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AD-A150 641

**BLACKSTONE RIVER BASIN
WORCESTER, MASSACHUSETTS**

**BELL POND DAM
MA 00148**

**PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM**



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

OCTOBER 1978

UNCLASSIFIED

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The dam is 230 feet long and has maximum height of 3.7 feet. The depth of the pond is about 10 to 13 feet. The dam is in fair condition. It has been placed in the "significant" hazard category. The dam is considered to be a hazard because of the lack of a low-level regulating outlet and the accumulation of debris at the upstream end of the existing catch basin outlet.		

BELL POND DAM

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BLACKSTONE RIVER BASIN
WORCESTER, MASSACHUSETTS

PHASE I - INSPECTION REPORT
NATIONAL DAM INSPECTION
PROGRAM

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

BRIEF ASSESSMENT

Identification No.: MA00148

Name of Dam: Bell Pond

Town: Worcester

County and State: Worcester County, Massachusetts

Stream: None

Date of Inspection: September 18, 1978

Bell Pond is located in a depression on top of a bedrock hill. An earthfill dam built some time prior to 1843 is located on the south shore of the pond. The dam is 230 feet long and has a maximum height of 3.7 feet. The depth of the pond is about 10 to 13 feet. The crest of the dam is about 14 feet wide and varies from elevation (El) 670.0 to 671.3. The side slopes are made of earth and slope at 2:1 on the upstream face and 3:1 on the downstream face. Downstream of the dam is an earth channel 14 feet wide and 2 feet deep. This channel leads down a steep slope to a series of erosion control channels which eventually discharge into a storm drainage basin. At the northeast corner of the pond is a catch basin with an outlet pipe at invert El 668.8. This serves as the only spillway at the site. The pipe reportedly drains to the drainage collection system beneath Belmont Street along the north shore of the pond.

There are deficiencies which must be corrected to assure the continued performance of this dam. This conclusion is based upon the visual inspection at the site, the lack of engineering data, and limited operating and maintenance information. Generally, the dam is in fair condition. It has been placed in the "significant" hazard category, according to the Corps of Engineers guidelines for the classification of hazard potential.

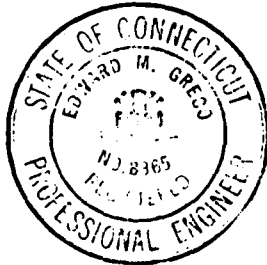
BELL POND DAM

The dam is considered to be a hazard because of the lack of a low-level regulating outlet and the accumulation of debris at the upstream end of the existing catch basin outlet. The following are other signs of distress observed at the site: slight seepage through the embankment of the dam along the downstream toe, a dense growth of trees and brush on the downstream slope of the dam, and deteriorated concrete and accumulated debris in the stormwater drainage basin below the erosion control channels.

Hydraulic analyses indicate that the outlet pipe at the catch basin can discharge an estimated 20 cubic feet per second (cfs) when the pond level is at El 670.0, which is the low point on the crest of the dam. A test flood outflow (one-half probable maximum flood (PMF)) of 36 cfs will overtop the dam by a maximum of 0.2 feet. The outlet pipe can discharge about 56 percent of the test flood outflow.

It is recommended that the Owner employ the services of a qualified consultant to design a low level outlet for the pond. In addition, the Owner should accomplish the following: remove accumulated debris from the catch basin and outlet pipe; control seepage at the toe of the dam; clear trees and brush from the slopes of the embankment; and repair the concrete and remove debris at the stormwater drainage basin below the erosion control channels. The Owner should also implement a systematic program of inspection and maintenance.

Removal of debris from the catch basin and outlet pipe should be undertaken by the Owner within six months of receipt of this Phase I Inspection Report. The other recommendations and remedial measures described above and in Section 7 should be implemented by the Owner within a period of two years. An alternative to these recommendations would be to breach or remove the dam.



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BELL POND DAM

This Phase I Inspection Report on Bell 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.

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

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

SAUL C. COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

BELL POND DAM

PREFACE

This report is prepared under guidance contained in Recommended Guidelines for Safety Inspection of Dams, for a Phase I Investigation. 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 inspections are not intended to provide detailed hydrology 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 conditions and the downstream damage potential.

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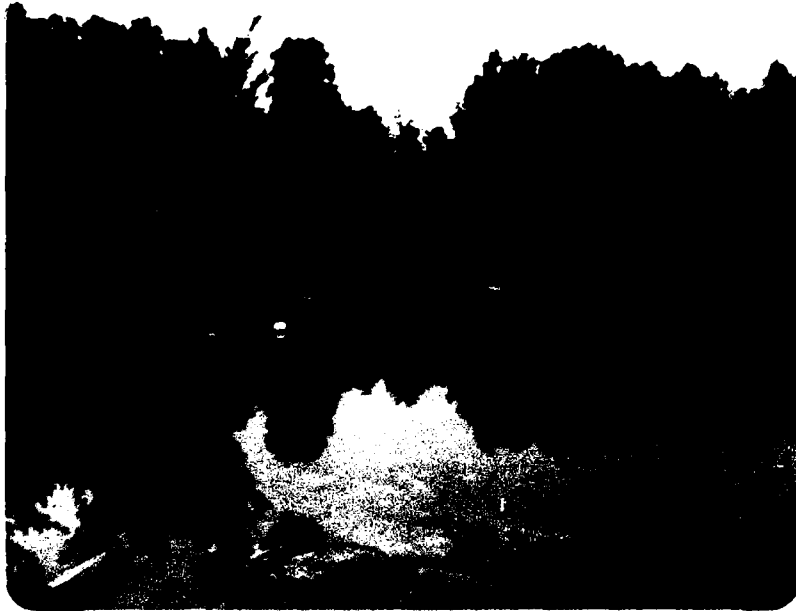
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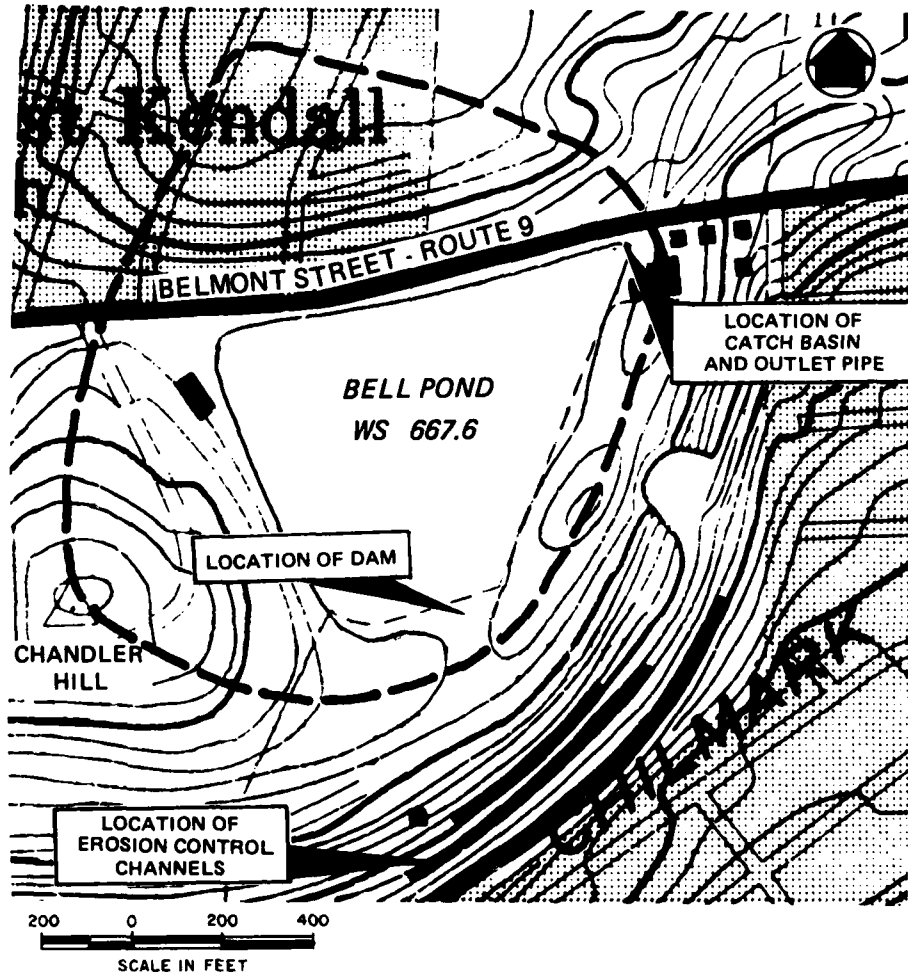
**OVERVIEW
BELL POND
WORCESTER, MASSACHUSETTS**



