

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
HOPEDALE POND DAM (MA) (U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV JUN 79

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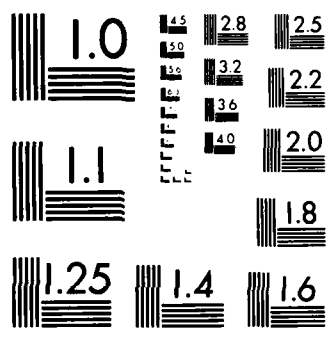
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BLACKSTONE RIVER BASIN
HOPEDALE, MASSACHUSETTS

HOPEDALE POND DAM
MA 00624

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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JUN 20 1985
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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

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

REPLY TO
ATTENTION OF:

NEDED

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

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Dear Governor King:

Inclosed is a copy of the Hopedale Pond 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, Draper Division of Rockwell International.

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
MAX B. SCHEIDER

Colonel, Corps of Engineers
Division Engineer

Incl
As stated

BLACKSTONE RIVER BASIN
HOPEDALE, MASSACHUSETTS

HOPEDALE POND DAM
MA 00624

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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

JUNE 1979

HOPEDALE POND DAM
MA 00624

BLACKSTONE RIVER BASIN
HOPEDALE, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Identification No. : MA 00624
Name of Dam: HOPEDALE POND DAM
Town: HOPEDALE
County and State: WORCESTER COUNTY, MA
Stream: MILL RIVER
Date of Inspection: 5 DECEMBER 1978

BRIEF ASSESSMENT

Hopedale Pond Dam is an earth embankment 265 feet long and 19 feet high with a concrete and stone masonry spillway with flashboards near the right end of the dam. Freedom Street forms the crest of the dam. The downstream face of the dam terminates at a mill building which parallels the dam. A channel adjacent and parallel to the spillway services the reservoir drain and intake for a turbine. A separate smaller intake for fire protection is located near the right abutment.

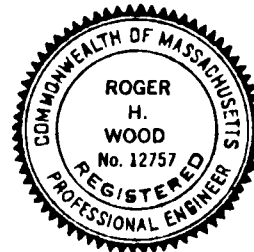
The earth embankments and the spillway are generally in good condition. However, because of the limited hydraulic capacity of both the spillway and discharge channel, the dam is considered to be in fair condition. Minor deficiencies noted during the site examination are included in Section 3 of the report.

Based on the size, small, and hazard classification, high, in accordance with the Corps of Engineers Guidelines, the spillway test flood is the Probable Maximum Flood (PMF). The test flood peak outflow was estimated to be 7,600 cfs and would result in overtopping the dam by approximately 4.8 feet. Hydraulic analysis indicates that the spillway will only pass 1,400 cfs, or 18 percent of the test flood with all the flashboards removed. The mill building immediately downstream of the spillway can pass little more before it becomes a hydraulic control acting as a secondary dam.

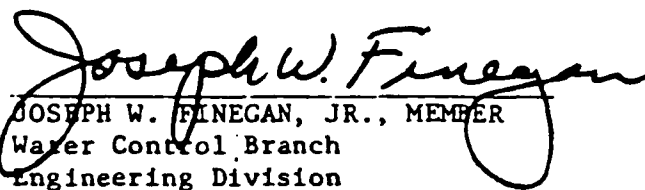
Recommended additional investigation by the Owner includes a detailed hydrologic-hydraulic study of the adequacy of the capacity of the spillway and the channel beneath the downstream mill building. Recommended remedial measures include the repair of locally eroded areas and voids in the riprap, the removal of debris from the discharge channel and resetting of cascade stones, the attending to minor maintenance items at the walkway, control works and fire protection intake and the expanding of the existing written operations procedures and emergency preparedness plans. These recommendations and remedial measures, as delineated in Section 7 of the report, should be undertaken within one year of receipt of the report by the Owner.

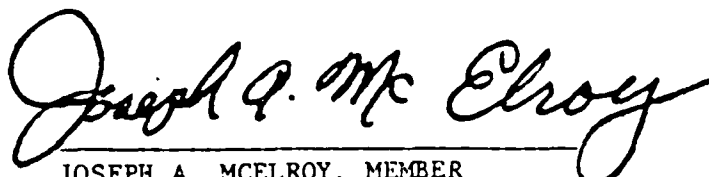
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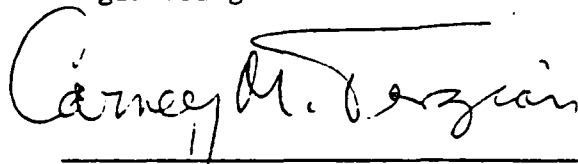
Roger H. Wood
Roger H. Wood
Vice President



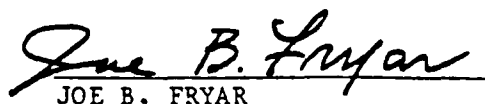
This Phase I Inspection Report on Hopedale Pond Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice,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


JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division


JOSEPH A. MCELROY, MEMBER
Foundation & Materials Branch
Engineering Division


CARNEY M. TERZIAN, CHAIRMAN
Chief, Structural Section
Design Branch
Engineering Division

APPROVAL RECOMMENDED:


JOE B. FRYAR
Chief, Engineering Division

PREFACE

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

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I Investigations are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the test flood is based on the estimated "probable maximum flood" for the region (greatest reasonably possible storm runoff), or a fraction thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

TABLE OF CONTENTS

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

REPORT

1. PROJECT INFORMATION

1.1 General	
a. Authority	1-1
b. Purpose of Inspection	1-1
1.2 Description of Project	
a. Location	1-2
b. Description of Dam and Appurtenances	1-2
c. Size Classification	1-3
d. Hazard Classification	1-3
e. Ownership	1-3
f. Operator	1-3
g. Purpose of Dam	1-3
h. Design and Construction History	1-3
i. Normal Operational Procedures	1-4
1.3 Pertinent Data	1-4

2. ENGINEERING DATA

2.1 Design	2-1
2.2 Construction	2-1
2.3 Operation	2-1
2.4 Evaluation	2-1

3. VISUAL INSPECTION

3.1 Findings	
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 PROCEDURES

4.1 Procedures	4-1
4.2 Maintenance of Dam	4-1
4.3 Maintenance of Operating Facilities	4-1
4.4 Description of any Warning System in Effect	4-1
4.5 Evaluation	4-1

TABLE OF CONTENTS (Cont'd)

	<u>Page</u>
5. HYDRAULIC/HYDROLOGIC	
5.1 Evaluation of Features	5-1
a. General	5-1
b. Design Data	5-1
c. Experience Data	5-1
d. Visual Observations	5-1
e. Test Flood Analysis	5-2
f. Dam Failure Analysis	5-3
6. STRUCTURAL STABILITY	
6.1 Evaluation of Structural Stability	6-1
a. Visual Observation	6-1
b. Design and Construction Data	6-1
c. Operating Records	6-1
d. Post-Construction Changes	6-1
e. 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
d. Need for Additional Investigation	7-1
7.2 Recommendations	7-1
7.3 Remedial Measures	7-1
a. Operation and Maintenance Procedures	7-1
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



1. OVERVIEW OF DAM FROM RIGHT ABUTMENT.

The downstream channel enters under the mill building complex and traverses its length essentially under the mill. The channel emerges briefly in a courtyard between the shop and foundry buildings where it splits into two separate channels. These enter under the foundry building where they merge into one channel. This stone channel eventually becomes a natural ground channel downstream of the foundry building. Each of the channels in the courtyard were in good hydraulic condition. Flow in one of the channels is controlled by two gates and in the other by flashboards. It was not possible to observe channel conditions under the buildings. Hydraulic analyses for these reaches are based on the drawings included in Appendix B.

- e. Test Flood Analysis - Based upon the Corps of Engineers Guidelines, the recommended test flood for this project's size (small) and hazard potential (high) is within the range of a 1/2 PMF to a full PMF (Probable Maximum Flood). The PMF was determined using the Corps of Engineers Guidelines for "Estimating Maximum Probable Discharge" in Phase I Dam Safety Investigations. The watershed terrain was determined to have moderate side slopes draining to a very flat and wide valley. A peak inflow rate of 875 cfs per square mile was selected because of the high storage existing in the valley. There are three Ponds upstream of Hopedale Pond. The largest, North Pond, is located at the head of the drainage area. It has a surface area about three times that of Hopedale Pond, and receives runoff from the upper third of the drainage area. Friske Mill Pond and West Street Pond, which are located between North and Hopedale ponds, are each about one fourth the surface area of Hopedale Pond. All three ponds upstream of Hopedale Pond will help attenuate the magnitude of the test flood inflow to Hopedale Pond.

The selected inflow of 875 cfs per square mile for the 10.5 square mile drainage area yields a PMF inflow of 9200 cfs. Since the dam is in the upper regions of its size classification and is in the high hazard classification, the full PMF of 9200 cfs was selected for the test flood. Evaluation of the effects of the test flood inflow is based on the assumption that the pond level at the start of the test flood is at 51.4. This elevation corresponds to the existing conditions at the spillway at the time of the field inspection. Based on this assumption, and the storage and spillway characteristics of the Hopedale Pond Dam, the surcharge storage routing of the PMF results in an outflow of 7,600 cfs at a stage of 57.4. The routed outflow overtops the embankment to the right of the spillway by 4.8 feet. The capacity of the spillway at the test flood stage is about 640 cfs.

Further analysis indicates that if the four flashboards in place at the time of the field inspection were removed, the spillway capacity would increase to about 1400 cfs at test flood stage. Removal of the flashboards decreases the test flood stage slightly to elevation 57.2, while the routed test flood discharge remains at 7600 cfs.

SECTION 5: HYDRUALIC/HYDROLOGIC

5.1 Evaluation of Features

- a. General - Hopedale Pond Dam consists of an earth embankment with a roadway on its crest and a concrete-stone masonry spillway. The left embankment is about 200 feet long, and the right embankment is about 15 feet long. The spillway crest is approximately 3.5 feet below the underside of a highway bridge. The bridge is supported on four concrete piers which rest on the spillway. The spillway diverges from an upstream width of 49.5 feet to a downstream width of 54.5 feet. The capacity of the spillway is limited. The height from the spillway crest to the downstream toe of dam is about 14.5 feet.

About 9 feet downstream of the spillway, the discharge is channeled into nine brick archways and flows under the adjacent mill building. The capacity of the channel under the building is also limited.

Hydrologically, Hopedale Pond is a high spillage-low surcharge storage project. The spillway capacity is low but discharge can readily occur over the top of dam. Such has been the case during past flood events. However, it should be noted that, in these cases, the adjacent mill building becomes a hydraulic control acting as a secondary dam.

- b. Design Data - No hydraulic/hydrologic design data are available for the dam site.
- c. Experience Data - The Owner indicated that the flood of August 19, 1955 overtopped the right embankment and entered the Draper Corp. building through the windows (window sill elevation 49.95). The flood elevation was recorded at 32 inches above the top of flashboards, but the number of flashboards in place at the time is not known. No other records of past floods are available for the dam site.
- d. Visual Observations - A visual inspection was made of the spillway, the outlet channel, and the pond's drain outlet. All were observed to be in good hydraulic condition. During high discharge with no flashboards in place, the inlet end of the spillway channel under the Freedom Street Bridge will be the hydraulic control. With the flashboards in place during high discharge, the hydraulic control will be at the flashboards where an orifice is formed with the underside of the bridge.

SECTION 4: OPERATIONAL PROCEDURES

- 4.1 Procedures - The owners have written procedures for operation of the dam. The procedures are primarily based on the control of the water level at Hopedale Pond and the two upstream ponds but does not include observation of the dam and names of responsible persons to contact in emergencies.
- 4.2 Maintenance of the Dam - The dam and spillway receive maintenance on a demand basis. No formal maintenance procedure for the dam was located.
- 4.3 Maintenance of Operating Facilities - There is no formal procedure for the maintenance of operating facilities. The spillway flashboards and fire protection intake structure are constantly in use and appear to have received continual maintenance. The operating mechanisms for the pond drain appeared not to have been recently lubricated.
- 4.4 Description of any Warning System in Effect - The established procedure contains the furnishing of names of responsible persons to the communities who they can contact in times of emergencies but it does not contain procedures which the owner is to follow to contact the downstream communities.
- 4.5 Evaluation - The existing formal operational procedure should be expanded to delineate the specific areas of the dam to be viewed during the weekly checks of the dam, the routine maintenance to be performed on the dam, including the frequency of the maintenance, the inclusion of an annual technical inspection by the Owner, and the establishment of warning systems and emergency preparedness plans.

The intake for fire protection water at the right abutment of the dam as shown in Photos 1 and 8 is in good condition. Several cracks are present in the top slab which should be sealed to prevent future deterioration.

The outlet works is on the left side of the spillway. The position of the inlet channel and discharge precluded close visual examination. The reservoir drain operator shown in Photos 6 and 7 appeared to be in good condition but not recently maintained.

- d. Reservoir Area - The lower region of the pond is developed while the upper regions of the pond transition into a marsh. The side slope to the west is generally wooded and undeveloped. The side slope to the east has a road along the shore of the pond and a portion of the developed area of the Town of Hopedale slightly higher up on the slope. No significant potential for landslides into the pond which would create waves that might overtop the dam were observed during the site examination. No conditions were noted which could result in a sudden increase in sediment load into the pond.
- e. Downstream Channel - The downstream channel originates at the spillway and passes under the adjacent mill building through a series of brick arches and into a stone masonry channel. The channel splits into two channels before it passes beneath a foundry building. It emerges as a single stone masonry channel. A series of pedestrian, roadway and railroad bridges cross the channel before it becomes a natural ground channel. The upper regions of the stone masonry channel are within the mill yard complex with flat outside work areas flanking the channel and the structures mentioned before over the channel. Immediately downstream, the channel runs along the boundary of another industrial development.

3.2 Evaluation - Except for minor erosion damage of the embankments and the presence of debris and displaced riprap at the base of the spillway cascade noted in the visual examination, the Hopedale Pond Dam appears to be in good condition. There was no observed evidence of significant potential for failure of the spillway and dam at that time.

SECTION 3: VISUAL INSPECTION

3.1 Findings

- a. General - The Phase I visual examination of Hopedale Pond Dam was conducted on 5 December 1978.

In general, the earthen embankments, the spillway, and the outlet channel were in good condition; however, due to the indicated hydraulic capacity of the spillway as discussed in other sections of this report, the project is considered in only fair condition.

Visual inspection checklists for the site visit are included in Appendix A and selected photographs are shown in Appendix C.

- b. Dam - The earth embankments and the spillway are generally in good condition. There is no visual evidence of significant settlement, lateral movement, seepage or major erosion.

The following specific items were noted:

- (1) There has been local erosion loss at the upstream edge of the roadway pavement, close to the dam's left abutment, possibly due to the loss of stone from the slope protection.
 - (2) There is evidence of past slight seepage through the downstream face/foundation wall to the left of the spillway, and slight flow with iron staining from a pipe that enters the areaway to the right of the spillway. Neither location showed any indication of soil particle movement.
 - (3) There is an obvious low area in roadway pavement grade to the right of the spillway, thereby reducing available freeboard, but this condition does not appear to be due to embankment settlement.
 - (4) The wall along the front face of the dam to the left of the spillway has minor vegetation at the top, several cracks and an area of spalling and deterioration.
 - (5) Stone from the spillway cascade has become displaced at the bottom of the spillway and minor debris is present in the same area as shown in Photo 3.
 - (6) Minor rusting of the railings is present along the walkway.
- c. Appurtenant Structures - The roadway bridge over the spillway, as shown in Photo 1 is in fair condition. Erosion of concrete has taken place at the bridge piers, especially near the right side. The underside of the deck exhibits spalling on the upstream right side and reinforcement is exposed.

SECTION 2: ENGINEERING DATA

- 2.1 Design Records - No design records were located for the Hopedale Dam.
- 2.2 Construction Records - No records of the original construction were located. Modification plans of the spillway area dated 1928-1929 were located.
- 2.3 Operation Records - No operational records were located for the dam.
- 2.4 Evaluation
 - a. Availability - No records for the dam other than prior inspection reports and modification drawings were located.
 - b. Validity - There are no known design, construction or operating records. The drawings of modifications to the spillway were in good agreement with conditions observed during the site examination.
 - c. Adequacy - The absence of known records of the original design and construction requires that the evaluation of the dam during this investigation be based primarily on the visual examination described in the following section and the modification drawings.

