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QUINAPOXET RESERVOIR..(U) CORPS OF ENGINEERS WALTHAM MA
NEW ENGLAND DIV SEP 80

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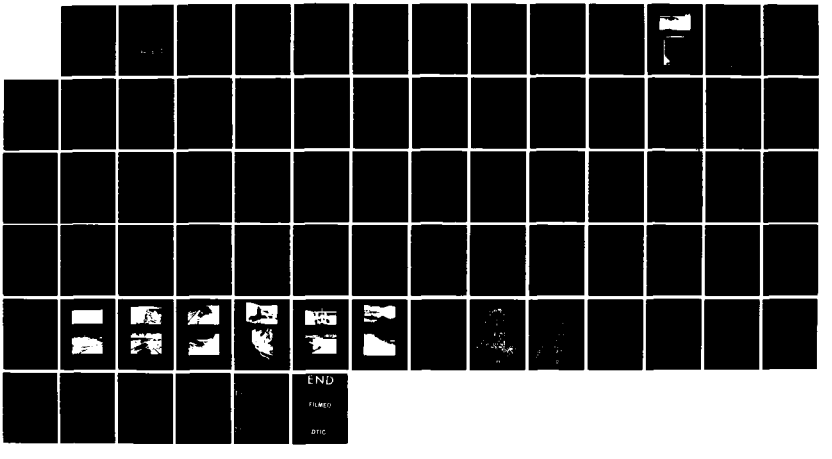
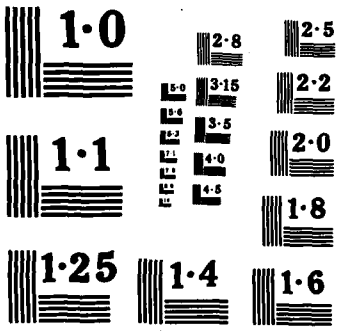
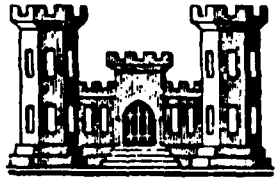




MERRIMACK RIVER BASIN
HOLDEN, MASSACHUSETTS

QUINAPOXET RESERVOIR DAM
MA 00929

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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

SEPTEMBER 1980

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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4. TITLE (and Subtitle) Quinapoxet Reservoir Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT 6. PERFORMING ORG. REPORT NUMBER
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

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,

Merrimack River Basin
Holden, Massachusetts
Quinapoxet River

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

The dam is about 1050 ft. long including the spillway and has a maximum height of about 45 ft. The facility is considered to be in good condition. Evidence of minor seepage was observed on the downstream slope of the dam adjacent to the left wall of the spillway discharge channel. The size is intermediate, and the hazard potential classification is high.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:

NEDED

OCT 28 1980

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts 02133

Dear Governor King:

Inclosed is a copy of the Quinapoxet Reservoir Dam - MA-00929 Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. In addition, a copy of the report has also been furnished the owner, the City of Worcester.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be 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 your cooperation in carrying out this program.

Sincerely,

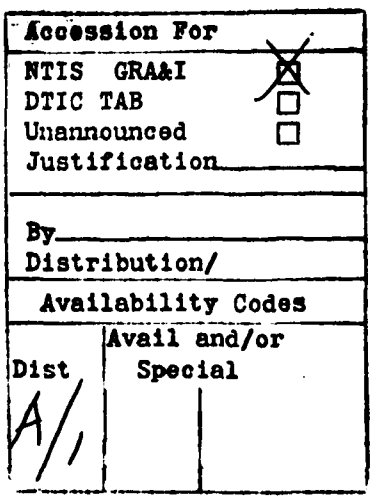
MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

QUINAPOXET RESERVOIR DAM
MA 00929

MERRIMACK RIVER BASIN
HOLDEN, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Identification: MA 00929
Name of Dam: QUINAPOXET RESERVOIR DAM
Town: TOWN OF HOLDEN
County and State: WORCESTER COUNTY
Stream: QUINAPOXET RIVER
Date of Inspection: 29 MAY 1980

BRIEF ASSESSMENT

Quinapoxet Reservoir Dam is approximately 1,050 feet long including the spillway and has a maximum height of approximately 45 feet. It consists of an earth embankment with riprap wave protection at the upstream face and a loamed and seeded crest and downstream face. The outlet works sluice gate operator stand is near the center of the dam and the spillway is near the right abutment of the dam. A low earth dike, approximately 370 ft. long, is located about 1,000 ft. south of dam.

The facility is considered to be in good condition. Evidence of minor seepage was observed on the downstream slope of the dam adjacent to the left wall of the spillway discharge channel.

Based on the size classification, intermediate, and hazard potential classiffcation, high, in accordance with Corps of Engineers Guidelines, the spillway test flood is the Probable Maximum Flood. Hydraulic analyses indicate that the routed test flood outflow of 12,000 cfs (inflow 12,900 cfs or 650 csm) could be passed with a freeboard of about 2.5 ft. and an unused surcharge-storage of about 785 acre-ft. remaining. The principal spillway capacity with water at top of dam is about 175 percent of the routed test flood outflow.

An investigation is recommended to evaluate the significance of the observed evidence of seepage relative to long-term embankment stability. Recommended remedial measures include the removal of brush from the dam and dike, the restoration and periodic reading of the existing piezometers, the replacement of a flashboard brace, the repairs of a wall joint and the resealing of other wall joints. The Owner should develop a formal maintenance program, operational procedure, and emergency procedures plan and should institute a program of biennial technical inspections. The remedial measures and recommendations should be performed as discussed in Section 7 within two years of receipt of this report by the Owner.

CAMP DRESSER & McKEE INC.

Roger H. Wood

Roger H. Wood
Vice President

This Phase I Inspection Report on Quinapoxet Reservoir 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.

RICHARD DIBUONO, MEMBER
Water Control Branch
Engineering Division

ARAMAST MAHTESIAN, MEMBER
Geotechnical Engineering Branch
Engineering Division

CARNEY M. TERZIAN, CHAIRMAN
Design Branch
Engineering Division

APPROVAL RECOMMENDED:

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 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 runoff), 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.

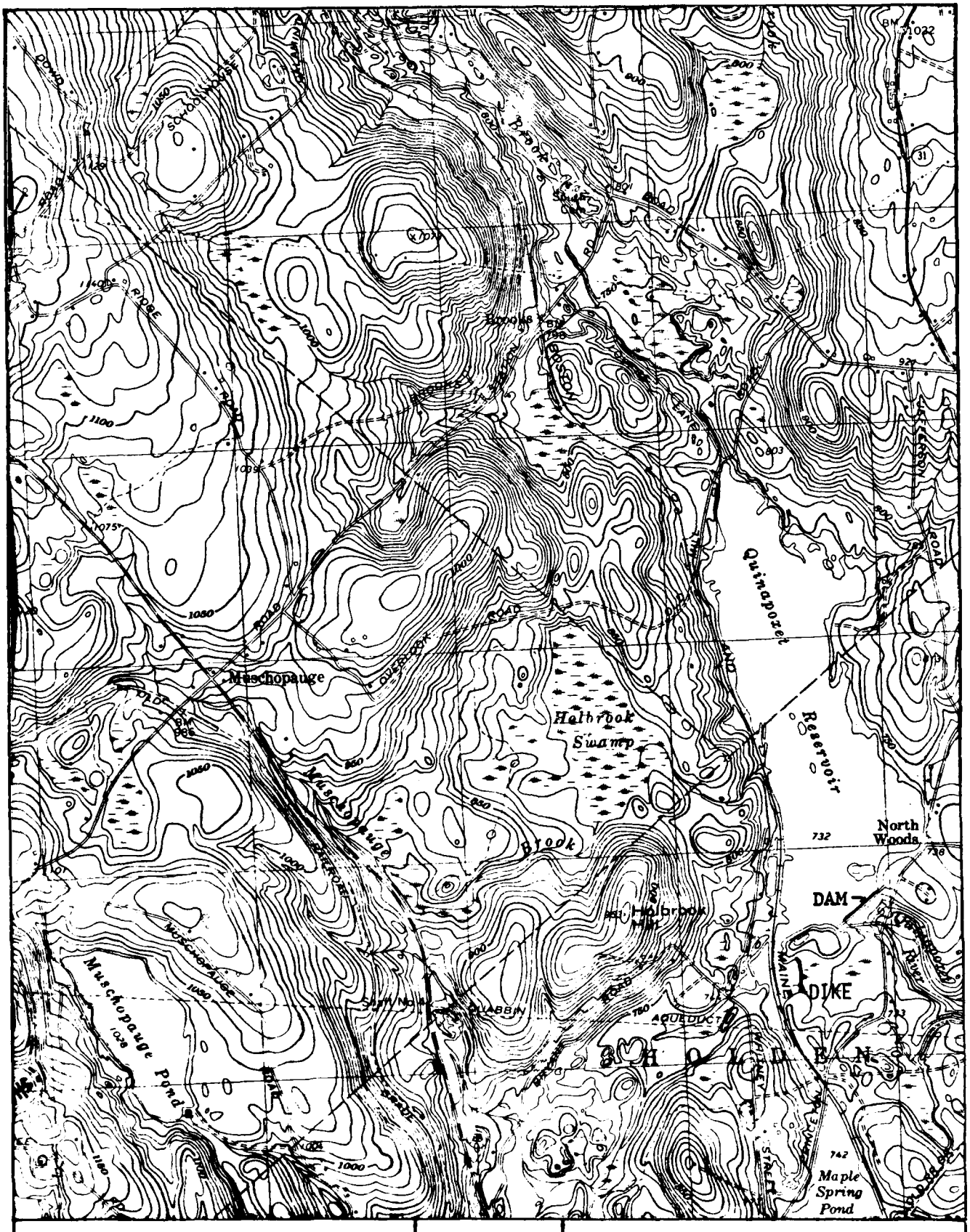
TABLE OF CONTENTS

Table of Contents (Cont'd)

APPENDIXES

1. OVERVIEW OF DAM FROM RIGHT ABUTMENT.

2. PROJECT PLAQUE.



DAM Quinapoxet Reservoir Dam

IDENTIFICATION NO. MA 00929

LOCATION MAP

USGS QUADRANGLE WASCHUSETT MTN.,MA

APPROX. SCALE: 1" = 2083'

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

QUINAPOXET RESERVOIR DAM
MA 00929

1.1 General

a. Authority - Public Law 92-367, 8 August 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.

Camp Dresser & McKee 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 was issued to Camp Dresser & McKee Inc. under a letter of 27 March 1979, from Colonel John P. Chandler, Corps of Engineers. Contract No. DACW 33-79-C-0053 has been assigned by the Corps of Engineers for this work. Contract Modification No. P0003, effective 2 May 1980 was subsequently issued by Colonel William E. Hodgson, Jr., Corps of Engineers. Haley and Aldrich, Inc. has been retained by Camp Dresser & McKee Inc. for the soils and geological portions of the work.

b. Purpose - The primary purpose of the investigation is 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 assist the States to initiate quickly effective dam safety programs for non-Federal dams.

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

1.2 Description of Project

a. Location - Quinapoxet Reservoir Dam is located on the west side of Princeton Street in the Town of Holden, Massachusetts, as shown on the report's Location Map. The northern half of the reservoir is located in the Town of Princeton, Massachusetts. The dam impounds the waters of South Wachusett Brook to form Quinapoxet Reservoir. The Quinapoxet River flows from the dam to the Wachusett Reservoir, a distance of approximately 7 miles. The coordinates for the dam are 71 degrees-52.8 minutes longitude and 42 degrees-23.3 minutes latitude.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations - No evidence of spillway or embankment instability was observed during the site examination. The apparent local seepage is not, at this time, considered significant with respect to embankment stability.

b. Design and Construction Data - Available documents include:

1) "Memorandum on Design of Dam Section" which summarizes stability and seepage analyses;

2) Plans and Specifications;

3) Construction Progress Reports;

4) a "Final Report" summarizing design and construction.

Based on a review of these records, it is considered that the spillway and embankments should have an adequate margin of safety under static conditions.

c. Operating Records - There are no known operating records, other than State and County inspection reports, to aid in evaluation of the stability of the facility. These reports give no indication of any instability.

d. Post Construction Changes - The original facility was modified by the addition of a stone jetty and reconstruction of the spillway flashboards in 1977. This construction is not considered significant relative to the stability of the facility. Also, the piezometers shown on the plans have apparently been cut off or covered.

e. Seismic Stability - Quinapoxet Reservoir is located within Seismic Zone 2 (a moderate risk area) and in accordance with recommended Corps of Engineers Guidelines, does not warrant seismic analysis.

f. Dam Failure Analysis - Based on the Corps of Engineers Guidelines for estimating Dam Failure Hydrographs, and assuming a failure would occur along 40 percent of the mid-height length with water at test flood stage, the dam failure outflow would be approximately 89,500 cfs. The project discharge prior to failure would be 12,000 cfs for a combined dam failure outflow of approximately 101,500 cfs. Flooding downstream of the dam prior to a dam failure due to the 12,000 cfs project discharge would overtop each roadway between the dam and Wachusett Reservoir by 1.5-ft. to 4-ft. depth. One house at State Route 31 would be flooded to about 2-ft. above its sill. As a result of a dam failure, substantial domestic development, including several roadways, would be affected with a resulting "high" hazard. In the area between the dam and State Route 31, Princeton Street and Mill Street would be overtopped by about 13 to 15 ft. One house near Princeton Street would be affected by about 4 ft. of water. About 22 houses would be affected near the Route 31 area. In the area around Wachusett River Street which is located about 3,000 ft. downstream of Route 31, another 14 houses would be affected. The street would be overtopped by about 25 ft. of water. Downstream of Wachusett River Street, one railroad embankment and another roadway would be affected before the flood wave would reach the Thomas Basin of the Wachusett Reservoir where the flood wave would attenuate.

is pumped about 2.5 miles from Quinapoxet Reservoir to Kendall Reservoir. The pumps are actuated manually based on water demand and water levels at other reservoirs within the City of Worcester's water supply system. An examination of available records indicated that the highest reservoir level was 0.7 ft. above spillway crest flashboards (El. 733.7 NGVD) on 23 March 1972 as a result of a total of 1.35 inches of rainfall in three days. On 24 January 1979 the reservoir level reached El. 733.5 or 0.5 ft. above spillway crest flashboards, as a result of 6.81 inches of rainfall in seven days. It was noted that about 15 to 25 MGD was being pumped from the reservoir during the period of 20 to 26 January 1979 while little to no water was pumped during March 1972. The August 1955 storm was a significant event in this region but there are no records available relative to the Quinapoxet Reservoir water level. Thus the highest recorded level is 733.7 which indicates a spillway discharge of about 375 cfs.

d. Visual Observations - The visual inspection of the dam was made on 29 May 1980. At the time, the reservoir level was at spillway crest. The freeboard at the dam was 7.0 ft. but only about 5.0 ft. at a natural swale located about 1,000 ft. to the left of the dam and about 5.5 ft. at the dike located about 1,000 ft. to the right of the dam. The spillway, chute and stilling basin were clear of debris. The outlet works sluice gate was closed and no leakage was oberserved. The Owner's representative opened and closed the sluice gate during the inspection of the dam to demonstrate its operability.

e. Test Flood Analysis - Based on the Corps of Engineers Guidelines, the recommended test flood for the size, intermediate, and hazard potential, high, is the PMF (Probable Maximum Flood). The test flood was estimated using the Corps of Engineers "Guidelines for Estimating Maxmimum Probable Discharge in Phase I Dam Safety Investigations". Based on the watershed terrain being undeveloped with moderate to flat slopes and significant upstream storage, a PMF peak inflow rate of 650 cfs per square mile was selected for the 19.85 sq. mi. drainage area. The resulting peak test flood inflow is approximately 12,900 cfs.

