BRANFORD RIVER BASIN
NORTH BRANFORD, CONNECTICUT

LAKE GAILLARD DAM
CT. 00387

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

SEPTEMBER 1978

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NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification Number:	CT 00387
Name:	Lake Gaillard Dam
State Location:	Connecticut
County Location:	New Haven
Stream:	Branford River
Date of Inspection:	August 1, 1978

BRIEF ASSESSMENT

The Lake Gaillard Dam consists of a gravity-concrete structure that is 1,050 feet long and is convered with an earth embankment on the downstream side. There is an earth dike with an emergency spillway on the east side of the lake.

Based on visual inspection, records available at the site and past operational performance, the facility is judged to be in good condition. A review of the engineering data available reveals that there are areas of concern which must be corrected in order to assure the safety of the facility.

Seepage discharges in the vicinity of the lower valve chamber of the main dam and the downstream earth slopes of the east dike should be further investigated to determine their origin and monitored to determine any change.

The project will not pass the Probable Maximum Flood (PMF) (recommended spillway design flood) without overtopping the dam; however, the spillway capacity is not judged seriously inadequate because the water will flow 0.9 feet over a concrete non-overflow section of the dam. The spillway capacity is only 42.2 percent of the PMF (up to the top of the dam, elevation 195).

A detailed study by Ronald Haested, Inc. in 1977 shows that the PMF will overtop the dam by only 0.3 feet. This figure, although it is less than that calculated by the cursory method supplied by the Corps of Engineers would tend to be more exact and would increase the capacity percentage of the PMF. Since the section of the dam that will be overtopped is concrete and the length of time the water will be flowing over will not be long, the dam appears to be in no great danger.

Because of the potential damage to the areas immediately downstream should a failure occur, it is imperative that a formal warning system is developed and practiced with test exercises to insure its workability in an emergency situation.

Some recommended measures to be undertaken by the owner include establishing metering points for seepage measurements and a formal warning system.

The owner should implement the recommendations and remedial measures described in Section 7 within two to three years after receipt of this Phase I Inspection Report.

Joseph F. Merluzzo
Connecticut P.E. #7639
Project Manager

Richard F. Lyon
Connecticut P.E. #8443
Project Engineer

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 investigations and analyses involving topographic mapping, subsurface evaluations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify the 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. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through 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. Because of the magnitude and varity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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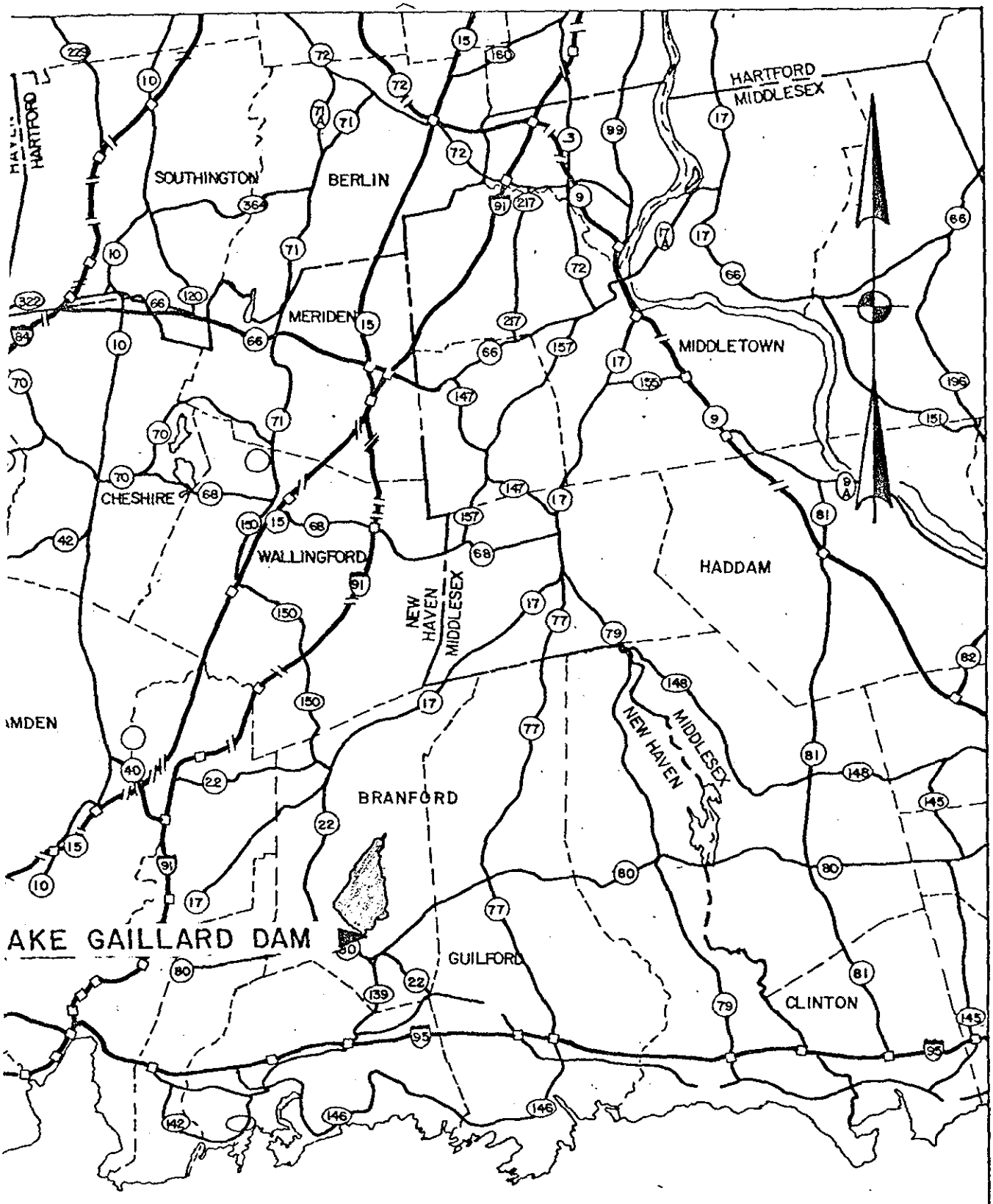


.S. ARMY, CORPS OF ENGINEERS
NEW ENGLAND DIVISION
WALTHAM, MASS.

APPROXIMATE SCALE
SCALE OF MILES 0 10

LOCATION MAP

PHASE I INSPECTION REPORT

LAKE GAILLARD DAM

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 New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Storch Engineers has been retained by the New England Division to inspect and report on selected dams in the State of Connecticut. Aurthorization and notice to proceed were issued to Storch Engineers under a letter of May 3, 1978 from Ralph T. Garver, Colonel, Corps of Engineers. Contract No. DACW33-78-C-000 has been assigned by the Corps of Engineers for this work.

b. Purpose -

(1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) Encourage and prepare the states to initiate quickly, effective dam safety programs for non-Federal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

The Lake Gaillard Dam is owned and operated by the New Haven Water Department, New Haven County, Connecticut. The facility includes a main dam and an east dike and impounds Lake Gaillard which serves as primary water supply for the greater New Haven area. It is located approximately seven miles northeast of the City of New Haven in the Town of Branford (See Location Map). Its discharge receiving water is the Branford River.

The main dam is a gravity-concrete structure that is covered along its downstream face with an earth embankment and is approximately 1,050 feet long. The east dike is a concrete core earth embankment approximately 1,420 feet long with a 50 foot wide concrete spillway and a stone lined spillway channel. The main dam has a gate house and a lower valve chamber with a 36 inch diameter blowoff to a channel which flows to the Branford River.

The size classification of the facility is intermediate (95 feet high and 53,500 acre-feet) and the hazard classification is high per the criteria set forth in the Recommended Guidelines for Safety Inspection of Dams by the Corps of

Engineers. Its failure would cause inundation of a majority of the center of the Town of Branford, a portion of the Connecticut Turnpike and a portion of main railroad line between Boston and New York (Appendix D, Plate 6).

The Lake Gaillard Dam was constructed in 1929 from designs prepared for the New Haven Water Company. There is a regular staff of approximately six people that work at the site. The function of the maintenance staff is not only the care of the grounds but also the control of the water level in the reservoir. There are inlet and outlet conduits at the east and west sides of the reservoir, respectively.

The person in charge of day to day operation for this dam is Norman Paluba, New Haven Water Company, New Haven, Connecticut; Telephone Number: 624-6671.

1.3 Pertinent Data

a. Drainage Area - A 7.5 square mile drainage area contributes to the facility. The terrain is forested with no residential development.

b. Discharge at Damsite - The maximum known spillway discharge was approximately 1,950 cfs during the flood of September, 1938.

(1) Outlet works: size 24 inch and 36 inch and invert elevation: 96.5.

(2) Maximum known flood at damsite: 1,950 cfs.

(3) Ungated spillway capacity at maximum pool elevation: 2,180 cfs at 195 elevation.

(4) Gated spillway capacity at pool elevation: N/A cfs at N/A elevation.

(5) Gated spillway capacity at maximum pool elevation: N/A cfs at N/A elevation.

(6) Total spillway capacity at maximum pool elevation: 2,180 cfs at 195 elevation.

c. Elevation (Feet above MSL)

(1) Top of dam: 195.0

(2) Maximum pool-design surcharge: 195.0

(3) Full flood-control pool: N/A

(4) Recreation pool: N/A

(5) Spillway crest: 190.0

(6) Upstream portal, invert diversion tunnel: 95.39

(7) Streambed at centerline of dam: 95.0

(8) Maximum tailwater: 101.0

d. Reservoir

(1) Length of maximum pool: 12,700 $\pm$ feet

(2) Length of recreation pool: N/A

(3) Length of flood-control pool: N/A

e. Storage (Acre-Feet)

(1) Recreation pool: N/A

(2) Flood-control pool: N/A

(3) Design surcharge: 53,500

(4) Top of dam: 53,500

f. Reservoir Surface (Acres)

(1) Top of dam: 1,110

(2) Maximum pool: 1,110

(3) Flood-control pool: N/A

(4) Recreation pool: N/A

(5) Spillway crest: 1,102

g. Dam

(1) Type: concrete with downstream earth face

(2) Length: 1,020 feet ±

(3) Height: 95 feet ±

(4) Top width: 10 feet ±

(5) Side Slopes: varies, see cross section Appendix B, Plate 1

(6) Zoning: N/A

(7) Impervious Core: 8 feet ±

(8) Cutoff: 8 feet ±

(9) Grout curtain: 8 to 10 feet

(10) Other: N/A

h. Diversion and Regulating Tunnel

(1) Type: cast iron

(2) Length: 300 feet ±

(3) Closure: N/A

(4) Access: None

(5) Regulating Facilities: manually operated gate valves (24" watermain and 36" blowoff) at main dam

i. Spillway (East Dike)

(1) Type: Concrete-fixed weir

(2) Length of weir: 50 feet

(3) Crest elevation: 190.0 feet

(4) Gates: None

(5) U/S Channel: underwater

(6) D/S Channel: stone lined channel

(7) General: N/A

j. Regulating Outlets

Regulating outlets consist of a 24 inch watermain and a 36 inch blowoff.

