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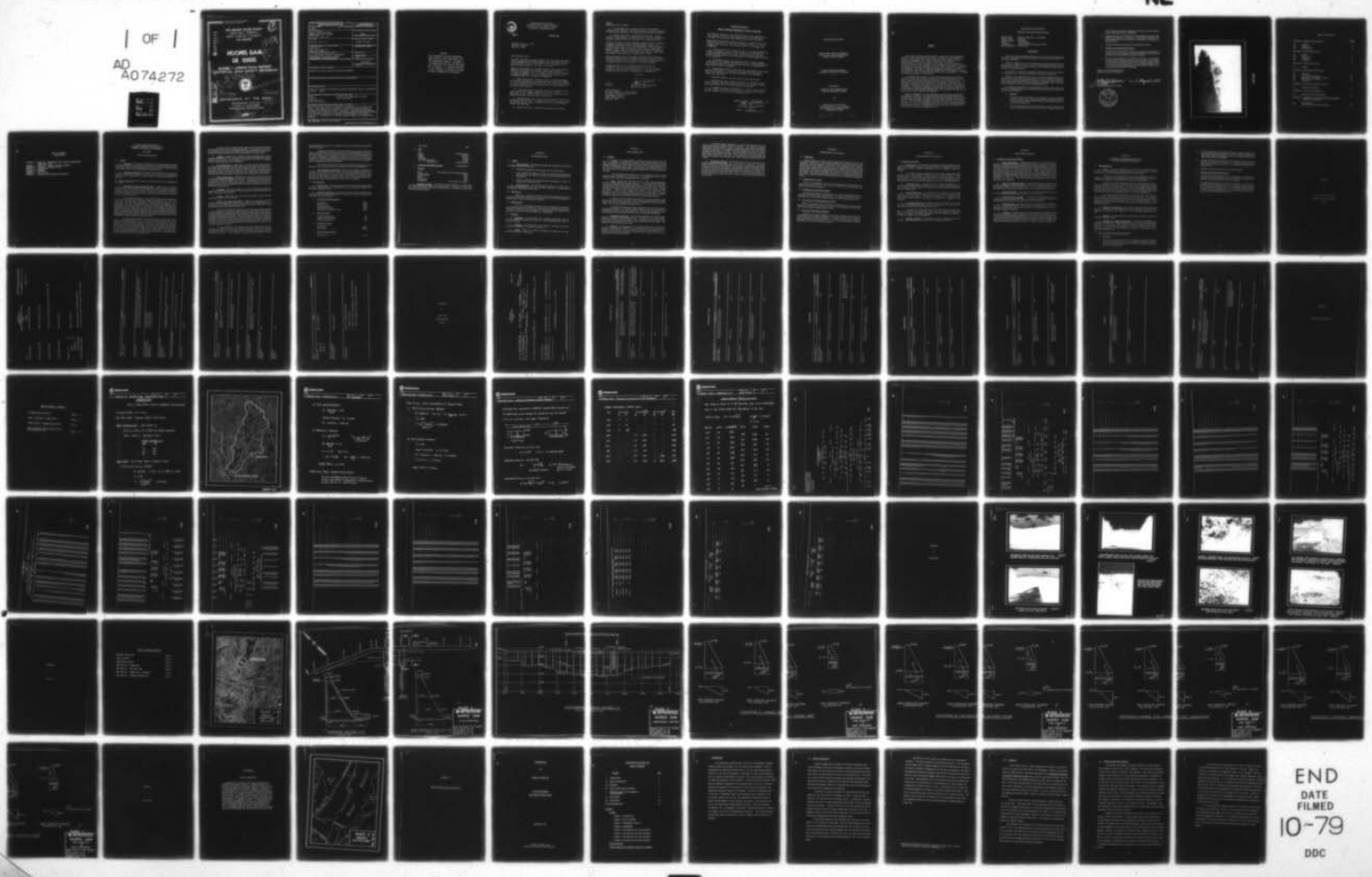

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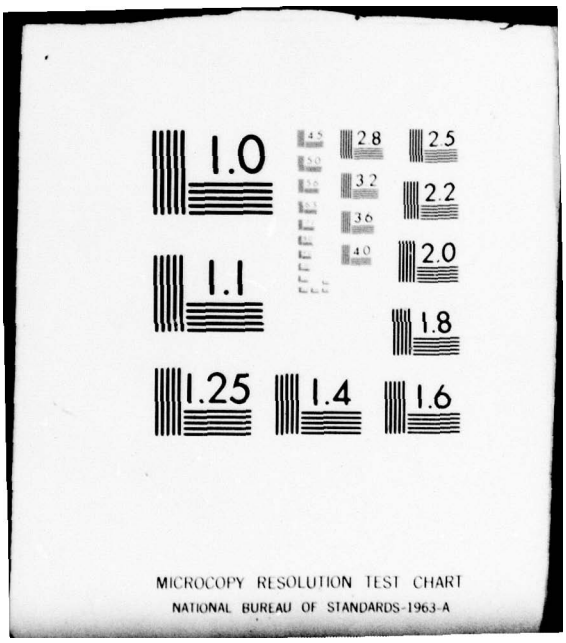
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DELAWARE RIVER BASIN
OLD MILL STREAM
NEW CASTLE COUNTY
DELAWARE

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HOOPES DAM
DE 00015

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Hoopes Dam (DE-00015) Delaware River Basin, Old Mill Stream, New Castle County, Delaware. Phase 1 Inspection Report.

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DEPARTMENT OF THE ARMY
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REPORT DOCUMENTATION PAGE

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4. TITLE (and Subtitle): Phase I Inspection Report National Dam Safety Program Hoopes Dam New Castle County, DE	5. TYPE OF REPORT & PERIOD COVERED: FINAL
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Williams, John J. P.E.	8. CONTRACT OR GRANT NUMBER(s): DACW61-79-C-0011
9. PERFORMING ORGANIZATION NAME AND ADDRESS: O'Brien & Gere Suite 1760 1617 J.F. Kennedy Blvd. Phila. Pa. 19103	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Engineer District, Philadelphia Custom House, 2d & Chestnut Streets Philadelphia, Pennsylvania 19106	12. REPORT DATE: July 1979 13. NUMBER OF PAGES: 65
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18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Flow
Seepage
Hoopes Dam, N.J.
Structural Analysis
National Dam Inspection Act report
Visual Inspection

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

17 SEP 1979

Honorable Pierre S. Du Pont
Governor of Delaware
Dover, DE 19901

Dear Governor Du Pont:

Inclosed is the Phase I Inspection Report for Hoopes Dam in New Castle County, Delaware which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Hoopes Dam, a high hazard potential structure, is judged to be in fair overall condition and the spillway is considered adequate. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. While the spillway is adequate to pass the Probable Maximum Flood without overtopping, the dam has been determined to be unstable for loading conditions imposed by the PMF. Post-tensioning of the dam to provide adequate stability during the PMF was being performed at the time of the inspection.

b. A flow measuring weir has been constructed to monitor seepage rates from the left abutment downstream of the dam. Monthly monitoring of this discharge should be continued to detect any future changes which might require further investigation.

c. Seepage has been noted issuing from the downstream face of the dam near the left abutment. A program of low pressure grouting of the deteriorated concrete within the dam is scheduled to be performed to correct this deficiency.

d. Vegetation should be removed from the downstream channel.

NAPEN-D
Honorable Pierre S. DuPont

e. The discharge control valves at the site are presently repaired only as required. The valves should be periodically operated to insure proper performance during potentially hazardous conditions.

f. A downstream warning system should be developed. During periods of heavy rainfall, the dam should be monitored and downstream residents should be alerted in the event of an impending failure.

A copy of the report is being furnished to James Wilson III, Delaware Department of Natural Resources and Environmental Control, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Thomas B. Evans. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

Jack Kallaher LTC

JAMES G. TON
Colonel Corps of Engineers
for District Engineer

1 Incl
As stated

Copies Furnished:
Mr. James Wilson III, Acting Secretary
Department of Natural Resources and
Environmental Control
Edward Tatnall Building
Dover, DE 19901

HOOPES DAM (DE00015)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 24 May 1979 by O'Brien & Gere Engineers, Inc. under contract to the U.S. Army Engineer District, Philadelphia, in accordance with the National Dam Inspection Act, Public Law 92-367.

Hoopes Dam, a high hazard potential structure, is judged to be in fair overall condition and the spillway is considered adequate. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. While the spillway is adequate to pass the Probable Maximum Flood without overtopping, the dam has been determined to be unstable for loading conditions imposed by the PMF. Post-tensioning of the dam to provide adequate stability during the PMF was being performed at the time of the inspection.

b. A flow measuring weir has been constructed to monitor seepage rates from the left abutment downstream of the dam. Monthly monitoring of this discharge should be continued to detect any future changes which might require further investigation.

c. Seepage has been noted issuing from the downstream face of the dam near the left abutment. A program of low pressure grouting of the deteriorated concrete within the dam is scheduled to be performed to correct this deficiency.

d. Vegetation should be removed from the downstream channel.

e. The discharge control valves at the site are presently repaired only as required. The valves should be periodically operated to insure proper performance during potentially hazardous conditions.

f. A downstream warning system should be developed. During periods of heavy rainfall, the dam should be monitored and downstream residents should be alerted in the event of an impending failure.

APPROVED: Joel Gallobon LTC
for JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 13 September 1979

DELAWARE RIVER BASIN

Name of Dam: Edgar M. Hoopes Dam
County & State: New Castle, Delaware
Inventory Number: DE00015

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared by:

O'BRIEN & GERE ENGINEERS, INC
JUSTIN & COURTNEY DIVISION

For

DEPARTMENT OF THE ARMY
Philadelphia District, Corps of Engineers
Custom House-2nd & Chestnut Streets
Philadelphia, PA 19106

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

Name of Dam:	Edgar M. Hoopes Dam ID #DE00015
State Located:	Delaware
County Located:	New Castle
Stream:	Old Mill Stream
Coordinates:	Latitude 39^{o} 46.4', Longitude 75^{o} 38.1'
Date of Inspection:	May 24, 1979

ASSESSMENT

Based upon visual observations and review of the information obtained from the City of Wilmington, Water Division, Edgar M. Hoopes Dam is considered to be in overall fair condition.

Edgar M. Hoopes Dam is a concrete gravity structure about 845 feet long with a maximum height of 127 feet. A 25-foot wide concrete overflow section is located near the center of the dam which has a crest elevation 12 feet below the top of the non-overflow section.

The spillway is capable of discharging 100 percent of the PMF without overtopping the dam. Therefore, the spillway is classified as "Adequate".

O'Brien & Gere Engineers, Inc., Justin & Courtney Division recently performed a study of conditions at Hoopes Dam for the City of Wilmington, Delaware. Their report, entitled, "Investigation of Edgar M. Hoopes Dam", dated September 1977, presents the results of a detailed analysis of conditions noted during the Phase I investigation. This report is enclosed as Appendix G.

The following observations and recommendations listed in their report are currently being implemented or are scheduled to be performed in the near future by the City of Wilmington.

a. Facilities

1. The dam has been determined to be unstable for loading conditions imposed by a PMF event. The recommended post-tensioning of the dam to provide adequate stability during the PMF was being performed at the time of the inspection.

2. A flow measuring weir has been constructed to monitor seepage rates from the right abutment downstream of the dam. Monthly monitoring

of this discharge should be continued to detect any future changes which might require further investigation.

3. Seepage has been noted issuing from the downstream face of the dam near the left abutment. A program of low pressure grouting of the deteriorated concrete within the dam is scheduled to be performed in the near future.

4. Vegetation should be removed from the downstream channel.

b. Operation and Maintenance Procedures

1. The discharge control valves at the site are presently repaired only as required. The valves should be periodically operated to insure proper performance during potentially hazardous conditions.

2. No flood warning system is in effect at this site. A downstream warning system should be developed. During periods of heavy rainfall, the dam should be monitored. Downstream residents should be alerted in the event of an impending failure. The warning system should remain in effect after the post-tensioning to provide adequate stability of the dam during the PMF, has been completed.

O'BRIEN & GERE ENGINEERS, INC.
JUSTIN & COURTNEY DIVISION

John J. Williams Date: 1 August 1979

John J. Williams, P.E.
Vice President
Delaware Registration No. 2884

OVERVIEW

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
EDGAR M. HOOPES DAM ID #DE00015

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority. This report is authorized by the Dam Inspection Act, Public Law 92-367, and has been prepared in accordance with contract #DACW 61-78-C-0052 between O'Brien & Gere Engineers, Inc., Justin & Courtney Division and the United States Army Corps of Engineers, Philadelphia District.

b. Purpose of Inspection. The purpose of this inspection is to evaluate the structural and hydraulic condition of the Edgar M. Hoopes Dam and appurtenant structures and to determine if the dam constitutes a hazard to human life or property.

1.2 Project Description (From information obtained from the City of Wilmington, Delaware).

a. Description of Dam and Appurtenances. Hoopes Dam is a concrete gravity structure approximately 845 feet long, with a maximum height of approximately 127 feet. The dam has a vertical upstream face, a top width of 19 feet and an average downstream slope of 0.6H:1V. The base of the structure is about 85 feet wide at the maximum section and is provided with an 8-foot by 8-foot keyway cut into the foundation rock.

The uncontrolled spillway, located near the center of the dam, consists of two bays, each about 12.5 feet wide, which are separated by a 3-foot wide center pier. The pier helps to support a reinforced concrete bridge with a low chord about 9 feet above the spillway crest. Discharge over the spillway crest is guided down the face of the dam by two concrete training walls extending above the downstream face about 2.5 feet. At the base of the spillway, the channel is constricted and the discharge is directed into a 6-foot square, concrete box culvert. The culvert extends about 400 feet downstream and directs the discharge into a trapezoidal channel with a bottom width of about 8 feet and side slope of approximately 1.5H:1V. About 1,300 feet downstream of the dam, flow in the trapezoidal channel discharges into Red Clay Creek.

An intake-outlet chamber is constructed about 75 feet left of the spillway along the upstream face of the dam and is used to control flow out of the reservoir. The intake consists of six, 3.5-foot square, grated inlet ports, which are clustered in two sets of three openings. The three low level inlets are vertically centered about Elev. 142.5 and the upper level inlets are vertically centered about Elev. 198.5. A 24-inch wide by 42-inch high sluice gate operated from the top of the dam controls discharge into a 36-inch steel outlet pipe. The outlet pipe extends approximately 300 feet downstream and terminates at a pumping station used to pump water to the City's treatment plant.

A 36-inch cast iron reservoir drain pipe has been constructed through the dam about 19 feet left of the spillway centerline. A concrete vault located at the downstream toe contains two horizontal-stem gate valves used for operation of the reservoir drain pipe which terminates at the entrance to the box culvert.

b. Location. Hoopes Dam is located on Barley Mill Road about 4 miles northwest of Wilmington. The dam site is shown on the USGS Quadrangle entitled "Kennett Square, Pa.-Del." at coordinates N 39° 46.4', W 75° 38.1'. A regional location plan is enclosed as Plate 1, Appendix E.

c. Size Classification. Hoopes Dam is classified as being "Intermediate" on the basis of its maximum reservoir storage volume of 11,000 acre-feet which is more than 1,000 acre-feet, but less than 50,000 acre-feet. The dam has a maximum height of 127 feet which places it in the "Large" size category because it's height is greater than 100 feet. The overall size classification is the larger of these two determinations, and accordingly the dam is classified as "Large" in size.

d. Hazard Classification. Outflow from Hoopes Dam flows into Red Clay Creek about 0.25 miles downstream of the dam. A pump station (usually manned) is located about 300 feet downstream of the dam. Several homes are located along the right bank of Red Clay Creek approximately 1 mile downstream of the dam, in addition to roads and the Baltimore and Ohio Railroads. Therefore, the dam is in the "High" hazard category.

e. Ownership. The dam is owned by the City of Wilmington, Delaware, Department of Public Works, Water Division, 800 French Street, Wilmington, DE 19801. Telephone: (302) 571-4171.

f. Purpose. Hoopes Dam is a pumped storage project used for back-up water supply to the City of Wilmington.

g. Design and Construction History. Hoopes Dam (originally Old Mill Stream Dam) was designed by Fuller and McClintock, Consulting Engineers, as indicated on the contract drawings dated September 1929. Construction of the dam took place from July 1930 to February 1931.

The City of Wilmington, Department of Public Works retained O'Brien & Gere Engineers, Inc., Justin & Courtney Division in December 1976 to investigate the condition of Hoopes Dam and to determine if there were any deficiencies or potential deficiencies in the dam. The study included a review of the contract drawings, an underwater inspection of the upstream face, a program of coring and sampling of the concrete in the dam and the foundation rock; tension, compression and shear testing of the concrete core samples, a seismic and geologic study in the vicinity of the dam site, a hydrologic study of the watershed and an analysis of the structural stability of the dam.

It was concluded in the ensuing report (See Appendix G) that the spillway was adequate to pass the Probable Maximum Flood (PMF) without overtopping the dam, but the structure would be unstable for the loading conditions imposed by this event. The consultant recommended the installation of post-

tensioned cables anchored in the foundation rock to provide adequate dam stability for the PMF event.

Subsequently, O'Brien & Gere was retained by the Owner to prepare a design, cost estimate, and contract documents for implementation of the report recommendations. The scope of work for this contract included post-tensioning of the dam, measurement of hydrostatic pressures at the base of the dam, the acquisition of additional foundation rock samples, the determination of the location of the structure and foundation interface, and construction of a weir for measurement of seepage noted in the left abutment.

The contract for this work, awarded to Nicholson Anchorage Company, Bridgeville, Pa., in March 1979, was in progress at the time of the inspection.

h. Normal Operating Procedures. Under normal operating conditions, the reservoir is self regulating. The reservoir pool elevation usually fluctuates at or near the spillway crest, however, on the day of the inspection the reservoir level was about 10 feet below the spillway crest. According to the Owner's representative, Mr. John Hanley, because of high turbidity in Brandywine Creek, water was being taken from Hoopes Reservoir for the City's water supply.

1.3 Pertinent Data

a. Drainage Area. The drainage area above the structure is approximately 2.0 square miles, as taken from information provided the City of Wilmington and verified on topographic maps.

b. Discharge at Dam Site. No high pool or spillway discharge records were made available. The spillway capacity at the design top of dam is approximately 3,200 cubic feet per second (cfs).

c. Elevation (Feet-USGS Datum)

Top of Dam	232.0
Spillway Crest	220.0
Outlet pipe invert	135.0
Reservoir drain invert	117.5
Streambed at centerline of dam	105.0

d. Reservoir (miles)

Length of Normal Pool	2.8
Length of Maximum Pool	2.9
Fetch at Normal Pool	2.0

e. Storage (Acre-feet)

Normal Pool	6,300
Top of Dam	11,000

f. Reservoir Surface (Acres)

Normal Pool	192

Top of Dam	220

g. Dam.

