

AD-A155 653

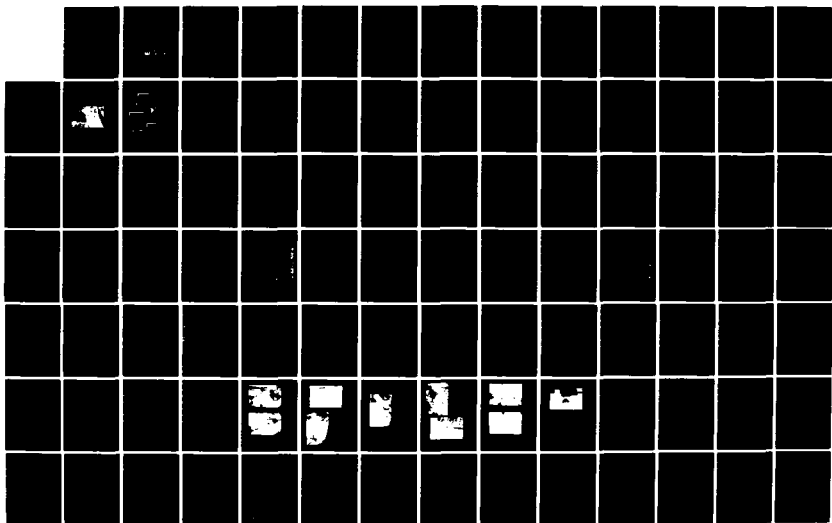
NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
ROBERTS MEADOW UPPER (U) CORPS OF ENGINEERS WALTHAM MA
NEW ENGLAND DIV JUN 80

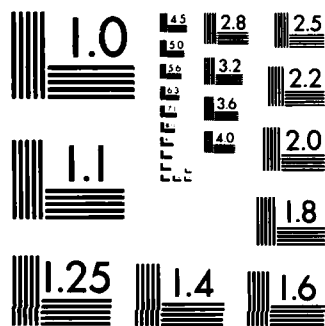
1/2

UNCLASSIFIED

F/G 13/13

NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A155 653

CONNECTICUT RIVER BASIN
NORTHAMPTON, MASS.

ROBERTS MEADOW
UPPER RESERVOIR DAM
MA 00760

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Copy available to DTIC does not
permit fully legible reproduction



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

DTIC FILE COPY

JUNE 1980

DISTRIBUTION STATEMENT A

Approved for public release;
Distribution Unlimited

85 5 31 048

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MA 00760	2. GOVT ACCESSION NO. A155653	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Roberts Meadow Upper Reservoir Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS		8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE June 1980
		13. NUMBER OF PAGES 80
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED		
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, Connecticut Rivwr Basin Northampton, Mass. Roberts Meadow Brook		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The dam is a cut stone masonry earth gravity dam having a hydraulic height of 35 ft. length of 305 ft. including a 150 ft. long dike. It is small in size with a significant hazard potential. The dam itself is in poor condition. There are some major concerns which are listed in the report itself.		

DISCLAIMER NOTICE

**THIS DOCUMENT IS BEST QUALITY
PRACTICABLE. THE COPY FURNISHED
TO DTIC CONTAINED A SIGNIFICANT
NUMBER OF PAGES WHICH DO NOT
REPRODUCE LEGIBLY.**



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

REPLY TO
ATTENTION OF:

NEDED

SEP 9 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 Roberts Meadow Upper Reservoir Dam 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, City of Northampton, Northampton, Massachusetts 01060.

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

ROBERTS MEADOW UPPER RESERVOIR

MA 00760

CONNECTICUT RIVER BASIN
NORTHAMPTON, MASSACHUSETTS

Accession For	
NTIS GRA&I	☒
ETIC TAB	☒
Unannounced	☐
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A/1	(V)

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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 the 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 inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid 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.

Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

Identification No.:	MA 00760
Name of Dam:	ROBERTS MEADOW UPPER RESERVOIR
City:	NORTHAMPTON
County and State:	HAMPSHIRE, MASSACHUSETTS
Stream:	ROBERTS MEADOW BROOK
Date of Inspection:	2 MAY 1980

BRIEF ASSESSMENT

Roberts Meadow Upper Reservoir Dam is a cut stone masonry and earth gravity dam having a hydraulic height of 35 feet, length of 305 feet including a 150 foot long dike. The stone masonry section is approximately 65 feet wide, is slightly arched in an upstream direction, has a crest width of 4.5 feet and serves as the spillway. The dam is owned by the City of Northampton.

An earthen embankment extends from the southerly end of the spillway to Chesterfield Road, a distance of approximately 65 feet. From the northerly end of the spillway an earthen embankment extends northerly a distance of approximately 25 feet and then turns westerly a distance of 150 feet to form a four foot high dike.

The reservoir is 1600 feet long with a normal surface area of about 5 acres. The reservoir has a maximum storage capacity of 72 acre feet. The dam was originally constructed in 1883 to form a regulating reservoir for use in water supply for the City of Northampton.

Roberts Meadow Middle Reservoir Dam (MA 00761) lies approximately 1.3 miles downstream of the Roberts Meadow Upper Reservoir Dam. Immediately downstream of Roberts Meadow Middle Reservoir is Roberts Meadow Lower Reservoir (MA 00753). The village of Leeds lies 800 feet downstream of the Lower Reservoir.

Roberts Meadow Upper Reservoir Dam has a small size and a significant hazard classification. In accordance with Corps of Engineers guidelines the test flood is $\frac{1}{2}$ the Probable Maximum Flood (PMF). The $\frac{1}{2}$ PMF test flood inflow for Roberts Meadow Upper Reservoir Dam, having a drainage area of 8.8 square miles was determined to be 7480 cfs which would overtop the dam by about 3.4 ft.

The $\frac{1}{4}$ PMF, which is comparable to the 100 year flood, was also determined for this dam and it was found that the dam would be overtopped by approximately 1 foot for this flow. The small reservoir storage capacity has a negligible effect on reducing peak inflows during high flows.

The spillway capacity at the top of the dam is 1500 cfs which is 20 percent of the test flood discharge.

* Numbers denote references listed at end of Section 1.

The regulating controls at the dam are now destroyed and the water supply aspects have been abandoned although the reservoir may still provide certain indirect water supply benefits by maintaining the groundwater level and adjacent forest growth.

The dam itself is in poor condition. The major concerns are: The large amount of leakage through the stone masonry section which has the potential for freezing and dislocating stone blocks in the face of the dam; internal erosion of the earth embankment at the southerly end of the spillway; brush and tree growth on the embankment sections; and a large unstable mass of bedrock overhanging the downstream channel at the northerly abutment.

The City of Northampton should implement the results of the recommendations and remedial measures given in Sections 7.2 and 7.3 within one year after receipt of this Phase I Inspection Report.

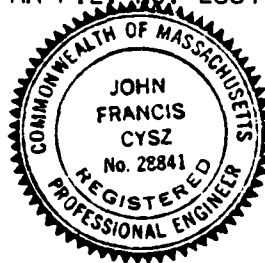
The recommendations in general are that the City of Northampton should engage a qualified Registered Professional Engineer to:

- Evaluate the stability of the dam against sliding and overturning.
- Design procedures for and inspect the clearing of trees and brush from the embankment sections of the dam.
- Design repairs to control leakage through the dam.
- Investigate the sink-hole distress on the southerly embankment.
- Study the feasibility of providing a low level outlet.
- Study the feasibility of rehabilitating the sluice gates and appurtenances.
- Study the advisability of increasing the spillway capacity.
- Perform an examination of the downstream toe of the stone masonry section during a period of low flow.

The City of Northampton should also implement the recommended remedial program including the prevention of trespassing on the embankments and the establishment of a formal operation and maintenance program and a formal surveillance and warning program. In addition, a qualified Registered Professional Engineer should be engaged to make a comprehensive technical inspection of the dam once a year.

John F. Cysz

John F. Cysz
Project Manager
MA P.E. No. 28841



This Phase I Inspection Report on Roberts Meadow Upper 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.

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Richard J. DiBuono

RICHARD DIBUONO, MEMBER
Water Control Branch
Engineering Division

Aramast Mahtesian

ARAMAST MAHTESIAN, CHAIRMAN
Geotechnical Engineering Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
Letter of Transmittal	
Brief Assessment	
Review Board Page	
Preface	i
Table of Contents	ii-iv
Overview Photo	v
Location Map	vi

REPORT

1. PROJECT INFORMATION

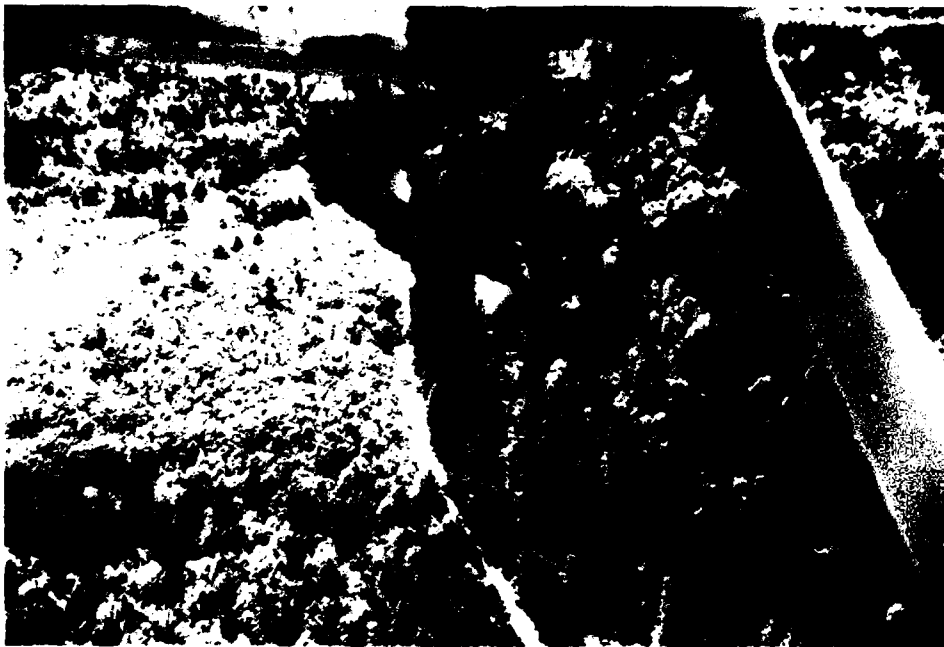
1.1 General	1-1
a. Authority	1-1
b. Purpose of Inspection	1-1
1.2 Description of Project	1-1
a. Location	1-1
b. Description of Dam and Appurtenances	1-2
c. Size Classification	1-2
d. Hazard Classification	1-2
e. Ownership	1-2
f. Operator	1-2
g. Purpose of Dam	1-3
h. Design and Construction History	1-3
i. Normal Operational Procedure	1-3
1.3 Pertinent Data	1-3
a. Drainage Area	1-3
b. Discharge at Damsite	1-3
c. Elevation	1-4
d. Reservoir	1-4
e. Storage	1-4
f. Reservoir Surface	1-5
g. Dam	1-5
h. Diversion and Regulating Tunnel	1-5
i. Spillway	1-5
j. Regulating Outlets	1-6

<u>Section</u>	<u>Page</u>
2. ENGINEERING DATA	
2.1 Design Data	2-1
2.2 Construction Data	2-1
2.3 Operation Data	2-1
2.4 Evaluation of Data	2-1
a. Availability	2-1
b. Adequacy	2-1
c. Validity	2-1
3. VISUAL INSPECTION	
3.1 Findings	3-1
a. General	3-1
b. Dam	3-1
c. Appurtenant Structures	3-1
d. Reservoir Area	3-2
e. Downstream Channel	3-2
3.2 Evaluation	3-2
4. OPERATIONAL AND MAINTENANCE PROCEDURES	
4.1 Operational Procedures	4-1
a. General	4-1
b. Description of any Warning System in Effect	4-1
4.2 Maintenance Procedures	4-1
a. General	4-1
b. Maintenance and Operating Facilities	4-1
4.3 Evaluation	4-1
5. EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES	
5.1 General	5-1
5.2 Design Data	5-1
5.3 Experience Data	5-1
5.4 Test Flood Analysis	5-1
5.5 Dam Failure Analysis	5-2

<u>Section</u>	<u>Page</u>
6. EVALUATION OF STRUCTURAL STABILITY	
6.1 Visual Observations	6-1
6.2 Design and Construction Data	6-1
6.3 Post-Construction Changes	6-1
6.4 Seismic Stability	6-1
7. ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES	
7.1 Dam Assessment	7-1
a. Condition	7-1
b. Adequacy of Information	7-1
c. Urgency	7-1
7.2 Recommendations	7-1
7.3 Remedial Measures	7-2
a. Operating and Maintenance Procedures	7-2
7.4 Alternatives	7-2

APPENDIXES

APPENDIX A - INSPECTION CHECKLIST	A-1
APPENDIX B - ENGINEERING DATA	B-1
APPENDIX C - PHOTOGRAPHS	C-1
APPENDIX D - HYDROLOGIC AND HYDRAULIC COMPUTATIONS	D-1
APPENDIX E - INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS	E-1



OVERVIEW OF
ROBERTS MEADOW UPPER RESERVOIR DAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
ROBERTS MEADOW UPPER RESERVOIR DAM
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. Robert G. Brown & Associates, 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 Robert G. Brown & Associates, Inc. under a letter of 14 March 1980 from William E. Hodgson, Colonel, Corps of Engineers. Contract No. DACW33-80-C-0037, has been assigned by the Corps of Engineers for this work.

b. Purpose of Inspection

- (1) To 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) To encourage and prepare the States to initiate quickly effective dam safety programs for non-Federal dams.
- (3) To update, verify and complete the National Inventory of Dams.

1.2 DESCRIPTION OF PROJECT

a. Location

The Roberts Meadow Upper Reservoir Dam is located in the City of Northampton, Massachusetts. The dam impounds Roberts Meadow Brook to form the Roberts Meadow Upper Reservoir, commonly called Upper Reservoir or the Hoxie Reservoir. After discharging at the damsite, Roberts Meadow Brook flows a distance of 5700 feet before it enters Roberts Meadow Middle Reservoir (presently drawn down.) ^{1/}

Roberts Meadow Upper Reservoir is shown on the USGS Easthampton, Massachusetts Quadrangle at Latitude 42° 20.3' and Longitude 72° 43.7'.

The dam site is located within a glacial meltwater valley in the foothills of the Berkshires north of the Mineral Hills and immediately west of the Connecticut River Basin.

b. Description of Dam and Appurtenances

Roberts Meadow Upper Reservoir Dam is a cut stone masonry and earth gravity dam having a hydraulic height of 35 feet, length of 305 feet including a 150 foot long dike at the northerly end of the dam. The stone masonry section which serves as the spillway is approximately 65 feet long, has a crest width of 4.5 feet and is slightly arched in an upstream direction.

An earthen embankment extends from the southerly end of the spillway to Chesterfield Road a distance of approximately 60 feet. From the northerly end of the spillway an earthen embankment extends northerly a distance of approximately 25 feet, then turns westerly a distance of 150 feet to form a 4 foot high dike.

The original gate house, which has now been removed, was located at the southerly end of the spillway. The gate chamber is still visible but is largely collapsed. Remains of a timber splash pad, which acted as an energy dissipation device for the spillway discharge, can be seen along the downstream banks. A pond drain is indicated on the original plan of the dam but was not visible during the inspection. Parts remain of the original flashboard supports.

Bedrock exposure at the damsite indicate the abutments lie in schistose rock having nearly vertical foliation. Differential weathering has caused etching of the shist and has localized joint plane separations.

c. Size Classification

Small (hydraulic height - 35 feet; storage 72 acre-feet) based on height and storage (25 to 40 feet; 50 to 1000 acre feet) as given in the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification

Significant hazard. A major break could wash out the Kennedy Road bridge and cause siltation of downstream municipal water supplies. Loss of life resulting from the failure of this dam is remotely possible.

e. Ownership

Roberts Meadow Upper Reservoir Dam is owned by the City of Northampton.

f. Operator

The operator of the dam is the City of Northampton Board of Public Works Water Division, 237 Prospect Street, Northampton, MA, Telephone: (413) 586-6950, Robert Kozash, Superintendent.

g. Purpose of Dam

The impoundment formed by the dam was originally used as a regulating reservoir for the City of Northampton Water Supply System. The water supply aspects of the dam have now been abandoned; however, the reservoir may still provide certain indirect water supply benefits by maintaining the ground-water level and adjacent forest growth. The reservoir also provides sediment storage. Present use is primarily aesthetic.

h. Design and Construction History

The dam was constructed around 1883. The designer was Engineer E.C. Davis of Northampton.

The planned capacity of the reservoir was 12 million gallons (37 acre-feet). Flashboards were to provide an additional 2 million gallons (6 acre-feet). The stone masonry work was performed by J. Brown and W. Kyle of Northampton.

The cost of the dam was greater than anticipated due to added excavation required to reach a solid foundation. The dam design was reviewed by Engineer Clemens Herschel of Holyoke who recommended in his report of August 28, 1883, that the dam be provided with an additional 1 foot of free-board.

According to recent field measurements, modifications to the original plans were made relative to the height of the dam. The width of the spillway was also decreased and a dike was added at the northerly abutment. No records of post construction changes or repairs were disclosed.

i. Normal Operating Procedures

Operating of Roberts Meadow Upper Reservoir Dam was abandoned in the late 1950's.

1.3 PERTINENT DATA

a. Drainage Area

The drainage area consists of 8.8 square miles (5600 acres) of mountainous and wooded terrain. The normal pool has a surface area of 5 acres, which constitutes less than ½ percent of the watershed. The watershed is almost entirely undeveloped.

b. Discharge at Damsite

- (1) Outlet works - 1-12" C.I. gate valve (contained in collapsed gate chamber). Floor of gate chamber elevation 428+ MSL; capacity with water at top of dam - 20 cfs.
- (2) The maximum discharge at damsite is unknown.
- (3) Ungated spillway (principal) capacity @ top of dam elevation - 1520 cfs @ 454.0 MSL.
- (4) Ungated spillway capacity @ test flood elevation - 4052 cfs @ 457.4 MSL.