(1) Invert: 96.5

(2) Size: 36" and 24"

(3) Description: Cast iron

(4) Control Mechanism: manually operated gates

(5) Other: N/A

k. East Dike

(1) Type: earth

(2) Length: 1,500 feet ±

(3) Top elevation: 196.83 feet

(4) Height: 20 feet ±

(5) Core: concrete

(6) Cutoff: 10 feet ±

(7) Grout curtain: unknown

SECTION 2 - ENGINEERING DATA

2.1 Design

The facility was designed in 1926 by Albert B. Hill, consulting engineer. The design calculations for the original construction were not located but the "state of the art" at that time did not require such calculations. In 1977, there was a "Stability and Hydrologic Analysis of Lake Gaillard - Main Dam and East Dike" done by Ronald Haestad, Inc., Consulting Engineer of Middlebury, Connecticut (Appendix B, Reference 6).

A copy of the summary of Haestad's structural stability calculations is contained in Appendix B. Haestad's report also contained a hydrological analysis using the probable maximium precipitation (PMP).

2.2 Construction

The facility was constructed between 1926 and 1929 by C. W. Blakeslee & Sons, Inc. of New Haven, Connecticut. The construction was not recorded with any photographs and other written information was very limited, however, the contract plans were secured and reviewed. None of the staff of the New Haven Water Company had any recollections of the construction period. In 1947, the face of the main dam was resurfaced with a gunite treatment.

2.3 Operation

The valves at the main dam are exercised yearly as they serve no specific function since the water supply drawoff has been relocated to the west bank tunnel. Because the lake is primarily for purposes of water supply, the level is mainly controlled by the west bank tunnel. According to maintenance personnel, the water level is usually so low (3 to 8 feet down) that the spillway does not flow.

2.4 Evaluation

a. Availability - Design, construction and operation information is readily available. A list of references used to study the dam is contained in Appendix B.

b. Adequacy - The information made available along with the visual inspection, past performance history and hydrologic and hydraulic assumptions were more than adequate to access the condition of the facility.

c. Validity - The validity of the information is not questionable and the history of the facility seems to bear this out.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

a. General - The visual inspection was conducted on August 1, 1978 by members of the engineering staff of Storch Engineers, with the help of Mr. Norman Paluba of the New Haven Water Company. A copy of the visual inspection check list is contained in Appendix A.

The following procedures was used for the inspection:

1. The exposed concrete surfaces were surveyed for cracks, spalling, seepage and efflorescence.
2. The downstream banks were inspected for leakage or water loss.
3. The upstream face was checked for structural damage.
4. A survey was made for bulges or movement in the existing embankment.
5. Measurements were made of seepage flow and temperature as well as upstream and downstream temperatures.
6. The gate house and the lower valve chamber were inspected including the condition of their mechanical equipment.
7. A visual check was made of the dike, spillway and downstream channel.

8. The dam, dike and appurtenant structures (Appendix C, Plate 5) were photographed.

Before the inspection commenced, the design and construction documents were studied and compact sketchs were prepared for use during the inspection (Appendix B, Plates 1 and 2).

In general, the overall appearance and condition of the facility and its appurtenant structures is good.

b. Dam - The downstream face of the main dam has many trees and brush which obscured the view of the embankment. At the lower level, there is a 20 inch diameter pipe (Appendix C, Photo 4, Page II-2A) for the purpose of carrying the surface runoff from the roadway, which is just below the crest into the downstream channel. Beneath the rubble stone masonry walls lining the channel, a steady seepage flow (Appendix C, Photo 5, Page II-3A) was observed of approximately 5 to 10 gallons/min.

The east dike where the water level is approximately 3 to 5 feet below the spillway crest has a straight alignment with no signs of movement or distress. In two spots that are delineated on Plate 2, Appendix B, there are wet or soft areas which are usually dry only during the month of August. Although these spots are spongy, there is no visible sign of any seepage.

c. Appurtenant Structures - The gate house and the lower valve chamber are in excellent condition with no visible signs of cracking or spalling. The valves and operators are operable, but are only tested once a year. Because the landowners downstream have small ponds there has been an agreement with the New Haven Water Company to discharge only minimal amounts from the reservoir. The headwall for the discharge pipes (Appendix C, Photo 2, Page II-1A) has some badly spalled concrete and loose rubble stones which are in need of repair.

The spillway on the east dike is made of reinforced concrete and appears very sound. A steel truss pedestrian bridge with a wooden walkway spans the spillway width. The decking of the walkway has rotted and it is in need of repair.

d. Reservoir Area - The upstream face of the main dam and the riprapped face of the east dike appear in good condition with no visible signs of distress. The area immediately adjacent to the facility is in a very natural state with no signs of erosion.

e. Downstream Channel - The channel for the outlet of the main dam is overgrown with many trees and one large pine tree that is lying in the channel. There is a catch basin in the lower roadway with several underdrains entering and then discharging easterly into the downstream channel. All

of the discharge crosses a metering weir and this flow measures approximately one inch. The resident maintenance supervisor informed us that he measured the height on the weir each month and that it was usually about one inch. This weir is approximately eight feet wide and yields a flow of approximately 5 gallons/sec with a one inch flow. It cannot be ascertained at this time if this flow is seepage from the body of the main dam.

The reservoir area level is down about three feet from the crest of the spillway. The downstream channel of the spillway is dry and is lined with 8-10 inch stones. There is no evidence of washout or distress in this channel.

3.2 Evaluation

The visual inspection did not reveal any apparent areas of distress. The general condition of the facility and its appurtenant structures is good.

The seepage flows from the body of the main dam could not be monitored because there were no underdrains. The normal flow of the water through the dam appears slight and was observed at the outlet structure of the main dam. Surface cracks, embankment bulges, piping or boils were not observed.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

The responsibility of maintenance for the facility is with the New Haven Water Company. There are approximately 8-10 persons that have their center of operations at the site. The care of the main dam, the east dike and the appurtenant structures as well as the control of the water level is the responsibility of the maintenance staff. There is no written or formal operating procedure available for control of the flow during a major storm.

4.2 Maintenance of Dam

The items that are maintained on a regular basis are the mowing of grass at the east dike and the roadway area of the main dam and the general up-keep of the embankment area of the reservoir. The face of the main dam is overgrown with trees and heavy brush (Appendix C, Photo 2, Page II-1A).

4.3 Maintenance of Operating Facilities

The facilities which operate the main dam consist of a 36 inch diameter blowoff line with a 30 inch valve and hand operator at both the gate house and lower valve chamber. These valves appear to be maintained, but are only exercised once each year. The condition of the gate house and lower valve chamber which contain these operators is discussed in Section 3.

4.4 Description of Warning System

There is no warning system in effect for the facility.

4.5 Evaluation

The maintenance of the operating equipment is adequate, however, the overgrowth on the face of the main dam should be removed. Discussions of the recommendations for these routine items of maintenance are presented more fully in Section 7.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data - The 50 foot spillway at the east dike and the 36 inch blowoff at the main dam are available to transmit water downstream. Under conditions of the Probable Maximum Flood (PMF), the spillway will carry only a portion of the flood water.

Using the guide curves supplied by the Corps of Engineers (rolling), the PMF inflow is 12,975 cfs and the routed outflow is 5,165 cfs. The pond elevation at the PMF is 195.9 or 0.9 feet over the top of the main dam and 0.1 feet below the east dike. The Spillway Design Flood (SDF) is 2,180 cfs, approximately 42.2% of the PMF (Appendix D).

A detailed hydrologic/hydraulic study by Ronald Haested, Inc. in 1977 shows that PMF will overtop the dam by 0.3 feet.

b. Experience Data - The Lake Gaillard Dam has experienced the floods of March, 1930; September, 1938 (maximum) and August and October, 1955. During the flood of September, 1938, the depth of flow over the main dam was approximately 4.6 feet and the discharge was approximately 1,950 cfs.

c. Visual Observations - The spillway and the spillway channel at the time of inspection appeared in good condition.

d. Overtopping Potential - Our calculations indicate that the PMF will overtop the main dam by 0.9 feet. A separate detailed calculation (Haestad's 1977 Study) showed that the PMF will overtop the main dam by 0.3 feet.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observation - Routine yearly inspections have been conducted by the resident staff since the program was initiated two years ago. Occasionally, the maintenance workers operate the valves in the gate house and lower valve chamber with simultaneous monitoring of the downstream channel walls for signs of distress. The present visual inspection did not reveal the signs indicative of a decrease of structural stability with the exception of a considerable amount of seepage at the toe of the main dam.

b. Design and Construction Data - The design and construction data available were the contract drawings, hydrological data and the stability and hydrology analysis.

c. Operating Records - There are operating records for water reservoir level (daily) and the discharges in the downstream channel from the lower gate house (periodically). These records are maintained by the superintendent of maintenance and are kept at the site.

d. Post Construction Changes - The following primary changes to the Lake Gaillard Dam facility have been noted since the completion of construction in 1929:

1. Heavy vegetation (brush, trees) on the downstream slopes and banks of the dam, especially of the main dam (Appendix C, Photo 2, Page II-1A).

2. Considerable distress in the concrete and stone masonry walls of the lower valve chamber (Appendix C, Photos 2, 4 and 5, Pages II-1A through II-3A).

3. Seepage discharges of approximately 5 gallons per second measured at the metering weir from the zone of the lower valve chamber and the drainage system of the main dam (Appendix C, Photo 5, Page II-3A).

