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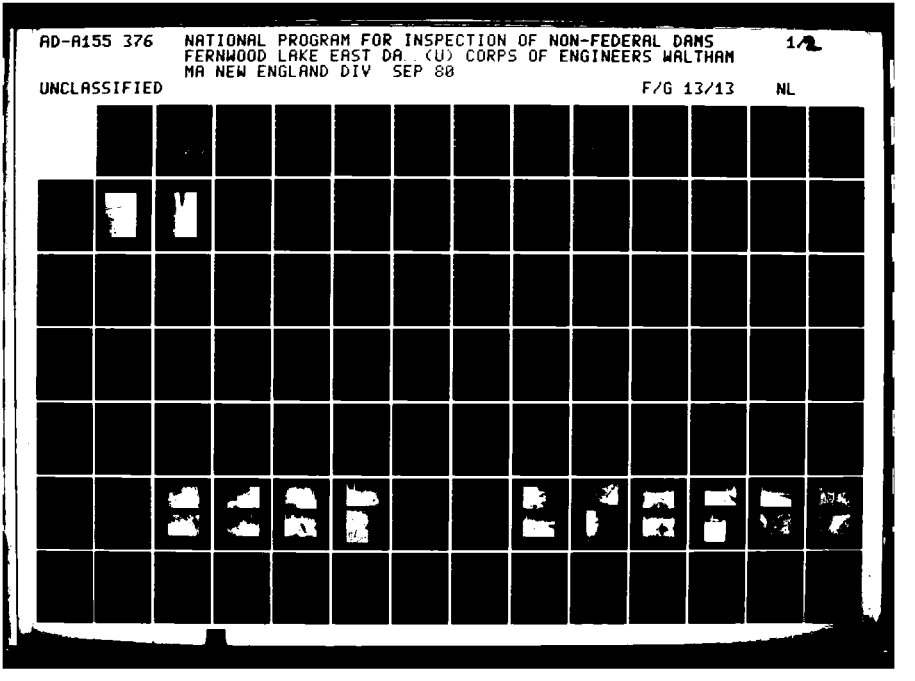
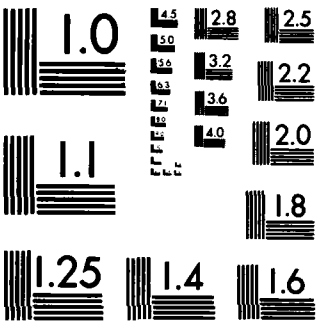


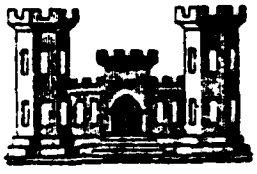


MASSACHUSETTS COASTAL BASIN
GLOUCESTER, MASSACHUSETTS

FERNWOOD LAKE EAST DAM
MA 01336

FERNWOOD LAKE WEST DAM
MA 01337

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



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

SEPTEMBER, 1980

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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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.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Massachusetts Coastal Basin
Gloucester, Massachusetts
Streams to Upper Banjo Pond and Wallace Pond

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

The East dam is about 100 ft. long and has a maximum height of 5 ft.The West dam is about 400 ft. long and a maximum height of 11 ft. Both are classified in the high hazard category, being small in size. Both dams are also in poor condition. Although several deficiencies were noted, there was no evidence of settlement, lateral movement or other signs of structural failure, or other conditions which would warrent urgent remedial action.

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REPLY TO
ATTENTION OF:
NEDED

APR 2 1981

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

Dear Governor King:

Inclosed is a copy of the Fernwood Lake East Dam (MA-01336), and Fernwood Lake West Dam (MA-01337) 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, the City of Gloucester, Public Works Department, Popular Street, Gloucester, MA 01930.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Environmental Quality Engineering for your cooperation in carrying out this program.

Sincerely,

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

Incl
As stated

MASSACHUSETTS COASTAL BASIN
GLOUCESTER, MASSACHUSETTS

FERNWOOD LAKE EAST DAM
MA 01336

FERNWOOD LAKE WEST DAM
MA 01337

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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

SEPTEMBER 1980

NATIONAL DAM INSPECTION PROGRAM
PHASE I INVESTIGATION REPORT

Identification Nos.:	MA 01336 and MA 01337
Name of Dams:	Fernwood Lake East and West
Town:	Gloucester
County and State:	Essex, Massachusetts
Stream:	Streams to Upper Banjo Pond and Wallace Pond
Date of Site Visits:	21 August 1979 and 2 May 1980

BRIEF ASSESSMENT

Fernwood Lake is impounded by three separate earth embankment dams believed to have been built in 1877. (There is also a 325 ft. long South Dike separating a portion of the south end of the lake; however, it has a "low" hazard potential and thus was excluded from inspection.)

East Dam is approximately 100 ft. long and has a maximum height of 5 ft. Its 8-in. diameter outlet pipe has been blocked. West Dam is approximately 400 ft. in length and a maximum of 11 ft. in height. It has a 14-in. diameter low-level outlet. The main dam at the north end of the lake is 450 ft. in length, 19 ft. in height and has a 19 ft. long spillway crest. The main Fernwood Lake (North) Dam - MA 00184 was the subject of a previous Phase I Inspection Report dated April 1979.

The East and West dams were initially classified as having a "low" hazard potential, based on preliminary observations. More detailed analyses were since performed to determine the extent of downstream development that would be affected in the event the dams were to fail. It is now concluded that the East and West dams have a "high" hazard potential in accordance with Corps of Engineers guidelines.

The East and West dams are both in poor condition, based on visual examinations of the structures. Although several deficiencies were noted, there was no evidence of settlement, lateral movement or other signs of structural failure, or other conditions which would warrant urgent remedial action.

Based on the "small" size and "high" hazard potential classifications of these dams in accordance with Corps of Engineers guidelines, the test flood is one-half the Probable Maximum Flood (1/2 PMF). Hydraulic analyses indicate that the test flood outflow of 370 cfs (inflow 475 cfs or 913 csm) would overtop East Dam by 0.5 ft. and that a freeboard of 1.5 ft. would remain at

West Dam. (A freeboard of 1.6 ft. would remain at North Dam and South Dike would be overtopped by 0.3 ft.) With the water level at the top of East Dam, the spillway capacity at North Dam with flashboards in place is about 80 cfs or 22 percent of the peak test flood outflow.

The City of Gloucester, owner of these dams, should engage a qualified registered professional engineer to direct removal of trees, stumps and roots on embankments, and restoration of the embankment cross-sections; and carry out other hydrologic/hydraulic investigations related to overtopping potential and outlet works, and a seismic stability investigation of the dams. These items are outlined in Section 7.2.

The implementation of work as directed by the engineering consultant and remedial measures, including the clearing of brush on the embankments; repairing eroded and bare areas; repairing the upstream walls and slopes where they have deteriorated; and monitoring seepage, as outlined in Section 7.3, should be undertaken within one year after receipt of this report. The Owner should also prepare a formal operations and maintenance manual for the dams and establish an emergency preparedness plan and downstream warning system.

HALEY & ALDRICH, INC.
by:

Richard A. Brown
Senior Engineer

Peter L. LeCount
Vice President

This Phase I Inspection Report on Fernwood Lake East Dam (MA-01336) and Fernwood Lake West Dam (MA-01337) has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

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

ARAMAST MAHTESIAN, CHAIRMAN
Geotechnical Engineering Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the office of Chief of Engineers, Washington, 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 will 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 aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential. Consideration of downstream flooding other than in the event of a dam failure is beyond the scope of this investigation.

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

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

1. Overview photo of Fernwood Lake East Dam from right side of dam (2 May 1980)

2. Overview photo of Fernwood Lake West Dam taken when lake level was low (6 December 1978)

DAM: Fernwood Lake East

IDENTIFICATION NO. MA 01336

DAM: Fernwood Lake West

IDENTIFICATION NO. MA 01337

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LOCATION MAP

U.S.G.S. QUADRANGLE

GLOUCESTER, MA

APPROX. SCALE: 1" = 2000'

FILE NO. 4270 A44

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
FERNWOOD LAKE EAST DAM
MA 01336
FERNWOOD LAKE WEST DAM
MA 01337

SECTION 1 - PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, 8 August 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 28 November 1978 from Colonel Max B. Scheider, Corps of Engineers. Contract No. DACW33-79-C-0018 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/hydrologic aspects of the Investigation.

b. Purpose of Inspection. 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 effective dam safety programs for non-Federal dams.

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

1.2 Description of Project

a. Location. The East and West dams are located on opposite sides of Fernwood Lake in Gloucester, MA, as shown on the Location Map, page viii. The latitude and longitude of East Dam are N42°36.7' and W70°41.9'. The latitude and longitude of West Dam are N42°36.5' and W70°42.1'. Seepage through East Dam would drain eastward to Upper Banjo Pond. Discharge through the outlet at West Dam would be conveyed southwestward to Wallace Pond.

The relative locations of these dams to North Dam and South Dike on Fernwood Lake are shown on the plan of land included as page B-2.

b. Description of Dams and Appurtenances. The East and West dams are earth embankments with gated outlet pipes through them. The general configuration of each dam and its appurtenant structures is shown on the respective "Site Sketch Plan", pages C-1 and C-6.

East Dam is approximately 100 ft. long with a maximum hydraulic height of 5 ft. The crest is generally about 8 to 9 ft. wide. There is irregularly placed boulder riprap on the upstream side. The downstream slope is about 1 horizontal to 1 vertical.

The outlet works for East Dam is a single 8-in. diameter iron pipe protruding from the downstream face of the dam. The outlet works is reported to be abandoned and the pipe plugged at an unknown location. There is no known valve on this outlet pipe.

West Dam is approximately 400 ft. long and slightly "vee" shaped. It has a maximum hydraulic height of about 11 ft., although the toe of the dam is generally about 9 ft. below the crest. The upper 3.5 ft. of the upstream slope is a vertical stone masonry wall. There is generally stone riprap on the slope below the wall. The width at the top of the dam is about 7 to 8 ft. The downstream slope is fairly steep, at least 2 horizontal to 1 vertical.

The outlet works for West Dam is a pipeline through the dam which discharges into a stone paved channel downstream of the access road at the toe of the dam. The pipeline is controlled by a gate valve located in a manhole at the downstream toe of the dam. The diameter of the pipeline at the point of discharge is 14 inches.

North Dam and South Dike were described in a previous report entitled Fernwood Lake Dam - MA 00184, Phase I Inspection Report, National Dam Inspection Program, Corps of Engineers, April 1979. Briefly, North Dam consists of an earth embankment approximately 450 ft. in length and a 19 ft. long flashboard controlled spillway crest at the right abutment. South Dike is approximately 325 ft. long and separates a small portion of the lake at the south end.

The elevations of the tops of the three dams and one dike on Fernwood Lake vary as follows:

Identification of Structure, Based on Location	Approximate Elevation at top of Embankment, ft. above NGVD
East Dam	93.4
West Dam	95.4
North Dam	95.5
South Dike	93.6

c. Size Classification. The storage to the top of Fernwood Lake East Dam is estimated to be 310 acre-ft., and the corresponding hydraulic height of the dam is approximately 5 ft. The storage to the top of Fernwood Lake West Dam is estimated to be 380 acre-ft., and the corresponding hydraulic height of the dam is approximately 11 ft. Storage of less than 1,000 acre-ft. and a height of less than 40 ft. classifies both of these dams in the "small" size category according to guidelines established by the Corps of Engineers.

d. Hazard Classification. Based on studies for Fernwood Lake Dam - MA 00184 in the Phase I Inspection Program Report dated April 1979, East Dam and West Dam appeared to have "low" hazard potential. However, dam failure analysis computations in Appendix D, which are based on "Guidance for Estimating Downstream Dam Failure Hydrographs" demonstrate why these dams were reclassified to a "high" hazard potential in the Corps of Engineers National Inventory of Dams. Failure of East Dam would cause flooding at least 6 ft. deep at LePages, Inc. adjacent to Lower Banjo Pond. Failure of West Dam would result in flooding of several dwellings and a water treatment plant. Either event could result in excessive property damage and loss of more than a few lives.

e. Ownership. The name, address and number of the current owner are:

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

Mr. James McNulty is the director of the Public Works Department.

The City of Gloucester purchased Fernwood Lake and some adjacent shoreline, including the dams, in 1952. Prior to that, the property was owned by the Cape Pond Ice Company which dates back to 1877, the year the dams were originally constructed.

f. Operator. Mr. Wilfred Burke, Chief Operator, is responsible for operation, maintenance and safety of the dams, and has been associated with the Public Works Department for 32 years. His phone number at the West Gloucester Filtration Plant adjacent to Wallace Pond is (617) 283-3218.

g. Purpose of Dams. The lake is used only as a water supply for the City of Gloucester. The original purpose of the dams was to impound water for cutting ice.

h. Design and Construction History. No details of the original construction were disclosed. The earliest available county inspection report on North Dam dated 23 April 1912 contains a statement that T.W. Homans of the Cape Pond Ice Co. owned this dam in 1877 and probably built it himself. It is therefore likely that the East and West Dams were also built at that time.

A sketch of a typical section through East Dam appears in the earliest available county inspection report on that dam dated 24 April 1912, page B-3. The present configuration of the dam is similar, except that the crest is generally 8 to 9 ft. wide instead of 14 ft. Although not mentioned in the county inspection reports, the 8-in. diameter outlet pipe was reportedly blocked shortly after the City of Gloucester became the owner in 1952 to prevent water from being diverted to Upper Banjo Pond from Fernwood Lake.

A sketch of a typical section through West Dam appears in the the earliest available county inspection report on that dam dated 24 April 1912, page B-7. Subsequent, county inspection reports indicated that the embankment was raised about 2 ft., as was North Dam, in 1929. The 3.5 ft. high dry laid stone masonry wall on the upstream side of the dam was also built at that time. The 14-in. diameter outlet pipe was reportedly installed shortly after the City of Gloucester became the owner in 1952, although no records of this construction are available.

i. Normal Operational Procedures. There are apparently no operational procedures in effect for East Dam. West Dam is viewed on a weekly basis. The operator, as required, allows water to

flow through the West Dam outlet pipe to supplement the natural drainage to Wallace Pond. West Dam is maintained on an as needed basis, but actual maintenance work performed is at very infrequent intervals.

1.3 Pertinent Data

In lieu of better information, all elevations reported herein are approximate and based on the assumption that the top of the concrete spillway weir at North Dam is El. 91.0 NGVD (the level of Fernwood Lake shown on the USGS Gloucester Quadrangle Map).

a. Drainage Area. The drainage area of the dams is approximately 335 acres (0.52 sq. mi.) and is located south of Essex Avenue in western Gloucester, about 2,000 ft. inland from the Atlantic. Elevations in the watershed vary from a low of about El. 90 to a high of about El. 200. The drainage area consists of approximately 70 percent well preserved woodlands, 10 percent water surface and 20 percent swamp. A map of this area is shown on page D-1.

b. Discharge at Dam Site

1. Outlet works.....	14-in. diameter pipe at West Dam, invert El. 85.0 and discharge capacity of 15 cfs. 8-in. diameter pipe at East Dam, invert El. 88.4 and no discharge capacity because it was plugged by the Owner
2. Maximum known flood at dam site.....	Unknown. However, a maximum pool level of El. 93.3 was recorded at North Dam on 20 March 1968
3. Ungated spillway capacity at top of dam.....	Not applicable
4. Ungated spillway capacity at test flood pool elevation.....	Not applicable
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.	Not applicable
8. Total project discharge at top of dam.....	Not applicable at East Dam. At West Dam, 15 cfs at El. 95.4 if outlet valve is open
9. Total project discharge at test flood pool elevation.	At East Dam, 88 cfs at El. 93.9. At West Dam, 13.6 cfs at El. 93.9 if outlet valve is open

c. Elevation (ft. above NGVD)

1. Streambed at toe of dam...	88.4 at East Dam 84.4 at West Dam
2. Bottom of cutoff.....	Unknown
3. Maximum tailwater.....	Not applicable at East Dam. At West Dam, 85.4 (See page D-17)
4. Normal pool.....	91.0
5. Full flood control pool...	Not applicable
6. Spillway crest.....	Not applicable
7. Design surcharge - original design.....	Unknown
8. Top of dam.....	93.4 (East Dam) 95.4 (West Dam)
9. Test flood design surcharge.....	93.9

d. Length of Reservoir (ft. estimated)

1. Normal pool.....	2,100
2. Flood control pool.....	Not applicable
3. Spillway crest pool.....	Not applicable
4. Top of dam.....	2,200 (East Dam) 2,400 (West Dam)
5. Test flood pool.....	2,300

e. Storage (acre-ft.)

1. Normal pool.....	225
2. Flood control pool.....	Not applicable
3. Spillway crest pool.....	Not applicable
4. Top of dam.....	310 (East Dam) 380 (West Dam)
5. Test flood pool.....	340

f. Reservoir Surface (acres)

1. Normal pool	28
2. Flood control pool	Not applicable
3. Spillway crest	28
4. Test flood pool	36
5. Top of dam	34 at East Dam 41 at West Dam

g. East Dam

1. Type	Earth embankment
2. Crest length	100 ft.
3. Height	5 ft. maximum
4. Top width	8 to 9 ft.
5. Side slopes	Upstream unknown. Downstream 1H to 1V
6. Zoning	Unknown
7. Impervious core	Unknown
8. Cutoff	Unknown
9. Grout curtain	Unlikely
10. Other	None

West Dam

1. Type	Earth embankment with dry-laid stone wall on upstream side
2. Length	400 ft.
3. Height	11 ft. maximum
4. Top width	7 to 8 ft.
5. Side slopes	Upper 3.5 ft. of upstream slope vertical; otherwise both slopes fairly steep, at least 2H to 1V
6. Zoning	Unknown
7. Impervious core	Unknown
8. Cutoff	Unknown
9. Grout curtain	Unlikely
10. Other	Embankment raised approximately 2 ft. in 1929

h. Diversion and Regulating Tunnel. Not applicable

i. Spillway. Not applicable. Spillway is at North Dam. See separate report on Fernwood Lake Dam - MA 00184, April 1979.

j. Regulating Outlet at East Dam

1. Invert	El. 88.4
2. Size	8-in. diameter
3. Description	Cast iron pipe
4. Control mechanism	Could not be located
5. Other	Reportedly blocked by owner around 1952

Regulating Outlet at West Dam

1. Invert	Estimated El. 85.0 upstream, El. 84.4 downstream
2. Size	14-in. diameter
3. Description	Cast iron pipe approximately 100 ft. long
4. Control mechanism	Gate valve
5. Other	Added to West Dam around 1952

SECTION 2 - ENGINEERING DATA

2.1 Design Data

No design data for the dams were located and none are believed to exist. The reason for raising the West Dam embankment in 1929 was to provide adequate discharge and reduce the likelihood of the dam being overtopped, but no actual design calculations were disclosed.

2.2 Construction Data

No data concerning the original construction of the dams were disclosed. However, there are several county inspection reports that pertain to the modification of West Dam in 1929.

2.3 Operation Data

The operation data of the two dams consist of conditions reported in prior inspection reports dating back to 1912 and water level elevations measured at the spillway at Fernwood Lake (North) Dam on a weekly basis.

2.4 Evaluation of Data

a. Availability. A list of the engineering data available for use in preparing this report is included on page B-1. Selected documents from the list are also included in Appendix B.

b. Adequacy. There was a lack of engineering data available to aid in the evaluation of Fernwood Lake East and West Dams. This Phase I assessment was therefore based primarily on visual examination, preliminary hydraulic and hydrologic computations, consideration of past performance and application of engineering judgement.

c. Validity. The limited engineering data may generally be considered valid.

SECTION 3 - VISUAL EXAMINATION

3.1 Findings

a. General. The Phase I visual examination of the East and West dams on Fernwood Lake was conducted on 21 August 1979. The upstream water surface elevation was about 0.5 ft. below the flashboards at the North Dam spillway that day. A second visual examination of the dams was conducted on 2 May 1980 in order to view them at a time when there was less foliage to obscure them. On that day the upstream water surface elevation was about 0.7 ft. higher than on 21 August 1979.

In general, the projects were found to be in poor condition. Several deficiencies which have developed due to lack of maintenance require correction.

The visual inspection check lists are included in Appendix A and selected photographs of the project are given in Appendix C. A "Site Plan Sketch" of each dam, pages C-1 and C-6, shows the direction of view for each photograph.

b. Dams.

East Dam:

The upstream slope of East Dam is overgrown with trees, saplings and brush, as shown on Photos No. 1 and 3. The numerous birch trees are as large as 10 in. in diameter. Many of them lean out over the water, Photo No. 8. Apparently boulders were placed along the upstream side of the dam. Those that can be observed indicate an irregular upstream slope.

The East Dam embankment is irregular in cross-section. Ground surface is highest at a narrow ridge at the top of the upstream slope, Photo No. 6. A narrow pathway crosses the embankment at about the middle of the crest, Photo No. 8. Ground surface along the path is about 6 in. to 1 ft. lower than that immediately upstream. The top of the embankment is choked with the roots of brush and trees, Photos No. 6 and 8. The embankment is barely visible when there is foliage on the vegetation, Photo No. 7.

The downstream slope of East Dam is covered by brush and trees including oak, birch and maple, Photos No. 1 and 8. The area at and beyond the toe of the dam is wet and swampy. No seepage was observed from the embankment itself, although examination was obscured by vegetation and fallen leaves on the slope.

The abutments of East Dam are natural hillsides. Bedrock outcrops at the left abutment.

West Dam:

The construction of the upstream wall at West Dam is best shown on Photo No. 2, which was taken when the water level was approximately 6.7 ft. below the top of dam. The upstream side was almost totally obscured by very dense brush, young saplings and a higher lake level on 21 August 1979, Photo No. 11. The dry laid stone wall has collapsed in localized areas near the left abutment, Photo No. 12. Closeups of two such areas are shown on Photos No. 13 and 14. In the area of Photo No. 14, the upstream side of the embankment has been eroded back about 2 ft. for a 6 ft. length.

The 7 to 8 ft. wide crest of West Dam is shown on Photos No. 15 and 16. Near the middle of the dam, the crest is as narrow as 5 ft. due to erosion of the downstream slope where motorbikes and pedestrians have traveled up to the crest from the nearby unimproved roadway, Photos No. 17 and 18. There is a narrow bare path worn along the crest of the dam.

The downstream slope of West Dam is covered by brush and small saplings, Photos No. 17 and 19. Some of these are as much as 10 to 12 ft. in height. Apparently, about 4 or 5 years ago, large trees, principally oak and maples, were cut from the embankment. There are a number of stumps visible at the top and upper portion of the slope, some of which are 16 to 20 in. in diameter at the base. Over 40 rings were counted on the largest stumps. Tree roots were visible on the embankment near stumps and trees, Photo No. 19. Also note the fallen tree on the embankment slope on Photo No. 19.

It was only possible to examine about 3/4 of the downstream slope for animal holes because of the very dense brush. Although none were observed, it is understood that there have been skunk holes in this embankment in the past. Remnants of a low stone wall near the base of the downstream slope were visible at the middle of the dam, Photo No. 17.

There was ponded water at two locations beyond the downstream toe of West Dam on 21 August 1979. About 25 ft. left of the manhole, water was ponded just below the toe of the dam over a length of approximately 25 to 30 ft. The water occurred between the dirt roadway and the dam. There was another small pool of water somewhat downstream of the toe toward the right end of the structure. No ponded water was observed on 2 May 1980, but some areas near the toe were moist.

The West Dam embankment grades into the natural terrain at the right abutment. There is a dirt road leading up to the crest of the dam at the left abutment, seen in the foreground of Photo No. 19.

c. Appurtenant Structures. There is a cast iron pipe approximately 8-in. in diameter which crosses under the East Dam embankment and is exposed for 12 ft. beyond the downstream toe, Photo No. 9. This outlet pipe is abandoned and presently of no use. There was no water exiting the pipe. The intake end of the pipe and the valve stem control could not be located.

A pool of rust stained still water was observed below the 8-in. pipe on 21 August 1979, Photo No. 10. There was also ponded water there on 2 May 1980, but the water was clear. This water may be a result of drainage characteristics of the lowlying area and/or may indicate seepage along the abandoned pipe.

West Dam contains a gated 14-in. diameter cast iron outlet pipe used to transfer water to Wallace Pond. No information is available on the intake. The gate valve is operated by a stem within a manhole approximately 25 ft. from the discharge end of the pipe, Photo No. 20. Note that the manhole cover is kept covered by earth to camouflage its location from vandals. The gate valve was operated on 2 May 1980. The pipe terminates at a concrete headwall where there is a short section of stone paved channel, Photo No. 21. The headwall has a minor crack present, Photo No. 22. The paved channel is in good condition, but there are overhanging trees and brush. The natural channel starting at the end of the paved section is heavily overgrown with trees and brush.

Seepage was apparently occurring in the area downstream of the West Dam outlet pipe discharge end on 21 August 1979. The total flow in the downstream channel was estimated to be 3 to 4 gallons per minute. However, some of this water originated from a swampy area 2 ft. above the channel bed and about 12 ft. downstream on the left side from the discharge end of the outlet pipe.

d. Reservoir Area. Fernwood Lake is bordered by two homes and a manufacturing office building at the north end. Except for the dams and dike, the shoreline is otherwise undeveloped and generally wooded. The terrain is gentle along the west and slightly steeper on the east. There is no significant probability of landslides into the reservoir affecting the safety of the dams. Sedimentation has apparently not been a problem at the dam sites.

e. Downstream Channel.

