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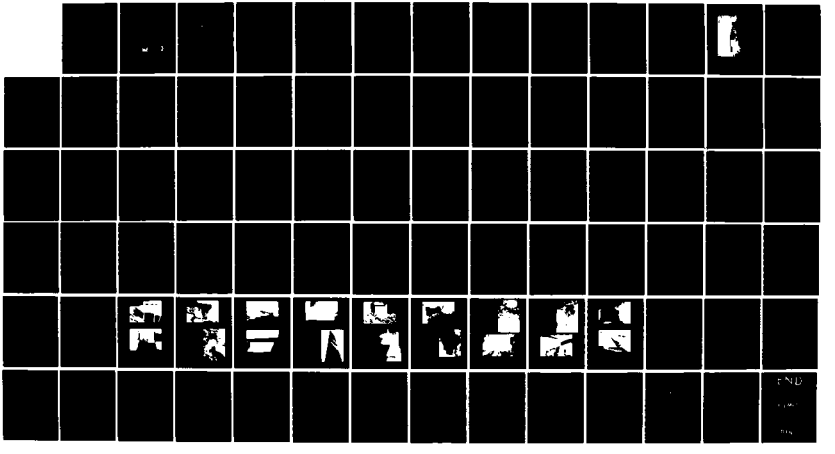

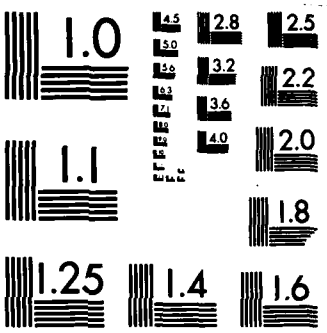

CONNECTICUT RIVER BASIN

HARRISVILLE, NEW HAMPSHIRE

HOWE RESERVOIR DAM

NH 00095

NHWRB 109.12

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

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

MAY 1979

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Connecticut River Basin
Harrisville, New Hampshire
Howe Reservoir Offstream

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

The dam consists of dry rubble masonry capped with concrete and an earthfill embankment with a total length of about 157 ft. and 28 ft. above the stream bed. The dam is judged to be in good condition. THe protective covering of the stone placed on the outlet channel has been washed away. It is intermediate in size with a high hazard potential. There are various remedial measures which must be corrected to assure the continued performance of the dam.

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HOWE RESERVOIR DAM

NH 00095
NHWRB 109.12

CONNECTICUT RIVER BASIN
HARRISVILLE, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

Identification No.	NH 00095
Name of Dam:	Howe Reservoir Dam
Town:	Harrisville
County & State:	Cheshire, New Hampshire
Stream:	Howe Reservoir Offstream
Date of Inspection:	May 18, and May 22, 1978

BRIEF ASSESSMENT

Howe Reservoir Dam, constructed prior to 1924, consists of dry rubble masonry capped with concrete and an earth fill embankment with a total length of approximately 157 feet with a maximum height of 28 feet above the stream bed. The spillway, which is located in the southern portion of the dam, is approximately 75 feet long and 2 feet lower than the crest of the dam.

Based on visual inspection, the dam is judged to be in good conditon. The protective covering of the stone placed in the outlet channel has been washed away. Seepage was observed at the junction of the embankment and outlet chamber and below the spillway in the center of the dam. The spillway weir, capped with concrete, shows several areas of erosion. Continuance of this classification depends on proper operations and maintenance of the dam.

This dam falls under the category of high hazard potential, and it is intermediate in size. The test flood peak inflow is equal to the Probable Maximum Flood, 15,750 cfs, and the test flood peak outflow is 2,650 cfs. Hydraulic analysis indicate that the maximum surcharge pool elevation is 1279.0, approximately 4.5 feet above the spillway crest. The test flood will overtop the dam by 2.5 feet. The spillway alone will pass approximately 24% of the test flood peak outflow without overtopping the dam. Whereas the spillway and the outlet channel together will pass about 68% of the test flood peak outflow without overtopping the dam.

As stated in Section 7, riprap should be placed in the outlet channel within 1 year of receipt of this Phase I report by the new Hampshire Water Resources Board, and within 2 years, implement the results of the following recommendations:

1. Assess further the potential for overtopping.

2. Extent of damage in the Town of Marlborough in the event of failure of this dam.

The following operating and maintenance measures, as stated in Section 7.3, should also be implemented:

1. Riprap should be placed in the outlet channel.

2. All concrete surfaces should be repaired.

3. Seepage areas should be monitored to determine the cause, and corrective measures should be taken.

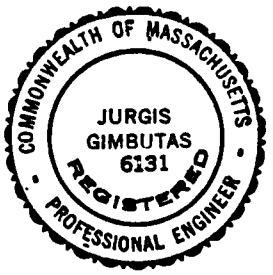
4. The gate controlling the flow through the outlet conduit should be checked for damage and repaired if necessary.

5. Downstream outlet and discharge channel should be cleaned of any debris.

6 A program of regular maintenance should be established.

7. A program of technical annual periodic inspection of the project features should be prepared and initiated.

8. Surveillance and a warning system be developed for periods of unusually heavy rains and runoff.



FAY, SPOFFORD & THORNDIKE, INC.
By

Jurgis Gimbutas, P.E.
Project Engineer

Richard W. Albrecht, P.E.
Vice President

PREFACE

This report is prepared under guidance contained in 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 assessmnet 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. 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 reasonable possible storm runoff), or fractions thereof. Because of the magnitude and rarity 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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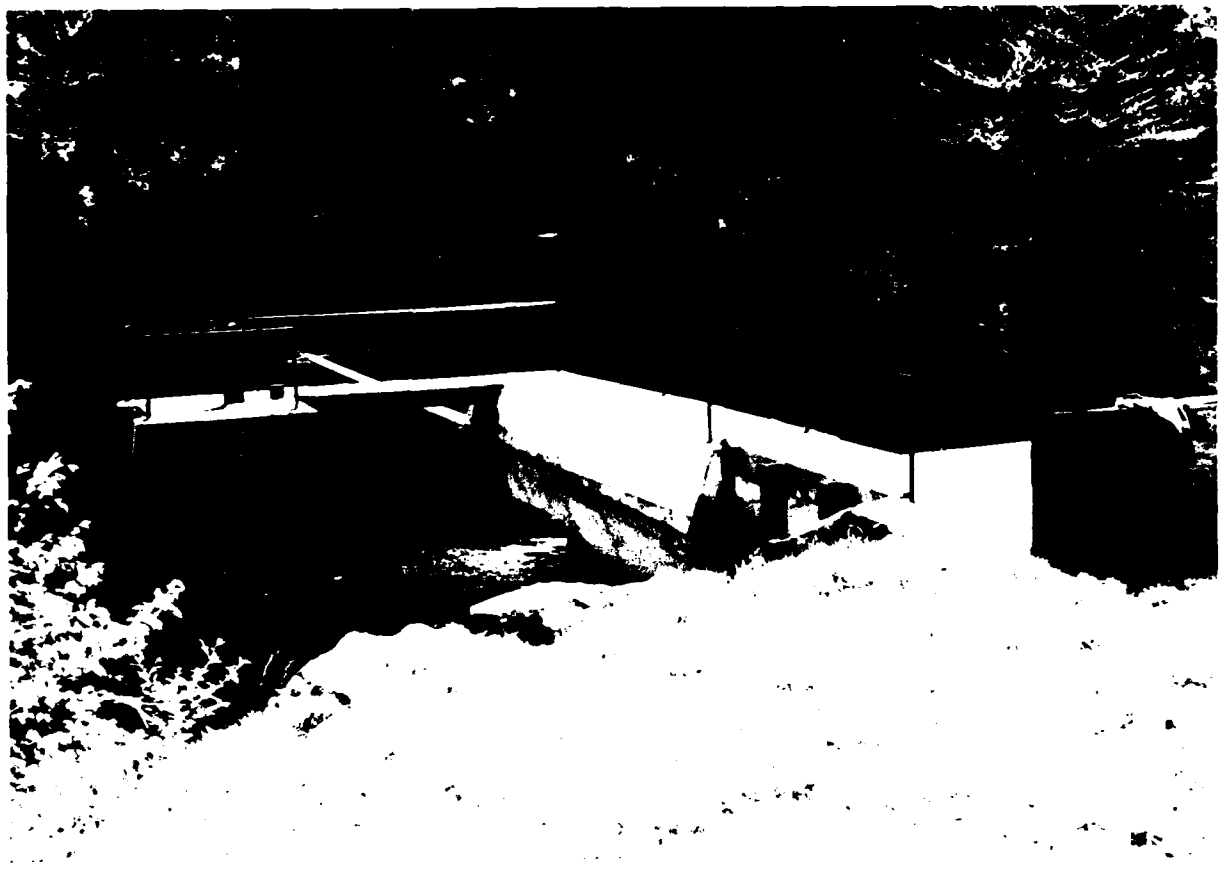
OVERVIEW PHOTOGRAPH



HOWE RESERVOIR DAM, LOOKING SOUTH
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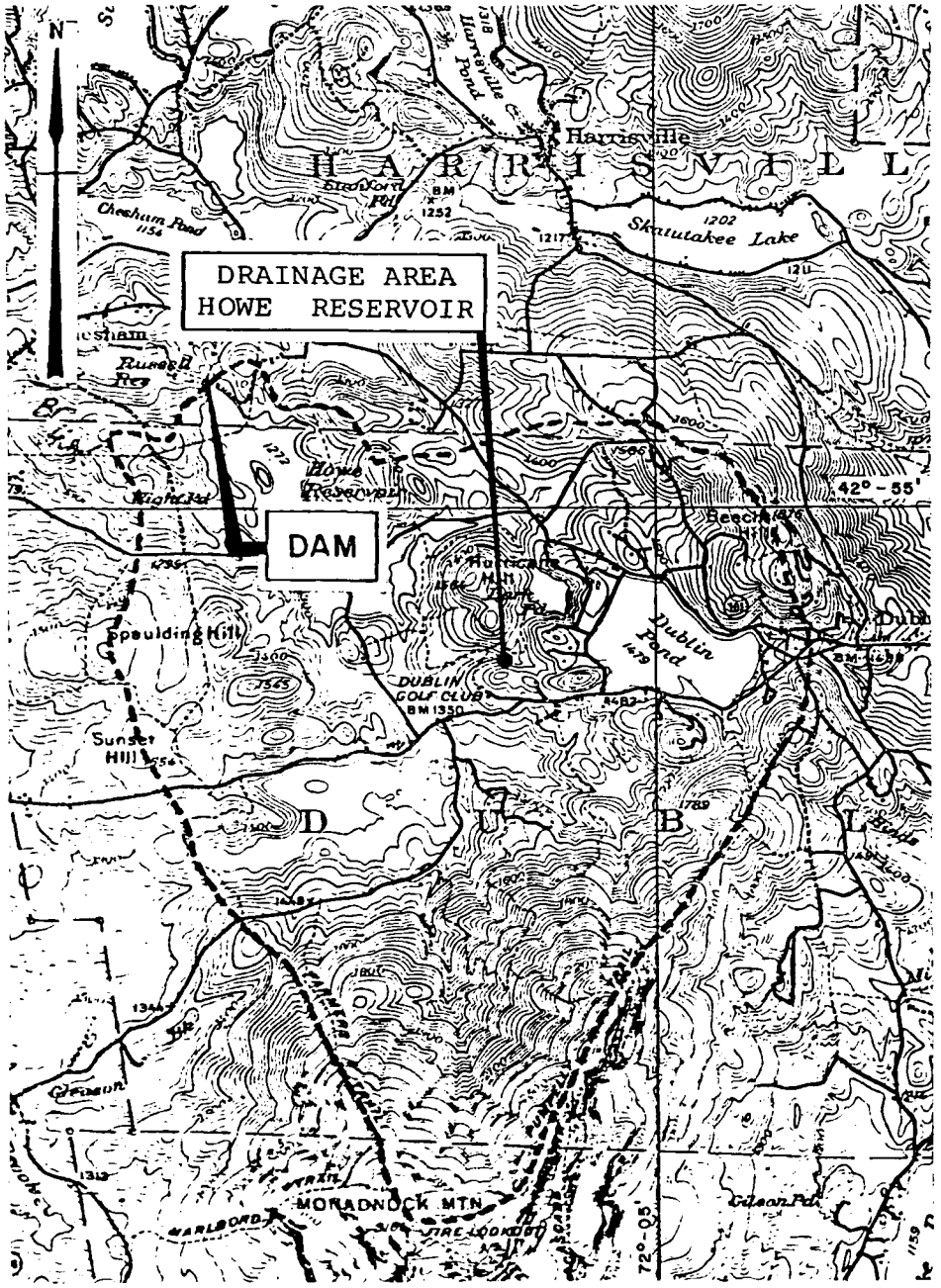

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UNITED STATES
DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY

NEW HAMPSHIRE
MONADNOCK QUADRANGLE
1949
AMS 6569 I-SERIES V 712

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

(1) This dam falls under the category of high hazard potential, and it is intermediate in size. Using the "Recommended Guidelines for Safety Inspection of Dams", the recommended spillway test flood peak inflow is equal to the Probable Maximum Flood. The spillway design test flood inflow hydrograph, estimated, is furnished in Appendix D. The spillway test flood peak inflow is 15,750 cfs.

(2) The estimated maximum peak outflow corresponding to the spillway test flood inflow hydrograph routed through the reservoir is 2650 cfs. Refer to Appendix D for details.

(3) Howe Reservoir storage capacity versus elevation, an estimated curve is furnished in Appendix D.

(4) The estimated discharge rating curve for the spillway is furnished in Appendix D.