(6) D/S Channel-----Rock riprap leading through
nine brick archways at the
face of the mill building and
into a stone tunnel under the
building.

- j. Regulating Outlets - There is an outlet works to the left of the spillway. An open channel parallel to the spillway services two outlets. One feeds a turbine; the other is a pond drain. The pond drain is controlled by a gate which is normally closed. The gate controls are housed in a wooden box at the left end of walkway over the spillway.

f. Reservoir Surface (acres)

- (1) Normal Pool-----89 (Est.)
- (2) Flood-control pool-----N/A
- (3) Spillway crest-----89 (Est.)
- (4) Test flood pool-----294 (Est.)
- (5) Top of dam-----180 (Est.)

g. Embankments

- (1) Type-----Earth fill embankment retained by
concrete and masonry walls with
crest roadway
- (2) Length-----Approx. 200 ft. to the left
and 15 ft. to the right of
the spillway
- (3) Height-----16 ft. (Est.)
- (4) Top width-----30 ft. (Est.)
- (5) Side slopes-----Partial vertical concrete
wall U/S; vertical stone
masonry wall D/S
- (6) Zoning-----Unknown
- (7) Impervious Core-----Unknown
- (8) Cutoff-----Unknown
- (9) Grout Curtain-----Probably none

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

i. Spillway

- (1) Type-----Concrete broad crested with
facilities for flashboards.
- (2) Length of weir-----54.5 ft.
- (3) Crest elevation-----48.93 ft.
- (4) Gates-----Provisions for 3 feet of flashboards.
- (5) U/S Channel-----Five channels created by four bridge
piers.

- (6) Gated spillway capacity at test flood elevation-----N/A
- (7) Total spillway capacity at test flood elevation-----
1400 cfs @ elev. 57.2
- (8) Total project discharge at test flood elevation-----
7600 cfs @ elev. 57.2

c. Elevation (Local Datum)

- (1) Streambed at centerline of dam-----39.0 (Est.)
- (2) Test flood tailwater-----55.0 (Est.)
- (3) Upstream portal invert diversion tunnel-----N/A
- (4) Normal pool-----49.0
- (5) Full flood control pool-----N/A
- (6) Spillway crest-----48.93
- (7) Design surcharge (Original Design)-----Unknown
- (8) Top of dam-----Right bank 52.7/Left bank 53.6
- (9) Test flood design surcharge-----57.2

d. Reservoir

- (1) Length of test flood pool-----2.5 miles
- (2) Length of normal pool-----1.5 miles
- (3) Length of flood control pool-----N/A

e. Storage (acre-feet)

- (1) Normal pool-----295 (Est.)
- (2) Flood control pool-----N/A
- (3) Spillway crest pool-----295 (Est.)
- (4) Top of dam-----907 (Est.)
- (5) Test flood pool-----2078 (Est.)

(4) The window sill elevations in the vicinity of the spillway at the first floor of the mill immediately downstream have been raised by about 3.25 feet.

(5) Additional buildings have been constructed downstream of the dam over the discharge channel.

- i. Normal Operational Procedures - To ensure the availability of process water in the months of July and August, the Owners make an effort to achieve maximum storage in Hopedale Pond as well as in the West Street Pond, Friske Mill Pond, and North Pond, all of which are located in the upstream watershed of Hopedale Pond. The level in Hopedale Pond is maintained low through the winter in anticipation of snow melt and precipitation runoff during the spring. Maintenance of the dam and spillway is performed on an as-needed basis. There is no written procedure for the maintenance of the Hopedale Pond Dam.

1.3 Pertinent Data

Elevations used in this report are based on a local benchmark located on the northwest corner of a stone bound at the corner of Freedom and Progress streets. Its reference elevation is 52.88, which is used by the Owners as the reference for the plans and profiles shown in Appendix B. This benchmark elevation appears to be about 225 feet lower than National Geodetic Vertical Datum (NGVD).

- a. Drainage Area - The sparsely developed drainage area tributary to Hopedale Pond is about 10.5 square miles. About 6 percent of the total drainage area is artificially ponded surface water. Hopedale Pond occupies about 1.5 percent of the total drainage area. The area is characterized by moderately sloping, rolling hills draining to a very flat valley. The length of the watershed is approximately three times its width and the average slope through the basin is less than 0.2 percent. Development within the basin is centered around the banks of North Pond and Hopedale Pond.

b. Discharge at Dam Site

- (1) Outlet works size - A 5.5 ft. x 4.0 ft. gated opening serves as the pond drain. Estimated invert elevation is 44.0.
- (2) Maximum known flood at damsite-----August 19, 1955.
Pond level crested at 32 inches above top of flashboards.
- (3) Ungated spillway capacity at top of dam-----
835 cfs @ elev. 52.7
- (4) Ungated spillway capacity at test flood elevation-----
1400 cfs @ elev. 57.2
- (5) Gated spillway capacity at normal pool elevation-----N/A

- c. Size Classification - Hopedale Pond Dam has a height of 19.4 feet measured from the top of the left embankment to the downstream toe of the spillway. The estimated storage capacity at top of dam is 907 acre-feet. According to the guidelines established by the Corps of Engineers, the dam is classified in the small category.
- d. Hazard Classification - Based on the results of the Dam Failure Analysis (Section 5.1f), Hopedale Pond Dam is classified as having a high hazard potential. Analysis of the downstream impact area indicates that both the basement, boiler room, and the first floor levels of the mill shop would be flooded, creating a high potential for loss of life and property.
- e. Ownership - The dam is owned by the Draper Division of Rockwell International. The contact person is Mr. Harold Anderson. The address is: Draper Corporation, 25 Hopedale Street, Hopedale, MA 01747, Telephone 617/478-5000.
- f. Operator - Mr. Harold Anderson serves as the contact person for the owners and operators of the dam.
- g. Purpose of Dam - Hopedale Pond is used as the source for the process and fire protection water requirements of the downstream mill. Water from the pond may also be diverted through the outlet works for power generation.
- h. Design and Construction History - No information was located with respect to the design and construction history of the dam. Several drawings (dated about 1928-29) detailing modifications to the spillway area and the downstream channel are included in Appendix B.

A comparison of the drawings with the conditions observed at the time of inspection indicates that the following additional modifications have been made at the site:

- (1) The bridge deck spanning the spillway has been widened to include sidewalks on both sides.
- (2) Three pipe lines are located above the crest elevation of the dam starting at the right spillway abutment and extending to the left end of the dam.
- (3) The screened concrete intake structure located at the upstream right spillway abutment has been raised by about 2 feet.

1.2 Description of Project

- a. Location - Hopedale Pond Dam is located on Mill River in the Town of Hopedale, Massachusetts, as shown on the report's location map. The dam is located at the south end of Hopedale Pond where the crest of the dam serves as Freedom Street.
- b. Dam and Appurtenances - Hopedale Pond Dam consists of an earth and riprap embankment. Freedom Street runs along the crest of the dam with a bridge spanning over the concrete spillway. The upstream face of the embankment is protected by a wall anchored on 3.5 feet deep sheet piling and extending about 45 feet to the right and 50 feet to the left of the spillway. The remaining 150 feet of the left embankment is protected with a sloped rock fill. Except at the spillway where there is a riprap embankment, the downstream face of the dam embankment is essentially the foundation wall of a mill building complex. The concrete spillway is located under the Freedom Street bridge with about 3.5 feet clearance between the bottom of the bridge deck and the spillway. The spillway is divided into five channels by four concrete piers which support the 28 foot wide bridge. The spillway, just beyond the downstream face of the bridge, has provisions for the insertion of up to five flashboards (total height of 3.0 feet) to control the elevation of the pond. Discharge from the spillway flows over a stone masonry wall and a riprap-embankment leading into nine brick archways and a tunnel under a mill building. The height from the invert of the tunnel to the spillway crest is about 14.5 feet.

A concrete channel just to the left of the spillway leads to two outlets. One of these discharges at the downstream face of the spillway and serves as the pond drain. The other is diverted through a turbine before discharging to the spillway discharge channel. The gate controls for the pond drain are housed in a wooden box at the left, downstream corner of the spillway. A screened concrete structure at the right abutment of the dam is the intake for a 20-inch outlet pipe which is intended to augment water supply during peak fire demands in the vicinity.

To the right of the spillway, the pond shoreline turns upstream and the roadway pavement surface drops about a foot below the level of the left embankment. On the mill side of the road, there is a paved areaway about 5 ft. deep between the sidewalk and the building. This areaway has a stone masonry wall on the roadway side and brick building walls on the downstream side. The areaway is connected to the spillway channel at the left end by a brick-arch.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

HOPEDALE POND DAM
MA 00624

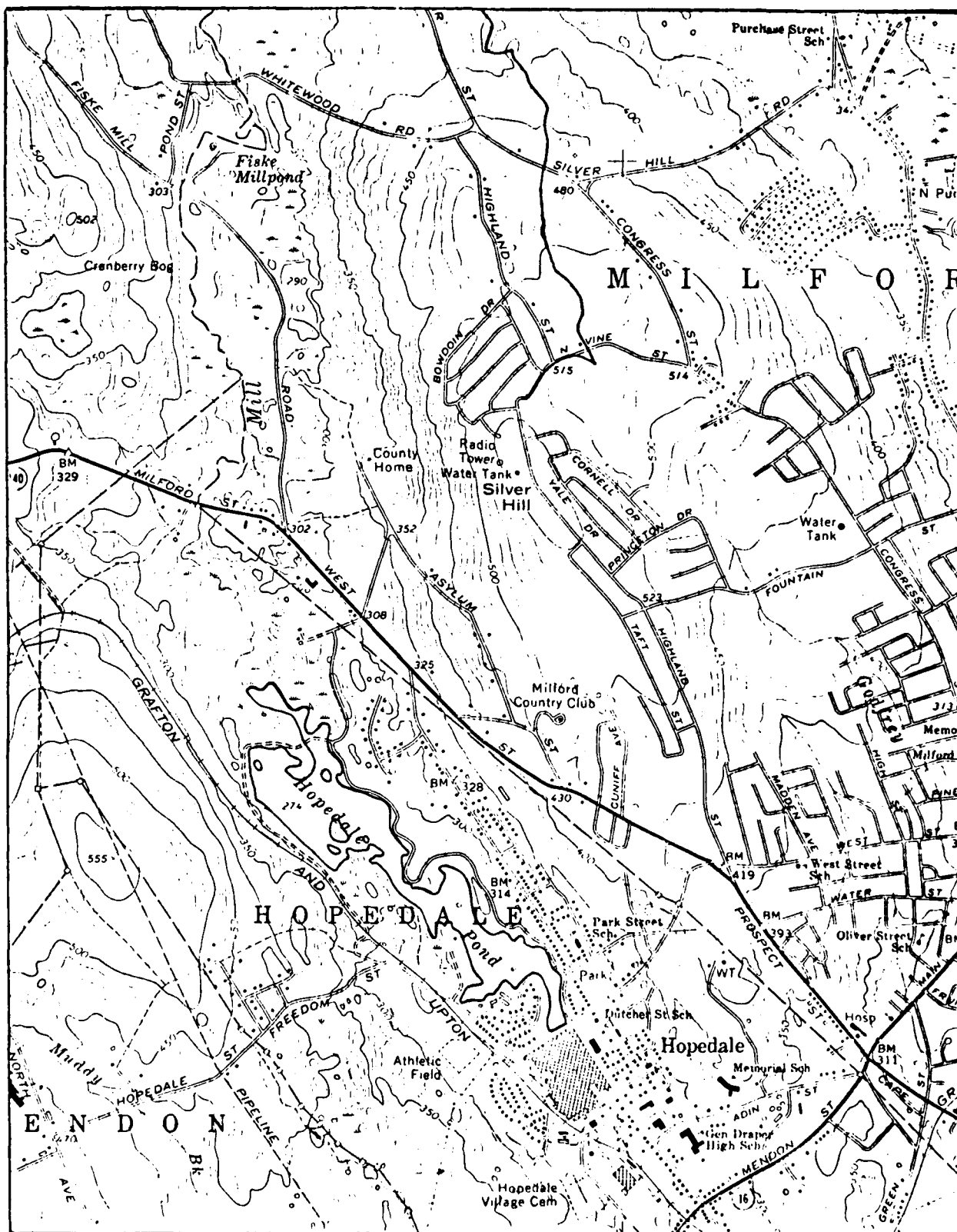
SECTION 1: PROJECT INFORMATION

1.1 General

- a. Authority - Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England region.

Camp Dresser & McKee Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed was issued to Camp Dresser & McKee Inc. under letters of 12 July 1978 and 23 October 1978 from Colonel John P. Chandler, Corps of Engineers. Contract No. DACW 33-78-C-0354 has been assigned by the Corps of Engineers for this work. Haley and Aldrich, Inc. has been retained by Camp Dresser & Inc. for the soils and geological portions of the work.

- b. Purpose - The primary purpose of the investigation is to:
- (1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.
 - (2) Encourage and assist the states to initiate quickly effective dam safety programs for non-federal dams.
 - (3) Update, verify and complete the National Inventory of Dams.



DAM HOPEDALE POND DAM

IDENTIFICATION NO. MA 00624



LOCATION MAP
USGS QUADRANGLE

MILFORD, MA.

APPROX. SCALE: 1" = 2000'

- f. Dam Failure Analysis - Hydraulic analyses of the channel downstream of the dam were performed to determine the hazards, resulting from a dam failure. It was assumed that, in the event of a dam failure, the spillway would breach completely. The resulting discharge based on the Corps of Engineers Guidelines for Estimating Dam Failure Outflows is about 7250 cfs. Assuming the dam fails when the pond elevation is at the top of dam (el. 52.7), only 2650 cfs can be carried by the downstream channel under that head. At this point, the face of the building will be acting as the dam with resulting flooding of the basement, first floor, and boiler room levels of the mill's shop building. These conditions will develop a high potential hazard to life and property in the shop building. Beyond the shop building the discharge channel emerges in a courtyard. Here the channel splits into two channels. The flow in one channel is controlled by flashboards and, in the other, is controlled by two gates. The worst hazard would result if the gates were closed and the maximum number of flashboards were in place. Under this condition, most of the flow reaching the courtyard would overtop the stone channels and flow overland around the mill's foundry building. The resulting shallow depth flow may cause minor damage to nearby structures but presents minimal potential for loss of life. Downstream of the foundry the overland flow will collect and for the most part be contained in the Mill River channel with no further hazard downstream.

The limited capacity of the discharge channel under the shop building has two effects. First, it creates pressure flow under the building with consequent flooding of the shop building and, secondly it attenuates the dam failure discharge, thus reducing potential hazards beyond the shop building. Due to the high potential for loss of life and property in the mill's shop building, Hopedale Pond Dam is classified in the high hazard category.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Embankment Structural Stability

- a. Visual Observations - There was no visible evidence of dam embankment or spillway instability during the site visit on 5 December 1978.
- b. Design and Construction Data - There are neither design drawings nor construction data which show the embankment cross section and the physical properties of the materials in the embankment. Thus, a theoretical analysis of the structural stability of the dam embankment is not possible.

Hopedale Pond Dam is relatively low, and, in the absence of significant seepage, the wide dam embankment would be expected to be adequately stable under static loading conditions.

Modification drawings of the spillway were located; however, they did not present any material information on the type and extent of the materials used in the original construction to allow a theoretical analysis of the stability of the spillway. The buttressing effect of the dumped riprap in the 1928-1929 modification of the spillway would be expected to result in an adequately stable structure under static loading conditions. This does not mean that the dumped riprap would not ravel during high flows nor does it mean that it is not necessary to replace or reset stone that has ravelled.