East Dam:

The 8-in. diameter outlet conduit at East Dam was reportedly blocked at an unknown location by the City of Gloucester. Therefore, there was no surface flow from Fernwood Lake into the downstream channel of East Dam.

The downstream channel, which has a total length of about 4,000 ft. between East Dam and the Annisquam River, includes the Upper and Lower Banjo Ponds, with open channel and closed conduit sections in between.

Discharge over the top of East Dam would flow in an approximately 300 ft. long channel which is overgrown with dense brush and trees before reaching Upper Banjo Pond. In this area, the land on both banks of the channel slopes up, creating a relatively deep and wide valley.

Flow through Upper Banjo Pond is controlled at a piped outlet of a 16.5 ft. high concrete dam located about 130 ft. south of Essex Street (Route 133). Reportedly, about five years ago the water level in the pond was lowered significantly when large cracks were observed in the concrete dam. The overall condition of this dam apparently has deteriorated since then. A low water level is generally maintained by leaving the outlet valve partially open. The outlet channel beyond the dam has a trapozoidal section with a bottom width of 2.7 ft. side slopes of 1 horizontal to 2 vertical and a 4.4 ft. depth. The channel gradient is relatively steep at 17 percent between the dam and a culvert underneath Route 133. The length of the channel at this reach is about 120 ft.

The box culvert underneath Route 133 is 60 ft. long with a cross section of 1.5 ft. height and 4 ft. width. The bottom gradient of the culvert is estimated to be 12 percent. Discharge through the culvert disappears in a swampy-looking area which was overgrown with vegetation. This area extends for a distance of about 250 ft. from Route 133 to Lower Banjo Pond.

The Lower Banjo Pond is located between the B&M Railroad and the facilities of LePages, Inc., which owns both the Lower and Upper Banjo Ponds. There are two outlets from Lower Banjo Pond. Flow through the first outlet is by gravity through an approximately 18-in. diameter underground conduit underneath the B&M railroad to the Annisquam River. The second outlet is used to convey water for cooling.

The total flow through the Lower Banjo Pond gravity outlet system would depend on the level of the tide in the ocean, condition and chacteristics of the underground conduit, discharges from local drains, number of turns at the inlet valve, water level in the pond and the amount of water withdrawn through the cooling water recirculation system.

West Dam:

Normally there is no outflow from Fernwood Lake at the West Dam because the gate valve on the existing 14-in. diameter single outlet pipe is usually closed. The outlet valve is operated only during dry months for supplementing the Wallace Pond storage, which is a source of water supply for the City of Gloucester.

The downstream end of the outlet pipe is protected with a concrete headwall. A section of the channel about 15 ft. long immediately downstream of the headwall is lined with large stone blocks. The rest of the channel is formed naturally and contains various size cobbles, bushes and other types of vegetation. The area surrounding the channel is overgrown with dense bushes and trees. In this area, the channel has a trapozoidal section with about a 6 ft. wide bottom and a depth of about 6 ft. The side slopes are estimated to be 1 horizontal to 1 vertical.

The channel joins a swampy valley at a distance of about 300 ft. from the dam. This 200 ft. wide by 1,000 ft. long valley carries discharges from the West Dam outlet to Wallace Pond.

3.2 Evaluation

Based on the visual examinations conducted on 21 August 1979 and 2 May 1980, the East and West dams are considered to be in poor condition, primarily due to a lack of maintenance of the embankments. Specific deficiencies noted include the extensive and dense cover of trees and brush on upstream and downstream slopes of both embankments; deteriorating cross-sections of the dams; lack of an upstream control for the West Dam outlet pipe (therefore, line is under continuous head beneath embankment); and and vegetation in the West Dam outlet pipe discharge channel.

Wet areas were also noted downstream of both embankments. The outlet pipe at East Dam offers potential for future leakage along the abandoned pipe. Ponded water noted beyond the downstream toe of West Dam is not believed to have adverse connotations insofar as the safety of the dam is concerned at this time.

Although the dams are currently performing satisfactorily, the various deficiencies could provide sufficient potential for embankment failure under conditions of higher than normal water levels or heavy winds.

SECTION 4 - OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General. In general, there are no formal procedures to provide routine operational maintenance and satisfactory operation of the dams. The 14-in. diameter draw-off pipe at the West Dam has frequently been used in the past three years to supplement the City of Gloucester water supply in Wallace Pond as needed. Prior to this recent need for water from Fernwood Lake, the draw-off pipe was rarely operated.

b. Description of any Warning System in Effect. There is no warning system or emergency preparedness plan in effect for these structures.

4.2 Maintenance Procedures

a. General. There are no established procedures or manuals for inspection and maintenance of the dams. Remedial measures such as the cutting of brush and trees are not performed on a regular basis. The West Dam is observed approximately once a week, but the East Dam is very rarely checked.

b. Operating Facilities. The outlet pipe at the East Dam is reported to be abandoned and purposely plugged. The outlet valve at the West Dam is operational. The operating stem is in a manhole which is kept covered with earth to minimize vandalism. There is no formal plan to maintain the gate valve control at the West Dam. The discharge channels at both dams are not kept free of debris and vegetation.

4.3 Evaluation

Maintenance of West Dam is poor and at East Dam is nonexistent. For structures of this type and classification, an annual observation and maintenance program should be established to examine the dams, control vegetation growth and maintain slopes, walls and channels. A formal procedure should also be established for the removal of flashboards at the main (North) dam during periods of expected high flows.

Since failure of either dam would probably cause loss of life and property damage downstream, the owner should also prepare a formal emergency preparedness plan and warning system.

SECTION 5 - EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General

There are three earthfill dams at Fernwood Lake, located at the north, west and east ends, and a dike at the south end. The East Dam is the lowest of the Fernwood Lake dams. Only the main (north) dam has a spillway section. The only outlet from the East Dam, an 8-in. diameter conduit located about 5 ft. below the dam crest, was blocked; therefore, no discharge from Fernwood Lake into Upper Banjo Pond could occur without overtopping East Dam.

The West Dam of Fernwood Lake consists of an earthfill embankment with no spillway section. The only outlet from the dam is a 14-in. diameter conduit located about 10 ft. below the dam crest. A gate valve on the outlet conduit is operated during dry months to allow a flow from Fernwood Lake into the downstream channel in the direction of Wallace Pond. The maximum flow rate through this outlet is estimated to be 15 cfs.

5.2 Design Data

No hydrologic or hydraulic design data were available for the East or West dam sites.

5.3 Experience Data

There are no records of any major hydrologic occurrences at the East or West dam sites. The maximum reservoir level recorded at North Dam spillway was El. 93.3 on 20 March 1968.

5.4 Test Flood Analysis

Based on the Corps of Engineers Guidelines, the recommended test flood range for the size "small" and hazard potential "high" dams is the 1/2 PMF to PMF (Probable Maximum Flood). The 1/2 PMF was selected for the test flood as the size of the dams place them near the low end of the classification range. The PMF was determined using the Corps of Engineers Guidelines for "Estimating Maximum Probable Discharge" in Phase I Dam Safety Investigations.

The 0.52 sq. mi. drainage area of Fernwood Lake consists of flat-coastal to rolling terrain. An inflow rate of 913 cfs per sq. mi. (one-half the full PMF rate of 1,825 csm) was interpolated for the drainage area, which results in a test flood inflow (1/2 PMF) of 475 cfs.

Surcharge-storage routing of the test flood inflow was performed through Fernwood Lake using the related stage-discharge and area-volume curves which are shown in Appendix D.

When the existing flashboards at the North Dam spillway are in place, the test flood outflow is estimated to be 370 cfs (88 cfs over East Dam, 150 cfs over North Dam spillway and 132 cfs over South Dike) and the water surface elevation in Fernwood Lake would be El. 93.9. At this stage only East Dam and South Dike would be overtopped, by about 0.5 ft. and 0.3 ft., respectively. A freeboard of 1.5 ft. would be available at West Dam and 1.6 ft. at North Dam under the test flood condition.

Preliminary computations show that the East Dam crest elevation must be raised by about one foot to eliminate the possibility of the dam being overtopped under the test flood condition. This modification would provide about 0.4 ft. of freeboard at the dam.

When overtopped, South Dike and the naturally high ground downstream of it would tend to act as an overflow spillway to convey flow to Wallace Pond.

5.5 Dam Failure Analysis

East Dam:

Based on the Corps of Engineers Guidelines for estimating dam failure hydrographs, and assuming that a failure would occur along 40 percent of the mid-height of East Dam with pool level at the top of dam, the peak failure outflow is estimated to be 678 cfs. There would be negligible flow in the downstream channel system prior to the failure because there is no spillway or operating outlet at this dam.

It is assumed that the existing Upper Banjo Pond dam remains intact and the existing flashboards at the North Dam spillway remain in-place. The intensity of the East Dam failure flood flow would be dampened significantly at Upper Banjo Pond and the peak discharge over the concrete dam would be about 246 cfs.

This rate of flow is not expected to cause any significant flooding in the downstream channel and above the Route 133 culvert, although a surcharge of 2.6 ft. is expected to occur at the culvert entrance due to the capacity restriction at this facility. The flow over Route 133 is estimated to be 1.4 ft. deep over a length of about 100 ft. with a velocity of about 0.4 fps, which is considered minor.

As shown in Appendix D, the capacity of the existing gravity outlet from Lower Banjo Pond is relatively small (about 5 to 10 cfs). Therefore, almost all of the failure flood water passing over the Upper Banjo Pond dam would fill Lower Banjo Pond.

Following the failure, the water surface in Lower Banjo Pond is estimated to rise to about El. 21. The parking lot, driveway, storage and shop areas of LePages Inc., would be subjected to flooding of about six feet of water. If the existing outlet conduit is not plugged during the flood stage, it would take about three days to drain the area. Emergency pumpage would be required to drain the area in a shorter period or if the outlet conduits are plugged.

It is concluded that a potential for loss of more than a few lives and excessive property damages exists, and the hazard potential classification of East Dam is therefore considered "high".

Because of the very poor condition of the existing concrete dam structure at Upper Banjo Pond, the flood impact of this dam failing following the failure of East Dam was also investigated. Under this condition, as shown in Appendix D, the flood water reaching Lower Banjo Pond would raise the water surface to about El. 25. As a result, the main access road to the area, parking lot, work shops and office building of LePages Inc. would be inundated by about a 10 ft. water depth.

West Dam:

Based on the Corps of Engineers Guidelines for estimating dam failure hydrographs, and assuming that a failure would occur along 40 percent of the mid-height of West Dam with pool level at the top of dam, the peak failure outflow is estimated to be 7,360 cfs. There would be no or negligible flow in the downstream channel system prior to the failure.

For the purpose of hydraulic studies, the failure flood impact area is divided into four reaches. These are, starting from West Dam, a wide valley extending to Wallace Pond (Reach 1), Wallace Pond (Reach 2), the area between Wallace Pond Dam and the B&M Railroad embankment (Reach 3), and a brook valley extending from the railroad opening to Little River (Reach 4).

The hydraulic analyses in Appendix D show that the flood flow resulting from a failure of West Dam would raise the water level of Wallace Pond to approximately El. 64.3, or 2.3 ft. above the crest of Wallace Pond Dam. (The study indicates that a potential for failure of the Wallace Pond Dam exists; in that event the spillway and a newly built intake structure for the City of Gloucester would also be damaged.) Assuming that Wallace Pond Dam remains intact, a hazard potential for loss of lives exists in Reach 3 because the maximum flood water depth just upstream of the railroad embankment would rise to about 15 ft. and a dwelling on the right bank would be under 10 ft. of water.

In Reach 4, jetting of flood water through the opening underneath the railroad with a velocity of about 20 fps would create a hazard potential for loss of lives on the relatively busy Magnolia Avenue immediately downstream. The jetting would also damage the roadway embankment and vehicles which may happen to be passing the railroad opening. Flooding to depths up to 5 ft. at the City of Gloucester water treatment plant would cause a hazard potential for loss of lives and damage at the plant.

Based on the above findings, it is concluded that Fernwood Lake West Dam is in the "high" hazard potential category.

SECTION 6 - EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations

There was no visual evidence of settlement, lateral movement, or other signs of structural instability in the dams during the site examinations. The deterioration of sections of the West Dam upstream wall does not appear to be the result of lateral movement of the embankment. However, the reservoir level was high, making a detailed examination impractical. Based on those conditions that were observed, no reason was found to question the static structural stability of the dams.

6.2 Design and Construction Data

No design or construction data were located which show embankment cross-sections and the physical properties of the materials used to construct the embankments in 1877. Therefore, a theoretical analysis of embankment stability is not possible.

6.3 Post-Construction Changes

The absence of design and construction data for East Dam precludes an evaluation of post-construction changes. It is reported that the 8-in. outlet line was blocked in an unknown location around 1952.

Review of the available county inspection reports does indicate that in 1929 the West Dam embankment was raised approximately two feet and the stone wall on the upstream side was constructed. These modifications were apparently intended to increase the resistance of the embankment to damage by wave action and overtopping. The outlet pipe at West Dam was reportedly added around 1952, but no engineering data regarding this post-construction change was located.

6.4 Seismic Stability

Fernwood Lake East and West Dams are located in a Seismic Zone 3 and in accordance with Recommended Phase I Guidelines, suitable analysis relative to seismic stability should be on record. The pertinent data required for seismic analysis appears not to be readily available and no record of such studies was located. Therefore, the stability of the dams under seismic loading is unknown.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. The visual examination of Fernwood Lake East and West Dams revealed that the structures were in poor condition. Although there were no signs of impending structural failure or other conditions which would warrant urgent remedial action, several deficiencies were noted.

Based on the results of computations included in Appendix D and described in Section 5, the 1/2 PMF test flood inflow of 475 cfs (913 csm) would raise the level of Fernwood Lake to El. 93.9 if the existing flashboards are in place at the North Dam spillway. The test flood outflow of 370 cfs would overtop East Dam and South Dike by 0.5 ft. and 0.3 ft., respectively, although a freeboard of 1.5 ft. would remain at West Dam. With the water level at the top of East Dam (lowest dam on lake), the North Dam spillway capacity with flashboards is about 80 cfs or 22 percent of the peak test flood outflow. Removal of the flashboards would provide only a minor increase in spillway capacity.

b. Adequacy of Information. This evaluation of the dams is based primarily on visual examination, preliminary hydraulic and hydrologic computations, consideration of past performance and application of engineering judgement. Generally, the information available or obtained was adequate for the purposes of a Phase I assessment. However, it is recommended that additional information needed to assess the seismic stability of the dams, as outlined in Section 7.2, be obtained.

c. Urgency. The recommended additional investigations and remedial measures outlined in Sections 7.2 and 7.3, respectively, should be undertaken by the Owner and completed within one year after receipt of this report.

7.2 Recommendations

It is recommended that the Owner engage a registered professional engineer qualified in the design and construction of earth dams to undertake the following investigations:

1. Develop program for cutting trees on the embankments, removing all stumps and major root systems, and backfilling the voids, restoring the embankment cross-sections, and restoring turf cover.

2. Conduct a detailed hydrologic/hydraulic investigation to evaluate the adequacy of the discharge capacity of Fernwood Lake System (spillway and outlet works) and the overtopping potential of the East and West Dams.

3. Develop procedures for removing the abandoned 8-in. diameter outlet pipe from East Dam and filling the resultant void or, if desired, making the outlet operational.

4. Develop a means of providing an upstream control for shutoff and operation of the 14-in. diameter outlet pipe at the West Dam.

5. Perform a seismic stability investigation of the dams.

The Owner should implement the recommendations of the engineer.

7.3 Remedial Measures

Because the dams are generally in poor condition, it is considered important that the following items be accomplished:

a. Operation and Maintenance Procedures. The following should be undertaken by the City of Gloucester, in addition to implementing measures resulting from the investigations outlined in Section 7.2, to correct deficiencies noted during the visual examination:

1. Clear the upstream and downstream slopes of the embankments of brush and debris. After clearing, examine the embankment for evidence of animal burrowing activity and seepage. Establish and maintain ground cover on the downstream slope and cut growth at least once a year.

2. Repair local eroded areas in the embankments and establish turf to resist erosion where it is bare on the crests. If foot traffic is unrestricted and does not permit such a growth, the trafficked areas should be protected by pavement or other means.

3. Repair the upstream wall of West Dam in areas where it has collapsed.

4. Clear brush and treees from the downstream channel of the West Dam outlet pipe.

5. Regularly monitor the wet areas at the downstream toes of the dams, including checks during higher than normal reservoir levels, to determine if conditions are changing with time.

6. Prepare an operations and maintenance manual for the dams. The manual should include provisions for annual technical inspection of the dams and for surveillance of the dams during periods of heavy precipitation and high reservoir water levels. The procedures should delineate the routine operational procedures and maintenance work to be done on the dams to ensure satisfactory operation and to minimize deterioration of the facilities.

7. Develop a written emergency preparedness plan and warning system to be used in the event of impending failure of the dams. The plan should be developed in cooperation with local officials and downstream inhabitants.

7.4 Alternatives

There are no practical alternatives to the above recommendations.

APPENDIX A - INSPECTION CHECK LIST

VISUAL INSPECTION PARTY ORGANIZATION

NATIONAL DAM INSPECTION PROGRAM

Dams: Fernwood Lake East and West

Date: 21 August 1979

Time: 1300-1530

Weather: Clear with moderate termperatures (65-70°F)

Water Surface Elevation Upstream: El. 91.8 (0.5 ft. below top of flashboards in spillway at North Dam)

Stream Flow: Not applicable

Inspection Party:

Harl P. Aldrich, Jr. Richard A. Brown Haley & Aldrich, Inc.	-	Soils/Geology
A. Ulvi Gulbey Paul Keohan	-	Hydraulic/Hydrologic
Roger H. Wood Camp, Dresser & McKee, Inc.	-	Structural/Mechanical

Present During Inspection:

Jack Marchant
City of Gloucester, Public Works Department

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Fernwood Lake - East Dam DATE: 21 August 79

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	El. 93.4
Current Pool Elevation	El. 91.8
Maximum Impoundment to Date	El. 93.3 on 20 March 1968
Surface Cracks	None observed
Pavement Condition	No pavement (3 ft. wide path along crest present)
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	Varies
Horizontal Alignment	Varies
Condition at Abutment and at Concrete Structures	Grades into natural shoreline
Indications of Movement of Structural Items on Slopes	No structural items on slopes
Trespassing on Slopes	Access to dam by path. Evidence of trespassing
Animal Burrows in Embankment	None observed
Vegetation on Embankment	Heavy brush, many trees
Sloughing or Erosion of Slopes or Abutments	Irregular crest with tree roots growing throughout
Rock Slope Protection - Riprap Failures	Stone slope protection in good condition
Unusual Movement or Cracking at or near Toes	None observed
Unusual Embankment or Downstream Seepage	Damp along toe, no seepage observed
Piping or Boils	None observed
Foundation Drainage Features	None known to exist
Toe Drains	None known to exist
Instrumentation Systems	None known to exist

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Fernwood Lake - East Dam DATE: 21 August 79

AREA EVALUATED	CONDITION
OUTLET WORKS	The 8" pipe outlet is reported to be plugged and abandoned. The inlet to the pipe was apparently underwater and not observable. There is no change in configuration in the U/S face of the dam nor the projecting structure which would indicate its location.
a. Approach	
Slope Conditions	
Bottom Conditions	Unknown
Rock Slides or Falls	Unknown
Log Boom	None
Debris	None observed
b. Mechanical	
Service Gates	None located. There is a small local depression in the crest of the dam on the line of the discharge pipe. Local probing of the area did not locate a a valve stem or indications of a former manhole structure.
c. Discharge	
General Condition	The discharge end of the 8" pipe projects out from the D/S toe of the dam and above the discharge channel. No water was observed seeping or flowing from the pipe. Below the pipe was a pool of rust stained still water.
Loose Rock Overhanging Channel	None observed
Trees Overhanging Channe	The channel is overgrown with trees and brush.
Floor of Channel	The channel floor was moist and marshy.
Other Obstructions	No other material obstruction observed.

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Fernwood Lake - West Dam DATE: 21 August 79

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	El. 95.4
Current Pool Elevation	El. 91.8
Maximum Impoundment to Date	El. 93.3 on 20 March 1968
Surface Cracks	None observed
Pavement Condition	No pavement; a foot path crosses the dam
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	Satisfactory
Horizontal Alignment	Satisfactory (crest of dam slightly "vee" shaped)
Condition at Abutment and at Concrete Structures	Satisfactory (no concrete structure)
Indications of Movement of Structural Items on Slopes	No structural items on slopes
Trespassing on Slopes	Unrestricted
Animal Burrows in Embankment	None observed, but impossible to examine downstream slope thoroughly because of vegetation
Vegetation on Embankment	Brush and saplings up to 10 to 12 ft.; very dense in places
Sloughing or Erosion of Slopes or Abutments	Minor, principally at one motor bike path on downstream slope near center of dam
Rock Slope Protection - Riprap Failures	Dry laid stone wall, difficult to examine but top stone generally in place
Unusual Movement or Cracking at or near Toes	None observed
Unusual Seepage or Downstream Seepage	Seepage noted below cast iron blow-off pipe; ponded water just below toe of dike about 25 to 50 ft. left of pipe and also right of pipe. Water clear
Piping or Boils	None observed
Foundation Drainage Features	None known to exist
Toe Drains	None known to exist
Instrumentation Systems	None known to exist

FNE NO 4454

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Fernwood Lake - West Dam DATE: 21 Aug. 1979

AREA EVALUATED	CONDITION
OUTLET WORKS	
a. Approach	
Slope Conditions	The intake was underwater and not observable during the inspection.
Bottom Conditions	Unknown
Rock Slides or Falls	Unknown
Log Boom	None
Debris	None
b. Mechanical	
Service Gates	The manually operated gate, in a manhole at the east edge of the road at the D/S toe of the dam, is operational.
c. Discharge	
General Condition	The 14" pipe outlets at a concrete headwall. The concrete is cracked at the crown of the pipe.
Loose Rock Overhanging Channel	None observed
Trees Overhanging Channel	Trees overhang the channel from both sides
Floor of Channel	Channel immediately below pipe outlet is paved with quarry stone. A drop is present at the end of the paved area where it becomes a natural stream bed. Paved area is good but D/S is overgrown with brush and trees.
Other Obstructions	No other material obstruction observed.