(5) The discharge rating curve for pool levels above top of dam (assuming the dam remains intact) is furnished in Appendix D.

(6) The hydrologic map of watershed above dam site, including reservoir area, is included in Appendix D.

b. Experience Data

From the rainfall records available for the years 1892 through 1941, it is noted that significant monthly rainfalls were recorded in March, 1936 and September, 1938. The following is the recorded rainfall for the years 1936 through 1938.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

Howe Reservoir Dam is being operated by the New Hampshire Water Resources Board. Reservoir level is maintained by the uncontrolled overflow spillway located in the southern portion of the dam. Drawdown is accomplished by either the outlet structure or the combination of the outlet structure and the outlet conduit. The outlet structure is controlled by stop logs and the outlet conduit by a gate, both manually operated. During late spring when floods are expected, the gate of outlet conduit is opened as necessary.

4.2 Maintenance of Dam

The maintenance of Howe Reservoir Dam is the responsibility of the New Hampshire Water Resources Board.

4.3 Maintenance of Operating Facilities

Throughout the year, the dam is checked on a weekly or bi-weekly schedule by the Hampshire Water Resources Board. Maintenance of the operating facilities to operate the 42-inch circular gate to control the flow in the 3-foot diameter circular sluice pipe in the body of the non-overflow section of the dam is satisfactory. The approach and the accessibilty to the operating platform is well maintained. Maintenance of the facilities for operating stop logs across the outlet channel provided in the body of dam near the right abutment is good.

4.4 Description of any Warning System in Effect

A flood warning system is not in effect.

4.5 Evaluation

The operation and maintenance procedures for Howe Reservoir Dam consisting of either a weekly or bi-weekly program of inspeciton, should ensure that all problems encountered can be remedied within a reasonable period of time.

3.2 Evaluation

The observed condition of the dam is good. The potential problems observed during the visual inspection are listed as follows:

1. Lack of protective covering of stone in the outlet channel.

2. Seepage at the junction of the embankment and the outlet channel, and below the spillway in the center of dam.

3. Concrete erosion.

4. Potential for overtopping.

The gate controlling the flow through the outlet conduit is in operable condition. Minor flow was observed in this pipe when the gated was closed.

d. Reservoir Area

Howe Reservoir is located near the lower end of the Pratt Brook Watershed. The area of the pond is 208 acres. The Reservoir area is accessible, its shoreline is heavily wooded and the lake area is rocky (Photographs No. 11 and 17, Appendix C).

e. Downstream Channel

(1) Outlet Channel - The outlet channel is in poor condition. The protective covering of the stone placed in this channel during the construction of the outlet structure in 1975 had been washed away. The channel bottom adjacent to the outlet structure is approximately 3 feet below the concrete lip. At the extreme northeastern portion of the channel, the interface of the concrete and rock foundation can be seen (Photograph No. 9, Appendix C).

Nearly vertical slopes were noted on the north side of the channel in the vicinity of the outlet structure.

Debris was observed in the channel. The small quantity of debris observed will not significantly impede the flow in the channel.

(2) Discharge Channel - The discharge channel and the existing slopes are in good condition.

An old rock slide, minor in nature, was observed on the south side of the channel within 30 feet of the dam. It appears that this slide has no effect on the stability of the dam.

Observations indicate that the protective covering of the stone placed in the outlet channel has washed into this channel.

Rock slide, debris and stone from the outlet channel is small in quantity and, therefore, will not significantly impede the flow in the channel.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

a. General

The Phase I inspection of Howe Reservoir Dam was performed on May 18, and 22, 1978. A copy of the inspection check list is included in Appendix A.

In general, the soil and rock features are in good condition. The concrete of the right abutment, new outlet channel and the intake structure is in excellent condition. The old concrete capping of the spillway shows several areas of erosion, see subparagraph c.

b. Dam

No evidence of vertical or horizontal misalignment was observed. There is no indication of sloughing, bulging or movement of the slopes, nor is there evidence of piping.

Water was observed flowing from the north side of the outlet chamber into the outlet channel along the interface of the concrete and soil backfill. This flow has caused minor erosion at the northwest side of the outlet chamber.

Seepage, minor in nature, was observed below the spillway approximately in the center of the dam.

Observations indicate that a 6-foot by 8-foot area in the lower southern portion of the dam has been repaired with concrete. At the time of inspection, no seepage was observed in this area.

c. Appurtenant Structures

The intake structure (with gate), the outlet structure (with stop logs), the service footbridge, all within the new right abutment, are in excellent condition. The spillway weir, capped with concrete, shows several areas of erosion. In one area near the right abutment, some reinforcing is exposed (Photographs No. 7 and 8, Appendix C).

The concrete cover of the upstream slope of the masonry could not be seen due to the fact it was underwater. The exposed faces of rubble masonry appear to be sound.

SECTION 2 - ENGINEERING DATA

2.1 Design

Drawings indicating plans, elevations and section of the dam, appurtenant structures and outlet works were obtained from the project records. Selected drawings are included in Appendix B following the listing of records and past inspection reports.

2.2 Construction

Limited engineering data are available on the construction of this dam. During the reconstruction of this dam in 1924, Nazareth Portland Cement from Pennsylvania was used and tested by the testing laboratory of the New Hampshire Highway Department. The aggregate was brought from Garmon-Weave, New Hampshire. See Appendix B for listing of data related to testimg of materials.

Air-entrained concrete of 3,000 psi strength was specified for the construction of the outlet channel in 1975.

2.3 Operation

Records of performance observations are not available. For operational procedures refer to Section 4.

For information pertaining to history of previous failures or deficiencies, refer to Section 1. It is not known whether any remedial measures of known deficiencies are contemplated.

2.4 Evaluation

a. Availability

Pertinent structural, geotechnical and hydrologic and hydraulic data which formed the basis of the design of the dam are available on a limited basis.

b. Adequacy

Sufficient engineering data are available for a Phase I inspection.

c. Validity

The available engineering data is considered valid on the basis of the results of the visual inspection.

h. Spillway

(1)	Type	Ungated concrete weir
(2)	Length of Weir	75 feet
(3)	Crest Elevation	1274.5
(4)	Gates	None
(5)	U/S Channel	Reservoir

i. Regulating Outlet

(1)	Invert	1267.0
(2)	Size	12 feet wide; 9.5 feet deep; 15 feet long
(3)	Description	Reinforced concrete channel
(4)	Control Mechanism	Stop logs
(5)	Other	
	(a) Description	36-inch steel conduit
	(b) Invert	1259.0
	(c) Control Mechanism	42-inch gate operated manually

f. Reservoir Surface (Acres)

(1) Top dam - 268 acres.

(2) Test flood pool elevation - 343 acres.

(3) Flood control pool - not applicable.

(4) Recreation pool - 208 acres.

(5) Spillway crest - 208 acres.

g. Dam

(1)	Type	Dry rubble masonry and earth fill
(2)	Length	157 feet
(3)	Height	28.5 feet
(4)	Top Width	Minimum 3.5 feet
(5)	Side Slopes	
	(a) Dry Rubble Masonry	
	(1) Upstream	1 vertical to 1 horizontal
	(2) Downstream	Vertical
	(b) Rolled Earth Fill	
	(1) Upstream	Flatter than 1 vertical to 2 horizontal
	(2) Downstream	1 vertical to 1.5 horizontal
(6)	Zoning	Not applicable
(7)	Impervious Core	None
(8)	Cutoff	Heel - dry rubble masonry Center - earth fill
(9)	Grout Curtain	None

(2) Maximum known flood at dam site - Exact figure is not known, but the flood of September, 1938 is considered to be the maximum.

(3) Ungated spillway capacity at top of dam 636 cfs at Elevation 1276.5.

(4) Ungated spillway capacity at test flood maximum pool Elevation 2148 cfs at Elevation 1279.0.

c. Elevation (Feet above MSL)

(1) Top dam - 1276.5.

(2) Test flood maximum pool elevation - 1279.0.

(3) Full flood control pool - unknown.

(4) Recreation pool - 1274.5.

In the absence of pertinent data, it is assumed that recreation pool elevation is the same as spillway crest elevation.

(5) Spillway crest - 1274.5.

(6) Stream bed at centerline of dam - 1256 (estimated).

(7) Maximum tail water - 1270 (estimated).

d. Reservoir

(1) Length of maximum pool - 1.8 miles (estimated).

(2) Length of recreation pool - 1.4 miles (estimated).

(3) Length of flood control pool - not applicable.

e. Storage (Acre-Feet)

(1) Top of dam - 2086 acre-feet.

(2) Test flood maximum pool elevation - 2205 acre-feet.

(3) Flood control pool - unknown.

(4) Recreation pool - 1610 acre-feet.

(5) Spillway crest - 1610 acre-feet.

The stop log section of the outlet structure allows the reservoir to be lowered between 5 and 10 feet in the fall and spring. Previous drawdowns, prior to 1975, resulted in a drawdown of approximately 12 feet through the waste gate.

The stop logs are lifted manually with a hooked pole and stored in a locked wooden stop log box. All three sections of the sluice gate have locks to prevent lifting the stop logs by unauthorized persons. The gate that controls the flow through the 36-inch outlet conduit is operated by a crank which is removed each time to prevent vandalism, as vandalism did occur in 1972.

1.3 Pertinent Data

a. Drainage Area

Howe Reservoir, as shown on the U.S.G.S. map, is located at a distance of eight miles east of Keene, New Hampshire. This reservoir is completely artificial. It has a drainage area of 10.5 square miles and an exclusive drainage area below other storage ponds of 4.5 square miles. The watershed area is heavily wooded, undulated and rolling.

b. Discharge at Dam Site

(1) Outlet works (conduit):

(a) 36-inch diameter conduit and invert Elevation 1259.0.

Estimated discharges through this conduit are:

133.6 cfs at spillway crest elevation 1274.5.
142 cfs at top of dam Elevation 1276.5.
152.0 cfs at test flood maximum pool Elevation 1279.0.

(b) Outlet channel with stop logs and Invert Elevation 1267.0 and width 12 feet.

Estimated discharges through the outlet channel are furnished below:

890 cfs at spillway crest Elevation 1274.5.
1170 cfs at top of dam Elevation 1276.5.
1801 cfs at test flood maximum pool Elevation 1279.0.

higher than the new spillway crest with a total rise of 6 feet over the original crest elevation.

A 36-inch diameter steel outlet conduit was installed through the dam just beyond the northern limit of the spillway. This conduit is located at the lower portion of the dam, Invert Elevation 1259. The water flowing through this outlet conduit is controlled by a 42-inch cast iron circular gate operated manually from a bench stand. This reconstruction began July 25, 1924, and was completed September 4, 1924 (Photograph No. 4, Appendix C), and still is in operable condition.

Construction records indicate that a concrete cutoff wall was incorporated in the embankment during the reconstruction of this dam. Field observations indicate that the existing dam does not conform to the plans prepared for the reconstruction of this dam as follows:

(1) Embankment elevation is approximately 1276.5, approximately 1.5 feet lower than shown on the plans.

(2) Upstream slope of the embankment is considerably flatter than shown on the plans.

In 1975, a new outlet structure was constructed in the northern portion of this dam under the supervision of the New Hampshire Water Resources Board. This outlet structure consists of a reinforced concrete channel, 12 feet wide, 9.5 feet deep and approximately 15 feet long, with 16-foot long wingwalls on either side. Available plans indicate that no cutoff was incorporated in the structure. The flow through this structure is controlled by stop logs. The stop log section is divided into three equal sections, each section being 4 feet wide. Field observations indicated that the wingwalls on either side of the structure were never constructed (Photograph No. 2, Appendix C).

i. Normal Operational Procedure

This dam is checked either on a weekly or bi-weekly schedule by personnel of the New Hampshire Water Resources Board, using their established procedures. Since 1975, the crest control of this dam has been provided by either the outlet structure or the combination of outlet structure and the 36-inch outlet conduit. The file of records, described in Appendix B, does not include any detailed check list of items to be used in inspection and operating procedures.

Service Company of New Hampshire. At the present time, the Howe Reservoir Dam is owned by the New Hampshire Water Resources Board.

f. Operator

This dam is being operated by the New Hampshire Water Resources Board.

g. Purpose of Dam

The original purpose of this dam was for storage of water, and equalizing the flow of water in Minnewawa Brook in Marlborough for use at the mills and hydro-electric stations further down this stream. Today, the prime purpose is for recreation.

h. Design and Construction History

Prior to 1924, a dry rubble masonry dam was constructed at this site with a length of approximately 100 feet and a maximum height of 22 feet above the stream bed. The crest elevation was approximately at Elevation 1270.5 with a spillway length of 60 feet. The downstream slope was vertical with an upstream slope inclined about 45 degrees covered with a timber deck.

In 1924, L. H. Shattuck, Inc., Engineers, contractors in Manchester, New Hampshire, obtained permission from the Public Utilities Commission of the State of New Hampshire for the reconstruction and raising of this dam 4 feet for the Keene Gas and Electric Company. Cost analysis performed indicated that the reconstruction and raising of this dam was more economical than the construction of a new arch dam a short distance upstream. To increase the height of this dam, it was necessary to raise the bridge of State Highway Route 101, which crosses the reservoir at the southern end. This work was done by the State Highway Department prior to the reconstruction of this dam. Field observations indicate that this road does not act as a dam.

