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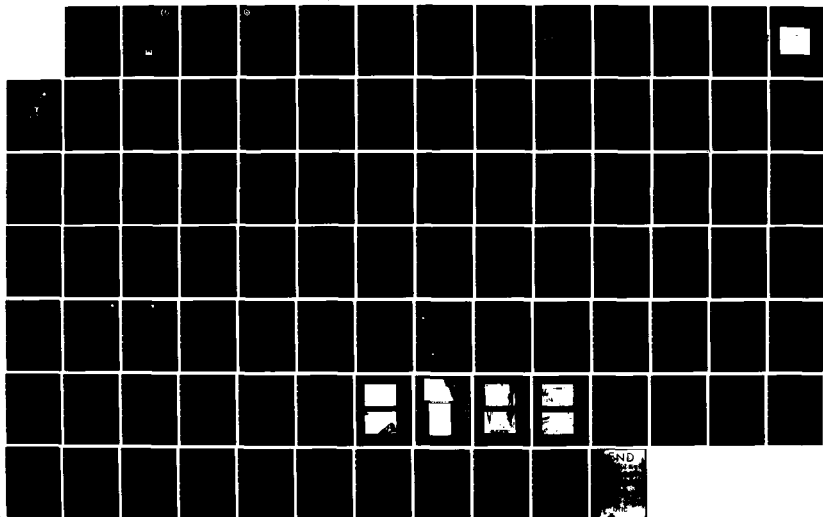
NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
UPPER BANJO POND DAM (U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV SEP 79

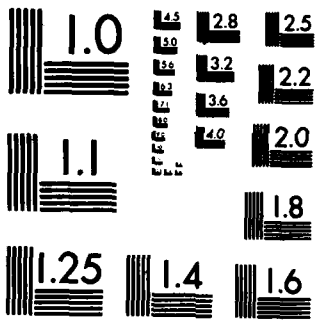
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AD-A147 156

MASSACHUSETTS COASTAL BASIN
GLOUCESTER, MASSACHUSETTS



UPPER BANJO POND DAM
MA 00185

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

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

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) DAMS, INSPECTION, DAM SAFETY, Mass. Coastal Basin Gloucester, Mass.		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Upper Banjo Pond Dam is a concrete slab and buttress dam flanked by earth embankments. The dam is approximately 140 feet long and has a maximum height of 17 feet. The dam is in poor condition and in need of extensive repair work. The dam has been classified in the "small" size and "high" hazard categories. A test flood equal to the full PMF was selected. ←		



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

REPLY TO
ATTENTION OF
NEDED

JAN 17 1980

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

Dear Governor King:

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

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. In addition, a copy of the report has also been furnished the owner, LePage Division of Papercraft Corporation, Gloucester, Massachusetts.

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

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

Sincerely,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

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UPPER BANJO POND DAM

MA 00185

MASSACHUSETTS COASTAL BASIN
GLOUCESTER, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION
PROGRAM

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

BRIEF ASSESSMENT

Identification No.: MA00185

Name of Dam: Upper Banjo Pond

Town: Gloucester

County and State: Essex County, Massachusetts

Stream: Unnamed tributary to Annisquam River

Date of Inspection: April 20, 1979

Upper Banjo Pond Dam, which was built in 1908, is a concrete slab and buttress dam (Ambursen type) flanked by earth embankments. The dam is approximately 140 feet long and has a maximum height of 17 feet. There is also an earth dike, adjacent to the east abutment of the dam, which is 4 feet high and 170 feet long. The crest of the dam is formed by the concrete deck of the buttressed section at El 84.6, and a concrete cap wall incorporated in the earth embankments at El 84.5. The crest of the dike ranges from El 84.6 to El 85.2. The spillway is a 10.6-foot long overflow weir recessed into the top of the dam. The crest of the weir is at El 83.5. Water flowing over the spillway drops vertically to an earth slope at the toe of the dam. There is no spillway chute or stilling basin. The outlet for the dam consists of an 8-inch diameter pipe which discharges about 72 feet downstream of the dam.

The dam is in poor condition and in need of extensive repair work and additional engineering investigations in order to assure its continued performance. This conclusion is based on the visual inspection of the site, and a review of the limited data available on the dam.

UPPER BANJO POND DAM

The following deficiencies were observed at the site: moderate seepage through the buttressed concrete section of the dam; severe spalling, cracking and efflorescence in the concrete of the buttressed dam and in the cap wall; erosion and riprap missing from the upstream face of the earth embankments and the dike; erosion on the crest and downstream slopes of the embankments; lack of fill behind the retaining walls on the downstream slope of the earth embankments; lack of adequate protection on the earth slope below the spillway weir; and trees and dense vegetation growing on the slopes of the dam and the dike.

Based on Corps of Engineers' guidelines, the dam has been classified in the "small" size and "high" hazard categories. A test flood equal to the full probable maximum flood (PMF) was used to evaluate the capacity of the spillway. The total drainage for Upper Banjo Pond is 448 acres (0.7 square miles). However, much of the drainage is diverted by a spillway and outlet at Fernwood Lake, which is west of the pond. After adjusting for this diversion, the test flood inflow for Upper Banjo Pond is calculated to be 230 cubic feet per second (cfs). The test flood outflow is also 230 cfs, since there is no adjustment for storage in the pond. The test flood outflow with the pond at El 85.0 will overtop the capwall on the dam by 0.5 feet. The spillway capacity at El 84.5 (top of the capwall) is 35 cfs, which is 17 percent of the test flood outflow. A test flood equal to one-half the PMF would result in an outflow of 96 cfs with the pond at El 84.8 and would overtop the capwall by 0.3 feet.

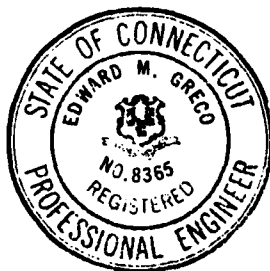
It is recommended that the Owner employ a qualified engineering consultant to conduct a more detailed hydraulic and hydrologic study to evaluate spillway capacity and overtopping potential. The consultant should also conduct a complete geotechnical and structural investigation of the structure, including an evaluation of the seepage through the concrete section of the dam. This investigation should also include an evaluation of the seismic stability of the dam. It is recommended that the Owner maintain the pond at approximately El 75.5 until the recommendations by the consultant are implemented.

UPPER BANJO POND DAM

The Owner should repair the deficiencies listed above, as described in Section 7.3.

The Owner should also implement a program of annual technical inspections and monthly maintenance inspections, including monitoring for seepage through the concrete and in the gate chamber. It is also recommended that the Owner implement a plan for surveillance of the embankment during and after periods of high runoff and a plan for warning nearby residents in the event of an emergency at the site.

The measures outlined above and in Section 7 should be implemented by the Owner within a period of one year after receipt of this Phase 1 Inspection Report.



Edward M. Greco

Edward M. Greco, P.E.
Project Manager
Metcalf & Eddy, Inc.

Connecticut Registration
No. 08365

Approved by:

Stephen L. Bishop

Stephen L. Bishop, P.E.
Vice President
Metcalf & Eddy, Inc.

Massachusetts Registration
No. 19703



UPPER BANJO POND DAM

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

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

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

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

APPROVAL RECOMMENDED:

Joe B. Fryar
JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in Recommended Guidelines for Safety Inspection of Dams, for a Phase I Investigation. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, 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 inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general conditions and the downstream damage potential.

UPPER BANJO POND DAM

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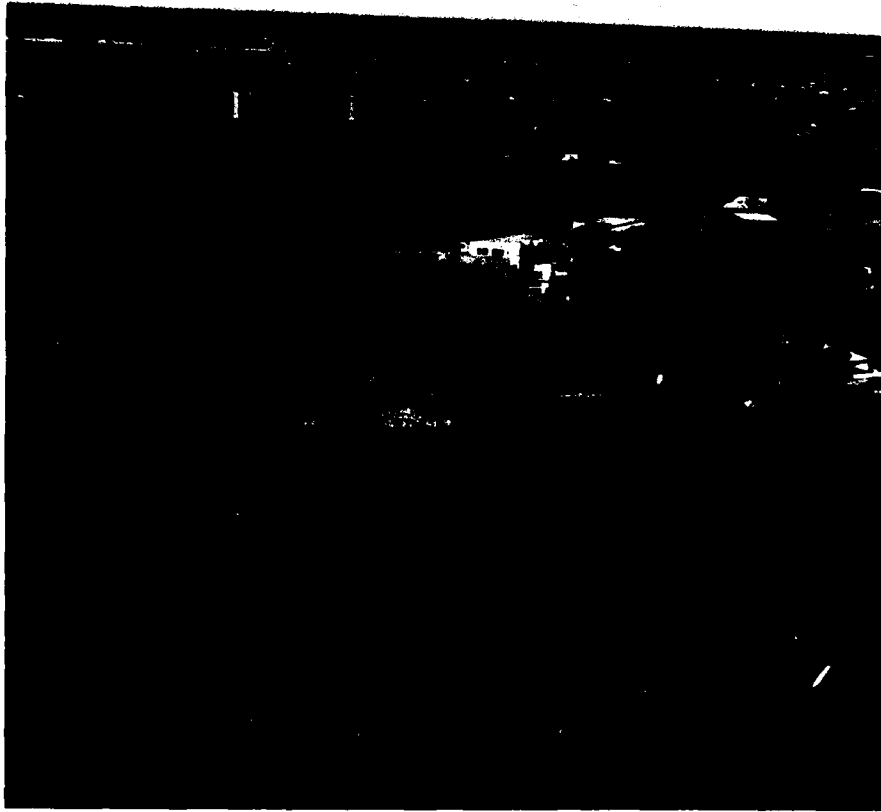
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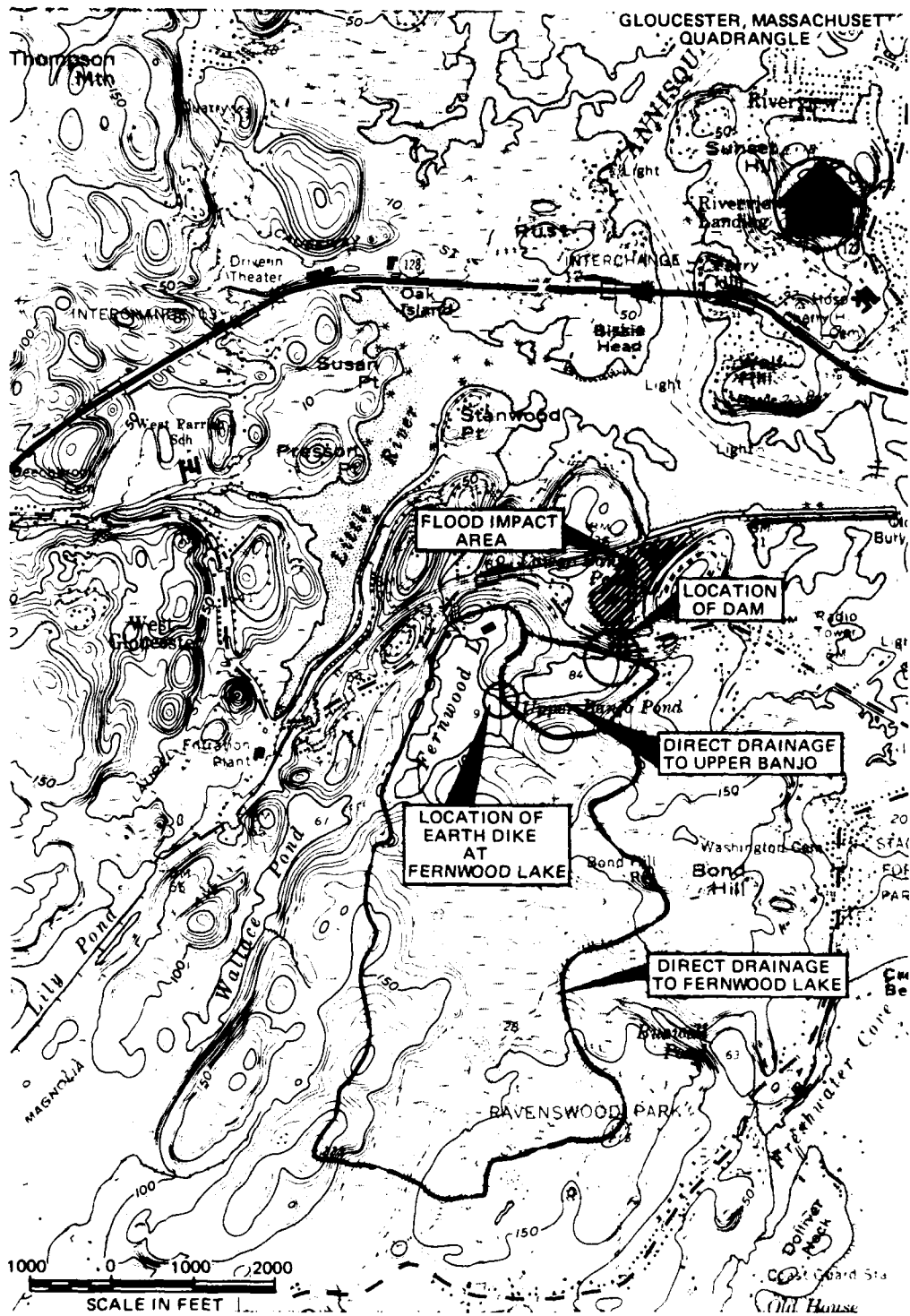
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UPPER BANJO POND DAM

**OVERVIEW
UPPER BANJO POND DAM
GLOUCESTER, MASSACHUSETTS**





LOCATION MAP - UPPER BANJO POND

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

UPPER BANJO POND DAM

SECTION 1

PROJECT INFORMATION

1.1 General

- a. Authority. Public Law 92-367, dated August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Metcalf & Eddy, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Contract No. DACW 33-79-C-0054, dated March 27, 1979, has been assigned by the Corps of Engineers for this work.
- b. Purpose:
- (1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.
 - (2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.
 - (3) Update, verify and complete the National Inventory of Dams.

1.2 Description of Project

- a. Location. The dam is located on an unnamed tributary of the Annisquam River, in the City

UPPER BANJO POND DAM

of Gloucester, Essex County, Massachusetts (see Location Map). The coordinates of this location are latitude 42 deg. 36.7 min. north and longitude 70 deg. 41.5 min. west.

- b. Description of Dam and Appurtenances. Upper Banjo Pond Dam is a reinforced concrete slab and buttress dam, also known as an Ambursen type dam, flanked by east and west earth embankments (Figures B-1 and B-2). The dam is a total of 140 feet long and 17 feet high. The crest of the dam is formed by the upper edge of the concrete deck of the buttress section, and a concrete cap wall that extends to the abutments of the earthfill sections. The concrete deck is 2.5 feet wide and at El 84.6. The cap wall is 1 foot wide and at El 84.5. The cap wall is less than a foot above the earthfill, but there is no information on the depth of the wall beneath the fill. According to early inspection reports, the foundation of the concrete section of the dam rests on "hard pan" (glacial till) and the earth abutments are on bedrock.

The upstream face of the concrete section of the dam is a reinforced concrete slab that slopes at about 1.5:1 (horizontal:vertical). The slab is supported by parallel concrete buttresses. The buttresses and end walls of the concrete section form seven concrete bays. One bay is 5 feet wide, and the remaining bays are approximately 9.5 feet wide (see Figure B-2).

The floor slab is visible at the base of the buttresses. As shown on Figure B-2, the slab is at three elevations: 67.2 in the center, and 69.4 and 71.0 in the west and east bays, respectively. The underside of the sloping upstream face intersects with a vertical concrete wall at the upstream end of each bay. The joint at the intersection of the two walls is covered with gunite. Three of the bays are reinforced by concrete "frames" formed by a vertical column attached to each buttress, and a horizontal beam across the sloping wall.

The end buttresses of the concrete section are tied into the earth embankments by the cap wall visible on the crest. The crest on each side of the cap wall is exposed earth with local areas of erosion. The upstream face of

each embankment is protected by riprap. The downstream face is a steep, vine-covered slope ending in a nearly vertical stone retaining wall. Both walls extend at an angle from the end buttresses.

The spillway is an overflow weir which consists of a rectangular notch recessed in the top of the concrete deck of the dam. The crest of the weir is at El 83.5, which is 1.1 feet below the elevation of the deck. The crest is flat, 10.6 feet long and 3 feet wide. There is no approach channel to the weir other than the sloping concrete face of the dam. Flow over the spillway drops vertically about 16 feet to the toe of the dam. There is no chute or apron to channel the flow. The slope below the weir is earth that was originally protected by a pavement of small stones. Some of the overflow would be funneled into a gunite and stone-lined channel downstream of the outlet. The remaining flow could discharge over Essex Avenue before draining to Lower Banjo Pond.

There are no plans available showing the details of the outlet works. The outlet at the dam is an 8-inch diameter pipe. The pipe extends from an inlet on the upstream face of the dam to a point approximately 72 feet downstream of the dam, where it discharges into the gunite and stone channel. The submerged inlet is recessed into the sloping upstream face of the dam. The elevation of the upstream end of the pipe is unknown, but assumed to be approximately 66.0. There is no trash rack visible at the inlet. The invert at the outlet end of the pipe is at El 57.4. The gate chamber is one of the bays in the buttressed section of the dam. Part of the pipe and the gate valve housing are visible on the floor of the chamber. Here the pipe appears to be coated with tar paper; however, at the discharge point, the exposed pipe is clay. The gate valve housing is of cast-iron. The wrench for turning the gate valve is not at the site. The entrance to the chamber is closed by a wooden door which is kept locked by the Owner.

An earthfill dike is located at the east end of the dam, perpendicular to the axis of the

UPPER BANJO POND DAM

dam. It is approximately 170 feet long and 4 feet high. The crest and downstream slope of the dike is covered with grass. The crest is approximately 20 feet wide and ranges in elevation from 84.6 to 85.2. The upstream face of the dike is fairly steep (up to 1:1), and protected with riprap at the northern end. The south abutment of the dike ties into natural ground in a wooded area. The north abutment of the dike ties into the east abutment of the dam. There is a house located on natural ground just east of this abutment. The downstream face of the dike grades into the backyard of a residence.

- c. Size Classification. Upper Banjo Pond Dam is in the "small" size category since it has a maximum height of 17 feet and a maximum storage capacity of 66 acre-feet.
- d. Hazard Classification. The stream draining Upper Banjo Pond flows in a culvert under State Route 133, and into Lower Banjo Pond, about 450 feet downstream of the dam. Factory buildings and a parking lot, all associated with the LePage Division of Papercraft Corporation, are situated on the east side of Lower Banjo Pond. Failure of the dam at Upper Banjo Pond would cause flooding of Route 133 and the area of the lower pond. It is estimated that Lower Banjo Pond has less than half the storage volume of the upper pond. Furthermore, flow from Lower Banjo Pond would be restricted by the railroad embankment downstream of the pond. The failure flow confined in this area could therefore result in considerable property damage and possible loss of life at the factory. For this reason, the dam at Upper Banjo Pond has been classified in the "high" hazard category.
- e. Ownership. The dam is owned by the LePage Division of the Papercraft Corporation, Post Office Box 291, Gloucester, Massachusetts 01930. Mr. Arthur J. Douglas, Vice President of Manufacturing (telephone: 617/283-1000) granted permission to enter the property and inspect the dam.

