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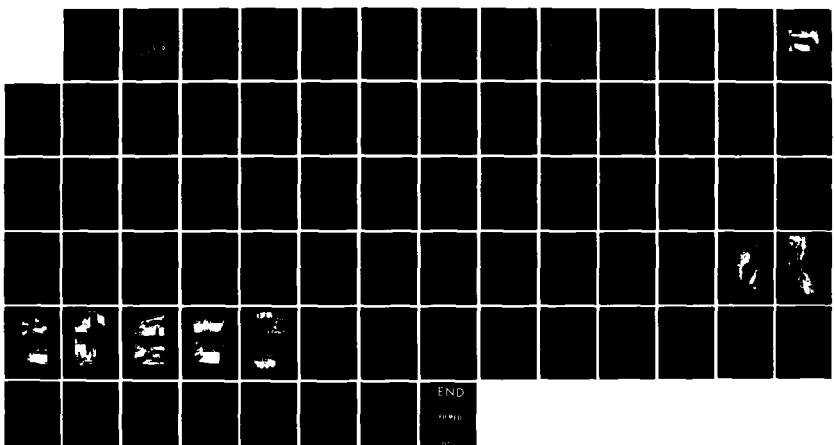
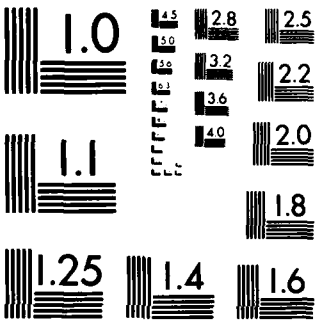


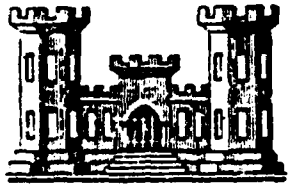


AD-A155 407

CONNECTICUT RIVER BASIN
WARE, MASSACHUSETTS

WARE INDUSTRIES MAIN (UPPER) DAM
MA 00594

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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

NOVEMBER 1978

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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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
Ware, Massachusetts
Ware River

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

The dam consists of a main spillway 115 ft. long and about 34 ft. high, a spillway extension 50 ft. long and 4 ft. high. It is currently classified as having a high hazard potential. The dam is in good to fair condition. The owner should engage in a qualified engineer to determine the structural stability of the main dam.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:

NEDED-E

OCT 5 1979

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts

Dear Governor King:

Inclosed is a copy of the Ware Industries Main (Upper Dam) Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. The report is based upon a visual inspection, a review of past performance, and a preliminary hydrological analysis. A brief assessment is included at the beginning of the report.

The preliminary hydrologic analysis has indicated that the spillway capacity for the Ware Industries Main (Upper Dam) would likely be exceeded by floods greater than 7 percent of the Probable Maximum Flood (PMF), the test flood for spillway adequacy. Our screening criteria specifies that a dam of this class which does not have sufficient spillway capacity to discharge fifty (50) percent of the PMF, should be adjudged as having a seriously inadequate spillway and the dam assessed as unsafe, non- emergency, until more detailed studies prove otherwise or corrective measures are completed.

The term "unsafe" applied to a dam because of an inadequate spillway does not indicate the same degree of emergency as that term would if applied because of structural deficiency. It does indicate, however, that a severe storm may cause overtopping and possible failure of the dam, with significant damage and potential loss of life downstream.

It is recommended that within twelve months from the date of this report the owner of the dam engage the services of a professional or consulting engineer to determine by more sophisticated methods and procedures the magnitude of the spillway deficiency. Based on this determination, appropriate remedial mitigating measures should be designed and completed within 24 months of this date of notification. In the interim a detailed emergency operation plan and warning system should be promptly developed. During periods of unusually heavy precipitation, round-the-clock surveillance should be provided.

NEDED-E
Honorable Edward J. King

I have approved the report and support the findings and recommendations described in Section 7, with qualifications as noted above. I request that you keep me informed of the actions taken to implement these recommendations since this follow-up is an important part of the non-Federal Dam Inspection Program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. This report has also been furnished to the owner of the project, Nenameseck Industrial Properties, Inc., East Main Street, Ware, Massachusetts 01082.

Copies of this report will be made available to the public, upon request to this office, under the Freedom of Information Act, thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Environmental Quality Engineering for the cooperation extended in carrying out this program.

Sincerely,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

CONNECTICUT RIVER BASIN
WARE, MASSACHUSETTS

WARE INDUSTRIES MAIN (UPPER) DAM
MA 00594

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

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

NOVEMBER 1978

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PHASE I INVESTIGATION REPORT
NATIONAL DAM INSPECTION PROGRAM

Identification No.:	MA 00594
Name of Dam:	Ware Industries Main (Upper)
Town:	Ware
County:	Hampshire
State:	Massachusetts
Stream:	Ware River
Date of Site Visit:	12 May 1978

BRIEF ASSESSMENT

The Ware Industries Main (Upper) Dam is located on the Ware River in Ware, Massachusetts. The dam consists of a main spillway 115 ft. long and approximately 34 ft. high, a spillway extension 50 ft. long and 4 ft. high, a concrete emergency spillway, a gate house with control works to a canal, and a 115 ft. long overflow weir from the canal. The dam was constructed in the years 1880 to 1882 to power mill equipment.

The dam is currently classified as having a "high" hazard potential in the Corps of Engineers National Inventory of dams.

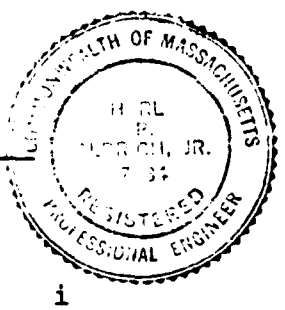
Based on a visual examination of the structure, the project is in good to fair condition. There was no evidence of structural failure or other conditions which would warrant urgent remedial action.

Based on size and hazard classifications in accordance with Corps of Engineers guidelines, the test flood for this dam is the Probable Maximum Flood (PMF). The PMF outflow of 109,200 cfs would overtop the dam by 11.25 ft. With the water level at the top of dam, the spillway system can pass 7980 cfs which is 7.3 percent of the test flood.

Nenameseck Industrial Properties, Inc., owner of the dam, should engage a registered professional engineer to determine the structural stability of the main dam, to evaluate alternative measures for increasing the discharge capacity of the dam and to inspect the main spillway weir during no flow condition as outlined in Section 7.2. The results of those investigations and the remedial measures, including repair of concrete surfaces, reconstruction or stabilization of a stone wall donwstream of the right abutment for the emergency spillway, and other work as outlined in Section 7.3, should be implemented by the Owner within one year after receipt of this report.

HALEY & ALDRICH, INC.
by:

Harl Aldrich
President



This Phase I Inspection Report on Ware Industries Main Upper 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, DC 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 be any chance that unsafe conditions be detected.

Phase I Investigations are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the test flood is based on the estimated "probable maximum flood" for the region (greatest reasonably possible storm run-off), or a fraction 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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1. Overview of main dam

PHASE I INVESTIGATION REPORT
NATIONAL DAM INSPECTION PROGRAM

WARE INDUSTRIES MAIN (UPPER) DAM
MA 00594

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.

Haley & Aldrich, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed were issued to Haley & Aldrich, Inc. under a letter dated 26 April 1978 from Colonel Ralph T. Garver, Corps of Engineers. Contract No. DACW33-78-C-0301 has been assigned by the Corps of Engineers for this work. Camp, Dresser & McKee, Inc. was retained as consultant to Haley & Aldrich, Inc. on the structural, mechanical/electrical and hydraulic/hyrologic aspects of the investigation.

B. Purpose. The primary purposes of the National Dam Inspection Program are to:

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 PROJECT DESCRIPTION

A. Location. The Ware Industries Main (Upper) Dam is located on the Ware River in Ware, Massachusetts, as indicated on the Location Map, page vii.

B. Dam and Appurtenances. The dam consists of a concrete-capped main spillway with a higher concrete spillway extension to the right, separated by a concrete wall. There is an emergency spillway left of the dam and an outlet gate house to a canal right of the dam, all connected by either concrete or stone walls. A stone-capped overflow weir is located on the side of the canal downstream of the main spillway. There are no earth embankments. The dam and appurtenances are all believed to be founded on rock. A "Site Plan" is shown in Appendix B-4.

The main spillway is 115 ft. in length and approximately 34 ft. high. The 50 ft. long spillway extension has a crest elevation of 464.8, 12 inches higher than the main spillway crest. The extension is founded on rock and only about 3 to 4 ft. high. The spillways are shown in Photos No. 2 and 4. The concrete emergency spillway left of the main spillway is 16 ft. in length with a crest elevation of 466.9. There are stone walls upstream and downstream of the spillway at both abutments, as shown in the plan in Appendix B-5 and Photos No. 10, 12 and 13.

A gate house located right of the spillways is the outlet to a canal shown on the plan in Appendix B-3. The structure consists of 5 timber slide gates and a timber bulkhead. The overflow weir downstream of the gate house is 115 ft. in length and has a crest elevation of approximately 466.35 with the exception of an 8 ft. length at El. 464.45 where the 22-in. thick cap stone has been removed, as shown in Photo No. 8.

C. Size Classification. The storage to the top of the dam is estimated to be 746 acre-ft., and the height of the dam is approximately 40 ft. Storage of less than 1000 acre-ft. or a height of less than 40 ft. classifies the dam in the "small" category according to guidelines established by the Corps of Engineers.

D. Hazard Classification. The dam is currently classified as having a "high" hazard potential in the Corps of Engineers National Inventory of Dams.

During the September 1938 huuricane, extensive damage to the surrounding residential, industrial and commercial structures as well as to the dam itself was incurred. Flood waters resulting from approximately 6 in. of rainfall in six hours inundated East Main Street by 4 ft. and caused the bridge to be washed out. The South Street bridge downstream was also washed out and the flood waters rose to the top of the first floor windows of the old Ware Woolen Company. At the dam, the emergency spillway was washed out and the homes on the easterly side of the dam became islands, as the water rushed down the adjoining streets.

Based on dam failure analysis computations, Appendix D-11, the flow generated from a breach of the dam is approximately 1.5 times greater than that of the 1938 hurricane and would likely cause an even greater amount of structural damage and loss of life downstream of the dam. Therefore, it is recommended that the "high" hazard potential classification be retained.

E. Ownership. The name and address of the current owner is:

Nenameseck Industrial Properties, Inc.
East Main Street
Ware, MA 01082
(Phone: (617) 967-5191)

Mr. Edward C. Beaudin, Receiver's Agent, represented the owner during the course of this investigation.

Ware Industries, Inc. of the same address as above was the owner from 1937 until it went bankrupt in 1978. Prior to 1937, Otis Company of an unknown address owned the dam.

F. Operator. Mr. Edward C. Beaudin has been responsible for operation and maintenance of the dam.

G. Purpose of the Dam. The dam was originally used for generating power. Presently, the dam serves no specific purpose.

H. Design and Construction History. The dam is believed to have been constructed between 1880 and 1882 as part of a power generating system for mills in the area. This system included the adjacent canal downstream of the gate house and

penstocks from the canal. Mr. Joseph A. Nowak of Springfield, MA, is an engineer familiar with this project. He believes that seven water wheels operated prior to the 1938 flood and that at least two operated into the 1950's. Some water is still being used from the canal for manufacturing purposes, but the penstocks have been plugged.

The original design and construction records are not available. Although not documented, the only apparent major post-construction changes to the dam were the addition of the spillway extension and reconstruction to the emergency spillway following the 1938 flood. Repairs proposed in 1975 were never implemented.

I. Normal Operational Procedures. There is no formal established routine for the operation of the dam. The control gates are operated on a demand basis.

1.3 PERTINENT DATA

Elevation given in this report are based on field measurements correlated with those appearing on a "Site Plan" prepared by Nowak in 1975, a copy of which is included in Appendix B-3. The datum for those elevations is believed to be the National Geodetic Vertical Datum (NGVD).