The dam reconstruction consisted of removing the timber decking on the upstream side and replacing it with a 6-inch reinforced concrete slab and sealing the upstream masonry slope. A trench was blasted in the ledge at the heel of the dam and filled with concrete. As part of increasing the height of the dam by 4 feet, the spillway length was increased from 60 to 75 feet. On the north bank, an earth embankment consisting of impervious material about 5 feet in height and 42 feet in length was to be built, at approximately Elevation 1278. Plans indicate the upstream slope to be 1 vertical to 2 horizontal and the downstream slope to be 1 vertical to 1.5 horizontal. Between the spillway and the earth embankment, a new concrete abutment 40 feet long, with a top elevation of 1276.5, was constructed 2 feet

Route 101 crosses this reservoir on a bridge, one mile south from the dam.

b. Description of Dam

The dam consists of dry rubble masonry, capped with concrete, and an earth fill embankment with a total length of approximately 157 feet and a maximum height of approximately 28 feet above the stream bed. The portion of the dam consisting of dry rubble masonry has a vertical downstream face and an upstream face inclined about 45 degrees with a 6-inch reinforced concrete slab laid over the upstream face. On the upstream side, a cutoff trench was excavated to bedrock at the heel of the dam filled with concrete. The top width of the masonry dam is 3.5 feet and the earth embankment more than 20 feet.

The plans and construction records available indicate that a concrete wall extending to bedrock was incorporated in the embankment and that the embankment consists of impervious material. The upstream face of this embankment is gradually sloped and the downstream slope is approximately 1 vertical to 1.5 horizontal.

The spillway is located in the southern portion of the dam with a crest elevation of 1274.5. The concrete crest is approximately 1 foot wide and 75 feet long.

c. Size Classification

The storage capacity at top of dam is 2086 acre-feet which falls in the range $\geqslant$ 1000 and $<$ 50,000 acre-feet. Therefore, the dam is classified as intermediate in size.

d. Hazard Classification

In the event of failure of this dam, the lower Russell Reservoir Dam will be affected first. By domino effect, if this dam should also fail, the town of Marlborough, which is 5 to 6 miles downstream, will be affected. It is estimated that in the event of failure of this dam, loss of more than a few lives and excessive property damage would probably occur. Therefore, this dam falls in the category of high hazard potential.

e. Ownership

In 1924, this dam was probably owned by Keene Gas and Electric Co. and Breed Co. of Marlborough. Between 1924 and 1926, available records indicate that Ashuelot Gas & Electric Co. became the owner. Records indicate that in 1930 this dam was owned by the Public

HOWE RESERVOIR 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. Fay, Spofford & Thorndike, Inc., Engineers, have been retained by the New England Divison to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to Fay, Spofford & Thorndike, Inc., under a letter of May 3, 1978, from Mr. Ralph T. Garver, Colonel, Corps of Engineers. Contract No. DACW 33-78-C-0308 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

a. Location

Howe Reservoir Dam is located in the southwestern part of the State of New Hampshire. It is located on the northern tip of the reservoir, about one mile upstream from the village of Chesham and eight miles east of Keene, New Hampshire. This reservoir flows into the Russell Reservoir in Chesham, and from there to Minnewawa Brook in Marlborough, which is a tributary to the Ashuelot and Connecticut Rivers. Howe Reservoir is surrounded by woods on all sides. State

Year	Total	Maximum Monthly
1936	42.45 inches	7.60 inches (March)
1937	43.74 inches	6.38 inches (June)
1938	51.30 inches	12.43 inches (Sept.)

1892-1936 - Annual Average - 37.34 inches

Available data indicates that in 1938 the precipitation for the month of September was at least 3.5 times greater than the monthly average rainfall for the years 1892 to 1941. The flood of 1938 is considered to be the maximum flood that has occurred. On the basis of regional frequency studies, the flood of 1938 corresponds to a 100-year flood and available records indicate that this dam was not damaged during this flood.

c. Visual Observations

The valley cross section immediately below the dam is sufficiently deep and wide to convey from the reservoir the peak outflow which is estimated to be about 2,650 cfs. The valley cross section of the downstream channel at a significant impact area, namely Marlborough which is about five miles downstream, is not sufficient to carry this flood discharge. In the event of failure of the dam, several residential houses in the town of Marlborough would be in danger of being flooded.

d. Overtopping Potential

The spillway test flood peak inflow is 15,750 cfs. Assuming the dam remains intact after being overtopped, it is determined by flood routing that the maximum pool level would rise to Elevation 1279.0. Therefore, the maximum surcharge height over the crest of the spillway is 4.5 feet. The dam would be overtopped by 2.5 feet. It should be emphasized that these values have been estimated by allowing overflow not only over the 40-foot length of the dam but also the 42-foot earth embankment. The spillway will pass approximately 24% of the test flood peak outflow without overtopping the dam. If the stop logs across the outlet channel are removed in time, then the spillway and the outlet channel will pass about 68% of the test flood peak outflow without overtopping the dam.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The upstream slope could not be seen due to the fact that it was underwater. The visual inspection revealed the following evidence of possible stability problems:

1. Lack of protective covering of stone in the outlet chamber.

2. Seepage at the junction of the embankment and the outlet chamber, and below the spillway in the center of dam.

Visual inspection of the concrete outlet structure and spillway did not reveal any evidence of instability.

b. Design and Construction Data

There are construction drawings dated 1924, but no structural computations. There are design computations and drawings of the stop log section constructed in 1975.

c. Operating Records

Except for memorandums and correspondence listed in Appendix B, other operating records were not available at the office of the New Hampshire Water Resources Board.

d. Post-Construction Changes

No changes were made after improvements done in 1975 as described in Section 1.2h.

e. Seismic Stability

The dam is located in Seismic Zone 2 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

An examination of available documents and visual inspection of the Howe Reservoir Dam and appurtenant structures did not reveal any defects which would render the project inadequate from the standpoint of structural stability, and the dam is judged to be in good condition.

b. Adequacy of Information

An adequate assessment of the dam consistent with the scope of Phase I investigation has been made based upon the visual inspection and available information.

c. Urgency

Riprap should be placed in the outlet channel within 1 year of receipt of this Phase I report by the owner. All other remedial measures and recommendations enumerated below should be implemented within 2 years.

d. Need for Additional Investigation

The information available from the visual inspection is adequate to identify the potential problem of overtopping. This problem will require the attention of a competent engineer who will have to make additional engineering studies to design or specify remedial measures to rectify the problem.

7.2 Recommendations

It is recommended that the New Hampshire Water Resources Board should accomplish the remedial measures resulting from the following:

(1) In view of the possibility of overtopping of the embankment abutment of the dam, it is considered advisable to conduct detailed studies to evaluate the possible extent of damage in the town of Marlborough in the event of failure of the dam.

(2) Hydraulic analysis indicate that the spillway will pass approximately 24% of the test flood peak outflow without overtopping the dam, whereas the spillway and the outlet

channel together will pass approximately 68% of the test flood peak outflow without overtopping the dam. Therefore, studies should be made to evaluate further the potential for overtopping.

7.3 Remedial Measures

Although the dam is generally maintained in good condition, it is considered important that the following operating and maintenance procedures be attended to or early as practical:

a. Riprap should be placed in the outlet channel. The volume of riprap should be such that it cannot be moved by the water discharging from the outlet structure.

b. All concrete surfaces should be repaired as continued deterioration could develop into a serious problem.

c. Seepage areas should be monitored to determine the cause, and corrective measures should be taken.

d. The gate controlling the flow through the outlet conduit should be checked for damage and repaired, if necessary.

e. Downstream outlet and discharge channel should be cleared of any debris.

f. A program of regular maintenance should be established.

g. A program of technical annual periodic inspection of the project features should be prepared and initiated.

h. Because the dam is located upstream from a populated area, round-the-clock surveillance should be provided during periods of high precipitation.

i. The owner should develop a formal warning system. An operational procedure to follow in event of emergency should also be adopted.

7.4 Alternatives

Until the hydraulic and hydrologic condition of this dam is improved, the reservoir should be operated at lower levels to provide more storage during extreme flood events and spring runoff.

APPENDIX A

VISUAL INSPECTION CHECK LISTS

APPENDIX A

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Howe Reservoir Dam

DATE May 18, & 22, 1978
May 18 - 1100-1200
TIME May 22 - 1300-1600
May 18 - Rain
WEATHER May 22 - Fair

W.S. ELEV. 1274.5 U.S. DN.S.

PARTY:

1.	Jurgis Gimbutas, P.E.	Team Captain - Structural and Concrete
2.	Harvey H. Stoller, P.E.	Soils, Geology and Foundations
3.	V. Rao Maddineni, P.E.	Hydraulics and Hydrology
4.		
5.		

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Dam Embankments	H. H. Stoller	Good
2.	Intake Structure	J. Gimbutas	Very Good
3.	Outlet Conduit	J. Gimbutas	Good
4.	Outlet Structure	J. Gimbutas V. R. Maddineni	Very Good
5.	Outlet Channel	H. H. Stoller	Poor
6.	Spillway Weir	J. Gimbutas	Fair
7.	Approach and Discharge Channels	V. R. Maddineni H. H. Stoller	Fair to Good
8	Service Footbridge	J. Gimbutas	Very Good
9.	Reservoir and Downstream Channel	V. R. Maddineni	Very Good

PERIODIC INSPECTION CHECK LIST

PROJECT Howe Reservoir Dam DATE May 18, & May 22, 1978

PROJECT FEATURE Dam Embankment

DISCIPLINE Soils & Foundations NAME Henry H Stiller

PROJECT FEATURE

DISCIPLINE NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	1276.5 M.S.L.
Current Pool Elevation	1274.5 M.S.L.
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed
Pavement Condition	None
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	No visual vertical misalignment observed
Horizontal Alignment	No visual horizontal misalignment observed
Condition at Abutment and at Concrete Structures	Slope protection in front of the outlet structure is in poor condition (see narrative)

PERIODIC INSPECTION CHECK LIST

PROJECT Howe Reservoir Dam DATE May 18, & May 22, 1978

PROJECT FEATURE Dam Embankment

DISCIPLINE Soils & Foundations NAME [signature]

PROJECT FEATURE _____

DISCIPLINE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
Indications of Movement of Structural Items on Slopes	None observed
Trespassing on Slopes	None observed
Sloughing or Erosion of Slopes or Abutments	None observed
Rock Slope Protection - Riprap Failures	Outlet channel
Unusual Movement or Cracking at or Near Toes	None
Unusual Embankment or Downstream Seepage	See narrative
Piping or Boils	None observed
Foundation Drainage Features	None
Toe Drains	None
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT Howe Reservoir Dam DATE May 18, & May 22, 1978

PROJECT FEATURE Intake Structure

DISCIPLINE Structures & Concrete NAME [illegible]

PROJECT FEATURE _____

DISCIPLINE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	None
b. Intake Structure	
Condition of Concrete	Good condition
c. Mechanical and Electrical	
Air Vents	None
Float Wells	None
Crane Hoist	None
Elevator	None
Hydraulic System	None
Service Gates	In good working condition
Emergency Gates	None

PERIODIC INSPECTION CHECK LIST

PROJECT Howe Reservoir Dam DATE May 18, & May 22, 1978

PROJECT FEATURE Intake Structure

DISCIPLINE Structures & Concrete NAME [illegible]

PROJECT FEATURE _____

DISCIPLINE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
Lightning Protection System	None
Emergency Power System	None
Wiring and Lighting System	None

PERIODIC INSPECTION CHECK LIST

PROJECT Howe Reservoir Dam DATE May 18, & May 22, 1978

PROJECT FEATURE Outlet Channel

DISCIPLINE Structures NAME [illegible]

PROJECT FEATURE

DISCIPLINE NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - CONDUIT	
Size	36-inch diameter steel pipe
General Condition of Pipe	Good condition
Erosion or Cavitation	None observed

PERIODIC INSPECTION CHECK LIST

PROJECT Howe Reservoir Dam **DATE** May 18, & May 22, 1978

PROJECT FEATURE Outlet Structure

DISCIPLINE Structures **NAME** [signature]

PROJECT FEATURE Outlet Channel

DISCIPLINE Soils & Foundations **NAME** Harry N. Stoller

DISCIPLINE Hydraulics & Hydrology **NAME** [signature]

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	Very good condition
Rust or Staining	None observed
Spalling	None observed
Erosion or Cavitation	None observed
Visible Reinforcing	None observed
Any Seepage or Efflorescence	None observed
Condition at Joints	Good condition
Drain Holes	None observed
Stop Logs and Slots	Good condition, a few leaks
Channel	
Loose Rock or Trees Overhanging Channel	No loose rocks; one tree overhanging channel
Condition of Discharge Channel	Slope protection is in poor condition (see narrative)

PERIODIC INSPECTION CHECK LIST

PROJECT Howe Reservoir Dam DATE May 18, & May 22, 1978

PROJECT FEATURE Spillway Weir

DISCIPLINE Structures NAME [illegible]

PROJECT FEATURE Approach Channel

DISCIPLINE Soils & Foundations NAME [illegible]

DISCIPLINE Hydraulics & Hydrology NAME [illegible]

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Good condition
Loose Rock Overhanging Channel	None observed
Trees Overhanging Channel	None observed
Floor of Approach Channel	With water at crest elevation floor not visible
b. Spillway Weir	
General Condition of Concrete	Fair to poor condition
Rust or Staining	Little staining
Spalling	Approximately 3-foot long, 6- 12-inch wide shallow spall near joint at mid length (see narrative)

PERIODIC INSPECTION CHECK LIST

PROJECT Howe Reservoir Dam DATE May 18, & May 22, 1978

PROJECT FEATURE Spillway Weir

DISCIPLINE Structures NAME [illegible]

PROJECT FEATURE Discharge Channel

DISCIPLINE Soils & Foundations NAME [illegible]

DISCIPLINE Hydraulics & Hydrology NAME [illegible]

