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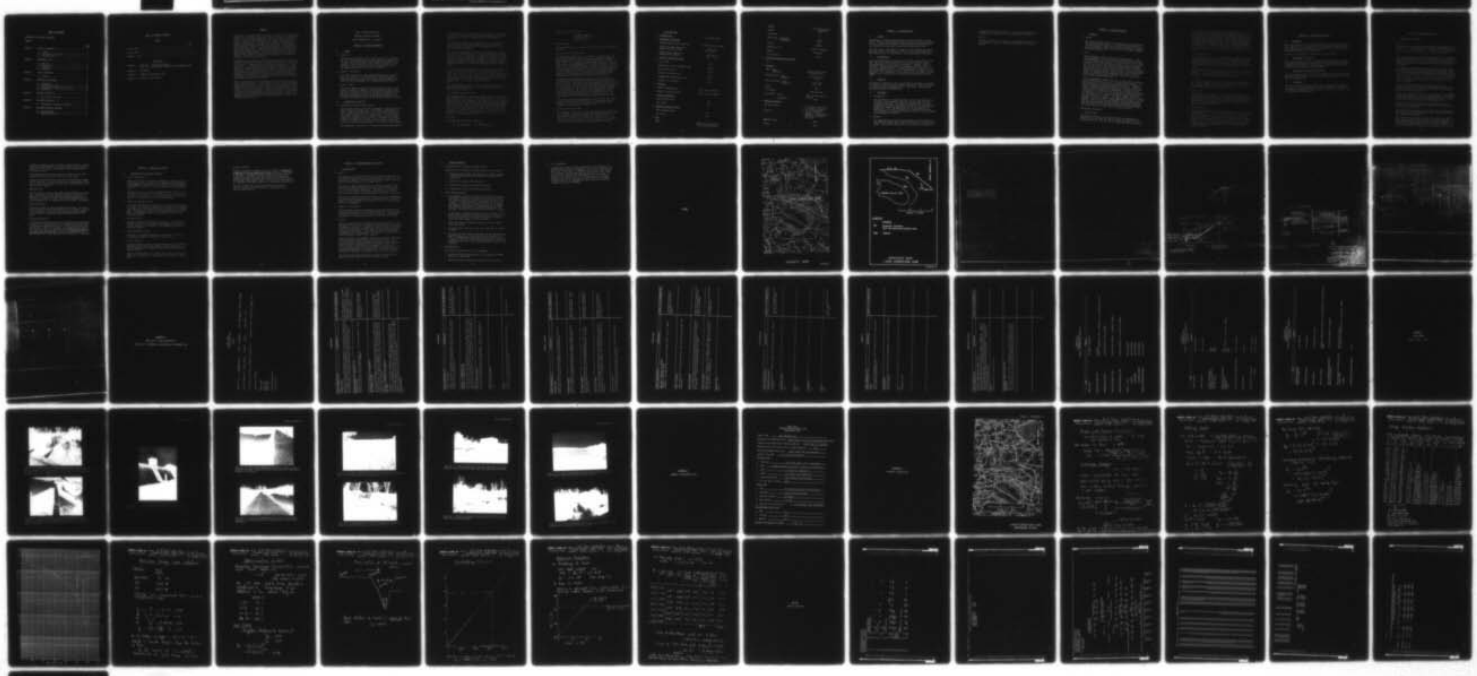

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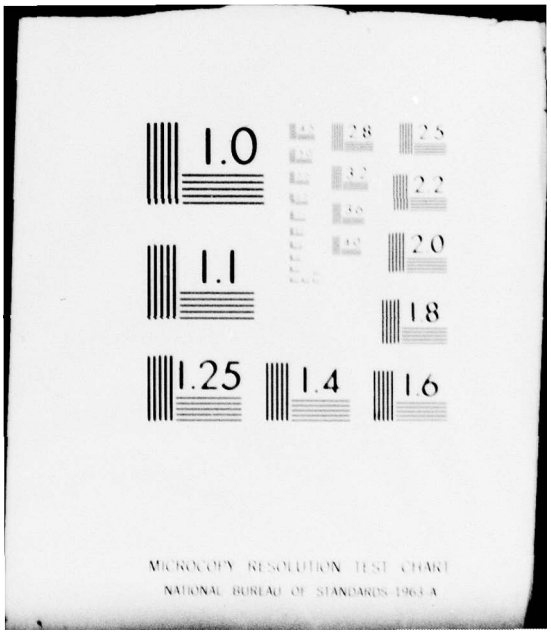
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RAHWAY RIVER BASIN
SOUTH BRANCH ROCKAWAY CREEK
HUNTERDON COUNTY
NEW JERSEY

LAKE CUSHETUNK DAM
NJ 00347

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DEPARTMENT OF THE ARMY
Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

August, 1979

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NJ00347
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): Phase I Inspection Report
National Dam Safety Program
Lake Cushetunk Dam
Hunterdon County, N.J.

5. TYPE OF REPORT & PERIOD COVERED: (9) FINAL rept.,

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): Posch, Anthony G., P.E.

8. CONTRACT OR GRANT NUMBER(s): (15) DACW61-79-C-0011

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
Harris ECI
453 Amboy Ave.
Woodbridge, N.J.
(12) 82

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:

11. CONTROLLING OFFICE NAME AND ADDRESS:
U.S. Army Engineer District, Philadelphia
Custom House, 2d & Chestnut Streets
Philadelphia, Pennsylvania 19106
(11)

12. REPORT DATE: Aug[redacted]79

13. NUMBER OF PAGES: 50

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):
(10) Anthony G. /Posch

15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

(6) National Dam Safety Program. Lake Cushetunk Dam (NJ00347), Rahway River Basin, South Branch Rockaway Creek, Hunterdon County, New Jersey. Phase 1 Inspection Report.

18. SUPPLEMENTARY NOTES

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)

Dams
Embankments
Visual inspection
Structural analysis
National Dam Inspection Act Report
Lake Cushetunk Dam,N.J.

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
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IN REPLY REFER TO
NAPEN-D

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

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Lake Cushetunk Dam in Hunterdon 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, Lake Cushetunk Dam, initially listed as a high hazard potential structure but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in poor overall condition. The dam's spillway is considered inadequate since 79 percent of the Spillway Design Flood--SDF - would overtop the dam. (The SDF, in this instance, is one half of the Probable Maximum Flood.) 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.

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

c. The following remedial actions should be completed within six months from the date of approval of this report:

(1) The existing dam plans and drawings should be annotated and updated to form a coherent as-built set.

(2) A safe means of lowering the lake should be provided. This would involve restoring the existing outlets to operable condition and reinstating the footbridge across the spillway.

(3) Repair all cracked and spalled concrete with epoxy cement.

(4) The embankment material that has been eroded from the downstream face, particularly adjacent to the right wingwall of the spillway, should be replaced with quarry-process stone or gravel. Slopes should be reconstructed with keying and compaction of material to improve stability and to support the abutments and wingwalls. Slopes should not be steeper than 2H:1V and should be protected with riprap near the spillway.

d. The following remedial actions should be completed within one year from the date of approval of this report:

(1) Provide riprap protection along the entire upstream face of the dam.

(2) All brush and trees should be removed from the downstream and upstream slopes to lessen the piping potential. The embankment face should then be seeded to develop a growth of grass for surface erosion protection. Remove all vegetation from cracks.

(3) Study the necessity for and, if required, provide additional low-level outlet facilities.

(4) A formalized program of annual inspections of the dam by an experienced party should be initiated, utilizing the standard visual check list in this report. Headwater and tailwater gages should be installed in the dam, and read out during severe rainstorms and at routine operating and maintenance visits to the dam. A permanent log should be kept of all maintenance and operating events of the dam, the lake and the outlet passages. Movement and settlement of the embankment should be monitored regularly by means of surveying monuments.

NAPEN-D
Honorable Brendan T. Byrne

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 provision 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.

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

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Management
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

LAKE CUSHETUNK DAM (NJ00347)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 3 May 1979 by Fredric R. Harris, 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.

Lake Cushetunk Dam, initially listed as a high hazard potential structure but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in poor overall condition. The dam's spillway is considered inadequate since 79 percent of the Spillway Design Flood--SDF - would overtop the dam. (The SDF, in this instance, is one half of the Probable Maximum Flood.) 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.

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

c. The following remedial actions should be completed within six months from the date of approval of this report:

(1) The existing dam plans and drawings should be annotated and updated to form a coherent as-built set.

(2) A safe means of lowering the lake should be provided. This would involve restoring the existing outlets to operable condition and reinstating the footbridge across the spillway.

(3) Repair all cracked and spalled concrete with epoxy cement.

(4) The embankment material that has been eroded from the downstream face, particularly adjacent to the right wingwall of the spillway, should be replaced with quarry-process stone or gravel. Slopes should be reconstructed with keying and compaction of material to improve stability and to support the abutments and wingwalls. Slopes should not be steeper than 2H:1V and should be protected with riprap near the spillway.

d. The following remedial actions should be completed within one year from the date of approval of this report:

(1) Provide riprap protection along the entire upstream face of the dam.

(2) All brush and trees should be removed from the downstream and upstream slopes to lessen the piping potential. The embankment face should then be seeded to develop a growth of grass for surface erosion protection. Remove all vegetation from cracks.

(3) Study the necessity for and, if required, provide additional low-level outlet facilities.

(4) A formalized program of annual inspections of the dam by an experienced party should be initiated, utilizing the standard visual check list in this report. Headwater and tailwater gages should be installed in the dam, and read out during severe rainstorms and at routine operating and maintenance visits to the dam. A permanent log should be kept of all maintenance and operating events of the dam, the lake and the outlet passages. Movement and settlement of the embankment should be monitored regularly by means of surveying monuments.

APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 22 Sep 1979

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Lake Cushetunk, I.D. NJ00347
State Located:	New Jersey
County Located:	Hunterdon County
Stream:	South Branch Rockaway Creek
Date of Inspection:	May 3, 1979

Assessment of General Condition

Lake Cushetunk Dam is an earth-fill embankment approximately 615 feet in length and 20 feet high, having a concrete spillway. The left embankment is covered by a concrete slab for 260 feet of its length. Lake Cushetunk Dam is in poor overall condition. There is evidence of slow progressive settlement on both embankments. On the left embankment, the concrete cover slab is cracked, and on exposed embankment faces, erosion of fill has taken place. The concrete in the spillway is extensively spalled at the waterline, and the footbridge over the spillway is missing. Excessive tree and vegetative growth on the embankment is impairing stability. There is no operable low-level outlet. The hazard potential is rated as "significant."

The safety of Lake Cushetunk Dam is considered questionable in view of its lack of spillway capacity to pass one-half the PMF without overtopping the dam. The spillway is capable of passing a flood equal to 39% of the PMF, and is rated "inadequate."

At present, the engineering data available is not sufficient to make a definitive statement on the stability of the dam.

The following actions, therefore, are recommended along with a timetable for their completion.

1. Establish a flood warning system for the downstream communities within three months.

2. Existing plans and drawings of the dam should be annotated and updated to form a coherent as-built set, within six months.

3. Carry out a more precise hydrologic and hydraulic analysis of the dam within six (6) months, to determine the need and type of mitigating measures necessary. If required, conduct a study of the means of increasing spillway discharge capacity and develop alternative schemes for construction. This should include the installation of headwater and tailwater gages.

4. Install observation wells or piezometers in the downstream embankment, and log the borings to determine engineering properties of the dam fill and foundation material. This program and a stability analysis based on the findings should be completed within six months.

5. Carry out remedial measures to the dam structure within six months, including repair of eroded, spalled and cracked concrete with epoxy cement; restoration of both low-level outlets; reinstatement of the footbridge; replacement of eroded fill to a slope of 2H:1V.

6. Remove trees and vegetation from the embankment and seed exposed faces with grass within 12 months.

7. Provide rip-rap protection along entire upstream face within 12 months.

Furthermore, while of a less urgent nature, the following additional action is recommended and should be carried out within a reasonable period of time.

1. A program of annual inspection and maintenance should be initiated. This should include lowering the lake, and updating the operation and maintenance log. Movement and settlement of the embankment should also be monitored by means of surveying monuments.

2. Provision of additional low-level outlet facilities should be considered.

Anthony G. Posch, P.E.

AGP/REJ:cc

Lake Cushetunk Dam
Overall view of dam from the right. May 2, 1979

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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 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 aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

LAKE CUSHETUNK DAM, I.D. NJ00347

SECTION I: PROJECT INFORMATION

1.1 General

a. Authority

The National Dam Inspection Act (Public Law 92-367, 1972) provides for the National Inventory and Inspection Program by the U.S. Army Corps of Engineers. This inspection was made in accordance with this authority under Contract C-FPM No. 35 with the State of New Jersey who, in turn is contracted to the Philadelphia District of the Corps of Engineers.

b. Purpose of Inspection

The visual inspection of Lake Cushetunk Dam was made on May 3, 1979. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

The report summarizes available pertinent data relating to the project; presents a summary of visual observations made during the field inspection; presents an evaluation of hydrologic and hydraulic conditions at the site; presents an evaluation as to the structural adequacy of the various project features; and assesses the general condition of the dam with respect to safety.

1.2 Description of Project

a. Description of Dam and Appurtenances

Lake Cushetunk Dam is an earth-fill embankment, about 615 feet in length, having a straight axis. Its height is approximately 20 feet. The main spillway consists of two concrete sections of ogee shape on either side of a concrete pier. It is restricted by concrete wingwalls, and is located to the right of the dam. It has a net length of 52 feet. There is evidence that a footbridge once crossed the spillway, giving access to a gate stem of the 24" diameter low-level outlet. This bridge is now missing.

The embankment to the right of the spillway extends approximately

80 feet and consists of earth fill with a concrete core wall at the center. The upstream as well as the downstream faces have irregular slopes which are approximately 2 horizontal on 1 vertical.

The slopes have no protective blanket and are mostly covered with vegetation (brush, growth and trees). A 30" diameter ceramic pipe passes through the right embankment at toe level, but this outlet is blocked.

The earthfill embankment to the left of the spillway is covered for 260 feet of its length by a 6" thick concrete slab, making it into an auxiliary spillway. The embankment supports a growth of trees for the remainder of its length. A concrete core wall is known to run the full length, and has been cut down under the auxiliary spillway. Upstream and downstream slopes are 2H:1V and the crest width is 8 feet. The slab has transverse expansion joints.