UPPER BANJO POND DAM

- f. Operator. The dam is operated by personnel at LePage.
- g. Purpose of the Dam. The dam was built in 1908 for the Russia Cement Company. The water in the pond was used in the manufacturing of glue from fish skins. LePage acquired the company about 1954, but no longer uses the water for manufacturing. The pond is now used solely for recreation by the local residents.
- h. Design and Construction History. There are no drawings or specifications available on the original design and construction of the dam. Inspection reports by the Essex County Engineering Department provide general information on the condition of the dam and a record of repairs made to the structure (see Appendix B).

Since 1925, the County inspectors have noted the poor condition of the concrete in the dam. One report attributed the problem to poor quality of the original concrete mix design. Spalling, cracking and wet patches indicative of seepage through the concrete were often cited as evidence of deterioration of the dam.

Subsequent to the original construction in 1908, there were three separate periods of repair and minor reconstruction. In 1926, disintegrated concrete was removed from each bay of the dam, and the surface prepared for bonding new concrete. According to the 1926 inspection report, in each bay the whole space from the intersection of the sloping wall with the floor slab "to the point where the height is about 7 feet is being filled with concrete". The west wall (buttress) of the west bay was so badly deteriorated that nearly the whole thickness was removed and a new wall built next to it.

The 1934 inspection report stated that the amount of seepage through the dam was somewhat reduced since the time of the 1932 inspection. The concrete "frames" had been added to two of the bays for unknown reasons.

UPPER BANJO POND DAM

In 1954 the County inspector reported that the dam was in "very, very poor condition" (see Page B-12). Significant cracks were noted in the outlet structure and at each end wall of the dam. The concrete was heavily spalled, and seepage was visible through the concrete, under the base slab, and at the joints between both end walls and the earth embankments. At this time, the water level was 0.5 inch above the crest of the spillway.

In 1954, apparently as a result of the unfavorable report, extensive repairs were carried out at the dam by the Gunitite Restoration Company. All disintegrated concrete was once again removed from the buttresses and the sloping wall. The holes were built up with gunitite to the original construction. After sandblasting, a wire mesh reinforcing was added to the surface and then the entire area coated with a 2-inch layer of gunitite. The discharge channel below the outlet was cleaned out and the rubble stone sidewalls of the channel were covered with gunitite.

Later inspection reports stated that although the repair work may have strengthened the dam, leaks and seepage around and under the concrete were still occurring.

No other major repair or reconstruction work has been done at the site since 1954. As discussed in Section 3 of this report, the dam is still in "poor" condition.

1. Normal Operating Procedures. The gate valve on the outlet is operated on an irregular schedule by the Owner. Due to the deteriorated condition of the dam, the Essex County Engineer's Office directed about 10 years ago that the water level in the pond be maintained at or below an elevation of 8 feet below the spillway. However, at the time of the inspection, the water was 5 feet below the spillway. The Owner reportedly visits the site after periods of heavy rain to check the water level and to clean out the discharge channel when necessary.

UPPER BANJO POND DAM

1.3 Pertinent Data

- a. Drainage Area. The total possible drainage area to Upper Banjo Pond is 448 acres (0.7 square miles). However, the normal direct drainage to the pond is about 38 acres of steep, very sparsely developed woodland. The greater part of the watershed, about 410 acres, drains directly into Fernwood Lake, which is west of Upper Banjo. This area is a combination of hilly woodland and about 20 percent swamp. There is no development in the Fernwood Lake watershed. There are three outlets from Fernwood Lake that discharge during periods of high flow. Only one outlet, at the east end of the lake, flows into Upper Banjo Pond. Therefore, the actual drainage into Upper Banjo is less than would be anticipated based on the size of the total watershed.

- b. Discharge. Normal discharge from Upper Banjo Pond is through the 8-inch diameter outlet pipe. The pipe extends from the gate chamber below the crest of the dam to a V-shaped discharge channel just upstream of Essex Avenue. The channel is 24 feet long and lined with rubble rock which has been covered with gunite. At the downstream end of the channel there is an inlet to a 3-foot wide box culvert under Essex Avenue. Flow through the culvert discharges into a small stream north of the roadway, and then into Lower Banjo Pond, which is about 300 feet downstream of Essex Avenue.

Discharge from the spillway drops vertically to the earth slope below the concrete section of the dam. Much of the flow would be funneled into the discharge channel, and then the culvert under Essex Avenue. Minor overflow onto the road is also likely.

Hydraulic analyses indicate that the spillway can discharge an estimated 35 cfs with the pond level at El 84.5, which is the elevation of the concrete cap wall. The test flood outflow (full PMF) is estimated to be 203 cfs, with the pond at El 85.0. The spillway capacity is 17 percent of this outflow. During the flood, the dam would be overtopped by a total of 0.5 feet.

UPPER BANJO POND DAM

The maximum discharge rate at the dam is unknown. In 1938, it was reported that there was a low stoplog on the crest of the spillway, and water was "spilling or leaking through". This is an indication of less than 1 foot of freeboard at the dam. There is, however, no record of overtopping of the dam or dike.

c. Elevation (feet above Mean Sea Level (MSL)).

A benchmark was established at El 60.5 on a stone highway boundary marker. The elevation is based on a topographic survey of the City of Gloucester.

- (1) Top dam - Concrete slab and buttress section: 84.6;
- Earth embankment: 84.5 (top of concrete cap wall);
- Dike: 84.6
- (2) Test flood pool: 85.0
- (3) Design surcharge (original design):
Unknown
- (4) Full flood control pool: Not Applicable (N/A)
- (5) Recreation pool: 75.5 (elevation as directed by Essex County Engineer)
- (6) Spillway crest: 83.5
- (7) Upstream portal invert diversion tunnel:
N/A
- (8) Streambed at centerline of dam: 67.2
- (9) Tailwater: N/A

d. Reservoir

- (1) Length of maximum pool: 1,200 feet
- (2) Length of recreation pool: 1,100 feet
- (3) Length of flood control pool: N/A

UPPER BANJO POND DAM

e. Storage (acre-feet)

- (1) Test flood surcharge (net): 15 at El 85.0
- (2) Top of dam: 66
- (3) Flood control pool: N/A
- (4) Recreation pool: 7.5
- (5) Spillway crest: 55

f. Reservoir Surface (acres)

- *(1) Top dam: 10.1
- *(2) Test flood pool: 10.1
- (3) Flood control pool: N/A
- (4) Recreation pool: 2.6
- (5) Spillway crest: 10.1

g. Dam

- (1) Type - Main dam: reinforced concrete slab and buttressed (Ambursen) with earthfill embankments at each end
- Dike: earthfill
- (2) Length - Main dam: 140 feet
- Dike section: 170 feet
- (3) Height - Main dam: 17.4
- Dike section: 3.6
- (4) Top width - Main dam: concrete wall - 1 to 2.5 feet
- Dike section: 20 to 23 feet

*Based on the assumption that the surface area will not significantly increase with changes in pond elevation from 83.5 to 85.0.

UPPER BANJO POND DAM

- (5) Side slopes - Main dam (concrete):
 - upstream - 1.5 to 1
 - downstream - vertical- Dike section:
 - upstream - almost 1:1
 - downstream - 2:1

- (6) Zoning: N/A
- (7) Impervious core: N/A
- (8) Cutoff: Unknown
- (9) Grout curtain: Unknown

h. Spillway

- (1) Type: Broad concrete crest (notch in concrete dam)
- (2) Crest length: 10.6 feet
- (3) Crest elevation: 83.5
- (4) Gates: None
- (5) Upstream channel: None. Upstream face of concrete dam slopes up to crest of spillway.
- (6) Downstream channel: None. Flow over spillway drops vertically 16 feet to earth slope below. Discharge channeled into stone box culvert beneath Essex Avenue (Route 133).

- 1. Regulating Outlets. The regulating outlet at the dam consists of an 8-inch diameter pipe which extends from the inlet inside the dam to the outlet discharge channel 72 feet downstream. The invert of the outlet end of the pipe is at El 57.4. Flow is normally controlled by a gate valve locked inside the gate chamber. Discharge is into a concrete and stone-lined channel which leads to a stone box culvert under Essex Avenue.

UPPER BANJO POND DAM

SECTION 2
ENGINEERING DATA

2.1 General. There are no plans, specifications or drawings available relative to the design, construction or repair of this dam. There is one plan, dated 1906, and entitled "Plan of Additional Water Supply for the Russia Cement Co., Gloucester", showing the topography of the pond bed prior to construction of the dam. The plan is available from the Essex County Registry of Deeds in Salem, Massachusetts.

We acknowledge the assistance and cooperation of the Essex County Engineering Department; the Massachusetts Department of Environmental Quality Engineering, Division of Waterways; and Mr. Arthur J. Douglas of the LePage Division of Papercraft Corporation.

2.2 Construction Records. There are no construction records or as-built drawings for the dam or dike. Previous inspection reports by the Essex County Engineering Department provided a brief summary of repairs and post-construction changes at the site.

2.3 Operating Records. No operating records are available, and there is no daily record kept of the elevation of the pool or rainfall at the dam site.

2.4 Evaluation

- a. Availability. There is no engineering data available for this dam.
- b. Adequacy. The lack of detailed hydraulic, structural and construction data did not allow for a definitive review. Therefore, the evaluation of the adequacy of this dam is based on the visual inspection, past performance history, and engineering judgment.
- c. Validity. Comparison of the limited available data from the Essex County Engineering Department with the field survey conducted during the inspection indicates that the information is valid for the Phase I Assessment.

UPPER BANJO POND DAM

SECTION 3
VISUAL INSPECTION

3.1 Findings

- a. General. The Phase I Inspection of the dam at Upper Banjo Pond was performed on April 20, 1979. A second visit was made to the site on April 24, 1979, for a further evaluation of the structural stability of the concrete section of the dam. A copy of the inspection checklist is included in Appendix A. Previous inspection reports were conducted by the Essex County Engineer's Office from 1912 to 1968. A summary of those reports is included in Appendix B.

- b. Dam. The dam is 140 feet long, and constructed with a buttressed concrete section, flanked by earth embankments with a concrete cap wall at the crest. The spillway and outlet works are located within the concrete section of the dam.

The dam is in poor condition. The most severe signs of deterioration to the structure are in the buttressed concrete section of the dam, particularly on the downstream face. As discussed in detail in the inspection checklist (Appendix A), signs of seepage, cracking, spalling and efflorescence are evident on the buttresses and upstream walls of the bays. Accumulated concrete rubble, broken glass and other debris cover the bottom slab, or floor of the concrete structure. Photographs No. 4 and 5 in Appendix C are examples of the worst conditions in the dam. In Photograph No. 4, the vertical crack in the west buttress (in Bay No. 7) shows evidence of seepage as well as spalling. Several horizontal cracks and some construction joints show heavy efflorescence. Some of the previous concrete repair work is also visible on the buttress. Photograph No. 5 shows the extent of the deterioration in Bay No. 2 (the second bay from the east end of the dam). Seepage is apparent in two heavily spalled areas on the west buttress, and through a construction joint at the upstream end of the sloping wall.

UPPER BANJO POND DAM

Much of the rubble from the spalling concrete has accumulated at the foot of the buttress. Also, the gunite repair work performed in 1954 shows numerous hairline fractures throughout. The gunite has fallen away in one of the seepage areas, exposing the wire fabric that was added to the wall before the gunite was applied. Not visible in Photograph No. 5 is the accumulation of orange-stained water in the floor of the bay.

Photograph No. 6 shows the poor condition of the concrete in Bay No. 3, which is also the gate chamber. Heavy efflorescence and staining, as a result of seepage through the concrete, is visible in both buttresses and in the upstream, vertical wall. In addition, there is water dripping from the ceiling of the chamber where the concrete is heavily spalled and crumbling. Some steel reinforcing is visible in the spalled areas.

There is a large crack in the upper part of the right buttress (not shown in the photograph) of Bay No. 3 that extends vertically through the concrete deck of the dam, to the recessed inlet in the upstream face of the dam.

Early inspection reports, and the condition of the concrete during the most recent inspection indicate that the original concrete work was not satisfactory. According to the reports, particular problems arose in the selection of the aggregate and the insufficient density of the concrete.

The upstream face of the concrete section of the dam is a smooth concrete slope. Minor spalling is visible at and below the present water line, and some of the wire fabric is exposed where the gunite has been eroded. There is a horizontal crack across the face of the slope to the east of the recessed inlet to the gate chamber.

The earth embankments on either side of the concrete buttress dam section are in fair condition. As shown in Photographs No. 1 and 2, there is no riprap protecting the upstream

UPPER BANJO POND DAM

face where it abuts the sloping concrete slab of the dam. Elsewhere along the embankment, the riprap cover is relatively continuous. The cap wall on the crest of each embankment shows heavy spalling and chipping of the concrete.

There is also a 1/4-inch wide crack through the cap wall on the west embankment. Some repair work in the form of gunite is apparent on the concrete wall. The earthfill on either side of the cap wall is bare and heavily eroded on the upper part of the slopes. A few small trees are growing on the crest, adjacent to the cap wall.

The downstream slope and toe of the two earth embankments are partially covered by vines and brush. The stone retaining walls of the embankments are in poor condition. Both walls were probed and voids up to 2.5 feet deep were measured between the stones. The west wall shows a slight bulge in the downstream direction. Some of the stones in the east wall are fractured in place. The slope above the east wall has an irregular surface, apparently created by a rough stone pavement that has been covered with soil and vegetation.

There are no signs of seepage through the earth embankments, although the amount of vegetation at the toe of the dam prevented a closer inspection.

The embankment of the dike is in fair condition. The northern half of the upstream slope is covered with hand-placed riprap. At the southern end of the riprap, however, there is a slight bulge in the slope and the rock has slumped into the pond (see Photograph 8). There are several trees growing at the top of the slope, but there are no trees on the crest of the dike. The crest and downstream slope are covered with grass. No seepage was visible at the toe, however the water level in the reservoir was below the elevation of the toe of the slope.

UPPER BANJO POND DAM

- c. Appurtenant Structures. The spillway is a 10.6-foot long weir recessed in the crest of the concrete section of the dam. The concrete work is in good condition, with only minor spalling and efflorescence on the left wall of the weir. There is no approach or discharge channel. Water flowing over the crest of the weir drops vertically about 16 feet to the earth slope downstream of the concrete dam. With no spillway chute or spilling basin, the flow will erode the soil on the slope, and possibly affect the stability of the earth embankments. According to one early inspection report, there was a pavement of small stones protecting this slope from the effects of the flow over the weir. However, this was not visible at the time of the inspection due to the heavy growth of brush and a number of small trees growing on the slope.

The outlet for the pond is an 8-inch diameter pipe which discharges into a gunite and stone-rubble channel about 72 feet downstream of the dam. The visible portion of the inlet, above the water surface, is in fair condition. A crack extends across the headwall of the inlet, through to the downstream side of the concrete deck. Spalling in this area has exposed the wire fabric in the crack. The inlet to the pipe could not be inspected due to the debris accumulated on the water surface. It is not known whether debris was clogging the inlet below the water surface. No trash rack was visible.

As seen in Photograph No. 6 and discussed previously in Section 3.1.b., the gate chamber in the dam is in poor condition. At the time of the inspection, the pipe was visible above the floor of the chamber. However, the Owner's representative stated that the pipe is usually covered with water. The source of the water may be either the seepage through the concrete or a leak in the pipe or gate valve.

The pipe appears to be wrapped in tar paper for most of its exposed length and encased in concrete at the downstream end of the gate chamber. The stem on the gate valve is visible, but there is no operating mechanism at the site. The Owner reports that the gate is operable. A wooden door on the gate

UPPER BANJO POND DAM

chamber is locked to prevent unauthorized operation of the gate valve.

- d. Reservoir Area. Development on the perimeter of the pond is limited to one house, located at the east abutment of the dam. The pond has a steep, rocky shoreline with dense woods growing at the top of the bank. At the time of the inspection, the water level in the pond was about 5 feet below the spillway crest, 3 feet higher than the level recommended by the Essex County Engineer. Discharge from Fernwood Lake would enter Upper Banjo Pond by overflowing the small dike at the east end of the lake. The 8-inch pipe through the dike, which would normally conduct the overflow from Fernwood Lake to Upper Banjo, is blocked.
- e. Downstream Channel. The discharge channel below the outlet has a stone-paved floor and rubble stone side walls covered with a thick coat of gunite. The channel is in fair condition, although there are several small trees growing on its banks and overhanging the sides. Minor erosion of the ground surface has occurred just upstream of the outlet.

The discharge channel conducts flow to a stone box culvert under Essex Avenue. The headwall of the culvert has partially collapsed, blocking the inlet with a large section of grouted stone. Downstream of Essex Avenue, the stream discharges from the culvert at the headwall on the north slope of the highway embankment. The headwall is constructed of mortared stone blocks.

Below the culvert, the stream continues in a narrow channel through an overgrown, marshy area. The channel at low flow is barely visible. About 450 feet downstream of the dam, the stream enters Lower Banjo Pond.

- 3.2 Evaluation. The visual inspection indicates that the dam is in poor condition and in need of extensive repair work to prevent further deterioration. It is evident that the dam is not adequately maintained. Recommended measures to improve these conditions are stated in Section 7.3.

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SECTION 4

OPERATING PROCEDURES

- 4.1 Procedures. The Owner has stated that about 10 years ago, the Essex County Engineer requested that the pond level be maintained at least 8 feet below the elevation of the spillway. However, this level is not always maintained. During our inspection the level was only 5 feet below the spillway. The gate valve is reportedly operated infrequently, usually when the water level gets too high. Although the water has not been used for industrial processing in many years, the Owner attempts to maintain a suitable recreational level in the pond rather than drain it completely.
- 4.2 Maintenance of Dam. There is no evidence of recent maintenance work at the dam. According to past inspection reports and the Owner, the last program of maintenance was conducted in 1954 when much of the deteriorated concrete in the buttresses was removed and replaced.
- 4.3 Maintenance of Operating Facilities. There is no record of any maintenance performed on the outlet works of the dam. The Owner reports that the gate valve is operable. However, the condition of the pipe and evidence of seepage in the gate chamber indicates that the operating facilities have been neglected. The inlet to the culvert under Essex Avenue was blocked by debris during the last inspection. This condition was reported in several earlier inspection reports as well. The only recent maintenance work consisted of replacing the wooden door to the gate chamber as it is frequently destroyed by vandals.
- 4.4 Description of Any Warning System in Effect. There is no warning system in effect at this dam.
- 4.5 Evaluation. There is no adequate maintenance program at Upper Banjo Pond Dam, nor is there any program of technical inspections or a warning system in effect. This is extremely undesirable considering the dam is in the "high" hazard category. A regular program of inspection and maintenance should be implemented as recommended in Section 7.3.

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SECTION 5

HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

- a. General. The impounding structures on Upper Banjo Pond consist of a 140-foot long concrete buttressed and earthfill dam, and a 170-foot long earth dike. The crests of both the dike and dam are at approximately the same elevation. The only regulating outlet at the pond is an 8-inch diameter pipe controlled by a gate valve which is housed beneath the crest of the dam.

The total possible drainage area to Upper Banjo Pond is 0.7 square miles. However, the direct drainage to the pond is limited to 0.06 square mile of steep woodland on the perimeter of the pond. Upper Banjo Pond can receive drainage from Fernwood Lake, which is immediately upstream. The watershed for Fernwood Lake is about 0.64 square mile of hilly woodland, and approximately 20 percent swamp. Discharge from Fernwood Lake to Upper Banjo Pond is from the east end of the lake through an 8-inch pipe (which is now blocked) or by overflowing of the dike at this location. However, the principal outlet at Fernwood Lake is a spillway which discharges directly into a brook leading to the Annisquam River. A third outlet at the south end of the lake also discharges some of the high flows out of the Upper Banjo watershed. As a result, the peak flow to Upper Banjo Pond is less than that indicated by the size of the drainage area.