- c. Operating Records - The only operating records located were pond level readings and county and state inspection reports.
- d. Post-Construction Changes - Without design or "as-built" drawings, the extent of post-construction changes to the dam embankment is not known. The concrete walls along the upstream face of the dam may be of more recent construction than the original stone masonry.
- e. Seismic Stability - The dam is located in Seismic Zone 2 and, in accordance with recommended Phase I guidelines, does not warrant seismic analysis.

SECTION 7: ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

- a. Condition - The visual examination of the Hopedale Pond Dam embankment did not reveal any evidence of failure or conditions which would warrant urgent remedial treatment. The embankment portions of the project are considered to be in good condition; however, due to the limited capacity of the spillway, the project is considered to be in only fair condition.
- b. Adequacy of Information - The information for the Phase I Investigation was obtained from visual examination, limited measurements at the site, and the modification drawings included in Appendix B. This information has been sufficient for the purpose of this investigation, but it does not permit detailed evaluation of stability.
- c. Urgency - The recommended additional investigations and remedial measures outlined in Sections 7.2 and 7.3, respectively, should be undertaken within one year of receipt of the report by the Owner.
- d. Need for Additional Investigations - Additional investigations should be performed by the Owner as outlined in the following section.

7.2 Recommendations

It is recommended that the Owner engage a Registered Professional Engineer to perform the following additional investigation.

- (1) A detailed hydrologic-hydraulic investigation to determine the adequacy of the spillway including intake and discharge channels and to determine and implement any necessary modifications and/or corrective actions to provide adequate capacity.

7.3 Remedial Measures

- a. Operation and Maintenance Procedures - It is recommended that the following remedial work be undertaken by the Owner, in addition to the investigations outlined in Section 7.2, to correct deficiencies noted during the visual examination:
 - (1) Repair the local erosion at the left end of the upstream face of the dam embankment, and restore rock erosion protection as necessary to protect against future erosion.

- (2) Remove debris and reset displaced riprap at the bottom of the spillway cascade. Fill any remaining voids in the cascade with riprap.
- (3) Perform minor maintenance work including touch-up painting of rusted spots on the walkway railing, removal of debris from flashboards, lubricating and checking reservoir drain gate, sealing of concrete cracks at the fire portection intake and removal of vegetation and patching of concrete at the dam's upstream concrete wall.
- (4) Expand the existing operational procedure to delineate the specific areas of the dam to be viewed during the weekly checks of the dam, the routine maintenance to be performed on the dam and the establishment of warning systems and emergency preparedness plans.

Due to the limited capacity of the spillway, the Owner should be especially diligent in keeping the spillway under observation during periods of high precipitation. The Owner should institute a program of annual technical inspections.

7.4 Alternatives - There are no practical alternatives recommended.

APPENDIX A
INSPECTION TEAM ORGANIZATION AND CHECKLIST

	<u>Page No.</u>
<u>VISUAL INSPECTION PARTY ORGANIZATION</u>	A-1
<u>VISUAL INSPECTION CHECKLIST</u>	
Right Embankment	A-2
Left Embankment	A-3
Spillway	A-4
Outlet Works - Power Intake and Reservoir Drain	A-5
Outlet Works - Water Intake and Fire Protection	A-6

VISUAL INSPECTION PARTY ORGANIZATION
NATIONAL DAM INSPECTION PROGRAM

DAM: Hopedale Pond

DATE: December 5, 1978

TIME: 1400

WEATHER: Partly Cloudy - 50 F

WATER SURFACE ELEVATION UPSTREAM: 16½" below top of concrete well
right embankment pond side

STREAM FLOW: unknown

INSPECTION PARTY:

1. Roger H. Wood - Structural & Operation
2. Charles E. Fuller - Hydraulics & Hydrology
3. Joseph E. Downing - Ass't. Hydraulics & Hydrology
4. William C. Rowe - Ass't. Structural
5. Peter L. LeCount (H & A) - Soils
6.

PRESENT DURING INSPECTION:

1.
2.
3.
4.

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Hopedale Pond

DATE: 5 December 1978

EMBANKMENT: (Right)

CHECK LIST	CONDITION
1. Upstream Slope a. Vegetation b. Sloughing or Erosion c. Rock Slope Protection - Riprap Failures d. Animal Burrows	1. a. None-concrete wall b. N/A c. N/A d. None
2. Crest a. Vegetation b. Sloughing or Erosion c. Surface cracks d. Movement or Settlement	2. a. Grass alongside road b. None c. Few cracks in walk, roadway OK. d. Pav't apparently built 1-2' lower than bridge deck.
3. Downstream Slope a. Vegetation b. Sloughing or Erosion c. Surface cracks d. Animal Burrows e. Movement or Cracking near toe f. Unusual Embankment or Downstream Seepage g. Piping or Boils h. Foundation Drainage Features i. Toe Drains	3. a. None-stone masonry wall b. N/A - c., d. N/A e. None evident f. Sl. flow from drain in wall g. None observed - h., i. None observed
4. General a. Lateral Movement b. Vertical Alignment c. Horizontal Alignment d. Condition at Abutments and at Structures e. Indications of Movement of Structural Items f. Trespassing g. Instrumentation Systems	4. - a., b., c. Road & downstream wall alignment looks good. d. Looks OK e. None observed f. Public road g. None

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Hopedale Pond

DATE: 5 December 1978

EMBANKMENT: (Left)

CHECK LIST	CONDITION
1. Upstream Slope a. Vegetation b. Sloughing or Erosion c. Rock Slope Protection - Riprap Failures d. Animal Burrows	1. a. Mostly concr. wall, left end grass & weeds in stone slope. b. None evident, except sl. loss @ pav'd edge @ left end. c. Poss. single stone lost @ end @ erosion location. d. None
2. Crest a. Vegetation b. Sloughing or Erosion c. Surface cracks d. Movement or Settlement	2. a. None b. None c. V. few minor pav't cracks d. None evident
3. Downstream Slope a. Vegetation b. Sloughing or Erosion c. Surface cracks d. Animal Burrows e. Movement or Cracking near toe f. Unusual Embankment or Downstream Seepage g. Piping or Boils h. Foundation Drainage Features i. Toe Drains	3. a. None-building foundation wall @ dam face. b. N/A c. N/A d. N/A e. None observed f. Calcium carbonate deposits on founda- tion wall in deep basement area alongside channel, but no signifi- cant seepage. g. N/A h., i. None
4. General a. Lateral Movement b. Vertical Alignment c. Horizontal Alignment d. Condition at Abutments and at Structures e. Indications of Movement of Structural Items f. Trespassing g. Instrumentation Systems	4. a., b., c. Street & wall alignments & grades look good. d. Good e. None observed f. Public road g. None

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Hopedale Pond Dam

DATE: 5 December 1978

SPILLWAY: _____

CHECK LIST	CONDITION
1. Approach Channel a. General Condition b. Obstructions c. Log Boom etc. 2. Weir a. Flashboards b. Weir Elev. Control (Gate) c. Vegetation d. Seepage or Efflorescence e. Rust or Stains f. Cracks g. Condition of Joints h. Spalls, Voids or Erosion i. Visible Reinforcement j. General Struct. Condition 3. Discharge Channel a. Apron b. Stilling Basin c. Channel Floor d. Vegetation e. Seepage f. Obstructions g. General Struct. Condition 4. Walls a. Wall Location _____ (1) Vegetation (2) Seepage or Efflorescence (3) Rust or Stains (4) Cracks (5) Condition of Joints (6) Spalls, Voids or Erosion (7) Visible Reinforcement (8) General Struct. Condition	1. a. Approach under bridge. Bridge piers (4) show deterioration. Underside of Br. deck spalled right side - Reinf exposed b. None observed-Bridge does constrict flow c. None observed 2. a. Series of 10 flashboards, one lower than others during inspection. Minor debris upstream side of flashboards. Flashboards in good condition. b. Flashboards only c. None observed d. Flow obscured conditions e. Flow obscured conditions f. Flow obscured conditions g. Flow obscured conditions h. Flow obscured conditions i. N.A. j. Observed portions appeared good 3. a. Dumped riprap cascade, some rocks displaced b. N.A. c. Main channel beneath bldg-not observable d. None observed e. Not observable f. Minor debris at base of cascade g. General condition is good. Walkway decking unpainted but in good condition. Railing, esp. at bot of posts, starting to rust. 4. a. (1) Minor vegetation present (2) None observed (3) None observed (4) Several cracks present (5) See (6) (6) Area present of deterioration and spalling (7) None observed (8) Fair condition

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Hopedale Pond Dam

DATE: 5 December 1978

OUTLET WORKS: Power intake-Reservoir drain

CHECK LIST	CONDITION
1. Inlet a. Obstructions b. Channel c. Structure d. Screens e. Stop Logs f. Gates 2. Control Facility a. Structure b. Screens c. Stop Logs d. Gates e. Conduit f. Seepage or Leaks 3. Outlet a. Structure b. Erosion or Cavitation c. Obstructions d. Seepage or Leaks 4. Mechanical and Electrical a. Crane Hoist b. Hydraulic System c. Service Power d. Emergency Power e. Lighting f. Lightning Protection	1. a. Intake clear but entrance constricts flow b. Beneath roadway - not observable c. Beneath roadway - not observable d. None observed e. None observed f. Hidden by struct. Not observable Appear to be wooden sluice gates 2. a. Drain operator enclosed in wooden box. Mortar in base stone joints cracking. b. None observed c. None observed d. See 1 (f) e. Not observable f. Not observable due to flow 3. a. Discharges directly into spillway D/S of weir b. & c. Dumped riprap present at discharge d. Not observable 4. N.A. - manual operation

VISUAL INSPECTION CHECK LIST NATIONAL DAM INSPECTION PROGRAM	
DAM: <u>Hopedale Pond Dam</u>	DATE: <u>5 December 1978</u>
OUTLET WORKS: <u>Water intake - Fire protection</u>	
CHECK LIST	CONDITION
1. Inlet a. Obstructions b. Channel c. Structure d. Screens e. Stop Logs f. Gates	1. a. None observed b. None - faces pond c. Concrete - top slab cracked but in good condition d. Present at face of struct - good condition e. & f. Slide gates
2. Control Facility a. Structure b. Screens c. Stop Logs d. Gates e. Conduit f. Seepage or Leaks	2. N.A. 3. Pipelines 4. N.A. manual operation
3. Outlet a. Structure b. Erosion or Cavitation c. Obstructions d. Seepage or Leaks	
4. Mechanical and Electrical a. Crane Hoist b. Hydraulic System c. Service Power d. Emergency Power e. Lighting f. Lightning Protection	

APPENDIX B

LIST OF AVAILABLE DOCUMENTS AND
PRIOR INSPECTION REPORTS

Page No.

LIST OF AVAILABLE DOCUMENTS

B-1

PRIOR INSPECTION REPORTS

<u>DATE</u>	<u>BY</u>	
1. April 27, 1925	County of Worcester, Mass.	B-2
2. July, 1939	County of Worcester, Mass.	B-3, B-4
3. December 9, 1941	County of Worcester, Mass.	B-5
4. July 24, 1942	County of Worcester, Mass.	B-6
5. November 16, 1944	County of Worcester, Mass.	B-7
6. March 27, 1950	County of Worcester, Mass.	B-8
7. September 12, 1955	County of Worcester, Mass.	B-9
8. July 21, 1961	County of Worcester, Mass.	B-10
9. May 6, 1963	County of Worcester, Mass.	B-11
10. April 2, 1964	County of Worcester, Mass.	B-12
11. March 19, 1968	County of Worcester, Mass.	B-13
12. March 21, 1969	County of Worcester, Mass.	B-14
13. April 5, 1972	Mass. Dept. of Public Works	B-15

DRAWINGS

<u>NO.</u>	<u>TITLE</u>	
1.	Plan of Freedom Street Dam	B-16
2.	Elevation View of Freedom Street Dam	B-17
3.	General Plan of Canal Downstream of Freedom Street	B-18
4.	Elevation View of Canal Downstream of Freedom Street	B-19

LIST OF DOCUMENTS

HOPEDALE POND DAM

<u>DOCUMENT</u>	<u>LOCATION</u>
1. Freedom Street Dam - Plan View, February 1928	Draper Division of Rockwell International 25 Hopedale Street Hopedale, Massachusetts 01747
2. Sketch of Gates at Wheel Room, February 1928	Same
3. Not titled. Shows two section details of Upstream Dam Embankment Concrete Protection Wall.	Same

Decree No.

Dam No. 22-02

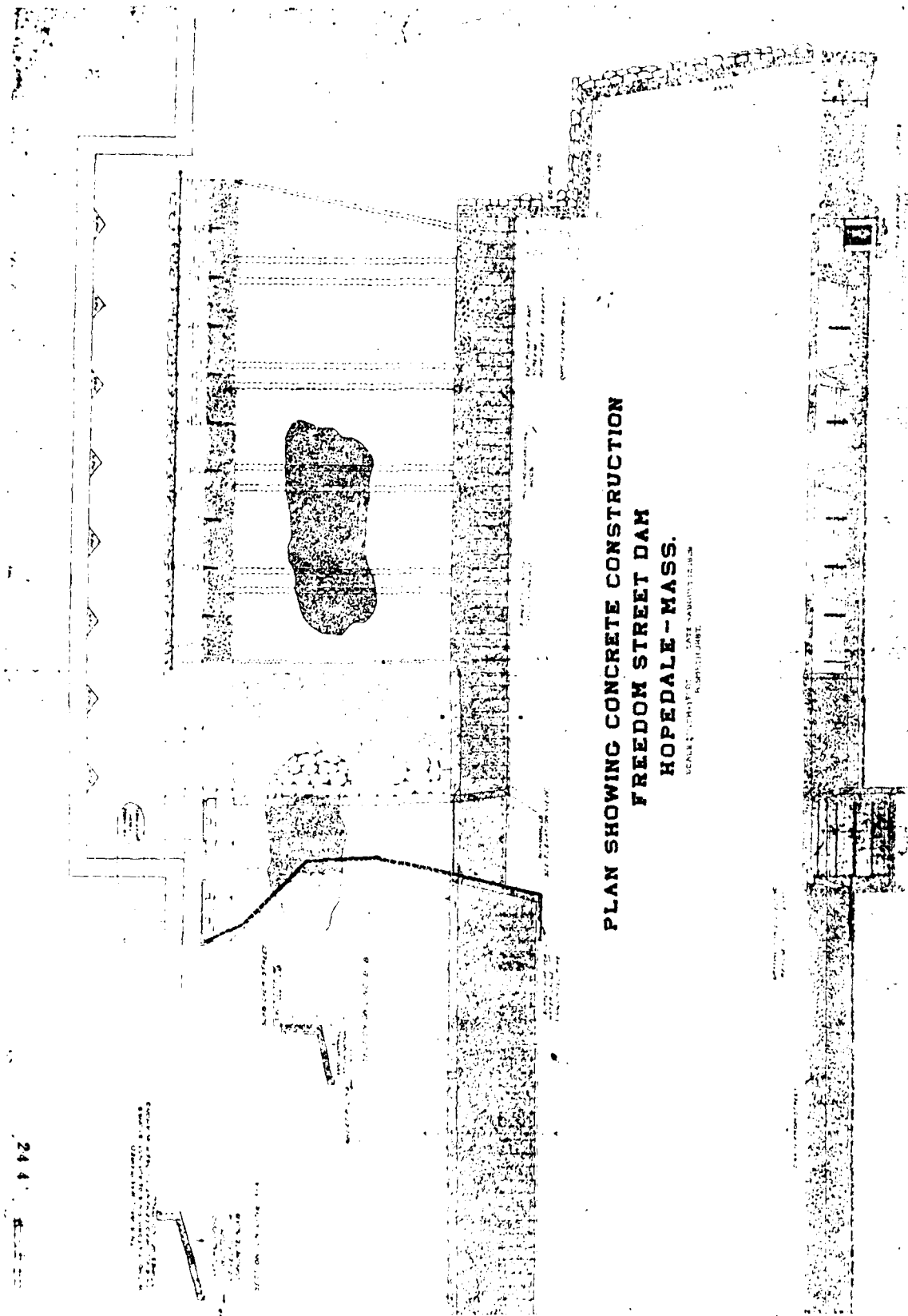
COUNTY OF WORCESTER, MASSACHUSETTS

OFFICE OF COUNTY ENGINEER

Neg. Nos.

