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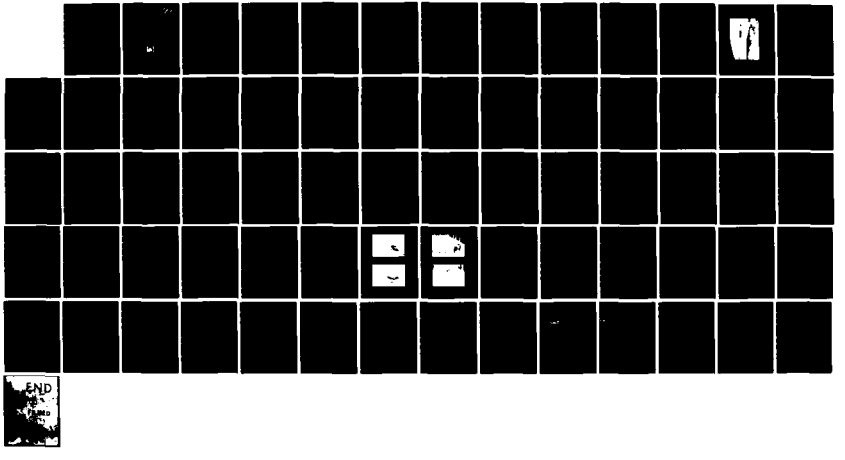

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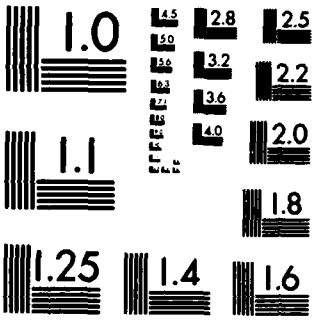
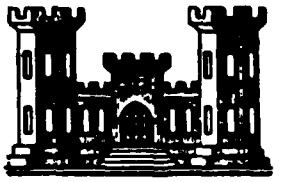


CONNECTICUT RIVER BASIN
COLRAIN, MASSACHUSETTS

KENDALL CO. NO. I DAM
MA 00047

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

JANUARY 1981

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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Connecticut River Basin
Colrain, Massachusetts

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

Kendall Company No.1 Dam is a run of river facility that diverts water into a flume leading to the company's plant. The height of the dam, measured at the abutments of the spillway overflow section, is 24 feet. Based on visual inspection, the dam is judged to be in poor condition. The dam is classified as "Small" in size, with a "Significant" hazard potential. A test flood equal to the ½ PMF was selected.

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

REPLY TO
ATTENTION OF:

NEDED

JUN 16 1981

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

Dear Governor King:

Inclosed is a copy of the Kendall Co. No. 1 Dam (MA-00047) 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, Kendall Company, Griswoldville, MA.

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

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

Sincerely,

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

Incl
As stated

KENDALL COMPANY NO. 1 DAM
MA 00047

CONNECTICUT RIVER BASIN
COLRAIN, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION

PROGRAM

PHASE I INSPECTION REPORT

BRIEF ASSESSMENT

IDENTIFICATION NO: MA 00047

NAME OF DAM: Kendall Company No. 1 Dam

TOWN: Colrain

COUNTY AND STATE: Franklin, Mass.

STREAM: North River

DATE OF INSPECTION: November 11, 1980

Kendall Company No. 1 Dam is a run of river facility that diverts water into a flume leading to the company's plant. Within the river channel there is a rock-filled, timber crib spillway structure 238 feet long. This overflow structure has a topwidth of 5 feet, and it has 2.9-foot high flashboards on its crest. The height of the dam, measured at the abutments of the spillway overflow section, is 24 feet. Intake facilities for the concrete-lined flume are located at the left abutment of the spillway. There is no low-level outlet works for the dam. A wooden training wall and a wood crib abutment retaining structure are located at the right abutment of the overflow section. An earthen dike adjoins this abutment and extends upstream along the right bank of the river for a distance of about 1200 feet. The top of the dike is at approximately the same level as the abutments of the overflow section. The dike has a maximum height of about 9 feet, and it is breached at one location. A channel through the breach leads from the West Branch North River, upstream from the dam, to North River downstream from the dam.

Based on visual inspection, the dam is judged to be in poor condition. The major concerns with respect to the integrity of the dam are deterioration of the wood crib abutment structure at the right end of the overflow section; trees growing in the wood crib abutment structure, on the upstream and downstream sides of the right abutment and on the dike; hazards resulting from the existing breach in the dike; lack of adequate erosion protection on the bank of the downstream channel near the left abutment; trees growing on the

strip of ground between the dry stone masonry wall, on the left side of the downstream channel, and the right side of the concrete-lined flume on the left side of the valley; and lack of a low-level outlet for the dam.

Based on the Recommended Guidelines for Safety Inspection of Dams, prepared by the Corps of Engineers, the dam is classified as "small" in size, with a "significant" hazard potential. A test flood equal to one-half the Probable Maximum Flood (1/2 PMF) was selected for the analysis performed for this report. Hydraulic analysis indicates that with pool level at the top of the dam, the spillway capacity is 13,370 cfs when the flashboards are in place, and 22,630 cfs when the flashboards are removed. The spillway capacities listed above are, respectively, about 22 percent and 38 percent of the routed test flood outflows. The depths of overtopping of the dam and dike that would occur during the test flood are 4.2 feet with the flashboards in place, and 3.5 feet with the flashboards removed.

It is recommended that the owner engage a professional engineer experienced in the design of dams to perform more detailed hydrologic and hydraulic analyses, determine whether the dike should be repaired or removed, design erosion protection along the left bank of the downstream channel, investigate the condition of the overflow section of the dam, and provide a low-level outlet or other means of drawing down the pool level. In addition, the Owner should make necessary repairs for the deficiencies listed above and should also implement the remedial measures described in Paragraph 7.3.

The measures outlined above, and discussed in detail in Section 7, should be implemented within one year after receipt of this Phase I Inspection Report.

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.

Houghton R. Hallock, P.E.

F. James Knight, P.E.
Assistant Vice President
Project Manager

This Phase I Inspection Report on Kendall Co. No. 1 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 judgement and practice, and is hereby submitted for approval.

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

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

ARAMAST MAHTESIAN, CHAIRMAN
Geotechnical Engineering Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in 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 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.

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

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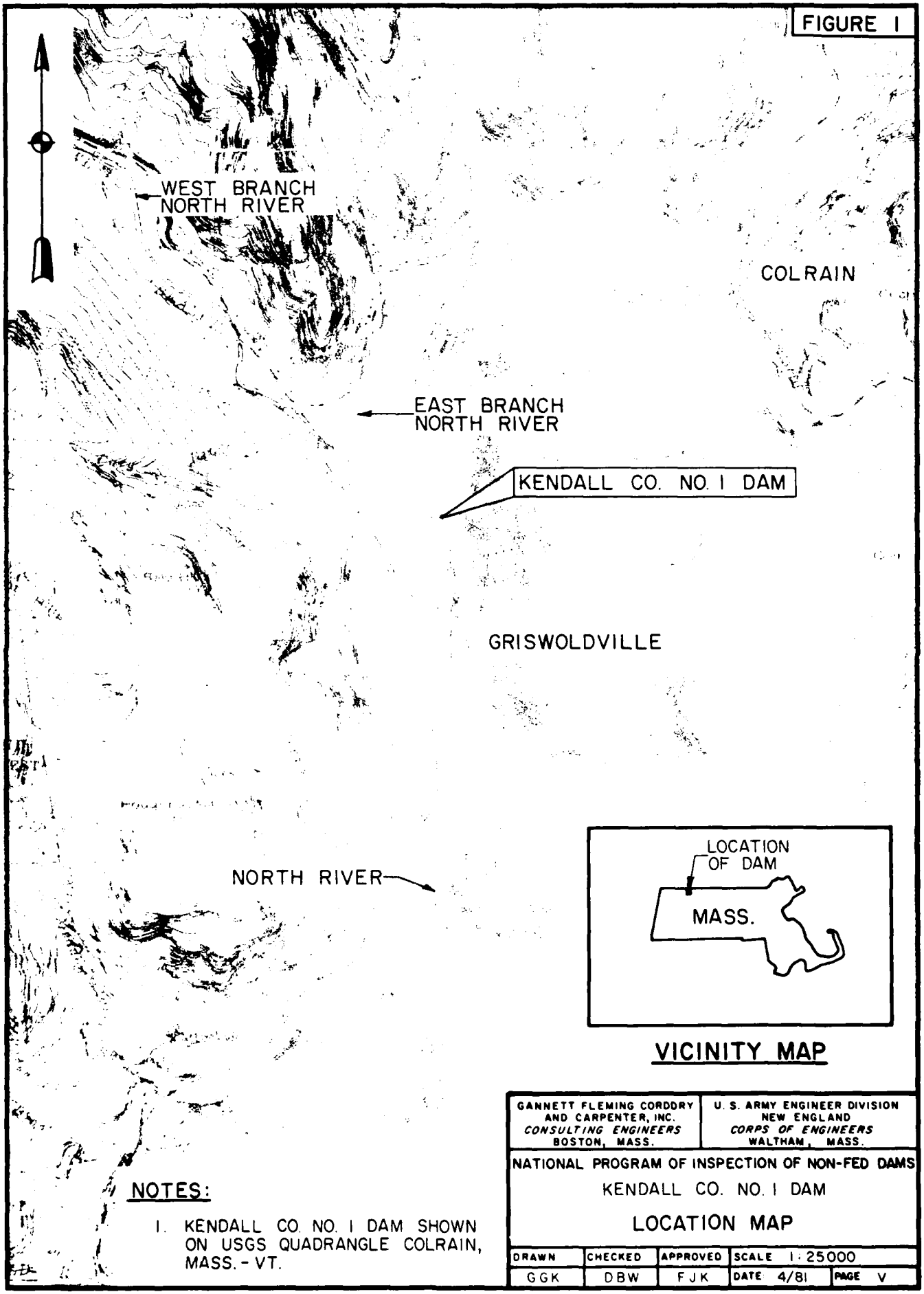
KENDALL COMPANY NO. 1 DAM

Overview

FIGURE 1



VICINITY MAP

GANNETT FLEMING CORDDRY AND CARPENTER, INC. CONSULTING ENGINEERS BOSTON, MASS.	U. S. ARMY ENGINEER DIVISION NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

KENDALL CO. NO. 1 DAM

LOCATION MAP

DRAWN	CHECKED	APPROVED	SCALE 1:25000	
GGK	DBW	FJK	DATE 4/81	PAGE V

NOTES:

1. KENDALL CO. NO. 1 DAM SHOWN ON USGS QUADRANGLE COLRAIN, MASS. - VT.

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
KENDALL COMPANY NO. 1 DAM

SECTION 1

PROJECT INFORMATION

1.1 General.

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspections throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility for supervising the inspection of dams within the New England Region. Gannett Fleming Corddry and Carpenter, Inc., has been retained by the New England Division to inspect and report on selected dams in the States of Massachusetts and Vermont. Contract No. DACW33-81-C-0013 dated November 3, 1980, has been assigned by the Corps of Engineers for this work.

b. Purpose. The purpose of the inspection and evaluation of non-Federal dams is to accomplish the following:

(1) 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 quickly initiate effective dam safety programs for non-Federal dams.

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

1.2 Description of Project.

a. Location. The dam is located on North River and lies entirely within the Town of Colrain, Franklin County, Massachusetts. North River is a tributary of Deerfield River, which, in turn, drains to the Connecticut River. The dam is shown on USGS Quadrangle Colrain, MASS.-VT., at latitude N 42°39'44" and longitude W 72°42'58". The location is shown on Figure 1 on page v.

b. Description of Dam and Appurtenances. Kendall Company No. 1 Dam is a run of river facility that creates the head necessary for diversion of water through a flume to the company's plant. Details of the dam are shown on Figure 2 in Appendix B, on the Overview Photograph, and on the photographs in Appendix C.

Within the river channel there is a rock-filled, timber crib spillway structure about 238 feet long and 24 feet high, measured at the abutments (Photo 2). This overflow structure has a topwidth of 5 feet and side slopes of 1V on 1H. It is topped by flashboards that are 2.9 feet high. The flashboards are reportedly damaged by ice each year, and are replaced by the Kendall Company each spring.

At the left abutment of the overflow section, there are intake facilities for a flume (Photo No. 1). The intake facilities consist of a wood frame building that straddles the flume and houses the operating mechanisms for the intake gates. The flume itself is located along the left bank of the river and is partially lined with concrete.

At the right abutment of the overflow section is a wooden training wall and a wood crib, abutment retaining structure (Photo Nos. 3, 4 and 5). The cribbing appears to be filled with earthen material. An earthen dike adjoins the right abutment of the overflow section. The dike has a maximum height of about 9 feet and a length of about 1,200 feet. It extends upstream from the abutment of the overflow section along the right bank of the river to an area of high ground. The top of the dike is approximately at the level of the abutment at the right end of the overflow section. The dike is overgrown with brush and trees, and there is one area where the dike has been breached, probably as a result of overtopping. The bottom of the breach is about 20 feet wide. There is an overgrown, irregular channel that runs through the breach. It leads from the West Branch North River, upstream from the dam, to North River downstream from the dam. There are extensive deposits of river sands and gravels in the channel. Water would begin flowing through the breach when the pool level rises about 5 feet above the top of the flashboards.

c. Size Classification. Size classification is determined in accordance with Corps of Engineers guidelines and is based on either height or storage capacity, whichever gives the larger size category. Kendall Company No. 1 Dam has a maximum height of 24 feet and a maximum storage capacity of 378 acre-feet. By virtue of its storage capacity, Kendall Company No. 1 Dam meets the requirements for a "small" size dam.

d. Hazard Classification. The valley downstream from the dam is broad and has a gentle gradient. Failure of the dam could result in flooding of the mill and adjacent dwellings. It is likely that this flood could result in significant property damage and possible loss of a few lives. Accordingly, the dam has been placed in the "significant" hazard category.

e. Ownership. The dam is owned by the Kendall Company, Griswoldville, Massachusetts. Mr. Fay Gammell (413-624-3456) granted permission to enter the property and inspect the dam.

f. Operator. The dam is operated by personnel from the Kendall Company.

g. Purpose of Dam. Water from Kendall Company No. 1 Dam is used as process water in the manufacture of products at the Kendall Company's mill.

h. Design and Construction History. The dam was reportedly constructed about 1930. There are no records available concerning its design or construction.

i. Normal Operational Procedures. The flume intake gates are reportedly operable. The gates are normally open to divert water via the flume to the Kendall Company's mill. The spillway flashboards are replaced annually. There is no low level outlet.

1.3 Pertinent Data.

a. Drainage Area. The drainage area for Kendall Company No. 1 Dam is approximately 105 square miles. The area is mountainous, and most of the watershed is forested.

b. Discharge at the Dam. Outlet facilities of the dam are comprised of the gated outlet and flume on the left abutment (Photo No. 1) and the spillway overflow section (Photo No. 2). No low level outlet exists. A portion of the normal discharge enters the flume through the intake structure, while the remaining normal discharge flows over the ungated, 238-foot long spillway section. Flashboards 2.9 feet high are maintained on the spillway during as much of the year as flow and ice conditions permit. The flashboards are reportedly damaged each winter by ice flow and are replaced following spring floodflows. With water level at the top of the abutment sections, the spillway can discharge 13,370 cfs with the flashboards in place and 22,630 cfs with the flashboards removed. The maximum capacity of the flume is estimated to be about 100 cfs.

c. Elevation (feet above NGVD).

