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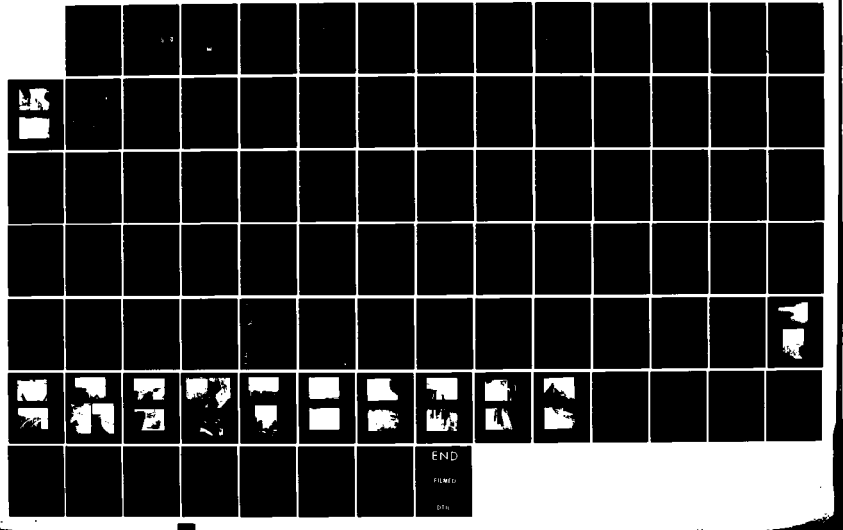

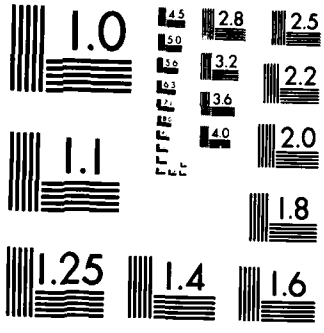

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MINNEWAWA DAM

N.H. 00104

NHWRB-151.06

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MINNEWAWA DAM

N.H. 00104

NHWRB-151.06

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

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

SEPTEMBER 1978

UNCLASSIFIED
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AD-A155 098

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1. REPORT NUMBER: NH 00104	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
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18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Connecticut River Basin
Marlborough, New Hampshire
Minnewawa Brook

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

Based on the visual inspection, available records and past performance, the dam is considered to be in fair condition. The dam is believed to be safe under normal operating conditions. Based on size and hazard classifications in accordance with Corps guidelines, the test flood is the PMF. In addition to long term recommendations, there are several remedial measures which should be implemented immediately.

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MINNEWAWA DAM

N.H. 00104

CONNECTICUT, RIVER BASIN

MARLBOROUGH, NEW HAMPSHIRE

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Identification No.:	-	N.H. 00104
Name of Dam:	-	Minnewawa Dam
Town:	-	Marlborough
County and State:	-	Cheshire County, New Hampshire
Stream:	-	Minnewawa Brook
Date of Inspection:	-	13 Jan 78, 7 Jun 78

BRIEF ASSESSMENT

Based on the visual inspection, available records and past performance, the Minnewawa Dam is considered to be in fair condition. The dam is believed to be safe under normal operating conditions. Its serviceability under the test flood load and ice forces is unknown. These peak loading conditions should be more fully investigated.

Based on size and hazard classifications in accordance with Corps guidelines, the test flood is the Probably Maximum Flood. A PMF outflow of 19,000 cfs (826 csm) would overtop the dam by 7.2 feet. The spillway will pass 1710 cfs, or about 9 percent of the PMF outflow. A cursory analysis was made to assess the downstream impact of a sudden failure. With the reservoir at top of dam, it is estimated that a 17-foot surge would result just downstream of the structure over the water level that existed just before failure. Due to the extreme steepness of the channel slope and banks between the dam and the first grouping of homes, 0.7 mile downstream, little attenuation of the flood wave could be expected and a high hazard to loss of life would result.

Due to the potential for overtopping and the lack of formal stability analyses, it is recommended in Section 7 of this report that the owner engage the services of a qualified consultant to evaluate the stability of the concrete arch. Further, a more detailed investigation should be made of the hydraulic and hydrologic aspects of the dam.

In addition to the long term recommendations, there are several remedial measures which should be implemented immediately.

1. Periodic Inspections of Minnewawa Dam by the owner should be established.

2. A formal warning program should be developed and implemented, along with a plan for monitoring the structure during periods of unusually high flow.

3. There is a considerable amount of brush in the spillway approach channel, which should be controlled.

4. Both the sluice gate and penstock gates are inoperative. The penstock trash rack is clogged with debris. The sluice appears susceptible to blockages. Both should be inspected and cleaned periodically.

William H Rodger

WILLIAM H. RODGER P.E.
Massachusetts Reg. #29048

This Phase I Inspection Report on Minnewawa Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Charles G. Tiersch

CHARLES G. TIERSCH, Chairman
Chief, Foundation and Materials Branch
Engineering Division

Fred J. Ravens Jr.

FRED J. RAVENS, Jr., Member
Chief, Design Branch
Engineering Division

Saul Cooper

SAUL COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. 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 by 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 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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APPENDIX A

(3) There is a considerable amount of brush in the spillway approach channel, which should be controlled.

(4) Both the sluice gate and penstock gates are inoperative. The penstock trash rack is clogged with debris. The sluice appears susceptible to blockages. Both should be inspected and cleaned periodically.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment.

a. Condition. Based on the visual inspection, available records and past performance, the Minnewawa Dam is considered to be in fair condition.

b. Adequacy of Information. Information gathered during the search of the project files is considered to be adequate to make a valid assessment of the pertinent features of Minnewawa Dam.

c. Urgency. Recommendations and remedial measures made by this report should be accomplished within 12 months after the receipt of this Phase I report by the owner.

d. Need for Additional Investigation. As previously stated, Minnewawa Dam is considered to be in fair condition, but further study by a qualified consultant is recommended to cover the subjects listed in Para. 7.2 below.

7.2 Recommendations.

a. Since the spillway can pass about 9 percent of the test flood without overtopping the dam, a qualified consultant should be engaged to assess hydrological conditions and develop plans for any modification necessary to avoid overtopping.

Analyses of the structural stability of the concrete arch should be included in the consultants scope of work. The response of the arch to ice loads and effects of temperature changes should be investigated by the consultant.

7.3 Remedial Measures.

a. Alternatives. Not applicable - Alternative solutions to improve inadequate spillway capacity are beyond the scope of this report.

b. Operating and Maintenance Procedures. Operating procedures employed at Minnewawa Dam are inadequate. Therefore, the following O&M procedures are recommended.

(1) A biennial periodic technical inspection program for Minnewawa Dam should be established.

(2) A formal warning program should be developed and implemented, along with a plan for monitoring the structure during periods of unusually high flow.

c. Operating Records. There are no records which indicate a stability problem since the dam was built in 1923. There have been several major events during the life of the structure. Therefore, the dam's performance with respect to stability has been adequate to date.

d. Post Construction Changes. There is no data indicating any modifications have been made to the dam since construction was completed. The inspection revealed the spillway and portions of the main arch have been treated with gunite.

e. Seismic Stability. The dam is located in Seismic Zone No. 2 and in accordance with recommended Phase I guidelines does not warrant seismic analysis.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. No evidence was observed indicating structural instability of the concrete arch or spillway at this time. However, several conditions which could affect the overall stability of the dam were noted.

(1) There is a significant amount of efflorescence on the downstream face of the dam. These deposits are caused by leakage through the dam.

(2) The extent of major cracks and spalled areas of concrete should be more fully investigated. This information will yield a better check on the present stability of the concrete arch.

(3) Reinforcing steel was exposed on the upstream face of the dam. The size and grade of steel is unknown. The steel is continuous thru the horizontal construction joints and the vertical construction joints. Spacing of reinforcing is estimated to be 12" on center in both directions.

These conditions could have an effect upon structural stability in the future and should be further investigated by a qualified consultant.

b. Design and Construction Data. Pertinent design and construction data for Minnewawa Dam is described in Section 1.2.g. - Design and Construction and SECTION 2 - ENGINEERING DATA.

The original stability stress analysis for the concrete arch is available. The maximum compressive stresses in the dam are relatively small compared to the estimated ultimate compressive strength of the concrete mix used during construction. The analysis of the arch is consistent with accepted engineering practices. No stability or stress analysis was performed for ice loads or the effects of temperature changes. In addition to the computed behavior, the past performance of the dam must be considered. There has been no major failure of the structure during its 55-year existence. The evaluation of present stability must include an accurate determination of the dams existing condition. There are areas of significant cracking and spalled concrete with exposed reinforcing steel which cause a decrease in the effective sections of the arch. This reduction causes a subsequent increase in stresses within the arch.

Based on the visual inspection, available records and past performance, Minnewawa Dam is believed to be structurally stable during normal operating conditions. Stability during the projected test flood and ice forces cannot be determined by visual observations. Therefore, these peak loading conditions should be more fully investigated.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features.

a. Design Data. A search of Public Service Company of New Hampshire and New Hampshire Water Resources Board files revealed no detailed hydraulic or hydrologic design data.

b. Experience Data. There is no experience data available. It was stated in section 1.3 that the maximum flood of record for the site is estimated to be in excess of 150 csm. No damages to the structure occurred during this event.

c. Visual Observations. The shore of the lake is totally undeveloped. Inundation of this area would occur during the test flood. However, no damage to life or property could occur in the reservoir area.

There is no streambank development for a distance of about 0.7 mile downstream. Beginning at this point, however, there are several homes constructed on or near the streambank. These would be lost or heavily damaged in the event of any type of dam failure. About 1.6 miles downstream of the dam, Minnewawa Brook meets N.H. Route 101 and the village of Marlborough. Due to the steepness of the channel and banks between the dam and this area, a breach could produce considerable disruption of travel and probable loss of life.

d. Overtopping Potential. Based on U.S. Geological Survey Water Supply Paper 1887, "Maximum Floodflows in the Conterminous United States", the Probable Maximum Flood (PMF) for Minnewawa Brook is estimated to be 31,000 cfs (1,348 csm). However, 1.8 square miles, or 8 percent of the upstream drainage area is occupied by lakes and ponds which would tend to reduce peak flows.

The Corps of Engineers' MacDowell Dam is located on Nubanusit Brook, 12 miles east of Minnewawa Dam. The watersheds are adjacent, and contain similar amounts of storage. The Probable Maximum Flood used in designing MacDowell Dam was 36,300 cfs (825 csm). Based on the similar watershed characteristics, 19,000 cfs, or 826 csm was selected as the PMF for Minnewawa Brook.

Based on the size classification (INTERMEDIATE) and the hazard potential (HIGH), the full PMF was selected as the test flood. A discharge of 19,000 cfs would result in a peak pool elevation of 1,080.2 feet msl, or 7.2 feet over the top of dam. With both gates open, this value would be lowered about 0.2 feet.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures. As previously discussed both outlets are left open at all times, and the project is not operated for flood control purposes. During the summer, the reservoir is essentially empty.

4.2 Maintenance of Dam. There is no formal annual maintenance program for Minnewawa. Necessary minor repairs to the dam have not been made. Funds for major repairs must be appropriated by the Public Service Co. of New Hampshire.

4.3 Maintenance of Operating Facilities. Not applicable for Minnewawa Dam.

4.4 Description of any Warning System in effect. There is no warning system during flood periods.

4.5 Evaluation. Periodic inspections of Minnewawa Dam by engineers from the Public Service Co. of New Hampshire must be established. Minor deficiencies can be eliminated by annually maintaining the structure. Major repairs are the responsibility of Public Service.

A formal warning program should be developed and implemented, along with a plan for monitoring the structure during periods of unusually high flow.

SECTION 3 - VISUAL INSPECTION

3.1 Findings.

a. General. The Phase I inspection of the dam and Minnewawa Brook was performed on 13 January 1978. The area adjacent to the dam was covered with 18 inches of snow. The pool was below the spillway crest. The concrete spillway and arch were reinspected 7 June 1978. The pool was completely drawn down. This allowed access to the downstream and upstream faces of the dam under dry conditions. A copy of the visual inspection report is included in Appendix A. Photographs contained in Appendix C have been keyed to the inspection check list.

b. Dam. The dam is considered to be in fair condition. There was no evidence of vertical or horizontal misalignment detected in the dam. However, the dam does require maintenance and several concrete repairs.

(1) The concrete arch has a significant amount of efflorescence on the downstream face. Many cracks, which appear to be shrinkage cracks, were noted. No leakage was observed during the inspection. It should be noted the pool was low during the winter inspection and there was no water impounded during the June inspection.

(2) There were spalled areas of concrete on both the upstream and downstream faces of the arch. Reinforcing steel was exposed on the upstream face.

c. Appurtenant Structures. Not applicable to Minnewawa Dam.

d. Reservoir Area. The shore of the lake is totally undeveloped. Inundation of this area would occur during the test flood. However, no damage to life or property could occur in the reservoir area.

e. Downstream Channel. There is no streambank development for a distance of about 0.7 mile downstream. Beginning at this point, however, there are several homes constructed on or near the streambank. These would be lost or heavily damaged in the event of any type of dam failure. About 1.6 miles downstream of the dam, Minnewawa Brook meets N.H. Route 101 and the village of Marlborough. Due to the steepness of the channel and banks between the dam and this area, a breach could produce considerable disruption of travel and probable loss of life.

3.2 Evaluation. As stated previously, the condition of Minnewawa Dam is considered to be fair. No major problems associated with either the serviceability or operation of the dam were discovered. There are, however, several areas which will require periodic maintenance and concrete repairs to ensure continued serviceability.

SECTION 2- ENGINEERING DATA

2.1 Design. There was design data available for Minnewawa. Letters pertaining to the original design and specifications were obtained. The available design data included some stability computations.

2.2 Construction. Construction records for the original project were obtained. These records give a general overall picture of the structure and its pertinent features. Sketches showing the elevation and section of the dam and pertinent design and construction records are included in Appendix B.

2.3 Operation. Information pertaining to the operation and operational procedures was not available.

2.4 Evaluation. There is a limited amount of engineering data available for this project. The general features of the existing structures, sections and elevations are detailed. A limited amount of engineering design criteria was gained from this information.

Data for the report was made available by the combined cooperate efforts of the New Hampshire Water Resources Board and the Public Service Company of New Hampshire.

d. Reservoir.

Length of Pool - varies around 0.2 mile (± 0.1 mi.)

e. Storage (acre-feet).

Normal Pool - varies (see capacity curve Appendix D)
Spillway Crest - 140 (approx.)
Top Dam - 175 (approx.)

f. Reservoir Surface (acres).

Pool surface varies with pool fluctuations.

g. Dam.