Type	Concrete gravity
Length	845 feet
Height	127 feet
Top Width	19 feet
Side Slopes (upstream)	Vertical
(downstream)	Average 0.6H:1V

h. Diversion and Regulating Tunnel. Not Applicable

i. Spillway.

Type	Flat-crested, concrete overflow spillway
Length of weir	25 feet
Crest elevation	220.0
Gates	None
U/S Channel	None
D/S Channel	6-foot square box culvert

j. Regulating Outlets. The reservoir outlet consists of a 36-inch steel pipe controlled by a sluice gate in the outlet chamber. In addition, a 36-inch cast iron reservoir drain pipe controlled by gates located in a downstream vault can be used for reservoir drainage.

SECTION 2

ENGINEERING DATA

2.1 Design

a. Data Available. The engineering data made available by the City of Wilmington includes the following:

1. Contract Drawings for Old Mill Stream Dam, September 1929.

2. Report entitled, "Investigation of Edgar M. Hoopes Dam" by O'Brien & Gere Engineers, Inc., Justin & Courtney Division, dated September 1977 (Appendix G).

3. Contract documents for Post-Tensioned Strengthening of Edgar M. Hoopes Dam dated January 1979.

b. Design Features. The principal design features for the dam and its appurtenant structures are shown on the drawings in Appendix E. A description of the features is discussed in Section 1.2.a.

2.2 Construction

Based upon a comparison between the contract drawings and previous engineering studies (See Section 1.2.g) available from the City of Wilmington, it appears that the dam was constructed as designed.

2.3 Operation Data

The City of Wilmington maintains records of discharge and reservoir pool elevations below the spillway crest. According to the Owner's representative, no pool elevation records are maintained for elevations above the spillway crest and there is no record of maximum stage in the impoundment.

2.4 Evaluation

a. Availability. All information made available was obtained from the City of Wilmington, Delaware and O'Brien & Gere Engineers, Inc., Justin & Courtney Division.

b. Adequacy. The information made available concerning design and construction is adequate for a Phase I investigation.

c. Validity. There is no reason to question the validity of the data provided by the City of Wilmington.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General. The field inspection of Hoopes Dam took place on May 24, 1979. At the time of inspection, the reservoir water surface was about 10 feet below the spillway crest. According to the Owner's representative, because of high turbidity in Brandywine Creek, water was being taken from Hoopes Reservoir for the City of Wilmington's water supply. No underwater areas were inspected. The dam was found to be constructed in general conformance with the construction drawings.

The observations and comments of the field inspection team are in the checklist which is Appendix B of this report. The appearance of the facility indicates that the dam and its apprutenances are maintained.

b. Dam. Seepage was noted issuing from a number of the construction joints in the downstream face of the structure. At many locations, calcification was observed along the very slightly opened joints. The majority of the seeps are concentrated near the east abutment about 60 feet below the dam crest. The total discharge from seepage in this area of the dam was estimated at about one gallon per minute. There is some cracking and spalling of the concrete on the downstream face of the dam, although there are no large areas of exposed aggregate. There are no indications or evidence observed of distortions in vertical or horizontal alignment or grade that would indicate movement of the dam.

A zone of very soft ground was detected on the east abutment slope about 50 feet downstream of the dam. The seepage associated with this wet area travels down the east abutment slope through a measuring weir and into the box culvert. The flow was measured to be about 5 gpm.

The Nicholson Anchorage Company, Bridgeville, Pa., was in the process of percussion drilling 9-inch diameter holes through the dam for installation of post-tensioning cables at the time of inspection. Section 1.2.g describes the scope and purpose of this contract authorized by the City of Wilmington, Delaware.

c. Appurtenant Structures. The operating assemblies for the four sluice gates in the intake structure were missing. According to the Owner's representative, all control valves are operable and the operating wheels are stored in the pump station downstream of the dam to insure that they are not stolen. The wheels are readily available when needed.

d. Reservoir. Reconnaissance of the reservoir disclosed no evidence of significant siltation, slope instability or other features that would adversely affect reservoir storage capacity. The slopes along the perimeter of the reservoir are on gradients which overall range between 15 and 30 percent. Nearly all of the terrain surrounding the reservoir is forested.

A two-lane highway supported by an earth dike (causeway) has been constructed across the northern end of the reservoir. The causeway is approximately 500 feet long with the surface of the road elevation about 8 feet above normal pool. Upstream of the causeway a shallow impoundment is created with an estimated surface area of 18 acres. The impoundment is connected to Hoopes Reservoir by two double-box concrete culverts. Each opening is 5 feet high by 5 feet 6-inches wide and 30 feet long. The impoundment is maintained near the Hoopes Dam spillway crest elevation with wooden flashboards placed within each culvert.

e. Downstream Channel. The Old Mill Stream valley has steep (up to 30 percent gradients) forested slopes and a floor about 0.1 mile wide. The outlet channel downstream of the 6-foot square box culvert is a small trapezoidal section overgrown with brush and small trees. The trapezoidal channel has a bottom width of about 8 feet and the side slopes are approximately 1.5H:1V. The confluence of this channel with Red Clay Creek is about 1,300 feet downstream of the dam. The potential damage area along Red Clay Creek is a narrow, forested meandering stream valley which contains a number of homes, roads, and the Baltimore and Ohio Railroad.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedures

Hoopes Reservoir is used to provide supplemental storage for the City of Wilmington's water system. Under normal operating conditions the reservoir is self regulating. The pool elevation fluctuates at or near the spillway crest. However, during periods of high turbidity or low flow in the Brandywine Creek, the City's primary water supply source, reservoir storage is available to meet daily demand requirements. The sluice gate operated from the top of the dam is normally in the open position and reservoir discharges are controlled by valves in the pumphouse downstream. This facility can be used to pump water into Hoopes Reservoir during periods of low system demand and high discharge with low turbidity in Brandywine Creek.

4.2 Maintenance of the Dam

The dam is maintained by the City of Wilmington, Delaware, Department of Public Works, Water Division. The structure is inspected on a regular basis and repairs are performed as required.

4.3 Maintenance of Operating Facilities

The operating facilities are maintained by the City of Wilmington,Delaware, Department of Public Works, Water Division. All control valves at the site are operable and are repaired when needed according to the Owner's representative.

4.4 Description of any Warning System in Effect

There is no warning system or procedure established to be followed during periods of exceedingly heavy rainfall. However, a City employee is at the site at least once each day to measure reservoir levels.

4.5 Evaluation of Operational Adequacy

A program of regular operation of all outlet control valves should be implemented to insure proper performance for possible drawdown of the reservoir during potentially hazardous conditions. A formal warning system should be developed because of the possibility of loss of life and excessive property damage downstream in the event of a failure of the dam.

SECTION 5

HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features

a. Design Data. No information is available concerning design data for Hoopes Dam. Visual inspection of the existing facilities indicates that the dam appears to be built in general conformance with the available construction drawings.

The Hoopes Reservoir watershed is a long, narrow basin with a total drainage area of 2 square miles. Elevations range from 420.0 to 220.0 at normal reservoir level. The watershed is almost entirely wooded and contains a few private homes and farms in its upper reaches. It is not expected that runoff characteristics of the watershed will change appreciably in the foreseeable future.

b. Experience Data. According to the Owner's representative, no reservoir stage records are maintained for above the spillway crest for this site, and no estimates could be given. The Owner only maintains reservoir pool levels below the spillway crest.

c. Visual Observation. The spillway system appears to be in good condition. On the day of the inspection, there was no evidence of materials which could obstruct the spillway. Observations regarding the condition of the downstream channel, spillway and reservoir are discussed in Appendix B and Section 3.

d. Overtopping Potential. The Spillway Design Flood (SDF) for this site based upon the dam height, storage capacity and distance to the hazard area is determined to be the Probable Maximum Flood (PMF).

The peak inflow and outflow rates for the SDF were determined to be 8,444 cfs and 2,145 cfs, respectively. Based upon the hydrologic analyses, the spillway is capable of discharging 100 percent of the PMF without overtopping of the dam (See Appendix C for computations).

e. Spillway Adequacy. The spillway system is "Adequate" since the spillway system will pass the entire PMF without overtopping of the dam.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations. Seepage was observed to be flowing from a number of construction joints on the downstream face of the dam. At several locations, calcification was observed along the very slightly opened joints. Most of the seeps are concentrated near the east abutment approximately 60 feet below the top of the dam. It was estimated that there is about one gallon per minute total seepage discharge in this area of the dam. There is some cracking and spalling of the concrete on the downstream face of the dam, although there are no large areas of exposed aggregate. There are no indications or evidence observed of distortions in vertical or horizontal alignment or grade that would indicate movement of the dam. No other structural inadequacies were noted during the visual inspection.

b. Design & Construction Data. The dam appears to have been built in general conformance with the construction drawings. Stability analyses were performed by O'Brien & Gere Engineers, Inc., in 1977 to determine if there were any deficiencies or potential deficiencies in the dam as designed and constructed.

c. Operating Records. The Owner only maintains reservoir pool levels below the spillway crest; the maximum pool of record is unknown.

d. Post-Construction Changes. A contract for the post-tensioning of Hoopes Dam was in progress at the time of inspection. According to the Owner's representative, there have been no other post-construction changes.

e. Seismic Stability. The dam is located in Seismic Zone 1 of the "Seismic Zone Map of Contiguous States". It can normally be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake conditions.

f. Evaluation. Stability analyses of the dam (performed by O'Brien & Gere Engineers, Inc.) indicate that the foundation reaction is not in the middle third of the base for loading conditions imposed by the PMF event. The dam is stable under normal loading conditions and would be stable for up to a 100 year statistical flood loading condition (National Weather Service, TP #40, 6 hr., 100 yr. rainfall). The results of the stability analyses are presented on Plates 4 through 7 of Appendix E.

SECTION 7

ASSESSMENT, RECOMMENDATIONS AND PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety. The visual inspection and review of the material supplied by the City of Wilmington, Delaware indicates that the structure is in fair condition and was built in general conformance with the drawings.

Examination of the hydrologic and hydraulic calculations, shown in Appendix C, indicate that the spillway system will pass 100 percent of the PMF. Therefore, the spillway of the structure is considered to be "Adequate".

According to stability analyses performed by O'Brien & Gere Engineers, Inc., the foundation reaction is not in the middle third of the base for loading conditions imposed by the PMF event. The dam is stable under normal loading conditions and would be stable for up to a 100 year statistical flood loading condition (National Weather Services, TP #40, 6 hr., 100 yr., rainfall). The results of the stability analyses are presented on Plates 4 through 7 of Appendix E.

The seepage noted issuing from the downstream face of the dam has been previously investigated by core borings through the dam. The concrete samples obtained at the elevation of the seeps were badly fractured and of poor quality with approximately one quarter inch diameter cavities apparent. It is probable that the leakage is the result of water seepage through this zone of weak and porous concrete.

b. Adequacy of Information. The available information obtained from the City of Wilmington, Delaware, along with visual observation made during the inspection are considered to be sufficient to make a reasonable assessment of the dam.

c. Urgency. The recommended remedial measures in Section 7.2 should be performed in the near future.

d. Necessity for Further Investigations. No further investigations are necessary at Hoopes Dam. O'Brien & Gere Engineers, Inc., has been studying the conditions at the site since 1977. Remedial repairs are currently being implemented or are scheduled to be performed in the near future by the City of Wilmington according to the recommendations presented in the O'Brien & Gere report of September, 1977.

7.2 Recommendations and Remedial Measures

a. Facilities .

1. The dam has been determined to be unstable for loading conditions imposed by a PMF event. The recommended post-tensioning of the dam to provide adequate stability during the PMF was being performed at the time of the inspection.

2. A flow measuring weir has been constructed to monitor seepage rates from the left abutment downstream of the dam. Monthly monitoring of this discharge should be continued to detect any future changes which might require further investigation.

3. Seepage has been noted issuing from the downstream face of the dam near the left abutment. A program of low pressure grouting of the deteriorated concrete within the dam is scheduled to be performed in the near future.

4. Vegetation should be removed from downstream channel.

b. Operation and Maintenance Procedures

1. The discharge control valves at the site are presently repaired only as required. The valves should be periodically operated to insure proper performance during potentially hazardous conditions.

2. No flood warning system is in effect at this site. A downstream warning system should be developed. During periods of heavy rainfall, the dam should be monitored. Downstream residents should be alerted in the event of an impending failure. The warning system should remain in effect after the post-tensioning to provide adequate stability of the dam during the PMF, has been completed.

APPENDIX

A

Check List Engineering Data

Design, Construction, Operation

Phase I

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Edgar M. Hoopes Dam

ID # DE 00015

ITEM	REMARKS
AS-BUILT DRAWINGS	As-Built are not available.
REGIONAL VICINITY MAP	Refer to Appendix E, Plate 1.
CONSTRUCTION HISTORY	The dam was built between July 1930 and February 1931.
TYPICAL SECTIONS OF DAM	Refer to Appendix E.
OUTLETS - PLAN	Refer to Appendix E.
DETAILS	
CONSTRAINTS	
DISCHARGE RATINGS	Continuous recorder in downstream pumphouse.
RAINFALL/RESERVOIR RECORDS	City personnel maintain daily reservoir level records.

ITEM	REMARKS
DESIGN REPORTS	Not available.
GEOLOGY REPORTS	A detailed report discussing site geology was prepared by Dr. Allan Thompson for O'Brien & Gere Engineers, Inc. as part of their dam evaluation in 1977.
DESIGN COMPUTATIONS	No data available
HYDROLOGY & HYDRAULICS	No data available
DAM STABILITY	No data available
SEEPAGE STUDIES	No data available
MATERIALS INVESTIGATIONS	
BORING RECORDS	
LABORATORY	Three sheets included in contract drawings show subsurface profiles and dirlling logs.
FIELD	
POST-CONSTRUCTION SURVEYS OF DAM	A survey was performed by O'Brien & Gere
BORROW SOURCES	Unknown.

ITEM	REMARKS
MONITORING SYSTEMS	Flow meter in pumphouse records pump discharge to water treatment plant.
MODIFICATIONS	The dam was being post-tensioned at time of inspection by Nicholson Anchorage Company.
HIGH POOL RECORDS	None
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Report entitled "Investigation of EDGAR M. HOOPES DAM" dated September 1977 by O'Brien & Gere Engineers, Inc., Justin & Courtney Division.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None
MAINTENANCE OPERATION RECORDS	None

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	Refer to Appendix E.
OPERATING EQUIPMENT PLANS & DETAILS	Refer to Appendix E.
MISCELLANEOUS	Material Available for Review: 1. Contract drawings. 2. Report entitled "Investigation of EDGAR M. HOOPS DAM". 3. Contract documents for post-tensioning the dam.

APPENDIX

B

Check List

Visual Inspection

Phase I

CHECK LIST
VISUAL INSPECTION
PHASE I

Name Dam Edgar M. Hoopes Dam County New Castle State Delaware National ID # DE 00015

Type of Dam Concrete Gravity Hazard Category High

Date(s) Inspection May 24, 1979 Weather Overcast W/Rain Temperature 70°

Pool Elevation at Time of Inspection 210.0 M.S.L. Tailwater at Time of Inspection - M.S.L.

Inspection Personnel:

Mr. Lee H. DeHeer
Mr. Leonard Beck
Mr. David Campbell
Mr. Steve Snider

Mr. Steve Snider Recorder

Remarks:

Accompanied by Mr. John Hanley of the City of Wilmington, Water Department

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	Some seepage noted between construction joints near left abutment about 60 feet below dam crest.	Currently under investigation by O'Brien & Gere Engineers, Inc.
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	A zone of soft ground exists on the east abutment slope about 50 feet below downstream toe. Seepage estimated at 5 gpm.	Currently under study by O'Brien & Gere. Flow measuring weir to be built under current construction contract.
DRAINS	None	None
WATER PASSAGES	None	None
FOUNDATION	Schist and gneiss outcrops in vicinity of dam site.	None

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Some minor spalling and cracking of non-overflow sections of the dam.	None
STRUCTURAL CRACKING	None noted	None
VERTICAL AND HORIZONTAL ALIGNMENT	No misalignments observed.	None
MONOLITH JOINTS	Calcification and seepage noted at some slightly open joints.	None
CONSTRUCTION JOINTS	No problems.	None

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	None observed	None
INTAKE STRUCTURE	Under water at time of inspection	None
OUTLET STRUCTURE	Operating wheel for sluice gate was missing.	Owner's representative stated that wheel is in pump house downstream of dam.
OUTLET CHANNEL	No problems observed.	None
EMERGENCY GATE	Emergency gate valves located in vault at downstream toe. No problems observed.	None

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	No problems noted	None
APPROACH CHANNEL	N/A	None
DISCHARGE CHANNEL	Discharge flows into a concrete box culvert.	None
BRIDGE AND PIERS	No problems noted.	None

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Some small trees and brush noted in channel.	Vegetation should be removed.
SLOPES	Moderate, tree-covered slopes forming a narrow, meandering stream valley.	None.
APPROXIMATE NO. OF HOMES AND POPULATION	There are at least 10 homes in the flood plain downstream of the dam (Approx. 50 people).	A formal warning system should be implemented.

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Moderate, tree-covered slopes. No evidence of instability.	None
SEDIMENTATION	None observed.	None

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	As-Built survey by O'Brien & Gere indicated that the dam crest varies within 0.1 feet of design elevation.	None
OBSERVATION WELLS	None	None
WEIRS	None	Weir scheduled to be built to measure seepage noted in left downstream abutment.
PIEZOMETERS	None	None
OTHER	None	None

APPENDIX

C

Hydrologic & Hydraulic Data

TABLE OF CONTENTS - APPENDIX C

Tp COMPUTATIONS & PMP DATA	SHEET 1 - 6
STAGE - DISCHARGE: CAMPBELL ROAD	SHEET 4 - 5
HOOPES RESERVOIR DRAWDOWN CALCULATIONS	SHEET 6
HEC-1 DAM SAFETY VERSION COMPUTER OUTPUT WITHOUT BREACH OF DAM	SHEET 7 - 21

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO
EDGAR M. HOOPES DAM DE00015	1/6	SHS		

HYDROLOGY

HEC 1 - DAM SAFETY VERSION - PROGRAM CALCULATIONS

Drainage Area = 2.0 SQ. MI.

Sub-basin above Campbell Road = 0.87 SQ. MI.