(1) Streambed at toe of dam - 500.0
(2) Bottom of cutoff - unknown
(3) Maximum tailwater - 514.0
(4) Normal pool (top of flashboards) - 517.2
(5) Full flood control pool - not applicable
(6) Spillway crest - 514.3
(7) Design surcharge (original design) - unknown
(8) Top of dam - 524.1
(9) Test flood pool (flashboards removed) - 527.6
(10) Test flood pool (flashboards in place) - 528.3.

d. Reservoir (length in feet).

(1) Normal pool - 1500
(2) Flood control pool - not applicable
(3) Spillway crest pool - 1400
(4) Top of dam - 3000
(5) Test flood pool - 3300

e. Storage (acre-feet).

(1) Normal pool (flashboard crest) - 84
(2) Flood control pool - not applicable
(3) Spillway crest pool - 52
(4) Top of dam - 378
(5) Test flood pool - 560

f. Reservoir Surface (acres).

(1) Normal pool (flashboard crest) - 13
(2) Flood control pool - not applicable
(3) Spillway crest - 11
(4) Test flood pool - 47
(5) Top of dam - 47

g. Dam and Dike.

		Dam	Dike
(1)	Type	Rockfilled, wood crib	Earthen embankment
(2)	Length	250 feet	1200 feet
(3)	Height	24.1 feet	9 feet
(4)	Topwidth	5 feet	5 feet
(5)	Side slopes	1V on 1H	1V on 2H
(6)	Zoning	Not applicable	Unknown
(7)	Impervious Core	None	Unknown
(8)	Cutoff	Unknown	Unknown
(9)	Grout curtain	Unknown	Unknown
(10)	Other	not applicable	20-foot wide breach at one location.

h. Diversion and Regulating Tunnel. Not applicable.

i. Spillway.

(1) Type - overflow weir with 2.9-foot high flashboards
(2) Length of weir - 238 feet
(3) Crest elevation - 514.3
(4) Flashboard elevation - 517.2
(5) Gates - none

i. Spillway. (Cont'd.)

(6) Upstream channel-natural sand and gravel streambed
(7) Downstream channel-natural sand and gravel streambed

j. Regulating Outlets. None.

SECTION 2

ENGINEERING DATA

2.1 Design Data. No engineering data, design drawings or records are known to exist for Kendall Company No. 1 Dam.

2.2 Construction Data. No construction records are available.

2.3 Operation Data. No operating records are available.

2.4 Evaluation of Data.

a. Availability. There are no engineering data available for this dam.

b. Adequacy. Not applicable.

c. Validity. Not applicable.

SECTION 3

VISUAL INSPECTION

3.1 Findings.

a. General. The Phase I inspection of the Kendall Company No. 1 Dam was performed on November 11, 1980. A copy of the inspection checklist is included in Appendix A. A summary of the results of the inspection is included in Appendix B (Figure 3). Photographs taken during the inspection are in Appendix C.

b. Dam. The dam is located at the left edge of the floodplain of the North River. The floodplain itself is about one-quarter mile wide at the location of the dam. Bedrock is exposed above the east side of the highway (Photo No. 2), which is adjacent to the left (east) abutment of the dam, but it is not possible to determine on the basis of the visual inspection alone whether the left abutment of the dam is bedrock or soil. The presence of sand and gravel deposits in the channel immediately downstream of the dam, and the absence of bedrock exposures in the channel, make it appear likely that the dam is founded on soil.

No seepage was observed at either the right or the left abutments. The presence of tailwater at the downstream toe of the dam made it impossible to determine whether any seepage was discharging through the foundation of the dam. The overflow structure itself is in fair condition. There are a few rotted and broken members, but overall the structure is intact. The flashboards atop the overflow section are in good condition.

The right abutment of the overflow section is in poor condition. A wood crib abutment retaining structure adjacent to the wooden training wall at the right abutment is almost completely rotted (Photo No. 3). The soil fill in the cribbing has subsided as much as 3 feet, and large sumac trees are growing out of the cribbing immediately adjacent to the training wall on both the upstream and downstream sides of the abutment. There is a large, decaying stump near the upstream end of the training wall. A dike extends westward from the right end of the overflow section (Photo Nos. 6 and 7). The dike is about 1,200 feet long and it is completely overgrown with brush and mature trees. The top of the dike is at approximately the same elevation as the abutment of the overflow section. The dike is breached at one location, apparently the result of overtopping in the past. The bottom of the breach is about 20 feet wide. It is estimated that flow through the breach would occur when pool levels rose to about 5 feet above the flashboard level. The channel through the breach in the dike leads from the West Branch North River,

upstream from the dam, to the North River downstream of the dam (Photo No. 4). No water was flowing in this channel at the time of the inspection, but extensive deposits of river sands and gravels were visible in the channel. The channel is very irregular and overgrown with thick brush and many trees. The section that would act as a hydraulic control for the channel could not be identified during the visual inspection because of the brush and trees. Discharge capacity of the channel could vary significantly due to shifting controls caused by sedimentation and due to substantial obstruction by debris, but it is estimated that its capacity is small compared to the spillway capacity. The channel discharges into the North River immediately adjacent to the toe of the dam at the right abutment (Photo No. 4) and, although there is no evidence of erosion at the toe of the right end of the dam, it would appear that such erosion could occur, and that it would threaten the stability of the right abutment of the dam if it did occur.

c. Appurtenant Structures. There is a wood frame gate house at the left end of the dam for the purpose of controlling the flow of water into a concrete-lined flume (Photo No. 1), which carries water along the left bank of the downstream channel to the Kendall Company's industrial plant. The gate house appears to be in fair condition, and the gates were reported to be operable. There are many trees growing on the narrow strip of ground between the right side of this concrete-lined channel and the left bank of the North River. If one of the trees were to fall over and cause a rupture in the concrete channel lining, it could initiate erosion on the left bank of the downstream channel of the North River, which, in turn, could threaten the stability of the left abutment of the dam. A dry stone masonry wall which retains the left bank of the North River next to the concrete-lined flume appears to be in fair condition, but is susceptible to erosion during floodflow. There is no low-level outlet for the dam, so there is no means of drawing the pool level down for inspection, repairs, or during emergency situations.

d. Reservoir Area. Sediment has accumulated against the upstream side of the dam to an unknown depth. The effect of the earth pressures produced by the accumulated sediments on the stability of the timber crib dam cannot be evaluated because of the lack of information about the details of the cross section of the dam and the depth of sediment.

e. Downstream Channel. The bottom of the downstream channel is sand and gravel. As noted in Paragraph 3.1c, the dry stone masonry retaining wall on the left side of the channel immediately downstream of the dam does not appear to provide adequate erosion protection for the dam and the adjacent abutment. Trees growing along the wall in the strip of ground between the wall and the concrete lined flume are a potential problem, should they fall over and rupture the concrete-lined flume or initiate a failure of the dry stone masonry wall.

3.2 Evaluation. On the basis of the visual inspection, the dam is judged to be in poor condition. Timber cribbing, which is an integral part of the right abutment of the overflow section, is almost completely rotted and the soil in the cribbing has subsided as much as 3 feet. Trees are growing out of this timber cribbing and also on the soil slopes of the upstream and downstream sides of the abutment. If the timber crib abutments fail, the wooden training wall along the abutment will also fail, and the dam is likely to be breached. If one of the trees growing on the abutment falls over and pulls out its root structure, or if one of the trees dies and its roots rot, a serious seepage or piping problem might develop. The wood-plank facing of the overflow section has degraded and failed in several places. While it was not possible to observe many portions of the timber crib dam, it could be inspected at some locations and was observed to be in a state of partial decay. The internal structure of the overflow section and its condition are unknown, but should be considered questionable.

The dike that extends upstream from the right abutment of the overflow section is in poor condition. The dike is overgrown with brush and trees, which could seriously affect the stability of the dike. Although the dike is already breached at one location, the dike still has significant effect on ponding of water during large floods. A recurrence of a large flood could cause further failure of the dike, which might result in release of enough water to cause damage downstream. In addition, flow of water through the breach could cause erosion at the downstream toe of the overflow section, which might result in failure of the dam.

The lack of the adequate erosion protection on the left abutment of the downstream channel could result in erosion and failure of the left abutment during floodflows over the dam.

Trees growing on the strip of ground between the left bank of the downstream channel and the right side of the concrete-lined flume, on the left side of the valley, could cause serious erosion problems if they fall over and pull out their roots.

The lack of a low-level outlet is unsatisfactory. Provisions are needed to allow the pool to be drawn down for inspection, repairs, or during emergency situations.

The above findings indicate that the dam is in poor condition and that there are deficiencies which require attention. Recommended measures to improve these conditions are stated in Section 7.

SECTION 4

OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures.

a. General. There are no formal operating procedures for Kendall Company No. 1 Dam. Water is released from the reservoir through the gated outlet structure and is conducted to the firm's industrial plant via the flume situated along the left bank of the North River. Reportedly, the gates are operated frequently.

b. Description of any Warning System in Effect. There is no formal warning system for Kendall Company No. 1 Dam.

4.2 Maintenance Procedures.

a. General. It is reported that the flashboards on top of the dam are damaged and removed by ice annually. Because the flashboards are essential to the facilities' operation, they are replaced each spring. It was also reported that damaged portions of the wood structure are replaced on a regular basis. No new plank facing or timber sections were observed during the inspection.

b. Operating Facilities. The only operating mechanisms are the gates on the release facility. They are reportedly maintained on a regular basis. There is no low-level outlet.

4.3 Evaluation. Although personnel from Kendall Company's industrial plant visit the dam regularly, the maintenance program is not adequate. There is no regular program of technical inspection nor is there a written warning system. Several elements of the dam are in need of attention. This situation is undesirable considering the dam is in the "significant" hazard category. These programs should be implemented by the owner as recommended in Paragraph 7.3.

SECTION 5

EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General. Kendall Company No. 1 Dam has a drainage area of about 105 square miles. The watershed area is mountainous, mostly wooded, and mostly undeveloped. There are no upstream dams or lakes within the watershed that would significantly affect flood flows at Kendall Company No. 1 Dam.

The dam is a run of river facility with a dike that extends upstream along the right bank. Within the river channel there is a rock-filled, timber crib spillway structure 238 feet long. The dam, measured at its abutments, has a maximum height of 24 feet. The top width of the spillway section is about 5 feet. Flashboards, 2.9 feet high, are normally in place atop the spillway. The abutments of the dam and the top of the dike are about 9.8 feet higher than the crest of the spillway.

The dike that adjoins the right end of the overflow section is about 1,200 feet long and has a maximum height of about 9 feet. The dike is breached at one location. The bottom width of the breach is about 20 feet, and it was estimated that flow through the breach would begin when the pool level reached an elevation about 5 feet higher than the top of the flashboards. The channel that passes through the breach is irregular and overgrown with trees and brush. Although sedimentation that was observed in the channel indicates that some floodflow goes through the breach, the discharge capacity of the channel is very small compared to the spillway capacity. For that reason, flow through the breach was not considered in the hydraulic analysis. The flow that would occur overtop of the dike was included in the analysis to determine the maximum depth of overtopping for the dam.

There is a flume intake located at the left end of the dam. The capacity of the flume is small compared to the spillway capacity, so its effects are minor and were not included in the analysis. The hydrologic and hydraulic computations performed for this report are in Appendix D.

5.2 Design Data. There are no hydrologic or hydraulic design data for the dam.

5.3 Experience Data. There are no records of the maximum discharge at the site.

5.4 Test Flood Analysis. Kendall Company No. 1 Dam is in the "small" size category and in the "significant" hazard category. In accordance with Corps of Engineer guidelines, a spillway design flood ranging between the 100-year flood and the one-half Probable Maximum Flood (1/2 PMF) should be used to

evaluate the spillway. In the following analysis, the 1/2 PMF was used as the test flood. The analysis considered two cases: (1) flashboards in place; and (2) flashboards removed. The test flood (1/2 PMF) inflow of 60,375 cfs is based on a watershed area of 105 square miles in mountainous terrain. Spillway rating curves were developed for both cases, and the test flood was routed through the reservoir in accordance with Corps of Engineer Guidance for Estimating Effect of Surcharge Storage on Maximum Probable Discharges. The routings were started with the pool level at the spillway crest or at the top of the flash-boards, as applicable. For the case with flashboard in place, the routed test flood outflow was determined to be 59,800 cfs. For the case with flashboards removed, the routed test flood outflow was 60,000 cfs. The corresponding maximum spillway capacities for the two cases are 13,370 cfs (flashboard in place) and 22,630 cfs (flashboards removed). Those capacities are, respectively, about 22 percent and 38 percent of the routed test flood outflows. The depths of overtopping during the test flood are 4.2 feet with the flashboards in place and 3.5 feet with the flashboards removed.

5.5 Dam Failure Analysis. The impact of failure of the dam was assessed using the Rule of Thumb Guidance for Estimating Downstream Dam Failure Hydrographs, as prepared by the Corps of Engineers. The breach discharge was estimated with the pool level at the top of the dam and a breach width equal to 40 percent of the mid-height length of the overflow section. The effects of failure of the dike were not considered in the analysis. The downstream hydrograph is the sum of the breach discharge and the remaining spillway discharge. Both cases, with and without flashboards, were checked. The downstream river stages were estimated using two reaches. Pre-failure and post-failure discharges and river stages were determined at the location of the primary damage center, which consists of industrial buildings and dwellings in Griswoldville. For the case with flashboards in place, the pre-failure discharge was 13,370 cfs, and the pre-failure river stage was 10.2 feet above streambed. After failure, the discharge at the damage center was 22,785 cfs, and the river stage was 13.1 feet above streambed. For the case with the flashboards removed, the pre-failure discharge was 22,630 cfs, and the pre-failure river stage was 12.8 feet. After failure, the discharge at the damage center was 28,830 cfs, and the river stage was 14.3 feet above streambed. At the damage center, it was estimated that damages would start when the river stage reached about 11 feet which is the approximate floor level of the lowest industrial building. The analysis showed that depths would increase as a result of dam failure, and accordingly, failure would cause an increase in property damage. Some buildings that would not be flooded without failure could be flooded during failure. Buildings that would be affected include the Kendall Company buildings and approximately 10 nearby dwellings. Generally, it

is estimated that flooding depths would be in the range of one to three feet. It was judged that a few lives could be lost as a result of dam failure. For this reason, the dam has been placed in the "significant" hazard category. The probable flood impact area is shown in Appendix D (Figure 5).

SECTION 6

EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations. Wooden cribbing adjacent to the wooden training wall at the right end of the dam is almost completely rotted. The soil fill in the cribbing has subsided as much as 3 feet, and large sumac trees are growing out of the cribbing immediately adjacent to the training wall. In addition, there are other trees close to the training wall on both the upstream and downstream sides of the abutment, and there is a large, decaying stump near the upstream end of the training wall.

The dike that extends westward from the right end of the overflow section is in poor condition. It is completely overgrown with brush and mature trees, which will result in further deterioration of the dike in the future. Although the dike is already breached at one location, the dike still can have significant effect on ponding of water during large floods. A recurrence of a large flood could result in further erosion at the breach and failure of a large portion of the dike. The consequence of such a failure could be release of enough water to cause damage in downstream areas. Even if the dike did not suffer further failure, flow of water in the channel through the breach could threaten the stability of the right abutment of the overflow section, because the channel discharges into the North River immediately adjacent to the toe of the structure.