VIEW OF UPSTREAM FACE OF DAM

**Location and Direction of Photographs
Shown on Figure in Appendix B**

WORCESTER NORTH QUADRANGLE
MASSACHUSETTS-WORCESTER CO.



LOCATION MAP - BELL POND DAM

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

BELL POND DAM

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. Metcalf & Eddy, 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 Metcalf & Eddy, Inc. under a letter of July 28, 1978, from Ralph T. Garver, Colonel, Corps of Engineers. Contract No. DACW 33-78-C-0306 has been assigned by the Corps of Engineers for this work.
- b. Purpose
- (1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal 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.

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1.2 Description of Project

- a. Location. Bell Pond Dam is located on Chandler Hill in the City of Worcester, Worcester County, Massachusetts (see Location Map). The pond is a naturally-occurring body of water which is located in a depression near the top of a bedrock hill. The dam was constructed at this site to increase the storage capacity of the pond. The pond has no inlet or outlet watercourse other than the stormwater collection system.

- b. Description of Dam and Appurtenances. Bell Pond Dam is a 230-foot long, earthfill dam located on the southern slope of the pond (see Figure B-1). The dam has a maximum height of 3.7 feet, and the crest varies from El 670.0 to 671.3. The depth of the pond is about 10 to 13 feet. A foot path is located on the crest of the dam which is about 14 feet wide. The upstream slope, which is covered with grass and brush, slopes at 2:1. The downstream slope is covered with brush and small trees and slopes at 3:1. Outcrops of granite bedrock are located at both abutments of the dam.

The foundation of an abandoned gate house is located near the midpoint of the dam on the upstream face. The foundation is 11 feet square in size and constructed of mortared granite blocks with an interior lining of brick. There is an opening in the upstream wall which contains iron guides for two sets of flashboards. The interior of the gate house has been backfilled with soil, and the flashboards are gone.

Downstream of the dam and opposite the gate house is an earth channel about 14 feet wide and 2 feet deep. An abandoned gate valve stem is protruding from the floor of the channel at about 80 feet below the dam. The channel passes over a saddle in the ridge around the pond and leads to the steep south slope of Chandler Hill, beginning at about 230 feet from the dam. On the lower half of the slope, a series of erosion control channels have been constructed in three levels. These are built

BELL POND DAM

along the contours of the slope, and runoff is directed laterally, then drops from the end of each level to the next lower level, eventually collecting at the bottom of the hill and into a stormwater drainage basin. The channels are constructed with a downslope vertical concrete retaining wall 2 to 3.7 feet high. Riprap has been placed on the slope of the hill.

There is a catch basin and outlet pipe located at the northeast corner of the pond. This serves as the only spillway at the site. The catch basin is constructed of a concrete slab with a metal grating on top and a trash rack facing the pond. The catch basin is clogged with debris. The invert of the outlet conduit is approximately at El 668.8. Although the outlet pipe was not visible, the diameter of the pipe was estimated to be 15 inches. This pipe reportedly drains to the drainage collection system beneath Belmont Street which is located along the north shore of the pond.

- c. Size Classification. Bell Pond Dam is classified in the "small" category since it has a maximum height of 3.7 feet and a maximum storage capacity of 65 acre-feet.
- d. Hazard Classification. Bell Pond Dam is located on a hill in the downtown area of Worcester. Failure of the dam could cause flood damage to residences and roadways at the bottom of Chandler Hill. However, in the event of failure of the dam, the quantity of water which would be released is small. It is unlikely that loss of life or more than an appreciable amount of property damage could occur. Accordingly, the dam has been placed in the "significant" hazard category.
- e. Ownership. The dam is owned by the City of Worcester, and is under the control of the Department of Public Works, 20 East Worcester Street, Worcester, Massachusetts. Mr. F. Worth Landers, Commissioner, (telephone 617-798-8151), granted permission to enter the property and inspect the dam.
- f. Operator. Since there are no operating facilities at this site, there are no operators of the dam.

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- g. Purpose of Dam. The dam was built some time prior to 1843 and served as the first water supply reservoir for the City of Worcester. The pond is currently part of a park and is being used for recreation, such as swimming and fishing. A bath house and beach are located at the northwest corner of the pond.
- h. Design and Construction History. A drawing dated 1843 shows that Bell Pond was originally called Bladder Pond. The gate house on the southern shore is shown discharging to an "aqueduct" which carried water to the small town of Worcester. A drawing dated 1873 shows the pond, the gate house, and a long narrow island in the pond along the west and north shores. A drawing dated 1910 (see Figure B-2) shows a second gate house at the northeast corner of the pond. None of these drawings show details of the dam.

Previous inspection reports state that the gate house had been abandoned by 1955. Personnel at the Worcester Department of Public Works state that the erosion control channels on the south side of Chandler Hill were constructed about 1956. In 1965, the catch basin and outlet pipe were built at the northeast corner of the pond.

Beginning in 1966, the City of Worcester sent several requests to the State Division of Waterways to do flood control work at Bell Pond. The proposed repairs consisted of "blocking off the old spillway, raising the embankment of the dam, and building a headwall at the outlet pipe near Belmont Street". These repairs have not been made.

1. Normal Operational Procedures. There are no normal operating procedures at this dam.

1.3 Pertinent Data

- a. Drainage Area. The topographic drainage area for Bell Pond is approximately 30 acres (0.05 square miles). This area is divided by Belmont Street which is located along the north shore of the pond. North of Belmont Street is a thickly developed residential area built on a

BELL POND DAM

hillside which slopes at about 20 percent. South of Belmont Street, the area around Bell Pond is a park and is therefore undeveloped except for a bath house at the northwest corner of the pond. The land is hilly with numerous outcrops of bedrock and a slope of about 15 percent. The area is partly wooded and partly grassed.

