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BLACK AND VEATCH KANSAS CITY MO

NATIONAL DAM SAFETY PROGRAM, RICHMOND SCHOOLS DAM (MO 10588), M--ETC(U)

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MISSOURI-KANSAS CITY BASIN
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RICHMOND SCHOOLS DAM
RAY COUNTY, MISSOURI
MO 10888

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM



United States Army
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St. Louis District

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. <i>AL A166 364</i>	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) National Dam Inspection Report National Dam Safety Program Richmond Schools Dam (MO 10588) Ray County, Missouri		5. TYPE OF REPORT & PERIOD COVERED Final Report
6. AUTHOR(s) Black & Veatch, Consulting Engineers		7. PERFORMING ORG. REPORT NUMBER
8. PERFORMING ORGANIZATION NAME AND ADDRESS Army Engineer District, St. Louis Inventory and Inspection Section, LMSED-PD Tucker Blvd., North, St. Louis, Mo. 63101		9. CONTRACT OR GRANT NUMBER(s) DAON43-81-C-0037 ✓
10. CONTROLLING OFFICE NAME AND ADDRESS Army Engineer District, St. Louis Inventory and Inspection Section, LMSED-PD Tucker Blvd., North, St. Louis, Mo. 63101		11. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
12. MONITORING National Dam Safety Program. Richmond Schools Dam (MO 10588), Missouri-Kansas City Basin, Ray County, Missouri. Phase I Inspection Report.		13. REPORT DATE December 1980
14. DISTRIBUTION Approved for release; distribution unlimited.		15. NUMBER OF PAGES Approximately 55
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		16. SECURITY CLASS. (of this report) UNCLASSIFIED
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

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MISSOURI-KANSAS CITY BASIN

**RICHMOND SCHOOLS DAM
RAY COUNTY, MISSOURI
MO 10588**

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PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM



United States Army
Corps of Engineers
Serving the Army
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St. Louis District

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

FOR: STATE OF MISSOURI

DECEMBER 1980



REPORT TO
ATTENTION OF

DEPARTMENT OF THE ARMY

ST. LOUIS DISTRICT, CORPS OF ENGINEERS

210 TUCKER BOULEVARD, NORTH

ST. LOUIS, MISSOURI 63101

SUBJECT:

Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Richmond Schools Dam MO 10588.

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

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

- a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.
- b. Overtopping of the dam could result in failure of the dam.
- c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY:	SIGNED	3	MAR 1981
	Chief, Engineering Division		Date
APPROVED BY:	SIGNED	4	MAR 1981
	Colonel, CE, District Engineer		Date

RICHMOND SCHOOLS DAM

RAY COUNTY, MISSOURI

MISSOURI INVENTORY NO. 10588

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

DECEMBER 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Richmond Schools Dam
State Located	Missouri
County Located	Ray County
Stream	Lick Creek, a Tributary of Willow Creek
Date of Inspection	2 December 1980

Richmond Schools Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten lives and property. The estimated damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are two dwellings, a railroad, a dam (Mo. ID. 10239), two trailer homes, and a municipal sewage lagoon. Contents of the estimated downstream hazard zone were verified by the inspection team.

Our inspection and evaluation indicates 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 not pass the probable maximum flood without overtopping but will pass 25 percent of the probable maximum flood. The spillways will pass the flood which has a one percent chance of occurrence in any given year (100-year flood). The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the hazard zone and the reservoir storage volume, the spillway design flood should be 50 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge which may be expected from the most severe combination of critical meteorologic and hydrologic conditions which are reasonably possible in the region.

Based on visual observations, this dam appears to be in somewhat less than satisfactory condition. Deficiencies visually observed by the inspection team were seepage downstream of the dam left of the spillway

pipe and near the right abutment. Standing water was observed in holes and ruts to the right of the outlet pipe. Seepage appeared to be under a low head at less than 1 gpm. Other deficiencies include erosion along the upstream slope, erosion behind the inlet to the principal spillway pipe, deep vehicle ruts near the right abutment, tree growth, and animal burrows. Seepage and stability analyses required by the guidelines were not available.

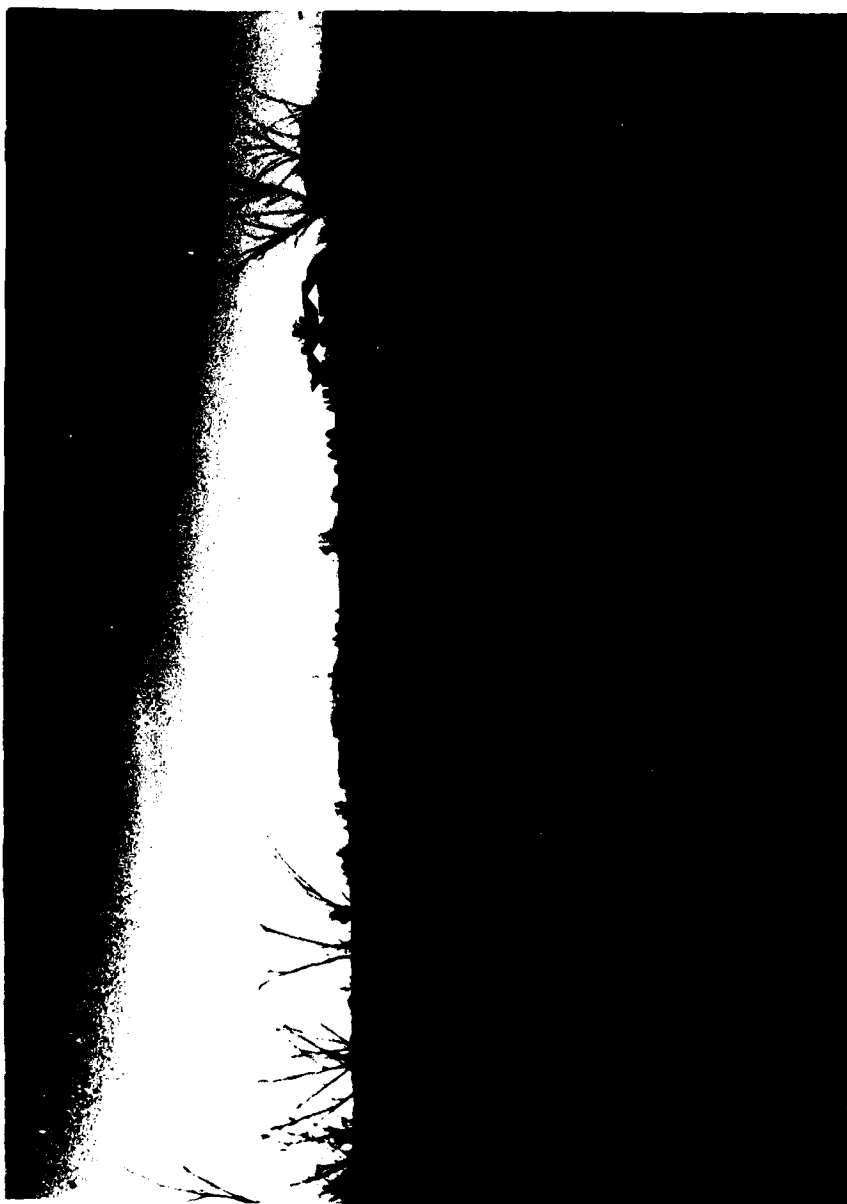
There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.