INSPECTION OF DAMS, RESERVOIR DAMS AND RESERVOIRS

Town Hopedale Date April 27, 1925 Dam No. 22-02
 Location at Draper Plant Name of Pond or Stream Mill River
 Inspected by L. O. Hadden
 Owner Draper Mfg. Co. Use Power Fire Protection
 MATERIAL & TYPE Hy. Emb. earth - riprap 1 1/2:1 u.s. cut stone
 masonry spillway - steel flashboard frames.
 Elevations in feet: above (+) or below (-) full pond or reservoir level.
 FOR DAM Bed of stream below 84 top of spillway 96.7
 FOR RESERVOIR
 top of dam 100 top of flashboards 91.5 ground surface below 90+-
 level of overflow pipe 86 about 4' wide length in feet 175+-
 width top in feet 32+- width bottom in feet 40+- size pipe to mill
 inches length spillway in feet 60+- head in feet
 Size of wheel H. P. developed
 Size of gates location of gates to mill at east end dam
 Foundation and details of construction ledge-boulders - brick mill foundation
 forms lower vertical wall. condition of embankment good except holes
 gates to mill and spillway
 Constructed by date
 Designed by location
 Recent repairs and date none
 Evidence of leakage none
 Condition good
 Topography of country below Broad valley sparsely wooded on slopes
 Nature of buildings and roads below dam Mills of Draper Mfg. Co.
 No. Acres in watershed No. Acres in pond
 Plans secured Percent watershed in cultivation
 Percent in forests Note: Cross out word not applicable
 Spillway section is rubble wall dry laid plank apron
 Section filled with large loose rocks about 4' below top.
 Concrete section below bridge.
 No letter necessary



PLAN SHOWING CONCRETE CONSTRUCTION
 FREEDOM STREET DAM
 HOPEDALE - MASS.
 SCALE: 1" = 10' (SEE NOTE ON SHEET 1)

344

244

INSPECTION REPORT & DATA FOR DAMS

Owner: DEALER CORP 70 MR ANDERSON
 His Address: 25 HOPDALE ST HOPDALE
 Function of Dam: _____

Location & Access: 1/2 MILE WEST OF HOPDALE

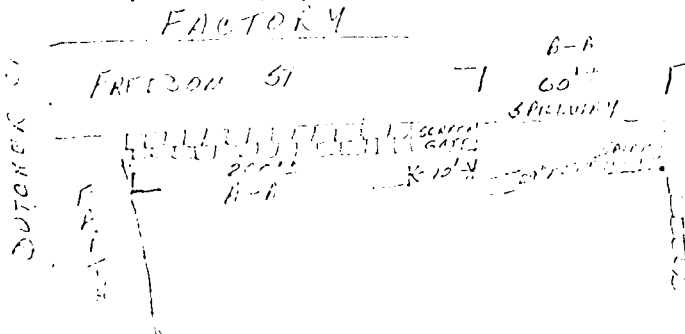
USGS Quad. MILFORD Lat. 42-00-00 Long. 71-20-15
 Drain. Ar. 1000 Sq. Mi.; Ponds: 1 ac.; Res. @ dam: _____
 Character of D.A.: _____

Estimated
 Discharge: _____
 Capacity: _____

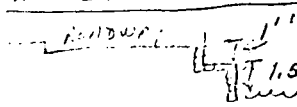
General Description of Dam and Discharge Control:

- HWY EMB EARTH & RIPRAP 2' W. END
- LEN. SPILLWAY 60' FLASHBOARD 2X12'
- SIZE GATE 5.5X4 TO MILL EAST END DAM

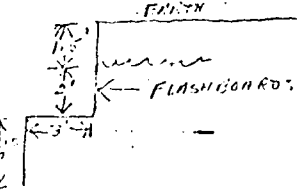
Sketch (Not to Scale):



A-A END VIEW DAM



B-B SPILLWAY SIDE VIEW



Remarks and Recommendations:

AT EAST END OF SPILLWAY A 24" PIPE ENTERS A RL CUBICAL HOUSE. PIPE COMES UNDER WATER ACROSS END OF DAM + SPILLWAY. LENGTH UNKNOWN

Date

By

Comment

4/14/54

J. J.

Dam No.

3-14-135-01
 3-14-138-02

TOWN HOPE DALE DAM NO. 22-02
LOCATION _____ STREAM _____

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by _____ Place _____ Use _____

Inspected by J. ASPERO Date MARCH 21, 1967

Type of Dam _____ Condition _____

SPILLWAY

Flashboards in Place YES Recent Repairs _____

Condition 10 RAISE 1 HAS 5 PLANKS 8 HAVE 4 PLANKS

Repairs Needed 1 HAS 2 PLANKS WATER IS 27' DEPTH

11 CLOSED RAY WITH 5 PLANKS EACH PLANK IS 8' HIGH

EMBANKMENT

Recent Repairs _____

Condition _____

Repairs Needed _____

GATES

Recent Repairs GATE CLOSED

Condition _____

Repairs Needed _____

LEAKS

How Serious _____

By _____ County Engineer

TOWN Hopedale DAM NO. 22-02
LOCATION Freedom St STREAM Mill River

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by Draper Corporation Place Hopedale Use Mill Pond
Inspected by R.B. Reynolds Date 3-19-68 12:15 P.M.
Type of Dam Highway embankment Condition Good

SPILLWAY

Flashboards in Place Boards removed Recent Repairs _____
Condition _____
Repairs Needed _____

EMBANKMENT

Recent Repairs Water level on this date is at the top of the concrete wall.
Condition _____
Repairs Needed _____

GATES

Recent Repairs _____
Condition _____
Repairs Needed _____

LEAKS

How Serious _____

Inspected by _____ County Engineer

TOWN Hopedale DAM NO. 22-021

LOCATION At the upper end of Hopedale Pond STREAM Mill River
at a Public Park

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by Draper Corp. Place Hopedale Use Mill Pond

Inspected by FEP - WOL Date Apr. 2, 1964

Type of Dam Proposed new stone dam Condition To be built

SPILLWAY

Flashboards in Place _____ Recent Repairs _____

Condition Conference regards this proposed new dam to be built

Repairs Needed across the upper end of Hopedale Pond. Propose to
raise this upper storage pond about 2 ft.

EMBANKMENT

Recent Repairs Howard Turner is the Consulting Engineer

Condition _____

Repairs Needed This dam will probably be built in 1965.

GATES

Recent Repairs _____

Condition _____

Repairs Needed _____

LEAKS

How Serious _____

DATE: _____ County Engineer _____

TOWN Hopedale DAM NO. 22-02
LOCATION Freedom St. STREAM Mill River

Hopedale Pond
WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by Draper Corp. Place Hopedale Use Mill Pond
Inspected by WOL Date May 6, 1963
Type of Dam Roadway Embankment Condition Good

SPILLWAY

Flashboards in Place _____ Recent Repairs _____
Condition The spillway area is very small - the lower
Repairs Needed windows in the mill bldg have been bricked in to
minimize drainage from any future floods.

EMBANKMENT

Recent Repairs _____
Condition The roadway embankment is good.
Repairs Needed _____

GATES

Recent Repairs _____
Condition The gate to the Mill is good.
Repairs Needed _____

LEAKS

How Serious No leaks are visible.

DATE: _____ County Engineer _____

TOWN HopedaleDAM NO. 22-02

LOCATION _____

STREAM _____

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by Draper Corp. Place Hopedale Use IndustryInspected by L.O.M. A. Fitzgerald, M.M. Date July 21, 1961 ✓

Type of Dam _____ Condition _____

SPILLWAY

Flashboards in Place Yes Recent Repairs NoneCondition OKRepairs Needed None

EMBANKMENT

Recent Repairs NoneCondition OKRepairs Needed None

GATES

Recent Repairs NoneCondition OK

Repairs Needed _____

LEAKS

How Serious None visibleDATE: July 21, 1961 L.O. Madden County Engineer

TOWN <u>Hopedale</u>	DAM NO. <u>3202</u>
LOCATION _____	STREAM _____
WORCESTER COUNTY ENGINEERING DEPARTMENT WORCESTER, MASSACHUSETTS DAM INSPECTION REPORT	
OWNED BY <u>Draper Corp.</u>	PLACE _____ USE _____
INSPECTED BY <u>JAH</u>	DATE <u>SEP 12, 1955</u>
TYPE OF DAM _____	CONDITION _____
<u>SPILLWAY</u>	
FLASHBOARDS IN PLACE _____	RECENT REPAIRS _____
CONDITION <u>good</u>	
REPAIRS NEEDED _____	
<u>EMBANKMENT</u>	
RECENT REPAIRS _____	
CONDITION <u>good</u>	
REPAIRS NEEDED _____	
<u>GATES</u>	
RECENT REPAIRS _____	
CONDITION <u>OK</u> <u>closed</u>	
REPAIRS NEEDED _____	
<u>LEAKS</u>	
HOW SERIOUS _____	
	DATE _____
COUNTY ENGINEER _____	

TOWN Hopedale

DAM NO. 2-02

LOCATION Draper Pond

STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT

WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

OWNED BY Draper Corp

PLACE Hopedale

USE Highway

INSPECTED BY Long

DATE March 27, 1957

TYPE OF DAM Hy Emb Stone & concrete spillway

CONDITION Good

SPILLWAY

FLASHBOARDS IN PLACE

RECENT REPAIRS

CONDITION

REPAIRS NEEDED

EMBANKMENT

RECENT REPAIRS

CONDITION

REPAIRS NEEDED

GATES

RECENT REPAIRS

CONDITION

REPAIRS NEEDED

LEAKS

HOW SERIOUS

DATE March 27, 1957

L.O. Winder
COUNTY ENGINEER

WORCESTER COUNTY ENGINEERING DEPT.

WORCESTER, MASS.

DATE Nov. 16, 1944

SUBJECT: Dam No. 22-02 Hopedale - Dezer Mfg Co

TO

This dam is in good condition

CAR USED
CAR MILEAGE
END TRIP

L.O. Martin

SIGNATURE

COUNTY OF WORCESTER MASSACHUSETTS

COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs

Inspected by

L.M.

Date

7-24-42

Dam No.

22

Town

*Hopedale
Draper Mt. G.*

Location

Hopedale

Owner

Use

Material and Type

Dam Designed by

Constructed by

Year

SPILLWAY

El. top Abutment

El. Crest

El. Apron

El. Streambed

Width top Abutment

Width top Crest

Width bottom Spillway

Width Flashboards carried

Kind Flashboards

El. Flowline Cleanout Pipe

Size and Kind Cleanout Pipe

Kind of Foundation under Spillway

Condition

OK

EMBANKMENT

El. Top

El. Natural Ground

Width Top

Width of Bottom

Upstream Slope

Downstream Slope

Kind of Corewall

Riprap

Material in Embankment

Foundation

Condition

OK

GATES

Location

Size

Kind

El. Flowline

Condition

OK

WHEEL

Kind

Size

Rated H. P.

Location

Ave. Head

Evidence of Leaks in Structure

None visible

Recent Repairs and Date

None

Topography of Country below Dam

Nature of Buildings and Roads below Dam

Number Acres in Pond

Drainage Area in Square Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

WORCESTER COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs

Inspected by L. O. Marden Date 12-9-41 Dam No. 22-8

Town Hopdale Location _____

Owner Draper Mfg Co Use _____

SPILLWAY

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

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

Width flashboards _____ Kind Flashboards _____

El. Flowline Clearout Pipe _____ Size and Kind Pipe _____

Kind of Foundation under Spillway _____

Condition OK

EMBANKMENT

El. Top _____ El. Natural Ground _____ Width Top _____

Width of Borrom _____ Upstream Slope _____ Downstream Slope _____

Kind of Corewall _____ Riprap _____

Material in Embankment _____ Foundation _____

Condition OK

GATES

Size _____ Kind _____ El. Flowline _____

Condition Making repairs

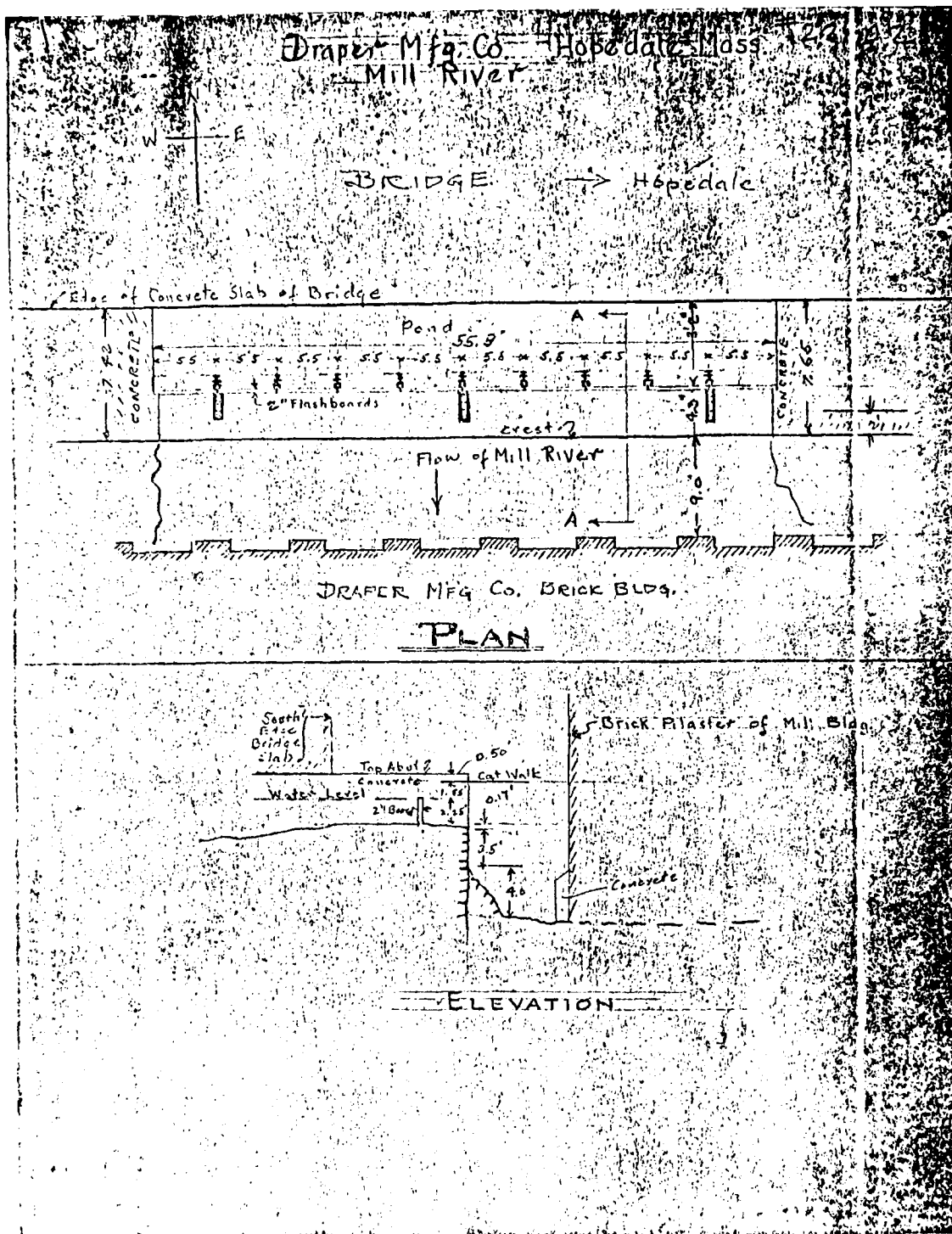
Evidence of Leaks in Structure None visible

Recent Repairs and Date _____

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

Height in Second Foot per Square Mile _____

Estimated Storage Million Cubic Feet _____



COUNTY OF WORCESTER MASSACHUSETTS

COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Inspected by *E. E. Brown*

