of September to allow flow into Pond 2.

The embankment appeared to be in good condition. The gravel covered crest of the embankment was well maintained, with a width of 13 ft.

The vertical alignment of the crest was generally good, with some irregularities of the profile observed (See Sheets 4 and 5 of Appendix A).

Embankment slopes on the upstream and downstream slopes were 1V on 2H. The upstream slope was generally tree covered, varying from scattered to a dense growth. The downstream slope varied from light tree and brush growth to dense growth.

A navigation channel about 50 ft wide had been cleared along the pond perimeter inside the embankment from Station 5 + 00 to Station 160 + 00 (See Photograph No. 2). Numerous navigation fingers extended into the pond area to the various duck blinds located within the pond.

No significant erosion or other unusual movement of the embankment was noted. No animal burrows were observed.

The construction material for the embankment was obtained from the excavation of the adjacent levee system. The levee is continuous around the embankment except from Station 170 to Station 195. The levee system provides for upland drainage and for carrying discharges from Pond 2 and Pond 3. The levee height, above the dam embankment, varies from a maximum of 4 ft along the western boundary to equal elevation with the dam embankment along the east and north boundary. The levee embankment was densely covered with brush and trees. Intermediate openings through the levee embankment to the adjacent drainage ditch was noted at each of the spillway pipes (See Photograph No. 9). Additional openings through the levee embankment were observed at about 500 ft spacing.

Shallow auger probes into the crest of the embankment indicate the dam to be constructed of a dark gray silty clay (CL).

C. Appurtenant Structures:

C.1 Principal Spillway:

The principal spillway system for this dam includes two 24 in. and one 36 in. CMP with slide gate controls. All gates appeared to be in good working condition and well maintained. These gates along with the 36 in. inlet gate are used annually for raising and lowering the lake level. The lake is filled prior to duck hunting season and lowered shortly after the season closes. The inlets to the spillway structures were clear.

C.2 Emergency Spillway:

There is no emergency spillway associated with this dam.

D. Reservoir:

The reservoir area, which is contained entirely within the embankment area, is a flat wooded surface with some agricultural terrain. The seeded areas provide a source of food for the ducks. No excessive erosion, slides, or wave wash was observed. Siltation of the reservoir appeared to be minor.

E. Downstream Channel:

The downstream channels, consisting of the refuge levee system, were well maintained and in relatively good condition. Beyond the levee, the channel is barely discernible in the broad flat valley.

3.2 EVALUATION:

The maintenance of the levee, embankment, and the discharge structures appears to be adequate except for the dense tree and brush growth. Due to the low height of the embankment, the broad floodplain below the dam, and the relatively short time duration of water storage, none of the conditions observed are significant enough to indicate a need for immediate action. If left uncontrolled, the dense growth of trees and brush on the downstream slope could lead to the development of potential problems.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

The drainage area of the lake is entirely enclosed within the embankment. The pool level is usually maintained at normal pool only during the duck hunting season. No permanent water storage is maintained during the rest of the year. Normal rainfall, evaporation, and the control structures are utilized to provide the desired pool elevation. The water for filling the pond prior to the duck hunting season is diverted from Pond 1 through the 36 in. inlet pipe between Pond 1 and Pond 2. No information was available as to how long the gate from Pond 1 must be open to allow Pond 2 to reach its desired water level.

4.2 MAINTENANCE OF DAM:

The crest of the dam and the slopes, except for the dense tree growth, are well maintained. No riprap was used along the shoreline, although erosion of the slope does not appear to be a problem.

4.3 MAINTENANCE OF OPERATING FACILITIES:

All hydraulic structures are well maintained and appear to be in good operating condition.

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 operational and maintenance schedules appear to be adequate for the dam and appurtenant structures.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

No hydrologic or hydraulic design computations for this dam were available.

B. Experience Data:

No recorded rainfall, discharge, or reservoir stage data were available for this lake. Mr. Shaffer indicated the dam has never been overtopped. The maximum water level within the lake was not available. Our hydrologic and hydraulic analyses using U. S. Army Corps of Engineers guidelines appear in Appendix C.

C. Visual Observations:

The only source of inflow, other than the direct rainfall into the lake is through the gated inlet pipe from Pond 1. This gate is used only prior to duck hunting season to fill Pond 2. The two 24 in. and one 36 in. outlet pipe gated structures are normally open except for the time Pond 2 is being filled and during duck hunting season. The lake area is maintained as a green belt by the Conservation Department.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U. S. Army Corps of Engineers guidelines and the HEC-1 computer program) were based on: (1) a field survey of the discharge structure dimensions and embankment elevations; and (2) reservoir storage and the pool and drainage areas from the Missouri Conservation Commission plans.

Based on the hydrologic and hydraulic analysis presented in Appendix C, overtopping of the dam will occur for discharge in excess of 40 percent of the Probable Maximum Flood (PMF). 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 (intermediate size with significant

downstream hazard potential) pass or store 50 percent to 100 percent of the PMF, without overtopping. Considering the dam's small size, the low storage capacity, and the short duration of permanent water impoundment, 50 percent of the PMF has been determined to be the appropriate design flood. The routing study indicates that a 1 percent probability flood will be totally stored in the reservoir without overtopping the dam.

Application of the probable maximum precipitation (PMP), resulted in a flood hydrograph peak inflow of 20,440 cfs. For 50 percent of the PMF, the peak inflow was 10,220 cfs.

The routing of the PMF, assuming that the gates will be fully opened indicates that the dam will be overtopped by 0.7 ft at elevation 343.1. The duration of the overtopping will be 9.7 hours, and the maximum outflow will be 9,780 cfs. The routing of 50 percent of the PMF indicates that the dam will be overtopped by 0.2 ft at elevation 342.6. The maximum outflow will be 250 cfs, and the duration of overtopping will be 6.8 hours. Overtopping of the embankment, due to the routing of 50 percent of the PMF, will be along the western boundary of the pond. Flows will then be diverted to the drainage ditch beyond the levee embankment through the intermittent levee embankment openings. Overtopping of the embankment by 0.2 ft is not expected to cause serious damage to the embankment.

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:

No design and construction data for Pond 2 were available. 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:

No post-construction changes to the dam have been reported.

E. Seismic Stability:

The structure is located in seismic zone 3. Since the dam is located in seismic zone 3, it is possible that an earthquake could occur of sufficient intensity to cause severe damage or failure of the embankment.

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 good condition. The dense tree and brush growth on the upstream and downstream is a deficiency which should be corrected and controlled.

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

The dam will be overtopped by flows in excess of 40 percent of the Probable Maximum Flood.

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 considered by the owner. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will deteriorate and possibly could become serious in the future. Based upon the small height of the dam, the broad floodplain, and the lack of permanent water impoundment, except during September to December, the deficiencies are not as serious to the safety of this dam as would normally be expected of an intermediate size dam.

D. Necessity for Additional Inspection:

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

E. Seismic Stability:

The structure is located in seismic zone 3. Since this dam is located in seismic zone 3, it is possible that an earthquake could occur of sufficient intensity to cause severe damage or failure of the embankment.

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:

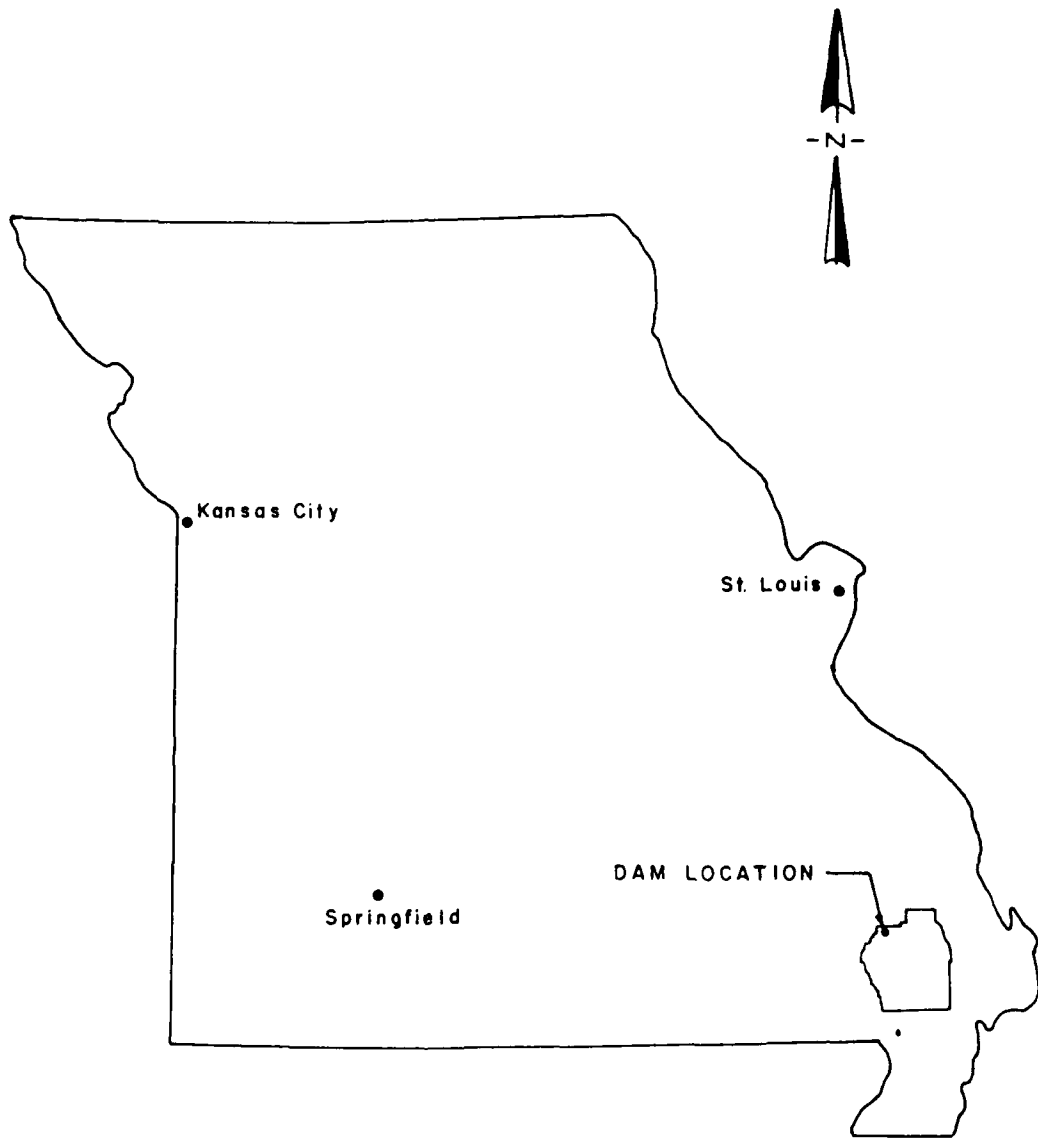
- (1) Spillway size and/or height of dam could be increased to pass 50 percent of the PMF. In either case, the spillway should be protected to prevent erosion.