- b. Discharge at the Dam Site. Water is discharged through a catch basin and outlet conduit located at the northeast corner of the pond. The catch basin has a trash rack facing the pond. The outlet pipe is assumed to be a minimum of 15 inches in diameter and has an invert at approximately El 668.8. The pipe reportedly drains to the drainage collection system beneath Belmont Street. The system drains to the Mill Brook Drain, which is the main interceptor beneath Worcester. Eventually flow is discharged into the Blackstone River.

Hydraulic analyses indicate that the outlet conduit can discharge 20 cfs with the pond level at El 670.0, which is the low point on the crest of the dam. An outflow test flood of 36 cfs (one-half the full probable maximum flood) will overtop the dam by a maximum of 0.2 feet and will overflow the area near the catch basin and outlet pipe by about 0.1 feet.

Personnel at the Worcester Department of Public Works recall that the dam was overtopped during the hurricane of 1955 and that water also overflowed the northeast corner of the pond and flowed down Belmont Street.

- c. Elevation (feet above Mean Sea Level (MSL)). A benchmark elevation of 670.0 was established on the steel grating of the catch basin at the outlet conduit. This elevation was estimated from a U. S. Geological Survey topographic map.

- (1) Top dam: 670.0 to 671.3
- (2) Test flood pool: 670.2
- (3) Design surcharge (original design):
Unknown

BELL POND DAM

- (4) Full flood control pool: Not applicable (N/A)
- (5) Recreation pool: 668.8 - invert of catch basin
- (6) Spillway crest: 668.8 - invert of catch basin
- (7) Upstream portal invert diversion tunnel: N/A
- (8) Stream bed at dam: N/A
- (9) Maximum tailwater: None

d. Reservoir

- (1) Length of maximum pool: 900 feet
- (2) Length of recreation pool: 900 feet
- (3) Length of flood control pool: N/A

e. Storage (acre-feet)

- (1) Test flood surcharge (net): 12 at El 670.2
- (2) Top of dam: 65
- (3) Flood control pool: N/A
- (4) Recreation pool: 54 - invert of catch basin
- (5) Spillway crest: 54 - invert of catch basin

f. Reservoir Surface (acres)

- *(1) Top dam: 9
- *(2) Maximum pool: 9

*Based on the assumption that the surface area will not significantly increase with changes in reservoir elevation from 668.8 to 670.0

BELL POND DAM

- (3) Flood-control pool: N/A
- (4) Recreation pool: 9
- (5) Spillway crest: 9

g. Dam

- (1) Type: earthfill
- (2) Length: 230 feet
- (3) Height: 3.7 feet
- (4) Top width: 14 feet
- (5) Side slopes: Upstream: 2:1,
Downstream: 3:1
- (6) Zoning: Unknown
- (7) Impervious core: Unknown
- (8) Cutoff: Unknown
- (9) Grout curtain: Unknown

i. Spillway

- (1) Type: The catch basin and outlet pipe serve as a spillway at this site.
- (2) Length of weir: N/A
- (3) Crest elevation: 668.8 (invert of catch basin)
- (4) Gates: None
- (5) Upstream channel: None
- (6) Downstream channel: 15-inch pipe leads to storm drain beneath Belmont Street and eventually to Blackstone River via Mill Brook Drain.

- j. Regulating Outlets. The only outlet at the dam is a pipe with an invert at approximately El 668.8. The pipe is assumed to be 15 inches in diameter. The intake to the pipe is a catch basin which has a metal grating on top and a trash rack opening facing the pond.

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SECTION 2
ENGINEERING DATA

- 2.1 General. Three drawings, dated 1843, 1873 and 1910 showing Bell Pond are available at the Worcester Department of Public Works. These show the pond and locations of gate houses, but do not give details of the dam. The drawing dated 1910 is included in Appendix B. There are no other plans, specifications or computations available from the Owner, State or County offices relative to the design and construction of the dam. The only data available for this evaluation were visual observations made during inspection, review of previous inspection reports, and conversations with City, State, and County personnel.

We acknowledge the assistance and cooperation of personnel of the Massachusetts Department of Public Works: Messrs. Willis Regan and Raymond Rochford, and of the Massachusetts Department of Environmental Quality Engineering, Division of Waterways: Messrs. John J. Hannon and Joseph Iagallo.

Also, we acknowledge the cooperation and assistance of personnel from the Worcester County Engineer's Office: Messrs. John O'Toole and Joseph Brazauskas.

Personnel from the Worcester Department of Public Works - Messrs. F. W. Landers, Dick Grant, and Ed Mara - also provided information on the history of the dam.

- 2.2 Construction Records. There are no construction records available.
- 2.3 Operating Records. No operating records are available, and there is no daily record kept of the elevation of the pool or rainfall at the dam site.
- 2.4 Evaluation
- a. Availability. Due to the age of this dam, there is no engineering data available.

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- b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and engineering judgment.
- c. Validity. The limited engineering data available is valid.

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SECTION 3
VISUAL INSPECTION

3.1 Findings

- a. General. The Phase I Inspection of the dam at Bell Pond was performed on September 18, 1978. A copy of the inspection check list is in Appendix A. Previous inspections by others have been made since 1927. A partial listing of these inspections is in Appendix B. An inspection was made by the Massachusetts Department of Public Works in 1973. A letter summarizing their findings is included in Appendix B.
- b. Dam. The dam is in fair condition. The ground along the downstream toe of the dam is wet and soft indicating slight seepage. Cattails are growing in that area. Seepage was reported at about 30 feet west of the abandoned gate house in the 1973 inspection report by the Massachusetts Department of Public Works.
- The downstream face of the dam is heavily overgrown with brush and small trees. Some brush is also growing on the upstream face of the dam. There is no riprap protection on the upstream slope.
- c. Appurtenant Structures. The only spillway is a catch basin and outlet pipe at the northeast corner of the pond. The catch basin and upstream end of the pipe are clogged with soil, leaves and trash. In its present condition, the outlet is practically inoperable. The land around the outlet is low in elevation, and there is only about 1.3 feet of freeboard above the invert of the conduit (El 668.8).
- d. Reservoir Area. The area around the pond is mostly a park, and the only structures are a bath house at the northeast corner and a small commercial building near the northeast

BELL POND DAM

corner. Belmont Street (State Route 9) is located along the north shore of the pond. The land is generally hilly and partly grassed and partly wooded.

- e. Downstream Channel. The channel downstream of the dam is an unlined earth channel with sloping sides. The floor of the channel is moist and contains organic material. The sides are densely overgrown with trees. There is a gate valve stem protruding from the floor of the channel about 80 feet downstream of the dam. Below Chandler Hill, the floor as well as the sides of the channel are overgrown with trees. The concrete on the erosion control channels is cracked and spalled in some places. Sections of the channels contain an accumulation of leaves and soil up to a foot thick. The concrete on the stormwater drainage basin at the bottom of the hill is severely eroded and crumbling. There is an accumulation of leaves and other debris in the trash racks on the sides of the basin.

- 3.2 Evaluation. The above findings indicate that the dam and appurtenant structures have several signs of distress which require attention. It is evident that the dam is not adequately maintained and that deterioration will continue unless action is taken. Recommended measures to improve these conditions are included in Section 7.

