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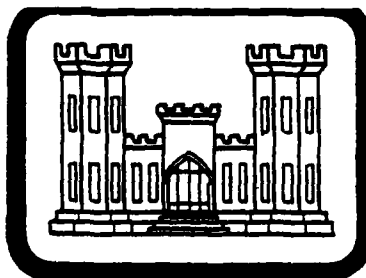
**SUSQUEHANNA RIVER BASIN
TRIBUTARY TO HUNLOCK CREEK, LUZERNE COUNTY**

**PENNSYLVANIA
NDS ID PA. 01063
DER ID 40-227**

GROOPS DAM

PHASE I INSPECTION REPORT NATIONAL DAM INSPECTION PROGRAM

WOODWARD-CLYDE CONSULTANTS
DACW31-80-C-0018



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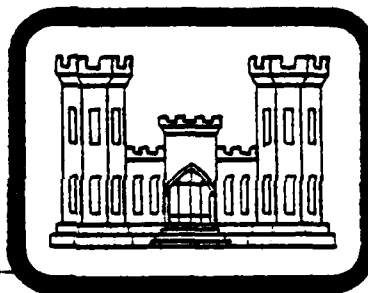
② National Dam Inspection Program
Croops Dam

SUSQUEHANNA RIVER BASIN
Tributary to Hunklock Creek,
~~CROOPS DAM~~, LUZERNE COUNTY,
PENNSYLVANIA

(NDS I.D. NO. PA 01063
JER I.D. NO. 40-227)

Number

PHASE I INSPECTION REPORT
~~NATIONAL DAM INSPECTION PROGRAM~~



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AUG 13 1980

15. DHCN31-84-C-0018

Prepared by:

WOODWARD-CLYDE CONSULTANTS
5120 Butler Pike
Plymouth Meeting, Pennsylvania 19462

Submitted to:

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

JUNE 1980

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of 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: Croops Dam
County Located: Luzerne County
State Located: Pennsylvania
Stream: Unnamed tributary to
Hunlock Creek
Coordinates: Latitude 41° 12.5'
Longitude 76° 5.6'
Date of Inspection: May 15, 1980

↙
Croops Dam is privately owned, and the reservoir is used for recreational purposes. The dam is currently in poor condition.

In accordance with criteria established by Federal (OCE) Guidelines, the recommended spillway design flood for this "Small" size dam and "Significant" hazard classification is the 100 Year Flood to one-half the Probable Maximum Flood (PMF). Based on the small capacity of the reservoir and the fact that no loss of life is likely during failure of the structure, the 100 year event has been selected as the spillway design flood.

Hydrologic and hydraulic computations presented in Appendix D indicate that the spillway structures are not capable of discharging the 100 year event without overtopping the embankment by about 1.18 feet for about 7.0 hours, assuming the spillways are not clogged. If the spillways are clogged by debris, the embankment is expected to be overtopped by 1.24 feet for greater than eight hours. The structure is considered to have an "Inadequate" spillway as it will not pass the spillway design flood without overtopping the embankment.

↘
It is recommended that the following measures be undertaken immediately. All work should be performed under the supervision of a registered professional engineer experienced in the design and construction of dams.

1. A detailed hydrologic/hydraulic study should be made and the spillway upgraded to meet current hydrologic/hydraulic criteria.

CROOPS DAM, NDS I.D. No. PA 01063

2. A study should be made to measure and evaluate the potential effects of excessive seepage and apparent piping of fine materials through the dam.
3. All trees and brush should be removed from the downstream face of the dam.

Because of the potential for property damage in the event of failure, a formal procedure of observation and warning during periods of high precipitation should be developed and implemented for this facility. This procedure could be coordinated with local authorities and should include a method of warning downstream residents that high flows are expected.

It is noted that formal operational and maintenance procedures should be developed and implemented. It should be noted that these procedures should include an inspection checklist, which would indicate a listing of items to be checked during each inspection and repaired as necessary to insure proper performance of the structure.

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Date

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7/1/80
Date

APPROVED BY:

James W. Beck

31 July 1980
Date



OVERVIEW
CROOPS DAM, LUZERNE COUNTY, PENNSYLVANIA

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
CROOPS DAM
NATIONAL ID NO. PA 01063
DER NO. 40-227

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 roject.

a. Dam and Appurtenances. Croops Dam is an approximately 26.4 foot high earth embankment across an unnamed tributary to Hunlock Creek. The approximately 250 foot long dam impounds an estimated 45 acre-foot reservoir with water surface at the top of dam within a 0.42 square mile drainage basin. The embankment appears to be constructed of earth fill, although numerous large boulders are visible in the downstream slope of the dam. The visible portion of the upstream slope of the dam was measured to be about 2H:1V above 753, and about 2.8H:1V between 753 and 751.8. The flatter slope appears to extend below the water line. The downstream slope is variable, ranging from 1.3H:1V to 2.1H:1V with nearly vertical slopes near the crest and at the toe near the right abutment. In general, slopes are steeper near the crest and toward the left end. The large boulders exposed at the downstream toe, together with boulders beyond the toe of the dam, prevent a definite delineation of the downstream toe. Elevation 731.1 is assessed to represent the minimum elevation at the downstream toe, and the height of the dam is measured from here. Low flow discharge from the principal spillway flows through the channel bed, forming a pool at 729.2. Elevations of the dam crest vary between 757.5 and 759.6, and the crest is 12 to 18 feet wide (Plate 3, Appendix E). A large outcrop of sandstone is at the left abutment of the dam. A private driveway crosses the dam to a house built on the left bank of the reservoir.

The principal spillway consists of a 14 inch diameter cast iron pipe riser and a 14 inch CIP conduit beneath the embankment at about the middle of the dam. The 14 inch diameter pipe extends about 45 feet upstream from the riser and has a gate valve at the upstream end, forming the pond drain. A fine mesh screen and trash bars over the riser pipe are shown in Photograph 1. The Owner reported that anti-seep collars were installed along the conduit. Photograph 2 shows the discharge of the spillway pipe at the downstream toe of the dam.

The overflow spillway consists of two 12 inch diameter cast iron pipes through the embankment approximately three feet below the crest (Photograph 3). The upstream invert of these pipes is at about elevation 754.8, and the pipes discharge directly on the downstream face of the dam.

b. Location. The dam is located approximately one mile west of the confluence of Hunlock Creek with the Susquehanna River in Hunlock Township, Luzerne County, Pennsylvania. The dam site and reservoir are shown on USGS Quadrangle entitled "Nanticoke, Pennsylvania" at coordinates N 41° 12.5' W 76° 5.6'. A regional location plan is enclosed as Plate 1, Appendix E.

c. Size Classification. The dam is classified as a "Small" size structure by virtue of its 26.4 foot height and estimated 45 acre-foot total storage capacity.

d. Hazard Classification. A "Significant" hazard classification is assigned consistent with the potential for appreciable property damage, but with few or no lives lost.

e. Ownership. The dam is owned in trust by the Stanley C. Croop estate. All correspondence should be addressed to Mrs. Stanley Croop, Post Office Box 184, Hunlock Creek, Pennsylvania 18621.

f. Purpose of Dam. The dam and reservoir were constructed for recreational purposes.

g. Design and Construction History. Croops Dam was built about 1958, and drawings, specifications or other documents are not available. The late Mr. Russell Worall of Wilkes Barre, Pennsylvania, provided design assistance for this dam. Photographs in the Owner's possession indicated that the 14 inch spillway pipe was placed in a bulldozed swale at the base of the dam embankment. Soil and rock materials were then apparently bulldozed from the reservoir area outward towards the downstream face of the dam. It then appeared from the photographs that embankment fill was bulldozed in nearly

horizontal lifts. Reportedly, before constructing the embankment, the area was excavated to the rock surface and replaced with compacted fill. Sheet metal cutoffs were reportedly installed on the discharge pipe beneath the embankment.

The dam was overtopped by Tropical Storm Agnes in 1972, and breaching occurred at about the midpoint of the embankment. The crest was lowered to about the normal pool level. The breach area was refilled to obtain the present configuration of the dam.

h. Normal Operating Procedures. Under normal operating procedures, all water flows into the riser pipe and through the 14 inch cast iron pipe beneath the embankment.

1.3 Pertinent Data.

A summary of pertinent data for Croops Dam and reservoir are presented as follows.

a.	Drainage Area (square miles)	0.42
b.	Discharge at Dam Site (cfs)	
	Maximum Spillway Capacity	23
	Maximum Flood	Unknown
	Minimum Required Flow	None
c.	Elevations (feet above MSL) ⁽¹⁾	
	Top of Dam	
	Minimum Existing Crest	
	Elevation	757.5
	Principal Spillway Weir Crest	
	(normal pool)	753.2±
	Pond Drain Upstream Invert	Unknown
	Downstream Invert	735.2
	Overflow Spillway	
	Upstream Invert	754.8
	Downstream Invert	754.2 and 753.8
	Downstream Toe	731.1
	Downstream Water Surface	
	(water flows through rocks	
	forming channel bed)	729.2
d.	Reservoir (feet)	
	Length at Normal Pool	900
	Length at Maximum Pool	930

(1) Left abutment elevation assumed to be 760 from USGS map. All other elevations are relative to this elevation.

e.	Storage (acre-feet)	
	Normal Pool (estimated)	23
	Top of Dam (estimated)	45
f.	Reservoir Surface (acres)	
	Normal Pool	4
g.	Dam Data	
	Type	Earth/rock fill
	Length	250 feet
	Height	26.5 feet
	Crest Width	12 to 18 feet
	Side Slopes	
	Upstream	
	To 753.2	2H:1V
	Between 753.2 and 751.8	2.85H:1V
	Downstream	Varies from 1.3H:1V to 2.1H:1V
	Volume	8,800 cubic yards
	Cutoff	None known
	Grout Curtain	None known
h.	Principal Spillway	
	Type	14 inch CIP riser & 14 inch CIP conduit
	Location	Embankment midpoint
	Length (estimate)	150 feet
	Discharge Channel	Discharges at downstream toe
	Weir Crest	753.2± feet
	Outlet Invert	735.2 feet
	Pond Drain	
	Type	14 inch extension of principal spillway conduit, gated at upstream end
	Length	45-50 feet upstream of riser
	Outlet	Through principal spillway conduit
i.	Overflow Spillway	
	Type	Two 12 inch CIP
	Upstream Invert	754.8
	Downstream Invert	753.8 and 754.2

SECTION 2 ENGINEERING DATA

2.1 Design.

a. Availability. There are no engineering data available for Croops Dam. Documents upon which this report are based consist of the photographs in the Owner's possession.

b. Design Features. A plan view, section and an elevation profile of this dam are presented in Appendix E. A summary of the design features as determined from this inspection is included in Section 1.3.