Below the dam, the spillway and outlet from Upper Banjo Pond discharges to a stone box culvert under Essex Avenue and into a natural stream channel. The stream discharges into Lower Banjo Pond about 450 feet downstream.

The 8-inch outlet pipe can discharge a flow of approximately 7.1 cfs when the level of the pond is at El 83.5, the crest of the spillway. From that elevation, and with no additional inflow into the pond, the outlet can lower the pond by 1 foot in about 17.2 hours.

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Maximum storage in Upper Banjo Pond is estimated to be 65 acre-feet. The Essex County Engineering Department had previously recommended that the water level in the pond be maintained 8 feet below the spillway crest elevation. This was presumably a safety measure enforced due to the poor condition of the dam.

As part of the Phase I investigation, preliminary calculations were made to determine the effect on overtopping potential of maintaining the pond level 8 feet below the spillway. It was determined that the direct drainage into Upper Banjo Pond would eliminate any flood storage created by the lower water level. The test flood outflow from Upper Banjo Pond would therefore be equal to the inflow from Fernwood Lake, and would overtop the dam. Additional hydraulic analysis in a Phase II investigation would be required to determine the effective flood storage volume for Upper Banjo Pond.

- b. Design Data. There are no hydraulic or hydrologic computations available for the design of the spillway at Upper Banjo Pond Dam.
- c. Experience Data. Hydraulic records are not available for this dam. There is no record of overtopping at the dam.
- d. Visual Inspection. The spillway at the dam consists of an overflow weir recessed in the crest of the buttressed section of the dam. The crest of the spillway is 10.6 feet long and at El 83.5, which is 1 foot below the top of the cap wall, and 1.1 feet below the crest of the dam.

There is no chute or stilling basin on the spillway. Water flowing over the spillway drops vertically about 16 feet to the earth slope at the toe of the concrete structure. Reportedly, when the dam was built this slope was protected with small stones. However, there was no evidence of any stone protection during the inspection.

The outlet for the dam is an 8-inch pipe that discharges in an open stone masonry and gunite-covered channel about 70 feet downstream of

UPPER BANJO POND DAM

the dam. This channel would also collect some of the overflow from the spillway. The gate valve is housed in a gate chamber which is also one of the bays in the concrete dam. According to the Owner, the gate is operable and was partly open at the time of the inspection. There are no plans available showing the details of the outlet works. The invert of the outlet end of the pipe is at El 57.4.

The entrance to the culvert under Essex Avenue is blocked with debris, mostly fallen rock and concrete from the headwall. If the gate valve were opened completely, the discharge would probably back up at the culvert and overflow the highway. The Owner reported that this did happen in the past, when the gate valve was opened by trespassers at the site.

Additional observations of the condition of the dam and appurtenances are given in Section 3, Visual Inspection, and in Appendix A.

- e. Test Flood Analysis. Upper Banjo Pond Dam has been placed in the "small" size category and in the "high" hazard category. According to the Corps of Engineers' guidelines, a range of from one-half to full PMF rate should be used to evaluate the capacity of the spillway at the dam. The full PMF rate was chosen for this analysis. As described in Section 5.1.e. of this report, only part of the discharge from Fernwood Lake is diverted into Upper Banjo Pond. Therefore, for this analysis, the test flood inflow rate was first calculated for Fernwood Lake from its watershed. The spillway at Fernwood Lake had flashboards mounted on the crest at the time of the inspection, thereby reducing the amount of available storage. The test outflow from Fernwood was calculated with and without the flashboards in place. The outflow was then adjusted based on the elevation of the dike at Fernwood Lake and the capacity of the channel between Fernwood Lake and Upper Banjo Pond. Finally, this peak outflow rate was added to the inflow calculated from the direct drainage area for Upper Banjo Pond.

UPPER BANJO POND DAM

The PMF rate for the Fernwood Lake watershed is 1,750 cfs per square mile of drainage area. This calculation is based on the average slope of the drainage area of 2.5 percent, the pond-plus-swamp area to drainage area ratio of 20 percent, and the U.S. Army Corps of Engineers' guide curves for Maximum Probable Flood Peak Rates (dated December 1977). Applying the full PMF rate to the 0.64 square miles of drainage area results in a calculated peak flood flow of 1,124 cfs as the test flood inflow. By adjusting the test flood inflow for surcharge storage, the maximum total discharge rate (flashboards in place) was established as 1,010 cfs (1,578 cfs per square mile) with the level of the lake at El 93.9.

The following summary of data from the figure on page D-4 of the hydraulic computations shows how much of the total discharge from Fernwood Lake reaches Upper Banjo Pond by overflowing the dike:

<u>Flow, cfs</u>	<u>Condition at Fernwood Lake</u>
180	Flashboards on spillway
130	No flashboards on spillway

The peak inflow to Upper Banjo Pond from the direct drainage was then calculated using a PMF rate of 3,000 cfs per square mile. The full rate times the 0.06 square miles of direct drainage results in a peak test flood direct inflow of 174 cfs. As shown on page D-5 of the computations, the direct inflow is combined with the outflow contributed from Fernwood Lake. The resulting test flood peak inflow to Upper Banjo Pond is 203 cfs with the pond level at El 85.0. Since the water level at Upper Banjo Pond will be at a higher elevation due to the direct inflow, no adjustment for storage is made for the combined test flood inflow. Therefore, the inflow is equal to the outflow from Upper Banjo Pond.

Hydraulic analyses indicate that the spillway at Upper Banjo Pond can discharge a maximum of 35 cfs with the pond at El 84.5, which is the elevation of the cap wall. This discharge is

UPPER BANJO POND DAM

17 percent of the test flood. During the test flood, the cap wall would be overtopped by 0.5 feet. Discharge over the wall would be at a rate of 1.20 cfs per foot of width. The depth at critical flow would be 0.35 feet, at a velocity of 3.4 feet per second.

- f. Dam Failure Analysis. The peak discharge rate due to failure of the dam was calculated to be 3,700 cfs, assuming a 17.4-foot head. Failure of the dam would produce a flood wave approximately 5.5 feet high at Route 133 (Essex Avenue). Some of the flow may spread west down the highway, but the major impact will occur directly north of the highway in the vicinity of Lower Banjo Pond and the factory. Based on the calculations, failure of the dam at Upper Banjo Pond would cause a 9.8-foot increase in depth at the lower pond. The increase is due to the fact that there is only a limited outlet from Lower Banjo Pond. The bedrock knoll and high railroad embankment near the factory would prevent the flood from spreading into the tidal area north of the ponds.

The combination of the flood wave and flooding as a result of the rise in water level at Lower Banjo Pond could cause considerable damage and possible loss of life. The impact would be experienced particularly in the lower floor of the factory buildings, and in the parking area. For this reason, the dam has been placed in the "high" hazard category.

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SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

- a. Visual Observations. The evaluation of the structural stability of the dam at Upper Banjo Pond is based on a review of the available data, chiefly previous inspection reports, and visual inspections conducted on April 20 and 24, 1979.

As a result of the visual inspection, the dam was found to be in poor condition and requiring repairs and/or restoration to prevent further deterioration. Seepage, cracking and severe spalling was noted in the concrete section of the dam, particularly on the downstream face. The heavy growth of vegetation on the downstream slopes of the earth embankments prevented a closer inspection of this area for seepage or settlement. It is recommended that the Owner employ a qualified consultant to further evaluate the condition of the slopes and the stability of the buttressed concrete section.

- b. Design and Construction Data. The dam was constructed in 1908. There are no plans or specifications available showing the design and construction of the concrete dam or the earth embankments. No other information is available concerning the concrete mix design or concrete strengths, type, shear strength or permeability of the soil in the embankment.

An inspection report by the Essex County Engineering Department, dated April 24, 1912, is included in Appendix B. According to the report, the dam is constructed of heavily reinforced concrete. The concrete foundation is 10 feet deep and rests on a "hardpan"; the abutments of the earth embankments are founded on bedrock. It is not known whether the concrete wall on the crest of the earth embankments is a core wall which extends the full height of the dam, or simply a cap wall buried a few feet into the embankment.

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- c. Operating Records. There is no instrumentation of any type in the embankment at Upper Banjo Pond Dam, and no instrumentation was ever installed at this site. The performance of the concrete dam and/or embankment under prior loading can only be inferred by physical evidence at the site.
- d. Post-Construction Changes. The post-construction changes noted in previous inspection reports generally consisted of repairs to the concrete in the buttressed section of the dam. These changes were also described in Section 1.2.h. Design and Construction History. In 1926, concrete was added to provide additional strength in the bays between the buttresses on the downstream face of the dam. Much of the spalled concrete was also removed and replaced at this time. In 1934, concrete "frames" consisting of two vertical columns and a horizontal beam were built at the entrance to three of the bays. The only other repair work consisted of applying gunite to the surface and replacing any badly deteriorated concrete in the bays and buttresses. This work was done in 1954. No other post-construction changes were reported.
- e. Seismic Stability. Upper Banjo Pond Dam is located in Seismic Zone No. 3, indicating that there is a potential for major damage due to earthquakes in this area. This classification is based on the intensity of past earthquakes, and does not indicate the probability of such events in the future. The highest intensity earthquakes for this area were VII and VIII on the Modified Mercalli Scale, and occurred in 1727 and 1755, respectively. There is no record of any major seismic events since 1908 when the dam was built.

The effect of a high intensity earthquake on the stability of the concrete section of the dam is unknown, particularly on the deteriorated buttresses. The pertinent data required for a seismic stability analysis is not available at this time. Information is required on the in situ properties of the concrete, embankment material and foundation material. Considering that the dam is in the "high"

UPPER BANJO POND DAM

hazard category, a seismic investigation
should be conducted as recommended in Section
7.2.

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SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

- a. Condition. Based upon a review of available data, and the visual inspection of the site, the dam at Upper Banjo Pond has been found to be in poor condition, and in need of substantial repairs to prevent further deterioration. In general, the deficiencies which must be corrected to assure the continued performance of the dam are as follows: severe seepage through the buttressed concrete section of the dam; heavy spalling, cracking and efflorescence in the concrete of the buttressed dam and the cap wall; erosion and missing riprap from the upstream face of the earth embankments and the dike; erosion on the crest and downstream slopes of the embankments; lack of fill behind the retaining walls on the downstream slope of the earth embankments, lack of adequate protection on the earth slope below the spillway; blocked entrance to the culvert under Essex Avenue; and trees and dense vegetation growing on the slopes of the dam and the dike.

Hydraulic analyses indicate that the spillway at Upper Banjo Pond Dam can discharge a maximum of 35 cfs with the pond at El 84.5, which is the elevation of the cap wall. An outflow test flood (full PMF) of 203 cfs will overtop the dam by 0.5 feet. The spillway can discharge 17 percent of the test flood before the dam is overtopped.

- b. Adequacy. The lack of detailed design and construction data did not allow for a definitive review. Therefore, the evaluation of this dam is based on a review of the available data, the visual inspection, past performance and engineering judgment.
- c. Urgency. The recommendations and remedial measures outlined below should be implemented

UPPER BANJO POND DAM

by the Owner within one year after receipt of this Phase I Inspection Report.

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

7.2 Recommendations. In view of the concerns over the continued performance of the dam, it is recommended that the Owner engage a qualified engineering consultant to:

- a. Conduct a more detailed hydraulic/hydrologic investigation to evaluate spillway adequacy and overtopping potential. Until the results of this investigation are known, the Owner should maintain the water level in the pond at least 8 feet below the spillway crest, as agreed to previously with the Essex County Engineer.
- b. Conduct a complete geotechnical and structural investigation of the dam, including the stone retaining walls. The investigation would determine the present static and seismic stability of the dam and should include development of recommended repair procedures.

The Owner should implement the recommendations of the engineering consultant.

7.3 Remedial Measures

- a. Operating and Maintenance Procedures. It is recommended that the Owner accomplish the following:
 - (1) Repair or replace deteriorated concrete work on the dam in accordance with the recommendations of the consultant.
 - (2) Initiate a program of selective clearing of trees and brush from the embankments, particularly the downstream slope. All excavations for stumps and roots should be backfilled with select materials.

UPPER BANJO POND DAM

- (3) Backfill the eroded areas on the crest and the upstream slopes and replace any missing riprap on both the dam and the dike.
- (4) Remove any trees, brush, and vines from the slopes of the dam, and from the toe of the slope immediately below the spillway overflow.
- (5) Protect the toe of the dam, below the spillway, with riprap or other suitable paving material to prevent erosion of the earth slope by overflow from the weir.
- (6) Contact the State Highway Department to clear the debris and repair the head wall at the entrance to the Essex Avenue culvert.
- (7) Implement a systematic program of maintenance inspections. As a minimum, the inspection program should consist of a monthly inspection of the dam, dike and appurtenances, supplemented by additional inspections during and after severe storms. All repairs and maintenance should be undertaken in accordance with all applicable State regulations.
- (8) Periodic technical inspections of this dam should be continued on an annual basis.
- (9) Institute a definite plan for surveillance of the embankment during and after periods of unusually heavy rainfall and establish a plan to notify residents in case of an emergency at the project.

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7.4 Alternatives. The alternative to implementing the recommendations and remedial measures listed above would be to drain the pond and breach the dam.

Another possible alternative would be to permanently maintain the water level at a lower elevation. This elevation would be determined by a qualified engineering consultant. In conjunction with this alternative, the dike at Fernwood would probably have to be raised to prevent inflow to Upper Banjo Pond.

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APPENDIX A
PERIODIC INSPECTION CHECKLIST

PERIODIC INSPECTION

PARTY ORGANIZATION

PROJECT UPPER BANJO POND

DATE 4-20-79

TIME 10:00 A.M.

WEATHER SUNNY, 50'S

W.S. ELEV. 78.6 U.S. - DN.S.

PARTY:

- | | |
|----------------------|-----------|
| 1. <u>M. Larson</u> | 6. _____ |
| 2. <u>S. Pierce</u> | 7. _____ |
| 3. <u>W. Checchi</u> | 8. _____ |
| 4. <u>H. Lord</u> | 9. _____ |
| 5. <u>P. Tilton</u> | 10. _____ |

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	<u>Dam</u>	<u>Larson/Pierce/Tilton</u>	
2.	<u>Spillway and outlet</u>	<u>Larson/Branagan</u>	
3.	_____	_____	_____
4.	_____	_____	_____
5.	_____	_____	_____
6.	_____	_____	_____
7.	_____	_____	_____
8.	_____	_____	_____
9.	_____	_____	_____
10.	_____	_____	_____

PERIODIC INSPECTION CHECK LIST

PROJECT UPPER BANJO POND DAM DATE 4-20-79

PROJECT FEATURE RIGHT (EAST) EARTHFILL NAME M. LARSON

DISCIPLINE EMBANKMENT
GEOTECHNICAL NAME S. PIERCE

u/s = upstream d/s = downstream

AREA EVALUATED	CONDITIONS
<u>DAM EMBANKMENT</u>	
Crest Elevation	84.5 (cap wall)
Current Pool Elevation	78.6
Maximum Impoundment to Date	Unknown
Surface Cracks	Heavy spalling, some cracking and exposed aggregate on cap wall
Pavement Condition	No grass on earth crest just brush and trees, dense root system
Movement or Settlement of Crest	None visible
Lateral Movement	None visible
Vertical Alignment	Heavy erosion on either side of cap wall
Horizontal Alignment	Straight
Condition at Abutment and at Concrete Structures	Right abutment ties into abutment of dike fenced in and overgrown with brush
Indications of Movement of Structural Items on Slopes	Concrete steps just d/s of slope-covered by leaves and brush;no apparent movement
Trespassing on Slopes	Foot traffic
Sloughing or Erosion of Slopes or Abutments	D/s: irregular slope, pitted surface formed by rough stone pavement covered with earth and vegetation, retaining wall in poor cond.
Rock Slope Protection - Riprap Failures	U/s: missing riprap, erosion, many small trees at top of slope D/s: Very steep slope overgrown with vines
Unusual Movement or Cracking at or near Toes	No movement, visible, some fracturing of stones in retaining wall; Voids behind wall, probed to 2.5 feet
Unusual Embankment or Downstream Seepage	None visible - toe covered by brush
Piping or Boils	None visible
Foundation Drainage Features	None
Toe Drains	None
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT UPPER BANJO POND DAM DATE 4-20-79
 PROJECT FEATURE LEFT (WEST) EMBANKMENT NAME M. LARSON
 PROJECT FEATURE EARTHFILL EMBANKMENT NAME S. PIERCE
 DISCIPLINE GEOTECHNICAL

AREA EVALUATED	CONDITION
<u>DAM EMBANKMENT</u>	Earth sections flanking conc. buttressed dam. Concrete cap wall on crest; d/s slope also has stone masonry retaining walls. 84.5 (cap wall)
Crest Elevation	
Current Pool Elevation	78.6
Maximum Impoundment to Date	Unknown
Surface Cracks	None visible in earth section; one 1/4" wide crack thru cap wall, slightly offset
Pavement Condition	Heavy spalling on cap wall, some concrete chipped some repairs made with gunite; earthfill bare
Movement or Settlement of Crest	None visible
Lateral Movement	None visible
Vertical Alignment	Assume originally flat, now heavily eroded both sides of cap wall, and at left abutment
Horizontal Alignment	Cap wall angles towards downstream
Condition at Abutment and at Concrete Structures	Left abutment is bedrock knoll, covered with trees, foot paths; cap wall ties into concrete section of dam
Indications of Movement of Structural Items on Slopes	No Structural Items
Trespassing on Slopes	Foot traffic; heavy growth of trees & bushes, one bush growing out of cap wall
Sloughing or Erosion of Slopes or Abutments	d/s-heavy erosion by foot traffic and runoff u/s-erosion adjacent to right abutment
Rock Slope Protection - Riprap Failures	Riprap missing from right u/s abutment, minor sloughing; elsewhere hand-placed riprap in fair condition
Unusual Movement or Cracking at or near Toes	No movement visible. D/s retaining wall shows slight bulge; soil washed out from behind wall has left it almost free-standing. Probed up to 2 ft. behind wall. stones partially covered with gunite.
Unusual Embankment or Downstream Seepage	None visible; seepage limited to concrete section of dam, particularly at abutments with earth embankments
Piping or Boils	None visible
Foundation Drainage Features	None
Toe Drains	None
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT UPPER BANJO POND DAM DATE 4-20-79

PROJECT FEATURE CONCRETE BUTTRESSED SECTION NAME M. LARSON

DISCIPLINE GEOTECHNICAL NAME S. PIERGE
Upstream Slope

1. Steep, smooth concrete slope (approximately 30 angle)

-good to fair condition, possibly gunited; expansion joint visible at right end of spillway;

-horizontal crack along face of slope, to right of recessed inlet, about 5.6 feet below crest;

-spalling visible above and below waterline; wire fabric exposed near waterline (1' high by 2' wide)

PERIODIC INSPECTION CHECK LIST

PROJECT UPPER BANJO POND DAM DATE 4/20/79
 PROJECT FEATURE CONCRETE BUTTRESSED SECTION NAME M. LARSON
 D/S face
 DISCIPLINE GEOTECHNICAL NAME S. PIERCE

Beginning at right (east) abutment of dam
 Bay No. 1

- (with concrete inner "frame"):
- spalling heaviest at base of buttresses;
 - concrete missing from base of right buttress, d/s end, moisture collecting at same location;
 - horizontal crack in overhanging slab(cap), heavy efflorescence, stalactites at joint of sloped back wall and "frame";
 - evidence of guniting on all walls;
 - floor concrete, mossy, moist;
 - two blocked pipes protruding from right buttress.

Bay No. 2:

- heavy spalling, particularly on left (west) buttress; wet, crumbly areas; one 2.5 feet square, up to 3-inches deep; wire fabric (2-in. mesh) exposed; one oblong, up to 6 inches deep, orange stained, wet. More spalling along this wall, and at base of right buttress, about 5 inches deep;
- exposed steel in cap, visible efflorescence; large crack through top of left buttress, about one foot below cap;
- floor covered with orange water, rubble concrete, stone, and debris.

Bay No. 3:

- exterior of gate chamber
- spalling, efflorescence;
 - large crack in upper part of right buttress crack continues vertically through cap;
 - locked wooden door set in concrete frame, door recently replaced due to vandalism

Bay No. 4:

- also has a concrete inner "frame"
- entire area shows spalling, worst up to 3-inches deep; right buttress shows signs of patching;
- cracks, efflorescence, everywhere;
- guniting in construction joints;
- joint between cap and left buttress open, no apparent bearing for cap wall;
- some exposed rebar;
- floor relatively clear, dry, concrete. Much broken glass.

UPPER BANJO POND DAM

Bay No. 5:

- spalling everywhere, but not as severe, hole in sloped wall;
- many hairline cracks, efflorescence;
- poor job of guniting, particularly at intersection of sloped wall and u/s vertical wall;
- evidence of patching in left buttress;
- 3, 1-inch pipes protruding from u/s vertical wall, all plugged
- floor is concrete, relatively clear, except for broken glass; moisture in right corner, u/s end of bay, but no standing water.

Bay No. 6:

- 4 horizontal cracks across u/s wall and sloped wall; heavy efflorescence, dripping water, and few stalactites;
- horizontal crack about 1.5 feet from base of left buttress; less efflorescence on buttresses than on u/s wall;
- guniting at joint of u/s wall and sloping wall;
- 4, 1-inch plugged pipes protruding from u/s wall;
- floor covered with water, rocks, and crumbled concrete; moisture along base of all 3 sides of bay.

Bay No. 7, with inner frame:

- spalling, heavy efflorescence u/s of frame; and at d/s end of left buttress, at vertical joint with stone masonry slope of earth embankment; water is dripping out of this joint;
- guniting at joints, particularly between u/s wall and sloping wall;
- few pieces of rebar protruding from walls; also a few plugged pipes;
- generally poor concrete construction; every construction joint is obvious.

PERIODIC INSPECTION CHECK LIST

PROJECT UPPER BANJO POND DAM DATE 4-20-79
 PROJECT FEATURE DIKE NAME M. LARSON
 DISCIPLINE GEOTECHNICAL NAME S. PIERCE

AREA EVALUATED	CONDITION
<u>DIKE EMBANKMENT</u>	Earth embankment at right abutment of dam; d/s slope grades into backyard 84.6 to 85.2
Crest Elevation	
Current Pool Elevation	78.6
Maximum Impoundment to Date	Unknown
Surface Cracks	None visible
Pavement Condition	Grass crest, flat; few trees roots on crest
Movement or Settlement of Crest	None visible
Lateral Movement	None visible
Vertical Alignment	Relatively flat
Horizontal Alignment	Straight
Condition at Abutment and at Concrete Structures	No structures; ties into natural ground at right into dam at right; house at left abut. fence on d/s side of crest and enclosing abutments
Indications of Movement of Structural Items on Slopes	None
Trespassing on Slopes	Birch trees at top of riprap, overhanging slope; bushes
Sloughing or Erosion of Slopes or Abutments	Very steep riprap face; considerable erosion on top of slope, due to water and foot traffic
Rock Slope Protection - Riprap Failures	U/s; toe of riprap rises toward right abutment; stones moved in area of bulge; riprap slope failure next to it.
Unusual Movement or Cracking at or near Toes	Apparent bulge in one area of u/s slope; movement of riprap evident
Unusual Embankment or Downstream Seepage	None visible; lilac and pines planted at toe; garden shed and garage.
Piping or Boils	None
Foundation Drainage Features	None
Toe Drains	None
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT UPPER BANJO POND DAM DATE 4-20-79
 PROJECT FEATURE SPILLWAY NAME L. BRANAGAN
 DISCIPLINE HYDRAULIC NAME M. LARSON

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS</u>	
a. Approach Channel	No channel, spillway is notch cut in concrete crest of dam
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	Spillway cut into concrete section; walls are about 1 foot high
General Condition of Concrete	Good to fair
Rust or Staining	None
Spalling	Left wall is cracked and spalled
Any Visible Reinforcing	None visible
Any Seepage or Efflorescence	Some efflorescence in left wall
Drain Holes	None
c. Discharge Channel	Discharge drops 17 ft. straight down to earth slope below dam
General Condition	Very poor-no real channel until about 70 ft. below dam
Loose Rock Overhanging Channel	Discharge eventually funnelled to concrete and stone masonry trough leading to culvert under Essex Avenue. Trough in fair condition
Trees Overhanging Channel	Small trees
Floor of Channel	Reportedly lined with riprap, now obscured by soil and vegetation
Other Obstructions	Entrance to culvert blocked by fallen rock and material from "headwall"

PERIODIC INSPECTION CHECK LIST

PROJECT UPPER BANJO POND DAM DATE 4-20-79
 PROJECT FEATURE INTAKE CHANNEL FOR OUTLET NAME M. LARSON
 DISCIPLINE GEOTECHNICAL NAME S. PIERCE

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE</u>	
a. Approach Channel	No channel; recess in concrete of u/s face of dam
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	Intake recessed into concrete face of dam 3' Vert. "headwall" then 2 1/2' to water line
Condition of Concrete	Crack across headwall, continuous to d/s side; spalling, heavy wire fabric exposed in crack.
Stop Logs and Slots	None; floating debris at inlet

c. CONDUIT

Outlet pipe is 8 -inch diameter clay pipe in open trench on floor of gate chamber. Pipe covered with tar paper inside gate house. Encased in concrete downstream of gate valve.

PERIODIC INSPECTION CHECK LIST

PROJECT UPPER BANJO POND DAM DATE 4-20-79
 PROJECT FEATURE GATE CHAMBER NAME M. LARSON
 DISCIPLINE GEOTECHNICAL NAME S. PIERCE

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - CONTROL TOWER</u>	
a. Concrete and Structural	BAY #3 is also gate chamber
General Condition	Poor
Condition of Joints	Poor-efflorescence in joints in ceiling and walls
Spalling	Considerable spalling, crumbling on ceiling, walls
Visible Reinforcing	Steel reinforcing exposed in spalling areas
Rusting or Staining of Concrete	Considerable, due to seepage and efflorescence
Any Seepage or Efflorescence	Heavy efflorescence on ceiling and walls; water dripping from ceiling; heavy seepage from right wall
Joint Alignment	-
Unusual Seepage or Leaks in Gate	Owner reports that floor of chamber usually filled with water, some standing water now. May be seepage thru walls or leak in gate
Cracks	Mostly spalled; No cracks visible
Rusting or Corrosion of Steel	Yes
b. Mechanical and Electrical	
Air Vents	-
Float Wells	-
Crane Hoist	-
Elevator	-
Hydraulic System	None
Service Gates	None
Emergency Gates	Gate valve on exposed 8" diam. pipe-wrench not at site; gate partly opened
Lightning Protection System	-
Emergency Power System	-
Wiring and Lighting System in Gate Chamber	None - natural light from screened section of Bay, above doorway

PERIODIC INSPECTION CHECK LIST

PROJECT UPPER BANJO POND DAM
 PROJECT FEATURE OUTLET CHANNEL
 DISCIPLINE GEOTECHNICAL

DATE 4-20-79
 NAME M. LARSON
 NAME S. PIERCE

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL</u>	Stone masonry open channel, gunited surface
General Condition of Concrete	Good to fair
Rust or Staining	None
Spalling	Very minor
Erosion or Cavitation	None
Visible Reinforcing	None
Any Seepage or Efflorescence	None
Condition at Joints	N/A
Drain Holes	None
Channel	Ground surface u/s of outlet discharge is eroded;d/s channel leads to culvert
Loose Rock or Trees Overhanging Channel	Branches and bushes overhanging channel. Floor of channel is paved with stones.
Condition of Discharge Channel	Inlet to road culvert is blocked by fallen section of stone and concrete wall

Below Essex Ave. culvert discharges at granite block headwall in steep slope. D/s area filled with trash, brush and trees. Stream channel poorly defined.

APPENDIX B

PLANS OF DAM AND PREVIOUS
INSPECTION REPORTS

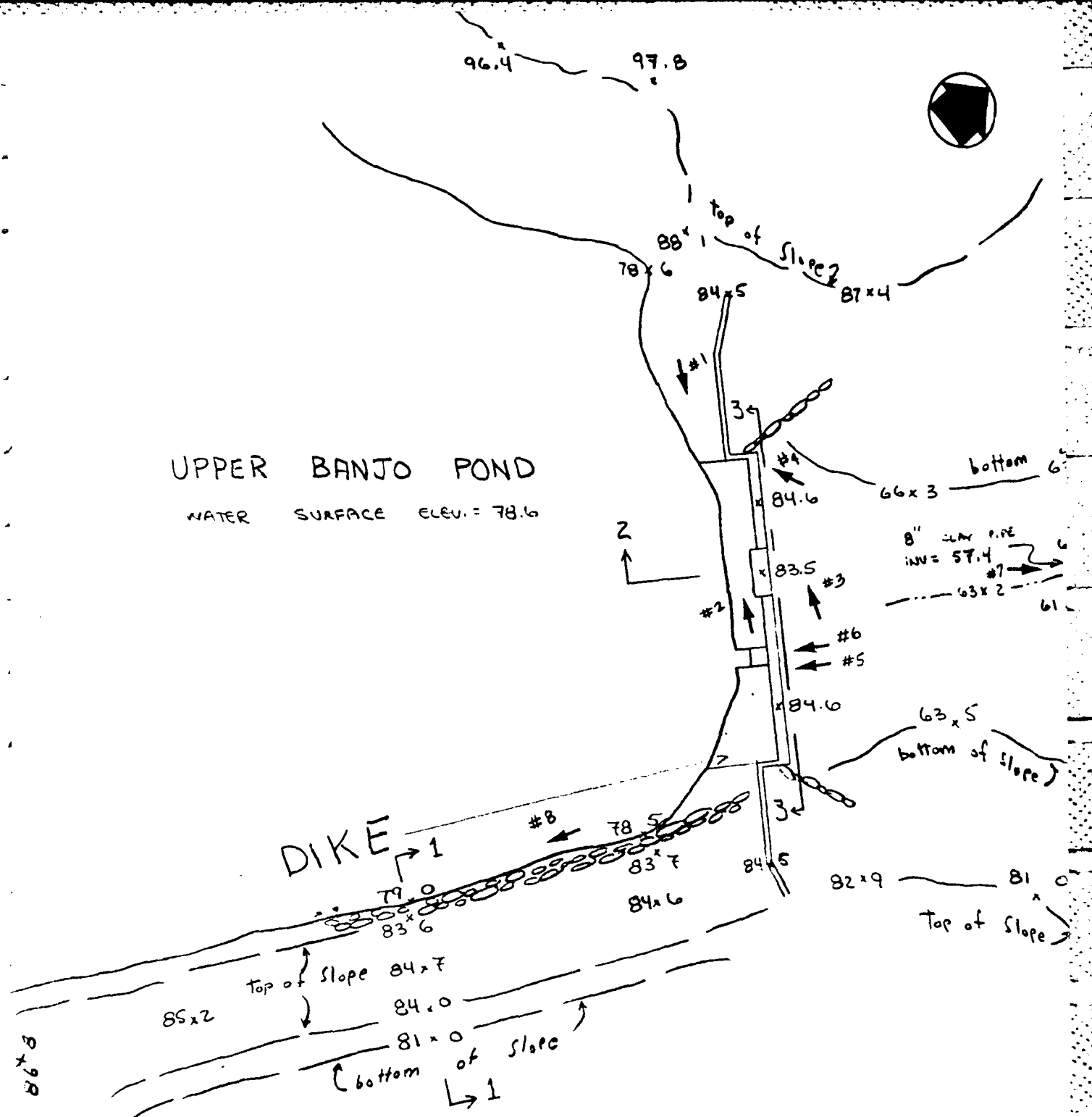
	<u>Page</u>
Figure B-1, Plan of Dam and Dike	B-1
Figure B-2, Sectons through Dam and Dike	B-2
Figure B-3, Fernwood Lake Spillway and Earth Dike	B-3
Previous Inspection Reports	B-4



96.4 97.8

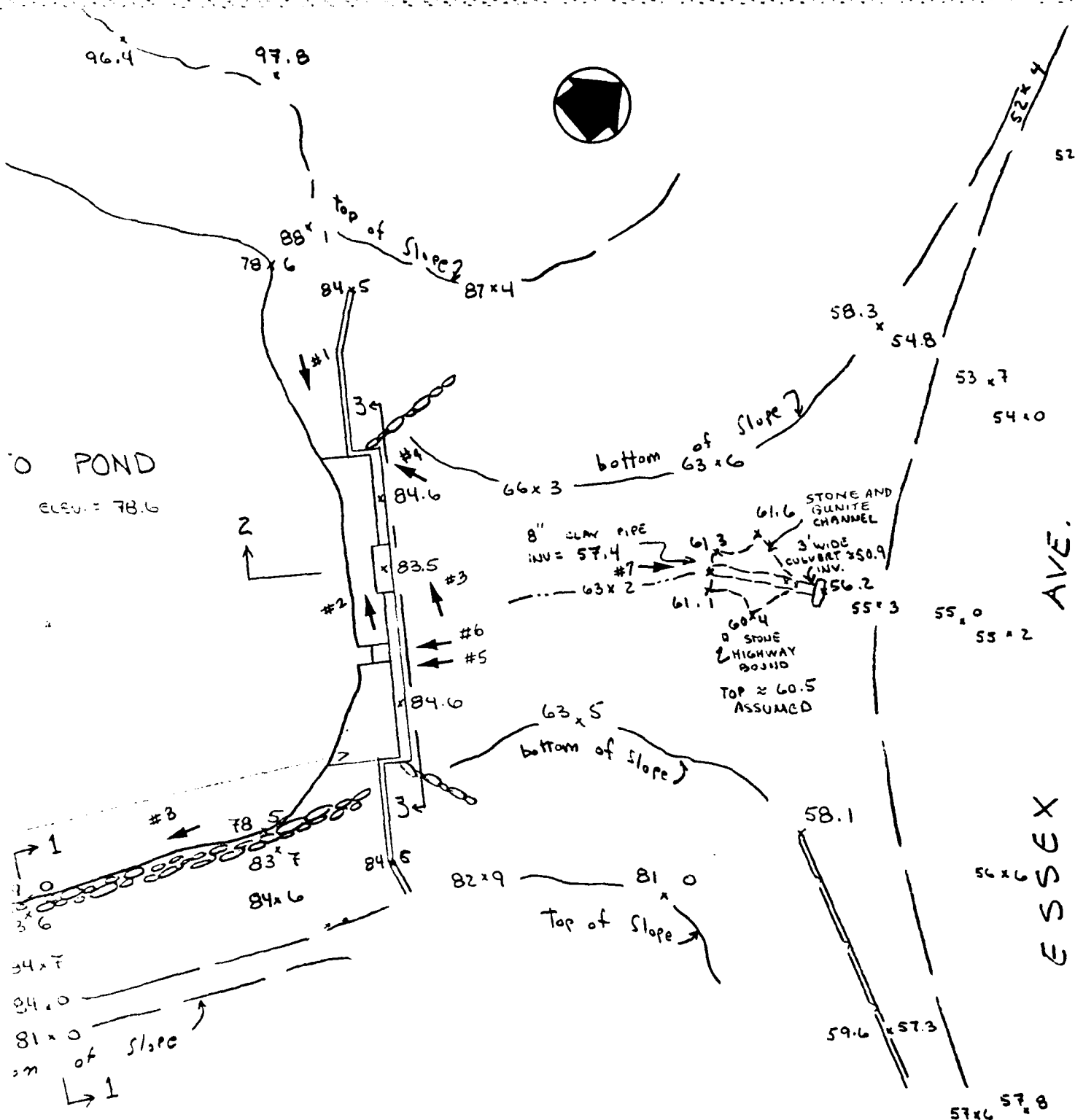
UPPER BANJO POND

WATER SURFACE ELEV. = 78.6



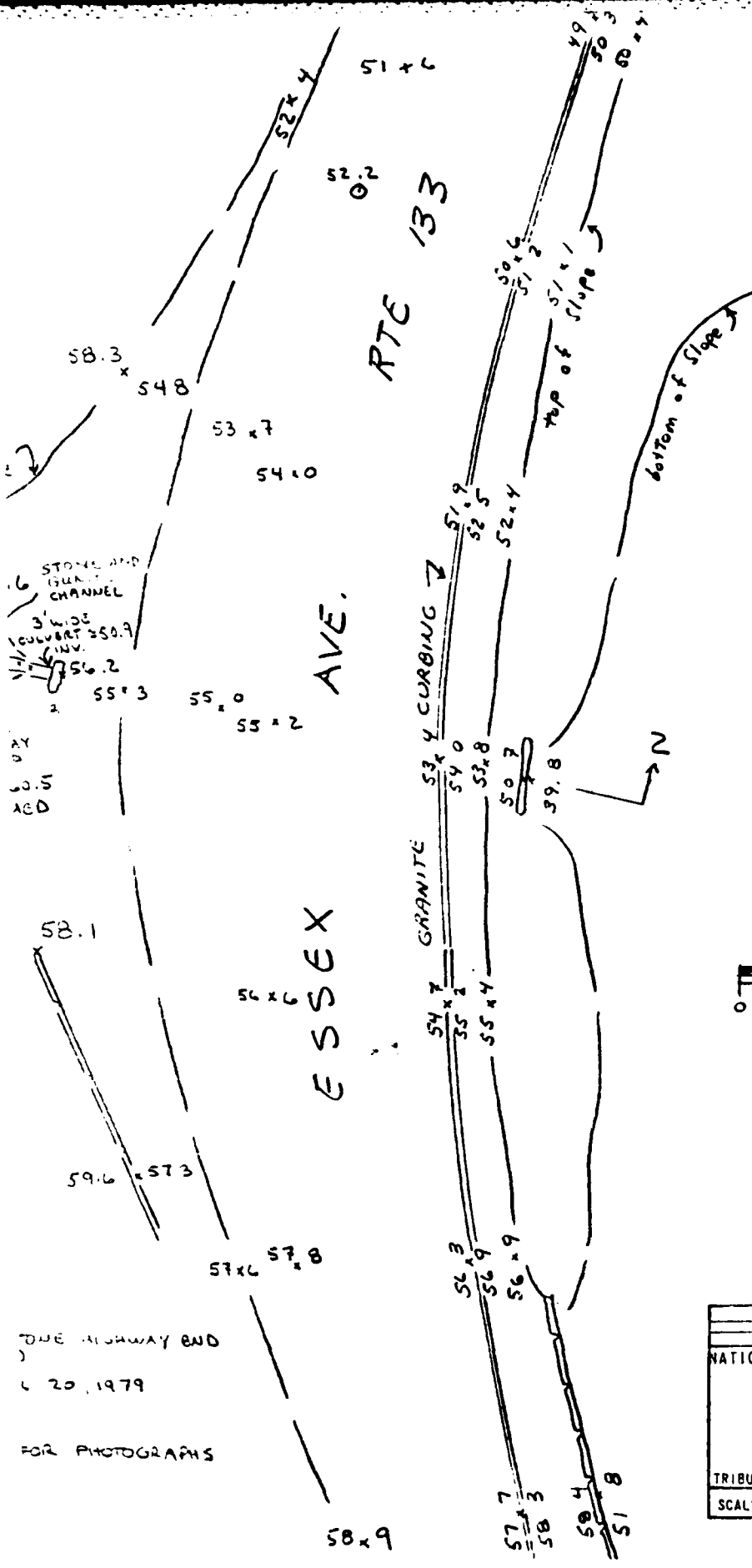
NOTES:

1. ELEVATIONS SHOWN BASED ON ASSUMED ELEV. 60.5 RELATIVE TO GLOUCESTER TOPOGRAPHIC SURVEY
2. INFORMATION SHOWN BASED ON FIELD SURVEY
3. ↕ DENOTES SEEPAGE
4. ↗ #2 INDICATES LOCATION AND DIRECTION

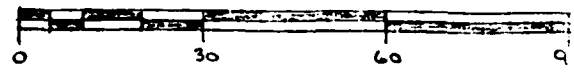


NOTES:

- 1 ELEVATIONS SHOWN BASED ON ASSUMED ELEV. 60.5 ON STONE HIGHWAY BND RELATIVE TO GLOUCESTER TOPOGRAPHIC SURVEY (USLS)
- 2 INFORMATION SHOWN BASED ON FIELD SURVEY OF APRIL 20, 1979
3. ∇ DENOTES SEEPAGE
4. \rightarrow #2 INDICATES LOCATION AND DIRECTION OF VIEW FOR PHOTOGRAPHS



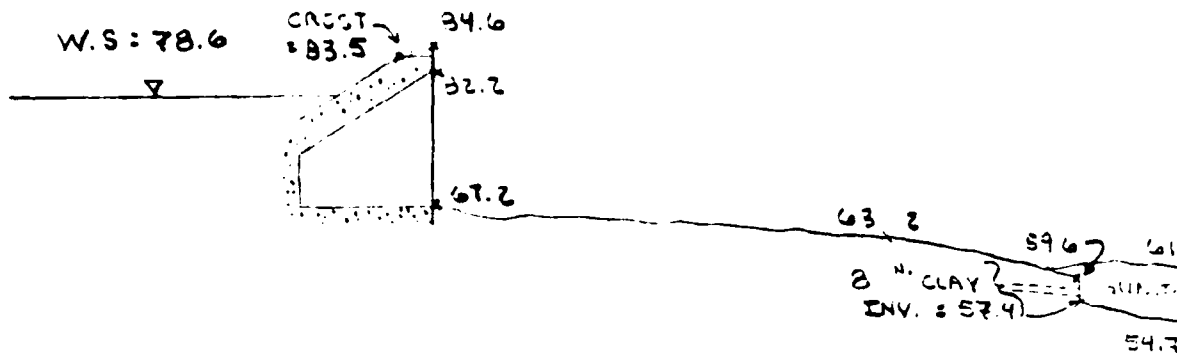
PLAN SCALE
in feet



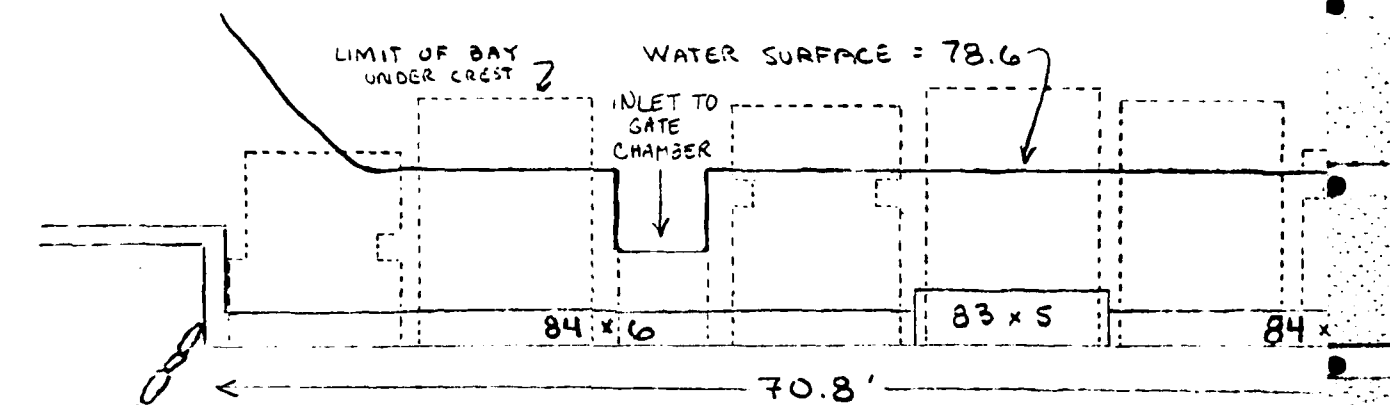
THE HIGHWAY END
4 20 1979
FOR PHOTOGRAPHS

METCALF & EDDY, INC. ENGINEERS BOSTON, MA.	U. S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS BOSTON, MA.
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	
UPPER BANJO POND DAM	
FIGURE 8-1 PLAN OF DAM AND DIKE	
TRIBUTARY ANNISQUAM RIVER	MASACHUSETTS
SCALE: 1" = 30'	DATE: APRIL, 1979

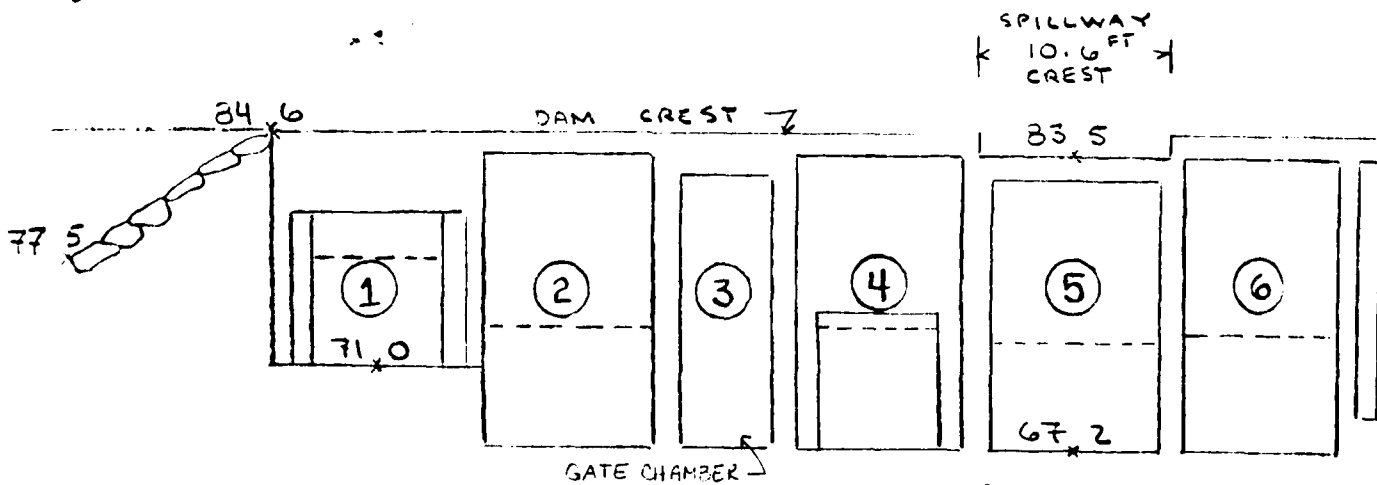
3



SECTION
 SPILLWAY AND
 SCALE 1 IN =

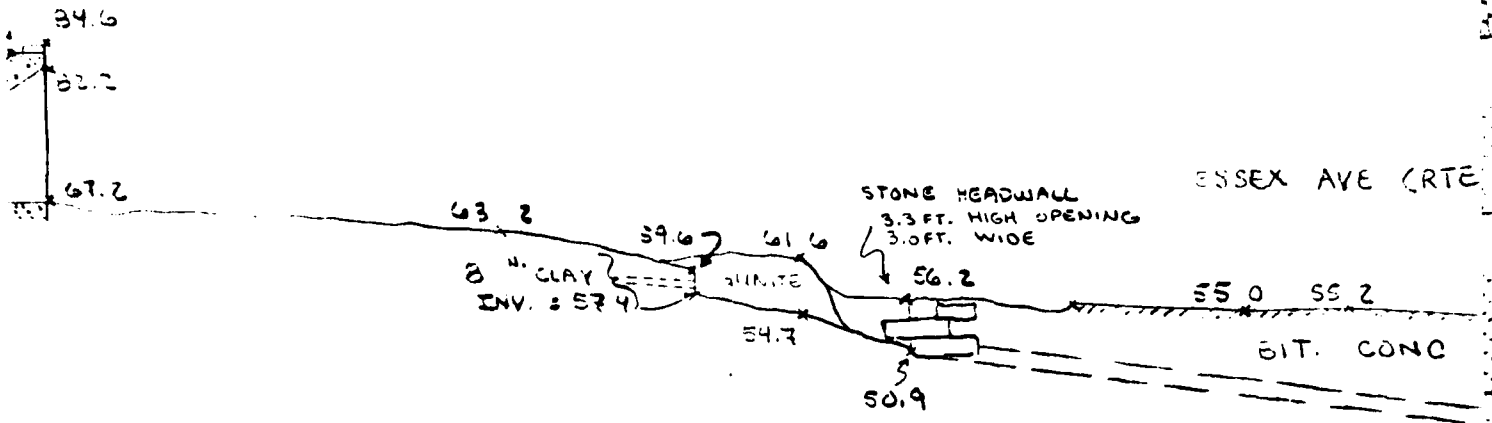


PLAN VIEW OF DAM
 SCALE 1 IN = 10 FT.

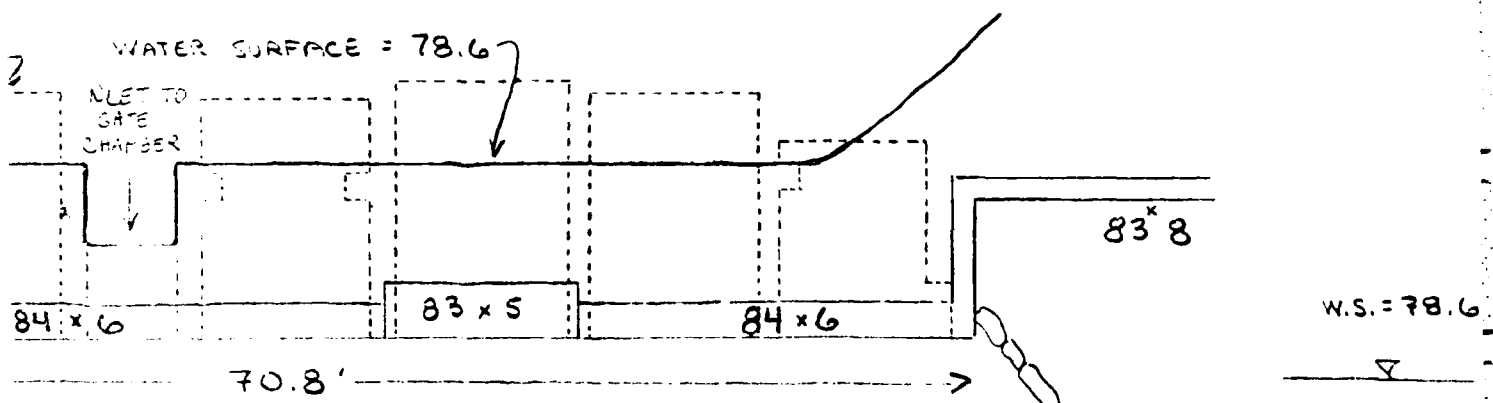


SECTION 3-3
 ELEVATION VIEW OF DAM
 SCALE 1 IN = 10 FT.

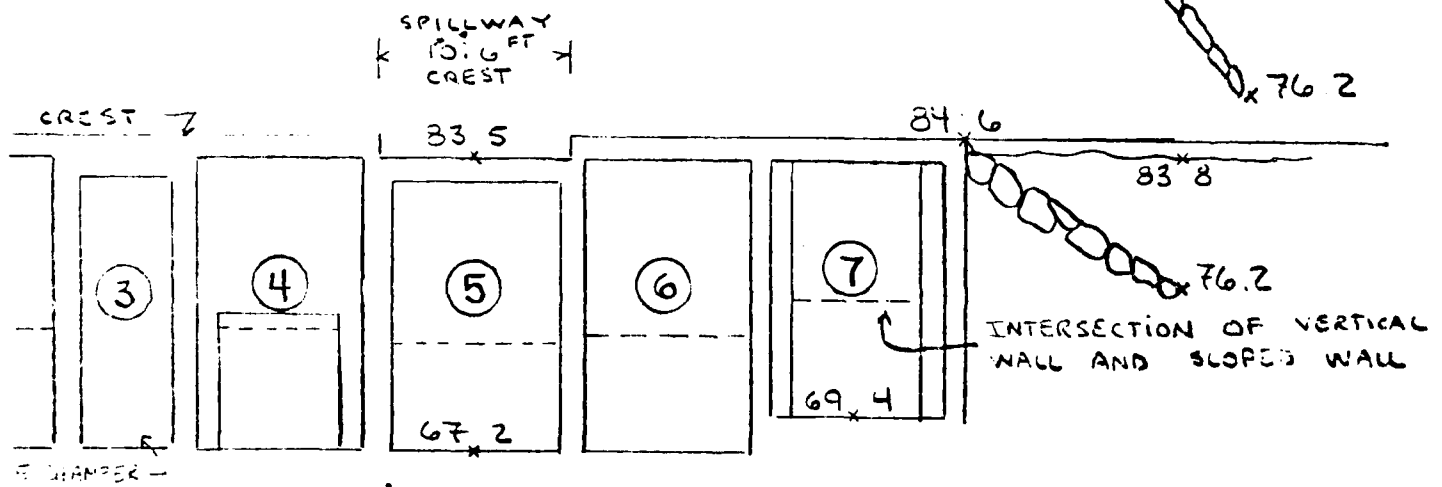
①



SECTION 2-2
 SPILLWAY AND OUTLET CHANNEL
 SCALE 1 IN = 20 FT.



PLAN VIEW OF DAM
 SCALE 1 IN = 10 FT.

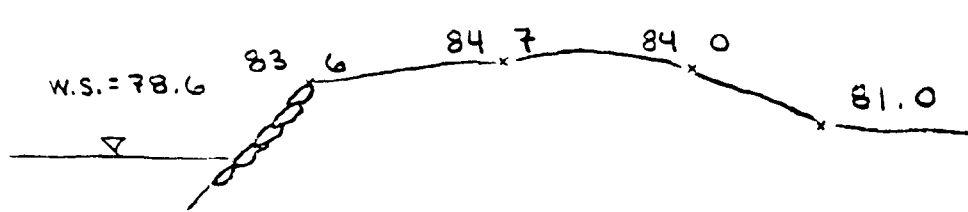
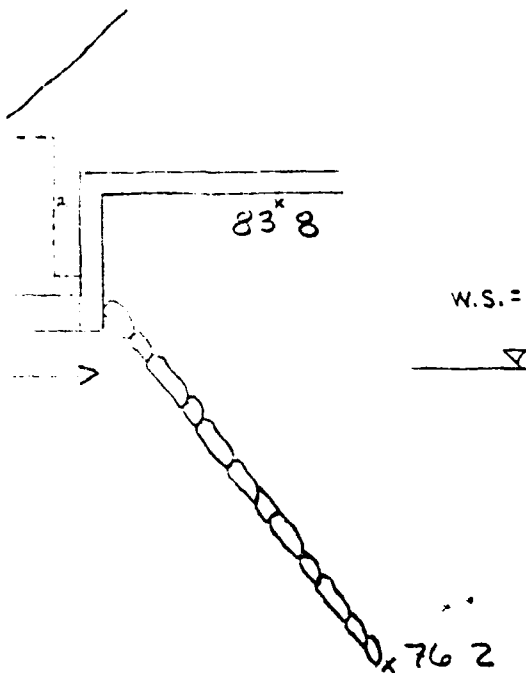
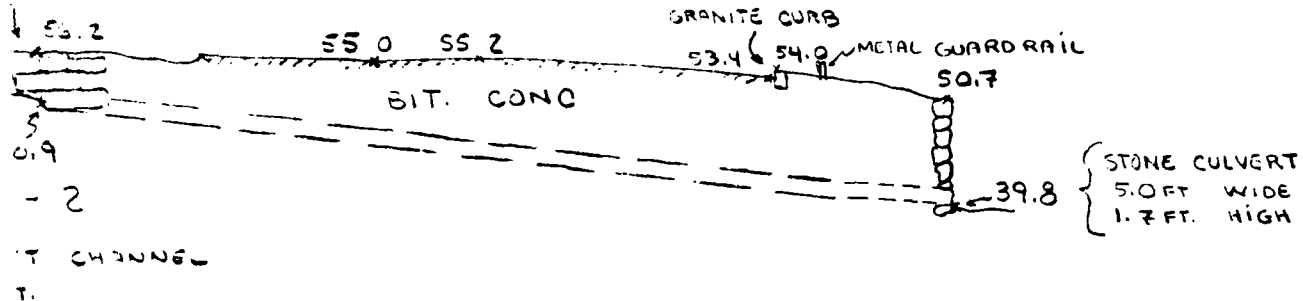


SECTION 3-3
 ELEVATION VIEW OF DAM
 SCALE 1 IN = 10 FT.

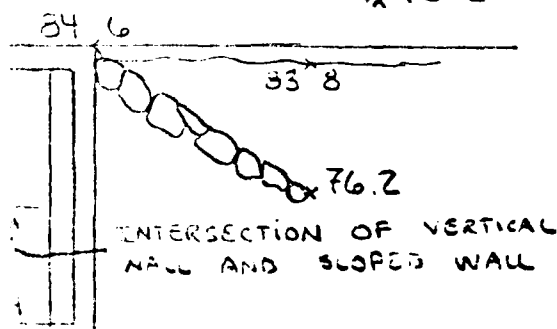
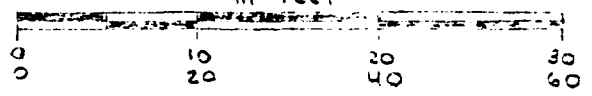
① INDICATES BAY NUMBER
 2

ESSEX AVE (RTE. 133)

TONE HEADWALL
3.3 FT. HIGH OPENING
3.0 FT. WIDE



SECTION 1-1
DIKE EMBANKMENT
SCALE 1" = 10 FT.
SECTION SCALE
in feet

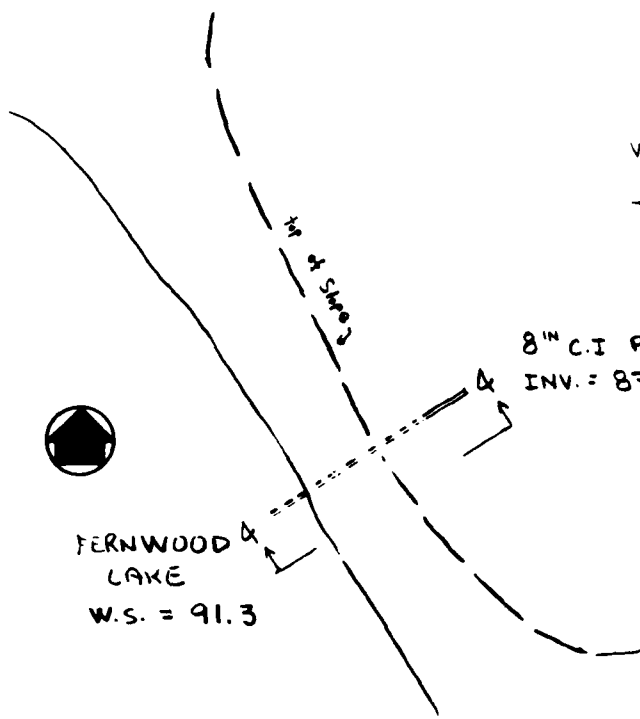


INTERSECTION OF VERTICAL
WALL AND SLOPED WALL

ATES BAY NUMBER
2

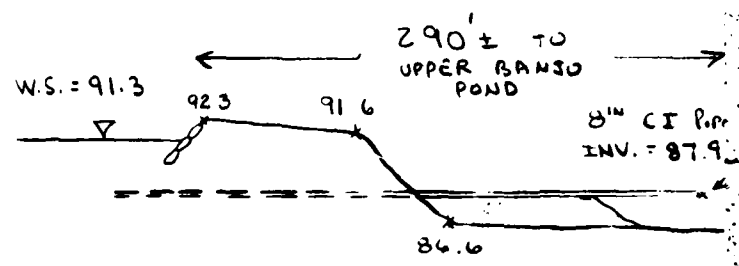
METCALF & EDDY, INC. ENGINEERS 40 TOWN SQ. WARREN, MA	U.S. ARMY ENGINEER DIV., NEW ENGLAND CORPS OF ENGINEERS BOSTON, MA
NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS	
UPPER BANJO POND DAM	
FIGURE B-2 SECTIONS THROUGH DAM AND DIKE	
TRIBUTARY ANNISQUAM RIVER	MASSACHUSETTS
SCALE: AS SHOWN	DATE: APRIL, 1979

3

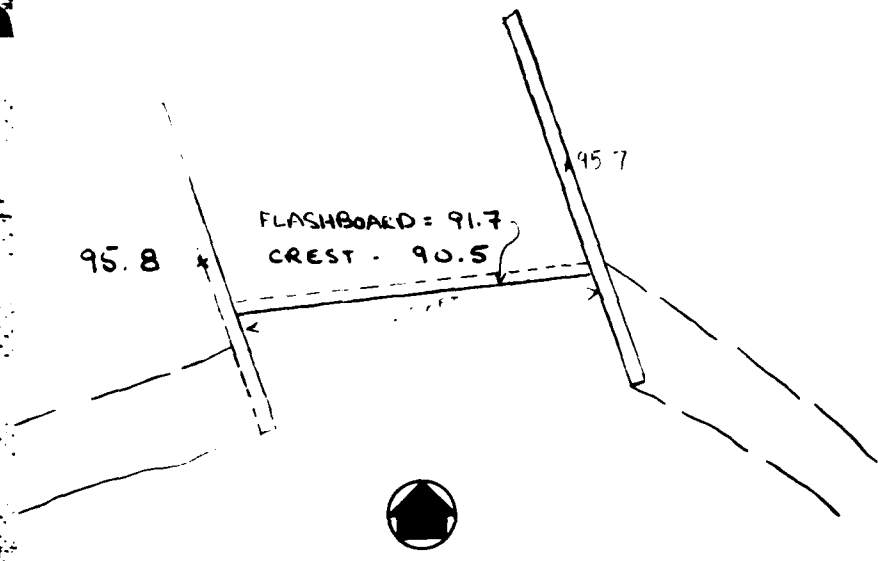


FERNWOOD LAKE
W.S. = 91.3

PLAN VIEW
EARTH DIKE AT FERNWOOD
SCALE 1 in = 20 FT



SECTION 4-4
EARTH DIKE AT FERNWOOD
SCALE 1 in = 10 FT



FERNWOOD LAKE
W.S. = 91.3
PLAN VIEW
OF
FERNWOOD SPILLWAY
SCALE 1 in = 10 FT

METCALF & EDDY, INC ENGINEERS BOSTON, MA.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA.
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	
UPPER BANJO POND DAM	
FIGURE D-3 FERNWOOD LAKE SPILLWAY AND EAST DIKE	
TRIBUTARY ANNISQUAM RIVER	MASSACHUSETTS
SCALE: AS SHOWN	DATE: APRIL, 1979

D 11
GLOUCESTER
5-5-1971-13

L.E. WILKINSON

7/7/71

1

ON UPPER "BANJO POND", BEGIN ON ESSEX AVE. (ROUTE 13 AT STANWOOD AVE. TAKE ESSEX AVENUE EASTERLY 0.40 MI. DAM CAN BEEN SEEN FROM ESSEX AVE. ON SOUTH SIDE TAKE FOOT PATH 15 FT.

LEPAGE DIVISION OF PAPER-CRAFT CORPORATION
MANUFACTURING

REINFORCED CONCRETE APRON TYPE DAM.

18.0 ± FT.

70.0 ± FT.

21. INCHES

11.3 ACRES

35,500,000 ±

0.30 ±

WATER LEVEL IN POND 7.0 FT. BELOW SPILLWAY.

TO-DAY. CONCRETE DAM & SPILLWAY IN GOOD CONDITION - OUTLET UNDER ROAD PLUGGED UP SO WATER GOING OVER SPILLWAY WOULD FLOW ACROSS ROAD - THERE IS AN 8" OUTLET PIPE ^{THROUGH BOTTOM} ~~OF DAM~~ OF DAM EMPTYING INTO 4' X 3' BOX CULV. (CONC. 4' X 3' BOX CULV. (DOWNSTREAM OPENING))

NEEDS CLEANING OUT, & HEADWALL (STONE MASONRY) NEEDS REPAIR. NORTH SIDE OF ROADWAY

O 10 -5C
D 11 R S.P.

COUNTY OF ESSEX, MASSACHUSETTS
ENGINEERING DEPARTMENT

Inspection of Dams, Reservoirs, and Stand Pipes

0 10
SUB NUM
D 11 R
Neg. No. 1

Inspector *C. C. Barker* Date *April 27 1912* *Classification *1*
City or Town *Gloucester* Location *Southern side of Essex Ave.*

Owner *Russia Cement Co.* Use *Reserved for Mfg. purposes*
Include such details as cores, cut off walls, paving, settling, class of masonry, kind of cement, (rat. or port.) etc.

Material and Type *Reinforced concrete apron dam. The dam is heavily reinforced.*

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 bo
For Res. or S. P.
{ Crown surface below Bottom of res. Level of over flow pipe Top of res.

Length in ft. *70±* Top width in ft. *21 in* Pond area *11.2 acres* Area of watershed *25± ac*
For Res. or S. P. *storage* Capacity *35,571,070 gals.* *0.3± sq. covered*

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

Stand pipe thickness at base diam. of rivet head Pitch *1 in*

Foundation and details of construction *The foundation is 10 ft. deep concrete on bed rock.*
Amurson

Constructed by and date *Amurson Hyd. Cement Co. in 1908*

Recent repairs and date

Evidence of leakage *Slight leakage underneath the apron that is thru the joints in the masonry.*

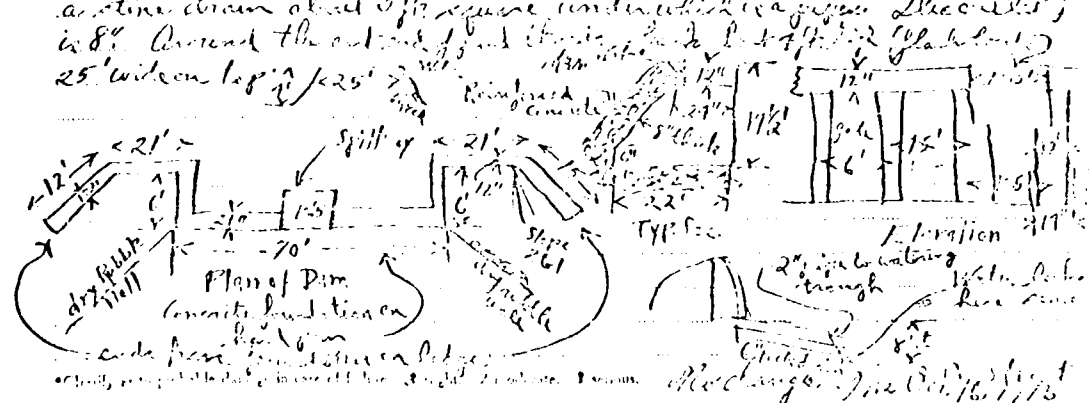
Condition *Good* *So. Part repainted*

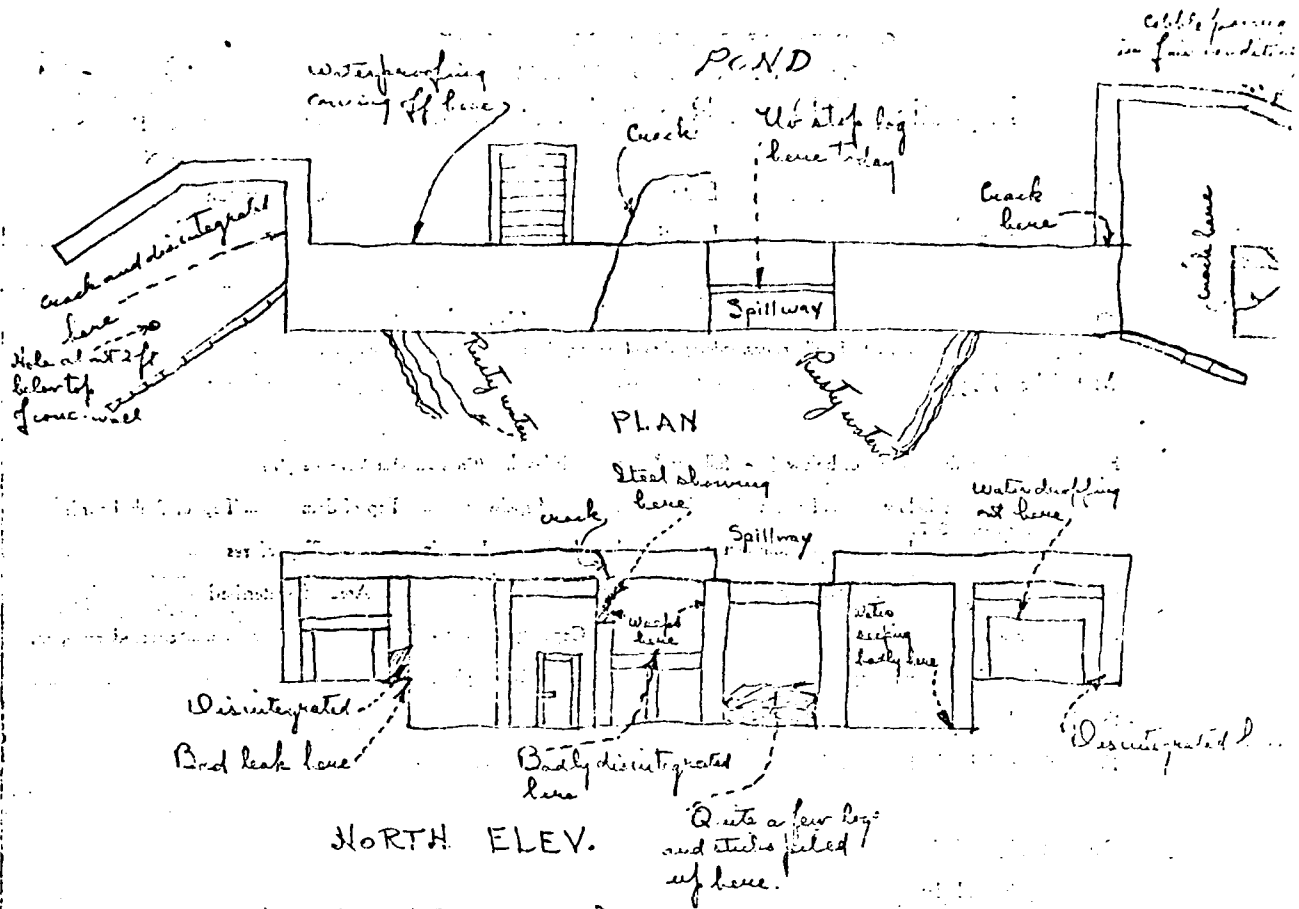
Topography of country below *Open*

Nature, extent, proximity, etc. of buildings, roads or other property in danger if failure should occur *No houses or other property below, the only damage would be to wash out a road.*

Plans and data secured or available *Bill contract plans & specifications will be mailed on request by the Russia Cement Co.*

Notes, sketches, sections, etc. *The spillway is 10 1/2 ft wide with the water fall on a stone drain about 3 ft square under which is a pipe. The outlet is 8" around the outside of the pipe. The pipe is 4 ft long & has a 25" wide on top. The concrete is reinforced with 1/2" bars.*





Sketch July 25, 1944 D.W.W.

Gloucester D. 11

1917, March 26. Watershed 0.3 sq. m. Max. ht. 17.0 ft. Apparent condition, Good.

1925, Oct. 28. R. R. Evans, Insp. Dam on south side of Essex Ave., Russia Cement Co., owners. This is a reinforced concrete dam of the "Ambursen" type. The concrete on the side away from the water shows some disintegration and reinforcing bars are exposed over a considerable area at the east end near the lowest part of the slab. The water in the pond is very low at time of inspection, so that very little leakage would be expected, but the slab shows wet patches on the underside at points below water level. Apparently gravel was used for the aggregate in the concrete and there are indications that there may have been considerable dirt in it, and the concrete in places seems of poor quality especially in the west abutment wall. There is no evidence of over-stress or of incipient failure in any part. Portions of the concrete should be cut away and replaced with new, especially where the rods are exposed. It would appear that more water might flow over this dam than could be cared for by the culvert across the road below. This culvert is no part of the dam. Mr. Jewett knew this inspection was to be made but did not accompany us.

1925 Report to Co. Comm. Same as above.

1926, Nov. 16. R. R. Evans, Insp. Dam on south side of Essex Ave. Russia Cement Co., owners. No notice of these repairs had been given, but happening to pass the dam on the above date, I noticed work in progress and stopped to investigate. Talked with Mr. Hardy (or Harding) who seems to be in charge of the work, but the equipment is marked with the name John S. Pomeroy. There is an air compressor at work and the concrete on the under side of the sloping slab is being roughed up for a width of two or three feet where it is some seven feet above the bottom slab and the partition walls and bottom slab are also being roughed up and all disintegrated concrete removed in each compartment of the dam, but this roughening does not extend the entire distance to the point where the inclined slab meets the bottom slab. In places holes are being driven through the partition walls and dowels placed in each compartment the whole space from the intersection of the two slabs out to the point where the height is about seven feet is being filled solid with concrete. The concrete which is being roughed up shows sound and hard and rods where exposed are not rusted. The only exception so far as the area exposed when I was there is concerned is the west wall against the fill which seems to be of very poor concrete and practically the whole thickness of this wall is being removed, and a few walls built outside it. About one-half the compartments have been filled and work is in progress on those remaining. Sand and gravel from Haegstroms bank on Eastern Avenue is being used without screening. So far as can be determined by visual inspection, the sand and gravel seem satisfactory and the new concrete seems good. Mr. Hardy speaks of water proofing the water face of the slab with asphalt but I do not understand that this is fully decided upon.

1926, Oct. 5. C. C. Barker, Insp. Dam on the southerly side of Essex Ave., is owned by the Russia Cement Company, and holds the water for manufacturing purposes. I gave a copy of the notice to R. A. Jewett, Supt., who inspected the dam with me. In case of failure much damage would result and the main highway just below the dam would be washed out and possibly the pond at the Russia Cement Company plant

Gloucester D. 11

would over-flow and do some damage to their buildings. It is not likely that there would be any loss of life. The conditions are the same and there have been no changes, except to make repairs to prevent leakage. The top of the dam and slopes are in good condition. The water level today is seven or eight feet below the top of the dam. There is quite a little leakage under the dam next to the end bays. There is some leakage through the concrete in the bay east of the spillway. Mr. Jewett says the dam was patched and repaired by a local contractor in the spring of 1927, and does not leak any where near as much now as it did then. Next year it will have to be repaired again in other places.

1928 Report to Co. Comm. Russia Cement Co. Dam south of Essex Ave., a reinforced concrete dam. At the time of our last inspection, I called attention to the disintegrating concrete in the dam south of Essex Avenue and this has been repaired, although I understand that further repairs are contemplated. I visited the dam on November 30th, at which time there was practically no water in the pond, so that there was no percolation through the concrete, but I understand that there is such percolation in times of high water.

1930, Sept. 16. C. C. Barker, Insp. Dam on the southerly side of Essex Ave., is owned by the Russia Cement Co., and holds the water for manufacturing purposes. I gave a copy of the notice to R. A. Jewett, Supt. No one inspected the dam with me. Failure of this dam would cause a great deal of damage. The main road just below the dam would be washed out, the lower pond would overflow and damage their buildings and possibly the railroad. It is not likely there would be any loss of life. The conditions are the same and there have been no changes since the last inspection. The dam seems to be in fair condition except that there is quite a little leakage underneath and seepage through the dam. Water level is 7 or 8 feet below the top.

1930, Nov. 10. R. R. Evans, Insp. Practically no water in pond. Patching done a few years ago seems effective. Can see no evidence of disintegration now in progress.

1930, Report to Co. Comm. A dam on the south side of Essex Ave. forms a small pond immediately below Fernwood Lake, and is owned by the Russia Cement Co. This dam is of the Ambursen type and failure would result in damage to the roadway and by over-flowing another pond immediately below might result in damage to the buildings of the Russia Cement Co. The pond was practically empty at the time of inspection, but it would seem that the patching of the concrete done a few years ago has reduced seepage to a considerable extent. The structure is apparently safe and in fair condition.

1932, Aug. 2. C. C. Barker, Insp. Mr. Jewett, Supt., did not accompany me to the dam. The conditions are the same and there has been no change. The dam is in fair condition except there is a great deal of leakage. The water level is about 3 feet below the top of the spillway. There is a great deal of leakage in and under the two end bays at each end of the dam. There are a few bushes on top at the westerly end, which should be cut.

1932, Nov. 2. R. R. Evans, Insp. There is considerable seepage through the concrete, but no appreciable disintegration is in evidence since repairs were made a few years ago. Pond nearly full.

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1932 Report to Co. Comm. There is a dam on the south side of Essex Avenue belonging to the Russia Cement Company near their plant. It is a concrete dam of the Ambursen type and is of some importance as it would cause damage to the state highway immediately below if it failed. It has shown considerable leakage at all our previous inspections and shows it today. The concrete has been repaired within recent years where some of the reinforcing rods were exposed. It is in substantially the same condition now as at the time of my last report, and while I could hardly say without qualification that the structure is in good condition, I see nothing about it to indicate that there is danger of failure or that any immediate repairs are required.