VISUAL INSPECTION PARTY ORGANIZATION

NATIONAL DAM INSPECTION PROGRAM

Dams: Fernwood Lake East and West

Date: 2 May 1980

Time: 0820-1005

Weather: Partly cloudy, 60's F

Water Surface Elevation Upstream: El. 92.5 (0.2 ft. above top of flashboards in spillway at North Dam)

Stream Flow: Not applicable

Inspection Party:

Richard A. Brown Haley & Aldrich, Inc.	-	Soils/Geology
A. Ulvi Gulbey	-	Hydraulic/Hydrologic
Roger H. Wood Camp, Dresser & McKee, Inc.	-	Structural/Mechanical

Present During Inspection:

Neil Burke
City of Gloucester, Public Works Department

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Fernwood Lake - East Dam DATE: 2 May 1980

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	El. 93.4
Current Pool Elevation	El. 92.5
Maximum Impoundment to Date	El. 93.3 on 20 March 1968
Surface Cracks	None observed
Pavement Condition	No pavement (3 ft. wide foot path along crest)
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	Varies
Horizontal Alignment	Varies
Condition at Abutment and at Concrete Structures	Bedrock outcrops at left abutment. Dam grades into natural slopes on each side
Indications of Movement of Structural Items on Slopes	No structural items on slopes. Birch trees along upstream slope lean out over lake. Many trees on downstream slope
Trespassing on Slope	No restrictions
Animal Burrows in Embankment	None observed
Vegetation on Embankment	Brush, saplings and mature trees growing on both slopes of embankment
Sloughing or Erosion of Slopes or Abutments	Eroded foot path on crest. Slopes covered with leaves
Rock Slope Protection - Riprap Failures	Tops of boulders on upstream side visible above water
Unusual Movement or Cracking at or near Toes	None observed
Unusual Embankment or Downstream Seepage	Damp along toe, no seepage observed
Piping or Boils	None observed
Foundation Drainage Features	None known to exist
Toe Drains	None known to exist
Instrumentation Systems	None known to exist

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Fernwood Lake - East Dam DATE: 2 May 1980

AREA EVALUATED	CONDITION
OUTLET WORKS	Condition is the same as on 21 Aug. 1979 (see page A-3) except for pipe discharge comment.
a. Approach	
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
b. Mechanical	
Service Gates	
c. Discharge	
General Condition	Still water below outlet end of pipe was not rust stained.
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Channel	
Other Obstructions	

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Fernwood Lake - West Dam DATE: 2 May 1980

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	El. 95.4
Current Pool Elevation	El. 92.5
Maximum Impoundment to Date	El. 93.3 on 20 March 1968
Surface Cracks	None observed
Pavement Condition	No pavement; a foot path crosses the dam
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	Satisfactory
Horizontal Alignment	Satisfactory
Condition at Abutment and at Concrete Structures	Satisfactory
Indications of Movement of Structural Items on Slopes	No structural items on slopes
Trespassing on Slopes	No restrictions
Animal Burrows in Embankment	None observed
Vegetation on Embankment	Heavy brush on upstream side. Brush and saplings on downstream side, heaviest near left abutment
Sloughing or Erosion of Slopes or Abutments	Eroded back 2 ft. in localized area of riprap failure. Active erosion of downstream slope near middle of dam
Rock Slope Protection - Riprap Failures	Several sections of stone wall collapsed near left abutment
Unusual Movement or Cracking at or near Toes	None observed
Unusual Embankment or Downstream Seepage	None observed
Piping or Boils	None observed
Foundation Drainage Features	None known to exist
Toe Drains	None known to exist
Instrumentation Systems	None known to exist

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: Fernwood Lake - West Dam DATE: 2 May 1980

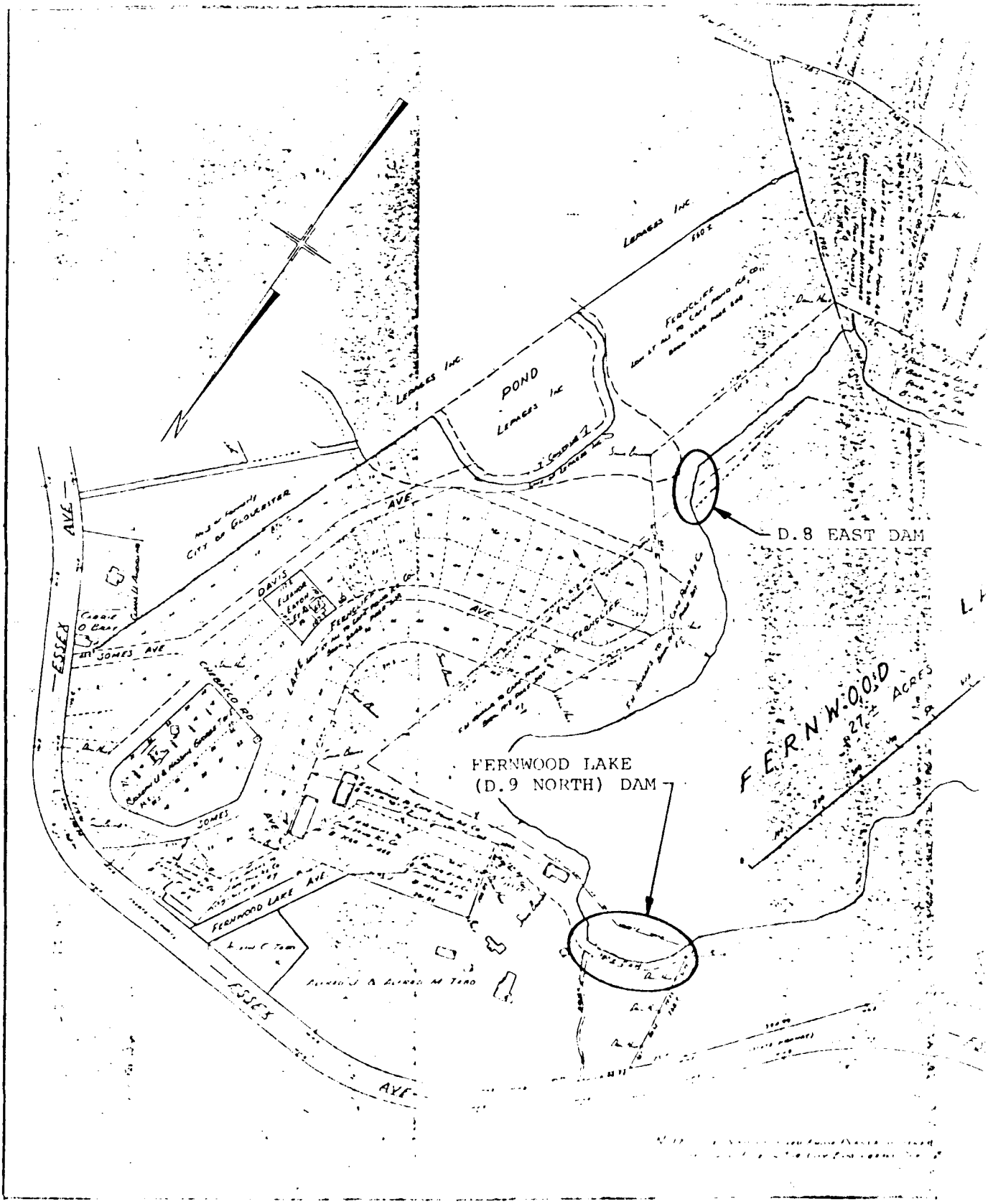
AREA EVALUATED	CONDITION
OUTLET WORKS	Condition is the same as on 21 August 1979 (see page A-5).
a. Approach	
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
b. Mechanical	
Service Gates	
c. Discharge	
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Channel	
Other Obstructions	

APPENDIX B - ENGINEERING DATA

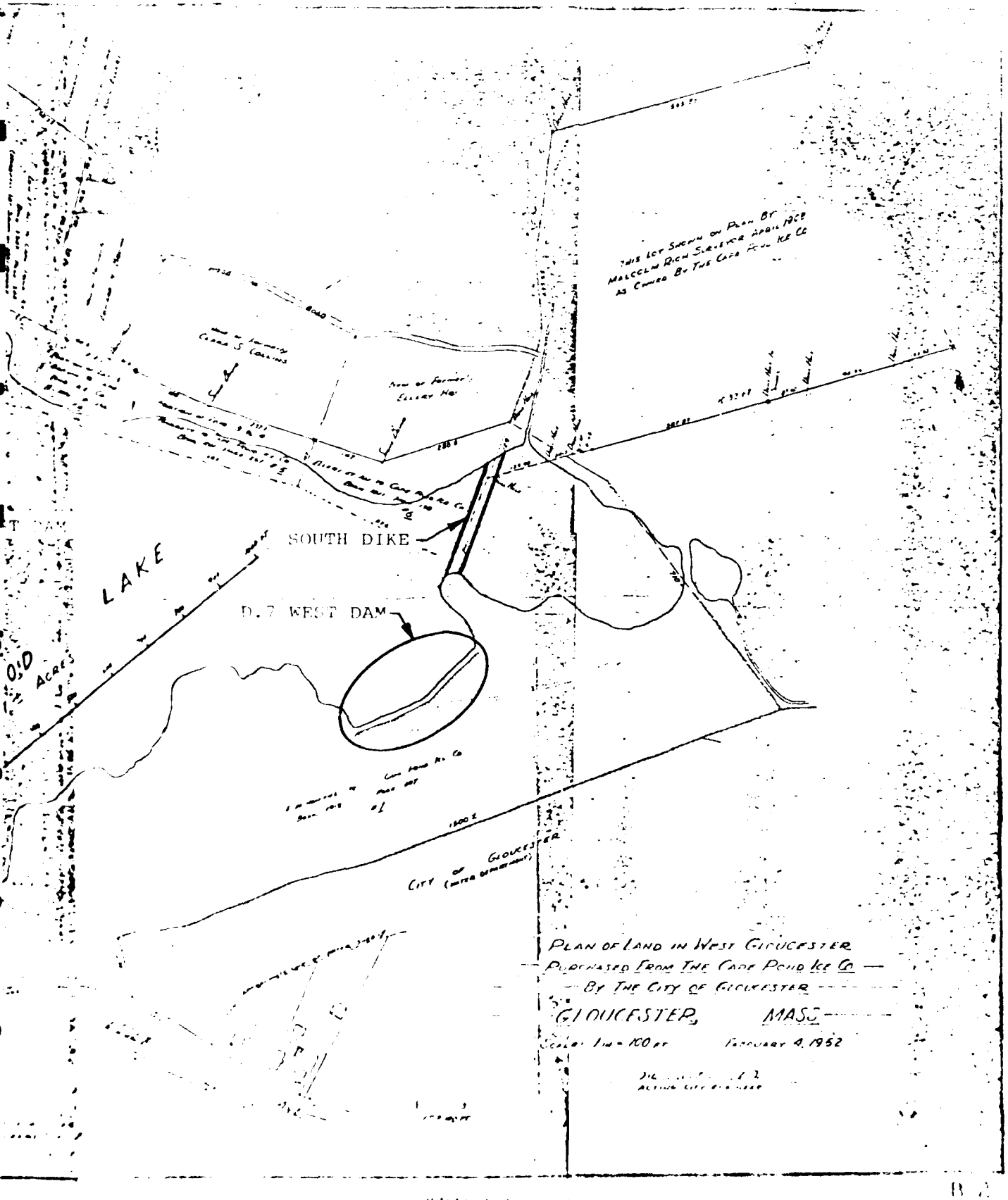
LIST OF AVAILABLE DATA
FERNWOOD LAKE EAST AND WEST DAMS

Document	Contents	Location
Plan of Land in West Gloucester Purchased from the Cape Pond Ice Company by the City of Gloucester, 4 February 1952	Plan of Fernwood Lake (with the locations of Fernwood Lake Dam and other dams on Fernwood Lake added to the drawing)	Gloucester Public Works Dept. Poplar Street Gloucester, MA 01930 and page B-2
Essex County inspection reports, Gloucester Dam D.8 (East Dam)	Report dated 24 April 1912 and summary of 22 inspections from 1917 through 1966 of dam at outlet to Upper Banjo Pond	Essex County Engineers Office 32 Federal Street Salem, MA 01970 and page B-3
Essex County inspection reports, Gloucester Dam D.7 (West Dam)	Report dated 24 April 1912 and summary of 25 inspections from 1917 through 1969 of dam along the southwest shoreline and also the dike across the south end of the lake	Essex County Engineers Office and page B-7
State inspection reports Gloucester Dam No. 5-5-107-9A (West Dam)	One report dated 7 July 1971 of dam on southwest shoreline, including a location map	Mass. Dept. of Environmental Quality Engineering Division of Waterways 100 Nashua Street Boston, MA 02114 and page B-13
Operation records	Reservoir levels	Gloucester Public Works Dept.

106


D.8 EAST DAM
FERNWOOD LAKE
(D.9 NORTH) DAM
POND
LEMKES INC
FERNWOOD
ACRES
ESSEX AVE
JONES AVE
FERNWOOD LAKE AVE
CHEBACCO RD
DAVIS
CITY OF GLOUCESTER

2052


SOUTH DIKE
D.7 WEST DAM
LAKE
PLAN OF LAND IN WEST GLOUCESTER
PURCHASED FROM THE CAPE POND ICE CO
BY THE CITY OF GLOUCESTER
GLOUCESTER, MASS.
Scale: 1in = 100 ft
February 4, 1952

B-2

COUNTY OF ESSEX, MASSACHUSETTS
ENGINEERING DEPARTMENT

Inspection of Dams, Reservoirs, and Stand Pipes

O 103-5C
SUB NUMBER
D. 8 R. S. P.
Neg. Nos. 493

Inspector P. C. Parker, Date April 24, 1912 *Classification 3

City or Town Gloucester Location Northeasterly end of Fernwood Lake
East of West Gloucester Station

Owner Cape Pond Ice Co. Use Ice Pond

Include such details as cores, cut off walls, paving, sodding, class of masonry, kind of cement, (nat. or port.) etc.

Material and Type Earth and stone (45 ft. high)

Elevations in feet: above (+) or below (−) full pond or reservoir level. (Cross out what does not apply.)

For Dam: Bed of stream below ..... Bottom of pond ..... Bottom of spillway ..... Top of dam ..... Top of flash boards .....

For Res. or S. P.: ~~Ground surface below~~ ~~Bottom of res.~~ ~~Level of over flow pipe~~ ~~Top of res.~~

For dam: Length in ft. 100 Top width in ft. 14 Pond area 20± acres Area of watershed ½± sq. mi.

For Res. or S. P.: Inside dimensions ~~Capacity~~ ~~covered~~ ~~open.~~

Length of overflow or spillway ..... Outlet pipes (size and nature) .....

~~Stand pipe, thickness at base~~ ~~diam. of rivet head~~ ~~Pitch~~ ~~Hor.~~ ~~Ver.~~

Foundation and details of construction .....

Constructed by and date .....

Recent repairs and date .....

Evidence of leakage Land below is wet ~~None~~

Condition Good ~~S. P. when painted Inside~~ ~~Out~~

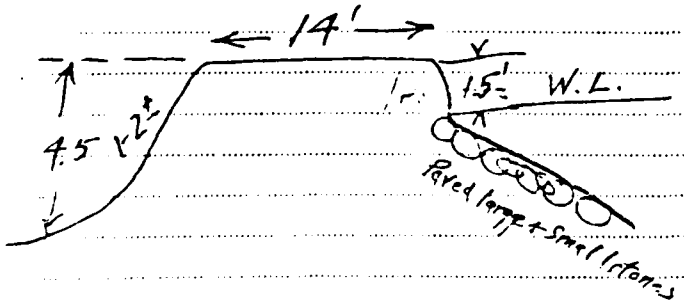
Topography of country below (Woody)

Nature, extent, proximity, etc. of buildings, roads or other property in danger if failure should occur None

Plans and data secured or available .....

Use separate sheet for sketches if necessary.

Notes, sketches, sections, etc. There is another pond 500± ft. below this dam. There is an 8" outlet or draw-off pipe no overflow.



No change Dec. Oct. 16, 1914 C.E.P.

*Classify as to probable damage in case of failure. 3 slight. 2 moderate. 1 serious.

B-3

Gloucester D. 8

1917, March 26. Watershed 0.5 sq. m. Max. Ht. 4.5 ft. Apparent condition, Good.

1925, Oct. 29. R. R. Evans, Insp. There are three separate dams forming Fernwood Lake, all belonging to the Cape Pond Ice Co. At the north east end the earth dam (#8) or dike is low and narrow, about four feet over the swamp below it, having very little height above full pond level. The pipe outlets are small and water from this point would find its way into the Russia Cement Company's pond on the south side of Essex Ave., but it is not apparent that any wash-out could occur which would release a flood wave of any magnitude.

1925 Report to Co. Comm. Same as above.

1928, Oct. 5. C. C. Barker, Insp. Dam on the easterly end of Fernwood Lake, is owned by the Cape Pond Ice Company, and the pond is used for cutting ice. I gave a copy of the notice to E. Raymond Abbott, Supt., who went to the dam with me. There is another pond just below this dam and there would be no damage in case of failure. The dam is in good condition and there have been no changes since the last inspection. There are some bushes on this dam which are cut every fall.

1928, Nov. 30. R. R. Evans, Insp. See D. 7

1928 Report to Co. Comm. See D. 7 - 1928 Report

1930, Sept. 16. C. C. Barker, Insp. Dam on the easterly end of Fernwood Lake, is owned by the Cape Pond Ice Company. This pond is used for cutting ice. I gave a copy of the notice to E. Raymond Abbott, Supt. No one inspected the dam with me. There is another pond just below this dam and in case of failure, there would be no damage. The conditions are the same and there have been no changes since the last inspection.

1930 Report to Co. Comm. See D. 7 - 1930 Report.

1932, Aug. 2. C. C. Barker, Insp. The dam is in good condition and there has been no change.

1932 Report to Co. Comm. Little importance.

1934, Sept. 28. C. C. Barker, Insp. The condition is the same and there has been no change.

1934 Report to Co. Comm. Structure is of little importance.

1936August 10. C.C.Barker, Insp. This dam is in good condition, there has been no change.

1936 Report to Co. Comm. Structure is of little importance.

1938 October 26, C.C.Barker, Insp. This dam is in good condition and there has been no change.

1938 Report to Co. Comm. Structure is of little importance.

Gloucester D. 8

1940 Oct. 4, C.C.Barker, Insp. This dam is in good condition and there has not been any change.

1940 Report to Co. Comm. Structure is of little importance.

1942 Aug. 3, C.C.Barker, Insp. This dam is in good condition, and there has not been any change.

1942 Report to Co. Comm. Structure is of little importance.

1944 Nov. 13, S.W.Woodbury, Insp. I gave a copy of the notice to Mr. Abbott. I visited the dam alone. A new pipe has been placed around the shut-off valve. The pond is allowed to rise until it is 1 inch below the lip of the spillway at D 9 then valve at D 8 is opened and water is allowed to run to Russia Cement Company plant.

1944 Report to Co. Comm. Structure is of little importance.

1946 Sept. 24, S.W.Woodbury, Insp. New owner, see D 9. I gave a copy of the notice to Mr. Tebo and went to the dam alone. Condition is the same.

1946 Report to Co. Comm. Structure is of little importance

1948 Sept. 30, S. W. Woodbury, Insp. Gave a copy of the notice to Mr. Sundback for Mr. Tebo and went to dam alone. Water level today: Gate is open. Water is running through. 8" pipe about 1/4 full. Condition of the dam is the same.

1948 Report to Co. Comm. Structure is of little importance.

1950 Sept. 27, S.W.Woodbury, Insp. Gave a copy of the notice to Mr. Tebo and went to dam alone. Water level today: Same as D9 (Gate has been kept open to give water to Russia Cement Co. Condition of the dam is the same.

1950 Report to Co. Comm. Structure is of little importance.

1952 Sept. 24, E.H.Page, Insp. City of Gloucester (Water Works) new owner) Gave a copy of the notice to Mr. Hull at Water Dept. and went to dam alone. Water level today: Same as D 9. Gate closed today. Condition is the same.

1952 Report to Co. Comm. Structure is of little importance.

1954, May 28, E.H.Page, Insp. Seepage at toe. Gate is closed.

1954 Report to Co. Comm. Structure is of little importance.

1956 Sept. 13, E.H.Page, Insp. Condition: Same.

1956 report to Co. Comm. Structure is of little importance.

1958, Dec. 30, E.H.Page & K.M.Jackson, Insps. Condition: same. Some seepage around pipe.

1958 Report to Co. Comm. Structure is of little importance.

1960 Report to Co. Comm. Structure is of little importance.

1962 Dec. 17, K.M.Jackson, Insp. Owner: City of Gloucester Water Works. Condition of dam: Same as 1960 report.

1962 Report to Co. Comm. Structure is of little importance.

1964 Dec. 29, P.D.K. & K.M.J., Insps. Conditions the same.

1964 Report to Co. Comm. Structure is of little importance.

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

1966 Report to Co. Comm. Structure is of little importance.

COUNTY OF ESSEX, MASSACHUSETTS
ENGINEERING DEPARTMENT

Inspection of Dams, Reservoirs, and Stand Pipes

O 108-5C
SUB NUMBER
D. 7 R. S. P.
Neg. Nos. 492

Inspector C. C. Barker Date April 24, 1912 *Classification 3

City or Town Gloucester Location Westerly end of Fernwood Lake South of Essex Ave.

Owner Cape Pond Ice Co. Use Ice pond

Include such details as cores, cut off walls, paving, sodding, class of masonry, kind of cement, (nat. or port.) etc.

Material and Type Earth faced on the upstream side with large and small field stone

Elevations in feet: above (+) or below (−) full pond or reservoir level. (Cross out what does not apply.)

For Dam: Bed of stream below ..... Bottom of pond ..... Bottom of spillway ..... Top of dam ..... Top of flash boards .....

For Res. or S. P.: ~~Ground surface below~~ ..... ~~Bottom of res.~~ ..... ~~Level of over flow pipe~~ ..... ~~Top of res.~~ .....

For dam: Length in ft. 400 Top width in ft. 8 Pond area 20± acres Area of watershed ½± sq. mi.

For Res. or S. P.: ~~Inside dimensions~~ ..... ~~Capacity~~ ..... ~~covered~~ ~~open~~.

Length of overflow or spillway ..... Outlet pipes (size and nature) .....

~~Stand pipe, thickness at base~~ ..... ~~diam. of rivet head~~ ..... ~~Pitch~~ hor. ..... ver. .....

Foundation and details of construction .....

Constructed by and date .....

Recent repairs and date .....

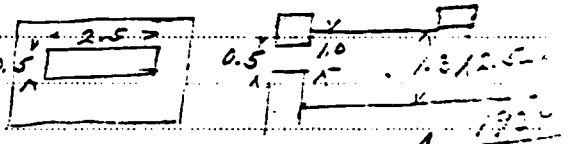
Evidence of leakage Land below is quite wet probably some leakage

Condition Fair ~~S. P. when painted~~ inside ..... out .....

Topography of country below .....

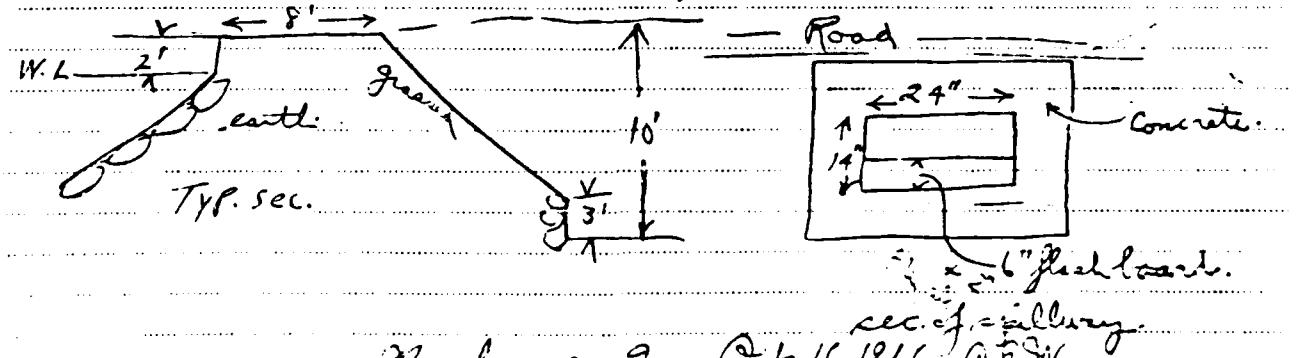
Nature, extent, proximity, etc. of buildings, roads or other property in danger if failure should occur None

Plans and data secured or available .....



Use separate sheet for sketches if necessary.

Notes, sketches, sections, etc. There is a concrete spillway west of dam that empties into Wallace Res. 24" wide 14" deep with 6" of flash boards.



No change Ins. Oct 16 1916 A.P.W.

*Classify as to probable damage in case of failure. 3 slight. 2 moderate. 1 serious.

Gloucester, D. 7

1917, March 26. Watershed 0.5 sq. m. Max. Ht. 10.0 ft. Apparent condition, Fair.

1925, Oct. 29. R. R. Evans, Insp. There are three separate dams forming Fernwood Lake, all belonging to the Cape Pond Ice Co. The dam (#7) at the north end is an earth dam between rubble walls. It is in fairly good condition and is somewhat higher than that at the north east end.

1925 Report to Co. Comm. Same as above.

1928, Oct. 5. C. C. Barker, Insp. Dam on the westerly end of Fernwood Lake south of Essex Avenue, is owned by the Cape Pond Ice Company, and the pond is used for cutting ice. I gave a copy of the notice to E. Raymond Abbott, Supt., who went to the dam with me. Below the dam is a flat woody country and there would not be much, if any, damage in case of failure. In two places on the upper side the bank is somewhat washed out. These holes should be filled in and some stones put along the upper face to prevent wave action. The dam is well grassed over and there are quite a few bushes on the dam which should be cut. West of this dam at the outlet to the pond there is a small spillway which is in good condition. The Cape Pond Ice Company try to keep this pond at the same level and let the waste water go into Wallace Pond to be used by the city. Mr. Abbott thinks the city should clean out the brook for their own benefit and build a larger spillway so they would be able to get more water. When the pond rises faster than the small spillway will take care of it, the eight inch draw off pipe at the other end of the pond is opened and the water goes into the Russia Cement Company's pond. Mr. Abbott says that the bushes along the dam are cut every year and he intends to put some stones along the upper slope and fix any slopes that are washed out, and he will co-operate in any way to keep the dam in good condition.

1928, Nov. 30. R. R. Evans, Insp. Fernwood Lake: I inspected various dams except that at north end, which is rather unimportant. Too much depends on regulating the level of this pond by means of the draw off pipes which are small. There should be a spillway. The spillway at the end next Wallace Pond could easily be made sufficient, which would add water shed of this pond to that of Wallace Pond. Levels and further investigations are needed to determine just what would become of the overflow in case of failure of the dam along Essex Avenue side nearest Wallace Pond, and conference with the owner seems desirable. At the present level of the pond there is not enough height of embankment above the water in many places

1928 Report to Co. Comm. Fernwood Lake Dams. There are three dams at Fernwood Lake at the east, north and west sides and a very low dam at the south end with a small culvert leading through it. All are owned by the Cape Pond Ice Company. The dam at the east end is of little importance. There is another pond below it and no failure seems likely which would cause serious damage. The dam at the northerly end, is the highest, about sixteen feet, and if it failed would cause damage to the highway, to the railroad, and probably to the garage on the north side of the highway, while the dam at the west side which is about eight feet high at maximum, is bordered by flat country between it and the highway and practically all of the flood in case of a break here would apparently find its way to Wallace Pond and might cause trouble there. There is no spillway for the discharge of flood water from the lake, entire

Gloucester, D. 7

reliance being placed on opening the gates and drawing down the pond level so that it will be safe in times of heavy rains, and none of the dams is as high above water level as it stood at the time of my visit on November 30 as they should be. The small culvert at the south end is of no value as a spillway. In view of the character of these dams, which are all of earth, there should be a spillway of adequate dimensions provided at some point, and the dams should be raised or the pond level lowered. This spillway might be located at the south end, allowing the overflow water to discharge into Wallace Pond if agreeable to the City of Gloucester, in which case the addition of the Fernwood Lake watershed to the water shed of that pond would have to be considered or, it might discharge at some other point. Under present conditions, it is not apparent that wide spread damage would be done by a failure at these dams except possibly at Wallace Pond, but there is a considerable amount of building going on in this locality and a spillway should be provided at once.