There are many trees growing along the narrow strip of ground between the right side of the concrete-lined flume, which carries water to an industrial plant, and the left bank of the North River. If one of these were to fall over and cause a rupture in the concrete flume lining, it could initiate erosion of the left bank of the North River, which could threaten the stability of the left abutment of the dam. A dry stone masonry wall, which retains the left bank of the North River channel next to the concrete-lined flume, appears to be in fair condition but is susceptible to erosion during floodflow.

6.2 Design and Construction Data. No design and construction data are available.

6.3 Post-Construction Changes. Other than the reported annual replacement of damaged flashboards, no post-construction change records are available.

6.4 Seismic Stability. This dam is in Seismic Zone 2 and in accordance with the Phase I guidelines does not warrant seismic analysis.

SECTION 7

ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment.

a. Condition. The visual examination indicates that the dam is in poor condition. The major concerns with respect to the integrity of the dam are:

(1) Deterioration of the wood crib abutment structure adjacent to the wooden training wall at the right end of the overflow section.

(2) Trees growing in the wood crib abutment structure, on the upstream and downstream sides of the right abutment, and on the dike, which might cause a seepage and piping failure of the dam if one of the trees should fall over and pull out its roots, or if a tree dies and its roots rot.

(3) The existing breach in the dike, which could be enlarged by erosion during large floods and result in failure of a large portion of the dike, or which could result in erosion and failure of the right abutment of the overflow section.

(4) Lack of adequate erosion protection on the bank of the downstream channel near the left abutment, which could lead to erosion and failure of the abutment.

(5) Trees growing on the strip of ground between the dry stone masonry wall, on the left side of the downstream channel, and the right side of the concrete-lined flume on the left side of the valley. If one of these trees should fall over, it could break the concrete flume lining or the dry stone masonry wall and, in either case, lead to erosion of the left abutment of the dam.

(6) Lack of a low-level outlet or other means for drawing down the pool level for inspection, repairs, or during emergency situations.

Hydraulic analysis indicates that with pool level at the top of the dam, the spillway capacity is 13,370 cfs when the flashboards are in place, and 22,630 cfs when the flashboards are removed. The test flood for the dam is the 1/2 PMF. The spillway capacities listed above are, respectively, about 22 percent and 38 percent of the routed test flood outflows. The depths of overtopping that would occur during the test flood are 4.2 feet with the flashboards in place, and 3.5 feet with the flashboards removed.

b. Adequacy of Information. The available information is such that the assessment of this dam must be based primarily on the results of the visual inspection.

c. Urgency. The owner should implement the recommendations in Paragraphs 7.2 and 7.3 within one year after receipt of this Phase I report.

7.2 Recommendations. The following investigations and needed corrections should be carried out under the direction of a registered professional engineer qualified in the design and construction of dams:

(1) Perform more detailed hydrologic and hydraulic analyses to determine the spillway adequacy.

(2) Perform investigations to determine whether the dike should be repaired or removed to eliminate the hazards that exist due to the present condition of the dike. If the dike is removed, measures should be designed to protect remaining portions of the dam from erosion during floods.

(3) Design erosion protection adequate to protect the dam along the left bank of the downstream channel.

(4) Investigate the condition of the overflow section of the dam. This could be done most effectively during low flow conditions when this structure could be observed more fully than at the time of inspection.

(5) Provide a low-level outlet or other means for drawing down the pool level.

7.3 Remedial Measures.

a. Operating and Maintenance Procedures. The owner should:

(1) Clear trees from the strip of land between the left bank of the downstream channel and the right side of the concrete-lined flume on the left side of the valley.

(2) Visually inspect the dam and appurtenant structures once a month.

(3) Engage a registered engineer qualified in the design and construction of dams to make a comprehensive technical inspection of the dam once every year.

(4) Establish a surveillance program for use during and after heavy rainfall and also a downstream warning and emergency operations program to follow in case of emergency.

7.4 Alternatives. There are no practical alternatives to the above recommendations.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Kendall Co. No. 1 Dam
MA 00047

DATE November 11, 1980

TIME p.m.

WEATHER Partly cloudy, 35° F., windy

W.S. ELEV. 517.4 U.S. 504 DN.S.

PARTY:

1. F. James Knight (GFCC)
2. Ronald Hirschfeld (GEI)
3. Dennis Mehue (BAI)
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Geotechnical	Hirschfeld	
2.	Physical/Hydrology	Knight	
3.	Dimensional	Mehue	
4.			
5.			
6.			
7.			
8.			
9.			
10.			

PERIODIC INSPECTION CHECKLIST

PROJECT Kendall Co. No. 1 Dam MA DATE November 11, 1980

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT	No embankment
Crest Elevation	
Current Pool Elevation	
Maximum Impoundment to Date	
Surface Cracks	
Pavement Condition	
Movement or Settlement of Crest	
Lateral Movement	
Vertical Alignment	
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	
Indications of Movement of Structural Items on Slopes	
Trespassing on Slopes	
Sloughing or Erosion of Slopes or Abutments	
Rock Slope Protection - Riprap Failures	
Unusual Movement or Cracking at or Near Toe	
Unusual Embankment or Downstream Seepage	
Piping or Boils	
Foundation Drainage Features	
Toe Drains	
Instrumentation System	
Vegetation	

PERIODIC INSPECTION CHECKLIST

PROJECT Kendall Co. No. 1 Dam MA DATE November 11, 1980

PROJECT FEATURE Dike NAME Knight

DISCIPLINE _____ NAME Hirschfeld

AREA EVALUATED	CONDITIONS
DIKE EMBANKMENT	
Crest Elevation 517.2	524.1
Current Pool Elevation	517.4
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed
Pavement Condition	Not applicable
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	Appears to be as constructed
Horizontal Alignment	Appears to be as constructed
Condition at Abutment and at Concrete Structures	Right abutment breached. Left abutment is the decayed wood crib at right end of dam.
Indications of Movement of Structural Items on Slopes	None
Trespassing on Slopes	None
Sloughing or Erosion of Slopes or Abutments	None
Rock Slope Protection - Riprap Failures	None
Unusual Movement or Cracking at or Near Toes	None
Unusual Embankment or Downstream Seepage	None observed
Piping or Boils	None observed
Foundation Drainage Features	Unknown
Toe Drains	None
Instrumentation System	None
Vegetation	Heavy growth of trees and brush

PERIODIC INSPECTION CHECKLIST

PROJECT Kendall Co. No. 1 Dam MA DATE November 11, 1980

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - CONTROL TOWER	Not applicable
a. Concrete and Structural	
General Condition	
Condition of Joints	
Spalling	
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System	

PERIODIC INSPECTION CHECKLIST

PROJECT Kendall Co. No. 1 Dam MA DATE November 11, 1980

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	Not applicable
a. Approach Channel	
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	
Condition of Concrete	
Stop Logs and Slots	

PERIODIC INSPECTION CHECKLIST

PROJECT Kendall Co. No. 1 Dam MA DATE November 11, 1980

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - TRANSITION AND CONDUIT	Not applicable
General Condition of Concrete	
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECKLIST

PROJECT Kendall Co. No. 1 Dam MA DATE November 11, 1980

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	Not applicable
General Condition of Concrete	
Rust or Staining	
Spalling	
Erosion or Cavitation	
Visible Reinforcing	
Any Seepage or Efflorescence	
Condition at Joints	
Drain Holes	
Channel	
Loose Rock or Trees Overhanging Channel	
Condition of Discharge Channel	

PERIODIC INSPECTION CHECKLIST

PROJECT Kendall Co. No. 1 Dam MA DATE November 11, 1980

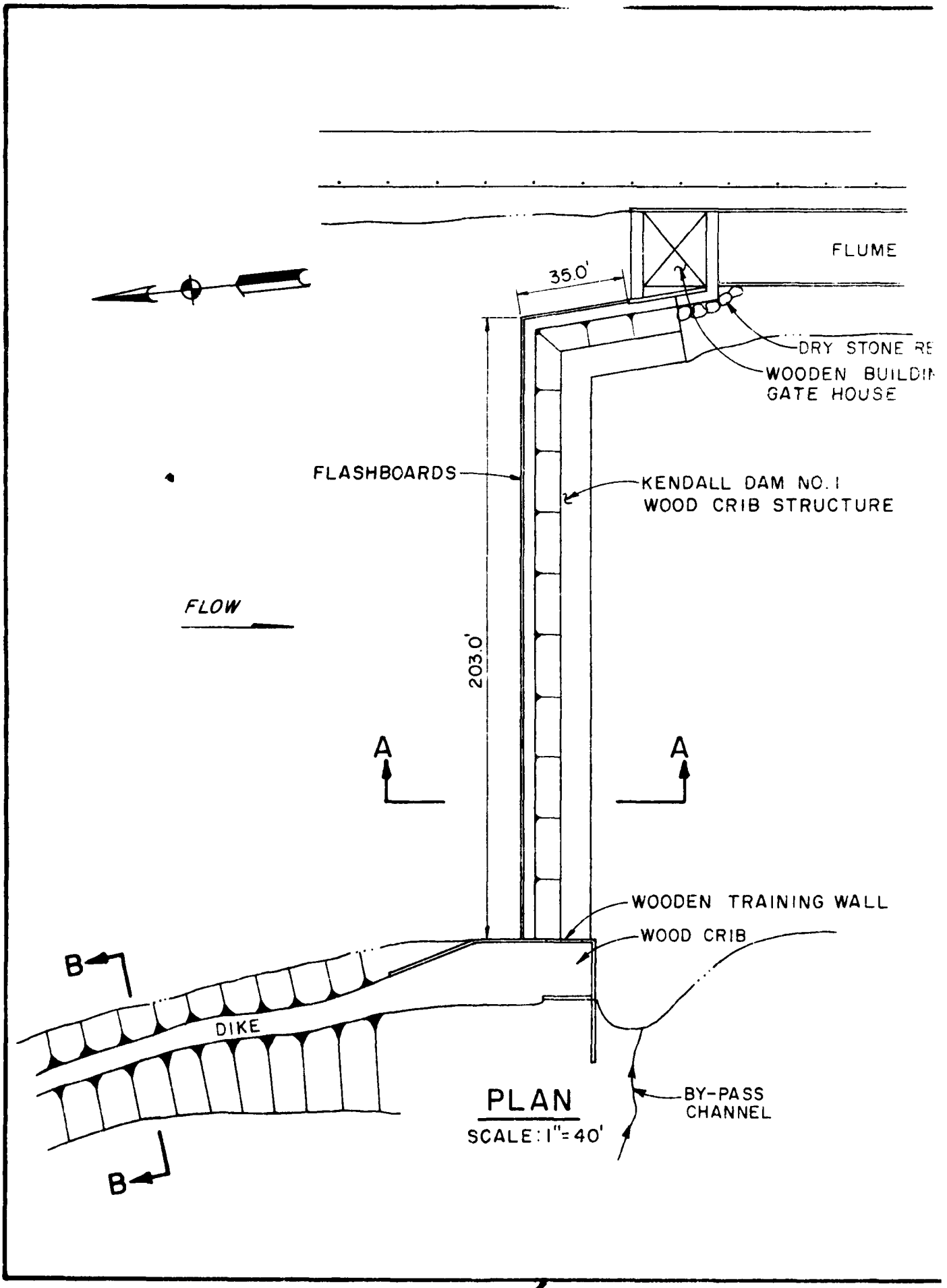
PROJECT FEATURE Spillway NAME Knight

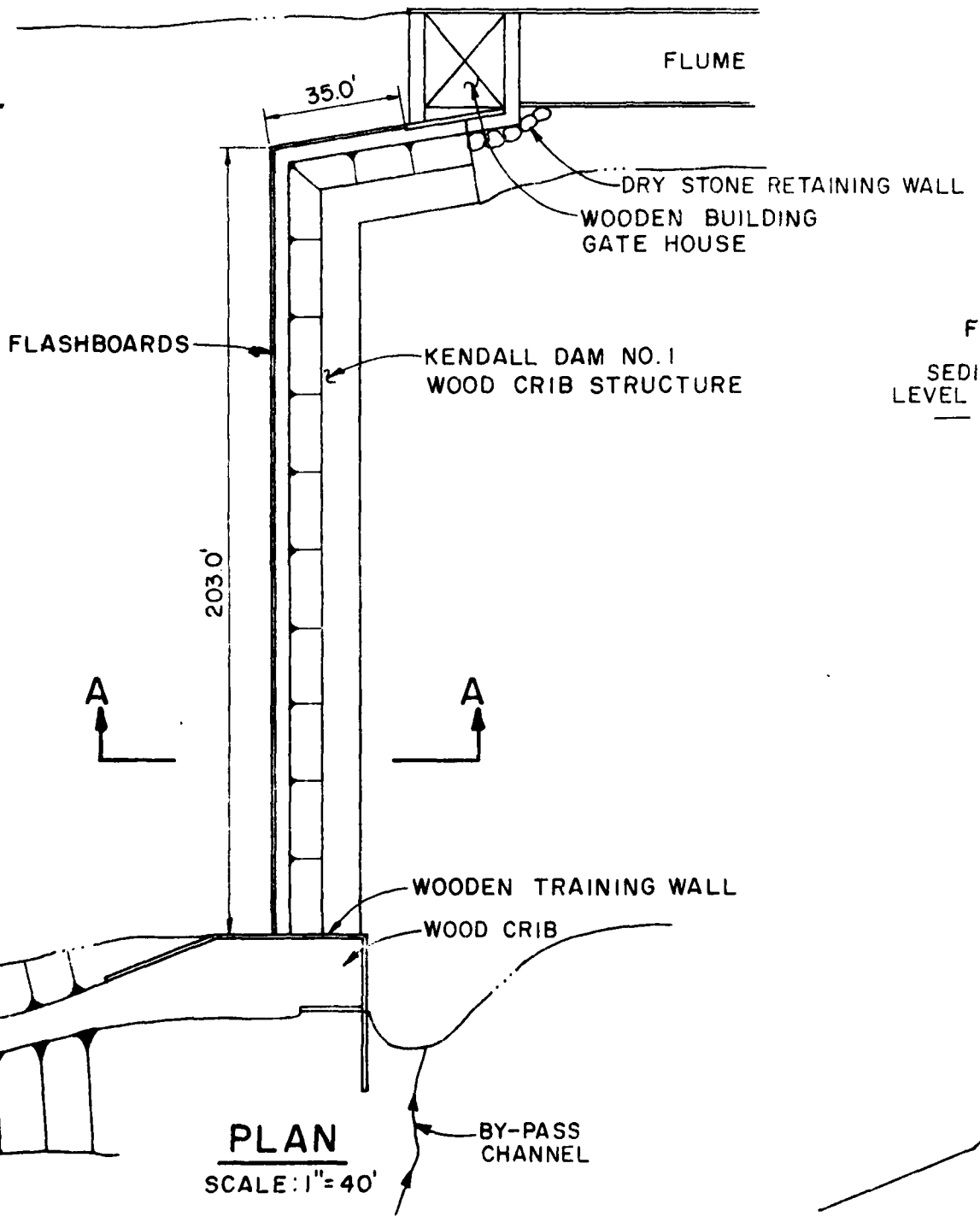
DISCIPLINE _____ NAME Hirschfeld

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	Trees overhanging banks of wide (+200') channel
Floor of Approach Channel	Sediment has accumulated against upstream side of dam to an unknown depth
b. Weir and Training Walls	
General Condition of Concrete	Not a concrete structure
Rust or Staining	
Spalling	
Any Visible Reinforcing	
Any Seepage or Efflorescence	
Drain Holes	
c. Discharge Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	Trees overhanging banks of wide (+200') channel
Floor of Channel	Sand, gravel and boulders
Other Obstructions	None
Other Comments	
d. Wood Crib Structure	
General condition	Fair. Some rotted and broken members.
Flashboards	Good condition. Replaced annually.
Abutments	Right in poor condition. Timber crib and training wall severely decayed. Left in fair condition. Stone masonry and dry stone wall in fair condition.

