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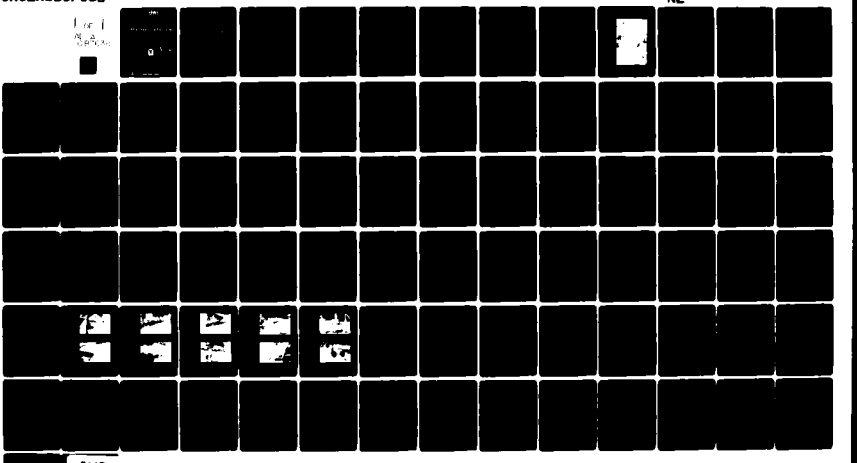

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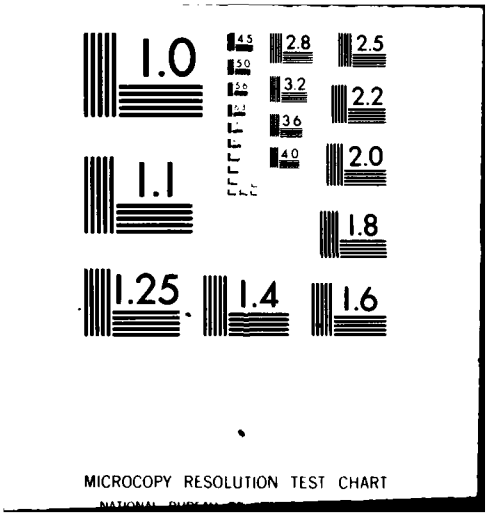
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LEVEL II

RARITAN RIVER BASIN
CRANBURY BROOK, MIDDLESEX COUNTY
NEW JERSEY

BRAINERD LAKE DAM
NJ 00152

AD A087638

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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

MARCH 1980

APPROVED FOR PUBLIC RELEASE;
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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(10) Richard McDermott

REPORT DOCUMENTATION PAGE

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Visual Inspection
Strucutral Analysis
National Dam Safety Program
Brainerd Lake Dam, New Jersey
Spillway

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

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

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

IN REPLY REFER TO
NAPEN-N

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

04 AUG 1980

Dear Governor Byrne:

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

Based on visual inspection, available records, calculations and past operational performance, Brainerd Lake Dam, initially listed as a "high" hazard potential structure, but reduced to a "significant" hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The dam's spillway is considered inadequate because a flow equivalent to 17 percent of the 100-year flood would cause the dam to be overtopped. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The adequacy of the spillway should be determined using more precise and sophisticated methods and procedures by a qualified, professional consultant, engaged by the owner, within six months from the date of approval of this report. Within three months of the consultant's findings, remedial measures to ensure spillway adequacy should be initiated.

b. Within six months from the date of approval of this report the following remedial actions should be initiated:

(1) With the lake drawn down, the masonry wall on the upstream side of dam should be thoroughly inspected and repaired.

(2) The spillway structure and discharge culvert should be thoroughly inspected and repaired with the lake drawn down. Special attention should be given to the possibility of leakage in the spillway structure around the outlet works and to the crack at the downstream end of the discharge culvert.

(3) Trees on the embankment should be removed.

(4) The partially rotted planks on the walkway should be replaced.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

e. The owner should develop an emergency action plan together with an effective warning system outlining actions to be taken by the operator to minimize downstream effects of an emergency at the dam within six months from the date of approval of this report.

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

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

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

Sincerely,

1 Incl
As stated

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

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

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

BRAINERD LAKE DAM (NJ00152)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 12 November 1979 by Storch Engineers under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Brainerd Lake Dam, initially listed as a "high" hazard potential structure, but reduced to a "significant" hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The dam's spillway is considered inadequate because a flow equivalent to 17 percent of the 100-year flood would cause the dam to be overtopped. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The adequacy of the spillway should be determined using more precise and sophisticated methods and procedures by a qualified, professional consultant, engaged by the owner, within six months from the date of approval of this report. Within three months of the consultant's findings, remedial measures to ensure spillway adequacy should be initiated.

b. Within six months from the date of approval of this report the following remedial actions should be initiated:

(1) With the lake drawn down, the masonry wall on the upstream side of dam should be thoroughly inspected and repaired.

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(3) Trees on the embankment should be removed.

(4) The partially rotted planks on the walkway should be replaced.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

e. The owner should develop an emergency action plan together with an effective warning system outlining actions to be taken by the operator to minimize downstream effects of an emergency at the dam within six months from the date of approval of this report.

APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 9 July 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Brainerd Lake Dam, N.J.00152
State Located:	New Jersey
County Located:	Middlesex
Drainage Basin:	Raritan River
Stream:	Cranbury Brook
Date of Inspection:	November 12, 1979

Assessment of General Condition of Dam

Based on visual inspection, past operational performance and Phase I engineering analysis, Brainerd Lake Dam is assessed as being in fair overall condition.

Based on investigations of the downstream flood plain made in connection with this report, it is recommended that the hazard potential classification be downgraded from high to significant hazard.

Hydraulic and hydrologic analyses indicate that the spillway is inadequate. Discharge capacity of the spillway is not sufficient to pass the designated spillway design flood (100-year storm) without an overtopping of the dam. The spillway is capable of passing approximately 16 percent of the spillway design flood. Therefore, the owner should engage a professional engineer experienced in the design and construction of dams in the near future to perform more accurate hydraulic and hydrologic analyses. Based on the findings of the analyses, the need for and type of remedial measures should be determined and then implemented.

The owner should, in the near future, develop an emergency action plan together with an effective warning system outlining actions to be taken by the operator to minimize downstream effects of an emergency at the dam.

In addition, it is recommended that the following remedial measures be implemented by the owner in the near future.

1) With the lake drawn down, the masonry wall on the upstream side of dam should be thoroughly inspected and repaired.

2) The spillway structure and discharge culvert should be thoroughly inspected and repaired with the lake drawn down. Special attention should be given to the possibility of leakage in the spillway structure around the outlet works. Also, special attention should be given to the crack at the downstream end of the discharge culvert.

3) Trees on the embankment should be removed.

4) The partially rotted planks on the walkway should be replaced.

In the near future, the owner of the dam should develop written operating procedures and a periodic maintenance plan to insure the safety of the dam.

Richard J. McDermott, P.E.

John E. Gribbin, P.E.

OVERVIEW - BRAINERD LAKE DAM

29 NOVEMBER 1979

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 30214. 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 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 the unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

BRAINERD LAKE DAM, I.D. NJ00152

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972 authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The Division of Water Resources of the New Jersey Department of Environmental Protection (NJDEP) in cooperation with the Philadelphia District of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the State of New Jersey. Storch Engineers has been retained by the NJDEP to inspect and report on a selected group of these dams. The NJDEP is under agreement with the Philadelphia District of the Corps of Engineers.

b. Purpose of Inspection

The visual inspection of Brainerd Lake Dam was made on November 12, 1979. The purpose of the inspections was to make a general assessment of the structural integrity and operational adequacy of the dam structure and its appurtenances.

1.2 Description of Project

a. Description of Dam and Appurtenances

Brainerd Lake Dam consists of an earthfill, roadway embankment, with a concrete horseshoe, overflow spillway. Water which passes over the spillway discharges through the dam via a stone and brick arch culvert.

The overall length of the dam, which is oriented north/south, is 382 feet. The embankment has a top width of approximately 40 feet. A public paved road in generally good condition is located on the crest. The downstream face of the embankment is grass covered and has a uniform slope of 3 horizontal to 1 vertical. The upstream face of the dam consists of a vertical masonry wall with a concrete cap. The crest elevation of the dam is 90.1 National Geodetic Vertical Datum (N.G.V.D.) and the elevation of the stream bed downstream from the dam is 77.6. The height of the dam is 12.5 feet. The concrete, horseshoe shaped spillway has verticle faces both upstream and downstream, with a crest breadth of 1.2 feet and overall length of 34 feet. The spillway crest elevation is 87.2 (N.G.V.D.).

The outlet works operating mechanism is located at the center of the spillway crest and obstructs 2 feet of its length. The outlet works consists of a 42-inch diameter opening in the upstream end of the spillway structure controlled by a lift gate fitted to the upstream side of the wall.

A timber walkway with steel pipe railings spans the spillway stilling basin and connects the outlet control with the upstream face of dam.

b. Location

Brainerd Lake Dam is located in the Township of Cranbury, Middlesex County, New Jersey. The dam impounds Brainerd Lake, used primarily for recreational purposes. Discharge from the spillway of the dam flows into Cranbury Brook. Access to the dam is provided by a county road (Route 535), known as Georges Road or Main Street, which traverses the dam crest.

c. Size and Hazard Classification

Size and Hazard Classification criteria presented in "Recommended Guidelines for Safety Inspection of Dams," published by the U.S. Army Corps of Engineers are as follows:

SIZE CLASSIFICATION

	Impoundment	
	Storage (Ac-ft)	Height (Ft.)
Small	<1000 and 50	<40 and ≥ 25
Intermediate	≥ 1000 and $50,000$	≥ 40 and < 100
Large	$\geq 50,000$	≥ 100

HAZARD POTENTIAL CLASSIFICATION

Category	Loss of Life (Extent of Development)	Economic Loss (Extent of Development)
Low	None expected (no permanent structures for human habitation	Minimal (Undeveloped to to occasional structures or agriculture)
Significant	Few (No urban developments and no more than a small number of inhabitable structures	Appreciable (Notable agriculture, industry or structures)
High	More than a small number	Excessive (Extensive community, industry or agriculture)

The following data relating to size and downstream hazard for Brainerd Lake Dam have been obtained for this Phase I assessment:

Storage: 152 Acre-feet (At top of dam)

Height: 12.5 feet

Potential Loss of Life:

Heavily used road (Main Street) traverses dam crest. Failure of dam could possibly cause loss of life.

Potential Economic Loss:

Dam failure would cause severe damage to Main Street which is a heavily used county road (Route 535).

Therefore, Brainerd Lake Dam is classified as "Small" size and "Significant" hazard potential.

d. Ownership

Brainerd Lake Dam is owned by the County of Middlesex, P. O. Box 1110, New Brunswick, New Jersey 08903.

e. Purpose of Dam

The purpose of the dam is the impoundment of a lake used for recreation.

f. Design and Construction History

Brainerd Lake Dam reportedly was originally constructed in 1840. It is also believed to have been rebuilt in 1910. No plans for the construction of the dam could be obtained for this report.

g. Normal Operation Procedures

The dam and appurtenances are operated by the Township of Cranbury, whereas maintenance is performed by the County of Middlesex, Department of Roads and Bridges. There is no fixed schedule of maintenance; repairs are made as the need arises.

The outlet works is used to drain the lake for maintenance purposes and during times of high water level to attenuate flooding conditions.

1.3 Pertinent Data

a.	Drainage Area	10.8 square miles
b.	Discharge at Damsite	
	Maximum flood at damsite	Unknown
	Outlet works at pool elevation	121 c.f.s.
	Spillway capacity at top of dam	524 c.f.s.
c.	Elevation (N.G.V.D.)	
	Top of dam	90.1
	Maximum pool-design surcharge	91.8
	Recreation pool	88.0
	Spillway crest	87.2
	Stream bed at centerline of dam	77.6
	Maximum tailwater	84.0 (Estimated)

d. Reservoir

Length of maximum pool	4200 feet (Estimated)
Length of recreation pool	3800 feet (Scaled)

e. Storage (Acre-feet)

Recreation pool	60 acre-feet
Design surcharge	318 acre-feet
Top of dam	152 acre-feet

f. Reservoir Surface (Acres)

Top of dam	132 acres (Estimated)
Maximum pool	222 acres (Estimated)
Recreation pool	22 acres
Spillway crest	20 acres

g. Dam

Type	Earthfill road embankment
Length	382 feet
Height	12.5 feet
Sideslopes	
Embankments - Upstream	Vertical
- Downstream	3 horiz. to 1 vert.
Zoning	Unknown
Impervious core	Unknown
Cutoff	Unknown
Grout curtain	Unknown

h. Diversion and Regulating Tunnel N.A.

i. Spillway

Type	Uncontrolled concrete weir
Length of weir	32 feet
Crest elevation	87.2
Gates	N.A.
Approach channel	N.A.
Discharge channel	Stone and brick arch culvert through dam

j. Regulating Outlet

42-inch diameter lift gate

SECTION 2: ENGINEERING DATA

2.1 Design

No calculations, reports or plans pertaining to the design of the dam are available.

2.2 Construction

No data or reports pertaining to the construction of the dam are available.

2.3 Operation

No records of operation of the lake or dam and no inspection reports subsequent to construction are available.

2.4 Evaluation

a. Availability

No engineering information is available for the subject dam.

b. Adequacy

Available engineering data pertaining to Brainerd Lake Dam are not adequate to be of significant assistance to the performance of a Phase I evaluation. A list of absent information is included in paragraph 7.1.b.

c. Validity

The validity of engineering data cannot be assessed due to the absence of data.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

The inspection of Brainerd Lake Dam took place on November 12, 1979 by members of the staff of Storch Engineers. A copy of the visual inspection check list is contained in Appendix 1. The following procedures were employed for the inspection:

1) The embankment of the dam, appurtenant structures and adjacent areas were examined.
2) The embankment and appurtenant structures were measured and key elevations determined by a surveyor's level.
3) The embankment and appurtenant structures and adjacent areas were photographed.
4) Depths of water were measured at various locations in the lake.

b. Dam

The dam embankment forms the base for a roadway, paved with bituminous pavement, which appeared to be in good condition. A few trees were observed along both sides of the roadway. There were no signs of settlement, seepage, or sloughing of the embankment.

A stone masonry wall with a concrete cap forms the upstream face of the dam embankment. The concrete cap is in generally good condition, however the stone wall shows signs of deterioration, with some stones and mortar dislodged. A concrete patch approximately 15 feet long was observed near the south end of the wall.

