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WOODWARD-CLYDE CONSULTANTS PLYMOUTH MEETING PA
NATIONAL DAM INSPECTION PROGRAM. NDA I.D. NUMBER PA-00221. DER --ETC(U)
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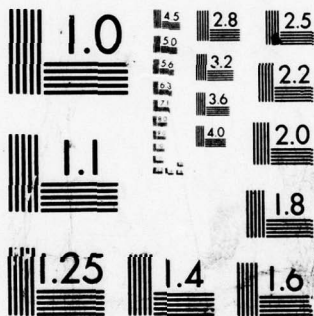
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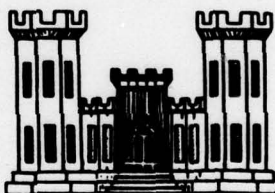
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DER I.D. NO. 9-174
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6 PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM.

NDA I.D. Number PA-00221.
DER I.D. Number 9-174. SCS PA-611.
Delaware River Basin. Warrington Dam,
Bucks County, Pennsylvania.
Phase I Inspection Report.



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Prepared by:

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Submitted to:

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

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PREFACE

Accession For	NTIS Grant	DEC TAB	Unannounced	Justification	By	Date	Approved by	Dist
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This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is to expeditiously identify those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, and only through continued care and maintenance can these conditions be prevented or corrected.

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

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam: Warrington Dam
County Located: Bucks County
State Located: Pennsylvania
Stream: Little Neshaminy Creek
Coordinates: Latitude 40° 13.6'
Longitude 75° 9.6'
Date of Inspection: 23 April 1979

Warrington Dam is owned and maintained by Neshaminy Water Resources Authority. The dam and reservoir are used as a flood control structure for Neshaminy Watershed upstream of Warrington, Pennsylvania. This dam is one of a series of 10 either constructed or proposed flood control dams within Neshaminy Watershed. The dam was designed by the United States Department of Agriculture, Soil Conservation Service, in 1972 and 1973. The structure was completed in April 1976.

The dam and reservoir are considered to be in fair condition. This assessment is due to the lack of maintenance of the embankment and pond drain system. The dam is classified as an "Intermediate" size dam with a "High" hazard potential consistent with the possibility, in the event of failure, for extensive property damage and probable loss of life along the creek. The main damage center is located in Warrington, Pennsylvania, approximately 1½ to 2½ miles east-northeast of the dam site.

Calculations presented in this report indicate the system is capable of passing the Probable Maximum Flood without overtopping. Therefore, the spillway system is considered "Adequate".

Visual inspection and review of available documentation indicate the dam was designed with adequate factors of safety for the embankment and appurtenant structures. Construction documentation reviewed for this inspection indicates that all work was performed in accordance with specification requirements. However, visual inspection revealed that maintenance of this structure is deficient and many items require rehabilitation. Recommendations pertaining to these deficiencies are presented below.

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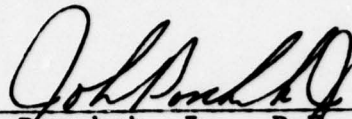
It is recommended that the following steps be taken immediately.

1. The pond drain gate hoist should be rehabilitated and suitably protected to minimize the possibility of future vandalism to this system.
2. Erosion on upstream and downstream slopes should be corrected and vegetation established in a satisfactory manner on the entire embankment.
3. The crest of the dam should be cleaned of mud and ruts and the top stabilized with stone or as recommended by the SCS.
4. Seepage noted beyond the downstream toe should be monitored. If there is an increase in the seepage, appropriate remedial measures should be taken.

The following measures should be taken as soon as practical.

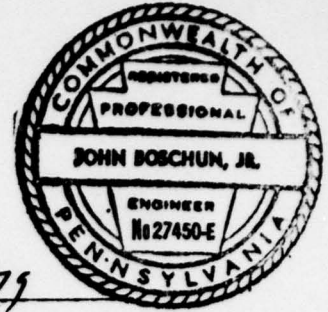
1. Debris along the upstream slope and along the sides of the reservoir should be removed to minimize the potential for clogging the spillway intake system.
2. Erosion along the shoreline, if it continues to worsen, should be stabilized with designed riprap. Recommendations for this stabilization should be obtained from the Soil Conservation Service (SCS).
3. If at all possible, devices should be installed to discourage vehicular traffic along the crest and slopes of the embankment. Without this unauthorized traffic, the erosion, ruts and general deterioration of the slopes would have been minimal.
4. Erosion along the walls of the impact basin should be repaired.

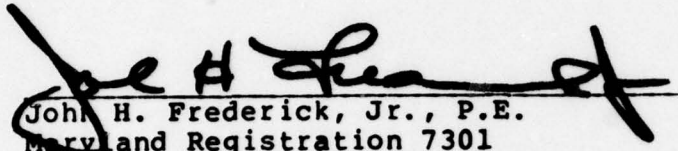
It is understood that Neshaminy Water Resources Authority is preparing an operation and maintenance procedure in accordance with SCS guidelines. It is also understood that this procedure contains a warning system to be implemented in the event of an emergency. The procedures should be completed as soon as practical and should include the suggestions presented in Section 7.2, paragraph b. The procedures should then be issued to responsible personnel who should be thoroughly familiar with the contents of the procedure.



John Boschuk, Jr., P.E.
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Woodward-Clyde Consultants

6/12/79
Date



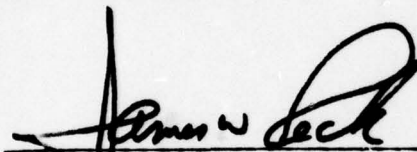


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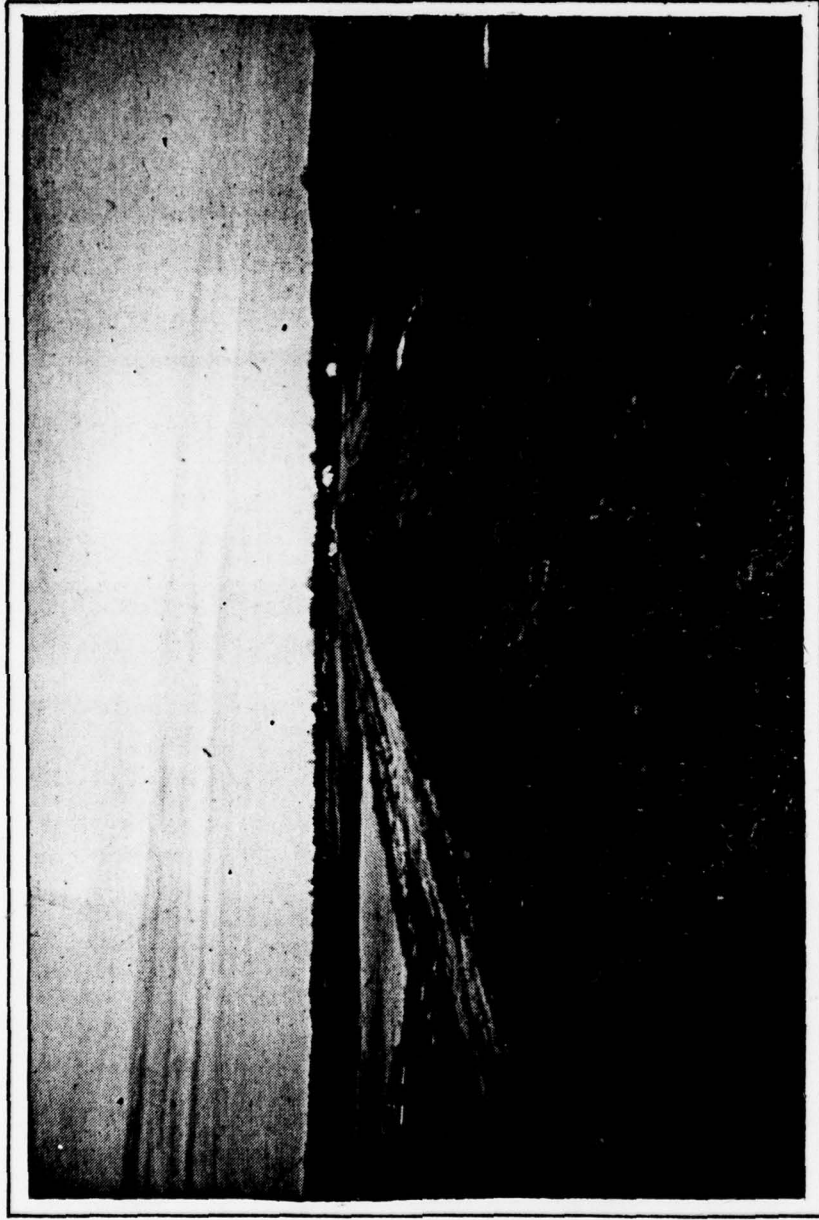


APPROVED BY:



JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

17 July 79
Date



OVERVIEW
WARRINGTON DAM, BUCKS COUNTY, PENNSYLVANIA

TABLE OF CONTENTS

	<u>PAGE</u>
Preface	i
Assessment and Recommendations	ii
Overview Photograph	v
SECTION 1 - PROJECT INFORMATION	
1.1 General	1
1.2 Description of Project	1
1.3 Pertinent Data	3
SECTION 2 - ENGINEERING DATA	
2.1 Design	5
2.2 Construction	5
2.3 Operational Data	5
2.4 Evaluation	6
SECTION 3 - VISUAL INSPECTION	
3.1 Findings	7
3.2 Evaluation	9
SECTION 4 - OPERATIONAL PROCEDURES	
4.1 Procedures	10
4.2 Maintenance of the Dam	10
4.3 Maintenance of Operating Facilities	10
4.4 Warning Systems In Effect	10
4.5 Evaluation	10
SECTION 5 - HYDROLOGY/HYDRAULICS	
5.1 Evaluation of Features	11
SECTION 6 - STRUCTURAL STABILITY	
6.1 Evaluation of Structural Stability	13
SECTION 7 - ASSESSMENT/REMEDIAL MEASURES	
7.1 Dam Assessment	15
7.2 Remedial Measures	15
APPENDIX	
A	Engineering Data, Design, Construction and Operation
B	Visual Inspection
C	Hydrology/Hydraulics
D	Photographs
E	Plates
F	Geology

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
WARRINGTON DAM
NATIONAL ID #PA 00221
DER #9-174

SECTION 1
PROJECT INFORMATION

1.1 General.

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

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Warrington Dam is a 45 foot high zoned earth embankment, 1,600 feet long, with an emergency spillway at each end of the embankment. ~~The plan of the dam is shown on Plate 2, Appendix E.~~ The embankment contains an impervious core constructed over a cutoff trench under the dam centerline. The core and cutoff trench are composed of materials classified as silty clays and clayey silts (Zone 1) and encompassed by less permeable materials classified as silty gravels (Zone 2). The upstream slope is 3H:1V with a 10 foot berm at approximately elevation 241.5, normal pool level. The downstream slope is 2.5H:1V with a 12 foot wide berm that serves as an access road along the downstream face of the embankment. The impervious Zone 1 core upstream slope is 2H:1V and the downstream slope is 1.5H:1V. The 14 foot wide embankment crest is at a design elevation of 272.9. Both upstream and downstream slopes are protected with grass. ~~Plan and cross-sections of the dam are shown on Plates 2 and 3, Appendix E.~~

Embankment seepage is controlled by a drain trench near the downstream toe, which contains a 12-inch perforated drain pipe which discharges through the impact basin at the downstream toe. The principal spillway consists of a concrete drop inlet riser, a 240 foot long, 60-inch reinforced concrete pipe and an impact basin. The reservoir drain, located at the base of the riser, has an invert elevation of 229.5 and the

riser weir elevation is 241.0. The outlet invert and impact basin end sill elevations are 227.5. Typical sections of the principal spillway are presented on Plates 6 through 9 in Appendix E.

Due to construction constraints and local topography, Warrington Dam was constructed with two emergency spillways, one located at each end of the embankment. These spillways are shown on Plate 2 and typical profiles are shown on Plate 10, Appendix E. Both spillways are excavated in weathered rock and have some grass growing on the side slopes and bottoms. Both spillways have a level control section located at elevation 265.1. The spillway on the left abutment is 450 feet wide and the abutment spillway is 150 feet wide.

b. Location. The dam is located on Little Neshaminy Creek in Warrington Township, Bucks County, Pennsylvania. The dam is located approximately 1.5 miles northwest of the intersection of Route 611 and County Line Road. The dam site and reservoir are located on USGS Quadrangle entitled "Ambler, Pennsylvania" at coordinates N 40° 13.6' W 75° 9.6'. A regional location plan of Warrington Dam is shown on Plate 1, Appendix E.

c. Size Classification. The dam is classified as an "Intermediate" size dam by virtue of its 45 foot maximum height and 4,175 acre-foot total storage capacity.

d. Hazard Classification. A "High" hazard classification is assigned consistent with the potential for extensive property damage and loss of life along Little Neshaminy Creek downstream of the dam.

e. Ownership. Warrington Dam is owned and maintained by Neshaminy Water Resources Authority. All correspondence should be sent to Mr. William Taylor, Neshaminy Water Resources Authority, Post Office Box 6, Cross Keys Office Center, 4259 Swamp Road, Doylestown, Pennsylvania 18901.

f. Purpose of Dam. The purpose of this dam is flood control. The structure is one of ten dams in Neshaminy Creek Watershed that are scheduled for construction with the assistance of the United States Department of Agriculture, Soil Conservation Service (SCS). This is the fifth project of the series.

g. Design and Construction History. The dam was designed by the SCS in 1972 and 1973. The application to construct this dam was submitted on May 1, 1973, and the "Report Upon the Application" issued by the State of Pennsylvania on June 6, 1973. Records indicate construction was

performed by Durkin Construction Company in 1974, and the dam was officially completed on April 16, 1976.

Records in Department of Environmental Resources files indicate that all work was performed in a satisfactory manner and documents prepared by SCS personnel indicate density tests all exceeded at least 95 percent of the Standard Proctor, with several tests being over 100 percent of the Standard Proctor for Zone 1 fill.

h. Normal Operating Procedures. Reservoir outflow is controlled by the principal and emergency spillways. Under normal conditions, water flows through the principal spillway. There are no minimum discharge requirements for this structure. Excess water is stored up to elevation 265.1, the crest of the emergency spillway. Thereafter, water is discharged through the emergency spillways at either side of the embankment.

1.3 Pertinent Data.

A summary of pertinent data for Warrington Dam is presented as follows.

a.	Drainage Area (sq miles)	10.92
b.	Discharge at Dam Site (cfs)	
	Maximum Known Flood at Site	Unknown
	At Design High Water	7,354
	At Top of Dam	
	Design	33,367
	Existing Conditions	28,500
c.	Elevation (feet above MSL)	
	Top of Dam	272.9
	Design High Water	268.4
	Emergency Spillway Crests	265.1
	Principal Spillway	
	Weir Crest (normal pool)	241.0
	Pond Drain Invert	229.5
	Outlet Invert	227.5
d.	Reservoir (miles)	
	Length at Normal Pool	0.6
	Fetch at Normal Pool	0.6
e.	Storage (acre-feet)	
	Sediment Normal Pool	124

	To Emergency Spillway Crest	2,373
	To Top of dam	4,175
f.	Reservoir Surface (acres)	
	Sediment Pool	26
	Normal Pool	26
g.	Dam Data	
	Type	Zoned rolled earth
	Volume	212,000 cu yd
	Length	1,600 feet
	Maximum Height	45 feet
	Top Width	14 feet
	Side Slope	
	Upstream	3H:1V
	Downstream	2.5H:1V
	Cutoff	Trench beneath centerline.
	Grout Curtain	None
h.	Principal Spillway Intake	Concrete drop inlet riser w/ a weir inlet & 60" x 48" pond drain intake at the base of the riser.
	Discharge Conduit	240' long 60" I.D. RCP with 9 anti-seep collars.
	Elevations	
	Weir	241.0
	Pond Drain Invert	229.5
	Pipe Outlet Invert	227.5
	Downstream Channel	226.0±
i.	Emergency Spillway	
	Type	Trapezoidal grass-lined channel at each end of the embankment.
	Size	
	Left	450' wide w/ 200' long control section
	Right	150' wide w/ 355.7' long control section
	Side Slopes	3H:1V and 2.5H:1V
	Channel	Protected w/grass on bottom and riprap on inside side slope.

SECTION 2 ENGINEERING DATA

2.1 Design.

a. Data Available. A summary of engineering data on SCS Dam PA 611, known as Warrington Dam, is attached as Appendix A. Engineering data available for review is contained in a several hundred page design folder and a 42-page set of as-built plans. The folder was located in Department of Environmental Resources' (DER) files and as-built drawings were obtained from the Owner's files. All of these records were prepared by the United States Department of Agriculture, Soil Conservation Service (SCS). Additional information was obtained from miscellaneous letters, correspondence and monthly construction reports in DER and SCS files.

b. Design Features. The principal design features of Warrington Dam are illustrated on the plans and profiles enclosed in Appendix E as Plates 2 through 10. A detailed description of the design features is also described in Section 1.2, paragraph a, and pertinent data relative to the structure is presented in Section 1.3. In addition to the plans of the dam, Plates 11 and 12 are enclosed to show the location of the boring logs and results of typical compaction tests performed as part of this design.

2.2 Construction.

Details of construction are presented in Section 1.2, paragraph g. Construction records are located in DER and SCS files and specific aspects of construction were obtained from Neshaminy Water Resources Authority's representative.

2.3 Operational Data.

There are no operational records maintained. There are no minimum flow requirements for the downstream channel. There are no water level measurements or rainfall records maintained within this watershed, although Neshaminy Water Resources Authority maintains a rain gage at their office in Cross Keys, Pennsylvania.

2.4 Evaluation.

a. Availability. All engineering data evaluated and reproduced for this report was provided by either DER or SCS and supplemented by conversations and data obtained from representatives of Neshaminy Water Resources Authority.

b. Adequacy. Data included in State files, supplemented with data obtained from Neshaminy Water Resources Authority and information received from State and Authority representatives, are considered adequate to evaluate the dam and appurtenant structures.

c. Validity. There is no reason to question the validity of this data.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. Observations and comments of the field inspection team are contained in the checklist enclosed herein as Appendix B, and are summarized and evaluated as follows. In general, the dam and its appurtenant facilities are in fair condition, needing some maintenance and repair work. At the time of inspection, water was flowing through the principal spillway and there was no access to the top of the riser in order to exercise the pond drain gate.

b. Dam. During the visual inspection, there were no indications of distortion in alignment or grade that would be indicative of movement of the embankment or foundation. There were no surface cracks noted along the crest, but the crest was noted to have muddy areas and to be rutted as a result of unauthorized vehicles traversing the crest. The upstream slope is protected with grass and is not riprapped along normal pool level. As a result, minor erosion is occurring along the shoreline, but the design includes a soil berm at normal pool to protect the embankment at this level. The upstream slope is covered with debris as shown on the photographs in Appendix D, which could float and partially clog the principal spillway. The 12 foot wide berm along the downstream slope serves as an access road to the downstream area of the dam. Erosion was noted on this slope as a result of traffic by all-terrain vehicles and motorbikes.

Beyond the toe in the spoil area, erosion gullies up to two feet deep were noted. These gullies drain towards the dam into a poorly drained area which produces a marshy condition.

Beyond the spoil area along the access road, a low wet area and spring were noted. Clear seepage from the spring was discharging into the spillway discharge channel. It was assessed that this spring and low wet area along the access road are probably associated with groundwater seepage as a result of storage behind the embankment and poor drainage, respectively. There was no evidence along the downstream toe of seepage through the embankment except for clear seepage discharging into the impact basin from the embankment drainage system.

c. Appurtenant Structures.

1. Intake Riser. Exposed portions of the concrete riser were noted to be in good condition with no significant cracking, spalling or undue deterioration of the concrete above the waterline. The interior of the riser could not be inspected as a result of flow over the weirs. It was noted that the pond drain gate hoist at the top of the riser was bent and that two upstream bolts are missing, possibly rendering the valve unserviceable. The Owner's representative was not aware of this condition and indicated that they would remedy the situation as soon as possible. The impact basin at the downstream toe was inspected and found to be in good condition with no significant cracking, spalling of the concrete or erosion adjacent to the structure. The downstream channel was also inspected and found to be in good condition with no unacceptable erosion or deterioration.

2. Emergency Spillways. The grass-lined trapezoidal emergency spillways at each abutment were inspected and found to be stable and in good condition. The riprap-protected side slopes are also in good condition. The left emergency spillway is sparsely vegetated in many areas and there is some erosion on the left side of the slope. It is noted that the right side of the right spillway in the control section, as shown on sheet 5a, Appendix B, is high where rock was not excavated to design grade. Based on a survey performed at the time of inspection, it was estimated that this rise begins near the centerline of the spillway and slopes upward approximately 2.4 feet to the right edge of the spillway.

d. Reservoir. Reservoir side slopes are moderate and flat at the upper end of the reservoir. Land surrounding the reservoir is wooded or open/farmland. There is minimal sedimentation at the upper end, which has no effect on flood water storage.

e. Downstream Channel. The downstream channel is about 200 feet wide with two to three foot high banks. The valley gradient is 0.0025. The stream flows through woods for 1.4 miles where it flows under PA Route 611. At that point are several businesses, two or three of which are subject to damage if the dam fails. About 0.7 miles further downstream, Little Neshaminy Creek passes under PA Route 132, downstream of which are eight homes built adjacent to the creek and are subject to flooding from high flows in the creek.

3.2 Evaluation.

Inspection of the dam and appurtenant facilities disclosed no evidence of apparent past or present movement that would indicate existing instability of the dam, principal or emergency spillways. Interior portions of the principal spillway riser and discharge pipe could not be inspected due to flow through the system. The principal spillway discharge channel was inspected and found to be in good condition. The pond drain sluice gate was not exercised, but was observed to be damaged at the valve base on top of the riser. Emergency spillway discharge channels were found to be in good condition, well vegetated or stabilized with rock.

Debris was noted along the upstream slope of the dam, which is considered undesirable and could partially clog the principal spillway. Muddy areas, ruts, erosion, and general deterioration of both the upstream and downstream slopes and the benches were noted, predominantly as a result of unauthorized vehicular traffic across the dam and slopes.

SECTION 4 OPERATIONAL PROCEDURES

4.1 Procedures.

Operational procedures are discussed in some detail in Section 1.2. Operation of the dam does not require a dam tender. Under these normal conditions, flow discharges through the principal spillway. Excess water is stored until it reaches the crests of the emergency spillways at elevation 265.1. As reported by the Owner's representatives, water has never flowed over the emergency spillways. Operation and maintenance procedures are currently being prepared by Neshaminy Water Resources Authority, and final procedures should be made available within the near future.

