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NATIONAL DAM SAFETY PROGRAM. CRANDON LAKE DAM (NJ 00267), DELAW--ETC(U)
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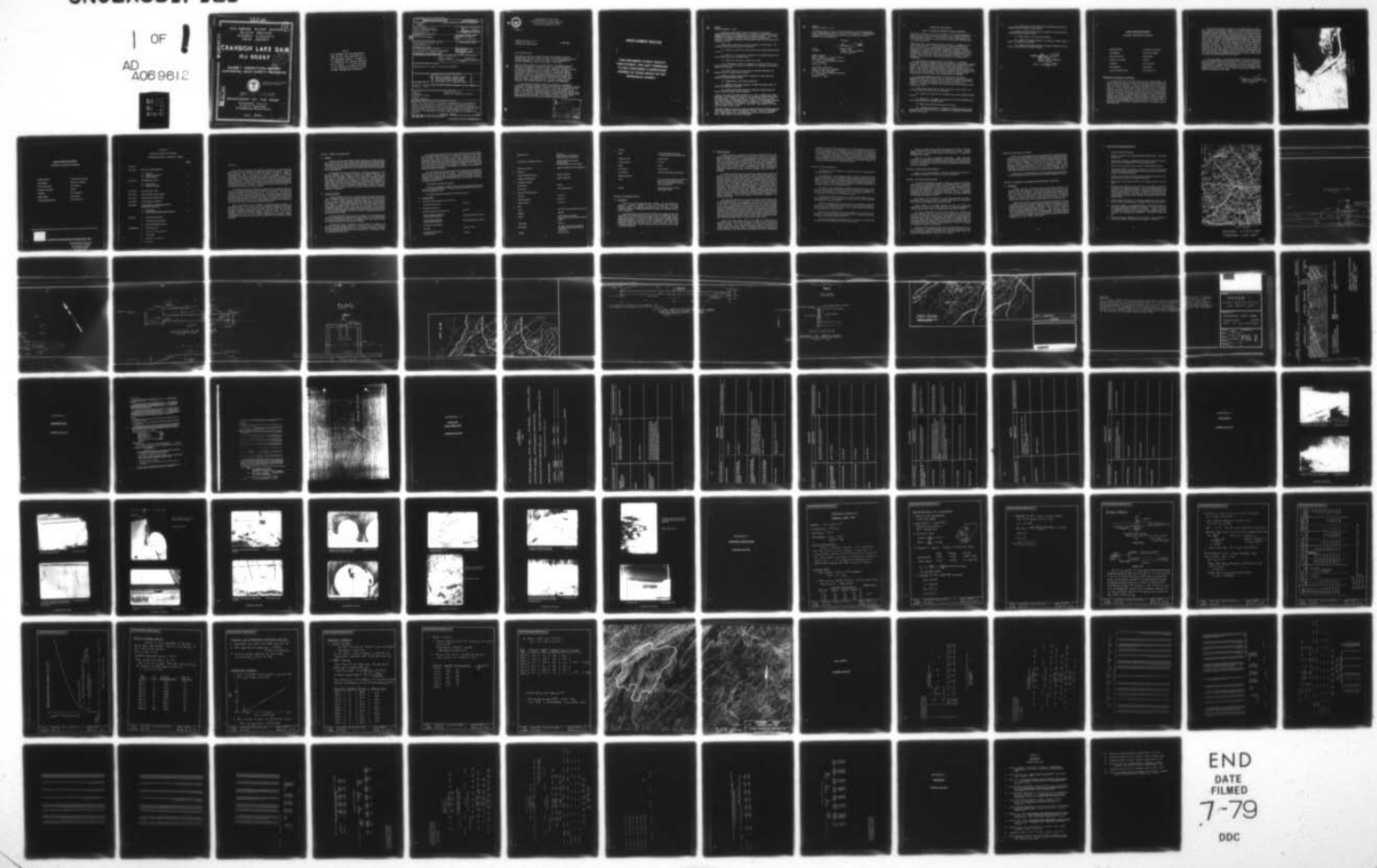

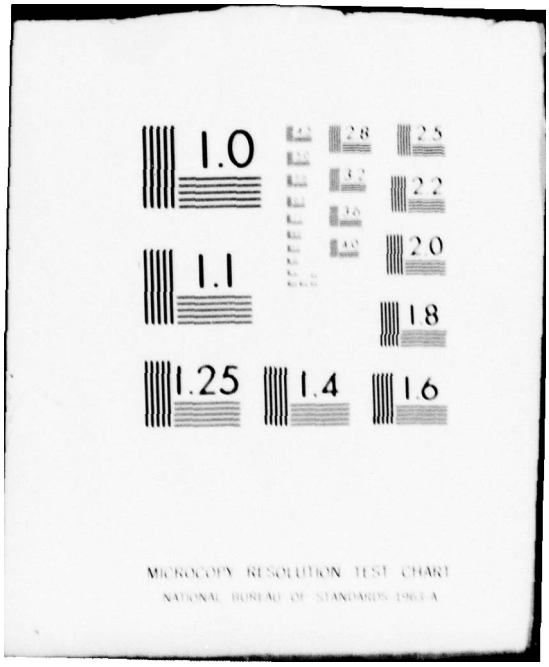
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DELAWARE RIVER BASIN
BLACK BROOK
SUSSEX COUNTY
NEW JERSEY

CRANDON LAKE DAM
NJ 00267

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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DEPARTMENT OF THE ARMY

Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

May, 1979

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

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Visual inspection
Crandon Lake Dam,N.J.
National Dam Inspection Act Report

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE – 2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

17 MAY 1979

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Crandon Lake Dam in Sussex County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Crandon Lake Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 21 percent of the Probable Maximum Flood would overtop the dam. The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the fact that failure from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. In the interim, a detailed emergency operation plan and warning system, should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

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b. Within six months from the date of approval of this report, engineering studies and analyses should be initiated to determine the dam's embankment and foundation condition and structural stability. This should include test borings to determine material properties relative to stability. Any remedial measures found necessary should be initiated within calendar year 1980.

c. Within three months from the date of approval of this report, the following remedial actions should be completed:

(1) Replace or reline the two corrugated metal pipes passing through the dam.

(2) Repair and, if necessary, strengthen the concrete headwalls for the box spillway and the discharge pipes.

(3) Remove all trees from the area of the dam.

(4) Investigations should be conducted to locate the inlet of the 36-inch diameter blow-off pipe and to determine the existence and operating condition of its gate.

(5) Eroded areas of the dam should be suitably backfilled and measures taken to prevent future erosion.

d. Within six months from the date of approval of this report the following actions should be taken:

(1) Repair leaks in the drop-box spillway.

(2) Operate sluice gate regularly, at least two times a year, to ensure its operational condition.

(3) Animal burrow holes should be completely plugged and steps taken to prevent further animal burrowing.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman James A. Courter of the Thirteenth District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

NAPEN-D
Honorable Brendan T. Byrne

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N. J. Dept. of Environmental Protection
P. O. Box CN029
Trenton, NJ 08625

John O'Dowd, Acting Chief
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CRANDON LAKE DAM (NJ00267)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 13 and 20 December 1978 by Langan Engineering Associates, Inc. under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Crandon Lake Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 21 percent of the Probable Maximum Flood would overtop the dam. The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the fact that failure from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. In the interim, a detailed emergency operation plan and warning system, should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. Within six months from the date of approval of this report, engineering studies and analyses should be initiated to determine the dam's embankment and foundation condition and structural stability. This should include test borings to determine material properties relative to stability. Any remedial measures found necessary should be initiated within calendar year 1980.

c. Within three months from the date of approval of this report, the following remedial actions should be completed:

(1) Replace or reline the two corrugated metal pipes passing through the dam.

(2) Repair and, if necessary, strengthen the concrete headwalls for the box spillway and the discharge pipes.

(3) Remove all trees from the area of the dam.

(4) Investigations should be conducted to locate the inlet of the 36-inch diameter blow-off pipe and to determine the existence and operating condition of its gate.

(5) Eroded areas of the dam should be suitably backfilled and measures taken to prevent future erosion.

d. Within six months from the date of approval of this report the following actions should be taken:

(1) Repair leaks in the drop-box spillway.

(2) Operate sluice gate regularly, at least two times a year, to ensure its operational condition.

(3) Animal burrow holes should be completely plugged and steps taken to prevent further animal burrowing.

APPROVED: James G. Ton
JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 17 May 1979

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

NAME OF DAM:	CRANDON LAKE DAM
ID NUMBER:	FED ID No NJ00267
STATE LOCATED:	NEW JERSEY
COUNTY LOCATED:	SUSSEX
STREAM:	BLACK BROOK
RIVER BASIN:	DELAWARE
DATE OF INSPECTION:	DECEMBER 1978

ASSESSMENT OF GENERAL CONDITIONS

Crandon Lake Dam is 20 years old and in fair overall condition. The spillway outlet pipes and the low level outlet pipe have rusted over the lower portion of their circumference. There are trees growing on the slopes of the dam. Erosion has occurred on the slopes of the dam and near the spillway structure. There are animal holes in the downstream slope. The drop-box headwall has cracked and water is seeping into the left corner of the box. There are numerous cracks on the concrete headwall for the discharge pipes. Only little information concerning the design and construction of the dam is available. No records of material quality or degree of compaction achieved during construction are available. The maximum depth to which the subsurface conditions were investigated before construction appears to have been about four feet, this is also unacceptable. The spillway capacity as determined by CE Screening criteria is inadequate. We estimate the dam can adequately pass only 20% of the PMF.

We recommend to replace or reline the two CM pipes passing through the dam. Repair and, if necessary, strengthen the concrete headwalls for the box spillway and the discharge pipes. Remove all trees from the area of the dam. Investigation should be conducted to locate the inlet of the 36in-dia blow-off pipe and to determine the existence and operating condition of its gate. Eroded areas of the dam should be suitably backfilled and measures taken to prevent future erosion. The above recommendations should be done soon. Repair leaks in the drop-box spillway. This should be done in the near future. Borings and tests should be made in the dam and foundation materials to determine their engineering properties. The actual configuration of the dam section, in particular the upstream slope below normal pool elevation, should be determined by field survey. Analyses should be made of the actual degree of stability of the dam with respect to conventional safety margins under static and seismic loading. This should be done in the near future. Animal burrow hole should be completely plugged and steps taken to prevent further animal burrowing. This should be done in the near future.

The actual capacity of the spillway should be determined using more precise and sophisticated methods and procedures. The need for and type of mitigating measures should be determined. Around the clock surveillance during periods of unusually heavy precipitation should be provided, and a warning system established. This should be done very soon. Operate sluice gate regularly, at least two times a year to ensure its operational condition. This should be done regularly in the future.

Dennis J. Leary

Dennis J. Leary, P.E.

OVERVIEW
CRANDON LAKE DAM

13 December 1978

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

NAME OF DAM:	CRANDON LAKE DAM
ID NUMBER:	FED ID No NJ00267
STATE LOCATED:	NEW JERSEY
COUNTY LOCATED:	SUSSEX
STREAM:	BLACK BROOK
RIVER BASIN:	DELAWARE
DATE OF INSPECTION:	DECEMBER 1978

LANGAN ENGINEERING ASSOCIATES, INC.

Consulting Civil Engineers
990 CLIFTON AVENUE
CLIFTON, NEW JERSEY
201-472-9366

CONTENTS

NATIONAL DAM SAFETY REPORT

CRANDON LAKE DAM FED ID No. NJ00267

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. 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 continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aide 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.

SECTION 1 PROJECT INFORMATION

1.1 General

Authority to perform the Phase I Safety Inspection of Crandon Lake Dam was received from the State of New Jersey, Department of Environmental Protection, Division of Water Resources by letter dated 20 November 1978. This Authority was given pursuant to the National Dam Inspection Act, Public Law 92-367 and by agreement between the State and the US Army Engineers District, Philadelphia.

The purpose of the Phase I Investigation is to develop an assessment of the general conditions with respect to safety of Crandon Lake Dam and appurtenances based upon available data and visual inspection, and, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted. The assessment is made using screening criteria established in Recommended Guidelines for Safety Inspection of Dams prepared by the Department of Army, Office of the Chief of Engineers. It is not the purpose of the inspection report to imply that a dam meeting or failing to meet the screening criteria, is per se, certainly adequate or inadequate.

1.2 Project Description

Crandon Lake Dam is a 20 year old, 428-ft-long, 20-ft-high, earthfill dam with a compacted central core. It is reported that the dam has a top width of 28 ft, a 2H:1V partially riprapped upstream slope, and a 3H:1V grassed downstream slope. Visual inspection shows the upstream slope above lake level is about 5H: 1V. It has a drop box spillway with a total weir length of 49 feet. The spillway discharge passes under the dam by means of two 6-ft-dia corrugated metal pipes. There are provisions for stop planks in the north face of the box spillway and there is a gated 3-ft-dia CM low level outlet pipe about 40 feet west of the spillway. The top of the dam is an asphalt paved roadway that also encircles the lake.

The dam is located at the south end of Crandon Lake on the Hampton and Stillwater Township line in Sussex County, New Jersey. It is at north latitude 41° 7.6' and west longitude 74° 50.5'. A regional vicinity map is given in Fig 1 and essential features of the dam are given in Fig 2.

Crandon Lake Dam is classified as being "Small" on the basis of its maximum reservoir storage volume of 510 acre-feet, which is more than 50-acre feet, but less than 1,000-acre feet. It is classified as "Small" on the basis of its total height of 20 feet, which is less than 40 feet. Accordingly, the dam is classified as "Small" in size.

In the National Inventory of Dams, Crandon Lake Dam has been classified as having "High Hazard Potential" on the basis that failure of the dam would cause excessive property damage to residences downstream, and could potentially cause more than a few deaths. Visual inspection shows that a smaller lake locates about 1/4 mile downstream from the dam and that breach of the dam would be very hazardous to people utilizing Benevolence Road on top of the dam and would cause excess damage and hazard to the residences situated abutting the lower lake. Accordingly, it is proposed not to change the Hazard Classification Potential.

The dam is known to have been owned by the Crandon Lakes Development Company, Inc., RD #3, Newton, New Jersey. The information provided by the State indicates that the dam is presently owned by Stillwater Township. However, from a telephone conversation with Mdm. Ellen Vanstone of Stillwater Township, it is understood that the Township does not own the dam. Its present ownership is unknown to us.

The purpose of the dam is recreation.

The dam was designed by Waldo J. Clarke, Professional Engineer and Land Surveyor, Franklin, New Jersey. Construction work was started in 1957 and the dam was completed in 1959.

No normal operational procedures are known to be used.

1.3 Pertinent Data

a. At dam site, the drainage area is 2.45 sq mi

The area of the Lake is:	70 Acres ±

b. Discharge at Dam Site

Maximum known flood at dam site:	Unknown
Ungated spillway capacity at maximum pool elevation:	840 cfs (governed by culvert)
Total spillway capacity at maximum pool elevation:	840 cfs (governed by culvert)

c. Elevation (ft above MSL)

Top dam:	Approx. El. 859
Normal pool (assumed at spillway crest):	El. 855.3

	Spillway crest:	El. 855.3 (Stop plank crest elevation at 854.44 at time of inspection)
	Streambed at centerline of dam:	El. 843.4 (invert of 36-in-dia blow-off pipe) El. 845.3 (invert of 6-ft-dia CMP)
	Maximum tailwater:	Approx. El. 846 at time of inspection.
d.	Reservoir	
	Length of Maximum pool:	Approx. 4025 feet
	Length of normal pool:	Approx. 4000 feet
e.	Storage (acre-feet)	
	Normal pool:	230 AF
	Top of dam:	510 AF (estimated)
f.	Reservoir Surface (acres)	
	Top dam:	74 Acres ±
	Recreation pool:	70 Acres ±
	Spillway crest:	70 Acres ±
g.	Dam	
	Type:	Earth fill with compacted central core
	Length:	428 feet
	Height:	16 feet (above streambed) 20 feet (estimated maximum structura height)
	Top width:	28 feet ±
	Side slopes:	U/S 3H:1V; D/S 3H:1V (reported) U/S above lake level 5H:1V (visual inspection)
	Zoning:	None observed

h. Spillway

Type:	Concrete drop box feeds into 2 - 6-ft-dia CMP under embankment.
Length of weir:	49 feet, total
Crest elevation:	El. 855.3
Gates:	None
U/S channel:	None observed
D/S channel:	2-6-ft-dia CMP under embankment.

i. Regulating Outlets

Type:	36-in-dia blow-off pipe with underwate gate at west side of spillway box and 3" x 8" stop planks in north face of the spillway box.
Length:	Blow-off pipe approx. 92 feet Stop planks 3 feet.

SECTION 2 ENGINEERING DATA

2.1 Introduction

There is very little engineering data available. The specification and records of inspection indicate the dam was satisfactorily constructed. However, there is no quantitive information e.g. test results or testing frequency available. Available geotechnical, hydraulic, and hydrologic data are given in Appendix 1.

It is reported that in the early phase of construction, compaction was done using rubber tired earth movers. In our opinion that is unsatisfactory and it is likely that both the core and shell sections of the dam have highly variable engineering properties. The maximum depth of subsurface exploration before construction appears to be about 4-ft which corresponds to the bottom of the exploration trench that was dug along the base of the dam. This is also considered unsatisfactory. There is insufficient information upon which to make a complete evaluation.

