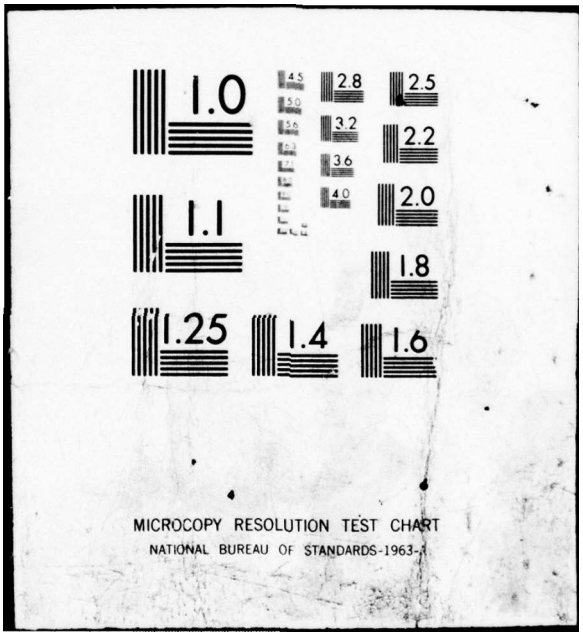
AD-A070 613 BERGER ASSOCIATES INC HARRISBURG PA F/G 13/2
NATIONAL DAM INSPECTION PROGRAM. SWEET ARROW LAKE DAM (NDI-PA-0--ETC(U)
APR 79 DACW31-79-C-0012
UNCLASSIFIED NL

1 OF 2
AD A070613


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SUSQUEHANNA RIVER BASIN

SWEET ARROW LAKE DAM

NDI NO. PA-00680
DER NO. 54-102

SCHUYLKILL COUNTY, PENNSYLVANIA

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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

BY

Berger Associates, Inc.
Harrisburg, Pennsylvania

APRIL 1979

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DDC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

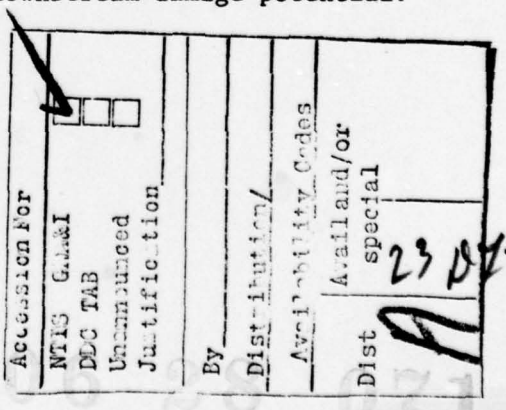
PREFACE

This report has been 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. 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 evoluntionary 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.



PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

BRIEF ASSESSMENT OF GENERAL CONDITIONS AND RECOMMENDATIONS

Name of Dam:	SWEET ARROW LAKE DAM, NDS NO. PA-00680
State & State No.	PENNSYLVANIA, 54-102
County:	SCHUYLKILL
Stream:	UPPER LITTLE SWATARA CREEK
Date of Inspection:	November 8, 1978

Based on the visual inspection, past performance and the available engineering data, the dam and its appurtenant structures appear to be in fair condition.

In accordance with the Corps of Engineers' evaluation guidelines the combination of storage and spillway capacity is capable of passing only 32 percent of the Probable Maximum Flood (PMF) and the spillway is considered to be seriously inadequate. The dam in its present condition is considered to be unsafe, non-emergency.

The following recommendations are made for action by the owner:

1. That a detailed engineering investigation be conducted by a professional engineer, qualified in the design of dam construction, to determine what measures should be taken to improve the capacity of the spillway.

2. That the top of dam and the downstream slope be provided with a protective cover. (11) Apr 79

3. That a procedure be developed and implemented to provide regular maintenance of the embankment slopes and spillway, including the removal of trees and brush on slopes. (12) 114p

4. That the footbridge be supplied with a safe walking platform, and a manhole cover be installed on the intake tower platform.

5. That the blowoff facilities be operated and serviced at least twice a year.

6. That a formal surveillance and downstream warning system be developed to be used during periods of high or prolonged precipitation.

SUBMITTED BY:

BERGER ASSOCIATES, INC.
HARRISBURG, PENNSYLVANIA

DATE: April 6, 1979

APPROVED BY:

G. E. WITHERS
Colonel, Corps of Engineers
District Engineer
DATE 22 Apr 79

OVERVIEW
SWEET ARROW LAKE DAM

TABLE OF CONTENTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

SWEET ARROW LAKE DAM

NDS-ID NO. PA-00680
DER-ID NO. 54-102

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 inspections of dams throughout the United States.

B. Purpose

The purpose is to determine if the dam constitutes a hazard to human life and property.

1.2 DESCRIPTION OF PROJECT

A. Description of Dam and Appurtenances

Sweet Arrow Lake Dam is an earthfill embankment with a maximum height of 35.5 feet. The length of the dam crest is about 480 feet. The ends of the embankment tie into the remains of an older and higher dam which failed, due to overtopping, in 1862. A cutoff trench was excavated to solid rock and a grout curtain was installed. The spillway, which has a crest elevation of 14.5 feet below the top of the dam is located in the west (left) abutment, and is separated by a high ridge from the embankment. The 50 feet wide spillway was excavated in rock and is unlined. An intake tower is located at the toe of the upstream slope. The intake is controlled by two 18-inch gate valves and the discharge is through a concrete conduit beyond the downstream toe of the dam.

ABSTRACT

B.	Location:	Pine Grove Township, Schuylkill County U.S.G.S. Quadrangle, Swatara Hill, PA Latitude 40°-34.2', Longitude 76°-22.0' (Appendix F, Plates I and II)
C.	Size Classification:	Intermediate (35.5 feet high, 3110 acre-feet)

D. Hazard Classification: High (Section 3.1.E)

E. Ownership: Borough of Pine Grove
17 Mifflin Street
Pine Grove, PA 17963

F. Purpose of Dam: Recreation

G. Design and Construction History:

The present dam was built on the site of a previous dam which had been constructed as a water supply dam for the Union Canal. That dam was probably about 10 feet higher than the present embankment and failed in June 1862, due to blocking of the spillway by a log jam. The breach width across the valley was about 200 feet as can be noticed from contours on Plate III, Appendix F.

The present dam was designed and constructed by the J. C. White Engineering and Construction Company, New York, for the East Penn Electric Company. The reservoir water was to be used for a power plant located about 3/4 mile downstream. The East Penn Electric Company was later acquired by the Pennsylvania Power and Light Company. The original design was slightly revised on the recommendation of PennDER and a permit for construction was issued on October 12, 1922. Construction started in early 1923 and was completed on December 10, 1923.

H. Normal Operating Procedures

The reservoir at present is used for recreation, fishing and boating. The Borough of Pine Grove acquired the dam for possible future use in their water supply system. All inflow is either stored or discharged over the spillway.

1.3 PERTINENT DATA

A. Drainage Area (square miles)

From files - 19.3
Computed for this report - 20.5

Use 20.5

B. Discharge at Dam Site (cubic feet per second)
See Appendix C for hydraulic calculations

Maximum known flood, since construction of dam, June 22, 1972 based on records for the U.S.G.S. gaging station, which is located 20 miles downstream from dam: 7,000

Outlet works low pool outlet at pool Elev. 534.0	10
Outlet works at pool level Elev. 548.0 (spillway crest)	34
Warm water outlet at pool Elev. 548.0 (spillway crest)	27
Spillway capacity at pool Elev.562.5 (top of dam)	8,200

C. Elevation (feet above mean sea level)

Top of dam	562.5
Spillway crest	548.0
Upstream portal invert (4.6'x 5.5' conduit)	523.0
Downstream portal invert (4.6' x 5.5' conduit)	522.1
Streambed at centerline of dam (Estimated)	527.0

D. Reservoir (miles)

Length of normal pool	1.3
Length of maximum pool	2.5

E. Storage (acre-feet)

Spillway crest (Elev. 548.0)	1,105
Top of dam (Elev. 562.5)	3,110

F. Reservoir Surface (acres)

Top of dam (Elev.562.5) from HEC-1	200
Spillway crest (Elev. 548.0)	92

G. Dam

Type: Homogeneous earthfill with a rockfill slope on the upstream side and a downstream rock toe drain.

Length: 480 feet.

Height: 35.5 feet.

Top Width: Total 12 feet consisting of 7 feet impervious material and 5 feet rockfill.

Side Slopes: Upstream - impervious material 2H to 1V
Rockfill 2.35H to 1V above elevation 548.0 and 3H to 1V below spillway crest elevation.

Downstream - 3H to 1V.

Zoning: Rockfill of variable width on upstream side.

Impervious Core: None.

Cutoff: Trench on centerline dam to solid rock with a concrete wall.

Grout Curtain: On centerline of trench, grout holes 20 feet deep on 8 feet centers.

H. Outlet Facilities

There is a eight-foot inside diameter intake tower located 95 feet upstream from the centerline of the dam. Access is by means of a single-span steel-truss bridge from the top of the dam. Water is admitted to the tower through two 18-inch gate valves with centerline elevations 537.0 and 532.5.

Water is released from the tower through a single 18-inch gate valve with centerline elevation of 530.5. Water flows from the discharge valve into the top of the outlet tunnel. The arch type, reinforced concrete tunnel has a cross sectional area of 20 square feet and is 220 feet long. It is uncontrolled at the downstream end and discharges into the natural channel of Upper Little Swatara Creek. The water is not used for any purpose and the valves have not been operated since 1961 (17 years).

I. Spillway

Type: Uncontrolled, unlined, broad crested weir and channel cut through a rock ridge about 120 feet from the left end of the dam.

Length of weir: 50 feet with vertical unlined rock walls.

Crest elevation: 548.0.

Upstream channel: The spillway channel bottom rises slightly for the first 80 feet from the reservoir and there is a slight riffle at the end of that reach. This riffle is the weir that determines the lake elevation at low flows. At greater flows, the lake elevation is determined by the channel friction in the first 200 feet of the channel.

Downstream channel: For the next 120 feet after the riffle, the channel bottom has a downstream slope of 0.0060. At a point about 400 feet from the lake there is a 20-foot high rocky falls which dissipates the stream energy. From that point, a channel with a flat slope returns the water to the natural stream. The total length of the cut is 430 feet with the highest walls being at the point of the riffle, about 80 feet from the lake. The total length of the spillway channel from the lake shore to the junction with the natural channel is about 1,200 feet.

J. Regulating Outlets

See Section 1.3.H.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

A. Hydrology and Hydraulics

The files of Pennsylvania Department of Environmental Resources (PennDER) did not contain hydraulic design data for this dam. The Report on application for construction of the dam states that the spillway capacity is 8,500 cfs which was considered ample.

B. Embankment

Design data and analysis for the embankment were not in the files of PennDER. The files of PennDER included, however, the construction drawings (Plates III and IV, Appendix F) and bi-weekly progress charts. The Report on application for construction describes the proposed construction. Test pits were excavated at numerous locations. The report indicates that at the left side, the subsurface was clay with old roots and on the right side clay was encountered on the upstream side and shaly gravel further downstream. Rock was, in general, 2 to 10 feet below the surface and consisted of fractured sandstone and some shale.

PennDER recommended that the cutoff trench be excavated to sound rock and that the rock be tested by drilling holes not farther than 50 feet apart and to pressure test these holes. If the rock strata was found to be pervious, the rock had to be grouted in holes 20 feet deep and not farther than 8 feet apart. A cutoff wall, 3 feet high, was to be constructed in the centerline of the trench.

The cutoff trench is located on the centerline of the dam except near the right abutment, where it curves upstream. The trench does not extend into the side hills beyond the abutments.

The dam was designed as a homogeneous embankment with a rockfill on the upstream side. Borrow material was obtained from the left side of the reservoir a short distance upstream of the dam and consisted of a sandy clay. A rock toe drain to elevation 537.0 is provided on the downstream side.

C. Appurtenant Structures

The only available design data is shown on the construction drawings in Appendix F. Design criteria is not available. The intake tower was founded on rock and is a reinforced concrete circular tower with two 18-inch gate valve controlled inlets. The water is discharged through another 18-inch gate valve into the top of an arch shaped reinforced concrete conduit. This conduit had a direct opening to the upstream

side of the tower during the construction phase, but this opening was blocked off with concrete after construction was completed. The conduit has four seepage collars and ends 10 feet beyond the downstream toe of the dam. Access to the intake tower is from the breast of the dam by a truss supported footbridge.

The spillway is located away from the dam and is excavated into rock. No lining was required and the discharge channel makes a plunge at about 400 feet from the beginning of the spillway and joins the old streambed 600 feet downstream from the dam. The channel was to be excavated on a slope of about 0.6 percent.

2.2 CONSTRUCTION

Construction of the dam and appurtenant structures was accomplished under supervision of a resident engineer. Bi-weekly progress charts are available in the files and one, dated November 15, 1923, is included as Plate V in Appendix F. Inspection reports by PennDER indicate that construction was done in accordance with the plans. Pressure testing of the rock strata after the trench was excavated, indicated the need for pressure grouting. Testing after the grouting was completed indicated that the grouting was effective. Plate V, Appendix F, shows that no grouting was done under the conduit because the conduit had been constructed before the cutoff trench was excavated. After construction was completed, inspection reports indicate that some seepage occurred adjacent to the conduit outlet.

2.3 OPERATION

No records of operation were available in the PennDER files. One letter indicates that the dam was nearly overtopped in August 1933. The Borough of Pine Grove bought the reservoir and dam from PP&L in 1973 for possible future use as a domestic water supply. At present, the reservoir is used for recreation only and the gate valves are not operated at all. Seepage has been noticed at the conduit outlet for many years. Inspection reports indicate that the downstream slope was never seeded or sodded.

2.4 EVALUATION

A. Availability

The available engineering data was limited to construction drawings and some reports by PennDER. Actual design criteria and design analysis were not in the files.

B. Adequacy

1. Hydrology and Hydraulics

There is not sufficient information available to evaluate the design criteria for this dam. However, the construction drawings are sufficient to review the hydraulic adequacy of this facility for this report.

2. Embankment

There is no data available on the soil parameters of the borrow material and no results of compaction tests. This prevents the review of the stability and seepage adequacy of the embankment. The embankment was, however, detailed in accordance with acceptable engineering practice.

3. Appurtenant Structures

The available construction drawings are sufficient to review the adequacy of the structures.

C. Operating Records

Formal operating records have not been maintained for these facilities. It appears that maintenance procedures have been lacking and that the gate valves have not been operated since 1961.

D. Post Construction Changes

No changes or additions have been reported since the construction was completed in 1923.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

A. General

The general appearance of Sweet Arrow Lake Dam is fair. Present maintenance procedures are limited. The dam and lake were acquired by the Borough of Pine Grove in 1973 from PP&L for future use as a water supply. At present, the lake is used for fishing only. The Pennsylvania Fish Commission stocks the reservoir. The inspection team was accompanied by Mr. Frank Winsheimer, Borough Council President and Mr. Harold Zimmerman, Works Manager of the Borough. The visual inspection check list is in Appendix A of this report. Photographs taken during the inspection are reproduced in Appendix E.

B. Embankment

The upstream embankment slope is protected with a rockfill, but a considerable amount of brush is growing on this slope. The breast of the dam was level and straight (see survey Appendix A) and consisted of dirt and some small gravel. The edges were rounded off, causing an uneven width. The downstream slope was covered with some grass, weeds, brush and small and large trees. Motor bike traffic has caused three bare tracks on the slope and these tracks are susceptable to erosion. The dam was constructed on the site of a previous dam and the remnants of this old dam, which was higher than the present one, are easy to detect where the new dam ties into the hillside. The downstream slope was dry except two pools of standing water at the toe. No movement of water was detected and the amount of seepage is probably minimal. One pool was the outlet for the conduit. A rock toe drain is visible.

C. Appurtenant Structures

The intake tower is located about half way between the abutments of the dam and is accessible by a footbridge. Most of the planking on the steel truss bridge has disappeared and the inspector had to climb along the truss chord to check the intake tower. The manhole cover on the tower was missing and the owners representatives stated that the valves had not been operated since 1961. In 1974 an effort was made to operate the valves, but no movement was obtained. The valves are on 18-inch pipes and if operable, could be used to draw down the reservoir to an elevation of 531.0.

The conduit outlet ends in a small pool, which is closed off by a dirt access road (See Plate A-II, Appendix A), and prevents a free flow. Considerable siltation has occurred in the conduit. It appears, however, that sufficient opening is still available in the large conduit to pass the discharge flow of the 18-inch upstream blowoff valve.

The spillway is located in the left hillside beyond the previous dam abutment. The channel is cut in the rock and was in good condition. There is no concrete weir and some brush near the left entrance causes a small obstruction. The discharge channel is rather flat over the first 300 feet and then drops vertically over natural rock to the stream.

D. Reservoir Area

Some of the banks around the reservoir are steep and wooded. A highway parallels the north bank of the lake (Plate II, Appendix F). The reservoir banks on that side of the reservoir are flat and used as farmland. All banks are stable and no sedimentation has been reported.

E. Downstream Channel

The spillway channel joins the natural stream about 600 feet downstream from the dam. This stream, with wooded banks, crosses a highway another 1500 feet further downstream. Several houses are located near the stream in this area and it is expected that the hazard to loss of life would increase significantly if the dam would fail due to overtopping. The hazard category is therefore considered to be "High".

3.2 EVALUATION

The dam and appurtenant works appear to be in need of maintenance. The structural integrity of the dam appears to be good, but preventive maintenance is required. Brush and trees should be removed from the slopes, tracks and the top of the dam should be seeded. Access to the intake tower should be provided by installing planking and the gate valves on the 18-inch pipes should be made operable.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURE

The dam and reservoir were bought by the Borough for possible future use as a domestic water supply. At present the reservoir is used for fishing and picnicking and no operational procedures have been established.

4.2 MAINTENANCE OF DAM

Maintenance is presently not performed on the dam embankment.

4.3 MAINTENANCE OF OPERATING FACILITIES

At present the facilities are not used and no maintenance procedures exist.

4.4 WARNING SYSTEM

A formal warning system or surveillance procedure has not been established. The dam is policed, but no regular visitation by Borough personnel is maintained.

4.5 EVALUATION

Operational procedures do not exist at the present time. It is recommended that a regular maintenance schedule for the embankment and operating facilites be developed. A formal surveillance and downstream warning system should be established to be used during periods of heavy or prolonged precipitation.

SECTION 5 - HYDROLOGY/HYDRAULICS

5.1 EVALUATION OF FEATURES

A. Design Data

The hydrologic and hydraulic analyses available from PennDER for Sweet Arrow Lake Dam were not very extensive. No frequency curve, unit hydrograph, nor flood routings were submitted by the designer to PennDER. A Pennsylvania Water Supply Commission report in the file stated that the spillway capacity was 8,500 cfs or 450 cfs per square mile. It was further stated that it would take 4-1/2 to 5 hours to overtop the dam if the runoff were to be 500 cfs per square mile.

B. Experience Data

The present dam was built in 1923 to supply cooling water for a coal-fired generating plant of the East Penn Electric Company (now PP&L). Calculations based on the records of the U.S.G.S. gaging station at Harper Tavern indicate that the greatest flood since 1923 occurred on June 22, 1972 and produced an inflow to the reservoir of about 7,000 cfs. The project passed that flood without damage.

C. Visual Observations

On the date of the inspection, no conditions were observed that would indicate that the appurtenant structures of the dam could not operate satisfactorily during a flood event, until the dam is overtopped.

There is some brush growing in the spillway channel which should be removed.

D. Overtopping Potential

Sweet Arrow Lake Dam has a total storage capacity of 3,110 acre-feet and an overall height of 35.5 feet, both referenced to the top of the dam. These dimensions indicate a size classification of "Intermediate". The hazard classification is "High" (see Section 3.1.E).

The recommended Spillway Design Flood (SDF) for a dam having the above classifications is the Probable Maximum Flood (PMF). For this dam, the PMF peak inflow is 29,817 cfs (see Appendix C for HEC-1 inflow computations).

Comparison of the estimated PMF peak inflow of 29,817 cfs with the estimated spillway discharge capacity of 8,030 cfs indicates that a potential for overtopping of the Sweet Arrow Lake Dam exists.

An estimate of the storage effect of the reservoir and routing of the computed inflow hydrograph through the reservoir shows that this dam does not have the necessary storage available to pass the PMF without overtopping. The spillway-reservoir system can pass a flood event equal to 32% of a PMF.

Improving the embankment by eliminating the low area in the top of the dam will not significantly increase the capacity of the spillway-reservoir system.

E. Dam Break Evaluation

The calculations to determine the behavior of the dam in the event of an overtopping and a resulting breaching of the embankment indicates a substantial increase in water levels downstream from the dam.

Several houses are located near the stream about 2,400 feet downstream from the dam where State Route 443 crosses the stream. On the basis of the results of a dam break analysis, using the U.S. Army Corps of Engineers' HEC-1 computer program, the water surface elevation in the vicinity of the houses would be about 533.3 when the water surface in the reservoir above the dam is just at the low point elevation of the embankment (no overtopping). (Refer to Table 1, Appendix C). It is expected that 34 percent of the PMF would cause the water level in the lake to reach an elevation that would result in a breach (.5 foot above crest elevation). Just prior to failure by the 34 percent PMF flow, the water surface elevation 2,400 feet downstream would be about 533.7. The increase due to overtopping under no failure condition would be about (533.7 - 533.3) .4 feet. While more property would be exposed to flooding, the increase to the danger of loss of life is not considered significant. With failure, however, the breaching analysis indicates a rise of 8.9 feet above the flow level just prior to breach when considering a 15 minute time to complete the breach and a 5.3 feet rise above flow level just prior to breach when considering a 2-hour time to complete the breach. The increase in hazard to loss of life and property damage is reflected not only in the increase in depth of water of about 8.9 feet in the 15-minute breach and about 5.3 feet in the 2-hour breach, but more significantly in the shorter time to reach the peak, less time would be available to respond to the flooding under the breach conditions.

Being an earth embankment, it is judged that a breach is likely to develop when the depth of flow over the crest is 0.5 foot or greater and that the breach will be completed between the 15 minute and the 2-hour period. The numerical difference of water levels is about

3.6 feet. The property damage would be similar with either time. Again, however, the time factor is most significant regarding loss of life. Calculations indicate that the water depth will increase at a rate of about 8.9 feet in one-half hour under the 15-minute breach condition.

F. Spillway Adequacy

The intermediate size category, in accordance with the Corps of Engineers criteria and guidelines, indicates that the Spillway Design Flood (SDF) for this dam should be the full Probable Maximum Flood (PMF).

Calculations show that the spillway discharge capacity and reservoir storage capacity combine to handle 32% of the PMF (Refer to Sheet 15 of Appendix C).

Since the spillway discharge and reservoir storage capacity cannot pass one-half of the PMF without overtopping and failure of the dam, and because the downstream hazard to loss of life is high and this hazard is significantly increased when the dam is overtopped as compared to just prior to overtopping, the spillway is judged to be seriously inadequate.

The hydrologic analysis for this investigation was based upon existing conditions of the watershed. The effects of future development were not considered.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

A. Visual Observation

1. Embankment

There were no visual indications of undue embankment stresses or sloughage and the slopes appear to be stable and adequate. To prevent further erosion of the downstream slope, this slope should be seeded. Seepage near the conduit outlet could not be observed due to the presence of a pool of water. The downstream slope was dry and no seepage was detected.

2. Appurtenant Structures

The spillway is in good condition and the rock cut does not appear to have an erosion problem. The discharge is at a considerable distance from the embankment and no damage could occur. Although deterioration of the concrete intake tower has occurred, the tower is considered to be in acceptable structural condition at the present. The gate valves are not operable at present and it is recommended that blowoff facilities should be made operable for emergencies.

B. Design and Construction Data

1. Embankment

The available construction data indicates that the embankment was designed and constructed in accordance with good engineering practice. The rock strata was not grouted under the conduit and this could allow some seepage at the downstream conduit outlet. The rock toe drain is also directing all seepage to this low point.

2. Appurtenant Structures

The available data indicates that all structures were well designed, detailed and adequately reinforced.

C. Operating Records

The only available records are inspection reports by PennDER, which indicate that the two main problems were the omission of seeding the downstream slope and some seepage near the conduit outlet. Brush and tree growth on the embankment slopes and in the spillway entrance have been reported repeatedly, indicating poor maintenance procedures.

D. Post Construction Changes

No reported modifications have been made to the original dam design.

C. Seismic Stability

This dam is located in Seismic Zone 1 and it is considered that the static stability is sufficient to withstand minor earthquake induced dynamic forces. No studies or calculations have been made to confirm this assumption.

