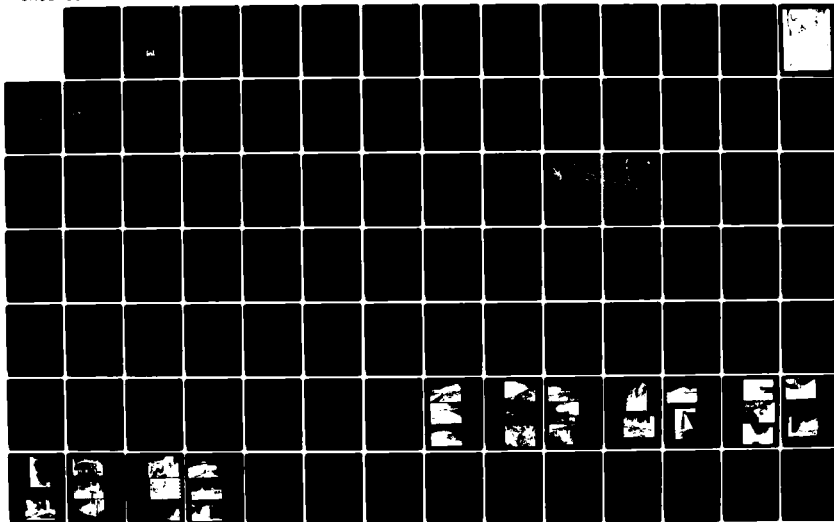
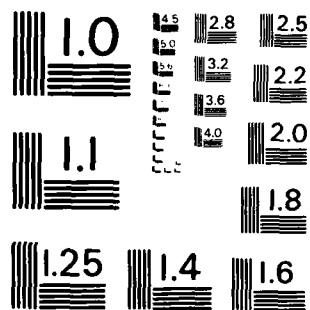


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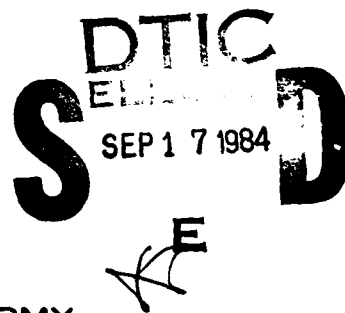
AD-A145 564

CONNECTICUT RIVER BASIN
RUSSELL, MASSACHUSETTS

COBBLE MOUNTAIN RESERVOIR DAM
MA 00068

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

MARCH 1980

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MA 00068	2. GOVT ACCESSION NO. A145 564	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Cobble Mountain Reservoir Dam		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT
NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254		12. REPORT DATE March 1980
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		13. NUMBER OF PAGES 120
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) DAMS, INSPECTION, DAM SAFETY, Connecticut River Basin Russell, Massachusetts		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The dam is a sluiced earth fill between massive rock toe embankments. The top of the dam is about 730 feet long and about 250 feet above the valley bottom at the toe. The dam is generally in GOOD condition, well maintained, with no excessive or dangerous leakage. The preliminary hydrologic and hydraulic analysis for this LARGE size, HIGH hazard dam indicated that the spillway is adequate. The test fild is the PMF and for a tributary drainage area of 45.8 square miles of mountainous terrain which is more than 80% forested, the unit discharge rate is 440 CFS/square miles.		



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

REPLY TO
ATTENTION OF:
NEDED

DEC 9 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 Cobble Mountain Reservoir Dam (MA-00068) Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. In addition, a copy of the report has also been furnished the owner, City of Springfield Water Department, Mass.

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,

WILLIAM E. HODGSON, JR.
Colonel, Corps of Engineers
Acting Division Engineer

Incl
As stated

COBBLE MOUNTAIN RESERVOIR DAM

MA 00068

CONNECTICUT RIVER BASIN
RUSSELL, MASSACHUSETTS

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

Identification No.:	MA 00068
Mass. DPW No.:	1-7-256-11
Name of Dam:	Cobble Mountain Reservoir Dam
Town:	Russell
County and State:	Hampden County, Massachusetts
Stream:	Little River
Date of Inspection:	November 15, 1979

BRIEF ASSESSMENT

The Cobble Mountain Reservoir Dam embankment is located in Russell, Massachusetts on the Little River about thirteen (13) miles above its point of discharge into the Westfield River at a point that is about nine miles above its confluence with the Connecticut River. This facility is located where the three Towns of Blandford, Granville and Russell abut, with the diversion tunnel inlet and the upstream toe dam lying in Blandford and the emergency spillway and intake control tower located in Granville. The dam is a sluiced earth fill between massive rock toe embankments. The top of the dam is about 730 feet long and about 250 feet above the valley bottom at the toe. A spillway with a reinforced concrete overflow weir 135 feet long standing six (6) feet above the spillway floor has been cut through rock about 1500 feet south of the dam. An intake and power tunnel 10 feet by 11.5 feet has been driven through rock about 3000 feet south of the dam. A diversion tunnel 10.5 feet by 10.5 feet is located through rock about 1000 feet northwest of the dam.

The dam is generally in GOOD condition, well maintained, with no excessive or dangerous leakage. However, the stability of the embankment in modern engineering terms, particularly with respect to seismic loading and the potential for liquifaction of the hydraulic fill has not been analyzed, and for this reason, the dam has been rated as FAIR.

The preliminary hydrologic and hydraulic analysis for this LARGE size, HIGH hazard dam indicates that the spillway is adequate. The test flood is the Probable Maximum Flood and for a tributary drainage area of 45.8 square miles of mountainous terrain which is more than 80% forested, the unit discharge rate is 1440 CFS/square mile. The inflow to the reservoir from the maximum probable flood would be about 66,000 cfs. When routed through the reservoir by preliminary methods, the maximum outflow would be about 38,000 cfs which would flow over the spillway weir with about 15.3 feet of head. This leaves about 4.7 feet of freeboard to the top of the dam.

The spillway has a capacity of approximately 145% of the routed test flood outflow.

Failure of the dam could cause floodwater to race down the Little River valley as much as 90 feet deep. The City of Westfield could be flooded up to about elevation 168 ft. MSL. This is about twenty (20) feet above Main Street and Broad Street and would reach nearly to Noble Hospital. About 5,000 acres of Westfield and Southwick might be flooded. Dikes along the Westfield River could be topped by several feet and much of the Merrick area of West Springfield and the Eastern States Exposition grounds could be flooded as well as much low land in Agawam along the Westfield and Connecticut Rivers.

The recommendation for seismic stability and liquefaction analysis should be initiated within one (1) year of receipt of this report by the Owner. The remedial measures listed in Section 7 should be implemented within two (2) years of the receipt of this report by the Owner.



John W. Powers
Engineer

JOHN W. POWERS

MASSACHUSETTS REGISTRATION 23106

This Phase I Inspection Report on Cobble Mountain Reservoir Dam (MA-00068) 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.

Aramast Martesian

ARAMAST MARTESIAN, MEMBER
Geotechnical Engineering Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Richard J. DiBuono

RICHARD DIBUONO, CHAIRMAN
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

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

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

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

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

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

The Phase I Investigation does 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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APPENDICES

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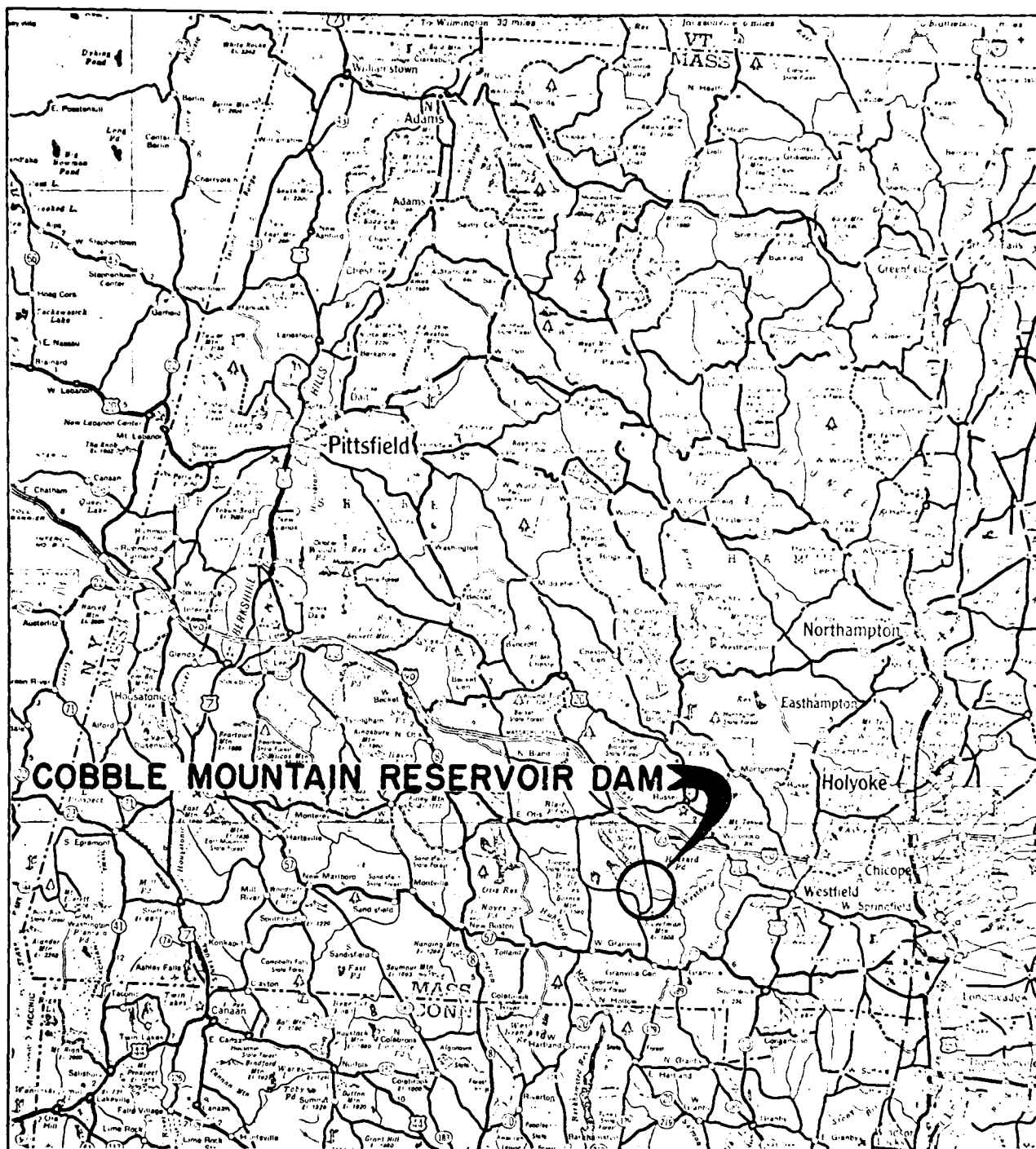
APPENDIX B - ENGINEERING DATA

APPENDIX C - PHOTOGRAPHS

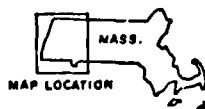
APPENDIX D - HYDROLOGIC AND HYDRAULIC COMPUTATIONS

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





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CONSULTING ENGINEERS
EASTHAMPTON, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

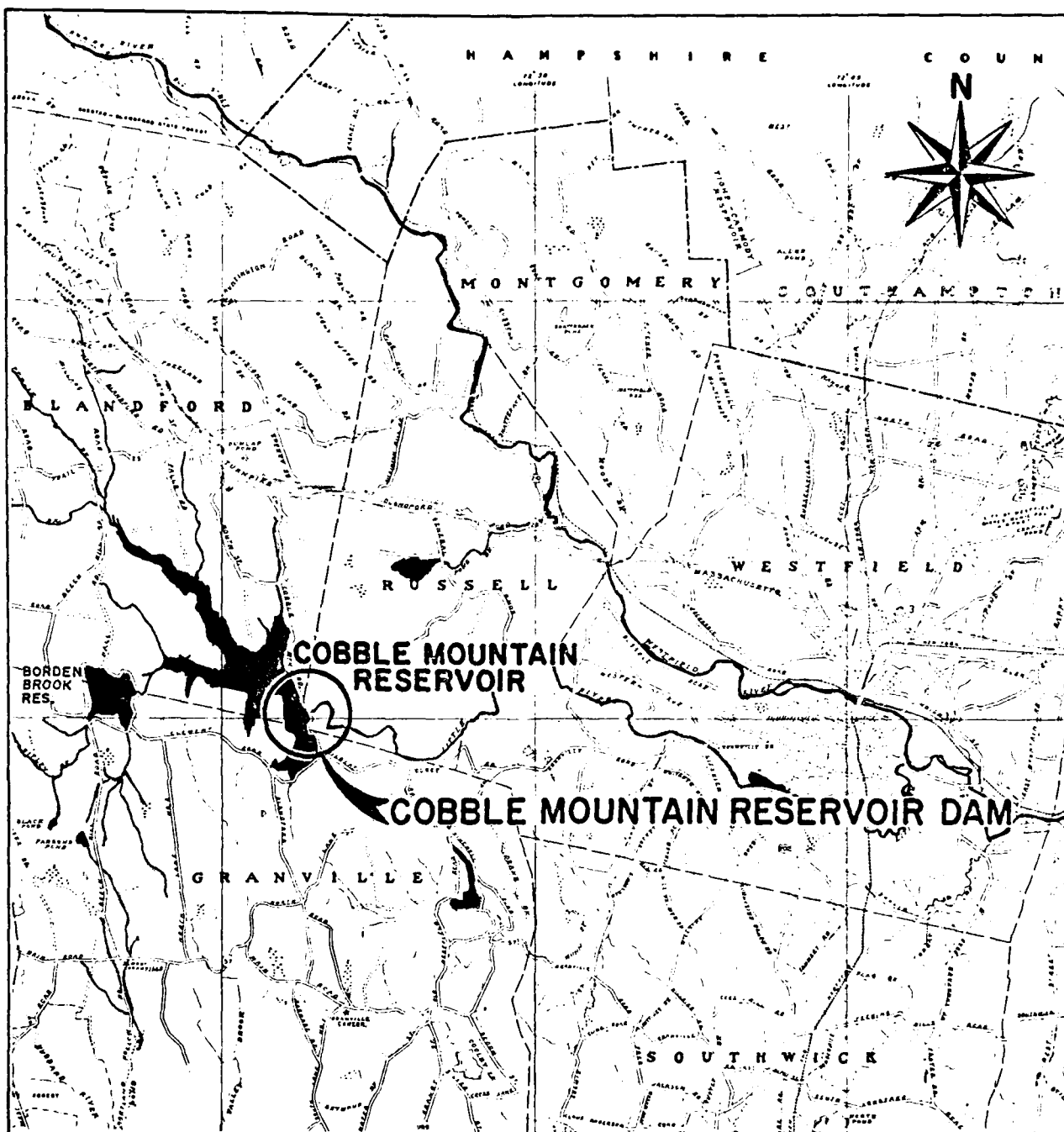
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LOCUS PLAN I

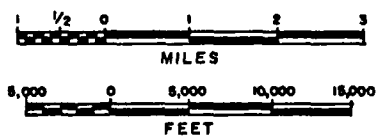
COBBLE MOUNTAIN RESERVOIR DAM (MA 00068) RUSSELL
HAMPTEN COUNTY MASSACHUSETTS

SCALE: AS NOTED

DATE: MARCH 1980



- SCALE -



FROM: GENERAL HIGHWAY MAP,
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WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCUS PLAN 2

COBBLE MOUNTAIN RESERVOIR DAM (MA 00068) RUSSELL
HAMPDEN COUNTY MASSACHUSETTS

SCALE: AS NOTED

DATE: MARCH 1980

PHASE I INSPECTION REPORT
COBBLE MOUNTAIN RESERVOIR 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 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. Tighe & Bond/SCI has been retained by the New England Division to inspect and report on selected dams in Massachusetts. Authorization and notice to proceed were issued to Tighe & Bond/SCI under a letter of October 24, 1979 from Colonel William E. Hodgson, Jr., Corps of Engineers. Contract No. DACW 33-80-C-0005 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 prepare the states to initiate quickly effective dam safety programs for non-federal dams.
- 3) Update, verify, and complete the National Inventory of Dams.

(c) Scope

The program provides for the inspection of non-federal dams in the high hazard potential category based upon location of the dams, and those dams in the significant hazard potential category believed to represent an immediate danger based on condition of the dams.

1.2 Description of Project

(a) Location

Cobble Mountain Reservoir Dam is located on Little River about thirteen (13) miles from its confluence with the Westfield River which is at the east end of the City of Westfield. Cobble

Mountain Dam is west of the City of Westfield about 8.9 miles from Elm Street and Main Street via Granville Road and Wildcat Road in the Town of Russell. The spillway and intake tunnel are in the Town of Granville. The dam is shown on U.S.G.S. topographic quadrangle "Blandford" and the spillway on U.S.G.S. topographic quadrangle West Granville. The dam is located at latitude N 42°-07'-34", longitude W 72°-53'-37". See Locus Plans 1 and 2.

(b) Description of Dam and Appurtenances

The dam consists of a hydraulic fill earth embankment about 730 feet long and 250 feet high. A free overflow concrete spillway weir and outflow channel is located about 1500 feet to the south, beyond Cobble Mountain. An intake tunnel control structure is located south of the spillway about 3000 feet south of the dam. A diversion tunnel intake control structure is located about 1000 feet northwest of the dam.

1) Embankment (B-1, B-2, B-3, B-4, B-5, B-6, B-7, B-8, B-9, and B-10)

The dam embankment, which has no appurtenant structures within its mass, is a sluiced hydraulic fill with a 1510 feet base width along the stream and 50 feet wide at the top with a top length of about 730 feet. A rock diversion dam with an impervious zone seal at the upstream face forms the upstream toe of the dam. A rock foundation drain fills the bottom of the valley to a depth of about 30 feet from a point about 200 feet downstream of the cutoff walls to the concrete arch toe dam at the downstream toe of the dam. The concrete toe dam is provided with three 4 ft. x 6 ft. weep holes to allow exit of foundation drainage. Topsoil was stripped up to 125 feet wide and a concrete cutoff wall was placed to a depth of at least five (5) feet into sound ledge rock across the valley and up to an elevation of 955. A second cutoff wall was placed across the valley bottom up to an elevation of about 765. In addition, extensive foundation grouting was carried out along the cutoff walls. Sluiced hydraulic fill was placed up to about elevation 945 and a puddled core up to elevation 956. The upstream and downstream embankment slopes were designed and constructed with variable slopes which begin fairly flat at the toe and increase in steepness toward the top of the dam. The embankment slopes vary from 1 on 4.72 and 1 on 4.52 at low levels to 1 on 1.5 above about elevation 959. The design drawings (Appendix B) indicate the design top of dam elevation was 965, however, during construction this was increased and a roadway was constructed across the top of the dam. Dam embankment construction was carried up to elevation 969.5 and road construction completed the embankment to elevation 973. Measurements made during this inspection indicate that the lowest point along the top of the dam is presently about elevation 972±.

Substantial rock fills were provided at both upstream and downstream toes of the embankment. The upstream face was covered with five (5) feet of rock to elevation 910 and 15 feet of rock above that elevation. The downstream face was provided with a five (5) foot thick cover up to elevation 860. Then the rock cover thinned to two feet thick from elevation 910 to elevation 956. Above elevation 956 the rock face became thicker as the sides were steepened to raise the top from design elevation of 965 to final top of road at elevation 973.

2) Spillway (B-1, B-11, B-12, B-13, and B-14)

The spillway is an open rock cut up to fifty (50) feet deep and fifty (50) feet wide at the bottom. A reinforced concrete overflow weir 135 feet long controls overflow. Weir crest is at elevation 952.0 feet NGVD. Concrete abutments rise six feet above the weir crest which stands six feet above the sand floor approach channel and concrete lined spillway chute. The concrete lined spillway chute narrows to about fifty (50) feet wide at the roadway bridge which is 175 feet downstream from the weir and extends past the bridge to a point about 210 feet downstream from of the weir.

The spillway bridge is an elliptical concrete arch thirty (30.00) feet wide with a sixty (60) foot span at spring line and an elevation of 967 NGVD at the soffit of the crown.

(3) Intake (B-16, B-17, B-18, and B-19)

The intake control tower is a 32 ft. x 28 ft. reinforced concrete structure housing 20 ft. x 20 ft. trash rack and roller gate and hoisting machinery. The structure also contains a six (6) foot diameter control valve and its emergency hydraulic operating pump, as well as a 7 ft. x 13 ft. air vent and tunnel access shaft. Principal operating power is electric, remotely controlled at the powerhouse and filter plant. Emergency power for the roller gate hoist is a battery at an upper level of the control tower. Emergency operation of the 6 ft. diameter valve is by a hand operated hydraulic pump.

A 10.0 ft. wide x 11.5 ft. high concrete lined tunnel with an invert at elevation 830 and 218 feet long connects the control tower with the reservoir. A concrete lined tunnel 10.0 ft. wide x 9.33 ft. high and 6350 ft. long connects the control tower to a 10 ft. diameter steel power plant inlet that delivers water to the hydroelectric power house at the Intake Reservoir.

(4) Diversion (B-15)

A concrete lined 10.5' x 10.5' horseshoe section tunnel 1600 ft. long allows stream diversion and reservoir draining

around the dam embankment. The tunnel floor at the reservoir inlet is at elevation 754. Control is via two 42 in. diameter steel pipes and valves at elevation 753.25 ft. MSL at centerline. Each pipe is fitted with a 39-3/4 inch rotary valve by Escher-Wyss with 4 in. bypass and then a 42 in. x 30 in. Larner-Johnson discharge regulator discharging through a brick wall into the discharge tunnel which has an air vent and separate stairway from the valve room to the surface. The valves are operated by hand wheels from an operating floor above the valve room.

(c) Size Classification

Both the structural height of 250 feet and capacity of 96,500 acre feet put this dam in the LARGE size classification.

(d) Hazard Classification

The extensive flooding and great loss of life in Westfield and West Springfield that would result from failure of this dam places it in the HIGH hazard classification. There is a high potential for severely damaging hundreds of homes with the attendant possible loss of hundreds of lives as well as numerous highway and railroad bridges, industrial and commercial areas, and other structures.

(e) Ownership

Cobble Mountain Reservoir Dam is owned by the City of Springfield, represented by its Board of Water Commissioners. The address is as follows:

City of Springfield Water Department
City Hall, Court Square
Springfield, Massachusetts 01105
Tel: 413-787-6060

(f) Operator

Cobble Mountain Reservoir Dam is operated by the City of Springfield, acting through its Water Department.

The operator at the dam site on a daily basis is:

Mr. William York
Borden Brook Reservoir
Granville, Massachusetts 01034
Tel: 413-357-8733
Emergency Tel: 413-787-6206

(g) Purpose of Dam

The purpose of Cobble Mountain Reservoir Dam is to provide a water supply reservoir for the City of Springfield, Massachusetts. The reservoir also provides for hydroelectric generation.

(h) Design and Construction History

Cobble Mountain Reservoir Dam was designed by Mr. Allen Hazen of New York and built during the period 1927 to 1932 under multiple construction contracts.

Notes of Mr. James L. Tighe who reviewed the design and construction for the Hampden County Commissioners indicate that close control was maintained over the quality of the material being sluiced into the hydraulic fill core. On May 20, 1930 sluicing operations were stopped because of excessively fine material. Construction methods and borrow areas were reorganized and construction resumed on September 20, 1930. Construction proceeded steadily thereafter with adjustments of borrow material from time to time and, on occasion, removal of unsatisfactory material from the core. Core construction was completed October 17, 1931 and rock paving was completed on January 30, 1932 when the reservoir water level was at elevation 832. Diversion tunnel gates were closed on August 25, 1931 to start reservoir filling. The City of Springfield started using water from Cobble Mountain Reservoir on December 1, 1931. Road construction was completed at a later date.

A seepage weir with a crest length of 4.0 feet was constructed downstream of the dam. James L. Tighe's notes indicate that seepage increased as the reservoir filled. The reservoir reached an elevation of 938.7 on January 31, 1933 when flow over the seepage weir was 0.98 cfs. Seepage flow during 1933 and 1934 correlated closely with reservoir levels. On June 16, 1934 with the reservoir at elevation 939.6, the seepage flow was 0.86 cfs.

The dam was designed to have a top elevation of 965.0 feet MSL, a top width of 50 feet, and variable embankment slopes with a maximum slope downstream of 1 on $2\frac{1}{4}$ and 1 on $2\frac{3}{4}$ upstream. The top of the dam was raised during construction to a final elevation of 969.5 before road construction by increasing the steepness of the upper part of the dam to 1 on $1\frac{1}{2}$ both upstream and downstream.

The spillway was designed to have a crest in the concrete floor at elevation 945.0 with flashboards mounted on steel pipes seven feet high to elevation 952.0. The concrete spillway weir was actually constructed to an elevation of 952.0 with no provision for flashboards. At the same time, the concrete spillway abutments were raised from elevation 955.0 to elevation 958.0.

Maintenance grouting has been carried out in the diversion tunnel to control seepage. In 1973, the spillway weir wall was reconstructed and the concrete outflow channel floor and side walls were resurfaced and weepholes were installed.

(i) Normal Operating Procedures

The dam, intake works, supply tunnel, diversion tunnel and diversion control structure are owned and maintained by the City of Springfield. Daily operation of the power plant which regulates reservoir level is under control of Northeast Utilities. The operating agreement specifies minimum reservoir levels for each month of the year based on annual water demand by the City of Springfield. Minimum daily discharge required to meet the requirements of the City of Springfield is released. Within these limits the power company operates to use all inflow to the reservoir. Normally there will be no flow over the spillway. Normally, the reservoir will be within about a foot of the spillway crest in late spring and at its lowest level in late fall. There are no special operations for flood control purposes.

1.3 Pertinent Data

(a) Drainage Area

The drainage area tributary to this dam is about 45.8 square miles including 8 square miles tributary to Borden Brook Reservoir which is upstream of Cobble Mountain Reservoir. Most of the area is steep and mountainous with good forest cover.

Controlled flow from the watershed of the Littleville Flood Control Dam can be diverted to the Reservoir via a pumping station located in Russell.