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SECTION 4

OPERATING PROCEDURES

- 4.1 Procedures. There are no operable facilities and no regular operating procedures at this dam.
- 4.2 Maintenance of Dam. The dam is leaking slightly as evidenced by wet and soft ground along the downstream toe. There is also a dense growth of trees and brush on the downstream slope of the dam and a moderate growth of brush on the upstream slope of the dam.
- 4.3 Maintenance of Operating Facilities. The catch basin and outlet pipe are clogged with soil, leaves and trash. In the present condition, flow in the pipe is severely restricted. There is no low-level outlet at this dam to draw down the pond in an emergency.
- 4.4 Description of Any Warning System in Effect. There are no warning systems in effect at this dam.
- 4.5 Evaluation. There is no regular program of maintenance or any warning system in effect at Bell Pond Dam. This is undesirable considering that the dam is in the "significant" hazard category. A program of maintenance for this dam should be implemented as recommended in Section 7.3.

BELL POND DAM

SECTION 5

HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

- a. Design Data. The probable maximum flood (PMF) rate was determined to be 3,350 cfs per square mile. This calculation is based on an average drainage area slope of 15.0 percent, the pond area to drainage area ratio of 28 percent, and the U.S. Army Corps of Engineers' Flow Rates (dated December 1977). Applying one-half the PMF rate to the 0.047 square miles of drainage area results in a calculated peak flood flow of 76 cfs as the inflow test flood. By adjusting the inflow test flood for surcharge storage, the maximum discharge rate was established as 36 cfs (720 cfs per square mile) with a water surface at El 670.2.

Flow over the crest of the dam during the test flood is predicted to be 8 cfs. Flow through the outlet pipe (estimated to be 15-inch diameter pipe) would be 25 cfs with water overflowing the northeast corner of the pond and down Belmont Street at a rate of 3 cfs. The maximum depth on the crest of the dam would be 0.2 feet with a discharge of 0.23 cfs per foot of width. Depth at critical flow would be at 0.12 feet with a velocity of 1.9 feet per second.

Hydraulic analyses indicate that the existing outlet pipe (assuming a 15-inch diameter pipe) can discharge at 20 cfs with the water surface at El 670.0 which is the low point on the crest of the dam. This is 56 percent of the test flood.

- b. Experience Data. Hydraulic records are not available for this dam, however, personnel at the Worcester Department of Public Works recall that the dam was overtopped during the hurricane of 1955, causing water to flow over the southern slope of Chandler Hill and into the Chilmark Street and Shrewsbury Street

BELL POND DAM

areas. Water also overflowed the northeast corner of the pond and down Belmont Street. Since that time, the catch basin and outlet pipe have been constructed at the northeast corner of the pond.

- c. Visual Observations. Discharge from Bell Pond is through a catch basin and pipe with an invert at approximately El 668.8. The size of the outlet pipe could not be determined and was assumed to be 15 inches in diameter. The pipe reportedly leads to a drainage collection system beneath Belmont Street. The northeast corner of the pond, where the outlet pipe is located, is a low area immediately adjacent to Belmont Street. This street grades steeply from the edge of the pond down the east slope of Chandler Hill.

During periods of high runoff, discharge over the crest of the dam will flow in an earth channel over the southern edge of Chandler Hill. A series of erosion control channels has been constructed on the steep southern slope of the hill. These will divert flow laterally and downward in steps and eventually collect the runoff in a stormwater drainage basin at the bottom of the hill. A more detailed record of observation is included in Section 3, Visual Inspection.

- d. Overtopping Potential. Overtopping of the dam by about 0.2 feet is expected under the outflow test flood of 36 cfs. The low area next to the catch basin and pipe will also be overtopped by about 0.1 feet.

Failure of the dam would produce a peak discharge of 187 cfs and a flood wave 1.7 feet high with a velocity of 6.3 fps (feet per second).

BELL POND DAM

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

- a. Visual Observations. The evaluation of the structural stability of Bell Pond Dam is based on the visual inspection conducted on September 18, 1978. As discussed in Section 3, Visual Inspection, the embankment appears to be in fair condition. Slight seepage is indicated along the downstream toe where the ground is wet and soft. There is a dense growth of trees and brush on the downstream slope of the dam, and some brush growing on the upstream slope of the dam.
- b. Design and Construction Data. There are no plans, specifications, or computations available on the design, construction, or repair of this dam from the Owner, County, or State offices. Furthermore, information does not appear to exist on the type, shear strength, and permeability of the soil and/or rock materials of the embankment.
- c. Operating Records. There is no evidence that instrumentation of any type was ever installed in Bell Pond Dam. The performance of this dam under prior loading can only be inferred by physical evidence at the site.
- d. Post-Construction Changes. There are no as-built drawings available for Bell Pond Dam.
- e. Seismic Stability. The dam is located in Seismic Zone No. 2 and in accordance with Phase I "Recommended Guidelines" does not warrant seismic analyses.

BELL POND DAM

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

- a. Condition. Bell Pond Dam was neither designed nor constructed according to the current approved state-of-the-art procedures. Based on the visual inspection of the site, there are areas of concern which must be corrected to assure the continued performance of this dam. Generally, the dam is considered to be in fair condition. The major problems are: an accumulation of debris blocking the catch basin and outlet pipe at the northeast end of the pond, the lack of a low level outlet at the dam, slight seepage through the dam along the downstream toe, and a dense growth of trees and brush on the downstream slope of the embankment.

Hydraulic analyses indicate that the outlet pipe (assumed diameter of 15 inches) can discharge an estimated 20 cfs when the pond level is at 670.0, which is the low point on the crest of the dam. An outflow test flood of 36 cfs (one-half the PMF) will overtop the dam by a maximum of 0.2 feet and will overflow the pond near the outlet pipe by about 0.1 feet.

- b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and engineering judgment.
- c. Urgency. The recommendations and remedial measures outlined below should be implemented by the Owner within two years after receipt of this Phase I Inspection Report. However, removal of accumulated debris from the catch basin and outlet pipe should be undertaken within six months.

BELL POND DAM

d. Need for Additional Investigations. Additional investigations to further assess the adequacy of the dam are outlined below in Section 7.2, Recommendations.

7.2 Recommendations. In view of the concerns over the continued performance of the dam it is recommended that the Owner employ a qualified consultant to design a low level, gated outlet for the pond.

The recommendations on repairs and maintenance procedures are outlined below under Section 7.3, Remedial Measures.

7.3 Remedial Measures

a. Operating and Maintenance Procedures. The dam and appurtenant structures are not adequately maintained. It is recommended that the Owner accomplish the following:

- (1) remove accumulated debris from the catch basin and outlet pipe at the northeast corner of the pond
- (2) control slight seepage along the downstream toe of the dam
- (3) clear trees and brush from the downstream slope of the dam, and brush from the upstream slope of the dam
- (4) repair deteriorating concrete on the stormwater drainage basin at the bottom of the erosion control channels, and remove accumulated debris from the trash racks on the sides of the basin.
- (5) institute a definite plan for surveillance and a warning system during periods of unusually heavy rain and/or runoff.
- (6) implement a systematic program of maintenance inspections. As a minimum, the inspection program should consist of a monthly inspection of the dam and appurtenances, supplemented by additional

BELL POND DAM

inspections during and after severe storms. All repairs and maintenance should be undertaken in accordance with all applicable State regulations.

(7) technical inspections of this dam should be conducted on an annual basis.

7.4 Alternatives. An alternative to the recommendations and remedial measures outlined above would be to breach or remove the dam.