A. Drainage Area. The drainage area of the Ware River at the Ware Industries Main (Upper) Dam in 199 square miles (127,360 acres). The pond surface comprises 39.5 acres (0.03 percent) of this total. The topography within the watershed varies from rolling to very hilly while the major tributary streams are the East and West Branches of the Ware River and the Burnshirt River. These tributaries all enter upstream of South Barre and only two minor tributaries, Moose Brook and Prince River enter between South Barre and Ware.

B. Discharge at Dam Site. The maximum known flood at the damsite is that which occurred during the September 1938 hurricane (approx. 6 in. of rain in 6 hours). This storm resulted in a peak inflow of 22,700 cfs. However, because of the construction of the Barre Falls Dam, this peak would be decreased to approximately 17,700 cfs, if the same storm were to occur at present.

1. Outlet Works.....Not applicable
2. Maximum known flow at dam site.....22,700 cfs
3. Ungated spillway capacity at top of dam.....7,980 cfs at El. 470.0

4. Ungated spillway capacity at test flood pool elevation..... 109,200 cfs (the test flood outflow) provided the top of dam was raised 37.8 ft. to El. 507.8
5. Gated spillway capacity at normal pool elevation..... Not applicable
6. Gated spillway capacity at test flood pool elevation..... Not applicable
7. Total spillway capacity at test flood pool elevation..... 109,200 cfs (the test flood outflow) provided the top of dam was raised 37.8 ft. to El. 507.8
8. Total project discharge at test flood pool elevation..... 109,200 cfs at El. 481.25

C. Elevation (ft. above NGVD)

1. Top Dam..... 470 (Est.)
2. Test flood pool-design surcharge..... 481.25
3. Design surcharge-original design..... Unknown
4. Full flood control pool..... Not applicable
5. Recreation pool..... 463.8
6. Main spillway crest (no flashboards)..... 463.8
7. Upstream portal invert diversion tunnel..... Not applicable
8. Streambed at centerline of dam..... 430 (Est.)
9. Maximum tailwater..... Unknown

D. Reservoir

1. Length of maximum pool..... 0.88 mi. (Est.)
2. Length of recreation pool..... 0.88 mi. (Est.)
3. Length of flood control pool..... Not applicable

E. Storage (acre-feet)

1.	Top of dam	746 (Est.)
2.	Test flood pool	3,535 (Est.)
3.	Flood-control pool	Not applicable
4.	Recreation pool	145 (Est.)
5.	Spillway crest	145 (Est.)

F. Reservoir Surface (acres)

1.	Top of dam	181 (Est.)
2.	Test flood pool	315 (Est.)
3.	Flood control pool	Not applicable
4.	Recreation pool	39.5 (Est.)
5.	Spillway crest	39.5 (Est.)

G. Dam Embankment..... Not applicable

H. Diversion and Regulating Facilities..... Not applicable

I. Spillway

1.	Type	"Broad-crested" irregularly shaped weir
2.	Length of weir	
	Main dam	115 ft.
	Extension	50 ft.
3.	Crest elevation	
	Main dam	463.8 ft.
	Extension	464.8 ft.
4.	Gates	None
5.	U/S Channel	Flat slope; wide flood plain
6.	D/S Channel	Approx. 3 percent; Ware Woolen Co. Dam located approx 1,950 ft. downstream from Ware Road

J. Regulating Outlets. There are five double-stem manually operated (through rack and pinion gears) gates in a gate house located upstream of the right abutment. The gates are five feet wide and are estimated to be four to five feet in height. The invert elevation of the gates is unknown. The gates are operable.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN RECORDS

No records of the original design are available. Drawings by Joseph A. Nowak, Consulting Engineer, in 1975 and flow calculations dated 22 April 1976 are the only "design" records available.

2.2 CONSTRUCTION RECORDS

No original construction records are available and no subsequent construction is documented in prior inspection reports or correspondence.

2.3 OPERATION RECORDS

No operational records specific to this dam are available. However, the New England Division of the Corps of Engineers made general studies of this area following the 1938 flood.

2.4 EVALUATION

A. Availability. A detailed list of all engineering data available for use in preparing this report is included in Appendix B-1. Selected documents from the listing are also included in Appendix B.

B. Adequacy. A review of design and construction data is a highly desirable factor in developing a thorough Phase I assessment. However, there were insufficient engineering data available for this dam to allow for such a review. The evaluation of the dam is based primarily on visual inspection, past performance and engineering judgement.

C. Validity. The three 1975 drawings by Joseph A. Nowak show the general configuration of the dam and site, but details such as the elevation of the overflow weir are incorrect. Furthermore, the repairs shown on the 1975 drawing "Emergency Spillway Repairs" by Joseph A. Nowak were never implemented.

SECTION 3 - VISUAL EXAMINATION

3.1 FINDINGS

A. General. The Phase I visual examination of the Ware Industries Main (Upper) dam was conducted on 11 May 1978.

In general, the project was found to be in good to fair condition, although the main dam could not be examined because of discharge over the weir. A few deficiencies which require correction were noted.

A visual inspection check list is included in Appendix A and selected photographs of the project are given in Appendix C.

B. Dam. The view of the main dam (spillway weir) was obscured by flowing water during the inspection. The left side wall is constructed of cut granite masonry. A number of the blocks at the downstream end of this wall are loose and have fallen free, barely visible in Photo No. 2. The right wall of the main dam is constructed of concrete, Photo No. 3. The wall is undermined at the downstream end and has small spalls on the edges of the concrete, Photo No. 7.

A spillway extension wall extends 50 ft. to the right from the main dam, Photo No. 4. Concrete shows considerable deterioration at the top edge and the vertical downstream face. The wall is undermined at the right end, Photo No. 5, and at the left end adjacent to the main dam, Photo No. 6. The wall exhibits cracks and efflorescence. The wall is 2 ft. wide at the top and has an upstream slope which was measured to be 2 horizontal to 1.3 vertical.

The main dam and the extension are believed to be founded on bedrock. The downstream channel is also on the schist. Minor rock debris is present in the downstream channel.

C. Appurtenant Structures. The flow of water to the canal is controlled by gates located in a gate house at the entrance of the canal. The canal is located to the right of the spillway extension. The gate house shows the effect of vandalism and lack of maintenance. The top cord of the main truss on the canal side shows considerable deterioration at a panel point. A light temporary brace has been inserted at this point to support the roof.

The gate mechanisms are in good condition. The gate structure is supported by cut stone masonry walls on each side of the canal. The walls have open joints and voids near the water surface.

An overflow weir is present on the southeast side of the canal, allowing water to flow back into the main channel. The weir is made up of cut quarry stones for the main portion of the wall and a cut granite cap for the weir crest. One section of the cut granite cap has been removed to provide a pilot channel, Photo No. 8. Trees and brush has been cut recently downstream of the channel. They are presently piled in the channel itself. The access bridge which parallels the overflow weir is in good condition. It is of timber construction. Several of the pier caps for this bridge have cracked timbers. Conditions on the approach to the overflow weir are shown in Photo No. 9.

A separate concrete emergency spillway is located to the left of the main dam, Photos No. 10 and 11. The upper portion of the weir and concrete side walls are in good condition. The lower regions of the weir show considerable efflorescence. There is one large spall out of the face of the left side wall, Photo No. 12. In back of the side walls are cut quarry stone retaining walls. The left wall primarily, Photo No. 12, contains no mortar in the joints. The right wall, Photo No. 13, has mortared joints but the lower regions of the wall have failed. Stones have fallen to the channel invert below. This wall is considered to be unsafe and on the verge of failure. The downstream channel from the emergency spillway contains considerable debris at the toe of the weir and brush and young trees in the channel further downstream.

The cut stone masonry flood wall located between the main dam and the emergency spillway is in fair condition. Seepage estimated to be 8 to 12 gpm was noted throught the base of the wall near its center. The "head" producing this seepage is 6 in., the difference between the reservoir level and ponded water downstream of the floodwall.

D. Reservoir Area. The area around the Ware Industries Main (Upper) dam and reservoir has variable slopes and is generally wooded with open areas. There were no conditions observed which could cause a sudden increase in sediment load into the reservoir. There is no possibility of a major landslide into the reservoir which could result in a wave overtopping the dam.

E. Downstream Channel. The channel immediately downstream of the main dam is the bed of the Ware River and is in satisfactory condition. The floor of the channel is ledge rock, predominantly amphibole schist with interspersed bands of granite gneiss. There are some rock falls present.

3.2 EVALUATION

Based on visual observations during the site examination, the general condition of the project is satisfactory, although the main dam could not be examined. The dam extension does require repair. The cut quarry stone wall on the right side of the emergency spillway is on the verge of failure. Plans which propose repairs to the emergency spillway are available, Appendix B-5.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

In general, there are no formal procedures to assure regular maintenance and satisfactory operation of the dam.

4.2 MAINTENANCE OF DAM

There are no established procedures or manuals to assure periodic inspection and maintenance of the dam.

4.3 MAINTENANCE OF OPERATING FACILITIES

The operating facilities in the gate house were operated on a demand basis. The gate house and gates have received minimum maintenance.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no warning system or emergency preparedness plan in effect for this structure.

4.5 EVALUATION

For a high hazard structure of this size, an annual inspection and maintenance program should be developed. In addition, the Owner should prepare a formal emergency preparedness plan and warning system, since failure of the dam would cause loss of life and extensive property damage.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

A. Design Data. No hydraulic or hydrologic design data were found for the original dam. However, proposed repair work to the emergency spillway is shown on two blueline prints prepared by Joseph A. Nowak of Springfield, Massachusetts, dated May 1, 1975. Copies of these prints are included in Appendix B. From the field inspection, it was found that these repairs were never implemented. However, in the absence of any other data, these plans provided an adequate "Site Plan" of the main dam and a cross-section of the emergency spillway which were used as a basis for the hydraulic and hydrologic analyses.

The recommended test flood for the size (small) and hazard potential (high) classification of this dam is between the one half probable maximum flood (½ PMF) and the probable maximum flood (PMF).

B. Experience Data. The PMF was determined by using the chart prepared by the Corps of Engineers, New England Division, in the Guidelines. The portion of the drainage area upstream of the Barre Falls Dam was excluded because the downstream drainage area will have peaked before the peak outflow from the Barre Falls Dam reaches this dam. Therefore, the PMF was determined on the basis of the 112 square mile drainage area between the Barre Falls Dam and this dam.

A combination of the rolling and mountainous curves were used, tending more towards the rolling terrain. This resulted in a PMF of 109,800 cfs. When the effect of surcharge storage is considered, the PMF is reduced to 109,200 cfs. Because the water surface area of the pond is only 39.5 acres, flood routing techniques were not deemed worthwhile. The value for the ½ PMF is, therefore, 54,600 cfs.

C. Visual Observations. The inspection revealed that the emergency spillway repairs proposed in 1975 were never accomplished. It appeared that the only major change in the original dam was the 50-foot concrete dam extension on the right side. This addition and reconstruction of the emergency spillway were completed after the September 1938 hurricane.

On the day of the inspection, water appeared to flow quite smoothly over the main dam. There was also water flowing from the canal over the overflow weir where the capstone had been removed, cascading down the steep, bedrock slope into the channel downstream of the main dam. The downstream channel is severely overgrown with weeds, brush, bushes and small trees.

The downstream channel has steep, rocky embankments covered with increasing amounts of vegetation as one proceeds downstream and is approximately 60 ft. in width. The channel itself is scattered with cobbles and some scattered large boulders and has a moderate slope. The East Main Street Bridge, which is located approximately 420 ft. downstream of the dam, is a stone arch spanning an approximately 60-ft. width. A cornerstone bearing the date of 1898 was located on the easterly side of the bridge along with a section of what appeared to be the original abutment. The remaining portion of the bridge had been rebuilt after its washout in the 1938 flood.

Downstream of the East Main Street Bridge, the right bank is lined with industries in low lying areas and the left bank reflects the same except that these structures appear to be at a higher elevation. The channel in this portion of the river has similar characteristics as its preceding portion except that it is interrupted by a small dam located approximately midway between East Main Street and South Street. After this dam, the channel widens to approximately 100 ft.