4. Wet areas on the downstream slopes of the east dike (Appendix C, Photo 4, Page II-2B).

5. Repair to the face of the main dam by gunite in 1947.

e. Seismic Stability - The facility is located in Seismic Zone No. 1 and in accordance with recommended Phase I Guidelines does not warrant seismic analysis.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS & REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition - The conclusion made from the study of available documents, the results of the inspection, the hydraulic calculations and the meetings with the resident staff is that the general condition of Lake Gaillard Dam is good. However, there is enough seepage through the body of the main dam so that the source as well as the extent should be identified.

b. Adequacy of Information - The assessment of the condition of the facility can be based on the information available as well as the visual inpsection.

c. Urgency - It is suggested that the recommendations below should be implemented within two to three years after receipt of this Phase I Inspection Report.

d. Need for Additional Investigations - Taking into account the obtained results, additional observations and investigations should be performed. Primary attention should be given to obtain a more accurate definition of the seepage discharges and to identify any pervious zones.

7.2 Recommendations

Considering the need for additional data to definitively evaluate the safety of the facility and the lack of instrumentation data, the following should be undertaken by the owner:

1. Measurements

a. Downstream water levels before the metering weir, daily;

b. Discharges in the drainage pipe at the lower gate house, the drainage pipe through downstream channel wall, the springs under the downstream channel wall, the drainage pipe from the roadway catch basin and the metering weir on the downstream channel, monthly. Instruments for measurement of seepage discharges (gutters, pipes, manholes, metering weirs) should be installed;

c. Temperature of seepage water and reservoir water at a depth of one foot below the water surface and near the reservoir bottom simultaneously with measurement of seepage discharges, monthly;

d. Piezometers should be installed within the body of the facility to monitor seepage pressures especially in the areas around the corner of the valve chamber of the main dam and the wetted areas of the east dike, monthly;

e. Settlement of the crest of the main dam, once every two to three years, surface movement monuments could be installed at intervals of 150-200 feet along the tops of the concrete and earth portions;

2. Sketches and photographs of damaged surfaces of the top, upstream and downstream slopes, spillway and downstream channel walls, yearly;

3. Chemical analyses of the reservoir and seepage water in all the springs and drainage pipes simultaneously with the measurement of the dishcarges, yearly. The water should be checked for pH, hardness, Ca, Mg, CO_3, HCO_3, Na+K and CO_2;

4. The existing inspection program should be completed during periods of the highest and lowest reservoir levels, to assure that all features of the dam are continually evaluated.

7.3 Remedial Measures

It is considered important that the following items be attended to as early as practical:

a. Alternatives - Not applicable.

b. O & M Maintenance and Procedures -

1. Grass, brush and trees on the downstream slopes of the main dam should be removed to facilitate visual observations.

2. Repairs should be made to the concrete and stone masonry walls of the channel from the lower valve chamber and the bottom of the channel should be cleaned of loose materials, stones, brush and trees.

3. Because the facility is located in a populated area, a formal warning system should be adopted. Around-the-clock surveillance is recommended during periods of unusually heavy rainfall/runoff.

APPENDIX A

VISUAL INSPECTION CHECK LIST A-1 to A-8

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Lake Gaillard Dam

DATE: 8-1-78

TIME

WEATHER Sunny

W.S. ELEV. 186.50 U.S. 96.0± D.N.S.

PARTY:

1. Richard Lyon
2. Miron Petrovsky
3. Gary Grioux
4. John Schearer
5. Norman Paluba (New Haven Water Company)
6.
7.
8.
9.
10.

PROJECT FEATURE	INSPECTED BY	REMARKS
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Temperature of Air 65° F
Temperature of Water 73° F (upstream)
Temperature of Water 55° F (downstream)
Temperature of Seepage 50° F

PERIODIC INSPECTION CHECK LIST

PROJECT Lake Gaillard Dam DATE 8-1-78

PROJECT FEATURE _____ NAME R. Lyon

DISCIPLINE _____ NAME M. Petrovsky

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	
Crest Elevation	Good
Current Pool Elevation	Good
Maximum Impoundment to Date	Good
Surface Cracks	None observed
Pavement Condition	N/A
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	N/A
Trespassing on Slopes	Not permitted
Sloughing or Erosion of Slopes or Abutments	None
Rock Slope Protection - Riprap Failures	None
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	Wet spot observed at two locations downstream
Piping or Boils	None
Foundation Drainage Features	None
Toe Drains	None

PERIODIC INSPECTION CHECK LIST

OJECT Lake Gaillard Dam DATE 8-1-78

OJECT FEATURE NAME G. Giroux

SCIPLINE NAME J. Schearer

AREA EVALUATED	CONDITION
~~EXEMBANKMENT~~ DAM EMBANKMENT	
Crest Elevation	Good
Current Pool Elevation	Good
Maximum Impoundment to Date	Good
Surface Cracks	Hairline cracks in concrete
Pavement Condition	Fair condition needs some patching
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	None observed
Trespassing on Slopes	Not permitted
Sloughing or Erosion of Slopes or Abutments	Concrete face near ground line at main dam shows some minor damage
Rock Slope Protection - Riprap Failures	N/A
Unusual Movement or Cracking at or near Toes	None observed
Unusual Embankment or Downstream Seepage	Unusual seepage observed at the base of the wall of the outer channel
Piping or Boils	None observed
Foundation Drainage Features	N/A
Toe Drains	N/A
Instrumentation System	N/A

PERIODIC INSPECTION CHECK LIST

PROJECT Lake Gaillard Dam DATE 8-1-78

PROJECT FEATURE NAME M. Petrovsky

DISCIPLINE NAME J. Schearer

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channe	
Slope Conditions	
Bottom Conditions	Underwater
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	
Condition of Concrete	Good
Stop Logs and Slots	Screen slots in gate house - seemed to be in sound condition

PERIODIC INSPECTION CHECK LIST

PROJECT Lake Gaillard Dam DATE 8-1-78

PROJECT FEATURE _____ NAME G. Giroux

DISCIPLINE _____ NAME R. Lyon

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	
General Condition	Good
Condition of Joints	Good
Spalling	None observed
Visible Reinforcing	None
Rusting or Staining of Concrete	None observed
Any Seepage or Efflorescence	None
Joint Alignment	Good
Unusual Seepage or Leaks in Gate Chamber	None (mostly underwater)
Cracks	None observed
Rusting or Corrosion of Steel	None observed
b. Mechanical and Electrical	
Air Vents	N/A
Float Wells	N/A
Crane Hoist	Hand hoist operable
Elevator	N/A
Hydraulic System	N/A
Service Gates	Operable (exercised once a year)
Emergency Gates	Blowoff
Lightning Protection System	N/A
Emergency Power System	N/A
Wiring and Lighting System in [illegible]	N/A

PERIODIC INSPECTION CHECK LIST

PROJECT Lake Gaillard Dam DATE 8-1-78

PROJECT FEATURE NAME M. Petrovsky

DISCIPLINE NAME G. Giroux

AREA EVALUATED	CONDITION
OUTLET WORKS - TRANSITION AND CONDUIT	
General Condition of Concrete	
Rust or Staining on Concrete	36 inch diameter conduit in body of dam (not accessible)
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECK LIST

PROJECT Lake Gaillard Dam DATE 8-1-78

PROJECT FEATURE _____ NAME J. Schearer

DISCIPLINE _____ NAME G. Giroux

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete & Stone	Crumbling badly
Rust or Staining	None observed
Spalling	All concrete work had spalled
Erosion or Cavitation	Stone walls showed damage
Visible Reinforcing	None observed
Any Seepage or Efflorescence	Seepage at base of channel wall
Condition at Joints	N/A
Drain holes	Subsurface drainage observed at three points
Channel	Covered with debris & rock
Loose Rock or Trees Overhanging Channel	A number of tree overhang. One tree is in the channel
Condition of Discharge Channel	Channel has many obstructions

PERIODIC INSPECTION CHECK LIST

PROJECT Lake Gaillard Dam DATE 8-1-78

PROJECT FEATURE NAME R. Lyon

DISCIPLINE NAME J. Schearer

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Underwater
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	
General Condition of Concrete	Good
Rust or Staining	None
Spalling	
Any Visible Reinforcing	
Any Seepage or Efflorescence	
Drain Holes	
c. Discharge Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	
Floor of Channel	Riprap with minor vegetation
Other Obstructions	Bridge downstream

APPENDIX B

LIST OF REFERENCES

1. Recommended Guidelines for Safety Inspection of Dams. Department of the Army; Office of the Chief of Engineers; Washington, D.C.; November, 1975.

2. "Guide Curves for the Probable Maximum Flood (PMF)" for Regions of New England based on past Corps of Engineers' studies; March, 1978.

3. "Preliminary Guidance for Estimating Maximum Probable Discharges in Phase I Dam Safety Investigations"; New England Division; Corps of Engineers; March, 1978.

4. Rule of Thumb. Guidance for Estimating Downstream Dam Failure Hydrographs; Corps of Engineers; April, 1978.

5. "Instrumentation of Earth and and Rockfill Dams" EM 1110-2-1908; Deaprtment of the Army; Corps of Engineers; 31 August 1971.

6. "Stability and Hydrological Analysis of Lake Gaillard - Main Dam and East Dike"; Roald Haestad, Inc; Consulting Engineers of Middlebury, Connecticut; 1977.

7. Drawings for the Lake Gaillard Dam: (1) Map and Profiles of Totket Dam and East Dike; (2) Cross Sections of Totoket Dam and East Dike; (3) Plan of Gate House on Dam, Gate House below Dam; Blowoff Intake, Headwall and Apron; (4) Plan of Lower Gate House and Blowoff Headwall; (5) Vault for Blowoff and Supply Mains; (6) Plan of Wall around Lower Gate House; New Haven Water Company; North Branford Development; Town of North Branford, Connecticut; 1926-1929.

8. Table of Capacities and Areas of North Branford Reservoir; New Haven Water Company.

9. Table of Width and total Volumes for Section of Dam, one foot long; New Haven Water Company; North Branford Dam; Town of North Branford, Connecticut; Jaunary, 1926.