SECTION 7 - ASSESSMENT AND RECOMMENDATIONS

7.1 DAM ASSESSMENT

A. Safety

The visual inspection, the review of available design data and the operational history indicates that Sweet Arrow Lake Dam is in fair condition and has been designed in accordance with acceptable engineering practice. The maintenance procedures for the embankment and facilities are poor.

In accordance with the Corps of Engineers' evaluation guidelines, the combination of storage and spillway capacity is sufficient to pass only 32 percent of the Probable Maximum Flood (PMF). Overtopping of the dam with an inflow of 34 percent of the PMF could cause failure of the dam. Such a failure would significantly increase the hazard to loss of life downstream. The spillway is, therefore, considered to be seriously inadequate, and the dam is unsafe, non-emergency.

B. Adequacy of Information

The available data is considered sufficient to make a reasonable assessment of the embankment and facilities.

C. Urgency

Because of the serious inadequacy of the spillway and the "High" hazard classification of the facilities, it is considered important that the recommendations presented in this report be implemented at once.

D. Necessity for Additional Studies

The results of this inspection indicate the need for additional detailed hydrologic and hydraulic studies to determine the requirements for improving the capacity of the dam.

7.2 RECOMMENDATIONS

A. Facilities

The following recommendations are presented for action by the owner:

1. That a detailed engineering investigation be conducted by a professional engineer, qualified in the design of dam construction, to determine what measures can be taken to improve the capacity of the spillway.

2. That the top of the dam and the downstream slope be provided with a protective cover against erosion.

3. That the footbridge be supplied with a safe walking platform.

4. That a manhole cover be provided on the intake tower.

B. Operation and Maintenance Procedures

It is recommended that the owner initiate the following maintenance procedures:

1. A regular maintenance procedure of the embankment slopes and crest of dam, which will include removal of trees, brush and high weeds.

2. A twice a year schedule of greasing and operation of the drawdown valves.

3. Removal of brush in the spillway entrance.

4. The development of a formal surveillance and downstream warning system to be used during periods of high or prolonged precipitation.

APPENDIX A

CHECKLIST OF VISUAL INSPECTION REPORT

CHECK LIST

PHASE I - VISUAL INSPECTION REPORT

PA DER # 54-102 NDI NO. PA-00 680

NAME OF DAM Sweet Arrow Lake HAZARD CATEGORY High

TYPE OF DAM Earthfill

LOCATION Pine Grove TOWNSHIP Schuylkill COUNTY, PENNSYLVANIA

INSPECTION DATE 11/8/78 WEATHER Cloudy TEMPERATURE 50's

INSPECTORS:	OWNER'S REPRESENTATIVE(s):
H. Jongsma (Recorder)	
A. Bartlett	Frank Zimmerman
R. Steacy	Harold Winsheimer

NORMAL POOL ELEVATION: 548.0 AT TIME OF INSPECTION:

BREAST ELEVATION: 562.5 POOL ELEVATION: 548.0+

SPILLWAY ELEVATION: 548.0 TAILWATER ELEVATION:

MAXIMUM RECORDED POOL ELEVATION: 553.7 (Estimated)

GENERAL COMMENTS:

Valves last opened in 1961. Have tried to open but no movement in 1974.
Conduit outlet underwater in a pool.
Used by Pennsylvania Fish Commission for fishing.
Bought in 1973 by Borough of Pine Grove from PP&L for possible use as water supply.

NDI NO. PA-00 680

VISUAL INSPECTION
EMBANKMENT

	OBSERVATIONS AND REMARKS
A. SURFACE CRACKS	None observed on breast of dam (dirt).
B. UNUSUAL MOVEMENT BEYOND TOE	None detected.
C. SLOUGHING OR EROSION OF EMBANKMENT OR ABUTMENT SLOPES	Three bike and erosion tracks on downstream slope. Abutments tie into previous dam abutment.
D. ALIGNMENT OF CREST: HORIZONTAL: VERTICAL:	Good. Irregular breast width due to rounding of edges. Good. (See survey sketch).
E. RIPRAP FAILURES	None.
F. JUNCTION EMBANKMENT & ABUTMENT OR SPILLWAY	Good abutment junctions. Spillway cut out of hillside and away from dam.
G. SEEPAGE	Pool at conduit outlet. No water movement noticeable.
H. DRAINS	Rockfill toe.
J. GAGES & RECORDER	None.
K. COVER (GROWTH)	Upstream - loose riprap and brush. Breast - dirt. Downstream - some grass, weeds, brush and trees.

NDI NO. PA-00 680

VISUAL INSPECTION
OUTLET WORKS

	OBSERVATIONS AND REMARKS
A. INTAKE STRUCTURE	Circular concrete tower on upstream side. Concrete top deteriorating. Manhole cover missing.
B. OUTLET STRUCTURE	Concrete conduit outlet underwater in a pool formed by roadway.
C. OUTLET CHANNEL	Blocked by roadway without a pipe. Wide valley available for discharge.
D. GATES	Three operator stands on top of tower. None operated since 1961.
E. EMERGENCY GATE	Not operable - 18" valve.
F. OPERATION & CONTROL	None.
G. BRIDGE (ACCESS)	Truss footbridge from top of dam. Most planking has disappeared. Hazardous to cross.

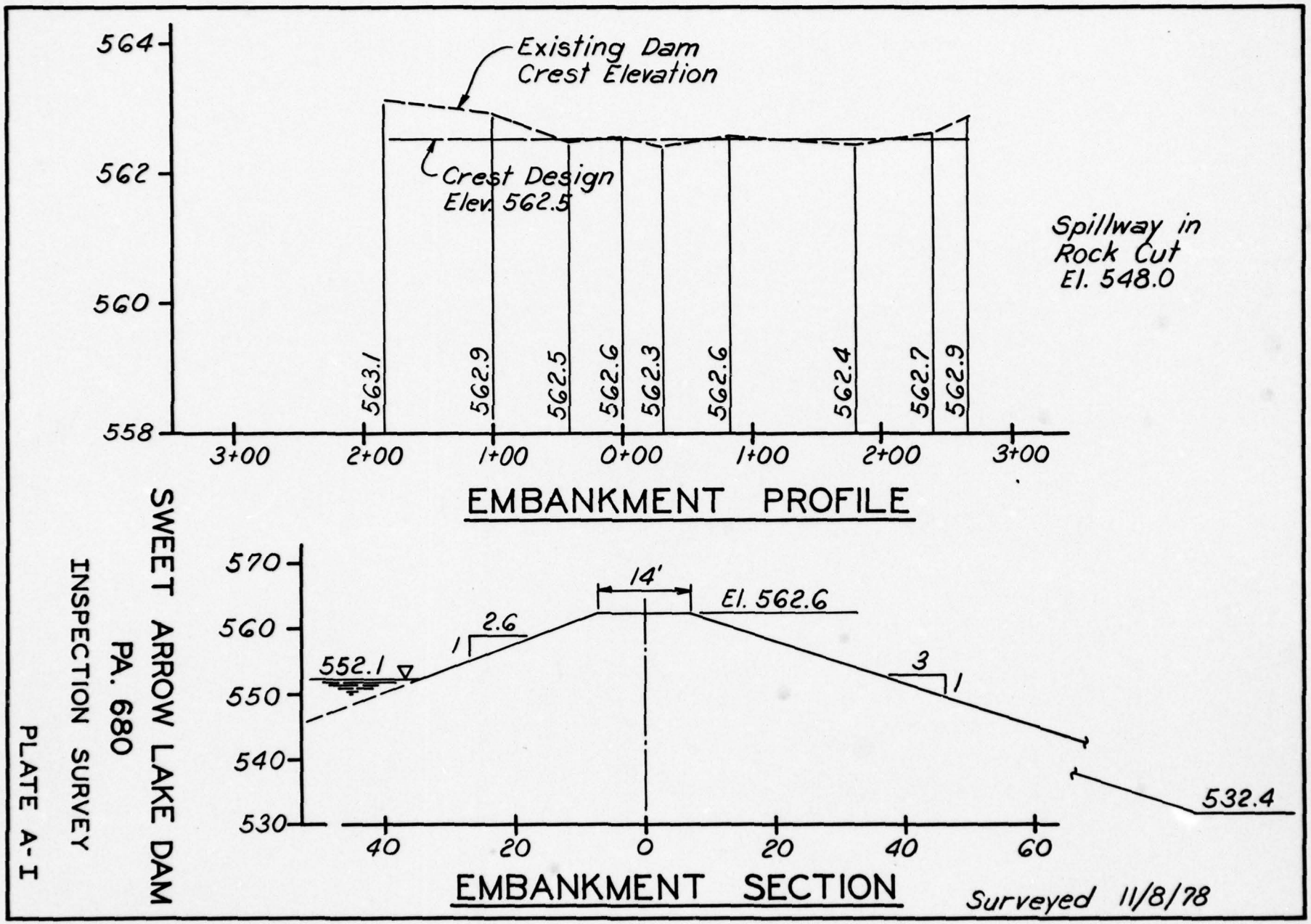
NDI NO. PA-00 680

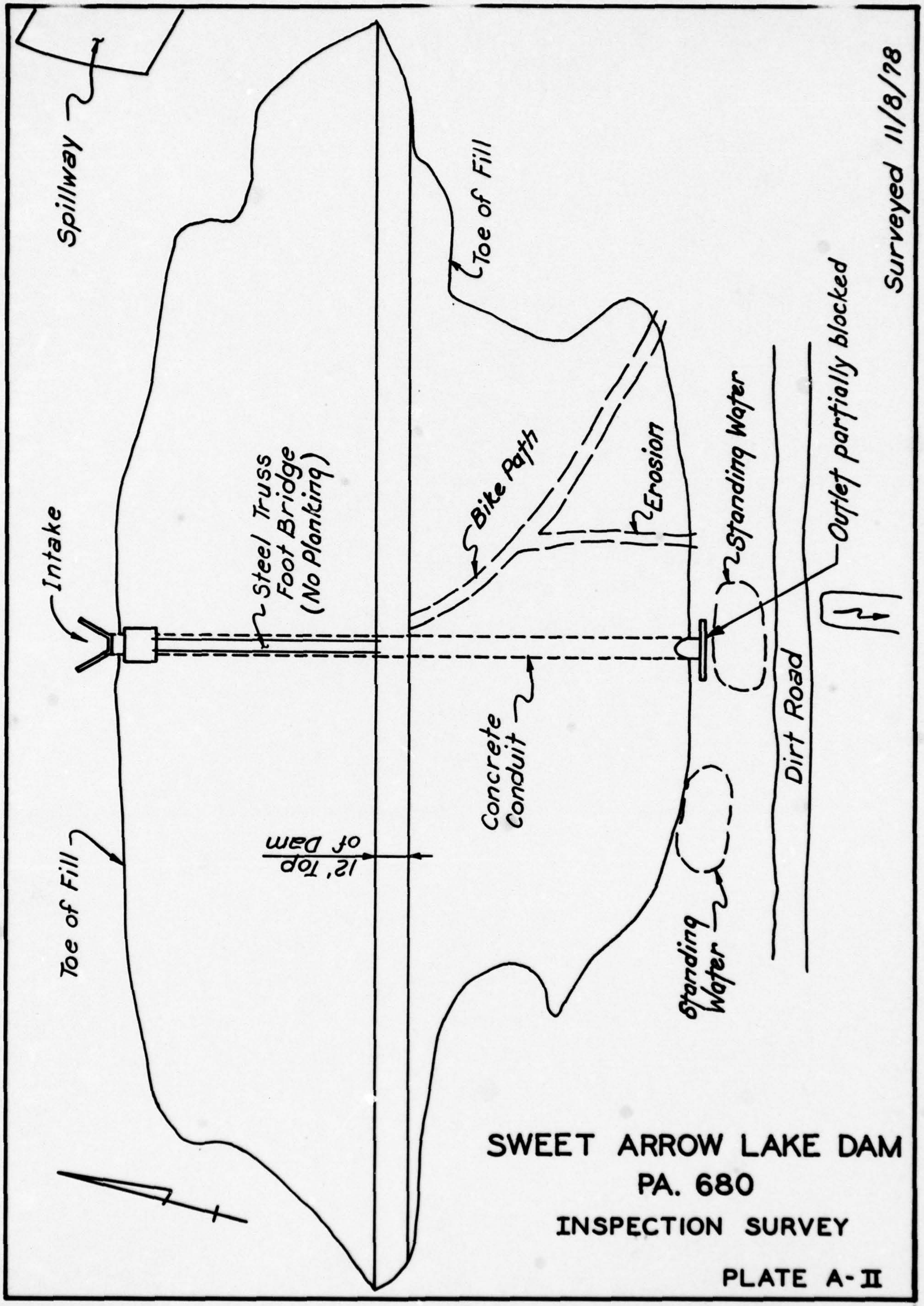
VISUAL INSPECTION
SPILLWAY

	OBSERVATIONS AND REMARKS
A. APPROACH CHANNEL	Cut in rock. Some brush growing near left abutment.
B. WEIR: Crest Condition Cracks Deterioration Foundation Abutments	None - rock cut.
C. DISCHARGE CHANNEL: Lining Cracks Stilling Basin	Cut in rock. Good condition. Drop of at least 15 feet at end in natural stream.
D. BRIDGE & PIERS	None.
E. GATES & OPERATION EQUIPMENT	None.
F. CONTROL & HISTORY	None. Maximum water surface estimated at 5.7 feet during Agnes (1972) above spillway (1 foot above road).

VISUAL INSPECTION

	OBSERVATIONS AND REMARKS
INSTRUMENTATION Monumentation	None.
Observation Wells	None.
Weirs	None.
Piezometers	None.
Staff Gauge	None.
Other	
RESERVOIR Slopes	Some steep, some flat in built up area (houses, roadway).
Sedimentation	None.
Watershed Description	Mostly farmland, except wooded in the mountains.
DOWNSTREAM CHANNEL Condition	Natural stream.
Slopes	Stable.
Approximate Population	200 in Pine Grove.
No. Homes	4 houses nearby.


564
562
560
558
Existing Dam
Crest Elevation
Crest Design
Elev. 562.5
563.1
562.9
562.5
562.6
562.3
562.6
562.4
562.7
562.9
3+00
2+00
1+00
0+00
1+00
2+00
3+00
Spillway in
Rock Cut
El. 548.0
EMBANKMENT PROFILE
570
560
550
540
530
14'
El. 562.6
2.6
1
552.1
3
1
532.4
40
20
0
20
40
60
EMBANKMENT SECTION
Surveyed 11/8/78
SWEET ARROW LAKE DAM
PA. 680
INSPECTION SURVEY
PLATE A-I



SWEET ARROW LAKE DAM
PA. 680
INSPECTION SURVEY

PLATE A-II

APPENDIX B

CHECKLIST OF ENGINEERING DATA

CHECK LIST
ENGINEERING DATA

PA DER # 54-102 NDI NO. PA-00 680

NAME OF DAM Sweet Arrow Lake

ITEM	REMARKS
AS-BUILT DRAWINGS	None.
REGIONAL VICINITY MAP	U.S.G.S. Quadrangle Swatara Hill, PA See Plate II, Appendix F
CONSTRUCTION HISTORY	Constructed by J.C. White Construction Corporation, New York in 1923 at the site of an older and higher dam, which failed in 1862.
GENERAL PLAN OF DAM	See Plate III, Appendix F.
TYPICAL SECTIONS OF DAM	See Plate III, Appendix F.
OUTLETS: PLAN DETAILS CONSTRAINTS DISCHARGE RATINGS	 See Plate III and IV, Appendix F. None. None.

NDI NO. PA-00 680

ENGINEERING DATA

ITEM	REMARKS
RAINFALL & RESERVOIR RECORDS	None.
DESIGN REPORTS	None, except Report on the application for permit to construct by DER.
GEOLOGY REPORTS	None.
DESIGN COMPUTATIONS: HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None.
MATERIALS INVESTIGATIONS: BORING RECORDS LABORATORY FIELD	None. Test pits on general plan show top of rock.
POST CONSTRUCTION SURVEYS OF DAM	None.
BORROW SOURCES	Probably on the left side upstream of the dam.

ENGINEERING DATA

ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	None.
HIGH POOL RECORDS	None.
POST CONSTRUCTION ENGINEERING STUDIES & REPORTS	None
PRIOR ACCIDENTS OR FAILURE OF DAM Description: Reports:	A dam at this site constructed for the Union Canal failed in August 1862, due to overtopping as a result from a log jam in the spillway. None.
MAINTENANCE & OPERATION RECORDS	None.
SPILLWAY PLAN, SECTIONS AND DETAILS	Plate III, Appendix F.

ENGINEERING DATA

ITEM	REMARKS
OPERATING EQUIPMENT, PLANS & DETAILS	Plate IV, Appendix F.
CONSTRUCTION RECORDS	Bi-weekly progress charts in files. One chart reproduced as Plate V, Appendix F. Inspection Reports by DER. Construction photographs.
PREVIOUS INSPECTION REPORTS & DEFICIENCIES	Inspection reports by DER indicate that downstream slope was not seeded and that upstream slope was irregular. Seepage has been noticed at the conduit outlet, except recently due to the presence of a small pool. Brush and tree growth has been reported many times.
MISCELLANEOUS	Original construction drawing dated August and September 1922 have been superseded by the drawings reproduced in Appendix F. Changes were made at the request of DER.

NDI NO. PA-00 680

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: _____

ELEVATION:

TOP NORMAL POOL & STORAGE CAPACITY: Elev. 548.0 Acre-Feet: 1105

TOP FLOOD CONTROL POOL & STORAGE CAPACITY: Elev. 562.5 Acre-Feet: 3110

MAXIMUM DESIGN POOL: Elev. Unknown

TOP DAM: Elev. 562.5

SPILLWAY:

a. Elevation 548.0

b. Type Uncontrolled, unlined broadcrested weir and channel cut through rock.

c. Width 50

d. Length 400

e. Location Spillover In left abutment.

f. Number and Type of Gates None.

OUTLET WORKS:

a. Type Reinforced concrete tower and arch shaped conduit.

b. Location Tower at upstream toe of dam.

c. Entrance inverts 531.75

d. Exit inverts 522.1

e. Emergency drawdown facilities 18-inch gate valve.

HYDROMETEOROLOGICAL GAGES:

a. Type None

b. Location _____

c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE: 8200 cfs (spillway)

APPENDIX C

HYDROLOGY AND HYDRAULIC CALCULATIONS

SUMMARY DESCRIPTION
OF
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION

The hydrologic and hydraulic evaluation for this inspection report has employed computer techniques using the Corps of Engineers computer program identified as the Flood Hydrograph Package (HEC-1) Dam Safety Version.

The program has been designed to enable the user to perform two basic types of hydrologic analyses: (1) the evaluation of the overtopping potential of the dam, and (2) the capability to estimate the downstream hydrologic-hydraulic consequences resulting from assumed structural failures of the dam. A brief summary of the computation procedures typically used in the dam overtopping analysis is shown below.

- Development of an inflow hydrograph to the reservoir.

- Routing of the inflow hydrograph(s) through the reservoir to determine if the event(s) analyzed would overtop the dam.

- Routing of the outflow hydrograph(s) of the reservoir to desired downstream locations. The results provide the peak discharge, time of the peak discharge and maximum stage of each routed hydrograph at the outlet of the reach.

The output data provided by this program permits the comparison of downstream conditions just prior to a breach failure with that after a breach failure and the determination as to whether or not there is a significant increase in the hazard to loss of life as a result of such a failure.

The results of the studies conducted for this report are presented in Section 5.

For detailed information regarding this program refer to the Users Manual for the Flood Hydrograph Package (HEC-1) Dam Safety Version prepared by the Hydrologic Engineering Center, U. S. Army Corps of Engineers, Davis, California.

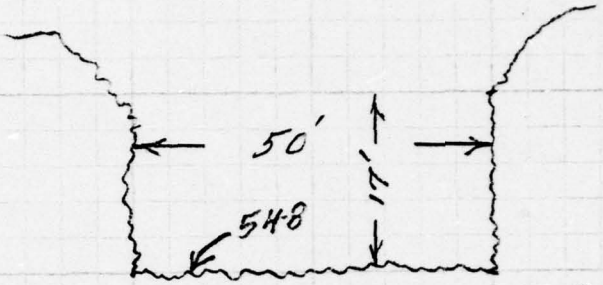
PROJECT Dam Investigation SHEET NO. 1 OF 13

SUBJECT Sweet Arrow Lake Dam ID No. 680

COMPUTED BY RES DATE 12-4-78 CHECKED BY JJP 12-5-78

Spillway Rating

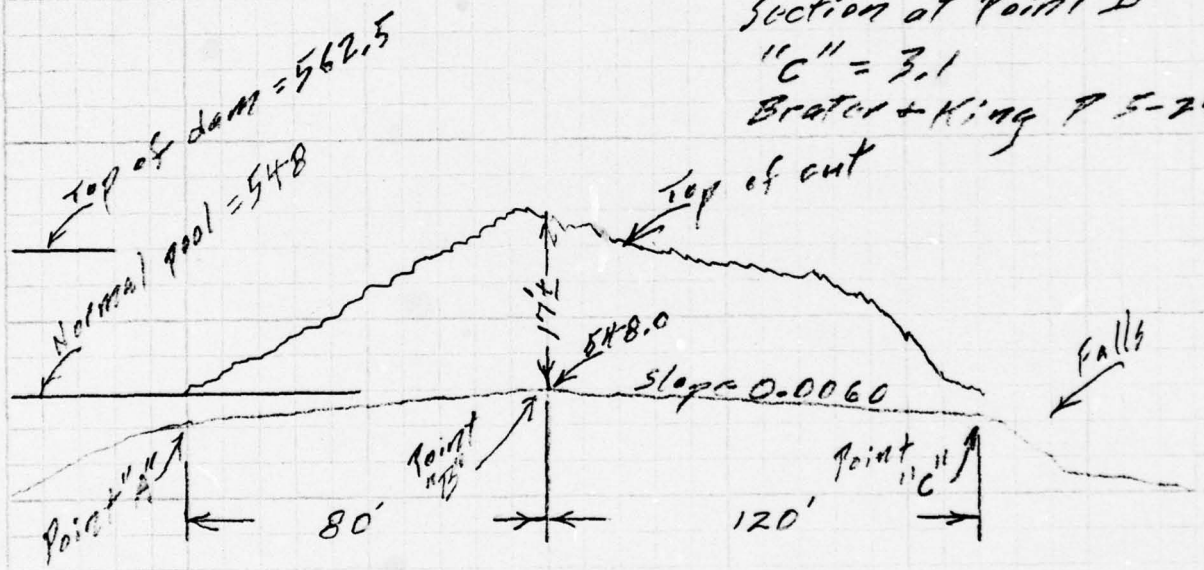
Spillway is unlined, rectangular cut through rock ridge 120 feet from left end of dam. Width 50 feet, crest elevation 548.0



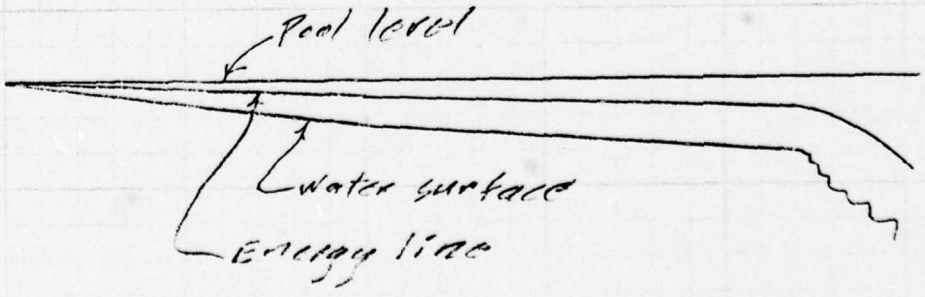
Section at Point "B"

"C" = 3.1

Brater + King P 5-24



Profile along cut.



PROJECT Dam Investigation SHEET NO. 2 OF 15
SUBJECT Sweet Arbor Lake Dam ID No. 680
COMPUTED BY KES DATE 12-4-78 CHECKED BY JJP 12-5-78

Spillway Rating (Cont.)

Pool level 562.5 (top of dam)

Assume Q = 7,000 cfs

compute friction drop Pt. "A" to Pt. "B"

$$V = \frac{1.486}{n} r^{2/3} S^{1/2}$$

$$S^{1/2} = \frac{V \times n}{1.486 \times r^{2/3}}$$

$$S^{1/2} = \frac{9.66 \times 0.03}{1.486 \times (9.18)^{2/3}}$$

$$= \frac{0.290}{6.52}$$

$$= 0.0445$$

$S = 0.00198$

$$V = \frac{7,000}{50 \times (562.5 - 548)}$$

$$= \frac{7000}{725} = 9.66 \text{ ft/sec.}$$

$n = 0.03$

$$r = \frac{725}{50 + 14.5 + 14.5} = \frac{725}{79}$$

$= 9.18$ ft

Friction drop $= 0.00198 \times 80 = 0.16$ ft.