The South Street Bridge is also approximately 100 ft. in width and is basically a concrete structure with a 3-ft. wide center pier. Downstream of this bridge, the left bank contains low lying buildings. The right side is primarily residential. These structures are somewhat protected by a high concrete retaining wall which lines the right bank.

D. Overtopping Potential. Based on the size and hazard classifications published in the Guidelines, the test flood is the PMF. However, the combined capacities of the spillway system (as shown in Appendix D) at El. 470.0 (top of dam) is only approximately 7,980 cfs, whereas the values of the PMF is 109,200 cfs. Therefore, it is evident that the spillway system cannot handle the test flood. The dam would be overtopped by 11.25 ft.

The spillways' inadequacy was also demonstrated in both the 1936 and 1938 floods. In these two storms, there was local flooding in the residential area immediately adjacent to the emergency spillway. In the 1936 flood, the Ware Road Bridge was overtopped, and in the 1938 flood, both the East Main Street Bridge and the South Street Bridge were washed out. Although the main dam was extended after the 1938 storm, the spillway system is still unable to handle flows resulting from an occurence of not only the PMF but also of a 1/2 PMF.

E. Evaluation. As stated previously, the spillway system cannot pass the test flood. In the event of a dam failure, even greater flows would be generated than during the September 1938 storm and excessive economic losses from commercial, industrial, and residential structural damage as well as loss of life would likely prevail downstream of the dam along both banks of the Ware River.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF EMBANKMENT STRUCTURAL STABILITY

There is no earth embankment included in the Ware Industries Main (Upper) dam.

Although the concrete dam extension has deteriorated and is undermined, it is only 4 ft. high, has a broad base, and is founded on rock. Although a failure is unlikely, such a failure in the absence of failure of the main dam would not cause extensive damage downstream.

The stone masonry flood wall left of the main dam is considered unsafe in the event of the PMF. Again, the wall is about 5 to 6 ft. in height and a failure during the flood would have little additional adverse effect.

6.2 EVALUATION OF SPILLWAY STRUCTURAL STABILITY

A. Visual Observations. There was no evidence that movement or distress is present in the main dam, dam extension and emergency spillway. However, the main spillway weir was obscured by flowing water. The cut quarry stone wall on the right side and downstream of the emergency spillway was considered to be unsafe and on the verge of failure, based on the visual observations. A failure of this wall could result in a breach immediately right of the emergency spillway.

B. Design and Construction Data. No design data or construction plans were located for this dam. Data in the form of proposed modifications to the overflow weir at the canal and modifications to the emergency spillway in the form of construction plans were located. Since the geometry (cross-section) of the main dam is not known, it was not possible to determine its structural stability under static loading conditions.

C. Operating Records. No operating records or field measurements are known to exist for this dam.

D. Post-Construction Changes. Due to the differences in concrete, it is estimated that this facility has been through a number of changes. However, other than the previously mentioned proposed changes to the overflow weir from the canal and the proposed changes to the emergency spillway, no documentation for post-construction changes were located.

E. Seismic Stability. This facility is located in Seismic Zone 2 and in accordance with recommended Phase I guidelines does not warrant seismic analysis.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 DAM ASSESSMENT

A. Condition. The visual examination of Ware Industries Main (Upper) dam revealed that the structure was in good to fair condition. Although there were no signs of structural failure or other conditions which would warrant urgent remedial action, several deficiencies were noted.

Based on the results of computations included in Appendix D and described in Section 5, the spillway is not capable of passing the test flood, which for this structure is the PMF. The PMF outflow of 109,200 cfs would overtop the dam by 11.25 ft. With the water level at the top of the dam, the spillway system can pass 7980 cfs which is 7.3 percent of the test flood.

B. Adequacy of Information. A review of design and construction data is a highly desirable factor in developing a thorough Phase I assessment. However, there were insufficient engineering data available for this dam to allow for such a review. The evaluation of the dam is based primarily on visual inspection, past performance and engineering judgement.

C. Urgency. The recommendations for additional investigations and remedial measures outlined in Section 7.2 and 7.3, respectively, should be undertaken by the Owner and completed within one year after receipt of this report.

D. Need For Additional Investigation. Additional investigations should be performed by the Owner as outlined in the following section.

7.2 RECOMMENDATIONS

It is recommended that the Owner engage a registered professional engineer to undertake the following investigations:

1. Determine the dimensions of the various spillway structures, in particular the main dam, in order that mathematical structural stability calculations can be performed.

2. Perform hydrologic and structural studies to determine what alternative measures are required to significantly increase the discharge capabilities at the dam.

3. Main spillway weir should be inspected during no flow condition.

7.3 REMEDIAL MEASURES

A. Operation and Maintenance Procedures. The following remedial work should be undertaken by the Owner:

1. Repair the concrete surfaces on the concrete dam extension to prevent continued deterioration of this structure in the future. Loose weak concrete should be removed and the surface restored by the application of concrete mortar, shotcrete or other methods. Areas of contact with bedrock should also be restored.

2. Rebuild or otherwise stabilize the cut quarry stone wall at the right side of the emergency spillway. This wall may be stabilized by instituting the proposed revision to the emergency spillway as delineated on drawings now in the hands of the Owner.

3. Place mortar in open joints in the left side wall of emergency spillway to prevent loss of stone from this wall.

4. Renew the main supports for the gate house structure.

5. Clear the downstream channel of the emergency spillway of trees, brush and debris. Complete the clearing and brush removal downstream of the overflow weir.

Because the dam is classified as having a "high" hazard potential, the Owner should prepare an operations and maintenance manual for the dam. The manual should include provisions for biennial technical inspection of the dam and for surveillance of the dam during periods of heavy precipitation and high river water levels. The procedures should delineate the routine maintenance work to be done on the dam to ensure satisfactory operation and to minimize deterioration of the facility.

The Owner should also develop a written emergency preparedness plan and warning system to be used in the event of impending failure of the dam. The plan should be developed in cooperation with local officials and downstream inhabitants.

7.4 ALTERNATIVES

Not applicable.

APPENDIX A
INSPECTION TEAM ORGANIZATION AND CHECK LIST

VISUAL INSPECTION PARTY ORGANIZATION

NATIONAL DAM INSPECTION PROGRAM

Dam: Ware Industries Main (Upper)

Date: 12 May 1978

Time: 1100-1445

Weather: High thin clouds and cool (60's F.)a.m.
Clear and warm (70's F.)p.m.

Water Surface Elevation Upstream: Approximately El. 464.5 (water level 3" below top of main dam extension.)

Stream Flow: Not known

Inspection Party:

Harl P. Aldrich, Jr. Haley & Aldrich, Inc.	Soils
Roger H. Wood Camp, Dresser & McKee, Inc.	Structural/Mechanical
Allen W. Hatheway Haley & Aldrich, Inc.	Geology

Present During Inspection:
John Critchfield, Haley & Aldrich, Inc.
Mrs. Edward Beaudin, Ware Industries, Inc. (present part-time)

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Ware Industries Main (Upper) DATE: 11 May 78

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIRS, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel to All Spillways	Spillway essentially at reservoir
General Condition	Good - some reed growth one side of spillway
Floor of Approach Channel	Not visible
b. Weirs and Training Walls, Main Dam and Extension	
General Condition	Main dam spillway not visible due to flowing water. Right side wall of main dam deteriorated and undercut at downstream end. Left side wall main dam has loose masonry blocks downstream end. Concrete dam extension is undermined at right and left sides. Seepage under wall appears to be present. Efflorescence present downstream face. Top of spillway deteriorated at both ends
c. Discharge Channel Below Main Dam	
General Condition	Satisfactory (bed of river)
Loose Rock Overhanging Channel	Could not examine (see photographs of rock faces)
Trees Overhanging Channel	Some young tree growth in channel and at sides, but not significant
Floor of Channel	Bed of river is bedrock; some large blocks of stone and concrete (cannot examine most of floor because of water)
Other Obstructions	None of significance observed

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Ware Industries Main (Upper) DATE: 11 May 78

AREA EVALUATED	CONDITION
d. Emergency Spillway	
General Condition	Sixteen-foot long concrete weir with concrete abutments in good to excellent condition. Masonry wall behind concrete abutment on left side has open joints. Wall behind right abutment downstream of weir has missing blocks and is on the verge of collapse
e. Discharge Channel Below Emergency Spillway	
General Condition	Poor; piled debris at toe of weir and channel floor wooded. Granite masonry wall on right side of spillway in poor condition
Loose Rock Overhanging Channel	None observed
Trees Overhanging Channel	Yes, numerous
Floor of Channel	Wooded; irregular; some debris
OUTLET WORKS - GATE HOUSE AND CHANNELS	
a. Approach Channel	
General Condition	Good
Bottom Conditions	Not visible
Log Boom	None present
Debris	Light material
Condition of Walls	Stone masonry construction with open joints, fair condition
b. Gate House	
General Condition	Fair. Timber building with no shingles. Four pieces of siding missing. Main support truss has deteriorated panel point
Stop Logs and Slots	None observed
c. Mechanical and Electrical	Electrical service has been discontinued

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Ware Industries Main (Upper) DATE: 11 May 78

AREA EVALUATED	CONDITION
Service Gates	Total of five rack and pinion gates, in working condition but have received little maintenance. Gates are 5 ft. wide, estimated to be 4 to 5 ft. high
d. Downstream Channel	
General Condition of Walls	Masonry walls with open joints
Erosion or Cavitation	Joints are wider at water surface
Alignment	Alignment of stones good
Channel Floor	Not visible
OVERFLOW WEIR AND WALKWAY	
a. Overflow Weir	Overflow weir of cut quarry stone with granite cap stone. Horizontal and vertical alignment are good. One cap stone removed for pilot channel. Weir joints show loss of mortar. Moss growth present on weir. Stone training walls are in fair condition. Upstream channel has no training walls and contains brush. Channel is filled at right end for vehicle access. Downstream channel is bedrock with some boulders and medium tree growth. Center section has trees and brush removed recently and piled along the left side wall
b. Walkway	Walkway bridge is in good condition but is in need of repainting. Several timber pier caps have large cracks present. Bridge bearing areas are good