Type	Concrete Arch
Length	Approx. 200 feet
Height	Varies, 60' Max.
Top Width	4'-0"

Side Slopes
Concrete Arch

(a) Vertical Upstream Face

(b) The downstream face is vertical for the top 10.00 feet and has a 1.5 horizontal on 10 vertical batter below this point.

h. Spillway. The side-channel spillway consists of a 45-foot ogee weir. A 1.5-foot pier results in an effective spillway length of 43.5 feet. The crest is at elevation 1068. There are no spillway gates.

There is a shallow spillway approach channel, now overgrown with brush. Flows from the spillway pass through a narrow rock cut, then plunge about 60 feet to the main river channel, just downstream of the dam. Photographs of these features are included in Appendix C.

i. Regulating Outlets. There are two regulating outlets: a 4-foot circular penstock with invert at about elevation 1049, and a 2-foot circular sluice with invert at about elevation 1020. The penstock formerly extended 6,000 feet downstream to a power station, but has since been removed, and now has a free outfall into the dam's tailwater. With the pool at spillway crest, the total outlet capacity is about 340 cfs (15csm), which is considered adequate.

The penstock gate, which has been removed, was hand-operated from atop the dam. The sluice gate is hand-operated from a platform at the toe of the dam. The condition of the gate machinery is questionable and believed inoperative. Pictures are located in Appendix C.

f. Operator.

Public Service Co. of New Hampshire
Hampshire Plaza
Manchester, N.H.
Tel: (Area Code 603) 669-4000

g. Purpose of Dam. The initial purpose was to provide a pool for hydroelectric power generation. At present, the dam is not utilized for any purpose.

h. Design and Construction History. Minnewawa Dam was completed in November, 1923. It was designed and constructed by L.H. Shattuck, Inc., Engineers-Contractors, 208 Granite Street, Manchester, New Hampshire for the Ashuelot Gas and Electric Company, Keene, New Hampshire (now Public Service Company of New Hampshire). Sketches pertaining to the pertinent features of Minnewawa were obtained from the Water Resources Board. Correspondence pertaining to foundation conditions, design parameters and a set of construction photographs were also obtained. Essential information pertaining to the design and construction of the dam is contained in Appendix B.

i. Normal Operation Procedures. Both gates in the structure are left open at all times, and the pool elevation fluctuates depending on runoff conditions in the watershed. At the time of the inspection, the pool was at about elevation 1056 feet, msl. The project is not operated for flood control purposes. During the June inspection, the pool was at the sluice invert El. 1020 (±).

1.3 PERTINENT DATA.

a. Drainage Area at Damsite. 23 square miles.

b. Discharge at Damsite. There are no discharge records available for the site. The largest known flood in this region occurred in September, 1938. Examination of U. S. Geological Survey records for other streams in the area indicate Minnewawa Brook sustained flows in excess of 150 cubic feet per second per square mile (csm).

Flows may be passed through the 2-foot sluice, through the 4-foot penstock, over the 43.5 foot spillway, or over the 200-foot crest of the dam. With the pool at elevation 1073 (top of dam), the spillway capacity is 1650 cfs (72 csm). A rating curve for the spillway and top of dam is located in Appendix D.

c. Elevations (feet, msl).

Top of Dam - 1073
Spillway Crest - 1068
Normal Pool - fluctuates (essentially empty during the summer)
Penstock Invert - 1049 (scaled from photos)
Sluice Invert - 1020 (scaled from photos)
Streambed at Dam Centerline - 1012 (approx.)

PHASE I INSPECTION REPORT

MINNEWAWA DAM, NEW HAMPSHIRE 00104

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.

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 interest.

(2) Encourage and assist the States to initiate quickly effective dam inspection programs for non-Federal dams.

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

1.2 DESCRIPTION OF PROJECT.

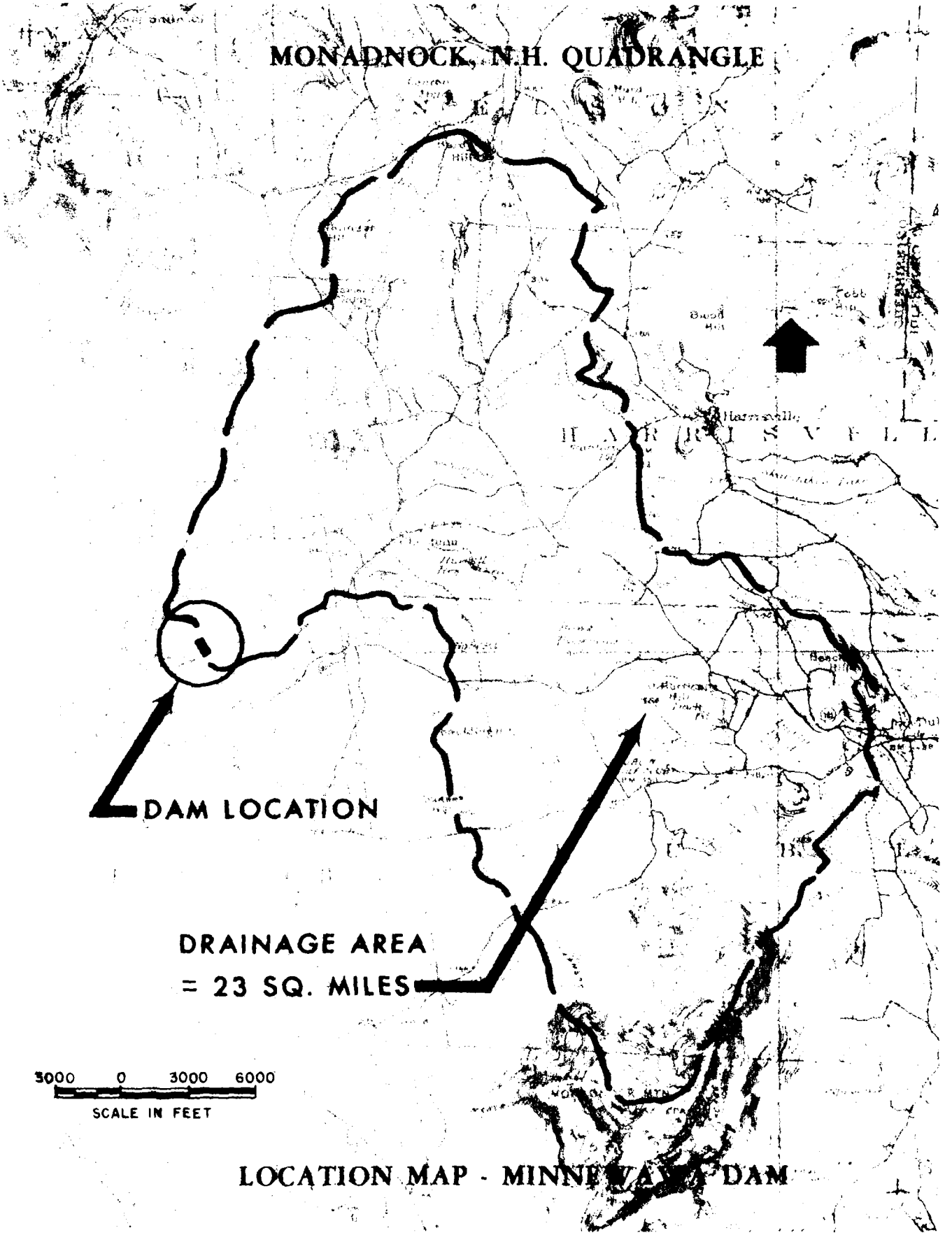
a. Location. The dam is located on the western end of the impoundment of Minnewawa Brook in the Town of Marlborough, New Hampshire, approximately 1.6 miles upstream of the village of Marlborough.

b. Description of Dam and Appurtenances. The Minnewawa Dam is a constant radius concrete arch dam. The structure has two distinct features. The arch section is 200 feet long and has a top elevation of 1073.0 (msl). This arch is keyed into ledge. The concrete spillway, which is approximately 43.5 feet long, has a crest elevation of 1068.0 (msl). The spillway is also founded on ledge.

c. Size Classification. Minnewawa is an intermediate dam, based on height.

d. Hazard Classification. The structure is classified as a high hazard potential. (See Section 3.1.e).

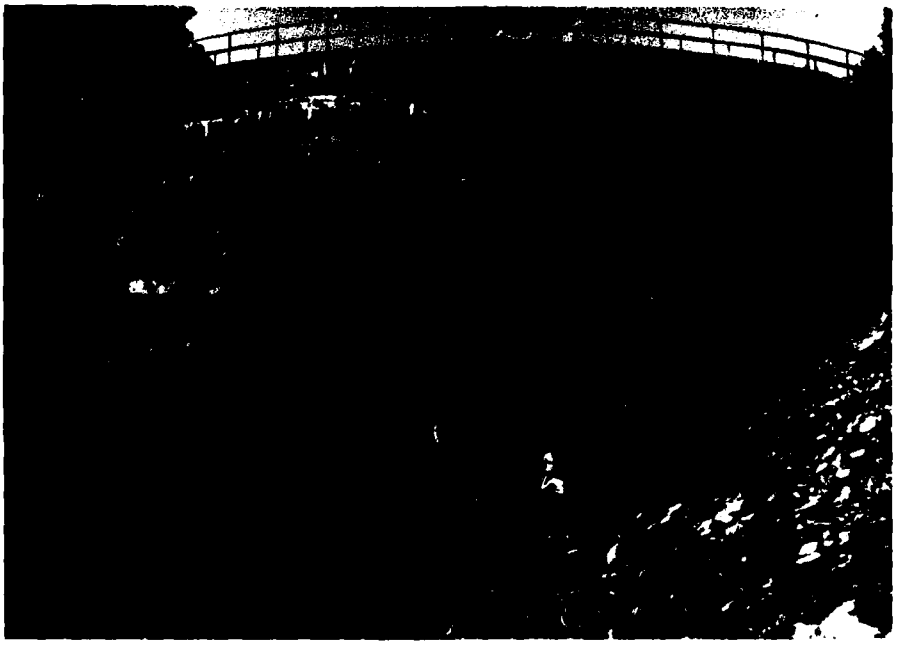
e. Ownership. The dam is owned by the Public Service Company of New Hampshire.



LOCATION MAP - MINNEWASKA DAM

MINNEWAWA DAM

DOWNSTREAM FACE



UPSTREAM FACE

APPENDIX A - MINNEWAWA DAM
PHASE I
VISUAL INSPECTION

PARTY ORGANIZATION

PROJECT Minnewawa Dam
LOCATION Marlboro, New Hampshire
STREAM Minnewawa Brook
Inventory No. N.H #00104

DATE 7 June 19[illegible]
TIME 10:00
WEATHER Sunny
W.S. ELEV. - U.S. - DN.S.

PARTY:

1. W. Rodger
2. G. A. Laraway
3. J. McElroy
4.
5.
6.
7.
8.
9.
10.

PROJECT FEATURE	INSPECTED BY	REMARKS
1. Sluice Outlet (Fig. 13 & 15)	Laraway	Some debris
2. Penstock Outlet (Fig. 13 & 14)	Laraway	Some debris
3. Spillway (Fig. 16 & 17)	Laraway	Inadequate
4. Concrete Arch (Fig. 6 & 7)	McElroy, Rodger	See Check List
5.		
6.		
7.		
8.		
9.		
10.		

NOTE: 1. Portions of the structure appear to have been repaired with a gunite coat. No record of this treatment was found.
2. (Fig. No.) refers to photographs contained in Appendix C.

PHASE I

VISUAL INSPECTION CHECK LIST

PROJECT Minnewawa Dam DATE 7 June 1978

PROJECT FEATURE Conc. Arch NAME Rodger

DISCIPLINE Structure, & Concrete NAME McElroy

AREA EVALUATED	COMMENTS
DAM (Fig. 3 thru 10)	
Crest Elevation	1073.0 msl
Current Pool Elevation	1021.0 msl
Maximum Impoundment to Date	Unknown
Surface Cracks	Many surface cracks with efflorescence downstream.
Pavement Condition	N/A
Movement or Settlement of Crest	None Observed.
Lateral Movement	Appears Good.
Vertical Alignment	Appears Good.
Horizontal Alignment	Appears Good.
Condition at Abutment and at Concrete Structures	Good.
Indications of Movement of Structural Items on Slopes	N/A
Trespassing on Slopes	N/A
Sloughing or Erosion of Slopes or Abutments	N/A
Rock Slope Protection - Riprap Failures	N/A
Unusual Movement or Cracking at or near Toes	None
Unusual Downstream Seepage	None
Piping or Boils	N/A
Foundation Drainage Features	None
Toe Drains	None
Instrumentation System	None

PHASE I

VISUAL INSPECTION CHECK LIST

PROJECT Minnewawa Dam DATE 7 June 1978

PROJECT FEATURE Outlet NAME Inspection Team

DISCIPLINE - NAME -

AREA EVALUATED	COMMENTS
OUTLET WORKS (Fig. 13 thru 15)	
a. Concrete and Structural	
General Condition	Fair
Condition of Joints	Good
Spalling	Several large spalls
Visible Reinforcing	Yes, upstream face of dam
Rusting or Staining of Concrete	Yes
Any Seepage or Efflorescence	Yes, downstream face
Joint Alignment	Good
Unusual Seepage or Leaks in Gate Chamber	N/A reservoir down
Cracks	Numerous surface cracks
Rusting or Corrosion of Steel	Both exposed re-steel & trash rack bars
b. Mechanical and Electrical	
Air Vents	None
Float Wells	Abandoned
Crane Hoist	None
Elevator	None
Hydraulic System	None
Service Gates	Inoperative
Emergency Gates	None
Lightning Protection System	None
Emergency Power System	None
Wiring and Lighting System in Gate Chamber	None

PHASE I

VISUAL INSPECTION CHECK LIST

PROJECT Minnewawa Dam — DATE 7 June 1978

PROJECT FEATURE Outlet — NAME Inspection Team

DISCIPLINE - — NAME -

AREA EVALUATED	COMMENTS
OUTLET STRUCTURE	(Fig. 9, 11 & 12)
General Condition of Concrete	Fair
Rust or Staining	Some
Spalling	Yes
Erosion or Cavitation	Yes
Visible Reinforcing	Yes
Any Seepage or Efflorescence	Some
Condition at Joints	Good
Drain Holes	N/A
Channel	N/A
Loose Rock or Trees Overhanging Channel	None
Condition of Discharge Channel	Natural channel - good

PHASE I

VISUAL INSPECTION CHECK LIST

PROJECT	Minnewawa Dam	DATE	7 June 1978
PROJECT FEATURE	Spillway	NAME	Inspection Team
DISCIPLINE	-	NAME	-

AREA EVALUATED	COMMENTS
SPILLWAY, APPROACH AND/OR DISCHARGE CHANNELS	
a. Approach Channel	(Fig. 1)
General Condition	Some brush
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None
b. Training Walls	
General Condition of Concrete	Good
Rust or Staining	None
Spalling	None
Any Visible Reinforcing	No
Any Seepage or Efflorescence	No
Drain Holes	None
c. Discharge Channel	(Fig. 2, 17)
General Condition	Fair
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None loose (see photos)
Floor of Channel	Rock
Other Obstructions	None

APPENDIX B

APPENDIX B - CONTENTS

(1923)

Ashuelot Gas & Electric Co. Owners
L. H. Shattuck Inc. Contractors
Marlboro, N. H.
Minnewawa Brook

Started July 1923. Completed December 1923.
Plans were filed June 19, 1923.

