

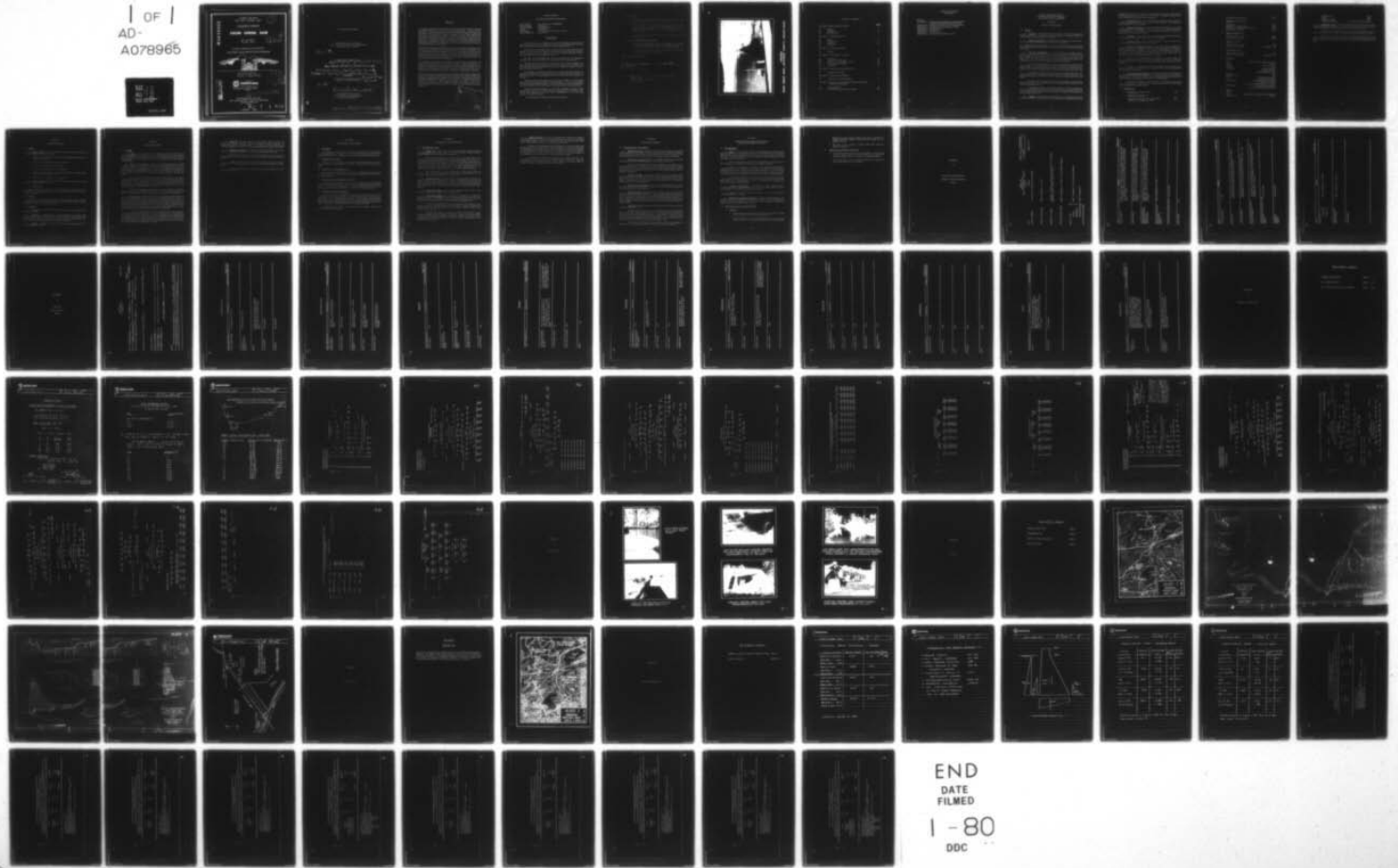
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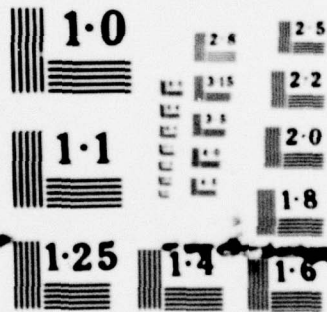
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NATIONAL DAM SAFETY PROGRAM. CRUM CREEK DAM (NDI-PA-00350, PA-D--ETC(U)
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DELAWARE RIVER BASIN
CRUM CREEK, DELAWARE COUNTY

PENNSYLVANIA

CRUM CREEK DAM

NDI - PA 00350
PA DER 23-20

LEVEL #

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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Prepared By
O'BRIEN & GERE
Justin & Courtney Division
PHILADELPHIA, PENNSYLVANIA
19103

ORIGINAL CONTAINS COLOR PLATES: ALL DDC
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FOR

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT CORPS OF ENGINEERS
BALTIMORE, MARYLAND

21203

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AUGUST 1979

DELAWARE RIVER BASIN

Name of Dam: Crum Creek Dam
County & State: Delaware County, Pennsylvania
Inventory Number: PA00350

11 Aug 79

6 PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM, Crum Creek

Dam (NDI-PA-00350, PA-DE R-23-20),
Delaware River Basin, Crum Creek,
Delaware County, Pennsylvania, Phase I

Prepared by:

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

Inspection
Report

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For

15 DACW 32-79-C-0070

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

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ORIGINAL CONTAINS COLOR PLATES: ALL DDC
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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 investigations, 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. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

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 frequent inspections can unsafe conditions be detected, and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design 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.

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PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam: Crum Creek Dam ID #PA00350
State Located: Pennsylvania
County Located: Delaware County
Stream: Crum Creek
Coordinates: Latitude 39° 55.5', Longitude 75° 22.0'
Date of Inspection: June 13, 1979

ASSESSMENT

Crum Creek Dam is a masonry gravity structure (cyclopean concrete) about 610 feet long and 25 feet high. A 210-foot long ungated overflow spillway is located along the length of the dam about 80 feet from the right abutment.

The dam forms a reservoir with a surface area of 27.5 acres and a storage capacity of 282 acre-feet at normal pool. Maximum storage capacity (Elevation 117.0) is about 670 acre-feet. Based on the maximum height and storage capacity, the dam is classified in the "Small" size category.

The dam and impoundment are owned and operated by the Philadelphia Suburban Water Company; the facility is operated as a water supply reservoir.

The dam, which is classified as "High" hazard, has a Spillway Design Flood (SDF) equal to the Probable Maximum Flood (PMF). A review of the results of the hydrologic and hydraulic analyses indicates that the spillway is capable of passing about 23 percent of the PMF.

The spillway is classified as "Inadequate" for passing the PMF; however, the spillway is not considered "Seriously Inadequate" since the hazard potential due to a failure of the dam is not significantly greater than the hazard without a failure of the dam.

Stability analyses were performed for both the overflow and non-overflow sections for the anticipated range of loading conditions. A review of the results indicates that the resultant of forces is located outside the middle third of the base width for 50 percent of the PMF, PMF and normal pool with ice loading conditions.

Based on visual observations, review of the information provided by the Pennsylvania Department of Environmental Resources (DER), Division of Dam Safety, and conversations with the Owner's representative, Crum Creek Dam appears to be in good condition.

Recommendations and Remedial Measures are as follows:

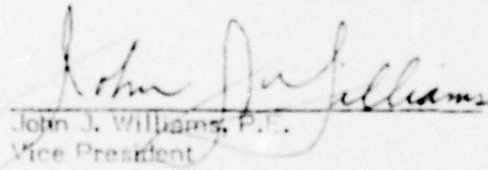
a. Facilities.


1. The spillway capacity should be increased in accordance with the results of further hydrologic and hydraulic studies.
2. Recommendations for remedial strengthening of the dam will depend on a review of the further detailed hydrologic and hydraulic studies and in-depth stability analyses. This work is to be done by a licensed professional engineer experienced in the design and construction of dams.
3. The stem on the downstream reservoir drain valve should be repaired or replaced.

b. Operation and Maintenance Procedures

1. 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.
2. The Owner should have the facility inspected by an experienced professional engineer on an annual basis.

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

 Date: 5 Sept. 1979
John J. Williams, P.E.
Vice President
Pennsylvania Registration PE006720E

Approved by:  Date: 19 Sep 1979
JAMES W. PECK
Colonel, Corps of Engineers
District Engineer



**OVERVIEW
CRUM CREEK DAM, DELAWARE COUNTY, PENNSYLVANIA**

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CRUM CREEK DAM ID #PA00350

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose of Inspection. The purpose of this inspection is to determine if Crum Creek Dam constitutes a hazard to human life or property.

1.2 Description of Project (Based upon information provided by the Pennsylvania Department of Environmental Resources (DER), Division of Dam Safety, Harrisburg, Pennsylvania)

a. Dam and Appurtenances. Crum Creek Dam is a masonry gravity structure (cyclopean concrete construction) with a total length of about 610 feet and a height of about 25 feet at its maximum section. The dam extends approximately 470 feet from the right abutment (south abutment) across Crum Creek; from this point the axis alignment is changed (approximately 30° in the downstream direction) and the dam continues to the left abutment.

The non-overflow section of the dam is constructed to Elevation 117.0. The upstream face is sloped at one horizontal to 20 vertical (1H:20V), the downstream slope is vertical above Elevation 108.5 and sloped at 2H:3V below this elevation. The crest of the non-overflow section of the dam is about four feet wide.

The overflow section is 210 feet long and is constructed as an uncontrolled Ogee spillway. It is located about 80 feet from the right abutment. The control section of the spillway is a formed concrete cap constructed to Elevation 112.0.

The dam creates a reservoir with a storage capacity at normal pool of about 282 acre-feet. The impoundment is used as a water supply reservoir for the Owner's distribution system.

The intake structure is located about 400 feet from the right abutment. A 36-inch diameter pipe (terra cotta) extends from the intake structure through the non-overflow section, and is used to divert water to a chamber located about 140 feet downstream of the dam.

b. Location. Crum Creek Dam is located on Crum Creek about one mile northeast of Media, Pennsylvania, in Nether Providence and Springfield Townships,

Delaware County. The dam site is shown on the USGS "Lansdowne, Pennsylvania" Quadrangle at coordinates N 39° 55.5', W 75° 22.0'. A regional vicinity map of Crum Creek Dam is included as Plate 1, Appendix E.

c. Size Classification. Crum Creek Dam has a maximum height of 25 feet and an estimated maximum storage capacity of 670 acre-feet. The structure is classified in the "Small" size category.

d. Hazard Classification. Several manufacturing businesses are located approximately 0.5 miles downstream of Crum Creek Dam. A failure of the dam could possibly result in loss of life and extensive property damage. The structure is classified in the "High" hazard category.

e. Ownership. Crum Creek Dam is owned by the Philadelphia Suburban Water Company, 762 Lancaster Avenue, Bryn Mawr, PA 19010.

f. Purpose of Dam. The dam was constructed to form a water supply reservoir for the Owner's water distribution system.

g. Design and Construction History. Crum Creek Dam was designed by George S. Beal, Division Engineer for the Water Supply Commission of Pennsylvania and was constructed by the Andrew O'Neill Company of Philadelphia, PA. Construction started in September 1918 and was completed in 1920. The original Owner of the dam was the Springfield Consolidated Water Company which later was reorganized as the Philadelphia Suburban Water Company.

A review of the correspondence indicates that the original intake pipe (36-inch diameter terra cotta) was partially replaced by a 36-inch cast iron pipe between 1930 and 1937. There is no record of any additional modifications made to the dam.

Failure of the road embankment, approximately 50 feet downstream of the right abutment, was reported to have occurred in 1959. This failure apparently did not affect the structure.

h. Normal Operating Procedures. According to the Owner's representative, Mr. Thomas Kiely, the reservoir water surface is normally maintained at or near the spillway crest. Releases are made from Geist Storage Reservoir (located about 3 miles upstream) to supplement normal runoff to Crum Creek Dam.

The average quantity of water diverted to the distribution system from Crum Creek Reservoir is about 20 mgd. The sluice gate on the 36-inch diameter line is positioned to meet this demand.

1.3 Pertinent Data

a. <u>Drainage Area.</u> (square miles)	29.1
b. <u>Discharge at Dam Site.</u> (cfs)	
Maximum Flood of Record (Elevation 115.0) (Tropical Storm Agnes, June, 1972)	3,928

	Maximum Spillway Capacity	8,452
c.	<u>Elevation.</u> (feet above MSL)	
	Top of Dam	117.0
	Spillway Crest (Normal Pool)	112.0
	Streambed at Downstream Toe of Dam	92±
	Invert, Water Supply Pipe	101.3
d.	<u>Reservoir Length.</u> (feet)	
	Normal Pool, Elev. 112.0	4,000
	Top of Dam, Elev. 117.0	5,000
e.	<u>Storage.</u> (acre-feet)	
	Normal Pool, Elev. 112.0	282
	Top of Dam, Elev. 117.0	(Estimated) 670
f.	<u>Surface Area.</u> (acres)	
	Normal Pool, Elev. 112.0	27.5
	Top of Dam, Elev. 117.0	(Estimated) 128
g.	<u>Dam Data.</u>	
	Type	Masonry gravity (cyclopean concrete)
	Length	610 feet
	Height	25 feet (maximum)
	Top Width	4 feet
	Side Slopes	1H:20V (upstream) 2H:3V (downstream) vertical above Elev. 108.5
	Zoning	N/A
	Impervious Core	N/A
	Cutoff	The structure is keyed into the rock foundation.
	Grout Curtain	A single line of holes on 8-foot centers (25 feet deep) was grouted under pressures up to 60 psi.
	Drain System	A French drain system was constructed in the dam foundation.
h.	<u>Spillway.</u>	
	Type	Ogee masonry gravity (cyclopean concrete)
	Length of Weir	210 feet

Crest Elevation	112.0
Gates	None
Upstream Channel	None
Downstream Channel	Crum Creek (natural streambed)

i. Regulating Outlets. A 36-inch diameter terra cotta and cast iron pipe extends from the intake structure to a chamber below the dam. 36-inch diameter valves are positioned on the line upstream and downstream of the dam.

A reservoir drain system (24-inch diameter) is constructed through the dam. Two 24-inch diameter valves are positioned in series downstream of the dam.