1930, Sept. 16. C. C. Barker, Insp. Dam on the westerly end of Fernwood Lake south of Essex Avenue, is owned by the Cape Pond Ice Company. The pond is used for cutting ice. I gave a copy of the notice to E. Raymond Abbott, Supt. No one inspecfed the dam with me. The country below the dam is flat and woody. There would be no damage in case of failure. Since the last inspection, this dam has been raised about 2 feet and put in good condition. A vertical dry wall about 3.5 feet high has been built along the inner face of the dam.

1930 Report to Co. Comm. Three dams on Fernwood Lake south of Essex Avenue at the westerly, easterly and northerly sides of the pond, are the property of the Cape Pond Ice Company. The state highway is below this pond and there are some buildings which might be damaged in case of failure, especially of the northerly dam. Both the westerly and northerly dams have been raised and a spillway built since the last inspection, and these were described in my report of last year. The structures are now apparently safe and in good condition.

1932, Aug. 2. C. C. Barker, Insp. I saw Mr. E. Raymond Abbott, Supt. The dam is in good condition. There has been no change.

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

1934, Sept. 28. C. C. Barker, Insp. I gave a copy of the notice to E. Raymond Abbott, Supt. No one inspected the dams with me. This dam is in good condition, except there are a few bushes that should be cut, and there has been no change.

1934 Report to Co. Comm. Safe and in reasonably good condition.

1936 August 10, C.C.Barker, Insp. I saw E. Raymond Abbott, Supt. This dam is in good condition except for a bushes which are cut every year. There has been no change.

1936 Report to Co. Comm. Safe and in reasonably good condition.

Gloucester D. 7

1938 October 26, C.C.Barker, Insp. I gave a copy of the notice to E. Raymond Abbott, Supt. This dam is in good condition and there has been no change. However, at the westerly end of the pond the small outlet to the culvert has been closed and if the water level raised 6 inches it would overflow the wood road at this culvert. It would cause no damage.

1938 Report to Co. Comm. Safe and in reasonably good condition.

1940 Oct. 4, C.C.Barker, Insp. I talked with Mr. Abbott, Supt. over the telephone. This dam is in good condition and there has not been any change.

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

1942 Aug. 3, C.C.Barker, Insp. I talked over the phone with E. Raymond Abbott, Supt., and left a copy of the notice at the office for him. This dam is in good condition. The pond is full and there has not been any change.

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

1944 July 26, S.W.Woodbury, Insp. I gave a copy of the notice to Mr. Abbott, but visited this dike alone. Dike is covered with high bushes. There is a wood road just below this dike. Conditions here apparently are about the same.

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

1946 Sept. 24, S.W.Woodbury, Insp. There is a new owner. See D9. I gave a copy of the notice to Mr. Tebo and went to dam alone. Condition of the dam is the same.

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

1948 Sept. 30, S. W. Woodbury, Insp. Gave a copy of the notice to Mr. Sundbeck for Mr. Tebo and went to dam alone. Condition of the dam is the same.

1948 Report to Co. Comm. Safe and in reasonably good condition.

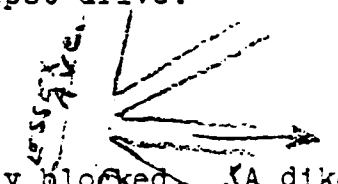
1950 Sept. 27, S.W.Woodbury, Insp. Gave a copy of the notice to Mr. Tebo and went to dam alone. Water level today: Same as D 9. Condition of the dam is the same. Culvert nearly blocked. Note: Another dike here should be numbered?

1950 Report to Co. Comm. Safe and in reasonaoly good condition.

1952 Sept. 25, E.H.Page, Insp. City of Gloucester New owner,(Water Works) Gave a copy of the notice to Mr. Hull at Water Dept. Office and went to dam alone. Water level today same as D 9. Culvert nearly blocked.

1952 Report to Co. Comm. Safe and in reasonably good condition.

1954, May 28, E.H.Page, Insp. (Atten. Insp. - Take middle wood road at D.P.W. Maintenance Depot drive.



Culvert almost completely blocked. A dike has been built across this end of the lake about 200' or 300' from the end. It is constructed out of boulders with a gravel top. It is about 11' or 12' wide. Wave action is washing away gravel on the lake side. Water is about 12" below top now. Water level is the same on both sides, but I do not see any culvert. At the old dike, the culvert is blocked tight. Some seepage on the southerly side of culvert.

1954 Report to Co. Comm. At Fernwood Lake, westerly end, south of Essex Street, a new dike has been built across this end of the lake about two hundred or three hundred feet from the end. It is constructed of boulders with a gravel top and is eleven or twelve feet wide. Wave action is washing away gravel on the lake side as the water is only about twelve inches from the top. Water level is the dams on both sides of the dike, although there is no culvert visable. At the old dike, the culvert is blocked tight. Some seepage on the southerly side of the culvert.

1956, Sept. 13, E.H.Page, Insp. Elev. of Water: Water about 3' below new dike across the end of the pond. Leaks: Some seepage.

1956 Report to Co. Comm. At Fernwood Lake, there is a great deal of debris on each side of the flashboards. This should be removed.

1958, Jan. 29, E.H.Page & A.A., Insps. Elev. of water: 0.3 over flashboards. Much debris holding back water against flashboards.

1958, Dec. 30, E.H.Page & R.M.Jackson, Insps. Elev. of water: Water about 1' ± below new dike. Heavy erosion on new dike. Some rubble has fallen into pond from old dike.

1958 Report to Col Comm. At Fernwood Lake, at the westerly end, there is heavy erosion on the new dike and some of the rubble wall of the old dike has fallen in the pond. At the northerly end there is a great deal of debris up against the flashboards.

1961, Jan. 12, E.H.Page & P.D.Killam, Insps. Condition: Same.

1960 Report to Co. Comm. At Fernwood Lake at the westerly end, there is heavy erosion on the new dike. This is not too important as water is the same height on either side of dike. Some of the rubble wall on the old dike has fallen into the pond.

1962 Report to Co. Comm. At Fernwood Lake at westerly end, there is erision of the new dike. This is not too important as water is same height on either side of the dike. Some rubble from wall on the old dike has fallen into the pond.

1964 Dec. 29, P.D.K. & K.M.J., Insps. Brush and large trees should be controlled.

1964 Report to Co. Comm. Safe and in reasonably good condition.

1966 April 17, 1967. Brush and large trees should be controlled.

1966 Report to Co. Comm. Brush and trees on earth embankment should be cut.

1968 April 38, 1969. P.D.Killam and J. Fitzgerald. Brush and tree. cutting has been carried on here

D. 9A —

GLOUCESTER
5-5-107-10

L. E. WILKINSON 7/7/71 2

SOUTHWESTERLY SIDE OF FERNWOOD LAKE. BEGIN ON ESSEX AVE. (ROUTE 133) AT STANWOOD AVE. - TAKE ESSEX AVE. WESTERLY 0.20 M. TO A WOODS ROAD ON SOUTH SIDE OF ESSEX AVE. TAKE THIS ACCESS ROAD SOUTHERLY 0.20 M. TO DAM.

OWNER: CITY OF GLOUCESTER

USE: WATER SUPPLY

MATERIALS & TYPE: EARTH AND STONE PAVED ON LAKE SIDE.

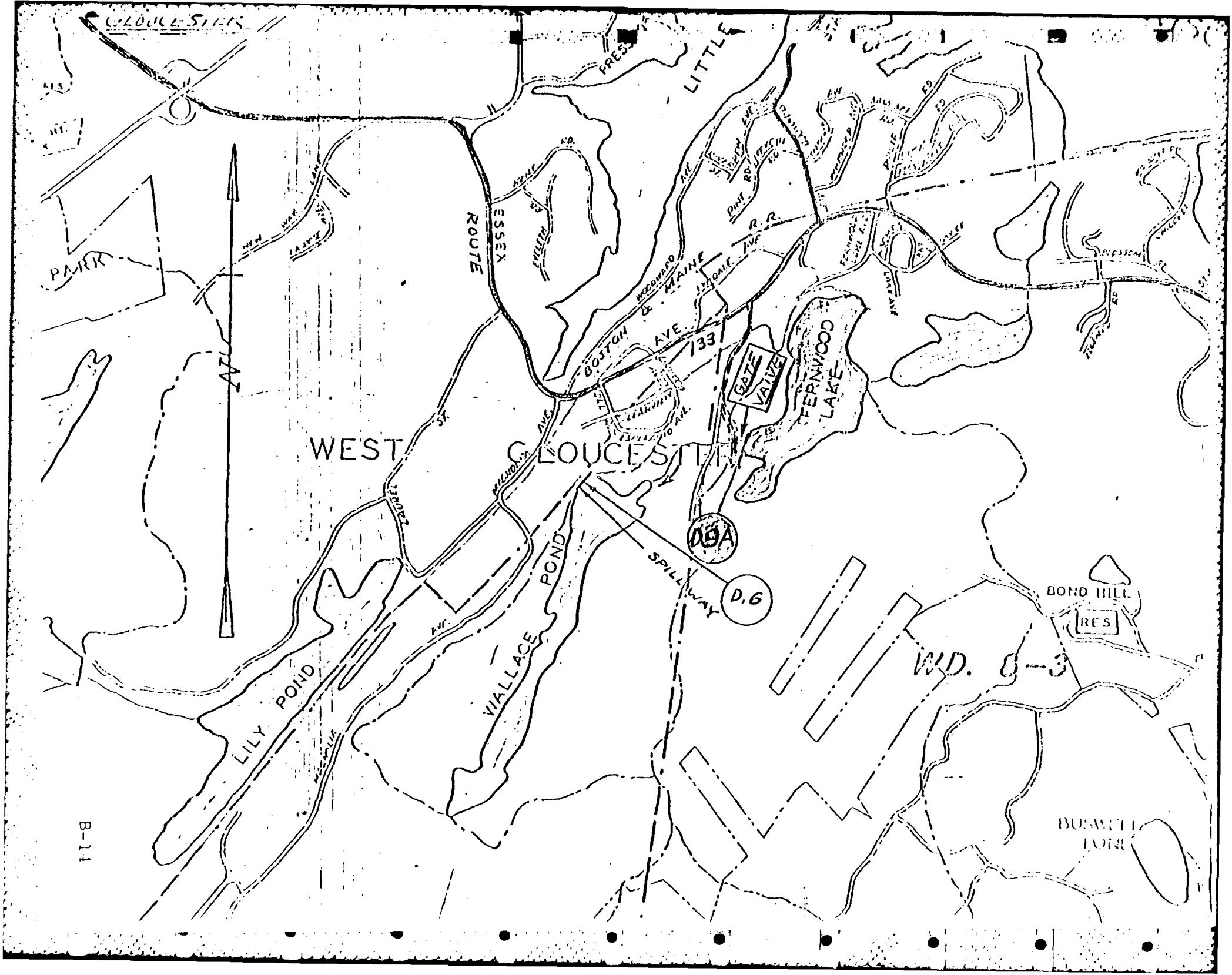
HEIGHT OF DAM: 6.0 ± FT.

LENGTH: 330.0 ± FT. TOP WIDTH: 10.0 ± FT. POND AREA: 20.0 ± ACRES

VOLUME OF WATER IMPOUNDED: 0.50 —

DESCRIPTION OF SPILLWAY: NONE. THIS DAM FUNCTIONS AS A SIMPLE DIKE EXCEPT THERE IS A 14" STEEL DRAW OFF PIPE THROUGH IT WITH GATE VALVE LOCATED JUST BELOW FOOT OF DOWNSTREAM FACE OF DAM. THIS PIPE OUTLETS INTO BROOK CHANNEL FLOWING INTO WALLACE POND.

RECOMMENDATIONS: EVERYTHING AT THIS DAM IN GOOD CONDITION WATER LEVEL 2.0 FT. BELOW TOP TO-DAY.

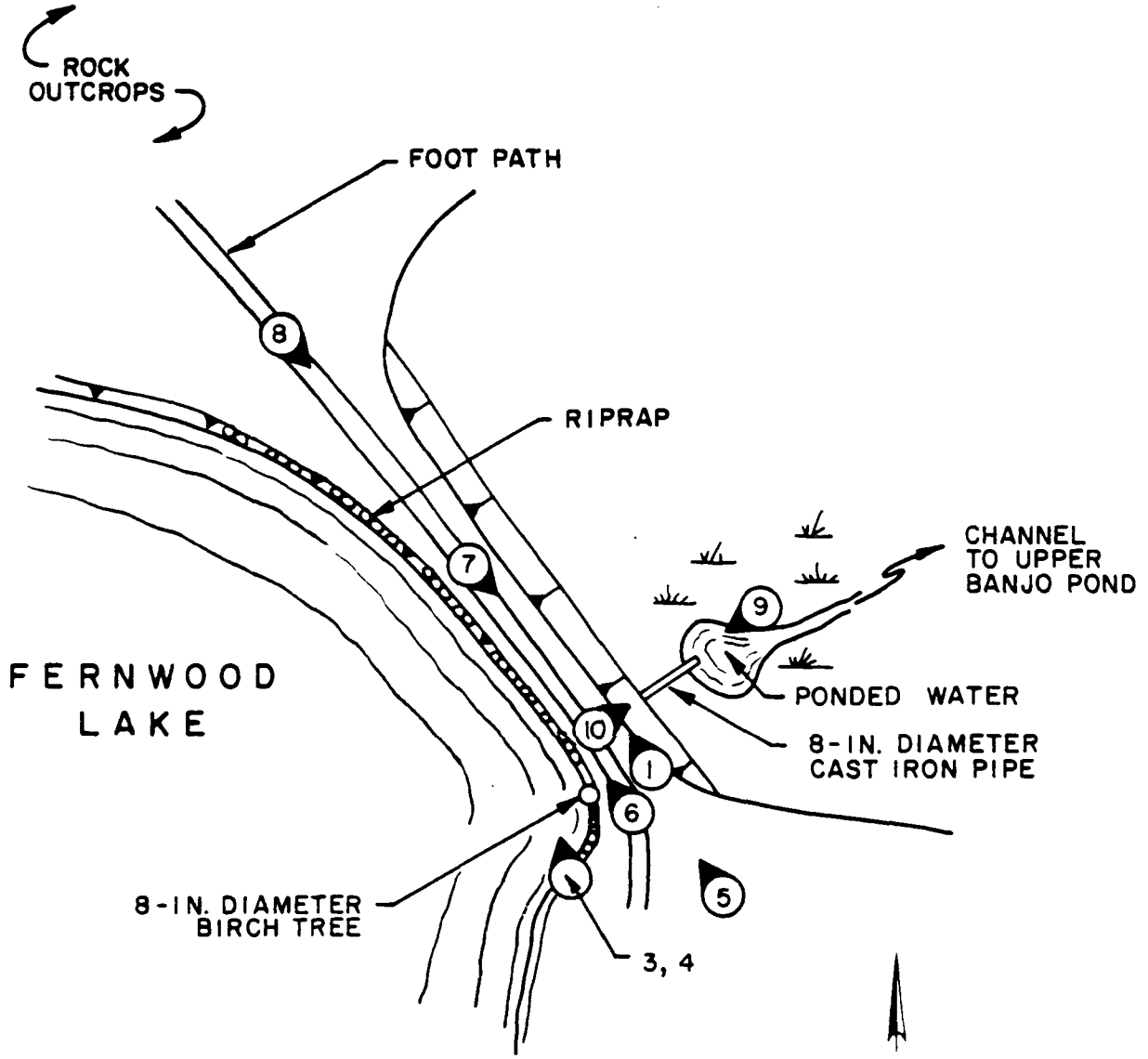

GLOUCESTER
LITTLE
ESSEX
ROUTE
PARK
BOSTON & MAINE R.R.
BOSTON AVE
133
GATE VALVE
FERNWOOD LAKE
WEST GLOUCESTER
D9A
D.6
SPILLWAY
WALLACE POND
LILY POND
BOND HILL RES
W.D. 8-3
B-14

APPENDIX C - PHOTOGRAPHS

PHOTOGRAPHS OF WEST DAM (cont'd)

No.	Title	Roll	Frame	Page
16.	Crest of right portion of embankment (2 May 1980)	C47	4	C-0
17.	Downstream face near middle of embankment (2 May 1980)	C47	3	C-10
18.	Closeup of localized downstream slope erosion near middle of embankment (21 August 1979)	20	8	C-10
19.	Trees and roots on downstream side of dam near left abutment (2 May 1980)	C47	9	C-11
20.	Handle for operating outlet gate valve inserted through opening in buried manhole cover (2 May 1980)	C47	10	C-11
21.	Outlet structure and channel downstream of West Dam (2 May 1980)	C47	2	C-12
22.	Closeup of concrete headwall and discharge end of outlet pipe (21 August 1979)	20	6	C-12

BRUNING 44-141 35356



NOTE

PLAN DEVELOPED FROM FIELD OBSERVATIONS MADE ON 21 AUGUST 1979 AND 2 MAY 1980.

LEGEND

(6) PHOTOGRAPH NUMBER AND DIRECTION OF VIEW

Fernwood Lake
East Dam
Gloucester, MA

SITE PLAN SKETCH

Approx. Scale: 1" = 30' June 1980

HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS

FILE NO 4270 A45

C-1

3. Upstream side of East Dam (21 August 1979)

4. Upstream side of East Dam (2 May 1980)

5. View of East Dam from right abutment (2 May 1980)

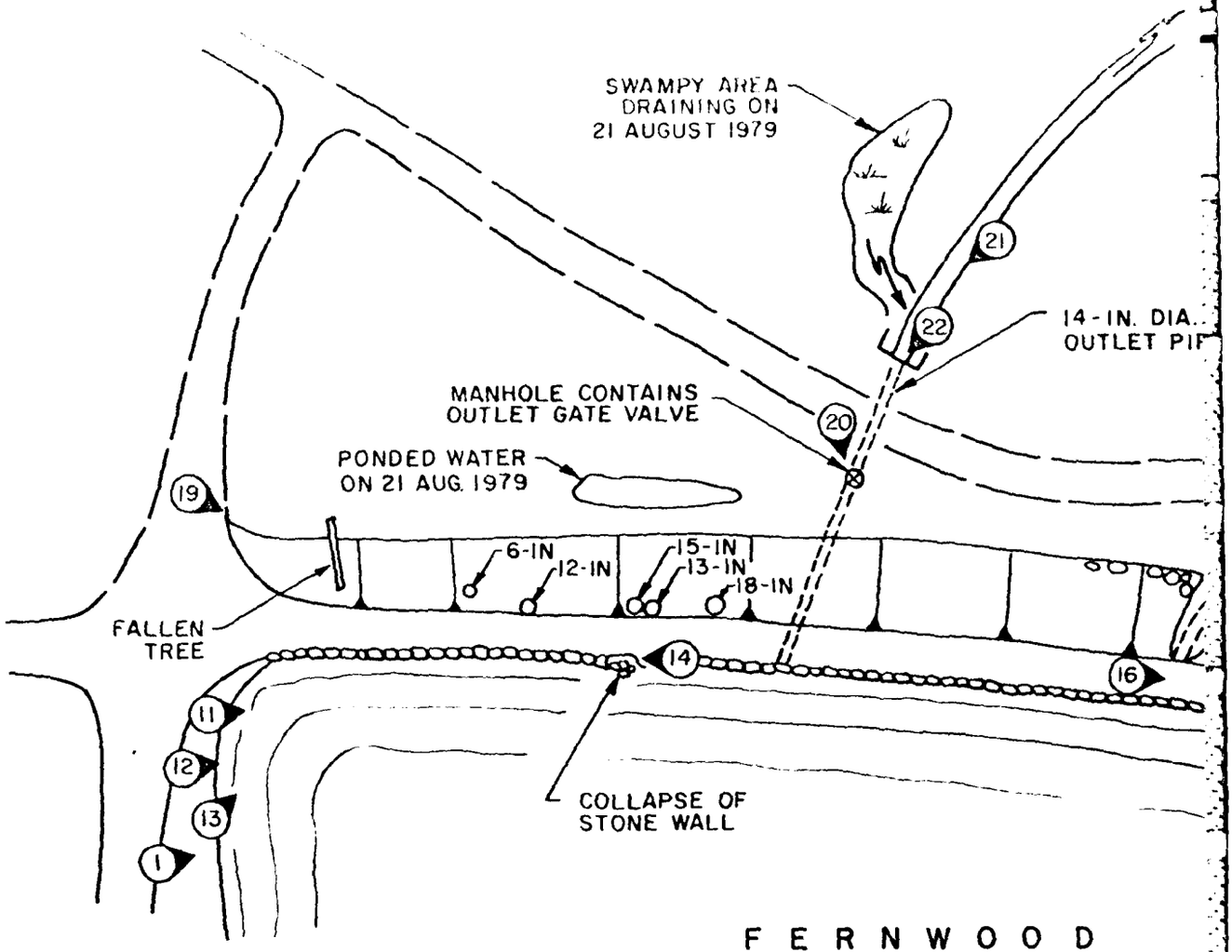
6. Trees, brush and roots on embankment (2 May 1980)

7. Dense vegetation obscures embankment (21 August 1979)

8. View of embankment from left abutment (2 May 1980)

9. Outlet pipe at downstream toe (2 May 1980)

10. Outlet pipe and ponded water at downstream toe (21 August 1979)



NOTE

PLAN DEVELOPED FROM FIELD OBSERVATIONS MADE ON 21 AUGUST 1979 AND 2 MAY 1980.