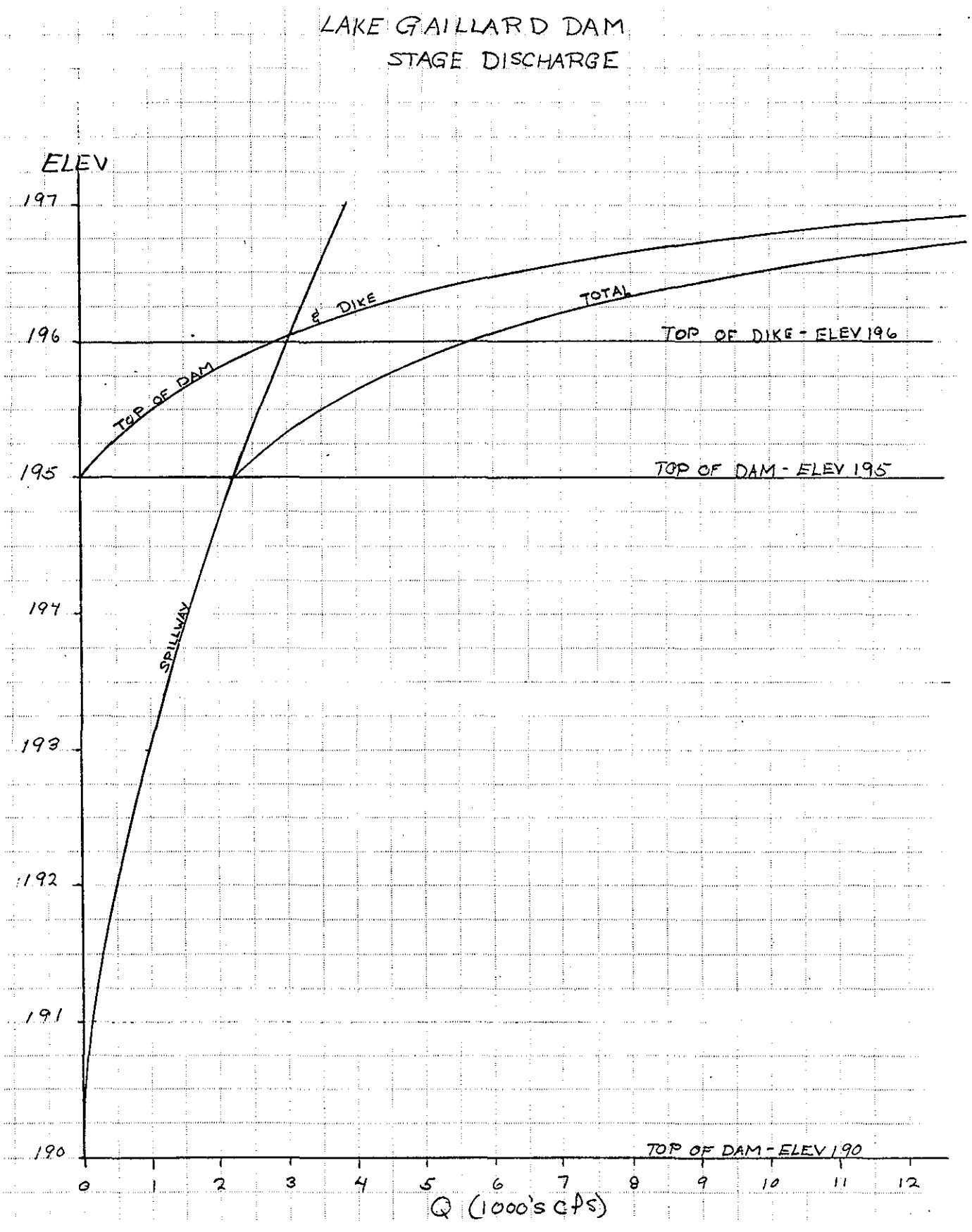
10. Storage Diagram for Lake Gaillard; New Haven Water Company.

LAKE GAILLARD DAM
STAGE DISCHATRGE

SEE PLATES & FOR PLAN & ELEVATION

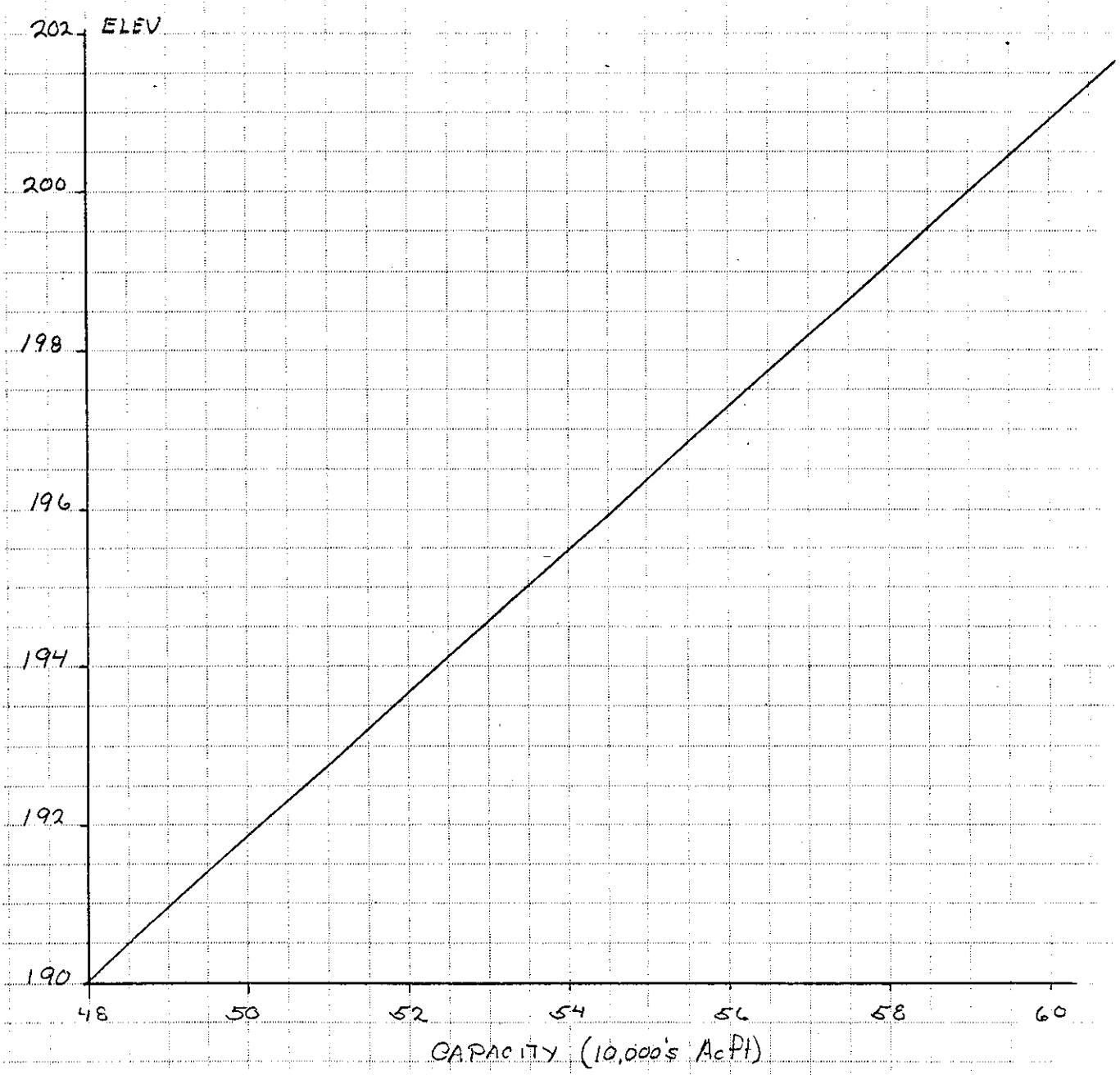
$$Q = C L H^{3/2}$$

	SPILLWAY				DAM				
ELEV	H	C	L	Q	H	C	L	Q	Q_T
190	0	0	50	0					0
191	1	3.3		165					165
192	2	3.47		490					490
193	3	3.67		955					955
194	4	3.78		1510					1510
195	5	3.9		2180					2180
196	6	4.06		2985	1	2.68	1020	2735	5720
197	7	4.17		3860	2	2.68	2470	18,720	22,580


LAKE GAILLARD DAM
STAGE DISCHARGE
ELEV
197
196
195
194
193
192
191
190
0
1
2
3
4
5
6
7
8
9
10
11
12
Q (1000's CFS)
TOP OF DAM
℄ DIKE
TOTAL
SPILLWAY
TOP OF DIKE - ELEV 196
TOP OF DAM - ELEV 195
TOP OF DAM - ELEV 190

LAKE GAILLARD DAM
CAPACITY

ELEV	DEPTH	AREA	AVG AREA	VOL.	Σ VOL. (Ac Ft)
190		1102			48,000
	6		1102	6612	
196		1102			54,612



ASSUMPTIONS AND CONSTANTS USED FOR THE STRUCTURAL AND STABILITY ANALYSES

Unit weight of water = 62.5 lbs/cu. ft

Unit weight of concrete = 150 lbs/cu. ft[7]

Unit shear resistance of both concrete and rock = 400 lbs/sq. in.[7]

Coefficient of internal friction of concrete or of concrete on rock = 0.65[7]

Horizontal and vertical component of assumed earthquake shock has an acceleration of 0.1 gravity[1] (Conservative value corresponding to Zone 3 - Seismic Zone Map) and for combined effects, occuring simultaneously.

Maximum ice pressure is 8,000 lbs/lin. ft of dam and the maximum ice thickness is 2 ft[2]

Uplift pressure on the base on any horizontal section varies from full-reservoir pressure at the upstream face to zero at the downstream face, and is considered to act over two-thirds the area of the section. Uplift is assumed to be unaffected by earthquake shock, and to have no effect on stresses in the interior of the dam.[7]

The concrete in the dam is a homogeneous, isotropic, and uniformly elastic material. It is assumed to have an allowable compressive strength of 900 psi, an allowable tensile strength of zero psi, and an allowable shear strength of 400 psi. Maximum allowable sliding factor (f) = .75 and minimum allowable shear-friction (g) = 5.[2]

There are no differential movements which occur at the dam site due to water loads on the reservoir walls and floors.

The base of the dam is thoroughly keyed into the rock foundation. (See Figure 3, page 17).

All loads are carried by the gravity action of vertical, parallel side cantilevers which receive no support from the adjacent elements on either side.[7]

Unit vertical pressures, or normal stresses on horizontal planes, vary uniformly as a straight line from the upstream face to the downstream face.[7]

The East Dike Embankment material has the following characteristics[3]:

Upstream - Ød = 25°, unit weight of soil - wet = 110 lb/cu. ft
Cohesion = 100 psf sat. = 125 lb/cu. ft
Downstream-Ød = 30°, unit weight of soil - wet = 100 lb/cu. ft
Cohesion = 100 psf sat. = 110 lb/cu. ft

Phreatic surface is below the surface of failure.