Permission given to go ahead with construction July 6, 1923.

The excavation was started the first part of July. Ledge was found the entire length of the dam. Pouring concrete was started August 18, 1923 and the last pouring made November 12, 1923.

This is of solid concrete construction single arch type 60' high and 200' long. Drainage area is 22 sq. miles. The water is taken by penstock downstream about six thousand feet to the Power House, which gives them a head of 254'. The installation of this plant is 2500 H.P.

Informal 1373 Plan D-49

157.06

ONSTRUCTION
STRUCTION
TIONS
ES

L. H. SHATTUCK, INC.

ENGINEERS—CONTRACTORS

208 GRANITE STREET

MANCHESTER, N. H.

REPORTS AND DESIGN
WATER POWER
WATER SUPPLY
SEWERAGE
BRIDGES

June 18, 1923.

Mr. John W. Storrs,
Chairman and Engineer,
New Hampshire Public Service Commission,
Concord, New Hampshire.

Subject: Dam to erected at
Marlboro, N. H., for Ashuelot
Gas & Electric Company, Keene, N.H.

Dear Sir:-

We are submitting plans and information in regard to the design of the proposed dam for the Ashuelot Gas & Electric Company at Marlboro, New Hampshire.

GENERAL DATA

The proposed dam will be built on Minnewawa Brook about one and one-half miles above the village of Marlboro, N. H. The watershed drained is 22 square miles. This watershed while hilly contains several large ponds providing a considerable storage and tending to reduce the size of flood flows.

The maximum recorded spring floods from this and adjoining watersheds yield not over 25 cu. ft. per second per square mile. In the design of the proposed dam we have anticipated a maximum flood of 65 cu. ft. per second per square mile. The design adopted would also permit an unexpected flood to flow over the entire length of the dam without damage to the construction.

The capacity of the proposed pond is about 140 acre feet or 600,000 cubic feet.

DESIGN DATA

As shown by the accompanying plans the proposed structure is a concrete arch dam of solid concrete masonry. The maximum height above river bed would be about 55 ft., and above foundations probably 60 ft. The thickness at the top is four feet and at the bottom eleven feet.

The dam is provided at its northern end with a spillway 40 ft. long and 5 ft. deep with a short auxiliary spillway 3 ft. deep. The capacity of this spillway to the top of the arch portion of the dam is about 1700 cu. ft. per second.

The dam will have a constant radius of 85 ft. to the upstream face.

The concrete used will be mixed in proportion one part cement, two ~~and one-half~~ parts sand, ~~three~~ four (F.A.S.) parts crushed stone or gravel and possibly an addition of cobbles or plums, if such an addition is found economical. To the concrete will be added eight parts of hydrated lime to one hundred parts by weight of cement to increase water tightness.

COMPUTATION FOR DESIGN

Constant Radius Dam

Formula used $p = \frac{q\ r_u}{t}$ Creager page 149

or

$$t = \frac{q\ r_u}{p}$$

p = Unit stress in concrete per square foot. Taken as 40,000# per square foot or 278# per square inch.

q = Load per square foot taken by the arch at any elevation.

t = Thickness of the arch in feet at any elevation.

r_u = Upstream radius of dam in feet. In this case = 85 ft.

RESULTS OF CALCULATIONS

Height h	Pressure q = 62.5h	Computed Thickness t	Thickness Used	Actual Unit Compression p
0	0	0	4	o+
10	625	1.33	4	13300
20	1250	2.66	5.5	19300
30	1875	4.00	7.0	22800
40	2500	5.32	7.5	28400
50	3125	6.65	10.0	26600
60	3750	8.00	11.0	29000

Taking the ultimate strength of 1-2½-5 concrete as 300,000# per sq. ft. we have a minimum factor of safety of over 10.

+Except from possible ice action.

CONSTRUCTION DATA

The site is a deep gorge in which the bed rock is only slightly overlayed with soil. The rock is a micca shist of varying hardness. In most cases where the ledge has been exposed the rock is hard, but on the south slope the dip of the strata is with the slope of the hill and the surface rock has been softened and loosened by frost and root action.

All of the partially disintegrated rock will be removed and a trench excavated in the hard rock. The foundation of the dam will be built in this trench. Preparation will be made to grout the seams in the rock if they are found to be loose on inspection and test drilling.

The horizontal joints in the dam will be as few as is practical and will be carefully cleaned and bonded. Vertical expansion joints will be spaced on about 40 ft. centers, and will be made water tight by the insertion of strips of sheet lead.

Plans The details of the proposed dam are shown on the accompanying plans.

We shall be glad to furnish the Commission with any additional information desired, or will accompany them when inspecting the site. We have attached a list of references used in the design of this structure, and a diagram of the maximum recorded flood flows on small New Hampshire streams.

Very truly yours,
L. H. SHATTUCK, INC.

L. H. SHATTUCK, INC.

197.06

REFERENCES USED IN DESIGN AND SPECIFICATION FOR ARCH DAM

1st & Principally

W. P. Creager - Masonry Dams, pages 148-171

2nd

Lamar Lyndon - Hydro-electric Power, Vol. I, Pages 228-233

3rd

Concrete Engineers Handbook by Hool & Johnson, page 736

4th

Daughterty - Hydraulics, page 35

5th

American Society Civil Engineers proceedings - April 1914 and discussions - The Huacal Dam, Senora, Mexico. Describes and illustrates a typical thin arch dam, with interesting discussions of the design of arch dams.

6th

May 1914 and discussions - The Constant Angle Arch Dam by Lars R. Jorgensen, with discussion of the design of arch dams in general.

151.06

Tenn Gen & El. Co. Minnemora Kiosk Dam

June-25-1923

J.N.S.

Radius = 85'

h = (1073 - 1020) = 53'

T at 1020 = 10'-3¼" = 10.25

S = 62.3 r h / t

S = 62.5 × 85 × 53 / 10.25 = 27470. □'

4.7958800
1.9294189
1.7242759
5.4495748
1.0107239

Log 4.4388509

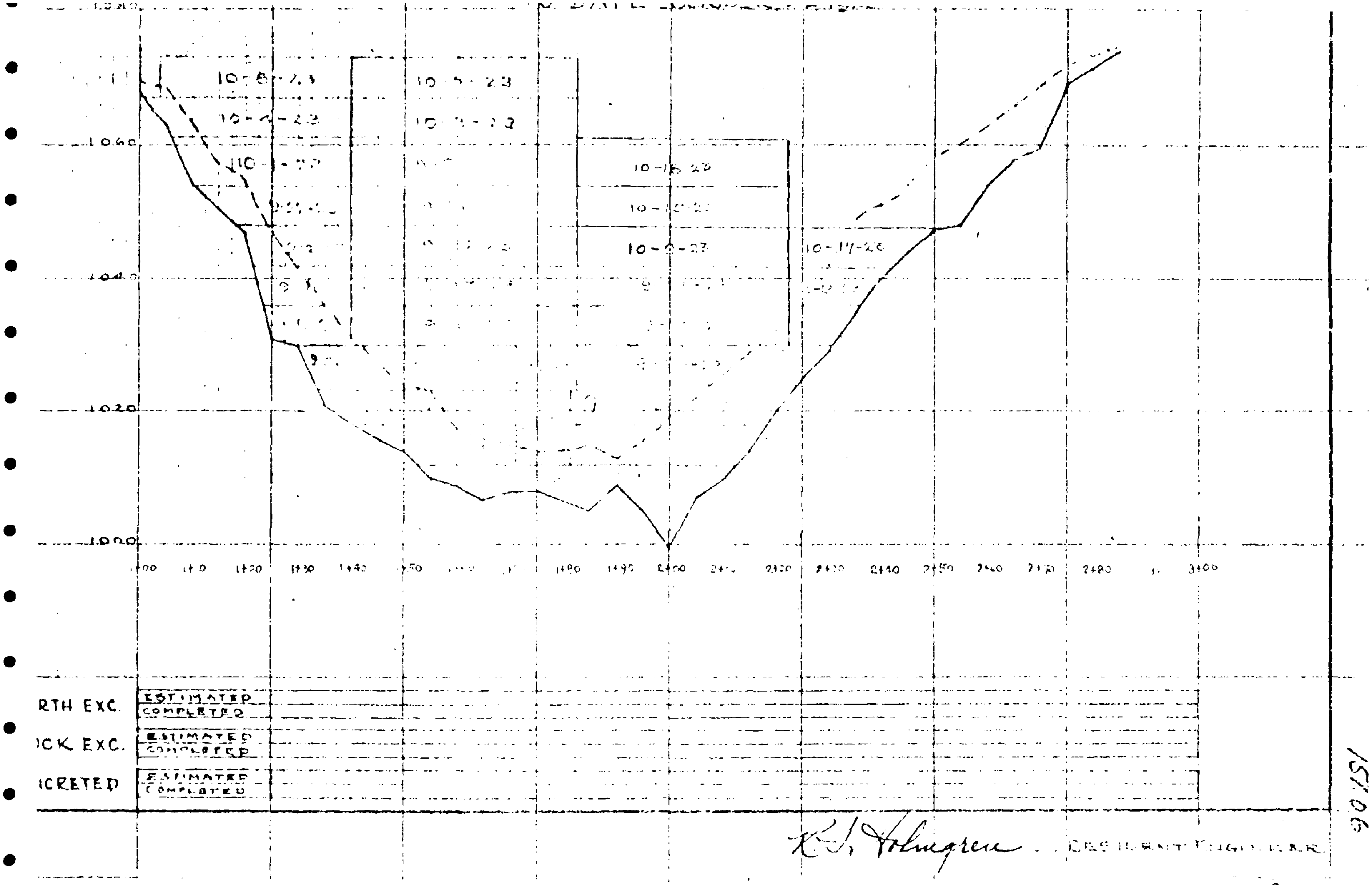
144□" 2.1583625

Log 2.2804984

S = 192.76 #/□"

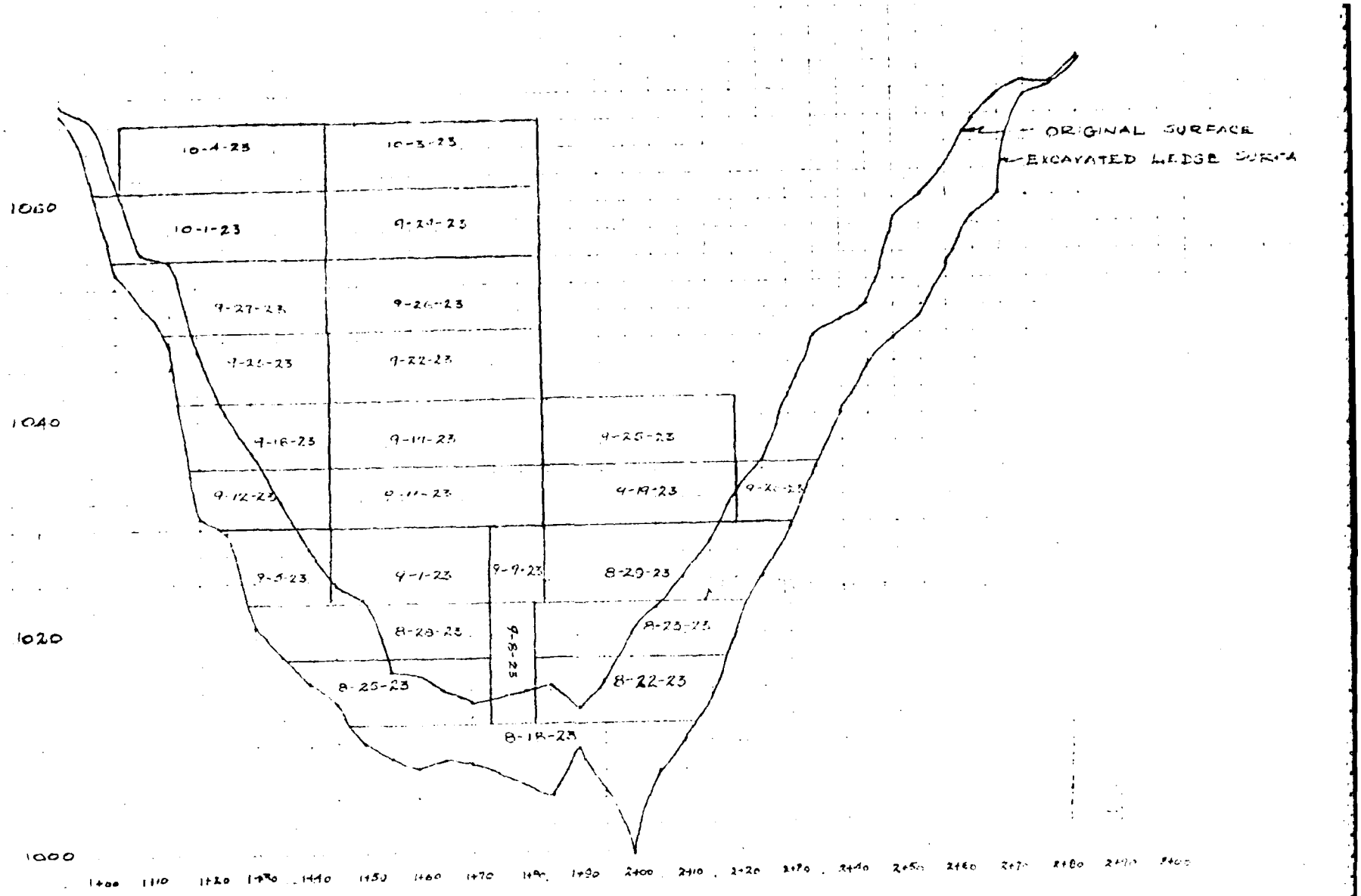
[illegible]

[illegible]



K. J. Holmgren

151.06


ORIGINAL SURFACE
EXCAVATED LEDGE SURFACE
1060
1040
1020
1000
10-4-23
10-3-23
10-1-23
9-29-23
9-27-23
9-26-23
9-22-23
9-18-23
9-11-23
9-25-23
9-19-23
9-12-23
9-5-23
9-1-23
9-9-23
8-29-23
8-28-23
8-25-23
8-22-23
8-18-23
1+00
1+10
1+20
1+30
1+40
1+50
1+60
1+70
1+80
1+90
2+00
2+10
2+20
2+30
2+40
2+50
2+60
2+70
2+80

Mr. L. W. Bigelow. Oct. 4, 1923

DAM AT MARLBORO , ASQUELOT GAS & ELECTRIC CO.