APPENDIX B

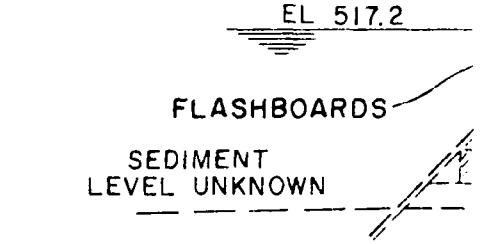
ENGINEERING DATA

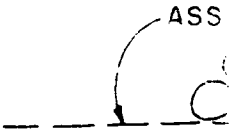

FLUME
35.0'
DRY STONE RE
WOODEN BUILDIN
GATE HOUSE
FLASHBOARDS
KENDALL DAM NO. I
WOOD CRIB STRUCTURE
FLOW
203.0'
A
A
WOODEN TRAINING WALL
WOOD CRIB
B
DIKE
B
BY-PASS
CHANNEL
PLAN
SCALE: 1"=40'

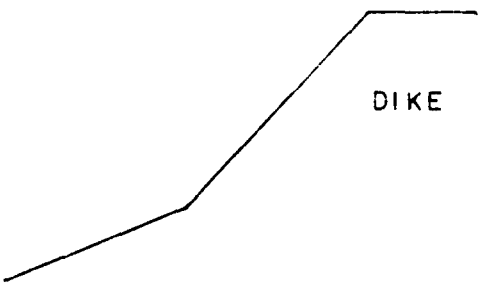


PLAN

SCALE: 1"=40'







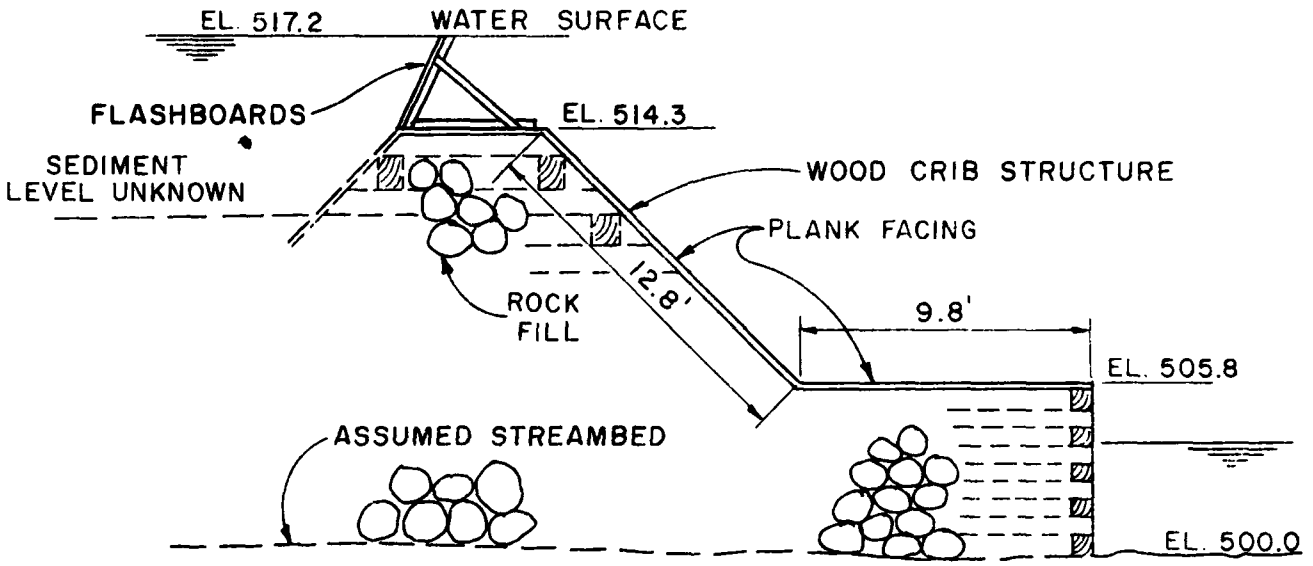
SECTION

(TYPICAL

SCALE 1" =

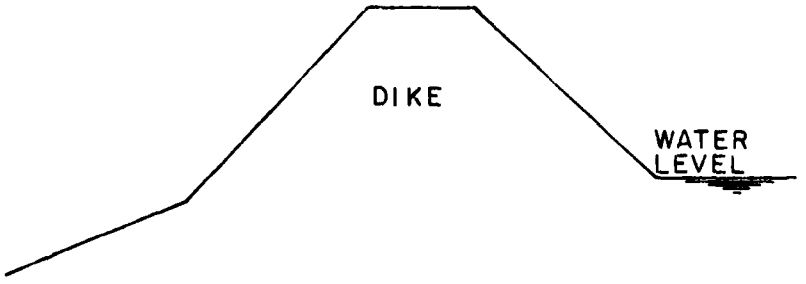
FIGURE 2

TAINING WALL
G



SECTION A-A

SCALE: 1"= 6'



SECTION B-B

(TYPICAL)
SCALE: 1 " = 10'

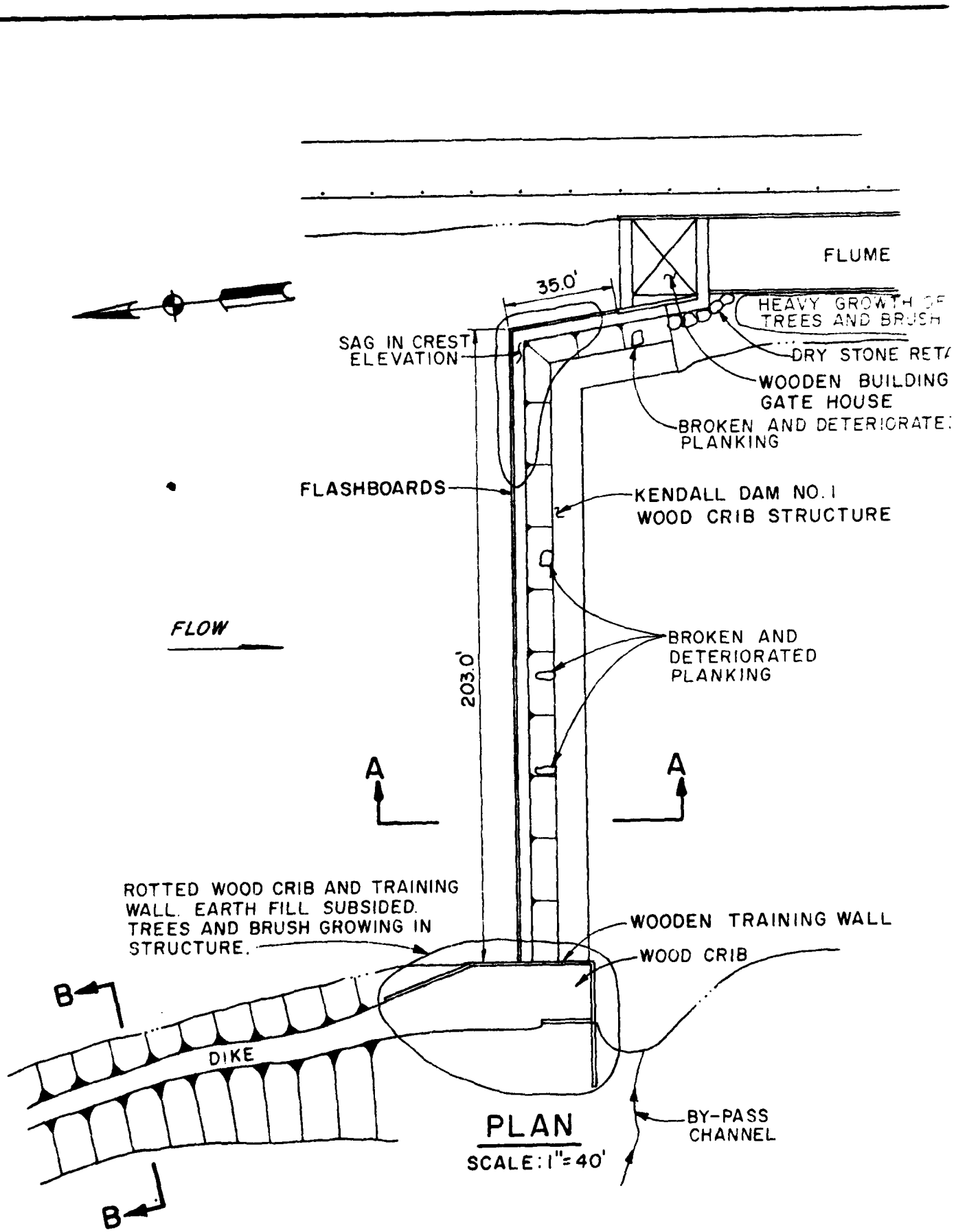
GANNETT FLEMING CORDDRY AND CARPENTER, INC. *CONSULTING ENGINEERS* BOSTON, MASS.	U. S. ARMY ENGINEER DIVISION NEW ENGLAND *CORPS OF ENGINEERS* WALTHAM, MASS	

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

KENDALL CO. NO. 1 DAM

PLAN AND SECTIONS

DRAWN	CHECKED	APPROVED	SCALE: AS SHOWN	
D. M. U.	D. B. W.	F. J. K.	DATE: 12/80	PAGE B-1


FLUME
35.0'
HEAVY GROWTH OF TREES AND BRUSH
SAG IN CREST ELEVATION
DRY STONE RETA
WOODEN BUILDING GATE HOUSE
BROKEN AND DETERIORATE PLANKING
FLASHBOARDS
KENDALL DAM NO. 1 WOOD CRIB STRUCTURE
FLOW
203.0'
BROKEN AND DETERIORATED PLANKING
A
A
ROTTED WOOD CRIB AND TRAINING WALL. EARTH FILL SUBSIDED. TREES AND BRUSH GROWING IN STRUCTURE.
WOODEN TRAINING WALL
WOOD CRIB
B
DIKE
B
PLAN
SCALE: 1"=40'
BY-PASS CHANNEL

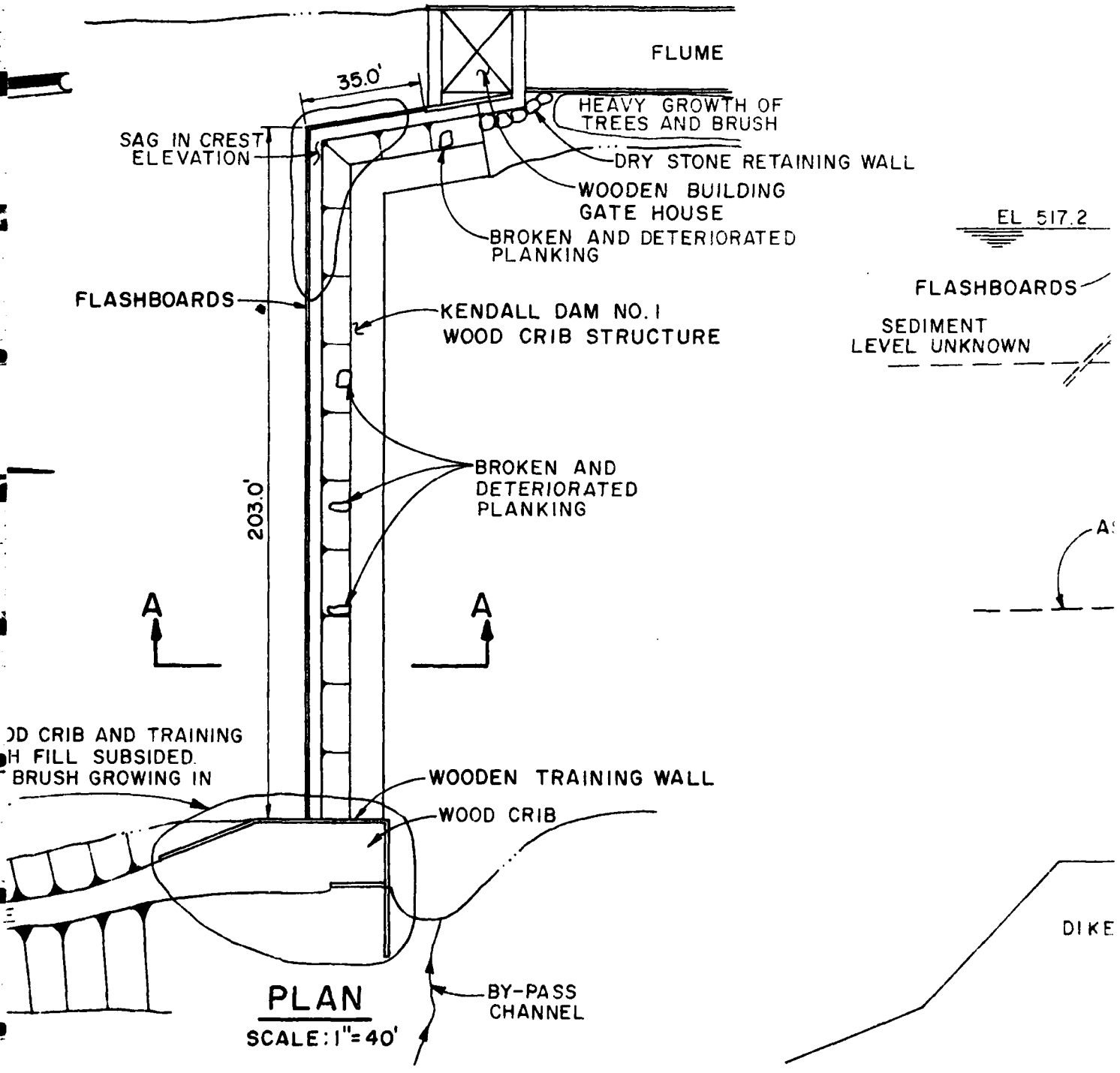
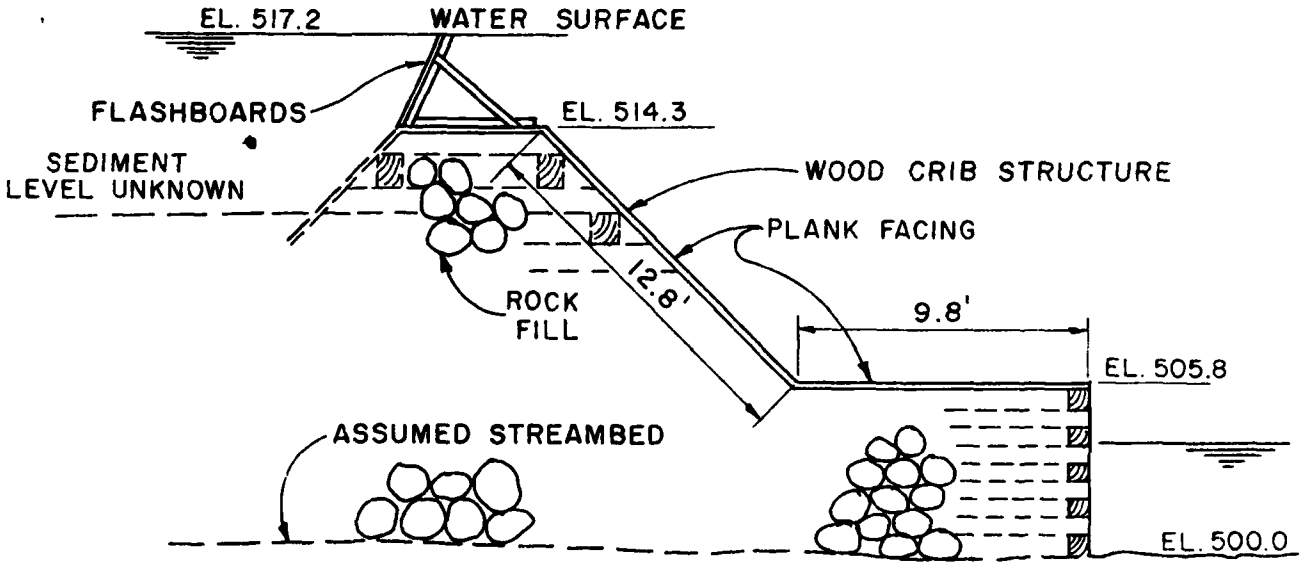