A 20-inch diameter cast iron pipeline extends from the reservoir to the water treatment facility and is used to flush the coagulating basin at the treatment facility. 20-inch diameter valves are positioned upstream and downstream of the dam.

SECTION 2
ENGINEERING DATA

2.1 Design

a. Data Available. The engineering data provided by DER for review of Crum Creek Dam includes the following:

1. "Permit, "Application", and "Report Upon the Application" to construct Crum Creek Dam, 1918.
2. Original spillway discharge capacity calculations.
3. Construction Contract and Specifications.
4. Construction progress reports and photographs.
5. Periodic inspection reports and photographs (reports dated 1920, 1925, 1930, 1937, 1947, 1959, and 1970).
6. Miscellaneous correspondence and memoranda.

b. Design Features. The design features are described in Section 1.2.a and are shown in Appendix E, Plates 2 and 3.

2.2 Construction

Based on the field investigation and the information available in the construction reports, the dam appears to have been constructed in general conformance with the design drawings.

2.3 Operation

According to the Owner's representative, daily operation consists of positioning of the 36-inch sluice gate at the intake. The operation of this gate regulates the quantity of flow to the water supply system.

2.4 Evaluation

a. Availability. The information utilized in this report was provided by the Pennsylvania DER.

b. Adequacy. A limited quantity of design calculations and drawings were provided by DER. However, this information in conjunction with observations made in the field investigation and discussions with the Owner's representative, Mr. Thomas Kiely, is considered adequate for a Phase I investigation.

c. Validity. It appears that there is no reason to question the validity of the data obtained from DER.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. Crum Creek Dam was inspected on June 13, 1979. At the time of the inspection, the reservoir water surface elevation was about 0.3 feet above the spillway crest (Elevation 112.3). No underwater areas were inspected. The observations and comments recorded by the field inspection team are presented in Appendix B.

b. Dam. The non-overflow section of the dam appears to be in good condition. The entire structure has recently been surfaced with gunite. No open cracks or indications of seepage were noted in any visible portions of the dam. Horizontal and vertical alignment appear to be in the as-constructed condition; no evidence of structural displacement was detected. Rock outcrops are evident in the vicinity of the right abutment. No seepage was noted in either of the abutment areas.

The overflow section of the dam is an Ogee spillway. The control section (crest) appears to be a formed concrete cap. The downstream slope is surfaced with rubble masonry; the masonry has recently been protected with a gunite coating. The spillway crest shows no evidence of horizontal or vertical displacement. A thorough inspection of the crest and downstream face of the spillway was prevented due to the flow conditions.

The dam foundation was not visible at the time of inspection. However, there is no evidence of foundation deterioration. Due to the flow conditions, the existence and effectiveness of the foundation drain system could not be verified.

c. Appurtenances. The intake structure is located on the left side of the dam in the non-overflow section. The structure and operating mechanisms appear to be well maintained. No trash was accumulated on the trashrack at the time of inspection. Flow into the intake is regulated by a 36-inch circular sluice gate. The gate is normally positioned to permit maximum inflow. Flow is conveyed from the intake to the gatehouse in a 36-inch diameter pipe. Two pipes in parallel, one 30-inch diameter and one 36-inch diameter, extend from the gatehouse to a water treatment facility located about 400 feet downstream of the dam.

A 24-inch diameter pipe is located through the base of the right non-overflow section of the dam; this pipe is used as a reservoir drain. A second pipe, a 20-inch diameter vitrified clay pipe, is used to provide water to the treatment plant to periodically (about twice a year) flush the coagulating basin. According to operating personnel, all valves and pipelines are operational except for one of the two valves located on the downstream side of the reservoir drain. The stem is bent and complete functioning of the valve is doubtful.

d. Reservoir. The slopes adjacent to the reservoir range from 10 to 40 percent and are well vegetated. There is no evidence of slope instability. A training wall (about 5 feet high) constructed upstream of the right abutment has failed for a length of about fifty feet. The exposed embankment appears to be stable.

e. Downstream Channel. The stilling basin was not visible at the time of inspection. However, deposits of gravel were noted downstream of the dam.

The channel below the dam is generally between 30 to 40 feet wide; the channel banks are about 4 feet high. The banks are vegetated with slopes of about 2H:1V.

A highway bridge is located about 500 feet downstream of the dam. The flow area available through this structure is about 15 feet (high) by 75 feet (wide).

Several manufacturing businesses are located approximately 0.5 miles downstream of the dam.

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SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

The Philadelphia Suburban Water Company operates the Crum Creek facility as a water supply reservoir. About 20 mgd is diverted from the impoundment to the water distribution system. Operating personnel attend the facility on a daily basis.

4.2 Maintenance of the Dam

The dam is maintained by the Philadelphia Suburban Water Company. According to the Owner's representative maintenance is performed on an "as required" basis.

4.3 Maintenance of Operating Facilities

The operating facilities are maintained by the Philadelphia Suburban Water Company. According to the Owner's representative, maintenance is performed on an "as required" basis.

4.4 Description of any Warning System in Effect

No formal warning system or procedures are established for monitoring the structure during periods of heavy rain or in the event of impending dam failure. However, it is reported that the Owner is presently engaged in planning meetings with County Civil Defense representatives to develop a formal warning system.

4.5 Evaluation of Operational Adequacy

The operation and maintenance procedures for Crum Creek Dam are considered to be adequate. Records of performed maintenance, however, should be maintained. Upon completion and acceptance of the formal warning system, operating personnel should be familiarized with the procedures for alerting downstream residents and appropriate agencies during periods of anticipated high volume flows. Procedures for evacuation should also be included in this plan.

It appears that the dam is accessible under all weather conditions for inspection and emergency action.

SECTION 5

HYDROLOGY AND HYDRAULICS

5.1 Evaluation of Features

a. Design Data. Design information is limited to data submitted with the Dam Application Report dated August 3, 1918 and consists of stage-discharge-storage relationships and drainage area computations.

The computed drainage area contributing to Crum Creek Dam is 29.1 square miles. However, runoff from about 21.5 square miles of this watershed is controlled by Geist Storage Dam (NDI No. PA00348) located about 3 miles upstream. Ground elevations within the drainage area range from about 550 feet to 112.0 feet (MSL) at the normal pool. The watershed is about equally proportioned in urbanization, woodlands and open fields. The runoff characteristics of the watershed may undergo change in the future as a result of further urbanization.

The design capacity for the impoundment at normal pool (Elevation 112.0) is 282 acre-feet. The maximum theoretical spillway discharge at the maximum reservoir stage (Elevation 117.0) is 8,452 cfs.

b. Experience Data. No rainfall or reservoir water surface elevations are recorded for this dam. However, the Owner's representative stated that the maximum water surface elevation observed at the dam site occurred during Tropical Storm Agnes (June, 1972) when the reservoir water surface was approximately 3 feet above the spillway crest. This corresponds to a spillway discharge of approximately 3,900 cfs.

c. Visual Observations. On the date of inspection, there were no indications that the spillway would not perform as designed.

d. Overtopping Potential. Crum Creek Dam is classified as a "Small" size, "High" hazard dam. Accordingly, the Spillway Design Flood (SDF) ranges from fifty percent of the PMF to the PMF. In view of potential high hazard to loss of life in the event of a dam failure, the PMF was selected as the appropriate SDF.

The PMF was developed and routed through the facility (starting water surface elevation at the spillway crest) using the HEC-1 Computer Program, Dam Safety Version. The computer model included the hydraulic effect of Geist Storage Dam on Crum Creek Dam.

The PMF peak inflow and outflow are 46,331 and 46,303 cfs, respectively; the resulting reservoir stage is 123.99 MSL. Further review of the results indicates that the spillway can adequately pass about 23 percent of the PMF prior to overtopping the non-overflow portions of the dam. Refer to Appendix C for the computer input and output.

e. Spillway Adequacy. In view of the unfavorable results of the stability analyses (Refer to Section 6.1.f), a dam break analysis was performed to evaluate the increased "hazard to loss of life downstream from the dam from that which would exist just before failure" (ETL 1110-2-234, 10 May 1978).

A review of the analysis indicates that failure of Crum Creek Dam would increase the maximum depth of flow at the hazard area from 12.9 feet to 14.2 feet for thirty percent of the PMF, an increase in the depth of flow of about 10 percent. The peak discharge at the hazard area would increase from 11,656 cfs to 16,778 cfs for 30 percent of the PMF. Failure of Crum Creek Dam is not considered to significantly increase the hazard to loss of life or property damage.

The spillway is classified as "Inadequate" for discharging the SDF. It is not classified as "Seriously Inadequate" because failure of the dam would not significantly increase the hazard for loss of life or property damage even though the spillway is capable of passing only 23 percent of the PMF.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations. No deficiencies which might affect the structural integrity of the dam were noted during the visual inspection. A complete inspection of the dam was not possible due to flow conditions at the time of inspection. The existence and effectiveness of the foundation drain system could not be verified.

b. Design and Construction Data. All available material provided by DER was reviewed. A listing of this information is presented in Section 2.1.a.

A report and analyses of the structural stability of the spillway section were provided by DER. This information was reviewed and was found to agree closely with the analyses performed herein for the one similar loading condition (normal pool with full uplift). A summary of the stability data provided by DER is included in Appendix G.

c. Operating Records. No operating records relative to recorded water surface elevations or ice depth were available. However, according to the Owner's representative, the maximum water surface elevation observed was about 3 feet above the spillway crest. This corresponds to an Elevation of 115.0. The tailwater elevation at this time was not recorded.

d. Post-Construction Changes. According to information provided by DER, no modifications have been made to the dam. The visual inspection revealed that the structure has been recently quitted.

e. Seismic Stability. The dam is located in Seismic Zone 1 as shown on the "Seismic Zone Map of Contiguous States". Unless geological abnormalities exist at this site, a dam located in this zone can be considered stable for seismic loading if it can be demonstrated that the dam is stable for the design loading conditions. No adverse geological conditions are known to exist for this location, however, static seismic stability analyses have been conducted in view of the results obtained for design loadings.

f. Evaluation. Stability analyses were performed for the spillway and non-overflow sections of the dam.

An examination of the results of the analyses indicates that stability requirements relative to overturning are not met for normal pool with ice, PMF and fifty percent of the PMF loading conditions. The resultant of forces for these conditions is located outside the middle third of the base width. Criteria outlined in the Recommended Guidelines for Safety Inspection of Dams require that the resultant of forces fall within the middle third of the base width.

A summary of the results of the stability analyses are presented in Appendix G. The assumptions and calculations are also included in Appendix G.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety. A review of the results of the visual inspection of the dam and appurtenances, and of the material provided by DER indicates that the structure appears to be in good condition and was constructed in general compliance with the drawings. A recent surfacing treatment prevented a visual inspection of the structural condition of the dam.

Minor scouring of the channel below the spillway was noted; however, this condition is not considered detrimental to the stability of the dam.

Based on a review of the results of the hydrologic and hydraulic calculations, the spillway is capable of passing about 23 percent of the PMF without overtopping of the dam. However, the increased hazard due to a dam breach does not significantly increase the potential for loss of life or property damage. Therefore, the spillway is classified as "Inadequate", but not "Seriously Inadequate".

The resultant of forces is not located in the middle third of the base width (spillway and non-overflow sections) for fifty percent of the PMF, PMF and normal pool with ice loading conditions. Tension is developed in the upstream face of the dam for these loading situations.

b. Adequacy of Information. The information made available by DER, conversations with the Owner's representative and visual observations are considered adequate to make a Phase I evaluation of the dam.

c. Urgency. The recommendations presented in Section 7.2 should be implemented as soon as possible.

d. Necessity for Further Investigation. Further detailed hydrologic and hydraulic studies should be made to determine the extent to which the spillway capacity needs to be increased. In-depth stability analyses should be performed to determine if remedial measures are necessary.

7.2 Recommendations and Remedial Measures

a. Facilities.

1. The spillway capacity should be increased in accordance with the results of further hydrologic and hydraulic studies.
2. Recommendations for remedial strengthening of the dam will depend on a review of the further detailed hydrologic and hydraulic

studies and in-depth stability analyses. This work is to be done by a licensed professional engineer experienced in the design and construction of dams.

3. The stem on the downstream reservoir drain valve should be repaired or replaced.

b. Operation and Maintenance Procedures.

1. 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.
2. The Owner should have the facility inspected by an experienced professional engineer on an annual basis.

APPENDIX

A

Check List Engineering Data
Design, Construction, Operation
Phase I

NAME OF DAM Crum Creek Dam
IU # PA 00350

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

Sheet 1 of 4

ITEM	REMARKS
AS-BUILT DRAWINGS	No "as-built" drawings are available.
REGIONAL VICINITY MAP	Refer to Appendix E, Plate 1.
CONSTRUCTION HISTORY	Available information relative to construction history was provided by DER. Refer to Section 1.2.g.
TYPICAL SECTIONS OF DAM	Refer to Appendix E, Plate 3 for available drawings.
OUTLETS - PLAN	} Refer to Appendix E for available drawings.
DETAILS	
CONSTRAINTS	
DISCHARGE RATINGS	Refer to Appendix C.
RAINFALL/RESERVOIR RECORDS	

ITEM	REMARKS
DESIGN REPORTS	Design reports are limited to a design summary made by personnel of The Water Supply Commission, Commonwealth of Pennsylvania, and submitted with the construction permit application (dated August 3, 1918).
GEOLOGY REPORTS	Geology reports are limited to a summary made by personnel of The Water Supply Commission, Commonwealth of Pennsylvania, and submitted with the construction permit application (dated August 3, 1918).
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Computations are limited to a summary made by personnel of The Water Supply Commission, Commonwealth of Pennsylvania, and submitted with the construction permit application (dated August 3, 1918).
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY } FIELD }	Refer to Appendix E, Plate 3.
POST-CONSTRUCTION SURVEYS OF DAM	None recorded
BORROW SOURCES	N/A

ITEM	REMARKS
MONITORING SYSTEMS	None
MODIFICATIONS	Portions of the original 36-inch terracotta water supply pipe have been replaced with cast iron pipe.
HIGH POOL RECORDS	The maximum reservoir surface elevation observed is approximately 115.0 during Tropical Storm Agnes, June, 1972.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	The dam was last inspected and a report prepared and published in March, 1976. The firm engaged for the inspection was Woodward-Clyde Consultants.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None recorded.
MAINTENANCE OPERATION RECORDS	None recorded.