Assuming that the flashboards collapse at design reservoir surcharge elevation 734.0 (1-ft. depth over flashboards) the routed test flood outflow is 12,000 cfs at a stage of 737.5. Neither the dam, dike, or swale to the north of the dam would be overtopped. The depth of water over the spillway would be about 6.5 ft. with the flashboards collapsed. The spillway capacity at the test flood elevation is about 12,000 cfs or 100 percent of the routed test flood outflow. The drain capacity at top of flashboards (elevation 733.0) is approximately 430 cfs.

The tailwater analysis indicates that the downstream spillway channel has the hydraulic capacity to carry 12,000 cfs without overtopping its bank. However, the capacity of the bridge at Princeton Street is less than that of the spillway channel. A discharge of 12,000 cfs would overtop Princeton Street by about 2.2 ft. and would flood the toe of the dam by about 2.5 feet.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. General - Quinapoxet Reservoir Dam is an earth embankment located in Holden, Massachusetts and forming a water supply impoundment for the City of Worcester, Massachusetts. The impoundment is fed by South Wachusett Brook and discharges to the Quinapoxet River. The watershed is 19.85 square miles of undeveloped land with flat to moderate slopes and significant upstream storage. At the concrete spillway crest (El. 731.0 NGVD) the reservoir storage is about 3,424 acre-feet, increasing to 6,174 acre-feet at the top of the dam (El. 740.0 NGVD). The 200 ft. long spillway has facilities for 2 feet of flashboards which are always in place. The length of the dam, including the spillway, is about 1,050 ft. and the overall height of the dam is about 45 ft. The reservoir drain is a 4-ft. square reinforced concrete conduit located near the center of the dam and controlled from a gate operator on its crest. The dam is basically a high spillage-low surcharge project.

b. Design Data - The following hydraulic/hydrologic design data for the dam was obtained from the 14 September 1953 final report on "The Construction of Quinapoxet Reservoir and Appurtenances" by Metcalf and Eddy Engineers, 50 Staniford Street, Boston, MA 02114.

Drainage Area	19.85 sq.mi.
Reservoir capacity	1,200 mil. gal.
Water surface area	285 acres
Spillway length	200 ft.
Spillway crest elev.	El. 731
Height of flashboards	2 ft.
Water surface on collapse of flashboards	El. 734
Design flood at spillway	3,300 Sec. - ft
Design flood per sq.mi. of drainage area	240 Sec. - ft.

c. Experience Data - The City of Worcester maintains a record of water levels at the Quinapoxet Reservoir. However, it is difficult to correlate rainfall to spillway discharge because water

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures - Water levels are recorded daily and the pumping rates from the reservoir are adjusted accordingly to minimize spillage from the reservoir to the Quinapoxet River.

4.2 Maintenance of the Dam - There is no established formal maintenance program for this dam. The operator indicated that maintenance is performed on a demand basis. The grass on the slopes is cut once per year and twice per year on the flat areas. The condition of the dike indicates that this structure is not included in this program.

4.3 Maintenance of Operating Facilities - Two feet of flashboards are maintained year round on the spillway. The reservoir drain is kept normally closed. The gate operator is cranked and greased annually to insure it is kept operable.

4.4 Description of Any Warning System in Effect - There is no established warning system or emergency preparedness plan in effect for this structure.

4.5 Evaluation - The dam is currently being operated on a routine basis and maintenance is being performed on the basis of need. The dike should be added to the maintenance work being performed.

The procedures being employed should be compiled in writing and expanded where necessary for ready reference by the operating personnel. It should also contain provisions for the biennial technical inspection of the dam, an emergency preparedness plan and the details of operation of a warning system.

c. Appurtenant Structures

(1) The outlet works is in good condition. The sluice gate was opened slightly during the site examination and then closed as shown in Photos 11 and 12.

(2) The dike is also in good condition with no observed evidence of embankment settlement, lateral movement or other major deficiencies. The dike however is covered by tall grass, weeds and a significant amount of brush and small trees as shown in Photos 13 and 14.

d. Reservoir area - The Quinapoxet Reservoir is surrounded by moderately sloped hills which are heavily forested. The shore line of the pond is undeveloped and no structures would be affected by the test flood surcharge.

The side slopes to the pond are moderate and there appears to be no significant potential for landslides into the pond which would create waves that might overtop the dam. No conditions were noted that could result in a sudden increase in sediment load into the pond.

e. Downstream Channel - The Quinapoxet River flows from the dam on a moderate slope to the Wachusett Reservoir. The river crosses a pocket of development around the State Route 31 area, but otherwise flows through undeveloped land.

3.2 Evaluation - The dam, dike and appurtenant structures are considered to be in good condition, based on the visual examination. The evidence of seepage noted on the downstream slope of the dam is not considered serious at this time. However, changes in the quantity or pattern of seepage could be significant relative to the performance of the dam embankment.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General - The Phase I visual examination of Quinapoxet Reservoir Dam was conducted on 29 May 1980.

In general, the earthen embankments, spillway and outlet works were observed to be in good condition. The reservoir level at the time of the site examination was at the top of flashboards Elev. 733.0.

Visual inspection checklists for the site visit are included in Appendix A, prior inspection reports in Appendix B, and selected photographs in Appendix C.

b. Dam - The dam and spillway, Photos 1, 8 and 9 appear to be in generally good condition, based on the visual site examination. No evidence of embankment settlement, lateral movement or other major deficiencies was observed. The following specific items were noted:

(1) The crest and downstream slope of the dam have good grass cover as shown in Photos 3 and 4. Some brush and small trees are present in the riprap along the upstream slope as shown in Photo 5.

(2) A small amount of clear seepage flow (perhaps 1 to 2 gpm) was observed at the base of the riprapped slope, on the left side, just below the end of the spillway stilling basin as shown in Photo 10. This flow is assumed to be from the blanket drain system.

(3) A wet area was observed on the downstream slope of the dam, just below the berm about mid-height and adjacent to the spillway left channel wall. The seepage appears to originate near the location of piezometer P-2 as shown on Sheet 4 of the contract drawings (see Appendix B), although the piezometer itself was not found. The wet area extends roughly 50 ft. along the spillway channel to a point where the seepage flows over the channel wall.

(4) No piezometers were found on the dam embankment.

(5) One of the flashboard braces near the right end of the spillway is missing as shown in the foreground of Photo 7.

(6) The side wall joint immediately downstream of the spillway weir at its right end is exhibiting structural distress in the form of cracking, as shown in Photo 6. The sealant at other joints in the spillway side channel, chute and stilling basin is in need of renewal.

SECTION 2: ENGINEERING DATA

2.1 Design Records - Design records in the form of construction plans and a final construction report dated September 14, 1953 by Metcalf & Eddy were located. Plans and specifications for Restoration of the Spillway Flashboards and Construction of a Stone Jetty in 1977 were also located.

2.2 Construction Records - A final construction report described above is available.

2.3 Operational Records - The City of Worcester maintains records on rainfall, pumpage from the reservoir, and reservoir water levels. Inspection reports by the County and the Division of Waterways, State of Massachusetts, were also located and are included in Appendix B.

2.4 Evaluation

a. Availability - The construction plans, final construction report and reservoir operation records are available at the City of Worcester DPW Building, 20 E. Worcester St., Worcester, MA.

b. Validity - The available data was in good agreement with conditions observed during the site examination.

c. Adequacy - The available data, in combination with the visual evaluation described in the following section, is adequate for the purpose of the Phase I investigation.

i. Spillway

(1) Type.....Broad crested side discharge spillway with flashboards, chute and stilling basin

(2) Length of weir.....200 ft.

(3) Crest elevation a) with flashboards.....733.0

b) without flashboards.....731.0

(4) Gates.....None

(5) U/S Channel.....Quinapoxet Reservoir

(6) D/S Channel.....Concrete Rectangular channel with varying slope, width and side depth. A 40-ft. long, 8 ft. high concrete impact wall with a 5-ft. V-notch drain forms a stilling basin followed by a riprapped basin prior to the beginning of the Quinapoxet River's natural channel.

j. Regulating Outlets

(1) Invert: U/S.....702.0

D/S.....698.4

(2) Size: Box Culvert.....4-ft. by 4-ft.

Length..... 310-ft.

(3) Description.....Reinforced concrete box culvert located near the center of the dam.

(4) Control Mechanism.....Manually operated Sluice gate (4-ft. sq.) with operator stand at crest of dam.

(5) Other.....6" dia. gated bypass around sluice gate

(2) Flood control pool.....N/A

(3) Spillway crest pool.....3,424

(4) Top of dam.....6,174

(5) Test flood pool.....5,389

f. Reservoir Surface (acres)

(1) Normal pool.....285

(2) Flood-control pool.....N/A

(3) Spillway crest.....267

(4) Top of dam.....343

(5) Test flood pool.....322

g. Embankments

	Dam	Dike
(1) Type	Zoned earth Embankment	Earth Embankment
(2) Length	1050 ft.	370 ft.
(3) Height	45 ft.	7 ft.
(4) Top width	20 ft.	20 ft.
(5) Side Slopes, Upstream	2H to 1V (upper) 2.5H to 1V (lower)	3H to 1V
Downstream	2H to 1V	3H to 1V
(6) Zoning	"Impervious" core with "pervious" shells	None
(7) Impervious Core	Compacted Glacial Till	None
(8) Cutoff	Core extends to rock	None
(9) Grout curtain	None	None

h. Diversion and Regulating Tunnel.....None

(5) Gated spillway capacity at normal pool elevation.....N/A

(6) Gated spillway capacity at test flood elevation.....N/A

(7) Total spillway capacity at test flood elevation: 12,000 cfs @ 737.5 elev.

(8) Total Project discharge at test flood elevation: 12,000 cfs @ 737.5 elev.

c. Elevation (ft. above NGVD)

(1) Streambed at centerline of dam.....695.0

(2) Test flood tailwater.....709.7

(3) Upstream portal invert diversion tunnel.....N/A

(4) Normal pool.....733.0

(5) Full flood control pool.....N/A

(6) Spillway crest a. with flashboards.....733.0

b. without flashboards.....731.0

(7) Design surcharge (Original Design).....Unknown

(8) Top of dam.....740.0

(9) Test flood surcharge.....737.5

d. Length of Reservoir (miles estimated)

(1) Normal pool.....1.4

(2) Flood control pool.....N/A

(3) Spillway crest pool.....1.2

(4) Top of dam.....1.7

(5) Test flood pool.....1.6

e. Storage (acre-feet)

(1) Normal pool.....3,976

i. Normal Operating Procedure - Maintenance at the dam is performed on a routine basis. There is a caretaker permanently assigned to the City of Worcester's reservoir system who is responsible for the operation and maintenance of the facility. The grass is cut at least once a year and the outlet works manual sluice gate operator is greased and tested each year. Two feet of flashboards are maintained on the spillway crest year round and require no adjustment. A pump station, located on the west bank of the reservoir, is manually regulated to optimize pumpage from Quinapoxet Reservoir to Kendall Reservoir and thus into the City of Worcester's water distribution system.

1.3 Pertinent Data

Elevations given in this report are on National Geodetic Vertical Datum (NGVD) formerly referred to as Mean Sea Level.

a. Drainage Area - The drainage area tributary to the dam site is 19.85 square miles. The watershed is flat and undeveloped except for some scattered houses. The undeveloped land is heavily forested with swampy areas throughout. Muschopauge Pond, which is part of the Quinapoxet Reservoir drainage area, is used as a water supply to the Towns of Rutland and Holden. The Quinapoxet Reservoir accounts for approximately 2 percentage of the total drainage area.

b. Discharge at Dam Site - The City of Worcester takes daily readings of the reservoir water level together with daily pumping rates from the reservoir and daily readings of precipitation. An examination of these records indicates that the reservoir level is kept at top of flashboards (El. 733.0.NGVD) or below, even during periods of high precipitation. The highest recorded reservoir level is El. 733.7, occuring on 23 March 1972, apparently as a result of all other City of Worcester reservoirs being full at the time so that no pumpage was occurring. The precipitation for the period of 21 to 23 March 1972 was 1.35-inches. A reservoir level of El. 733.7 would result in an estimated discharge of 375 cfs.

(1) Outlet works size: 4-ft. by 4-ft. reinforced concrete box culvert. Discharge capacity at top of flashboards is approximately 430 cfs.

(2) Maximum known flood at damsite: 375 cfs (Est.) on 23 March 1972.

(3) Ungated spillway capacity at top of dam: 21,000 cfs @ 740 elev.

(4) Ungated spillway capacity at test flood elevation: 12,000 cfs @ 737.5 elev.

lined circular basin under the masonry Princeton Street Bridge and into the original Quinapoxet River bed.

The outlet works consist of a 4-ft. by 4-ft. reinforced concrete box culvert which extends 310-ft. from its intake structure, through a sluice gate chamber, to the spillway stilling basin. The sluice gate chamber and manual gate operator are located near the center of the dam. A gated 6-in. diameter sluice gate bypass is located at the invert of the gate chamber which may be used to maintain a flow in the Quinapoxet River when the reservoir level is below spillway crest and the sluice gate is closed. The outlet works' intake is a reinforced concrete special structure which incorporates a flared inlet with provision for stoplogs.

c. Size Classification - The maximum height of the dam is approximately 45 feet and the estimated total storage capacity at the top of the dam is 6,174 acre-feet. According to guidelines established by the Corps of Engineers, the dam is classified in the intermediate category based on both storage capacity and height.

d. Hazard Classification - The results of the dam failure analysis indicate that about 35 homes would be affected by water depths of 1 to 15 ft. and the potential loss of life would be in excess of 10 persons. Consequently, the dam is classified in the "high" hazard category.

e. Ownership - The dam is owned by the City of Worcester. The owner is represented by Mr. Richard Grant, Assistant Commissioner of Public Works, 20 East Worcester Street, Worcester, MA 01608, tel. (617) 798-8151.

f. Operator - Mr. Kenneth Starbard is assigned responsibility for operation of the dam. His business address is Kendall Reservoir, South Road, Holden, MA 01520, tel. (617) 829-4811.

g. Purpose of the Dam - Quinapoxet Reservoir Dam provides for water supply storage to the City of Worcester. Water from the Quinapoxet Reservoir is pumped to Kendall Reservoir and eventually to the City of Worcester water distribution system. The water which discharges over the spillway enters the Quinapoxet River and becomes part of the Metropolitan District Commission's Water Supply through the Wachusett Reservoir.

h. Design and Construction History - The dam was designed in 1952 and was essentially complete by mid-July 1953. Impoundment of water was started on 6 July 1953. The original facility was modified by the addition of a stone jetty and reconstruction of spillway flashboards in 1977. According to Worcester County records a former dam located approximately 2,400-ft. upstream of the site of the existing facility and which impounded only South Wachusett Brook to form Quinapoxet Pond was destroyed by City on 1 August 1952.

b. Description of Dam and Appurtenances - Quinapoxet Reservoir Dam consists of a zoned earth embankment, with an outlet conduit extending beneath the center of the dam and a concrete spillway structure located at the right abutment. There is also a low earth dike extending across a natural saddle, roughly 1,000 ft. beyond the right abutment of the main dam. The general layout of the dam, dike and appurtenant structures is shown on the location plan included in Appendix C.