FLUME
35.0'
HEAVY GROWTH OF TREES AND BRUSH
SAG IN CREST ELEVATION
DRY STONE RETAINING WALL
WOODEN BUILDING GATE HOUSE
BROKEN AND DETERIORATED PLANKING
EL 517.2
FLASHBOARDS
FLASHBOARDS
KENDALL DAM NO. 1 WOOD CRIB STRUCTURE
SEDIMENT LEVEL UNKNOWN
203.0'
BROKEN AND DETERIORATED PLANKING
A
A
A
OD CRIB AND TRAINING
H FILL SUBSIDED.
BRUSH GROWING IN
WOODEN TRAINING WALL
WOOD CRIB
DIKE
BY-PASS CHANNEL
PLAN
SCALE: 1"=40'
SECTIOI
(TYPIC
SCALE:

FIGURE 3

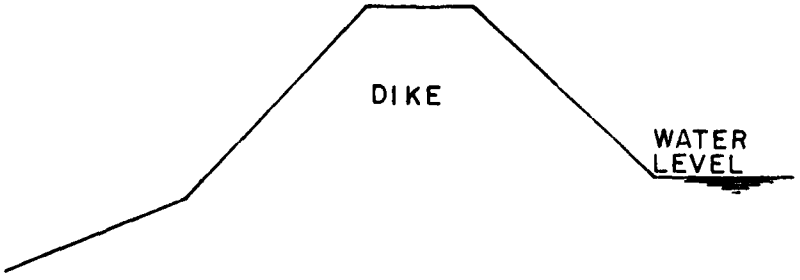
AINING WALL

D



SECTION A-A

SCALE: 1"= 6'



SECTION B-B

(TYPICAL)

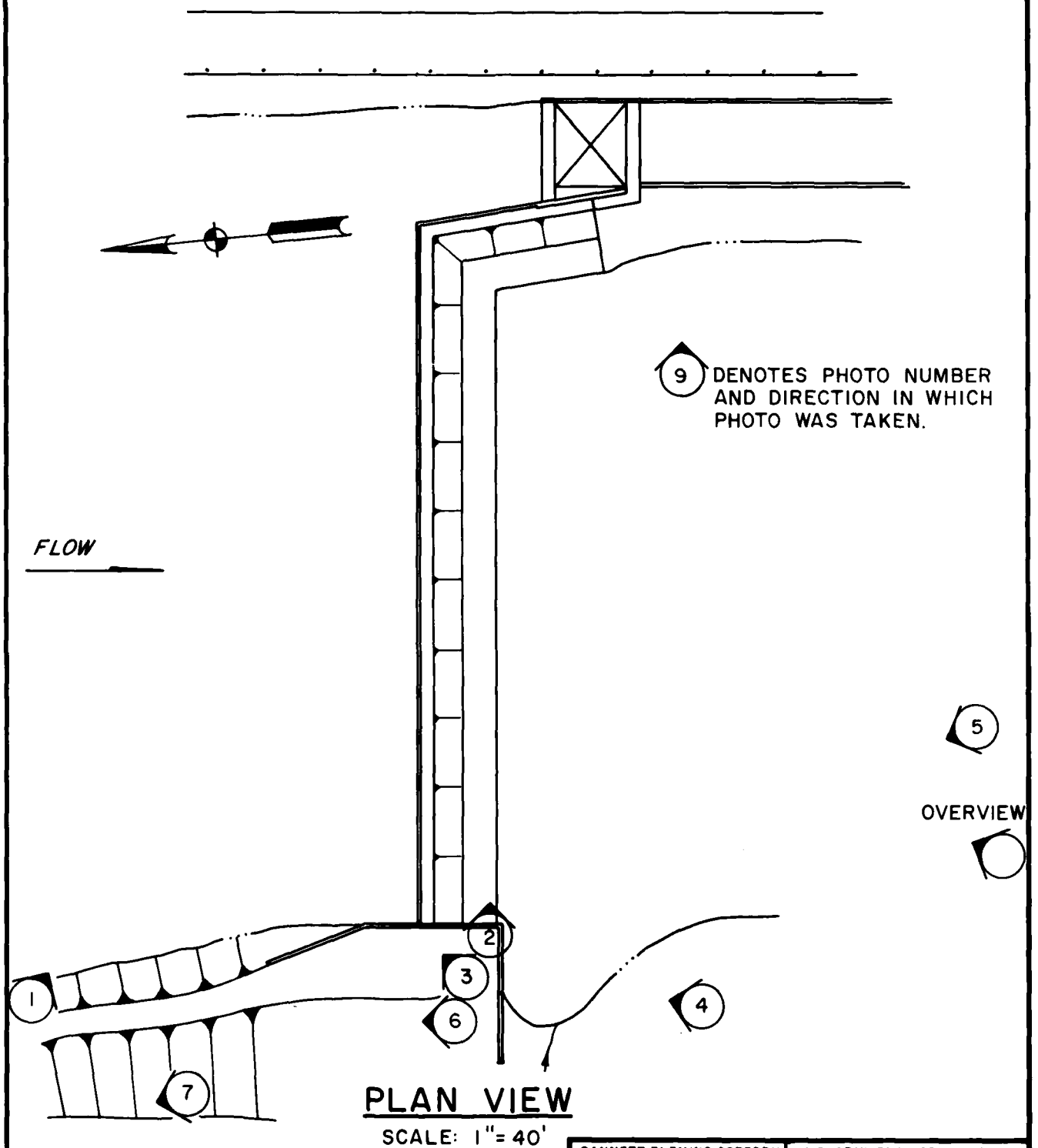
SCALE: 1 " = 10'

GANNETT FLEMING CORDDRY AND CARPENTER, INC. CONSULTING ENGINEERS BOSTON, MASS.			U. S. ARMY ENGINEER DIVISION NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.
NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS KENDALL CO. NO. 1 DAM RESULTS OF VISUAL INSPECTION			
DRAWN	CHECKED	APPROVED	SCALE: AS SHOWN
D.M.U.	D.B.W.	F.J.K.	DATE: 12/80 PAGE B-2

APPENDIX C

PHOTOGRAPHS

FIGURE 4



PLAN VIEW

SCALE: 1"= 40'

GANNETT FLEMING CORDDRY AND CARPENTER, INC. CONSULTING ENGINEERS BOSTON, MASS.	U.S. ARMY ENGINEER DIVISION NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

KENDALL CO. NO. 1 DAM

GUIDE TO PHOTOGRAPHS

DRAWN	CHECKED	APPROVED	SCALE: AS SHOWN
D. M.U.	D. B.W.	F. J.K.	DATE: 12/80 PAGE: C-1

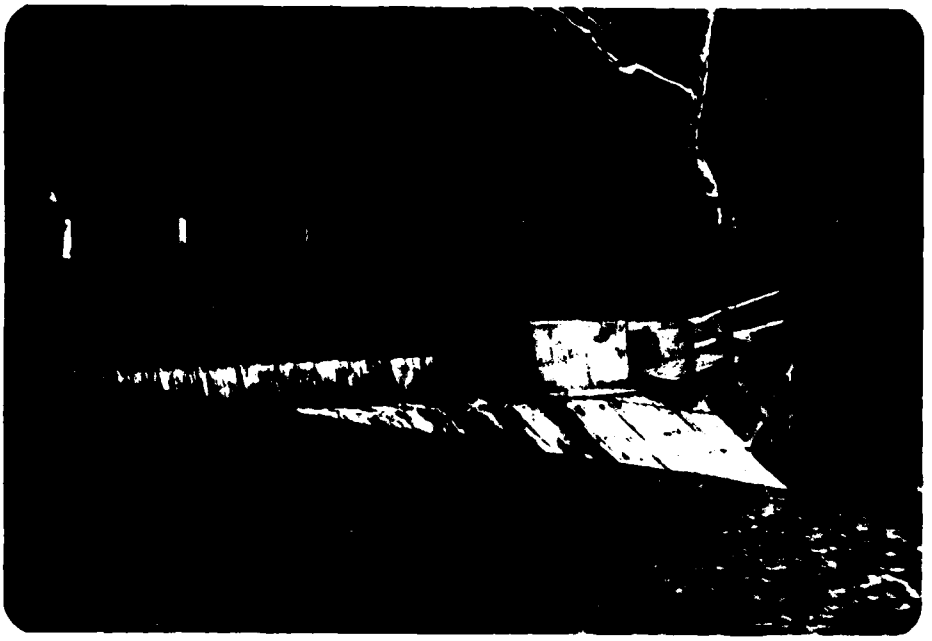


Photo No. 1

View of left (east) abutment, control house and flume intake.

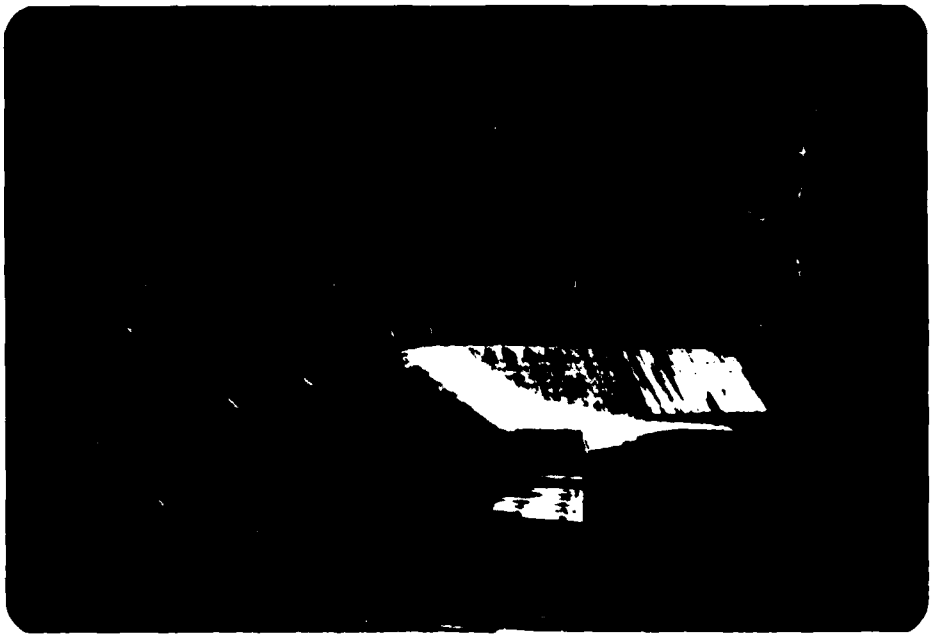


Photo No. 2

View of downstream face of dam.

Photo No. 5

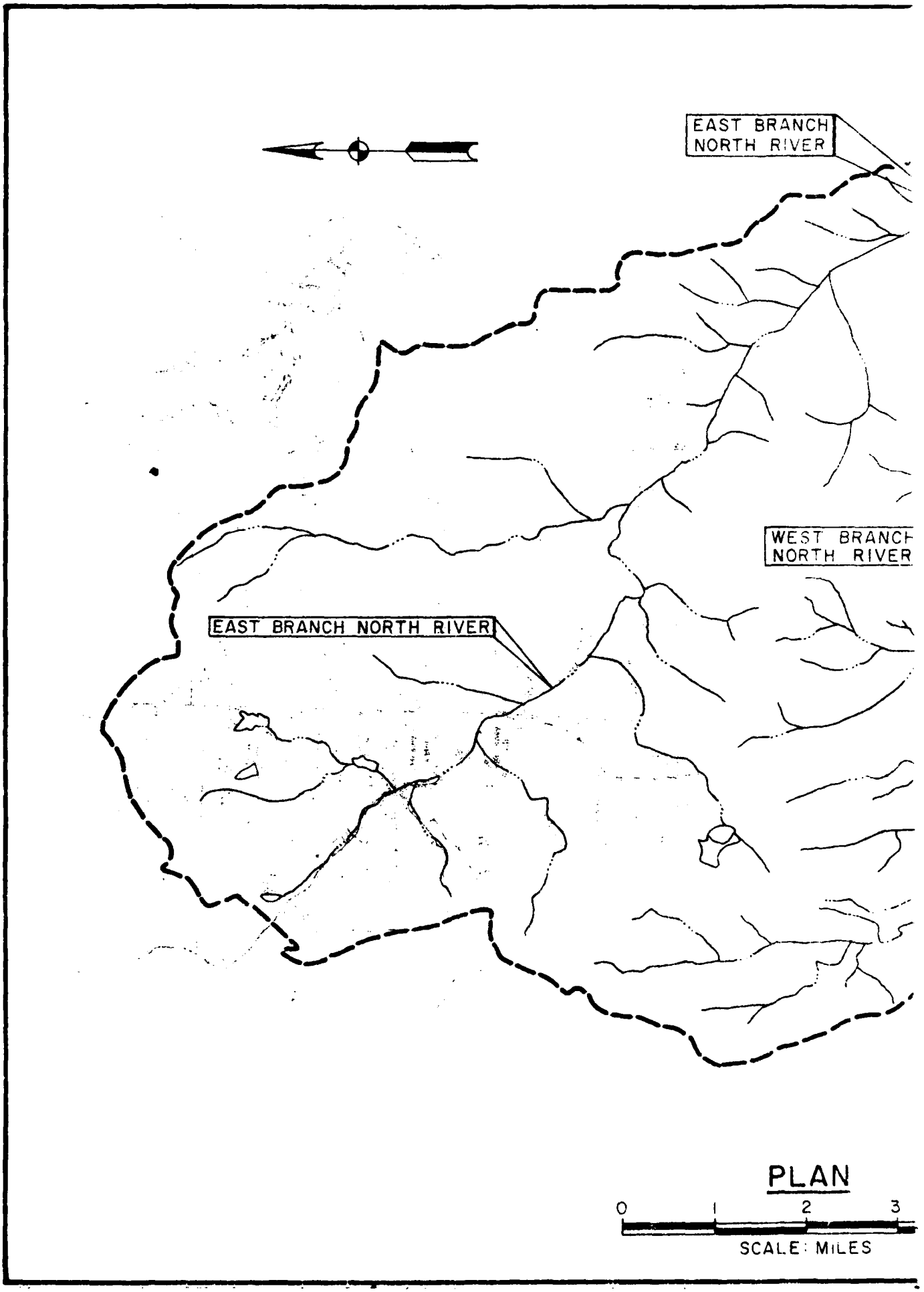
View of right abutment.