ITEM	REMARKS
SPILLWAY PLAN	Refer to Appendix E, Plate 3.
SECTIONS DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	Refer to Appendix E, Plate 3.
MISCELLANEOUS	

APPENDIX

B

Check List

Visual Inspection

Phase I

CHECK LIST
VISUAL INSPECTION
PHASE I

Name Dam Crum Creek Dam County Delaware State Pennsylvania National ID # PA 003150

Type of Dam Masonry Gravity (cyclopean concrete) Hazard Category High

Date(s) Inspection June 13, 1979 Weather Clear Temperature 52° F

Pool Elevation at Time of Inspection 112.3 ± M.S.L. Tailwater at Time of Inspection 92 ± M.S.L.

Inspection Personnel:

- Mr. John J. Williams _____
- Mr. Leonard R. Beck _____
- Mr. Robert R. Bowers _____
- _____ Recorder

Remarks:

The inspection team was accompanied by Mr. T. M. Kiely, Design Engineer, Philadelphia Suburban Water Company and Richard Bateman, Manager of the water treatment facility

CONCRETE/MASONRY DAMS

Sheet 2 of 11

VISUAL EXAMINATION OF OBSERVATIONS REMARKS OR RECOMMENDATIONS

ANY NOTICEABLE SEEPAGE No seepage was observed

STRUCTURE TO
ABUTMENT/EMBANKMENT
JUNCTIONS

No deficiencies noted

DRAINS

Existence of the foundation drainage system shown on the drawing could not be verified during the inspection.

WATER PASSAGES

Not observed

FOUNDATION

Not observed

CONCRETE/MASONRY DAMS

Sheet 3 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	None noted. The entire structure has been recently surfaced with gunite.	
STRUCTURAL CRACKING	None observed	
VERTICAL AND HORIZONTAL ALIGNMENT	Vertical and horizontal alignment appear to be good.	
MONOLITH JOINTS	No joints were visible due to the recent gunite surfacing treatment	
CONSTRUCTION JOINTS	No joints were visible due to the recent gunite surfacing treatment	

OUTLET WORKS

Sheet 6 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	N/A	

INTAKE STRUCTURE	No deficiencies noted in those portions visible.	
------------------	--	--

OUTLET STRUCTURE	N/A	
------------------	-----	--

OUTLET CHANNEL	N/A	
----------------	-----	--

EMERGENCY GATE	According to the Owner's representative, a stem on one of the two downstream control valves is bent.	The valve stem should be repaired or replaced
----------------	--	---

UNGATED SPILLWAY

Sheet 7 of 11

VISUAL EXAMINATION OF _____ OBSERVATIONS _____ REMARKS OR RECOMMENDATIONS

CONCRETE WEIR
No problems observed. Entire spillway section has recently been surfaced with gunite.

APPROACH CHANNEL
None

DISCHARGE CHANNEL
Slight scour and gravel deposits are evident at the downstream toe of the spillway section.

This area should be visually inspected periodically to detect the development of any further adverse conditions.

BRIDGE AND PIERS
None

GATED SPILLWAY

Sheet 8 of 11

<u>VISUAL EXAMINATION: OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
CONCRETE SILL	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE AND PIERS	N/A	
GATES AND OPERATION EQUIPMENT	N/A	

INSTRUMENTATION

Sheet 9 of 11

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION

MONUMENTATION/SURVEYS

None

OBSERVATION WELLS

None

WEIRS

None

PIEZOMETERS

None

OTHER

None

RESERVOIR

Sheet 10 of 11

VISUAL EXAMINATION OF OBSERVATIONS REMARKS OR RECOMMENDATIONS

SLOPES

The slopes adjacent to the reservoir are relatively mild and well vegetated. However, the slope adjacent to the right abutment is formed in a steep rock cut. The exposed rock slope appears to be stable.

SEDIMENTATION

None observed.

DOWNSTREAM CHANNEL

Sheet 11 of 11

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION OF

CONDITION
(OBSTRUCTIONS,
DEBRIS, ETC.)

The downstream channel narrows from a 200-foot width below the spillway to about a 40-foot width, 500 feet downstream of the dam. A highway bridge (Beatty Road) is also located about 500-feet below the dam. The bridge opening is 75-feet wide by 15-feet high.

SLOPES

The overbanks of Crum Creek (downstream of the dam) are relatively flat and well vegetated.

APPROXIMATE NO.
OF HOMES AND
POPULATION

The nearest downstream damage center is a small industrial complex. Approximately 100 people are employed within this facility.

APPENDIX

C

Hydrologic & Hydraulic Data

TABLE OF CONTENTS - APPENDIX C

HYDROLOGY AND HYDRAULICS	SHEETS 1 - 3
HEC-I COMPUTER RESULTS	SHEETS 4 -12
HEC-I COMPUTER RESULTS (WITH DAM BREAK)	SHEETS 13-19

SUBJECT	SHEET	BY	DATE	JOB NO.
CRUM CREEK DAM	1	RRB	4/20/79	

HYDROLOGY CALCS.

DRAINAGE AREAS (PLANNIMETERED ON USGS QUAD SHEET)

FULL DRAINAGE BASIN: 29.1 mi.²

GEIST RESERVOIR SUB-BASIN: 21.7 mi.²

CRUM CREEK DAM SUB-BASIN: 7.4 mi.²

PMP CALCULATIONS (HMR 33)

AREA IS IN ZONE 6

24 HR., 200 SQ. MI. RAINFALL = 23.5"

<u>HR</u>	<u>%</u>	<u>RAINFALL</u>	<u>DRF</u>
6	103	24.2"	24.2"
12	112	26.3"	2.1"
24	122	29.7"	2.4"
48	134	31.5"	2.8"

SNYDER COEFFICIENTS

FROM INFO. PROVIDED BY COE FOR THE
DELAWARE RIVER BASIN, ZONE 10:

$$C_p = 0.60$$

AND $C_e = 1.25$

GEIST

$L = 10.2$ mi. $L_{ca} = 5.7$ mi.

$$t_p = 1.25 (10.2 \cdot 5.7)^{0.3} = 4.23 \text{ HR.}$$

$$t_p = C_e (L \cdot L_{ca})^{0.3}$$

CRUM CREEK DAM

$L = 4.5$ mi. $L_{ca} = 2.1$ mi.

$$t_p = 1.25 (4.5 \cdot 2.1)^{0.3} = 2.45 \text{ HR.}$$



O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO.
CRUM CREEK DAM	2	RRB	4/20/79	

GEIST RESERVOIR ROUTING

(INFORMATION OBTAINED FROM BALT. COE PHASE I INSPECTION REPORT
BY WOODWARD-CLYDE CONSULTANTS)

<u>STAGE</u>	<u>STORAGE (ACRE-FOOT)</u>
125 (ORIGINAL STREAMBED ELEVATION)	0
200	10,740
207	13,577
220 *	20,100

* - ELEVATION 220 CONTOUR WAS PLANNIMETERED ON USGS QUAD SHEET AS 550 ACRES, WHICH WAS CONVERTED TO STORAGE BY THE CONIC METHOD.

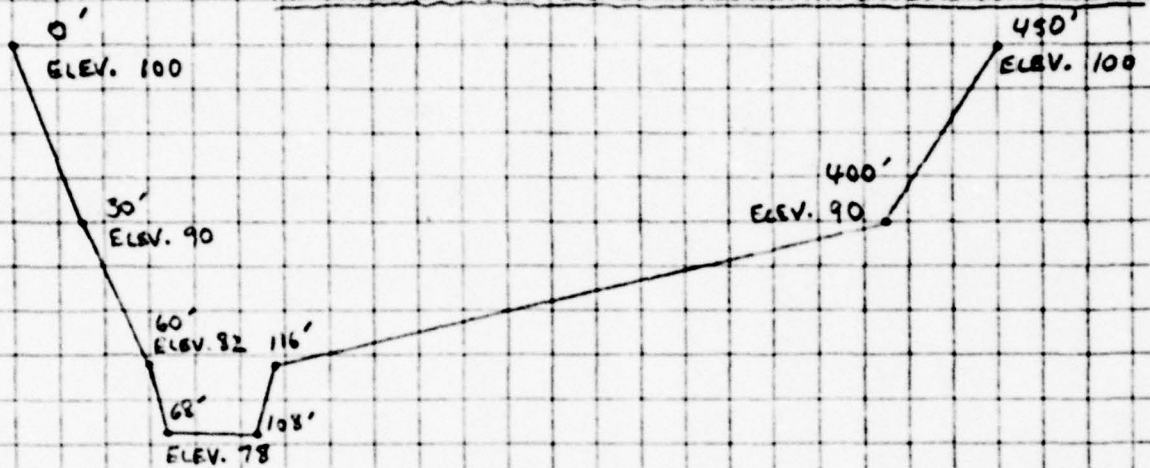
STAGE-DISCHARGE INFORMATION IS OBTAINED FROM THE ORIGINAL CHANNEL CAPACITY CURVE FOR THE GEIST DAM SPILLWAY ON SHEET 4, APPENDIX C OF THE ABOVE MENTIONED REPORT.

<u>STAGE</u>	<u>DISCHARGE (CFS)</u>
200	0
201	1100
202	3100
203	5700
204	8500
205	10,100
206	11,300
207	12,100
208	12,900
210	13,700

SUBJECT	SHEET	BY	DATE	JOB NO.
CRUM CREEK DAM	3	R2B	4/20/75	

DOWNSTREAM CROSS-SECTION FOR MEC-1 DAM BREAK ANALYSIS

APPROX. 0.5 MILES DOWNSTREAM FROM THE DAM



Stage-Storage Information from DER Files

<u>Stage (Ft. above MSL)</u>	<u>Storage (Millions of Gallons)</u>	<u>Storage (Ac. Ft.)</u>
103	2.22	6.8
104	4.52	13.9
105	7.13	21.9
106	11.33	34.8
107	18.53	56.9
108	28.53	87.7
109	40.93	125.8
110	55.63	171.0
111	72.53	222.9
112	91.98	282.7
113	113.68	349.4
114	137.08	421.3
115	162.18	498.4
117	218.0	670
125	553.2	1700

.....
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1974
 LAST MODIFICATION 25 SEP 78

LINE NO.	DESCRIPTION	VALUE	UNIT	DESCRIPTION	VALUE	UNIT
1						
2						
3						
4		390	0		0	0
5		5	1		0	0
6		1	1		0	0
7		1	1		0	0
8		1	1		0	0
9		1	1		0	0
10		1	1		0	0
11		1	1		0	0
12		1	1		0	0
13		1	1		0	0
14		1	1		0	0
15		1	1		0	0
16		1	1		0	0
17		1	1		0	0
18		1	1		0	0
19		1	1		0	0
20		1	1		0	0
21		1	1		0	0
22		1	1		0	0
23		1	1		0	0
24		1	1		0	0
25		1	1		0	0
26		1	1		0	0
27		1	1		0	0
28		1	1		0	0
29		1	1		0	0
30		1	1		0	0
31		1	1		0	0
32		1	1		0	0
33		1	1		0	0
34		1	1		0	0
35		1	1		0	0
36		1	1		0	0
37		1	1		0	0
38		1	1		0	0
39		1	1		0	0
40		1	1		0	0
41		1	1		0	0
42		1	1		0	0
43		1	1		0	0
44		1	1		0	0
45		1	1		0	0
46		1	1		0	0
47		1	1		0	0
48		1	1		0	0
49		1	1		0	0
50		1	1		0	0
51		1	1		0	0
52		1	1		0	0
53		1	1		0	0
54		1	1		0	0
55		1	1		0	0
56		1	1		0	0
57		1	1		0	0
58		1	1		0	0
59		1	1		0	0
60		1	1		0	0
61		1	1		0	0
62		1	1		0	0

NATIONAL DAM INSPECTION PROGRAM
 CRUM CREEK DAM
 PVE HYDROGRAPH

RUNOFF TO GEIST RESERVOIR

ROUTING THROUGH GEIST RESERVOIR

ROUTING THROUGH CRUM CREEK LAKE

COMBINING RUNOFF AND INFLOW FROM GEIST RESERVOIR

ROUTING THROUGH CRUM CREEK LAKE

LINE NO.	DESCRIPTION	VALUE	UNIT	DESCRIPTION	VALUE	UNIT
1						
2						
3						
4						
5						
6						
7						
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59						
60						
61						
62						

.....
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1974
 LAST MODIFICATION 25 SEP 78

RUN DATE 05/01/79
 TIME 12:15:46.

NATIONAL DAM INSPECTION PROGRAM
 CUM CHECK DAM
 PWF HYDROGRAPH

overlapped analysis

NO NHR NWIN IDAY IMA IMIN METRC IPLT IPRT MSTAN
 300 0 30 0 0 0 0 0 0 0 0 0
 JPRP NWT LROPT TRACE
 5 0 0 0 0

MULTI-PLAN ANALYSES TO BE PERFORMED
 MPLAN 1 NATION 1 LATIOM 1

RTIOS .20 .30 .40 .50 .60 .70 .80 .90 1.00

.....

SUB-AREA RUNOFF COMPUTATION
 RUNOFF TO GEIST RESERVOIR

ISTAG ICOMP IECON ITAPE JPLT JPRY INAME ISTAGE IAUTO
 14-65T 0 0 0 0 0 0 1 0 0
 IMYG IUG TAREA SWAP TMSO4 TMSPC RATIO ISHOW ISAME LOCAL
 1 1 21.70 0.00 29.10 0.00 0.600 0 1 1 0

PRECIP DATA

SPEE PMS 06 R12 024 R48 R72 R96
 0.00 23.50 103.00 112.00 122.00 136.00 0.00 0.00

TRAC COMPUTED BY THE PROGRAM IS .834

LOSS DATA
 LROPT STAGE DLTR RTIOL ERATN STKRS RTIOK STSTL CNSTL ALSWS RTIMP
 0 0.00 0.00 1.00 0.00 0.00 1.00 1.00 1.00 .05 0.00 0.00

UNIT HYDROGRAPH DATA
 TPO 4.23 CAP .40 NYAR 0

RECESSION DATA
 STAGE -1.50 ORCSVE -.05 RTIOM 2.00

UNIT HYDROGRAPH AS END-OF-PERIOD ORDINATES. LAGS 4.22 HOURS. CAP .41 VOL 1.00
 76. 28. 512. 822. 1256. 1585. 1836. 1989. 2041. 1993.
 1763. 1502. 1385. 1227. 1088. 964. 854. 757. 671. 595.
 527. 467. 416. 367. 325. 288. 256. 226. 201. 178.
 150. 140. 124. 97. 86. 76. 68. 60. 53.
 47. 42. 37. 33. 29. 26. 23. 20. 18.