(b) Discharge at Dam Site

1) Outlet Works

Normal discharge from the reservoir is via a ten (10) foot diameter concrete lined tunnel which delivers water to a hydroelectric powerhouse. The invert of the tunnel intake is at elevation 830.0 MSL. Inlet controls consist of a 6 foot diameter valve and a 20 ft. x 20 ft. steel roller gate which are installed in series with the steel roller gate on the upstream side of the intake structure. The intake tunnel has a capacity of approximately 1120 CFS with the reservoir level at the spillway test flood elevation of 967.3.

A reservoir drain and diversion tunnel consisting of a 10½ ft. x 10½ ft. concrete lined tunnel has inlet invert at elevation 754.0 feet MSL. Control is via two 42 in. diameter steel pipes. Each pipe discharges through two valves in series into the outlet tunnel. The diversion tunnel has a capacity of approximately 3780 CFS with the reservoir level at the spillway test flood elevation of 967.3.

2) Maximum Known Flood

The maximum flood record at this site occurred on August 19, 1955. Peak inflow has been estimated to be about 19,600 cfs. Peak outflow via spillway and intake tunnel has been estimated at 12,850 cfs. The reservoir stage reached a maximum elevation of 959.1 feet NGVD, which is 7.1 feet above the spillway crest.

3) Ungated Spillway Capacity at Top of Dam

The capacity of the spillway above the crest elevation (952.0 feet NGVD) to the top of the dam (elevation 972.± feet NGVD) is about 55,000 cfs.

Elevation 972± is the low point along the roadway over the top of the dam as field measured during this inspection.

4) Ungated Spillway Capacity at Test Flood

The capacity of the spillway above the crest elevation (952.0 feet NGVD) with the reservoir at test flood elevation (967.3 feet NGVD) is about 38,000 cfs.

5) Gated Spillway Capacity at Normal Pool

None

6) Gated Spillway Capacity at Test Flood

None

7) Total Spillway Capacity at Test Flood

The capacity of the spillway above the crest elevation (952.0 feet NGVD) with the reservoir at test flood elevation (967.3 feet NGVD) is about 38,000 cfs.

8) Total Project Discharge at Top of Dam

Total project discharge including spillway, intake tunnel and diversion tunnel with reservoir at top of dam elevation (972 feet NGVD) is about 60,000 cfs.

9) Total Project Discharge at Test Flood

Total project discharge including spillway, intake tunnel and diversion tunnel with reservoir at test flood elevation (967.3 feet NGVD) is about 42,900 cfs.

(c) Elevation (feet above MSL NGVD)

- 1) Stream bed at toe of dam: 722±

2)	Bottom of cutoff:	710±
3)	Maximum tailwater:	Unknown
4)	Normal pool:	952.0
5)	Full flood control pool:	not applicable
6)	Spillway crest:	952.0
7)	Design surcharge: Based on:	958.5
	a) Design spillway crest	945.0
	b) Design top of dam	965.0
8)	Top of dam	
	a) as built	973
	b) existing low point	972±
9)	Test flood surcharge:	967.3
(d)	<u>Reservoir</u> (length in feet)	
1)	Normal pool (952.0 NGVD):	21,000
2)	Flood control pool:	Not applicable
3)	Spillway crest pool (952.0 NGVD):	21,000
4)	Top of dam (972 NGVD):	22,600
5)	Test flood surcharge (967.3 NGVD) :	22,300
(e)	<u>Storage</u> (acre-feet)	
1)	Normal pool (952.0 NGVD):	70,000
2)	Flood control pool:	Not applicable
3)	Spillway crest pool (952.0 NGVD):	70,000
4)	Top of dam (972 NGVD):	96,500
5)	Test flood pool (967.3 NGVD):	91,200
(f)	<u>Reservoir Surface</u> (acres)	
1)	Normal pool (952.0 NGVD):	1134
2)	Flood control pool:	Not applicable

- | | | |
|----|-----------------------------------|------|
| 3) | Spillway crest pool (952.0 NGVD): | 1134 |
| 4) | Top of dam (972.1 NGVD): | 1445 |
| 5) | Test flood pool (967.3 NGVD): | 1385 |

(g) Dam

- | | | |
|----|------------------|---|
| 1) | Type: | Hydraulic fill between rock toes |
| 2) | Length: | 730 feet |
| 3) | Height: | 250 feet |
| 4) | Top width: | 50 feet |
| 5) | Side slopes: | upstream: 1:4.72 to 1:1.5
downstream: 1:4.52 to 1:1.5 |
| 6) | Zoning: | sluiced hydraulic core
rock fill toe upstream and downstream
rock facing upstream and downstream
rock riprap upstream upper zone |
| 7) | Impervious core: | sluiced hydraulic fill |
| 8) | Cutoff: | 3 ft. wide x 3 ft. high concrete at least 5 ft.
deep in good rock. One wall full width of
dam, one wall across valley bottom |
| 9) | Grout curtain: | 15 ft. deep full valley width and 8 holes
25 feet deep |

h) Diversion and Intake Tunnels

	<u>Diversion</u>	<u>Intake</u>
1) Type:	concrete lined rock bore	concrete lined rock bore
2) Length:	1550 feet	7500 feet
3) Closure:	Concrete 48 feet long	Inlet control structure
4) Access:	Gatehouse shaft	Gatehouse shaft
5) Regulating Facilities:	2-42" steel pipes each with 1 rotary valve and 1 retracting plug valve	20' x 20' steel roller gate 6' diam. valve & turbine controls @ power plant

i) Spillway

- 1) Type: Concrete wall 6 ft. high, 4 in. x 4 in. chamfered front corner, rounded downstream corner of 3 ft. wide top.
- 2) Length of weir: 135.0 feet
- 3) Crest elevation: 952.0 NGVD
- 4) Gates: none
- 5) Upstream channel: sand and gravel
- 6) Downstream channel: concrete lined for 210 ft. then rock cut
- 7) General: Channel floor drops 15 ft. in 200 ft. and narrows from 135 ft. to 50 ft., then 1% slope in rock cut.

(j) Regulating Outlets

	<u>Diversion</u>	<u>Intake</u>
1) Invert	754.0	830.0
2) Size	2-42 in. in parallel	20 ft. x 20 ft. 6 ft. diam.
3) Description	40 in. rotary retracting plug	roller gate valve
4) Control mechanism	handwheels	electric hoist hydraulic operator

SECTION 2 - ENGINEERING DATA

2.1 Design Data

Design data shown on eighteen sheets of design plans and reports of the County Commissioner's Engineer and Review Board indicate the dam was designed in accordance with good engineering practice of the time.

The site was well mapped and investigated for foundation and embankment material. Project facilities were located to assure maximum integrity of the dam embankment. There were no abrupt changes in the regular "V" shaped valley profile that would indicate potential problems. Drainage was specifically provided for. Generous spillway capacity for that time - 20,000 cfs - was provided at a site removed from the embankment. Generous, secure diversion and intake works were provided.

2.2 Construction Data

The diary and notes of James L. Tighe who inspected the work for the Hampden County Commissioners, other review commission reports, and published reports indicate that construction was carefully supervised to assure that good quality material was properly placed during construction.

2.3 Operation Data

The dam, intake works, supply tunnel, diversion tunnel and diversion control structures are owned and maintained by the City of Springfield. Daily operation of the power plant which regulates reservoir level is under the control of Northeast Utilities. The operating agreement specifies minimum reservoir levels for each month of the year based on annual water demand by the City of Springfield. Minimum daily discharge required to meet the requirements of the City of Springfield is released. Within these limits, the power company operates to use all inflow to the reservoir. Normally there will be no flow over the spillway. Normally the reservoir will be within about a foot of the spillway crest in late spring and lowest in late fall. There are no special operations for flood control purpose.

Maintenance records are available from the City of Springfield. Detailed records of operation including reservoir elevation, discharge, etc., are available from Northeast Utilities, the power plant operation.

2.4 Evaluation of Data

(a) Availability

Plans of the dam as built and basic information were readily available from the Springfield Water Department. Additional reports were readily available in publications of the New England Water Works Association. Notes and design plans and reports were

obtained from the files of Tighe & Bond/SCI, Easthampton, Massachusetts. Records of materials placed during construction are available from the Springfield Water Department.

(b) Adequacy

The data and information was adequate, when combined with visual inspection and engineering experience and judgment, to evaluate the safety of Cobble Mountain Reservoir Dam under normal operating conditions. The data examined for this report was not adequate to evaluate the safety of Cobble Mountain Reservoir Dam under seismic load conditions. There may not be adequate existing information for seismic analyses, including the potential for liquefaction of the hydraulic fill.

(c) Validity

Since visual inspection observations confirm the available data and reports from several independent sources concur on construction procedures, it is concluded that the data is valid and reliable.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

(a) General

Cobble Mountain Reservoir Dam is in GOOD condition at the present time.

(b) Dam (see photos in Appendix C)

The dam embankment was found to be covered with rock. The upstream face had a thick layer of rock that obscured any observation of underlying material. The downstream face was not as thickly covered and gravel and sand were at the surface in some areas. Brush growth on all faces of the dam had been cut and was obviously well controlled. Drainage through the concrete toe dam was clear and free from silt though red iron oxide sludge was present in the bottom of pools. Rock debris filled the bottom of the valley nearly to the top of the weep holes. There was no sign of leakage from the face of the dam above the toe dam. The concrete toe dam showed weather deterioration up to 2 inches deep on all exposed faces. There was minor seepage from the face of the toe dam near the right abutment. The road across the top of the dam was in good condition. The road at the center of the dam was observed to be about 1.8 feet lower than the approaches to the dam.

This difference is believed to be due to a combination of minor settlement of the dam embankment and the formation of a vertical curvature in the roadway with the abutment areas being built up forming the roadway approaches. The abutment areas are believed to be somewhat higher than elevation 973 due to the roadway construction.

(c) Appurtenance Structures

The spillway was found to be in good condition. The spillway weir wall was found sound and in good condition with only minor hairline cracks. Concrete sidewalls and floor had been repaired. Minor seepage was apparent at some joints. Weep holes appeared to be functioning. The spillway bridge was found in excellent condition. The lower part of the spillway with natural rock walls was found with considerable growth of brush up to 2 inches in diameter that would have no detrimental effect on the operation of the spillway.

The intake control building was found in excellent condition. Submerged portions of the structure and equipment were not inspected. Equipment appeared to be in good condition except for a leaky hand hydraulic pump and a jerry-rigged float well for depth indication. Emergency operating facilities appeared to be adequate. The diversion tunnel access building was found in good

condition. Windows were boarded for security against vandalism. Only minor leakage and efflorescence was observed in lower portions of the access shaft. The valve operating floor was in good condition with operating handwheels for all valves in position and no significant deterioration. The valve chamber was found in good condition with no significant deterioration. All valves appeared to be operable; no operation was tested. The valves are frequently operated as part of the powerhouse operation and for routine inspection and maintenance. The diversion tunnel was found in good condition. Some debris from trespass intruders was observed, but none that would prevent normal function. Some leakage and efflorescence was observed in the 340 feet of tunnel nearest the outlet end. Grout holes and evidence of grouting work was noted. The outlet portal showed weather deterioration up to 2 inches deep. A steel grate barrier had been installed but was not maintained closed.

(d) Reservoir Area

The reservoir and shore line appeared to be reasonably clear up to spillway elevation with only scattered brush and minor debris noted at any location.

(e) Downstream Channel

In the valley bottom downstream of the dam to the powerhouse the only flow is leakage through the dam and rare spillway overflows below the spillway. The valley floor was found to have a substantial growth of brush and small trees up to 3 inches in diameter.

3.2 Evaluation

The dam and appurtenances are generally in excellent condition. The maintenance staff is to be complimented.

The following deficiencies or problems may warrant attention:

1. A proper float well and depth indicator should be installed.
2. The hand operated hydraulic pump should be replaced or repaired and located above possible high water.
3. The diversion tunnel outlet gate should be removed if it is not to be maintained secure to avoid the possibility that debris inside the tunnel may partially block the outlet and cause back pressure at the valve chamber.
4. The present elevation and profile of the top of the dam should be determined.

SECTION 4 - OPERATION AND MAINTENANCE PROCEDURES

4.1 Operation Procedures

See Section 1.2(i), page 1-5, for a general description of operating procedures.

There are no special operations for flood control purposes or other dam failure contingencies. The Springfield Water Department has an "Emergency Operations Plan" for dealing with general emergencies concerning the water supply and distribution system.

4.2 Maintenance Procedures

Regular maintenance is performed by a full time staff under the supervision of a foreman who lives at the reservoir. Daily visits are made to the intake control building and dam site. Regular maintenance includes:

Cleaning, lubrication and maintenance of intake control equipment;

Cleaning and maintenance of intake control building and diversion tunnel control building;

Clearing brush from dam, spillway and reservoir area;

General maintenance and debris removal from the reservoir, public areas, and City-owned watershed areas; and

An annual shutdown inspection and maintenance of power facilities and intake tunnel.

No formal program of technical inspections by the Springfield Water Department of the dam, spillway, and diversion tunnel is in effect.

4.3 Evaluation

The framework of normal operating procedures is adequate except for the following deficiencies:

1. A downstream emergency flood warning system should be developed and put into operation.
2. Generation and release operations responding to storm or flood warnings should be developed and put into practice.
3. A biennial program of technical inspections by a registered professional engineer qualified in dam design and inspection should be developed and put into practice.

SECTION 5 - EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General

Cobble Mountain Reservoir Dam is located in Russell, Massachusetts on the Little River about 13 miles above its confluence with the Westfield River in Westfield, Massachusetts. The reservoir is about eight miles west of Westfield at the eastern margin of the Berkshire Hills. The drainage area of about 45.8 square miles is in mountainous terrain that varies to areas of rolling terrain in upper elevations. Bedrock is mica schist covered with glacial deposits of great variety and generally of low permeability. About 80% of the watershed is covered with good forest.

Downstream of the dam, the Little River valley has a steep gradient of about 2% and a steep "V" shaped ravine of about 1:2 to 1:1.2 slope. This valley extends downstream past the power house and intake dam about eight (8) miles to the eastern escarpment of the Berkshire upland at the rolling valley floor of the western part of Westfield. From this point, the river flows through a flood plain by the south margin of the City about five (5) miles to the Westfield River at the east end of the City of Westfield. The Westfield River winds about 3 miles across a flood plain until it enters the water gap between East Mountain and Provin Mountain at the West Springfield town line. For the next 5½ miles the Westfield River flows through a narrow channel between West Springfield and Agawam to the west edge of the Connecticut River flood plain. The Westfield River then flows more than a mile across the Connecticut River flood plain to empty into the Connecticut River less than a mile upstream from the Springfield-Longmeadow town line.

The spillway of the dam is a reinforced concrete wall standing six (6) feet above the approach and discharge channel floor. The spillway weir is 135 feet long. The discharge chute converges to 50 feet wide and drops in elevation about 15 feet in 200 feet and flows through a deep rock cut 50 feet wide to discharge into the Little River valley about half a mile below the toe of the dam.

The flow into the Cobble Mountain Reservoir can be augmented by water pumped from the Littleville Dam impoundment via a pumping station and pipeline to Cobble Mountain. The pumping station is located within the Town of Huntington and presently is equipped with 3 pumps having a combined capacity of about 45 MGD (million gallons per day). Provisions have been made for the future installation of a fourth pump which would increase the capacity by an additional 15 MGD.

5.2 Design Data

Design plans provide a spillway discharge profile and hydraulic calculations for a flow of 20,000 cfs, reported to be 3½ times record flow prior to design date. Page B-11 of Appendix B indicates a design water elevation of 958.5 feet at a 20,000 CFS discharge rate. Reports indicate that model studies were made of the proposed spillway and modifications indicated thereby were adopted. The design plans provide for a concrete crest threshold flush with the spillway floor in an

unlined rock channel. The spillway was actually constructed with concrete lining for about 200 feet from the crest through the bell mouth construction past the bridge. The six foot high concrete weir wall was constructed at a later date. A detailed technical analysis of downstream effects due to dam failure was not carried out in conjunction with the design of this dam based on records available for review.

5.3 Experience Data

Reports made at the time of design indicate flows of about 5700 cfs had been reported at this site and the storm of December 1878 was reported to yield runoff of about 150 cfs per square mile on the Westfield River.

A report by the Springfield Water Department on the storm of August 1955 indicates that the maximum inflow to the reservoir was about 19,600 cfs and the maximum discharge was about 12,850 cfs. The reservoir surface was 7.1 feet above the spillway crest wall. (Reservoir Stage = 959.1 NGVD)

5.4 Test Flood Analysis

The objective of the test flood analysis is to assess the capacity of the dam to safely pass a severe runoff event of a size commensurate with the size of the dam and the downstream hazard to life and property.

Guidelines for establishing a test flood are specified in "Recommended Guidelines" of the Corps of Engineers. The height of this dam (250 feet) and storage volume (96,500 acre-feet) put this dam in the LARGE size classification. The potential for flooding most of the City of Westfield below the elevation of Noble Hospital puts this dam in the HIGH hazard class. Table 3 of the Corps of Engineers "Recommended Guidelines" indicated that the spillway test flood for a LARGE size, HIGH hazard dam should be the probable maximum flood. The spillway test flood applied was PROBABLE MAXIMUM FLOOD.

Storm runoff of a maximum probable flood was estimated based on U.S. Corps of Engineers, New England Division "Preliminary Guidance for Estimating Maximum Probable Discharges." A discharge of 1440 cfs per square mile on the drainage area of 45.8 square miles gives a peak inflow of 66,000 cfs. Routing the probable maximum flood through the reservoir and spillway by preliminary methods assuming the initial reservoir level at spillway crest elevation (952.0 ft. NGVD), results in a maximum reservoir stage of about elevation 967.3 feet NGVD or about 4.7 feet below the top of the dam. Maximum discharge over the spillway would be about 38,000 cfs.

Analysis was made to evaluate the possibility of overtopping Cobble Mt. Dam if Borden Brook Reservoir Dam failed. If Borden Brook Dam failed during a storm with Cobble Mt. Reservoir at elevation 960 (8 feet above the spillway and higher than any past reservoir elevation) the maximum stage of Cobble Mt. Reservoir would be elevation 966.7 ft. NGVD which is 14.7 ft. above spillway crest, and 5.3 ft. below top of dam. Maximum discharge would be about 35,800 cfs over the spillway.

It is concluded that the spillway capacity is adequate to prevent overtopping of the dam due to a Probable Maximum Flood event.

5.5 Dam Failure Analysis

The hazards and potential damages resulting from failure of Cobble Mountain Reservoir Dam were evaluated assuming reservoir level at test flood elevation (967.3 feet NGVD) by the procedures suggested in New England Division, Corps of Engineers "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs." No allowance was made for possible clogging of waterways caused by trees and debris. The length of the dam at mid height and the height of the dam were taken from the plans of the dam provided by the Springfield Water Department. The distance across the valley was taken as 370 feet at elevation 850 and the dam height as 250 feet. The peak discharge using the suggested "Rule of Thumb" is 904,000 cfs. This flow was routed downstream to the Connecticut River.

The PMF discharge via the spillway of 38,000 cfs will flow down the Little River canyon at a depth of about 19 feet and velocities of about 24 fps. This flow would overtop the Intake Dam non-overflow sections by about six (6) feet probably causing considerable damage though not complete collapse. There would probably be some damage to the powerhouse. Dam failure flow could be as much as 90 feet deep in the valley and would probably destroy the powerhouse and possibly the Intake Dam at hazard area (2).

At Northwest Road - hazard area (3) - the PMF spillway discharge would probably flood the road across the valley about eight (8) feet deep and flood two (2) houses and about 250 acres of land. Dam failure flow would inundate Northwest Road as deep as 31 feet, flooding about six (6) houses and 400 acres.

At Horton's Bridge, where Granville Road crosses Little River - hazard area 4 - the PMF spillway discharge would probably flow over the road three (3) feet deep flooding the factory and about five houses above the dam there. Cobble Mountain Dam failure would result in water over the road to a depth of about 41 feet and the flooding of the mill and about 110 houses.

At the Route 202 bridge over the Little River - hazard area 5 - the PMF spillway flow of about 38,000 cfs from the Little River could result in flood water reaching the top of the road with little damage. Cobble Mountain Dam failure would result in flood waters up to about 12 feet above the road, flooding the mill and about 125 houses.

At hazard area 6, the former New Haven railroad embankment and bridge constitutes such a barrier and restriction that the PMF spillway flow would probably flow through the center of Westfield at depths of as much as five feet above some of the City streets. About 400 acres of the City might be flooded, the water reaching an elevation of about 149 feet MSL. The failure of Cobble Mountain Dam would create a flood wave about 19 feet higher than the PMF flood. This failure would flood as much as 600 acres, reaching elevations of about 168 feet MSL, nearly the elevation of Noble Hospital (Elev. 170).

At hazard area 7, the PMF spillway flow would rise as high as about elevation 125 feet MSL before it could pass through the water gap at the West Springfield - Westfield town line. This would inundate about 800 acres in Westfield and Southwick. Cobble Mountain Dam failure would result in water rising to elevation 157 feet MSL, inundating up to 3600 acres in a wide area.

At Dewey Street and Westfield Road - hazard area 8 - the PMF spillway flow would possibly rise to three feet above the road and flood 12 houses and buildings in the area. Dam failure could result in water up to eighteen feet deep over Route 20, Westfield Road, flooding about 30 houses and buildings.

At Front Street in West Springfield - damage area 9 - damage would probably be light as even the dam failure flood would be well below the railroad at Front Street and Bridge Street.

At the Memorial Drive bridge to Agawam - hazard area 10 - the PMF spillway discharge from the dam would pass satisfactorily but the dam failure peak flow would probably overtop the Westfield River flood protection dike by about two feet which could result in flooding about 210 acres of low land near the Eastern States Exposition.

Failure of Cobble Mt. Reservoir Dam would probably cause considerable flooding of low lying areas along the Connecticut River that are not protected by dikes - hazard area 10.

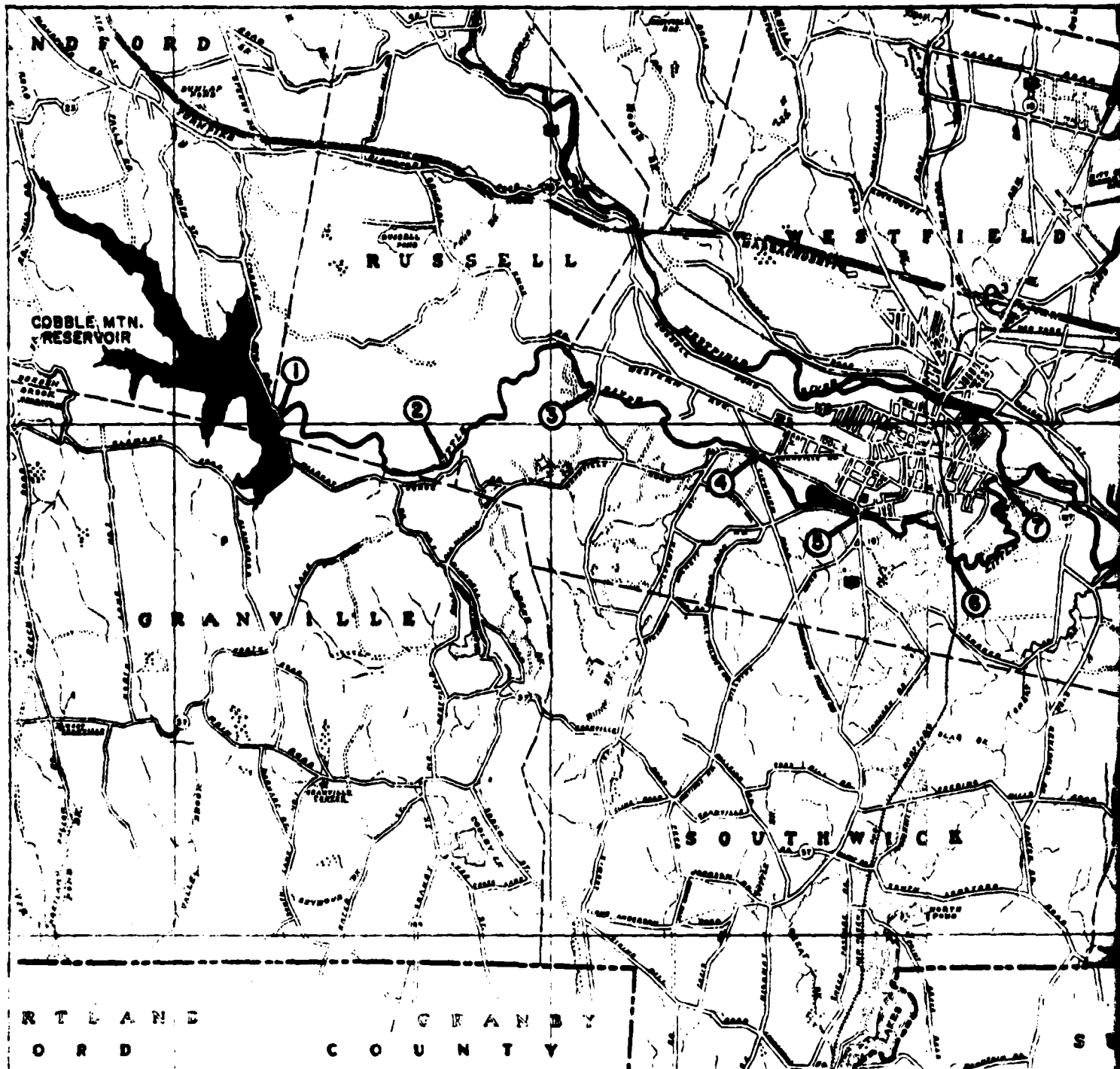
The information reviewed above is summarized in the following table of "Downstream Impacts of Dam Failure," the "Location and Hazard Map," and more fully developed in the computations in Appendix D.

In summary, a Cobble Mountain Dam failure would result in extensive flooding and great loss of life in Westfield and West Springfield. There is a high potential for severely damaging hundreds of homes with attendant possible loss of hundreds of lives as well as numerous highway and railroad bridges, industrial and commercial areas, and other structures.