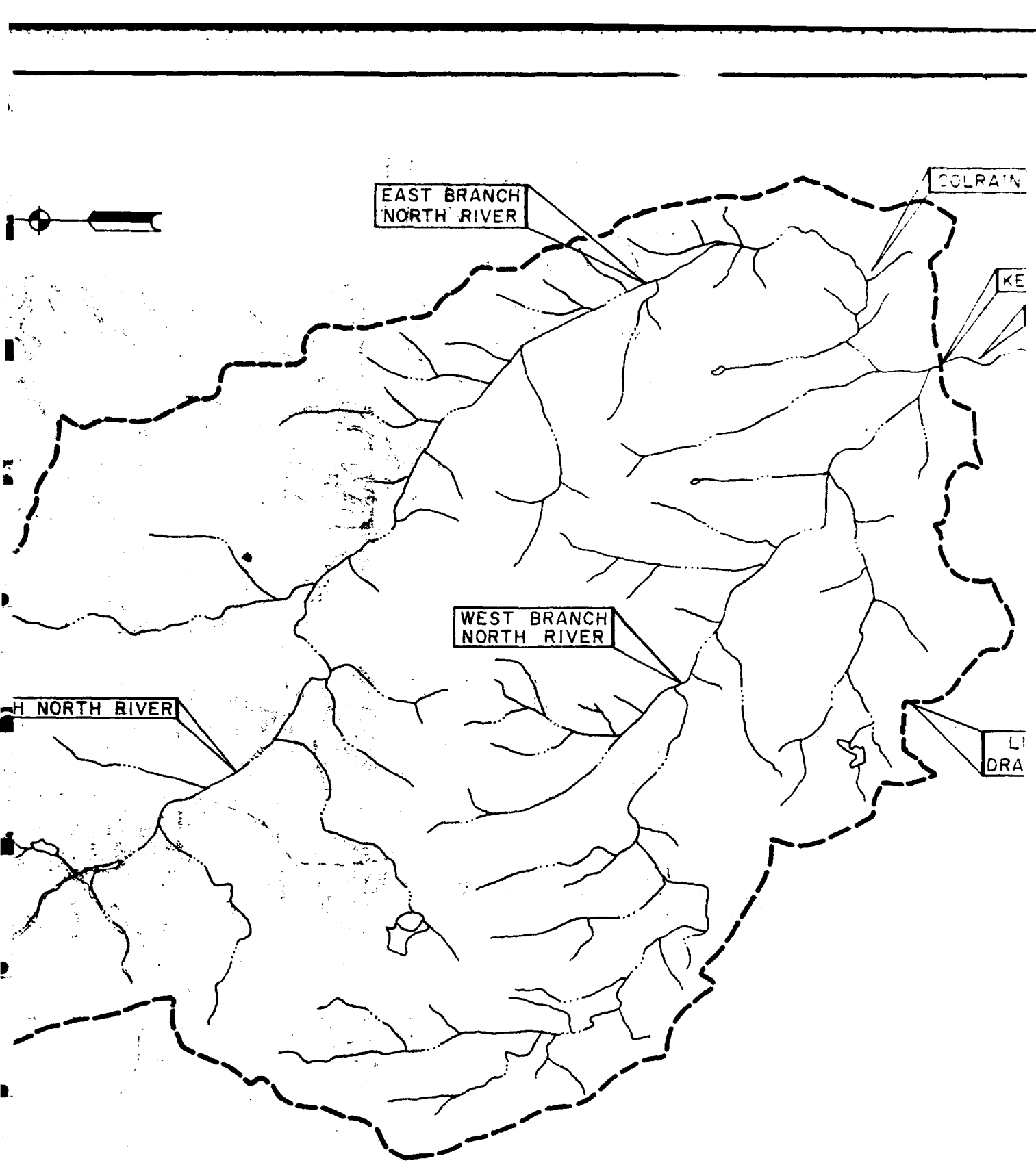
Photo No. 6

View along top of dike.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

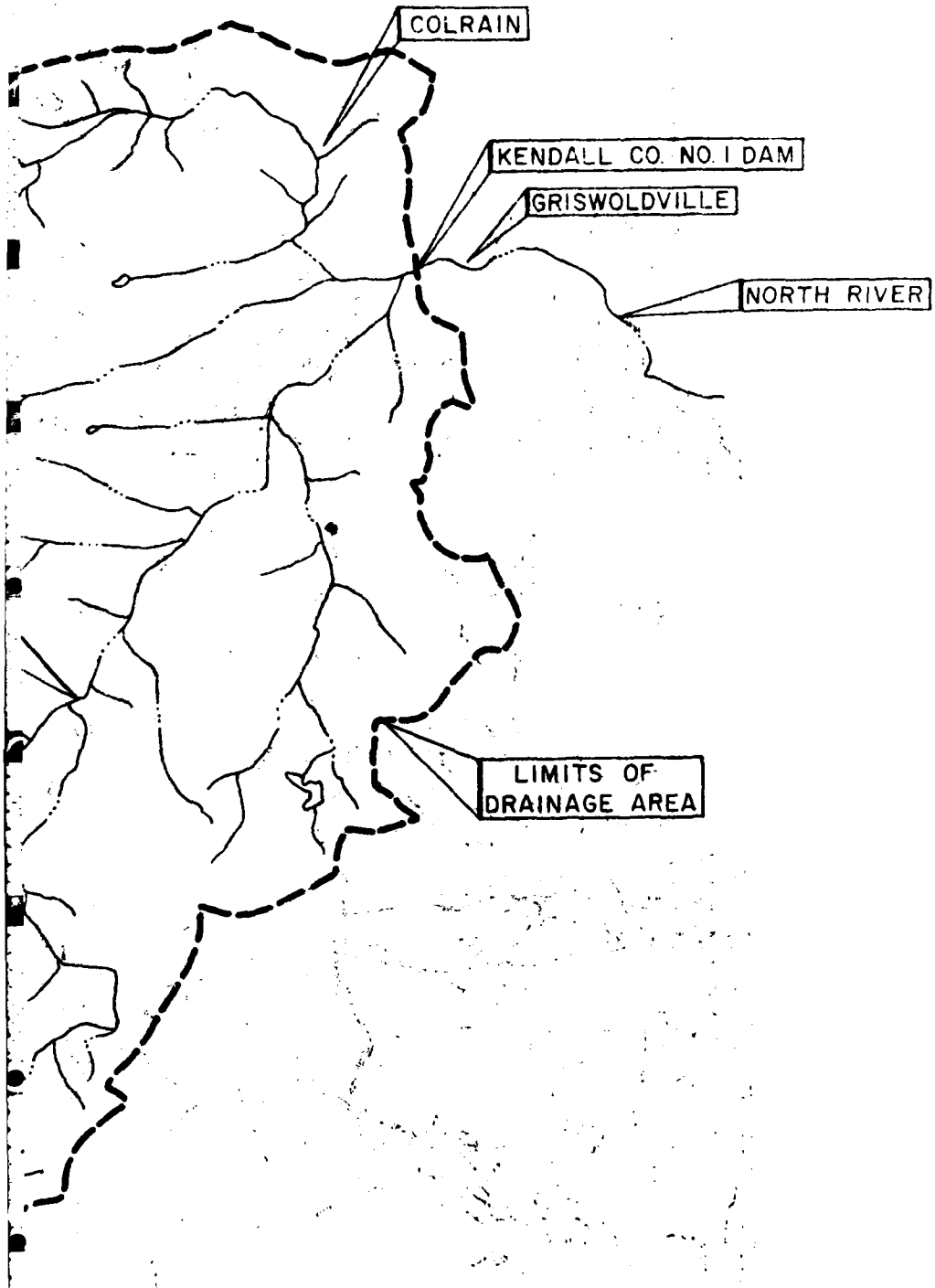

EAST BRANCH
NORTH RIVER
WEST BRANCH
NORTH RIVER
EAST BRANCH NORTH RIVER
PLAN
0
1
2
3
SCALE: MILES



PLAN

0 1 2 3 4

SCALE: MILES



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NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

KENDALL CO. NO. 1 DAM

DRAINAGE AREA MAP

DRAWN	CHECKED	APPROVED	SCALE AS SHOWN	
L. L. R.	D. B. W.	F. J. K.	DATE 12/80	PAGE

4

BY DJW DATE 12/80 SUBJECT Kendall Co. No. 1 Dam SHEET NO 1 OF 4
CHKD BY [illegible] DATE 12/17/80 Hydrology and Hydraulics JOB NO

Kendall Co. No. 1 Dam

Basic Data

Drainage Area = 105 mi^2 (determined from USGS)
Watershed Classification: Mountainous
Size: Small (24.1 feet high; max. storage = 378 acre-feet)
Hazard Classification: Significant Hazard
Reservoir Surface Area:
- At Spillway Crest: 11 Acres
- At Top of Dam: 47 Acres

Storage Capacity:
- At Spillway Crest: 52 acre-ft
- At Top of Flashboards: 84 acre-ft
- At Top of Dam: 375 acre-ft

Spillway length: 238 feet
Elevations:

Streambed at Toe	El. 500.0
Spillway Crest	El. 514.3
Top of Flashboards	El. 517.2
Top of Dam and Dike	El. 524.1
Avg. streambed slope at dam	0.005
Length of dam and dike	1200 feet

Test Flood Inflow

For size (small) and hazard classification (significant hazard), the recommended test flood ranges from the 100-year flood to the 1/2 PMF. Because downstream damages due to dam failure could be substantial (damage to a mill and other industrial buildings), the 1/2 PMF is selected as the test flood for the analysis.

Using the curve for mountainous regions and using D.A = 105 mi^2:

Test Flood Inflow = $Q_{p_1} = (105\ mi^2)(1{,}150\ cfs/mi^2) \times (1/2)$

$Q_{p_1} = 60{,}375$ cfs (1/2 PMF)

Rating Curve

The project consists of the spillway, the abutment sections, and a dike that extends upstream along the right bank of the river. The spillway length is 238 feet, and the combined length of the abutment sections and the dike is about 1,200 feet. There is a breach in the dike near its upstream end. The bottom width of the breach is about 20 feet, and an overgrown channel leads from the West Branch North River (upstream from the dam) to the North River (downstream from the dam). The bottom of the breach is about 5 feet above normal pool level.

A combined rating curve will be used for the spillway and the dike. Flow that could occur through the breach is small and will not be included in the rating curve for the following reasons:

1) Breach size is very small compared to spillway size
2) Flow would not occur in breach until the pool level rose 5 feet.
3) The channel through the breach is heavily overgrown and could easily be obstructed even more during floods.

Rating Curve with Flashboards in Place:

$$Q_{TOTAL} = Q_{SPILLWAY} + Q_{DIKE}$$

$$Q_T = (3.1)(238)(\text{Pool El} - 517.2)^{3/2} + (3.1)(1200)(\text{Pool El} - 524.1)^{3/2}$$

Rating Curve with Flashboards Removed:

$$Q_T = (3.1)(238)(\text{Pool El} - 514.3)^{3/2} + (3.1)(1200)(\text{Pool El} - 524.1)^{3/2}$$

Routing Curve for Test Flood

Stor = Storage in inches

$$Q_{p2} = Q_{p1}\left(1 - \frac{Stor}{9.5}\right)$$

$$Stor = \frac{\text{Storage (acre-ft)} \times 12}{105 \times 640} = 0.000179 \times \text{Storage (acre-ft)}$$

Routing Curve - Flashboards in Place

Pool Elevation	Storage (acre-ft)	Stor (inches)	Q_{p2} (cfs)
517.2	0	0	60,375
524.1	315	0.06	60,020
530.0	592	0.11	59,700

Routing Curve - Flashboards Removed

Pool Elevation	Storage (acre-ft)	Stor (inches)	Q_{p2} (cfs)
514.3	0	0	60,375
524.1	347	0.06	60,020
530.0	624	0.11	59,700

Notes

1. Routing computations started with pool level at spillway crest or at top of flashboards.
2. For practical purposes, both routing curves are the same.

Overtopping Analysis:

From results shown on Figure 1 (next sheet):

With flashboards in place:

depth overtopping = 4.2' for 1/2 PMF

With flashboards removed:

depth overtopping = 3.5' for 1/2 PMF

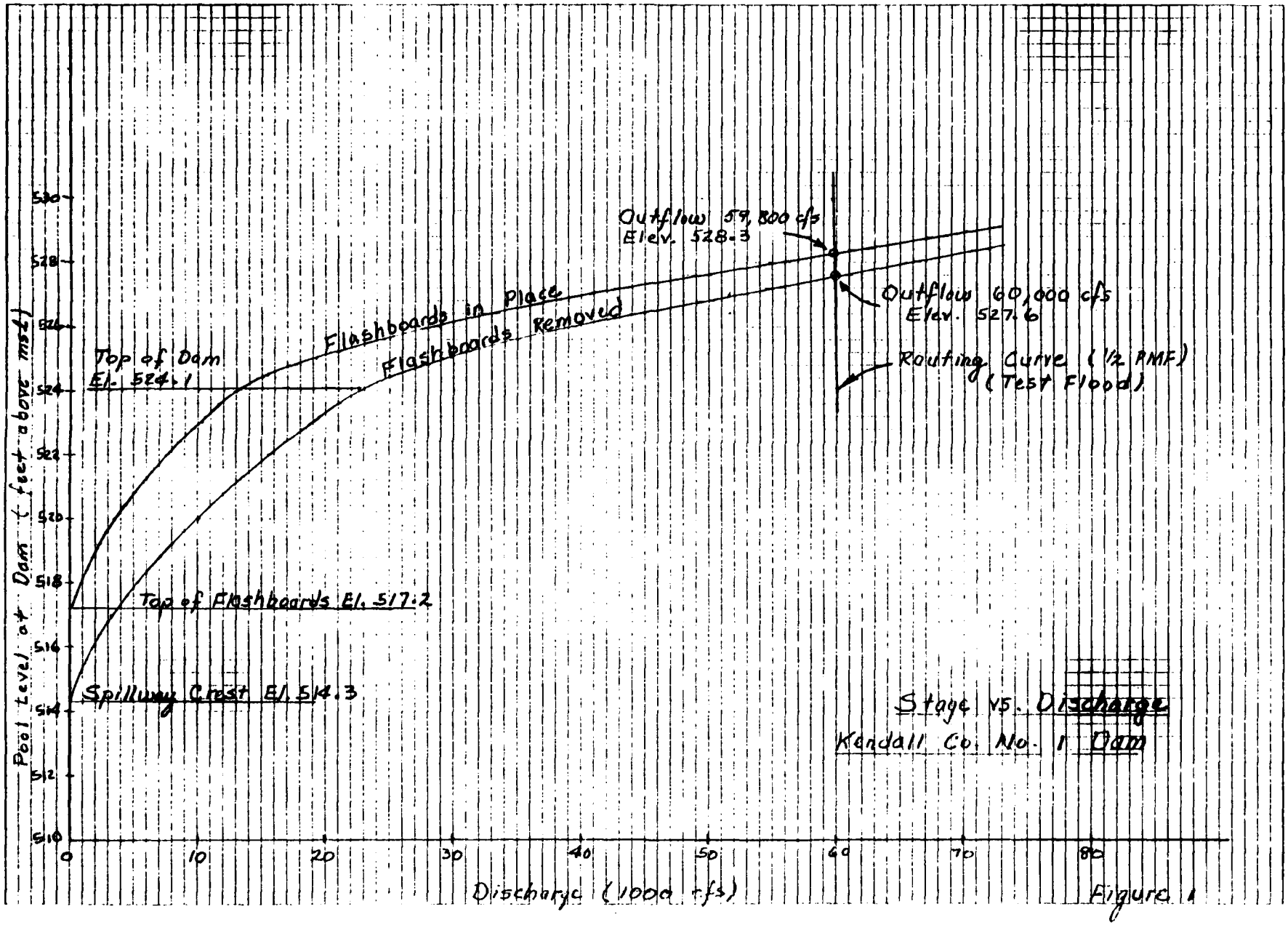

Outflow 59,800 cfs
Elev. 528.3
Outflow 60,000 cfs
Elev. 527.6
Routing Curve (½ PMF)
(Test Flood)
Flashboards in Place
Flashboards Removed
Top of Dam
El. 524.1
Top of Flashboards El. 517.2
Spillway Crest El. 514.3
Stage vs. Discharge
Kendall Co. No. 1 Dam
Pool level at Dam (feet above msl)
Discharge (1000 cfs)
530
528
526
524
522
520
518
516
514
512
510
0
10
20
30
40
50
60
70
80