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) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.
- (3) Brush and tree growth should be removed from the embankment. This should be done under the guidance of a professional engineer experienced in the design and construction of dams. Indiscriminate clearing methods could jeopardize the safety of the dam.
- (4) The spillway gate valves should be inspected and maintained periodically.
- (5) Operational procedures should be written to include provisions for personnel to be available to open the spillway gate valves during periods of anticipated high water.

APPENDIX A

Dam Location and Plans.



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LOCATION MAP

DUCK CREEK STATE WILDLIFE REFUGE #2
STODDARD COUNTY, MISSOURI

MO. I. D. No. 40093

SHEET 1, APPENDIX A

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REFUGE 367

Snake Bluff Cr.

SCALE 1:25,000
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WILDLIFE REFUGE BDY.
WILDLIFE REFUGE BDY.

36

WAYNE CO.
BOELLINGER CO.

DUCK CREEK

STODDARD CO.

STATE WILDLIFE REFUGE

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POND 1
MO. I. D. No. 40063

POND 2
MO. I. D. No. 40093

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POND 3
MO. I. D. No. 40094

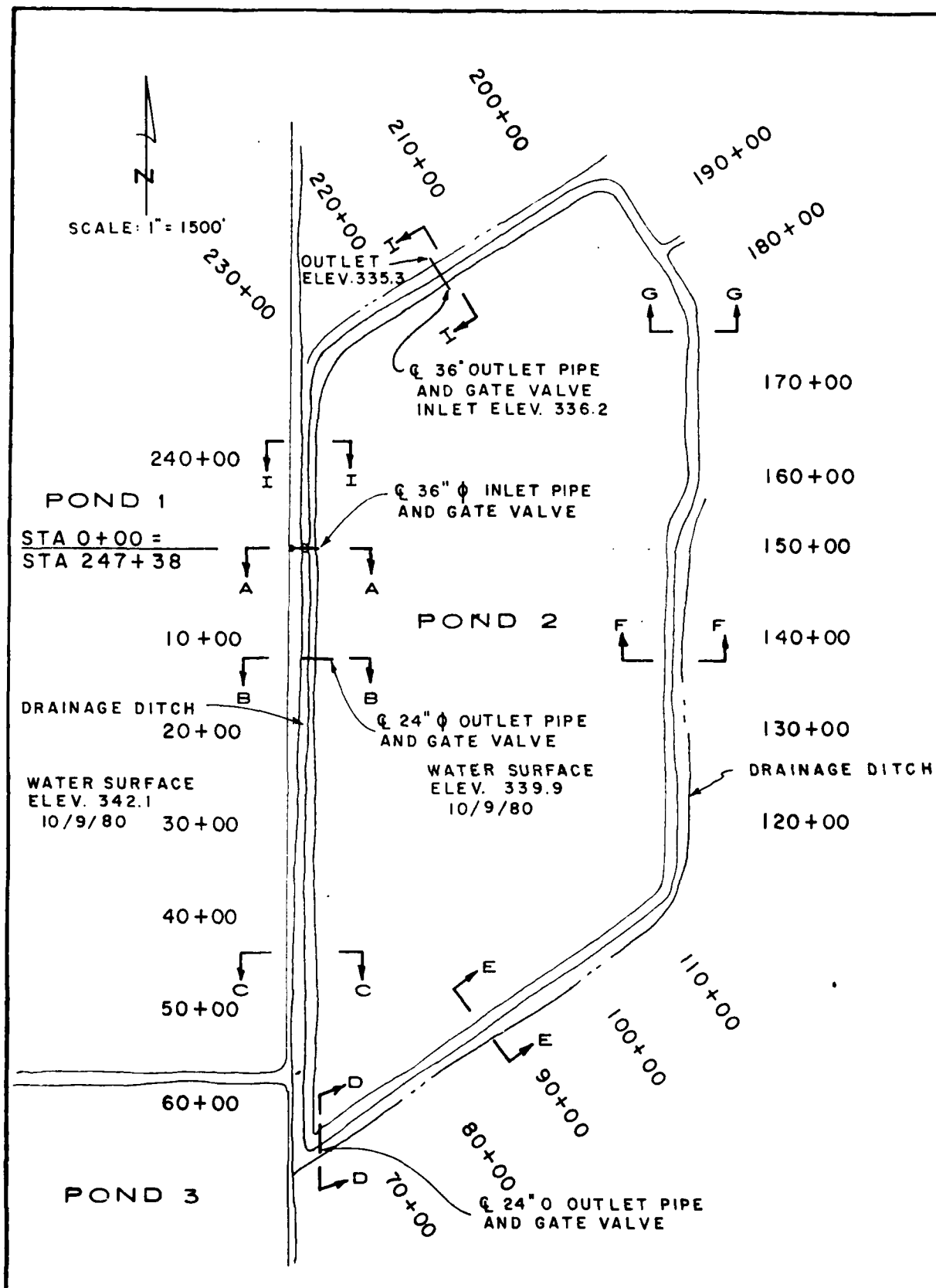
DUCK CREEK

Kinder

ST. LOUIS - SAN FRANCISCO

SHEET 2, APPENDIX A

Du



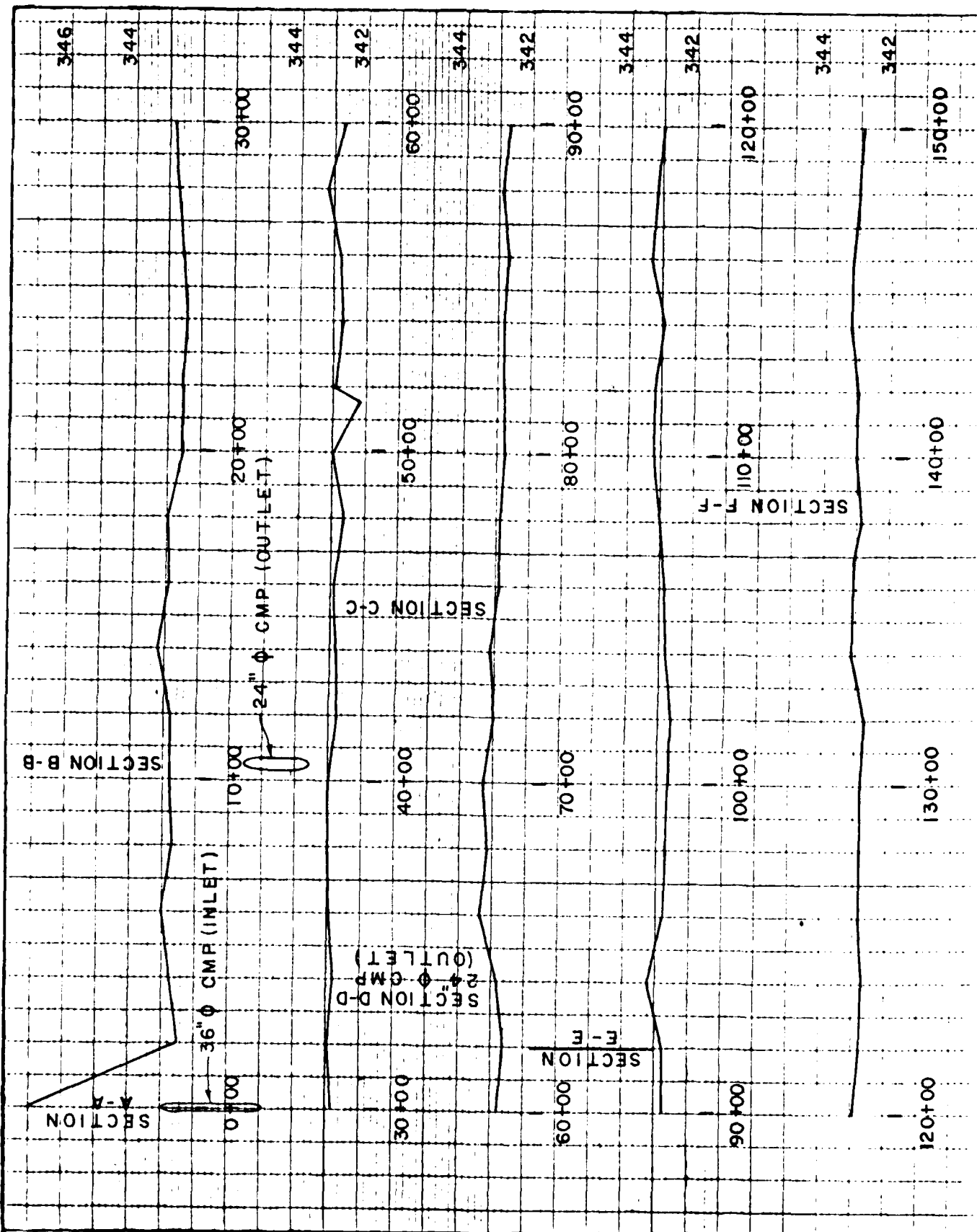
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DUCK CREEK STATE WILDLIFE REFUGE #2
 STODDARD COUNTY, MISSOURI
 MO. I. D. No. 40093