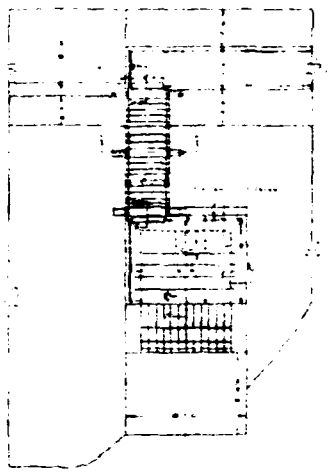
AREA EVALUATED	CONDITION
Any Visible Reinforcing	Yes, see Photograph No. 7
Any Seepage or Efflorescence	None observed
Drain Holes	None observed
c. Discharge Channel	
General Condition	Good condition
Loose Rock Overhanging Channel	None observed
Trees Overhanging Channel	None observed
Floor of Channel	Fair to good condition (see narrative)
Other Obstructions	None observed

APPENDIX C

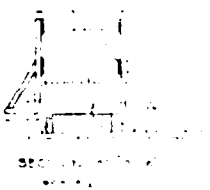
REPRESENTATIVE PHOTOGRAPHS OF PROJECT

APPENDIX C

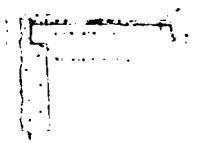
PHOTOGRAPHS



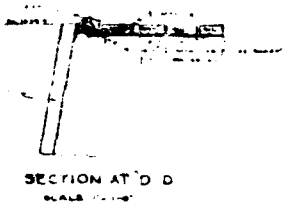
PLAN OF GATE CHAMBER



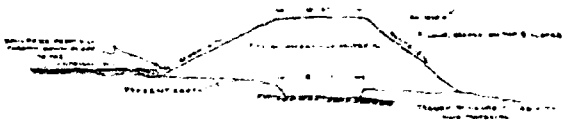
SECTION AT C C



SECTION AT B B

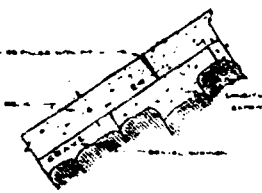


SECTION AT D D

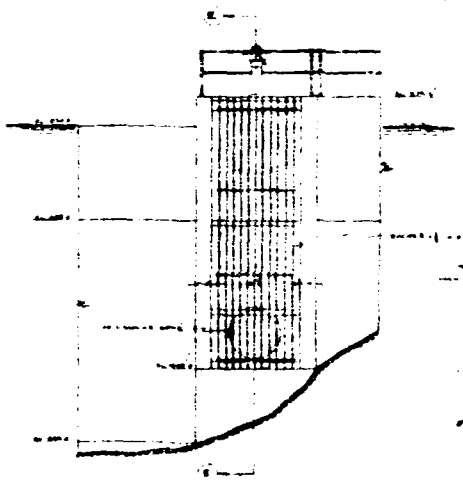


SECTION THRU EARTH EMBANKMENT

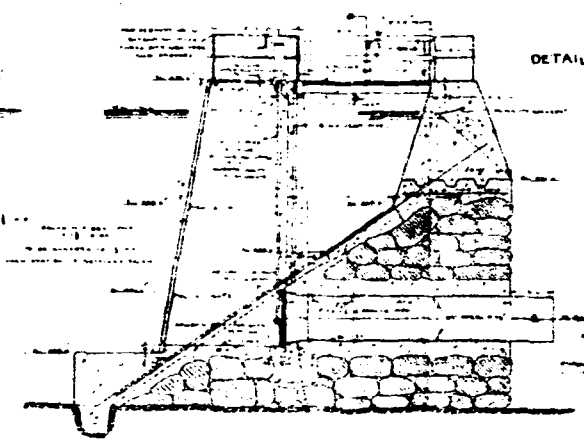
DETAIL TOP OF SPILLWAY



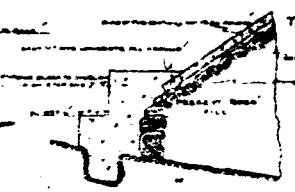
DETAIL OF SEAM UNDER ALL EXPANSION JOINTS



ELEVATION OF GATE CHAMBER



SECTION



CLOSURE SECTION

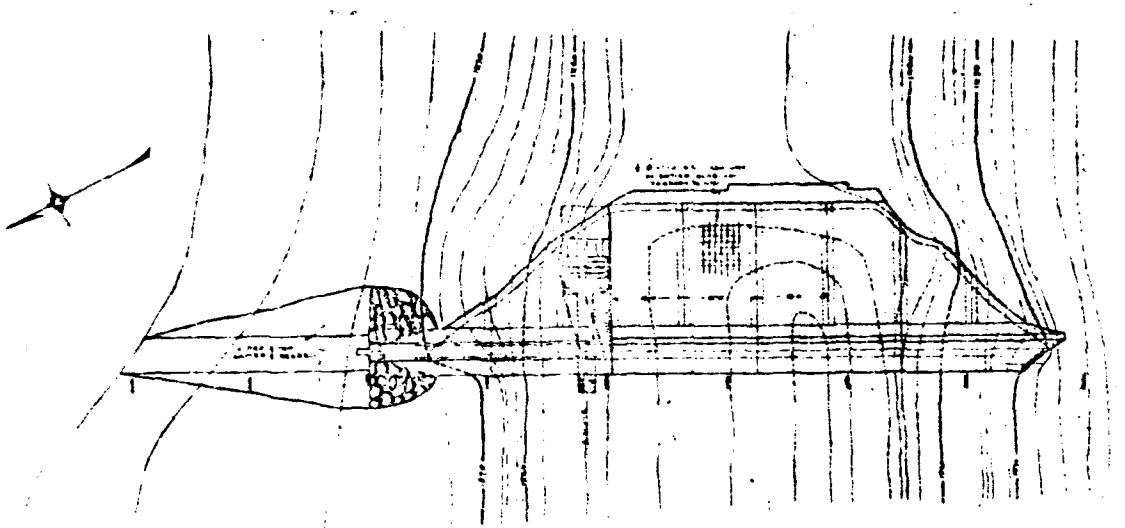
TYPICAL SECTION THRU DAM

ASHUELOT GAS & ELECTRIC C

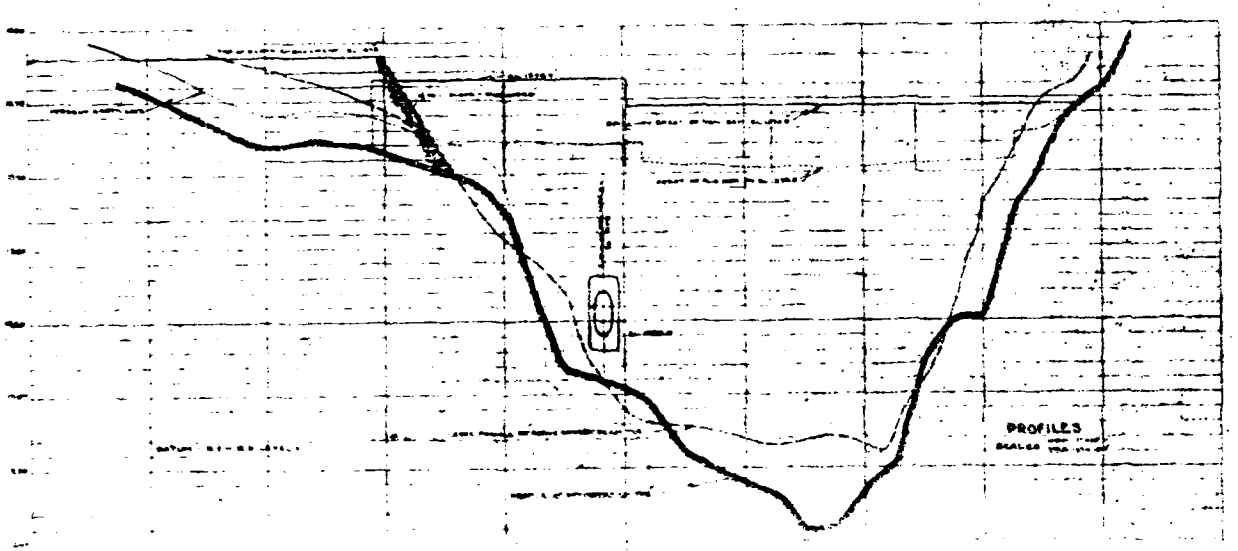
MINNEWAWA DEVELOPMENT

HOWE RESERVOIR DAM

GENERAL DETAILS



PLAN OF DAM



PROFILES

ASHUELOT GAS & ELECTRIC CO.

HOWE RESERVOIR DAM

HARRISVILLE, N. H.

PLAN AND PROFILE OF DAM

SCALES AS NOTED

MARCH 5 1934

L. H. SHATTUCK, ENG'R

MANCHESTER, N. H.

CHIEF ENG.

MEMORANDUM

TO: Peter Merkes and Donald Rapoza

FROM: Vernon A. Knowlton, Cheif Engineer

DATE: September 16, 1975

SUBJECT: Site Inspection - September 12, 1975 - Silver Lake - Howe Reservoir

SILVER LAKE

In the abutement wall on the west side of the discharge chute downstream of the stop log section there is a diagonal crack from top to bottom. It appears to go completely through the wall. The back side behind the wall is up 1' below the top slope toward the wall and catches water. The grade should be raised 6" above the top of the wall, after considering constructing a drain behind the wall.

HOWE RESERVOIR

A seal cap 4" to 6" in diameter should be installed in the penstock seal to prevent plugging and freezing or thawing. A heavy coating of grease should be placed on top of the gate stem and adjoining area to prevent water from getting into the mechanism. A railing should be installed downstream of the stop log section and consideration should be given to the construction of a stop log box. The crack on the walk way at the south abutement of the stop log section should be sealed with appropriate material. Leakage through the abutement should be checked occasionally.

vi

NEW HAMPSHIRE WATER CONTROL COMMISSION
DATA ON DAMS IN NEW HAMPSHIRE

LOCATION STATE NO. 109.12

Town Harrisville: County Cheshire

Stream Howe Reservoir

Basin-Primary Conn R: Secondary Minnewawa Bk

Local Name

Coordinates—Lat. 42 55' + 3,600: Long. 72° 10' -2800

GENERAL DATA

Drainage area: Controlled Sq. Mi.: Uncontrolled Sq. Mi.: Total 10.3 Sq. Mi.

Overall length of dam 147 ft.: Date of Construction

Height: Stream bed to highest elev. 25 ft.: Max. Structure 23' ft.

Cost—Dam : Reservoir

DESCRIPTION Masonery- Stone— Concrete

Waste Gates

Type

Number 1: Size ft. high x ft. wide

Elevation Invert 16': Total Area (3' dia.) sq. ft.

Hoist

Waste Gates Conduit

Number : Materials

Size ft.: Length ft.: Area sq. ft.

Embankment

Type

Height—Max. ft.: Min. ft.

Top—Width : Elev. ft.

Slopes—Upstream on: Downstream on

Length—Right of Spillway : Left of Spillway

Spillway

Materials of Construction Masonry

Length—Total ft.: Net 81' ft.

Height of permanent section—Max. 23 ft.: Min. ft.

Flashboards—Type : Height ft.

Elevation—Permanent Crest U S G S 1272: Top of Flashboard

Flood Capacity 810 cfs.: 78.6 cfs/sq. mi.

Abutments

Materials:

Freeboard: Max. 2.0' ft.: Min. ft.

Headworks to Power Devel.—(See "Data on Power Development")

OWNER Public Service Co of N H

REMARKS Use Storage

Tabulation By A A N & R L T Date December 12, 1938.

B&E21234

#10912

File under Howe

Cross Reference Dublin Lake

MEMORANDUM

TO: NANCY A. MILLER,

FROM: THOMAS C. MOORE

DATE: 10/4/ 1968

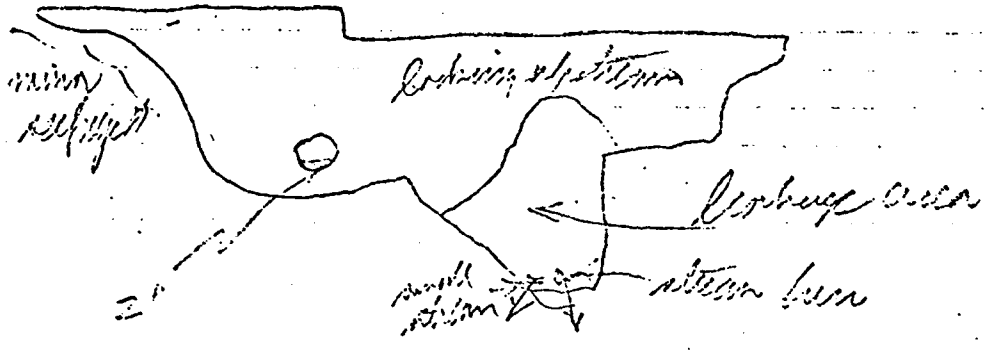
SUBJECT: Dublin Lake and Howe Reservoir

On October 4, 1968, I visited dams at outlets of Dublin Lake and Howe Reservoir and found the following:

Howe Reservoir Dam:

There are two sizable leaks just above ledge through masonry at bottom of dam - not serious. Considerable area near middle way of dam in lower half of masonry is leaking some. Also, downstream of the north abutment, there is a trickle from groundwater. Water was 1.0' below spillway crest and showed 1.1' on gauge.
This dam seems capable of overtopping without serious damage. The north abutment might cut a little but ledge is not far below.