4.2 Maintenance of the Dam.

The dam is maintained by Neshaminy Water Resources Authority staff who periodically check the embankments, mow the grass, and remove woody vegetation and debris from the slopes.

4.3 Maintenance of Operating Facilities.

Maintenance of these facilities includes cleaning debris from the intake systems and checking the structural integrity of the spillways. It is noted that a pond drain gate hoist was damaged and may not be serviceable.

4.4 Warning Systems In Effect.

There are no formalized warning systems in effect for these dams. However, it is understood that Neshaminy Water Resources Authority is preparing a formal warning system which would be used for all of their dams.

4.5 Evaluation.

It is judged that current operating procedure, which does not require a dam tender, is a realistic means of operating the relatively simple control facilities at Warrington Dam.

Formal operation, maintenance and warning procedures are reportedly under preparation by Neshaminy Water Resources Authority. It is important that these procedures include an inspection checklist to insure that all items are carefully inspected and maintained on a periodic basis.

SECTION 5
HYDROLOGY/HYDRAULICS

5.1 Evaluation of Features.

a. Design Data. The complete folder of design calculations was reviewed and portions of this folder are presented in Appendix C.

The watershed is about 4.5 miles long, irregularly shaped, with widths ranging from 1.5 to 3.7 miles, and having a total area of 10.92 square miles. Elevations range from 500 in the upper reaches to 241 at normal pool elevation. The watershed is predominantly open/farmland, about 25 percent residential development and 15 percent wooded. Residential development can be expected to progress rapidly. Design inflow hydrographs were developed assuming 79 percent commercial, industrial and residential development.

In accordance with criteria established by Federal (OCE) Guidelines, the recommended spillway design flood for this "Intermediate" size dam and "High" hazard classification is the Probable Maximum Flood (PMF). The Soil Conservation Service designed this dam as a Class C structure, which requires that the spillway systems be designed to pass the PMF.

b. Experience Data. There are no records of reservoir levels kept for this dam. Rainfall is measured and records are kept at Neshaminy Water Resources Authority's office in nearby Cross Keys, Doylestown, Pennsylvania. There are no estimates or records of previous high water levels.

c. Visual Observations. On the date of inspection, the only condition observed that would indicate a reduction in spillway capacity was the unexcavated rock in the right emergency spillway, as discussed in Section 3. Observations regarding the condition of the downstream channel, spillways and reservoir are located in Appendix B and discussed in detail in Section 3.

d. Overtopping Potential. The dam was designed to pass the PMF without overtopping. The PMF inflow hydrograph and flood routing are presented in Appendix C. Because of the high rock in the right spillway, it was decided to reevaluate the emergency spillway capacities according to existing conditions and current SCS criteria, TR-39. A combined capacity of about 28,500 cfs was obtained. As the design PMF

reservoir routing could not be completely accepted as adequate, it was necessary to recompute the inflow hydrograph according to criteria established for this investigation. It is to be noted that the original SCS inflow hydrograph and Snyder's evaluation hydrograph are only two of several types of synthetic hydrographs. The computed PMF peak inflow value is 27,159 cfs, which is less than the estimated combined emergency spillway discharge of about 28,500 cfs. Therefore, no reservoir routing is required and the spillway systems for this dam are considered "Adequate" as the dam will pass the PMF without overtopping.

e. Downstream Conditions. Little Neshaminy Creek flows through woods for about 1.4 miles before passing under the third downstream bridge, PA Route 611, where several businesses are located. At least two of these are subject to damage in the event of dam failure. About 0.7 miles farther downstream, Little Neshaminy Creek flows under PA Route 132, downstream of which are eight homes built adjacent to the creek and subject to flooding in the event of high flows and damage in the event of dam failure. In conclusion, it is evaluated that a significant increase in downstream damage would result from failure of the dam during a PMF than damage resulting from large flows during passage of the PMF.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. Visual observations detected no evidence of existing or pending embankment instability. Upstream and downstream slopes were stable, in fair condition, with some slope erosion and areas of poor vegetation. There were no exterior signs or other evidence to indicate that internal drainage systems were not operating properly.

The only seepage noted is shown on sheet 5a and is located downstream of the dam beyond the spoil area along an access road. This seepage was assessed to be associated with a localized rise of groundwater as a result of impoundment behind the dam.

Exposed portions of the principal spillway were inspected and judged to be in good condition. The pond drain gate hoist was inspected and found to be vandalized and probably not serviceable. The grass-lined emergency spillways were assessed to be in good condition with no signs of sloughing, excessive erosion or deterioration.

b. Design and Construction Data. Design documentation is very complete as a several hundred page design folder prepared by the Soil Conservation Service (SCS) was available and reviewed for this investigation. Data included in these files are a foundation report, results of the stability calculations for the embankment, as well as structural calculations for the pertinent facilities and principal spillway. The report contains permeability tests, shear strength results and sediment analysis. Also included in this report are a complete set of specifications and a material quantity estimate.

The stability analysis performed by SCS showed that, for rapid drawdown, the minimum factor of safety was 1.35. A somewhat higher factor of safety was reported for steady state seepage conditions. According to Corps of Engineers' criteria, EM 1110-2-1902, these values are acceptable.

Included in this design folder is a complete set of hydrologic/hydraulic calculations. Other design documents reviewed included a 44-sheet set of drawings prepared by SCS and stamped "As-Built".

Principal features of this structure were extracted from these drawings and calculations, and are located in

Appendix E and C, respectively. Progress reports prepared by SCS' resident engineer and inspection reports prepared by Department of Environmental Resources representatives indicate that work was performed in accordance with SCS requirements. All compaction tests exceeded the minimum specification of 95 percent of the Standard Proctor as defined by ASTM D 698. Other testing, such as concrete tests and gradation tests, were also documented in the construction inspector's records to meet specification requirements.

c. Operating Records. There are no operational records for this structure.

d. Post-Construction Changes. There are no reports nor is there any evidence that modifications were made to this dam.

e. Seismic Stability. The dam is located in Seismic Zone 1. Normally it can be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake conditions. As the static stability analysis resulted in a minimum factor of safety of 1.35 under rapid drawdown conditions, the most critical loading conditions, it can be assumed that the seismic stability requirements are also satisfied.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Evaluation. Visual inspection and review of design and construction documentation indicate that the dam, foundation and appurtenant structures of Warrington Dam are in good condition with the exception of the reservoir sluice gate and erosion noted along the slopes and on the embankment crest. These deficient areas are significant and remedial measures should be taken, as recommended in Section 7.2. Hydrologic and hydraulic computations presented in Appendix C indicate the structure will pass the Probable Maximum Flood without overtopping. Therefore, the spillway systems for this structure are considered to be "Adequate". In the event that high flows are passed through the emergency spillway, property damage is still likely to occur along Little Neshaminy Creek since homes are built adjacent to the creek about 2.1 miles downstream. In the event the dam fails while retaining a significant quantity of water, extreme property damage and probable loss of life would be expected.

b. Adequacy of Information. Information available for this investigation was sufficiently adequate to evaluate the structural and hydraulic aspects of the basin.

c. Urgency. It is recommended that the suggestions presented in Section 7.2 be implemented during routine maintenance of the structure, which should not be less than at least once per year.

7.2 Remedial Measures.

a. Facilities. It is recommended that the following measures be undertaken immediately.

1. The pond drain gate hoist should be rehabilitated and suitably protected to minimize the possibility of future vandalism to this system.
2. Erosion on the upstream and downstream slopes should be corrected and vegetation established in a satisfactory manner on the entire embankment.
3. The crest of the dam should be cleaned of mud and ruts and the top stabilized with stone or as recommended by the SCS.

4. Seepage noted beyond the downstream toe should be monitored. If there is an increase in the seepage, appropriate remedial measures should be taken.

These measures should be taken as soon as practical.

1. Debris along the upstream slope and along the sides of the reservoir should be removed to minimize the potential for clogging the spillway intake system.
2. Erosion along the shoreline, if it continues to worsen, should be stabilized with designed riprap. Recommendations for this stabilization should be obtained from the Soil Conservation Service (SCS).
3. If at all possible, devices should be installed to discourage vehicular traffic along the crest and slopes of the embankment. Without this unauthorized traffic, the erosion, ruts and general deterioration of the slopes would have been minimal.
4. Erosion along the walls of the impact basin should be repaired.

b. Operation and Maintenance Procedures. It is understood that Neshaminy Water Resources Authority is currently preparing operation and maintenance procedures in accordance with SCS guidelines for all existing dams in the Neshaminy Watershed. These procedures should include a checklist to insure that all items are periodically protected and maintained in the best possible condition. Furthermore, it is also understood that a warning system is also in preparation and will be implemented as soon as practical.

It is recommended that these procedures provide for a period of observation after significant quantities of water are stored behind the embankment. These observations should include monitoring discharge from the embankment drainage system and looking for sources of uncontrolled seepage.

APPENDIX

A



NAME OF DAM Marrington Dam
 ID # PA 00221

CHECK LIST
 ENGINEERING DATA
 DESIGN, CONSTRUCTION, OPERATION
 PHASE I

REMARKS
 Sheet 1 of 4

ITEM	REMARKS
AS-BUILT DRAWINGS	Yes. See drawings in Appendix E.
REGIONAL VICINITY MAP	Yes. See Plate 1, Appendix E.
CONSTRUCTION HISTORY	Yes. See Section 1.2, paragraph g.
TYPICAL SECTIONS OF DAM	Yes. See Appendix E.
OUTLETS - PLAN	}
DETAILS	
CONSTRAINTS	
DISCHARGE RATINGS	Data contained in SCS design report.
RAINFALL/RESERVOIR RECORDS	None available.

REMARKS

ITEM

DESIGN REPORTS

Yes. Complete SCS design report contained in DER files.

GEOLOGY REPORTS

Geologic data contained in SCS design report in DER files.

DESIGN COMPUTATIONS
HYDROLOGY & HYDRAULICS
DAM STABILITY
SEEPAGE STUDIES

All data contained in SCS design report in DER files.

MATERIALS INVESTIGATIONS
BORING RECORDS
LABORATORY
FIELD

Yes. Data in DER files.

POST-CONSTRUCTION SURVEYS OF DAM

None

BORROW SOURCES

Borrow sources located on SCS drawings.

ITEM	REMARKS
MONITORING SYSTEMS	<i>None</i>
MODIFICATIONS	<i>None</i>
HIGH POOL RECORDS	<i>None available.</i>
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	<i>None</i>
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	<i>None</i>
MAINTENANCE OPERATION RECORDS	<i>Detailed records are not available but SCS has an O & M procedure.</i>

ITEM	REMARKS
SPILLWAY PLAN	} See Appendix E.
SECTIONS DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	} See Appendix E.

MISCELLANEOUS

1. 21 construction photographs.
2. Water Resources Inventory Form.
3. Operation and Maintenance Inspection reports by SCS.
4. SCS construction inspection reports.
5. "Report Upon the Application of the Neshaminy Water Resources Authority" dated June 6, 1973.

APPENDIX

B

CHECK LIST
VISUAL INSPECTION
PHASE I

Sheet 1 of 11

Name Dam Warrington Dam County Bucks State Pennsylvania National ID # PA 00221
Type of Dam Earth Hazard Category I-High
Date(s) Inspection 23 April '79 Weather Clear and Cool Temperature 60's

Pool Elevation at Time of Inspection 247 $\frac{1}{2}$ M.S.L. Tailwater at Time of Inspection N/A M.S.L.

Inspection Personnel:

John Boschuk, Jr. (Geotechnical) Raymond Lambert (Geologist) John H. Frederick (Geotechnical)
Mary F. Beck (Hydrologist) Vincent McKeever (Hydrologist)

John Boschuk, Jr. Recorder

Remarks:

Messrs. William Taylor and Charles Burger of the Neshaminy Water Resources Authority
and Mr. Eugene B. McGough of William G. Major Associates, Inc., were on site
and provided assistance to the inspection team.

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF OBSERVATIONS REMARKS OR RECOMMENDATIONS

ANY NOTICEABLE SEEPAGE

N/A

STRUCTURE TO
ABUTMENT/EMBANKMENT
JUNCTIONS

N/A

DRAINS

N/A

WATER PASSAGES

N/A

FOUNDATION

N/A

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	N/A	
STRUCTURAL CRACKING	N/A	
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS	N/A	

EMBANKMENT

Sheet 4 of 11

VISUAL EXAMINATION OF OBSERVATIONS REMARKS OR RECOMMENDATIONS

SURFACE CRACKS

None observed. The crest is rutted and muddy in areas as a result of unauthorized vehicles.

**UNUSUAL MOVEMENT OR
CRACKING AT OR BEYOND
THE TOE**

None observed.

**SLOUGHING OR EROSION OF
EMBANKMENT AND ABUTMENT
SLOPES**

No significant erosion observed on the embankment but as shown on Sheet 5a, substantial erosion was noted beyond the toe. Upstream slopes contain a lot of debris. See photographs.

**VERTICAL AND HORIZONTAL
ALIGNMENT OF THE CREST**

Alignment both vertically and laterally is good.

RIPRAP FAILURES

None observed. It is noted that the upstream is not protected with riprap and that some slope erosion is occurring.

EMBANKMENT

Sheet 5 of 11

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
------------------------------	---------------------	-----------------------------------

CREST AND BENCHES

As shown on Sheet 5a the crest contains rutted and muddy areas and the benches contain low points due to poor grading which collects water.

JUNCTION OF EMBANKMENT
AND ABUTMENT, SPILLWAY
AND DAM

Good condition.

ANY NOTICEABLE SEEPAGE

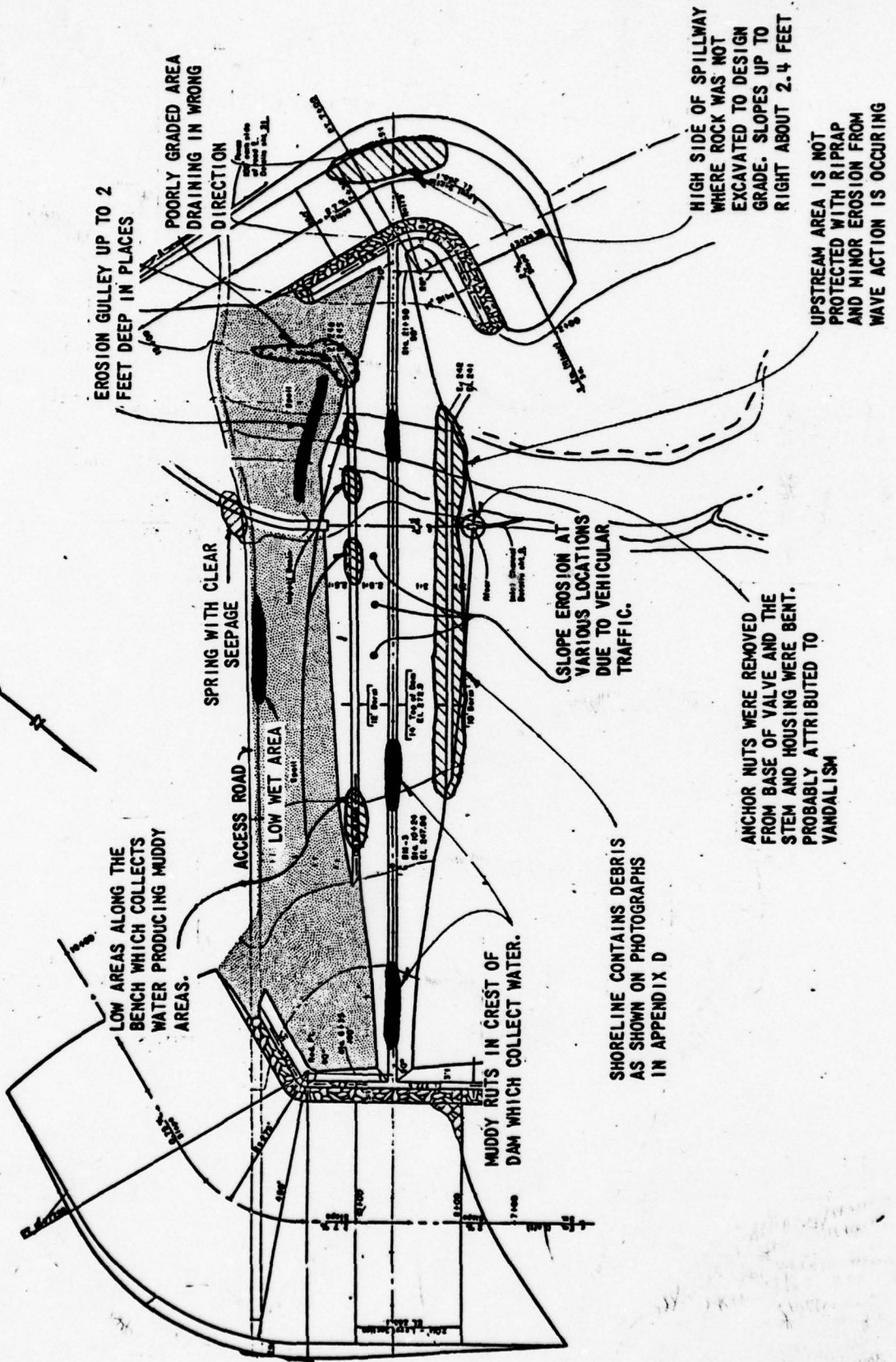
As shown on Sheet 5a, wet areas and a spring were noted 120 to 150 feet downstream of the toe along an access road. These wet areas with clear flowing water are probably associated with the local rise in the groundwater. Very slight seepage upstream of impact basin, no erosion noted.

STAFF GAGE AND RECORDER

None

DRAINS

Embankment drain outlets were inspected at the impact basin. Clear seepage was flowing from the drains.



FIELD OBSERVATION PLAN
 WARRINGTON DAM
 SHEET 5A OF 11

OUTLET WORKS

Sheet 6 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	<i>None observed.</i>	
INTAKE STRUCTURE	<i>Good condition.</i>	
OUTLET STRUCTURE	<i>Good condition.</i>	
OUTLET CHANNEL	<i>Good condition.</i>	

POND DRAIN

The valve mechanism could not be exercised due to no access and the fact that two bolts on the valve were vandalised and the housing was bent.

UNGATED SPILLWAY

Sheet 7 of 11

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
CONCRETE WEIR		<i>Grass lined channel control sections for both spillways are in good condition.</i>
APPROACH CHANNEL	<i>Good condition.</i>	
DISCHARGE CHANNEL		<i>Generally good condition, minor sloughing on left side of left spillway. Vegetative cover on floor of left spillway needs improving.</i>
BRIDGE AND PIERS		<i>None</i>

GATED SPILLWAY

Sheet 8 of 11

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

INSTRUMENTATION

Sheet 9 of 11

VISUAL EXAMINATION OBSERVATIONS REMARKS OR RECOMMENDATIONS

MONUMENTATION/SURVEYS

None

OBSERVATION WELLS

None

WEIRS

None

PIEZOMETERS

None

OTHER

None

RESERVOIR

Sheet 10 of 11

VISUAL EXAMINATION OF OBSERVATIONS REMARKS OR RECOMMENDATIONS

SLOPES

Reservoir side slopes are stable flat to moderate and vegetated to water's edge with trees and grass.

SEDIMENTATION

Little or no sedimentation at upper end, no effect on flood storage.

DOWNSTREAM CHANNEL

Sheet 11 of 11

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION OF

CONDITION
(OBSTRUCTIONS;
DEBRIS, ETC.)

Immediately downstream of the dam the 20 foot wide channel flows through woods. The steep banks are about 2.5 feet high. There is relatively little debris in the channel, no fallen trees.

SLOPES

The valley gradient is about 0.003.

APPROXIMATE NO.
OF HOMES AND
POPULATION

About 1-1/4 miles downstream are several homes and businesses subject to damage in the event of failure. About one mile further downstream are at least 8 homes built adjacent to the stream.

APPENDIX

C

WARRINGTON DAM
CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Predominantly open farm with 15% wooded, about 25% developed.
ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 241.0 feet (124 Acre-Feet).
ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 272.9 feet. (4175 Acre-Feet).
ELEVATION MAXIMUM DESIGN POOL: 272.9 feet.
ELEVATION TOP DAM: 272.9 feet.

EMERGENCY SPILLWAYS

- a. Elevation 265.1.
b. Type Two trapazoidal channels.
c. Width 450 feet and 150 feet.
d. Length 900 feet and 908 feet.
e. Location Spillover Left and right abutments.
f. Number and Type of Gates None.

PRINCIPAL SPILLWAY

- a. Type Drop inlet riser, conduit and impact basin.
b. Location Station 16 + 70.
c. Entrance inverts 241.0 feet.
d. Exit inverts 227.5 feet.
e. Emergency draindown facilities Pond drain at 229.5 feet.

HYDROMETEOROLOGICAL GAGES:

- a. Type Standard rain gage.
b. Location Neshaminy Water Resources Authority Office at Cross Keys, Pa.
c. Records Kept at office.

MAXIMUM NON-DAMAGING DISCHARGE: Not determined.

HEC-1, REVISED
FLOOD HYDROGRAPH PACKAGE

The original "Flood Hydrograph Package" (HEC-1), developed by the Hydrologic Engineering Center, Corps of Engineers, has been modified for use under the National Dam Inspection Program. The "Flood Hydrograph Package (HEC-1), Dam Safety Version", hereinafter referred to as, HEC-1, Rev., has been modified to require less detailed input and to include a dam breach analysis. The required input is obtained from the field inspection of a dam, any available design/evaluation data, relatively simple hydraulic calculations, or information from the USGS Quadrangle maps. The input format is flexible in order to reflect any unique characteristics of an individual dam.

HEC-1, Rev. computes a reservoir inflow hydrograph based on individual watershed characteristics such as: area, percentage of impervious surface area, watershed shape, and hydrograph characteristics determined from regional correlation studies by the Corps of Engineers, Baltimore District. The inflow is routed through the reservoir using spillway discharge data obtained from the field inspection or design data. Flood storage capacity is determined from USGS maps or design information and verified by the field inspection. In the event a spillway cannot discharge 0.5 PMF without overtopping and failure of the dam, downstream channel characteristics obtained from the field inspection and USGS maps are inputted and flows are routed downstream to the damage center and a dam breach analysis is performed.

Included in this Appendix are the HEC-1, Rev. pertinent input values and a summary print-out tables.

Classification (Ref. Recommended Guidelines for Safety Inspection of Dams)

1. The hazard potential is rated as "high" as there would be loss of life if the dam failed
2. The size classification is "intermediate" based on its 45 ft. height and 475 Ac-ft total storage capacity.
3. The spillway design flood, based on size and hazard classification is the Probable Maximum Flood (PMF).