PMP CALCULATIONS - HMS REPORT 33

Area is in Zone 6 of PMP ALL SEASON ENVELOPE

24 hr., 200 SQ. MI. RAINFALL ≃ 23.5"

STORM DISTRIBUTION

HR.	%
6	113
12	124
24	132

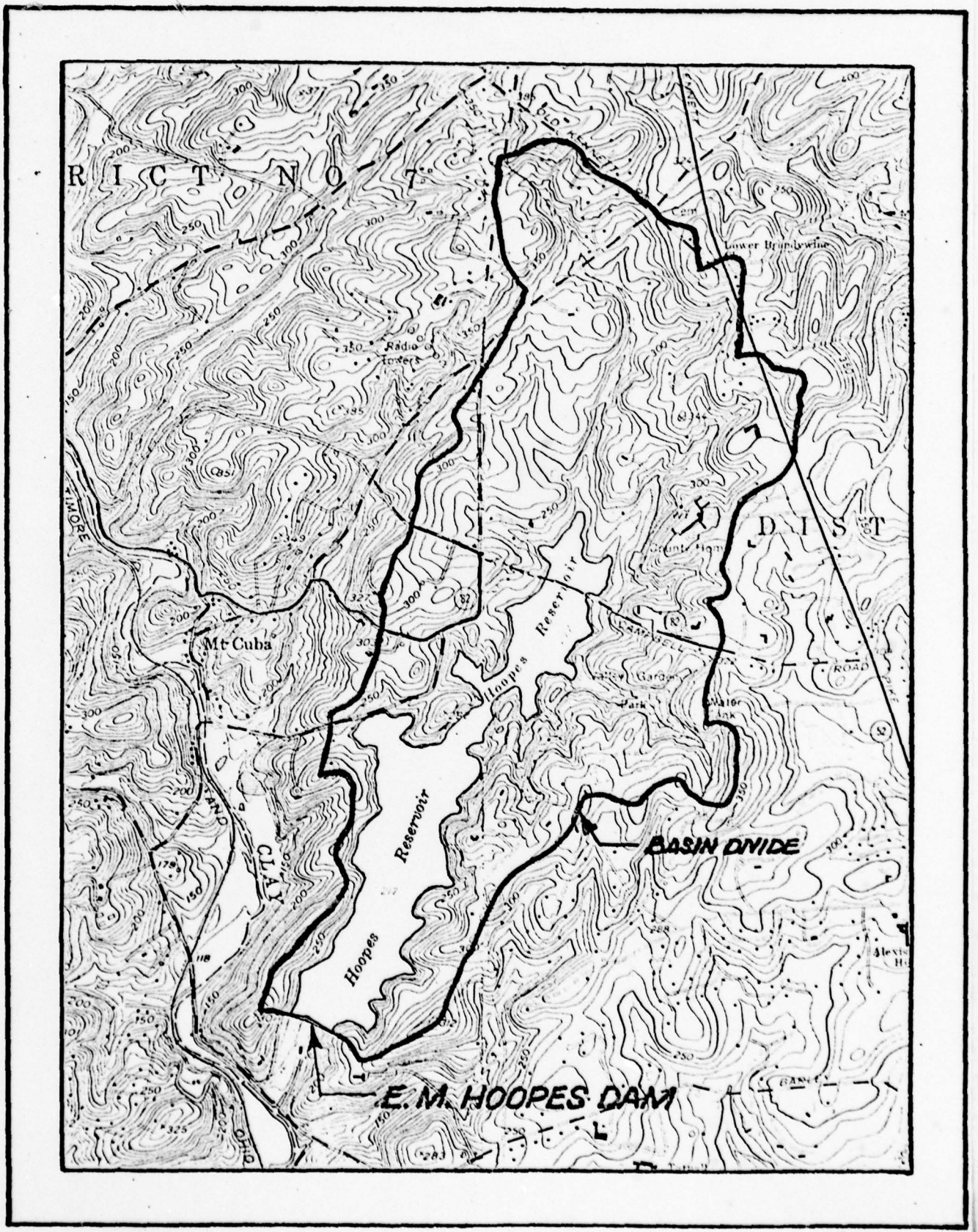
LAG TIME - Sub-basin above Campbell Road

1. SCS Curve Number Method:

$l = 6200$ ft. $C = 60$ $\left(\therefore S = \frac{1000}{C} - 10 = 6.67\right)$

$y = 6\%$

$$L = \frac{l^{0.8}(S+1)^{0.7}}{1900\, y^{0.5}} = 0.96 \text{ HRS.}$$


R I C T O N O. 7
Mt Cuba
Hoopes Reservoir
Hoopes Reservoir
BASIN DIVIDE
E. M. HOOPES DAM
CLAY
D I S T

SHEET 1A

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO
HOOPES DAM - HYDROLOGY	2/6	SHS/DBC		

2. SCS Upland Method:

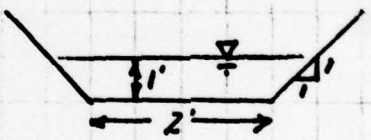
$$S_1 = \frac{420-330}{1000} = 0.09$$

WOODS & MEADOWS $V_1 = 0.8$ fps

$t_1 = 1000/0.8 = 1250$ sec.

3. MANNING'S FORMULA:

$$V_2 = \frac{1.49}{n} R_h^{2/3} S^{1/2}$$



$$S_2 = \frac{330-222}{5200} = 0.02$$

$n = 0.05 \quad R_h = 0.6$

$\therefore V_2 = 3.3$ fps $\quad t_2 = \frac{5200}{3.3} = 1576$ sec.

USE $\Rightarrow L = 1.0$ HR.

UPPER POND (above Campbell Road) DATA:

Surface Area @ normal pool El. 222 ≃ 18 acres
Surface Area @ top of Campbell Road El. 228 ≃ 20 acres
Surface Area @ El. 230 ≃ 21 acres

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO.
HOOPES DAM - HYDROLOGY	3/6	SHS		

LAG TIME - Basin downstream of Campbell Road

1. SCS Curve Number Method:

$l = 3000$ ft. $CN = 70$ $\therefore S = \frac{1000 - 10}{70} = 4.29$

$Y = 10\%$

$$L = \frac{l^{0.8}(S+1)^{0.7}}{1900 y^{0.5}} = 0.48 \text{ HRS.}$$

2. SCS Upland Method:

$S = 10\%$

WOODS & MEADOWS $V = 1.0$ fps

$T_c = 3000/1.0 = 3000 \text{ sec.} = 0.83 \text{ HRS.}$

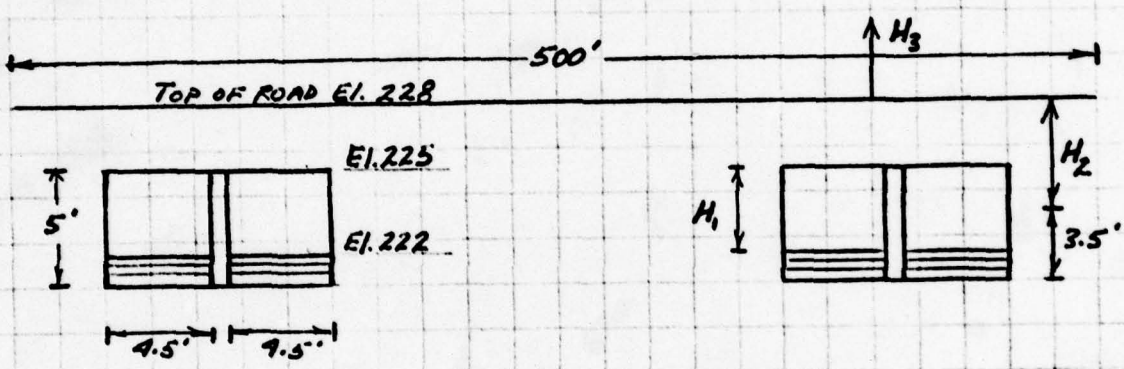
$L \simeq 0.6\, T_c = 0.49 \text{ HRS.}$

USE $\Longrightarrow L = 0.5$ HRS.

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO
HOOPES DAM - HYDROLOGY/HYDRAULICS	4/6	SHS/DBC		

Discharge from impoundment created by Campbell Road at north end of HOOPES RES. passes through two double-box concrete culverts which are provided with wooden flashboards.



DISCHARGE CONDITION : El. 222 - 225

$Q = C_1 L H_1^{3/2}$ $C = 3.1$ $L_1 = 4(4.5) = 18$ ft.

DISCHARGE CONDITION : El. 225 - 228

$Q = C_2 A \sqrt{2gH_2}$ $C_2 = 0.8$ Ref. HANDBOOK OF HYDRAULICS, KING & BRATER

$A = 4(3)4.5 = 54$ SQ. FT. $R_H = 0.9$ $L = 30$ ft.

DISCHARGE CONDITION : El. 228 - 230

$Q = C_2 A \sqrt{2gH_2} + C_3 L_3 H_3^{3/2}$ $C = 2.6$ $L_3 = 500'$

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO.
HOOPES DAM - HYDROLOGY/HYDRAULICS	5/6	SHS/DBC		

STAGE - DISCHARGE : UPPER POND

El.	$Q = 3.1 L H_1^{3/2}$		$Q = 0.8 A\sqrt{2gH_2}$		$Q = 2.6 L_3 H_3^{3/2}$		Q_T
	H_1	Q	H_2	Q	H_3	Q	cfs
222	0	0	-	-	-	-	0
223	1	56	-	-	-	-	56
224	2	158	-	-	-	-	158
225	-	-	1.5	424	-	-	424
226	-	-	2.5	548	-	-	548
227	-	-	3.5	649	-	-	649
228	-	-	4.5	735	-	-	735
229	-	-	5.5	813	1	1300	2113
230	-	-	6.5	883	2	3676	4559

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO
HOOPES DAM - HYDRAULICS	6/6	SHS		

DRAWDOWN CALCULATIONS

The reservoir drain is a 36" diameter pipe which discharges into a box culvert about 55' downstream of the dam.

Orifice Eq'n: $Q = CA\sqrt{2gH}$ $\quad A = \frac{\pi D^2}{4} = 7.07$ sq. ft.

$C = 0.6$

RES. EL.	HEAD	$Q = 4.24\sqrt{4.9H}$	Q_{AVG}	V(A-F)	T(HRS.)
220	102	344			
			335	1696	61
210	92	326			
			317	1305	50
200	82	308			
			299	969	39
190	72	289			
			279	729	32
180	62	268			
			257	571	21
170	52	245			
			233	420	22
160	42	221			
			207	283	17
150	32	192			
			176	170	12
140	22	160			
			139	91	9
130	12	118			
			83	32	5
120	2	48			
			24	1	1
118	0	0			

$\Sigma T = 275$ HRS ≈ 11.5 days

****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79
****

RUN DATE= 07/31/79.
TIME= 13.08.24.

NATIONAL DAM INSPECTION PROGRAM
EDGAR M. HOOPES DAM
PMF HYDROLOGY

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
150	0	20	0	0	0	0	0	3	0

JOPER	NWT	LROPT	TRACE
3	0	0	0

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW TO UPPER RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
SUB1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.87	0.00	2.00	0.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.50	113.00	124.00	132.00	0.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.50	.15	0.00	0.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= 1.00

RECESSION DATA
STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 17 END OF PERIOD ORDINATES. TC= 0.00 HOURS. LAG= 1.00 VOL= 1.00

44.	218.	347.	347.	271.	162.	101.	65.	41.	25.
14.	10.	6.	4.	3.	2.	1.			

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.20	1	.03	0.00	.03	1.	1.02	1.20	76	0.00	0.00	0.00	58.
1.01	.40	2	.03	0.00	.03	1.	1.02	1.40	77	0.00	0.00	0.00	54.
1.01	1.00	3	.03	0.00	.03	1.	1.02	2.00	78	0.00	0.00	0.00	51.
1.01	1.20	4	.03	0.00	.03	1.	1.02	2.20	79	0.00	0.00	0.00	47.

Sh 7

1.01	1.40	5	.03	0.00	.03	1.	1.02	2.40	80	0.00	0.00	0.00	44.
1.01	2.00	6	.03	0.00	.03	1.	1.02	3.00	81	0.00	0.00	0.00	41.
1.01	2.20	7	.03	0.00	.03	1.	1.02	3.20	82	0.00	0.00	0.00	38.
1.01	2.40	8	.03	0.00	.03	1.	1.02	3.40	83	0.00	0.00	0.00	36.
1.01	3.00	9	.03	0.00	.03	1.	1.02	4.00	84	0.00	0.00	0.00	33.
1.01	3.20	10	.03	0.00	.03	1.	1.02	4.20	85	0.00	0.00	0.00	31.
1.01	3.40	11	.03	0.00	.03	1.	1.02	4.40	86	0.00	0.00	0.00	29.
1.01	4.00	12	.03	0.00	.03	1.	1.02	5.00	87	0.00	0.00	0.00	27.
1.01	4.20	13	.03	0.00	.03	1.	1.02	5.20	88	0.00	0.00	0.00	25.
1.01	4.40	14	.03	0.00	.03	0.	1.02	5.40	89	0.00	0.00	0.00	24.
1.01	5.00	15	.03	0.00	.03	0.	1.02	6.00	90	0.00	0.00	0.00	22.
1.01	5.20	16	.03	0.00	.03	0.	1.02	6.20	91	0.00	0.00	0.00	21.
1.01	5.40	17	.03	0.00	.03	0.	1.02	6.40	92	0.00	0.00	0.00	19.
1.01	6.00	18	.03	0.00	.03	0.	1.02	7.00	93	0.00	0.00	0.00	18.
1.01	6.20	19	.11	0.00	.11	0.	1.02	7.20	94	0.00	0.00	0.00	17.
1.01	6.40	20	.11	0.00	.11	0.	1.02	7.40	95	0.00	0.00	0.00	16.
1.01	7.00	21	.11	0.00	.11	0.	1.02	8.00	96	0.00	0.00	0.00	15.
1.01	7.20	22	.11	0.00	.11	0.	1.02	8.20	97	0.00	0.00	0.00	14.
1.01	7.40	23	.11	0.00	.11	0.	1.02	8.40	98	0.00	0.00	0.00	13.
1.01	8.00	24	.11	0.00	.11	0.	1.02	9.00	99	0.00	0.00	0.00	12.
1.01	8.20	25	.11	0.00	.11	0.	1.02	9.20	100	0.00	0.00	0.00	11.
1.01	8.40	26	.11	.01	.10	1.	1.02	9.40	101	0.00	0.00	0.00	10.
1.01	9.00	27	.11	.06	.05	7.	1.02	10.00	102	0.00	0.00	0.00	10.
1.01	9.20	28	.11	.06	.05	23.	1.02	10.20	103	0.00	0.00	0.00	9.
1.01	9.40	29	.11	.06	.05	45.	1.02	10.40	104	0.00	0.00	0.00	8.
1.01	10.00	30	.11	.06	.05	67.	1.02	11.00	105	0.00	0.00	0.00	8.
1.01	10.20	31	.11	.06	.05	83.	1.02	11.20	106	0.00	0.00	0.00	7.
1.01	10.40	32	.11	.06	.05	93.	1.02	11.40	107	0.00	0.00	0.00	7.
1.01	11.00	33	.11	.06	.05	99.	1.02	12.00	108	0.00	0.00	0.00	6.
1.01	11.20	34	.11	.06	.05	103.	1.02	12.20	109	0.00	0.00	0.00	6.
1.01	11.40	35	.11	.06	.05	105.	1.02	12.40	110	0.00	0.00	0.00	6.
1.01	12.00	36	.11	.06	.05	107.	1.02	13.00	111	0.00	0.00	0.00	5.
1.01	12.20	37	.71	.66	.05	146.	1.02	13.20	112	0.00	0.00	0.00	5.
1.01	12.40	38	.71	.66	.05	276.	1.02	13.40	113	0.00	0.00	0.00	4.
1.01	13.00	39	.71	.66	.05	482.	1.02	14.00	114	0.00	0.00	0.00	4.
1.01	13.20	40	.85	.80	.05	698.	1.02	14.20	115	0.00	0.00	0.00	4.
1.01	13.40	41	.85	.80	.05	889.	1.02	14.40	116	0.00	0.00	0.00	4.
1.01	14.00	42	.85	.80	.05	1035.	1.02	15.00	117	0.00	0.00	0.00	3.
1.01	14.20	43	1.06	1.01	.05	1158.	1.02	15.20	118	0.00	0.00	0.00	3.
1.01	14.40	44	1.06	1.01	.05	1281.	1.02	15.40	119	0.00	0.00	0.00	3.
1.01	15.00	45	1.06	1.01	.05	1402.	1.02	16.00	120	0.00	0.00	0.00	3.
1.01	15.20	46	1.86	1.81	.05	1556.	1.02	16.20	121	0.00	0.00	0.00	3.
1.01	15.40	47	5.09	5.04	.05	2012.	1.02	16.40	122	0.00	0.00	0.00	2.
1.01	16.00	48	1.13	1.08	.05	2786.	1.02	17.00	123	0.00	0.00	0.00	2.
1.01	16.20	49	.99	.94	.05	3341.	1.02	17.20	124	0.00	0.00	0.00	2.
1.01	16.40	50	.99	.94	.05	3292.	1.02	17.40	125	0.00	0.00	0.00	2.
1.01	17.00	51	.99	.94	.05	2884.	1.02	18.00	126	0.00	0.00	0.00	2.
1.01	17.20	52	.78	.73	.05	2362.	1.02	18.20	127	0.00	0.00	0.00	2.
1.01	17.40	53	.78	.73	.05	2019.	1.02	18.40	128	0.00	0.00	0.00	2.
1.01	18.00	54	.78	.73	.05	1769.	1.02	19.00	129	0.00	0.00	0.00	1.
1.01	18.20	55	.05	.00	.05	1529.	1.02	19.20	130	0.00	0.00	0.00	1.
1.01	18.40	56	.05	.00	.05	1239.	1.02	19.40	131	0.00	0.00	0.00	1.
1.01	19.00	57	.05	.00	.05	985.	1.02	20.00	132	0.00	0.00	0.00	1.
1.01	19.20	58	.05	.00	.05	681.	1.02	20.20	133	0.00	0.00	0.00	1.
1.01	19.40	59	.05	.00	.05	372.	1.02	20.40	134	0.00	0.00	0.00	1.
1.01	20.00	60	.05	.00	.05	233.	1.02	21.00	135	0.00	0.00	0.00	1.
1.01	20.20	61	.05	.00	.05	165.	1.02	21.20	136	0.00	0.00	0.00	1.
1.01	20.40	62	.05	.00	.05	154.	1.02	21.40	137	0.00	0.00	0.00	1.
1.01	21.00	63	.05	.00	.05	143.	1.02	22.00	138	0.00	0.00	0.00	1.
1.01	21.20	64	.05	.00	.05	134.	1.02	22.20	139	0.00	0.00	0.00	1.
1.01	21.40	65	.05	.00	.05	125.	1.02	22.40	140	0.00	0.00	0.00	1.
1.01	22.00	66	.05	.00	.05	116.	1.02	23.00	141	0.00	0.00	0.00	1.