2.2 Construction.

Nothing is known concerning construction beyond the information presented in Section 1.2, paragraph g.

2.3 Operational Data.

There are no operational records maintained for this dam.

2.4 Evaluation.

a. Availability. All information presented herein was obtained from conversations with the Owner's representative and from photographs in the Owner's possession.

b. Adequacy. The available data are not adequate to evaluate the engineering aspects of this dam.

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

SECTION 3 VISUAL INSPECTION

3.1 Findings.

a. General. The observations and comments of the field inspection team are contained in the checklist enclosed herein as Appendix A and are summarized and evaluated in the following subsections. In general, the appearance of the facilities indicates that the dam is currently in poor condition and not well maintained.

b. Dam. The vertical alignment of the dam crest was checked and, as shown on Plate 3, Appendix E, crest elevations range from 757.6 to 759.6. A private road crosses the crest, and the elevation of the crest increases toward each end, allowing surface runoff to flow along vehicle tracks, ponding at the embankment low points. Small channels were recently dug to the upstream and downstream faces of the dam to drain the ponded area, and fill was placed in the depressions. At another location on the dam crest (Photograph 6), water was ponded from recent rainstorms.

The upstream face of the dam above the water level is grassed and has an average measured slope of about 2H:1V. The slope is benched at the normal pool elevation (753), and the slope between 753 and 751.8 is about 2.8H:1V. Stone is on the embankment face both above and below the waterline. As stone was not reported placed on the embankment, exposed stone is probably fill material.

The downstream face has variable slopes ranging from near vertical to 2.1H:1V. Nearly vertical slopes are near the crest and have been caused, at least in part, by erosion. The toe near the right abutment is nearly vertical and formed by rock. In general, the slopes are steeper near the crest and toward the left end.

The downstream face is heavily grown with brush and trees up to six inches in diameter. Some of this vegetation, particularly near the right abutment was recently cut down. An area, approximately 20 feet along the length of the dam, to the left of the dam center on the downstream crest face, has the appearance of a recent landslide. Two smaller areas to the left of the 20 foot area appear to have resulted from erosion. Surficial materials on the lower portion of the downstream dam face are large stones and boulders, some of which are shown in Photographs 2 and 10. Surficial materials near the crest are predominantly soil and show evidence of

erosion. In the vicinity where erosion as the result of overtopping was reported, stones are also exposed, as shown in Photograph 9.

There is considerable seepage at the toe of the embankment immediately to the left of the principal spillway outlet. The seepage exits the dam from an area containing boulders at a higher elevation than the spillway pipe. Flow from this seepage is estimated to be equal to, if not greater than, flow through the spillway and at a rate of about 200 gallons per minute. Although the seepage appears to be clear, silty fine sand has accumulated on the rocks at the toe of the dam.

c. Appurtenant Structures.

The overflow spillway facilities for the dam are the two 12 inch diameter pipes through the dam approximately three feet below the crest. The pipes project at least eight feet beyond the dam crest and discharge directly on the downstream face (Photograph 4). The outlets of both pipes are at a lower elevation than the inlets.

The principal spillway through which the reservoir level is maintained is underwater, except for the fine mesh screen and reinforcing bar trash rack on top of the riser (Photograph 1). This screen is frequently clogged with leaves and brush after storms. The pond drain control is underwater and requires a boat and valve key to operate it. The gate valve was reported last operated two to three years prior to the inspection. A subsequent visit to the site disclosed the Owner had lowered the reservoir level over one foot by opening the gate valve in an effort to locate the source of seepage. The gate valve reseated completely.

d. Reservoir. Reservoir side slopes are moderate to steep and vegetated with trees, grass and brush to the water's edge. No large debris was observed in the reservoir. However, leaves and small brush were seen which could be washed into the reservoir and clog the riser pipe and overflow pipes. A small amount of sediment was observed at the upper end of the lake, but is not expected to have any influence upon the flood storage capacity of the lake. The surface area of the reservoir is estimated to be four acres from the current USGS map.

e. Downstream Channel. Spillway discharge and seepage through the dam disappear into a rock channel and reappear about 40 feet downstream. The downstream channel is rocky with a gradient greater than 0.2 that, at a distance of several hundred feet from the dam, decreases to about 0.025.

This channel appears to be in good condition, with moderate to heavy woods on the channel banks.

There are no structures between the dam and Hunlock Creek, approximately 1,700 feet below the dam. For approximately 0.8 mile along Hunlock Creek there are several garages and a shed that may be damaged in the event of dam failure. About one mile farther downstream, Hunlock Creek flows into the Susquehanna River.

3.2 Evaluation.

Inspection of the dam and appurtenant facilities indicates that little routine maintenance has been provided to the structure. The visual survey of the dam disclosed areas of erosion and the slide area on the downstream edge near the crest. Also detrimental to the stability of the embankment is the excessive seepage and possibility of piping. There are no records of previous inspections of this dam and its seepage. Therefore, an assessment cannot be made concerning the changes in seepage, and the dam is considered to be in poor condition.

The principal spillway and overflow pipes are assessed to be in good condition. However, the discharge of the overflow pipes directly onto the downstream face of the dam is assessed to be a detrimental situation.

SECTION 4 OPERATIONAL PROCEDURES

4.1 Procedures.

Normal conditions do not require a dam tender. All flow is discharged through the riser pipe and pipe beneath the dam. It is unknown if any minimum downstream flow is required.

4.2 Maintenance of the Dam.

Maintenance of the dam is provided by the Owner's son. There is little evidence of routine maintenance of this structure.

4.3 Maintenance of Operating Facilities.

Maintenance of operating facilities is provided by the Owner's son. The screen over the riser pipe is cleaned as necessary. The discharge valve from the dam was operated two or three years ago.

4.4 Warning Systems In Effect.

There are no formal warning systems or procedures established to be followed during periods of exceedingly heavy rainfall. It was stated that if there is reason to fear for the safety of the dam, the state police and local fire department would be notified.

4.5 Evaluation.

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

In conclusion, it is noted that formal operational, maintenance and warning procedures should be developed and implemented. It should be noted that these procedures should include an inspection checklist, which would indicate a listing of items to be checked during each inspection and repaired as necessary to insure proper performance of the structure.

Since a formal warning procedure does not exist, one should be developed and implemented during periods of extreme rainfall. This procedure should consist of a method of notifying residents downstream that potentially high flows are imminent or dangerous conditions are developing.

SECTION 5 HYDROLOGY/HYDRAULICS

5.1 Evaluation of Features.

a. Design/Evaluation Data. There are no original design data or subsequent evaluation data available for Croops Dam. The small mountaintop watershed is approximately 80 percent wooded with only scattered residential development. The watershed is about 5,000 feet long and averages about 2,500 feet wide, having a total area of 0.42 square mile. Elevations range from a high of 1,400 feet in the upper reaches to the normal pool elevation of about 753 feet. The runoff characteristics of the watershed are not expected to change significantly in the near future.

In accordance with criteria established by Federal (OCE) Guidelines, the recommended spillway design flood for this "Small" size dam and "Significant" hazard classification is the 100 Year Flood to one-half the Probable Maximum Flood (PMF). Based on the small capacity of the reservoir and the fact that no loss of life is likely during failure of this structure, the 100 Year event has been selected as the spillway design flood.

b. Experience Data. No reservoir level records or rainfall records are maintained for this dam by the Owner. During Tropical Storm Agnes, 1972, the embankment was overtopped and breached to an elevation approximating the normal pool level. The closest National Weather Service rain gauging station is in Wilkes Barre, where consecutive 24 hour rainfall readings of 2.27 inches and 2.62 inches were recorded in June 1972. Debris had partially blocked both the riser and the overflow pipes, contributing to the overtopping of the embankment.

c. Visual Observations. At the time of the inspection, the only condition observed that would indicate a reduced spillway capacity during an extreme event is the small size of the riser and overflow pipes. The surrounding watershed is wooded, thus small debris is available to be washed into the reservoir and clog the pipes. Other observations regarding the condition of the downstream channel, spillway and reservoir are located in Appendix A and discussed in greater detail in Section 3.

d. Overtopping Potential. The overtopping potential of this dam was estimated using the HEC-1, Dam Safety Version, computer program. A brief description of the program is

included in Appendix D. Calculations for this investigation indicate a peak 100 year inflow of 627 cfs. This value was compared to 580 cfs, the value determined according to procedures in the "Hydrologic Study - Tropical Storm Agnes", December 1975, prepared by the Department of the Army, North Atlantic Division, Corps of Engineers. The difference in the two values is about eight percent, within the required accuracy for this investigation. The peak discharge from both the riser and the overflow spillways is estimated to be 23 cfs with the reservoir level at the minimum elevation of the dam. Routing the 100 year event through the reservoir results in a 1.18 foot overtopping of the dam for about seven hours. The storm was then routed through the reservoir assuming that all spillways were clogged with debris, which resulted in the dam being overtopped by about 1.24 feet for about 8.5 hours.

e. Spillway Adequacy. The spillway for this structure is considered to be "Inadequate" as it will not pass the spillway design storm without overtopping the embankment.

f. Downstream Conditions. Discharge from Croops Dam flows about 1,700 feet through a wooded valley before joining Hunlock Creek. About 600 feet downstream of the confluence of Croops Dam discharge and Hunlock Creek, a township building and garage are built on a filled area in the floodplain. These structures were reported not to be flooded during Tropical Storm Agnes in June 1972. About 1,200 feet farther downstream, Hunlock Creek flows under a bridge where garages and sheds could be damaged in the event of dam failure, but the first floor of the house is about 12 feet above the stream bank. About 2,200 feet farther downstream, Hunlock Creek flows under a highway. A nearby home owner reported that his house was not flooded during Tropical Storm Agnes and had no water in its basement. About a mile farther downstream, Hunlock Creek enters the Susquehanna River. Failure of Croops Dam could result in property damage, but loss of life is not envisioned. Therefore, a "Significant" hazard potential classification is justified.