DOWNSTREAM IMPACTS OF DAM FAILURE

Map Location No.	Distance From Dam ft.	Feature	Before Dam Failure			After Dam Failure			Comments
			Flood Stage cfs	Depth Over Road ft.	Bldgs-Area Flooded each, acres	Flood Stage cfs	Depth Over Road ft.	Bldgs-Area Flooded each, acres	
1	0	Dam	38,000 19	---	---	904,000 91	---	---	---
2	14,000	Intake Dam	38,000 19	---	---	861,000 90	70	1	Power Station flooded by dam failure.
3	31,500	North-west Rd.	38,000 16	8	2 250 Ac.	802,000 38	31	6 400 Ac.	
4	44,000	Horton's Bridge	38,000 7	3	5	720,000 45	41	110	Mill at dam damaged by base flood.
5	52,000	Rte. 202 Bridge	38,000 11 Elev. 164	---	---	677,500 41 Elev. 176	12	125 257 Ac.	Dam & mill destroyed by dam failure
6	59,600	N.H. R.R. Bridge	38,000 5 Elev. 149	5	400 Ac.	605,000 Elev. 168	24	600 Ac.	Main St., Elm St., Broad St., flooded by base flood to City Hall; by failure to Noble Hospital.
7	69,000	East Main St.	38,000 Elev. 125	3	800 Ac.	210,000 Elev. 157	35	3600 Ac.	Base flood over East Main St. Failure floods wide area.
8	88,700	Dewey St.	38,000 20	3	12	196,000 35	18	30	

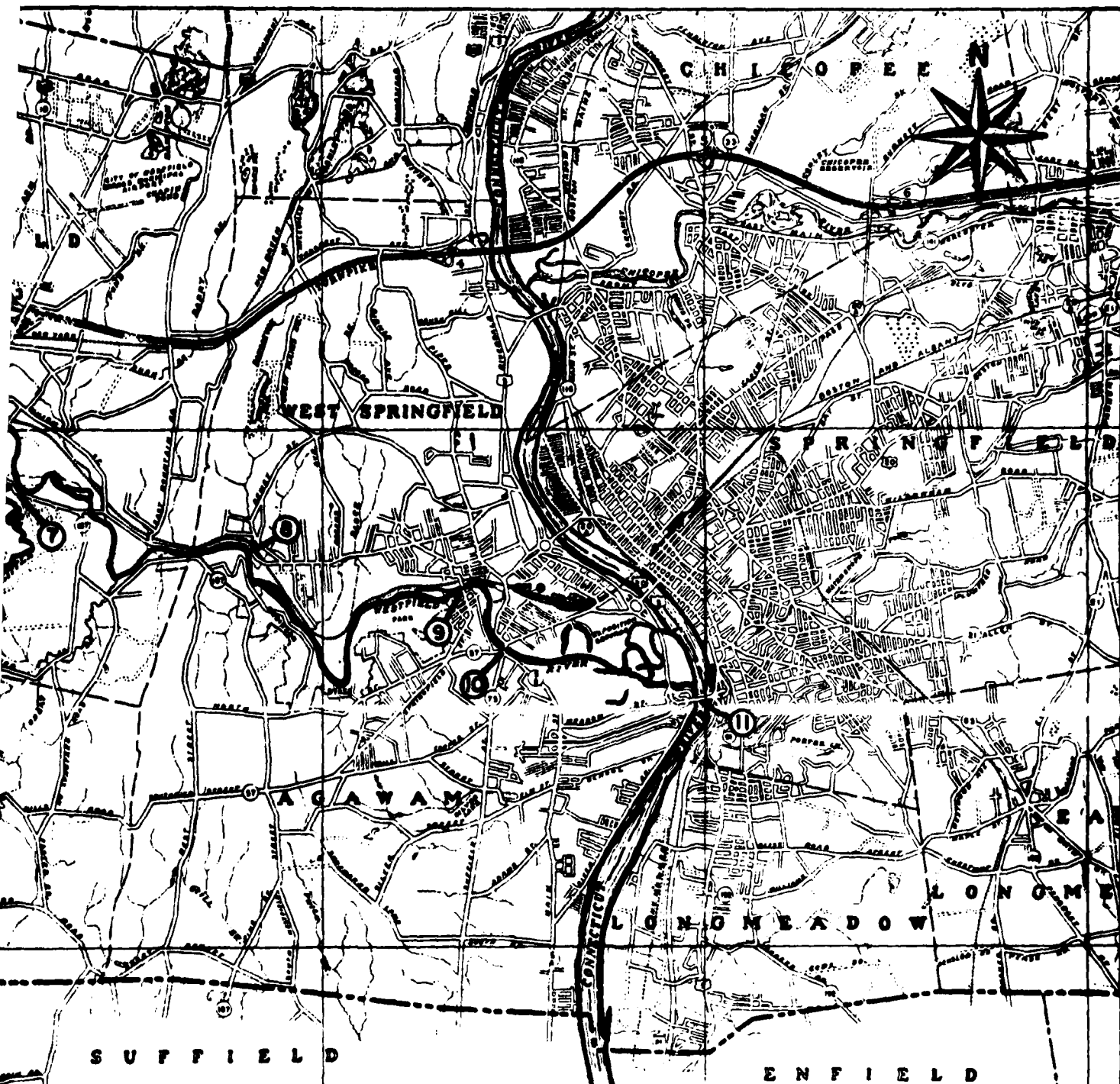
Map Location No.	Distance From Dam ft.	Feature	Before Dam Failure			After Dam Failure			Comments
			Flood Stage cfs	Depth Over Road ft.	Bldgs-Area Flooded each acres	Flood Stage cfs	Depth Over Road ft.	Bldgs-Area Flooded each acres	
9	110,200	Front St.	38,000 14	---	---	194,000 26	---	---	No Damage
10	116,000	Agawam Bdg.	38,000	---	---	194,000 Elev. 72	11	210	Failure flood is 2' above flood dike.
11	129,000	So. End Bdg.	54,000 Elev. 44	---	---	210,000 15 Elev. 58	--	---	Dam failure floods unprotected low areas.



- ① : COBBLE MTN. RESERVOIR DAM
- ② : 14,600' D.S. INTAKE DAM
- ③ : 31,500' D.S. NORTHWEST ROAD
- ④ : 44,000' D.S. HORTON'S BRIDGE
- ⑤ : 52,000' D.S. ROUTE U.S. 20
- ⑥ : 59,600' D.S. RAILROAD BRIDGE

- ⑦ : 69,000' D.S. EAST MAIN ST., RTE. 20
- ⑧ : 88,700' D.S. DEWEY STREET
- ⑨ : 110,200' D.S. FRONT STREET
- ⑩ : 116,000' D.S. AGAWAM BRIDGE
- ⑪ : 129,000' D.S. SOUTH END BRIDGE

5,000



-SCALE-



FROM: GENERAL HIGHWAY MAP,
HAMPDEN COUNTY

TIGHE & BOND / SCI
CONSULTING ENGINEERS
EASTHAMPTON, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

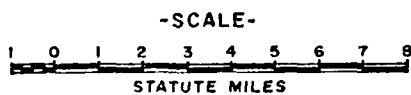
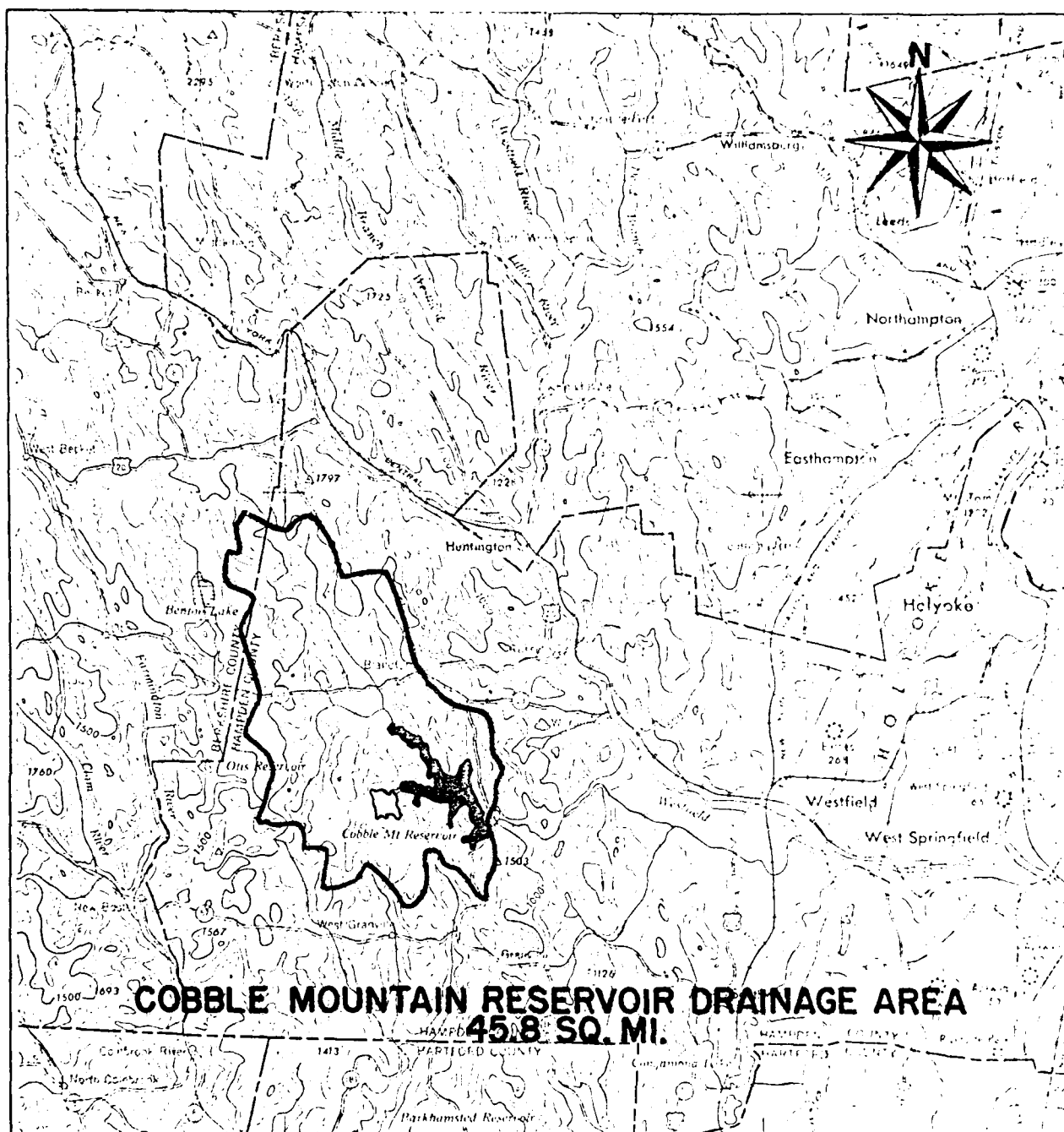
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION AND DOWNSTREAM HAZARD MAP

COBBLE MOUNTAIN RESERVOIR DAM (MA 00068) RUSSELL
HAMPDEN COUNTY MASSACHUSETTS

SCALE: AS NOTED

DATE: MARCH 1960



FROM: U.S.G.S. TOPOGRAPHIC MAP
 NK 18-6, ALBANY, UNITED
 STATES



THIS MAP LOCATION

TIGHE & BOND / SCI
 CONSULTING ENGINEERS
 EASTHAMPTON, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
 CORPS OF ENGINEERS
 WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

DRAINAGE AREA MAP

COBBLE MOUNTAIN RESERVOIR DAM (MA 00068) RUSSELL
 HAMPSHIRE COUNTY MASSACHUSETTS

SCALE: AS NOTED

DATE: MARCH 1980

SECTION 6 - EVALUATION OF STRUCTURE STABILITY

6.1 Visual Observation

Visual inspection of Cobble Mountain Dam did not reveal any signs of abnormal or alarming movement of the structure; nor signs of any significant leakage that should be cause for concern.

6.2 Design and Construction Data

Design and construction data and published reports provide information on the nature and arrangement of materials in the dam. The reports and information examined were not adequate to make a modern analysis of stability of the embankment or to evaluate seismic susceptibility of the dam. The plans and reports indicate that the best practice of the day was followed and no signs of distress have been observed.

6.3 Post Construction Changes

Near the end of construction, the slopes of the upper 14 to 17 feet were steepened from 1 on 2.25 and 1 on 2.75 to 1 on 1.5 to increase the height of the dam by seven (7) feet to elevation 973 feet MSL.

Sometime after construction was complete the flashboards were replaced with a reinforced concrete wall seven (7) feet higher than the design crest. This reduced the freeboard safety and ability to pass severe storms without overtopping the dam. It is estimated that even so, the project can pass a probable maximum flood safely.

Other post construction work, namely, diversion tunnel grouting and spillway concrete repair, have not altered the characteristics of the project, but have been carried out to maintain them in good condition.

The diversion tunnel outlet portal barrier grate which was installed to prevent trespass has not been successful.

The Massachusetts Division of Waterways' most recent inspection report dated May 2, 1978 was not available for review.

6.4 Seismic Stability

The dam is located in seismic zone No. 2. According to the recommended Corps of Engineers Guidelines, a seismic analysis would not normally be warranted. However, due to the susceptibility of hydraulic fill dams to failure due to earthquake motion and to the extremely high hazard to downstream communities in the event of dam failure, it is recommended that seismic stability studies including the potential for liquefaction of the hydraulic fill be undertaken.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

Cobble Mountain Reservoir Dam is generally in good condition. Leakage is not excessive nor is there any sign of piping or seepage that should be cause for concern. Maintenance is good and the project condition is excellent. No sign of structural distress was observed. However, due to the lack of a seismic stability analysis for this hydraulic fill dam, it has been rated as FAIR.

(b) Adequacy of Information

Information on soil and rock embankment materials in place that would be adequate to perform modern stability analyses or seismic analysis was not available. Information concerning design and construction was otherwise complete and adequate. Information regarding the current post construction elevation of the top of the dam was not available.

(c) Urgency

The recommendation for a seismic stability analysis should be initiated within one (1) year from receipt of this report by the Owner.

The remedial measures described herein should be implemented within two (2) years.

7.2 Recommendations

It is recommended that the following items be investigated under the supervision of a qualified registered professional engineer:

1. Determine the strength and stability of the embankment especially with respect to seismic loading conditions, including the potential for liquifaction of the hydraulic fill.

7.3 Remedial Measures

The following remedial, maintenance and operation procedures are recommended:

1. Develop an "Emergency Action Plan" that will include an effective pre-planned downstream warning system, locations of emergency equipment, materials and manpower, authorities to contact and potential areas that require evacuation.
2. Determine the current elevation and profile of the top of the dam.

3. Install a secure, reliable depth measurement float.
4. Correct leak and relocate hand hydraulic pump to an upper floor.
5. Remove diversion tunnel outlet security gate.
6. Institute a biennial technical inspection by a registered professional engineer qualified in dam design and inspection.

7.4 Alternatives

There are no practical alternatives to the above stated Recommendations and Remedial Measures.

APPENDIX A
INSPECTION CHECKLIST

INSPECTION CHECK LIST

PARTY ORGANIZATION

PROJECT Cobble Mountain Reservoir Dam

DATE 11/15/79

TIME 8:30

WEATHER Clear, breezy

W.S. ELEV. 936 U.S. MSL D.N.S.

PARTY: Tighe & Bond/SCI

Based on design elevations of
structures

- | | |
|---|---------------------------------|
| 1. <u>John W. Powers, Project Manager</u> | 6. <u>Omer H. Dumais, Civil</u> |
| 2. <u>George H. McDonnell, Hydrology/</u> | 7. _____ |
| 3. <u>Edward A. Moe, Soils/Hydraulics</u> | 8. _____ |
| 4. <u>David M. Lenart, Civil</u> | 9. _____ |
| 5. <u>Howard A. Koski, Civil</u> | 10. _____ |

PROJECT FEATURE	INSPECTED BY	REMARKS
1. <u>All project features were inspected by all party members.</u>		
2. _____		
3. _____		
4. _____		
5. _____		
6. _____		
7. _____		
8. _____		
9. _____		
10. _____		

Present for the Owner: Francis Broderick, William York

INSPECTION CHECK LIST

PROJECT Cobble Mountain DamDATE 11/15/79PROJECT FEATURE EmbankmentNAME Tighe & Bond party

DISCIPLINE _____

NAME _____

AREA EVALUATED	CONDITIONS
<u>DAM EMBANKMENT</u>	
Crest Elevation	972.1+ (35.8' ± above water level)
Current Pool Elevation	936.3 ± (15.7' ± below spillway crest)
Maximum Impoundment to Date	959.1 (7.1' above spillway crest)
Surface Cracks	None Concrete toe wall shows surface weathering & deterioration up to 2" deep
Pavement Condition	Road pavement - good
Movement or Settlement of Crest	0.9' based on recon. levels 1.8' based on road grade observations
Lateral Movement	None evident
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Good, only minor erosion
Indications of Movement of Structural Items on Slopes	None. variations in downstream slope rock on gravel bed appears to be as built, not subsequent movement.
Trespassing on Slopes	Yes, some debris, no damage.
Vegetation on Slopes	Small brush. Maintenance clearing is good.
Sloughing or Erosion of Slopes or Abutments	No sloughing. Moss on rock & gravel indicate stability. Minor localized erosion along rock pocket at abutment.
Rock Slope Protection - Riprap Failures	Good condition both faces.
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	No seepage at surface. Maximum passing dam estimated at about 1 cfs. Minor seepage through toe wall near rock face.
Piping or Boils	None. No silt in outflow.
Foundation Drainage Features	Rock foundation drain to toe wall & weep holes appear to be functioning well.
Toe Drains	3-6' wide weep holes - tops seen above rock. Outflow clear - no silt, some iron oxide sludge.
Instrumentation System	None

INSPECTION CHECK LIST

PROJECT Cobble Mountain DamDATE 11/15/29PROJECT FEATURE Diversion tunnel control towerNAME Tighe & Bond party

DISCIPLINE _____

NAME _____

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - CONTROL TOWER</u>	
a. Concrete and Structural	
General Condition	Excellent
Condition of Joints	Good
Spalling	None
Visible Reinforcing	None
Rusting or Staining of Concrete	None
Any Seepage or Efflorescence	Minor leakage & efflorescence below Level 8
Joint Alignment	Good. Brick wall around Larner-Johnson discharge nozzles
Unusual Seepage or Leaks in Gate Chamber	No. Only minor leakage
Cracks	None
Rusting or Corrosion of Steel	None
b. Mechanical and Electrical	
Air Vents	Good - 10'x4'-8" vent & hoist shaft
Float Wells	None
Crane Hoist	None fixed
Elevator	None
Hydraulic System	None
Service Gates	2-42" pipe & 42" x 30" Larner-Johnson discharge regulators
Emergency Gates	2-39-3/4" Escher-Wyss rotary valves & 4" bypass
Lightning Protection System	None
Emergency Power System	Valves are hand wheel operated from floor 10' above
Wiring and Lighting System in Gate Chamber	None except temporary drop light

INSPECTION CHECK LIST

PROJECT Cobble Mountain DamDATE 11/15/79PROJECT FEATURE Diversion TunnelNAME Tighe & Bond party

DISCIPLINE _____

NAME _____

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL</u>	
General Condition of Concrete	Good at gate chamber to fair at outlet portal
Rust or Staining	None
Spalling	Minor, less than 1½" deep at some joints in last 430'
Erosion or Cavitation	None
Visible Reinforcing	None
Any Seepage or Efflorescence	Some last 430'. Gets worse toward outlet end. Localized near joints. Grout holes evident.
Condition at Joints	
Drain holes	None
Channel	
Loose Rock or Trees Overhanging Channel	No
Condition of Discharge Channel	Rocky & brushy with trees less than 3" ø
Outlet Portal	Steel grate barrier & door, not locked. Concrete shows general surface deterioration

INSPECTION CHECK LIST

PROJECT Cobble Mountain Dam

DATE 11/15/79

PROJECT FEATURE Spillway

NAME Tighe & Bond party

DISCIPLINE _____

NAME _____

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS</u>	
a. Approach Channel	
General Condition	Concrete abutment top 6.0' above spillway crest.
Loose Rock Overhanging Channel	Crest of spillway weir wall is 6.2'+ above sand approach channel
Trees Overhanging Channel	Good. Some minor hairline cracks of surface concrete at 8'-10' spaces
Floor of Approach Channel	No
b. Weir and Training Walls	No
General Condition of Concrete	Sand & gravel floor, ledge sides
Rust or Staining	135' long crest
Spalling	Good. Recent surface repair
Any Visible Reinforcing	Minor under bridge
Any Seepage or Efflorescence	Minor less than 1/4" deep of surface repair plaster at some joints of training walls
Drain Holes	None
c. Discharge Channel	Minor at some joints & cracks
General Condition	Recent 2 1/2" Ø plastic, 5' above floor
Loose Rock Overhanging Channel	Older 3 1/2" Ø steel, 1' above floor.
Trees Overhanging Channel	Good. Wall joint sealer sagging in some joints
Floor of Channel	None
Other Obstructions	Some up to 5" Ø downstream of bridge
	Concrete past bridge. Ledge beyond that
	Brush up to 2" Ø more than 100' below bridge to outlet end

INSPECTION CHECK LIST

PROJECT Cobble Mountain Dam

DATE 11/15/79

PROJECT FEATURE Spillway Bridge

NAME Tighe & Bond party

DISCIPLINE _____

NAME _____

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - SERVICE BRIDGE</u>	
a. Super Structure	
Bearings	None - elliptical arch structure
Anchor Bolts	None
Bridge Seat	None
Longitudinal Members	Minor efflorescence & seepage at joints between 3 segments of arch.
Under Side of Deck	
Secondary Bracing	None
Deck	Bituminous concrete paved. Random cracks at 8' +
Drainage System	Subsurface abutment weep holes near spring line
Railings	Concrete in good condition
Expansion Joints	Good
Paint	None
b. Abutment & Piers	
General Condition of Concrete	Good
Alignment of Abutment	Good
Approach to Bridge	Good
Condition of Seat & Backwall	--- weep holes are functioning some seepage

INSPECTION CHECK LIST

PROJECT Cobble Mountain Dam

DATE 11/15/79

PROJECT FEATURE Power Tunnel Intake Tower

NAME Tighe & Bond party

DISCIPLINE _____

NAME _____

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - CONTROL TOWER</u>	
a. Concrete and Structural	
General Condition	Excellent
Condition of Joints	Good
Spalling	None
Visible Reinforcing	None
Rusting or Staining of Concrete	None
Any Seepage or Efflorescence	None
Joint Alignment	No joints evident
Unusual Seepage or Leaks in Gate Chamber	Not observed - it is submerged
Cracks	None
Rusting or Corrosion of Steel	None
b. Mechanical and Electrical	
Air Vents	
Float Wells	In corner of inlet well
Crane Hoist	Fixed stop log hoist in place. Electric drive controlled at powerhouse or filter plan
Elevator	Battery stand by power
Hydraulic System	None
Service Gates	Good. For service gate. Emergency hand pump
Emergency Gates	60" ϕ
Lightning Protection System	20' x 20' steel roller gate
Emergency Power System	None
Wiring and Lighting System in Gate Chamber	Battery & hand hydraulic pump
	None

INSPECTION CHECK LIST

PROJECT Cobble Mountain DamDATE 11/15/79PROJECT FEATURE Power Tunnel IntakeNAME Tighe & Bond party