Sh 8

1.01	22.20	67	.05	.00	.05	109.	1.02	23.20	142	0.00	0.00	0.00	1.
1.01	22.40	68	.05	.00	.05	101.	1.02	23.40	143	0.00	0.00	0.00	1.
1.01	23.00	69	.05	.00	.05	94.	1.03	0.00	144	0.00	0.00	0.00	1.
1.01	23.20	70	.05	.00	.05	88.	1.03	.20	145	0.00	0.00	0.00	0.
1.01	23.40	71	.05	.00	.05	82.	1.03	.40	146	0.00	0.00	0.00	0.
1.02	0.00	72	.05	.00	.05	77.	1.03	1.00	147	0.00	0.00	0.00	0.
1.02	.20	73	0.00	0.00	0.00	72.	1.03	1.20	148	0.00	0.00	0.00	0.
1.02	.40	74	0.00	0.00	0.00	67.	1.03	1.40	149	0.00	0.00	0.00	0.
1.02	1.00	75	0.00	0.00	0.00	62.	1.03	2.00	150	0.00	0.00	0.00	0.
									SUM	24.82	21.01	3.81	37466.
										(630.)	(534.)	(97.)	(1060.92)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3341.	1784.	518.	250.	37463.
CMS	95.	51.	15.	7.	1061.
INCHES		19.07	22.14	22.25	22.25
MM		484.43	562.47	565.25	565.25
AC-FT		884.	1027.	1032.	1032.
THOUS CU M		1091.	1267.	1273.	1273.

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HYDROGRAPH ROUTING

ROUTING THROUGH UPPER RESERVOIR

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
SUBRTE	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	0	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
0	0	0	0.000	0.000	0.000	-222.	-1

STAGE	222.00	223.00	224.00	225.00	226.00	227.00	228.00	229.00	230.00
FLOW	0.00	56.00	158.00	424.00	548.00	649.00	735.00	2113.00	4559.00
SURFACE AREA=		18.	21.						
CAPACITY=		0.	156.						
ELEVATION=		222.	230.						

CRFL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
222.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
228.0	0.0	0.0	0.

END-OF-PERIOD HYDROGRAPH ORDINATES

MO.DA	HR.MN	PERIOD	HOURS	INFLOW	OUTFLOW	STORAGE	STAGE
1.01	.20	1	.33	1.	5.	2.	222.1
1.01	.40	2	.67	1.	5.	2.	222.1

Sh 9

1.01	1.00	3	1.00	1.	5.	1.	222.1
1.01	1.20	4	1.33	1.	4.	1.	222.1
1.01	1.40	5	1.67	1.	4.	1.	222.1
1.01	2.00	6	2.00	1.	4.	1.	222.1
1.01	2.20	7	2.33	1.	4.	1.	222.1
1.01	2.40	8	2.67	1.	3.	1.	222.1
1.01	3.00	9	3.00	1.	3.	1.	222.1
1.01	3.20	10	3.33	1.	3.	1.	222.1
1.01	3.40	11	3.67	1.	3.	1.	222.0
1.01	4.00	12	4.00	1.	3.	1.	222.0
1.01	4.20	13	4.33	1.	2.	1.	222.0
1.01	4.40	14	4.67	0.	2.	1.	222.0
1.01	5.00	15	5.00	0.	2.	1.	222.0
1.01	5.20	16	5.33	0.	2.	1.	222.0
1.01	5.40	17	5.67	0.	2.	1.	222.0
1.01	6.00	18	6.00	0.	2.	1.	222.0
1.01	6.20	19	6.33	0.	2.	1.	222.0
1.01	6.40	20	6.67	0.	1.	0.	222.0
1.01	7.00	21	7.00	0.	1.	0.	222.0
1.01	7.20	22	7.33	0.	1.	0.	222.0
1.01	7.40	23	7.67	0.	1.	0.	222.0
1.01	8.00	24	8.00	0.	1.	0.	222.0
1.01	8.20	25	8.33	0.	1.	0.	222.0
1.01	8.40	26	8.67	1.	1.	0.	222.0
1.01	9.00	27	9.00	7.	1.	0.	222.0
1.01	9.20	28	9.33	23.	2.	1.	222.0
1.01	9.40	29	9.67	45.	5.	2.	222.1
1.01	10.00	30	10.00	67.	9.	3.	222.2
1.01	10.20	31	10.33	83.	15.	5.	222.3
1.01	10.40	32	10.67	93.	21.	7.	222.4
1.01	11.00	33	11.00	99.	27.	9.	222.5
1.01	11.20	34	11.33	103.	33.	11.	222.6
1.01	11.40	35	11.67	105.	38.	12.	222.7
1.01	12.00	36	12.00	107.	44.	14.	222.8
1.01	12.20	37	12.33	146.	51.	16.	222.9
1.01	12.40	38	12.67	276.	69.	21.	223.1
1.01	13.00	39	13.00	482.	113.	28.	223.6
1.01	13.20	40	13.33	698.	209.	40.	224.2
1.01	13.40	41	13.67	889.	399.	54.	224.9
1.01	14.00	42	14.00	1035.	503.	68.	225.6
1.01	14.20	43	14.33	1158.	590.	83.	226.4
1.01	14.40	44	14.67	1281.	669.	99.	227.2
1.01	15.00	45	15.00	1402.	815.	116.	228.1
1.01	15.20	46	15.33	1556.	1456.	125.	228.5
1.01	15.40	47	15.67	2012.	1771.	130.	228.8
1.01	16.00	48	16.00	2786.	2450.	138.	229.1
1.01	16.20	49	16.33	3341.	3210.	144.	229.4
1.01	16.40	50	16.67	3292.	3342.	145.	229.5
1.01	17.00	51	17.00	2884.	3028.	143.	229.4
1.01	17.20	52	17.33	2362.	2526.	139.	229.2
1.01	17.40	53	17.67	2019.	2111.	135.	229.0
1.01	18.00	54	18.00	1769.	1903.	132.	228.8
1.01	18.20	55	18.33	1529.	1659.	128.	228.7
1.01	18.40	56	18.67	1239.	1394.	124.	228.5
1.01	19.00	57	19.00	905.	1083.	120.	228.3
1.01	19.20	58	19.33	601.	764.	115.	228.0
1.01	19.40	59	19.67	372.	708.	108.	227.7
1.01	20.00	60	20.00	233.	662.	98.	227.2
1.01	20.20	61	20.33	165.	604.	86.	226.5
1.01	20.40	62	20.67	154.	544.	74.	226.0
1.01	21.00	63	21.00	143.	480.	64.	225.4
1.01	21.20	64	21.33	134.	424.	56.	225.0

Sh 10

1.01	21.40	65	21.67	125.	329.	49.	224.6
1.01	22.00	66	22.00	116.	261.	44.	224.4
1.01	22.20	67	22.33	109.	213.	41.	224.2
1.01	22.40	68	22.67	101.	178.	38.	224.1
1.01	23.00	69	23.00	96.	155.	36.	224.0
1.01	23.20	70	23.33	88.	146.	35.	223.9
1.01	23.40	71	23.67	82.	138.	33.	223.8
1.02	0.00	72	24.00	77.	130.	32.	223.7
1.02	.20	73	24.33	72.	122.	30.	223.6
1.02	.40	74	24.67	67.	114.	29.	223.6
1.02	1.00	75	25.00	62.	107.	27.	223.5
1.02	1.20	76	25.33	58.	101.	26.	223.4
1.02	1.40	77	25.67	54.	95.	25.	223.4
1.02	2.00	78	26.00	51.	89.	24.	223.3
1.02	2.20	79	26.33	47.	83.	23.	223.3
1.02	2.40	80	26.67	44.	78.	22.	223.2
1.02	3.00	81	27.00	41.	73.	21.	223.2
1.02	3.20	82	27.33	38.	68.	20.	223.1
1.02	3.40	83	27.67	36.	64.	20.	223.1
1.02	4.00	84	28.00	33.	60.	19.	223.0
1.02	4.20	85	28.33	31.	56.	18.	223.0
1.02	4.40	86	28.67	29.	54.	17.	223.0
1.02	5.00	87	29.00	27.	52.	17.	222.9
1.02	5.20	88	29.33	25.	50.	16.	222.9
1.02	5.40	89	29.67	24.	48.	15.	222.9
1.02	6.00	90	30.00	22.	46.	15.	222.8
1.02	6.20	91	30.33	21.	44.	14.	222.8
1.02	6.40	92	30.67	19.	42.	14.	222.7
1.02	7.00	93	31.00	18.	40.	13.	222.7
1.02	7.20	94	31.33	17.	38.	12.	222.7
1.02	7.40	95	31.67	16.	36.	12.	222.6
1.02	8.00	96	32.00	15.	35.	11.	222.6
1.02	8.20	97	32.33	14.	33.	11.	222.6
1.02	8.40	98	32.67	13.	31.	10.	222.6
1.02	9.00	99	33.00	12.	30.	10.	222.5
1.02	9.20	100	33.33	11.	28.	9.	222.5
1.02	9.40	101	33.67	10.	27.	9.	222.5
1.02	10.00	102	34.00	10.	25.	8.	222.5
1.02	10.20	103	34.33	9.	24.	8.	222.4
1.02	10.40	104	34.67	8.	23.	7.	222.4
1.02	11.00	105	35.00	8.	22.	7.	222.4
1.02	11.20	106	35.33	7.	20.	7.	222.4
1.02	11.40	107	35.67	7.	19.	6.	222.3
1.02	12.00	108	36.00	6.	18.	6.	222.3
1.02	12.20	109	36.33	6.	17.	6.	222.3
1.02	12.40	110	36.67	6.	16.	5.	222.3
1.02	13.00	111	37.00	5.	15.	5.	222.3
1.02	13.20	112	37.33	5.	15.	5.	222.3
1.02	13.40	113	37.67	4.	14.	4.	222.2
1.02	14.00	114	38.00	4.	13.	4.	222.2
1.02	14.20	115	38.33	4.	12.	4.	222.2
1.02	14.40	116	38.67	4.	12.	4.	222.2
1.02	15.00	117	39.00	3.	11.	4.	222.2
1.02	15.20	118	39.33	3.	10.	3.	222.2
1.02	15.40	119	39.67	3.	10.	3.	222.2
1.02	16.00	120	40.00	3.	9.	3.	222.2
1.02	16.20	121	40.33	3.	9.	3.	222.2
1.02	16.40	122	40.67	2.	8.	3.	222.1
1.02	17.00	123	41.00	2.	8.	2.	222.1
1.02	17.20	124	41.33	2.	7.	2.	222.1
1.02	17.40	125	41.67	2.	7.	2.	222.1
1.02	18.00	126	42.00	2.	6.	2.	222.1

Sh 11

1.02	18.20	127	42.33	2.	6.	2.	222.1
1.02	18.40	128	42.67	2.	6.	2.	222.1
1.02	19.00	129	43.00	1.	5.	2.	222.1
1.02	19.20	130	43.33	1.	5.	2.	222.1
1.02	19.40	131	43.67	1.	5.	2.	222.1
1.02	20.00	132	44.00	1.	4.	1.	222.1
1.02	20.20	133	44.33	1.	4.	1.	222.1
1.02	20.40	134	44.67	1.	4.	1.	222.1
1.02	21.00	135	45.00	1.	4.	1.	222.1
1.02	21.20	136	45.33	1.	3.	1.	222.1
1.02	21.40	137	45.67	1.	3.	1.	222.1
1.02	22.00	138	46.00	1.	3.	1.	222.1
1.02	22.20	139	46.33	1.	3.	1.	222.1
1.02	22.40	140	46.67	1.	3.	1.	222.0
1.02	23.00	141	47.00	1.	2.	1.	222.0
1.02	23.20	142	47.33	1.	2.	1.	222.0
1.02	23.40	143	47.67	1.	2.	1.	222.0
1.03	0.00	144	48.00	1.	2.	1.	222.0
1.03	.20	145	48.33	0.	2.	1.	222.0
1.03	.40	146	48.67	0.	2.	1.	222.0
1.03	1.00	147	49.00	0.	2.	1.	222.0
1.03	1.20	148	49.33	0.	2.	1.	222.0
1.03	1.40	149	49.67	0.	1.	0.	222.0
1.03	2.00	150	50.00	0.	1.	0.	222.0

PEAK OUTFLOW IS 3342. AT TIME 16.67 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3342.	1675.	514.	250.	37510.
CMS	95.	47.	15.	7.	1062.
INCHES		17.91	22.00	22.28	22.28
MM		454.86	558.80	565.95	565.95
AC-FT		831.	1020.	1033.	1033.
THOUS CU M		1024.	1258.	1275.	1275.

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SUB-AREA RUNOFF COMPUTATION

INFLOW TO HOOPES DAM

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
IN	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	1.13	0.00	2.00	0.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.50	113.00	124.00	132.00	0.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.50	.15	0.00	0.00

Sh 12

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .50

RECESSION DATA
STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

TIME INCREMENT TOO LARGE--(NHO IS GT LAG/2)

UNIT HYDROGRAPH 10 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .50 VOL= 1.00
387. 824. 560. 231. 105. 45. 21. 9. 4. 0.

0 END-OF-PERIOD FLOW

NO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	NO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.20	1	.03	0.00	.03	2.	1.02	1.20	76	0.00	0.00	0.00	81.
1.01	.40	2	.03	0.00	.03	1.	1.02	1.40	77	0.00	0.00	0.00	75.
1.01	1.00	3	.03	0.00	.03	1.	1.02	2.00	78	0.00	0.00	0.00	70.
1.01	1.20	4	.03	0.00	.03	1.	1.02	2.20	79	0.00	0.00	0.00	65.
1.01	1.40	5	.03	0.00	.03	1.	1.02	2.40	80	0.00	0.00	0.00	61.
1.01	2.00	6	.03	0.00	.03	1.	1.02	3.00	81	0.00	0.00	0.00	57.
1.01	2.20	7	.03	0.00	.03	1.	1.02	3.20	82	0.00	0.00	0.00	53.
1.01	2.40	8	.03	0.00	.03	1.	1.02	3.40	83	0.00	0.00	0.00	50.
1.01	3.00	9	.03	0.00	.03	1.	1.02	4.00	84	0.00	0.00	0.00	46.
1.01	3.20	10	.03	0.00	.03	1.	1.02	4.20	85	0.00	0.00	0.00	43.
1.01	3.40	11	.03	0.00	.03	1.	1.02	4.40	86	0.00	0.00	0.00	40.
1.01	4.00	12	.03	0.00	.03	1.	1.02	5.00	87	0.00	0.00	0.00	38.
1.01	4.20	13	.03	0.00	.03	1.	1.02	5.20	88	0.00	0.00	0.00	35.
1.01	4.40	14	.03	0.00	.03	1.	1.02	5.40	89	0.00	0.00	0.00	33.
1.01	5.00	15	.03	0.00	.03	1.	1.02	6.00	90	0.00	0.00	0.00	31.
1.01	5.20	16	.03	0.00	.03	1.	1.02	6.20	91	0.00	0.00	0.00	29.
1.01	5.40	17	.03	0.00	.03	1.	1.02	6.40	92	0.00	0.00	0.00	27.
1.01	6.00	18	.03	0.00	.03	0.	1.02	7.00	93	0.00	0.00	0.00	25.
1.01	6.20	19	.11	0.00	.11	0.	1.02	7.20	94	0.00	0.00	0.00	23.
1.01	6.40	20	.11	0.00	.11	0.	1.02	7.40	95	0.00	0.00	0.00	22.
1.01	7.00	21	.11	0.00	.11	0.	1.02	8.00	96	0.00	0.00	0.00	20.
1.01	7.20	22	.11	0.00	.11	0.	1.02	8.20	97	0.00	0.00	0.00	19.
1.01	7.40	23	.11	0.00	.11	0.	1.02	8.40	98	0.00	0.00	0.00	18.
1.01	8.00	24	.11	0.00	.11	0.	1.02	9.00	99	0.00	0.00	0.00	16.
1.01	8.20	25	.11	0.00	.11	0.	1.02	9.20	100	0.00	0.00	0.00	15.
1.01	8.40	26	.11	.01	.10	5.	1.02	9.40	101	0.00	0.00	0.00	14.
1.01	9.00	27	.11	.06	.05	35.	1.02	10.00	102	0.00	0.00	0.00	13.
1.01	9.20	28	.11	.06	.05	85.	1.02	10.20	103	0.00	0.00	0.00	12.
1.01	9.40	29	.11	.06	.05	118.	1.02	10.40	104	0.00	0.00	0.00	12.
1.01	10.00	30	.11	.06	.05	131.	1.02	11.00	105	0.00	0.00	0.00	11.
1.01	10.20	31	.11	.06	.05	137.	1.02	11.20	106	0.00	0.00	0.00	10.
1.01	10.40	32	.11	.06	.05	140.	1.02	11.40	107	0.00	0.00	0.00	9.
1.01	11.00	33	.11	.06	.05	141.	1.02	12.00	108	0.00	0.00	0.00	9.
1.01	11.20	34	.11	.06	.05	142.	1.02	12.20	109	0.00	0.00	0.00	8.
1.01	11.40	35	.11	.06	.05	142.	1.02	12.40	110	0.00	0.00	0.00	8.
1.01	12.00	36	.11	.06	.05	142.	1.02	13.00	111	0.00	0.00	0.00	7.
1.01	12.20	37	.71	.66	.05	372.	1.02	13.20	112	0.00	0.00	0.00	7.
1.01	12.40	38	.71	.66	.05	861.	1.02	13.40	113	0.00	0.00	0.00	6.
1.01	13.00	39	.71	.66	.05	1193.	1.02	14.00	114	0.00	0.00	0.00	6.
1.01	13.20	40	.85	.80	.05	1385.	1.02	14.20	115	0.00	0.00	0.00	5.
1.01	13.40	41	.85	.80	.05	1564.	1.02	14.40	116	0.00	0.00	0.00	5.
1.01	14.00	42	.85	.80	.05	1670.	1.02	15.00	117	0.00	0.00	0.00	5.
1.01	14.20	43	1.06	1.01	.05	1797.	1.02	15.20	118	0.00	0.00	0.00	4.
1.01	14.40	44	1.06	1.01	.05	1993.	1.02	15.40	119	0.00	0.00	0.00	4.
1.01	15.00	45	1.06	1.01	.05	2120.	1.02	16.00	120	0.00	0.00	0.00	4.
1.01	15.20	46	1.86	1.81	.05	2480.	1.02	16.20	121	0.00	0.00	0.00	4.
1.01	15.40	47	5.09	5.04	.05	4409.	1.02	16.40	122	0.00	0.00	0.00	3.
1.01	16.00	48	1.13	1.08	.05	5994.	1.02	17.00	123	0.00	0.00	0.00	3.