Date *July 1939*

Dam No. *22-02*

Town *Hopedale*

Location *Mill River*

Owner *Drapac Co.*

Use

Material and Type *Masonry*

Dam Designed by

Constructed by

Year

SPILLWAY—Length *55.5* Feet. Depth *4.3* Feet

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

Width top Abutment *Width top Crest* *Width bottom Spillway*

Width Flashboards carried *2'* Kind Flashboards *Wood*

El. Flowline Cleanout Pipe *Size and Kind Cleanout Pipe*

Kind of Foundation under Spillway

Condition *O.K.*

EMBANKMENT—Length overall *Feet* *North Side of Roadway*

El. Top *El. Natural Ground* *Width Top*

Width of Bottom *Upstream Slope* *Downstream Slope*

Kind of Corewall *Riprap*

Material in Embankment *Foundation*

Condition

GATES *Not Found*

Location

Size *Kind* *El. Flowline*

Condition

WHEEL *Kind* *Size* *Rated H. P.*

Location *Ave. Head*

Evidence of Leaks in Structure

Recent Repairs and Date

Topography of Country below Dam *Under Mill Bldg*

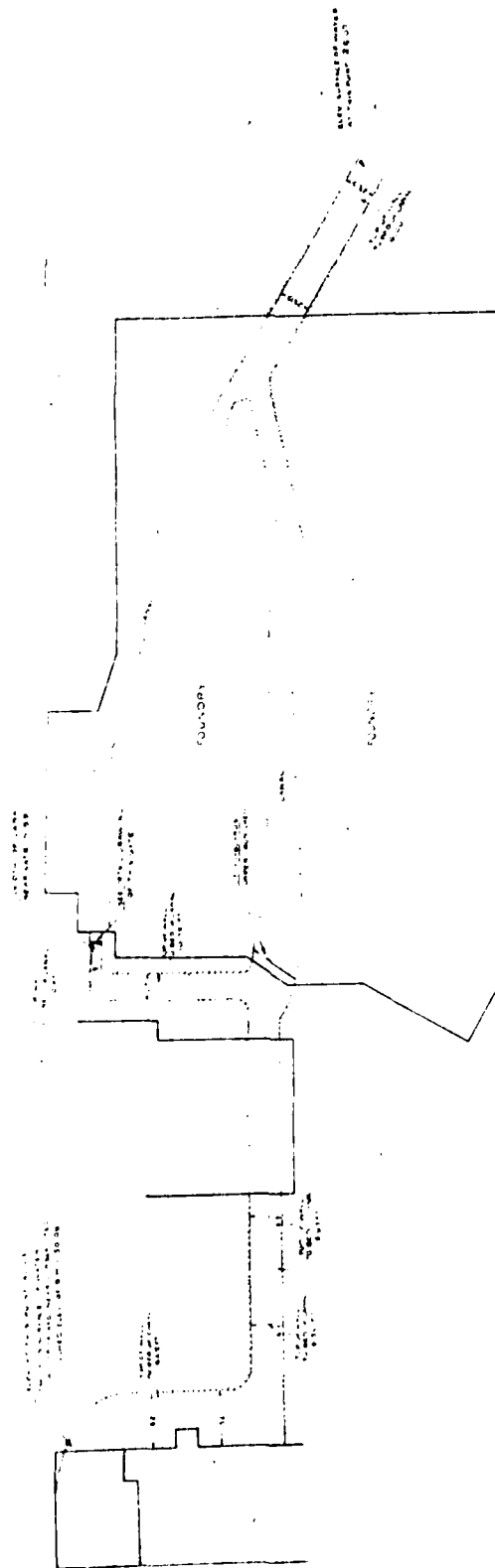
Nature of Buildings and Roads below Dam *Back Mill Bldgs*

Number of Acres in Pond *Drainage Area in Square Miles*

Discharge in Second Feet per Square Mile

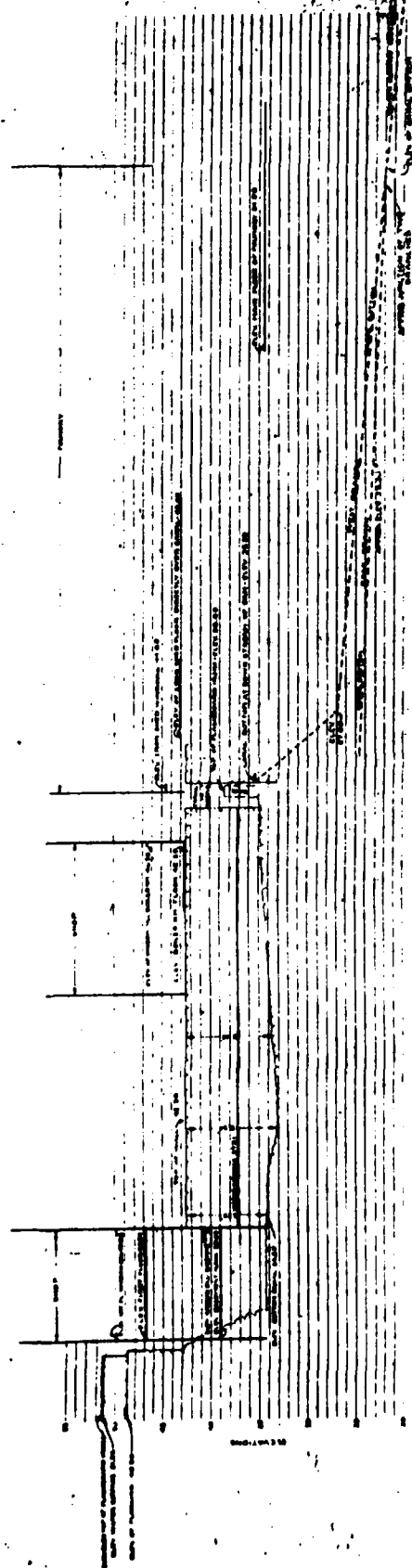
Capacity in Million Cubic Feet

APPENDIX B-3



NOTE: THERE IS ABOUT 12 FEET
OF SPILL BETWEEN EACH CANAL
AND FLOODS WHERE CHINESE FARMERS
UNDER TOWN

GENERAL PLAN OF CANAL
SCALE 1:500 1/2 INCHES



DRAWER CORPORATION - KOREDALE NASD
 SKETCH SHOWING EXISTING DATA
 ON
 WATERWAYS BELOW PILED BY STREET.
 SCALE
 HORIZ. 1" = 30'
 VERT. 1" = 3'
 R. SMITHURST JULY 1918

ELEVATIONS SHOWN ON THIS DRAWING ARE BASED UPON AN ASSUMED
 "LOW WATER" (LOW OF STAGE) BASED UPON RECORDS OF PREVIOUS AND PRESENT
 AT THE INTERSECTION OF THE SEWER AND STORM LINES. THIS DRAWING IS A BASE FOR THE
 ELEVATIONS AND CAN BE USED AT ANY TIME AND FOR ANY
 OTHER CONSTRUCTION.

APPENDIX C
SELECTED PHOTOGRAPHS OF PROJECT

LOCATION PLAN

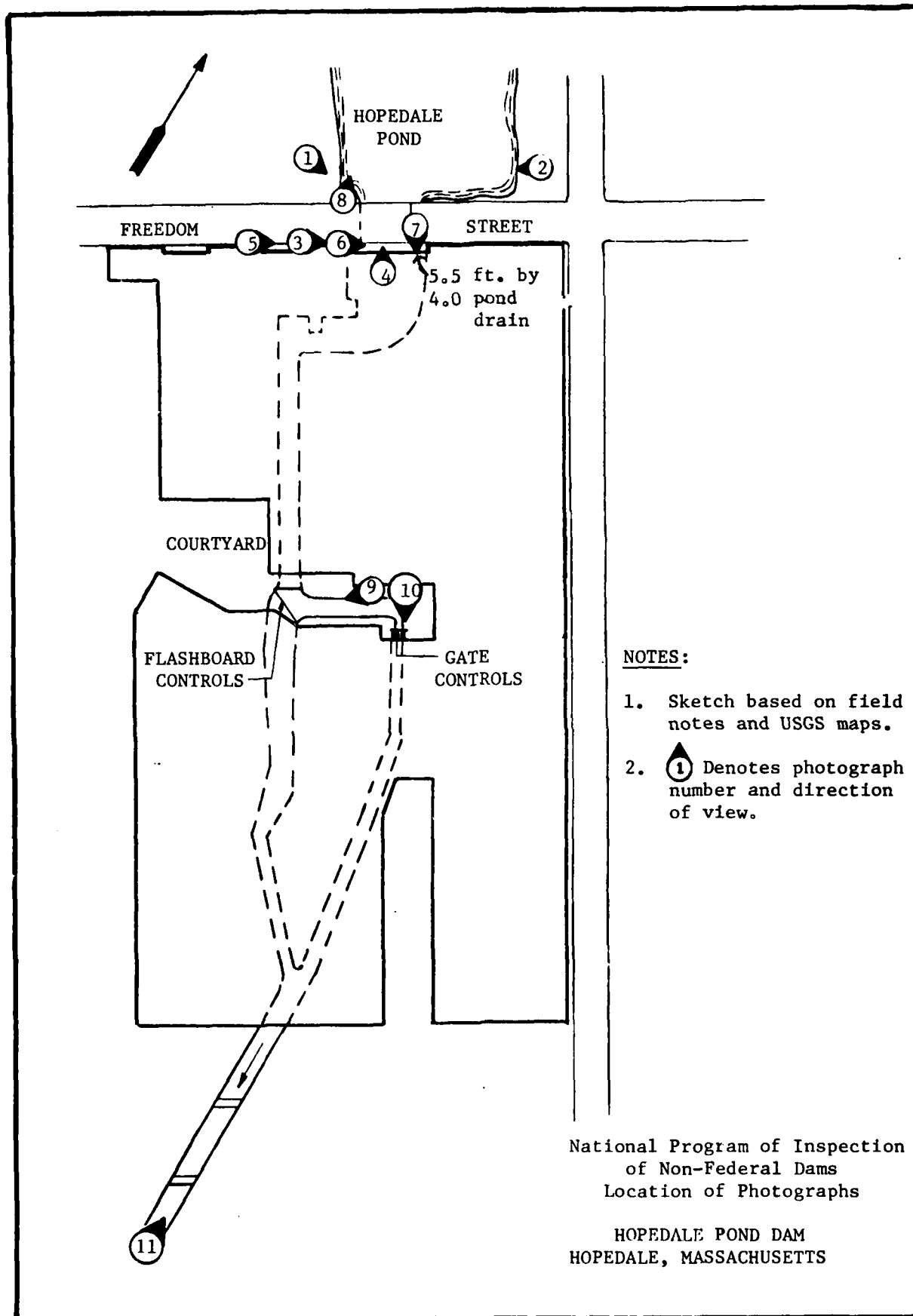
Location of Photographs

Page No.

C-1

PHOTOGRAPHS

<u>No.</u>	<u>Title</u>	<u>Page No.</u>
1.	Overview of Dam From Right Abutment	iv
2.	Overview of Dam From Left Abutment	C-2
3.	Downstream Face of Spillway and Discharge Channel Inlets Beneath Building	C-2
4.	View of Flashboard Showing End Supports From Access Walkway	C-3
5.	View of Drainage Trough Located Along the Right Downstream Edge of Dam Crest	C-3
6.	Outlet Works Gate Operator Structure	C-4
7.	Interior of Wooden Box (Photo No. 6) Housing Gate Operator for Outlet Works	C-4
8.	View of Hopedale Pond From Right Spillway Abutment	C-5
9.	Spillway Discharge Channel Within Court Yard of Adjacent Mill Complex	C-5
10.	Control Gates for Left Spillway Discharge Channel as it Leaves Court Yard	C-6
11.	Overview of Discharge Channel and Adjacent Mill Buildings Looking North	C-6

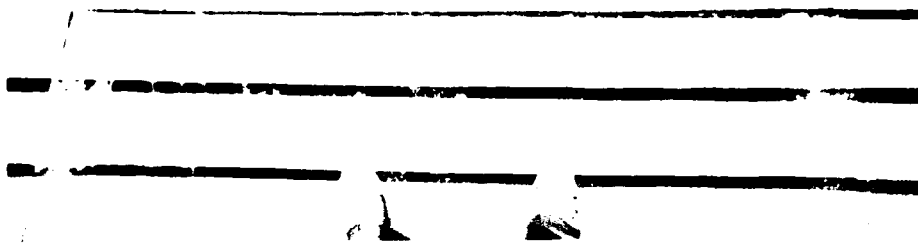
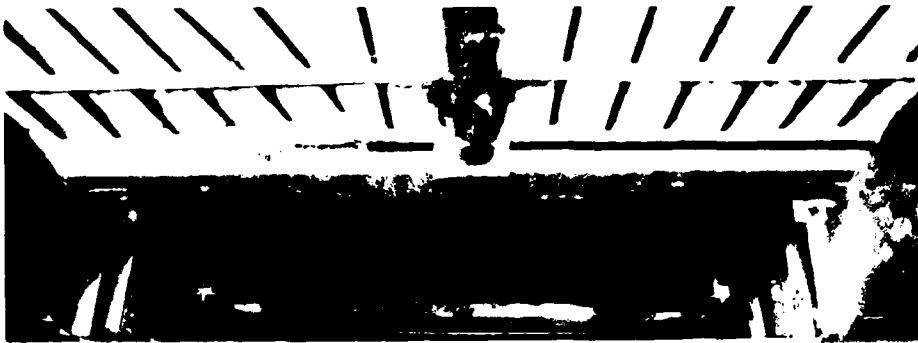




2. OVERVIEW OF DAM FROM LEFT ABUTMENT.



3. DOWNSTREAM FACE OF SPILLWAY AND DISCHARGE CHANNEL INLETS BENEATH BUILDING. FLASHBOARDS ACCESS WALKWAY WITH HAND-RAIL ALSO SHOWN.



4. VIEW OF FLASHBOARD SHOWING END SUPPORTS FROM ACCESS WALKWAY.



5. VIEW OF DRAINAGE TROUGH LOCATED ALONG THE RIGHT DOWNSTREAM EDGE OF DAM CREST.



6. OUTLET WORKS GATE OPERATOR STRUCTURE.



7. INTERIOR OF WOODEN BOX (PHOTO NO. 6) HOUSING GATE OPERATOR FOR OUTLET WORKS.



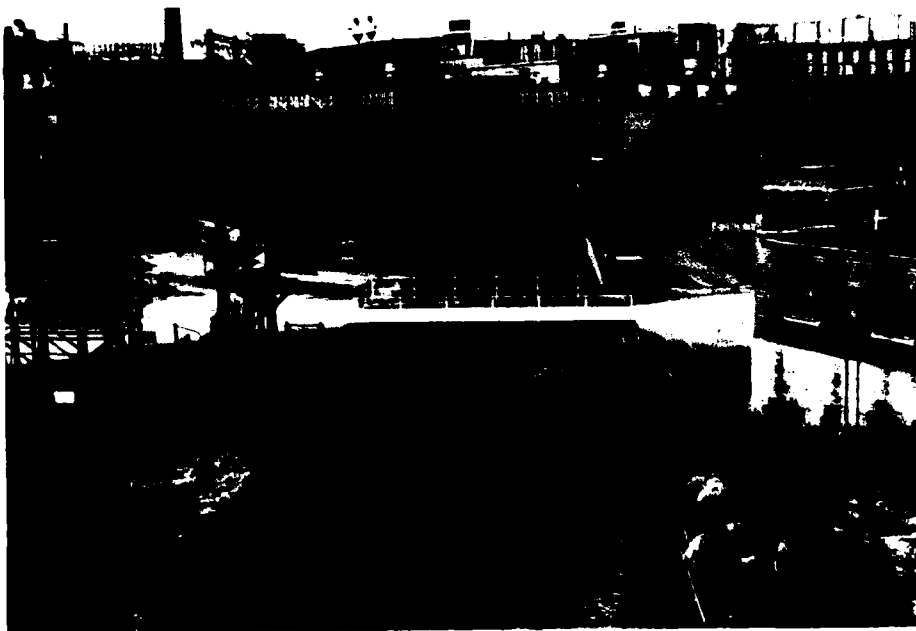
8. VIEW OF HOPEDALE POND FROM RIGHT SPILLWAY ABUTMENT. PROCESS WATER/FIRE DEMAND INTAKE IS IN FOREGROUND.