The following are the stations of the expansion joints

1+ 06.1 Gravity to arch
1+ 44.3
1+ 82.4
2+ 20.5
2+ 58.6

The following are the horozontal joint elevations.

1023.0 Top of footing.
1030.1
1036.3
1042.6
1048.8
1055.1
1061.3
1067.6
1073.0

The station of the sluice pipe is 1+ 84.6

H. E. WHEELER, PURCHASING AGENT P. A. SHAW, M. AM. SOC. C. E., CHIEF ENGINEER

157.06

T-ON
ON

L. H. SHATTUCK, INC.

ENGINEERS — CONTRACTORS

208 GRANITE STREET

MANCHESTER, N. H.

REPORTS AND DESIGN
WATER POWER
WATER SUPPLY
SEWERAGE
BRIDGES

Marlboro, N.H.
October, 4, 1923

r. L. W. Bigelow,
/o Public Service Commission,
oncord. N. H.

Re.,- Dam at Marlboro for Ashuelot Gas & Electric Co.

ear Mr. Bigelow,-

In accordance with our conversation today am sending you a sketch showing the profile of the dam, and he concrete pours to date. This profile does not include the pillway as we have taken no profile here yet. I will show this n a future letter to you after I have this information.

On another sheet enclosed I am giving the exact values f the elevations poured to each time, also the stationing of he expansion joints. The stationing is simply started by dopting a large enough value for the station of the sluice ipe to give us a positive value for all points on the dam. It s not started at any particular point. The profile is run on line four feet back from the upstream side of the dam. The rofile is drawn looking upstream.

Any other data which I can give you, I shall be pleased to o so at your request.

Very truly yours,

Richard S. Holmgren

Resident Engineer.

nc.

.39 9

September 19, 1923.

Public Service Commission,
Concord, New Hampshire.

Dear Sirs:

Herewith I submit my report on the inspection of the dam at Marlboro for the Keene Gas & Electric Company.

The opening which was left for flow, as by my report of September 7 has been closed. The flow is being discharged now through the sluice gate. At the time I was there it was running about one-third full.

The south half of the dam has been poured up to elevation 1036. The north half would be up to elevation 1042 last night as they were pouring the section nearest the bank while I was there. They expect, this week, to have the concrete up to elevation 1042 the entire length of the dam.

The power house is poured up to the roof and they expect to have it roofed in the latter part of next week.

The work at the dam is being carried on in a very satisfactory manner, all joints, both horizontal and vertical, being kept free from chips and other dirt.

Respectfully submitted,

[signature]

Engineer.

TESTING LABORATORY

REPORT ON SAMPLE OF PORTLAND CEMENT

Report 9/13 1923

tory No. 3870 Exam. 8/16 1923

Portland Cement / Town

lication Marks

ted by L.K.Shattuck Co., Keene Gas & Electric Co., Storrs, Bigelow Title Address

d , 19 Received 8/15 , 19 23

from

ty represented

of Material

n used or to be used

ned for

TEST RESULTS

Chemical Tests

	Requirements: American Society for Testing Materials and New Hampshire Highway Department. Per cent.
n ignition, per cent	not over 4.00
ble residue, per cent	not over 0.85
ric Anhydride (SO_3), per cent	not over 2.00
sia (MgO), per cent	not over 5.00

Physical Tests

c Gravity	not less than 3.10
nt. retained on 200 mesh sieve 18.7	not over 22.00
est O.K.	No distortion, cracking, checking or disintegration

Gillmore Needle

set 2 hours 20 Minutes	not less than 60 minutes
set 5 hours 5 minutes	not over 10 hours

Tensile Strength

(1:3 Ottawa Sand.)

7 days.		28 days.	
321		405	
321		391	
309		426	
307	200 pounds	402	300 pounds

Average:

Meets requirements 7 & 28 day tests.

Respectfully submitted, Thomas O. Marston

Chemist and Testing Engineer.

HIGHWAY DEPARTMENT

TESTING LABORATORY

REPORT ON SAMPLE OF GRAVEL, SAND OR BITUMINOUS CONCRETE

Report 9/20 1923

aboratory No. 3586 Exam. 8/20 1923

ame Fine Aggregate for Concrete Town Keene

entification Marks

bmitted by L.L.Shattuck Co.-Keene Gas & Electric Co.-Storrs-Bigelow Title Address

mpled 8/17, 19 23 Received 8/18, 1923

mple from Car from Carmon's Pit-E.Weare, N.H.

antity represented

rce of Material

cation used or to be used Keene Dam

mined for

TEST RESULTS

SAND—Mechanical Analysis

FRACTION	%
Retained ¼" screen	
Passing ¼", retained 10 mesh	
" 10, " 20 "	
" 20, " 30 "	
" 30, " 40 "	
" 40, " 50 "	
" 50, " 60 "	
" 60, " 80 "	
" 80, " 100 "	
" 100, " 200 "	
" 200, mesh	
al:	

GRAVEL—Mechanical Analysis

FRACTION	%
Retained 3½" screen	Fineness Modulus
Passing 3½", retained 3"	~ Coarser than
" 3" " 2½"	
" 2½" " 2"	
" 2" " 1½"	#100——97
" 1½" " 1"	48——87
" 1" " ¾"	28——57
" ¾" " ½"	14——23
" ½" " ¼"	8——7
" ¼" screen	4——1
	Fm.-2.74
Total:	

or:

e 2

COMPRESSIVE TENSILE STRENGTH (Cement-Sand Briquets—1:3)

	SAMPLE SAND			STANDARD OTTAWA SAND		
	3 day	7 day	28 day	3 day	7 day	28 day
		955	1564		924	1496
		1000	1701		856	1591
		1073	1615		901	1564
		1009	1627		894	1551
		113%	104%			

Per cent. of Wear

Asphalt %

Remarks:

Meets requirements #1 Sand on 7 & 28 day tests. This sample is clean.

Chemist and Testing Engineer.

373

September 7, 1923.

Public Service Commission,
Concord, New Hampshire.

Dear Sirs:

I herewith submit a report on the inspection of the dam at Marlboro for the Keene Gas & Electric Company yesterday.

The concrete is poured up to elevation 1030, the full length, with the exception of an opening about eight feet in width which was left for the flow of water.

On the south end of the dam they were obliged to go down about 15' from approximately elevation 1020 to find a solid foundation owing to seams. Good solid rock was found at about elevation 1010 but they went about five feet in good solid rock. This pocket was only about 10' in length.

The cut-off on both banks has been carried down to good hard rock. In carrying the dam up, the cut-off will be filled solid with concrete on the upstream side as, of course, the line of ledge excavation is rather irregular.

The sluice gate was put in position yesterday and they expect to fill in the opening on Saturday and Sunday and send the water down through the sluice gate.

Construction seems to be carried on in a very workmanlike manner. The joints are kept free from dirt and debris.

They are using sectional forms which are very rigid and are handled by an overhead cableway. The forms are, also, kept clean and in good shape.

With ordinary working conditions they expect to finish the dam about the first or second week in October.

Respectfully submitted,

W B Boylston

Engineer.

DATA ON DAMS IN NEW HAMPSHIRE

LOCATION STATE NO. 151.06

Town Marlboro : County Cheshire

Stream Minnewawa Brook

Basin-Primary Connecticut R : Secondary Ashuelot R

Local Name

Coordinates—Lat. 42° 58' + 300' : Long. 72° 10' + 3350'

GENERAL DATA

Drainage area: Controlled 25 Sq. Mi.: Uncontrolled Sq. Mi.: Total 25 Sq. Mi.

Overall length of dam 250 ft.: Date of Construction

Height: Stream bed to highest elev. 60 ft.: Max. Structure 55 ft.

Cost—Dam : Reservoir

DESCRIPTION Arch--- Concrete on Ledge

Waste Gates

Type 1

Number : Size ft. high x ft. wide

Elevation Invert : Total Area 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

Length—Total 3 bays 14' each ft.: Net 42 f

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

Flashboards—Type : Height 2 f

Elevation—Permanent Crest 1072.228 : Top of Flashboard

Flood Capacity 1775 cfs.: 71 cfs/sq. mi.

Abutments

Materials:

Freeboard: Max. 5 ft.: Min. f

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

OWNER Public Service Co of N H

REMARKS 800 ft penstock— 4' in diameter

Tabulation By A A K Date January 30, 1939

BAE21281

DATA ON RESERVOIRS & PONDS IN NEW HAMPSHIRE

LOCATION AT DAM NO. 151.06

Town Marlboro : County Cheshire

Stream Minnewawa Brook

Basin—Primary Connecticut : Secondary Ashuelot

Local Name

DRAINAGE AREA

Controlled 25 Sq. Mi.: Uncontrolled Sq. Mi.: Total Sq. Mi.

ELEVATION vs. WATER SURFACE AREA vs. VOLUME

Point	Head Feet	Surface Area Acres	Volume Acre Ft.
(1) Max. Flood Height			
(2) Top of Flashboards			
(3) Permanent Crest			
(4) Normal Drawdown		140	
(5) Max. Drawdown			
(6) Original Pond			

Base Used : Coef. to change to U.S.G.S. Base

RESERVOIR CAPACITY

	Total Volume	Useable Volume
Drawdown	ft.	ft.
Volume	ac. ft.	ac. ft.
Acre ft. per sq. mi.		
Inches per sq. mi.		

USE OF WATER Public Utility

OWNER Public Service Co of N H

REMARKS

Tabulation By Date January 30, 1939

LOCATION AT DAM NO. 151.06

Town Marlboro : County Cheshire

Stream Minnewawa

Basin-Primary Connecticut : Secondary Ashuelot

Local Name

GENERAL DATA

Head-Max. 269 ft.: Min. ft.: Ave. ft.

Date of Construction : Use of Power Public Utility

Pondage ac. ft.: Storage ac. ft.

DESCRIPTION

Racks

Size of Rack Opening

Size of Bar : Material

Area: Gross Sq. Ft.: Net sq. ft.

Head Gates

Type

Number : Size ft. high x ft. wide

Elevation of Invert : Total Area sq. ft.

Hoist

Penstock

Number 1 : Material Wood

Size 4' diameter : Length 300'

Turbines

Number 2 : Makers S. Morgan Smith horizontal

Rating HP. per unit 1250 : Total Capacity 2500 HP.

Max. Dement C.F.S., per unit : Total cfs.

Drive

Type

Generator

Number 2

Make G.E.

Rating KW., per unit 800 ; Total Capacity 1600 K. W.

Exciter

Number : Make

Rating-per unit : Total Capacity K. W.

OUTPUT—KWHRS

19	:	19	
19	:	19	
19	:	19	
19	:	19	
19	:	19	

OWNER Public Service Co of N. H.

Tabulation By Date January 22, 1939

Elev	Thickness Ins	Actual Unit of Compression	Unit of Comp. per Sq. In
1063.0	4.0	15781	109.59
1060.0	4.44	15555	108.02
1056.0	5.9	20710	143.82
1050.0	7.35	23852	165.64
1153.3	9.91	25929	130.00
1133.3	10.27	27611	191.74

Calculated Aug 23. 1923

Press check Calculations submitted by

L. M. Shattuck Inc.

By [signature]

157.06

$S = \frac{62.5 \times 85 \times 10}{4}$

S = 15781

109.59

850
62.5
4250
1700
5100
4) 53125.0
15781.

191.74
144) 27611

180
144) 25929
144
1152
1152

165.64

109.59
144) 15781
144
1381
1296
850
720
1300

144) 15333 (106.02
144
1152
...

193.52

P = radius of curve $S = 62.5 \frac{H \cdot R}{T}$ (L Williams P228) 157.06
H = head of water at point
T = thickness of Dam
S = Comp. Stress

$S = \frac{62.5 \times 85 \times 53}{10.27}$

S = 27611
191.74

$S = \frac{62.5 \times 85 \times 43}{8.81}$

S = 25929
180.0

$S = \frac{62.5 \times 85 \times 33}{7.35}$

S = 23852
165.64

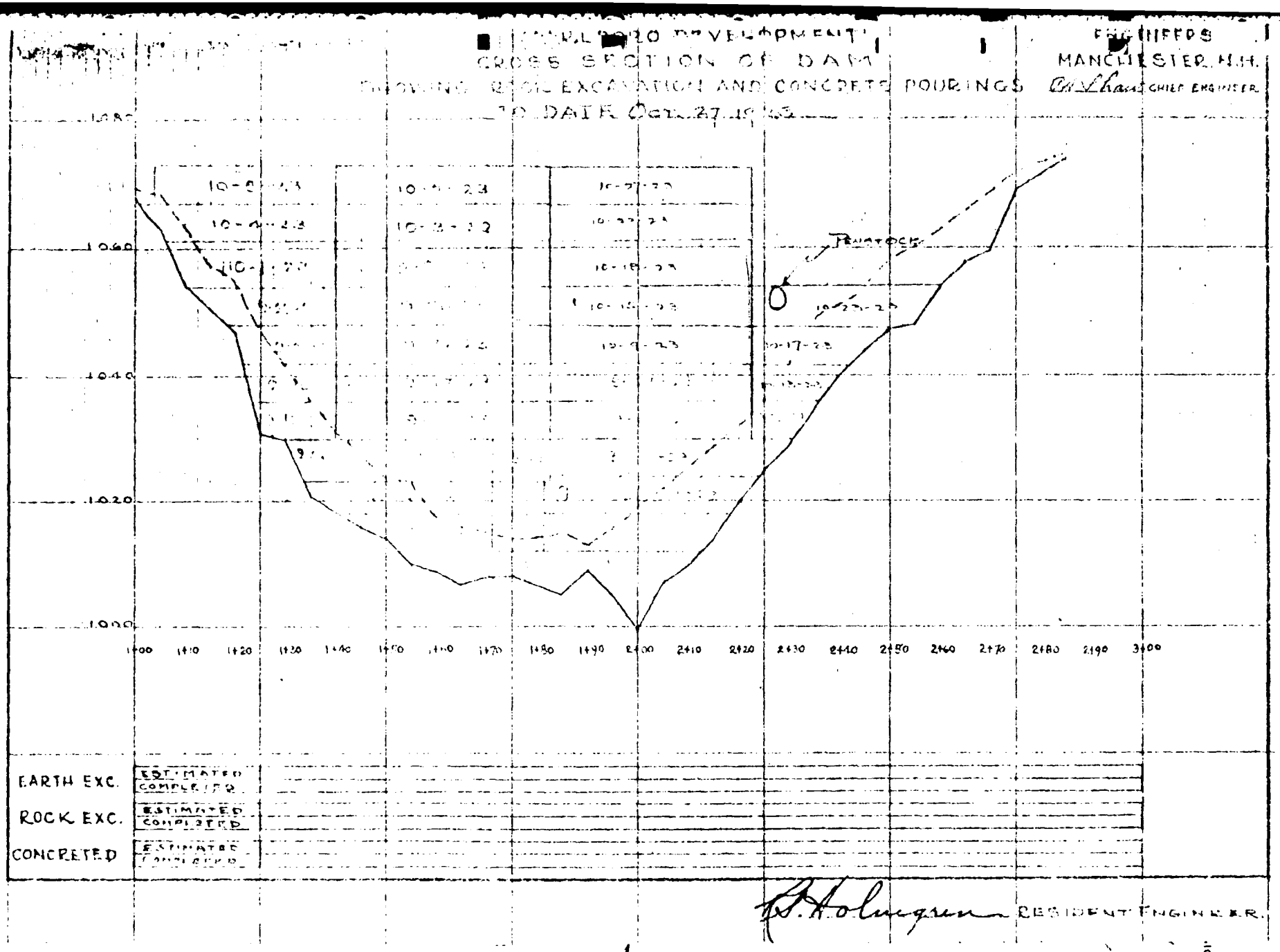
$S = \frac{62.5 \times 85 \times 23}{5.9}$