- (5) Gated spillway capacity @ normal pool elevation - not applicable.
- (6) Gated spillway capacity @ test flood elevation - not applicable.
- (7) Total spillway capacity @ test flood elevation - 4052 cfs @ 457.4 MSL.
- (8) Total project discharge at top of dam - 1520 cfs @ 454.0 MSL.
- (9) Total project discharge @ test flood elevation - 7480 cfs @ 457.4 MSL.
- c. Elevation (feet above MSL; see (6) below)
 - (1) Streambed at centerline of dam - 420 (at downstream toe).
 - (2) Bottom of cutoff - unknown.
 - (3) Maximum tailwater - unknown.
 - (4) Normal pool - 450.
 - (5) Full flood control pool - not applicable.
 - (6) Spillway crest - 450 (interpolated from USGS Quadrangle sheet).
 - (7) Design surcharge (original design) - 453.5.
 - (8) Top of dam - 454.0 @ northerly end; 455.0 @ southerly end.
 - (9) Test flood surcharge - 457.4.
- d. Reservoir (length in feet)
 - (1) Length of normal pool - 1600.
 - (2) Length of flood control pool - not applicable.
 - (3) Length of spillway crest pool - 1600.
 - (4) Length of top of dam pool - 1700.
 - (5) Length of test flood pool - 1800.
- e. Storage (acre-feet)
 - (1) Normal pool - 35.
 - (2) Flood control pool - not applicable.
 - (3) Spillway crest pool - 35.

- (4) Top of dam - 65 @ 454.0 MSL (north end).
72 @ 455.0 MSL (south end).
- (5) Test flood pool - 90.
- f. Reservoir Surface (acres)
 - (1) Normal pool - 5.
 - (2) Flood control pool - not applicable.
 - (3) Spillway crest - 5.
 - (4) Top of dam - 7.
 - (5) Test flood pool - 9.
- g. Dam
 - (1) Type - cut stone masonry and earth gravity.
 - (2) Length - 305'. (including 150' dike)
 - (3) Height - 35' hydraulic.
 - (4) Top width - 4.5' (stone masonry spillway crest)
10' (earth embankment)
 - (5) Side slopes of dam - upstream - 1H: 2V.
(per original plan - not visible)
- downstream - 3/8H: 1V batter.
 - (6) Side slopes of embankment section - upstream - 1H: 1V.
- downstream - 2 1/2H: 1V.
 - (7) Zoning - unknown.
 - (8) Impervious core - 4' wide rock corewall shown on original plan for earth embankment section south of dam.
 - (9) Cutoff- unknown.
 - (10) Grout curtain - unknown.
- h. Diversion and Regulating Tunnel - not applicable
(See j. next page)
- i. Spillway
 - (1) Type - stone masonry (slight arch upstream).
 - (2) Length of weir - 65' approx.
 - (3) Crest elevation - 450 MSL (spillway low point).

- (4) Gates - none.
- (5) U/S Channel - Reservoir is open.
- (6) D/S Channel - Roberts Meadow Brook is a natural channel for about 1000 feet before it enters trapezoidal channel at upstream end of Roberts Meadow Middle Reservoir. Kennedy Road bridge spans brook 800 feet below the dam.

j. Regulating Outlets

- (1) Invert - floor of gate chamber elevation 428+ MSL.
- (2) Size - 12" gate valve.
- (3) Description - gate chamber collapsed (see Appendix C, Figure 4).
- (4) Control Mechanism - handwheel in gate chamber; access unsafe.
- (5) Pond drain - approx. 3' high x 1½' wide, shown on original plans is not visible.

REFERENCES

- 1/ Phase I Inspection Report, National Dam Inspection Program, Roberts Meadow Reservoir (Middle Dam), MA 00761, August 1978.

SECTION 2 ENGINEERING DATA

2.1 DESIGN DATA

Limited design data were available for Roberts Meadow Upper Reservoir Dam. Available data was in the form of the original 1883 design plan (1 sheet). No calculations were disclosed.

2.2 CONSTRUCTION DATA

No construction data were available. Limited information can be obtained from records of meetings of the Northampton Water Commissioners.

2.3 OPERATION DATA

No engineering operational data were obtained. The dam has not been operated within the last 20 years.

2.4 EVALUATION OF DATA

a. Availability

No detailed engineering data or calculations were available for Roberts Meadow Upper Reservoir. Direct contact with the City of Northampton Board of Public Works, Water Division, and a search of the files at the Hampshire County Hall of Records revealed only a limited amount of data. Previous inspection reports and sketches prepared by the Massachusetts Department of Public Works and the engineer for Hampshire County are available.

b. Adequacy

The final assessments and recommendations of this investigation are based on the visual inspection and the hydrologic and hydraulic calculations.

c. Validity

No detailed engineering data were available to validate. A comparison of field measurements with the original plan indicates changes were made in the design either during or after construction. Sketches made by the Massachusetts Department of Public Works adequately describe the dam.

SECTION 3 VISUAL INSPECTION

3.1 FINDINGS

a. General

The Roberts Meadow Upper Reservoir was inspected on May 2, 1980. At the time of inspection water was passing over the spillway approximately 7 inches deep at the low point of the spillway crest. The upstream face of the dam could only be inspected above this water surface.

b. Dam

The earth embankment at the southerly end of the spillway is showing possible evidence of internal erosion and settlement. A 3 foot diameter, 18 inch deep depression was noted at a location in line with leaks appearing at the downstream face of the dam. This depression is shown in Appendix C, Figure 3. This depression was noted in previous inspection reports by the Massachusetts Department of Public Works and county engineer as far back as 1970. According to these reports, the rate of enlargement of this feature appears to be slow.

A large amount of leakage estimated to total approximately 5 to 8 cfs is passing through the stone masonry spillway section at various locations.

Leakage at the northerly end of the spillway is along the joint between the ledge abutment and the stone masonry of the dam. A leakage condition also exists where the stone masonry at the southerly end of the spillway meets the ledge abutment. Bedrock fractures may be responsible for at least a part of the leakage at the bedrock-masonry interface. A large amount of leakage is occurring where the stone masonry wingwall rests on bedrock at the southerly end of the spillway.

The downstream slopes of both the embankment at the south end of the dam and the dike at the northerly end have trees growing from them. A small amount of brush growth is also present at the top of the stone masonry.

A wet area at the base of the earth dike, about 100 feet upstream of the northerly abutment, is most likely a result of surface water from the sloping ground to the north.

c. Appurtenant Structures

The original gate house has been removed from the dam. The gate house was located at the southerly end of the spillway. Visible remains of the gate house include protruding reinforcing steel and old concrete work. There are no details on the original gate house structure.

Beneath the gate house location is a stone arch gate chamber which houses a 12 inch gate valve. Presently the arch roof of this chamber is collapsed making entry unsafe.

A pond drain is shown on the original plan of the dam, however, it was not visible at the time of inspection. There is no visible means for operation of such a drain.

Parts of hinged flashboard supports remain; however, there are not a sufficient number of supports to retain any flashboards.

A timber plank apron which was formerly located at the base of the spillway is now destroyed and its remains can be seen downstream.

d. Reservoir Area

No structures were observed immediately adjacent to the reservoir upstream. One house is located approximately 300 feet upstream of the dam on the south side of Chesterfield Road. The house is constructed on a knoll and is at least 10 feet above the reservoir. Sediment has accumulated at the upper end of the reservoir, but the reservoir is open with no significant emergent vegetation at the surface.

e. Downstream Channel

The channel walls immediately downstream of the dam are bedrock outcrops. A large loose rock mass is presently resting about 20 feet above the channel at the northerly abutment. This rock mass appears to be slipping as indicated by measurements taken by the Massachusetts Department of Public Works.

The falling water from the spillway has formed a plunge pool in the channel at the base of the dam. Between the bedrock outcrops at the damsite and the Kennedy Road crossing 800 feet downstream of the dam, the channel bottom is gravel, cobbles, and boulders, with brush and trees submerged at higher stages. The banks of the stream become less steep with distance downstream.

Downstream of the Kennedy Road crossing, Roberts Meadow Brook is contained in a man-made trapezoidal channel having a bottom width of 15 feet, and side slopes approximately 3H to 1V. This artificial channel parallels Reservoir Road and forms the inlet to Roberts Meadow Middle Reservoir.

3.2 EVALUATION

Based on the visual inspection, Roberts Meadow Upper Reservoir Dam is presently in poor condition.

Trees and brush are growing on the southerly embankment which could potentially affect the stability of the stone wing wall which contains the embankment. As the trees grow larger there is also more potential for up-lifting of large root masses if the trees blow over.

Leakage through the face of the dam can freeze and widen the joints in the stone blocks which form the spillway. Continued movement of the blocks could eventually lead to instability and potential dislocation. At present the main arch portion of the spillway appears to be stable with only minor dislocations of the stone blocks. The stone blocks which formerly supported the gate house have major dislocations as shown in Appendix C, Figure 4.

SECTION 4
OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 OPERATIONAL PROCEDURES

a. General

No written operational procedures exist for Roberts Meadow Upper Reservoir Dam. Operation of the dam was abandoned over 20 years ago.

b. Description of any Warning System in Effect

No written warning system exists for the dam.

4.2 MAINTENANCE PROCEDURES

a. General

The owner, City of Northampton, is responsible for the maintenance of dam.

b. Maintenance and Operating Facilities

No formal maintenance program was disclosed. An engineering report in 1976 considered repairs to the dam; however, no work has been done.

4.3 EVALUATION

Formal operational and maintenance procedures should be developed to ensure that problems which may develop can be discovered and remedied within a reasonable period of time.

SECTION 5 EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 GENERAL

The Roberts Meadow Upper Reservoir Dam is a stone masonry and earth gravity dam which impounds a reservoir of small size. Operation of the dam as a regulating reservoir for water supply has been abandoned and the outlet conduit is no longer operational. The reservoir level is controlled solely by the spillway although leakage through the face of the dam could cause drawdown below the spillway crest during dry weather.

5.2 DESIGN DATA

No hydrologic or hydraulic design data were found. Field measurements indicate that the dam was constructed with less spillway width than called for on the original plan.

5.3 EXPERIENCE DATA

No hydrologic or hydraulic experience data were disclosed except that the dam has withstood significant floods. The dam was overtopped in 1955.

At the time of the inspection, no visual evidence was noted of damage to the structure caused by overtopping.

5.4 TEST FLOOD ANALYSIS

Roberts Meadow Upper Reservoir Dam is classified as being small in size having a hydraulic height of 35 feet and a maximum storage capacity of 72 acre-feet. It was determined that the dam currently has a significant hazard classification. Using the Recommended Guidelines for Safety Inspection of Dams, test flood range is the 100 year to $\frac{1}{2}$ of the Probable Maximum Flood (PMF). The 100 year flood is comparable to the $\frac{1}{4}$ PMF.

The $\frac{1}{2}$ PMF was selected as the test flood because that magnitude most closely relates to the involved risk. Using the $\frac{1}{2}$ PMF, the test flood inflow for Roberts Meadow Upper Reservoir Dam, having a drainage area of 8.8 square miles, was determined to be 7480 cfs based upon the "Preliminary Guidance for Estimating Maximum Probable Discharges" provided by the Corps of Engineers. The overtopping analysis indicates that the northerly dike would be overtopped by approximately 3.4 feet during the test flood conditions. The water depth discharging through the principal spillway would be 7.4 feet and would amount to 4050 cfs. Spillway capacity @ top of dam (approx. 454 MSL) is 1520 cfs, which is 20 percent of test flood discharge.

The $\frac{1}{4}$ PMF inflow was determined to be 3740 cfs which would overtop the dam by approximately 2 feet.

5.5 DAM FAILURE ANALYSIS

The impact of failure of the dam at top of dam was assessed using the Guidance for Estimating Downstream Dam Failure Hydrographs issued by the Corps of Engineers. The analysis covered the reach extending from the dam to Roberts Meadow Middle Reservoir (MA 00761) a distance of 5500 feet. A breach width of 40% of dam length at mid-height was assumed (24 feet). It was also assumed that the breach would occur with water at the top of the dam (elevation 454). The breach discharge was determined to be approximately 7300 cfs. This was added to the flow over the spillway other than the breach (approximately 1080 cfs) to give a total breach discharge of approximately 8380 cfs. The antecedent discharge (spillway capacity at top of dam prior to breach) was determined to be approximately 1500 cfs.

The bridge opening at Kennedy Road, approximately 800 feet downstream of the dam, was evaluated for its ability to pass the breach discharge. This analysis indicates that the bridge opening is capable of passing the antecedent discharge; however the breach discharge would flow over the road. The water surface elevation would be approximately 5 feet over the roadway at its low point which is at the intersection of Kennedy and Chesterfield Roads. There are no residences or other buildings in this vicinity.

In order to estimate the potential impact that the failure of the Roberts Meadow Upper Reservoir Dam would have on the Roberts Meadow Middle Reservoir, the 65 acre-feet top of dam storage of Upper Reservoir was added to Middle Reservoir. The water surface elevation in Middle Reservoir is estimated to rise approximately 1.5 feet to within 0.5 feet of the top of dam under this assumed condition. This analysis assumes that a 1500 cfs antecedent flow water surface elevation exists in Middle Reservoir prior to the breach and that no outflow is occurring from Middle Reservoir. It is also assumed that Middle Reservoir is restored to its original design condition.

Loss of life as a result of a breach of Upper Reservoir is remotely possible. However, the breach of Roberts Meadow Upper Reservoir could wash out the Kennedy Road Bridge and flood the Kennedy Road - Chesterfield Road intersection as well as causing siltation of downstream municipal water supplies. Therefore, the hazard classification is judged to be significant.

The present condition of Roberts Meadow Middle Reservoir Dam can be seen in Appendix C, Figure 10.

SECTION 6 EVALUATION OF STRUCTURAL STABILITY

6.1 VISUAL OBSERVATIONS

Items noted relative to structural stability are: Leakage through the face of the dam and the potential for stone blocks in the face of the arched spillway to become dislodged; internal erosion and settlement of the southerly embankment; trees growing on the downstream face of the southerly embankment and northerly dike; erosion at the base of the dam caused by spillway discharge falling over the crest.

6.2 DESIGN AND CONSTRUCTION DATA

The original design plan (1 sheet) is available.

No engineering operational records were obtained.

6.3 POST-CONSTRUCTION CHANGES

No information regarding post-construction changes were disclosed although field measurements indicate changes were made to the original design. The spillway width is less than called for on the original design. The dike at the northerly end of the dam was not a part of the original plan.

6.4 SEISMIC STABILITY

This dam is located in Seismic Zone 2 and, in accordance with the Phase I guidelines, does not warrant seismic analysis.

SECTION 7
ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.2 DAM ASSESSMENT

a. Condition

The visual inspection indicates that Roberts Meadow Upper Reservoir Dam is in poor condition. The major concerns with respect to the integrity of the dam, if left uncorrected, are:

- (1) General leakage through the face of the stone masonry portion of the dam and the potential for freeze-thaw action to dislodge stone blocks. Stonework within the arched spillway presently appears in stable condition with only minor dislocations noted.
- (2) Stonework in the area of the former gate house is now collapsed.
- (3) Internal erosion in the southerly embankment as evidenced by a 3 feet diameter depression and noticeable settlement at the top of the embankment.
- (4) Trees growing on the downstream slopes of the southerly embankment and northerly dike.

b. Adequacy of Information

The information available is such that the assessment of this dam must be based primarily on the results of the visual inspection.

c. Urgency

The recommendations made in 7.2 and 7.3 should be implemented by the owner within one year after receipt of this Phase I Inspection Report.

7.2 RECOMMENDATIONS

The owner should engage a qualified Registered Professional Engineer to:

- (1) Evaluate the stability of the dam against sliding and overturning and to design remedial measures, if needed.
- (2) Design procedures for and inspect the clearing of trees and brush from the embankment sections of the dam.
- (3) Design repairs to control leakage through the dam.
- (4) Investigate the sink-hole distress on the southerly embankment and design remedial measures, if necessary.
- (5) Study the feasibility of providing a low level outlet or other means in order to lower the normal pool.

- (6) Study the feasibility of rehabilitating the sluice gates and appurtenances in order to have the reservoir function as a back up water supply system.
- (7) Study the advisability of increasing the spillway capacity.
- (8) Perform an examination of the downstream toe of the stone masonry section during a period of low flow.

The owner should carry out the recommendations made by the Engineer.

7.3 REMEDIAL MEASURES

a. Operating and Maintenance Procedures

The owner should:

- (1) Prevent trespassing on the embankment sections of the dam.
- (2) Engage a qualified Registered Professional Engineer to make a comprehensive technical inspection of the dam once every year.
- (3) Establish a formal operation and maintenance program.
- (4) Establish a written surveillance program for use during and immediately after a heavy rainfall, and also a warning program to follow in case of emergency conditions. The surveillance and warning program for this dam should be correlated with those of the downstream dams.

7.4 ALTERNATIVES

There are no practical alternatives to the above recommendations.

APPENDIX A

VISUAL INSPECTION CHECKLIST

VISUAL INSPECTION PARTY ORGANIZATION

NATIONAL DAM INSPECTION PROGRAM

DAM: Roberts Meadow Upper Reservoir 00760

DATE: May 2, 1980

TIME: 1:30 p.m.

WEATHER: Sunny 65°F

W.S. ELEV. 450.6 (MSL) 426 MSL
100.6 U.S. 76 DN.S. (Original Plan Datum)

ELEV. DATUM: Datum of Original Plan
Elevation 100. on Plan datum is approximately Elevation (450 MSL)

INSPECTION PARTY: (All project features inspected by all party members)

1. J. F. Cysz, P.E.
2. J. E. Walsh, P.E. (Baystate Environmental Consultants, Inc.)
3. K. N. Hendrickson, P.E.
4. L. D. Zwingelstein
5. H. T. Shumway
6. _____

OTHERS PRESENT DURING INSPECTION:

1. Craig Nehring - City of Northampton Water Dept.
2. _____
3. _____
4. _____

VISUAL INSPECTION CHECKLIST

DAM: Roberts Meadow Upper Reservoir MA 00760 DATE: May 2, 1980

AREA EVALUATED	CONDITION
<u>DAM EMBANKMENT</u> (Southerly and Northerly Ends)	
Crest Elevation	455 MSL south end; 454 north end
Current Pool Elevation	450.6 MSL.
Maximum Impoundment to Date	Higher than 454 MSL- flowed over northerly dikes 1955.
Surface Cracks	Depression 18" deep, 3' diameter at southerly embankment.
Pavement Condition	No pavement
Movement or Settlement of Crest	Settlement of southerly embankment on sides of core wall.
Lateral Movement	Slight movement at northerly abutment
Vertical Alignment	Settlement as noted above
Horizontal Alignment	Satisfactory
Condition at Abutment and at Concrete Structures	Okay at abutment. Cracks and leakage at interface between spillway and embankment.
Indications of Movement of Structural Items on Slopes	Wingwall at southerly end of spillway is okay.
Trespassing on Slopes	Minor trespass
Vegetation on Slopes	18" trees D/S slope - southerly end, smaller trees on dike.
Sloughing or Erosion of Slopes or Abutments	None detected
Rock Slope Protection - Riprap Failures	None observed. Minor erosion at normal water line.
Unusual Movement or Cracking at or near Toes	None observed.