A recently constructed valve house, controlling one of the outlets from the Round Valley Reservoir, is located about 1,000 feet downstream of the dam. Water discharges from below the valve house, onto a concrete apron and thence into South Branch Rockaway Creek. The building is owned by the Bureau of Water Facilities and Operation, of the State of New Jersey (ATT: Mr. W. O'Rourke 201-735-5112). It is shown in the photographs.

b. Location

Lake Cushetunk Dam is located in the Township of Readington, Hunterdon County, New Jersey. It is accessible by a private road which connects to Route 22.

c. Size and Hazard Classification

Lake Cushetunk Dam has a structural height of 20 feet and a reservoir storage of 365 acre-feet. Since its storage is less than 1,000 acre-feet and its height is less than 40 feet, it is classified in the dam size category as being "small." A hazard potential classification of "significant" has been assigned to the dam on the basis of the results of the hydrologic analysis, which indicates that only minor damage may be expected to the valve house and Route 22 downstream, in the event of 1/2 PMF. There is one inhabited house in the estimated flood path upstream of Route 22. No damage is expected below Route 22.

d. Ownership

Lake Cushetunk Dam is owned jointly by:

Mr. John Ploskonka Mr. Arthur Burgess

whose office is located at:

701 Amboy Avenue
Woodbridge, NJ 07095

(201) 636-0020

e. Purpose of Dam

Lake Cushetunk Dam is intended to retain the lake for recreational use only.

f. Design and Construction History

The dam was built about 1927. No drawings or specifications of the original structure could be located. It appears from available correspondence, that by 1934 the embankment had settled about 1 foot. It is assumed that about that time repair work was done to raise the embankment to the original elevation. A severe flood in 1955 caused heavy damage to the dam structure. The crest of the dam was overtopped by about 1.5 feet. The downstream-fill of the embankment was washed out in many areas, exposing the concrete core wall down to the foundation. The abutments and the wingwalls of the spillway also sustained considerable damage. Downstream damage caused by the floow is not on record.

Following the overtopping, the dam was repaired and modified. The modification was intended to provide a larger overflow capacity at flood condition, without impairing the structural integrity of the dam. To achieve that, the embankment crest on the left of the spillway was lowered about 4' below the right embankment, for a length of 260 feet, thus providing an auxiliary spillway at flood condition. The new left side embankment was covered with concrete paving along the crest as well as along the upstream and downstream sloping faces. The purpose of the concrete paving is to reduce flow friction and to prevent erosion.

The repair work was completed about the end of 1958. The structure was inspected by a representative of the New Jersey State Department of Conservation, Division of Water Policy, about January, 1959 and approved for public use.

g. Normal Operating Procedures

The discharge from the lake is over the unregulated spillway, and it is allowed to naturally balance with inflow. Neither of the two low-level outlets are operable, and thus the lake is not lowered on a regular basis. Operation of the valve house downstream is under the control of a superintendant and, at present, a discharge of approximately 30 mgd. is regularly released.

1.3 Pertinent Data

a. Drainage Area	12.5 square miles
b. Discharge at Dam Site	
Maximum known flood at dam site:	1.5 feet over top of dam
Ungated spillway capacity at elevation of top of dam:	6,546 cfs (elev. 140')
Total spillway capacity at maximum pool elevation:	8,404 cfs (elev. 140.45')
c. Elevation (Feet above MSL)	
Top of dam:	140'
Maximum pool design surcharge (SDF):	140.45'
Main spillway crest:	134.6'
Auxiliary spillway crest:	136.7'
Streambed at centerline of dam:	120'
Tailwater at inspection:	122.5'
d. Reservoir	
Length at maximum pool:	2200 ± feet (estimate)
Length of recreation pool:	2000 ± feet (estimate)
e. Storage (Acre-feet)	
Main spillway crest:	212
Top of dam:	365
f. Reservoir Surface (Acres)	
Main spillway crest:	12.1
Top of dam:	49.5
g. Dam	
Type:	Earth fill with concrete core wall and spillway.

Length:	594' (effective for computation)
Height:	20'
Top width:	8'
Side slopes - Upstream:	2H:1V
- Downstream:	2H:1V
Zoning:	Unknown.
Impervious core:	Concrete corewall.
Cutoff:	Not known.
Grout curtain:	None.

h. Diversion and Regulating Tunnel

N/A

i. Spillway

Type:	Main:	Double concrete ogee.
	Auxiliary:	Concrete ogee.
Length of weir:	Main:	52' (effective)
	Auxiliary:	260'
Crest elevation:	Main:	134.6' MSL
	Auxiliary:	136.7' MSL
Gates:		None
U/S Channel:		Lake Cushetunk
D/S Channel:	Main:	Flat concrete apron to channel.
	Auxiliary:	None

j. Regulating Outlets

Low level outlet:	1. 24" diameter gated pipe in center of spillway. 2. 30" ø ceramic pipe
Controls:	1. Manually operated by handwheel, (inaccessible). 2. Operating facilities not known
Emergency gate:	None
Outlet:	None

SECTION 2: ENGINEERING DATA

2.1 Design

No drawings or computations pertaining to original design could be found. However, three drawings giving details of the 1958 reconstruction are included in the report. These drawings were obtained from the Consulting Engineers who surveyed and redesigned the dam.

Some soil data is available in a report on soil sampling pits which were dug in 1958. The sampling was done as part of the modification and rehabilitation of the structure. No soil properties are given.

2.2 Construction

No records have been found covering the original construction of the dam. The owners have no knowledge of, and do not know of anyone having knowledge of the original construction. However, there is information available pertaining to subsequent construction work in the three included drawings. A permit application, dated 1957, for repair and modification of the dam, gives some data on dimensions and hydrology. This information is on michrofiche at the NJDEP. A brief summary of the reconstruction history has been provided in Section 1.2.f.

2.3 Operation

No records of operation of the lake are kept by the owners. The lake is allowed to operate naturally without regulation. Some information on lake levels and overtopping during a 1955 flood is contained in the above mentioned correspondence.

2.4 Evaluation

a. Availability

The availability of engineering data is fair. The best data is contained in the drawings, which are only available from the Consulting Engineers. The remaining available data are those contained in the permit application of 1957 and in correspondence between the owners' representative and the NJ Department of Conservation - Division of Water Policy, Trenton, New Jersey. This information is freely available from the New Jersey Department of Environmental Protection.

b. Adequacy

The engineering data available was adequate to perform hydrologic and hydraulic computations, although the depth of the lake is not known. The data was insufficient to perform even an approximate

computation of the dam's stability. A preliminary assessment of the dam could be made with the data obtained in the field.

c. Validity

The data contained in the drawings is predominently valid, but some updating is needed. The datum used does not correspond to MSL.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

The visual inspection made of Lake Cushetunk Dam revealed that the dam and spillway were not in good condition, and that a regular program of inspection and repair is required to improve its serviceability. Water was flowing over the main spillway during the inspection.

b. Dam

The dam exhibits signs of neglect and deterioration. On the right embankment, extensive erosion has taken place on upstream and downstream faces, exposing the corewall by more than 3 feet in places. The trees growing on the dam are up to feet high and 18" in diameter, and their roots have been partially exposed, causing the trees to lean outwards, cracking the fill locally. The erosion is particularly severe adjacent to the right wingwall. Seven feet from the wingwall, the core has a vertical settlement crack. No seepage from this embankment was noted, except a slight leak from the blocked auxiliary low-level outlet pipe, and no animal burrows were noted.

The left embankment, modified for 260' of its length to serve as an auxiliary spillway, is also in a deteriorated condition. The modified section, covered on top and both faces by a concrete slab, shows signs of settlement and erosion of fill. Extensive surface cracking parallel and normal to the axis has taken place on the concrete covering of the embankment. The most serious cracking is on the upstream side of the crest, where the covering is sheared by up to 6". All cracks appear to have penetrated the full thickness of the concrete. In several places, vegetation and small bushes are growing in the cracks, aggravating the cracking process. At the toe, there is minor superficial cracking, and the weephole drains in this zone are blocked. The upstream concrete slab has been undermined by wave action and pronounced misalignment has occurred. The unmodified section of the left embankment is covered with a very heavy growth of trees and brush.

c. Appurtenant Structures

1. Spillway (Main)

The spillway consists of two concrete ogee weirs separated by a concrete pier. No slots for stop log guides are provided at the spillway end walls. The flow over the ogees was smooth, indicating

that horizontal alignment is good. Any leakage through or around the spillway was not detectable due to the water flow. Erosion has taken place at the junction between spillway and wingwalls, and on the pier at the waterline. In the approach channel, wingwalls are badly spalled at the waterline and the right wingwall is cracked and sheared by 3/4 inch. The concrete spillway apron is in good condition except at the junction with the wingwalls, where erosion of concrete has taken place. Undermining at the toe of the apron is slight. Large holes in the apron downstream of each ogee were observed, but not identified. They are possibly baffles.

2. Low-level Outlet

The main low-level outlet is a 24 inch diameter pipe in the center of the spillway at the toe. The outlet is controlled by a gate valve with a stem extension ending at the central concrete pier. The stem is presently inaccessible and the outlet is considered to be inoperable. The concrete surrounding the pipe outlet is eroded.

An auxiliary low-level outlet passes through the base of the right embankment, and is a 30 inch diameter ceramic pipe. It is not known if this is operable and it is seeping a small amount of water. No control facilities for this outlet were visible.

3. Bridge

The original footbridge giving access across the spillway and to the low-level outlet valve shaft has been removed. The footings are cracked, and the central pier is in danger of collapse due to the severe cracking at the waterline.

d. Reservoir Area

The reservoir rim is moderately sloped and no indications of instability were readily apparent. The slopes above the reservoir are heavily wooded. No buildings or dwellings have been built on the shoreline, with only a few boat docks. The property around the lake is privately owned and it was reported that access to the lake is controlled by the owners.

e. Downstream Channel

The downstream channel is a natural streambed in a broad, gently sloping valley. The valley is heavily wooded. A large plunge pool has formed downstream of the spillway, and the banks around the pool are undermined. A second channel downstream of the right embankment has developed, and this joins the main channel approximately 200 feet downstream. 1,000 feet downstream of the dam is a valve house for the Round Valley Reservoir, which discharges directly into the downstream channel. The structure appears to be well maintained.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

Lake Cushetunk Dam is used to impound water for recreation activities only. The policy is to maintain a nearly constant lake level close to the elevation of the spillway crest. The lake level is maintained by unregulated discharge over the spillway.

The lake is not lowered or attended to on a regular basis.

4.2 Maintenance of the Dam

There is no program of regular inspection and maintenance of the dam and appurtenant structures. No Authority has been identified as being responsible for operating or maintaining the dam itself and no recent records of these functions have been found.

4.3 Maintenance of Operating Facilities

The operating facilities consist of two defunct low-level outlets with manually operated valves. No recent maintenance is known to have taken place on either facility.

4.4 Evaluation

The present procedures are not conducive to satisfactory operation of the dam. The level of maintenance is particularly poor, and should be amended by substantial initial repairs followed by a program of regular inspection and maintenance.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

The drainage area above Lake Cushetunk Dam is approximately 12.5 square miles. A drainage map of the watershed of the dam site is presented on plate 1, Appendix D. A Round Valley Reservoir valve house discharges up to 30 mgd. into the downstream channel.

The topography within the basin is moderately sloped. Elevations range from approximately 820 feet above MSL at the north end of the watershed to about 400 feet at the dam site. Land use patterns within the watershed are mostly forest, with light residential development.

The evaluation of the hydraulic and hydrologic features of the dam and lake was based on criteria set forth in the Corps Guidelines and additional guidance provided by the Philadelphia District, Corps of Engineers. The Spillway Design Flood for the dam falls in a range of 100 year to 1/2 PMF. In this case, the upper end of the range, 1/2 PMF is chosen since the factors used to select the hazard classification are on the high side of their respective ranges.

The unit hydrograph was determined by Snyder's Method. Snyder's peaking coefficient Cp was specified by the Corps of Engineers as 0.62. The synthetic unit hydrograph was developed with the aid of HEC1-DB program.

Initial and infiltration loss rates were applied to the Probable Maximum Storm rainfall to obtain rainfall excesses. The rainfall excesses were applied to the unit hydrographs to obtain the PMF and various ratios of PMF utilizing program HEC1-DB.

The SDF peak outflow calculated for the spillway and dam is 8,404 cfs. This value is derived from the 1/2 PMF, and results in overtopping of the dam.

The stage-outflow relation for the spillway was determined from the geometry of the spillway and dam, and is shown in the Hydrologic Computations (Appendix D).

The reservoir stage-storage capacity relationship was computed directly by the conic method, utilizing the HEC1-DB program. The conic method assumes that the reservoir capacity resembles a series of vertically stacked cones. The reservoir surface areas at various elevations were measured by planimeters from U.S.G.S.

Quadrangle topographic maps. Reservoir storage capacity included surcharge levels exceeding the top of the dam, and the spillway rating curve was based on the assumption that the dam remains intact during routing.

The discharge from the valve house is less than 1% of the peak spillway and dam outflow and is ignored in this study.

Drawdown calculations indicate that the lake would empty through the 24" ø pipe in 5 1/2 days, assuming a 2 cfs/square mile inflow. This is considered an excessive time frame, and additional outlet facilities are required.

b. Experience Data

From the reports on file at the NJDEP, some information was available. The capacity of the principal spillway is 1,200 cfs at a freeboard of 5 feet and the capacity of auxiliary spillway is 1,880 cfs at a head of 2.5 feet. The above discharges are estimated discharges and not comparable with the present calculations.

c. Visual Observation

The slopes around the lake are moderate and wooded. The valley below the dam is 600 feet wide and is flat. It supports a growth of trees and reeds. The valve house downstream does not appear to be in danger of sustaining appreciable damage from 1/2 PMF flows.

d. Overtopping Potential

A storm of magnitude equivalent to the SDF would cause overtopping of the dam to a height of 0.47 feet. Computations indicate that the dam can pass approximately 39% of the PMF without overtopping the dam crest. Since 1/2 the PMF is the Maximum Spillway Design Flood (SDF) for this dam, according to the Recommended Guidelines for Safety Inspection of Dams, by the Corps of Engineers, the spillway capacity of Lake Cushetunk Dam is assessed as "inadequate."

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There are no signs of significant embankment sloughing, but local slides and erosion are visible. No seepage was detected along the embankment. The stability of the wingwalls is questionable as described in Section 3c, and this requires further investigation.

Settlement of fill in the left embankment was detected by the continuous crack along the downstream side of the crest over the cut-down core. The amount of settlement appears to be minor and uniform. No evidence was found of forward movement.

b. Design and Construction Data

No design computations were uncovered during the report preparation phase. No complete foundation soil parameters are available for carrying out a conventional stability analysis on the embankment. No construction data or specifications relating to the degree of embankment compaction are available for use in the stability analysis.

c. Operating Records

No operating records are available relating to the stability of the dam. According to available correspondence, a severe flood in 1955 resulted in overtopping of the embankment and caused structural damage.

d. Post-construction Changes

Stability of the dam was improved by the addition, in 1958, of an auxiliary spillway as described in Section 1.2.a.

e. Static Stability

A static stability analysis was not performed for Lake Cushetunk Dam because the lack of data on which to base assumptions of material properties and foundation conditions might produce misleading results.

Cracks in the wingwalls, the corewall and in the concrete slabs, would all indicate that a slow progressive settlement is taking place.

f. Seismic Stability

The dam is located in Seismic Zone 1, as defined in Recommended Guidelines for Safety Inspection of Dams, prepared by the Corps of Engineers. In general, projects located in Seismic Zones 0, 1 and 2 may be assumed to present no hazard from earthquake, provided the static stability conditions are satisfactory and conventional safety margins exist. Until the last two conditions are confirmed, the seismic stability is considered questionable.

The dam is located on the Triassic Brunswick Formation of soft, red shale with sandstone beds, as indicated on the Geologic Map (Plate 2).