The embankment is about 1,050 ft. long (including spillway), has a maximum height of 45 ft., and is 20 ft. wide at the crest. The grass-covered downstream slope is 2H to 1V, with a 6-ft. wide berm at mid-height. The upstream slope is 2H to 1V near the crest and flattens to 2-1/2H to 1V, 17 ft. below the crest. Riprap wave protection extends to the crest on the upstream side.

The embankment consists of two zones. The central core zone consists of compacted impervious glacial till which extends to bedrock. The other zone consists of upstream and downstream shells which are composed of clean, well-graded gravel with a sand binder. Sheet 10A of 18 of the contract drawings (included in Appendix B) shows the embankment section as described in the Designer's Final Report. It should be noted that embankment sections on other sheets show a zone of "random material" which was not actually placed. Also, the Designer's Final Report states that excess material from the spillway excavation was spread on the upstream toe.

A horizontal blanket drain is located beneath the downstream portion of the embankment and extends downstream from the middle section of the dam. The drain consists of layers of "selected pervious material" and "washed stone", with a system of collector pipes which discharge collected seepage near the downstream end of the spillway channel. According to available plans, eight (8) piezometers were installed during the original construction to monitor seepage conditions within the embankment.

The dike is a homogeneous earth embankment 370 ft. long, 7 ft. high, and 20 ft. wide at the crest. Side slopes are 3H to 1V upstream and downstream. The dike slopes are grass and brush covered, with no riprap.

The 200 ft. long concrete spillway consists of a 4 ft. wide horizontal crest with a 4H to 1V sloped riprap upstream face and a 2.8H to 1V sloped concrete downstream face. Two feet of flashboards are maintained on the crest of the dam year round. The flashboards consist of eight (8), 25-ft. long hinged sections which are held in place by special bolts designed to fail when the reservoir has a side channel discharge which conveys the flow to an 8-ft. high, 25' wide channel chute and then to a stilling basin. The stilling basin varies in width from 25 to 40 feet and has side wall heights of up to 20 feet at the end. The stilling basin is formed by a concrete impact wall which incorporates a v-notch drain designed to prevent the formation of ice within the stilling basin. Flow from the stilling basin is channeled by a riprapped

SECTION 7: ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition - Based on the visual examination and review of available records, the dam is considered to be in good condition. While some evidence of local seepage was noted, no conditions which would require urgent remedial action were observed.

b. Adequacy of Information - The evaluation of the dam has been based on the visual examination, consideration of available documents and past performance, and application of engineering judgement. Generally, the information available or obtained has been adequate for the purposes of the Phase I assessment. However, it is recommended that additional information relative to embankment seepage be obtained as outlined in Section 7.2.

c. Urgency - The recommendations for an additional investigation and remedial measures, outlined in Sections 7.2 and 7.3, respectively, should be undertaken by the Owner within two years after receipt of this report.

7.2 Recommendations

It is recommended that the Owner arrange for the following investigation to be performed by a registered professional engineer experienced in dam design and construction:

1) Evaluate the significance of the observed evidence of seepage relative to long-term embankment stability, and assess the need for corrective action. Piezometers should be located and restored to service where possible. Criteria should be established for monitoring of restored piezometers by the Owner. The Owner should implement corrective action as required, based on the results of the evaluation.

7.3 Remedial Measures

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

(1) Remove brush from dam and dike. Mow both embankments at least once a year to permit visual inspection.

(2) Periodic readings should be made on any piezometers that can be restored. This data would provide a useful check of embankment and drainage system performance.

(3) Replace the missing flashboard brace near the right end of the spillway weir.

(4) Repair the cracked wall joint immediately downstream of the right end of the spillway weir and reseal other joints in the spillway, chute and stilling basin walls.

(5) Establish a formal maintenance program and operational procedures for the dam.

(6) Prepare a formal emergency procedures plan and warning system in cooperation with downstream officials and institute a program of biennial technical inspections.

7.4 Alternatives - There are no practical alternatives recommended.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION PARTY ORGANIZATION

NATIONAL DAM INSPECTION PROGRAM

DAM: Quinapoxet Reservoir Dam

DATE: 29 May 1980

TIME: 1:00 PM

WEATHER: Sunny

WATER SURFACE ELEVATION UPSTREAM: 333 (NGVD)

STREAM FLOW: Minor (wave action and some leakage through flashboards)

INSPECTION PARTY:

1. Roger H. Wood, CDM
2. Joseph E. Downing, CDM
3. Joseph R. Araujo, CDM
4. Douglas G. Gifford, H&A
5. John Critchfield, H&A

PROJECT FEATURE	INSPECTED BY	REMARKS
1. Structural/Operations	Roger Wood	
2. Hydraulics/Hydrology	Joseph Downing and Joseph Araujo	
3. Embankments	Douglas Gifford and John Critchfield	
4.		

PRESENT DURING INSPECTION:

1. Bruce Blanchard, Owner Representative & Operator
2.
3.

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Quinapoxet Reservoir Dam DATE: 29 May 1980
EMBANKMENT: DAM

CHECK LIST	CONDITION
1. Upstream Slope	1.
a. Vegetation	a. Few saplings among riprap stones.
b. Sloughing or Erosion	b. None apparent.
c. Rock Slope Protection - Riprap Failures	c. Riprap (cobbles to 2 ft. stones) extends to crest. Good condition.
d. Animal Burrows	d. None observed.
2. Crest	2.
a. Vegetation	a. Grass.
b. Sloughing or Erosion	b. None observed.
c. Surface cracks	c. None observed.
d. Movement or Settlement	d. None apparent.
3. Downstream Slope	3.
a. Vegetation	a. Grass.
b. Sloughing or Erosion	b. None observed.
c. Surface Cracks	c. None observed.
d. Animal Burrows	d. None observed.
e. Movement or Cracking near toe	e. None apparent.
f. Unusual Embankment or Downstream Seepage	f. Noted wet area below berm, near spillway. Wet and soggy, no apparent flow. Spillway wall also wet.
g. Piping or Boils	g. None observed.
h. Foundation Drainage Features	h,i D/S drainage blanket with collection pipe.
i. Toe Drains	
4. General	4.
a. Lateral Movement	a. None apparent.
b. Vertical Alignment	b. Crest appears level except slightly higher near gate valve.
c. Horizontal Alignment	c. Good.
d. Condition at Abutments and at Structures	d. Apparent lateral movement of retaining wall at right end of spillway, with associated backfill settlement.
e. Indications of Movement of Structural Items	e. See 4d.
f. Trespassing	f. Infrequent, locked gate.
g. Instrumentation Systems	g. Piezometers shown on plan but not located in field.

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Quinapoxet Reservoir Dam DATE: 29 May 1980
EMBANKMENT: DIKE

CHECK LIST	CONDITION
1. Upstream Slope	1.
a. Vegetation	a. Grass, weeds, brush.
b. Sloughing or Erosion	b. None apparent.
c. Rock Slope Protection - Riprap Failures	c. No riprap.
d. Animal Burrows	d. None observed.
2. Crest	2.
a. Vegetation	a. Grass, weeds, brush.
b. Sloughing or Erosion	b. None observed.
c. Surface cracks	c. None observed.
d. Movement or Settlement	d. None apparent.
3. Downstream Slope	3.
a. Vegetation	a. Brush and trees.
b. Sloughing or Erosion	b. None observed.
c. Surface Cracks	c. None observed.
d. Animal Burrows	d. None observed.
e. Movement or Cracking near toe	e. None apparent.
f. Unusual Embankment or Downstream Seepage	f. Swampy area downstream.
g. Piping or Boils	g. None observed.
h. Foundation Drainage Features	h. None.
i. Toe Drains	i. None.
4. General	4.
a. Lateral Movement	a. None apparent.
b. Vertical Alignment	b. Good.
c. Horizontal Alignment	c. Good.
d. Condition at Abutments and at Structures	d. Good.
e. Indications of Movement of Structural Items	e. No structural items.
f. Trespassing	f. Infrequent.
g. Instrumentation Systems	g. None

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Quinapoxet Reservoir Dam DATE: 29 May 1980

SPILLWAY: _____

CHECK LIST	CONDITION
1. Approach Channel	1.
a. General Condition	a. Good condition.
b. Obstructions	b. None.
c. Log Boom etc.	c. None observed.
2. Weir	2.
a. Flashboards	a. Two feet, brace at right end missing.
b. Weir Elev. Control (Gate)	b. Flashboards only.
c. Vegetation	c. None observed.
d. Seepage or Efflorescence	d. Flow precludes evaluation.
e. Rust or Stains	e. Flow precludes evaluation.
f. Cracks	f. None observed.
g. Condition of Joints	g. Flow precludes evaluation.
h. Spalls, Voids or Erosion	h. Flow precludes evaluation.
i. Visible Reinforcement	i. None observed.
j. General Struct. Condition	j. Good.
3. Discharge Channel	3.
a. Apron	a. Good condition.
b. Stilling Basin	b. Good condition.
c. Channel Floor	c. Good conditon.
d. Vegetation	d. None observed.
e. Seepage	e. None observed.
f. Obstructions	f. All structures clear.
g. General Struct. Condition	g. Good.
4. Walls	4.
a. Wall Location _____	a. All Spillway Walls
(1) Vegetation	(1) No major condition observed.
(2) Seepage or Efflorescence	(2) Efflorescence right side intake wall.
(3) Rust or Stains	(3) None observed.
(4) Cracks	(4) Cracked joint right side D/S of weir. Possible diagonal cracks right side U/S of weir.
(5) Condition of Joints	(5) See (4), a number of joints have no sealant.
(6) Spalls, Voids or Erosion	(6) See (4) for spalls, no major erosion.
(7) Visible Reinforcement	(7) None observed.
(8) General Struct. Condition	(8) Good.

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Quinapoxet Reservoir Dam DATE: 29 May 1980
OUTLET WORKS: _____

CHECK LIST	CONDITION
1. Inlet	1. Not visible, under water.
a. Obstructions	
b. Channel	
c. Structure	
d. Screens	
e. Stop Logs	
f. Gates	
2. Control Facility	2.
a. Structure	a. Visible portion in good condition.
b. Screens	b. None observed.
c. Stop Logs	c. None observed.
d. Gates	d. Manual, operational.
e. Conduit	e. Not visible.
f. Seepage or Leaks	f. None observed.
3. Outlet	3.
a. Structure	a. Opening in stilling basin wall, good condition.
b. Erosion or Cavitation	b. None observed.
c. Obstructions	c. None observed.
d. Seepage or Leaks	d. None observed.
4. Mechanical and Electrical	4.
a. Crane Hoist	a. Not applicable.
b. Hydraulic System	b. Not applicable.
c. Service Power	c. Manually operated.
d. Emergency Power	d. Not applicable.
e. Lighting	e. Not applicable.
f. Lightning Protection	f. Not applicable.
5. Other	

APPENDIX B

ENGINEERING DATA

* Inspection Reports on former dam located upstream of existing facility are included for their historic and hydrologic content.

LIST OF DOCUMENTS

QUINAPOXET RESERVOIR

DOCUMENT	LOCATION
1. Complete Set of Design Drawings, and a Final Construction Report.	Metcalf & Eddy Engineers 54 Staniford Street Boston, MA
2. Design Drawings, Final Construction Report, and Operating Records.	City of Worcester DPW Building 20 E. Worcester Street Worcester, MA 01608
3. Design Drawings and Monthly Construction Reports.	Worcester County County Court House Worcester, MA
4. Plans and Specifications for Restoration of Spillway Flashboards and Construction of a Stone Jetty in 1977.	Coffin & Richardson 141 Milk Street Boston, MA 02109

LOCATION Near Princeton T.L. - Quinapoxet Pond - Near Princeton St. C. C. DOCKET NO.

DESCRIPTION OF DAM

Type	Earth - Impervious Fill Core
Length	1100'±
Height	35'± Max. Top Elev. 740
Thickness top	20'
" bottom	180'± Max.
Downstream Slope	2:1
Upstream "	2:1 and 2½:1 below elev. 723
Length of Spillway	200' Top Elev. 734
Size of Gates	4'x4' Drain Conduit
Location of Gates	Approx. center of Dam
Flashboards used	2' Height
Width Flashboards or Gates	200'
Dam designed by	Metcalf & Eddy consulting engrs Boston
" constructed by	Coleman Bros. Corp.
Year constructed	1952-1953

GENERAL REMARKS

Owned by City of Worcester Water Dept.

DESCRIPTION OF RESERVOIR & WATERSHED

Name of Main Stream	Quinapoxet River
" " any other Streams	Muschopoxet Br. - Maynard Br. - South Wachusett Br. - Brook from Mark Spring Rod
Length of Watershed	
Width " "	
Is Watershed Cultivated	
Percent in Forests	
Steepness of Slope	
Kind of Soil	
No. of Acres in Watershed	19.85 Sq. Mi. 20.7 Sq. M
" " " " Reservoir	Water Surface 280 Acres
Length of Reservoir	Capacity 1200 Million Gallons
Width " "	
Max Flow Cu. Ft. per Sec.	
Head or Flashboards-Low Water	
" " " -High "	

GENERAL REMARKS

2-Library Bureau 16-2858

TOWN OR CITY Holden DECREE NO. PLAN NO. 1938 Flood DAM NO. 21-10

LOCATION Near Princeton T.L. - Quinapoxet Pond - Near Princeton St. C. DOCKET NO.

DESCRIPTION OF DAM

Type	Earth - Dry Walls - Stone Apron - Elev
Length	300'±
Height	8'±
Thickness top	8'±
" bottom	16'±
Downstream Slope	Vertical
Upstream "	1½:1
Length of Spillway	Depth = 3'5 Length = 60'±
Size of Gates	None
Location of Gates	
Flashboards used	Yes
Width Flashboards or Gates	8"
Dam designed by	
" constructed by	
Year constructed	

GENERAL REMARKS

Owned by Walker, Ice Co., Worcester. Coal &

Inspected: Dec. 7, 1928 - L.O. Marden.
" Aug. 24 1932 - " "
" Mar. 26 1937 - W. O. Lindquist
" Oct. 5, 1938 - L. H. Spofford
Patrol Meas Mar. 27, 1939 " "

DESCRIPTION OF RESERVOIR & WATERSHED

Name of Main Stream	South Wachusett Brook
" " any other Streams,	
Length of Watershed	
Width " "	
Is Watershed Cultivated	
Percent in Forests	
Steepness of Slope	
Kind of Soil	
No. of Acres in Watershed	
" " " " Reservoir	80.
Length of Reservoir	
Width " "	
Max Flow Cu. Ft. per Sec.	
Head or Flashboards-Low Water	
" " " -High "	

See other Card for new Dam 21-10

GENERAL REMARKS

1942± City of Worcester Water Dept
Inspected: Nov. 18, 1947 - E. Perry Hardy - LOM

Old Dam 21-10 destroyed by City of Worcester Aug. 1, 1952, and number was given to New Dam downstream from old site.

2-Library Bureau 16-2858

discharge of 12,000 cfs would overtop Princeton Street by about 2.2 ft. and would flood the toe of the dam by about 2.5 feet.