The downstream slope of the embankment, north of the discharge channel was grass-covered, uniformly graded and in good condition. The downstream face south of the discharge channel consists of a concrete wall which forms the wingwall for the discharge channel and a stone masonry wall running parallel to the dam. The stone masonry wall was in generally satisfactory condition with evidence of numerous patches in the grout. Minor erosion was observed at the junction of the downstream face of the dam and spillway discharge culvert.

c. Spillway

The spillway structure consists of a concrete, horseshoe-shaped wall located at the upstream end of the arch culvert. Although the surfaces were obscured by overflow, the structure appeared generally sound. The crest appeared to be partially spalled. The apron forming the bottom of the small stilling basin encircled by the spillway weir was obscured by tailwater and not observed.

Two planks in the walkway were partially rotted although the remainder of the walkway and railing was in generally good condition.

The brick surface of the culvert appeared to be in generally satisfactory condition with some patching and loose bricks noted on the north side near the upstream end. A crack, or separation, between the brickwork and stonework at the downstream end was noted.

d. Outlet Works

The outlet works consist of a 42-inch diameter lift gate located in the spillway structure. The upstream side of the gate was submerged and the downstream side was obstructed by the discharge over the spillway. Reportedly, during dry periods signs of leakage are visible from the downstream side.

There was no operating wheel on the outlet mechanism and therefore the gate was not tested at the time of inspection.

e. Downstream Channel

Flow through the arch culvert discharges into a natural stream lined by a concrete wall on the south side, and stone rubble walls and riprap on the north side. The condition of the concrete was good, although the wall was leaning into the stream approximately 6 inches.

f. Reservoir Area

Brainerd Lake is long and narrow averaging 250 feet in width and 3800 feet in length. Shores of the lake are grassed on the west portion and generally wooded along the east, or upstream portion of the lake. Soundings at various locations in the lake indicated little accumulation of sediment.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

The water level in Brainerd Lake is regulated naturally by discharge over the spillway. Reportedly each year the outlet works are opened to permit a drawdown of approximately 4 feet to allow maintenance of lakefront properties. Also, the outlet is opened at times of intense storms in order to attenuate flood water level.

The time required to draw down the lake is estimated to be approximately 8 hours.

4.2 Maintenance of the Dam

There is no program of regular inspection and maintenance of the dam and appurtenant structures. Maintenance is performed on an "as needed" basis.

4.3 Maintenance of Operating Facilities

Maintenance of operating facilities is performed on an "as needed" basis.

4.4 Description of Warning System

Reportedly, no formal warning system is in use at the present time.

4.5 Evaluation of Operational Adequacy

The operation of the dam has been unsatisfactory to the extent that the dam was reportedly overtopped by 18 inches in the summer of 1975.

Maintenance documentation is poor but the overall condition of the dam indicates that significant attention has been directed toward the upkeep of the dam. However, areas of maintenance that have not been adequately performed are:

1) Trees on embankment not removed.

2) Stone masonry wall on upstream face of dam not completely repaired.

3) Some deterioration of brick arch culvert not completely repaired.

4) Two partially rotted planks in walkway not replaced.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

The quantity of storm water runoff that the spillway should be able to pass without an overtopping of the dam is based on the size and hazard classification of the dam. This runoff, called the Spillway Design Flood (SDF), is described in terms of frequency or probable maximum flood (PMF) depending on the extent of the dam's size and potential hazard. According to the "Recommended Guidelines for Safety Inspection of Dams," published by the U.S. Army Corps of Engineers, the SDF for Brainerd Lake Dam falls in a range of 100-year frequency to 1/2 PMF. In this case, the low end of the range, 100-year frequency, is chosen since the factors used to select size classification are on the low side of their respective ranges.

The SDF hydrograph for Brainerd Lake was computed by use of the HEC-1-DB computer program using the SCS Method. Hydrologic computations and computer output are contained in Appendix 4. The calculated SDF peak inflow for Brainerd Lake Dam is 3222 c.f.s.

Discharge capacity for the spillway was computed by considering free discharge over the spillway weir. Hydraulic computations are contained in Appendix 4. The spillway discharge with lake level equal to the top of dam was computed to be 524 c.f.s.

The SDF was routed through the dam by the use of the HEC-1-DB computer program using the modified Puls method. In routing the SDF, it was found that the dam would be

overtopped by a depth of 1.7 feet above the crest. Accordingly, the subject spillway is assessed as being inadequate in accordance with criteria developed by the U.S. Army Corps of Engineers.

b. Experience Data

Reportedly, Brainerd Lake Dam was overtopped by 18 inches in 1975. Apparently no significant damage was sustained by the dam or the downstream area at that time.

c. Visual Observation

No evidence was found at the time of inspection that would indicate that the dam had been overtopped.

d. Overtopping Potential

As indicated in paragraph 5.1.a, a storm of magnitude equivalent to the SDF would cause overtopping of the dam by a height of 1.7 above the top of the dam. The spillway is capable of passing approximately 16 percent of the SDF.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The embankment appeared, at the time of inspection, to be outwardly stable. No significant indications of distress were observed nor was settlement, seepage or sloughing noted.

b. Generalized Soil Description

The generalized soils description of the dam site consists of recent alluvium, composed of stratified materials deposited by streams, overlying a discontinuous mantle of stratified, alluvial material deposited during the Quaternary period, known as the Pensauken Formation. The Quaternary deposits consist of sand, silty sand and sandy silt. The underlying formations are consolidated Cretaceous sediments known as Magothy and Raritan Formations.

c. Design and Construction Data

Analyses of structural stability and construction data for the embankment and spillway structure are not available.

d. Operating Records

No operating records are available for the dam. The water level of Brainerd Lake is not monitored.

e. Post Construction Changes

No records of any post construction changes are available.

f. Seismic Stability

Brainerd Lake Dam is located in Seismic Zone 1 as defined in "Recommended Guideline for Safety Inspection of Dams," which is a zone of very low seismic activity. Experience indicates that dams in Seismic Zone 1 will have adequate stability under seismic loading conditions if they have adequate stability under static loading conditions. Brainerd Lake Dam appeared to be outwardly stable under static loading conditions at the time of inspection.

SECTION 7: ASSESSMENT AND RECOMMENDATIONS

7.1 Dam Assessment

a. Based on hydraulic and hydrologic analyses outlined in Section 5 and Appendix 4, the spillway of Brainerd Lake Dam is considered inadequate. The spillway is not able to pass the SDF designated for the dam without an overtopping of the dam.

The dam appeared to be outwardly stable at the time of inspection. However, sufficient data is not available to allow a complete assessment of the present structural condition of the dam and appurtenances.

b. Adequacy of Information

Information sources for this study include 1) field inspection, 2) USGS quadrangle sheet, 3) aerial photography from Middlesex County, and 4) consultation with maintenance and operations personnel from Middlesex County and Cranbury Township.

The information obtained is sufficient to allow a Phase I assessment as outlined in "Recommended Guidelines for Safety Inspection of Dams."

Some data not available are as follows:

1) Stream and lake gaging records.
2) Description of dam embankment structures and materials.
3) Hydraulic and structural design reports.
4) Construction and as-built drawings.
5) Maintenance documentation.
6) Inspection reports.

c. Necessity for Additional Data/Evaluation

Although engineering data pertaining to Brainerd Lake Dam is not available, additional data are not considered imperative for this Phase I evaluation.

7.2 Recommendations

a. Remedial Measures

Based on hydraulic and hydrologic analyses outlined in paragraph 5.1.a, the spillway is considered to be inadequate. Therefore, it is recommended that a professional engineer experienced in the design and construction of dams be engaged in the near future to perform more accurate hydraulic and hydrologic analyses. Based on the findings of these analyses, the need for and type of remedial measures should be determined and then implemented.

The owner should, in the near future, develop an emergency action plan together with an effective warning system outlining actions to be taken by the operator to minimize downstream effects of an emergency at the dam.

In addition, it is recommended that the following remedial measures be implemented by the owner in the near future.

1) With the lake drawn down, the masonry wall on the upstream side of dam should be thoroughly inspected and repaired.

2) The spillway structure and discharge culvert should be thoroughly inspected and repaired with the lake drawn down. Special attention should be given to the possibility of leakage in the spillway structure

around the outlet works. Also, special attention should be given to the crack at the downstream end of the discharge culvert.

3) Trees on the embankment should be removed.

4) The partially rotted planks on the walkway should be replaced.

b. Maintenance

In the near future, the owner of the dam should develop written operating procedures and a periodic maintenance plan to insure the safety of the dam.