BELL POND DAM

APPENDIX A
PERIODIC INSPECTION
CHECKLIST

BELL POND DAM

PERIODIC INSPECTION

PARTY ORGANIZATION

PROJECT Bell Pond Dam

DATE 9-18-78

TIME 8:00 am

WEATHER 60°

W.S. ELEV. 667.6 U.S. — DN.S.

Benchmark elevation 670.0
established on top of catch basin

PARTY:

- | | |
|-------------------------|-------------------------|
| 1. <u>Ed Greco</u> | 6. <u>Lyle Branagan</u> |
| 2. <u>Carol Sweet</u> | 7. _____ |
| 3. <u>Frank Sviokla</u> | 8. _____ |
| 4. <u>Henry Lord</u> | 9. _____ |
| 5. <u>David Cole</u> | 10. _____ |

PROJECT FEATURE	INSPECTED BY	REMARKS
1. <u>Dam</u>	<u>Ed Greco</u>	
2. <u>Outlet and Catch Basin</u>	<u>L. Branagan</u>	
3. _____		
4. _____		
5. _____		
6. _____		
7. _____		
8. _____		
9. _____		
10. _____		

PERIODIC INSPECTION CHECK LIST

PROJECT Bell Pond Dam DATE 9-18-78
 PROJECT FEATURE Dam NAME E. Greco
 DISCIPLINE Geotechnical NAME _____

AREA EVALUATED	CONDITIONS
<u>DAM EMBANKMENT</u>	<i>earthfill dike @ south end of pond at abandoned outlet works</i>
Crest Elevation	
Current Pool Elevation	<i>667.6</i>
Maximum Impoundment to Date	<i>(See '55 Report)</i>
Surface Cracks	<i>none visible</i>
Pavement Condition	<i>Not applicable</i>
Movement or Settlement of Crest	<i>irregular crest</i>
Lateral Movement	<i>none</i>
Vertical Alignment	<i>slightly irregular</i>
Horizontal Alignment	<i>relatively straight</i>
Condition at Abutment and at Concrete Structures	<i>bedrock outcrops at abutments</i>
Indications of Movement of Structural Items on Slopes	<i>none</i>
Trespassing on Slopes	<i>footpaths - beach @ NW corner of pond</i>
Sloughing or Erosion of Slopes or Abutments	<i>slight erosion of slopes</i>
Rock Slope Protection - Riprap Failures	<i>Scattered riprap - outcrops along shore - local sloughing</i>
Unusual Movement or Cracking at or near Toes	<i>none visible</i>
Unusual Embankment or Downstream Seepage	<i>toe + downstream channel saturated - cattails</i>
Piping or Boils	<i>none</i>
Foundation Drainage Features	<i>none</i>
Toe Drains	<i>none</i>
Instrumentation System	<i>none</i>

PERIODIC INSPECTION CHECK LIST

PROJECT BELL POND DAM
 PROJECT FEATURE OUTLET WORKS
 DISCIPLINE HYDRAULIC

DATE 9-18-78
 NAME L. Branagan
 NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	<i>abandoned structure</i>
a. Approach Channel	<i>X</i>
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	
General Condition of Concrete	
Rust or Staining	
Spalling	
Any Visible Reinforcing	
Any Seepage or Efflorescence	
Drain Holes	
c. Discharge Channel	<i>earth channel</i>
General Condition	<i>fair</i>
Loose Rock Overhanging Channel	<i>none</i>
Trees Overhanging Channel	<i>densely overgrown</i>
Floor of Channel	<i>earth-moist</i>
Other Obstructions	<i>abandoned gate valve stem</i>

f. overflow check walls on rock face south of pond- rip rap slopes
e. catch basin @ NE corner of pond adjacent to Belmont St.

APPENDIX B

PLAN OF DAM AND PREVIOUS
INSPECTION REPORTS

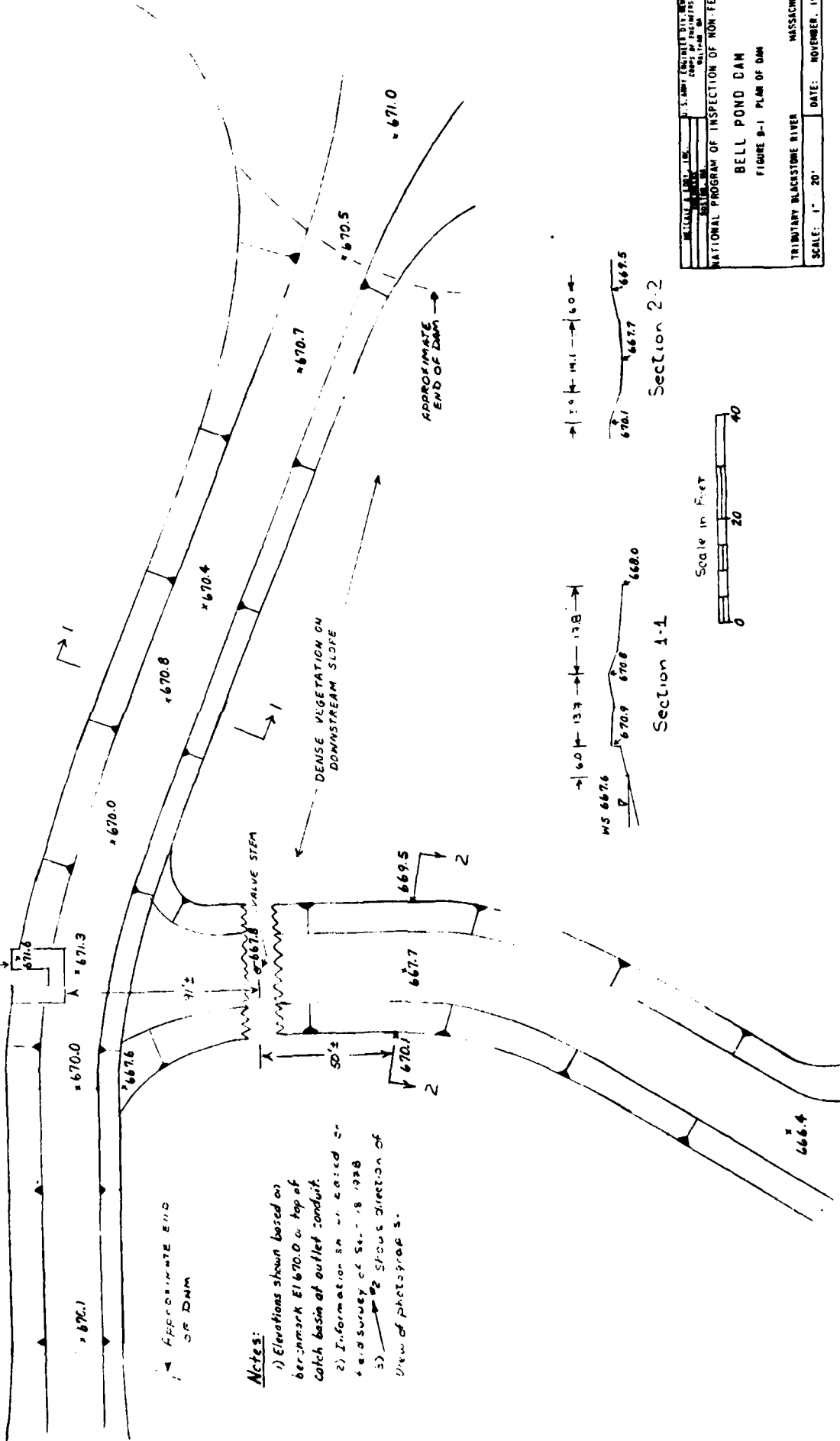
	<u>Page</u>
Figure B-1. Plan of Dam,	B-1
Figure B-2. Plan of Chandler Hill and Bell Pond, dated 1910	B-2
Previous Inspections (Partial Listing)	B-3
Letter of Inspection by Massachusetts Depart- ment of Public Works, April, 1973	B-4

