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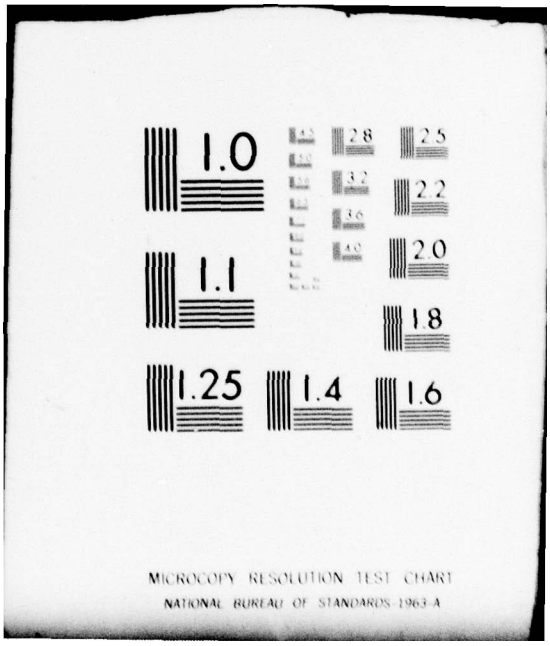
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PASSAIC RIVER BASIN
GREEN POND BROOK, MORRIS COUNTY
NEW JERSEY

LEVEL II

PICATINNY LAKE DAM

NJ 00002

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

(6) Picatinny Lake Dam (NJ-00002).
Passaic River Basin, Green Pond
Brook, Morris County, New Jersey.
Phase 1 Inspection Report.

(10) Anthony G. /Posch

(15) DACW61-79-C-0011 (9) Final rept.,

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

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REPORT DOCUMENTATION PAGE

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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)

Dams	Concrete	Structural Analysis
Spillways	Seepage	
Embankments	Visual Inspection	
Slopes	National Dam Inspction 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 - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

SUBJECT: Dam Inspection Program

Commander
U.S. Army Armanent Research and Development Command
DRDAR - PSE - CF
Dover, New Jersey 07801

27 SEP 1979

1. Inclosed is the Phase I Inspection Report for Picatinny Lake Dam, Picatinny Arsenal, Morris County, New Jersey which has been prepared for the U.S. Army Engineer District, Philadelphia. A brief assessment of the dam's condition is given in the front of the report.

2. Based on visual inspection, available records, calculations and past operational performance, Picatinny Lake Dam, a high hazard potential structure, is judged to be in good overall condition. The dam's spillway is considered inadequate since 7 percent of the Spillway Design Flood--SDF - would overtop the dam. (The SDF, in this instance, is the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination 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. 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 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 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. A complete topographic survey of the dam area should be made within twelve months from the date of approval of this report, in order to develop a detailed plan and several cross-sections of the dam. The location of utilities on the dam should be shown in the drawings, and any benchmarks shown.

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

(1) The embankment material that has been lost by erosion from the downstream face, adjacent to the left wingwall of the spillway, should be replaced with quarry-process stone, and slope protection should be provided to prevent recurrence of the erosion due to use of the area as a footpath.

(2) All embankment slopes which are steeper than 2H:1V should be regraded, by addition of suitable material, to a slope no steeper than 2H:1V.

(3) Investigate the embankment for animal burrows and fill in the burrows with a suitable material. Implement measures to prevent recurrence of burrowing.

(4) Provide concrete underpinning to the right downstream wingwall.

(5) Repair all eroded, cracked and spalled concrete with epoxy cement.

(6) Clean and repaint all the steel-work on the spillway bridge, flashboards and operating mechanisms. Replace missing tie bars on the flashboards, and check the flashboard timbers for rot, replacing as necessary. Replace the missing lifting chain and grease all moving parts of the operating mechanism.

(7) Check the operability of the flashboards.

(8) All brush and trees should be removed from the downstream slope to avoid problems which may develop from their roots. The embankment should then be seeded to develop a growth of grass for surface erosion protection.

(9) Study the need for a low-level discharge pipe. If found necessary, initiate installation within calendar year 1980.

(10) Review the present operational procedures, and develop specific guidelines on gate operation and emergency procedures. The guidelines, to be agreed upon by upstream and downstream users and by all parties concerned, should then be implemented.

(11) Remove the fish screens if no longer needed. Otherwise provide new screens and repair the lifting mechanisms.

(12) A formalized program of annual inspection of the dam should be initiated utilizing the standard visual check list in this report. Headwater and tailwater gages should be 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 and the lake. Movement and settlement of the embankment should be monitored at each visit by means of surveying monuments, and discharge from the drain pipe should be measured, recorded and checked for discoloration.

3. 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.

4. 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 to implement our recommendations.

1 Incl
As stated

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

Copies Furnished (trip)
U.S. Army Armanent Research and Development Command
DRDAR - PSE - E
Dover, New Jersey 07801
Attention: C. Berkowitz

PICATINNY LAKE DAM (NJ00002)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 12 July 1979 by Frederic R. Harris, Inc. for the U.S. Army Engineer District, Philadelphia.

Picatinny Lake Dam, a high hazard potential structure, is judged to be in good overall condition. The dam's spillway is considered inadequate since 7 percent of the Spillway Design Flood--SDF - would overtop the dam. (The SDF, in this instance, is the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination 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. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

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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. A complete topographic survey of the dam area should be made within twelve months from the date of approval of this report, in order to develop a detailed plan and several cross-sections of the dam. The location of utilities on the dam should be shown in the drawings, and any benchmarks shown.

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

(1) The embankment material that has been lost by erosion from the downstream face, adjacent to the left wingwall of the spillway, should be replaced with quarry-process stone, and slope protection should be provided to prevent recurrence of the erosion due to use of the area as a footpath.

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(3) Investigate the embankment for animal burrows and fill in the burrows with a suitable material. Implement measures to prevent recurrence of burrowing.

(4) Provide concrete underpinning to the right downstream wingwall.

(5) Repair all eroded, cracked and spalled concrete with epoxy cement.

(6) Clean and repaint all the steel-work on the spillway bridge, flashboards and operating mechanisms. Replace missing tie bars on the flashboards, and check the flashboard timbers for rot, replacing as necessary. Replace the missing lifting chain and grease all moving parts of the operating mechanism.

(7) Check the operability of the flashboards.

(8) All brush and trees should be removed from the downstream slope to avoid problems which may develop from their roots. The embankment should then be seeded to develop a growth of grass for surface erosion protection.

(9) Study the need for a low-level discharge pipe. If found necessary, initiate installation within calendar year 1980.

(10) Review the present operational procedures, and develop specific guidelines on gate operation and emergency procedures. The guidelines, to be agreed upon by upstream and downstream users and by all parties concerned, should then be implemented.

(11) Remove the fish screens if no longer needed. Otherwise provide new screens and repair the lifting mechanisms.

(12) A formalized program of annual inspection of the dam should be initiated utilizing the standard visual check list in this report. Headwater and tailwater gages should be 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 and the lake. Movement and settlement of the embankment should be monitored at each visit by means of surveying monuments, and discharge from the drain pipe should be measured, recorded and checked for discoloration.

APPROVED: _____

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 26 Apr 79

PHASE I INSPECTION REPORT

Name of Dam: Picatinny Lake, I.D. NJ00002

State Located: New Jersey

County Located: Morris County

Stream: Green Pond Brook

Date of Inspection: July 12, 1979

Assessment of General Condition

Picatinny Lake Dam is an earth-fill embankment, approximately 500 feet long and 15 feet high, having a gated concrete spillway and a concrete bulkhead wall on the upstream face. Picatinny Lake Dam is in good overall condition. There is no sign of distress of the embankment or spillway. The concrete and steel-work in the spillway have undergone minor surface deterioration, and operability of some of the flashboard gates is suspect. There is no low-level outlet. The hazard potential is rated as "high."

The adequacy of Picatinny Lake 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 6% of the PMF, and is assessed as "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 time-table for their completion. All recommended actions should be conducted under the supervision of an engineer who is experienced in the design, construction and inspection of dams.

1. Develop and implement formal operational procedures containing guidelines on gate operation within twelve months.

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

3. Carry out a more precise hydrologic and hydraulic analysis of the dam within six months, to determine the need and type of mitigating measures necessary. Based on the results of these studies, remedial measures should be instituted. This should include the installation of a tailwater gage.

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 twelve months.

5. Carry out remedial measures to the dam structure within twelve months, including replacement of eroded fill; repair of eroded, cracked and spalled concrete with epoxy cement; provision of slope protection behind the left wingwall; filling in of existing animal burrows and prevention of recurrence of burrowing; regrading of the downstream face to slope no steeper than 2H:1V; underpinning of right wingwall with concrete.

6. Clean and repaint all the steel-work on the spillway bridge, flashboards and operating mechanisms. Replace missing tie-bars on the flashboards, and check the flashboard timbers for rot, replacing as necessary. Replace the missing lifting chain and grease all moving parts of the operating mechanism. This work should be completed within twelve months.

7. Check operability of all flashboards within twelve months.

8. Remove trees and vegetation from the downstream embankment face and seed with grass within twelve 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. Consider providing a low-level discharge pipe.

2. Conduct a complete topographic survey of the dam and surrounding area, in order to develop a detailed plan and several cross-sections of the dam. Annotate and update the existing drawings, and form a coherent as-built set.

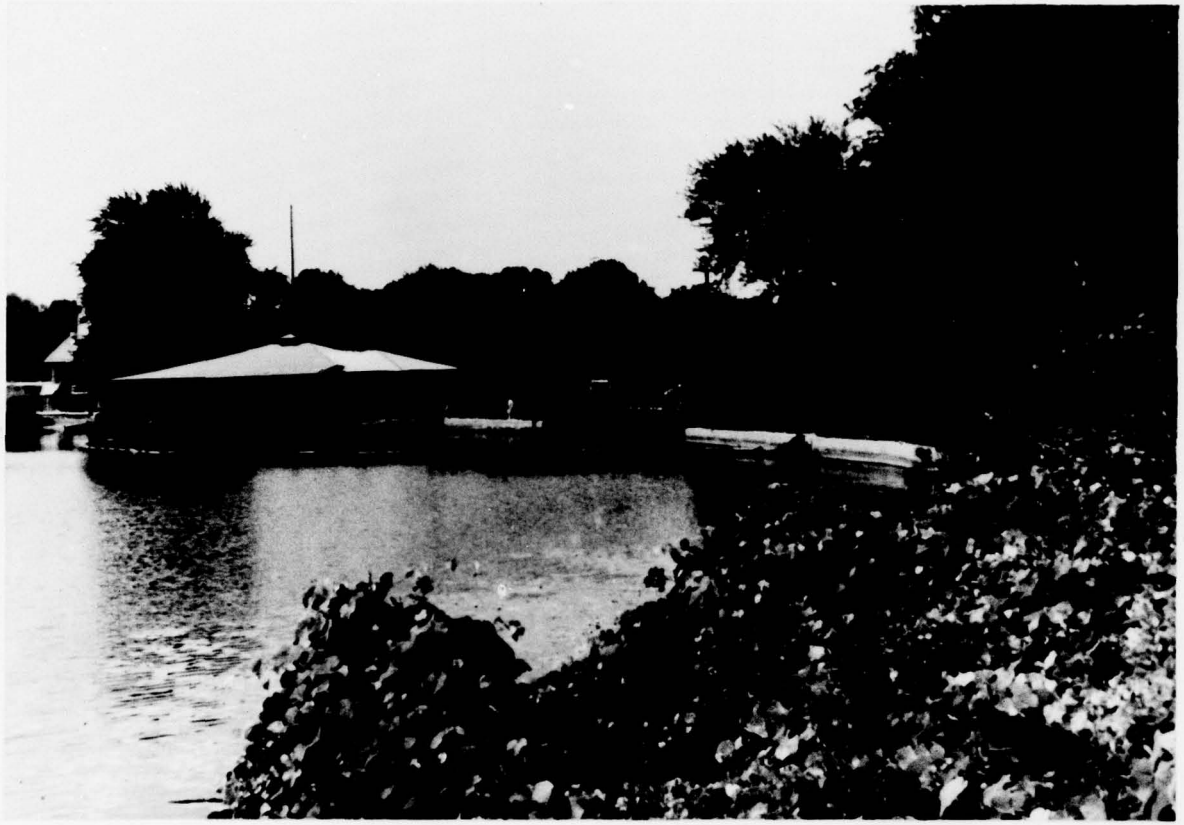
3. A program of annual inspection and maintenance should be initiated. This should include lowering the lake, and updating the operation and maintenance log. Movement of the embankment should also be monitored by means of surveying monuments, and discharge from the drainpipe should be measured, recorded and checked for discoloration.

4. Remove fish screens if no longer needed. Otherwise provide new screens and repair lifting mechanisms.

A. G. Posch

Anthony G. Posch, P.E.

AGP/REJ/ak



Picatinny Lake Dam
Overall view of upstream face of dam from the right.

July 12, 1979

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PLATES

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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

PICATINNY LAKE DAM, I.D. NJ00002

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

This inspection was made under Contract No. DACW61-79-D-0018 with the Philadelphia District of the Corps of Engineers, in accordance with the terms of Work Order No. 2, at the request of the Facilities Engineer for Picatinny Arsenal.

b. Purpose of Inspection

The visual inspection of Picatinny Lake Dam was made on July 12, 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

This 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

Picatinny Lake Dam is an earth-fill embankment, approximately 15 feet high, having a gated concrete spillway towards the right side of the dam. A concrete bulkhead wall, 500 feet long and of indeterminate height, has been constructed along the upstream face, with its top elevation at 713.5 feet NGVD. The spillway is 61 feet long between wingwalls and is trapezoidal in section with an ogee profile on the downstream face. It is subdivided by concrete piers into a central channel and two side channels, and flow is regulated by manually raised flashboards. No discharge facility exists for lowering the reservoir below 708.7' NGVD (lowest spillway crest elevation).

Pedestrian access across the spillway consists of a concrete and steel footbridge, from which the flashboard raising mechanisms are operated. Fish-screens have been provided and these also are raised and lowered manually from the footbridge. A 5-inch diameter insulated steam-line and 4-inch diameter air-line pass over the spillway, and surface-borne oil is prevented from polluting the downstream area by a floating barrage. A stainless steel headwater gage, giving readings to NGVD, is fixed to the bulkhead wall, to the left of the spillway.

The earth embankment of the dam is considered to be made up of glacial till with many boulders, and not founded on or keyed into the underlying Kittatinny Dolostone bedrock. The embankment is rather poorly defined, except near the spillway where the downstream slope is approximately 1.5H:1V. Towards the left end, the embankment broadens into a wide (>100 feet), gently sloping section. On top of the left embankment is the paved approach road and building (337) of the hunting and fishing club.

b. Location

Picatinny Lake Dam is located on the Picatinny Arsenal, Morris County, New Jersey. It is accessible by means of Reilly Road.

c. Size and Hazard Classification

Picatinny Lake Dam has a structural height of 15 feet and a reservoir storage of 294 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 "high" has been assigned to the dam on the basis that overtopping or failure would result in excessive damage to industrial buildings of an important strategic nature. Part of the industrial center of the arsenal is located within the potential flood path, and the possibility exists of the loss of more than a few lives. Within approximately 5 miles downstream, and in the potential damage zone are State Route 15, Interstate 80 and the Town of Dover.

d. Ownership

Picatinny Lake Dam is owned by the Department of the Army.

Enquiries should be addressed to:

U.S. Army Armanent Research and Development Command
DRDAR - PSE - E
Dover, New Jersey 07801
Attention: C. Berkowitz
(201) 328-2462

e. Purpose of Dam

Picatinny Lake Dam impounds water for industrial use. The reservoir provides cooling water to the Power and Steam Generating Plant on the left bank, and supplies the fire hydrant system. It also feeds six 150,000 gallon storage tanks. In addition, the reservoir is used for recreational boating and fishing.

f. Design and Construction History

The earliest records of the dam are from reconstruction drawings dated 1904, which show an existing head-race and gate structure to the left of the present spillway. The drawings indicate an earth embankment with a core-wall, and give details for an unregulated concrete spillway with wingwalls. Elevations are not given, nor is the material of construction for the core. Plans for a new headrace are shown, but details are not available.

A later modification was made to the spillway in 1936 by the Works Progress Administration. The extent of this work included the addition of the two spillway side-channels adjacent to the original spillway section, and an extension to the rear apron.

By 1946, the moveable flashboards and chain gear apparatus had been installed, and the moveable fishscreens were in place. A photograph dated 1946 shows the spillway structure in substantially the same condition as at present, having the footbridge and the insulated steam-pipe across the spillway.

It could not be ascertained when and to what depth the concrete bulkhead wall was constructed, but it appears on a drawing dated 1967.

The spillway was rehabilitated due to its poor surface condition in July, 1968. Seepage from the embankment, above the old headraces, was investigated in 1968. Following the presentation of a report on the investigation, a system for draining the seepages through French drains to a 6-inch diameter drain-pipe was installed. Details of this installation are not available. The masonry wingwall extensions were built at this time. No major construction has been made on the dam since 1968.

g. Normal Operating Procedures

Operation of the dam and reservoir is the responsibility of the Water Systems Tender who is on 24-hour call. The reservoir level is normally controlled by raising the flashboards in the side spillway channels. A minimum water surface elevation of 709' NGVD must be maintained, to supply the Power and Steam Plant cooling intakes. However, it is also required to maintain a flow downstream to provide cooling water for industrial buildings and to feed

suction lines to fire-trucks.

In the event of a forecast of heavy rainfall, the operator will raise the flashboards to draw down the reservoir before the flood.

The operator works by his own judgement, based on many years experience, and operation has thus far proved to be satisfactory. However, no formal procedures exist to prevent, for instance, flooding of the downstream reaches from excessive discharge over the spillway.

1.3 Pertinent Data

a. Drainage Area	10.2 square miles
b. Discharge at Dam Site	
Maximum known flood at dam site:	Never known to have been overtopped.
Spillway capacity at elevation of top of dam (flashboards raised):	1,248 cfs (elev. 713.5' NGVD)
c. Elevation (NGVD)	
Top of dam:	713.5'
Maximum pool design surcharge (SDF stage):	718.7'
Normal pool:	712.4'
Top of flashboard (closed position):	712.4'
Spillway crest (low point):	708.7'
Streambed at centerline of dam:	698.5'
Maximum tailwater:	710' (estimate)
d. Reservoir	
Length of maximum pool:	6,000 ± feet (estimate)
Length of normal pool:	5,500 ± feet (estimate)
e. Storage (Acre-feet)	
Spillway Design Flood Pool:	693
Top of dam:	294
Normal pool:	150
Spillway crest:	59
f. Reservoir Surface (Acres)	
Normal pool:	64

g. Dam

Type:	Earth fill with concrete spillway.
Length:	500 feet
Height:	15 feet
Top width:	Varies (15 feet minimum to in excess of 100 feet)
Side Slopes - Upstream:	Vertical with concrete bulkhead.
- Downstream:	1.5H:1V steepest.
Zoning:	Partially known.
Impervious core:	Not confirmed.
Cutoff:	Not confirmed.
Grout curtain:	None.

h. Diversion and Regulating Tunnel

N/A

i. Spillway

Type:	Gated concrete dropped overflow.
Length of weir:	55.2 feet (effective)
Crest elevation (low point):	708.7' NGVD
Gates:	6 manually raise flashboards.
U/S channel:	Subdivided by 2 bridge piers into 3 channels.
D/S channel:	Green Pond Brook.

j. Regulating Outlets

Low-level Outlet:	None.
Emergency gate:	Flashboards to lower level to 708.7' NGVD minimum.
Controls:	Manually operated chain mechanism.