PLATES

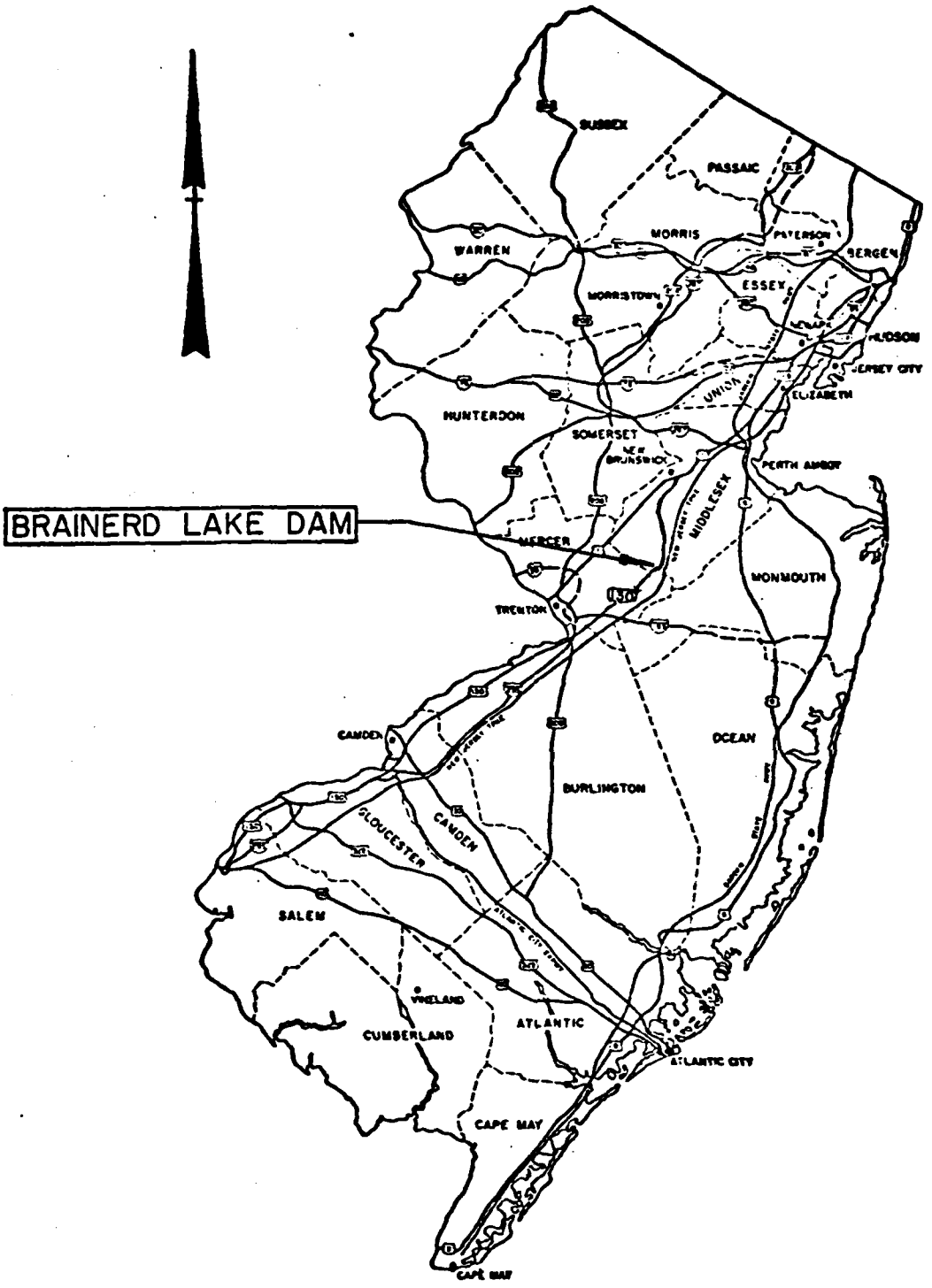


PLATE 1

STORCH ENGINEERS
FLORHAM PARK, NEW JERSEY

DIVISION OF WATER RESOURCES
N.J. DEPT. OF ENVIR. PROTECTION
TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

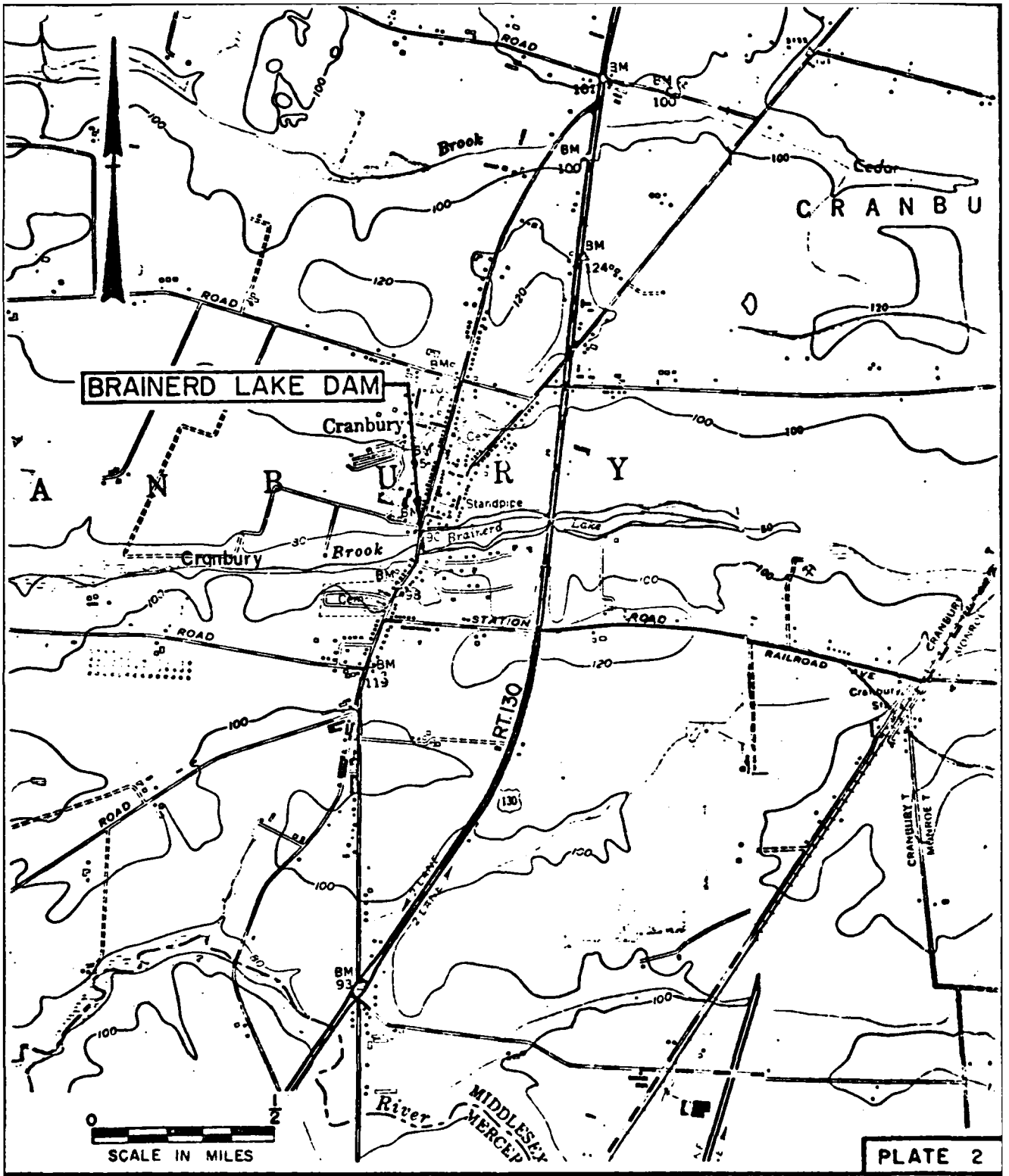
KEY MAP

BRAINERD LAKE DAM

I.D. N.J. 00152

SCALE: NONE

DATE: NOV., 1979



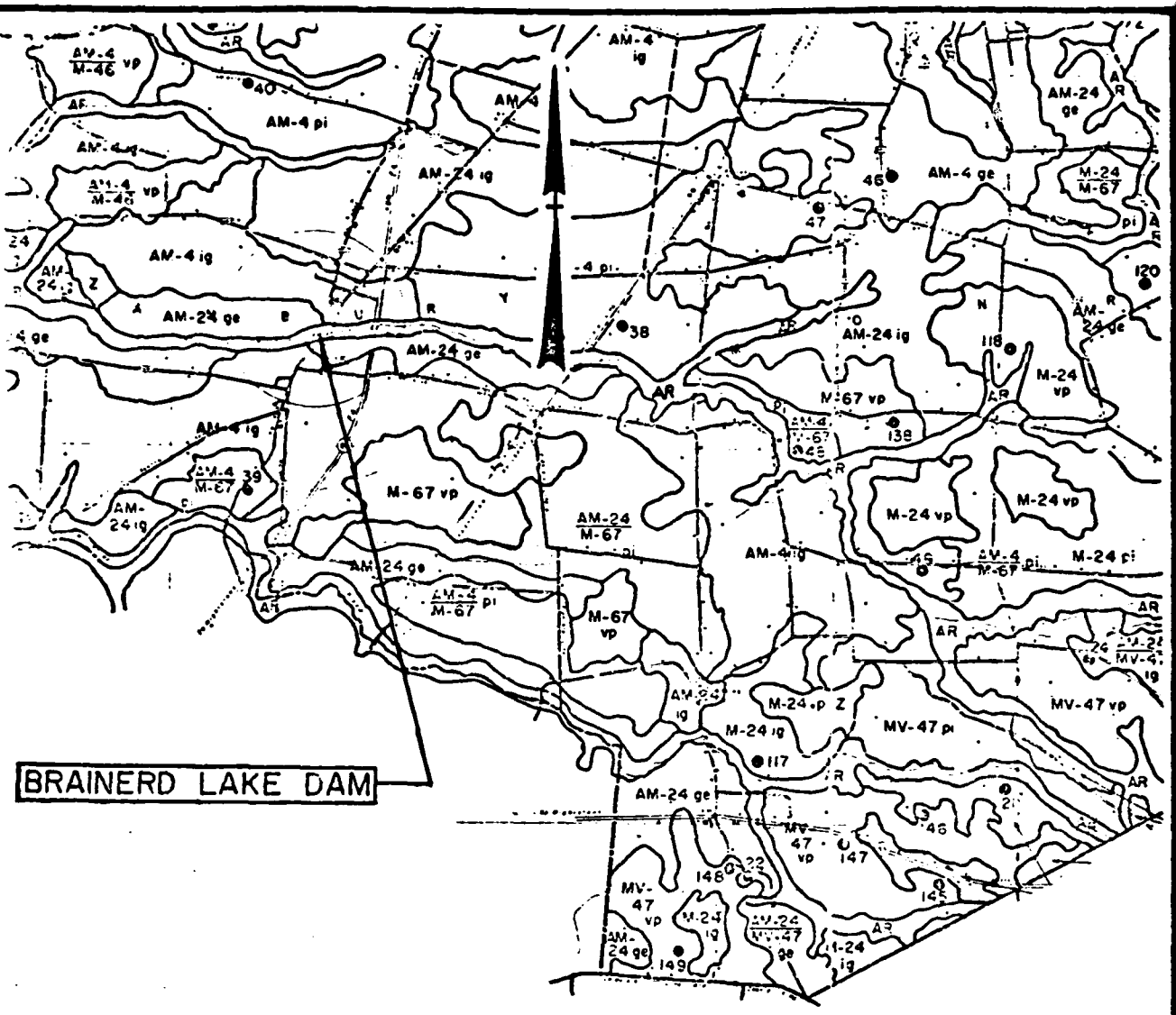
STORCH ENGINEERS
FLORHAM PARK, NEW JERSEY

DIVISION OF WATER RESOURCES
N.J. DEPT. OF ENVIR. PROTECTION
TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

VICINITY MAP
BRAINERD LAKE DAM

I. D. N.J. 00152	SCALE: AS SHOWN
	DATE: NOV., 1979



Legend

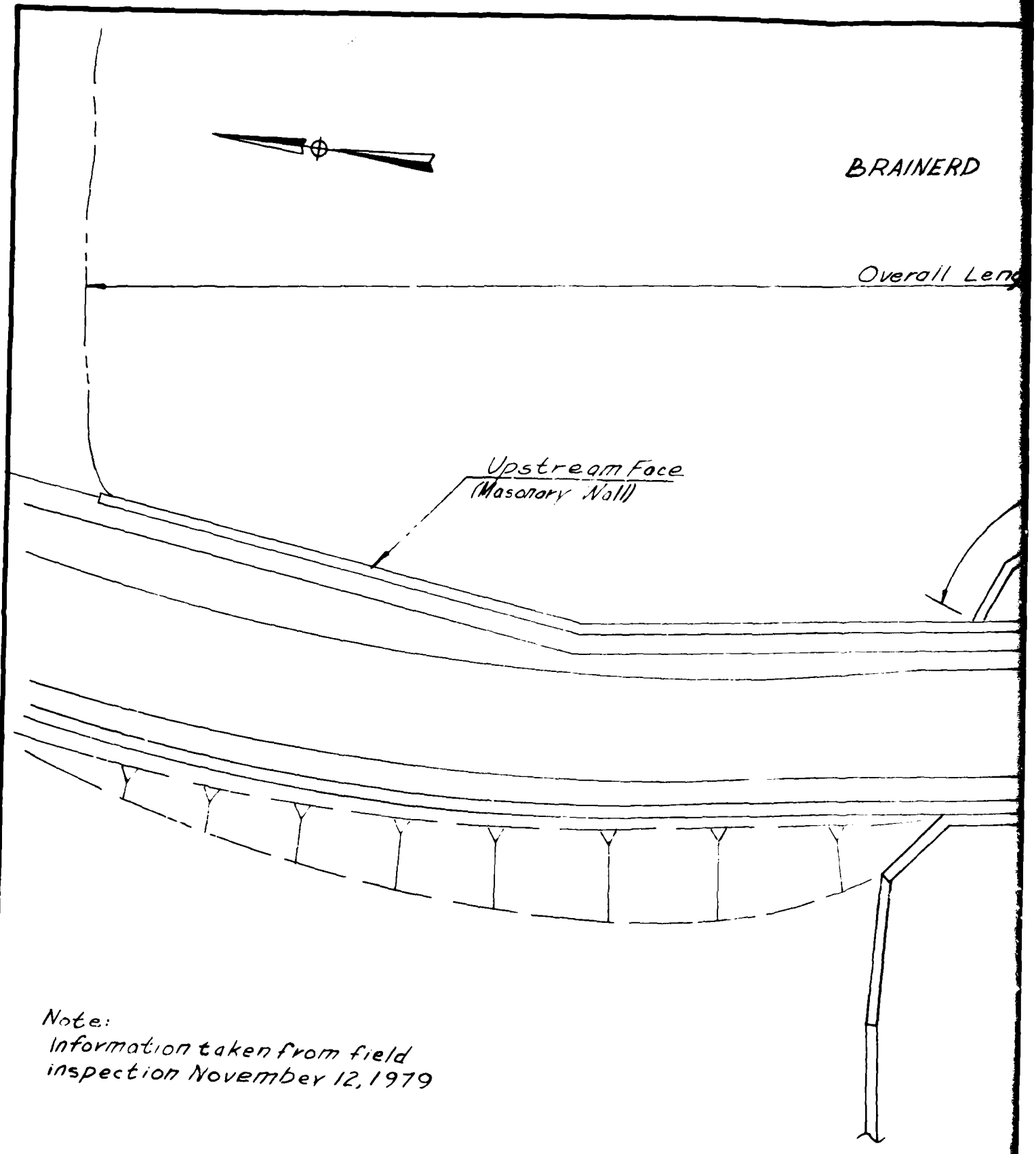
AR — Recent alluvium composed of stratified materials deposited by streams.

AM-24 — Sand, silty sand and sandy silt deposited during the Quanterary period. (Pensauken Formation).

NOTE: Information taken from Rutgers University Soil Survey of New Jersey, Report No. 10, Middlesex County, and Geological Map of New Jersey prepared by Lewis and Kummel.

PLATE 3

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS SOIL MAP BRAINERD LAKE DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. NJ 00152 — SCALE: NONE DATE: NOV., 1979