TABLE II

EAST DIKE

SHEAR FAILURE FACTORS OF SAFETY

CASE	LOADING CONDITION	FACTORS OF SAFETY	RECOMMENDED FACTORS OF SAFETY[3]	REMARKS
I	Sudden drawdown from spillway crest to minimum drawdown elevation upstream embankment.	1.2	1.2	Additional stability offered by the riprap on the upstream slope was neglected.
II	Partial pool with assumed horizontal steady seepage saturation upstream embankment.	2.0	1.5	
III	Steady seepage from spillway crest. Downstream embankment.	1.7	1.5	Phreatic surface is assumed to be below the failure plane.
IV	Earthquake Case III with seismic loading. Downstream embankment.	1.3	1.0	0.1 seismic coefficient based on Zone 3 Seismic Zone Map[1]

NOTES:

1. Method of Analysis: "Taylor's Stability #'s" [6]

2. Assumptions (See Appendix I)

3. From Table IV "Recommended Guidelines for Safety Inspection of Dams", Dept. of the Army, Office of the Corps of Engineers.

COMPUTATIONS SUPPLIED BY THE NEW HAVEN WATER COMPANY

TABLE I

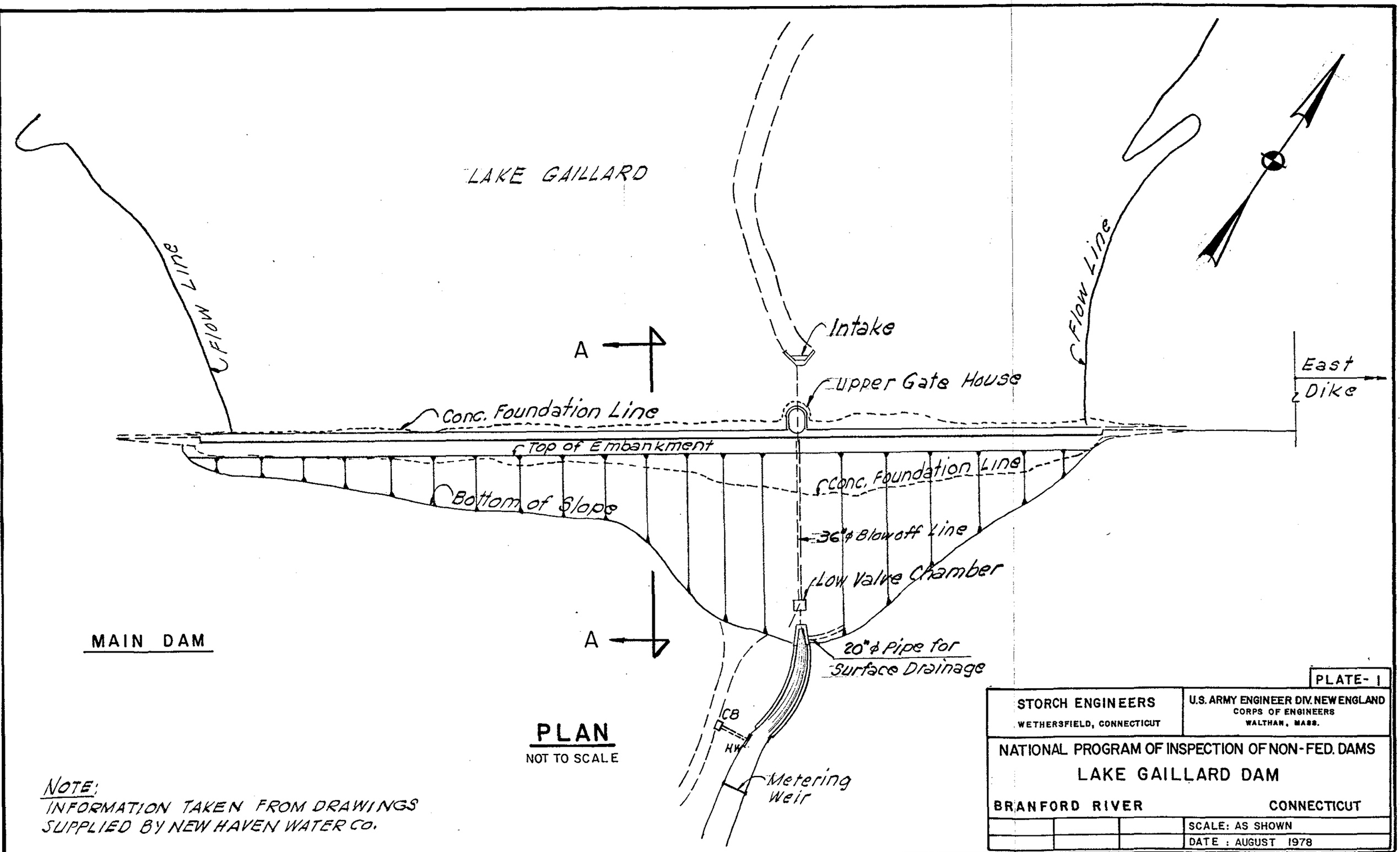
LAKE GAILLARD - MAIN DAM STRUCTURE
MAXIMUM STRESSES (AT D.S. & U.S. FACES), MAXIMIM SLIDING FACTOR
AND MINIMUM SHEAR-FRICTION FACTOR FOR VARIOUS LOADINGS
GRAVITY METHOD OF ANALYSIS

LOADING CONDITION	STRESS-lbs/in^2 COMPR. (MAX. ALLOWABLE 900)	TENSION lbs/in^2 (MAX. ALLOWABLE 0)	MAX. SHEAR lbs/in^2 (MAX. ALLOWABLE 400)	MAXIMUM$^+$ SLIDING FACTOR (f) (MAX. ALLOWABLE .75)	MINIMUM^{++} SHEAR-FRICTION (g) (MIN. ALLOWABLE 5)
Reservoir Empty (Normal)	103 U.S. & D.S. Elev. 94	none	48 D.S. Elev. 94	---	---
Normal Full Reservoir Operation (Normal)	201 D.S. Elev. 94	none	95 D.S. Elev. 94	.35 Elev. 140	22 Elev. 160
Maximum Reservoir Elevation (Unusual)	218 D.S. Elev. 94	none	102.3 D.S. Elev. 94	.37 Elev. 160	19.7 Elev. 94
Maximum Reservoir Elev. w/o Downstream Embankment (Extreme)	122 D.S. Elev. 94	none	57 D.S. Elev. 94	.75 Elev. 94	14.4 Elev. 94
Normal Full Reservoir with Earthquake Effect (Extreme)	252 D.S. Elev. 94 *	2 U.S. Elev. 94	118 D.S. Elev. 94	.46 Elev. 140	13.5 Elev. 94
Normal Full Reservoir with Maximum Ice Load (Unusual)	209 D.S. Elev. 94	5 U.S. Elev. 180	98 D.S. Elev. 94	.45 Elev. 180	21 Elev. 94

* Direction of earthquake acceleration

\+ Sliding factor = $\frac{\text{Horizontal Force}}{\text{Weight - Uplift}}$

++ Shear-friction factor = $\frac{\text{(Weight-Uplift) x coefficient of internal friction + horizontal area x unit shear resistance}}{\text{Horizontal Force}}$



MAIN DAM

PLAN

NOT TO SCALE

NOTE:
INFORMATION TAKEN FROM DRAWINGS SUPPLIED BY NEW HAVEN WATER CO.

PLATE- 1

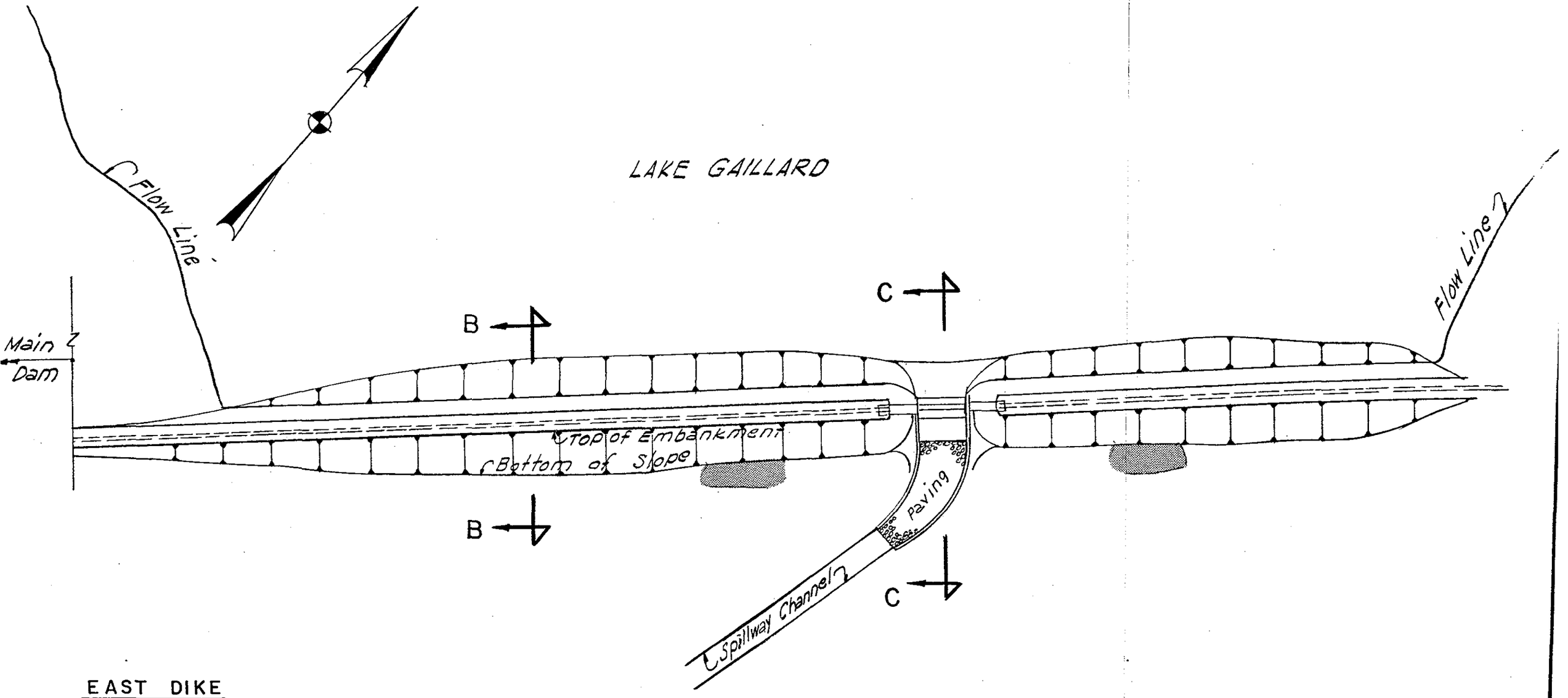
STORCH ENGINEERS WETHERSFIELD, CONNECTICUT	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LAKE GAILLARD DAM