COUNTY OF WORCESTER MASSACHUSETTS

COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Inspected by W. O. Lindquist Date 3-27-37 Dam No. 21-10

Town Holden Location Quinapoxet Pond

Owner Use

Material and Type

Dam Designed by Constructed by Year

SPILLWAY—Length Feet. Depth Feet

El. top Abutment El. Crest El. Apron El. Streambed

Width top Abutment Width top Crest Width bottom Spillway

Width Flashboards carried Kind Flashboards

El. Flowline Cleanout Pipe Size and Kind Cleanout Pipe

Kind of Foundation under Spillway

Condition 1 flashboard on at present time. Logs and old rowboats partly blocking flow of water. Large cracks easterly abutment wall.

EMBANKMENT—Length overall Feet

El. Top El. Natural Ground Width Top

Width of Bottom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition 2 washouts should be filled in No leaks evident. Fair condition.

GATES Location

Size Kind El. Flowline

Condition Open at present.

WHEEL Kind Size Rated H. P.

Location Ave. Head

Evidence of Leaks in Structure

Recent Repairs and Date

Topography of Country below Dam

Nature of Buildings and Roads below Dam

Number of Acres in Pond Drainage Area in Square Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

WORCESTER COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs

nspected by L. H. Spofford Date 10-5-38 Dam No. 21-10

'own Holden Location Quinapoxet Lake

)wner Walker Ice Co. Use Impounding

Earth embankment, faced with concrete stone masonry on pond side.
SPILLWAY 70' wide with rock apron. Remains of few flashboard, catwalk
El.top abutment El.Crest El.Apron El.St.Bed stayed

Width top Abut. Width top Crest Width bottom Sp.way

Width flashboards Kind Flashboards

El.Flowline Cleanout Pipe Size and Kind Pipe

Kind of Foundation under Spillway

Condition High water mark was approximately 4'6" over crest of spillway.

EMBANKMENT

El. Top El.Natural Ground Width Top

Width of Borrom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition 1 washout about 2 ft. deep x 12' long east end. 1 washout about 1½ ft. deep x 10 ft. west end (washed out in 1936 and not repaired)

GATES Location

Size Kind El.Flowline

Condition Evidence that flood topped the embankment about a foot where washout occurred.

Evidence of Leaks in Structure

Recent Repairs and Date

Number Acres in Pond Drainage Area in Sq. Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

WORCESTER COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs

Inspected by L. H. Spafford Date Mar 27/39 Dam No. 21-10

Town Holden Location Dimaprel Lake

Owner Walker Ice Co. Use Surrounding

SPILLWAY

El.top abutment ____ El.Crest ____ El.Apron ____ El.Ct.Bed ____

Width top Abut. ____ Width top Crest ____ Width bottom Sp.way ____

Width flashboards 6" top log Kind Flashboards ____

El.Flowline Cleanout Pipe ____ Size and Kind Pipe ____

Kind of Foundation under Spillway ____

Condition Fair - Concrete abutments have been cracked but no great hazard.

EMBANKMENT

El. Top ____ El.Natural Ground ____ Width Top ____

Width of Borrom ____ Upstream Slope ____ Downstream Slope ____

Kind of Corewall ____ Riprap ____

Material in Embankment Earth Foundation ____

Condition Poor - no repairs have been made to washouts since Sept 1938 flood - see October 1938 inspection.

GATES Draw-off gate gone Location East end of spillway

Size 3' wide x 3½' deep opening Kind ____ El.Flowline ____

Condition Water is running thru opening about 3' deep - opening must be partially plugged up.

Evidence of Leaks in Structure Note:- on account of 5" of water going over spillway on this date

Recent Repairs and Date None See last inspection for H W mark.

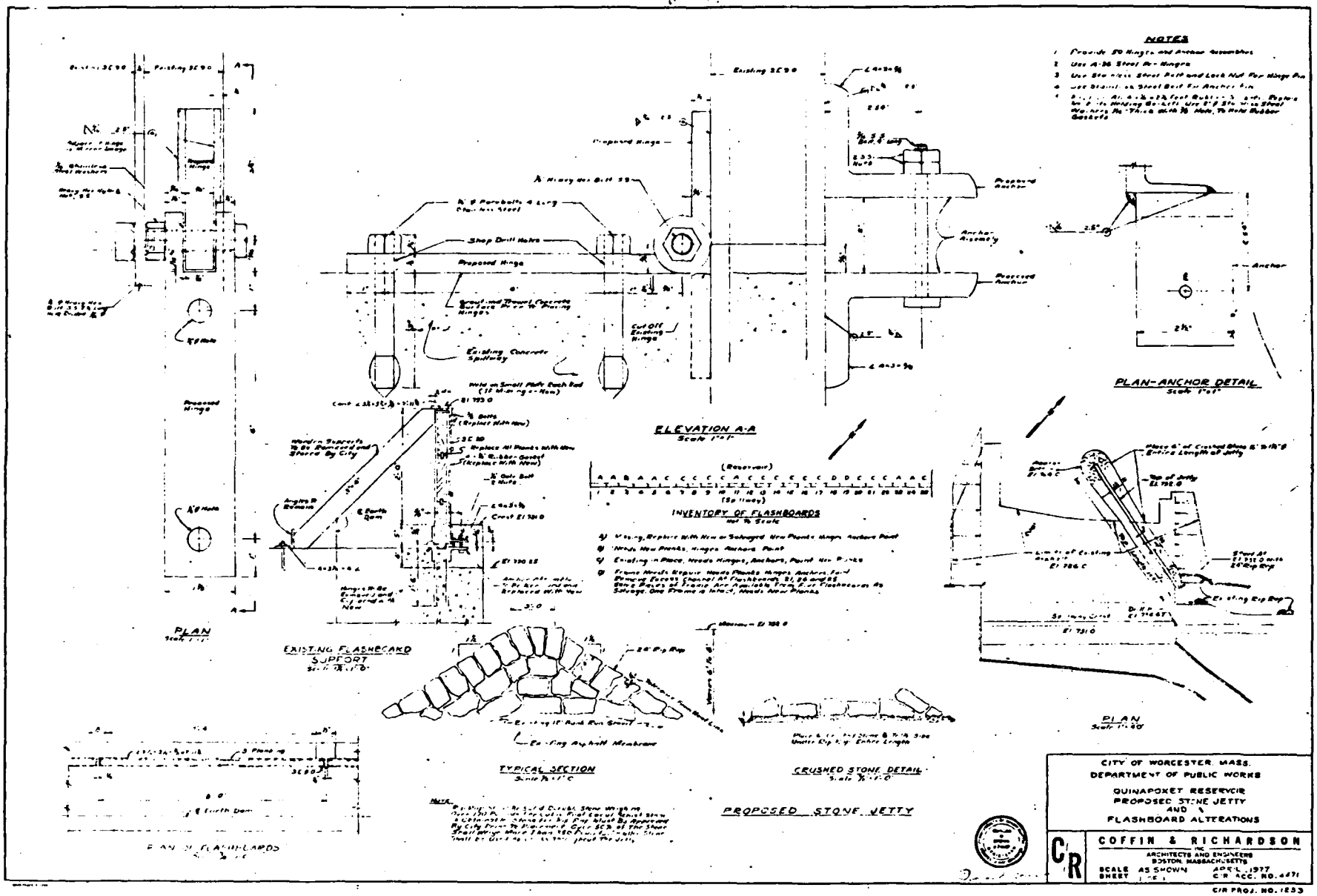
Number Acres in Pond ____ Drainage Area in Sq. Miles ____

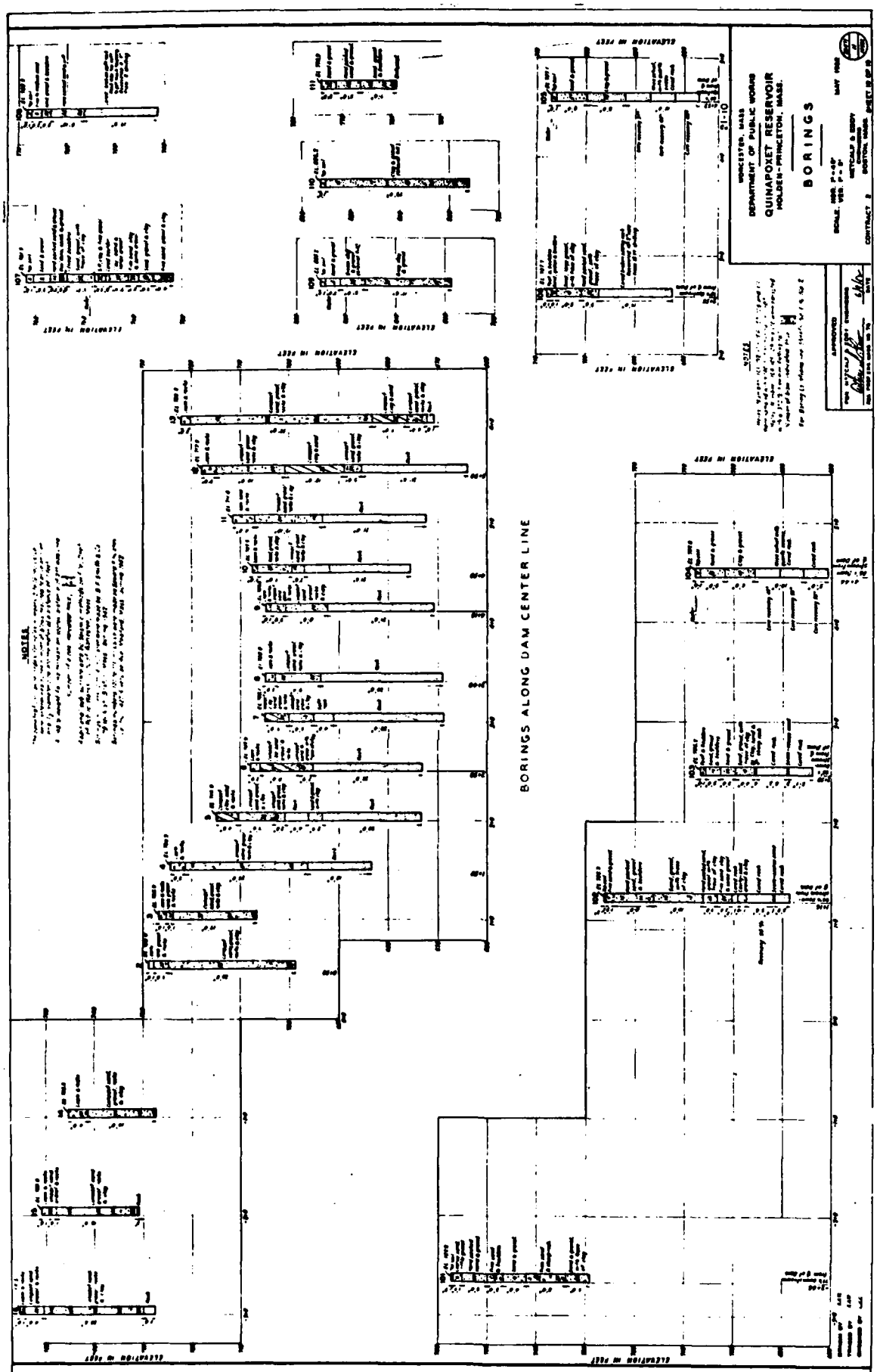
Discharge in Second Feet per Square Mile ____

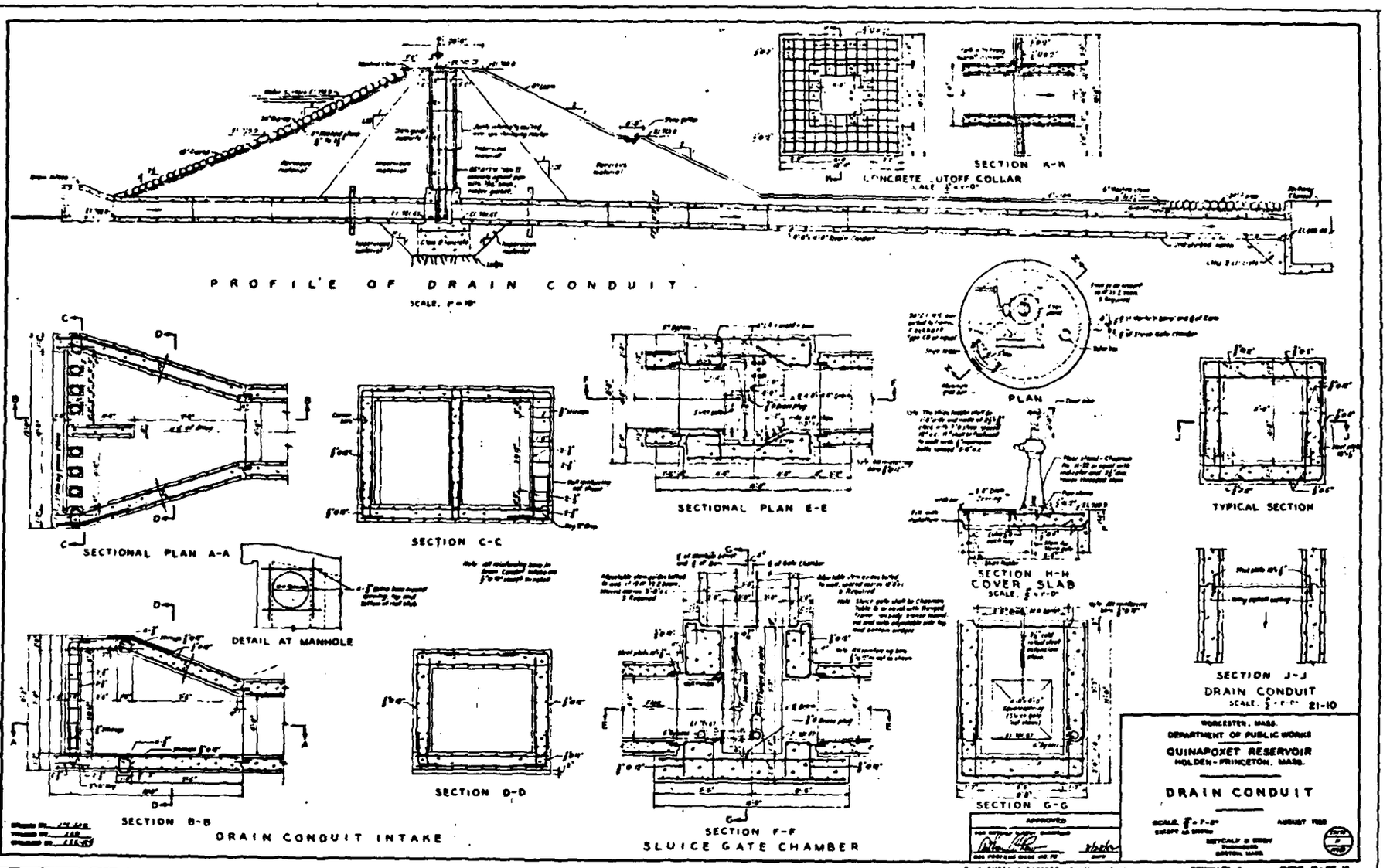
Estimated Storage Million Cubic Feet ____