SECTION 6 STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. Visual observations indicated evidence of potential embankment instability which would result from overtopping or a piping failure of the dam. There are localized erosion features visible on the downstream face of the dam that are assessed to not presently have a serious influence on the stability of the dam. The excessive amount of seepage through the dam, together with evidence of piping, cannot be considered to represent a stable condition as there are no records to provide a basis of evaluation. The downstream slope of the dam is covered with brush and trees up to six inches in diameter. The embankment is judged to be in poor condition.

The outlet facilities are judged to be in good condition. However, these may be readily clogged with leaves and brush during periods of storm discharge from the dam. The overflow pipes from the dam discharging a vertical fall of water onto the downstream slope of the dam are judged to be a potentially detrimental feature.

b. Design and Construction Data. No design or construction data are known to exist, other than the photographs in the Owner's possession. Data concerning the physical features of the dam were obtained from these photographs and by visual observations.

c. Operating Procedures. No operating procedures currently exist.

d. Post-Construction Changes. Post-construction changes appear to have been limited to filling in of the erosion that occurred following overtopping during Tropical Storm Agnes in 1972.

e. Embankment Stability. There were no embankment stability evaluations available. Based on the visual observation, the dam appears to be stable at the present time, provided overtopping does not occur and seepage conditions do not change.

f. 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. Since the dam is qualitatively assessed to be stable at the present time under static loading conditions, it can also reasonably be considered to be stable under seismic loading conditions.

SECTION 7 ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Evaluation. Visual inspection indicates that Croops Dam is in poor condition, and the spillway systems, although greatly undersized, are in good condition.

In accordance with criteria established by Federal (OCE) Guidelines, the recommended spillway design flood for this "Small" size dam and "Significant" hazard classification is the 100 Year Flood to one-half the Probable Maximum Flood (PMF). Based on the small capacity of the reservoir and the fact that no loss of life is likely during failure of the structure, the 100 year event has been selected as the spillway design flood.

Hydrologic and hydraulic computations presented in Appendix D indicate that the spillway structures are not capable of discharging the 100 year event without overtopping the embankment by about 1.18 feet for about seven hours, assuming the spillways are not clogged. If the spillways are clogged by debris, the embankment is expected to be overtopped by 1.24 feet for greater than eight hours. The structure is considered to have an "Inadequate" spillway as it will not pass the spillway design flood without overtopping the embankment.

b. Adequacy of Information. The combined visual inspection and simplified calculations presented in Appendix D were sufficient to indicate that further investigations are required for this structure.

c. Urgency. It is recommended that the measures presented in Section 7.2 be implemented as specified.

7.2 Remedial Measures.

a. Facilities. It is recommended that the following measures be undertaken immediately. All work should be performed under the supervision of a registered professional engineer experienced in the design and construction of dams.

1. A detailed hydrologic/hydraulic study should be made and the spillway upgraded to meet current hydrologic/hydraulic criteria.

2. A study should be made to measure and evaluate the potential effects of excessive seepage and apparent piping of fine materials through the dam.
3. All trees and brush should be removed from the downstream face of the dam.

b. Operation and Maintenance Procedures. Because of the potential for property damage in the event of failure, a formal procedure of observation and warning during periods of high precipitation should be developed and implemented for this facility. This procedure could be coordinated with local authorities and should include a method of warning downstream residents that high flows are expected.

It is noted that formal operational and maintenance procedures should be developed and implemented. It should be noted that these procedures should include an inspection checklist, which would indicate a listing of items to be checked during each inspection and repaired as necessary to insure proper performance of the structure.

APPENDIX

A

CHECK LIST
VISUAL INSPECTION
PHASE I

Sheet 1 of 11

Name Dam Croops Dam County Lucerne State Pennsylvania National ID # PA 01063
Type of Dam Earth/rock Hazard Category Significant
Date(s) Inspection 5/15/80 Weather Partly sunny Temperature 60's

Pool Elevation at Time of Inspection 753.4 M.S.L. Tailwater at Time of Inspection 729.2 M.S.L.

Inspection Personnel:

Mary F. Beck (Hydrologist) Vincent McKeever (Hydrologist)
Raymond S. Lambert (Geologist) John Frederick (Geotechnical)
Richard E. Mabry (Geotechnical/Civil)
Mary F. Beck Recorder

Remarks:

Mr. James Croop, the Owner's representative and Mr. John Chermesky, from the Wilkes Barre

DER office, were on site.

CONCRETE/MASONRY DAMS

Sheet 2 of 11

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

Sheet 3 of 11

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.

UNUSUAL MOVEMENT OR
CRACKING AT OR BEYOND
THE TOE

None observed.

SLOUGHING OR EROSION OF
EMBANKMENT AND ABUTMENT
SLOPES

Erosion of downstream slope resulted from overtopping of the embankment in 1972. Dam crest serves as access road to house and surface runoff from road also flows over the downstream edge.

VERTICAL AND HORIZONTAL
ALIGNMENT OF THE CREST

See Sheet 5A and Plate 3.

RIPRAP FAILURES

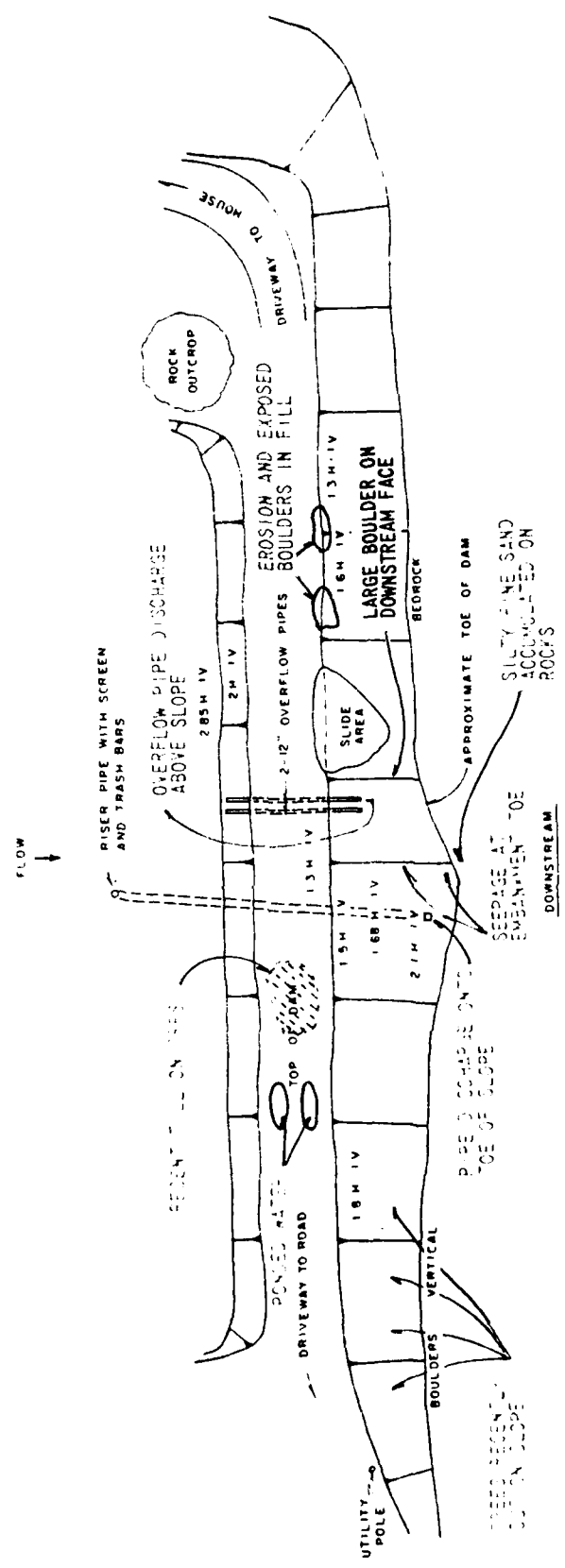
No riprap. Stone is at embankment surface both above and below waterline. As stone was not reported placed on embankment, exposed stone is probably fill material.

EMBANKMENT

Sheet 5 of 11

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
Vegetation	Embankment slopes are covered with grass and vegetation including briars, ferns, weeds, and trees. Trees on upstream slope have been cut. Trees on downstream slope are being cut.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	All abutment and embankment junctions are in good condition with no gullying observed.	
ANY NOTICEABLE SEEPAGE	Yes, volume of seepage is estimated to be greater than discharge through spillway. See Sheet 5A of 11.	
STAFF GAGE AND RECORDER	None.	
DRAINS	None located.	

FIELD OBSERVATION PLAN
CROOPS DAM
SHEET 5A OF 11



SCALE IN FEET
0 10 30

OUTLET WORKS

Sheet 6 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	N/A	
INTAKE STRUCTURE		A 14-inch steel riser located about 30 feet upstream of crest.
OUTLET STRUCTURE		None. 14-inch steel pipe discharges directly into channel at downstream toe.
OUTLET CHANNEL		Rock channel at toe appears stable. Discharge from outlet pipe and seepage disappears into channel and reappears about 40 feet downstream.
EMERGENCY GATE		About 45 to 50 feet upstream of the riser is a gate valve which is completely underwater.

UNGATED SPILLWAY

Sheet 7 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

CONCRETE WEIR	None, ungated spillway consists of two 12-inch cast iron pipes laid through the embankment. With no trash rack, the pipes are subject to clogging by small debris.	
---------------	--	--

APPROACH CHANNEL	None.	
------------------	-------	--

DISCHARGE CHANNEL	None. Overflow pipes discharge directly on downstream embankment.	
-------------------	---	--

BRIDGE AND PIERS	None.	
------------------	-------	--

GATED SPILLWAY

Sheet 8 of 11

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

INSTRUMENTATION

Sheet 9 of 11

<u>VISUAL EXAMINATION</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
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 moderate to steep and vegetated to water's edge with trees or grass. No large debris was noted, but small branches and leaves were noted which could block the screen over the riser or overflow pipes.

SEDIMENTATION

*There is a small amount of sediment at upper end of reservoir.
Sedimentation has little or no effect on flood water storage.*

DOWNSTREAM CHANNEL

Sheet 11 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

CONDITION
(OBSTRUCTIONS,
DEBRIS, ETC.)

The rocky channel appears in good condition.

SLOPES

The valley gradient immediately below the dam is greater than 0.2 decreasing to about 0.025.

APPROXIMATE NO.
OF HOMES AND
POPULATION

There are no structures between the dam and Hunlock Creek, a distance of about 1700 feet. In the next 0.8 mile along Hunlock Creek are several garages and sheds that may be damaged in the event of dam failure but no occupied houses are expected to be damaged.