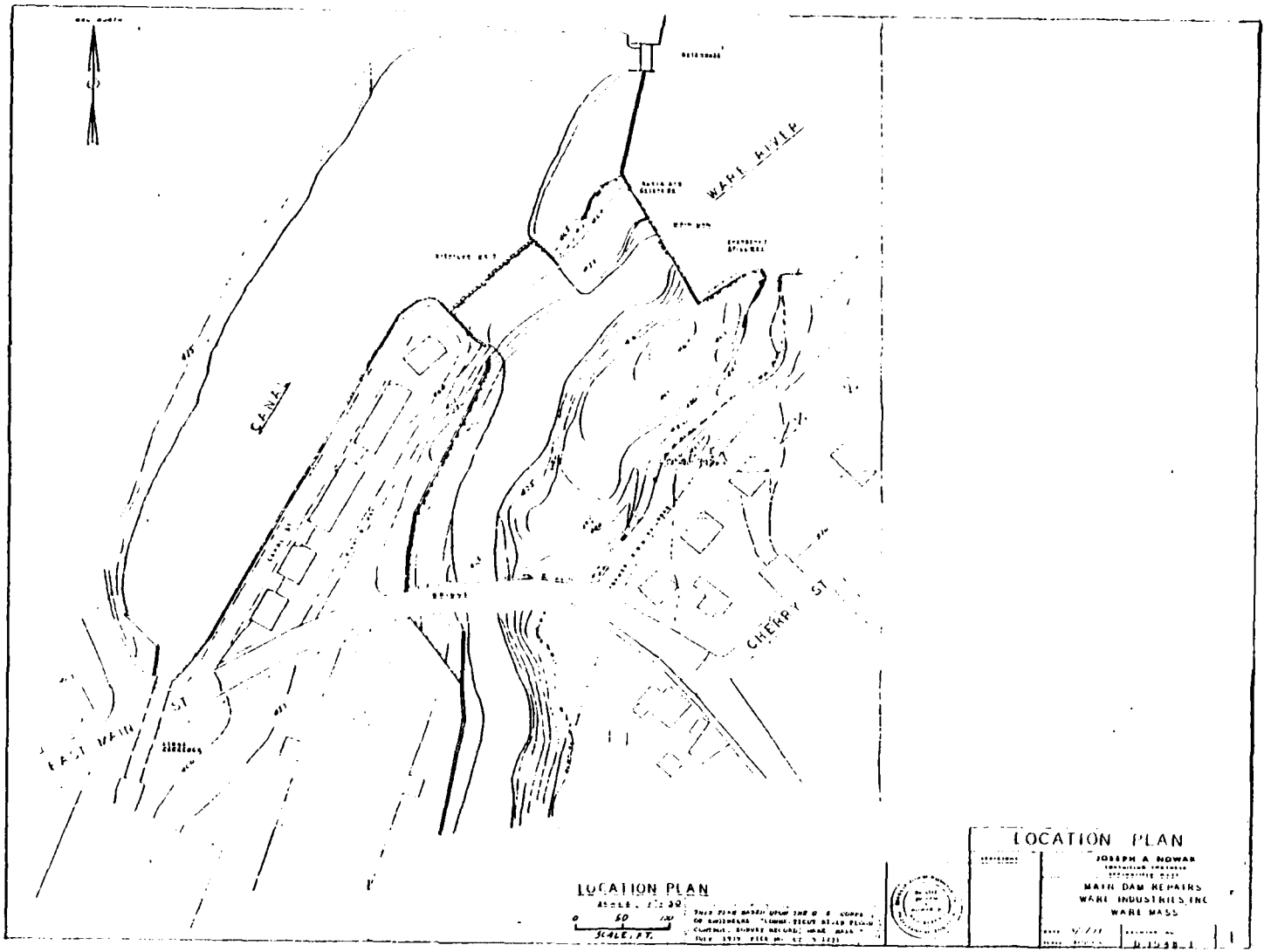
APPENDIX B
LIST OF AVAILABLE DOCUMENTS AND
PRIOR INSPECTION REPORTS

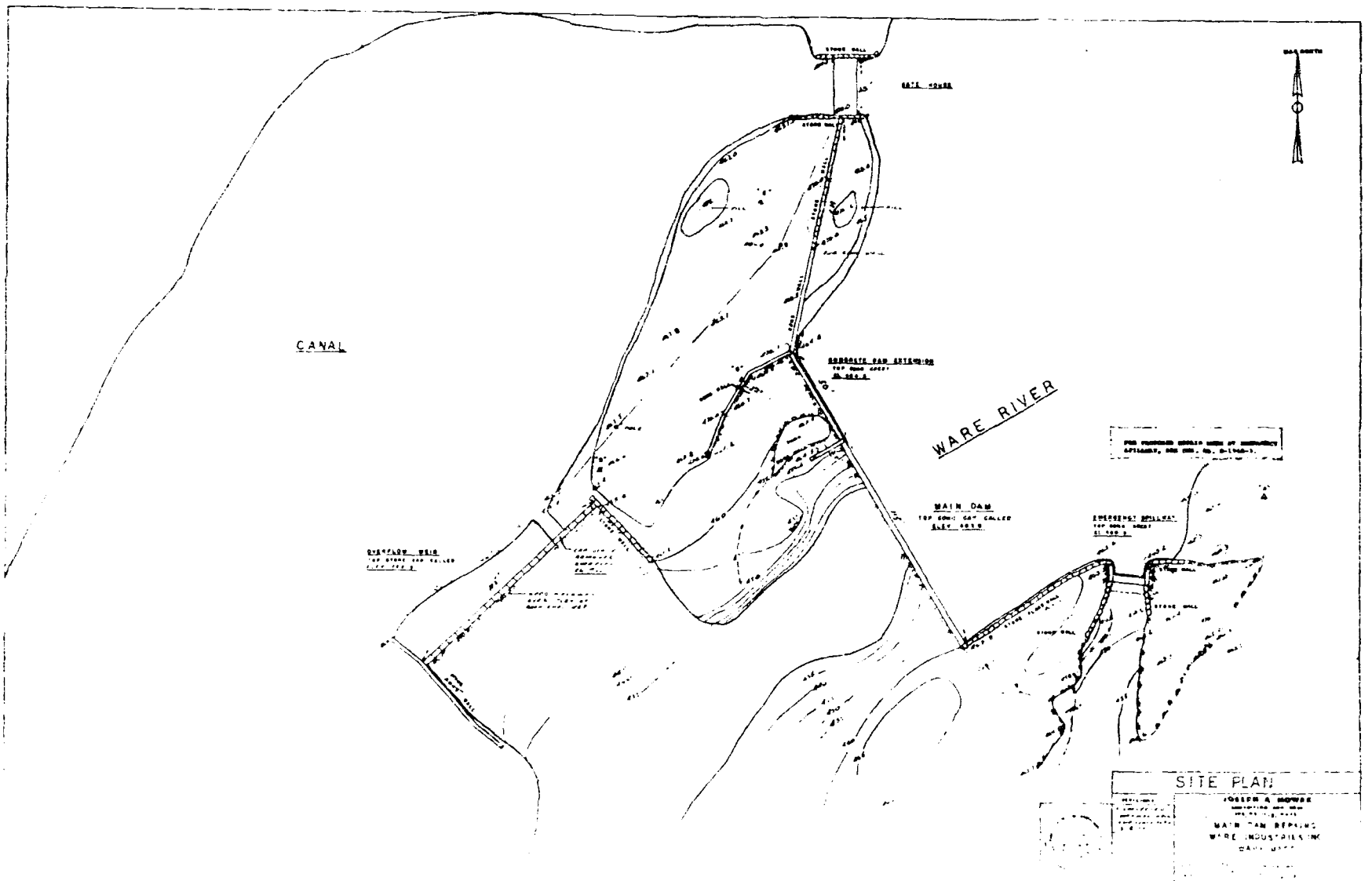
LIST OF AVAILABLE DOCUMENTS
WARE INDUSTRIES MAIN (UPPER) DAM

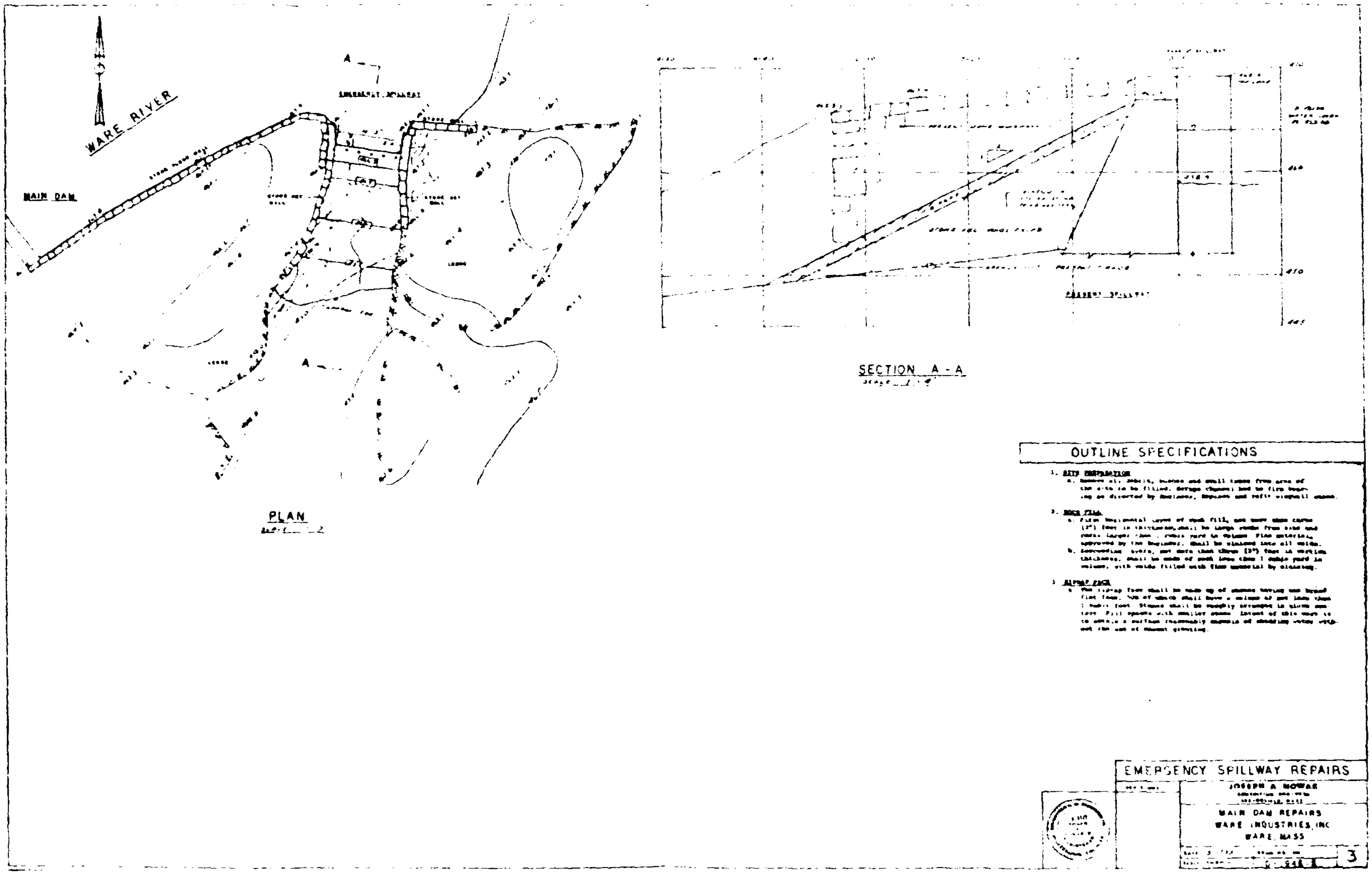
DOCUMENT	CONTENTS	LOCATION
"Location Plan, Main Dam Repairs", Drawing No. 1, Joseph A. Nowak, Springfield, MA, 1 May 1975	50 scale location plan	Mass. Department of Environmental Quality Engineering, 100 Nashua Street, Boston, MA, 02114 and Appendix B-3
"Site Plan, Main Dam Repairs", Drawing No. 2, Joseph A. Nowak, Springfield, MA, 8 May 1975	20 scale site plan	Nenameseck Industrial Properties, Inc., East Main Street, Ware, MA 01082 and Appendix B-4
"Emergency Spillway Repairs, Main Dam Repairs", Drawing No. 3, Joseph A. Nowak, Springfield, MA, 1 May 1975	Plan and section for proposed repairs	Nenameseck Industrial Properties, Inc., East Main Street, Ware, MA 01082 and Appendix B-5
Flow Calculations, Joseph A. Nowak, Springfield, MA, 22 April 1976	Site data, flow records and flow calculations for various situations	Nenameseck Industrial Properties, Inc., East Main Street, Ware, MA 01802 and Appendix B-6
Inspection report by Tighe & Bond Consulting Engineers for the Hampshire County Commissioner dated 26 June 1970	States condition and deficiencies of dam	Hampshire County Commissioner's Office, Hampshire County Courthouse, Northampton, MA 01060 and Appendix B-9
Letter from NED, Corps of Engineers, to Town of Ware, dated 31 October 1973	Results of reconnaissance study of water resource problems along the Ware River in Ware, Massachusetts	Mass. Dept. of Environmental Quality Engineering, 100 Nashua Street, Boston, MA 02114

LIST OF AVAILABLE DOCUMENTS
WARE INDUSTRIES MAIN (UPPER) DAM (Continued)

DOCUMENT	CONTENTS	LOCATION
Inspection reports by the Mass. Dept. of Environmental Quality Engineering, dated 22 August 1973, 17 January 1974 and 15 March 1976	States condition and deficiencies of dam	Mass. Dept. of Environmental Quality Engineering, 100 Nashua Street, Boston, MA 02114 and Appendix B-11


WARE RIVER
CHERRY ST
EAST MAIN ST
LOCATION PLAN
SCALE, FT.
LOCATION PLAN
JOSEPH A. NOWAK
MAIN DAM REPAIRS
WARE INDUSTRIES, INC
WARE MASS


CANAL
WARE RIVER
MAIN DAM
SITE PLAN


WARE RIVER
MAIN DAM
PLAN
SECTION A-A
PRESENT SPILLWAY
OUTLINE SPECIFICATIONS
EMERGENCY SPILLWAY REPAIRS
JOSEPH A. NOWAK
MAIN DAM REPAIRS
WARE INDUSTRIES, INC
WARE, MASS
3

RECEIVED 12 MAY 78
#1460
WORE INDUSTRIES
MAIN (UPPER)

4/22/78
1948
WARE ENG.