2.2 Regional Geology

Crandon Lake Dam is located in the Valley and Ridge Province. This province encompasses one-twelfth of the land area of the state - chiefly in Warren and Sussex Counties. It is characterized by a series of nearly parallel ridges and valleys that trend northeast-southwest. The ridges are underlain with northwest dipping Silurian and Devonian sandstones and conglomerates. The upper Delaware Valley is underlain with weak Devonian limestones and shales while the Kittatinny Valley is underlain with folded Cambrian and Ordovician limestones and shales. Kittatinny Mountain is the most prominent topographic feature and its nearly even crest averages 1600 to 1800 feet in elevation.

The Valley and Ridge Province is divided into western, middle, and eastern sections that include the Upper Delaware Valley, Kittatinny Mountain, and Kittatinny Valley. The Upper Delaware Valley encompasses the region west of Kittatinny Mountain that has been eroded in Devonian limestones and shales. Kittatinny Mountain makes up the middle section of the Province and forms the eastern border of the Upper Delaware Valley and the northwestern border of Kittatinny Valley. The ridge is underlain with the very resistant lower Silurian Shawangunk conglomerate and High Falls sandstone. The northeastern side is bordered by the escarpments of the Shawangunk conglomerate, which rise steeply from the Kittatinny Valley floor. The Shawangunk conglomerate has been extensively broken up into large rock fragments by mechanical weathering and frost action and forms mass wasted talus slopes along the ramparts of the eastern escarpment. These talus slopes are extensively developed in the Delaware Water Gap.

The Kittatinny Valley area is a broad northeast-southwest lowland where the Harrisburg Peneplain is well developed. The valley is 10 to 13 miles wide and lies between the New Jersey Highlands on the east and Kittatinny Mountain on the west. The Wisconsin ice sheet covered all of the Valley and Ridge Province and deposited a terminal moraine south of the province near Belvidere. Much of the land surface north of the terminal moraine consists of a thin sheet of glacial till and ice-scoured bedrock surfaces. In addition, fluvial deposits of stratified drift consisting of eskers, kames, kame terraces, and deltas mantle many of the areas of the valley bottoms. Discontinuous recessional moraines were deposited during stillstands in the ice retreat. These moraines now form a discontinuous low band of hills across nearly all of Sussex County.

Glacial till covers large areas of the Valley and Ridge Province. Generally the till is extremely thin and sometimes present only in patches or as scattered boulders. It is best developed on broad summits, interstream surfaces, and in low passes or cols, and is thinnest or absent on steep slopes, on narrow ridges, and in narrow valleys. The greatest thickness of the till in the Kittatinny Valley is over 100 feet just on the edge of the valley at Ogdensburg.

Estimates of the thickness range from 8 to 10 feet along the west slope of Kittatinny Mountain; 2 to 3 feet along the crest of Kittatinny Mountain; 5 to 10 feet on the limestone belts of Kittatinny Valley; 8 to 12 feet on the shale belts of Kittatinny Valley; and from 5 to 20 feet in Vernon Valley. The composition of till is largely of local origin and reflects the character of the underlying rock. It is generally compact because of the high clay content derived from the weathered shales and has many resistant boulders of Shawangunk conglomerate as well as erratics derived from more distant sources.

SECTION 3 VISUAL INSPECTION

The general overall conditions of Crandon Lake Dam and appurtenant structures appear fair.

The alignment of the embankment and its junction with the abutments appeared satisfactory. No noticeable seepage or leakage was observed. Both slopes of the embankment are overgrown with small to medium size trees and bushes. Erosion was observed along the sides of the downstream headwalls for the outlet conduits. Some erosion was also observed on upstream slope near the drop-box structure and at a few other locations.

At the time of our inspection, the lake was partially frozen and the water level was approximately 2 inches below the top of the spillway. Drainage out of the lake was maintained by removing some of the stop-logs placed in the vertical slot on the north face of the drop-box spillway.

The drop-box spillway structure has a few localized spalled areas and surface deterioration. Small seepage was observed at the left corner abutting the headwall for the outlet conduits.

There are numerous cracks on both upstream and downstream headwalls for the two 6-ft-dia CMP outlet conduits which run across the base of the dam. These cracks vary in width from hairline to 1 inch. Some of them extend across the exposed surfaces of the structure.

There are minor spalling on the outlet headwall for the 3-ft-dia low level CM pipe. A metal drum lies across its outlet channel. No inlet structure was observed for this conduit during our inspection.

The two 6-ft-dia spillway outlet pipes and the 3-ft-dia low level outlet pipe have rusted over the lower portion of their circumferences.

There are numerous homes around the perimeter of the lake. The slopes appear relatively flat and stable with occasional minor eroison. Vertical bulkheads exist in front of some homes at the waterfront. No significant sedimentation was noted.

There are no homes immediately downstream. About 1000 feet downstream is a lower lake surrounded by numerous scattered homes with a few at relatively low elevation. The lower lake has a surface area of approximately 10 acres. The downstream channel was partially obstructed by fallen leaves, trees and wood boards.

SECTION 4 OPERATIONAL PROCEDURES

There is no readily available information concerning operational or maintenance procedures or the existence of any working system.

SECTION 5 HYDRAULIC/HYDROLOGIC

The hydraulic/hydrologic evaluation is based on a Spillway Design Flood (SDF) equal to the full Probable Maximum Flood (PMF) chosen in accordance with the evaluation guidelines for dams classified as High Hazard and Small in size. Hydrologic design data for this dam is not available. The PMF has been determined by developing a synthetic hydrograph based on the maximum probable precipitation of 22 inches (200 square mile - 24 hour). Hydrologic computations are presented in Appendix 4. The PMF peak inflow determined for the subject watershed is 7,807 cfs.

The capacity of the spillway at maximum pool elevation (El. 859) is governed by the capacity of the two 6-ft-dia CMP under the embankment, which is 840 cfs and is significantly less than the SDF.

Flood routing for the PMF indicates the dam will overtop by approximately 3.2 feet. For 1/2 PMF the same will overtop by approximately 1.7 feet. We estimate the dam can adequately pass only 20% of the PMF.

The nearest downstream potential damage centers are a roadway and residential dwellings which are situated abutting a small lake located 1/4 mile to a mile from the dam. Based on our visual inspection of the downstream topography, and the dam and knowledge of the degree of overtopping potential it is our opinion that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. However, overtopping by 1/2 PMF is not likely to cause failure.

Drawdown of the reservoir has been evaluated considering that the 36 in-dia blow-off pipe is functioning properly and is utilized for lowering the lake. Our calculations indicate that the lake level could be lowered 3 feet from spillway crest approximately 1 day and 6 ft in 1 1/2 days.

SECTION 6 STRUCTURAL STABILITY

Based on our visual inspection, the dam appears stable. The geometry and dimensions of the dam together with our review of the available records also indicate the dam is stable. There are no available operating records or records of post construction changes. It is our opinion that the dam is presently stable and it is likely its stability is within conventional safety margins. This likelihood should be confirmed by means of appropriate analyses using representative engineering properties of the dam and foundation. We are particularly concerned with the cracks in the spillway headwall and the continued rusting of the invert portions of the pipes that pass through the dam.

Because there is inadequate data concerning engineering properties of the materials used in the dam it is uncertain as to the seismic stability of the dam.

SECTION 7 ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Assessment

Crandon Lake Dam is 20 years old and in fair overall condition. The spillway outlet pipes and the low level outlet pipe have rusted over the lower portion of their circumference. There are trees growing on the slopes of the dam. Erosion has occurred on the slopes of the dam and near the spillway structure. There are animal holes in the downstream slope. The drop-box headwall has cracked and water is seeping into the left corner of the box. There are numerous cracks on the concrete headwall for the discharge pipes.

Only little information concerning the design and construction of the dam is available. No records of material quality or degree of compaction achieved during construction are available. Compaction of the core and shell sections of the dam involved the use of rubber tired earth movers to achieve compaction which is not an acceptable present day method. The maximum depth to which the subsurface conditions were investigated before construction appears to have been about four feet, this is also unacceptable. The spillway capacity as determined by CE screening criteria is inadequate. We estimate the dam can adequately pass only 20% of the PMF.

7.2 Recommendations/Remedial Measures

We recommend the following:

1. Replace or reline the two CM pipes passing through the dam. This should be done soon.

2. Repair and, if necessary, strengthen the concrete headwalls for the box spillway and the discharge pipes. This should be done soon.

3. Remove all trees from the area of the dam. This should be done soon.

4. Investigation should be conducted to locate the inlet of the 36-in-dia blow-off pipe and to determine the existence and operating condition of its gate. This should be done soon.

5. Eroded areas of the dam should be suitably backfilled and measures taken to prevent future erosion. This should be done soon.

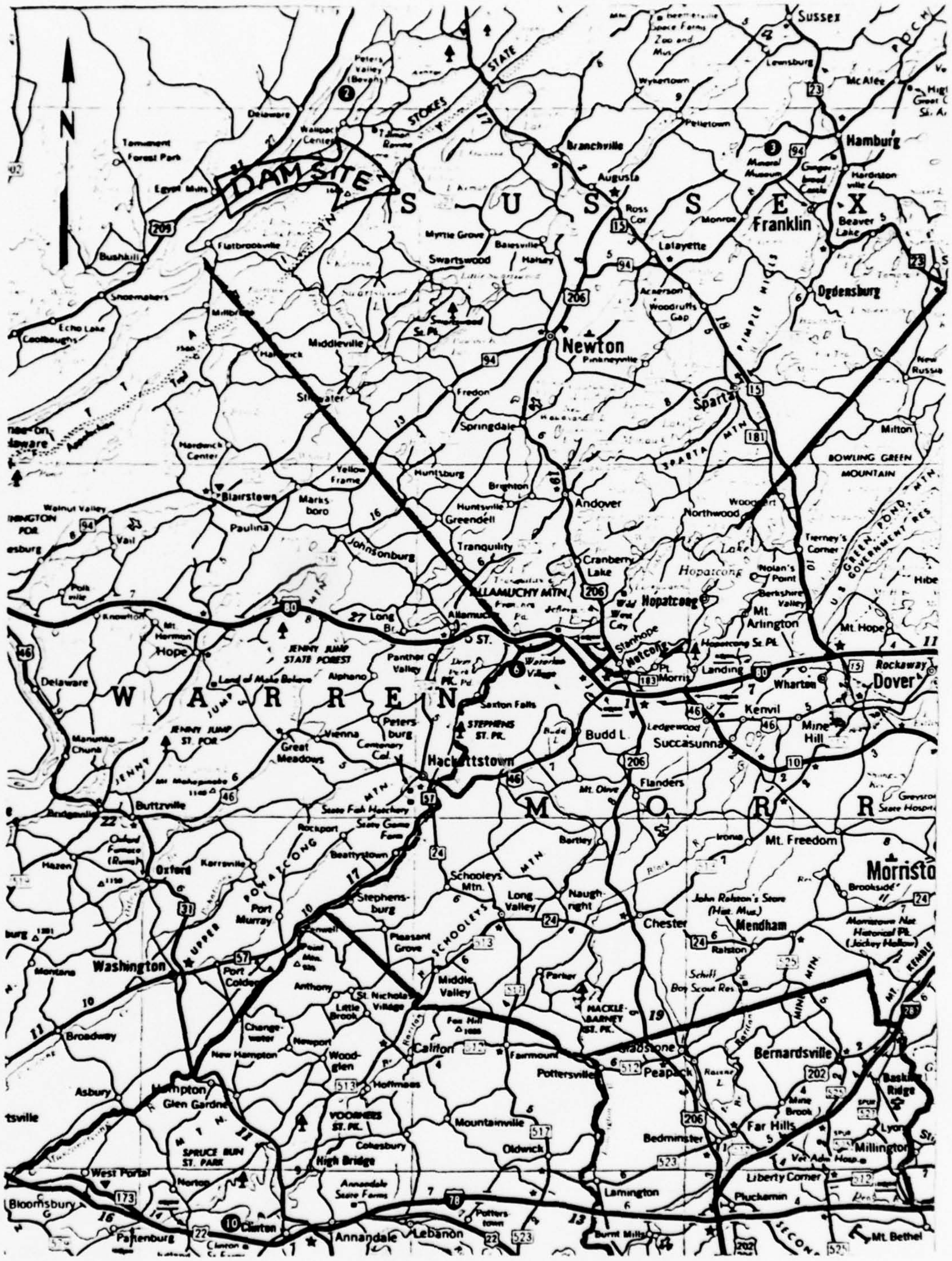
6. Repair leaks in the drop-box spillway. This should be done in the near future.

7. Borings and tests should be made in the dam and foundation materials to determine their engineering properties. The actual configuration of the dam section, in particular the upstream slope below normal pool elevation, should be determined by field survey. Analyses should be made of the actual degree of stability of the dam with respect to conventional safety margins under static and seismic loading. This should be done in the in the near future.

8. Animal burrow holes should be completely plugged and steps taken to prevent further animal burrowing. This should be done in the near future.

9. The actual capacity of the spillway should be determined using more precise and sophisticated methods and procedures. The need for and type of mitigating measures should be determined. Around the clock surveillance during periods of unusually heavy precipitation should be provided, and a warning system established. This should be done very soon.

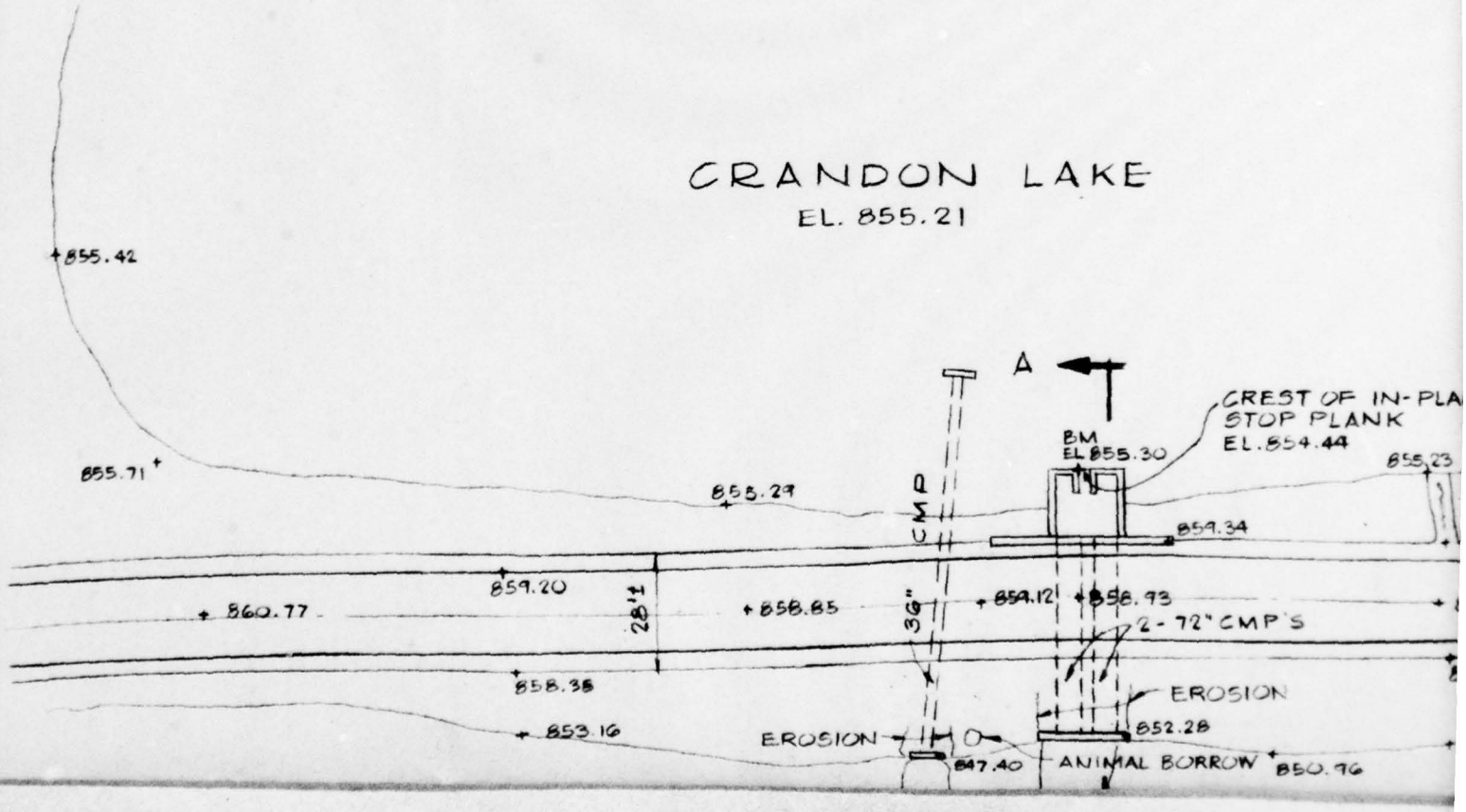
10. Operate sluice gate regularly, at least two times a year, to ensure its operational condition. This should be done regularly in the future.