APPENDIX

B

NAME OF DAM Croops Dam
 ID # PA 01063

Sheet 1 of 4

CHECK LIST
 ENGINEERING DATA
 DESIGN, CONSTRUCTION, OPERATION
 PHASE I

REMARKS

None

ITEM

AS-BUILT DRAWINGS

REGIONAL VICINITY MAP

See Plate 1, Appendix E

CONSTRUCTION HISTORY

See Text, Section 1.2

TYPICAL SECTIONS OF DAM

See Appendix E

OUTLETS - PLAN

DETAILS

CONSTRAINTS

DISCHARGE RATINGS

RAINFALL/RESERVOIR RECORDS

See Appendix E

See Appendix D

No rainfall or reservoir records

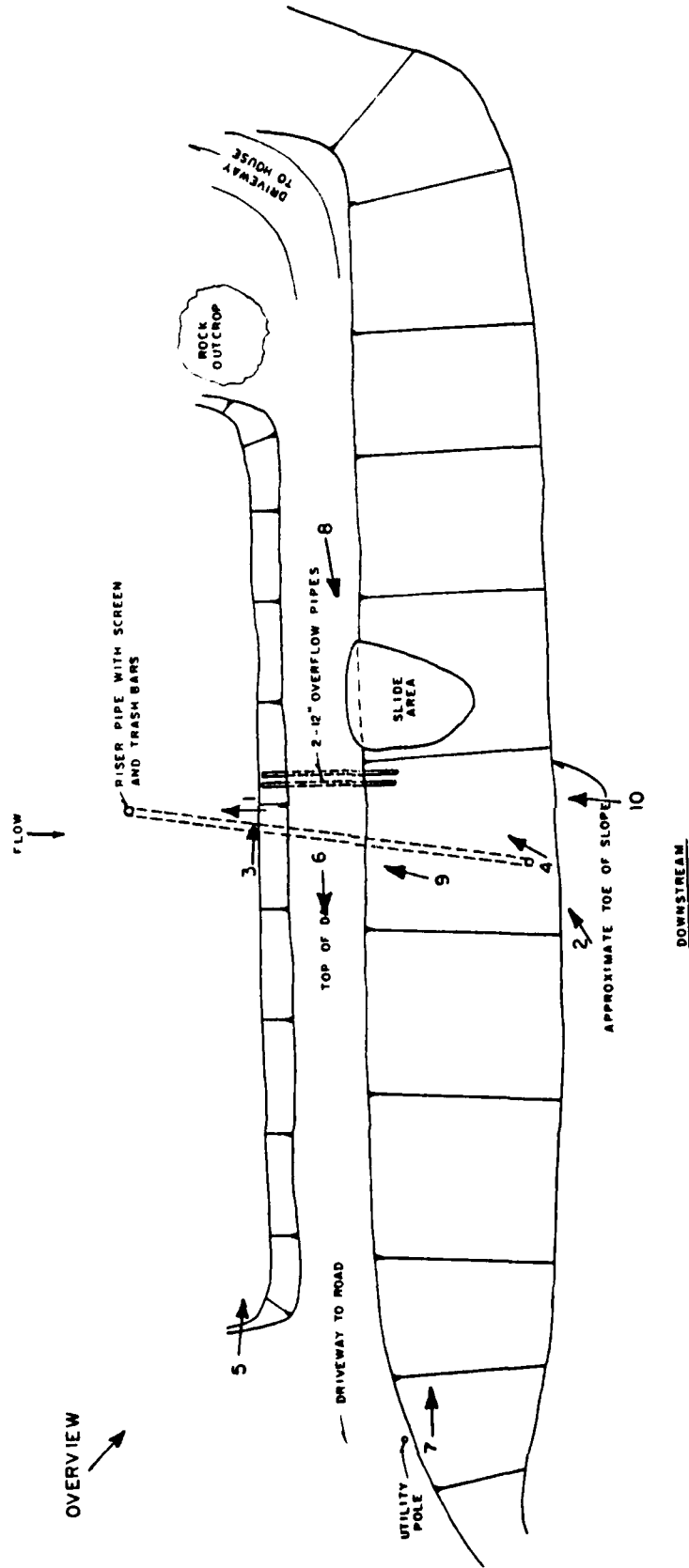
ITEM	REMARKS
DESIGN REPORTS	None
GEOLOGY REPORTS	See Appendix F
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None
POST-CONSTRUCTION SURVEYS OF DAM	None
BORROW SOURCES	Embankment materials obtained from present reservoir bottom

ITEM	REMARKS
MONITORING SYSTEMS	None
MODIFICATIONS	None
HIGH POOL RECORDS	None
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	Yes - See Text
MAINTENANCE OPERATION RECORDS	None

ITEM	REMARKS
SPILLWAY PLAN	<i>See Appendix E</i>
SECTIONS	
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	<i>None</i>

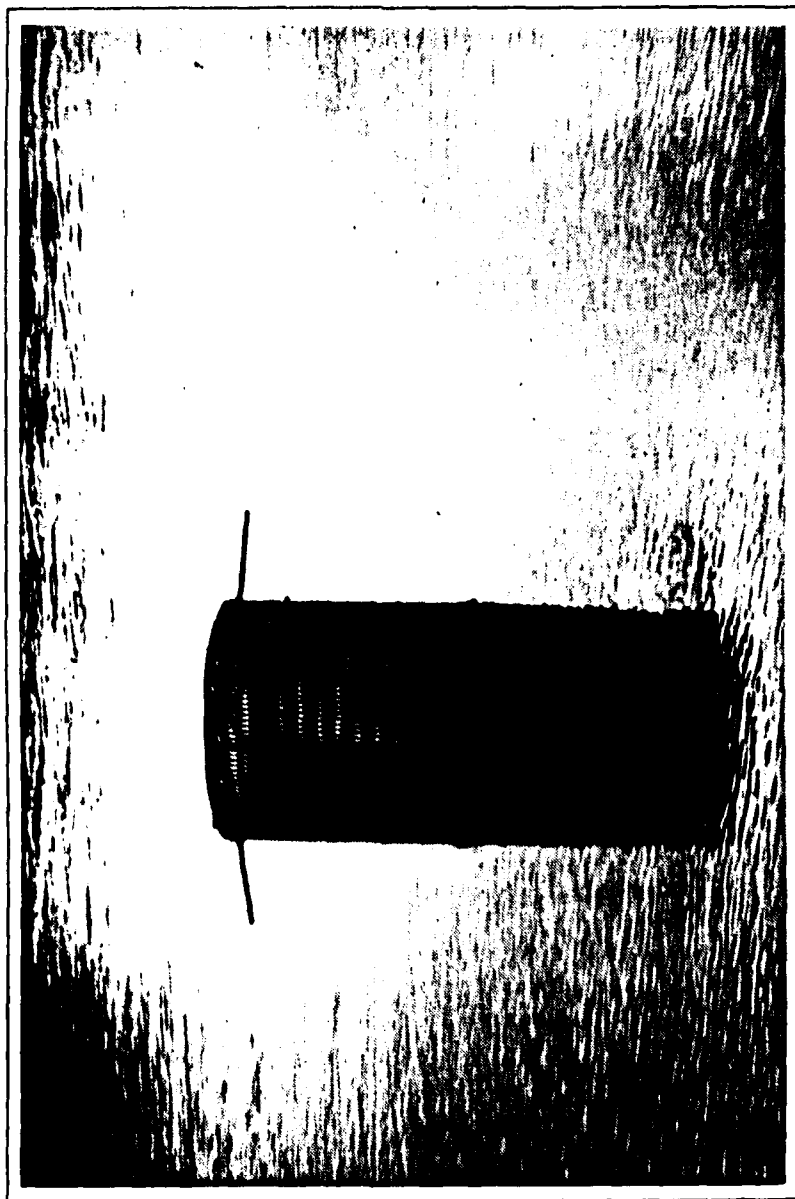
APPENDIX

C



SCALE IN FEET
0 10 20 30

PHOTOGRAPH LOCATION PLAN
CROOPS DAM
PLATE C-1



SPILLWAY INTAKE SCREEN.

PHOTOGRAPH NO. 1



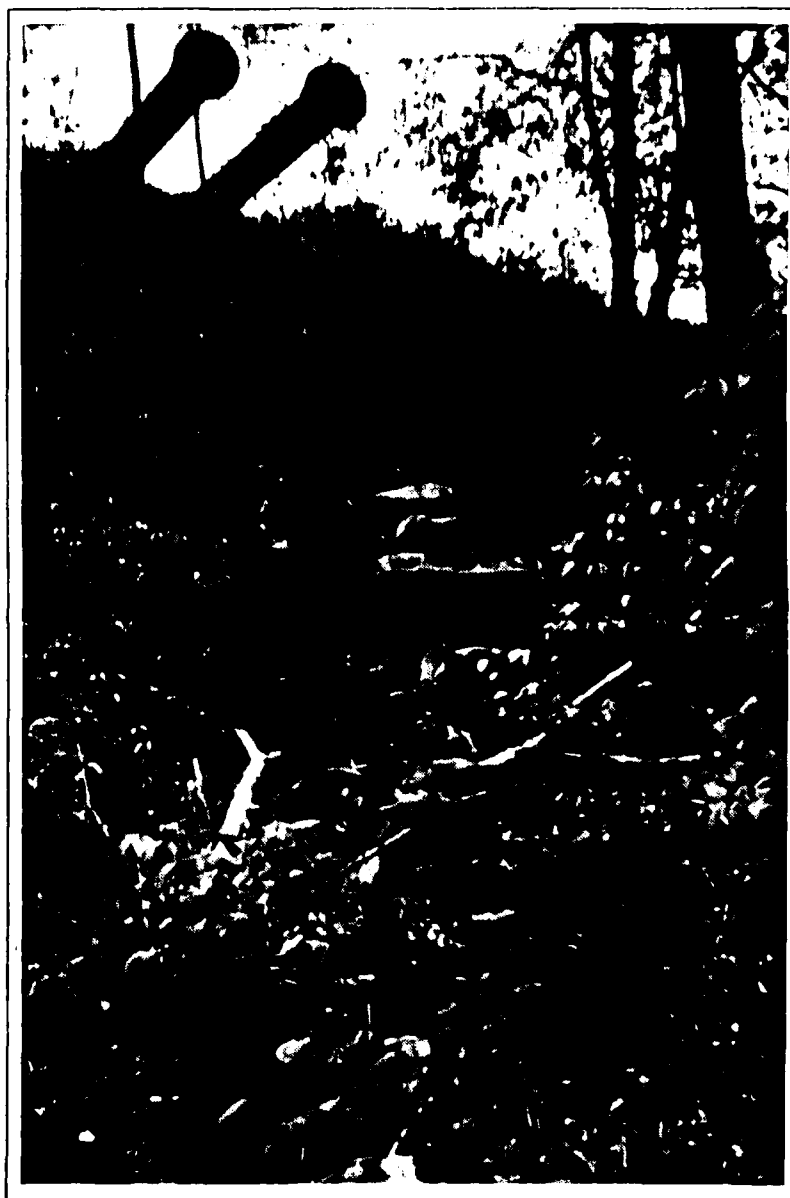
FOURTEEN INCH SPILLWAY PIPE
DISCHARGES AT DOWNSTREAM TOE.