FLOW CALCULATIONS

(1)

1. SITE DATA FOR CALCULATIONS

ITEM	ELEV	LENGTH	Δ EL. TOP MAIN DAM
MAIN DAM	463.8	115'	—
OVERFLOW WEIR	463.9	115'	+0.1'
NO. DAM. EXTENSION	464.8	50'	+1.0'
EMERGENCY SPILLWAY	466.9	16'	+3.1'
STONE FLOOD WALL	469.8		+6.0'
WEST RETAINING WALL	470.0		+6.2'
GATE HOUSE WALL	470.0		+6.2'

2. FLOWS OVER MAIN DAM (NO FLOW NO. DAM EXTENSION)

a. GATE CLOSED: OVERFLOW L = 115'

$$Q = 3.33 \times 115 \times (464.8 - 463.8)^{3/2}$$
$$= \underline{383} \text{ CFS} \quad \underline{248.2} \text{ MGD}$$

b. GATE OPEN: OVERFLOW L = 230'
(MAIN DAM + OVERFLOW WEIR)

2. FLOW

$$Q = \underline{766} \text{ CFS} \quad \underline{496.4} \text{ MGD}$$

3. FLOWS BEFORE EMERGENCY SPILLWAY HAS FLOW. Δh = 3.1'

a. GATE CLOSED:
MAIN DAM; $Q = 3.33 \times 115' \times (3.1)^{3/2} = 2,090$
NO. EXTEN: $Q = 3.33 \times 50' \times (2.1)^{3/2} = \underline{503}$ CFS
$\underline{2,593}$ CFS

THOMAS
1958
WARE INC

(2)

b. GATES OPEN:

MAIN DAM: $Q = 3.33 \times 115' \times (3.1)^{3/2} = 2,090$
NO. EATON: $Q = 3.33 \times 50 \times (3.1)^{3/2} = 907$
OV. WEIR: $Q = 3.33 \times 115 \times (3.1)^{3/2} = 2,090$
4,087 CFS

4. EMBARGENCY SPILLWAY IN ACTION
WATER LEVEL = 463.2

a. GATES CLOSED

	CFS
MAIN DAM: $Q = 3.33 \times 115' \times (463.2 - 463.6)^{3/2}$ =	4,805.4
NO. EAT: $Q = 3.33 \times 50' \times (463.2 - 464.0)^{3/2}$ =	1,536.2
EM. SPILL: $Q = 3.33 \times K' \times (463.2 - 462.9)^{3/2}$ =	185.8
	6,527.4

b. GATES OPEN:

MAIN DAM:	Q =	4,805.4 CFS
OV. WEIR:	Q =	4,805.4
NO. EAT:	Q =	1,536.2
EM. SPILL:	Q =	185.8
		11,333.3 CFS

5. FLOW RECORDS (GIBBS CROSSING)
(ADJUSTMENTS FOR DIVERSION)

MAXIMUM NON-FLOOD: JAN. 1952 = 2,460 CFS
AVERAGE: 41 YEARS TO 1953 = 319 CFS
MINIMUM FLOW TO 1953 = 7 CFS
FLOOD, MARCH, 1936 = 12,200 CFS
FLOOD, SEPT. 1938 = 22,700 CFS
FLOOD, AUG. 1955 = 12,200

BARRE FALLS DAM IN OPERATION

FLOOD OF SEPT, 1938 = 17,700 CFS

1348
WARE INC.

CALCULATIONS & NOTES FOR OPTIONS

1. NORTH DAM EXTENSION REMOVED

THIS WOULD LOWER RIVER LEVEL TO ELEV. OF ROCK ON NORTH SIDE, OR ELEV. 460.8 ± Δ = -3.0 MAIN DAM.

a. FLOW TO REACH MAIN DAM LEVEL 463.8

$Q = 3.33 \times 50' \times (3.0)^{3/2}$ = 865 CFS > 319 CFS. AVG.

b. GATES OPEN: WATER LEVEL = 466.9 BM. SHELL

NO. EXTENSIONS: $3.33 \times 50' \times (466.3 - 460.8)^{3/2}$ = 2,502
MAIN DAM = 2,090
OVERFLOW WEIR = 2,090
6,682 CFS

THIS IS GREATER THAN 2,460 CFS (NON-FLOOD)

2. OVERFLOW WEIR LOWERED 1.0' TO EL 463.8
GATES ALWAYS OPEN

$Q = 3.33 \times 115' \times (1)^{3/2}$ = 383 CFS > 319 CFS

a. RIVER LEVEL AT EL. 464.8 Δh = 1.0

		MAIN DAM
WEIR =	$Q = 3.33 \times 115' \times (464.8 - 463.8)^{3/2}$	= 1,083
DAM =	$3.33 \times 115' \times (1')^{3/2}$	= 383 CFS
		1,466 CFS

GEORGE H McDONNELL
PHILIP W SHERIDAN
EDWARD J BAYON

TIGHE & BOND CONSULTING ENGINEERS

CIVIL SANITARY AND ELECTRICAL ENGINEERING
INVESTIGATIONS REPORTS PLANS AND SPECIFICATIONS
SUPERVISION OF CONSTRUCTION AND OPERATION

BOWERS AND PEQUOT STREETS
HOLYOKE, MASSACHUSETTS
TEL JEFFERSON 3-3991

H-36 Ware
June 26, 1970

The Honorable the Board of County Commissioners
Hampshire County Courthouse
Northampton, Massachusetts

Gentlemen:

Attached hereto is our inspection report on dams located within the Town of Ware. We are including herewith, suggested letters to be sent to four dam owners, three of which indicate necessary repairs, and the fourth letter is sent at the request of the dam owner, as he wishes to have a letter of notice on file that his dams were observed to be satisfactory.

Very truly yours,

Tighe & Bond, Inc.

George H. McDonnell
Chief Engineer

GHM/amd
Encl.

The remaining portion of the dam is estimated to be only 3 ft. to 4 ft. in height and little or no water is stored. Actually, the dam is nothing more than a shallow waterfall in the stream.

The dam does not present any danger to persons and property as it now exists.

K. Ware Industries Main Dam - Upper

The concrete crest of the main dam shows further evidence of erosion, particularly at the downstream edge. On the day of inspection no flashboards were on the crest of this dam which extends across the width of the stream, and water was overflowing the entire crest length. Based upon the amount of water passing over the crest and little evidence of any motion in the adjacent canal, it would appear that the industry is using little or no water from the pool in back of the dam.

Because of the heavy flow of water over the crest, the toe of the dam in the bed of the stream could not be inspected. However, since the bed of the stream is ledge, there is little doubt but what the toe of the dam and its foundation are o. k.

The left abutment stone masonry wall is satisfactory. The right stone masonry and concrete abutment was also satisfactory. Conditions on the natural ledge at the right abutment are o. k.

The emergency concrete overflow spillway upstream of and to the left of the main dam was noted to be in satisfactory condition with the exception that at the right stone masonry abutment wall just downstream from the concrete overflow, there has been a failure at the face of the wall. Stones above the failure are improperly supported and seepage which takes place thru this area of the wall will undoubtedly contribute to further failure with the passing of time. Should this stone masonry wall fail as a result of collapse of the unsupported stone masonry, the failure might have an undesirable effect on the left abutment wall of the main dam located 20 ft. to 25 ft. behind the damaged wall. Thus, the industry should carefully examine the failure at the stone masonry wall as pointed out herein and should provide proper support, thru repair of the walls, for the upper stone blocks forming the wall.

INSPECTION REPORT - DAMS AND RESERVOIRS

1. LOCATION:

~~City~~/Town Ware. County Hampshire. Dam No. 2-8-309-9.

Name of Dam Ware Industries Main Dam "upper".

Topo Sheet No. 17C. Mass. Rect. Coordinates: N 460,600, E 400,900.

Inspected by: Harold T. Shumway, On March 15, 1976. Date Last Inspection 8-22-73 1-17-74.

2. OWNER/S: As of March 15, 1976

per: Assessors —, Reg. of Deeds ____, Prev. Insp. X, Per. Contact X.

1. Ware Industries, Inc. East Main St., Ware, Mass.
Name St. & No. ~~City~~/Town State Tel. No.

2. ____
Name St. & No. City/Town State Tel. No.

3. ____
Name St. & No. City/Town State Tel. No.

3. CARETAKER: (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Edward Beaudin, Supt., Ware Industries, Inc., East Main St., Ware, Mass.
Name St. & No. City/Town State Tel. No.

4. DATA:

No. of Pictures Taken None. Sketches See description of Dam.
Plans, Where ____.

5. DEGREE OF HAZARD: (if dam should fail completely)*

1. Minor ____.
2. Moderate ____.
3. Severe X.
4. Disastrous ____.

Comments: Approx. 167 million gallons impoundment - dense development immediately downstream.

*This rating may change as land use changes (future development).

(6.) OUTLETS: OUTLET CONTROLS AND DRAWDOWN

No. 1 Location and Type: Approx. center of dam - crest overflow spillway 114' W. - 1' H. on northerly end - 6½' H. on southerly end with a dropwall 35' high.

Controls Yes, TYPE: Provisions for stop logs.

Automatic____. Manual X. Operative Yes____, No Y.

Comments: Most of stanchion pins bent or broken off.

No. 2 Location and Type: 80' easterly of east end of dam - conc. overflow spillway - 10' W. X 2' H. with 15'± high dropwall.

Controls None, Type:_____.

Automatic_____. Manual_____. Operative Yes_____, No_____.

Comments: Spillway crest 3.4' above crest of main spillway. Slight spalling of easterly aput.

No. 3 Location and Type: See report on Ware Industries Canal Dam "Upper" No. 2-8-309-10 for another outlet.

Controls_____, Type:_____.

Automatic_____. Manual_____. Operative Yes_____, No_____.

Comments:_____.

Drawdown present Yes X, No_____. Operative Yes X, No_____.
Comments: See Inspection Report on Dam No. 2-8-309-10.

(7.) DAM UPSTREAM FACE: Slope 3:1 variable, Depth Water at Dam 5½' to 6'.

Material: Turf_____. Brush & Trees_____. Rock fill___. Stone Masonry X. Wood___.

Other_____.

Condition: 1. Good_____. 3. Major Repairs_____.
Unknown
2. Minor Repairs X. 4. Urgent Repairs_____.

Comments: Slope under water - not possible to determine exact grade or condition of slope.

(8.) DAM DOWNSTREAM FACE: Slope Vertical.

Material: Turf_____. Brush & Trees___. Rock Fill_____. Stone Masonry X. Wood_____.

Other_____.

Condition: 1. Good_____. 3. Major Repairs X.

2. Minor Repairs_____. 4. Urgent Repairs_____.

Comments: Bottom of wall is ledge and stone paving. Crest is concrete, scalled and lip is unraveling - seepage noted through easterly wall.

EMERGENCY SPILLWAY: Available Yes, Needed ____.

Height Above Normal Water 1 Ft.

Width 46 Ft. Height 5.3 Ft. Material Concrete - ledge

Condition: 1. Good ____. 3. Major Repairs ____.

2. Minor Repairs ____. 4. Urgent Repairs ____.

Comments: Also, see item 6, part 2, for emergency spillway.

WATER LEVEL AT TIME OF INSPECTION: 1 Ft, above X. Below ____.

Top Dam ____ F.L. Principal Spillway X.