SECTION 2: ENGINEERING DATA

2.1 Design

Design drawings from 1904 give original plan and cross-sections of the dam and spillway. However, no data on foundation material are shown. The 1968 Embankment Investigation Report gives data on soil borings, permeability and seepage, local contours, a partial construction history, and the relevant extracts from the unpublished 1962 Passaic River Report. A stability analysis was performed in the investigation, but it is not included. Data on the hydraulic adequacy of the spillway are contained in the 1962 Passaic River Report and in a 1969 Hydrology and Hydraulics Study of the dams at Picatinny Lake and Lake Denmark.

2.2 Construction

Data is not available concerning the as-built condition of the dam, and the 1968 survey uncovered no trace of a masonry core. However, the location of the two disused headraces was confirmed and evidence of an impervious blanket was found. Photographs of the spillway after the 1936-42 rebuilding are on file, and the before and after photographs of the 1968 refacing of the spillway are also available. It is not known in detail how the recommended remedial measures were implemented. A drawing dated 1967-71 giving details of proposed repairs to the spillway was available for inspection.

2.3 Operation

Formal operation records are not kept for this dam and reservoir. All operation data was obtained verbally from the Water System Tender and from the Civil Engineer for the Facilities Engineering Division.

2.4 Evaluation

a. Availability

All engineering data quoted were available from the Facilities Engineering Division. Drawings prepared by the WPA in 1936 are referred to in some of the reports, but could not be located.

b. Adequacy

The engineering data available was sufficient to make a preliminary assessment of the stability of the dam. However, it was not adequate to develop accurate existing cross-sections. Details of the concrete bulkhead wall are insufficient. Data concerning the measures taken in 1968 to drain the seepage are not adequate. The 1969 Hydrology and Hydraulics Study examines the effect downstream of a flood with an expected 50-year return period. For a Phase I study this is not adequate, but the report contains some

useful information on the ground floor elevation of important downstream buildings. The 1962 Passaic River Report gives the predicted flow rate for a PMF, but information on the method used to obtain the flow rate is not available.

c. Validity

The validity of the 1904 drawings is questionable, with regard to the as-built spillway and the core. The validity of the dam height given in the data is questionable. The validity of the 1962 and 1969 Hydraulic and Hydrologic Studies could not be assessed because of a lack of back-up information on the methods used, and therefore the results of the studies are not incorporated into this assessment. As a result of the visual inspection and limited measurements taken, the remaining available data was found to be valid.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

The visual inspection of Picatinny Lake Dam revealed that the dam and spillway were in serviceable condition, but that some remedial action followed by a regular program of inspection and repair was required to maintain its serviceability. The reservoir stage was not lowered below the spillway crest for the inspection.

b. Dam

The earth embankments appear to be basically sound. No surface cracking on the embankments or at the toe was noted. The attitude of trees on the downstream face indicated that the slopes were not subject to creep or sloughing. Erosion of the embankments was limited to a worn footpath behind the left wingwall and minor undermining of the masonry section of the right wingwall. The steepest slope found was 1.5H:1V in the sections within approximately 100 feet on each side of the spillway. In this area a heavy growth of trees and brush was found, and a few animal burrows. No appreciable misalignment of the bulkhead wall in the vertical or horizontal plane was found. At the steps near Building 337, some cracking was noted, indicating local settlement due to the construction of the steps. Hairline shrinkage cracks in the gunnite surfacing of the bulkhead wall were found. No seepage was found in any portion of the downstream embankment face. A 6-inch diameter drain-pipe was discharging water into an open drain in front of Building 333 at a rate not exceeding 3 gpm (visual estimate). This pipe is reported to drain seepage water from a french drain over an old headrace. This source could not be confirmed at the inspection. The headwater gage attached to the bulkhead wall was in good condition.

c. Appurtenant Structures

1. Spillway

The spillway was basically in good condition. The gunnite refacing exhibited minor shrinkage cracks, a small hole (2" x 4") in the central portion of the ogee and minor erosion at the waterline. No undermining of the toe was apparent and the new masonry wingwalls were sound, apart from being slightly undermined. Flow was predominently smooth, and was discharging mainly from the side channels. In the central section, flow was concentrated towards the left side, but this was considered to be due to the partially open flashboard and not to any significant horizontal misalignment. No low-level outlet is provided.

2. Bridge, Piers and Services

The steel and concrete foot-bridge over the spillway was found to be structurally sound. Surface rusting of the steel stringers and handrailing was noted. On the bridge piers and abutments, minor spalling of concrete was observed, and the steel protection was rusted surficially. The insulated 5" diameter steam line and the 4" diameter air-line appeared to be adequately supported and to present no hazard to the dam.

3. Gates and Operating Equipment

The timber spillway flashboards exhibited minor signs of rot, but this was difficult to verify. Steel reinforcement of the flashboards was rusted and some tie-rods were missing. The steel gate-guides were rusted and somewhat congested with debris, and appeared to be a tight fit.

The handwheel operating mechanisms were locked, but were reported to be operational. The steelwork was mildly rusted and one chain was detached from a flashboard. Moving parts were short of grease.

4. Fishscreens

The 1/2-inch gauge steel fishscreens on the upstream side of the footbridge are totally deteriorated and unserviceable. Raising and lowering mechanisms appeared operational but were not tested.

d. Reservoir Area

Sedimentation is reported to be negligable. The slopes surrounding the reservoir are steep and heavily wooded, and an access road runs around the rim. A few industrial and storage buildings are located around the reservoir, and some small-boat landing stages were noted on the banks. A railroad and steamline run along the right bank, and on the left bank near the dam are the cooling water outlet and intakes for the Power and Steam Plant. The oil slick barrage appeared to be capable of functioning satisfactorily.

No evidence was found for a potential massive slide into the reservoir, but boulders are known to occasionally fall down from the steep right bank.

e. Downstream Channel

The downstream channel is well defined and has a rocky, horizontal stream bed, approximately 15 feet wide, with 8 to 12 foot high banks. The banks are sloped at 1H:1V, are covered with trees and vegetation and are protected in places with rip-rap. No

seepage was detected in the banks within 200 feet downstream of the spillway. Artificial steps have been formed with loose boulders in the stream bed, but blockage by debris is minimal. A steel road-bridge and a steam pipe cross the stream approximately 350 feet downstream of the spillway. Green Pond Brook flows through the industrial center of the arsenal, and joins the Rockaway River, 5 miles downstream at Dover.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

Operation of the dam and reservoir is the responsibility of the Water Systems Tender who is on 24-hour call. The reservoir level is normally controlled by raising the flashboards in the side spillway channels. A minimum water surface elevation of 709' NGVD must be maintained, to supply the Power and Steam Plant cooling intakes. However, it is also required to maintain a flow downstream to provide cooling water for industrial buildings and to feed suction lines to fire-trucks.

In the event of a forecast of heavy rainfall, the operator will raise the flashboards to draw down the reservoir before the flood.

The operator works by his own judgement, based on many years experience. However, no formal procedures exist to prevent, for instance, flooding of the downstream reaches from excessive discharge over the spillway.

4.2 Maintenance of the Dam

The dam is maintained on an irregular schedule, as and when the need for repairs becomes pressing. There is no regular program of inspection and maintenance. Maintenance of the dam is under the jurisdiction of the Facilities Engineering Division of Picatinny Arsenal.

4.3 Maintenance of Operating Facilities

The operating facilities consist of the flashboards and their lifting mechanisms, and the fishscreens. These facilities are under the day-to-day supervision of the Water Systems Tender, and sufficient maintenance has been carried out to insure the operability of at least two flashboards. All the facilities exhibit signs of a lack of regular maintenance.

4.4 Evaluation

The operational procedures for Picatinny Lake Dam have so far proved satisfactory, but the lack of formally approved procedures relating reservoir stage, rainfall etc. to the number of gates to be raised is not considered conducive to satisfactory future operation.

The maintenance procedures for the dam and operating facilities are considered to be inadequate, because there is no regular program of inspection and maintenance.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

The drainage area above Picatinny Lake Dam is a total of 10.2 square miles, comprising a drainage area of 4.5 square miles above Lake Denmark Dam upstream, an additional drainage area of 4.5 square miles above the confluence of Green Pond Brook with Burnt Meadow Brook, and a local drainage area of 1.2 square miles between Picatinny Lake Dam and the confluence. A drainage map of the watershed of the dam site is presented in Appendix D.

The topography within the basin is steeply to moderately sloped. Elevations range from approximately 1,260 feet NGVD at the north-east end of the watershed to about 715 feet at the dam. Land use patterns within the watershed are mostly forest, with light industrial development. The hydraulic and hydrologic studies of 1962 and 1969 were not used as a basis for this study. The evaluation of the hydraulic and hydrologic features of the lake was based on criteria set forth in the Corps Guidelines and additional guidance provided by the Philadelphia District, Corps of Engineers. The SDF for the dam falls in a range of 1/2 PMF to PMF. In this case the high end of the range, PMF, is chosen since the factors used to select hazard classification are on the high side of the range.

The probable maximum flood (PMF) was calculated from the probable maximum precipitation using Hydrometeorological Report No. 33 with standard reduction factors. Due to the presence of Lake Denmark Dam and Green Pond upstream, the following method was used to develop the inflow hydrograph for Picatinny Lake Dam. The SCS triangular unit hydrograph with the curvilinear transformation was used to develop the inflow hydrograph for Lake Denmark Dam, and for Green Pond Brook (neglecting the reservoir of Green Pond) up to its confluence with Burnt Meadow Brook. The Lake Denmark hydrograph was routed to the confluence, at which point both hydrographs were combined. The hydrograph thus obtained was routed downstream to Picatinny lake, taking two intermediate sections and considering channel storage, and combined with the local inflow hydrograph for Picatinny Lake Dam. The HEC1-DB Flood Hydrograph Computer Program was used.

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

The SDF peak outflow calculated for Picatinny Lake Dam is 22,562 cfs

This value is derived from the 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 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 planimeter 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.

A breach analysis indicated that the hazard potential for loss of life downstream, due to dam failure from overtopping, is not significantly greater than that which exists without failure. At a lower flow (say 10% of the PMF), there will be a rise of 2.4 feet in water surface elevation at the downstream reach due to dam failure, but this does not significantly increase hazard to life.

A drawdown computation was made to determine the time required to lower the reservoir from 712.4' NGVD to the lowest drawdown elevation, 708.7', with all flashboards open. Assuming a constant inflow of 2 cfs/square mile, the time to lower the reservoir is 25 hours, and this is considered to be adequate. Provision of a low-level outlet to empty the reservoir should be considered, but the following points should be noted: only 59 acre-feet of storage exists below elevation 708.7'; there is a risk of inadvertantly allowing the reservoir stage to fall below the elevation of the cooling intakes to the Power Plant. Drainage of the reservoir, if required, could be achieved by syphon.

b. Experience Data

The greatest known flood to have occurred at this site was in October, 1903, before the existing dam was constructed. No records of reservoir stage or spillway discharge are maintained but it is known that the dam has not been overtopped in its present form.

c. Visual Observation

Industrial development below the dam is extensive. Immediately below the dam is Building 333 and its attendant 2,400 volt electrical sub-station. Overhead electric cable pylons are located on the stream banks, with their bases below the maximum predicted stage. Further downstream are administrative and industrial buildings of the arsenal, and these are of an important strategic nature.

By inspection, the most likely location of breach in the event of overtopping is at the narrowest cross-section, adjacent to the spillway.

d. Overtopping Potential

A storm of magnitude equivalent to the SDF would cause overtopping of the dam to a height of 5.2 feet. Computations indicate that the spillway can pass approximately 6% of the PMF without overtopping the dam crest. Since the PMF is the Spillway Design Flood (SDF) for this dam, and since the hazard potential for loss of life downstream due to dam failure caused by overtopping is not significantly greater than that which exists without failure, the spillway capacity for Picatinny Lake Dam is assessed as "inadequate."

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There are no signs of distress in either the earth embankments or the spillway of Picatinny Lake Dam. Horizontal and vertical alignments are good. The slope on the downstream face of 1.5H:1V is considered excessively steep, but no sign of sloughing was noted. No uncontrolled seepage was found in any part of the dam or downstream channel. The controlled drainage from above the old headraces was clear of silt, and has functioned well for 10 years. Undermining of the downstream portion of the right wingwall poses no immediate threat to stability but should be corrected in the near future. The large trees observed growing near the spillway could pose a threat to stability.

b. Design and Construction Data

Available design and construction data were adequate to make a preliminary assessment of the stability of the dam. Based upon a review of the embankment investigation report of 1968, it is unlikely that the earth fill dam or concrete spillway is founded on or keyed to bedrock. The investigation indicates that the predominant foundation material is a compact gravelly, sandy glacial till of generally medium permeability. This same material was likely used in construction of the dam itself.

c. Operating Records

No operating records are available relating to the stability of the dam. The dam has served satisfactorily since its raising at the turn of the century.

d. Post-Construction Changes

A detailed history of the dam is given in Section 1.2.f. The principal changes relating to the stability of the dam are: lengthening of the spillway and provision of flashboards between 1936 and 1942: construction of the concrete bulkhead at an unknown date: measures taken in 1968 to reduce the harmful effects of seepage: construction in 1968 of downstream spillway wingwalls.

e. Static Stability

A static stability analysis of the spillway was made in the 1968 embankment investigation. For a reservoir stage of 713.5' NGVD (top of dam), the factors of safety against overturning and sliding were 1.31 and 1.38 respectively. These are both below the accepted minimum of 1.5, but in view of past performance and present condition, they are considered adequate.

Based on a review of available data and on the findings of the visual inspection, the preliminary assessment of the static stability of the embankment is that it is satisfactory. However, this can only be confirmed by detailed analysis, based on additional information on constituent soil parameters, foundation conditions and embankment cross-sections.

f. Seismic Stability

A major fault passes several hundred feet west of the dam, along the base of Green Pond Mountain. This is a very ancient fault and considered to be completely inactive.

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. Since static stability safety factors are considered to be adequate, seismic stability may be assumed to be satisfactory. A geologic map is presented in 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 adequacy of Picatinny Lake Dam is in question because the dam does not have adequate spillway capacity to pass the PMF without overtopping. Overtopping of the dam carries with it the danger of possible progressive failure of the dam or spillway. The dam's present spillway capacity can pass only about 6% of the PMF.

No definitive statement pertaining to the safety of the embankment can be made without acquisition of embankment and foundation material engineering properties and determination of phreatic levels in the downstream part of the embankment. The present embankment, however, has performed adequately since its construction, without failure or evidence of instability.

b. Adequacy of Information

The information and data uncovered is adequate to perform an approximate evaluation of the dam's stability. However, it is not adequate to develop accurate embankment cross-sections, or engineering parameters of the embankment soil and foundation to perform a rigorous analysis. The following information is also deficient: details of the concrete bulkhead, hydrologic information, 1968 remedial measures taken to control the seepage problem.

c. Urgency of Studies

All recommended studies should be conducted under the supervision of an Engineer who is experienced in the design, construction and inspection of dams.

A more precise hydrologic and hydraulic analysis of the dam should be conducted within six months, to determine the need and type of mitigating measures necessary. This should include the installation of a tailwater gage, and determination of the ability of the dam to withstand overtopping.

Observation wells or piezometers should be installed in boreholes in the downstream slope of the embankment to obtain soil samples and 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. Stability analyses should then be performed in accordance with Chapter 4.4 of the Corps Guidelines. This work should be commenced within 12 months.

A complete topographic survey of the dam area should be made within 12 months, in order to develop a detailed plan and several cross-sections of the dam. The location of utilities on the dam should be shown in the drawings, and any benchmarks shown.

7.2 Remedial Measures

a. Alternatives for Increasing Spillway Capacity

Alternatives for increasing spillway capacity are as follows:

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

2. Lower the weir crest elevation.

3. Widen the weir structure.

4. A combination of any of the above alternatives.

b. Other Remedial Measures, to be undertaken within 12 months.

1. The embankment material that has been lost by erosion from the downstream face, adjacent to the left wingwall of the spillway, should be replaced with quarry-process stone, and slope protection should be provided to prevent recurrence of the erosion due to use of the area as a footpath.

2. All embankment slopes which are steeper than 2H:1V should be regraded, by addition of suitable material, to a slope no steeper than 2H:1V.

3. Investigate embankment for animal burrows and fill in the burrows with a suitable material. Implement measures to prevent recurrence of burrowing.

4. Provide concrete underpinning to the right downstream wingwall.

5. Repair all eroded, cracked and spalled concrete with epoxy cement.

6. Clean and repaint all the steel-work on the spillway bridge, flashboards and operating mechanisms. Replace missing tie-

bars on the flashboards, and check the flashboard timbers for rot, replacing as necessary. Replace the missing lifting chain and grease all moving parts of the operating mechanism.

7. Check operability of flashboards.

8. All brush and trees should be removed from the downstream slope to avoid problems which may develop from their roots. The embankment should then be seeded to develop a growth of grass for surface erosion protection.

c. Recommendations

The following additional action is recommended.