DISCIPLINE _____

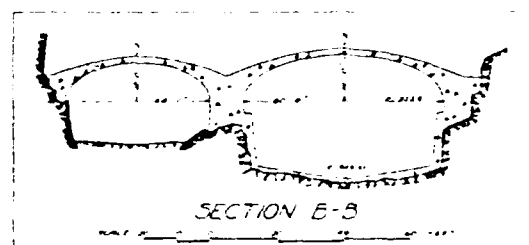
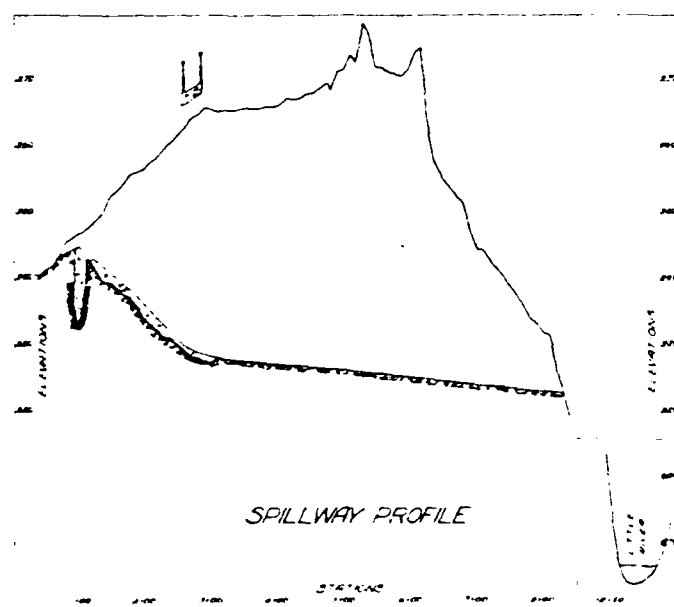
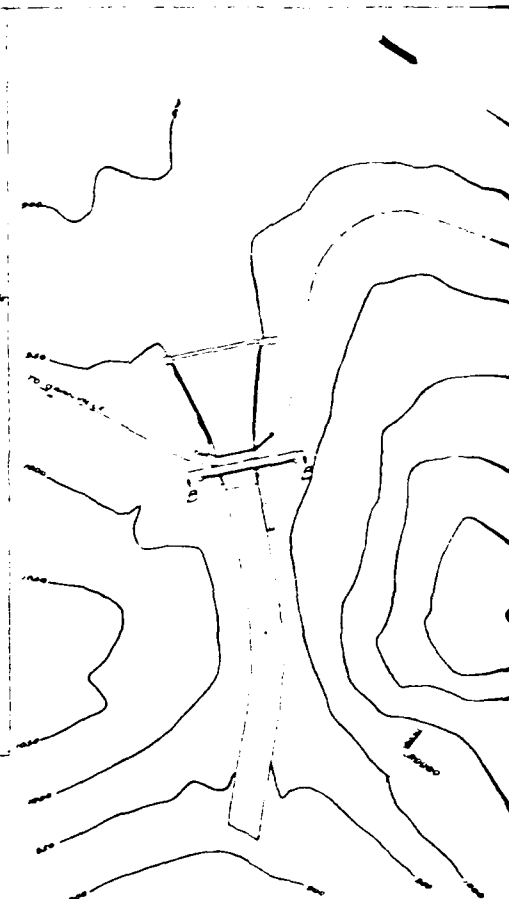
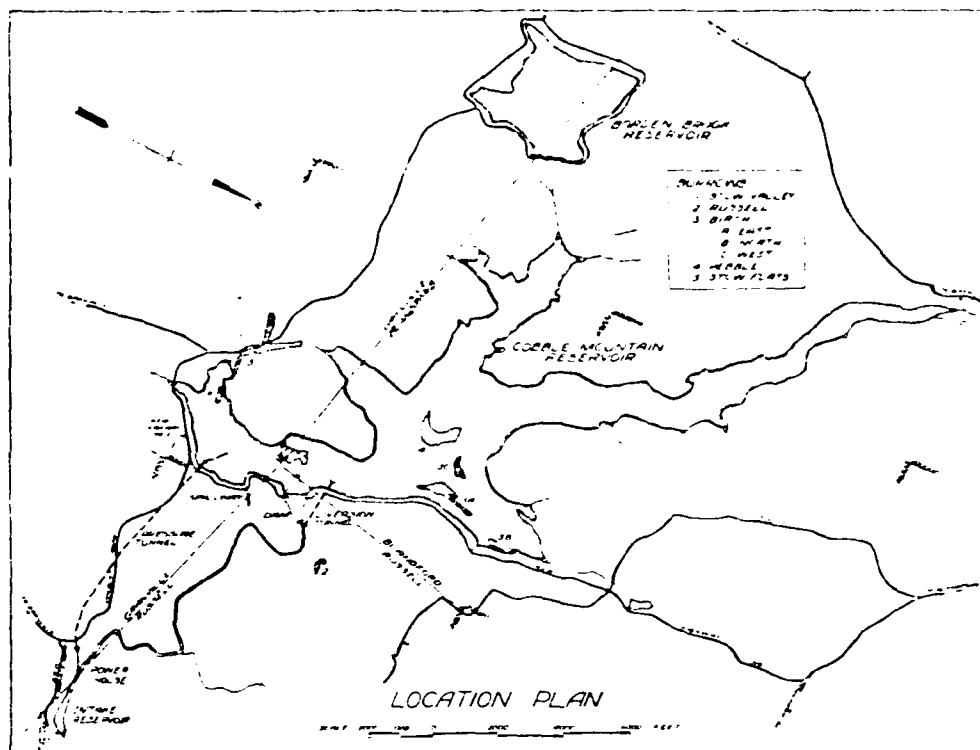
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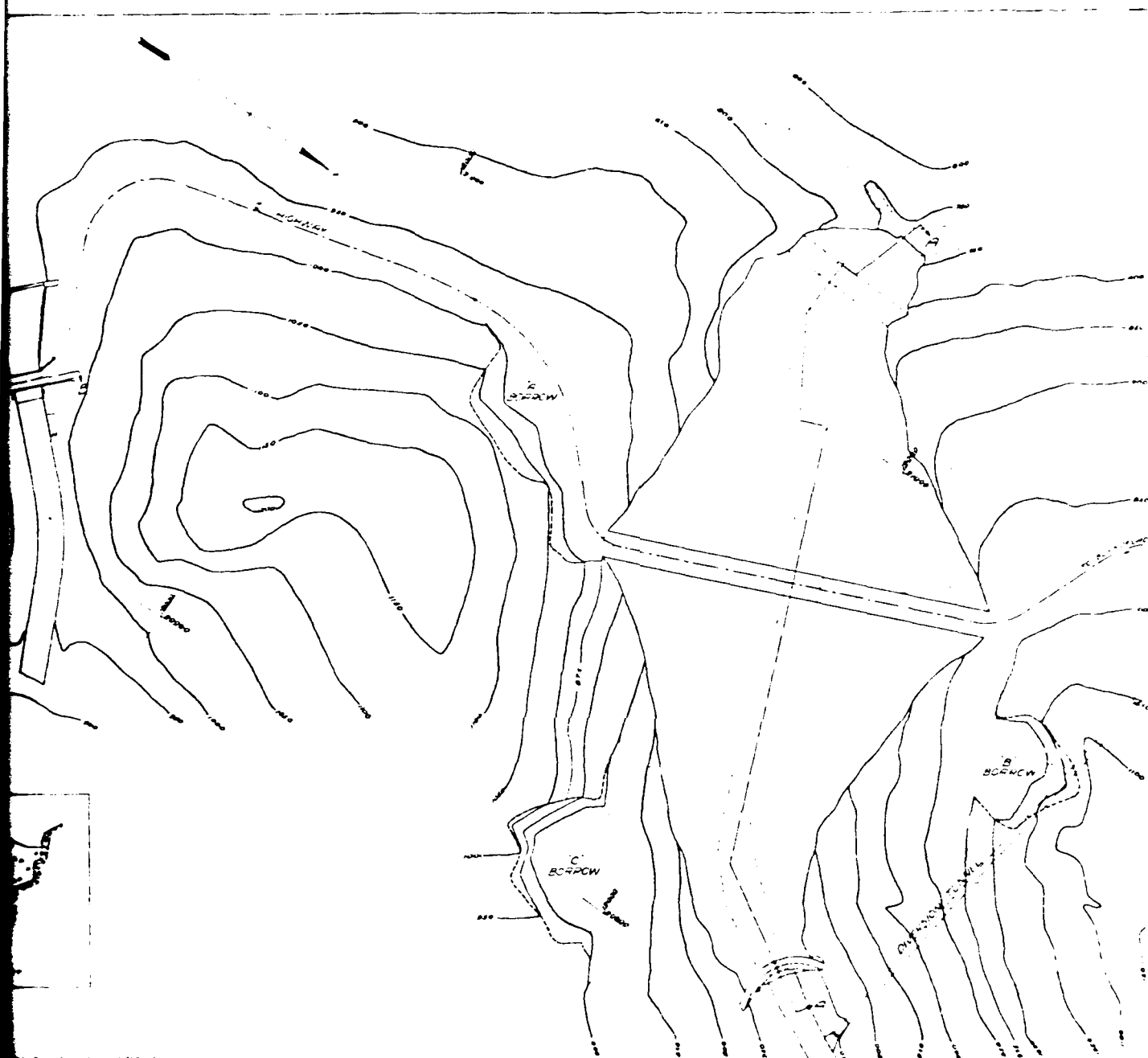
AREA EVALUATED	CONDITION
<u>OUTLET WORKS - INTAKE CHANNEL AND</u> <u>INTAKE STRUCTURE</u>	
a. Approach Channel	
Slope Conditions	Submerged
Bottom Conditions	Submerged
Rock Slides or Falls	None evident
Log Boom	None
Debris	None
Condition of Concrete Lining	Submerge. All concrete observed was in excellent condition.
Drains or Weep Holes	
b. Intake Structure	
Condition of Concrete	Excellent
Stop Logs and Slots	Good
Trash screen	3" spaces

APPENDIX B
ENGINEERING DATA

Design and construction information is available at the following locations:

<u>Item</u>	<u>Location</u>
Construction plans	City of Springfield Water Department
Construction records	City of Springfield Water Department
Report on Construction	New England Water Works Association Vol. XLVI No. 4, December 1932
Notes of James L. Tighe Inspector for Commissioners of Hampden County	Tighe & Bond/SCI, Easthampton, MA
Plans of Spillway Repairs, 1973	City of Springfield Water Department
Inspection Reports	Mr. John Hannon, Mass. D.E.Q.E. Waterways Division, 100 Nashua St. Boston, MA
Plans attached:	
General As Built Plan	Attached hereafter
Design Plans (18 sheets)	Attached hereafter

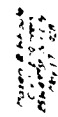




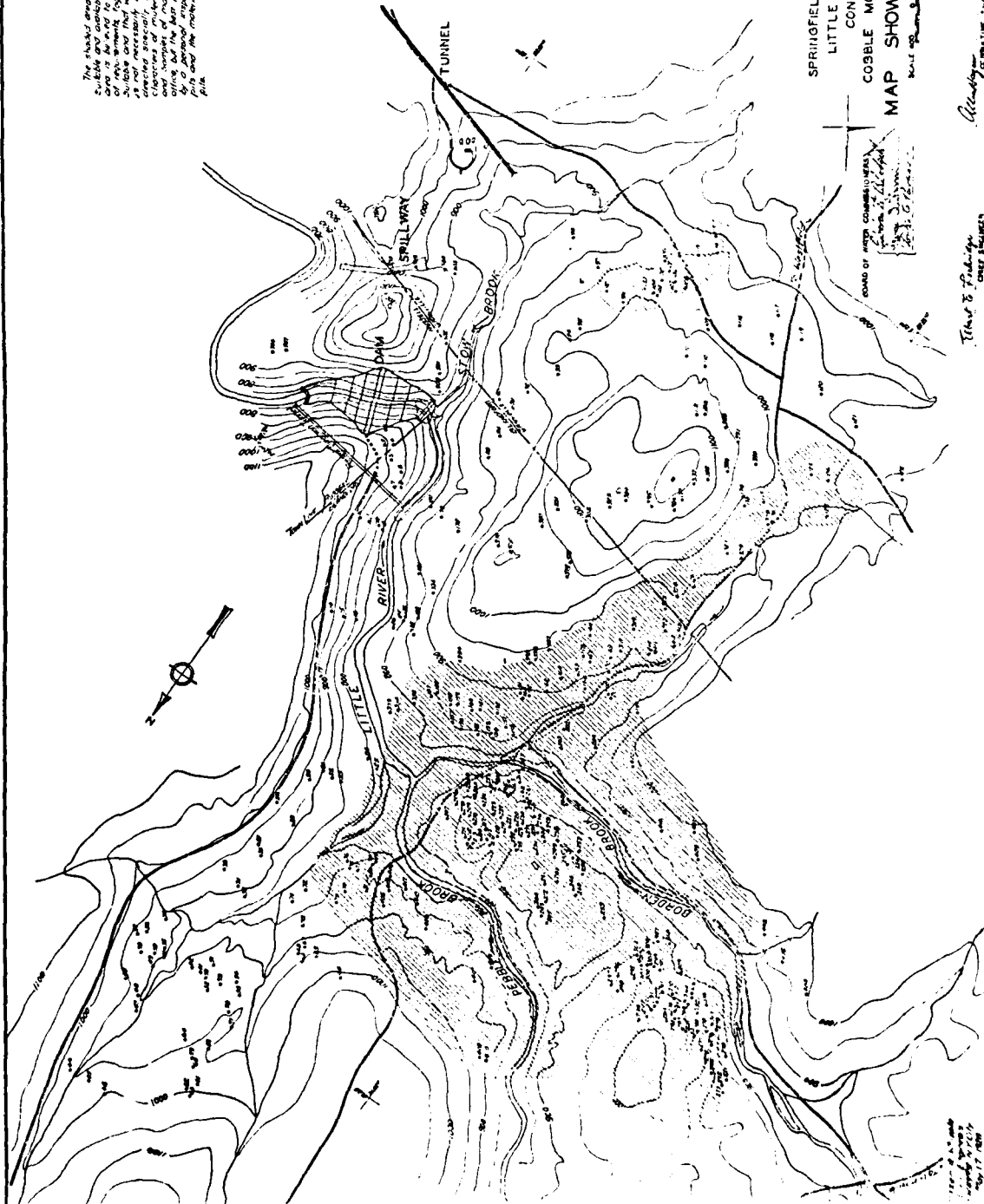
PLAN

Scale 1:50,000
 Date of Survey 1955
 Date of Publication 1955

Sheet 1 of 1
 Contour Interval 100
 Elevation of Sea Level 0
 Elevation of Highest Point 1200
 Elevation of Lowest Point 1000
 Elevation of Mean Sea Level 1050

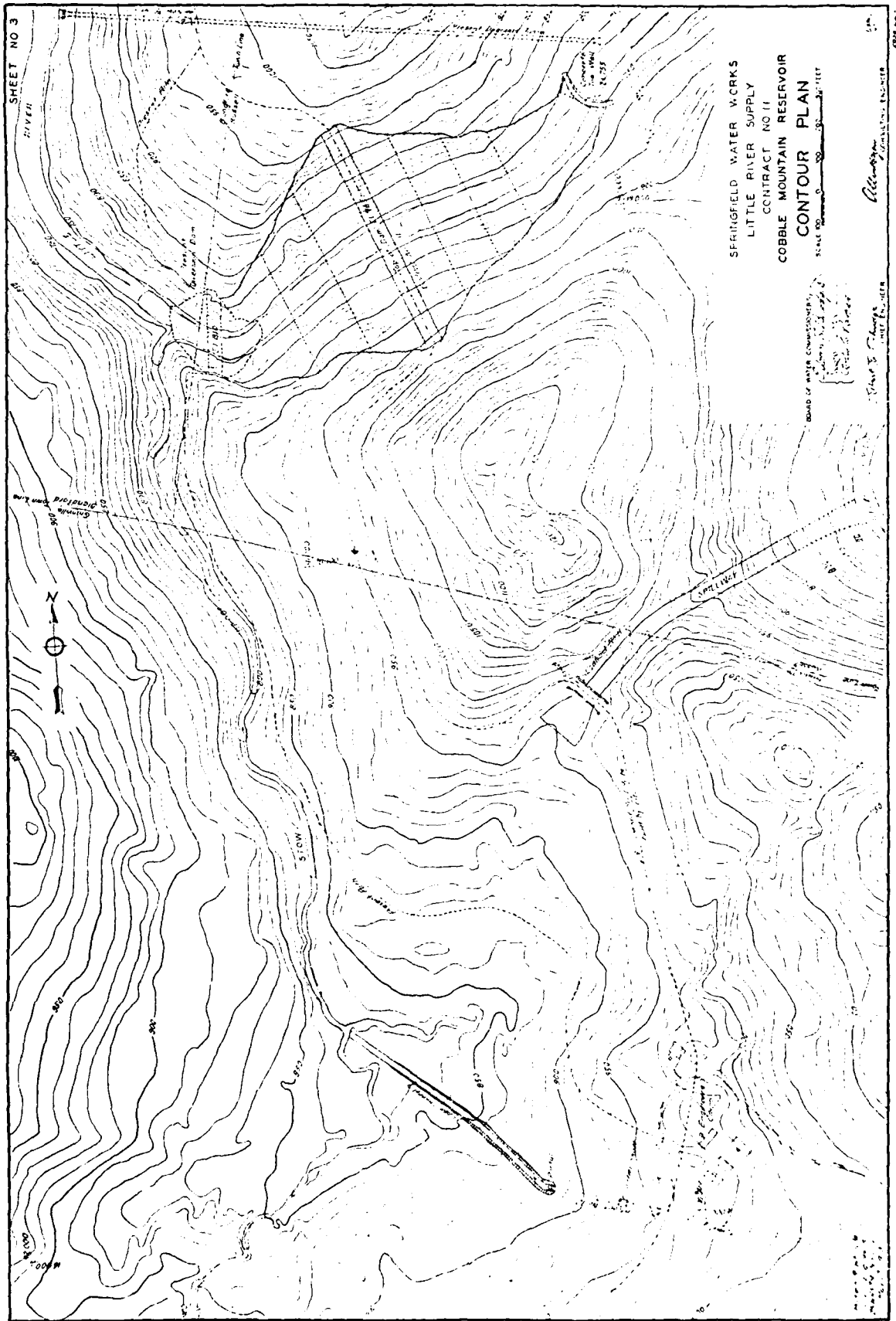


The shaded area is selected as containing the most suitable and available material for dam construction. This area is bounded by the Little River and the Little River Spillway. The material is of good quality and is available in such quantities that it is not necessary to haul material from any other source. The character of the material is such that it may be placed in the dam without any special treatment. The material is of a good quality and is available in such quantities that it is not necessary to haul material from any other source. The character of the material is such that it may be placed in the dam without any special treatment.



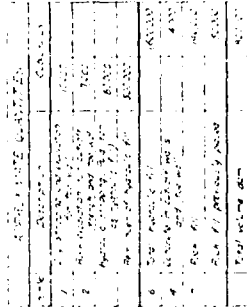
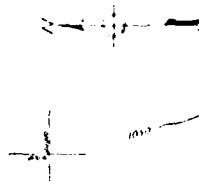
SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO 11
COBBLE MOUNTAIN RESERVOIR
MAP SHOWING TEST PITS
SCALE 1" = 100' FEET

Wm. B. Fisher
Chief Engineer
Cobble Mountain Reservoir
June 17, 1909

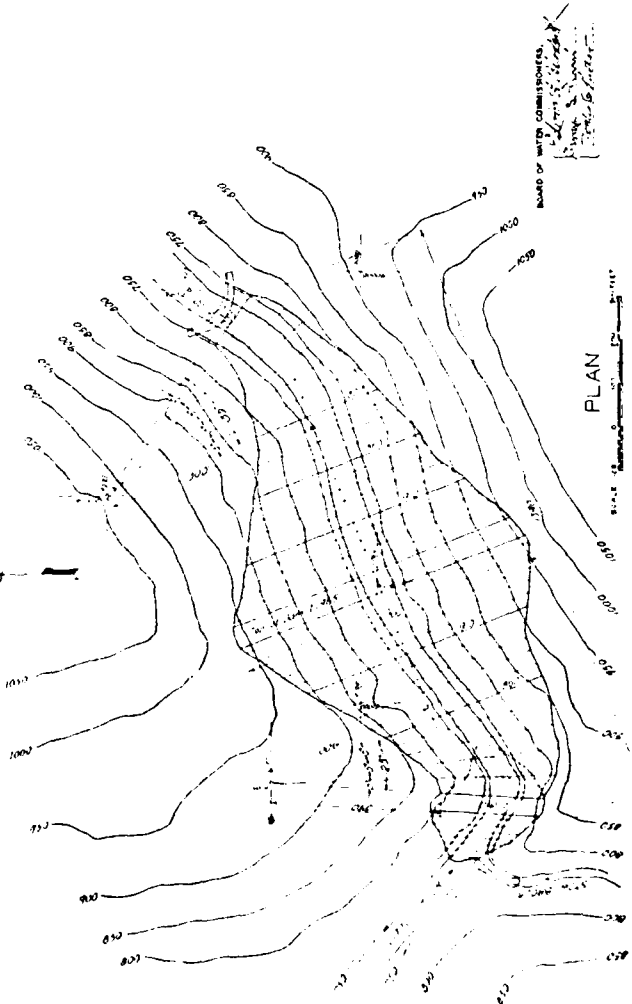




STANDARD SECTION



SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO 11
COBBLE MOUNTAIN RESERVOIR
DAM
PLAN AND SECTION
WITH DIMENSIONS
SCALE AS INDICATED

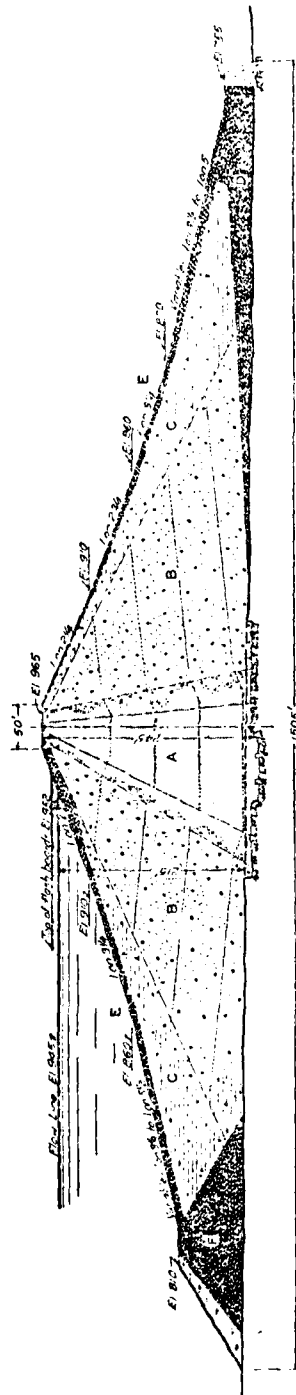


Edward F. Lohmeyer
CHIEF ENGINEER

Chlorine

Allan Briggs
Consulting Engineer

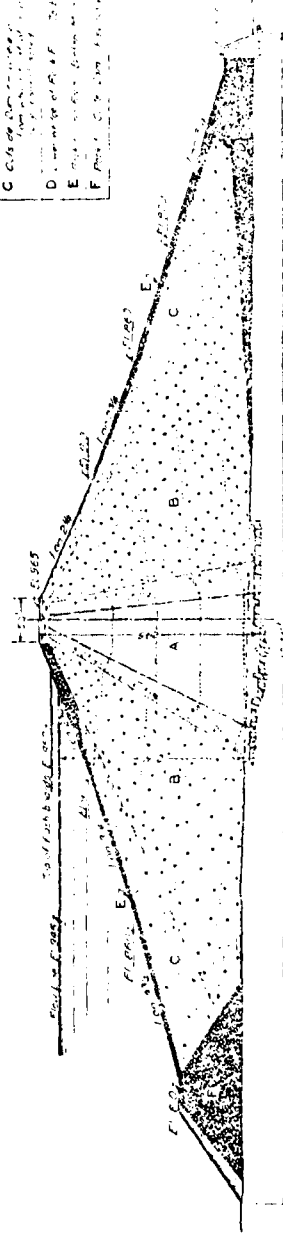
Dr. A. L. King
No. 100 N. 1st St.
St. Paul, Minn.



ACTUAL DEVELOPED SECTION
This shows approximately the maximum section of the dam following the existing of the river at the time.

LEGEND

- A Core-Cast concrete (see note on page 1)
- B Sand, gravel, and crushed stone (see note on page 1)
- C Crushed concrete (see note on page 1)
- D Concrete (see note on page 1)
- E Rock (see note on page 1)
- F Foundation (see note on page 1)



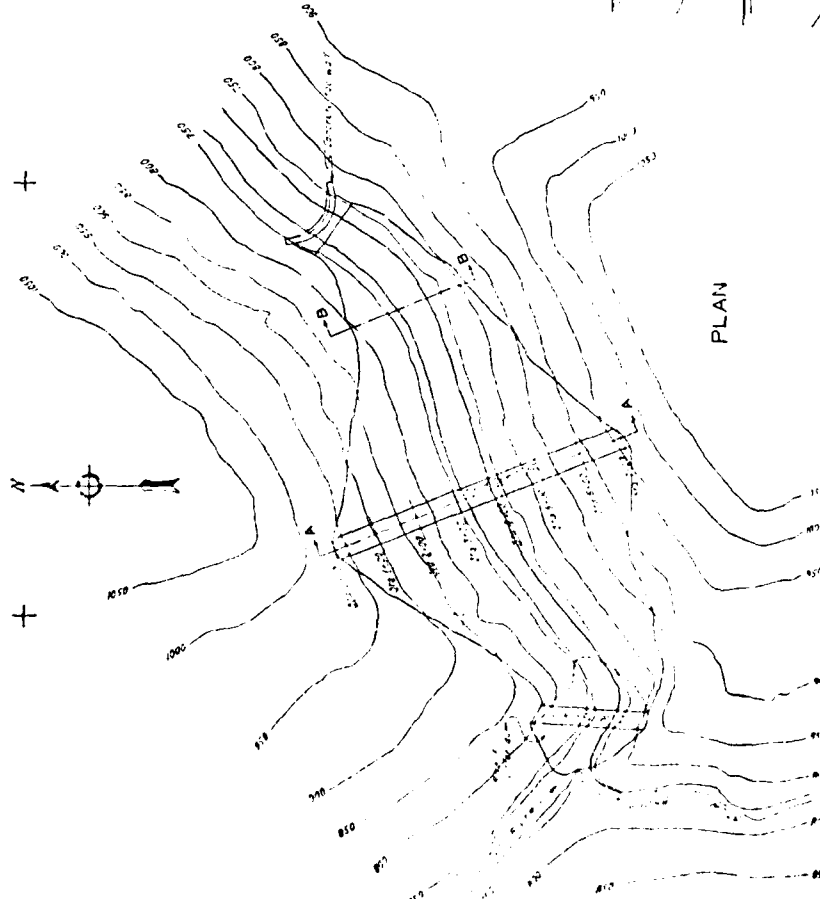
STANDARD SECTION

This shows the standard section of the dam. It is based on the actual section, but is simplified for use in the design of the dam. It is based on the actual section, but is simplified for use in the design of the dam.