BELL POND DAM



Bell Pond
MS 657.6

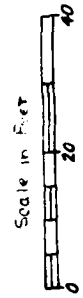
Accreted Gate House

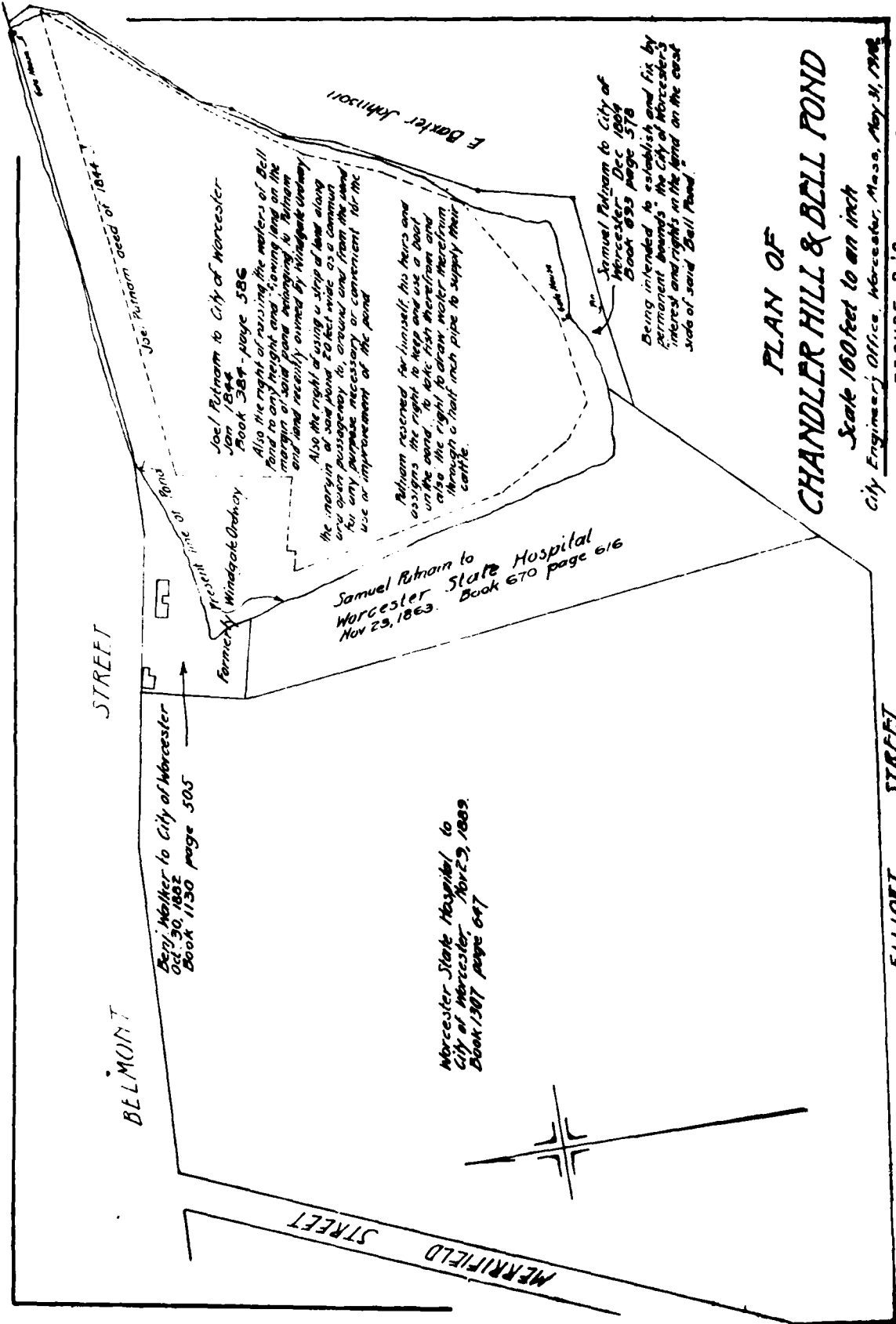


Notes:

- 1) Elevations shown based on benchmark El 670.0 at top of catch basin at outlet conduit.
- 2) Information in this record is a survey of September 1978.
- 3) Section 2 shows direction of view of photograph 3.

MILLER, L. L.	U.S. ARMY CORP. DISTRICT DIVISION
CONTRACT NO. 657.6	CONTRACT NO. 657.6
NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS	
BELL POND DAM	
FIGURE B-1 PLAN OF DAM	
TRIMBURY BLACKSTONE RIVER	MASSACHUSETTS
SCALE: 1" = 20'	DATE: NOVEMBER, 1978





TOWN OR CITY *Worcester* DECREE NO.
 LOCATION *Bell pond - Belmont St.*

PLAN NO.
 DAM NO. *67-22*
 C. C. DOCKET NO.

DESCRIPTION OF DAM

Type
 Length
 Height
 Thickness top
 " bottom
 Downstream Slope
 Upstream "
 Length of Spillway
 Size of Gates
 Location of Gates
 Flashboards used
 Width Flashboards or Gates
 Dam designed by
 " constructed by
 Year constructed

GENERAL REMARKS

*Owned by City of Worcester.W.D.
 Inspected Oct. 6, 1927- L.O. Marden.*

DESCRIPTION OF RESERVOIR & WATERSHED

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

GENERAL REMARKS

*trace
 0.07 Sg.M
 12*

PREVIOUS INSPECTIONS (PARTIAL LISTING)
 COPY OF INSPECTION CARD ON FILE AT THE MASSACHUSETTS
 DEPARTMENT OF PUBLIC WORKS, DISTRICT OFFICE, WORCESTER.

3

April 2, 1973

Mr. Richard Grant
Assistant Commissioner of Public Works
Division of Operations
20 East Worcester Street
Worcester, Massachusetts

RE: Inspection of Dams
Worcester
City of Worcester Dams

Dear Mr. Grant:

An engineer from the Massachusetts Department of Public Works has inspected dams, located in Worcester and owned by the City of Worcester.

The inspections were made in accordance with Chapter 253 of the Massachusetts General Laws, as amended by Chapter 595 of the Acts of 1970.

The results of the inspections are as follows:

A. Parsons Reservoir Dam #3-14-348-18

Overall condition appears good with minor repairs indicated as follows:

1. Replace missing granite paving blocks that have washed away.
2. Repair aqueduct intake, the approach spillway and downstream side of the spillway.

B. Salisbury Pond Dam #3-14-348-19

Overall condition appears good.

1. Remove brush growing on the embankment.

C. North Pond (Indian Lake) Dam #3-14-348-21

Overall condition appears good.