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety

The dam has been inspected visually and a review has been made of the available engineering data. This assessment is subject to the limitations inherent in the visual inspection procedures stipulated by the Corps of Engineers for a Phase I report.

The safety of Lake Cushetunk Dam is in question because the dam does not have adequate spillway capacity to pass the PMF or even 1/2 of the PMF without overtopping. Overtopping of the dam carries with it the danger of possible progressive failure of the dam. The dam's present spillway capacity is about 39% of the PMF.

No definitive statement pertaining to the safety of the embankment can be made without acquisition of embankment material engineering properties and determination of phreatic levels in the downstream part of the embankment.

b. Adequacy of Information

The information uncovered was adequate to perform hydrologic and hydraulic computations. The data was insufficient to perform even an approximate computation of the dam's stability. A preliminary assessment of the dam could be made by visual observation only.

d. Urgency

Carry out a more precise hydrologic and hydraulic analysis of the dam within twelve months, to determine the need and type of mitigating measures necessary. If required, conduct a study of the means of increasing spillway discharge capacity and develop alternative schemes for construction. This should include the installation of headwater and tailwater gages. The ability of the dam to withstand overtopping should also be studied.

Observation wells or piezometers should be installed in the embankment to determine the location of the phreatic surface. The borings should be logged according to the Unified Soil Classification system by qualified personnel and samples taken to determine the values of pertinent soil parameters for stability. This information should be obtained within six months, and should be evaluated immediately upon acquisition to perform stability analyses in accordance with Chapeter 4.4 of the Corps Guidelines.

The existing dam plans and drawings should be annotated and updated to form a coherent as-built set within 6 months.

7.2 Remedial Measures

a. Alternatives for Increasing Spillway Capacity

Alternatives for increasing spillway capacity are as follows:

1. Increase the dam height, thus permitting a higher discharge to pass over the spillway and reducing the possibility of overtopping.

2. Lower either spillway crest elevation.

3. Increase the effective spillway crest length.

4. A combination of any of the above alternatives.

b. Other Remedial Measures

1. The embankment material that has been eroded from the downstream face, particularly adjacent to the right wingwall of the spillway, should be replaced with quarry-process stone or gravel. Slopes should be reconstructed with keying and compaction of material to improve stability and to support the abutments and wingwalls. Slopes should not be steeper than 2H:1V and should be protected with rip-rap near the spillway. This work should be undertaken within six months.

2. A safe means of lowering the lake should be provided. This would involve restoring the existing outlets to operable condition and reinstating the footbridge across the spillway. This work should commence within six months.

3. Repair all cracked and spalled concrete with epoxy cement within six months.

4. Provide rip-rap protection along entire upstream face within 12 months.

5. All brush and trees should be removed from the downstream and upstream slopes to avoid problems which may develop from roots. The embankment face should then be seeded to develop a growth of grass for surface erosion protection. Remove all vegetation from cracks. This program should be started within 12 months.

c. Recommendations

The following additional action is recommended.

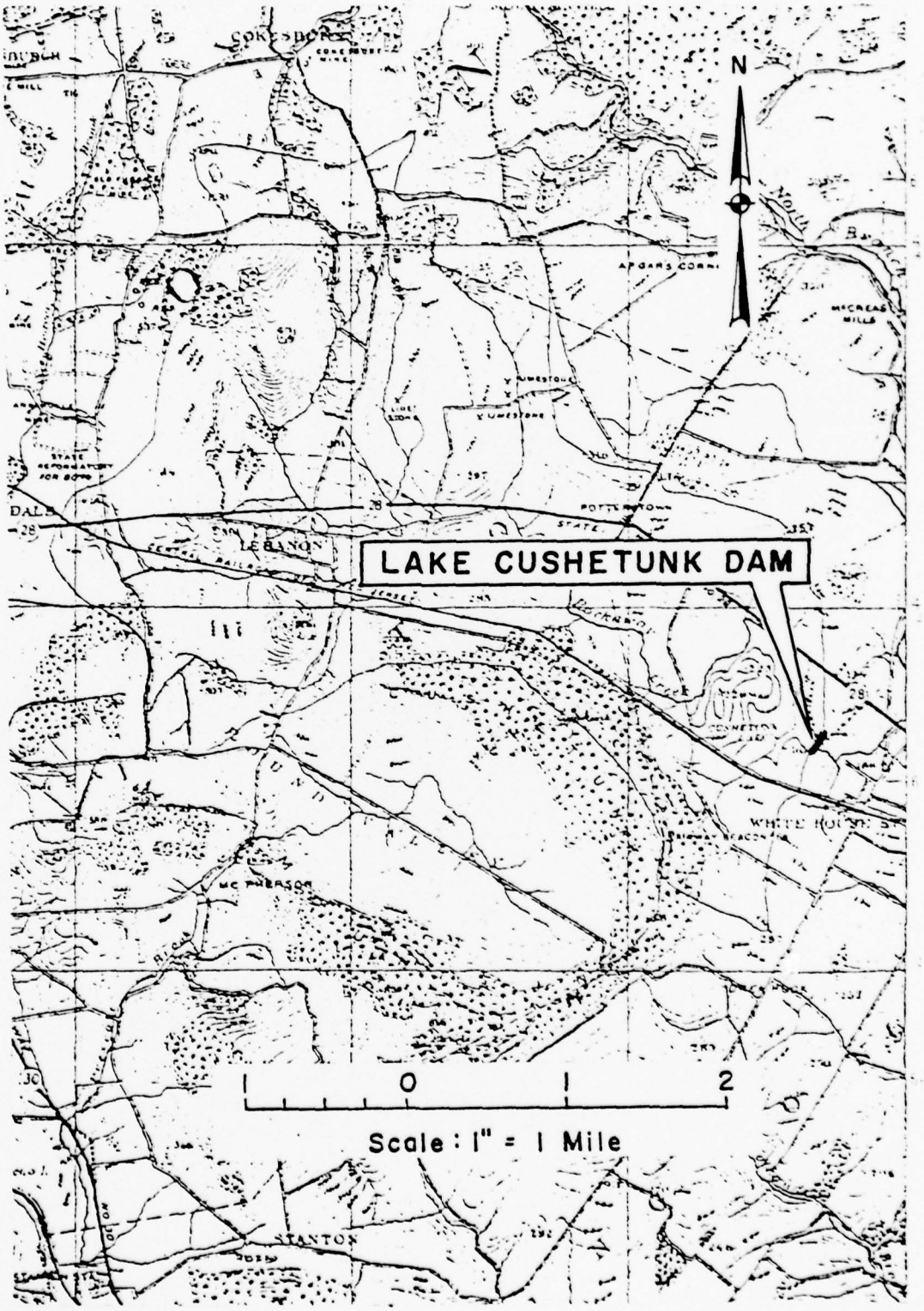
1. Establish a flood warning system for the downstream communities within three months.

2. Consider providing additional low-level outlet facilities.

d. O & M Procedures

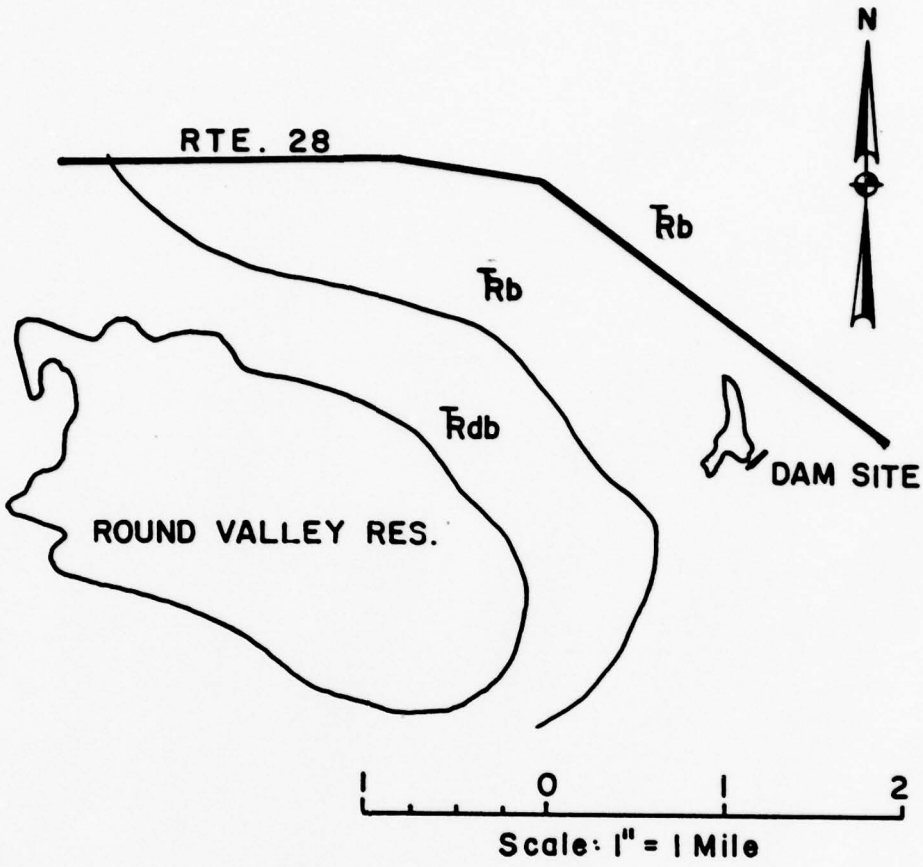
A formalized program of annual inspections of the dam by an experienced party should be initiated, utilizing the standard visual check list in this report. Headwater and tailwater gages should be installed in the dam, and read out during severe rain storms and at routine operating and maintenance visits to the dam. A permanent log should be kept of all maintenance and operating events of the dam, the lake and the outlet passages. Movement and settlement of the embankment should be monitored regularly by means of surveying monuments.

PLATES



VICINITY MAP

PLATE 1



LEGEND

TRIASSIC

TRb	Brunswick Formation Soft red shale with sandstone beds
TRdb	Diabase

GEOLOGIC MAP
LAKE CUSHETUNK DAM

PLATE 2

SPECIFICATIONS

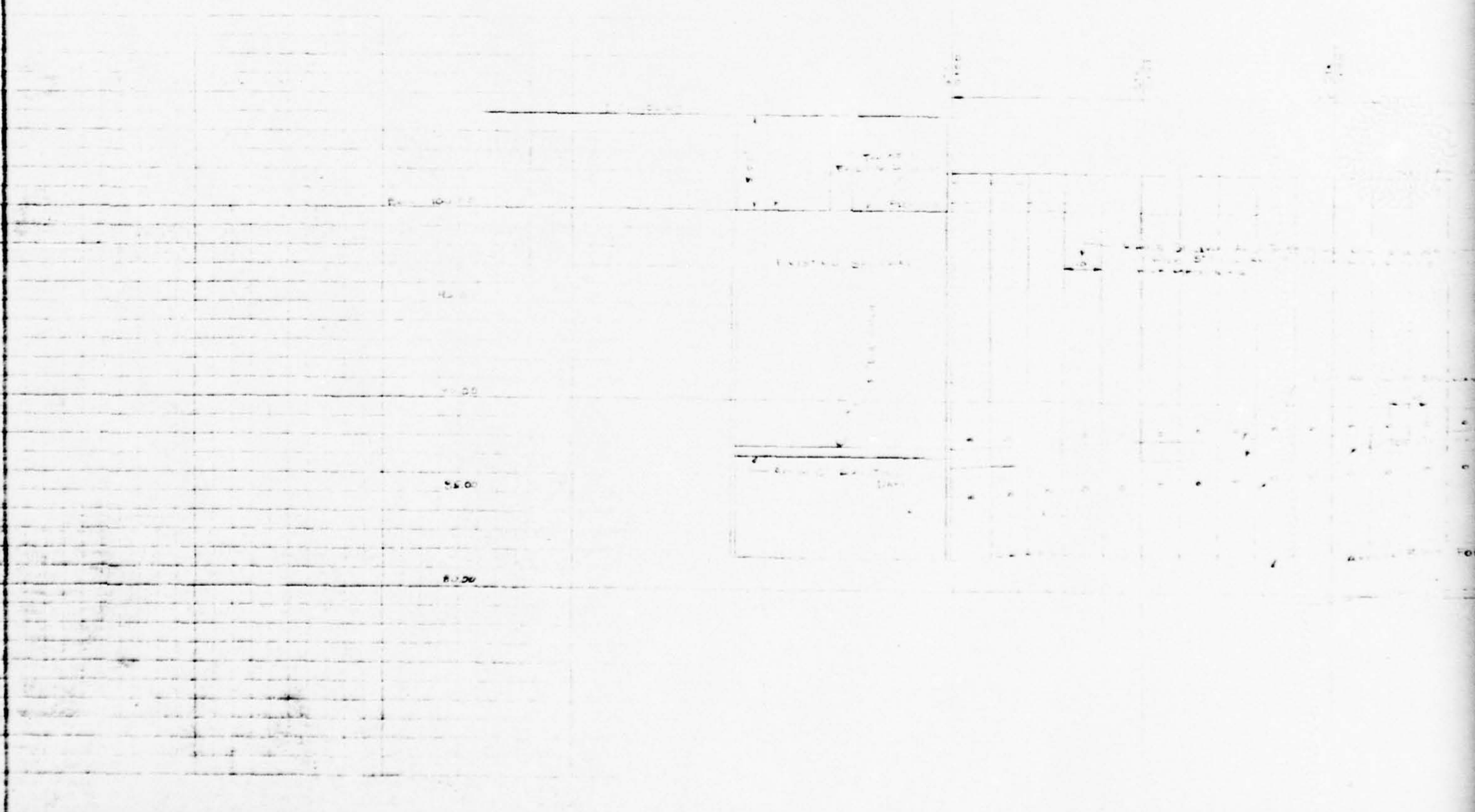
EXCAVATION: EXCAVATE [illegible]
[illegible]