VISUAL INSPECTION CHECKLIST

DAM: Roberts Meadow Upper Reservoir MA 00760

DATE: May 2, 1980

AREA EVALUATED

CONDITION

DAM EMBANKMENT (continued)

Unusual Embankment or Downstream
Seepage

Yes. Leakage through face of southerly
embankment connected to depression.

Piping or Boils

None other than above

Foundation Drainage Features

None

Toe Drains

None

Instrumentation System

None

VISUAL INSPECTION CHECKLIST

DAM: Roberts Meadow Upper Reservoir MA 00760

DATE: May 2, 1980

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - CONTROL TOWER</u>	This section not applicable.
a. Concrete and Structural	Old gate house shown on original plan is now destroyed. Remains include old concrete work and protruding reinforcing steel. (See Appendix C, Figure 4)
General Condition	
Condition of Joints	
Spalling	
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	Not applicable
Air Vents	None
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	12" C.I. gate valve with handwheel inoperable. Gate chamber is collapsed.
Emergency Gates	
Lightning Protection System	None
Emergency Power System	None
Wiring and Lighting System in Gate Chamber	None

VISUAL INSPECTION CHECKLIST

DAM: Roberts Meadow Upper Reservoir MA 00760

DATE: May 2, 1980

AREA EVALUATED

CONDITION

OUTLET WORKS - TRANSITION AND CONDUIT

General Condition of Concrete

Rust or Staining on Concrete

Spalling

Erosion or Cavitation

Cracking

Alignment of Monoliths

Alignment of Joints

Numbering of Monoliths

Note: The 12 inch cast iron gate valve for outlet conduit is visible in the collapsed stone gate chamber. The outlet conduit is closed off and is no longer operable.

VISUAL INSPECTION CHECKLIST

DAM: Roberts Meadow Upper Reservoir MA 00760 DATE: May 2, 1980

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL</u>	
General Condition of Concrete	Stone masonry arch gate chamber is partly collapsed. Stone blocks dislocated.
Rust or Staining	Not applicable
Spalling	Not applicable
Erosion or Cavitation	Not applicable
Visible Reinforcing	Yes. Remains of reinforced concrete gate house.
Any Seepage or Efflorescence	Leakage through dislocated joints in stone blocks in area of old outlet works.
Condition at Joints	Severe - arch is partially collapsed at old gate chamber.
Drain holes	Heavy leakage
Channel	Not applicable
Loose Rock or Trees Overhanging Channel	See comments for spillway, sheet 8.
Condition of Discharge Channel	

VISUAL INSPECTION CHECKLIST

DAM: Roberts Meadow Upper Reservoir MA 00760 DATE: May 2, 1980

AREA EVALUATED

CONDITION

OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE

a. Approach Channel

Not applicable - no approach channel -
open reservoir upstream.

Slope Conditions

Bottom Conditions

Rock Slides or Falls

Log Boom

Debris

Condition of Concrete Lining

Drains or Weep Holes

b. Intake Structure

Condition of Concrete

Old 12" C.I. outlet blocked and gate
valve inoperable. Stone gate cham-
ber is collapsed.

Stop Logs and Slots

VISUAL INSPECTION CHECKLIST

DAM: Roberts Meadow Upper Reservoir MA 00760

DATE: May 2, 1980

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS</u>	
(Cut stone masonry arch spillway)	
a. Approach Channel	
General Condition	Satisfactory
Loose Rock Overhanging Channel	No
Trees Overhanging Channel	No
Floor of Approach Channel	Not observed
b. Weir and Training Walls	
General Condition of Concrete	No concrete - stone masonry, fair. A few dislocated blocks in downstream face.
Rust or Staining	Not applicable
Spalling	Not applicable
Any Visible Reinforcing	Yes, at remains of old gate house
Any Seepage or Efflorescence	Major leakage 5-8 cfs mainly where stone blocks displaced; also where blocks abut bedrock and where wingwall rests on bedrock at southerly abutment end of spillway.
Drain Holes	None
c. Discharge Channel	
General Condition	Good - plunge pool
Loose Rock Overhanging Channel	Large rock mass at northerly abutment is unstable.
Trees Overhanging Channel	Minor

VISUAL INSPECTION CHECKLIST

DAM: Roberts Meadow Upper Reservoir MA 00760

DATE: May 2, 1980

AREA EVALUATED

CONDITION

OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS

Floor of Channel

Brook bed, plunge pool. Old splash pad washed d/s.

Other Obstructions

Boulders, remains of splash pad, debris.

Note: Remains of old flashboards - hinge pins and slots visible at southerly and northerly ends of spillway. Small trees growing out of spillway crest.

VISUAL INSPECTION CHECKLIST

DAM: Roberts Meadow Upper Reservoir MA 00760

DATE: May 2, 1980

AREA EVALUATED

CONDITION

OUTLET WORKS - SERVICE BRIDGE

This section not applicable - no service bridge.

a. Super Structure

Bearings

Anchor Bolts

Bridge Seat

Longitudinal Members

Under Side of Deck

Secondary Bracing

Deck

Drainage System

Railings

Expansion Joints

Paint

b. Abutment & Piers

General Condition of Concrete

Alignment of Abutment

Approach to Bridge

Condition of Seat & Backwall

APPENDIX B

ENGINEERING DATA

- B-1. LIST OF AVAILABLE DESIGN, CONSTRUCTION AND
MAINTENANCE RECORDS
- B-2. PREVIOUS INSPECTION REPORTS
- B-3. PLANS, SECTIONS AND PROFILES
- B-4. BORING LOGS

LIST OF AVAILABLE DESIGN
CONSTRUCTION AND MAINTENANCE RECORDS

- A. PLANS - Original Design Plan, one sheet is on file at the office of the Board of Public Works, Water Division, 237 Prospect Street, Northampton, MA.
- B. SPECIFICATIONS - None found
- C. DESIGN RECORDS - None found
- D. CONSTRUCTION RECORDS - Several entries in the Annual Reports of the Board of Water Commissioners refer to construction progress. The Reports are filed at the Water Division office, 237 Prospect Street, Northampton, MA
- E. MAINTENANCE - Maintenance records are filed at the Water Division office.

PREVIOUS INSPECTION REPORTS

Note: Additional Inspections on Dams located within the City of Northampton, MA were performed by the Hampshire County Engineer in the years 1962, 1964, 1966, 1968 and 1970. Copies of these reports are on file at the County Court House in Northampton.

Cond. 4

October 5, 1976

SUBJECT: Dam - Northampton
Roberts Meadow "Upper" or Moxie Reservoir
Dam No. 2-8-214-15

Mr. Robert T. Tierney, P.E.
Chief Engineer
Mass. Dept. Public Works
100 Nashua Street
Boston, Massachusetts 02114

Attention: Mr. John J. Hannon
Chief Engr. of Waterways Division

Dear Sir:

Enclosed is a Dam Reinspection Report for the Roberts Meadow "Upper" or
Moxie Reservoir Dam No. 2-8-214-15, in Northampton.

Please note that this dam is listed as unsafe.

Very truly yours,

Francis J. Hoxby
FRANCIS J. HOXY, P.E.
District Highway Engineer

MTS:ma
e-HED
Encls.

Top at 20 ft. wall severely under excavation on R side
brush growth in crevices, staining
severe leakage thru wall

Lower dam - 1' water over crest - debris in stream
below dam - vertical crack in R. abut. wall
severe leakage thru 6' dam structure of crest
minor brush growth - same displacement of riprap

Hoxie dam

Pressure head of water 18 ft -
water level at 10 ft gate chamber
the dam is heavily overgrown with brush

September 2, 1976

Roberts Meadow Reservoir-Middle
Hoxie or Roberts Meadow Reservoir-Upper
SUBJECT: Dam Roberts Meadow Reservoir-Lower
Dam Nos. 2-8-214-14
2-8-214-15
2-8-214-16

delivered Sept. 7, 1976
with application for permit
for both upper & middle.

City of Northampton
D.P.W. - Water Division
237 Prospect Street
Northampton, Massachusetts 01060

ATTENTION: Mr. Leon Murray, Supt.

Dear Sir:

Chapter 595 of the Acts of 1970 requires that all dams in Massachusetts be inspected by the Department of Public Works periodically. Please be advised that the above dam, of which you are the caretaker or owner, is scheduled for inspection in the near future. If you wish to be present during the inspection an appointment may be arranged by contacting Mr. Harold T. Shumway of this office at telephone number 584-1611.

Very truly yours,

Francis J. Hoey

FRANCIS J. HOEY, P.E.
District Highway Engineer

HTS/fo
C-HBB

Sept. 1, 1976 - Call from Leon Murray on dam
- lands leaving next Monday night. I will call by
Sept. 9-15-76.

called 9-15-76 - will be two weeks before any more alternate to
wetlands leaving on upper dam - To 2/3 of structure
middle one will be repaired - preliminary plans proceed for rep
coming up is the point of advertising for repair contracts.
Lower one is being repaired in late fall.

INSPECTION REPORT - DAMS AND RESERVOIRS

1. LOCATION:

City/Town Northampton County Hampshire Dam No. 2-8-214-15

Name of Dam Robert H. "Upper" or Middle Reservoir

Mass. Reet.

Topo Sheet No. 11 C Coordinates: N 408,200, E 208,000

Inspected by: Harold L. Drumrey, On Sept. 22, 1976 Date 7-23-74
Last Inspection

2. OWNER/S: As of Sept. 22, 1976

per: Assessors _____, Reg. of Deeds _____, Prov. Insp. X, Per. Contact X

City of Northampton

1. Board of Public Works, Water Division, 237 Prospect St., Northampton, Mass.

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

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

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.

Mr. Leon Murray

Supt. of Water Division, 237 Prospect St., Northampton, Mass.

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

4. DATA:

No. of Pictures Taken None Sketches See description of Dam.
Plans, Where At Northampton Water Division Office.

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

1. Minor _____	3. Severe _____
2. Moderate _____	4. Disastrous _____

Comments: Approx. 8 million gallons-impoundment-hazard is dependent on how well
Roberts Meadow Reservoir-Middle Dam No. 2-8-214-14 holds.

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

6.

OUTLETS: OUTLET CONTROLS AND DRAWDOWN

No. 1 Location and Type: Northerly end of dam-crest overflow spillway 70'± W. X 3'
with dropwall 29'± H.

Controls Yes, TYPE: Provisions for stop logs-none in place.

Automatic . Manual X. Operative Yes , No X.

Comments: Spillway dropwall built of stone masonry-seepage and leaks evident
Old plans show sluiceway 2' X 2' through center dropwall.

No. 2 Location and Type: below tail water level.

Controls Unk., Type Unknown

Automatic . Manual . Operative Yes , No , Unk.

Comments: No visible field evidence of this sluiceway.
Concrete lined stone masonry vault

No. 3 Location and Type: South of spillway-for gate valve.

Controls Yes, Type: 12" dia. C.I. gate valve.

Automatic . Manual X. Operative Yes , No X.

Valve not operated with in memory of present Supt.-concrete lined
Comments: mostly concrete-lined vault structure in poor condition.

Drawdown present Yes X, No . Operative Yes , No Unk.

Comments: See item No. 2 and No. 3 above.

7.

DAM UPSTREAM FACE: Slope 1:2 variable, Depth Water at Dam 18'±
Stone

Material: Turf X. Brush & Trees . Rock fill . Masonry X. Wood

Other Stone masonry dropwall and abuts.-turf on south embankment and on dike also
north side of pond.

Condition: 1. Good . 3. Major Repairs X

2. Minor Repairs . 4. Urgent Repairs

Comments:

8.

DAM DOWNSTREAM FACE: Slope Slight batter on dropwall
2:1 on embankment slopes.

Material: Turf X. Brush & Trees . Rock Fill . Masonry X. Wood
Stone

Stone masonry on wing walls, dropwall, gate vault, and north abutment,
Other embankments turf covered.

Condition: 1. Good . 3. Major Repairs

2. Minor Repairs . 4. Urgent Repairs X

Comments: Heavy seepage, large leaks, pressure leak or piping condition,
displaced stone masonry, ledge block disintegrating.

9. EMERGENCY SPILLWAY: Available No ____ . Needed No ____ .

Height Above Normal Water: ____ Ft.

Width $70\frac{1}{2}$ Ft. Height 31 Ft. Material Stone masonry

Condition: 1. Good ____ . 3. Major Repairs X ____ .
2. Minor Repairs ____ . 4. Urgent Repairs ____ .

Comments: North abutment top would add another $25\frac{1}{2}$ to spillway width in
extreme high water levels.

10. WATER LEVEL AT TIME OF INSPECTION: $1\frac{1}{6}$ Ft. Above X ____ . Below ____ .

Top Dam ____ F.L. Principal Spillway X ____ .

Other ____

Normal Freeboard 3.5 Ft. From crest to top of North abutment.

11. SUMMARY OF DEFICIENCIES NOTED:

Growth (Trees and Brush) on Embankment Brush growth in stone masonry crevices.

Burrow near edge of water on South embankment.

Animal Burrows and Washouts Sump hole in South embankment.

Damage to Slopes or Top of Dam Yes-see remarks

Cracked or Damaged Masonry Yes-see remarks

Evidence of Seepage Yes-seepage noted through dropwall and gate vault.

Evidence of Piping Pressure leak at base of downstream south face wall, and sump
hole in top of embankment above indicate piping.

Leaks Several large and small leaks.

Erosion Stilling pool at top of spillway shows erosion of stream bed.

Trash and/or Debris Impeding Flow Timber splash pad lays in stream bed $20\frac{1}{2}$
downstream of spillway dropwall too.

Clogged or Blocked Spillway None found.

Other Gate vault slowly collapsing-unsafe to enter in present condition.

- 4 -

(12.)

OVERALL CONDITION:

1. Safe _____.
2. Minor repairs needed _____.
3. Conditionally safe - major repairs needed _____.
4. Unsafe X _____.
5. Reservoir impoundment no longer exists (explain)
Recommend removal from inspection list _____.

(13.)

REMARKS AND RECOMMENDATIONS: (Fully Explain)

Reference is made to the last inspection report of 9-23-74 for a detailed description of the condition of this dam. No repairs have been made since that time and all leaks, cracked masonry, ledge block movement, etc., have increased since last inspection. The timber splash pad, once located at toe of spillway dropwall, has torn loose and now lies approx. 20' downstream, lodged on boulders and brush growth. The pressure leak has increased in volume in the south abutment wing wall and could well be a piping condition. The gate vault has deteriorated to the point where it would be unsafe to venture inside to operate the gate valve, if valve were operable, which it appears not to be. The stone masonry above the gate vault is shifting and moving out of alignment.

According to Mr. Leon Murray, Northampton Water Division Supt., plans are in progress to remove this dam structure down to 1/3 of its present level. Per Mr. Murray a Wetlands Hearing was held on Monday evening, Sept. 13, 1976, concerning this removal. Per Mr. Murray it will be 2 or 3 weeks before a decision is reached by interested parties of this hearing. Mr. Murray stated that if request to lower the dam is denied the Water Division will repair the structure.

At this present inspection the deteriorating condition of dam was such that the District is now rating this dam as unsafe.

Mr. Murray stated in a phone conversation with our office on Sept. 29, 1976 that an application for authorization to construct or alter a reservoir, Reservoir Dam, or Mill Dam, had been filed with your office on Sept. 7, 1976, concerning plans for proposed lowering of this dam or repairs to same if lowering of structure is not allowed.

HTS/at

September 26, 1974

SUBJECT: Dams - Northampton
Roberts Meadow "Upper" or Hoxie Reservoir
Dam Number 2-8-214-15

Mr. Malcolm E. Graf
Associate Commissioner
Massachusetts Department of Public Works
100 Nashua Street
Boston, Massachusetts 02114

Attention: Mr. Norman L. DiGoli, P. E.
Acting Deputy Chief Engineer for Waterways

Dear Sir:

Enclosed are Dam Description and Dam Inspection Reports for the
Roberts Meadow "Upper" or Hoxie Reservoir Dam, Number 2-8-214-15,
in Northampton.

Very truly yours,

Francis J. Huey

FRANCIS J. HUEY, P. E.
District Highway Engineer

RCS/ed
C - RTT
HJB ✓

Enclosures

INSPECTION REPORT - DAMS AND RESERVOIRS

1. LOCATION:

City/Town Northampton County Hampshire Dam No. 2-8-214-15

Name of Dam Roberts Meadow "Upper" or Hoxie Reservoir

Mass. Rect.

Topo Sheet No. 11C Coordinates: N 490,000, E 268,000

Date

Inspected by: Russell C. Salls, P.E. On Sept. 23, 1974. Last Inspection 1970

2. OWNER/S: As of November, 1972

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

City of Northampton,

1. B. P. W. Water Division, 237 Prospect Street, Northampton, Mass. 01060
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.

Mr. Leon Murray,

Superintendent of Water Division, 237 Prospect Street, Northampton, Mass. 01060
Name St. & No. City/Town State Tel. No.

4. DATA:

No. of Pictures Taken None Sketches See description of Dam.
Plans, Where At Northampton Water Division Office.

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

1. Minor 3. Severe

2. Moderate X 4. Disastrous

Hazard is dependent on how well Middle Roberts Meadow Dam, No. 2-8-214-14
Comments: holds.