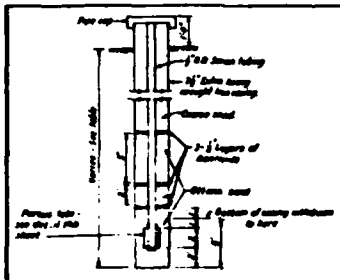
APPENDIX C

SELECTED PHOTOGRAPHS OF PROJECT

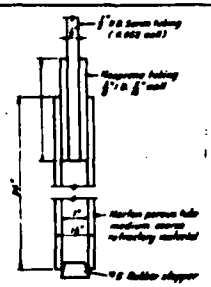

NOTES
PLAN
ELEVATION A-A
PLAN-ANCHOR DETAIL
EXISTING FLASHBOARD SUPPORT
TYPICAL SECTION
CRUSHED STONE DETAIL
PLAN
PLAN OF FLASHBOARDS
PROPOSED STONE JETTY
CITY OF WORCESTER MASS.
DEPARTMENT OF PUBLIC WORKS
QUINAPOXET RESERVOIR
PROPOSED STONE JETTY
AND
FLASHBOARD ALTERATIONS
COFFIN & RICHARDSON
ARCHITECTS AND ENGINEERS
BOSTON, MASSACHUSETTS
SCALE AS SHOWN
APRIL 1977
SHEET 1 OF 1
C/R ACC. NO. 4471
C/R PROJ. NO. 1833


BORINGS
QUINAPOXET RESERVOIR
HOLDEN-PRINCETON, MASS.
DEPARTMENT OF PUBLIC WORKS
WORCESTER, MASS
BORINGS ALONG DAM CENTER LINE
NOTES
APPROVED


PROFILE OF DRAIN CONDUIT
SECTION A-A
CONCRETE CUTOFF COLLAR
SECTION A-A
SECTION C-C
SECTIONAL PLAN E-E
PLAN
TYPICAL SECTION
SECTION H-H
COVER SLAB
DETAIL AT MANHOLE
SECTION J-J
DRAIN CONDUIT
SECTION B-B
SECTION D-D
SECTION F-F
SECTION G-G
DRAIN CONDUIT INTAKE
SLUICE GATE CHAMBER
WORCESTER, MASS.
DEPARTMENT OF PUBLIC WORKS
QUINAPOXET RESERVOIR
HOLDEN - PRINCETON, MASS.
DRAIN CONDUIT
21-10



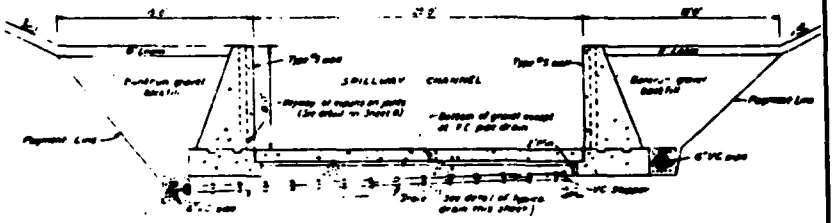
TYPICAL PIEZOMETER DETAIL
NOT TO SCALE



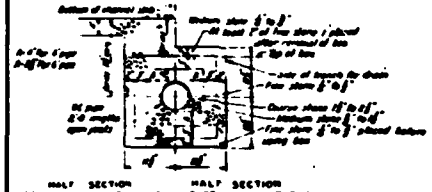
POROUS TUBE DETAIL
HALF SIZE

PIEZOMETER TABLE

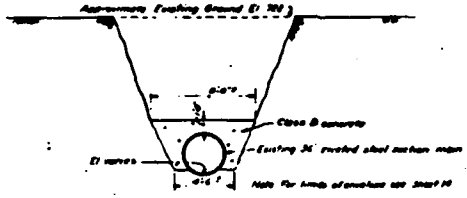
P-1	20
P-2	20
P-3	20
P-4	20
P-5	20
P-6	20
P-7	20
P-8	20



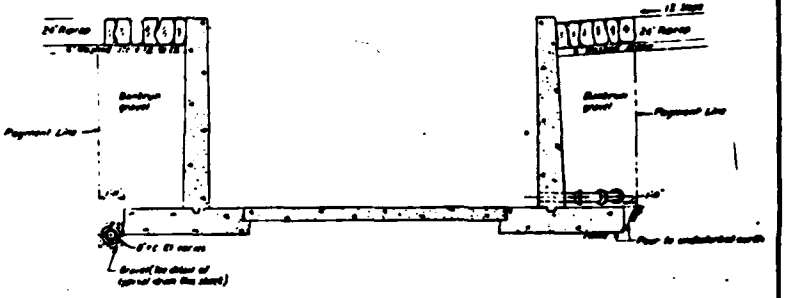
SECTION 1-1
SCALE 1/4"=1'-0"



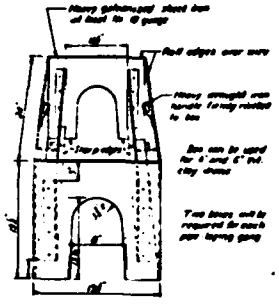
HALF SECTION BENEATH CHANNEL SLAB
HALF SECTION AT OTHER LOCATIONS
TYPICAL DRAIN
SCALE 1"=1'0"



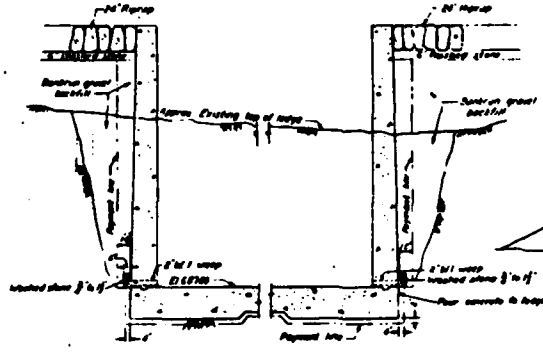
CONCRETE ENVELOPE FOR SUCTION MAIN
SCALE 1/4"=1'-0"



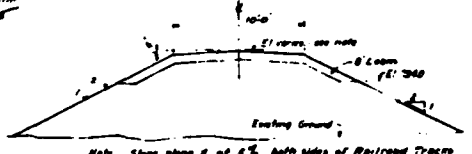
SECTION 2-2
SCALE 1/4"=1'-0"



BOX FOR SEGREGATION OF STONE AROUND SPILLWAY DRAINS
NOT TO SCALE



SECTION 3-3
SCALE 1/4"=1'-0"



TYPICAL SECTION
CAUSEWAY TO PUMPING STATION INTAKE
SCALE 1/4"=1'-0"

NOTES:
1. For location of Sections 1-1, 2-2, and 3-3 see Sheet No 4
2. For location of Piezometers see Sheet No 4

21-10

WORCESTER, MASS
DEPARTMENT OF PUBLIC WORKS
QUINAPOXET RESERVOIR
HOLDEN PRINCETON MASS

MISCELLANEOUS
SECTIONS AND DETAILS

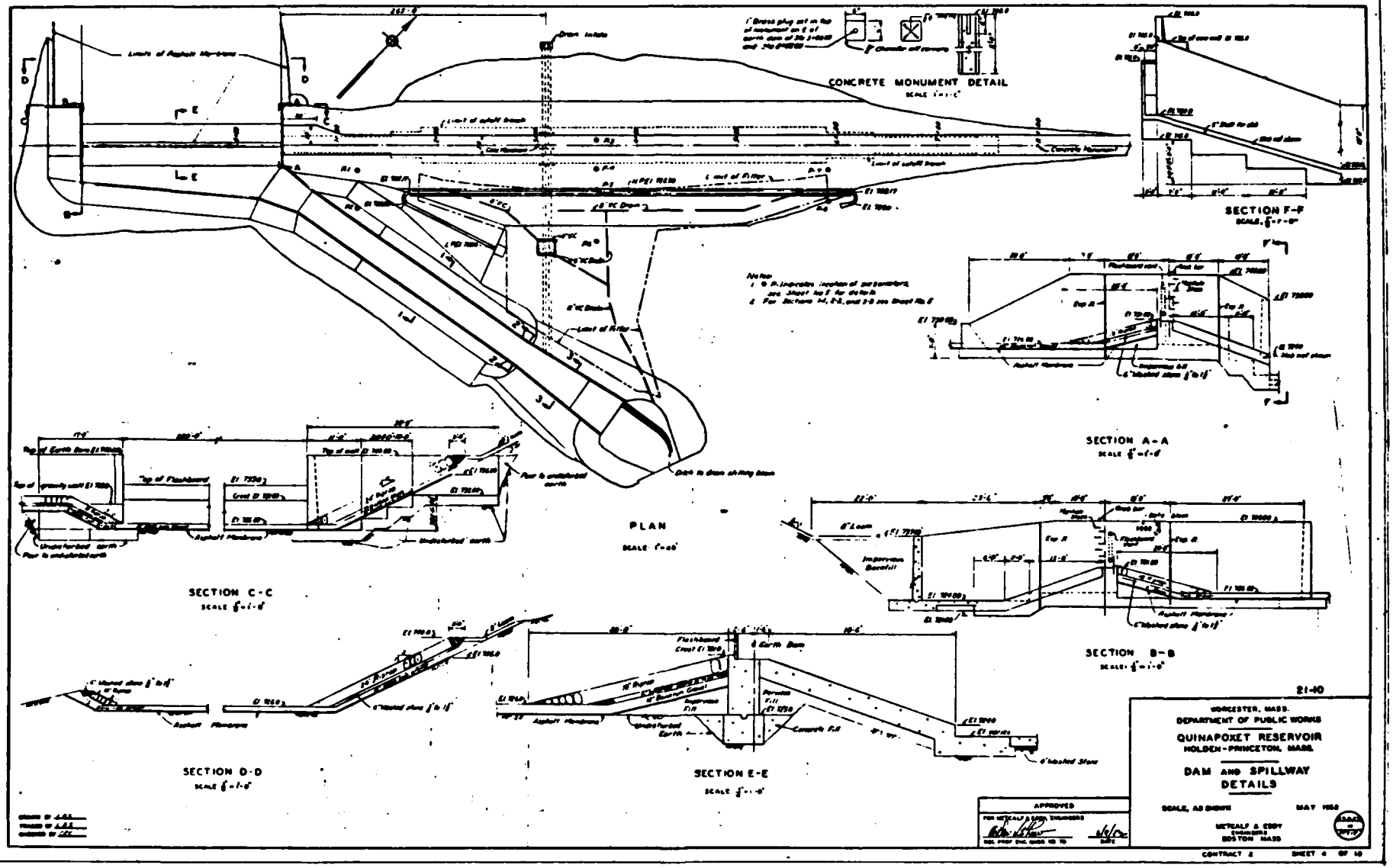
SCALE AS SHOWN MAY 1932

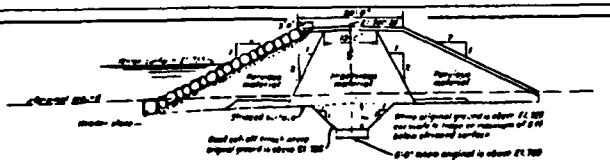
METCALF & EDDY
ENGINEERS
BOSTON, MASS.

APPROVED

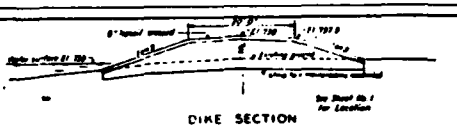
CONTRACT 2 SHEET 5 OF 19

B-15

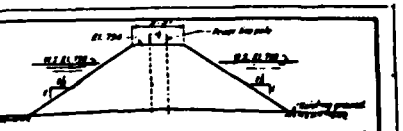

CONCRETE MONUMENT DETAIL
SECTION F-F
SECTION A-A
PLAN
SECTION C-C
SECTION B-B
SECTION D-D
SECTION E-E
WORCESTER, MASS.
DEPARTMENT OF PUBLIC WORKS
QUINAPOXET RESERVOIR
HOLDEN-PRINCETON, MASS.
DAM AND SPILLWAY DETAILS
21-40
METCALF & EDDY
ENGINEERS
BOSTON MASS.



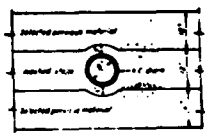
TYPICAL SECTION ABOVE EL. 725



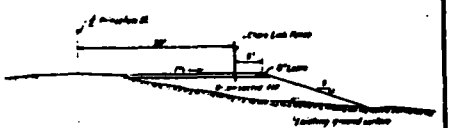
DIKE SECTION



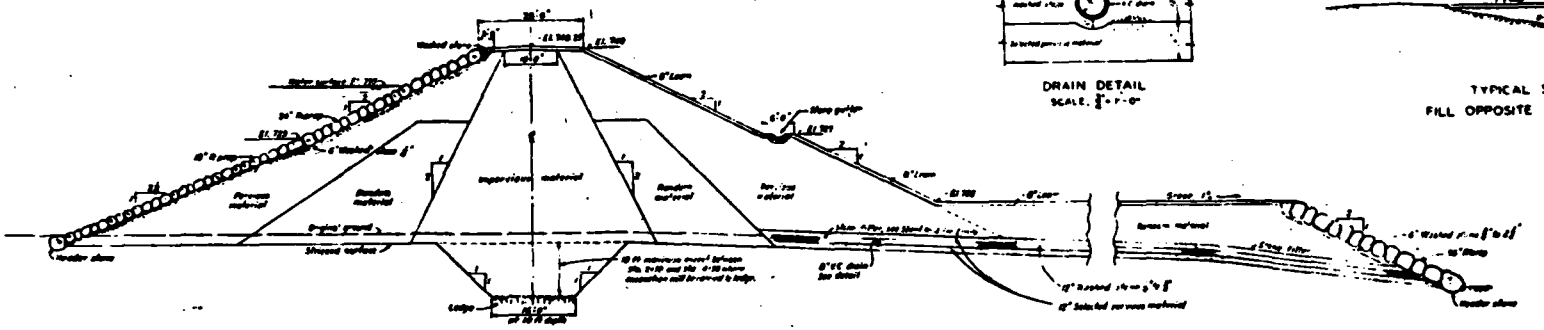
TYPICAL SECTION OF EMBANKMENT
UNDER POWER LINE
SCALE. 1"=5'



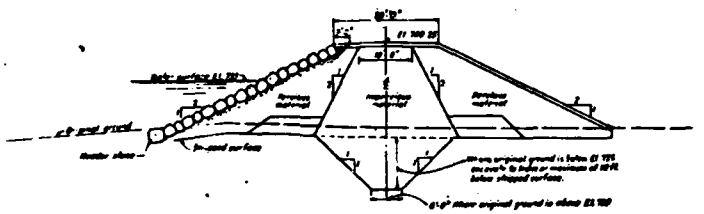
DRAIN DETAIL
SCALE. 3/4"=1'-0"



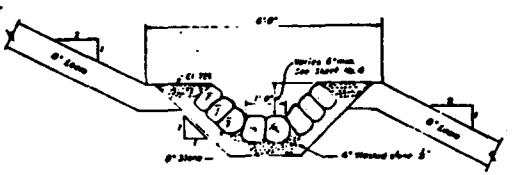
TYPICAL SECTION
FILL OPPOSITE ELMWOOD ST



TYPICAL SECTION



TYPICAL SECTION ABOVE EL. 720



DETAIL OF STONE GUTTER
SCALE. 3/4"=1'-0"

21-10

WORCESTER, MASS.
DEPARTMENT OF PUBLIC WORKS

QUINAPOXET RESERVOIR
HOLDEN-PRINCETON, MASS.

TYPICAL SECTIONS

SCALE, 1"=10'
APRIL 1938

METCALF & EDDY
ENGINEERS
BOSTON, MASS.