1. Consider providing a low-level discharge pipe.

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

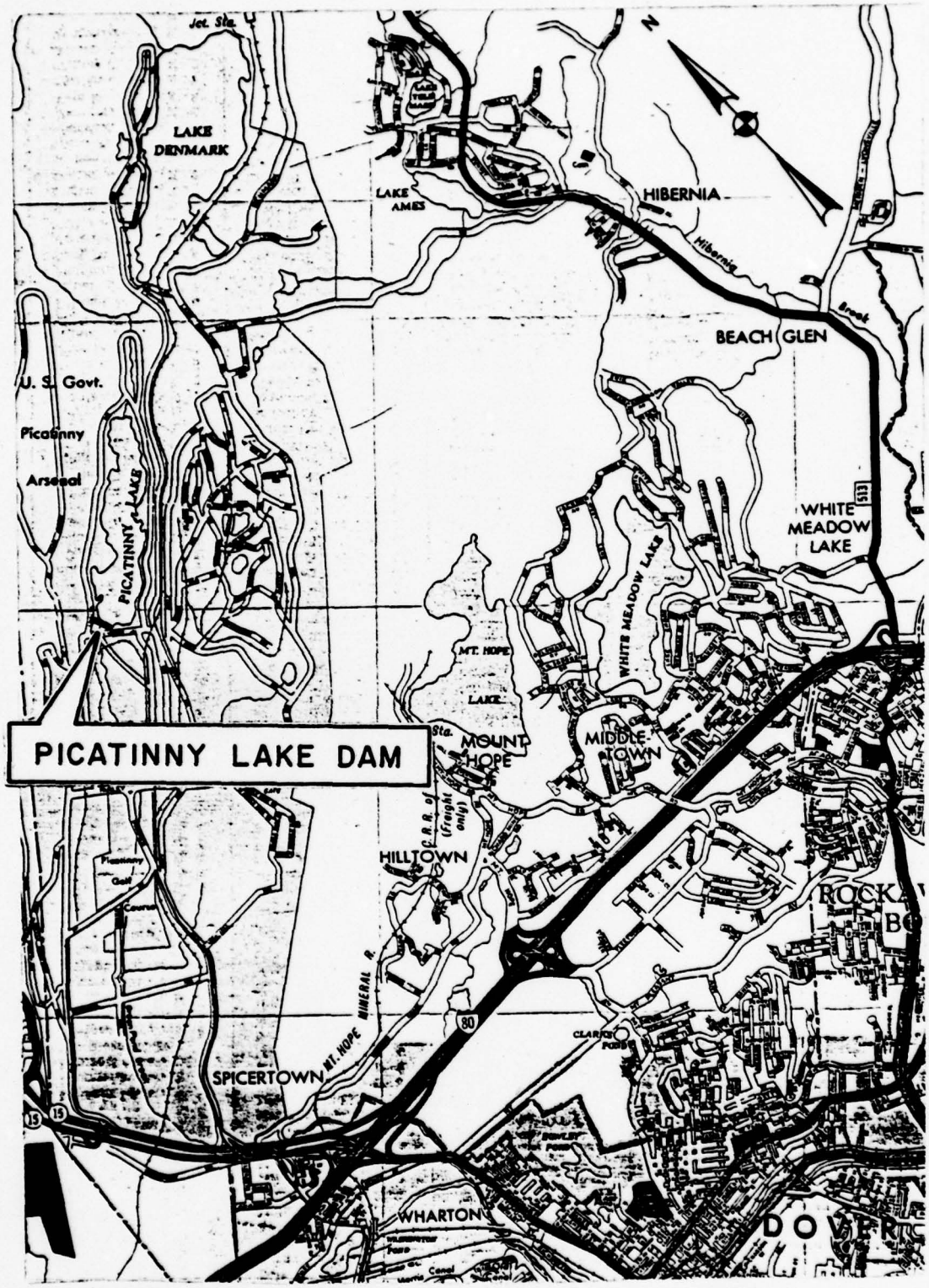
3. Review the present operational procedures, and develop specific guidelines on gate operation and emergency procedures. The guidelines, to be agreed upon by upstream and downstream users and by all parties concerned, should be implemented within 12 months.

4. Remove the fish screens if no longer needed. Otherwise provide new screens and repair lifting mechanisms.

d. O & M Procedures

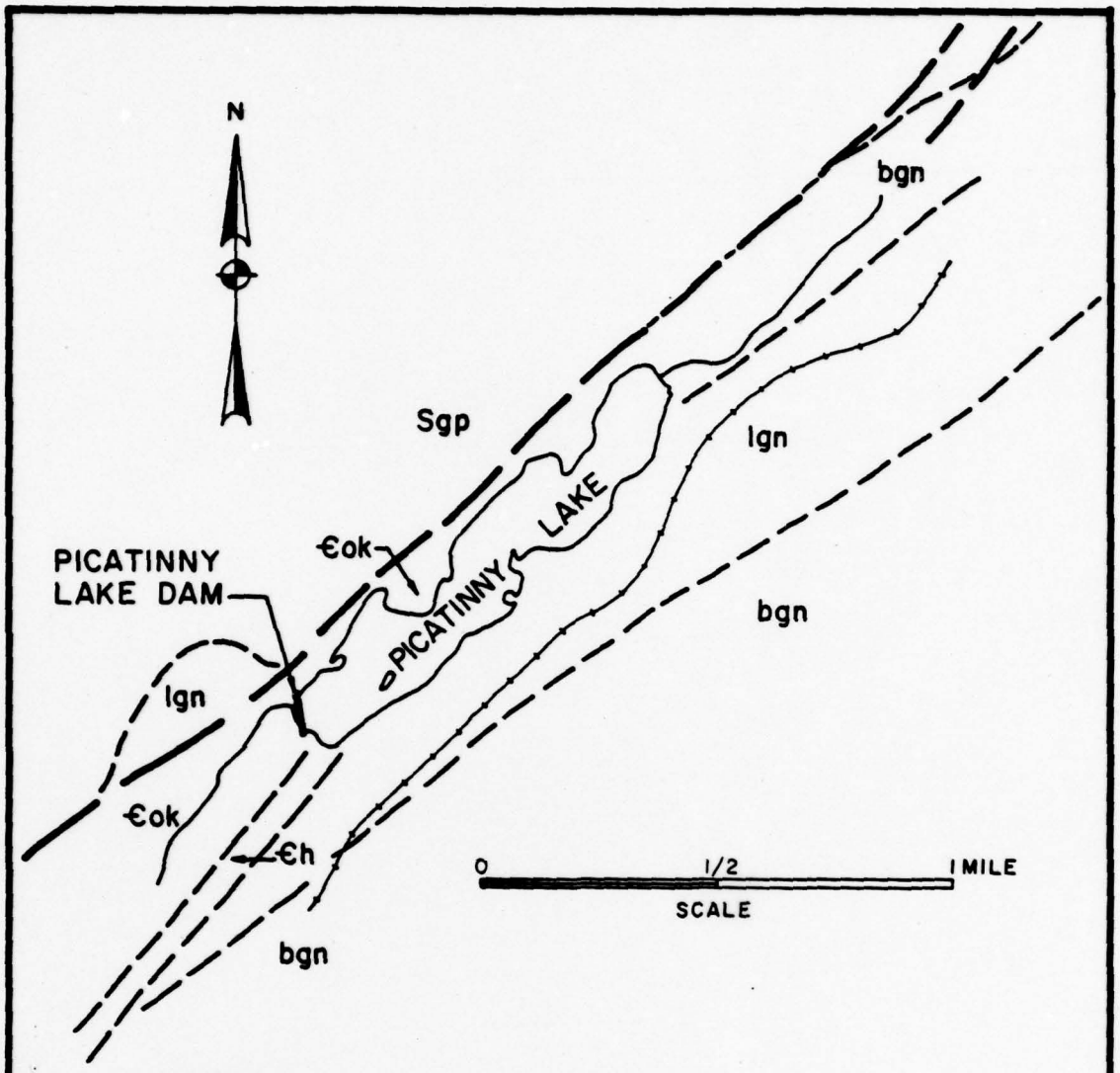
A formalized program of annual inspection of the dam by an Engineer experienced in the design and inspection of dams should be initiated, utilizing the standard visual check list in this report. Headwater and tailwater gages should be read out during severe rain storms and at routine operating and maintenance visits to the dam. A permanent log should be kept of all maintenance and operating events of the dam and the lake. Movement and settlement of the embankment should be monitored at each visit by means of surveying monuments, and discharge from the drainpipe should be measured, recorded and checked for discoloration.

PLATES



VICINITY MAP

PLATE 1

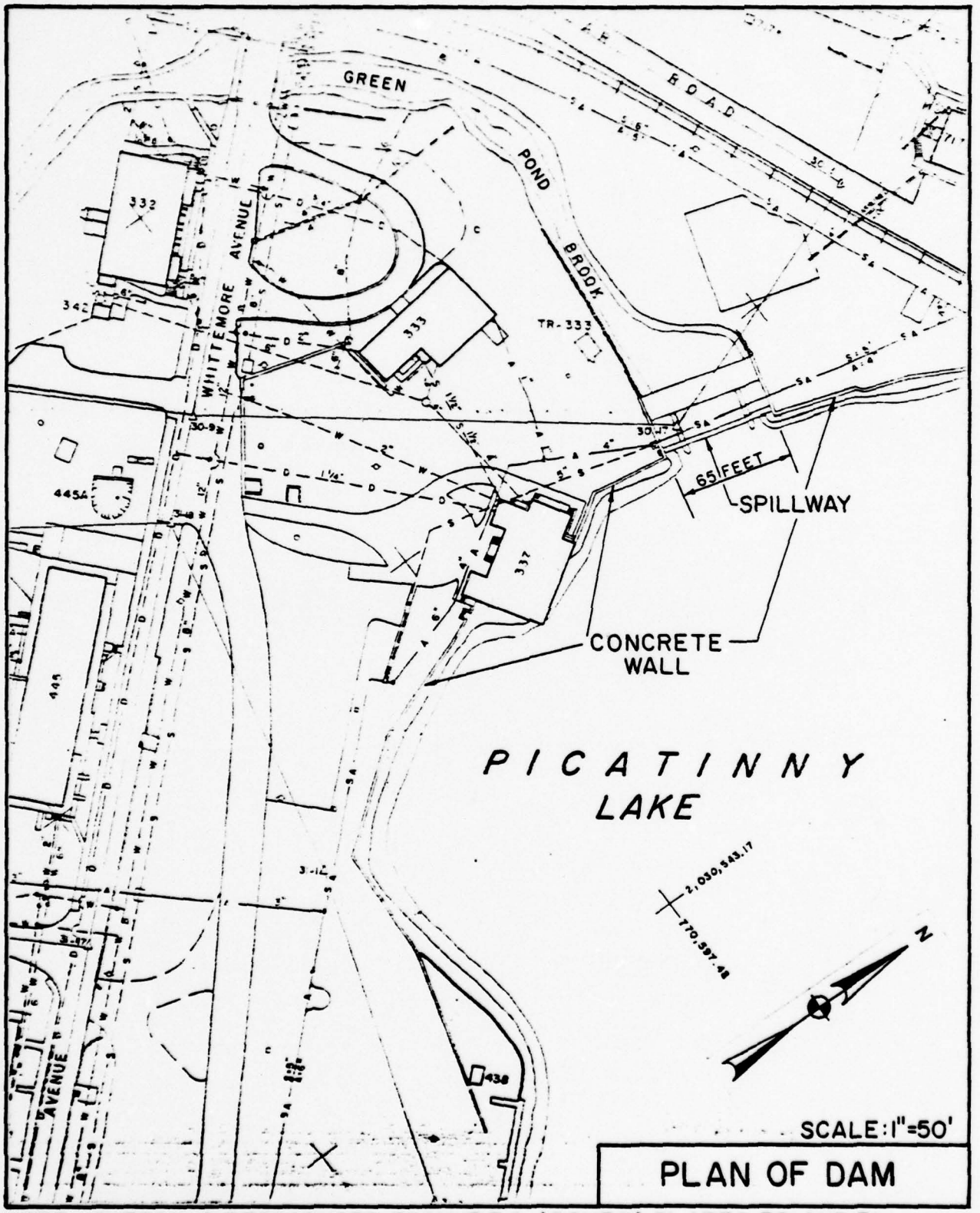


LEGEND

———	FAULT (HIGH ANGLE)
— — —	APPROX. CONTACT BETWEEN BEDROCK UNITS
Sgp	GREENPOND CONGLOMERATE
€ok	KITTATINNY DOLOSTONE
€h	HARDYSTONE QUARTZITE
bgn	BYRAM GNEISS
lgn	LOSEE GNEISS
pgn	POCHUNK GNEISS

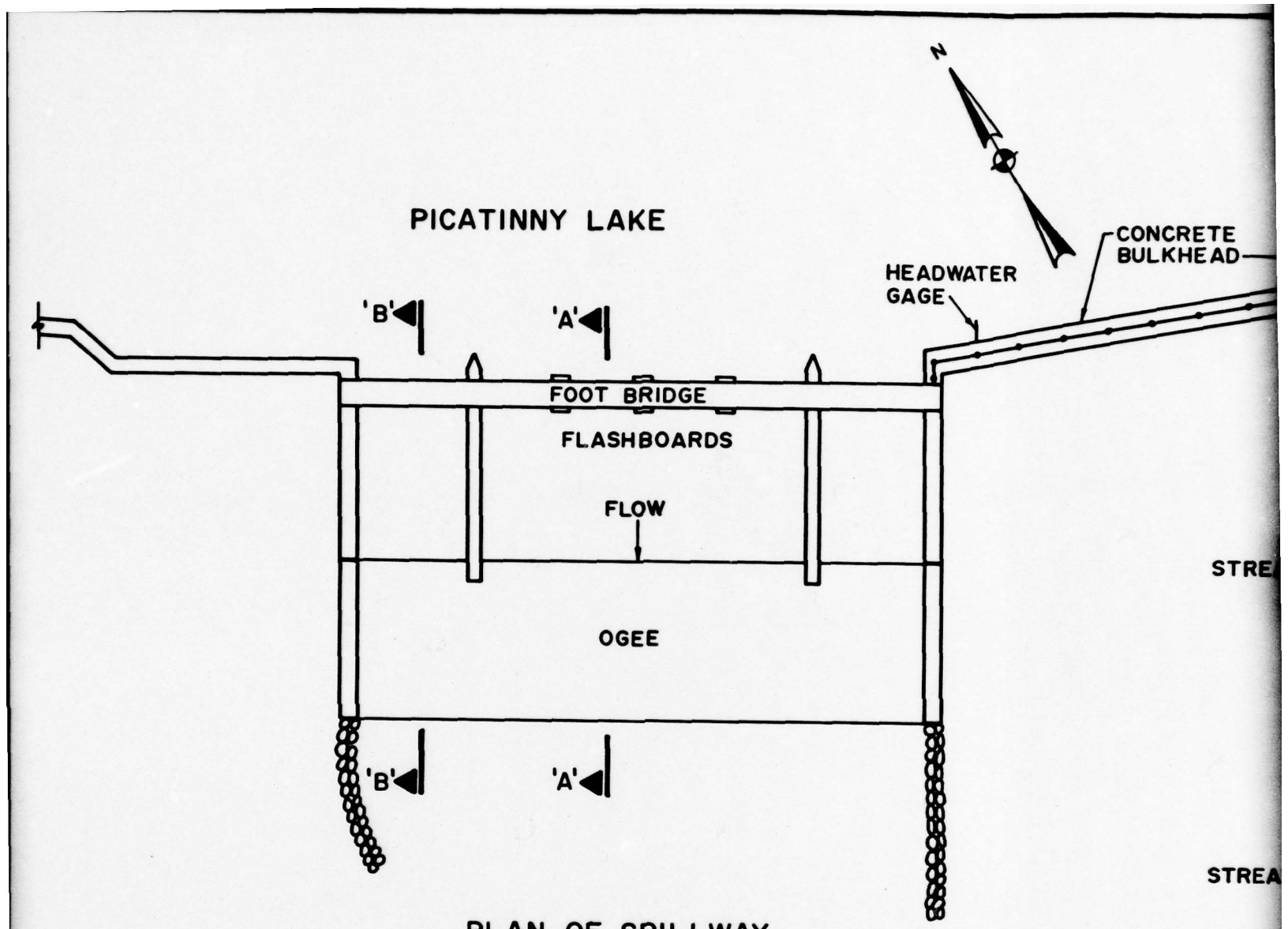
GEOLOGIC MAP
PICATINNY LAKE DAM

PLATE 2

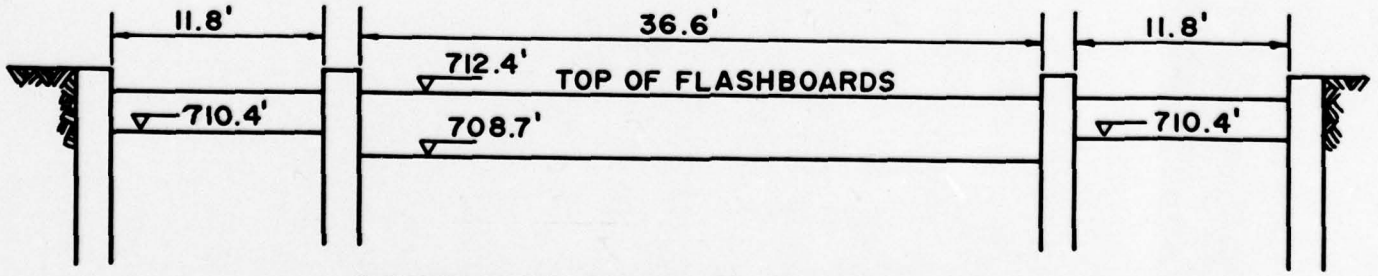


NOTE: SKETCH IS REPRODUCED FROM F.E.D. (DOVER) PLATES 30 AND 31 WITH ADDENDA.