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

6. OUTLETS: OUTLET CONTROLS AND DRAWDOWN

Dropwall overflow spillway 70'± wide - 3.5' high
No. 1 Location and Type: dropwall 29'±.

Controls Yes, TYPE: Unused provisions for stoplogs.

Automatic . Manual X. Operative Yes , No X.

Comments: Stone masonry structure. Original width of spillway apparently reduced by abutment on north end.

Old plans show sluiceway 2' x 2' through center dropwall
No. 2 Location and Type: below tail water level.

Controls Unk., Type: Unknown

Automatic . Manual . Operative Yes , No . Unknown.

Comments: No evidence of this sluiceway visible in field.

In masonry gate vault or house at base of dam
No. 3 Location and Type: 12" gate valve.

Controls Yes, Type: 12" cast iron gate valve.

Automatic . Manual . Operative Yes , No . Not operated within memory of present Superintendent

Comments: Valve originally imbedded in concrete floor of gate house. Concrete deteriorated so that much of gate body is exposed.

Drawdown present Yes X, No . Operative Yes , No . Unknown.

Comments: See Items 2 and 3.

7. DAM UPSTREAM FACE: Approximately (per old plan)
Slope 1' to 2', Depth Water at Dam 19'± sounding.

Material: Turf X. Brush & Trees . Rock fill . Stone Masonry X. Wood .
Stone masonry on dropwall; turf on embankment on south end and on dike
Other on north side pond.

Condition: 1. Good . 3. Major Repairs .

2. Minor Repairs X. 4. Urgent Repairs .

Comments: Condition assumed from the condition of portion visible below water.

8. DAM DOWNSTREAM FACE: Slight batter on face dropwall -
Slope 2:1 on embankment.

Material: Turf X. Brush & Trees . Rock Fill . Stone Masonry X. Wood .
Stone masonry on wingwalls, dropwall, gate house, and north abutment
Other turf on embankments.

Condition: 1. Good . 3. Major Repairs .

2. Minor Repairs . 4. Urgent Repairs X.

Comments: Loose blocks of stone in gate house could fall and damage gate valve. Many open joints in stone masonry. In north ledge abutment, large block ledge is slowly loosening. See remarks.

9. EMERGENCY SPILLWAY: Available No, Needed No.

Height Above Normal Water 0.5 Ft.

Width 70± Ft. Height 3.5 Ft. Material Stone Masonry.

Condition: 1. Good , 3. Major Repairs x.

2. Minor Repairs , 4. Urgent Repairs .

Comments: Entire width of spillway would become emergency spillway and north abutment would add another 25' of width to dropwall in extremely high water.

10. WATER LEVEL AT TIME OF INSPECTION: 0.2 Ft. Above x Below .

Top Dam F.L. Principal Spillway x.

Other .

Normal Freeboard 3.5 Ft. Crest to top left or north abutment.

11. SUMMARY OF DEFICIENCIES NOTED:

Growth (Trees and Brush) on Embankment Weeds and brush growing in cracks in stone masonry.

Animal Burrows and Washouts One burrow in south abutment near edge of water.

Damage to Slopes or Top of Dam Yes. Considerable deterioration of masonry at gate house and adjacent dropwall. Also many open joints in other areas. In ledge abutment just downstream of dam, large blocks of stone are loose.

Cracked or Damaged Masonry

Evidence of Seepage None noted.

Evidence of Piping Leaks and/or piping through many of joints in stone masonry including wings on south end and abutment on north end. Leaks through and over gate house.

Leaks

Erosion Some wave and ice erosion on dike and embankment.

Trash and/or Debris Impeding Flow No

Clogged or Blocked Spillway No

Other Gate house is integral part of dam and is in very poor condition. Collapse of stone arch roof appears imminent.

(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)

This old stone masonry dam apparently has been in a deteriorating condition for some time. The 1970 report of the County Engineer reports on many of the items noted hereafter. This dam appears to have received only a minimum amount of maintenance, little more than yearly mowing of the embankments in recent years. Mr. Murray, the Superintendent of the Water Division told us that in his memory the gate valve had never been operated and he has never seen the waste way shown on the old plans.

This dam is upstream of the Roberts Meadow Reservoir "Middle", Number 2-8-214-14, impounding over 75 million gallons of water which is also in a deteriorated condition. A failure of the upper dam would very likely trigger a failure of the middle dam and result in a disastrous flood in Leeds Village.

This dam, according to old plans, was originally built in 1886, on a ledge foundation. The original arched stone masonry spillway structure was 80 feet wide with a center weir notch, one-half foot deep and about 25' wide for low water flow. At the south or right end of the arched overflow a stone masonry gate house or vault was incorporated into the downstream face of the dam. This contains a 12" cast iron gate valve originally almost completely imbedded in the concrete floor. Since the original construction the right of south abutment and adjacent embankment has been raised about a foot and a stone masonry abutment was built on the left or north end of the spillway wall. This abutment is about 25 feet long, 6 feet wide, and its top is $3\frac{1}{2}$ foot above the spillway crest. About 10 to 12 feet of this abutment appears to have been built out on to the spillway crest narrowing the original 80 feet of spillway width to about 70 feet. Also an earth dike, its top level with the north abutment, has been built along the north side of the pond.

That portion of the arched stone masonry spillway between the gate house and the ledge and stone abutment on the north end had no noticeable bulges or settlement and all stones appeared to be in their original location. Leakage through joints was quite general at

- 5 -

13. REMARKS AND RECOMMENDATIONS: CONTINUED

much of the mortar in the joints had disappeared. Some weeds were growing out of joints on the crest where water was not overflowing and in some joints on the vertical face. Our sounding of the tail water pool tended to indicate that scouring since construction had deepened the pool about a foot.

On the north end of the spillway wall the stone abutment appeared sound but there was a considerable amount of water leaking through the base of the abutment apparently along the joints between the ledge foundation and stone masonry.

At the base of the ledge wall, against the downstream face of the spillway wall, there is a large block of stone say 10' by 8' which is being loosened and undermined by the elements. Because of the water, from the leak through the abutment above, it was not possible to determine if water was flowing through cracks in the ledge here.

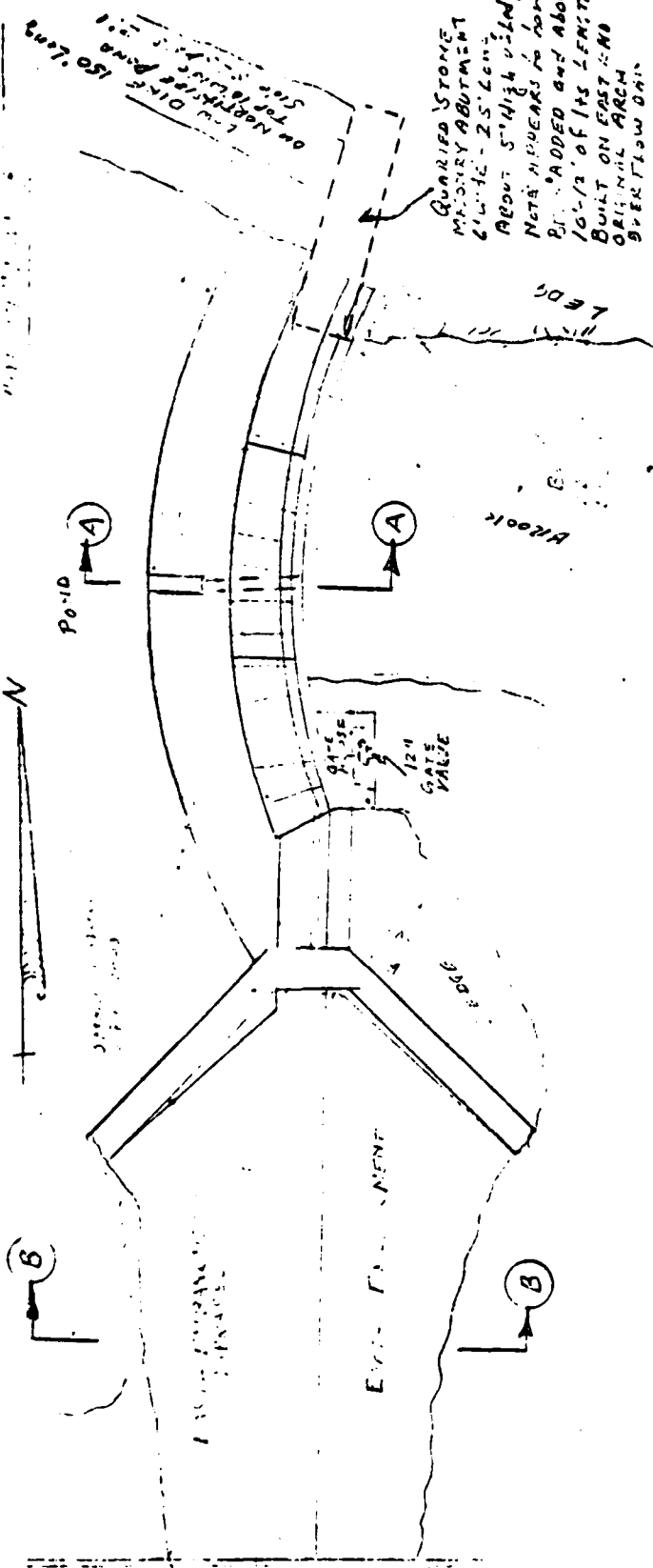
At the south end of the arched spillway the gate house structure is badly deteriorated. Leakage through the wall above the gate house and on either side of the gate house were very noticeable. The concrete cover over the face of the wall and the stone arched gate house roof has deteriorated badly. Some of the stones in the arched roof are loose and are held up only by the reinforcing steel in the concrete liner of the gate house. The gate valve appears to have originally been imbedded in the concrete floor of the gate vault but over the years the deterioration of the concrete has progressed so that almost all of the entire gate valve is exposed.

In the right abutment's wingwall, fourteen feet below the abutment's top, and about four feet from the abutment's face, there is a large pressure leak. In the surface of the earth behind the wingwall on the top of the embankment, there is a sink hole about a foot deep and two feet in diameter which appears to be stabilized for the present time. The upstream wingwall of this abutment shows signs of ice and frost action in its top portions but is still effective. There is a small animal burrow behind this wall, about twenty feet from the face of the abutment.

Since this structure is upstream of two other dams and its failure could easily trigger a disastrous flood, the District believes that some action should be demanded of the owner to correct or determine the extent of the following conditions: The extent of and possible consequence of the deterioration of the ledge in the north abutment where a large block of stone appears ready to fail; the repair or removal of the stone arch roof of the gate house before it fails and cracks the valve; and the exact nature of the sump hole behind and the leak in the downstream wingwall of the south spillway abutment.

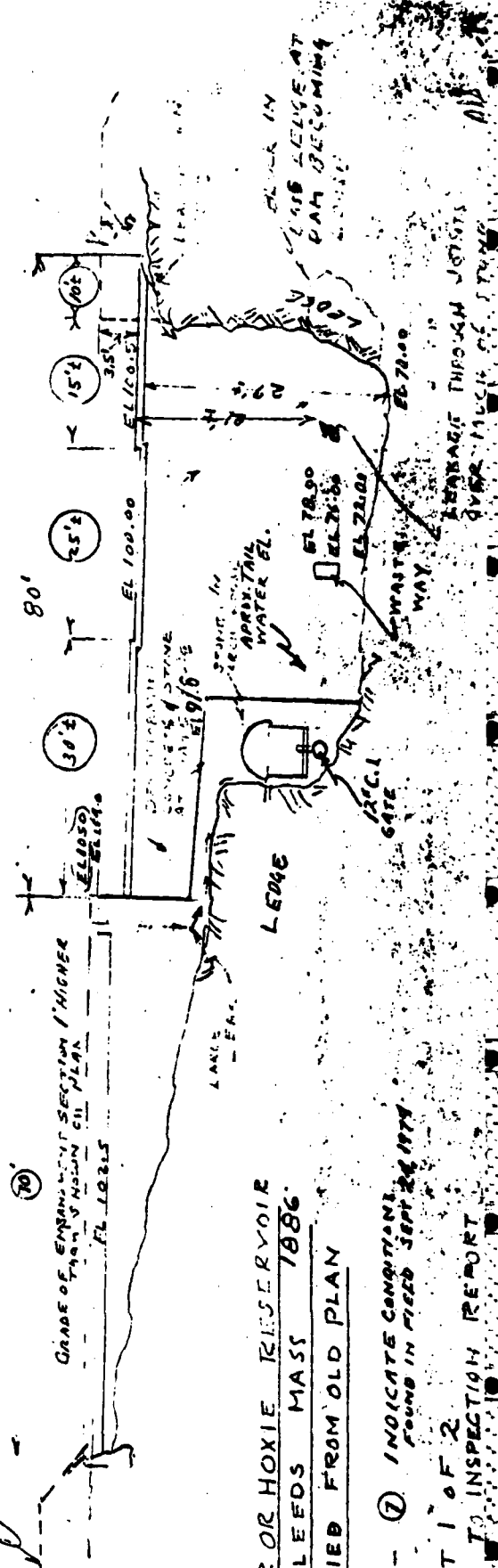
Unless some remedial actions are taken before the next inspection, the District would undoubtedly be forced to declare this dam unsafe.

RCS/sd
Attachments



PLAN

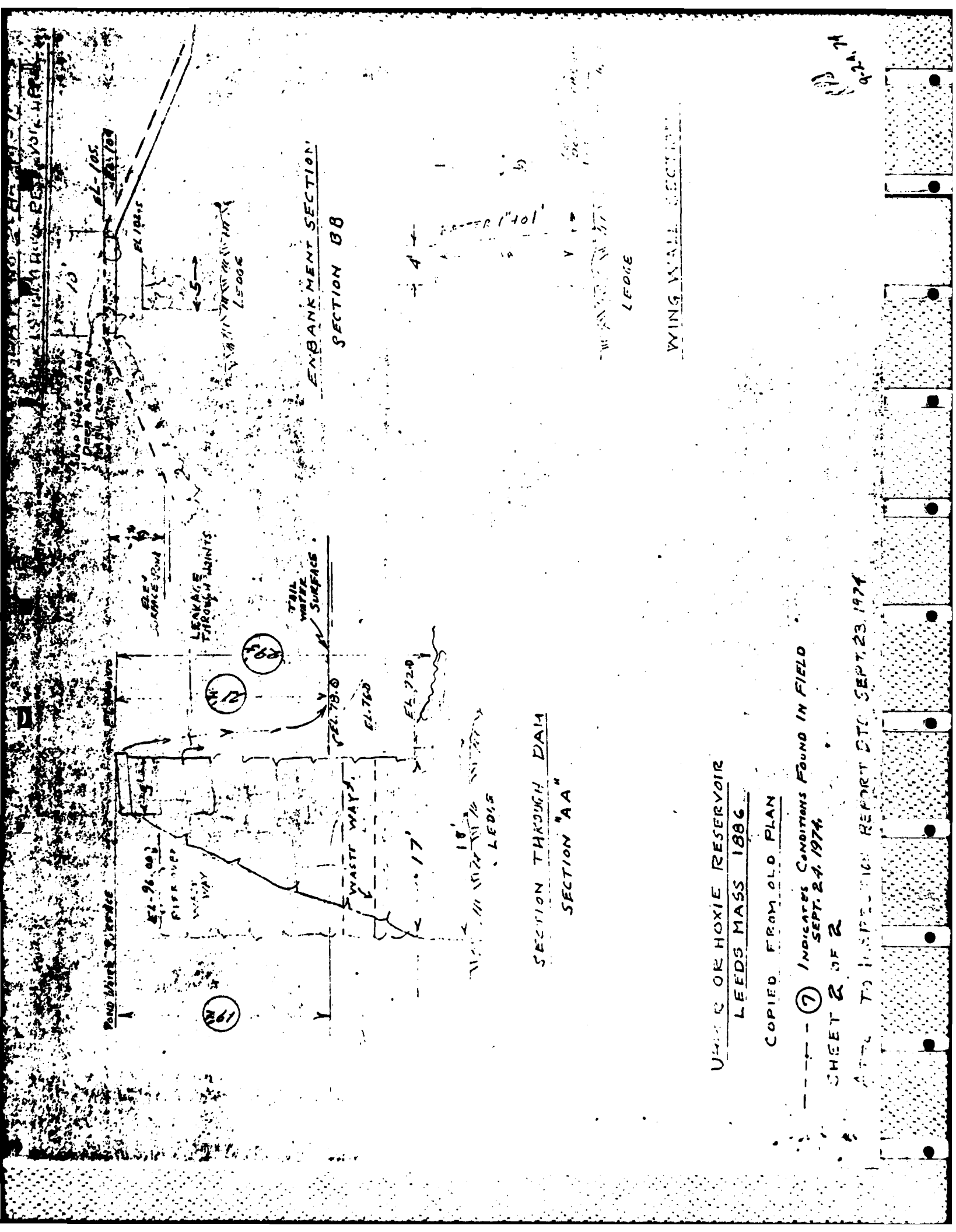
Chesterfield 20
APPARENTLY BUILT
along with them same way



UPPER OR HOXIE RESERVOIR
LEEDS MASS 1886
COPIED FROM OLD PLAN

⑦ INDICATE CONDITIONS FOUND IN FIELD SEPT 24 1974

SHEET 1 OF 2
ATTACH TO INSPECTION REPORT



UNDER OR HOXIE RESERVOIR

LEEDS MASS 1886

COPIED FROM OLD PLAN

--- (7) INDICATES CONDITIONS FOUND IN FIELD

SEPT. 24, 1974

SHEET 2 OF 2

ATTN TO INSPECTION REPORT DTC SEPT. 23, 1974

DESCRIPTION OF DAM

DISTRICT II.Submitted by Russell C. Salls, P. E. Dam No. 2-8-214-15Date September 23, 1974 City/~~town~~ NorthamptonName of Dam Roberts Meadow -
Upper or Hoxie Reservoir1. Location: Topo Sheet No. 11C Mass. Rect. Coordinates N 490,000 E 268,000Provide $8\frac{1}{2}$ " x 11" in clear copy of topo map with location of Dam clearly indicated.On Roberts Meadow Brook just north of Chesterfield Road about 1,000 feet
westerly from Reservoir Road.2. Year built 1886 Year/s of subsequent repairs Unknown3. Purpose of Dam: Water Supply X Recreational _____
Flood Control _____ Irrigation _____ Other _____
Largely unused now. Used only as auxiliary source.4. Drainage Area: 8 7/10 sq. mi. _____ acres.
Type: City, Bus. & Ind. _____ Dense Res. _____ Suburban _____ Rural, Farm 20%
Wood & Scrub Land 80% Slope: Steep 80% Med. 20% Slight _____5. Normal Ponding Area: 3 $\frac{1}{2}$ Acres; Ave. Depth 7'
Impoundment: 8 Million gals.; 24.5 acre ft.
Silted in: Yes X No _____ Approx. Amount Storage Area 50%6. No. and type of dwellings located adjacent to pond or reservoir _____
i.e. summer homes etc. None.7. Dimensions of Dam: Length 165' plus 150' dike on 29'± on spillway
34' on embankment
Freeboard 3.5 at north abutment
Slopes: Upstream Face 1 to 2 on stone spillway wall; 2:1 on embankment
Vertical on stone spillway
Downstream Face 2:1 on embankments
5' on stone spillway
Width across top 10' on embankments

Dam No. 2-8-214-15

8.