Note:
Information taken from field
inspection November 12, 1979

ERD LAKE

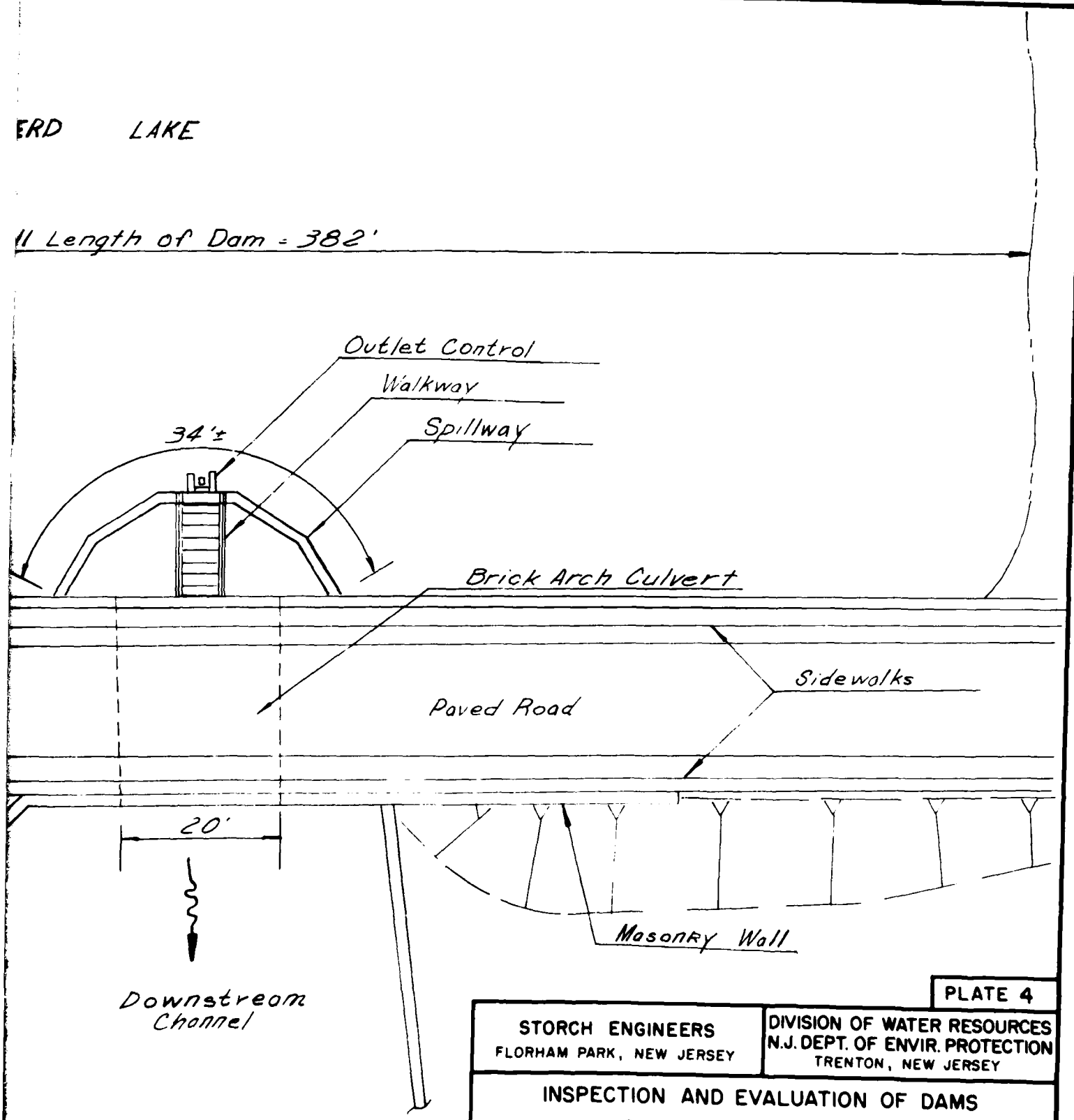


PLATE 4

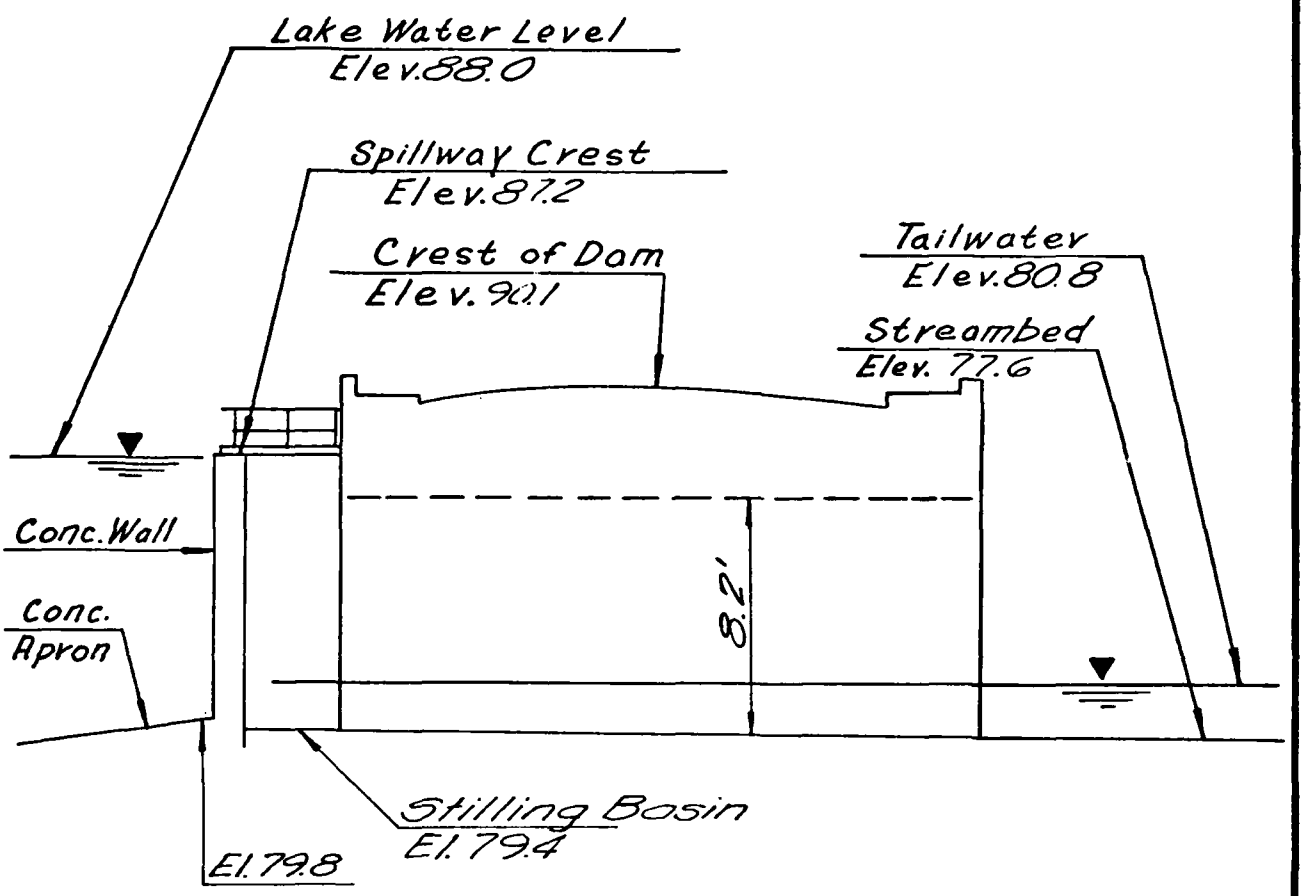
STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

GENERAL PLAN

BRAINERD LAKE DAM

I.D. N.J. 00152	SCALE: NO TO SCALE
	DATE: DEC. 1979

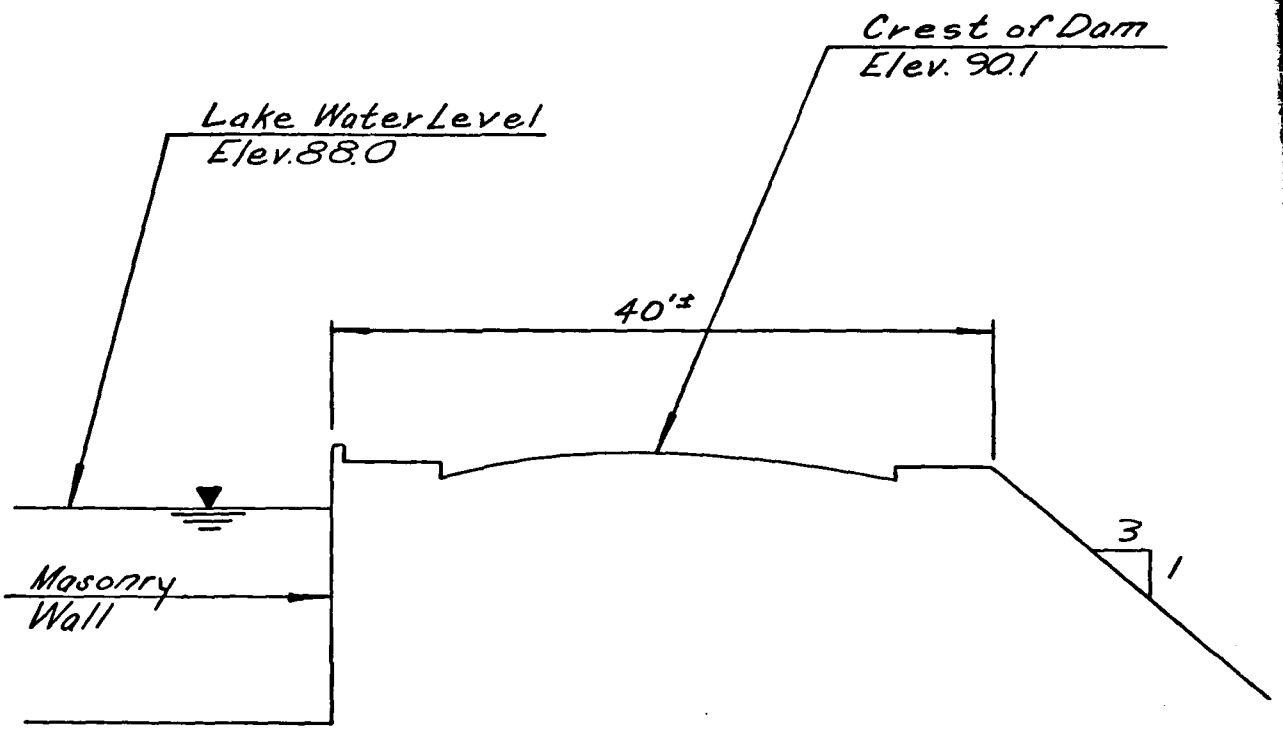


Notes:

1. Information taken from field inspection November 12, 1979.
2. Elevations based on Benchmark provided by the Town of Cranbury.

PLATE 5

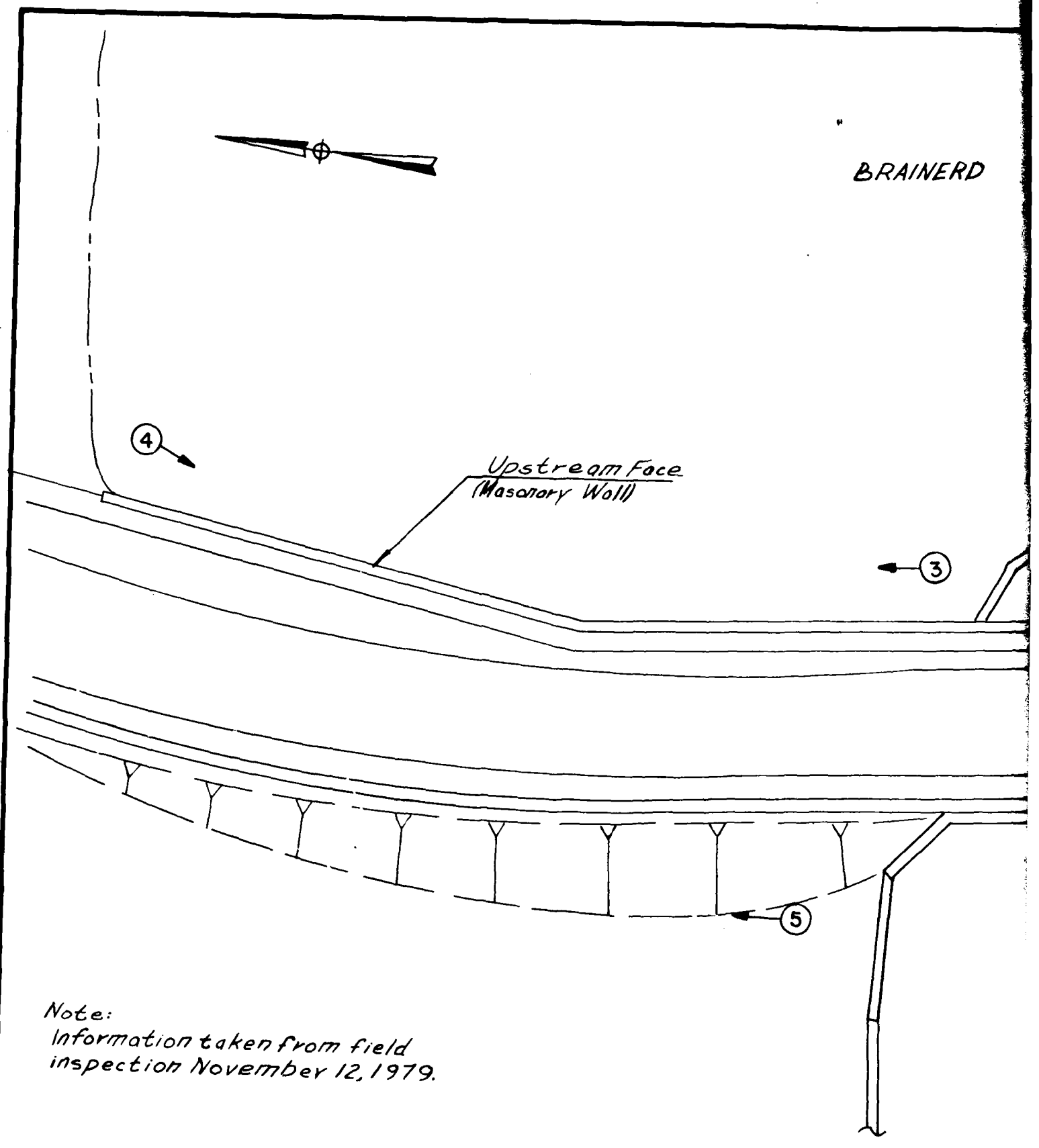
STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS SPILLWAY SECTION BRAINERD LAKE DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. N.J. 00152 — SCALE: NOT TO SCALE DATE: DEC. 1979



Notes:
1. Information taken from plan by John E. Studer September, 1949 and field inspection November 19, 1979
2. Elevations based on Benchmark provided by Township of Cranbury.

PLATE 6

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS **DAM SECTION** BRAINERD LAKE DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. N.J. 00152 — SCALE: NOT TO SCALE DATE: JAN. 1980



Note:
Information taken from field
inspection November 12, 1979.

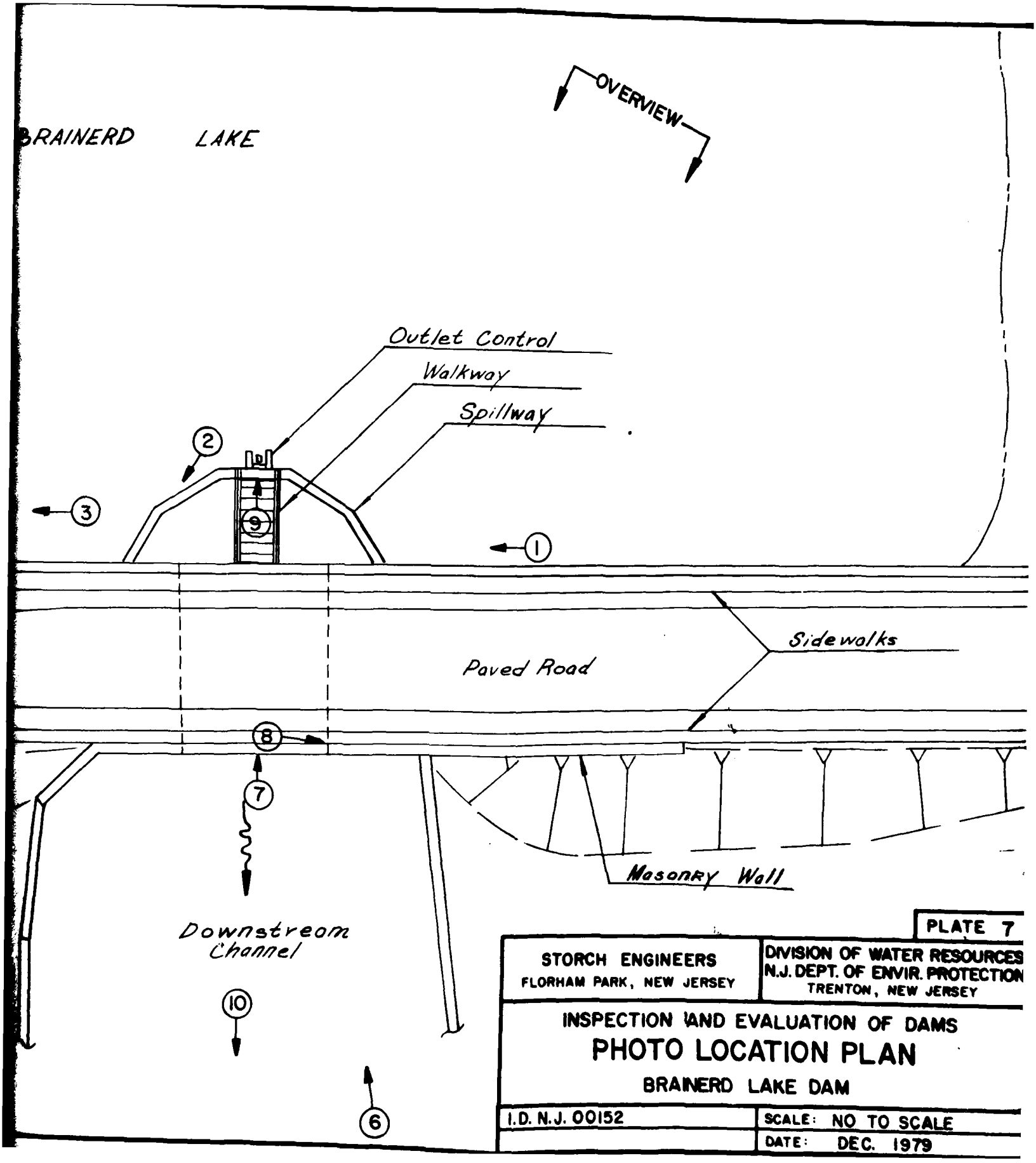


PLATE 7

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

PHOTO LOCATION PLAN

BRAINERD LAKE DAM

I.D. N.J. 00152	SCALE: NO TO SCALE
	DATE: DEC. 1979

APPENDIX 1

Check List - Visual Inspection

Check List - Engineering Data

Check List
Visual Inspection
Phase I

Name of Dam Brainerd Lake Dam County Middlesex State New Jersey Coordinators NJDEP

Date(s) Inspection 11/12/79 Weather P-Cloudy Temperature 45°F

Pool Elevation at Time of Inspection 88.0 M.S.L. Tailwater at Time of Inspection 80.8 M.S.L.