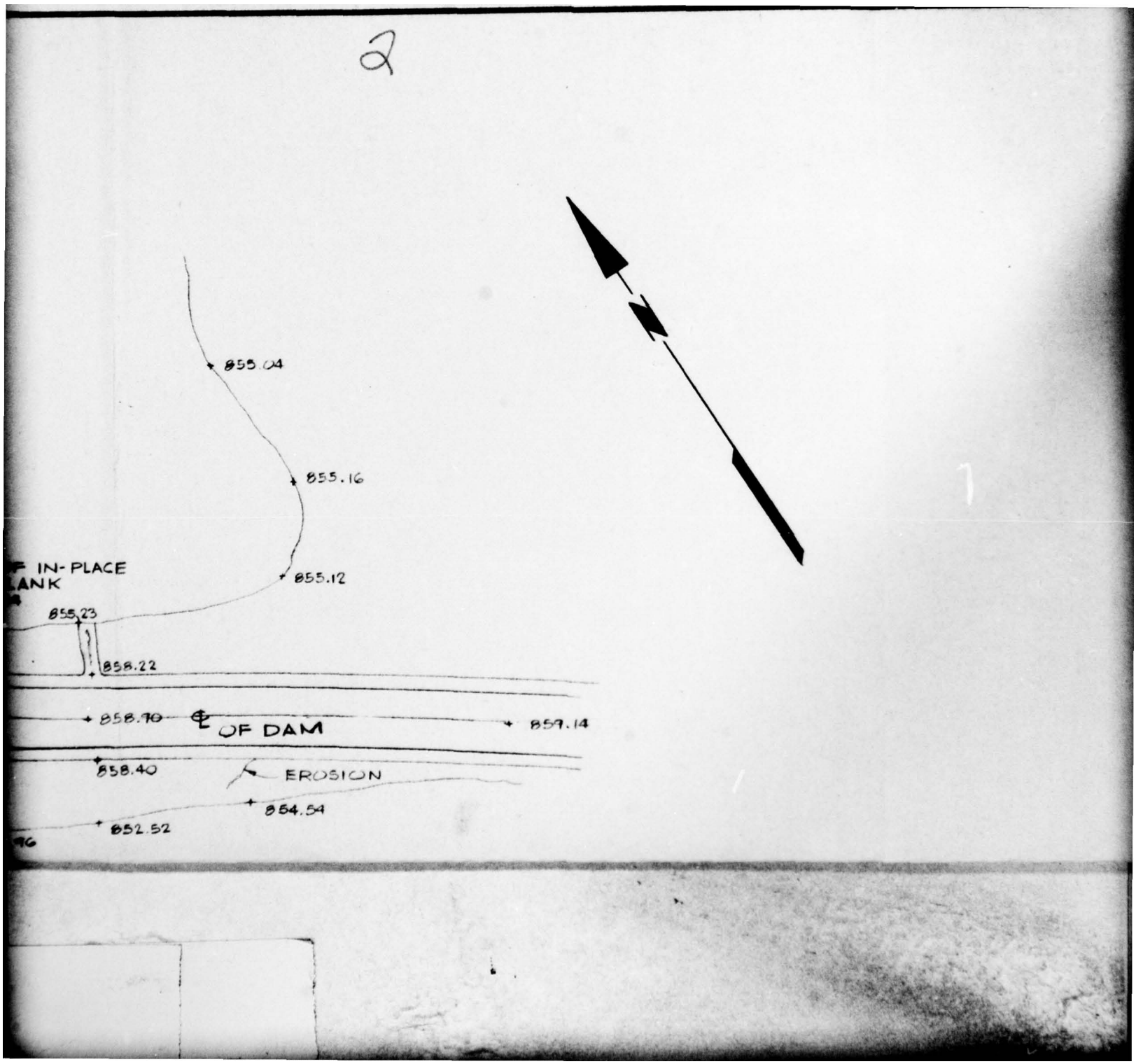


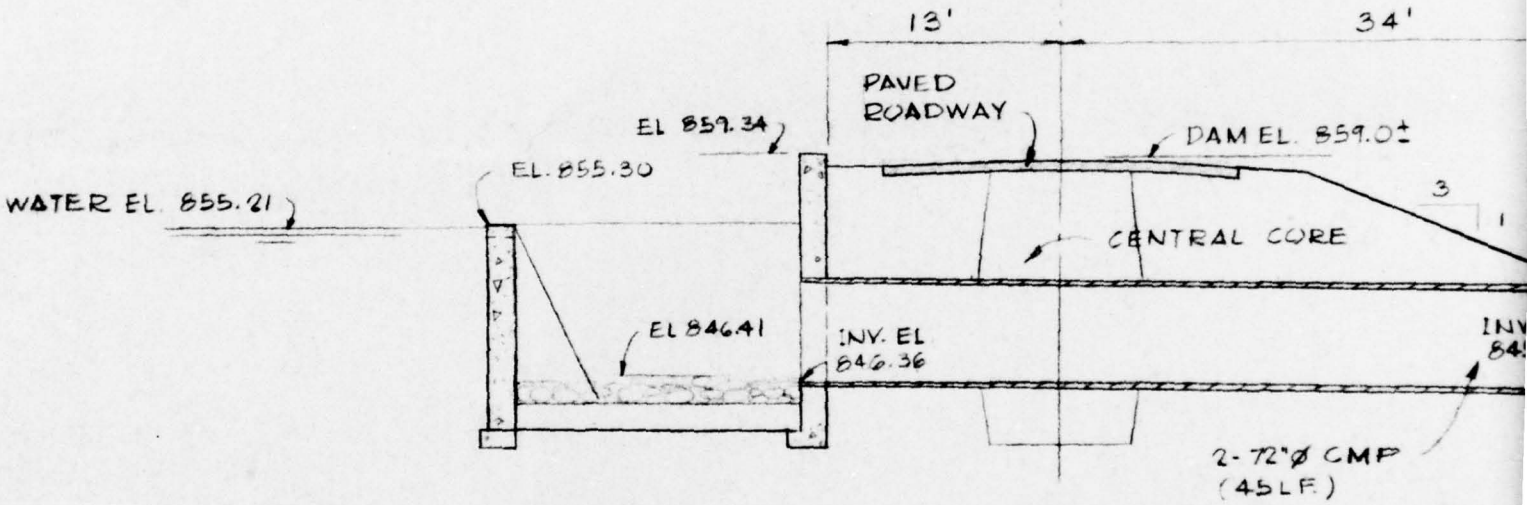
1in. ≈ 5.2mi

REGIONAL VICINITY MAP
CRANDON LAKE DAM

Fig. 1

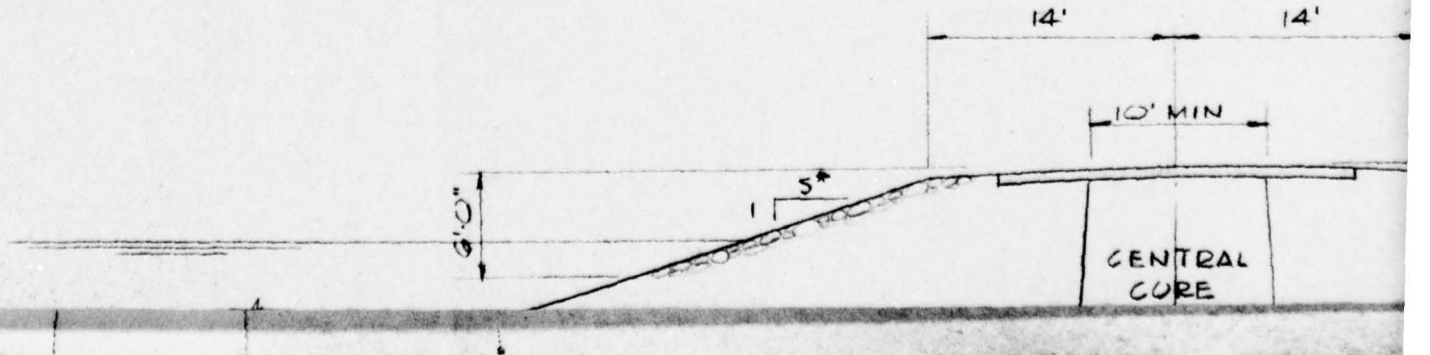

CRANDON LAKE
EL. 855.21
855.42
855.71
858.29
A
BM
EL 855.30
CREST OF IN-PLA
STOP PLANK
EL. 854.44
855.23
859.34
PLUG
860.77
859.20
28'±
858.85
36"
859.12
858.93
2 - 72" CMP'S
858.38
853.16
EROSION
852.28
EROSION
847.40
ANIMAL BORROW
850.76

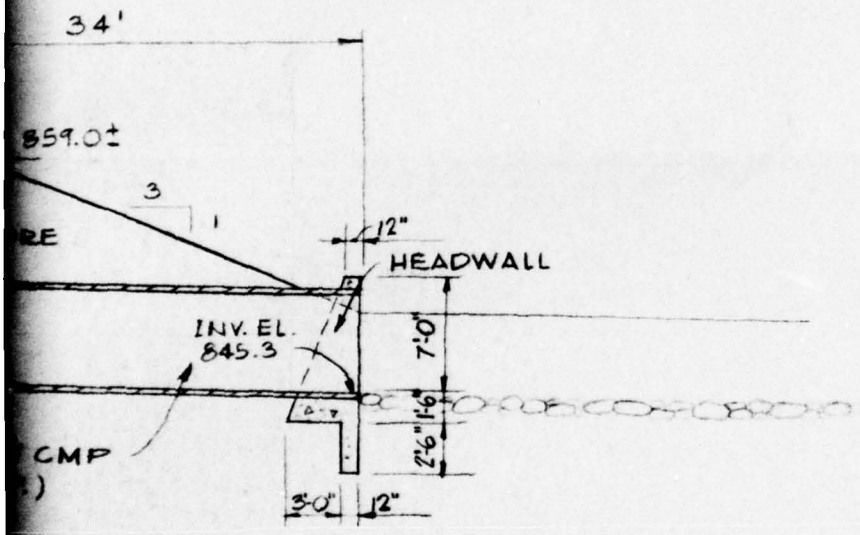

2
855.04
855.16
F IN-PLACE
ANK
855.12
855.23
858.22
858.90
℄ OF DAM
859.14
858.40
EROSION
854.54
852.52
96



SECTION A-A

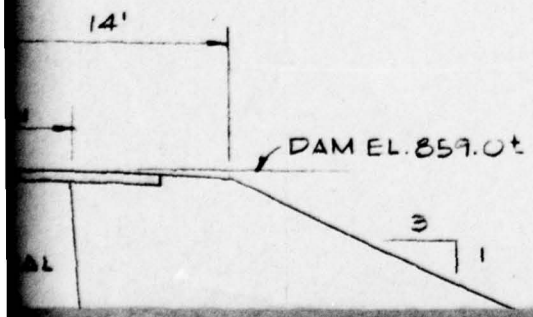
SCALE: 1" = 10'

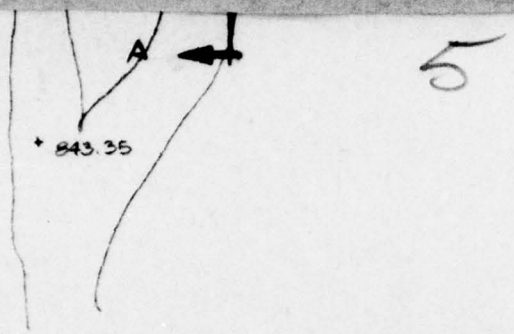



34'
859.0±
3
1
RE
12"
HEADWALL
INV. EL.
845.3
7'-0"
1'-6"
2'-7½"
CMP
3'-0"
12"

A - A

10'