Classification of Dam by Material:

Earth X Conc. Masonry _____ Stone Masonry X
Timber _____ Rockfill _____ Other Ledge

8a.

Dam Type: Gravity X Straight _____ Curved, Arched X Other wall
Overflow X Non-overflow _____

9.

A. Description of present land usage downstream of dam:

90 % rural; 10 % ~~developed~~ developed

B. Is there a storage area or flood plain downstream of dam which could accommodate the impoundment in the event of a complete dam failure? Yes X No _____

C. Character Downstream Valley: Narrow _____ Wide X Developed _____
Rural X Urban _____

To "Middle" Dam.

10.

Risk to life and property in event of complete failure.

No. of people Questionable - Condition of two lower dams determine amount of damage to be expected. If they fail - SAY 5 lives and 7 houses.

No. of homes _____

No. of businesses See above. Post Office.

No. of industries See above - 1 Type General manufacturing building at junctio
with Mill River.

No. of utilities 4 Type Water supply - electrical and telephone
pole lines - sewer lines.

Railroads None

Roberts Meadow Middle Dam, No. 2-8-214-14 and

Other dams Roberts Meadow Lower Dam, No. 2-8-214-16

Other Bridges on town roads.

11.

Attach Sketch of dam to this form showing section and plan on 8 $\frac{1}{2}$ " x 11" sheet.

RCS/vk /sd

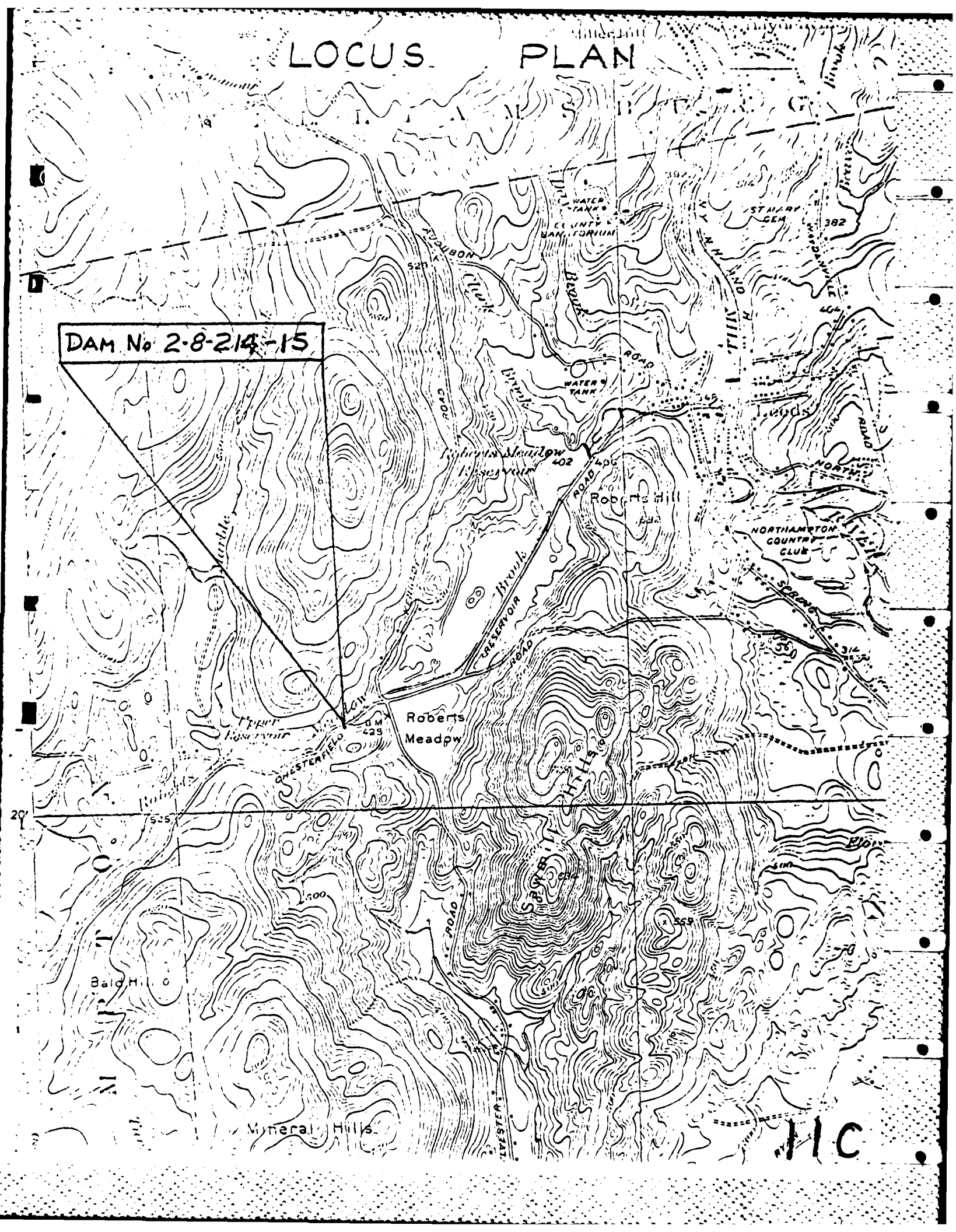
Attachments

Locus Plan

Sketches

LOCUS PLAN

DAM No 2-8-214-15



-8-

Copy of 1970 County Engineer's (Tighe & Bond)
 Dam Inspection Rept - City of Northampton

In spite of the concentrated leakage through the joints of the left stone masonry wall of the dam, there is no evidence of movement of the masonry blocks and, as a result, it is the opinion of the undersigned that the dam is safe. Since the reservoir behind the dam apparently is no longer used by the Northampton Water Dept., the department is probably not interested in spending money to seal the leaks. If this is to be done, it should be done from the upstream side.

No changes have been made or taken place at this dam since the time of the last inspection except for the fact that leakage seems to have increased.

In the opinion of the undersigned, the dam is safe.

M. Roberts Meadow Reservoir - Upper Dam

2-8-214-15
~~4-19-6~~ (Sheet 11c)

This dam is in the same general condition as previously reported. The sink hole on the surface of the earth fill just back of the right abutment is a bit larger and deeper than observed previously. This sink hole is caused by seepage occurring through and behind the right abutment wall. The condition as yet does not endanger the dam.

The old stone and concrete masonry portal structure just below the dam and at the right side is becoming more eroded and dilapidated. It serves no purpose at the present time and its condition does not endanger the dam.

Leakage through the right abutment is about the same as previously observed.

The toe area of the dam is in satisfactory condition. The left abutment area was noted to be o.k.

The spillway was satisfactory. Stone masonry was in fair condition and water level in storage was at crest elevation of the spillway. There were no flashboards on the spillway.

The earth embankment section of the dam to the right was o.k. except for the reported sink hole just behind the right abutment masonry.

No changes or alterations have been made to this dam since the time of the last inspection and in the opinion of the undersigned, the dam is safe.

A. SKETCHES COMPILED DURING PHASE I INSPECTION SHOWING
GENERAL LAYOUT OF DAM, TYPICAL SECTIONS AND DETAILS
OF SIGNIFICANT FEATURES

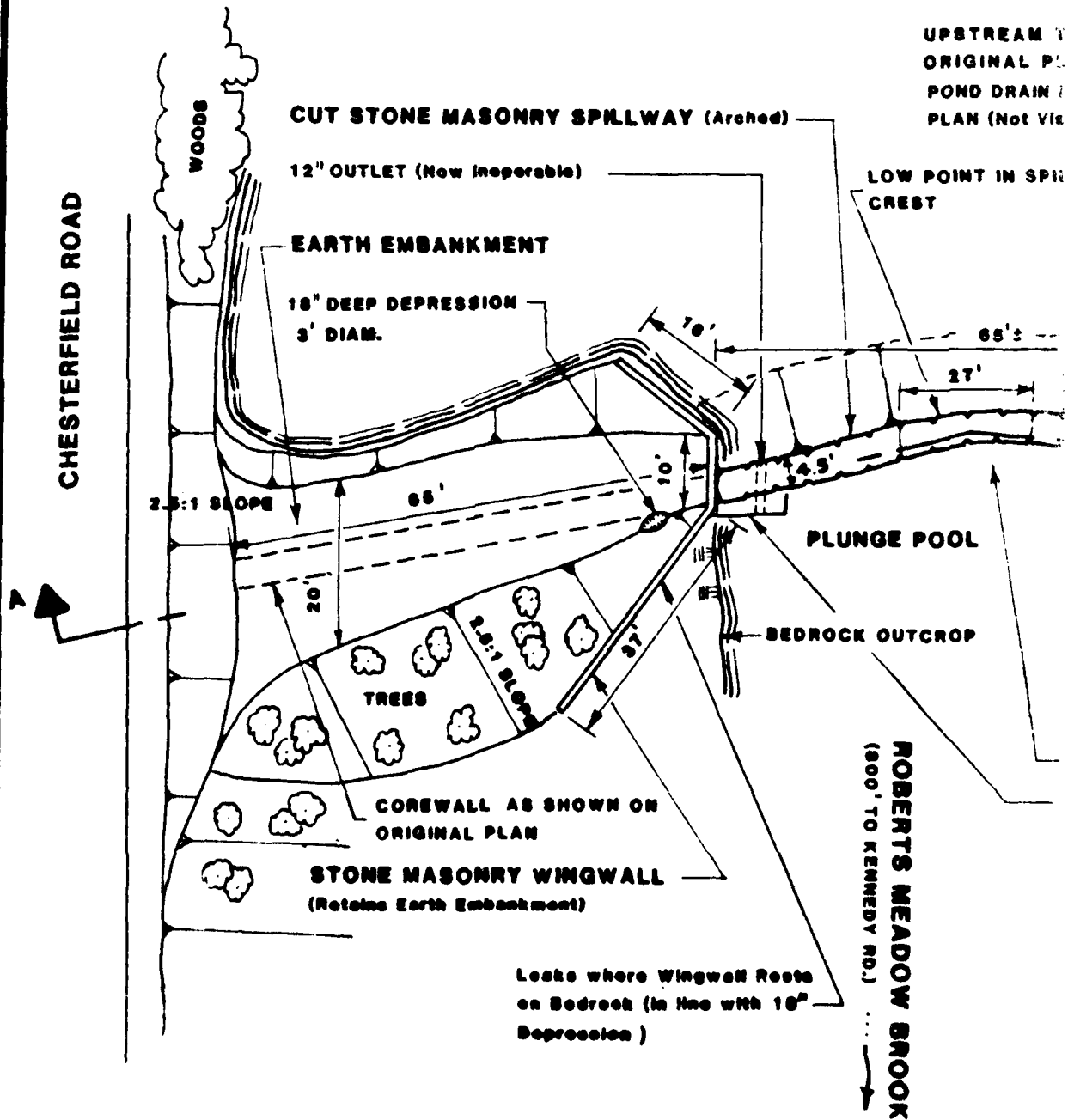
Figure 1. General Plan of Damsite

Figure 2. A-A and Kennedy Road Bridge

Figure 3. Section B-B

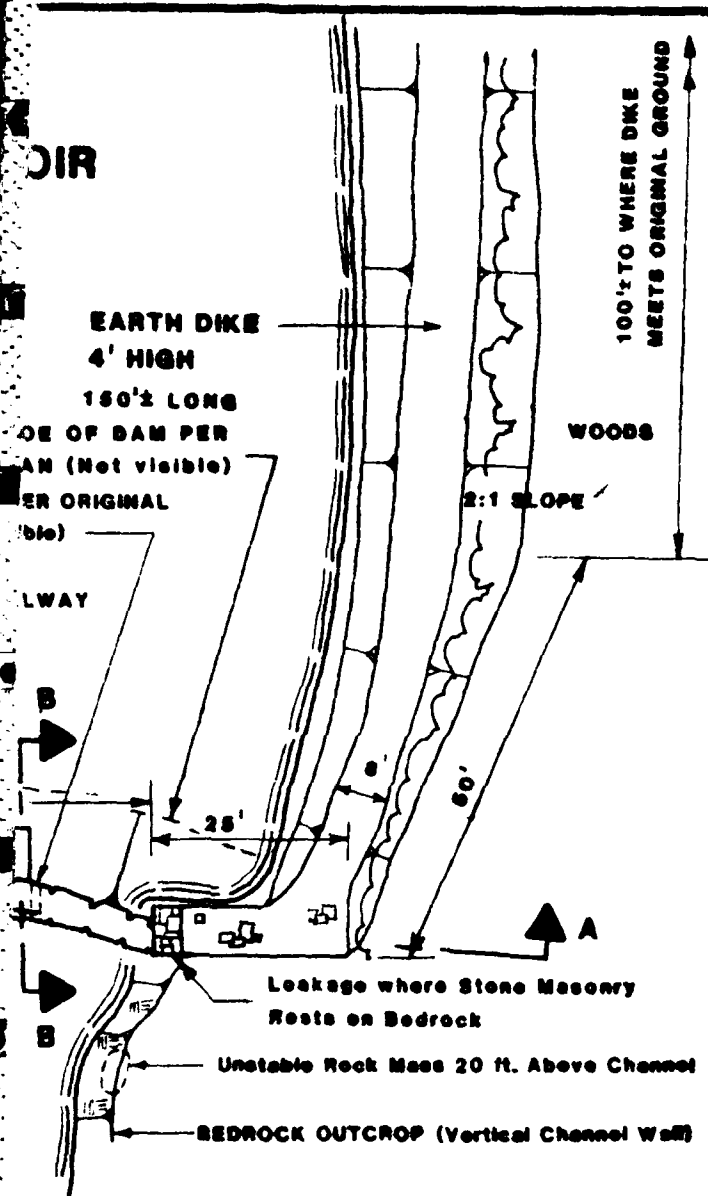
B. RECORD PLANS - Original Design Plan on U/L file at
Water Division office. (See Appendix B-1)

ROBERTS MEADOW UPPER RESERV

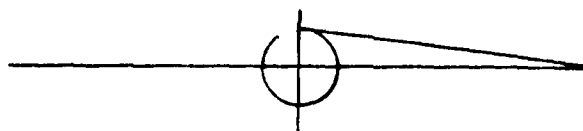


104-2

AIR



NOTE: Spillway Crest Elevation 100.0 on Original 1883 Plan is Approximately Assumed Elevation 450 MSL (Interpolated from USGS Easthampton, Mass. Quadrangle)



APPENDIX B-3 FIGURE 1

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS

ROBERT G. BROWN & ASSOCIATES, INC
Pittsfield, Massachusetts

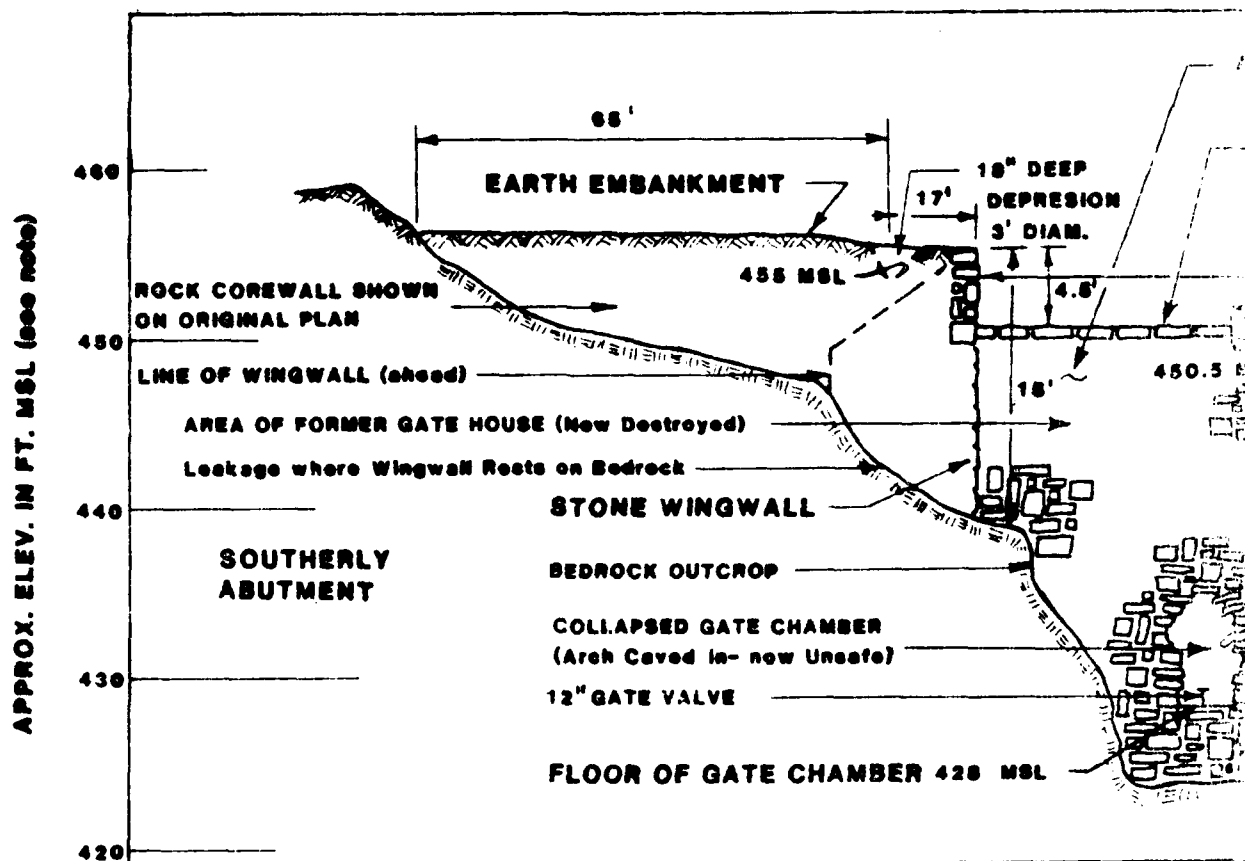
NATIONAL PROGRAM FOR
INSPECTION OF NON-FEDERAL DAMS
**ROBERTS MEADOW
UPPER RESERVOIR**