PEAK OUTFLOW IS 3194. AT TIME 44.50 HOURS

.....

SUB-AREA RUNOFF COMPUTATION

RUNOFF TO CRUM CREEK LAKE

ISTAG	ICOMP	IECON	ITAPE	JPLY	JPRY	INAME	ISTAGE	IAUTO
IN-CRM	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IMYDG	IUMG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	7.40	0.00	29.10	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PWS	R6	H12	H24	R48	R72	R96
0.00	23.50	103.00	112.00	122.00	134.00	0.00	0.00

TRAPE COMPUTED BY THE PROGRAM IS .634

LOSS DATA

LRUPT	STR2	DLTR	RTIOL	ERAIN	STARS	RTIOM	STRTL	CMSTL	ALCNR	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00

UNIT HYDROGRAPH DATA

TPX 2.45 CPM .60 NTAP 0

RECESSION DATA

STARTX -1.50 GRCSLN -.05 RTIOM 2.00

UNIT HYDROGRAPH 20 END-OF-PERIOD ORDINATES, LAG= 2.45 HOURS, CPM .60 VOL= 1.00

97.	352.	690.	997.	1169.	1165.	973.	787.	637.	515.
417.	337.	273.	221.	179.	145.	117.	95.	77.	62.
59.	41.	33.	27.	21.	17.	14.	11.	9.	

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP 0
0	0	0	0	0	0	0

SUM 26.20 26.20 0.00 250000.
 (667.11 667.11 0.11 7331.12)

.....

COMBINE HYDROGRAPHS

COMBINING RUNOFF AND INFLOW FROM GEIST RESERVOIR

ISTAG	ICOMP	IECON	ITAPE	JPLY	JPRY	INAME	ISTAGE	IAUTO
COMBIN	2	0	0	0	0	1	0	0

.....

HYDROGRAPH ROUTING

ROUTING THROUGH CUM CHEER LAKE

ISTAD	1	ICOMP	0	IECON	0	ITAPE	0	JPLT	0	JPRY	0	INAME	1	ISTAGE	0	IAUTO	0
OUT-CM	0	ROUTING DATA	0														
QLSS	0.0	AVG	0.00	IRIS	1	ISAME	1	IOPT	0	IPMP	0	LSTM	0				
		NSTPS	0	LAG	0	AMSKK	0	TSK	0.000	STORA	-112.	ISPRAT	0				
CAPACITY	9.	282.	670.	1790.													
ELEVATION	92.	112.	117.	125.													
		CREL	SPRIG	COOQ	ERP	ELEV	COOL	CAREA	ERPL								
		112.0	210.0	3.6	1.5	0.0	0.0	0.0	0.0								

DAM DATA
 TOPEL 117.0
 COOD 3.1
 ERPD 1.5
 DAMWID 760.

- C PEAK OUTFLOW IS 7552. AT TIME 66.50 HOURS
- C PEAK OUTFLOW IS 11656. AT TIME 66.50 HOURS
- C PEAK OUTFLOW IS 14963. AT TIME 66.00 HOURS
- C PEAK OUTFLOW IS 17913. AT TIME 63.50 HOURS
- C PEAK OUTFLOW IS 21987. AT TIME 65.00 HOURS
- C PEAK OUTFLOW IS 26996. AT TIME 66.50 HOURS
- C PEAK OUTFLOW IS 35586. AT TIME 66.50 HOURS
- C PEAK OUTFLOW IS 41880. AT TIME 66.00 HOURS
- C PEAK OUTFLOW IS 46303. AT TIME 66.00 HOURS

.....

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS															
				RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9							
HYDROGRAPH AT IN-GST	1	21.70	1	5954.	10430.	13927.	17384.	20861.	24338.	27814.	31291.	34768.							
	(56.20)	(149.00)	(245.36)	(393.81)	(492.26)	(590.71)	(689.16)	(787.62)	(886.07)	(
ROUTED TO	1	21.70	1	5964.	8928.	10989.	13841.	18901.	23025.	27848.	30679.	34194.							
	(56.20)	(165.06)	(249.97)	(311.17)	(391.92)	(535.23)	(652.01)	(765.00)	(868.73)	(
HYDROGRAPH AT IN-CW	1	7.40	1	3367.	5051.	6735.	8418.	10102.	11786.	13470.	15153.	16837.							
	(19.17)	(95.35)	(143.03)	(190.71)	(238.38)	(286.06)	(333.74)	(381.41)	(429.09)	(
2 COMBINED	1	29.10	1	7599.	11745.	15018.	17979.	24097.	30167.	35961.	41224.	46331.							
	(75.37)	(215.18)	(332.54)	(425.26)	(509.10)	(682.36)	(856.23)	(1018.29)	(1167.36)	(
ROUTED TO	1	29.10	1	7552.	11656.	14903.	17913.	23087.	29096.	35586.	41080.	46303.							
	(75.37)	(213.45)	(330.07)	(423.70)	(507.23)	(679.23)	(849.34)	(1007.00)	(1163.27)	(

SUMMARY OF DAM SAFETY ANALYSIS

Beist Spring Reservoir

TOP OF DAM
207.00
13577.
12100.

SPILLWAY CREST
200.00
10700.
0.

INITIAL VALUE
200.00
10700.
0.

ELEVATION
STORAGE
OUTFLOW

PLAN 1

RATIO OF PMF	MAXIMUM RESERVOIR STORAGE U.S.-ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	203.06	0.00	11980.	5864.	0.00	45.50	0.00
.30	204.20	0.00	12444.	8820.	0.00	45.50	0.00
.40	205.74	0.00	13067.	10900.	0.00	46.00	0.00
.50	207.38	.38	13769.	13861.	2.50	46.00	0.00
.60	207.99	.99	14074.	16901.	4.50	45.00	0.00
.70	208.39	1.39	14275.	23025.	6.50	44.50	0.00
.80	208.72	1.72	14441.	27040.	7.50	44.50	0.00
.90	209.00	2.00	14580.	30679.	8.00	44.50	0.00
1.00	209.25	2.25	14705.	34194.	9.00	44.50	0.00

SUMMARY OF DAM SAFETY ANALYSIS

Crain Creek Dam

TOP OF DAM
117.00
676.
8452.

SPILLWAY CREST
112.00
282.
0.

INITIAL VALUE
112.00
282.
0.

ELEVATION
STORAGE
OUTFLOW

PLAN 1

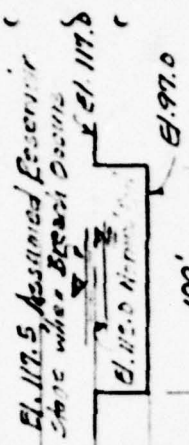
RATIO OF PWF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	116.64	0.00	642.	7552.	0.00	44.50	0.00
.30	117.93	.93	790.	11656.	6.00	44.50	0.00
.40	118.71	1.71	891.	14963.	9.00	44.00	0.00
.50	119.34	2.34	971.	17913.	11.00	43.50	0.00
.60	120.50	3.50	1120.	23987.	12.50	45.00	0.00
.70	121.53	4.53	1223.	28994.	13.50	44.50	0.00
.80	122.52	5.42	1368.	35386.	14.50	44.50	0.00
.90	123.24	6.24	1474.	41086.	15.50	44.00	0.00
1.00	123.99	6.99	1570.	46303.	16.00	44.00	0.00

11/11

Dam Break Analysis

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

LINE NO.	DESCRIPTION	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
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42																			
43																			
44																			
45																			
46																			
47																			
48																			
49																			
50																			
51																			



The portion of the dam assumed to be breached is based on the geometry of the site. The depth of flow over the top of the dam is assumed to be 10 feet. The portion of the dam assumed to be breached is based on the geometry of the site. The depth of flow over the top of the dam is assumed to be 10 feet. The portion of the dam assumed to be breached is based on the geometry of the site. The depth of flow over the top of the dam is assumed to be 10 feet.

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

RUN DATE 07/31/79
 TIME 13.15.52

Dam Break Analysis

NATIONAL DAM INSPECTION PROGRAM
 CRUIER CREEK DAM
 PMF HYDROGRAPH

NO 300 WMB 0 NMIN 30 IDAY 0 JOPER 5
 JMR SPECIFICATION
 IHD 0 IMIN 0 METRC 0 IPLY 0 IAPT 0 NSTAN 0
 NUT 0 LROPT 0 TRACE 0

MULTI-PLAN ANALYSES TO BE PERFORMED
 PLAN 2 NOTION 1 LATIOn 1

RTIOns .30

..... SUR-AREA RUNOFF COMPUTATION

RUNOFF TO RST RESERVOIR

ISTAG 1 ICOMP 0 IECOM 0 IIADE 0 JPLT 0 JAPT 0 INAME 1 ISTAGE 0 IAUTO 0
 IN-GST 0

HYDROGRAPH DATA

THYNG 1 IING 1 YARFA 21.70 SMAP 0.00 TMSDA 29.10 TDSPC 0.00 RATIO 0.00 ISNOW 0 ISAME 1 LOCAL 0

PRECIP DATA

SPPF 0.00 PMS 23.50 R6 103.00 R12 112.00 R24 122.00 R60 136.00 R72 0.00 R96 0.00

..... TAPSE COMPUTED BY THE PROGRAM IS .034

LOSS DATA

LROPT 0 STARR 0.00 MLTBR 0.00 RTIOL 1.00 FRAIN 0.00 STOPS 0.00 RTIOK 1.00 STOTL 1.00 CHSTL .05 ALSMR 0.00 RTIMP 2.00

UNIT HYDROGRAPH DATA

TPs 4.23 CPs .60 RTao 0

PRECSSION DATA

STRTOm -1.50 ORCSNR -.05 RTIOns 2.00

UNIT HYDROGRAPH 49 END-OF-PERIOD ORDINATES, LAGS 4.22 HOURS, CPs .61 VOLs 1.00

76.	284.	572.	802.	1256.	1545.	1836.	1989.	2041.	1945.
1763.	1562.	1305.	1227.	1088.	964.	854.	757.	671.	505.
527.	467.	416.	367.	325.	288.	255.	226.	201.	178.
158.	140.	124.	110.	97.	86.	76.	68.	60.	53.
47.	42.	37.	33.	29.	26.	23.	20.	18.	

STAGE	78.00	78.00	79.79	80.48	81.58	82.67	83.37	84.26	85.16
	86.05	87.04	88.74	89.63	90.53	91.62	92.32	93.21	94.11
FLOd	0.00	55.88	179.53	357.74	586.59	886.76	1281.04	1796.88	2455.14
	6280.06	5496.19	4962.52	8621.29	10750.33	13131.25	15402.72	18708.02	21861.76

MAXIMUM STAGE IS 98.0

MAXIMUM STAGE IS 92.2

Don't Use - Analogy

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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

Daniel B. ...

OPERATION	STATION	AREA	PLAN RATIO	1	2
HYDROGRAPH AT IN-GST	IN-GST	21.70 (56.20)		1	10630.
				2	295.361
ROUTE TO OUT-GT	OUT-GT	21.70 (56.20)		1	8828.
				2	249.071
HYDROGRAPH AT IN-COM	IN-COM	7.40 (19.17)		1	5051.
				2	163.031
2 COMBINED	COMBINED	29.10 (75.37)		1	11765.
				2	332.561
ROUTE TO OUT-CR	OUT-CR	29.10 (75.37)		1	11656.
				2	15707.
ROUTE TO MAZAO	MAZAO	29.10 (75.37)		1	11503.
				2	328.261
					630.731

SUMMARY OF DAM SAFETY ANALYSIS

Crum Creek Dam
Dam Break Analysis

PLAN 1 INITIAL VALUE 112.00 SPILLWAY CREST 112.00 TOP OF DAM 117.00
 STORAGE 282.00 OUTFLOW 0.00
 ELEVATION 117.00
 RESERVOIR W.S.-ELEV 282.00
 MAXIMUM STORAGE 799.00
 MAXIMUM DEPTH OVER DAM .93
 MAXIMUM OUTFLOW CFS 11456.00
 DURATION OVER TOP 6.00 HOURS
 TIME OF MAX OUTFLOW 66.50 HOURS
 TIME OF FAILURE 9.00 HOURS

PLAN 2 INITIAL VALUE 112.00 SPILLWAY CREST 112.00 TOP OF DAM 117.00
 STORAGE 282.00 OUTFLOW 0.00
 ELEVATION 117.00
 RESERVOIR W.S.-ELEV 282.00
 MAXIMUM STORAGE 799.00
 MAXIMUM DEPTH OVER DAM .62
 MAXIMUM OUTFLOW CFS 16770.00
 DURATION OVER TOP 1.71 HOURS
 TIME OF MAX OUTFLOW 66.02 HOURS
 TIME OF FAILURE 63.00 HOURS