Inspection Personnel:

John Gribbin Alan Volle

Ronald Lai Thomas Miller

Richard McDermott

J. Gribbin Recorder

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
GENERAL	Paved roadway on crest of embankment in generally satisfactory condition. Downstream face uniformly graded and grass covered. A few trees were observed along both sides of the roadway.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Junction between spillway and embankment generally sound with minor erosion.	
ANY NOTICEABLE SEEPAGE	None observed.	
STAFF GAGE AND RECORDER	None observed.	
DRAINS	No toe drains observed. Storm water drains discharging into lake appeared to be in generally satisfactory condition. Weep holes in stone masonry wall at spillway observed - condition could not be determined.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	No sloughing observed. Minor erosion observed at junction of downstream face of dam and spillway discharge culvert.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Vertical: Generally level. Horizontal: Straight	
UPSTREAM FACE	Stone masonry wall appeared generally stable with some deterioration including dislodged stones and mortar.	Upstream face is formed by stone masonry wall with concrete cap. Recommend repair of wall with lake drawn down.

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SURFACES IN OUTLET CONDUIT	Not observed.	
INTAKE STRUCTURE	Not observed. (Submerged)	Recommend inspection with lake drawn down.
OUTLET STRUCTURE	Not observed - obscured by discharge over spillway.	
OUTLET CHANNEL	Same as spillway discharge channel.	
GATE AND GATE HOUSING	Gate not observed. Operating mechanism appeared to be in satisfactory condition, not operated at time of inspection.	

SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
WEIR	Spillway structure appeared generally sound - surfaces were obscured by discharge. Concrete crest was partially spalled.	
APPROACH CHANNEL	N.A.	
DISCHARGE CHANNEL	Brick surface of culvert appeared to be generally satisfactory with some patching and loose bricks noted on the north side near the upstream end. A crack, or separation, between the brickwork and stonework at the downstream end was noted.	Discharge channel consists of brick arch culvert through dam.
APRON	The apron forming the bottom of a small stilling basin encircled by the spillway weir was obscured by tail water and not observed.	

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	N.A.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Shores of lake are grassed along the west portion of the lake and wooded along the east portion. Slopes are approximately 6 horiz. to 1 vert.	
SEDIMENTATION	Soundings at various locations in the lake indicated the presence of little sediment accumulation.	
STRUCTURES ALONG BANKS	Several dwellings are located along the west portion of the lake. The Route 130 bridge is located on the lake approximately 1800 feet from its west end.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The downstream channel is a natural stream with walled sides in the vicinity of the dam. No significant obstructions were observed.	
SLOPES	Bank slopes vary from 10 horiz. to 1 vert. to 2 horiz. to 1 vert. Banks are generally wooded.	
STRUCTURES ALONG BANKS	Two dwellings are located in the vicinity of the dam and lie above its crest. One shed is located approximately 1300 feet downstream.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM		REMARKS
DAM -	PLAN	Not Available
	SECTIONS	
SPILLWAY -	PLAN	Not Available
	SECTIONS	
	DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS		Not Available
OUTLETS -	PLAN	Not Available
	DETAILS	
	CONSTRAINTS	
	DISCHARGE RATINGS	
HYDRAULIC/HYDROLOGIC DATA		Not Available
RAINFALL/RESERVOIR RECORDS		Not Available
CONSTRUCTION HISTORY		Not Available
LOCATION MAP		Not Available

ITEM	REMARKS
DESIGN REPORTS	Not Available
GEOLOGY REPORTS	Not Available
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Not Available
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Not Available
POST-CONSTRUCTION SURVEYS OF DAM	Not Available
BORROW SOURCES	Not Available

ITEM	REMARKS
MONITORING SYSTEMS	Not Available
MODIFICATIONS	Not Available
HIGH POOL RECORDS	Not Available
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Not Available
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	Not Available
MAINTENANCE OPERATION RECORDS	Not Available

APPENDIX 2

Photographs

PHOTO 1

SPILLWAY

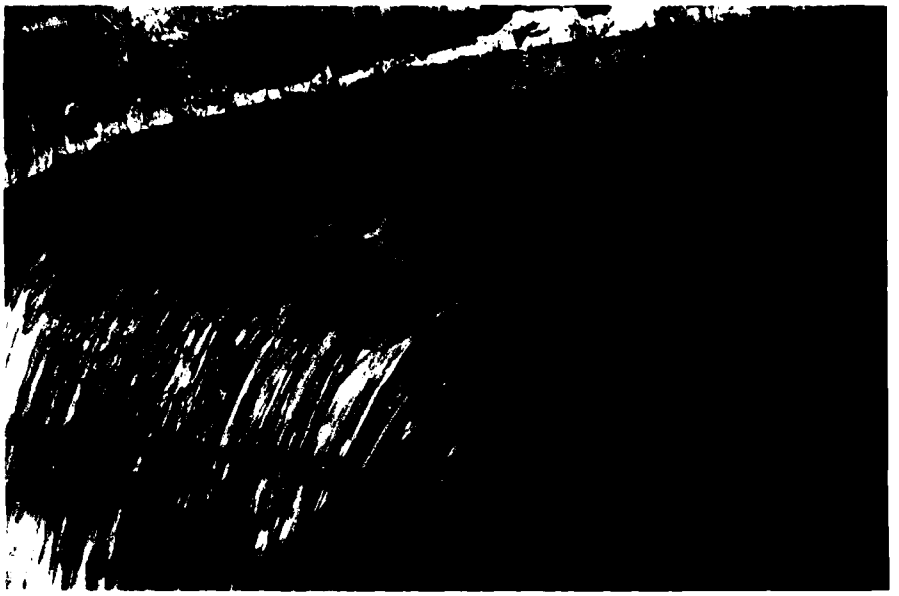


PHOTO 2

SPILLWAY CREST

BRAINERD LAKE DAM
12 NOVEMBER 1979

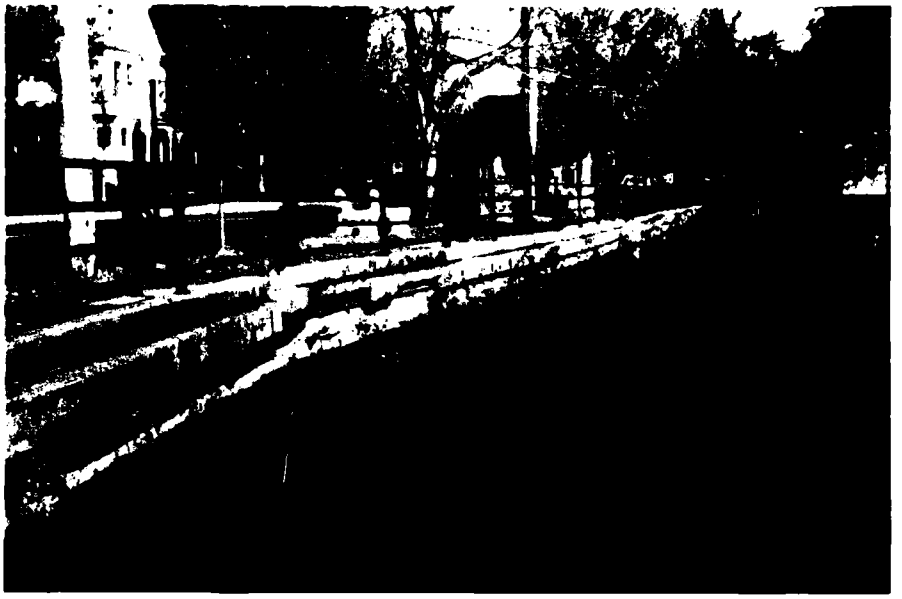


PHOTO 3

UPSTREAM FACE OF DAM - LOOKING NORTH

PHOTO 4

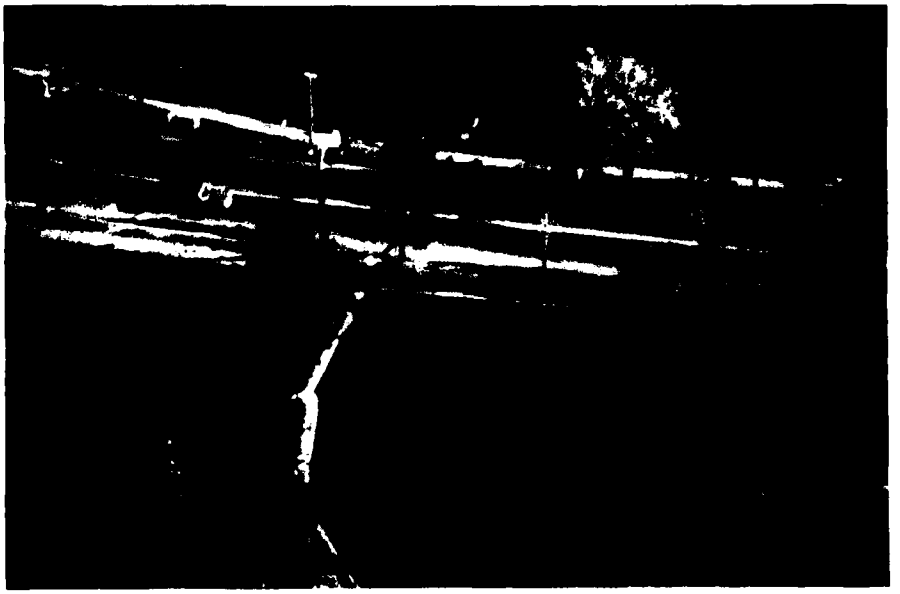
UPSTREAM FACE OF DAM - LOOKING SOUTH

BRAINERD LAKE DAM
12 NOVEMBER 1979

12 NOVEMBER 1979

PHOTO 5

DOWNSTREAM FACE OF DAM



29 NOVEMBER 1979

PHOTO 6

DOWNSTREAM VIEW OF SPILLWAY AND SPILLWAY DISCHARGE

BRAINERD LAKE DAM

PHOTO 7

SPILLWAY DISCHARGE CULVERT

PHOTO 8

CRACK AT DOWNSTREAM END OF DISCHARGE CULVERT

BRAINERD LAKE DAM
12 NOVEMBER 1979

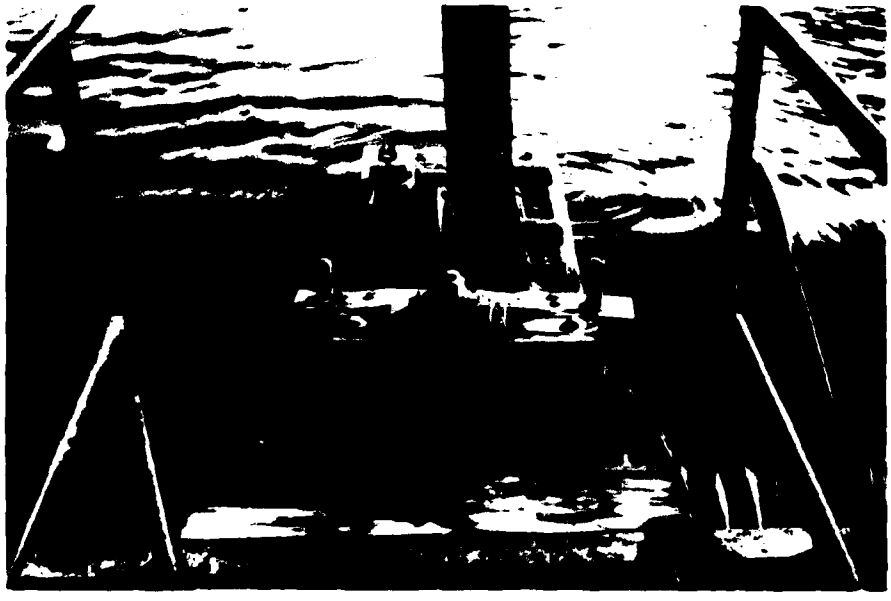


PHOTO 9

OUTLET WORKS OPERATING MECHANISM

PHOTO 10

DOWNSTREAM CHANNEL

BRAINERD LAKE DAM
12 NOVEMBER 1979

APPENDIX 3

Engineering Data

CHECK LIST

HYDROLOGIC AND HYDRAULIC DATA

ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Mostly undeveloped fields

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 88.0 (60 acre -feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N.A.

ELEVATION MAXIMUM DESIGN POOL: 91.8

ELEVATION TOP DAM: 90.1

SPILLWAY CREST: Uncontrolled concrete weir

a. Elevation 87.2
b. Type Broad crested
c. Width 1.2 feet
d. Length 32 feet
e. Location Spillover Upstream side of dam
f. Number and Type of Gates N. A.

OUTLET WORKS: 42-inch gate on upstream side of spillway wall

a. Type Sluice with lift gate
b. Location Upstream end of spillway structure
c. Entrance inverts 79.4
d. Exit inverts 79.4
e. Emergency draindown facilities: Open gate

HYDROMETEOROLOGICAL GAGES: None

a. Type N.A.
b. Location N.A.
c. Records N.A.

MAXIMUM NON-DAMAGING DISCHARGE:

(Lake stage equal to top of dam) 524 c.f.s.

APPENDIX 4

Hydraulic/Hydrologic Computations

HYDROLOGY

HYDROLOGIC ANALYSIS - RUNOFF HYDROGRAPH WILL BE DEVELOPED BY HEC-1-DB USING SCS TRIANGULAR HYDROGRAPH WITH CURVILINEAR TRANSFORMATION.

DRAINAGE AREA = 10.8 SQUARE MILES.