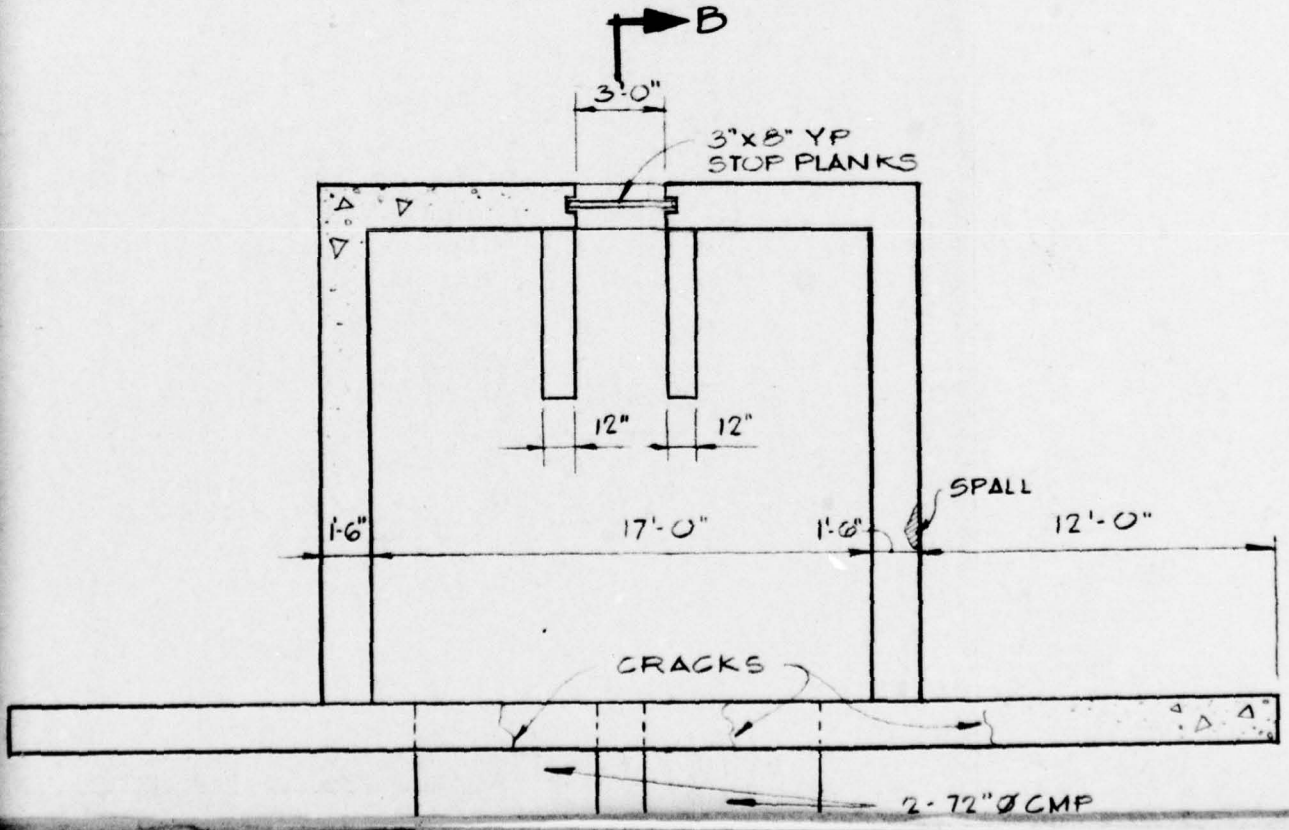

14'
DAM EL. 859.0±
3
1



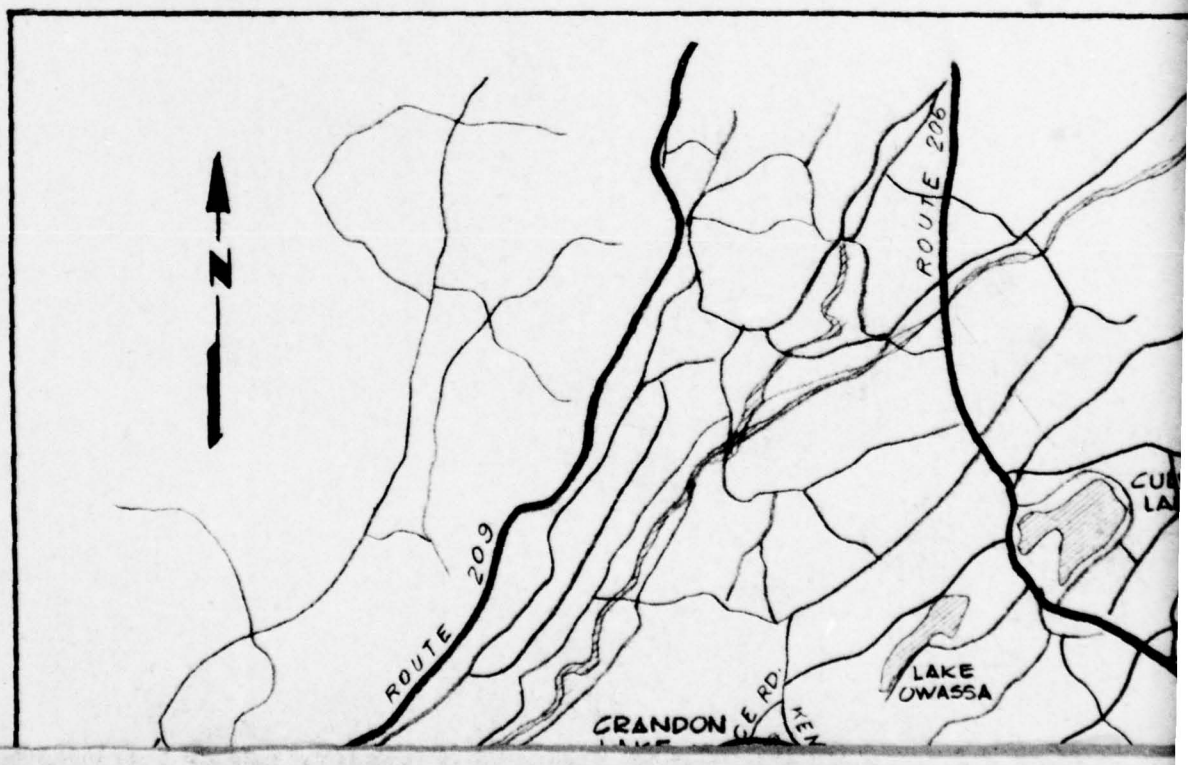
5

PLAN

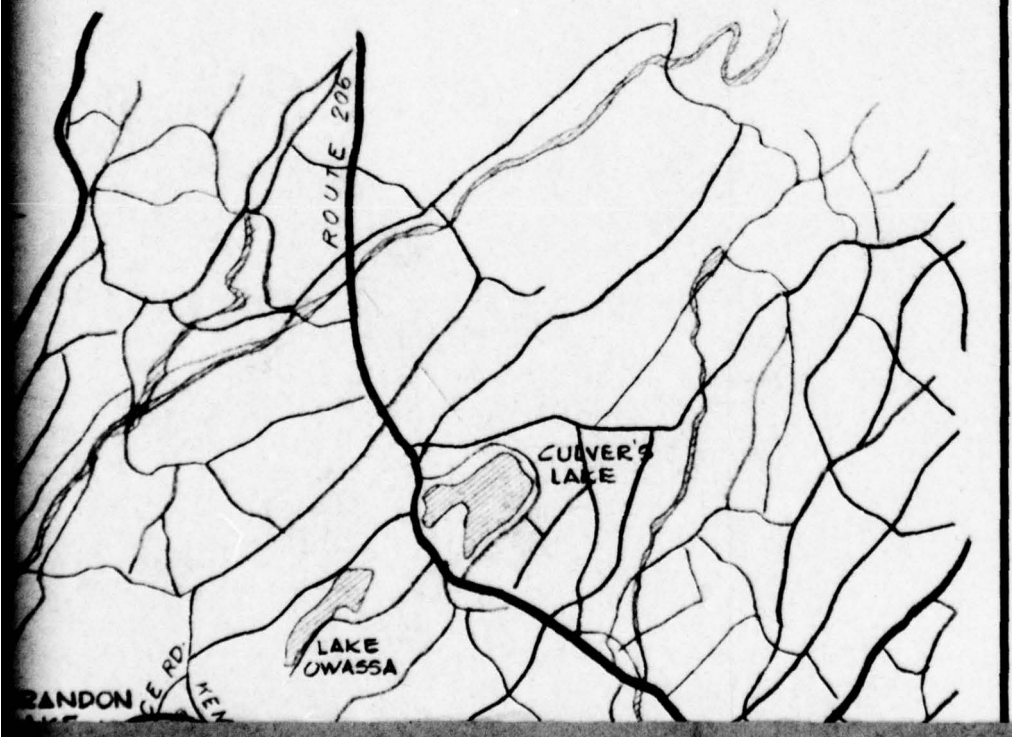
SCALE: 1"=40'

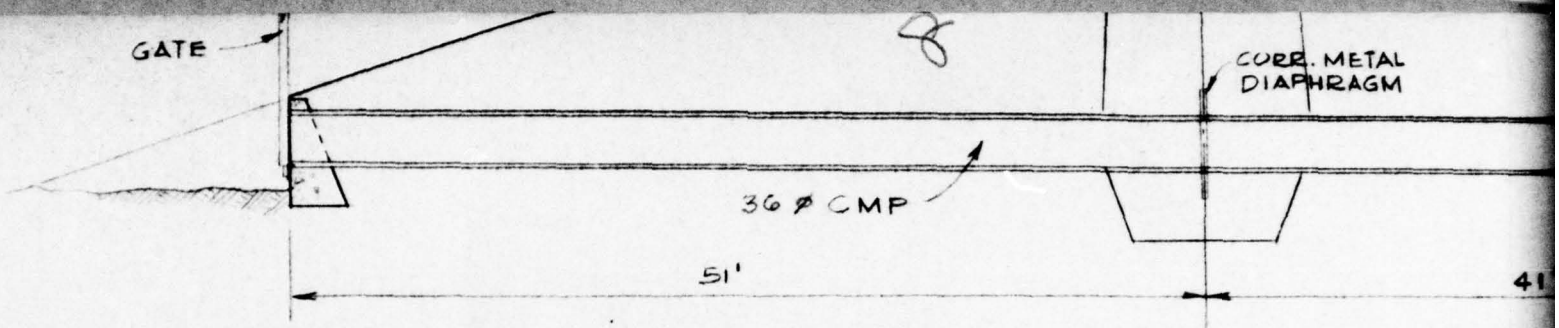


6



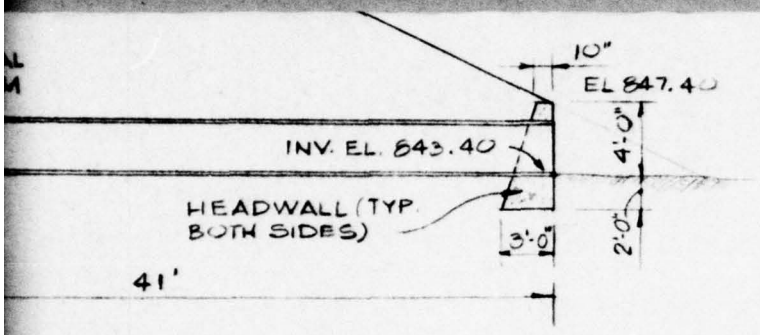
7





* It is reported that the upstream slope of the embankment is 2H:1V
Visual inspection shows the upstream slope above lake level is about 5H:1V

TYPICAL SECTION OF D
THRU BLOW-OFF PIPE
SCALE 1" = 10'

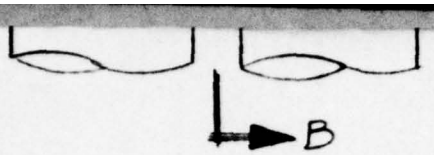


9

N OF DAM
IPE

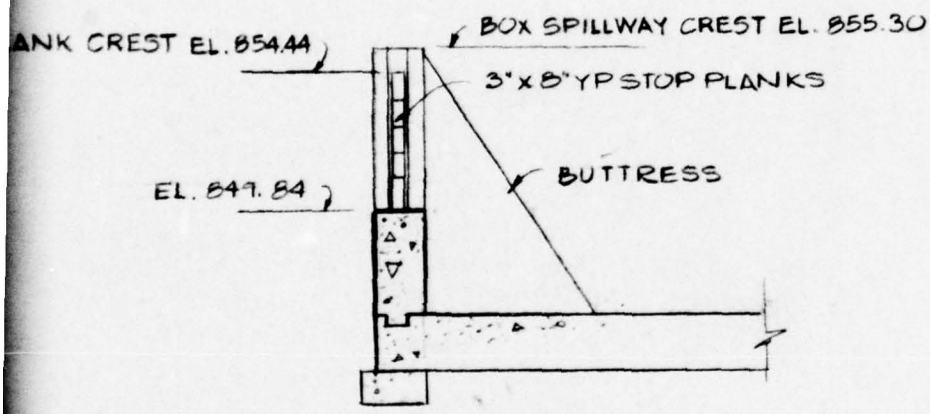
STOP PLANK CREST

DET



10

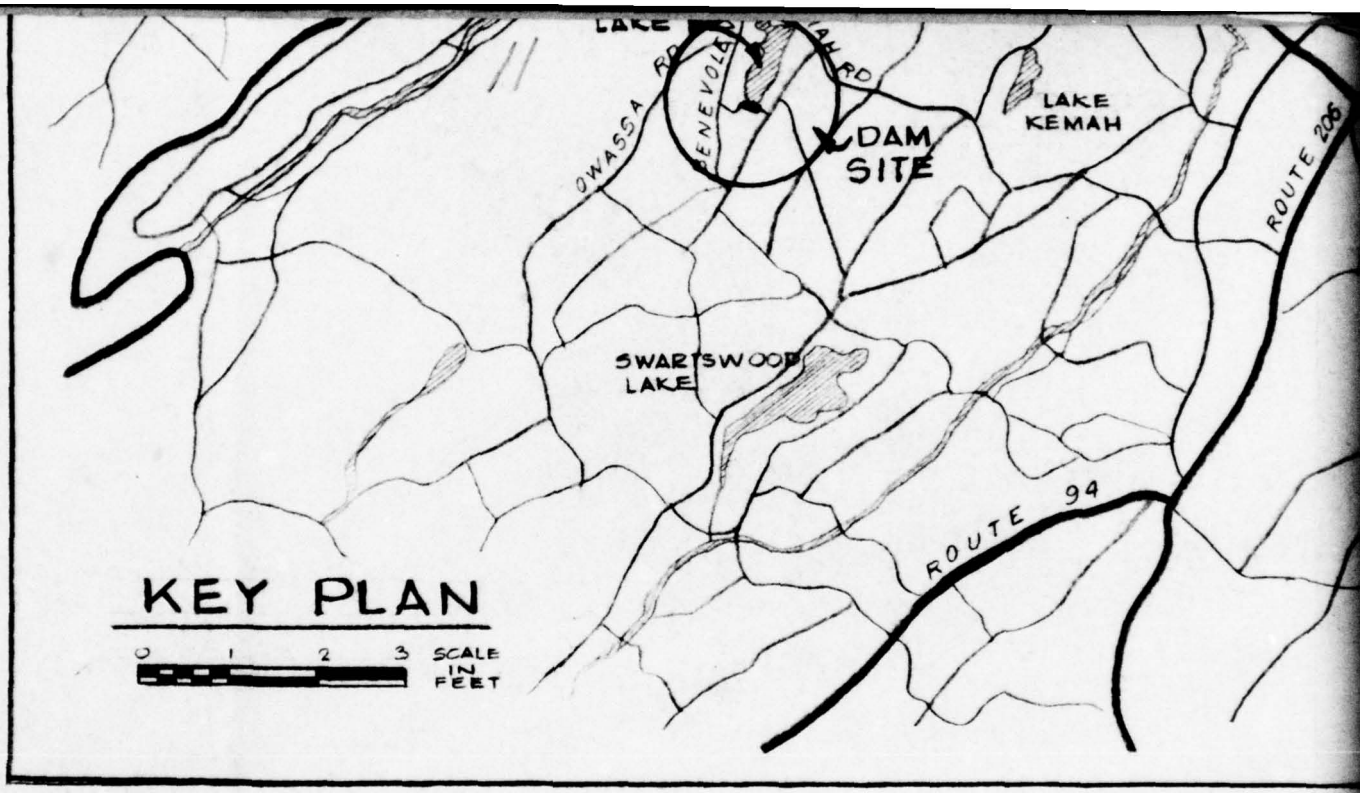
PLAN

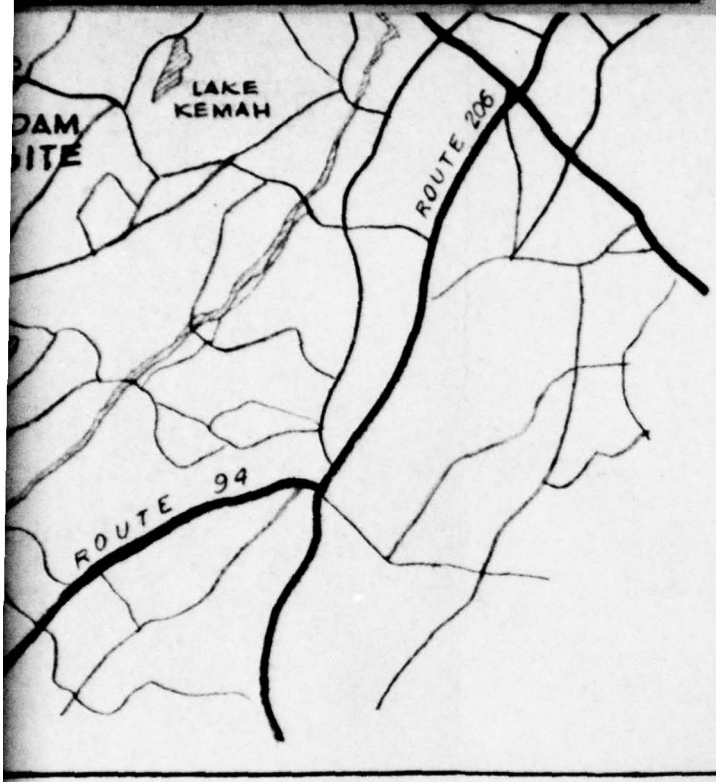


SECTION B-B

DETAIL OF SPILLWAY

SCALE : 1" = 6'


LAKE
OWASSA RD
DAM SITE
LAKE KEMAH
ROUTE 206
SWARTSWOOD LAKE
ROUTE 94
KEY PLAN
0 1 2 3 SCALE IN FEET



12

DATE	DESCRIPTION	NO.
REVISIONS		

NOTE:

THE ELEVATIONS SHOWN WERE OBTAINED USING A SURVEYOR'S TRANSIT AND LEVEL. THE BENCHMARK ELEVATION OF 855.30 ON THE WALL OF THE SPILLWAY WAS USED AS WAS INDICATED ON THE DRAWINGS ENTITLED "CRANDON LAKE DAM, CRANDON LAKES DEV. CO. INC. HAMPTON STILLWATER TWPS. - SUSSEX CO. JUNE 1957, WALDO J CLARKE, P.E. FRANKLIN, N.J.. THESE ELEVATIONS ARE APPROXIMATE. INFORMATION SHOWN BELOW GROUND SURFACE AND WATER LEVEL ARE INFERRED ON THE BASIS OF THE ABOVE MENTIONED DWGS.

14

INED USING A SURVEYORS
N OF 855.30 ON THE WALL
ON THE DRAWINGS
DEV. CO. INC. HAMPTON
VALDO J CLARKE, P.E.
ROXIMATE. INFORMATION
LEVEL ARE INFERRED
GS.

PROJECT

PHASE I

INSPECTION & EVALUATION
of
NEW JERSEY DAMS

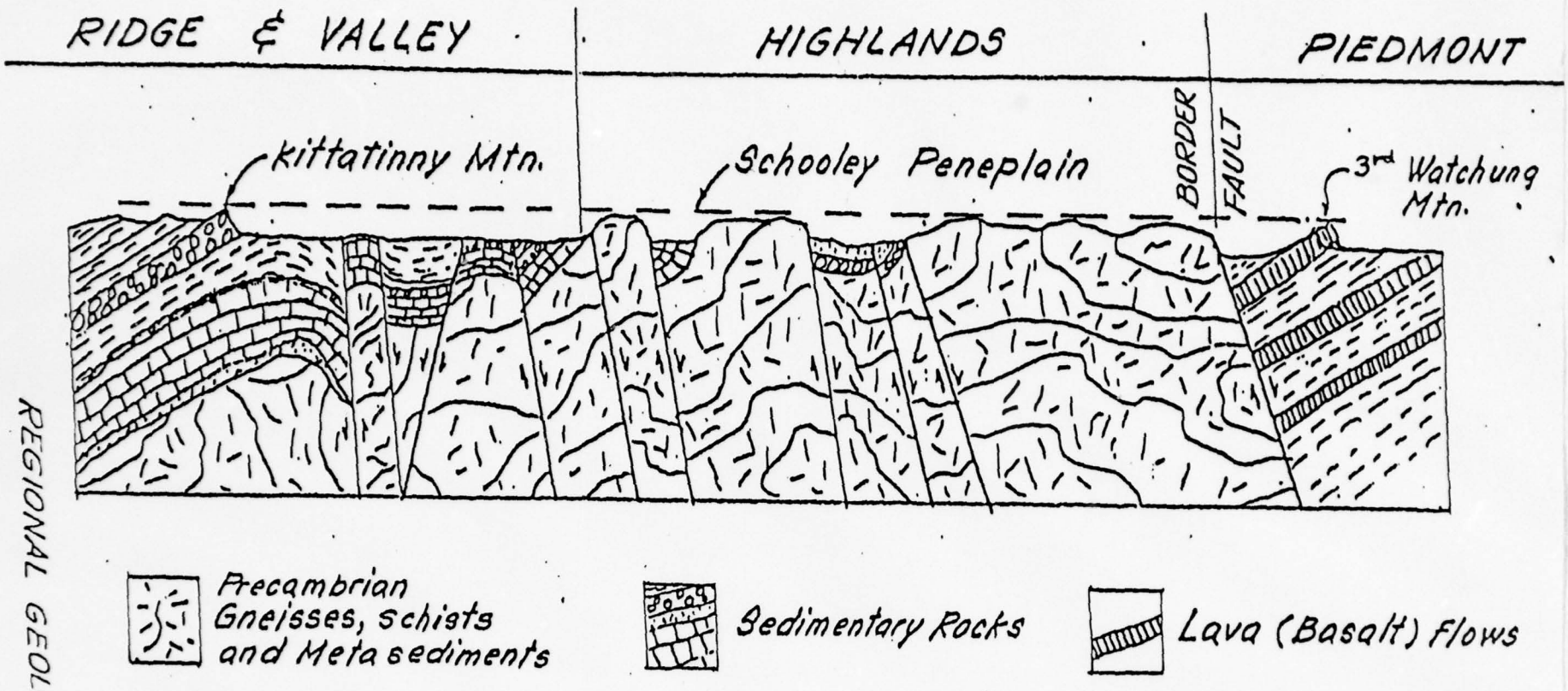
DRAWING TITLE

CRANDON LAKE DAM

FEBRUARY 1979

FED. I.D. NO. NJ00267

JOB NO. J-783B	DRAWING NO.
DATE 5 FEB 1979	
SCALE AS NOTED	FIG 2
DRN. BY J.R.	
CHKD. BY D.J.L.	