1. Remove debris from the spillway.

Inspection of Dams

April 2, 1973

North Pond (con't)

2. Remove trees and brush from the embankment.

D. Ball Pond Dam #3-14-348-22

Overall condition indicates that the following repairs are needed:

1. Repair or replace missing granite blocks in the spillway.
2. Remove sand and debris from the spillway channel.
3. Investigate the leak approximately 30' westerly of the spillway, and correct as necessary.

E. Green Hill Pond Dam #3-14-348-23

Overall condition appears good.

Remove debris from the spillway.

F. Green Hill Dick Pond Dam #3-14-348-23.1

Overall condition appears good.

G. Burncoat Park Pond Dam #3-14-348-35

Overall condition appears good.

1. Remove brush and trees from the embankment.

We call these conditions to your attention now before they become serious and expensive to correct.

Very truly yours,

F. C. Schwelm

FRED. C. SCHWELM, P.E.
Deputy Chief Engineer

LRM
LRM/afs

cc: G. E. Lybrand DME/#3

A. Troiano Dist. #3

APPENDIX C
PHOTOGRAPHS

BELL POND DAM



NO. 1 VIEW OF POND FROM ABANDONED OUTLET



NO. 2 VIEW OF ABANDONED OUTLET STRUCTURE



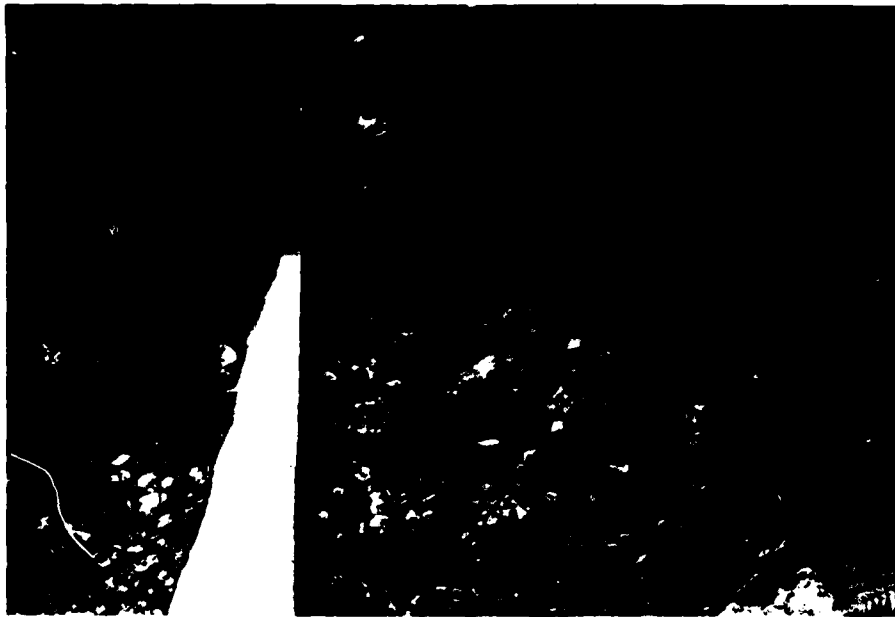
NO. 3 VIEW OF STONE RETAINING WALL ALONG BELMONT STREET



NO. 4 VIEW OF CATCH BASIN AT NORTHEAST CORNER OF POND



NO. 5 VIEW OF EARTH CHANNEL DOWNSTREAM OF OUTLET



NO. 6 VIEW OF CONCRETE WALL FOR EROSION CONTROL

APPENDIX D
HYDROLOGIC AND HYDRAULIC
COMPUTATIONS

BELL POND DAM

(I) Test Flood, 100 year storm & Storage Functions *EMG 11/17/78

1- Total Drainage Area - 0.047 mi²

2- Pond(s) Area: 0.013 mi²
Swamp(s) Area: —
Total Area Pond(s) & Swamp(s): 0.013 mi²

% Ponds & Swamps = $\frac{0.013}{0.047} = 27.7\%$

3- West: $\frac{75}{450} = 16.7\%$
 North: $\frac{80}{600} = 13.3\%$ } Say Ave Slope = 15%

4- Using C. of E. Curves for Peak Flow Rates & above guide values the Peak Flow Rate was estimated to be on "Rolling" extrapolated to the D.A. and taken at 3250 c.f.s./mi²
 Size Class: Small ; Hazard Pot.: Significant ; Spill. Des. Flood: $\frac{1}{2}$ to 1 PMF
 Use: Test Flood = $\frac{1}{2}$ PMF

5- Test Flood Inflow = $\frac{1}{2}(3250)0.047 = 76$ c.f.s.

6- Pond Storage

The pond area is 0.013 sq. mi. at elev. 100 (Nom. at Survey)
 Based on a const. area, storage increases at 8.3 ac. feet per foot of depth increase.
 - Outlet elev. 101.1, Top outlet elev. 102.4, $\Delta h = 1.3$ feet
 Storage = 0 @ elev. 101.1
 = 10.8 ac. ft. @ elev. 102.4

7- Storage Functions are based on $Q_{out} = Q_{in} \left[1 - \frac{S_{out}}{R} \right]$

S_{out} = Storage Vol. in Reservoir related to final Q_{out} in terms of inches of rain over the drainage area.

S (in Inches) = $12 D \left(\frac{0.013}{0.047} \right) = 3.3 D$; $R = 6$ hr rain of storm

D = Storage Depth (above spillway) on reservoir, in feet

8- Storage Functions: (F_{TF}); $D = 0$ @ Pond El. 101.1

$F_{TF} = 76 - 8 S = 76 - 26.4 D$

* Elevations for these computations based on water surface El. 100. Water surface elevation in report is 667.6. Therefore add 567.6 to elevations herein

NONREPRODUCIBLE GRID FORM 148

METCALF & EDDY, ENGINEERS

II Discharge Ratings

A - Side Opening in Outlet [Ref.: V.T. Chow "Op. Ch. Hydr." - pg 498]

Opening Invert El. 101.1
 Opening 4' wide x 1' high - treat as culvert w/ inlet cont.
 $Q_{so} = \text{Disch.} = (\text{Value from Ref. Fig 17-29}) \times (4' \text{ width}) ; d = 1'$

$H/d =$	0.3	0.5	1.0	1.5	2.0	3.0	4.0	5.0
$Q_{so} =$	2.0	4.8	13.3	19.6	23.2	30.4	36.0	40.0
Pond Elev.	101.4	101.6	102.1	102.6	103.1	104.1	105.1	106.1

B - Top Grating - 2' x 2.3' Square - 55% bars - area $\approx 2 \text{ ft}^2$

$Q_T = C_d A \sqrt{2gh}$; Use $C_d = 0.6$ w/ no approach vel.
 Grating @ Elev. 102.4

Pond Elev	102.4	103.1	104.1	105.1	106.1
h	0.2	0.7	1.7	2.7	3.7
Q_T	4.3	8.0	12.5	15.8	18.5

C. Max Outlet Capacity

Assume 15" ϕ outlet pipe. Max Vel $\approx 20 \text{ fps}$.
 \therefore Max. Assumed Cap = $20 \times 1.227 \text{ ft}^2 \approx 25 \text{ cfs}$.