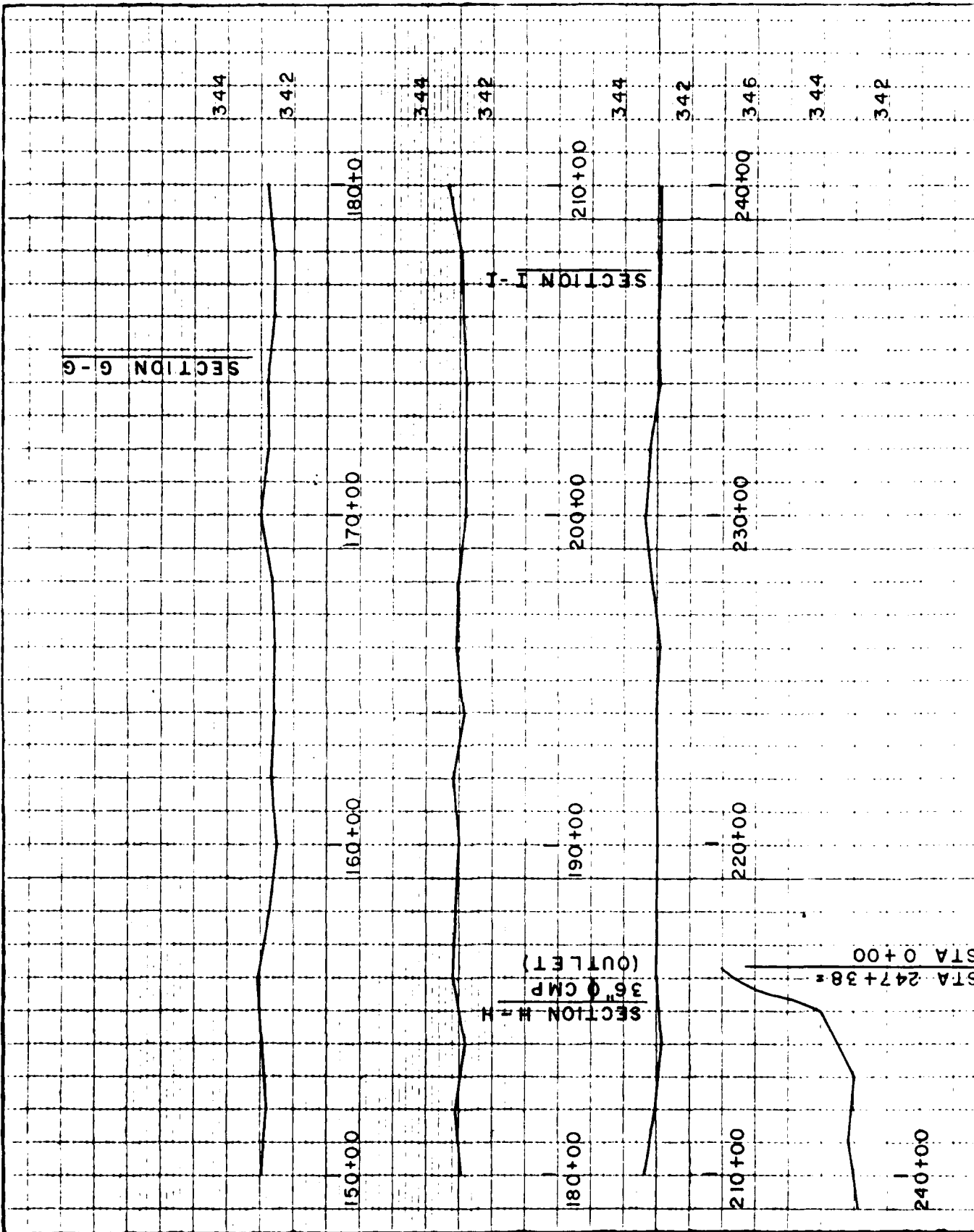
PLAN VIEW

SHEET 3, APPENDIX A



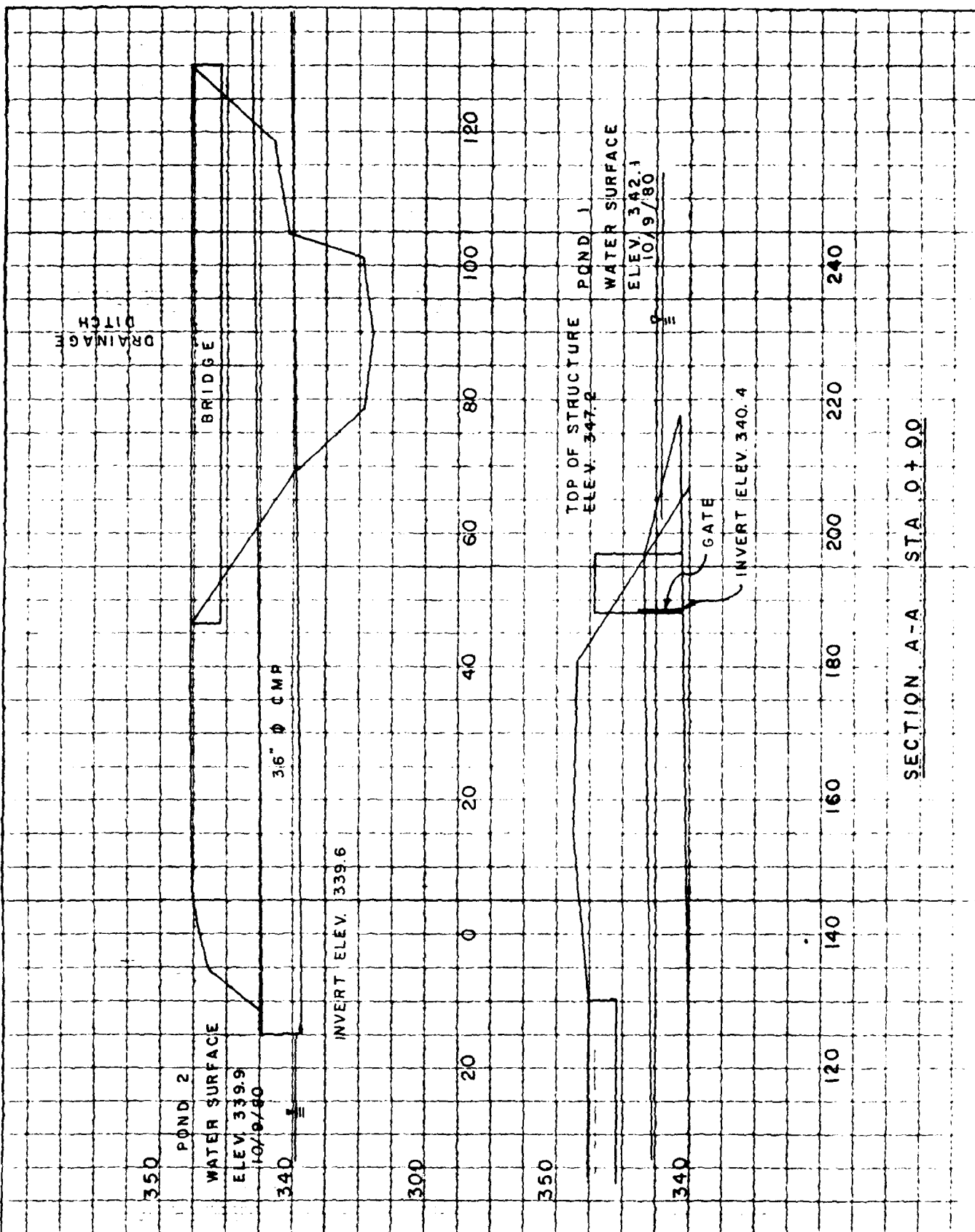
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DUCK CREEK STATE WILDLIFE REFUGE #2
 STODDARD COUNTY, MISSOURI
 MO. I. D. No. 40093
PROFILE



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STODDARD COUNTY, MISSOURI
MO. I.D. No 40093
PROFILE

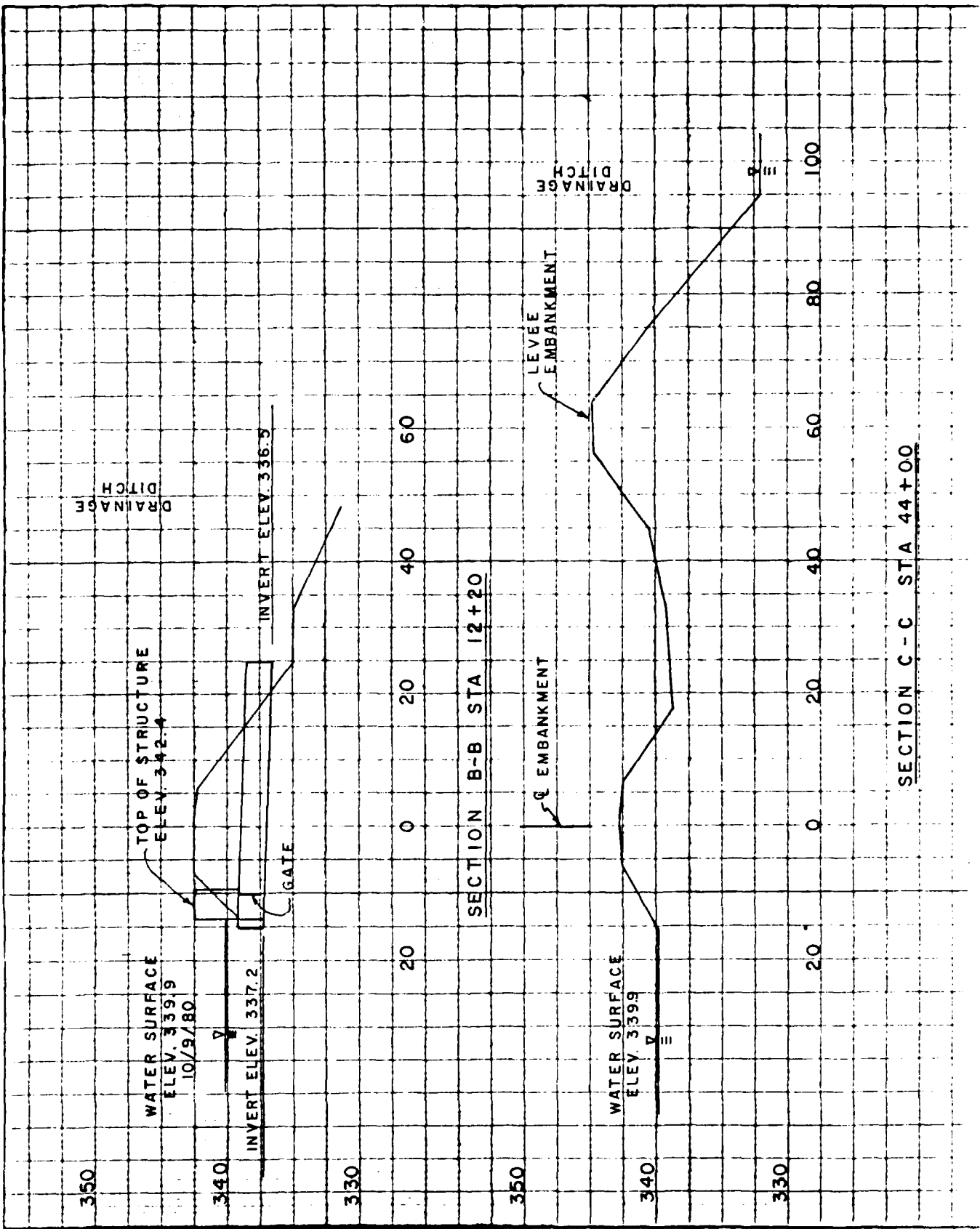


SECTION A-A STA 0+00

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DUCK CREEK STATE REFUGE #2
 STODDARD COUNTY, MISSOURI
 MQ I.D. No. 40093
CROSS - SECTIONS