PHOTOGRAPH NO. 2



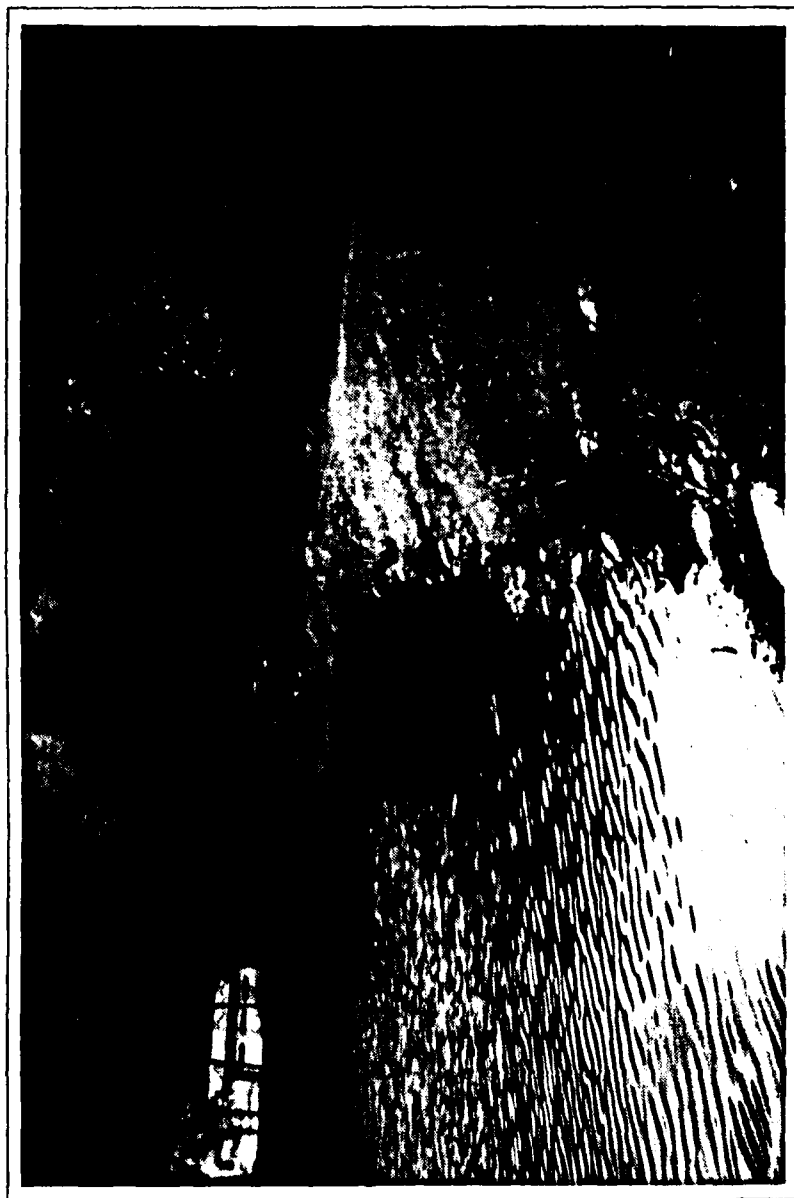
EMERGENCY SPILLWAY PIPES-INTAKE
AT UPSTREAM CREST.

PHOTOGRAPH NO. 3



EMERGENCY SPILLWAY PIPES-
DISCHARGE ABOVE DOWNSTREAM
SLOPE.

PHOTOGRAPH NO. 4



VIEW OF UPSTREAM SLOPE OF DAM



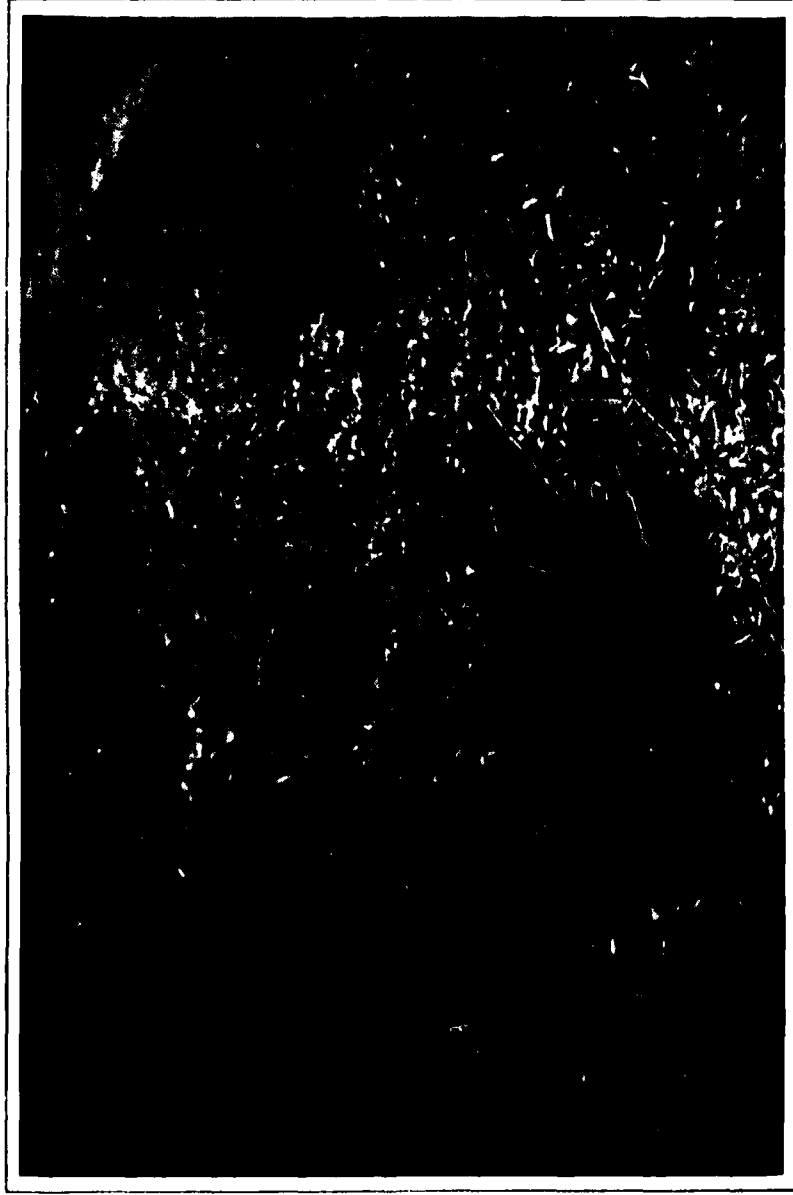
DAM CREST SHOWING PONDED
WATER.

PHOTOGRAPH NO. 6



DOWNSTREAM SLOPE OF DAM SHOWING
PARTIAL BRUSH AND TREE CUTTING.

PHOTOGRAPH NO. 7



EROSION AREA ON DOWNSTREAM SLOPE
OF DAM. RECENTLY FILLED AREA OF
DAM CREST IN BACKGROUND.

PHOTOGRAPH NO. 8

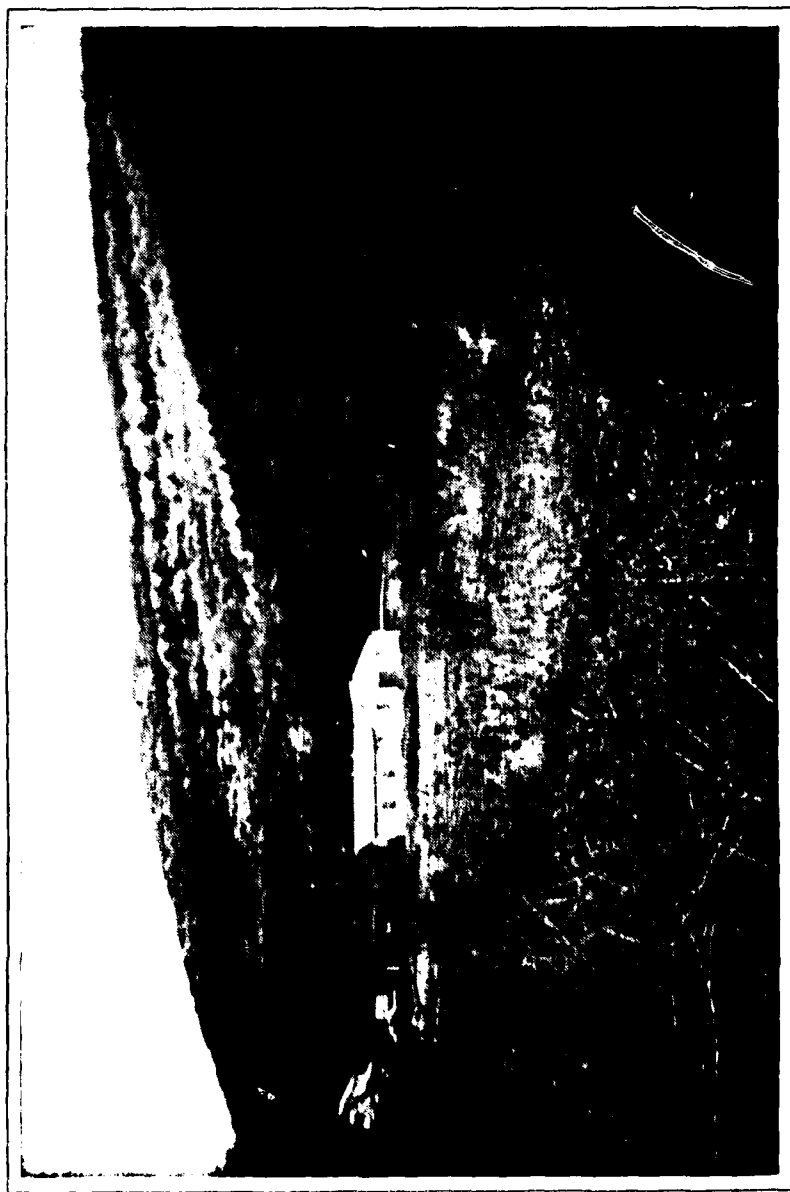


DOWNSTREAM SLOPE NEAR CREST WHERE
OVERTOPPING OCCURRED.