REGIONAL GEOLOGIC FEATURES

Fig. 3

Schematic Cross-section of Ridge & Valley Physiographic Province (After Wolfe, 1977)

APPENDIX 1

ENGINEERING DATA

CRANDON LAKE DAM

Foundation Information

This dam will be constructed in a presently completely wooded area. The stream channel and flood plain upstream of the dam site are flat, offering an excellent location for a lake.

At the examiner's request, a trench, approximately 4 ft. deep and 8 ft. wide, was dug along the center line of the dam for its full length. Several test holes were also dug into the bottom of this trench. The entire foundation below stripping level was shown to be a tight, highly impervious gray clay, satisfactory for the foundation into which the compacted, central core will penetrate.

In the examiner's opinion, this clay may not be satisfactory for the central core due to the absence of coarser materials, and the probable resultant high plasticity. At his request, therefore, a site for borrow material was located which contained material, which by inspection, appeared to be very satisfactory for the compacted, central core. It contained a yellow clay with sufficient coarse grain material to prevent the core from cracking when dry, or becoming plastic when wet. See Inspection Report dated June 10, 1957.

Hydrology

Encroachment Applications #910 & 911 (21-37 & 21-38) approved county bridges e.s. for Central Jersey curve run-off.

Lake Kenah dam on an adjacent watershed, Appl. 105 (21-20) was approved for 75% South Jersey curve run-off.

Quick Pond and Mecca Lake are two large ponds a short distance above the proposed lake. The two existing and the proposed new 70-acre lake will, in the opinion of the examiner, suppress major floods to below Central Jersey curve run-off. A conservative design having a frequency of from 50 to 100 years is therefore estimated as C.J. curve run-off.

Hydraulics of Spillway Trunk for Q = 560 cfs.

Invert at Outlet	El.	645.30
Probable Depth at Outlet		6.00 ft.
Vel. Hd. at Outlet		1.52 ft.
Friction loss for n = .021		.55 ft.
Entrance loss, K = 0.5		.76 ft.
Energy line & Spillway Pool level	El.	654.13
Spillway Crest	El.	655.30

Spillway Hydraulics

H for the design flood of 560 cfs (no submergence) $\left(\frac{560}{(123.33}\right)^{2/3}$ = 2.34 ft.

Q for H = 4.00 ft. (dam awash) is as follows, as computed from the formula for correction of weir coefficient due to submergence:-

$$C' = C(1-h^{2/3})^{.385}$$

1. Compute submergences of spillway crest for several critical values of discharge in accordance with the method of the preceding paragraph.
2. Plot submergence vs discharge (See attached curves).
3. For a selected H, compute the discharges corresponding to several critical submergences, using corrected weir coefficients from above formula.
4. Again plot submergence vs discharge.
5. The intersection of the two plotted lines gives the corrected discharge for the selected H.

Thus the spillway and spillway trunk have capacity to discharge 823 cfs with the dam awash. This is approximately equal to Mean, N.4 C.J. curve run-off.

that the spillway and spillway trunk have capacity to discharge 823 cfs with the dam awash. This is approximately equal to Mean, U.S. C.J. curve run-off.

Specifications

The specifications include and adequately cover all necessary provisions for the proper construction of the dam.

as may be considered necessary, ~~and further reserves the right to suspend or revoke this permit at any time should such action be deemed advisable~~ in the interest of public safety.

(See below) 3. ~~That the work shall be under the direction of a competent engineer, and that he or a competent representative shall be on the project during the construction and until the dam [illegible] of the dam~~

4. That the Commission shall be notified in advance of the proposed time of the commencement of the work; that no material shall be placed on any portion of the foundation until such portion of the foundation has been approved in writing by a representative of the Commission.

5. That a report, on forms to be submitted by the Commission, on the status of the construction work shall be mailed to the State Water Policy Commission, 28 West State Street, Trenton, New Jersey, on the first day of each month until the work upon the dam has been completed.

6. That no brush or waste timber cleared from the area under this approval shall be burned unless and until the party doing the work shall have obtained a permit from the Fire-warden of the district in which the burning is to be done, in accordance with Title 13:9-19 of the Revised Statutes.

7. That no fashboards or other obstruction shall be placed or permitted to remain on the crest of the spillway.

8. That the work shall be started within **one year** from date of this permit and completed within **two years** from said date; otherwise, this permit, if not previously revoked or otherwise extended, shall cease and be void and void.

9. This permit shall not become operative unless and until the applicant shall file with the Commission within thirty days from date hereof, upon a form furnished by the Commission, its written acceptance of the terms and conditions hereby imposed.

3. That all work shall be performed under the direct supervision at all times of a competent professional engineer licensed in the State of New Jersey, or his qualified representative. Acceptance of the dam for operation will be subject to a certification by the engineer that the dam has been constructed in conformance with the drawings and specifications submitted and hereby approved, or with modifications of these drawings subsequently approved.

10. The drawings hereby approved are three sheets prepared by Baldo J. Clarke, P.E., entitled as follows:

Sheet 1 - "Map of a Portion of the Property of Crandon Lakes Dev. Co. Ins. Hampton & Stillwater Twps. Sussex Co. N.J." dated March, 1957.

Sheet 2 - "Crandon Lake Dam, Crandon Lakes Dev. Co. Inc., Hampton-Stillwater Twps. - Sussex Co.", dated June, 1957.

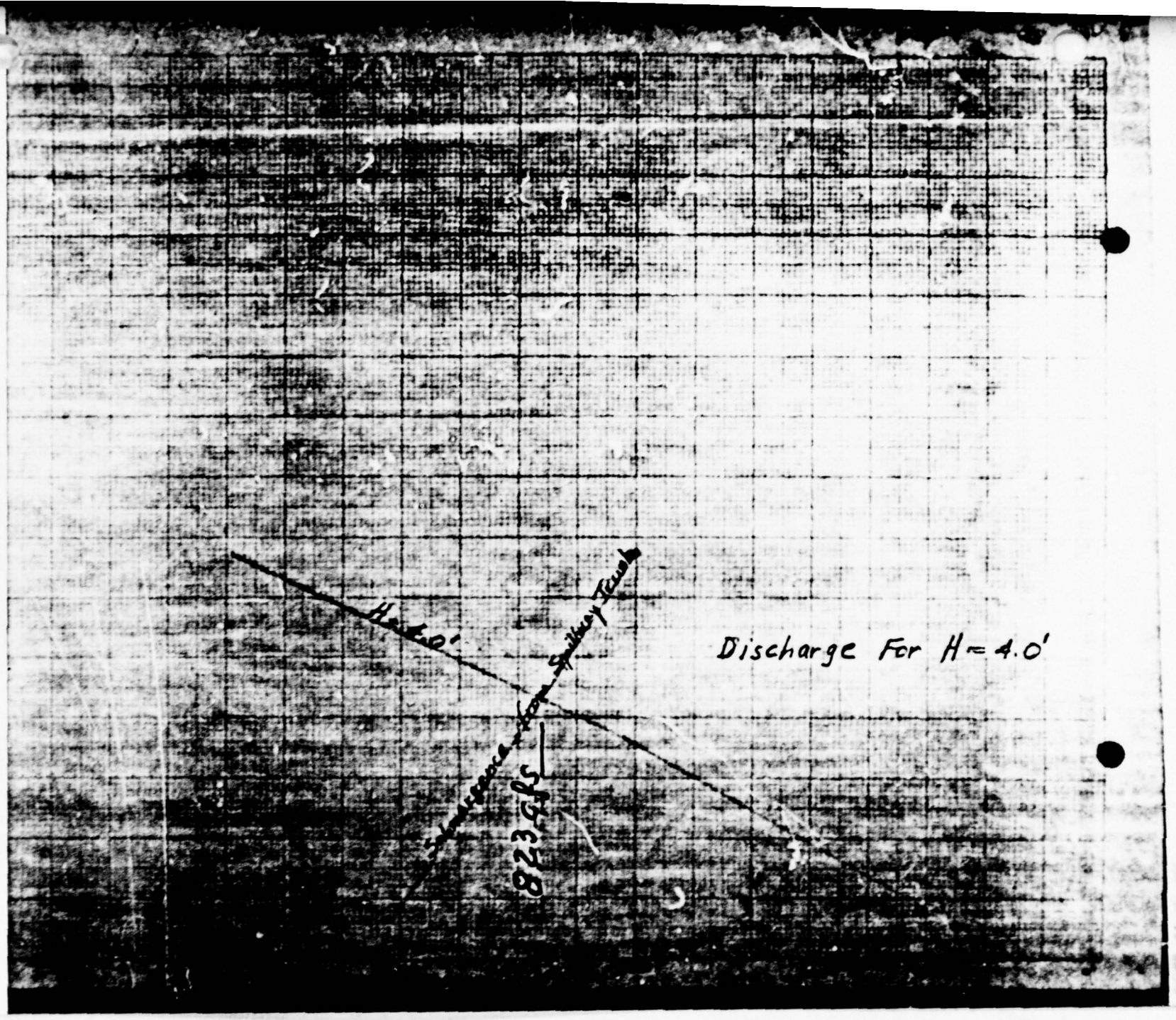
Sheet 3 - "Crandon Lake Dam, Crandon Lakes Dev. Co., Inc., Hampton-Stillwater Twps.- Sussex Co.", dated June, 1957.

[illegible] Engineer.

[illegible] in Charge [illegible] inar & [illegible] rector

Trenton, New

July 23,


Discharge For H = 4.0'
H = 4.0'
Submergence from spillway crest
823 cfs

APPENDIX 2

CHECK LIST

VISUAL INSPECTION

CRANDON LAKE DAM

CHECK LIST
VISUAL INSPECTION

Phase I

NAME DAM Crandon Lake Dam COUNTY Sussex STATE New Jersey COORDINATORS N.J.D.E.P.

DATE(s) INSPECTION See below WEATHER Overcast & cold TEMPERATURE 25° F

POOL ELEVATION AT TIME OF INSPECTION 855.2* M.S.L. TAILWATER AT TIME OF INSPECTION 846* M.S.L.

* Elevations based on BM of El. 855.3 (Ref. Fig 2)

INSPECTION PERSONNEL:

J. Richards	12/20/78	J. Rizzo	12/13/78
	12/13/78		
P. Yu	12/20/78	D. Leary	12/13/78
C. Campbell	12/13/78		

Peter Yu RECORDER

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Leaves, wood boards, a few fallen trees partially obstruct downstream channel.	Debris and obstructions should be removed.
SLOPES	Appear satisfactory	
APPROXIMATE NO. OF HOMES AND POPULATION	No homes immediately downstream. Approximately (5) at relatively low elevations around the perimeter of the lower lake about 1000 ft downstream and numerous scattered homes at high elevations. Est. population 30 people, lower lake area about 10 acres, USGS Topo Map and visual inspection.	

EMBANKMENT

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	Trees grow on slopes of embankment. Erosion has occurred along the sides of the downstream headwalls for outlet conduits. Some erosion has occurred on upstream slope near the drop box structure and at a few other locations	Eroded areas should be filled
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Appear satisfactory	
RIPRAP FAILURES	Riprap not uniform along upstream face; no failures observed.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
OTHER	Six inch diameter by ten inch deep animal hole downstream slope near the 36 in-dia outlet structure.	Hole should be filled.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Appear Satisfactory	
ANY NOTICEABLE SEEPAGE	None Observed	
STAFF GAGE AND RECORDER	None Observed	
DRAINS	None Observed	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Rust on the two 6-ft-dia spillway outlet pipe and the 36-in blow-off pipe near flow line.	Rusted pipes should be replaced or relined.
INTAKE STRUCTURE	Numerous cracks observed on upstream face of concrete headwall of the 6-ft-dia conduit. Three cracks extend to the top and appear on exposed sides of the wall. At left junction of drop box/headwall, water seepage.	Cracks should be further investigated. Leakage at junction should be repaired.
OUTLET STRUCTURE	Approx. 1-in-wide crack on downstream face of headwall for the two 6-ft-dia conduits. Minor spalling on headwall for the 36-in pipe.	Cracked and spalled concrete should be repaired.
OUTLET CHANNEL	Metal drum in outlet channel of the 36-in pipe.	Outlet channel should be cleaned of any debris.
EMERGENCY GATE	None observed	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARK OR RECOMMENDATIONS
SLOPES	Satisfactory condition except some minor erosion in limited area. (6 Hor. to 1 Vert. earth slope with occasional vertical bulkhead from some homes.)	
SEDIMENTATION	Appears satisfactory	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Concrete spalled on left weir outside edge, 8-in x 4-in x 1/2-in. Minor deterioration on inside faces of the drop box spillway.	Concrete should be repaired.
APPROACH CHANNEL	None Observed	
DISCHARGE CHANNEL	Appears satisfactory.	
BRIDGE AND PIERS	None observed	

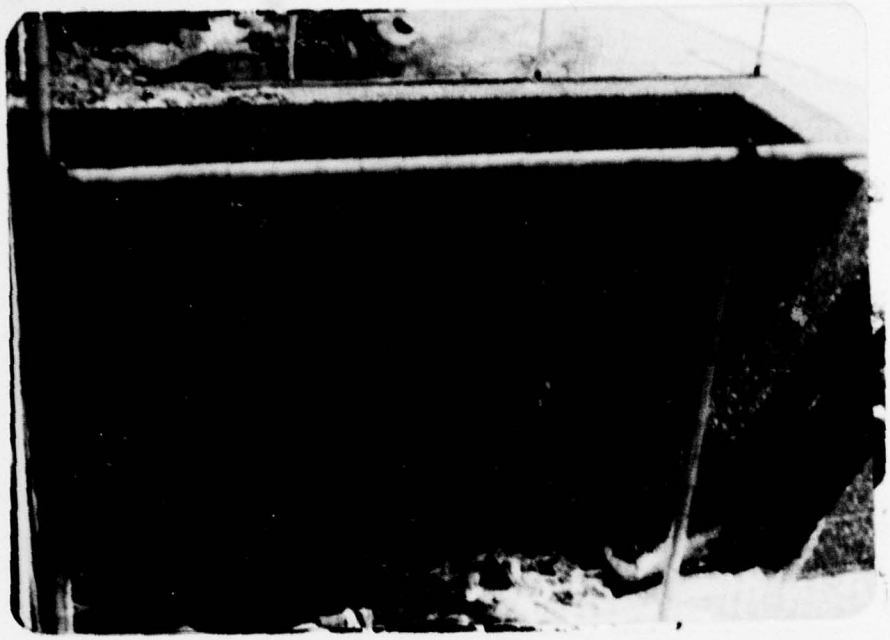
APPENDIX 3

PHOTOGRAPHS

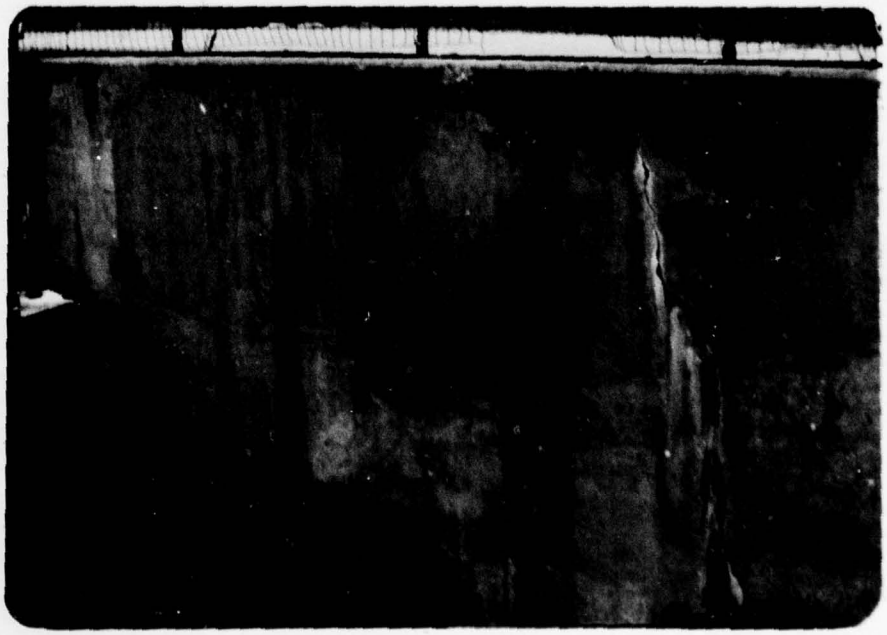
CRANDON LAKE DAM

Upstream face of dam. Looking west. 20 December 1978

Upstream face of dam. Looking east. 20 December 1978



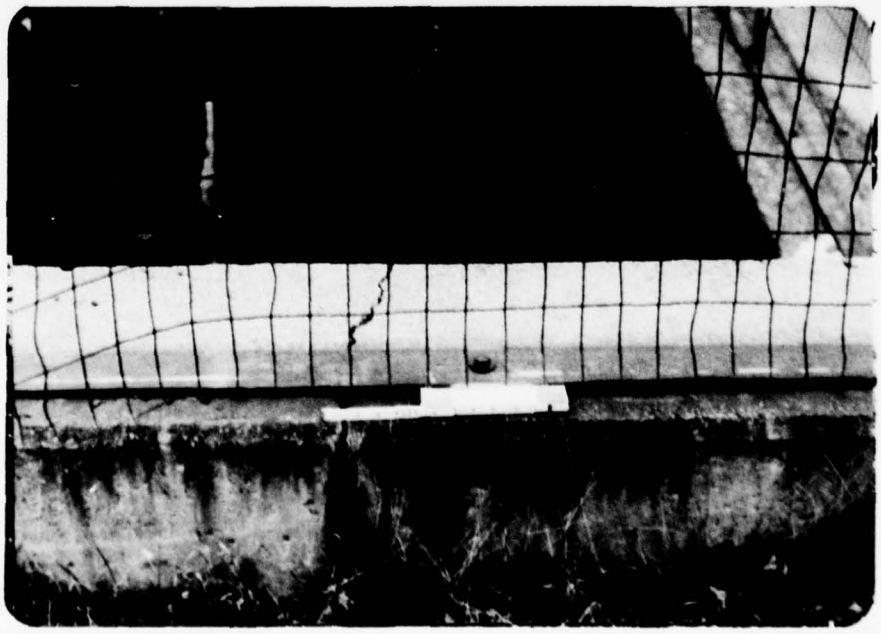
Concrete drop box spillway. 20 December 1978



Cracks in headwall of drop box spillway. Note frozen seepage in corner of box at left of photo. 20 December 1978

Water seeping at joint at left wall of drop box spillway.