Hydrology and Hydraulic Analysis

1. Design Data. The H & H section of the design folder was available for review. The PMF inflow hydrograph was determined according to procedures in the SCS National Engineering Handbook, Section 4. Hydrograph calculations and flood routing were performed by the SCS computer program, TR-20. Portions of the original design folder are included in this Appendix, as sheets 8, 9 & 10
2. Evaluation - original design parameters were checked against current information and/or criteria.
 - Drainage area, 10.92 sq. miles, was verified by current USGS maps.
 - Emergency spillways - capacity was estimated using current SCS criteria, TR-59, and dimensions obtained from field survey. Minimum top of dam elev 274.06.
 - Left Spillway
 - bottom width = 450 ft
 - level length = 200 ft
 - entrance length ~ 250 ft (measured from d/s edge of level section)
 - measured bottom elevations, 265.47, 265.68, 265.68
 - $H_p = 274.06 - 265.68 = 8.38$
 - $H_{ec} = 9.24$ ES-171, Ch. 1 for $L = 250'$
 - $Q = 22,300$ cfs ES-174, Ch. 9
 - (a minimum value as $L < 250'$)

Note: elevations based on left side of right emergency spillway set at 265.1, design value

BY MEB DATE 5/25/79

SUBJECT _____

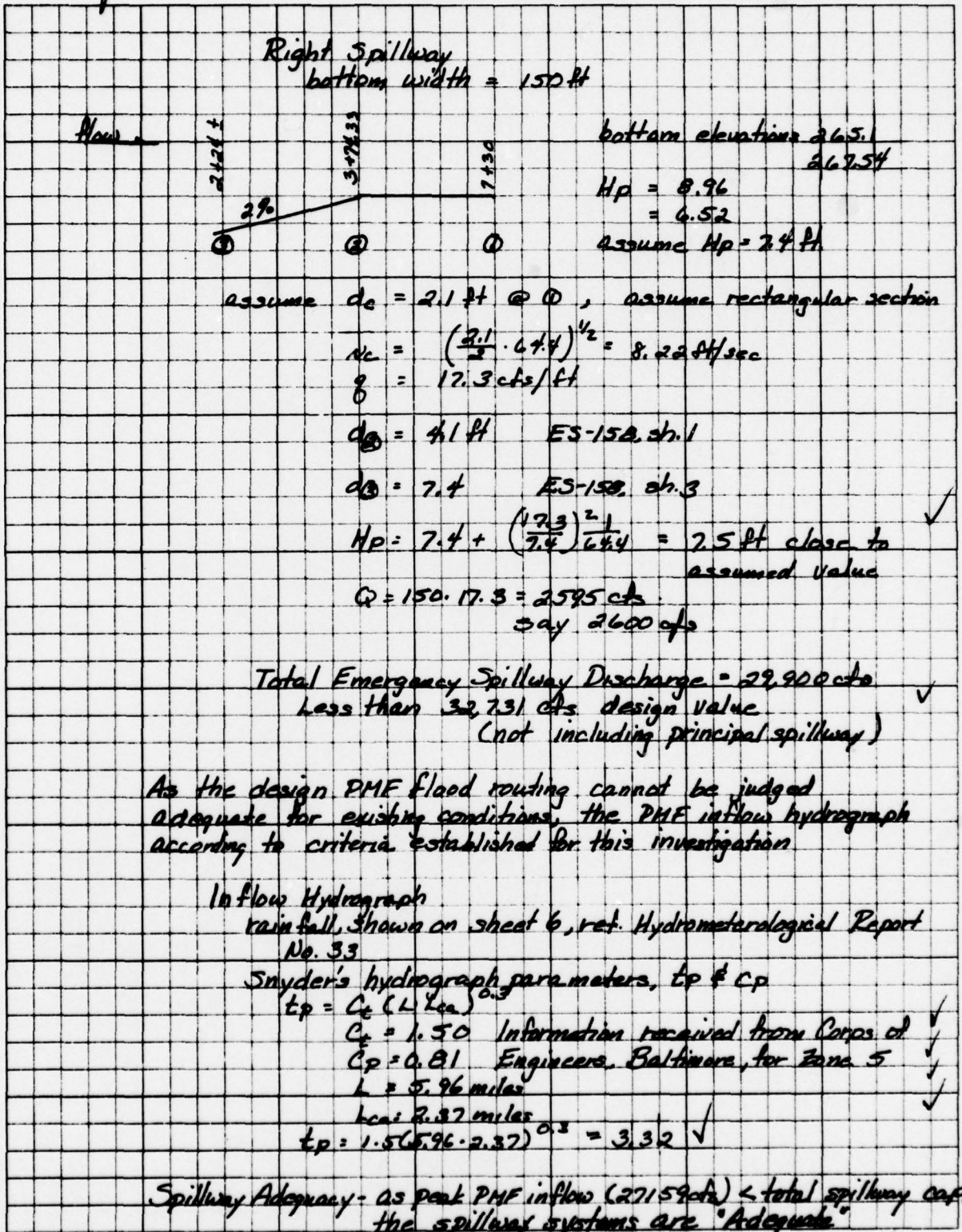
SHEET 4 OF 10

CHKD. BY [Signature] DATE _____

Warrington Dam

JOB No. _____

Hydrology / Hydraulics



MFB

5/25/79

Warrington Dam
Hydrology/Hydraulics

SH. 5 OF 10

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

RUN DATE* 79/05/25.
TIME* 11.10.26.

WARRINGTON DAM
NAT ID NO. PA 00221 DER NO. 9-174
INFLOW HYDROGRAPH

NO	MHR	NMIN	IDAY	JOB SPECIFICATION				IPLT	IPRT	NSTAN
				IHR	IMIN	METRC	TRACE			
200	0	15	0	0	0	0	0	-4	0	
	JOPER		5	NUT	LROPT	TRACE				
				0	0	0				

RTIOS= .90 .95 1.00
MULTI-PLAN ANALYSES TO BE PERFORMED
MPLAN= 1 MRTIO= 3 LRTIO= 1

MFB 5/25/79

Warrington Dam
Hydrology/Hydraulics

SH. 6 OF 10

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

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

HYDROGRAPH DATA

IHYD	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	10.92	0.00	10.92	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.50	112.00	122.00	131.00	142.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .803

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= 3.32 CP= .81 NTA= 0

RECESSION DATA

STRT0= -1.50 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 42 END-OF-PERIOD ORDINATES, LAG= 3.29 HOURS, CP= .80 VOL= 1.00

44.	161.	320.	497.	683.	870.	1057.	1241.	1418.	1568.
1674.	1738.	1764.	1755.	1711.	1632.	1508.	1321.	1117.	944.
798.	674.	570.	481.	407.	344.	291.	246.	207.	175.
148.	125.	106.	89.	76.	64.	54.	46.	39.	33.
28.	23.								

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	FYCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q			
0																
SUM													26.80	24.38	2.42	67785.
													(681.)	(619.)	(61.)	(19192.73)

MFB

5/25/79

Warrington Dam
Hydrology / Hydraulics

SH. 7 OF 10

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECUMHIF 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
				.90	.95	1.00

HYDROGRAPH AT	IN	10.92	1	24443.	25801.	27159.
	(28.28)	(692.15)	(730.60)	(769.05)

State PENNSYLVANIA Project NESHAMINY CREEK SH. 8 OF 10
 By H.L.W. Date 11/67 Checked By R.Q.S. Date 5-14-68 Job No. PA-611
 Subject WORK PLAN - DESIGN COMPARISON Sheet 1 of

ITEM	UNIT	WORK PLAN	DESIGN	COMMENTS
<u>DRAINAGE AREA</u>	SQ MI.	<u>10.92</u>	<u>10.92</u>	
<u>STORAGE CAPACITY</u>				
SEDIMENT (INC AERATED)	AC.FT.	<u>182</u>	<u>242</u>	
BENEFICIAL	AC.FT.			
RETARDING	AC.FT.	<u>1974</u>	<u>2132</u>	
TOTAL	AC.FT.	<u>2156</u>	<u>2374</u>	
BETWEEN HIGH & LOW S.	AC.FT.			
<u>SURFACE AREA</u>				
NORMAL POOL	ACRE	<u>26</u>	<u>26</u>	
RETARDING POOL	ACRE	<u>179</u>	<u>180</u>	
DESIGN HIGH WATER	ACRE			
<u>VOLUME OF FILL</u>	CU.YD	<u>222,400</u>		
<u>TOP OF DAM ELEV.</u>	FEET	<u>272.4</u>	<u>272.7</u>	<u>272.9</u> updated criteria
<u>MAX. HEIGHT OF DAM</u>	FEET	<u>45.4</u>	<u>45.7</u>	<u>45.9</u> " "
<u>EMERGENCY SPILLWAY</u>				
CREST ELEVATION	FEET	<u>264.0</u>	<u>265.1</u>	
BOTTOM WIDTH	FEET	<u>500</u>	<u>500</u>	<u>600</u> " "
TYPE	-	<u>SOD</u>	<u>SOD</u>	<u>weath. shale</u> " "
PERCENT CHANCE OF USE	-	<u>1</u>	<u>1</u>	
AVE. CURVE NO. COND. II	-	<u>81</u>	<u>81</u>	
<u>EM. SP. HYDROGRAPH</u>				
STORM RAINFALL - 6 HR.	IN.	<u>10.5</u>	<u>10.5</u>	
STORM RUNOFF	IN.	<u>8.12</u>	<u>8.12</u>	
VELOCITY OF FLOW - V	FPS.	<u>8.4</u>	<u>8.2</u>	
PEAK DISCHARGE RATE	CFS	<u>7,100</u>	<u>7,344</u>	<u>7354</u> " "
MAX. WATER SURFACE EL.	FEET	<u>267.4</u>	<u>268.2</u>	<u>268.9</u> " "
<u>FREEBOARD HYDROGRAPH</u>				
STORM RAINFALL - 6 HR.	IN.	<u>25.5</u>	<u>25.5</u>	
STORM RUNOFF	IN.	<u>22.89</u>	<u>22.89</u>	
VELOCITY OF FLOW - V	FPS	<u>14.2</u>	<u>15.5</u>	
PEAK DISCHARGE RATE	CFS	<u>33,750</u>	<u>33,367</u>	<u>272.9</u>
MAX. WATER SURFACE EL.	FEET	<u>272.4</u>	<u>272.7</u>	
<u>PRINCIPAL SPILLWAY</u>				
RISER SIZE	FT.		<u>5x15'</u>	
MAX. LOW STAGE FLOW	CFS	<u>562</u>	<u>579</u>	
ORIFICE SIZE	FT.			
MAX. HIGH STAGE FLOW	CFS			
PIPE SIZE	DIA.		<u>60"</u>	
<u>CAPACITY EQUIVALENTS</u>				
TOTAL SEDIMENT VOL.	IN.	<u>0.31</u>	<u>0.31</u>	
RETARDING STORAGE	IN.	<u>3.39</u>	<u>3.4</u>	<u>3.95</u>
EM. SPILLWAY STORAGE TO TOP OF DAM	IN.	<u>3.31</u>	<u>3.47</u>	<u>3.26</u>
<u>CLASS OF STRUCTURE</u>	-	<u>C</u>	<u>C</u>	
<u>CONSTRUCTION COSTS</u>	-			
<u>B-C RATIO</u>	-			

REF.: SCS Design folder

MFB 5/25/79

Warrington Dam
Hydrology / Hydraulics

SH 9 of 10

E. S. DESIGN AND FLEEWBOARD ROUTINGS.											
NESHAMINY CREEK PA 611					2-28 F.W.						
CURVE NO. 01.		TC 3.27		STORM DURATION 6.00							
EMER. SPW. RAINFALL 10.50					FREEBOARD RAINFALL 25.50						
CASE NO.		C. DRAINAGE AREA 10.92		EMER. SPW. CREST 265.1							
001	600.	L1	200.	802	600.	L2	300.	803	600.	L3	500.
ELEVATION		STORAGE		CFS		CFS		CFS			
241.00			110.			0.			0.		0.
243.00			170.			245.			245.		245.
247.00			362.			420.			420.		420.
251.00			607.			460.			460.		460.
255.00			933.			497.			497.		497.
259.00			1406.			531.			531.		531.
263.00			2001.			564.			564.		564.
265.00			2350.			597.			597.		597.
265.10			2371.			597.			597.		597.
265.60			2480.			761.			731.		707.
266.10			2589.			1278.			1170.		1062.
266.60			2698.			2138.			1928.		1688.
267.10			2806.			3231.			2937.		2595.
267.60			2915.			4631.			4229.		3689.
268.10			3024.			6283.			5772.		5076.
269.00			3220.			10055.			9323.		8367.
269.10			3243.			10474.			9718.		8734.
270.10			3483.			15491.			14369.		12917.
271.00			3700.			20676.			19483.		17994.
271.10			3723.			21252.			20052.		18558.
272.10			3963.			27499.			25963.		24193.
273.00			4180.			34190.			32422.		30312.
273.10			4205.			34934.			33140.		30992.
274.99			4680.			51070.			48901.		46394.

Ref. SCS Design Folder

MFB 5/25/79

Warrington Dam
Hydrology / Hydraulics

SH. 10 OF 10

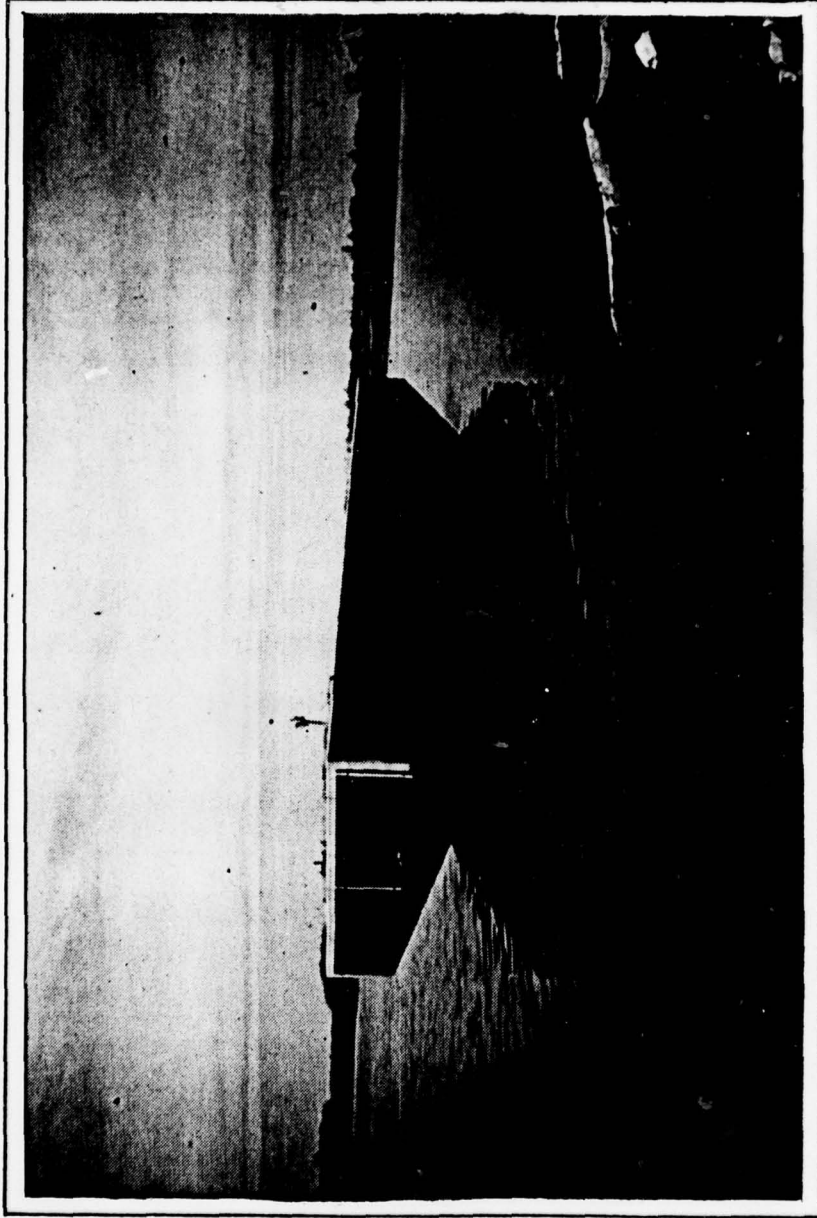
FREEBOARD ROUTING.				
NESHAMINY CREEK PA 611			2-28 F.W.	
BD = 600.	L = 200.	CREST =	265.10	
TIME	INFLOW	AVE IN	OUTFLOW	ELEV.
0.25	9.	4.	0.	241.00
0.50	19.	14.	1.	241.01
0.75	103.	61.	6.	241.05
1.00	211.	157.	18.	241.15
1.25	499.	355.	45.	241.37
1.50	957.	728.	101.	241.82
1.75	1712.	1334.	201.	242.64
2.00	3261.	2486.	277.	243.74
2.25	4868.	4064.	348.	245.35
2.50	8342.	6605.	428.	247.80
2.75	11616.	10079.	461.	251.04
3.00	16476.	14146.	493.	254.50
3.25	21454.	18965.	522.	257.88
3.50	26069.	23762.	550.	261.34
3.75	30383.	28226.	594.	264.86
4.00	33879.	32131.	695.	267.67
4.25	35505.	34692.	14718.	269.94
4.50	36979.	36242.	23308.	271.42
4.75	36152.	36566.	29133.	272.31
5.00	35324.	35738.	32336.	272.75
5.25	33607.	34466.	33368.	272.84
5.50	31694.	32650.	33020.	272.84
5.75	29732.	30713.	31901.	272.69
6.00	27735.	28733.	30365.	272.48
6.25	25794.	26764.	28615.	272.25
6.50	23965.	24880.	26893.	272.00
6.75	22132.	23049.	25264.	271.74
7.00	20248.	21190.	23537.	271.46
7.25	18364.	19306.	21744.	271.17
7.50	16447.	17406.	19989.	270.88
7.75	14523.	15485.	18199.	270.57
8.00	12732.	13628.	16382.	270.25
8.25	11028.	11880.	14588.	269.94
8.50	9463.	10245.	13110.	269.62
8.75	8140.	8802.	11580.	269.32
9.00	6863.	7502.	10179.	269.02
9.25	5908.	6386.	8932.	268.73
9.50	4953.	5430.	7771.	268.45
9.75	4256.	4604.	6721.	268.20
10.00	3593.	3924.	5882.	267.97
10.25	3059.	3326.	5187.	267.76
10.50	2598.	2829.	4557.	267.57
10.75	2193.	2395.	4050.	267.39
11.00	1871.	2032.	3576.	267.22
11.25	1564.	1718.	3158.	267.06
11.50	1333.	1449.	2836.	266.91
11.75	1102.	1218.	2532.	266.78
12.00	924.	1013.	2246.	266.64
12.25	750.	837.	2012.	266.52
12.50	609.	680.	1811.	266.40
12.75	484.	547.	1620.	266.29
13.00	380.	432.	1441.	266.19
13.25	304.	342.	1276.	266.09

Top of O...
PEAK OCCURS PREVIOUS LINE

Ref- SCS Design Folder

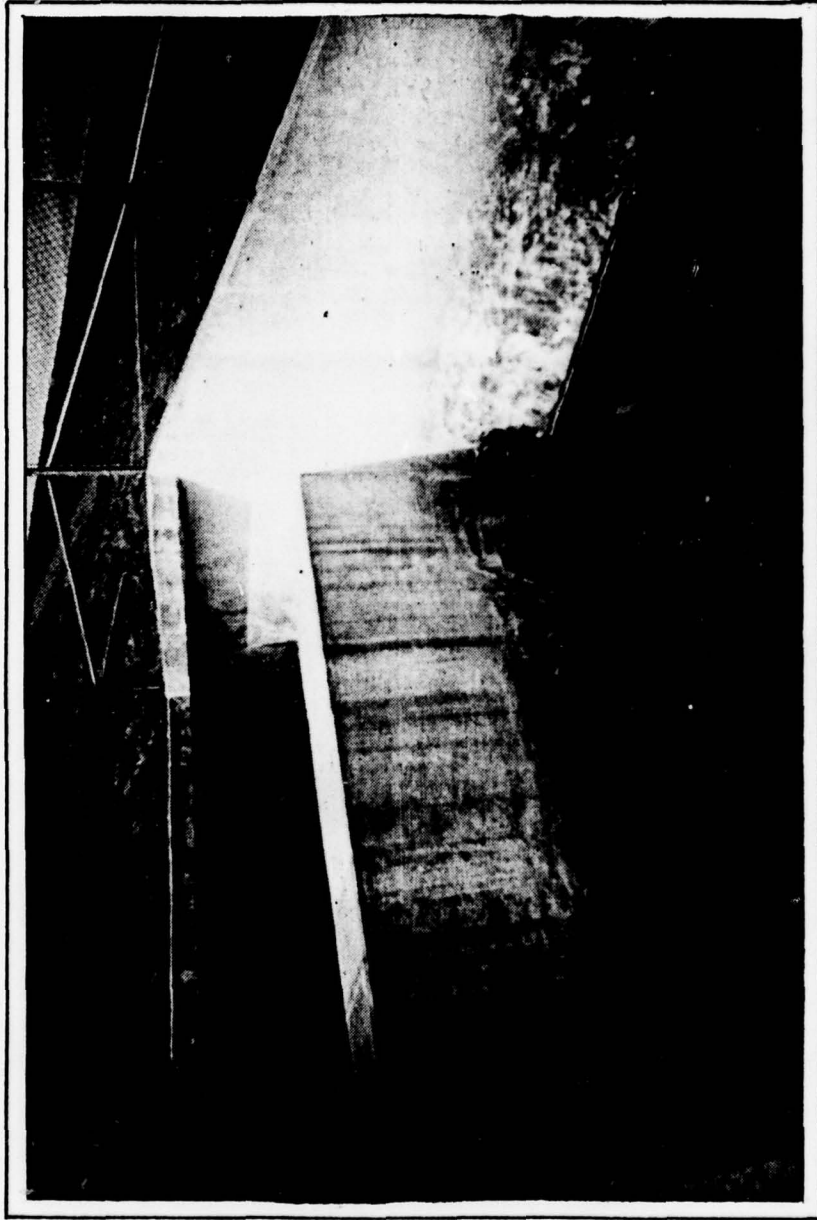
APPENDIX

D



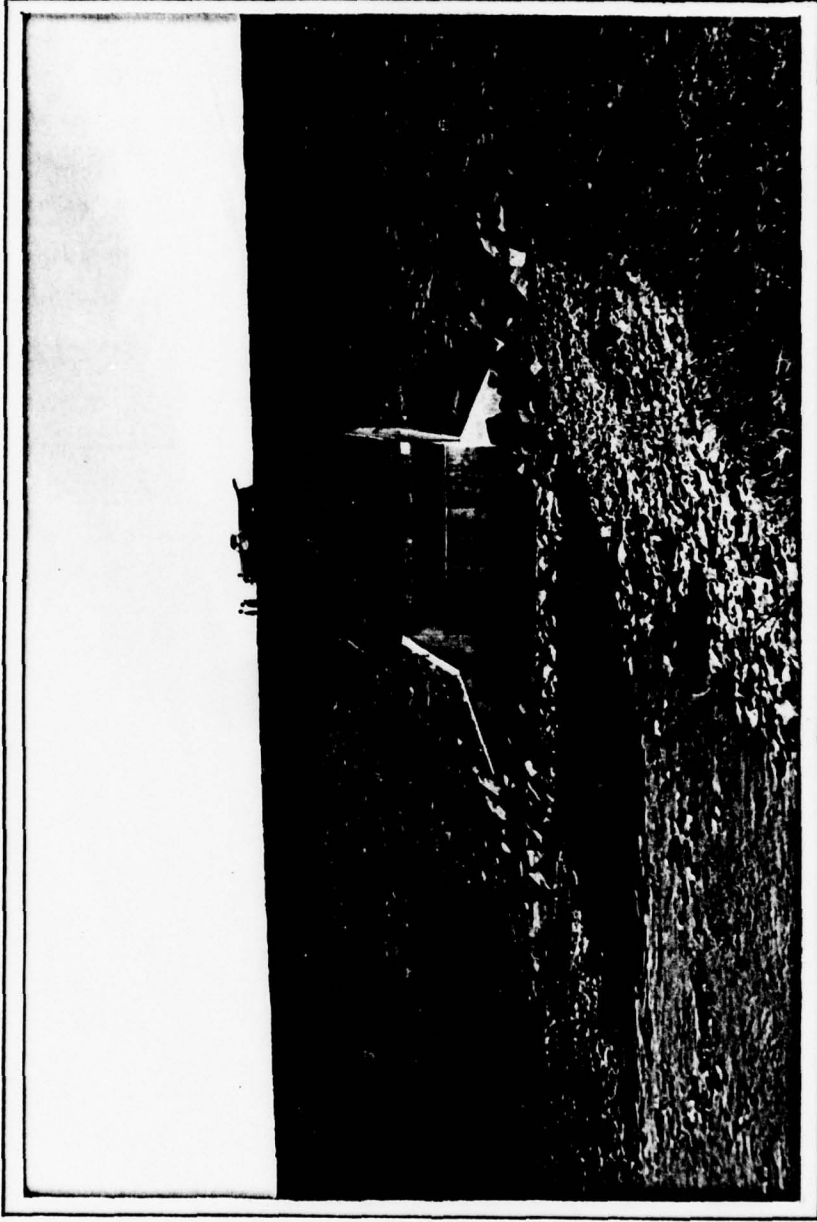
OVERVIEW OF PRINCIPAL SPILLWAY RISER.