S = 20710
143.82

$S = \frac{62.5 \times 85 \times 13}{4.44}$

S = 15555

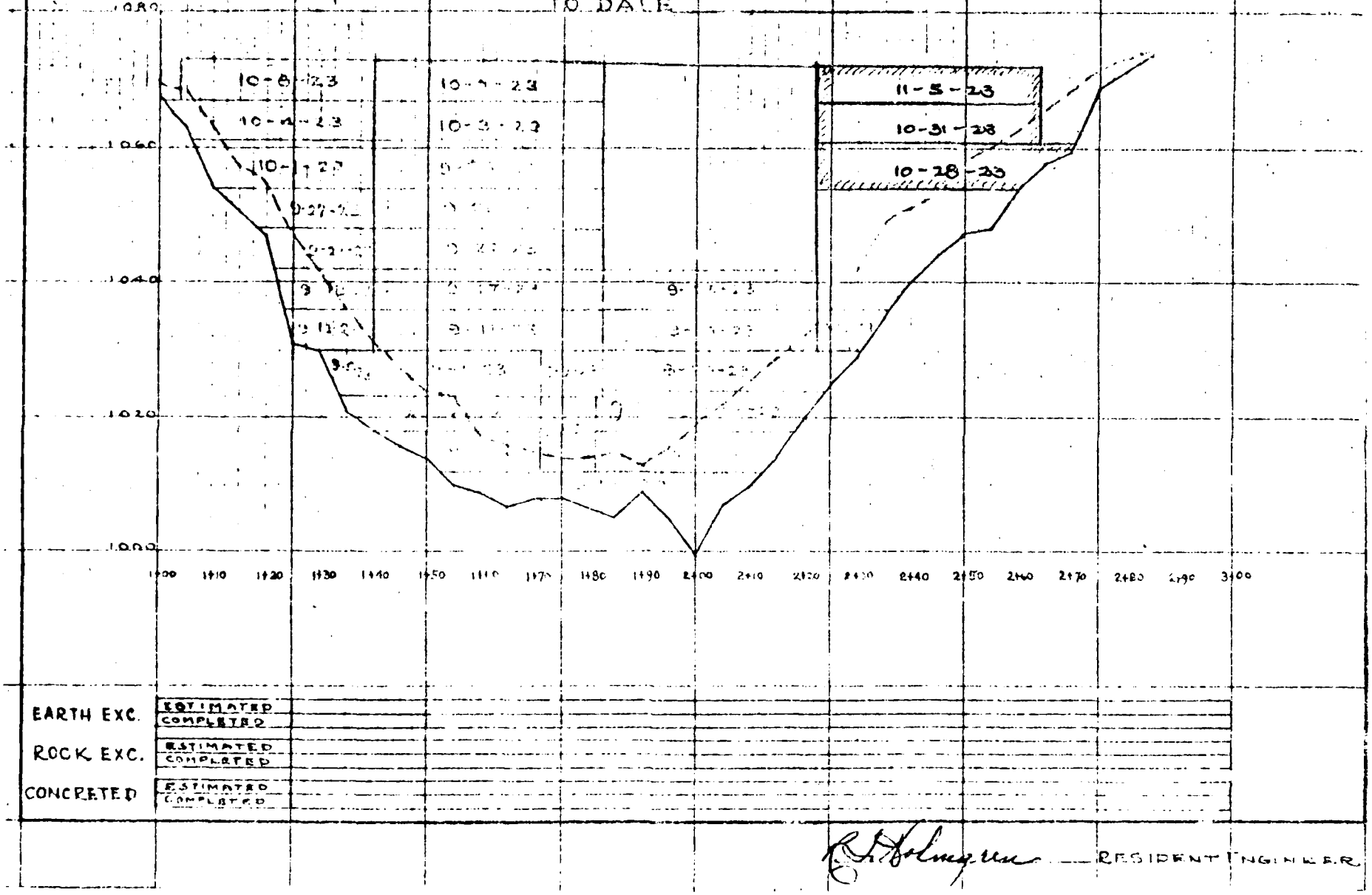
85 × 53	10.27	27610.7
255	8.81	10.27) 283562.50
425	7.35	2054
4505	5.9	7816
62.5	4.44	7189
22525		6272
9010		6162
27030		1105
283562.5		1027
		7800
85 × 43		25929
255		8.81) 228437.50
340		1762
3655		5223
62.5		4405
18275		8187
7310		7929
21930		2583
228437.5		1762
		8230
85 × 33		7929
255		7.35) 175312.50 (23852
255		1470
2805		2831
62.5		2205
14025		6262
5610		5880
16830		3823
175312.5		3675
		1500
85 × 23		5.9) 122187.5 (20709
255		118
170		418
1955		413
62.5		575
9775		531
3910		44
11730		
122187.5		
85 × 13		4.44) 69062.50 (15555
255		444
1105		2466
		2220
		2462
		2220
		2425
		2220


CROSS SECTION OF DAM
SHOWING BASIC EXCAVATION AND CONCRETE POURINGS
TO DATE Oct. 27 19 43
ENGINEERS
MANCHESTER, N.H.
CHIEF ENGINEER
1080
1060
1040
1020
1000
1+00
1+10
1+20
1+30
1+40
1+50
1+60
1+70
1+80
1+90
2+00
2+10
2+20
2+30
2+40
2+50
2+60
2+70
2+80
2+90
3+00
FRONTOCH
EARTH EXC.
ESTIMATED COMPLETED
ROCK EXC.
ESTIMATED COMPLETED
CONCRETED
ESTIMATED COMPLETED
RESIDENT ENGINEER.

L. H. SHATTUCK, INC.
ENG. ENGINEERS
MANCHESTER, N.H.

SHOWING ROCK EXCAVATION AND CONCRETE POURINGS TO DATE

CHIEF ENGINEER

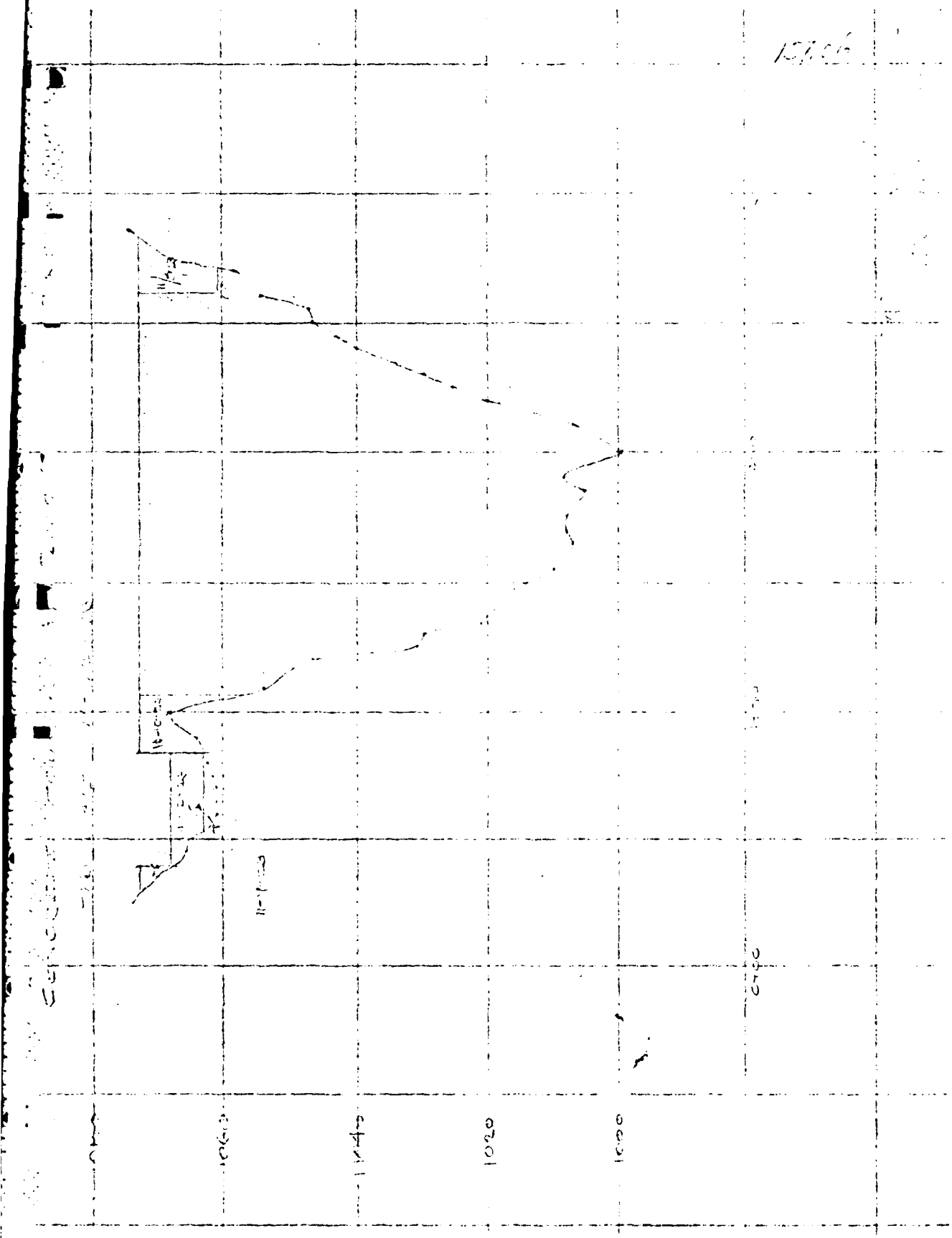


EARTH EXC.	ESTIMATED	
	COMPLETED	
ROCK EXC.	ESTIMATED	
	COMPLETED	
CONCRETED	ESTIMATED	
	COMPLETED	

RESIDENT ENGINEER

L. H. SHATTUCK, INC.

157.06



OF

NEW HAMPSHIRE

INSPECTOR'S REPORT

November 6 19 23

Subject: Dam, Marlboro; Ashuelot Light & Power Co.

Herewith I submit my report on the inspection of the dam at Marlboro for The Ashuelot Light & Power Company on Nov. 6th.

The abutment section of the dam has been completed from station 1 + 00 to about station 2 + 63. From 2 + 63 to the south end the concrete has been poured to Elv. 261.0, and this should be completed by the end of this week.

On the spillway excavation they run into a pocket and the yardage was increased quite a lot from the original estimate but this has been completed and they will start pouring concrete this week.

The power house is completed with the exception of the doors and windows.

About two thousand feet of the penstock line is in place most of which is on the power house end. They have now started in and are laying from the dam as well.

Respectfully submitted,

J. W. Boylston

Engineer.

Attatched is progress chart to Nov. 5th.

OF

NEW HAMPSHIRE

INSPECTOR'S REPORT

December 4, 1923.

Subject: Dam, Marlboro; Ashuelot Gas & Electric Co.

I herewith submit my report for the final inspection of t the dam at Marlboro for the Ashuelot Gas & Electric Company on December 4th.

The concrete has all been placed in both the abutment and spillway sections of the dam. The racks and gate for penstock are all in place. Railings have also been placed along the crest of the abutment section, and a wooden bridge has been built from the bank accrossed the spillway to the end of the abutment section.

At the time of my inspection there was about a foot of water going over the spillway which made the water in the pond at about elevation 1069. The earth which was not excavated below the spillway has been washed out by the high water of Nov. 24th when the water reached an elevation of 1070, this has left the ledge exposed the entire length the spillway from the concrete to top of the cliff. This shows up a natural channel in the ledge.

There is a slight seepage through the concrete at about elevation 1040 at about station 1+70 and covers about six sq. ft. but does not amount to anything more then a slight moisture on the surface.

PUBLIC SERVICE COMMISSION
OF
NEW HAMPSHIRE

157.06

INSPECTOR'S REPORT

19

Subject Dam,Marlboro continued

The penstock has been completed to within about thirty feet of the Power House.The surge tank is about 50% erected. At the Power House the Transformer tower is about 75% complete.

The Company expects under fair working condidtions to have the power house in operation sometime in January.

The work has been carried on throughout in a business and workmanlike manner.

Respectfully submitted,

J W Boynton

Engineer.

Inspected June 19, 1930.

Public Service Company of N. H.

Minnewawa Dam.

Concrete arch dam. The spillway has splashboards at present. Considerable brush and timber collected at spillway. The downstream face of the dam shows evidence of small seepage, and several panels have surface filling similar to that shown at intake. The bed of the stream below the dam was fairly dry. There is one stone arch small dam above the power station and two small timber dams in ruins. These are all former dams owned by the Keene Gas and Electric Company in Marlboro. The small stone arch dam is in good shape.

DIVI-16

DIVI-17

DIVI-18

M E M O

August 27, 1976

Dam #151.06

On August 3rd I inspected the dam on the Minnewawa Brook.