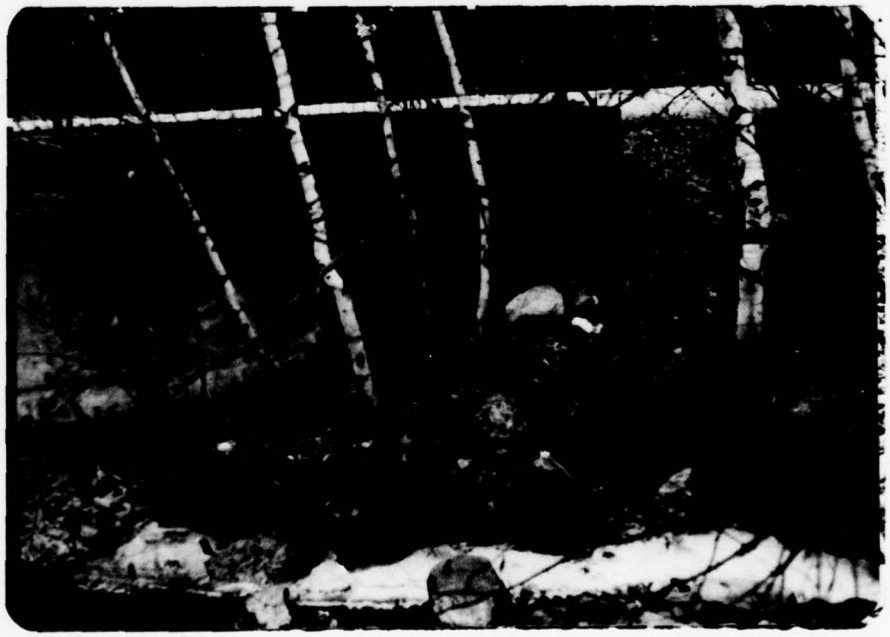
20 December 1978



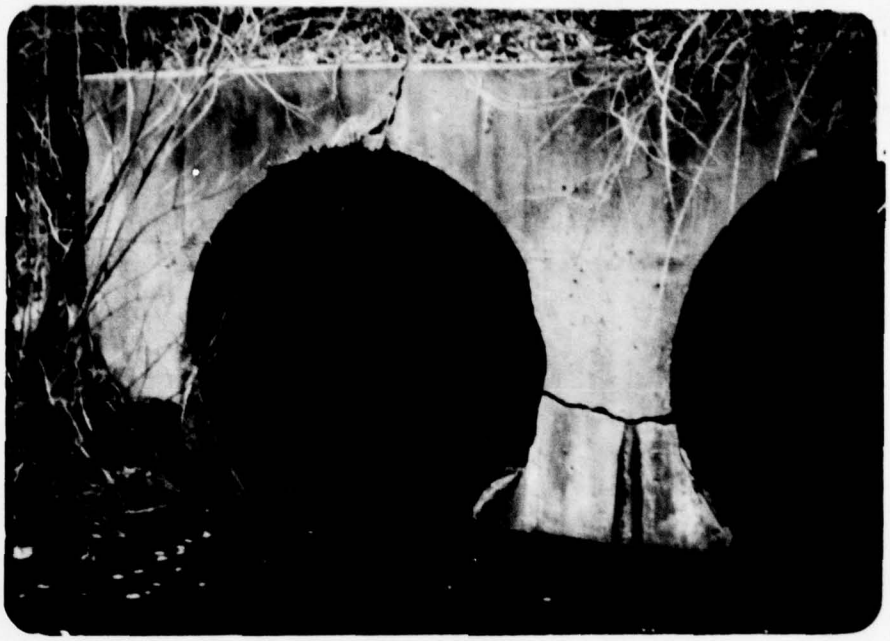
Open crack, 1/2-in at headwall of drop-box spillway.

20 December 1978

Erosion at left spillway/embankment junction. 20 December 1978



Erosion at right spillway/embankment junction. 20 December 1978



Spillway outlet conduits. Concrete cracked at top and at spring line. 20 December 1978

Left spillway outlet conduit. 20 December 1978

Low level outlet conduit.
Looking upstream.

20 December 1978

Debris, riprap and trees on
upstream face of dam.

20 December 1978

Discharge channel for drop-box spillway. Looking downstream. 20 December 1978

Downstream discharge where channel drop-box spillway and low level outlet discharge merge. 20 December 1978

Concrete slope protection along discharge channel for drop-box spillway.

20 December 1978

Crandon Lake.

20 December 1978

APPENDIX 4

HYDROLOGIC COMPUTATIONS

CRANDON LAKE DAM

LANGAN ENGINEERING ASSOCIATES, INC.

HYDROLOGIC COMPUTATIONS

CRANDON LAKE DAM

Location: Sussex County, N.J.

Drainage Area: 2.45 sq. mi.

Lake Area: 70 Ac.

Classification: Size – Small
Hazard – high

Spillway Design Flood

Based on available information, it is understood that the spillway has been designed on the basis of a design flood of 560 cfs with 2.34 ft head (no submergence). This peak discharge corresponds to a flood having a frequency of 50 years. . In accordance with evaluation criteria, ½ PMF to PMF should be used. PMF is chosen for analysis.

Compute PMF

1. Dam located in Zone 1 (south boundary)
   PMP = 22 inches

2. PMF must be adjusted for basin size (since dam locates close to zone 6, ∴ take average)

Duration	% Factor (for 10 sq mi) Zone 1	Zone 6	Average	Reduction Factor
0-6	111	112	112	
0-12	123	123	123	0.80
0-24	133	132	133	
0-48	142	142	142	

BY Dy DATE 2-1179 Crandon Lake Dam JOB NO. J-783 B

CKD ~~TED~~ DATE 4-19-79 SHEET NO. 1 OF 12

LANGAN ENGINEERING ASSOCIATES, INC.

DETERMINE TIME OF CONCENTRATION

1. Majority area of watershed is hilly and wooded
2. Main channel is about 9400' stream (including 2 lakes) & 3800' overland flow
3. Estimated slopes

$$\text{overland} = \frac{560}{3800} = 14.7\%$$

$$\text{stream} = \frac{80}{9400} = 0.85\%$$

4. Estimate T_c based on average velocity and lengths

	slope	Velocity	remarks
overland flow	14.7%	1.2 fps	wooded valley
stream channel	0.85%	1.85 fps	use gutter flow

$$T_c = \left[\frac{3800}{1.2} + \frac{9400}{1.85}\right] \div 3600 \doteq 2.29 \text{ hrs.}$$

$L = 0.6\, T_c = 1.4$ hr.

5. Estimate T_c from State DEP Nomograph

$\Delta H = 640$ ft

$L = 13200$ ft

$T_c = 37$ min.

$\therefore L = 22$ min.

BY RJ DATE 2-20-79 Crandon Lake JOB NO. J-783B

CKD [illegible] DATE 4-19-79 SHEET NO. 2 OF 12

6. Estimate Tc from curve number method SCS (Tech Release 55 Fig. 3-3)

$l = 13200$ ft.

$$\text{Ave slope} = \frac{14.7 \times 3800 + 0.85 \times 9400}{13200} = 4.84\%$$

$CN = 80$

$L = 1.3$

Use $\boxed{L = 1.3 \text{ hrs.}}$

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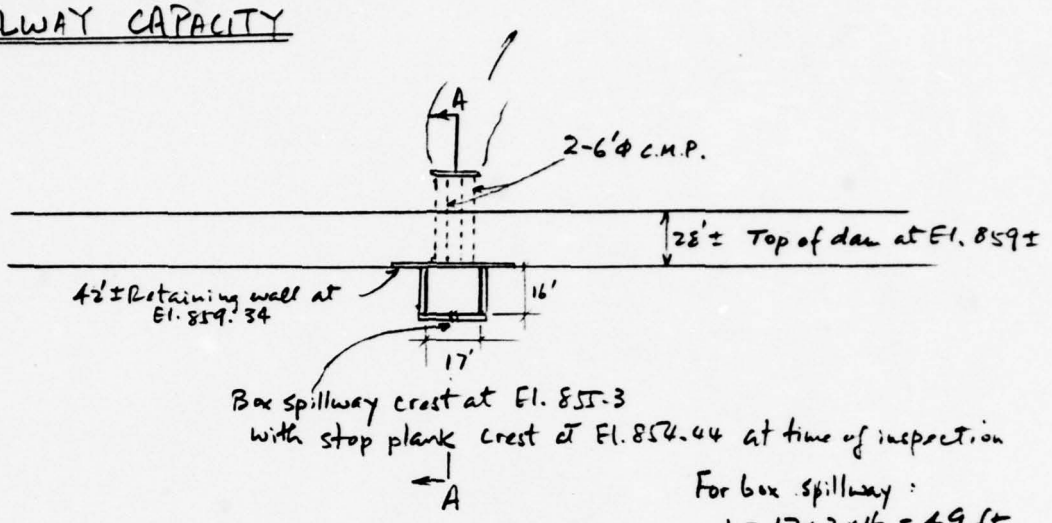
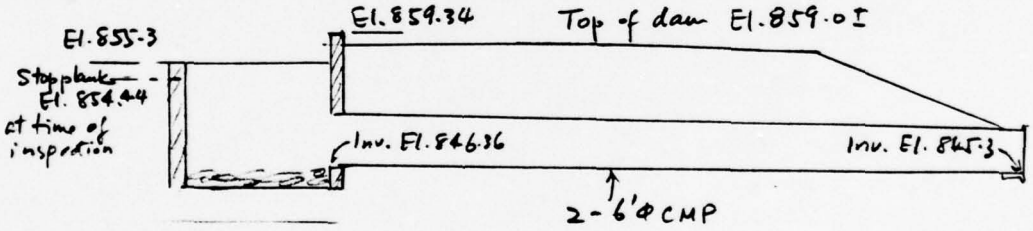
SPILLWAY CAPACITY



Plan View



Section A-A

At time of inspection, one stop plank (3' long) was removed from the spillway box, and its crest was at El. 854.44. Since existing condition is below its normal flowline (spillway crest), it would be unconservative to analyze existing condition. Therefore, it is assumed that the stop plank is replaced and storm starts when pool level is at spillway crest. As discharge increases, the headwater in the culvert pipes rises; and eventually the culvert filled. Discharge capacity will be governed by the culvert if its capacity ever becomes less than that of the spillway.

Discharge of culvert when just filled (headwater for culvert at 852.36):

'Open-Channel Hydraulics' by Chow, 1959
Fig. 17-30 on pg. 498

$\frac{H}{d} = 1$, $d = 72$, then $Q = 2 \times 200 = 400$ cfs (2 - 6'ϕ CMP)

Approximate head above box spillway when culvert entrance filled

$H = \left(\frac{Q}{CL}\right)^{2/3}$ use $C \doteq 3.0$ (Table 5-3 of 'Handbook of Hydraulics' by King & Brater)

$= \left(\frac{400}{3 \times 49}\right)^{2/3}$

$\doteq 1.95$ ft

∴ Culvert filled when lake elevation at El. 857.25

For embankment section, assume discharge obeys weir equation when overtop

use $C_{avg} = 2.7$

Section with retaining wall (above culvert entrance) crest at El. 859.34:

$L = 42$ ft

Section with embankment crest at El. 859.0

$L = 428 - 42 = 386$ ft.

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BY PJ DATE 2-20-79 Crandon Lake Dam
CKD [illegible] DATE 4.9.79
JOB NO. T-7838
SHEET NO. 6 OF 12

Elevation (ft)	Box Spillway			Culvert (2 - 6'ϕ CMP)			Embankment		Embankment at retaining wall section		Total (cfs) $Q_T = Q_{BS} + Q_E + Q_{ER}$
	H(ft)	C	Q_{BS}(cfs)	H(ft)	H/d	Q_C(cfs)	H(ft)	Q_E(cfs)	H(ft)	Q_{ER}(cfs)	
855.3	0		0			Controlled by box spillway					0
856.3	1	2.75	135								135
857.3	2	3.03	420	10.94	1.82	750					420
858.3	3	3.32	845	11.94	1.99	820					820
859.0	3.7		Controlled by Culvert	12.64	2.11	840	0				840
859.34	4.04			12.98	2.16	850	0.34	207	0		1057
860.34	5.04			13.98	2.33	920	1.34	1617	1	113	2650
861.34	6.04			14.98	2.50	990	2.34	3731	2	323	5044
862.34	7.04			15.98	2.66	1030	3.34	6362	3	589	7981
863.34	8.04			16.98	2.83	1080	4.34	9423	4	907	11410
864.34	9.04			17.98	3.00	1120	5.34	12861	5	1268	15249

$Q_S = 49 C H^{3/2}$

Q_C from Fig. 17-30 on pg. 498 of 'Open-channel Hydraulics' by Chow, 1959

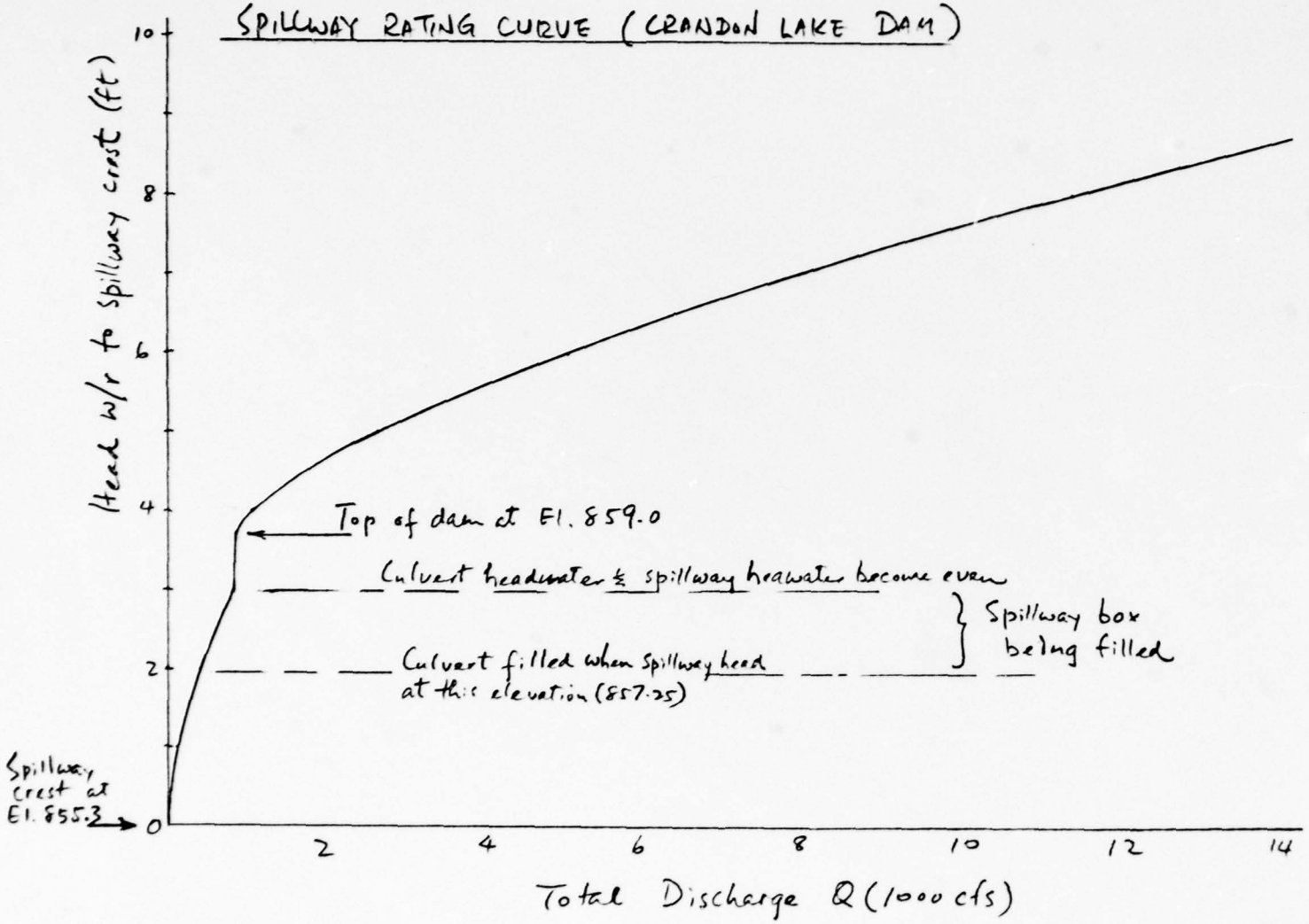
$Q_E = 1062.2 H^{3/2}$

$Q_{ER} = 113.4 H^{3/2}$

LANGAN ENGINEERING ASSOCIATES, INC.