INFILTRATION DATA - MOSTLY UNDEVELOPED

USE: INITAL INFILTRATION = 1.5 INCHES
CONSTANT INFILTRATION = 0.15 INCHES/HOUR

TIME OF CONCENTRATION

BY SCS; TR-55 CHART ON OVERLAND FLOW

OVERLAND FLOW = 4000' @ 3.3% V = 1.3 FPS

CHANNEL FLOW = 43500' @ 0.16%; V = 1 FPS

$$T_C = \left[\frac{4000}{1.3} + \frac{43500}{1.0}\right] \frac{1}{3600}$$

T_C = 0.8 HOURS (OVERLAND) + 12.1 HOURS (CHANNEL)

T_C = 12.9 HOURS

OVERLAND TIME OF CONCENTRATION - BY KERBY
Ref: "HANDBOOK OF APPLIED HYDROLOGY" BY CHOW

$T_c^{2.14} = 2/3\ Ln/\sqrt{S}$

T_c = overland time of concentration (min)
L = length of overland flow (ft)
n = Roughness coefficient ($n = 0.4$)
S = slope (ft/ft)

$T_c^{2.14} = 2/3\ 4000\ (0.4)/\sqrt{.033}$

$T_c = 58$ MINUTES $= 0.96$ HOURS ~ 1.0 HOUR

TOTAL T_c: 1.0 HOURS (OVERLAND) + 12.1 HOURS (CHANNEL)

$T_c = 13.1$ HOURS

TIME OF CONCENTRATION - BY CALIFORNIA CULVERTS PRACTICE
Ref: "DESIGN OF SMALL DAMS" pg. 71

$$T_c = \left(\frac{11.9\ L^3}{H}\right)^{0.385}$$

T_c = time of concentration (hours)
L = length of watercourse (miles)
H = elevation difference (feet)

$$T_c = \left[\frac{11.9\ (8.2)^3}{70}\right]^{0.385}$$

$L = 43500' = 8.2$ MILES
$H = 70'$

$T_c = 5.74$ HOURS

TIME OF CONCENTRATION - BY SNYDER ref: pg 135 "INTRODUCTION TO HYDROLOGY" - VIESSMAN et al.

$$t_t = C_t (L L_{ca})^{0.3}$$

where:
- t_t = LAG TIME (HOURS)
- C_t = COEFFICIENT REPRESENTING VARIATIONS OF WATERSHED SLOPES & SURFACES (AVE = 2.0)
- L = LENGTH OF MAIN CHANNEL FROM OUTLET TO DIVIDE (9.0 MILES)
- L_{ca} = LENGTH ALONG MAIN CHANNEL TO A POINT OPPOSITE THE WATERSHED CENTROID (4.3 MILES)

$t_t = 2.0 \quad (9.0 \times 4.3)^{0.3}$ LAG TIME = 6.0 HOURS

FOR COMPUTER INPUT: USE T_c = 11.0 HOURS

LAG TIME = 0.6 × 11.0

LAG TIME = 6.6 HOURS

STORCH ENGINEERS Sheet 4 of 9

Project BRAINERD LAKE DAM Made By STO Date 1/28/80

Chkd By JG Date 3/3/80

24- HOUR RAINFALL DISTRIBUTION (AT 15 MIN. INTERVAL

INTERVAL	HOUR - MIN	RAINFALL (INCHES)	INTERVAL	HOUR - MIN.	RAINFALL (INCHES)	INTERVAL	HOUR - MIN.	RAINFAL (INCHES)
1	0 - 15	.020	33	- 15	.037	65	15	.100
2	- 30	.020	34	30	.037	66	30	.100
3	45	.020	35	45	.037	67	45	.100
4	1 - 0	.020	36	9 - 0	.037	68	17 - 0	.100
5	- 15	.020	37	15	.037	69	15	.084
6	30	.021	38	30	.037	10	30	.083
7	45	.021	39	45	.037	71	45	.083
8	2 - 0	.021	40	10 - 0	.037	72	18 - 0	.083
9	15	.021	41	15	.038	73	15	.038
10	30	.021	42	30	.038	74	30	.038
11	45	.021	43	45	.038	75	45	.038
12	3 - 0	.021	44	11 - 0	.038	76	19 - 0	.038
13	15	.021	45	- 15	.038	77	15	.037
14	30	.021	46	- 30	.038	18	30	.037
15	45	.021	47	- 45	.038	79	45	.037
16	4 - 0	.021	48	12 - 0	.038	80	20 - 0	.037
17	15	.021	49	- 15	.083	81	15	.021
18	30	.021	50	30	.083	82	30	.021
19	45	.021	51	45	.083	83	45	.021
20	5 - 0	.021	52	13 - 0	.083	84	21 - 0	.021
21	15	.021	53	15	.083	85	15	.021
22	30	.021	54	30	.084	86	30	.021
23	45	.021	55	45	.084	87	45	.021
24	6 - 0	.021	56	14 - 0	.084	88	22 - 0	.021
25	15	.021	57	15	.220	89	15	.021
26	30	.021	58	30	.220	90	30	.021
27	45	.021	59	45	.230	91	45	.021
28	7 - 0	.021	60	15 - 0	.230	92	23 - 0	.021
29	15	.021	61	15	.270	93	15	.021
30	30	.021	62	30	.770	94	30	.020
31	45	.021	63	45	1.680	95	45	.020
32	8 - 0	.021	64	16 - 0	.280	96	24 - 0	.020

TOTAL 24 HOUR = 7.20

LAKE STORAGE VOLUME

WATER SURFACE ELEVATION	SURFACE AREA (ACRES)
79.8	0
88	22
100	653

HEC-1-DB COMPUTER PROGRAM WILL GENERATE STORAGE CAPACITY FROM SURFACE AREAS & ELEVATIONS.

INFORMATION OBTAINED FROM USGS QUADRANGLE AND SOUNDINGS TAKEN DURING FIELD INSPECTION.

HYDRAULICS

THE SPILLWAY AT BRAINERD LAKE IS A CONCRETE, HORSESHOE-SHAPED, FREE OVERFLOW WEIR. THE SPILLWAY IS AT ELEVATION 87.2 ; WITH AN EFFECTIVE LENGTH OF 32' (34' TOTAL - 2' OBSTRUCTED BY OUTLET WORKS MECHANISM)

DISCHARGE WILL BE TABULATED USING THE FORMULA;

$Q = CLH^{3/2}$ WHERE: Q = discharge over spillway
C = discharge coefficient
L = effective length of spillway
H = total head on spillway

DISCHARGE VALUES IN THE FOLLOWING TABULATION DO NOT INCLUDE OVERTOPPING OF 356' (382' TOTAL - 26' OF DAM CREST NOT OVERTOPPED, DOWNSTREAM OF SPILLWAY) OF DAM CREST AT ELEVATION 90.1, AS THIS WILL BE COMPUTED BY THE HEC-1-DB COMPUTER PROGRAM

VALUES FOR THE DISCHARGE COEFFICIENT, "C" WHERE TAKEN FROM THE "HANDBOOK OF HYDRAULICS"
-BY KING & BRATER.

STAGE DISCHARGE TABULATION

WATER SURFACE ELEVATION	HEAD (FT)	"C"	DISCHARGE (CFS)
87.2	0	-	0
88.2	1	2.75	88
89.2	2	3.03	274
90.1	2.9	3.32	524
91.2	4	3.32	850
92.2	5	3.32	1188
93.2	6	3.32	1561
94.2	7	3.32	1968
95.2	8	3.32	2404
96.2	9	3.32	2868

STORCH ENGINEERS

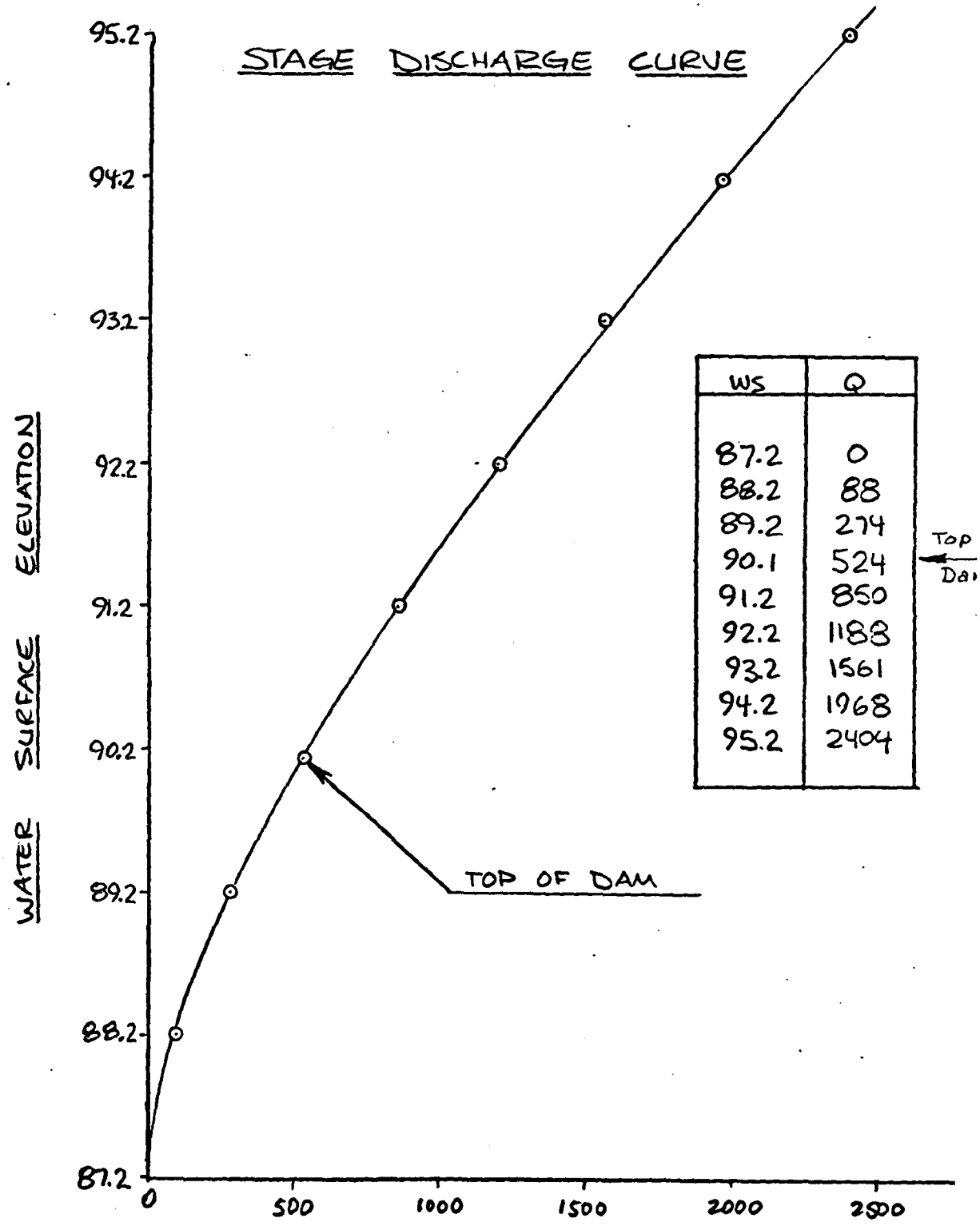
Project BRAINERD LAKE DAM

Sheet 8 of 9

Made By STO Date 1/24/8

Chkd By RL Date 2/7/8

STAGE DISCHARGE CURVE



WS	Q
87.2	0
88.2	88
89.2	274
90.1	524
91.2	850
92.2	1188
93.2	1561
94.2	1968
95.2	2404

TOP
DA

OUTLET WORKS CAPACITY

THE OUTLET WORKS AT BRAINERD LAKE CONSIST OF 3.5' ROUND SLIDE GATE LOCATED WITHIN THE SPILLWAY SECTION. ASSUME DRAWDOWN BY LIFTING GATE. DRAWDOWN DISCHARGE WILL BE MADE TREATING GATE AS A SUBMERGED ORIFICE USING THE EQUATION, $Q = CA\sqrt{2gh}$

$A = 9.62$ SF

$C = 0.6$
$h = 2.6$ (ave.)

$$Q = (0.6)(9.6)\sqrt{2(32.2)(2.6)}$$

$Q = 75$ CFS (AVERAGE)

Q AT POOL ELEVATION 88.0 = 121 CFS

$$\text{DRAWDOWN} = \frac{\text{STORAGE AT SPILLWAY}}{\text{DRAWDOWN DISCHARGE - NORMAL INFLOW}}$$

$$= \frac{44 \text{ AC-FT} \quad (43560\ ^{SF}/_{AC})}{75 \text{ CFS} - (1 \text{ CFS/SM} \times 10.8 \text{ SM})\ (3600\ ^{SEC}/_{HR})}$$

$= 8.3$ HOURS

HEC-1-DB COMPUTATIONS

```
A1                                  NATIONAL DAM SAFETY PROGRAM
A2                                      BRAINERD LAKE DAM
A3                                   100 YEAR STORM ROUTING
B      200          0         15                                                  3
B1       5
J        1          1          1
J1       1
K        0       LAKE                                                    1
K1                                 INFLOW HYDROGRAPH TO BRAINERD LAKE
M        0          2       10.8                10.8
O       96
O1  0.020      0.020      0.020      0.020      0.020      0.021      0.021      0.021      0.021      0.021
O1  0.021      0.021      0.021      0.021      0.021      0.021      0.021      0.021      0.021      0.021
O1  0.021      0.021      0.021      0.021      0.021      0.021      0.021      0.021      0.021      0.021
O1  0.021      0.021      0.037      0.037      0.037      0.037      0.037      0.037      0.037      0.037
O1  0.038      0.038      0.038      0.038      0.038      0.038      0.038      0.038      0.083      0.083
O1  0.083      0.083      0.083      0.084      0.084      0.084      0.220      0.220      0.230      0.230
O1  0.270      0.770      1.680      0.280      0.100      0.100      0.100      0.100      0.084      0.083
O1  0.083      0.083      0.038      0.038      0.038      0.038      0.037      0.037      0.037      0.037
O1  0.021      0.021      0.021      0.021      0.021      0.021      0.021      0.021      0.021      0.021
O1  0.021      0.021      0.021      0.020      0.020      0.020
T                                                                    1.5        0.15
W2                6.6
X       -1.0     -0.05       2.0
K        1         DAM
K1                                    ROUTE DISCHARGE THRU DAM
Y                                            1          1
Y1       1                                                      -88         -1
Y4    87.2       88.2       89.2       90.1       91.2       92.2       93.2       94.2       95.2       96.2
Y5       0         86        274        524        850       1188       1561       1968       2404       2868
$A       0         22        653
$E    79.8         88        100
$$    87.2
$D    90.1       2.63        1.5        356
K       99
A
A
A
A
A
```