PLAN 1 STATION HAZARD

RATIO .30
 MAXIMUM FLOW-CFS 11493.00
 MAXIMUM STAGE-FT 90.0
 TIME 66.50 HOURS

PLAN 2 STATION HAZARD

RATIO .30
 MAXIMUM FLOW-CFS 15520.00
 MAXIMUM STAGE-FT 92.2
 TIME 65.00 HOURS

APPENDIX

D

Photographs

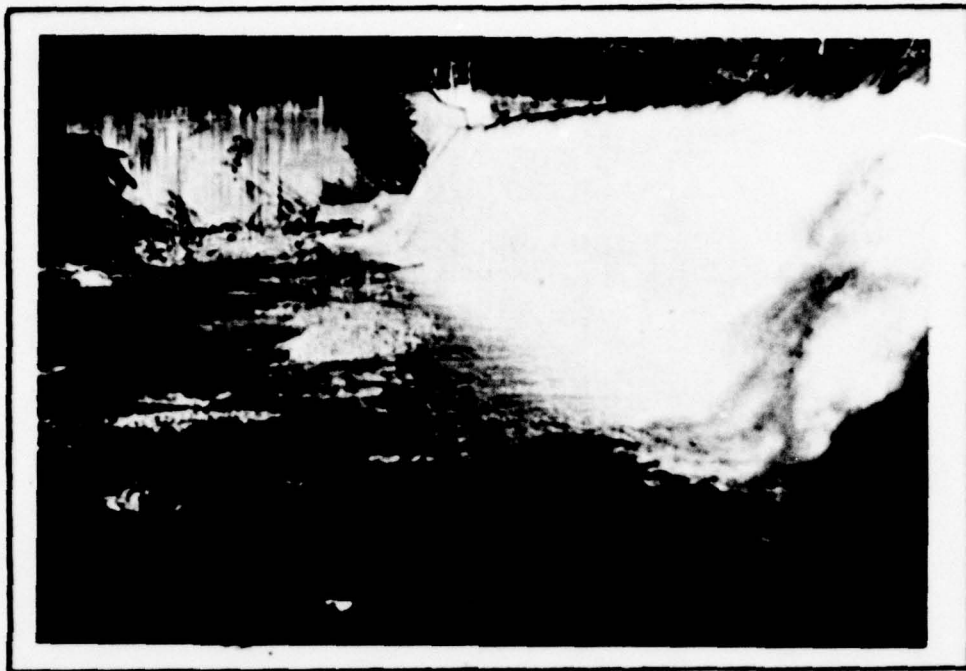


INLET GATE SYSTEM
HOIST AND TRASH
GUARD



VIEW OF THE SPILLWAY LOOKING
TOWARDS THE RIGHT ABUTMENT

D-1



*VIEW OF THE SPILLWAY LOOKING TOWARDS
THE RIGHT ABUTMENT AS SEEN FROM THE
DOWNSTREAM TOE OF THE DAM*



*HIGHWAY BRIDGE ABOUT 500 FEET
DOWNSTREAM OF THE DAM*



*VIEW ABOUT 1,000 FEET DOWNSTREAM OF THE DAM
LOOKING UPSTREAM AT THE PHILADELPHIA SUBURBAN
WATER COMPANY'S WATER TREATMENT PLANT*



*POTENTIAL DAMAGE AREA APPROXIMATELY
2,000 YARDS DOWNSTREAM OF THE DAM*

APPENDIX

E

Drawings

TABLE OF CONTENTS - APPENDIX E

REGIONAL VICINITY MAP	PLATE 1
TOPOGRAPHICAL PLAN	PLATE 2
PROFILE, SECTIONS, AND DETAILS	PLATE 3
PLAN VIEW OF DAM	PLATE 4

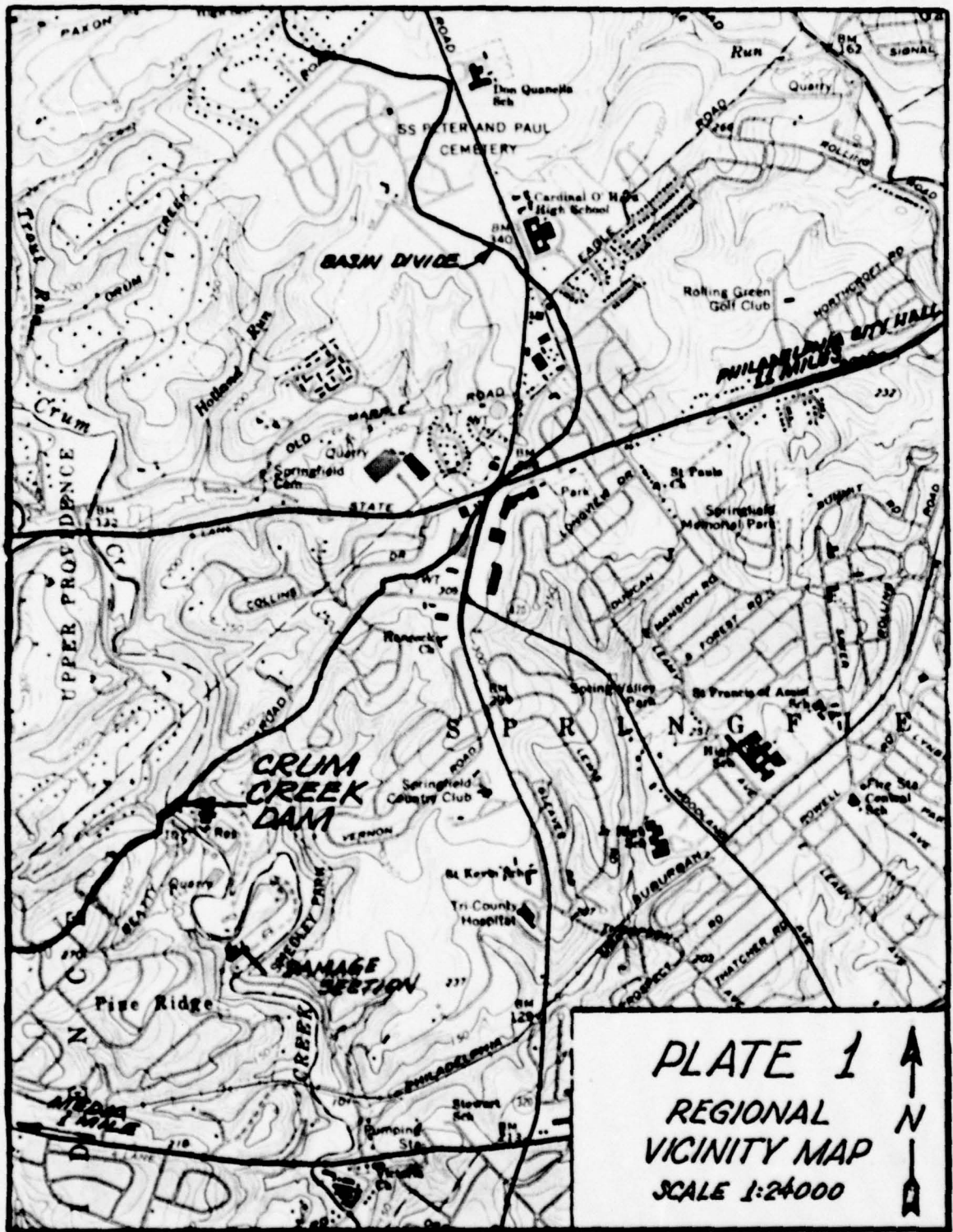
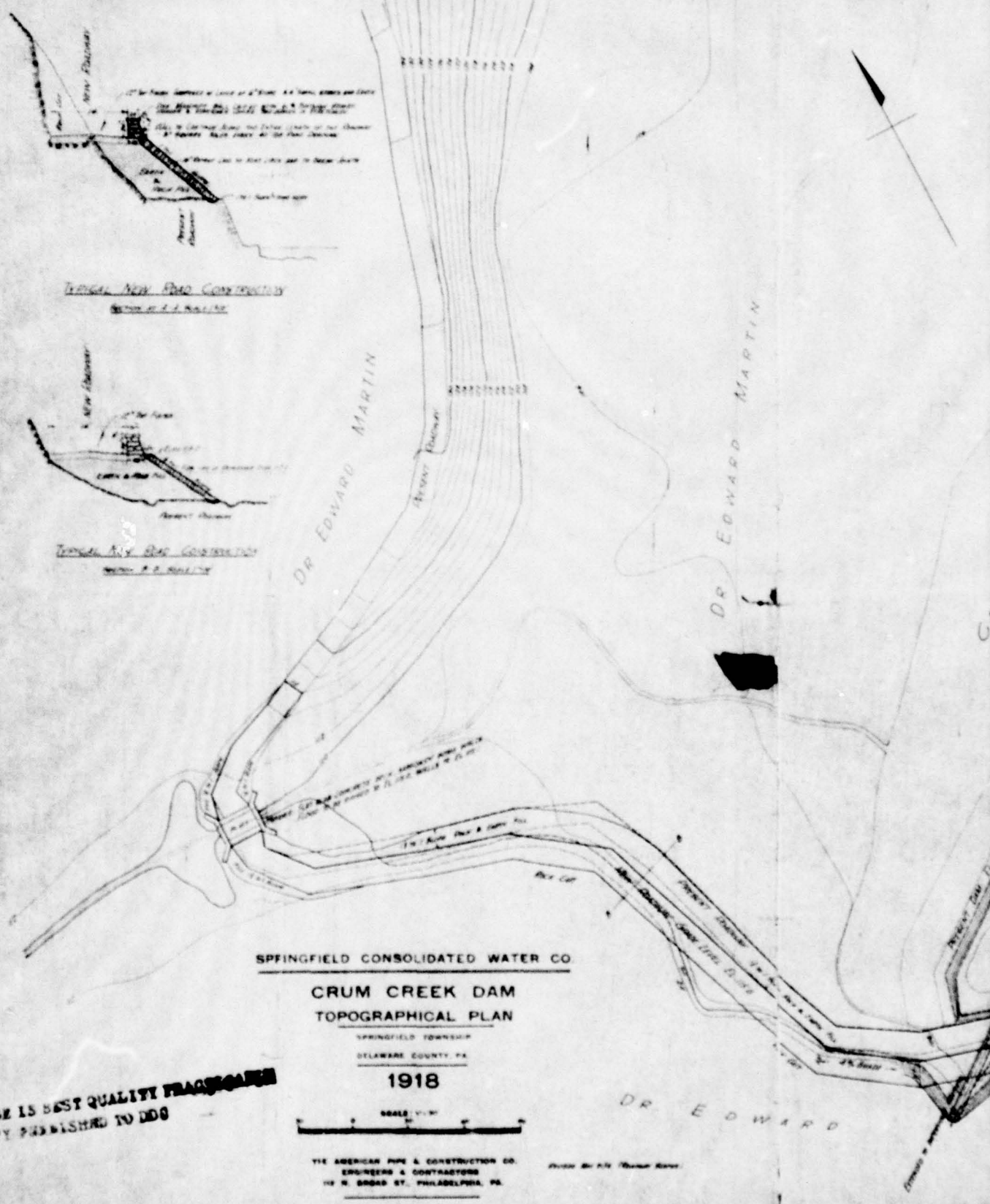


PLATE 1
 REGIONAL
 VICINITY MAP
 SCALE 1:24000

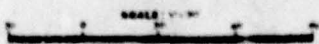


SPRINGFIELD CONSOLIDATED WATER CO.

**CRUM CREEK DAM
TOPOGRAPHICAL PLAN**

SPRINGFIELD TOWNSHIP
DELAWARE COUNTY, PA.

1918



THE AMERICAN PIPE & CONSTRUCTION CO.
ENGINEERS & CONTRACTORS
112 N. BROAD ST. PHILADELPHIA, PA.

Printed by the American Pipe & Construction Co.