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1.01	16.20	49	.99	.94	.05	4677.	1.02	17.20	124	0.00	0.00	0.00	3.
1.01	16.40	50	.99	.94	.05	3176.	1.02	17.40	125	0.00	0.00	0.00	3.
1.01	17.00	51	.99	.94	.05	2561.	1.02	18.00	126	0.00	0.00	0.00	3.
1.01	17.20	52	.78	.73	.05	2195.	1.02	18.20	127	0.00	0.00	0.00	2.
1.01	17.40	53	.78	.73	.05	1900.	1.02	18.40	128	0.00	0.00	0.00	2.
1.01	18.00	54	.78	.73	.05	1726.	1.02	19.00	129	0.00	0.00	0.00	2.
1.01	18.20	55	.05	.00	.05	1369.	1.02	19.20	130	0.00	0.00	0.00	2.
1.01	18.40	56	.05	.00	.05	728.	1.02	19.40	131	0.00	0.00	0.00	2.
1.01	19.00	57	.05	.00	.05	310.	1.02	20.00	132	0.00	0.00	0.00	2.
1.01	19.20	58	.05	.00	.05	281.	1.02	20.20	133	0.00	0.00	0.00	2.
1.01	19.40	59	.05	.00	.05	262.	1.02	20.40	134	0.00	0.00	0.00	1.
1.01	20.00	60	.05	.00	.05	244.	1.02	21.00	135	0.00	0.00	0.00	1.
1.01	20.20	61	.05	.00	.05	228.	1.02	21.20	136	0.00	0.00	0.00	1.
1.01	20.40	62	.05	.00	.05	213.	1.02	21.40	137	0.00	0.00	0.00	1.
1.01	21.00	63	.05	.00	.05	199.	1.02	22.00	138	0.00	0.00	0.00	1.
1.01	21.20	64	.05	.00	.05	185.	1.02	22.20	139	0.00	0.00	0.00	1.
1.01	21.40	65	.05	.00	.05	173.	1.02	22.40	140	0.00	0.00	0.00	1.
1.01	22.00	66	.05	.00	.05	161.	1.02	23.00	141	0.00	0.00	0.00	1.
1.01	22.20	67	.05	.00	.05	150.	1.02	23.20	142	0.00	0.00	0.00	1.
1.01	22.40	68	.05	.00	.05	140.	1.02	23.40	143	0.00	0.00	0.00	1.
1.01	23.00	69	.05	.00	.05	131.	1.03	0.00	144	0.00	0.00	0.00	1.
1.01	23.20	70	.05	.00	.05	122.	1.03	.20	145	0.00	0.00	0.00	1.
1.01	23.40	71	.05	.00	.05	114.	1.03	.40	146	0.00	0.00	0.00	1.
1.02	0.00	72	.05	.00	.05	106.	1.03	1.00	147	0.00	0.00	0.00	1.
1.02	.20	73	0.00	0.00	0.00	99.	1.03	1.20	148	0.00	0.00	0.00	1.
1.02	.40	74	0.00	0.00	0.00	93.	1.03	1.40	149	0.00	0.00	0.00	1.
1.02	1.00	75	0.00	0.00	0.00	86.	1.03	2.00	150	0.00	0.00	0.00	0.
									SUM	24.82	21.01	3.81	49903.
										(630.)	(534.)	(97.)	(1413.10)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	5994.	2389.	689.	333.	49904.
CMS	170.	68.	20.	9.	1413.
INCHES		19.67	22.70	22.82	22.82
MM		499.55	576.60	579.71	579.71
AC-FT		1185.	1367.	1375.	1375.
THOUS CU M		1461.	1687.	1696.	1696.

COMBINE HYDROGRAPHS

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
	2	0	0	0	0	0	0	0

SUM OF 2 HYDROGRAPHS AT

7.	6.	6.	6.	5.	5.	5.	4.	4.	4.
3.	3.	3.	3.	3.	3.	2.	2.	2.	2.
2.	2.	2.	1.	1.	6.	36.	88.	123.	141.
152.	161.	168.	175.	181.	186.	422.	930.	1306.	1594.
1962.	2173.	2387.	2662.	2936.	3936.	6181.	8444.	7887.	6518.
5588.	4722.	4011.	3628.	3028.	2122.	1393.	1045.	969.	907.
832.	757.	678.	609.	501.	422.	363.	318.	286.	269.
252.	236.	221.	207.	194.	181.	170.	159.	149.	139.
130.	121.	113.	106.	99.	94.	89.	85.	80.	76.
72.	68.	65.	61.	58.	55.	52.	49.	46.	44.
41.	39.	37.	34.	32.	31.	29.	27.	26.	24.

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23.	21.	20.	19.	18.	17.	16.	15.	14.	13.
12.	11.	11.	10.	9.	9.	8.	8.	7.	7.
6.	6.	6.	5.	5.	5.	4.	4.	4.	4.
3.	3.	3.	3.	3.	2.	2.	2.	2.	2.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	8444.	3952.	1203.	583.	87414.
CMS	239.	112.	34.	17.	2475.
INCHES		18.38	22.37	22.59	22.59
MM		466.84	568.25	573.72	573.72
AC-FT		1959.	2385.	2408.	2408.
THOUS CU M		2417.	2942.	2970.	2970.

•••••••••• •••••••••• •••••••••• •••••••••• ••••••••••

HYDROGRAPH ROUTING

RESERVOIR ROUTING THROUGH HOOPES RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
OUT	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	0	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
0	0	0	0.000	0.000	0.000	-220.	0

SURFACE AREA=	192.	205.	230.
CAPACITY=	0.	1985.	4158.
ELEVATION=	220.	230.	240.

CREL	SPWID	COQW	EXPW	ELEVL	COOL	CAREA	EXPL
220.0	25.0	3.8	1.5	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
232.0	3.1	1.5	850.

END-OF-PERIOD HYDROGRAPH ORDINATES

MO.DA	HR.MN	PERIOD	HOURS	INFLOW	OUTFLOW	STORAGE	STAGE
1.01	.20	1	.33	7.	3.	19.	220.1
1.01	.40	2	.67	6.	3.	19.	220.1
1.01	1.00	3	1.00	6.	3.	19.	220.1
1.01	1.20	4	1.33	6.	3.	20.	220.1
1.01	1.40	5	1.67	5.	3.	20.	220.1
1.01	2.00	6	2.00	5.	3.	20.	220.1
1.01	2.20	7	2.33	5.	3.	20.	220.1
1.01	2.40	8	2.67	4.	3.	20.	220.1
1.01	3.00	9	3.00	4.	3.	20.	220.1
1.01	3.20	10	3.33	4.	3.	20.	220.1
1.01	3.40	11	3.67	3.	3.	20.	220.1
1.01	4.00	12	4.00	3.	3.	20.	220.1
1.01	4.20	13	4.33	3.	3.	20.	220.1
1.01	4.40	14	4.67	3.	3.	20.	220.1

1.01	5.00	15	5.00	3.	3.	20.	220.1
1.01	5.20	16	5.33	3.	3.	20.	220.1
1.01	5.40	17	5.67	2.	3.	20.	220.1
1.01	6.00	18	6.00	2.	3.	20.	220.1
1.01	6.20	19	6.33	2.	3.	20.	220.1
1.01	6.40	20	6.67	2.	3.	20.	220.1
1.01	7.00	21	7.00	2.	3.	20.	220.1
1.01	7.20	22	7.33	2.	3.	20.	220.1
1.01	7.40	23	7.67	2.	3.	20.	220.1
1.01	8.00	24	8.00	1.	3.	20.	220.1
1.01	8.20	25	8.33	1.	3.	19.	220.1
1.01	8.40	26	8.67	6.	3.	20.	220.1
1.01	9.00	27	9.00	36.	3.	20.	220.1
1.01	9.20	28	9.33	88.	4.	22.	220.1
1.01	9.40	29	9.67	123.	4.	24.	220.1
1.01	10.00	30	10.00	141.	5.	28.	220.1
1.01	10.20	31	10.33	152.	6.	32.	220.2
1.01	10.40	32	10.67	161.	8.	36.	220.2
1.01	11.00	33	11.00	168.	9.	40.	220.2
1.01	11.20	34	11.33	175.	11.	45.	220.2
1.01	11.40	35	11.67	181.	12.	49.	220.3
1.01	12.00	36	12.00	186.	14.	54.	220.3
1.01	12.20	37	12.33	422.	17.	62.	220.3
1.01	12.40	38	12.67	930.	25.	80.	220.4
1.01	13.00	39	13.00	1306.	41.	110.	220.6
1.01	13.20	40	13.33	1594.	64.	148.	220.8
1.01	13.40	41	13.67	1962.	97.	195.	221.0
1.01	14.00	42	14.00	2173.	139.	249.	221.3
1.01	14.20	43	14.33	2387.	191.	307.	221.6
1.01	14.40	44	14.67	2662.	252.	370.	221.9
1.01	15.00	45	15.00	2936.	325.	440.	222.3
1.01	15.20	46	15.33	3936.	423.	524.	222.7
1.01	15.40	47	15.67	6181.	581.	649.	223.3
1.01	16.00	48	16.00	8444.	838.	831.	224.3
1.01	16.20	49	16.33	7887.	1148.	1029.	225.3
1.01	16.40	50	16.67	6518.	1426.	1192.	226.1
1.01	17.00	51	17.00	5588.	1649.	1316.	226.7
1.01	17.20	52	17.33	4722.	1825.	1410.	227.2
1.01	17.40	53	17.67	4011.	1956.	1479.	227.5
1.01	18.00	54	18.00	3628.	2053.	1529.	227.8
1.01	18.20	55	18.33	3028.	2121.	1563.	227.9
1.01	18.40	56	18.67	2122.	2145.	1575.	228.0
1.01	19.00	57	19.00	1393.	2124.	1565.	227.9
1.01	19.20	58	19.33	1045.	2076.	1540.	227.8
1.01	19.40	59	19.67	969.	2020.	1512.	227.7
1.01	20.00	60	20.00	907.	1964.	1483.	227.5
1.01	20.20	61	20.33	832.	1907.	1453.	227.4
1.01	20.40	62	20.67	757.	1850.	1423.	227.2
1.01	21.00	63	21.00	678.	1792.	1393.	227.1
1.01	21.20	64	21.33	609.	1734.	1362.	226.9
1.01	21.40	65	21.67	501.	1675.	1330.	226.8
1.01	22.00	66	22.00	422.	1616.	1298.	226.6
1.01	22.20	67	22.33	363.	1556.	1265.	226.4
1.01	22.40	68	22.67	318.	1497.	1232.	226.3
1.01	23.00	69	23.00	286.	1440.	1200.	226.1
1.01	23.20	70	23.33	269.	1385.	1169.	226.0
1.01	23.40	71	23.67	252.	1333.	1139.	225.8
1.02	0.00	72	24.00	236.	1283.	1109.	225.7
1.02	.20	73	24.33	221.	1235.	1081.	225.5
1.02	.40	74	24.67	207.	1189.	1053.	225.4
1.02	1.00	75	25.00	194.	1145.	1027.	225.3
1.02	1.20	76	25.33	181.	1103.	1001.	225.1

1.02	1.40	77	25.67	170.	1062.	976.	225.0
1.02	2.00	78	26.00	159.	1024.	952.	224.9
1.02	2.20	79	26.33	149.	987.	928.	224.8
1.02	2.40	80	26.67	139.	951.	906.	224.6
1.02	3.00	81	27.00	130.	917.	884.	224.5
1.02	3.20	82	27.33	121.	885.	862.	224.4
1.02	3.40	83	27.67	113.	853.	842.	224.3
1.02	4.00	84	28.00	106.	823.	822.	224.2
1.02	4.20	85	28.33	99.	795.	802.	224.1
1.02	4.40	86	28.67	94.	767.	783.	224.0
1.02	5.00	87	29.00	89.	741.	765.	223.9
1.02	5.20	88	29.33	85.	716.	747.	223.8
1.02	5.40	89	29.67	80.	692.	730.	223.8
1.02	6.00	90	30.00	76.	668.	714.	223.7
1.02	6.20	91	30.33	72.	646.	698.	223.6
1.02	6.40	92	30.67	68.	625.	682.	223.5
1.02	7.00	93	31.00	65.	605.	667.	223.4
1.02	7.20	94	31.33	61.	585.	652.	223.4
1.02	7.40	95	31.67	58.	566.	638.	223.3
1.02	8.00	96	32.00	55.	548.	624.	223.2
1.02	8.20	97	32.33	52.	531.	611.	223.1
1.02	8.40	98	32.67	49.	514.	598.	223.1
1.02	9.00	99	33.00	46.	498.	585.	223.0
1.02	9.20	100	33.33	44.	483.	573.	223.0
1.02	9.40	101	33.67	41.	468.	561.	222.9
1.02	10.00	102	34.00	39.	453.	549.	222.8
1.02	10.20	103	34.33	37.	440.	538.	222.8
1.02	10.40	104	34.67	34.	426.	527.	222.7
1.02	11.00	105	35.00	32.	414.	517.	222.7
1.02	11.20	106	35.33	31.	401.	506.	222.6
1.02	11.40	107	35.67	29.	390.	496.	222.6
1.02	12.00	108	36.00	27.	378.	486.	222.5
1.02	12.20	109	36.33	26.	367.	477.	222.5
1.02	12.40	110	36.67	24.	357.	467.	222.4
1.02	13.00	111	37.00	23.	346.	458.	222.4
1.02	13.20	112	37.33	21.	337.	450.	222.3
1.02	13.40	113	37.67	20.	327.	441.	222.3
1.02	14.00	114	38.00	19.	318.	433.	222.2
1.02	14.20	115	38.33	18.	309.	425.	222.2
1.02	14.40	116	38.67	17.	300.	417.	222.2
1.02	15.00	117	39.00	16.	292.	409.	222.1
1.02	15.20	118	39.33	15.	284.	401.	222.1
1.02	15.40	119	39.67	14.	277.	394.	222.0
1.02	16.00	120	40.00	13.	269.	387.	222.0
1.02	16.20	121	40.33	12.	262.	380.	222.0
1.02	16.40	122	40.67	11.	255.	373.	221.9
1.02	17.00	123	41.00	11.	248.	367.	221.9
1.02	17.20	124	41.33	10.	242.	360.	221.9
1.02	17.40	125	41.67	9.	235.	354.	221.8
1.02	18.00	126	42.00	9.	229.	348.	221.8
1.02	18.20	127	42.33	8.	224.	342.	221.8
1.02	18.40	128	42.67	8.	218.	336.	221.7
1.02	19.00	129	43.00	7.	212.	330.	221.7
1.02	19.20	130	43.33	7.	207.	324.	221.7
1.02	19.40	131	43.67	6.	202.	319.	221.7
1.02	20.00	132	44.00	6.	197.	314.	221.6
1.02	20.20	133	44.33	6.	192.	309.	221.6
1.02	20.40	134	44.67	5.	187.	303.	221.6
1.02	21.00	135	45.00	5.	183.	299.	221.5
1.02	21.20	136	45.33	5.	178.	294.	221.5
1.02	21.40	137	45.67	4.	174.	289.	221.5
1.02	22.00	138	46.00	4.	170.	284.	221.5

Sk 17

1.02	22.20	139	46.33	4.	166.	280.	221.5
1.02	22.40	140	46.67	4.	162.	275.	221.4
1.02	23.00	141	47.00	3.	158.	271.	221.4
1.02	23.20	142	47.33	3.	155.	267.	221.4
1.02	23.40	143	47.67	3.	151.	263.	221.4
1.03	0.00	144	48.00	3.	148.	259.	221.3
1.03	.20	145	48.33	3.	144.	255.	221.3
1.03	.40	146	48.67	2.	141.	251.	221.3
1.03	1.00	147	49.00	2.	138.	247.	221.3
1.03	1.20	148	49.33	2.	135.	243.	221.3
1.03	1.40	149	49.67	2.	132.	240.	221.2
1.03	2.00	150	50.00	2.	129.	236.	221.2

PEAK OUTFLOW IS 2145. AT TIME 18.67 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2145.	1863.	999.	530.	79539.
CMS	61.	53.	28.	15.	2252.
INCHES		8.66	18.58	20.55	20.55
MM		220.04	471.96	522.04	522.04
AC-FT		924.	1981.	2191.	2191.
THOUS CU M		1139.	2443.	2703.	2703.

•••••••••• •••••••••• •••••••••• •••••••••• ••••••••••

Sh 18

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

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	SUB1	3341.	1784.	518.	250.	.87
		(94.61)	(50.51)	(14.66)	(7.07)	(2.25)
ROUTED TO	SUBRTE	3342.	1675.	514.	250.	.87
		(94.62)	(47.43)	(14.57)	(7.08)	(2.25)
HYDROGRAPH AT	IN	5996.	2389.	689.	333.	1.13
		(169.73)	(67.65)	(19.52)	(9.42)	(2.93)
2-COMBINED		8444.	3952.	1203.	583.	2.00
		(239.11)	(111.90)	(34.05)	(16.50)	(5.18)
ROUTED TO	OUT	2145.	1863.	999.	530.	2.00
		(60.74)	(52.74)	(28.28)	(15.02)	(5.18)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	222.10	222.00	228.00
STORAGE	2.	0.	115.
OUTFLOW	6.	0.	735.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.00	229.50	1.50	145.	3342.	4.67	16.67	0.00

Sh 20

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	220.10	220.00	232.00
STORAGE	19.	0.	2400.
OUTFLOW	3.	0.	3949.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.00	227.99	0.00	1575.	2145.	0.00	18.67	0.00

84 21

APPENDIX

D

Photographs

UPSTREAM FACE OF THE DAM SHOWING THE INTAKE-OUTLET STRUCTURE AND THE SPILLWAY 5/24/79

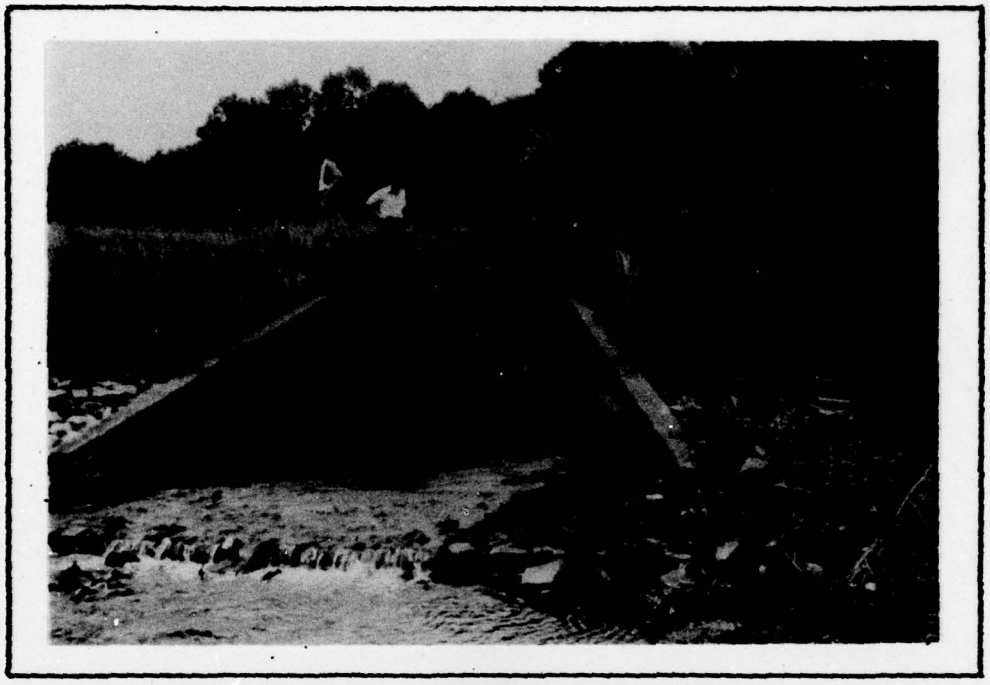
THE TOP OF THE DAM AS VIEWED FROM THE LEFT ABUTMENT 5/24/79

DOWNSTREAM VIEW OF THE DAM AS SEEN FROM THE PUMP HOUSE ABOUT 300 FEET DOWNSTREAM OF THE DAM
5/24/79

VIEW OF THE DOWNSTREAM FACE OF THE DAM SHOWING THE POST-TENSIONING HOLE DRILL RIGS

TYPICAL LEAKAGE FROM THE DOWNSTREAM FACE OF THE DAM BETWEEN THE SPILLWAY AND THE LEFT ABUTMENT 5/24/79

SEEPAGE FROM THE LEFT ABUTMENT DOWNSTREAM OF THE DAM 5/24/79



LEFT DOUBLE-BOX CONCRETE CULVERT BUILT THROUGH THE CAUSEWAY CROSSING HOOPES RESERVOIR ABOUT TWO MILES UPSTREAM OF THE DAM 5/24/79