9. SPILLWAY DISCHARGE CHANNEL WITHIN COURT YARD OF ADJACENT MILL COMPLEX.



10. CONTROL GATES FOR LEFT SPILLWAY DISCHARGE CHANNEL AS IT LEAVES COURT YARD.

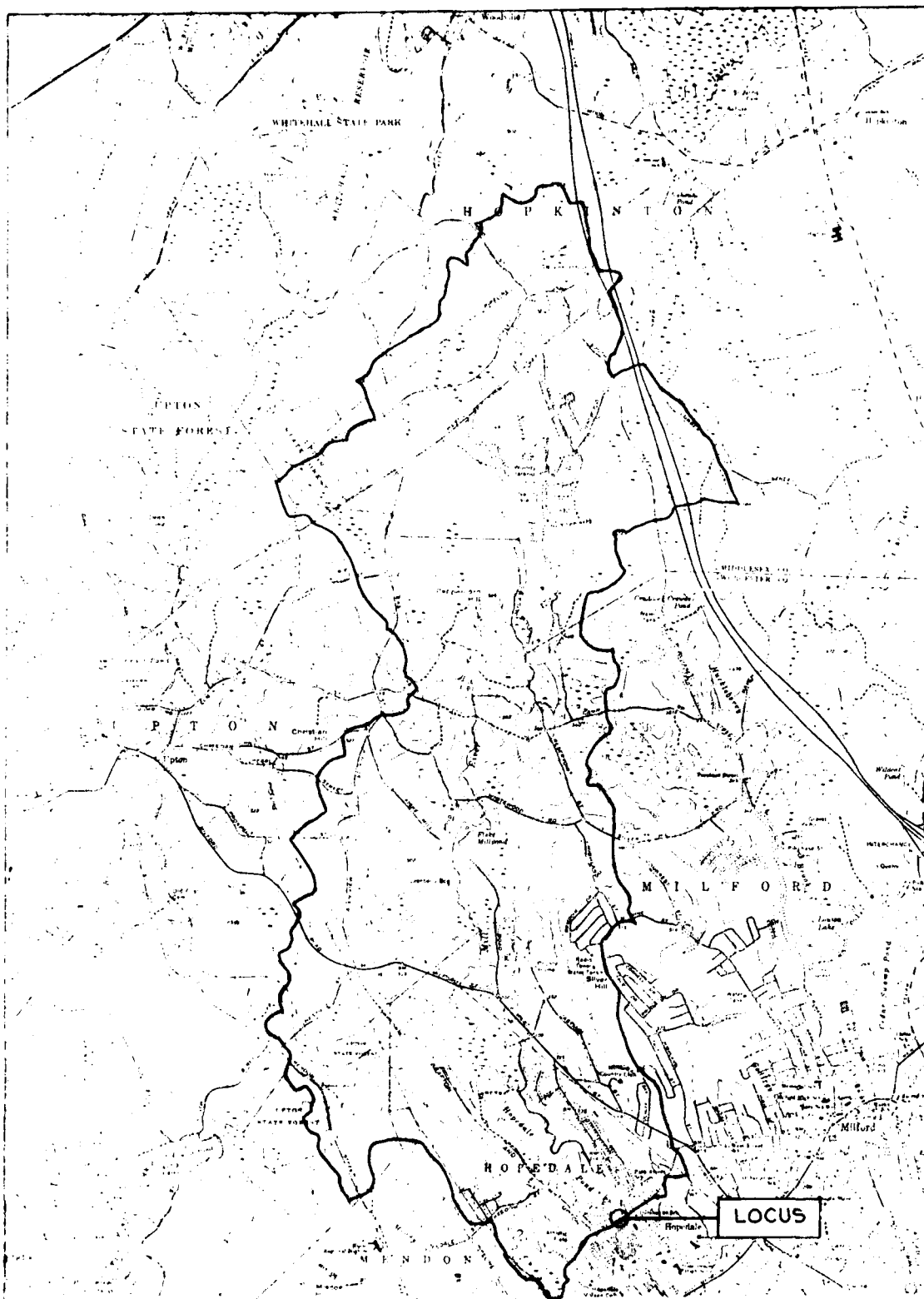


11. OVERVIEW OF DISCHARGE CHANNEL AND ADJACENT MILL BUILDINGS LOOKING NORTH.

APPENDIX D

DRAINAGE AREA AND DAM FAILURE IMPACT
AREA MAPS, AND HYDRAULIC COMPUTATIONS

	<u>Page No.</u>
<u>DRAINAGE AREA MAP</u>	D-1
<u>COMPUTATIONS</u>	
Drainage area; water surface areas	D-2
Elevations; surface areas; storage volumes; size classification; hazard classification	D-3
Test flood determination; storage-discharge relationship	D-4
Dam site detail	D-5
Determination of stage-discharge relationship	D-6-10
Graphical representation of stage-discharge-storage relationship	D-11
Surcharge storage routing	D-12-13
Tailwater analysis	D-14-18
Dam failure analysis	D-19-20
Dam failure impact area map	D-21



NAME: HOPEDALE POND DAM
 IDENTIFICATION NO.: MA 00623



DRAINAGE AREA MAP

APPROX. SCALE: 1" = 3100'

HOPEDALE POND DAM

DRAINAGE AREA

SOUTH PORTION

1. 32.37
2. 32.40 } 32.385 in²

NORTH PORTION

1. 40.90
2. 41.08 } 40.99 in² ✓

TOTAL:

73.375 in² = 6737.6 A = 10.528 mi² ✓

WATER SURFACE AREAS

EL. 274

1. 0.97
2. 0.96 } 0.965 in² = 88.613 A = .1385 mi² ✓

EL. 280

1. 2.54
2. 2.58 } 2.56 in² = 235.08 A = .3673 mi² ✓

EL. 290

1. 5.50
2. 5.60 } 5.55 in² = 509.64 A = .7963 mi² ✓

Note: Elevations shown above are based on the 1929 USGS N. American Datum. Assuming water surface elevation shown on USGS Milford Quadrant to correspond to spillway crest elevation, USGS Datum is +225 feet higher than the reference elevation used by the Town of Hopedale.

ELEVATIONS

Spillway crest w/o and w/ four flushboards	48.93 ; 51.4
Toe of Dam	34.3
Left Embankment Top of Road/Water Crest	53.6 / 55.6
Right Embankment	52.7
Bottom of Bridge Deck	52.4
Top of Bridge Deck	53.6

Elevations based on Draper Corp. Drawings and Town of Hopedale Datum.

SURFACE AREAS

@ el. 48.93 : 88.6 acres $\approx$ 0.139 mi. sq.
 55.0 : 235.1 acres $\approx$ 0.367 mi. sq.
 65.0 : 509.6 acres $\approx$ 0.796 mi. sq.

Drainage Area $\approx$ 6737.8 acres $\approx$ 10.5 mi sq

STORAGE VOLUMES

assumed avg. depth

@ spillway crest el 48.93 $V = \frac{1}{3}(88.6)(10) = 295 \text{ ac-ft}$
 el 55.0 $V = \frac{(88.6 + 235.1)}{2} \times 6.07 + 295 = 1277.5 \text{ ac-ft}$
 el 65.0 $V = \frac{(235.1 + 509.6)}{2} \times 10 + 1277 = 5000.5 \text{ ac-ft}$

SIZE CLASSIFICATION

Hydraulic Ht $< 40 \text{ ft}$ $\therefore$ small

Storage @ top of dam $\approx 907 \text{ ac-ft}$ $\therefore$ small

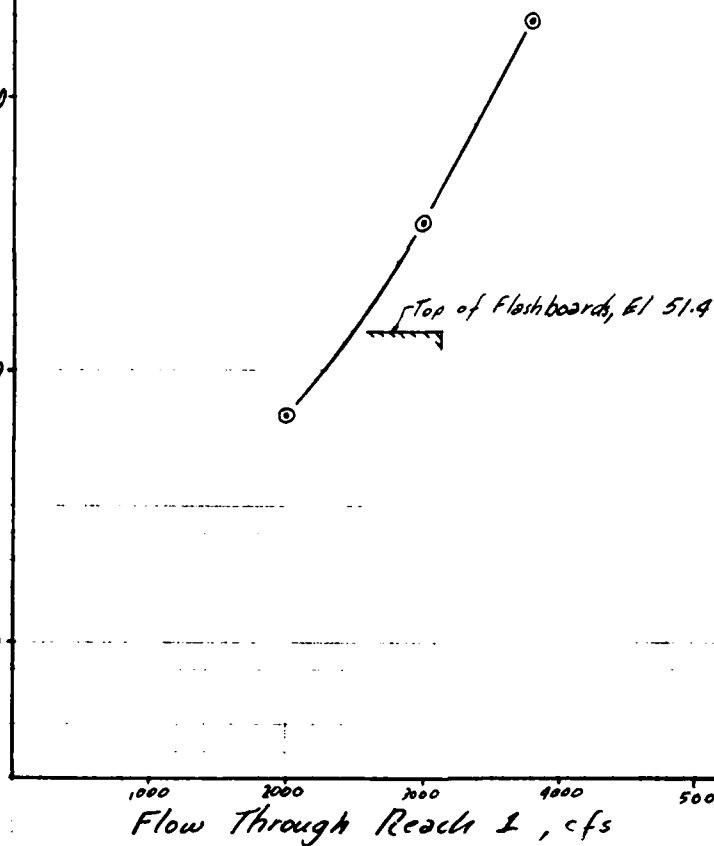
HAZARD CLASSIFICATION

The dam failure analysis (pages 18 through 19) indicates that a failure would result in flooding of the basement, boiler room and first floor of the Draper Corp. The potential loss of human life is high (> 10 people) and economic losses would be significant. $\therefore$ Hazard is HIGH

CLIENT COEJOB NO 380-5-19PAGE 16PROJECT DAM INSP.DATE CHECKED 6-6-79DATE 5-29-79DETAIL Hopedale Pond DamCHECKED BY JEDCOMPUTED BY Jae H.Stage Computation

Flow cfs	Assumed Stage ① @ Outyard, ft	Head loss ② in Reach 1	Reg'd Stage ③ @ Spillway
2000	43.0	5.36	48.36
3000	43.5	11.89	55.39
3800	43.75	19.07	62.82

Required Stage at Spillway, (ft)



CLIENT COE
PROJECT DAM INSP.
DETAIL Hopedale Pond Dam

JOB NO 380-5-19
DATE CHECKED 6-6-79
CHECKED BY JD

PAGE 15
DATE 5-28-79
COMPUTED BY Joe P.

Special Resistance Losses ② in Reach 1

Nature of Special Resistance	K _{obs}	Upstream Area (ft ²)	Downstream Area (ft ²)	Q = 2000 cfs			Q = 3000 cfs			Q = 3800 cfs		
				V _u (fps)	V _d (fps)	h _L (ft)	V _u (fps)	V _d (fps)	h _L (ft)	V _u	V _d	h _L
Exit Loss	0.5	76x30		8.77	13.16	0.60			1.34	16.67		2.16
90° Bend	0.7	8.3x50		4.82	7.22	0.25			0.57	9.15		0.91
Sudden Expansion	1.0	8.3x30	8.3x52	8.03	4.63	0.67		6.95	1.50	8.80		2.91
Sudden Contraction	0.5		8.3x30		8.03	0.50		12.05	1.13	15.26		1.81
90° Bend	0.7	8.3x52		4.63	6.95	0.23			0.53	8.80		0.84
Sudden Contraction	0.5		8.3x52		4.38	0.15		6.57	0.34	8.32		0.59
Sudden Expansion	1.0	319 ft ²	12.5x80	6.27	2.00	0.55		3.00	1.23	3.8		1.98
Sudden Conf.	0.5		319 ft ²		6.27	0.38		9.40	0.69	11.91		1.10
Σ h _L						3.33			7.33			11.75

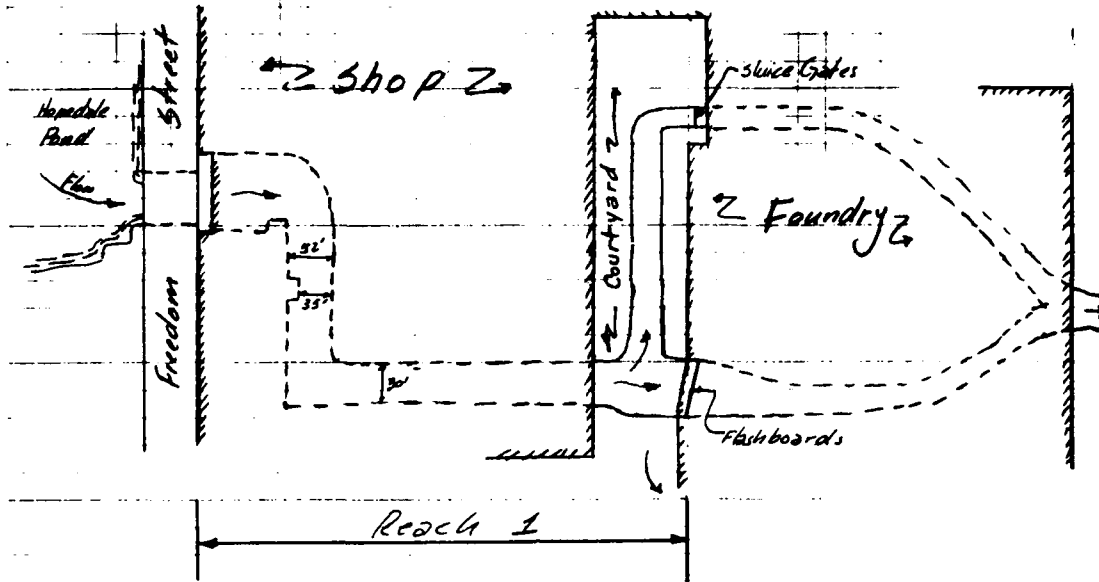
Wall Resistance Losses in Reach 1 ②

Length of Reach (ft)	Area (ft ²)	Hydraulic Radius (ft)	Wall friction Coeff., n	Q = 2000 cfs			Q = 3000 cfs			Q = 3800 cfs		
				Head loss, h _L (ft)			Head loss, h _L (ft)			Head loss, h _L (ft)		
350	8.5x30	3.31	0.03	1.77	3.98	6.39						
150	8.3x52	3.58	0.03	0.24	0.54	0.87						
110	12.5x80	5.41	0.03	0.02	0.04	0.06						
Σ h _L				2.03	4.56	7.32						

Total Resistance in Reach 1	Q, cfs	head loss, ft
	2000	5.36
	3000	11.89
	3800	19.07

Notes: ① Exit Losses, Contraction & 90° Bend losses are based on $h_L = \left(\frac{V^2}{2g}\right) \times K$. Expansion losses are based on $h_L = \left(\frac{V_u^2}{2g} - \frac{V_d^2}{2g}\right) \times K$.

② Wall Resistance Losses are based on Mannings Eq., $h_L = \left(\frac{Q \times n}{1.49 \times A \times R^{2/3}}\right)^2 \times L$



Plan of Channel Downstream
of the Spillway
N.T.S.

Reach 1 - Spillway to Court yard located between the Draper Corp. "shop" and "foundry", as shown above. The spillway discharge channel runs under the "shop" and splits into two channels in the courtyard. Flow through each of these channels is controlled. One channel is controlled by two gates, and the other by flash boards. There is no written operational procedure for these controls, therefore, it is difficult to predict conditions during a flood. But once water overtops the canal in the courtyard, it can flow overland around the foundry.

Examine the hydraulics of reach 1.

CLIENT COE
 PROJECT DAM INSP.
 DETAIL Hoodale Pond Dam

JOB NO. 280-5-19
 DATE CHECKED 6-6-79
 CHECKED BY JED

PAGE 13
 DATE 5-24-79
 COMPUTED BY be A.