Compute Q as broad crested weir at point "B"

$$Q = CLH^{3/2}$$

$$= 3.1 \times 50 \times (14.3)^{3/2}$$

$= 8,382$ cfs

$C = 3.1$
$L = 50$ ft.
$H = 562.5 - 0.2 - 548.0$
$= 14.3$ ft.

Compute Q in channel Point "B" to Point "C"

Assume velocity head at "B" = 4.1 ft

Depth at "B" = $562.5 - .2 - 4.1 - 548 = 10.2$ ft.

Velocity at "B" $= \frac{8382}{50 \times 10.2} = 16.4$ ft/sec.

Velocity head $= \frac{V^2}{2g} = \frac{(16.4)^2}{64.3} = 4.18$ ft.

PROJECT _____ SHEET NO. _____ OF _____

SUBJECT Sweet Arrow Lake Dam I.D. No. 680

COMPUTED BY RES DATE 12-4-78 CHECKED BY JJP 12-5-78

Spillway Rating (Cont)

Assume water surface slope = bottom slope = 0.0060 ft/ft.

$$V = \frac{1.486}{n} r^{2/3} s^{1/2}$$

$n = 0.03$

$$V = \frac{1.486}{0.03} \times (7.19)^{2/3} \times (0.0060)^{1/2}$$

$$r = \frac{50 \times (562.5 - 0.2 - 4.2 - 548)}{50 + 10.1 + 10.1}$$

$$= 49.5 \times 3.73 \times 0.0775$$

$$= \frac{505}{70.2} = 7.19 \text{ ft}$$

$= 14.3$ ft/sec

$s = 0.0060$

$Q = AV = 50 \times 10.1 \times 14.3$

$= 7,221$ cfs ($h_V = 3.18' \neq 4.2'$ - Try again)

Recompute with new velocity head at "B"

Velocity at "B" $= \frac{7220}{50 \times 10.2} = 14.2$ ft/sec

Velocity head $= \frac{V^2}{2g} = \frac{(14.2)^2}{64.3} = 3.14$ ft

$$V = \frac{1.486}{0.03} \times (7.73)^{2/3} \times 0.0775$$

$$r = \frac{50(562.5 - .2 - 3.1 - 548)}{50 + 11.2 + 11.2}$$

$$= 49.5 \times 3.91 \times 0.0775$$

$$= \frac{560}{72.4} = 7.73 \text{ ft}$$

$= 15.0$ ft/sec

$Q = 50 \times 11.2 \times 15.0$

$= 8,400$ cfs

Try $Q = 8,000$ cfs

Velocity at "B" $= \frac{8,000}{50 \times 11.0} = 14.54$ ft/sec

Velocity head $= \frac{V^2}{2g} = \frac{(14.54)^2}{64.3} = 3.29$ ft

PROJECT Dam Investigation SHEET NO. 4 OF 15

SUBJECT Sweet Arrow Lake Dam ID No. 680

COMPUTED BY RES DATE 12-4-78 CHECKED BY JJD 12-5-78

Spillway Rating (Cont)

$$V = \frac{1.486}{0.03} \times (7.64)^{2/3} \times 0.0775$$

$$= 49.5 \times 3.88 \times 0.0775$$

$$= 14.88 \text{ ft/sec}$$

$$r = \frac{50(562.5 - .2 - 3.3 - 548)}{50 + 11.0 + 11.0}$$

$$= \frac{550}{72} = 7.64 \text{ ft}$$

$$Q = AV = 50 \times 11.0 \times 14.88$$

$$= 8,184 \text{ cfs}$$

Use 8,200 cfs

PROJECT Dam Investigation SHEET NO. 2 OF 5
SUBJECT Sweet Arrow Lake Dam - ID No. 660
COMPUTED BY RES DATE 11-13-78 CHECKED BY JJP 12-5-78

Spillway Rating (cont)

Flood of June 22 1972

Town of Pine Grove manager reported lake level was one foot over right bank highway at peak of 1972 flood. Levels indicated this level to be 5.7 ft over spillway crest.

$Q = CLH^{3/2} = 3.1 \times 50 \times (5.7)^{3/2}$

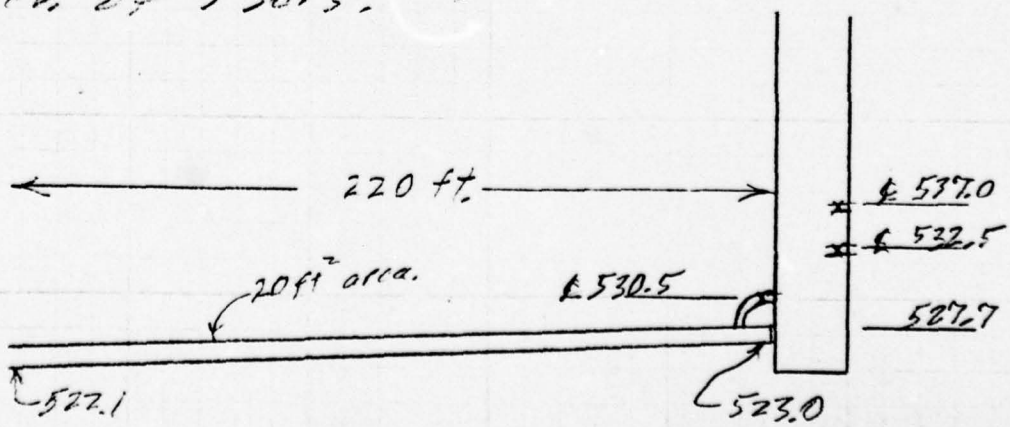
$= 2,100$ cfs outflow.

For USGS gage at Harpers Tavern for flood of June 22, 1972

Drain. Area 337 sq mi, $Q = 66,700$ cfs

$\left(\frac{20.5}{337}\right)^{.8} \times 66,700 = 7,100$ cfs inflow. USGS 7,000

Outlet works There is a ten-foot diameter intake tower located 95 ft upstream from the center line of the dam. It is connected to the downstream side of the dam by a conduit having a length of ~220 ft and a cross-sectional area of 20 sq ft. Water is admitted to the tower through 18-inch gate valves having ℄ elevations of 537.0 and 532.5. Water is delivered from the tower to the outlet conduit through an 18-inch gate valve with ℄ elev. of 530.5.



PROJECT Dam Surveying Class SHEET NO. 6 OF 16
SUBJECT Sweet Arrow Lake Dam - ID No. 680
COMPUTED BY RES DATE 11-13-78 CHECKED BY JJP 12-5-78

Outlet works (cont.)

Pool Elev. 534

$Q = Ca\sqrt{2gh}$ $C = 0.6$ $a = \pi(0.75)^2 = 1.77$ ft.^{2}

$h = 534 - 532.5 = 1.5$ ft.

$= 0.6 \times 1.77 \times (64.3 \times 1.5)^{1/2}$

$= 10.4$ cfs

Pool Elev. 548.0 All 3 valves open.

Assume water surface elev. in tower = 544

Head on each intake valve = $548 - 544 = 4.0$

$Q_{\text{each valve}} = Ca\sqrt{2gh}$

$= 0.6 \times 1.77 \times (64.3 \times 4)^{1/2}$

$= 17.03$ cfs

Both valves $= 2 \times 17.03 = 34.06$ cfs

Head on discharge valve $= 544 - 527.7$

$= 16.3$ ft.

$Q_{\text{disch valve}} = Ca\sqrt{2gh}$

$= 0.6 \times 1.77 \times (64.3 \times 16.3)^{1/2}$

$= 34.38$ cfs

Use $Q = 34$ cfs

Warm water Outlet - Pool Elev. 548.0
Intake valve at 537.0 and outlet valve open.
Water in tower at elev. $\frac{548 + 527.7}{2} = 537.8$

$Q = Ca\sqrt{2gh}$ $h = 548 - 537.8 = 10.2$ ft.

$= 0.6 \times 1.77 \times (64.3 \times 10.2)^{1/2}$

$= 27.2$ cfs

BY DJR DATE 1/15/79 BERGER ASSOCIATES SHEET NO. 7 OF 11
CHKD. BY DATE PROJECT D8490
SUBJECT SWEET ARROW LAKE.

EFFECTIVE SPILLWAY WEIR COEFFICIENT:

$$Q = C_w L H^{3/2}$$

$$C_w = \frac{Q}{L H^{3/2}} = \frac{8200}{50 \times (14.5)^{1.5}} = 2.97 \longleftarrow$$

SPILLWAY RATING : EFFECTIVE WEIR COEF CW = 2.97

ELEV. 549 $Q = 2.97 \times 50 \times 1^{1.5} = 148.5$ cfs

ELEV. 551 $Q = 2.97 \times 50 \times 3^{1.5} = 772$ cfs

ELEV. 554 $Q = 2.97 \times 50 \times 6^{1.5} = 2182$ cfs

ELEV. 558 $Q = 2.97 \times 50 \times 10^{1.5} = 4696$ cfs

ELEV. 562.3 $Q = 2.97 \times 50 \times 14.3^{1.5} = 8030$ cfs

ELEV. 562.6 $Q = 2.97 \times 50 \times 14.6^{1.5} = 8285$ cfs

ELEV. 562.7 $Q = 2.97 \times 50 \times 14.7^{1.5} = 8370$ cfs

ELEV. 562.9 $Q = 2.97 \times 50 \times 14.9^{1.5} = 8541$ cfs

ELEV. 564 $Q = 2.97 \times 50 \times 16^{1.5} = 9504$ cfs

ELEV. 563.1 $Q = 2.97 \times 50 \times 15.1^{1.5} = 8713$ cfs

ELEV. 566 $Q = 2.97 \times 50 \times 18^{1.5} = 11340$

ELEV. 570 $Q = 2.97 \times 50 \times 22^{1.5} = 15324$ cfs

ELEV. 566.1 $Q = 11435$

ELEV 566.5 $Q = 11816$

ELEV 567 $Q = 12299$

EMBANKMENT RATING :

ELEV. 562.6 $Q_1 = 2.7 \times (28+59)(.15)^{1.5} = 14$

$Q_2 = 2.7 \times (91 + (\frac{2}{3})62)(.1)^{1.5} = 11$

$Q = 25$ cfs

ELEV. 562.9 $Q_1 = 2.7 \times 62 \times (.2)^{1.5} = 15$

$Q_2 = 2.7 \times 43 \times (.35)^{1.5} = 24$

$Q_3 = 2.7 \times 87 \times (.45)^{1.5} = 71$

EMBANKMENT RATING (CONT.)

ELEV 562.9 (CONT): $Q_4 = 2.7 \times 91 \times (.4)^{1.5} = 62$

$Q_5 = 2.7 \times 62 \times (.35)^{1.5} = 35$

$Q = 207$

ELEV 570: $Q_1 = 2.7 \times 35 \times (3.45)^{1.5} = 606$

$Q_2 = 2.7 \times 79 \times (7)^{1.5} = 3950$

$Q_3 = 2.7 \times 62 \times (7.3)^{1.5} = 3302$

$Q_4 = 2.7 \times 43 \times (7.45)^{1.5} = 2361$

$Q_5 = 2.7 \times 87 \times (7.55)^{1.5} = 4873$

$Q_6 = 2.7 \times 91 \times (7.5)^{1.5} = 5047$

$Q_7 = 2.7 \times 62 \times (7.45)^{1.5} = 3404$

$Q_8 = 2.7 \times 26 \times (7.2)^{1.5} = 1356$

$Q_9 = 2.7 \times 20 \times (3.55)^{1.5} = 361$

$Q = 25260$ cfs

ELEV 564: $Q_1 = 2.97 \times 79 \times 1^{1.5} = 235$

$Q_2 = 2.97 \times 62 \times 1.3^{1.5} = 273$

$Q_3 = 2.97 \times 43 \times 1.45^{1.5} = 223$

$Q_4 = 2.97 \times 87 \times 1.55^{1.5} = 499$

$Q_5 = 2.97 \times 91 \times 1.7^{1.5} = 599$

$Q_6 = 2.97 \times 62 \times 1.45^{1.5} = 322$

$Q_7 = 2.97 \times 26 \times 1.2^{1.5} = 102$

$Q = 2253$ cfs

EMBANKMENT RATING (CONT.):

ELEV. 566.1 :

$Q_1 = 2.97 \times 15.2 \times 1.5^{1.5} = 83$
$Q_2 = 2.97 \times 79 \times 3.05^{1.5} = 1250$
$Q_3 = 2.97 \times 62 \times 3.35^{1.5} = 1129$
$Q_4 = 2.97 \times 43 \times 3.5^{1.5} = 836$
$Q_5 = 2.97 \times 87 \times 3.6^{1.5} = 1765$
$Q_6 = 2.97 \times 91 \times 3.75^{1.5} = 1963$
$Q_7 = 2.97 \times 62 \times 3.5^{1.5} = 1206$
$Q_8 = 2.97 \times 26 \times 3.25^{1.5} = 452$
$Q_9 = 2.97 \times 9.0 \times 1.6^{1.5} = 54$

$Q = 8738$ cfs

ELEV. 566.5 :

$Q_1 = 2.97 \times 17.2 \times 1.7^{1.5} = 113$
$Q_2 = 2.97 \times 79 \times 3.45^{1.5} = 1504$
$Q_3 = 2.97 \times 62 \times 3.75^{1.5} = 1337$
$Q_4 = 2.97 \times 43 \times 3.9^{1.5} = 984$
$Q_5 = 2.97 \times 87 \times 4.0^{1.5} = 2067$
$Q_6 = 2.97 \times 91 \times 4.15^{1.5} = 2285$
$Q_7 = 2.97 \times 62 \times 3.9^{1.5} = 1418$
$Q_8 = 2.97 \times 26 \times 3.65^{1.5} = 538$
$Q_9 = 2.97 \times 10.2 \times 1.8^{1.5} = 73$

$Q = 10319$ cfs

ELEV. 567 :

$Q_1 = 2.97 \times 19.8 \times 1.95^{1.5} = 160$
$Q_2 = 2.97 \times 79 \times 3.95^{1.5} = 1842$
$Q_3 = 2.97 \times 62 \times 4.25^{1.5} = 1613$
$Q_4 = 2.97 \times 43 \times 4.4^{1.5} = 1179$
$Q_5 = 2.97 \times 87 \times 4.5^{1.5} = 2467$
$Q_6 = 2.97 \times 91 \times 4.65^{1.5} = 2710$
$Q_7 = 2.97 \times 62 \times 4.4^{1.5} = 1700$
$Q_8 = 2.97 \times 26 \times 4.15^{1.5} = 653$
$Q_9 = 2.97 \times 11.5 \times 2.05^{1.5} = 100$

$Q = 12424$ cfs

EMBANKMENT RATING (CONT.)

ELEV. 566

$Q_1 = 2.97 \times 14.7 \times 1.45^{1.5} = 76$
$Q_2 = 2.97 \times 79 \times 3^{1.5} = 1219$
$Q_3 = 2.97 \times 62 \times 3.3^{1.5} = 1104$
$Q_4 = 2.97 \times 43 \times 3.45^{1.5} = 818$
$Q_5 = 2.97 \times 87 \times 3.55^{1.5} = 1728$
$Q_6 = 2.97 \times 91 \times 3.7^{1.5} = 1924$
$Q_7 = 2.97 \times 62 \times 3.45^{1.5} = 1180$
$Q_8 = 2.97 \times 26 \times 3.2^{1.5} = 442$
$Q_9 = 2.97 \times 8.7 \times 1.55^{1.5} = 50$

$Q = 8541$ cfs

Combined Spillway and Embankment Rating

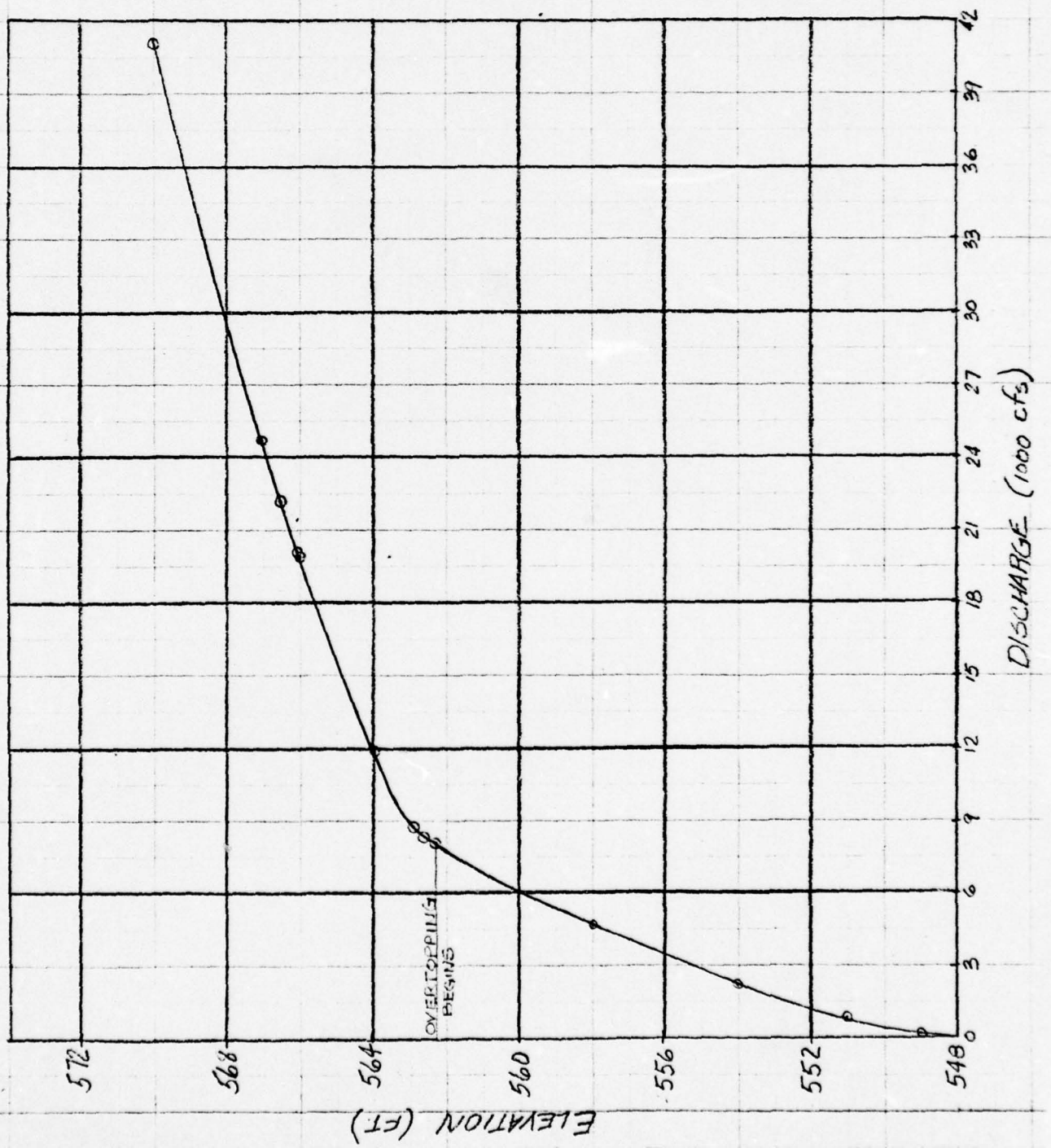
ELEVATION	DISCHARGE
548	0
549	149
551	772
554	2182
558	4696
562.3	8030
562.6	8310
562.9	8748
564	11757
566	19881
570	40584
566.1	20173
566.5	22135
567	24723

BY DJR DATE 1/15/79 **BERGER ASSOCIATES** SHEET NO. 12 OF 15

CHKD. BY DATE PROJECT D8490

SUBJECT SWEET ARROW LAKE - EMBANKMENT AND SPILLWAY RATING CURVE

EMBANKMENT AND
SPILLWAY RATING CURVE:



SIZE CLASSIFICATION :

Maximum Storage = 3107 acre-feet
Maximum Height = 35.5 feet
Size Classification is "INTERMEDIATE"

HAZARD CLASSIFICATION :

Several Houses are located near the stream about 2400 feet downstream from the dam where state route 443 crosses the stream. USE HIGH.

RECOMMENDED SPILLWAY DESIGN FLOOD (SDF)

The above classifications indicate use of an SDF equal to the PROBABLE MAXIMUM FLOOD.

BY DJR DATE 1/24/79 BERGER ASSOCIATES SHEET NO. 14 OF 15
CHKD. BY DATE PROJECT D8490
SUBJECT SWEET ARROW LAKE DAM

HEC-1 DATA

DRAINAGE AREA = 20.5 SQ. MI.

SUSQUEHANNA BASIN REGION 15B

$C_p = .85$

$C_T = 2.2$

Longest Water Course $L = 10.2$ mi

LENGTH To Centroid $L_{CA} = 5.3$ mi

$$T_p = C_T (L \times L_{CA})^{.3}$$

$T_p = 7.3$ hrs.

RAINFALL (HMR-33)

INDEX = 23.2 in.

Zone 6

Incremental Rainfall

6 hr = 106 %

12 hr = 116 %

24 hr = 125 %

48 hr = 136.5 %

PLANIMETERED AREAS (FROM QUAD SHEETS)

ELEV.: 548 = 92 ACRES

560 = 175 ACRES

580 = 404 ACRES

ZERO STORAGE ELEV.

