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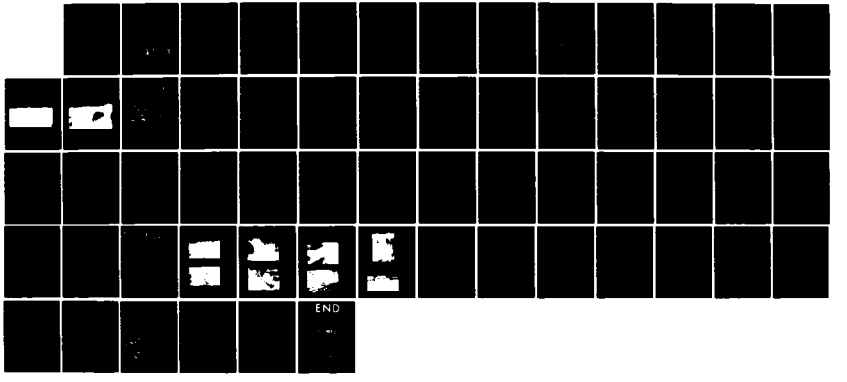

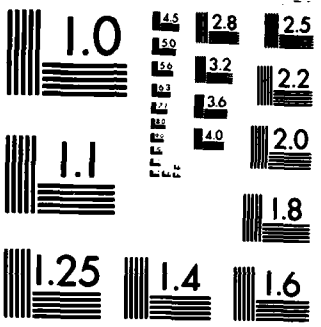

MERRIMACK RIVER BASIN
LOWELL, MASSACHUSETTS

LOWELL RESERVOIR DAM

MA. 01188

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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

JANUARY 1981

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Merrimack River Basin
Lowell Massachusetts

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

The dam is an earth embankment structure which forms five of the six sides of Lowell Reservoir. It is small in size with a hazard classification of high. A breach of the dam would release water rapidly down a steep hill flooding about five houses. The dam is judged to be in generally fair condition.The main concerns are the growth of brush and mature trees along the two southerly embankments, and the lack of the seismic analysis.

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

REPLY TO
ATTENTION OF:
NEDED

MAY 2 6 1981

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

Dear Governor King:

Inclosed is a copy of the Lowell Reservoir Dam (MA-01188) Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. In addition, a copy of the report has also been furnished the owner, City of Lowell, c/o Lowell Water Department, Hampshire Street, Lowell, Massachusetts 01850.

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,

C. E. EDGAR, III
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

LOWELL RESERVOIR DAM

MA 01188

MERRIMACK RIVER BASIN
LOWELL, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

Identification No.:	MA 01188
Name of Dam:	Lowell Reservoir Dam
City:	Lowell
County and State:	Middlesex County, Massachusetts
Stream:	None
Date of Inspection:	23 October 1980

BRIEF ASSESSMENT

Lowell Reservoir Dam is an earth embankment structure which forms five of the six sides of Lowell Reservoir. The total crest length of the embankments is 1,650 ft. The sixth side of the reservoir is formed by natural ground and is about 270 ft. long. The maximum height of the dam is 26 ft. at the south-east embankment. The reservoir is used as a standby domestic water supply source for the City of Lowell. The reservoir is filled via a 12 in. dia. pipe which is the overflow pipe for a smaller, covered reservoir called Intermediate Reservoir located about 150 ft. north-east of Lowell Reservoir. The only known outlet facility for the reservoir is a 30 in. dia. pipe which is connected to the City's water distribution system and is controlled by a gate valve and a check valve.

The surface area of the reservoir pool is about 5.1 acres at normal water surface level. The catchment area for the reservoir is about 6.4 acres. The reservoir pool is normally maintained at a level which is about 5.7 ft. below the top of the dam. The maximum storage to top of dam is about 114 acre-ft. Based on capacity and height, the size classification is small. A breach of the dam at a point along its highest embankment would release water rapidly down a steep hill flooding about five houses, a sewage treatment plant, a state road and two local roads and potentially could cause the loss of more than a few lives; therefore, the dam has been classified as having a high hazard potential. Based upon the guidelines, the recommended test flood ranges from a ½ PMF to a full PMF. A test flood equal to a full PMF was selected.

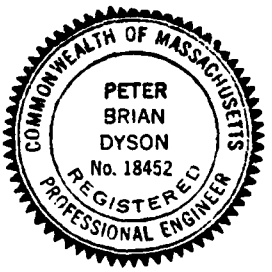
For the test flood it was assumed that there would be no outflow from the reservoir and it was found that the reservoir could contain the estimated probable maximum precipitation for a 72 hour duration storm without overtopping the dam. About 1.9 ft. of freeboard would remain after the test flood event.

The dam is judged to be in generally fair condition. The main concerns are the growth of brush and mature trees along the two southerly embankments, and the lack of a seismic analysis.

Within one year after receipt of this Phase I Inspection Report, the owner, the City of Lowell, should retain the services of a qualified registered professional engineer to (1) determine whether the 12 in. dia. outlet pipe at the southeast embankment exists as shown on the plans, and if so study the feasibility of using it as a means of completely draining the reservoir; (2) oversee the removal of brush and tree growth, including their root system on the south and south-east embankments and backfilling the voids with a suitable backfill material; and, (3) make a seismic investigation of the dam and analysis by conventional equivalent static load methods.

The owner should also implement the following operating and maintenance measures: (1) repair voids in the upstream riprap; (2) remove brush and light tree growth on the upstream slopes of all embankments and on the downstream slopes of the north and east embankments; (3) develop a formal surveillance and downstream emergency warning plan; (4) institute procedures for an annual technical inspection of the dam and its appurtenant structures; and (5) implement a regular periodic maintenance program.

Peter B. Dyson
Project Manager



This Phase I Inspection Report on Lowell Reservoir Dam (MA 01188) 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 judgement and practice, and is hereby submitted for approval.

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

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

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

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

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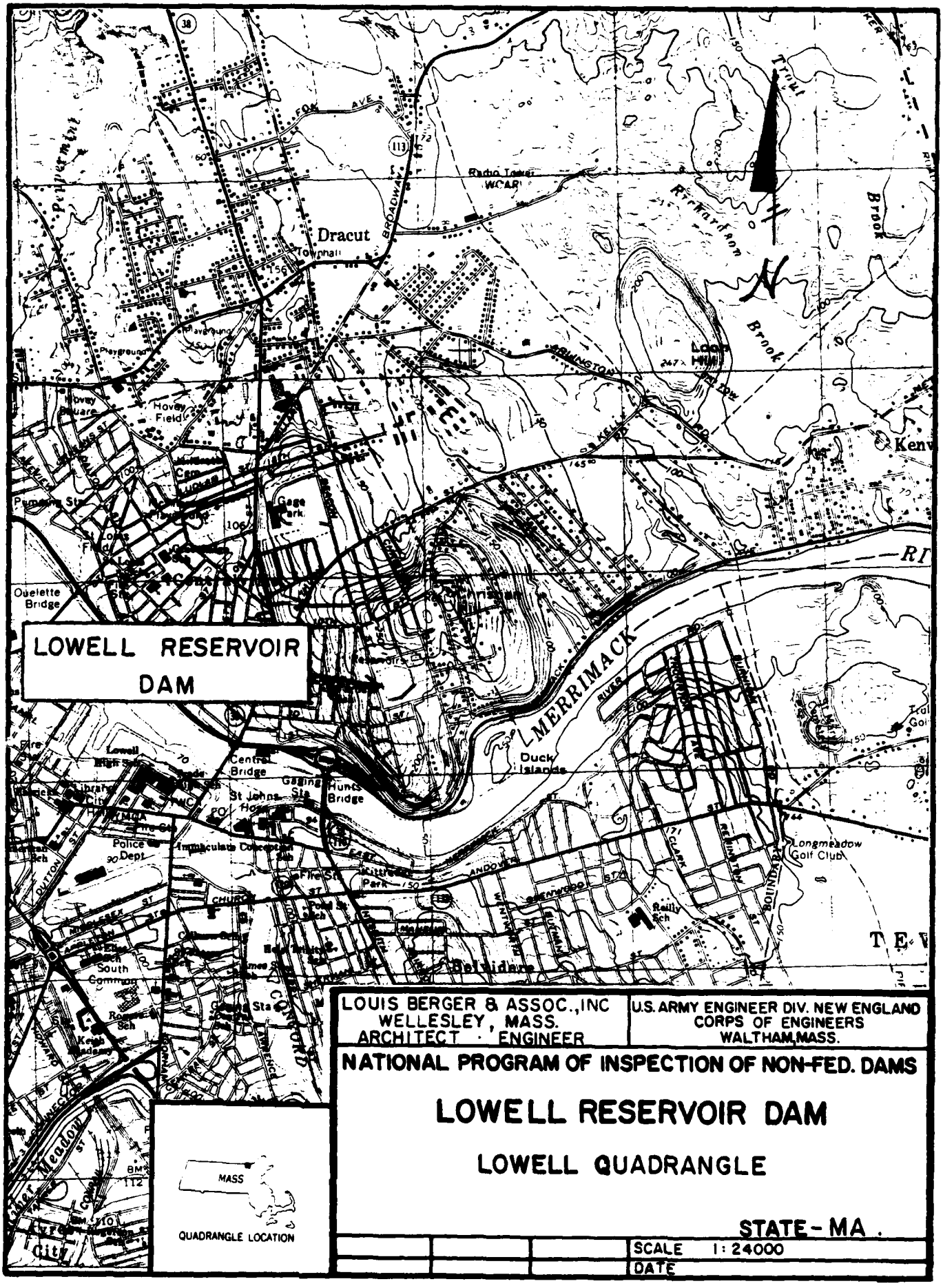
LOWELL RESERVOIR DAM

OVERVIEW PHOTO OF NORTH AND WEST EMBANKMENTS

LOWELL RESERVOIR DAM

OVERVIEW PHOTO OF SOUTH AND EAST EMBANKMENTS



LOUIS BERGER & ASSOC., INC WELLESLEY, MASS. ARCHITECT · ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOWELL RESERVOIR DAM

LOWELL QUADRANGLE

STATE - MA

			SCALE 1:24000
			DATE

PHASE I INSPECTION REPORT

LOWELL RESERVOIR DAM MA 01188

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. Louis Berger & Associates, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed was issued to Louis Berger & Associates, Inc. under a letter of 15 October 1980 from William E. Hodgson, Jr., Colonel, Corps of Engineers. Contract NO. DACW33-80-C-0043 Job Change No. 2 has been assigned by the Corps of Engineers for this work.

b. Purpose of Inspection

(1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.