RIGHT DOUBLE-BOX CONCRETE CULVERT BUILT THROUGH THE CAUSEWAY CROSSING HOOPES RESERVOIR ABOUT TWO MILES UPSTREAM OF THE DAM 5/24/79

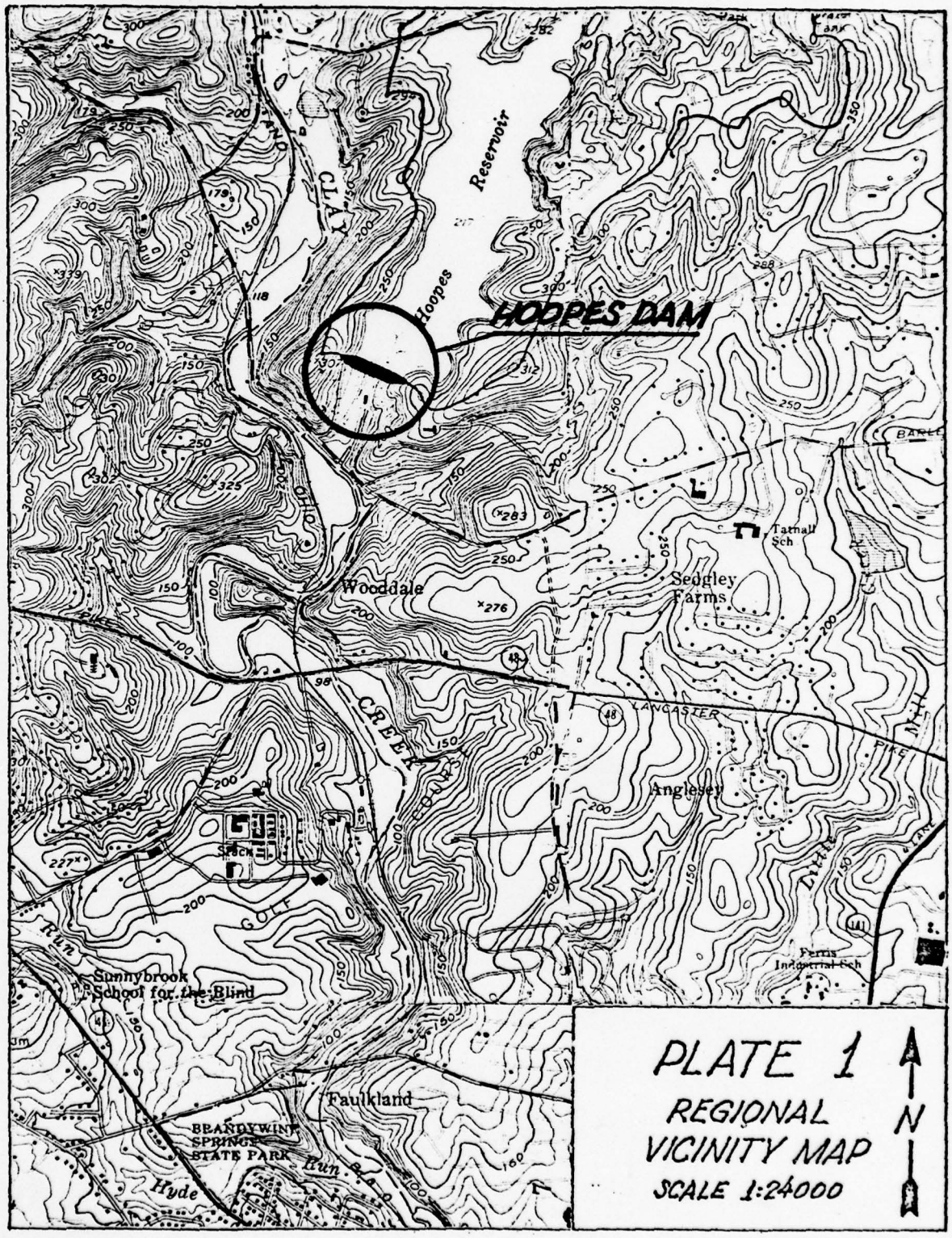
APPENDIX

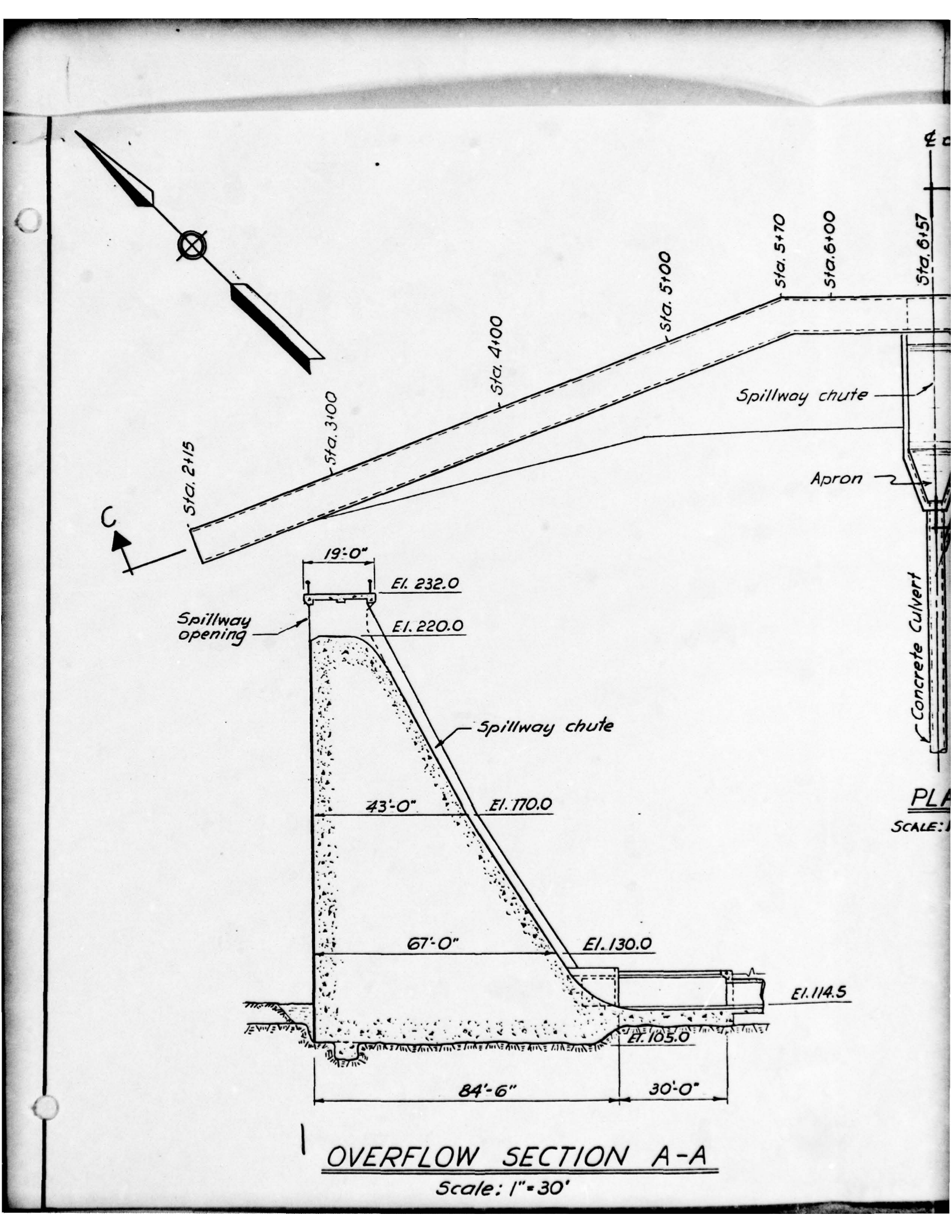
E

Drawings

TABLE OF CONTENTS-APPENDIX E

REGIONAL VICINITY MAP	PLATE 1
PLAN & SECTIONS	PLATE 2
LONGITUDINAL SECTION	PLATE 3
DAM STABILITY - NORMAL POOL	PLATE 4
DAM STABILITY - 100 YEAR FLOOD	PLATE 5
DAM STABILITY - NORMAL POOL & EARTHQUAKE	PLATE 6
DAM STABILITY - PROBABLE MAXIMUM FLOOD	PLATE 7


HOOPES DAM
Hoopes
Reservoir
CLAY
Wooddale
Seagley
Farms
Tatnall
Sch
Anglesey
CREEK
LANCASTER
PIKE
Run
Sunnybrook
School for the Blind
Faulkland
BRANDYWINE
SPRINGS
STATE PARK
Run
Hyde
Ferris
Industrial Sch
PLATE 1
REGIONAL
VICINITY MAP
SCALE 1:24000
N

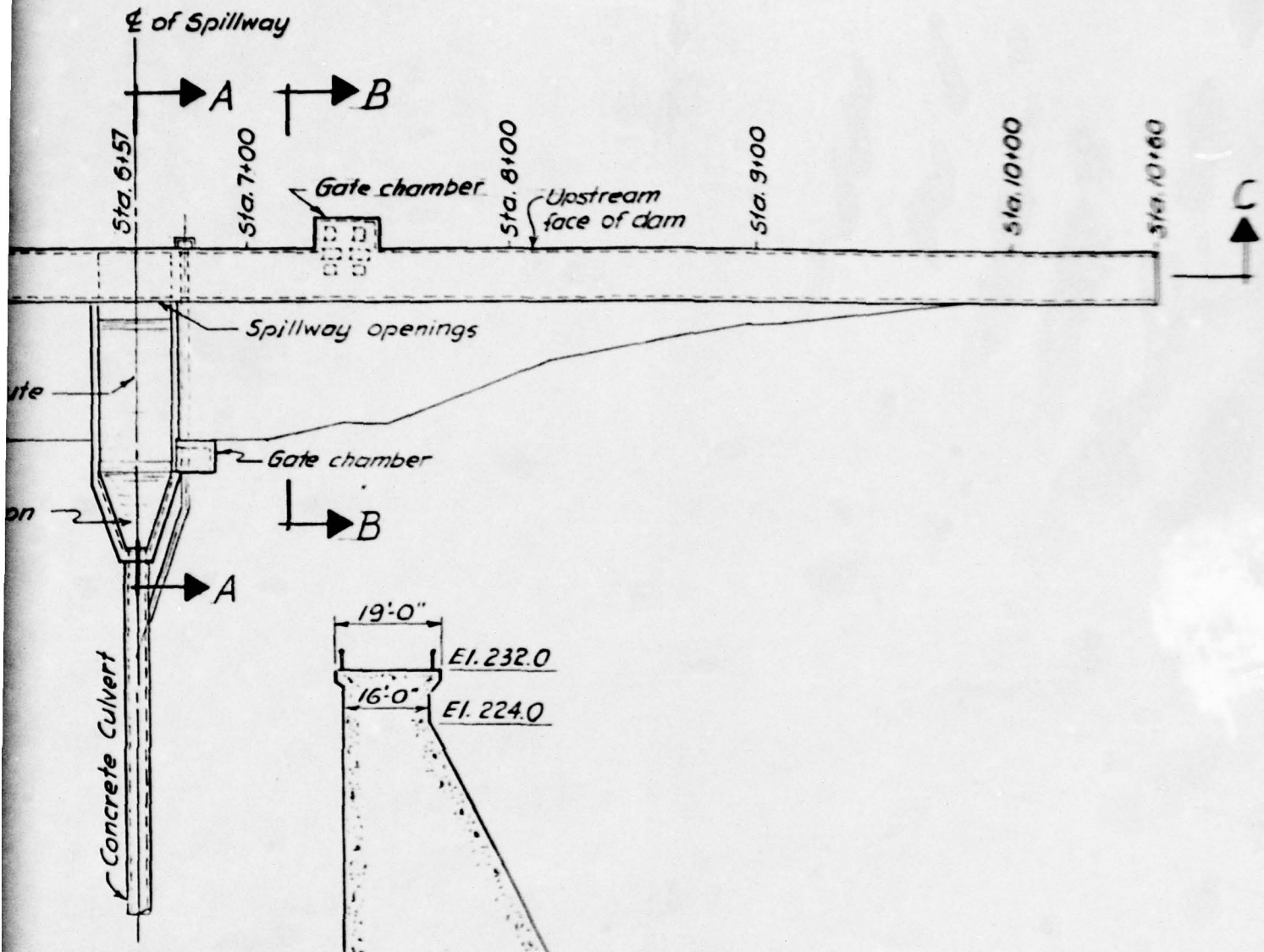


PLA

SCALE:

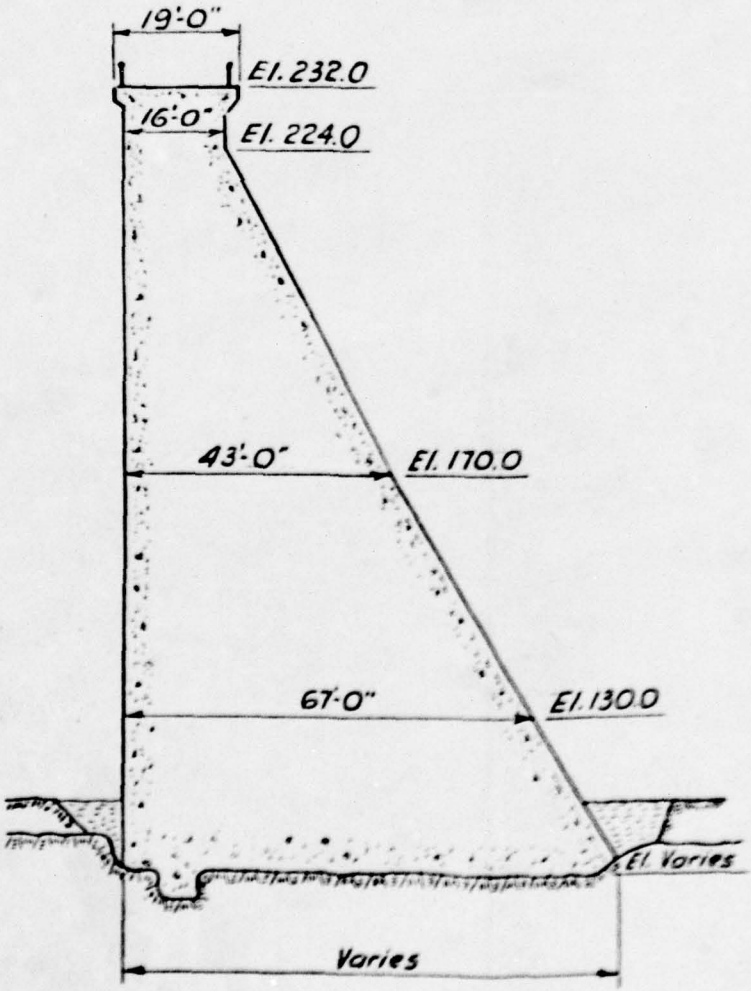
OVERFLOW SECTION A-A

Scale: 1" = 30'



PLAN

SCALE: 1" = 60'



NON-OVERFLOW SECTION B-B

Scale: 1" = 30'