SHEET 6 , APPENDIX A



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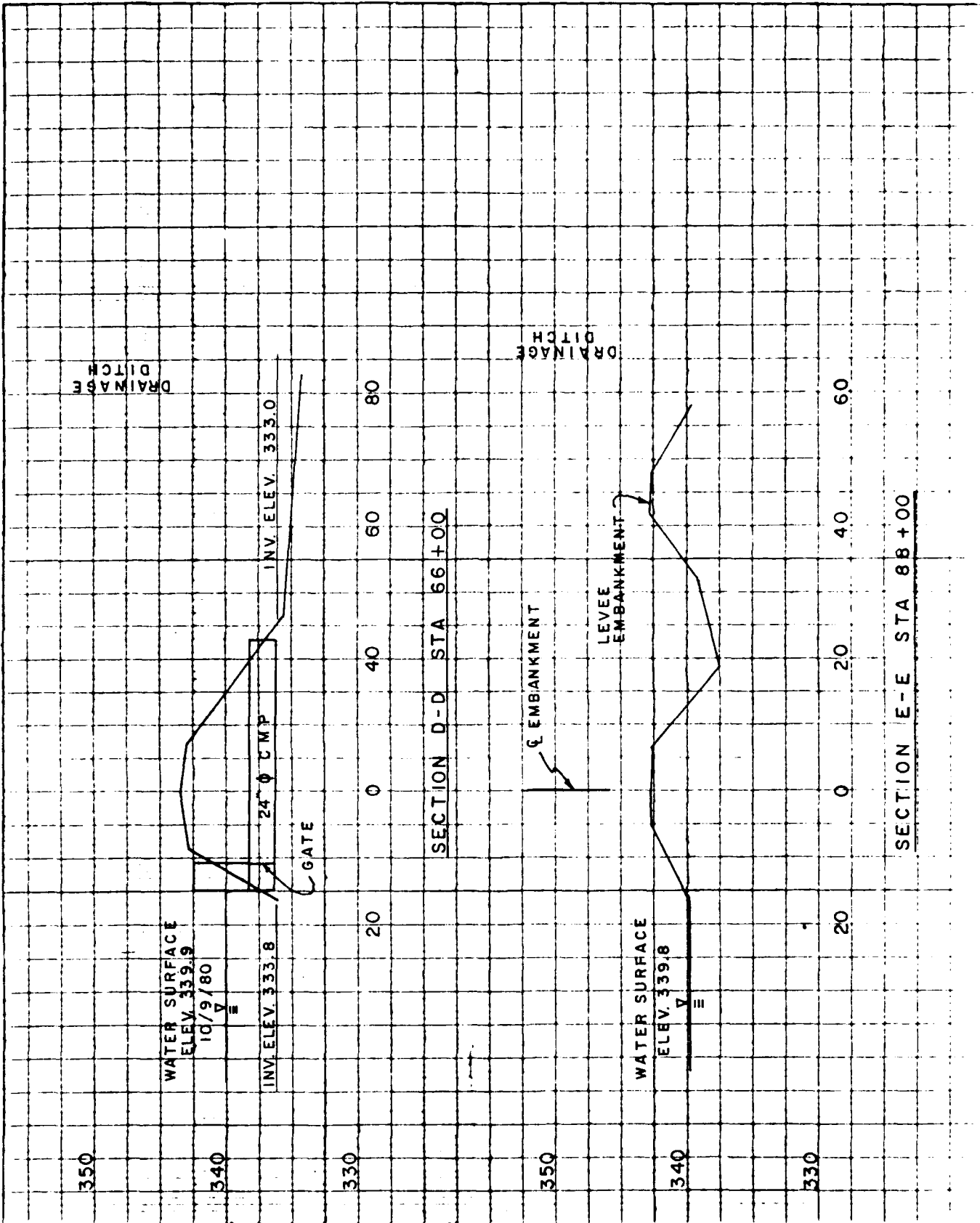
DUCK CREEK STATE REFUGE #2
STODDARD COUNTY, MISSOURI
 MO. I. D. No. 40093
CROSS - SECTIONS