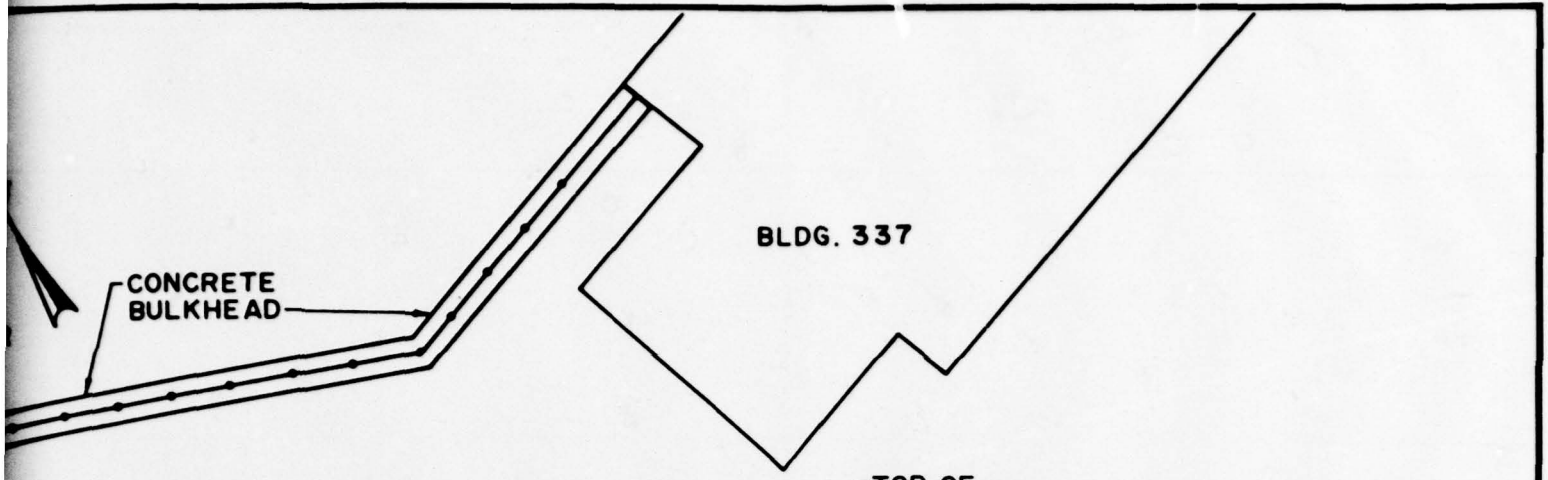
PLATE 3

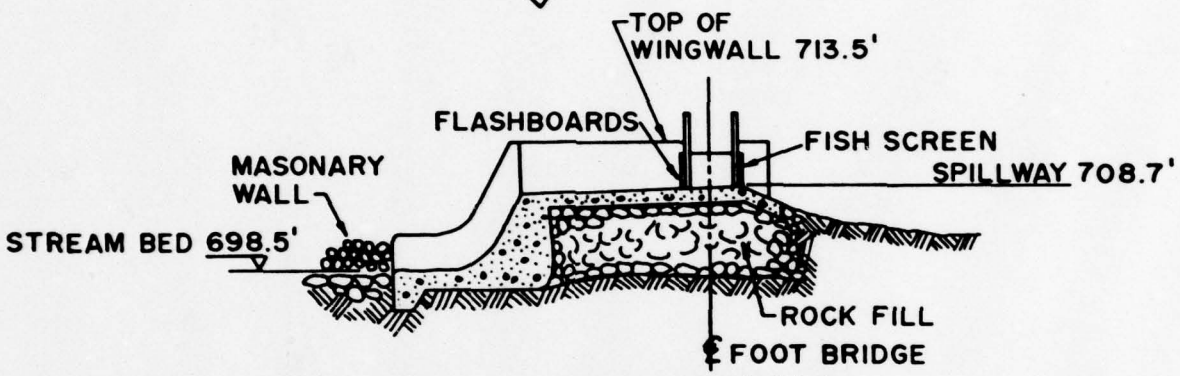


PLAN OF SPILLWAY
SCALE: 1/16"=1'-0"

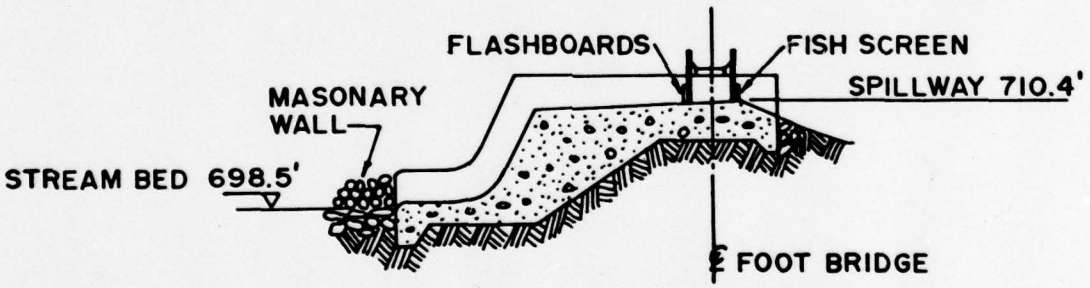


SCHEMATIC PROFILE OF SPILLWAY
NOT TO SCALE

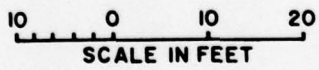




SECTION 'A'-'A'

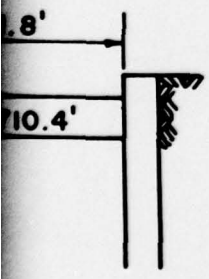


SECTION 'B'-'B'



NOTE: CROSS SECTIONAL VIEWS ARE TAKEN FROM FIG. 49 OF THE PASSAIC RIVER REPORT. DATED JUNE 1962 (UNPUBLISHED).

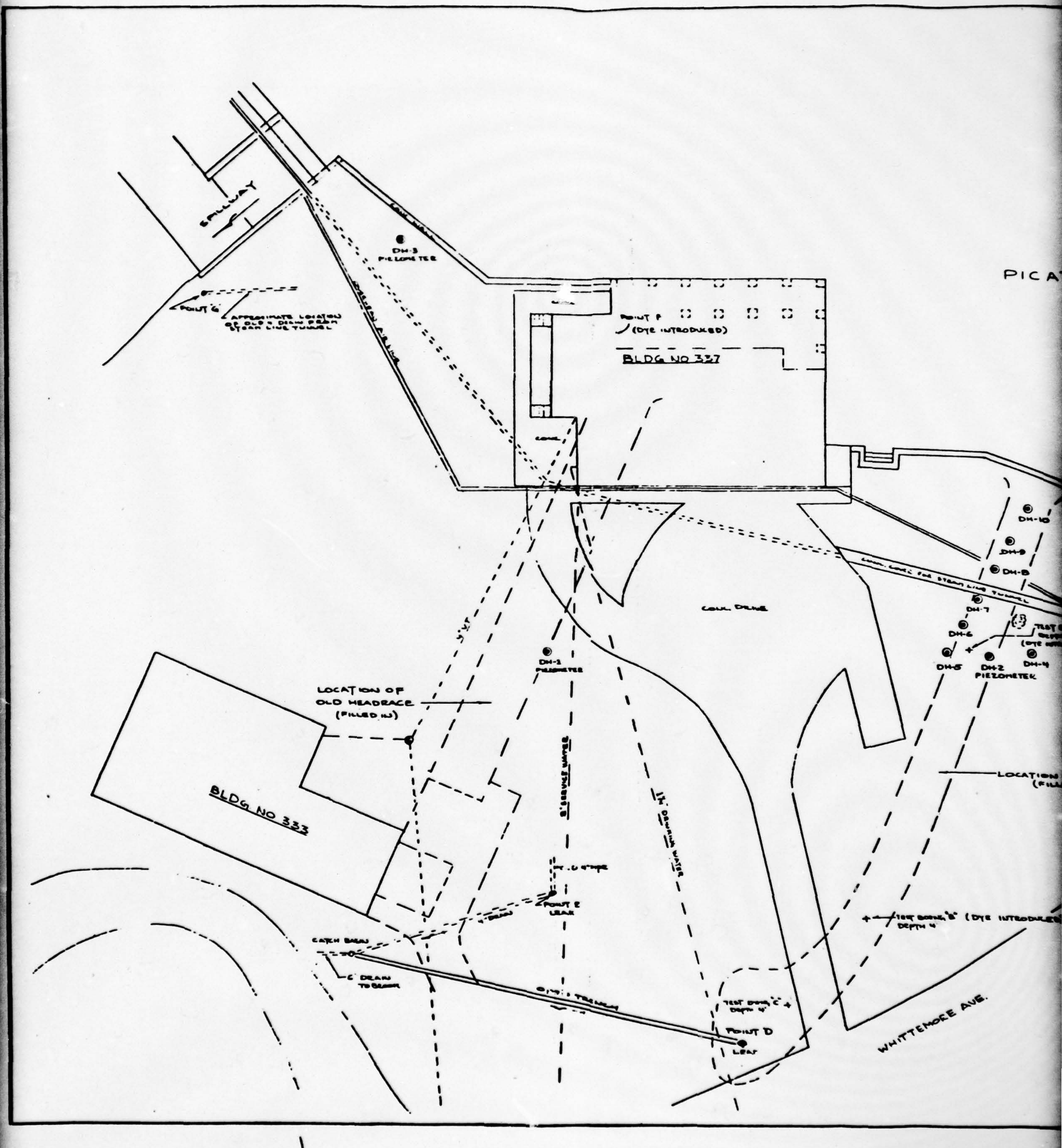
2



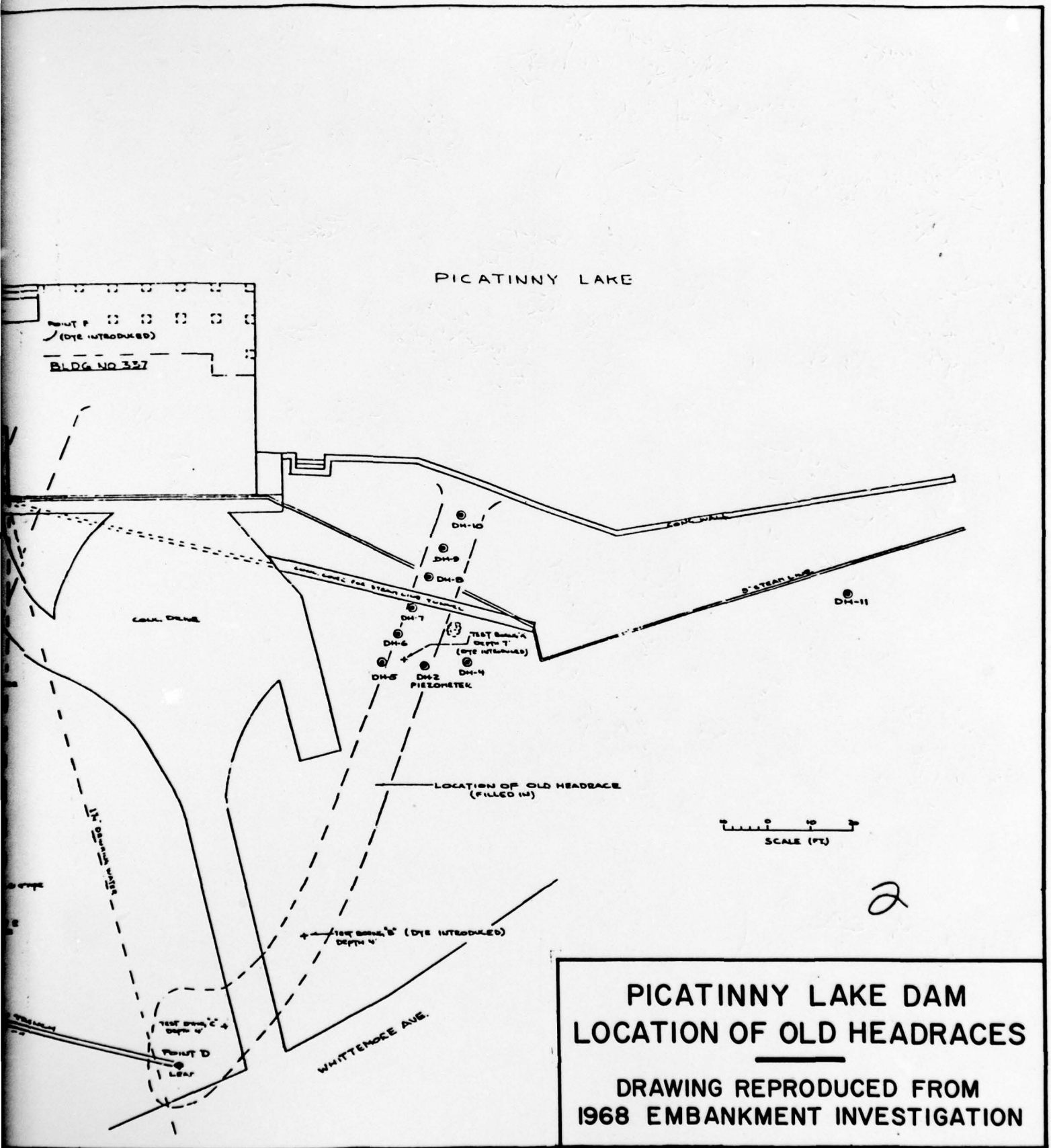
PICATINNY LAKE DAM
SPILLWAY DETAILS

SKETCH MADE UP FROM AVAILABLE ENGINEERING DATA. AUGUST 1979.

PLATE 4



SPILLWAY
DH-3
PIEZOMETER
POINT 'G'
APPROXIMATE LOCATION OF OLD 6" DRAIN FROM STEAM LINE TUNNEL
POINT F
(DYE INTRODUCED)
BLDG NO 337
PICA
COAL DRIVE
DH-10
DH-9
DH-8
DH-7
DH-6
DH-5
DH-2
PIEZOMETER
DH-4
DH-1
PIEZOMETER
LOCATION OF
OLD HEADRACE
(FILLED IN)
BLDG NO 333
POINT E
LEAK
CATCH BASIN
6" DRAIN TO BROOK
TEST BORING "C"
DEPTH 4'
POINT D
LEAK
TEST BORING "B" (DYE INTRODUCED)
DEPTH 4'
WHITTEMORE AVE.



PICATINNY LAKE DAM
LOCATION OF OLD HEADRACES

DRAWING REPRODUCED FROM
1968 EMBANKMENT INVESTIGATION

PLATE 5

APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

CHECK LIST - ENGINEERING, CONSTRUCTION, MAINTENANCE DATA

CHECK LIST
VISUAL INSPECTION

PHASE I

Name of Dam Picatinny Lake County Morris State New Jersey Coordinators C.O.E.

Date(s) Inspection July 12, 1979 Weather Sunny Temperature 70°

Pool elevation at Time of Inspection 711.5' M.S.L. Tailwater at time of Inspection 699.4' M.S.L.

Inspection Personnel:

C. Chin
R. Ernest-Jones
R. Fickies
W. Flynn
H. King

Owner/Representative:

C. Berkowitz, Civil Engineer
(Facilities Engineering Division)

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SURFACE CRACKS	No surface cracks noted. Both embankments were examined over the full length of the concrete bulkhead.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None noted. Embankments and the downstream channel were examined to approximately 200 feet downstream from the spillway.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	No significant erosion noted. A few animal burrows were found in the downstream face, behind Building 333. The attitude of trees on the downstream face indicates that the slope is stable. Steepest slope found was 1.5H:1V.	Measures should be taken to prevent animals from burrowing in the dam. Investigate and fill in existing burrows.
VERTICAL & HORIZONTAL ALIGNMENT OF THE CREST	Good. The levels taken during the survey accord with previous surveys, and a visual inspection revealed good horizontal and vertical alignment. Some cracking of the bulkhead wall near the steps by Building 337 indicated localized settlement.	Monitor alignment at routine O & M inspections. Local settlement near Building 337 is not detrimental to stability.
RIPRAP FAILURES	None. Rip-rap protection of the channel banks was substantially intact.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
VEGETATION	A heavy growth of trees and brush was found on the downstream embankment face within approximately 100 feet on each side of the spillway.	Remove all trees and seed with grass.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No obvious signs of distress. Erosion in the area behind the left wingwall has been caused, due to its use as a footpath. Undermining of the downstream portion of the right wingwall has occurred.	Provide surface protection behind the left wingwall. Underpin the right wingwall with concrete.
ANY NOTICEABLE SEEPAGE	No seepage was found in any portion of the downstream embankment face or channel banks.	
STAFF GAGE AND RECORDER	A headwater gage attached to the bulkhead wall to the left of the spillway has been installed to give water levels to NGVD. The gage was in good condition.	
DRAINS	1. A drain pipe, installed to drain water from the French drain over the old headrace, was discharging into an open drain in front of Building 333, at a rate of less than 3gpm (visual estimate). 2. Weepholes in the downstream wingwalls were unblocked, but not seeping water.	Monitor discharge from drain for flow rate and sediment content to check for possible commencement of piping.

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CONCRETE WEIR		
	Weir is of trapezoid cross-section with an ogee on the downstream face and flow is predominently smooth. The concrete surfacing is in good condition, exhibiting minor surface cracks, one small hole in the central spillway face and minor erosion at the waterline.	Repair the deteriorated areas of concrete with epoxy mortar.
APPROACH CHANNEL		
	Subdivided into three channels by two piers. Flow passes through deteriorated fish screens. A floating oil barrier has been provided. Surface deterioration of bridge pier protection.	Clean and repaint the pier protection. Replace fish screens if required for conservation. Not needed for trash retention.
DISCHARGE CHANNEL		
	Discharge channel constricts rapidly to the left after the spillway. No undermining of the spillway toe was noted.	
BRIDGE AND PIERS		
	Steel and concrete foot-bridge over spillway is in satisfactory condition. Light corrosion present on all steel members. Concrete piers have undergone minor erosion and spalling at water line.	Repair the deteriorated concrete with epoxy mortar. Clean and repaint steel members.
GATES & OPERATION EQUIPMENT		
	The spillway gates consist of six timber flashboards, capable of being raised vertically in guides by chain and handwheel mechanisms, operated from the footbridge. Handwheel mechanisms are satisfactory and one chain is detached from a flashboard. The steel reinforcement of the gates is rusty and some tie rods are missing. Gate guides appear to be a tight fit due to corrosion. The timber appeared rotten in places.	Clean and repaint all steel work on the gates, guides and operating mechanisms. Grease the handwheels. Replace missing tie-rods and chain link. Check the timber for rot, and repair as necessary. Check operation.

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CRACKING & SPALLING OF CONCRETE SURFACES IN STILLING BASIN	None noted.	
INTAKE STRUCTURE	N/A	
OUTLET STRUCTURE	N/A	
OUTLET FACILITIES	N/A	Provide low-level outlet.
EMERGENCY GATE	Flashboards in central spillway channel are all reported to be operable, capable of lowering the lake to 708.7' MSL. No other emergency gate is installed.	Check and ensure operability of all flashboards on a regular basis.

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
MONUMENTATION/SURVEYS	A benchmark to NGVD exists near the dam, but could not be located by arsenal personnel.	Chart location of the benchmark on a drawing.
OBSERVATION WELLS	N/A	
WEIRS	Flow is reported to be monitored downstream at Building 80 (The Sewage Treatment Plant).	*Obtain records from the* supervisor.
PIEZOMETERS	Some capped piezometers from the 1968 embankment investigation are still in place.	
OTHERS	A headwater gage in good condition and reading to MSL is attached to the concrete bulkhead. No tailwater gage exists.	Install a tailwater gage.

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SLOPES	Steep and heavily wooded, with a few industrial and storage buildings, and landing stages around the rim. Inlet and outlet from Power and Steam Plant on left bank. Road running along both banks. Railroad on right bank. No evidence for potential massive slide into reservoir, but boulders are known to occasionally fall down from the steep right bank.	
SEDIMENTATION	Negligible, according to visual inspection and verbal reports.	
USE	Industrial storage for plant cooling water and fire hydrant system. Feeds six 150,000 gallon storage tanks.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)		
Well defined channel, approximately 15 feet wide. Artificial steps in stream bed, constructed from loose boulders, but debris is minimal. Steel road bridge and steam pipe cross the stream 350 feet downstream of dam.		Steam pipe and possibly bridge would be washed out in the event of overtopping.
SLOPES		
8-12 foot high banks sloped at 1H:1V and protected in places with rip-rap. Slopes are tree-covered. Overhead electric cable pylons are located on the right bank, with their bases approximately 8 feet above normal stream elevation, and at the top of the left bank 40 feet downstream of the dam is a 2,400 volt substation supplying Building 333.		Electric supply would be damaged by overtopping.
APPROXIMATE NUMBER OF HOMES AND POPULATION		
Approximately 20 occupied industrial and residential buildings of an important strategic nature are estimated to be in the PMF breach flood path. In addition, essential services and access routes in flood path.		"High" hazard potential is confirmed.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	Available from Facilities Engineering Division, Picatinny Arsenal. (copy included)
REGIONAL VICINITY MAP	County Map for Morris County. U.S.G.S. Quad Sheets for Dover, Boonton, Franklin & Newfoundland, NJ.
CONSTRUCTION HISTORY	Formal dam built 1904. History traced in a 1968 embankment investigation report, filed at the F.E.D. Picatinny.
TYPICAL SECTIONS OF DAM	Approximate sections available. Included.
HYDROLOGIC/HYDRAULIC DATA	Some data given in a 1969 H & H Study, available from F.E.D., Picatinny.
OUTLETS - PLAN	N/A
- DETAILS	N/A
- CONSTRAINTS	N/A
- DISCHARGE RATINGS	N/A
RAINFALL/RESERVOIR RECORDS	Greatest flood in 1903, October. No details on record.