PLATE 2

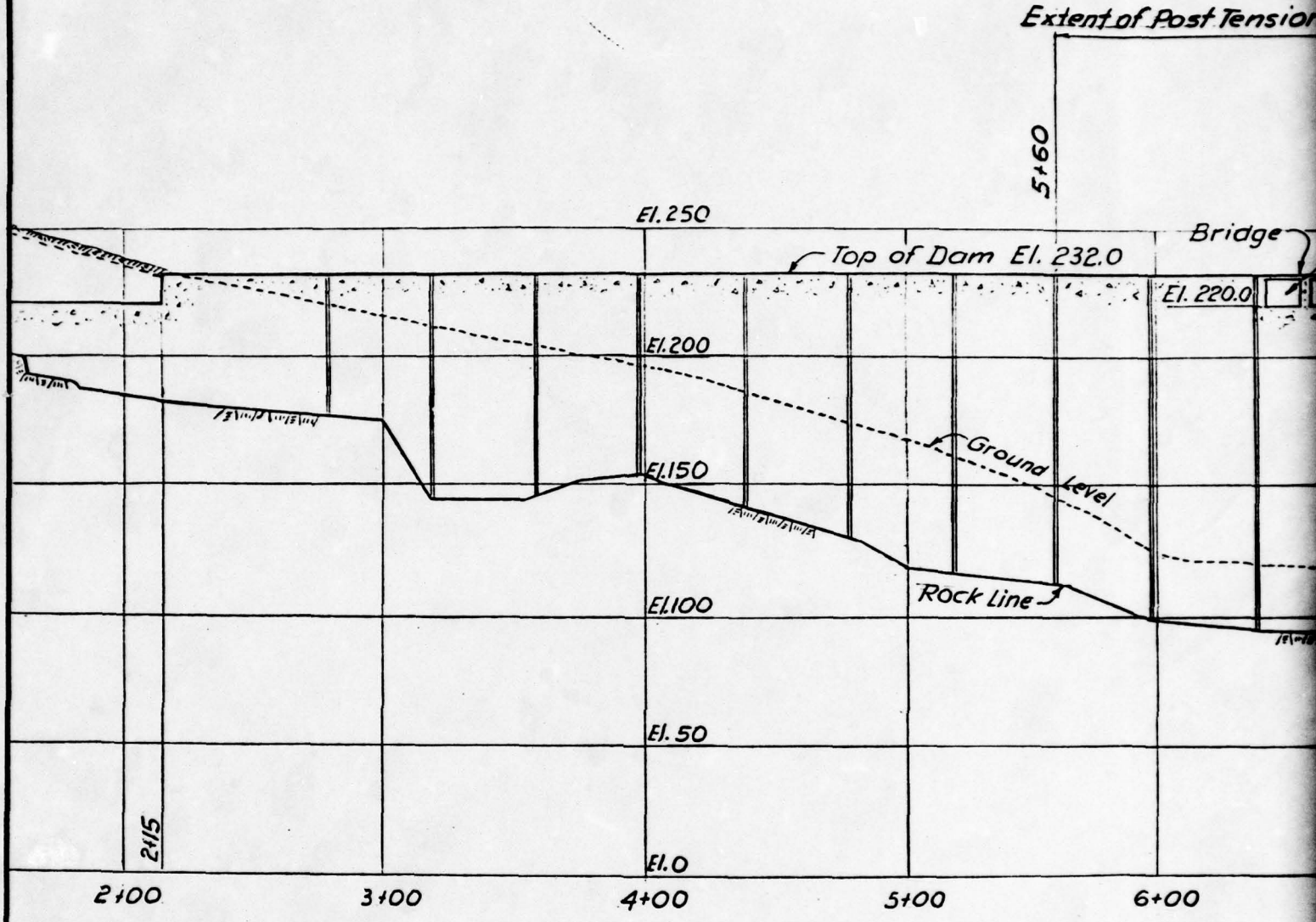
JUSTIN & COURTNEY

CONSULTING ENGINEERS

HOOPES DAM

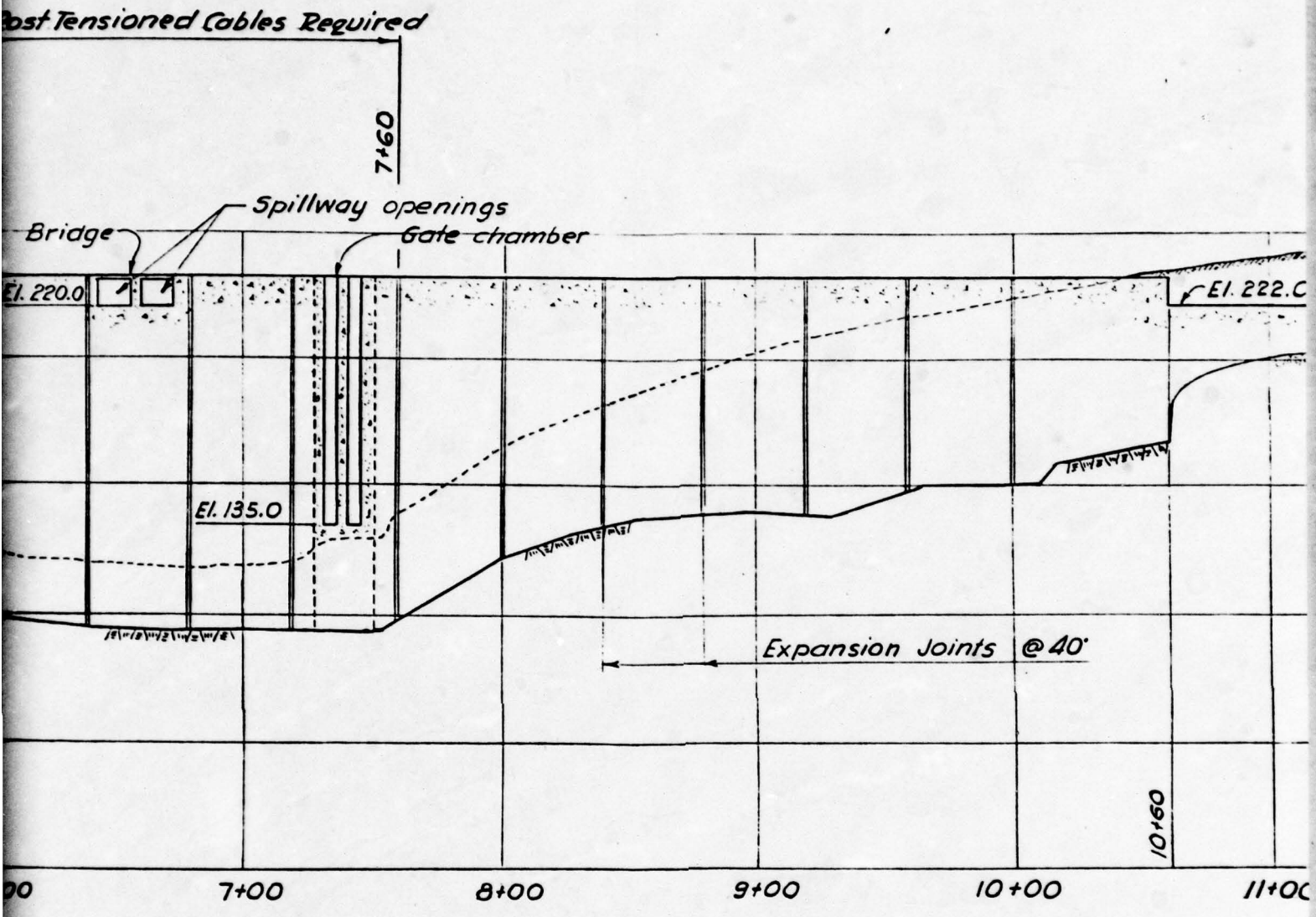
PLAN & SECTIONS

SCALE: AS NOTED	FIGURE
DATE: MARCH 1977	
DESIGNED BY: L.D.H.	
DRAWN BY: M.P.	



LONGITUDINAL

SCALE: 1"



IDINAL SECTION C-C

SCALE: 1"=60'

2

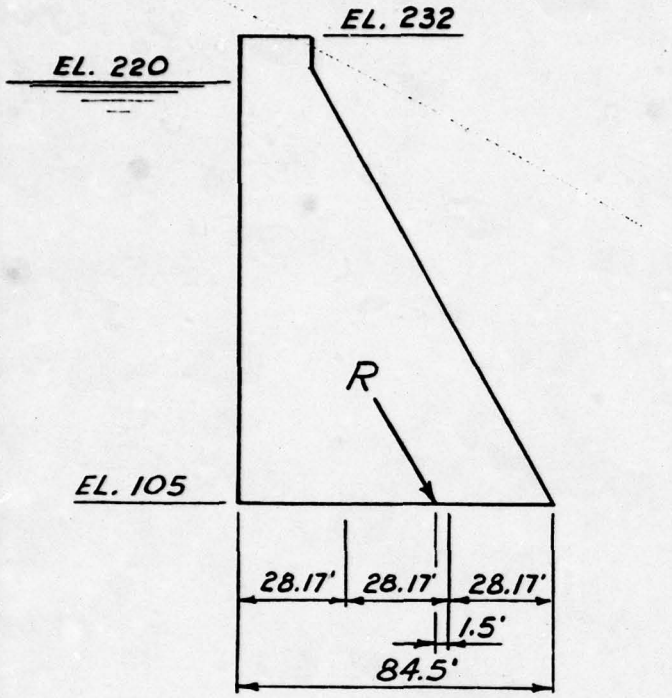
PLATE 3

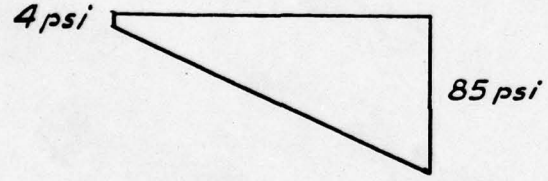
JUSTIN & COURTNEY
DIVISION OF O'BRIEN & GERE ENGINEERS

HOOPES DAM

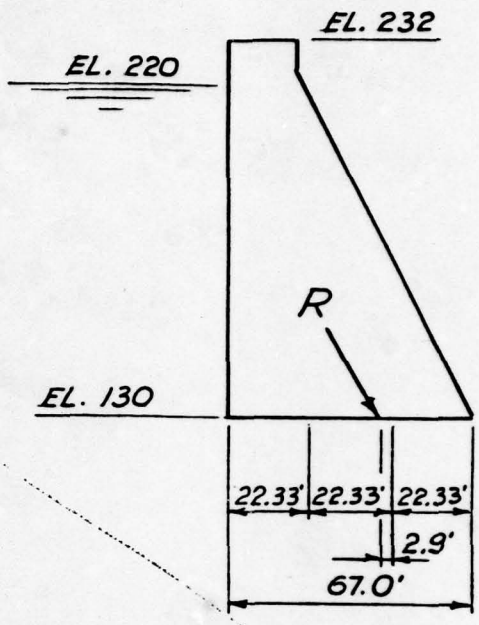
LONGITUDINAL SECTION

SCALE: 1" = 60'	FIGURE
DATE: MARCH 1977	
DESIGNED BY: L.D.H.	
DRAWN BY: M.P.	



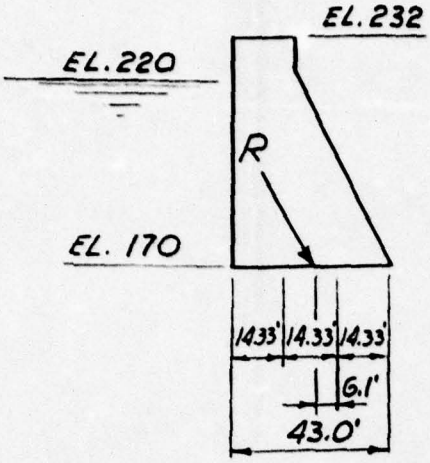


BASE PRESSURE DIAGRAM
@ ELEVATION 105

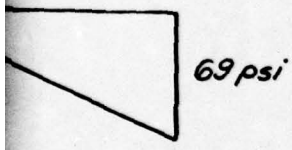


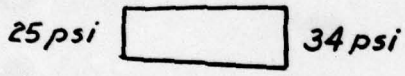
BASE PRESSURE DIAGRAM
@ ELEVATION 130

CONDITION A - NORMAL PO



NOTE:
R = RESULTANT OF FORCES





SSURE DIAGRAM
TION 130

BASE PRESSURE DIAGRAM
@ ELEVATION 170

2

A - NORMAL POOL

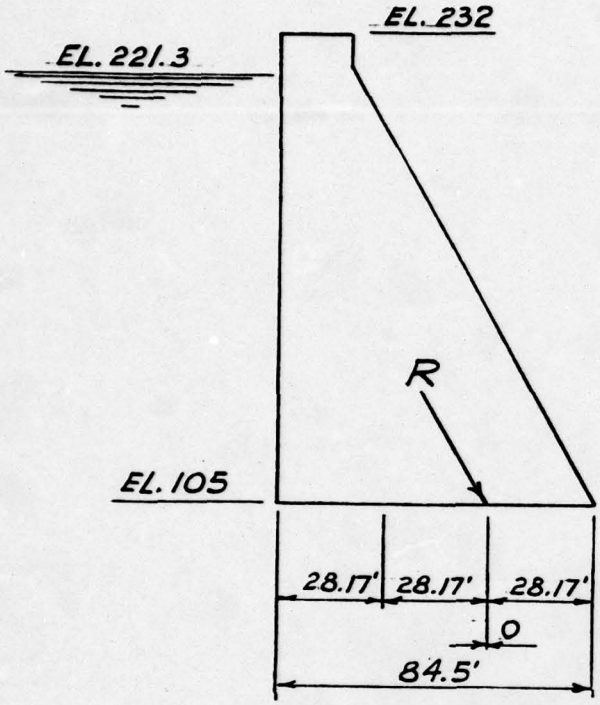
PLATE 4

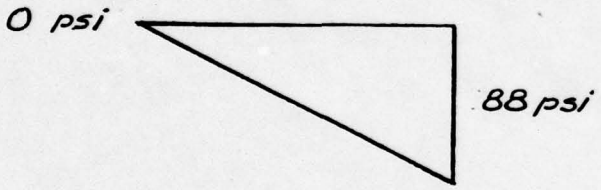
JUSTIN & COURTNEY
DIVISION OF O'BRIEN & GERE ENGINEERS

HOOPES DAM

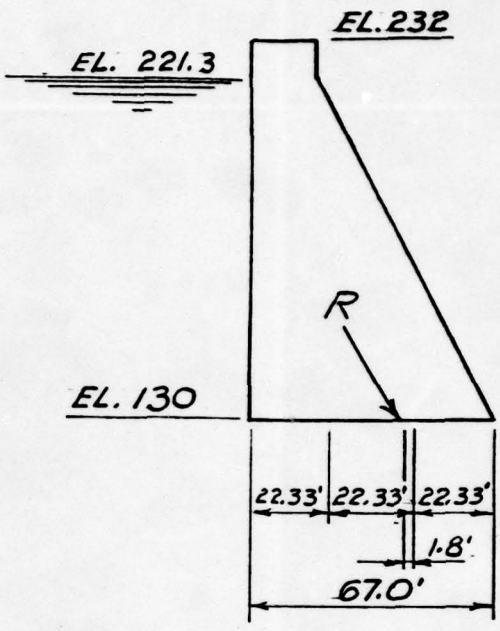
DAM STABILITY & BASE PRESSURES

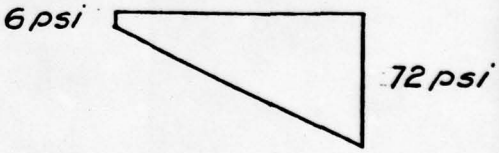
SCALE: 1" = 50'	FIGURE
DATE: MARCH 1977	
DESIGNED BY: L. D. H.	
DRAWN BY: M. P.	





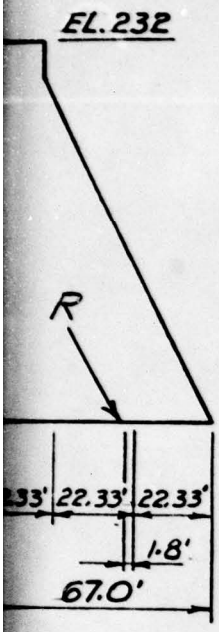
BASE PRESSURE DIAGRAM
@ ELEVATION 105

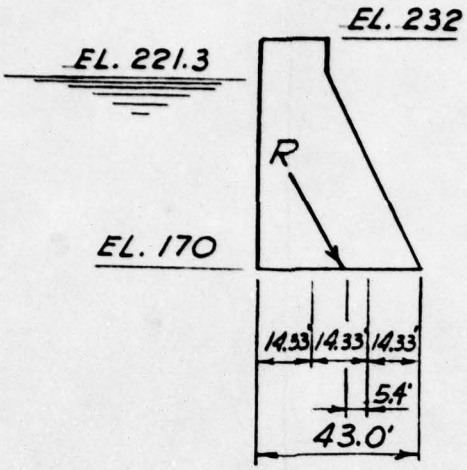




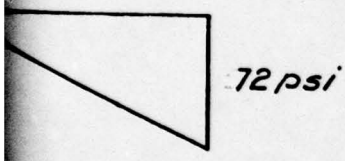
BASE PRESSURE DIAGRAM
@ ELEVATION 130

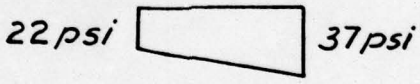
CONDITION B - 100 YEAR F





NOTE:
R = RESULTANT OF FORCES





RESSURE DIAGRAM
LEVATION 130

BASE PRESSURE DIAGRAM
@ ELEVATION 170

2

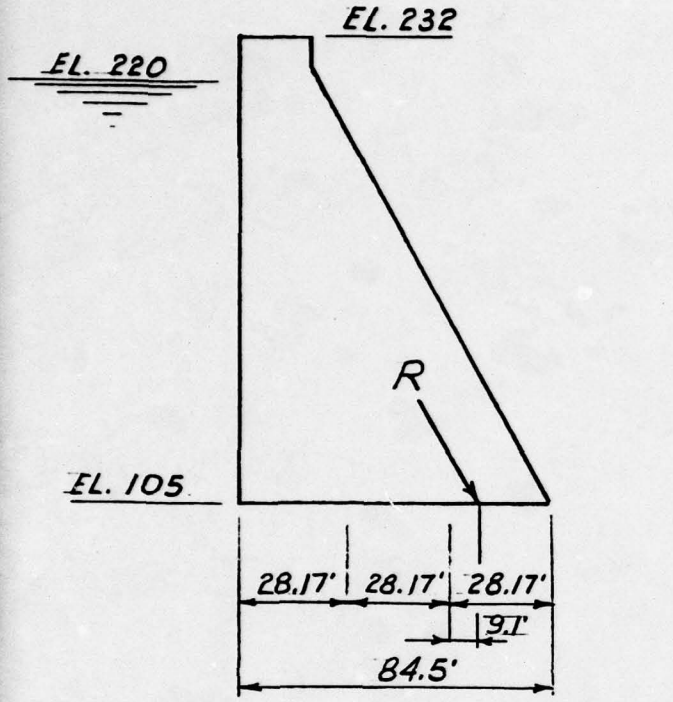
3 - 100 YEAR FLOOD

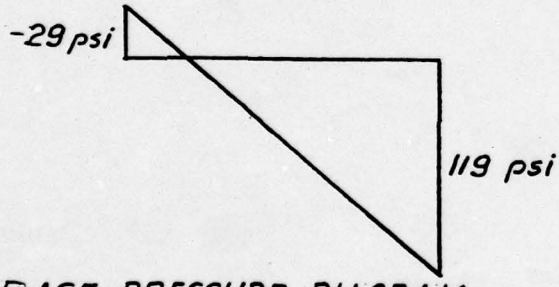
PLATE 5

JUSTIN & COURTNEY
DIVISION OF O'BRIEN & GERE ENGINEERS

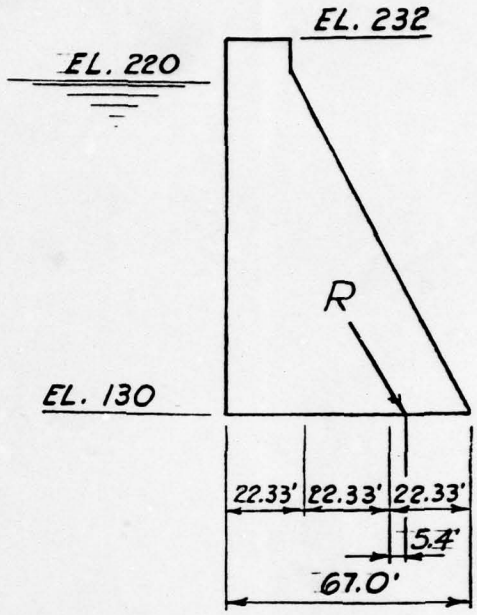
HOOPES DAM
DAM STABILITY
&
BASE PRESSURES

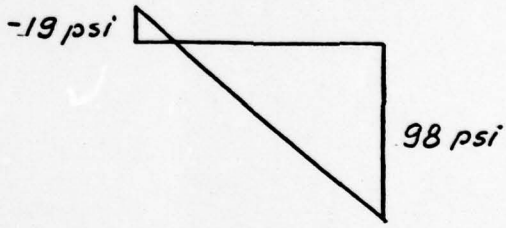
SCALE: 1" = 50'	FIGURE
DATE: MARCH 1977	
DESIGNED BY: L.D.H.	
DRAWN BY: M.P.	