ELEV. = 548 - (STORAGE x 3/AREA)

= 512

BY DJR DATE 1/17/79 **BERGER ASSOCIATES** SHEET NO. 15 OF 15

CHKD. BY DATE PROJECT DB490

SUBJECT SWEETARROW CAPACITY CURVE

SPILLWAY CAPACITY CURVE:

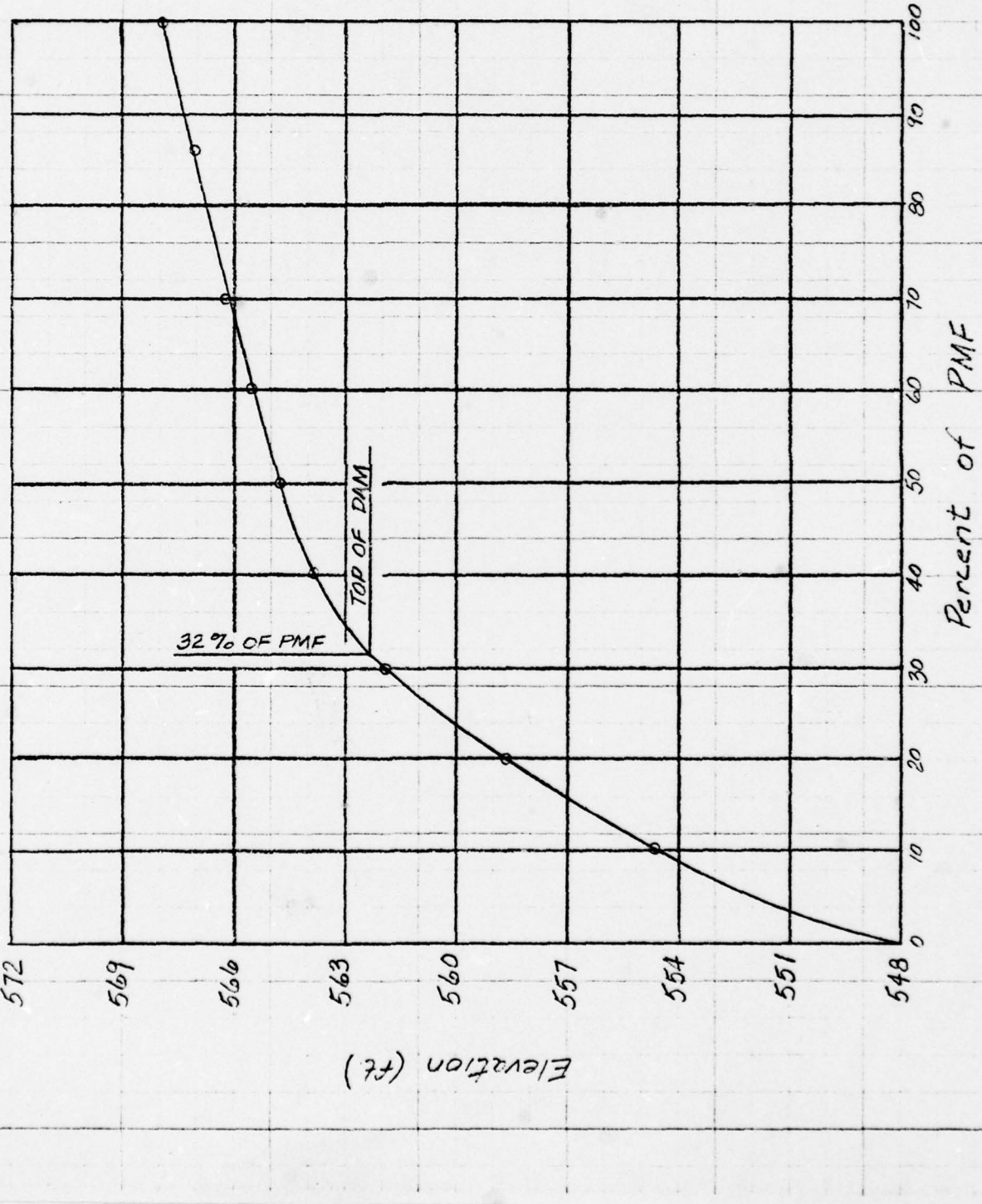


TABLE NO.1

COMPARISON OF WATER SURFACE ELEVATIONS

SWEET ARROW LAKE DAM

PMF = 29,817 cfs

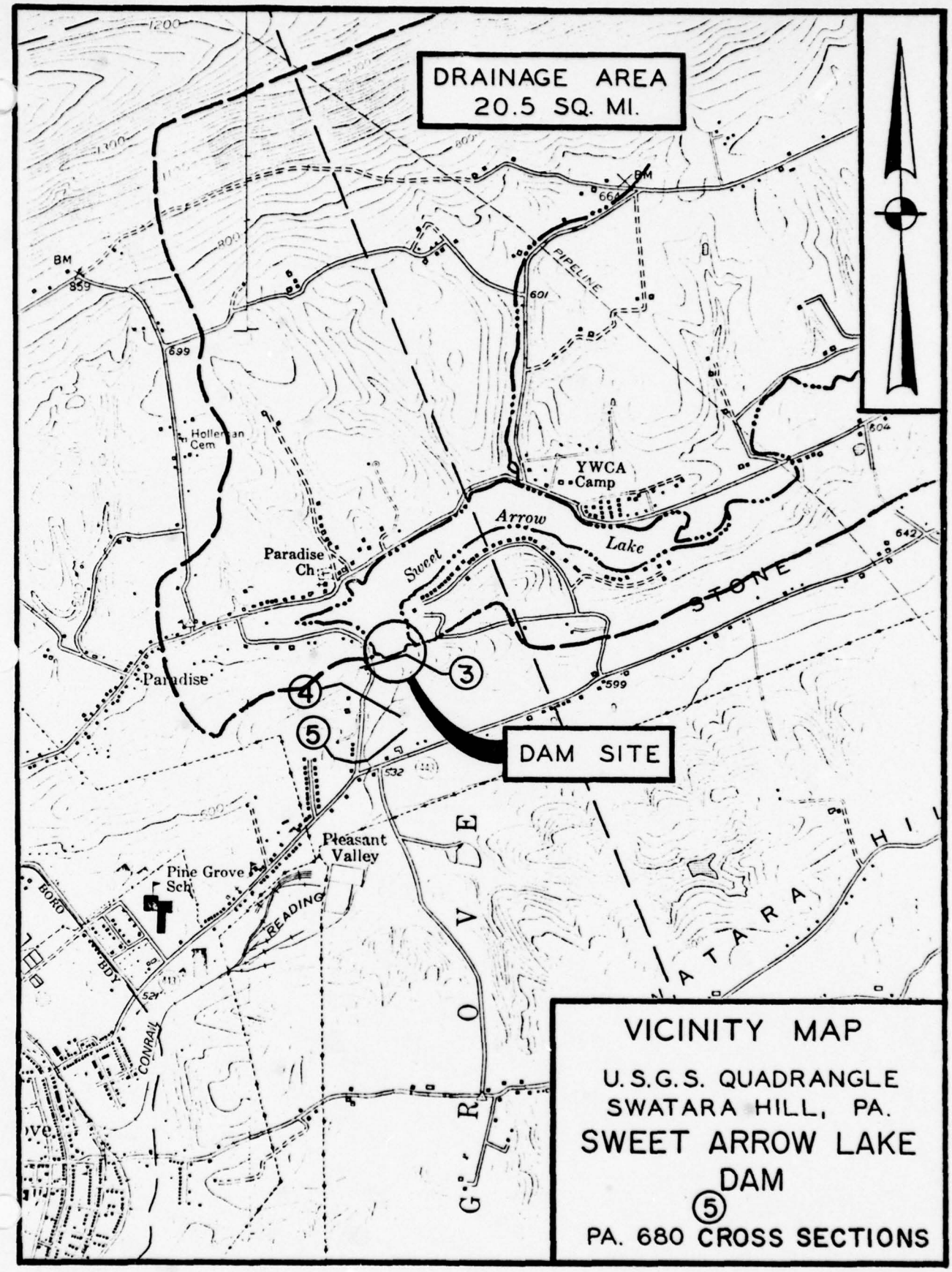
Crest Elevation = 562.5 Low Point = 562.3 Spillway Elevation = 548.0

STAGE	CREST OF DAM ELEVATION	CREST OF DAM DEPTH	2400' D/S OF DAM* APPROX. ELEVATION
A. At low point in embankment crest	562.3	0	533.3
B. 34% Overtopping No Breach	562.98	.68	533.7
C. 34% PMF Overtopping (15 Minute Breach)	562.82	.52	542.6
D. 34% PMF Overtopping (2 Hour Breach)	562.86	.56	539.0

*Several Houses located about 2,400 feet downstream of Sweet Arrow Lake Dam.

CONDITION C:

(Time refers to elapsed time after start of storm).
Time to reach breach elevation 562.8 at dam = 47.5 hours.
Water level 2,400' downstream just prior to breach = 533.7
Duration of Breach = 15 Minutes.
Time for Breach to peak 2,400 feet downstream = .5 Hours.
Peak elevation 2,400' downstream due to breach = 542.6.
Rate of increase in water level = 8.9' in one-half hour.


DRAINAGE AREA
20.5 SQ. MI.
DAM SITE
Paradise
Paradise Ch
Sweet Arrow Lake
YWCA Camp
Pleasant Valley
Pine Grove Sch
PIPELINE
READING
CONRAIL
STONE
VICINITY MAP
U.S.G.S. QUADRANGLE
SWATARA HILL, PA.
SWEET ARROW LAKE
DAM
(5)
PA. 680 CROSS SECTIONS

```
 LAST MODIFICATION  21 AUG 78
 **********************************
    1          A1      SWEET ARROW LAKE DAM ****  UPPER LITTLE SWATARA CREEK
    2          A2      PINE GROVE TWP., SCHUYLKILL COUNTY
    3          A3      NDI # PA-00680   PA DER # 54-102
    4          B   300      0      15       0       0       0       0       0      -4       0
    5          B1    5
    6          J     1      9       1
    7          J1    1    .85      .7      .6      .5      .4      .3      .2      .1
    8          K              1                                       1
    9          K1                 INFLOW HYDROGRAPH
   10          H     1      1    20.5
   11          P          23.2     106     116     125   136.5
   12          T                                                    1     .05
   13          W   7.3     .85
   14          X  -1.5    -.05       2
   15          K     1      2                                       1
   16          K1                 RESERVOIR ROUTING
   17          Y                                      1       0
   18          Y1    1                                                1105      -1
   19          Y4  548     549     551     554     558   562.3   562.6   562.9     564     566
   20          Y4 566.1   566.5     567     570
   21          Y5    0     149     772    2182    4696    8030    8310    8748   11757   19881
   22          Y5 20173   22135   24723   40584
   23          $A    0      92     175     404
   24          $E  512     548     560     580
   25          $$  548
   26          $D 562.3
   27          K    99
    1                     PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

                                  RUNOFF HYDROGRAPH AT          1
                                  ROUTE HYDROGRAPH TO           2
                                  END OF NETWORK

 1**********************************
  FLOOD HYDROGRAPH PACKAGE (HEC-1)
  DAM SAFETY VERSION     JULY 1978
    LAST MODIFICATION  21 AUG 78
  **********************************

  RUN  DATE# 79/02/23.
       TIME# 08.07.44.


                        SWEET ARROW LAKE DAM ****  UPPER LITTLE SWATARA CREEK
                        PINE GROVE TWP., SCHUYLKILL COUNTY
                        NDI # PA-00680   PA DER # 54-102

                                    JOB SPECIFICATION
                    NQ      NHR     NMIN     IDAY      IHR     IMIN    METRC     IPLT     IPRT    NSTAN
                   300        0       15        0        0        0        0        0       -4        0
                                     JOPER      NWT    LROPT    TRACE
                                         5        0        0        0


                                MULTI-PLAN ANALYSES TO BE PERFORMED
                                NPLAN= 1 NRTIO= 9 LRTIO= 1
```

SWEET ARROW LAKE DAM **** UPPER LITTLE SWATARA CREEK
PINE GROVE TWP., SCHUYLKILL COUNTY
NDI # PA-00680 PA DER # 54-102

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	15	0	0	0	0	0	-4	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED

NPLAN= 1 NRTIO= 9 LRTIO= 1

RTIOS= 1.00 .85 .70 .60 .50 .40 .30 .20 .10

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

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

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

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	20.50	0.00	20.50	0.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.20	106.00	116.00	125.00	136.50	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .824

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	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 7.30 CP= .85 NTA= 0

RECESSION DATA

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

UNIT HYDROGRAPH 67 END-OF-PERIOD ORDINATES, LAG= 7.22 HOURS, CP= .81 VOL= 1.00

17.	62.	124.	194.	269.	345.	422.	498.	574.	648.
720.	791.	859.	925.	990.	1052.	1112.	1171.	1227.	1282.
1336.	1387.	1436.	1478.	1509.	1530.	1542.	1547.	1546.	1538.
1525.	1506.	1484.	1457.	1426.	1392.	1353.	1311.	1266.	1216.
1162.	1102.	1036.	962.	869.	762.	660.	572.	495.	429.
371.	322.	279.	241.	209.	181.	157.	136.	118.	102.
88.	76.	66.	57.	50.	43.	37.			

0 END-OF-PERIOD FLOW

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

SUM 26.09 23.66 2.43 1258242.
(663.)(601.)(62.)(35629.45)

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

HYDROGRAPH ROUTING

RESERVOIR ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	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
1	0	0	0.000	0.000	0.000	1105.	-1

STAGE	548.0	549.0	551.0	554.0	558.0	562.3	562.6	562.9	564.0	566.0
	566.1	566.5	567.0	570.0						
FLOW	0.	149.	772.	2182.	4696.	8030.	8310.	8748.	11757.	19881.
	20173.	22135.	24723.	40584.						
SURFACE AREA=	0.	92.	175.	404.						
CAPACITY=	0.	1104.	2680.	8312.						
ELEVATION=	512.	548.	560.	580.						

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
548.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
562.3	0.0	0.0	0.

PEAK OUTFLOW IS 29520. AT TIME 46.75 HOURS

PEAK OUTFLOW IS 25108. AT TIME 46.75 HOURS

PEAK OUTFLOW IS 20572. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 17619. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 14600. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 11253. AT TIME 47.75 HOURS

PEAK OUTFLOW IS 7689. AT TIME 48.50 HOURS

PEAK OUTFLOW IS 5128. AT TIME 48.50 HOURS

PEAK OUTFLOW IS 2522. AT TIME 48.75 HOURS

1 ********** ********** ********** ********** **********

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
				1.00	.85	.70	.60	.50	.40	.30	.20	.10
HYDROGRAPH AT	1	20.50	1	29817.	25345.	20872.	17890.	14909.	11927.	8945.	5963.	2982.
		(53.09)		(844.33)(	717.68)(	591.03)(	506.60)(	422.17)(	337.73)(	253.30)(	168.87)(	84.43)
ROUTED TO	2	20.50	1	29520.	25108.	20572.	17619.	14600.	11253.	7689.	5128.	2522.
		(53.09)		(835.91)(	710.97)(	582.55)(	498.90)(	413.43)(	318.64)(	217.73)(	145.20)(	71.40)

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	548.01	548.00	562.30
STORAGE	1105.	1104.	3107.
OUTFLOW	1.	0.	8030.

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
1.00	567.90	5.60	4365.	29520.	11.75	46.75	0.00
.85	567.06	4.76	4156.	25108.	10.75	46.75	0.00
.70	566.18	3.88	3944.	20572.	9.75	47.00	0.00
.60	565.44	3.14	3773.	17619.	9.00	47.00	0.00
.50	564.70	2.40	3606.	14600.	7.75	47.00	0.00
.40	563.82	1.52	3416.	11253.	5.75	47.75	0.00
.30	561.86	0.00	3021.	7689.	0.00	48.50	0.00
.20	558.56	0.00	2435.	5128.	0.00	48.50	0.00
.10	554.54	0.00	1839.	2522.	0.00	48.75	0.00

1**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 21 AUG 78
****
EOI ENCOUNTERED.
N>

```
DAM SAFETY VERSION  JULY 1978
 LAST MODIFICATION  21 AUG 78
**********
    1          A1     SWEET ARROW LAKE DAM  ####  UPPER LITTLE SWATARA CREEK
    2          A2     PINE GROVE TWP., SCHUYLKILL COUNTY
    3          A3     NDI # PA-00680   PA DER # 54-102
    4          B   300      0     15      0      0      0      0      0     -4      0
    5          B1    5
    6          J     1      1      1
    7          J1  .34
    8          K              1                                        1
    9          K1                  INFLOW HYDROGRAPH
   10          M     1        1   20.5
   11          P              23.2    106    116    125  136.5
   12          T                                                     1    .05
   13          W   7.3     .85
   14          X  -1.5    -.05      2
   15          K     1        2                                        1
   16          K1                  RESERVOIR ROUTING
   17          Y                                    1      0
   18          Y1    1                                                1105    -1
   19          Y4  548      549     551     554     558  562.3   562.6  562.9   564     566
   20          Y4 566.1    566.5     567     570
   21          Y5    0      149     772    2182    4696   8030    8310   8748  11757   19881
   22          Y5 20173    22135   24723   40584
   23          $A    0       92     175     404
   24          $E  512      548     560     580
   25          $$  548
   26          $D 562.3
   27          K     1        3                                        1
   28          K1                  REACH 2-3
   29          Y                                    1      0
   30          Y1    1
   31          Y6   .1      .04      .1     525    560    200    .01
   32          Y7    0      560      90     540    200    530    205    525    220    525
   33          Y7  225      530     250     540   1100    560
   34          K     1        4                                        1
   35          K1                  REACH 3-4
   36          Y                                    1      0
   37          Y1    1
   38          Y6   .1      .04      .1     523    560   1200  .0017
   39          Y7    0      560      50     540    100    528    110    523    120    523
   40          Y7  130      528     470     540    630    560
   41          K     1        5                                        1
   42          K1                  REACH 4-5
   43          Y                                    1      0
   44          Y1    1
   45          Y6   .1      .04      .1     521    560   1000  .002
   46          Y7    0      560     200     540    450    525    520    521    528    521
   47          Y7  530      525     700     540    830    560
   48          K    99
    1                  PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

                       RUNOFF HYDROGRAPH AT          1
                       ROUTE HYDROGRAPH TO           2
                       ROUTE HYDROGRAPH TO           3
                       ROUTE HYDROGRAPH TO           4
                       ROUTE HYDROGRAPH TO           5
                       END OF NETWORK
```

SWEET ARROW LAKE DAM **** UPPER LITTLE SWATARA CREEK
PINE GROVE TWP., SCHUYLKILL COUNTY
NDI # PA-00680 PA DER # 54-102

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	15	0	0	0	0	0	-4	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 1 LRTIO= 1

RTIOS= .34

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

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

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

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	20.50	0.00	20.50	0.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.20	106.00	116.00	125.00	136.50	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .824

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	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA
TP= 7.30 CP= .85 NTA= 0

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

UNIT HYDROGRAPH 67 END-OF-PERIOD ORDINATES, LAG= 7.22 HOURS, CP= .81 VOL= 1.00

17.	62.	124.	194.	269.	345.	422.	498.	574.	648.
720.	791.	859.	925.	990.	1052.	1112.	1171.	1227.	1282.
1336.	1387.	1436.	1478.	1509.	1530.	1542.	1547.	1546.	1538.
1525.	1506.	1484.	1457.	1426.	1392.	1353.	1311.	1266.	1216.
1162.	1102.	1036.	962.	869.	762.	660.	572.	495.	429.
371.	322.	279.	241.	209.	181.	157.	136.	118.	102.
88.	76.	66.	57.	50.	43.	37.			

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	26.09	23.66	2.43	1258242.
										(663.)(601.)(62.)(35629.45)			

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

HYDROGRAPH ROUTING

RESERVOIR ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	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
1	0	0	0.000	0.000	0.000	1105.	-1

STAGE	548.0	549.0	551.0	554.0	558.0	562.3	562.6	562.9	564.0	566.0
	566.1	566.5	567.0	570.0						
FLOW	0.	149.	772.	2182.	4696.	8030.	8310.	8748.	11757.	19881.
	20173.	22135.	24723.	40584.						
SURFACE AREA=	0.	92.	175.	404.						
CAPACITY=	0.	1104.	2680.	8312.						
ELEVATION=	512.	548.	560.	580.						

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
548.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
562.3	0.0	0.0	0.

PEAK OUTFLOW IS 8976. AT TIME 48.25 HOURS

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

HYDROGRAPH ROUTING

REACH 2-3

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
3	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
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.1000	.0400	.1000	525.0	560.0	200.	.01000

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

HYDROGRAPH ROUTING

REACH 2-3

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
3	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
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.1000	.0400	.1000	525.0	560.0	200.	.01000

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 560.00 90.00 540.00 200.00 530.00 205.00 525.00 220.00 525.00
225.00 530.00 250.00 540.00 1100.00 560.00

STORAGE	0.	0.	0.	1.	1.	1.	2.	3.	5.	6.
	8.	12.	15.	20.	25.	31.	38.	45.	54.	63.
OUTFLOW	0.	154.	498.	1042.	1902.	3099.	4699.	6759.	9333.	12402.
	16620.	22061.	28926.	37413.	47708.	59985.	74411.	91147.	110348.	132163.
STAGE	525.0	526.8	528.7	530.5	532.4	534.2	536.1	537.9	539.7	541.6
	543.4	545.3	547.1	548.9	550.8	552.6	554.5	556.3	558.2	560.0
FLOW	0.	154.	498.	1042.	1902.	3099.	4699.	6759.	9333.	12402.
	16620.	22061.	28926.	37413.	47708.	59985.	74411.	91147.	110348.	132163.

MAXIMUM STAGE IS 539.5

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

HYDROGRAPH ROUTING

REACH 3-4

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	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
1	0	0	0.000	0.000	0.000	0.	0

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

HYDROGRAPH ROUTING

REACH 3-4

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	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
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.1000	.0400	.1000	523.0	560.0	1200.	.00170

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00	560.00	50.00	540.00	100.00	528.00	110.00	523.00	120.00	523.00
130.00	528.00	470.00	540.00	630.00	560.00				

STORAGE	0.	1.	2.	4.	9.	17.	28.	43.	62.	83
	107.	131.	157.	183.	211.	240.	270.	301.	333.	366
OUTFLOW	0.	53.	197.	478.	994.	1819.	3034.	4708.	6908.	9785
	13508.	17806.	22669.	28093.	34079.	40629.	47744.	55432.	63697.	72545
STAGE	523.0	524.9	526.9	528.8	530.8	532.7	534.7	536.6	538.6	540.
	542.5	544.4	546.4	548.3	550.3	552.2	554.2	556.1	558.1	560.
FLOW	0.	53.	197.	478.	994.	1819.	3034.	4708.	6908.	9785
	13508.	17806.	22669.	28093.	34079.	40629.	47744.	55432.	63697.	72545

MAXIMUM STAGE IS 540.0

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

HYDROGRAPH ROUTING

REACH 4-5

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
5	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
1	0	0	0.000	0.000	0.000	0.	0

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

HYDROGRAPH ROUTING

REACH 4-5

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
5	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
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.1000	.0400	.1000	521.0	560.0	1000.	.00200

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 560.00 200.00 540.00 450.00 525.00 520.00 521.00 528.00 521.00
530.00 525.00 700.00 540.00 830.00 560.00

STORAGE	0.	1.	4.	10.	17.	28.	42.	58.	76.	98.
	122.	147.	175.	203.	234.	266.	299.	334.	371.	409.
OUTFLOW	0.	101.	525.	1563.	3157.	5368.	8251.	11863.	16261.	21497.
	27832.	35113.	43270.	52319.	62274.	73152.	84972.	97754.	111515.	126276.
STAGE	521.0	523.1	525.1	527.2	529.2	531.3	533.3	535.4	537.4	539.5
	541.5	543.6	545.6	547.7	549.7	551.8	553.8	555.9	557.9	560.0
FLOW	0.	101.	525.	1563.	3157.	5368.	8251.	11863.	16261.	21497.
	27832.	35113.	43270.	52319.	62274.	73152.	84972.	97754.	111515.	126276.

MAXIMUM STAGE IS 533.7

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

1

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
OPERATION	STATION	AREA	PLAN	RATIO 1
				.34
HYDROGRAPH AT	1	20.50	1	10138.

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)

OB 7/7

OPERATION	STATION	AREA	PLAN	RATIO 1 .34
HYDROGRAPH AT	1	20.50 (53.09)	1	10138. (287.07)(
ROUTED TO	2	20.50 (53.09)	1	8976. (254.17)(
ROUTED TO	3	20.50 (53.09)	1	8977. (254.21)(
ROUTED TO	4	20.50 (53.09)	1	8965. (253.86)(
ROUTED TO	5	20.50 (53.09)	1	8971. (254.02)(

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	548.01	548.00	562.30
STORAGE	1105.	1104.	3107.
OUTFLOW	1.	0.	8030.

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
.34	562.98	.68	3243.	8976.	3.50	48.25	0.00

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	8977.	539.5	48.25

PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	8965.	540.0	48.50

PLAN 1 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	8971.	539.7	48.50

LAST MODIFICATION 21 AUG 78

BREACH ANALYSIS 1/20

```
**********
    1        A1     SWEET ARROW LAKE DAM **** UPPER LITTLE SWATARA CREEK
    2        A2     PINE GROVE TWP., SCHUYLKILL COUNTY
    3        A3     NDI # PA-00680   PA DER # 54-102
    4        B   300      0     15      0      0      0      0      0     -4      0
    5        B1    5
    6        J     5      1      1
    7        J1  .34
    8        K             1                                          1
    9        K1                 INFLOW HYDROGRAPH
   10        M     1      1   20.5                                                1
   11        P           23.2    106    116    125  136.5
   12        T                                                      1   .05
   13        W   7.3    .85
   14        X  -1.5   -.05      2
   15        K     1      2                                          1
   16        K1                 RESERVOIR ROUTING - DAM BREACH
   17        Y                                 1      1
   18        Y1    1                                                1105    -1
   19        Y4  548    549    551    554    558  562.3  562.6  562.9   564   566
   20        Y4 566.1  566.5    567    570
   21        Y5    0    149    772   2182   4696   8030   8310   8748 11757 19881
   22        Y5 20173  22135  24723  40584
   23        $A    0     92    175    404
   24        $E  512    548    560    580
   25        $$  548
   26        $D 562.3
   27        $B   50      1    538   .25    548  562.8
   28        $B   50      1    538    .5    548  562.8
   29        $B   50      1    538     1    548  562.8
   30        $B   50      1    538     2    548  562.8
   31        $B   50      1    538     4    548  562.8
   32        K     1      3                                          1
   33        K1                 REACH 2-3
   34        Y                                 1      1
   35        Y1    1
   36        Y6   .1    .04     .1    525    560    200    .01
   37        Y7    0    560     90    540    200    530    205    525    220    525
   38        Y7  225    530    250    540   1100    560
   39        K     1      4                                          1
   40        K1                 REACH 3-4
   41        Y                                 1      1
   42        Y1    1
   43        Y6   .1    .04     .1    523    560   1200  .0017
   44        Y7    0    560     50    540    100    528    110    523    120    523
   45        Y7  130    528    470    540    630    560
   46        K     1      5                                          1
   47        K1                 REACH 4-5
   48        Y                                 1      1
   49        Y1    1
   50        Y6   .1    .04     .1    521    560   1000  .002
1  51        Y7    0    560    200    540    450    525    520    521    528    521
   52        Y7  530    525    700    540    830    560
   53        K    99
1                  PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

                        RUNOFF HYDROGRAPH AT          1
                        ROUTE HYDROGRAPH TO           2
                        ROUTE HYDROGRAPH TO           3
                        ROUTE HYDROGRAPH TO           4
                        ROUTE HYDROGRAPH TO           5
```

SWEET ARROW LAKE DAM **** UPPER LITTLE SWATARA CREEK
PINE GROVE TWP., SCHUYLKILL COUNTY
NDI # PA-00680 PA DER # 54-102

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	15	0	0	0	0	0	-4	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 5 NRTIO= 1 LRTIO= 1

RTIOS= .34

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

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

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

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	20.50	0.00	20.50	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.20	106.00	116.00	125.00	136.50	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .824

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	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA
TP= 7.30 CP= .85 NTA= 0

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

UNIT HYDROGRAPH 67 END-OF-PERIOD ORDINATES, LAG= 7.22 HOURS, CP= .81 VOL= 1.00

17.	62.	124.	194.	269.	345.	422.	498.	574.	648.
720.	791.	859.	925.	990.	1052.	1112.	1171.	1227.	1282.
1336.	1387.	1436.	1478.	1509.	1530.	1542.	1547.	1546.	1538.
1525.	1506.	1484.	1457.	1426.	1392.	1353.	1311.	1266.	1216.
1162.	1102.	1036.	962.	869.	762.	660.	572.	495.	429.
371.	322.	279.	241.	209.	181.	157.	136.	118.	102.
88.	76.	66.	57.	50.	43.	37.			