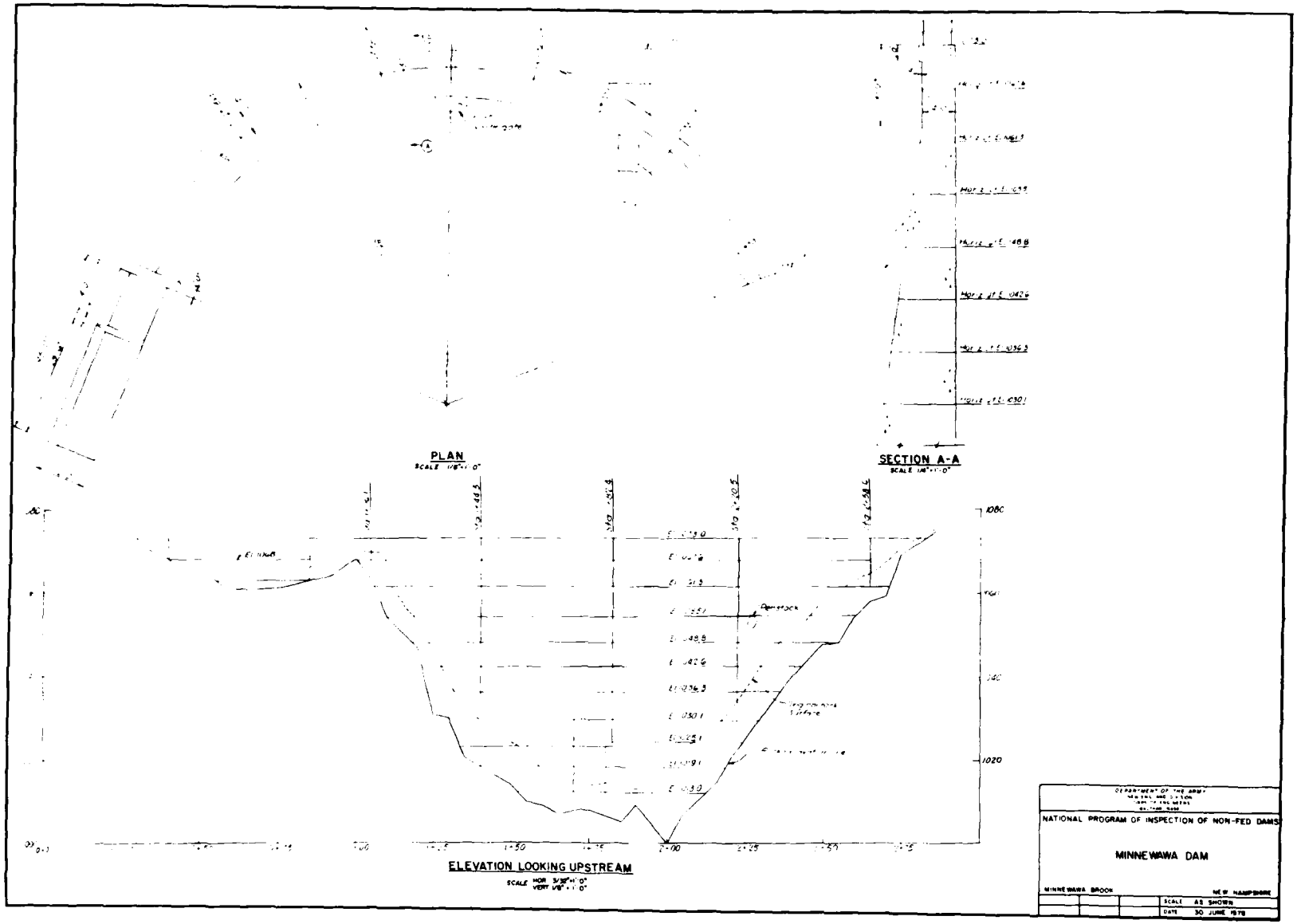
This dam has no structural changes since the last inspection (November 1974).

There are some rebars showing on the upstream face.

This dam should be inspected in two years.

SCBurritt

CORPS OF ENGINEERS



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

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

MINNEWAWA DAM

MINNEWAWA BROOK — NEW HAMPSHIRE

SCALE AS SHOWN
DATE 30 JUNE 1978

APPENDIX C

PHOTOGRAPHS

Fig. 1	Facing Upstream from Dam
Fig. 2	Facing Downstream from Dam
Fig. 3	Right Abutment (downstream face)
Fig. 4	Left Abutment (downstream face)
Fig. 5	Downstream Face (Note surface cracks and efflorescence)
Fig. 6	Downstream Face
Fig. 7	Walkway at Top of Dam El. 1073
Fig. 8	Upstream Face
Fig. 9	Intake Structure for Penstock, trash racks (Note excessive buildup of debris)
Fig.10	Detailed View of Condition of concrete on upstream face
Fig.11	Gate - Operating Machinery at Inlet to Penstock and Cabinet for water level Indicator
Fig.12	Work platform at inlet structure
Fig.13	Outlet - 24" dia. Sluice & 48" dia. Penstock
Fig.14	Outlet - 48" dia. Penstock
Fig.15	Outlet - 24" dia. Sluice and Gate Valve
Fig.16	Upstream View of Spillway
Fig.17	Spillway Outlet Channel thru V-Notch in ledge
Fig.18	Facing Upstream from Dam
Fig.19	Upstream Face of Arch (Note exposed reinforcing steel)
Fig.20	Inlet Structure
Fig.21	Detail of Exposed Reinforcing Steel and Spalled Concrete Surfaces

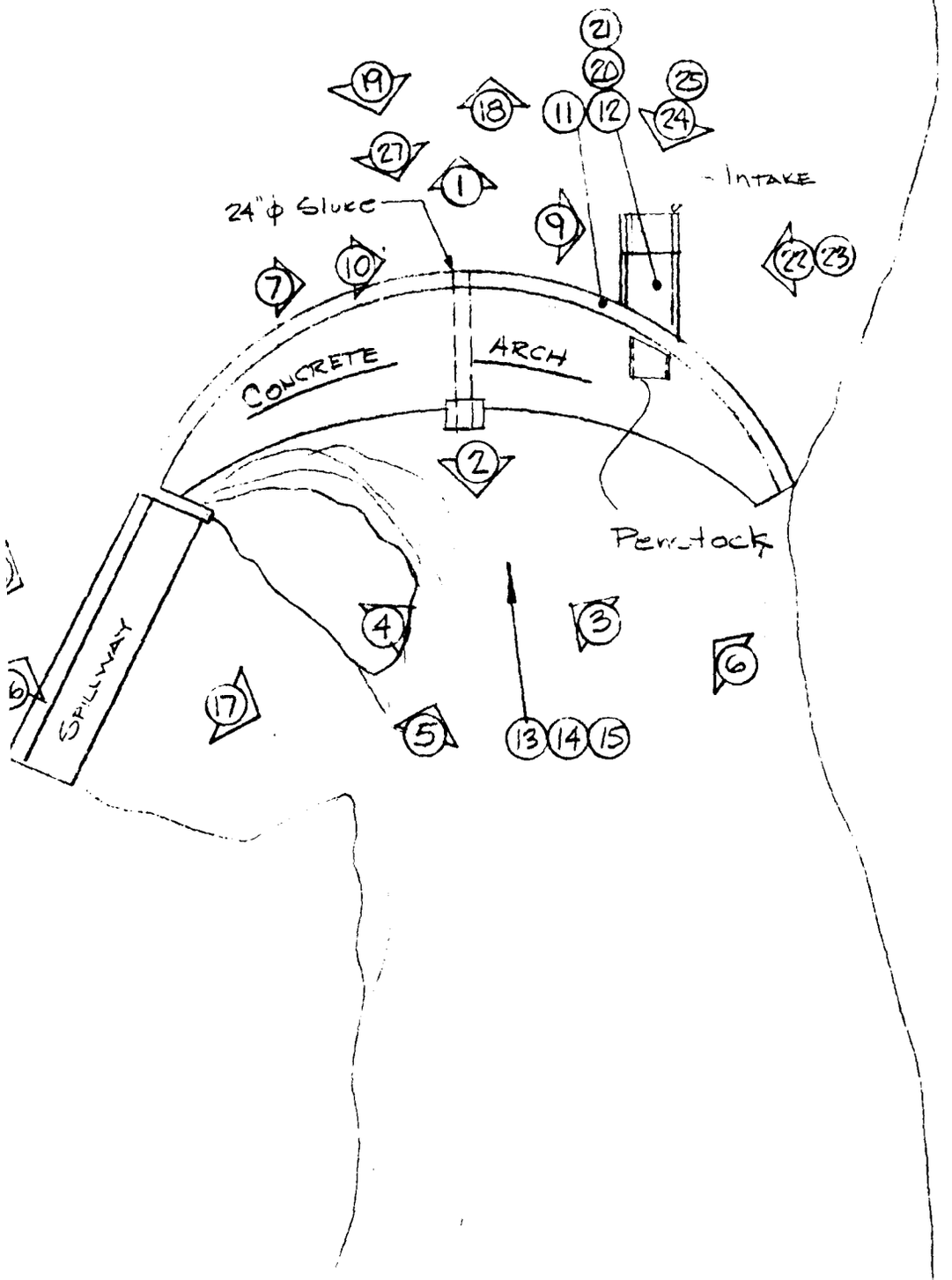


Photo Index

Minnewanna Dam

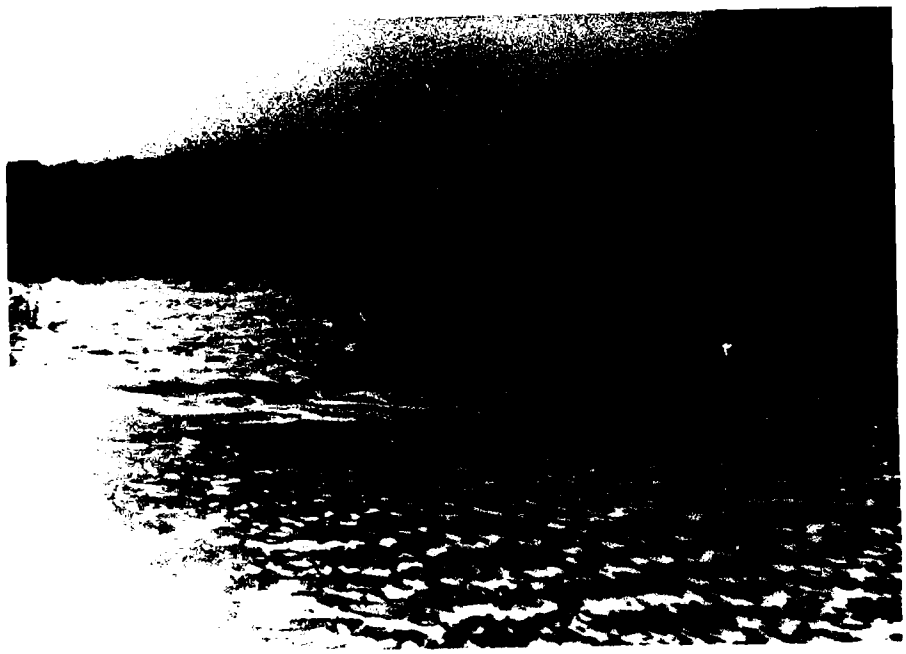


FIG. 1 Facing Upstream from Dam

FIG. 2 Facing Downstream from Dam

M 223
49

NEW ENGLAND DIVISION

CORPS OF ENGINEERS, U. S. ARMY

PAGE 1

[illegible]

N OVERFLOW COMPS.

BY [illegible] CHECKED BY Spillway Sec. DATE 4/78

1 Elev.

(ft.)

$C = 3.4$
$L = 43.5$
$CL = 147.9$

	$Q = 0$
[illegible]	$Q = 147.9(.5)^{3/2} = 52.4$ cfs
69	$Q = 147.9(1)^{3/2}$ 148
70	$Q = 147.9(2)^{3/2} = 419$
71	$Q = 147.9(3)^{3/2} = 769$
72	$Q = 147.9(4)^{3/2}$ 1183
3	$Q = 147.9(5)^{3/2}$ 1653
373.5	$Q = 147.9(5.5)^{3/2} = 1908$
74	$Q = 147.9(6)^{3/2} = 2173$
75	$Q = 147.9(7)^{3/2} = 2739$
77	$Q = 147.9(9)^{3/2} = 3993$
80	$Q = 147.9(12)^{3/2} = 6148$
81	$Q = 147.9(13)^{3/2} = 6932$

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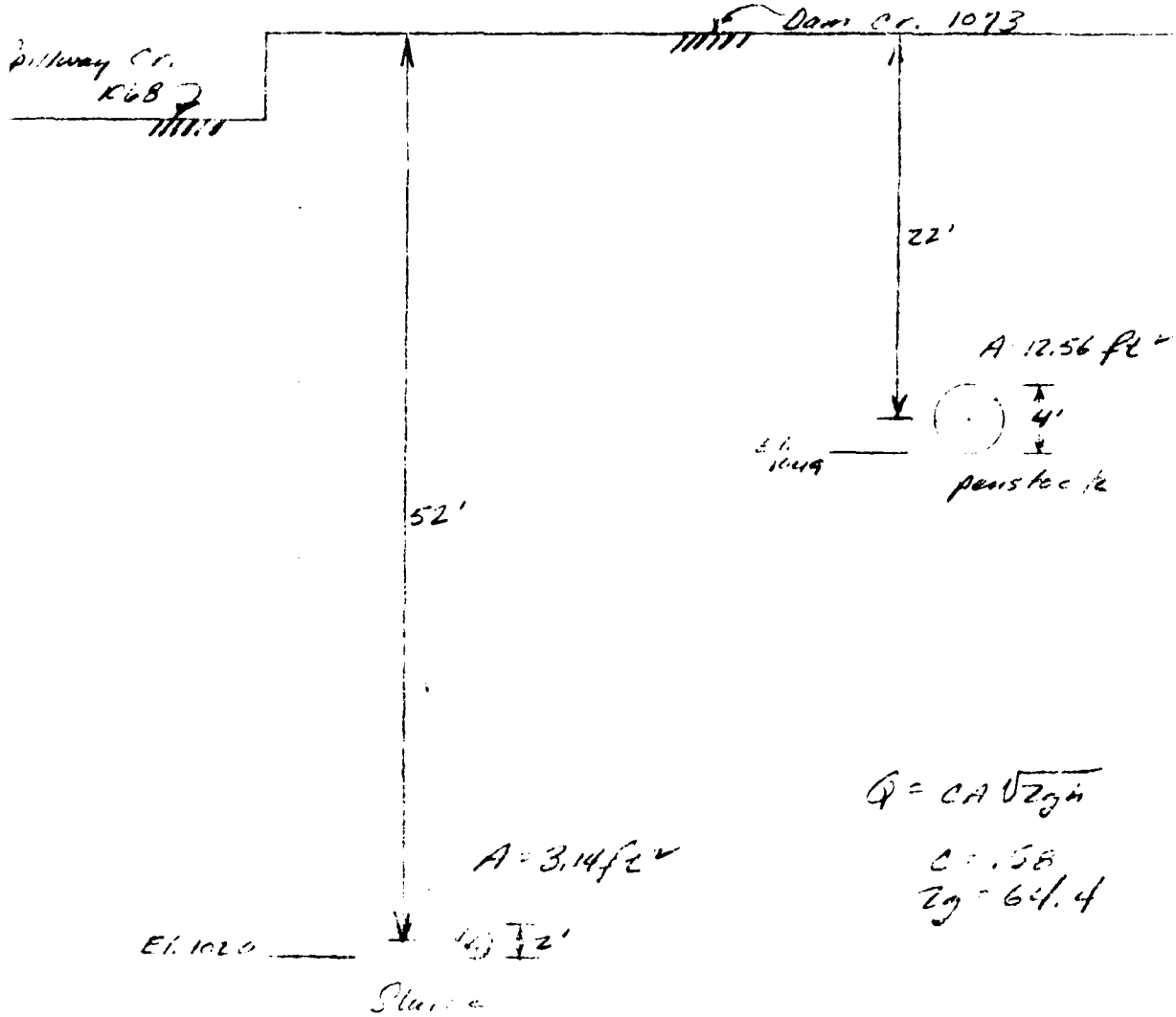
pt 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

PAGE

ATION Gate Computations

ED BY CHECKED BY DATE



$Q = CA\sqrt{2gh}$

$C = .58$

$2g = 64.4$

Sluice

$= .58(3.14)\sqrt{64.4(47)}$

$Q = 100$ cfs

$= .58(3.14)\sqrt{64.4(52)}$

$Q = 105$ cfs

$= .58(3.14)\sqrt{64.4(5)}$

$Q = 11.2$ cfs

W.S. @ 1068 (Spr.)