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1

DR. EDWARD MARTIN

Creek

Grum

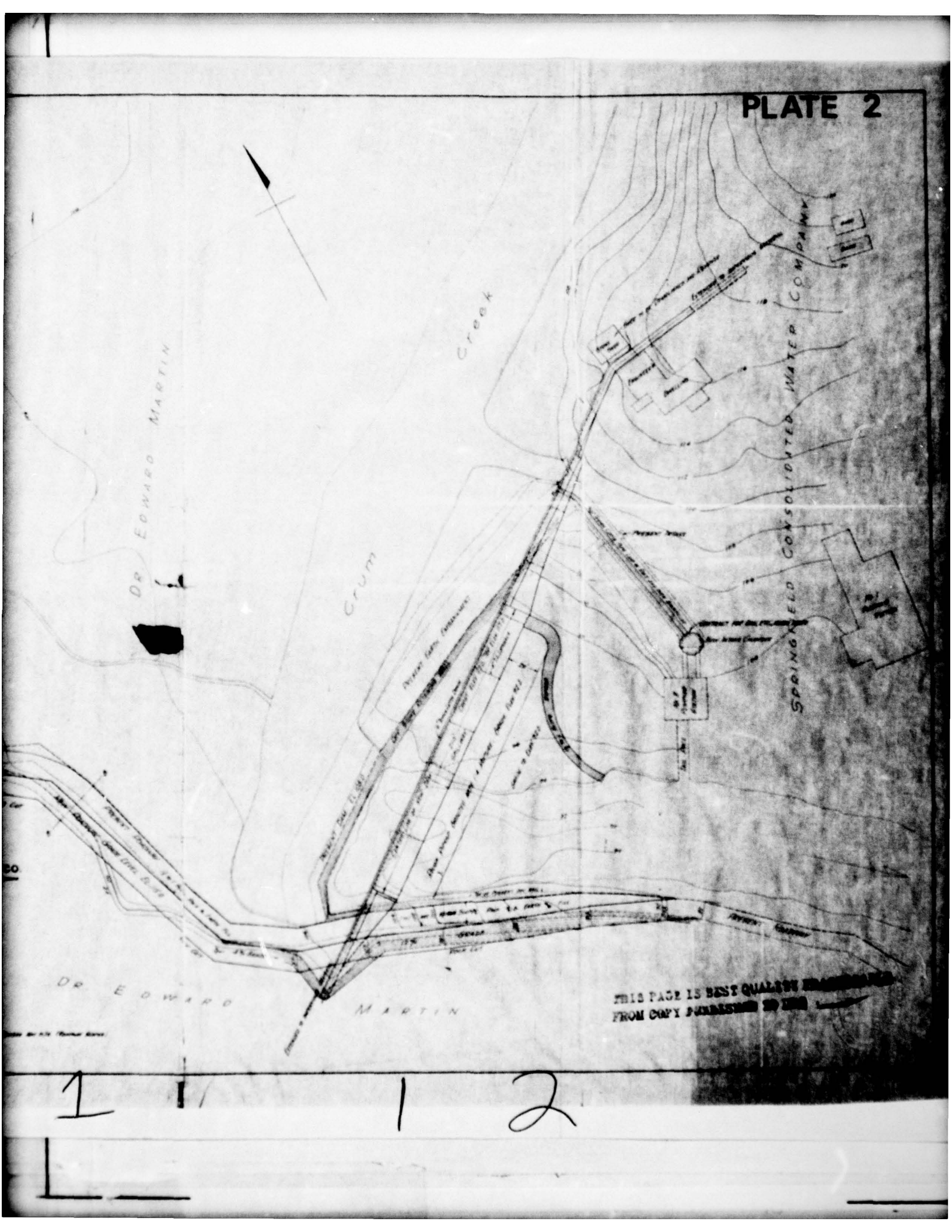
SPRING FLD CONSOLIDATED WATER COMPANY

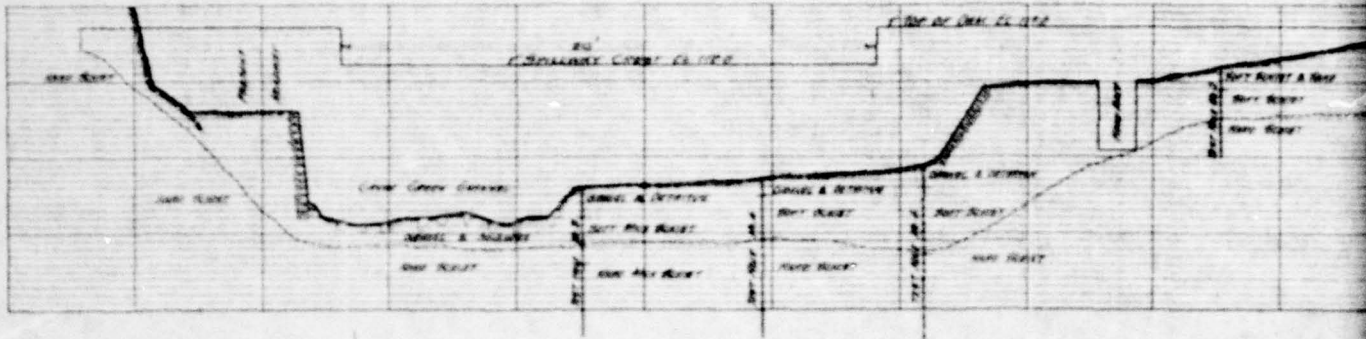
DR. EDWARD

MARTIN

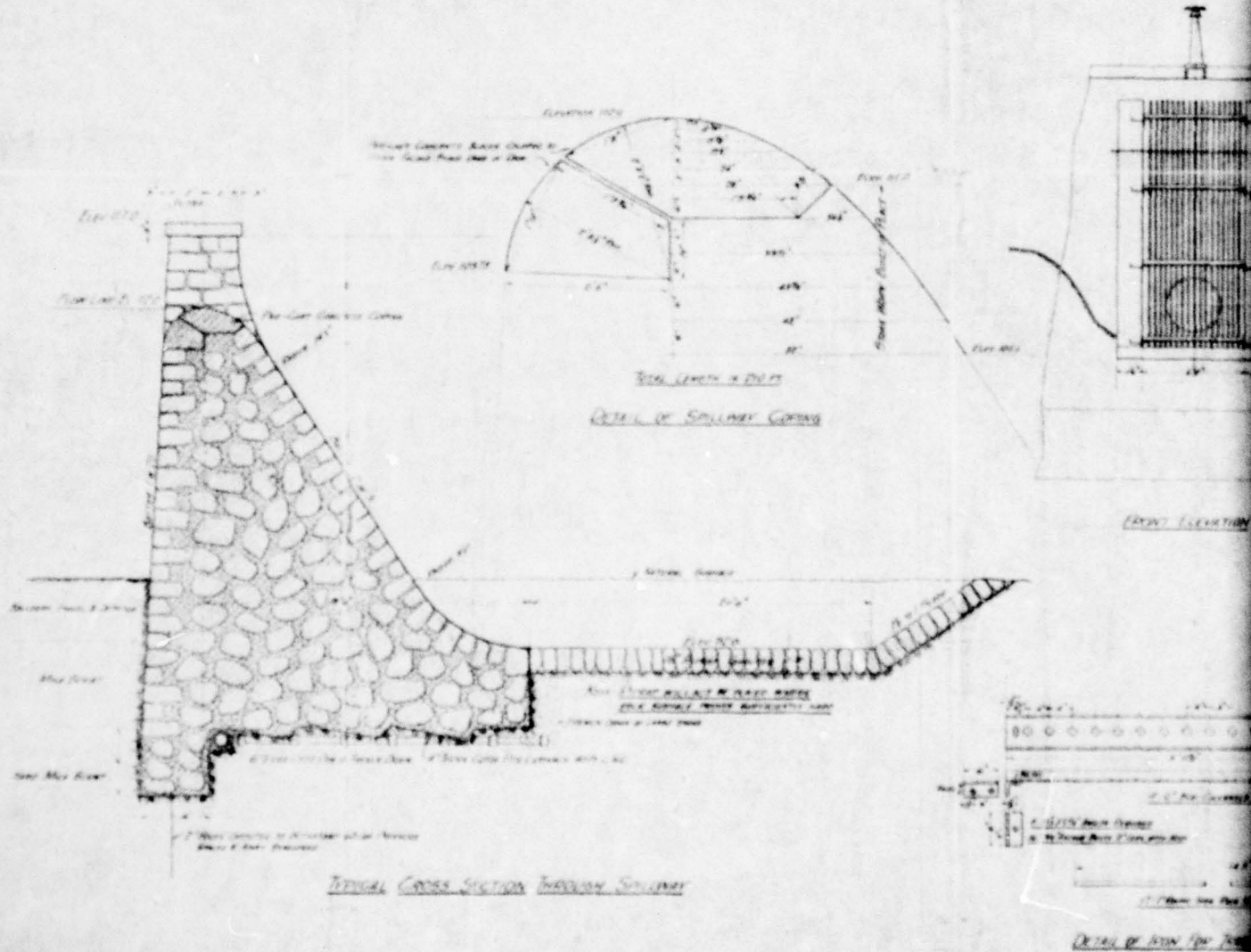
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PROFILE ALONG CENTRE LINE OF DAM LOOKING UP-STREAM
 SCALE HORIZONTAL 1"=100' VERTICAL 1"=10'

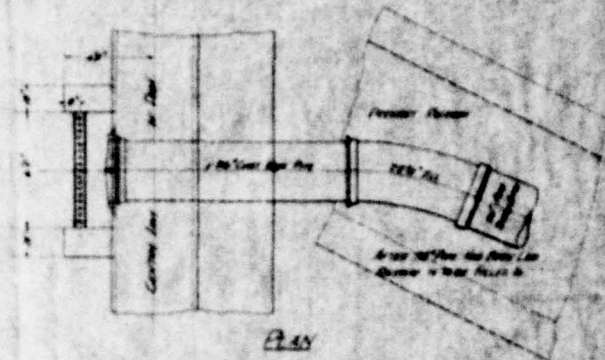
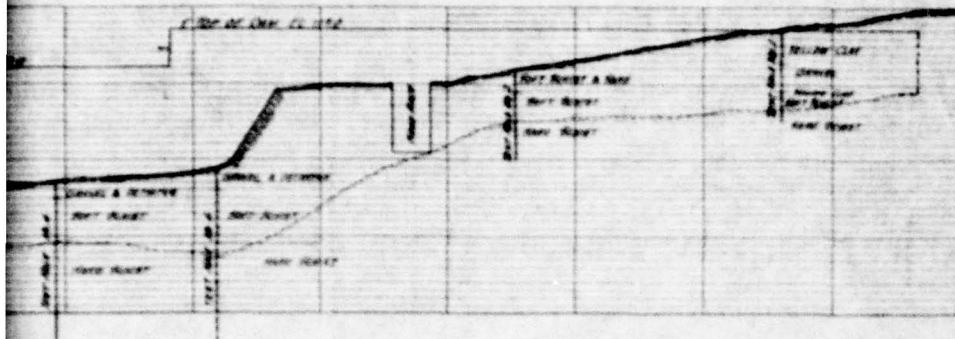


TYPICAL CROSS SECTION INCLUDING SPILLWAY

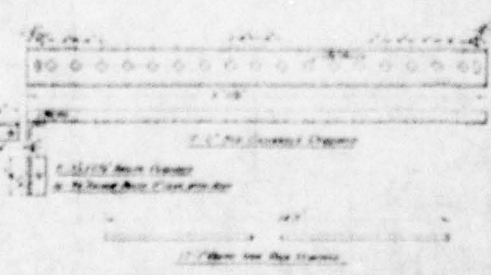
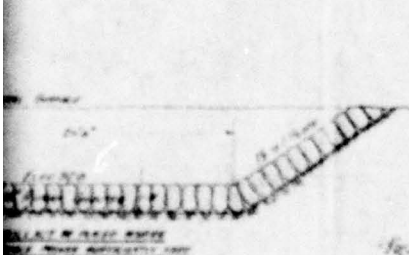
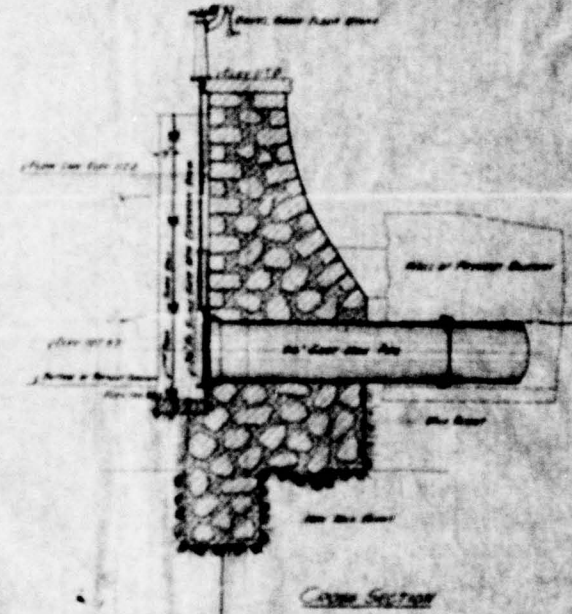
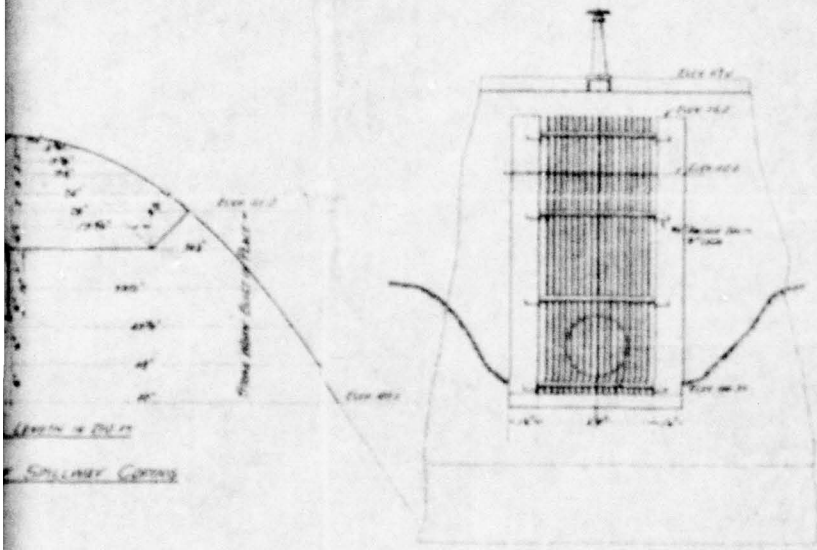
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PLATE 3



Profile of Dam Looking Up-Stream
 and Vertical Part



Detail of Outlet Pipe and Frame

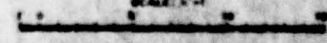
SPRINGFIELD CONSOLIDATED WATER CO.

CRUM CREEK DAM PROFILE, SECTIONS AND DETAILS

SPRINGFIELD TOWNSHIP, DELAWARE COUNTY, PA.

1918

SCALE: 1" = 10'

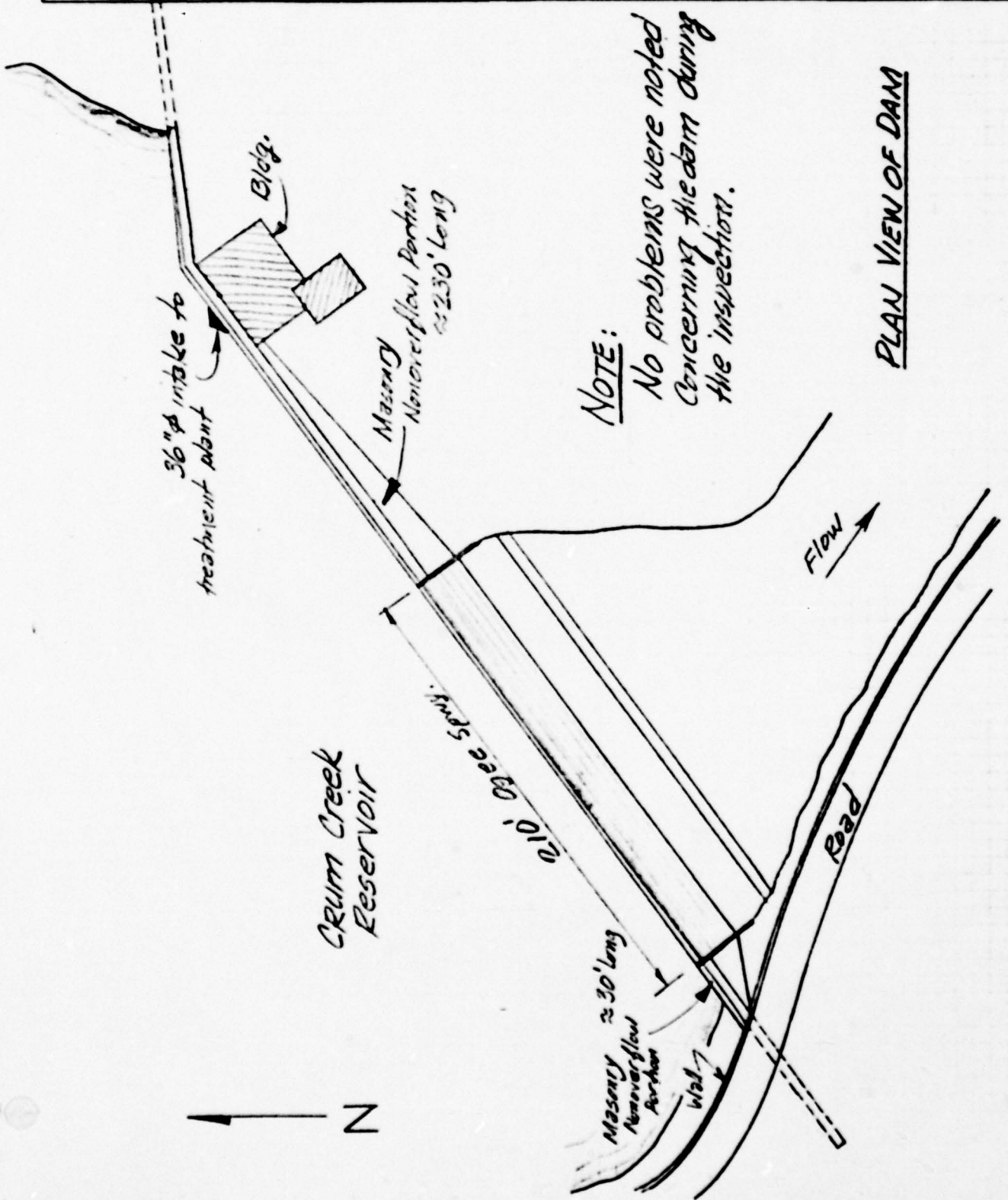


THE DESIGN AND CONSTRUCTION OF
 ENGINEERS & ARCHITECTS
 110 N. BROAD ST., PHILADELPHIA, PA.