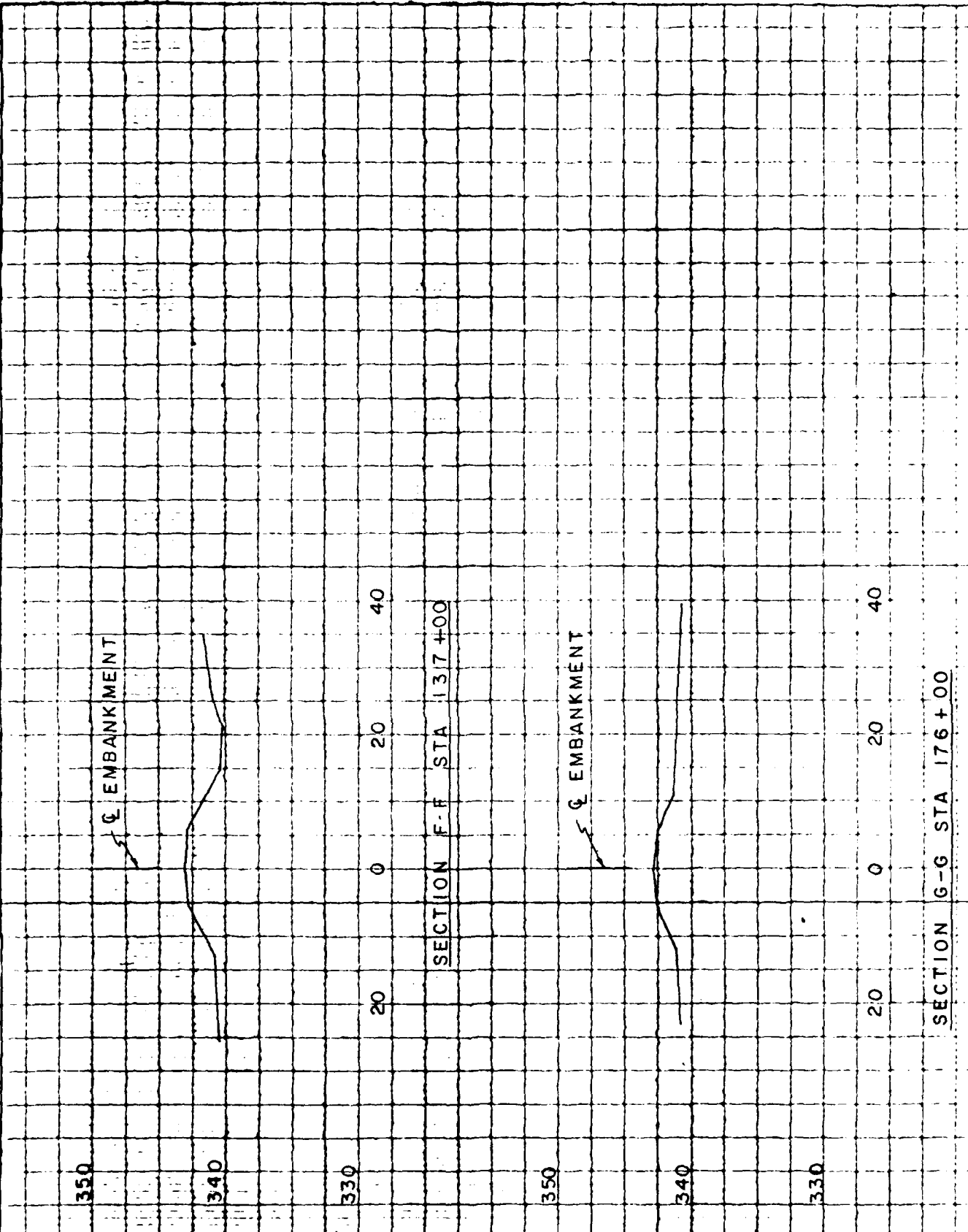
SHEET 7 , APPENDIX A

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 MO. I. D. No. 40093
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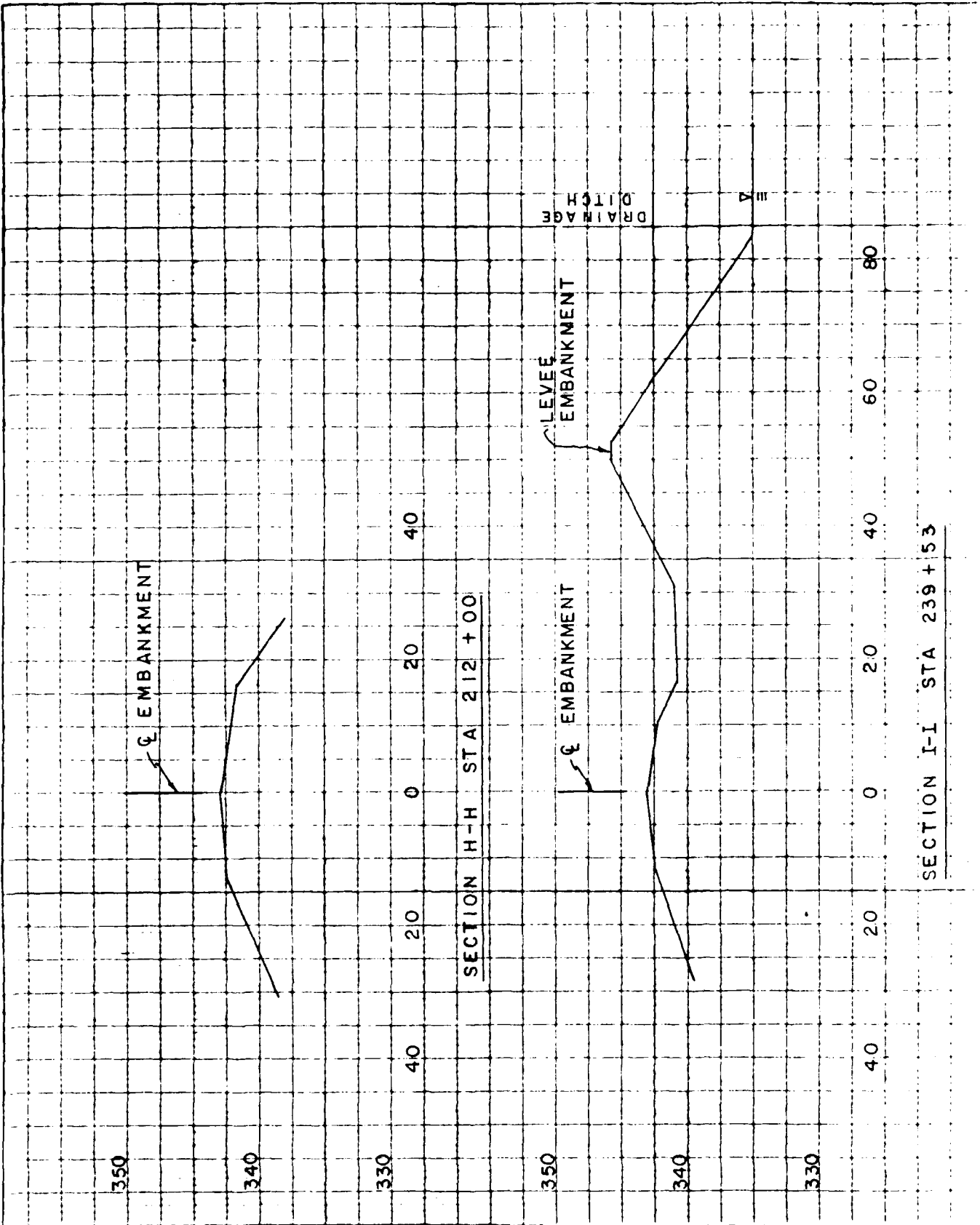
SHEET 8 , APPENDIX A





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 STODDARD COUNTY, MISSOURI
 MO. I.D. No. 40093
CROSS - SECTIONS



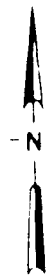
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DUCK CREEK STATE REFUGE #2
 STODDARD COUNTY, MISSOURI
 MO. I. D. No. 40093
CROSS - SECTIONS

SHEET 10 , APPENDIX A

APPENDIX B

Geology and Soils



LEGEND

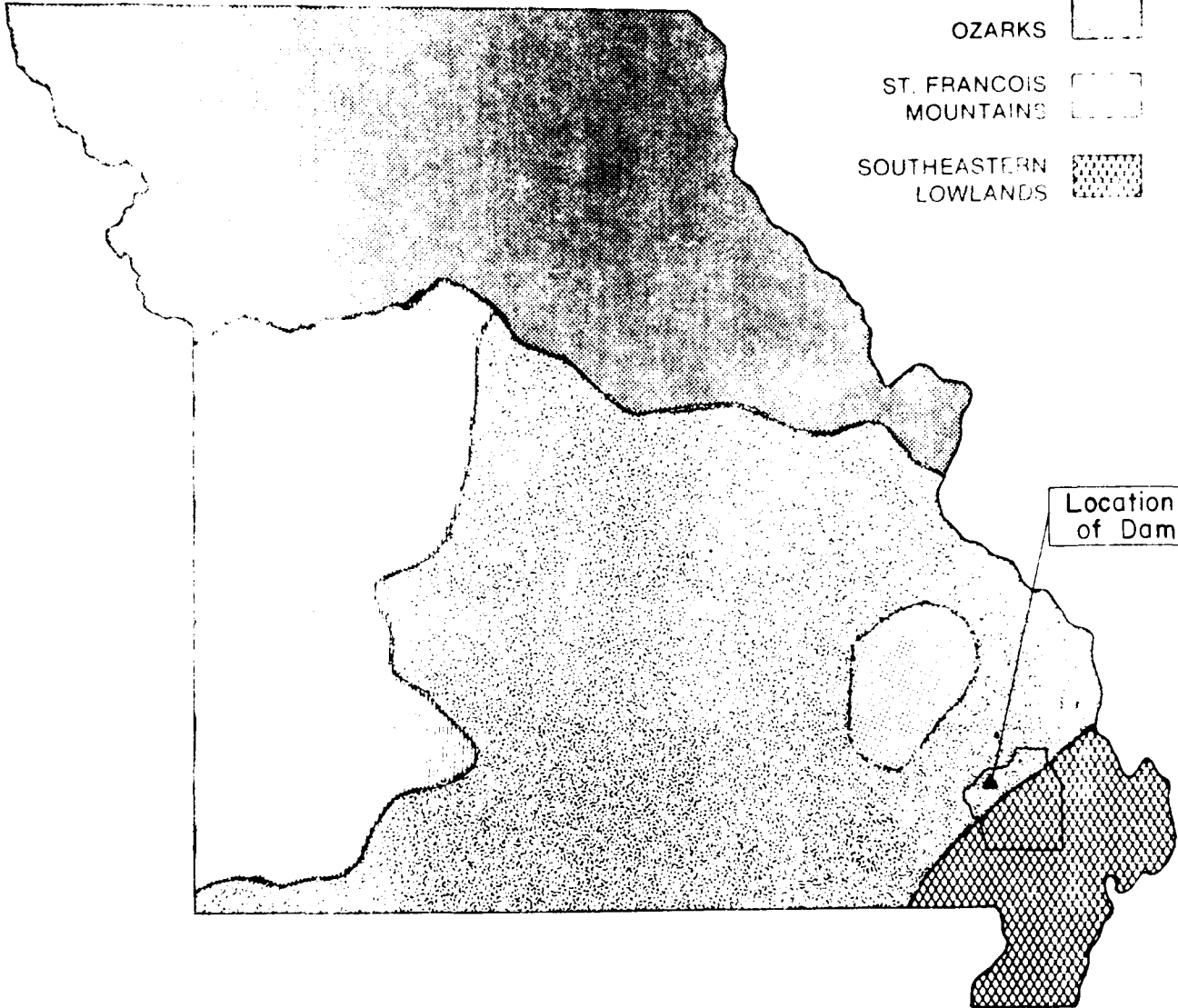
GLACIATED PLAINS 

WESTERN PLAINS 

OZARKS 

ST. FRANCOIS MOUNTAINS 

SOUTHEASTERN LOWLANDS 



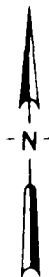
MAJOR GEOLOGIC REGIONS OF MISSOURI



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Duck Creek State Wildlife Refuge #2 Dam
Stoddard County, Missouri
Mo. I.D. No. 40093