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	26.09	23.66	2.43	1258242.
										(663.)	(601.)	(62.)	(35629.45)

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

HYDROGRAPH ROUTING

RESERVOIR ROUTING - DAM BREACH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

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

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	1105.	-1

STAGE	548.0	549.0	551.0	554.0	558.0	562.3	562.6	562.9	564.0	566.0
	566.1	566.5	567.0	570.0						
FLOW	0.	149.	772.	2182.	4696.	8030.	8310.	8748.	11757.	19881.
	20173.	22135.	24723.	40584.						
SURFACE AREA=	0.	92.	175.	404.						
CAPACITY=	0.	1104.	2680.	8312.						
ELEVATION=	512.	548.	560.	580.						

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
548.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
562.3	0.0	0.0	0.

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
50.	1.00	538.00	.25	548.00	562.80

BEGIN DAM FAILURE AT 47.50 HOURS

PEAK OUTFLOW IS 32629. AT TIME 47.75 HOURS

THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF .005 HOURS DURING BREACH FORMATION.
DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF .250 HOURS.
THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH.
INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	- COMPUTED BREACH HYDROGRAPH (CFS)	= ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
47.500	0.000	8624.	8624.	0.	0.	0.
47.505	.005	9104.	8784.	320.	320.	0.
47.510	.010	9584.	8916.	668.	988.	0.
47.515	.015	10064.	9073.	991.	1979.	1.
47.520	.020	10544.	9252.	1292.	3272.	1.
47.525	.025	11025.	9452.	1573.	4845.	2.
47.530	.030	11505.	9670.	1835.	6680.	3.
47.535	.035	11985.	9905.	2079.	8759.	4.

TIME (HOURS)	BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	-	COMPUTED BREACH HYDROGRAPH (CFS)	=	ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
47.500	0.000	8624.		8624.		0.	0.	0.
47.505	.005	9104.		8784.		320.	320.	0.
47.510	.010	9584.		8916.		668.	988.	0.
47.515	.015	10064.		9073.		991.	1979.	1.
47.520	.020	10544.		9252.		1292.	3272.	1.
47.525	.025	11025.		9452.		1573.	4845.	2.
47.530	.030	11505.		9670.		1835.	6680.	3.
47.535	.035	11985.		9905.		2079.	8759.	4.
47.540	.040	12465.		10158.		2307.	11066.	5.
47.545	.045	12945.		10428.		2517.	13583.	6.
47.550	.050	13425.		10713.		2712.	16296.	7.
47.555	.055	13905.		11013.		2892.	19188.	8.
47.560	.060	14385.		11329.		3057.	22244.	9.
47.565	.065	14865.		11659.		3207.	25451.	11.
47.570	.070	15345.		12003.		3342.	28794.	12.
47.575	.075	15826.		12361.		3464.	32258.	13.
47.580	.080	16306.		12733.		3572.	35830.	15.
47.585	.085	16786.		13119.		3667.	39497.	16.
47.590	.090	17266.		13518.		3748.	43245.	18.
47.595	.095	17746.		13930.		3816.	47061.	19.
47.600	.100	18226.		14355.		3871.	50932.	21.
47.605	.105	18706.		14792.		3914.	54846.	23.
47.610	.110	19186.		15242.		3944.	58790.	24.
47.615	.115	19666.		15705.		3962.	62751.	26.
47.620	.120	20146.		16179.		3967.	66718.	28.
47.625	.125	20627.		16666.		3961.	70679.	29.
47.630	.130	21107.		17164.		3943.	74622.	31.
47.635	.135	21587.		17674.		3913.	78535.	32.
47.640	.140	22067.		18195.		3871.	82406.	34.
47.645	.145	22547.		18728.		3819.	86225.	36.
47.650	.150	23027.		19272.		3755.	89979.	37.
47.655	.155	23507.		19830.		3677.	93656.	39.
47.660	.160	23987.		20408.		3579.	97236.	40.
47.665	.165	24467.		20996.		3471.	100707.	42.
47.670	.170	24947.		21596.		3351.	104058.	43.
47.675	.175	25428.		22207.		3221.	107279.	44.
47.680	.180	25908.		22828.		3079.	110358.	46.
47.685	.185	26388.		23460.		2927.	113285.	47.
47.690	.190	26868.		24103.		2765.	116050.	48.
47.695	.195	27348.		24756.		2592.	118642.	49.
47.700	.200	27828.		25419.		2409.	121050.	50.
47.705	.205	28308.		26093.		2216.	123266.	51.
47.710	.210	28788.		26779.		2009.	125275.	52.
47.715	.215	29268.		27477.		1791.	127066.	53.
47.720	.220	29748.		28186.		1583.	128629.	53.
47.725	.225	30229.		28903.		1325.	129954.	54.
47.730	.230	30709.		29631.		1078.	131032.	54.
47.735	.235	31189.		30367.		822.	131854.	54.
47.740	.240	31669.		31112.		557.	132411.	55.
47.745	.245	32149.		31866.		283.	132694.	55.
47.750	.250	32629.		32629.		0.	132694.	55.

1OVF

STATION 2

TIME (HRS)

(O) INTERPOLATED BREAC . HYDROGRAPH
(B) COMPUTED BREACH HYDROGRAPH

STATION 2

B
5/20

TIME (HRS)

(O) INTERPOLATED BREACH HYDROGRAPH
(B) COMPUTED BREACH HYDROGRAPH

8000.	12000.	16000.	20000.	24000.	28000.	32000.	36000.	0.	0.	0.	0.

47.50 1. B
47.51 2. BO
47.51 3. B O
47.52 4. B O
47.52 5. B O
47.53 6. B O
47.53 7. B O.
47.54 8. B O
47.54 9. B .O
47.55 10. B O
47.55 11. B O
47.56 12. B O
47.56 13. B O
47.57 14. B. O
47.57 15. B O
47.58 16. .B O
47.58 17. . B .O
47.59 18. . B . O
47.59 19. . B . O
47.60 20. B O
47.60 21. . B . O
47.61 22. . B . O
47.61 23. . B . O
47.62 24. . B. O.
47.62 25. . B O
47.63 26. . . B . O
47.63 27. . . B . O
47.64 28. . . B . O
47.64 29. . . B . O
47.65 30. B O
47.65 31. . . B . O
47.66 32. . . B O.
47.66 33. . . .B O
47.67 34. . . . B .O
47.67 35. . . . B . O
47.68 36. . . . B . O
47.68 37. . . . B . O
47.69 38. . . . B. O
47.69 39. . . . B O
47.70 40. B O
47.70 41. . . . . B O
47.71 42. . . . . B .O
47.71 43. . . . . B . O
47.72 44. . . . . B. O
47.72 45. . . . . B O
47.73 46. . . . . . B O
47.73 47. . . . . . B O
47.74 48. . . . . . B O
47.74 49. . . . . BO.
47.75 50. B
47.75 51. . . . . . B

1OVN

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
50.	1.00	538.00	.50	548.00	562.80

B
6/20

BEGIN DAM FAILURE AT 47.50 HOURS

PEAK OUTFLOW IS 30491. AT TIME 48.00 HOURS

THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF .010 HOURS DURING BREACH FORMATION.
DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF .250 HOURS.
THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH.
INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	- COMPUTED BREACH HYDROGRAPH (CFS)	= ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
47.500	0.000	8624.	8624.	0.	0.	0.
47.510	.010	8934.	8787.	147.	147.	0.
47.520	.020	9245.	8923.	322.	469.	0.
47.530	.030	9555.	9082.	473.	942.	1.
47.540	.040	9865.	9263.	602.	1544.	1.
47.550	.050	10176.	9464.	712.	2255.	2.
47.560	.060	10486.	9682.	804.	3059.	3.
47.570	.070	10796.	9918.	879.	3938.	3.
47.580	.080	11107.	10169.	938.	4875.	4.
47.590	.090	11417.	10436.	981.	5857.	5.
47.600	.100	11727.	10717.	1011.	6867.	6.
47.610	.110	12038.	11012.	1026.	7893.	7.
47.620	.120	12348.	11320.	1028.	8921.	7.
47.630	.130	12658.	11641.	1017.	9938.	8.
47.640	.140	12969.	11975.	993.	10932.	9.
47.650	.150	13279.	12321.	958.	11889.	10.
47.660	.160	13589.	12679.	910.	12799.	11.
47.670	.170	13900.	13049.	851.	13650.	11.
47.680	.180	14210.	13429.	781.	14431.	12.
47.690	.190	14520.	13820.	700.	15131.	13.
47.700	.200	14831.	14222.	609.	15740.	13.
47.710	.210	15141.	14633.	508.	16248.	13.
47.720	.220	15451.	15055.	397.	16645.	14.
47.730	.230	15762.	15486.	276.	16920.	14.
47.740	.240	16072.	15926.	146.	17066.	14.
47.750	.250	16382.	16382.	0.	17066.	14.
47.760	.260	16947.	16855.	91.	17158.	14.
47.770	.270	17511.	17338.	173.	17331.	14.
47.780	.280	18075.	17829.	246.	17577.	15.
47.790	.290	18640.	18329.	310.	17887.	15.
47.800	.300	19204.	18838.	366.	18253.	15.
47.810	.310	19768.	19355.	414.	18666.	15.
47.820	.320	20333.	19879.	453.	19120.	16.
47.830	.330	20897.	20413.	484.	19604.	16.
47.840	.340	21461.	20960.	501.	20105.	17.
47.850	.350	22026.	21514.	512.	20617.	17.
47.860	.360	22590.	22075.	515.	21131.	17.
47.870	.370	23154.	22643.	511.	21643.	18.
47.880	.380	23719.	23217.	501.	22144.	18.
47.890	.390	24283.	23798.	485.	22630.	19.
47.900	.400	24847.	24384.	464.	23093.	19.
47.910	.410	25412.	24975.	436.	23530.	19.
47.920	.420	25976.	25572.	404.	23934.	20.
47.930	.430	26541.	26174.	367.	24300.	20.

B
7/20

TIME (HRS) — (O) INTERPOLATED BREACH HYDROGRAPH; (B) COMPUTED BREACH HYDROGRAPH

```
          8000.   10000.   12000.   14000.   16000.   18000.   20000.   22000.   24000.   26000.   28000.   30000.
47.50  1.  B      .        .        .        .        .        .        .        .        .        .        .
47.51  2.  BO     .        .        .        .        .        .        .        .        .        .        .
47.52  3.  BO     .        .        .        .        .        .        .        .        .        .        .
47.53  4.  B O    .        .        .        .        .        .        .        .        .        .        .
47.54  5.  B  O.  .        .        .        .        .        .        .        .        .        .        .
47.55  6.  B  .O  .        .        .        .        .        .        .        .        .        .        .
47.56  7.  B . O  .        .        .        .        .        .        .        .        .        .        .
47.57  8.  B  O  .        .        .        .        .        .        .        .        .        .        .
47.58  9.  .B  O  .        .        .        .        .        .        .        .        .        .        .
47.59 10.  .....B....O.....................................................................................
47.60 11.  .  B  O.  .        .        .        .        .        .        .        .        .        .
47.61 12.  .  B  O   .        .        .        .        .        .        .        .        .        .
47.62 13.  .    B . O  .        .        .        .        .        .        .        .        .        .
47.63 14.  .    B . O  .        .        .        .        .        .        .        .        .        .
47.64 15.  .      B  O  .        .        .        .        .        .        .        .        .        .
47.65 16.  .      . B  O  .        .        .        .        .        .        .        .        .        .
47.66 17.  .      . B  O  .        .        .        .        .        .        .        .        .        .
47.67 18.  .      .  B  O.  .        .        .        .        .        .        .        .        .        .
47.68 19.  .      .    B  .O  .        .        .        .        .        .        .        .        .        .
47.69 20.  .....................B...O.....................................................................
47.70 21.  .      .       .B  O  .        .        .        .        .        .        .        .        .
47.71 22.  .      .       .  B  O  .        .        .        .        .        .        .        .        .
47.72 23.  .      .       .    B O  .        .        .        .        .        .        .        .        .
47.73 24.  .      .       .     B O.  .        .        .        .        .        .        .        .        .
47.74 25.  .      .       .       B  .        .        .        .        .        .        .        .        .
47.75 26.  .      .       .        . B  .        .        .        .        .        .        .        .        .
47.76 27.  .      .       .        .  BO  .        .        .        .        .        .        .        .        .
47.77 28.  .      .       .        .    BO  .        .        .        .        .        .        .        .        .
47.78 29.  .      .       .        .     BO  .        .        .        .        .        .        .        .        .
47.79 30.  ..........................................BO.....................................................
47.80 31.  .      .       .        .        . B O  .        .        .        .        .        .        .
47.81 32.  .      .       .        .        .    B O.  .        .        .        .        .        .        .
47.82 33.  .      .       .        .        .     B. O  .        .        .        .        .        .        .
47.83 34.  .      .       .        .        .       . B O  .        .        .        .        .        .        .
47.84 35.  .      .       .        .        .       .   B O  .        .        .        .        .        .        .
47.85 36.  .      .       .        .        .       .     B O  .        .        .        .        .        .        .
47.86 37.  .      .       .        .        .       .       B O  .        .        .        .        .        .        .
47.87 38.  .      .       .        .        .       .       .  B O  .        .        .        .        .        .        .
47.88 39.  .      .       .        .        .       .       .    B O.  .        .        .        .        .        .        .
47.89 40.  ..........................................................B.O.....................................
47.90 41.  .      .       .        .        .       .       .       .  B O  .        .        .        .        .        .        .
47.91 42.  .      .       .        .        .       .       .       .    B O  .        .        .        .        .        .        .
47.92 43.  .      .       .        .        .       .       .       .      B O  .        .        .        .        .        .        .
47.93 44.  .      .       .        .        .       .       .       .       .B O  .        .        .        .        .        .        .
47.94 45.  .      .       .        .        .       .       .       .       .  B O  .        .        .        .        .        .        .
47.95 46.  .      .       .        .        .       .       .       .       .    BO  .        .        .        .        .        .        .
47.96 47.  .      .       .        .        .       .       .       .       .      BO  .        .        .        .        .        .        .
47.97 48.  .      .       .        .        .       .       .       .       .       . BO  .        .        .        .        .        .        .
47.98 49.  .      .       .        .        .       .       .       .       .       .  BO  .        .        .        .        .        .        .
47.99 50.  ..........................................................................................BO.....
48.00 51.  .      .       .        .        .       .       .       .       .       .       .        .        .        .        .        .  B
```

18OVN#

DAM BREACH DATA

B
8/20

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
50.	1.00	538.00	1.00	548.00	562.80

BEGIN DAM FAILURE AT 47.50 HOURS

PEAK OUTFLOW IS 26667. AT TIME 48.50 HOURS

1THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF .021 HOURS DURING BREACH FORMATION.
DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF .250 HOURS.
THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH.
INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	-	COMPUTED BREACH HYDROGRAPH (CFS)	=	ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
47.500	0.000	8624.		8624.		0.	0.	0.
47.521	.021	8859.		8800.		60.	60.	0.
47.542	.042	9094.		8948.		146.	205.	0.
47.563	.063	9329.		9122.		207.	413.	1.
47.583	.083	9564.		9317.		247.	660.	1.
47.604	.104	9799.		9531.		268.	928.	2.
47.625	.125	10034.		9763.		272.	1199.	2.
47.646	.146	10269.		10010.		260.	1459.	3.
47.667	.167	10504.		10271.		233.	1692.	3.
47.688	.188	10739.		10546.		193.	1885.	3.
47.708	.208	10974.		10834.		140.	2025.	3.
47.729	.229	11209.		11134.		76.	2100.	4.
47.750	.250	11444.		11444.		0.	2100.	4.
47.771	.271	11817.		11765.		52.	2152.	4.
47.792	.292	12190.		12095.		95.	2247.	4.
47.813	.313	12563.		12435.		128.	2375.	4.
47.833	.333	12936.		12782.		154.	2529.	4.
47.854	.354	13309.		13138.		171.	2700.	5.
47.875	.375	13682.		13500.		181.	2881.	5.
47.896	.396	14055.		13871.		183.	3064.	5.
47.917	.417	14427.		14268.		160.	3224.	6.
47.938	.438	14800.		14671.		129.	3354.	6.
47.958	.458	15173.		15081.		92.	3446.	6.
47.979	.479	15546.		15497.		49.	3494.	6.
48.000	.500	15919.		15919.		0.	3494.	6.
48.021	.521	16372.		16346.		26.	3520.	6.
48.042	.542	16825.		16787.		38.	3558.	6.
48.063	.563	17278.		17233.		45.	3603.	6.
48.083	.583	17731.		17682.		49.	3651.	6.
48.104	.604	18184.		18135.		49.	3700.	6.
48.125	.625	18637.		18591.		46.	3747.	6.
48.146	.646	19090.		19049.		41.	3788.	7.
48.167	.667	19543.		19509.		35.	3822.	7.
48.188	.688	19996.		19970.		26.	3849.	7.
48.208	.708	20449.		20431.		18.	3867.	7.
48.229	.729	20902.		20893.		9.	3875.	7.
48.250	.750	21355.		21355.		0.	3875.	7.
48.271	.771	21798.		21816.		-18.	3857.	7.
48.292	.792	22241.		22275.		-35.	3822.	7.
48.313	.812	22683.		22733.		-49.	3773.	6.
48.333	.833	23126.		23187.		-62.	3711.	6.
48.354	.854	23569.		23639.		-71.	3641.	6.
48.375	.875	24011.		24087.		-76.	3565.	6.

STATION 2

B
9/20

TIME (HRS)

(O) INTERPOLATED BREACH HYDROGRAPH
(B) COMPUTED BREACH HYDROGRAPH

	8000.	10000.	12000.	14000.	16000.	18000.	20000.	22000.	24000.	26000.	28000.	0.
47.50	1.	B										
47.52	2.	B										
47.54	3.	B										
47.56	4.	BO										
47.58	5.	BO										
47.60	6.	BO.										
47.63	7.	BO										
47.65	8.	BO										
47.67	9.	.B O										
47.69	10.		BO									
47.71	11.		BO									
47.73	12.		B									
47.75	13.		B									
47.77	14.		B.									
47.79	15.		BO									
47.81	16.		BO									
47.83	17.		BO									
47.85	18.		BO									
47.87	19.		B									
47.90	20.			BO								
47.92	21.			.BO								
47.94	22.			BO								
47.96	23.			BO								
47.98	24.			BO								
48.00	25.			B								
48.02	26.			B								
48.04	27.			B								
48.06	28.			B								
48.08	29.			BO.								
48.10	30.			B								
48.12	31.			B								
48.15	32.			B								
48.17	33.			B								
48.19	34.			B								
48.21	35.			B								
48.23	36.			BO								
48.25	37.			B								
48.27	38.			B.								
48.29	39.			.B								
48.31	40.			OB								
48.33	41.			B								
48.35	42.			B								
48.37	43.			B								
48.40	44.			OB								
48.42	45.			OB								
48.44	46.			B								
48.46	47.			B.								
48.48	48.			.B								
48.50	49.			B								

1OVN

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL

B
10/20

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
50.	1.00	538.00	2.00	548.00	562.80

BEGIN DAM FAILURE AT 47.50 HOURS

PEAK OUTFLOW IS 20604. AT TIME 49.50 HOURS

1THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF .042 HOURS DURING BREACH FORMATION.
DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF .250 HOURS.
THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH.
INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	- COMPUTED BREACH HYDROGRAPH (CFS)	= ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
47.500	0.000	8624.	8624.	0.	0.	0.
47.542	.042	8820.	8813.	6.	6.	0.
47.583	.083	9015.	8973.	42.	48.	0.
47.625	.125	9210.	9155.	55.	103.	0.
47.667	.167	9406.	9355.	51.	154.	1.
47.708	.208	9601.	9569.	32.	186.	1.
47.750	.250	9797.	9797.	0.	186.	1.
47.792	.292	10054.	10035.	19.	205.	1.
47.833	.333	10311.	10282.	28.	233.	1.
47.875	.375	10568.	10538.	30.	264.	1.
47.917	.417	10825.	10799.	25.	289.	1.
47.958	.458	11082.	11067.	15.	304.	1.
48.000	.500	11339.	11339.	0.	304.	1.
48.042	.542	11632.	11614.	18.	322.	1.
48.083	.583	11926.	11892.	34.	356.	1.
48.125	.625	12220.	12171.	48.	405.	1.
48.167	.667	12514.	12476.	37.	442.	2.
48.208	.708	12807.	12788.	19.	462.	2.
48.250	.750	13101.	13101.	0.	462.	2.
48.292	.792	13423.	13415.	8.	470.	2.
48.333	.833	13745.	13734.	11.	481.	2.
48.375	.875	14067.	14061.	6.	487.	2.
48.417	.917	14389.	14387.	2.	489.	2.
48.458	.958	14711.	14711.	0.	489.	2.
48.500	1.000	15033.	15033.	0.	489.	2.
48.542	1.042	15340.	15352.	-12.	478.	2.
48.583	1.083	15647.	15667.	-19.	458.	2.
48.625	1.125	15955.	15977.	-23.	436.	1.
48.667	1.167	16262.	16283.	-21.	414.	1.
48.708	1.208	16569.	16583.	-14.	401.	1.
48.750	1.250	16877.	16877.	-0.	401.	1.
48.792	1.292	17142.	17163.	-21.	380.	1.
48.833	1.333	17407.	17442.	-35.	345.	1.
48.875	1.375	17673.	17713.	-40.	305.	1.
48.917	1.417	17938.	17974.	-36.	268.	1.
48.958	1.458	18204.	18227.	-23.	245.	1.
49.000	1.500	18469.	18469.	0.	245.	1.
49.042	1.542	18673.	18701.	-28.	217.	1.
49.083	1.583	18877.	18923.	-45.	172.	1.
49.125	1.625	19082.	19133.	-51.	121.	0.
49.167	1.667	19286.	19332.	-46.	75.	0.
49.208	1.708	19490.	19519.	-29.	46.	0.
49.250	1.750	19695.	19695.	0.	46.	0.
49.292	1.792	19844.	19957.	11.	75.	0.