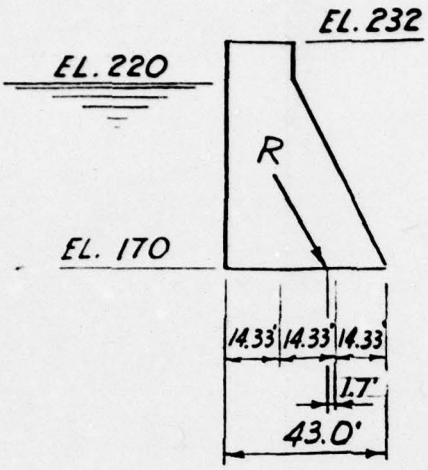
BASE PRESSURE DIAGRAM
@ ELEVATION 105



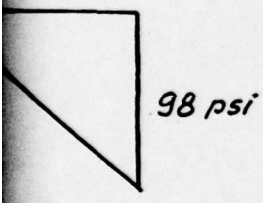


BASE PRESSURE DIAGRAM
@ ELEVATION 130

CONDITION C - NORMAL POOL + EARTH



NOTE:
R = RESULTANT OF FORCES



URE DIAGRAM
ON 130

BASE PRESSURE DIAGRAM
@ ELEVATION 170

2

L POOL + EARTHQUAKE

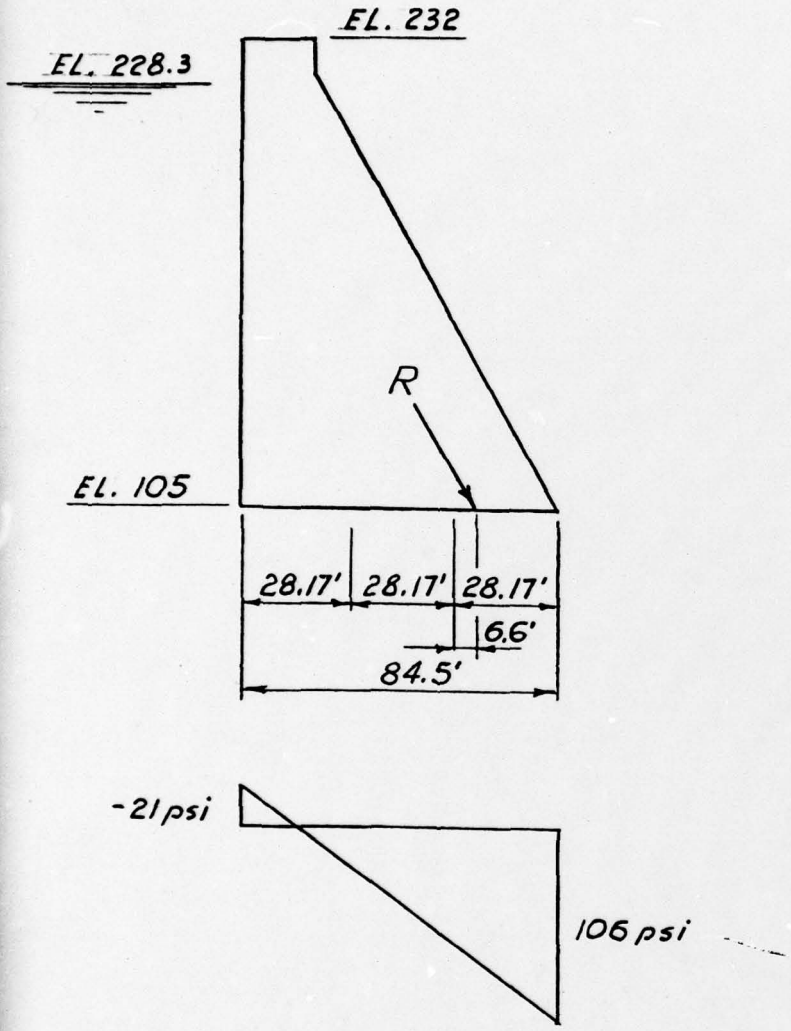
PLATE 6

JUSTIN & COURTNEY
DIVISION OF O'BRIEN & GERE ENGINEERS

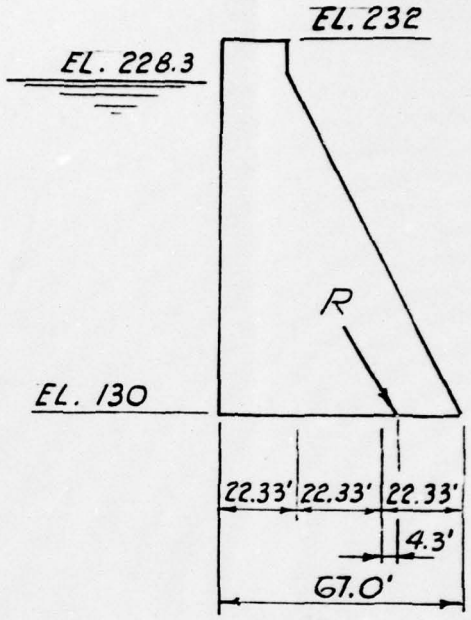
HOOPES DAM

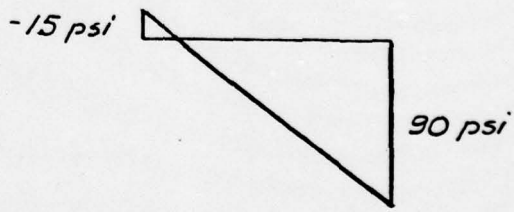
DAM STABILITY & BASE PRESSURES

SCALE: 1" = 50'	FIGURE
DATE: MARCH 1977	
DESIGNED BY: L.D.H.	
DRAWN BY: M.P.	



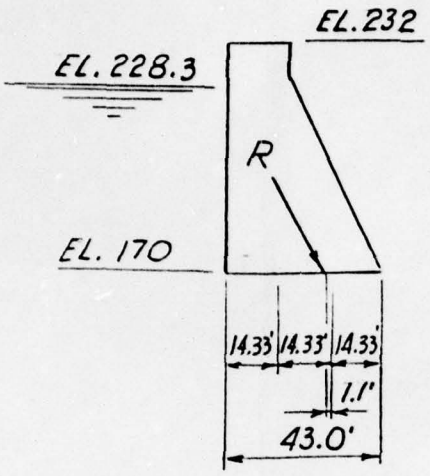
BASE PRESSURE DIAGRAM
@ ELEVATION 105



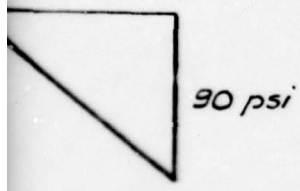


BASE PRESSURE DIAGRAM
@ ELEVATION 130

CONDITION D - PROBABLE MAXIMUM



NOTE:
R = RESULTANT OF FORCES



SURE DIAGRAM
ION 130

BASE PRESSURE DIAGRAM
@ ELEVATION 170

2

MAXIMUM FLOOD

PLATE 7

JUSTIN & COURTNEY
DIVISION OF O'BRIEN & GERE ENGINEERS

HOOPES DAM

DAM STABILITY & BASE PRESSURES

SCALE: 1" = 50'	FIGURE
DATE: MARCH 1977	
DESIGNED BY: L.D.H.	
DRAWN BY: M.P.	

APPENDIX

F

Site Geology

SITE GEOLOGY

EDGAR M. HOOPES DAM

Hoopes Dam is located in the Upland section of the Piedmont Physiographic province. Foundation bedrock at the dam site consists of foliated schists and gneisses comprising the Paleozoic Wissahickon formation. According to a study performed by Dr. Allan M. Thompson for O'Brien & Gere Engineers, Inc., the dam straddles the contact between gneissic rocks to the west and pelitic schists to the east. In his report, Dr. Thompson concludes that the contact is probably not a fault, but one of a number of fracture zones which comprise a lineament observed on satellite photos and confirmed by an aeromagnetic survey. Dr. Thompson further stated that groundwater flow through the shear zone may cause preferential weathering of the bedrock beneath the dam. The seepage noted during the visual inspection on the east abutment below the dam may, therefore, be reservoir water traveling beneath the dam through this fracture zone.

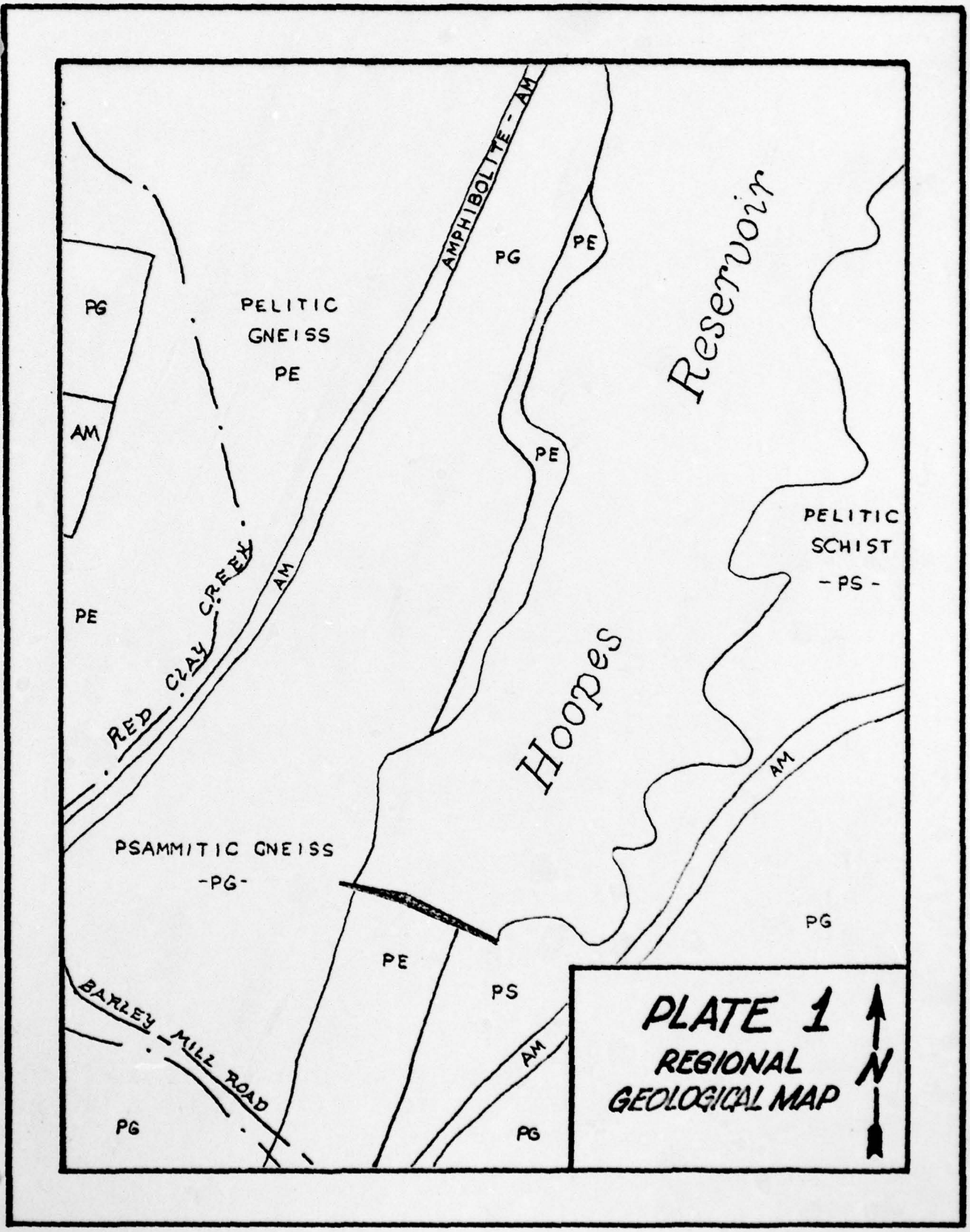

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PLATE 1
REGIONAL
GEOLOGICAL MAP
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APPENDIX G

PREVIOUS INVESTIGATIONS AND REPORTS

INVESTIGATION

OF

EDGAR M. HOOPES DAM

CITY OF WILMINGTON

DEPARTMENT OF PUBLIC WORKS

SEPTEMBER 1977

JUSTIN & COURTNEY, INC.
Division of O'Brien & Gere Engineers

INVESTIGATION OF HOOPES DAM

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APPENDIX

FIGURES

FIGURE 1- LOCATION PLAN

FIGURE 2- PLAN & SECTIONS

FIGURE 3- LONGITUDINAL SECTION

FIGURE 4- HYDROGRAPHS

FIGURE 5- DAM STABILITY AND BASE PRESSURES

FIGURE 6- DAM STABILITY AND BASE PRESSURES

FIGURE 7- DAM STABILITY AND BASE PRESSURES

FIGURE 8- DAM STABILITY AND BASE PRESSURES

GEOLOGIC REPORT

FIELD SAMPLING AND LABORATORY TESTING OF CONCRETE

I. INTRODUCTION

The Department of Public Works of the City of Wilmington, Delaware retained Justin and Courtney, Inc. by contract dated December 3, 1976 to investigate the condition of Hoopes dam, a 127 foot high concrete gravity dam west of the city of Wilmington, to determine if there are any deficiencies or potential deficiencies in the dam. This report presents the results of these investigations, which included: a review of existing drawings of the dam, an underwater inspection of the upstream face of the dam, a program of drilling and sampling of the concrete in the dam and the foundation rock, laboratory testing of concrete core samples, a seismic and geologic study of the area, a hydrologic study of the watershed, and an analysis of the structural stability of the dam. The underwater inspection was done by Walker Diving Company of Laurel Springs, New Jersey. The boring work was done by Law Engineering Testing Company of McLean, Virginia and Sprague and Henwood, Inc. of Bridgeport, New Jersey. Laboratory testing of concrete core samples was done by Law Engineering Testing Co.. The detailed seismic and geologic study was done by Dr. Allan M. Thompson of the University of Delaware.

II. PROJECT DESCRIPTION

Edgar M. Hoopes dam is located on Old Mill Stream about four miles northwest of the City of Wilmington, Delaware, as shown on Figure 1. The capacity of the reservoir is about two billion gallons and the reservoir covers an area of about 200 acres at the spillway level. The reservoir stores runoff from the two square mile drainage area upstream of the dam and water which is pumped into the reservoir from Brandywine Creek. The water from Hoopes reservoir is released into the City of Wilmington's water system for treatment and distribution.

The dam is a concrete structure 127 feet high and 845 feet long which was built by the City of Wilmington in 1929. A plan and cross-sections of the dam are shown on Figures 2 and 3. The dam has a vertical upstream face and an average downstream slope of about 0.6 foot horizontal to one foot vertical. Control of the flow out of the reservoir is accomplished by gates located in a gate chamber near the center of the dam. A pumping station is located 300 feet downstream of the dam, with a 36 inch steel pipe connecting the dam and the pumping station.

The spillway consists of two openings near the center of the dam, each 12.5 feet wide by 9.5 feet high. The spillway discharge flows into a chute on the downstream face of the dam and then into a 6 foot by 6 foot box culvert 500 feet long, which discharges into the Old Mill Stream which flows into Red Clay Creek. From Red Clay Creek, the water flows into White Clay Creek, the Christiana River through Wilmington, and into the Delaware River.

Hoopes dam is in the large size category and has a high hazard potential. The hazard potential classification pertains to the "potential loss of human life or property damage in the area downstream of the dam in the event of failure or misoperation of the dam or appurtenant facilities".[1] The high hazard potential category covers those structures where many lives would be lost and extensive damage would result from failure or misoperation of the dam. Placing Hoopes dam in the high hazard potential category says nothing about the possibility of the dam failing, but only describes the consequences of failure should it occur. The potential loss of human life or property damage in the event of a failure of Hoopes dam is high. Therefore, conservative design criteria should be used to evaluate the dam. The design criteria used for the analysis of the dam described in this report are commensurate with the size and hazard potential classifications for Hoopes dam.

[1] Recommended Guidelines for Safety Inspection of Dams, Dept. of Army, Office of the Chief of Engineers, Washington, D.C.

III. HYDROLOGY

Since Hoopes dam has a small drainage area, rainfall on the watershed will produce relatively small flood discharges. However, since Hoopes dam is a large dam with a high hazard potential, the Recommended Guidelines for Safety Inspection of Dams states that the dam should be able to pass the flood produced by the Probable Maximum Flood (PMF) without endangering the dam. The Probable Maximum Flood is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is derived from Probable Maximum Precipitation (PMP), which is available from the National Weather Service.

The PMF at Hoopes dam has a peak discharge of 13,800 cubic feet per second (cfs). The peak outflow over the spillway after this flood has been routed through the reservoir, is 2,000 cfs, assuming that the reservoir is at the spillway crest at the beginning of the storm. It is seen from the large reduction in peak discharge that most of the inflow is stored in the reservoir during the period of high inflow. The inflow and outflow hydrographs are shown on Figure 4.

The spillway crest elevation is 220 and the elevation of the top of the dam is 232. The maximum reservoir elevation produced by the PMF is 228.3. Since the PMF can be passed over the spillway without overtopping the dam, it is concluded that the spillway for Hoopes dam is hydraulically adequate. The PMF would still damage downstream facilities, but the reservoir storage would reduce the flood peak and downstream damages.

IV. GEOLOGY AND SEISMIC POTENTIAL

The geologic environment and seismic potential of Hoopes dam has been studied in detail by Dr. Allan Thompson of the University of Delaware. A copy of his report is included in the appendix. This study was initiated because of the discovery on a land satellite photograph of a lineament or straight line on the ground running through Hoopes dam and reservoir. Due to the scale of the satellite photo, this "line" on the photograph is actuall a zone 200 to 300 yards wide on the ground. The appearance of this lineament suggested the possible existence of a fault or some other anomalous geologic condition near the dam. Since earthquakes have occurred recently in Delaware and since an active fault at this location could have serious consequences with respect to the dam, it was essential to determine whether or not this lineament represents a threat to the safety of the dam. The geologic study was undertaken to make this determination and to investigate any other geolog conditions which would affect the dam.

A number of faults and fractures in the rock in the vicinity of the dam were found or postulated. Two major faults which were formed during the metamorphic alteration of the rock were discovered, but they show no evidence of movement since the rock has hardened. Other faults were inferred from aeromagnetic and air photo analysis or were noted during the rock boring program. However, no evidence was uncovered which indicates that any of the faults are active or should be cause for concern regarding the safety of the dam. No fault or faults were discovered in the exact location and direction of the lineament, although the rock in this area contains many fractures. It is therefore concluded that the lineament is a zone of fractures rather than a fault.

A fracture zone was encountered in the rock at a depth of 55 feet in the borehole drilled in the east abutment of the dam. (Logs of the borings are included in the geological report in the appendix). This is of special interest because of the leakage which appears downstream of the dam on the east abutment. It is suspected that reservoir leakage is travellir through this fracture zone in the abutment and coming out downstream of the dam, but this was not verified by the geological investigations. Fracture zones other than the one encountered in the drilling program are postulated to exist near the center and west abutment areas of the dam. Further investigation of these areas is recommended by the geologist since leakage through fractured zones may cause accelerated weathering and alteration of the condition of the rock.

It is concluded that seismic activity is not likely to occur along the faults near Hoopes dam. However, the occurrence of minor earthquakes in the Delaware region means that stress is building up in the area and future earthquakes are possible. It is therefore recommended that the dam be analyzed for a ground acceleration coefficient of 0.10 g, which has been done. The results of this analysis are described in Section V of this report.