TAILWATER ANALYSIS

- Right Embankment - Water overtopping the right embankment may take one of four possible routes. Some will flow over the bridge deck into the spillway discharge area. Some will flow across Freedom St. into a channel located between the Draper Corp. Bldg. and Freedom Street. From this channel some of the water will be diverted to the spillway channel through a brick culvert, and some will enter the building through the windows and flow through the bldg. The window sill elevations are about 49.95'. The brick culvert has dimensions of 5'W x 1.75'H x 27'L and an invert of 44.9'. The fourth route open to flow is around the corner of the building. The street elevation at the corner of the Draper Corp. Bldg. is about 54.5'.

Given these routes to flow, it seems reasonable to assume no tailwater effects from the right embankment.

- Left Embankment - Some backwater effects are anticipated on the left embankment as a result of the Draper Corp. Bldg. extending along a good part of the left embankment. To account for these backwater effects, the effective weir used to compute the stage-discharge relationship was reduced by one-fourth (50-feet). Water flowing over the remaining weir length will flow to the spillway discharge area and around the corner of the bldg. The street elevation at the corner of the Draper Corp. Bldg. is about 53.5'.

- Spillway - Water overtopping the right and left embankments can easily flow around the bldg. at the Test Flood Stage. But a small fraction of the discharge over the embankments will probably be diverted to the spillway discharge area together with the discharge under and over the bridge.

Examine the capacity of the channel leading from the spillway and the possible tailwater effects on the spillway area.

Condition 2 - No Flashboards in place; Spillway crest elevation 98.9

subtract 295 ac-ft from the Total Storage indicated on page to obtain "storage above spillway crest". Use the value obtained to route the surcharge storage for condition 2.

$Q_p = 9200 \text{ cfs}$; surcharge Height to pass Q_p is 57.55

$$STOR_1 = \frac{1915 \text{ Ac-ft} \times 12 \frac{1}{19}}{6737.8 \text{ Ac}} = 3.41 \text{ inches}$$

Probable Max. Flood Runoff: $Q_{p2} = Q_p \times \left(1 - \frac{STOR_1}{19}\right) = 9200 \times \left(1 - \frac{3.41}{19}\right) = 7548 \text{ cfs}$

surcharge Height To pass Q_{p2} is 57.10, and

$$STOR_2 = \frac{1755 \times 12 \frac{1}{19}}{6737.8 \text{ Ac}} = 3.13 \text{ inches}$$

$$STOR_{AVG} = \frac{3.41 + 3.13}{2} = 3.27 \text{ inches}$$

$$Q_{p3} = Q_p \times \left(1 - \frac{STOR_{AVG}}{19}\right) = 9200 \left(1 - \frac{3.27}{19}\right) = 7616 \text{ cfs}$$

surcharge height to pass Q_p is 57.2. Therefore, for condition 2, the routed test flood results in:

Stage - 57.2 ft

Discharge - 7600 cfs

The difference in stage and discharge between condition 1, and condition 2 is negligible.

Under either condition, it is evident that the spillway is inadequate to contain the test flood. The dam is overtopped by the test flood with water depths of 3.5 plus feet over the roadway under either condition.

SURCHARGE STORAGE ROUTING

Condition 1 - Four flashboards in-place; top of flashboard @ elevation 51.4.

Note that the figure on page 10 indicates Total Storage. Subtract 400 cu-ft from the Total Storage to obtain "Storage above top of fourth flash board". Use the value obtained to route the surcharge storage for condition 1.

$Q_{p1} = 9200 \text{ cfs}$ (see page 3 for Test Flood Determination)

Surcharge Height to pass Q_{p1} is 57.75

$$STOR_1 = \frac{\text{Surcharge Storage}}{\text{Drainage Area}} = \frac{1900 \text{ Ac-ft} \times 12 \frac{\text{in}}{\text{ft}}}{6737.8 \text{ Ac}} = 3.38 \text{ inches}$$

Probable Max. Flood Runoff:

$$Q_{p2} = Q_{p1} \times \left(1 - \frac{STOR_1}{19}\right) = 9200 \times \left(1 - \frac{3.38}{19}\right) = 7563 \text{ cfs}$$

Surcharge Height to pass Q_{p2} is 57.35

$$STOR_2 = \frac{1780 \text{ Ac-ft} \times 12 \frac{\text{in}}{\text{ft}}}{6737.8 \text{ Ac}} = 3.17 \text{ inches}$$

$$STOR_{AVG} = \frac{3.38 + 3.17}{2} = 3.275 \text{ inches}$$

$$Q_{p3} = Q_{p1} \times \left(1 - \frac{STOR_{AVG}}{19}\right) = 9200 \times \left(1 - \frac{3.275}{19}\right) = 7614 \text{ cfs}$$

Surcharge Height to pass Q_{p3} is 57.40. The storage related to stage 57.40 is about 3.2 inches which is close to $STOR_{AVG}$.

Therefore, The routed test flood results in:

Stage - 57.40 ft

Discharge - 7600 cfs

CAMP DRESSER & MAYER INC.

CLIENT COE

JOB NO 380-5-19

PAGE 10

PROJECT DRM INSP

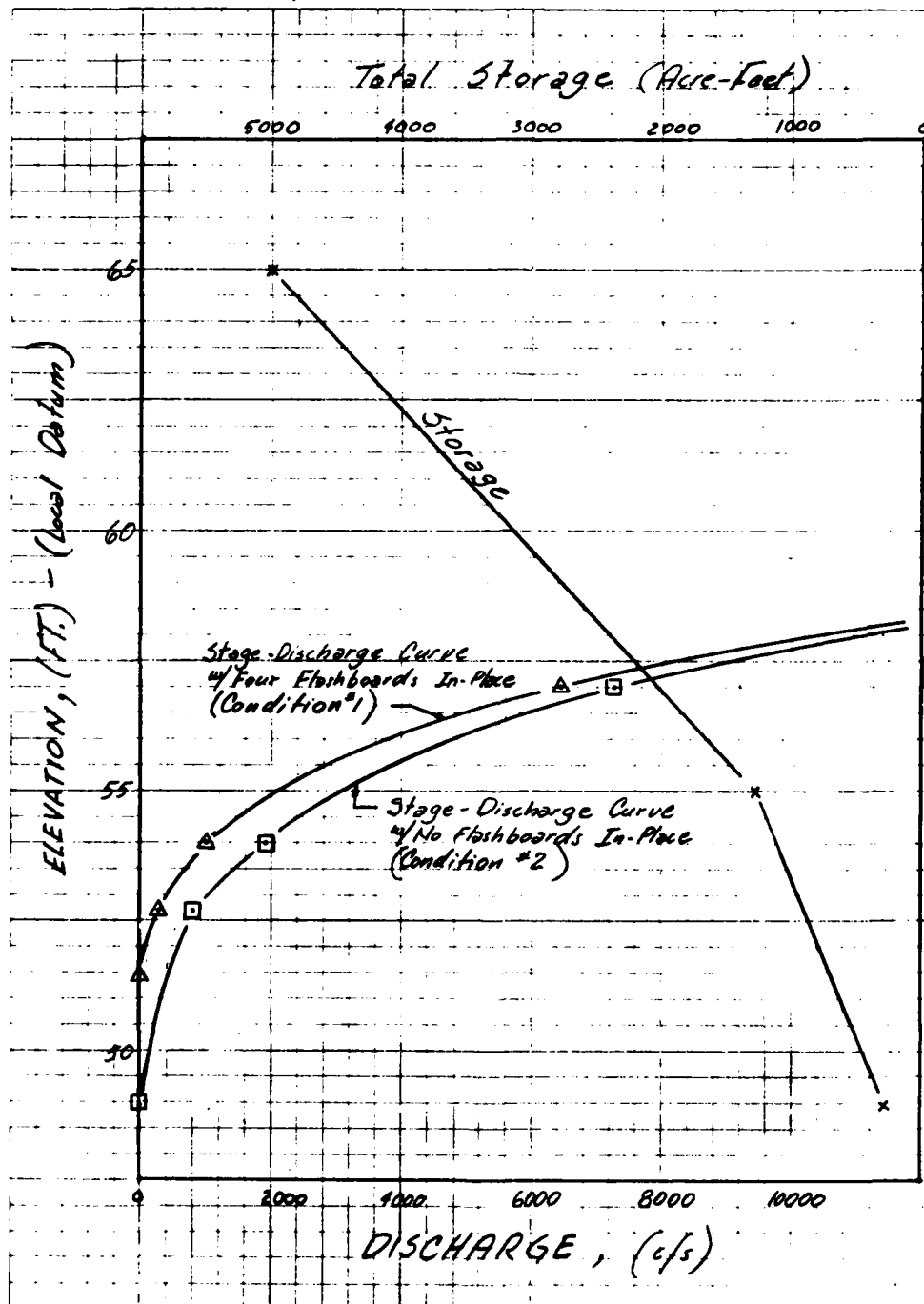
DATE CHECKED 6-6-79

DATE 5-24-79

DETAIL Hopedale Pond Dam

CHECKED BY JED

COMPUTED BY Joe A.



STAGE-DISCHARGE RELATIONSHIPS

Condition 1 — Four Flashboards in-place; Top of flashboards @ El 514

WS El	Q ₁		Q ₂		Q ₃		Q ₄		Q ₅		Q ₆		Q ₇		Q ₈		Total Flow (cfs)	
	Head	Flow	H	F	H	F	H	F	H	F	H	F	H	F	H	F	Total Flow (cfs)	
514																	0	
540	2.1	395															900	
570	5.1	615	14	225	14	41	4.3	2996	3.4	2184							4366	
600	8.1	775	4.4	1258	4.4	231	7.3	5522	6.4	5667	3.0	727					18492	

① Spillway discharge at stage equals top of dam is $Q = 0.7 \times 48.5 \text{ feet} \times 10.8 = 243 \text{ cfs}$

Condition 2 — No Flashboards in-place; spillway crest El 48.9

Except for Q₁, all other flows are identical for Condition 1 and Condition 2. The orifice area for Condition 2 is 136 ft².

WS El.	Q ₁		Summation of (Q ₂ +Q ₃ +Q ₄ +Q ₅ +Q ₆ +Q ₇)		Total Flow (cfs)	
	Flow	Head	Flow	Head	Flow	Head
48.9	0		0		0	
540	1343		505		1848	
570	1396		5751		7147	

② The spillway discharge at stage equals top of dam is computed on page 7, as 836 cfs.

@ Stage 57.0 - Assume submerged outlet

$$Q = CA \sqrt{\frac{2g(h_1 - h_2)}{1 + \frac{29C^2 n^2 L}{R^{4/3}}}}$$

from page 2, Type 4 flow. Refer to same reference called @ stage 54.0.

where $C = 0.85$ from Table 5, page 42 of above ref.

$A = 145.6 \text{ sq. ft}$

$h_1 = 57.0 - 48.9 = 8.1 \text{ ft} = \text{head u/s}$

$h_2 = \text{assumed at } 6.1 \text{ ft} = \text{tailwater head}$

$n = \text{Manning's friction coeff assumed @ } 0.015$

$L = \text{length of channel} = 25 \text{ ft}$

$R = \text{Average hydraulic radius} \approx 6.0$

$$Q = 0.85 \times 145.6 \sqrt{\frac{64.4(8.1 - 6.1)}{1 + \frac{29 \times 0.85^2 \times 0.015^2 \times 25}{6.0^{4/3}}}}$$

$$= 1396 \text{ cfs}$$

Estimate the total flow being diverted to spillway area.

$Q_{\text{total}} = \text{spillway flow} + \text{bridge deck flow} + \text{friction of left \& right embankment}$

$$= 1396 + 225 + 311_{\text{left embk.}} + 1000_{\text{right embk.}} = 2932 \text{ cfs}$$

from page 16 of the Tailwater Analysis, the head due to tailwater is 6.1 ft. The assumption above checks and

$$Q_{\text{el } 57.0} = 1396 \text{ cfs.}$$

CLIENT COE
 PROJECT DAM INSP.
 DETAIL Hopedale Pond Dam

JOB NO. 380-5-19
 DATE CHECKED 6-6-79
 CHECKED BY JED

PAGE 7
 DATE 5-24-79
 COMPUTED BY bc B.

therefore $Q = 2.86 \times 39.3 \times 3.8^{1.5} = 833 \text{ cfs}$

At stage 59.0 - Assume a condition of critical depth at the outlet of spillway.

$$Q = CA \sqrt{g(h-d_2)} \quad \text{from page 25 of "Measurement of Peak Discharge at Culverts by Indirect Method" by G. L. Bodhaine, Chapter A3, 11365- Dept. of Interior.}$$

where: C from page 39, fig 20 = 0.90 @ $h/D = \frac{5.1}{6.3} = 0.8$

$$A = (8.0 + 9.2 + 9.2 + 9.2 + 6.0) 3.5 = 145.6 \text{ ft}^2$$

$$h = 59.0 - 48.9 = 5.1 \text{ ft}$$

d_2 is as computed below.

Compute d_2 :

from fig 10, page 25 of above ref.

$$@ h/D = 0.8, d_2/D \approx 0.5 \therefore d_2 = 0.5 \times 6.3 = 3.15 \text{ ft}$$

approx. flow from eq. 3 of above ref is

$$Q = 5.67 b d_a^{1.5} \quad \text{where } b = \text{width of channel} = 39.3$$

$$= 5.67 \times 39.3 \times 3.15^{1.5} = 1296 \text{ cfs}$$

$$\text{now compute } \frac{Q^2}{29 h^3 b^2 C^2} = \frac{1296^2}{64.4 \times 5.1^3 \times 39.3^2 \times 0.90^2} = 0.15$$

and enter in fig. 14 of above ref. (page 29)

$$d_2/h = 0.68 \quad \text{and } d_2 = 3.47 \text{ ft}$$

$$\text{then, } Q = 0.9 \times 145.6 \sqrt{64.4 (5.1 - 3.47)}$$

$$= 1393 \text{ cfs}$$

— Flow over left embankment, (Q_{L1} & Q_{L2}):
Weir flow, $Q = CBH^{3/2}$

where C = coefficient, assumed @ 2.5 along the fence and 2.8 beyond the edge of the fence

B = Length of weir. Due to backwater effects anticipated from the Draper Corp. bldg, assume that 50-ft of weir length is ineffective.

H = Head over the weir defined in same manner as for bridge deck. See weir profile on page 4, for weir crest elevation.

See page 9 for Tabulation of Condition 2 Stage-Discharge Relationship.

Compute Stage-Discharge Relationship for CONDITION 2

The S-D Relationship for the Bridge Deck, Right and Left Embankment for Condition 2 are identical with the stage-discharge relationship for Condition 1. That for the spillway channel will be different.

— Flow through Spillway channels:

Flow through the spillway channels will vary depending on the total flow being diverted to the channel downstream of the spillway (see Tailwater Analysis in the spillway area, especially page 16)

@ Stage 52.7 or top of dam crest. Assume the spillway behaves as a Broad crested weir.

$$Q = CBH^{3/2}$$

where C = 2.86 from page 10 of "Measurement of Peak Discharge at Dams by Indirect Method" by Harry Hulsing, chapter 5A, Dept. of Interior-USGS

$$B = 8.0 + 9.2 + 9.2 + 9.2 + 3.7 = 39.3 \text{ ft}$$

$$H = 52.7 - 48.9 = 3.8'$$

Compute Stage-Discharge Relationship for CONDITION 1:

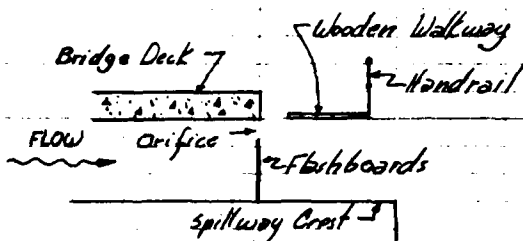
— Flow through spillway channel, (Q_s):

Orifice flow, $Q = CA\sqrt{2gh}$ where: C = coefficient = 0.7 for orifice w/one contraction downstream
 A = orifice area = Total of $2ft \times 54.5ft = 54.5ft^2$

However, there are four bridge piers about 3-ft upstream of orifice. These are an average of 3-ft thick and will reduce the orifice flow. To account for this, reduce the length by 6-ft. Therefore

$$A = 48.5 \times 1 = 48.5 \text{ ft. sq.}$$

h = head measured as the difference between the WSE of the orifice and the up WSE .