BRANFORD RIVER CONNECTICUT

			SCALE: AS SHOWN
			DATE : AUGUST 1978



EAST DIKE

PLAN

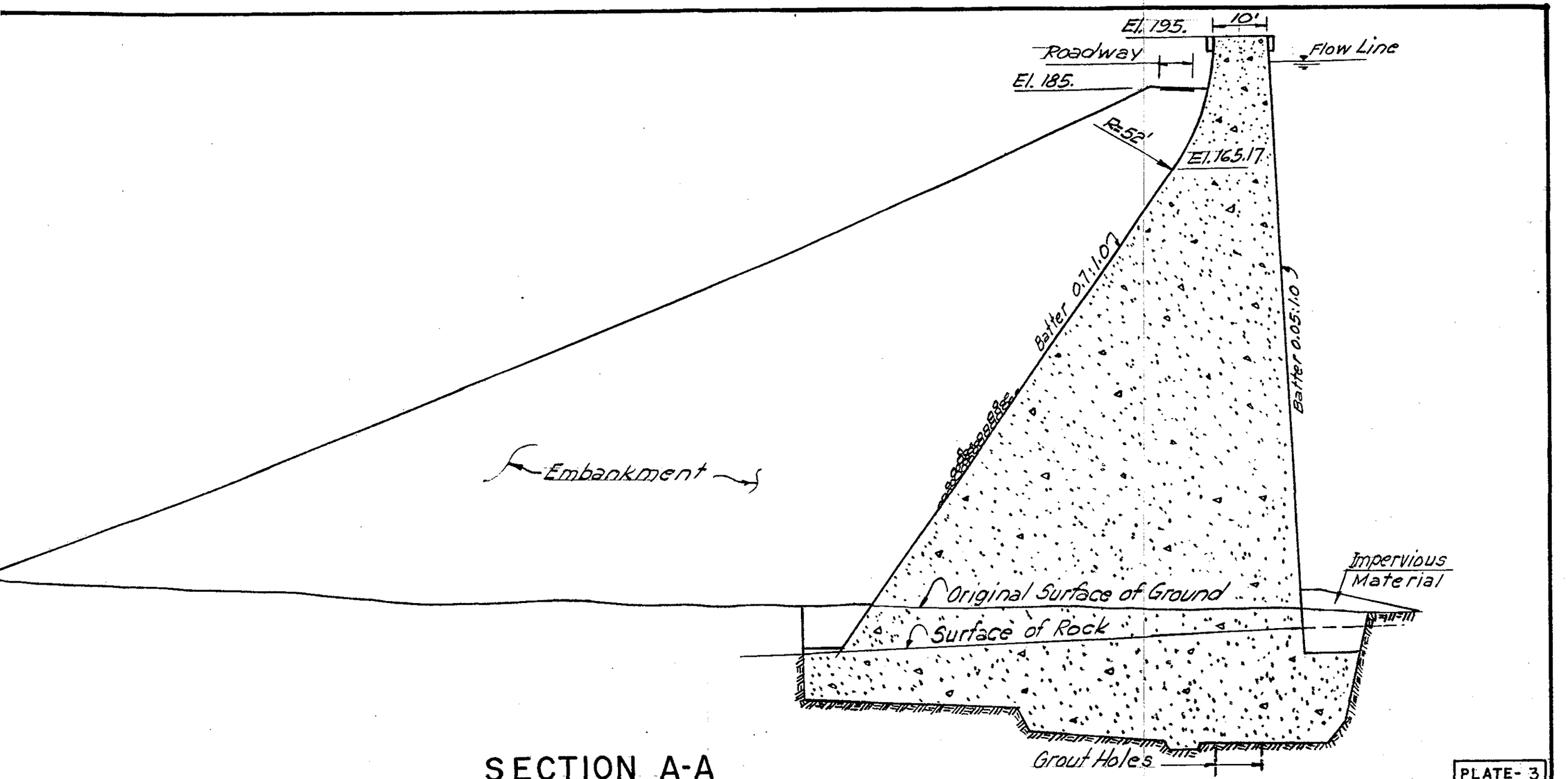
NOT TO SCALE

▒ DENOTES WET SPOT

NOTE:
INFORMATION TAKEN FROM DRAWINGS SUPPLIED BY NEW HAVEN WATER CO.

PLATE-2

STORCH ENGINEERS WETHERSFIELD, CONNECTICUT	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS LAKE GAILLARD DAM BRANFORD RIVER CONNECTICUT	
	SCALE: AS SHOWN
	DATE : AUGUST 1978



SECTION A-A

NOT TO SCALE

NOTE:
INFORMATION TAKEN FROM DRAWINGS SUPPLIED BY NEW HAVEN WATER Co.

PLATE- 3

STORCH ENGINEERS WETHERSFIELD, CONNECTICUT	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

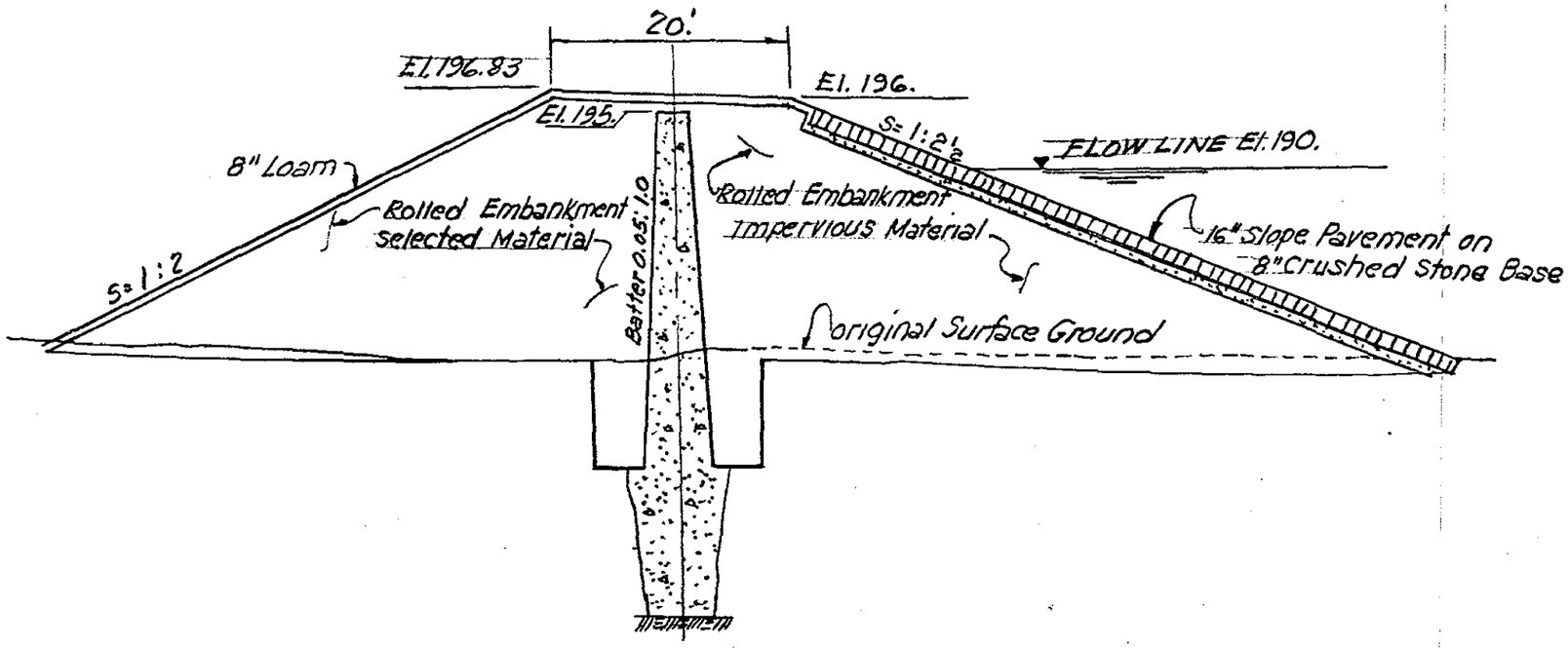
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LAKE GAILLARD DAM

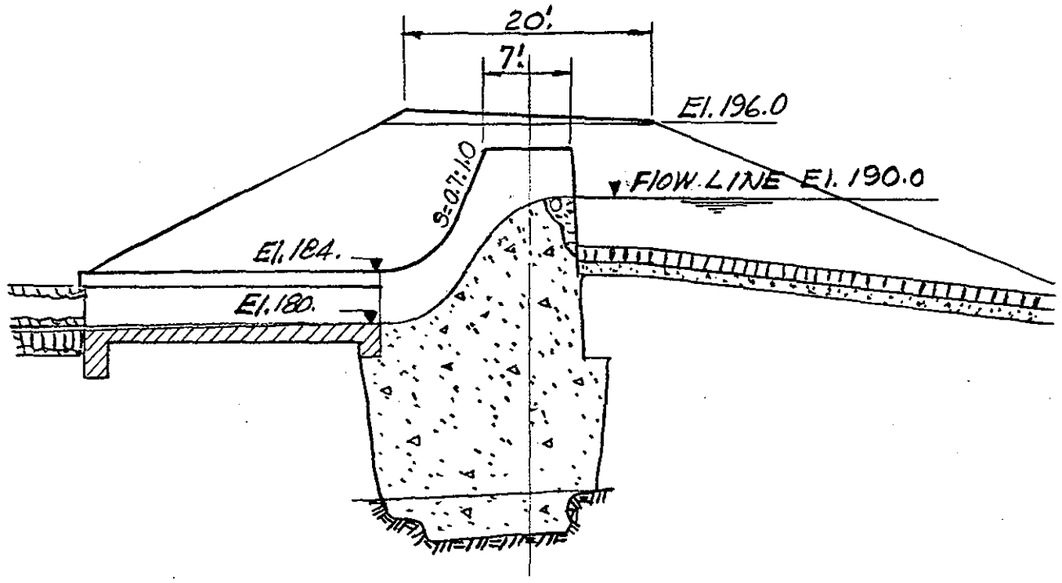
BRANFORD RIVER CONNECTICUT

SCALE: AS SHOWN

DATE : AUGUST 1978



SECTION B-B



SECTION C-C

NOTE:
INFORMATION TAKEN FROM DRAWINGS SUPPLIED BY NEW HAVEN WATER Co.