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

ITEM	REMARKS
DESIGN REPORTS	None available.
GEOLOGY REPORTS	None available.
DESIGN COMPUTATIONS	None available.
HYDROLOGY & HYDRAULICS	1962 Passaic River Report, 1969 H & H Engineering Report No. 16:69, P.E.D.
DAM STABILITY	1968 Embankment Investigation Report, filed at P.E.D.
SEEPAGE STUDIES	1968 Embankment Investigation Report.
MATERIALS INVESTIGATIONS	1968 Embankment Investigation Report
BORING RECORDS	1968 Embankment Investigation Report
LABORATORY	1968 Embankment Investigation Report
FIELD	1968 Embankment Investigation Report
POST-CONSTRUCTION SURVEYS OF DAM	1946 by Senior Hydraulic Engineer, NJ State. 1968 Topographic Survey
BORROW SOURCES	Not known.
SPILLWAY PLAN - SECTIONS	Available in P.E.D. files, included.
- DETAILS	Available in P.E.D. files, included.

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

ITEM	REMARKS
OPERATING EQUIPMENT PLANS AND DETAILS	Not available.
MONITORING SYSTEMS	None known to exist.
MODIFICATIONS	Spillway rebuilt in 1936 and 1942. Spillway re-faced with gunite in 1968.
HIGH POOL RECORDS	By regulating, none above 713' MSL.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	1968 Embankment Investigation, filed at F.E.D., Picatinny.
PRIOR ACCIDENTS OF FAILURE OF DAM - DESCRIPTION - REPORTS	None on record.
MAINTENANCE OPERATION RECORDS	No records kept. Water System Tender is responsible for regulating flow and works by judgement based on experience.

APPENDIX B

PHOTOGRAPHS

(Taken on July 12, 1979)

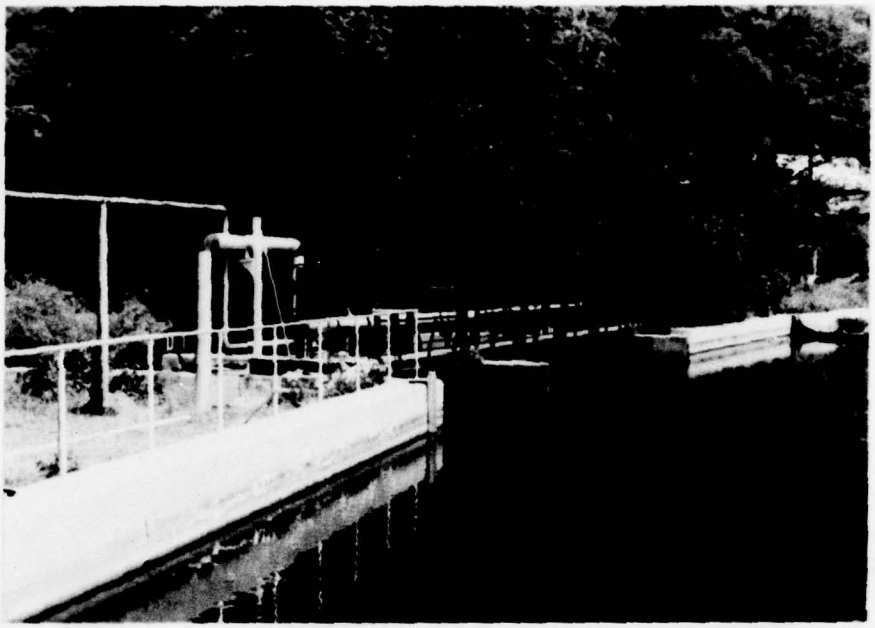


Photo No. 1 - View of upstream face of dam and spillway. Note the oil barrier, headwater gage, and the 5" ø steam line and 4" ø air line passing across the spillway. The trash/fish screens are totally deteriorated, but deterioration of the spillway structure is surficial only.

Photo No. 2 - View of downstream face of spillway. Note the minor deterioration on the submerged surfaces and the good overall condition.

Photo No. 3 - View of right wingwall, showing the undermining that has occurred at the downstream section. Note that the right side of the channel is blocked by fill, on which trees have grown.

Photo No. 4 - View of the left wingwall and downstream channel. Note the transformer and Building 333 immediately under the dam. Note also the intact rip-rap protection.

Photo No. 5 - Detail of the footbridge over the spillway showing the surface deterioration, but good structural condition. The manual lifting devices for the flashboards are to the left of the bridge, and for the fishscreens to the right.

Photo No. 6 - Typical detail of a flashboard in the center section. The flashboard shown has been raised by 1/2 inch to permit discharge from the lake. Note the missing tension rod, the rusted condition of the guides and steel gate-parts, and the spalled concrete under the footbridge.

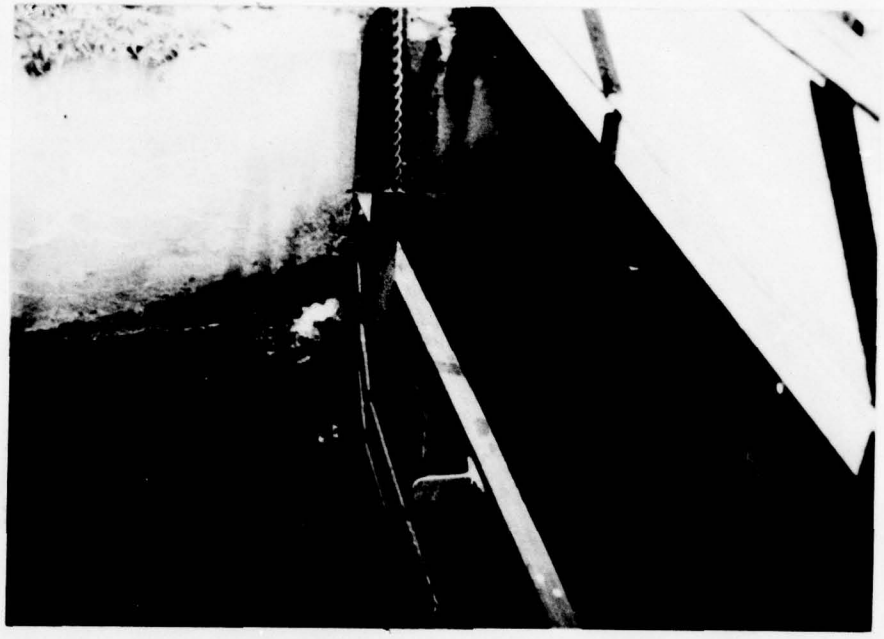


Photo No. 7 - Detail of the flashboard in the right section of the spillway. Corrosion in the guides would indicate difficulty of raising and lowering. Note the minor spalling of the concrete rendering, the irregular flow under the flashboard and the surface rusting of the steel components.

Photo No. 8 - Detail of drainage pipe, discharging the controlled seepage from the two old headraces into an open drain in front of Building 333.

Photo No. 9 - Typical view of downstream face of embankment sloped at 1.5H:1V and covered with trees near the spillway. Note the 1" diameter airline on the right of the picture, feeding Building 333.

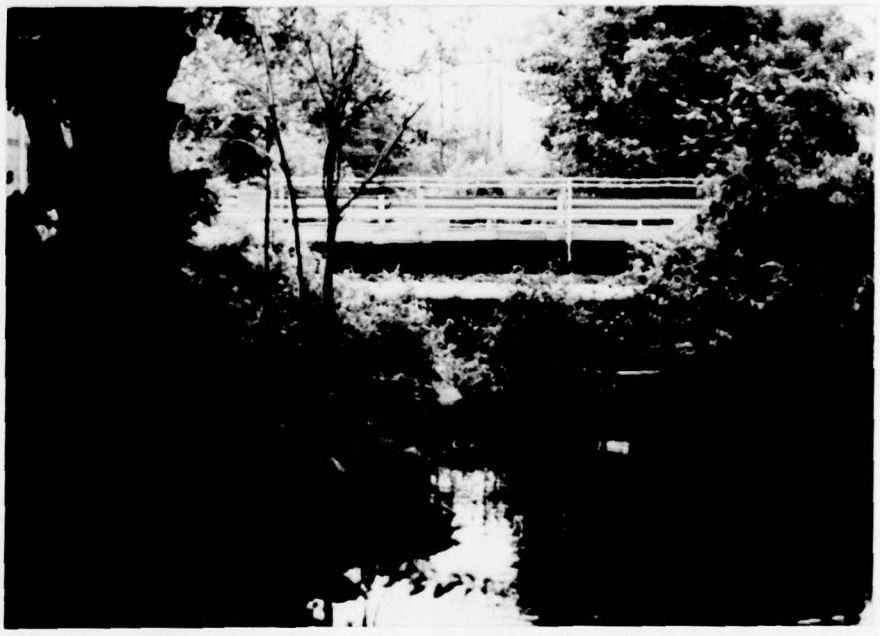


Photo No. 10- View of roadway bridge 350 feet downstream of the spillway, carrying Whittemore Avenue over Green Pond Brook. Note the steam pipe crossing the brook, and the electric cable pylon on the downstream channel bank.

APPENDIX C

SUMMARY OF ENGINEERING DATA

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

Name of Dam: Picatinny Arsenal

Drainage Area Characteristics: Heavily wooded, light residential, steep slopes.

Elevation Top Normal Pool (Storage Capacity): 712.4' NGVD (150 acre-feet)

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

Elevation Maximum Design Pool: (SDF = PMF) 718.7' NGVD (693 acre-feet)

Elevation Top Dam: 713.5' NGVD (294 acre-feet)

SPILLWAY CREST

a. Elevation 708.7' NGVD (low-point)

b. Type Gated concrete overflow, subdivided into 3 channels.

c. Width 15 feet

d. Length 55.2 feet (effective)

e. Location Spillover Full length

f. No. and Type of Gates 6 timber flashboards, manually operated.

OUTLET WORK

a. Type None

b. Location None

c. Entrance Inverts None

d. Exit Inverts None

e. Emergency Draindown Facilities Spillway flashboards.

HYDROMETEOROLOGICAL GAGES

a. Type None

b. Location None

c. Records None

MAXIMUM NON-DAMAGING DISCHARGE 1,248 cfs.

APPENDIX D

HYDROLOGIC COMPUTATIONS

PICATINNY LAKE DAM
DRAINAGE BASIN

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT N. J. Dam Inspection — Picatinny Lake Dam
SHEET NO. 1 OF
JOB NO. 10-A44-02
COMPUTED BY S.B. CHECKED BY
DATE Aug. 1979

Size Classification

Surface area of impoundment = 64 AC

Maximum height of Dam = 15 Ft

Classification of Dam = Small

SDF for small Dam High Hazard
= ½ PMF to PMF

PMF is considered as SDF

Hydrologic Analysis

a) Determine Local inflow to Lake Denmark (D.A = 4.5 sq. miles)

b) Route the inflow through the Reservoir

c) Determine Local inflow of Green Pond brook (neglecting the Lake of Green Pond) upto the confluence of Burnt Meadow brook. (Telephone discussion with Mr. George Sauls) (D.A = 4.5)

d) Add hydrograph b) & c)

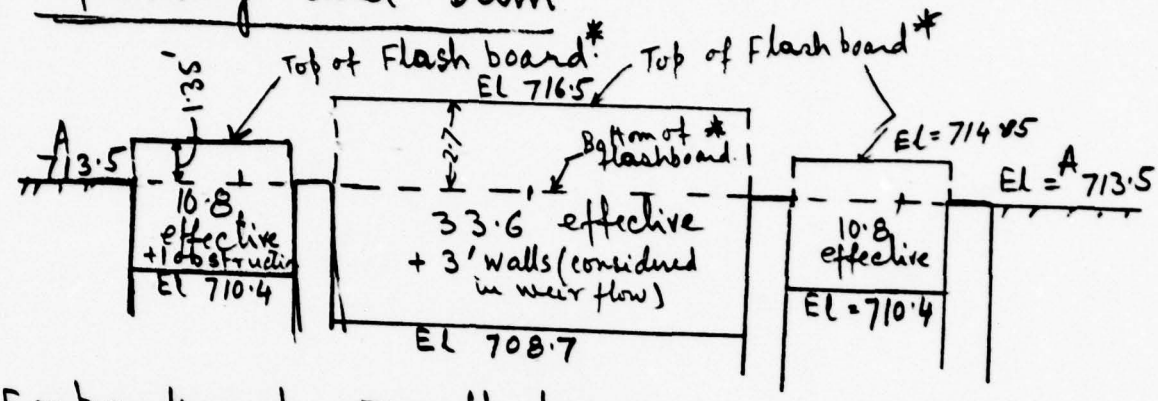
e) Route hydrograph(d) upto Picatinny Lake, Considering valley storage.

f) Local inflow from the confluence to Picatinny Lake. (D.A = 1.2)

g) Add hydrograph e) & f)

h) Route H.G through Dam.

Spillway and Dam



Embankment 500 ft long

Normal lake level = 712.4

From the Actual survey it is found out that there is no appreciable variation in the elevation of Dam. Assumed 713.5 (COE report)

* Flashboards are up during high flood with no freeboard.

(A) When the water level is upto 713.5

Weir flow over spillway C = 2.65

Weir flow over axilliary spillway C = 2.65

No Flow over Dam.

(B) When the water level is above 713.5

Free discharge through the spillway

Wier flow over the Dam C = 2.65

(C) When the water level is above 714.85

Free discharge over main spillway

Pressure and Wier (C = 3.0) over the auxiliary spillway

Wier flow over the Dam

(D) When the water level is above 716.5

Pressure and wier (C = 3.0) over main and aux. spill

Wier flow over the Dam.

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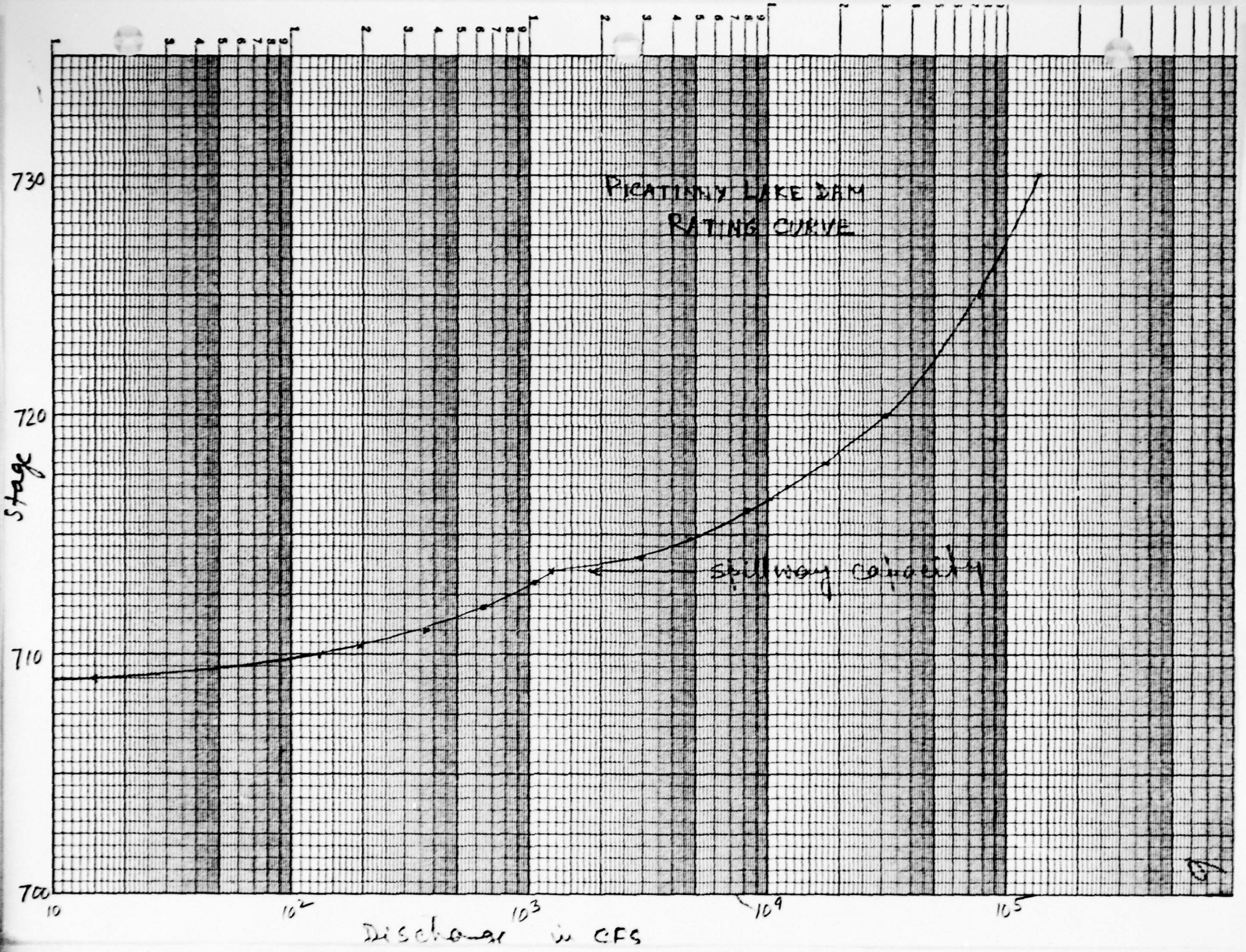
SUBJECT N.J. Dam Inspection SHEET NO. 4 OF
Picatiny Lake Dam JOB NO. 10-A44-02
COMPUTED BY S.B CHECKED BY DATE Aug 1979

Elevation	Height over Main Spill h_1	Q over Main Spill $2.65 \times 33.6 h_1^{1.5} = 89 h_1^{1.5}$	Height over aux. Spill h_2	Q over aux. Spillway $2.65 \times 21.6 h_2^{1.5} = 57.2 h_2^{1.5}$	Total Q
708.7	0	0			0
709	.3	15			15
710	1.3	132			132
710.4	1.7	197	0	0	197
711	2.3	310	.6	27	337
712	3.3	534	1.6	116	650
713	4.3	794	2.6	240	1034
713.5	4.8	936	3.1	312	1248

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection — Picatiny Lake Dam
SHEET NO. 5 OF
JOB NO. 10-A46-02
COMPUTED BY S.B CHECKED BY
DATE Aug. 1979