SHEET 1, APPENDIX B



FEET

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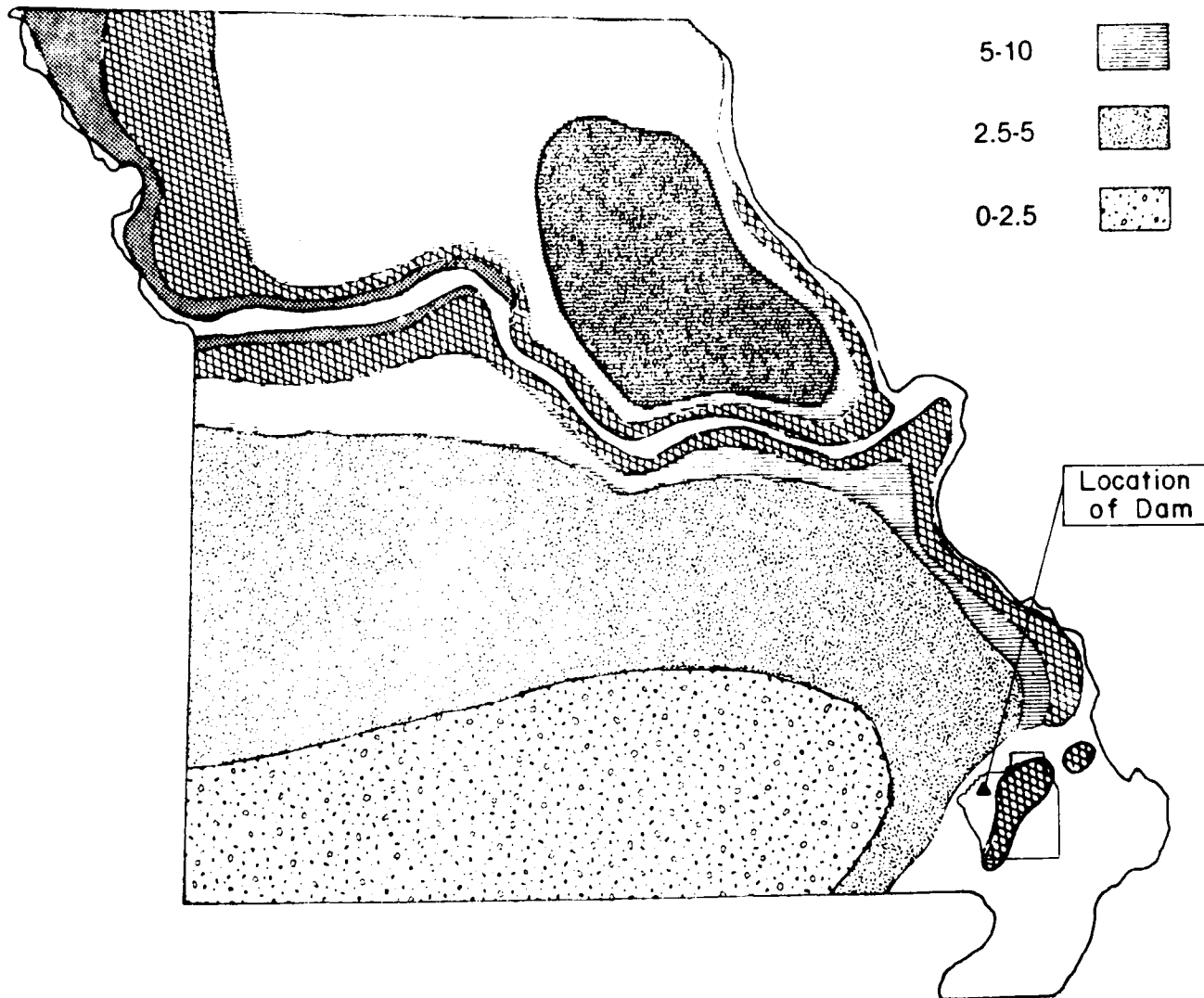
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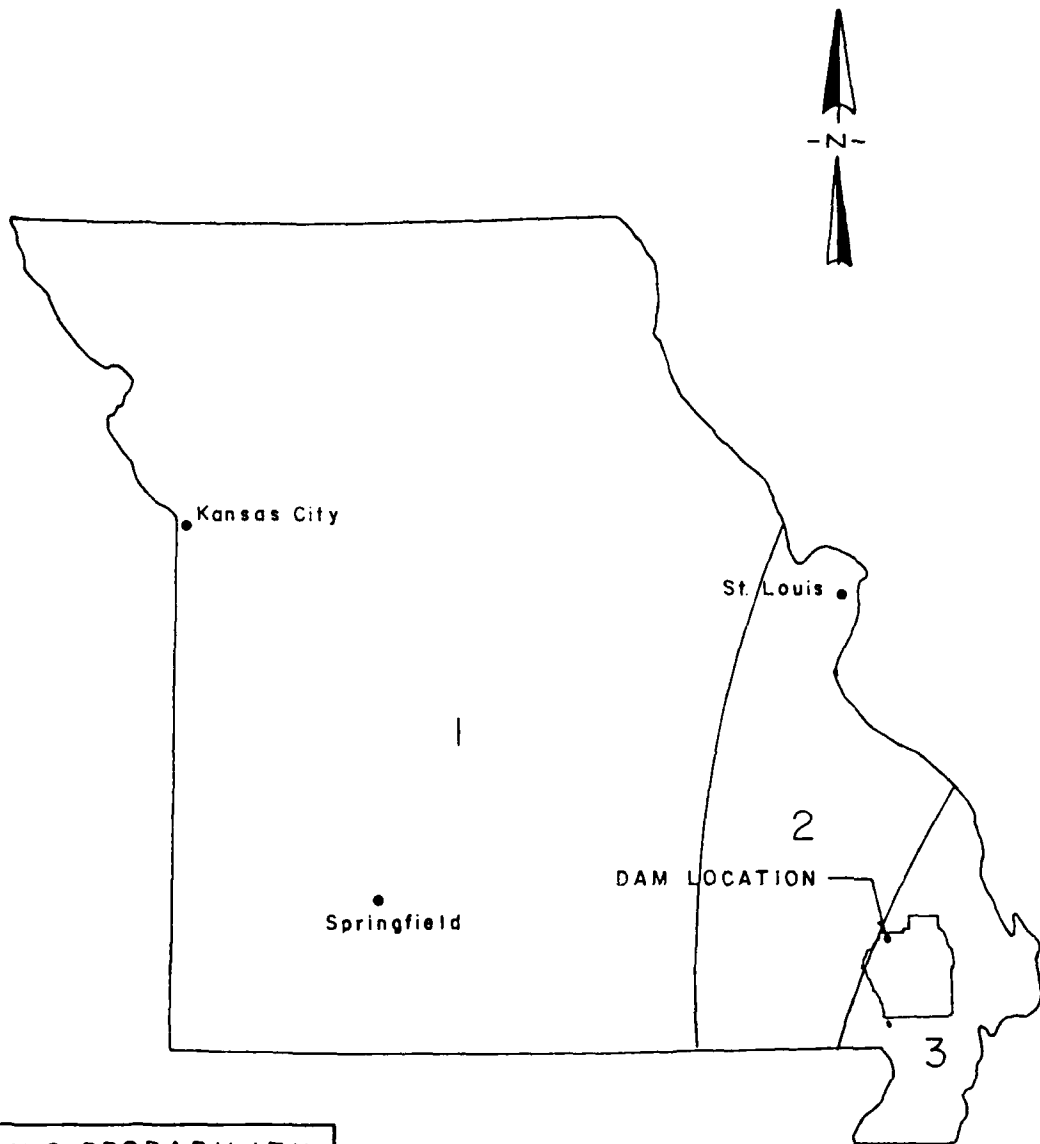
THICKNESS OF LOESSIAL DEPOSITS



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Duck Creek State Wildlife Refuge #2 Dam
Stoddard County, Missouri
Mo. I.D. No. 40093

SHEET 2, APPENDIX B



SEISMIC PROBABILITY	
ZONE	DAMAGE
1	MINOR
2	MODERATE
3	MAJOR

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SEISMIC ZONE MAP

DUCK CREEK STATE WILDLIFE REFUGE #2
STODDARD COUNTY, MISSOURI

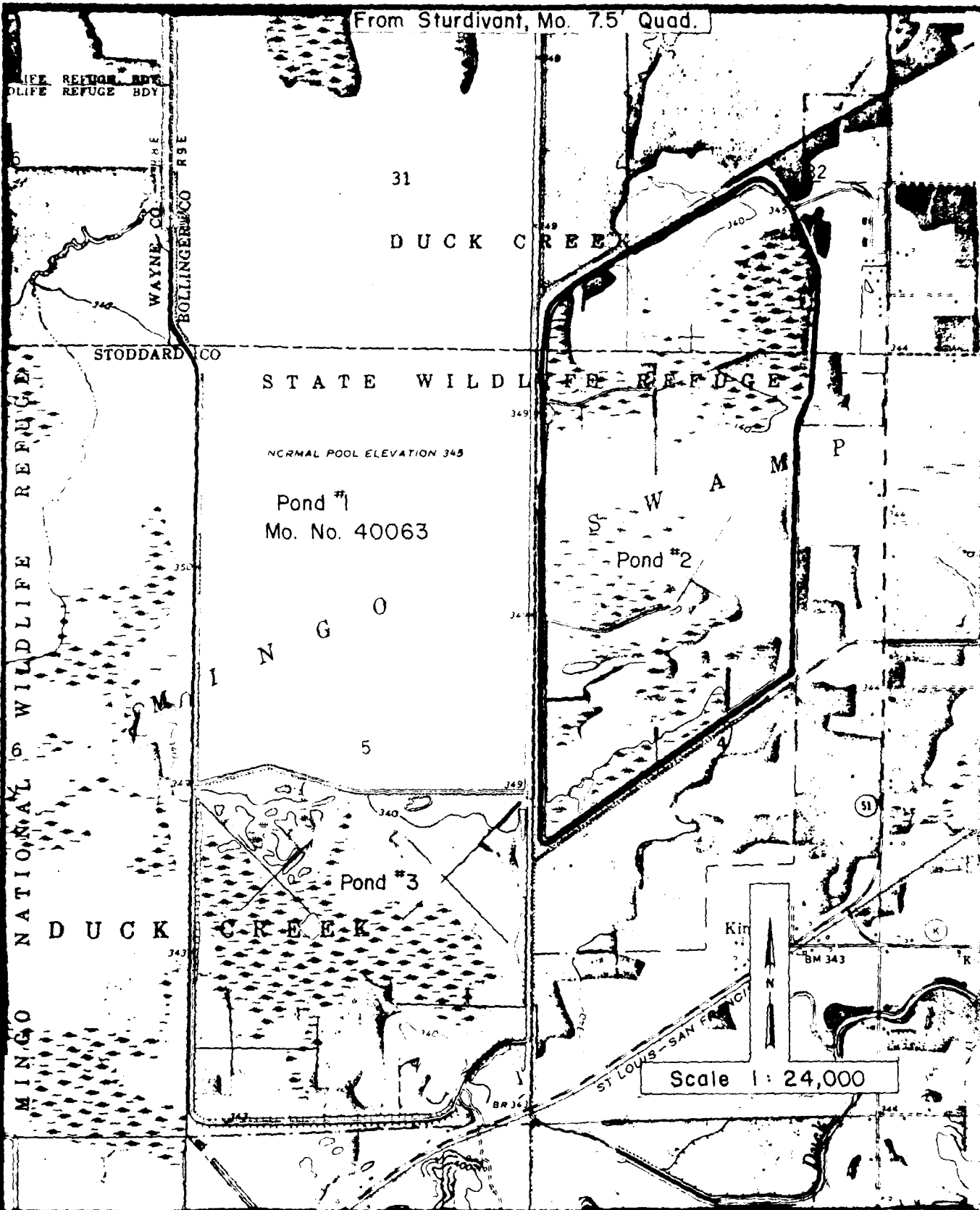
MO. I. D. No. 40093

SHEET 3, APPENDIX B

APPENDIX C

Overtopping Analysis

From Sturdivant, Mo. 7.5' Quad.



LAKE AND WATERSHED MAP

 **HANSON ENGINEERS**
INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Duck Creek State Wildlife Refuge #2 Dam
Stoddard County, Missouri
Mo. I.D. No. 40093

Sheet I, 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 48-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination). This results in a PMP value of 27.2 in. (24 hrs duration) for 200 sq miles and 102, 120, 130, 140 percent of PMP for 6, 12, 24, 48 hrs duration respectively. The total 48-hour PMP for the Duck Creek State Wildlife Refuge-Pond 2 drainage area results in 38.1 in. The drainage area is enclosed within a levee system. All rainfall was assumed to go into storage within the banks of the levee with no losses. Consequently, the storage within the reservoir will increase equal to the depth of the rainfall until overtopping occurs.

The synthetic unit hydrograph for the watershed was developed for a 10 minute rainfall (i) duration for a drainage area (A) of 712 acres. Considering that all the rainfall goes into storage:

$$Q = i.A$$

$$i = 1 \text{ in./10 min.} = 6 \text{ in./hr} = 0.5 \text{ ft/hr} = 0.5 \text{ ft/3600 sec.}$$

$$A = 712 \text{ acres} = 712 (43,560) \text{ ft}^2$$

$$Q = i.A = (0.5 \text{ ft/3600 sec})(712)(43,560) \text{ ft}^2 = 4,307.6 \text{ cfs}$$

$$Q = 4,307.6 \text{ cfs} = \text{total discharge produced for 1 in. of rainfall over the area.}$$

For (i) inches of rainfall:

$$Q = i, \text{ in.} \times 4,307.6 \text{ cfs}$$

Consequently, the temporal distribution of inflow to the reservoir was developed by simply multiplying the rainfall in inches by 4,307.6 to obtain the inflow in cfs.