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

RUN  DATE= 80/03/13.
     TIME= 08.49.00.
```

NATIONAL DAM SAFETY PROGRAM
BRAINERD LAKE DAM
100 YEAR STORM ROUTING

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
200	0	15	0	0	0	0	0	3	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

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

RTIOS= 1.00

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

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO BRAINERD LAKE

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

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	2	10.80	0.00	10.80	0.00	0.000	0	0	0

PRECIP DATA

NP	STORM	DAJ	DAK
96	0.00	0.00	0.00

PRECIP PATTERN

.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.04	.04	.04	.04	.04	.04	.04
.04	.04	.04	.04	.04	.04	.04	.08	.08
.08	.08	.08	.08	.08	.08	.22	.23	.23
.27	.77	1.68	.28	.10	.10	.10	.08	.08
.08	.08	.04	.04	.04	.04	.04	.04	.04
.02	.02	.02	.02	.02	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02			

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.50	.15	0.00	0.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= 6.60

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

UNIT HYDROGRAPH 134 END-OF-PERIOD ORDINATES, TC= 0.00 HOURS, LAG= 6.60 VOL= 1.00

9.	17.	30.	50.	70.	94.	120.	146.	179.	214.
251.	298.	344.	395.	449.	504.	551.	598.	641.	673.
705.	729.	747.	764.	770.	773.	775.	772.	769.	761.
743.	726.	707.	686.	666.	643.	620.	595.	566.	537.
505.	470.	436.	407.	378.	351.	331.	311.	292.	275.
258.	243.	229.	215.	204.	194.	183.	173.	162.	153.
145.	136.	127.	119.	111.	106.	100.	94.	88.	83.
78.	74.	70.	65.	61.	58.	54.	51.	48.	45.
42.	40.	38.	36.	33.	31.	30.	28.	26.	25.
23.	22.	21.	20.	18.	17.	16.	15.	14.	14.
13.	12.	11.	11.	10.	9.	9.	8.	8.	8.
7.	7.	7.	6.	6.	6.	5.	5.	5.	4.
4.	4.	3.	3.	3.	2.	2.	2.	2.	1.
1.	1.	0.	0.						

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.15	1	.02	0.00	.02	10.
1.01	.30	2	.02	0.00	.02	9.
1.01	.45	3	.02	0.00	.02	9.
1.01	1.00	4	.02	0.00	.02	8.
1.01	1.15	5	.02	0.00	.02	8.
1.01	1.30	6	.02	0.00	.02	7.
1.01	1.45	7	.02	0.00	.02	7.
1.01	2.00	8	.02	0.00	.02	6.
1.01	2.15	9	.02	0.00	.02	6.
1.01	2.30	10	.02	0.00	.02	5.
1.01	2.45	11	.02	0.00	.02	5.
1.01	3.00	12	.02	0.00	.02	5.
1.01	3.15	13	.02	0.00	.02	4.
1.01	3.30	14	.02	0.00	.02	4.
1.01	3.45	15	.02	0.00	.02	4.
1.01	4.00	16	.02	0.00	.02	4.
1.01	4.15	17	.02	0.00	.02	3.
1.01	4.30	18	.02	0.00	.02	3.
1.01	4.45	19	.02	0.00	.02	3.
1.01	5.00	20	.02	0.00	.02	3.
1.01	5.15	21	.02	0.00	.02	3.
1.01	5.30	22	.02	0.00	.02	2.
1.01	5.45	23	.02	0.00	.02	2.
1.01	6.00	24	.02	0.00	.02	2.
1.01	6.15	25	.02	0.00	.02	2.
1.01	6.30	26	.02	0.00	.02	2.
1.01	6.45	27	.02	0.00	.02	2.
1.01	7.00	28	.02	0.00	.02	2.
1.01	7.15	29	.02	0.00	.02	1.
1.01	7.30	30	.02	0.00	.02	1.
1.01	7.45	31	.02	0.00	.02	1.
1.01	8.00	32	.02	0.00	.02	1.
1.01	8.15	33	.04	0.00	.04	1.
1.01	8.30	34	.04	0.00	.04	1.
1.01	8.45	35	.04	0.00	.04	1.
1.01	9.00	36	.04	0.00	.04	1.
1.01	9.15	37	.04	0.00	.04	1.
1.01	9.30	38	.04	0.00	.04	1.
1.01	9.45	39	.04	0.00	.04	1.
1.01	10.00	40	.04	0.00	.04	1.
1.01	10.15	41	.04	0.00	.04	1.
1.01	10.30	42	.04	0.00	.04	1.
1.01	10.45	43	.04	0.00	.04	1.
1.01	11.00	44	.04	0.00	.04	1.
1.01	11.15	45	.04	0.00	.04	0.
1.01	11.30	46	.04	0.00	.04	0.
1.01	11.45	47	.04	0.00	.04	0.
1.01	12.00	48	.04	0.00	.04	0.
1.01	12.15	49	.08	0.00	.08	0.
1.01	12.30	50	.08	0.00	.08	0.
1.01	12.45	51	.08	.01	.07	0.
1.01	13.00	52	.09	.05	.04	1.
1.01	13.15	53	.08	.05	.04	2.
1.01	13.30	54	.08	.05	.04	3.
1.01	13.45	55	.09	.05	.04	6.
1.01	14.00	56	.09	.05	.04	9.
1.01	14.15	57	.22	.18	.04	15.
1.01	14.30	58	.22	.18	.04	23.
1.01	14.45	59	.23	.19	.04	34.
1.01	15.00	60	.23	.19	.04	49.
1.01	15.15	61	.27	.23	.04	70.
1.01	15.30	62	.77	.73	.04	100.
1.01	15.45	63	1.68	1.64	.04	149.
1.01	16.00	64	.28	.24	.04	206.
1.01	16.15	65	.10	.06	.04	279.
1.01	16.30	66	.10	.06	.04	371.
1.01	16.45	67	.10	.06	.04	471.
1.01	17.00	68	.10	.06	.04	583.
1.01	17.15	69	.08	.05	.04	706.
1.01	17.30	70	.08	.05	.04	838.
1.01	17.45	71	.08	.05	.04	979.
1.01	18.00	72	.08	.05	.04	1149.
1.01	18.15	73	.04	.00	.04	1320.
1.01	18.30	74	.04	.00	.04	1507.
1.01	18.45	75	.04	.00	.04	1698.
1.01	19.00	76	.04	.00	.04	1895.
1.01	19.15	77	.04	0.00	.04	2096.
1.01	19.30	78	.04	0.00	.04	2289.
1.01	19.45	79	.04	0.00	.04	2463.
1.01	20.00	80	.04	0.00	.04	2627.
1.01	20.15	81	.02	0.00	.02	2773.
1.01	20.30	82	.02	0.00	.02	2892.
1.01	20.45	83	.02	0.00	.02	2998.
1.01	21.00	84	.02	0.00	.02	3082.
1.01	21.15	85	.02	0.00	.02	3145.
1.01	21.30	86	.02	0.00	.02	3194.
1.01	21.45	87	.02	0.00	.02	3215.
1.01	22.00	88	.02	0.00	.02	3222.
1.01	22.15	89	.02	0.00	.02	3218.
1.01	22.30	90	.02	0.00	.02	3199.
1.01	22.45	91	.02	0.00	.02	3169.
1.01	23.00	92	.02	0.00	.02	3120.
1.01	23.15	93	.02	0.00	.02	3051.
1.01	23.30	94	.02	0.00	.02	2977.
1.01	23.45	95	.02	0.00	.02	2894.
1.02	0.00	96	.02	0.00	.02	2806.
1.02	.15	97	0.00	0.00	0.00	2713.
1.02	.30	98	0.00	0.00	0.00	2612.
1.02	.45	99	0.00	0.00	0.00	2507.
1.02	1.00	100	0.00	0.00	0.00	2395.

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.02	1.15	101	0.00	0.00	0.00	2276.
1.02	1.30	102	0.00	0.00	0.00	2154.
1.02	1.45	103	0.00	0.00	0.00	2027.
1.02	2.00	104	0.00	0.00	0.00	1898.
1.02	2.15	105	0.00	0.00	0.00	1773.
1.02	2.30	106	0.00	0.00	0.00	1660.
1.02	2.45	107	0.00	0.00	0.00	1552.
1.02	3.00	108	0.00	0.00	0.00	1454.
1.02	3.15	109	0.00	0.00	0.00	1367.
1.02	3.30	110	0.00	0.00	0.00	1285.
1.02	3.45	111	0.00	0.00	0.00	1208.
1.02	4.00	112	0.00	0.00	0.00	1135.
1.02	4.15	113	0.00	0.00	0.00	1066.
1.02	4.30	114	0.00	0.00	0.00	1004.
1.02	4.45	115	0.00	0.00	0.00	945.
1.02	5.00	116	0.00	0.00	0.00	890.
1.02	5.15	117	0.00	0.00	0.00	843.
1.02	5.30	118	0.00	0.00	0.00	797.
1.02	5.45	119	0.00	0.00	0.00	752.
1.02	6.00	120	0.00	0.00	0.00	708.
1.02	6.15	121	0.00	0.00	0.00	666.
1.02	6.30	122	0.00	0.00	0.00	628.
1.02	6.45	123	0.00	0.00	0.00	592.
1.02	7.00	124	0.00	0.00	0.00	557.
1.02	7.15	125	0.00	0.00	0.00	522.
1.02	7.30	126	0.00	0.00	0.00	490.
1.02	7.45	127	0.00	0.00	0.00	461.
1.02	8.00	128	0.00	0.00	0.00	435.
1.02	8.15	129	0.00	0.00	0.00	411.
1.02	8.30	130	0.00	0.00	0.00	386.
1.02	8.45	131	0.00	0.00	0.00	363.
1.02	9.00	132	0.00	0.00	0.00	341.
1.02	9.15	133	0.00	0.00	0.00	322.
1.02	9.30	134	0.00	0.00	0.00	303.
1.02	9.45	135	0.00	0.00	0.00	285.
1.02	10.00	136	0.00	0.00	0.00	268.
1.02	10.15	137	0.00	0.00	0.00	251.
1.02	10.30	138	0.00	0.00	0.00	237.
1.02	10.45	139	0.00	0.00	0.00	223.
1.02	11.00	140	0.00	0.00	0.00	210.
1.02	11.15	141	0.00	0.00	0.00	197.
1.02	11.30	142	0.00	0.00	0.00	185.
1.02	11.45	143	0.00	0.00	0.00	174.
1.02	12.00	144	0.00	0.00	0.00	164.
1.02	12.15	145	0.00	0.00	0.00	155.
1.02	12.30	146	0.00	0.00	0.00	146.
1.02	12.45	147	0.00	0.00	0.00	137.
1.02	13.00	148	0.00	0.00	0.00	129.
1.02	13.15	149	0.00	0.00	0.00	122.
1.02	13.30	150	0.00	0.00	0.00	115.
1.02	13.45	151	0.00	0.00	0.00	108.
1.02	14.00	152	0.00	0.00	0.00	102.
1.02	14.15	153	0.00	0.00	0.00	96.
1.02	14.30	154	0.00	0.00	0.00	90.
1.02	14.45	155	0.00	0.00	0.00	85.
1.02	15.00	156	0.00	0.00	0.00	80.
1.02	15.15	157	0.00	0.00	0.00	75.
1.02	15.30	158	0.00	0.00	0.00	71.
1.02	15.45	159	0.00	0.00	0.00	67.
1.02	16.00	160	0.00	0.00	0.00	63.
1.02	16.15	161	0.00	0.00	0.00	59.
1.02	16.30	162	0.00	0.00	0.00	56.
1.02	16.45	163	0.00	0.00	0.00	52.
1.02	17.00	164	0.00	0.00	0.00	49.
1.02	17.15	165	0.00	0.00	0.00	46.
1.02	17.30	166	0.00	0.00	0.00	44.
1.02	17.45	167	0.00	0.00	0.00	41.
1.02	18.00	168	0.00	0.00	0.00	39.
1.02	18.15	169	0.00	0.00	0.00	37.
1.02	18.30	170	0.00	0.00	0.00	35.
1.02	18.45	171	0.00	0.00	0.00	33.
1.02	19.00	172	0.00	0.00	0.00	32.
1.02	19.15	173	0.00	0.00	0.00	30.
1.02	19.30	174	0.00	0.00	0.00	29.
1.02	19.45	175	0.00	0.00	0.00	27.
1.02	20.00	176	0.00	0.00	0.00	26.
1.02	20.15	177	0.00	0.00	0.00	24.
1.02	20.30	178	0.00	0.00	0.00	23.
1.02	20.45	179	0.00	0.00	0.00	21.
1.02	21.00	180	0.00	0.00	0.00	20.
1.02	21.15	181	0.00	0.00	0.00	18.
1.02	21.30	182	0.00	0.00	0.00	17.
1.02	21.45	183	0.00	0.00	0.00	16.
1.02	22.00	184	0.00	0.00	0.00	15.
1.02	22.15	185	0.00	0.00	0.00	14.
1.02	22.30	186	0.00	0.00	0.00	13.
1.02	22.45	187	0.00	0.00	0.00	12.
1.02	23.00	188	0.00	0.00	0.00	11.
1.02	23.15	189	0.00	0.00	0.00	11.
1.02	23.30	190	0.00	0.00	0.00	10.
1.02	23.45	191	0.00	0.00	0.00	9.
1.03	0.00	192	0.00	0.00	0.00	9.
1.03	.15	193	0.00	0.00	0.00	8.
1.03	.30	194	0.00	0.00	0.00	7.
1.03	.45	195	0.00	0.00	0.00	7.
1.03	1.00	196	0.00	0.00	0.00	7.
1.03	1.15	197	0.00	0.00	0.00	6.
1.03	1.30	198	0.00	0.00	0.00	6.
1.03	1.45	199	0.00	0.00	0.00	5.
1.03	2.00	200	0.00	0.00	0.00	5.
		SUM	7.20	4.27	2.93	119311.
			(183.)(	109.)(	74.)(	3378.51)

HYDROGRAPH AT STA LAKE FOR PLAN 1, RTIO 1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3222.	2865.	1227.	597.	119301.
CMS	91.	81.	35.	17.	3378.
INCHES		2.47	4.23	4.28	4.28
MM		62.69	107.40	108.75	108.75
AC-FT		1421.	2434.	2465.	2465.
THOUS CU M		1753.	3003.	3040.	3040.

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