Edwin R. Burton, PE
Missouri E-10137



Harry L. Callahan, Partner
Black & Veatch



OVERVIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
RICHMOND SCHOOLS DAM

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Appendix A - Hydrologic and Hydraulic Analyses

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Richmond Schools Dam be made.

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

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

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth structure located in the valley of Lick Creek, a tributary of Willow Creek (see Plate 1). The watershed is an area of low hills with gentle slopes consisting of about 10 percent urban development, 30 percent grassland, and 60 percent agricultural cropland. The dam is approximately 470 feet long along the crest and 25 feet high. The dam crest is about 11 feet wide. The downstream face of the dam has a nonuniform slope from the crest to the valley floor below.

(2) The principal spillway is a 12-inch diameter iron pipe with a small steel plate above the inlet. The pipe outlet is located near the middle of the dam and discharges to a plunge pool in the natural stream channel near the dam's toe. The flow through the principal spillway is controlled by hydraulic conditions at the inlet.

(3) The emergency spillway for this structure is located at the west end of the embankment. The approach channel is about 35 feet in width and curves perpendicular to the dam's axis. A control section is evident near the embankment. The spillway discharges onto the downstream face of the dam. The physical characteristics of this spillway indicate to the inspection team that it was not completely built.

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

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

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category. A small size dam is classified as having a height less than 40 feet, but greater than or equal to 25 feet and/or a storage capacity less than 1,000 acre-feet, but greater than or equal to 50 acre-feet.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Richmond Schools Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Richmond Schools Dam the estimated flood damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are two dwellings, a railroad, a dam (Mo. ID. 10239), two trailer homes, and a municipal sewage lagoon. Contents of the estimated downstream hazard zone were verified by the inspection team.

e. Ownership. The dam is owned by the Richmond School District R-16, 316 E. N. Main Street, Richmond, Mo. 64085, c/o Dr. Larry Brown, Superintendent.

f. Purpose of Dam. The dam forms a 14.7-acre lake used for recreation and stabilization.

g. Design and Construction History. Data relating to the design and construction were not available. According to the Ray County Soil Conservation Office in Richmond, the dam was built in 1963. The County SCS office provided design assistance to the owner, however; no records of design or construction were retained.

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

1.3 PERTINENT DATA

a. Drainage Area - 95 acres

b. Discharge at Damsite.

- (1) Normal discharge at the damsite is through a 12-inch diameter iron pipe.
- (2) Estimated experienced maximum flood at damsite - Unknown.
- (3) Estimated ungated spillway capacity at maximum pool elevation 164 cfs (50% Probable Maximum Flood Pool El. 778.4).

c. Elevation (Feet above m.s.l. Approximate Tie to USGS Map).

- (1) Top of dam - 777.4 (see Plate 3)
- (2) Principal spillway invert - 773.3
- (3) Streambed at toe of dam - 752.8
- (4) Maximum tailwater - Unknown.

d. Reservoir.

- (1) Length of maximum pool - 1,575 feet $\pm$ (50% Probable maximum flood pool level)
- (2) Length of normal pool - 1,500 feet $\pm$ (Principal spillway invert)

e. Storage (Acre-feet).

- (1) Top of dam - 156
- (2) Principal spillway invert - 92
- (3) Design surcharge - Not available.

f. Reservoir Surface (Acres).

- (1) Top of dam - 16.5
- (2) Principal spillway invert - 14.7

g. Dam.

- (1) Type - Earth embankment
- (2) Length - 470 feet

- 3. Height - 25 feet +
- 4. Top width - 11 feet
- 5. Side slopes - upstream face between 1.0 V on 0.6 H and 1.0 V on 0.5 H, downstream face between 1.0 V on 2.4 H and 1.0 V on 3.0 H (see Plate -
- 6. Zoning - Unknown
- 7. Impervious core - Unknown
- 8. Cutoff - Unknown
- 9. Grout curtain - Unknown
- h. Diversion and Regulating Tunnel - None.
- i. Principal Spillway
 - (1) Type - 12-inch diameter iron pipe.
 - (2) Inlet invert elevation - 773.3 feet m.s.l.
 - (3) Outlet invert elevation - 752.8 feet m.s.l.
 - (4) Gates - None.
 - (5) Upstream channel - None.
 - (6) Downstream channel - Discharges to a plunge pool in the natural stream below the dam.
- j. Emergency Spillway
 - (1) Type - Grass lined channel with overflow berm.
 - (2) Crest Elevation - 777.4 feet m.s.l.
 - (3) Gates - None.
 - (4) Upstream Channel - Grass-lined approach channel.
 - (5) Downstream Channel - None, discharges to downstream face of embankment, then to natural stream channel.
- k. Regulating Outlets - None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data were not available.

2.2 CONSTRUCTION

Construction records were unavailable.

2.3 OPERATION

Operational records and documentation of past floods were unavailable.

2.4 GEOLOGY

The dam is located across a broad shallow valley that was formed by Lick Creek, a tributary of Willow Creek. The soil of the dam and reservoir area consists of the Sharpsburg-Macksberg-Lagonda and Knox-Marshall Associations which consists of clayey silt and silty clay developed in loess and loess over glacial material. Alluvial soil is present along the stream channels as silty clay. For engineering purposes these soils are classified as clayey silt (MC) and silty clay (CL). Bedrock of the area consists of interbedded limestone and shale of the Pennsylvanian age Marmon Group.

The foundation of the dam is on alluvial silty clay (CL) overlying bedrock at an unknown depth. Both the right and left abutments consist of silty clay (CL) derived from loess. The emergency spillway is cut through the same material.

2.5 EVALUATION

a. Availability. No engineering data were available.

b. Adequacy. No engineering data were available. Thus, an assessment of the design, construction, and operation could not be made. 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. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Richmond Schools Dam was made on 2 December 1980. The inspection team consisted of Edwin Burton, team leader; Shannon Casey, geologist; Gary Van Riessen, geotechnical engineer; Harvey Coppage, civil engineer; and Thomas Rutherford, hydraulic/hydrologic engineer. The dam is in somewhat less than satisfactory condition. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following conditions at the dam. No cracking, sliding, sloughing or other signs of settlement or instability were observed. The upstream and downstream slopes of the embankment are steep and have a dense grass cover. No instruments to measure the performance of the dam were located.