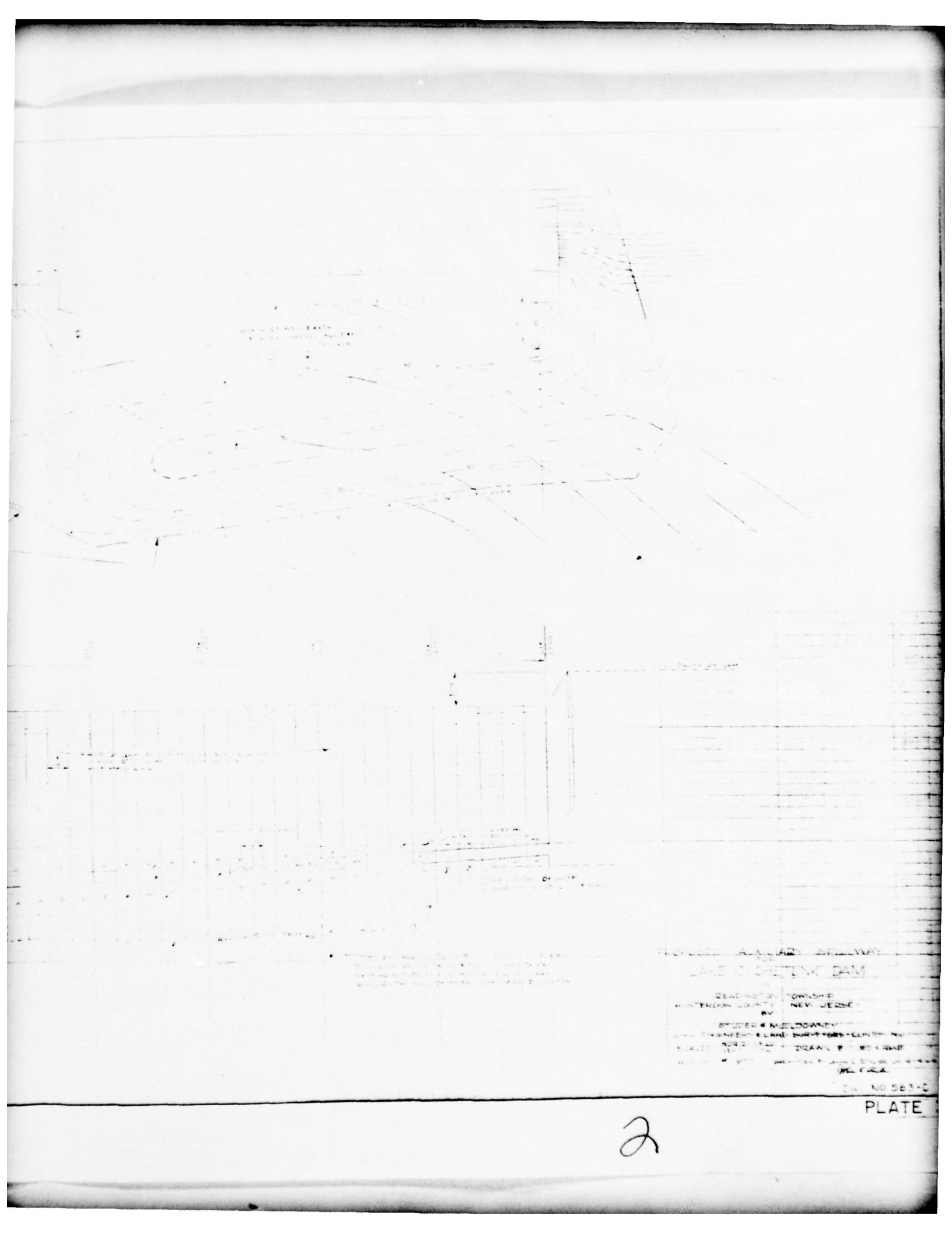
REINFORCING STEEL: [illegible]
[illegible] AS SHOWN [illegible]
CONCRETE [illegible]
[illegible]
[illegible]

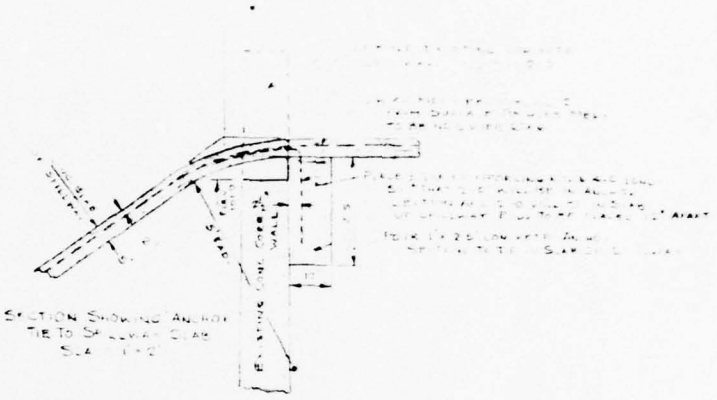
CONCRETE: ALL CONCRETE [illegible]
CONCRETE [illegible] 3" CONCRETE
[illegible]
CONCRETE [illegible] BE VIBRATED WITH A
STANDARD MECHANICAL [illegible]

NOTE COVERING CONSTRUCTION OF [illegible] CHANNEL AND TERRACE

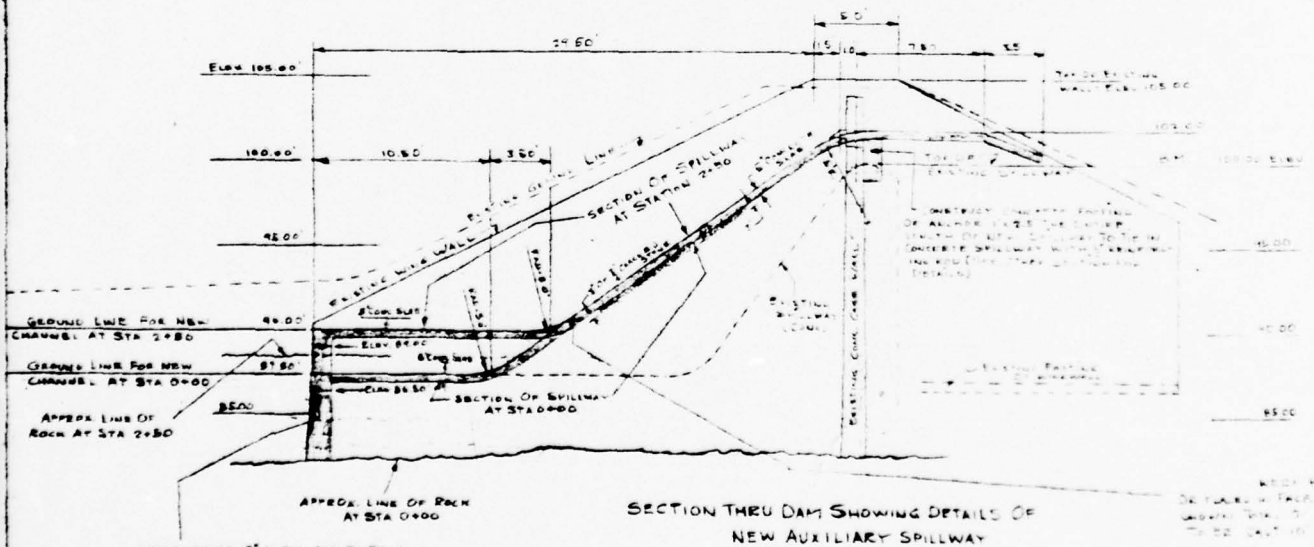
BEFORE GRADING IS STARTED THE WHOLE AREA BOUNDED BY THE LINES DESIGNATED "LIMIT OF GRADED AREA" IS TO BE CLEARED OF ALL BRUSH, TREES, STUMPS, ETC. ALL THE DEBRIS SHALL BE BURNED IN THE AREA AND THE STUMPS REMOVED. THE TOP SOIL IS TO BE REMOVED AND SAVED SO THAT IT WILL BE AVAILABLE TO SPREAD BACK ON TOP OF THE GRADED AREA. AFTER THE TOP SOIL HAS BEEN REPLACED IT SHALL BE [illegible] HARROWED AND THEN PLANTED WITH RYE GRASS.




LAKE DENMARK DAM
NEW JERSEY
PLATE
2

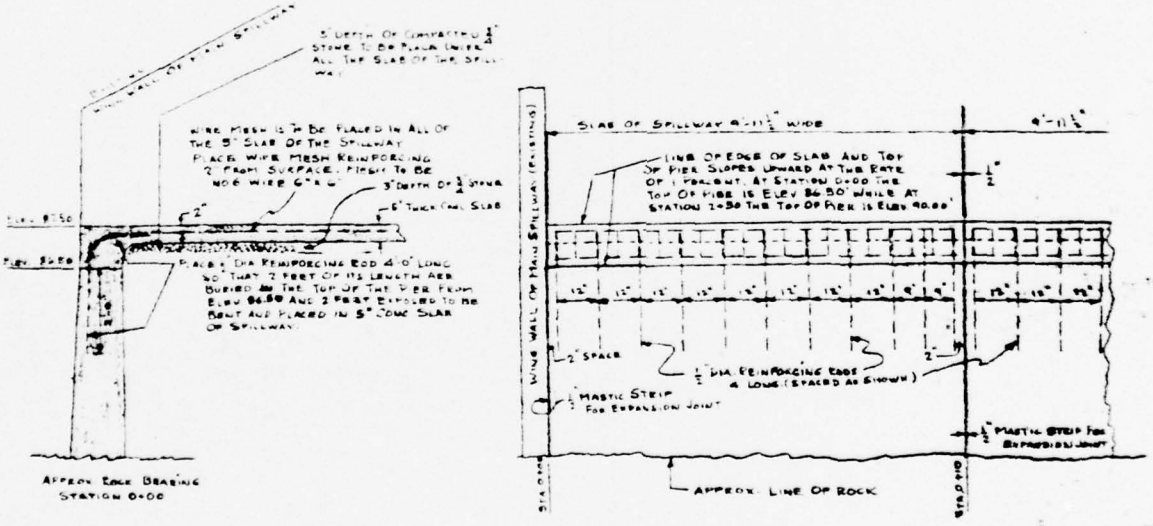


SECTION SHOWING ANCHOR TIE TO SPILLWAY SLAB
SCALE 1"=2'



SECTION THRU DAM SHOWING DETAILS OF NEW AUXILIARY SPILLWAY
SCALE 1"=5'

WEEP HOLES 2" IN DIA ARE TO BE CAST OR PLACED IN FIBRE OR CUTOFF WALL AT ELEVATIONS SHOWN TOTAL OF 36 HOLES IN FIBRE ARE TO BE CAST WHICH ARE TO BE SPACED 10' APART.

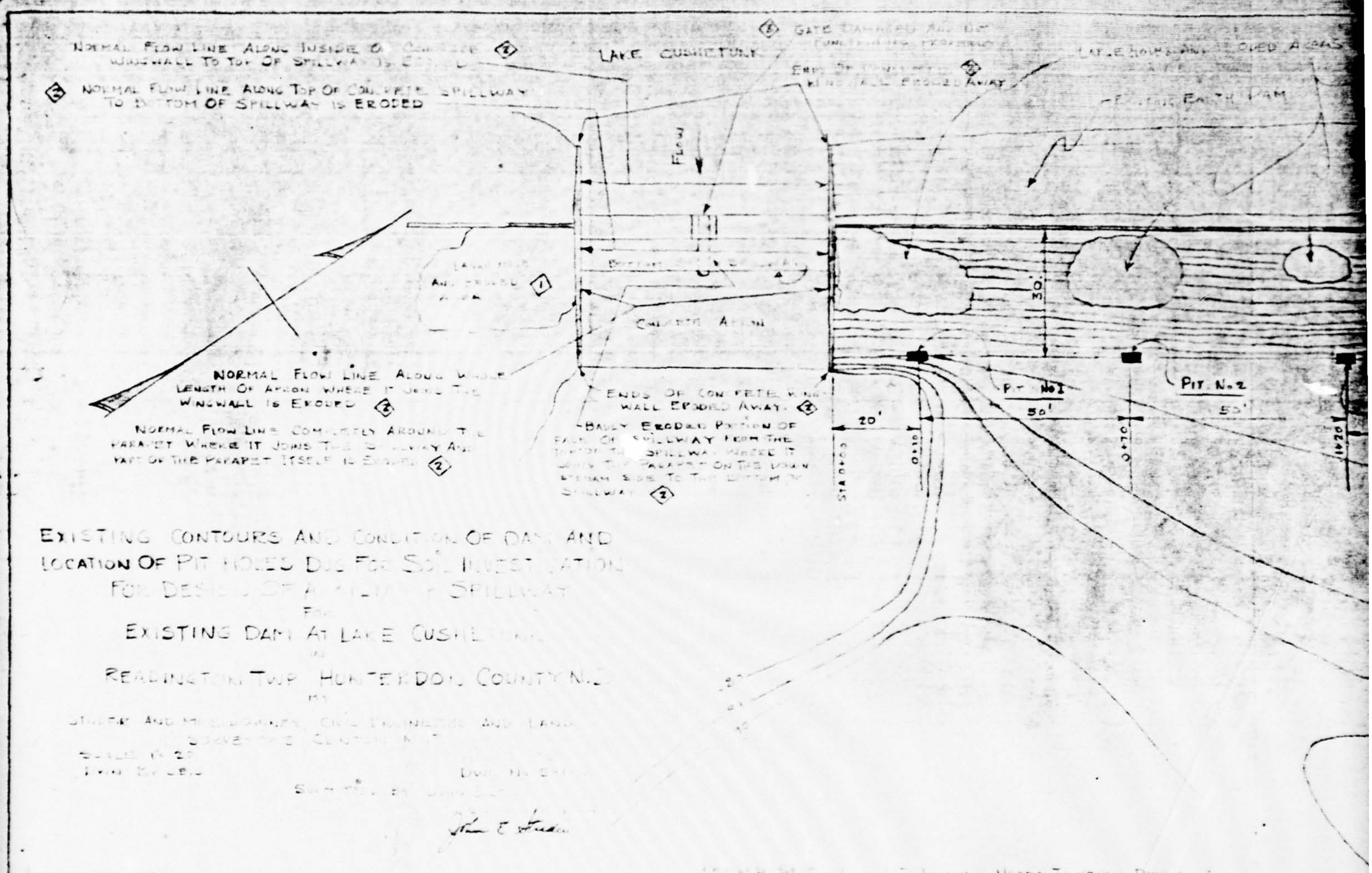


SECTION OF PIER AND SLAB OF SPILLWAY
SCALE 1"=2'

2

DETAILS OF PROPOSED AUXILIARY SPILLWAY
FOR
LAKE CUSHETUNK DAM
IN
READINGTON TOWNSHIP
HUNTERDON COUNTY, NEW JERSEY
BY
STUDER & McELDOWNEY
CIVIL ENGINEERS & LAND SURVEYORS
SCALE: AS SHOWN
AUGUST 15, 1967

PLATE 4



Normal Flow Line Along Inside Of Concrete Wingwall To Top Of Spillway Is Eroded
Normal Flow Line Along Top Of Concrete Spillway To Bottom Of Spillway Is Eroded
Lake Cushetunk
Flow
Existing Earth Dam
Concrete Apron
Normal Flow Line Along Whole Length Of Apron Where It Joins The Wingwall Is Eroded
Normal Flow Line Completely Around The Parapet Where It Joins The Spillway And Part Of The Parapet Itself Is Eroded
Ends Of Concrete Wingwall Eroded Away
Badly Eroded Portion Of Face Of Spillway From The Top Of The Spillway Where It Joins The Parapet On The Down Stream Side To The Bottom Of Spillway
Pit No 1
Pit No 2
20'
50'
STA 0+00
0+20
0+70
1+20
Existing Contours And Condition Of Dam And
Location Of Pit Holes Dug For Soil Investigation
Existing Dam At Lake Cushetunk
Readington Twp Hunterdon County N.J.