SEASIDE WATER WORKS
LITTLE RIVER, N.C.
CONTRACT NO. 11
COBBLE MOUNTAIN RESERVOIR
DAM
SECTIONS

SCALE 1" = 10'

ENGINEER: [Signature]
DATE: [Date]



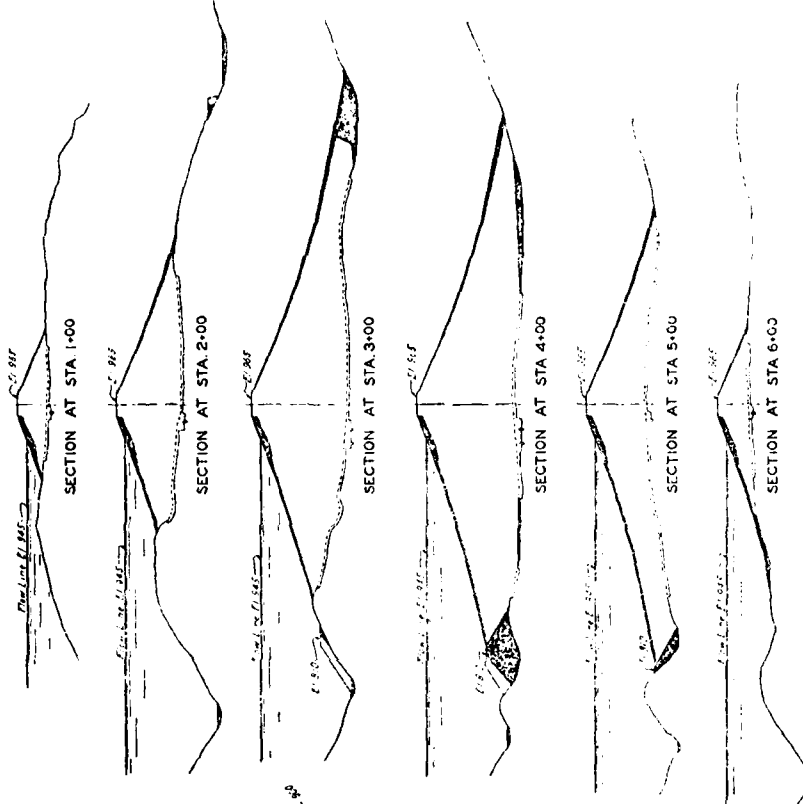
PLAN



SECTION B-B



SECTION A-A



SECTION AT STA 1+00

SECTION AT STA 2+00

SECTION AT STA 3+00

SECTION AT STA 4+00

SECTION AT STA 5+00

SECTION AT STA 6+00

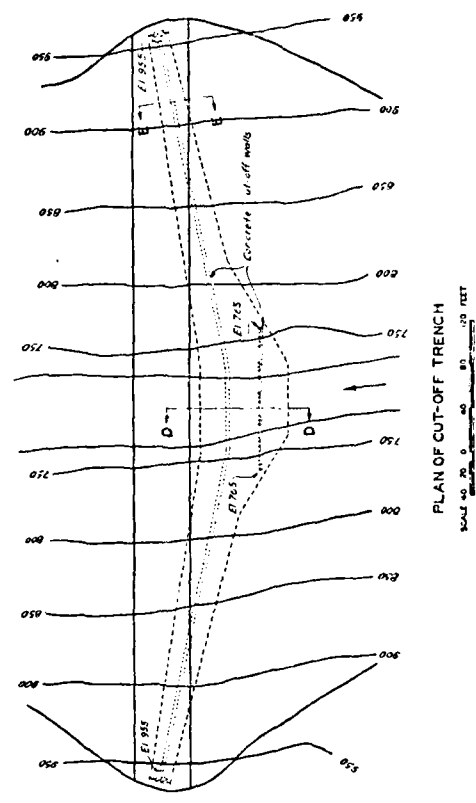
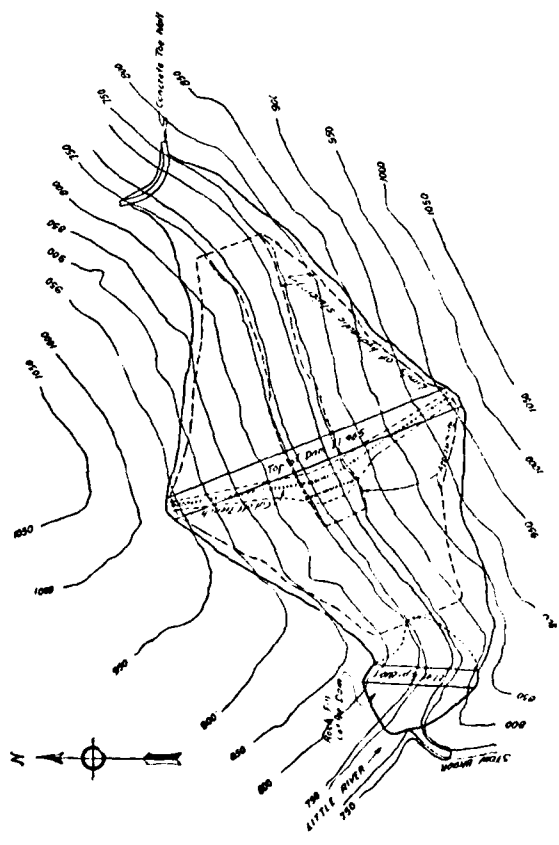
SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO 11
COBBLE MOUNTAIN RESERVOIR
DAM

MISCELLANEOUS SECTIONS
SCALE: HORIZ. 1" = 100' VERT. 1" = 10'

David S. Finkley
CIVIL ENGINEER

Allen H. Hight
CIVIL ENGINEER

REPORT NO. 100
DATE: MAY 1, 1928
BY: D. S. FINKLEY



PLAN OF STRIPPING



SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO 11
COBBLE MOUNTAIN RESERVOIR
DAM
CUT-OFF TRENCH AND STRIPPING

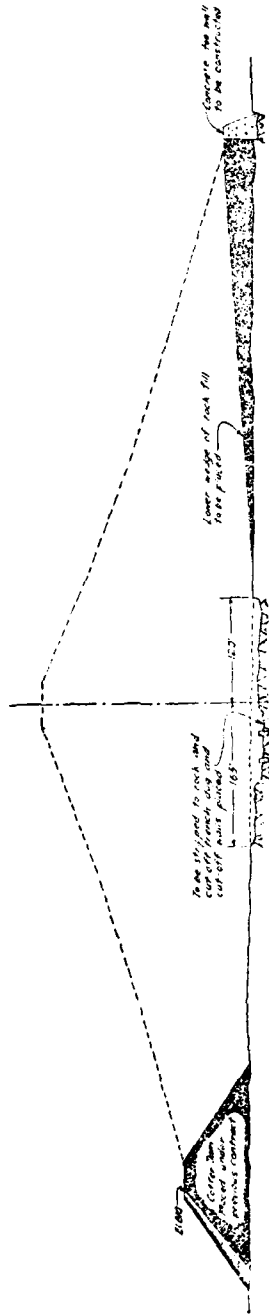
BOUND OF WATER (CONTRACT NO. 11)
CONTRACT NO. 11
COBBLE MOUNTAIN RESERVOIR
DAM

SCALE AS INDICATED

THOMAS B. CROOK
CHIEF ENGINEER

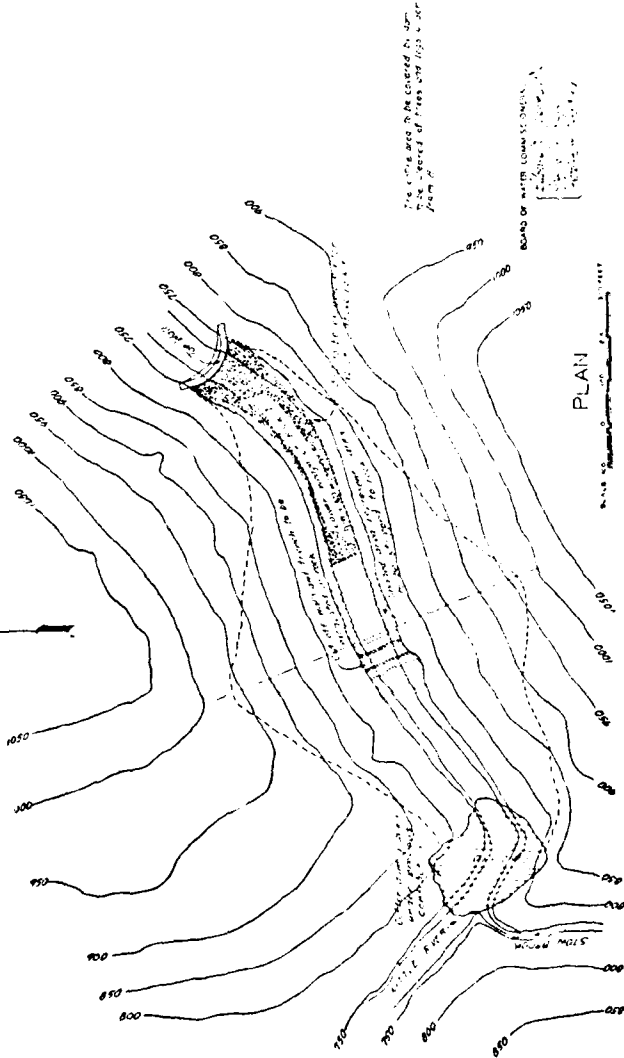
THOMAS B. CROOK
CHIEF ENGINEER

THOMAS B. CROOK
CHIEF ENGINEER



SECTION

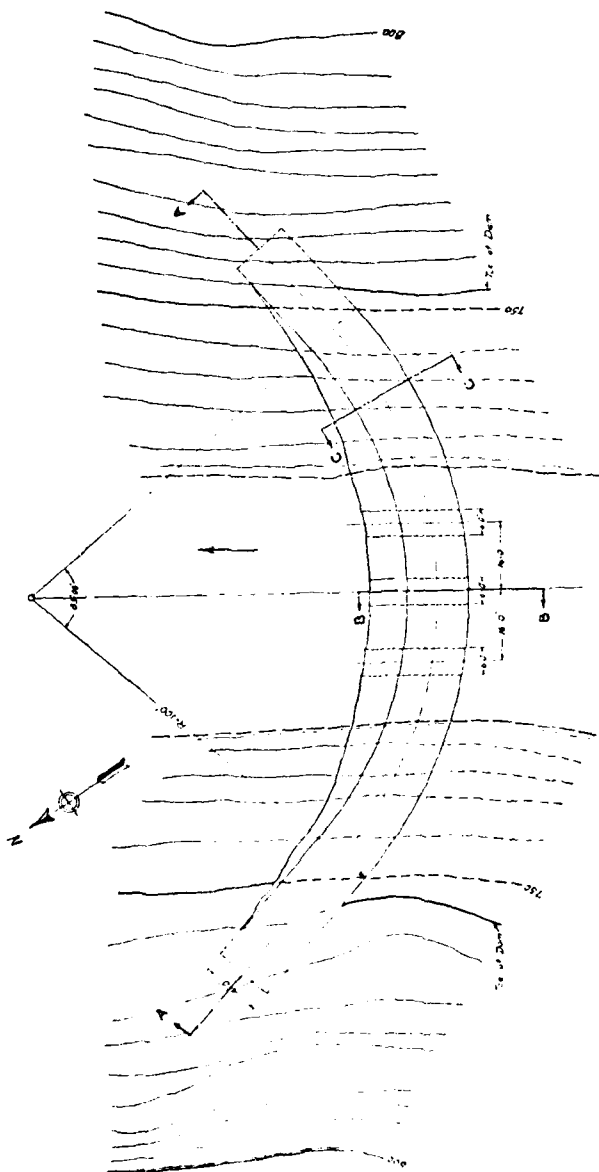
SCALE 1" = 100'



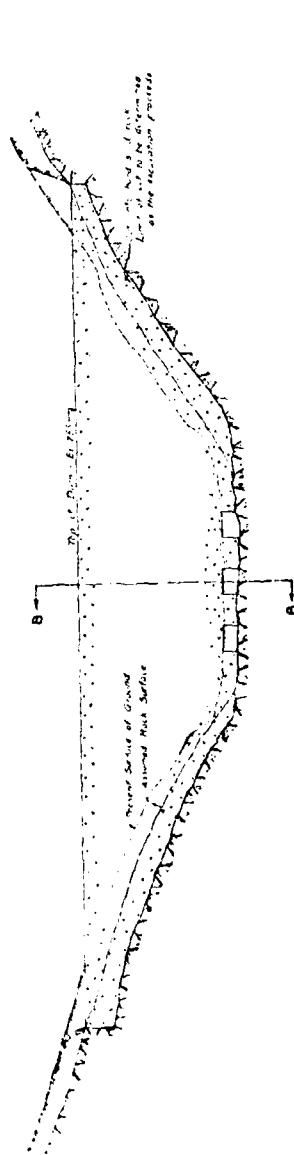
PLAN

SCALE 1" = 100'

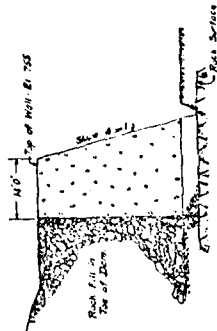
SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO II
CORBLE MOUNTAIN RESERVOIR
DAM
WORK TO BE DONE BEFORE
SLUICING IS STARTED
SCALE AS INDICATED



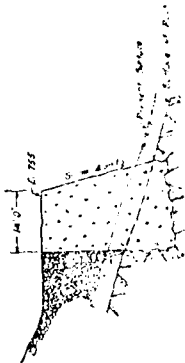
PLAN



SECTION A-A



SECTION B-B

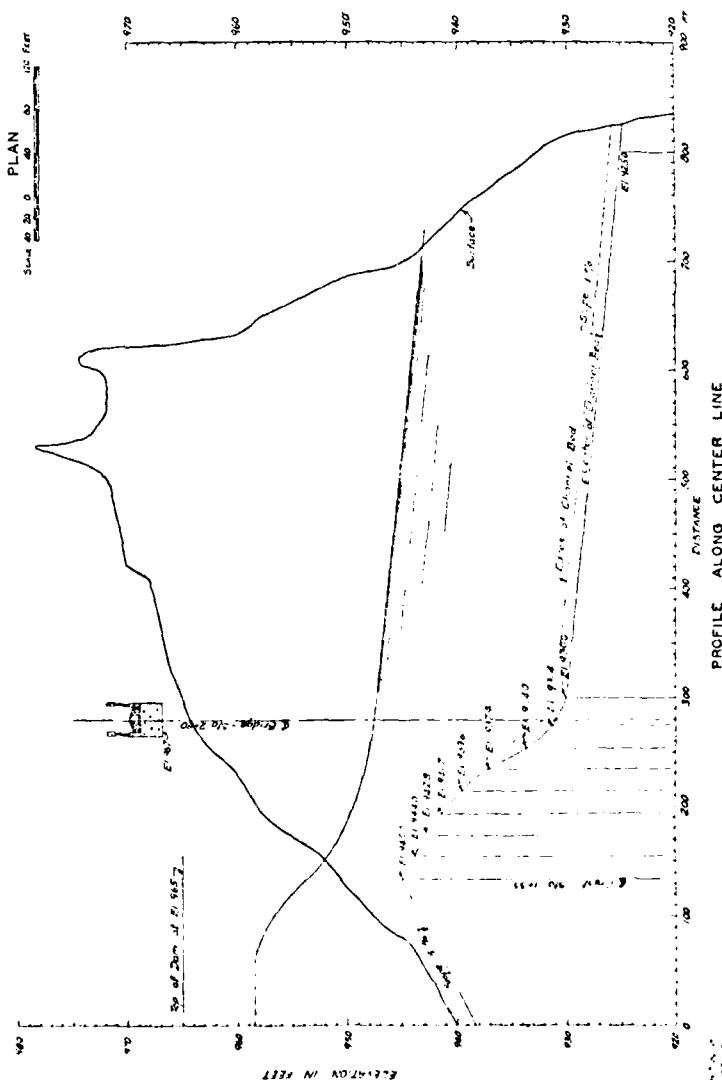
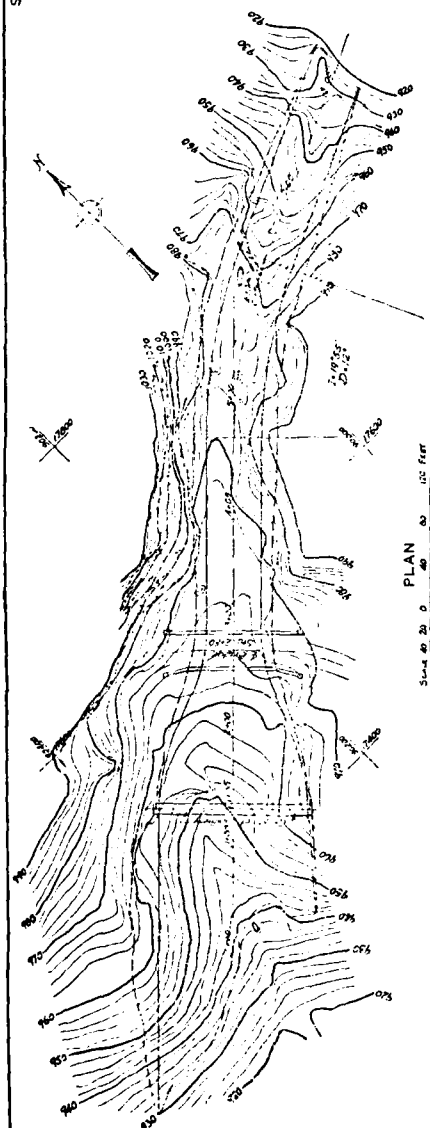


SECTION C-C

SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT 140 II
COBBLE MOUNTAIN RESERVOIR
DAM
CONCRETE WALL AT LOWER TOE



Designed by *W. H. H. H. H.*
Checked by *W. H. H. H. H.*
Date *10-1-1910*



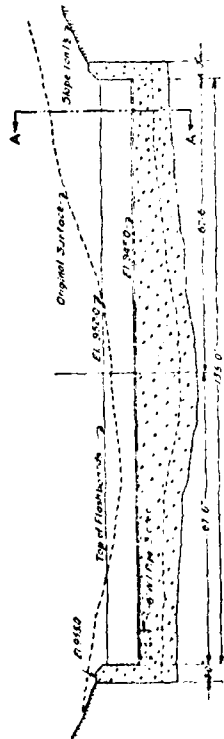
SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO. 11
COBBLE MOUNTAIN RESERVOIR
SPILLWAY

PLAN AND PROFILE
SCALES AS INDICATED

BOARD OF WATER COMMISSIONERS.

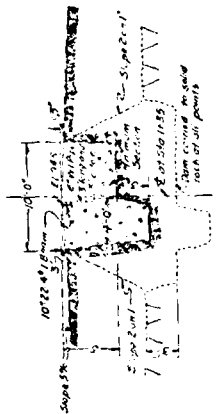
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 2376-2377
 2378-2379
 2380-2381
 2382-2383
 2384-2385
 2386-2387
 2388-2389
 2390-2391
 2392-2393
 2394-2395
 2396-2397
 2398-2399
 2400-2401
 2402-2403
 2404-2405
 2406-2407
 2408-2409
 2410-2411
 2412-2413
 2414-2415
 2416-2417
 2418-2419
 2420-2421
 2422-2423
 2424-2425
 2426-2427
 2428-2429
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 2434-2435
 2436-2437
 2438-2439
 2440-2441
 2442-2443
 244

[illegible]



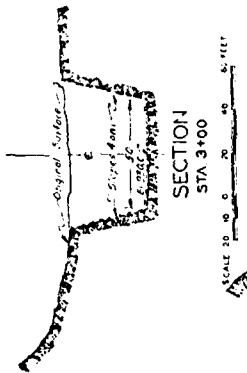
SECTION
STA 1+32

SCALE 1" = 20 FEET



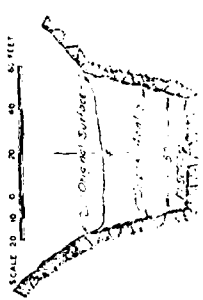
SECTION A-A

SCALE 1" = 20 FEET



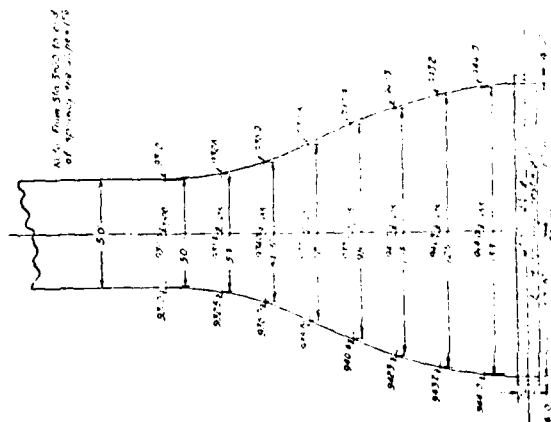
SECTION
STA 3+00

SCALE 1" = 20 FEET



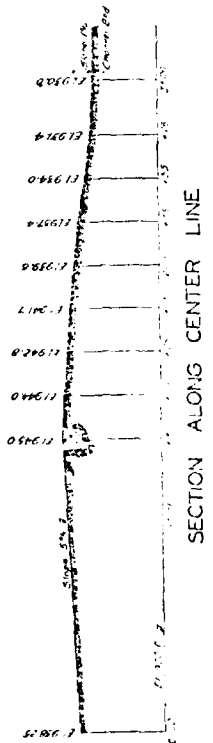
SECTION
STA 4+00

SCALE 1" = 20 FEET



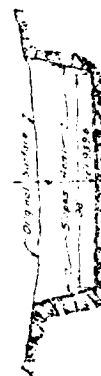
PLAN

SCALE 1" = 20 FEET



SECTION ALONG CENTER LINE

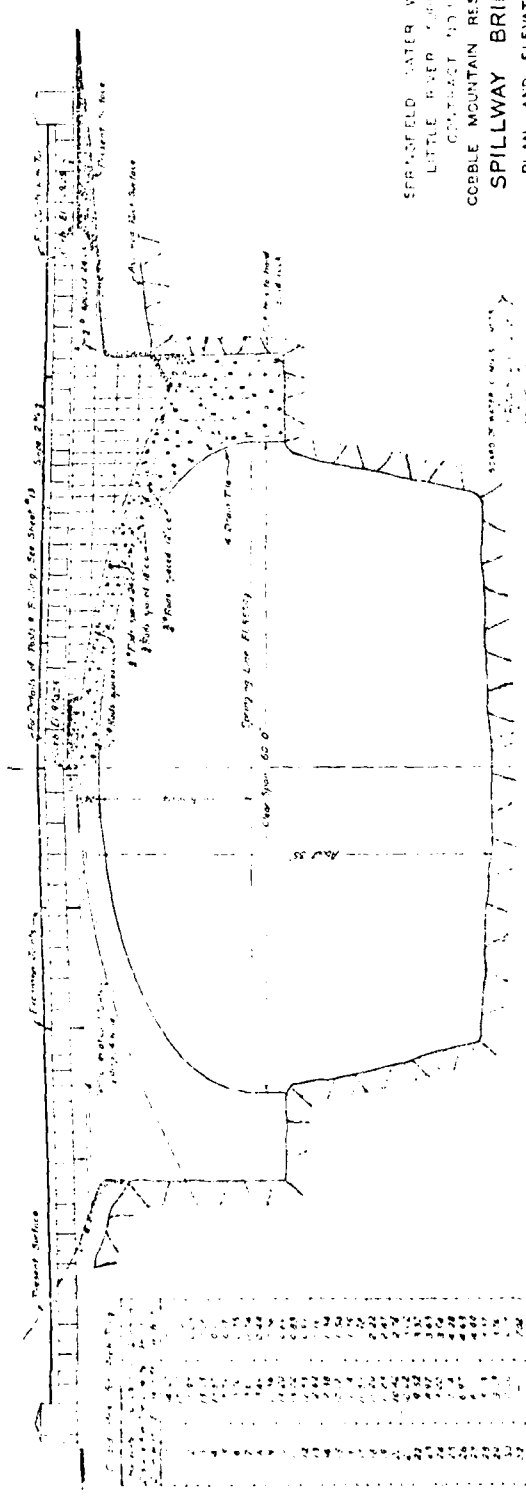
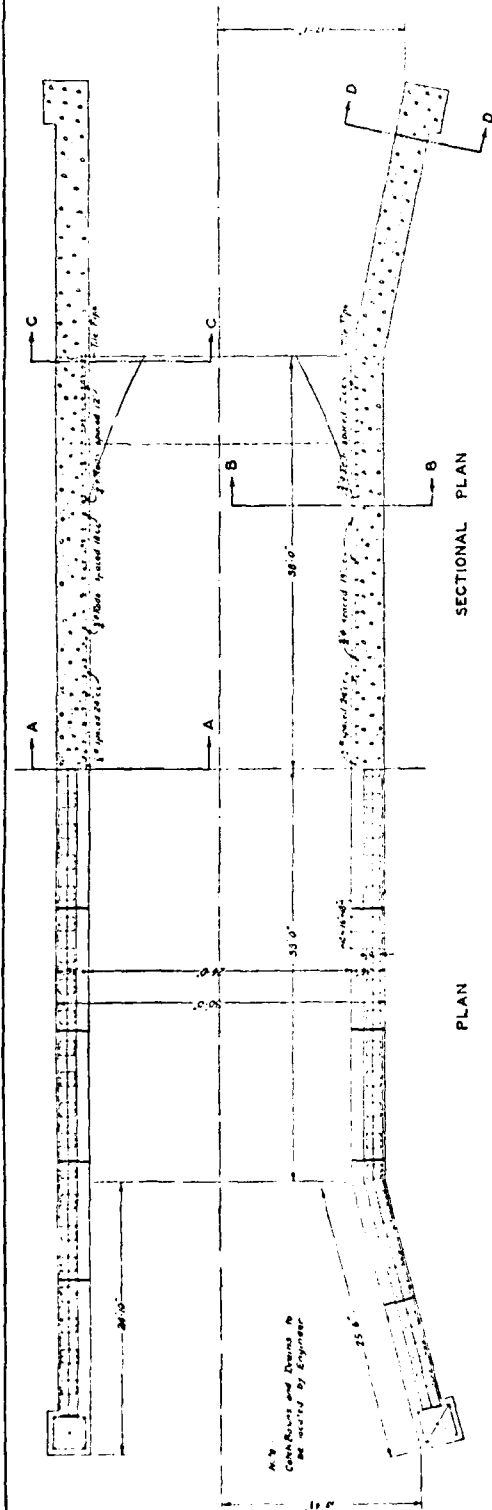
SCALE 1" = 20 FEET



SECTION
STA 2+15

SCALE 1" = 20 FEET

SPRINGFIELD WATER WORKS
LITTLE RIVER CANYON
CONTRACT NO. 11
COBBLE MOUNTAIN RESERVOIR
SPILLWAY
PLAN AND SECTIONS
SCALE AS INDICATED



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	
100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200

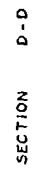
SPRINKLED WATER WARMS
LITTLE RIVER, ARIZONA
COBBLE MOUNTAIN RESERVOIR
SPILLWAY BRIDGE
PLAN AND ELEVATION

SCALE 1" = 10'-0"

DATE 1912

BY J. H. HARRIS

CHIEF ENGINEER



BOARD OF WATER COMMISSIONERS

SECTIONS				
SCALE	1	0	2	4
FEET				

That I, *John J. ...*
 CINCINNATI
 do hereby certify that the above is a true and correct copy of the original as the same appears in the records of the Board of Education of the City of Cincinnati.

B-14



SECTION B-B

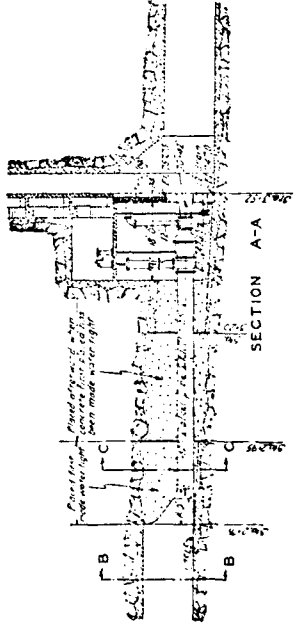
LEGEND

- Concrete already placed under another contract
- Concrete to be placed under this contract

Note: This part is general idea of the plan, and is not intended to be used for construction. The plan is intended to show the general layout of the project and the location of the various parts of the project.



SECTION C-C



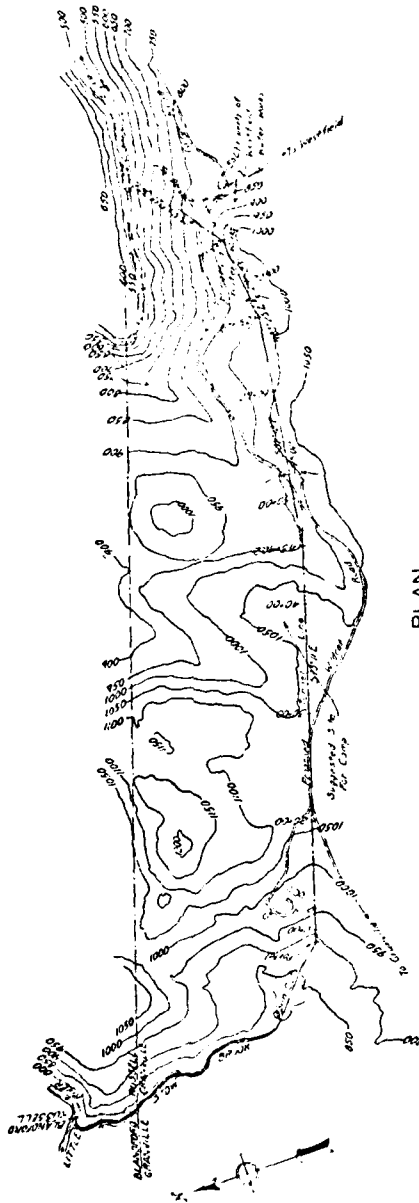
Notes of work completed, by
[Signature]
[Date]

SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO 11
COBBLE MOUNTAIN RESERVOIR
CLOSING OF DIVERSION TUNNEL
PLAN AND SECTIONS

SCALE 1" = 10' 0"

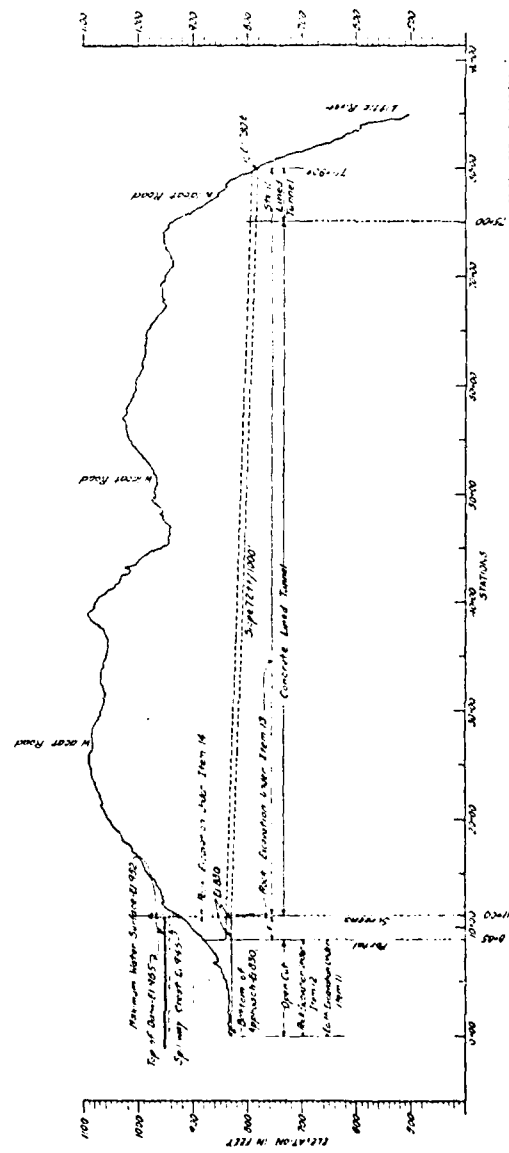
Prepared by [Signature]
Checked by [Signature]
Engineer [Signature]

SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO. 12
COBBLE MOUNTAIN TUNNEL
PLAN AND PROFILE
SCALE AS SHOWN



PLAN

SCALE 1" = 100'

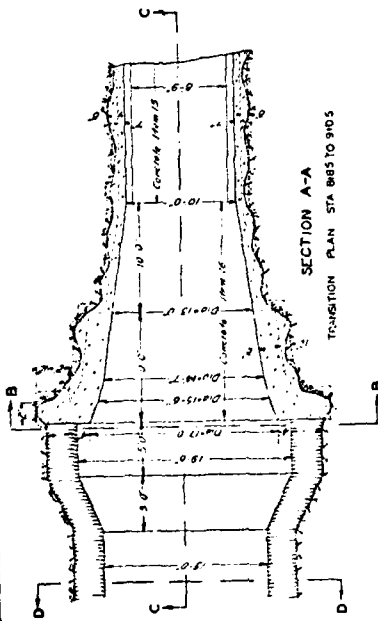


PROFILE

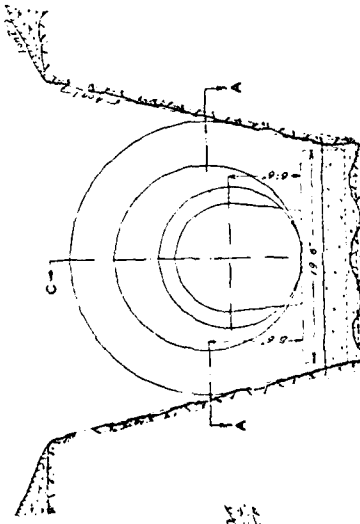
DESIGNED BY
C. J. FARRIS
1917

PLANNED BY
C. J. FARRIS
1917

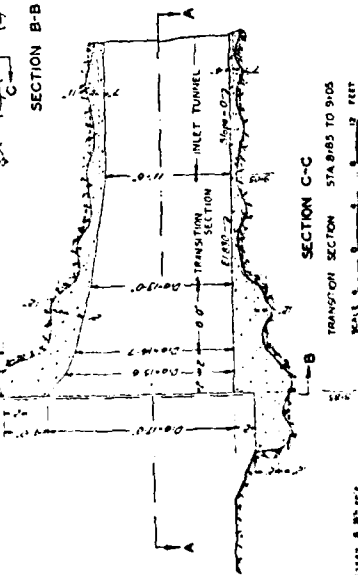
DESIGNED BY
C. J. FARRIS
1917



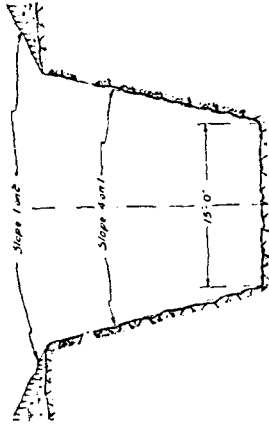
SECTION A-A
TRANSITION PLAN STA 885 TO 905



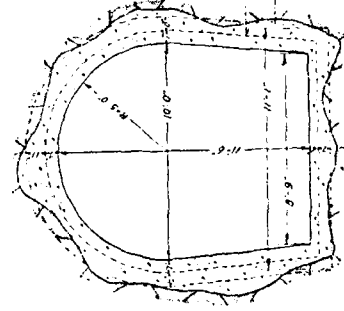
SECTION B-B



SECTION C-C
TRANSITION SECTION STA 885 TO 905

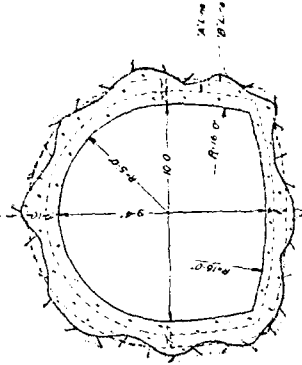


SECTION D-D
OPEN CUT



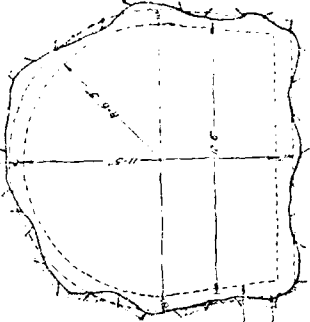
LINED SECTION
STA 905 TO 915

Area inside "A" Line = 122.7 sq ft
 "B" Line = 132.2 sq ft
 Excavation per ft = 9.5 cu yds
 Concrete = 1.81 cu yds



STANDARD LINED SECTION
STA 11+58 TO 25+00

Area inside "A" Line = 96.58 sq ft
 "B" Line = 124.2 sq ft
 Excavation per ft = 27.6 cu yds
 Concrete = 1.57 cu yds



UNLINED TUNNEL WITH WOODEN STEEL
STA 75+00 TO 79+00

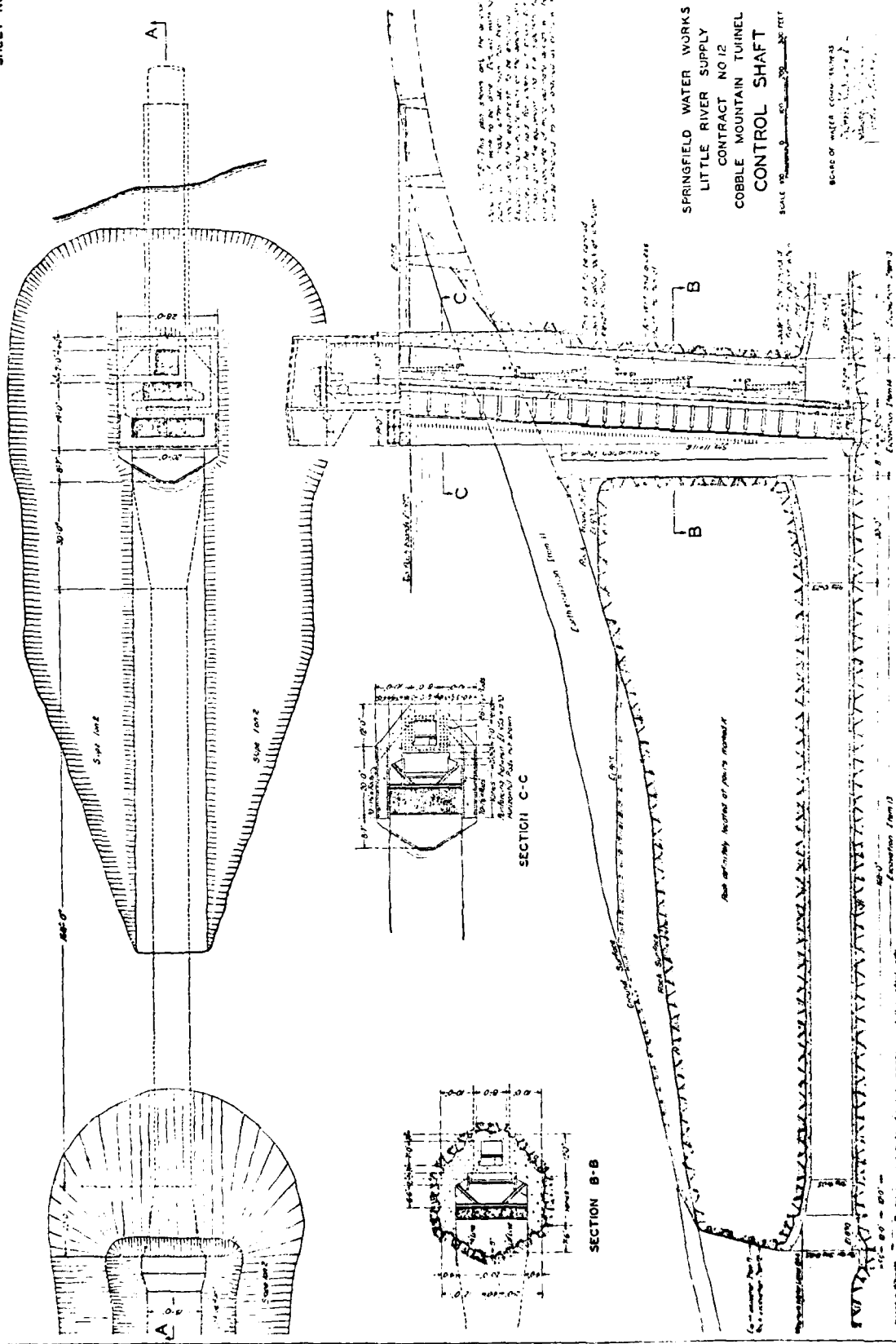
Area inside "A" Line = 122.7 sq ft
 "B" Line = 132.2 sq ft
 Excavation per ft = 9.5 cu yds
 Concrete = 1.81 cu yds

SCALE 1" = 10' FEET

SPRINGFIELD WATER WORKS
 LITTLE RIVER SUPPLY
 CONTRACT NO 12
 COBBLE MOUNTAIN TUNNEL
 SECTIONS
 SCALE AS INDICATED

BOARDS OF WATER COMMISSIONERS
 CHAS. S. BROWN
 JOHN S. BROWN

CHAS. S. BROWN
 JOHN S. BROWN
 CHIEF ENGINEER



SPRINGFIELD WATER WORKS
LITTLE RIVER SUPPLY
CONTRACT NO. 12
COBBLE MOUNTAIN TUNNEL
CONTROL SHAFT

SCALE 1" = 10'-0"

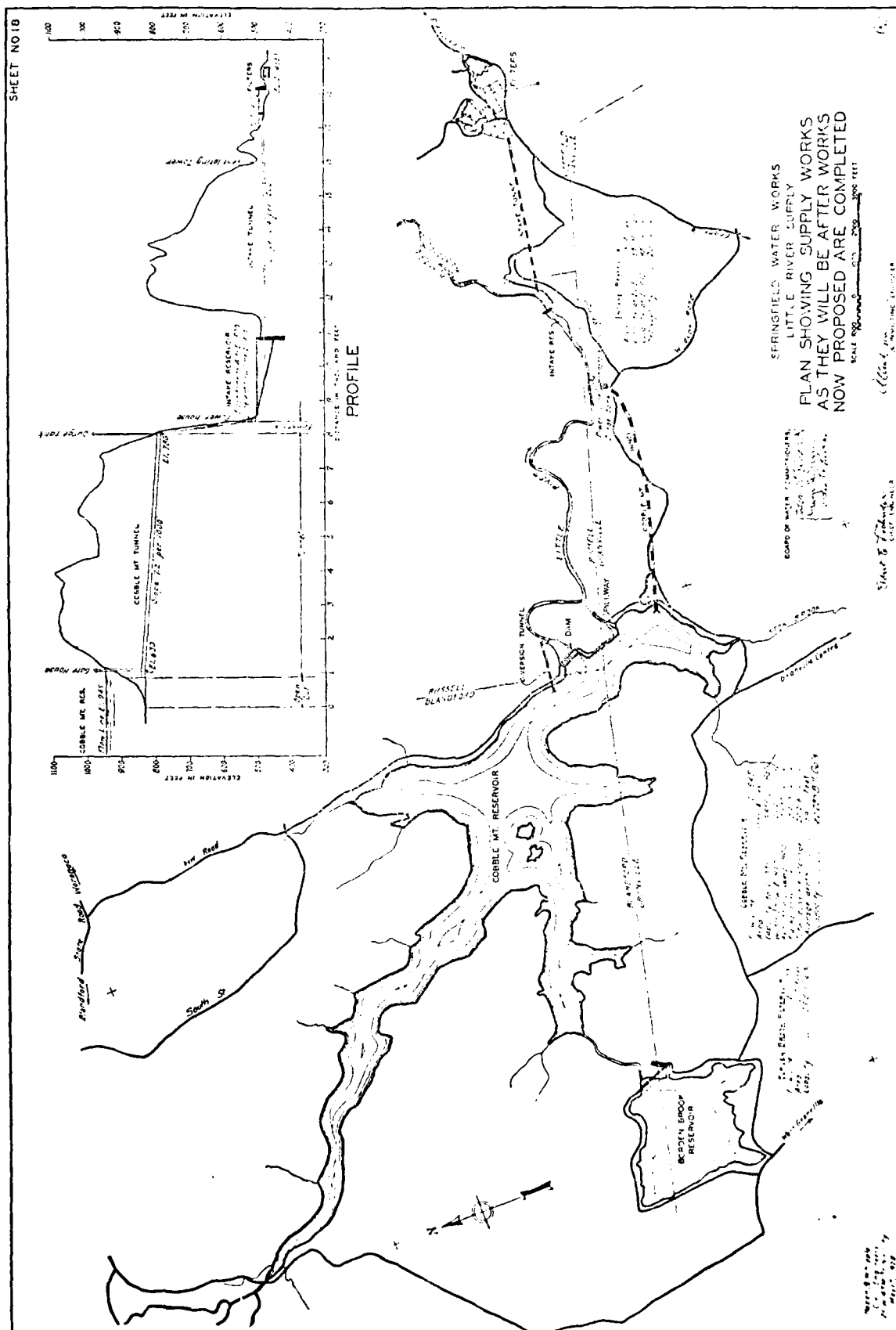
SCALE OF WATER CONVEYANCE

Plate 5 of 5
1918

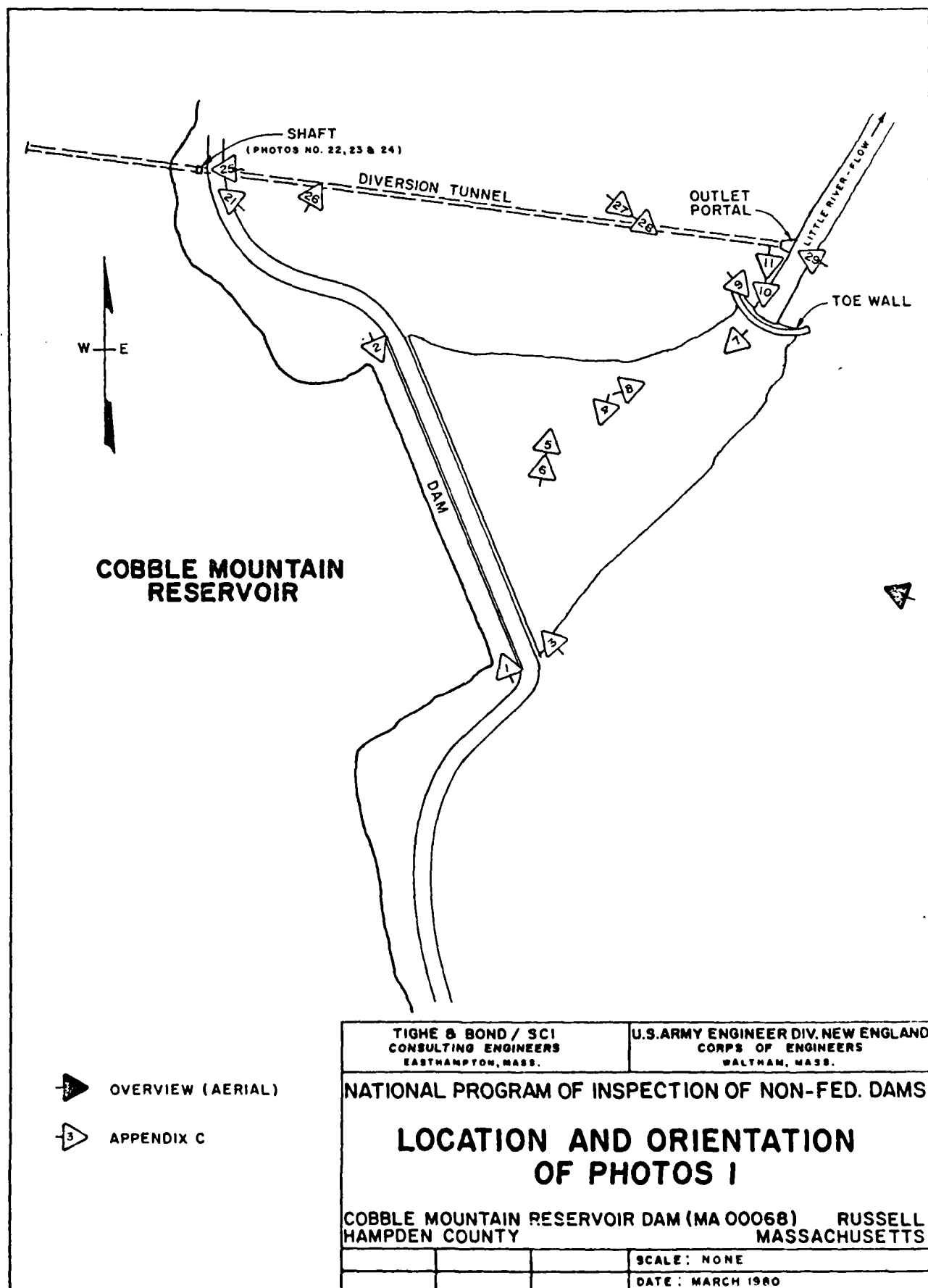
SECTION A-A

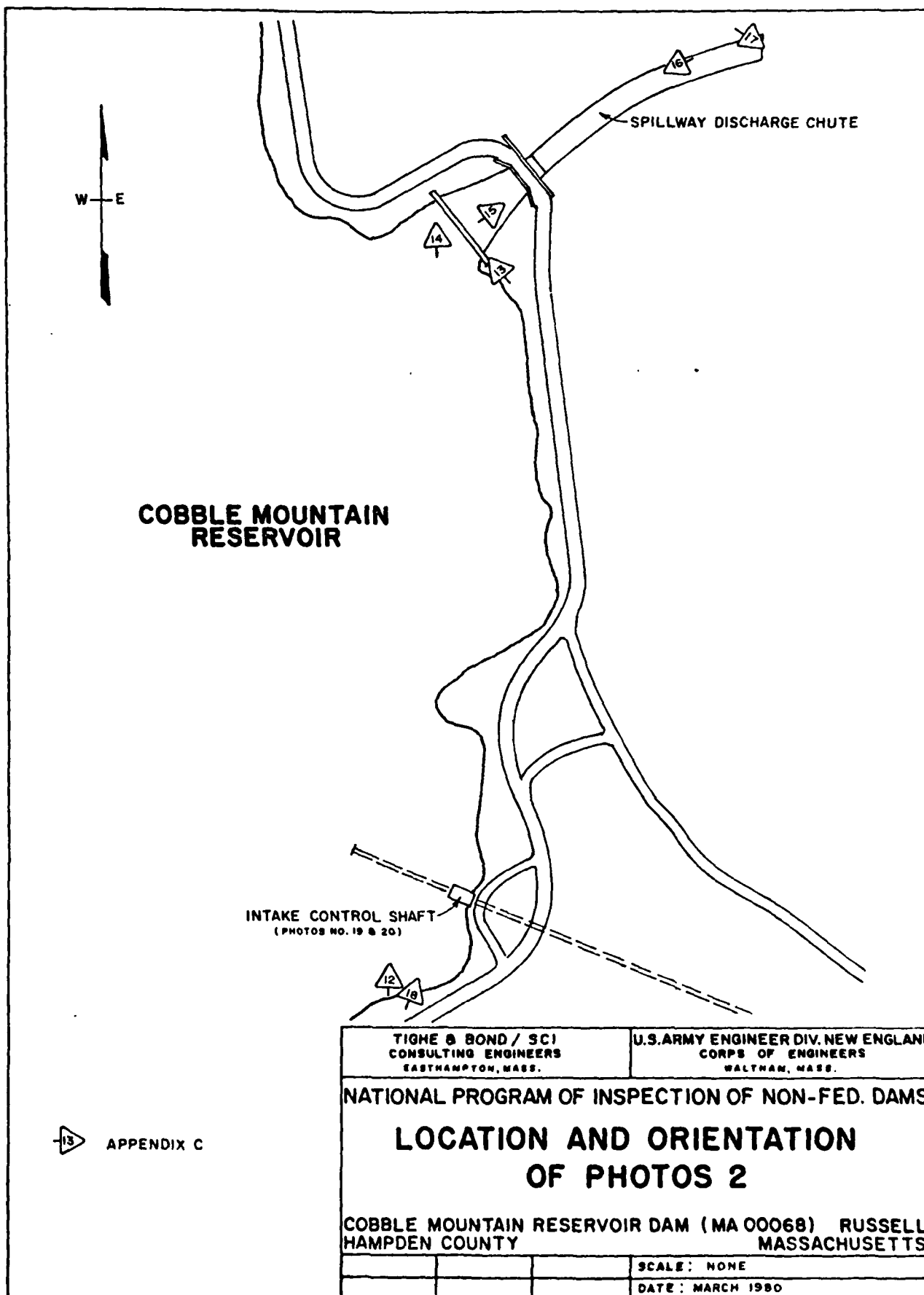
SECTION B-B

SECTION C-C



APPENDIX C
PHOTOGRAPHS





13 APPENDIX C



Photo 1

Upstream face of dam,
looking north at left end



Photo 2

Upstream face of dam,
looking southeast at
right end



Photo 3

Upstream face of dam,
looking southeast at
right end

Photo 4

Downstream face of dam,
upper part, looking south
at right end



Photo 5

Downstream face of dam,
mid height, showing rock,
spauls and growth



Photo 6

Downstream face of dam,
detail of rock surface
and growth





Plate 7

Down the hillside from the top of the hill.