A seepage area was observed on the downstream slope near the right abutment of the embankment at the downstream toe. It appeared at the time of the inspection that this was a nonflowing seepage area. No toe drains or relief wells were observed. A seepage area downstream from the toe of the embankment on the left side was also observed. Flow from this area was estimated to be less than 1 gpm. Immediately to the right of the outlet pipe are holes and ruts filled with standing water. Inspection did not confirm the source of the standing water.

The dam crest has an unmowed grass/weed cover with extensive worn spots, probably due to foot and vehicle traffic. Wave action erosion was observed on the upstream slope. What appears to be eroded material has formed a "shelf" along the upstream face of the dam above the invert elevation of the outlet pipe. A few trees ranging in size from 1 to 2 inches and one 6-inches were observed on the upstream and downstream slopes.

Some erosion gullies were observed on the upstream slope and around the inlet to the spillway pipe. The downstream slope near the right abutment has deep vehicle tracks.

No evidence was found to indicate that the embankment had ever been overtopped.

There was no evidence that a maintenance program was in effect. A few animal burrows were observed on the embankment.

c. Appurtenant Structures. The inspection team observed the following items pertaining to the appurtenant structures. The principal spillway is a 12-inch iron pipe located near the center of the dam.

There was evidence of erosion behind the spillway inlet. The spillway pipe was considered to be in good condition. It should be noted that an abnormally large principal spillway discharge would probably damage the embankment toe at the pipe outlet.

The emergency spillway does not appear to have been completely constructed. Abnormally large discharges through this spillway would probably damage the embankment. No visible problems were noted.

There was no development in the spillway area which would suffer damage due to flow through the spillway.

d. Geology. The soils in the area of the dam and reservoir consists of clayey silt to silty clay developed in loess and loess over glacial material. There were no bedrock outcrops.

The emergency spillway is cut into silty clay developed in loess.

A sample of the embankment material was taken near the center of the crest. The material consisted of silty clay, and it is surmised that the entire embankment is made up of this material.

The abutments and foundation of the dam are all silty clay material.

e. Reservoir Area. No slumping or slides of the reservoir banks were observed. The upstream channel to the lake contains some minor debris and a few trees. The lake was noted to be clean with no siltation.

f. Downstream Channel. The principal spillway discharges to a plunge pool in the natural streambed. The emergency spillway discharges on the downstream face of the dam and then to the natural streambed.

3.2 EVALUATION

The various deficiencies observed at the time of the inspection are not believed to represent an immediate safety hazard. They do, however, warrant monitoring and control.

The growth of trees and uncut grass, if allowed to go unchecked, could cause deterioration of the embankment. The roots of trees can loosen the embankment material and also can leave voids through which water can pass. The uncut grass provides habitat for burrowing animals which can damage the embankment.

Burrowing animals will continue to damage the embankment if a control program is not undertaken. Piping failure of embankments have resulted from damages caused by burrowing animals.

The observed areas of seepage on the downstream slope and downstream of the toe should be monitored regularly for quality and quantity. Seepage can cause internal erosion creating cavities and underground channels, thereby weakening the embankment and/or abutments.

The vehicle ruts at the right abutment interface with the embankment should be repaired.

The absence of riprap on the upstream slope of the dam has resulted in wave action erosion. If not corrected wave action will continue to erode the embankment and could lead to slope stability problems.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

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

4.2 MAINTENANCE OF DAM

There was no evidence that a maintenance program was in effect at the time of inspection. Vegetal growth was uncontrolled. Trees up to 6-inches in diameter were observed on the embankment.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing warning system or preplanned scheme for alerting downstream residents for this dam.

4.5 EVALUATION

A maintenance program should be initiated and should include mowing the grass cover on the embankment in order to discourage animal burrowing. Procedures for controlling tree growth should be formulated with the assistance of an engineer experienced in earthen dam maintenance.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. No design data were available.

b. Experience Data. The drainage area and lake surface area are developed from USGS Richmond, Mo. Quadrangle Map. The dam layout is from a survey made during the inspection.

c. Visual Observations.

(1) The principal spillway appears to be in good condition. The lake level at the time of the inspection (El. 771.3) was below the principal spillway pipe inlet. There were no obstructions to flow in the downstream channel. The existence of the steel plate at the top of the inlet has no appreciable effect on discharge through the principal spillway.

(2) The emergency spillway for this dam appears not to have been completed during construction. It consists of a grass-lined approach channel and overflow section.

(3) Spillway discharges could endanger the integrity of the dam.

d. Overtopping Potential. The spillways will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillways will pass 25 percent of the probable maximum flood without overtopping the dam. The spillways will pass the one percent chance flood estimated to have a peak outflow of 6 cfs developed from a 24-hour, one percent chance rainfall. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the downstream hazard and the reservoir storage volume, the appropriate spillway design flood should be 50 percent of the probable maximum flood. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 38 cfs of the total discharge from the reservoir of 202 cfs. The estimated duration of overtopping is 8.5 hours with a maximum height of 1.0 feet. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 741 cfs of the total discharge from the reservoir of 1,373 cfs. The estimated duration of overtopping is 10.3 hours with a maximum height of 2.5 feet. The embankment could be jeopardized should overtopping occur for these periods of time.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately two miles downstream of the dam. Two dwellings, a railroad, a dam (Mo. ID. 10239), two trailer homes and a municipal sewage lagoon are located within the estimated damage zone, and lives could be lost should failure of the dam occur. Contents of the estimated downstream hazard zone were verified by the inspection team. There does not appear to be any flood plain regulations or other constraints in force to limit future downstream development.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Operating Records. No operational records exist.

d. Postconstruction Changes. It is not known whether or not any changes have been made to the dam subsequent to its construction.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone. The seismic stability of an earth dam is dependent upon a number of factors: embankment and foundation material classifications and shear strengths; abutment materials, conditions, and strengths; embankment zoning; and embankment geometry. Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the visual inspection by the inspection team should be monitored and/or controlled. These are erosion on the upstream slope and behind the inlet to the spillway pipe, seepage areas on the downstream slope and downstream of toe, the dense growth of grass/weeds and trees on the embankment, deep vehicle ruts, and animal burrows in the embankment. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

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

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

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam nor does it identify any serious dangers which would require a Phase II investigation. However, the additional analyses noted in paragraph 2.5b are necessary for compliance with the guidelines.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. Spillway capacity and/or storage volume would need to be increased or the lake level would need to be permanently lowered to increase available flood storage in order to effectively pass

the spillway design flood. Spillway capacity could be increased by modifying the existing grass-lined emergency spillway or by increasing the principal spillway pipe size. The storage volume could be increased by raising the low positions of the dam crest to a level equal to the observed maximum elevation or by raising the entire dam crest.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended and should be carried out under the direction of a professional engineer experienced in the design, construction, and maintenance of earth dams.