Elevation	Press. flow into Main Spillway = $Cd \times A \times \sqrt{2gh}$ $= .62 \times (33.6 \times 4.8) \times 8\sqrt{h-708.7}$ $= 800\sqrt{h-708.7}$	Wier flow over the main spillway = $CL\, h^{3/2}$ $3 \times 33.6 (h-716.5)^{1.5}$ $= 101 (h-716.5)^{1.5}$	Pressure flow thro auxiliary spillway $= .62(2 \times 10.8 \times 3.1) \times 8\sqrt{h-710.4}$ $= 332\sqrt{h-710.4}$	Wier flow over the aux. spillway $= 3 \times (2 \times 11.8)(h-714.85)^{3/2}$ $= 71 (h-714.85)^{1.5}$	Wier flow over Dam $CL\, h^{3/2}$ $2.65 \times 500 (h-713.5)^{1.5}$ $= 1325 (h-713.5)^{1.5}$	Q total
714	1,842		630		468	2,940
714.5	1,984		700	0	2,078	4,762
715	2,008		712	4	2,434	5,158
716	2,161		786	88	5,238	8,273
716.5	2,234	0	820	150	6,885	10,089
717	2,305	36	853	224	8,676	12,094
718	2,440	1470	915	397	12,648	17,870
720	2,689	5238	1029	818	21,958	31,732
725	3,230	19,825	1269	2,296	51,673	78,293
730	3,692	39,682	1470	4,187	88,806	137,837

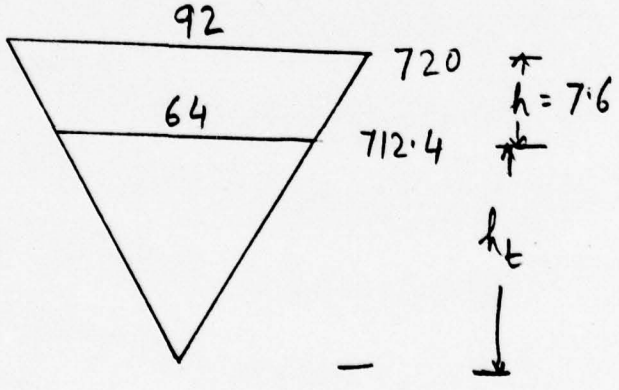

PICATINNY LAKE DAM
RATING CURVE
Spillway Crest
730
720
710
700
Stage
10
10^2
10^3
10^4
10^5
Discharge in CFS

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection — Picatiny Lake Dam
SHEET NO. 7 OF
JOB NO. 10-A44-02
COMPUTED BY S.B CHECKED BY
DATE Aug. 1979

Reservoir Stage area relations :-

Elevation	Area in Acres
702 (Elevation obtained from COE report; lowest contour line in the lake)	0
Lake (712.4 Ft) (information from COE)	64 Ac (From USGS Quad)
720	92 Ac (")
740	143 Ac (")



$$h_t = h / \left(\sqrt{\frac{A_2}{A_1}} - 1\right) = 38' \text{ (Not used)}$$

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SUBJECT N.J. Dam Inspection
Picatiny Lake Dam

SHEET NO. 8 OF
JOB NO. 10-A44-02
COMPUTED BY S.B CHECKED BY
DATE Aug. 1979

Determination of PMP

Probable maximum precipitation amount from HMS Report 33

= 22" (200 sq. miles - 24 hrs
(The all season envelope)

Depth area duration relationship. Percentage to be applied to the above figure.

6 hr = 112 %
12 hr = 123 %
24 hr = 132 %
48 hr = 143 %

Determination of Tc

A) To Lake Denmark

Tc = 4.6 hrs
Lag = 2.76

(See computation for Lake Denmark)

B) Greenpond brook up to the confluence of Burnt Meadow brook

1) Estimating Tc from velocity estimate and watercourse length.

	Slop	vel	
Overland flow	$\frac{1220-1060}{2600}$ = 6.2 %	3.0	Postures (uper portion of Watershed)
Green Pond Vicinity	Length 15,600 ft	NO flow	Lake
D/s of Green Pond to confluence	$\frac{1067-770}{11,200}$ = 2.7 %	1.0	Natural Channel

$$Tc = \frac{2600}{3 \times 3600} + \frac{11200}{1 \times 3600} = 3.35 \text{ hrs}$$

2) Estimating Tc assuming same vel. S = 1.5%

$$Tc = \frac{29,400}{1.5 \times 3600} = 5.44 \text{ hrs.}$$

3) From Nomograph (SCS Guide) - Same as Kirpich

Tc = 1.7 hrs.

Use $T_c = 4.6$ Hrs.

Lag $= 0.6\ T_c = 2.76$ hrs.

(C) From the confluence to Picatinny Lake

①	Slope	Vel	
Channel	$\frac{770-720}{3200} = 1.56\%$	1.0	
Lake	5600	—	Flow Thro' lake not considered

$$T_c = \frac{3200}{1 \times 3600}$$

$$= .88 \text{ hrs}$$

② Estimating T_c assuming same vel

slope $\frac{50}{8800} = .56\%$

$$\frac{8800}{1.5 \times 3600} = 1.63 \text{ hrs}$$

③ From Nomographs ~~of~~ from design of Small Dams (S.C.S Guide, Same as Kirpich

$T_c = 1$ hrs.

Assume $T_c = 1.63$ hrs

Lag $= .6 \times 1.63 = 0.98$ hrs.

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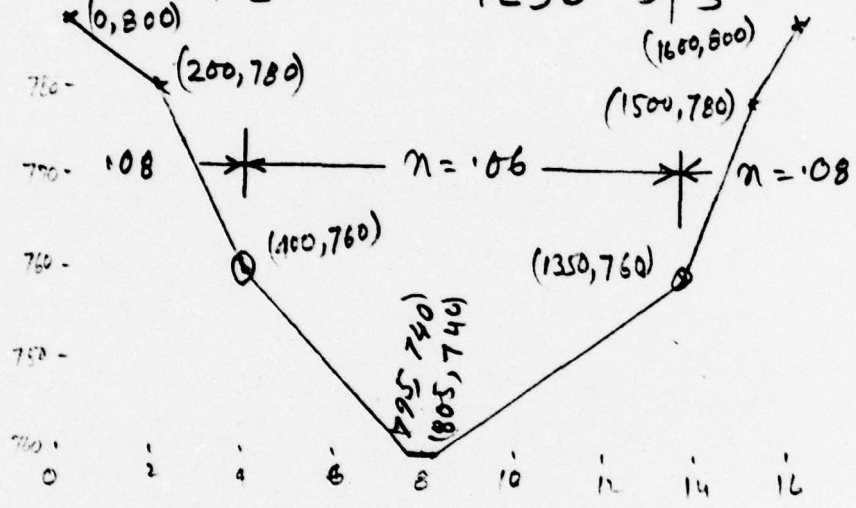
SUBJECT N.J. Dam Inspection — Picatinny Lake Dam — SHEET NO. 11 OF
JOB NO. 10-A44-02
COMPUTED BY S.B. CHECKED BY DATE Aug. 1979

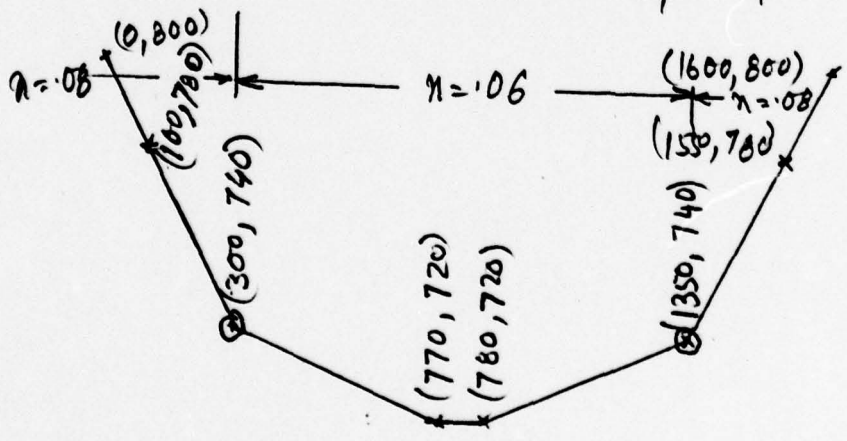
To consider routing between the confluence of Green Pond Brook and Burnt Meadow Brook to Picatinny Lake two sections are chosen

REACH 1 — 1250' D/S — $S = \frac{20}{1200} = .017$



Reach 2

REACH 2 — 1800' D/S of Reach 1 — $S = \frac{20}{1800} = .011$



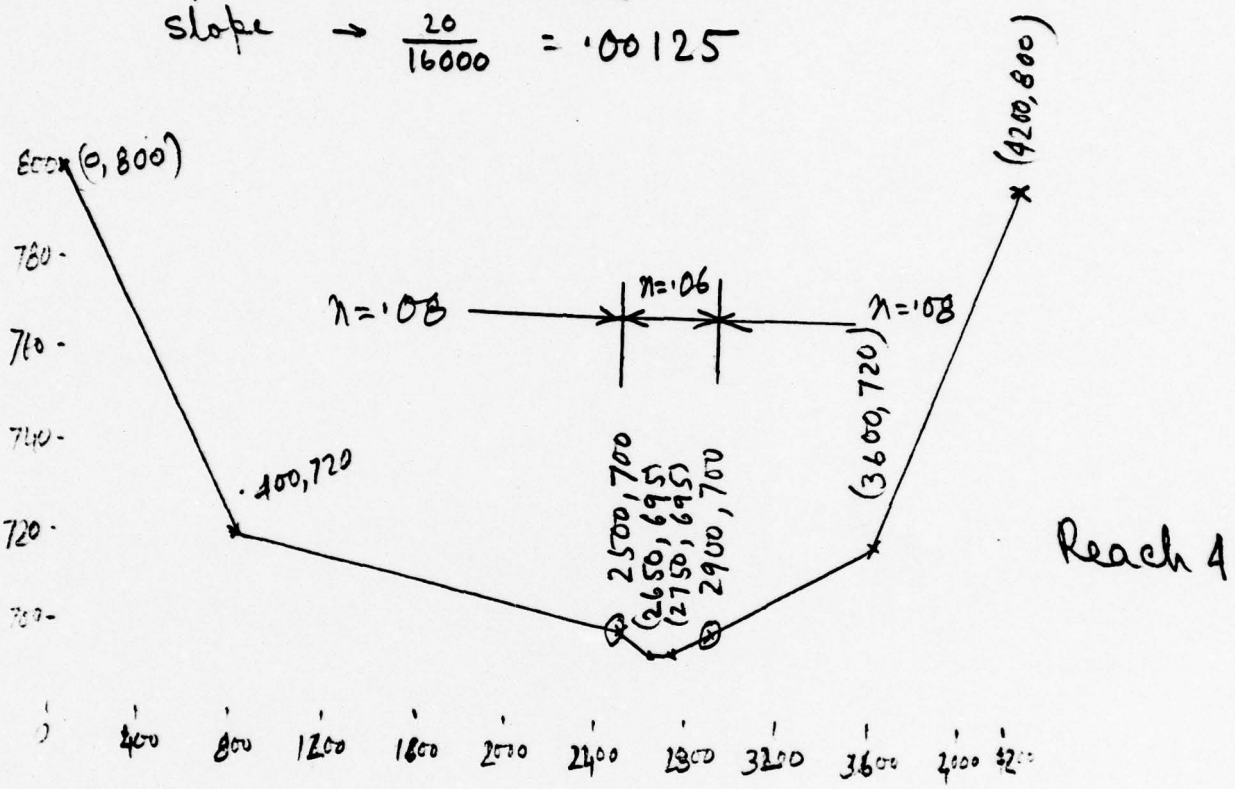
Reach 3

The channel n values are the weighted av value between 3rd point and 6th point.

Cross Section D/S of Picatinny Lake

D/S → 4000 Ft

slope → $\frac{20}{16000} = .00125$



Reach 4

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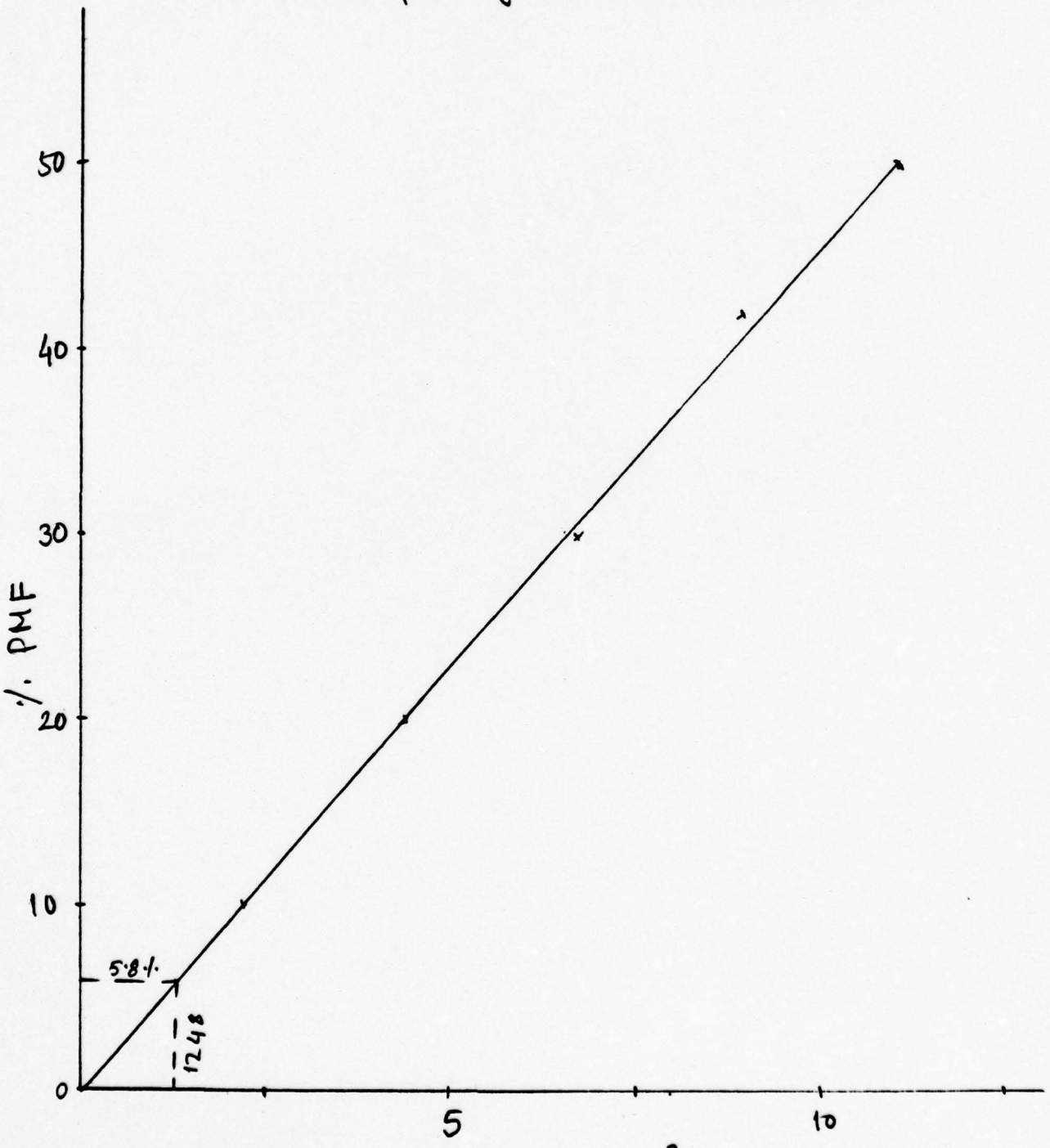
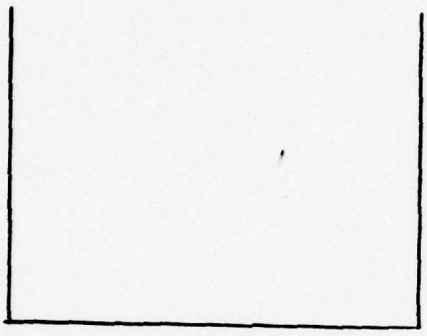
SUBJECT N. J. Dam Inspection — Picatinny Lake Dam — SHEET NO. 13 OF
JOB NO. 10-A44-02
COMPUTED BY S.B CHECKED BY DATE Aug. 1979

Overtopping Potential of Dam



Overtopping will occur at an elevation of 713.5
Q = 1248 cfs (≃ 6 % PMF)

Breach Analysis



Bottom of Breach
700.00 (assumed

Effect of breach was analysed at 4000 ft D/S of Dam which is considered as hazard location.

At D/S Reach

	% of PMF					
	100	50	40	30	20	10
Water Surface Elevation without Dam break	707.1	704.2	703.4	702.5	701.3	699.7
Water Surface Elevation with Dam Breach	707.1	704.2	703.4	703.0	702.7	702.1

At 100, 50 & 40% of PMF there will be no change of W.S.El at the D/S section due to Dam breach.

But at lower % PMF say at 10% of PMF the W.S. el will rise 2.4 Ft.

At PMF (SDF) there is a chance of damages at the D/S due to Dam failure or even without Dam failure

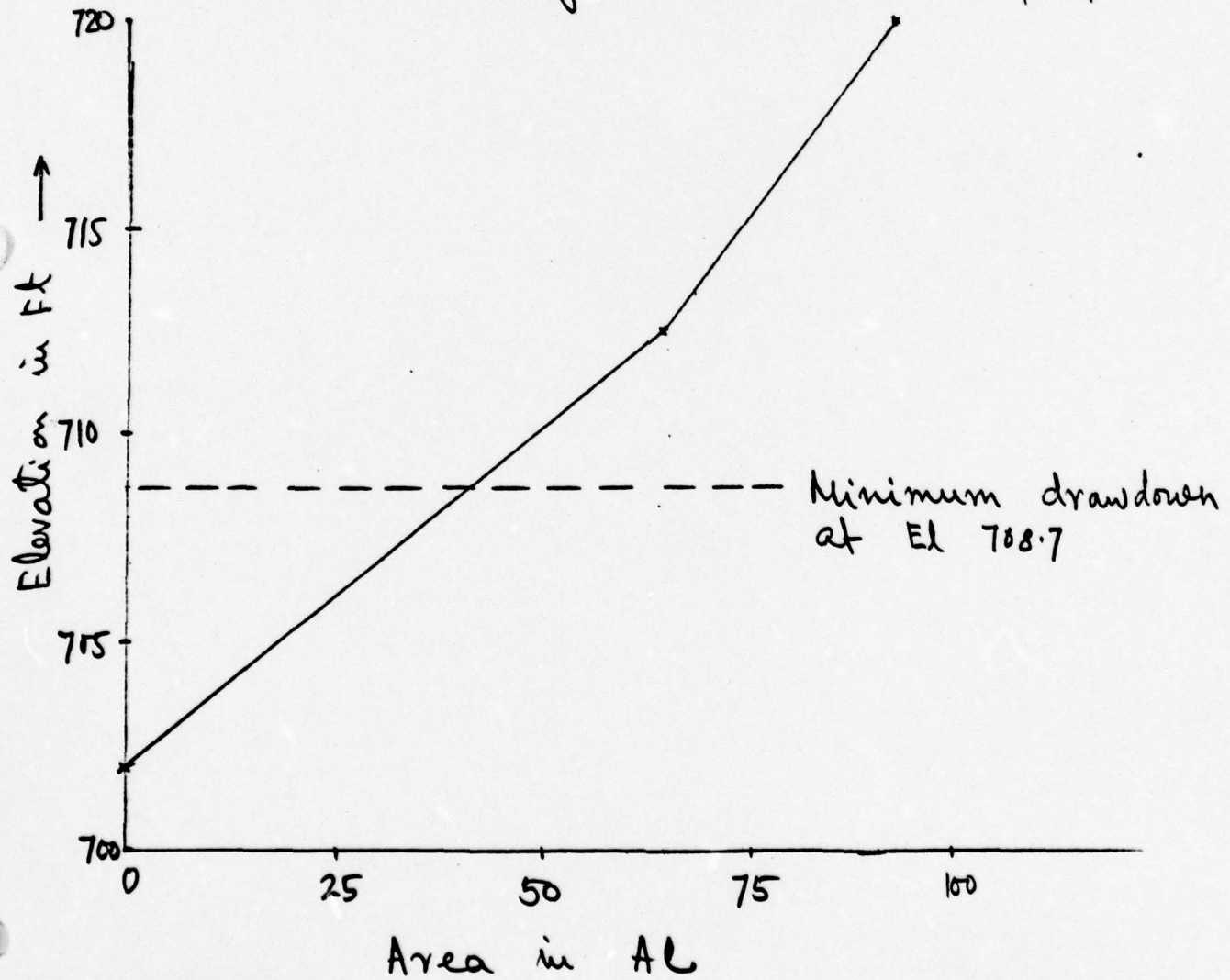
Reservoir Evaluation

a) Discharge Vs Head

Discharge Vs Head computed in pages 2 to 6 before

b) Area Vs. Head

Assume a straight line relationship from



c) Drainage area 10.2 sq miles

Inflow = 2 cfs / sq mile
= 20.4 cfs.