MA 00760

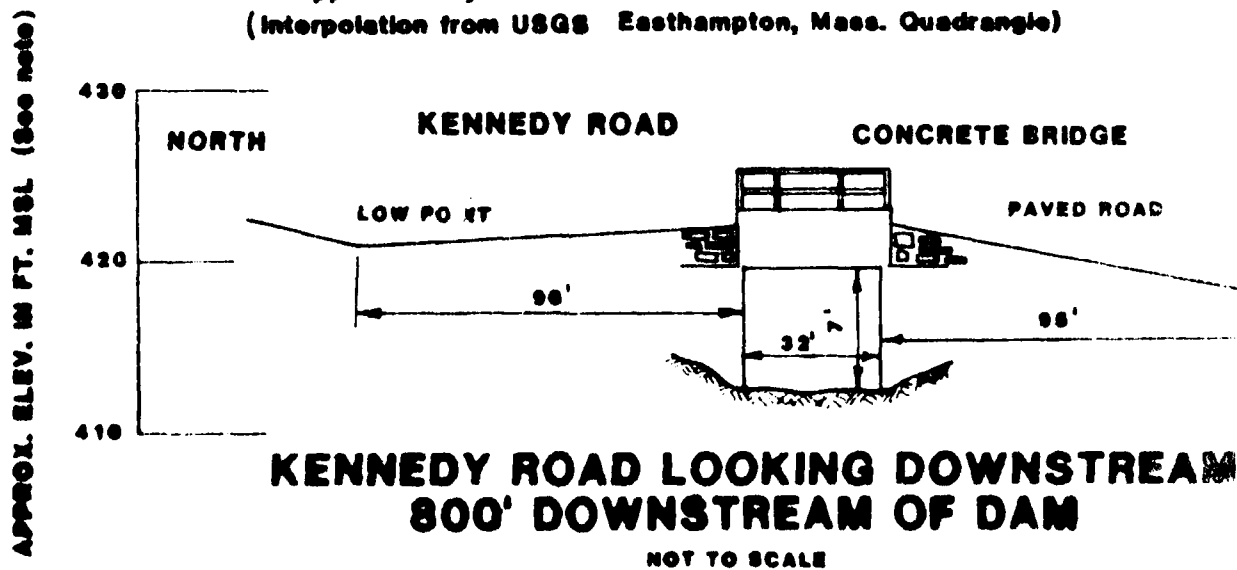
ROBERTS MEADOW BROOK
NORTHAMPTON MASSACHUSETTS

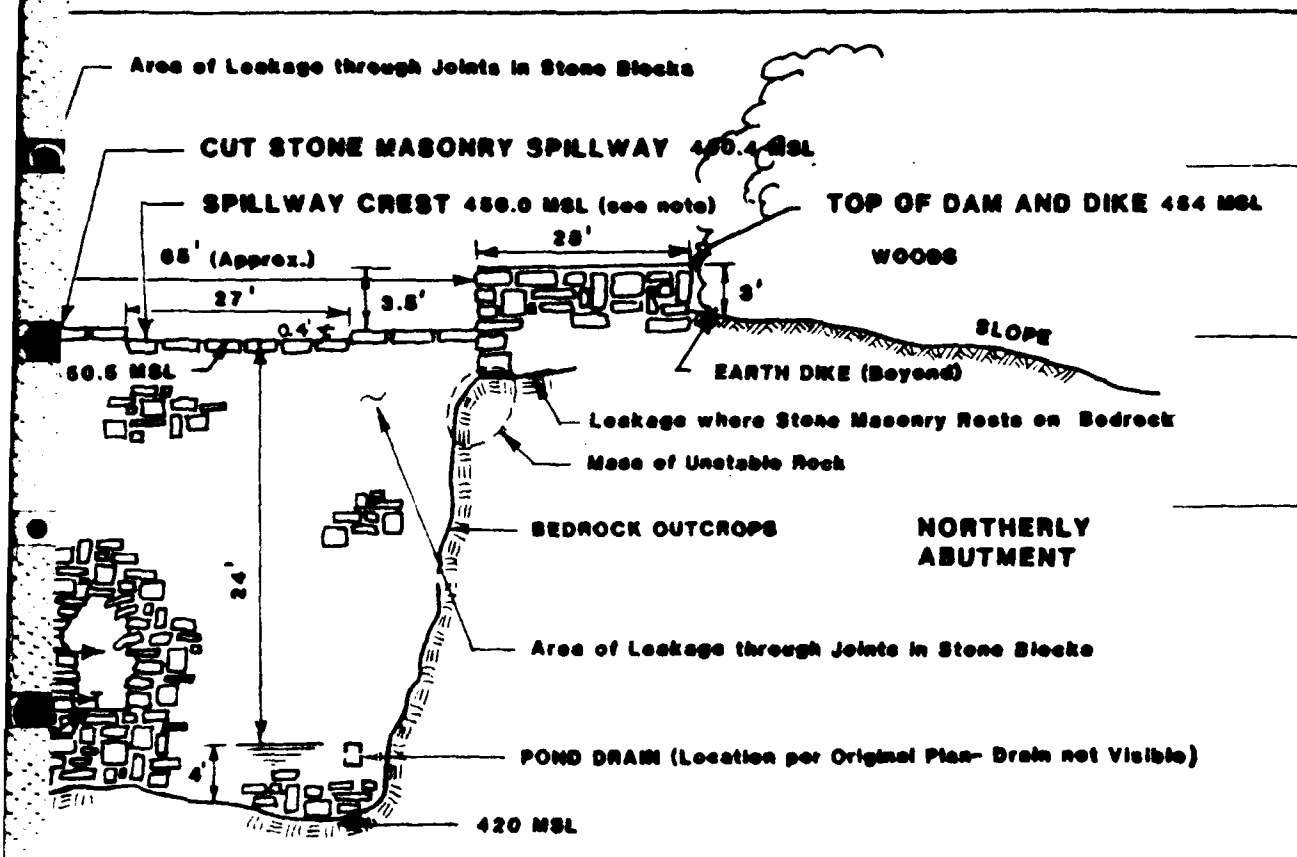
SCALE: NOT TO SCALE

DATE: MAY 1980



NOTE: Spillway Crest Elevation 100.0 on Original 1883 Plan
 is Approximately Assumed Elevation 450 MSL
 (Interpolation from USGS Easthampton, Mass. Quadrangle)





SECTION A-A

NOT TO SCALE

CHESTERFIELD RD.

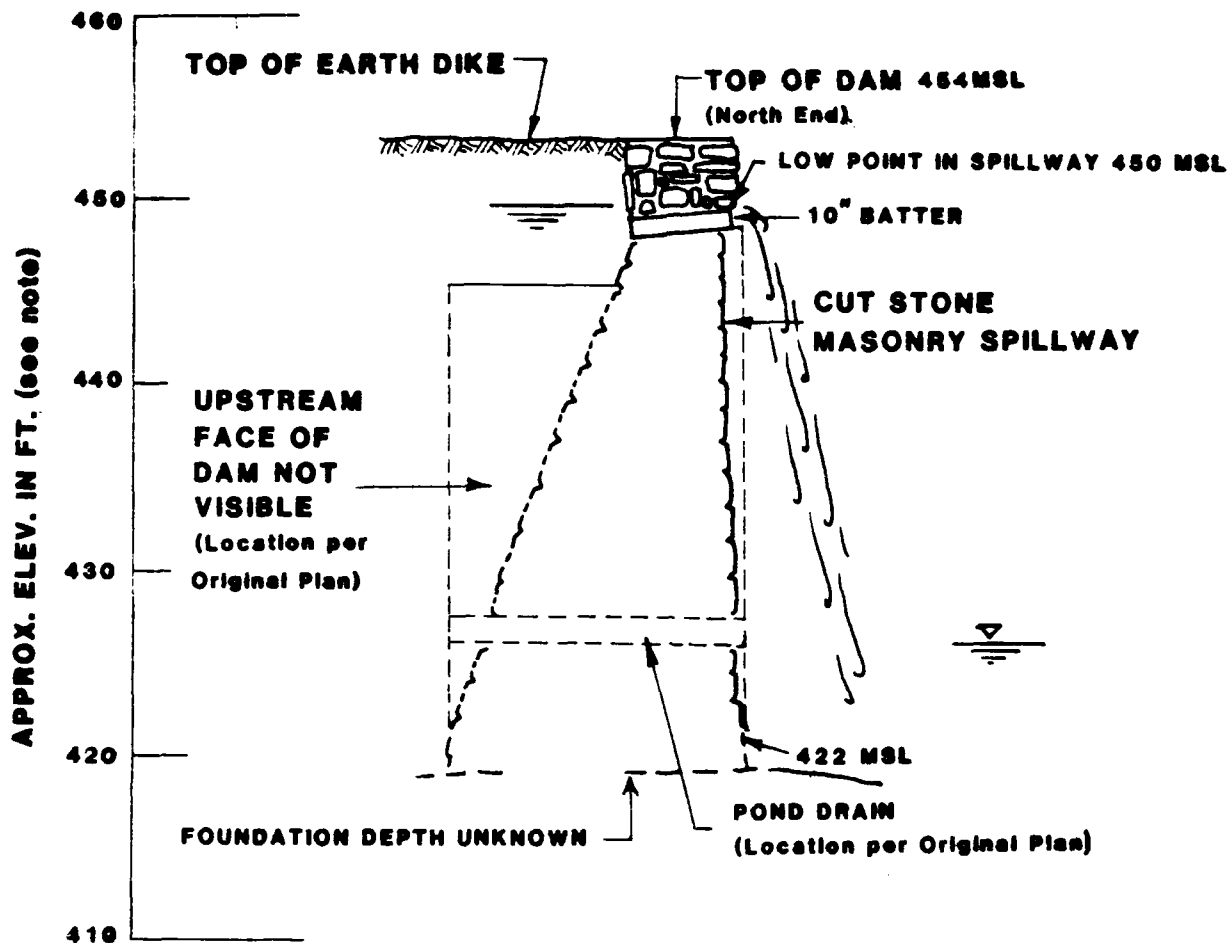
SOUTH

APPENDIX B-3 FIGURE B 2

ROBERTS MEADOW UPPER RESERVOIR

245

ENGINEERING AND ARCHITECTURE



SECTION B-B

NOT TO SCALE

NOTE: Spillway Crest Elevation 100.0 on Original 1883 Plan is
Approximately Assumed Elevation 450 MSL (Interpolated
from USGS Easthampton, Mass. Quadrangle)

APPENDIX B-3 FIGURE B 3

ROBERTS MEADOW UPPER RESERVOIR

TYPICAL BORING LOGS

A. None available

APPENDIX B-4

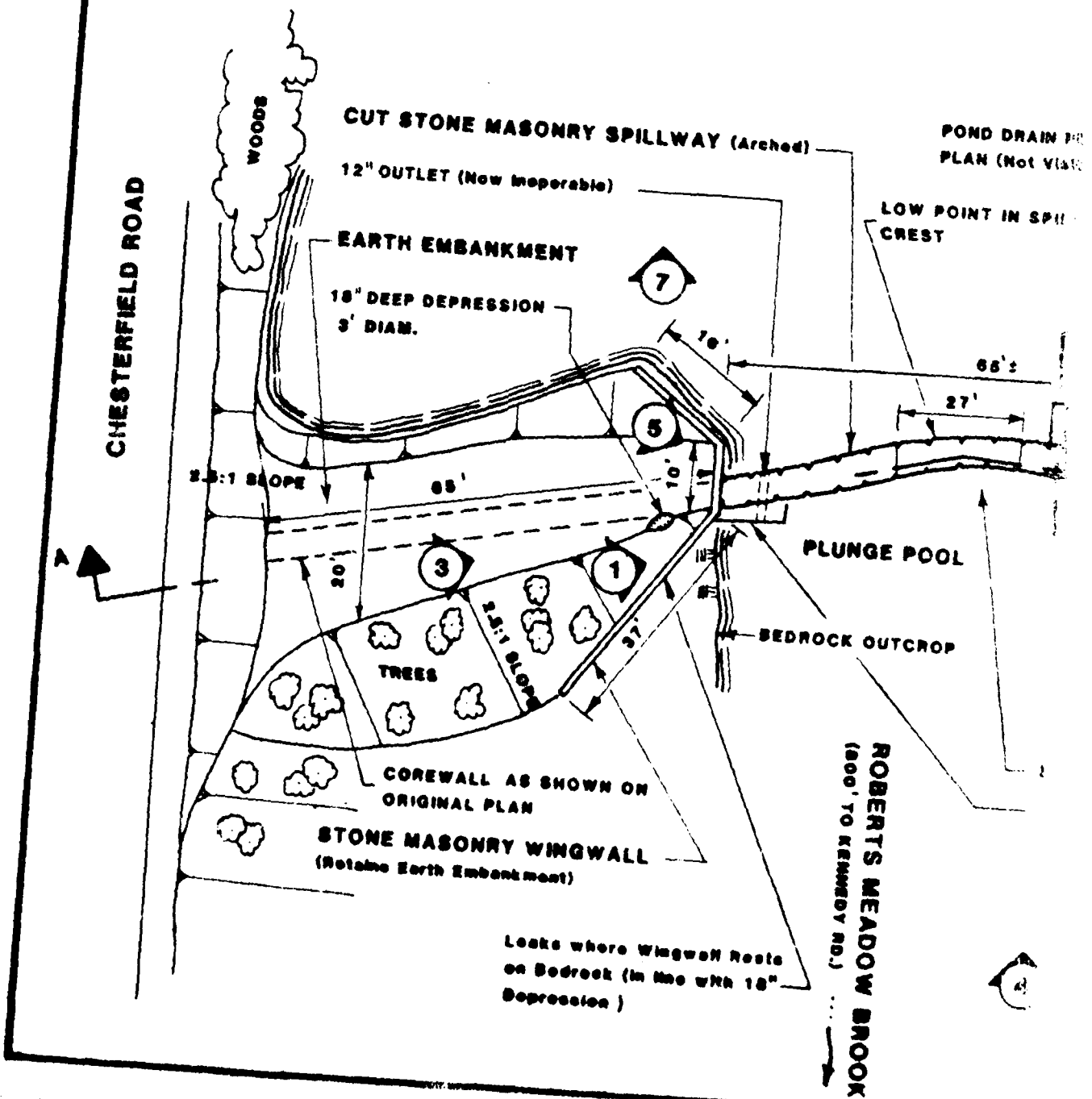
APPENDIX C

PHOTOGRAPHS

C-1. PHOTOGRAPH INDEX

C-2. SELECTED PHOTOGRAPHS

ROBERTS MEADOW UPPER RESERV



8 PHOTOGRAPHS 8, 9, 10 WERE TAKEN
9 DOWNSTREAM OF DAMSITE
10 (See Descriptions under Photographs)

PHOTOGRAPH INDEX

SCALE: NOT TO SCALE DATE: MAY 1980

**INDICATES PHOTOGRAPH NUMBER AND DIRECTION
IN WHICH PHOTOGRAPH WAS TAKEN**



Figure 1 - View of spillway crest showing arch. Note mass of unstable rock downstream of northerly abutment. Also note brush growing in face of dam.



Figure 2 - View of southerly abutment. Note slots for flashboards. Chesterfield Road is in upper right hand corner of photograph.

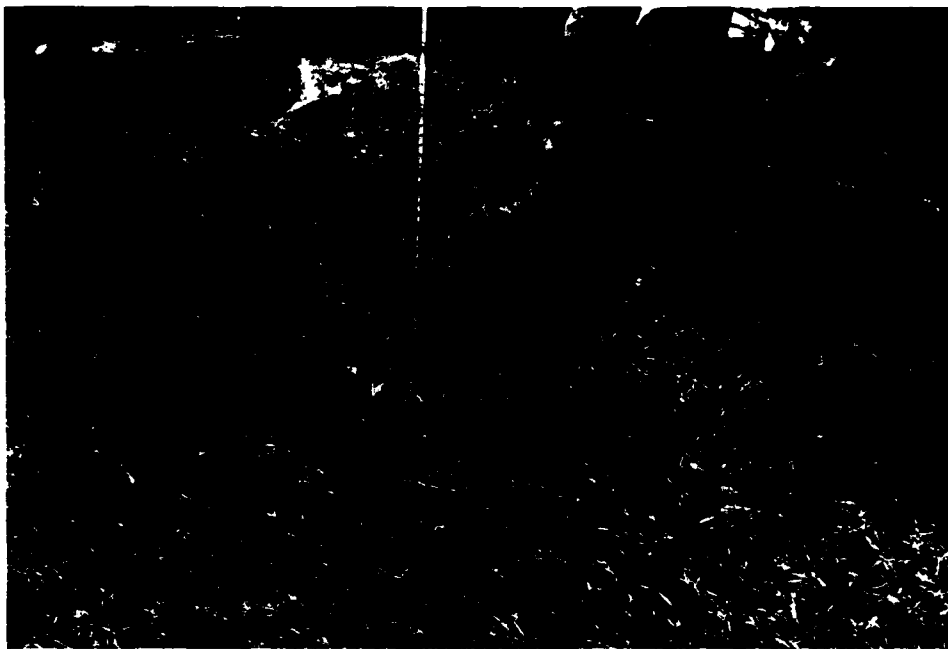


Figure 3 - View of 18 inch deep depression on top of embankment at southerly end of dam.



Figure 4

View of southerly end of dam taken from downstream. Note concrete work and protruding reinforcing steel in area of old gatehouse. The stones at the top of the gate chamber are collapsed. Note leakage through separated joints in stone masonry. Also note leakage at bottom of wingwall at left in photograph.