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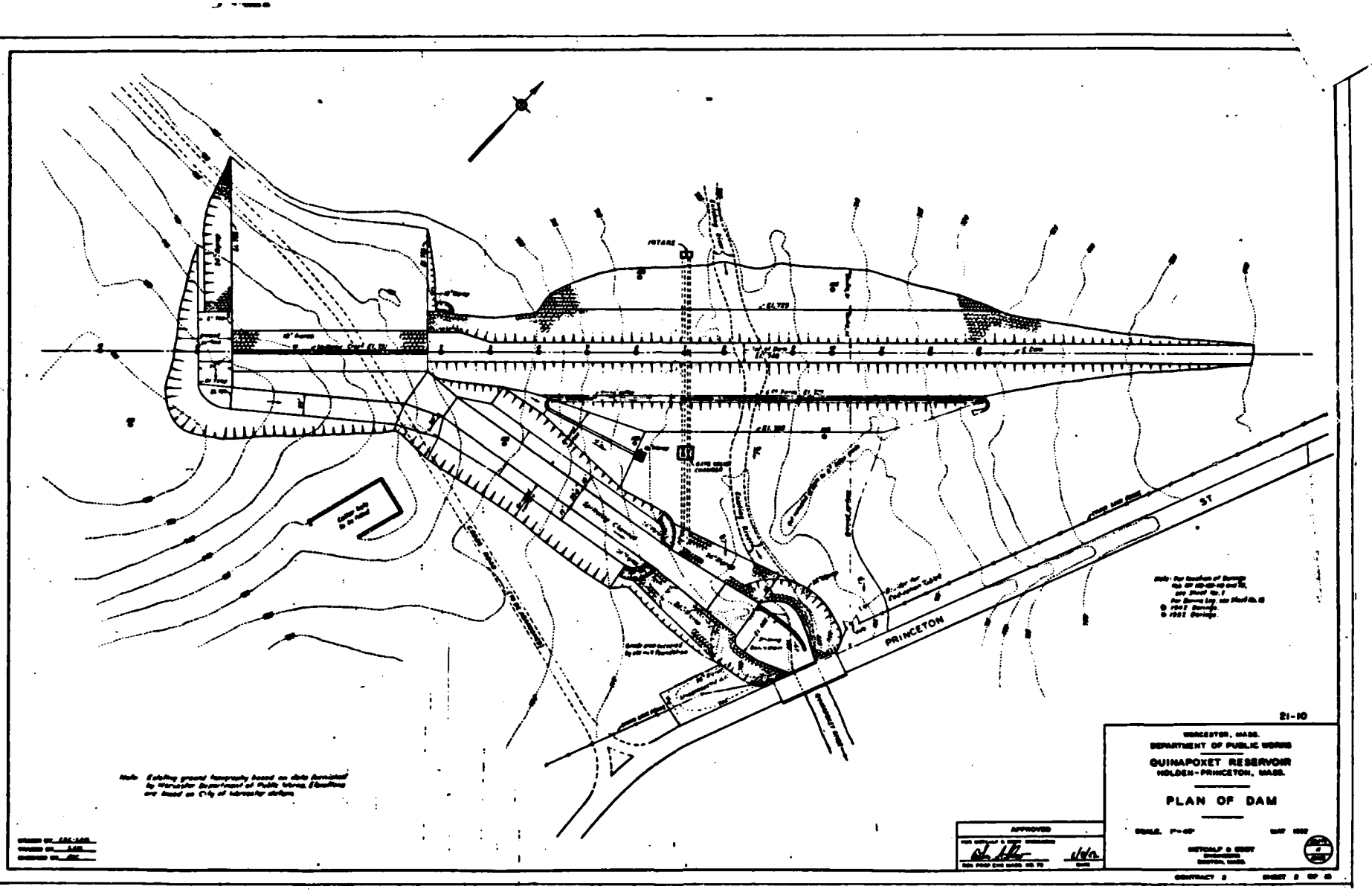
CONTRACT 8 SHEET 3 OF 10

B-13


PRINCETON
21-10
WORCESTER, MASS.
DEPARTMENT OF PUBLIC WORKS
QUINAPOXET RESERVOIR
HOLDEN - PRINCETON, MASS.
PLAN OF DAM

TOWN Holden DAM NO. 21-10 New

LOCATION W'ly side of Princeton St. STREAM Quinapoxet River

"Quinapoxet Reservoir."

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by City of Worcester Place Water Dept. Use Reservoir

Inspected by WOL Date June 4 1965

Type of Dam Concrete - Earth Condition Good

SPILLWAY

Flashboards in Place 2' of boards Recent Repairs _____

Condition Good (Pond is full to top of boards.)

Repairs Needed _____

Dam constructed in 1952 - 1953

EMBANKMENT

Recent Repairs Cap - 1200 Million Gals on Plaque

Condition Good

Repairs Needed _____

GATES

Recent Repairs _____

Condition Good

Repairs Needed _____

LEAKS

How Serious No leaks.

DATE: _____ County Engineer

TOWN Holden DAM NO. 21-20 ✓

LOCATION Quinapoxet Res. STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by City of Worcester Bureau of Water Place Holden Use

Inspected by Lloyd Starbard - L.O.M. Date May 25, 1960

Type of Dam Condition

SPILLWAY

Flashboards in Place Yes Recent Repairs

Condition OK

Repairs Needed None

EMBANKMENT

Recent Repairs None

Condition OK

Repairs Needed None

GATES

Recent Repairs None

Condition OK

Repairs Needed None

LEAKS

How Serious None

DATE: May 25, 1960

L. O. Ward
County Engineer

TOWN Holden DAM NO. 21-10

LOCATION Westerly side - Princeton St. STREAM Quinapoxet River

"Quinapoxet Reservoir"

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

D A M I N S P E C T I O N R E P O R T

Owned by City of Worcester Place Water Dept. Use Water Supply

Inspected by W.H. Date Oct. 3 1955

Type of Dam Earth and concrete. Condition Good

SPILLWAY

Flashboards in Place _____ Recent Repairs _____

Condition Good

Repairs Needed The reservoir is full to the spillway crest.

EMBANKMENT

Recent Repairs _____

Condition Good

Repairs Needed _____

GATES

Recent Repairs _____

Condition Good

Repairs Needed _____

LEAKS

How Serious _____

DATE: _____ County Engineer

TOWN Holden

DAM NO. 10 21-08

LOCATION Quinapoxet

STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT

WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

OWNED BY Mass. Water Dept PLACE Worcester USE Water Supply

INSPECTED BY LOM DATE Oct. 12, 1950

TYPE OF DAM Earth, Stone & Conc. Spillway CONDITION Good

SPILLWAY

FLASHBOARDS IN PLACE RECENT REPAIRS

CONDITION

REPAIRS NEEDED

EMBANKMENT

RECENT REPAIRS

CONDITION

REPAIRS NEEDED

GATES

RECENT REPAIRS

CONDITION

REPAIRS NEEDED

LEAKS

HOW SERIOUS

DATE Oct. 12, 1950

L. O. Miranda

COUNTY ENGINEER

TOWN Holden DAM NO. 21-40

LOCATION Quinapoxet Pond STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT

WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

OWNED BY Worcester Water Dept. PLACE Worcester USE storage

INSPECTED BY E.Perry-Hardy-Marden DATE Nov.18,1947

TYPE OF DAM Earth-stone and concrete CONDITION

SPILLWAY

FLASHBOARDS IN PLACE 18" RECENT REPAIRS 1942

CONDITION Good -new apron 1942

REPAIRS NEEDED New catwalk stringer s below catwalk top-reduce area spillway.

EMBANKMENT

RECENT REPAIRS none

CONDITION good

REPAIRS NEEDED none

GATES

RECENT REPAIRS none

CONDITION good

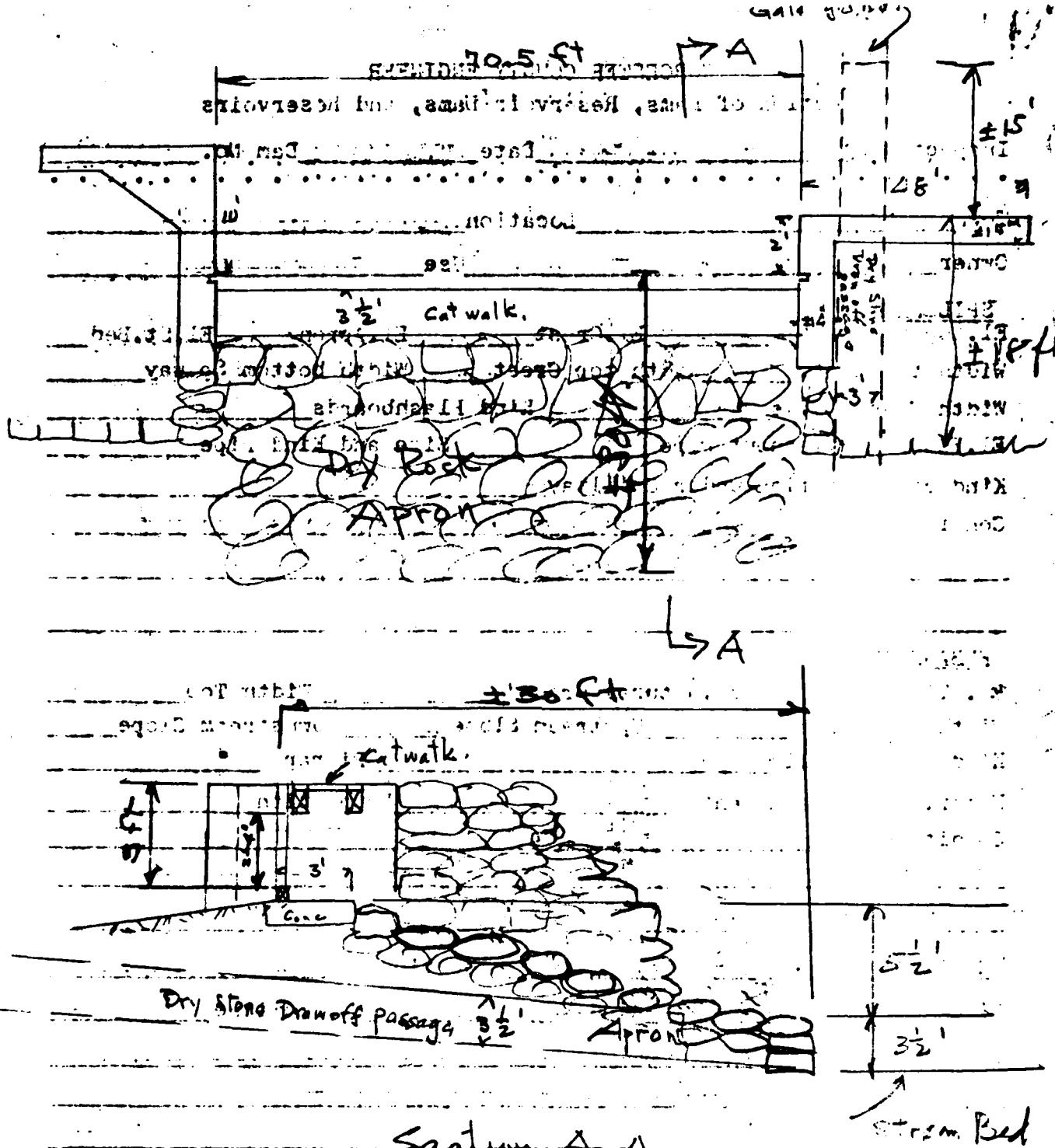
REPAIRS NEEDED none

LEAKS

HOW SERIOUS Seepage to east of spillway-not hazardous.

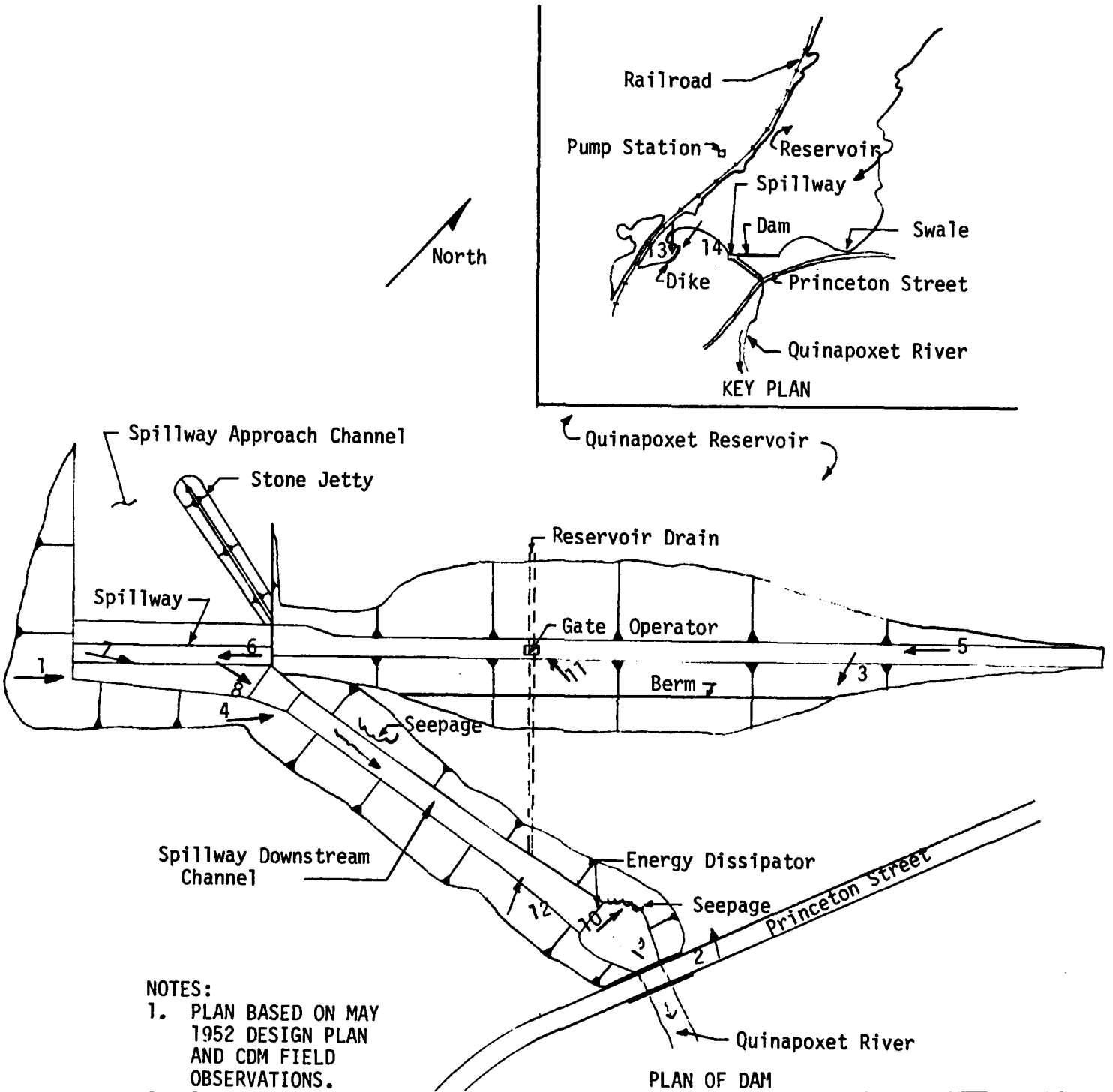
DATE Feb.10,1948

L. O. Marden
COUNTY ENGINEER



Section A-A

± 5' of water over crest



NOTES:
1. PLAN BASED ON MAY 1952 DESIGN PLAN AND CDM FIELD OBSERVATIONS.
2. 1 DENOTES PHOTOGRAPH NUMBER AND DIRECTION OF VIEW.