El	Area (Ac)	Av. Area Ac	Vol AF	Outlet Q	Time to draw = t_1 $\frac{\text{Vol} \times 24}{1.98 \times Q}$ (hrs)	Time to draw 20.4 cfs $\frac{20.4 \times t_1}{Q}$ t_2 (hrs)	Total Time $t_1 + t_2$
712.4	64						
		62.5	24.96	800	.38	.01	0.39
712	61						
		56.5	90.4	350	3.13	.18	3.31
710.4	52						
		47.0	79.9	60	16.14	5.49	21.63
708.7	42						
					16.65		25.33

Without any inflow time required for drawdown upto Spillway level = 16.65 hrs

With const. inflow of 2 cfs/SM = 25.33 hrs

After which the gate is closed.

HEC1-DB

COMPUTER PRINT-OUT

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

```
    1          A1     N.J. DAM INSPECTION
    2          A2     PICATINNY LAKE DAM
    3          A3     MULTI RATIO PMF ROUTING
    4          B   150       0      30       0       0       0       0       0       0       0
    5          B1    5
    6          J     1       6       1
    7          J1  1.0      .5      .4      .3      .2      .1
    8          K     ORES.DEN                                        1
    9          K1     LOCAL INFLOW TO LAKE DENMARK
   10          M     1       2     4.5                 4.5                                   1
   11          P     0      22     112     123     132     143
   12          T                                                   .1     .04             .01
   13          W2          2.76
   14          X    -1   -0.05       2
   15          K     1DAM,DEN
   16          K1     ROUTING THROUGH LAKE DENMARK
   17          Y                                     1       1
   18          Y1    1                                         -822.65     -1
   19          Y4822.65      823  823.61  823.89      824      825  825.45  825.72  825.76      826
   20          Y4   828      830     832     834.     837      840
   21          Y5     0       17      75     111      127      305     402     501     522      718
   22          Y5  4191     9573   16310   24168    37754    53235
   23          SA     0      299     940
   24          SE   800  822.65     840
   25          SS822.65
   26          K     1  REACH1                                     1
   27          K1     CHANNEL ROUTING MOD.PULS. UPTO CONFLUENCE
   28          Y                                     1       1
   29          Y1    1
   30          Y6   .1      .08      .1     766     800     1200    .05
   31          Y7    0      900    1050     800    1150      780    1690     766    1770      766
   32          Y7 2000      780    2400     800    2800      900
   33          K     0  REACH1
   34          K1     LOCAL INFLOW FROM GREEN POND BROOK UPTO CONFLUENCE
   35          M     1       2     4.5                 4.5                                   1
   36          P     0      22     112     123     132     143
   37          T                                                   1     .04             .01
   38          W2          2.76
   39          X    -1   -0.05       2
   40          K     2  REACH1                                     1
   41          K1     COMBINE HYDROGRAPH  AT CONFLUENCE
   42          K     1  REACH2
   43          K1     CHANNEL ROUTING MOD.PULS REACH 2
   44          Y                                     1       1
   45          Y1    1
   46          Y6  .08      .06      .08     740     750     1250    .017
   47          Y7    0      800      200     780     400      760     795     740     805      740
   48          Y7 1350      760     1500     780    1600      800
   49          K     1  REACH3
   50          K1     CHANNEL ROUTING MOD. PULS REACH 3
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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
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```
     1                A1       N.J. DAM INSPECTION
     2                A2       PICATINNY LAKE DAM
     3                A3       MULTI RATIO PMF ROUTING
     4                B    150         0        30         0         0         0         0         0         0         0
     5                B1     5
     6                J      1         6         1
     7                J1   1.0        .5        .4        .3        .2        .1
     8                K        DRES.DEN                                          1
     9                K1       LOCAL INFLOW TO LAKE DENMARK
    10                M      1         2       4.5                 4.5                                       1
    11                P      0        22       112       123       132       143
    12                T                                                        .1       .04                  .01
    13                W2             2.76
    14                X     -1      -0.05        2
    15                K       1DAM,DEN
    16                K1       ROUTING THROUGH LAKE DENMARK
    17                Y                                    1         1
    18                Y1     1                                                -822.65       -1
    19                Y4822.65       823   823.61   823.89       824       825   825.45   825.72   825.76       826
    20                Y4   828       830       832       834       837       840
    21                Y5     0        17        75       111       127       305       402       501       522       718
    22                Y5  4191      9573     16310     24168     37754     53235
    23                $A     0       299       940
    24                $E   800    822.65       840
    25                $$822.65
    26                K      1  REACH1                                                1
    27                K1       CHANNEL ROUTING MOD.PULS, UPTO CONFLUENCE
    28                Y                                    1         1
    29                Y1     1
    30                Y6    .1       .08        .1       766       800      1200       .05
    31                Y7     0       900      1050       800      1150       780      1690       766      1770       766
    32                Y7  2000       780      2400       800      2800       900
    33                K      0  REACH1
    34                K1       LOCAL INFLOW FROM GREEN POND BROOK UPTO CONFLUENCE
    35                M      1         2       4.5                 4.5                                       1
    36                P      0        22       112       123       132       143
    37                T                                                        1       .04                  .01
    38                W2             2.76
    39                X     -1      -0.05        2
    40                K      2  REACH1                                                1
    41                K1       COMBINE HYDROGRAPH  AT CONFLUENCE
    42                K      1  REACH2
    43                K1       CHANNEL ROUTING MOD.PULS REACH 2
    44                Y                                    1         1
    45                Y1     1
    46                Y6   .08       .06       .08       740       750      1250      .017
    47                Y7     0       800       200       780       400       760       795       740       805       740
    48                Y7  1350       760      1500       780      1600       800
    49                K      1  REACH3
    50                K1       CHANNEL ROUTING MOD. PULS REACH 3
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

```
RUNOFF HYDROGRAPH AT        S.DEN
ROUTE HYDROGRAPH TO         M.DEN
ROUTE HYDROGRAPH TO         REACH1
RUNOFF HYDROGRAPH AT        REACH1
COMBINE  2 HYDROGRAPHS AT   REACH1
ROUTE HYDROGRAPH TO         REACH2
ROUTE HYDROGRAPH TO         REACH3
RUNOFF HYDROGRAPH AT        REACH3
COMBINE  2 HYDROGRAPHS AT   REACH3
ROUTE HYDROGRAPH TO         M.PIC
ROUTE HYDROGRAPH TO         REACH4
END OF NETWORK
```

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

RUN  DATE= 79/08/28.
     TIME= 09.07.38.


                    N.J. DAM INSPECTION
                    PICATINNY LAKE DAM
                    MULTI RATIO 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= 6 LRTIO= 1
                RTIOS=   1.00     .50     .40     .30     .20     .10

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

                              SUB-AREA RUNOFF COMPUTATION

                    LOCAL INFLOW TO LAKE DENMARK

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

                                   HYDROGRAPH DATA
           IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
               1       2    4.50    0.00    4.50    0.00   0.000       0       1       0

                                     PRECIP DATA
                        SPFE     PMS      R6      R12     R24     R48     R72     R96
                        0.00   22.00  112.00  123.00  132.00  143.00    0.00    0.00
THSPC COMPUTED BY THE PROGRAM IS  .800

                                     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     .10     .04    0.00     .01

                                UNIT HYDROGRAPH DATA
                           TC=  0.00    LAG=  2.76

                                RECESSION DATA
                          STRTQ=   -1.00    QRCSN=    -.05    RTIOR= 2.00

      UNIT HYDROGRAPH 30 END OF PERIOD ORDINATES, TC=    0.00 HOURS, LAG=   2.76  VOL= 1.00
     55.     165.     338.     551.     685.     722.     688.     605.     495.     360.
    270.     205.     160.     122.      93.      71.      54.      41.      31.      24.
     18.      14.      11.       8.       7.       5.       4.       3.       1.       0.

      0                          END-OF-PERIOD FLOW
    MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS     COMP Q      MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS     COMP Q

    1.01    .30       1    .00    .00    .00         4.       1.02  14.00      76   1.18   1.16    .02     1755.
```

1.01	1.30	3	.00	.00	.00	4.	1.02	15.00	78	1.48	1.46	.02	3166.
1.01	2.00	4	.00	.00	.00	3.	1.02	15.30	79	1.80	1.78	.02	3989.
1.01	2.30	5	.00	.00	.00	3.	1.02	16.00	80	5.69	5.67	.02	5062.
1.01	3.00	6	.00	.00	.00	3.	1.02	16.30	81	1.38	1.36	.02	6324.
1.01	3.30	7	.00	.00	.00	3.	1.02	17.00	82	1.38	1.36	.02	7734.
1.01	4.00	8	.00	.00	.00	3.	1.02	17.30	83	1.08	1.06	.02	9152.
1.01	4.30	9	.00	.00	.00	3.	1.02	18.00	84	1.08	1.06	.02	10044.
1.01	5.00	10	.00	.00	.00	2.	1.02	18.30	85	.08	.06	.02	10298.
1.01	5.30	11	.00	.00	.00	2.	1.02	19.00	86	.08	.06	.02	9976.
1.01	6.00	12	.00	.00	.00	2.	1.02	19.30	87	.08	.06	.02	9168.
1.01	6.30	13	.01	.00	.01	2.	1.02	20.00	88	.08	.06	.02	7979.
1.01	7.00	14	.01	.00	.01	2.	1.02	20.30	89	.08	.06	.02	6553.
1.01	7.30	15	.01	.00	.01	2.	1.02	21.00	90	.08	.06	.02	5295.
1.01	8.00	16	.01	.00	.01	2.	1.02	21.30	91	.08	.06	.02	4205.
1.01	8.30	17	.01	.00	.01	2.	1.02	22.00	92	.08	.06	.02	3320.
1.01	9.00	18	.01	.00	.01	2.	1.02	22.30	93	.08	.06	.02	2596.
1.01	9.30	19	.01	.00	.01	2.	1.02	23.00	94	.08	.06	.02	2058.
1.01	10.00	20	.01	.00	.01	2.	1.02	23.30	95	.08	.06	.02	1654.
1.01	10.30	21	.01	.00	.01	2.	1.03	0.00	96	.08	.06	.02	1345.
1.01	11.00	22	.01	.00	.01	2.	1.03	.30	97	0.00	0.00	0.00	1102.
1.01	11.30	23	.01	.00	.01	2.	1.03	1.00	98	0.00	0.00	0.00	913.
1.01	12.00	24	.01	.00	.01	2.	1.03	1.30	99	0.00	0.00	0.00	756.
1.01	12.30	25	.08	.06	.02	5.	1.03	2.00	100	0.00	0.00	0.00	618.
1.01	13.00	26	.08	.06	.02	15.	1.03	2.30	101	0.00	0.00	0.00	510.
1.01	13.30	27	.10	.08	.02	37.	1.03	3.00	102	0.00	0.00	0.00	475.
1.01	14.00	28	.10	.08	.02	74.	1.03	3.30	103	0.00	0.00	0.00	444.
1.01	14.30	29	.12	.10	.02	123.	1.03	4.00	104	0.00	0.00	0.00	414.
1.01	15.00	30	.12	.10	.02	181.	1.03	4.30	105	0.00	0.00	0.00	386.
1.01	15.30	31	.15	.13	.02	245.	1.03	5.00	106	0.00	0.00	0.00	360.
1.01	16.00	32	.47	.45	.02	331.	1.03	5.30	107	0.00	0.00	0.00	336.
1.01	16.30	33	.11	.10	.02	432.	1.03	6.00	108	0.00	0.00	0.00	314.
1.01	17.00	34	.11	.10	.02	547.	1.03	6.30	109	0.00	0.00	0.00	293.
1.01	17.30	35	.09	.07	.02	664.	1.03	7.00	110	0.00	0.00	0.00	273.
1.01	18.00	36	.09	.07	.02	736.	1.03	7.30	111	0.00	0.00	0.00	255.
1.01	18.30	37	.01	.00	.01	757.	1.03	8.00	112	0.00	0.00	0.00	238.
1.01	19.00	38	.01	.00	.01	732.	1.03	8.30	113	0.00	0.00	0.00	222.
1.01	19.30	39	.01	.00	.01	668.	1.03	9.00	114	0.00	0.00	0.00	207.
1.01	20.00	40	.01	.00	.01	576.	1.03	9.30	115	0.00	0.00	0.00	193.
1.01	20.30	41	.01	.00	.01	466.	1.03	10.00	116	0.00	0.00	0.00	180.
1.01	21.00	42	.01	.00	.01	370.	1.03	10.30	117	0.00	0.00	0.00	168.
1.01	21.30	43	.01	.00	.01	288.	1.03	11.00	118	0.00	0.00	0.00	157.
1.01	22.00	44	.01	.00	.01	223.	1.03	11.30	119	0.00	0.00	0.00	146.
1.01	22.30	45	.01	.00	.01	169.	1.03	12.00	120	0.00	0.00	0.00	137.
1.01	23.00	46	.01	.00	.01	128.	1.03	12.30	121	0.00	0.00	0.00	127.
1.01	23.30	47	.01	.00	.01	98.	1.03	13.00	122	0.00	0.00	0.00	119.
1.02	0.00	48	.01	.00	.01	75.	1.03	13.30	123	0.00	0.00	0.00	111.
1.02	.30	49	.05	.03	.02	59.	1.03	14.00	124	0.00	0.00	0.00	103.
1.02	1.00	50	.05	.03	.02	51.	1.03	14.30	125	0.00	0.00	0.00	97.
1.02	1.30	51	.05	.03	.02	52.	1.03	15.00	126	0.00	0.00	0.00	90.
1.02	2.00	52	.05	.03	.02	62.	1.03	15.30	127	0.00	0.00	0.00	84.
1.02	2.30	53	.05	.03	.02	79.	1.03	16.00	128	0.00	0.00	0.00	78.
1.02	3.00	54	.05	.03	.02	98.	1.03	16.30	129	0.00	0.00	0.00	73.
1.02	3.30	55	.05	.03	.02	117.	1.03	17.00	130	0.00	0.00	0.00	68.
1.02	4.00	56	.05	.03	.02	134.	1.03	17.30	131	0.00	0.00	0.00	64.
1.02	4.30	57	.05	.03	.02	149.	1.03	18.00	132	0.00	0.00	0.00	59.
1.02	5.00	58	.05	.03	.02	159.	1.03	18.30	133	0.00	0.00	0.00	55.
1.02	5.30	59	.05	.03	.02	166.	1.03	19.00	134	0.00	0.00	0.00	52.
1.02	6.00	60	.05	.03	.02	172.	1.03	19.30	135	0.00	0.00	0.00	48.
1.02	6.30	61	.16	.14	.02	182.	1.03	20.00	136	0.00	0.00	0.00	45.
1.02	7.00	62	.16	.14	.02	203.	1.03	20.30	137	0.00	0.00	0.00	42.
1.02	7.30	63	.16	.14	.02	243.	1.03	21.00	138	0.00	0.00	0.00	39.
1.02	8.00	64	.16	.14	.02	305.	1.03	21.30	139	0.00	0.00	0.00	37.
1.02	8.30	65	.16	.14	.02	381.	1.03	22.00	140	0.00	0.00	0.00	34.
1.02	9.00	66	.16	.14	.02	461.	1.03	22.30	141	0.00	0.00	0.00	32.
1.02	9.30	67	.16	.14	.02	536.	1.03	23.00	142	0.00	0.00	0.00	30.

1.02	10.30	69	.16	.14	.02	657.	.04	0.00	144	0.00	0.00	0.00		26.
1.02	11.00	70	.16	.14	.02	697.	1.04	.30	145	0.00	0.00	0.00		24.
1.02	11.30	71	.16	.14	.02	726.	1.04	1.00	146	0.00	0.00	0.00		23.
1.02	12.00	72	.16	.14	.02	749.	1.04	1.30	147	0.00	0.00	0.00		21.
1.02	12.30	73	.99	.97	.02	812.	1.04	2.00	148	0.00	0.00	0.00		20.
1.02	13.00	74	.99	.97	.02	961.	1.04	2.30	149	0.00	0.00	0.00		18.
1.02	13.30	75	1.18	1.16	.02	1261.	1.04	3.00	150	0.00	0.00	0.00		17.
									SUM	25.17	23.69	1.48		142910.
										(639.)	(602.)	(38.)		(4046.99)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	10298.	7640.	2701.	992.	142907.
CMS	292.	216.	76.	28.	4047.
INCHES		15.79	22.34	24.61	24.62
MM		401.15	567.38	625.21	625.29
AC-FT		3788.	5358.	5904.	5905.
THOUS CU M		4673.	6609.	7283.	7284.