Figure 5
Hinged flashboard support



Figure 6

View of north end of dam
showing leakage at inter-
face between stone masonry
and bedrock.



Figure 7 - View of a portion of Roberts Meadow Upper Reservoir
looking upstream from dam.



Figure 8 - View of channel downstream of dam. Photograph taken looking upstream from area of Kennedy Road.

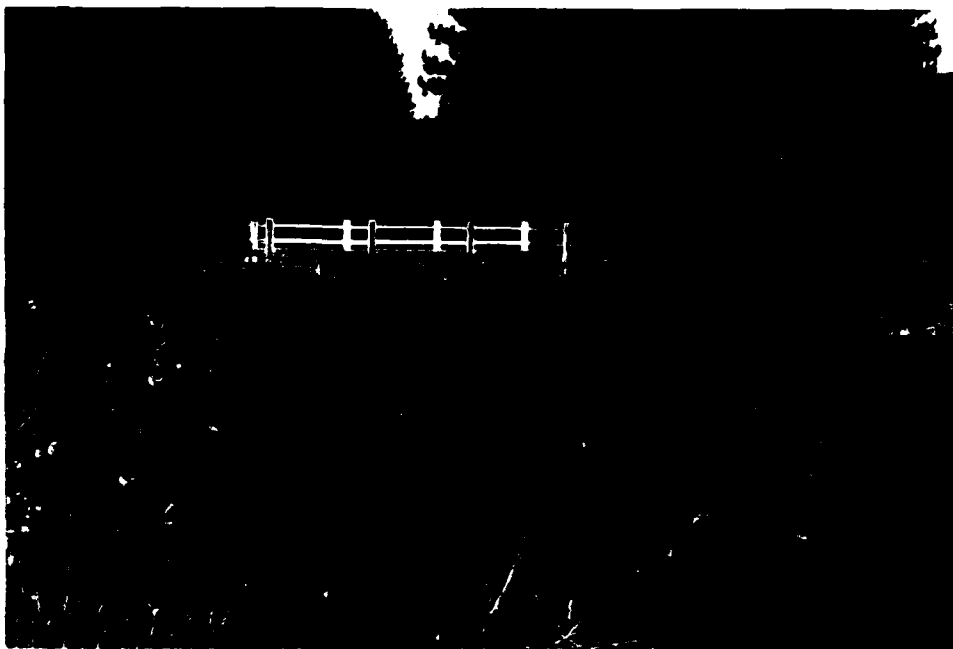


Figure 9 - View of Kennedy Road bridge looking downstream. Bridge is 800 feet downstream of dam.



Figure 10 - View of partial man-made breach in spillway of
Roberts Meadow Middle Reservoir Dam (MA 00761).
The future status of this dam is uncertain.

APPENDIX D

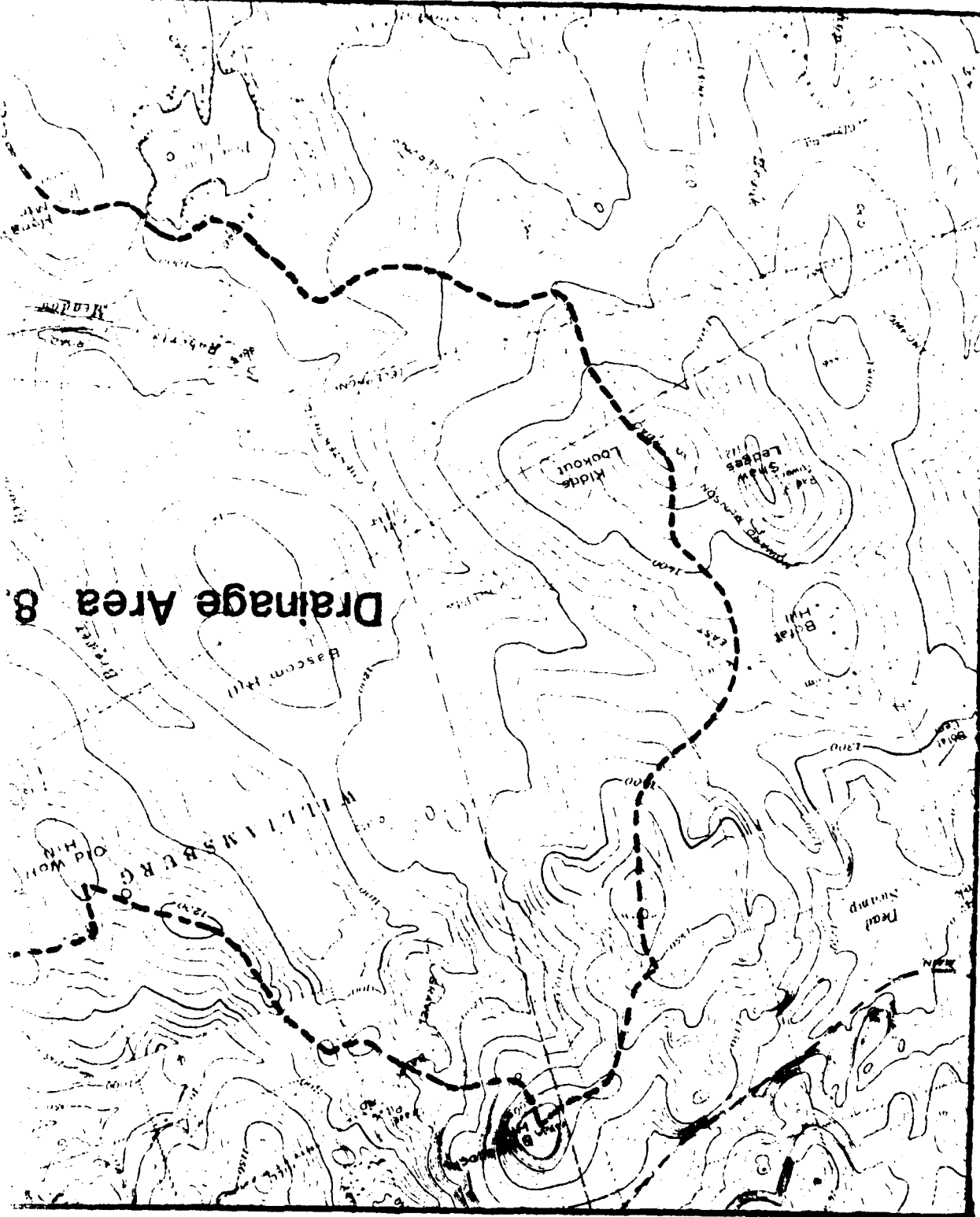
HYDRAULIC AND HYDROLOGIC COMPUTATIONS

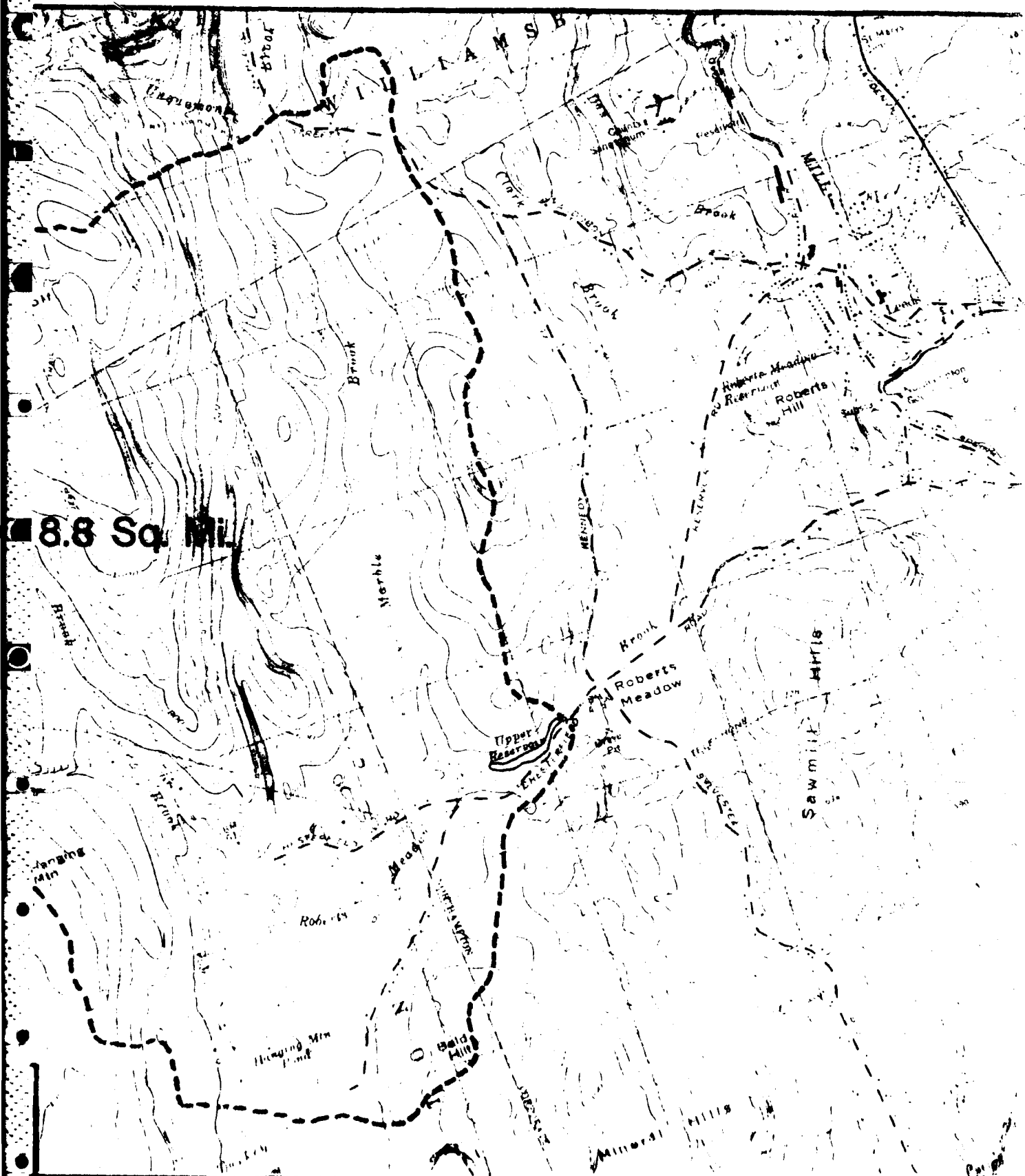
D-1. DRAINAGE AREA MAP

D-2. COMPUTATIONS

101

ROBERTS MEADOW Identification No. Easthampton Quadrangle
UPPER RESERVOIR MA 00760 1:25000





Robert G. Brown & Associates, Inc.

Berkshire Common Third Floor North
PITTSFIELD, MASSACHUSETTS 01201
(413) 499-1560

JOB MA 760 Upper Reservoir
SHEET NO 1 OF 19
CALCULATED BY JFC DATE 4/10/80
CHECKED BY UMC DATE 5/17/80
SCALE _____

Step 1 Calculate PMF using "Preliminary Guidance
for Estimating Maximum Probable Discharges
in Phase I Dam Safety Investigations"
March 1978

For Rolling Terrain, and 8.8 Square Mile
Drainage Area PMF = 1700 CSM ✓

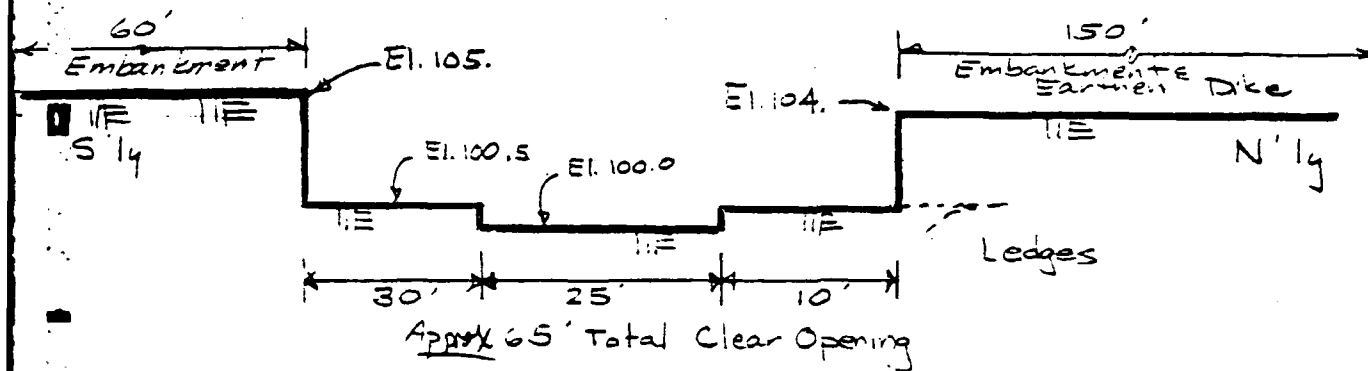
$$PMF = 1700 \times 8.8 = 14960 \text{ c.f.s.} \checkmark$$

$$\frac{1}{2} PMF = 14960 / 2 = 7480 \text{ c.f.s.} \checkmark$$

$$\frac{1}{4} PMF = 14960 / 4 = 3740 \text{ c.f.s.} \checkmark$$

Robert G. Brown & Associates, Inc.
Berkshire Common Third Floor North
PITTSFIELD, MASSACHUSETTS 01201
(413) 499-1560

JOB MA760 Upper Reservoir
SHEET NO 2 OF 19
CALCULATED BY JFC DATE 4/12/80
CHECKED BY JMC DATE 5/13/80
SCALE _____



A. prox. Date of Const 1836

- Report by Clemens Herschel 1883 recommended top of dam at El. 105 - original Top of Dam El. 104.
- Original Design by E.C. Davis Engr. of N Hamp.

Step 2a Determine Surge Ht. to pass test flood
1/2 PMF = 7480 cfs

Compute Stage Vs Discharge Curve
and Stage Vs Storage Curve

Note: Whitman-Howard Report estimates
major flood by Kinnison-Colby
formula = 2700 cfs.

Previous flood of record August 1955
recorded at U.S.G.S Gage in Northampton
6300 cfs (Approx. 117 cfs/sq mi)

Robert G. Brown & Associates, Inc.

Berkshire Common Third Floor North
PITTSFIELD, MASSACHUSETTS 01201
(413) 499-1560

JOB MA760 Upper Reservoir

SHEET NO. 3 OF 19

CALCULATED BY JFC DATE 4/10/30

CHECKED BY JMC DATE 5/13/30

SCALE _____

Elev	Flow over Spillway						Flow Over Dam (Sily)				Flow Over Dam (Dike Nly)				Total Q
	C	L ₁	H ₁	Q ₁	L ₂	H ₂	Q ₂	C	L	H	Q	C	L	H	Q
100	3.3	25	0	0	40	0	0								0
100.5	"	"	.5	29	"	1.5	242								29
102	"	"	2.0	233	"	3.5	864								475
104	"	"	4.0	660	"	4.5	1260	2.8	150	0	0	2.8	150	0	1524
105	"	"	5.0	922	"	5.5	1702	"	"	1.0	420	"	"	1.0	2602
106	"	"	6.0	1212	"	6.5	2187	"	"	2.0	1188	"	"	2.0	4282
107	"	"	7.0	1528	"	7.5	2711	"	"	3.0	2182	"	"	3.0	6406
108	"	"	8.0	1867	"	7.9	2392	"	"	4.0	3360	"	"	4.0	8873
107.4	"	"	7.4	1660	40	6.9									

REVISIONS: 11-11-80
 JTC 4/10/80
 VIM: E-11-84

Elevation in feet (Assumed Datum from 100 ft)

100 102 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140 142 144 146 148 150 152 154 156 158 160 162 164 166 168 170 172 174 176 178 180 182 184 186 188 190 192 194 196 198 200 202 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234 236 238 240 242 244 246 248 250 252 254 256 258 260 262 264 266 268 270 272 274 276 278 280 282 284 286 288 290 292 294 296 298 300 302 304 306 308 310 312 314 316 318 320 322 324 326 328 330 332 334 336 338 340 342 344 346 348 350 352 354 356 358 360 362 364 366 368 370 372 374 376 378 380 382 384 386 388 390 392 394 396 398 400 402 404 406 408 410 412 414 416 418 420 422 424 426 428 430 432 434 436 438 440 442 444 446 448 450 452 454 456 458 460 462 464 466 468 470 472 474 476 478 480 482 484 486 488 490 492 494 496 498 500 502 504 506 508 510 512 514 516 518 520 522 524 526 528 530 532 534 536 538 540 542 544 546 548 550 552 554 556 558 560 562 564 566 568 570 572 574 576 578 580 582 584 586 588 590 592 594 596 598 600 602 604 606 608 610 612 614 616 618 620 622 624 626 628 630 632 634 636 638 640 642 644 646 648 650 652 654 656 658 660 662 664 666 668 670 672 674 676 678 680 682 684 686 688 690 692 694 696 698 700 702 704 706 708 710 712 714 716 718 720 722 724 726 728 730 732 734 736 738 740 742 744 746 748 750 752 754 756 758 760 762 764 766 768 770 772 774 776 778 780 782 784 786 788 790 792 794 796 798 800 802 804 806 808 810 812 814 816 818 820 822 824 826 828 830 832 834 836 838 840 842 844 846 848 850 852 854 856 858 860 862 864 866 868 870 872 874 876 878 880 882 884 886 888 890 892 894 896 898 900 902 904 906 908 910 912 914 916 918 920 922 924 926 928 930 932 934 936 938 940 942 944 946 948 950 952 954 956 958 960 962 964 966 968 970 972 974 976 978 980 982 984 986 988 990 992 994 996 998 1000

UPPER RESERVOIR
 HA 760
 STAGE VS DISCHARGE

1/2 PMF

(11-11-80)