STATION 2

B

11/20

TIME (HRS)

(O) INTERPOLATED BREACH HYDROGRAPH
(B) COMPUTED BREACH HYDROGRAPH

	8000.	10000.	12000.	14000.	16000.	18000.	20000.	22000.	0.	0.	0.	0.
47.50	1.	B										
47.54	2.	B										
47.58	3.	B										
47.63	4.	B										
47.67	5.	B										
47.71	6.	B										
47.75	7.	B										
47.79	8.	B										
47.83	9.	BO										
47.88	10.	B										
47.92	11.	B										
47.96	12.	B										
48.00	13.	B										
48.04	14.	B										
48.08	15.	BO										
48.13	16.	B										
48.17	17.	BO										
48.21	18.	B										
48.25	19.	B										
48.29	20.	B										
48.33	21.	B										
48.38	22.	B										
48.42	23.	B										
48.46	24.	B										
48.50	25.	B										
48.54	26.	B										
48.58	27.	B										
48.63	28.	B										
48.67	29.	B										
48.71	30.	B										
48.75	31.	B										
48.79	32.	B										
48.83	33.	B										
48.88	34.	OB										
48.92	35.	B										
48.96	36.	B										
49.00	37.	B										
49.04	38.	OB										
49.08	39.	OB										
49.13	40.	OB										
49.17	41.	OB										
49.21	42.	OB										
49.25	43.	B										
49.29	44.	B										
49.33	45.	B										
49.38	46.	B										
49.42	47.	B										
49.46	48.	B										
49.50	49.	B										

DAM BREACH DATA

B

12/20

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
50.	1.00	538.00	4.00	548.00	562.80

BEGIN DAM FAILURE AT 47.50 HOURS

PEAK OUTFLOW IS 13564. AT TIME 50.17 HOURS

1THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF .083 HOURS DURING BREACH FORMATION.
DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF .250 HOURS.
THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH.
INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	- COMPUTED BREACH HYDROGRAPH (CFS)	= ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
47.500	0.000	8624.	8624.	0.	0.	0.
47.583	.083	8819.	8840.	-20.	-20.	-0.
47.667	.167	9015.	9018.	-3.	-23.	-0.
47.750	.250	9210.	9210.	0.	-23.	-0.
47.833	.333	9414.	9411.	4.	-20.	-0.
47.917	.417	9618.	9616.	3.	-17.	-0.
48.000	.500	9823.	9823.	0.	-17.	-0.
48.083	.583	10026.	10029.	-3.	-20.	-0.
48.167	.667	10230.	10233.	-3.	-23.	-0.
48.250	.750	10434.	10434.	0.	-23.	-0.
48.333	.833	10625.	10629.	-4.	-27.	-0.
48.417	.917	10817.	10817.	-1.	-27.	-0.
48.500	1.000	11008.	11008.	0.	-27.	-0.
48.583	1.083	11216.	11223.	-7.	-34.	-0.
48.667	1.167	11425.	11431.	-7.	-41.	-0.
48.750	1.250	11633.	11633.	0.	-41.	-0.
48.833	1.333	11834.	11843.	-9.	-50.	-0.
48.917	1.417	12035.	12044.	-9.	-59.	-0.
49.000	1.500	12236.	12236.	0.	-59.	-0.
49.083	1.583	12406.	12418.	-12.	-71.	-0.
49.167	1.667	12576.	12588.	-12.	-82.	-1.
49.250	1.750	12746.	12746.	0.	-82.	-1.
49.333	1.833	12878.	12891.	-13.	-96.	-1.
49.417	1.917	13010.	13024.	-13.	-109.	-1.
49.500	2.000	13143.	13143.	0.	-109.	-1.
49.583	2.083	13233.	13247.	-15.	-124.	-1.
49.667	2.167	13323.	13337.	-15.	-139.	-1.
49.750	2.250	13413.	13413.	0.	-139.	-1.
49.833	2.333	13458.	13473.	-15.	-153.	-1.
49.917	2.417	13503.	13518.	-15.	-168.	-1.
50.000	2.500	13548.	13548.	0.	-168.	-1.
50.083	2.583	13548.	13563.	-15.	-183.	-1.
50.167	2.667	13548.	13564.	-15.	-199.	-1.
50.250	2.750	13549.	13549.	0.	-199.	-1.
50.333	2.833	13528.	13518.	10.	-189.	-1.
50.417	2.917	13507.	13502.	5.	-184.	-1.
50.500	3.000	13486.	13486.	0.	-184.	-1.
50.583	3.083	13435.	13453.	-18.	-202.	-1.
50.667	3.167	13384.	13402.	-18.	-220.	-2.
50.750	3.250	13333.	13333.	0.	-220.	-2.
50.833	3.333	13229.	13246.	-17.	-237.	-2.
50.917	3.417	13125.	13143.	-17.	-254.	-2.
51.000	3.500	13022.	13022.	0.	-254.	-2.
51.083	3.583	12978.	12994.	-16.	-270.	-2.

STATION 2

B

2/20

TIME (HRS)

(O) INTERPOLATED BREACH HYDROGRAPH
(B) COMPUTED BREACH HYDROGRAPH

	8500.	9000.	9500.	10000.	10500.	11000.	11500.	12000.	12500.	13000.	13500.	14000.
47.50 1.	B											
47.58 2.	OB											
47.67 3.		B										
47.75 4.			B									
47.83 5.				B								
47.92 6.					B							
48.00 7.						B						
48.08 8.							B					
48.17 9.								B				
48.25 10.									B			
48.33 11.							B					
48.42 12.								B				
48.50 13.									B			
48.58 14.										B		
48.67 15.										OB		
48.75 16.											B	
48.83 17.												B
48.92 18.												B
49.00 19.												B
49.08 20.												B
49.17 21.												B
49.25 22.												B
49.33 23.												B
49.42 24.												B
49.50 25.												B
49.58 26.												B
49.67 27.												OB
49.75 28.												B
49.83 29.												B
49.92 30.												B
50.00 31.												B
50.08 32.												B
50.17 33.												B
50.25 34.												B
50.33 35.												BO
50.42 36.												B
50.50 37.												B
50.58 38.												B
50.67 39.												B
50.75 40.												B
50.83 41.												B
50.92 42.												B
51.00 43.												B
51.08 44.										OB		
51.17 45.										OB		
51.25 46.									B			
51.33 47.									B			
51.42 48.								B				
51.50 49.								B				

1OVN

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

HYDROGRAPH ROUTING

REACH 2-3

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
3	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME
ROUTING DATA

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

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

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.1000	.0400	.1000	525.0	560.0	200.	.01000

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
0.00 560.00 90.00 540.00 200.00 530.00 205.00 525.00 220.00 525.00
225.00 530.00 250.00 540.00 1100.00 560.00

STORAGE	0.	0.	0.	1.	1.	1.	2.	3.	5.	6.
	8.	12.	15.	20.	25.	31.	38.	45.	54.	63.
OUTFLOW	0.	154.	498.	1042.	1902.	3099.	4699.	6759.	9333.	12402.
	16620.	22061.	28926.	37413.	47708.	59985.	74411.	91147.	110348.	132163.
STAGE	525.0	526.8	528.7	530.5	532.4	534.2	536.1	537.9	539.7	541.6
	543.4	545.3	547.1	548.9	550.8	552.6	554.5	556.3	558.2	560.0
FLOW	0.	154.	498.	1042.	1902.	3099.	4699.	6759.	9333.	12402.
	16620.	22061.	28926.	37413.	47708.	59985.	74411.	91147.	110348.	132163.

MAXIMUM STAGE IS 547.6

MAXIMUM STAGE IS 547.4

MAXIMUM STAGE IS 546.5

MAXIMUM STAGE IS 544.8

MAXIMUM STAGE IS 542.1

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

HYDROGRAPH ROUTING

REACH 3-4

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	1	0	0	0	0	1	0	0

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

HYDROGRAPH ROUTING

REACH 3-4

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

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

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

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.1000	.0400	.1000	523.0	560.0	1200.	.00170

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 560.00 50.00 540.00 100.00 528.00 110.00 523.00 120.00 523.00
130.00 528.00 470.00 540.00 630.00 560.00

STORAGE	0.	1.	2.	4.	9.	17.	28.	43.	62.	83.
	107.	131.	157.	183.	211.	240.	270.	301.	333.	366.
OUTFLOW	0.	53.	197.	478.	994.	1819.	3034.	4708.	6908.	9785.
	13508.	17806.	22669.	28093.	34079.	40629.	47744.	55432.	63697.	72545.
STAGE	523.0	524.9	526.9	528.8	530.8	532.7	534.7	536.6	538.6	540.5
	542.5	544.4	546.4	548.3	550.3	552.2	554.2	556.1	558.1	560.0
FLOW	0.	53.	197.	478.	994.	1819.	3034.	4708.	6908.	9785.
	13508.	17806.	22669.	28093.	34079.	40629.	47744.	55432.	63697.	72545.

MAXIMUM STAGE IS 549.7

MAXIMUM STAGE IS 548.4

MAXIMUM STAGE IS 547.3

MAXIMUM STAGE IS 545.4

MAXIMUM STAGE IS 542.5

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

HYDROGRAPH ROUTING

REACH 4-5

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO

HYDROGRAPH ROUTING

REACH 4-5

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
5	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

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

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

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.1000	.0400	.1000	521.0	560.0	1000.	.00200

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 560.00 200.00 540.00 450.00 525.00 520.00 521.00 528.00 521.00
530.00 525.00 700.00 540.00 830.00 560.00

STORAGE	0.	1.	4.	10.	17.	28.	42.	58.	76.	98.
	122.	147.	175.	203.	234.	266.	299.	334.	371.	409.
OUTFLOW	0.	101.	525.	1563.	3157.	5368.	8251.	11863.	16261.	21497.
	27832.	35113.	43270.	52319.	62274.	73152.	84972.	97754.	111515.	126276.
STAGE	521.0	523.1	525.1	527.2	529.2	531.3	533.3	535.4	537.4	539.5
	541.5	543.6	545.6	547.7	549.7	551.8	553.8	555.9	557.9	560.0
FLOW	0.	101.	525.	1563.	3157.	5368.	8251.	11863.	16261.	21497.
	27832.	35113.	43270.	52319.	62274.	73152.	84972.	97754.	111515.	126276.

MAXIMUM STAGE IS 542.6

MAXIMUM STAGE IS 542.0

MAXIMUM STAGE IS 540.6

MAXIMUM STAGE IS 539.0

MAXIMUM STAGE IS 536.2

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

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)

B
17/20

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .34
HYDROGRAPH AT	1	20.50 (53.09)	1	10138. (287.07)(
			2	10138. (287.07)(
			3	10138. (287.07)(
			4	10138. (287.07)(
			5	10138. (287.07)(
ROUTED TO	2	20.50 (53.09)	1	32629. (923.95)(
			2	30491. (863.41)(
			3	26667. (755.14)(
			4	20604. (583.43)(
			5	13549. (383.65)(
ROUTED TO	3	20.50 (53.09)	1	31420. (889.72)(
			2	30109. (852.59)(
			3	26561. (752.11)(
			4	20586. (582.93)(
			5	13550. (383.69)(
ROUTED TO	4	20.50 (53.09)	1	32217. (912.28)(
			2	28500. (807.02)(
			3	25271. (715.60)(
			4	20364. (576.63)(
			5	13559. (383.95)(
ROUTED TO	5	20.50 (53.09)	1	31816. (900.94)(
			2	29382. (832.02)(
			3	24943. (706.31)(
			4	20197. (571.92)(

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	548.00	548.00	562.30
STORAGE	1104.	1104.	3107.
OUTFLOW	0.	0.	8030.

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
.34	562.82	.52	3210.	32629.	1.21	47.75	47.50

PLAN 2 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	548.00	548.00	562.30
STORAGE	1104.	1104.	3107.
OUTFLOW	0.	0.	8030.

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
.34	562.83	.53	3212.	30491.	1.32	48.00	47.50

PLAN 3 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	548.00	548.00	562.30
STORAGE	1104.	1104.	3107.
OUTFLOW	0.	0.	8030.

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
.34	562.84	.54	3214.	26667.	1.50	48.50	47.50

PLAN 4 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	548.00	548.00	562.30
STORAGE	1104.	1104.	3107.
OUTFLOW	0.	0.	8030.

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
.34	562.86	.56	3218.	20604.	1.79	49.50	47.50

PLAN 5 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	548.00	548.00	562.30
STORAGE	1104.	1104.	3107.
OUTFLOW	0.	0.	8030.

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
.34	562.89	.59	3224.	13564.	2.17	50.17	47.50

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	31420.	547.6	47.75

PLAN 2 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	30109.	547.4	48.00

PLAN 3 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	26561.	546.5	48.50

PLAN 4 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	20586.	544.8	49.50

PLAN 5 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	13550.	542.1	50.00

PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	32217.	549.7	48.00

PLAN 2 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	28500.	548.4	48.25

B
20/20

PLAN 3 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	25271.	547.3	48.50

PLAN 4 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	20364.	545.4	49.50

PLAN 5 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	13559.	542.5	50.25

PLAN 1 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	31816.	542.6	48.00

PLAN 2 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	29382.	542.0	48.25

PLAN 3 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	24943.	540.6	48.75

PLAN 4 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	20197.	539.0	49.50

PLAN 5 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.34	13557.	536.2	50.25

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION  JULY 1978
 LAST MODIFICATION  21 AUG 78
**********
```

```
  1          A1    SWEET ARROW LAKE DAM **** UPPER LITTLE SWATARA CREEK
  2          A2    PINE GROVE TWP., SCHUYLKILL COUNTY
  3          A3    NDI # PA-00680   PA DER # 54-102
  4          B   300     0     15      0      0      0      0      0     -4      0
  5          B1    5
  6          J     1     9      1                                                 /
  7          J1    1   .85    .7     .6     .5     .4     .3     .2     .1
  8          K            1                                   1
  9          K1                INFLOW HYDROGRAPH
 10          M     1      1   20.5
 11          P           23.2   106    116    125  136.5
 12          T                                               1    .05
 13          W   7.3    .85
 14          X  -1.5   -.05     2
 15          K     1      2                                   1
 16          K1                RESERVOIR ROUTING
 17          Y                              1      0
 18          Y1    1                                                1105     -1
 19          Y4  548    549    551    554    558  562.5
 20          Y5    0    149    772   2182   4696   8200
 21          $A    0     92    175    404
 22          $E  512    548    560    580
 23          $$  548
 24          $D 562.5   2.7    1.5    450
 25          K    99
```

1 PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

```
RUNOFF HYDROGRAPH AT          1
ROUTE HYDROGRAPH TO           2
END OF NETWORK
```

```
1**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION  JULY 1978
 LAST MODIFICATION  21 AUG 78
**********