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	S.DEN	4.50	1	10298.	5149.	4119.	3090.	2060.	1030.
		(11.65)		(291.62)	(145.81)	(116.65)	(87.49)	(58.32)	(29.16)
ROUTED TO	M.DEN	4.50	1	10298.	5149.	4119.	3090.	2060.	1030.
		(11.65)		(291.62)	(145.81)	(116.65)	(87.49)	(58.32)	(29.16)
ROUTED TO	REACH1	4.50	1	10299.	5142.	4119.	3087.	2057.	1029.
		(11.65)		(291.64)	(145.60)	(116.65)	(87.41)	(58.26)	(29.14)
HYDROGRAPH AT	REACH1	4.50	1	10298.	5149.	4119.	3090.	2060.	1030.
		(11.65)		(291.62)	(145.81)	(116.65)	(87.49)	(58.32)	(29.16)
2 COMBINED	REACH1	9.00	1	20598.	10291.	8239.	6176.	4117.	2059.
		(23.31)		(583.26)	(291.41)	(233.30)	(174.89)	(116.58)	(58.30)
ROUTED TO	REACH2	9.00	1	20591.	10294.	8232.	6179.	4116.	2056.
		(23.31)		(583.08)	(291.49)	(233.11)	(174.96)	(116.57)	(58.22)
ROUTED TO	REACH3	9.00	1	20573.	10288.	8228.	6170.	4115.	2054.
		(23.31)		(582.55)	(291.32)	(232.98)	(174.70)	(116.54)	(58.16)
HYDROGRAPH AT	REACH3	1.20	1	4205.	2102.	1682.	1261.	841.	420.
		(3.11)		(119.06)	(59.53)	(47.63)	(35.72)	(23.81)	(11.91)
2 COMBINED	REACH3	10.20	1	22520.	11262.	9007.	6754.	4505.	2249.
		(26.42)		(637.70)	(318.89)	(255.04)	(191.25)	(127.57)	(63.67)
ROUTED TO	M.PIC	10.20	1	22562.	11221.	8958.	6694.	4405.	2232.
		(26.42)		(638.87)	(317.75)	(253.66)	(189.56)	(124.73)	(63.20)
ROUTED TO	REACH4	10.20	1	22185.	11055.	8830.	6605.	4364.	2130.
		(26.42)		(628.22)	(313.04)	(250.05)	(187.04)	(123.57)	(60.31)

PLAN 1 STATION REACH1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	10299.	771.1	42.50
.50	5142.	769.7	42.50
.40	4119.	769.3	42.50
.30	3087.	768.8	42.50
.20	2057.	768.3	42.50
.10	1029.	767.6	42.50

PLAN 1 STATION REACH2

	MAXIMUM	MAXIMUM	TIME

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	20591.	749.5	42.50
.50	10294.	747.3	42.50
.40	8232.	746.7	42.50
.30	6179.	746.0	42.50
.20	4116.	745.1	42.50
.10	2056.	743.9	42.50

PLAN 1 STATION REACH3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	20573.	730.0	42.50
.50	10288.	727.6	42.50
.40	8228.	727.0	42.50
.30	6170.	726.3	42.50
.20	4115.	725.4	42.50
.10	2054.	724.1	42.50

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	708.70	708.70	713.50
STORAGE	59.	59.	294.
OUTFLOW	0.	0.	1248.

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	718.68	5.18	693.	22562.	15.00	42.50	0.00
.50	716.78	3.28	536.	11221.	10.50	42.50	0.00
.40	716.19	2.69	489.	8958.	9.50	42.50	0.00
.30	715.49	1.99	436.	6694.	8.50	42.50	0.00
.20	714.68	1.18	377.	4405.	6.50	42.50	0.00
.10	713.79	.29	314.	2232.	3.50	42.50	0.00

PLAN 1 STATION REACH4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	22185.	707.1	43.00
.50	11055.	704.2	43.00
.40	8830.	703.4	43.00
.30	6605.	702.5	43.00
.20	4364.	701.3	43.00
.10	2130.	699.7	43.50

DAM BREAK.

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

```
RUNOFF HYDROGRAPH AT          S.DEN
ROUTE HYDROGRAPH TO           M.DEN
ROUTE HYDROGRAPH TO           REACH1
RUNOFF HYDROGRAPH AT          REACH1
COMBINE  2 HYDROGRAPHS AT     REACH1
ROUTE HYDROGRAPH TO           REACH2
ROUTE HYDROGRAPH TO           REACH3
RUNOFF HYDROGRAPH AT          REACH3
COMBINE  2 HYDROGRAPHS AT     REACH3
ROUTE HYDROGRAPH TO           M.PIC
ROUTE HYDROGRAPH TO           REACH4
END OF NETWORK
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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********

RUN  DATE= 79/08/28.
     TIME= 14.38.00.


                    N.J. DAM INSPECTION
                    PICATINNY LAKE DAM
                    MULTYPLAN DAM FAILURE ANALYSIS

                              JOB SPECIFICATION
          NU      NHR     NMIN     IDAY      IHR     IMIN    METRC     IPLT     IPRT    MSTAN
         150       0       30        0        0        0        0        0        3        0
                                   JUPER      NDT    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


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

                              SUB-AREA RUNOFF COMPUTATION

                    LOCAL INFLOW TO LAKE DENMARK

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

                                   HYDROGRAPH DATA
                IMYDG     IUHG    TAREA     SNAP    THSDA    THSPC    RATIO    ISNOW    ISAME    LOCAL
                    1        2     4.50     0.00     4.50     0.00    0.000        0        1        0

                                   PRECIP DATA
                              SPFE      PMS       R6      R12      R24      R48      R72      R96
                              0.00    22.00   112.00   123.00   132.00   143.00     0.00     0.00
THSPC COMPUTED BY THE PROGRAM IS  .000

                                   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      .10      .04     0.00      .01

                                UNIT HYDROGRAPH DATA
                           TC=  0.00    LAG=  2.76

                                RECESSION DATA
                          STRTQ=   -1.00    QRCSN=    -.05    RTIOR= 2.00

          UNIT HYDROGRAPH 30 END OF PERIOD ORDINATES, TC=    0.00 HOURS, LAG=   2.76  VOL= 1.00
        55.      165.      336.      551.      685.      722.      688.      605.      495.      360.
       270.      205.      160.      122.       93.       71.       54.       41.       31.       24.
        18.       14.       11.        8.        7.        5.        4.        3.        1.        0.

                                0
                              END-OF-PERIOD FLOW
     MO.DA  HR.MN  PERIOD    RAIN    EXCS    LOSS     COMP Q      MO.DA  HR.MN  PERIOD    RAIN    EXCS    LOSS     COMP Q

     1.01    .30        1     .00     .00     .00          4.      1.02  14.00      76    1.18    1.16     .02     1755.
```

1.01	1.00	2	.00	.00	.00	4.
1.01	1.30	3	.00	.00	.00	4.
1.01	2.00	4	.00	.00	.00	3.
1.01	2.30	5	.00	.00	.00	3.
1.01	3.00	6	.00	.00	.00	3.
1.01	3.30	7	.00	.00	.00	3.
1.01	4.00	8	.00	.00	.00	3.
1.01	4.30	9	.00	.00	.00	3.
1.01	5.00	10	.00	.00	.00	2.
1.01	5.30	11	.00	.00	.00	2.
1.01	6.00	12	.00	.00	.00	2.
1.01	6.30	13	.01	.00	.01	2.
1.01	7.00	14	.01	.00	.01	2.
1.01	7.30	15	.01	.00	.01	2.
1.01	8.00	16	.01	.00	.01	2.
1.01	8.30	17	.01	.00	.01	2.
1.01	9.00	18	.01	.00	.01	2.
1.01	9.30	19	.01	.00	.01	2.
1.01	10.00	20	.01	.00	.01	2.
1.01	10.30	21	.01	.00	.01	2.
1.01	11.00	22	.01	.00	.01	2.
1.01	11.30	23	.01	.00	.01	2.
1.01	12.00	24	.01	.00	.01	2.
1.01	12.30	25	.08	.06	.02	5.
1.01	13.00	26	.08	.06	.02	15.
1.01	13.30	27	.10	.08	.02	37.
1.01	14.00	28	.10	.08	.02	74.
1.01	14.30	29	.12	.10	.02	123.
1.01	15.00	30	.12	.10	.02	181.
1.01	15.30	31	.15	.13	.02	245.
1.01	16.00	32	.47	.45	.02	331.
1.01	16.30	33	.11	.10	.02	432.
1.01	17.00	34	.11	.10	.02	547.
1.01	17.30	35	.09	.07	.02	664.
1.01	18.00	36	.09	.07	.02	736.
1.01	18.30	37	.01	.00	.01	757.
1.01	19.00	38	.01	.00	.01	732.
1.01	19.30	39	.01	.00	.01	668.
1.01	20.00	40	.01	.00	.01	576.
1.01	20.30	41	.01	.00	.01	466.
1.01	21.00	42	.01	.00	.01	370.
1.01	21.30	43	.01	.00	.01	288.
1.01	22.00	44	.01	.00	.01	223.
1.01	22.30	45	.01	.00	.01	169.
1.01	23.00	46	.01	.00	.01	128.
1.01	23.30	47	.01	.00	.01	98.
1.02	0.00	48	.01	.00	.01	75.
1.02	.30	49	.05	.03	.02	59.
1.02	1.00	50	.05	.03	.02	51.
1.02	1.30	51	.05	.03	.02	52.
1.02	2.00	52	.05	.03	.02	62.
1.02	2.30	53	.05	.03	.02	79.
1.02	3.00	54	.05	.03	.02	98.
1.02	3.30	55	.05	.03	.02	117.
1.02	4.00	56	.05	.03	.02	134.
1.02	4.30	57	.05	.03	.02	149.
1.02	5.00	58	.05	.03	.02	159.
1.02	5.30	59	.05	.03	.02	166.
1.02	6.00	60	.05	.03	.02	172.
1.02	6.30	61	.16	.14	.02	182.
1.02	7.00	62	.16	.14	.02	203.
1.02	7.30	63	.16	.14	.02	243.
1.02	8.00	64	.16	.14	.02	305.
1.02	8.30	65	.16	.14	.02	381.
1.02	9.00	66	.16	.14	.02	461.
1.02	9.30	67	.16	.14	.02	536.
1.02	14.30	77	1.48	1.46	.02	2409.
1.02	15.00	78	1.48	1.46	.02	3166.
1.02	15.30	79	1.80	1.78	.02	3989.
1.02	16.00	80	5.69	5.67	.02	5062.
1.02	16.30	81	1.38	1.36	.02	6324.
1.02	17.00	82	1.38	1.36	.02	7734.
1.02	17.30	83	1.08	1.06	.02	9152.
1.02	18.00	84	1.08	1.06	.02	10044.
1.02	18.30	85	.08	.06	.02	10298.
1.02	19.00	86	.08	.06	.02	9976.
1.02	19.30	87	.08	.06	.02	9168.
1.02	20.00	88	.08	.06	.02	7979.
1.02	20.30	89	.08	.06	.02	6553.
1.02	21.00	90	.08	.06	.02	5295.
1.02	21.30	91	.08	.06	.02	4205.
1.02	22.00	92	.08	.06	.02	3320.
1.02	22.30	93	.08	.06	.02	2596.
1.02	23.00	94	.08	.06	.02	2058.
1.02	23.30	95	.08	.06	.02	1654.
1.03	0.00	96	.08	.06	.02	1345.
1.03	.30	97	0.00	0.00	0.00	1102.
1.03	1.00	98	0.00	0.00	0.00	913.
1.03	1.30	99	0.00	0.00	0.00	756.
1.03	2.00	100	0.00	0.00	0.00	618.
1.03	2.30	101	0.00	0.00	0.00	510.
1.03	3.00	102	0.00	0.00	0.00	475.
1.03	3.30	103	0.00	0.00	0.00	444.
1.03	4.00	104	0.00	0.00	0.00	414.
1.03	4.30	105	0.00	0.00	0.00	386.
1.03	5.00	106	0.00	0.00	0.00	360.
1.03	5.30	107	0.00	0.00	0.00	336.
1.03	6.00	108	0.00	0.00	0.00	314.
1.03	6.30	109	0.00	0.00	0.00	293.
1.03	7.00	110	0.00	0.00	0.00	273.
1.03	7.30	111	0.00	0.00	0.00	255.
1.03	8.00	112	0.00	0.00	0.00	238.
1.03	8.30	113	0.00	0.00	0.00	222.
1.03	9.00	114	0.00	0.00	0.00	207.
1.03	9.30	115	0.00	0.00	0.00	193.
1.03	10.00	116	0.00	0.00	0.00	180.
1.03	10.30	117	0.00	0.00	0.00	168.
1.03	11.00	118	0.00	0.00	0.00	157.
1.03	11.30	119	0.00	0.00	0.00	146.
1.03	12.00	120	0.00	0.00	0.00	137.
1.03	12.30	121	0.00	0.00	0.00	127.
1.03	13.00	122	0.00	0.00	0.00	119.
1.03	13.30	123	0.00	0.00	0.00	111.
1.03	14.00	124	0.00	0.00	0.00	103.
1.03	14.30	125	0.00	0.00	0.00	97.
1.03	15.00	126	0.00	0.00	0.00	90.
1.03	15.30	127	0.00	0.00	0.00	84.
1.03	16.00	128	0.00	0.00	0.00	78.
1.03	16.30	129	0.00	0.00	0.00	73.
1.03	17.00	130	0.00	0.00	0.00	68.
1.03	17.30	131	0.00	0.00	0.00	64.
1.03	18.00	132	0.00	0.00	0.00	59.
1.03	18.30	133	0.00	0.00	0.00	55.
1.03	19.00	134	0.00	0.00	0.00	52.
1.03	19.30	135	0.00	0.00	0.00	48.
1.03	20.00	136	0.00	0.00	0.00	45.
1.03	20.30	137	0.00	0.00	0.00	42.
1.03	21.00	138	0.00	0.00	0.00	39.
1.03	21.30	139	0.00	0.00	0.00	37.
1.03	22.00	140	0.00	0.00	0.00	34.
1.03	22.30	141	0.00	0.00	0.00	32.
1.03	23.00	142	0.00	0.00	0.00	30.

1.02	10.00	68	.16	.14	.02	693.	1.04	23.30	143	0.00	0.00	0.00	28.
1.02	10.30	69	.16	.14	.02	657.	1.04	0.00	144	0.00	0.00	0.00	26.
1.02	11.00	70	.16	.14	.02	697.	1.04	.30	145	0.00	0.00	0.00	24.
1.02	11.30	71	.16	.14	.02	726.	1.04	1.00	146	0.00	0.00	0.00	23.
1.02	12.00	72	.16	.14	.02	749.	1.04	1.30	147	0.00	0.00	0.00	21.
1.02	12.30	73	.99	.97	.02	812.	1.04	2.00	148	0.00	0.00	0.00	20.
1.02	13.00	74	.99	.97	.02	961.	1.04	2.30	149	0.00	0.00	0.00	18.
1.02	13.30	75	1.18	1.16	.02	1261.	1.04	3.00	150	0.00	0.00	0.00	17.
									SUM	25.17	23.69	1.48	142918.
										(639.)	(602.)	(38.)	(4046.99)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	10298.	7640.	2701.	992.	142907.
CMS	292.	216.	76.	28.	4047.
INCHES		15.79	22.34	24.61	24.62
MM		401.15	567.38	625.21	625.29
AC-FT		3788.	5358.	5904.	5905.
THOUS CU M		4673.	6609.	7283.	7284.

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	S.DEN	4.50	1	10298.	5149.	4119.	3090.	2060.	1030.
		(11.65)		(291.62)	(145.81)	(116.65)	(87.49)	(58.32)	(29.16)
ROUTED TO	M.DEN	4.50	1	10298.	5149.	4119.	3090.	2060.	1030.
		(11.65)		(291.62)	(145.81)	(116.65)	(87.49)	(58.32)	(29.16)
ROUTED TO	REACH1	4.50	1	10299.	5142.	4119.	3087.	2057.	1029.
		(11.65)		(291.64)	(145.60)	(116.65)	(87.41)	(58.26)	(29.14)
HYDROGRAPH AT	REACH1	4.50	1	10298.	5149.	4119.	3090.	2060.	1030.
		(11.65)		(291.62)	(145.81)	(116.65)	(87.49)	(58.32)	(29.16)
2 COMBINED	REACH1	9.00	1	20598.	10291.	8239.	6176.	4117.	2059.
		(23.31)		(583.26)	(291.41)	(233.30)	(174.89)	(116.58)	(58.30)
ROUTED TO	REACH2	9.00	1	20591.	10294.	8232.	6179.	4116.	2056.
		(23.31)		(583.08)	(291.49)	(233.11)	(174.96)	(116.57)	(58.22)
ROUTED TO	REACH3	9.00	1	20573.	10288.	8228.	6170.	4115.	2054.
		(23.31)		(582.55)	(291.32)	(232.98)	(174.70)	(116.54)	(58.16)
HYDROGRAPH AT	REACH3	1.20	1	4205.	2102.	1682.	1261.	841.	420.
		(3.11)		(119.06)	(59.53)	(47.63)	(35.72)	(23.81)	(11.91)
2 COMBINED	REACH3	10.20	1	22520.	11262.	9007.	6754.	4505.	2249.
		(26.42)		(637.70)	(318.89)	(255.04)	(191.25)	(127.57)	(63.67)
ROUTED TO	M.PIC	10.20	1	22493.	11163.	10151.	9990.	9652.	7210.
		(26.42)		(636.93)	(316.09)	(287.44)	(282.88)	(273.32)	(204.15)
ROUTED TO	REACH4	10.20	1	22184.	11029.	8842.	7739.	7156.	5821.
		(26.42)		(628.17)	(312.30)	(250.37)	(219.14)	(202.64)	(164.83)

PLAN 1 STATION REACH1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	10299.	771.1	42.50
.50	5142.	769.7	42.50
.40	4119.	769.3	42.50
.30	3087.	768.8	42.50
.20	2057.	768.3	42.50
.10	1029.	767.6	42.50

PLAN 1 STATION REACH2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS

1.00	20591.	749.5	42.50
.50	10294.	747.3	42.50
.40	8232.	746.7	42.50
.30	6179.	746.0	42.50
.20	4116.	745.1	42.50
.10	2056.	743.9	42.50

PLAN 1 STATION REACH3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	20573.	730.0	42.50
.50	10288.	727.6	42.50
.40	8228.	727.0	42.50
.30	6170.	726.3	42.50
.20	4115.	725.4	42.50
.10	2054.	724.1	42.50

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ..1.....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	708.70	708.70	713.50
STORAGE	59.	59.	294.
OUTFLOW	0.	0.	1248.

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	714.87	1.37	391.	22493.	5.36	42.50	37.00
.50	713.87	.37	320.	11163.	.92	42.50	38.50
.40	713.91	.41	322.	10151.	.92	40.00	39.00
.30	713.83	.33	317.	9990.	.90	40.50	39.50
.20	713.96	.46	326.	9652.	.92	41.50	40.50
.10	713.79	.29	314.	7604.	1.30	43.38	42.50

PLAN 1 STATION REACH4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	22184.	707.1	43.00
.50	11029.	704.2	43.00
.40	8842.	703.4	43.00
.30	7739.	703.0	41.00
.20	7156.	702.7	41.50
.10	5821.	702.1	43.50

END 11-79