$Q_T = 341$

W.S. @ Pr. Co.

$Q_T = 379$

W.S. @ 1066

$Q_T = 477$

PENSTOCK

$Q = .58(12.56)\sqrt{64.4 \times 17}$

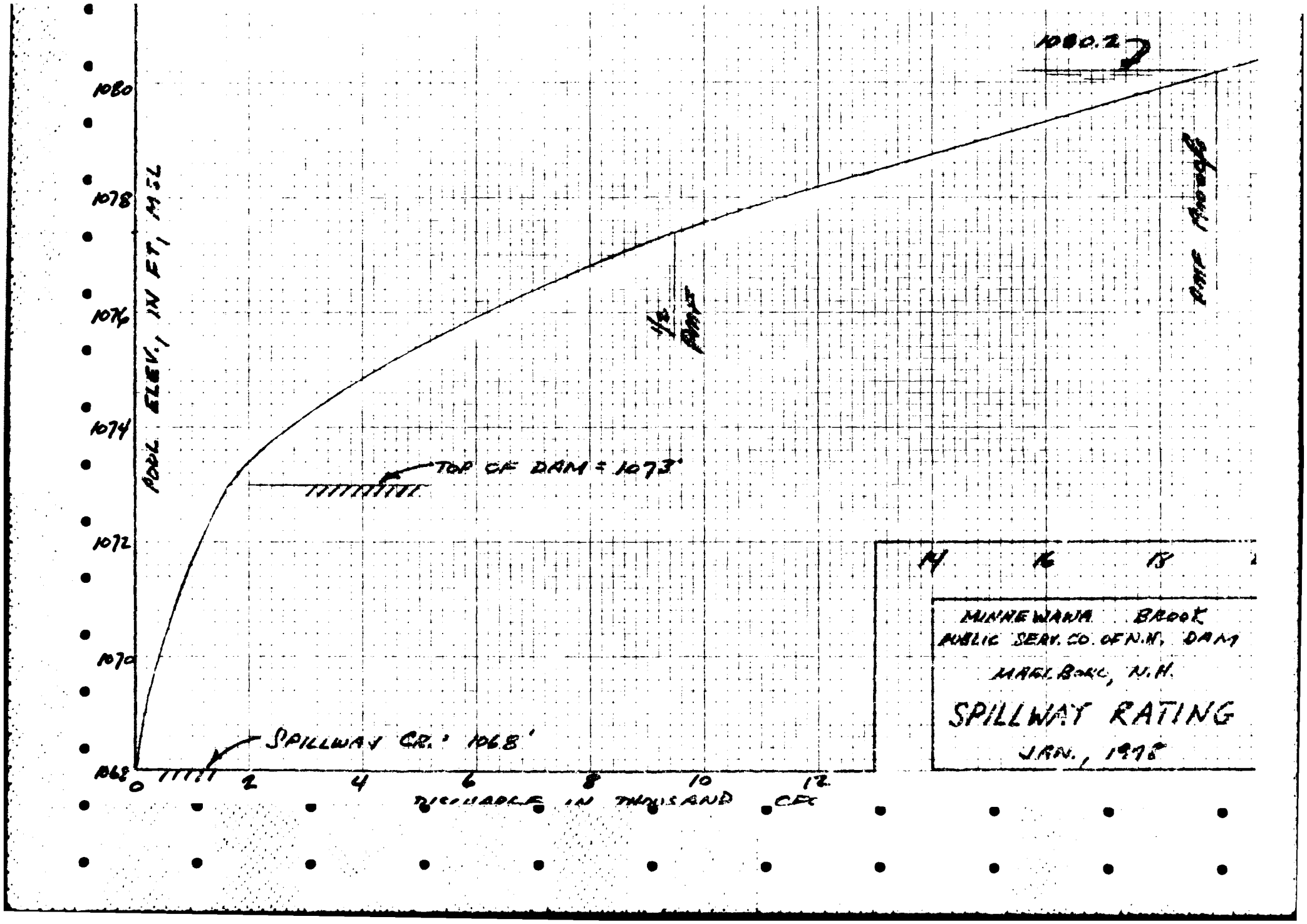
$Q = 241$ cfs

$Q = .58(12.56)\sqrt{64.4 \times 22}$

$= 274$

$Q = .58(12.56)\sqrt{64.4(5)}$

$Q = 71.2$


1080.2
SPILLWAY CREST
1/2 PMF
TOP OF DAM = 1073'
SPILLWAY CR. = 1068'
POOL ELEV., IN FT, MSL
1080
1078
1076
1074
1072
1070
1068
0
2
4
6
8
10
12
DISCHARGE IN THOUSAND CFS
MINNEWAWA BROOK
PUBLIC SERV. CO. OF N.H. DAM
MAPLEBORO, N.H.
SPILLWAY RATING
JAN., 1976

APPENDIX D

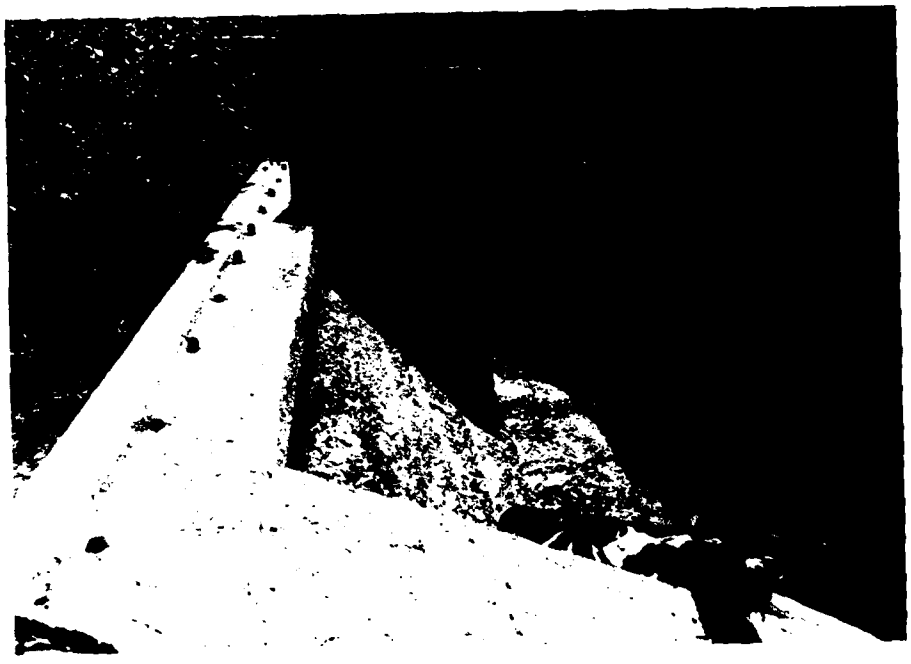


FIG. 26 Spillway

FIG. 27 Upstream Intake for 24" Dia. Sluice

FIG. 24 Trash Rack

FIG. 25 Detail of Exposed Steel and Debris at Inlet

FIG. 22 Gate-Operating Machinery

FIG. 23 Detail of Inlet Structure Wall

FIG. 20 Inlet Structure

FIG. 21 Detail of Exposed Reinforcing Steel and Spalled Concrete Surfaces

FIG. 18 Facing Upstream from Dam

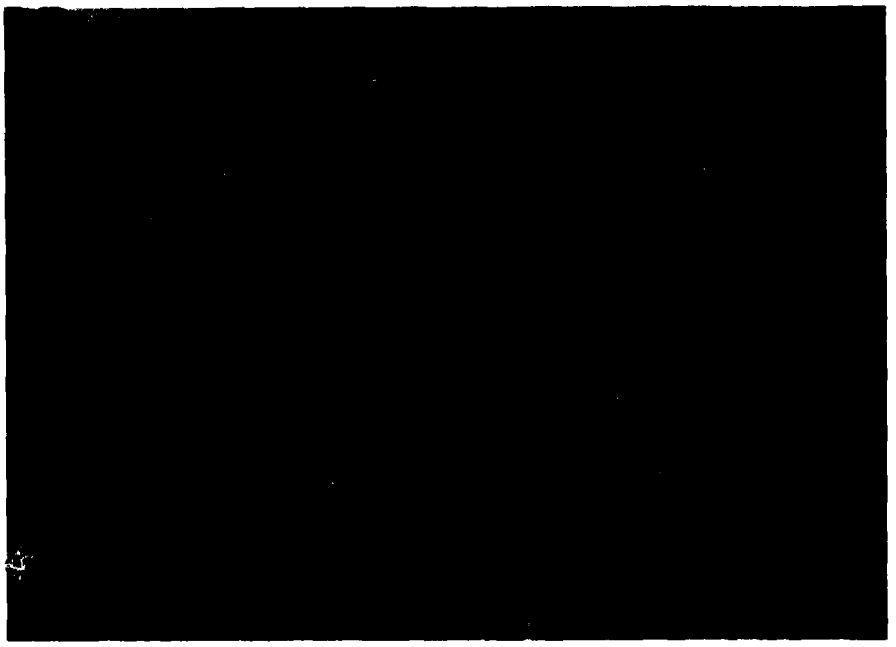


FIG. 19 Upstream Face of Arch (Note Exposed reinforcing steel)

FIG. 16 Upstream View of Spillway

FIG. 17 Spillway Outlet Channel thru V-Notch in ledge.

[illegible] Outlet - 24" dia. Sluice &
[illegible] dia. Ferrock

FIG. 14 Outlet - 48" dia. Ferrock

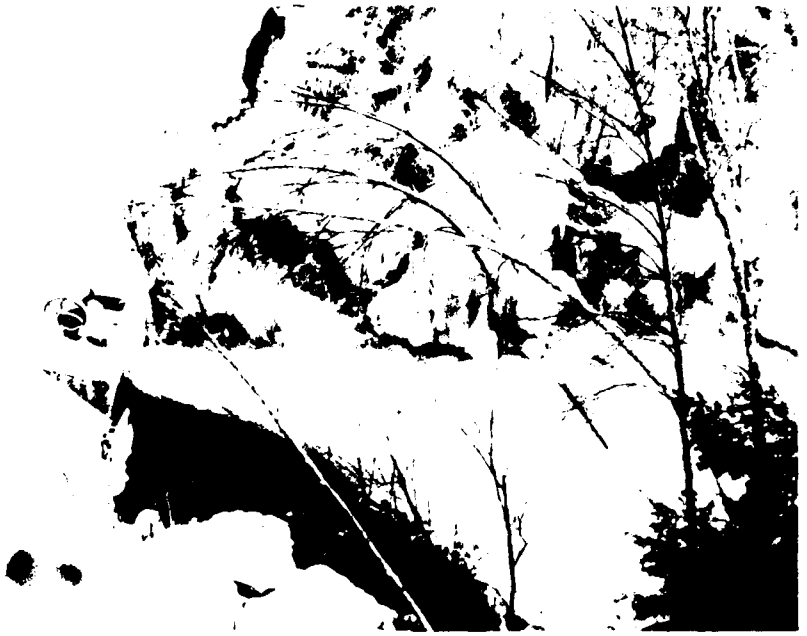


FIG. [illegible] Outlet - [illegible]" dia. Sluice and Gate Valve

FIG. 11 Gate - Operating Machinery at Inlet to Penstock and Cabinet for water level Indicator

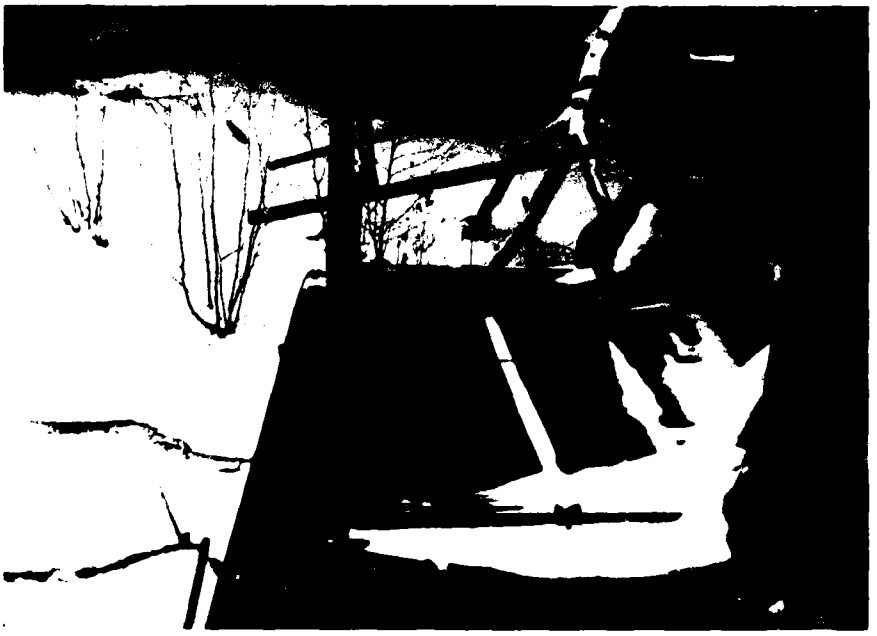


FIG. 12 Work platform at inlet structure

FIG. 8 Upstream Face

FIG. 9 Intake Structure for Penstock, trash racks (Note excessive buildup of debris)

FIG. 10 Detailed View of Condition of concrete on upstream face

FIG. 6 Downstream Face

FIG. 7 Walkway At Top of Dam El. 1073

27 Shot 49 | CORPS OF ENGINEERS, U.S. ARMY | PAGE 1

SUBJECT

COMPUTATION

COMPUTED BY | CHECKED BY | DATE

2 cases

$q = 2.6(200)(.5)^{3/2} = 184$

$q = 2.7(200)(1)^{3/2} = 540$

$q = 2.7(200)(2)^{3/2} = 1527$

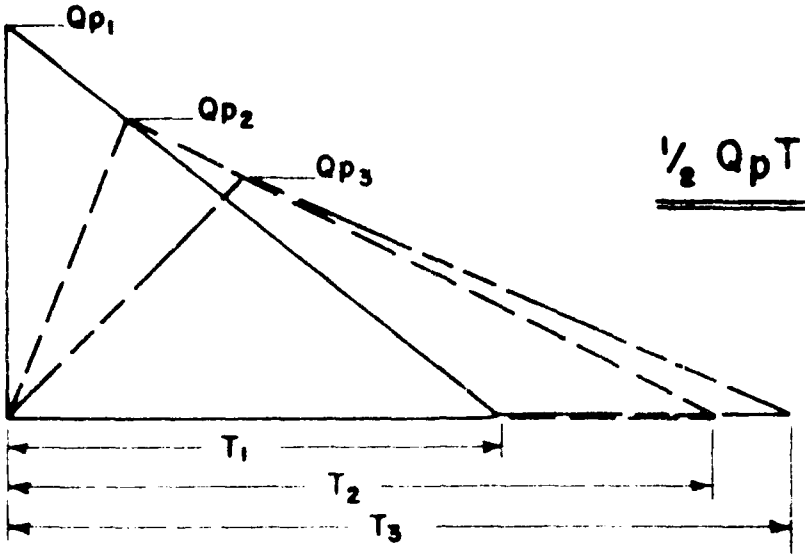
$q = 2.8(200)(4)^{3/2} = 4480$

$q = 3.3(200)(7)^{3/2} = 12223$

$q = 3.3(200)(8)^{3/2} = 14934$

	0		
	118		3
	9		419
	9		7
	183		115
	1653	0	1653
	1908	184	2092
	2713	540	2713
	5739	1527	4266
	8193	4480	8473
	6	12223	18371
	15	14934	21866

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



$\frac{1}{2} Q_p T = 12 S$

STEP 1: DETERMINE OR ESTIMATE RESERVOIR STORAGE (S) IN AC-FT AT TIME OF FAILURE.