The reservoir routing was accomplished by using the Modified Puls Method assuming the starting lake elevation at maintained normal pool (341.5). No antecedent storm was routed in order to determine the starting elevation. Outflow from the reservoir is possible through two 24 in., and one 36 in. corrugated metal pipes (CMP) controlled by gates. The invert elevations for these three pipes are below the maintained normal pool elevation. The reservoir routing was analyzed assuming that these gates will be fully open at the beginning of the routing. The results (see Sheet 8, Appendix C) indicated that overtopping will occur for discharges in excess of 40 percent of the PMF. For this study, the hydraulic capacity of the pipe system and the storage capacity of the reservoir were defined by the elevation-surface area-storage-discharge relationships shown in Table 1 (Sheet 4, Appendix C).

The reservoir routing was also studied, for comparison, assuming that the three gates will remain closed during the routing. The results (see Sheet 11 of Appendix C) indicated that in this case the overtopping will occur for discharges in excess of 25 percent of the PMF.

The rating curve for the pipes (see Table 2, Sheet 5, Appendix C) was determined assuming entrance and outlet control, using charts for corrugated metal pipes from the U. S. Bureau of Public Roads.

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. The lowest elevation of the crest of the dam, obtained from survey measurements, was assumed as top of dam elevation.

A summary of the routing analysis for different ratios of the PMF, assuming the gates fully open, is shown in Table 3 (Sheet 6, Appendix C). The routing study indicates that the 1 percent probability flood (7.5 in.) will be totally stored in the reservoir without causing overtopping of the dam.

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 7 to 11 of Appendix C.

TABLE 1

ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

<u>Elevation (ft, MSL)</u>	<u>Lake Surface Area (acres)</u>	<u>Lake Storage (acre-ft)</u>	<u>Spillway Discharge (cfs)</u>
336.2	0	0	-
339.5	27	-	-
340.0	111	35	-
340.5	278	132	-
341.0	544	337	-
*341.5	709	650	111
342.0	711	1,005	118
**342.4	712	1,290	124
343.0	714	1,717	131
343.5	718	2,075	136

*Maintained normal pool elevation

**Top of dam elevation (lowest point)

The above relationships were developed using data from the Missouri Conservation Commission Plans and the field measurements.

TABLE 2

DISCHARGE STRUCTURES RATING CURVE

Reservoir Elevation (MSL)	24 in. CMP Sta. 12+20 (cfs)	24 in. CMP Sta. 66+00 (cfs)	36 in. CMP Sta. 213+38 (cfs)	Total Discharge (cfs)
*341.5	22	33	56	111
342.0	24	34	60	118
**342.4	25	35	64	124
342.5	26	35	64	125
343.0	28	36	67	131
343.5	29	37	70	136
344.0	30	39	73	142
344.5	32	40	76	148

*Maintained normal pool

**Top of dam elevation

Method Used: Assuming outlet control for the two 24 in. CMP, and entrance control for the 36 in. CMP, using charts for corrugated metal pipes ($n = 0.024$) from the U. S. Bureau of Public Roads.

TABLE 3

RESULTS OF FLOOD ROUTINGS

(assuming gates fully open)

Ratio of PMF	Peak Inflow (cfs)	Peak Lake Elevation (ft, MSL)	Total Storage (acre-ft)	Peak Outflow (cfs)	Depth (ft) Over Top of Dam
0.10	2,044	*341.5	650	111	0
0.20	4,087	341.6	738	113	0
0.25	5,109	341.8	860	115	0
0.30	6,131	342.0	982	118	0
0.35	7,153	342.1	1,104	120	0
0.40	8,174	342.3	1,225	122	0
0.50	10,220	342.6	1,431	250	0.2
0.75	15,327	342.9	1,608	1,907	0.5
1.00	20,440	343.1	1,795	9,780	0.7

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

*Maintained normal pool elevation
Top of dam elevation = 342.4

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	1.11	1	2044.	4087.	5109.	6131.	7153.	8174.	10218.	15327.	20436.								
	(2.88)	(57.87)	(115.74)	(144.67)	(173.61)	(202.54)	(231.48)	(289.34)	(434.02)	(578.69)
ROUTED TO	2	1.11	1	0.	0.	0.	43.	184.	416.	1054.	7066.	11897.								
	(2.88)	(0.00)	(0.00)	(0.00)	(1.22)	(5.20)	(11.77)	(29.85)	(200.08)	(336.90)

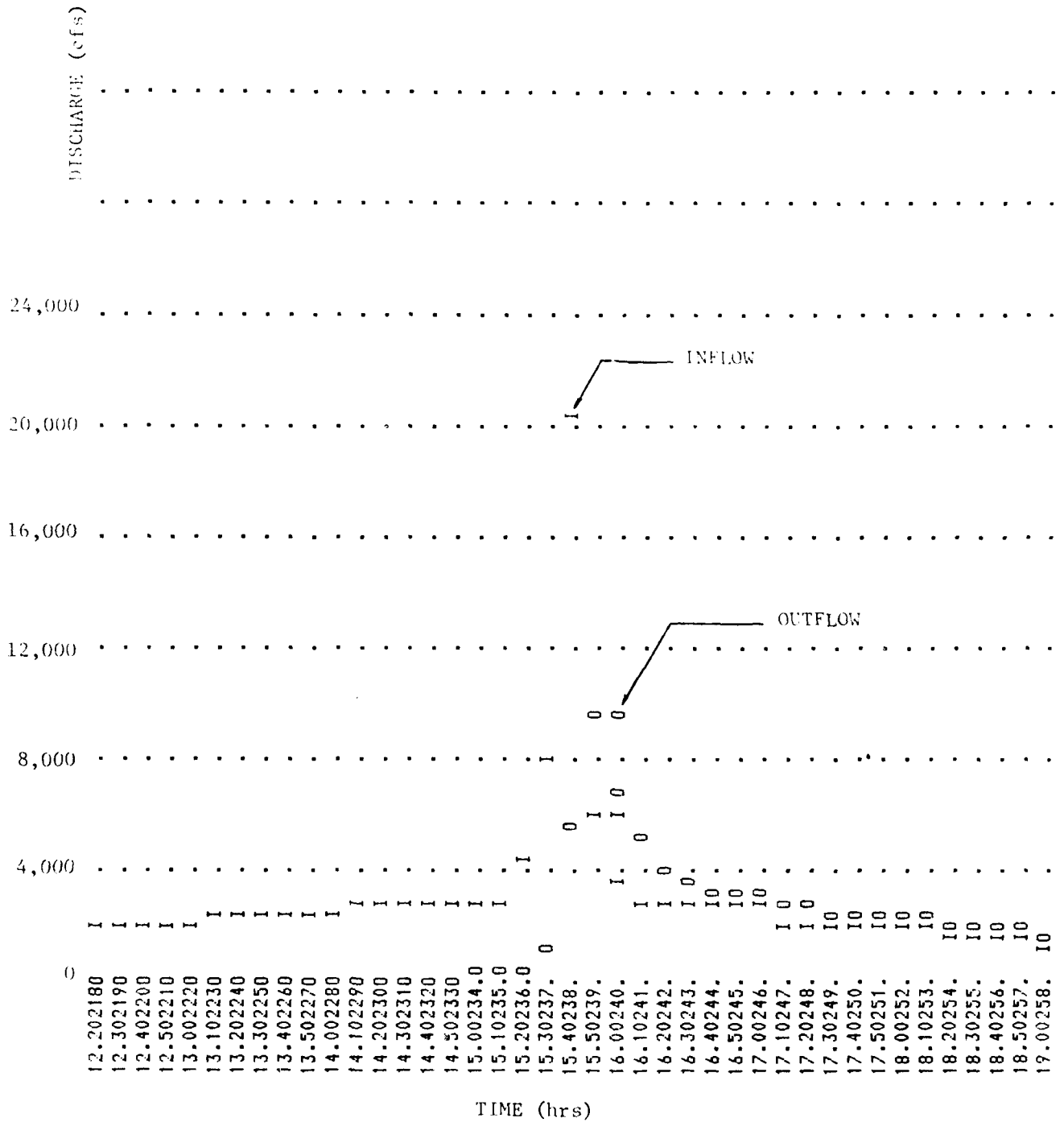
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	341.50	341.50	336.20	342.40
	STORAGE	650.	0.	1290.
	OUTFLOW	0.	0.	0.

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
0.10	341.85	0.00	898.	0.	0.00	0.00	0.00
0.20	342.20	0.00	1151.	0.	0.00	0.00	0.00
0.25	342.38	0.00	1275.	0.	0.00	0.00	0.00
0.30	342.53	0.13	1383.	43.	6.00	48.00	0.00
0.35	342.63	0.23	1455.	184.	7.67	45.17	0.00
0.40	342.70	0.30	1506.	416.	8.33	43.67	0.00
0.50	342.79	0.39	1569.	1054.	8.67	42.00	0.00
0.75	343.05	0.65	1752.	7066.	10.17	39.83	0.00
1.00	343.15	0.75	1826.	11897.	11.33	39.83	0.00

PMF RATIOS
 OUTPUT DATA
 (ASSUMING GATES CLOSED)

Max. Inflow = 20,440 cfs
 Max. Outflow = 9,780 cfs



INFLOW-OUTFLOW HYDROGRAPH
 FOR THE PMF
 (Assuming gates fully open)

A OVERTOPPING ANALYSIS FOR DUCK CREEK STATE REFUGE POND-2 DAM (# 29)

A STATE ID NO. 40093 COUNTY NAME : STODDARD

A HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 80S3001

B 288 10

B1 5

J 1 9 1

J1 .10 .20 .25 .30 .35 .40 .50 .75 1.0

K 0 1

K1 INFLOW HYDROGRAPH COMPUTATION **

M 1 -1 1.113 1

P 0 27.2 102 120 130 140

T 1

U 1

U14307.6

X 0 -.1 2

K 1 2

K1 RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **

Y 1 1

Y1 1 650

Y4 336.2 341.5 342.0 342.5 343.0 343.5 344.0 344.5

Y5 0 111 118 125 131 136 142 148

\$S 0 35 132 337 650 1005 1290 1717 2075

\$E 336.2 340.0 340.5 341.0 341.5 342.0 342.4 343.0 343.5

\$S 336.2

\$D 342.4

\$L 0 600 1100 3300 8100 11780 16900 22100 24500

\$V 342.4 342.5 342.6 342.7 342.8 342.9 343.0 343.1 343.3

K 99

PMF RATIOS
INPUT DATA
(Assuming gates fully open)