Plate 8

The top of the hill, looking down.

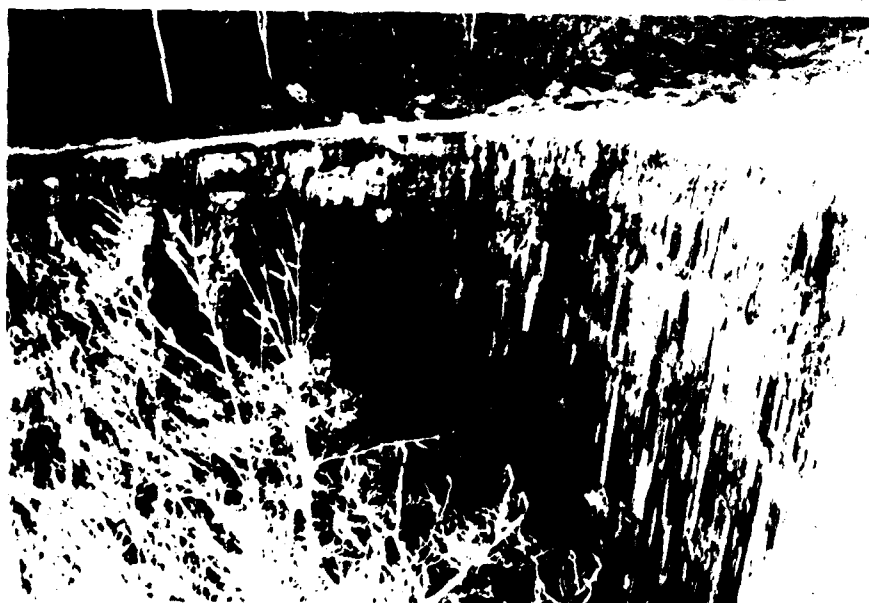


Plate 9

Down the hillside from the top of the hill.

Photo 10

Downstream face of toe dam
and weep hole tap



Photo 11

Toe dam weep hole





Photo 12

View looking north from intake structure at spillway; dam is beyond left end of mountain, left of spillway.



Photo 13

Spillway crest wall from right (southeast) abutment.

Photo 14

Northwest end of spillway;
crest wall showing approach
channel



Photo 15

Road bridge over spillway
channel showing repaired
concrete surfaces & weep holes



Photo 16

Spillway rock cut, looking
upstream toward bridge





Photo 17

Spillway discharge slope
from end of rock cut into
Little River Canyon

Photo 18

Intake gatehouse from southwest



Photo 19

Maximum reservoir levels
Aug. 1955, and Oct. 1955;
at intake gatehouse, showing
typical good condition

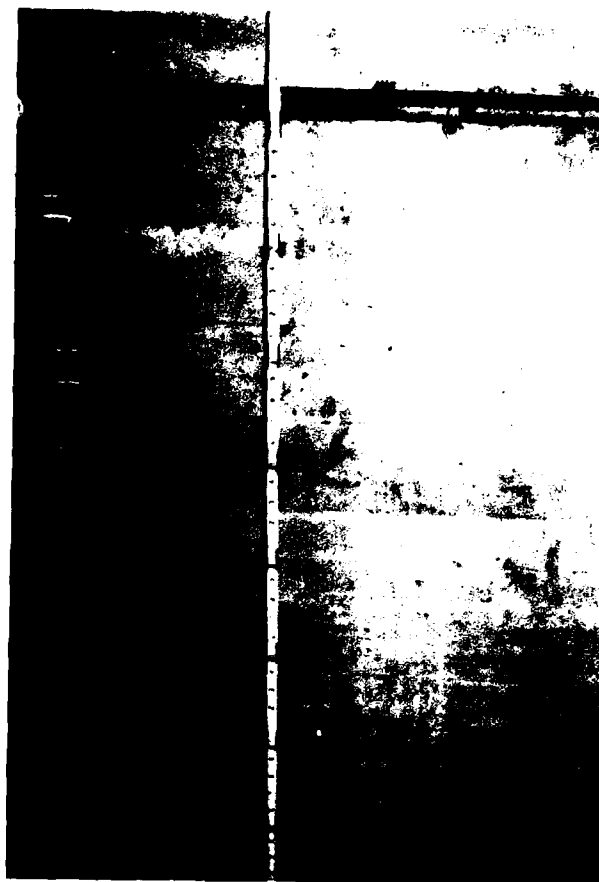


Photo 20

Hand hydraulic pump for
emergency operation of main
intake valve at intake gatehouse.





Photo 1
House at 1212 1/2
St. Paul, Minn.
1941-1942



Photo 2
Person standing next to
barrel for 1941-1942



Photo 3
Barrel for 1941-1942
not visible in photo

Photo 24

Typical operators and brass
for drain valves

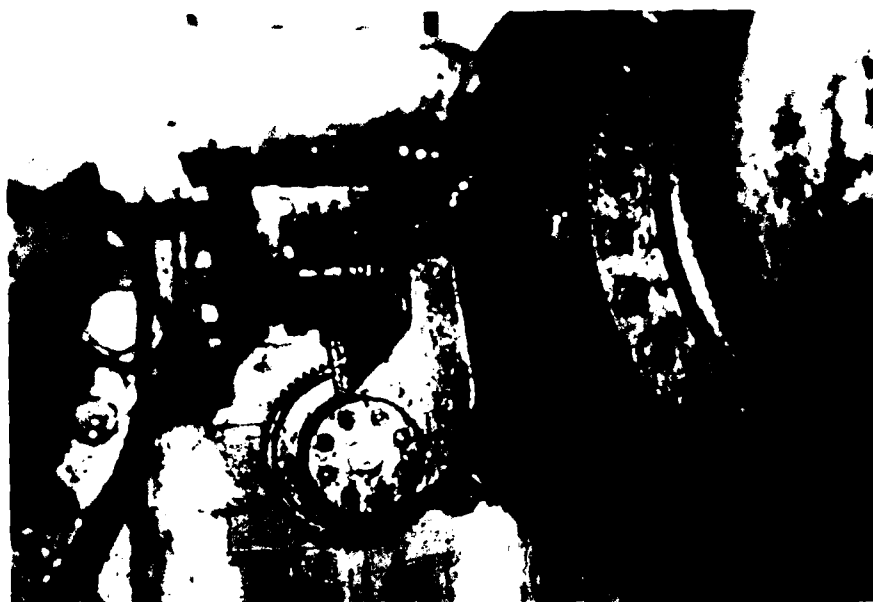


Photo 25

Discharge nozzles of reservoir
drums in diversion tunnel trans-
ition chamber



Photo 26

Typical concrete condition in
diversion tunnel near trans-
ition chamber





Photo 27

Typical leakage in diversion tunnel ceiling and ground surface in last 340 ft. (continued).



Photo 28

Typical leakage near floor of diversion tunnel, in last 340 ft. (continued).



Photo 29

Diversion tunnel entrance, showing leakage.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

APPENDIX D
HYDRAULIC AND HYDROLOGIC COMPUTATIONS

INDEX

Spillway Capacity	1-3/10
Stage Capacity Curves	4/10
Size Classification	5/10
Hazard Classification	5/10
Spillway Test Flood	5/10
Spillway Test Flood Summary	6/10
Maximum Probable Flood Curves	7/10
Diversion Tunnel Capacity	8/10
Intake Tunnel Capacity	9-10/10
Borden Brook Dam Analysis	11/11
Dam Failure Conditions	1/17
Dam Failure Flood Routing	2-16/17
Dam Failure Summary	17/17
Downstream Hazard Map	18

Spillway Capacity

Mus. Creek At. Dam 2

Spillway character below bridge:

$$Width = 50'$$

$$Slope = (923.5 - 923.4) / 500 = 0.002$$

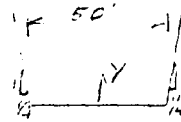
n : rough blasted rock face. assume rough with $n = 0.05$

$$A = 50Y + Y^3/4(F)$$

$$P = 50 + 2Y$$

$$R = A/P$$

$$Q = 1.486 \sqrt{R} A R^{2/3} S^{1/2} = 3.72 A R^{5/3} S^{1/2}$$



Elev. at 3+00 downstream of bridge

$$933.5 \quad Y = 5'; A = 255'; P = 60'; R = 4.25'; Q = 2500 \text{ cfs}; V = 17.6 \text{ ft/s}$$

$$945.5 \quad Y = 20'; A = 1100'; P = 90'; R = 11.1'; Q = 21,615 \text{ cfs}; V = 14.56 \text{ ft/s}$$

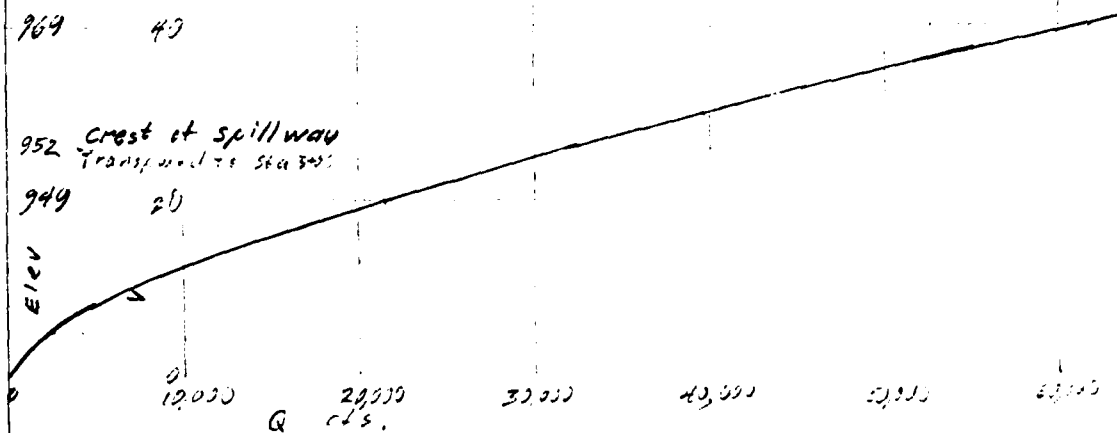
$$958.5 \quad Y = 30'; A = 1725'; P = 118'; R = 15.4'; Q = 39,760 \text{ cfs}; V = 23.0 \text{ ft/s}$$

$$966.5 \quad Y = 40'; A = 2400'; P = 132'; R = 18.1'; Q = 51,520 \text{ cfs}; V = 25.7 \text{ ft/s}$$

$$973.5 \quad Y = 50'; A = 3125'; P = 153'; R = 20.4'; Q = 66,530 \text{ cfs}; V = 27.3 \text{ ft/s}$$

$$982.0 \quad Y = 23.5';$$

Elev. at spillway weir



It looks like this will submerge spillway, we need $Q > 39,000$

$$\text{If } n = 0.05 \quad \& \text{ width } = 50' \quad S = 0.002$$

$$\text{then @ Weir elev. } S = 26,000 \text{ cfs}$$

Spl. Way - 4 ft wide

Water surface elev. = 100.30

Spl. way Downstream of spillway 100 ft

$$\text{First slope} = 945 - 151.2 = 00 =$$

$$\text{Water surface elev.} = 100.30 - 151.2 = 49.10$$

$$\begin{aligned} 100.30 \\ - 151.2 \\ \hline 49.10 \end{aligned}$$

$$A = 2Y^2 + 10Y + 155(Y+12) + 155 = 2Y^2 + 2Y^2 + 165Y + 1620$$

$$P = 2.23Y + 10 + 12 + 155 + 155 + 2.23Y = 4.47Y + 137$$

$$R = P/A \quad n = 0.15$$

$$Q = (1.49/n) A R^{2/3} S^{1/2} = 22.15 A R^{2/3} S^{1/2}$$

$$\begin{aligned} Y = 6; A = 310; P = 167; R = 5.61; Q = 65,701; V = 3.11 \text{ ft/s} \\ S = 0.05; Q = 13,960 \text{ cfs}; V = 2.4 \text{ ft/s} \\ Y = 12; A = 1020; P = 159; R = 13.10; Q = 177,857; V = 12.2 \text{ ft/s} \\ S = 0.05; Q = 57,150 \text{ cfs}; V = 35.3 \text{ ft/s} \\ Y = 4; A = 540; P = 143; R = 3.74; Q = 14,100; V = 63 \text{ ft/s} \end{aligned}$$

Considerations: For $Q \leq 65,701$ cfs, the spillway is not submerged except for backwater from rock cut.

But: rock cut hydraulics indicate it will be submerged for $Q > 20,000$ cfs. = 50,000 cfs.

What slope at $Y = 0$ gives $Q = 20,000$ cfs?

$$S = (Q^n / (1.49 A R^{2/3}))^2 = 26.4 \text{ ft/mile} \quad \text{at } Y = 0$$

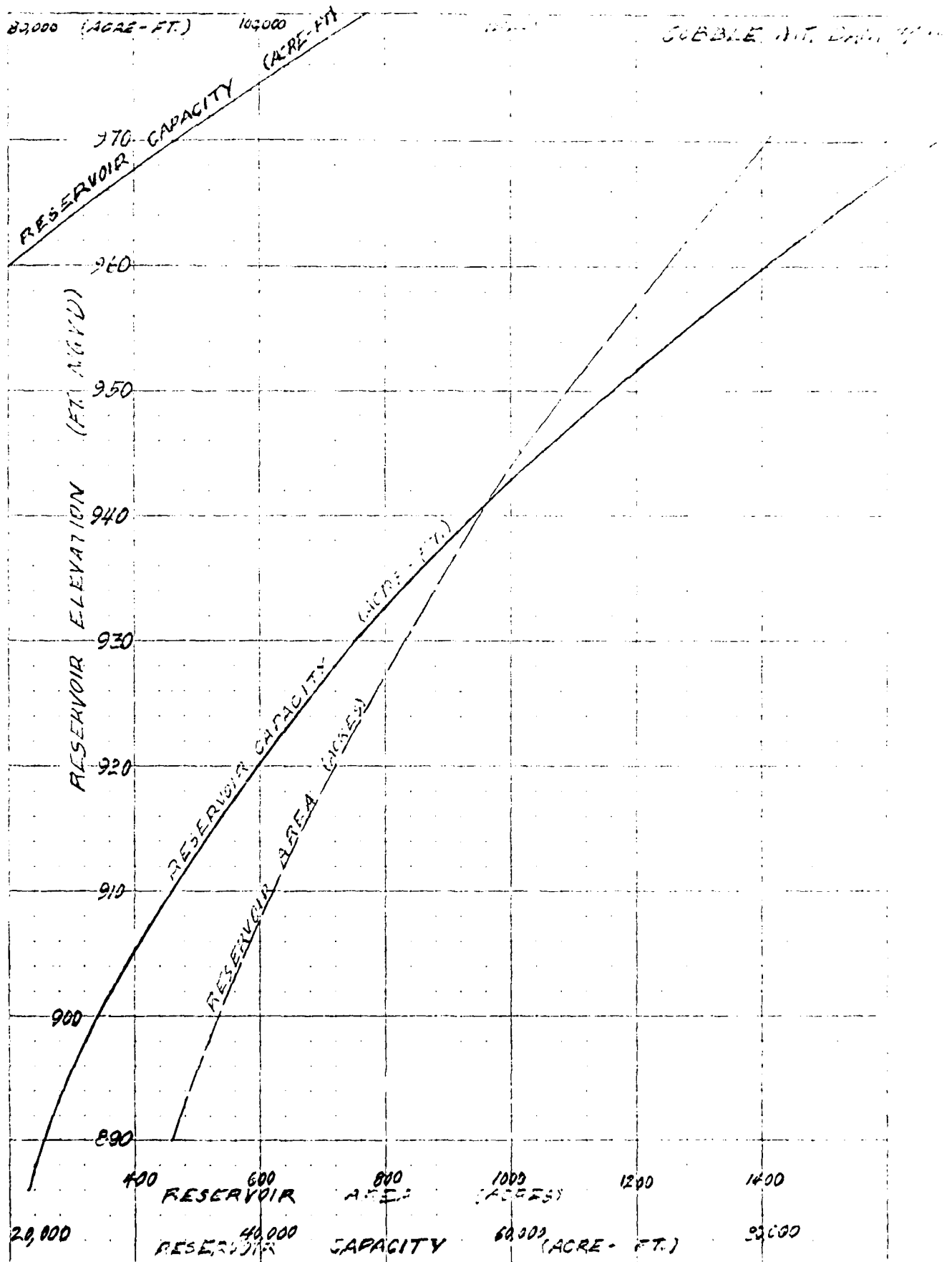
Since $S = 0.05$ is less than 26.4 ft/mile, the spillway is submerged. The water surface elevation is 100.30 ft.

Also, there will be a hydraulic jump in the channel. The water surface elevation will be 100.30 ft. The water surface elevation will be 100.30 ft.

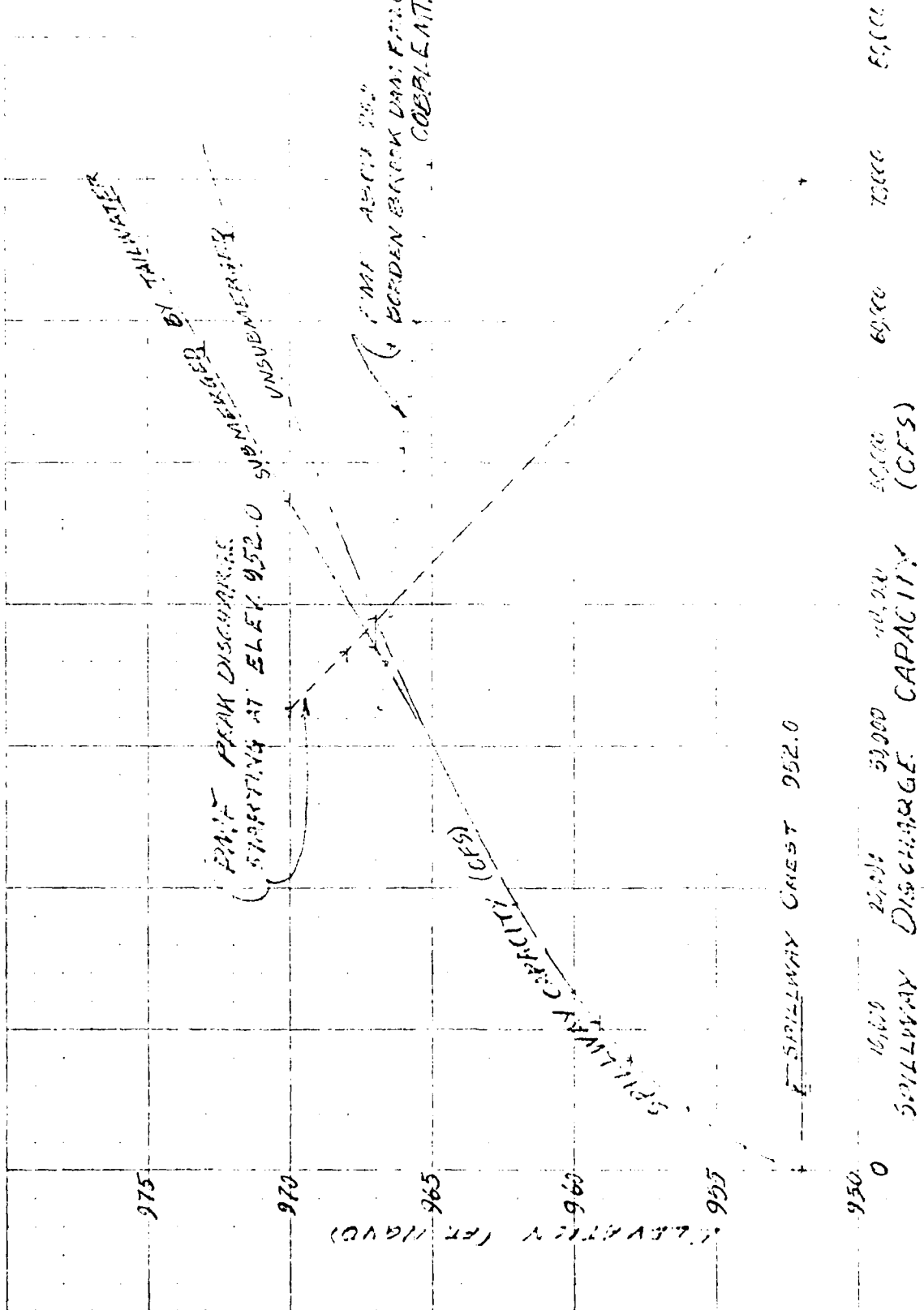
$$Q = 20,000 \text{ cfs} \quad Y = 10.5 \text{ ft} \quad A = 1080 \text{ ft}^2 \quad P = 151 \text{ ft} \quad R = 7.15 \text{ ft} \quad Q = 42,555 \text{ cfs} \quad V = 39.4 \text{ ft/s} \quad S = 0.05 \quad Q = 33,094 \text{ cfs} \quad V = 27.9 \text{ ft/s}$$

Add 3.5' to rock cut depths to get elev. at spillway weir.

U-3-29



U-8-29
COBBLE MT. DAM #1



SPILLWAY TEST

DATE: SEPTEMBER 20, 1951

DIM SIZE: Height = $972 - 722 = 250' > 100'$ LARGE

Impoundment = 90,500 AC.F. $> 50,000$ LARGE

Hazard Potential: Homes: 100 +
Industry: 500 + Major Industries
Commerce: 2 Major Shopping Areas

HIGH

Spillway Test Flood Magnitude:

PMF

Drainage Area =

45.8 sq. mi.

PMF

$$Q = 45.8 (1410) =$$

1420 cfs
65,950 cfs

Elev.	Spillway Q	Reservoir Storage	Spillway Q	Time	Stage
972.0	—	100,000	41.35	15.56	—
968.0	—	83,000	25.79	0.00	—
960.0	15,000	30,000	30.05	6.76	41,794
965.0	30,000	36,700	35.44	3.70	32,265
960.0	35,000	33,000	38.53	10.24	30,405
952.0	—	72,000	29.60	0.00	—
970.0	47,300	93,500	39.23	9.32	35,560
960.0	43,000	90,000	37.13	8.47	36,545

Spillway stage at 972.0 equals top of dam - 972.0 by 7.0

Dam would be overtopped by 3.12 by PMF

Route PMF down the reservoir for adequacy

Normal maximum pool = 960.0 = base of spillway weir

$$Q_{p27} = 65,950 \left(1 - \frac{6.96}{19}\right) = 41,794 \text{ cfs.}$$

$$Q_{p27} = 65,950 \left(1 - \frac{3.70}{19}\right) = 32,265 \text{ cfs.}$$

$$Q_{p27} = 65,950 \left(1 - \frac{10.24}{19}\right) = 30,405 \text{ cfs.}$$

$$Q_{p2} = 30,405 \text{ cfs}$$

Elev. = 955, Freeboard = 6.6

Start PMF at elev. 952.0 = spillway crest

$$Q_{p27} = 65,950 \left(1 - \frac{4.13}{19}\right) = 32,590 \text{ cfs. Elev. = 970.0 } \left(1 - \frac{6.96}{19}\right) = 2.1$$

$$Q_{p27} = 65,950 \left(1 - \frac{3.70}{19}\right) = 32,265 \text{ cfs. Elev. = 960.0}$$

$$Q_{p27} = 65,950 \left(1 - \frac{7.27}{19}\right) = 40,370 \text{ cfs. Elev. = 960.0}$$

$$Q_{p2} = 39,000 \text{ cfs. Elev. = 957.3}$$

Freeboard = 7.7

7-5

SPILLWAY TEST

McC. COLENT. DAM E..

CONCLUSIONS:

PMF = 16,000 cfs.
 SPILLWAY STAGE TO PMF 175.2 FE. MSL
 Dam Overtopped by 3.1 ft.

SPILLWAY TEST FLOOD ROUTED THRU RESERVOIR

Begin flood storage at base of spillway
 Elev. 946.0 MSL

Routed discharge Q = 31,400 cfs.

Reservoir stage 165.5 MSL

Dam Freeboard 3.5 ft.

Begin flood storage at top of spillway 175.2 MSL

Routed discharge Q = 39,000 cfs.

Reservoir stage 167.3 MSL

Dam Freeboard 4.7 ft.

No auxiliary discharge was assumed.