RUN  DATE= 79/02/23.
     TIME= 07.44.59.
```

SWEET ARROW LAKE DAM **** UPPER LITTLE SWATARA CREEK
PINE GROVE TWP., SCHUYLKILL COUNTY
NDI # PA-00680 PA DER # 54-102

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	15	0	0	0	0	0	-4	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 9 LRTIO= 1

RTIOS=	1.00	.85	.70	.60	.50	.40	.30	.20	.10

SWEET ARROW LAKE DAM **** UPPER LITTLE SWATARA CREEK
PINE GROVE TWP., SCHUYLKILL COUNTY
NDI # PA-00680 PA DER # 54-102

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	15	0	0	0	0	0	-4	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 9 LRTIO= 1

RTIOS= 1.00 .85 .70 .60 .50 .40 .30 .20 .10

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

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

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

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	20.50	0.00	20.50	0.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.20	106.00	116.00	125.00	136.50	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .824

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	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA
TP= 7.30 CP= .85 NTA= 0

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

UNIT HYDROGRAPH 67 END-OF-PERIOD ORDINATES, LAG= 7.22 HOURS, CP= .81 VOL= 1.00

17.	62.	124.	194.	269.	345.	422.	498.	574.	648.
720.	791.	859.	925.	990.	1052.	1112.	1171.	1227.	1282.
1336.	1387.	1436.	1478.	1509.	1530.	1542.	1547.	1546.	1538.
1525.	1506.	1484.	1457.	1426.	1392.	1353.	1311.	1266.	1216.
1162.	1102.	1036.	962.	869.	762.	660.	572.	495.	429.
371.	322.	279.	241.	209.	181.	157.	136.	118.	102.
88.	76.	66.	57.	50.	43.	37.			

0 END-OF-PERIOD FLOW

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

SUM 26.09 23.66 2.43 1258242.
(663.)(601.)(62.)(35629.45)

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

HYDROGRAPH ROUTING

RESERVOIR ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	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
1	0	0	0.000	0.000	0.000	1105.	-1

STAGE	548.0	549.0	551.0	554.0	558.0	562.5
FLOW	0.	149.	772.	2182.	4696.	8200.
SURFACE AREA=	0.	92.	175.	404.		
CAPACITY=	0.	1104.	2680.	8312.		
ELEVATION=	512.	548.	560.	580.		

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
548.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
562.5	2.7	1.5	450.

PEAK OUTFLOW IS 29477. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 25032. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 20568. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 17558. AT TIME 47.00 HOURS

PEAK OUTFLOW IS 14483. AT TIME 47.25 HOURS

PEAK OUTFLOW IS 11177. AT TIME 47.75 HOURS

PEAK OUTFLOW IS 7659. AT TIME 48.50 HOURS

PEAK OUTFLOW IS 5286. AT TIME 48.25 HOURS

PEAK OUTFLOW IS 2522. AT TIME 48.75 HOURS

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

1 ********** ********** ********** ********** **********

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 1.00	RATIO 2 .85	RATIO 3 .70	RATIO 4 .60	RATIO 5 .50	RATIO 6 .40	RATIO 7 .30	RATIO 8 .20	RATIO 9 .10
HYDROGRAPH AT	1	20.50	1	29817.	25345.	20872.	17890.	14909.	11927.	8945.	5963.	2982.
		(53.09)		(844.33)	(717.68)	(591.03)	(506.60)	(422.17)	(337.73)	(253.30)	(168.87)	(84.43)
ROUTED TO	2	20.50	1	29477.	25032.	20568.	17558.	14483.	11177.	7659.	5286.	2522.
		(53.09)		(834.69)	(708.81)	(582.42)	(497.18)	(410.11)	(316.50)	(216.89)	(149.68)	(71.40)

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	548.01	548.00	562.50
STORAGE	1105.	1104.	3146.
OUTFLOW	1.	0.	8200.

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
1.00	568.34	5.84	4478.	29477.	11.50	47.00	0.00
.85	567.44	4.94	4249.	25032.	10.75	47.00	0.00
.70	566.46	3.96	4010.	20568.	9.50	47.00	0.00
.60	565.73	3.23	3840.	17558.	8.50	47.00	0.00
.50	564.92	2.42	3655.	14483.	7.25	47.25	0.00
.40	563.89	1.39	3432.	11177.	5.25	47.75	0.00
.30	561.74	0.00	2997.	7659.	0.00	48.50	0.00
.20	558.38	0.00	2407.	5286.	0.00	48.25	0.00
.10	554.54	0.00	1839.	2522.	0.00	48.75	0.00

I**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 21 AUG 78
****
EOI ENCOUNTERED.

N>

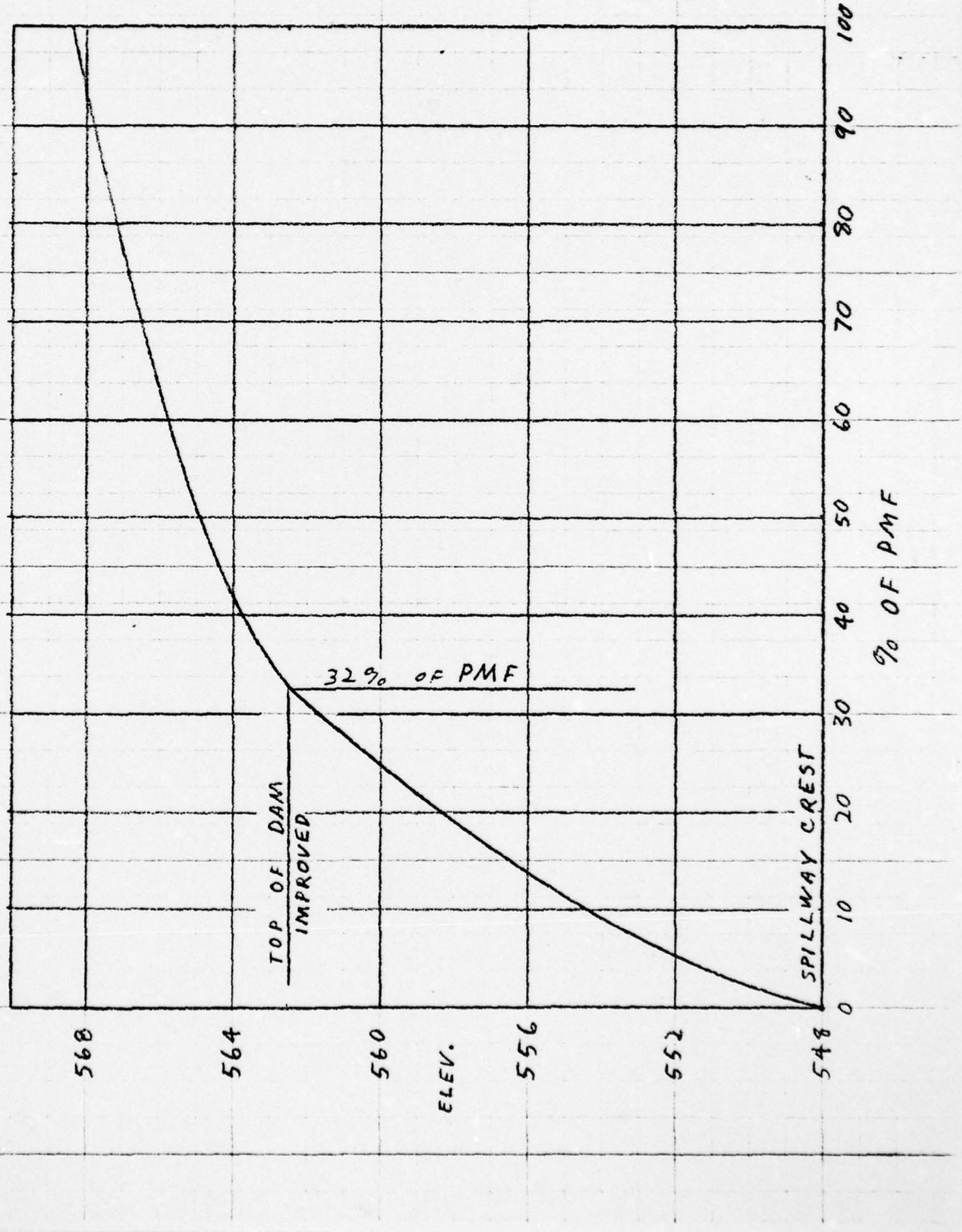
BY RLS DATE 2/23/79 **BERGER ASSOCIATES** SHEET NO. ____ OF ____

CHKD. BY ____ DATE ____ PROJECT D8490

SUBJECT SWEET ARROW LAKE DAM

SPILLWAY RATING CURVE

IMPROVED EMBANKMENT



APPENDIX D

GEOLOGIC REPORT

GEOLOGIC REPORT

Bedrock - Dam

Formation Name: Mahantango Formation, Montebello Sandstone Member.

Lithology: The Montebello Sandstone consists of gray, olive gray, yellowish brown and olive brown sandstone, with some conglomerate, conglomeratic sandstone siltstone or shale interbeds.

Bedrock - Reservoir

Formation Names: Bloomsburg Red Beds; Ridgeley Sandstane; Selinsgrove Limestone; Marcellus Formation and Mahantango Formation, including the lower shale and sandstone member, Montebello Sandstone Member, and upper shale member.

Lithologies: Bloomsburg Red beds, red shales and siltstones, locally calcareous; Ridgeley Sandstone, coarse to medium sandstone, with calcite cement; Selinsgrove limestone, gray, shaly, cherty limestone; Marcellus shale, black fissile shale, Mahantango Formation, dark gray silty shales, siltstones with interbedded sandstones, includes the Montebello Sandstone described above.

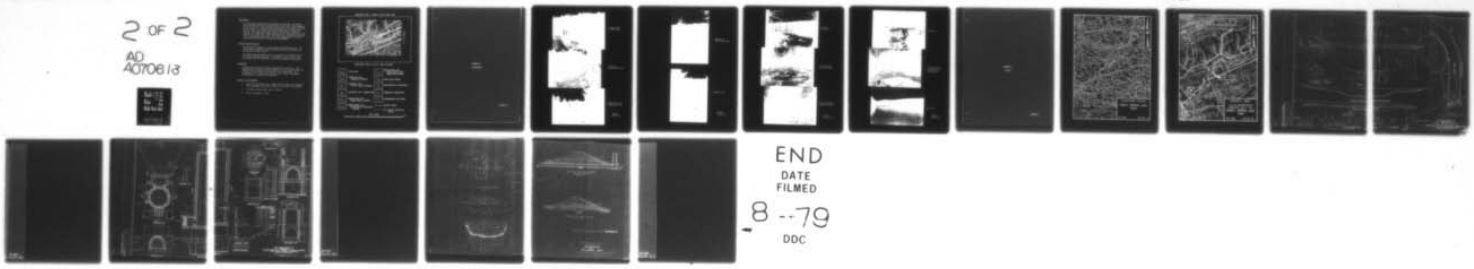
Structure

The Sweet Arrow Dam is located on the north flank of the Roedersville Anticline, an overturned, faulted anticline whose axis trends N70°E. Bedding in the Montebello Sandstone near the west end of the dam strikes N50°E and dips 50°SE, and is overturned. Fracture traces trend N25°E, N5°E, N40°W, N20°W and N70°W.

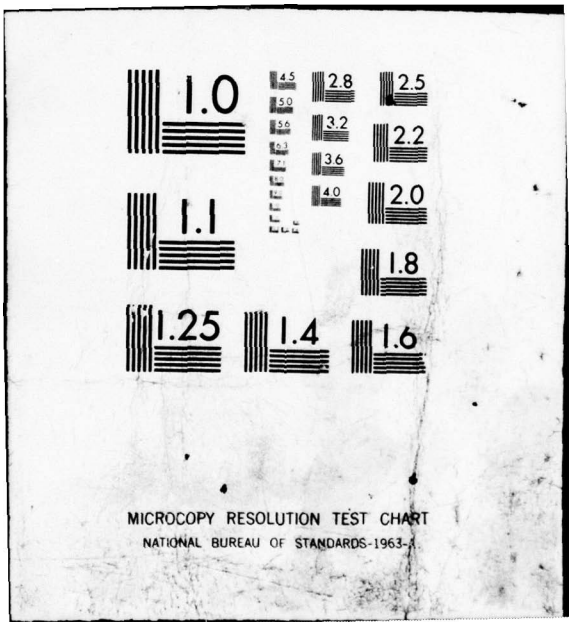
The area is one of tight folds and considerable faulting. Fracture cleavage is generally present in the silty and shaly rocks. Two branches of the Sweet Arrow Fault, a major thrust fault, pass through the reservoir. The strike of these faults is about N65°E and then dips steeply south. These faults formed at the times of folding, about 270 to 300 million years ago. There has been no known subsequent activity of these faults.