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

1.2 Description of Project

a. Location. Lowell Reservoir Dam is located in Middlesex County in the City of Lowell in north-eastern Massachusetts. The reservoir is situated on a hill near the center of Lowell about 2,000 ft. north of the Merrimack River and is bordered by Richards St. to the north, Christian St. to the east, Reservoir St. to the south, and Beacon St. to the west. The reservoir is shown on U.S.G.S. Quadrangle, Lowell, Mass.-N.H. with coordinates approximately at N42° 39' 03", W71° 17' 42".

b. Description of Dam and Appurtenances

(1) Description of Dam.The Lowell Reservoir Dam is a man-made, six-sided earth structure with earth embankments on five sides. The crest length along the perimeter of the reservoir is about 1,920 ft. and the crest width varies from 15 ft. to 20 ft. The

upstream slopes of the embankments are 1.5 horizontal to 1 vertical and are protected with a hand-placed granite riprap. The downstream slopes of the embankments are in general 2 horizontal to 1 vertical and the height of the embankments above downstream toe varies as follows:

Reservoir Side	Length (ft)	Height (ft.) Left End	Height (ft.) Right End
East	290	0	22
South-East	270	22	24.5
South	280	24.5	7
West	530	7	12.5
North	280	12.5	0
* North-East	270	0	0

* The upstream side of the reservoir meets natural ground on the Northeast side.

The maximum hydraulic height of the dam is about 26 ft. at the midpoint of the southeast embankment. The upstream toes of all the embankments are located 24 ft. below the crest except at the south-east embankment where there is a low point 26 ft. below the crest. There is a chain link fence along the crest of the embankment.

A small covered reservoir called Intermediate Reservoir is located about 150 ft. north-east of the north-east side of Lowell Reservoir. A 12 in. dia. pipe leads from Intermediate Reservoir to Lowell Reservoir and serves as an overflow pipe from Intermediate Reservoir to Lowell Reservoir. Water levels in the Intermediate Reservoir are controlled by a pumping station located on the Merrimack River. The pumping station and Intermediate Reservoir can be isolated by shutting valves in the City's water distribution lines.

A control house is located on the western embankment where a 30 in. dia. outlet pipe from the reservoir passes through the house and is connected to the City water distribution system. A gate valve and check valve are located on the 30 inch line on the downstream side of the control house. These valves control flows out of the reservoir and prevent backfeeding into the reservoir via this line.

An old plan of the reservoir on file at Lowell City Hall indicates there is a 12 in. dia. drainage pipe that passes underneath the south-east embankment. The plan shows that its inlet end is at the low point in the reservoir. However, the existence of this line could not be confirmed by City personnel.

c. Size Classification. Lowell Reservoir Dam has a maximum embankment height of 26 ft., and impounds a normal storage of 84.5 acre-ft. at normal water surface level and a maximum of about 114.5 acre-ft. to top of dam. In accordance with the criteria given in Recommended Guidelines for Safety Inspection of Dams, the project falls into the small category on the basis of height and capacity and is therefore classified accordingly. A small dam is one which is greater than 25 ft. and less than 40 ft. high and a storage capacity greater than 50 ac. ft. but less than 1,000 ac. ft.

d. Hazard Classification. A breach of any of the embankments forming Lowell Reservoir would release damaging flood waters to the heavily urbanized area surrounding the reservoir. In this report a breach of the south-east embankment was assumed for the failure analysis as this embankment has the greatest height. A breach of the south-east dike would release water across Reservoir St., thence down a steep hillside following the alignment of Christian St., thence across State Route 110, into a sewage treatment facility and then into the Merrimack River. It is estimated the maximum depth of flooding would be about 5 ft. and that about five houses would be flooded by the breach discharge. In this area of impact it is estimated that there is the potential for the loss of more than a few lives and excessive economic loss. In accordance with the Recommended Guidelines For Safety Inspection of Dams, Lowell Reservoir Dam has therefore been classified as having a high hazard potential.

e. Ownership. Lowell Reservoir Dam is owned by the City of Lowell, c/o Lowell Water Department, Hampshire St., Lowell, MA 01850. Tele: 617-452-2012

f. Operator. Mr. Edward Tierney, Lowell Water Department, Hampshire St., Lowell MA 01850. Tele: 617-452-2012.

g. Purpose of Dam. The dam impounds a reservoir used for standby domestic water supply purposes.

h. Design and Construction History. It is not known by whom the dam was designed or constructed. It was reported that the dam was constructed in 1872. An inspection of old plans on file at the Lowell City Engineer's Office revealed information about a slope paving failure on the upstream side of the western embankment at its northerly end. A plan dated December 1885 shows the extent of the repairs to the dam as a result of the failure.

i. Normal Operating Procedures. No written operating procedures for the dam were disclosed. The only known operating devices at the dam are 12 in. dia. overflow pipe from Intermediate Reservoir, and a 30 in. dia. outlet pipe from Lowell Reservoir to the City water distribution system controlled by a gate valve and check valve. Normal water demands for the City are met by pumping from the Merrimack River. The Lowell Reservoir is only operated in the event of a water supply emergency. It was reported that the reservoir holds enough water to supply the City for two days.

1.3 Pertinent Data

a. Drainage Area. The catchment area for Lowell Reservoir is estimated to be about 6.4 acres. Virtually all inflow to the reservoir is via a 12 in. dia. overflow pipe from a smaller, covered reservoir called Intermediate Reservoir which is located just northeast of Lowell Reservoir. Inflow to Intermediate Reservoir is via city distribution lines from a treatment plant which is fed by a pumping station located on the Merrimack River.

b. Discharge at Damsite

(1) Outlet Works Conduit. Low level discharge from Lowell Reservoir can be accomplished by shutting down the pumping station on the Merrimack River and opening a gate valve on a 30 in. dia. outlet pipe which leads to the City distribution system. Maximum discharge capacity is unknown and is limited by consumption rates within the City system. City personnel estimate Lowell Reservoir could be drained in about two days or at an average discharge of 21 CFS if the pumping station were shutdown.

(2) Maximum Known Flood at Damsite. No records are available of surcharge head during periods of heavy precipitation.

(3) Ungated Spillway Capacity at Top of Dam. Not applicable.

(4) Ungated Spillway Capacity at Test Flood Elevation. Not applicable.

(5) Gated Spillway Capacity at Normal Pool Elevation. Not applicable.

(6) Gated Spillway Capacity at Test Flood Elevation. Not applicable.

(7) Total Spillway Capacity at Test Flood Elevation. Not applicable.

(8) Total Project Discharge at Top of Dam. If the pumping station was shutdown and the reservoir outflow pipe open the average total project discharge would be about 21 CFS with the water level at top of dam, elevation 240.0.

(9) Total Project Discharge at Test Flood Elevation. If the pumping station was shutdown and the reservoir outflow pipe open, the average total average project discharge would be about 21 CFS with the water surface at test flood elevation 237.4.

c. Elevation (ft. N.G.V.D.) (All elevations assumed from U.S.G.S. Map)

(1) Natural Ground at toe of highest embankment - 214

(2) Bottom of cutoff - Unknown

(3) Maximum tailwater - Not applicable

(4) Normal pool - 234.3

(5) Full flood control pool - Not applicable

(6) Spillway crest - Not applicable

(7) Design surcharge (Original Design) - Unknown

(8) Test flood surcharge - 238.1

(9) Top of dam - 240.0

d. Reservoir (Length in feet)

(1) Normal pool - 438

(2) Flood control pool - Not applicable

(3) Spillway crest pool - Not applicable

(4) Test flood pool - 464

(5) Top of dam - 470

e. Storage (acre-ft.)

(1) Normal pool - 84

(2) Flood control pool - Not applicable

(3) Spillway crest pool - Not applicable

(4) Test flood pool - 104

(5) Top of dam - 114

f. Reservoir Surface (acres)

(1) Normal pool - 5.1

(2) Flood-control pool - Not applicable

(3) Spillway crest - Not applicable

(4) Test flood pool - 5.3

(5) Top of dam - 5.4

g. Dam

(1) Type - Earth embankment

(2) Length - 1,650 ft.

(3) Height - 26 ft. maximum

(4) Top width - Varies, 15 ft. to 20 ft.

(5) Side slopes - Downstream: 2 horizontal to 1 vertical
Upstream: 1½ horizontal to 1 vertical

(6) Zoning - Unknown

(7) Impervious core - Unknown

(8) Cutoff - Unknown

(9) Grout curtain - Unknown

h. Diversion and Regulating Tunnel - Not applicable

i. Spillway - Not applicable

j. Regulating Outlets

(1) Invert - Elevation 216.0 approximate

(2) Size - 30 inch dia.

(3) Description - Cast iron pipe to City water distribution system

(4) Control mechanism - Hand operated gate valve.

SECTION 2 - ENGINEERING DATA

2.1 Design Data

Very little data on the design of the dam or appurtenances has been recovered. A few plans showing design data are on file at the Lowell City Engineer's Office and were reviewed by the inspection team. One of these plans shows the reservoir in plan view and indicated there is a 12 in. dia. drain pipe passing through the southeast embankment. The pipe's invert is shown to be located at the low point in the reservoir at elevation 214.0. However, it could not be ascertained during the inspection whether this pipe exists nor were the owner's representatives able to recall whether it exists.

Another plan on file shows several cross sections of the reservoir. The plan of the cross sections indicated there are no cores in the embankments. The plan does indicate a bedding was placed beneath the granite riprap on the upstream slope of the embankments. In the course of the inspection, measurements were taken and a sketch plan of Lowell Reservoir has been prepared. This plan is included in Appendix B.

2.2 Construction Data

No records or correspondence have been found regarding the original construction of the reservoir. On file at the City Engineer's Office is a plan dated December 1885 which indicated the riprap on the northerly end of the western embankment slipped downward and had to be repaired. Copies of segments of this plan are included in Appendix B.

2.3 Operation Data

No engineering operational data were disclosed.

2.4 Evaluation of Data

a. Availability. There was little engineering data available. The basis of the evaluation presented in this report is principally the visual observations of the inspection team.

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 sound engineering judgement.

c. Validity. The plans on file at the City Engineer's Office generally conform to the data collected during the field inspection, with the exception that the 12 in. dia. drainage pipe shown to be passing through the southeast embankment could not be verified as existing.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

a. General. The visual inspection of Lowell Reservoir Dam took place on October 23, 1980. On that date the water level in the reservoir was 5.7 ft. below the crest of the embankments. City personnel reported this to be the normal water level maintained in the reservoir. The reservoir is used as a standby domestic water supply source for the City of Lowell.

On the day of the inspection no water was coming into or leaving the reservoir. There was no evidence of any major problems and in general the physical condition of the dam was judged to be fair.

b. Dam. Lowell Reservoir Dam is a man-made, six-sided basin with earth embankments on five sides. The sixth side of the reservoir abuts natural ground. The total crest length of the embankments is about 1,650 ft. and the total perimeter length of the reservoir is about 1,920 ft. The crest widths of the embankments vary from 15 ft. to 20 ft. The upstream slopes are 1.5 horizontal to 1 vertical and the downstream slopes are 2 horizontal to 1 vertical (see photo no. 1 and 2). The length and height above downstream toe of each embankment is noted in section 1 of this report.

The downstream toes of all embankments are 24 ft. below the crest of the dam except at the midpoint of the south-east embankment where the toe is 26 ft. below the crest. The center of the reservoir is about 25 ft. below the crest.

The upstream slope of each embankment is protected with hand-placed granite block riprap which is in generally good condition. However, there are occasional areas in the riprap with spalling or missing stones as shown in Photo No. 3. Near the crest on the upstream slopes on all sides of the reservoir there is abundent brush growth as shown in Photo No's 4 and 5. The downstream slope of the western embankment is free of brush and tree growth, however, there is light brush growth on the downstream slope of the northern embankment, light brush and tree growth on the downstream slope of the east embakment, and heavy brush and tree growth on the downstream slopes of the southeast and south embankments. It is estimated there are approximately eighty trees with diameters greater than 4 in. growing on the two southerly embankments. Photo No. 6 shows the brush and tree growth on the downstream slope of the south embankment.

There are heavily worn foot paths along the entire crest length and on the downstream slopes of all embankments. (see photo no.7). There are park benches located on the crest of the west embankment as shown in Photo No. 1.

The shape and alignment of all embankments appears to be very good and there is no evidence of seepage, movement or distress of any of the embankments.

An inspection was made of the side of Christian Hill down slope from the southerly embankment. There was no evidence of any distress or seepage emanating from the hill side for a distance of several hundred feet from the toe of the dam.

c. Appurtenant Structures. The only ancillary facilities visible are the outlet end of the inflow pipe from Intermediate Reservoir and a brick control house on the west embankment (see Photo No. 1). According to an old plan on file at the City Engineer's Office the control house contains an inflow and outflow chamber. However, it was reported by City personnel the reservoir can only be filled via the 12 in. dia. outflow pipe from Intermediate Reservoir. A 30 in. dia. outlet pipe from Lowell Reservoir connects to the City's water distribution system. The controls for the 30 in. dia. outlet pipe located downstream of the control house consist of a gate valve and a check valve which prevents backfeeding to the reservoir through this line. According to the same plan on file at the City Engineer's Office, a 12 in. dia. drainage pipe passes under the south-east embankment. The inlet is located at the low point of the reservoir. The location of the downstream end of the 12 in. dia. drainage pipe is not defined on the plan and the existence of this pipe could not be confirmed by City personnel, nor was any trace of it noted during the field inspection.

d. Reservoir Area. The general condtion appears satisfactory and no signs of excessive deterioration were noted. Vandalism is curtailed by a chainlink fence located along the entire crest of the dam near the upstream slope. Photo No. 8 is a view of Intermediate Reservoir (background) and Lowell Reservoir(foreground).

e. Downstream Channel. There is no channel downstream of the reservoir. The reservoir is sited on the side of a hill in urban Lowell. Houses and city streets are located on all sides of the reservoir.

3.2 Evaluation. The visual inspection adequately revealed key characteristics of the dam as they may relate to its stability and integrity. The dam and appurtenant works were judged to be in fair physical condition. The only items of concern noted were the brush growth on the upstream slope above the riprap to the crest, heavy tree growth on the south and southeast downstream embankment slopes, random brush growth on some of the other downstream embankment slopes, and minor voids in the riprap on the upstream slope. There is no regular periodic maintenance program for the dam.

SECTION 4 - OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operation Procedures

a. General. The dam is owned and operated by the City of Lowell. The reservoir serves as a standby domestic water supply source for the City. The reservoir is fed by first pumping to Intermediate Reservoir located about 150 ft. north-east of Lowell Reservoir. When Intermediate Reservoir is full, water passes through a 12 inch. dia. overflow pipe from Intermediate Reservoir to Lowell Reservoir. On one of the plans on file at the City Engineer's Office an inflow chamber and an outflow chamber are shown to exist in the gate house located on the western embankment of the reservoir. However, it was reported that the reservoir can no longer be fed through the inflow chamber because of a check valve located in the piping system. The only known way to draw down the reservoir is by closing the pumps in the water supply system and opening a gate valve located on the 30 in. dia. outlet pipe to the City's water distribution system.

b. Description of any Warning System in Effect. No warning system is in effect at Lowell Reservoir.

4.2 Maintenance Procedures

a. General. There is no documented regular periodic maintenance program in effect at Lowell Reservoir. There are, however, a few items which require periodic maintenance; such as surveillance of the downstream embankment slopes for seeps; removal of brush and tree growth from the embankments; maintenance of the outlet facility; and, maintenance of the riprap on the upstream slopes.

b. Operating Facilities. The only operating facilities at the dam are the valves at the control house. Maintenance of these facilities is said to be performed as required.

4.3 Evaluation

Overall maintenance of the dam is generally fair. Though some of the embankments are clear of brush and tree growth, others have been neglected and need to be cleared. On the upstream slope localized areas are missing riprap and it should be repaired. A regular periodic maintenance program should be implemented. The owner should also establish a formal downstream warning system for the dam in the event of an emergency.

SECTION 5 - EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General.

Lowell Reservoir Dam is a six sided earth embankment structure used for standby domestic water supply purposes for the City of Lowell. The reservoir has a normal water surface area of about 5.1 acres and the water surface is usually maintained at a level which is about 5.7 ft. below the top of the embankments. The normal storage capacity is about 84.5 acre-ft. and there is about 30 acre-ft. of storage capacity in the reservoir's surcharge space to top of dam. Water enters Lowell Reservoir as rainfall over a catchment area of about 6.4 acres and via a 12 in. dia. inflow pipe which serves as an overflow pipe for Intermediate Reservoir, located about 150 ft. north-east of Lowell Reservoir. Water is pumped to Intermediate Reservoir from a treatment plant on the Merrimack River through the City's water distribution system. Since the inflow to the reservoir is regulated, only rainfall was evaluated in the Test Flood Analysis in Section 5.4 below. The only known outlet facility at the reservoir is a 30 in. dia. pipe which is controlled by a gate valve and a check valve and leads to the City's water distribution system. City personnel report the reservoir could be drained in about two days based on current municipal demand if their water supply pumps were shut off and the 30 in. dia. outlet pipe was fully open.

5.2 Design Data

No hydrologic computations or hydraulic data have been recovered for the dam.

5.3 Experience Data

No records are available in regard to past operation of the reservoir, or of surcharge heights in the reservoir.

5.4 Test Flood Analysis

Hydrologic characteristics of Lowell Reservoir Dam were evaluated in accordance with criteria given in Recommended Guidelines for Safety Inspection of Dams. As indicated in Section 1.2, paragraphs c & d Lowell Reservoir Dam is classified as small in size and has a high hazard potential. The recommended test flood for hydraulic evaluation of such a dam ranges from a ½ PMF to a full PMF, (probable maximum flood). Because the reservoir is located in a highly urbanized area a full PMF was selected for the test flood. A precipitation event equivilant to the probable maximum precipitation, (PMP) over a 72 hour duration was assumed for the test analysis. It was further assumed there would be no outflow from the reservoir during the 72 hours of precipitation. Precipitation data was obtained from Hydrometerological Report No. 51, which for this area of Massachusetts is about 36 inches of 72 hour maximum rainfall over a 10 square mile area. At the beginning of the test flood it was assumed the reservoir

water surface would be at the level normally maintained.

For Lowell Reservoir, the rainfall would cause a rise in water level of approximately 3.8 ft. Since the reservoir is maintained with a normal freeboard of 5.7 ft., there will be a freeboard of 1.9 ft. at the end of the test storm. For a ½ PMF event the freeboard would be about 3.7 ft.

With the City's water supply system functioning as designed, the potential for overtopping appears almost nil. City personnel take periodic graph readings of the water level in Intermediate Reservoir and reduce the pumping rate when Intermediate Reservoir is full, thus preventing water from passing through Intermediate Reservoir's overflow pipe to the Lowell Reservoir. A new facility currently being constructed for the City Water Department will have an alarm system in it which will also alert the operators when Intermediate Reservoir is full.

5.5 Dam Failure Analysis.

A breach owing to structural failure of the dam by piping or sloughing is a possibility. Failure of any of the five embankments comprising the dam would release significant discharges through the highly developed downstream area surrounding the reservoir. For the breach analysis it was assumed the south-east embankment failed as it is the highest embankment in the dam. The "Rule of Thumb" method in the March 1978 Guidance Report was used for the breach analysis. The water level in the reservoir at the time of failure was assumed to be at the test flood elevation. With a breach width of 20 percent of the embankment length at the crest equal to 54 ft., an outflow of about 10,700 CFS would be realized (see Sheets D-6 thru D-8, Appendix D).

In the reach below the south-east embankment, the breach flood flows would cross over Reservoir St. and then rapidly travel down a steep incline generally following the alignment of Christian St. to and across State Route 110 located about 1,400 ft. below the dam and then pass through a sewage treatment plant located at the foot of the hill and adjacent to the Merrimack River. By the time the breach discharge reaches State Route 110 it is estimated the discharge will be reduced to about 7,500 CFS. Between the reservoir and the Merrimack River it is estimated two local roadways, State Route 110, the sewage treatment plant and five houses will be flooded to depths ranging up to about 5 ft. and that there is the potential for the loss of more than a few lives and excessive economic loss. Therefore, in accordance with the Recommended Guidelines For Safety Inspection of Dams the dam has been classified as having a high hazard potential. Sheet D-9, Appendix D shows the area of potential flooding.

SECTION 6 - EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations

The Lowell Reservoir Dam is in fair condition at the present time as revealed by the field inspection of October 23, 1980. There are a few items which were observed during the field visit and which will require treatment as outlined in Section 7. These items are: the brush growth on the upstream slope above the riprap to the crest; heavy tree growth on the south and southwest downstream embankment slopes; random brush growth on some of the other downstream embankment slopes; and, minor voids in the riprap on the upstream slopes.

6.2 Design and Construction Data

A set of plans and cross sections is available for the Lowell Reservoir Dam. However,these cross sections are not sufficiently detailed as to show the physical properties of the materials used for embankment construction. Calculations pertaining to the stability of the embankments is not available.

6.3 PostConstruction Changes

There are no records of any major postconstruction changes made to the dam or outlet structure over the course of its history. However, there is evidence of some remedial construction to the riprap slope located at the north end of the west embankment. These repairs indicate that the riprap was replaced after some shallow slumping sometime around December 1885.

6.4 Seismic Stability

The dam is located in Seismic Zone No. 3. Phase I Guidelines recommend as a minimum, that suitable analysis made by conventional equivilant static load methods should be on record for dams in Zone No. 3. As far as can be determined, no such analysis has been made.

SECTION 7

ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. On the basis of the Phase I visual examination, Lowell Reservoir Dam is judged to be in fair condition. If the reservoir water surface level is maintained at the same level which was observed on the day of the inspection the reservoir can contain the test flood event. The deficiencies reveal that further investigations should be carried out and that some remedial work is needed.

b. Adequacy of Information. 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 sound engineering judgement.

c. Urgency. The recommendations and remedial measures enumerated below should be implemented by the owner within one year after receipt of this Phase I Inspection Report.

7.2 Recommendations

It is recommended that the owner, the City of Lowell, should retain the services of a registered professional engineer experienced in the design of dams to make a thorough investigation of the following:

(1) Investigate whether the 12 in. drainage pipe shown on old records at the south-east embankment actually exists and study the feasibility of using it as an means for draining the reservoir independent of the distribution system in the event of an emergency.

(2) Oversee the removal of brush and tree growth including their root systems on the south and south-east embankments and backfilling the voids with a suitable backfill.

(3) Make a seismic investigation of the dam and analysis by conventional equivalent static load methods.

7.3 Remedial Measures

a. Operation and Maintenance Measures

(1) Repair voids in the upstream riprap.

(2) Remove brush and light tree growth on the upstream slopes of all embankments and on the downstream slopes of the north and east embankments.

(3) Develop an "Emergency Action Plan" that will include an effective pre-planned downstream warning system, locations of emergency equipment, materials and manpower, authorities to contact and potential areas that require evacuation.

(4) Institute procedures for an annual technical inspection of the dam and its appurtenant structures.

(5) Implement a regular periodic maintenance program.

7.4 Alternatives

There appear to be no practical alternatives to the above recommendations.

Appendix A

Inspection Checklist

VISUAL INSPECTION CHECKLIST
PARTY ORGANIZATION

PROJECT Lowell Reservoir DATE October 23, 1980

OWNER City of Lowell TIME 10:00 AM

WEATHER Sunny - 40°

W.S. ELEV. 234.3 U.S. N/A DN.S.

INSPECTION PARTY

A/E REPRESENTATIVES

1. Pasquale E. Corsetti
2. Roger F. Berry
3. Carl J. Hoffman
4. William S. Zoino
5.

PROJECT FEATURE	INSPECTED BY	REMARKS
1. Hydraulics	Roger F. Berry	LBA
2. Hydrology & Structures	Carl J. Hoffman	LBA
3. Geotechnical	William S. Zoino	GZA
4. General Features	Pasquale E. Corsetti	LBA
5.		
6.		
7.		
8.		
9.		
10.		

LBA - Louis Berger & Associates, Inc.
GZA - Goldberg-Zoino & Associates, Inc.

PERIODIC INSPECTION CHECKLIST

PROJECT Lowell Reservoir DATE October 23, 1980

PROJECT FEATURE Embankment NAME

DISCIPLINE Geotechnical NAME William Zoino

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT	
Crest Elevation	240.0
Current Pool Elevation	234.3
Maximum Impoundment to Date	Unknown
Surface Cracks	None
Pavement Condition	N/A
Movement or Settlement of Crest	None
Lateral Movement	None
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	None
Trespassing on Slopes	West dike used as park Footpath along crest all dikes
Sloughing or Erosion of Slopes or Abutments	None
Rock Slop Protection - Riprap Failures	Good - minor sporadic voids
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	None
Piping or Boils	None
Foundation Drainage Features	None
Toe Drains	None
Vegetation	Heavy tree growth d/s slope of south & south-east dikes, light brush crest of u/s slopes.

PERIODIC INSPECTION CHECKLIST

PROJECT Lowell Reservoir DATE October 23, 1980

PROJECT FEATURE Control House NAME

DISCIPLINE Structures NAME Carl J. Hoffman

AREA EVALUATED	CONDITIONS
OUTLET WORKS - CONTROL TOWER	NOTE: Control House not in use.
a. Concrete and Structural	
General Condition	Fair
Condition of Joints	N/A
Spalling	"
Visible Reinforcing	"
Rusting or Staning of Concrete	"
Any Seepage or Efflorescence	"
Joint Alignment	"
Unusual Seepage or Leaks in Gate Chamber	"
Cracks	"
Rusting or Corrosion of Steel	"
b. Mechanical and Electrical	N/A
Air Vents	"
Float Wells	"
Crane Hoist	"
Elevator	"
Hydraulic System	"
Service Gates	"
Emergency Gates	"
Lighting Protection System	"
Emergency Power System	"
Wiring and Lighting System in Gate Chamber	"

PERIODIC INSPECTION CHECKLIST

PROJECT Lowell Reservoir DATE October 23, 1980

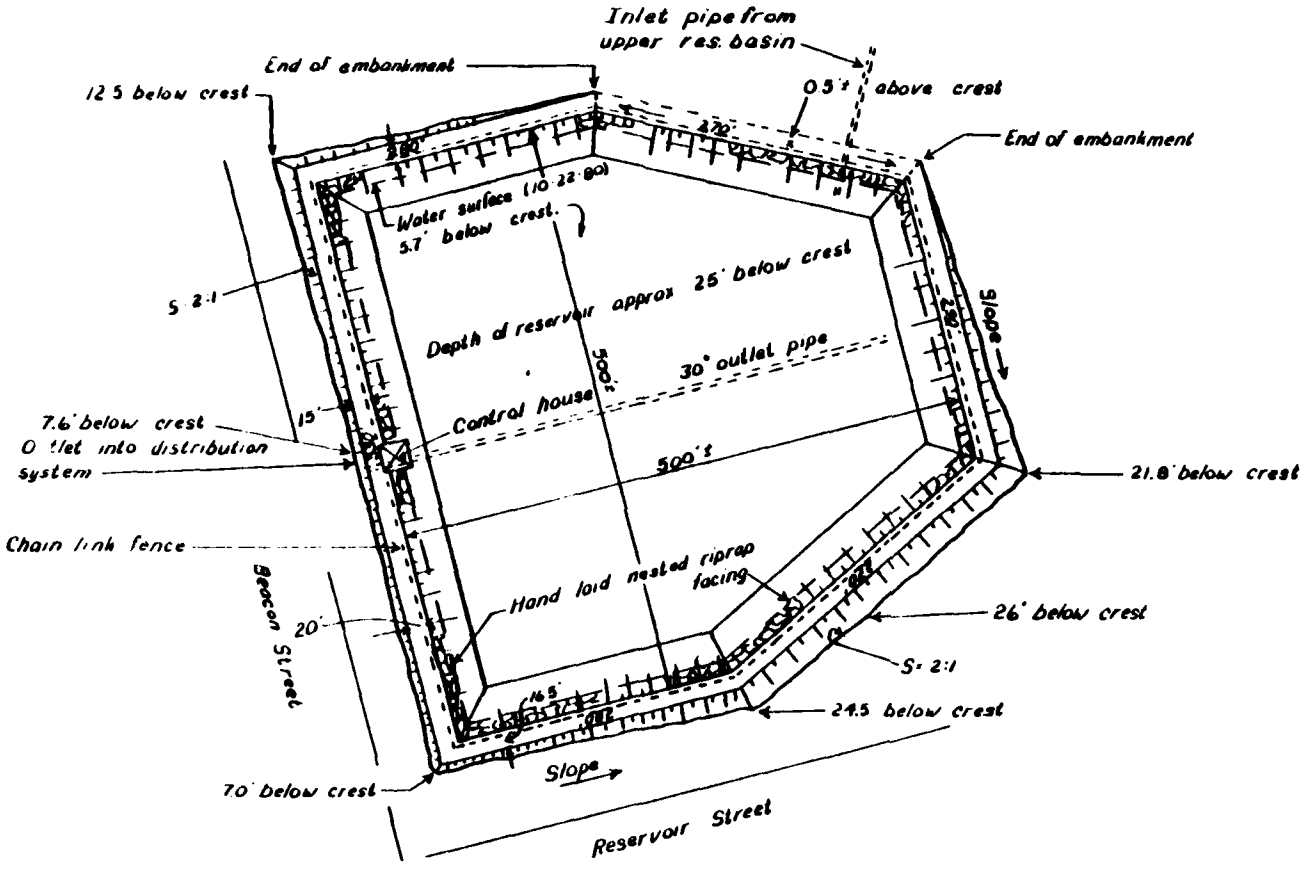
PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITIONS
Dike Embankment	N/A
Outlet Works - Intake Channel and Intake Structure	N/A
Outlet Works - Transition and Conduit	N/A
Outlet Works - Spillway Weir, Approach and Discharge Channels	N/A
Outlet Works - Service Bridge	N/A

Appendix B

Engineering Data



NOTES:

Reservoir built in 1872
capacity 32×10^6 gallons
12" feed pipe; 30" outlet pipe

Original drawings show dam crest elevation of 185.5.
USGS shows approx.
El. 240 m.s.l.

LOWELL RESERVOIR DAM

SECTIONS & PLAN

OF

SLOPE NORTH OF GATE HOUSE

BEACON STREET RESERVOIR

SHOWING

SLOPE AFTER SLIPPING OF PAVING

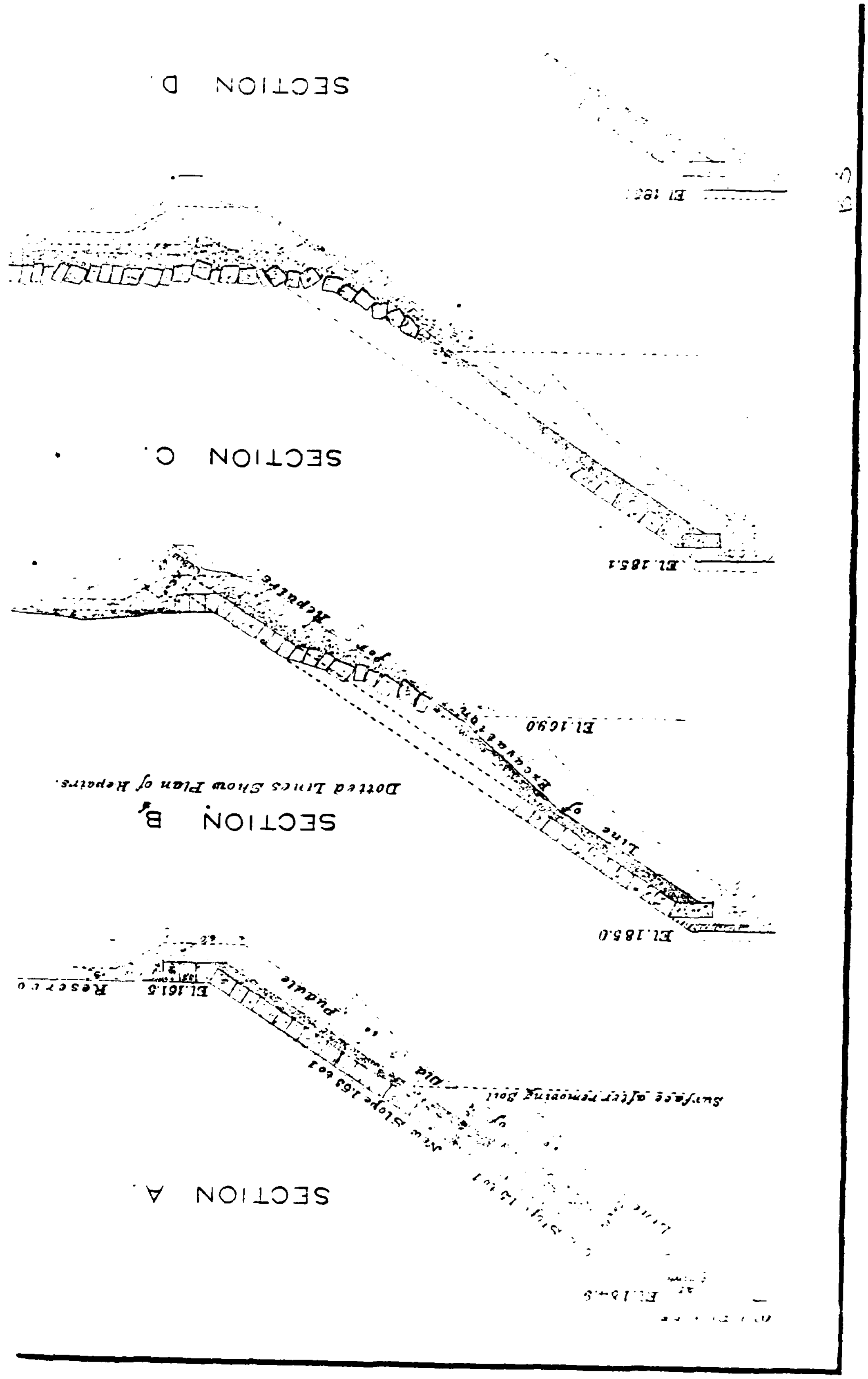
AND

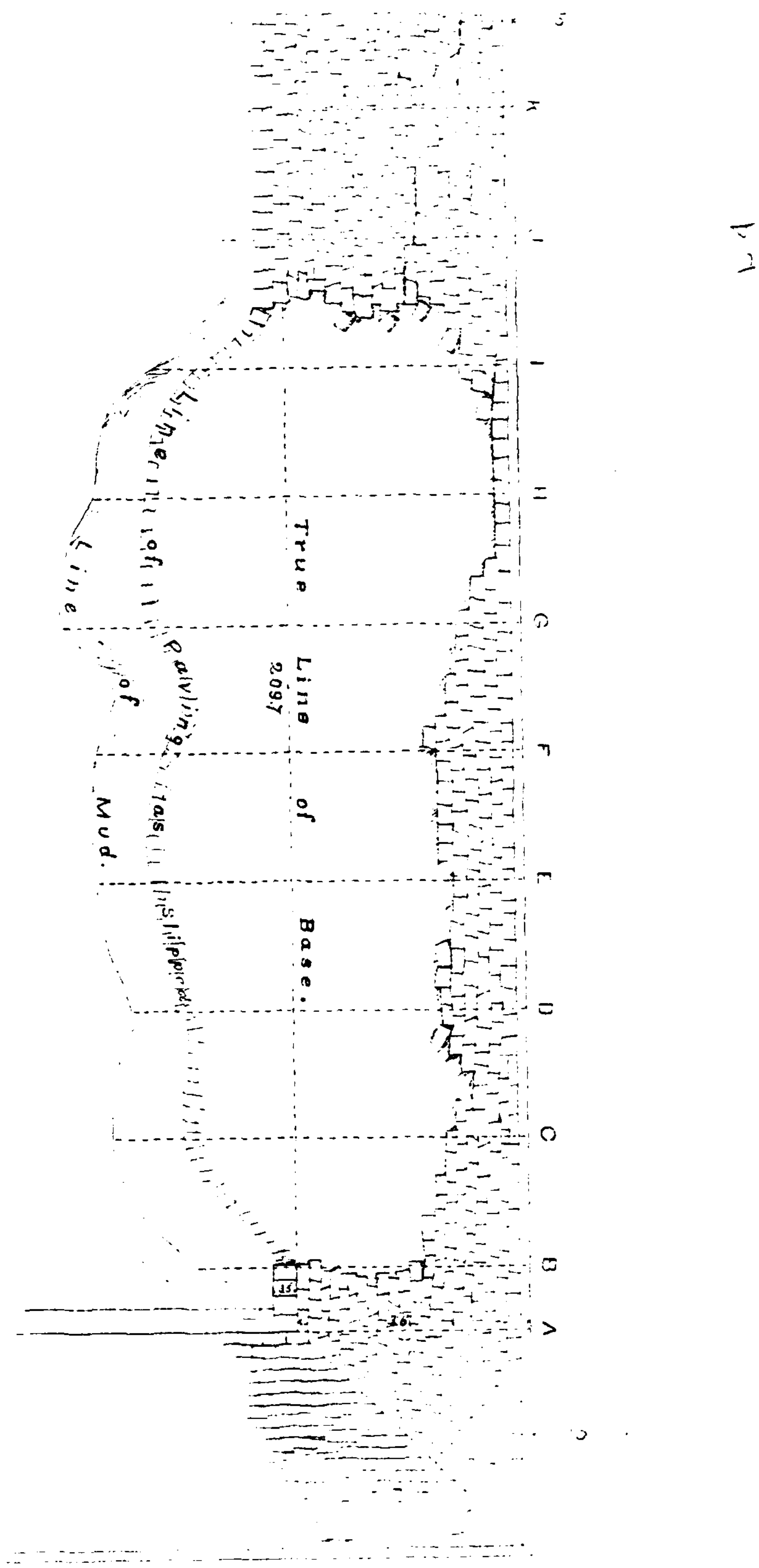
LINES OF EXCAVATION FOR REPAIRS

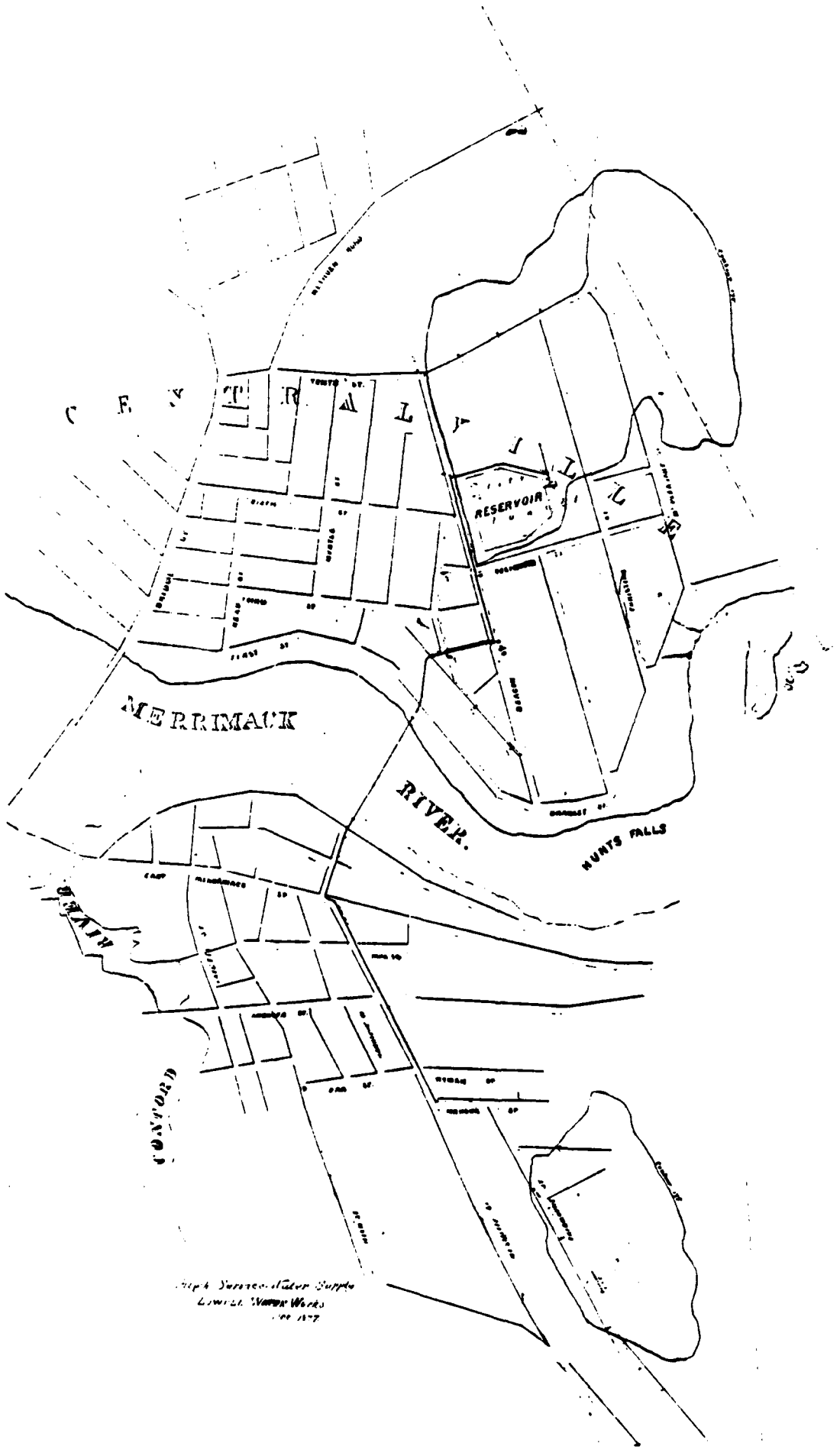
Dec. 1885.

Scale of Sections 8ft.=1in.
" " Plan 20ft.=1in.

Gu. E. E.

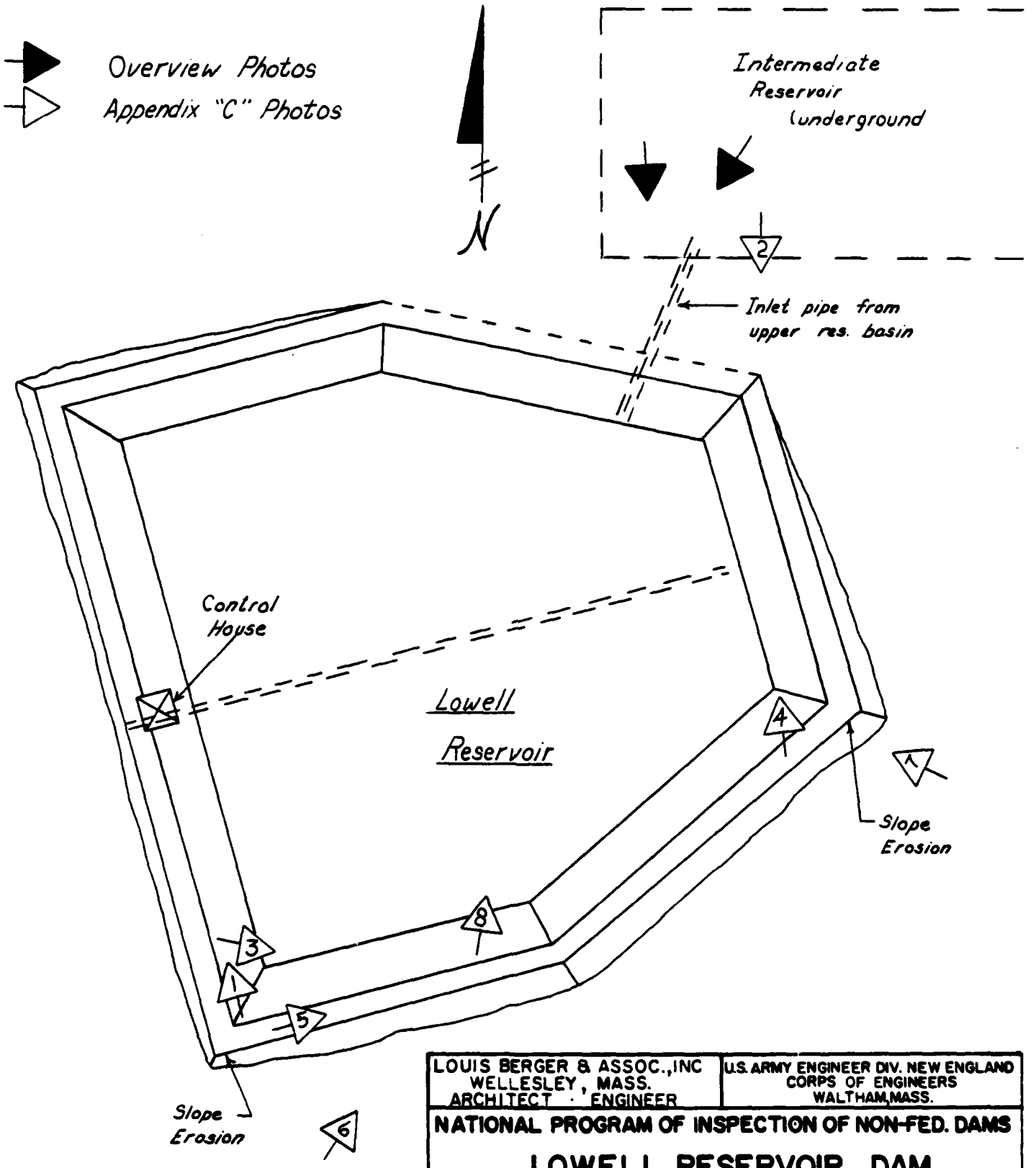





RESERVOIR
MERRIMACK
RIVER.
HUNTS FALLS
CONCORD
RIVER

Appendix C

Photos



LOUIS BERGER & ASSOC., INC WELLESLEY, MASS. ARCHITECT · ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOWELL RESERVOIR DAM

SKETCH PLAN SHOWING LOCATION & ORIENTATION OF PHOTOS

STATE - MA.

			SCALE NOT TO SCALE
			DATE

1. Crest and downstream slope of west embankment.Outlet control house at about mid length of embankment.

2. View of east embankment from Intermediate Reservoir.

3. Missing stones from upstream riprap.

4. Brush growth along upstream slope of east embankment.

5. Brush and tree growth along upstream slope and crest of south embankment.

6. Brush and tree growth along downstream slope of south embankment.

7. Foot path on downstream slope of southwest embankment.

8. View of covered Intermediate Reservoir (background) immediately north of Lowell Reservoir (foreground).

Appendix D

Hydrologic and Hydraulic Computations

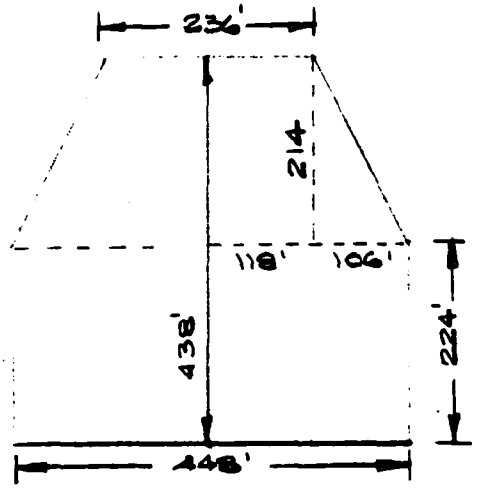
BY REB DATE 12-14-80 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 1 OF 2

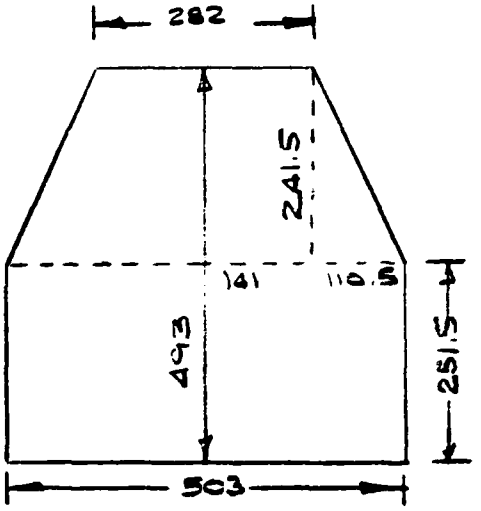
CHKD. BY DATE PROJECT

SUBJECT LOWELL RESERVOIR HYDROLOGY

CITY REPORTS NOMINAL CAPACITY = 32 X 10⁶ GALLONS

CHECK CAPACITY





SURFACE @ ELEV. 216.0

SURFACE @ ELEV. 234.3

AREA @ ELEV 216.0 = A_1

$A_1 = 224(448) + 118(214)(2) + (106)(214)(\frac{1}{2})(2) = 173\,540 \text{ FT}^2$

AREA @ ELEV. 234.3 = A_2

$A_2 = (251.5)(503) + 141(241.5)(2) + (110.5)(241.5)(2)(\frac{1}{2})$

$A_2 = 221,293 \text{ SQ. FT}$

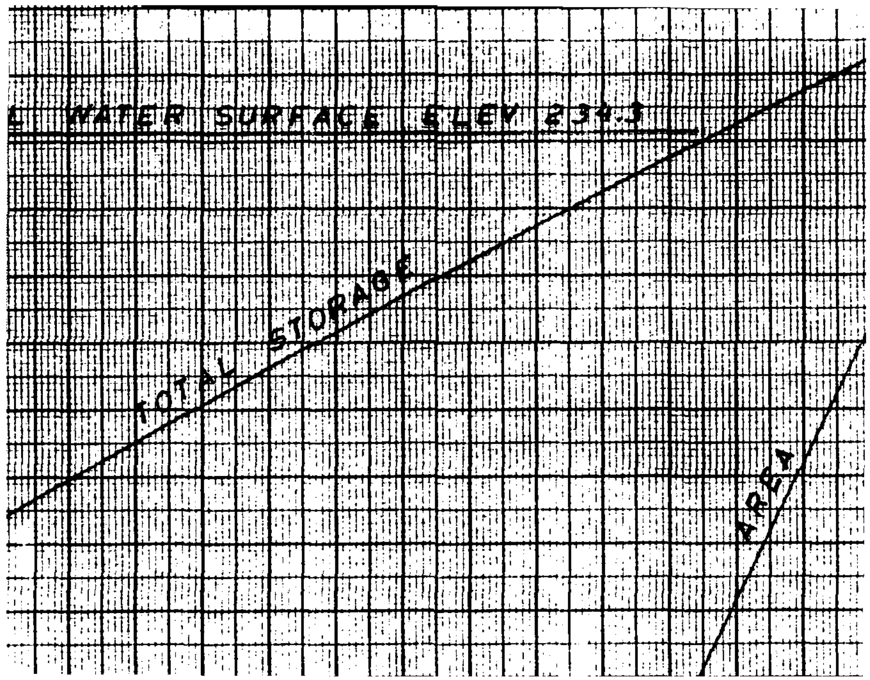
$A_1 = 3.98$ ACRES $A_2 = 5.08$ ACRES

VOLUME BELOW ELEV 216 = $\frac{1}{3} A_1 (h) = \frac{1}{3}(3.98)(1.25) = 1.66$ AF

* NOTE ABOVE DIMENSIONS SCALED FROM OLD PLAN OF RESERVOIR ON FILE AT LOWELL CITY HALL.

ELEV.	AREA	AVE AREA	ΔH	Δ STORAGE	TOTAL STORAGE
214.75	0	–	–	–	0
216	3.98	–	–	1.66	1.66
218	4.10	4.04	2	8.08	9.74
220	4.22	4.16	2	8.26	18.00
222	4.34	4.28	2	8.56	26.56
224	4.46	4.40	2	8.80	35.36
226	4.58	4.52	2	9.04	44.40
228	4.70	4.64	2	9.28	53.68
230	4.82	4.76	2	9.52	63.20
232	4.94	4.88	2	9.76	72.96
234.3	5.08	5.01	2.3	11.52	84.48
236	5.18	5.13	1.7	8.72	93.20
238	5.30	5.24	2	10.48	103.68
240	5.42	5.36	2	10.72	114.40

SAY VOLUME @ NORMAL STAGE ELEV 234.3
= 84.48 A.F.


WATER SURFACE ELEV 234.3
TOTAL STORAGE
AREA

BY RFB DATE 12-12-80 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 1 OF 2

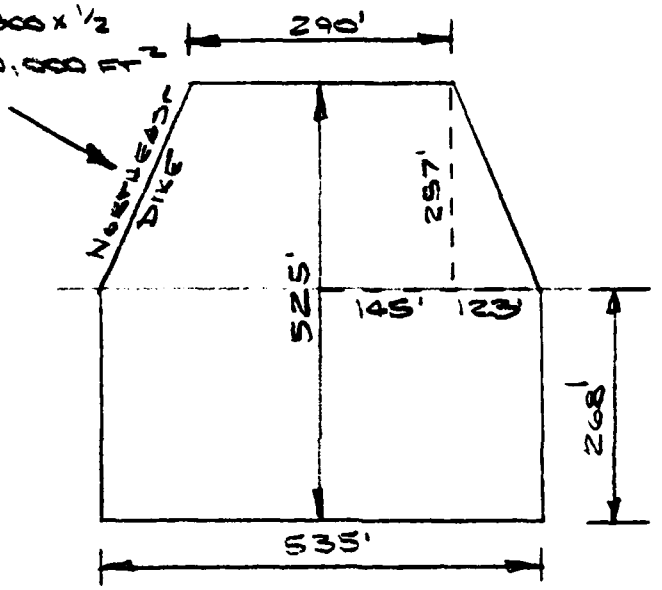
CHKD. BY DATE PROJECT

SUBJECT LOWELL RESERVOIRS PMP RUNOFF

ASSUME WATERSHED DIVIDE @ CENTERLINE OF CREST OF ALL DIKES EXCEPT AT NORTHEAST DIKE WHERE RUNOFF FROM A SMALL AREA OUTSIDE OF LIMITS OF RESERVOIR WILL DRAIN ACCROSS CREST.

$A_1 = 200 \times 300 \times 1/2$

$= 30{,}000 \text{ FT}^2$



$A_2 = (535)(268) + (145)(257)(2) + (123)(257)(2)(1/2)$

$A_2 = 249{,}521$

TOTAL AREA = $249{,}521 + 30{,}000 = 279{,}521 \text{ FT}^2$

TOTAL AREA = 6.42 ACRES

ASSUME 72 HR PMP, FROM "HYDROMETEOROLOGICAL REPORT NO. 51

PMP = 36" @ 10 MI^2

1/2 PMP = 18"

BY RFB DATE 12-12-80 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 2 OF 2

CHKD. BY DATE PROJECT

SUBJECT LONGLA RESERVOIR PMP RUNOFF

FIND VOLUME OF INFLOW FOR PMP:

VOL = 36 INCHES × 6.42 ACRES × 1 FT/12 IN

PMP INFLOW VOLUME = 19.26 A.F.

½ PMP INFLOW VOLUME = 9.63 A.F.

FIND FREEBOARD FOR PMP & ½ PMP

FOR PMP: TOTAL STORAGE = 84.48 + 19.26 = 103.7

RESERVOIR ELEV. = 238.1

PMP: FREEBOARD = 240.0 − 238.1 = 1.9 FT.

FOR ½ PMP: TOTAL STORAGE = 84.48 + 9.63 = 94.1

RESERVOIR ELEV. = 236.3

½ PMP: FREEBOARD = 240.0 − 236.3 = 3.7 FT

BY RFB DATE 12-15-80 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 1 OF 3

CHKD. BY DATE PROJECT W-195

SUBJECT LOWELL RESERVOIR FAILURE ANALYSIS

STEP 1

ASSUME FAILURE OF SOUTH-EAST EMBANKMENT WHICH IS THE LOWEST EMBANKMENT.

ASSUME FAILURE AT TOP FLOOD ELEVATION 238.1

STORAGE = S_1 = 104 ACRE-FT.

HEIGHT ABOVE DOWNSTREAM TOE = 238.1 - (240 - 26)