(1) Riprap should be placed on the upstream face of the dam to an elevation above normal lake level to prevent erosion of the embankment material.

(2) The seepage areas noted during the visual inspection should be closely monitored and documented as to quantity and quality of flow. Any significant changes should be evaluated.

(3) A maintenance program should be formulated and implemented to remove and control the growth of trees on the embankment. Grass/ weed cover on the embankments should be cut periodically.

(4) The vehicle ruts on the downstream slope at the right abutment should be backfilled with suitable material and compacted.

(5) The animal burrows in the embankment should be repaired since they can contribute to the occurrence of piping. Control measures should be implemented to discourage animal activity in the area. The embankment slope should be monitored by a qualified engineer during repair of the embankment.

(6) Seepage and stability analyses should be performed.

(7) A detailed inspection of the dam should be made periodically. This inspection should include measurement of seepage flows and analyzing water samples taken from the seep and lake. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increase.

(8) Although there was no indication of a trash build up problem, it is recommended that a trash rack be installed at the principal spillway inlet.

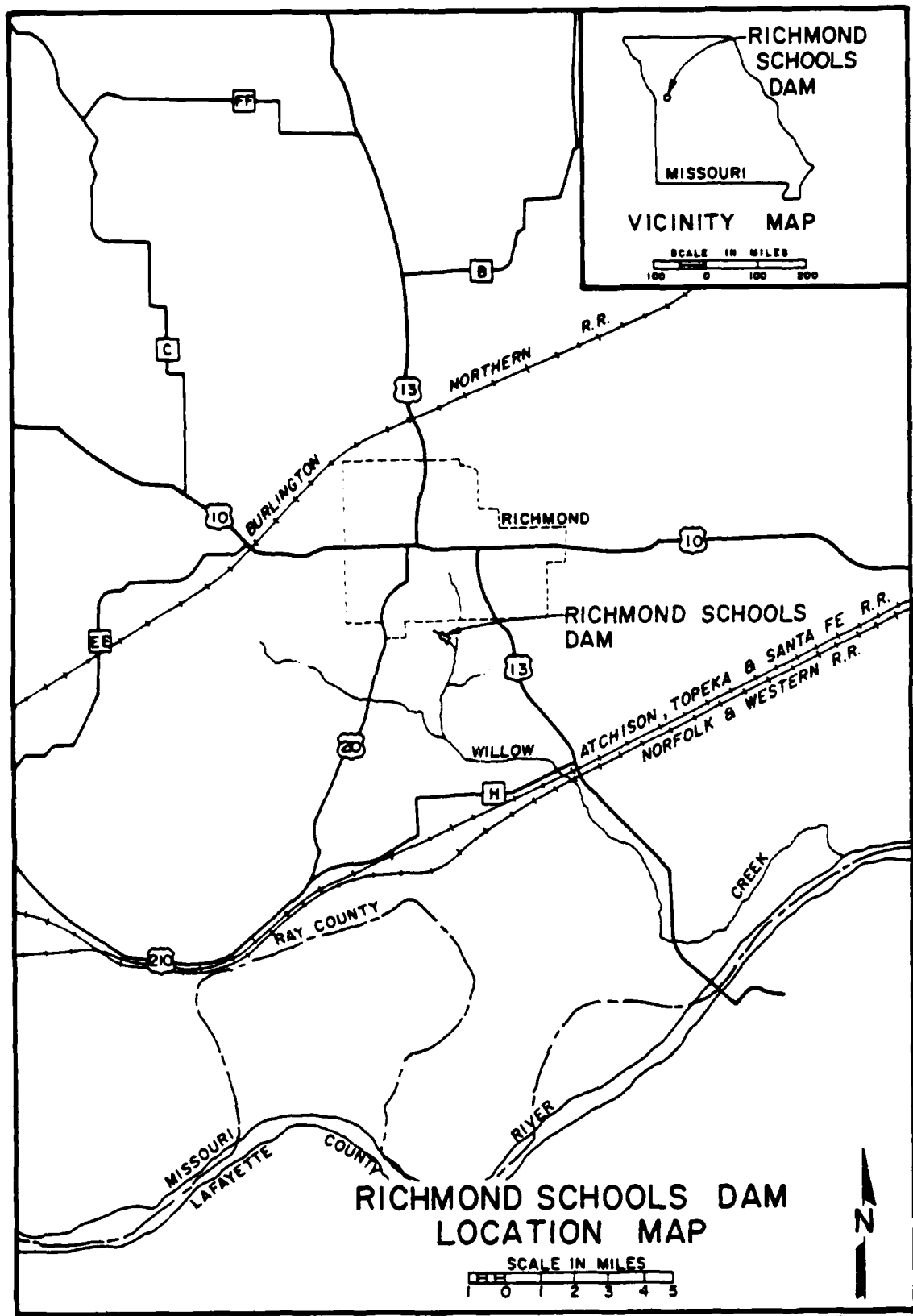


PLATE I

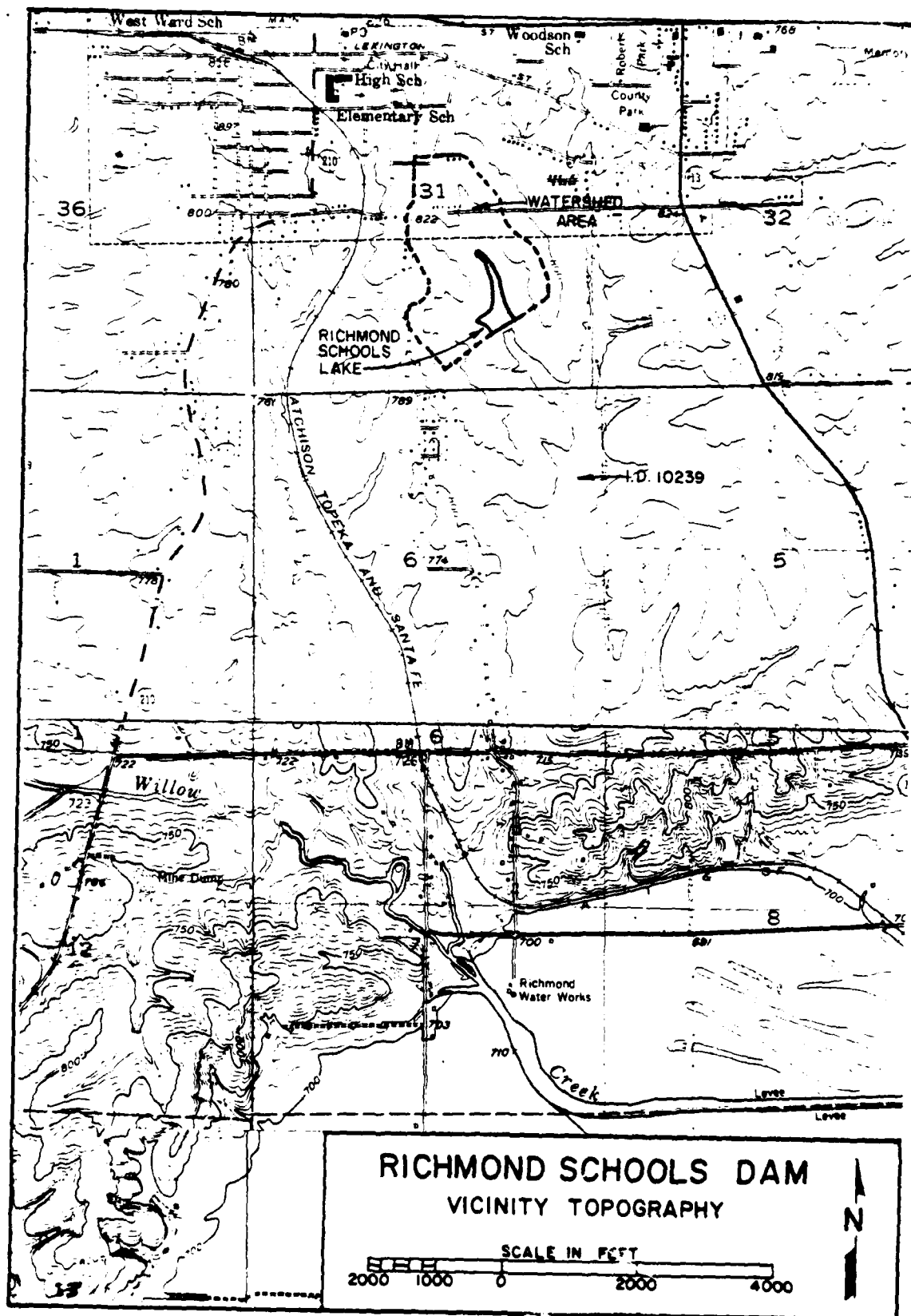
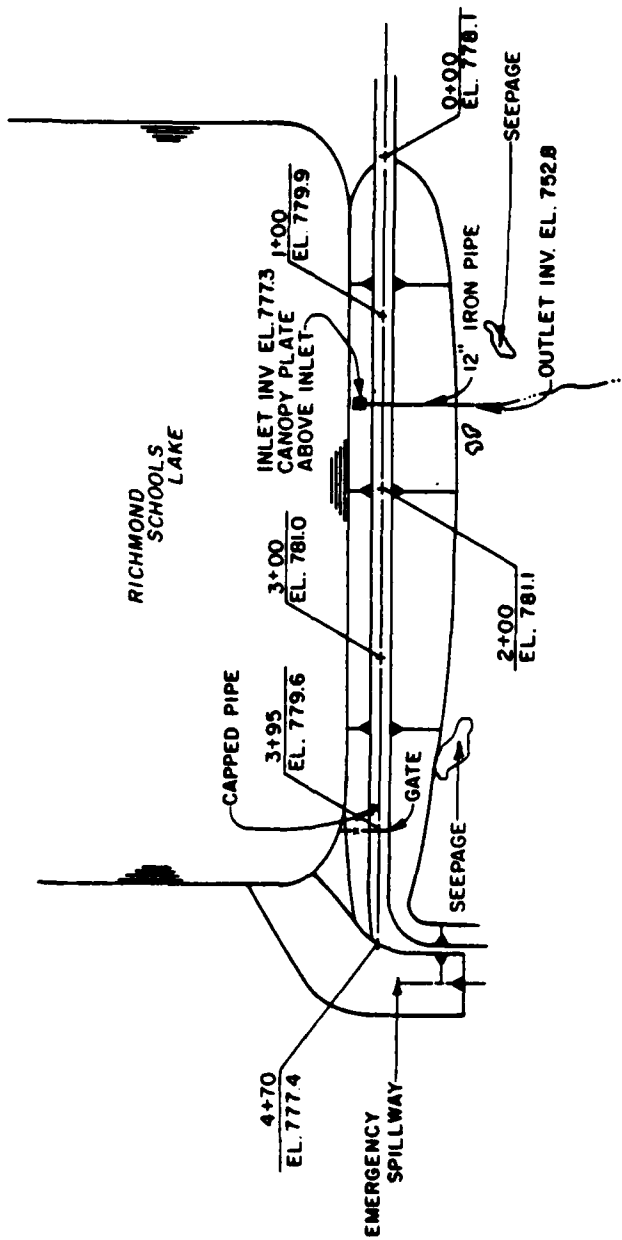
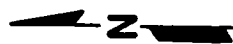
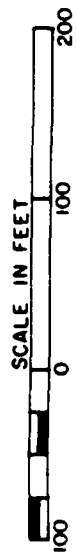