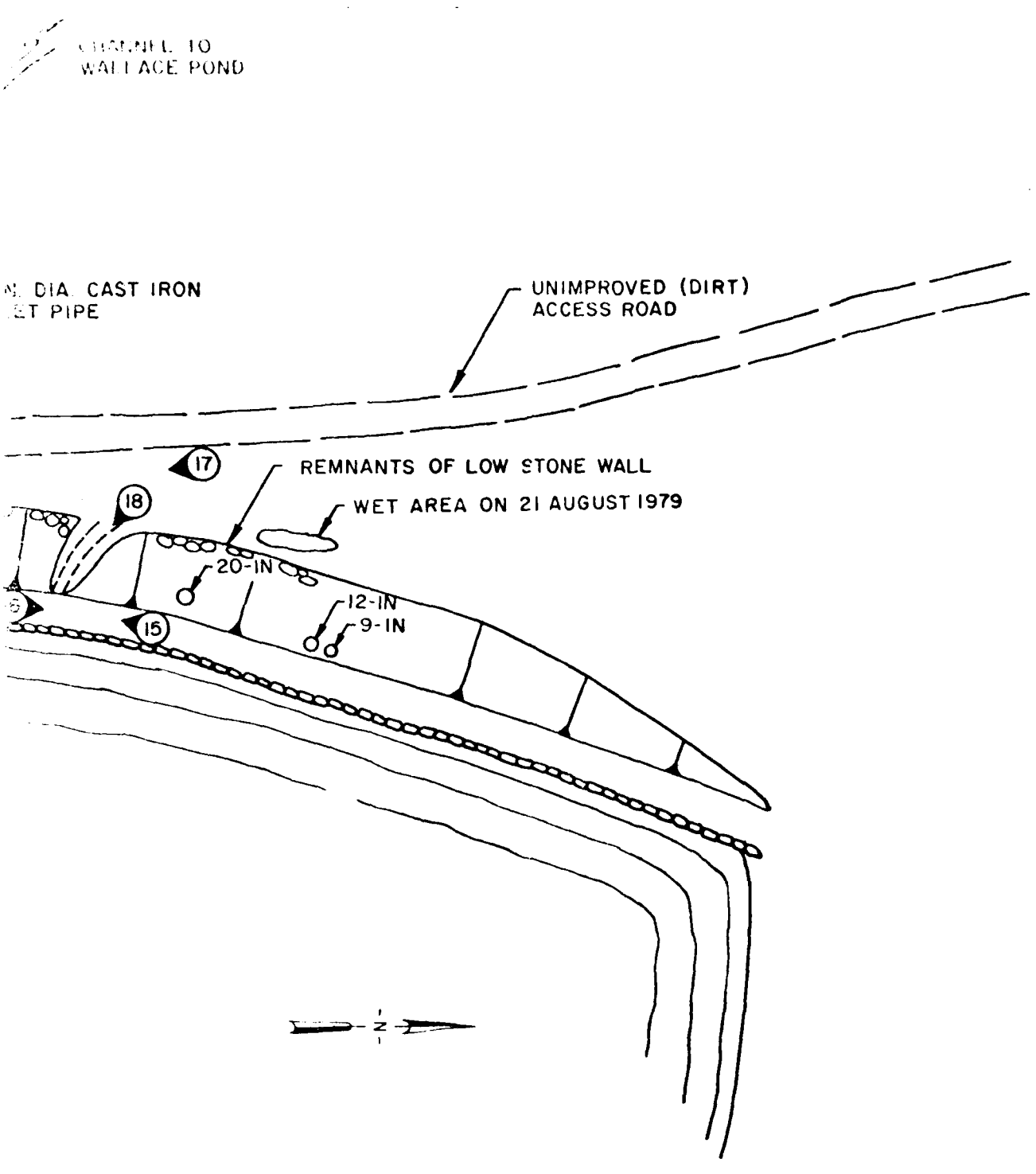
LEGEND

(2) PHOTOGRAPH NUMBER AND DIRECTION OF VIEW

18-IN DIAMETER OF TREE STUMP

HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS

10 E 2



Fernwood Lake
West Dam
Gloucester, MA

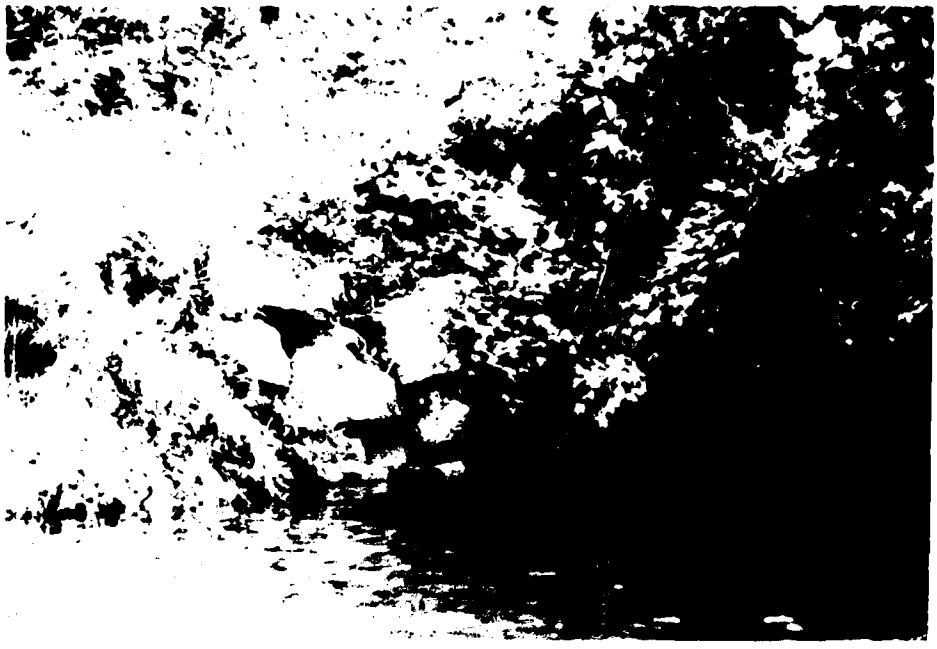
SITE PLAN SKETCH

Approx. Scale: 1" = 30' June 1980

2 of 2

11. Upstream side of West Dam (21 August 1979)

12. Upstream side of West Dam (2 May 1980)

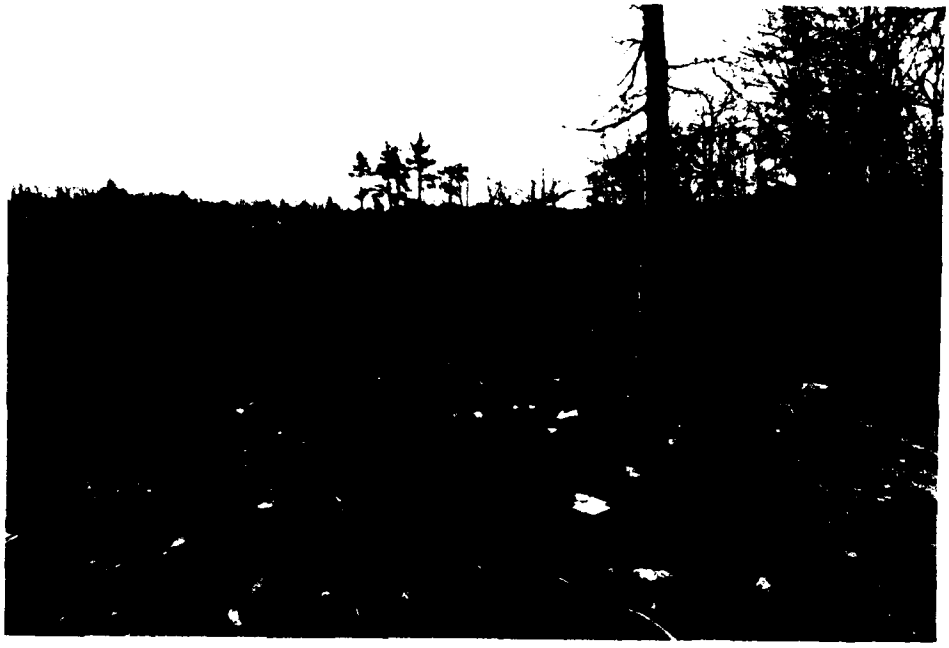


13. Closeup of dry-laid stone masonry wall on upstream side of dam (21 August 1979)

14. Localized collapse of upstream wall and subsequent erosion of embankment (2 May 1980)

15. Crest of left portion of embankment (2 May 1980)

16. Crest of right portion of embankment (2 May 1980)



17. Downstream face near middle of embankment (2 May 1980)

18. Closeup of localized downstream slope erosion near middle of embankment (21 August 1979)

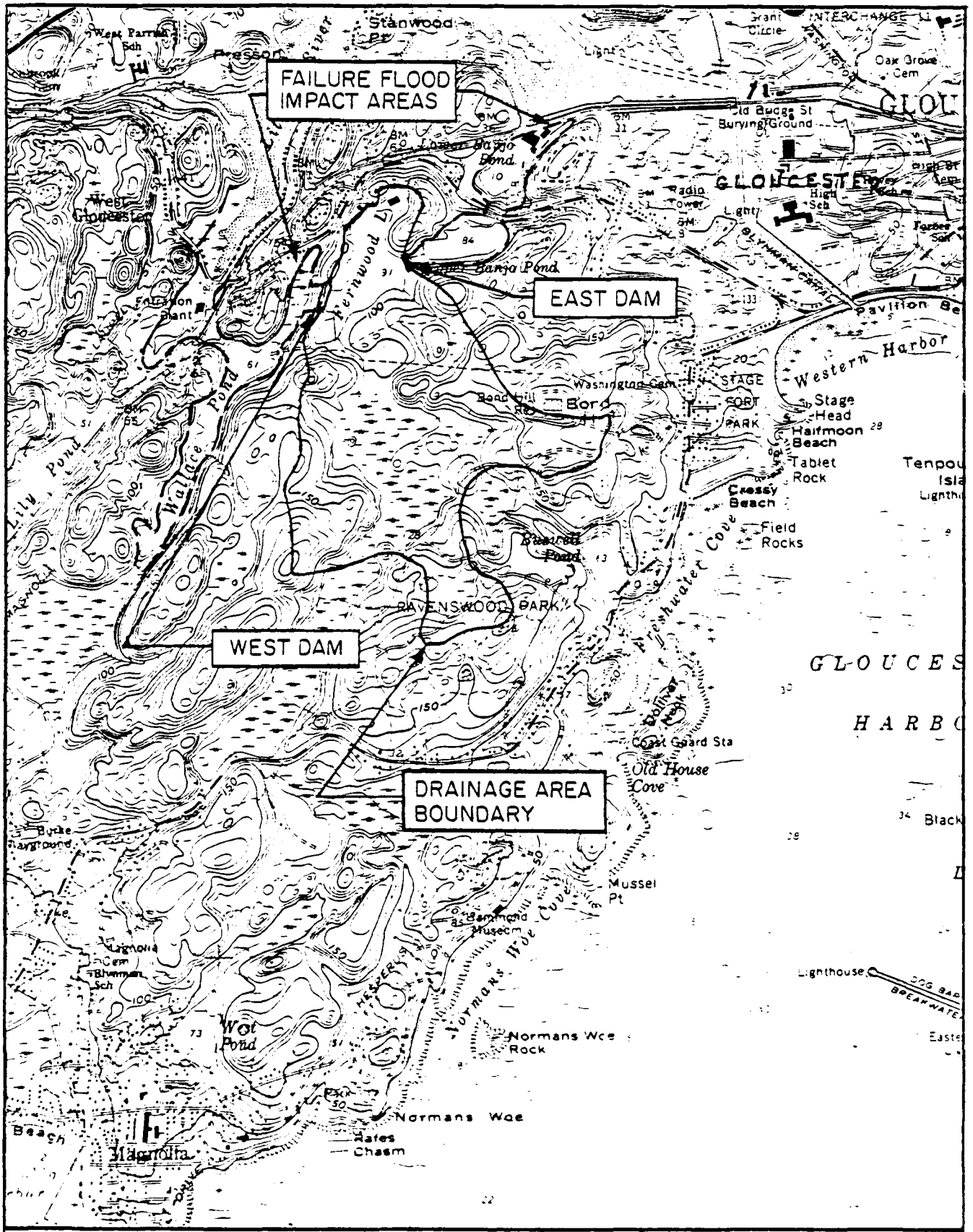
19. Trees and roots on downstream side near left abutment (2 May 1980)

20. Handle for operating outlet gate valve inserted through opening in buried manhole cover (2 May 1980)

21. Outlet structure and channel downstream of West Dam (2 May 1980)

22. Closeup of concrete headwall and discharge end of outlet pipe (21 August 1979)

APPENDIX D - HYDROLOGIC AND HYDRAULIC COMPUTATIONS



CAMP DRESSER & McKEE Inc.
Consulting Engineers
Boston, Mass.

FERNWOOD LAKE
EAST & WEST DAMS
DRAINAGE & FLOOD
IMPACT AREAS
SCALE: 1:24,000

Size Classification

Height: 93.4 - 88.4 = 5.0 - ft < 40 Ft.

Storage in Fernwood Lake @ El. 93.4 : 310 acre-ft < 1000 ac-ft.

Size Classification: SMALL

Hazard Potential Classification

Based on the results of the dam failure analysis, a failure at East Dam would result in the potential loss of several lives. Hazard classification is HIGH.

Test Flood Determination

Size: small , Hazard Potential: high

$$Q_T = \frac{1}{2} \text{ PMF} \quad \text{to} \quad \text{PMF}$$

Watershed: midway between flat-coastal and rolling;
Drainage Area: 0.52 sqmi Peak Flow Rate: 1,825 cfs/sqmi
PMF Inflow: 950 cfs Test Flood inflow: use $\frac{1}{2}$ PMF

$$Q_T = \frac{1}{2} \text{PMF} = 475 \text{ cfs}.$$

Surcharge - Storage Routing

An analysis was made for the condition that the existing 1.3 foot flashboards at North Dam would stay in place as they have been there during the last two years. The test flood routing would be the same as in the Fernwood Lake North Dam (see copy of the Stage - Discharge Curve) study.

Presently there is no operational outlet at East Dam.

The surcharge - storage routing for Fernwood Lake showed that East Dam would be overtopped by about 0.5 feet during the test flood. The discharge over the earthfill dam would be about 88 cfs which would be flowing into Upper Banjo Pond.

DAM SITE	CREST EL.	LENGTH (Ft)
North Dam	95.5	470
" Spillway	92.3	19
East Dam	93.4	100
South Dyke	93.6	325
West Dam	95.4	400

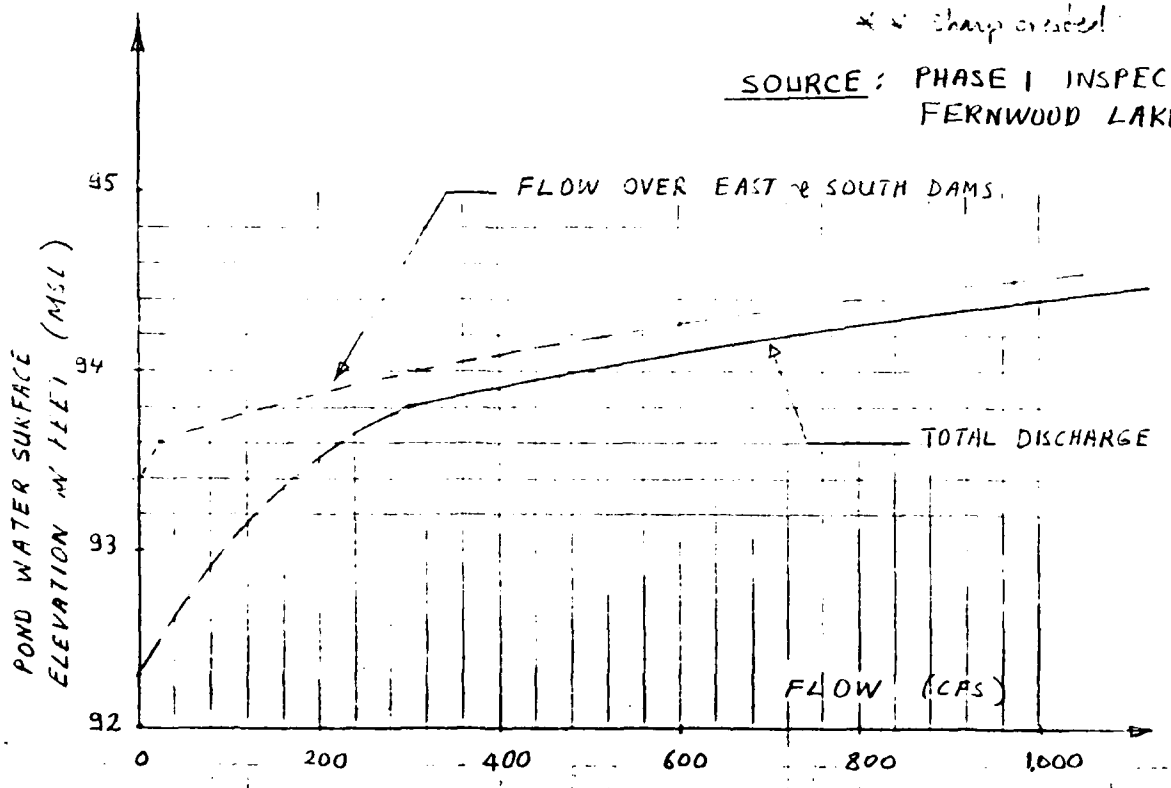
ESTIMATED STAGE-DISCHARGE QUANTITIES

Flow (cfs)	WSE @ start of d.s. channel*	Overflow East + South Dams	Overflow Spillway*	Δh reqd @ Spillway	WSE in Pond
300	91.8	150	150	1.7	93.8
500	92.3	320	180	1.9	94.0
1,000	92.5	800	200	2.1	94.4

*Effect of backflow from the downstream channel is included. Refer to tailwater studies.

*Sharp crested

SOURCE: PHASE I INSPECTION REPORT, FERNWOOD LAKE DAM, April, 1979



STAGE - DISCHARGE

(THE SPILLWAY AT NORTH HAS 1.3-FT HIGH FLASHBOARDS)

CAMP DRESSER & MCKEE INC.
CLIENT U.S.A.
PROJECT [illegible]
DETAIL Fernwood Lake Dam
JOB NO 561-9-11-5
DATE CHECKED 3/20/79
CHECKED BY JED
COMPUTED BY AUG
PAGE 4 2
DATE 3/12/79

CAMP DRESSER & McKEE

CLIENT H & A
PROJECT COE - Nat. Dam Insp.
DETAIL Fernwood Lake - East Dam

JOB NO 561-9-82-20
DATE CHECKED 5/29/80
CHECKED BY RK

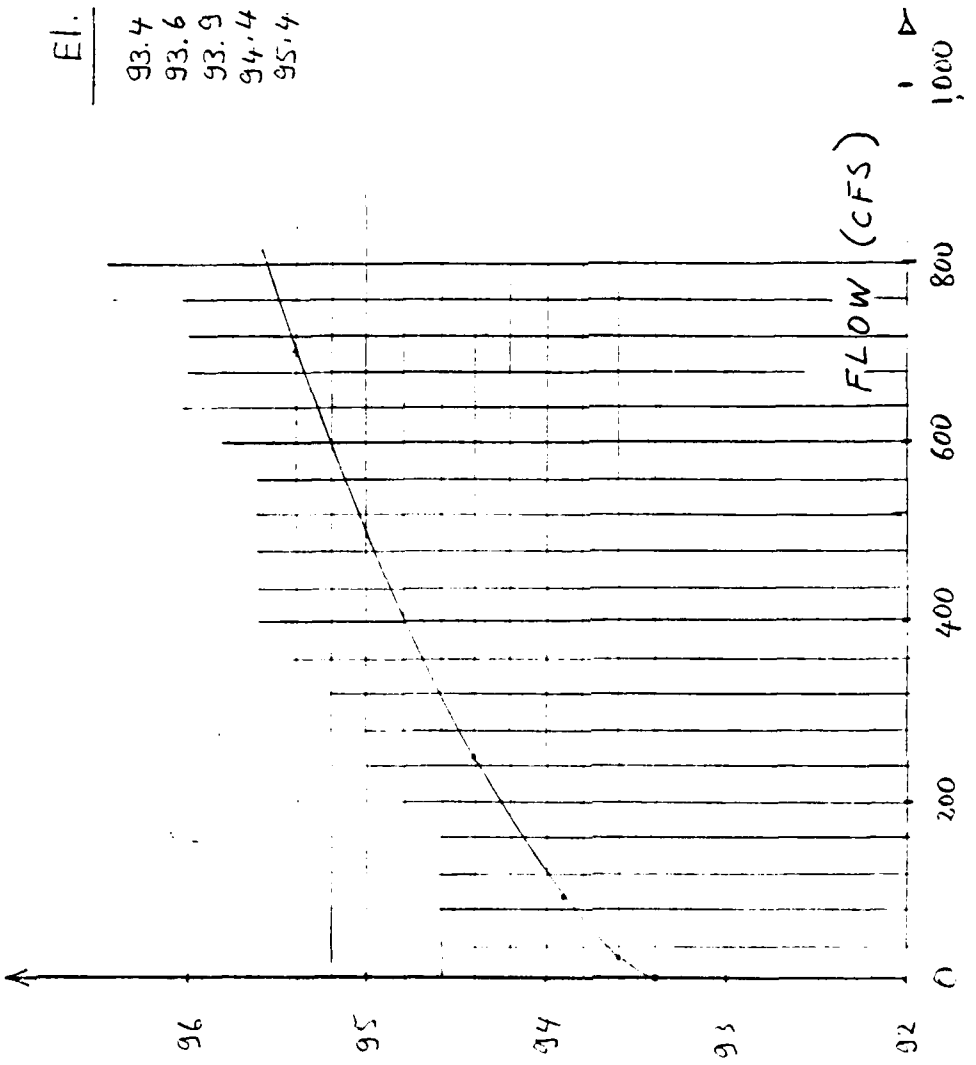
COMPUTED BY AUG
DATE 5/18/1980
PAGE NO 3

$Q = 2.5\ L\ H^{5/2}$ $L = 100\text{-ft}$

$Q = 250\ H^{5/2}$

El.	H	$H^{3/2}$	Q (cfs)
93.4	0	0	0
93.6	0.2	0.089	22
93.9	0.5	0.354	88
94.4	1.0	1.000	250
95.4	2.0	2.828	707

STAGE - DISCHARGE CURVE
- EAST DAM -



Dam Failure Analysis

Failure Flood Flow : $Q_{p_1} = \frac{8}{27} W_b \sqrt{g} Y_o^{3/2}$

$Y_o = 5\text{-ft}$ $Y_o^{3/2} = 11.2$ (El. top of Dam : 93.4)

$L_m = 90\text{-ft}$ (assumed to be the length at the mid-height of the dam)

Assume 40 % of the mid-height length fails :

$Q_{p_1} = \frac{8}{27}\ 0.4 \cdot 90 \sqrt{8} \cdot 11.2 = \underline{678}$ cfs

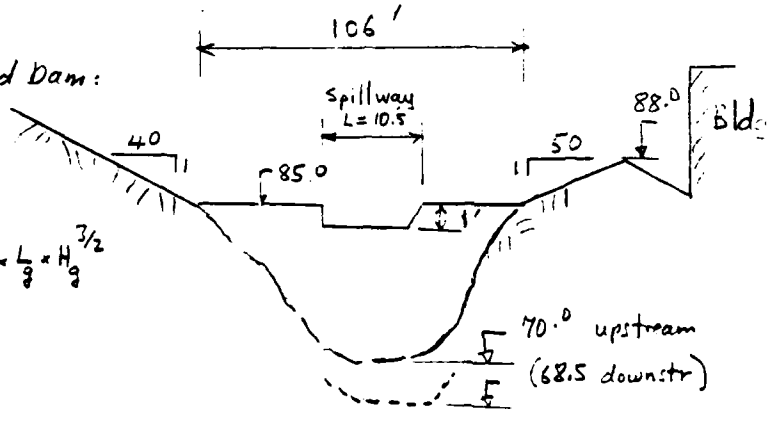
Assumption 1 : Upper Banjo Pond Dam would remain intact.

Reach 1 : Upper Banjo Pond

Stage-Discharge Relation @ U.B. Pond Dam :

Spillway crest width = 3.2 ft. (Broad crested)

$\Sigma Q = 2.6 \times 10.5 \times h_s^{3/2} + 2.5 \times 95.5 \times h_d^{3/2} + 2.5 \times L_g \times H_g^{3/2}$



Upper Banjo Pond Dam (Looking downstream)

WSE	h spillway	h dam	h over ground	ΣQ (cfs)
85	1	0	0	27
86	2	1	1	429
87	3	2	2	1,454

Estimate outflow : ($Q_1 = 678$ cfs)

WSE at Upper Banjo Pond (from stage-discharge curve) : 86.35

V_1 (from Area-Vol. curve) : 133 ac-ft. − 27 (dead volume) = 106 ac-ft.

Q_{p_2} (trial) $= 678 \left(1 - \frac{106}{S}\right)$ $S = 310 - 150 = 160$ ac-ft (See Area-Volume curve of Fernwood Lakes)

$Q_{p_2} = 229$ cfs → WSE @ U. Banjo Pond = 85.6 → $V_2 = 125 - 27 = 98$ ac-ft

$V_{av} = 102$ ac-ft.

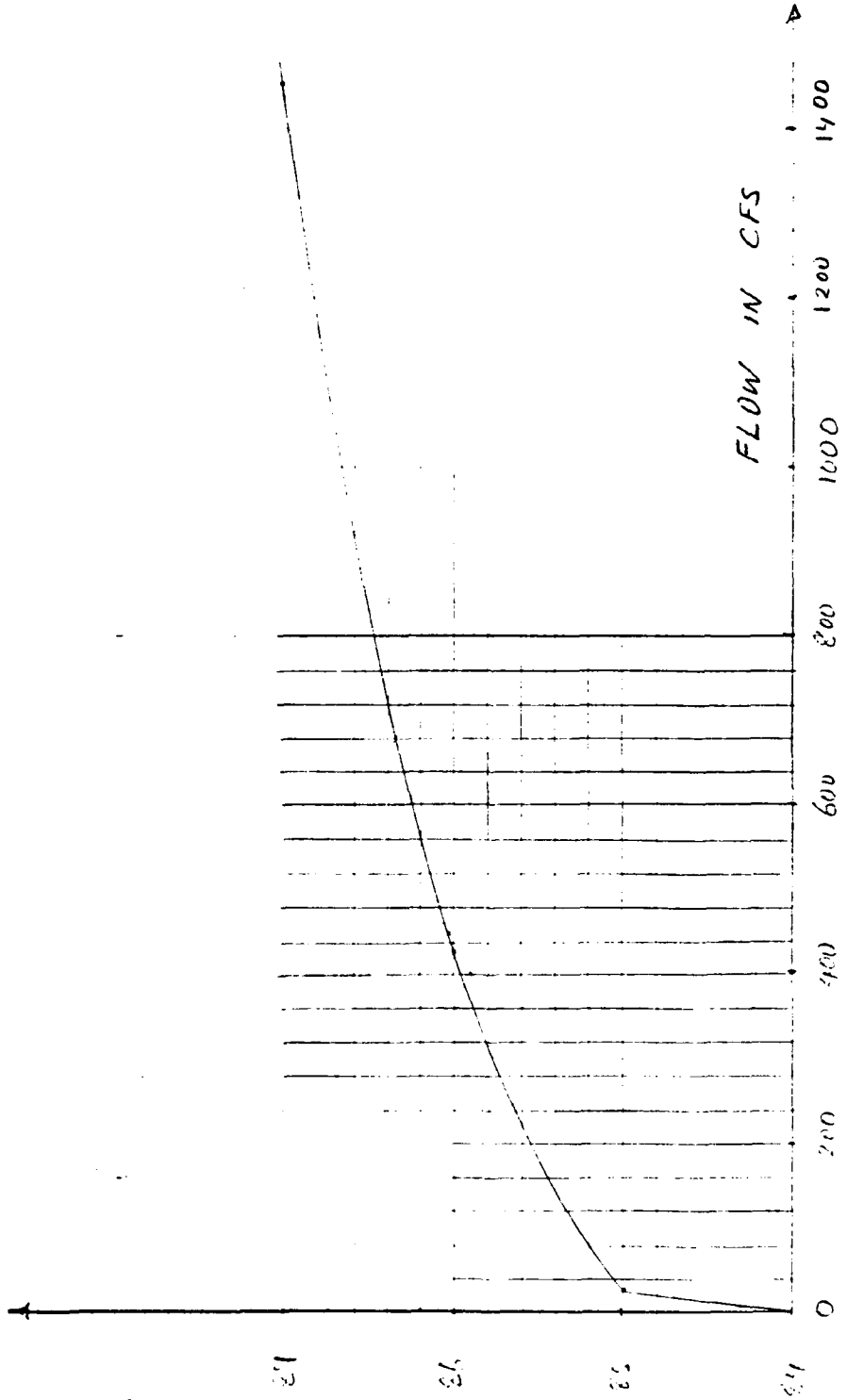
CAMP DRESSER & McKEE

CLIENT 4 of A
PROJECT COE Nat. Dam Inspection
DETAIL Fernwood Lake - East Dam

JOB NO. 561-9-RT-20
DATE CHECKED 5/29/90
CHECKED BY PWK

COMPUTED BY HLG
DATE 5/22/90
PAGE NO 5

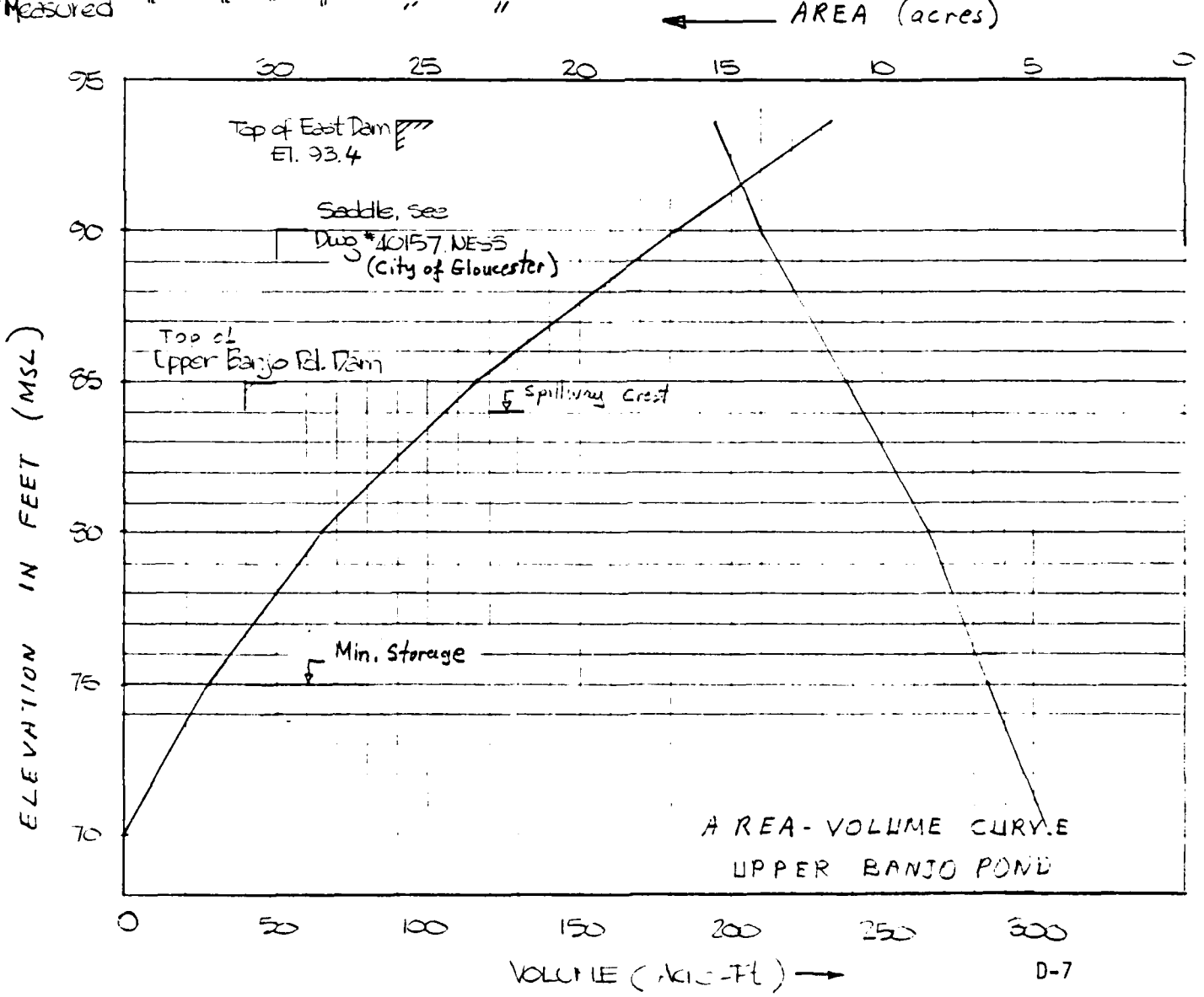
STAGE - DISCHARGE
UPPER POND DAM
(assuming the dam would not fail)



CAMP DRESSER & McKEE CLIENT H & A JOB NO 561-9-PT-20 COMPUTED BY FWK
PROJECT Fernwood Lake Dams DATE CHECKED 5/22/1980 DATE 5/19/80
DETAIL Upper Banjo Pond CHECKED BY AHG PAGE NO 6

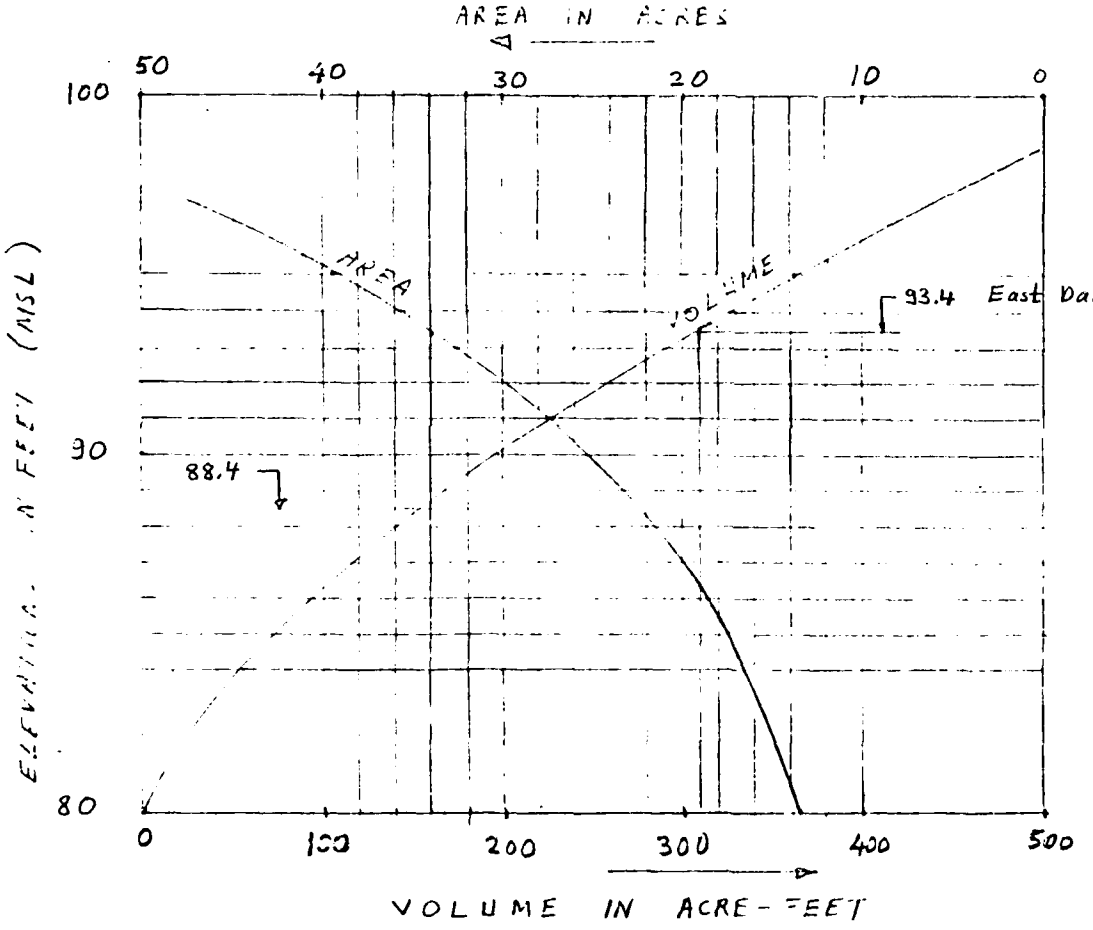
El	Area (A)	Ave Area (A)	Depth (ft)	Δ Volume	Volume
70.0 *	4.51 *				0
		5.59	5.0	27.9	
75.0	6.66 *				27.9
		7.53	5.0	37.6	
80.0	8.40 *				65.5
		10.16	5.0	50.8	
85.0	11.92 +				116.3
		12.99	5.0	64.9	
90.0	14.06 +				181.2
		14.81	3.5	51.8	
93.5	15.56 +				233.0

* Estimated from N.E.S.S. Topo (City of Gloucester)
+ Measured " " " " " "



El.	Area (acres)	h (ft)	Volume (ac-ft) Partial	Σ
80*	13.9	11	227	0
91	27.5			227
95*	39.5	4	134	361

* Areas estimated.



SOURCE: Phase I Inspection Report, Fernwood Lake Dam, April 1979.

AREA-VOLUME CURVE-FERNWOOD LAKE

(Source: USGS GLOUCESTER QUADRANGLE)

CAMP DRESSER & McKEE INC.
CLIENT
PROJECT
DETAIL
JOB NO 561-9.1+-5
DATE CHECKED 3/20/79
CHECKED BY JED
COMPUTED BY AHE
PAGE B 7
DATE 3/11/79

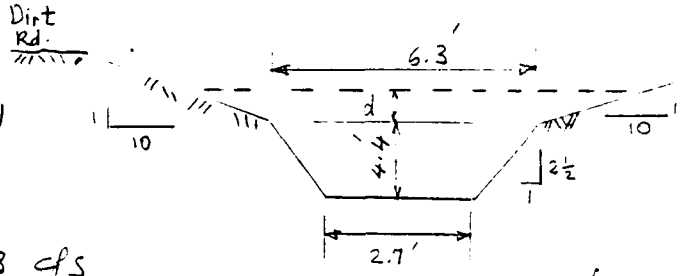
$Q_{P_2} = 678\left(1 - \frac{102}{160}\right) = 246$ cfs WSE ≈ 85.63

Reach 2 : a channel and a culvert sections between Upper and Lower Canjo Ponds :

(1) Channel :

$Q = \frac{1.49}{n} AR^{2/3} S^{1/2} = 246$ cfs

$n \tilde{=} 0.06$ $S = 0.17$ $S^{1/2} \tilde{=} 0.41$



Downstream channel (Upstream of Route 133)

Channel Capacity : $d = 0$

$Q = \frac{1.49}{0.06} \times 15.6 \times 1.37 \times 0.41 = 273$ cfs

273 cfs > 246 cfs : the flood flow will be confined in the channel.

Flood water depth in the channel :

W.S.E @ Upstream of Culvert : ≈ 48.5 + 4.3 = 52.8' (assuming no backwater effect from the road

(2) Culvert Capacity :

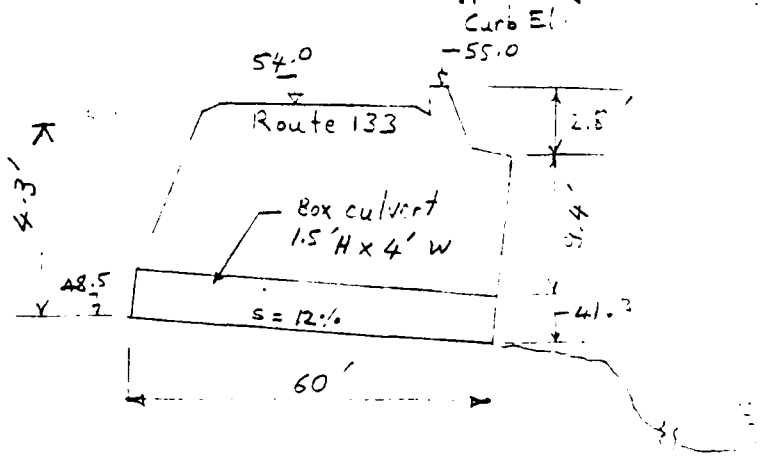
$A = 1.5 \times 4 = 6$ ☐'

$S = 0.12$ $\sqrt{S} = 0.346$

$n \tilde{=} 0.025$

$Q = \frac{1.49}{0.025} \times 6 \times 0.67 \times 0.346 = 83$ cfs.

$V_f = \frac{83}{6} = 13.8$ fps



Q = 273 cfs exceeds the culvert capacity; there would be an overland flow and flow through culvert would be under pressure.
It is estimated that 100-ft length of the road would be affected.

Flow over the curb : $q_r = 2.4 \times 100\ h^{3/2} = 240\ h^{3/2}$

Flow through culvert : the channel downstream of the culvert disappears in a flat swampy area which was covered with trees and bushes.

$S_{culvert} = \frac{56 - 42.8 - 3}{60} = 0.17$ ← inlet+outlet losses (estimated)

$S^{0.54} = 0.41$

$Q = 1.32 \cdot C_H \cdot R^{0.63} S^{0.54} \cdot A$

$R = \frac{6}{11} = 0.545$ $\quad R^{0.63} = 0.68$

$C_H \cong 100$

$Q = 1.32 \times 100 \times 0.68 \times 0.41 \times 6 = 220$ cfs

$\Delta Q = 273 - 220 = 53$ cfs.

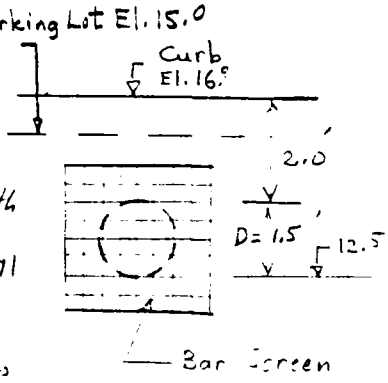
depth of water over the curb = $53 = 240 \times h^{1.5}$ $\quad h \cong 0.4$ - ft.

Depth of flood water over Route 133 = 55.4 - 54.0 = 1.4 feet

Velocity : $\frac{53}{100 \times 1.4} \cong 0.40$ fps. : not significant.

Reach 3 Lower Banjo Pond

The owner maintains a water surface elevation, in the Spring, flush with the parking lot & driveway. Therefore El. 15.00 is used for both the pond WSE and the paved area. The curb elev. is about a foot higher.



The only gravity outlet from Lower Banjo Pond is through an approximately 18-in dia. conduit. Capacity of this conduit:

$\phi 18"$ $\quad A = 1.77\ ft^2$ $\quad L = 1100'$ (up to a point south of RR)

$R = 0.375'$ $\quad R^{2/3} = 0.52$ $\quad S \cong 0.005$ $\quad \sqrt{S} = 0.071$

$\Delta h = 5.5'$ $\quad$ Inv. El. @ Mh : 7.0

This seems reasonable as there may be a drop in the manhole upstream of the RR culvert to provide a level difference for possible tidal effects (the mean high tide Elev. is 4.6 - ft)

$Q = \frac{1.49}{0.025} 1.77 \times 0.52 \times 0.071 \cong 4$ cfs The capacity is extremely small in comparison to the failure flood flow of Emt Dam.

As there is no other gravity outlet until about elevation 25 (RR embank. and as there would be no pumpage at the cooling water recirculation system after a flooding, the WSE at the area surrounding Lower Banjo Pond can be estimated as follows:

Volume of flood water reaching to L. B. Pond: 160 − 98 = 62 ac-ft (ignoring storage in the channel and culvert)

WSE (from Area-Volume Curve) = $\Sigma V = 62 + 63 = 125$ ac-ft →

WSE = 21 − ?

The parking lot and driveway of LeBoges Inc. would be flooded under 6-feet of water. If the outlet is not plugged during the flood stage, it would take about 3 days to drain the area without help of emergency pumpage.

Assumption 2: Upper Banjo Pond Dam would fail following failure of East Dam:

Reach 1 : Upper Banjo Pond

Assuming that a 70-ft long weir section would be established at elevation 75.0 after the U.B. Pond dam failure, a static discharge at the failed concrete dam section is shown in Page D-11.

$Q_{P_1} = 678$ cfs → WSE = 77.4 $I_1 = 45 - 27 = 18$ ac-ft

$Q_{P_2}(\text{trial}) = 678\left(1 - \frac{18}{160}\right) = 602$ cfs → WSE = 77.2 → $V_2 = 16$ ac-ft

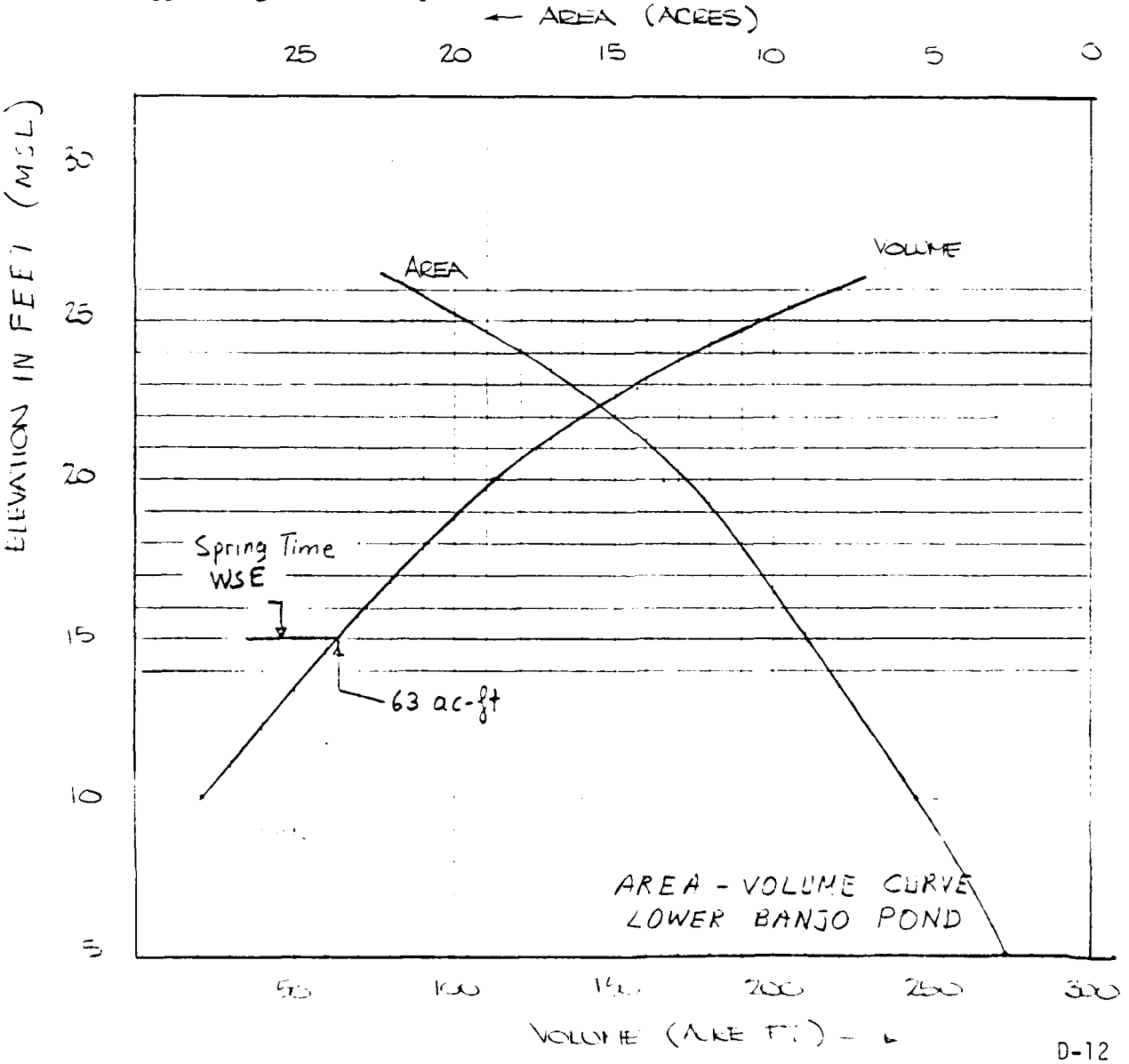
$V_{av} = 17$ ac-ft $Q_{P_2} = 678\left(1 - \frac{17}{160}\right) = 606$ cfs WSE = 77.2

CAMP DRESSER & McKEE CLIENT REA JOB NO. 561-3-Rt-20 COMPUTED BY PK
PROJECT _____ DATE CHECKED 5/29/20 DATE 5 29 20
DETAIL LOWER BANJO POND CHECKED BY AJG PAGE NO 11

LOWER BANJO POND

EL	Area (A)	Ac Area	depth (ft)	Δ Volume	Volume	Source
5.0 *	2.75*				0	
		4.13	5.0	20.65		
10.0	5.51				20.65	USGS
		9.19	10.0	91.9		
20.0	12.86				112.55	USGS
		16.07	5.0	80.35		
25.0	17.28				192.90	USGS

* ESTIMATED



CAMP DRESSER & McKEE

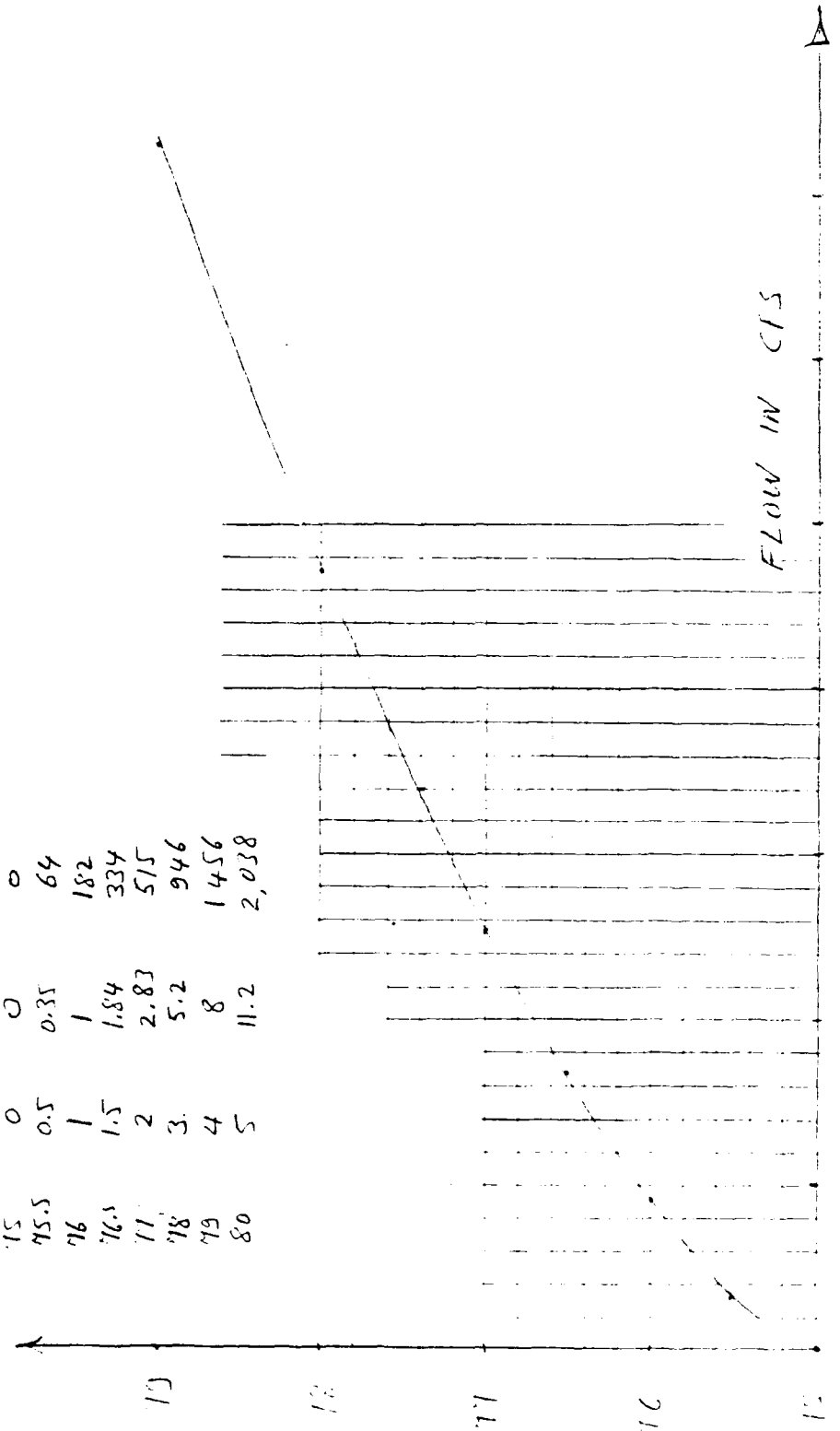
CLIENT H&A
PROJECT Nat. Dam Inspection
DETAIL Fernwood Lake - East Dam

JOB NO 561-9-Rt-20
DATE CHECKED 5-20-80
CHECKED BY RW

COMPUTED BY AUG
DATE 5/18/80
PAGE NO 12

$Q = 2.6\ L\ H^{3/2}$ $L \cong 70'$ $Q = 182\ H^{3/2}$ (Assuming a 70-ft long weir section to be established at El. 75)

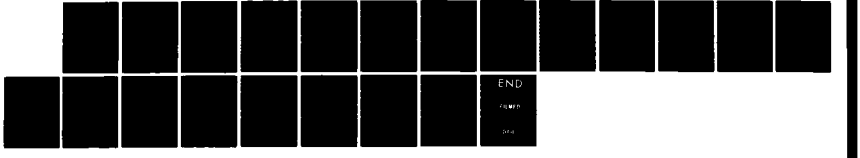
El.	H	$H^{1.5}$	Q (cfs)
75	0	0	0
75.5	0.5	0.35	64
76	1	1	182
76.5	1.5	1.84	334
77	2	2.83	515
78	3	5.2	946
79	4	8	1456
80	5	11.2	2,038

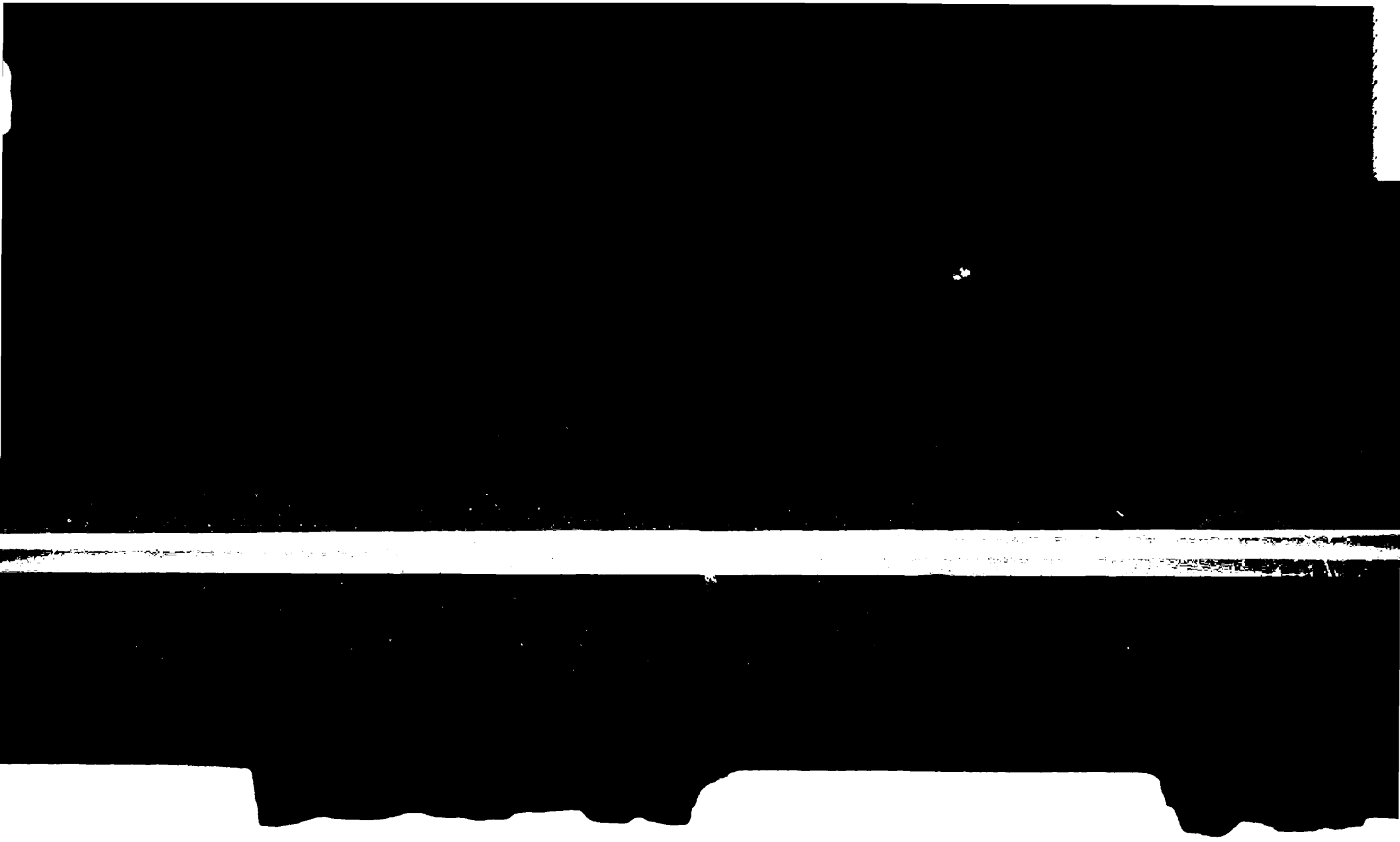


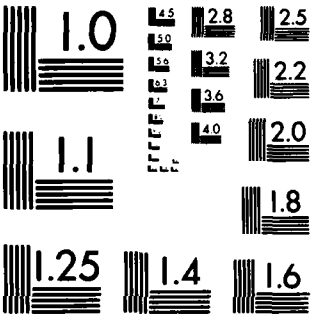
Charge - Discharge at Upper Banjo Pond Dam after Failure of Existing Conc. Dam

AD-A155 376 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS 2/2
FERNWOOD LAKE EAST DA. (U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV SEP 80

UNCLASSIFIED F/G 13/13 NL







Reach 2

Channel section : capacity (as shown in Page D-7): 273 cfs.

273 cfs < 606 cfs. There would be flow over the banks.

$\Delta d = 1.5'$ $d = 5.9'$ $A = 19.6 + 6.3 \times 1.5 = 29.05\ \square'$

$R = \frac{29.05}{12.2} = 2.38$ $R^{2/3} = 1.78$ $Q_1 = 24.8 \times 29.05 \times 1.78 \times 0.41 = 526$ cfs.

$Q_2 = 2 \times \frac{1.49}{0.15} \times 11.25 \times 0.82 \times 0.41 = 76$ cfs. $\Sigma Q = 602$ cfs. ≈ 606 cfs.

WSE upstream of the culvert: $48.3 + 5.9 = 54.2'$ (if no backwater from Route 133).

Culvert under Route 133 : assume 1.5-ft head on the road curb: and full section flow at downstream end:

$S = \frac{56.5 - 42.3 - 3}{60} = 0.178$ $A = 6\ \square'$ $R = 0.545'$

$S^{0.54} = 0.42$ $Q = 1.32 \times 100 \times 0.68 \times 0.42 \times 6 = 226$ cfs.

$\Delta Q = 606 - 226 = 380$ cfs. $380 = 240\ h^{3/2}$ $h = 1.4' \approx 1.5'$ O.K.

$V = \frac{380}{100 \times 1.4} = 2.7$ fps not too significant.

However debris from the dam failure could block Route 133 and cause damage.

Reach 3 Lower Banjo Pond (L.B.P.)

Volume of flood water reaching to L.B.P. quickly: $160 - 17 = 143$ ac-ft (as storage in the channel and the culvert is negligible)

WSE in L.B.P. = (for $V = 63 + 143 = 206$ ac-ft) = 25.3-ft (MSL)

The small amount above elevation 25.0-ft (railroad embankment) would be discharged quickly; the rest 10-ft deep flood water would inundate the driveway, parking lot and the other Lepage facilities surrounding L.B.P.

Conclusion : In case of a failure at East Dam, it is very likely that the Upper Banjo Pond dam, which appears to be structurally in poor condition, would fail; with this, Route 133 could be blocked with the debris, and vehicles which would happen to be passing by, could be damaged; and the area surrounding Lower Banjo Pond including a driveway, a parking lot and several facilities which belong to LePages, Inc. is expected to be subject to a 10-foot deep flooding because of limited outlet capacity. Therefore a potential for loss of lives and property damages exists.

The hazard potential classification is considered high.

Size Classification

Height : 95.4 - 84.4 = 11 feet < 40 feet

Res. Vol. (Fernwood Lake) : 380 ac-ft @ elev. 95.4 < 1000 ac-ft

Size Classification : SMALL

Hazard Potential Classification

Based on the results of the dam failure analysis, a failure at West Dam would result in the potential loss of more than a few lives: hazard classification is HIGH.

Test Flood Determination

Size : Small ; Hazard Potential : high

$\bar{x}_T = \frac{1}{2}$ PMF to PMF

$Q_T = \frac{1}{2}$ PMF = 475 cfs (see the East Dam computations)

Surcharge - Storage Routing

A test flood routing for Fernwood Lake has shown that the West Dam would not be overtopped (See Fernwood Lake Dam, Ma. 00184, Phase I Inspection Report, April 1979). Assuming that the existing flashboards at North Dam would stay in place, the test flood water surface elevation at the Lake Was estimated to be 93.9 or 1.5-ft below the crest of West Dam.

The existing 14-in outlet valve is assumed closed. Hydraulic capacity of the conduit is estimated to be about 15 cfs; a summary of the analysis on this is shown in the following page.

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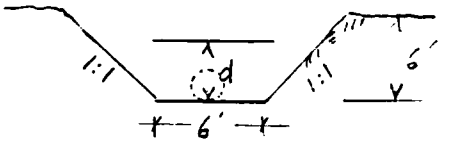
DETAIL Fernwood Lake-West Dam CHECKED BY RJC PAGE NO 2

Fernwood Lake - West Dam

Tailwater Stage-Discharge and Outlet pipe Capacity Estimate

$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$ $n \tilde{=} 0.15$ $S = 0.06$ $S^{1/2} = 0.245$ $Q = 2.43 A R^{2/3}$

Outlet pipe invert at channel: ≈ 84.4



d	WSE	A	w	$R^{2/3}$	Q (cfs)	
0.5	84.9	3.25	7.4	0.58	4.6	≈ 5.0
1.0	85.4	7.00	8.8	0.86	14.6	≈ 15.0
1.5	85.9	11.30	10.2	1.11	30.5	≈ 31.0
2.0	86.4	16	11.6	1.24	48.5	

$A = (6+d)\,d$

$w = 6 + 2 \times 1.41\, d = 6 + 2.82\, d$

Flow through Outlet pipe:
(D = 14-in, L = 100')

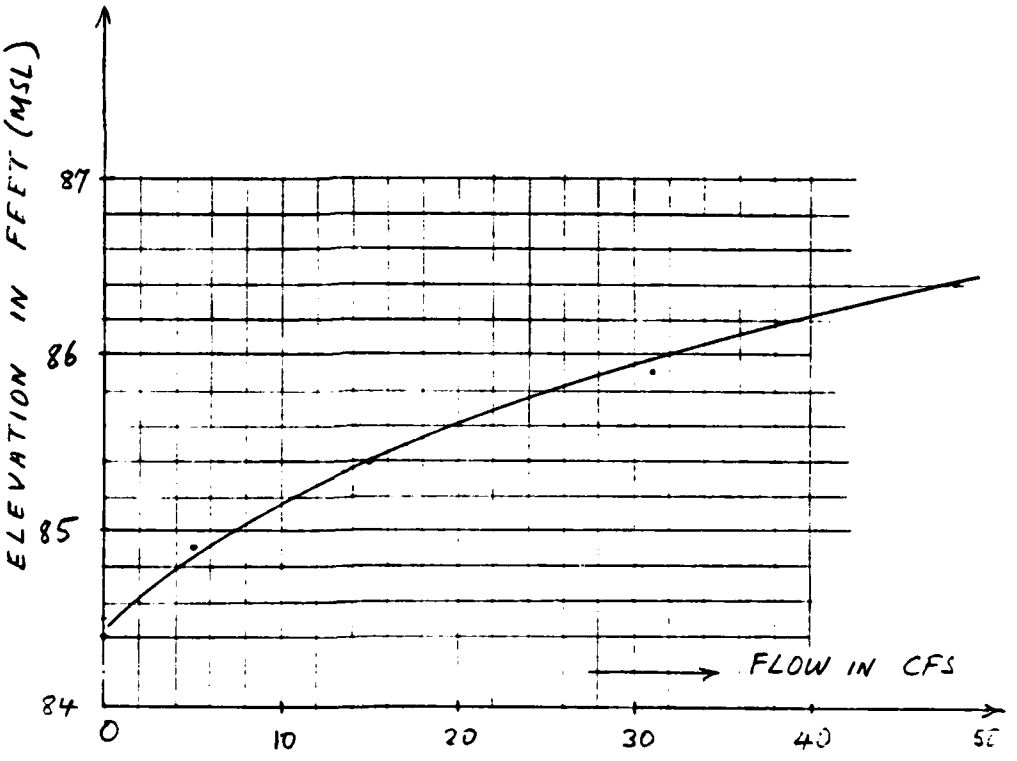
$q = 1.32 \times C_H\, A\, R^{0.63} S^{0.54}$

$C_H = 110$ $A = 1.07$ □'

$R = 0.29$ $R^{0.63} = 0.46$

$q = 71.5 \times S^{0.54}$

WSE in Lake	Q-pipe* (cfs)
95.4	15
96.4	15.6
97.4	16.3
98.4	13.6



Tailwater Stage-Discharge

* with trial and error; and with assumption of $h_v = 1.5 \frac{V^2}{2g}$ for inlet+outlet losses. The results show that capacity of the outlet conduit is relatively small (≈ 15 cfs) and it does not change significantly with fluctuations of WSE.

Dam Failure Analysis

Failure Flood Flow: $Q_{p_1} = \frac{8}{27} W_b \sqrt{g} Y_o^{3/2}$

$Y_o = 95.4 - 84.4 = 11$ -ft $\quad Y_o^{3/2} = 36.5$ $\quad W_b \cong 0.4 \times 300' = 120'$

$\sqrt{g} = 5.67$

$Q_{p_1} =$ **7,360 cfs.**

Failure Flood Impact For the purpose of this study the flood course is divided into four reaches; In order to include backwater effect, if any, in the hydraulic calculations, we developed stage - discharge relations starting in Reach 4, the most downstream area and worked towards upstream.

(a) A summary of stage - discharge computations for the Brook between Lily Pond and Little River (Reach 4) and the resulting curve are shown in Page D-19.

(b) The stage - discharge relation for the Magnolia Avenue overflow is shown in Page D-20. This represents the tailwater condition for the opening underneath the B & M railroad.

(c) Stage - Discharge Computations for the opening underneath the RR: ($L = 60$-ft)

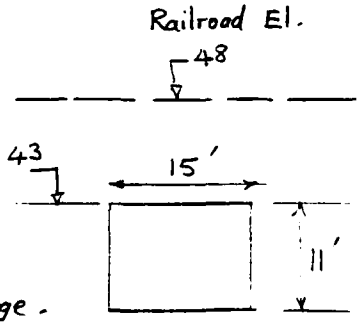
(1) Flowing full: WSE = 43.0

$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$ $\quad n \cong 0.035$

$A = 165\ \square'$ $\quad R = 3.17$

$S \cong 0.0185$ $\quad S^{1/2} = 0.136$

$Q = 2{,}100$ cfs. Tailwater El. 31.2 (Page D-20) no surcharge.



Opening underneath Railroad

(2) WSE = 48.0. (opening is under pressure)

Try $q_1 = 4000$ cfs. $\quad V = 24$ fps $\quad h_v \cong 1.5 \frac{V^2}{2g} = 13.5$ $\quad$ Tailwater: 32.0

$\Delta h = 48 - 13.5 - 32 = 2.5$-ft $\quad S = \frac{2.5}{60} = 0.042$ $\quad S^{0.54} \cong 0.18$

$q = 1.32 C_H \cdot A \cdot R^{0.63} S^{0.54}$ $\quad C_H \cong 100$ $\quad A = 165\ \square'$ $\quad R^{0.63} = 2.07$

$q = 45{,}095\ S^{0.54}$ $\quad q_1' = 8{,}100$ cfs $> 4{,}000$ cfs.

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JOB NO. 561-9-Rt-19
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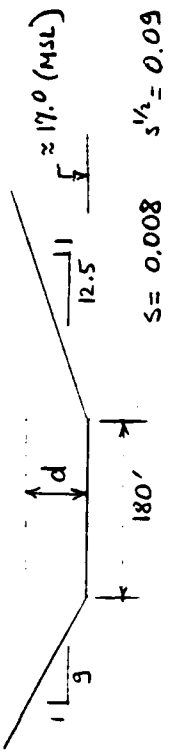
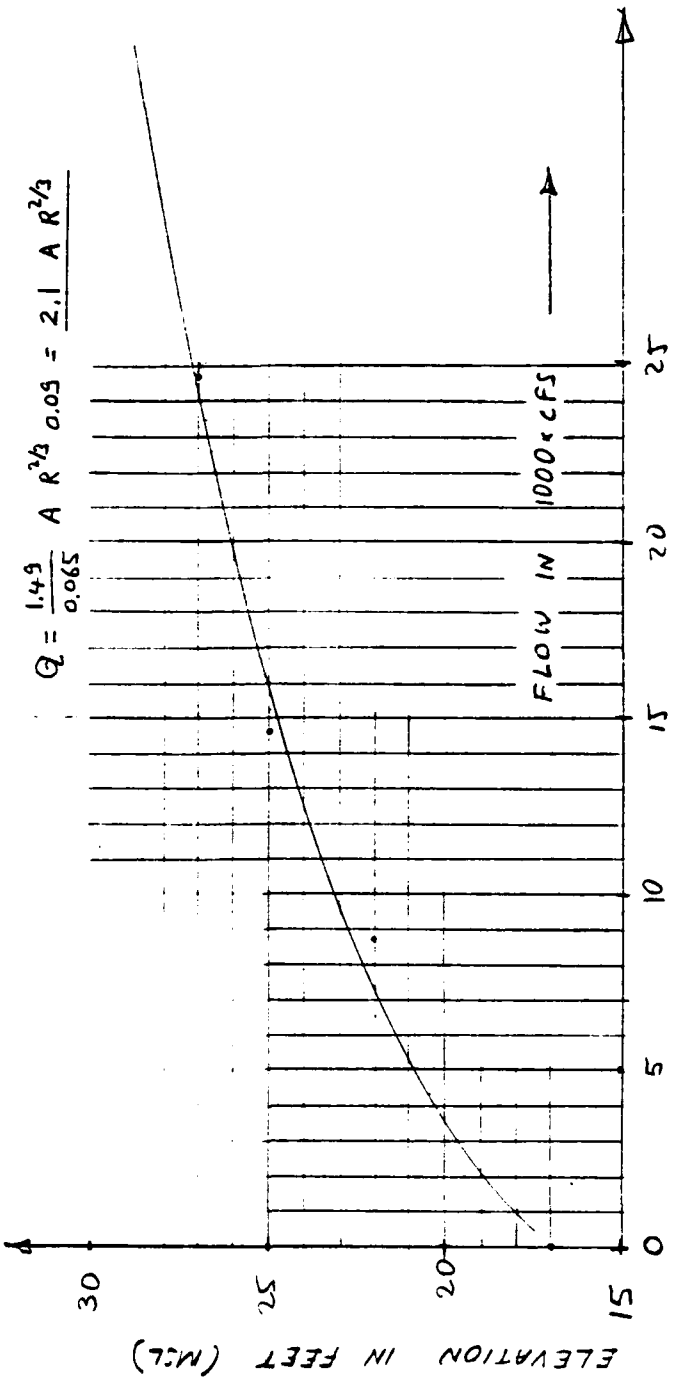
DATE 6/4/1980
PAGE NO 4

Stage-Discharge for Brook tributary to Little River



$$Q = \frac{1.49}{0.065} A R^{2/3} 0.09 = 2.1 A R^{2/3}$$

d	A	R	Q (cfs)
5	1,440	4.97	8,800
8	2,120	5.97	14,660
10	2,980	7.84	24,700



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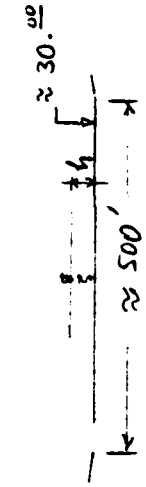
PAGE NO 5

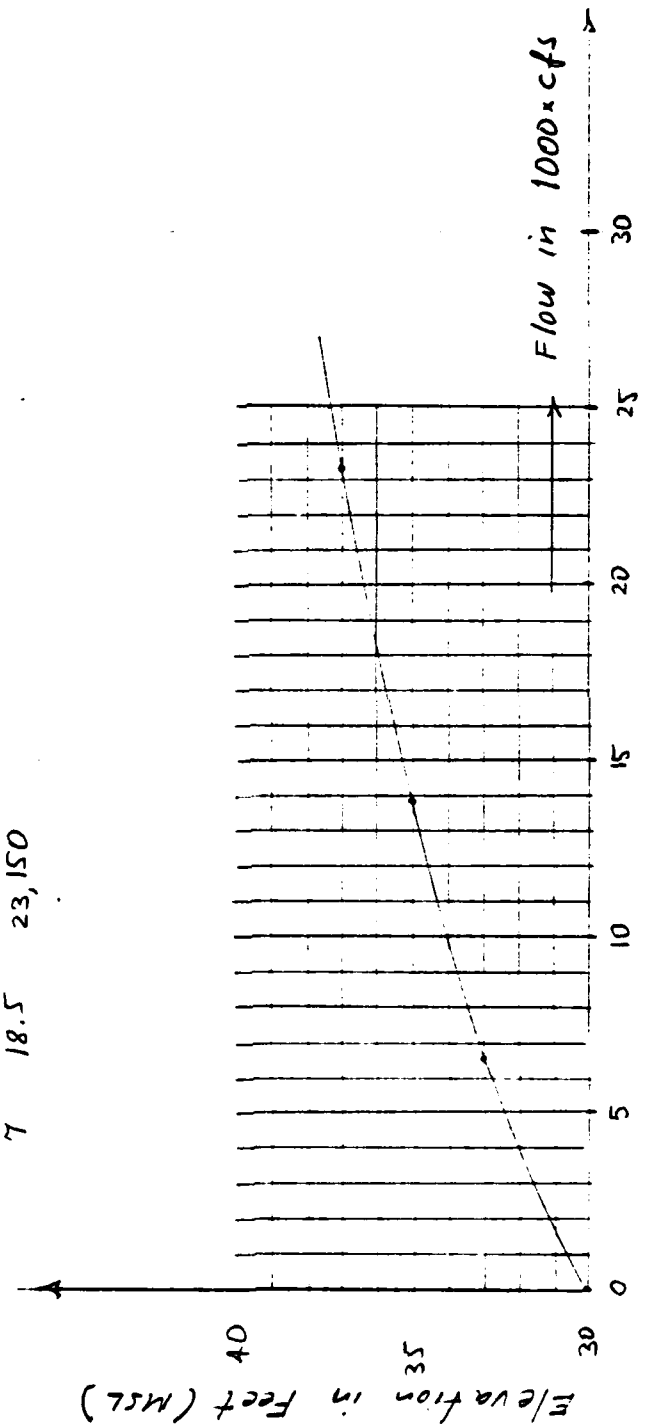


$Q = 2.5 \times L \times h^{3/2}$

$= 1,250\ h^{3/2}$

h	$h^{3/2}$	Q (cfs)
3	5.2	6,500
5	11.2	13,975
7	18.5	23,150

Stage – Discharge
Upstream of Magnolia Avenue
(Downstream of Railroad)



Try $q_2 = 4{,}200$ cfs $V = 25.5$ fps $h_v = 15.1'$

$\Delta h = 48.0 - 15.1 - 32.1 = 0.8$ $S = \frac{0.8}{60} = 0.0133$ $S^{0.54} = 0.097$

$q_2' = 4{,}380$ cfs. close enough.

WSE = 48.0 $q = 4{,}200$ cfs.

When WSE exceeds el. 48 it will flow over the RR embankment. Flow through the opening would not increase significantly because of inlet-outlet losses and the effect of tailwater.

Flow over the RR embankment:

$Q = CLh^{3/2}$ $L \cong 500$-ft. $C = 2.5$ $Q = 1{,}250\, h^{3/2}$

Summary of Stage-Discharge at the Opening:

El.	h	$h^{3/2}$	Q_{over}	$q_{opening}$	ΣQ (cfs)
43	–	–	–	2,100	2,100
48	–	–	–	4,200	4,200
49	1	1	1,250	4,300	5,550
50	2	2.83	3,540	4,400	7,940
51	3	5.20	6,500	4,500	11,000
52	4	8.0	10,000	4,500	14,500
53	5	11.18	14,000	4,500	18,500
54	6	14.70	18,400	4,500	22,900

Stage-Discharge curve for a section just upstream of the B&M railroad is shown in Page D-22. This applies to the downstream end of the Reach 3.

The above study assumes that the railroad embankment would not fail.