1/4 PMF

TOP OF DAM SLY ABOUT

TOP OF DAM DILE N.Y. ABOUT

Discharge in CFS

CL APPROX 145L

P. 4

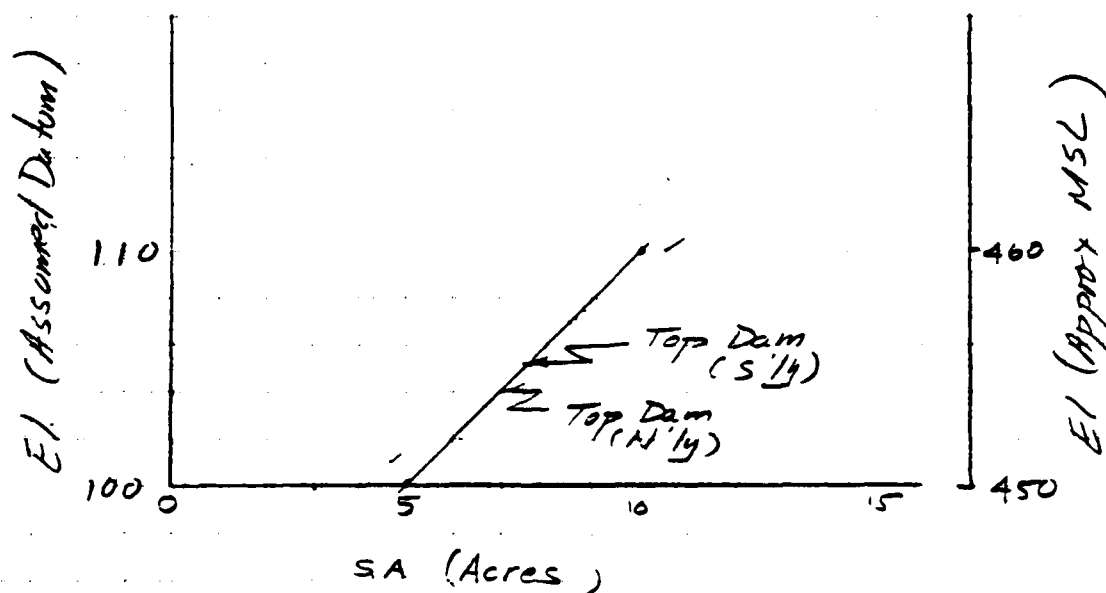
Robert G. Brown & Associates, Inc.
 Berkshire Common Third Floor North
 PITTSFIELD, MASSACHUSETTS 01201
 (413) 499-1560

JOB MA 760 Upper Reservoir
 SHEET NO. 5 OF 14
 CALCULATED BY JFC DATE 4/10/80
 CHECKED BY JMC DATE 5/13/80
 SCALE _____

Upper Reservoir Stage Vs Storage Curve

Elev.	Area Ac.	Storage Ac.-Ft.
100 ⁽⁴⁵⁰⁾	5 ✓	35 ✓
110 ⁽⁴⁶⁰⁾	10 ✓	110 ✓

Note: Area Data taken from
 USGS Quad by Planimeter



B.S. Brown & Assoc., Inc.
 JFC 11/10/80
 JMC 11/13/84

Note:

Low Pt. of Spillway Crest
 Assumed El. 100.0 per Original
 Plans in County Court re El. 450 MSL by Quad.

MA 760 Upper Res.
 Stage vs Storage

Test Flap 1001

Top of Dam (S. y Abut.)

Top of Dam's Dike (N. y Abut.)

STORAGE (AC-FT)

ELEVATION (in FT) Sep 1978

ELEVATION (Approx MSL)

P. 6

For Test Flood ($\frac{1}{2}$ PMF) = 7480 cfs. ✓

Step 2b Volume of Runoff in inches of runoff

$$Q_{p1} = 7480 \text{ cfs} \rightarrow \text{El. } 107.4 \text{ ✓}$$

$$\text{Storage at El. } 107.4 \rightarrow 90 \text{ Ac.Ft. ✓}$$

$$\Delta \text{ Storage between El. } 107.4 \text{ \& Spillway Crest} = 55 \text{ Ac.Ft. ✓}$$

$$\text{SDR1} = \left(\frac{55 \text{ ✓}}{53.3 \times 8.8 \text{ ✓}} \right) 0.117 \text{ " Runoff}$$

$$\frac{90 \text{ ✓}}{35 \text{ ✓}}$$

Step 2c Compute Q_{p2}

$$Q_{p2} = Q_{p1} \times \left(1 - \frac{\text{SDR1}}{19/2} \right) \text{ ✓}$$

$$Q_{p2} = 7480 \times \left(1 - \frac{0.117 \text{ ✓}}{9.5 \text{ ✓}} \right) = 7388 \text{ cfs ✓}$$

Step 3a Determine Surge Ht to Pass Q_{p2}

$$Q_{p2} = 7388 \text{ cfs} \rightarrow \text{El. } 107.35 \text{ ✓} \rightarrow 89 \text{ Ac.Ft. ✓}$$

$$\text{SDR2} = \left(\frac{54 \text{ ✓}}{53.3 \times 8.8 \text{ ✓}} \right) = 0.115 \text{ " Runoff ✓}$$

Step 3b Average SDR1 & SDR2

$$\frac{0.117 + 0.115}{2} = 0.116 \text{ " Runoff ✓}$$

$$\text{Surcharge Ht.} = 0.116 \text{ " } \times 8.8 \text{ S.M. } \times 52.3 \text{ Ac.Ft. } = 54.4 \text{ Ac.Ft. ✓}$$

"S.M.

$$\text{Test Flood Ht.} = \text{El. } 107.4 \text{ ✓} \text{ Storage} = 89 \text{ Ac.Ft. ✓}$$

Note: Available Surge Storage does not have significant effect in attenuating peak inflow

Robert G. Brown & Associates, Inc.

Berkshire Common Third Floor North
PITTSFIELD, MASSACHUSETTS 01201
(413) 499-1560

JOB MA760 Upper Reservoir

SHEET NO. 8 OF 14

CALCULATED BY JFC DATE 4/10/80

CHECKED BY JMC DATE 5/13/80

SCALE _____

Test Flood $\frac{1}{2}$ PMF - 7480 CFS (inflow) ✓
Test Flood Elev. El. 107.4 ✓
Test Flood Discharge 7390 CFS ✓
Top of Dam (S'ly) El. 105. ✓

Therefore dam is overtopped by
about 2.4' for the portion South of
Spillway. Dike and portion of dam
North of Spillway overtopped by about
3.4' during $\frac{1}{2}$ PMF. ✓

Note:

(Dam would be overtopped by at least 1' during
 $\frac{1}{4}$ PMF = 3740 CFS) ✓

Breach Analysis

Assume breach width W_b of 40% crest length at mid Ht.

$$W_b = 40\% \times 60' = 24' \checkmark$$

y_o = Ht from Strm bed to pool level at failure

Assume Pool at El. 104 $\checkmark$

$$y_o = \text{El. } 104 - 72 = 32' \checkmark$$

$$Q_p = 8/27 W_b \sqrt{g} y_o^{3/2} \checkmark$$

$$Q_p = (8/27)(24)(32.2)^{1/2}(32)^{3/2} = \underline{7304 \text{ cfs}} \checkmark$$

Flow over spillway other than breach $L = 65 - 24 = 41' \checkmark$

$$Q = 3.3 \times 41 \times 4^{3/2} = \underline{1082 \text{ cfs}} \checkmark$$

$$\underline{\text{Breach } Q = 8386 \text{ cfs}} \checkmark$$

From Spillway rating curve (P.4)

Antecedent Discharge - flow corresponding to el. 104 = 1500 cfs $\checkmark$

$$\text{Storage}_{104} = 65 \text{ Ac.Ft.} \checkmark$$

Robert G. Brown & Associates, Inc.

Berkshire Common Third Floor North
PITTSFIELD, MASSACHUSETTS 01201
(413) 499-1560

JOB MA 760 Upper Reservoir

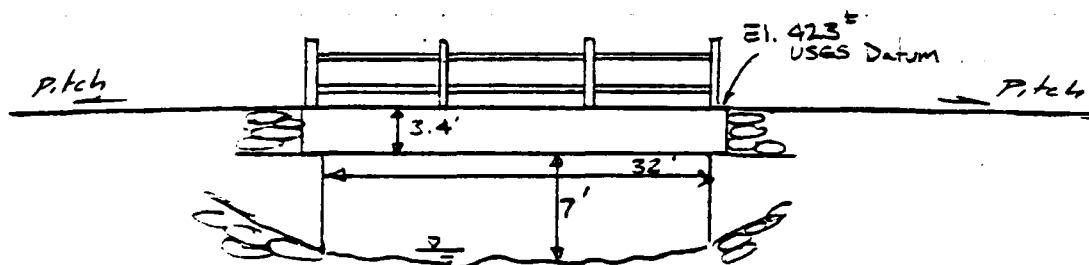
SHEET NO. 10 OF 14

CALCULATED BY JFC DATE 4/22/80

CHECKED BY JMC DATE 5/13/80

SCALE _____

Rate Bridge Opening at Kennedy Rd about
800' Downstream of Dam.



Note: El. Datum shown on record plan for Upper Res.
is not the USGS Datum.

Robert G. Brown & Associates, Inc.
Berkshire Common Third Floor North
PITTSFIELD, MASSACHUSETTS 01201
(413) 499-1560

JOB MA 760 Upper Reservoir
SHEET NO. 11 OF 14
CALCULATED BY JFC DATE 4/22/80
CHECKED BY Jmc DATE 5/13/80
SCALE _____

Rate bridge opening for low flow using Manning Eq.

$$Q = \frac{1.49}{n} A R^{2/3} S_o^{1/2}$$

Sides $n = 0.015$ ✓
Bottom $n = 0.030$ ✓

Elev.	Area	W per	Q (cfs)
413	0	0	0
415 (416)	64 ✓	36 ✓	566 ✓
417 (485)	128 ✓	40 ✓	1960 ✓
419 (425)	192 ✓	44 ✓	3620 ✓

0.035
0.030
0.030

Note - add (1-1/2') to Elev. at inlet for loss considerations

Pressure Flow + Weir Flow over Road

Bridge Opening

Flow over Road - $k = 2.3$ ✓

Elev	Area	H	$Q = CA \sqrt{2gH}$ $C = 0.84$ ✓	L	h_p	$Q = KLh_p^{3/2}$	Q_{TOTAL}
422	224	5.5	3541 ✓	110 ✓	2 ✓	371 ✓	4412 ✓
424	224	7.5	4135 ✓	140 ✓ 140	4 2	3136 ✓ 1143 ✓	8419 ✓

$$C = \frac{1}{\sqrt{1 + k_e + k_{cL}}}$$

$$C = \frac{1}{\sqrt{1 + 0.3 + 0.008}} = 0.84 \quad \checkmark$$

$$k_e = \left(\frac{29}{24^{4/3}} \right) \text{ for } n = 0.025$$

$$k_o = \frac{(29)(0.025)^2}{(224^{4/3})} = 0.0044 \quad \checkmark$$

$$k_{cL} = (0.0044)(20) = 0.008 \quad \checkmark$$

RG EMM # 15521 MK
JFC 4/22/80
VJC 5/12/80

MA 760 UPPER RES.
DOWNSTREAM HAZARD
RATING CURVE
BRIDGE AT KENNEDY RD.

ELEVATION IN FEET (APPROX 15% DASH)

426
424
422
420
418
416
414
412
410

BEACH
300
300

APPROX STREET 25
FLOW OVER THE BRIDGE

Antecedent
Q 1500 cfs

DISCHARGE IN THOUSAND CFS

2

3

4

5

6

7

8

LS BROWN ASSOC. INC.
 JFC 4/25/80
 JME 5/13/80

430

420

410

ELEV. IN FEET (APPROX. MSL DFM)

KENNEDY RD.

CONC. BRIDGE

BRIDGE
 OPENING
 (SEE SHT 10)

Antiquated
 Discharge

Breach Q

INTERSECTION W/ CHESTERFIELD RD.

CROSS SECTION
 ROBERTS MEADOW BROOK
 KENNEDY ROAD
 800 FT. DS. OF
 MA 760
 UPPER RESERVOIR

1" = 10' V
 1" = 30' H

VIEW LOOKING DOWNSTREAM

Downstream Hazard Evaluation

1. Based on hydraulic analysis of Kennerly Road Bridge. Opening it is likely that bridge and road would be washed out by assumed breach of Upper Reservoir.

2. Just downstream of Kennedy Road are the Roberts Meadow Middle Dam (MA 761) and Roberts Meadow Lower Dam (MA 753). Both of these dams received Phase I inspections in 1973. Failure of either of these downstream dams would result in damages and possibly loss of life in the Reservoir Road area and Water Street area of Leeds, VT.

Note: The future status of Roberts Meadow Middle Dam is uncertain. The dam spillway now has a partial breach (see photo) which was created in 1979 in order to eliminate permanent storage. The main portions of the dam remain intact and remain capable of impounding water during flood conditions. No determination has been made by Owner as to whether the dam will be repaired, replaced or removed completely.

3. (Impact on Middle Reservoir) SEE PAGE 4 A & 4 B

Phase I Inspection Report, National Dam Inspection Program
Lower Roberts Meadow Reservoir Dam; MA 753;
NED Corps of Engineers; Oct. 1973.

Robert G. Brown & Associates, Inc.
Berkshire Common - Third Floor North
PITTSFIELD, MASSACHUSETTS 01201
(413) 499-1560

JOB MA 760 Upper Reservoir
SHEET NO 14A OF 14
CALCULATED BY JFL DATE 4/22/80
CHECKED BY _____ DATE _____
SCALE _____

The 65 acre-feet top of dam storage of Upper Reservoir was added to Middle Reservoir. The water surface elevation in Middle Reservoir is estimated to rise approximately 1.5 feet to within 0.5 feet of the top of Dam under this assumed condition. This analysis assumes that a 500 cfs antecedent flow water surface elevation exists in the Middle Reservoir prior to the breach and that no outflow is occurring from Middle Reservoir. It is also assumed that Middle Reservoir is restored to its original design condition.

AD-A155 653

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
ROBERTS MEADOW UPPER (U) CORPS OF ENGINEERS WALTHAM MA
NEW ENGLAND DIV JUN 88

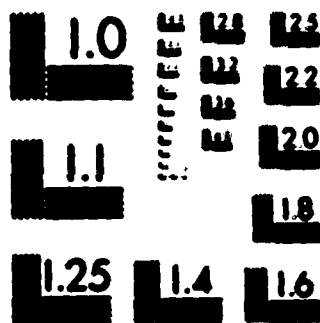
UNCLASSIFIED

F/G 13/13 NL

END

FILED

DATE



RESOLUTION TEST CHART
 NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX E

**INFORMATION AS CONTAINED IN
THE NATIONAL INVENTORY OF DAMS**

1990

[illegible][illegible]

TYPE OF CASE	YEAR COMPLETED	PERCENT	1953-1954	1954-1955	1955-1956	1956-1957	1957-1958	1958-1959	1959-1960	1960-1961	1961-1962	1962-1963	1963-1964	1964-1965	1965-1966	1966-1967	1967-1968	1968-1969	1969-1970	1970-1971	1971-1972	1972-1973	1973-1974	1974-1975	1975-1976	1976-1977	1977-1978	1978-1979	1979-1980	1980-1981	1981-1982	1982-1983	1983-1984	1984-1985	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024	2024-2025	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	2032-2033	2033-2034	2034-2035	2035-2036	2036-2037	2037-2038	2038-2039	2039-2040	2040-2041	2041-2042	2042-2043	2043-2044	2044-2045	2045-2046	2046-2047	2047-2048	2048-2049	2049-2050	2050-2051	2051-2052	2052-2053	2053-2054	2054-2055	2055-2056	2056-2057	2057-2058	2058-2059	2059-2060	2060-2061	2061-2062	2062-2063	2063-2064	2064-2065	2065-2066	2066-2067	2067-2068	2068-2069	2069-2070	2070-2071	2071-2072	2072-2073	2073-2074	2074-2075	2075-2076	2076-2077	2077-2078	2078-2079	2079-2080	2080-2081	2081-2082	2082-2083	2083-2084	2084-2085	2085-2086	2086-2087	2087-2088	2088-2089	2089-2090	2090-2091	2091-2092	2092-2093	2093-2094	2094-2095	2095-2096	2096-2097	2097-2098	2098-2099	2099-2100	2100-2101	2101-2102	2102-2103	2103-2104	2104-2105	2105-2106	2106-2107	2107-2108	2108-2109	2109-2110	2110-2111	2111-2112	2112-2113	2113-2114	2114-2115	2115-2116	2116-2117	2117-2118	2118-2119	2119-2120	2120-2121	2121-2122	2122-2123	2123-2124	2124-2125	2125-2126	2126-2127	2127-2128	2128-2129	2129-2130	2130-2131	2131-2132	2132-2133	2133-2134	2134-2135	2135-2136	2136-2137	2137-2138	2138-2139	2139-2140	2140-2141	2141-2142	2142-2143	2143-2144	2144-2145	2145-2146	2146-2147	2147-2148	2148-2149	2149-2150	2150-2151	2151-2152	2152-2153	2153-2154	2154-2155	2155-2156	2156-2157	2157-2158	2158-2159	2159-2160	2160-2161	2161-2162	2162-2163	2163-2164	2164-2165	2165-2166	2166-2167	2167-2168	2168-2169	2169-2170	2170-2171	2171-2172	2172-2173	2173-2174	2174-2175	2175-2176	2176-2177	2177-2178	2178-2179	2179-2180	2180-2181	2181-2182	2182-2183	2183-2184	2184-2185	2185-2186	2186-2187	2187-2188	2188-2189	2189-2190	2190-2191	2191-2192	2192-2193	2193-2194	2194-2195	2195-2196	2196-2197	2197-2198	2198-2199	2199-2200	2200-2201	2201-2202	2202-2203	2203-2204	2204-2205	2205-2206	2206-2207	2207-2208	2208-2209	2209-2210	2210-2211	2211-2212	2212-2213	2213-2214	2214-2215	2215-2216	2216-2217	2217-2218	2218-2219	2219-2220	2220-2221	2221-2222	2222-2223	2223-2
--------------	----------------	---------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	--------

COVER

[illegible]

DANGER FRAGILE HANDLE WITH CARE	DO NOT OPEN DO NOT TOUCH DO NOT REMOVE
---	--

USGR	(CNS) FUNCTION	REGULATORY AGENCY	OPERATION	MANUAL NAME
------	----------------	-------------------	-----------	-------------

[illegible]REMARKS

END

FILMED

8-85

DTIC