PLATE-4

STORCH ENGINEERS WETHERSFIELD, CONNECTICUT	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

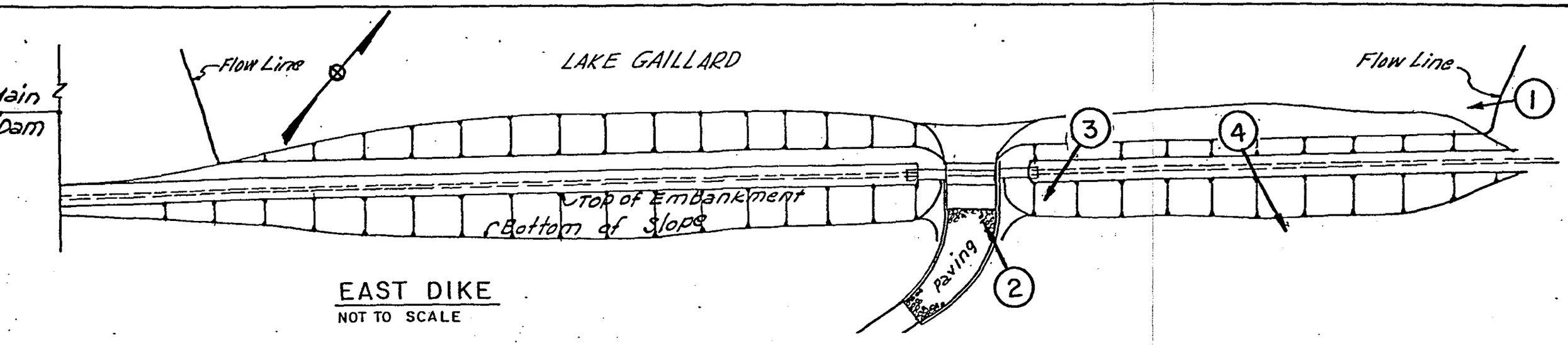
LAKE GAILLARD DAM

BRANFORD RIVER CONNECTICUT

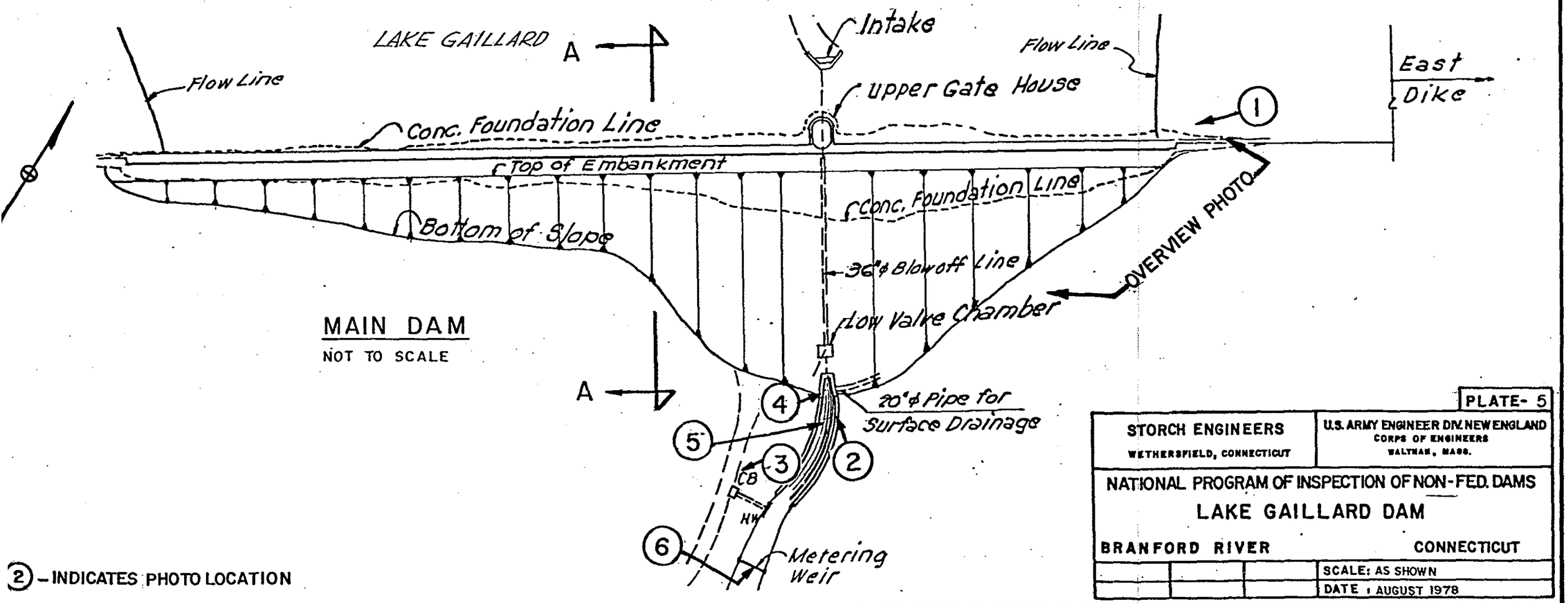
SCALE: AS SHOWN (Not to Scale)

DATE : AUGUST 1978

APPENDIX C



EAST DIKE
NOT TO SCALE



MAIN DAM
NOT TO SCALE

(2) – INDICATES PHOTO LOCATION

PLATE- 5

STORCH ENGINEERS WETHERSFIELD, CONNECTICUT	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LAKE GAILLARD DAM

BRANFORD RIVER — CONNECTICUT

SCALE: AS SHOWN

DATE : AUGUST 1978

PHOTO 1

CREST OF DAM AND UPPER GATE HOUSE

PHOTO 2

FACE OF DAM AND LOWER GATE HOUSE

PHOTO 3

SEEPAGE FLOW IN CATCH BASIN DOWNSTREAM

PHOTO 4

DRAINAGE OUTLET INTO DOWNSTREAM CHANNEL

PHOTO 5

SEEPAGE UNDER DOWNSTREAM CHANNEL WALL

PHOTO 6

METERING WEIR ON DOWNSTREAM CHANNEL

PHOTO 1

CREST AND UPSTREAM FACE OF EAST DIKE

PHOTO 2

DOWNSTREAM FACE OF SPILLWAY

PHOTO 3

DOWNSTREAM SPILLWAY CHANNEL

PHOTO 4

WET SPOT AT TOE OF EAST DIKE

APPENDIX D

400 Ac Ft = 1"

LAKE GAILLARD DAM
DETERMINATION OF PMF & SDF

Drainage Area - 7.5 SM

Inflow (ref.) - 1,730 cfs/SM

PMF = 1,730 (7.5) = 12,975 cfs

Determine the effect of surcharge storage on Maximum Probable Discharge (ref.)

① Q_{P1} = 12975 cfs

② a. H_1 = 196.75 (Elev)

b. $STOR_1$ = 7,400 Ac Ft = 18.5"

c. $Q_{P2} = Q_{P1}\left(1 - STOR_1/19\right) = 12{,}975\left(1 - 18.5/19\right) = 341$ cfs

③ a. H_2 = 191.65 (Elev)

$STOR_2$ = 1750 Ac Ft = 4.375"

b. $STOR_A$ = 11.4375"

$Q_{P3} = 12{,}975\left(1 - 11.4375/19\right) = 5{,}165$ cfs

H_3 = 195.9 (Elev)

PMF = 5165 cfs

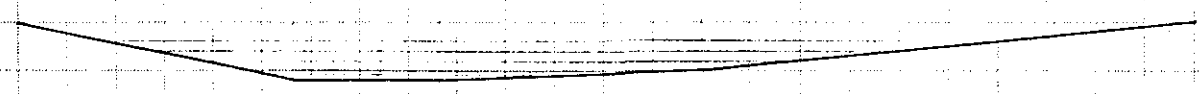
Capacity of spillway when pond elevation is @ top of dam.

Q = 2180 42.2 % PMF

LAKE GAILLARD DAM

SECTION NO. 1

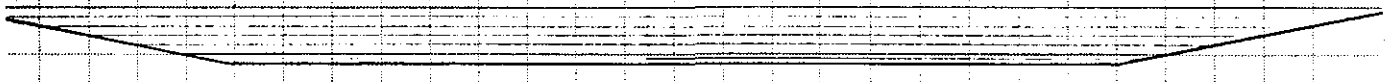
n = .035 S = .6 %



D	WP	A	R	$R^{2/3}$	$S^{1/2}$	V	Q
5	260	850	3.27	2.2	.079	7.4	6290
10	410	2700	6.58	3.5	.079	11.7	31,700
20	560	8000	13.8	5.25	.079	19.3	154,300
30	740	16,000	20.3	7.44	.079	24.95	374,320
40	910	22,800	25.1	8.57	.079	28.7	655,880

SECTION NO. 2

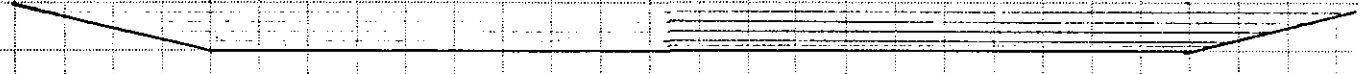
n = .035 S = .1 %



D	WP	A	R	$R^{2/3}$	$S^{1/2}$	V	Q
5	940	4650	4.8	2.86	.032	3.9	17,700
10	1000	9400	9.4	4.45	.032	6.05	56,925
20	1100	20000	18.2	6.92	.032	9.4	188,000
30	1200	31200	26.0	8.79	.032	11.9	372,430