AD-A070 613 BERGER ASSOCIATES INC HARRISBURG PA F/G 13/2
NATIONAL DAM INSPECTION PROGRAM. SWEET ARROW LAKE DAM (NDI-PA-0--ETC(U)
APR 79 DACW31-79-C-0012
UNCLASSIFIED NL

2 OF 2
AD
A070813



END
DATE
FILMED
8 -79
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Overburden

No drill hole information is available for this dam. The Montebello Sandstone does not weather deeply, fresh rock can be expected at 10 to 15 feet. Some alluvium was present in the valley of Little Swatara Creek. The plans for the dam called for a cutoff trench dug "to sound rock" and for grouting as indicated by pressure testing. An inspection report, dated July 21, 1923, states that the rock in the trench was "a hard fine grain (sic) sandstone which dips 70° in a downstream direction, the strike being about 15° to the centerline" of the dam. Grouting was recommended.

Aquifer Characteristics

The Montebello Sandstone is an essentially impermeable rock. All ground water movement is along bedding planes and fractures; and is generally rather limited.

The Selinsgrove limestone, which is exposed in the reservoir area is locally somewhat cavernous. Its outcrop is not close to the dam itself, and its structure is such that leakage is improbable.

Discussion

Grouting was carried out during construction of this dam. The leakage that was reported after completion of the dam was along the "blowoff line" and was not through the rock foundation. The foundation is in a sound, non-soluble rock, and not susceptible to alteration by ground water movement.

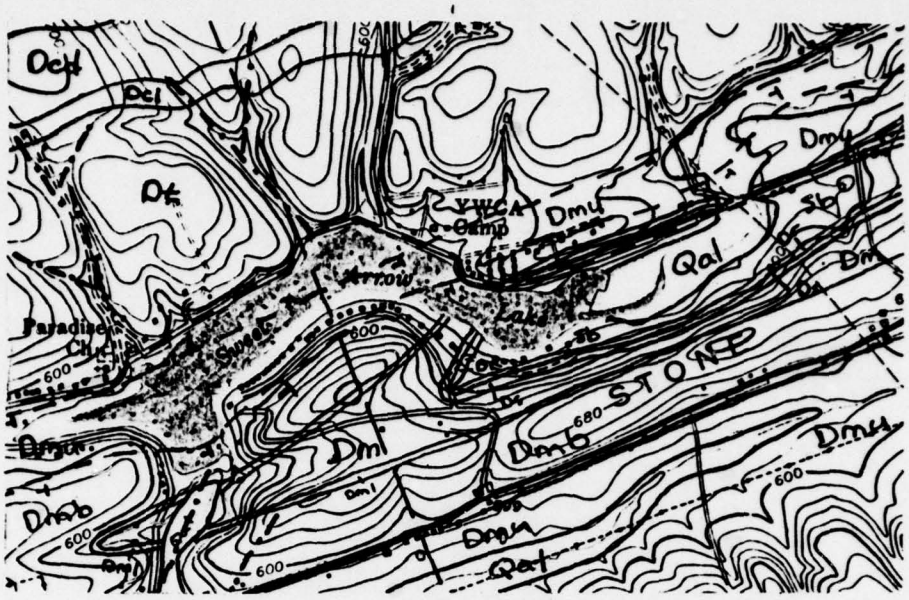
Sources of Information

1. Wood, G.R. and Kehn, T.M., (1968) "Geologic Map of the Swatara Hill Quadrangle, Schuylkill County, Pa." U.S.G.S. Map GQ 689.

2. Air Photos, dated 1969, scale 1:24,000.

3. Plans and Reports in file.

GEOLOGIC MAP - Sweet Arrow Lake Dam



(geology from U.S.G.S. Map GQ-689)

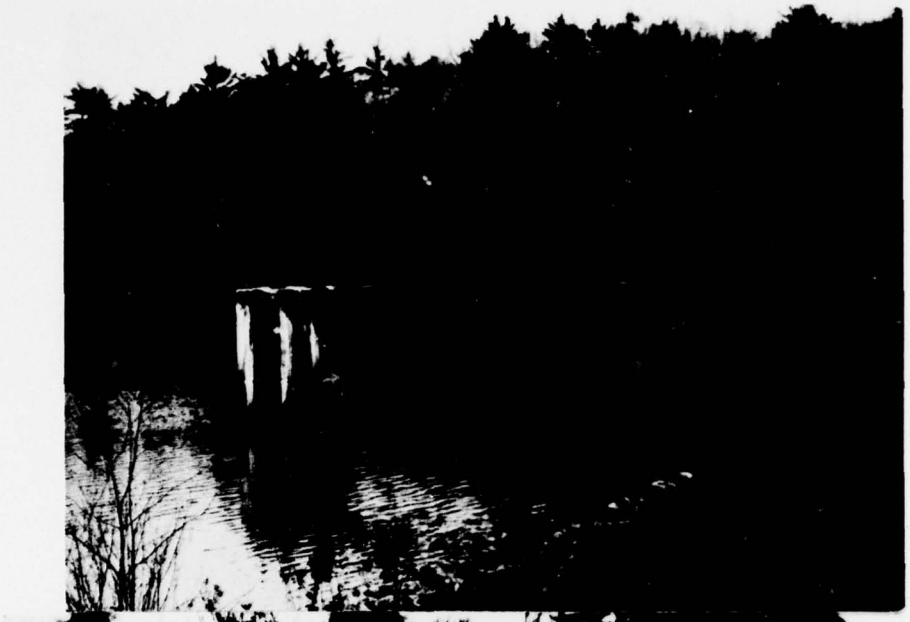
Qal	alluvium	Dml	Mahantango Fm.- lower shale and sandstone member
Dcd	Catskill Fm.- Damascus Member	Dm	Marcellus Shale
Dci	Catskill Fm.- Irish Valley Member	Ds	Selinsgrove limestone
Dt	Trimmers Rk. sandstone	Dr	Ridgeley Sandstone
Dmu	Mahantango Fm.- upper shale member	Sb	Bloomsburg Red beds
Dmb	Mahantango Fm.- Montebello sandstone member	—?—	thrust fault
		—·—·—	air photo fracture trace

SCALE 1:24000

1 0 1 MILE

APPENDIX E

PHOTOGRAPHS

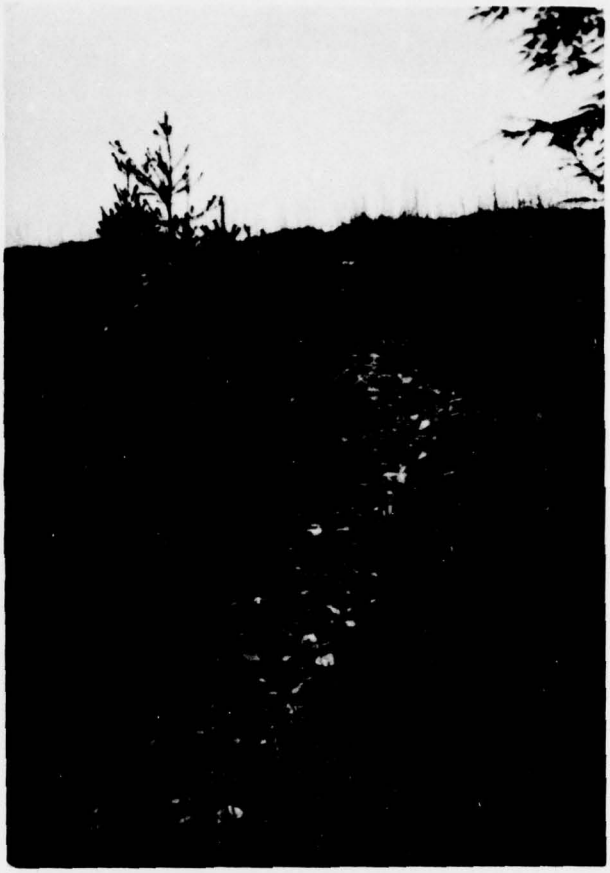


Intake Tower
& Footbridge

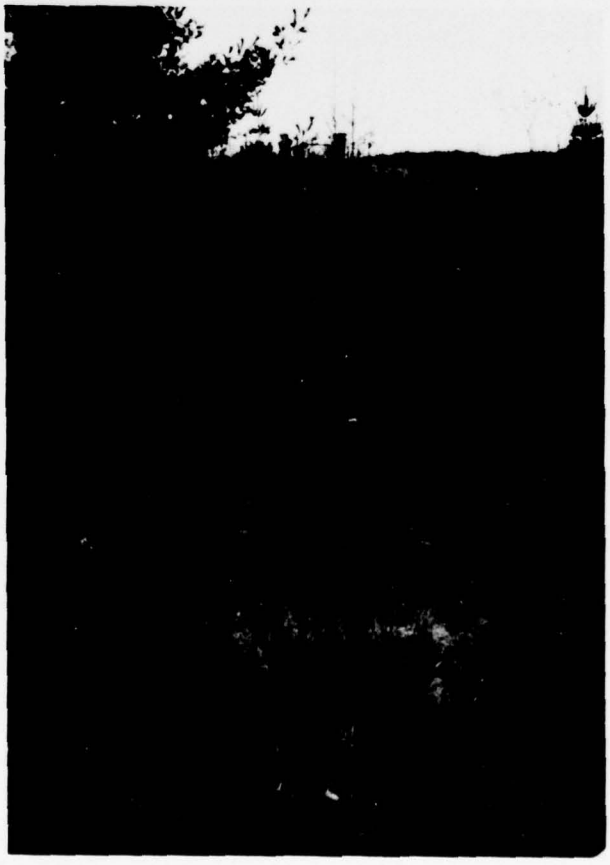
Trees on
Downstream Slope

"Bike Path" on
Downstream Slope

PA-680
PLATE E-I



Erosion on
Downstream Slope

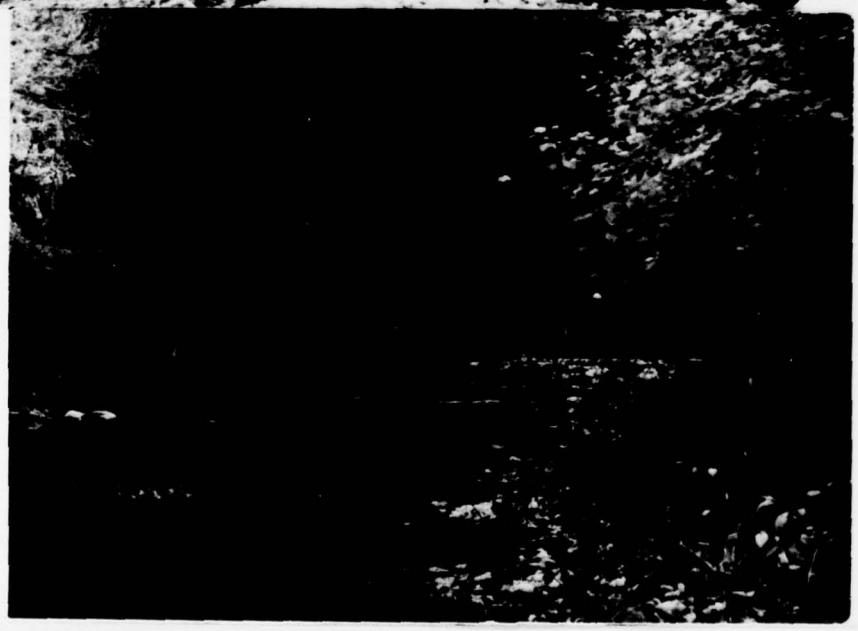


Rockfill Toe

PA-680
PLATE E-II

Entrance to
Spillway

Spillway Over
First 200 Feet

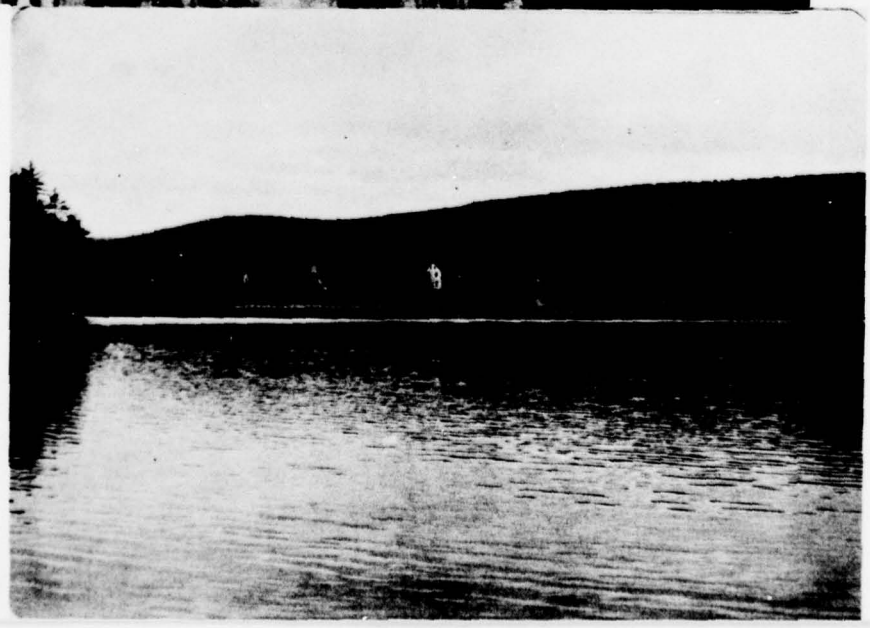


Spillway Channel
Just Above Drop

PA-680
PLATE E-III

Spillway

Conduit Outlet
With Creek in
Background

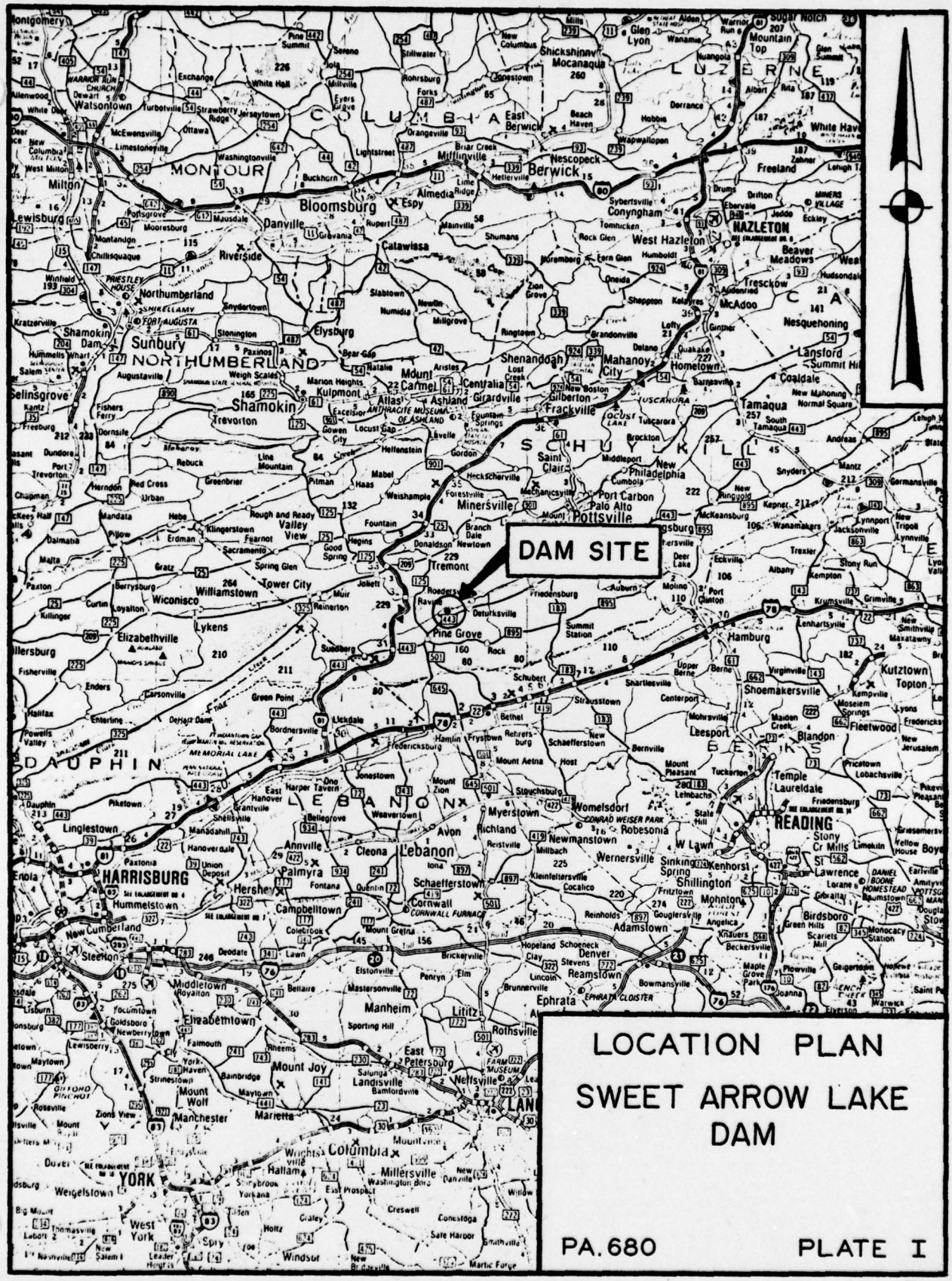


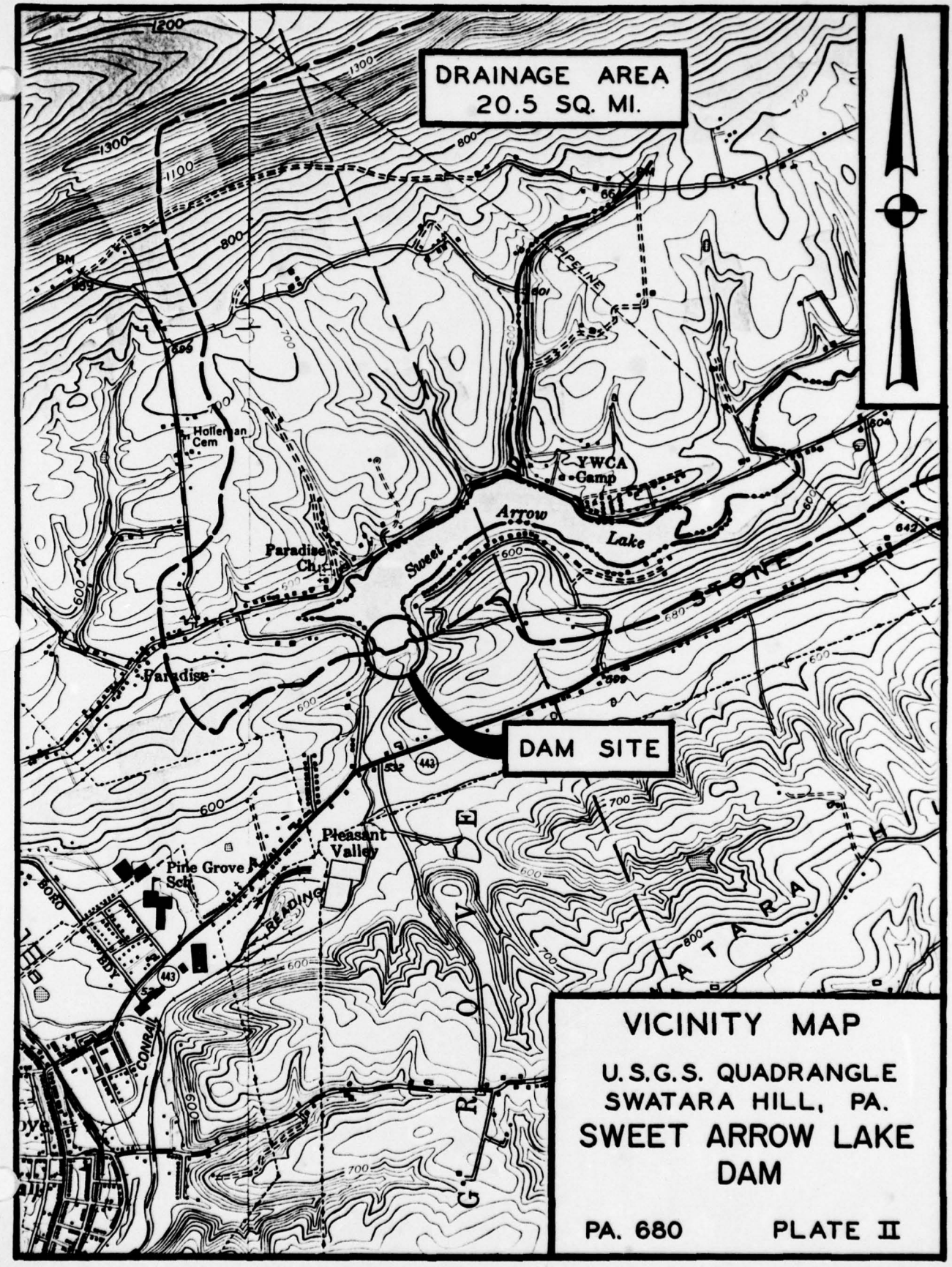
Reservoir

PA-680
PLATE E-IV

APPENDIX F

PLATES


DAM SITE
LOCATION PLAN
SWEET ARROW LAKE
DAM
PA. 680
PLATE I

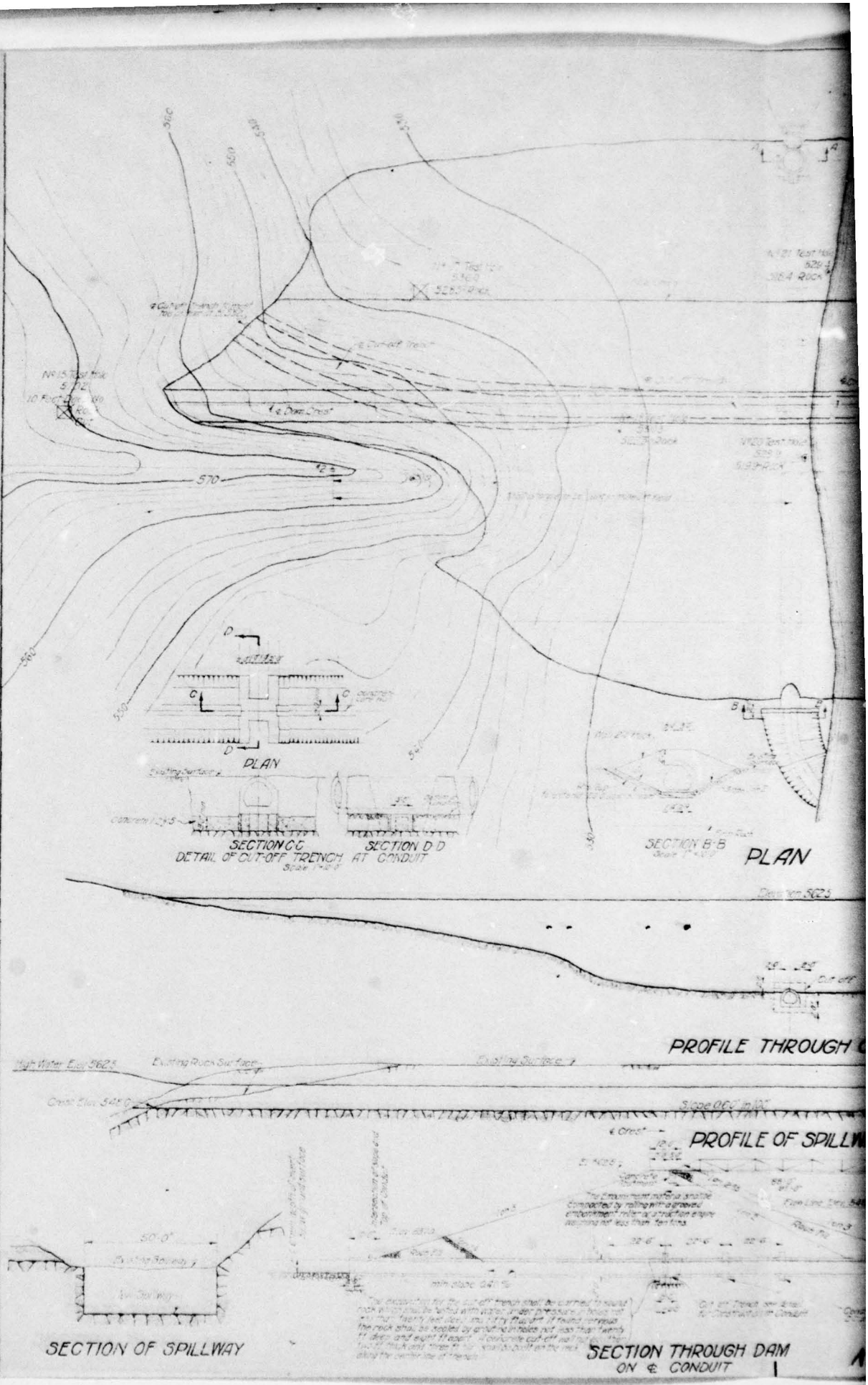


VICINITY MAP

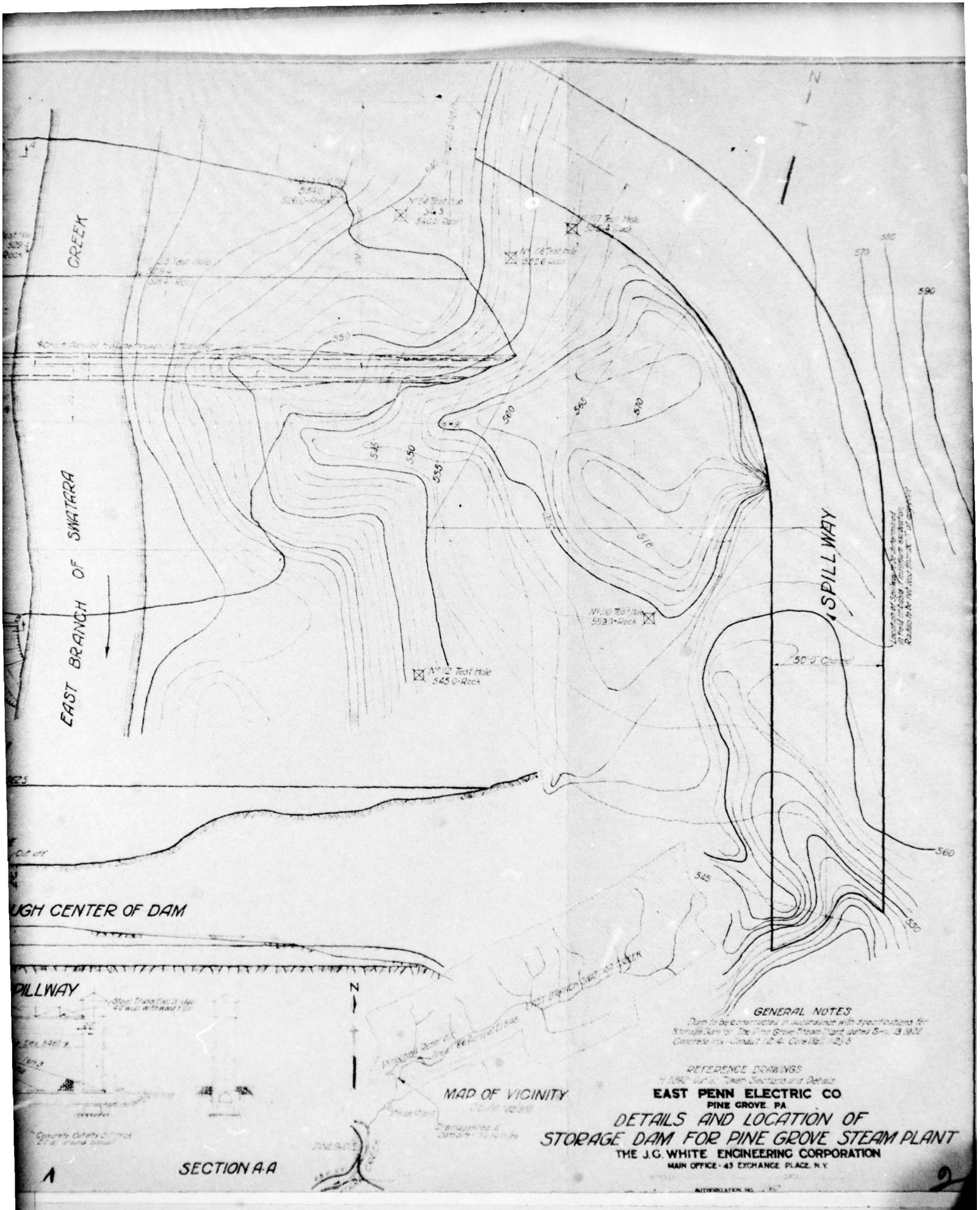
U.S.G.S. QUADRANGLE
SWATARA HILL, PA.

SWEET ARROW LAKE DAM

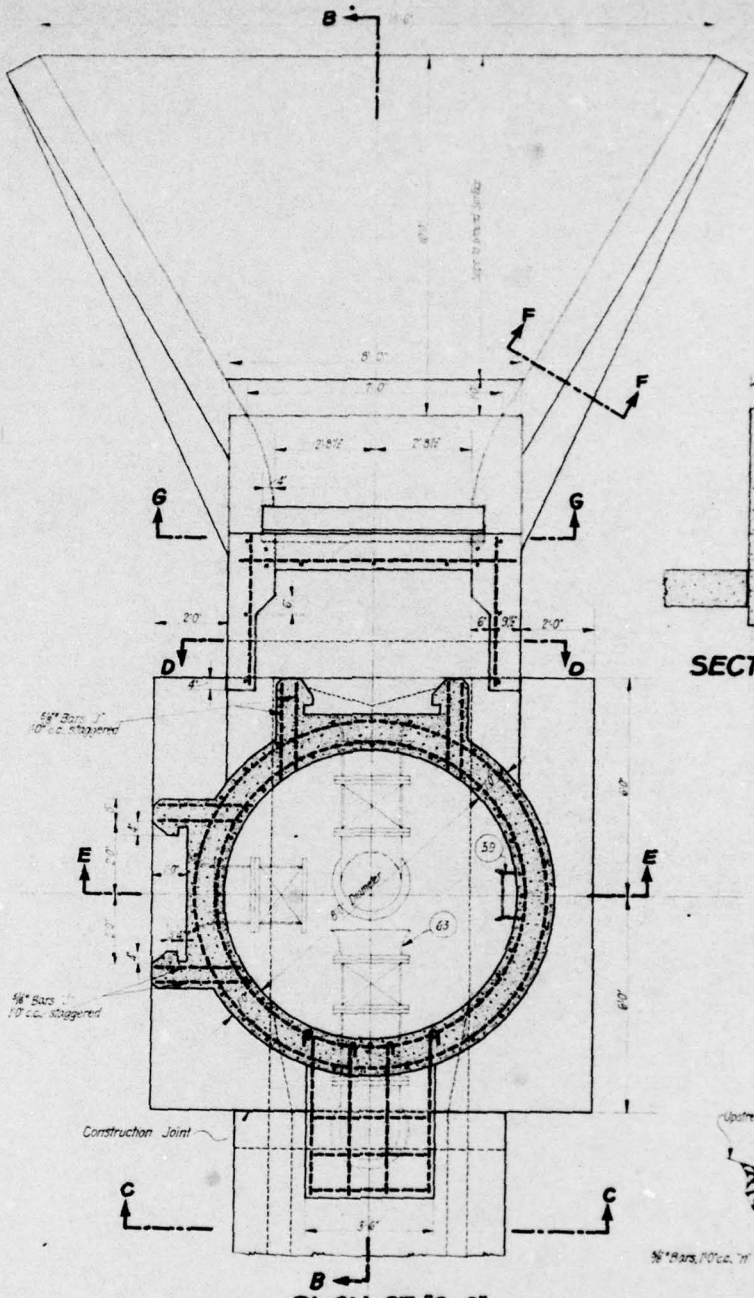
PA. 680 PLATE II



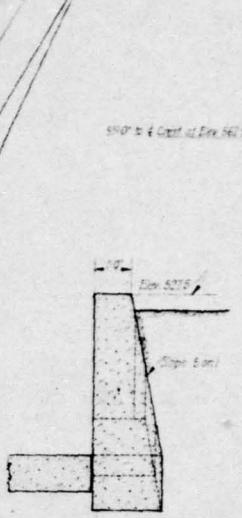
RECORD OF ISSUES AND REVISIONS


EAST BRANCH OF SWATARA
SPILL WAY
50'-0" Channel
No. 12 Test Hole
545.0-Rock
No. 10 Test Hole
559.0-Rock
No. 24 Test Hole
540.5 Rock
No. 17 Test Hole
No. 16 Test Hole
No. 13 Test Hole
UGH CENTER OF DAM
PILLWAY
SECTION A-A
MAP OF VICINITY
N
GENERAL NOTES
REFERENCE DRAWINGS
EAST PENN ELECTRIC CO.
PINE GROVE, PA.
DETAILS AND LOCATION OF
STORAGE DAM FOR PINE GROVE STEAM PLANT
THE J.G. WHITE ENGINEERING CORPORATION
MAIN OFFICE - 43 EXCHANGE PLACE, N.Y.
1
2

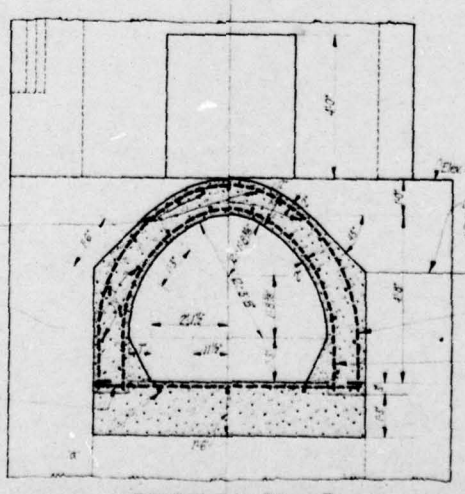
PA.680
PLATE III 3



PLAN AT "A-A"



SECTION "F-F"

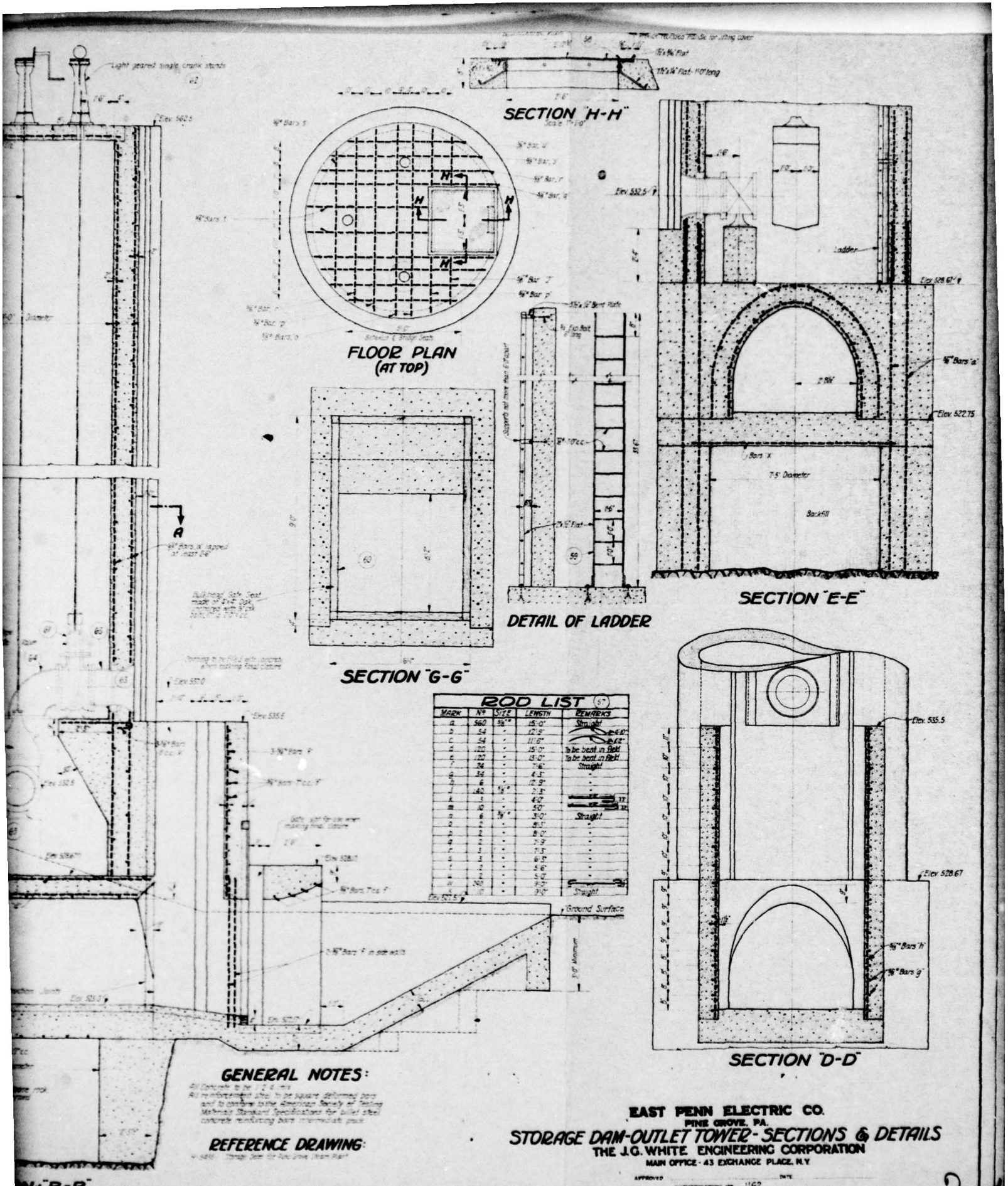


SECTION "C-C"

SECTION

RECORD OF ISSUES AND REVISIONS

DRAWN	TRACED	CHECKED	INTERIM CHECK	DATE
APPROVED				



ROD LIST

MARK	No	SIZE	LENGTH	REMARKS
a	560	5/8"	15'-0"	Straight
b	54	"	12'-9"	
c	54	"	11'-8"	
d	120	"	15'-0"	To be bent in field
e	120	"	13'-0"	To be bent in field
f	36	"	7'-6"	Straight
g	36	"	4'-3"	
h	6	"	12'-9"	
j	40	1/2"	2'-3"	
k	1	"	4'-2"	
m	10	"	5'-0"	
n	6	3/4"	3'-0"	Straight
o	2	"	6'-3"	
p	2	"	8'-0"	
q	2	"	7'-9"	
r	3	"	7'-3"	
s	3	"	6'-3"	
t	3	"	5'-6"	
u	3	"	5'-0"	
w	240	"	9'-3"	Straight
x	10	"	3'-0"	

GENERAL NOTES:

All concrete to be f'c = 3,000 psi.

All reinforcement shall be square deformed bars and to conform to the American Society of Testing Materials Standard Specifications for billet steel concrete reinforcing bars intermediate grade.

REFERENCE DRAWING:

W-1611 "Storage Dam for Pine Grove, Storm Plan"

EAST PENN ELECTRIC CO.
PINE GROVE, PA.

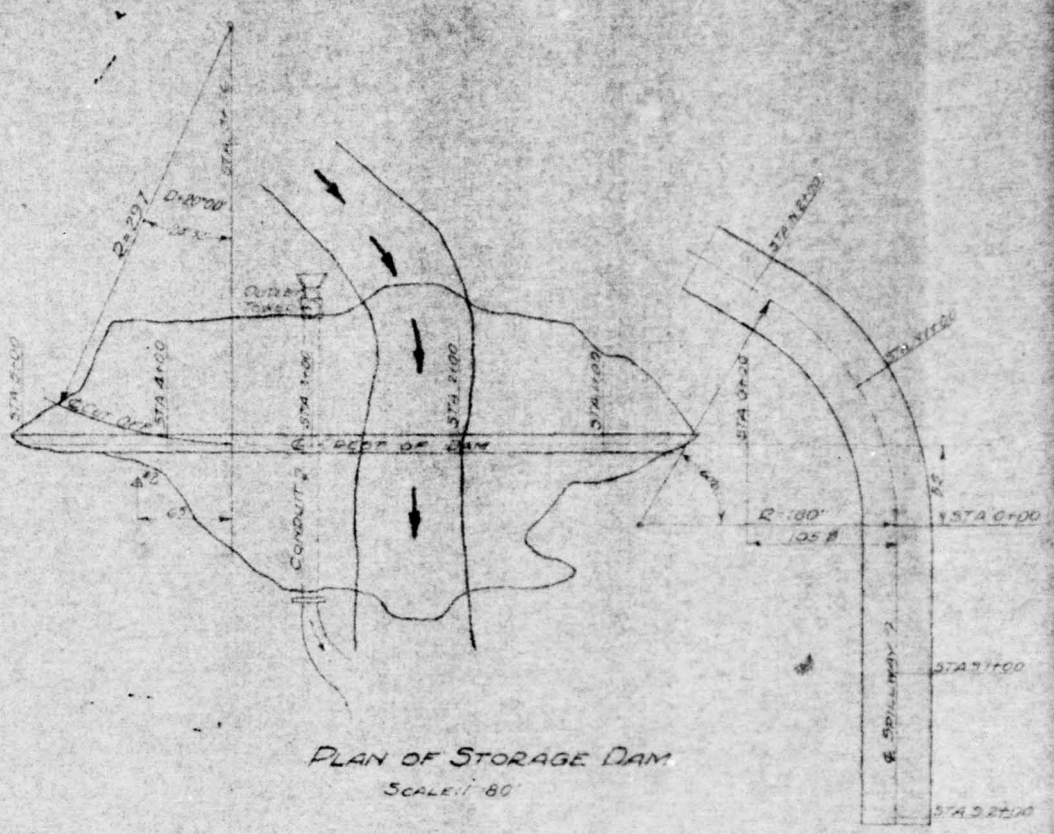
STORAGE DAM-OUTLET TOWER-SECTIONS & DETAILS

THE J.G. WHITE ENGINEERING CORPORATION
MAIN OFFICE - 43 EXCHANGE PLACE, N.Y.

APPROVED _____ DATE _____
AUTHORIZATION NO. 1162
SCALE 1/2"=1'-0" Except where otherwise noted

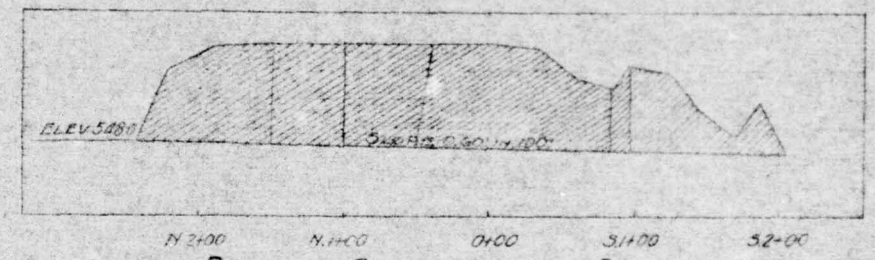
2

PA.680
PLATE IV 3



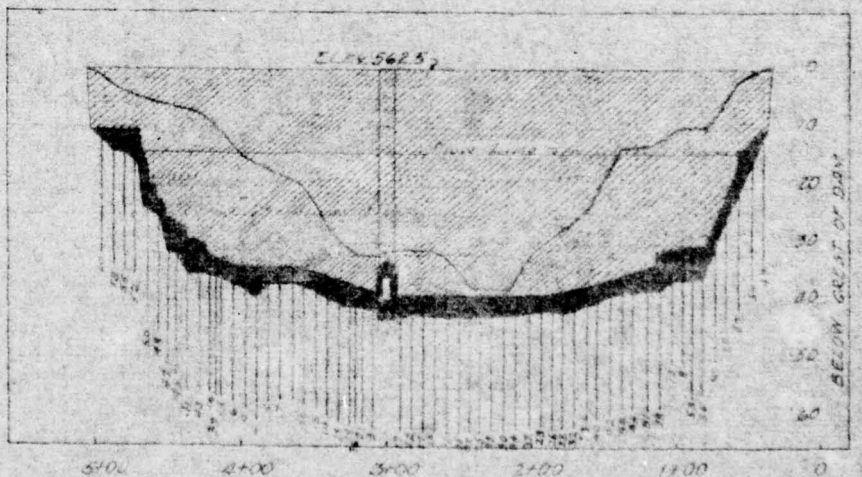
PLAN OF STORAGE DAM

SCALE: 1" = 80'



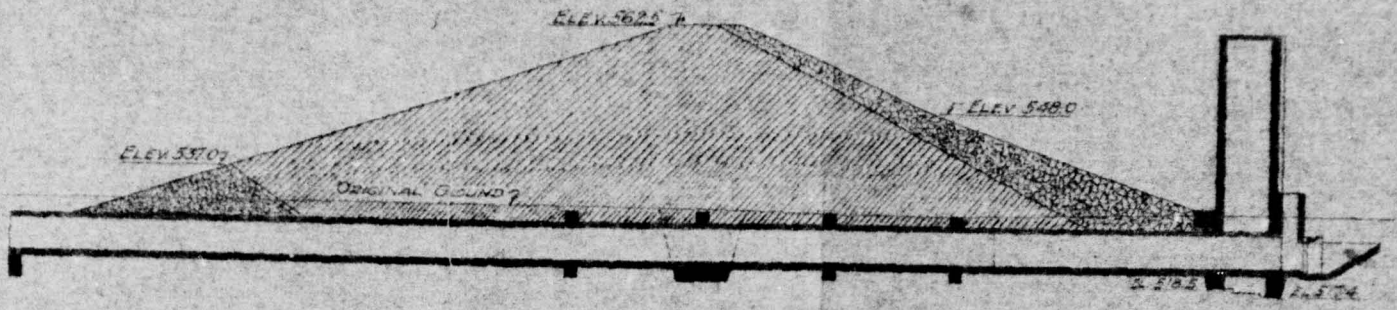
PROFILE - CENTER LINE OF SPILLWAY

SCALE { HOR 1" = 80
VER 1" = 20

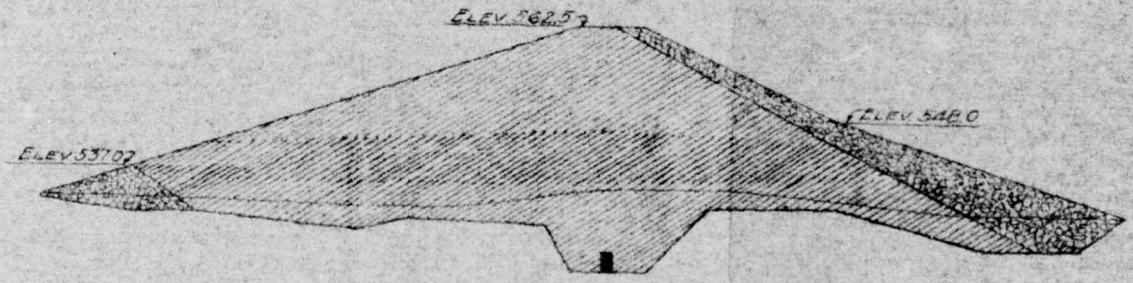


PROFILE CENTER LINE OF DAM

SCALE { HOR 1" = 80'
VER 1" = 20'



SECTION THRU DAM - STA. 3+00
AND ON ℄ CONDUIT
SCALE: 1" = 20'



SECTION THRU DAM - STA. 1+80
SCALE: 1" = 20'

PROGRESS FOR HALF-MONTH ENDING Nov. 15, 1923

EAST PENN ELECTRIC CO.
PINE GROVE, PA.

PROGRESS ON STORAGE DAM

THE J.G. WHITE ENGINEERING CORPORATION
MAIN OFFICE, 43 EXCHANGE PLACE, NEW YORK, N.Y.
FIELD OFFICE, PINE GROVE, PA.
MARCH 29, 1923

2.

PA.680
PLATE V 3