STEP 2: DETERMINE PEAK FAILURE OUTFLOW (Q_{p1}).

$$Q_{p_1} = \frac{8}{27} W_b \sqrt{g} Y_o^{\frac{3}{2}}$$

W_b = BREACH WIDTH - SUGGEST VALUE NOT GREATER THAN 40% OF DAM LENGTH ACROSS RIVER AT MID HEIGHT.

Y_o = TOTAL HEIGHT FROM RIVER BED TO POOL LEVEL AT FAILURE.

STEP 3: USING USGS TOPO OR OTHER DATA, DEVELOP REPRESENTATIVE STAGE-DISCHARGE RATING FOR SELECTED DOWNSTREAM RIVER REACH.

STEP 4: ESTIMATE REACH OUTFLOW (Q_{p2}) USING FOLLOWING ITERATION.

A. APPLY Q_{p1} TO STAGE RATING, DETERMINE STAGE AND ACCOPMANYING VOLUME (V_1) IN REACH IN AC-FT. (NOTE: IF V_1 EXCEEDS 1/2 OF S, SELECT SHORTER REACH.)

B. DETERMINE TRIAL Q_{p2}.

$$Q_{p_2}(\text{TRIAL}) = Q_{p_1}\left(1 - \frac{V_1}{S}\right)$$

C. COMPUTE V_2 USING Q_{p2} (TRIAL).

D. AVERAGE V_1 AND V_2 AND COMPUTE Q_{p2}.

$$Q_{p_2} = Q_{p_1}\left(1 - \frac{V_{AVG}}{S}\right)$$

STEP 5: FOR SUCCEEDING REACHES REPEAT STEPS 3 AND 4.

APRIL 1978

NEW ENGLAND DIVISION

CORPS OF ENGINEERS, U.S. ARMY

Failure Group

COMPUTED BY Conway CHECKED BY DATE 6/78

Storage @ time of failure 175 AF

Failure Outflow:

$Q_{BREACH} = 8/27\, W_b \sqrt{g}\, Y_0^{3/2}$

$= 8/27\,(48)\,5.67\,(60)^{3/2}$

$Q_{BREACH} = 37,476$ cfs

Spillway Q just prior to failure = 1650 cfs

$Q_{P1} = 37,478 + 1650$

$Q_{P1} = 39,128$

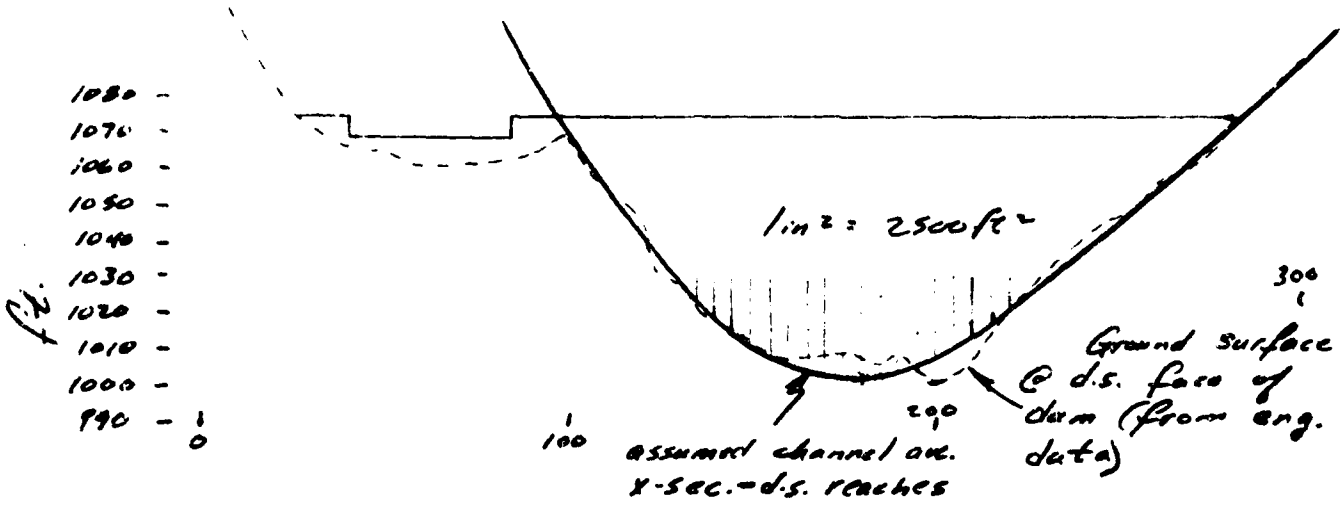
CORPS OF ENGINEERS, U.S. ARMY

PAGE

Minnewaska Brook

SUBJECT Stage/discharge rating of typical channel section

BY Doraway CHECKED BY DATE 6/78



$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

assume $n = .065$

$S = .202$

$$Q = 4.63\, AR^{2/3}$$

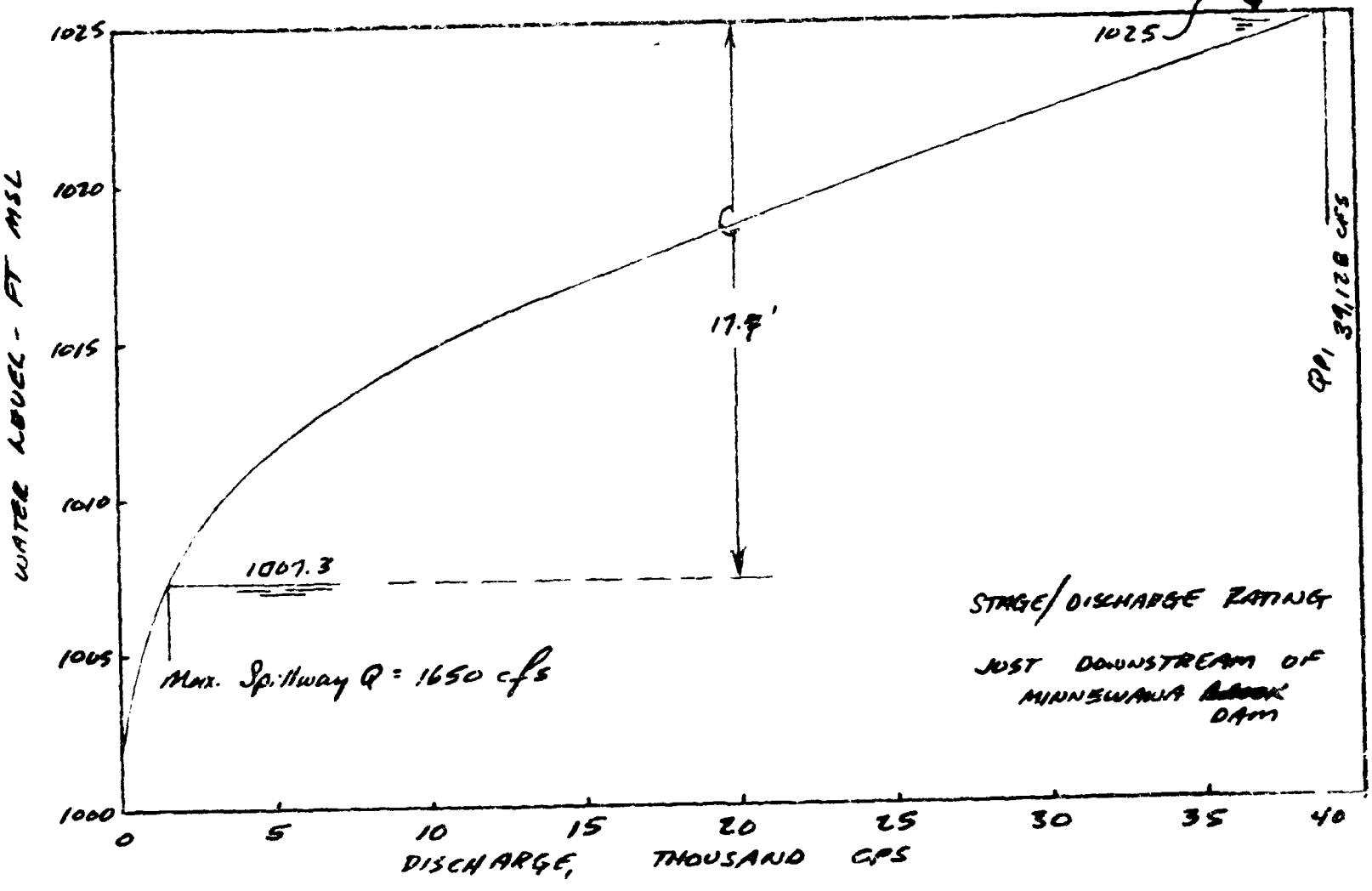
$$AR^{2/3} = \frac{Q}{4.63}$$

Substituting ave. depth (D) for R:

$$AD^{2/3} = \frac{Q}{4.63}$$

$$Q = 4.63\, AD^{2/3}$$

	D (avg.)	A	$D^{2/3}$	$AD^{2/3}$	Q
W.S. @ elev. 1002	0	0	0	0	0
1010	5.4'	250	5.1	775	3588
1015	8.3'	575	4.1	2358	10920
1020	12.6'	975	5.4	5265	24380
1025	15.3'	1350	6.2	8370	38750
1030	18.4'	1900	7.0	13300	61579



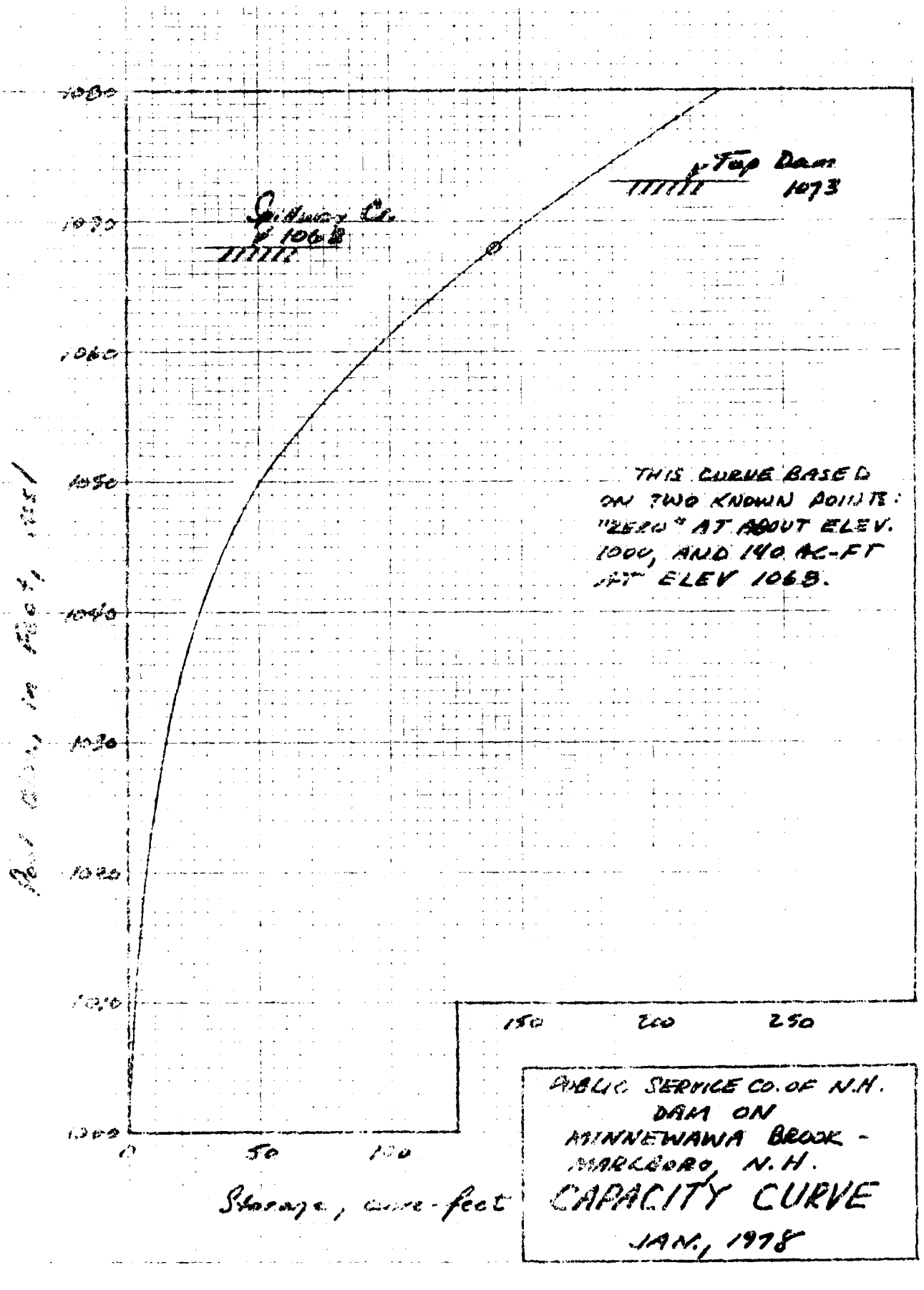
STAGE/DISCHARGE RATING

JUST DOWNSTREAM OF MINNEWAUKAN DAM

CORPS OF ENGINEERS, U.S. ARMY

COMPUTED BY

CHECKED BY



PUBLIC SERVICE CO. OF N.H.
DAM ON
ASHUELOT BROOK -
MARLBORO, N.H.
CAPACITY CURVE
JAN., 1978

APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS

END

FILMED

7-85

DTIC