PLATE 2

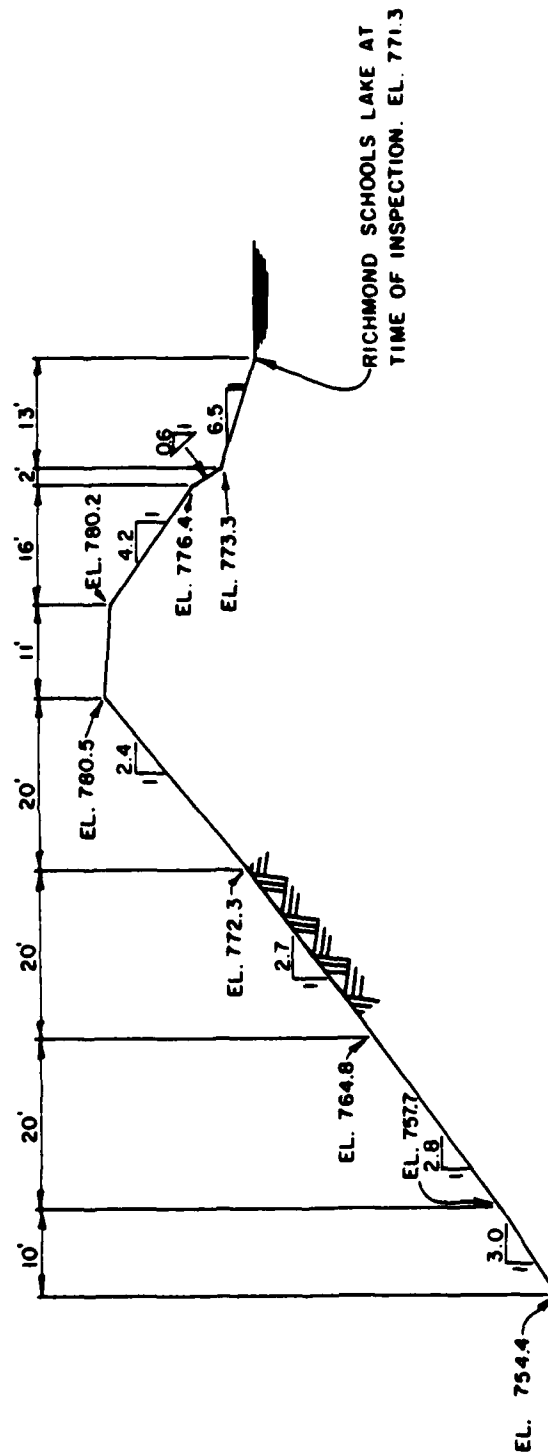
LEGEND
STATION
ELEVATION



NOTE:
PLAN DATA OBTAINED
FROM FIELD SURVEY.



**RICHMOND SCHOOLS DAM
DAM PLAN**



NOTE:
CROSS SECTION TAKEN
NEAR STATION 3+60.

RICHMOND SCHOOLS DAM DAM CROSS SECTION

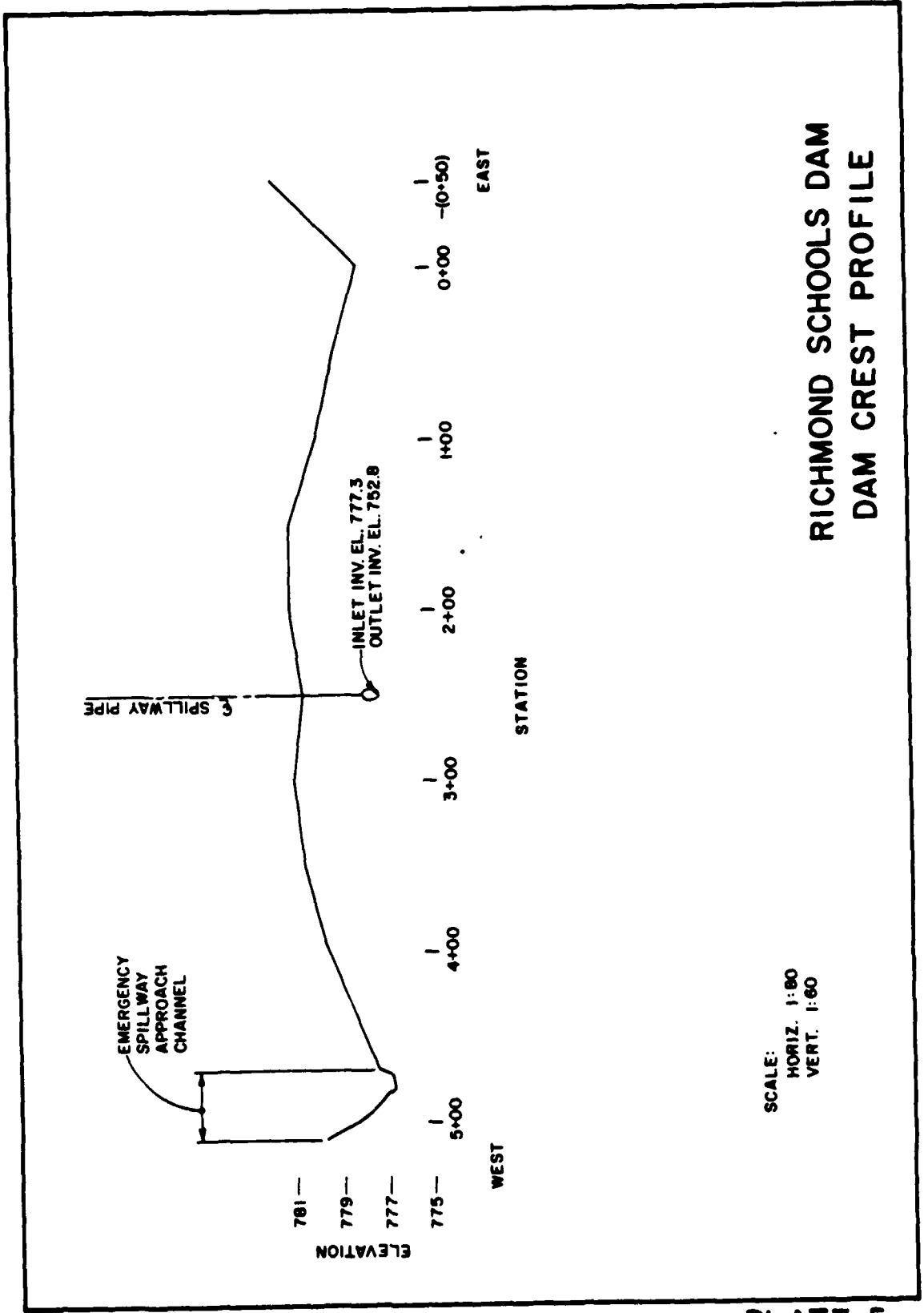
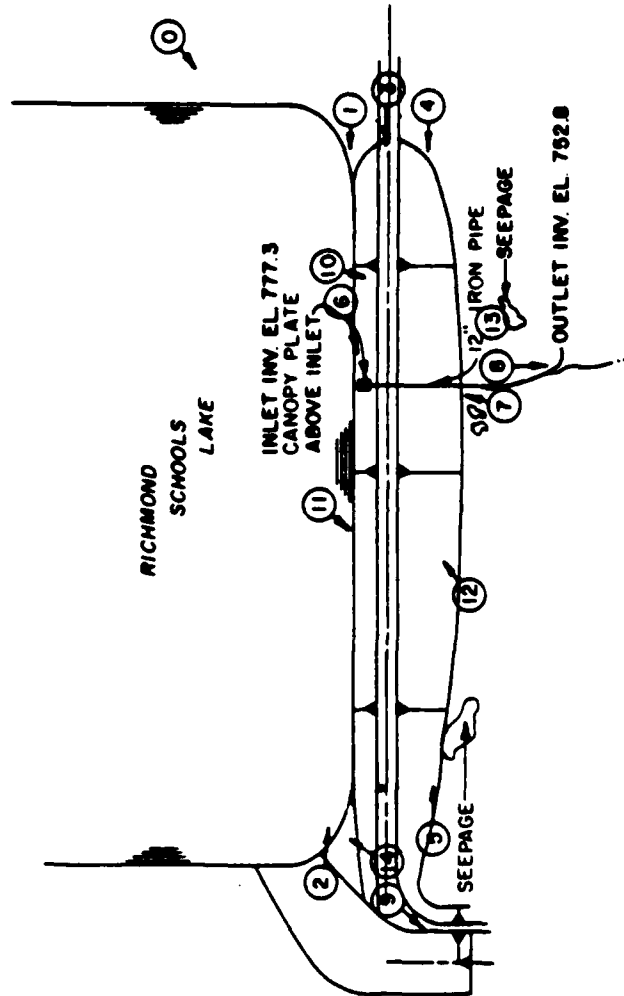