Howe Reservoir Down 1.0' - 24.3 sq ft from gate
1.1' on gauge also 24.3 sq ft discharge at dike section



5/17 → .4 - 3.47 = sq. cut from 2 1/2" to 1 1/4"

Inspected June 19, 1930.

Howe Reservoir Dam owned by

Public Service Company of New Hampshire

This dam is a stone wall with four feet of concrete in the top. Concrete deck in the upstream face. Water flowing out of partly open gate. No overflow. Gates working mechanically O. K. No signs of seepage. Very dark day with approaching shower. Had to use time shot on picture.

DIVI-22.

PUBLIC SERVICE COMMISSION
OF
NEW HAMPSHIRE

10/5/11, 12/12

INSPECTOR'S REPORT
(1)

May 21, 1924

Subject: Proposed Dams for Reservoirs Harrisville for The Keene Gas & Electric Company.

On May 20th Mr.White,Mr.Lord and I made an inspection of the proposed location of the new dams to be constructed at Childs', Howe and Seaver Reservoirs in the Town Of Harrisville.

10/5/12 Howe Reservoir was inspected first.The old stone dam is to be raised four feet from elevation 1270.46 to 1274.46.At the time of the inspection the water stood at elevation 1271.46 as one foot flashboards had been put on.There was more or less water flowing over the flash boards in the center of the dam as the old wooden deck is sagged to some extent in the centre,so that it was impossible to make an inspection to tell the extent of the seepage through the dam.I inquired from Mr.Shaw however if it showed seepage when the water was below the crest and he said that it did show a small amount of seepage at the south end of the dam. The upstream face is to be sealed with a reinforced concrete slab which should prevent seepage.The present dam is of rock and is built on ledge,the ledge showing up on both banks as well as the entire width of the brook bed.The spillway section of the new dam will be raised to elevation 1274.6 and will be 75' in length from the south bank.On the north bank an earth embankment about 5 ft.in heighth and 42 ft in length will be built as the ledge runs out at about elevation 1273,and the top of the embankment

Subject: Harrisville dams continued

will be elevation 1278.Between the spillway and the earth embankment there will be an abutment section 42 ft in length with a top elevation 1276.5.

(3) December 12, 1938. By New Hampshire Water Control Commission, tabulated by AAN & RLT.

(4) October 10, 1968, by Mr. Francis C. Moore of New Hampshire Water Resources Board, one-half page.

(5) September 12, 1975, by Mr. Vernon A. Knowlton, Chief Engineer of New Hampshire Water Resources Board, one-half page.

New Hampshire Water Resources Board has a file of records and correspondence, 1924 to 1976. The documents of importance to design, construction and maintenance are the following:

(1) April 19, 1924. Description and discussion by L.H. Shattuck, Inc, Engineer - contractors, of the proposed rebuilding and raising of Howe Reservoir Dam. This 3-page document was submitted to the Public Utilities Commission, State of New Hampshire, with plans and specifications.

(2) September 11, 1924. Five photographs and inspection report of the reconstructed dam.

(3) August and September 1924. Reports of samples of portland cement used in construction, by New Hampshire Highway Department Testing Laboratory.

(4) March 1929. Howe Reservoir storage curve, showing maximum 70 million cubic feet.

(5) 1892-1937. Monthly precipitation records.

(6) 1935-1939. Gauge readings of comparative water levels.

(7) December 24, 1947. Reservoir storage in cubic feet per second.

(8) April 17, 1972. Estimate for capital improvements, done by New Hampshire Water Resources Board.

(9) 1975, prior to March (not dated). Approximately 15 sheets of design computations and sketches for improvements; installation of a stop-log section.

(10) July 30, 1976. Howe Reservoir run-off computations.

2. Copies of Past Inspection Reports

Included with this report are the following past inspection reports:

(1) May 21, 1924, by Engineers of the Public Service Commission of New Hampshire, two pages.

(2) June 19, 1930. Not signed, one-half page.

APPENDIX B

1. Listing of Records and their Location

New Hampshire Water Resources Board in Concord, New Hampshire, 37 Pleasant Street, have these eight drawings (blueprints), filed under Town/Dam No. 109.12:

Ashuelot Gas & Electric Co.
Minnewawa Development, Howe Reservoir Dam
Harrisville, New Hampshire
L.H. Shattuck, Inc. Engineers, Manchester, New Hampshire:

(1) 103.1 Plan of Reservoir (corner torn away, no date).

*(2) 103.2 Plan and Profile of Dam, March 6, 1924.

*(3) 103.3A General Details, March 12, 1924.

(4) 103.4 Steel and Wrought Iron Details, March 21, 1924.

Keene Gas & Electric Co., Keene, New Hampshire
L. H. Shattuck, Inc., Engineers:

(5) Capacity curves for Howe Reservoir, Harrisville, New Hampshire, March 14, 1924.

(6) 132.1 Topography of Proposed Howe Hydro Development, March 31, 1925.

New Hampshire Water Resources Board, Concord, New Hampshire
Crest Control for Howe Reservoir Harrisville, New Hampshire:

(7) 109.12 - Sheet 1 of 2, March 4, 1975.

(8) 109.12 - Sheet 2 of 2, March 4, 1975.

*Asterix marked drawings (reproductions) are included with this report.

APPENDIX B

EXISTING AVAILABLE INFORMATION

PERIODIC INSPECTION CHECK LIST

PROJECT Howe Reservoir Dam DATE May 18, & May 22, 1978

PROJECT FEATURE Service Bridge

DISCIPLINE Structures NAME T.E. Whitten

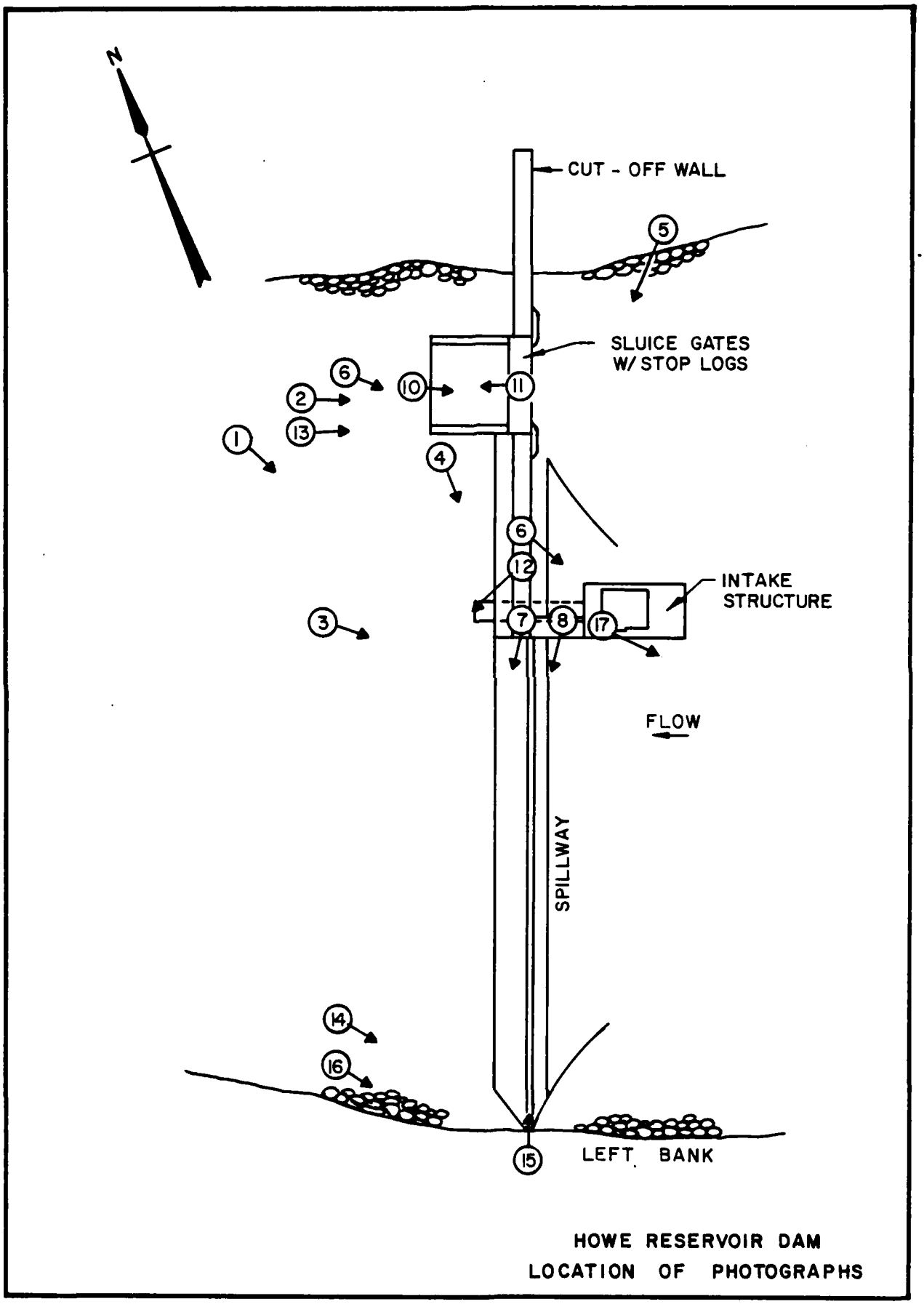
PROJECT FEATURE

DISCIPLINE NAME

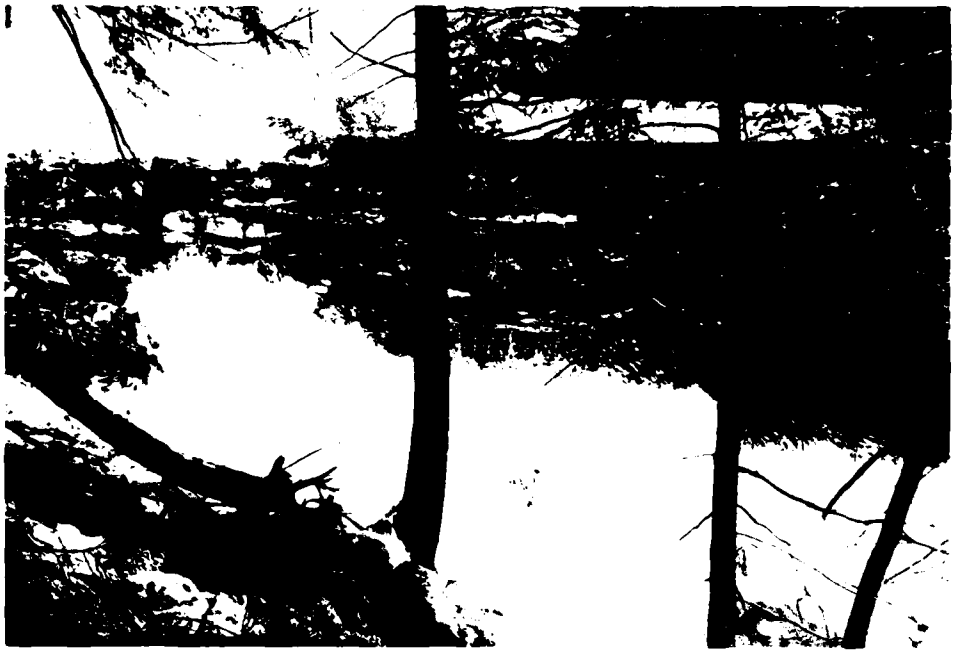
DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - SERVICE BRIDGE	
a. Location	Short foot bridge over the outlet structure to the gate structure
b. Superstructure	
Anchor Bolts	Very good condition
Bridge Seat	Very good condition
Longitudinal Members	Very good condition
Underside of Deck	Very good condition
Deck	Very good condition
Railings	Very good condition
Paint	Very good condition
c. Abutment and Piers	None

No.		Negative No.	Page
11.	Sluice stop logs partially open, looking downstream.	1-24	C-9
12.	Outflow pipe with the gate partially open.	1-26	C-9
13.	Ledge condition downstream of sluice gate, right bank.	4-19	C-10
14.	At the left abutment, looking upstream against the dam.	4-23	C-10
15.	Spillway crest looking from the left bank.	4-25	C-11
16.	Left abutment, looking upstream.	4-24	C-11
17.	Howe Reservoir looking upstream from the dam.	1-28	C-12
18.	Downstream condition at the outflow of Russell Reservoir at Chesham Village. Howe waters flow into Russell.	2-5	C-12