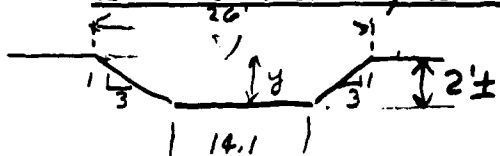
D - Flow Over Dike on South Side [Ref. pp 52-53]

Min. level of low dike is 102.4. Ave level $\approx 103 \pm$
 Use 90' @ El. 102.5 & 140' @ El. 103 ; Use $q_c = 2.55(H)^{1.5}$

Pond Elev.	102.6	103.1	104.1	105.1
Q_{c1}	7.2	106.7	464.5	962.0
Q_{c2}	—	11.3	411.9	1086.4

II Discharge Ratings - (Cont.)

E-Channel Capacity (dnstr. of South side dike)



$n = .04, S = \frac{1.2'}{86'}; \sqrt{S} = 0.118$
 $V = \frac{1.49}{.04} (.118) R^{2/3} = 4.4 R^{2/3}$

y	A	P	$R^{2/3}$	V	Q	Water El. @ Dike	Energy Level	MIN. POND ELEV.
2.0	40	26.7	1.31	5.75	230 cfs.	102	102.5	
1.5	27.75	23.5	1.12	4.92	136 "	101.5	101.9	
1.0	17	20.4	0.885	3.89	66 "	101	101.2	
0.5	7.75	17.26	0.586	2.58	20 "	100.5	100.6	
2.5	54	26.7	1.60	7.04	380 "	102.5	103.3	

F- Down Belmont St.

About 30' @ El. 102.5 ± - Use $q = 2.55 H^{1.5}; Q_B = 76.5 H^{1.5}$

Pond Elev.	102.6	103.1	104.1
Q_B	2.4	35.5	155

G- Summary

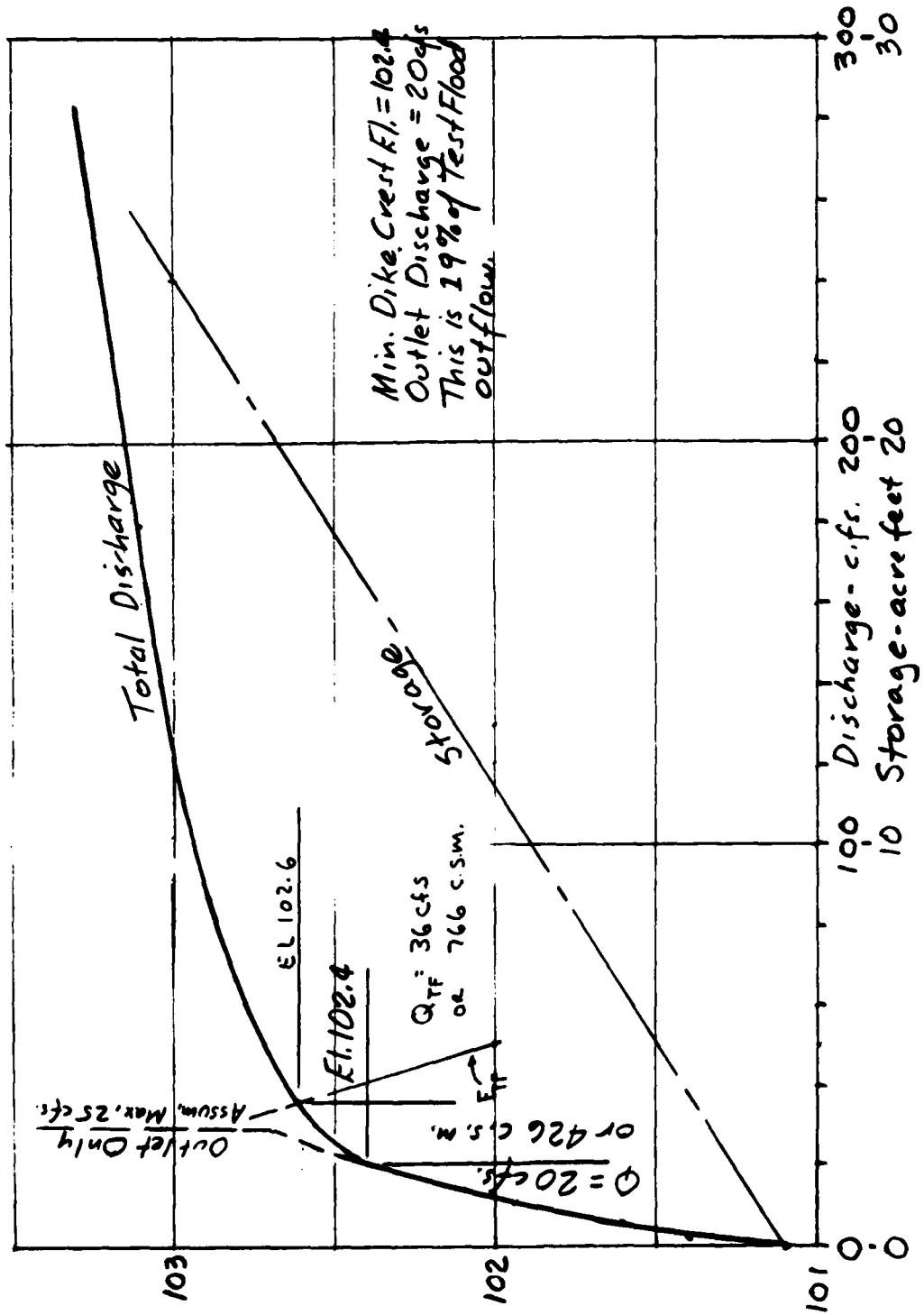
Pond Elev	101.4	101.6	102.1	102.6	103.1	104.1
Q_{50}	2	5	13	20	25*	25*
Q_T	—	—	—	4	—	—
Q_{C1}	—	—	—	7	107	465
Q_{C2}	—	—	—	—	11	412
Q_B	—	—	—	2	36	155
Q_{Total}	2	5	13	33	179	1057

* Limited by Outlet Pipe

ems 11/17/76

III Discharge, Storage, & Storage Function vs Pond Elev.

METCALF & EDDY, ENGINEERS



EM: 11/17/78

④ Results

Peak Outflow from Test Flood is 36 c.f.s with pond elev. 102.6. This requires that about 8 c.f.s. pass over the crest of the dam and about 3 c.f.s. down Belmont St.

Max. flow over dam is $2.55(0.2)^{1.5} = 0.23$ cfs/ft
 Where flow becomes critical:

$$y_c = \left(\frac{0.23^2}{32.2} \right)^{1/3} = 0.12' \quad \& \quad V_c = 1.9 \text{ f.p.s.}$$

⑤ Dam Failure

Pond El. = 102.4 (Min. DAM Elev.)

Toe El. = 100.0 ±

$$y_0 = 2.4'$$

Use full width of dam, above disch. channel, = 30'

$$Q_p = 1.68(30)(2.4)^{1.5} = 187 \text{ c.f.s.}$$

This produces a depth in the downstream channel of about 1.7' with a velocity of about 5.3 f.p.s.

Vol. of pond above elev 100 ± = $2.4(8.3) = 20$ ac.ft.

Time to Drain to elev 100:

$$\frac{20(43560)}{3600(\frac{1}{2})187} = 2.6 \text{ hours} = 155 \text{ minutes}$$

APPENDIX E
INFORMATION AS CONTAINED IN
THE NATIONAL INVENTORY OF
DAMS

BELL POND DAM

END

FILMED

3-85

DTIC