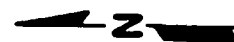
PLATE 5

LEGEND

PHOTO NO. 6
DIRECTION



**RICHMOND SCHOOLS DAM
PHOTO INDEX**



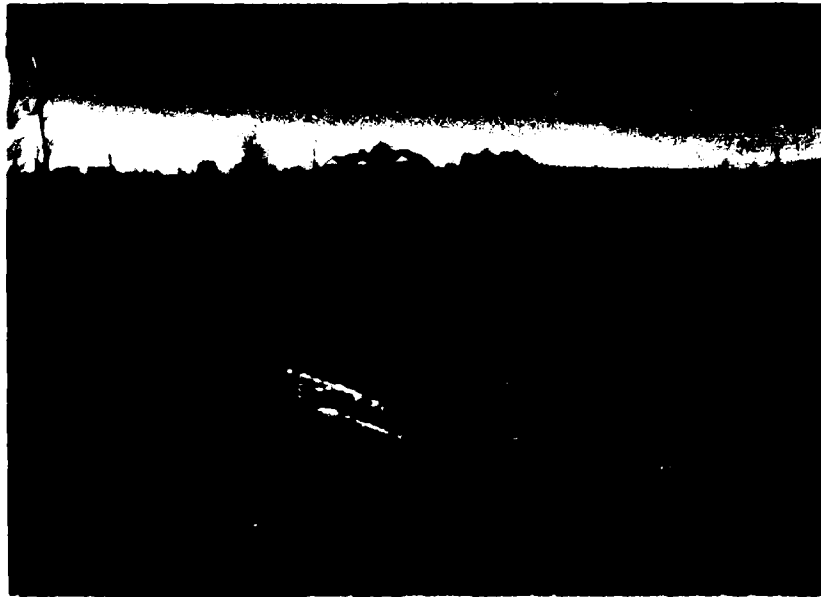


PHOTO 1: UPSTREAM FACE OF DAM



PHOTO 2: UPSTREAM FACE OF DAM LOOKING EAST



PHOTO 3: CREST OF DAM



PHOTO 4: DOWNSTREAM FACE OF DAM LOOKING WEST



PHOTO 5: DOWNSTREAM FACE OF DAM LOOKING EAST



PHOTO 6: PRINCIPAL SPILLWAY PIPE INLET



PHOTO 7: PRINCIPAL SPILLWAY PIPE OUTLET



PHOTO 8: STREAM CHANNEL BELOW PRINCIPAL SPILLWAY



PHOTO 9: EMERGENCY SPILLWAY



PHOTO 10: ANIMAL BURROWS ON UPSTREAM FACE OF DAM



PHOTO 11: ANIMAL BURROWS ON UPSTREAM SLOPE



PHOTO 12: ANIMAL BURROWS DOWNSTREAM OF DAM

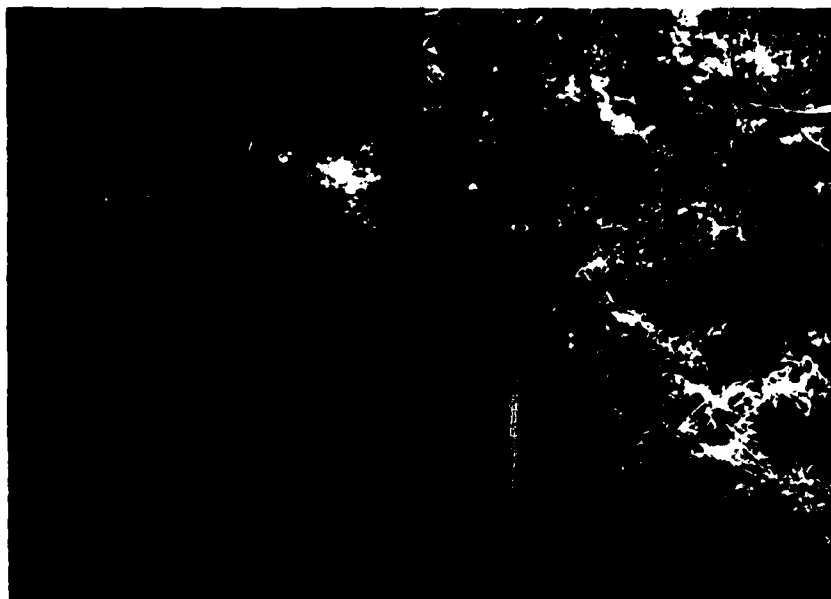


PHOTO 13: SEEPAGE AREA DOWNSTREAM OF DAM



PHOTO 14: LAKE AND WATERSHED AREA

APPENDIX A
HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC ANALYSES

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 determined using the computer program HEC-1 (Dam Safety Version) (1).

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33" (HMR-33) (2). Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm was determined according to the procedures outlined in HMR-33 and EM 1110-2-1411 (3). The Kansas City, Missouri rainfall distribution (5 min. interval - 24 hours duration), as provided by the St. Louis District, Corps of Engineers, was used when the one percent chance probability flood was routed through the reservoir and spillway.

The synthetic unit hydrograph for the watershed was developed by the computer program using the Soil Conservation Service (SCS) method (1.5). The parameters for the unit hydrograph are shown in Table 1. The formula from which the lag time was derived is noted in Table 1. The lag time was verified by the SCS curve number method (7).

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

The reservoir routing was performed using the modified Puls Method. The initial reservoir pool elevation for the routing of each storm was determined to be equivalent to the invert elevation of the principal spillway at elevation 773.3 feet m.s.l. in accordance with antecedent storm conditions AMC II, and AMC III preceding the one percent probability and probable maximum storms respectively, outlined by the U.S. Army Corps of Engineers, St. Louis District (4). The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation, surface area, storage, and discharge relationships shown in Table 3.

The rating curve for the spillway is shown in Table 4. The flow over the crest of the dam was determined using the non-level dam crest option (SL and SV cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir.

The result of the routing analysis indicates that a flood equivalent to a maximum of 25 percent of the PMF will not overtop the dam.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5.