PHOTOGRAPH NO. 9



DOWNSTREAM TOE SHOWING SEEPAGE
AREA TO LEFT OF SPILLWAY OUTLET.



TOWNSHIP BUILDING IN FLOOD PLAIN OF
HUNLOCK CREEK.



RESIDENTIAL AREA DOWNSTREAM WHERE
ROAD CROSSES HUNLOCK CREEK.

APPENDIX

D

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATADRAINAGE AREA CHARACTERISTICS: Small, mountainous, 80% wooded, very little residential development.ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 753.2 feet (23 Acre-Foot)ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 757.5 feet (45 Acre-Foot)ELEVATION MAXIMUM DESIGN POOL: ---ELEVATION TOP DAM: 757.5 feet

OVERFLOW SPILLWAY

a. Elevation 754.8± feetb. Type 2 12-inch conduitsc. Width N/Ad. Length 37± feete. Location Spillover Near midpointf. Number and Type of Gates None

OUTLET WORKS:

a. Type 14-inch riser and conduit through damb. Location At maximum sectionc. Entrance inverts 753.2± feet.d. Exit inverts 735.2 feete. Emergency draindown facilities Pond drain at base of riser

HYDROMETEOROLOGICAL GAGES:

a. Type None within watershedb. Location N/Ac. Records N/AMAXIMUM NON-DAMAGING DISCHARGE: Not determined

BY MFB DATE 6/9/80 SUBJECT Croops Dam SHEET 2 OF 10
CHKD. BY DATE Hydrology / Hydraulics JOB No.

Hydrologic Base Data

Drainage Area - 0.42 sq. miles measured from USGS map.

100yr. event Rainfall - Ref. Technical Paper 40.

30 min.	2.2 inches
1 hr.	2.75
2 hr.	3.4
3 hr.	3.6
6 hr.	4.5
12 hr.	5.5
24 hr.	6.4

Soil Conservation Hydrograph Parameters

Runoff Curve Number 7.5
Watershed Lag 0.36

Spillway Capacity at Maximum Water Level - 231 cfs.

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 Quandrangle 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 input 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.

BY MEB DATE 6/9/80
CHKD. BY RLM DATE 6/11/80

SUBJECT Crooks Dam
Hydrology / Hydraulics

SHEET 4 OF 10
JOB No. _____

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

1. The hazard classification is rated as "Significant" as there would be appreciable economic loss with few or no lives lost in the event of failure of the dam.
2. The size classification is "Small" based on its 265 ft. height and less than 1000 Ac-Ft. total storage capacity.
3. The selected spillway design flood, based on size and hazard classification, is the 100yr. event.

Hydrology and Hydraulic Analysis.

1. No original data or subsequent evaluation data is known to exist.

2. Evaluation Data.

Rainfall and Soil Conservation Service Hydrograph parameters are shown on sheet 2.

The value of the peak inflow was checked against the value of the 100yr inflow determined by procedures contained in "Hydrologic Study - Tropical Storm Agnes" by the Corps of Engineers, December 1975.

$$\log(Q_m) = C_m + 0.75 \log(A)$$

where $C_m = 2.8$ from fig. 21
 $A = 0.42$ sq. miles from USGS map.

$$\log(Q_m) = 1.717$$

$$S = C_s - 0.05 \log(A)$$

$C_s = 0.38$ from fig. 22

$$S = 0.399$$

$$g = +0.4 \text{ from fig. 23}$$

$$\log(Q_{100}) = \log(Q_m) + K(P_g) \cdot S$$

$K(P_g) = 2.62$ Pearson Type III Distribution
(Standard Table found in most Hydrology Texts)

$$\log(Q_{100}) = 1.717 + 2.62 \cdot 0.399$$
$$= 2.76$$
$$Q_{100} = 579 \text{ cfs}$$

BY RAW DATE 6/27/80
MEB DATE 6/9/80
 CHKD. BY REM DATE 6/4/80

SUBJECT Croops Dam
Hydrology / Hydraulics

SHEET 5 OF 10
 JOB No. _____

Elevation-storage Data. Areas were measured from USGS map. Normal pool (753.2) = 4 Ac.
 760 ft. contour = 7.6
 780 ft. contour = 10.8

Computer program computes volume.

Elevation-discharge Data.

Flows at low head, $Q = CLH^{3/2}$
 where $C = 3.1$

$$L = \pi D = 3.66 \text{ ft.}$$

H measured from 753.2 ft.

Flow at larger heads, $Q = aV$

a = area of 14" pipe.

V determined from:

$$H = \frac{V^2}{2g} (1 + K_e + K_p L)$$

where H is measured from 735.9 ft. of outlet

K_e = entrance loss, assumed 0.9

K_p = 0.0339, ref. SCS Nat. Eng. Handb'k,

$L \sim 130 \text{ ft.}$

Section 5

Flow thru overflow pipes estimated from culvert under inlet control, ref. SCS Nat. Eng. Handb'k, Section 4

W.S.	Principal Spillway				Overflow Spillway		Q
	Weir Control	Pipe Control			H	$Q \times 2 =$	
	H	Q	H	Q			
753.2	0						0
754.2	1	11	18.3	12.5		0	11
755.2	2	32	19.3	12.9	0.4	7.0	13
756.2			20.3	13.2	1.4	$3 \times 2 = 6$	19
757.2			21.3	13.5	2.4	$4.5 \times 2 = 9$	22
758.2			22.3	13.8	3.4	$5.5 \times 2 = 11$	25
759.2			23.3	14.1	4.4	$6.3 \times 2 = 12.6$	27
760.2			24.3	14.4	5.4	$7.5 \times 2 = 15$	29
761.2			25.3	14.7	6.4	$8.1 \times 2 = 16.8$	32

BY MFB DATE 6/9/80
CHKD. BY REM DATE 6/11/80

SUBJECT Creeps Dam
Hydrology / Hydraulics

SHEET 6 OF 10
JOB No. _____

- 3 Results of computer analysis. The peak inflow (Q_{max}) calculated by the HEC-1 program is 627 cfs, within 8% of the value computed above. The program indicates the dam will be overtopped by the 100yr event by about 1.18 ft. for 7.0 hours. The computer program was rerun with a reduced spillway capacity, assuming the small pipes blocked with debris. The dam would be overtopped by 1.24 ft. for 8.5 hours.
- 4 Spillway Adequacy - the spillway is considered "Inadequate" as it will not pass the selected spillway design flood without overtopping the embankment.

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

SHEET 7 OF 10

RUNOFF HYDROGRAPH AT IN
ROUTE HYDROGRAPH TO OUT
ROUTE HYDROGRAPH TO PSI
ROUTE HYDROGRAPH TO PS2
END OF NETWORK

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

RUN DATE= 80/06/09.
TIME= 14.14.28.

CROOPS DAM
NAT ID NO. PA 01063 DER ID 40-227
OVERTOPPING ANALYSIS

JOB SPECIFICATION
NO NHR NMIN IDAY IHR IMIN METRC IPLT IPRT NSTAN
96 0 15 0 0 0 0 0 -4 0
JOPER NUT LROPT TRACE
5 0 0 0

MULTI-PLAN ANALYSIS TO BE PERFORMED
NPLAN= 1 NR1ID= 1 LRTID= 1
RTIOS= 1.00

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

ISTAO ICOMP IECON ITAPE JPLT JPRI INANE ISTAGE IAUTO
IN 0 0 0 0 0 0 1 0 0

HYDROGRAPH DATA

INYBG IUNG TAREA SNAP TRSDA TRSFC RATIO ISHOW ISANE LOCAL
0 2 .42 0.00 .42 1.00 0.000 0 1 0

LOSS DATA

LROPT STRKR DTKR RTIOL ERAIN STRKS RTIOL STRTL CMSTL ALSHX RTIMP
0 0.00 0.00 1.00 0.00 0.00 1.00 -1.00 -75.00 0.00 0.00

CURVE NO = -75.00 WETNESS = -1.00 EFFECT CN = 75.00

UNIT HYDROGRAPH DATA

TC= 0.00 LAG= .36

RECESSION DATA

STRTO= -1.50 ORCSN= -.05 RTIOR= 2.00

END-OF-PERIOD FLOW

NO.DA HR.MM PERIOD RAIN EXCS LOSS COMP 0 NO.DA HR.MM PERIOD RAIN EXCS LOSS COMP 0

SUN 6.40 3.62 2.77 3962.
(163.)(92.)(70.)(112.19)

Assumed Rainfall Distribution

U 96
01.01 .01 .01 .02 .02 .02 .02 .02 .02 .02
01.02 .02 .02 .02 .02 .02 .02 .02 .02 .02
01.02 .02 .02 .02 .04 .04 .04 .04 .04 .04
01.04 .04 .04 .04 .04 .04 .04 .04 .04 .04
01.04 .04 .04 .04 .05 .05 .05 .05 .05 .05
01.075 .075 .075 .075 .075 .075 .106 .106 .075 .075
01.275 1.1 1.1 .275 .106 .106 .106 .106 .075 .075
01.075 .075 .02 .02 .02 .02 .02 .02 .02 .02
01.02 .02 .02 .02 .02 .02 .02 .02 .02 .02
01.02 .02 .02 .01 .01 .01 .02 .02 .02 .02