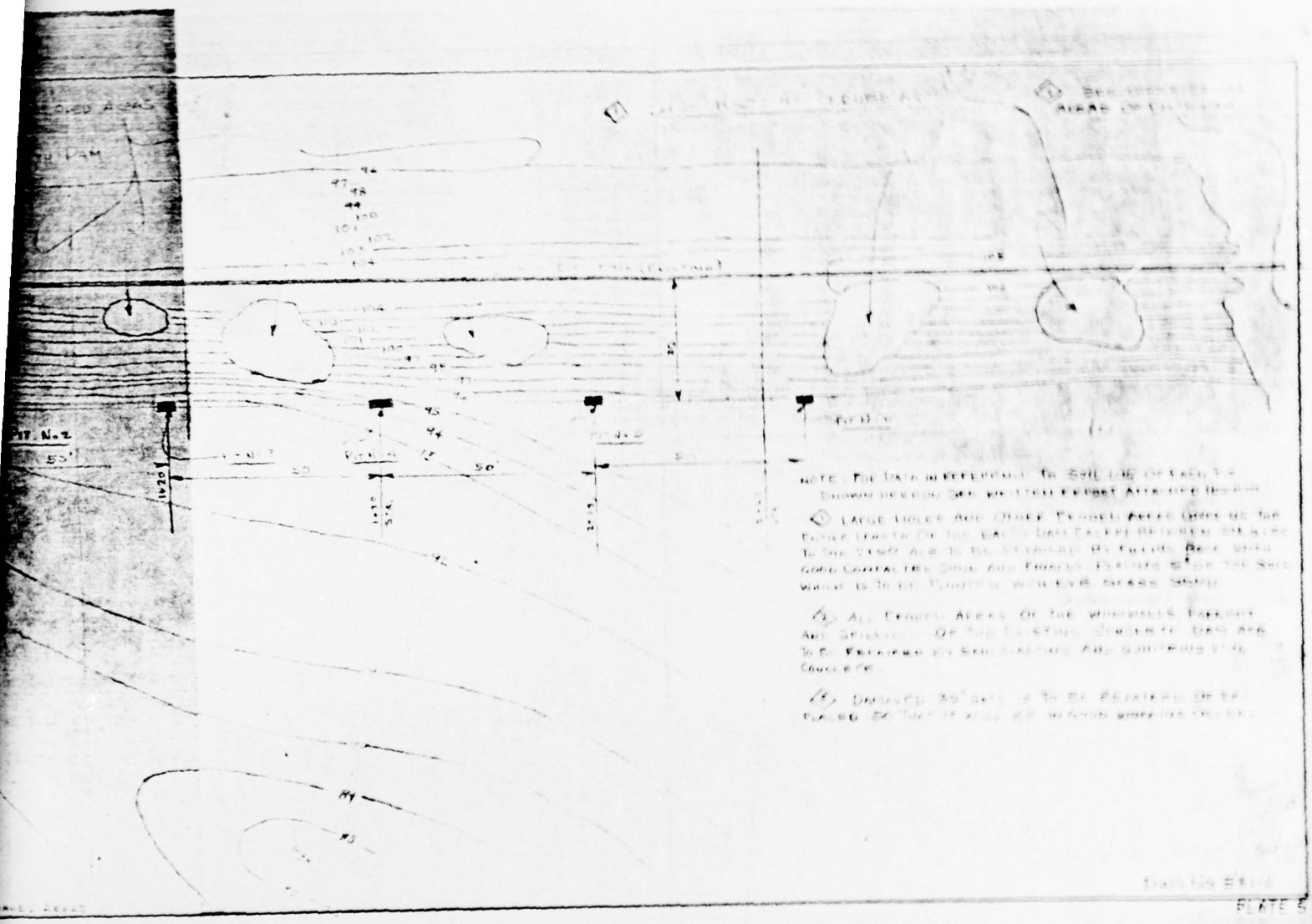


PLATE 5

APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

CHECK LIST - ENGINEERING, CONSTRUCTION, MAINTENANCE DATA

CHECK LIST
VISUAL INSPECTION

PHASE I

Name of Dam Cushetunk Lake County Hunterdon State New Jersey Coordinators NJDEP

Date(s) Inspection May 3, 1979 Weather Sunny Temperature 75°

Pool elevation at Time of Inspection 134.8' M.S.L. Tailwater at time of Inspection 122.5' M.S.L.

Inspection Personnel:

May 3, 1979

Eugene Koo
Henry King
Chuck Chin

Owner/Representative:

None attended.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SURFACE CRACKS	Extensive surface cracking parallel and normal to the axis has taken place on the concrete covering of the left embankment. The most serious cracking is on the upstream side of the crest, where the covering is sheared by up to 6". All cracks appear to have pentrated the full thickness of the concrete.	Additional protection is needed on the upstream face. All other cracks should be repaired with epoxy. No major instability indicated by cracks.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	Cracking of the fill near the downstream toe of the right embankment. Minor surficial cracking at toe of left embankment.	Probably due to local stress caused by trees, undermined at the roots.
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	On the right embankment, extensive erosion has taken place on upstream and downstream faces, exposing the corewall and tree roots and creating vertical slopes in places. On the left embankment, fill under the upstream concrete protection has been eroded by flow and wave action, causing cracks up to 6" across in the concrete.	Replace lost fill material with quarryrun stone and protect with rip-rap. Place rip-rap on left upstream side.
VERTICAL & HORIZONTAL ALIGNMENT OF THE CREST	Settlement of the right embankment evidenced by vertical crack in exposed core-wall. Settlement of fill in the left embankment detected by the continuous crack along the d/s side of the crest over the cut-down core. Amount of settlement appears to be minor and uniform. No evidence found of forward movement. The foundation is reported to be red shale.	Monitor alignments periodically.
RIPRAP FAILURES	N/A	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
TREES & VEGETATION	Trees on the right and extreme left embankments have exposed roots and are leaning outward. Vegetation is growing in the cracks in the concrete, aggravating the cracking process.	Trees are a stability hazard and should be removed. Remove vegetation from cracks.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	On the right side, considerable erosion of fill has taken place behind the wingwall on both faces, exposing the corewall by more than 3 feet. Corewall has a vertical settlement crack 7' from the wingwall. Upstream wingwall is cracked and sheared by 3/4". Overall condition of junction on left side is good.	Replace the lost material with quarryrun and protect with riprap.
ANY NOTICEABLE SEEPAGE	No signs of seepage from the left embankment. From the right embankment, water seeping from auxiliary low-level outlet, but not through fill.	
STAFF GAGE AND RECORDER	None.	
DRAINS	Weep-holes at the toe of the left embankment are partially clogged. No water was observed seeping from them.	Clean weepholes.

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CONCRETE WEIR	Horizontal alignment is good, and spillway surface appears satisfactory. Severe erosion at junction with wingwalls and central buttress.	Repair deteriorated concrete.
APPROACH CHANNEL	Concrete wingwalls in spillway approach are severely spalled at the water line. On the right wingwall, cracking and dislocation have occurred.	Repair spalled areas. Investigate right wingwall crack.
DISCHARGE CHANNEL	The spillway apron descends to the downstream channel. There is heavy erosion and spalling at the junction of apron and wingwalls. The apron appears level.	Prompt repair recommended to avoid further deterioration.
BRIDGE AND PIERS	The original footbridge giving access across the spillway and to the low-level outlet valve shaft has been removed. The footings are cracked, and the central pier is in danger of collapse due to the severe cracking at the waterline.	Reinstate a footbridge and undertake major repairs to the central pier.
AUXILIARY SPILLWAY	Left embankment, covered by concrete, serves as an auxiliary spillway at reservoir elevations 2 feet above main spillway.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CRACKING & SPALLING OF CONCRETE SURFACES IN STILLING BASIN	Submerged. Unconfirmed holes in apron, possibly former outlet or baffle.	Investigate when water is drawn down and annotate drawing.
INTAKE STRUCTURE	Intake structures for the main low-level outlet and the auxiliary were both under water.	
OUTLET STRUCTURE	A 24" diameter pipe in the center of the spillway forms the main low-level outlet. The gate-valve stem is inaccessible, and the outlet is deemed to be inoperable. Concrete surrounding the pipe is eroded.	After access is restored, test outlet for operability and repair as necessary.
OUTLET FACILITIES	Auxiliary outlet facility is a 30" diameter ceramic pipe at the right of the right embankment. Operability is not known, but a small flow (less than 1 gallon per hour) is seeping out.	Investigate the outlet further for operability.
EMERGENCY GATE	None.	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
MONUMENTATION/SURVEYS	A state benchmark is reported to exist 1,000 feet from the dam. This was not found.	Install a benchmark near the dam, and relate to MSL.
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHERS	None.	Install head-water and tail-water gages.

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SLOPES	Slopes around the perimeter of the lake are moderate and are covered with a heavy growth of brush and trees.	
SEDIMENTATION	Sedimentation rate not known; lake not drawn down. However, does not appear to be a problem.	
USE	Recreation only.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Large plungepool below spillway, with two channels leading out. Channels join within 200 feet of dam. Plungepool banks are undermined. Valley is heavily wooded downstream. About 1,000 feet downstream is a valve house controlling an outlet from the Round Valley Reservoir; discharges into South Branch Rockaway Creek.	
SLOPES	Downstream valley is broad and flat.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	Route 22 within 4,000 feet. Approximately 1 inhabited building in flood path before Route 22. The valve house downstream is regularly occupied, but the floor elevation is above the maximum predicted channel elevation.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	Available. (Included)
REGIONAL VICINITY MAP	Available. U.S.G.S. Quadrangle sheet. (Califon, N. J. and Flemington, N.J.)
CONSTRUCTION HISTORY	From microfiche on file at NJDEP.
TYPICAL SECTIONS OF DAM	Limited data available. Drawings included.
HYDROLOGIC/HYDRAULIC DATA	Limited information on microfiche (NJDEP).
OUTLETS - PLAN	None available.
- DETAILS	None available.
- CONSTRAINTS	None available.
- DISCHARGE RATINGS	None available.
RAINFALL/RESERVOIR RECORDS	None available.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
DESIGN REPORTS	None available.
GEOLOGY REPORTS	None available.
DESIGN COMPUTATIONS	None.
HYDROLOGY & HYDRAULICS	None.
DAM STABILITY	None.
SEEPAGE STUDIES	None.
MATERIALS INVESTIGATIONS	None.
BORING RECORDS	Some available on microfiche. (NJDEP)
LABORATORY	None.
FIELD	None.
POST-CONSTRUCTION SURVEYS OF DAM	Shown on drawings.
BORROW SOURCES	Unknown.
SPILLWAY PLAN - SECTIONS	Shown on drawings.
- DETAILS	Shown on drawings.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
OPERATING EQUIPMENT PLANS AND DETAILS	Not available.
MONITORING SYSTEMS	Not available.
MODIFICATIONS	Reconstructed in 1958.
HIGH POOL RECORDS	Limited information available in correspondence on microfiche from NJDEP.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	1957 survey recorded on drawings.
PRIOR ACCIDENTS OF FAILURE OF DAM	Dam overtopped in 1955.
- DESCRIPTION	Information in correspondence on microfiche. (NJDEP)
- REPORTS	
MAINTENANCE OPERATION RECORDS	None.

APPENDIX B

PHOTOGRAPHS

(Taken on May 3, 1979)

Photo No. 1 - Overall view of spillway from left side. The foot-bridge has been removed. Note the key shaft for the low level outlet valve in the central buttress, and the advanced deterioration of the concrete at the water line.

Photo No. 2 - View of spillway from the right embankment showing the exposed core-wall and the left embankment with its concrete cover. Note also the crack in the upstream wingwall and the general deterioration of concrete.

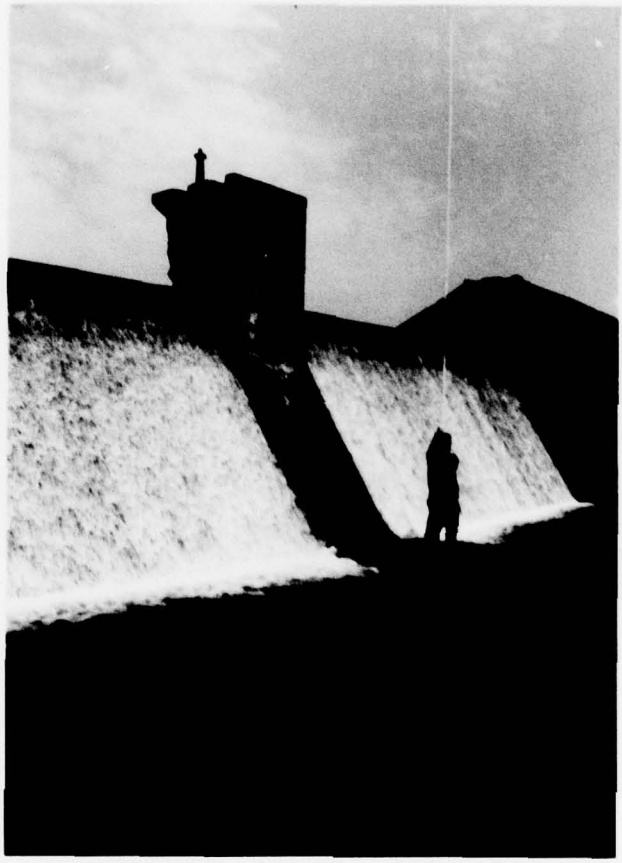


Photo No. 3 - View of spillway from downstream, showing low-level outlet.

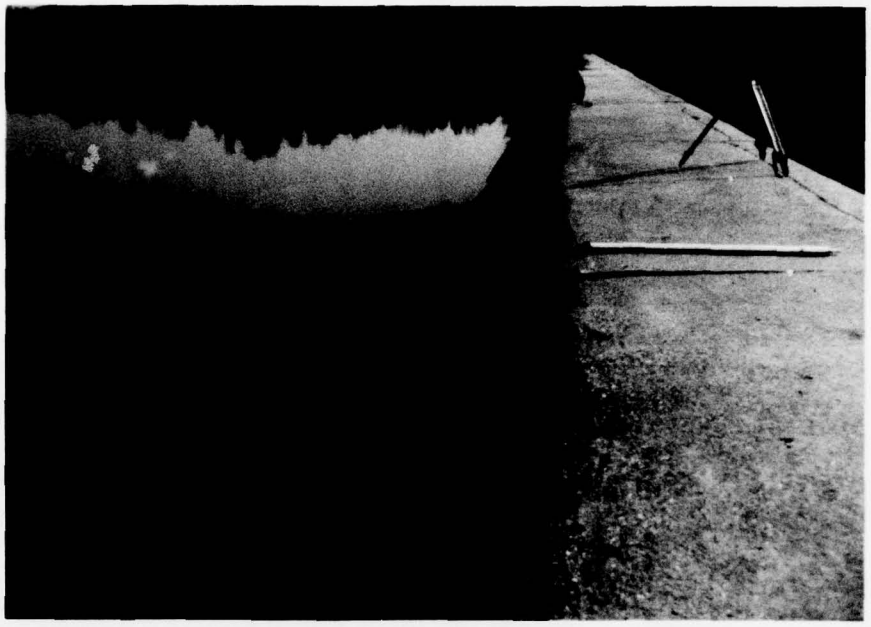


Photo No. 4 - View of left embankment, covered by concrete to form an emergency spillway. Extensive cracking has occurred and vegetation is growing in the cracks.

Photo No. 5 - View of left embankment looking towards the spillway. Note that toe protection has been provided along the length of the embankment.

Photo No. 6 - Detail showing exposed core wall in the right embankment. Note the settlement crack and the extensive loss of fill.