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	1.11	1	2044.	4087.	5109.	6131.	7153.	8174.	10218.	15327.	20436.							
	(2.88)	(57.87)	(115.74)	(144.67)	(173.61)	(202.54)	(231.48)	(289.34)	(434.02)	(
ROUTED TO	2	1.11	1	111.	113.	115.	118.	120.	122.	249.	1907.	9785.							
	(2.88)	(3.14)	(3.19)	(3.26)	(3.33)	(3.40)	(3.46)	(7.06)	(54.00)	(

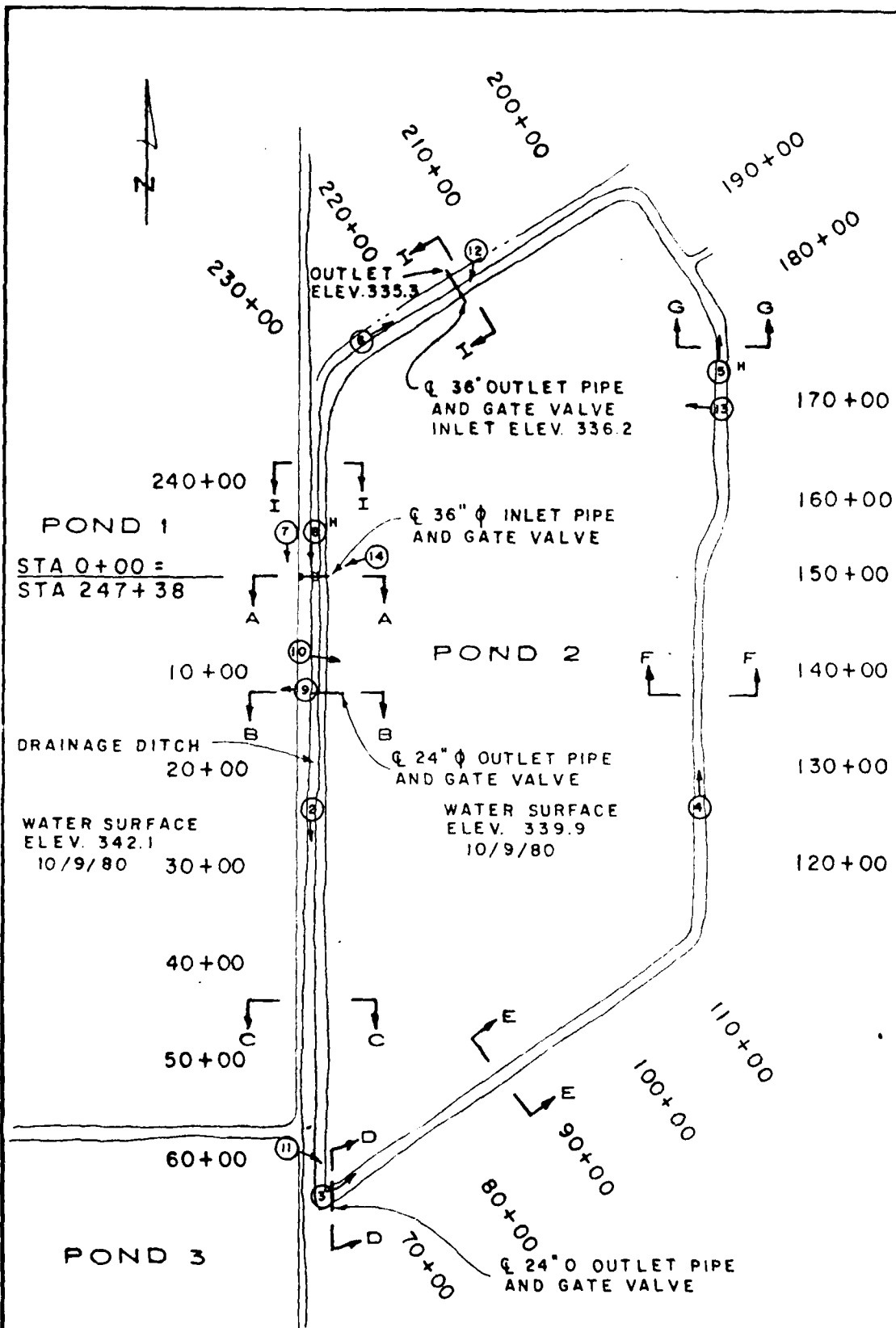
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM	RATIO OF PMF	MAXIMUM RESERVOIR STORAGE 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
	341.50	341.50	336.20	342.40	0.10	341.50	0.00	650.	111.	0.00	0.00	0.00
	650.	650.	0.	1290.	0.20	341.62	0.00	738.	113.	0.00	45.00	0.00
	111.	111.	0.	124.	0.25	341.80	0.00	860.	115.	0.00	45.50	0.00
					0.30	341.97	0.00	982.	118.	0.00	46.00	0.00
					0.35	342.14	0.00	1104.	120.	0.00	46.17	0.00
					0.40	342.31	0.00	1225.	122.	0.00	46.50	0.00
					0.50	342.60	0.20	1431.	249.	6.83	45.33	0.00
					0.75	342.85	0.45	1608.	1907.	8.50	41.00	0.00
					1.00	343.11	0.71	1795.	9785.	9.67	39.83	0.00

PMF RATIOS
 OUTPUT DATA
 (Assuming gates fully open)

APPENDIX D

Photographs



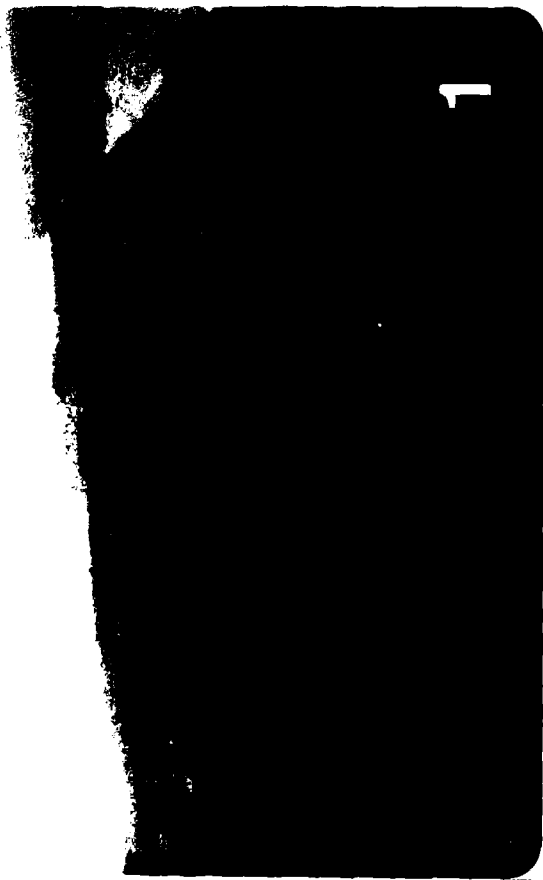
A/E ANDERSON ENGINEERING, INC.
 730 N. BENTON AVE. • SPRINGFIELD, MO. 65802

DUCK CREEK STATE WILDLIFE REFUGE #2
 STODDARD COUNTY, MISSOURI
 MO. I.D. No. 40093
PHOTOGRAPH INDEX

SHEET 1, APPENDIX D

LIST OF PHOTOGRAPHS

<u>Photo No.</u>	<u>Description</u>
1	Aerial View (Looking South) Note Pond 1 to right side of Photo
2	Embankment and Lake (Looking South at Station 25 + 00) Note navigation channel
3	Embankment and Lake (Looking Northeast at Station 65 + 00) Note navigation channel
4	Crest of Embankment (Looking North at Station 125 + 00) Note dense tree and brush growth
5	Crest of Embankment (Looking North at Station 172 + 00)
6	Embankment and Lake (Looking Northeast at Station 223 + 00) Drainage ditch is beyond dense tree and brush growth
7	Inlet Pipe from Pond 1 (Looking South)
8	Inlet Structure at Pond 1 (Looking South)
9	Outlet Pipe into Levee at Station 12 + 20 (Looking West) Note discontinuity of levee between embankment and drainage ditch
10	Inlet Structure and Gate at Station 12 + 20 (Looking East)
11	Gate Valve at Station 66 + 00 (Looking Southeast)
12	Inlet Structure and Gate at Station 170 + 00 (Looking West)
13	Lake Area from Station 170 + 00 (Looking West toward Pond 1)
14	Bridge over Levee at Station 0 + 00 (Looking West toward Pond 1)







10



12



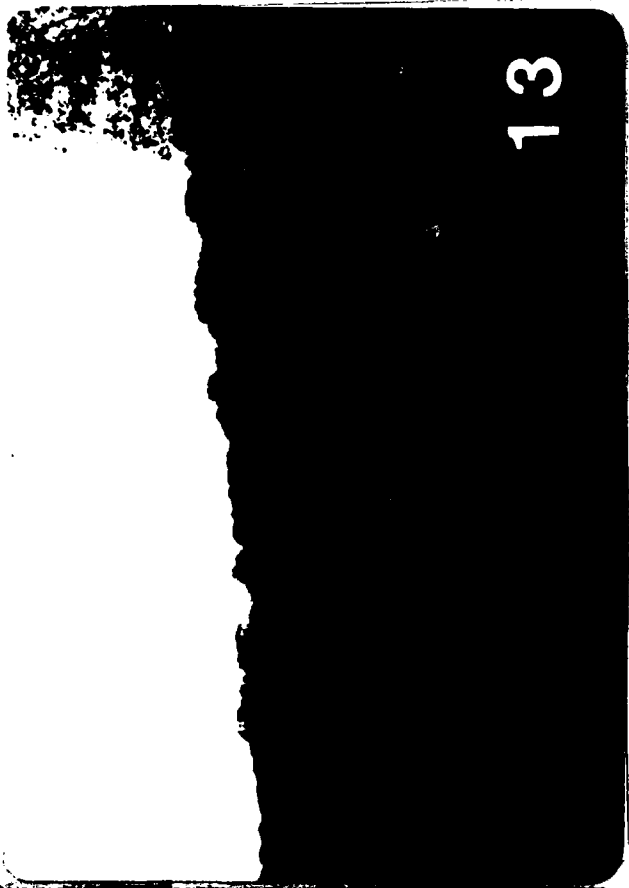
9



11



14



13

LMED