HYDROGRAPH ROUTING

OUTFLOW HYDROGRAPH

	ISTAD OUT	ICORP 1	IECON 0	ITAPE 0	JPLT 0	JPRT 0	INAME 1	ISTAGE 0	IAUTO 0
	ROUTING DATA								
	CLOSS 0.0	CLOSS 0.000	AVG 0.00	IRIS 1	ISARE 1	IOP1 0	IPMP 0	LSTR 0	
	NSTPS 1	NSTDL 0	LAG 0	ANSKK 0.000	X 0.000	TSK 0.000	STORA -753.	ISPRAT -1	
STAGE	753.20	754.20	755.20	756.20	757.20	758.20	759.20	760.20	761.20
FLOW	0.00	11.00	13.00	19.00	22.00	23.00	27.00	29.00	32.00
SURFACE AREA=	0.	4.	8.	11.					
CAPACITY=	0.	23.	42.	215.					
ELEVATION=	736.	753.	760.	780.					
	CREL 753.2	SPWID 0.0	CDOW 0.0	EXP0 0.0	ELEVL 0.0	COOL 0.0	CAREA 0.0	EXPL 0.0	
	SAN DATA								
	IOPEL 757.5	COOD 0.0	EXPD 0.0	SANWID 0.					
CREST LENGTH AT OR BELOW ELEVATION	0.	220.	290.						
	757.5	758.2	759.3						

HYDROGRAPH ROUTING

DOWNSTREAM SECTION AT TOWNSHIP BUILDING

	ISTAD DS1	ICORP 1	IECON 0	ITAPE 0	JPLT 0	JPRT 0	INAME 1	ISTAGE 0	IAUTO 0
	ROUTING DATA								
	CLOSS 0.0	CLOSS 0.000	AVG 0.00	IRIS 1	ISARE 1	IOP1 0	IPMP 0	LSTR 0	
	NSTPS 1	NSTDL 0	LAG 0	ANSKK 0.000	X 0.000	TSK 0.000	STORA 0.	ISPRAT 0	

NORMAL DEPTH CHANNEL ROUTING

DN(1)	DN(2)	DN(3)	ELNVT	ELMAX	RLNTH	SEL
.0400	.0350	.0400	680.0	690.0	580.	.00670

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

	0.00	700.00	70.00	690.00	324.00	689.80	333.50	681.50	393.50	680.00	
	403.00	690.00	413.00	700.00	423.00	710.00					
STORAGE	0.00	.07	.26	.58	.96	1.34	1.73	2.13	2.53	2.94	
	3.35	3.77	4.20	4.64	5.08	5.53	5.98	6.45	6.92	7.40	
OUTFLOW	0.00	8.06	51.17	153.11	348.89	600.31	903.27	1253.77	1648.91	2086.48	
	2564.77	3082.39	3638.23	4231.35	4860.98	5526.49	6227.34	6963.08	7733.33	8573.97	
STAGE	680.00	680.53	681.05	681.58	682.11	682.63	683.16	683.68	684.21	684.74	
	685.26	685.79	686.32	686.84	687.37	687.89	688.42	688.95	689.47	690.00	
FLOW	0.00	8.06	51.17	153.11	348.89	600.31	903.27	1253.77	1648.91	2086.48	
	2564.77	3082.39	3638.23	4231.35	4860.98	5526.49	6227.34	6963.08	7733.33	8573.97	

HYDROGRAPH ROUTING

DOWNSTREAM SECTION AT BRIDGE

ISTAG	ICOMP	IECON	ITAPE	JPLI	JPRI	INARE	ISTAGE	IAUTO
PS2	1	0	0	0	0	1	0	0
ROUTING DATA								
QLOSS	CLOSS	AVG	IRES	ISANE	IOPT	IPNP	LSTR	
0.0	0.000	0.00	1	1	0	0	0	
NSTPS	NSTBL	LAG	ANSKH	X	TSK	STORA	ISPRAT	
1	0	0	0.000	0.000	0.000	0.	0	

NORMAL DEPTH CHANNEL ROUTING

DN(1)	DN(2)	DN(3)	ELNVT	ELHAX	RLNTH	SEL
.0490	.0350	.0350	645.0	654.0	2250.	.01300

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

	0.00	654.00	100.00	650.70	144.00	647.30	148.00	645.00	198.00	645.00
	198.00	654.00	205.00	654.00	229.00	640.00				
STORAGE	0.00	1.23	2.49	3.76	5.05	6.37	7.78	9.34	11.03	12.87
	14.85	16.97	19.23	21.67	24.46	27.62	31.16	35.07	39.35	44.01
OUTFLOW	0.00	69.51	219.64	429.88	691.63	1001.17	1366.39	1782.85	2253.32	2780.16
	3365.55	4011.63	4720.45	5461.08	6267.45	7176.24	8192.73	9323.89	10577.14	11959.97
STAGE	645.00	645.47	645.95	646.42	646.89	647.37	647.84	648.32	648.79	649.26
	649.74	650.21	650.68	651.16	651.63	652.11	652.58	653.05	653.53	654.00
FLOW	0.00	69.51	219.64	429.88	691.63	1001.17	1366.39	1782.85	2253.32	2780.16
	3365.55	4011.63	4720.45	5461.08	6267.45	7176.24	8192.73	9323.89	10577.14	11959.97

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	RATIOS APPLIED TO FLOWS
					1.00	
HYDROGRAPH AT	IR	.42	1	627.		
	(	1.09)	(	17.75)	(	
ROUTED TO	OUT	.42	1	546.		
	(	1.09)	(	15.45)	(	
ROUTED TO	001	.42	1	589.		
	(	1.09)	(	16.68)	(	
ROUTED TO	002	.42	1	545.		
	(	1.09)	(	15.45)	(	

SUMMARY OF DAM SAFETY ANALYSIS

	ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
STORAGE	753.20	753.20	753.20	757.50
OUTFLOW	23.	23.	23.	45.
		0.	0.	23.

RATIO OF PMF	MAXIMUM RESERVOIR U.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	758.68	1.18	52.	546.	7.00	16.25	0.00

PLAN 1 STATION 881

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	589.	482.6	16.25

TOWNSHIP BUILDING ABOUT ELEV. 692

PLAN 1 STATION 882

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	545.	446.6	16.25

HOUSE ABOUT 654

SUMMARY OF DAM SAFETY ANALYSIS

	ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
STORAGE	753.20	753.20	753.20	757.50
OUTFLOW	23.	23.	23.	45.
		0.	0.	2.

SPILLWAY BLOCKED

RATIO OF PMF	MAXIMUM RESERVOIR U.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	758.74	1.24	53.	591.	8.50	16.00	0.00

PLAN 1 STATION 881

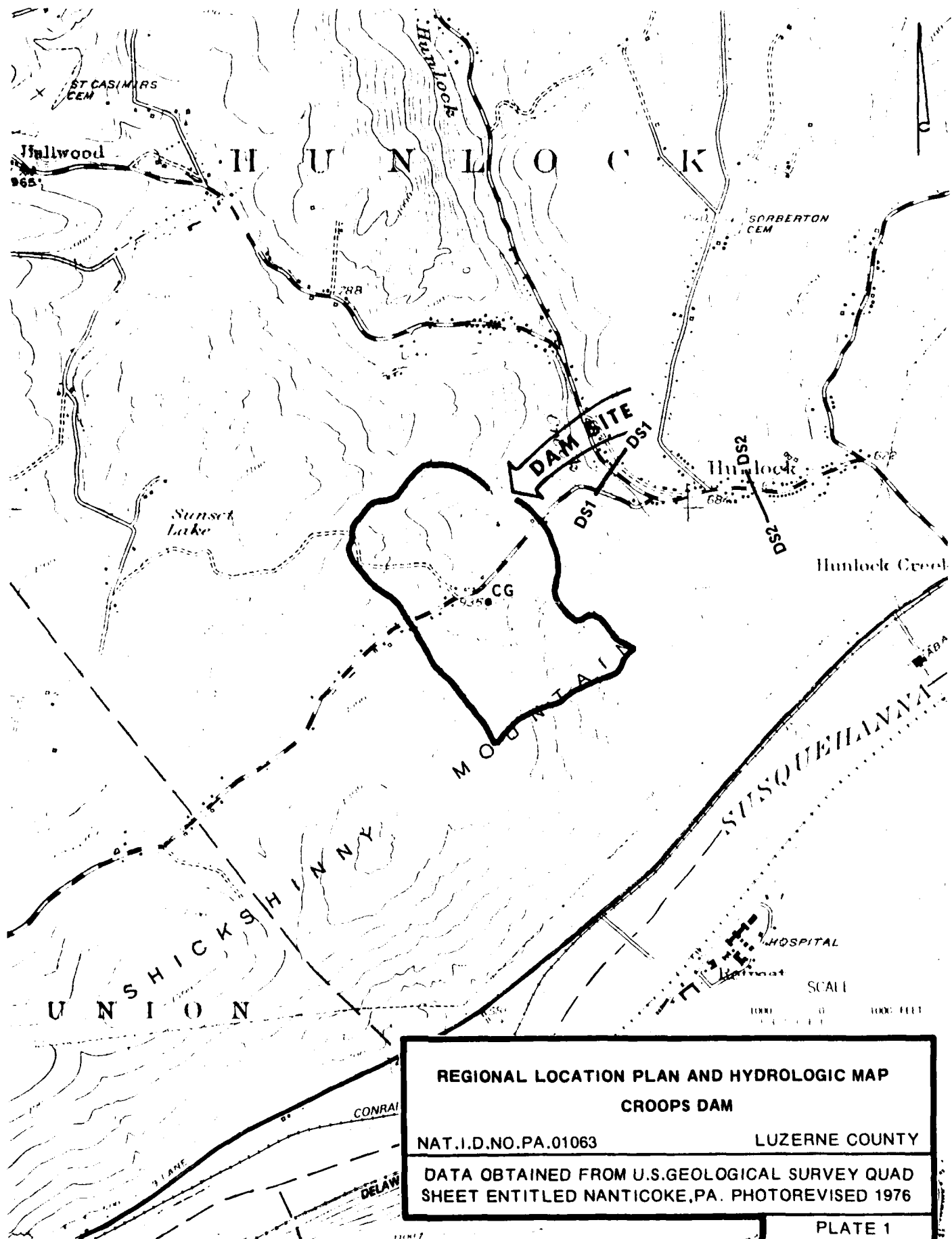
RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	592.	482.6	16.25