HOWE RESERVOIR DAM
LOCATION OF PHOTOGRAPHS

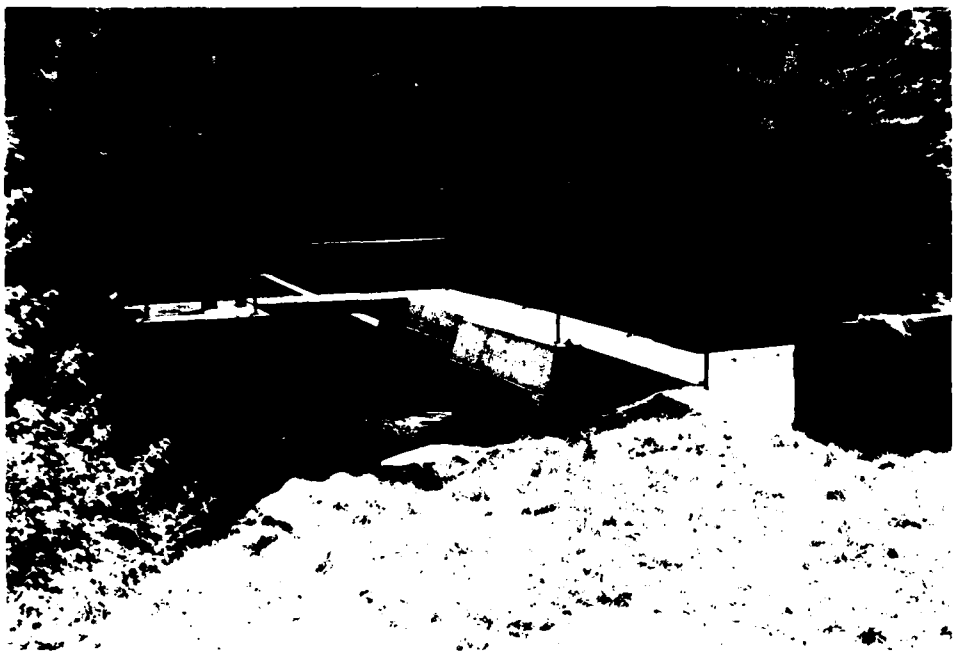


1. Overall view looking upstream.

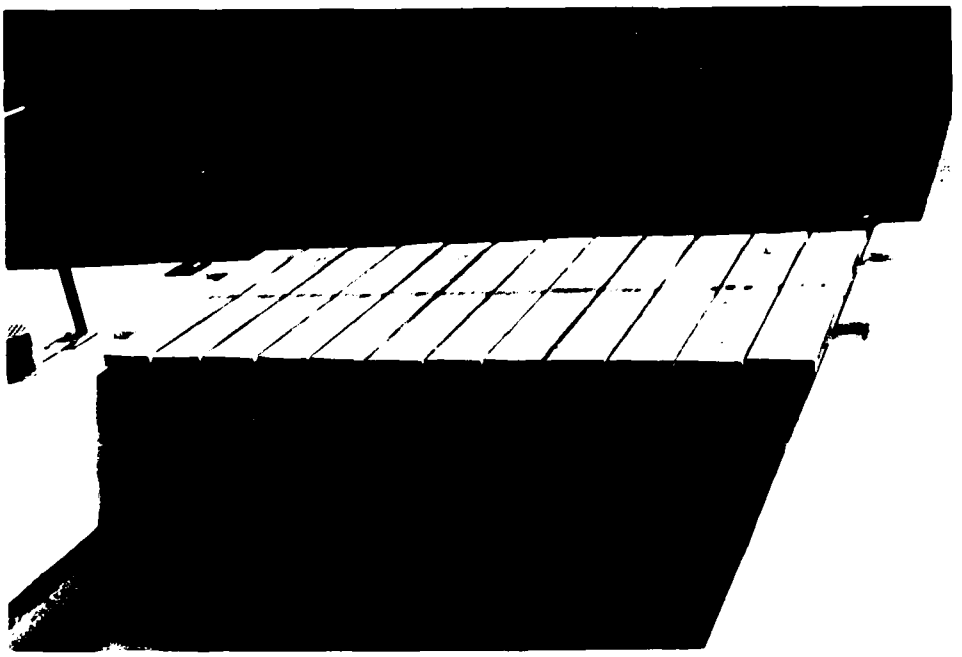
2. Sluice gates with three rows of logs removed and overflowing.

3. Outflow pipe and spillway crest showing the older masonry and the concrete caping added.

4. The outflow pipe with the intake gate closed.



5. Intake structure, footbridge and sluice gates near the right abutment looking south.

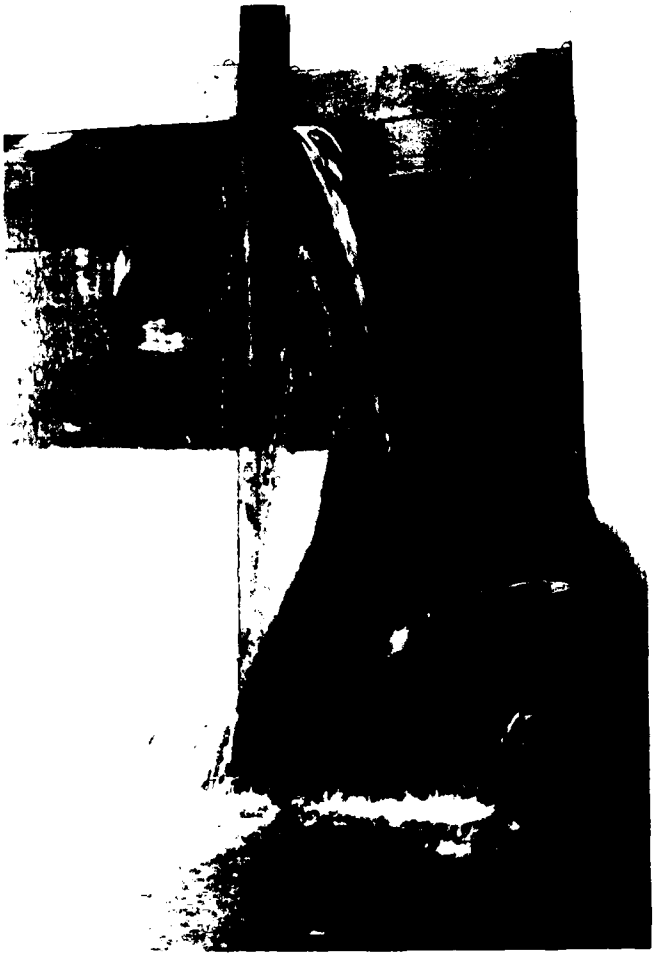


6. Footbridge from dam to the intake structure looking south.

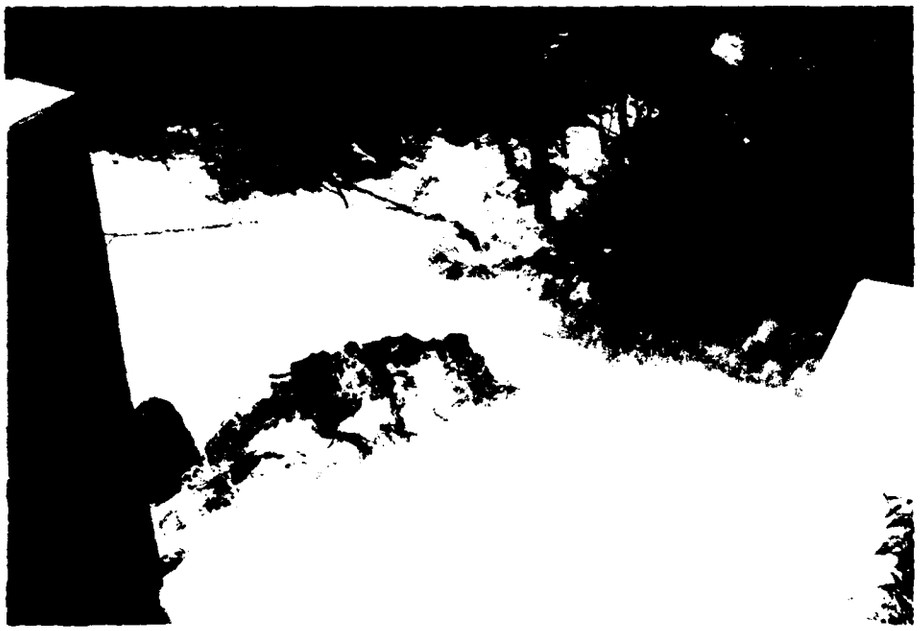
7. Erosion of concrete crest of spillway near the north end. Reinforcing exposed.

8. Erosion of concrete crest of spillway near its mid-length.

9. Sluice gates with all stop logs in place.



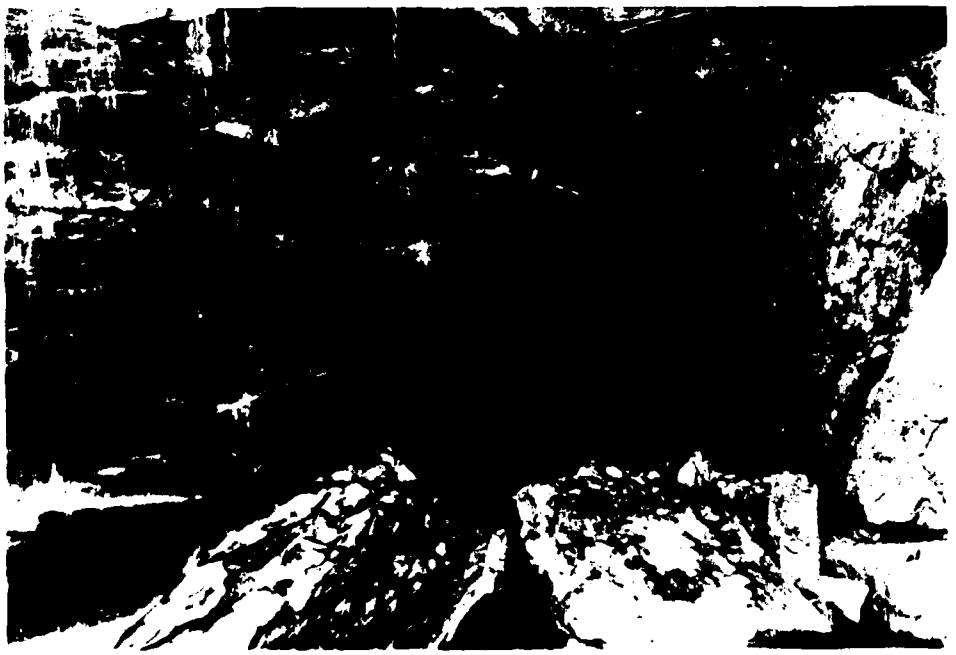
10. Sluice gates closed. Leakage at stop logs.



11. Sluice stop logs partially open, looking downstream.

12. Outflow pipe with the gate partially open.

13. Ledge condition downstream of sluice gate, right bank.



14. At the left abutment, looking upstream against the dam.

15. Spillway crest looking from the left bank.

16. Left abutment, looking upstream.

17. Howe Reservoir looking upstream from the dam.

18. Downstream condition at the outflow of Russell Reservoir at Chesham Village. Howe waters flow into Russell.

APPENDIX D

HYDROLOGIC & HYDRAULIC COMPUTATIONS

APPENDIX-D

SPOFFORD & THORNDIKE, INC
ENGINEERS
BOSTON

PROJECT EN-006(12)

FILE NUMBER EN-006
SHEET NUMBER 1
DATE 6-2-1978
COMPUTED BY VBM
CHECKED BY

NATIONAL DAM INSP. PROGRAM
HOPE RESERVOIR DAM

al drainage area of Hope Reservoir at the
m = 10.5 square miles

e drainage area of Hope Reservoir is
racterized by rolling topography. Hence,
m guide curves furnished by the Army
pt. of Engineers, it is found that

Suitable Maximum Flood Peak Inflow
= 10.5 x 1500
= 15,750 cfs.

ording to size classification, Hope
Reservoir Dam is intermediate.

ording to hazard classification, it
ld under the category of high hazard dam.

Spillway Test Flood Peak Inflow (Q_{P_1}).

= 15,750 cfs.

7,875

APPENDIX–D

FFORD & THORNDIKE, INC
ENGINEERS
BOSTON

PROJECT EN-C06 (12)

NATIONAL DAM INSP. PROGRAM

LAKE RESERVOIR DAM

FILE NUMBER [illegible]
SHEET NUMBER 2 OF
DATE [illegible]
COMPUTED BY [illegible]
CHECKED BY

ILLWAY TEST FLOOD INFLOW HYDROGRAPH:
ED ON SCS DIMENSIONLESS UNIT HYDROGRAPH

E OF CONCENTRATION:

maximum length of travel = 27,510 ft.
difference in elevation = 1865 ft.

time of concentration, $t_c = \dfrac{L^{1.15}}{7700 \times (H)^{0.38}}$ hrs.

$= \dfrac{(27510)^{1.15}}{7700 \times (1865)^{0.38}}$

$= \dfrac{127471.82}{7700 \times 17.41}$

$= 0.946$ hr ≈ 0.95 hr.

DEVELOPMENT OF SPILLWAY TEST FLOOD HYDROGRAPH:

Assume storm duration = T_c = 0.95 hr.
Assume time to Peak = T_c = 0.95 hr.

B. [illegible]

[illegible] Q_p = SPILLWAY TEST FLOOD PEAK INFLOW
= 16,750 cfs.

FAY, SPOFFORD & THORNDIKE, INC
ENGINEERS
BOSTON

PROJECT EN-006 (12)

FILE NUMBER [illegible]
SHEET NUMBER 3 OF
DATE 7-12-1978
COMPUTED BY [illegible]
CHECKED BY

SUBJECT NATIONAL DAM INSP. PROGRAM
HOPE RESERVOIR DAM

SPILLWAY TEST FLOOD INFLOW HYDROGRAPH

$T_p = 0.95$ hr

$Q_p = 15,750$ CFS

T	T/T_p	Q/Q_p	Q
0.2375	0.25	0.05	787.5
0.4750	0.50	0.18	2,835.0
0.7125	0.75	0.73	11,479.5
0.9500	1.00	1.00	15,750.0
1.1875	1.25	0.80	12,600.0
1.4250	1.50	0.40	6,300.0
1.6625	1.75	0.25	3,937.5
1.9000	2.00	0.17	2,677.5
2.1375	2.25	0.12	1,890.0
2.3750	2.50	0.09	1,417.5
2.6125	2.75	0.06	945.0
2.8500	3.00	0.04	630.0
3.0875	3.25	0.03	472.5
3.3250	3.50	0.02	315.0
3.5625	3.75	0.015	236.25
3.8000	4.00	0.010	157.5

FAY, SPOFFORD & THORNDIKE, INC
ENGINEERS
BOSTON

PROJECT EN-601 (12)

FILE NUMBER EN-166
SHEET NUMBER 4 OF
DATE 10-16-78
COMPUTED BY VEM
CHECKED BY

SUBJECT NATIONAL DAM INSP. PROGRAM
HOWE RESERVOIR DAM.