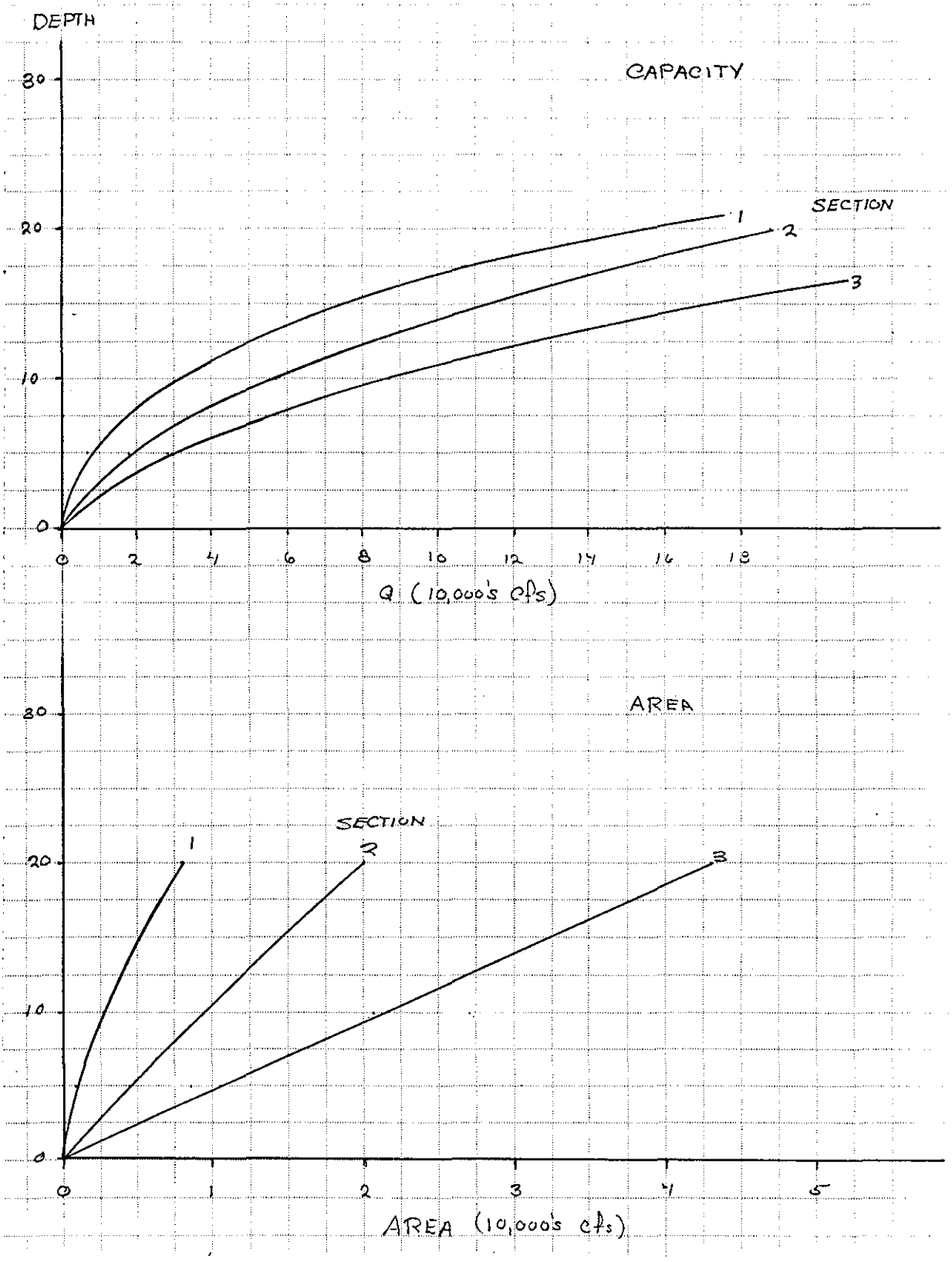
SECTION NO 3

n = .035 S = .05 %



D	WP	A	R	$R^{2/3}$	$S^{1/2}$	V	Q
5	2100	10500	5.0	2.9	.022	2.7	29,440
10	2150	20700	9.6	4.5	.022	4.2	87,000
20	2300	43000	18.7	7.1	.022	6.6	285,160
30	2500	70500	28.2	9.3	.022	8.7	612,700

LAKE GAILLARD DAM



LAKE GAILLARD DAM

"RULE OF THUMB" GUIDANCE FOR ESTIMATING DOWNSTREAM DAM FAILURE HYDROGRAPHS

SECTION 1 @ Dam

① $S = 48{,}000$ Ac-ft

② $Q_{P1} = 8/27\ W_b \sqrt{g}\ y^{3/2} = 8/27\ 100\sqrt{32.2}\ 95^{3/2} = 155680$ cfs

SECTION 2 @ Valley Rd. Section No. 1

③ See Rating Curve

④a $H_1 = 20.0'$ $L = 11100'$ $V_1 = 2040$ Ac-ft

b. $Q_{P2} = Q_{P1}(1 - V/S) = 155680(1 - 2040/48000) = 149{,}000$ cfs

c. $H_2 = 19'$ $A_2 = 7700$ ft^2

$A_{avg} = 7850$ ft^2 $V_{avg} = 2000$ Ac-ft

d. $Q_{P2} = 155680(1 - 2000/48000) = 149200$ cfs

$H_2 = 19.2'$ $A_2 = 7800$ ft^2

SECTION 3 @ 1000' D/S section 1 use section 2

④a. $H_2 = 19.2'$ $A_2 = 7800$ ft^2 $L_2 = 1000'$ $V_2 = 179$ Ac-ft

b. $Q_{P2} = 149200(1 - 179/48000) = 148{,}650$ cfs

c. $H_2 = 17.0'$ $A_2 = 17000$ ft^2

$A_{avg} = 12400$ ft^2 $V_{avg} = 285$ Ac-ft

d. $Q_{P3} = 149200(1 - 285/48000) = 148{,}300$ cfs

$H_3 = 17.0'$ $A_3 = 17000$ ft^2

SECTION 4 @ I-95

④ a. $H_3 = 17.0'$ $A_3 = 17000$ ft^2 $L_3 = 11100'$ $V_3 = 4331$ Ac-ft

b. $Q_{P3} = 148300(1 - 4331/48000) = 135{,}000$ cfs

c. $H_4 = 16'$ $A_4 = 16000$ ft^2

$A_{avg} = 165000$ ft^2 $V_{avg} = 4200$ Ac-ft

d. $Q_{P3} = 148300(1 - 4200/48000) = 135{,}300$ cfs

$H_4 = 16.2'$ $A_4 = 16700$ ft^2

LAKE GAILLARD DAM

SECTION 5 @ MONTOWESE ST use section 3

④ a. $H_4 = 16.2'$ $A_4 = 16700\ ft^2$ $L_4 = 8980$ $V_4 = 344\ Ac\text{-}ft$

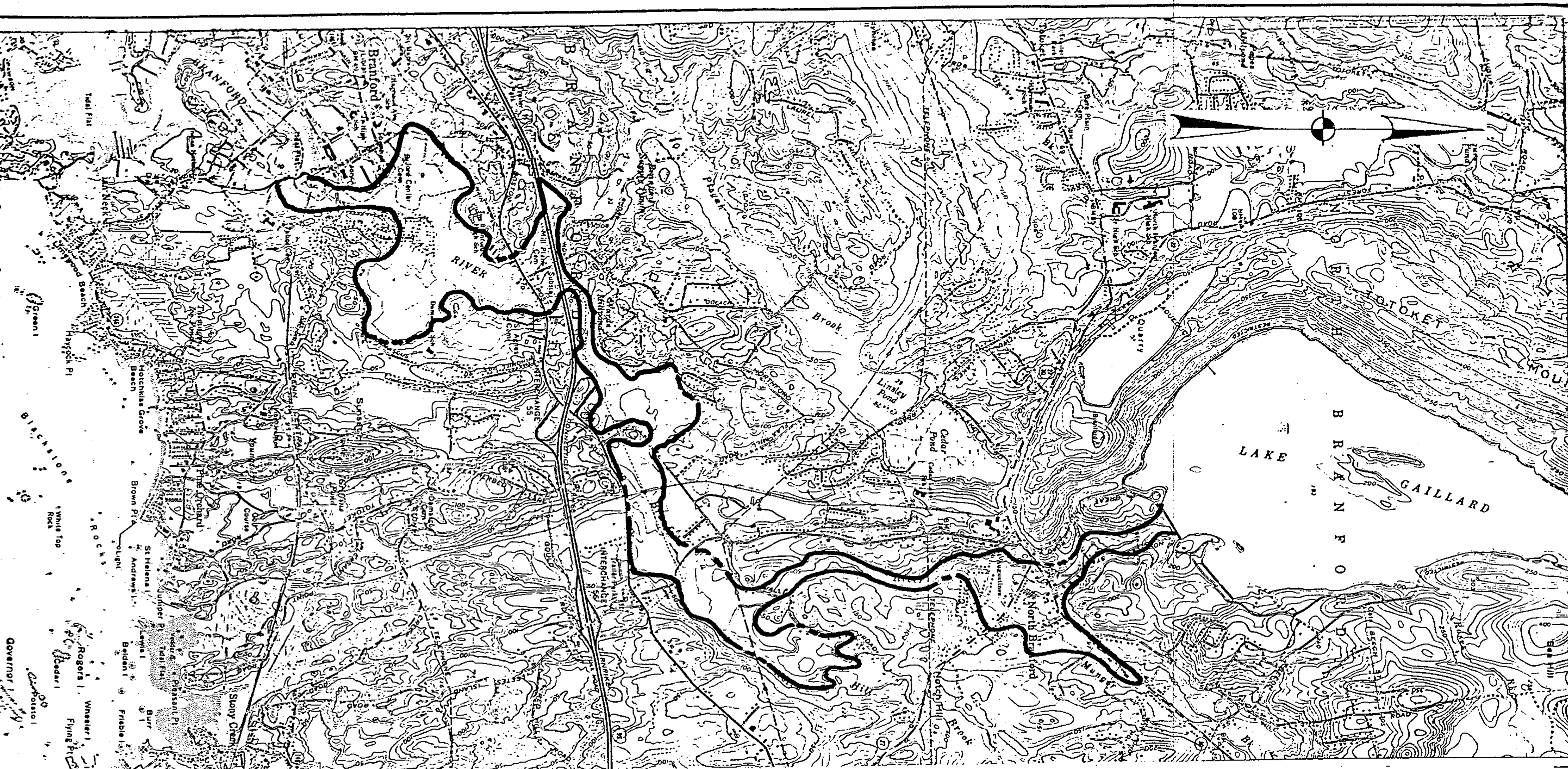
b. $Q_{P5} = 135300(1 - 344/48000) = 134330\ cfs$

c. $H_5 = 13'$ $A_5 = 28000\ ft^2$

$A_{avg} = 22350\ ft^2$ $V_{avg} = 4600\ Ac\text{-}ft$

d. $Q_{45} = 135300(1 - 4600/48000) = 122300\ cfs$

$H_5 = 12'$



REGIONAL VICINITY MAP

PLATE-6

LEGEND

——— - - DENOTES LIMITS OF FLOODING IN CASE OF DAM FAILURE

SCALE 1:24000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET

DATUM IS MEAN SEA LEVEL

STORCH ENGINEERS WETHERSFIELD, CONNECTICUT	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS LAKE GAILLARD DAM	
BRANFORD RIVER	CONNECTICUT
	SCALE: AS SHOWN
	DATE : AUGUST 1978

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS