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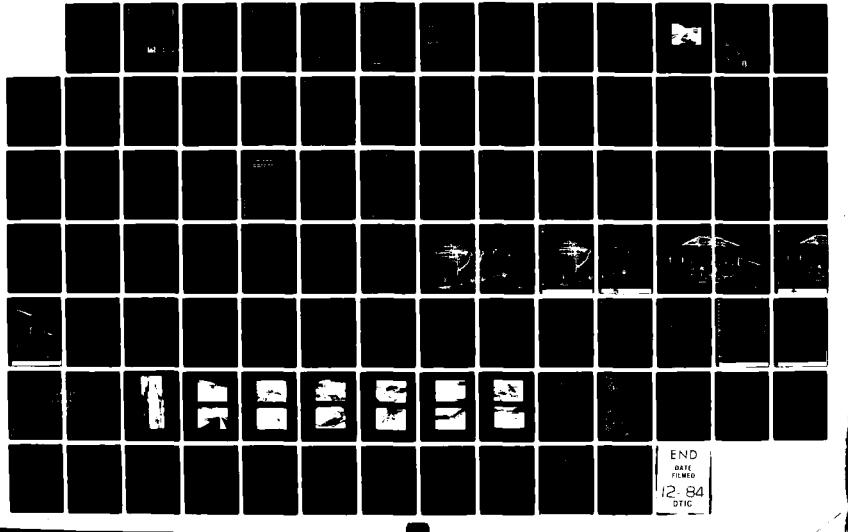
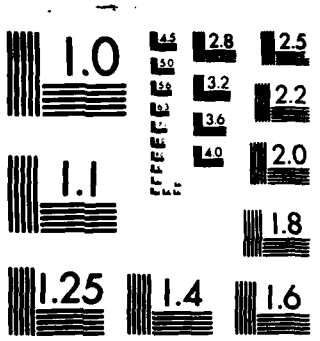
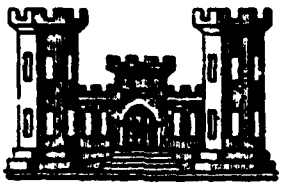




MASSACHUSETTS—RHODE ISLAND COASTAL BASIN
GLOUCESTER, MASSACHUSETTS

BABSON RESERVOIR DAM
MA 00187

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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

NOVEMBER 1978

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Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

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Mass. - Rhode Island Coastal Basin
Gloucester, Mass.

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

The dam consists of an earth embankment approximately 630 feet long and 40 ft. high with an ungated spillway about 40 feet long at the center of the structure. Babson Reservoir Reservoir Dam is currently classified as having a "high" hazard potential in the Corps of Engineers National Inventory of Dams. The test flood is the PMF.

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

REPLY TO
ATTENTION OF:

NEDED

JAN 22 1979

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

Dear Governor King:

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

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. In addition, a copy of the report has also been furnished the owner, City of Gloucester, Public Works Department, Poplar Street, Gloucester, Massachusetts 01930, ATTN: Mr. Robert O'Brien, Director.

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 yours,

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

MASSACHUSETTS-RHODE ISLAND COASTAL BASIN
GLOUCESTER, MASSACHUSETTS

BABSON RESERVOIR DAM
MA 00187

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

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

NOVEMBER 1978

PHASE I INVESTIGATION REPORT
NATIONAL DAM INSPECTION PROGRAM

Identification No.:	MA 00187
Name of Dam:	Babson Reservoir
Town:	Gloucester
County:	Essex
State:	Massachusetts
Stream:	Tributary to Mill River
Date of Site Visit:	8 September 1978

BRIEF ASSESSMENT

Babson Reservoir is located on Alewife Brook approximately one mile north of the City of Gloucester, Mass. A dam, spillway and intake works were constructed in 1930 to impound a water supply for the City. The dam consists of an earth embankment approximately 630 ft. long and 40 ft. high with an ungated spillway about 40 ft. long at the center of the structure. The only outlet is a 24-in. pipe from a gate house intake located in the upstream slope.

Babson Reservoir Dam is currently classified as having a "high" hazard potential in the Corps of Engineers National Inventory of dams.

Based on a visual examination of the structure, the earth embankment and spillway are in good to fair condition. There was no evidence of settlement, lateral movement or other signs of structural failure or other conditions which would warrant urgent remedial treatment.

Based on size and hazard classifications in accordance with Corps of Engineers guidelines, the test flood for this dam is the Probable Maximum Flood (PMF). The spillway has a capacity of 1790 cfs with flashboards removed and can pass the PMF outflow of 1530 cfs (750 csm) with the water level 0.6 ft. below the top of the concrete core wall.

Within two years after receipt of this Phase I Inspection Report, the City of Gloucester, owner of the dam, should engage a registered professional engineer to determine embankment slope stability during an earthquake event and implement the results of this evaluation. The owner should also implement the remedial measures, including removal of trees and brush from the downstream slope and repair of deteriorating concrete, as outlined in Section 7.3.

HALEY & ALDRICH, INC.
by:

Harl Aldrich
President

COMMONWEALTH OF MASSACHUSETTS
HARL P. ALDRICH, JR. 7734
REGISTERED PROFESSIONAL ENGINEER

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

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

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

JOSEPH A. MCELROY, CHAIRMAN
Chief, NED Materials Testing Lab.
Foundations & Materials 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, DC 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

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

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

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

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TABLE OF CONTENTS (Continued)

1. Overview of crest and upstream slope from left abutement.

FILE NO. 4160 A18

DAM: Babson Reservoir

IDENTIFICATION NO. MA 00187

N

LOCATION MAP

USGS QUADRANGLE

GLOUCESTER, MA.

APPROX. SCALE: 1"= 2000'

PHASE I INVESTIGATION REPORT
NATIONAL DAM INSPECTION PROGRAM
BABSON RESERVOIR DAM
MA 00187

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.

Haley & Aldrich, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed were issued to Haley & Aldrich, Inc. under a letter dated 26 April 1978 from Colonel Ralph T. Garver, Corps of Engineers. Contract No. DACW33-78-C-0301 has been assigned by the Corps of Engineers for this work. Camp, Dresser & McKee, Inc. was retained as consultant to Haley & Aldrich, Inc. on the structural, mechanical/electrical and hydraulic/hyrologic aspects of the investigation.

B. Purpose. The primary purposes of the National Dam Inspection Program are to:

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

2. Encourage and prepare the states to initiate quickly effective dam safety programs for non-Federal dams.

3. To update, verify and complete the National Inventory of Dams.

1.2 PROJECT DESCRIPTION

A. Location. The dam impounds Babson Reservoir on Alewife Brook, a tributary to the Mill River, in the City of Gloucester, Massachusetts. The dam is located on the southwest end of the reservoir, as shown on the Location Map, page vii.

B. Dam and Appurtenances. The Babson Reservoir Dam consists of an earth embankment, an ungated concrete-faced spillway near the middle of the embankment, and a gate house structure. The total length of the dam is approximately 630 ft. The "Site Sketch Plan", Appendix C-1, shows the general configuration of the dam and appurtenances. More detailed plans and sections are shown on construction drawings in Appendix B.

The right and left embankments are approximately 40 ft. high. Slopes are 2 horizontal to 1 vertical on the downstream side. The upper part of the upstream side is sloped 2.5 to 1, becoming 2.75 to 1 below a berm at El. 45. The embankments contain a 15-in. thick concrete core wall bearing on rock or interlocking steel sheet piling driven to rock, as shown on the section in Appendix B-10. The lower part of the upstream slope is protected by riprap and the upper part is paved with reinforced concrete. There is a gravel road on the crest of the left abutment and the downstream slopes are wooded.

The spillway is a broad crested weir with 2 horizontal to 1 vertical discharge slope supported by rock fill founded on bedrock. It is 40 ft. long with a crest at El. 55, 5.8 ft. below the top of the concrete core wall. Three rows of four 6-in. tile drains exit on the discharge slope. A cross-section through the spillway is also shown in Appendix B-10.

A gate house structure is located left of the spillway on the upstream slope of the dam embankment. The reservoir drain is a 24-in. pipe from the gate house with a hand operated valve near the discharge end. This pipe also feeds a 16-in. line to the pump station downstream of the left embankment.

C. Size Classification. Babson Reservoir has an estimated maximum storage of 925 acre-feet and the dam has a maximum height of about 40 feet. Storage of from 50 to 1,000 acre-feet and a height of from 25 to 40 feet classifies a dam to be in the "small" size category, according to guidelines established by the Corps of Engineers

D. Hazard Classification. Babson Reservoir is currently classified as having a "high" hazard potential in the Corps of Engineers National Inventory of Dams. Computations based on "Guidance for Estimating Downstream Dam Failure Hydrograph", included in Appendix D, confirm this classification. In the event of a failure of the dam, the water pumping station, the elderly housing development, and the dense residential district located near the foot of the dam would be completely inundated. Loss of life and excessive economic losses from structural damage would prevail along both sides of the brook from the dam to its outlet into Mill Pond Tidal Basin.

E. Ownership. The name and address of the owner are:

City of Gloucester
Public Works Department
Poplar Street
Gloucester, MA 01930
(Phone: 617/283-5940)

The dam has always been owned by the City of Gloucester. Mr. Robert O'Brien is the current director of the Public Works Department.

F. Operator. Mr. Wilford Burke is the superintendent of the water treatment plant and responsible for the day-to-day operation of the dam. He represented the owner during this investigation. His address and telephone number are the same as the owners, listed above.

G. Purpose of Dam. Babson Reservoir Dam was built and is used for impounding a water supply for the City of Gloucester.

H. Design and Construction History. The Babson Reservoir Dam was designed by Fay, Spofford & Thorndike in 1930 to create a water supply for the City of Gloucester. The scope of work included engineering studies of the Alewife Brook watershed and several test borings.

As indicated by the six test borings shown in Appendix B-9 and later during excavation and construction, the site was underlain by stiff blue clay, glacial till with boulders and bedrock which formed a natural basin. Steel sheeting and a 15-in. thick concrete core wall were used to effect a cut off to rock for the dam. Selected soils and boulders excavated from the reservoir were incorporated into the embankments and used for riprap. The gate house was founded on clay.

Construction of the dam began in July 1930 and was completed in six months by C. & R. Construction. Several contract drawings prepared by Fay, Spofford and Thorndike are included in Appendix B to show details of the original construction.

Flashboards were added as proposed by Metcalf & Eddy in 1950 to increase the capacity of the reservoir. Around 1968, a 30-in. diameter pipeline was constructed from Babson Reservoir to Goose Cove. In 1970 the water treatment plant adjacent to the dam was completed.

I. Normal Operational Procedures. There is no established formal routine for the operation of the dam. The dam, being a water supply dam, is operated according to the demand and supply of water and the funds available for its operation and maintenance.

1.3 PERTINENT DATA

All elevations appearing on drawings and referred to in this report are based on a local datum. To convert from the local datum to National Geodetic Vertical Datum (NGVD), add 3.03 ft. to elevations based on the local datum.

A. Drainage Area. The drainage area of Babson Reservoir is approximately 1,310 acres (2.04 square miles), including the watershed of Cape Pond, water supply for Rockport. The Cape Pond drainage area (Cape Pond is the source of Alewife Brook, the major tributary to Babson Reservoir) comprises an estimated 275 of the total 1,310 acres. Because runoff from the Cape Pond watershed would be tributory to the Babson Reservoir watershed during periods of high runoff, it has been included in the computations for the test flood. The Babson Reservoir pool occupies 40 acres, or 3.1 percent of the total drainage area. The watershed's topography is a mixture of flat and coastal terrain with some moderate hills and swampy areas located adjacent to Alewife Brook.

B. Discharge at Dam Site

1. Outlet Works.....	24-in. dia. pipe at invert El. 24
2. Maximum known impoundment at dam site.....	Unknown
3. Ungated spillway capacity at top of dam.....	1790 cfs at El. 60.8
4. Ungated spillway capacity at test flood pool elevation..	1530 cfs at El. 60.2
5. Gated spillway capacity at normal pool elevation.....	Not applicable
6. Gated spillway capacity at test flood pool elevation..	Not applicable

7. Total spillway capacity at test flood pool elevation.. 1530 cfs at El. 60.2
8. Total project discharge at test flood pool elevation.. 1530 cfs at El. 60.2

C. Elevation (Local datum)

1. Top dam..... 60.8
2. Test flood pool-design surcharge..... 60.2
3. Design surcharge-original design..... 58.25
4. Full flood control pool..... Not applicable
5. Water supply pool (full)..... 55
6. Spillway crest
   (with flashboards)..... 57.15
   (without flashboards)..... 55
7. Upstream portal invert diversion tunnel..... Not applicable
8. Streambed at centerline of dam..... 21
9. Maximum tailwater..... Unknown

D. Reservoir

1. Length of maximum pool..... 0.72 mi. (Est.)
2. Length of water supply pool (full)..... 0.72 mi. (Est.)
3. Length of flood control pool..... Not applicable

E. Storage (acre-feet)

1. Top of dam..... 925
2. Test flood pool..... 887
3. Flood control pool..... Not applicable
4. Water supply pool (full)..... 635
5. Spillway crest..... 635

F. Reservoir Surface (acres)

1. Top of dam..... 63.5
2. Test flood pool..... 62.5
3. Flood control pool..... Not applicable
4. Water supply pool (full)..... 56
5. Spillway crest..... 56

G. Dam Embankment

1. Type	Earth
2. Length	Approx. 630 ft.
3. Height	Approx. 40 ft.
4. Top Width	Approx. 15 ft.
5. Side Slopes	2.5:1 and 2.75:1 U/S and 2:1 D/S
6. Zoning	Selected pervious material downstream of core wall
7. Impervious core	Concrete core wall
8. Cutoff	Concrete core wall or steel sheet piling to rock
9. Grout curtain	None
10. Other	Core wall drain and toe drain

H. Diversion and Regulating Facilities. Not applicable.

I. Spillway

1. Type	Irregular shape (broad crested weir with discharge face sloped 2:1)
2. Length of weir	39.75 ft.
3. Crest elevation	55.0 (57.15 with flashboards)
4. Gates	None
5. U/S Channel	Approx. 0.15 percent slope
6. D/S Channel	Approx. one percent slope

J. Regulating Outlets. The main intake is a 24-in. cast-iron pipe with an invert at El. 24 at the gate house. The pipe feeds a 16-in. intake line to the pump station and a 16-in. bypass line. The capacity of this 16-in. intake line is approximately 40 cfs. At the junction of the 16-in. lines with the 24-in. intake, there is a 24-in. cast-iron blow off line to the stilling basin. The blow off line is controlled by a manually operated gate valve in a manhole at the toe of slope for the dam. During the field inspection, this blow off was shown to be operable.

The intake line is controlled by a manually operated valve in the gate house at the dam crest. There are places for three slots for screens in the gate house.

Two additional methods are available for the purpose of drawing down the level in the reservoir. One is to pump the water into Goose Cove via a 30-in. diameter cast iron pipe utilizing the 4 to 5 mgd capacity pumps located at Goose Cove. The second way is to run the water through the treatment plant at the reservoir via the 16-in. C.I. main.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN RECORDS

An engineering design report, Appendix B-4, and contract drawings for the dam prepared by Fay, Spofford & Thorndike in 1930 are available. The drawings include details of many design features. Correspondence from the Essex County Engineer relates to the spillway stability and design of the flashboards.

2.2 CONSTRUCTION RECORDS

The original construction activities were periodically observed and reported by the Essex County Engineer.

2.3 OPERATION RECORDS

Operation records in the form of reservoir water levels and inspection reports by outside agencies are available on the dam.

2.4 EVALUATION

A. Availability. All of the design, construction and operation records mentioned above and available for use in preparing this report are listed in Appendix B with the locations where they can be found. Selected documents from the listing are also included in Appendix B.

B. Adequacy. The available engineering data when used in combination with the visual examination described in Section 3 were adequate for the purposes of the Phase I Investigation.

C. Validity. The information contained in the engineering data may be generally considered valid. Details on the drawings are shown as designed and may vary slightly from those actually built. For example, the configuration of the channel immediately downstream of the spillway differs from that shown on the drawings.

SECTION 3 - VISUAL EXAMINATION

3.1 FINDINGS

A. General. The Phase I visual examination of the Babson Reservoir dam was conducted on 8 September 1978.

In general, the dam embankment and spillway were found to be in good to fair condition. Some deficiencies which require correction were noted.

A visual inspection check list is included in Appendix A and selected photographs of the project are given in Appendix C.

B. Dam. The earth embankment located right and left of the spillway is generally in good condition. There was no evidence of settlement, lateral movement or other serious defects. Concrete paving on the upstream slope is in satisfactory condition except for localized areas where the concrete has deteriorated. The downstream slope could not be examined closely because of brush and trees.

The following deficiencies were noted:

1. Concrete pavement slabs on the upstream slope have deteriorated in several localized areas, the most severe of which is shown in Photo No. 6. Isolated cracking and minor differential settlement of the slabs relative to the core wall has occurred. The sealant used at the slab joints has broken down and needs replacement. A number of joints now have vegetation. The upstream slope is shown in Photos No. 4 and 5.

2. The downstream slope is covered by trees, brush, weeds and grass. Trees are mature scotch pine from 10 to 15 in. in diameter and spaced 10 to 15 ft. apart. It appears that they were systematically planted. One tree located at the top of slope near the right abutment was blown over and uprooted. Vegetation on the downstream slope is shown in Photos No. 2, 3, 7 and 8 as well as others.

3. Minor seepage in the form of a small (less than 10 ft. square) wet area occurs at the toe of the embankment, approximately 105 ft. left of the spillway. No flowing water was noted. It is understood that this condition has existed for years.

4. Earth fill at the top of the embankment immediately right of the spillway has been eroded by rainfall and foot traffic. The maximum depth is about 3 ft. at the top of the downstream slope. Since the concrete core wall at El. 60.8 forms the top of the dam, minor erosion downstream of the wall is not considered serious.

5. Minor small depressions in the embankment immediately downstream of the core wall were noted. The cause of these depressions is not known, but does not appear to be a result of erosion through joints in the concrete core wall.

The core wall and toe drains discharge into the stilling basin at the toe of the spillway. Both drains were flowing clear. The left drain is shown immediately left of the 24-in. blowoff pipe in Photo No. 11. The outlet of the right drain is submerged, and is located just in front of the observer in Photo No. 12. Coarse gravel and stones cover the end of the pipe.

The exposed portion of the concrete core wall is in good condition. The wall has been patched a number of times and a portion of these patches are now loose. The surface of the wall has eroded and exposed the aggregate. The sealant at the wall joints has broken down and needs replacement. Minor vegetation is present at some of these joints. Other joints have started to break down.

C. Appurtenant Structures. The spillway was found to be in good condition. The approach to the spillway is formed by pavement slabs on the upstream face of the dam, Photo No. 9. The surface of the slabs has eroded and the aggregate is exposed. The sealant at slab joints has broken down. Two logs are present at the entrance to the spillway, Photo No. 9. The impact of these logs against the core wall has caused spalling of the wall. Flashboards on top of the weir are in good condition. The flashboards have been securely bolted to each other and fastened to the training walls. It is questionable whether these flashboards would release under flood conditions.

The downstream side of the spillway, Photo No. 10, is formed by inclined pavement slabs placed on rock fill. The slabs show considerable erosion on the surface. Joint sealant has broken down at the joints and vegetation is present. Cold

joints in the slab have been exaggerated by the erosion. The side walls of the downstream portion of the weir (chute) have been patched. A number of these patches are now loose. Shrinkage cracks and several stress cracks are present in the side walls. Efflorescence is present on the wall surfaces. Considerable erosion has taken place at the downstream end of the chute where it joins the stilling basin. The surface of the chute has stains from the discharge of drain holes in the chute, Photo No. 12.

The side walls of the stilling basin are of reinforced concrete. The left side wall shows considerable cracking and efflorescence. This wall should be considered in good to fair condition. The right side wall shows minor cracking and some efflorescence. This wall is in good condition. The end walls of the stilling basin are of cut stone masonry. One small section of this wall, on the left side where it joins the downstream channel, is on the verge of collapse. The rest of the cut stone masonry wall is in good condition with some open joints.

The gate house, Photo No. 14, is in good condition. The superstructure is of cut stone masonry. One crack was noticed in the stone work on the left side of the gate house. Metal work in the form of ladders, railings, hatches and screen guides show considerable deterioration. Hatches have been removed from the openings they once covered. This metal work is considered to be in good condition. The exterior surface of the concrete has been eroded to expose the aggregate at the water line. The interior surfaces of the concrete show cracking and efflorescence.

The service bridge to the gate house is in good condition except for the concrete support brackets at the gate house end. The two brackets show considerable cracking and loose concrete. These brackets should be considered in poor condition.

All railings observed on the service bridge and within the gate house are considered to be in poor condition. Major portions of these railings are missing. The remaining portions show considerable deterioration.

D. Reservoir Area. The area around Babson Reservoir is generally wooded with irregular topography and rock outcrops. There are no conditions which would lead to a significant increase in sediment load to the reservoir or landslides which would cause waves to overtop the dam.

E. Downstream Channel. The channel downstream of the stilling basin is shown in Photo No. 13. It is a narrow channel formed by stone masonry walls and differs from the 48 ft. wide "ditch" shown on the drawing in Appendix B-9. The channel is discussed further in Section 5.

3.2 EVALUATION

Based on visual observations during the site examination, the general condition of the project is satisfactory. Deficiencies which have been noted should not have a serious effect on the performance or safety of the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

In general, there are no formal procedures to assure regular maintenance and satisfactory operation of the dam. The current dam operator attempts to keep an adequate water supply in the reservoir by pumping water to or from Goose Cove Reservoir.

4.2 MAINTENANCE OF DAM

There are no established procedures to assure periodic inspection and maintenance of the dam. A maintenance crew from the Gloucester Public Works Department is available to perform work when requested.

4.3 MAINTENANCE OF OPERATING FACILITIES

The operation of the facility is based on the demand and supply of water rather than any formal established operational procedures.

The outlet from the dam does not receive regular maintenance, but is operational. However, the gates appear to have received limited maintenance.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no formal warning system or emergency preparedness plan in effect for this structure.

4.5 EVALUATION

The current operation and maintenance procedures for Babson Reservoir are inadequate for a high hazard structure of this size. An annual inspection and maintenance program should be developed to remedy deficiencies before they become a threat. In addition, the City of Gloucester should establish a formal written emergency preparedness plan and warning system, since failure of the dam would cause loss of life and extensive property damage.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

A. Design Data. A set of plans entitled "Alewife Dam and Reservoir - Gloucester, Mass." bearing the date of June, 1930 were the basis for the construction of this facility. The reservoir was constructed in order to augment the City's water supply and was designed for a safe yield of 1 MGD. Hydraulic design data developed by Fay, Spofford, and Thorndike indicate that the spillway had been designed for a flow of 800 cfs. for a depth of flow of 3.25 ft. over the weir. However, the total freeboard of the dam above the weir level was designated to be 6 ft. for safety. The reservoir's inflow was computed using the Rational Method on the basis of a 2.25 square mile drainage area. However, because of land use changes and the construction of man-made drainage divides (i.e. Route 128), the present size of the watershed is approximately 2.04 square miles.

The recommended test flood for the size (small) and hazard potential (high) of this dam is in the range of the one-half probable maximum flood (1/2 PMF) to the probable maximum flood (PMF).

B. Experience Data. The PMF was determined using the chart prepared by the Corps of Engineers, New England Division in the Guidelines. Assuming flat and coastal terrain, the PMF is 1740 cfs. By taking advantage of surcharge storage, this peak is decreased to 1530 cfs. Because the water surface area is an estimated 3.05 percent (40 acres) of the total drainage area, flood routing techniques were not deemed worthwhile. The spillway will discharge the peak flow of 1530 cfs. with the reservoir water surface at El. 60.2, 0.6 ft. below the top of the concrete core wall.

C. Visual Observations. The inspection revealed that no significant modifications have been made to the inlet or outlet works since the construction of the dam, with the exception of the channel immediately downstream which is of man-made origin with vertical stone masonry walls. Approximately 62 ft. downstream of the dam's stilling basin, there exists a 60-inch diameter concrete pipe which carries the flow for an estimated 41 ft. at which point the stone channel resumes, Photo No. 13.

Approximately 260 ft. further downstream, the brook is conveyed in twin 48-inch concrete pipes under the road leading to the elderly housing project. After this point, the brook flows in a natural earth channel with cobbles and dense vegetation encroaching upon it. It is confined to culverts under the private way on the westerly side of the housing project (twin 36-in. diameter and one 12-in. diameter concrete pipes) under Cherry Street (36 in. x 58 in. C.M. Plate Arch) and under the D.P.W. Yard (48-in. diameter concrete pipe). It empties into what appears to be a tidal flood basin on the westerly side of the D.P.W. Yard and eventually into Mill Pond.

D. Overtopping Potential. As stated previously, based on the size (small) and hazard (high) classifications published in the Guidelines, the test flood falls in the range of the 1/2 PMF to the PMF. However, because of the elderly housing located in such close proximity to the base of the dam, as well as the surrounding dense residential district, the test flood has been designated the PMF. A rating curve for the dam's spillway was developed, and demonstrated that the spillway was capable of handling approximately 1790 cfs with the flashboards removed. Therefore, since the value of the PMF is 1530 cfs , it is estimated that the spillway can pass the test flood with 0.6 ft. of freeboard remaining.

E. Evaluation. As stated previously, the spillway is capable of handling the PMF. However, a failure of this dam would result in extensive downstream damage and loss of life would be unavoidable. The degree of this damage would lessen as one approached Mill Pond Tidal Basin. However, the high hazard potential from this flow would still exist until it entered the tidal basin. At this point, the available storage in the basin would most likely contain the flow.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF EMBANKMENT STRUCTURAL STABILITY

A. Visual Observations. There was no visual evidence of instability of the earth embankment during the site examination on 8 September 1978. However, it was not possible to closely examine the downstream slope because of dense vegetation.

B. Design and Construction Data. A theoretical analysis of the structural stability of the embankment slopes was not possible due to lack of pertinent design and construction data, in particular with reference to the properties of earth materials placed in the embankment. Nevertheless, since the embankment is only 40 ft. high, has a 2 horizontal to 1 vertical downstream slope and a central concrete core wall to rock and internal drains, the embankment slope can be expected to be stable under static loading conditions. Upstream slopes of 2.5:1 and 2.75:1 are reasonably flat.

C. Operating Records. No operating records or measurements from field instrumentation are known to exist for this dam.

D. Post-Construction Changes. There are no known post-construction alterations or additions to the project which affect embankment stability.

E. Seismic Stability. Babson Reservoir is located in Seismic Zone 3. The stability of the embankment slopes during an earthquake is unknown. Settlement of the crest and downslope movements during a seismic event are a function of foundation soils below the embankment and properties of embankment materials. These conditions should be determined and stability analyses made using conventional equivalent static load methods.

6.2 EVALUATION OF SPILLWAY STRUCTURAL STABILITY

A. Visual Observations. There was no visual evidence that movement or distress had taken place in the spillway.

B. Design and Construction Data. Design data in the form of construction plans are available on the spillway. A letter from the design engineers shown in Appendix B-7 states that the spillway as originally designed would have a stability "factor of safety of at least four".

The spillway is formed by concrete pavement slabs over rock fill on a 2:1 slope. The structural stability of the spillway is, therefore, dependent on the stability of the rock fill. Rock fill on a 2:1 slope, confined by concrete walls, can be expected to be adequately stable under static loads.

C. Operating Records. No records or other information was located which indicated stability problems with the spillway.

D. Post-Construction Changes. Although flashboards were added to the spillway after the original construction, there have been no post-construction structural alterations to the spillway.

E. Seismic Stability. The stability of this spillway under earthquake loading is dependent upon the seismic stability of rock fill which supports the concrete pavement slabs. While a Zone 3 earthquake event would cause some shifting and possible downslope movement of boulder fill and thus damage to the spillways, it is unlikely that the spillway would suffer a catastrophic failure.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 DAM ASSESSMENT

A. Condition. The visual examination of the Babson Reservoir dam revealed that the embankment and spillway are generally in good to fair condition. There were no obvious signs of failure or other conditions which would warrant urgent remedial treatment.

Based on the results of computations included in Appendix D, the spillway is capable of passing the test flood, which is based on the probable maximum flood, with 0.6 ft. of freeboard remaining.

B. Adequacy of Information. The information available concerning the design and construction of the dam are adequate for a Phase I Investigation when supplemented by field observations.

C. Urgency. The recommended additional investigation and remedial work outlined in Section 7.2 and 7.3 should be undertaken by the Owner and completed within 24 months after receipt of this Phase I Inspection Report.

D. Need for Additional Investigation. An additional investigation is required, as outlined in the following section.

7.2 RECOMMENDATIONS

It is recommended that the Owner engage a registered professional engineer experienced in dam design to undertake an investigation of embankment stability under earthquake loading conditions for Seismic Zone 3.

7.3 REMEDIAL MEASURES

A. Alternatives. Not Applicable.

B. Operating and Maintenance Procedures. The following remedial work should be undertaken by the City of Gloucester:

1. Cut and remove trees on the downstream slope of the embankment. Stumps may be cut flush with the ground and left in place. Remove all brush and cut grass

and weeds. For the future, the downstream slope should be mowed at least once a year to limit the height of vegetation and allow for visual examination of the embankment.

2. Place earth fill in shallow depressions at the top of the embankment adjacent to the concrete core wall. Place earth fill immediately right of the spillway where erosion has occurred, to restore embankment cross-section to the original design geometry.

3. Clear debris from the stilling basin below the spillway, in particular in the area of the underdrain discharge pipe on the right side. The pipe should flow freely without obstruction.

4. Repair the concrete support brackets at the gate house end of the service bridge.

5. Renew railings at this facility.

6. Renew gratings, hatches and ladders within the gate house structure.

7. Reseal all joints in the concrete pavement on the upstream slope, exposed core wall and spillway. Remove all loose concrete patches, fill all resultant voids, spalls, and missing pieces of pavement with concrete.

8. Resurface the chute portion of the spillway with shotcrete, mortar or other materials to prevent further deterioration of the spillway.

9. Repair the cut stone masonry wall at the entrance to the discharge channel.

Due to the "high" hazard potential classification, the Owner should establish a formal operations and maintenance manual for this dam. The operating procedure should include provisions for biennial technical inspection of the dam and for surveillance of the dam during periods of heavy precipitation and high reservoir water levels. The procedures should delineate the maintenance work to be done on the dam to ensure satisfactory operation and to minimize deterioration of the facility.

The Owner should develop a formal emergency preparedness plan and warning system to be used in the event of impending failure of the dam. The system should be developed in cooperation with other local officials and downstream inhabitants.

APPENDIX A
INSPECTION TEAM ORGANIZATION AND CHECK LIST

VISUAL INSPECTION PARTY ORGANIZATION

NATIONAL DAM INSPECTION PROGRAM

Dam: Babson Reservoir

Date: 8 September 1978

Time: 0900-1430

Weather: Clear and Cool (50's F.)

Water Surface Elevation Upstream: 51.45 (local datum)

Stream Flow: Negligible

Inspection Party:

Harl P. Aldrich, Jr. Haley & Aldrich, Inc.	- Soils/Geology
Roger H. Wood Camp, Dresser & McKee, Inc.	- Structural/Mechanical
Charles E. Fuller Camp, Dresser & McKee, Inc.	- Hydraulic/Hydrologic

Present During Inspction:

Wilford Burke, Chief of Treatment Plant
Richard A. Brown, Haley & Aldrich, Inc.
Donna D'Amore, Camp, Dresser & McKee, Inc.

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Babson Reservoir DATE: 8 Sept 78

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	60.0 (local datum); Top of concrete core wall El. 60.8
Current Pool Elevation	51.45
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed
Pavement Condition	No pavement
Movement or Settlement of Crest	None observed, except for numerous small shallow depressions adjacent to concrete core wall
Lateral Movement	None observed
Vertical Alignment	Good (top of concrete wall slightly uneven, by 1 to 2 in. in places)
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Conditions at abutments good; good immediately left of spillway; right of spillway, adjacent to wall, there has been erosion by rainfall and foot traffic up to 3 ft. depth, 4 ft. wide, at downstream side of crest
Indications of Movement of Structural Items on Slopes	No structural items on slopes
Trespassing on Slopes	Frequent at crest of dam and upstream slope, although area is posted
Animal Burrows in Embankment	None observed, but downstream slope difficult to examine because of vegetation
Vegetation on Embankment	Top of embankment is grass, mowed; trees, brush, weeds and grass on downstream slope including mature scotch pine from 10 to 15-in. diameter spaced 10 to 15 ft. apart
Sloughing or Erosion of Slopes or Abutments	Minor, but some at contact with spillway
Rock Slope Protection - Riprap Failures	No riprap; upstream slope is paved with a 6 in. reinforced concrete slab above El. 45; The surface of the concrete pavement has eroded and the aggregate is exposed. There is differential settlement

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Babson Reservoir DATE: 8 Sept 78

AREA EVALUATED	CONDITION
Rock Slope Protection - Riprap Failures (Cont.)	of the pavement slabs. Joints are in need of new sealant. There are a number of joints with minor vegetation present. There are isolated instances of broken slabs and small missing portion of pavement slabs
Unusual Movement or Cracking at or near Toes	None observed
Unusual Embankment or Downstream Seepage	Small wet area (less than 10 ft. square) at toe of embankment about 105 ft. left of spillway, no flowing water; another moist area nearby downstream toe.
Piping or Boils	None observed
Foundation Drainage Features and Toe Drains	6-inch vetrified clay drains immediately downstream of concrete core wall and at toe of embankment, discharge into spillway stilling chamber; water flowing from both pipes.
Instrumentation Systems	None
Exposed Concrete Core Wall	The exposed portion of the core wall has been patched in a considerable number of places. A number of these are now loose. Vertical cracks and efflorescence are present. The surface has eroded and exposed the aggregate. Joints have been sealed but it needs to be renewed. Breakdown of the concrete is ocurring at some of the joints. There are isolated instances of vegetation in the joints. The major portion of the railing on top of the wall is missing; the remaining portion is in disrepair.

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Babson Reservoir DATE: 8 Sept 78

AREA EVALUATED	CONDITION
OUTLET WORKS - APPROACH CHANNEL, SPILLWAY WEIR, STILLING BASIN AND DISCHARGE CHANNEL	
a. Approach Channel	
General Condition	Good condition. The channel is formed by pavement slabs which exhibit surface erosion. Sealant at joints has broken down and needs replacement
Log Boom	Two logs are present; one is an irregular tree trunk. This one appears susceptable of breaking at the small diameter end and becoming lodged in the spillway. The impact of the booms have caused spalls in the core wall
b. Weir and Training Walls	
General Condition of Concrete	Good condition. The weir is formed by inclined pavement slabs. The downstream portion of the weir has an eroded surface, breakdown of construction and cold joints, and vegetation in the joints. The sidewalls have been patched. Some of the patches are now loose. The sidewalls have shrinkage cracks and a few stress cracks. Earth has eroded from behind the right side wall. Stains from exposed tie wires are present on the back face of this wall. Considerable erosion and deterioration occurs where the downstream end of the weir or chute joins the stilling basin. This portion of the weir is stained by discharge from the drainholes. Efflorescence is present on the side walls. The flashboards on the weir are in good condition

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Babson Reservoir DATE: 8 Sept 78

AREA EVALUATED	CONDITION
Drain Holes	Drain holes on spillway slope are generally open. Three of four located at the toe are flowing
c. Stilling Basin	
General Condition	The left side wall shows many cracks and considerable efflorescence. The right side wall shows little cracking and some efflorescence. The end wall is cut stone masonry with some open joints. One small area of this wall where it becomes the left side wall of the discharge channel is almost completely broken down. The basin contains considerable soil reported to have been washed down from the dam embankment. The blowoff pipe as well as the underdrains from the dam discharge into the stilling basin. All pipes appear to be clear to drain although one of the underdrain outlets is presently below the silted area. Bottom of basin has automobile tires and other debris
d. Discharge Channel	
General Condition	Narrow vertical channel formed by stone masonry walls. Generally free of vegetation and debris. See text of report and photographs
OUTLET WORKS - GATE HOUSE	
a. Approach Channel	The outlet works is adjacent to the reservoir; no approach channel present

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Babson Reservoir DATE: 8 Sept 78

AREA EVALUATED	CONDITION
b. Gate House Structure	
General Condition	Good condition; the stone masonry superstructure has one noticeable crack in stone work. Windows and doors need replacement. Interior metal work especially ladder, hatches and guides for screens need replacement. Other interior metal work needs repainting. The concrete substructure shows erosion on the exterior surfaces at the water line. Efflorescence and cracking was observed on the interior side. There is debris present on the gate house floor
c. Bridge to Gate House	
General Condition	The concrete bridge is in good structural condition other than the concrete support brackets at the gate house end. The brackets indicate sever cracking and need for rebuilding. The bridge railing is in need of replacement
d. Mechanical and Electrical	
Reservoir Gauge	The mechanical float gauge is operable; reservoir level indicated by pointer on circular dial
Hoist	The hoist is operable but needs repainting
Service Gates	The service gates are operable but need repainting
Lightning Protection System	None observed
Emergency Power System	None
Wiring and Lighting System in Gate Chamber	Conduits and outlets have rust present. It is presently operable but its condition is only considered fair. It should be renewed

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Babson Reservoir DATE: 8 Sept 78

AREA EVALUATED	CONDITION
e. Outlet Pipeline	The pipeline is not visible for inspection

APPENDIX B
LIST OF AVAILABLE DOCUMENTS AND PRIOR INSPECTION REPORTS

LIST OF AVAILABLE DOCUMENTS
BABSON RESERVOIR DAM

DOCUMENT	CONTENTS	LOCATION*
Design report, Fay, Spofford & Thorndike, Inc., Boston, MA, 31 May 1930	Text, hydraulic calculations and location map for original dam design	Essex County Engineers Office(1) and Appendix B-4
Contract Drawings - Alewife Dam and Reservoir, Fay, Spofford & Thorndike, Inc., Boston, MA, June 1930	Sheet 1 - "General Plan and Key Map" Sheet 2 - "Plan of Dam, Boring and Grading" Sheet 3 - "Sections of Dam and Details" Sheet 4 - "Profile of Dam and Details" Sheets 5 & 6 - "Gatehouse and Substructure" Sheet 7 - "Pumping Station Plan and Sections" Sheet 8 - "Pumping Station Elevations and Details" Sheet 9 - "Pumping Station Electrical Details" Sheet 10 - "Miscellaneous Iron and Steel" Sheet 11 - "Elevated Tank and Force Main"	Gloucester Public Works Department(2) and Appendix B-9 and Appendix B-10

1

2

LIST OF AVAILABLE DOCUMENTS
BABSON RESERVOIR DAM (Cont.)

DOCUMENT	CONTENTS	LOCATION
"Alewife Dam, Gloucester, MA Inspections Made During Construction", R.R. Evans, Salem, MA, 1930	Detailed reports and a summary letter of construction inspections by the Essex County Engineer	Essex County Engineers Office(1) and Appendix B-11
"Stability Under Various Assumptions", R.R. Evans, Salem, MA, 30 October 1930	Calculations for stability against sliding by the Essex County Engineer	Essex County Engineers Office(1)
Letter from Fay, Spofford & Thorndike, Inc. to Essex County Engineer, dated 3 November 1930	Statement regarding adequacy of spillway stability design	Essex County Engineers Office(1) and Appendix B-7
Water Treatement Facilities, Contract No. 1964-2, City of Gloucester, 14 October 1964	Plans and specifications for treatment plant completed in 1970	Gloucester Public Works Department(2)
Letter from Metcalf & Eddy, Engineers, to Essex County Engineer, dated 5 November 1969	Discussion and plan drawing of filter and drain separating new treatment lagoon and the downstream slope of dam	Essex County Engineers Office(2)

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LIST OF AVAILABLE DOCUMENTS
BABSON RESERVOIR DAM (Cont.)

DOCUMENT	CONTENTS	LOCATION
Inspection reports from 1930 through 1968	As listed on cover page of Appendix B	Essex County Engineers Office(1) and Appendix B-13
Inspection reports after 1968	15 July 1971 report	Mass. Department of Environmental Quality Engineering(3) and Appendix B-20
Operation records	Reservoir levels	Gloucester Public Works Department(2)

*Addresses:

(1) Essex County Engineers Office
32 Federal Street
Salem, MA 01970

(2) Gloucester Public Works Department
Poplar Street
Gloucester, MA 01930

(3) Mass. Department of Environmental Quality Engineering
Division of Waterways
100 Nashua Street
Boston, MA 02114

FAY, SPOFFORD & THORNDIKE
CONSULTING ENGINEERS

TELEPHONE HUBBARD 1881
CABLE "FAYSPOR" BOSTON

44 SCHOOL STREET, BOSTON, MASS.

May 31, 1930

County Commissioners
Essex County
Salem, Massachusetts

Attention Mr. Robert R. Evans, County Engineer

Gentlemen:

We have been engaged by the Board of Water Commissioners of Gloucester, Massachusetts, to prepare contract drawings and specifications of a dam and reservoir together with appurtenant structures which they desire to build at the earliest possible moment on Alewife Brook in the City of Gloucester. They have requested us to submit to you all necessary data for your approval as required by the General Laws of the Commonwealth. We are, therefore, submitting herewith a United States Geological sheet upon which we have shown the location of the project and the extent of the natural watershed tributary to the site of the dam; a topographical plan of the dam and reservoir site showing the exact location of the dam; and a drawing showing the size of the dam and details of construction. We respectfully request for the Board of Water Commissioners your approval of the plans for the construction of this dam.

Location of Dam. The site of the dam is north of the built-up area of Gloucester proper on Alewife Brook about 400 feet distant from the corner of Poplar Street and Russell Avenue.

Area of Watershed. The area of the watershed of Alewife Brook which is tributary to the site of the dam, including the watershed of Cape Pond, is approximately 2.25 square miles. Cape Pond used by the Town of Rockport as a source of water supply is located in the upper part of this watershed and is the source of Alewife Brook. The area of the watershed tributary to Cape Pond is about .55 of a square mile. These areas have been determined from United States Geological Surveys and from aerial photographic surveys.

Description of Dam. The dam will have a maximum height of about 35 feet and will be about 600 feet long at the crest. It will be built of earth with a reinforced concrete core wall and a sheet pile cut-off. The downstream slope will be 2 to 1 and the upstream slope will be 2-1/2 to 1 between elevation 57

and elevation 45, and 2-3/4 to 1 from elevation 45 to the bed of the valley. There will be a five-foot berm at the upstream side of the dam at elevation 45. It will be necessary to strip the site of the reservoir to prepare it for the storage of the water and it is planned to use as much of this material in the construction of the dam as possible. The site of the reservoir will be thoroughly cleared and grubbed previous to stripping. Adjacent to the downstream side of the core wall, the plans call for clean gravel with a thickness varying from four feet at the base of the dam to 2 feet at the top. Between this material and a slope from the top of the dam of 1 to 1, it is proposed to use selected material from the reservoir stripping which will consist of loam, sand and gravel or if this material does not seem satisfactory to use, we will substitute a more suitable material obtained below the surface of the ground in the reservoir site which will not contain very much organic matter. Between this material and the downstream face, the embankment will consist of stripping material from the reservoir site. Ten inch vitrified pipe underdrains laid with open joints wrapped with cheesecloth and surrounded by clean gravel or broken stone will be built to drain any seepage through the core wall and through the gravel material adjacent to the core wall. These underdrains will keep the degree of saturation of the embankment below the core wall to a minimum. The material in the upstream side of the core wall will consist almost entirely of earth to be stripped from the reservoir site. The part of the slope above the berm will be protected by gravel and concrete paving. That part of the slope below the berm will be protected by gravel or broken stone or large stones which can not be used in the earth embankment. The specifications will call for the embankment to be thoroughly compacted either by use of rollers especially adapted for the purpose or by the hauling equipment to be used in hauling the material to the embankment.

Outlet Conduit. For use in carrying the flow of the brook during the construction, the plans call for the construction of a 36-inch class B cast iron, Bell and Spigot pipe laid in a continuous concrete cradle underneath the dam. This pipe will be closed at the upper end after the completion of the dam and previous to the storage of water by a cast iron pipe cap; it will also be closed at the center of the dam by the use of concrete in a manhole especially designed for the purpose.

Spillway. The spillway will be located in the middle of the dam and will consist of concrete side walls with steel sheet pile cut-offs, a stilling chamber at the foot of the spillway and a paved slope of reinforced concrete. The plans call for a

stone embankment underneath the spillway and below the concrete cut-off wall. The part of the dam adjacent to the spillway on the upstream side of the cut-off wall will be of earth from the reservoir stripping similar to the remaining portion of the dam. The spillway has been designed for a flow of 300 cubic feet per second for about a depth of flow of 3.25 feet over the weir. We have computed the maximum flood flow from this area for the design of the spillway by the rational method. We have not considered the effect of storage in Cape Pond but have considered the effect of storage in the proposed reservoir which has a surface area of about 40 acres. We estimate that the maximum rate of run-off from this area may amount to 1250 cubic feet per second. This is based, however, upon a time of concentration of about one hour. The time of concentration for the maximum flow over the spillway will be materially lengthened on account of the storage of water in the reservoir between the level of the weir and flood level. We estimate that when the run-off entering the reservoir coincides with the capacity of the weir at a depth of flow on the weir of about 3.25 feet, the time of concentration will be about 2-1/2 hours. We believe these estimates of flood flow are very conservative but however, we have designed the dam with a free board great enough to care for a much larger flow than that estimated. The total free board of the dam above the weir level is 6 feet.

Foundations of Dam. We have taken several wash borings at the site of the dam, and find that there is a top stratum of sand and silt of an average thickness of 3 to 4 feet, and underlying this stratum, there is medium blue clay and hard yellow clay for a depth of about 35 feet resting upon bed rock.

Gate House. The water from the reservoir will enter the distribution system through a reinforced concrete gate house, located between the berm on the upstream face of the dam and the top of the dam. There will be a 24-inch cast iron pipe laid in a concrete cradle extending from the gate house to a pumping station below the dam.

We will be glad to furnish you with any additional information regarding this project which you may desire. The Board of Water Commissioners desire to proceed with the construction of this project at once. We would, therefore, appreciate very much your immediate consideration of this request for approval of the plans.

Very truly yours,

FAY, SPOFFORD AND THORNDIKE
By
E. B. Wyatt

EBW:M

03605

FAY, SPOFFORD & THORNDIKE
CONSULTING ENGINEERS

FREDERIC H. FAY — CHARLES M. SPOFFORD
JOHN AYER — DON A. DOWNARD
CARROLL A. FARWELL — RALPH W. HORNE

TELEPHONE HUBBARD 1881
CABLE "FAYSDIKE BOSTON"

44 SCHOOL STREET, BOSTON, MASS.

BRIDGES
WATER SUPPLY AND SEWERAGE
PORT AND TERMINAL WORKS
INDUSTRIAL BUILDINGS
FIRE PREVENTION

INVESTIGATIONS, REPORTS
SUPERVISION OF CONSTRUCTION

November 3, 1930

Robert R. Evans, Esq.
County Engineer
Court House
Salem, Massachusetts

Dear Mr. Evans:

Our Mr. Myott has told me of his talks with you regarding the stability of the spillway section of the dam at Gloucester. He has also informed me of the work already done and to be done on this spillway in addition to that called for by the plans and specifications.

1930

In view of the doubts which may have arisen in your mind, I have today personally reviewed the situation in order to check once more the design prepared by us and to consider also the effect of the modifications of the design agreed upon between Mr. Myott and yourself.

As regards the original design of this spillway, I am satisfied from the investigations made today that it would have had a factor of safety of at least four. In other words, that the resistance to failure of the spillway construction as originally proposed would have been at least four times the maximum force which could be exerted on it due to a combination of water pressure and earth pressure against the upstream face of the core wall.

The changes in the construction of the spillway made as the result of your suggestions; that is, the grouting of the upper layer of rock fill, additional dowelling, and the substitution of concrete for a portion of the rock fill; have in my judgment added materially to its stability. The construction now being carried out makes of this spillway practically a concrete surfaced dam with a rock fill center. It has no analogy to the ordinary type of rock fill dam, some of which dams, as we well know, have failed for good and sufficient reasons.

In reaching these conclusions we have carried through calculations of hydrostatic and earth pressures according to commonly accepted practice; we have checked these results with the results of extensive tests on actual earth pressures made at the Massachusetts Institute of Technology on a large model

Fay, Spofford & Thorndike
Consulting Engineers
Boston, Mass.

in connection with the design of a portion of the "Fifteen Mile Falls" dam of the New England Power Company; and we have checked them also against the results of experience in building retaining walls and bulkheads on waterfront and other constructions which have to withstand the pressure of saturated earths, in which type of construction I and my associates have had a good many years experience.

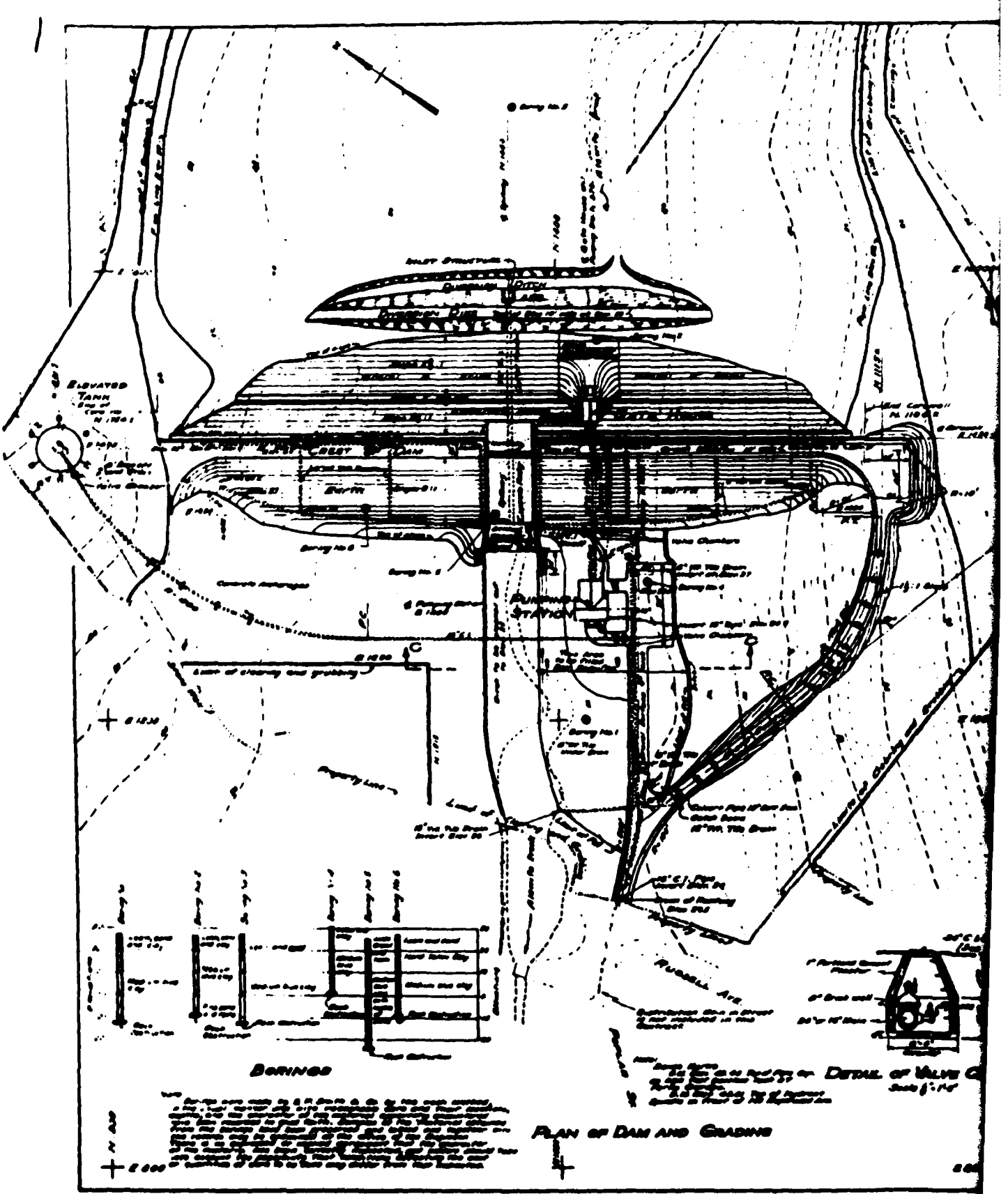
It is in the light of all this information that I base my conclusions regarding the ample margin of safety of the spillway.

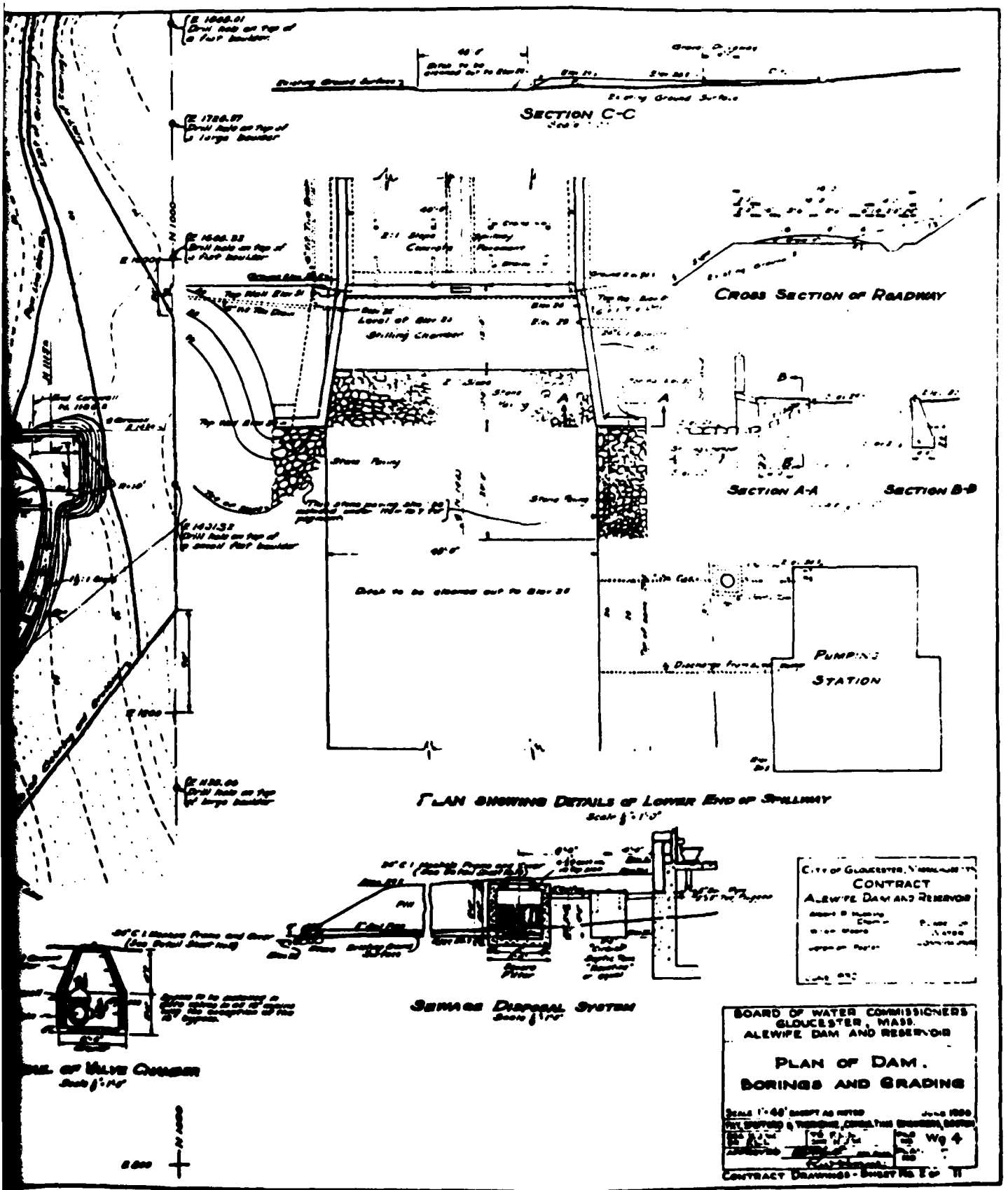
If there is further doubt in your mind as to the stability of this structure I shall be glad to discuss it with you personally, and to go into the matter in full detail, at some mutually convenient time.

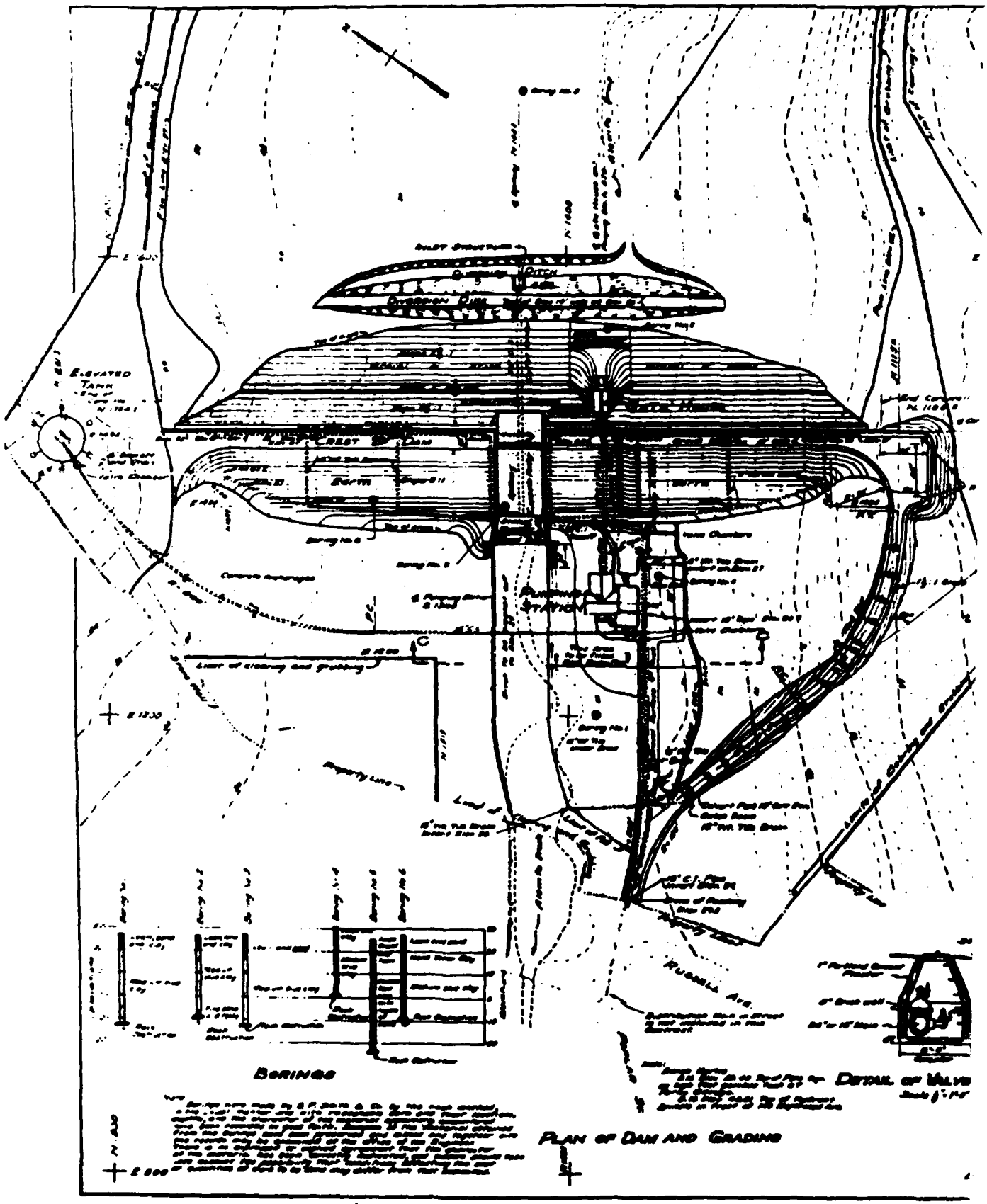
Very truly yours,

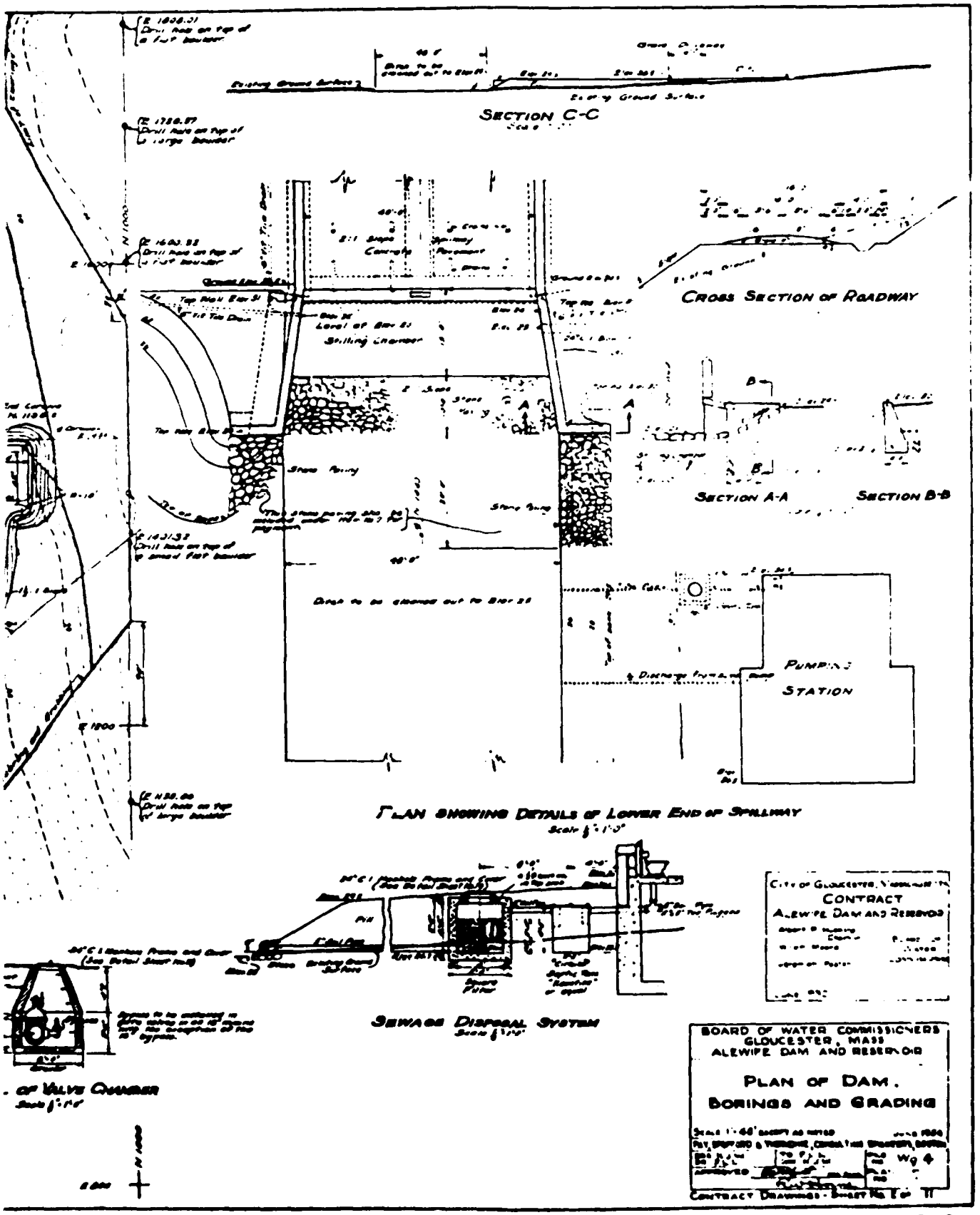
Frederic H. Fay

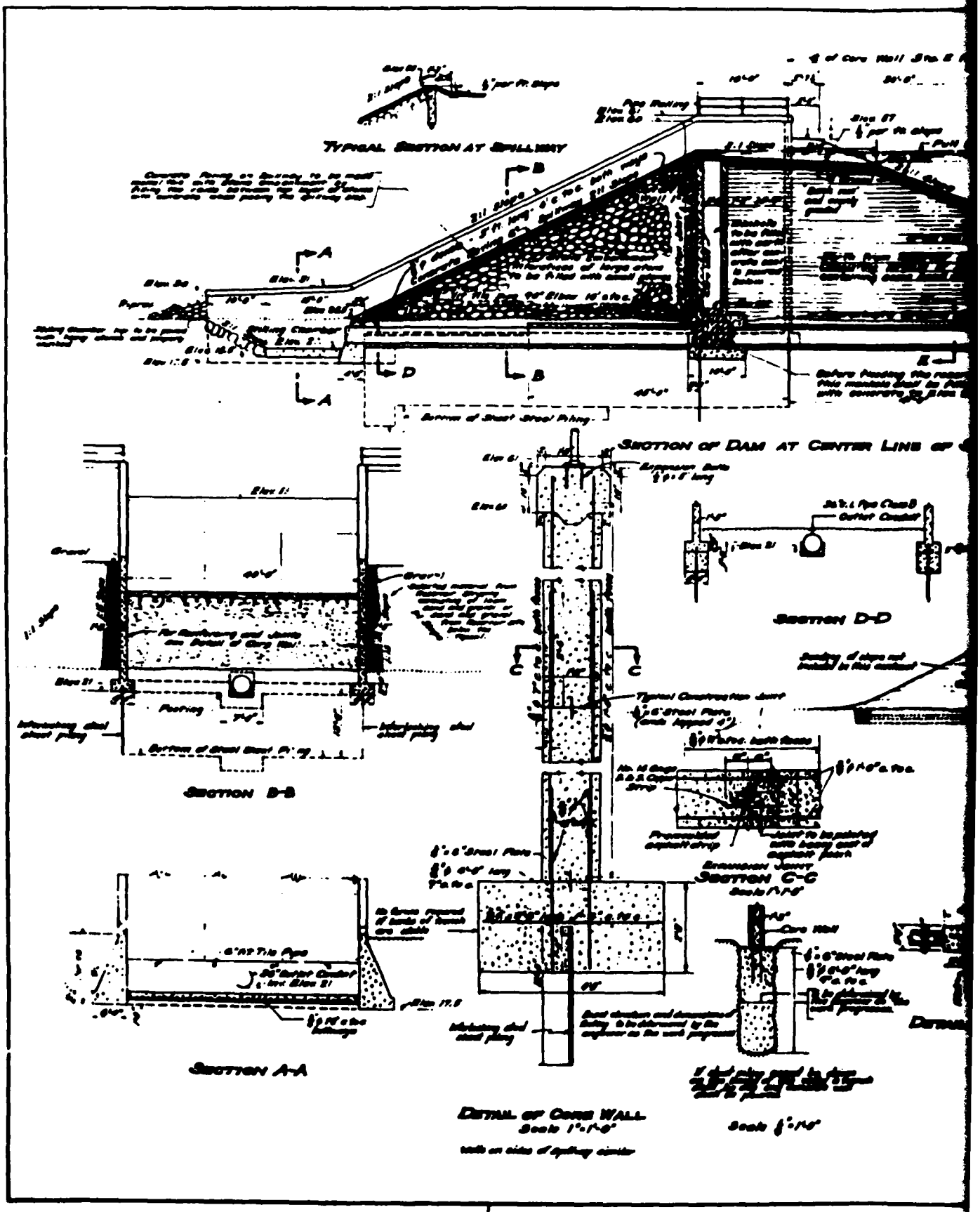
FHF:M

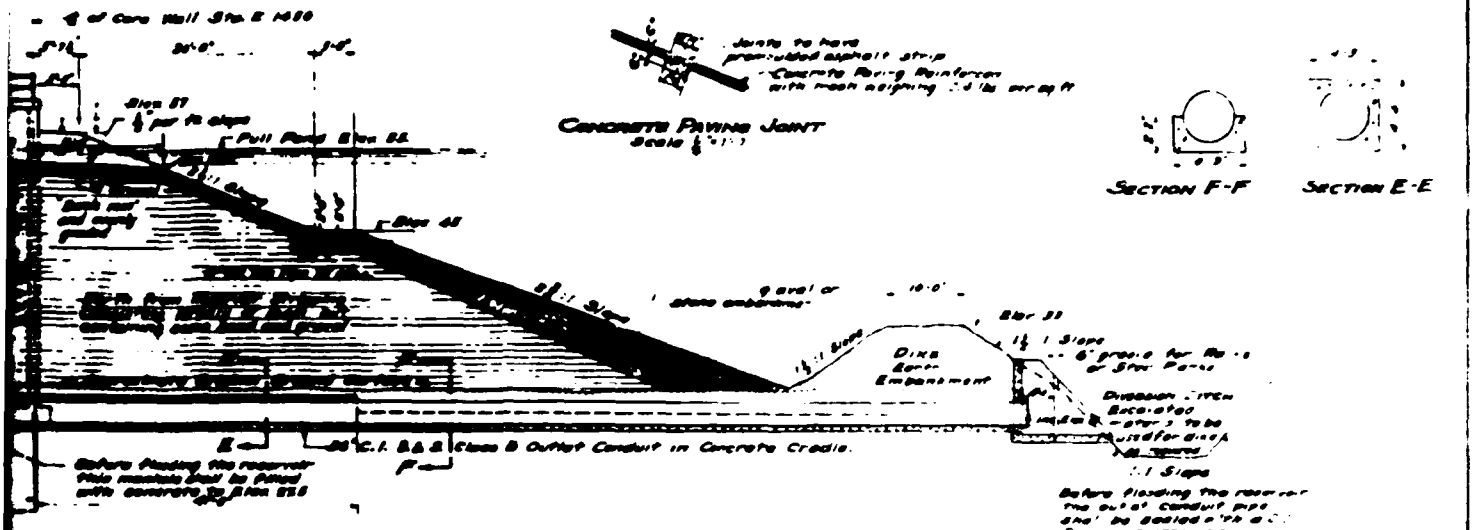

Elevated Tank
Pumping Station
Borings
Detail of Valve
Plan of Dam and Grading


SECTION C-C
CROSS SECTION OF ROADWAY
SECTION A-A
SECTION B-B
PUMPING STATION
PLAN SHOWING DETAILS OF LOWER END OF SPILLWAY
SEWAGE DISPOSAL SYSTEM
CONTRACT
ALEWIFE DAM AND RESERVOIR
BOARD OF WATER COMMISSIONERS
GLOUCESTER, MASS.
ALEWIFE DAM AND RESERVOIR
PLAN OF DAM.
BORINGS AND GRADING
Wg 4

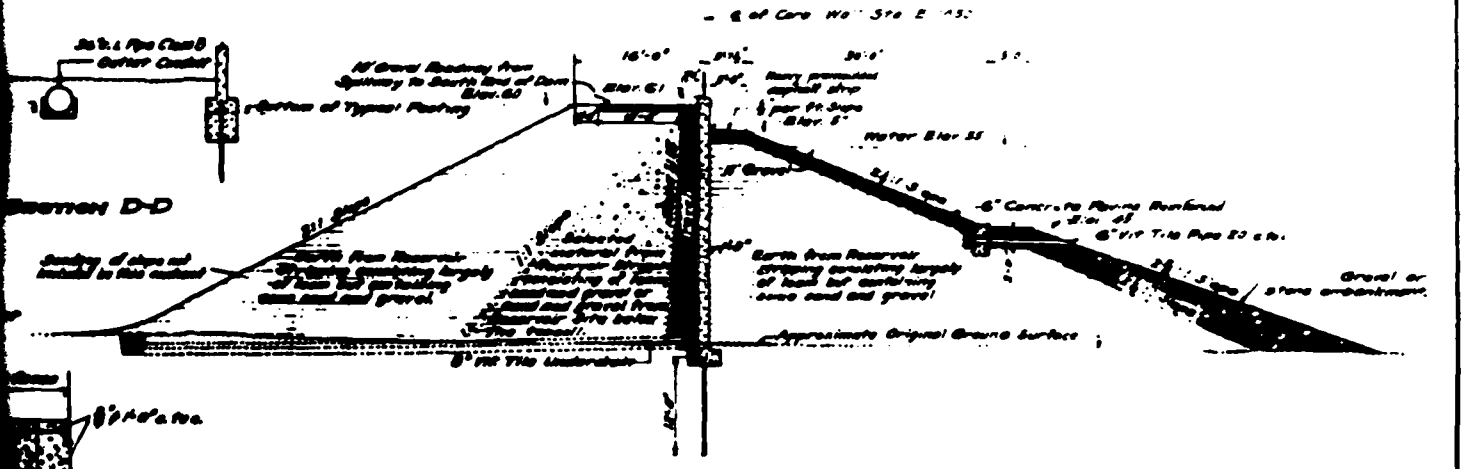

Elevated Tank
Crest Dam
Borings
Detail of Valve
Plan of Dam and Grading


SECTION C-C
CROSS SECTION OF ROADWAY
SECTION A-A
SECTION B-B
PUMPING STATION
PLAN SHOWING DETAILS OF LOWER END OF SPILLWAY
SEWAGE DISPOSAL SYSTEM
CONTRACT
ALEWIFE DAM AND RESERVOIR
BOARD OF WATER COMMISSIONERS
GLOUCESTER, MASS
ALEWIFE DAM AND RESERVOIR
PLAN OF DAM.
BORINGS AND GRADING

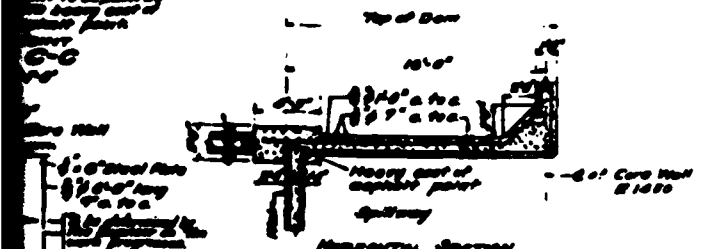

TYPICAL SECTION AT SPILLWAY
SECTION OF DAM AT CENTER LINE OF
SECTION B-B
SECTION D-D
SECTION C-C
SECTION A-A
DETAIL OF CORE WALL
Scale 1"=1'-0"



AT CENTER LINE OF SPILLWAY (N 1440)



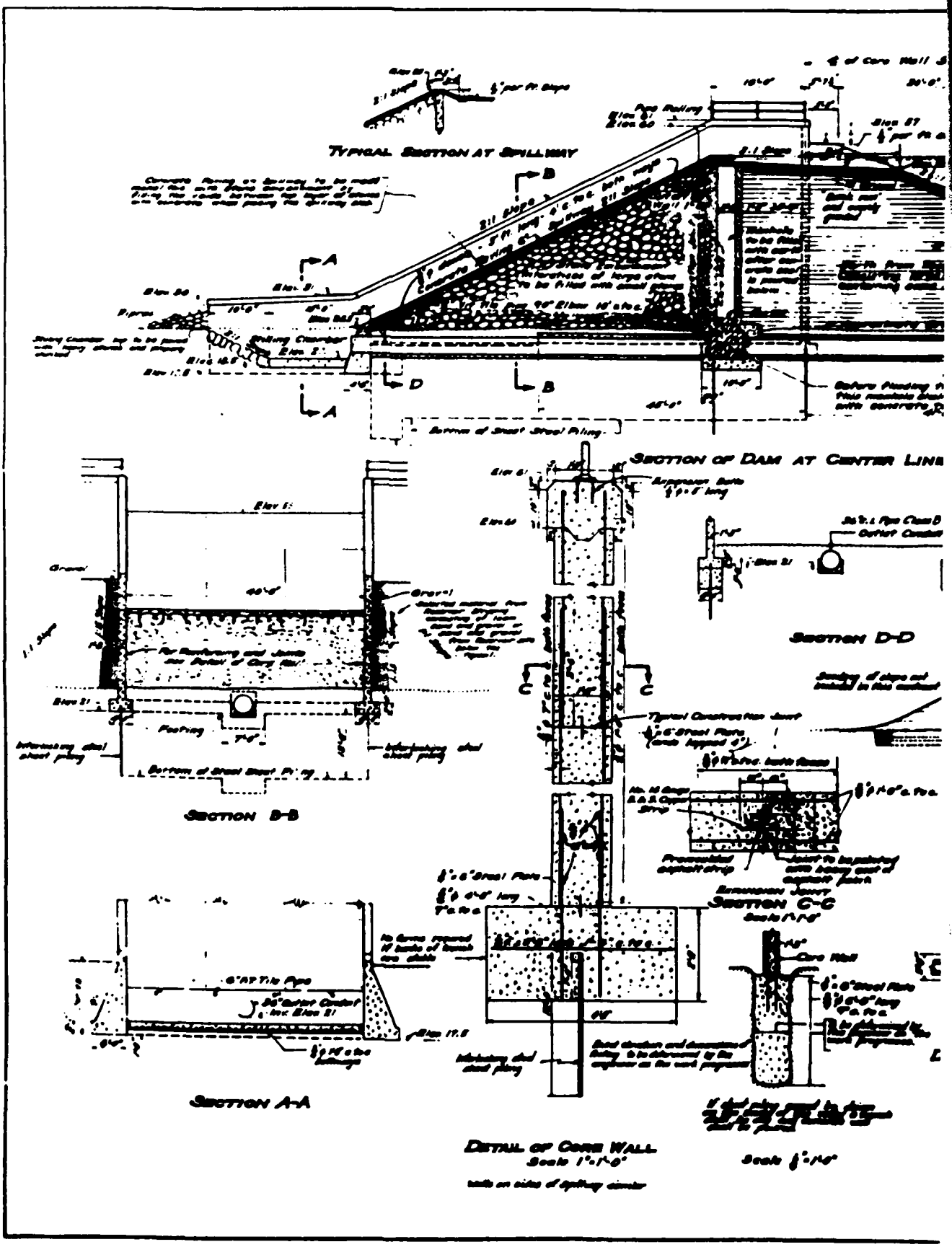
SECTION OF DAM AT ABOUT N 1200

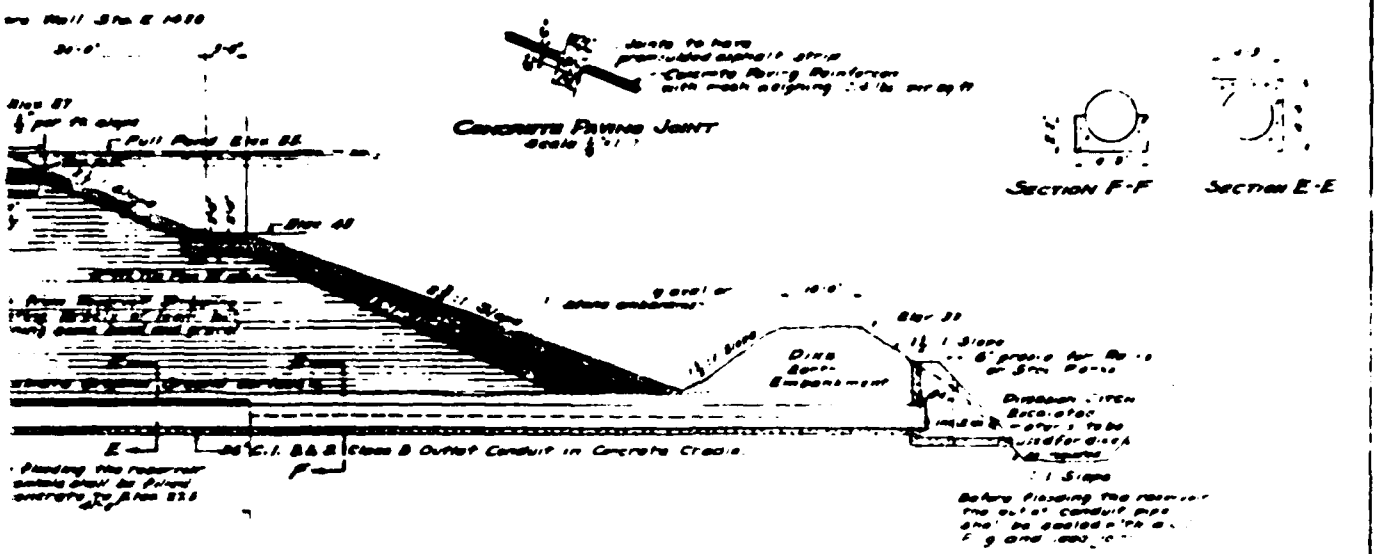


DETAIL OF CORE WALL AT SPILLWAY
Scale 1/4" = 1'-0"

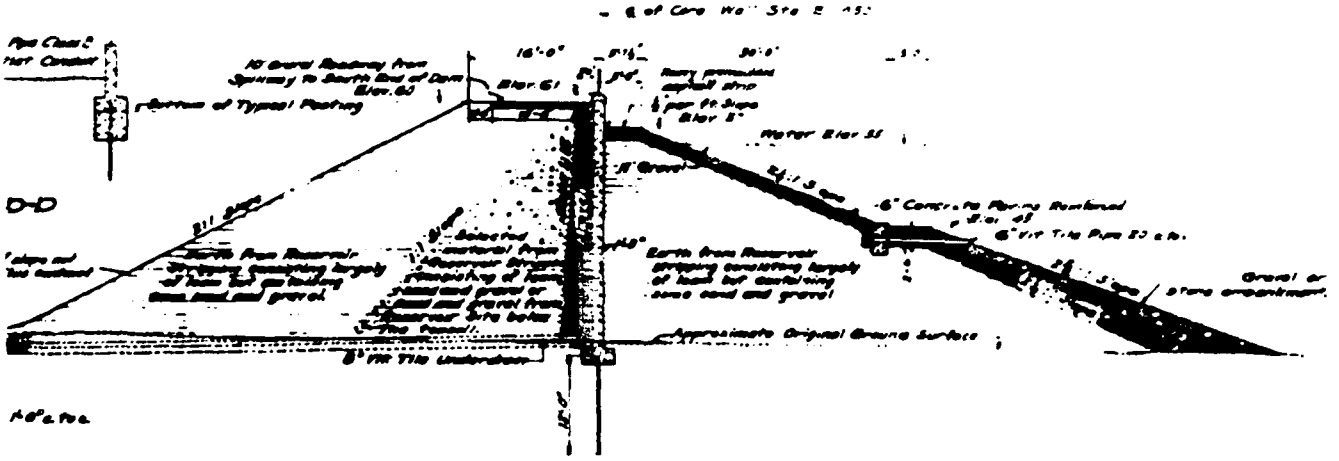
City of Gloucester, Massachusetts
CONTRACT
ALEWIFE DAM AND RESERVOIR
Board of Water Commissioners
1939

BOARD OF WATER COMMISSIONERS
GLOUCESTER, MASS.
ALEWIFE DAM AND RESERVOIR
SECTIONS OF DAM AND DETAILS
Wg-4
8
CONTRACT DRAWINGS - SHEET No. 5 OF 11

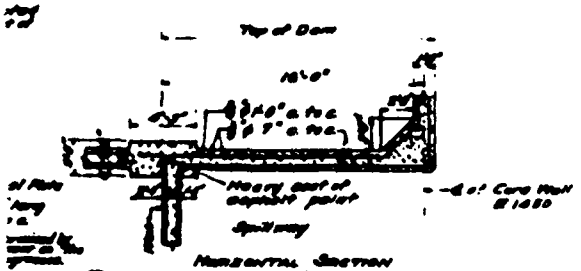

Typical Section at Spillway
Section of Dam at Center Line
Section D-D
Section B-B
Section C-C
Section A-A
Detail of Core Wall



ER LINE OF SPILLWAY (N1440)



SECTION OF DAM AT ABOUT N1200



DETAIL OF CORE WALL AT SPILLWAY

CITY OF GLOUCESTER, MASSACHUSETTS
CONTRACT
ALEWIFE DAM AND RESERVOIR
BOARD OF WATER COMMISSIONERS

BOARD OF WATER COMMISSIONERS
GLOUCESTER, MASS.
ALEWIFE DAM AND RESERVOIR

SECTIONS OF DAM AND DETAILS

0310 C

December 5, 1930.

To the Commissioners of Essex County:

Gentlemen:

I submit herewith the following report as to the construction of the Alewife Dam in Gloucester, plans and specifications for which were approved by the County Commissioners on June 20th, 1930.

Work was begun shortly after your approval was issued, and I have visited the dam at various times since then as follows, viz: July 22, August 11, September 5, 17 and 29, October 14, 17, 21 and 23, November 1, 7 and 20, and December 4, the structure at the time of this last visit being substantially complete, so that the filling of the reservoir will probably start within a week.

The material encountered in the foundation has proved to be what was anticipated, a fairly hard tenacious blue clay from about four feet below the surface, and the steel sheeting has been driven substantially as called for on the plans, but for a short distance at both the northerly and southerly ends boulders were found and here a concrete wall was used in place of the sheeting.

Under the gate house it was deemed best to omit the pile foundation, as the material seemed to be unquestionably hard enough to carry the load. This was done with my approval, and in fact I believe it is better construction than if the piles had been used.

The material for the embankment has been found at least as good as required by the specifications, and a large part of it has come from borrow pits excavated within the limits of the reservoir. In the construction of the embankment, material has been hauled in by trucks and by trailers hauled by tractors, dumped in piles and levelled off by a bulldozer. During the construction of the lower half of the embankment, the weather was very dry and no watering of the material was done. Apparently, however, the continued hauling of the material sufficed to give a well compacted embankment, and reasonable attention seems to have been given to removal of roots and perishable material.

As the work progressed on the rock fill of the spillway it became evident that this fill would not be what I had assumed in approving the plans. The boulders were mostly rounded and were being dumped into place, but no hand placing done to reduce the voids to a minimum, and the stone placed on top of these to fill

the voids and level up to the concrete slab were, in my judgment, too small. Following several conferences with the engineer in charge, three trenches were excavated in this rock fill transversely to the slope of the spillway, and concrete walls were built and well grouted into the rock fill, extending nearly to the surface and tied into the concrete paving. These small stone, for a depth of at least a foot, were also grouted before placing the concrete slab, and the apex of the triangle forming the upper half of the spillway section was cast as a solid concrete block, resting on the rock fill beneath.

Care was taken to provide free drainage for the rock fill at the spillway, and careful attention seems to have been given to the placing of the porous gravel on the downstream side of the core wall in other parts of the dam and to the under-drains leading from it. The concrete in the core wall is apparently of good quality and care has been given to the installation of the copper expansion joints, and, in general, I feel confident that the structure has been well built substantially in accordance with the plans and specifications.

Respectfully submitted,

County Engineer.

E/A-2

Gloucester D. 17

Alewife Brook Dam, northeasterly from the corner of Poplar St. to Russell Ave. Gloucester Water Works, Owners.

1930. Watershed 2.25 sq. m. Max. Ht. 41.5'.

1930, June. R. R. Evans Investigation of Alewife Dam)
1930, June 20. R. R. Evans Report to Co. Comm. on) See 0360 C - 1930
petition of Board of Water Commissioners of Gloucester)
for approval of plans and specifications to construct dam)
1930. R. R. Evans Insp. made during construction)

1930, June. Contract Plans approved by the Co. Comm. on file in County Engineer's Office.

1930, Dec. 5. R. R. Evans Report to Co. Comm. See 0360 C - 1930.

1931, Jan. 21. C. C. Barker, Insp. I visited the new dam at "Dog Town Common". The water level was 48.7' or 6.3' below the top of the spillway. There is evidence of slight seepage from the weep holes at the base of the spillway, but there was none today. The dam is apparently in very good shape.

1931, April 24. C. C. Barker, Insp. Today about one-half inch of water is flowing over the spillway, and one cannot see whether there is any water flowing in the underdrains or out of the drain pipes in the spillway. About 120 feet south of the spillway and several feet from the toe of the slope a small stream of clear water is flowing on the surface in a slight gutter to the stilling basin. It is said this comes from a spring. Also more southerly at the toe of the slope and the old earth there is slight seepage. The ground below the dam where stumps etc. were deposited at the southerly end below the dam is more or less wet and there is rusty and slimy water in the ditch along the driveway. On the north side of the spillway channel the ground below the dam is quite wet and there is some seepage or ground water. At the north end next old surface there is slight seepage. One construction joint near the north end has opened some. The slopes and dam are in good condition.

1932, Aug. 2. C. C. Barker, Insp. The dam is apparently in good condition. At each end of the spillway on the upper side the concrete slab next the spillway has settled a little, the one on the nort h end about 3 inches. There is no seepage through the drains on the slope of the spillway, those at the base are covered by the water in the stilling basin. The fourth block of concrete slope paving north of the spillway has disintegrated some. There is some seepage at the toe of the slope on the south end, also some on the north end about the same as at last inspection. The water level is about 4 inches below the top of the spillway. The slopes are grassed, six rows of pine trees have been planted and also some honey suckle vines.

1932, Nov. 2. R. R. Evans, Insp. Reservoir full and water about 1" in depth running over spillway. Ground wet below dam near south end. No indication that it comes through the dam. Everything which can be seen at this stage of the water seems to be in good condition.

1932 Report to Co. Comm. Safe and in reasonably good condition.

Gloucester D. 17

1934, Sept. 28. C. C. Barker, Insp. I gave a copy of the notice to Mr. Moran, Supt. At the dam I saw Mr. Bray, one of Mr. Moran's men. The water level is very low, the reservoir has just been drawn down as low as possible. There is a slight trickle of water out of the lower drains at the bottom of the spillway. The south east corner of the concrete apron is slightly out of place and somewhat cracked. The cutoff wall on the upper side is somewhat disintegrated at the expansion joint near the south end also one on the northerly end. The base wall at the bottom of the concrete apron about 100 feet from the north end has disintegrated very much. The slab of concrete in the spillway on the upper side of the crest on the south side has fallen about 5 inches and the slab on the north side has fallen about 6 inches. Under the center slab there is somewhat of a cavity. There is settlement in the spillway on the upper side of the crest. The fill next the south side of the spillway has washed some. The lower slopes are well covered with vines and pine trees. As the water is low there is no seepage today.

1934, Dec. 12. R.R.Evans, Insp. Of three slabs up side of spillway wall that at each end has settled some two inches or more at edge against wall, these should be cut out and fill beneath investigated.

1934 Report to Co. Comm. The new dam at Alewife Brook seems to be in good condition in all essential respects except that just back of the cut-off wall in the spillway two of the three concrete slabs have settled considerably, although the material underneath them was supposed to be compacted so that this could not happen. I believe that enough of these concrete slabs should be removed so that investigation can be made to ascertain the cause of this settlement, and make sure that it is not serious.

1936 August 10 , C.C.Barker, Insp. I left a copy of the notice at the office for John W. Moran, Supt., no one went to the dam with me. On the south side next the spillway there is a gully in the embankment, three feet wide and 2.5 to 3 feet deep, the earth having washed out down to the stone. At the lower end of the spillway there is a crack in each side wall. Water is trickling out of the two northerly and the south drain pipes at the bottom of the spillway, almost 1/4 inch deep. The settlement in the concrete slabs on upper side of the spillway is about the same. On the upper side the concrete has cracked in a number of places, and the concrete slope paving has settled in some places. At the south end the bottom of the embankment is wet and there must be a large amount of seepage from all indications. Also there is some at the north end. The water level today is about one foot below the spillway.

1936 Report to Co. Comm. The new Alewife dam is in good condition, except that the concrete paving just back of the spillway has settled several inches, and apparently there is a cavity of unknown extent below it, but no investigation by removing parts of the slab has apparently been made. Such an investigation should be made to make sure that the condition is not serious, and some washing which has occurred adjacent to the side walls of the spillway in the earth embankment should be refilled and protected from further wash.

1936 Nov. 20 Mr. Evans, Insp. See Sheet 3

Gloucester D. 17

1938 October 25, C.C.Barker, Insp. I gave a copy of the notice to D. R. Bradley Asst. Supt. The water has been drawn off and is very low. The ~~cast~~ wall on the south portion of the dam has been repaired where some of the concrete spalled off. Next the spillway on the south side where the earth fill washed out on the lower slope concrete steps have been built. On the upper slope there are several spots in the concrete apron and toe wall where there is much disintegration also in the cut off wall on the north portion. There is disintegration in the concrete gate house at the water line. The settlement in the concrete slabs on the upper side next the crest of the spillway is greater. The north slab has settled 8" and the south slab 6" next the crest of the spillway. It is hollow under the center slab, which, I was told by Mr. Wheeler one of the Water Works men, is supported by the man hole which was used during the construction of the dam. Mr. Wheeler says the seepage remains about the same. The earth slopes are well covered with pine trees and honeysuckle vines.

1936 R.R.Evans, Insp. Saw this dam November 20 with Mr. Barker. Along the side wall of the spillway nearest Gloucester there has been considerable washing of embankment. Broken pieces of ledge rock have been filled in against the wall. The top of this fill is rough and considerably below the original level of the earth. Whether some excavation has been made purposely in which to place these stone is not quite evident, bu t apparently this might have been done to form a gutter. If this is the purpose it should be brought up to the original level, and bound with asphalt or otherwise to prevent washing. The water is barely flowing over the spillway today. Through the water it is possible to see that the slabs behind the spillway are sunken, but not to make any examination . An examination should be made here by removing some of the concrete to ascertain what is below it as Mr. Barker says it sounded hollow when he mad his investigation. The parapet wall along the main dam is disintegrating badly. As yet there is no apparent weakness which would reduce the amount of freeboard, but if it continues that will apparently happen before many years. The embankment seems to be in good condition and no seepage along the toe of the bank is noticeable, but a new drain has apparently been laid a short distance below the toe of the slope discharging into the outlet from the spillway and quite a stream of water is running through this drain. How much of it, if any, comes through the dam cannot be determined as the land towards Gloucester is wet.

1938 November 9, R.R.Evans, Insp. With Mr. Barker visited Alewife Dam in Gloucester to observe conditions beneath the slab on the water side of the spillway where concrete has recently been removed, since my previous conversation with Mr. Moran. Found that for a width of six or eight feet back of the apron on the inside slope the concrete slab has been renewed across the entire width of the spillway, and a space some three or four inches deep is exposed between this opening and the cut-off wall and on the other side of the opening toward the pond this space can be seen to extend many feet. It seems to be an even settlement. The concrete slabs rest on the top of the abandoned manhole and there is no evidence that the water found any outlet. A man, who is apparently an employee of the water board was at the work when I inspected it and I later called on Mr. Moran to talk the situation over with him. I told him that it would, of course, be possible to fill this space under the slab by grouting but that I felt that

Gloucester D. 17

a better job might be obtained, and perhaps cost less, to remove the apron immediately back of the cut-off wall and renew some ten or twelve feet of the slab on the side toward the pond, to fill the depression with gravel similar to that which was used originally under the slab, well tamped, to avoid further settlement, and to construct new concrete slabs the same as originally built. He apparently agrees with me that this is the best method to follow and as I understand him will attempt to have it done.

1938 Report to Co. Comm. It was noted in my last report that the concrete paving back of the spillway at the Alewife Dam in West Gloucester had settled and that there was a cavity beneath it. The same condition was found at the present inspection and again called to the attention of the Superintendent of the Water Board. At that time the reservoir was practically empty to permit some work which is being done at the upper end of the pond, and the Superintendent caused these sunken slabs to be removed so that we could inspect the fill beneath them. We found that the earth fill had settled some four inches or more, but found no evidence that the water was finding any outlet through it behind the concrete block forming the spillway. The matter was discussed with the Superintendent and it is my understanding that he is removing the remaining portions of this slab under which settlement has taken place, and will bring the fill up to grade and lay a new concrete pavement upon it. Concrete steps have been built against the wall on the side of the spillway and erosion of this fill by the surface water running down the embankment has been stopped.

1940 Oct. 2, C.C.Barker, Insp. I gave a copy of the notice to L. B. Hull, Supt. Gloucester Water Works. This dam is in good condition. Water is just splashing over the spillway. Some water id dripping out of the weep holes at the base of the spillway. The seepage at the south end is about the same. The upstream face of the northerly cut-off wall is badly disintegrated in two places. There are side walls, 5 feet apart and 3.5 feet high, on the outlet stream below the dam.

1940 Report to Co. Comm. Safe and in reasonably good condition.

1942 July 31, C.C.Barker, Insp. I gave a copy of the notice to L. B. Hull, Supt. This dam is in good condition. The reservoir is full and spilling over. There is much seepage at the southerly end about the same as in the past. There has not been any change.

1942 Report to Co. Comm. Safe and in reasonably good condition.

1944 July 20, S.W.Woodbury, Insp. I gave a copy of the notice to Mr. Hull, but visited the dam alone. Water level is 4 ft. below the lip of the spillway. Concrete is badly disintegrated at corners of walls at spillway, at northerly end and at the lower part of the spillway. Concrete paving is cracked at southerly end. The concrete walls are cracked and spalled at expansion joints. There is some seepage through the lower holes of the spillway. The sidewalls of the spillway are badly cracked at the bottom. The condition of the dam is about the same as when last reported. No repairs have been made.

Gloucester D. 17

1944 Report to Co. Comm. Safe and in reasonably good condition.

1946 Sept. 20, S.W.Woodbury, Insp. I gave a copy of the notice to Mr. Hall and went to the dam alone. Bushes have been cut on slopes, also the branches of the pine trees have been cut about 6 ft. up. Water just running over spillway. Concrete wall is badly disintegrated at points previously reported. At the bottom of the spillway in the middle there is a block of concrete about 6" x 10" and 12 ft. long scoured out.

1946 Report to Co. Comm. Safe and in reasonably good condition.

1948 Sept. 21, S. W. Woodbury, Insp. Left a copy of the notice for Mr. Hull at his office and went to dam alone. Further inspection needed to see that concrete is repaired. No repairs since last inspection. Conditions below the dam: A new highway (route 128) has been built just below the dam. Water level today: 6" below crest of spillway. Condition of the dam: Concrete very badly disintegrated in many places. Concrete at bottom of spillway should be repaired.

1948 Report to Co. Comm. The Alewife Brook Dam, a large important dam, should be kept in good repair. The concrete on the upstream side is badly disintegrated in many places. Also the concrete at the bottom of the spillway should be repaired. The dam may be considered safe, but the repairs should be made and the dam kept in good condition.

1950 Sept. 27, S.W.Woodbury, Insp. Left a copy of the notice for Mr. Hull at his office and went to the dam alone. Further inspection needed to see that concrete is repaired. New permanent stop planks 2 ft. high have been built on the spillway (Freeboard is now about 3.5 ft.) Conditions below the dam: Gloucester Housing Development is just below the dam. Highway Dept. buildings below the dam. Water level today: 13 ft. below crest of concrete spillway. Concrete very badly disintegrated in many places. Concrete at bottom of spillway has not been repaired.

1950 Report to Co. Comm. The Alewife Brook Dam, due to its location, is a very important dam and should be kept in good repair. The concrete in many places is very badly disintegrated and should be repaired. Recently, flash boards two feet in height were placed in the spillway to give the reservoir increased storage capacity upon the approval of the County Commissioners. This dam may be considered safe, but it should be kept in good condition.

1952 Sept. 25, E.H.Page, Insp. Gave a copy of the notice to Mr. Hull, Supt. of Water Dept., at his office on Proctor Street and went to reservoir alone. No repairs since last inspection. Water level today: 1.3 above crest of conc. spillway and 0.7 below top of permanent flashboards. Conc. badly disintegrated in many places. Conc. at bottom of spillway needs repairing.

1952 Report to Co. Comm. The Alewife Brook Dam, a very important dam due to its location, should be kept in good condition. Although the dam may be considered safe, the concrete is badly disintegrated in many places and should be repaired.

1954, May 28, E.H.Page, Insp. Owner's agent, Wilfred Bourque. Height of glashboards: 2'-1". Minimum freeboard: 2'-11'. Spillway clear. Bad place in conc. wall about 100' easterly of gate house. One place about 3" thickness has spalled off. Quite a lot of seepage at the toe about opposite the above mentioned spalled place. Mr. Bourque said it seems to be a lot worse since they added 2' of flashboards.

1954 Report to Co. Comm. At the Babson Reservoir on Alewife Brook, a very important dam, due to its location, should be kept in good condition. The concrete is badly disintegrated in many places. There is a very bad place in the concrete wall and slope paving about one hundred feet easterly of the gatehouse where the concrete has spalled off to a depth of about three inches. At this point in the dam the toe is very wet.

1956, Sept. 12, E.H.Page, Insp. Owner G.W.W. No repairs since last inspection. Leaks: Toe wet as previously noted. Height of flashboards: 2'. Condition: Same. Conc. spalling very badly in places.

1956 Report to Co. Comm. At the Babson Reservoir on Alewife Brook, a very important dam, due to its location, the concrete is badly disintegrated in many places. It should be kept in good condition. There is a very bad place in the concrete wall and the slope paving has settled about one hundred feet easterly of the gatehouse where the concrete has spalled off to a depth of about three inches. At this point in the dam the toe is very wet.

1958, Dec. 30, E.H.Page & K.M.Jackson, Insp. Elev. of water: 21' below top of flashboards. Height of flashboards 2'. Condition: Same. Conc. spalling badly in many places on dam and spillway. Toe very wet southeasterly of gatehouse.

1958 Report to Co. Comm. At Babson Reservoir on Alewife Brook, a very important dam due to its location, the concrete is badly disintegrated in many places. There is a very bad place in the concrete wall and the slope paving has settled at a point about one hundred feet easterly of the gatehouse where the concrete has spalled off to a depth of about three inches. At this point in the dam the toe is very wet. The walls of the spillway are spalling and disintegrating.

1959 E.H.Page, Insp. Elev. of water 12 over flashboards.

1961, March 10, E.H.Page and P.D.Killam, Insps. Conditions below dam: Same. Elev. of water: 2" over flashboards. Leaks: Same. Height of flashboards: 2'. Condition of dam: Same.

1960 Report to Co. Comm. At Babson Reservoir on Alewife Brook, a very important dam due to its height and location, the concrete is badly disintegrated in many places. There is a bad place in the concrete wall and the slope paving has settled at a point about one hundred feet easterly of the gatehouse. The concrete has spalled off to a depth of about three inches. At this point in the dam the toe is very wet. The walls of the spillway are spalling and disintegrating

1962 Dec. 17, K.M.Jackson, Insp. Owner; City of Gloucester Water Works. Repairs since last inspection: Made boat ramp at east end of dam. Elev. of water: 2'. Height of flashboards: 2'. No obstructions in spillway. Condition: Same as 1960. Man at gate house said

some work was done this summer. He did not know just what it was.

1962 Report to Co. Comm. At Babson Reservoir on Alewife Brook, a very important dam, due to its height and location. There has been some work done on this dam. Because of height of water, it is hard to tell just how much has been done since last report. A boat ramp has been built at easterly end of dam. The walls of spillway are still spalling and disintegrating.

1964 Dec. 29, P.D.K. & K.M.J. Insps. Spalled portions at gate house and dam have been repaired.

1964 Report to Co. Comm. Spalled portions at gate house and dam have been patched. This should be continued at the walls of the spillway.

1966 April 17, 1967. P.D.K. & K.M.J. Insps. Conditions same.

1966 Report to Co. Comm. Safe and in reasonably good condition.

1968 March 31, 1969 P.D.Killam and J. Fitzgerald. There were two feet of flashboards in the spillway with two inches of water going over. Brush clearing has been done and should be continued. The flashboards and piers should be larger since the aereator unit is not working to keep the entrance to the spillway free of ice.

D. 17 —

GLOUCESTER
5-5-107-17

N.E WILKINSON 7/15/71 1

ON BABSON RESERVOIR, BEGIN ON ROUTE 128 AT WASHINGTON ST. TAKE WASHINGTON ST. NORTH TO POPLAR ST. 0.70 M.F. TAKE POPLAR ST. 0.56 MI EAST TO DAM.

CITY OF GLOUCESTER.

WATER SUPPLY

EARTH & STONE EMBANKMENTS WITH CONCRETE CORE WALL OVER STEEL SHEET PILING. (SEE PLAN ESSEX SURVEY NO. 2397 (6 SHEETS)

40.0 ± FT. 66.0

MEAN LOW WATER

625.0 FT. 10.3 FT. 40. ACRES

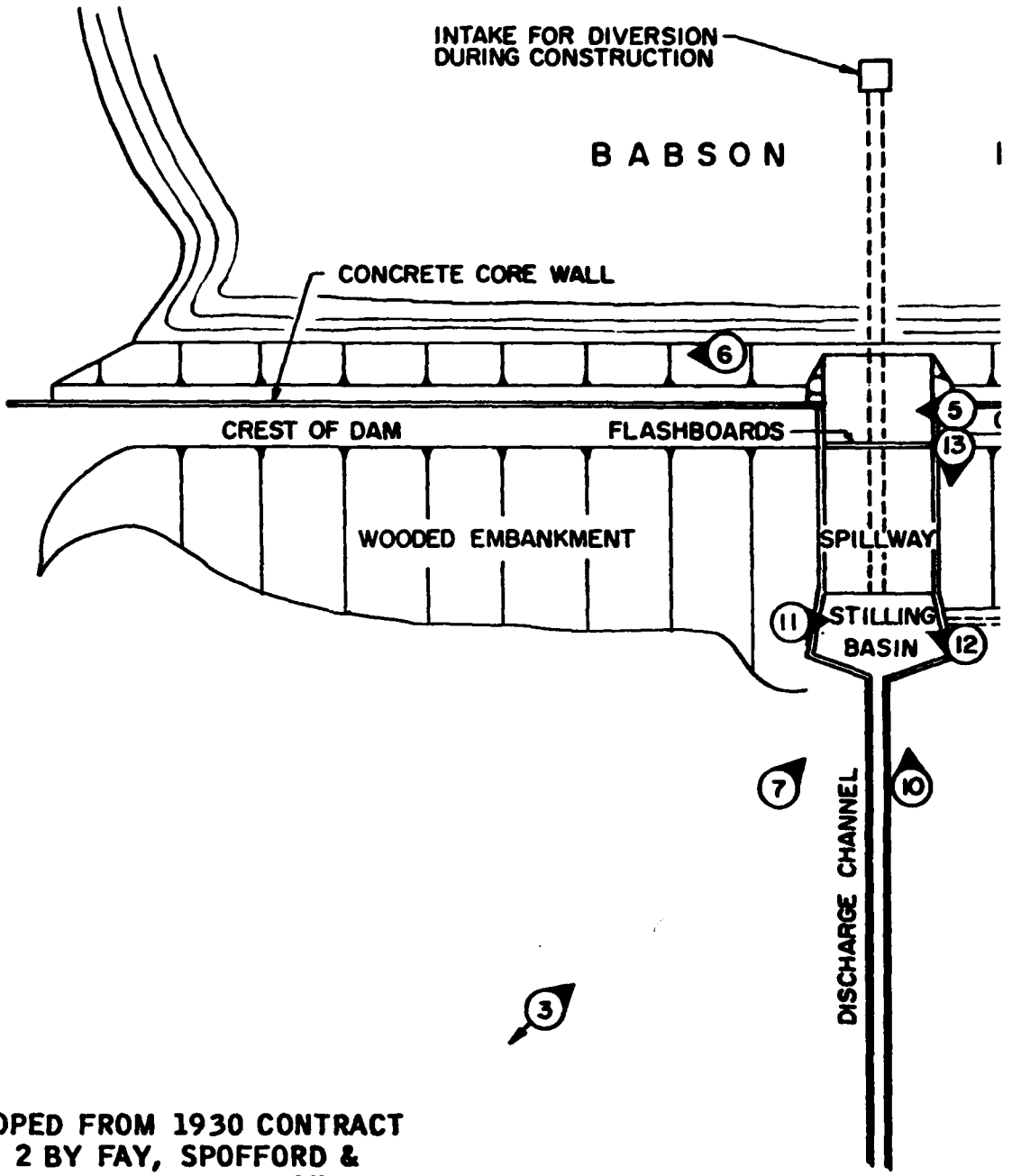
2.25

WATER LEVEL IN RESERVOIR 4.0 FT BELOW TOP OF FLASHBOARDS. SOME DISINTEGRATION OF SIDEWALL OF SPILLWAY SOUTHEAST END OF FLASH BOARDS ABOUT 3 FT. HIGH X 3 FT. WIDE TOWARD THE WATER AND 3 INCHES DEEP

PLASTER SPALLING CONCRETE IN SPILLWAY OTHERWISE DAM IN APPARENT EXCELLENT CONDITION.

APPENDIX C
SELECTED PHOTOGRAPHS OF PROJECT

No.		Roll	Frame	Page No.
1.	Overview of crest and upstream slope from left abutment	C16	13	vi
2.	Overview of dam from hillside downstream of left abutment	C16	21,22	2
3.	View of spillway and wooded embankment from elderly housing project	8	24	3
4.	Upstream paved slope at left end	8	10	3
5.	Top of embankment and upstream slope right of spillway	C16	18	4
6.	Deterioration of concrete in pavement on upstream slope, about 55 ft. right of spillway	8	14	4
7.	Downstream slope left of spillway	8	22	5
8.	Downstream slope right of spillway	8	20	5
9.	Spillway approach and log boom	C16	16	6
10.	Downstream face of spillway	8	21	6
11.	Training wall left of stilling basin showing 24-in. blow-off pipe and underdrain outlet	C17	6	7
12.	Training wall right of stilling basin	8	4	7
13.	Discharge channel downstream of spillway	8	6	8
14.	Gate house and service bridge	8	8	8



NOTE:

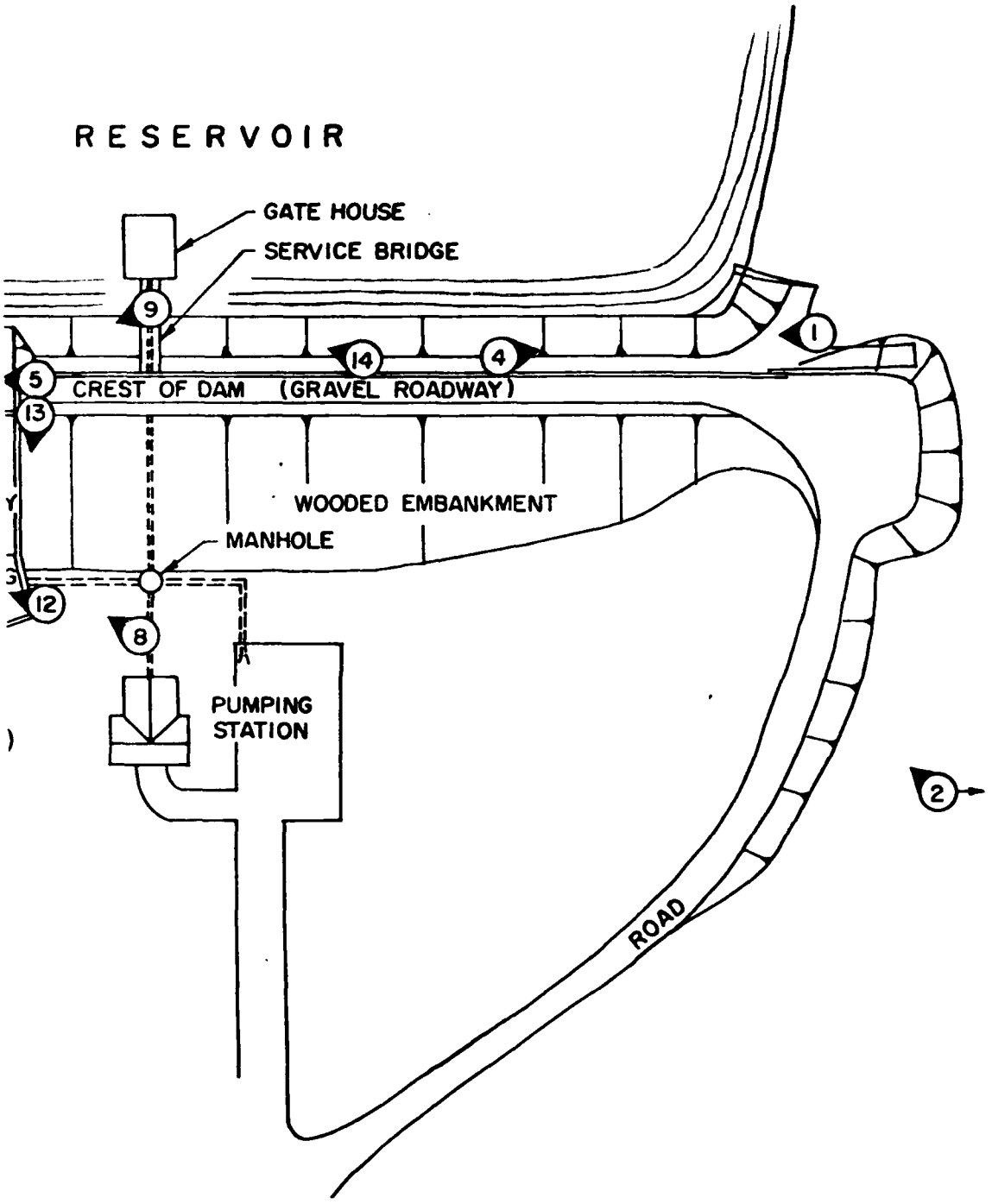
PLAN DEVELOPED FROM 1930 CONTRACT DRAWING NO. 2 BY FAY, SPOFFORD & THORNDIKE (APPENDIX B) AND OBSERVATIONS BY HALEY & ALDRICH, INC. ON 8 SEPTEMBER 1978.

LEGEND:

(5) PHOTO NUMBER AND DIRECTION OF VIEW

FILE NO. 4160-852

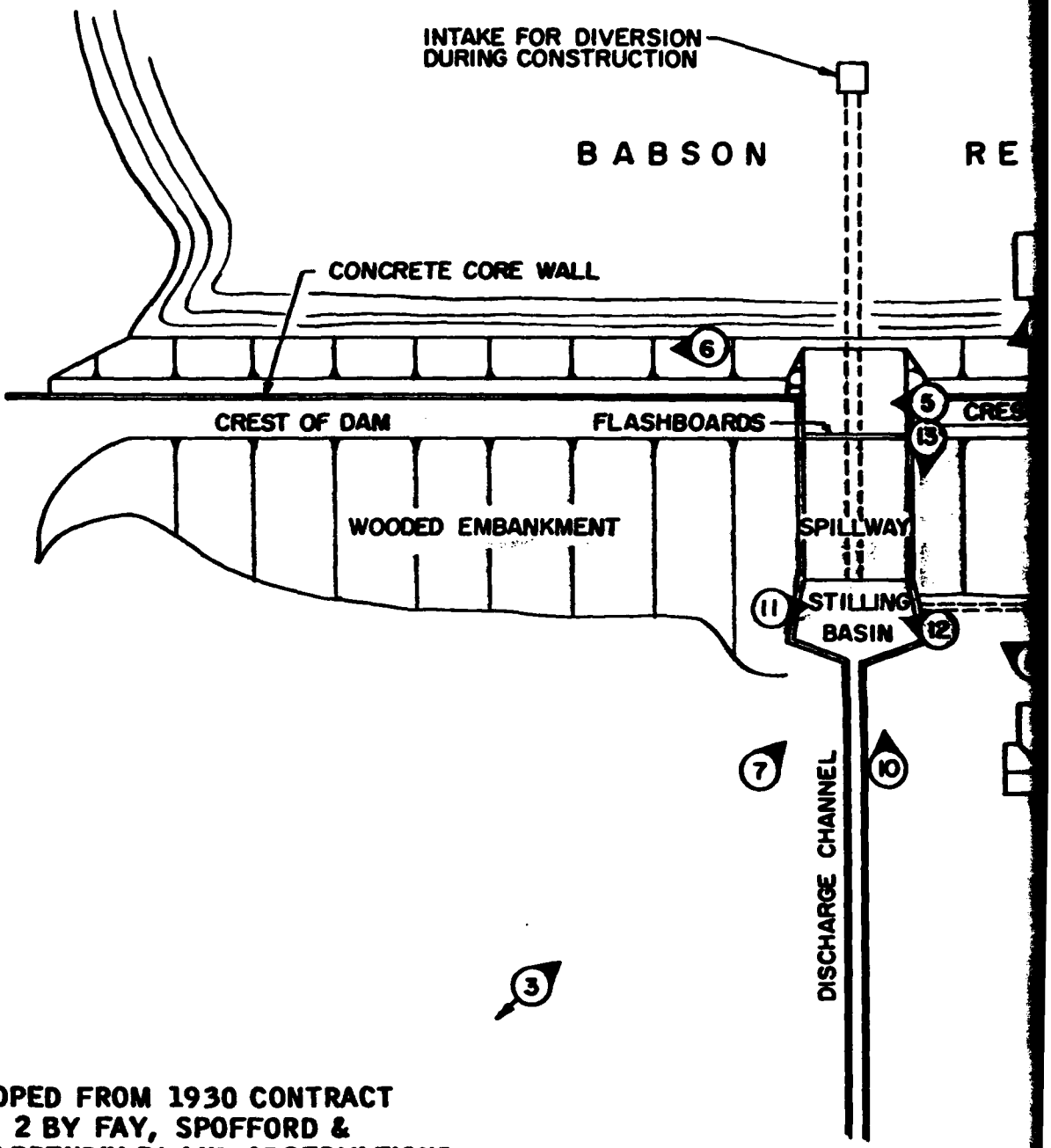
HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS



Babson Reservoir Dam
Gloucester, MA

SITE PLAN SKETCH

Scale: 1"=60' Nov. 1978



NOTE:

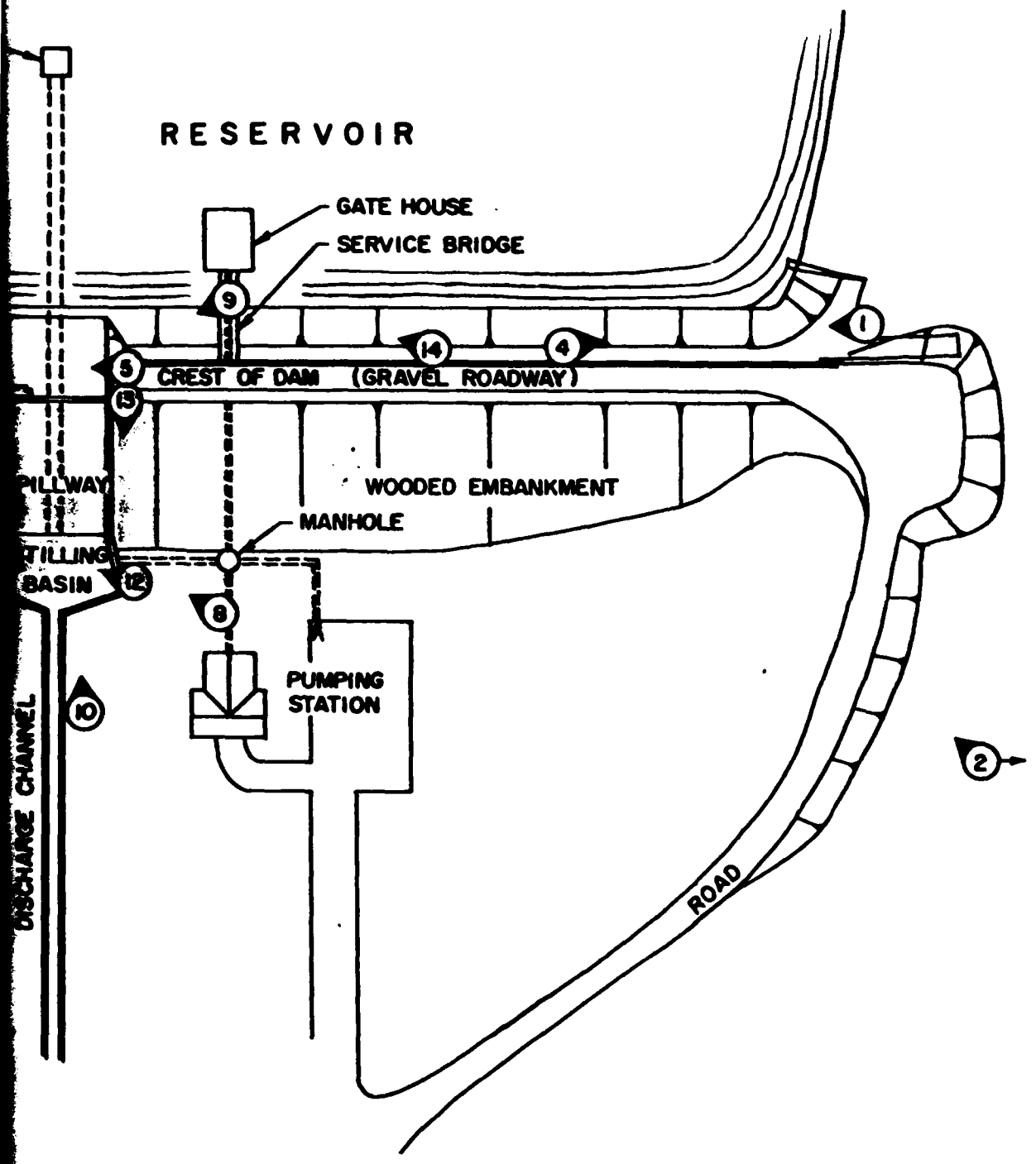
PLAN DEVELOPED FROM 1930 CONTRACT DRAWING NO. 2 BY FAY, SPOFFORD & THORNDIKE (APPENDIX B) AND OBSERVATIONS BY HALEY & ALDRICH, INC. ON 8 SEPTEMBER 1978.

LEGEND:

(5) PHOTO NUMBER AND DIRECTION OF VIEW

FILE NO. 4100-002

HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS



Babson Reservoir Dam
Gloucester, MA

SITE PLAN SKETCH

Scale: 1"=60' Nov. 1978

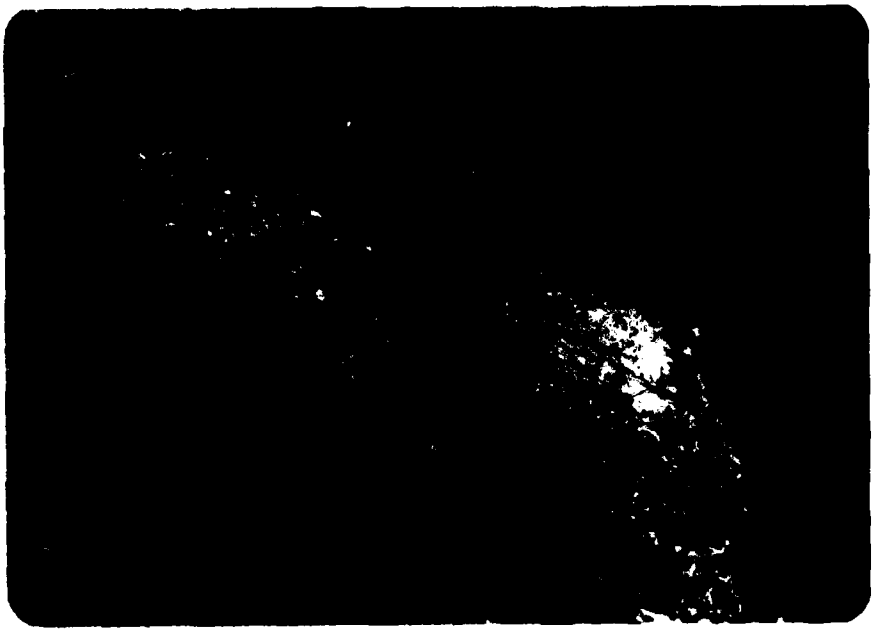
1 2

2. Overview of dam from hillside downstream of left abutment

3. View of spillway and wooded embankment from elderly housing project

4. Upstream paved slope at left end

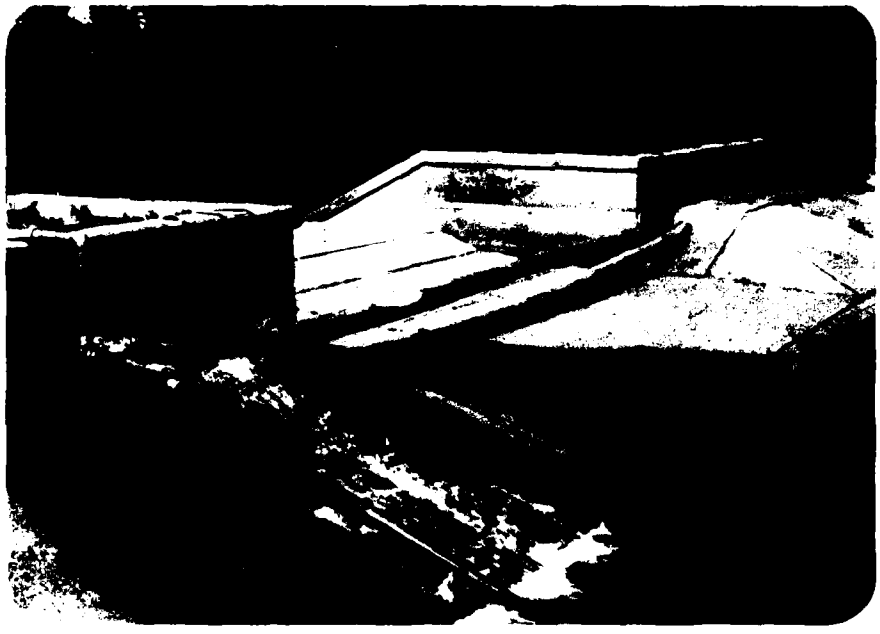
5. Top of embankment and upstream slope right of spillway



6. Deterioration of concrete in pavement on upstream slope, about 55 ft. right of spillway

7. Downstream slope left of spillway

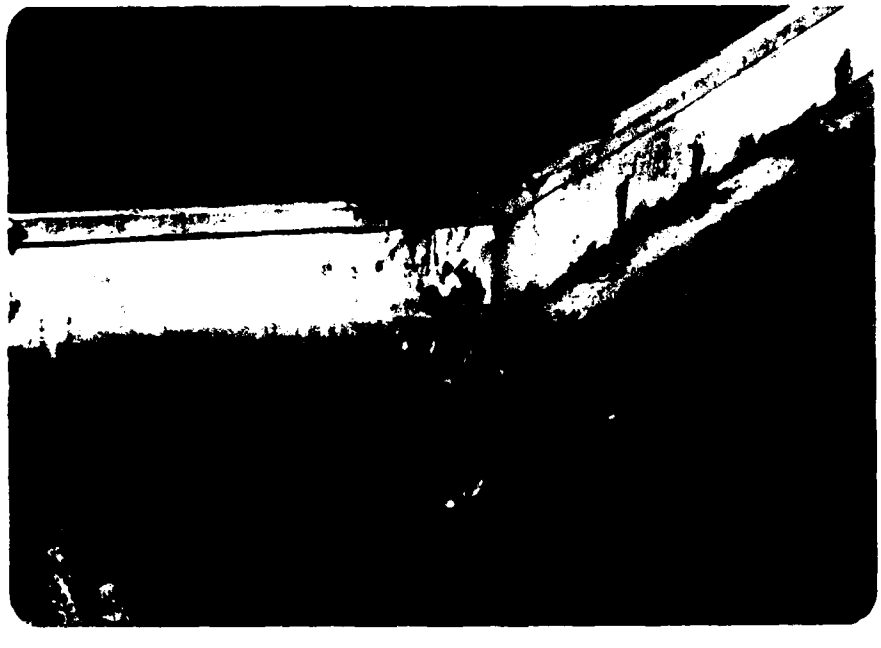
8. Downstream slope right of spillway



9. Spillway approach and log boom

10. Downstream face of spillway

11. Training wall left of stilling basin showing 24-in. blow-off pipe and underdrain outlet

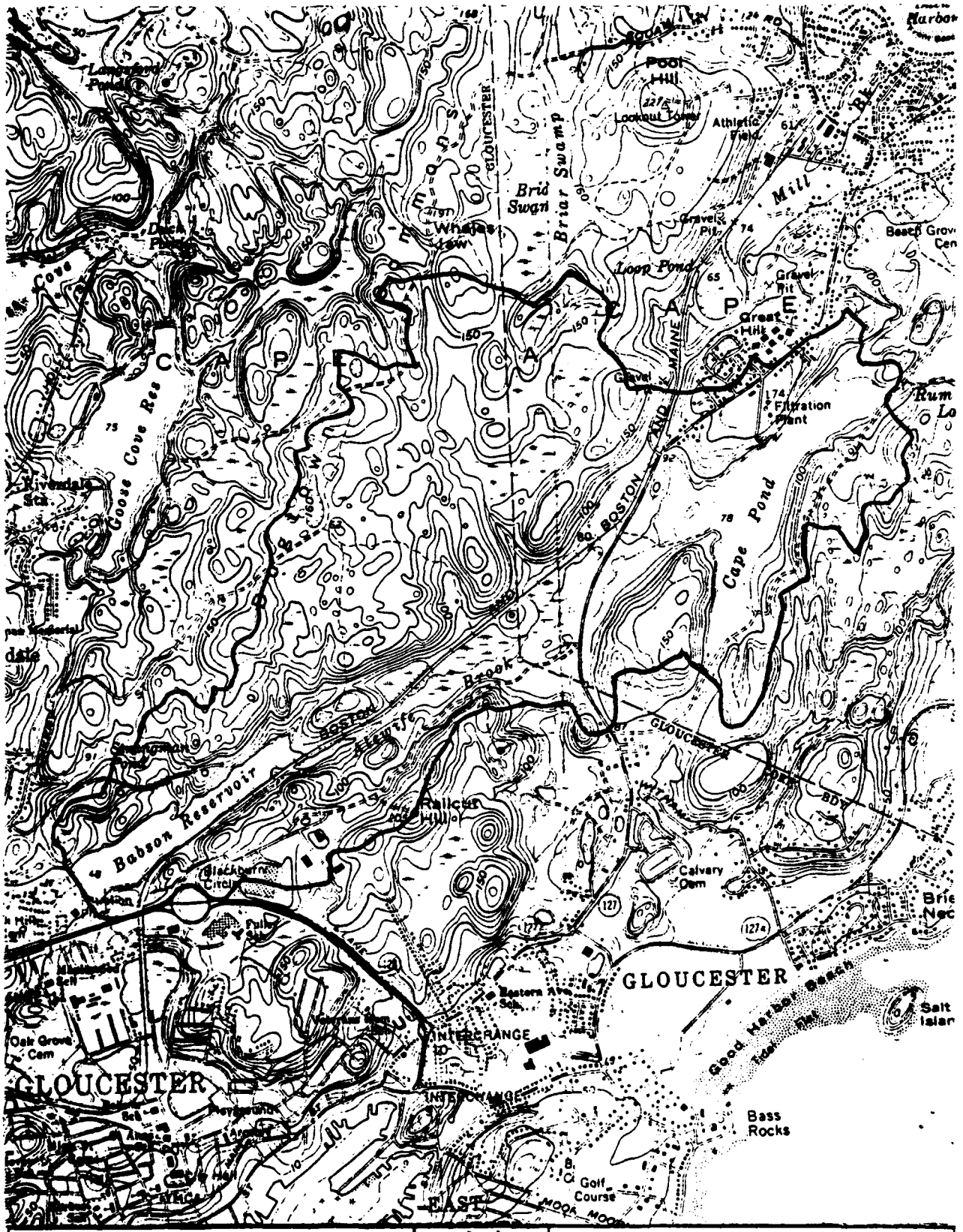


12. Training wall right of stilling basin

13. Discharge channel downstream of spillway

14. Gate house and service bridge

APPENDIX D
OUTLINE OF DRAINAGE AREA AND HYDRAULIC COMPUTATIONS



CAMP DRESSER & McKEE INC. Consulting Engineers Boston, Massachusetts	N	BABSON RESERVOIR Drainage Area Scale: 1:24,000

Size and Hazard Classification

Size Classification

Height of Dam = 35.8' (25 < 35.8 < 40)

Storage : $\frac{1}{3} \times 31' \times 56 + \left(\frac{56 + 42.5}{2}\right) \times 5.8'$

Storage = 925 Acre-Feet (50 < 925 < 1000)

∴ Size Classification is Small

Hazard Classification

Because of elderly housing development, as well as numerous homes and the Water Pumping Station located immediately downstream of dam, initially assume that the hazard classification will be high.

Drainage Area

Drainage Area to outlet of Babson Reservoir = 1308 ac

Water Surface Area of Babson (at elev. 98) = 40 Acres

Water comprises ~3.1% area (at USGS Datum)

Historical Floods

No gaging records available.

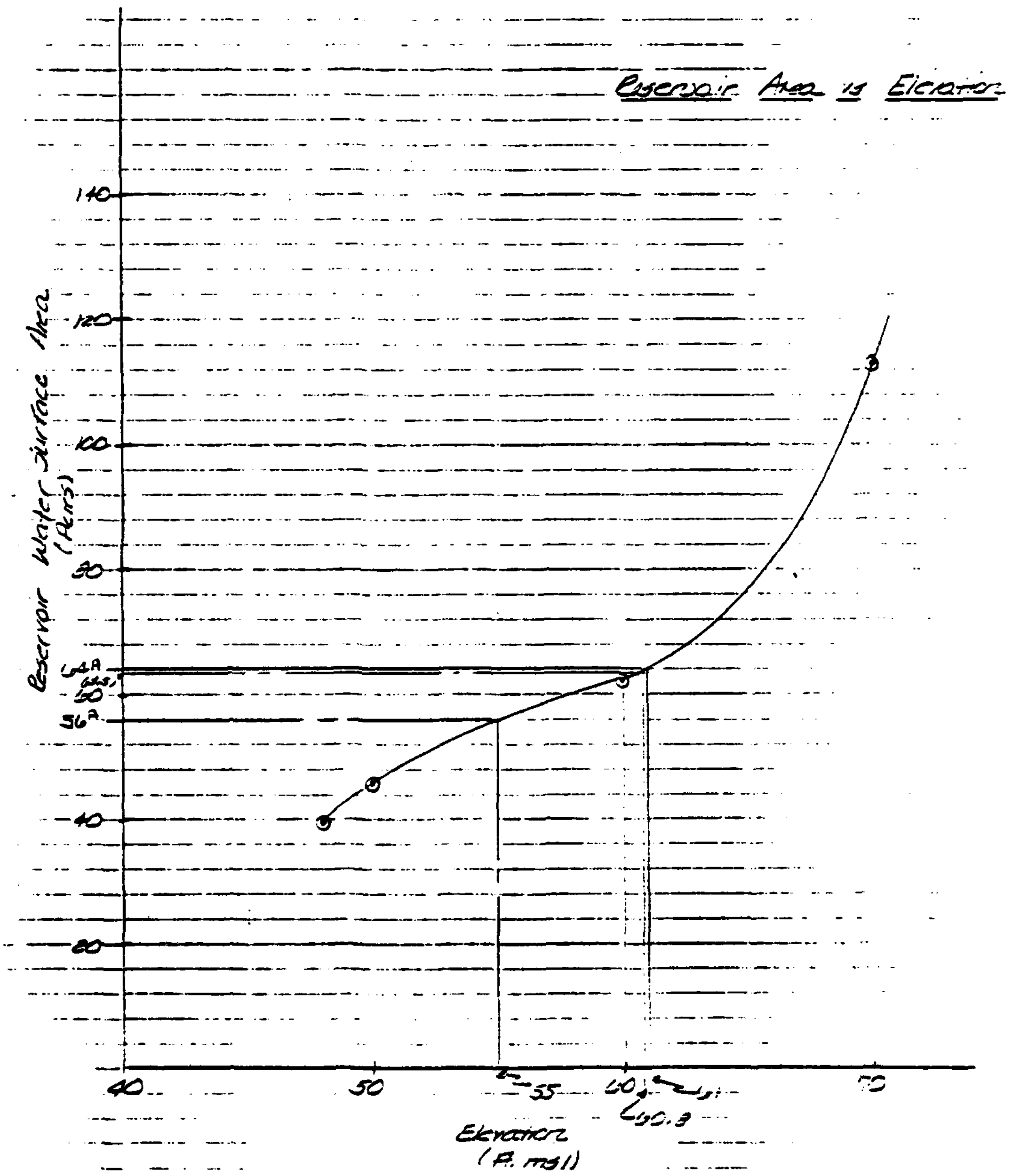
Test Flood

Size - Small
Hazard - High → Range of 1/2 PMF to PMF

* because of downstream [illegible] use the PMF as the Test Flood.

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT ________ PROJECT ________ DETAIL ________
JOB NO. ________ DATE CHECKED ________ CHECKED BY ________
PAGE 3 of 13 DATE ________ COMPUTED BY ________



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Environmental Engineers
Boston, Mass.

CLIENT _____ JOB NO: _____ PAGE 4 OF 13
PROJECT _____ DATE CHECKED _____ DATE _____
DETAIL _____ CHECKED BY _____ COMPUTED BY _____

Probable Maximum Flood Calculations

Drainage Area = 2.04 sq. mi. (1308 Acres)

* The drainage area is less than 10 square miles, so try SCS TP-149 Method for determining flow.

Curve Number Determination

Gloucester Soil Group : A
Rockport Soil Group : C

From boring information: top layer - loose, sand - gravel
middle layer - medium - hard clay (silt
bottom layer - bedrock (>40' down)

Use Hydrologic Soil Group B.

Land Use	Area	CN	CN x Area
Wood or Forest	1000	55	55330
Streets, Roofs	19	98	1862
Reservoir, Pond	35	100	3500
Marshland	180	98	17640
Homes (1/8 Acre)	13	75	1350
	1308		84682

Weighted CN = 65

Time of Concentration, Lag times

$$Lag = \frac{L^{0.8}(S+1)^{0.7}}{1900\ Y^{0.5}}$$

L = 11,500 feet

$S = \frac{1000}{CN} - 10$, $S = \frac{1000}{65} - 10 = 5.38462$

Slope 15% 1725' 62'

35% 9775' 74'

Slope $= \frac{12'}{8050'} = .0015$ $Y = .15\%$

$Lag = \frac{11{,}500^{0.8}\,(6.38462)^{.7}}{1900\,(0.15)^{.5}} = 8.82$ hours

$Tc = \frac{L}{.6} = 14.7$ hours

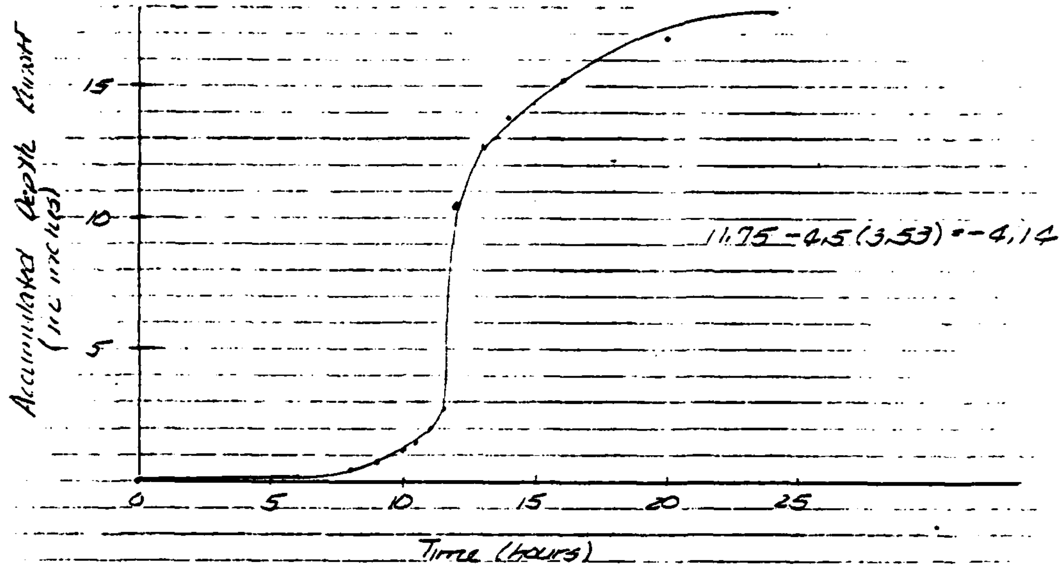
$\Delta D = 0.4L = 3.53$ hours

$TΔD = 24.71$ hours

$Q = \frac{(P-.25)^2}{P+0.85}$

*Maximum Probable Storm = 23 inches in 6 hours

Time (hours)	$\frac{P_t}{P_{24}}$	Mass P (inches)	Mass Q (inches)
0	0	0	0
2	.022	.51	.07
4	.048	1.12	.0003
6	.080	1.86	.10
8	.120	2.80	.42
9	.147	3.43	1.72
10	.181	4.22	1.16
10.5	.204	4.75	1.50
11	.235	5.48	2.00
11.5	.283	6.59	2.79 → 11.75
12	.663	15.45	10.46
13	.772	18.00	12.94
14	.820	19.11	13.89
16	.880	20.50	15.21
20	.952	22.18	16.81
24	1.000	23.00	17.89



Increment	Time (hours)	Mass Runoff (in.)	ΔQ (inches)	Δq cfs	Y	YΔq cfs
	-4.14	0				
ΔD_1			0	0	0.2	0
	-0.61	0				
ΔD_2			0	0	0.4	0
	2.92	0				
ΔD_3			0.15	14	0.6	8
	6.45	0.15				
ΔD_4			1.01	94	0.8	75
	9.98	1.16				
ΔD_5			11.84	1103	1.0	1103
	13.51	13				
ΔD_6			2.8	261	0.667	174
	17.04	15.8				
ΔD_7			1.6	149	0.333	50
	20.57	17.4				
						$\Sigma \approx 1410$ cfs

$$\Delta q = \frac{484\ A\ (\Delta Q)}{\frac{\Delta D}{2} + L} = \frac{484\ (2.04)\ \Delta Q}{\frac{3.53}{2} + 3.33} = 93.2\ \Delta Q$$

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT: Haley and Aldrich
PROJECT: [illegible]
DETAIL: Babson Reservoir

JOB NO. [illegible]
DATE CHECKED: 10-11-78
CHECKED BY: [illegible]

PAGE: 7 of 13
DATE: [illegible]
COMPUTED BY: [illegible]

Using Maximum Probable Flood, Peak Flow Rates Graph

— Flat and Coastal Curve, Q = 925 cfs/sq. mi
Babson: 1.50 x 925 = 1388 cfs
70% Cape Pond: .70 x .54 x 925 = 350 cfs
∴ Q = 1388 + 350 = 1738 cfs ← Use this Flow, more conservative

* Note that 1739 cfs is close to 1410 cfs

SURCHARGE STORAGE

$STOR_1 = \frac{5.63 \times 56}{2.04 \times 533} = 2.9"$, $Q_{P2} = 1738 (1 - \frac{2.9}{23}) = 1519$ cfs

$STOR_2 = \frac{5.13 \times 56}{2.04 \times 533} = 2.7"$ Ave STOR = 2.8

$Q_{P3} = 1738 (1 - \frac{2.8}{23}) = 1526$ cfs

elev. 59.2

Spillway Rating Curve

*FROM INSPECTION

— spillway length = 39.75'

Gloucester Datum:
- Elevation of spillway crest = 55'
- Elevation of spillway crest w/ flashboards = 57.15'
- Elevation of top of dam = 60.80'

Spillway shape → closely approximates Fig. 5.11 in King and Brater, Handbook of Hydraulics

$Q = CLH^{3/2}$

Elevation (local datum)	Head (ft.)	Q (cfs)
55	0	0
56	1	124
57	2	362
58	3	665
59	4	1024
60	5	1431
60.8	5.8	1788

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Environmental Engineers
Boston, Mass.

CLIENT: Haley and Aldrich
PROJECT: National Dam Insp.
DETAIL: Babson Reservoir

JOB NO. 541-9-RT
DATE CHECKED: 10-11-78
CHECKED BY: [illegible]

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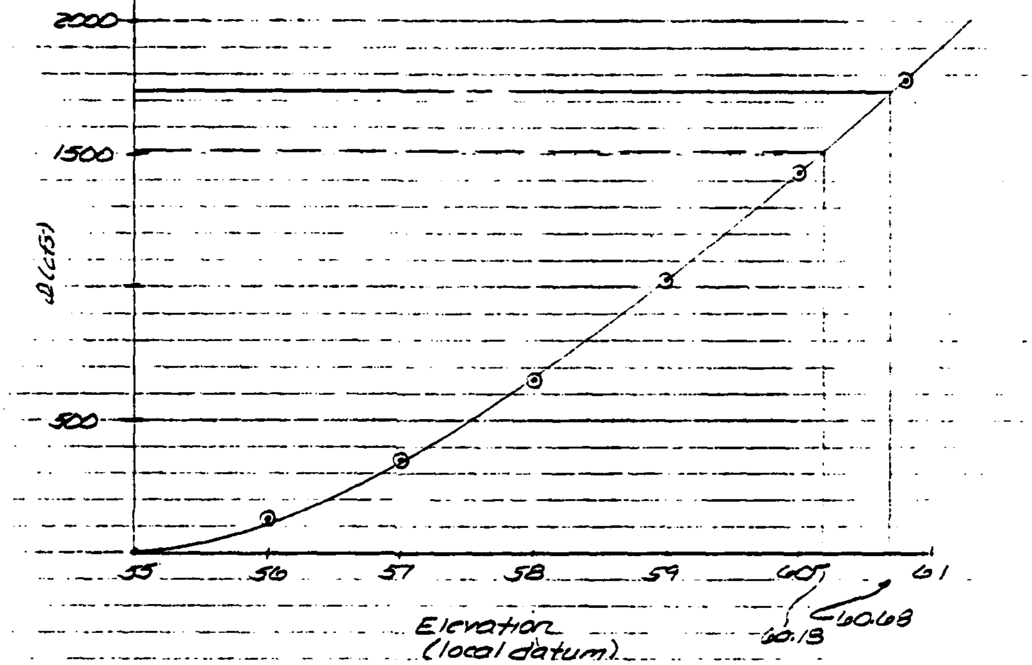
DATE [illegible]
COMPUTED BY [illegible]

Spillway Rating Curve



Guidance For Estimating Downstream Dam Failure Hydrographs

1. Reservoir Storage, S, in Acre-feet at top of dam:

$S = 925$ Acre-feet

2. $Q_{p1} = \frac{8}{27} W_b \sqrt{g}\ Y_o^{3/2}$

$Q_{p1} = \frac{8}{27} \times (.40 \times 600) \times \sqrt{32.2'/s^2} \times (35.3')^{3/2}$

$Q_{p1} \cong 86,435$ cfs

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CLIENT [illegible]
PROJECT [illegible]
DETAIL [illegible]

JOB NO. [illegible]
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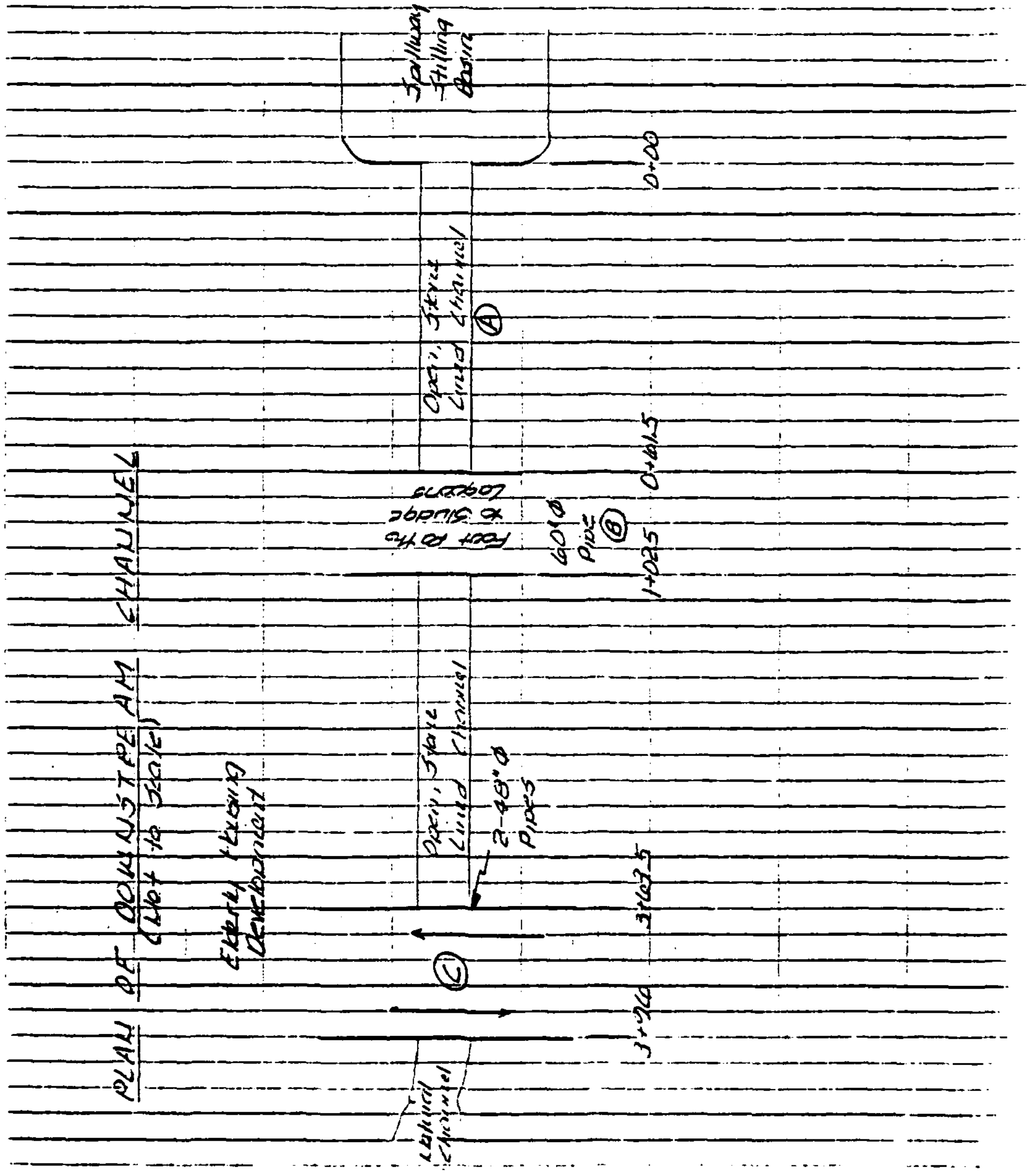

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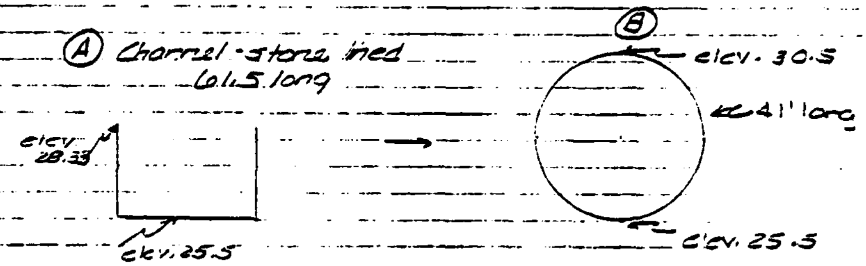
Environmental Engineers
Boston, Mass.

CLIENT [illegible] PROJECT [illegible] DETAIL [illegible] Reservoir
JOB NO. [illegible] DATE CHECKED [illegible] CHECKED BY [illegible]
PAGE 10 of 13 DATE [illegible] COMPUTED BY [illegible]

Top of mound
33.8

First Reach - local datum

Ⓐ Channel - stone lined
61.5 long



- Channel Flowing Full

$$Q = \frac{1.49}{.035} R^{2/3} S^{1/2} A$$

$A = 2.83' \times 4.25' = 12.04$ ft²
$WP = 9.91$

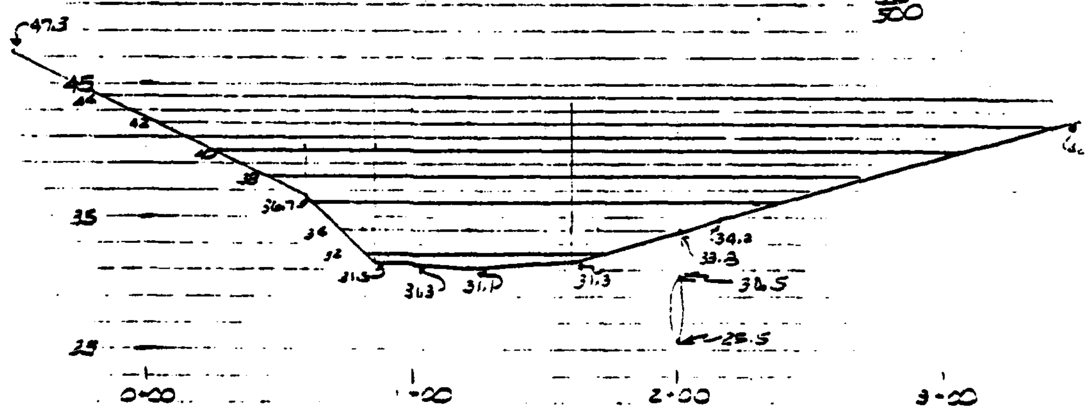
$$R = \frac{12.04}{9.91} = 1.215$$

Assume $S = .0001$

$$Q = \frac{1.49}{.035} (1.215)^{2/3} (.0001)^{1/2} \times 12.04 = 6 \text{ cfs}$$

Ⓑ Ground Profile at 60" Ø pipe, crossing to sludge lagoons looking downstream (local datum)

-50/500



Elev. (local datum)	Head (ft.)	Q pipe	Q overland	Q total
25.5	0	0	0	0
26.0	0.5	↓		
28.0	2.5	↓		
30.5	5.0	23		23
31.L	5.6	109	↓	109
32	6.5	172	188	360
34	8.5	262	1020	1282
36	10.5	329	2895	3224
38	12.5	384	5580	5964
40	14.5	432	7700	8138
42	16.5	475	9814	10289
44	18.5	515	12325	12840

Q overland: C = 2.5C
n pipe = .015
C pipe = 0.89

Pressure Flow - $Q = CA\sqrt{2gh}$

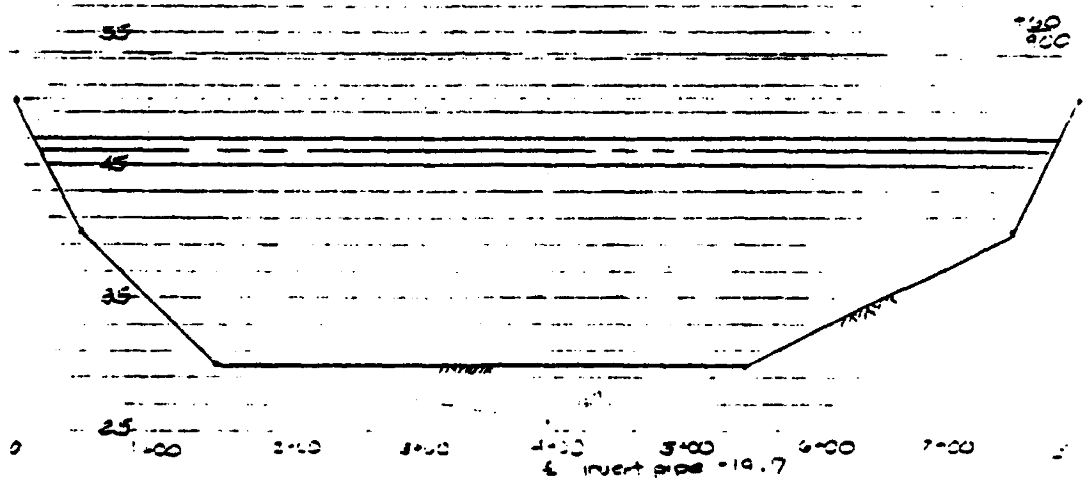
From Q total, one can see that pipe will be washed out, Pumping Stat. will be inundat.

Note: Carry full breach flow down to second reac

Elderly Housing Section (C)

looking downstream
Cross - Section

+20 -100 ← U.S.G.S. Datum



CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT Haley and Aldrich
PROJECT [illegible]
DETAIL Salem Reservoir

JOB NO. 511-2-PT
DATE CHECKED 10-11-79
CHECKED BY [illegible]

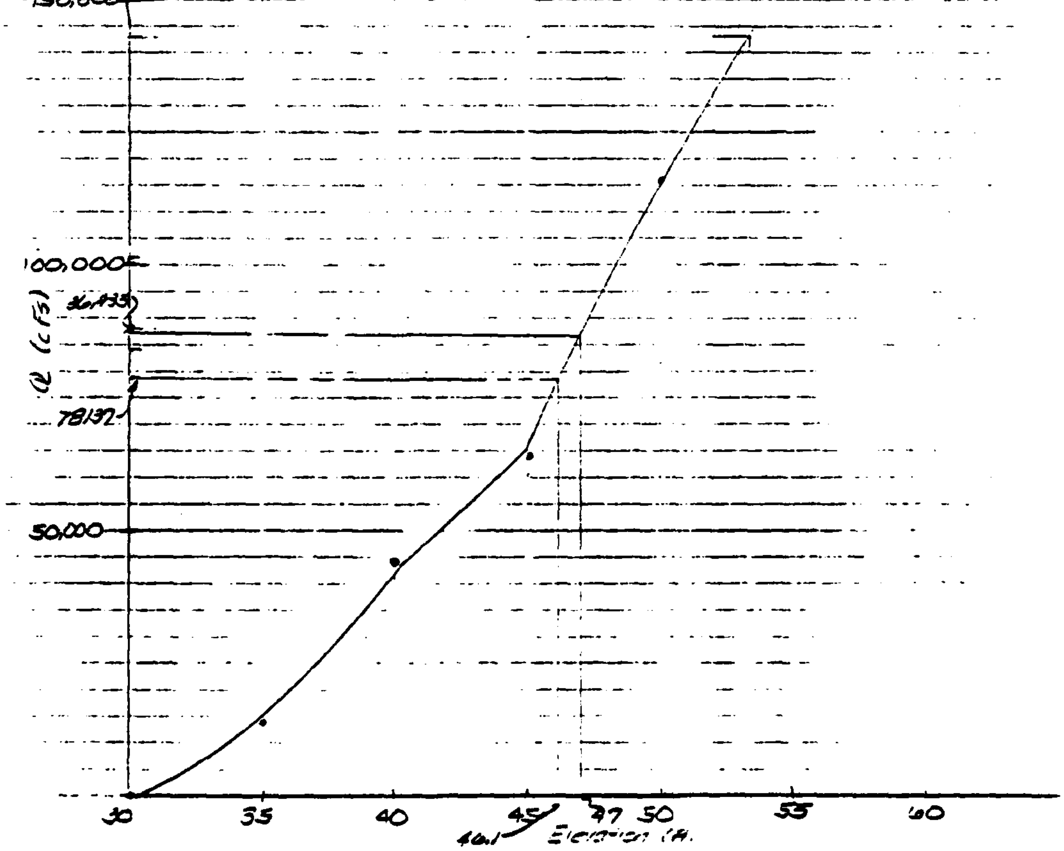
DATE [illegible]
COMPUTED BY [illegible]

Elevation ft (msl)	Head (ft)	Q pipes	Q spillway	Q total
30	6.3	451	0	451
35	11.3	604	13493	14097
40	16.3	725	43107	43832
45	21.3	829	63111	63940
50	26.3	921	114243	115164
60	36.3	1022	185216	186298

$Area_{pipes}$ = 12.57 ft^2

During field insp. pipes were not filled in with sand and grass clippings. Assume they are securely clean.

CROSS SECTION RATING CURVE



Peak Flow Analysis (continued)

a. Q_{p_1} = 26,935 cfs

Elevation = 47.0 (msl)

Area X-section = 10645 ft² Volume = $\frac{10645 \times 363.5}{43,560}$

Volume = 88.8 Acre-ft

$Q_{p_2} = 26,435\left(1 - \frac{88.8}{925}\right)$ = 78,137 cfs.

At 78,137 cfs, (Elev. 46.1) Area X section = 9953 ft²

Volume = $\frac{9953 \times 363.5}{43560}$ = 83.1 Acre-ft

$\frac{V_1 + V_2}{2} = \frac{88.8 + 83.1}{2}$ = 85.95 Acre-ft

$Q_p = 26,435\left(1 - \frac{85.95}{925}\right)$ = 78,405 cfs

at Elev. 46.2 (msl)

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	187	NED	MA	009	04				BABSON RESERVOIR DAM	4237.4	7040.1	15	NOV	78

(11) POPULAR NAME	(11) NAME OF IMPOUNDMENT
	BABSON RESERVOIR

(1) REGION	(10) BASIN	(13) RIVER OR STREAM	(14) NEAREST DOWNSTREAM CITY–TOWN–VILLAGE	(15) DIST FROM DAM (MI.)	(16) POPULATION
01	06	TR-MILL RIVER	GLOUCESTER	0	27209

(17) TYPE OF DAM	(18) YEAR COMPLETED	(19) PURPOSES	(20) STRUCTURAL HEIGHT (FT.)	(21) HYDRAULIC HEIGHT (FT.)	(22) IMPOUNDING CAPACITIES MAXIMUM (ACRE–FT.)	NORMAL (ACRE–FT.)	DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
PGHFCT	1930	S	40	34	925	635	NED	N	N	N	N	13DEC78

(28) REMARKS
21-CONCRETE CORE WALL

(23) D/S HAS	(24) SPILLWAY CREST LENGTH	(25) TYPE	(26) WIDTH (FT.)	(27) MAXIMUM DISCHARGE (FT.)	(29) VOLUME OF DAM (CY)	(30) POWER CAPACITY INSTALLED (MW)	PROPOSED (MW)	(31) NAVIGATION LOCKS NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
1	630	C	40	1790												

(4) OWNER	(39) ENGINEERING BY	(38) CONSTRUCTION BY
CITY OF GLOUCESTER	FAY SPOFFORD + THORNDIKE	C. + R. CONSTRUCTION

(37) REGULATORY AGENCY			
DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	NONE	MA DPW

(32) INSPECTION BY	(34) INSPECTION DATE DAY	MO	YR	(35) AUTHORITY FOR INSPECTION
HALEY + ALDRICH, INC.	08	SEP	78	PUBLIC LAW 92-367

(36) REMARKS

2