Other ____

Normal Freeboard 1 Ft. North, $6\frac{1}{2}$' South

SUMMARY OF DEFICIENCIES NOTED:

Growth (Trees and Brush) on Embankment Yes-In joints of stone masonry, flood training wall easterly of spillway.

Animal Burrows and Washouts None found

Damage to Slopes or Top of Dam Yes, severe spalling of concrete spillway cap and tops of walls on westerly end of dam.

Cracked or Damaged Masonry Yes, see above-also severe spalling of downstream face of westerly end of dam-several misplaced stones from side walls of emergency spillway.

Evidence of Seepage Yes-[illegible] and ledge. Major seepage through joint between easterly flood training wall and ledge.

Evidence of Piping None found

Leaks Yes, see above seepage notes

Erosion None found

Trash and/or Debris Impeding Flow None found

Clogged or Blocked Spillway None found

Other ____

DAM NO. 2-8-309-9

(12.) OVERALL CONDITION:

1. Safe_____.
2. Minor repairs needed_____.
3. Conditionally safe - major repairs needed X .
4. Unsafe_____.
5. Reservoir impoundment no longer exists (explain)

   Recommend removal from inspection list_____.

(13.) REMARKS AND RECOMMENDATIONS: (Fully Explain)

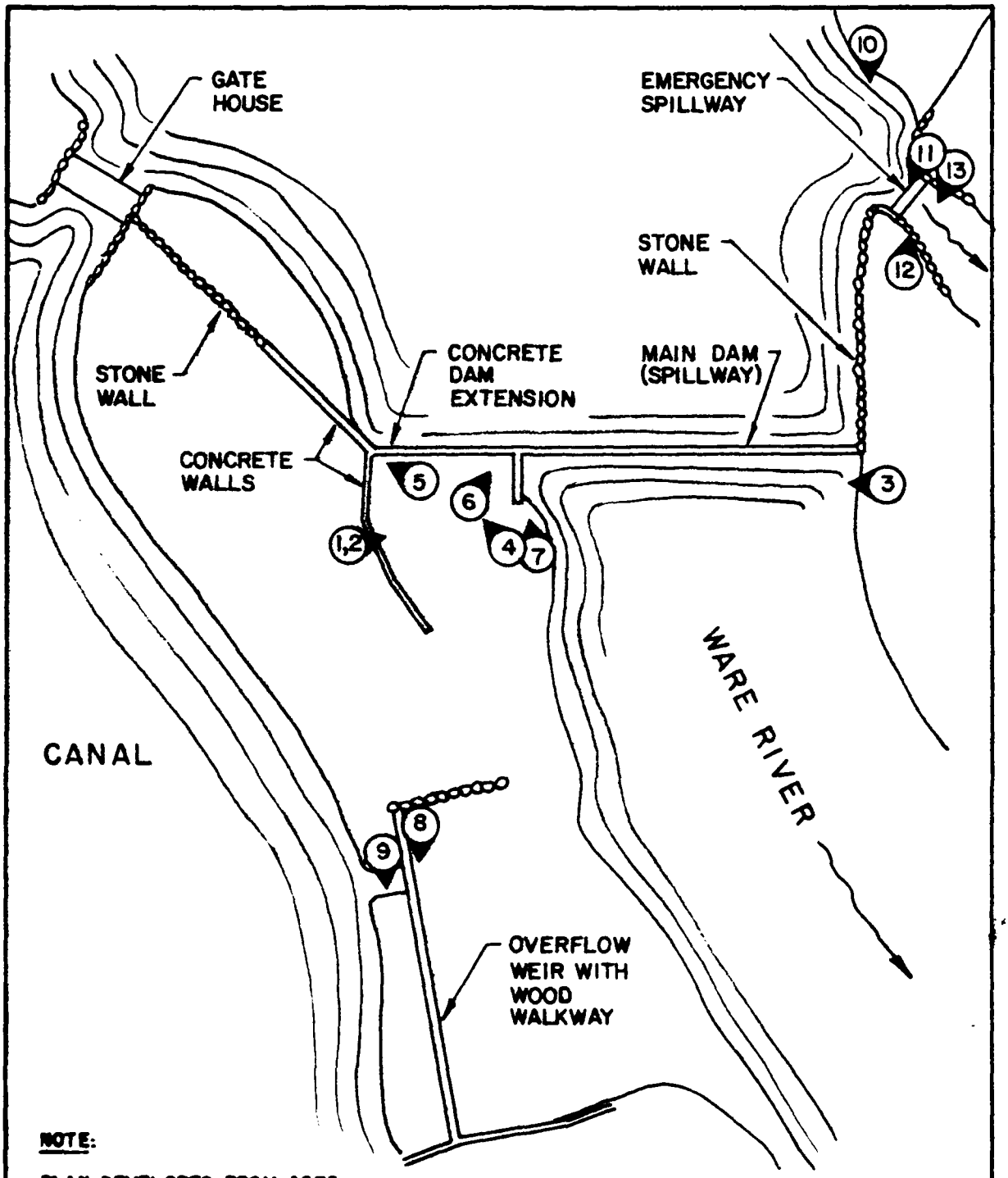
Conditions at this dam were found to be the same or slightly worse than when last inspected on January 17, 1974. Refer to inspection report of January 17, 1974, Remarks and Recommendations, for a detailed description of these problems. Further deterioration has occurred on the lip of main spillway, with a very ragged lip now evident. One foot deep overflow of water on main spillway prevented close inspection of dropwall or toe of dam. Severe seepage was noted in area of westerly abutment or sidewall of emergency spillway where several stones are misplaced. Only slight seepage was noted here two years ago.

The rubbish and debris noted, in last inspection at base of emergency spillway dropwall has been cleared away but a fresh accumulation ofdebris was noted at this inspection.

Mr. Edward Beaudin, Supt. of Ware Industries, was present during this inspection. He stated that a consulting firm has been retained by the company for investigation of problems concerning this dam and at present time it appears to be a question of whether to repair or dismantle the dam. Mr. Beaudin stated that Ware Industries, Inc. is holding a director's meeting in the near future and a decision should be made at that time as to the course of action the owners will take concerning dam.

HTS:ma

APPENDIX C
SELECTED PHOTOGRAPHS OF PROJECT



NOTE:

PLAN DEVELOPED FROM 1975 JOSEPH A. NOWAK SITE PLAN (APPENDIX B) AND OBSERVATIONS BY HALEY & ALDRICH, INC. ON 12 MAY 1978.

LEGEND:

(9) PHOTO NUMBER AND DIRECTION OF VIEW

HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS

Ware Industries
Main (Upper) Dam
Ware, Mass.

SITE PLAN SKETCH

Scale: 1"=50' Nov. 1978

FILE NO 4160 A51

C-1

2. Overview of main dam and left abutment

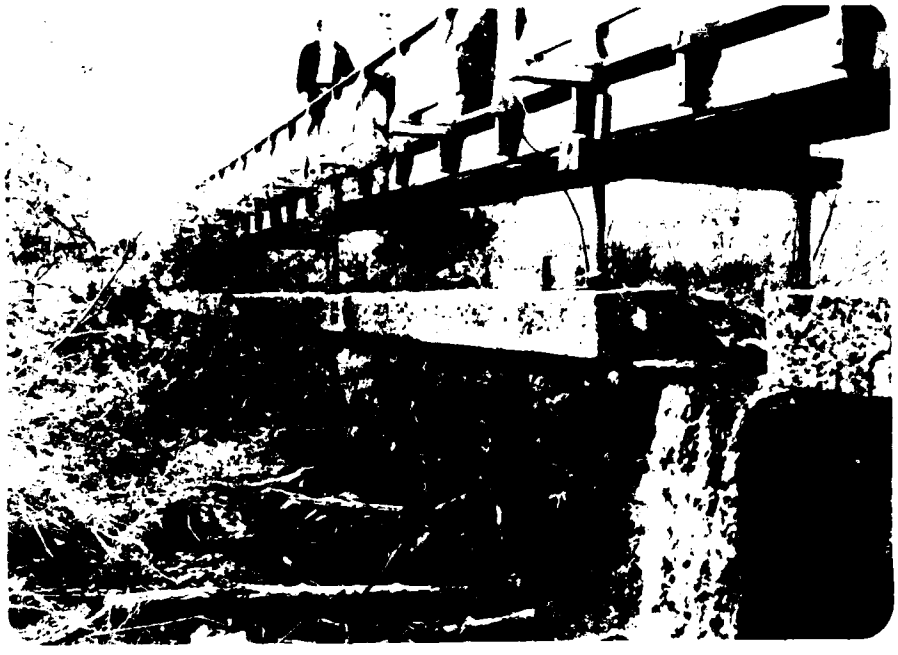
3. Overview of main dam and right abutment

4. Downstream side of concrete dam extension

5. Right end of concrete dam extension

6. Left end of concrete dam extension

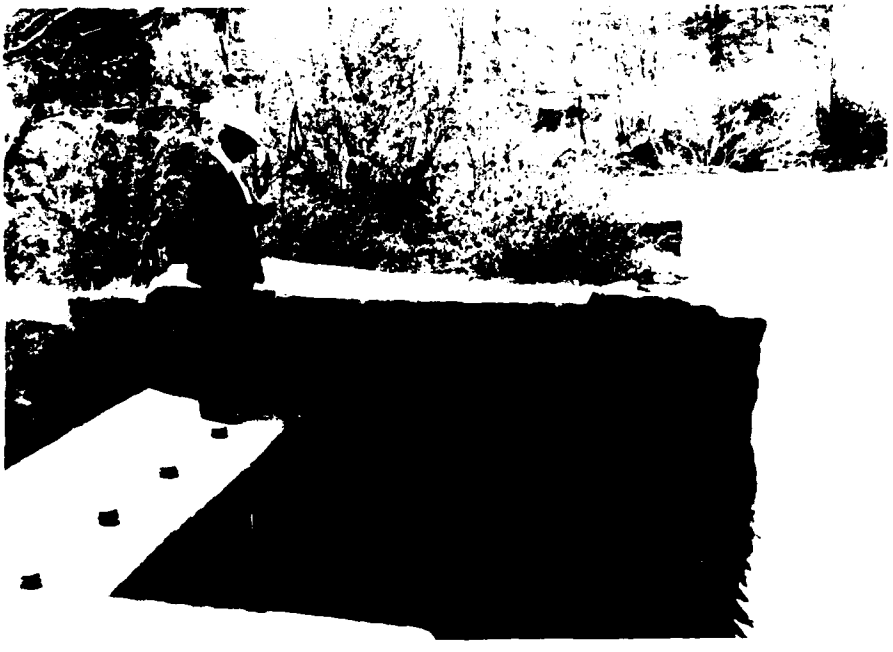
7. Concrete pier between main dam and concrete dam extension



8. Overflow weir with wood walkway

9. Approach to overflow weir from canal

10. Upstream side of emergency spillway



11. Right abutment of emergency spillway

12. Stone wall below left abutment of emergency spillway

13. Stone wall below right abutment of emergency spillway

APPENDIX D
OUTLINE OF DRAINAGE AREA AND HYDRAULIC COMPUTATIONS

CAMP DRESSER & McKEE INC. Consulting Engineers Boston, Massachusetts	N	WARE INDUSTRIES DAM DRAINAGE AREA Scale: 1:250,000

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT [illegible] JOB NO [illegible] PAGE 2 of [illegible]
PROJECT [illegible] DATE CHECKED 9-29-78 DATE 9/[illegible]/78
DETAIL [illegible] CHECKED BY [illegible] COMPUTED BY [illegible]

Size Classification and Hazard Classification

Size

Height: Top of Dam = 470.0'
Elevation of Stream Bed = 430'

Height = 40.0 feet

Top of Dam = 470' - L bed = 459'

Storage = $\frac{1}{3} \times 39.5 \times 43 + \frac{20.9+39.5}{2} \times 6.2$

Storage = 746 Acre-feet

50 < 746 < 1000
25 < 40 < 50
} So Size is SMALL

Hazard: On the basis of the destruction caused by the floodwaters of both the 1936 and 1938 floods, it will be initially assumed that the hazard classification will be HIGH