Photo No. 7 - Downstream face of the right embankment, showing the second low-level outlet and the general erosion of fill.

Photo No. 8 - View of valve house 1,000 feet downstream of the dam. The valve house controls an outlet from the Round Valley Reservoir.

Photo No. 9 - View of area where the discharge from the valve house enters the downstream channel.

Photo No. 10 - View of Lake Cushetunk looking upstream from the left. Note moderate slopes and extensive growth of trees.

Photo No. 11 - View of downstream channel area and stilling pool. Note undermining of the banks and the fallen trees.

APPENDIX C

SUMMARY OF ENGINEERING DATA

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

Name of Dam: Lake Cushetunk Dam

Drainage Area Characteristics: Mostly forest, with light residential development.

Elevation Top Normal Pool (Storage Capacity): 134.6' MSL (212 acre-feet)

Elevation Top Flood Control Pool (Storage Capacity): N/A

Elevation Maximum Design Pool: (SDF) 140.45' MSL (389 acre-feet)

Elevation Top Dam: 140' MSL (365 acre-feet)

SPILLWAY CREST

a. Elevation 134.6' MSL (main), 136.7' (auxiliary)

b. Type Double concrete ogee (main), concrete ogee (auxiliary)

c. Width 2' (main), 8' (auxiliary)

d. Length 52' (main), 260' (auxiliary)

e. Location Spillover Full length of main spillway.

f. No. and Type of Gates None.

OUTLET WORK

a. Type 24" ø low-level outlet (inaccessible)

b. Location Center of main spillway.

c. Entrance Inverts Not known.

d. Exit Inverts 123' MSL

e. Auxiliary Outlet Facilities 30" ø ceramic pipe (inoperable)

HYDROMETEOROLOGICAL GAGES

a. Type N/A

b. Location N/A

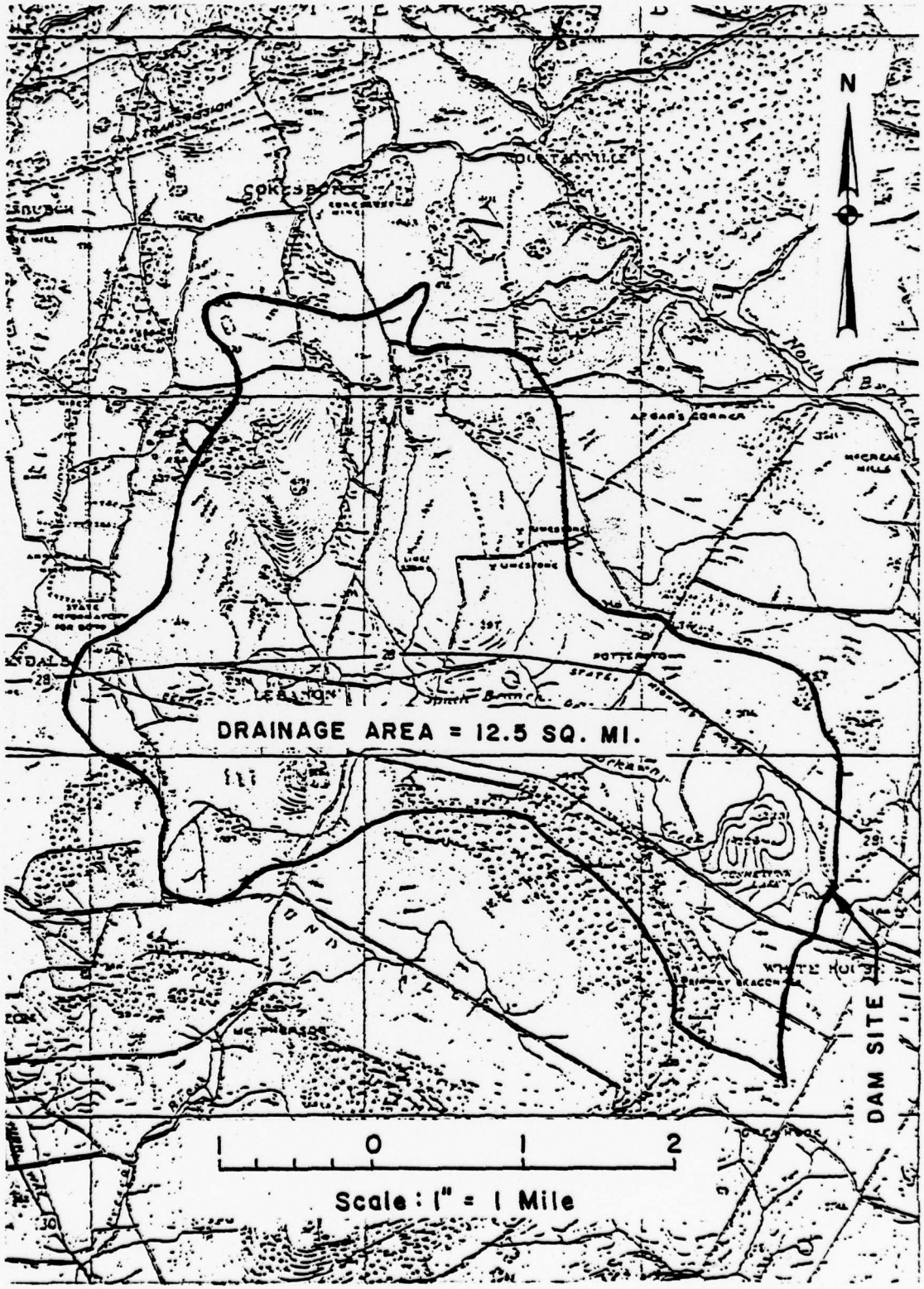
c. Records N/A

MAXIMUM NON-DAMAGING DISCHARGE 6,546 cfs

APPENDIX D

HYDROLOGIC COMPUTATIONS

PLATE I APPENDIX D



LAKE CUSHETUNK DAM
DRAINAGE BASIN

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection SHEET NO. 1 OF
Cushetunk Lake Dam JOB NO. 10-A20-01
COMPUTED BY S.B CHECKED BY DATE July 1979

Size and Hazard Classification

Surface area of Lake = 12.1 A C.
at elevation 134.6

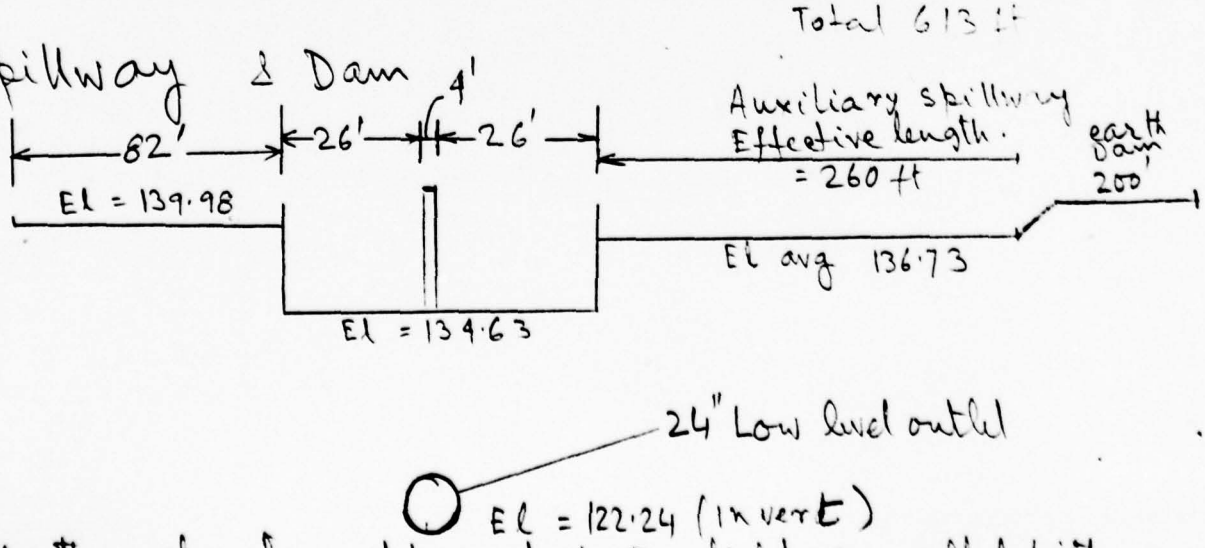
Max. Height of Dam = 20 Ft

Small Dam, "significant" Hazard potential.
(downrated from "High").
SDF = ½ PMF (Upper end of range because hazard is at upper end).

Hydrologic Analysis

D.A = 12.5 Sq Mi

Inflow Hydrograph at Dam was determined using HEC 1 DB program.
The inflow routed through reservoir to get outflow.



All the elevation obtained in the field are added with 40' to get the actual elevation (Assumed datum 100' = 140' USGS)

Rating Curve

Low level outlet :- (Low level outlet is assumed not operating during PMF routi
24" ϕ . Trailwater depth assumed $\frac{2}{3} \times 2 = 1.33$ ft

El = 122.24 + 1.33 = 123.57

Area = $\frac{\pi}{4} \times 2^2$ = 3.14 sq ft

Length of pipe = 40 ft (estimated)

head Loss due to friction = $\frac{n^2 L \times 2g}{(1.486)^2 \times R^{4/3}} \cdot \frac{V^2}{2g}$

$n = .015$
$L = 40$
$2g = 64.4$
$R = 0.5$

$\therefore h_f = .66 \frac{V^2}{2g}$

$h_{en.} = .15 \frac{V^2}{2g}$

$h_{exit} = 1 \frac{V^2}{2g}$

$1.81 \frac{V^2}{2g}$

$= \frac{1.81}{2gA^2} \cdot Q^2$

$= .003 Q^2$

$Q = C_d \cdot A \times \sqrt{2g(h - .003Q^2)}$

$= .8 \times 3.14 \times 8 \times \sqrt{h - .003Q^2}$

$Q^2 = 403 (h - .003Q^2)$

$2.21 Q^2 = 403 h$ $\therefore Q = 13.5 \sqrt{h}$

h is the head
z is the W.S.el.

$Q_1 = 13.5 \sqrt{z - 123.57}$

Discharge thro' spillway

$Q_2 = CL\,H^{3/2}$ $C = 3.75$ (end correction included in coefficient)

$L = 52'$ (effective)

$H = (Z - 134.6)$

$Q_2 = 3.75 \times 52 (Z - 134.6)^{1.5}$

$= 195 (Z - 134.6)^{1.5}$

Discharge through the Auxiliary Spillway (Looking D/S)

$Q_3 = CL\,H^{3/2}$

$= 2.7 \times 260 (Z - 136.73)^{1.5}$

$= 702 (Z - 136.73)^{1.5}$

Discharge over the earth Dam

$Q_4 = CL\,H^{3/2}$

$= 2.7 \times 282 \times (Z - 139.98)^{1.5}$

$= 761 (Z - 139.98)^{1.5}$

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection — Cushetunk Lake Dam
SHEET NO. 4 OF
JOB NO. 10-A20-C1
COMPUTED BY S.B CHECKED BY
DATE July, 1979

Stage Outflow Relations:

W.S. El.	Low level Outlet		Spillway		Flow Aux. spill		Flow over Dam		Total flow
Z	$Z-123.57$ h_1	Q_1 $13.5\sqrt{h_1}$	$Z-134.6$ h_2	Q_2 $195\,h_2^{1.5}$	$Z-136.73$ h_3	Q_3 $702\,h_3^{1.5}$	$Z-137.93$ h_4	Q_4 $761\,h_4^{1.5}$	$Q_2+Q_3+Q_4$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
125	1.43	16							
127	3.43	25							
129	5.43	31							
131	7.43	37							
133	9.43	41							
1346	11.03	45	0	0					0
135	11.43	46	.4	49					49
136	12.43	48	1.4	323					323
136.73	13.16	49	2.13	1080	0	0			1080
138	14.43	51	3.4	1223	1.27	1004			2227
139	15.43	53	4.4	1800	2.27	2,401			4201
139.8	16.41	55	5.38	2433	3.25	4,113	0	0	6546
140	16.43	55	5.4	2447	3.27	4,151	.02	1	6 599
142	18.43	58	7.4	3925	5.27	8,493	2.02	2184	14,602
144	20.43	61	9.4	5620	7.27	13,761	4.02	6134	25,515
146	22.43	64	11.4	7506	9.27	19,813	6.02	11,240	38,559
148	24.43	67	13.4	9 565	11.27	26,560	8.02	17,234	53,409
150	26.43	69	15.4	11,784	13.27	33,935	10.02	24,137	69,856
155	31.43	76	20.4	17,967	18.27	54,821	15.02	44,298	117,086
160	36.43	81	25.4	24,962	23.27	78,801	20.02	68,166	171,931

Low level outlet is not added with the rating curve. However calculations are made herewith and will be used in drawdown calculations

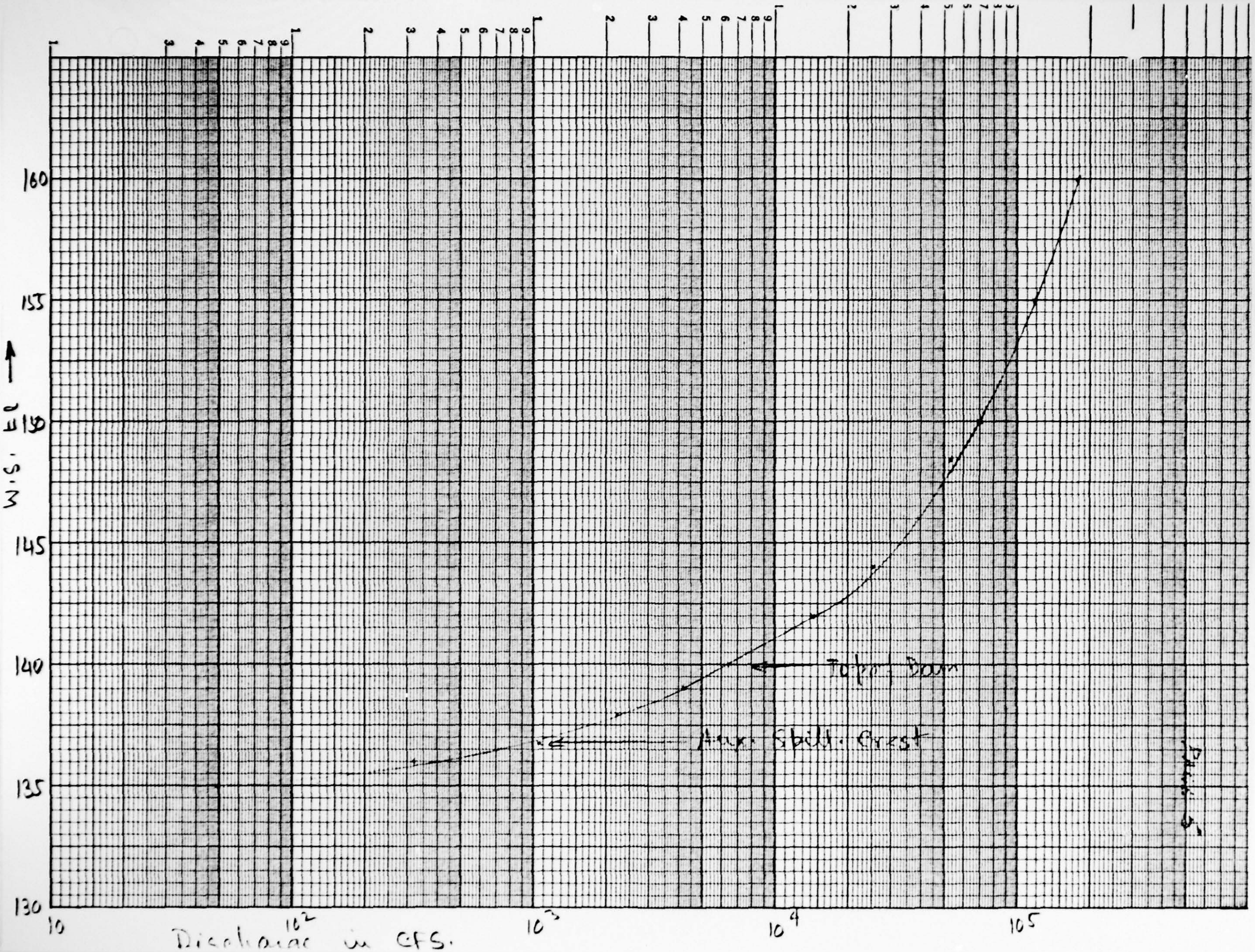


Plate 5
W.S. El.
160
155
150
145
140
135
130
10
10^2
10^3
10^4
10^5
Top of Dam
Aux. Spill. Crest
Discharge in CFS.