HEIGHT = Y_o = 24.1 FT

LENGTH OF EMBANKMENT = 270 FT @ CREST

W = 20% OF 270 = 54 FT

STEP 2

$$Q = 8/27\, W \sqrt{g}\, Y_o^{3/2}$$

$$Q = 1.68\,(54)(24.1)^{3/2}$$

$$Q = 10{,}730$$

REACH #1 - RESERVOIR TO MERRIMACK RIVER

STEP 3 L = 2100 FT

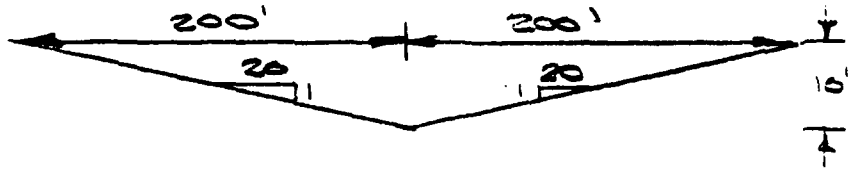
$$S = \frac{230-70}{1500} = 0.10$$

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

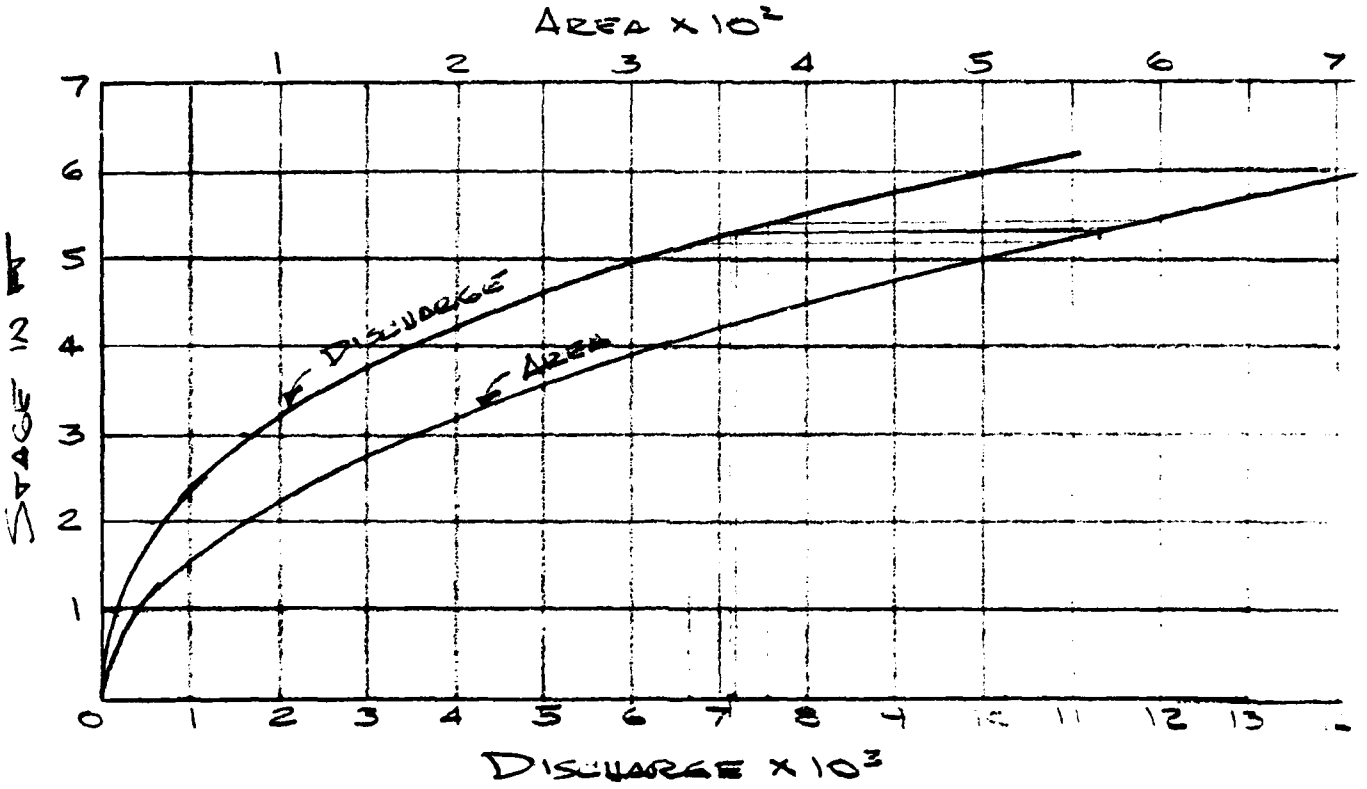
$$S^{1/2} = 0.316$$

$$Q = 6.71\, A R^{2/3}$$

$n = .070$



STAGE	AREA	P	$R^{2/3}$	Q
1	20	40	0.63	85
2	80	80.1	1.0	540
3	180	120.1	1.31	1560
4	320	160.2	1.59	3410
5	500	200.2	1.84	6170
6	720	240.3	2.08	10050



STEP 4

FOR Q = 10,730 , STAGE = 61 FT , AREA = 730

$$V_1 = \frac{730 \times 2100}{43{,}560} = 35 \text{ A.F.}$$

$$Q_{P2\,(TOTAL)} = 10{,}730\left(1 - \frac{35}{104}\right)$$

$$= 7{,}120 \text{ CFS}$$

FOR Q = 7,120 , STAGE = 5.3, AREA = 568 A.F.

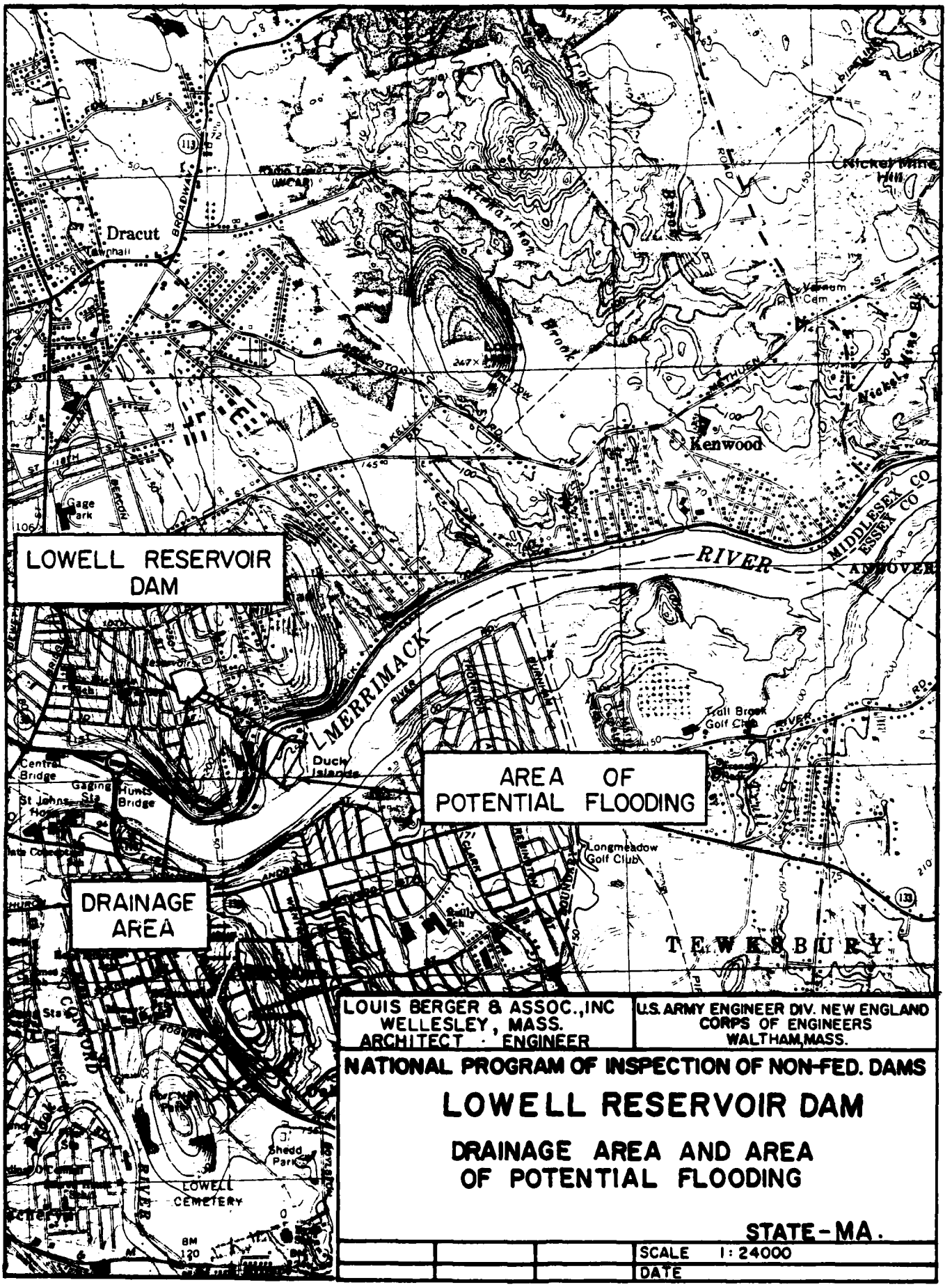
$$V_2 = \frac{568 \times 2{:}00}{43{,}560} = 27 \text{ A.F.}$$

$$\frac{V_1 + V_2}{2} = \frac{35+27}{2} = 31. \text{ A.F.}$$

$$Q_{P2} = 10{,}730 \left(1 - \frac{31}{104}\right)$$

Q_{P2} = 7,530 , STAGE ≅ 5.4' ±, AREA = 590

CHECK VELOCITY = $\frac{7530}{590} \cong$ 12.8 F/SEC.



LOUIS BERGER & ASSOC., INC WELLESLEY, MASS. ARCHITECT · ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOWELL RESERVOIR DAM

DRAINAGE AREA AND AREA OF POTENTIAL FLOODING

STATE - MA.

			SCALE 1:24000
			DATE

Appendix E

Information as Contained in the National Inventory of Dams

INVENTORY OF DAMS IN THE UNITED STATES

(1) STATE	(2) IDENTITY NUMBER	(3) DIVISION	(4) STATE	(5) COUNTY	(6) CONGR DIST.	(7) STATE	(8) COUNTY	(9) CONGR DIST.	(9) NAME	(10) LATITUDE (NORTH)	(11) LONGITUDE (WEST)	(12) REPORT DATE DAY | MO | YR
MA	118M	NED	MA	017	05				LOWELL RESERVOIR DAM	4239.0	7117.7	23OCT80

(13) POPULAR NAME	(14) NAME OF IMPOUNDMENT
	LOWELL RESERVOIR

(15) REGION	(16) BASIN	(17) RIVER OR STREAM	(18) NEAREST DOWNSTREAM CITY–TOWN–VILLAGE	(19) DIST FROM DAM (MI.)	(20) POPULATION
01	06	OFF STREAM	LOWELL	0	94200

(21) TYPE OF DAM	(22) YEAR COMPLETED	(23) PURPOSES	(24) STRUCTURAL HEIGHT (FT.)	(25) HYDRAULIC HEIGHT (FT.)	(26) IMPOUNDING CAPACITIES MAXIMUM (ACRE–FT.)	(27) IMPOUNDING CAPACITIES NORMAL (ACRE–FT.)	DIST	DWN	FED R	PRV/FED	SCS A	VER/DATE
RE	1872	S	26	25	114	84	NED	N	N	N	N	

(28) REMARKS

(29) D/S MAS	(30) SPILLWAY CREST LENGTH	(31) SPILLWAY TYPE	(32) SPILLWAY WIDTH (FT.)	(33) MAXIMUM DISCHARGE (FT.)	(34) VOLUME OF DAM (CY)	(35) POWER CAPACITY INSTALLED (MW)	(36) POWER CAPACITY PROPOSED (MW)	(37) NO.	(38) NAVIGATION LOCKS LENGTH (FT.)	(39) WIDTH (FT.)	(40) LENGTH (FT.)	(41) WIDTH (FT.)	(42) LENGTH (FT.)	(43) WIDTH (FT.)	(44) LENGTH (FT.)	(45) WIDTH (FT.)
1	1450	U			33300											

(46) OWNER	(47) ENGINEERING BY	(48) CONSTRUCTION BY
CITY OF LOWELL	UNKNOWN	UNKNOWN

(49) REGULATORY AGENCY DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	MA DEQE	MA DEQE

(50) INSPECTION BY	(51) INSPECTION DATE DAY | MO | YR	(52) AUTHORITY FOR INSPECTION
LOUIS BERGER & ASSOC INC	23OCT80	PL 92-367

(53) REMARKS

END

FILMED

7-85

DTIC