Figure 1

Dam Failure Analysis

For failure with pool level at top of dam:
Storage at time of failure = 378 acre-feet
Outflow just prior to failure = 13,370 cfs (with flashboards)
Outflow just prior to failure = 22,630 cfs (without flashboards)

Breach Outflow:

$Q_B = {}^8/_{27}\ W_b \sqrt{g}\ Y_o^{3/2}$

$W_b \leq$ 40% of dam length @ midheight $\leq 0.4 \times 250$

$Y_o = 24.1'$ Use $W_b = 100'$

$Q_B = (8/27)(100)(32.2)^{1/2}(24.1)^{3/2}$

$Q_B = 19,890$ cfs

Remaining spillway flow: Q_{SR}:

$Q_{SR} = (3.1)(138)(6.9)^{3/2} = 7,750$ cfs (with flashboards)

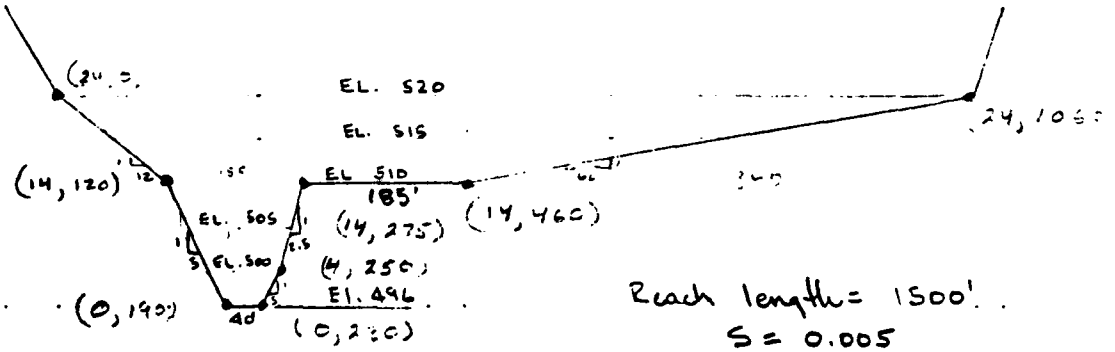
$Q_{SR} = (3.1)(138)(9.8)^{3/2} = 13,120$ cfs (without flashboards)

Total Failure Outflows: Q_{P1}:

$Q_{P1} = 19,890 + 7,750 = 27,640$ cfs (with flashboards)

$Q_{P1} = 19,890 + 13,120 = 33,010$ cfs (without flashboards)

Rating Curve: Reach 1



1" = 200' HOR.
1" = 20' VERT

Reach length = 1500'
S = 0.005
$n_{channel} = 0.04$
$n_{overbank} = 0.06$

Rating Curve: Reach 1

d	Q
4	1309
9	6505
14	16123
16	23837
19	37923

Prefailure stages in Reach 1:

with flashboards in place, stage = 13.0' (A = 1267 ft²)
with flashboards removed, stage = 15.8' (A = 2144 ft²)

Reach Outflow: Reach 1

With Flashboards:

Q_{p_1} = 27,640 cfs Stage = 16.8' Area = 2649 ft²

Δ Area = 2649 - 1267 = 1,382 ft²

$V_1 = (1{,}382\ ft^2)(1500\ ft)\left(\frac{1\ acre}{43560\ ft^2}\right) = 47.6$ acre-ft

Check for $V_1 \leq S/2$ where S = storage at top of dam

S = 378 acre-ft

$S/2 = 378/2 = 189$ $47.6 \leq 189$ Reach length OK

$Q_{p_2} = Q_{p_1}\left(1 - V_1/S\right) = 27640\left(1 - 47.6/378\right)$

Q_{p_2} = 24,159 cfs

Stage for Q_{p_2} = 16.2' Area = 2337 ft²

Δ Area = 2337 - 1267 = 1070 ft²

$V_2 = (1070)(1500)/(43560) = 36.8$ acre-ft

$V_{avg.} = \frac{47.6 + 36.8}{2} = 42.2$ acre-ft

$Q_{p_2} = Q_{p_1}\left(1 - V_{avg}/S\right) = 27640\left(1 - 42.2/378\right)$

Q_{p_2} = 24,552 cfs

Stage = 16.25'

Reach Outflow: Reach 1 Cont'd

Without Flashboards:

$Qp_1 = 33{,}010$ cfs Stage = 17.9' Area = 3289 ft²

Δ Area = 3048 − 2144 = 1145 ft²

$V_1 = \frac{(1145)(1500)}{43560} = 39.4$ acre-ft

Storage at time of failure = S = 378 acre-ft.

V_1 is < 378/2, so reach length is O.K.

$Qp_2 = 33010\,(1 - 39.4/378) = 29{,}569$ cfs

Stage for Qp_2 = 17.25' Area = 2900 ft²

Δ Area = 2900 − 2144 = 756 ft²

$V_2 = \frac{(756)(1500)}{43560} = 26.0$ acre-ft

$V_{avg} = \frac{39.4 + 26.0}{2} = 32.7$ acre-ft

$Qp_2 = 33010\,(1 - 32.7/378)$

$Qp_2 = 30{,}153$ cfs

Stage = 17.35 AREA = 2958 FT²

Δ AREA = 2958 − 2144 = 814

$V_2 = \frac{814 \times 1500}{43560} = 28.0$ ACRE-FT

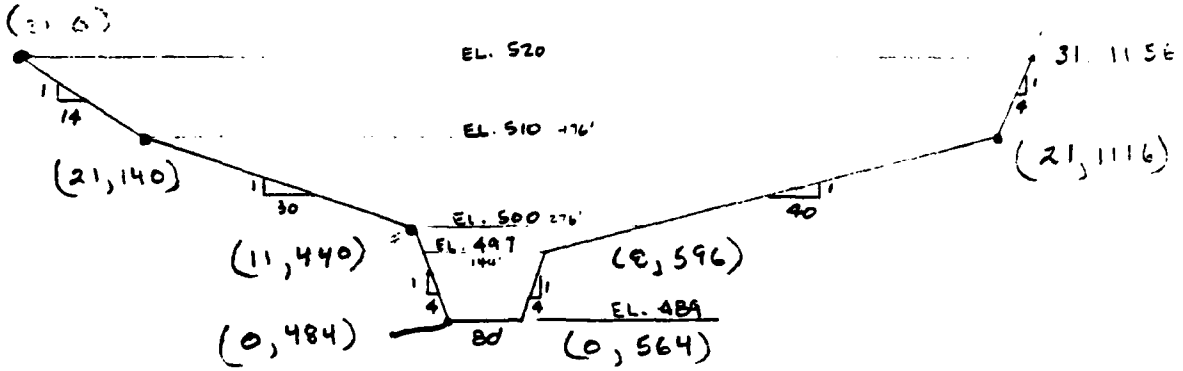
$Q_{P_2} = 33010\,(1 - 28/378)$

$Q_{P_2} = 30{,}562$

STAGE = 17.42'

Rating Curve: Reach 2

Reach length = 1200'
S = 0.005
n_c = 0.04 n_{ob} = 0.06



1" = 200' HOR.
1" = 20' VERT

d(ft)	Q(cfs)
5	3403
8	7959
11	15809
14	27645
16	38821

Prefailure stages in Reach 2:
With flashboards, stage = 10.2' (Area = 1319 ft²)
Without flashboards, stage = 12.8' (Area = 2136 ft²)

Reach Outflow: Reach 2

With Flashboards:

Q_{p1} = 24,552 cfs Stage = 13.4' Area = 2390 ft²

Δ Area = 2303 - 1319 = 1071 ft²

$V_1 = \frac{(1071)(1200)}{43560}$ = 29.5 acre-ft < 378/2 Reach length OK

$Q_{p2} = 24{,}552\left(1 - \frac{29.5}{378}\right)$ = 22,636 cfs

Stage for Q_{p2} = 13.0' Area = 2218 ft²

Δ Area = 2218 - 1319 = 899 ft²

$V_2 = \frac{(899)(1200)}{43560}$ = 24.8 acre-ft

$V_{avg} = \frac{24.8 + 29.5}{2}$ = 27.2 acre-ft

$Q_{p2} = 24{,}552\left(1 - \frac{27.2}{378}\right)$ =

Q_{p2} = 22,785 cfs Stage = 13.05'

Without Flashboards:

Q_{p1} = 30,562 cfs Stage = 14.67 Area = 3010 ft²

Δ Area = 3010 - 2136 = 874 ft²

$V_1 = \frac{(874)(1200)}{43560}$ = 24.1 acre-ft < 378/2 Reach length O.K.

$Q_{p2} = 30{,}562\left(1 - \frac{24.1}{378}\right)$ = 28,615 cfs

Stage for Q_{p2} = 14.3' Area = 2818 ft²

Δ Area = 2818 - 2136 = 682 ft²

$V_2 = \frac{(682)(1200)}{43560}$ = 18.8 acre-ft

$V_{avg} = \frac{24.1 + 18.8}{2}$ = 21.5 acre-ft

$Q_{p2} = 30{,}562\left(1 - \frac{21.5}{378}\right)$

Q_{p2} = 28,827 cfs

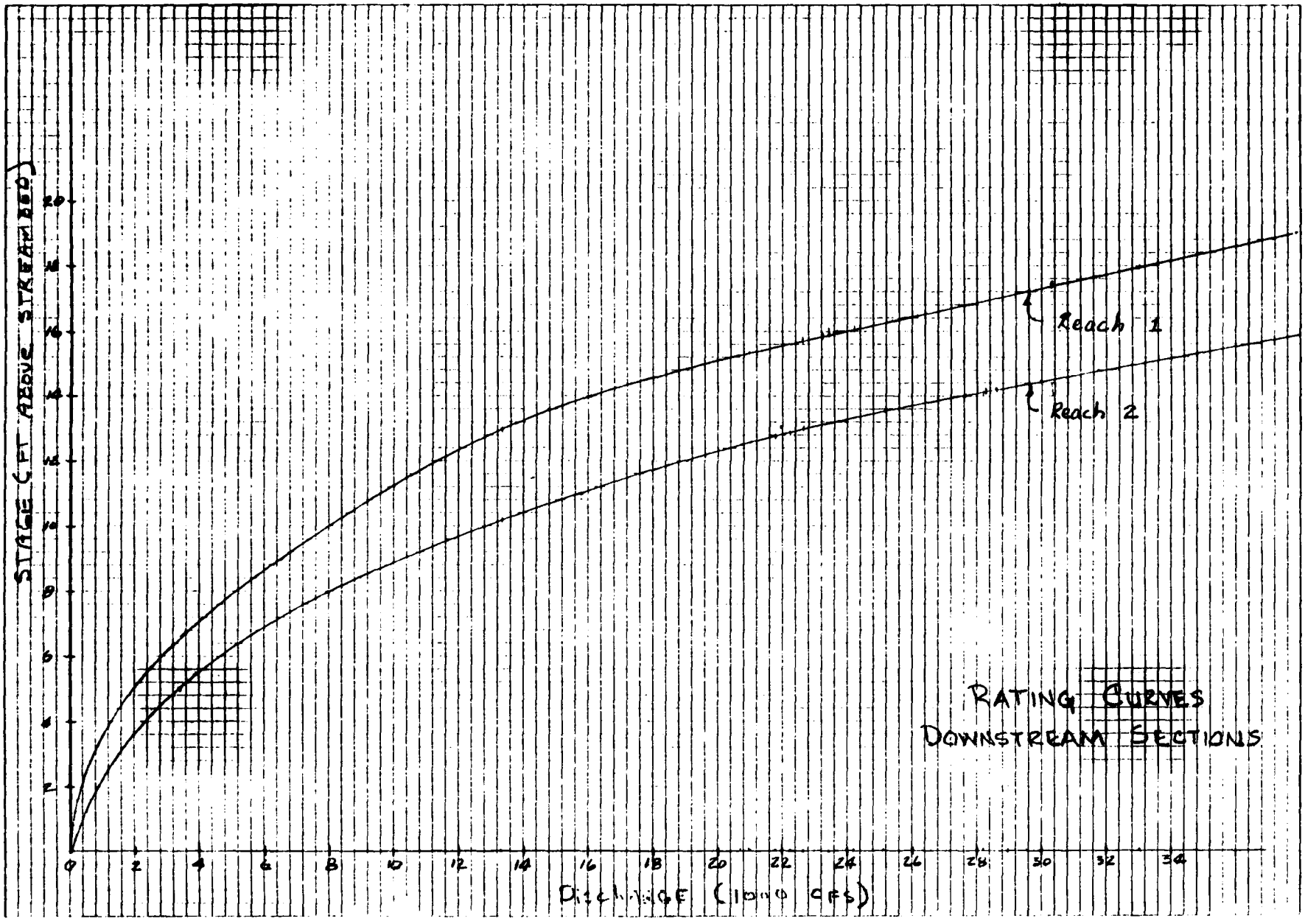
Stage = 14.33'

Summary of Stages at Damage Center

Condition	Stage	Δh
With flashboards in place:		
Just Prior to Failure	10.2'	2.9'
After Failure	13.1'	
With flashboards removed:		
Just Prior to Failure	12.8'	1.5'
After Failure	14.3'	