BY RMJ DATE 2-21-74 Crandon Lake Dam JOB NO. 2-7836

CKD CED DATE 4-15-74 SHEET NO. 7 OF 12



Reservoir Storage Capacity

Assume a linear distribution for the area of the lake with elevation. Start at a zero storage at the crest of the spillway.

Area of lake = 70 Ac.

Length of equivalent square = 1746 ft

Take average side slope = 1 V. : 6 H.

∴ for every foot of water above the crest of spillway the length of equivalent square increases by

$= 1 \times 6 \times 2 = 12$ ft.

Elev. (ft)	H (ft)	Length of equivalent square (ft)	Area of Lake (Acres)
855.3	0	1746	70
856.3	1	1758	71
857.3	2	1770	72
858.3	3	1782	73
859.3	4	1794	74
860.3	5	1806	75
861.3	6	1818	76
862.3	7	1830	77
863.3	8	1842	78
864.34	9.01	1854	79

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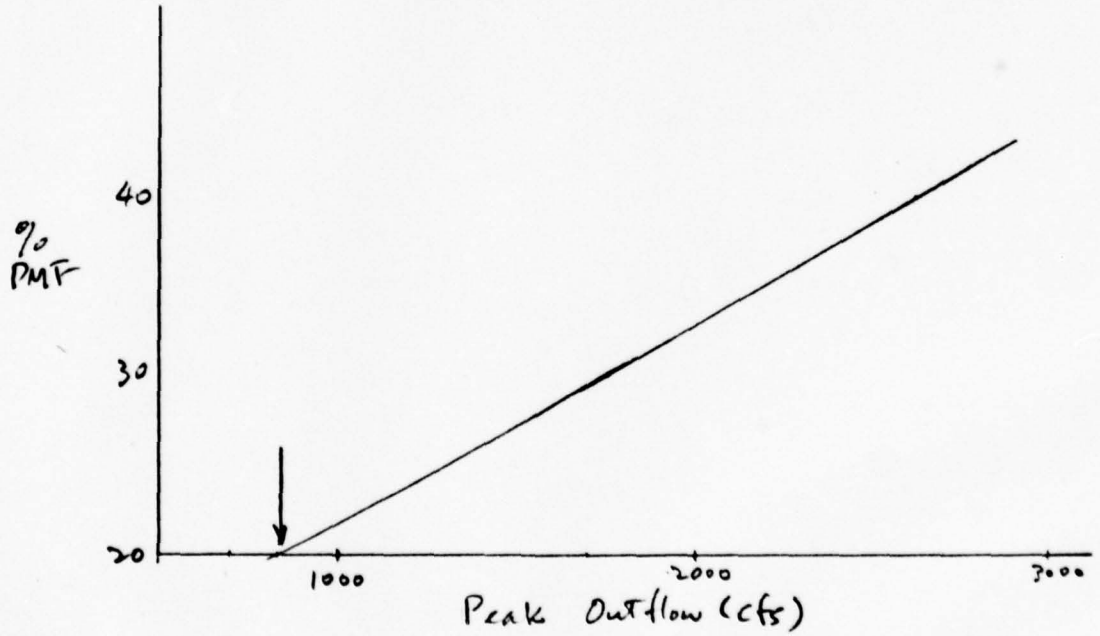
SUMMARY OF HYDROGRAPH AND FLOOD ROUTING

1. Hydrograph and routing calculated using HEC-1DB
2. PMF peak inflow for Crandon Lake is 7807 cfs
   (routed to 7489 cfs)
3. Routing indicates that the dam will overtop by approximately 3.2 ft for PMF

OVERTOPPING POTENTIAL

1. Various % of PMF has been routed using HEC-1DB
2. Plot peak outflow vs % PMF



3. Dam overtops at approx. El. 859 with Q = 840 cfs
   ∴ dam can pass approx. 20 % of PMF.

BY PG DATE 2-21-79 Crandon Lake Dam JOB NO. J-783 B
CKD EP DATE 4-19-79 SHEET NO. 9 OF 12

LANGAN ENGINEERING ASSOCIATES, INC.

DRAWDOWN ANALYSIS

1. Outlet structures

   One 36"-ϕ blow off pipe (length = 92' from available data)
   stop-planks in spillway box

   For this analysis, assume drawdown is achieved by opening the underwater gate for the 36"-ϕ pipe only.

2. Outlet capacity

   From Fig. 17-27 of Chow's book, the pipe can be determined as hydraulically long.

   ∴ pipe flows full. Inv. of outflow of pipe = El. 843.4

   Discharge of pipe based on $Q = A\sqrt{\frac{2gH}{1+K_m+K_pL}}$

   Take L = 92 ft, K_m = 1.0, K_p = 0.0267 (based on n = 0.025, Ref. NEH Sect. 5, ES-42)

   Use Fig. 6-25 of 'Baltimore County, Storm Water Management Policy'

Elev. (ft)	Head (ft)	Q (cfs)	Q out avg. (cfs)
855.3	12	93.9	91.9
854.3	11	89.9	87.8
853.3	10	85.7	83.5
852.3	9	81.3	79.0
851.3	8	76.6	74.2
850.3	7	71.7	69.1
849.3	6	66.4	63.5
848.3	5	60.6	57.4
847.3	4	54.2	50.6
846.3	3	46.9	42.6
845.3	2	38.3	

3. Storage Capacity

a. Assume capacity of lake at normal pool (El. 855.3) ≐ 230 Ac-ft
(Preconstruction information indicates lake capacity ≐ 230 Ac-ft)

b. Assume area varies linearly with height
Area of lake at El. 849.3 ≐ 7 Ac.

Elev. (Ft)	Area (Ac)	Δ Storage (Ac-ft)	Total (Ac-ft)
855.3	70		230
		65	
854.3	49.5		
		54	
853.3	49		
		44	
852.3	38.5		
		33	
851.3	28		
		23	
850.3	17.5		
		12	
849.3	7		

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4. Assume inflow to be 2 cfs/sq mi

$Q_{in} = 2 \times 2.45 = 4.9$ cfs

Elev. (ft)	$Q_{out\,avg}$ (cfs)	Q_{net}* (cfs)	Δ Storage (ac-ft)	Δt (hrs)	Σ Δt (hrs)	
855.3	91.9	87	65	9.0		
854.3	87.8	82.9	54	7.9		
853.3	83.5	78.6	44	6.8	23.7	(1 day)
852.3	79.0	74.1	33	5.4		
851.3	74.2	69.3	23	4.0		
850.3	69.1	64.2	12	2.3	35.4	(1.5 days)
849.3						

* $Q_{net} = Q_{out\,avg} - Q_{in} = Q_{out\,avg} - 4.9$

∴ lake can be lowered 3 ft in about 1 day
and 6 ft in about 1½ days (from spillway crest)

BY PJ DATE 2-21-79 Crandon Lake Dam JOB NO. J 783 B

CKD CED DATE 4-11-79 SHEET NO. 12 OF 12


LAKE
OWASSA
Quick
Pond
Bear
H A M
ROAD
Brook


FRANKFORD
Camp Columbus
OWASSA
Mt Pisgah
BM
689
Branchville
Swamp
MPTON
Lake Kemah
Kemah
Lake
County Farm
FRANKFORD
Myrtle Grove
De Lamar
MAP SOURCE: U.S.G.S.
CULVERS GAP, NEWTON WEST
SCALE: 1" = 2000'
2
DRAINAGE BASIN
CRANDON LAKE DAM
LANGAN ENGINEERING ASSOCIATES, INC.
CONSULTING ENGINEERS
CLIFTON, NJ 07013

HEC-1 OUTPUT

CRANDON LAKE DAM

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  11 JAN 79
**********
```

```
    1                A                              CRANDON LAKE DAM
    2                A                              INFLOW HYDROGRAPH AND ROUTING
    3                A                              N.J. DAM INSPECTION
    4                R     150       0       20       0       0       0       0       0       0       0
    5                B1      3
    6                K                1                                               1
    7                K1   COMPUTE HYDROGRAPH
    8                M        1       2    2.45                       0.8
    9                P               22.0     112     123     133     142
   10                T                                                       1     .15
   11                W2              1.3
   12                X       -2               1
   13                K        1       2                                      1
   14                K1   ROUTING COMPUTATIONS
   15                Y                                1
   16                Y1       1                                                     -1
   17                Y4  855.3   856.3   857.3   858.3   859.0  859.34  860.34  861.34  862.34  863.34
   18                Y4864.34
   19                Y5       0     135     420     820     840    1657    2650    5044    7981   11410
   20                Y5 15249
   21                $A      70      71      72      73      74      75      76      77      78      79
   22                $F  855.3   856.3   857.3   858.3   859.3   860.3   861.3   862.3   863.3   864.34
   23                $$  855.3
   24                $D  859.0
   25                K       99
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT	1
ROUTE HYDROGRAPH TO	2
END OF NETWORK	