1934, Sept. 28. C. C. Barker, Insp. I gave a copy of the notice to Mr. Jewett, Supt. He did not go to the dam with me. Although I understood Mr. Jewett to say nothing had been done in the past two years on this dam, it seems that two concrete posts 13" x 17" with a 17" x 12" beam across their tops have been built against the walls and apron in the east bay and the bay just east of the spillway. There does not seem to be as much seepage or leakage as before and the dam is apparently in good condition. The water level is about 5 feet below the top. Last May Mr. Jewett had a diver examine the inner slope of the dam, he found it in good condition and nothing to cause any worry. The conditions are the same.

1934 Report to Co. Comm. The dam on the outlet of Fernwood Lake on south side of Essex Avenue is of some considerable importance and has considerable leakage at previous inspections. Some repairs have apparently been made and it seems to be in fair condition.

1936 August 10, C.C.Barker, Insp. I gave a copy of the notice to Mr. Jewett, Supt. He did not go to the dam with me. This dam seems to be in good condition about the same as when last inspected. There is not as much seepage as some times. There is some leakage in the second bays from each end. There has been no change. Water level is about four feet from the top.

1936 Report to Co. Comm. The dam belonging to the Russia Cement Company, on the south side of Essex Avenue, seems to be in substantially the same condition as when last inspected, with no indication of apparent danger although showing considerable leakage as in the past.

1938 October 26, C.C.Barker, Insp. I gave a copy of the notice to Mr. Jewett. There is some disintegration of the concrete in several places. The counterfort between the first and second bays from the easterly end of the dam is cracked and disintegrated eight inches in at the bottom of the first bay at the outer edge and eight inches down a small stream of water is flowing out through the counter fort. In the bay, east of the spillway, at the top on the spillway level there is a large crack in the concrete apron through which water is seeping, also there is a crack and disintegration at the top of the counterfort on the east side of this bay. The water level is 1 foot below the top of the dam, at the level of the spillway. Although the pond is full there does not seem to be as much seepage as at previous inspections.

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1938 November 2, R.R.Evans, Insp. With Mr. Barker looked at concrete dam of Ambursen type belonging to Russia Cement Company on Essex Avenue in Gloucester. The pond is full. There is a stop log in the overflow and some water is spilling or leaking through. A few of the concrete buttresses show considerable spalling near their tops at the outer face of the apron and disclose a concrete which does not look to be of very good quality. There are some cracks in the slab through which a small amount of water is seeping. No reinforcing bars are exposed. The overflow from the spillway falls from a considerable height onto the ground which here is roughly paved with very small stone or riprap, which apparently would be eroded if water should overflow the full capacity of the spillway. There is so little freeboard in this dam above the spillway elevation that the practice of maintaining even a low stop log in the spillway introduces danger of a washout in the embankment. It has been stated in past reports that the amount of water held back is small and except for damage to state highway the owner of the dam would apparently be the only one liable to damage by any failure of it.

1938 Report to Co. Comm. The dam on the south side of Essex Avenue below Fernwood Lake, above the plant of the Russia Cement Company, is a concrete dam of the ambursen type, and at various times in the past repairs have been made by cutting out disintegrated concrete and replacing with new. There are today some further parts which should be so repaired. The spillway in this dam is narrow and its crest is about one foot only below the highest part of the concrete apron, and a stop log has been placed in this spillway so that when the spillway is in action there is practically no freeboard. Although overtopping might safely occur in a dam of this type under some conditions, the earth embankments extending both ways from the dam are little, if any, higher than the crest, and would also be overtopped, and the only provision against erosion of the earth at the toe of the dam is a pavement of small stones which would soon be cut out if the water overflowed to any considerable depth. The amount of water retained by the dam is small but probably enough to cause some damage to the state highway immediately below and to the plant of the Russia Cement Company, the owners of the dam, if a washout should occur. Removal of the stop log would be of some benefit.

1940 Oct. 4, C.C.Barker, Insp. I gave a copy of the notice to Mr. Jewett, Supt. The concrete is disintegrated and spalled off in several places, from the easterly abutment in the first, third and fifth counterforts and the westerly abutment. The counterfort on the east side of the middle bay is badly disintegrated and cracked at the top. This should be repaired. Although the water level is about 7 feet below the top of the dam there is some seepage. Mr. Jewett intends to make some repairs on this dam this fall.

1940 Report to Co. Comm. The concrete dam on the south side of Essex Avenue below Fernwood Lake shows quite extensive deterioration since last inspection, and was then stated to be in need of repairs, as the pond level is raised too high by use of a stop log. Repairs should not now be delayed, and it is understood that they are in contemplation for this Fall.

1942 Aug. 3, C.C.Barker, Insp. I gave a copy of the notice to Mr. Jewett, Supt. No repairs have been made on this dam since the last in-

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spection. The concrete is badly disintegrated and the leakage is about the same. The counterfort on the east side of the middle bay is in poor condition, being cracked and disintegrated at the top. The water level is about 7 feet below the top of the dam. This dam should be repaired and Mr. Jewett wants to do something about it. There has not been any change.

1942 Report to Co. Comm. The concrete dam on the south side of Essex Avenue below Fernwood Lake shows more deterioration and is very much in need of repairs which were contemplated but as yet have not been done. This dam should be repaired now.

1944 July 25, S.W. Woodbury, Insp. I gave a copy of the notice to Mr. Jewett, but visited the dam alone. The water level is 3.0 ft. below the lip of the spillway (See sketch on back of sheet 1 for location of leaks, etc.) No repairs have been made since the last inspection, but Mr. Jewett plans to repair the dam next year. The condition of the dam seems to be about the same as last reported. The culvert across Essex Avenue is almost blocked.

1944 Report to Co. Comm. The concrete dam on the south side of Essex Avenue, below Fernwood Lake, for the past few years has been deteriorating very much, and the concrete in many places has disintegrated and there is much leakage. Repairs have been contemplated for some time and should be made as soon as possible without further delay.

1946 Sept. 20, S.W. Woodbury, Insp. I gave a copy of the notice to Mr. Jewett and went to the dam alone. This dam is in very poor condition and attention should be given to it to see that it is strengthened. No repairs made since last inspection. Mr. Jewett says he plans to make repairs next August when the water is low and when it is quiet at the place. Water level today is 6.5' below crest of spillway. Leaks are same as last reported. Condition of the dam is same.

1946 Report to Co. Comm. The concrete dam on the south side of Essex Avenue below Fernwood Lake is in exceedingly poor condition and the concrete is badly disintegrated. It needs to be strengthened and repaired. This should be done. Repairs are contemplated.

1948 Sept. 30, S. W. Woodbury, Insp. Gave a copy of the notice to Mr. Jewett and went to dam alone. Further inspection is needed to see that repairs are made. No repairs since last inspection. Water level today 2.5' below crest of spillway. Leaks: same. Condition of dam: Same.

1948 Report to Co. Comm. The concrete dam owned by the Russia Cement Company, south of Essex Avenue below Fernwood Lake, is in a very poor condition. Much more disintegration has taken place in the concrete since the last inspection in 1946, and no repairs have been made. This dam should be thoroughly repaired and put in good condition, and, until that is done, the water in the pond should be kept at a low level.

1950 Sept. 19, S.W. Woodbury, Insp. Left a copy of the notice for Mr. Jewett at his office and went to dam alone. Further inspection needed to see that repairs are made. A cinder driveway has been built to the dam and concrete steps to the top of the dam, but no repairs have been made

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to strengthen the dam. Water level today: 5 ft. below crest of spillway. Leaks: same. Condition of the dam is the same. A section of concrete about 12" deep and 10 ft. long between the spillway and the gate is about ready to fall off.

1950 Report to Co. Comm. The Russia Cement Company's concrete dam, south of Essex Street below Fernwood Lake, is in very poor condition, much worse than when last inspected. No repairs have been made, but should be. Unless this dam is repaired extensively and strengthened, the water above the dam should be kept at a very low level.

1952 Sept. 25, E.H. Page, Insp. Gave a copy of the notice to Mr. Jewett at his office and went to the dam alone. No repairs since last inspection. Water level today: 5 ft. below crest of spillway. Wet also toe. Condition of the dam is the same. The 10' long 12" deep piece of conc. between gate and spillway is still in place.

1952 Report to Co. Comm. The Russia Cement Company's concrete dam, south of Essex Street below Fernwood Lake, is still in very poor condition and there is much seepage as no repairs have been made since the last inspection. This is a very important dam and should be repaired or the pond kept at a very low water level.

1954, May 19, E.H. Page and J.O. Harmaala, Insp. Elev. of water: 1/2" of water over spillway. Seepage through conc. A lot of seepage at the toe. Minimum freeboard with all possible stop logs etc. in place: 13". Spalling conc. Very, very poor condition. Channel below spillway should be paved and channel entrance opened up. Should remove slot for flashboards. Bad crack and leak at junction of dam and wing wall on both ends of the dam. Very bad crack at outlet structure. Spalling conc. and in some places rotted away into reinforcing.

1954 Report to Co. Comm. LePage's concrete dam, south of Essex Street below Fernwood Lake, has been extensively repaired by the Gunite Restoration Company. All the disintegrated concrete in the downstream face of the dam and the counterforts was chiseled out to solid concrete. In some places this meant going in to a depth of two and one-half feet. Then this was built up in layers by gunite to the original section. On the pond side of the dam, all cracks and construction joints were V-grooved to solid concrete. The whole area was sandblasted to remove dirt and slime. Bent pins were driven into the concrete at two feet on centers to hold the wire mesh reinforcing. This was then coated with a two inch coating of gunite. The channel below the dam at the culvert entrance has been cleaned and the rubble side walls gunited. There is still some seepage through the construction joints in the dam.

1956 Sept. 13, E.H. Page, Insp. Elev. of water: 1'-11" below spillway. Leaks: A place at the westerly end where it is pipes through under the conc. slab. Condition of dam: Fair. This dam was repaired by gun method of placing conc. This strengthened the dam considerably, but failed to stop all the leaks. A crack that was gunited has shown up again at the drawoff and also at the westerly end at the wing wall.

1955, Oct. 21, E.H. Page and J.O. Harmaala, Insp. Repairs have been completed. Some leakage through the core, but two major leaks are

at the ends. Water is coming around or under the ends. Top looks excellent.

1956 Report to Co. Comm. LePage's concrete dam, south of Essex Street, was repaired by the gun method of placing concrete. This strengthened the dam considerably, but failed to stop all the leaks. The largest leak is at the westerly end where the water is piping through under the concrete slab between counterforts. This water may be coming under the dam or around the end. Cracks that were gunited have shown up again at the drawoff and also at the westerly end at the wingwall.

1958, Jan. 29, E.H. Page, & A.A., Insp. Elev. of water: 0.1 over spillway. Culvert opening below dam plugged almost solid with leaves. I removed a 5 gallon paint bucket from the opening.

1958, Dec. 30, E.H. Page & K.M. Jackson, Insp. Elev. of water: 8" below No flashboards. Condition: Fair. There is still a lot of seepage through the conc. Entrance to culvert below dam has some debris that should be cleaned.

1958 Report to Co. Comm. At LePage's concrete dam, south of Essex Avenue, water is leaking through the concrete as previously reported. The largest leak is at the westerly end where water is piping through under the concrete slab between counterforts. This water may be coming under the dam or around the end. Cracks that were gunited have shown up again at the drawoff gate and at the westerly end at the wingwall.

1961, January 12, E.H. Page & P.D. Killam, Insp. Elev. of water: 2" below spillway. Leaks: Same. Condition: Same.

1960 Report to Co. Comm. At LePage's concrete dam, south of Essex Street, water is leaking through the concrete as previously reported. The largest leak is at the westerly end where water is piping through under the concrete slab between counterforts. This water may be coming under the dam or around the end. Cracks that were gunited have shown up again around the drawoff gate and at the westerly end of the wingwall.

1962, Dec. 17, K.M. Jackson, Insp. Owner: Johnson & Johnson, Inc. No repairs since last inspection. Elev. of water: About 1' ± below top of dam. Condition: Same as report of 1960.

1962 Report to Co. Comm. At LePage's concrete dam, south of Essex Street, water is leaking through, as previously reported. The largest leak is at the westerly end where water is piping through under the concrete slab between counterforts. This water may be coming under the dam or around the end. They have lowered the water level in this pond.

1964 Dec. 29, P.D.K. & K.M.J., Insp. Water is leaking under concrete slab between counterforts. This dam leaks at various places according to water level.

1964 Report to Co. Comm. Water is leaking under concrete slab between the counterforts. Water level in the pond is 6 feet below the spillway.

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

1966 Report to Co. Comm. A crack in the concrete wall at the easterly embankment is leaking water. Concrete is spalling.

1968 March 26, 1969. P.D.Killam and J. Fitzgerald. There is some spall on the easterly counterfort. No leaks observed today.

APPENDIX C

PHOTOGRAPHS

Note: Location and direction of photographs shown on
Figure B-1 in Appendix B.



NO. 1 UPSTREAM FACE OF DAM FROM LEFT EMBANKMENT



NO. 2 UPSTREAM FACE OF DAM AND LEFT EMBANKMENT

UPPER BANJO POND DAM

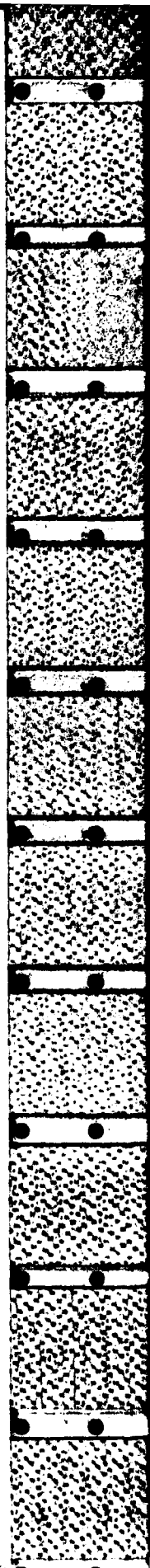


**NO. 3 DOWNSTREAM FACE OF DAM, BAYS
4 THROUGH 7 AND LEFT EMBANKMENT**



NO. 4 SPALLING IN LEFT WALL OF BAY NO. 7

UPPER BANJO POND DAM





NO. 5 SPALLING AND SEEPAGE IN BAY NO. 2



**NO. 6 OUTLET PIPE AND GATE VALVE
STEM IN GATE CHAMBER (BAY NO. 3)**

UPPER BANJO POND DAM



**NO. 7 CONCRETE AND STONE CHANNEL BETWEEN
OUTLET PIPE AND CULVERT UNDER ESSEX AVENUE**



NO. 8 VIEW OF DIKE FROM LEFT ABUTMENT

UPPER BANJO POND DAM

APPENDIX D
HYDROLOGIC AND HYDRAULIC
COMPUTATIONS

I General

Upper Banjo has a limited direct drainage area of about 0.058 mi.² It also receives drainage from Fernwood Lake which has a drainage area of about 0.642 mi.² However, Fernwood has two principle outlets; one over a weir to a brook which runs toward the Annisquam River; the second is via a pipe and irregular overland channel to Upper Banjo Pond. Moreover, at the very high pond levels associated with a Test Flood, Fernwood Lake may be expected to overflow on its southerly end toward Wallace Pond.

The hydraulic analysis will determine Test Flood levels in Fernwood & the associated peak outflow to Upper Banjo. The peak, direct flow to Upper Banjo will be estimated; and adjusted using the S.C.S. T.R. 55 Table 5-3 and an estimated time of concentration; and the result added to the peak rate from Fernwood to Upper Banjo to determine the Test Flood for Upper Banjo. Since Upper Banjo will be at a high elev. dur to direct inflow, no storage reduction will be made to the Test Flood Inflow. Thus: $T.F. Q_{in} = T.F. Q_{out}$

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II FERNWOOD LAKE
Test Flood, Storage & Storage Functions

1- Total Drainage Area - 0.642 mi² (Fernwood Lake)

2- Pond(s) Area:
 Swamp(s) Area: $.055 + .052 + .01 + .01 = 0.127$
Total Area Pond(s) & Swamp(s): 0.127

% Ponds & Swamps = $\frac{0.127}{0.642} = \pm 20\%$

3- $\frac{200 - 91}{5000} = .0218$ } Say Ave Slope = 2.5%

4- Using C. of E. Curves for Peak Flow Rates & above guide values the Peak Flow Rate was estimated to be closer to Flat & Coastal than Rolling and taken at 1750 c.f.s./mi²
 Size Class: Small ; Hazard Pot.: High ; Spill. Des. Flood: 1/2 to Full PMF
 Use: Test Flood = Full PMF

5- Test Flood Inflow = $(1750) 0.642 = 1124$ c.f.s.

6- Pond Storage
 The pond area is .047 sq. mi. at elev. 91.7 (top flashbd)
 Based on a const. area, storage increases at 30.3 ac. feet per foot of depth increase.

7- Spillway crest elev. is 91.7 (top flash boards)

8- Storage Functions are based on $Q_{out} = Q_{in} [1 - \frac{S_{out}}{R}]$
 S_{out} = Storage Vol. in Reservoir related to final Q_{out} in terms of inches of rain over the drainage area.

$S(\text{in Inches}) = 12 D \left(\frac{.0473}{0.642} \right) = 0.885 D$; $R = 6 \text{ hr rain of storm}$
 D = Storage depth in feet above spillway crest in reservoir

9- Storage Functions: (Test Flood & 1/2 PMF - if needed)

$F_{TF} = 1124 - 59.1 S = 1124 - 52.3 D$
$F_{1/2 PMF} = 562 - 59.1 S = 562 - 52.3 D$

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III Fernwood Lake - Discharge Relations

A - Spillway

Assume discharge controlled by 20' long weir & does not exceed capacity of channel. Crest top of flashboards elev. 91.7

Use Williams & Hazen: "Hydr. Tables":

	(90.8)	(91.5)	(92.5)	(93.8)	(94.8)	(92.2)	(92.3)
Pond El.	92	93	94	95	96	94.5	93.5
q	0.58	4.91	11.48	19.73	29.37	15.42	7.96
Q	10	100	230	390	590	310	160

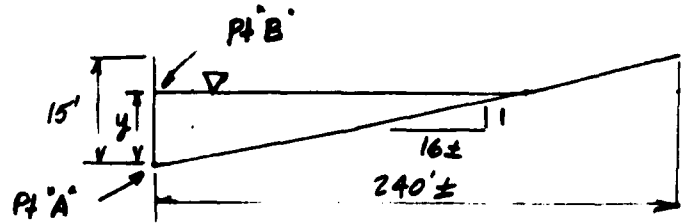
Note: Without flash boards, crest el. is 90.5. Same disch as above but 1.2 ft. lower

B - Outlet to Upper Banjo

L.P. Crest of dike @ el. 92.8 ±, ± 65 ft long. (ignore 8" φ pipe)
 Use $q = 2.7 H^{1.5}$ [ref. "Low Dams" - 1939 edit. - pg 61]

Pond El.	93.0	94	94.5	95	93.5
Q _B	20	230	390	570	100

C - Channel to Upper Banjo



$S = \frac{5}{130}$, $n \approx 0.08$
 $V = 3.65 R^{2/3} \approx 3.65 \left(\frac{H}{2}\right)^{2/3} = 2.34 H^{2/3}$
 Assume Pt. A @ el. 86.6 on M&E survey
 $A = B y^2$

Adj X-Section taken from Topo Dwg at el. 85'

dy	A	V	Q	El. Pt. B'
1'	200	6.7	1345	91.6'
2'	32	3.65	117'	88.6'

By inspection, channel to Upper Banjo should not restrict flow over outlet dike.