PHOTOGRAPH NO. 1



PRINCIPAL SPILLWAY IMPACT BASIN.

PHOTOGRAPH NO. 2



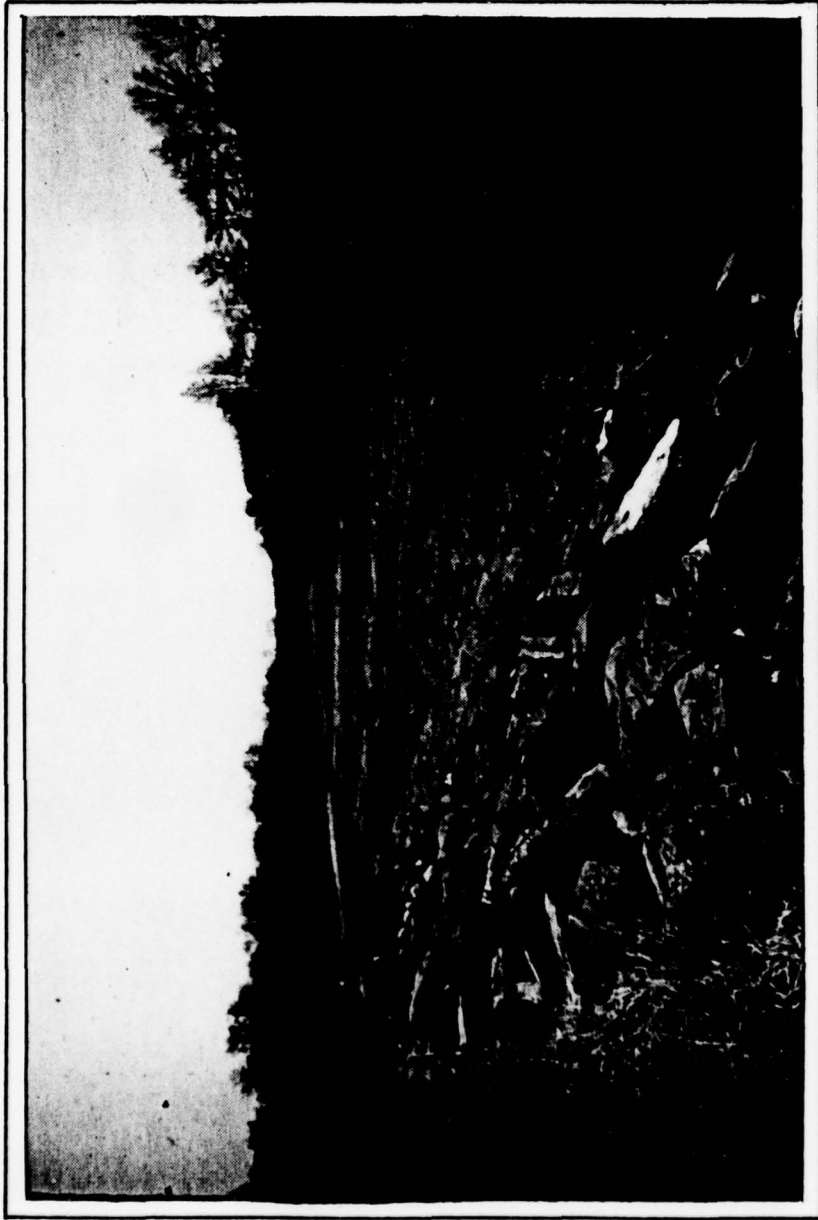
OVERVIEW OF IMPACT BASIN AND DISCHARGE
CHANNEL.

PHOTOGRAPH NO. 3



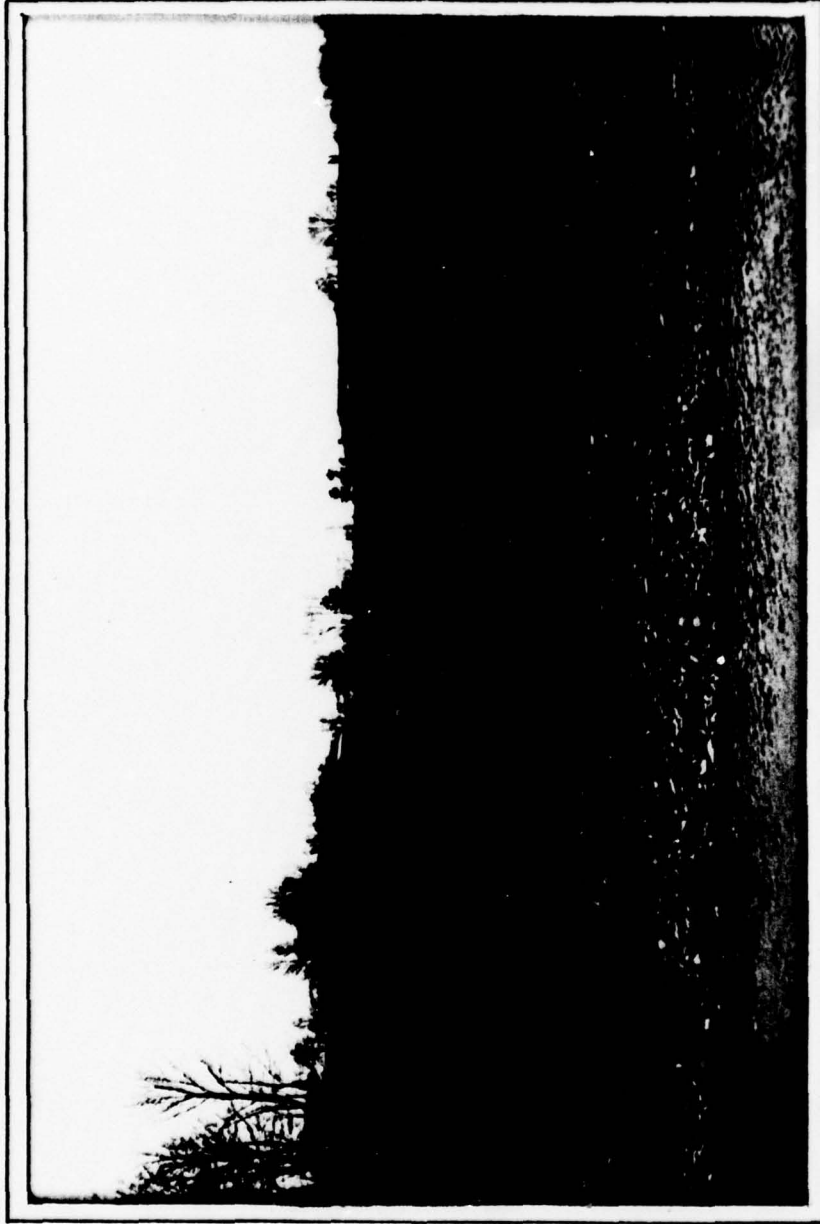
OVERVIEW OF PRINCIPAL SPILLWAY
DISCHARGE CHANNEL.

PHOTOGRAPH NO. 4



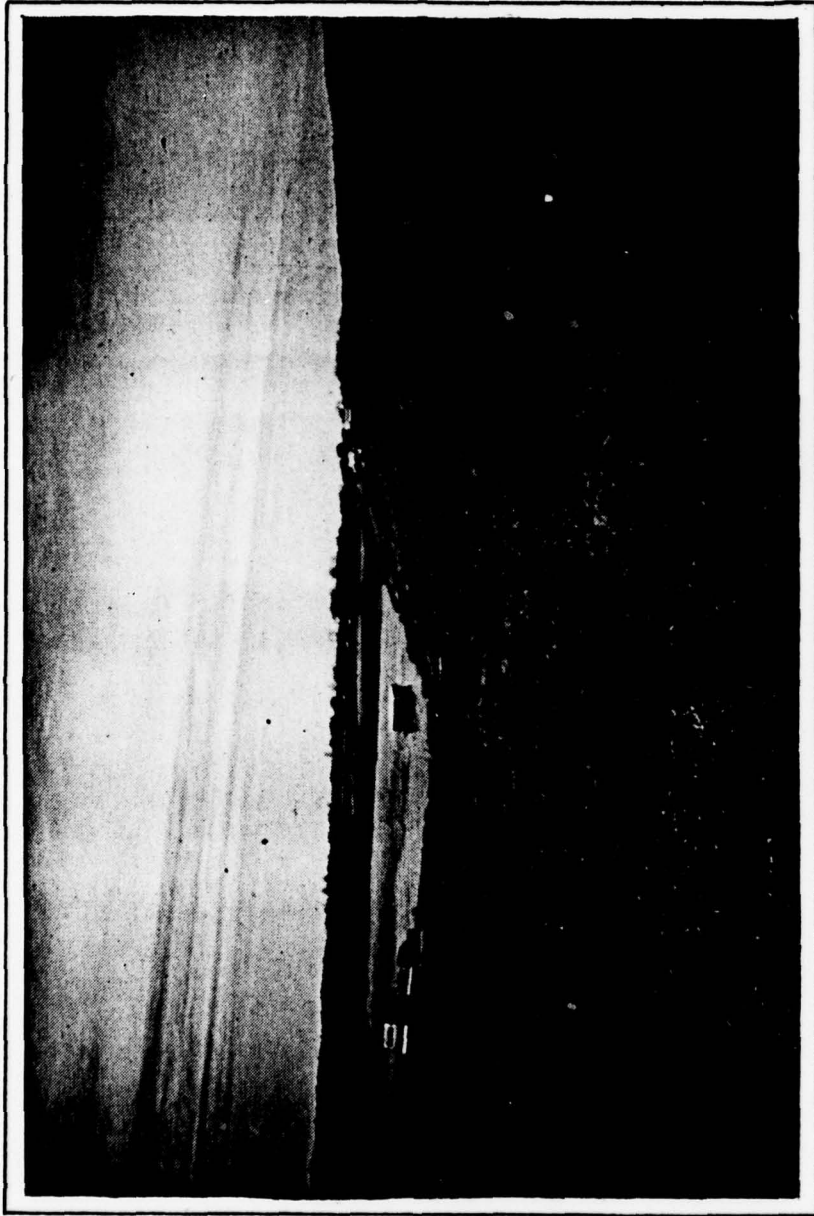
EMERGENCY SPILLWAY ALONG RIGHT ABUTMENT
LOOKING DOWNSTREAM.

PHOTOGRAPH NO. 5



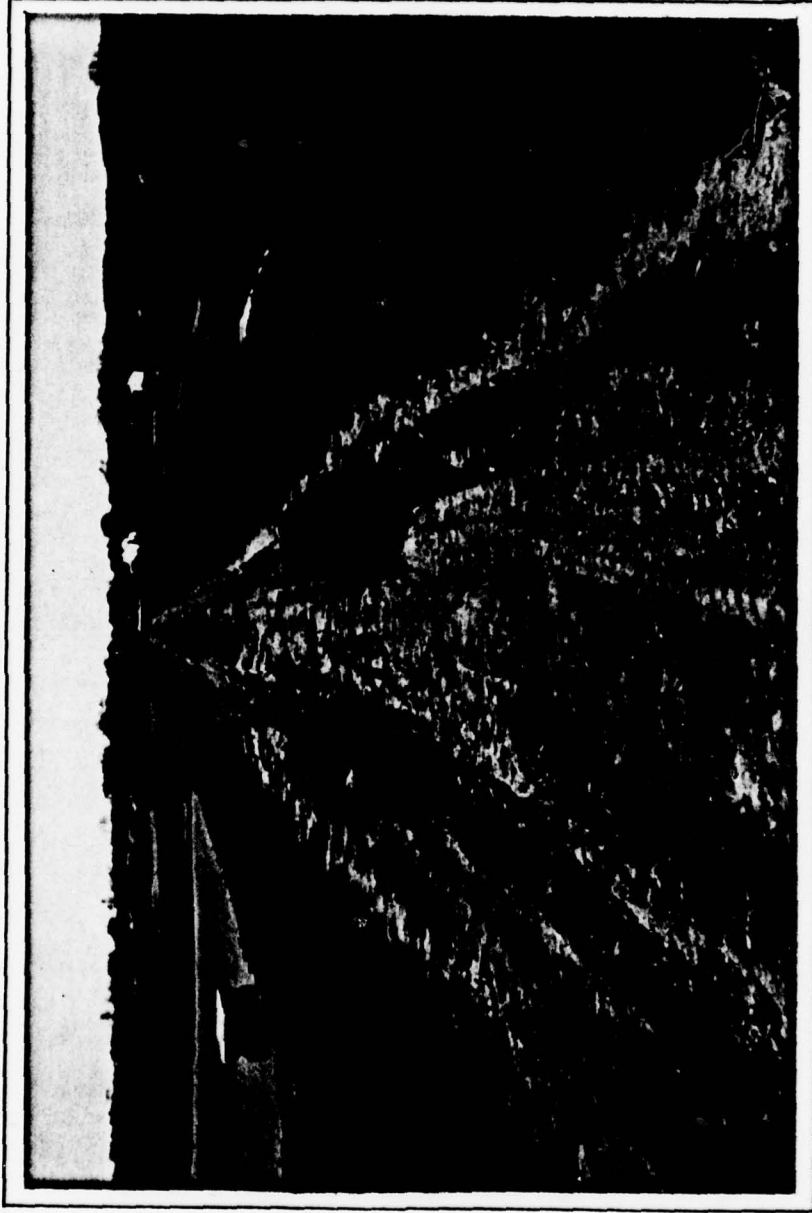
EMERGENCY SPILLWAY ALONG LEFT ABUTMENT
LOOKING DOWNSTREAM.

PHOTOGRAPH NO. 6



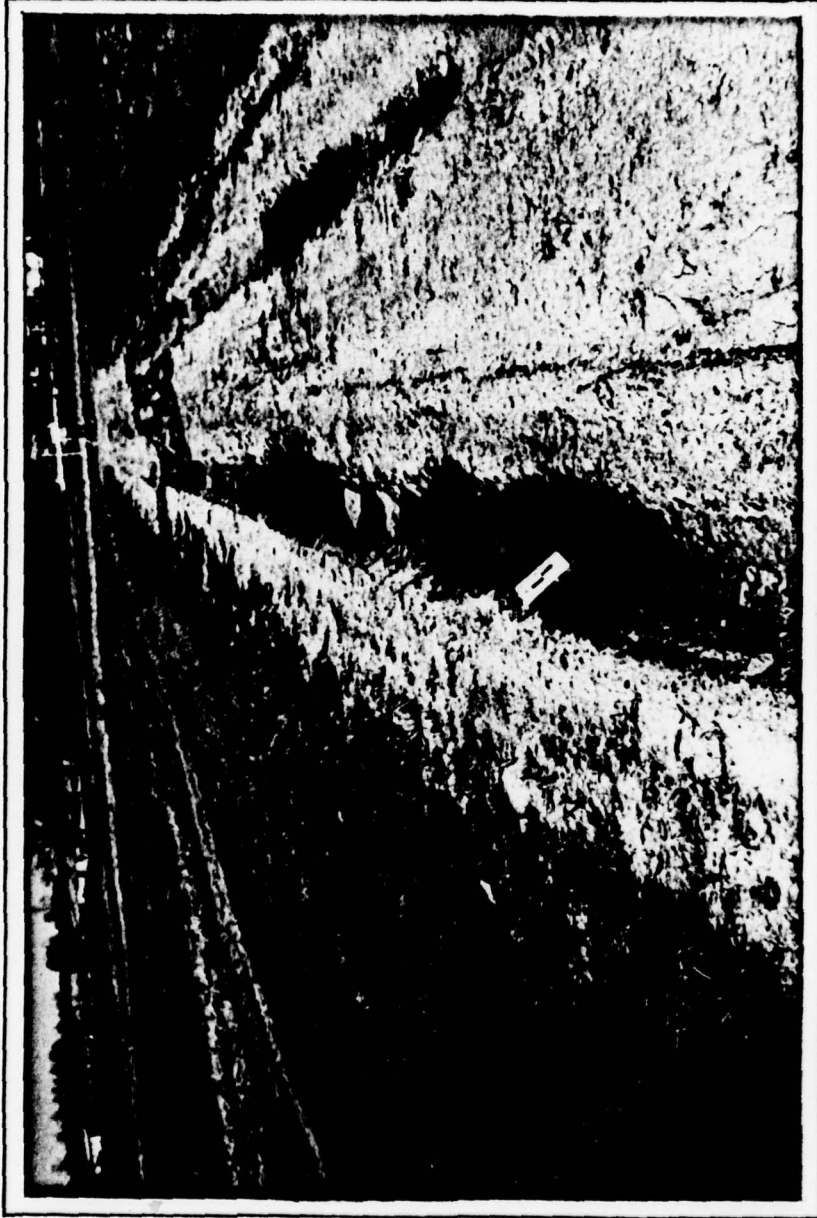
OVERVIEW OF UPSTREAM SLOPE.

PHOTOGRAPH NO. 7



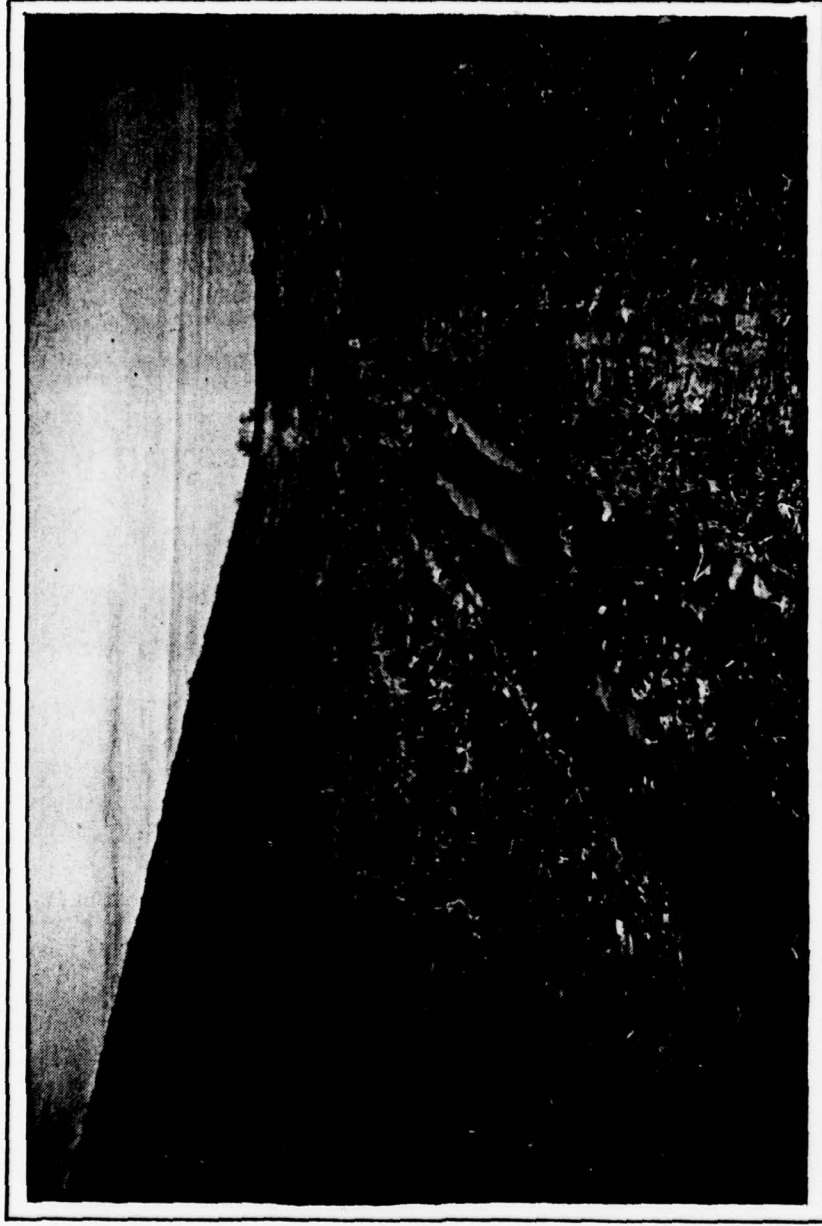
OVERVIEW OF CREST AND DOWNSTREAM
SLOPE LOOKING FROM RIGHT ABUTMENT.