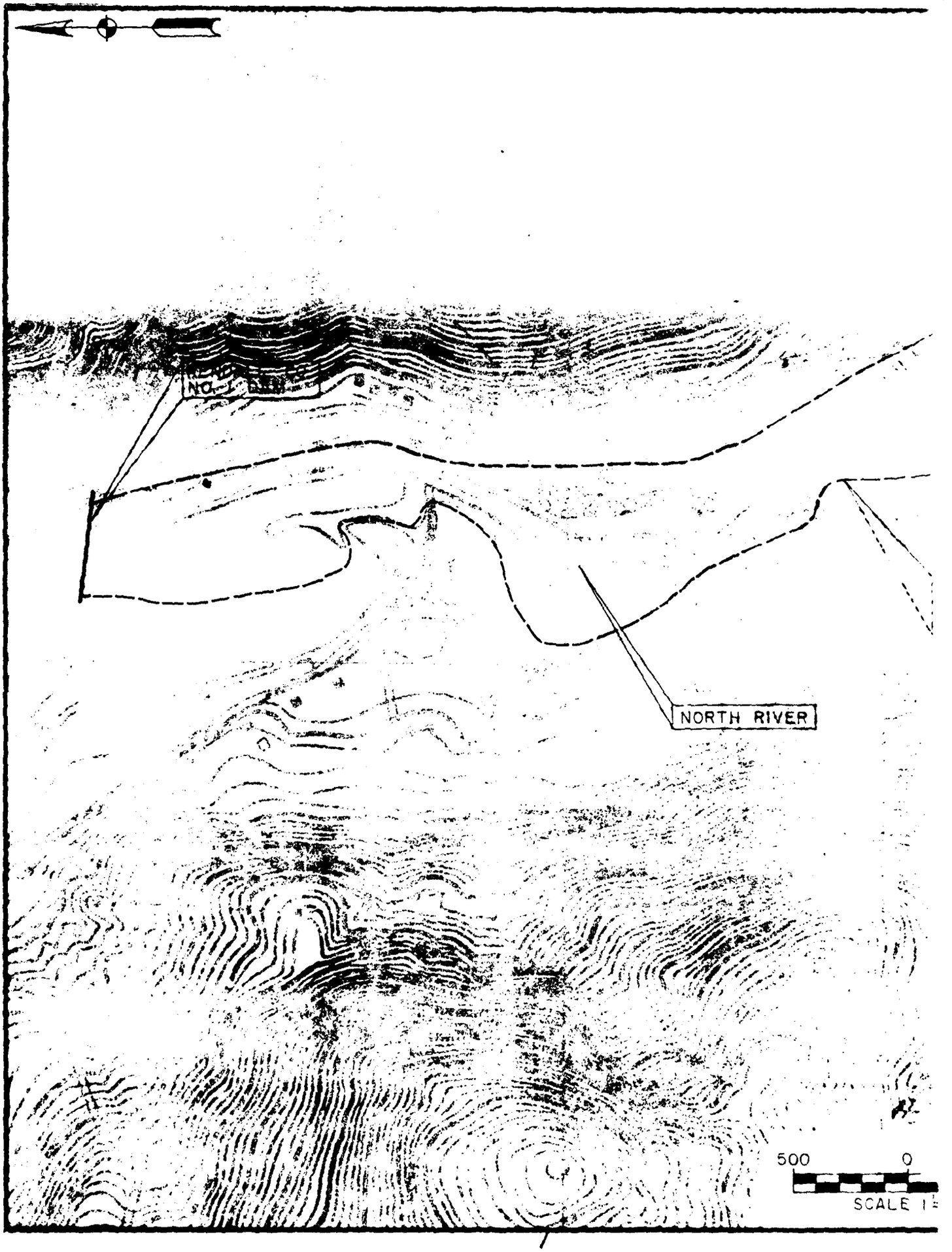
The rise in water surface at the damage center is sufficient to substantially increase downstream damages.

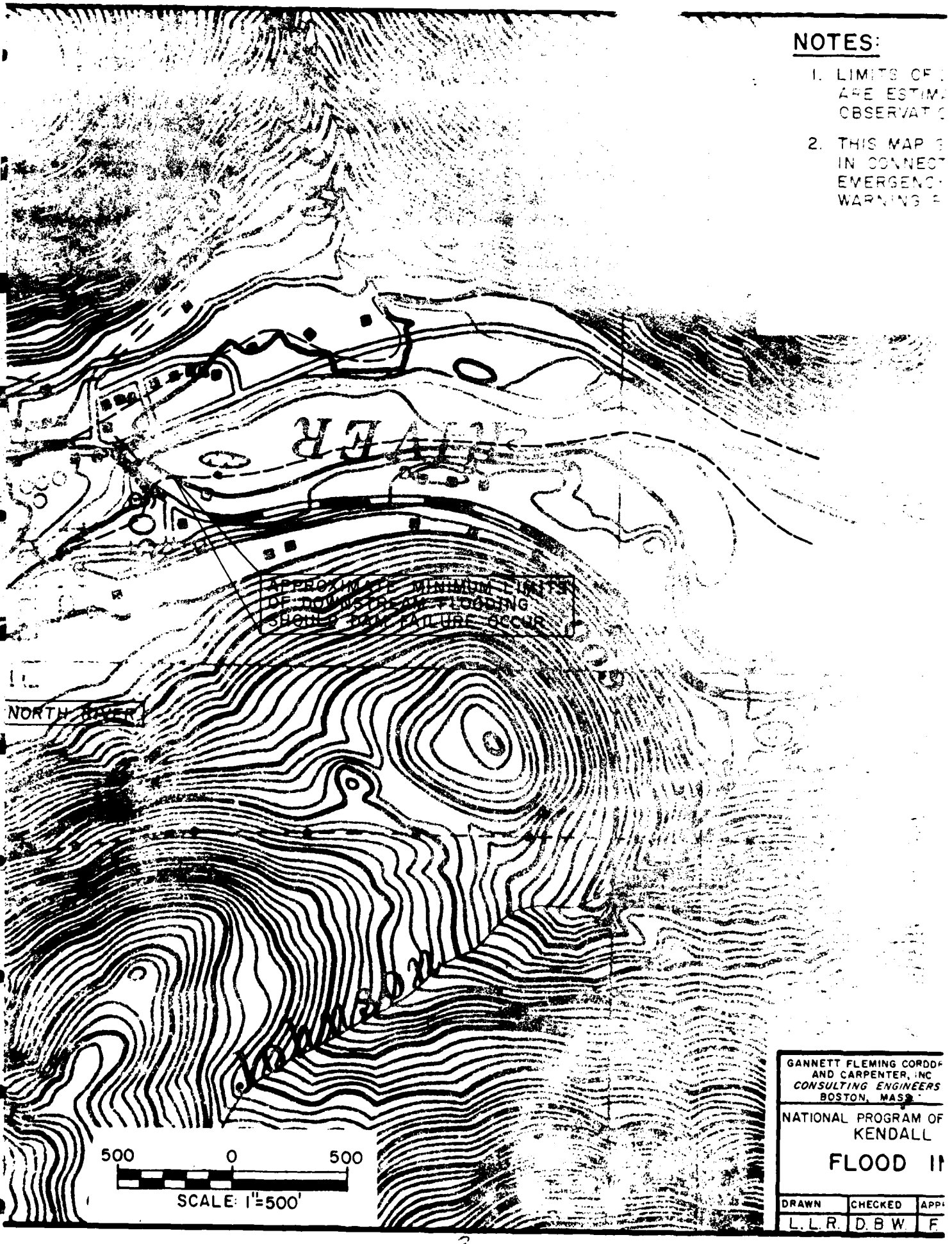
Since only property damage is involved, hazard classification is "significant" hazard.



RATING CURVES
DOWNSTREAM SECTIONS

11-0


NO. 1 BASIN
NORTH RIVER
500
0
SCALE 1


NOTES:
1. LIMITS OF
ARE ESTIM
OBSERVAT
2. THIS MAP
IN CONNEC
EMERGENC
WARNING
APPROXIMATE MINIMUM LIMITS
OF DOWNSTREAM FLOODING
SHOULD DAM FAILURE OCCUR
NORTH RIVER
500 0 500
SCALE: 1"=500'
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AND CARPENTER, INC
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KENDALL
FLOOD I
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L. L. R.
D. B. W.
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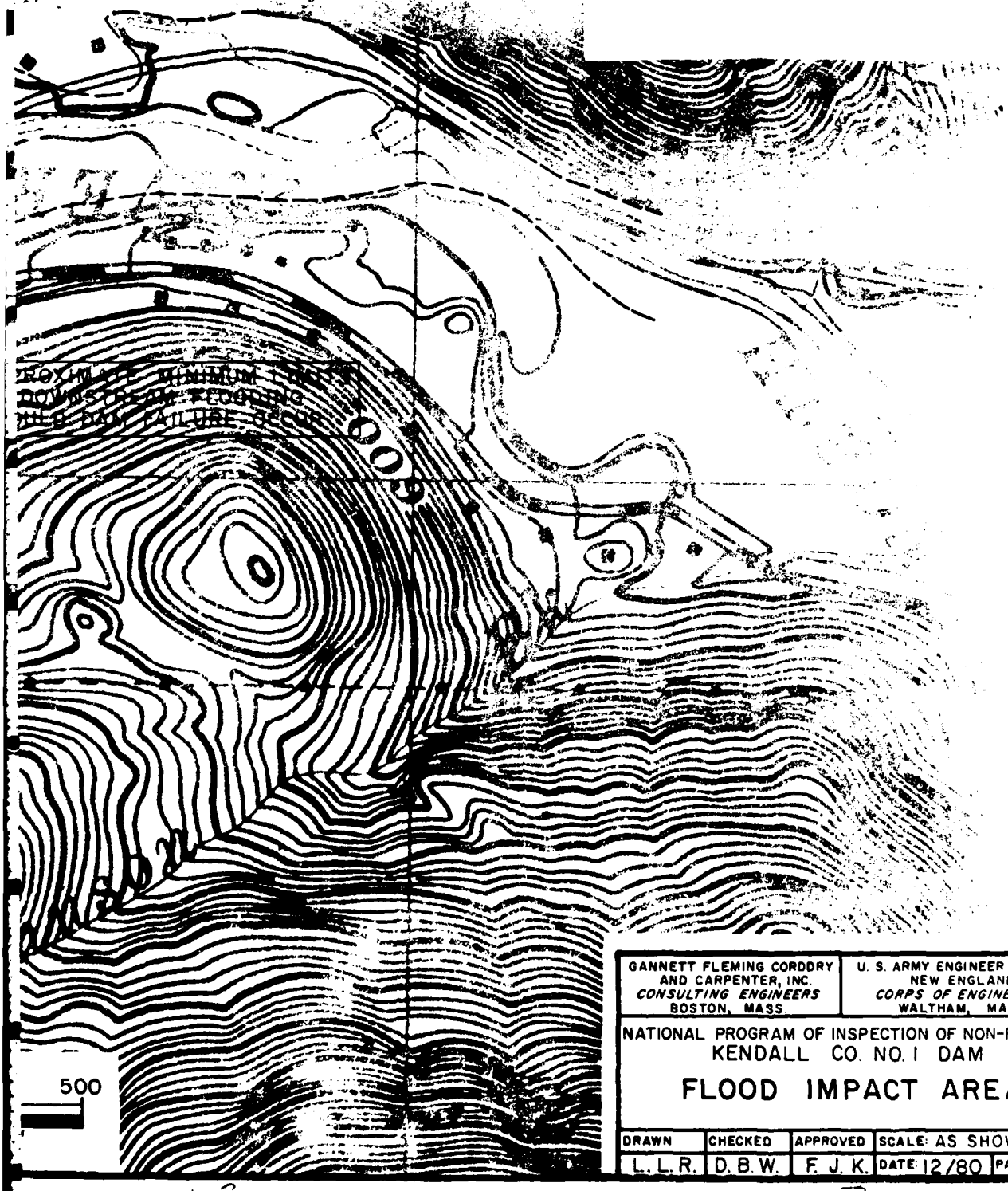
FIGURE 5

NOTES:

1. LIMITS OF DOWNSTREAM FLOODING ARE ESTIMATES BASED ON VISUAL OBSERVATIONS.
2. THIS MAP SHOULD NOT BE USED IN CONNECTION WITH THE EMERGENCY OPERATION AND WARNING PLAN.



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NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS
KENDALL CO. NO. 1 DAM

FLOOD IMPACT AREA

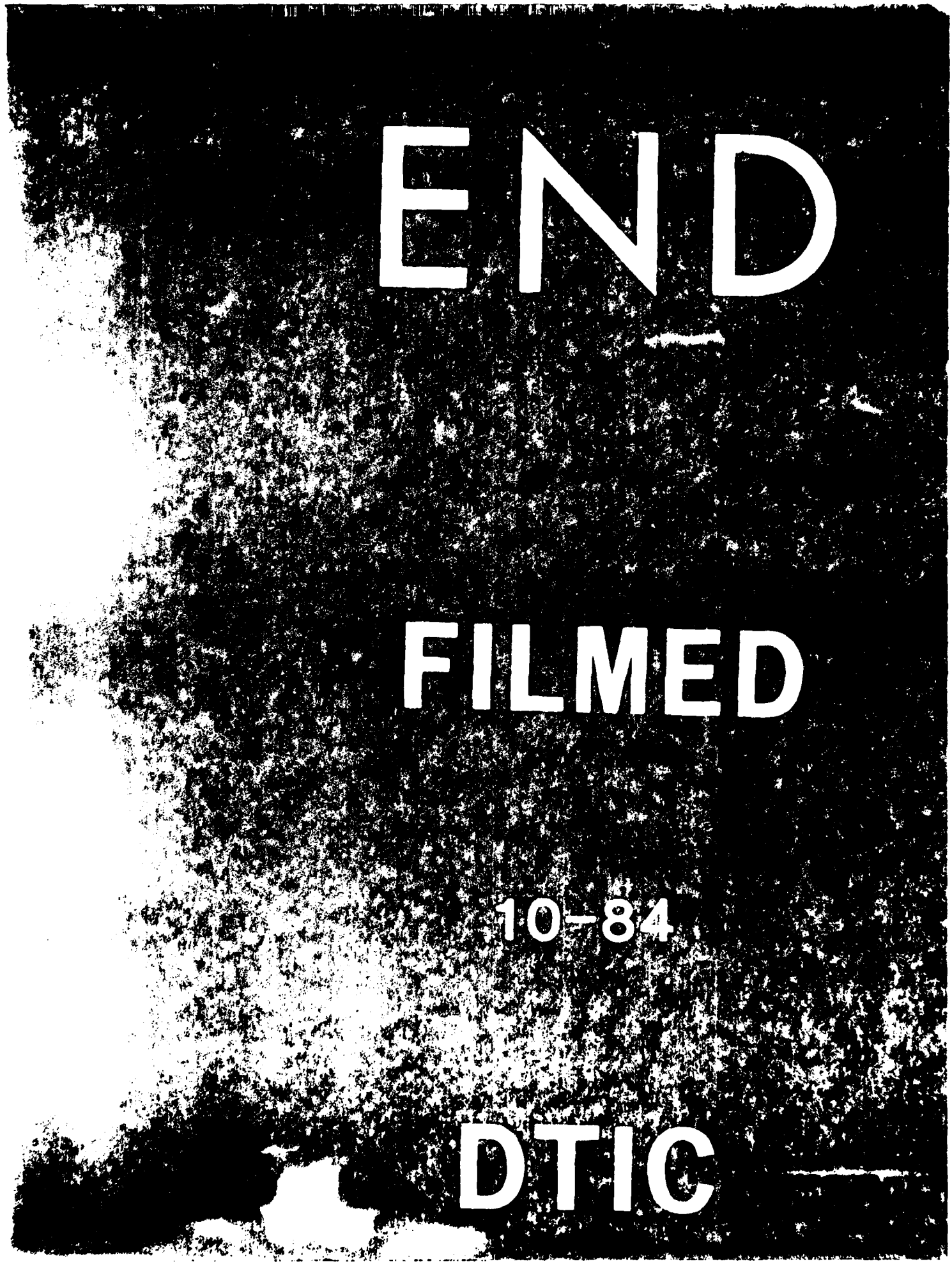
DRAWN	CHECKED	APPROVED	SCALE: AS SHOWN	
L. L. R.	D. B. W.	F. J. K.	DATE: 12/80	PAGE D-12

APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS

NOT AVAILABLE AT THIS TIME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