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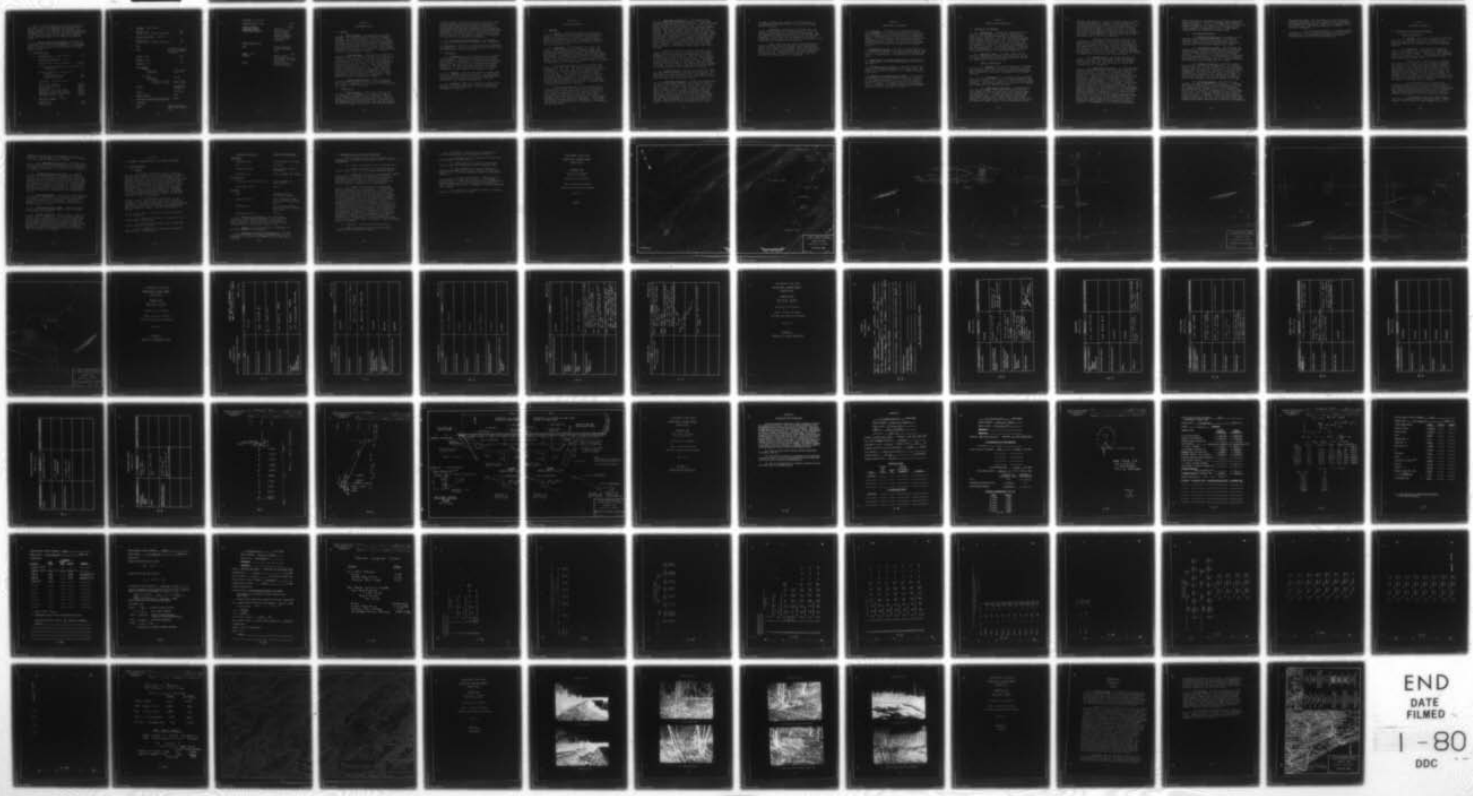

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SUSQUEHANNA RIVER BASIN

WOLFFS RUN, LUZERNE COUNTY

PENNSYLVANIA

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HUMBOLDT DAM

NDI ID NO. PA-00646

DER ID NO. 40-61

HAZLETON CITY AUTHORITY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

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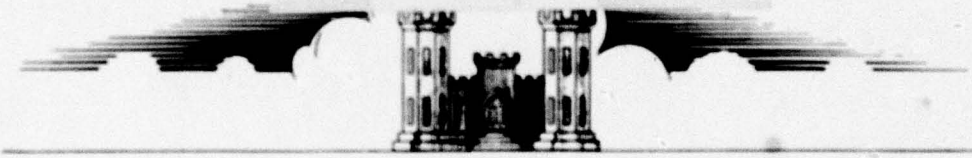

Prepared by

GANNETT FLEMING CORDDRY AND CARPENTER, INC.

Consulting Engineers

Harrisburg, Pennsylvania 17105

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For

DEPARTMENT OF THE ARMY

Baltimore District, Corps of Engineers

Baltimore, Maryland 21203

MAY 1979

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SUSQUEHANNA RIVER BASIN

WOLFFS RUN, LUZERNE COUNTY

PENNSYLVANIA

HUMBOLDT DAM

NDI ID No. PA-00646
DER ID No. 40-61

HAZLETON CITY AUTHORITY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

Prepared by

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
Consulting Engineers
P.O. Box 1963
Harrisburg, Pennsylvania 17105

For

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

MAY 1979

PREFACE

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

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. 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.

SUSQUEHANNA RIVER BASIN

WOLFFS RUN, LUZERNE COUNTY

PENNSYLVANIA

HUMBOLDT DAM

NDI ID No. PA-00646
DER ID No. 40-61

HAZLETON CITY AUTHORITY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

MAY 1979

CONTENTS

PLATES

(15) DACW31-79-C-0015

APPENDICES

Appendix	Title
A	Checklist - Engineering Data.
B	Checklist - Visual Inspection.
C	Hydrology and Hydraulics.
D	Photographs.
E	Geology.

(6) National Dam Inspection Program. Humboldt Dam (NDI ID Number PA-00646 DER ID Number 40-61), ~~Hazleton City Authority~~ Susquehanna River Basin, Wolffs Run, Luzerne County, Pennsylvania. Phase I Inspection Report,

(11) May '79 (12) 95

(10) Albert Charles Hooke

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PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

BRIEF ASSESSMENT OF GENERAL CONDITION

AND

RECOMMENDED ACTION

Name of Dam:	Humboldt Dam NDI ID No. PA-00646/DER ID No. 40-61
Owner:	Hazleton City Authority
State Located:	Pennsylvania
County Located:	Luzerne
Stream:	Wolffs Run
Date of Inspection:	11 April 1979
Inspection Team:	Gannett Fleming Corddry and Carpenter, Inc. Consulting Engineers P.O. Box 1963 Harrisburg, Pennsylvania 17105

Based on visual inspection, available records, calculations, past operational performance, and according to criteria established for these studies, Humboldt Dam is judged to be unsafe, nonemergency, because the spillway capacity is rated as seriously inadequate. The existing spillway can pass 28 percent of the Probable Maximum Flood (PMF) without overtopping of the dam. Because the Owner has placed sandbags on the spillway weir, the actual capacity is significantly less than 28 percent. The resulting outflows from the failure of Humboldt Dam would increase the hazard to loss of life downstream. As a whole, the dam is judged to be in poor condition.

If the low areas of the top of the embankment were raised 1.1 feet to the design elevation, the spillway could pass 50 percent of the PMF. The spillway capacity

would then be rated as inadequate. Raising the embankment to its design elevation would require the raising of the spillway approach wall. This is considered to be a major structural modification to the dam.

There is evidence of stability problems on the embankment. There is no evidence to suggest that the outlet works is operational. The lack of maintenance has created many serious problems at the dam.

The following measures are recommended to be undertaken by the Owner, in approximate order of priority, immediately:

(1) Remove the sandbags from the spillway weir.

(2) Remove the brush in the spillway approach channel and the brush on the upstream embankment slope.

(3) Engage the services of a professional engineer experienced in the design and construction of dams to determine the best method of removing the trees on the downstream slope and near the toe and to determine measures necessary to ensure that the integrity of the dam is preserved. Implement his recommendations.

(4) Engage the services of a professional engineer experienced in the design and construction of dams to perform the following studies: studies to more accurately determine the spillway capacity required at the dam and to determine the measures required to make the spillway and spillway channel hydraulically adequate, a study to determine the structural factors of safety for the embankment, a study to determine the best means of making the outlet works operational, a study to repair the deficiencies in the spillway area, and a study to determine the best means of continually monitoring the seepage and wet areas at the dam. These studies will require, as a minimum, installation of observation wells or other instrumentation to determine water levels in the embankment, an exploration program to determine the engineering properties of the embankment and foundation materials, a complete survey of the embankment and adjacent area, and grading of the area downstream of the toe to more accurately assess the seepage. Take appropriate action as required.

(5) Replace the riprap on the upstream slope.

(6) Remove the debris from the spillway outlet channel and the outlet works channel.

In addition, the Owner should institute the following operational and maintenance procedures:

(1) Develop a detailed emergency operation and warning system for Humboldt Dam.

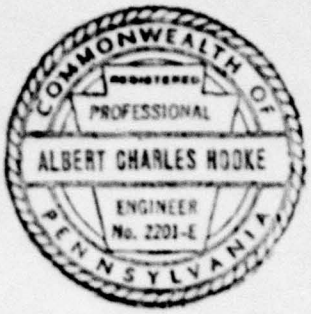
(2) During periods of unusually heavy rains, provide round-the-clock surveillance of Humboldt Dam.

(3) When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system.

(4) Institute an inspection program such that the embankment is inspected frequently. The program should include a formal annual inspection by a professional engineer experienced in the design and construction of dams. Utilize the results to determine if remedial measures are necessary.

(5) Institute a maintenance program to properly maintain all features of the dam.

Submitted by:



GANNETT FLEMING CORDDRY
AND CARPENTER, INC.

A. C. HOOKE
Head, Dam Section

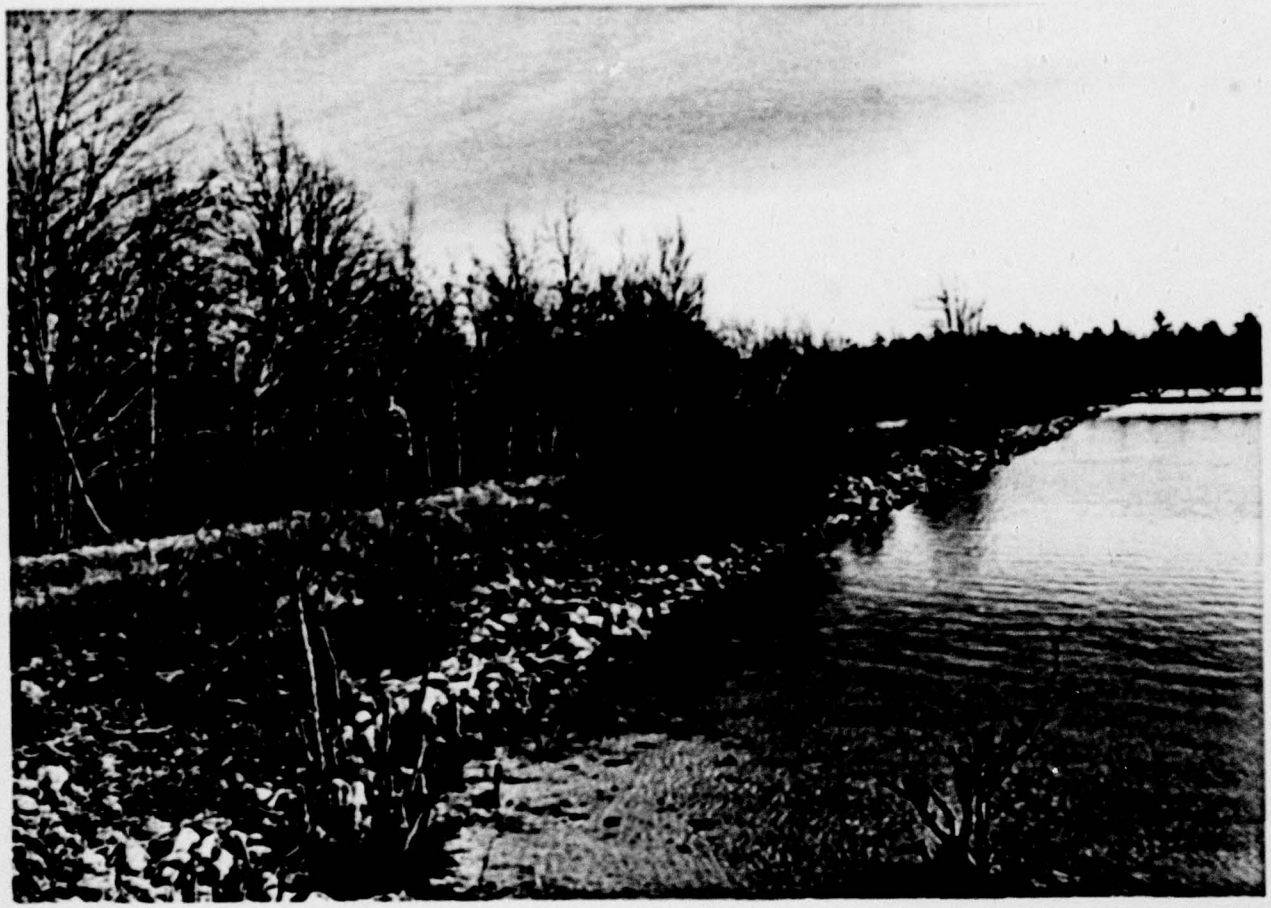
Date: 22 June 1979

Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

HUMBOLDT DAM



Overview

SUSQUEHANNA RIVER BASIN

WOLFFS RUN, LUZERNE COUNTY

PENNSYLVANIA

HUMBOLDT DAM

NDI ID No. PA-00646
DER ID No. 40-61

HAZLETON CITY AUTHORITY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

MAY 1979

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. Humboldt Dam is a homogeneous earthfill embankment with a masonry core-wall. The embankment is 974 feet long and 41 feet high at maximum section. A masonry gravity retaining wall, which acts as the spillway training wall, is at the right end of the embankment. The outlet works, CONT'

which is near the middle of the embankment, consists of a masonry and corrugated metal intake structure with sluice gates, a 12-inch diameter cast-iron pipe (CIP), and a valve house at the toe of the dam. The intake structure is located on the upstream slope of the embankment; a bridge extends to it. Water supply pipes also extend from the intake structure.