PHOTOGRAPH NO. 8



VIEW OF CREST CONTAINING RUTS AND
STANDING WATER.

PHOTOGRAPH NO. 9



VIEW OF BENCH ALONG DOWNSTREAM SLOPE.
NOTE POOR DRAINAGE AND RUTTED, MUDDY
SURFACE.



DOWNSTREAM SLOPE EROSION DUE TO MOTOR
BIKES AND ALL-TERRAIN VEHICLES.

PHOTOGRAPH NO. 11



DEBRIS ALONG UPSTREAM SLOPE.

PHOTOGRAPH NO. 12

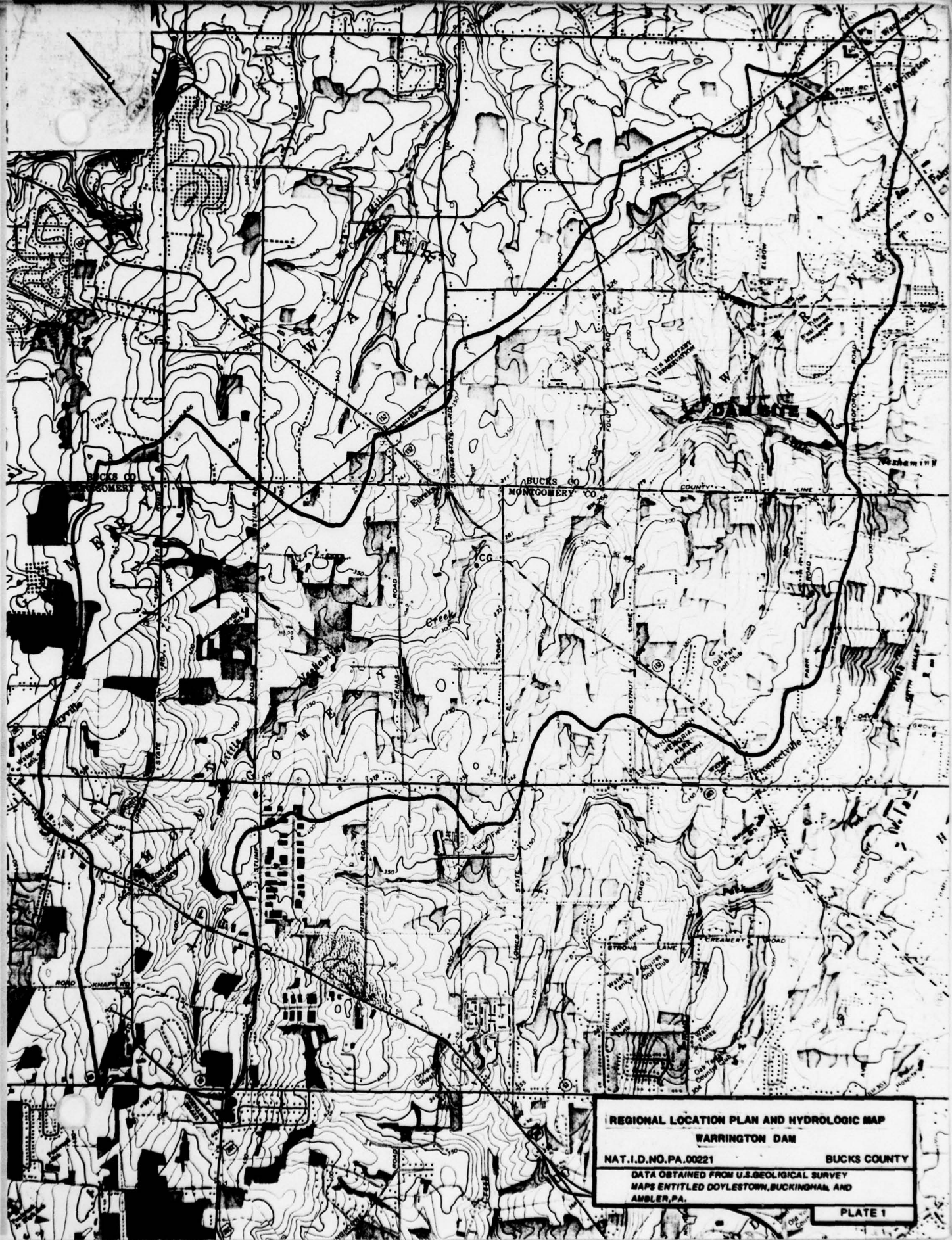


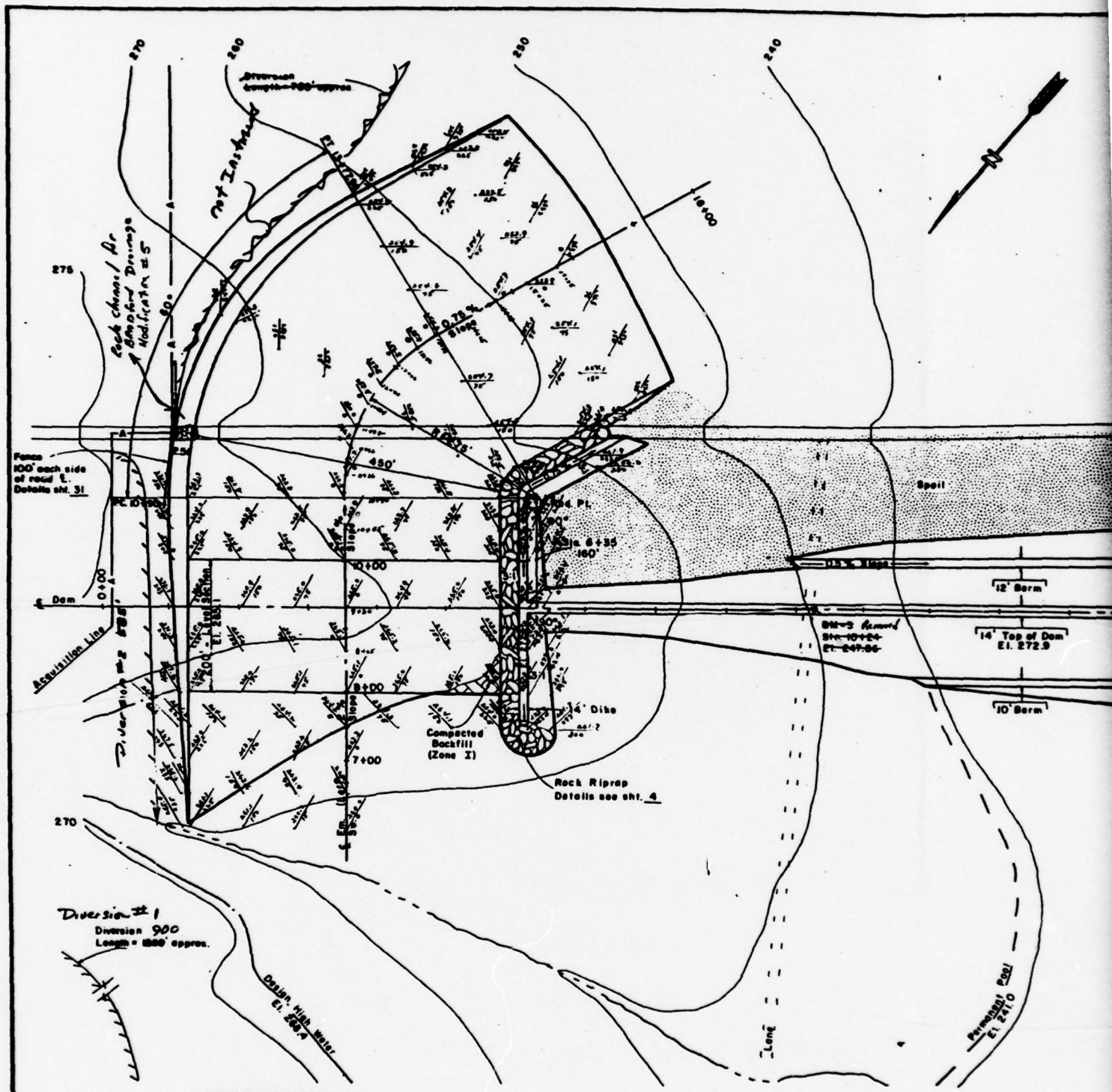
EROSION GULLY ALONG DOWNSTREAM TOE
ON THE RIGHT SIDE OF THE IMPACT
BASIN.

PHOTOGRAPH NO. 13

APPENDIX

E

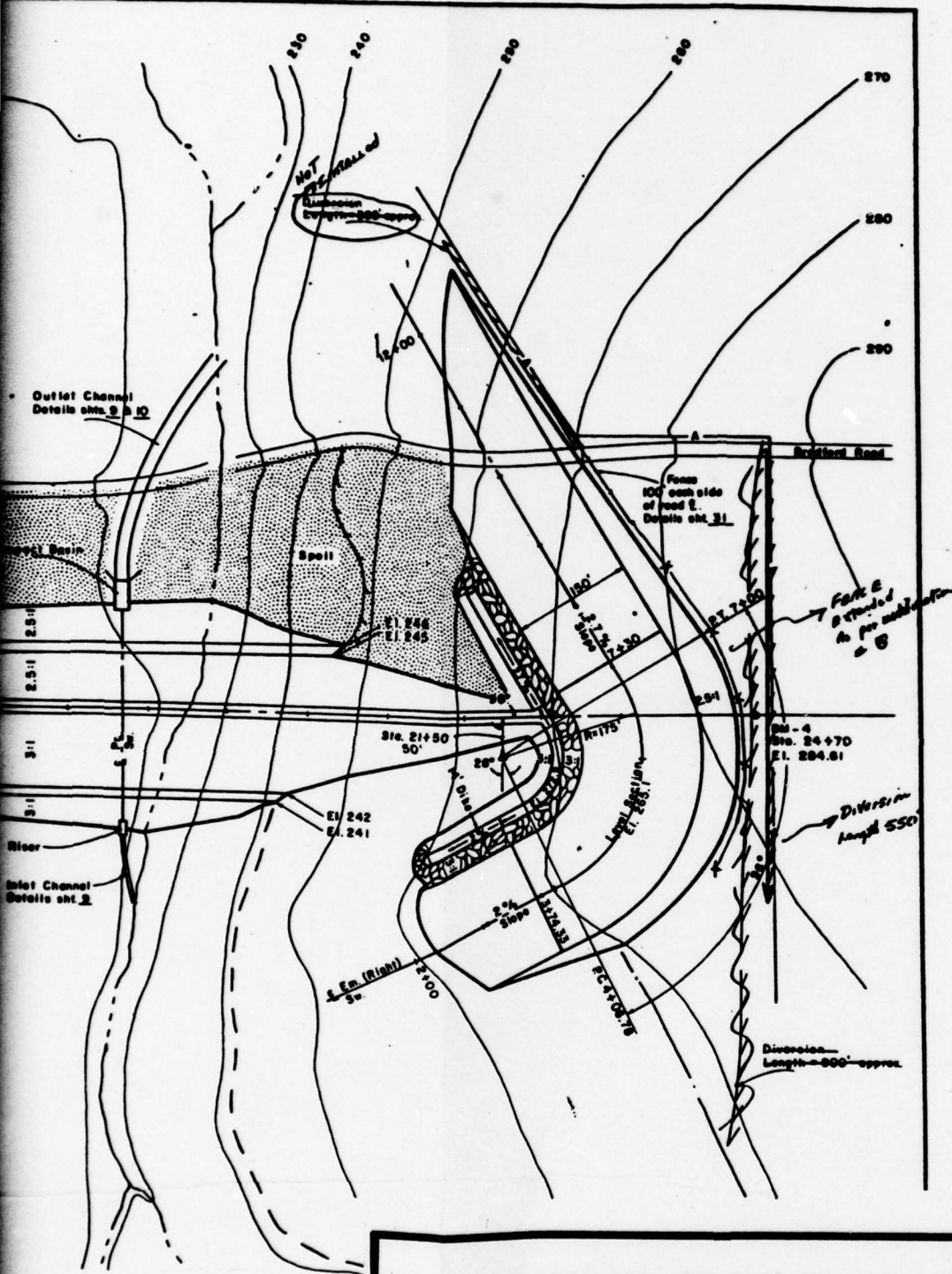




CONSTRUCTION NOTES

1. For E Dam Layout see sht. 2.
2. For Em. Su. Section see sht. 5.
3. For Profile along E. Em. Su. see sht. 31.
4. For Spoil Area Details see sht. 2.
5. Diversions - final line & grade to be determined by the Engineer.
6. Rock Treatment required in Em. Su., Fr. Su. & Cutoff Trench as directed by the Engineer. Spec. 216

AS BUILT PLANS
 100 50 20 0 100
 SCALE IN FEET



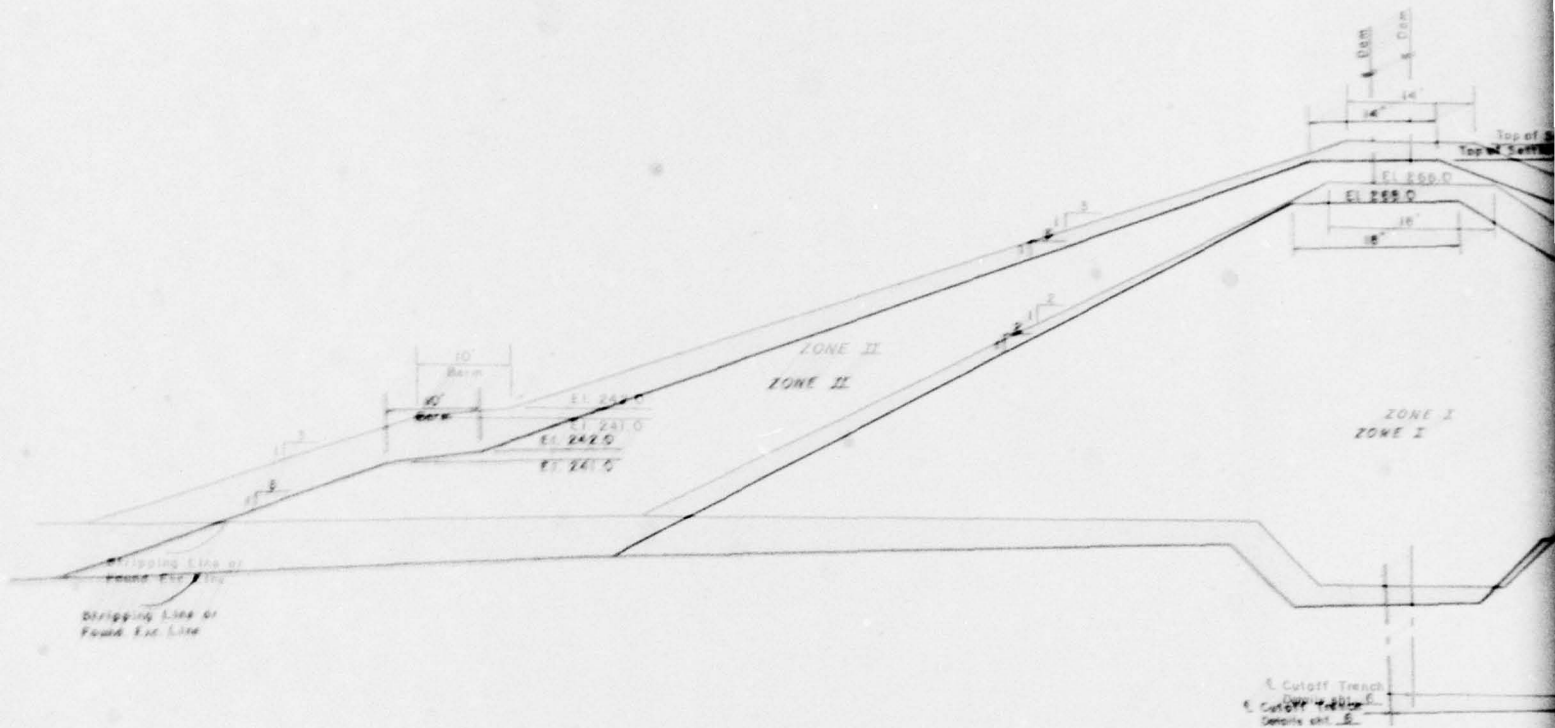
**PLAN OF DAM AND APPURTENANT STRUCTURES
WARRINGTON DAM**

NAT. I. D. NO. PA. 00221 BUCKS COUNTY

DATA OBTAINED FROM U.S. DEPT. OF AGRICULTURE, SOIL
CONSERVATION SERVICE, DRAWING NO. PA-611-P
SHEET NO. 3 OF 42, DATED 4/73

PLATE 2

2

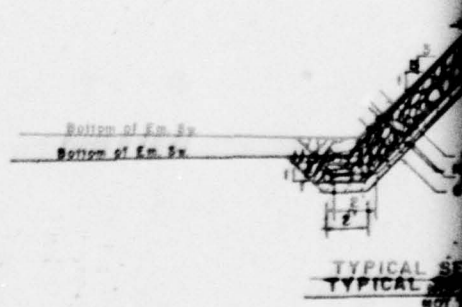


TYPICAL SECTION OF DAM
 TYPICAL SECTION OF DAM
 1" = 55.6 FT IN FEET
 SCALE IN FEET

ZONE	MATERIAL	MAX. ROCK SIZE	MAX. LIFT	REQ'D. WATER CONTENT	COMPACTION	
					CLASS	DEFINITION
I	Material as represented by TP-221, depth 0 to 10'.	6"	5'	Optimum + 3%	A	100% max density by ASTM D-698, Method A
II	Material as represented by TP-221, depth 10 to 14', depth 14 to 24'.	6"	5'	Optimum - 1% to + 3%	C	Min. 8 passes with 450 psi tamping roller
III	Material as represented by DP-219, depth 0 to 10', TP-221, depth 10 to 14', TP-221, depth 14 to 24'.	6"	5'	Optimum + 3% (min. 4 material)	C	Min. 8 passes with 450 psi tamping roller

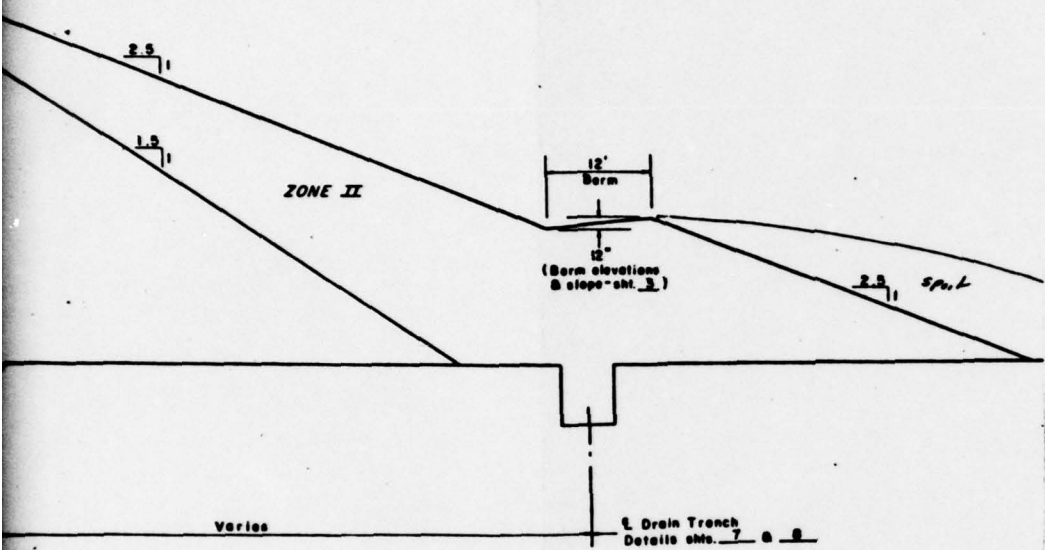
- 1 Water content of fill matrix at time of compaction. Variation from max. permissible may be checked before compaction.
- 2 Water content of fill matrix at time of compaction. Variation from water content shown may be approved by the Engineer.
- 3 For typical compaction curves see SHT. 51 & 52.

AS BUILT PLANS



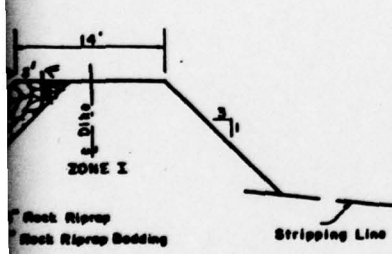
TYPICAL SECTION OF DAM

Red Fill, El. 272.9



CONSTRUCTION NOTES

1. Constructed Slopes are:
2.93:1 upstream
2.44:1 downstream
2. For constructed fill elevations see sht. 6.



SECTION OF DIKE
SCALE

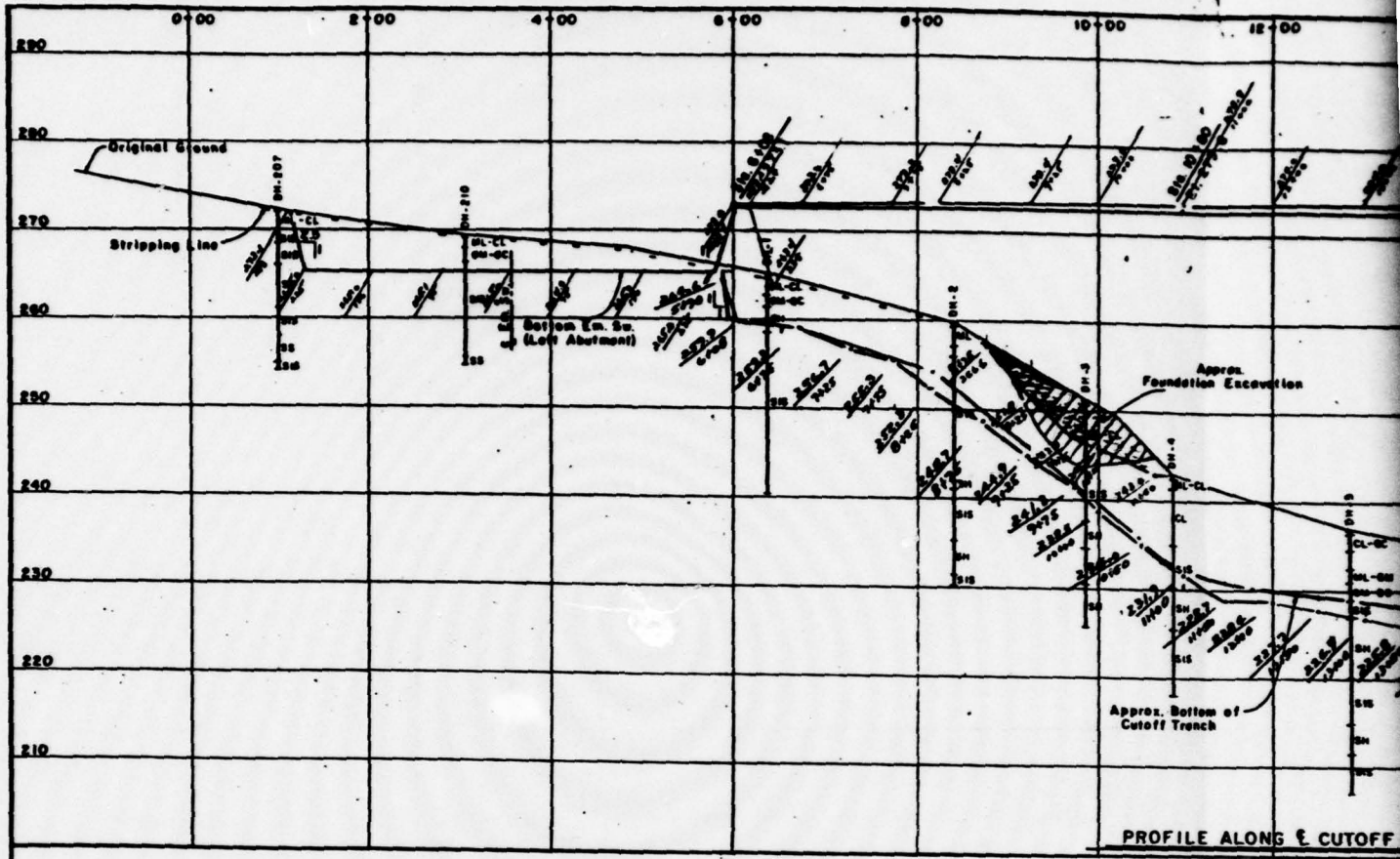
**TYPICAL EMBANKMENT SECTION
AND MATERIAL DESCRIPTIONS
WARRINGTON DAM**

NAT.I.D.NO.PA.00221 BUCKS COUNTY

DATA OBTAINED FROM U.S. DEPT. OF AGRICULTURE, SOIL
CONSERVATION SERVICE, DRAWING NO. PA-611-P
SHEET NO. 4 OF 42, DATED 12/72

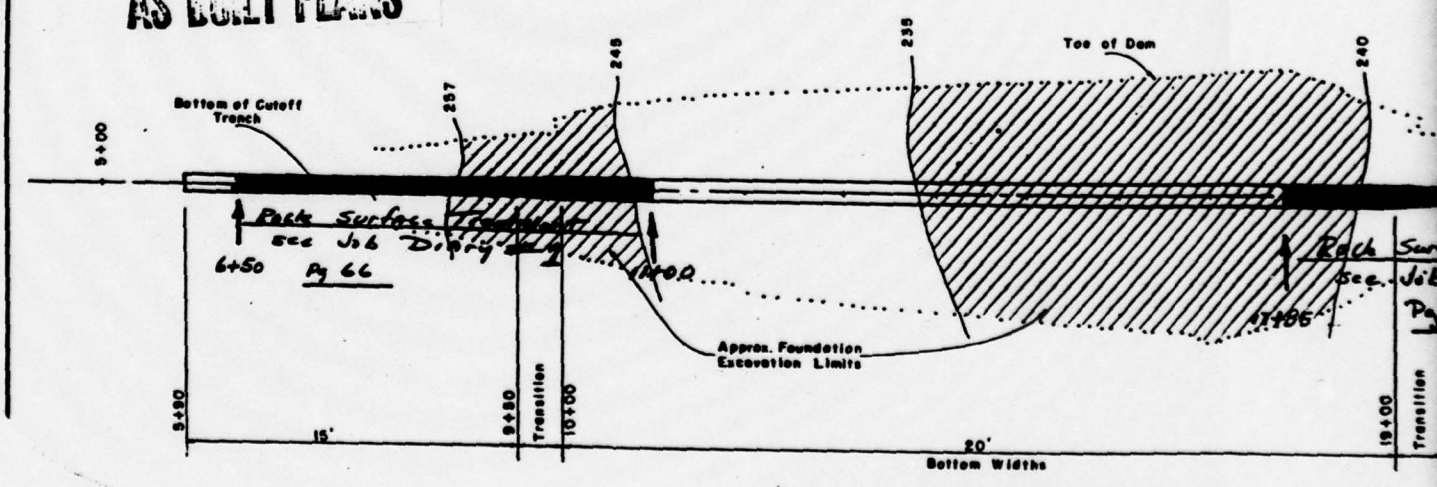
PLATE 3

2

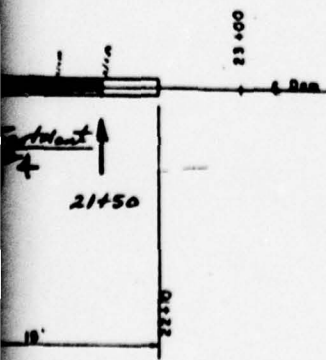
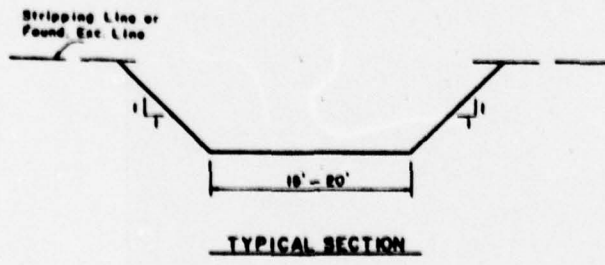
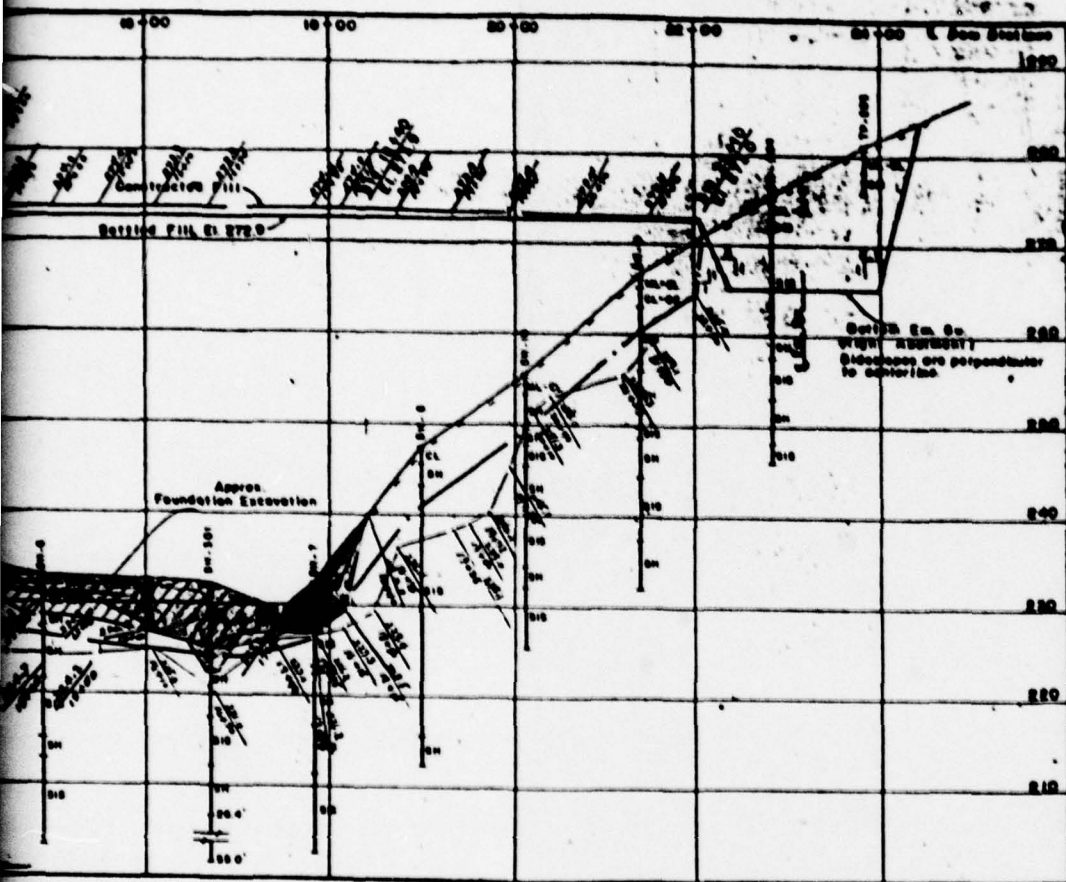


PROFILE ALONG CUTOFF

AS BUILT PLANS



PLAN VIEW
 100 50 20 0 100
 SCALE IN FEET



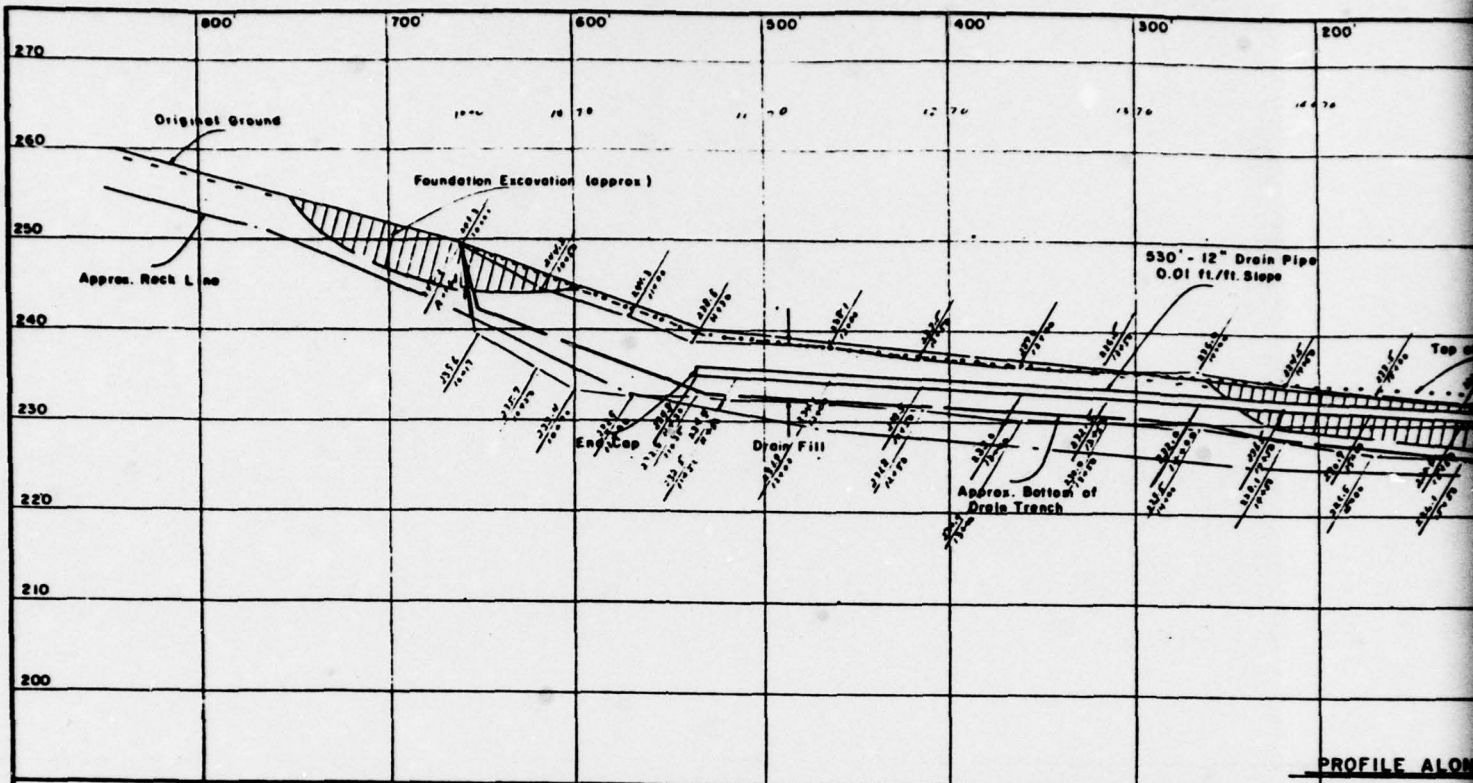
**CUTOFF TRENCH: AS-BUILT DETAILS
WARRINGTON DAM**

NAT. I.D. NO. PA. 00221 BUCKS COUNTY

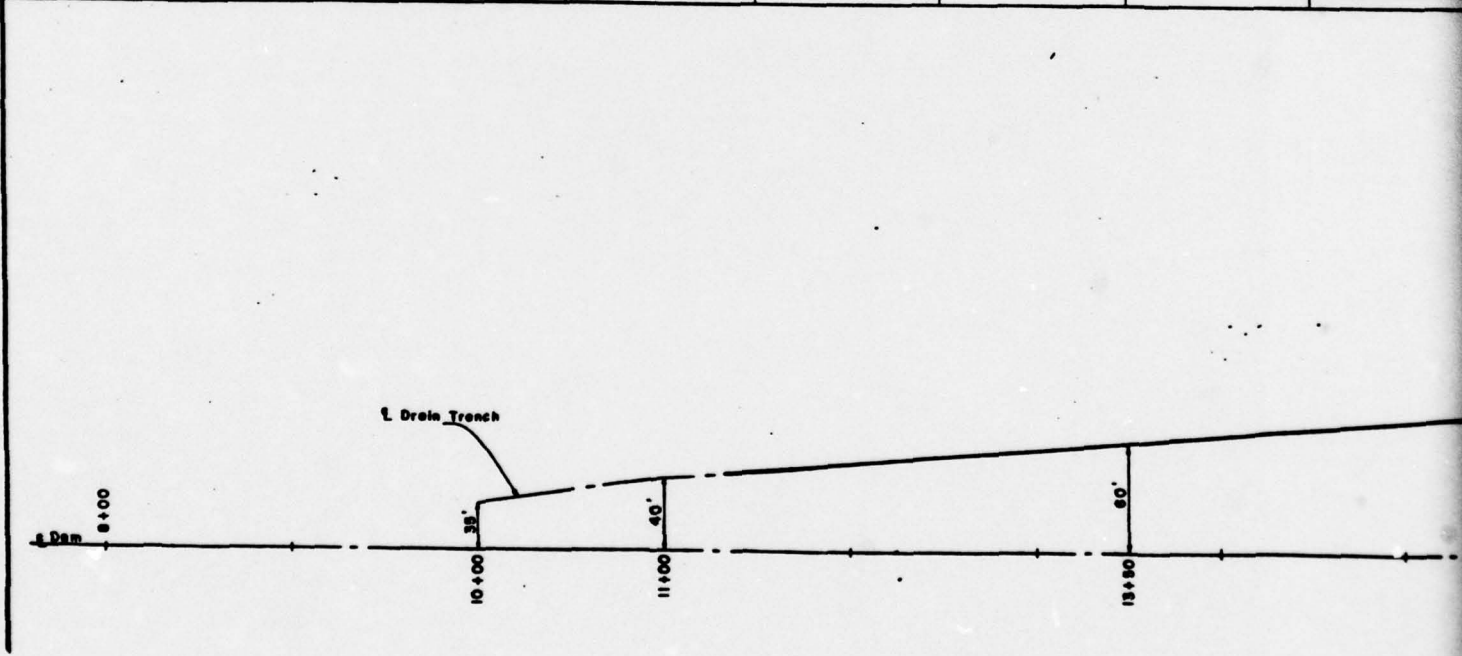
DATA OBTAINED FROM U.S. DEPT. OF AGRICULTURE, SOIL
CONSERVATION SERVICE, DRAWING NO. PA-611-P
SHEET NO. 6 OF 42, DATED 11/42

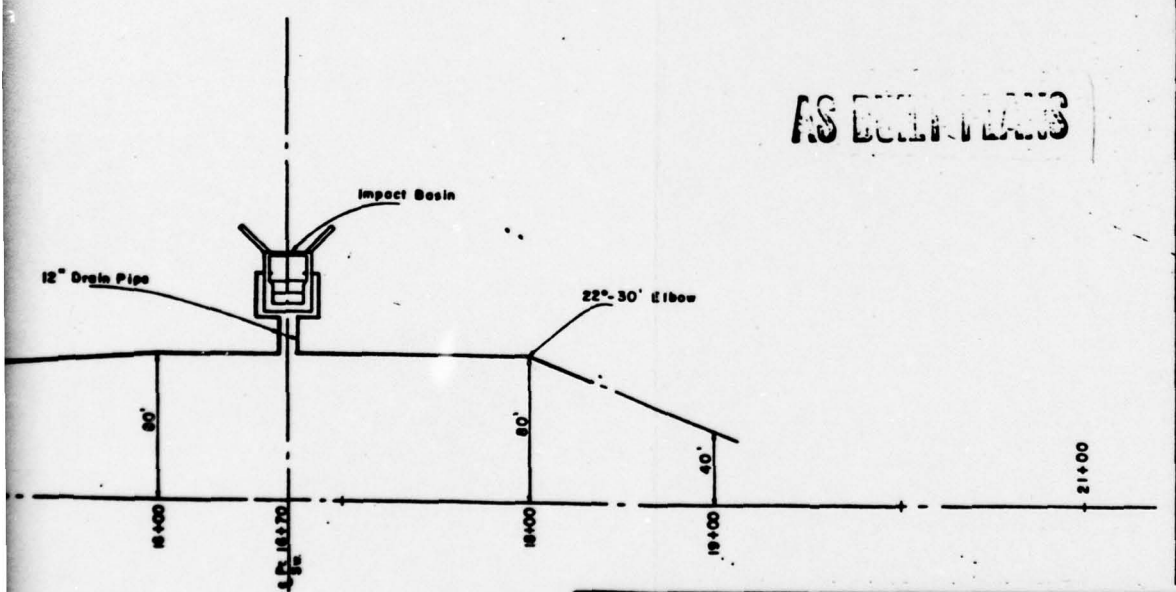
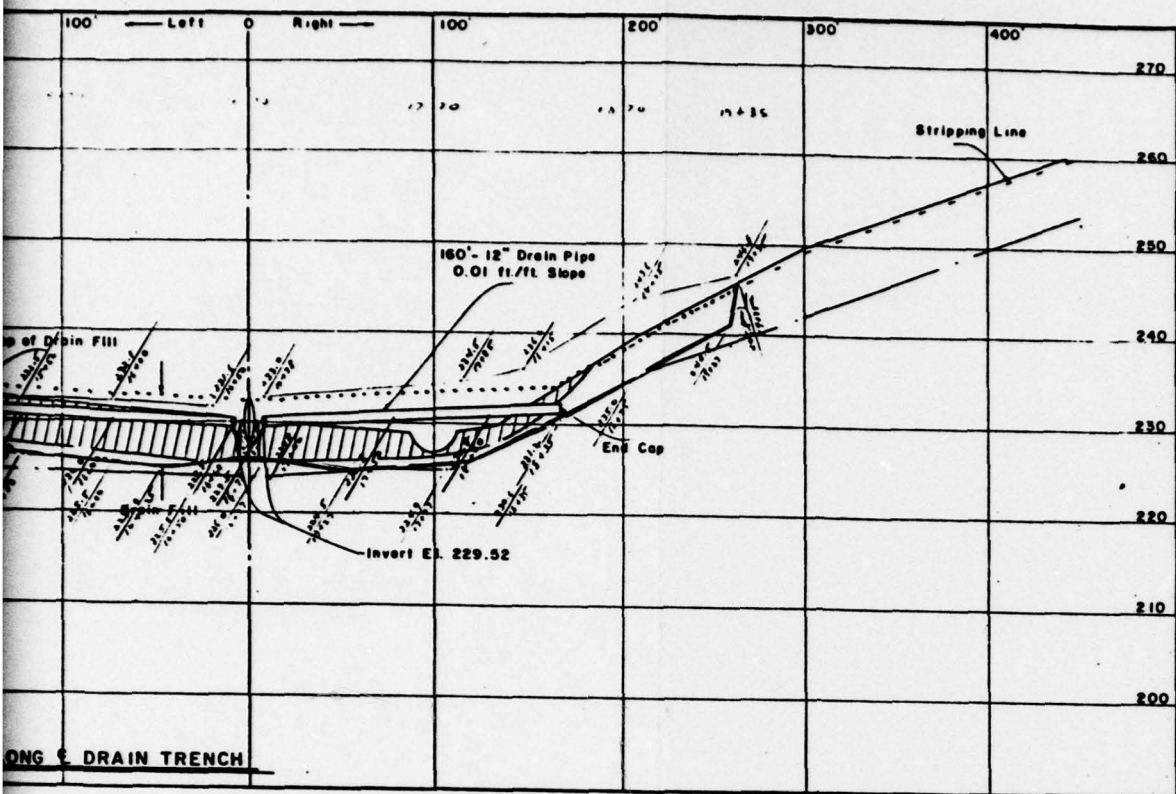
PLATE 4

2



PROFILE ALONG





AS BUILT PLANS

PLAN VIEW
 0 50 100
 SCALE IN FEET

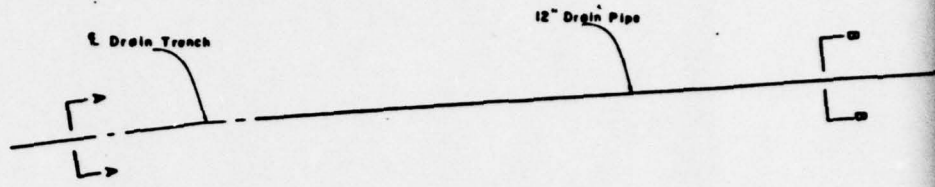
**EMBANKMENT DRAINAGE SYSTEM
 WARRINGTON DAM**