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  11 JAN 79
**********

RUN DATE= 79/02/21.
      TIME= 13.16.37.
```

CRANDON LAKE DAM
INFLOW HYDROGRAPH AND ROUTING
N.J. DAM INSPECTION

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
150	0	20	0	0	0	0	0	0	0
			JOPER	NWT	LROPT	TRACE			
			3	0	0	0			

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

SUB-AREA RUNOFF COMPUTATION

COMPUTE HYDROGRAPH

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

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	2.45	0.00	2.45	.80	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	24.00	112.00	123.00	133.00	142.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
3	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.15	0.00	0.00

UNIT HYDROGRAPH DATA

TC= 0.00 LAG= 1.50

RECESSION DATA

STRTQ= -2.00 QRCSN= 0.00 RTIOR= 1.00

UNIT HYDROGRAPH 21 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= 1.30 VOL= 1.00

100. 520. 637. 744. 780. 652. 460. 306. 212. 149.
102. 71. 48. 33. 23. 16. 11. 8. 6. 4.
2.

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.20	1	.00	0.00	.00	5.	1.02	1.20	76	.04	0.00	.04	5.
1.01	.40	2	.00	0.00	.00	5.	1.02	1.40	77	.04	0.00	.04	5.
1.01	1.00	3	.00	0.00	.00	5.	1.02	2.00	78	.04	0.00	.04	5.
1.01	1.20	4	.00	0.00	.00	5.	1.02	2.20	79	.04	0.00	.04	5.
1.01	1.40	5	.00	0.00	.00	5.	1.02	2.40	80	.04	0.00	.04	5.
1.01	2.00	6	.00	0.00	.00	5.	1.02	3.00	81	.04	0.00	.04	5.
1.01	2.20	7	.00	0.00	.00	5.	1.02	3.20	82	.04	0.00	.04	5.
1.01	2.40	8	.00	0.00	.00	5.	1.02	3.40	83	.04	0.00	.04	5.
1.01	3.00	9	.00	0.00	.00	5.	1.02	4.00	84	.04	0.00	.04	5.
1.01	3.20	10	.00	0.00	.00	5.	1.02	4.20	85	.04	0.00	.04	5.
1.01	3.40	11	.00	0.00	.00	5.	1.02	4.40	86	.04	0.00	.04	5.
1.01	4.00	12	.00	0.00	.00	5.	1.02	5.00	87	.04	0.00	.04	5.
1.01	4.20	13	.00	0.00	.00	5.	1.02	5.20	88	.04	0.00	.04	5.
1.01	4.40	14	.00	0.00	.00	5.	1.02	5.40	89	.04	0.00	.04	5.
1.01	5.00	15	.00	0.00	.00	5.	1.02	6.00	90	.04	0.00	.04	5.
1.01	5.20	16	.00	0.00	.00	5.	1.02	6.20	91	.11	.06	.05	11.
1.01	5.40	17	.00	0.00	.00	5.	1.02	6.40	92	.11	.06	.05	29.
1.01	6.00	18	.00	0.00	.00	5.	1.02	7.00	93	.11	.06	.05	66.
1.01	6.20	19	.01	0.00	.01	5.	1.02	7.20	94	.11	.06	.05	112.
1.01	6.40	20	.01	0.00	.01	5.	1.02	7.40	95	.11	.06	.05	157.
1.01	7.00	21	.01	0.00	.01	5.	1.02	8.00	96	.11	.06	.05	194.
1.01	7.20	22	.01	0.00	.01	5.	1.02	8.20	97	.11	.06	.05	221.
1.01	7.40	23	.01	0.00	.01	5.	1.02	8.40	98	.11	.06	.05	238.
1.01	8.00	24	.01	0.00	.01	5.	1.02	9.00	99	.11	.06	.05	250.
1.01	8.20	25	.01	0.00	.01	5.	1.02	9.20	100	.11	.06	.05	259.
1.01	8.40	26	.01	0.00	.01	5.	1.02	9.40	101	.11	.06	.05	265.
1.01	9.00	27	.01	0.00	.01	5.	1.02	10.00	102	.11	.06	.05	269.
1.01	9.20	28	.01	0.00	.01	5.	1.02	10.20	103	.11	.06	.05	272.
1.01	9.40	29	.01	0.00	.01	5.	1.02	10.40	104	.11	.06	.05	274.
1.01	10.00	30	.01	0.00	.01	5.	1.02	11.00	105	.11	.06	.05	275.
1.01	10.20	31	.01	0.00	.01	5.	1.02	11.20	106	.11	.06	.05	276.
1.01	10.40	32	.01	0.00	.01	5.	1.02	11.40	107	.11	.06	.05	277.
1.01	11.00	33	.01	0.00	.01	5.	1.02	12.00	108	.11	.06	.05	277.
1.01	11.20	34	.01	0.00	.01	5.	1.02	12.20	109	.66	.61	.05	333.
1.01	11.40	35	.01	0.00	.01	5.	1.02	12.40	110	.66	.61	.05	509.
1.01	12.00	36	.01	0.00	.01	5.	1.02	13.00	111	.66	.61	.05	859.
1.01	12.20	37	.04	0.00	.04	5.	1.02	13.20	112	.79	.74	.05	1311.
1.01	12.40	38	.04	0.00	.04	5.	1.02	13.40	113	.79	.74	.05	1782.
1.01	13.00	39	.04	0.00	.04	5.	1.02	14.00	114	.79	.74	.05	2224.
1.01	13.20	40	.05	0.00	.05	5.	1.02	14.20	115	.99	.94	.05	2602.
1.01	13.40	41	.05	0.00	.05	5.	1.02	14.40	116	.99	.94	.05	2935.
1.01	14.00	42	.05	0.00	.05	5.	1.02	15.00	117	.99	.94	.05	3263.

1.01	14.40	44	.07	0.00	.07	5.	1.02	15.40	119	4.72	4.67	.05	4424.
1.01	15.00	45	.07	0.00	.07	5.	1.02	16.00	120	1.05	1.00	.05	5681.
1.01	15.20	46	.12	0.00	.12	5.	1.02	16.20	121	.92	.87	.05	7128.
1.01	15.40	47	.32	.09	.23	14.	1.02	16.40	122	.92	.87	.05	7807.
1.01	16.00	48	.07	.02	.05	36.	1.02	17.00	123	.92	.87	.05	7677.
1.01	16.20	49	.06	.01	.05	71.	1.02	17.20	124	.72	.67	.05	7028.
1.01	16.40	50	.06	.01	.05	96.	1.02	17.40	125	.72	.67	.05	6105.
1.01	17.00	51	.06	.01	.05	106.	1.02	18.00	126	.72	.67	.05	5300.
1.01	17.20	52	.05	0.00	.05	102.	1.02	18.20	127	.06	.01	.05	4656.
1.01	17.40	53	.05	0.00	.05	88.	1.02	18.40	128	.06	.01	.05	4004.
1.01	18.00	54	.05	0.00	.05	70.	1.02	19.00	129	.06	.01	.05	3242.
1.01	18.20	55	.00	0.00	.00	54.	1.02	19.20	130	.06	.01	.05	2478.
1.01	18.40	56	.00	0.00	.00	40.	1.02	19.40	131	.06	.01	.05	1798.
1.01	19.00	57	.00	0.00	.00	29.	1.02	20.00	132	.06	.01	.05	1256.
1.01	19.20	58	.00	0.00	.00	22.	1.02	20.20	133	.06	.01	.05	874.
1.01	19.40	59	.00	0.00	.00	16.	1.02	20.40	134	.06	.01	.05	619.
1.01	20.00	60	.00	0.00	.00	13.	1.02	21.00	135	.06	.01	.05	442.
1.01	20.20	61	.00	0.00	.00	10.	1.02	21.20	136	.06	.01	.05	318.
1.01	20.40	62	.00	0.00	.00	9.	1.02	21.40	137	.06	.01	.05	233.
1.01	21.00	63	.00	0.00	.00	8.	1.02	22.00	138	.06	.01	.05	172.
1.01	21.20	64	.00	0.00	.00	7.	1.02	22.20	139	.06	.01	.05	128.
1.01	21.40	65	.00	0.00	.00	6.	1.02	22.40	140	.06	.01	.05	96.
1.01	22.00	66	.00	0.00	.00	6.	1.02	23.00	141	.06	.01	.05	79.
1.01	22.20	67	.00	0.00	.00	5.	1.02	23.20	142	.06	.01	.05	67.
1.01	22.40	68	.00	0.00	.00	5.	1.02	23.40	143	.06	.01	.05	59.
1.01	23.00	69	.00	0.00	.00	5.	1.03	0.00	144	.06	.01	.05	53.
1.01	23.20	70	.00	0.00	.00	5.	1.03	.20	145	0.00	0.00	0.00	49.
1.01	23.40	71	.00	0.00	.00	5.	1.03	.40	146	0.00	0.00	0.00	44.
1.02	0.00	72	.00	0.00	.00	5.	1.03	1.00	147	0.00	0.00	0.00	37.
1.02	.20	73	.04	0.00	.04	5.	1.03	1.20	148	0.00	0.00	0.00	30.
1.02	.40	74	.04	0.00	.04	5.	1.03	1.40	149	0.00	0.00	0.00	23.
1.02	1.00	75	.04	0.00	.04	5.	1.03	2.00	150	0.00	0.00	0.00	17.
									SUM	24.99	20.15	4.84	96254.
										(635.)	(512.)	(123.)	(2725.61)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	7807.	4555.	1322.	642.	96236.
CMS	221.	129.	37.	18.	2725.
INCHES		17.29	20.07	20.30	20.30
MM		439.24	509.81	515.62	515.62
AC-FT		2258.	2621.	2651.	2651.
THOUS CU M		2786.	3233.	3270.	3270.

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

HYDROGRAPH ROUTING

ROUTING COMPUTATIONS

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

ROUTING DATA

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

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

STAGE	855.30	856.30	857.30	858.30	859.00	859.34	860.34	861.34	862.34	863.34
	864.34									
FLOW	0.00	135.00	420.00	820.00	840.00	1057.00	2650.00	5044.00	7981.00	11410.00
	15249.00									
SURFACE AREA=	70.	71.	72.	73.	74.	75.	76.	77.	78.	79.
CAPACITY=	0.	70.	142.	214.	288.	362.	438.	514.	592.	674.
ELEVATION=	855.	856.	857.	858.	859.	860.	861.	862.	863.	864.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
855.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
859.0	0.0	0.0	0.

END-OF-PERIOD HYDROGRAPH ORDINATES

MO.DA	HR.MN	PERIOD	HOURS	INFLOW	OUTFLOW	STORAGE	STAGE
1.01	.20	1	.33	5.	0.	0.	855.3
1.01	.40	2	.67	5.	0.	0.	855.3
1.01	1.00	3	1.00	5.	1.	0.	855.3
1.01	1.20	4	1.33	5.	1.	0.	855.3
1.01	1.40	5	1.67	5.	1.	1.	855.3
1.01	2.00	6	2.00	5.	1.	1.	855.3
1.01	2.20	7	2.33	5.	2.	1.	855.3
1.01	2.40	8	2.67	5.	2.	1.	855.3
1.01	3.00	9	3.00	5.	2.	1.	855.3
1.01	3.20	10	3.33	5.	2.	1.	855.3
1.01	3.40	11	3.67	5.	2.	1.	855.3
1.01	4.00	12	4.00	5.	2.	1.	855.3
1.01	4.20	13	4.33	5.	2.	1.	855.3
1.01	4.40	14	4.67	5.	2.	1.	855.3

1.01	5.00	15	5.00	5.	3.	1.	855.3
1.01	5.20	16	5.33	5.	3.	1.	855.3
1.01	5.40	17	5.67	5.	3.	2.	855.3
1.01	6.00	18	6.00	5.	3.	2.	855.3
1.01	6.20	19	6.33	5.	3.	2.	855.3
1.01	6.40	20	6.67	5.	3.	2.	855.3
1.01	7.00	21	7.00	5.	3.	2.	855.3
1.01	7.20	22	7.33	5.	3.	2.	855.3
1.01	7.40	23	7.67	5.	3.	2.	855.3
1.01	8.00	24	8.00	5.	4.	2.	855.3
1.01	8.20	25	8.33	5.	4.	2.	855.3
1.01	8.40	26	8.67	5.	4.	2.	855.3
1.01	9.00	27	9.00	5.	4.	2.	855.3
1.01	9.20	28	9.33	5.	4.	2.	855.3
1.01	9.40	29	9.67	5.	4.	2.	855.3
1.01	10.00	30	10.00	5.	4.	2.	855.3
1.01	10.20	31	10.33	5.	4.	2.	855.3
1.01	10.40	32	10.67	5.	4.	2.	855.3
1.01	11.00	33	11.00	5.	4.	2.	855.3
1.01	11.20	34	11.33	5.	4.	2.	855.3
1.01	11.40	35	11.67	5.	4.	2.	855.3
1.01	12.00	36	12.00	5.	4.	2.	855.3
1.01	12.20	37	12.33	5.	4.	2.	855.3
1.01	12.40	38	12.67	5.	4.	2.	855.3
1.01	13.00	39	13.00	5.	4.	2.	855.3
1.01	13.20	40	13.33	5.	4.	2.	855.3
1.01	13.40	41	13.67	5.	4.	2.	855.3
1.01	14.00	42	14.00	5.	4.	2.	855.3
1.01	14.20	43	14.33	5.	4.	2.	855.3
1.01	14.40	44	14.67	5.	4.	2.	855.3
1.01	15.00	45	15.00	5.	4.	2.	855.3
1.01	15.20	46	15.33	5.	4.	2.	855.3
1.01	15.40	47	15.67	14.	5.	2.	855.3
1.01	16.00	48	16.00	36.	6.	3.	855.3
1.01	16.20	49	16.33	71.	8.	4.	855.4
1.01	16.40	50	16.67	96.	12.	6.	855.4
1.01	17.00	51	17.00	106.	17.	9.	855.4
1.01	17.20	52	17.33	102.	21.	11.	855.5
1.01	17.40	53	17.67	88.	25.	13.	855.5
1.01	18.00	54	18.00	70.	28.	14.	855.5
1.01	18.20	55	18.33	54.	30.	15.	855.5
1.01	18.40	56	18.67	40.	30.	16.	855.5
1.01	19.00	57	19.00	29.	31.	16.	855.5
1.01	19.20	58	19.33	22.	30.	16.	855.5
1.01	19.40	59	19.67	16.	30.	16.	855.5
1.01	20.00	60	20.00	13.	29.	15.	855.5
1.01	20.20	61	20.33	10.	28.	15.	855.5
1.01	20.40	62	20.67	9.	27.	14.	855.5
1.01	21.00	63	21.00	8.	26.	14.	855.5
1.01	21.20	64	21.33	7.	25.	13.	855.5
1.01	21.40	65	21.67	6.	24.	13.	855.5

1.01	22.00	66	22.00	6.	23.	12.	855.5
1.01	22.20	67	22.33	5.	22.	12.	855.5
1.01	22.40	68	22.67	5.	22.	11.	855.5
1.01	23.00	69	23.00	5.	21.	11.	855.5
1.01	23.20	70	23.33	5.	20.	10.	855.4
1.01	23.40	71	23.67	5.	19.	10.	855.4
1.02	0.00	72	24.00	5.	18.	10.	855.4
1.02	.20	73	24.33	5.	18.	9.	855.4
1.02	.40	74	24.67	5.	17.	9.	855.4
1.02	1.00	75	25.00	5.	16.	9.	855.4
1.02	1.20	76	25.33	5.	16.	8.	855.4
1.02	1.40	77	25.67	5.	15.	8.	855.4
1.02	2.00	78	26.00	5.	15.	8.	855.4
1.02	2.20	79	26.33	5.	14.	7.	855.4
1.02	2.40	80	26.67	5.	14.	7.	855.4
1.02	3.00	81	27.00	5.	13.	7.	855.4
1.02	3.20	82	27.33	5.	13.	7.	855.4
1.02	3.40	83	27.67	5.	12.	6.	855.4
1.02	4.00	84	28.00	5.	12.	6.	855.4
1.02	4.20	85	28.33	5.	12.	6.	855.4
1.02	4.40	86	28.67	5.	11.	6.	855.4
1.02	5.00	87	29.00	5.	11.	6.	855.4
1.02	5.20	88	29.33	5.	11.	6.	855.4
1.02	5.40	89	29.67	5.	10.	5.	855.4
1.02	6.00	90	30.00	5.	10.	5.	855.4
1.02	6.20	91	30.33	11.	10.	5.	855.4
1.02	6.40	92	30.67	29.	10.	5.	855.4
1.02	7.00	93	31.00	66.	12.	6.	855.4
1.02	7.20	94	31.33	112.	16.	8.	855.4
1.02	7.40	95	31.67	157.	22.	12.	855.5
1.02	8.00	96	32.00	194.	30.	16.	855.5
1.02	8.20	97	32.33	221.	39.	20.	855.6
1.02	8.40	98	32.67	238.	49.	26.	855.7
1.02	9.00	99	33.00	250.	59.	31.	855.7
1.02	9.20	100	33.33	259.	69.	36.	855.8
1.02	9.40	101	33.67	265.	79.	41.	855.9
1.02	10.00	102	34.00	269.	89.	46.	856.0
1.02	10.20	103	34.33	272.	98.	51.	856.0
1.02	10.40	104	34.67	274.	107.	56.	856.1
1.02	11.00	105	35.00	275.	116.	60.	856.2
1.02	11.20	106	35.33	276.	124.	65.	856.2
1.02	11.40	107	35.67	277.	132.	69.	856.3
1.02	12.00	108	36.00	277.	143.	73.	856.3
1.02	12.20	109	36.33	333.	160.	77.	856.4
1.02	12.40	110	36.67	509.	187.	84.	856.5
1.02	13.00	111	37.00	859.	239.	97.	856.7
1.02	13.20	112	37.33	1311.	327.	119.	857.0
1.02	13.40	113	37.67	1782.	466.	150.	857.4
1.02	14.00	114	38.00	2224.	684.	190.	858.0
1.02	14.20	115	38.33	2602.	828.	235.	858.6
1.02	14.40	116	38.67	2875.	1016.	286.	859.3

1.02	15.00	117	39.00	3263.	1918.	331.	859.9
1.02	15.20	118	39.33	3637.	2613.	364.	860.3
1.02	15.40	119	39.67	4424.	3465.	391.	860.7
1.02	16.00	120	40.00	5681.	4429.	422.	861.1
1.02	16.20	121	40.33	7128.	5710.	458.	861.6
1.02	16.40	122	40.67	7807.	6926.	490.	862.0
1.02	17.00	123	41.00	7677.	7449.	505.	862.2
1.02	17.20	124	41.33	7028.	7395.	502.	862.1
1.02	17.40	125	41.67	6105.	6823.	487.	861.9
1.02	18.00	126	42.00	5300.	6048.	467.	861.7
1.02	18.20	127	42.33	4656.	5306.	448.	861.4
1.02	18.40	128	42.67	4004.	4682.	430.	861.2
1.02	19.00	129	43.00	3242.	4039.	409.	860.9
1.02	19.20	130	43.33	2478.	3322.	387.	860.6
1.02	19.40	131	43.67	1798.	2613.	364.	860.3
1.02	20.00	132	44.00	1256.	2121.	341.	860.0
1.02	20.20	133	44.33	874.	1641.	318.	859.7
1.02	20.40	134	44.67	619.	1233.	299.	859.5
1.02	21.00	135	45.00	442.	990.	283.	859.2
1.02	21.20	136	45.33	318.	860.	268.	859.0
1.02	21.40	137	45.67	233.	835.	252.	858.8
1.02	22.00	138	46.00	172.	828.	235.	858.6
1.02	22.20	139	46.33	128.	821.	216.	858.3
1.02	22.40	140	46.67	96.	731.	198.	858.1
1.02	23.00	141	47.00	79.	640.	182.	857.8
1.02	23.20	142	47.33	67.	560.	167.	857.6
1.02	23.40	143	47.67	59.	489.	155.	857.5
1.03	0.00	144	48.00	53.	428.	143.	857.3
1.03	.20	145	48.33	49.	387.	134.	857.2
1.03	.40	146	48.67	44.	352.	125.	857.1
1.03	1.00	147	49.00	37.	319.	117.	856.9
1.03	1.20	148	49.33	30.	290.	109.	856.8
1.03	1.40	149	49.67	23.	262.	102.	856.7
1.03	2.00	150	50.00	17.	237.	96.	856.7

PEAK OUTFLOW IS 7489. AT TIME 41.00 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	7489.	4315.	1277.	618.	92758.
CMS	212.	122.	36.	18.	2627.
INCHES		15.38	19.39	19.57	19.57
MM		416.11	492.63	496.98	496.98
AC-FT		2140.	2533.	2555.	2555.
THOUS CU M		2639.	3124.	3152.	3152.

....

RUNOFF SUMMARY, AVERAGE FLOW IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES(SQUARE KILOMETERS)

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	1	7807.	4555.	1322.	642.	2.45
		(221.08)(	128.97)(	37.42)(	18.17)(	6.35)
ROUTED TO	2	7489.	4315.	1277.	618.	2.45
		(212.07)(	122.18)(	36.16)(	17.51)(	6.35)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	855.30	855.30	859.00
STORAGE	0.	0.	266.
OUTFLOW	0.	0.	840.

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
0.00	862.17	3.17	505.	7489.	7.00	41.00	0.00

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FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 11 JAN 79
****

****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 11 JAN 79
****

RUN DATE= 79/02/21.
TIME= 15.29.56.

CRANDON LAKE DAM
% PMF
N.J. DAM INSPECTION

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METPC	IPLT	IPRT	NSTAN
150	6	20	0	0	0	0	0	4	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 6 LRTIO= 1

RTIOS=	1.00	.50	.40	.30	.20	.10

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SUB-AREA RUNOFF COMPUTATION

COMPUTE HYDROGRAPH

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

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	2.45	0.00	2.45	.80	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	22.00	112.00	123.00	133.00	142.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.15	0.00	0.00

UNIT HYDROGRAPH DATA

TC= 0.00 LAG= 1.30

RECESSION DATA
STRTQ= -2.00 QRCSN= 0.00 RTIOR= 1.00

END-OF-PERIOD FLOW

0 MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	24.99	20.15	4.84	96254.
										(635.)	(512.)	(123.)	(2725.61)

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HYDROGRAPH ROUTING

ROUTING COMPUTATIONS

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

ROUTING DATA

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

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

STAGE	855.30	856.30	857.30	858.30	859.00	859.34	860.34	861.34	862.34	863.34
	864.34									
FLOW	0.00	135.00	420.00	820.00	840.00	1057.00	2650.00	5044.00	7981.00	11410.00
	15249.00									
SURFACE AREA=	70.	71.	72.	73.	74.	75.	76.	77.	78.	79.
CAPACITY=	0.	70.	142.	214.	288.	362.	438.	514.	592.	674.
ELEVATION=	855.	856.	857.	858.	859.	860.	861.	862.	863.	864.

CREL	SPWID	COOW	EXPW	FLEVL	COQL	CAREA	EXPL
855.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
859.0	0.0	0.0	0.

PEAK OUTFLOW IS 7489. AT TIME 41.00 HOURS

PEAK OUTFLOW IS 3566. AT TIME 41.33 HOURS

PEAK OUTFLOW IS 2024. AT TIME 41.67 HOURS

PEAK OUTFLOW IS 1150. AT TIME 41.67 HOURS

PEAK OUTFLOW IS 832. AT TIME 42.67 HOURS

PEAK OUTFLOW IS 402. AT TIME 42.67 HOURS

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

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 1.00	RATIO 2 .50	RATIO 3 .40	RATIO 4 .30	RATIO 5 .20	RATIO 6 .10
HYDROGRAPH AT	1	2.45	1	7807.	3904.	3123.	2342.	1561.	781.
		(6.35)		(221.08)(	110.54)(	88.43)(	66.32)(	44.22)(	22.11)(
ROUTED TO	2	2.45	1	7489.	3588.	2624.	1750.	832.	402.
		(6.35)		(212.07)(	101.60)(	74.31)(	49.55)(	23.57)(	11.38)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	855.30	855.30	859.00
STORAGE	0.	0.	266.
OUTFLOW	0.	0.	840.

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	862.17	3.17	505.	7489.	7.00	41.00	0.00
.50	860.73	1.73	395.	3588.	5.00	41.33	0.00
.40	860.32	1.32	364.	2624.	4.33	41.67	0.00
.30	859.77	.77	323.	1750.	3.33	41.67	0.00
.20	858.74	0.00	246.	832.	0.00	42.67	0.00
.10	857.24	0.00	137.	402.	0.00	42.67	0.00

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FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 11 JAN 79
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APPENDIX 5

REFERENCES

CRANDON LAKE DAM

APPENDIX 5

REFERENCES

CRANDON LAKE DAM

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3. Eby, C.F., 1976 Soil Survey of Morris County, New Jersey, U.S. Department of Agriculture, Soil Conservation Service, 111 pp.

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5. United States Department of Agriculture, Soil Conservation Service, Somerset, N.J. Urban Hydrology for Small Watersheds, Technical Release No. 55, January 1975.

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15. Inspection Report by M.J. Galley, dated 18 Nov. 1957.

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17. Inspection Report by R.L. Hardman, dated 19 Dec. 1957.

18. Letter to Crandon Lakes Development Co. from R.L. Hardman, Bureau of Water Control, dated 5 Oct. 1959.