A. DISCHARGE THROUGH 36-inch CONDUIT – INVERT ELEVATION 1259.0.

(i) RESERVOIR WATER SURFACE ELEVATION AT 1274.50

$$Q_1 = 0.6 \times \frac{\pi}{4} \times (3)^2 \times \sqrt{2g \times 15.50}$$

$$= 4.241 \times 8.0249 \times 3.937$$

$$= 133.6 \text{ cfs}.$$

(ii) RESERVOIR W.S. ELEV. AT 1279.0

$$Q_2 = 0.6 \times \frac{\pi}{4} \times (3)^2 \times \sqrt{2g \times 20}$$

$$= 4.24 \times 35.8887$$

$$= 152.209 \text{ cfs}.$$

$$\simeq 152.0 \text{ cfs (say)}$$

B. DISCHARGE THROUGH 12 FEET WIDE OUTLET CHANNEL WITH INVERT ELEV. 1267.0

(1) RESERVOIR W.S. ELEV. 1274.50

$$Q_1 = C_d \cdot b \cdot B \sqrt{2g y_1} = C_d \cdot B \sqrt{2g} \cdot y_1^{3/2}$$

FAY, SPOFFORD & THORNDIKE, INC
ENGINEERS
BOSTON

PROJECT EN-006

FILE NUMBER EN-006
SHEET NUMBER 5 OF
DATE 10-16-78
COMPUTED BY VRM
CHECKED BY

SUBJECT NATIONAL DAM INSP. PROGRAM.
HOWE RESERVOIR DAM.

$$Q_1 = C_d \cdot B \cdot \sqrt{2g} \cdot Y_1^{3/2}$$

$C_d = 0.45$ (Refer to ROUSE: Engg Hydraulics, P. 537 Fig. 17.

$B = 12.0$

$$Q_1 = 0.45 \times 12 \times 8.024 \times (7.5)^{3/2}$$

$$= 889.972 \text{ cfs.}$$

$$\simeq 890.0 \text{ cfs (say).}$$

(ii) RESERVOIR W.S. ELEV. 1279.0

$$Q_2 = 0.45 \times 12 \times 8.024 \times (12)^{3/2}$$

$$= 1801.19 \text{ cfs.}$$

$$\simeq 1801.0 \text{ cfs (say).}$$

FAY, SPOFFORD & THORNDIKE, INC
ENGINEERS
BOSTON

PROJECT EN-006(12)

FILE NUMBER EN-6.1
SHEET NUMBER 1 OF
DATE 10-16-78
COMPUTED BY [illegible]
CHECKED BY

SUBJECT NATIONAL DAM INSP. PROGRAM
HOWE RESERVOIR DAM

For the purpose of routing spillway test flood inflow hydrograph, it is assumed that the stop-logs across the outlet channel could not be removed in time, and the gate controlling the flow through the 36-inch conduit could not be opened.

For developing the discharge rating curve, it is assumed that the dam functions as a spillway above ELEV. 1276.5 and the adjacent dike functions as a spillway above ELEV. 1278.0.

The computations for developing the composite discharge rating curve are furnished on Page 7 in the APPENDIX-D.

	SPILLWAY L=75' CREST ELEV.=1274.5 $Q_1=3.0Lh^{3/2}$		DAM L=38' ELEV.=1276.5 $Q_2=2.8Lh^{3/2}$		OVERLAND L=40' ELEV.=1278.0 $Q_3=2.6Lh^{3/2}$		
ELEV.	h	Q_1	h	Q_2	h	Q_3	$Q=Q_1+Q_2+Q_3$
1274.5	0.0	0.00					0.00
1275.0	0.5	79.55					79.55
1275.5	1.0	225.00					225.00
1276.0	1.5	413.35					413.35
1276.5	2.0	636.40	0.0	0.00			636.40
1277.0	2.5	889.39	0.5	37.62			927.01
1277.5	3.0	1,169.13	1.0	106.40			1,275.53
1278.0	3.5	1,473.28	1.5	195.47	0.0	0.00	1,668.75
1278.5	4.0	1,800.00	2.0	300.94	0.5	36.77	2,137.71
1279.0	4.5	2,147.84	2.5	420.58	1.0	104.00	2,672.42
1280.0	5.5	2,902.19	3.5	696.70	2.0	294.16	3,893.05
1282.0	7.5	4,621.41	5.5	1,372.41	4.0	832.00	6,825.82
1284.0	9.5	6,588.22	7.5	2,185.41	6.0	1,528.48	10,302.11
1286.0	11.5	8,774.64	9.5	3,115.49	8.0	2,353.25	14,243.38
1290.0	15.5	13,730.30	13.5	5,277.67	12.0	4,323.20	23,331.17

PAY. BROCKFORD & THORNDIKE, INC. ENGINEERS BOSTON

PROJECT APPENDIX D-1

SUBJECT NET INFLOW DIAM. INSP. FLOOD

HOWE RESERVOIR DAM - RATING TABLE

FILE NUMBER EJS-2003

SHEET NUMBER 2 OF

DATE 7/11/79

COMPUTED BY PMM

CHECKED BY

PROJECT EN-[illegible] (12)

SUBJECT NATIONAL DAM INSP. PROGRAM

[illegible] RESERVOIR DAM - SPILLWAY TEST FLOOD

INFLOW HYDROGRAPH ROUTING THROUGH RESERVOIR

FLOOD ROUTING COMPUTATIONS

STEP	TIME INTERVAL (Hrs)	INFLOW I_1 (Beginning of Interval) (Ft³/Sec)	INFLOW I_2 (End of Interval) (Ft³/Sec)	INFLOW STORAGE $\frac{I_1+I_2}{2} \times t$ (M Ft³)	OUTFLOW O_1 (Beginning of Interval) (Ft³/Sec)	OUTFLOW O_2 (End of Interval) (Ft³/Sec)	OUTFLOW STORAGE $\frac{O_1+O_2}{2} \times t$ (M Ft³)	STORAGE IN THE RESERVOIR IN INTERVAL (M Ft³)	TOTAL STORAGE AT THE END OF INTERVAL (M Ft³)	RESERVOIR LEVEL ASSUMED (Ft)	ACTUAL ELEVATION (Ft)
1	0.0 – 0.20	0.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	0.20 – 0.40	200.0	[illegible]	[illegible]	25.00	50.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	0.40 – 0.60	[illegible]	[illegible]	5.6	50.00	100.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	0.60 – 0.80	[illegible]	[illegible]	[illegible]	100.00	400.0	0.33	7.09	83.69	[illegible]	1276.0 ok
5	0.80 – 1.00	13600.0	16000.0	10.73	400.00	1300.00	[illegible]	[illegible]	93.90	1277.5	1277.2 ok
6	1.00 – 1.20	16000.0	12100.0	10.12	1300.00	1700.00	1.03	9.04	102.84	1278.0	1278.0 ok
7	1.20 – 1.40	12100.0	[illegible]	[illegible]	1700.00	1150.0	1.20	[illegible]	108.37	1278.5	1278.5 ok
8	1.40 – 1.60	[illegible]	4400.0	3.96	1150.00	[illegible]	1.42	2.54	110.91	1278.75	[illegible]
9	1.60 – 1.80	[illegible]	[illegible]	[illegible]	2300.00	[illegible]	[illegible]	[illegible]	111.[illegible]	[illegible]	[illegible]
10	1.80 – [illegible]	2.[illegible]	[illegible]	[illegible]	2550.00	[illegible]	1.83	[illegible]	111.83	1278.90	1279.[illegible] ok
11	[illegible]	2300.00	1700.00	1.44	2550.00	2550.00	1.8[illegible]	– 0.40	111.5[illegible]	[illegible]	[illegible] ok
12	[illegible]	1700.00	[illegible]	1.46	2550.00	[illegible]	1.[illegible]	– 0.63	[illegible]	1278.50	[illegible]

IN THE VICINITY OF DAMAGE IMPACT AREA DUE TO BREACH IN THE DAM AT RESERVOIR FULL CONDITION.

As explained in section 1.2 d, it is not possible to generate downstream dam failure hydrograph in the vicinity of damage impact area, using USGS topo sheets on which the contours are at 20-foot intervals.

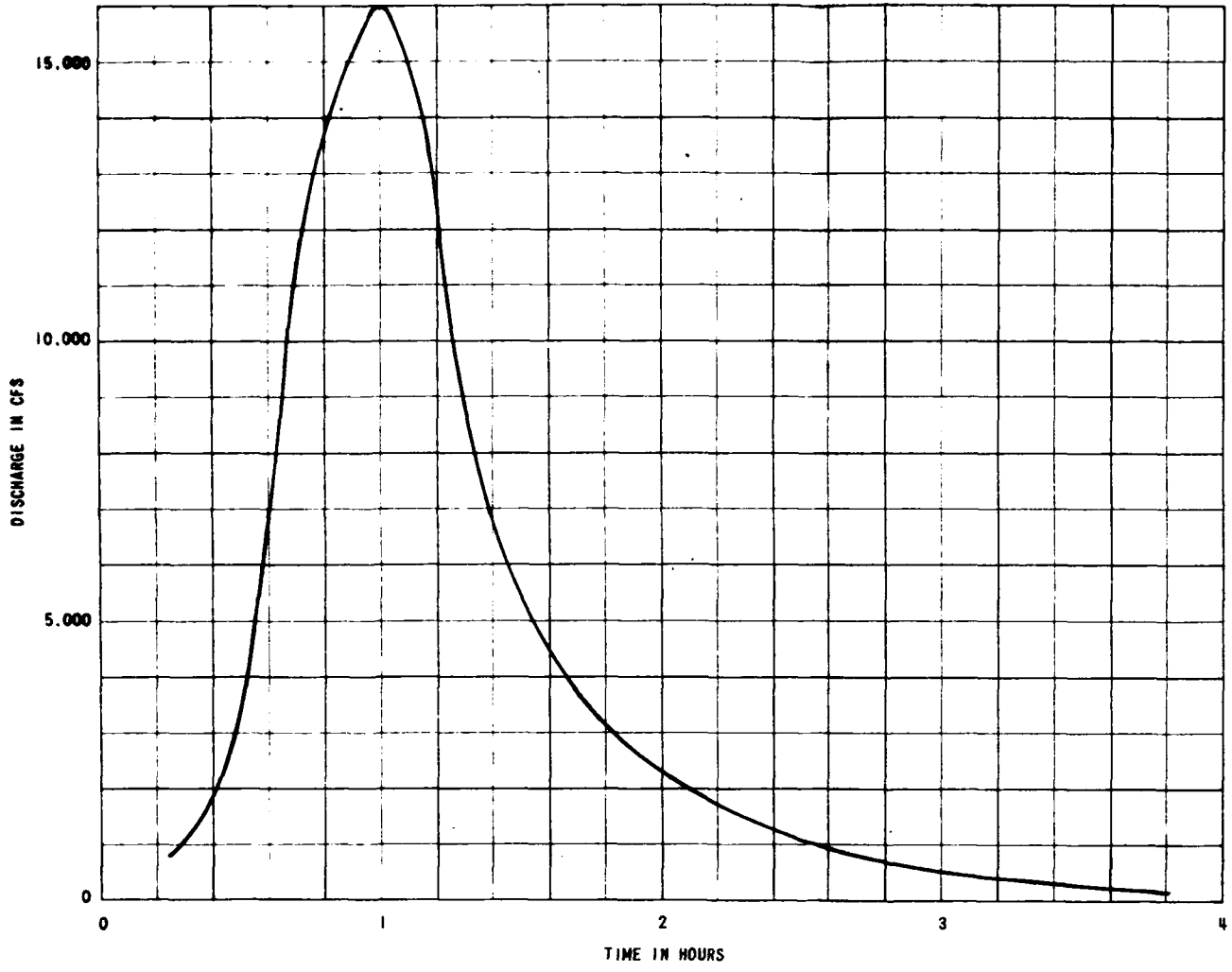
Besides, no other topographic map is available for the area.

From the knowledge of the damage impact area in the town of Marlborough which is 5 to 6 miles downstream from the dam, a ball park estimate has been made as follows.

Depth of water above the riverbed at F.R.L

$$= 1274.5 - 1256.0$$
$$= 18.5 \text{ feet.}$$

Height of flood wave at damage impact area is estimated to be 12 feet.
Width of water spread at damage impact area is approximately indicated on the USGS map included in the APPENDIX-D.