The masonry gravity spillway is at the right abutment of the dam. Its crest is 3.0 feet below the design elevation of the top of the dam and is 33.0 feet long. The spillway channel has a variable bottom width and a masonry gravity training wall on the left. The spillway channel extends along the right side of the valley. The various features of the dam are shown on the Plates at the end of the Report and on the Photographs in Appendix D.

b. Location. The dam is located on Wolffs Run approximately 4.5 miles west of Hazleton, Pennsylvania. Humboldt Dam is shown on USGS Quadrangle, Conyngham, Pennsylvania, with coordinates N40° 56'25" and W76° 03'40" in Luzerne County, Pennsylvania. A location map is shown on Plate 1.

c. Size Classification. Intermediate (41 feet high, 549 acre-feet).

d. Hazard Classification. High hazard. Downstream conditions indicate that a high hazard classification is warranted for Humboldt Dam (Paragraph 5.1c.).

e. Ownership. Hazleton City Authority, Hazleton, Pennsylvania.

f. Purpose of Dam. Water supply for Hazleton.

g. Design and Construction History. Humboldt Dam was built between 1909 and 1911 by the Diamond Water Company. The dam was designed by William Marple, who also supervised construction. Two separate contractors went bankrupt during the construction of the dam. The first contracting firm was Ruth and Jacoby. The second contracting firm was S.W. Childs. The dam was finished under force account. The 1914 Report by the Pennsylvania Water Supply Commission indicates that Mr. Marple maintained close supervision of the work during the entire construction period.

The top of dam progressively settled between 1914 and 1929. In 1929, considerable modifications were made to the dam. The embankment was raised to its design elevation, the riprap on the upstream slope was extended to the top of the dam, the timber upper-portion of the intake structure was replaced by corrugated metal, and a new bridge to the intake structure was built.

h. Normal Operational Procedure. The pool is maintained at the top of the sandbags on the spillway crest with excess inflow discharging over the spillway. Water is drawn directly from the reservoir for water supply purposes.

1.3 Pertinent Data.

a. Drainage Area. (square miles). 0.6

b. Discharge at Damsite. (cfs).

Maximum known flood at damsite.	Unknown
Outlet works at maximum pool elevation. (approximate).	20
Spillway capacity at maximum pool elevation.	
Existing Conditions:	280
Design Conditions:	530

c. Elevation. (feet above msl.).

Top of dam (design).	1763.0
Top of dam (existing).	1761.9
Maximum pool.	1761.9
Normal pool (spillway crest).	1760.0
Upstream invert outlet works.	1722.5
Downstream invert outlet works.	1722.5
Streambed at toe of dam.	1722.0

d. Reservoir Length. (miles).

Normal pool.	0.34
Maximum pool.	0.36

e. Storage. (acre-feet).

Normal pool.	442
Maximum pool (design conditions).	549

f. Reservoir Surface. (acres).

Normal pool.	35
Maximum pool (design conditions).	37

g. Dam.

Type	Homogeneous earthfill with masonry core-wall.
Length (feet)	974
Height (feet)	41
Topwidth (feet)	10
Side Slopes	
Design	
Upstream	1V on 2.75H
Downstream	1V on 2H
Existing	
Upstream	Varies
Downstream	
Above El. 1755.9	1V on 1.6H
Below El. 1755.9	1V on 2.25H
Zoning	Homogeneous earthfill.
Cutoff	Core-wall.
Grout Curtain	None.

h. Diversion and Regulating Tunnel. None.

i. Spillway.

Type	Masonry gravity weir with inclined top.

i. Spillway. (continued)

Length of Weir (feet).	33.0
Crest Elevation	1760.0
Upstream Channel	Reservoir.
Downstream Channel	Variable bottom width, steep natural channel extending beyond the toe of the embankment.

j. Regulating Outlets.

Type	Single cast-iron 12-inch diameter pipe.
Length (feet).	180
Closure	Gate valve at downstream toe and sluice gate in intake structure.
Access	Bridge extends to intake structure.

SECTION 2

ENGINEERING DATA

2.1 Design.

a. Data Available. No engineering data were available for review for the structure as originally designed. In a study performed in 1914 by the Pennsylvania Water Supply Commission an account of design concepts, geology, construction materials and methods, and design features was prepared for the components of the dam from interviews with the Owner, visual inspection, and other sources. The 1914 study also included analyses for hydrology and hydraulics. A summary of the results of the analyses is on file.

b. Design Features. The project is described in Paragraph 1.2g. The various features of the dam are shown on the Plates at the end of the Report and on the photographs in Appendix D. A profile of the dam is shown on Plate 2. A typical section of the embankment is shown on both Plates 2 and 3. The embankment is shown on Photographs A, B, and C. The outlet works profile is shown on Plates 2 and 3. The intake and outlet structures are shown on Photographs A and E. No plan is available for the embankment. No plan or other details are available for the spillway. These features are shown on Plate B-1 in Appendix B. The spillway is shown on Photographs G and H.

c. Design Considerations. Almost nothing is known about the design of the dam. The Pennsylvania Water Supply Commission did not raise any concerns about the design in their 1914 Report.

2.2 Construction.

a. Data Available. Construction data for the structure, that are available for review, consist of the information contained in the 1914 Report prepared by the Pennsylvania Water Supply Commission. The information is relatively well detailed. It reports that the embankment was constructed of clay that was placed in layers, sprinkled, and rolled. The material upstream

of the core-wall is described as being "selected". The material downstream of the core-wall is described as a fairly good clay with reasonably few "boulders". The masonry core-wall was reportedly founded below the natural ground on what was considered to be an impervious foundation. The maximum depth of the excavation for the core-wall is reported as 39 feet. Each end of the core-wall is reported as extending to bedrock. A discussion on site geology is presented in Appendix E.

b. Construction Considerations. The available information indicates that the dam was well constructed.

2.3 Operation. There are no formal records of operation. The Owner did not report any problems having occurred over the operational history of the dam.

2.4 Evaluation.

a. Availability. Engineering data were provided by the Bureau of Dam Safety, Obstructions, and Storm Water Management, Department of Environmental Resources, Commonwealth of Pennsylvania, and by the Owner, Hazleton City Authority. The Owner made available the General Manager for information during the week of the visual inspection. He also researched his files for further information at the request of the inspection team.

b. Adequacy. The type and amount of design data and other engineering data are limited, and the assessment must be based on the combination of available data, visual inspection, performance history, hydrologic assumptions, and hydraulic assumptions.

c. Validity. There is no reason to question the validity of the available data. Conflicting data concerning the design elevation of the top of the dam is discussed in Section 6.

SECTION 3

VISUAL INSPECTION

3.1 Findings.

a. General. The overall appearance of the dam is poor. Deficiencies were observed as noted below. A sketch of the dam with the location of deficiencies is presented in Appendix B on Plate B-1. Survey information acquired for this report is summarized in Appendix B. On the day of the inspection, the pool was 0.7 feet below spillway crest.

b. Embankment. The embankment is in poor condition. Brush extends along the upstream slope. The riprap along the upstream slope is either washed out, leaving the bedding material exposed, or weathering has deteriorated the riprap to the extent that it is no larger than gravel. The upstream edge of the top of the dam is eroded. The erosion has resulted in the top of the slope being vertical in many places. A maximum height of 1.5 feet was measured at one of these areas.

The downstream slope is thickly covered with mature trees. Near the right abutment, there is a discontinuity in the slope. The area is sketched on Detail A of Plate B-1. There are numerous wet areas along the toe of the dam. Clear seepage was observed at some of the wet areas. The approximate location of the conditions is shown on Plate B-1. The growth along the toe hindered the inspection of these areas. It should be noted that heavy rains occurred three days previously. There are mounds along some of the toe. A typical area is sketched on Detail B on Plate B-1.

The survey performed for this inspection revealed that the lowest area along the top of the dam is 1.9 feet above the spillway crest. The survey also revealed that the upper part of the downstream slope is 1V on 1.6H and that the lower part is 1V on 2.25H. Although this is assumed to be typical, the trees on the embankment made this assumption uncertain. The surveyed profile and cross-section are in Appendix B. There was insufficient area exposed above the reservoir to determine the upstream slope.

c. Appurtenant Structures. Structurally, the spillway is in fair condition. However, the Owner has placed sandbags across the spillway crest. This effectively raises the spillway crest about 1 foot. There is a significant amount of brush growing in the spillway approach channel. The masonry joints in the spillway weir are seeping. The total seepage, which is clear, is estimated at 1 gpm. The mortar in the joints is deteriorated. The masonry spillway approach wall is tilted and offset towards the spillway. The mortar in this wall is completely deteriorated. The mortar in the masonry spillway training wall is deteriorated. The wall is low and the ground directly behind it slopes toward the toe of the embankment. There is a substantial amount of debris in the spillway channel. The debris is not close to the spillway weir.

The outlet works is in poor condition. The intake structure is in good condition, as is the access bridge. The valve house at the downstream toe of the embankment is in poor condition. The roof is collapsed; it fills the interior of the valve house. There appears to be no ready access to the valves therein. The downstream channel is filled to the axis of the outlet pipe with muck and small debris. The Owner declined to operate the valve. He was concerned that the valve would remain in the open position, thus draining the reservoir.

d. Reservoir Area. Some of the watershed is owned and controlled by the Hazleton Municipal Authority. The watershed is wooded hills without any development. The left reservoir shore is fairly flat. The right reservoir shore is steep with some outcrop visible.

e. Downstream Conditions. Wolffs Run extends from the dam along a steep, wooded, and uninhabited reach for 0.8 mile to its confluence with Stony Creek. In this reach, Wolffs Run crosses under the access road to the dam in a small culvert. At the confluence, there is a water treatment plant belonging to the Hazleton City Authority. There is a dwelling immediately adjacent, which the Authority stated was not utilized any longer. The stream then proceeds for 1.1 mile to Interstate 81. The Interstate embankment is about 30 feet high at the stream. The culvert beneath it is approximately triangular, being about 15 feet high and 22 feet wide at

its base. Immediately upstream of the interstate is an abandoned strip mine; there is no vehicular access route to the mine.

Immediately downstream of Interstate 81, the stream flows adjacent to an industrial park. There is a small storage shed about 15 feet above streambed. The two lowermost occupied buildings are 20 and 21 feet above streambed. Stony Creek has its confluence with Black Creek near the center of the industrial park, about 0.5 mile downstream of the Interstate 81 culvert.

Black Creek crosses under a high Interstate 81 bridge and flows along an abandoned and overgrown strip mine to the community of Derringer, where dwellings are about 10 feet above the streambed. The above reach is 7.0 miles long. The strip mine appears to have substantial overbank storage. Downstream of Derringer there are many more dwellings within the floodplain.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedure. The reservoir is maintained at the top of sandbags on the spillway crest with excess inflow discharging over the spillway and into Wolffs Run. Water is drawn directly from the reservoir for water supply. A 12-inch diameter cast-iron water supply line discharges into Wolffs Run. Since this line is for emergency drawdown purposes, the valve and sluice gate on the Humboldt Dam water discharge line is usually closed.

4.2 Maintenance of Dam. The dam is visited daily by a caretaker who apparently adjusts the water supply valve in the intake structure. The remaining features of the dam are not maintained. No inspections of the dam are made.

4.3 Maintenance of Operating Facilities. Except for the water supply line, the operating facilities are not maintained.

4.4 Warning Systems in Effect. The Owner stated that there is no emergency operation and warning plan. He stated that, should the dam fail, no damage downstream would result.

4.5 Evaluation of Operational Adequacy. The lack of maintenance is a serious hazard to the dam. The lack of any inspection program is also a serious hazard. As described hereafter, the failure of the dam would result in damage. An emergency operation and warning plan is necessary to mitigate hazards downstream should evidence of stress develop at the dam.

SECTION 5

HYDROLOGY AND HYDRAULICS

5.1 Evaluation of Features.

a. Design Data. No data were available for review for the structure as designed. During 1914, a report on the dam was prepared by the Pennsylvania Water Supply Commission. The report estimated the maximum spillway capacity at 255 cfs. This was estimated with a 30-foot crest length and 2 feet of head. The crest measured 33 feet on the day of the inspection. As discussed in Section 6, the design top elevation of the dam is uncertain. A discharge capacity of 530 cfs, with the embankment at its design elevation of 1763.0, was estimated and used in this report (Appendix C).

b. Experience Data. The Owner stated that no records of maximum pool levels were available. He did not report any hydraulic problems having occurred over the operational history of the dam.

c. Visual Observations.

(1) General. The visual inspection of Humboldt Dam, which is described in Section 3, resulted in a number of observations relevant to hydrology and hydraulics. These observations are evaluated herein for the various features.

(2) Embankment. It is certain that the embankment is at least 0.1 foot below its design elevation. As discussed in Section 6, it may be 1.1 foot below its design elevation. The spillway capacity is reduced by the embankment being below its design elevation.

(3) Appurtenant Structures. The Owner stated that the system gets low on water storage during the late summer and that the sandbags provide extra storage. He considered this a "slight" deviation from approved operating methods. The sandbags are an immediate and very serious hazard to the dam because the spillway capacity is substantially reduced. The brush in the spillway approach channel reduces the spillway capacity even

further. The debris in the outlet channel does not reduce the spillway capacity. However, it may increase tailwater and cause water to overtop the training wall. Even if the brush were removed, it is not certain this wall is of sufficient height to contain the flow. It is believed that water overtopping the wall would flow along the toe of the embankment. Because of growth in the area, this could not be confirmed. Flow along the toe of the embankment would be an erosion hazard.

Upstream closure for the outlet works is provided by a sluice gate in the intake structure. Its operation was not observed on the day of the inspection. There is no apparent access to the outlet works valve at the downstream toe of the dam, since the roof is caved in. The debris in the outlet channel indicates that flow has not recently occurred in the channel; the debris may also prevent proper operation of the valve. There is no evidence to suggest that the outlet works is operational.

(4) Reservoir Area. No conditions were observed in the reservoir that might present significant hazard to the dam. The assessment of the dam is based on existing conditions, and the effects of future development are not considered.

(5) Downstream Conditions. No conditions were observed downstream from the dam that might present significant hazard to the dam. It is apparent that substantial spillway discharges would overtop the main access road. There are other roads extending around the reservoir. Judging by the USGS mapping, these would be traversable during periods of high runoff. Access to the dam is deemed adequate. If the dam were to fail, the water treatment plant would be flooded. Water would then pond behind the Interstate 81 embankment. The strip mine upstream of the embankment is shown, without updated contours, as a photo-revision to the USGS mapping. There is a possibility that water would pond behind the embankment without overtopping it. If it were to overtop the embankment, a hazard to vehicles on the road would exist; the failure of the roadway embankment might also occur. As there is insufficient information to assess the storage capabilities of the strip mine, its effects have been ignored in the analysis described hereafter. The mapping for the strip mine along Black

Creek is similar to the mapping for the above strip mine. There is no way to include its storage effects without further information. As such, the failure of the dam could present a hazard to the community of Derringer and the other communities downstream from it. A high hazard classification is warranted for Humboldt Dam.

d. Overtopping Potential.

(1) Spillway Design Flood. According to the criteria established by the Office of the Chief of Engineers (OCE), the Spillway Design Flood (SDF) for the size (Intermediate) and hazard potential (High) of Humboldt Dam is the Probable Maximum Flood (PMF).

(2) Description of Model. The watershed was modeled with the HEC-1DB computer program. The HEC-1DB computer program computes a PMF runoff hydrograph and routes the flows through both reservoirs and stream sections. In addition, it has the capability to simulate an overtopping dam failure. The PMF inflow to Humboldt Reservoir was routed through the dam. Identical methods were used for various percentages of the PMF.

(3) Summary of Results. Pertinent results are tabularized at the end of Appendix C. The analysis reveals that, with the existing top elevation of 1761.9, Humboldt Dam can pass about 28 percent of the PMF without overtopping. This analysis ignored the effects of the sandbags on the spillway crest. With the sandbags in place, the percentage would be significantly lower. If the dam were raised to its assumed design elevation of 1763.0, the spillway could pass 50 percent of the PMF.

(4) Spillway Adequacy. The criteria for rating a spillway is presented in Appendix C. Humboldt Dam would be overtopped by 0.53 foot during the 1/2 PMF. This would probably cause failure of the embankment. The embankment was assumed to fail over a 90-foot long breach 0.2 hour after the embankment would be overtopped by 0.1 foot. The breach was assumed to extend down to Elevation 1722.0. A breach of this size will result in a peak outflow of 45,800 cfs. This flow was routed downstream to Derringer. The effects of the strip mines and highway along the stream were not included in the analysis,

as noted previously. The dam break will raise the water surface at Derringer by 6.9 feet over the level that would occur without the dam break. There is an increased hazard to loss of life. The spillway capacity is rated as seriously inadequate.

If the dam were raised to its assumed design elevation of 1763.0, the spillway capacity would be rated as inadequate. As discussed in Section 6, the design elevation of the top of the dam is uncertain.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations.

(1) General. The visual inspection of Humboldt Dam, which is described in Section 3, resulted in a number of observations relevant to structural stability. These observations are evaluated herein for the various features.

(2) Embankment. The brush on the upstream slope is undesirable. The deteriorated or washed out riprap is an erosion hazard. The trees on the downstream slope are of serious concern. Their large size indicates that brush cutting has not been accomplished on the downstream slope for many years.

Plates 2 and 3 indicate that the design top elevation of the dam is 1763.0. However, both the 1914 Report by the Pennsylvania Water Supply Commission and a sketch in an inspection report prepared by the Commonwealth in 1944 indicate that there is only 2 feet between the spillway crest and the top of the dam. As measured for this Report, the wall is 2 feet high. The spillway crest is assumed to be at Elevation 1760.0. Therefore, the dam could not be raised to Elevation 1763.0, as shown on the Plates, without raising the approach wall. The reason for the difference is unknown.

The discontinuity on the slope, the variation between the actual and the design slopes, and the mounds along the toe could all be indications of poor construction grading. However, the 1914 Pennsylvania Water Supply Commission Report stated that the dam was apparently carefully constructed. As such, there is evidence that movement of the slope may have occurred.

The seepage at the toe of the dam may have been increased by the recent heavy rains. However, because of the location of some seepage areas, it is

reasonably certain that some seepage was from the reservoir. The seepage is not excessive but the number and size of the wet areas are of concern.

(3) Appurtenant Structures. The offset and shifted approach wall was probably caused by frost action. The other conditions at the spillway are an indication of a lack of maintenance. The outlet works is evaluated in Section 5.

b. Design and Construction Data. No stability analysis for the embankment is available for review. In their 1914 report, the Pennsylvania Water Supply Commission did not analyze the structural stability of the spillway section. No drawings are available to determine the structural dimensions of the weir or adjacent walls. All these structures are relatively low. As sketched in Appendix A, the masonry spillway weir is 4.5 feet high. Because masonry weirs of this height are usually stable, the lack of structural dimensions is not of paramount concern.

c. Operating Records. There are no formal records of operation. No evidence of instability on any feature of the dam is previously noted in the records, except for the settlement of the embankment. As noted in Paragraph 1.2g, the top of the dam was refilled to its design elevation in 1929.

d. Post-construction Changes. There have been no post-construction changes made to Humboldt Dam that would affect its stability.

e. Seismic Stability. Humboldt Dam is located in Seismic Zone 1. Normally it can be considered that if a dam in this zone has adequate factors of safety under static loading conditions, it can be assumed safe for any expected earthquake loading. However, since there are no formal static stability analyses, and there is the potential of earthquake forces moving or cracking the masonry core-wall, the theoretical seismic stability of Humboldt Dam cannot be assessed.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety.

(1) Based on available records, visual inspection, calculations, and past operational performance, Humboldt Dam is judged to be in poor condition. The spillway will pass only 28 percent of the PMF without overtopping of the dam. Because the Owner has placed sandbags on the spillway weir, the actual capacity of the spillway is significantly less than 28 percent. If the dam should fail, the resulting outflows will increase the hazard to loss of life downstream. The spillway capacity is rated as seriously inadequate. According to criteria established for these studies, the dam must be rated as unsafe, nonemergency, because the spillway capacity is seriously inadequate.

If the embankment were raised to its design elevation, the spillway could pass 50 percent of the PMF. The spillway capacity would then be rated as inadequate. Raising the embankment to its design elevation would require the raising of the spillway approach wall. This is considered a major structural modification to the dam.

(2) There is evidence of stability problems on the embankment.

(3) There is no evidence to suggest that the outlet works is operational.

(4) The lack of maintenance has created many serious problems at the dam.

(5) A summary of the features and observed deficiencies is listed below:

Feature and Location	Observed Deficiencies
Embankment:	
Upstream slope	Riprap washed out, brush.
Top	Low areas.
Downstream slope	Mature trees, evidence of movement.
Downstream toe	Trees, seepage, wet areas.
Outlet Works:	
Valve house at downstream toe	Roof collapsed, no ready access.
Downstream channel	Debris.
Spillway:	
Weir	Sandbags on weir, deteriorated mortar.
Approach channel	Wall tilted and offset with deteriorated mortar, brush.
Training wall	Deteriorating mortar, may be too low to contain high flows.
Downstream channel	Debris.

b. Adequacy of Information. The information available is such that an assessment of the condition of the dam can be inferred from the combination of visual inspection, past performance, and computations performed prior to and as part of this study.

c. Urgency. The recommendations in Paragraph 7.2 should be implemented immediately.

d. Necessity for Further Investigations. In order to accomplish some of the remedial measures outlined in Paragraph 7.2, further investigations by the Owner will be required.

7.2 Recommendations and Remedial Measures.

a. The following measures are recommended to be undertaken by the Owner, in approximate order of priority, immediately:

(1) Remove the sandbags from the spillway weir.

(2) Remove the brush in the spillway approach channel and the brush on the upstream embankment slope.

(3) Engage the services of a professional engineer experienced in the design and construction of dams to determine the best method of removing the trees on the downstream slope and near the toe and to determine measures necessary to ensure that the integrity of the dam is preserved. Implement his recommendations.

(4) Engage the services of a professional engineer experienced in the design and construction of dams to perform the following studies: a study to more accurately determine the spillway capacity required at the dam and to determine the measures required to make the spillway and spillway channel hydraulically adequate, a study to determine the structural factors of safety for the embankment, a study to determine the best means of making the outlet works operational, a study to repair the deficiencies in the spillway area, and a study to determine the best means of continually monitoring the seepage and wet areas at the dam. These studies will require, as a minimum, installation of observation wells or other instrumentation to determine water levels in the embankment, an exploration program to determine the engineering properties of the embankment and foundation materials, a complete survey of the embankment and adjacent area, and grading of the area downstream of the toe to more accurately assess the seepage. Take appropriate action as required.

(5) Replace the riprap on the upstream slope.

(6) Remove the debris from the spillway outlet channel and the outlet works channel.

b. In addition, the Owner should institute the following operational and maintenance procedures:

(1) Develop a detailed emergency operation and warning system for Humboldt Dam.

(2) During periods of unusually heavy rains, provide round-the-clock surveillance of Humboldt Dam.

(3) When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system.

(4) Institute an inspection program such that the embankment is inspected frequently. The program should include a formal annual inspection by a professional engineer experienced in the design and construction of dams. Utilize the results to determine if remedial measures are necessary.

(5) Institute a maintenance program to properly maintain all features of the dam.

SUSQUEHANNA RIVER BASIN

WOLFFS RUN, LUZERNE COUNTY

PENNSYLVANIA

HUMBOLDT DAM

NDI ID No. PA-00646
DER ID No. 40-61

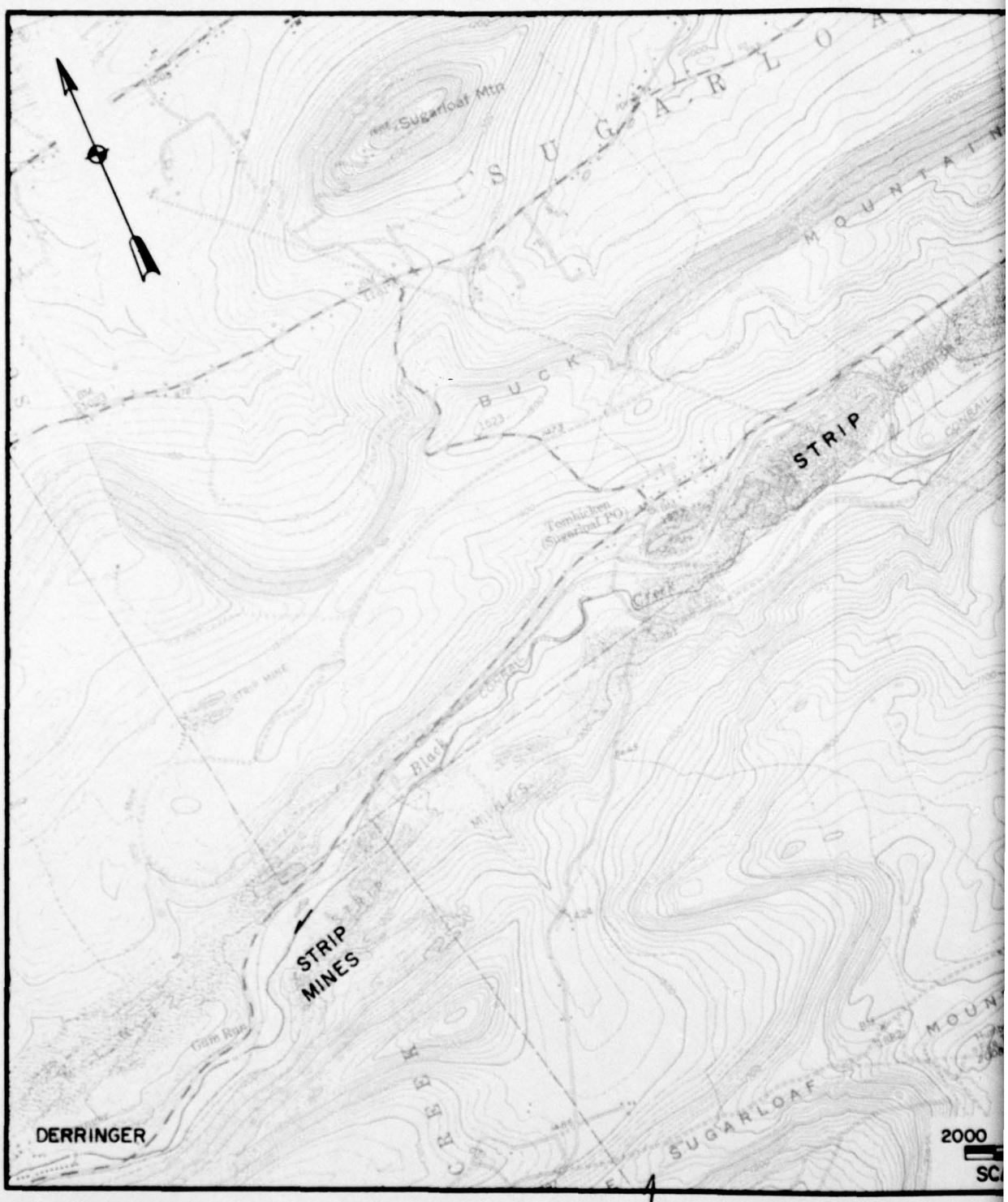
HAZLETON CITY AUTHORITY

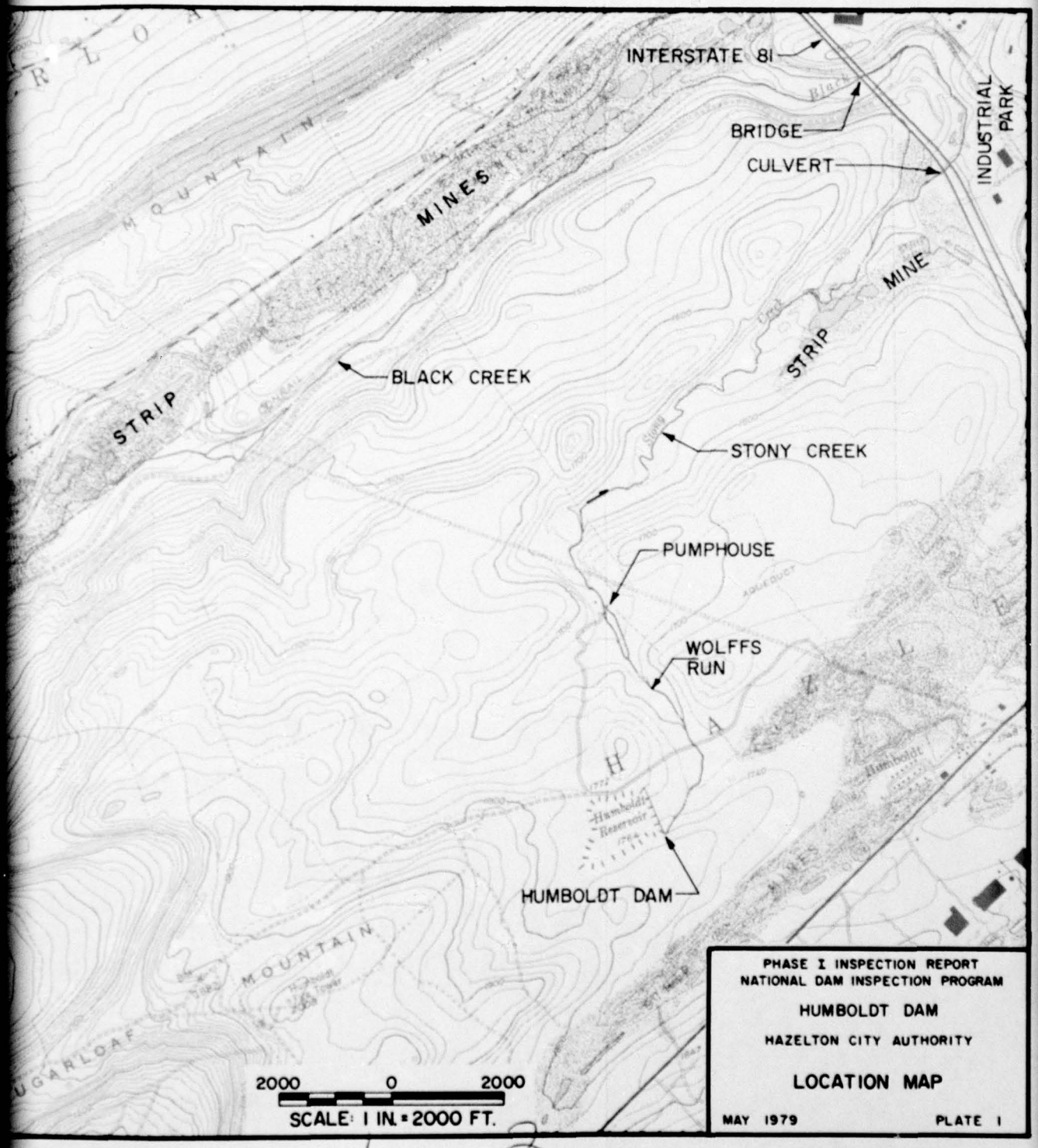
PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

MAY 1979

PLATES


SUGARLOA
MOUNTAIN
Sugarloaf Mtn
BUCK
STRIP
Tomhicken
(Sugarloaf PO)
Creek
Black
STRIP
MINES
Dam Run
DERRINGER
SUGARLOAF
2000



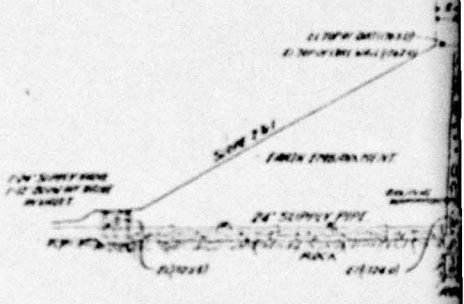
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

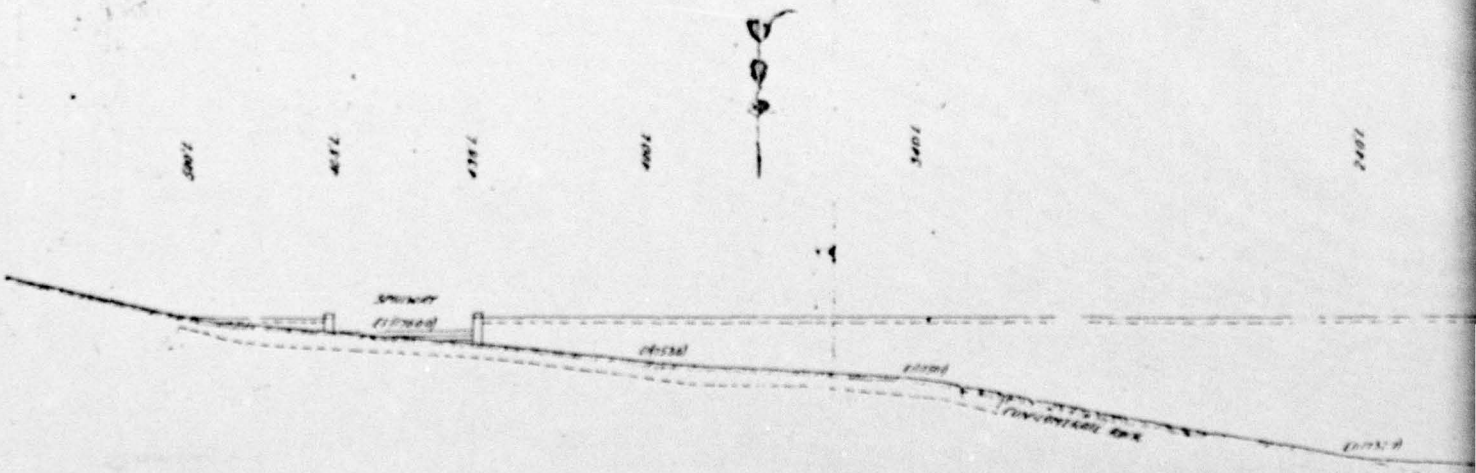
HUMBOLDT DAM

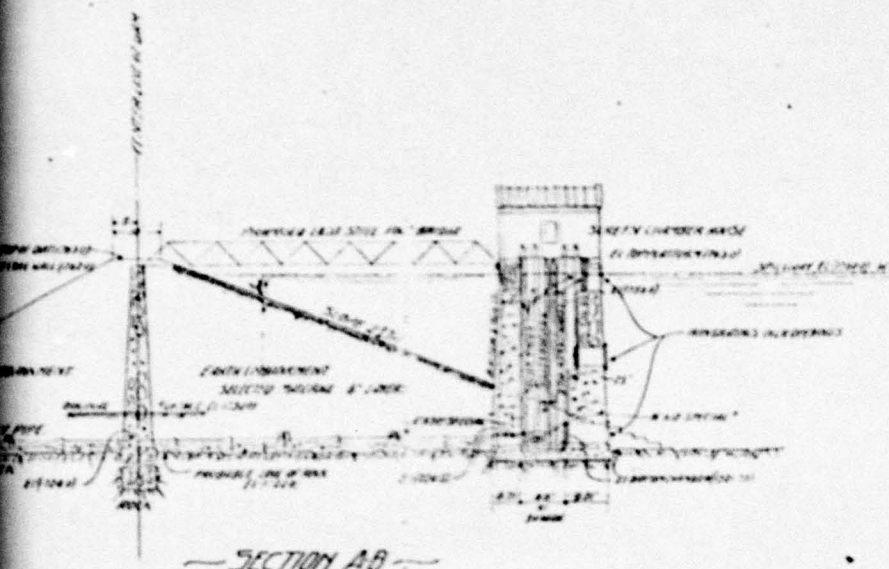
HAZELTON CITY AUTHORITY

LOCATION MAP

MAY 1979 PLATE 1





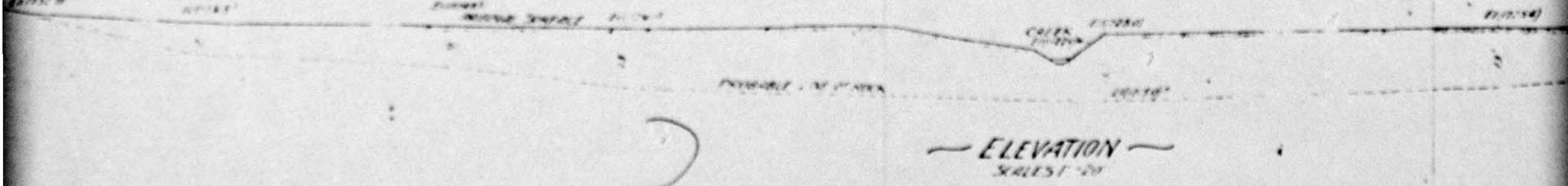


— SECTION A-B —
SCALE 1"=5'

FOOT OF SLOPE OUTSIDE

PLAN AT
SCALE 1"=

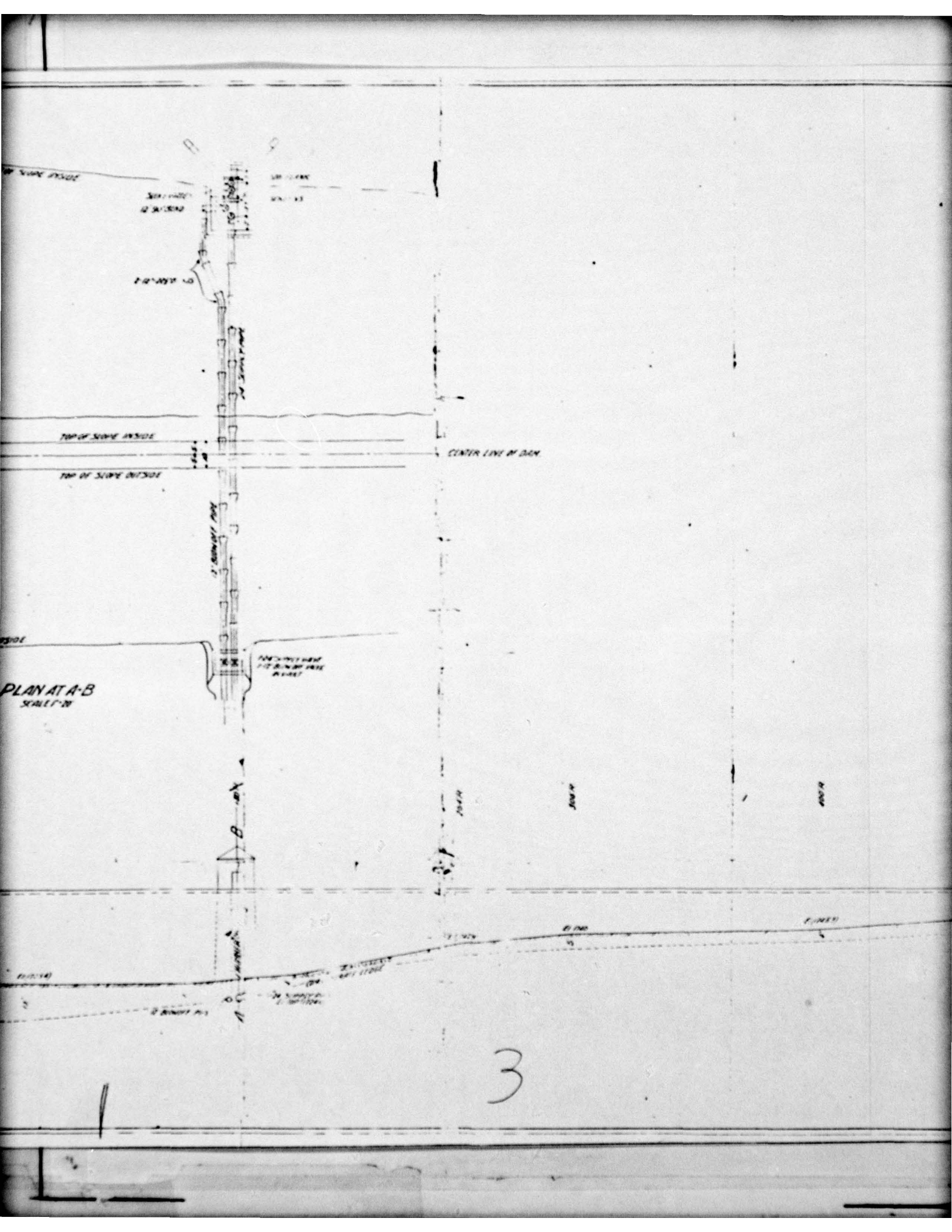
CREEK



— ELEVATION —
SCALE 1"=5'

2

1


TOP OF SLOPE INSIDE
TOP OF SLOPE OUTSIDE
CENTER LINE OF DAM
PLAN AT A-B
SCALE 1"=20'

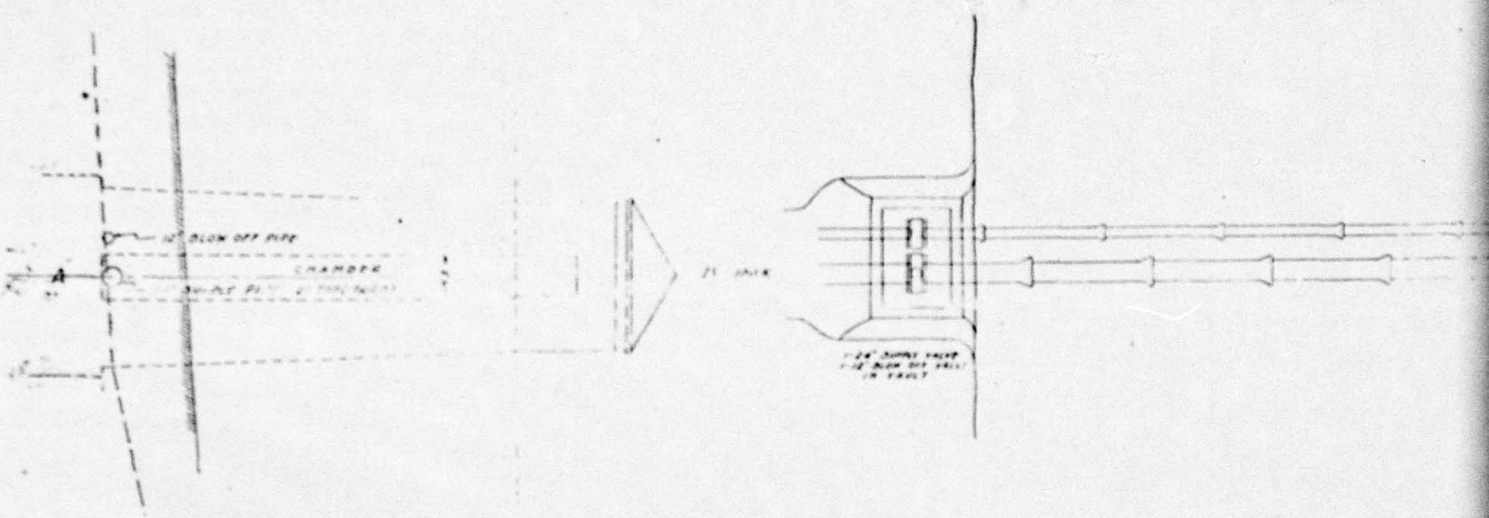
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

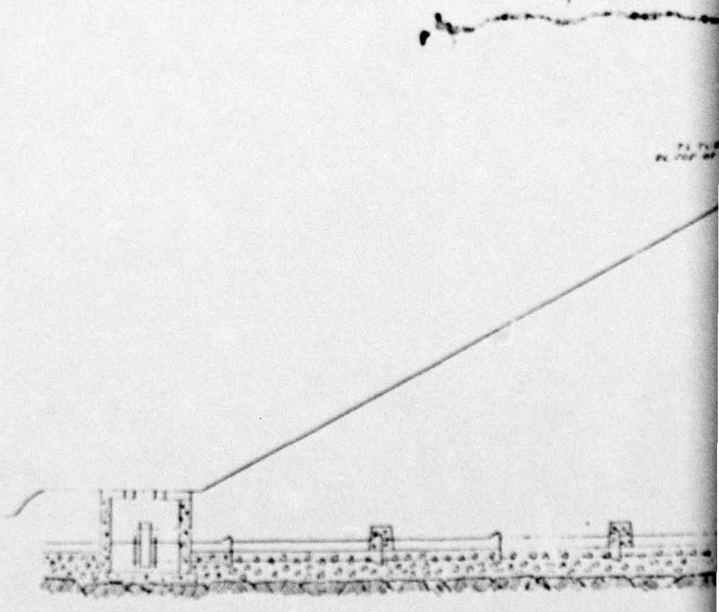
HUMBOLDT DAM

HAZELTON CITY AUTHORITY

PROFILE AND SECTION

MAY 1979 PLATE 2





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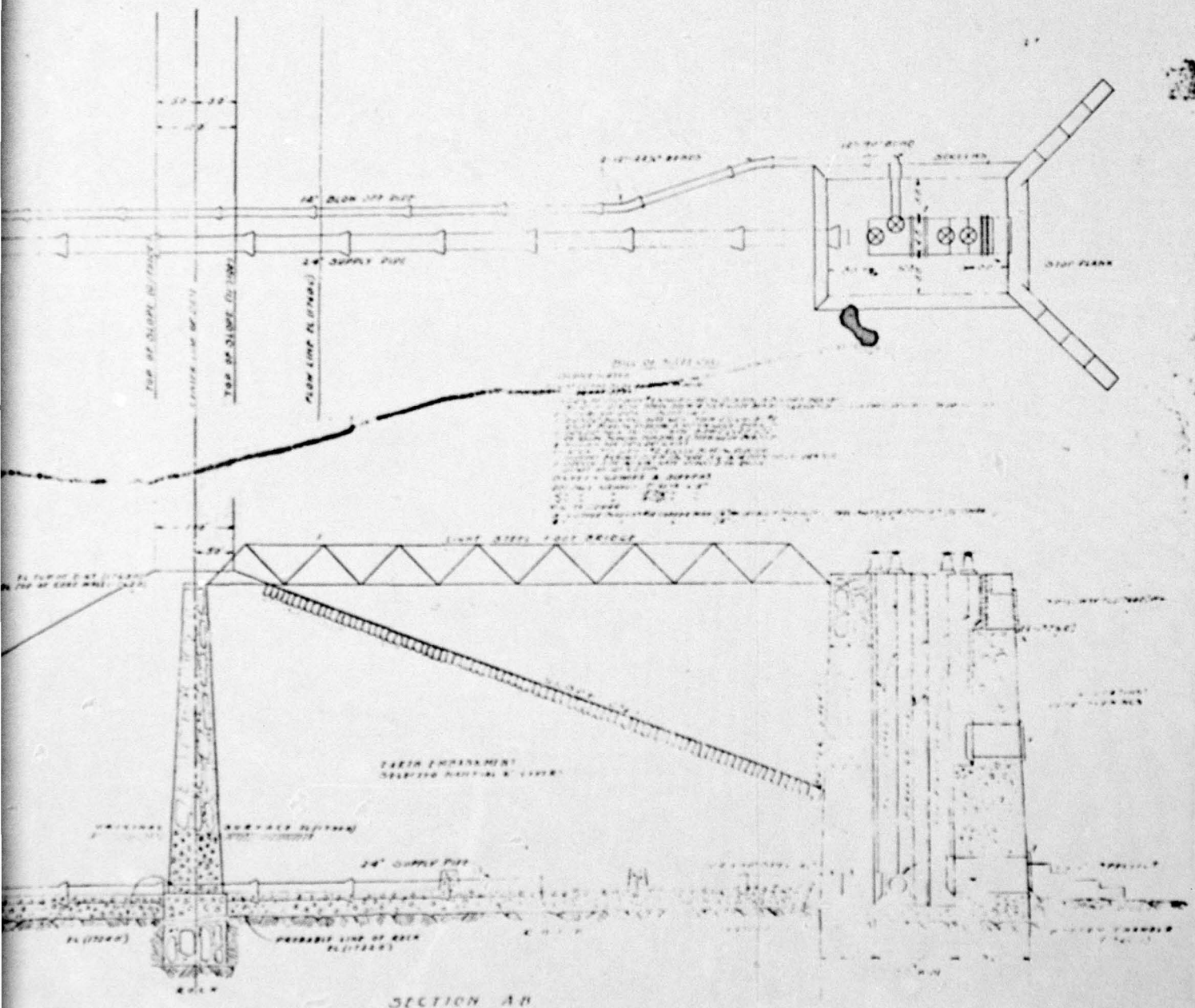


SECTION AB

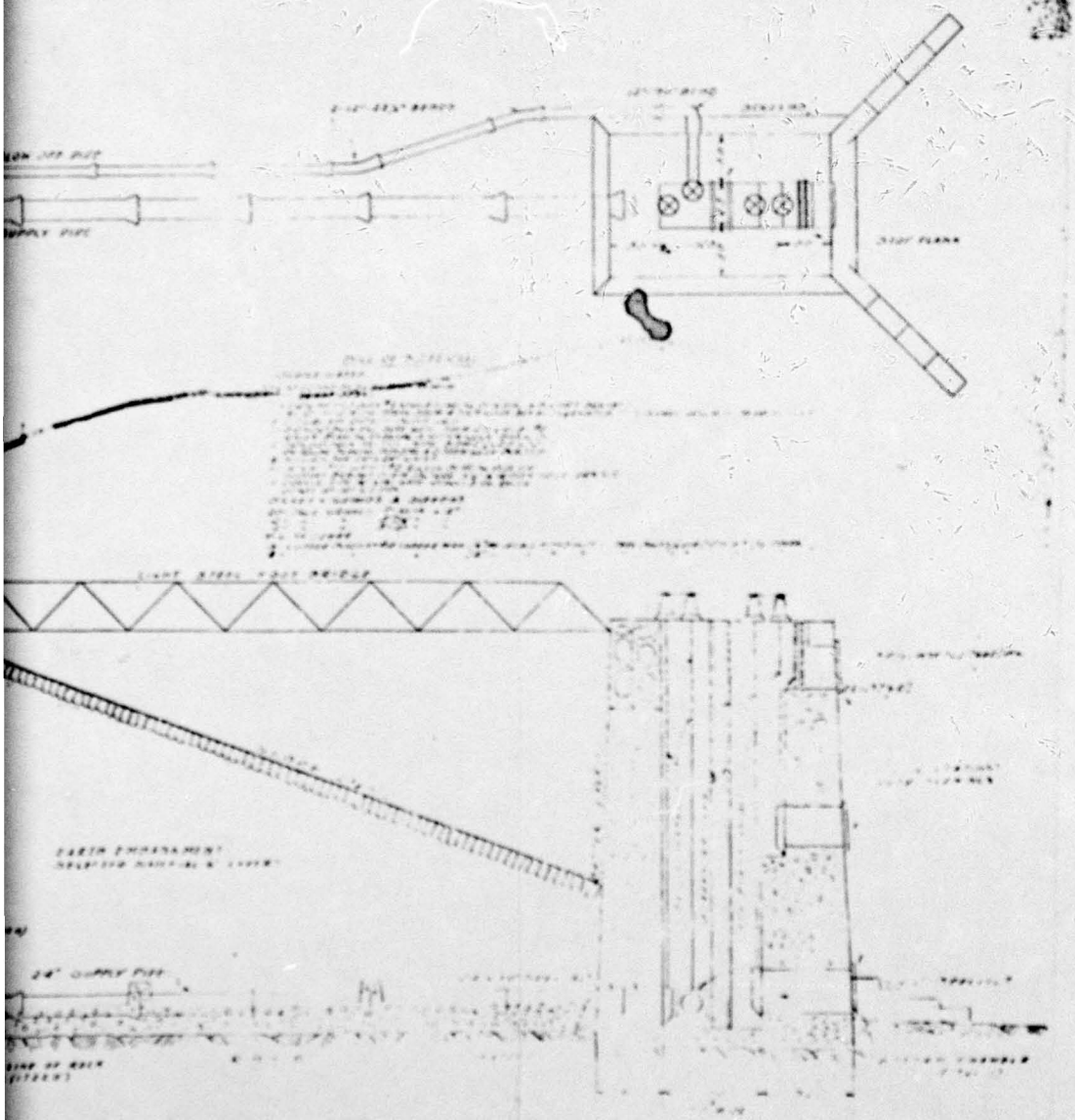
DIAGRAM WATER CONTROL

1 2

NAT

SECT

MAY



SECTION AA

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

HUMBOLDT DAM

HAZELTON CITY AUTHORITY

SECTION AND OUTLET WORKS

MAY 1979

PLATE 3

SUSQUEHANNA RIVER BASIN

WOLFFS RUN, LUZERNE COUNTY

PENNSYLVANIA

HUMBOLDT DAM

NDI ID No. PA-00646
DER ID No. 40-61

HAZLETON CITY AUTHORITY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

MAY 1979

APPENDIX A

CHECKLIST - ENGINEERING DATA

CHECKLIST

ENGINEERING DATA

DESIGN, CONSTRUCTION, AND OPERATION
PHASE I

NAME OF DAM: HUMBOLDT

NDI ID NO.: PA-00646 DER ID NO.: 40-61

Sheet 1 of 4

ITEM	REMARKS
AS-BUILT DRAWINGS	NONE
REGIONAL VICINITY MAP	SEE PLATE 1
CONSTRUCTION HISTORY	BUILT 1909-1911
TYPICAL SECTIONS OF DAM	SEE PLATES 2&3
OUTLETS: Plan Details Constraints Discharge Ratings	SEE PLATES 2&3 NO DISCHARGE RATINGS

A-1

ENGINEERING DATA

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	NONE
DESIGN REPORTS	1914 PENNSYLVANIA WATER SUPPLY COMMISSION REPORT
GEOLOGY REPORTS	SEE DESIGN REPORTS
DESIGN COMPUTATIONS: Hydrology and Hydraulics Dam Stability Seepage Studies	NONE
MATERIALS INVESTIGATIONS: Boring Records Laboratory Field	NONE
POSTCONSTRUCTION SURVEYS OF DAM	NONE

A-2

ENGINEERING DATA

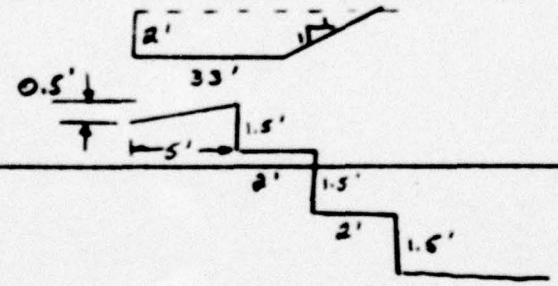
ITEM	REMARKS
BORROW SOURCES	NOT KNOWN
MONITORING SYSTEMS	NONE
MODIFICATIONS	NONE
HIGH POOL RECORDS	NOT KNOWN
POSTCONSTRUCTION ENGINEERING STUDIES AND REPORTS	NONE
PRIOR ACCIDENTS OR FAILURE OF DAM: Description Reports	NONE

ENGINEERING DATA

ITEM	REMARKS
MAINTENANCE AND OPERATION RECORDS	NONE
SPILLWAY: Plan Sections Details	NO PLANS AVAILABLE
OPERATING EQUIPMENT: Plans Details	SEE PLATES 2 & 3
PREVIOUS INSPECTIONS Dates Deficiencies	1919 - SLIGHT SETTLEMENT OF TOP (UP TO 8") BRUSH ON EMBANKMENT RIPRAP ON UPSTREAM SLOPE BELOW TOP WASHES ON DOWNSTREAM SLOPE. 1924 - BY OWNER - SLIGHT SETTLEMENT OF TOP (UP TO 1') 1924 - BRUSH ON EMBANKMENT. SETTLEMENT AS NOTED PREVIOUSLY. BRUSH IN SPILLWAY.
	1929 - WORK IN PROGRESS TO BRING TOP TO GRADE. LARGE SWAMPY AREA BELOW OUTLET WORKS & ANOTHER 150' TO RIGHT - NEGLIGIBLE SEEPAGE. BRUSH IN SPILLWAY CHANNEL.

A-4

ENGINEERING DATA

ITEM	REMARKS
PREVIOUS INSPECTIONS (CONTINUED)	1931 - BRUSH ON EMBANKMENT AND IN SPILLWAY CHANNEL. SWAMPY SPOTS ALL ALONG TOE. 1938 - PER 1931
	1944 - HEAVY BRUSH ON EMBANKMENT. BRUSH IN SPILLWAY CHANNEL POOLS OF WATER ALONG AND BELOW TOE - MAY BE FROM UNPROTECTED SPILLWAY CHANNEL. NOTES SPILLWAY DIMENSIONS
	
	1965 - TREES AND BRUSH ON DOWNSTREAM SLOPE.

A-5

SUSQUEHANNA RIVER BASIN

WOLFFS RUN, LUZERNE COUNTY

PENNSYLVANIA

HUMBOLDT DAM

NDI ID No. PA-00646
DER ID No. 40-61

HAZLETON CITY AUTHORITY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

MAY 1979

APPENDIX B

CHECKLIST - VISUAL INSPECTION

CHECKLIST

VISUAL INSPECTION

PHASE I

Name of Dam: HUMBOLDT County: LUZERNE State: PENNSYLVANIA

NDI ID No.: PA-00646 DER ID No.: 40-61

Type of Dam: HOMOGENEOUS EARTHFILL W/ CORE-WALL Hazard Category: HIGH

Date(s) Inspection: 11 April 1979 Weather: CLEAR Temperature: 55°F

SOIL CONDITIONS - VERY MOIST

Pool Elevation at Time of Inspection: 1759.3 msl/Tailwater at Time of Inspection: NONE msl

Inspection Personnel:

D. WOLF (GFCC)

D. EBERSOLE (GFCC)

A. WHITMAN (GFCC) Recorder

B-1

EMBANKMENT

Sheet 1 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	NONE	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	MOUNDS ALONG TOE 	IMPOSSIBLE TO DETERMINE IF CAUSED BY EMBANKMENT MOVEMENT.
SLOUGHING OR EROSION: Embankment Slopes Abutment Slopes	NEAR RIGHT ABUTMENT - AN AREA APPEARS SLOUGHED	
CREST ALIGNMENT: Vertical Horizontal	HORIZONTAL - NO DEFICIENCIES VERTICAL - SEE SURVEY DATA FOLLOWING INSPECTION FORMS	
RIPRAP FAILURES	UPSTREAM SLOPE - WASHOUTS IN RIPRAP	

B-2

EMBANKMENT

Sheet 2 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT WITH: Abutment Spillway Other Features	NO DEFICIENCIES	
ANY NOTICEABLE SEEPAGE	SEE PLATE B-1	
STAFF GAGE AND RECORDER	NONE	
DRAINS	NONE	
BRUSH	THICK BRUSH AND STUMPS ON UPSTREAM SLOPE.	VERY MANY MATURE TREES ON DOWNSTREAM SLOPE.

OUTLET WORKS

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	CAST IRON PIPE	
INTAKE STRUCTURE	LOCKED - NO ACCESS ON DAY OF INSPECTION	
OUTLET STRUCTURE	ROOF IS COLLAPSED, FILLING STRUCTURE.	NON-OPERATIONAL
OUTLET CHANNEL	CLEAR - SWAMPY/ ON BOTTOM	
EMERGENCY GATE	OWNER DECLINED TO OPERATE, FROM CONCERN THE VALVE WOULD STICK IN OPEN POSITION.	

UNGATED SPILLWAY

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
~~CONCRETE~~ MASONRY WEIR	MORTAR DETERIORATED	SANDBAGS (1' HIGH ±) ON SPILLWAY CREST
APPROACH CHANNEL	APPROACH WALL TILTED AND OFFSET BRUSH IN APPROACH CHANNEL.	
DISCHARGE CHANNEL	MORTAR IN TRAINING WALL DETERIORATED	SEEPAGE OF 1gpm± IN OUTLET CHANNEL - SEEPING THROUGH JOINTS IN MASONRY CREST
BRIDGE AND PIERS	NONE	

B-5

INSTRUMENTATION

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	NONE	
OBSERVATION WELLS	NONE	
WEIRS	NONE	
PIEZOMETERS	NONE	
OTHER	NONE	

RESERVOIR AND WATERSHED

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	GENERALLY GENTLE	
SEDIMENTATION	NO OBSERVED PROBLEMS	
WATERSHED DESCRIPTION	WOODED AND UNINHABITED.	