CAMP DRESSER & McKEE, INC. BOSTON, MASSACHUSETTS	U.S.ARMY ENG. DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION OF PHOTOGRAPHS

Quinapoxet Reservoir — Holden, MASSACHUSETTS

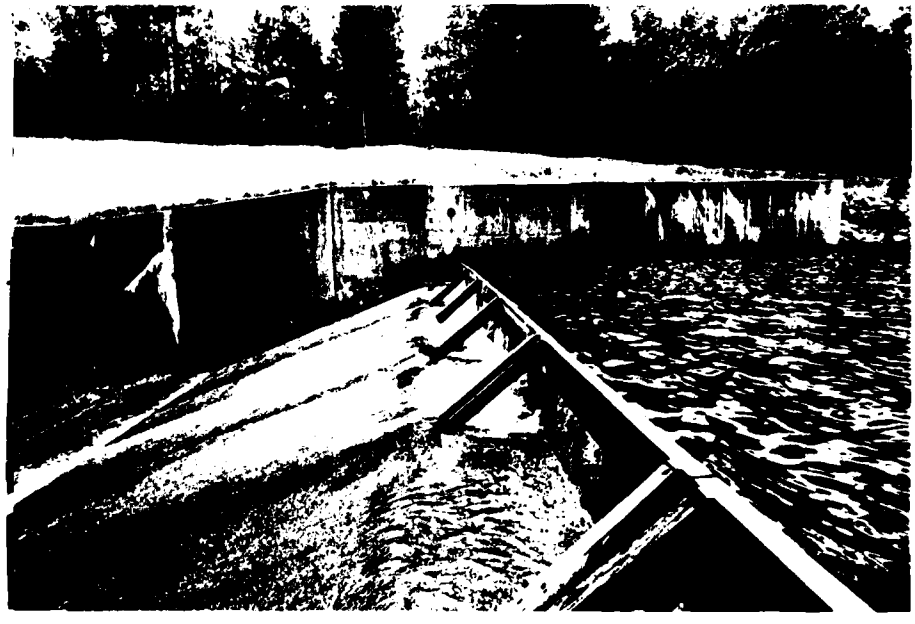
Scale: Not To Scale

Date: September, 1980

3. VIEW OF DAM AND SPILLWAY DOWNSTREAM CHANNEL FROM LEFT ABUTMENT.

4. DOWNSTREAM FACE OF DAM FROM RIGHT ABUTMENT SHOWING SPILLWAY DOWNSTREAM CHANNEL IN FOREGROUND.

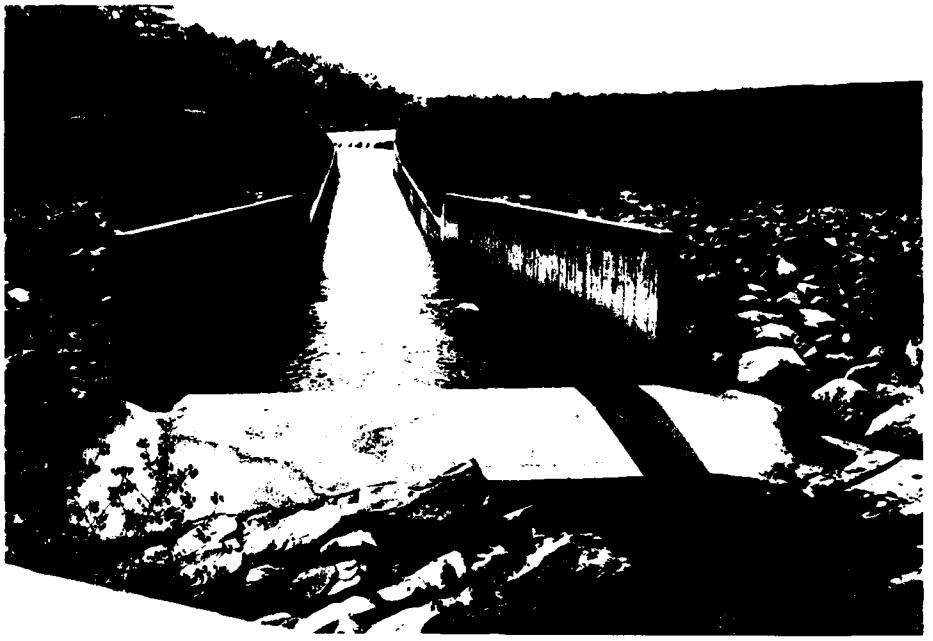
5. CREST AND UPSTREAM FACE OF DAM FROM LEFT ABUTMENT.



6. VIEW OF RIGHT SIDE OF SPILLWAY.

7. VIEW OF SPILLWAY AND SPILLWAY LEFT ABUTMENT.

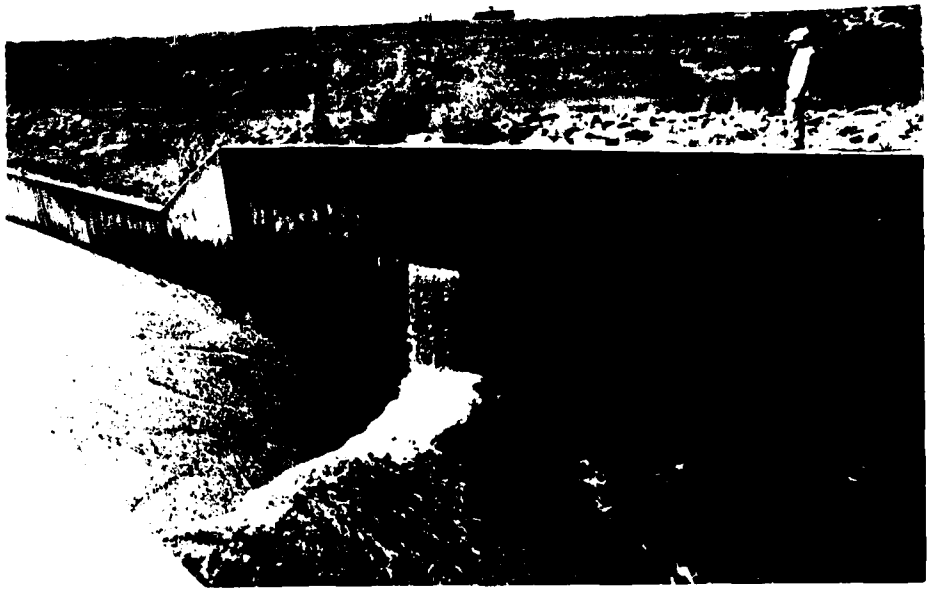
8. SPILLWAY DOWNSTREAM CHANNEL WITH PRINCETON STREET BRIDGE SHOWN AT END OF SPILLWAY CHANNEL.



9. VIEW OF SPILLWAY DOWNSTREAM CHANNEL FROM PRINCETON STREET BRIDGE. NOTE SILL AND V-NOTCH DRAIN IN FOREGROUND.

10. SEEPAGE AT RIPRAP TO THE LEFT OF THE STILLING BASIN SILL.

11. RESERVOIR DRAIN GATE OPERATOR ON DAM CREST. PUMP HOUSE IS VISIBLE ON FAR SIDE OF RESERVOIR.



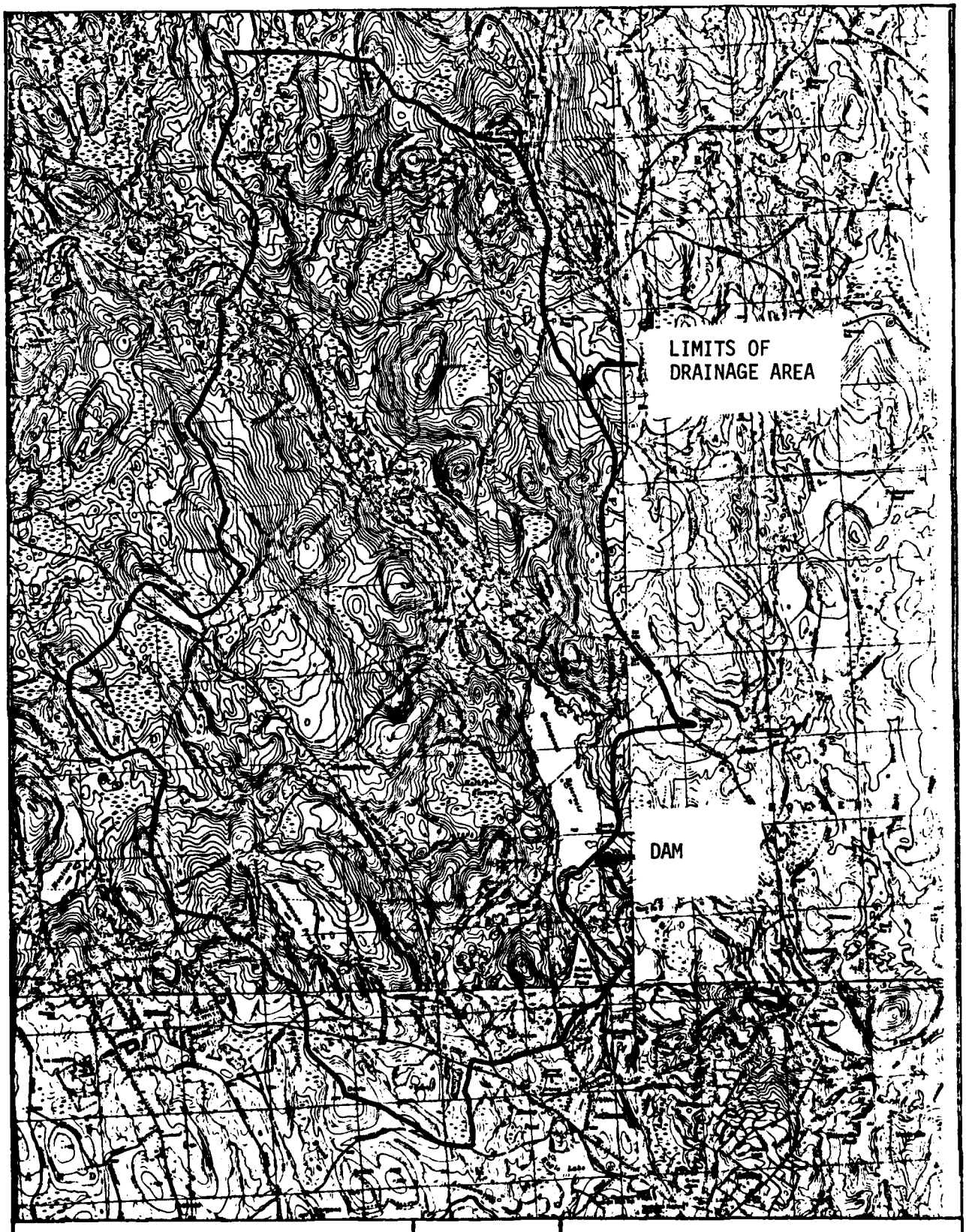
12. PHOTO OF RESERVOIR DRAIN OUTLET AT SPILLWAY CHANNEL. STILLING BASIN TAKEN DURING TEST OPERATION OF DRAIN.

13. UPSTREAM FACE OF DIKE FROM ITS LEFT ABUTMENT.

14. CREST OF DIKE FROM LEFT ABUTMENT. NOTE TREES GROWING ON THE DOWNSTREAM FACE.

APPENDIX D

HYDRAULIC AND HYDROLOGIC COMPUTATIONS

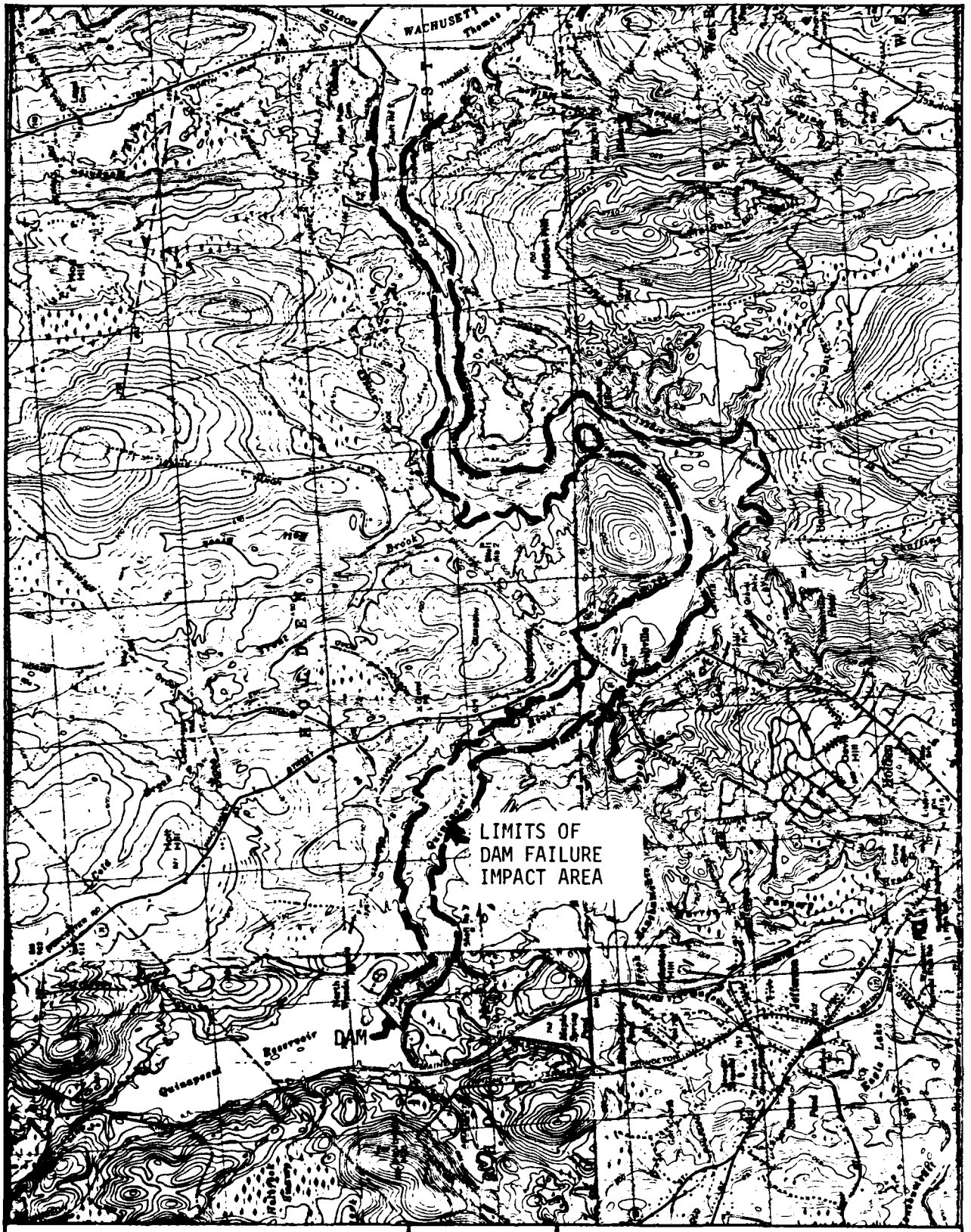


DAM Quinapoxet Reservoir Dam

IDENTIFICATION NO. MA 00929

DRAINAGE AREA MAP

APPROX. SCALE: 1" = 5,125'



DAM Quinapoxet Reservoir Dam

IDENTIFICATION NO. MA 00929

DAM FAILURE IMPACT AREA MAP

APPROX. SCALE: 1" = 3,280'

SER & McKEE CLIENT COE JOB NO. 380-6-RT-24 COMPUTED BY Joe H
PROJECT Dam Safety Insp. DATE CHECKED 7/25/80 DATE 6-20-80
DETAIL Quinapoxet Reservoir CHECKED BY JED PAGE NO. 1 - 7

ELEVATIONS

All elevations based on National Vertical Geodetic Datum (NGVD)

Concrete Spillway Crest w/flashboards 733.0; w/out flashboards 731.0
Top of Dam 740.0
Top of Dike (Located to the right of the dam) 738.5
Top of Swale on Princeton Street (Located to the left of the dam) 738.0
Toe of Dam @ natural ground @ end of spillway channel near Princeton Street 695.0

SURFACE AREAS

Drainage Area = 12,705 acres ≈ 19.85 square miles (from M&E 1953 report)
Reservoir Surface Areas:
@ El. 731.0 ≈ 267 acres (from 1953 Metcalf & Eddy Report)
@ El. 733.0 ≈ 285 acres "
@ El. 740.0 ≈ 343 acres (Determined by CDM)
@ El. 750.0 ≈ 428 acres "

POOL STORAGE VOLUMES

@ Spillway Crest El. 731.0, storage ≈ 3424 acre-feet (from M&E report)
@ El. 733.0, storage = $3424 + \left(\frac{267+285}{2}\right)2 = 3976$ acre-feet
@ El. 740.0, storage = $3976 + \left(\frac{285+343}{2}\right)7 = 6174$ acre-feet (Top of Dam)
@ El. 750.0, storage = $6174 + \left(\frac{343+428}{2}\right)10 = 10,029$ acre-feet

TEST FLOOD DETERMINATION

Based on an hydraulic height of 45 feet and a storage at top of dam (El. 740.0) of 6,174 acre-feet, the size classification is INTERMEDIATE, according to COE guidelines.