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JOB NO. 561-9-PT-19
DATE CHECKED 6/9/80
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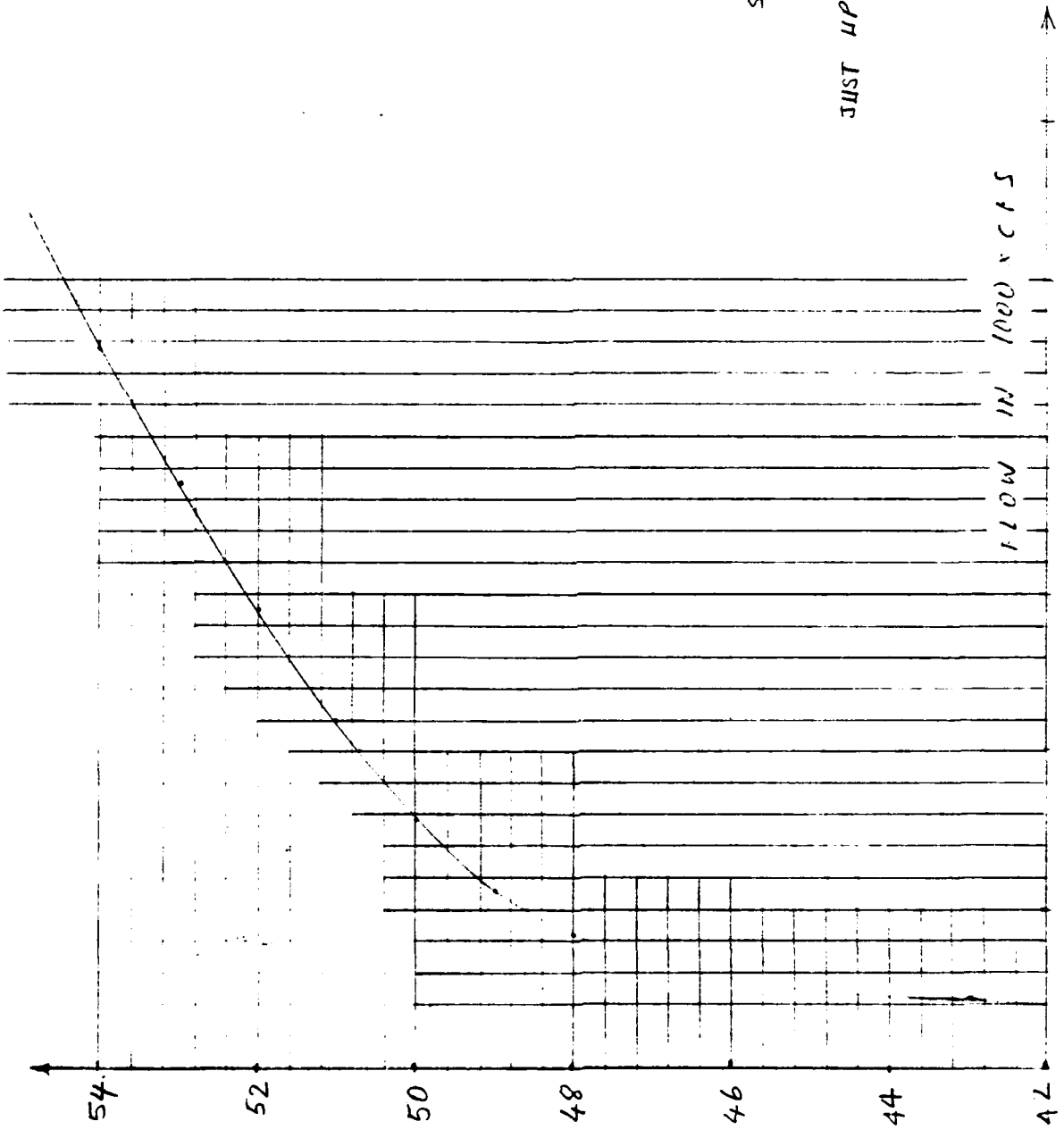
DATE 6/4/1980
PAGE NO 7

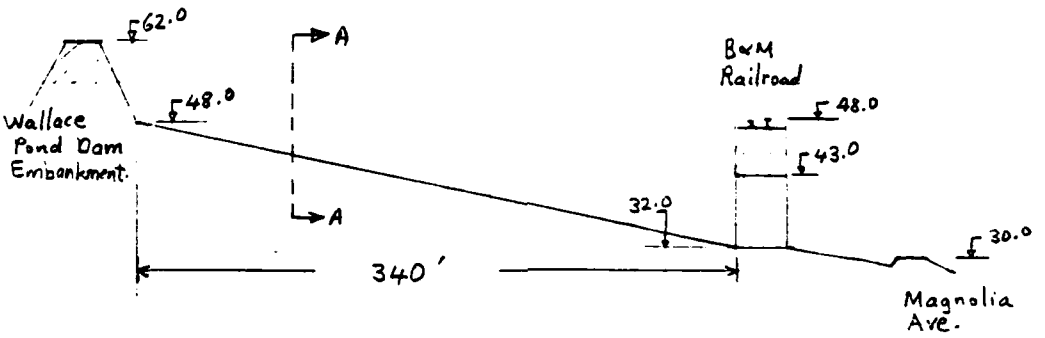
STAGE - DISCHARGE
@
JUST UPSTREAM OF B&M RAILROAD



D-22

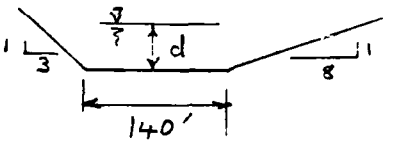
Reach 3 upstream end :

Wallace Pond Dam - Tailwater Stage - Discharge :



$Q = \frac{1.49}{0.08} A R^{2/3} S^{1/2} = 18.6\ A\ R^{2/3} S_{av}^{1/2}$

$Q_1 = 5{,}000$ cfs. determine "d" by trial & error:



$d_1 = 5'$ $A = 838\ \square'$ $w = 200'$

$R^{2/3} = 2.6$ $Q = 5{,}000\ cfs = 18.6 \times 838 \times 2.6 \times S_{av}^{1/2}$

$S_{av} = 0.0152$ WSE @ RR : 48.6 (Page D-22) $n \cong 0.080$

WSE at the dam apron : $48.6 + 0.0152 \times 340 = 53.8$ $d_1' = 53.8 - 48.0 = 5.8'$

Use : $S_{av} = \frac{5 + 5.8}{2} = 5.4'$ or tailwater S.E : $48 + 5.4 = \underline{53.4}$

$Q_2 = 10{,}000$ cfs.

d_1 (trial) $= 8'$ $A = 1472\ \square'$ $w = 230'$ $R^{2/3} = 3.45$

$10{,}000 = 18.6\ A R^{2/3} S^{1/2}$ $S_1 = 0.0112$

From WS profile : Downstream WSE from the curve on Page D-22 : 50.7

$S_2 = \frac{48 + 8 - 50.7}{340} = 0.0156$

$S_{av} = \frac{0.0112 + 0.0156}{2} = 0.0134$ $\Delta h = 4.5'$

Reach 3 upstream WSE = $50.7 + 4.5 = 55.2$

$d_1 = 7.2$ -ft.

Wallace Pond Spillway (El. 60.5) is not submerged

$Q_3 = 15{,}000$ cfs :

d_1 (trial) = 10′ Downstream WSE (from Page D-22) = 52.1

$S_1 = \frac{48+10-52.1}{340} = 0.017$ } $S_{av} = 0.014$

$A = 1950$ □′ $W = 250$′ $R^{2/3} = 3.94$ $S_2 = 0.011$

$\Delta h = 0.014 \times 340 = 4.8$′

Reach 3 - Upstream WSE $\cong$ 52.1 + 4.8 = 56.9

$d_{upst} = 56.9 - 48.0 = 8.9$-ft $= d_1$

56.9 < 60.5 the spillway not submerged.

$Q_4 = 20{,}000$ cfs :

d_1 (trial) = 12′ $S_1 = \frac{48+12-53.4}{340} = 0.0194$

$A = 2{,}472$ □′ $W = 275$′ $R^{2/3} = 4.32$

$S_2 = 0.010$ $S_{av} = 0.0147$ $\Delta h = 5$′

Reach 3 - Upst. WSE $\cong$ 53.4 + 5 = 58.4 $d_1 = 10.4$ -ft.

58.4 < 60.5 the spillway not submerged.

Stage - discharge curve for Wallace Pond Dam tailwater is shown on Page D-25.

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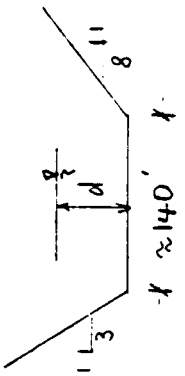
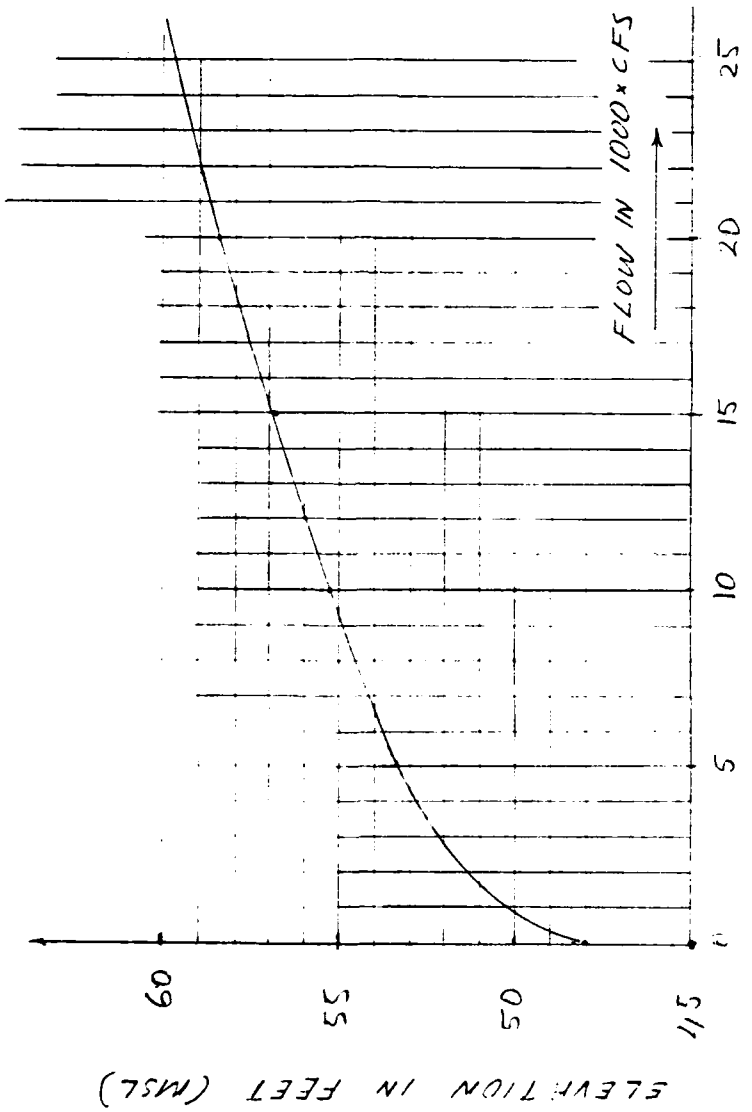
PROJECT Wallace Dam Improvements DATE CHECKED 9/6/80 DATE 6/2/1980
DETAIL Tailwater at West Dam CHECKED BY RWK PAGE NO 10

WALLACE POND DAM
TAIL WATER STAGE - DISCHARGE

Downstream Channel - Section



Q (cfs)	Tailwater Surface El.
5,000	53.4
10,000	55.2
15,000	56.9
20,000	58.4



Reach 2 : Wallace Pond

Area-volume curves and stage-discharge curves for Pond are shown on Pages D-27 and D-28, respec

Failure Flood Routing :

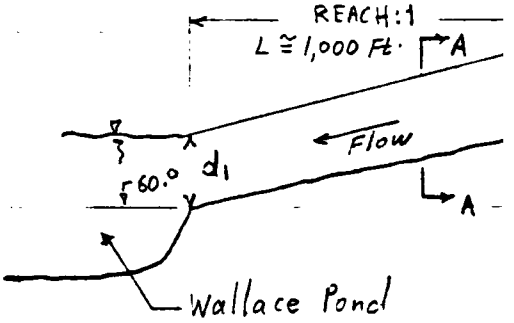
Reach 1 :

The valley between Fernwood Lake & Wallace P

West Dam Failure Flood Flow : 7,360 cfs (Pp. D-

S = 380 - 60 = 320 ac-ft (Vol. of Fernwood L. between S

$Q_{p_2}(\text{trial}) = Q_{p_1}\left(1 - \frac{V_1}{S}\right)$



Determine V_1 :

$d_2(\text{trial}) = 8'$ WSE = 76.0

$A = 2000\ \square'$ $W = 303'$ $R = 6.6$

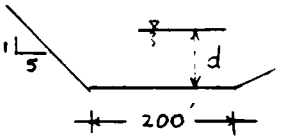
$R^{2/3} = 3.52$

$Q_{p_1} = 7,360 = \frac{1.49}{0.12} A R^{2/3} S^{1/2} =$

$S_{av} = 0.0071$ $\Delta h = 7.1$ ft.

WSE in Wallace Pond (From page D-28) : 65.6

SECTION A-A



WSE @ upstream of Reach 1 :
65.6 + 7.1 = 72.7 < 76.0

Use an average of El. 75.0 → $d_2 = 7.0'$

$A_{dst} = 5.6\left(200 + \frac{12.5 \times 5.6}{2}\right) = 1,316\ \square'$

$A_{upst.} = 7.0\left(200 + \frac{12.5 \times 7}{2}\right) = 1,706\ \square'$

$A_{av} = 1,511\ \square'$

$V_1 = 1,511 \times 1000 \times \frac{1}{43,560} = 35$ acre-ft.

$Q_{p_2}(\text{trial}) = 7,360\left(1 - \frac{35}{320}\right) = 6,558$ cfs.

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

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DETAIL Fernwood Lake - West Dam

JOB NO 561-9-Pt-19
DATE CHECKED 6/9/80
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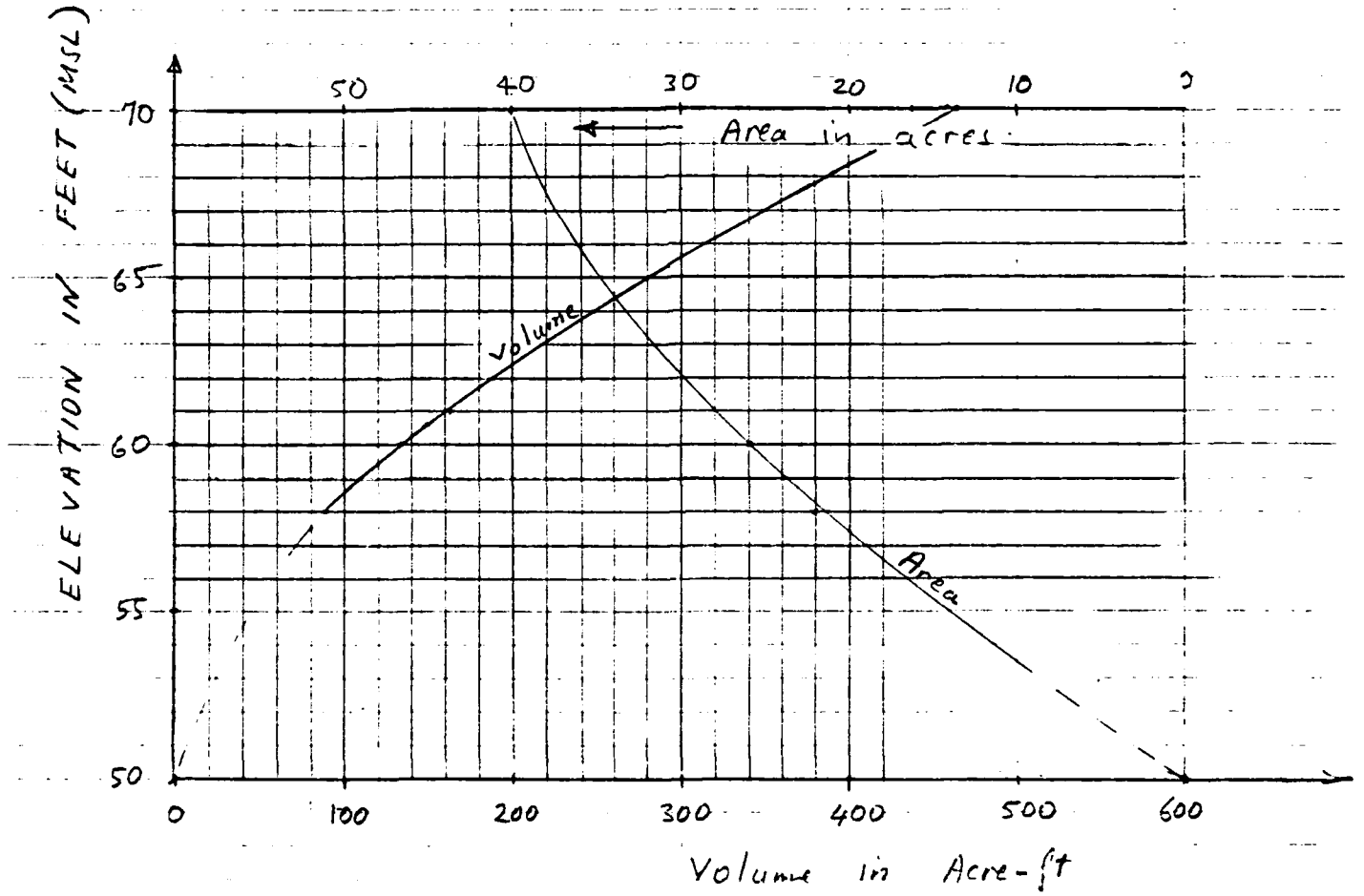
PAGE 12
DATE 6/4/1980
COMPUTED BY AMG

Area-Volume Curve - Wallace Pond

El. (MSL)	Area (ac.)	Ave. Area (ac)	depth (ft)	Storage (ac-ft)	Cum. Stor. ac.-ft	Source
50±	0	-	-	-	-	HH&B Rpt
58	22	11	8	88	88±	"
60	26±	24	2	48	136±	"
70	40	33	10	330	466±	USGS



AREA-VOLUME CURVES
Wallace Pond
(Reach 2)

D-27

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DETAIL Fernwood L. - West Dam

JOB NO. 561-9-RT-19
DATE CHECKED 6/9/80
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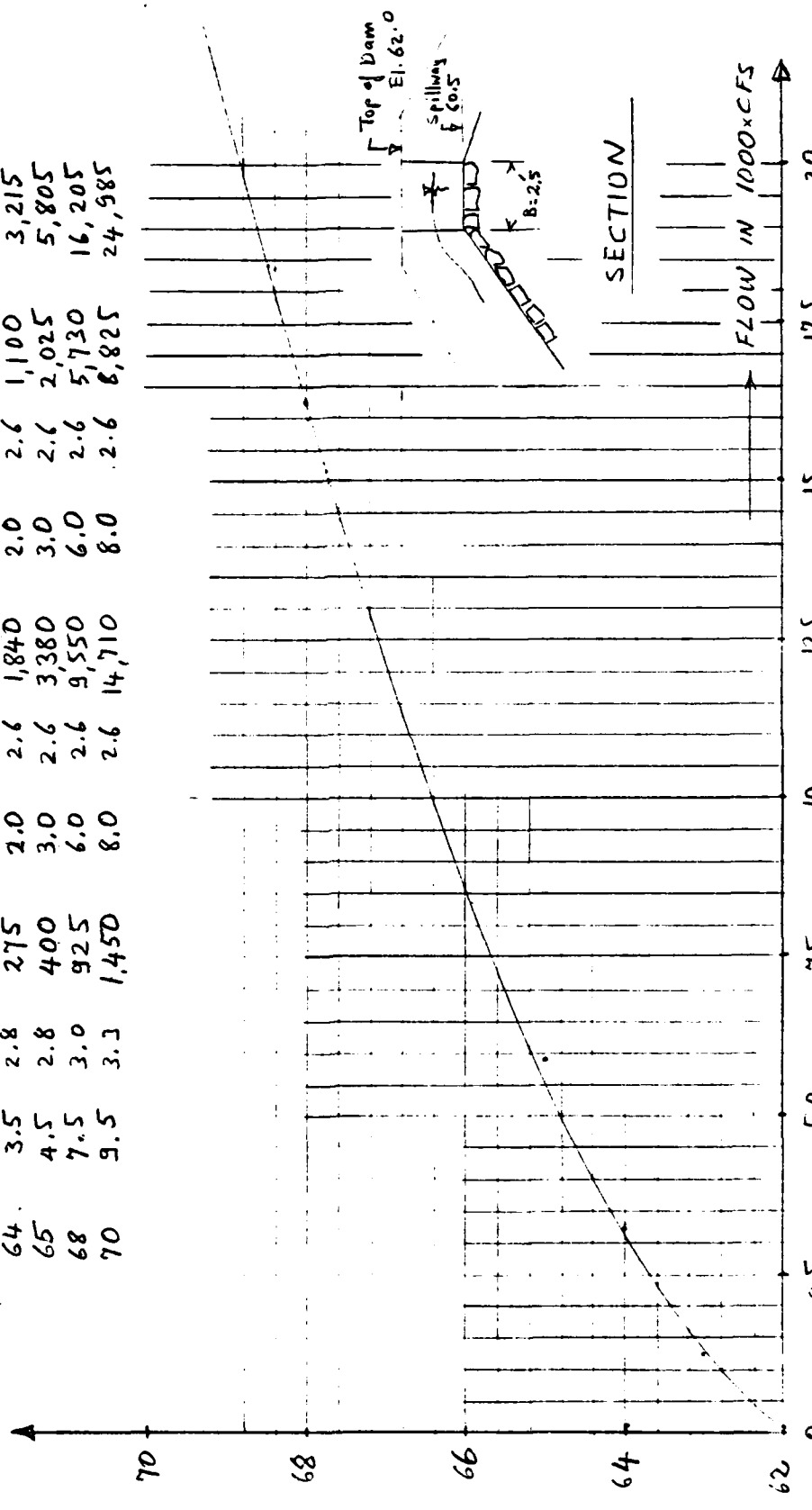
DATE 6/2/80
PAGE NO 13

Wallace Pond

El.	Spillway (L=15') h(ft)	C	q₁(cfs)	Dam (L=250') h	C	q₂	Dyke (L=150') h	C	q₃	Σq(cfs)
62	1.5	2.77	76	0	0	0	0	0	0	76
63	2.5	2.8	166	1.0	2.6	650	1.0	2.6	390	1,206
64	3.5	2.8	275	2.0	2.6	1,840	2.0	2.6	1,100	3,215
65	4.5	2.8	400	3.0	2.6	3380	3.0	2.6	2,025	5,805
68	7.5	3.0	925	6.0	2.6	9,550	6.0	2.6	5,730	16,205
70	9.5	3.3	1,450	8.0	2.6	14,710	8.0	2.6	8,825	24,985



Note: The above dimensions are from the actual field surveys and from 1"=100' topo maps by City of Gloucester.

Failure flood routing through Reach 1 (Cont'd)

Q_{P_2} (trial = 6,558 cfs WSE @ Wallace Pond = 65.4 from P. D-28)

$d_2 = 6.5'$ → $A_2 = 1{,}564$ sq ft

$d_1 = 65.4 - 60 = 5.4'$ → $A_1 = 1{,}262$ sq ft $A_{av} = 1{,}413$ sq ft

$V_2 = 32$ acre-ft.

$V_{av} = \frac{32+35}{2} = 33.5$ acre-ft.

$Q_{P_2} = 7{,}360\left(1 - \frac{33.5}{320}\right) = \underline{6{,}580}$ cfs.

Failure Flood Routing through "Reach 2" or Wallace Pond:

$Q_{P_2} = 6{,}580$ cfs. ⟶ WSE @ Wallace Pond = 65.4

$S = 320 - 33.5 = 286.5$ acre-ft.

V_{pond} @ El. 65.4 = ------ 295 acre-ft.
Wallace Pond Volume prior to flood = 150 " "
(assuming WSE at spillway crest)
V_1 = 145 " "

Q_{P_3} (trial) = $6{,}580\left(1 - \frac{145}{286.5}\right) = 3{,}250$ cfs. Pond WSE: 64.1

$V_2 = 250 - 150 = 100$ ac-ft. $V_{av} = \frac{145+100}{2} = 122.5$ ac-ft.

$Q_{P_3} = 6{,}580\left(1 - \frac{122.5}{286.5}\right) = 3{,}764$ cfs.

WSE @ Wallace Pond = 64.3 or 2.3 feet above the top of the dam.

Tailwater El. = 52.7 or free flow over the dam and the spillway.

Failure Flood Flow Routing Through Reach 3 – (Between Wallace Pond Dam and B&M Railroad Embankment)

Assuming that the Wallace Pond dam would remain intact:

$Q_{P_3} = 3,764$ cfs.

WSE upstream of Reach 3 (Tailwater of Wallace Pond Dam - Page D-25) : 52.7

$$A_1 = \left[140 + \frac{11\cdot(52.7-48.0)}{2}\right] 4.7 = 780 \square'$$

WSE downstream of Reach 3 : 47.5 (Upst. of RR opening) $\longrightarrow$ $A_2 = \left[140 + \frac{11(47.5-32)}{2}\right] 15.5 = 3,430 \square'$

$$\text{Vol. 1} = \frac{780 + 3,490}{2} \cdot 340 \frac{1}{43,560} \cong 16 \text{ acre-ft.}$$

$$Q_{P_4}(\text{trial}) = 3,764 \left(1 - \frac{16}{255 - 122.5}\right) = 3,400 \text{ cfs.}$$

Upstream Section: WSE : 52.6 $\longrightarrow$ $A_1 = 760 \square'$

Downstream Section: WSE : 47.2 $\longrightarrow$ $A_2 = 3,400 \square'$

$$\text{Vol. 2} = \frac{760 + 3,400}{2} 340 \frac{1}{43,560} \cong 16 \text{ ac-ft.}$$

$V_{av} = 16$ ac-ft $\longrightarrow$ $Q_{P_4} = 3,400$ cfs

Flow depth just upstream of RR embankment : 15.2-ft.

Impact of Failure Flood in Reach 3:

A- Property Damages:

(1) potential failure of Wallace Pond Dam and subsequent damages.

(2) Overtopping would possibly damage the newly built water intake structure and the related facilities.

(3) One dwelling on the right bank and near the railroad would be subject to 10-ft water depth.

B- Hazard potential for loss of lives exists.

Flood Routing through Reach 4:

Length = 1,200 -ft.

Qp_4 = 3,400 cfs.

Jetting velocity at the railroad opening: $V = \frac{3,400}{11 \times 15} = 20$ fps.

WSE at the Magnolia Ave. (Pp. D-20): 33.0

Water Depth on the road: 33 - 30 ≅ 3.0-ft.

V ≅ 3.0 fps.

Average water depth at the Brook Valley: 3 - ft. (assuming zero flow prior to failure).

WSE upstream: ≅ 23.0

Estimated water depth at the Water Treatment Plant: 3 to 5 feet

The other dwellings existing along the Brook in Reach 4 would not be affected by the flood flow under the above conditions.

Impact of Failure Flood in Reach 4:

A - Property Damages:

① Potential damage to Magnolia Avenue embankment and vehicles which may happen to be close to the opening underneath the railroad - Flow jetting velocity of 20 fps.

② Water Treatment Plant including vehicles & equipment

B - Hazard potential for Loss of lives exists.

Conclusion: The hazard potential classification is considered to be "High".

APPENDIX E - INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

NOT AVAILABLE AT THIS TIME

END

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