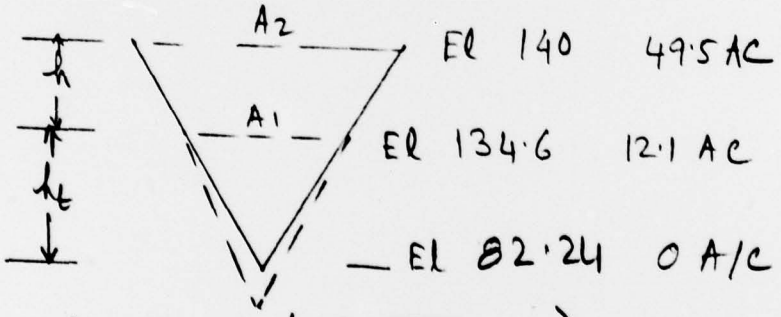
FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection — Cushetunk Lake Dam
SHEET NO 6 OF
JOB NO 10-A20-01
COMPUTED BY S.B CHECKED BY
DATE July 1979

Reservoir Stage area relations

Elevation	Area Acres
134.6 (Lake)	12.1 AC
140	49.5 AC
160	266.3 Ac

(Areas are measured from U.S.G.S Topographic Map



$$h_t = h / \left(\sqrt{\frac{A_2}{A_1}} - 1 \right) = 5.3$$

El of bottom of lake = 134.6 − 5.3 = 129.3
which is much higher than the bottom of Dam.

So the invert of L.L. outlet is considered as zero Area El = 82.24

Determination of PMP

Probable Maximum precipitation amount from HMS Report 33

= 23" 200 sq miles - 24 hrs (all season envelope

for 12.5 Sq.Mi., Depth area duration relationship. Percentage to be applied to the above figure

ZONE 6

6 hr = 110 %

12 hr = 120 %

24 hr = 130 %

48 hr = 140 %

For U.H.G

Snyder's Coefficient assumed

$C_p = 0.62$

$C_t = 2.0$

$t_p = C_t (L L_c)^{0.3}$

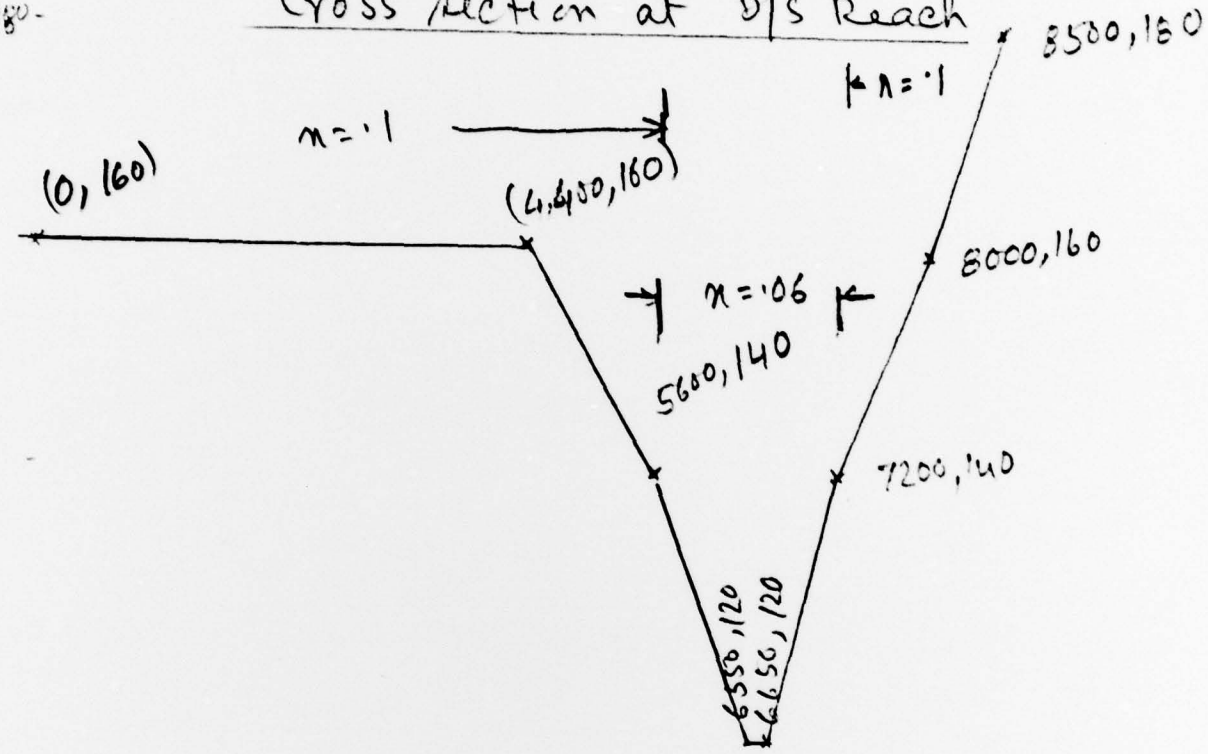
$= 2.0 (8 \times 3.6)^{0.3} = 5.48$

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection — Cushetunk Lake Dam
COMPUTED BY S.B CHECKED BY
SHEET NO. 8 OF
JOB NO. 10-A20-07
DATE Sept. 1979

180-

Cross section at D/s Reach



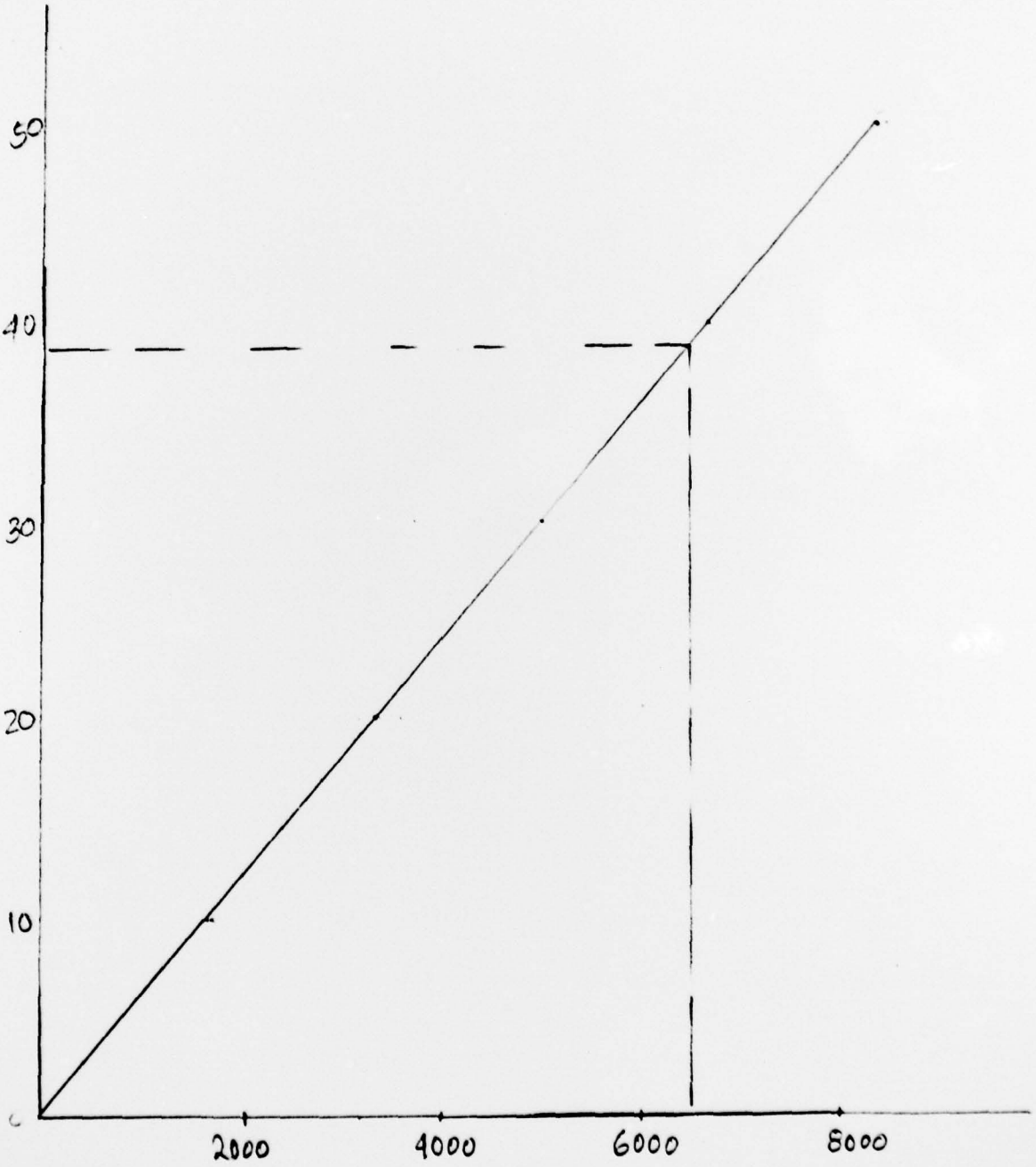
Gross section of reach 1, 4000 ft D/s of Dam.

$S = .0077$

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection SHEET NO. 9 OF
Cruhetunk Lake Dam JOB NO. 10-A20-01
COMPUTED BY S.B CHECKED BY DATE July, 1979

Overtopping Potential



Overflow of Dam occurs at an El of 139.98
Q = 6546 (39% of PMF)

Reservoir Evaluation

a) Discharge Vs. Head.

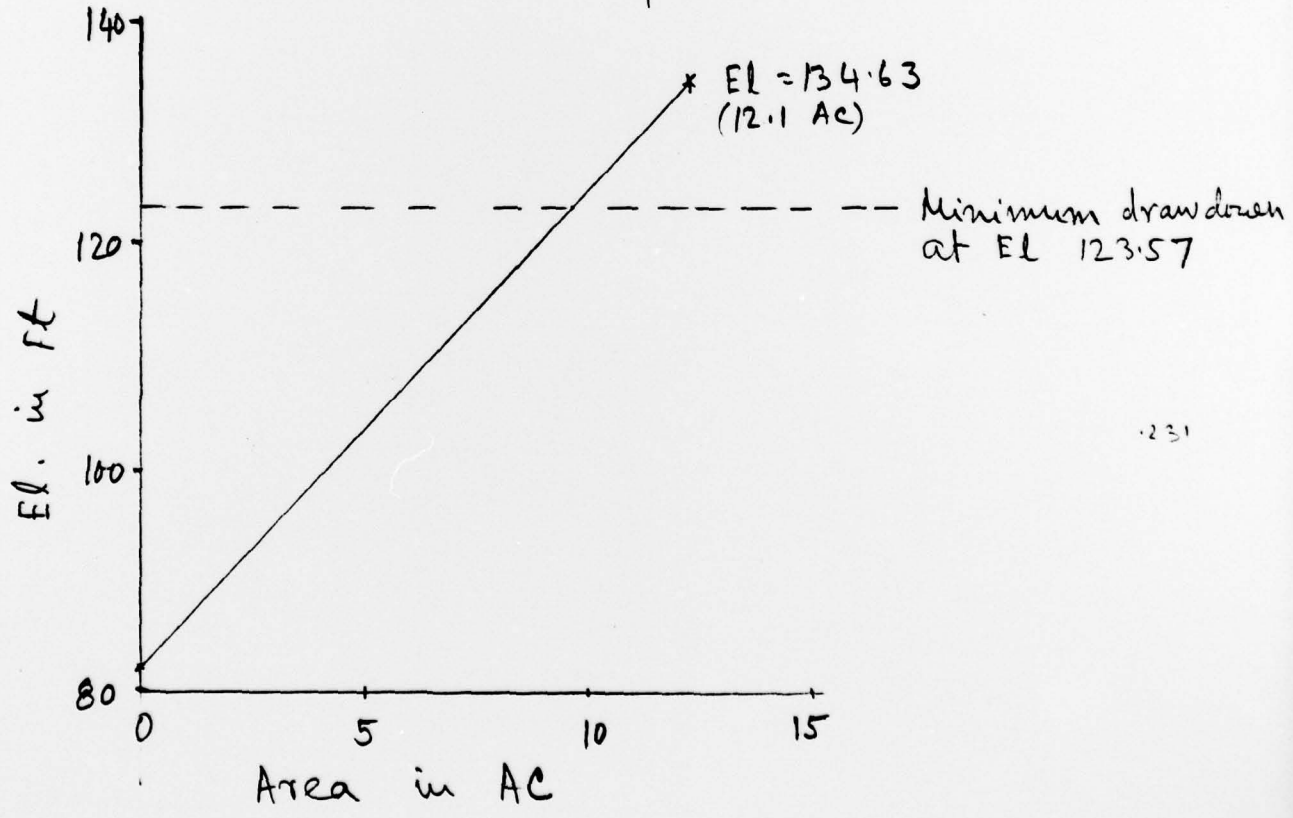
Low level outlet = 24"

Area = $\frac{\pi}{4} \times 2^2 = 3.14$ sq ft

$Q = 13.5\sqrt{h}$ (See page 2)

b) Area Vs. Head.

Assume a straight line relationship from normal water surface to the streambed.



c) Drainage area = 12.5 sq mi
Inflow = 2 cfs / sq mile = 25 cfs.