THIS PLATE IS BEST QUALITY ENGRAVED
 AND PRINTED BY THE
 ENGINEERING NEWS-BUILDING
 COMPANY

1 | 2

SUBJECT <i>Crum Creek Dam</i>	SHEET <i>4</i>	BY <i>J</i>	DATE <i>8/27/79</i>	JOB NO.
----------------------------------	-------------------	----------------	------------------------	---------



NOTE:
No problems were noted concerning the dam during the inspection.

PLAN VIEW OF DAM



APPENDIX

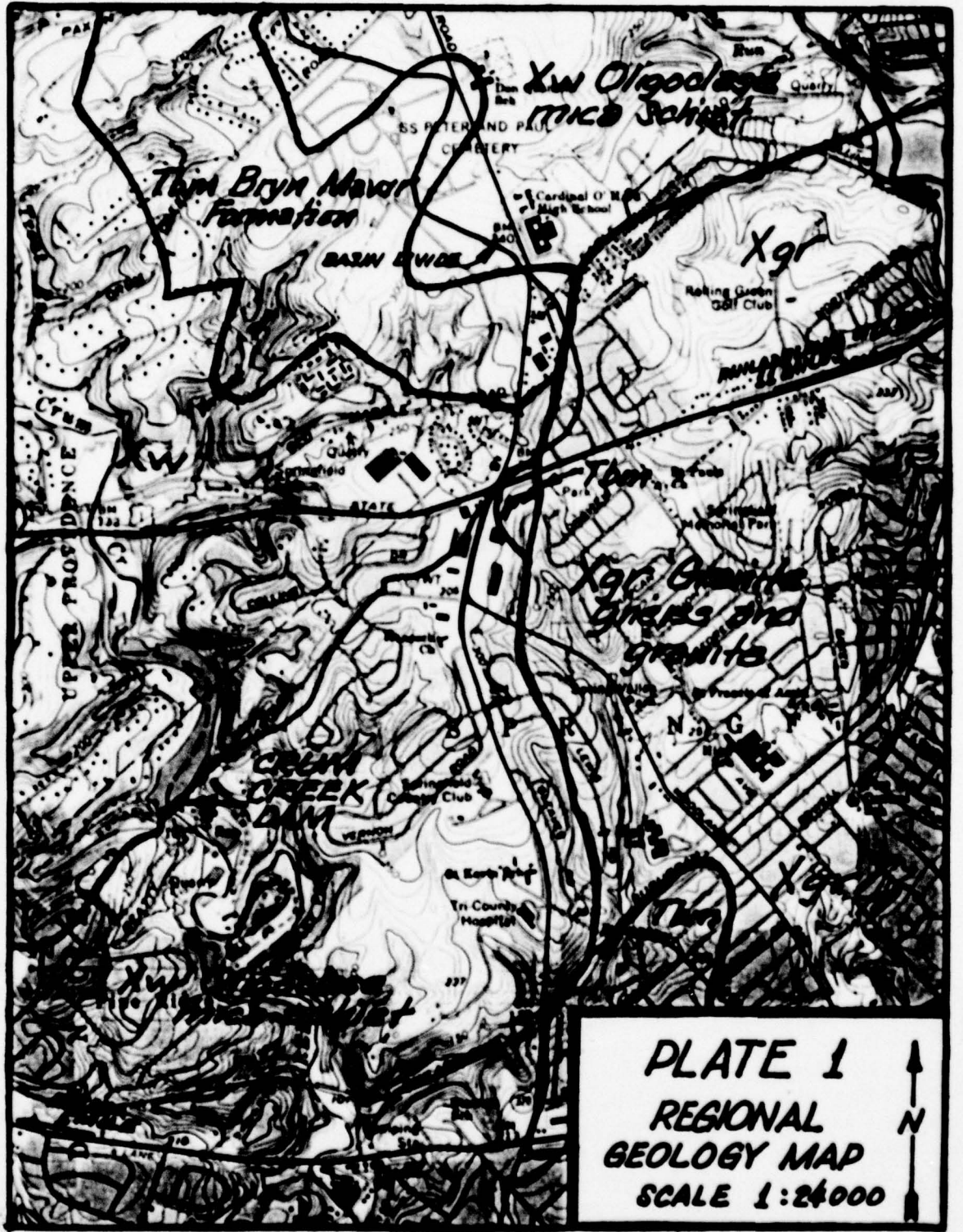
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Site Geology

SITE GEOLOGY

CRUM CREEK DAM

Crum Creek is located in the Uplands section of the Piedmont physiographic province. The structure was constructed upon a shallow stratum of unconsolidated stream alluvium. The underlying bedrock consists of mica schist which is a unit of the Paleozoic Wissahickon formation. No faults or major structural defects are noted in the vicinity of the dam or reservoir.



APPENDIX

G

Structural Stability Data

TABLE OF CONTENTS - APPENDIX G

SUMMARY OF STABILITY ANALYSES (PROVIDED BY DER) SHEET 1

STABILITY ANALYSES SHEET 2-15

CRUM CREEK DAM	SHEET 1	BY REH	DATE	JOB NO
----------------	------------	-----------	------	--------

- ORIGINAL DESIGN CALCULATIONS - SUMMARY

LOADING CONDITION	RESULTANT LOCATION	SLIDING SAFETY FACTOR
WSE = 117.0, No Uplift Base Elev. - 100.0 Base Width - 12.9'	5.23'	.55 = $\frac{\Sigma H}{\Sigma V}$
Reservoir Empty Base Elev. - 100.0 Base Width - 12.9'	4.98'	N/A
WSE = 117.0, No Uplift Base Elev. - 87.0 Base Width - 22.0'	8.53'	.57
WSE = 117.0, Uplift Base Elev. - 87.0 Base Width - 22.0'	8.28'	.67
Reservoir Empty Base Elev. - 87.0 Base Width - 22.0'	8.04'	N/A

Information provided by DER

SUBJECT CRUM CREEK DAM	SHEET 2	BY REH	DATE	JOB NO
---------------------------	------------	-----------	------	--------

— ASSUMPTIONS FOR STABILITY ANALYSES —

- MASONRY DENSITY 145 PCF
- SILT DENSITY, SUBMERGED 60 PCF
- EARTH PRESSURE COEFFICIENT 0.33
- SHEAR RESISTANCE AT DAM/

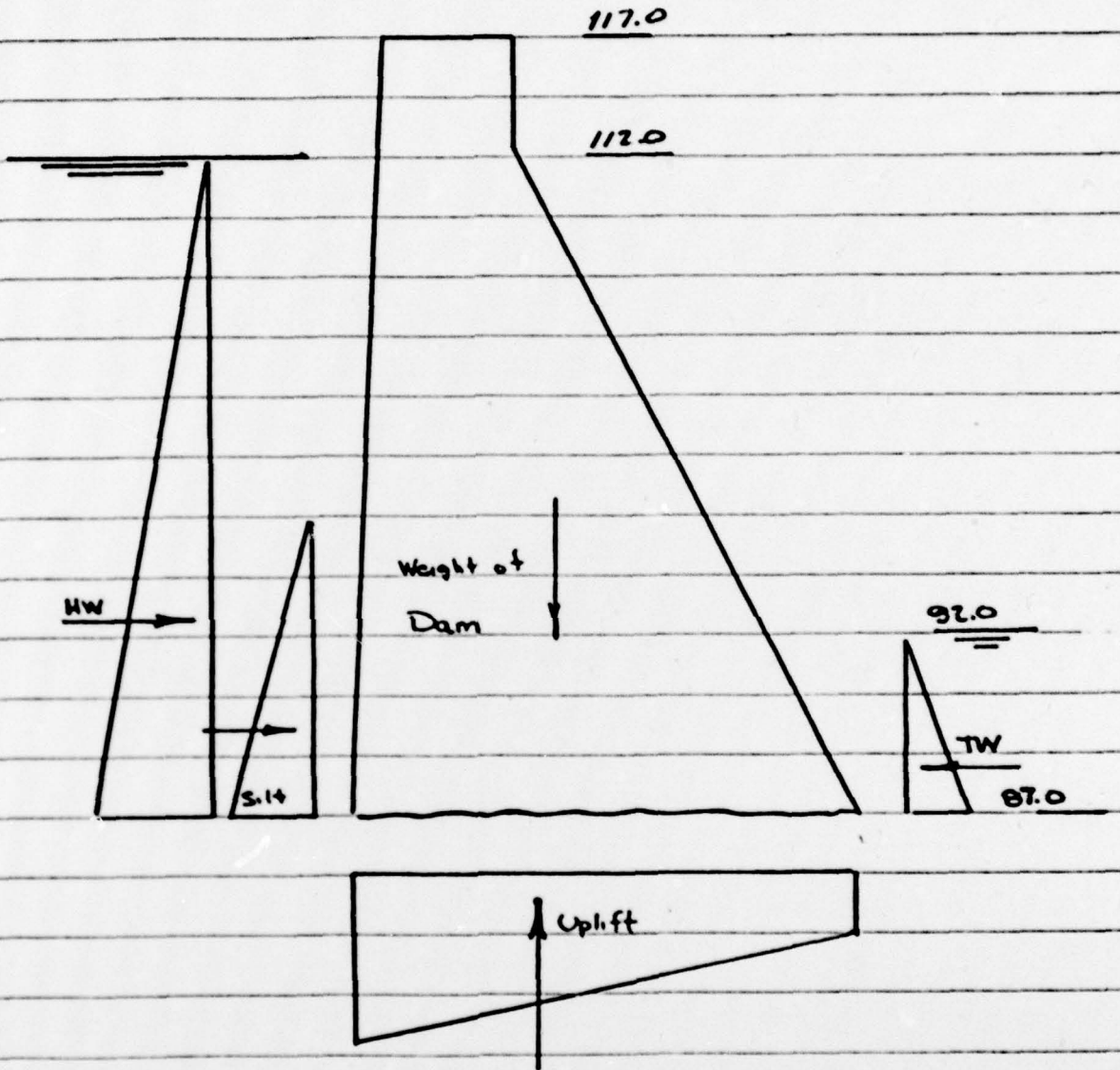
FOUNDATION INTERFACE

- COEFFICIENT OF FRICTION AT 0.60

DAM/FOUNDATION INTERFACE

- ICE PRESSURE (ONE FOOT THICK) 5,000 PSF
- EARTHQUAKE ACCELERATION 0.025 g
- ANY STABILIZING EFFECTS DUE TO PASSIVE EARTH PRESSURES HAVE NOT BEEN CONSIDERED

SUBJECT CRUM CREEK DAM	SHEET 3	BY REH	DATE	JOB NO
----------------------------------	-------------------	------------------	------	--------



— LOADING DIAGRAM FOR NORMAL P.O.U.L —

PROJECT	SHEET	BY	DATE	JOB NO.
CRUM CREEK DAM	4	REH		

STABILITY ANALYSES SUMMARY - NON-OVERFLOW SECTION

LOADING CONDITION	RESULTANT LOCATION ¹	BASE PRESSURES - PSI -	SAFETY FACTORS	
			Over- turning	Sliding
Normal Pool W.S.E. = 112.0	9.2	14.28 4.58	1.6	8.5
Normal Pool with Ice Load	5.96	23.05 - 3.76	1.3	7.3
PMF W.S.E. = 124.0	- 13.38	28.93 - 21.33	.8	5.2
1/2 PMF W.S.E. = 119.3	0.28	21.33 - 10.46	1.0	6.4
Normal Pool with Earthquake	8.57	15.88 2.98	1.5	7.8

¹ Resultant Location - Distance in feet from toe of dam
Base Width = 22.2 ft.



PROJECT	SHEET	BY	DATE	JOB NO.
CRUM CREEK DAM	5	REH		

STABILITY ANALYSES SUMMARY - SPILLWAY SECTION

LOADING CONDITION	RESULTANT LOCATION ¹	BASE PRESSURES - PSI -	SAFETY FACTORS	
			Over- turning	Sliding
Normal Pool W.S.E. = 112.0	7.76	15.64 .80	1.4	8.4
Normal Pool with Ice Load	4.1	24.41 - 7.54	1.2	7.2
PMF W.S.E. = 124.0	-18.73	23.45 - 18.28	.8	5.6
1/2 PMF W.S.E. = 119.3	-2.08	19.26 - 10.82	1.0	6.7
Normal Pool with Earthquake	7.14	17.02 - .58	1.4	7.7

¹ Resultant Location - Distance in feet from toe of dam
Base Width = 22.2 ft.