NAT. I.D. NO. PA. 00221 BUCKS COUNTY

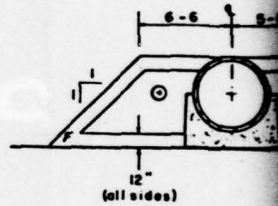
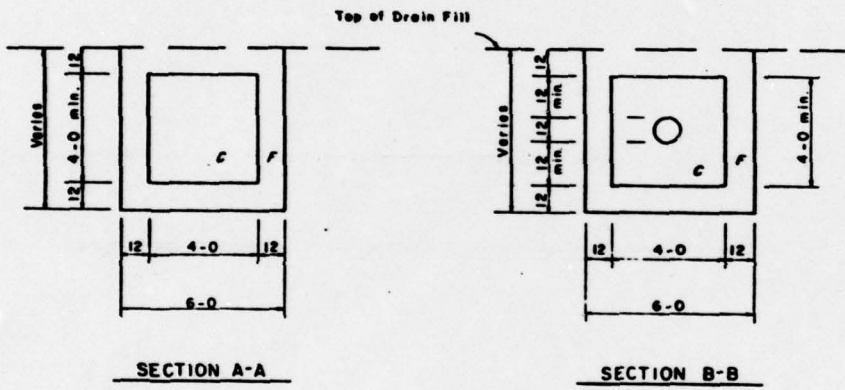
DATA OBTAINED FROM U.S. DEPT. OF AGRICULTURE, SOIL
 CONSERVATION SERVICE, DRAWING NO. PA-611-P
 SHEET NO. 7 OF 42, DATED 12/72

PLATE 5A

2

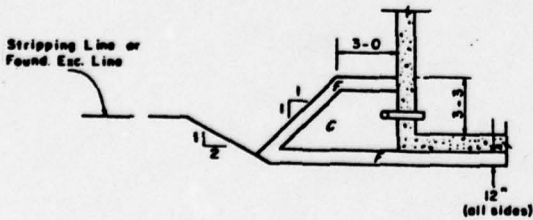


PLAN VIEW



SECTION C

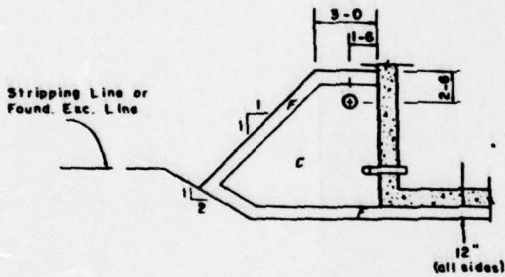
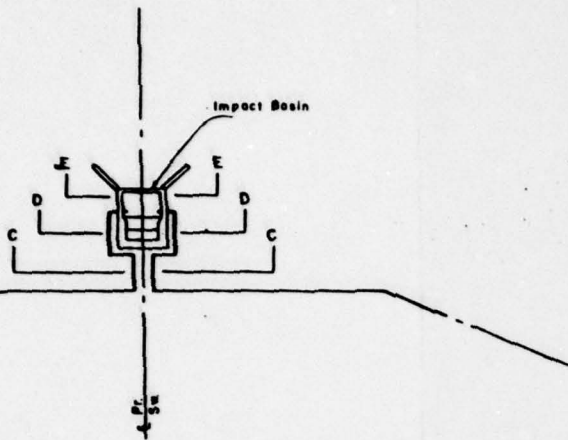
F = Fine Drain Fill
C = Coarse Drain Fill



SECTION E-E

AS SHOWN PLANS
NOT TO SCALE

FINE	
SIEVE NO.	
3/8"	
no. 4	
no. 8	
no. 16	
no. 30	
no. 50	
no. 100	
no. 200	



GRADATION LIMITS

DRAIN FILL	
% PASSING (BASED ON DRY WEIGHT)	
100	100
90 - 100	96.7
70 - 92	83.1
50 - 80	71.5
30 - 65	57.7
10 - 30	12.3
1 - 8	1.3
< 3	.2

COARSE DRAIN FILL	
SIEVE NO.	% PASSING (BASED ON DRY WEIGHT)
100	100
3/4"	90 - 100
3/8"	20 - 35
no 4	0 - 10
no 8	< 5

*see grading report dated 9-13-74
from Quantile's book*

CONSTRUCTION NOTE

All 12" drain pipe will be Class I, Shape 1, Coating A, 16 Gage, Perforated. (Spec. 551)

*changed by modification 9A-74
with justification statement used class 2
in pipe price U.L.ar*

*Tom Valley Forge Lab
Sample sent 9-17-74*

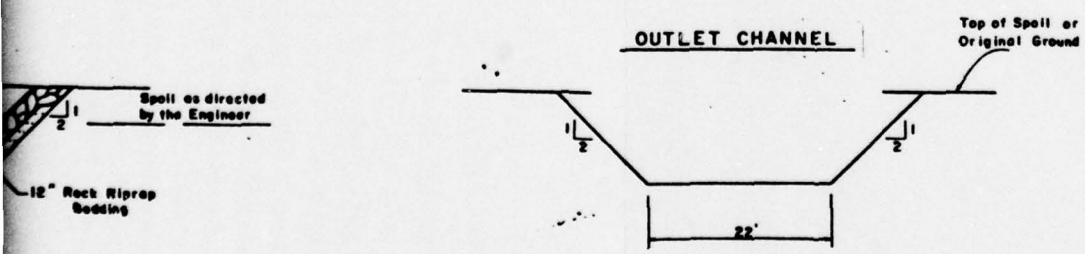
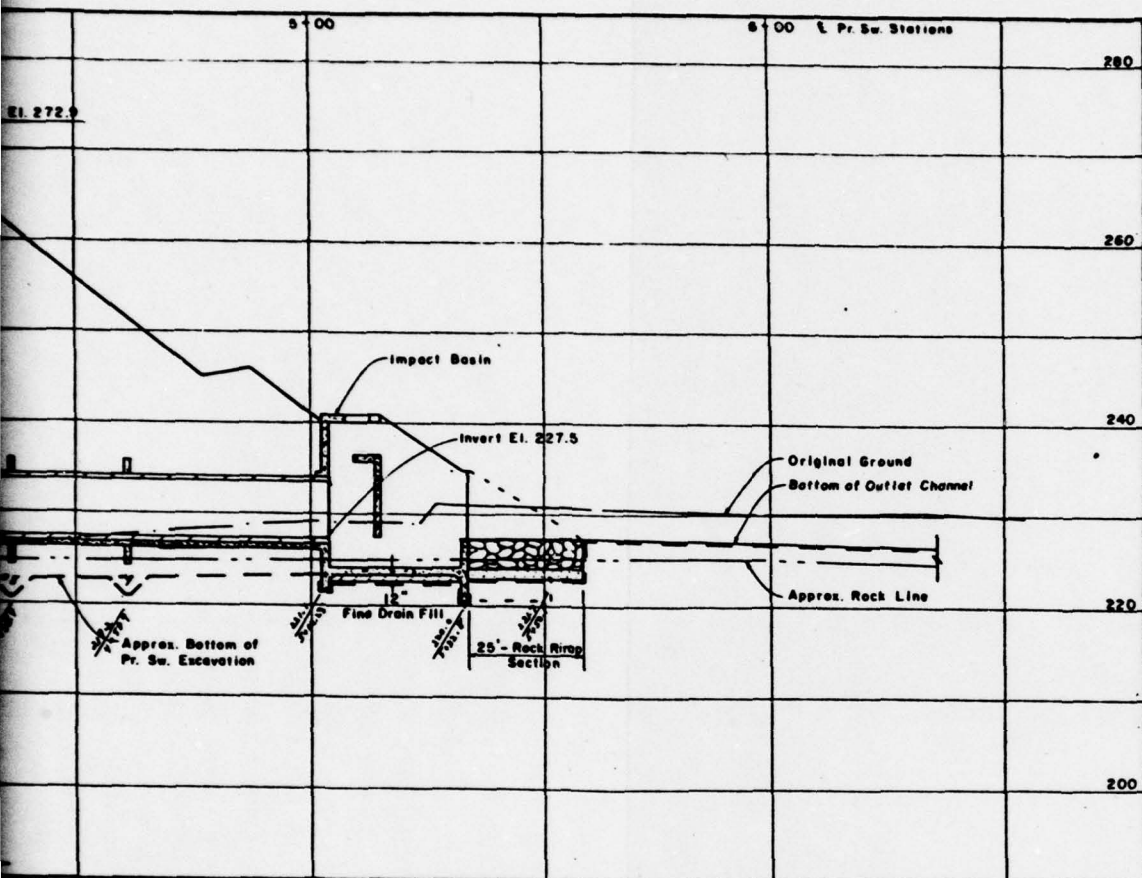
**EMBANKMENT DRAINAGE SYSTEM
WARRINGTON DAM**

NAT. I.D. NO. PA.00221 BUCKS COUNTY

DATA OBTAINED FROM U.S. DEPT. OF AGRICULTURE, SOIL
CONSERVATION SERVICE, DRAWING NO. PA-611-P
SHEET NO. 8 OF 42, DATED 12/72

PLATE 5B

2



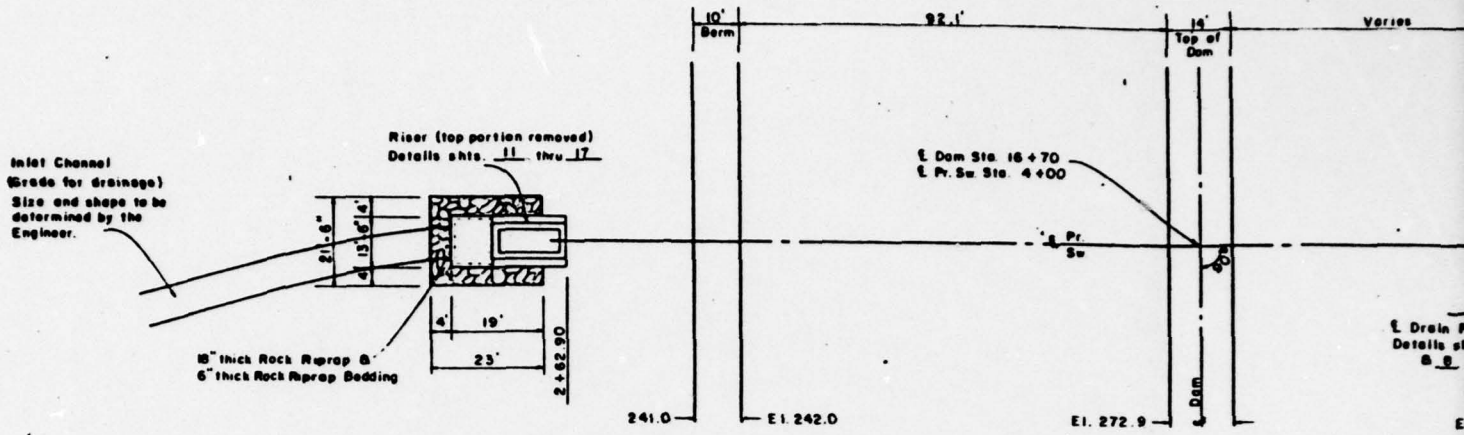
**PRINCIPAL SPILLWAY EXCAVATION
WARRINGTON DAM**

NAT. I.D. NO. PA.00221 BUCKS COUNTY

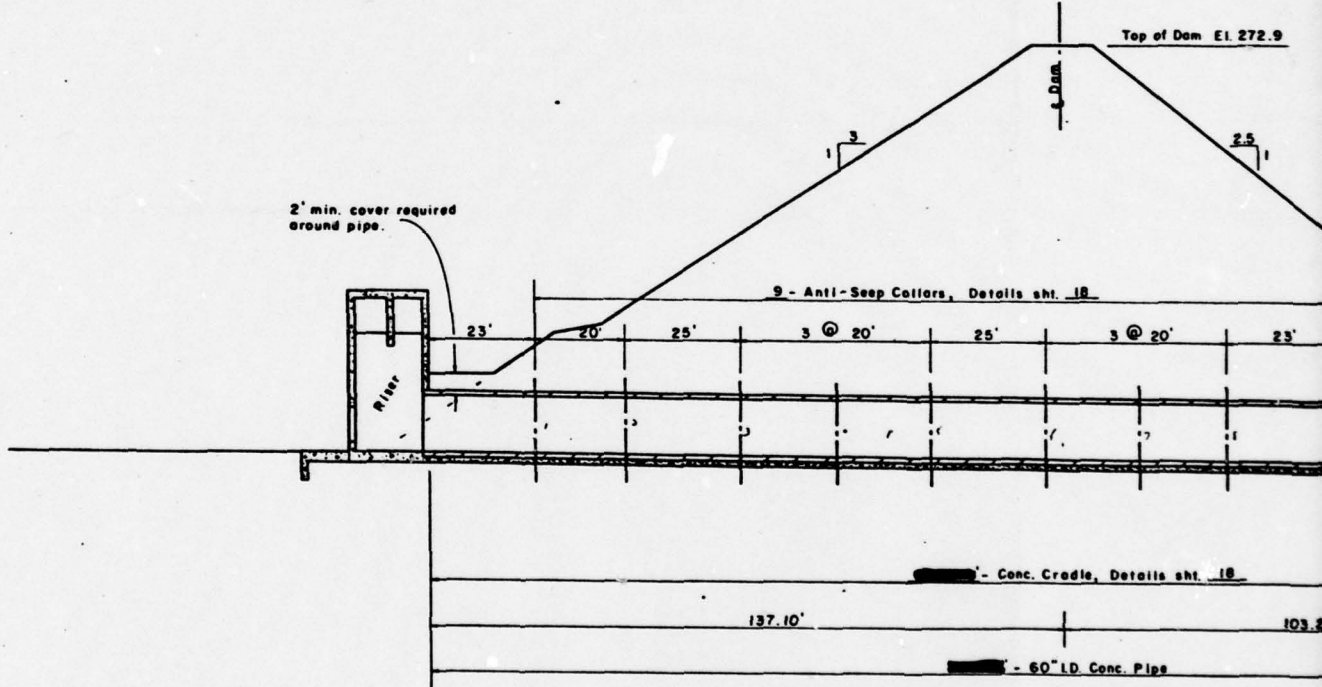
DATA OBTAINED FROM U.S. DEPT. OF AGRICULTURE, SOIL
CONSERVATION SERVICE, DRAWING NO. PA-611-P
SHEET NO. 10 OF 42, DATED 11/72

PLATE 6

2



PLAN VIEW
 20 10 4 0 20
 SCALE in FEET

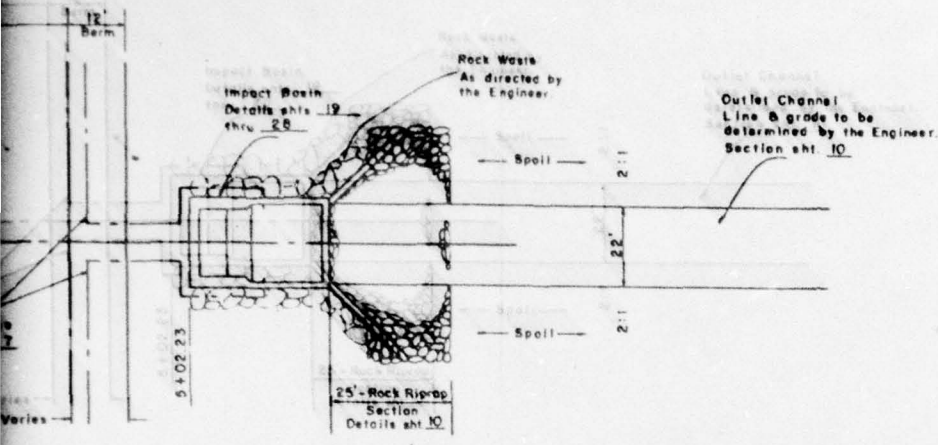


PROFILE ALONG E. PR. SW.
 20 10 4 0 10 5 2 0
 Horiz. Verr.
 SCALE in FEET

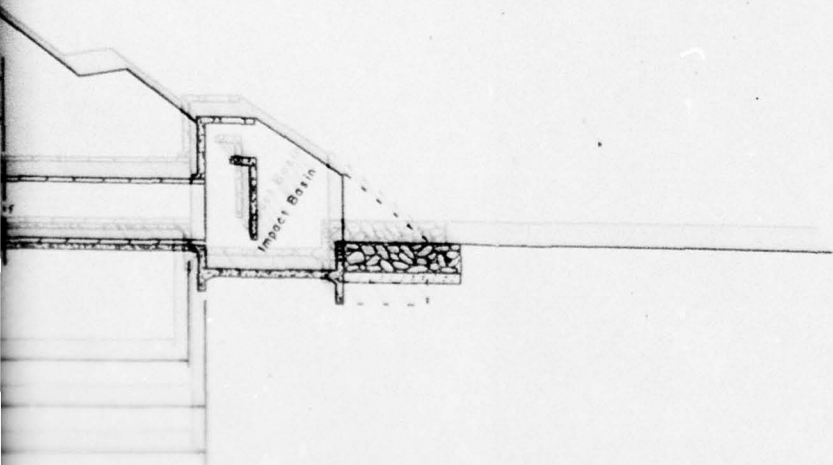
60" I.D. Reinforced Concrete Pressure Pipe
 Steel Cylinder Type, Spec. 541 (AWWA C-301)
 240' - Straight Sections
 1 - Spigot Ring Wall Fitting (for 15" wall)
 240.00' - Total

CONSTRUCTION NOTES

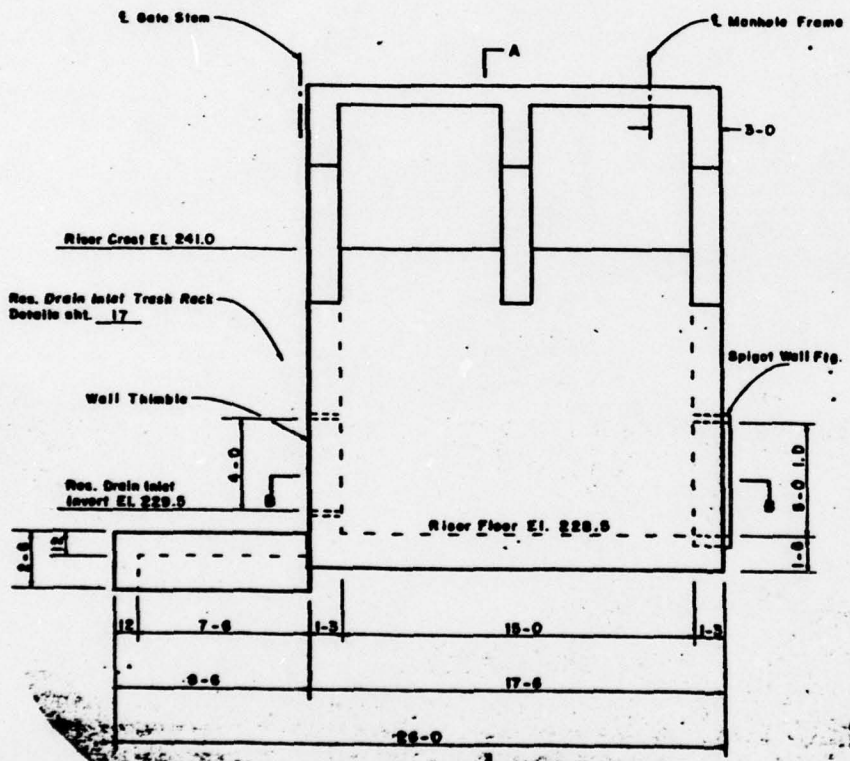
1. Outlet end of 60" pipe to be finished with no metal is exposed.
2. Pipe layout data to be furnished.
3. Riprap bedding shall meet grade fine drain fill. (sht. 8)
4. Rock Treatment required in Pr. Sw. Engineer.



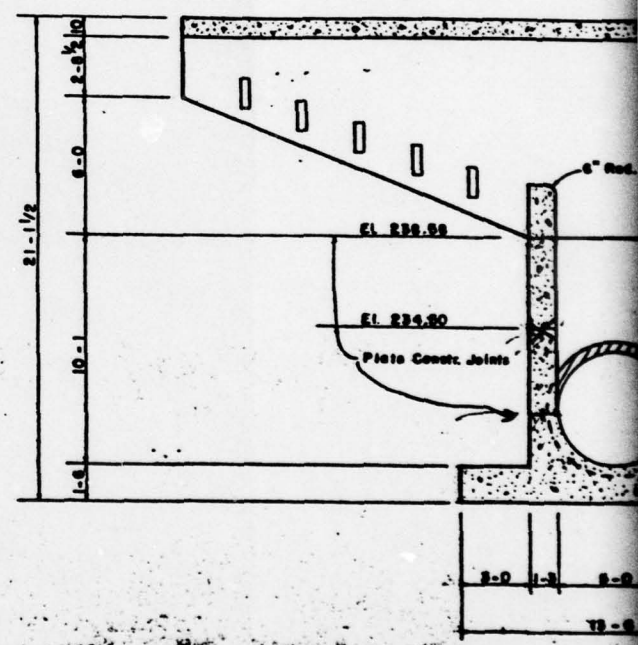
AS SHOWN



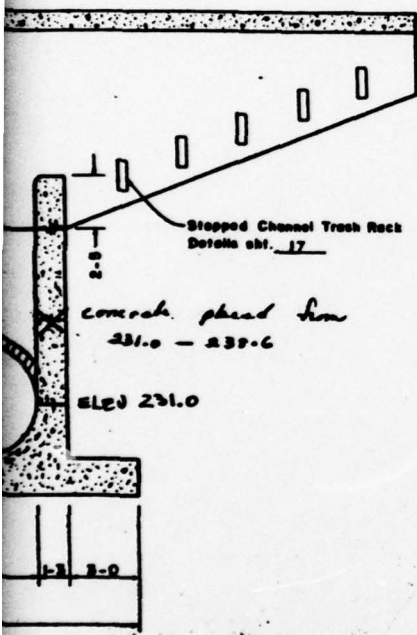
PRINCIPAL SPILLWAY DETAILS WARRINGTON DAM	
NAT. I.D. NO. PA. 00221	BUCKS COUNTY
<small>DATA OBTAINED FROM U.S. DEPT. OF AGRICULTURE, SOIL CONSERVATION SERVICE, DRAWING NO. PA-211-P SHEET NO. 9 OF 42, DATED 11/72</small>	
PLATE 7	



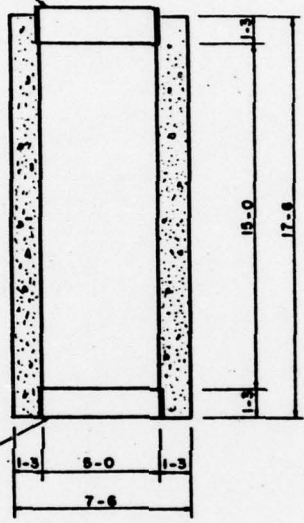
SIDE ELEVATION



SECTION



Spigot Well Fitting
Details sh. 18



Well Thimble (5' x 4')
Type E, 18" deep,
rectangular opening,
drill & top to
accommodate gate.

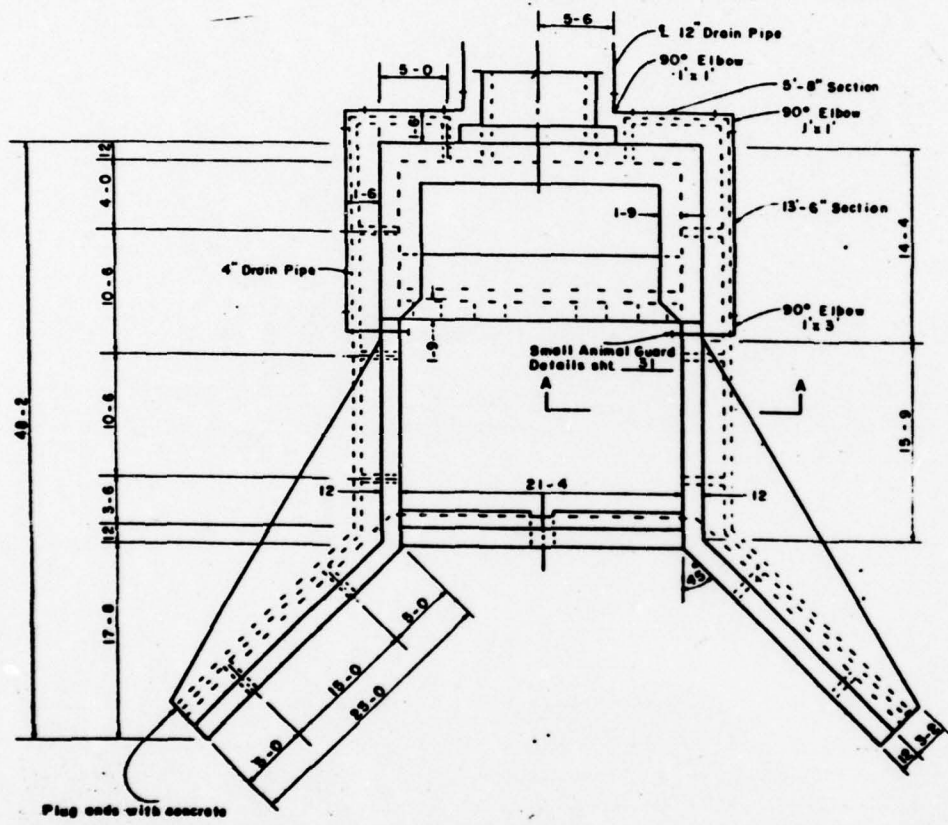
SECTION B-B

AS BUILT PLANS

SCALE IN FEET

RISER DETAILS WARRINGTON DAM	
NAT. I. D. NO. PA. 00221	BUCKS COUNTY
DATA OBTAINED FROM U.S. DEPT. OF AGRICULTURE, SOIL CONSERVATION SERVICE, DRAWING NO. PA-611-P SHEET NO. 11 OF 42, DATED 1/73	
PLATE 8	

2



Plug ends with concrete

PLAN

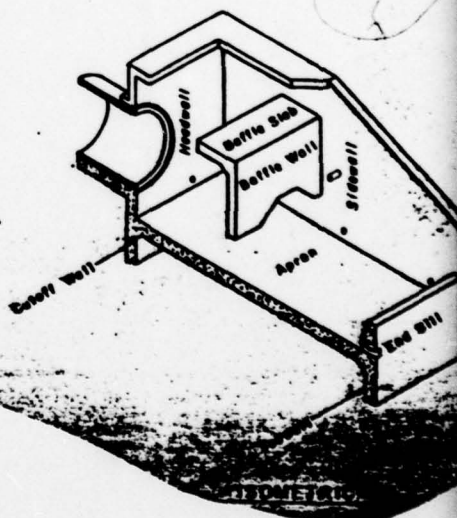
1/2" Expansion Joint Material, Type I Spec 535

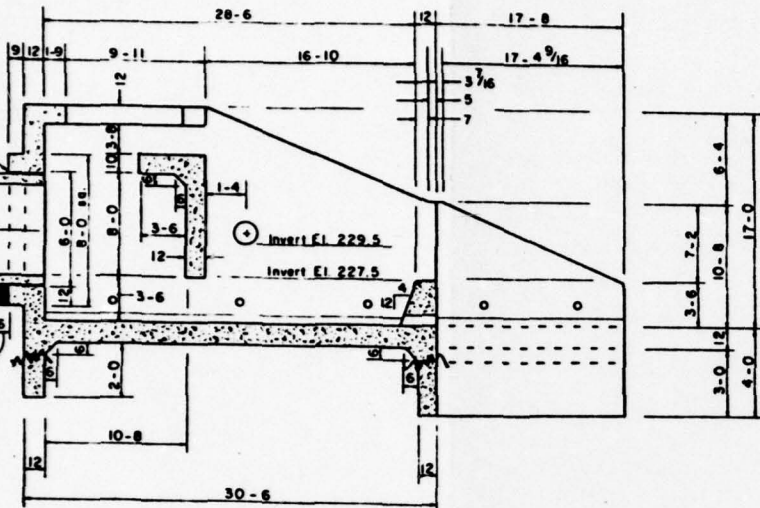
Last section of conduit to be laid horizontal.



Concrete Cradle

Compressible Material (Styrofoam)





SECTION ON CENTER LINE

AS BUILT PLANS
NOT TO SCALE

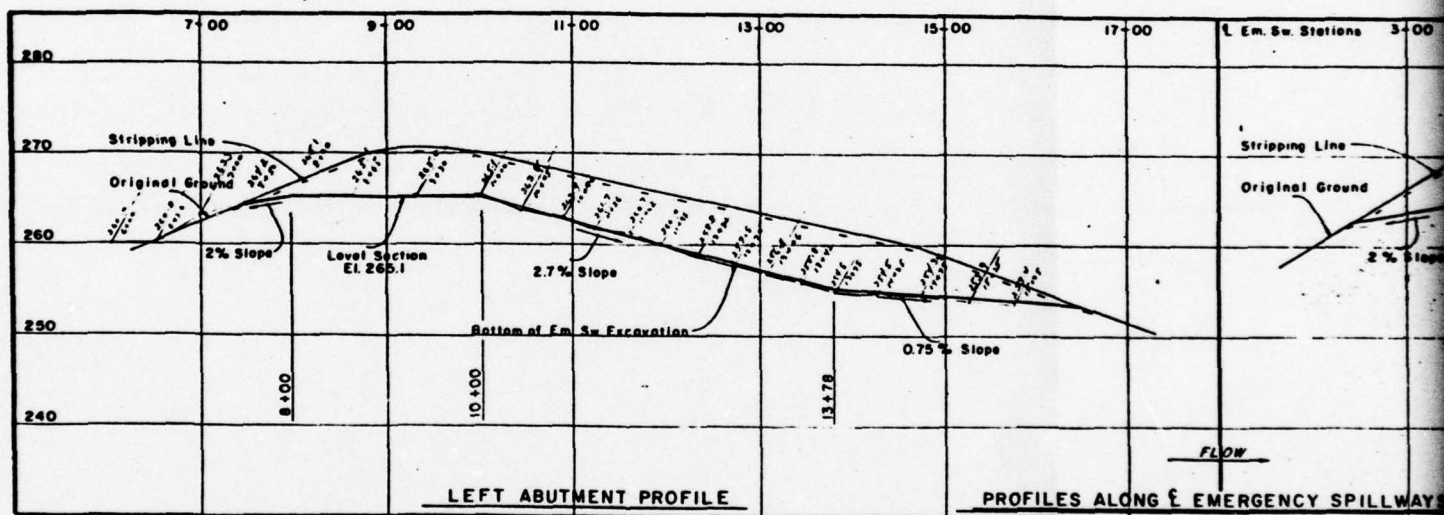
**IMPACT BASIN DETAILS
 WARRINGTON DAM**

NAT.I.D.NO.PA.00221

BUCKS COUNTY

DATA OBTAINED FROM U.S. DEPT. OF AGRICULTURE, SOIL
 CONSERVATION SERVICE, DRAWING NO. PA-811-P
 SHEET NO. 19 OF 42, DATED 1/73

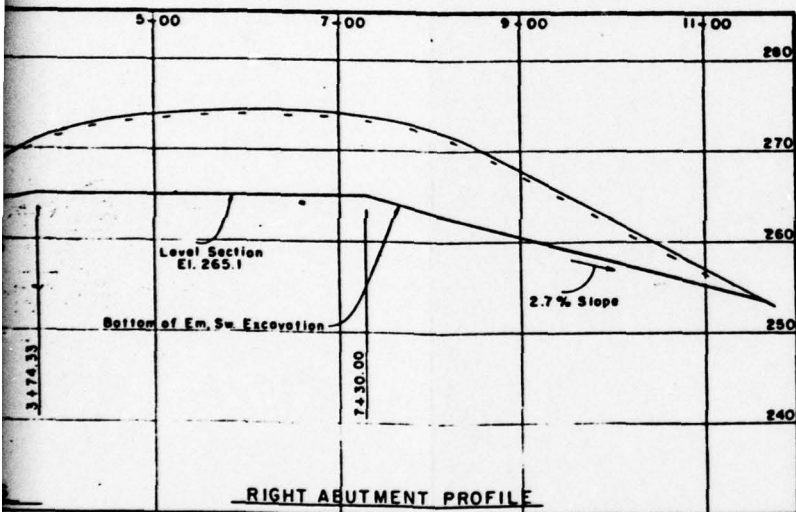
PLATE 9



LEFT ABUTMENT PROFILE

PROFILES ALONG E EMERGENCY SPILLWAY

FLOW



**LEFT AND RIGHT ABUTMENT SPILLWAY PROFILES
WARRINGTON DAM**

NAT. I.D. NO. PA.00221

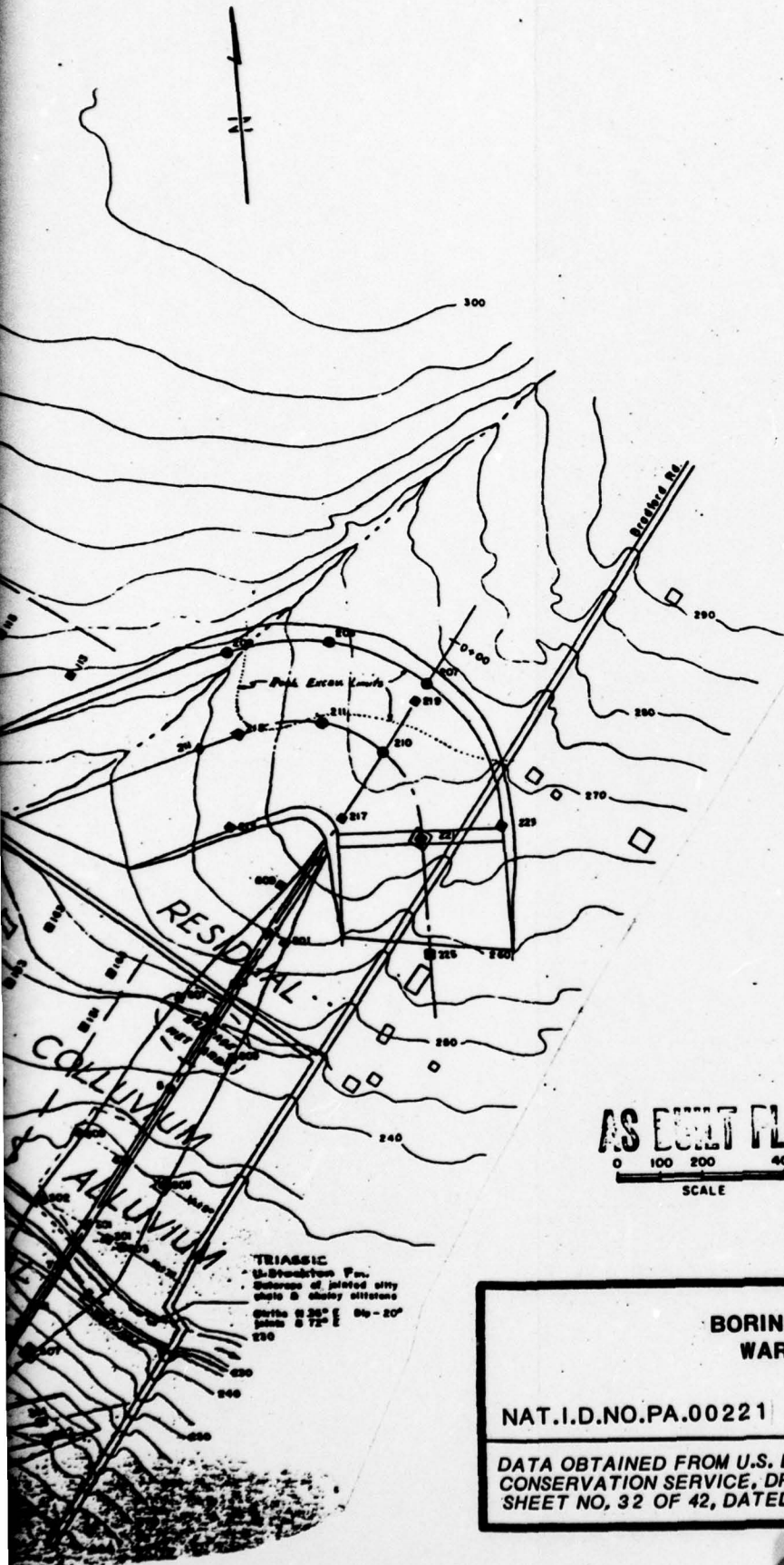
BUCKS COUNTY

DATA OBTAINED FROM U.S. DEPT. OF AGRICULTURE, SOIL
CONSERVATION SERVICE, DRAWING NO. PA-611-P
SHEET NO. 31 OF 42, DATED 12/72

PLATE 10

2





AS BUILT PLANS
 0 100 200 400 FEET
 SCALE

TRIASSIC
 15' Sandstone Pm.
 composed of jointed silty
 shales & shaly sandstone
 Dips to 25° E 0° - 20°
 to 72° E

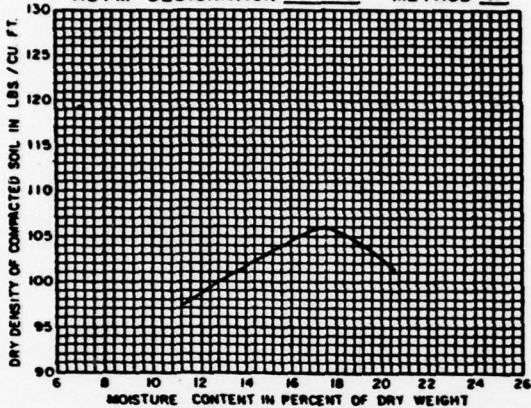
BORING LOCATION PLAN WARRINGTON DAM	
NAT. I.D. NO. PA.00221	BUCKS COUNTY
DATA OBTAINED FROM U.S. DEPT. OF AGRICULTURE, SOIL CONSERVATION SERVICE, DRAWING NO. PA-611-P SHEET NO. 32 OF 42, DATED 5/71	
PLATE 11	

2

COMPACTION CURVE

LABORATORY SAMPLE NO. 72W1858

ASTM DESIGNATION D-698 METHOD A

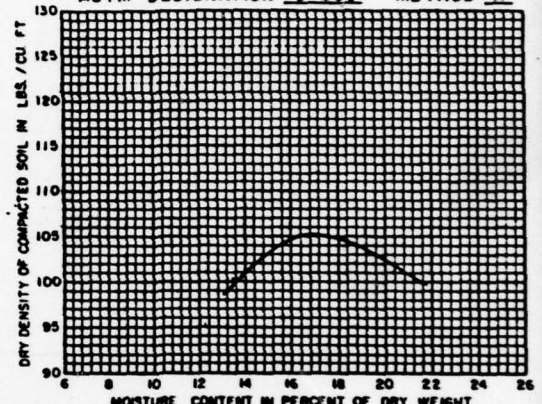


FIELD SAMPLE 221.1 DEPTH 0.8'-2'
LABORATORY CLASSIFICATION ML

COMPACTION CURVE

LABORATORY SAMPLE NO. 72W1851

ASTM DESIGNATION D-698 METHOD A



FIELD SAMPLE 119.1 DEPTH 2'-4.5'
LABORATORY CLASSIFICATION GM

COMPACTION CURVE

LABORATORY SAMPLE NO. 72W1852

ASTM DESIGNATION D-698 METHOD A

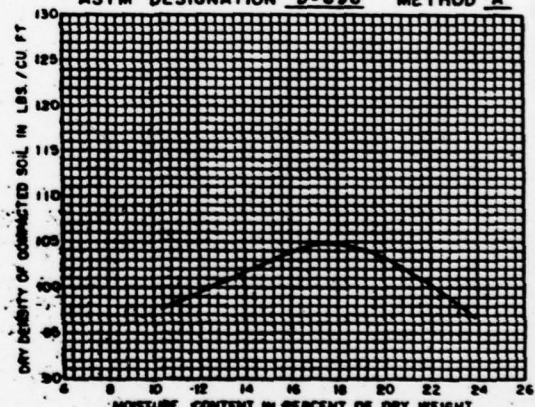


FIELD SAMPLE 221.2 DEPTH 1'-3'
LABORATORY CLASSIFICATION CL-ML

COMPACTION CURVE

LABORATORY SAMPLE NO. 72W1852

ASTM DESIGNATION D-698 METHOD A



FIELD SAMPLE 147.1 DEPTH 1'-3.5'
LABORATORY CLASSIFICATION CL

AS BUILT PLANS

TYPICAL SOIL COMPACTION DATA
WARRINGTON DAM

NAT.I.D.NO.PA.00221

BUCKS COUNTY

DATA OBTAINED FROM U.S. DEPT. OF AGRICULTURE, SOIL
CONSERVATION SERVICE, DRAWING NO. PA-611-P
SHEET NO. 41 OF 42, DATED 11/72

PLATE 12

2

APPENDIX

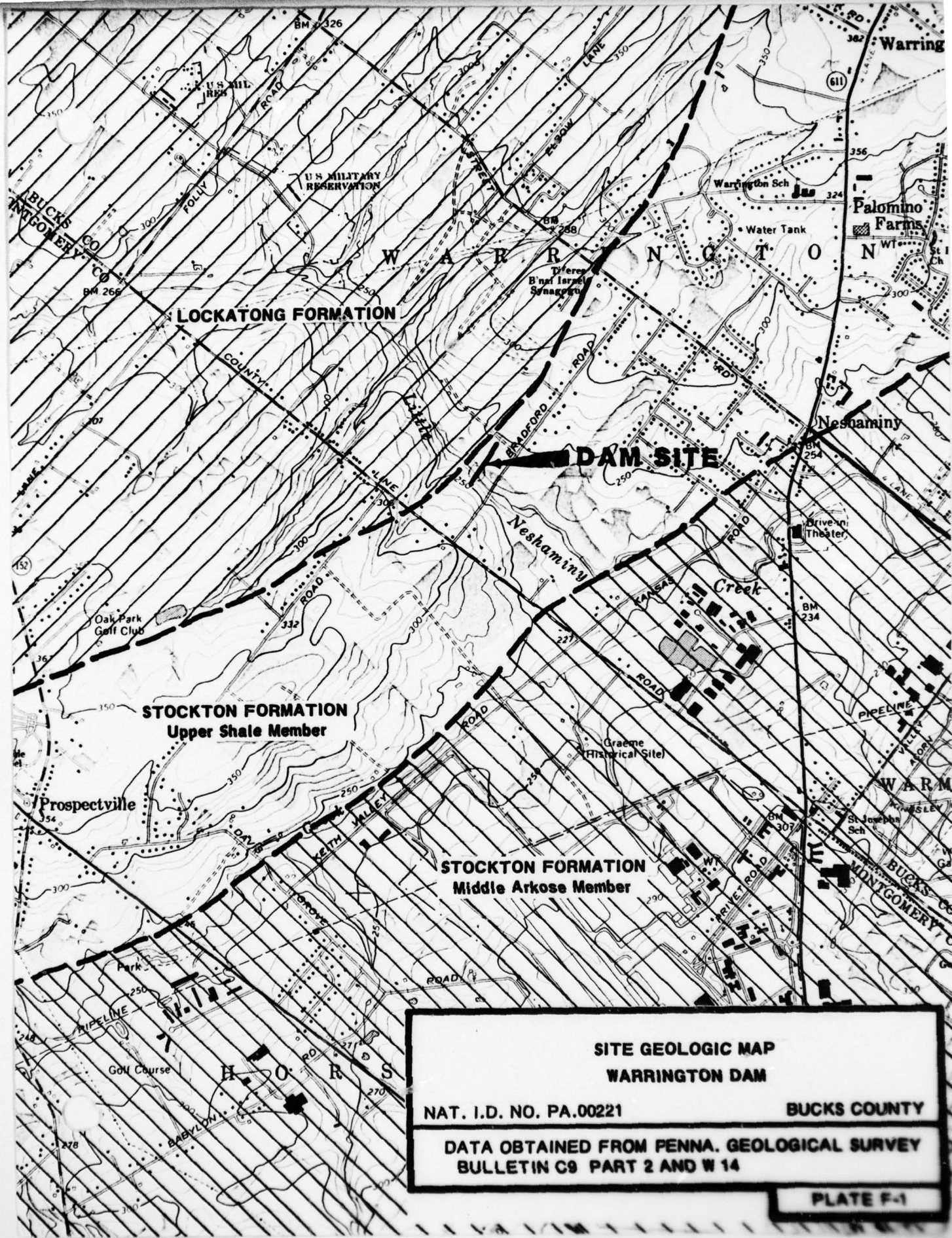
F

SITE GEOLOGY
WARRINGTON DAM

Warrington Dam is located in the Triassic Lowland Section of the Piedmont Physiographic Province. As shown on Plate F-1, the bedrock upon which the dam is constructed consists of the upper shale member of the Stockton Formation of Triassic Age. The major portion of the reservoir area lies upon the Lockatong shale.

Rock exposures located within the emergency spillways at the left and right abutments of the dam indicate the rock to strike to the northeast (near-parallel to the dam axis) and dip at low angles to the northwest (upstream direction). High angle rock jointing strikes to the northeast and northwest.

Aside from some rock jointing, the overall bedrock structure is favorable for water retention. Characteristic of the weathering of siltstone and shale bedrock, the upper several feet of rock would reflect the process of decomposition resulting in a silty residual soil. The high silt content and susceptibility to erosion would explain the observed gullying presently in progress in the general dam structure.



LOCKATONG FORMATION

**STOCKTON FORMATION
Upper Shale Member**

**STOCKTON FORMATION
Middle Arkose Member**

DAM SITE

**SITE GEOLOGIC MAP
WARRINGTON DAM**

NAT. I.D. NO. PA.00221 BUCKS COUNTY

DATA OBTAINED FROM PENNA. GEOLOGICAL SURVEY
BULLETIN C9 PART 2 AND W 14

PLATE F-1