The computer input data and a summary of the output data are presented at the back of this appendix.

TABLE 1
SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	95 acres
Length of Watercourse (L)	0.27 miles
Difference in Elevation (H)	59 feet
Time of concentration (T_c)	0.12 hours
Lag Time (L_g)	0.07 hours
Duration (D)	1.0 min. (use 5 min.)

<u>Time (Min.) *</u>	<u>Discharge (cfs) *</u>
0	0
5	517
10	442
15	130
20	40
25	12
30	4

* From HEC-1 computer output

FORMULAS USED:

$$T_c = (11.9 \times L^3/H) \quad 0.385 \quad (5)$$

$$D = 0.133 T_c$$

$$L_g = 0.6 T_c$$

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	32.11	30.53	1.58
1% Probability	24	7.69	4.88	2.81

Additional Data:

- 1) The soil associations in this watershed are Higginsville and Sibley (6).
55 percent of drainage area is hydrologic soil Group B
45 percent of drainage area is hydrologic soil Group C
60 percent of the land use was cropland
30 percent of the land use was grassland
10 percent of the land use was urban development
- 2) SCS Runoff Curve CN = 88 (AMC III) for the PMF.
- 3) SCS Runoff Curve CN = 76 (AMC II) for the one percent probability flood (7).

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>
*773.3	14.7	92	0
**777.4	16.5	156	8
778.4	17.2	173	164
779.4	17.7	190	448
780.4	18.3	210	816
781.4	19.0	232	1251

*Principal Spillway Inlet Invert Elevation

**Emergency Spillway Crest and Top of Dam Elevation

The relationships in Table 3 were developed from the Richmond, Missouri 7.5 minute quadrangle map and the field measurements.

TABLE 4

SPILLWAY RATING CURVE

<u>Reservoir Elevation (ft)</u>	<u>Principal Spillway Discharge (cfs)</u>	<u>Emergency Spillway Discharge (cfs)</u>	<u>Total Spillway Discharge (cfs)</u>
*773.3	0	-	0
775.3	5	-	5
776.3	7	-	7
**777.4	8	0	8
778.4	9	155	164
779.4	10	438	448
780.4	11	805	816
781.4	11	1240	1251

*Principal Spillway Inlet Invert Elevation

**Emergency Spillway Crest and Top of Dam Elevation

METHOD USED:

Principal spillway release rates are based on nomographs for a pipe culvert with inlet control (8).

Emergency spillway release rates are based on the weir flow equation:

$$Q = CL \times (H^{3/2})$$

C = Coefficient of Discharge = 3.1 (9)

L = Length of Weir Crest = 50 (feet)

H = Head over Crest (feet)

TABLE 5
RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (cfs)	Peak Lake Elevation (ft.-msl)	Total Storage (ac.-ft.)	Peak Outflow (cfs)	Depth (ft.) Over Top of Dam	Duration of Over- topping (hrs)
-	0	*773.3	92	0	-	-
0.25	548	776.8	146	7	0	-
0.50	1,095	778.4	173	202	1.0	8.5
1.00	2,190	779.9	199	1,373	2.5	10.3

* Principal spillway inlet invert elevation

- (1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Modification April 1980, Davis, California.
- (2) HMR 33, Seasonal Variations of Probable Maximum Precipitation, East of the 105th Meridian for Areas 10 to 1000 Square Miles and Durations from 6 to 48 Hours, U.S. Department of Commerce, NOAA, National Weather Service, 1956.
- (3) EM-1110-2-1411, Standard Project Flood Determinations, U.S. Army Corps of Engineers, 26 March 1952.
- (4) U.S. Army Corps of Engineers, St. Louis District, Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams, 22 August 1980.
- (5) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.
- (6) U.S. Department of Agriculture, Soil Conservation Service, Soil Interpretations Record, 1979.
- (7) U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, August 1972.
- (8) U.S. Department of Commerce, Bureau of Public Roads, Hydraulic Charts For The Selection Of Highway Culverts, December 1965.
- (9) U.S. Department of the Interior, Geological Survey, Techniques of Water Resources Investigations of the United States Geological Survey, Chapter A5, 1967.

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 FACILITY 06617 DATE 16 DEC 10 PAGE 5

CONFIDENTIAL

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 FROM WASHINGTON 1-20-60 (MC-11)
 DAY SAFETY V. 2510 JULY 1960
 LAST MODIFICATION: 1 APR 63

ATLANTA DAM INSPECTIONS
EIGHTH SCHOOL DAM

1. J. V. A. L. C. S.

7-10-68
CALCULATED INFLATION INDICATOR

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Figure 1

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PROGRAM M21/C-1V  TIME 09:21:41  CASE
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L J O H V C C C A P H I R A U E -

WLA CA P V C L C M PROJECT 00457 DATE 30 DEC 80 PAGE 1
 ELSD WDR(CM) 00457 - MC-1 PROGRAM M7/2-1V TIME 00:31:01 CASE

51	1775.0	773.0	75.0	70.0		
52	1775.0					
53	1777.0					
54	1777.0	24.0	121.0	237.0	575.0	440.0
55	1777.0	75.0	773.0	773.0	773.0	773.0
56	1777.0	75.0	773.0	773.0	773.0	773.0
57	1777.0	75.0	773.0	773.0	773.0	773.0
58	1777.0	75.0	773.0	773.0	773.0	773.0
59	1777.0	75.0	773.0	773.0	773.0	773.0
60	1777.0	75.0	773.0	773.0	773.0	773.0

[illegible]

INSPECTIONS
BY THE
MAYOR'S OFFICE

[illegible]

519-A16A 611289 COMPUTATION

CALCULATE INFLUX HYDROGRAPH TO LAKE

INVDG	INVG	INSTA	ICOMP	RECON	LTREF	JPLY	JPPY	INAME	ISTAGE	INUTC
1	1	1	3	3	0	0	3	1	1	0

NYCFCF M 1.412

NO	PERIOD	DATE	DAY
206			08
207			09
208			10
209			11
210			12
211			13
212			14
213			15
214			16
215			17
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218			20
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228			30
229			31

[illegible]

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	ELEVATION STORAGE OUTLET	INITIAL VALUE 775.10 92.0 1.0	SPILLWAY CREST 775.10 92.0 0.0	TOP OF DAM 777.10 196.0 8.0
RATIO OF P-4 1.00	MAXIMUM RESERVOIR W.S. ELEV 775.67	MAXIMUM DEPTH OVER DAM -60	MAXIMUM OUTFLOW CFS 125.0	TIME TO MAX OUTFLOW HOURS 24.00
				TIME OF FAILURE HOURS 4.00

NOTED FOR

END

DATE
FILMED

11-81

DTIC