El.	Area (AC)	Av. Area (AC)	Vol. (AF)	Head on outlet h(Ft)	Outlet Q $13.5\sqrt{h}$ (cfs)	Time to draw = t_1 $\frac{\text{Vol} \times 24}{1.98 \times Q}$ (Hrs)	Time to draw 25 cfs $\frac{25 \times t_1}{Q}$ t_2 (Hrs)	Total time $t_1 + t_2$
134.63	12.1							
		11.87	23.74	10.06	42.8	6.7	3.9	10.6
132.63	11.64							
		11.41	22.82	8.06	38.3	7.2	4.7	11.9
130.63	11.18							
		10.95	21.90	6.06	33.2	8.0	6.0	14.0
128.63	10.72							
		10.49	20.98	4.06	27.2	9.3	8.5	17.8
126.63	10.26							
		10.03	20.06	2.06	19.4	12.5	16.1	28.6
124.63	9.80							
		9.68	10.26	.53	9.8	12.7	32.4	45.1
123.57	9.56							
						56.4		128.0

Time of drawdown with no inflow
= 56.4 hrs = 2 days 8.4 hrs.

Time of drawdown with inflow of 2 cfs/SM
= 128 hrs. = 5 days 8 hrs.

Lake Cushetunk Dam is "significant" hazard potential and therefore no Dam Break Analysis is required.

HEC1-DB

COMPUTER PRINT-OUT

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
    1                 A1       N.J. DAM INSPECTION
    2                 A2       CUSHETUNK LAKE DAM
    3                 A3       MULTIRATIO PMF ROUTING
    4                 B    150       0       30        0        0        0        0        0        0        0
    5                 B1     5
    6                 J      1       5        1
    7                 J1   .5       .4       .3       .2       .1
    8                 K      0    RES.                                      1
    9                 K1       LOCAL INFLOW
   10                 M      1       1     12.5                12.5
   11                 P      0      23      110      120      130      140
   12                 T                                                 1      .10                .02
   13                 W   5.48     .62
   14                 X     -1   -0.05        2
   15                 K      1     DAM                                       1
   16                 K1       ROUTING THROUGH DAM
   17                 Y                                        1        1
   18                 Y1     1                                          -134.6       -1
   19                 Y4 134.6      135      136   136.73      138      139   139.98      140      142      144
   20                 Y4   146      148      150      155      160
   21                 Y5     0       49      323     1080     2227     4201     6546     6599    14602    25515
   22                 Y5 38559    53409    69856   117086   171931
   23                 $A     0     12.1     49.5    266.3
   24                 $E 82.24    134.6      140      160
   25                 $$134.63
   26                 $D139.98
   27                 K      1  REACH1                                       1
   28                 K1       CHANNEL ROUTING MOD. PULS. REACH 1
   29                 Y                                        1        1
   30                 Y1     1
   31                 Y6    .1      .06       .1      120      150     4000    .0077
   32                 Y7     0      160     4400      160     5600      140     6550      120     6650      120
   33                 Y7  7200      140     8000      160     8500      180
   34                 K     99
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT	RES.
ROUTE HYDROGRAPH TO	DAM
ROUTE HYDROGRAPH TO	REACH1
END OF NETWORK	

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

RUN  DATE= 79/09/04.
     TIME= 12.45.12.


                    N.J. DAM INSPECTION
                    CUSHETUNK LAKE DAM
                    MULTIRATIO PMF ROUTING

                              JOB SPECIFICATION
      NO      NHR     NMIN     IDAY     IHR     IMIN    METRC     IPLT     IPRT    NSTAN
     150       0       30        0       0        0        0        0        0        0
                              JOPER     NWT   LROPT   TRACE
                                  5       0       0       0


                          MULTI-PLAN ANALYSES TO BE PERFORMED
                              NPLAN= 1 NRTIO= 5 LRTIO= 1
            RTIOS=    .50     .40     .30     .20     .10

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

                          SUB-AREA RUNOFF COMPUTATION

               LOCAL INFLOW

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

                              HYDROGRAPH DATA
          IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
              1       1   12.50    0.00   12.50    0.00   0.000       0       0       0

                              PRECIP DATA
                SPFE     PMS      R6      R12     R24     R48     R72     R96
                0.00   23.00  110.00  120.00  130.00  140.00    0.00    0.00
THSPC COMPUTED BY THE PROGRAM IS  .808

                              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     .10    0.00     .02

                          UNIT HYDROGRAPH DATA
                    TP=  5.48    CP= .62    NTA=  0

                          RECESSION DATA
                    STRTQ=   -1.00    QRCSN=    -.05    RTIOR= 2.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=12.07 AND R=10.40 INTERVALS

     UNIT HYDROGRAPH 62 END-OF-PERIOD ORDINATES, LAG=  5.50 HOURS, CP=  .62  VOL= 1.00
   25.     93.    189.    301.    423.    551.    676.    782.    861.    913.
  936.    924.    867.    788.    715.    650.    590.    536.    487.    442.
  402.    365.    331.    301.    273.    248.    225.    205.    186.    169.
  153.    139.    127.    115.    104.     95.     86.     78.     71.     65.
   59.     53.     48.     44.     40.     36.     33.     30.     27.     25.
   22.     20.     18.     17.     15.     14.     13.     11.     10.      9.
    9.      8.
```

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	.30	1	.00	.00	.00	12.	1.02	14.00	76	1.23	1.18	.05	1658.
1.01	1.00	2	.00	.00	.00	11.	1.02	14.30	77	1.53	1.48	.05	2126.
1.01	1.30	3	.00	.00	.00	10.	1.02	15.00	78	1.53	1.48	.05	2743.
1.01	2.00	4	.00	.00	.00	10.	1.02	15.30	79	1.86	1.81	.05	3528.
1.01	2.30	5	.00	.00	.00	9.	1.02	16.00	80	5.90	5.85	.05	4584.
1.01	3.00	6	.00	.00	.00	8.	1.02	16.30	81	1.43	1.38	.05	5963.
1.01	3.30	7	.00	.00	.00	8.	1.02	17.00	82	1.43	1.38	.05	7564.
1.01	4.00	8	.00	.00	.00	7.	1.02	17.30	83	1.12	1.07	.05	9290.
1.01	4.30	9	.00	.00	.00	7.	1.02	18.00	84	1.12	1.07	.05	11060.
1.01	5.00	10	.00	.00	.00	7.	1.02	18.30	85	.09	.04	.05	12767.
1.01	5.30	11	.00	.00	.00	6.	1.02	19.00	86	.09	.04	.05	14280.
1.01	6.00	12	.00	.00	.00	6.	1.02	19.30	87	.09	.04	.05	15482.
1.01	6.30	13	.01	.00	.01	6.	1.02	20.00	88	.09	.04	.05	16310.
1.01	7.00	14	.01	.00	.01	6.	1.02	20.30	89	.09	.04	.05	16753.
1.01	7.30	15	.01	.00	.01	5.	1.02	21.00	90	.09	.04	.05	16802.
1.01	8.00	16	.01	.00	.01	5.	1.02	21.30	91	.09	.04	.05	16451.
1.01	8.30	17	.01	.00	.01	5.	1.02	22.00	92	.09	.04	.05	15699.
1.01	9.00	18	.01	.00	.01	5.	1.02	22.30	93	.09	.04	.05	14707.
1.01	9.30	19	.01	.00	.01	5.	1.02	23.00	94	.09	.04	.05	13644.
1.01	10.00	20	.01	.00	.01	5.	1.02	23.30	95	.09	.04	.05	12562.
1.01	10.30	21	.01	.00	.01	5.	1.03	0.00	96	.09	.04	.05	11503.
1.01	11.00	22	.01	.00	.01	5.	1.03	.30	97	0.00	0.00	0.00	10512.
1.01	11.30	23	.01	.00	.01	5.	1.03	1.00	98	0.00	0.00	0.00	9608.
1.01	12.00	24	.01	.00	.01	5.	1.03	1.30	99	0.00	0.00	0.00	8783.
1.01	12.30	25	.08	.00	.08	5.	1.03	2.00	100	0.00	0.00	0.00	8027.
1.01	13.00	26	.08	.00	.08	5.	1.03	2.30	101	0.00	0.00	0.00	7335.
1.01	13.30	27	.09	.00	.09	5.	1.03	3.00	102	0.00	0.00	0.00	6699.
1.01	14.00	28	.09	.00	.09	5.	1.03	3.30	103	0.00	0.00	0.00	6113.
1.01	14.30	29	.12	.00	.12	6.	1.03	4.00	104	0.00	0.00	0.00	5574.
1.01	15.00	30	.12	.00	.12	7.	1.03	4.30	105	0.00	0.00	0.00	5077.
1.01	15.30	31	.14	.00	.14	8.	1.03	5.00	106	0.00	0.00	0.00	4620.
1.01	16.00	32	.45	.34	.11	18.	1.03	5.30	107	0.00	0.00	0.00	4201.
1.01	16.30	33	.11	.06	.05	44.	1.03	6.00	108	0.00	0.00	0.00	3817.
1.01	17.00	34	.11	.06	.05	83.	1.03	6.30	109	0.00	0.00	0.00	3467.
1.01	17.30	35	.09	.04	.05	133.	1.03	7.00	110	0.00	0.00	0.00	3149.
1.01	18.00	36	.09	.04	.05	192.	1.03	7.30	111	0.00	0.00	0.00	2860.
1.01	18.30	37	.01	.00	.01	256.	1.03	8.00	112	0.00	0.00	0.00	2597.
1.01	19.00	38	.01	.00	.01	322.	1.03	8.30	113	0.00	0.00	0.00	2359.
1.01	19.30	39	.01	.00	.01	382.	1.03	9.00	114	0.00	0.00	0.00	2142.
1.01	20.00	40	.01	.00	.01	432.	1.03	9.30	115	0.00	0.00	0.00	1946.
1.01	20.30	41	.01	.00	.01	470.	1.03	10.00	116	0.00	0.00	0.00	1767.
1.01	21.00	42	.01	.00	.01	493.	1.03	10.30	117	0.00	0.00	0.00	1605.
1.01	21.30	43	.01	.00	.01	500.	1.03	11.00	118	0.00	0.00	0.00	1458.
1.01	22.00	44	.01	.00	.01	485.	1.03	11.30	119	0.00	0.00	0.00	1324.
1.01	22.30	45	.01	.00	.01	456.	1.03	12.00	120	0.00	0.00	0.00	1202.
1.01	23.00	46	.01	.00	.01	423.	1.03	12.30	121	0.00	0.00	0.00	1092.
1.01	23.30	47	.01	.00	.01	388.	1.03	13.00	122	0.00	0.00	0.00	992.
1.02	0.00	48	.01	.00	.01	354.	1.03	13.30	123	0.00	0.00	0.00	900.
1.02	.30	49	.06	.01	.05	322.	1.03	14.00	124	0.00	0.00	0.00	824.
1.02	1.00	50	.06	.01	.05	294.	1.03	14.30	125	0.00	0.00	0.00	769.
1.02	1.30	51	.06	.01	.05	270.	1.03	15.00	126	0.00	0.00	0.00	718.
1.02	2.00	52	.06	.01	.05	249.	1.03	15.30	127	0.00	0.00	0.00	669.
1.02	2.30	53	.06	.01	.05	233.	1.03	16.00	128	0.00	0.00	0.00	625.
1.02	3.00	54	.06	.01	.05	220.	1.03	16.30	129	0.00	0.00	0.00	583.
1.02	3.30	55	.06	.01	.05	210.	1.03	17.00	130	0.00	0.00	0.00	544.
1.02	4.00	56	.06	.01	.05	204.	1.03	17.30	131	0.00	0.00	0.00	507.
1.02	4.30	57	.06	.01	.05	200.	1.03	18.00	132	0.00	0.00	0.00	473.
1.02	5.00	58	.06	.01	.05	198.	1.03	18.30	133	0.00	0.00	0.00	442.
1.02	5.30	59	.06	.01	.05	198.	1.03	19.00	134	0.00	0.00	0.00	412.
1.02	6.00	60	.06	.01	.05	198.	1.03	19.30	135	0.00	0.00	0.00	385.
1.02	6.30	61	.15	.11	.05	202.	1.03	20.00	136	0.00	0.00	0.00	359.
1.02	7.00	62	.15	.11	.05	211.	1.03	20.30	137	0.00	0.00	0.00	335.

1.02	7.30	63	.15	.11	.05	230.	1.03	21.00	138	0.00	0.00	0.00	312.
1.02	8.00	64	.15	.11	.05	258.	1.03	21.30	139	0.00	0.00	0.00	291.
1.02	8.30	65	.15	.11	.05	298.	1.03	22.00	140	0.00	0.00	0.00	272.
1.02	9.00	66	.15	.11	.05	350.	1.03	22.30	141	0.00	0.00	0.00	254.
1.02	9.30	67	.15	.11	.05	413.	1.03	23.00	142	0.00	0.00	0.00	237.
1.02	10.00	68	.15	.11	.05	486.	1.03	23.30	143	0.00	0.00	0.00	221.
1.02	10.30	69	.15	.11	.05	567.	1.04	0.00	144	0.00	0.00	0.00	206.
1.02	11.00	70	.15	.11	.05	652.	1.04	.30	145	0.00	0.00	0.00	192.
1.02	11.30	71	.15	.11	.05	739.	1.04	1.00	146	0.00	0.00	0.00	179.
1.02	12.00	72	.15	.11	.05	825.	1.04	1.30	147	0.00	0.00	0.00	167.
1.02	12.30	73	1.02	.97	.05	928.	1.04	2.00	148	0.00	0.00	0.00	156.
1.02	13.00	74	1.02	.97	.05	1082.	1.04	2.30	149	0.00	0.00	0.00	146.
1.02	13.30	75	1.23	1.18	.05	1318.	1.04	3.00	150	0.00	0.00	0.00	136.
									SUM	26.01	22.36	3.65	362106.
										(661.)	(568.)	(93.)	(10253.70)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	16802.	14728.	6983.	2514.	362029.
CMS	476.	417.	198.	71.	10252.
INCHES		10.96	20.79	22.45	22.45
MM		278.40	527.95	570.19	570.27
AC-FT		7303.	13850.	14958.	14960.
THOUS CU M		9008.	17083.	18450.	18453.

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 .50	RATIO 2 .40	RATIO 3 .30	RATIO 4 .20	RATIO 5 .10
HYDROGRAPH AT	RES.	12.50	1	8401.	6721.	5041.	3360.	1680.
		(32.37)		(237.90)(	190.32)(	142.74)(	95.16)(	47.58)(
ROUTED TO	DAM	12.50	1	8404.	6734.	5036.	3357.	1669.
		(32.37)		(237.99)(	190.68)(	142.60)(	95.06)(	47.27)(
ROUTED TO	REACH1	12.50	1	8387.	6703.	5014.	3342.	1666.
		(32.37)		(237.50)(	189.80)(	141.97)(	94.62)(	47.18)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	134.60	134.63	139.98
STORAGE	211.	212.	365.
OUTFLOW	0.	4.	6546.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	140.45	.47	389.	8404.	4.50	45.00	0.00
.40	140.03	.05	368.	6734.	1.50	45.00	0.00
.30	139.35	0.00	336.	5036.	0.00	45.00	0.00
.20	138.57	0.00	304.	3357.	0.00	45.00	0.00
.10	137.38	0.00	266.	1669.	0.00	45.00	0.00

PLAN 1 STATION REACH1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	8387.	125.5	45.00
.40	6703.	125.0	45.00
.30	5014.	124.4	45.00
.20	3342.	123.6	45.00
.10	1666.	122.5	45.50