The dam failure analysis on pages 5-7 indicates a HIGH hazard classification.

Therefore, based on COE guidelines, the test flood is the PMF.

The drainage area is undeveloped, except for some scattered houses throughout the drainage area. It is heavily forested with swampy areas scattered throughout. Muschopauge Pond, located northeast of Quinapoxet Reservoir, is part of the drainage area to Quinapoxet Reservoir but serves as a water supply to Rutland and Holden. Therefore, relative to safe yield the drainage area to Muschopauge Pond (378 acres: 0.59 sq. miles) is independent of the D.A. to Quinapoxet Res. But relative to the test flood it will only act to attenuate the peak flow. It is further assumed that no water will be pumped from the Quinapoxet Reservoir during the test flood period. Based on the drainage area characteristics described above, the peak test flood inflow to Quinapoxet Reservoir is based on the "flat and coastal" curve of the NED Corps of Engineers "Preliminary Guidance for Estimating Maximum Probable Discharges in Phase I Dam Safety Investigations".

$$\therefore PMF = 650\,csm \times 19.85\,sq.mi = 12{,}900\,cfs$$

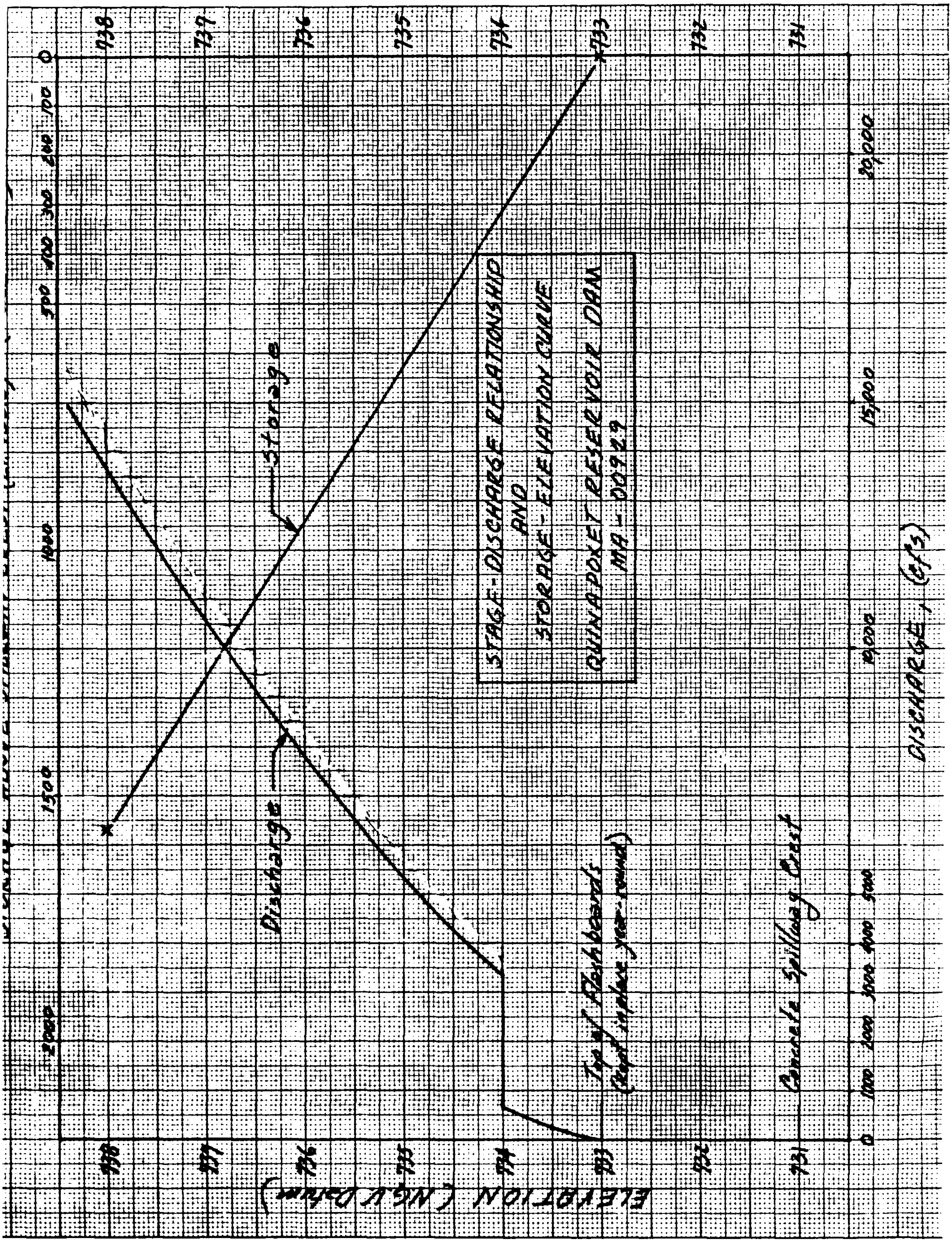
STAGE-DISCHARGE RELATIONSHIP

Reservoir Water Surface Elevation (NGVD)	Spillway Discharge Length = 200 ft		
	C-value	H-ft	Discharge, cfs
733.0 *	—	—	zero (assumes drain pipe to be closed)
733.5	3.3	0.5	233
734.0**	3.4; 3.2	1; 3	680; 3326
735.0	3.4	4	5,440
736.0	3.5	5	7,826
737.0	3.6	6	10,580
738.0	3.7	7	13,700

NOTES:

* The concrete spillway crest is at elevation 731.0, however, normal operation is to keep 2-feet of flashboards along the length of the spillway year-round.

** The spillway flashboards are designed to collapse when the reservoir water level reaches El. 734.0±


STAGE-DISCHARGE RELATIONSHIP
AND
STORAGE-ELEVATION CURVE
QUINAPOXET RESERVOIR DAM
MA-00929
Storage
Discharge
Top of Flashboards
Concrete Spillway Crest
DISCHARGE, (cfs)
ELEVATION (NGVD Datum)

SURCHARGE-STORAGE ROUTING

Peak Test Flood Inflow, Q_p = 12,900 cfs ; Surcharge El. = 737.75

$STOR_1 = \frac{\text{Surcharge Storage}}{\text{Drainage Area}} = \frac{1495 \text{ ac-ft} \times 12 \text{"/ft}}{12{,}705 \text{ acres}} = 1.412$ inches

Outflow, $Q_{p_1} = Q_p\left(1 - \frac{STOR_1}{19}\right) = 12{,}900\left(1 - \frac{1.412}{19}\right) = 11{,}940$ cfs → El. 737.45

$STOR_2 = (1400 \times 12)/12{,}705 = 1.322$-in ; $STOR_{AVG} = (1.412 + 1.322)/2 = 1.367$-in.

$Q_{p_2} = 12{,}900\left(1 - (1.367/19)\right) = 11{,}970$, say 12,000 cfs → El. 737.45

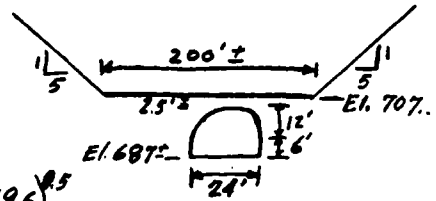
∴ Peak Inflow = 12,900 cfs
Routed Peak Outflow = 12,000 cfs @ Surcharge El. = 737.5 NGVD

DRAIN CAPACITY @ spillway crest

$Q = CA\sqrt{2gH}$ where $C = 0.60$, $A = 4 \times 4 = 16$ sq. ft
H ⇒ based on water surface @ spillway Crest, El. 733.0
$= 733 - 702 = 31$ ft

$Q = 0.60\,(16)\sqrt{64.4(31)} = 430$ cfs

TAILWATER ANALYSIS



Control Section is at Princeton St. Bridge

Orifice flow, $Q_1 = 0.7\,(370)\sqrt{64.4H} = 2078H^{0.5}$
$= 2078\,(WSE - 696)^{0.5}$

Channel flow over Roadway ≈ $\frac{1.49}{0.03} A R^{2/3} (0.01)^{0.5} = Q_2$

WSE (NGVD)	Orifice Flow		Channel Flow			Total Discharg cfs
	H	Q_1	A	R	Q_2	
709	13	7490	311	1.45	1980	9,470
711	15	8050	761	3.24	8280	16,330

∴ @ the routed test flood outflow of 12,000 cfs the tailwater elevation is about 709.7 or about 2.2 feet over the roadway. Thus, the spillway downstream channel would overflow its banks and erode the dam embankment structure.

DAM FAILURE ANALYSIS

a. Project Discharge Prior to Dam Failure. Assume WSE @ routed peak test flood surcharge, El. 737.5 (NGVD)

$\therefore Q_1 \approx 12{,}000$ cfs, which would overtop each street on the downstream channel (Quinapoxet River) all the way to its point of discharge at the Wachusett Reservoir. The depth of water over each roadway would vary from 1.5 to about 4ft @ River St. One house at State Route 31 would be affected by water about 2 feet above its sill.

b. Project Discharge After Dam Failure, WSE = 737.5

$$Q_2 = 8/27 (g)^{1/2} W_b (Y_b)^{1.5}$$ where $g = 32.2$ ft/sec^2

W_b = width of failure section. Assume 40% of the mid-height length would fail
$= 480 \times 0.4 = 192$ ft

Y_b = height of failure section
= WSE - Toe of Dam El
$= 737.5 - 695 = 42.5$ ft

$$\therefore Q_2 = 8/27 (32.2)^{1/2} (192) (42.5)^{1.5}$$

$\approx 89{,}500$ cfs

Total Failure Flow $\approx Q_p = 89{,}500 + 12{,}000 = 101{,}500$
say 100,000 cfs

Determine the impact of @ 100,000 cfs discharge on the downstream area.

Reach 1 – Dam to Princeton Street immediately D/s of dam. The section geometry was described on page 4 in the Tailwater Analysis.

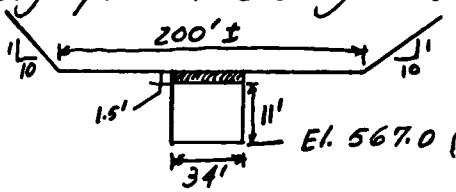
Stage-Discharge relationship

WSE	Orifice Flow	Channel Flow	Total Flow
717	9,500	51,000	60,500
722	10,600	97,800	108,400

$\therefore$ WSE @ Princeton St would be 721 ± or 13.5 ft above the roadway and over 4-ft above the sill of a house on the right downstream bank.

REACH 2 – Princeton Street to State Route 31, located about 10,000 ft downstream of the dam. There is no development in the reach, except around the Rt 31 area. The reach is relatively steep and offers no significant storage

Section Geometry: →



S ≈ 0.0128
n ≈ 0.045
El. 567.0 (from Flood Insurance Study Report)

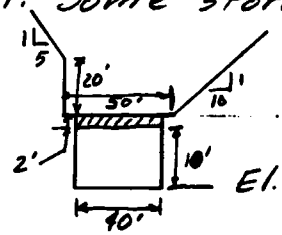
Stage-Discharge Relationship:

WSE	Orifice Flow	Channel Flow	Total Flow (cfs)
589.5	9,400	44,250	53,650
594.5	12,100	109,100	121,200

∴ WSE ≈ 593 ± @ Rt 31 bridge or about 13.5 feet above the roadway. About 18 houses would be affected, most of which severely (by depths greater than 5 feet).

REACH 3 – Rt 31 to River Street, located about 3,000 ft DS of Rt 31. Again most of the development centers around River Street. Some storage exists in this reach.

Section Geometry:



S ≈ 0.0031
n ≈ 0.045
El. 557.8 (FIS Report)

Stage-Discharge Relationship:

WSE	Orifice Flow	Channel flow	Total Discharge (cfs)
584.8	11,300	15,000	26,300
589.8	12,500	27,900	40,400
594.8	13,600	45,150	58,750

Storage:

WSE	Surface Area (ac)	Total Storage (ac-ft)	Avail. Surcharge Storage (ac-ft) (Assume init. WSE @ Q=12,000 cfs of 574±)
560	0	—	—
570	42	294	—
580	63	819	367
590	97	1619	1167
600	109	2649	2197

@ a peak dam failure outflow of 100,000 cfs, WSE ≈ 606± before routing.

routed outflow = $100{,}000\left(1 - \frac{\text{Storage in Reach}}{\text{Storage in Res.}}\right) = 100{,}000\left(1 - \frac{2506}{5163}\right) \approx 51{,}500$.

@ Q = 51,500 cfs, WSE ≈ 593±; Storage = 1976 & Avg Storage ≈ 1991 ac-ft

routed outflow ≈ $100{,}000\left(1 - \frac{1991}{5163}\right) \approx 61{,}400$ cfs

Say outflow ≈ 61,500 cfs; corresponding WSE = 595.5 ± about 2.6± feet over the roadway. About 14 houses would be affected by water depths of 1 to 15 feet.

Downstream of River Street, the area is undeveloped except for a couple of roadways which would be overtopped. The flood wave would attenuate in this area and dissipate into the Wachusett Reservoir.

In conclusion of the aforegoing analysis, the hazard resulting from a dam failure would be a

"HIGH" hazard

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

NOT AVAILABLE AT THIS TIME

END

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