HYDROGRAPH ROUTING

ROUTE DISCHARGE THRU DAM

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

ROUTING DATA

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

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-88.	-1

STAGE	87.20	88.20	89.20	90.10	91.20	92.20	93.20	94.20	95.20	96.20
FLOW	0.00	88.00	274.00	524.00	850.00	1188.00	1561.00	1968.00	2404.00	2868.00
SURFACE AREA=	0.	22.	653.							
CAPACITY=	0.	60.	3240.							
ELEVATION=	80.	88.	100.							

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
87.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
90.1	2.6	1.5	356.

STATION DAM, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

MO.DA	HR.MN	PERIOD	HOURS	INFLOW	OUTFLOW	STORAGE	STAGE
1.01	.15	1	.25	10.	66.	59.	87.9
1.01	.30	2	.50	9.	61.	58.	87.9
1.01	.45	3	.75	9.	57.	57.	87.8
1.01	1.00	4	1.00	8.	53.	56.	87.8
1.01	1.15	5	1.25	8.	49.	55.	87.8
1.01	1.30	6	1.50	7.	46.	54.	87.7
1.01	1.45	7	1.75	7.	42.	53.	87.7
1.01	2.00	8	2.00	6.	39.	53.	87.6
1.01	2.15	9	2.25	6.	36.	52.	87.6
1.01	2.30	10	2.50	5.	34.	51.	87.6
1.01	2.45	11	2.75	5.	31.	51.	87.6
1.01	3.00	12	3.00	5.	29.	50.	87.5
1.01	3.15	13	3.25	4.	27.	50.	87.5
1.01	3.30	14	3.50	4.	25.	49.	87.5
1.01	3.45	15	3.75	4.	23.	49.	87.5
1.01	4.00	16	4.00	4.	21.	49.	87.4
1.01	4.15	17	4.25	3.	20.	48.	87.4
1.01	4.30	18	4.50	3.	18.	48.	87.4
1.01	4.45	19	4.75	3.	17.	48.	87.4
1.01	5.00	20	5.00	3.	16.	47.	87.4
1.01	5.15	21	5.25	3.	14.	47.	87.4
1.01	5.30	22	5.50	2.	13.	47.	87.4
1.01	5.45	23	5.75	2.	12.	47.	87.3
1.01	6.00	24	6.00	2.	11.	47.	87.3
1.01	6.15	25	6.25	2.	11.	46.	87.3
1.01	6.30	26	6.50	2.	10.	46.	87.3
1.01	6.45	27	6.75	2.	9.	46.	87.3
1.01	7.00	28	7.00	2.	8.	46.	87.3
1.01	7.15	29	7.25	1.	8.	46.	87.3
1.01	7.30	30	7.50	1.	7.	46.	87.3
1.01	7.45	31	7.75	1.	7.	46.	87.3
1.01	8.00	32	8.00	1.	6.	45.	87.3
1.01	8.15	33	8.25	1.	6.	45.	87.3
1.01	8.30	34	8.50	1.	5.	45.	87.3
1.01	8.45	35	8.75	1.	5.	45.	87.3
1.01	9.00	36	9.00	1.	4.	45.	87.3
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1.01	9.30	38	9.50	1.	4.	45.	87.2
1.01	9.45	39	9.75	1.	4.	45.	87.2
1.01	10.00	40	10.00	1.	3.	45.	87.2
1.01	10.15	41	10.25	1.	3.	45.	87.2
1.01	10.30	42	10.50	1.	3.	45.	87.2
1.01	10.45	43	10.75	1.	3.	45.	87.2
1.01	11.00	44	11.00	1.	2.	45.	87.2
1.01	11.15	45	11.25	0.	2.	45.	87.2
1.01	11.30	46	11.50	0.	2.	45.	87.2
1.01	11.45	47	11.75	0.	2.	45.	87.2
1.01	12.00	48	12.00	0.	2.	45.	87.2
1.01	12.15	49	12.25	0.	2.	45.	87.2
1.01	12.30	50	12.50	0.	1.	44.	87.2
1.01	12.45	51	12.75	0.	1.	44.	87.2
1.01	13.00	52	13.00	1.	1.	44.	87.2
1.01	13.15	53	13.25	2.	1.	44.	87.2
1.01	13.30	54	13.50	3.	1.	44.	87.2
1.01	13.45	55	13.75	6.	2.	45.	87.2
1.01	14.00	56	14.00	5.	2.	45.	87.2
1.01	14.15	57	14.25	15.	3.	45.	87.2
1.01	14.30	58	14.50	23.	5.	45.	87.3
1.01	14.45	59	14.75	34.	7.	46.	87.3
1.01	15.00	60	15.00	49.	10.	46.	87.3
1.01	15.15	61	15.25	70.	15.	47.	87.4
1.01	15.30	62	15.50	100.	21.	49.	87.4
1.01	15.45	63	15.75	149.	30.	51.	87.5
1.01	16.00	64	16.00	206.	43.	54.	87.7
1.01	16.15	65	16.25	279.	60.	58.	87.9
1.01	16.30	66	16.50	371.	81.	63.	88.1
1.01	16.45	67	16.75	471.	120.	69.	88.4
1.01	17.00	68	17.00	583.	167.	77.	88.6
1.01	17.15	69	17.25	706.	216.	87.	88.9
1.01	17.30	70	17.50	836.	264.	98.	89.1
1.01	17.45	71	17.75	989.	333.	110.	89.4
1.01	18.00	72	18.00	1149.	407.	125.	89.7
1.01	18.15	73	18.25	1320.	481.	141.	89.9
1.01	18.30	74	18.50	1507.	589.	159.	90.2
1.01	18.45	75	18.75	1698.	822.	178.	90.5
1.01	19.00	76	19.00	1895.	1082.	195.	90.7
1.01	19.15	77	19.25	2096.	1340.	212.	90.8
1.01	19.30	78	19.50	2289.	1587.	227.	91.0
1.01	19.45	79	19.75	2463.	1819.	240.	91.1
1.01	20.00	80	20.00	2627.	2036.	253.	91.3
1.01	20.15	81	20.25	2773.	2237.	265.	91.4
1.01	20.30	82	20.50	2892.	2417.	275.	91.5
1.01	20.45	83	20.75	2998.	2577.	285.	91.5
1.01	21.00	84	21.00	3082.	2716.	293.	91.6
1.01	21.15	85	21.25	3145.	2836.	300.	91.7
1.01	21.30	86	21.50	3194.	2936.	306.	91.7
1.01	21.45	87	21.75	3215.	3015.	310.	91.7
1.01	22.00	88	22.00	3222.	3075.	314.	91.8
1.01	22.15	89	22.25	3218.	3117.	316.	91.8
1.01	22.30	90	22.50	3199.	3144.	318.	91.8
1.01	22.45	91	22.75	3169.	3156.	318.	91.8
1.01	23.00	92	23.00	3120.	3152.	318.	91.8
1.01	23.15	93	23.25	3051.	3133.	317.	91.8
1.01	23.30	94	23.50	2977.	3098.	315.	91.8
1.01	23.45	95	23.75	2894.	3050.	312.	91.8
1.02	0.00	96	24.00	2806.	2991.	309.	91.7
1.02	.15	97	24.25	2713.	2923.	305.	91.7
1.02	.30	98	24.50	2612.	2847.	300.	91.7
1.02	.45	99	24.75	2507.	2760.	295.	91.6
1.02	1.00	100	25.00	2395.	2667.	290.	91.6

1.02	1.15	101	25.25	2276.	2567.	284.	91.5	
1.02	1.30	102	25.50	2154.	2461.	278.	91.5	
1.02	1.45	103	25.75	2027.	2349.	271.	91.4	
1.02	2.00	104	26.00	1898.	2232.	265.	91.4	
1.02	2.15	105	26.25	1773.	2112.	258.	91.3	
1.02	2.30	106	26.50	1660.	1992.	251.	91.2	
1.02	2.45	107	26.75	1552.	1877.	244.	91.2	
1.02	3.00	108	27.00	1454.	1766.	237.	91.1	
1.02	3.15	109	27.25	1367.	1662.	231.	91.0	
1.02	3.30	110	27.50	1285.	1563.	225.	91.0	
1.02	3.45	111	27.75	1208.	1471.	220.	90.9	
1.02	4.00	112	28.00	1135.	1384.	214.	90.9	
1.02	4.15	113	28.25	1066.	1303.	209.	90.8	
1.02	4.30	114	28.50	1004.	1226.	204.	90.8	
1.02	4.45	115	28.75	945.	1155.	200.	90.7	
1.02	5.00	116	29.00	890.	1089.	196.	90.7	
1.02	5.15	117	29.25	843.	1028.	192.	90.6	
1.02	5.30	118	29.50	797.	971.	186.	90.6	
1.02	5.45	119	29.75	752.	919.	185.	90.5	
1.02	6.00	120	30.00	708.	869.	181.	90.5	
1.02	6.15	121	30.25	666.	823.	178.	90.5	
1.02	6.30	122	30.50	628.	779.	175.	90.4	
1.02	6.45	123	30.75	592.	737.	172.	90.4	
1.02	7.00	124	31.00	557.	699.	169.	90.3	
1.02	7.15	125	31.25	522.	662.	166.	90.3	
1.02	7.30	126	31.50	490.	628.	163.	90.3	
1.02	7.45	127	31.75	461.	597.	160.	90.2	
1.02	8.00	128	32.00	435.	569.	157.	90.2	
1.02	8.15	129	32.25	411.	544.	155.	90.1	
1.02	8.30	130	32.50	386.	524.	152.	90.1	
1.02	8.45	131	32.75	363.	512.	149.	90.1	
1.02	9.00	132	33.00	341.	499.	146.	90.0	
1.02	9.15	133	33.25	322.	485.	142.	90.0	
1.02	9.30	134	33.50	303.	471.	139.	89.9	
1.02	9.45	135	33.75	265.	456.	135.	89.9	
1.02	10.00	136	34.00	268.	440.	132.	89.8	
1.02	10.15	137	34.25	251.	423.	128.	89.7	
1.02	10.30	138	34.50	237.	407.	125.	89.7	
1.02	10.45	139	34.75	223.	390.	121.	89.6	
1.02	11.00	140	35.00	210.	373.	118.	89.6	
1.02	11.15	141	35.25	197.	356.	115.	89.5	
1.02	11.30	142	35.50	185.	338.	111.	89.4	
1.02	11.45	143	35.75	174.	321.	108.	89.4	
1.02	12.00	144	36.00	164.	305.	105.	89.3	
1.02	12.15	145	36.25	155.	288.	102.	89.3	
1.02	12.30	146	36.50	146.	273.	100.	89.2	
1.02	12.45	147	36.75	137.	262.	97.	89.1	
1.02	13.00	148	37.00	129.	251.	95.	89.1	
1.02	13.15	149	37.25	122.	240.	92.	89.0	
1.02	13.30	150	37.50	115.	229.	90.	89.0	
1.02	13.45	151	37.75	108.	219.	87.	88.9	
1.02	14.00	152	38.00	102.	208.	85.	88.8	
1.02	14.15	153	38.25	96.	197.	83.	88.8	
1.02	14.30	154	38.50	90.	187.	81.	88.7	
1.02	14.45	155	38.75	85.	176.	79.	88.7	
1.02	15.00	156	39.00	80.	166.	77.	88.6	
1.02	15.15	157	39.25	75.	156.	75.	88.6	
1.02	15.30	158	39.50	71.	147.	74.	88.5	
1.02	15.45	159	39.75	67.	138.	72.	88.5	
1.02	16.00	160	40.00	63.	129.	71.	88.4	
1.02	16.15	161	40.25	59.	120.	70.	88.4	
1.02	16.30	162	40.50	56.	112.	68.	88.3	
1.02	16.45	163	40.75	52.	105.	67.	88.3	
1.02	17.00	164	41.00	49.	97.	66.	88.3	
1.02	17.15	165	41.25	46.	91.	65.	88.2	
1.02	17.30	166	41.50	44.	86.	64.	88.2	
1.02	17.45	167	41.75	41.	83.	63.	88.1	
1.02	18.00	168	42.00	39.	80.	63.	88.1	
1.02	18.15	169	42.25	37.	77.	62.	88.1	
1.02	18.30	170	42.50	35.	74.	61.	88.0	
1.02	18.45	171	42.75	33.	71.	60.	88.0	
1.02	19.00	172	43.00	32.	68.	59.	88.0	
1.02	19.15	173	43.25	30.	65.	59.	87.9	
1.02	19.30	174	43.50	29.	62.	58.	87.9	
1.02	19.45	175	43.75	27.	59.	57.	87.9	
1.02	20.00	176	44.00	26.	56.	57.	87.8	
1.02	20.15	177	44.25	24.	54.	56.	87.8	
1.02	20.30	178	44.50	23.	51.	55.	87.8	
1.02	20.45	179	44.75	21.	49.	55.	87.8	
1.02	21.00	180	45.00	20.	46.	54.	87.7	
1.02	21.15	181	45.25	18.	44.	54.	87.7	
1.02	21.30	182	45.50	17.	42.	53.	87.7	
1.02	21.45	183	45.75	16.	40.	53.	87.7	
1.02	22.00	184	46.00	15.	38.	52.	87.6	
1.02	22.15	185	46.25	14.	36.	52.	87.6	
1.02	22.30	186	46.50	13.	34.	52.	87.6	
1.02	22.45	187	46.75	12.	32.	51.	87.6	
1.02	23.00	188	47.00	11.	31.	51.	87.5	
1.02	23.15	189	47.25	11.	29.	50.	87.5	
1.02	23.30	190	47.50	10.	27.	50.	87.5	
1.02	23.45	191	47.75	9.	26.	50.	87.5	
1.03	0.00	192	48.00	9.	24.	49.	87.5	
1.03	.15	193	48.25	8.	23.	49.	87.5	
1.03	.30	194	48.50	7.	22.	49.	87.4	
1.03	.45	195	48.75	7.	20.	48.	87.4	
1.03	1.00	196	49.00	7.	19.	48.	87.4	
1.03	1.15	197	49.25	6.	18.	48.	87.4	
1.03	1.30	198	49.50	6.	17.	48.	87.4	
1.03	1.45	199	49.75	5.	16.	48.	87.4	
1.03	2.00	200	50.00	5.	15.	47.	87.4	

SUMMARY OF DAM SAFETY ANALYSIS

•••••••••	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	88.00	97.20	90.10
STORAGE	60.	44.	152.
OUTFLOW	70.	0.	524.

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	91.81	1.71	318.	3156.	14.25	22.75	0.00

APPENDIX 5

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