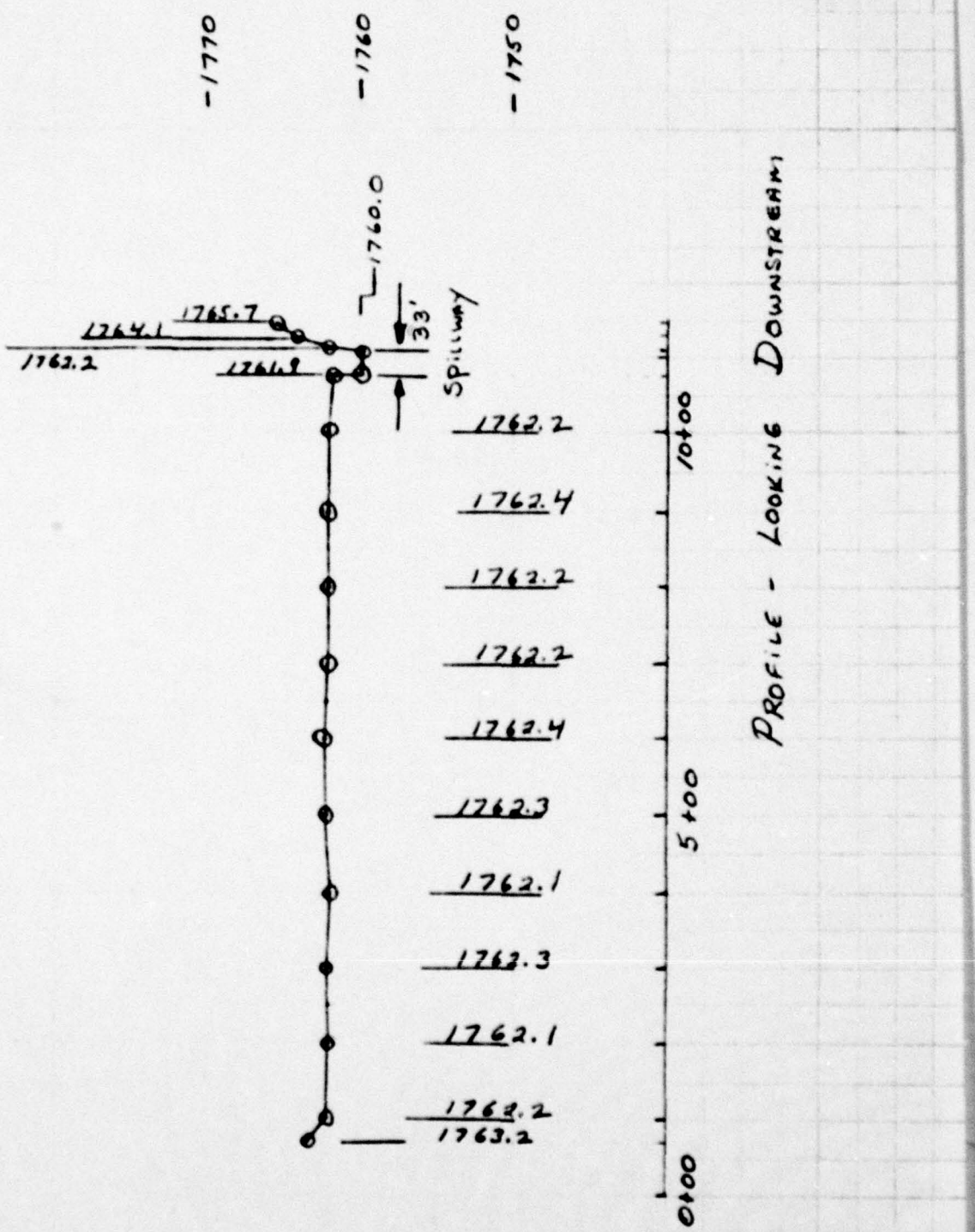
DOWNSTREAM CHANNEL

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION: Obstructions Debris Other	NEAR DAM MUCH DEBRIS IN CHANNEL	
SLOPES	VERY STEEP NEAR DAM	
APPROXIMATE NUMBER OF HOMES AND POPULATION	INDUSTRIAL PARK NEAR I-81. DORNINGER & FURTHER DOWNSTREAM - AT LEAST 60 HOMES	

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Humboldt Dam FILE NO.
SHEET NO. OF SHEETS
FOR
COMPUTED BY DATE CHECKED BY DATE

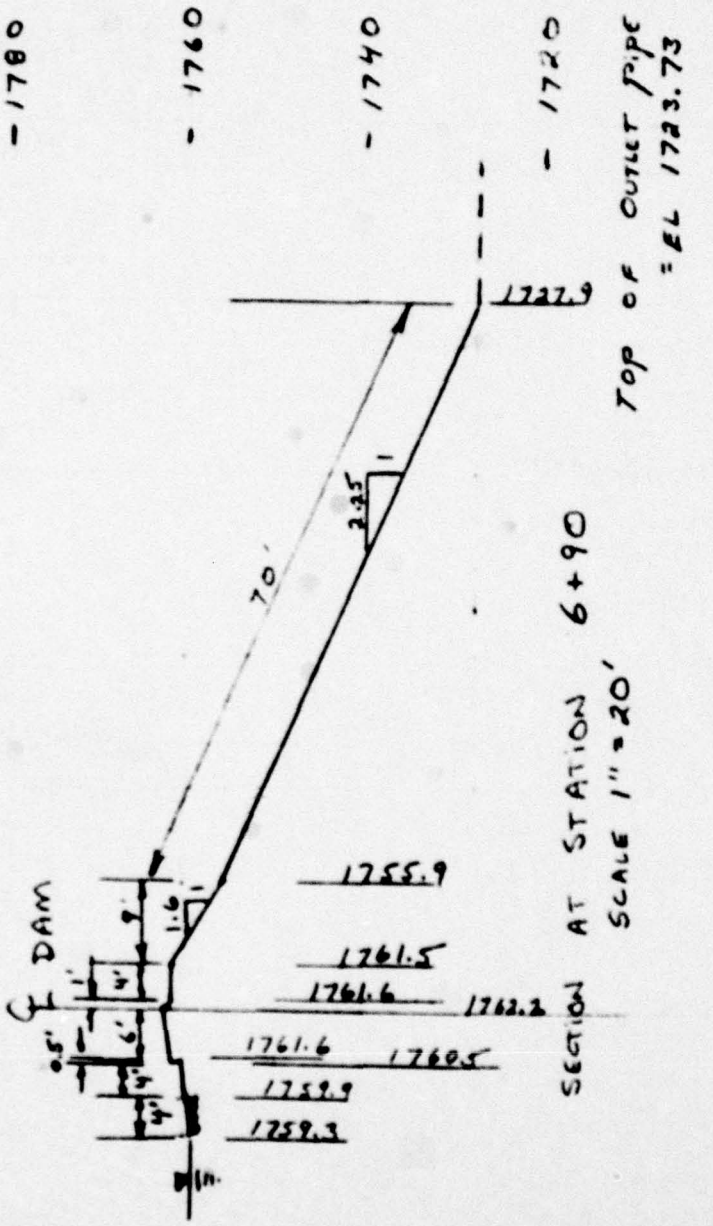


B-9

0015

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

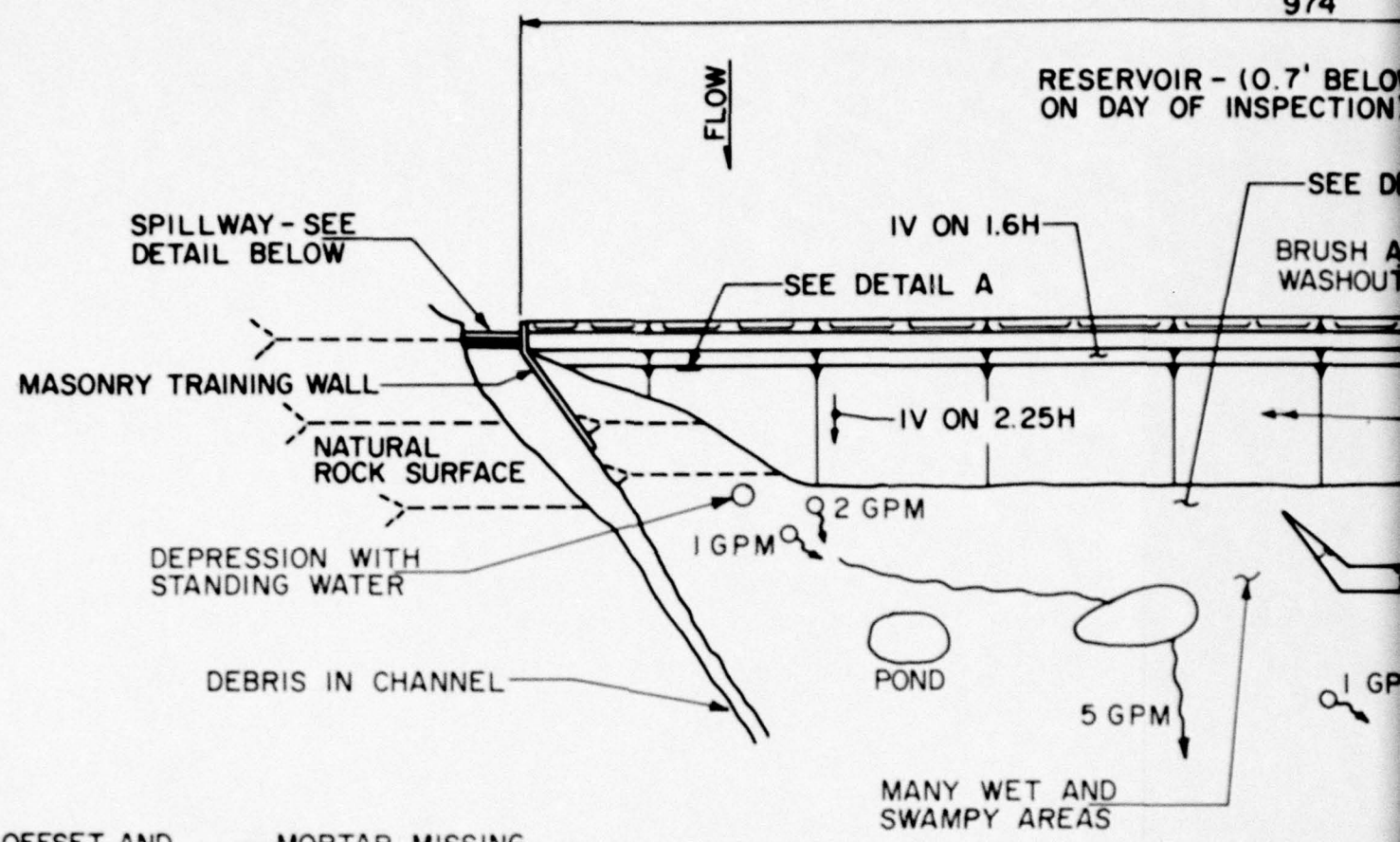
SUBJECT HUMBOLDT FILE NO.
SHEET NO. OF SHEETS
FOR
COMPUTED BY DATE CHECKED BY DATE



SECTION AT STATION 6+90
SCALE 1" = 20'

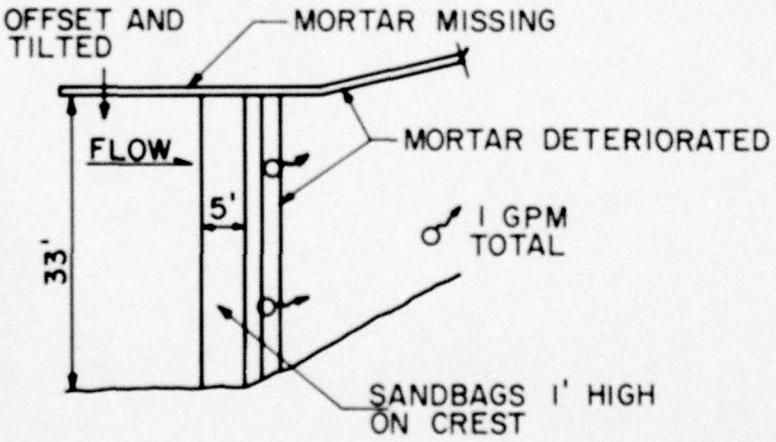
B-10

0015



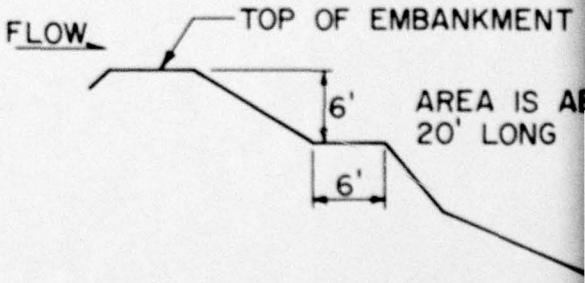
PLAN

APPROX. SCALE: 1 IN.