For Small Size and High Hazard = the spillway design flood is in the range of the 1/2 PMF - PMF

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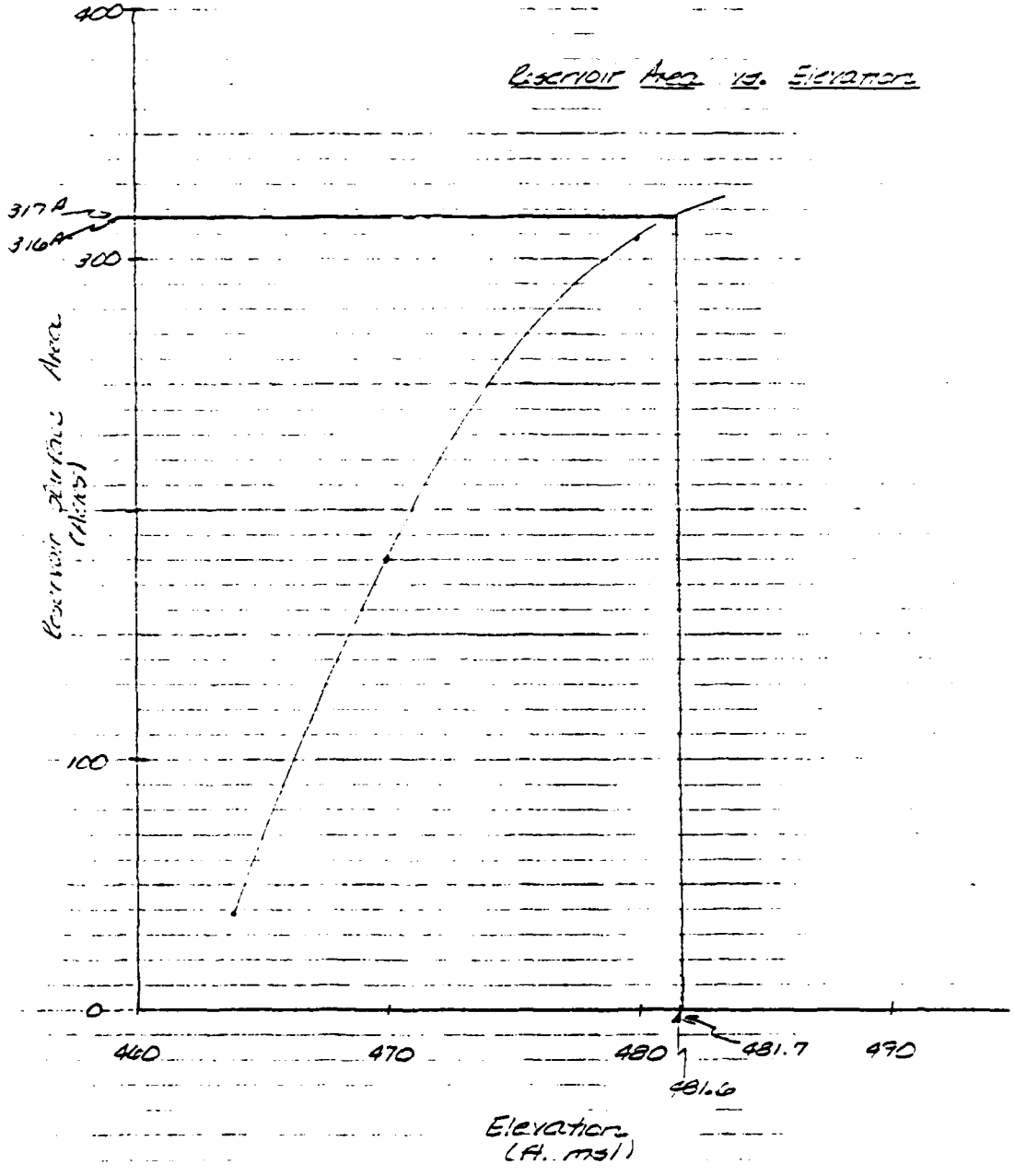

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DETAIL [illegible] Dam | CHECKED BY [illegible] | COMPUTED BY [illegible]

Calculation of PMF

U.S.G.S. Gaging Station at Gibbs Crossing, MASS.
on Ware River:
HISTORICAL FLOODS →
Maximum Discharge - 22700 c.f.s. on Sept. 21, 1938

$\therefore Q_{1938\ gage} = 22,700\ cfs / 199\ sq.mi. = 114.1\ csm$

so $Q_{1938\ W.I.} = 114.1\ csm \times 167\ sq.mi. = 19055\ c.f.s.$

since dam constructed at Barre Falls, deleted drainage area upstream of Barre Falls Reservoir

$19055\ c.f.s. \times \left(\frac{167-55}{167}\right) = 12779\ c.f.s.$

so for 112 sq. mi., $Q_{W.I.} = 12779\ cfs$
say 12800 c.f.s.

For PMF, use average of mountainous and rolling curves.

$Q \sim 980\ cfs/sq\ mi \times 112\ sq.mi. = $ <u>109760 c.f.s.</u>

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DETAIL [illegible]

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DATE [illegible]
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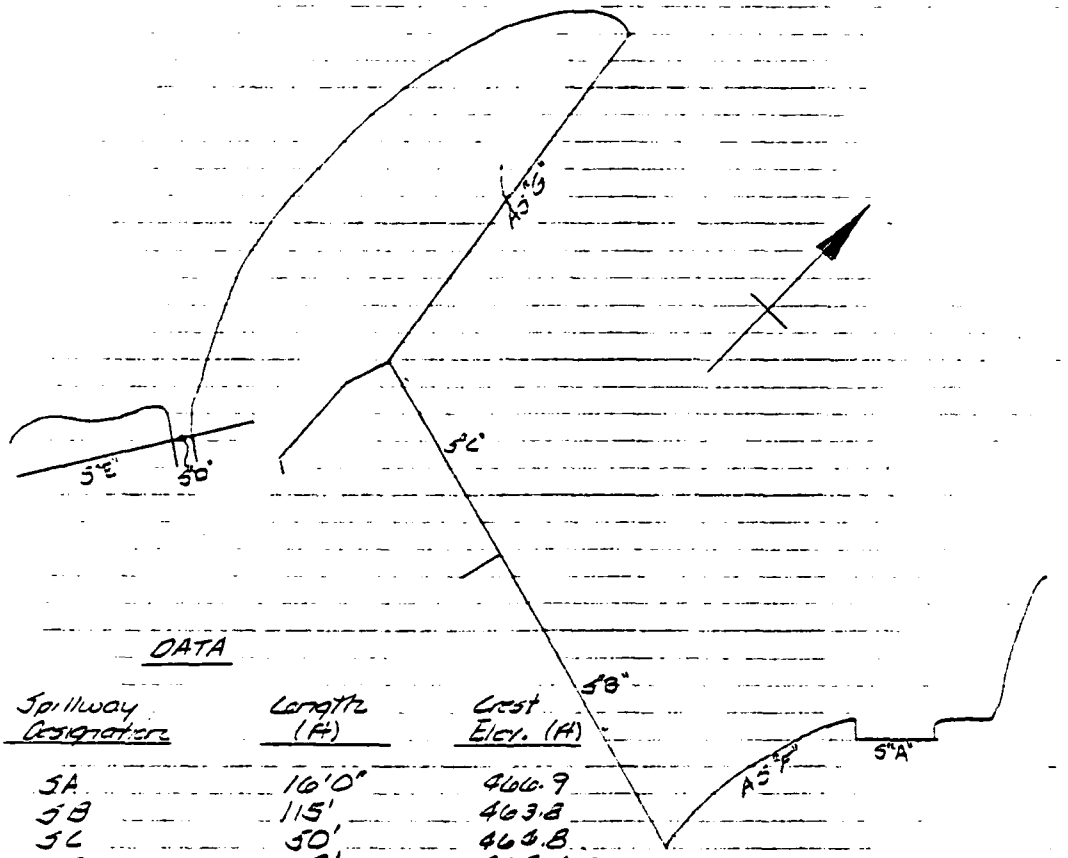
Plan View of Dams with Various Spillways (L.T.S.)



DATA

Spillway Designation	Length (ft)	Crest Elev. (ft)
5A	16'0"	466.9
5B	115'	463.8
5C	50'	463.8
5D	8'	464.45
5E	107'	466.35
A5F	~85'	469.8
A5G	120'	470.0

*A5- Abbrev. for 5-Saddle

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Spillway Rating Curve

$Q = CLH^{3/2}$

For "C" Value, King & Brakers Handbook of Hydraulics

Figure 5-22 (Crested Broad Weir).

Elev. of Flow (ft)	Weir Flows						
	3A	3B	3C	3D	3E	ASF	ASG
463.8	0	0	0	0	0	0	0
463.9	0	13	0	0	0	0	0
464.0	0	36	0	0	0	0	0
464.35	0	407	0	6	0	0	0
465.0	0	535	16	12	0	0	0
466.0	0	1321	233	55	0	0	0
466.35	0	1607	358	54	4	0	0
466.4	0	2050	528	103	154	0	0
467.0	2	2153	561	109	198	0	0
468.0	65	3217	933	174	803	0	0
469.0	159	4432	1399	252	1537	0	0
469.2	260	5493	1817	322	2228	0	0
470.0	226	5770	1927	340	2425	27	0
471.0	432	7221	2509	436	3487	390	425
472.0	600	8770	3140	539	4670	754	1153
473.0	723	10429	3810	650	5963	1520	2037
474.0	982	12175	4535	767	7358	2318	3120
476.0	1427	15927	6091	1020	10425	4265	5732
478.0	1923	20,000	7793	1297	13828	6487	8325
480.0	2466	24370	9630	1594	17537	9000	12333
482.0	3051	29019	11592	1912	21530	11772	16212
484.0	3677	33932	13671	2248	25786	14782	20429

Note: At ~ elevation 470, a large portion of overland flow occurs on the east side of dam. The above tabulation does not include this flow.

At top of dam (elev. 470), $Q_{weir} = 10,777$ say 10,800 c.f.s.

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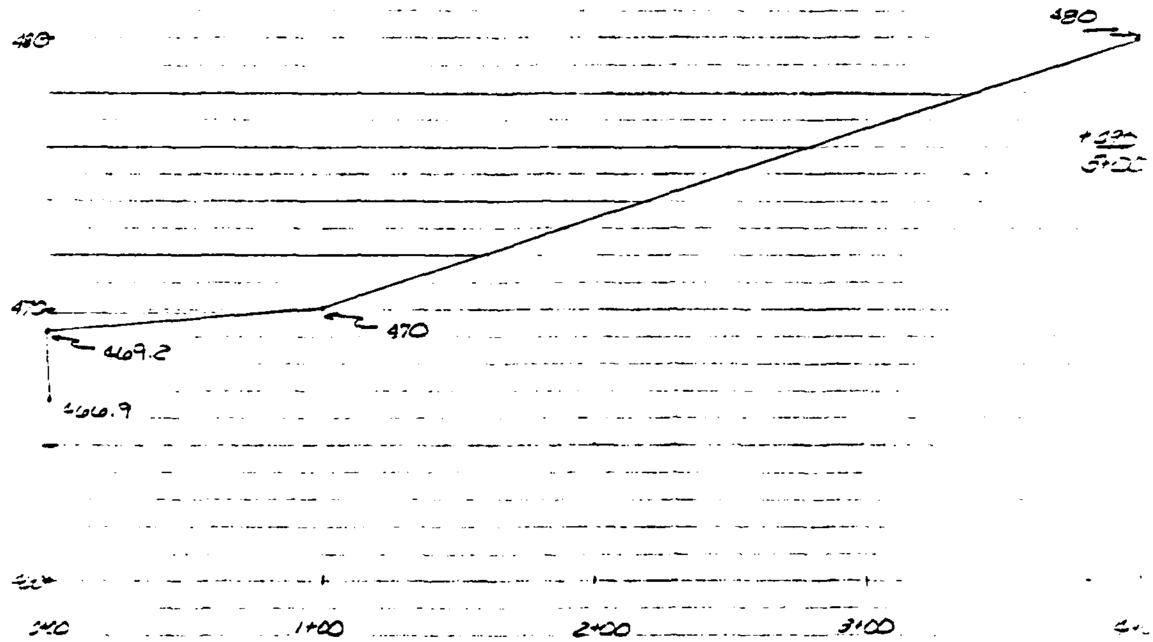
Overland Weir