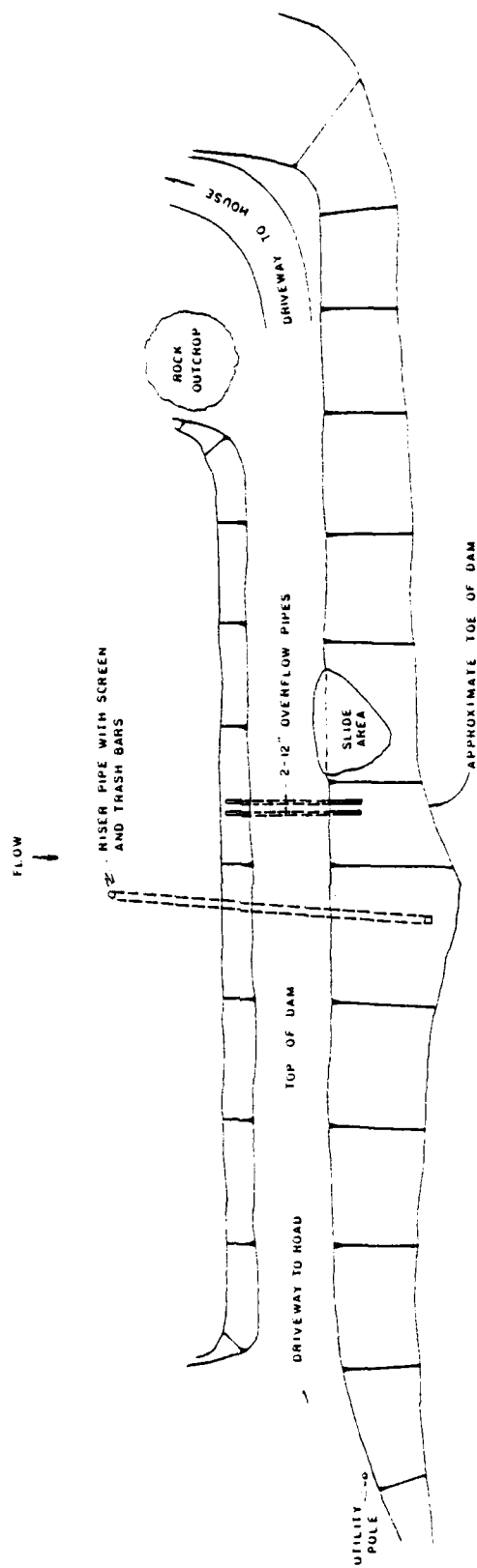
PLAN 1 STATION 882

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	634.	446.8	16.25

APPENDIX

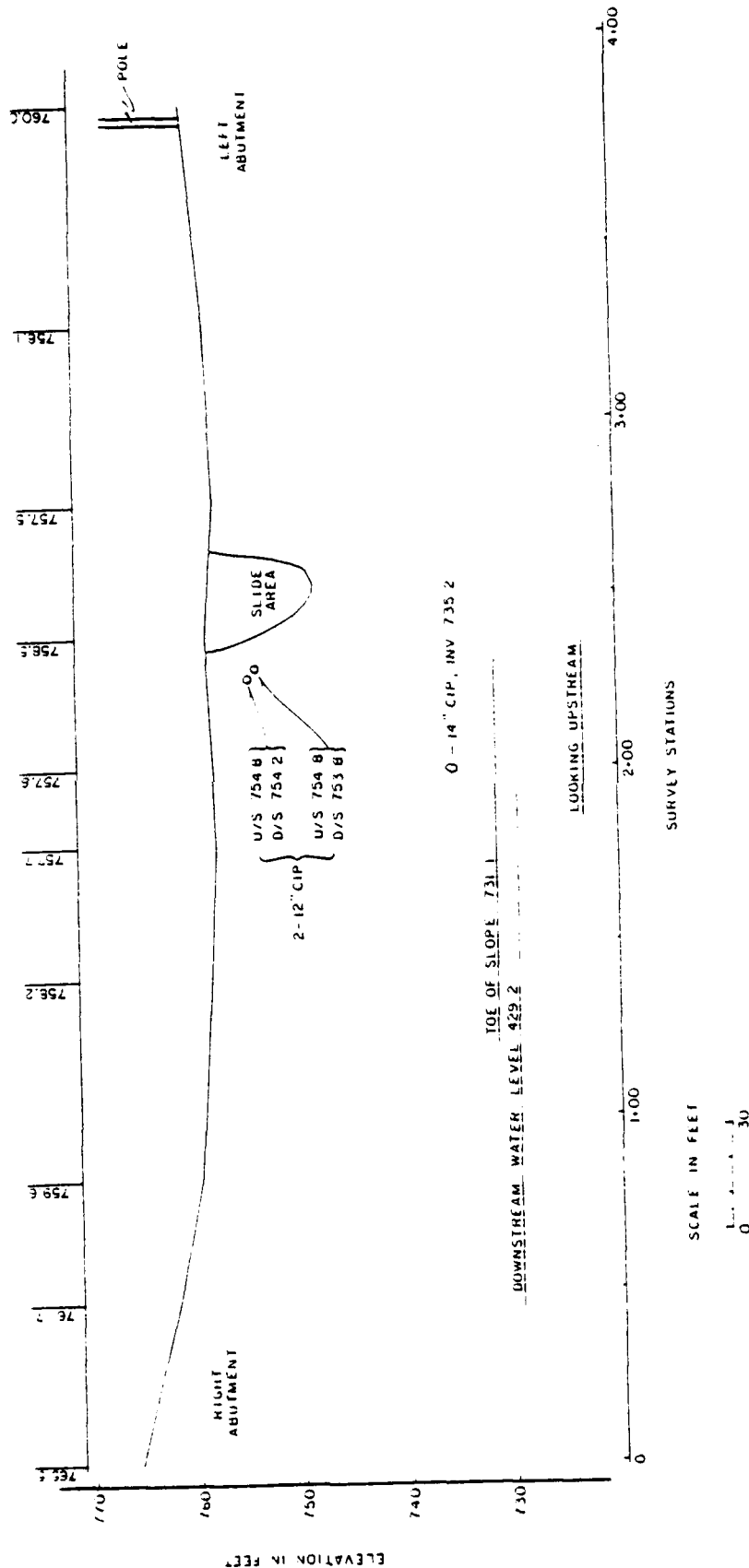
E



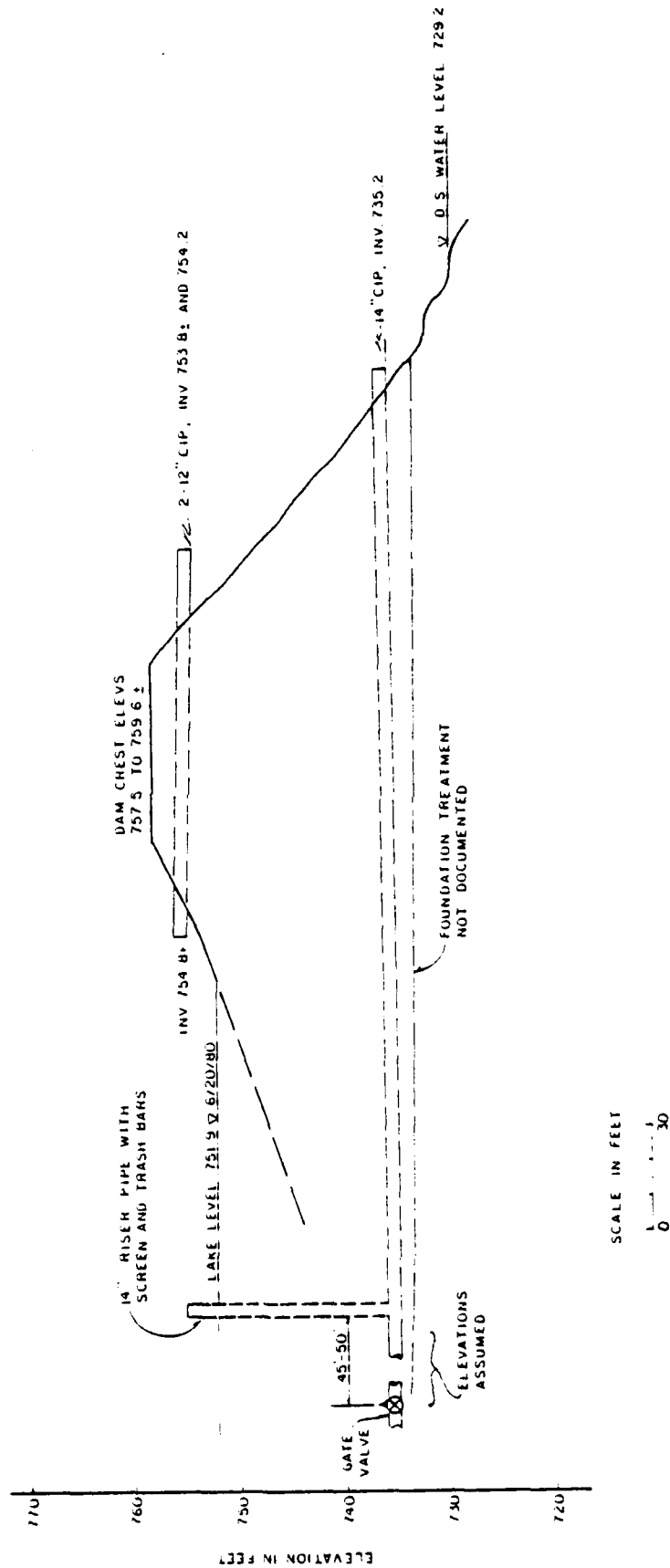


DOWNSIDE

SCALE IN FEET
0 10 20



PROFILE OF DAM
CROOPS DAM
PLATE 3



APPENDIX

F

SITE GEOLOGY CROOPS DAM

Croops Dam is located in the Appalachian Mountain Section of the Valley and Ridge Physiographic Province. As shown in Plate F-1, the dam is constructed upon the Catskill Formation of Upper Devonian age, consisting of red to tan shales and sandstones. The dam site region experienced glaciation during Pleistocene time, as did much of northeastern Pennsylvania. The site is situated along the northern margin of the Wyoming Valley, which is a major northeast trending syncline (downfold).

Bedrock is exposed over much of the local dam area. An exposure near the left abutment next to the access road consists of tan-gray well bedded fine sandstone. Bedding strikes oblique to the dam axis at N 78° E and dips 31 degrees south towards the right abutment. The predominant rock jointing strikes north-northeasterly (approximately perpendicular to the dam axis) and dips at high angles to the northeast. Any potential seepage related to bedrock conditions would most likely be enhanced by the nearness of bedrock to the ground surface and the rock jointing crossing the dam axis at approximately a right angle.