SPILLWAY TEST FLOOD INFLOW HYDROGRAPH

FAY, SPOFFORD & THORNDIKE, INC ENGINEERS BOSTON, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

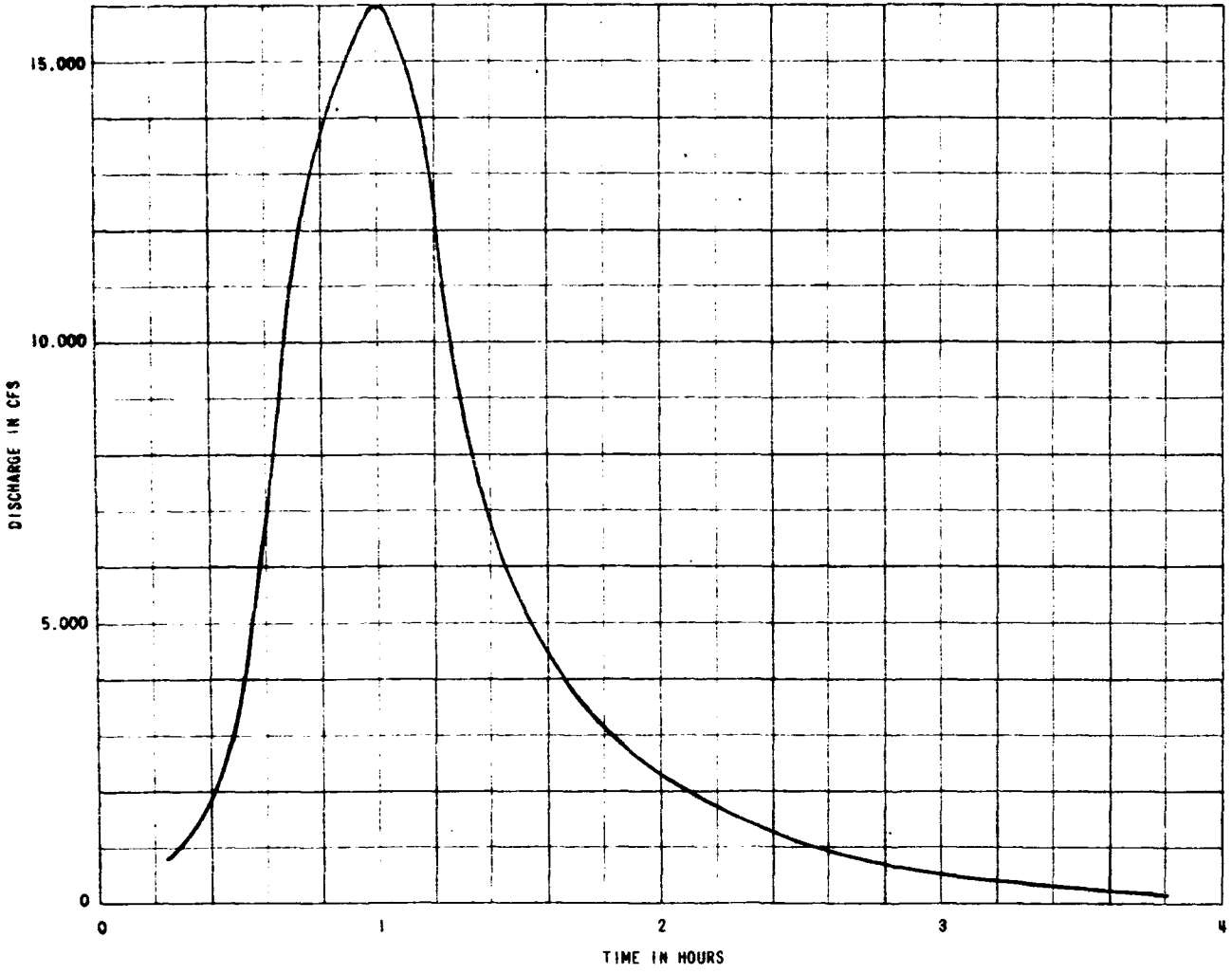
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

HOWE RESERVOIR DAM

MINNEWAWA BROOK — NEW HAMPSHIRE

SCALE AS SHOWN

DATE AUGUST 1978



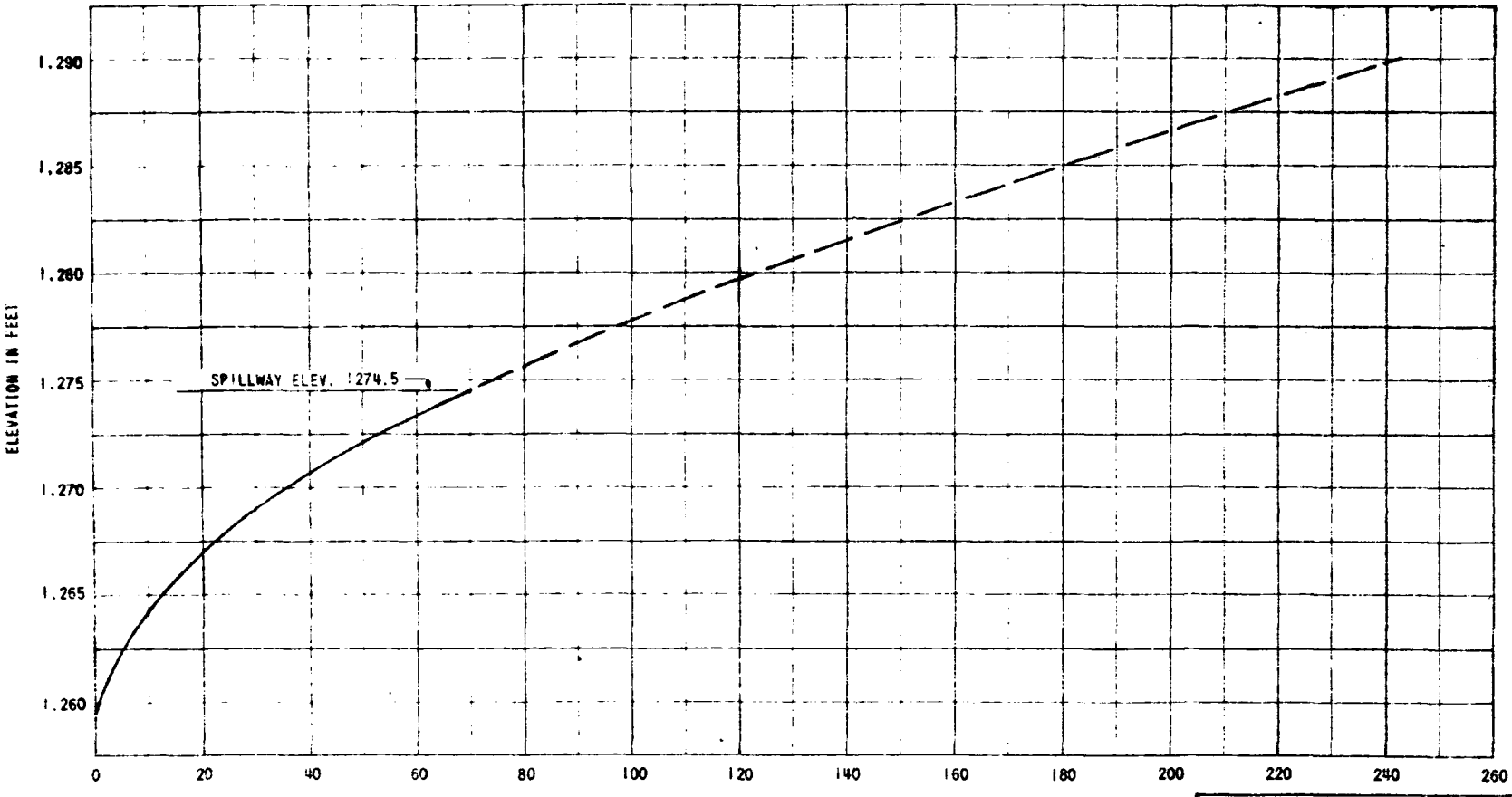
SPILLWAY TEST FLOOD INFLOW HYDROGRAPH

FAY, SPOFFORD & THORNDIKE, INC ENGINEERS BOSTON, MASS.	U.S ARMY ENGINEER DIV. NEW ENGL AND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

HOWE RESERVOIR DAM

MINNEWAWA BROOK — NEW HAMPSHIRE



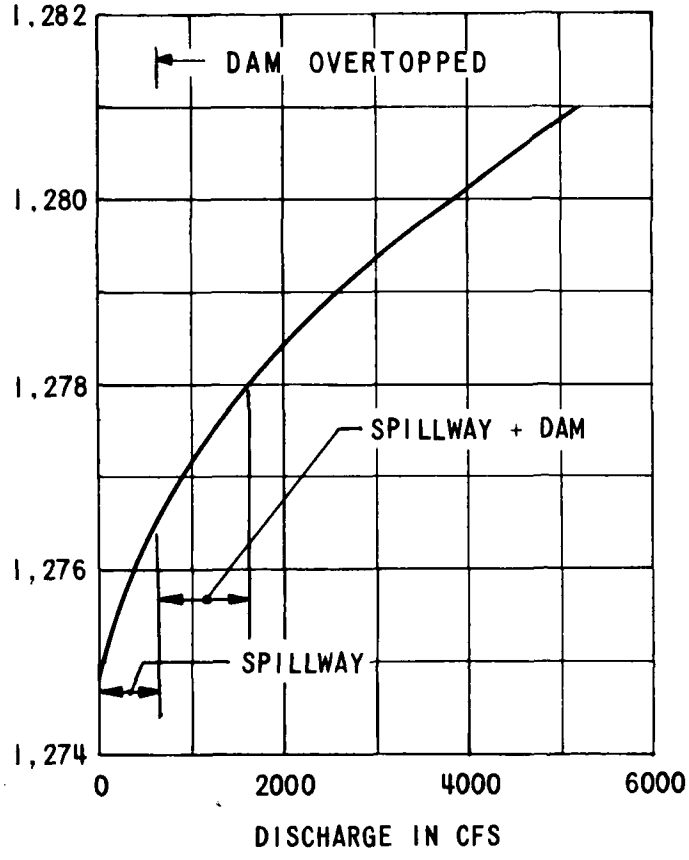
1 MILLION CUBIC FEET = 22.957 ACRE FEET

STORAGE CAPACITY - ELEVATION CURVE

FAY, SPOFFORD & THORNDIKE, INC. ENGINEERS BOSTON, MASS.	U.S. ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

HOWE RESERVOIR DAM



RATING CURVE FOR
SPILLWAY AND DAM

FAY, SPOFFORD & THORNDIKE, INC. ENGINEERS BOSTON, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

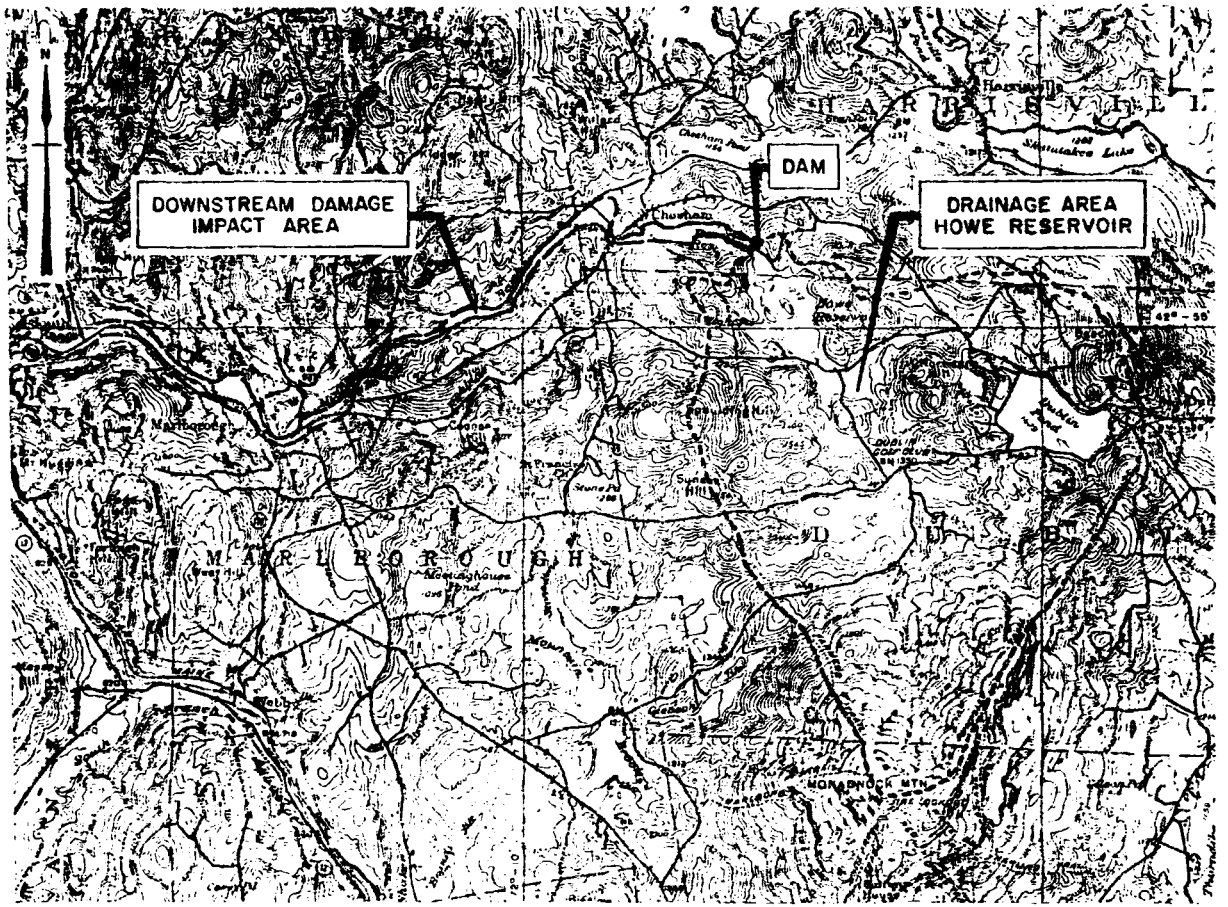
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

HOWE RESERVOIR DAM

MINNEWAWA BROOK — NEW HAMPSHIRE

SCALE	AS SHOWN
DATE	AUGUST, 1978

D-12



UNITED STATES
DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY

SCALE 1:62500 (ACTUAL)

NEW HAMPSHIRE
MONADNOCK QUADRANGLE
1949
AMS 6569 I-SERIES V 712

APPENDIX E

FORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

END

FILMED

8-85

DTIC