SPILLWAY DETAIL PLAN

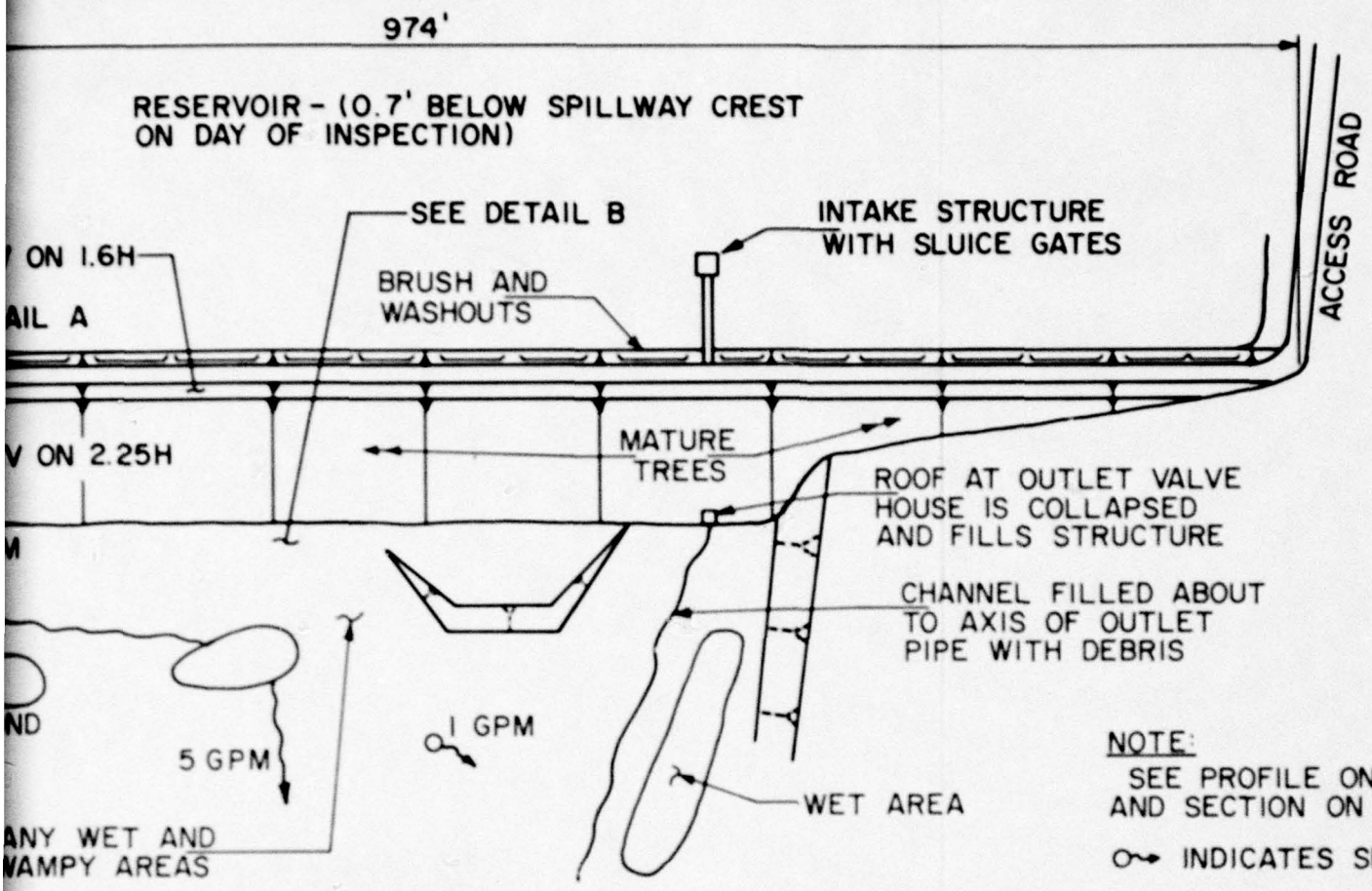
NOT TO SCALE



DETAIL A

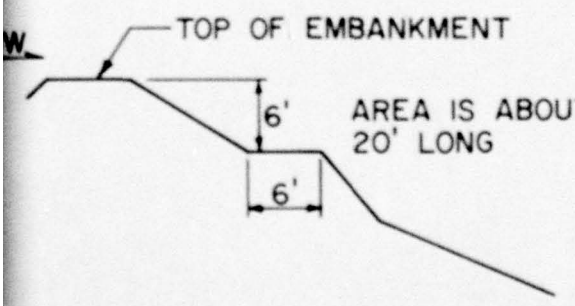
NOT TO SCALE

1



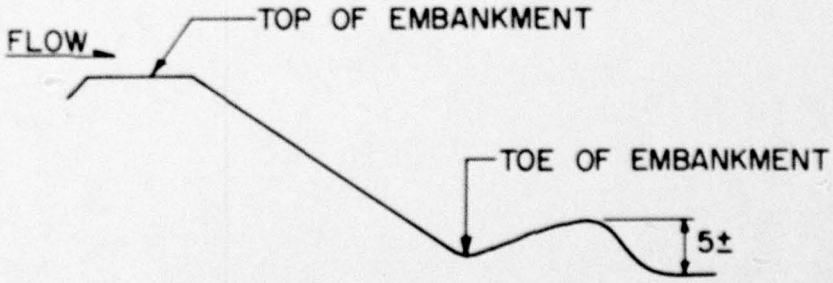
PLAN

APPROX. SCALE: 1 IN. = 100 FT.



DETAIL A

NOT TO SCALE



DETAIL B

NOT TO SCALE

NOTE: THIS IS TYPICAL FOR AREAS ALONG TOE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

HUMBOLDT DAM

HAZELTON CITY AUTHORITY

RESULTS OF VISUAL INSPECTION

MAY 1979

PLATE B-1

SUSQUEHANNA RIVER BASIN

WOLFFS RUN, LUZERNE COUNTY

PENNSYLVANIA

HUMBOLDT DAM

NDI ID No. PA-00646
DER ID No. 40-61

HAZLETON CITY AUTHORITY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

MAY 1979

APPENDIX C

HYDROLOGY AND HYDRAULICS

APPENDIX C

HYDROLOGY AND HYDRAULICS

In the recommended Guidelines for Safety Inspection of Dams, the Department of the Army, Office of the Chief of Engineers (OCE), established criteria for rating the capacity of spillways. The recommended Spillway Design Flood (SDF) for the size (small, intermediate, or large) and hazard potential (low, significant, or high) classification of a dam is selected in accordance with the criteria. The SDF for those dams in the high hazard category varies between one-half of the Probable Maximum Flood (PMF) and the PMF. If the dam and spillway are not capable of passing the SDF without overtopping failure, the spillway capacity is rated as inadequate. If the dam and spillway are capable of passing one-half of the PMF without overtopping failure, or if the dam is not in the high hazard category, the spillway capacity is not rated as seriously inadequate. A spillway capacity is rated as seriously inadequate if all of the following conditions exist:

(a) There is a high hazard to loss of life from large flows downstream of the dam.

(b) Dam failure resulting from overtopping would significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure.

(c) The dam and spillway are not capable of passing one-half of the PMF without overtopping failure.

APPENDIX C

SUSQUEHANNA River Basin

Name of Stream: WOLFES RUN

Name of Dam: HUMBOLDT

NDI ID No.: PA-00646

DER ID No.: 40-61

Latitude: N 40° 56' 25" Longitude: W 76° 03' 40"

Top of Dam (~~low-spot~~) Elevation: 1763.0

Streambed Elevation: 1722.0± Height of Dam: 41 ft

Reservoir Storage at Top of Dam Elevation: 549 acre-ft

Size Category: INTERMEDIATE

Hazard Category: HIGH (see Section 5)

Spillway Design Flood: PMF

UPSTREAM DAMS

Name	Distance from Dam (miles)	Height (ft)	Storage at top of Dam Elevation (acre-ft)	Remarks
NONE				

DOWNSTREAM DAMS

NONE				

SUSQUEHANNA River Basin

Name of Stream: WOLFFS RUN

Name of Dam: HUMBOLDT

~~NDS ID No.~~: _____

~~DER ID No.~~: _____

Latitude: N 40° 56' 25" Longitude: W 76° 03' 40"

DETERMINATION OF PMF RAINFALL

For Area A

which consists of Subareas A1 of 0.6 sq. mile

_____ _____

_____ _____

_____ _____

_____ _____

Total Drainage Area 0.6 sq. mile

PMF Rainfall Index = 22.15 in., 24 hr., 200 sq. mile

	Hydromet. 40 (Susquehanna Basin)	Hydromet. 33 (Other Basins)
Zone	N/A	_____
Geographic Adjustment Factor	100%	1.0
Revised Index Rainfall	22.2 in.	_____

RAINFALL DISTRIBUTION (percent)

Time	Percent
6 hours	118
12 hours	127
24 hours	136
48 hours	142
72 hours	145
96 hours	N/A

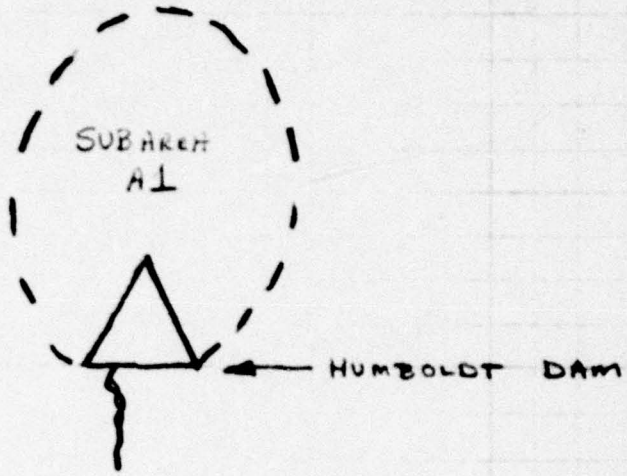
GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT _____ FILE NO. _____

_____ SHEET NO. ____ OF ____ SHEETS

FOR _____

COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____



SEE PLATE C-1
FOR LOCATION
OF DOWNSTREAM
ROUTING SECTIONS

SKETCH
OF
SYSTEM

0913

Data for Dam at Outlet of Subarea A1
(see Sketch on Sheet C-4)

Name of Dam: HUMBOLDT Sheet 1 of __

Height: 41 FT (existing)

Spillway Data:	Existing Conditions	Design Conditions
Top of Dam Elevation	1761.9	1763.0
Spillway Crest Elevation	1760.0	1760.0
Spillway Head Available (ft)	1.9	3.0
Type Spillway	MASONRY GRAVITY W/INCLINED TOP	
"C" Value - Spillway	3.1	3.1
Crest Length - Spillway (ft)	33.0	33.0
Spillway Peak Discharge (cfs)	280	530
Auxiliary Spillway Crest Elevation	NONE	NONE
Auxiliary Spillway Head Available (ft)	—	—
Type Auxiliary Spillway	—	
"C" Value - Auxiliary Spillway	—	—
Crest Length - Auxiliary Spillway (ft)	—	—
Auxiliary Spillway Peak Discharge (cfs)	—	—
Combined Spillway Discharge (cfs)	280	530

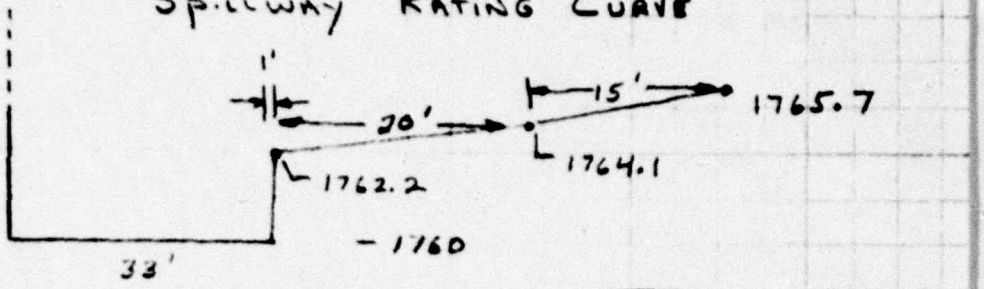
Spillway Rating Curve: SEE NEXT SHEET

Elevation	Q Spillway (cfs)	Q Auxiliary Spillway (cfs)	Combined (cfs)

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT HUMBOLDT DAM FILE NO.
SHEET NO. OF SHEETS
FOR
COMPUTED BY DATE CHECKED BY DATE

SPILLWAY RATING CURVE



ASSUME CRITICAL DEPTH $\sqrt{\frac{A^3 g}{T}} = Q$

$hv = V^2/2g = \frac{Q^2}{A^2 \cdot 2g}$ POOL = hv + ELEV

ELEV.	DEPTH	TOP WIDTH	AREA	Q(CFS)	hv(FT)	POOL
1760.0	0	–	0	0	0	1760.0
1760.5	0.5	33.23	16.56	66	.25	1760.7
1761.0	1.0	33.45	33.23	188	.50	1761.5
1761.3	1.3	33.59	43.28	279	.64	1761.9
1762.0	2.0	33.91	66.91	533	.99	1763.0
1762.2	2.2	34.00	73.7	616	1.08	1763.3
1764.1	4.1	54.00	157.3	1523	1.46	1765.6

VALUES ROUNDED:

POOL ELEV	Q
1760.0	0
1760.7	65
1761.5	190
1761.9	280
1763.0	530
1763.3	620
1765.6	1520

0013

Data for Dam at Outlet of Subarea A1

Name of Dam: HUMBOLDT Sheet 2 of __

Outlet Works Rating:		Outlet 1	Outlet 2	Outlet 3
Invert of Outlet		1722.5±		
Invert of Inlet		1722.5±		
Type		CIP		
Diameter (ft) = D		1		
Length (ft) = L		180		
Area (sq. ft) = A		.785		
N		.013		
K Entrance		0.5		
K Exit		1.0		
K Friction* = $29.1 N^2 L/R^{4/3}$		5.62		
Sum of K		7.12		
$(1/K)^{0.5}$ = C		0.375		
Maximum Head (ft) = HM		40.5		
Q = C A $\sqrt{2g(HM)}$ (cfs)		19		
Q Combined (cfs)	≈	20		

* R = Hydraulic Radius = (Area/Wetted Perimeter) = D/4 for Circular Conduits.

Data for Dam at Outlet of Subarea A1

Name of Dam: HUMBOLDT Sheet 3 of __

Storage Data:

Elevation	Area (acres)	Storage million gals	Storage acre-ft	Remarks
1721.6 = ELEVO*	0	0	0	
1760.0 = ELEV1	34.5 = A1	143.9	441.6 = S1	
1761.9	36		509	INTERPOLATED
1763.0	37		549	INTERPOLATED
1780.0 **	52			
**				

* ELEVO = ELEV1 - $(3S_1/A_1)$

** Planimetered contour at least 10 feet above top of dam

Reservoir Area at Top of Dam is 9 percent of watershed.

Remarks: _____

Data for Dam at Outlet of Subarea A1

Name of Dam: HUMBOLDT Sheet 4 of __

Breach Data:

Sketch of Dam Profile (not to scale):

SEE PLATE 2

Sketch of Top of Dam (not to scale):

SEE PLATE 2

Soil Type from Visual Inspection: SANDY SILT

Maximum Permissible Velocity (Plate 28, EM 1110-2-1601) 1.8 fps
(from $Q = CLH^{3/2} = V \cdot A$ and depth = (2/3) x H) $A = L \cdot d$

HMAX = $(4/9\ V^2/C^2)$ = .149 ft., C = 3.1

0.1 1761.9

HMAX + Top of Dam Elev. = 1762.0 = FAILEL

(Above is elevation at which failure would start)

Dam Breach Data:

BRWID = 90 ft (width of bottom of breach)

Z = 2 (side slopes of breach)

ELBM = 1722.0 (bottom of breach elevation, minimum of zero storage elevation)

WSEL = 1760.0 (normal pool elevation)

T FAIL = 12 mins

= 0.2 hrs (time for breach to develop)

SUSQUEHANNA River Basin

Name of Stream: WELSH RUN

Name of Dam: HUMBOLDT

~~NDS ID No.~~: _____

~~DER ID No.~~: _____

Latitude: N 40° 56' 25" Longitude: W 76° 03' 40"

Drainage Area: 0.6 sq. mile

Data for Subarea: A-1 (see Sketch on Sheet C-4)

Name of Dam at Outlet of Subarea: HUMBOLDT

Drainage Area of Subarea: 0.6 sq. mile

Subarea Characteristics:

Assumed Losses: 1.0-inch initial abstraction + 0.05 in/hr

The following are measured from outlet of subarea to the point noted:

L = Length of Main Watercourse extended to the divide = 1.6 miles

L_{CA} = Length of Main Watercourse to the centroid = 0.7 mile

From NAB Data: AREA 13 PLATE F

Cp = 0.50

C_T = 1.85

$Tp = C_T \times (L \times L_{CA})^{0.3}$ = 1.91 (hrs)

Flow at Start of Storm = 1.5 cfs/sq. mile x Subarea D.A = 0.9 cfs

Computer Data:

QRCSN = -0.05 (5% of peak flow)

RTIOR = 2.0

Remarks: _____

SELECTED COMPUTER OUTPUT

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
     1          A    NATIONAL DAM INSPECTION PROGRAM
     2          A    WOLFES RUN
     3          A    HUMBOLDT DAM
     4          B   300       0      15       0       0       0       0       0      -4       0
     5          B1    1
     6          J     1       6       1
     7          J1    1      .5      .4      .3      .2      .1
     8          K     0       1                                       1
     9          K1      RUNOFF INTO HUMBOLDT RESERVOIR
    10          M     1       1     0.6                     0.6                             1
    11          P           22.2     118     127     136     142     145
    12          T                                                     1     .05             .09
    13          U   1.91     0.5
    14          J    -1.    -0.05     2.0
    15          K     1       1                                       1
    16          K1      ROUTE THROUGH HUMBOLDT RESERVOIR
    17          T                               1
    18          T1    1                                           -1760     -1
    19          T4  1760    1760.7  1761.5  1761.9    1765    1765.3  1765.6
    20          T5     0        65     190     290     530     620    1520
    21          R6     0      36.5      52
    22          RE1721.6     1760    1780
    23          R8  1760
    24          RD1761.9
    25          RL     1        40     170     830     990    1010
    26          RM1761.9    1762.1  1762.2  1762.3  1762.4    1765
    27          K     99
```

C-12

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	RATIO 1 1.00	RATIO 2 .50	RATIOS APPLIED TO FLOWS RATIO 3 .40	RATIO 4 .30	RATIO 5 .20	RATIO 6 .10
HYDROGRAPH AT	1	.60	1	1199.	700.	540.	420.	280.	160.
	(	1.55)	(	33.42)(	19.81)(	15.85)(	11.89)(	7.92)(	3.96)(
ROUTED TO	1	.60	1	1195.	671.	499.	308.	187.	85.
	(	1.55)	(	33.31)(	19.04)(	13.97)(	8.72)(	5.31)(	2.41)(

SUMMARY OF DAM SAFETY ANALYSIS

HUMBOLDT DAM

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1760.00	1760.00	1761.90
STORAGE	442.	442.	505.
OUTFLOW	0.	0.	240.

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	1762.69	.79	537.	1395.	9.25	41.75	0.00
.50	1762.43	.53	529.	673.	5.75	42.25	0.00
.40	1762.36	.46	526.	493.	4.50	42.75	0.00
.30	1762.02	.12	515.	309.	2.25	43.50	0.00
.20	1761.68	0.00	496.	187.	0.00	43.75	0.00
.10	1760.83	0.00	470.	95.	0.00	44.00	0.00

41-C

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

```
   1  A                    NATIONAL DAM INSPECTION PROGRAM
   2  A                         WOLFFS RUN
   3  A                         HUMBOLDT DAM
   4  R    300       0       6       0       0       0       0       0      -4       0
   5  B1     5
   6  J      2       1       1
   7  J1   0.5
   8  K      0       1                                               1
   9  K1       RUNOFF INTO HUMBOLDT RESERVOIR
  10  M      1       1     0.6               0.6                                 1
  11  P            22.2     118     127     136
  12  T                                                               1    .05             .09
  13  W   1.91     0.5
  14  X   -1.5   -0.05     2.0
  15  K      1       1                                               1
  16  K1       ROUTE THROUGH HUMBOLDT RESERVOIR
  17  T                                       1       1
  18  T1     1                                                    -1760      -1
  19  T4  1760  1760.7  1761.5  1761.9    1763  1763.3  1765.6
  20  T5     0      65     190     280     530     620    1570
  21  SA     0    34.5      52
  22  SE1729.6    1760    1780
  23  SS  1760
  24  SD1761.9
  25  SL     1      60     170     830     990    1010
  26  SV1761.9  1762.1  1762.2  1762.5  1762.6    1765
  27  SS    90       2    1722     0.2    1760    1765
  28  SS    90       2    1722     0.2    1760    1762
  29  K      1       2                                               1
  30  K1       AREA DOWNSTREAM DAM
  31  T                                       1       1
  32  T1     1                                                      -1
  33  T6   .09     .07     .09    1695    1740    3000   .0267
  34  T7     0    1800     420    1760     750    1700     950    1695    1010    1695
  35  T7  1200    1700    1480    1740    1900    1800
  36  K      1       3                                               1
  37  K1       NEAR PUMPHOUSE
  38  T                                       1       1
  39  T1     1                                                      -1
  40  T6   .09     .07     .09    1640    1680    2800   .0214
  41  T7     0    1700      80    1680     150    1660     450    1640     680    1640
  42  T7   610    1640     700    1690    1100    1700
  43  K      1       4                                               1
  44  K1       DOWNSTREAM PUMPHOUSE
  45  T                                       1       1
  46  T1     1                                                      -1
  47  T6   .09     .07     .09    1580    1620    5200   .0154
  48  T7     0    1700     350    1640     580    1600     880    1580    1200    1580
  49  T7  1500    1600    1900    1640    2400    1700
  50  K      1       5                                               1
```

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```
51    E1      AREA-STRIP MINE UPSTREAM I-81
52    Y                                    1       1
53    Y1    1                                                    -1
54    Y6  .07      .09      .07     1480    1520    5200    .0154
55    Y7    0     1600      550     1520     650    1500     900    1480     950    1480
56    Y7 1090     1500     1200     1520    1700    1540
57    E     1        6                                          1
58    E1      INDUSTRIAL PARK AREA
59    Y                                    1       1
60    Y1    1                                                    -1
61    Y6  .09      .07      .09     1380    1420    5000     .02
62    Y7    0     1500      200     1440     350    1400     660    1380     700    1380
63    Y7  750     1400      900     1440    1150    1500
64    E     1        7                                          1
65    E1      STRIP MINE AREA
66    Y                                    1       1
67    Y1    1                                                    -1
68    Y6  .09      .07      .09     1340    1380    9200    .0043
69    Y7    0     1400      200     1340     350    1360     400    1340     500    1340
70    Y7  550     1360     1400     1360    1900    1400
71    E     1        8                                          1
72    E1      NEAR TOMHICKEN
73    Y                                    1       1
74    Y1    1                                                    -1
75    Y6  .09      .07      .09     1210    1240    9000    .0133
76    Y7    0     1400      320     1300     640    1260     890    1210    1100    1220
77    Y7 1350     1240     1500     1260    1900    1300
78    E     1        9                                          1
79    E1      STRIP MINE AREA
80    Y                                    1       1
81    Y1    1                                                    -1
82    Y6  .09      .07      .09     1182    1220    7200   .00555
83    Y7    0     1240      500     1200     600    1190     610    1182     650    1182
84    Y7  700     1190      950     1200    1050    1240
85    E     1       10                                          1
86    E1      GUN RUN AREA
87    Y                                    1       1
88    Y1    1                                                    -1
89    Y6  .09      .07      .09     1135    1180    5000     .008
90    Y7    0     1180      100     1160     300    1140     301    1135     361    1135
91    Y7  342     1140      500     1160     580    1180
92    E     1       11                                          1
93    E1      AT DERRINGER (DAMAGE CENTER)
94    Y                                    1       1
95    Y1    1                                                    -1
96    Y6  .09      .07      .09     1090    1120    4200    .0143
97    Y7    0     1200      350     1100     600    1100     601    1090     661    1090
98    Y7  662     1100      790     1100    1050    1200
99    E    99
```

C-16

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	RATIO APPLIED TO FLOWS 1 .50
HYDROGRAPH AT	1	.60	1	705.
	(	1.55)	(	19.97)(
			2	705.
			(	19.97)(
ROUTED TO	1	.60	1	672.
	(	1.55)	(	19.02)(
			2	43519.
			(	1232.33)(
ROUTED TO	2	.60	1	663.
	(	1.55)	(	18.77)(
			2	33811.
			(	957.62)(
ROUTED TO	3	.60	1	660.
	(	1.55)	(	18.70)(
			2	27627.
			(	782.30)(
ROUTED TO	4	.60	1	636.
	(	1.55)	(	18.00)(
			2	16653.
			(	471.55)(
ROUTED TO	5	.60	1	622.
	(	1.55)	(	17.61)(
			2	11106.
			(	314.48)(
ROUTED TO	6	.60	1	615.
	(	1.55)	(	17.41)(
			2	9505.
			(	269.14)(
ROUTED TO	7	.60	1	522.
	(	1.55)	(	14.79)(
			2	5801.
			(	164.27)(
ROUTED TO	8	.60	1	495.
	(	1.55)	(	14.01)(
			2	4432.
			(	125.51)(
ROUTED TO	9	.60	1	481.
	(	1.55)	(	13.62)(

			2	5951.
			(	109.35)(
ROUTED TO	10	.60	1	479.
	(	1.55)	(	13.56)(
			2	5651.
			(	102.93)(
ROUTED TO	11	.60	1	477.
	(	1.55)	(	13.52)(
			2	5536.
			(	100.13)(

SUMMARY OF DAM SAFETY ANALYSIS

HUMBOLDT DAM

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1760.00	1760.00	1761.90
STORAGE	442.	442.	509.
OUTFLOW	0.	0.	280.

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
.50	1762.43	.53	529.	672.	5.60	18.10	0.00

PLAN 2 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1760.00	1760.00	1761.90
STORAGE	442.	442.	509.
OUTFLOW	0.	0.	280.

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
.50	1762.02	.12	513.	65800.	.25	17.10	17.00

PLAN 1 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	663.	1696.0	18.30

PLAN 2 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	55811.	1703.4	17.20

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	460.	1662.6	18.50

PLAN 2 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	27627.	1653.4	17.30

PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	656.	1580.4	19.00

PLAN 2 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	16653.	1585.5	17.40

PLAN 1 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	622.	1682.5	19.50

PLAN 2 STATION 5

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	11106.	1690.8	17.80

PLAN 1 STATION 6

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	615.	1382.3	19.60

PLAN 2 STATION 6

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	9505.	1398.7	17.70

PLAN 1 STATION 7

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	522.	1342.2	20.70

PLAN 2 STATION 7

MAXIMUM	MAXIMUM	TIME

RATIO	FLOW,CFS	STAGE,FT	HOURS
.50	5401.	1342.9	18.00

PLAN 1 STATION 8

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	495.	1213.2	21.40

PLAN 2 STATION 8

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	6432.	1217.3	18.40

PLAN 1 STATION 9

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	481.	1185.0	22.00

PLAN 2 STATION 9

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	3851.	1191.2	18.70

PLAN 1 STATION 10

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	479.	1138.0	22.30

PLAN 2 STATION 10

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	3631.	1144.7	19.00

PLAN 1 STATION 11

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	477.	1092.6	22.50

DAMAGE CENTER

C-21

PLAN 2 STATION 11

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	3536.	1099.5	19.10

DAMAGE CENTER

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT _____ FILE NO. _____
SHEET NO. ____ OF ____ SHEETS
FOR _____
COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____

SUMMARY OF RESULTS
PMF RAINFALL = 25.75 INCHES

DAM WITH EXISTING CONDITIONS

	PMF	½ PMF
RUNOFF (INCHES)	23.37	11.69
PMF INFLOW (CFS)	1399	700
PMF OUTFLOW (CFS)	1395	673
DEPTH OF OVERTOPPING (FT)	0.79	0.53
DURATION OF OVERTOPPING (HRS)	9.25	5.75

DAM BREAK ANALYSIS

PEAK OUTFLOW AT FAILURE 45,800 CFS
PEAK OUTFLOW ASSUMING NO FAILURE 672 CFS

AT STATION 11
(COMMUNITY OF DERRINGER)

	FLOW (CFS)	WATER SURFACE EL.
ASSUMING NO FAILURE OF DAM	477	1092.6
ASSUMING FAILURE OF DAM	3536	1099.5
DIFFERENCE		6.9

0019

SUGARLOAF
CONRAIL
CONRAIL
Black
9
NOTE:
NUMBERS
USED IN CO
2000
SCALE


HUMBOLDT DAM
Humboldt Reservoir
NOTE:
NUMBERS INDICATE STATIONS USED IN COMPUTER ANALYSIS.
2000 0 2000
SCALE: 1 IN. = 2000 FT.
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
HUMBOLDT DAM
HAZELTON CITY AUTHORITY
STREAM CROSS SECTIONS
MAY 1979
PLATE C-1

SUSQUEHANNA RIVER BASIN

WOLFFS RUN, LUZERNE COUNTY

PENNSYLVANIA

HUMBOLDT DAM

NDI ID No. PA-00646
DER ID No. 40-61

HAZLETON CITY AUTHORITY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

MAY 1979

APPENDIX D

PHOTOGRAPHS

HUMBOLDT DAM

A. Top of Dam

B. Upstream Slope

C. Downstream Slope

D. Wet Area at Toe

E. Downstream Toe and Outlet Works

F. Downstream Outlet Works Valve House

G. Spillway Channel

H. Spillway Approach and Exit Channels

SUSQUEHANNA RIVER BASIN

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APPENDIX E

GEOLOGY

HUMBOLDT DAM

APPENDIX E

GEOLOGY

1. General Geology. The damsite and reservoir are located in Luzerne County. The rock formations exposed in Luzerne County range from the Post-Pottsville formations, of Pennsylvanian Age, down to the Onondaga formation, of Middle Devonian Age. The Wisconsin terminal moraine crosses the southern part of the County, and the greater part of the glacial outwash occur along the Susquehanna River and less extensive deposits along the smaller streams.

Nearly all of the Luzerne County lies in the Valley and Ridge Province in which nearly all the rocks have been strongly folded. In going from north to south across the County, five major folds are encountered, all of which trend northeast. The first of these is a shallow syncline on the crest of North Mountain, forming the Mehoopnay coal basin. The second is the Milton Anticline, which exposes the Portage group in the northwestern part of the County and gradually flattens out toward the northeast. The third and most pronounced is the Lackawanna Syncline, which originates in Lackawanna County to the north, and has preserved the post-Pottsville formations throughout the Wyoming Valley. The maximum depth of this syncline is reached in the vicinity of Wilkes-Barre and Plymouth. The double rim of this syncline is formed by the resistant Pottsville formation and Pocono sandstone, separated by the less resistant Mauch Chunk shale. The fourth fold is the Berwick (Montour) Anticline, which exposes a few feet of the Onondag formation in the vicinity of Beach Haven. This fold reaches its maximum development farther west and only the eastern portion reaches Luzerne County. The fifth major fold comprises a series of anticlines and synclines forming the Eastern Middle Anthracite Field in the vicinity of Hazleton. The synclinal basins in this region are relatively shallow and there are large areas from which all coalbeds have been eroded.

The general dips of the region vary from 0° to 40°, and the maximum dips are found on the rims and within the synclinal coal basins. The relatively soft Post-Pottsville beds in their cores are severely folded and

contorted with numerous minor faults. The northern and easternmost parts of the County border the Appalachian Plateau Province and are characterized by horizontal, or nearly horizontal strata. The Catskill continental group of rocks underlies those parts of Luzerne County that are outside of the five major folds.

2. Site Geology. The dam is situated on strata of the Pottsville formation of Pennsylvanian Age. The Pottsville formation in this area is composed of hard coarse quartz conglomerate, white and gray sandstone, brown sandstone, and a few thin seams of coal. This formation forms a ridge around the Wyoming Valley coal basin and is exposed around and between the coal areas near Hazleton. This formation has been folded into a large syncline forming the Wyoming Valley and into a series of smaller folds near Hazleton.

The available information indicates that the ends of the core-wall are founded on "solid conglomerate rock." Apparently most of the dam is founded on overburden. The available information pertinent to the foundation material is limited.

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GEOLOGIC MAP

MAY 1979 PLATE E-1