SKETCH OF ORIFICE

— Flow over the bridge deck, (Q_b):

Weir flow, $Q = CBH^{3/2}$

where: C = coefficient assumed @ 2.5 due to grid iron fence at the crest of weir

B = length of weir ≈ 54.5 ft

H = Difference in elevation between the upstream WSE and the crest of the weir. Due to three pipes of varying size which run across the length of the weir, assume the crest of the weir to be about 2-ft above the roadway elevation. Therefore weir crest elevation is approx. 55.6.

— Flow over Right embankment, ($Q_{R1}, Q_{R2}, Q_{R3}, Q_{R4}$)

Weir flow, $Q = CBH^{3/2}$

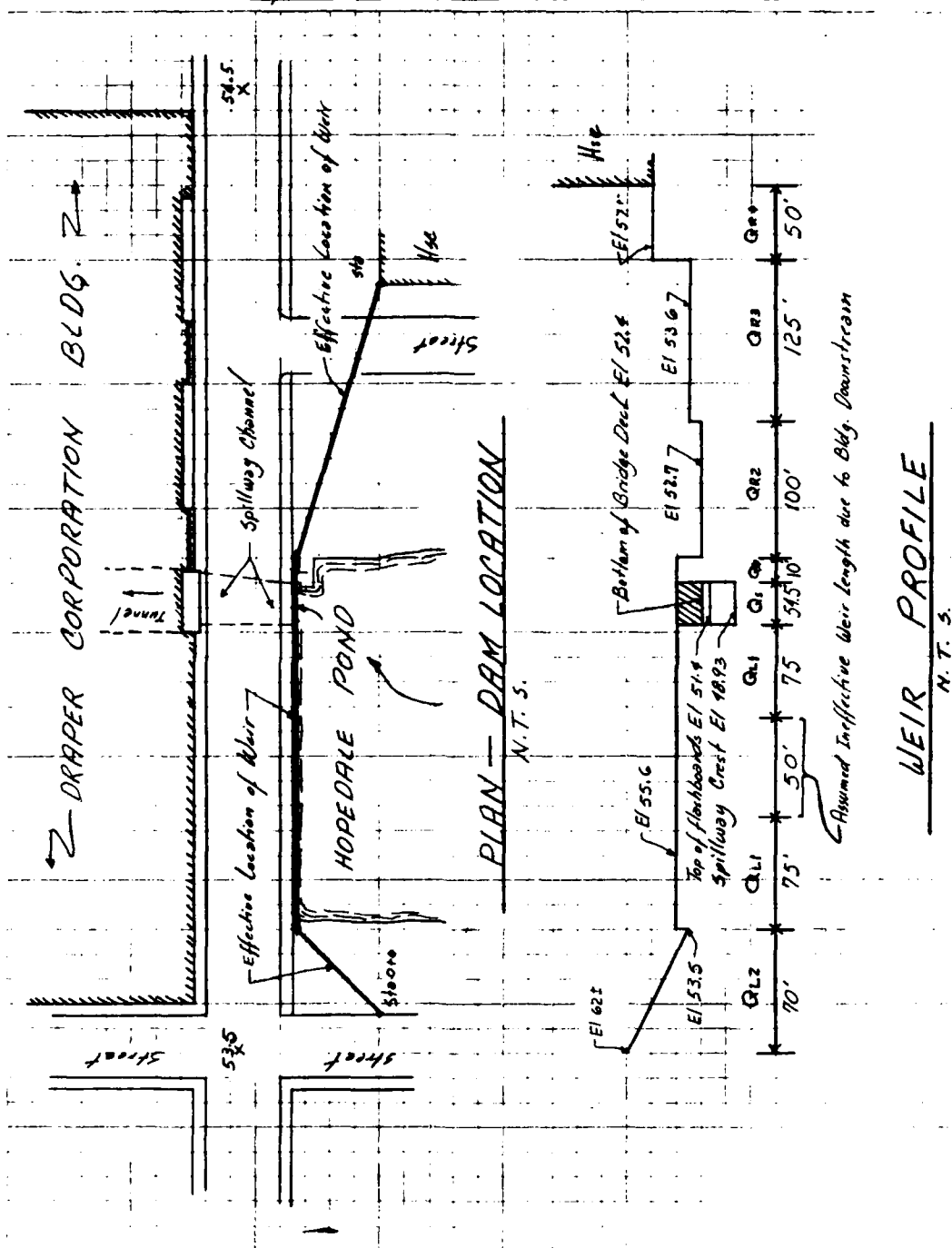
where $C = 2.8$, except at fence where $C = 2.5$.

B = length of weir. Variable, see profile, page

H = Weir head define in same manner as for bridge deck. Weir crest elevation is variable, see weir profile page

Where the weir crest is sloped, use avg. H .

PAGE 4
DATE 5-29-79
COMPUTED BY Joe A.



CLIENT COE
 PROJECT DAM INSP.
 DETAIL Hopedale Pond Dam

 JOB NO 380-5-19
 DATE CHECKED 6-6-79
 CHECKED BY JED

 PAGE 3
 DATE 5-24-79
 COMPUTED BY Joe A.

TEST FLOOD DETERMINATION

The Hopedale Pond Dam is classified under the small size and high hazard criteria. Therefore, the Test Flood ranges from a half to a full PMF. Due to the high hazard classification,

use Test Flood = PMF

The terrain within the drainage area to Hopedale Pond varies greatly. The side slopes to the main channel are of moderate slope. The channel itself is wide and flat providing significant storage. There are three ponds within the drainage area upstream of Hopedale Pond. The largest one is at the head of the basin and is called North Pond. About one mile downstream of North Pond, there is a smaller pond called Friske Mill Pond. This is followed by West Street Pond about half a mile downstream of Friske Mill Pond and half a mile upstream of Hopedale Pond.

The drainage area to North Pond is 3.17 sq miles. The Pond itself has a surface area of 251 ac. Considerable storage can be accumulated in North Pond. Downstream of North Pond there are two more dams (Friske Mill Pond and West Street Pond) in a wide and flat channel. To account for the storage upstream of Hopedale Pond, derive the PMF from a point slightly higher than the Flat and Coastal Curve of the U.S. Army Corps of Engineers' "Preliminary Guidance for Estimating Max. Probable Discharges in Phase I Dam Safety Investigations" March 1978.

$$\therefore \text{PMF} = 875 \frac{\text{cfs}}{\text{sq. mi}} \times 10.5 \text{ sq. mi} = 9188 \text{ cfs}$$

303 9200 cfs

STAGE-DISCHARGE RELATIONSHIP

Determine the S-D Relationship for two spillway conditions

Condition 1 - Condition in effect at time of field inspection;
Four flashboards in-place with top of flashboard @ el. 51.4.

Condition 2 - Max. spillway capacity. Assumes no flashboards in-place.
Spillway el. @ 48.93

See Spillway Profile for both conditions on next page.

From page 16, it is evident that the channel under the Draper Corporation building will take about 2980 cfs before any backwater effects will be felt at the spillway. For a total discharge of 2980 cfs from the pond, the resulting stage at the pond is about 55.3 ft. At a stage of 55.3, flow can easily get around both corners of the Draper Corp. bldg. (see page 4).

At the Test Flood stage of 57.4, the channel under the bldg. can carry about 3200 cfs (about 92 percent of the routed Test Flood). Examining the geometry and topographical characteristics of the pond discharge well, it is doubtful that even as much as 3000 cfs will be diverted to the spillway discharge area at test flood stage. Therefore, backwater effects at the spillway can be neglected.

DAM FAILURE ANALYSIS

Assume that at dam failure, only the spillway fails. It is unlikely that the embankments would fail since they are structurally connected to the Draper Corp. bldg. on the downstream side.

$$Q_p = \frac{8}{27} W_b \sqrt{g} Y_o^{1.5}$$

Where: W_b = width of breach.

Y_o = Height of water at failure. Assume pond W.S. El. @ top of dam @ failure, therefore $= 52.7 - 34.3 = 18.4$

$$Q_p = \frac{8}{27} (54.5) \sqrt{32.2} (18.4)^{1.5}$$

$$= 7232 \text{ cfs say } 7,250 \text{ cfs}$$

REACH 1 - Spillway to Courtyard of Draper Corp.

From page 16 it is clear that the channel under the building cannot take 7,250 cfs at a stage of 52.7 ft. At a stage of 52.7 only about 2650 cfs can discharge under the building.

As a result of a dam failure, the face of the building will act as a dam with W.S. El. @ 52.7 ft. Discharge will be attenuated by the limitations of the discharge channel under the bldg. thus reducing potential hazards to life and property downstream of the Draper Corp. Meanwhile, the Basement (el 39.00), Boiler Room (el 42.50), and the First Floor (el 46.84) of the Draper Corp. will be flooded with resulting high potential for loss of property and life.

BEYOND REACH 1 - It is difficult to predict what will happen beyond the courtyard due to existing channel controls at the courtyard and the storage that can be provided in Reach 1. Under the worst conditions, where the existing two gates at the courtyard are closed and the maximum number of flash boards are in-place, most of the flow reaching the

courtyard will spread around the Draper Corp. Foundry in low depth sheet flow. Downstream of the Foundry, the overland flow will again flow into the channel and be carried away.

the capacity of the channel downstream of the Foundry is

$$Q = \frac{1.49}{n} A R^{4/3} S^{1/2}$$

where $n = 0.03$

$$A = 30 \times 6 = 180 \text{ ft}^2$$

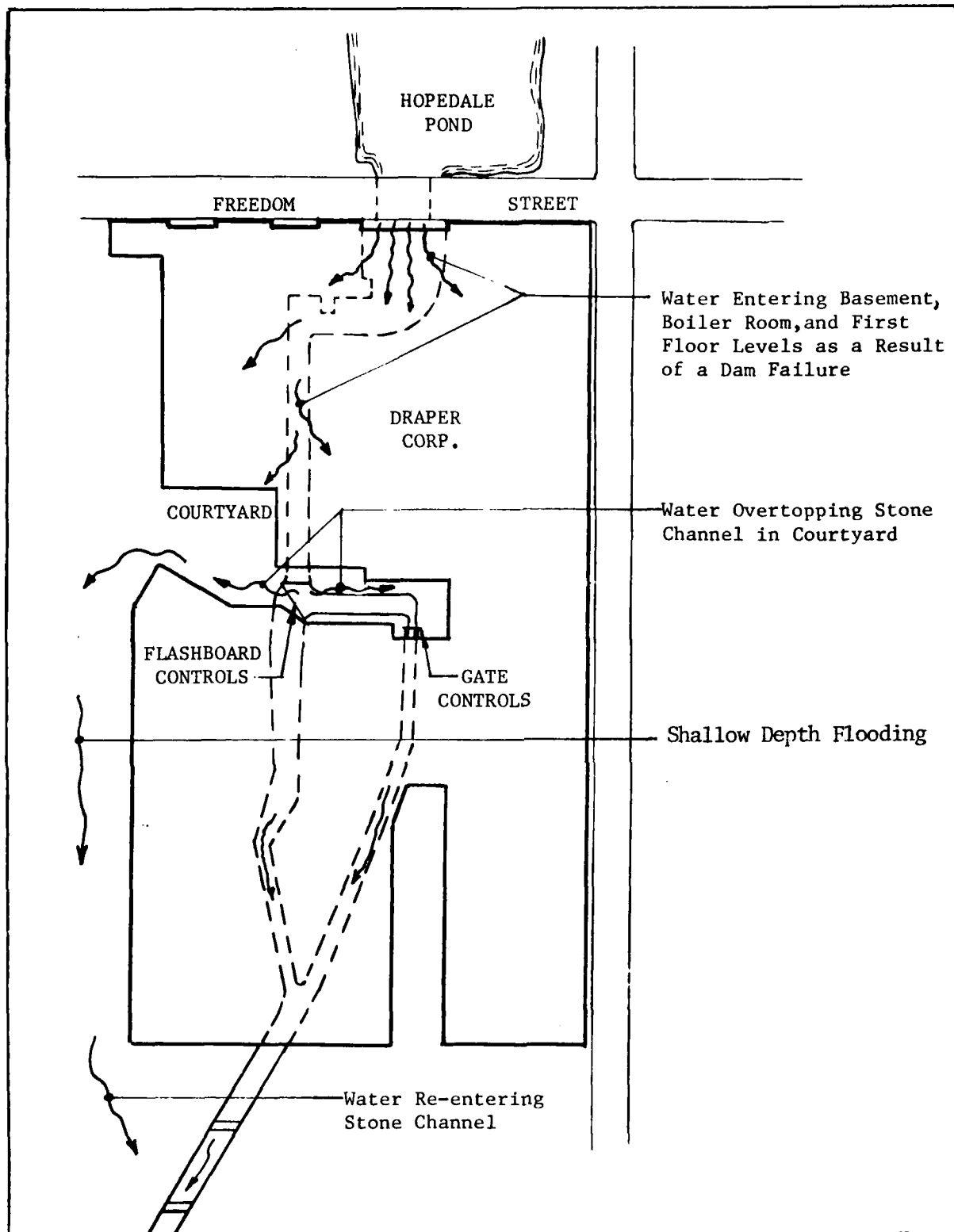
$$R = \frac{A}{P} = \frac{180}{30+12} = 4.29 \text{ ft}$$

$$S = \frac{1 \text{ ft}}{120} = 0.00833 \text{ ft/ft}$$

$$\therefore Q = \frac{1.49}{0.03} (180) (4.29)^{0.667} (0.00833)^{0.5}$$

= 2155 cfs, or practically all the discharge occurring at the spillway.

Assuming that the Miller River channel increase in capacity downstream of the Draper Corp., no additional hazards are anticipated.



DAM HOPEDALE POND DAM

IDENTIFICATION NO. MA 00624



DAM FAILURE IMPACT AREA MAP

APPENDIX E
INFORMATION AS CONTAINED IN
THE NATIONAL INVENTORY OF DAMS



INVENTORY OF DAMS IN THE UNITED STATES

(1) COUNTY	(2) STATE	(3) COUNTY	(4) DIST.	(5) CORNER	(6) NAME	(7) LATITUDE (NORTH)	(8) LONGITUDE (WEST)	(9) REPORT DATE
62	MS	42	03		HOPEDALE POND DAM	204.0	7152.7	22JUN79

(10) POPULAR NAME	(11) NAME OF IMPONDMENT
FREEDOM STREET DAM	HOPEDALE POND
(12) RIVER OR STREAM	(13) NEAREST DOWNSTREAM CITY-TOWN-VILLAGE
J106 MILL RIVER	HOPEDALE
(14) POPULATION	(15) DISTANCE
4014	0

(16) TYPE OF DAM	(17) YEAR COMPLETED	(18) PURPOSES	(19) STAINC HEIGHT (FEET)	(20) HYDRO HEIGHT (FEET)	(21) IMPOUNDING CAPACITIES (ACR.)	(22) DIST	(23) OWN	(24) FED	(25) M	(26) PRV	(27) DATE
MSD	1930	S	19	15	907	295	NEU	N	N	N	22JUN79

REMARKS	
22-YEAR OF SPILLWAY MODIFICATION	

(28) TYPE OF SPILLWAY	(29) MAXIMUM OPERATING HEAD (FEET)	(30) VOLUME OF DAM (CUYD)	(31) POWER CAPACITY (KW)	(32) NAVIGATION LOCKS
1	269	U	54	855

(33) OWNER	(34) ENGINEERING BY	(35) CONSTRUCTION BY
OPAFER CORPORATION		

(36) DESIGN	(37) CONSTRUCTION	(38) OPERATION	(39) MAINTENANCE
NONE	NONE	NONE	NONE

(40) INSPECTION BY	(41) INSPECTION DATE	(42) AUTHORITY FOR INSPECTION
CAMP DRESSER + MCKEE INC	05DEC78	PL 92-357

REMARKS	
32-101TH OF SPILLWAY APPROACH CHANNEL VARIES FROM 50 FT U/S TO 54 FT U/S	

END

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