.....
 CRUM CREEK DAM NON-OVERFLOW SECTION
 NORMAL POOL - ELEV. 112.0

.....
 C BASE ELEVATION= 87.00FT. TOP ELEVATION= 117.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
 HEADWATER ELEVATION= 112.00FT. TAILWATER ELEVATION= 92.00FT. EARTHQUAKE ACCELERATION= .000G (HOR:Z), .000G (VERT)
 SILT ELEVATION= 102.00FT. SILT DENSITY(SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT(K)= .33
 SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	50.93	14.36	731.24	162.34
HEADWATER	19.20	8.32		
TAILWATER	.70	1.66	1.30	261.90
UPLIFT	20.70	13.57		11.24
SILT	2.25	5.00
			732.83	455.48

.....
 C NET HORIZONTAL FORCE= 20.97 KIPS
 NET VERTICAL FORCE= 30.15 KIPS
 NET MOMENT= 277.33KIP-Feet
 A-BAR OF FOUNDATION REACTION= 9.20 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 1.90 FEET
 FOUNDATION REACTION PRESSURES= 14.20 PSI:.....SHELL= 4.50 PSI:.....
 OVERTURNING FACTOR OF SAFETY= 1.61
 SLIDING FACTOR OF SAFETY= .86
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .70
 SLIDING WITH SHEAR FACTOR OF SAFETY= 8.49(SHEAR ACROSS FULL BASE WIDTH)

.....
 CRUM CHECK DAM NON-OVERFLOW SECTION
 NORMAL FLOOD WITH ICE LOAD

BASE ELEVATION= 87.00FT. TOP ELEVATION= 117.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
 HEADWATER ELEVATION= 111.00FT. TAILWATER ELEVATION= 92.00FT. EARTHQUAKE ACCELERATION= 0.00G (HORIZ)..000G (VERT)
 SILT ELEVATION= 102.00FT. SILT DENSITY(SUBMERGED)= 80.00PCF SILT PRESSURE COEFFICIENT(K)= .33
 SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	50.93	14.34	731.24	143.63
HEADWATER	17.97	7.99		
TAILWATER	.78	1.64		
UPLIFT	20.09	13.52	1.30	271.65
SILT	2.25	5.00		11.24
ICE LOAD	5.00	24.50		122.50
			732.83	549.02

.....
 NET HORIZONTAL FORCE= 24.44 KIPS
 NET VERTICAL FORCE= 30.04 KIPS
 NET MOMENT= 183.62KIP-Feet
 X-BAR OF FOUNDATION REACTION= 5.96 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 3.14 FEET

FOUNDATION REACTION PRESSURES= 23.05 PSI @HEEL -3.76 PSI @TOE
 OVERTURNING FACTOR OF SAFETY= 1.33
 SLIDING WITH SHEAR FACTOR OF SAFETY= 7.30(SHEAR ACROSS FULL BASE WIDTH)
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .79

CRUP CREEK DAM NON-OVERFLOW SECTION
 ONE HALF PMF - ELEV. 119.3

BASE ELEVATION= 87.00FT. TOP ELEVATION= 117.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
 HEADWATER ELEVATION= 119.30FT. TAILWATER ELEVATION= 103.15FT. EARTHQUAKE ACCELERATION= 0.000G (HORIZ) .000G (VERT)
 SILT ELEVATION= 102.00FT. SILT DENSITY (SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT= .33
 SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	50.93	14.36	731.54	345.38
HEADWATER	32.39	10.66		
TAILWATER	8.14	5.38	43.74	413.89
UPLIFT	33.56	12.33		11.24
SILT	2.05	5.00		
			775.30	770.51

NET HORIZONTAL FORCE= 24.50 KIPS
 NET VERTICAL FORCE= 17.37 KIPS
 NET MOMENT= 4.79 KIP-FEET
 X-BAR OF FOUNDATION REACTION= .29 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 10.82 FEET
 FOUNDATION REACTION REACTION NOT IN CENTRAL THIRD OF BASE
 FOUNDATION REACTION PRESSURES AT HEEL OF DAM= 21.33 PSI
 OVERTURNING FACTOR OF SAFETY= 1.01
 SLIDING FACTOR OF SAFETY= 1.39
 DEVELOPED FRICTION FACTOR (NO SHEAR)= 1.53
 SLIDING WITH SHEAR FACTOR OF SAFETY= 4.43 (SHEAR ACROSS FULL BASE WIDTH)

.....
 CROM CREEK DAM NON-OVERFLOW SECTION
 NORMAL POOL WITH EARTHQUAKE

BASE ELEVATION= 87.00FT, TOP ELEVATION= 117.00FT, BASE WIDTH= 22.20FT, DENSITY= 145.00PCF
 HEADWATER ELEVATION= 112.00FT, TAILWATER ELEVATION= 92.00FT, EARTHQUAKE ACCELERATION= 0.25G (HORIZ), .000G (VERT)
 SILT ELEVATION= 102.00FT, SILT DENSITY(SUBMERGED)= 40.00PCF, SILT PRESSURE COEFFICIENT(K)= .33
 SHEAR STRESS= 50.00PSI, SHEAR WIDTH= 22.20FT, FRICTION FACTOR= .40

LOADING	FORCE(KIPS)	ARM(Feet)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	50.93	14.34	731.54	142.34
HEADWATER	19.50	6.32		
TAILWATER	.78	1.44	1.30	
UPLIFT	20.78	13.57		281.90
EARTHQUAKE INDUCED LOADINGS				
.....				
INERTIA-WATER	.53	10.00		5.31
HORIZONTAL INERTIA-DAM	1.27	10.72		13.65
.....				
SILT	2.25	5.00		11.24
.....				
			737.83	474.44

.....
 NET HORIZONTAL FORCE= 22.77 KIPS
 NET VERTICAL FORCE= 30.15 KIPS
 NET MOMENT= 258.40KIP-Feet
 X-BAR OF FOUNDATION REACTION= 9.57 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 2.53 FEET
 FOUNDATION REACTION PRESSURES= 15.90 PSI/HEEL= 2.98 PSI/TIE
 OVERTURNING FACTOR OF SAFETY= 1.54
 SLIDING FACTOR OF SAFETY= .79
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .74
 SLIDING WITH SHEAR FACTOR OF SAFETY= 7.01(SHEAR ACROSS FULL BASE WIDTH)
 NUMBER OF STATIONS TO DESCRIBE DAM= 5
 STATION ELEVATION

.00	87.00
16.70	117.00
16.70	117.00
20.70	117.00
22.20	87.00

.....
 CRUM CREEK DAM - SPILLWAY SECTION
 NORMAL POOL - ELEV. 112.0

BASE ELEVATION= 87.00FT. TOP ELEVATION= 112.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
 HEADWATER ELEVATION= 112.00FT. TAILWATER ELEVATION= 92.00FT. EARTHQUAKE ACCELERATION= 0.000G (HORIZ)..000G (VERT)
 SILT ELEVATION= 102.00FT. SILT DENSITY (SUBMERGED)= 80.00PCF. SILT PRESSURE COEFFICIENT= .33
 SHEAR STRESS= 50.00PSI. SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE (KIPS)	ARM (FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	47.04	13.59	638.18	182.34
HEADWATER	19.50	8.32		
TAILWATER	.78	1.66	1.30	281.90
UPLIFT	20.78	13.27		11.24
SILT	2.25	5.00		0.000000
			659.48	455.48

.....
 NET HORIZONTAL FORCE= 20.97 KIPS
 NET VERTICAL FORCE= 24.28 KIPS
 NET MOMENT= 204.00KIP-Feet
 X-BAR OF FOUNDATION REACTION= 7.74 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 3.34 FEET
 FOUNDATION REACTION PRESSURES= 15.64 PSI= 0.000000 SHEEL= .80 PSI= 0.000000
 OVERTURNING FACTOR OF SAFETY= 1.45
 SLIDING FACTOR OF SAFETY= .75
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .80
 SLIDING WITH SHEAR FACTOR OF SAFETY= 8.18 (SHEAR ACROSS FULL BASE WIDTH)

CAUM CREEK DAM - SPILLWAY SECTION
 NORMAL POOL WITH ICE LOAD

BASE ELEVATION= 87.00FT. TOP ELEVATION= 112.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
 HEADWATER ELEVATION= 111.00FT. TAILWATER ELEVATION= 92.00FT. EARTHQUAKE ACCELERATION= 0.0000 (HORZ) .0000 (VERT)
 SILT ELEVATION= 102.00FT. SILT DENSITY (SUBMERGED)= 40.00PCF SILT PRESSURE COEFFICIENT(N)= .33
 SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	47.04	13.59	638.10	143.43
HEADWATER	17.97	7.99		
TAILWATER	.78	1.44		
UPLIFT	20.09	13.52	1.30	271.65
SILT	2.25	5.00		11.24
ICE LOAD	5.00	24.50		122.50
			659.48	549.02

NET HORIZONTAL FORCE= 24.44 KIPS
 NET VERTICAL FORCE= 26.97 KIPS
 NET MOMENT= 110.47KIP-Feet
 X-BAR OF FOUNDATION REACTION= 4.10 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 7.00 FEET
 FOUNDATION REACTION REACTION NOT IN CENTRAL THIRD OF BASE
 FOUNDATION REACTION PRESSURES= 24.41 PSI HEEL= -7.54 PSI
 OVERTURNING FACTOR OF SAFETY= 1.20
 SLIDING FACTOR OF SAFETY= .48
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .91
 SLIDING WITH SHEAR FACTOR OF SAFETY= 7.20(SHEAR ACROSS FULL BASE WIDTH)

CRUM CREEK DAM - STILLWATER SECTION
 PROBABLE MAXIMUM FLOOD - ELEV. 174.0

BASE ELEVATION= 87.00FT. TOP ELEVATION= 112.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
 HEADWATER ELEVATION= 124.00FT. TAILWATER ELEVATION= 106.00FT. EARTHQUAKE ACCELERATION= .0000 (HORIZ)...0000 (VERT)
 SILT ELEVATION= 102.00FT. SILT DENSITY (SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT (K)= .33
 SHEAR STRESS= 50.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .40

LOADING	FORCE (KIPS)	ARM (FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	47.04	13.99	658.10	396.50
HEADWATER	38.22	10.37		
TAILWATER	11.26	6.33	71.26	476.67
UPLIFT	18.79	12.29		11.24
SILT	2.25	5.00		884.41

NET HORIZONTAL FORCE= 29.20 KIPS
 NET VERTICAL FORCE= 8.27 KIPS
 NET MOMENT= -154.87 KIP-Feet
 X-CENTR. OF FOUNDATION REACTION= -18.73 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 29.83 FEET
 FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE
 FOUNDATION REACTION PRESSURES= 23.45 PSI
 OVERTURNING FACTOR OF SAFETY= .62
 SLIDING FACTOR OF SAFETY= .17
 DEVELOPED FRICTION FACTOR (NO SHEAR)= 3.23
 SLIDING WITH SHEAR FACTOR OF SAFETY= 2.64 (SHEAR ACROSS FULL BASE WIDTH)

CRUM CREEK DAM - SPILLWAY SECTION
 ONE HALF PMF - ELEV. 119.3

BASE ELEVATION= 87.00FT. TOP ELEVATION= 112.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
 HEADWATER ELEVATION= 119.30FT. TAILWATER ELEVATION= 103.15FT. EARTHQUAKE ACCELERATION= 0.000G (HORIZ), 0.000G (VERT)
 SILT ELEVATION= 102.00FT. SILT DENSITY (SUBMERGED)= 40.00PCF SILT FRICTION COEFFICIENT(A)= .33
 SHEAR STRESS= 20.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .40

LOADING	FORCE (KIPS)	ARM (FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	47.26	13.99	658.18	304.85
HEADWATER	30.89	9.87		
TAILWATER	8.14	5.30	43.76	
UPLIFT	33.26	12.33		413.89
SILT	2.25	5.00		11.24
			701.95	729.97

NET HORIZONTAL FORCE= 25.00 KIPS
 NET VERTICAL FORCE= 13.50 KIPS
 NET MOMENT= -28.00 FT-KIPS
 X-DIR OF FOUNDATION REACTION= -2.08 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 13.18 FEET
 FOUNDATION REACTION PRESSURES AT HEEL OF DAM= 19.26 PSIF AT HEEL, -10.82 PSIF AT TOE
 FOUNDATION REACTION PRESSURES AT TOE= 19.26 PSIF AT HEEL, -10.82 PSIF AT TOE
 OVERTURNING FACTOR OF SAFETY= .96
 SLIDING FACTOR OF SAFETY= .22
 DEVELOPED FRICTION FACTOR (NO SHEAR)= 1.05
 SLIDING WITH SHEAR FACTOR OF SAFETY= 6.72 (SHEAR ACROSS FULL PAGE WIDTH)

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 CRUM CREEK DAM - SPILLWAY SECTION
 NORMAL POOL WITH EARTHQUAKE

BASE ELEVATION= 87.00FT. TOP ELEVATION= 112.00FT. BASE WIDTH= 22.20FT. DENSITY= 145.00PCF
 HEADWATER ELEVATION= 112.00FT. TAILWATER ELEVATION= 92.00FT. EARTHQUAKE ACCELERATION= .025G (HORIZ) .000G (VERT)
 SILT ELEVATION= 102.00FT. SILT DENSITY(SUBMERGED)= 60.00PCF SILT PRESSURE COEFFICIENT(K)= .33
 SHEAR STRESS= 20.00PSI SHEAR WIDTH= 22.20FT. FRICTION FACTOR= .60

LOADING	FORCE(KIPS)	ARM(Feet)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	47.04	13.99	658.18	162.34
HEADWATER	19.50	8.32		
TAILWATER	.78	1.66	1.30	281.90
UPLIFT	20.78	13.57		
EARTHQUAKE INDUCED LOADINGS				
.....				
INERTIA-WATER	.53	10.00		5.31
HORIZONTAL INERTIA-DAM	1.18	9.40		11.06
.....				
SILT	2.25	5.00		11.24
.....				
			659.48	471.66

NET HORIZONTAL FORCE= 22.68 KIPS
 NET VERTICAL FORCE= 26.128 KIPS
 NET MOMENT= 187.63 KIP-Feet
 X-PAR OF FOUNDATION REACTION= 7.14 FEET
 ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 3.96 FEET
 FOUNDATION REACTION NOT IN CENTRAL THIRD OF DAM
 FOUNDATION REACTION PRESSURES AT HEEL OF DAM= 17.02 PSIF
 OVERTURNING FACTOR OF SAFETY= 1.40
 SLIDING FACTOR OF SAFETY= 1.70
 DEVELOPED FRICTION FACTOR (NO SHEAR)= .86
 SLIDING WITH SHEAR FACTOR OF SAFETY= 7.74(SHEAR ACROSS FULL BASE WIDTH)
 NUMBER OF STATIONS TO DESCRIBE DAM= 5

STATION	ELEVATION
.00	87.00
14.30	108.50
16.60	112.00
21.00	109.70
22.20	87.00