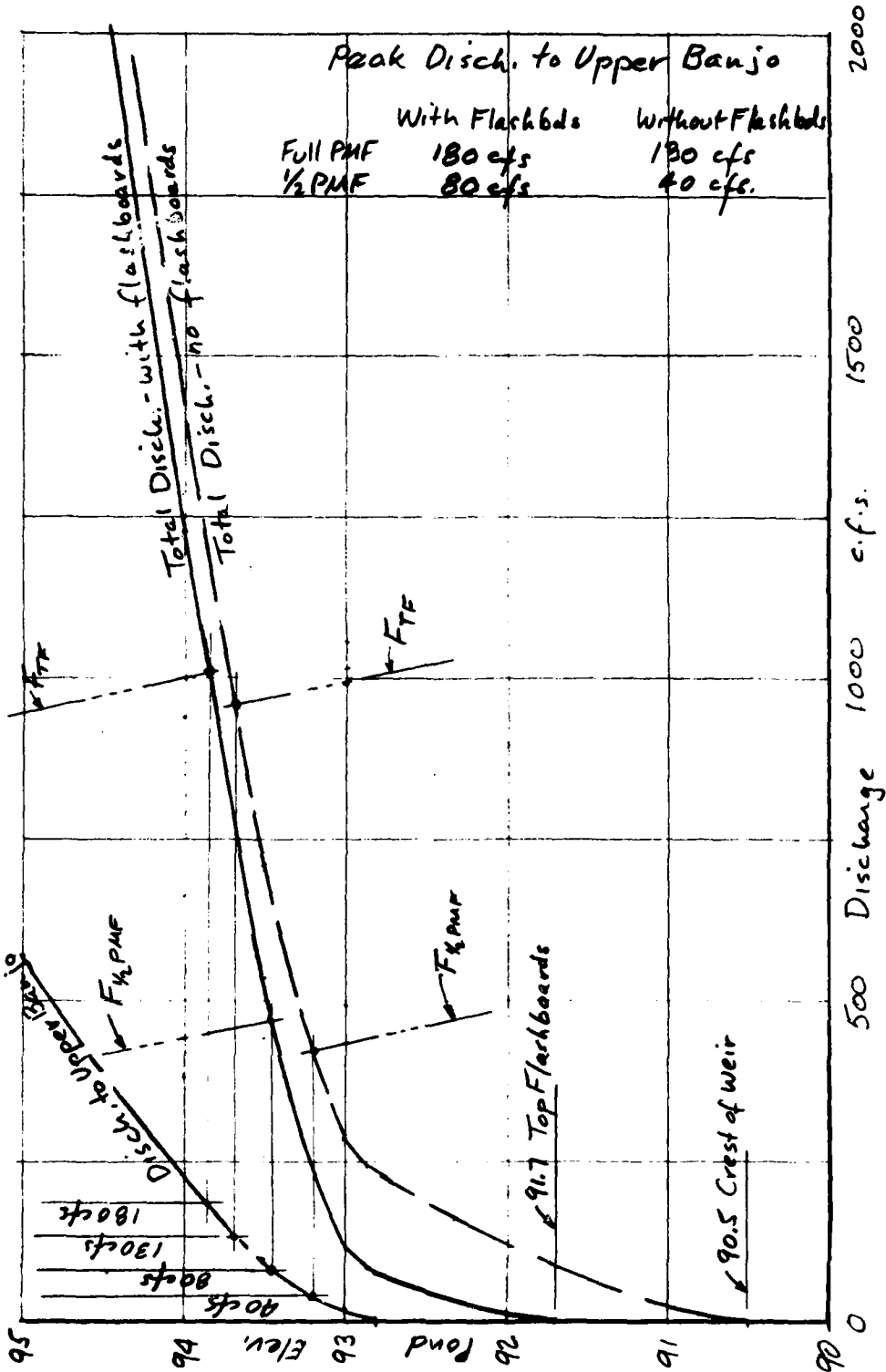
D - Overflow to Wallace Pond (via cutoff section of Fernwood)

Total length ± 300 ft at elev. 93.0. Use $q = 2.55 H^{1.5}$ [Ref. V.T. Chow - p. 52]

Pond El.	94	94.5	95	93.5
Q _D	765	1410	2160	270

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IV Fernwood Lake - Discharge & Storage Funct. vs Pond Eleu.



V Peak Inflow to Upper Banjo Pond.

1- Time of Conc. for Fernwood Lake

[Ref. "Des. of Sm. Dams", Second Ed., pg 71]

$$T_{c1} = \left(\frac{11.9 L^3}{H} \right)^{0.385} = \left(\frac{11.9 (1)^3}{109} \right)^{0.385} = 0.42 \text{ hours} \approx 0.4 \text{ hr.}^*$$

*Act. T_c may be signif. longer due to lake storage. However use $T_T = 0.25 \text{ hr.}$ also

2- Peak Direct Inflow to Upper Banjo

$$S \approx \frac{70}{800} = 8.75\% \quad , \quad \text{PMF} = 3000 \text{ cfs/sg. mi}$$

$$\text{Full PMF} = 3000 (.058) = 174 \text{ cfs}$$

$$\frac{1}{2} \text{ PMF} = \frac{1}{2} (174) = 87 \text{ cfs}$$

$$T_{c2} = \left[\frac{11.9 (.21)^3}{50} \right]^{0.385} = 0.09 \text{ hours} \approx 0.1 \text{ hr.} (T_T = 0)$$

$$S = D 12 \frac{.016}{.058} = 3.26 D \quad ; \quad S = \frac{174}{19} = 9.14$$

$$\therefore F_{TF} = 174 - 29.9 D$$

$$F_{\frac{1}{2} \text{ PMF}} = 87 - 29.9 D$$

3- Combine Fernwood & Direct Flows to Determine Peak Flow Rates

Ref: S.C.S. Tech. Rel. # 55, Table 5-3, to est. effect of T_c 's.

Full PMF

$$\text{With Flashboards: Peak } Q_{in} = 180 + 174 \left(\frac{132}{991} \right) = 203 \text{ cfs.}$$

$$\text{or Peak } Q_{in} = 180 \left(\frac{54}{508} \right) + 174 = 193 \text{ cfs}$$

$$\text{Without Flashboards: Peak } Q_{in} = 130 + 174 \left(\frac{132}{991} \right) = 153 \text{ cfs.}$$

$$\text{or Peak } Q_{in} = 130 \left(\frac{54}{508} \right) + 174 = 100 \text{ cfs.}$$

1/2 PMF

$$\text{With Flashboards: Peak } Q_{in} = 80 + 87 \left(\frac{132}{991} \right) = 92 \text{ cfs.}$$

$$\text{or Peak } Q_{in} = 80 \left(\frac{54}{508} \right) + 87 = 96 \text{ cfs.}$$

$$\text{Without Flashboards: Peak } Q_{in} = 40 + 87 \left(\frac{132}{991} \right) = 52 \text{ cfs.}$$

$$\text{or Peak } Q_{in} = 40 \left(\frac{54}{508} \right) + 87 = 91 \text{ cfs.}$$

VI Upper Banjo - Discharge Relations

A - Spillway

Width 10.6 ft, el. 83.5, Use William's & Hager "Hydr. Tables"

Pond Elev	84	85	86	87	86.5	84.5	85.5
q	1.20	6.09	13.01	21.60	17.10	3.33	9.32
Q_A	10	60	140	230	180	35	100

B - Dam Crest - Length 60.5', el. 84.6, calc. as above

Pond Elev.	85	85.5	86	86.5	87
Q_B	50	170	330	520	740

C - Cap wall Crest - Length 70'±, el. 84.5, calc. as above

Pond Elev.	85	85.5	86	86.5	87
Q_C	80	230	430	650	910

D - Dike Crest Flow - Length 100'±, Ave. el. 84.7, $q = 2.55(H)^{1.5}$

Pond Elev	85	85.5
Q_D	40	150

VII Crest Flow

T.F. Pond El.	85.0
L.P. Crest	84.5
Max H _d	0.5 ft.

From "Hydr Tab." - $q = 1.20$ cfs/ft

As critical flow:

$y_c = 0.35$ ft, $V_c = 3.4$ ft/sec

Note: Crest is concrete lip of dam or top of cap wall. Major impact of flow over crest could be on ground just down stream.

VIII Low Level Outlet

8" ϕ outlet, 90 ft long, ϕ el. 57.7±, Minor loss $\approx 2 h_v$, $h_f \approx .015 \frac{90}{.67} h_v$

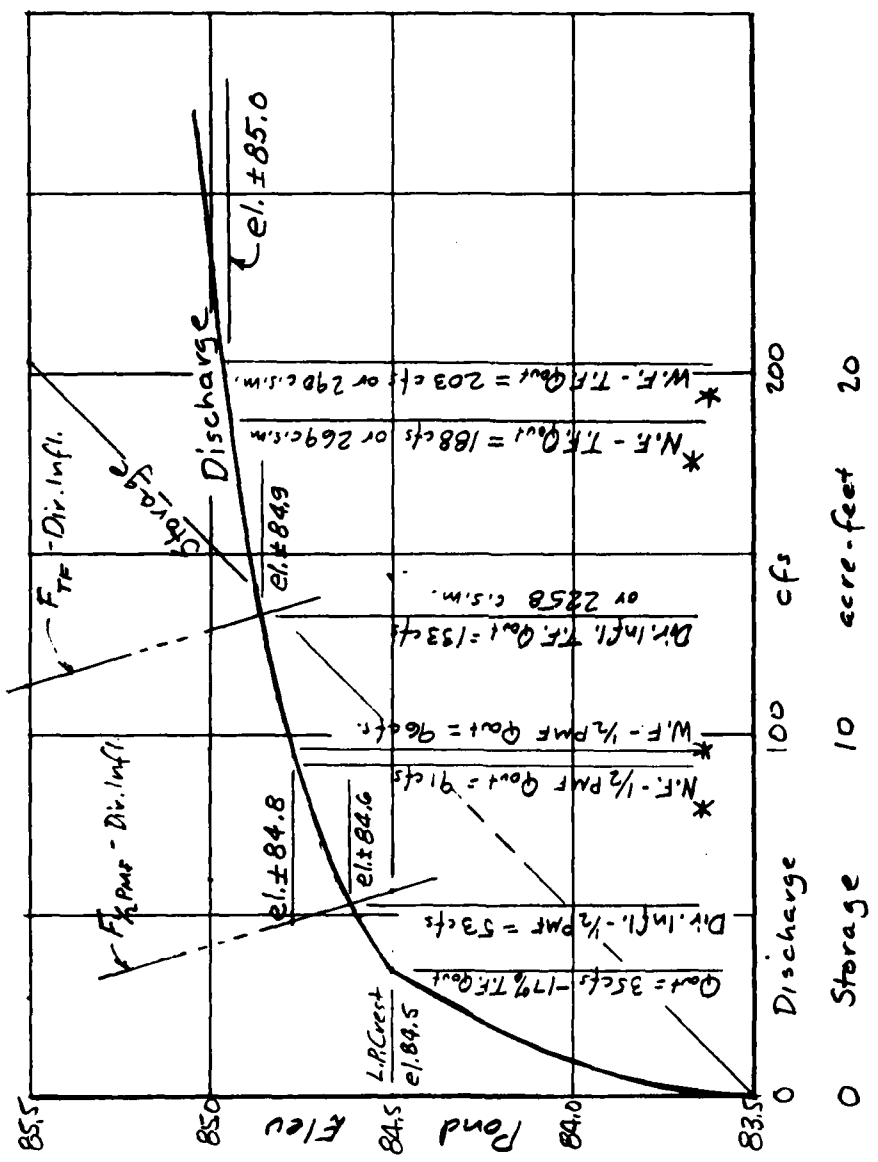
pond surf. el. 83.5, $H = 83.5 - 57.7 = 25.8$ ft

$H = 25.8 = h_v(2 + 2.01)$, $V = 20.35$ fps, $Q = 7.1$ cfs.±

Time to lower 1 ft = $\frac{10.1 \text{ acres} (43560)}{7.1 \text{ cfs} (3600)} = 17.2$ hours

IX Upper Banjo - Discharge, Storage & Storage Function vs. Pond Elev.

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* N.F. = No Flashboards at Fernwood
 * W.F. = With Flashboards at Fernwood

(X) Failure of Dam

Peak Failure Flow:

Pond Elevation - 84.6 (Dam crest)

Toe Elevation - 67.2

$Y_0 = 17.4 \text{ ft.}$

Dam Length Subject to Breaching = 30ft (3 bays)

$W_0 = 40\% () =$

$Q_P = 1.68 W_0 (Y_0)^{1.5} = 1.68 (30) (17.4)^{1.5} \approx 3700 \text{ cfs}$
 Ongoing discharge is $\pm 40 \text{ cfs}$.

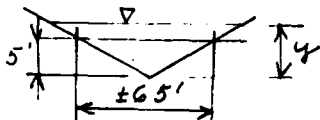
Storage Volume Released:

Storage Above Spillway $1.1 (10.1) = 11.1 \text{ ac. feet}$

Storage Below Spillway $\frac{1}{3} 16.3 (10.1) = 54.9 \text{ " "}$

$S = \text{Total Storage} = 66.0 \text{ " "}$

Channel Hydraulics:



$S = \frac{5}{42}$; $n = 0.05$, $A = 6.5 y^2$, $R \approx \frac{1}{2} y$

$V = \frac{1.49}{.05} (.119)^{1/3} (\frac{y}{2})^{2/3} = 6.48 y^{2/3}$

y	A	V	Q
2	26	10.3	270
5	162.5	18.9	3078
6	234	21.4	5010
1	6.5	6.48	40

Failure of dam, under above assumptions would increase flow depth just distr. from $\pm 1 \text{ ft}$ @ 6.5 fps to $\pm 5.5 \text{ ft.}$ @ 20 fps . Flow would divide at Rte 133, with some continuing straight toward the Lower Banjo Pond and the rest running northerly along Rte 133. Primary impact would be on factory beside Lower Banjo Pond.

Effect on Lower Banjo Pond

$\frac{\text{Storage Released}}{\text{Area Low. Ban. Pd.}} = \frac{66 \text{ ac. ft.}}{6.7 \text{ acres}} = 9.8 \text{ ft increase in depth}$
 Say 9 ft increase in depth (duo to area incr. 7 ft.)

Time to Drain:

$\frac{43560 (66)}{3600 (\frac{1}{2}) (3700)} = 0.43 \text{ Hours, or } 26 \text{ Minutes}$

(XI) Impact of Holding Pond 8 feet Below Spillway Crest

1 - Storage in upper 8 feet of Upper Banjo Pond

Assume surface area \propto to (depth)²

Depth below spillway $\approx 16.3'$
 Area at spillway level ≈ 10.1 acres

Area 8' below spillway level $\approx 10.1 \left(\frac{8.3}{16.3}\right)^2 = 2.62$ acres

Vol. in top 8' $\approx \frac{1}{3} [10.1(16.3) - 2.62(8.3)] = 47.6$ ac.ft.

2 - Rainfall Volumes (FULL PMP)

6 hr. rain - 19 in.
 infiltration, etc. - 0.1 in./hr.
 net runoff depth 18.4 in. or 1.53 ft.

Vol. from area directly trib. to Upper Banjo Pond = $0.058 \text{ mi}^2 \times 640 \times 1.53 = 56.9$ ac. ft.

Vol. from area directly trib. to Fernwood Lake = $0.642 \text{ mi}^2 \times 640 \times 1.53 = 630.0$ ac. ft.

3 - Storage in Fernwood Lake

Surface area - ± 30.3 acres

"Contained" storage above spillway crest =

Without flash b'ds : $(92.8 - 90.5) 30.3 = 69.7$ ac. ft.

With flashboards : $(92.8 - 91.7) 30.3 = 33.3$ ac. ft.

XI (Continued)

4 - PMF Volumes and Runoff Rate vs Time

Hour Ending	Percent of 6 Hr Rain Fallen	Volume of Runoff to:		Runoff Rate from:	
		Upper Banjo (acre feet)	Fernwood	Upper Banjo (cfs)	Fernwood
0	0%	0.0	0.0	55	608
0.5	4%	2.28	25.20	55	608
1.0	8%	4.55	50.40	69	763
1.5	13%	7.40	81.90	82	913
2.0	19%	10.81	119.70	124	1374
2.5	28%	15.94	176.40	413	4573
3.0	58%	33.01	365.40	262	2899
3.5	77%	43.83	485.10	82	913
4.0	83%	47.24	522.90	69	763
4.5	88%	50.09	554.40	55	608
5.0	92%	52.36	579.60	55	608
5.5	96%	54.64	604.80	55	608
6.0	100%	56.92	630.00	55	608

Note: Volumes calculated as in Item 2, runoff = $\frac{\Delta Vol}{Time}$

Although the total volume of actual runoff from such a storm would be similar, it would occur over a longer period of time & have lower peak runoff rates.

(XI) (Continued)

5- Summary

An 8 ft. flood storage volume at Upper Banjo would be almost equal to the total PMF runoff volume from direct inflow - without Fernwood. Since the direct inflow would eliminate the available storage, without developing significant outflow, then the peak discharge at Upper Banjo would be essentially equal to the peak inflow from Fernwood (see item (IV)).

Similar results would occur under a 1/2 PMF flood.

Fernwood Lake does not rise above elev 94 under a full PMF flood. If the dike between Upper Banjo Pond and Fernwood Lake was raised, say, two feet, then Upper Banjo would be cut off from Fernwood. Under this condition, the flood storage volume might be reduced to a lower value. A Phase II analysis of both ponds would be required to establish the necessary increase in dike level and the minimum desirable flood storage volume at Upper Banjo.

METCALF & EDDY, ENGINEERS

APPENDIX E

INFORMATION AS CONTAINED IN THE
NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

STATE	DIVISION	CONGR DIST.	COUNTY	NAME	LONGITUDE (WEST)	LATITUDE (NORTH)	REPORT DATE
MA	195	NED	MA 009 06	UPPER BANJO POND DAM	7041.5	4236.7	DAY MO YR 16 JUL 79

POPULAR NAME	NAME OF IMPROVEMENT
UPPER BANJO POND	UPPER BANJO POND
REGION/BASIN	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE
01 06	TR-ANNISQUAH RIVER
	GLOUCESTER
	POPULATION
	0
	27200

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FEET)	HYDRAULIC HEIGHT (FEET)	IMPOUNDING CAPACITIES (ACRES-FT.)
RECPBG	1908	R	17	17	66

DIST OWM FED R PRV/FED SCS A VER/DATE
NED · N' N N ; N

REMARKS

D/S HAS	SPILLWAY TYPE	MAXIMUM DISCHARGE (CFS)	VOLUME OF DAM (CY)	POWER CAPACITY (KW)	INSTALLED	PROPOSED	NO.	NAVIGATION LOCKS
1	U	11	35	1000				

OWNER	ENGINEERING BY	CONSTRUCTION BY
LEPAGE-PAPERRAFT CORP	AMBURSEN HYDRAULIC CONST	AMBURSEN HYDRAULIC CONST
REGULATORY AGENCY		
DESIGN	CONSTRUCTION	OPERATION
NONE	NONE	NONE
MAINTENANCE		
NONE		

INSPECTION BY	INSPECTION DATE
METCALF AND EDDY INC	DAY MO YR
	20APR79
	PL 92-367
AUTHORITY FOR INSPECTION	

REMARKS

END

FILMED

11-84

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