The overland "weir" flow should be included in the previous calculations though. On the westerly side of the dam, the land slopes very steeply (approximately 37 feet in elevation in 100 feet horizontal distance). This side will be ignored as a site of overland flow. However, the easterly side of the emergency spillway is less steep and since the USGS quadrangle is being used, a probable weir can be approximated



* This overland flow comes into effect at elevations greater than 469.2

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DETAIL [illegible] CHECKED BY [illegible] COMPUTED BY [illegible]

Emergency Spillway Rating Curve

Assumed C Value of Overland "Weir" = 2.50
(Land is first grassed with rocky patches; becomes streets and lawns)

Elevation of Water (feet)	Weir Flows From 3A-A5G	Overland Weir Flow (cfs)	Total Weir Flows (cfs)
469.0	7789	0	7789
469.8	10120	44	10164
470.0	10775	~89	10864
472.0	19867	937	20804
474.0	31317	2892	34209
476.0	44837	6206	51093
478.0	60153	11094	71247
480.0	76930	17,746	94676
482.0	95028	24,042	119,130
484.0	114525	31315	145,840

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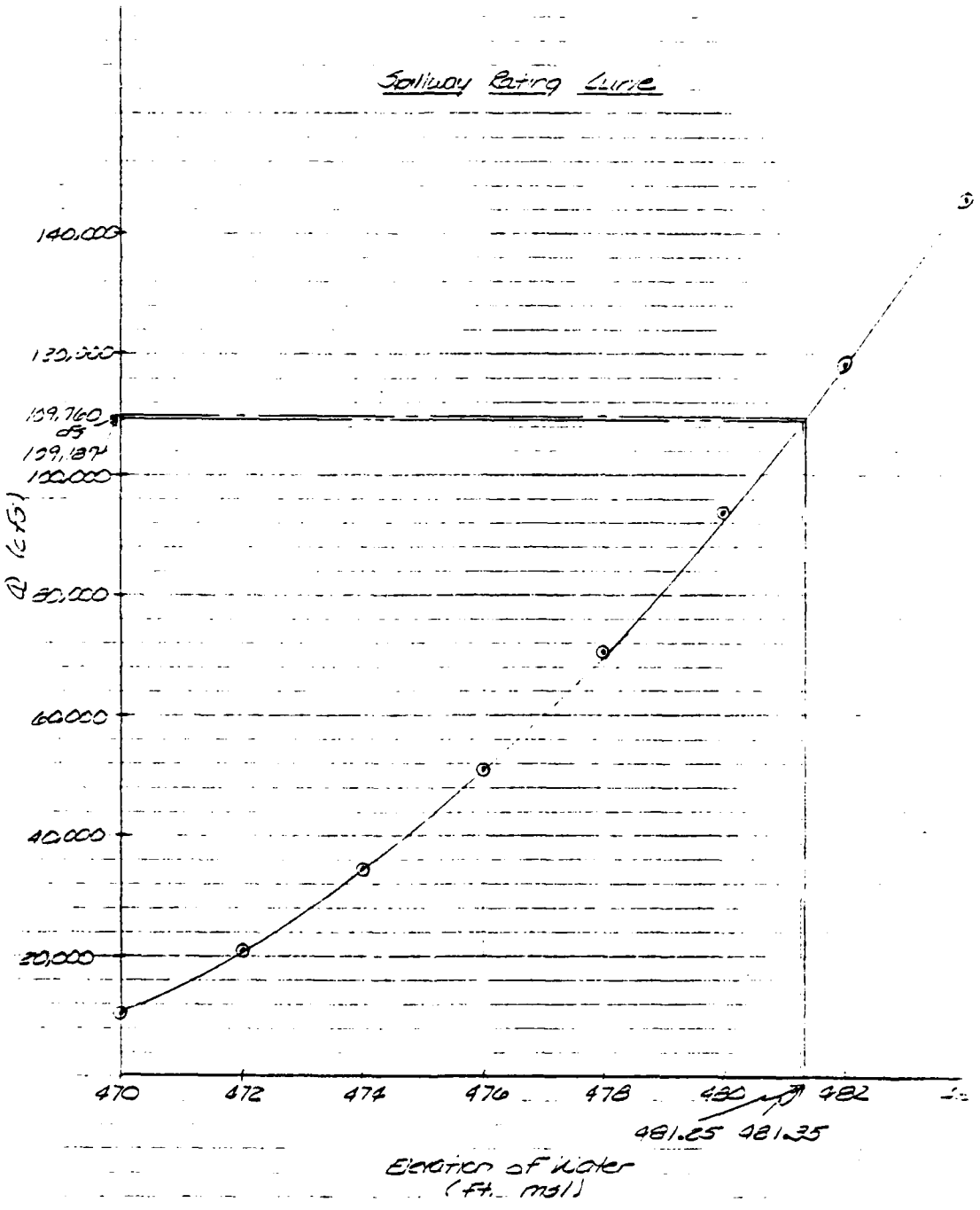

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Summary Effect of Surcharge Storage on Maximum Probable Discharges

1. Q_{D_1} = 109,760 c.f.s.

2. a. 481.35 - 463.2 = 17.55 feet

b. Volume of Surcharge in Inches of Runoff = $\frac{17.55 \times 39.5}{53.3 \times 1.12}$ = 0.12 inches

c. $Q_{D_2} = 109{,}760 \times \left(1 - \frac{.12}{23}\right)$ = 109,187 c.f.s.

3. a. height = 17.45 feet

$STOR_2$ = $\frac{17.45 \text{ feet} \times 39.5 \text{ Acre}}{53.3 \times 1.12}$ = 0.12 inches

b. so $STOR_{AVE}$ = 0.12 inches

c. Q_{D_3} = 109,187 c.f.s. at elev. 481.25 feet.

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Dam Failure Analysis

During the 1938 Flood, so much damage was done to bridges and buildings that the damage caused by a PMF (or even ½ PMF) occurrence would be much more extensive.

Damage caused by 1938 Flood:

1. Emergency Spillway was washed out
2. Water was 4 feet over Ware Road and this bridge eventually washed out too.
3. Next bridge on river was washed out
4. Water line mark above first floor windows on old Ware Woolen Company Mill.
5. Group of homes on east side of dam became an island. Water swept down streets; flooded basements.

The PMF is approximately 9 times greater in flow. Therefore, the damage caused by a PMF would be much more devastating. So the hazard should remain HIGH. A dam failure analysis, in view of the above data, would serve no further purpose.

Also, because of the large amount of damage and loss of life that could be incurred by a dam failure, it appears that the Spillway Design Flood should be the PMF.

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Dam Failure Analysis

At Elevation 470.0, S = 746 Acre-feet

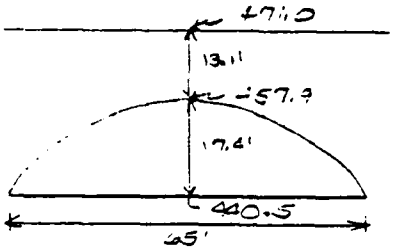
2) $Q_{P1} = \frac{8}{27} W_b \sqrt{g} Y_b^{3/2}$

$Y_b \approx 40$ feet
$W_b \approx 0.40 \times 165 = 66$ feet

$Q_{P1} = \frac{8}{27} \times 66 \sqrt{32.2} \times 40^{3/2} = 23,073$ cfs

say 23,100 cfs

3) Ware Road Culvert - located approximately 420 ft. d/s (East Main Street)



Slope Dam to East Main St. Bridge

$\frac{442.1 - 440.5}{420} = .00381$

Area of Opening = $\frac{\pi}{2} \times 32.5 \times 17.4 = 889.3$ ft

Perimeter of Opening = $\pi \sqrt{\frac{32.5^2 + 17.4^2}{2}} = 81.9$ ft

$Q = 1.49 \frac{A}{n} \left(\frac{A}{P}\right)^{2/3} (.00381)^{1/2}$ (Manning's)

$= \frac{1.49}{.040} \left(\frac{889.3}{81.9}\right)^{2/3} (.00381)^{1/2}$

≈ 9989 cfs

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DETAIL [illegible] CHECKED BY [illegible] COMPUTED BY [illegible]

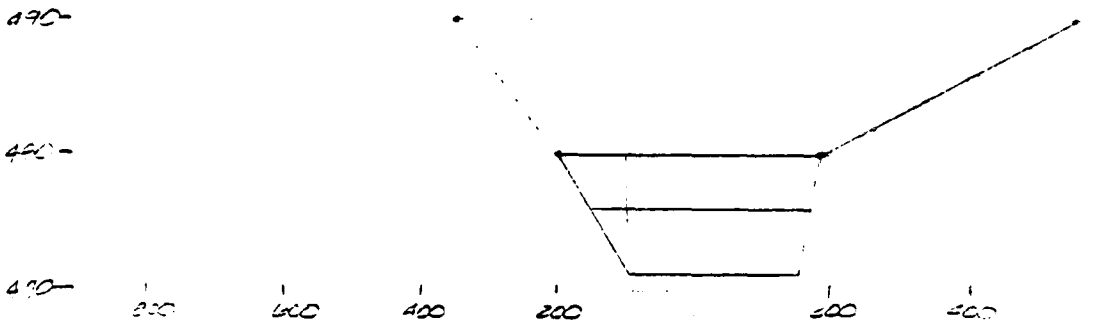
At el. 471.0,

$$Q = CA\sqrt{2gh}$$

$$= 0.65 \times 33[illegible]3 \times \sqrt{64.4 \times 13.1}$$

$$\approx 16771 \text{ cfs}$$

Road Profile (looking downstream)



Assume for Weir Equation, C = 2.6 for overland flow

$Q = CH^{3/2}$ for triangular section
$Q = CLH^{3/2}$ for straight section

Elev.	H	Q_c	Q_{weir}	Q_T
471		16771	0	16771
476	5	[illegible]	[illegible]	[illegible]
480	9	[illegible]	23994	[illegible]

at Q = 28,100 cfs, elev. Floodwaters ≈ 477.3 ft.

APPENDIX E
INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

STATE	IDENTITY NUMBER	DIVISION	STATE	COUNTY	CONGR DIST.	STATE	COUNTY	CONGR DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY	MO	YR
MA	594	NED	MA	015	01				WARE INDUSTRIES MAIN UPPER DAM	4215.7	7214.1	15	NOV	78

POPULAR NAME	NAME OF IMPOUNDMENT
	WARE RIVER

REGION	BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	DIST FROM DAM (MI.)	POPULATION
01	08	WARE RIVER	WARE	0	8679

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FT.)	HYDRAULIC HEIGHT (FT.)	IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	IMPOUNDING CAPACITIES NORMAL (ACRE-FT.)	DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
RERACTPG	1882	R	40	34	746	145	NED	N	N	N	N	13DEC78

REMARKS

D/S HAS	SPILLWAY CREST LENGTH	SPILLWAY TYPE	SPILLWAY WIDTH (FT.)	MAXIMUM DISCHARGE (FT.)	VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (MW)	POWER CAPACITY PROPOSED (MW)	NAVIGATION LOCKS NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
1	386	U	181	7980												

OWNER	ENGINEERING BY	CONSTRUCTION BY
NENAMESECK INDUSTRIAL PR		

REGULATORY AGENCY			
DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	NONE	MA DPW

INSPECTION BY	INSPECTION DATE DAY	MO	YR	AUTHORITY FOR INSPECTION
HALEY & ALDRICH, INC.	12	MAY	78	PUBLIC LAW 92-367

REMARKS
32-33-TOTAL SPILLWAY SYSTEM 46-PROPERTIES INC.

END

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