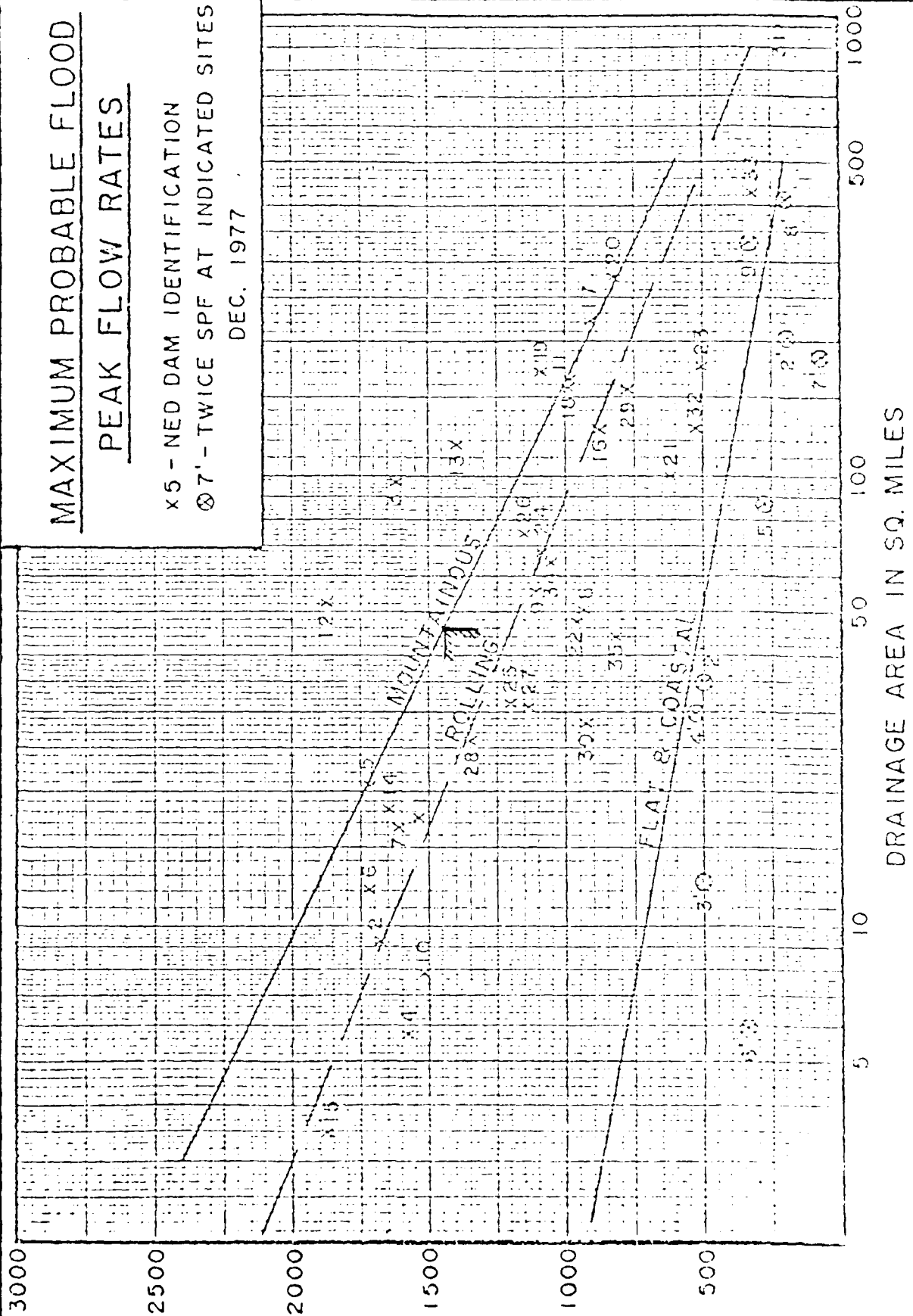
The spillway & reservoir will pass a Probable
 Maximum Flood without overtopping the dam.
 without auxiliary discharge.

No allowance made for spillway bridge. Brd. ...
 about made up by ... D-6

PEAK FLOW RATES

⊗ 7' - TWICE SPF AT INDICATED SITES

M.P.F. IN C.F.S./S.Q. MILE



AD-A145 564

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
COBBLE MOUNTAIN RESER. (U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV MAR 80

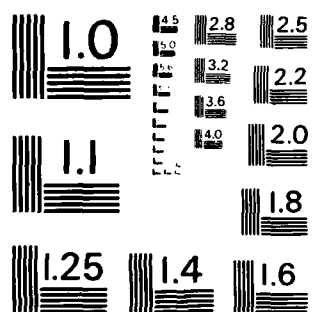
2/2

UNCLASSIFIED

F/G 13/13

NL

END
DATA
FILMED
10-84
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

CUTLEY WORKS

Map 62-45 W.T. 13/11

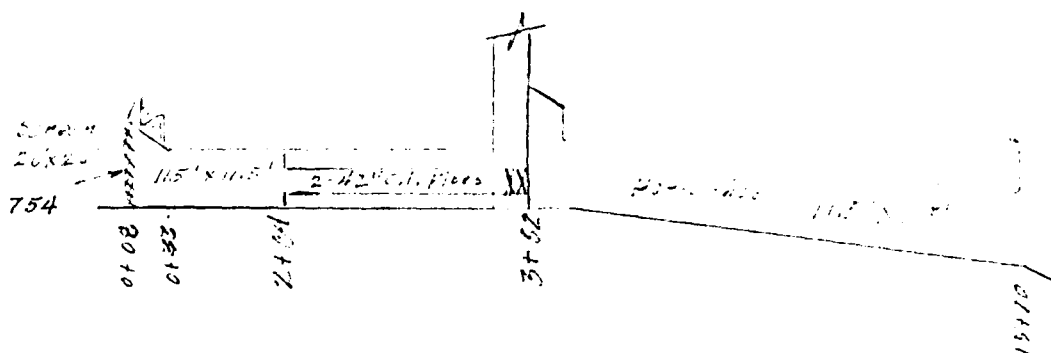
DIVERSION TUNNELL CAPACITY

Inlet: elevation of ...

754.0

Outlet: elevation of ...

730.2



$$H_1 = \left(0.15 \frac{11.5^2}{2(3.5)^4} + 0.13 \frac{108}{3.5} + 1.2 + 1 \right) + 0.5 \left(\frac{11.5}{11.5} + 1 \right) \sqrt{2g} H$$

$$= (0.326 + 5.4(4) + 1.2 + 1) + 1.5 \sqrt{2g} H = 0.150 \sqrt{2g} H$$

$$Q = AV = \pi \left(\frac{11.5}{2} \right)^2 \sqrt{2g} H / 11.56 = 245.2 \sqrt{H}$$

$$\text{At valve outlet } Q = \pi \left(\frac{11.5}{2} \right)^2 \sqrt{2g H / 9.77} = 234.0 \sqrt{H} \quad H_2 = 4.07 \sqrt{2g} H$$

Elev.	H	Q cfs
972.1	242	3914
972.1	218	3396
952.0	222	3653
946.0	216.0	3604
967.3	257.3	3777

TO outlet portal - Top of Dam

TO valve discharge - Top of Dam

TO outlet portal - Top of Spillway

" - Base of Spillway

" - Spillway Top Flood

402. *CHLORIS ALB. DENT.*

42 331 200 SHEETS 5 SQUARE
42 332 100 SHEETS 5 SQUARE
42 333 200 SHEETS 5 SQUARE

.....

730.0 4024

17' High for 1st
11.5' Hinges for
Combined

9.33' x 10' concrete section
concrete lined

Street lined
 small cypress trees
 small evergreens
 flowering shrubs
 flowering shrubs

2300

55

20' x 20' 50000 11411.5
11.5' x 11.5' 540 129 20.0
Air Speed 4 20000 540 11.5

10451

276. 461.

10-1-52

42

36,000 hp
7,720
44,520 hp

Power plant discharge maximum = 1120 cfs.
Head = 712 - 496 = 456 ft.
Reported by L. Patrick Phillips

check head required:

$$H_0 = 2W'H/500$$

$$H = 550 \text{ ft} / 1.34 = 550 \left(\frac{1}{1.34} \right) = 410.4 \text{ ft}$$

Apparent loss in turnout $\hat{\epsilon}$ given by $\epsilon = 45 - 13 = 32$

$$A_1 = \left(0.15 \frac{250}{11.5} + 1.3 + 0.15 \frac{250}{\sqrt{4.73 \times 10}} \left(\frac{1.5^2}{4.73 \times 10} \right) + 0.55 \frac{250}{2(1)} \left(\frac{1.5^2}{2} \right) \right) \sqrt{2}$$

$$= (1.30 + 1.3 + 15.1 + 14.3) \sqrt{2} = 32.0 \sqrt{2}$$

$$V = \frac{1}{2} \rho \int_{-L}^L \dot{y}^2 dx = \frac{1}{2} \rho \int_{-L}^L \left(\frac{\partial y}{\partial t} \right)^2 dx$$

$$H_2 = (10.5)^2 \times 9.8 = 52.1$$

CUTLET ...

400 ...

INTAKE ... CAPACITY

18

$$Q = AV = 15.7 \times 1.5 = 23.55$$

$$K = 0.5 \times 1.5 = 0.75 \times 5.151 = 3.862$$

Design ...

Flow ...

Flow ...

Top of dam ...

Flow ...

SPILLWAY TEST

PMF 1070 - 1055 + 10 = 1070

Borden Brook Reservoir Dam

$$\text{Normal Capacity at 1070.0} = 7073 \text{ cfs}$$

$$\text{Cobble Mt. Capacity at 1020.0} = 7073 \text{ cfs}$$

$$\text{Cobble Mt. Res. Capacity at 950.0} = 77,573 \text{ cfs}$$

Stage increase to stage 10.0 = 6.0'

Check PMF = PMF - Borden Brook

Since Borden Brook Reservoir is a spillway, it is not a dam.

$$Q = PMF = 65,950 \text{ cfs; Runoff volume} = 19' \times 2500' \times 43.0 \text{ ft}$$

$$7073 \text{ cfs} = 19' \times 2500' \times 43.0 \text{ ft}$$

$$Q_{p27} = 65,950 \left(1 - \frac{2.52}{14-3}\right) = 37,110 \text{ cfs; Elev. 970}$$

$$Q_{p27} = 65,950 \left(1 - \frac{2.47}{22}\right) = 40,500 \text{ cfs; Elev. 900}$$

$$\text{Spillway capacity at Elev. 900} = 49,000 \text{ cfs}$$

Check Borden Brook Reservoir Dam failure

$$\text{Height} = 1070 - 1055 + 10 = 90'$$

$$\text{Length reported to be} = 720'$$

$$\text{Length at elev. 1040} = 720/2 = 360 = 360 \pm \text{width of dam top}$$

$$\text{Capacity at top of dam}$$

$$10(2.13 + 2.51)/2$$

$$7073 \text{ cfs}$$

$$2322$$

$$9395 \text{ cfs}$$

$$Q_{p1} = 3/27 \text{ w/ } \sqrt{2} \text{ } Y_0^{3/2}$$

$$= 3/27 (.40) 360 \sqrt{2} 80^{3/2} = 173,200 \text{ cfs}$$

Borden Brook water shed = 3.2 sq. mi. vs. 4.5 sq. mi.

Borden Brook PMF peak would be earlier than Borden Brook.

Start Borden Brook failure at Borden Brook PMF = Elev. 960 > 1955

$$Q_{p27} = 13,000 + 173,200 \left(1 - \frac{86,000 - 50,000}{9993}\right) = 13,000 + 57,110 = 70,110 \text{ cfs Elev. 965}$$

$$Q_{p27} = 13,000 + 173,200 \left(1 - \frac{86,000 - 50,000}{9993}\right) = 13,000 + 38,000 = 51,000 \text{ cfs Elev. 900}$$

$$Q_{p27} = 13,000 + 173,200 \left(1 - \frac{86,000 - 50,000}{9993}\right) = 13,000 + 15,500 = 28,500 \text{ cfs Elev. 907}$$

$$Q_{p2} = 35,900 \text{ cfs; Elev.} = 960.7 \text{ From 60 min.} = 5.5'$$

11

10

1952-53 47-2211 1,17

453

33,000 64:.

52

2. 50,3

5.

370

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9236 40. 11.

First Reach: Cribble. Air. Dam to Intake Dam

Length = 14.20 ft

Storage Length = 13.

Valley X-Section

$$A = 52.3Y^3 + 1.2Y^2 + 1.5Y^{3/2} + 50Y$$

$$= 100 + 50Y + 1.5Y^2$$

$$S = (732 - 445) / 1400 = .020$$

$$n = .052 \quad f = (1 + 50Y) S^{1/2} \cdot 4.5^{1/2} = 4.2330 A R^{2/3}$$

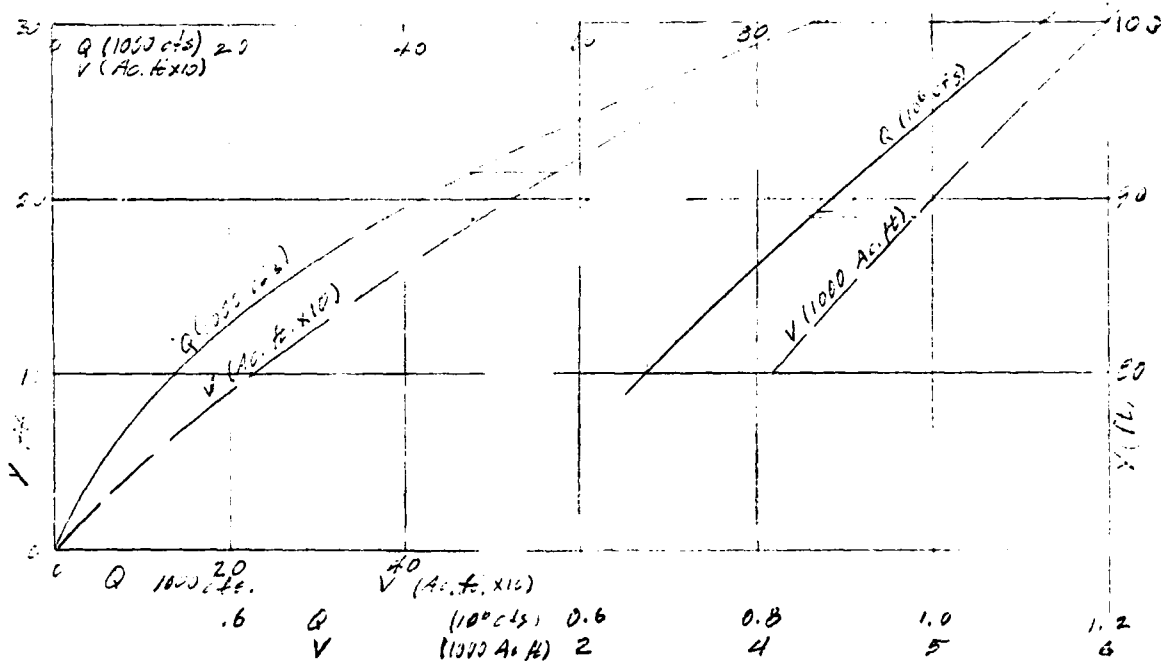
$$Y = 10'; S = 3.700'; A = 15.31 \text{ cfs}; V = 750 \text{ ft}^3; V = 224 \text{ A.H.}; V_1 = 175 \text{ ft}^3$$

$$Y = 20'; R = 15.60'; Q = 57,507 \text{ cfs}; A = 2700 \text{ ft}^2; V = 300 \text{ A.H.}; V_1 = 200 \text{ ft}^3$$

$$Y = 30'; R = 40.37'; Q = 1,127,731 \text{ cfs}; A = 23,100 \text{ ft}^2; V = 1000 \text{ A.H.}$$

$$Y = 40'; S = 4.150'; A = 684,840 \text{ ft}^2; V = 10,750 \text{ ft}^3; V = 5050 \text{ A.H.}; V_1 = 52 \text{ ft}^3$$

$$Y = 50'; R = 40.35'; Q = 677,156 \text{ cfs}; A = 13,700 \text{ ft}^2; V = 4090 \text{ A.H.}; V_1 = 270 \text{ ft}^3$$



$$Q_{base} = 38,000 \text{ cfs}; Y = 12.0'; A = (5) \text{ ft}^2; V = 473 \text{ A.H.}; V_1 = 23.8 \text{ ft}^3$$

$$Q_{p1} = 923,700 \text{ cfs}; Y = 90.8'; A = 17,907 \text{ ft}^2; V = 5075 \text{ A.H.}; V_1 = 53.1 \text{ ft}^3$$

$$Q_{p2} = 38,000 + 865,900 \left(1 - \frac{5075 - 473}{17,907}\right) = 38,000 + 922,060 = 960,060 \text{ cfs}; Y = 92.7'$$

$$V = 4,890 \text{ A.H.}; V_{ave} = (5075 + 4890)/2 = 4995 \text{ A.H.}$$

$$Q_{p2} = 38,000 + 865,900 \left(1 - \frac{4985 - 473}{90,800}\right) = 38,000 + 922,752 = 960,752 \text{ cfs}; Y = 92.3'$$

DAM FLOW

Max. water level 42.5 ft
above 40 (2)

INTAKE DAM

100 ft long - 10 ft high

Spillway

100 ft long - 10 ft high

Gate closed - 100 ft long

Gate closed - 100 ft long

$$Q = 3.9 (H + H_v)^{3/2} L = 606,120 \text{ cfs}$$

Non overflow section length = 50 - 40 = 10 ft

Gate closed on 40 ft 3' wide with spillways.

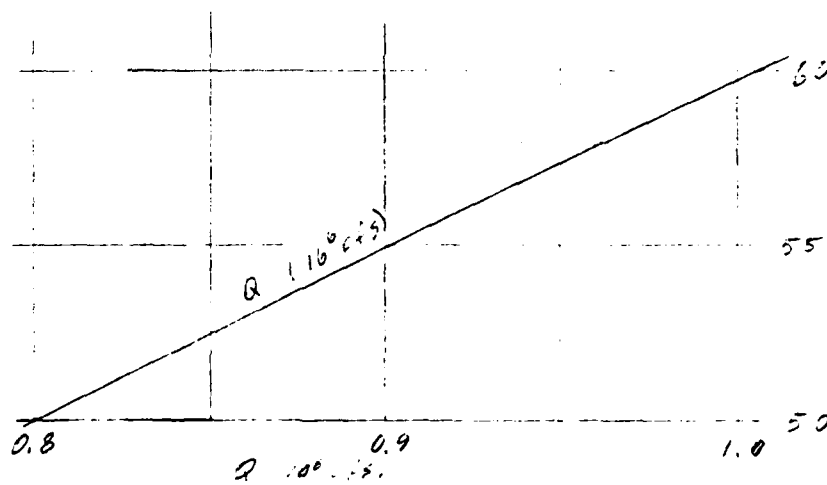
Top elev = 504.0

Riverbed = 445 ft

$$Q = 3.9 (H + H_v)^{3/2} L = 425 (H + H_v)^{3/2}$$

Station 40 42 44 46 48 50
H H Q H H Q H H Q

0.1	8	13,970	-	-	13,970
0.2	15.8	31,740	53	6,430	27,710
0.1	7.6	2,900	0	-	-
0.2	14	32,430	6	6,430	32,710
38	50	503,260	42	300,530	202,730
40	55	561,120	47	341,000	222,120
42	60	624,300	52	353,000	271,300
	57.8				961,000



DAM FAILURE

MISC. COEFFICIENT DAM 4/17

REACH 2

Intake Dam to

Vanguard Res.

Reach length: 16,900'

Slope = $(445 - 250) / 13,200 = 0.015$ $m = 0.050$

Valley x-section:

$$A = 60(5)^{2/3} + 1.5V^{2/3} + 50Y - 2Y^{2/3} = 1,100 + 60Y + 1.5Y^2$$

$$K = (1.486/n) S^{1/2} A R^{2/3} = 2.640 A R^{2/3}$$

$$Y = 15, R = 11.633'; Q = 27,050 cfs; A = 1445'; V = 512 Ac.H.$$

$$Y = 25, R = 14.26'; Q = 44,010 cfs; A = 2,031'; V = 577 Ac.H.$$

$$Y = 30, R = 15.316'; Q = 51,316 cfs; A = 2,512'; V = 3746 Ac.H.$$

$$Y = 35, R = 16.32'; Q = 55,000 cfs; A = 2,730'; V = 3,227 Ac.H.$$

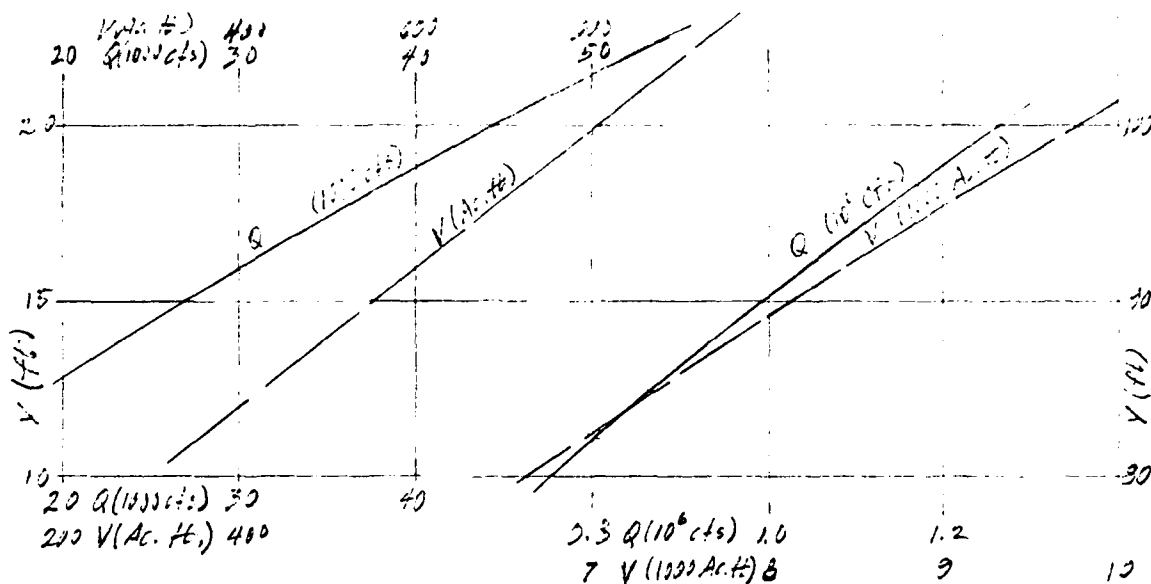
$$Y = 40, R = 17.32'; Q = 64,000 cfs; A = 3,250'; V = 7,550 Ac.H.$$

$$Q_1 = 18,700 cfs$$

$$Q_2 = 214,000 cfs$$

$$Q_3 = 20,200 cfs$$

$$Q_4 = 44,200 cfs$$



$$Q_{base} = 38,000 cfs; Y = 18.3'; V = 720 Ac.H.$$

$$Q_{p1} = 869,950 cfs; Y = 84.73'; V = 7350 Ac.H.$$

$$Q_{p2T} = 38,000 + 822,950 \left(1 - \frac{7350 - 720}{90,800}\right) = 38,000 + 762,860 = 800,860 cfs; Y = 82.4'$$

$$V = 6990 Ac.H.; V_{ave} = (6790 + 7350)/2 = 7170 Ac.H.$$

$$Q_{p2} = 38,000 + 822,950 \left(1 - \frac{7170 - 720}{90,800}\right) = 38,000 + 764,500 = 802,500 cfs; Y = 82.1'$$

DAM FAILURE 5,

1/100 COEFFICIENT DAM F.T.C

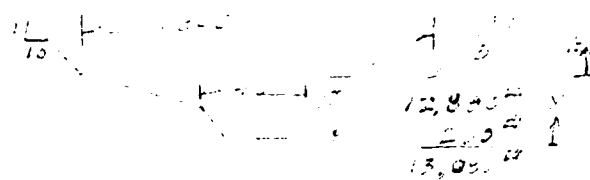
REACH 3

NORTHWEST R.I. TO 2000' ABOVE MONTANA DAM

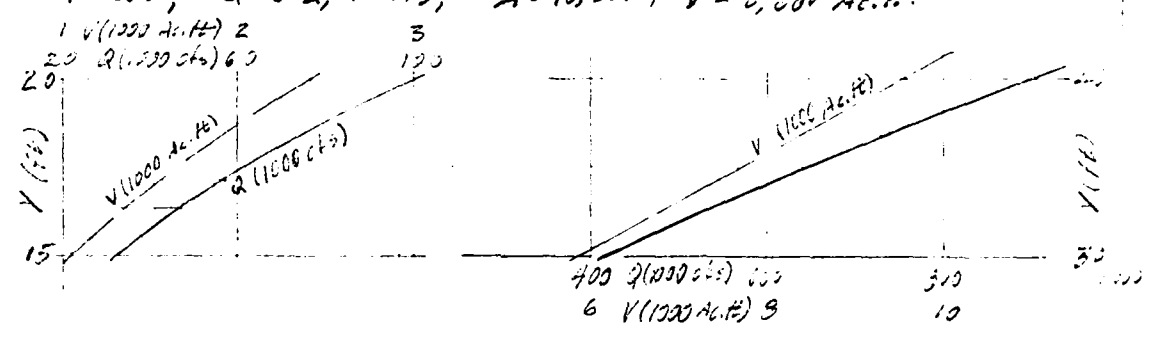
LENGTH = 500' $S = 30' / 100' = 0.3$ (from U.S. Westfall Riv. Study)

112,000 $Q = (4500) S^2 A F^3 = 2.585 A F^3$

Verify A-section:



$Y = 20'$	$Q = 111,530 \text{ cfs}$	$A = 13,080 \text{ ft}^2$	$V = 2.402 \text{ Ac.Ft.}$
$Y = 25'$	$Q = 172,880 \text{ cfs}$	$A = 25,350 \text{ ft}^2$	$V = 2.50 \text{ Ac.Ft.}$
$Y = 30'$	$Q = 254,134 \text{ cfs}$	$A = 42,450 \text{ ft}^2$	$V = 2.714 \text{ Ac.Ft.}$
$Y = 35'$	$Q = 358,000 \text{ cfs}$	$A = 64,770 \text{ ft}^2$	$V = 3.525 \text{ Ac.Ft.}$
$Y = 40'$	$Q = 482,500 \text{ cfs}$	$A = 92,080 \text{ ft}^2$	$V = 4.588 \text{ Ac.Ft.}$
$Y = 45'$	$Q = 638,800 \text{ cfs}$	$A = 125,350 \text{ ft}^2$	$V = 5.845 \text{ Ac.Ft.}$
$Y = 50'$	$Q = 802,500 \text{ cfs}$	$A = 164,351 \text{ ft}^2$	$V = 7.670 \text{ Ac.Ft.}$
$Y = 55'$	$Q = 974,500 \text{ cfs}$	$A = 209,080 \text{ ft}^2$	$V = 10.160 \text{ Ac.Ft.}$



$$Q_{p2T} = 38,000 + 764,500 \left(1 - \frac{8,180 - 1160}{90,800}\right) = 38,000 + 699,500 = 737,500 \text{ cfs.}$$

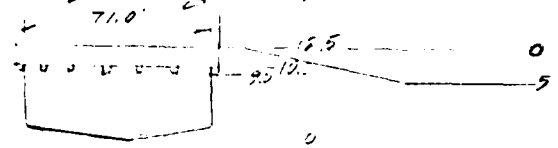
$$V = 8410 \text{ Ac.Ft. } V_{avg} = (3410 + 9830) / 2 = 8645 \text{ Ac.Ft. } , Y = 37.0'$$

$$Q_{p2} = 38,000 + 764,500 \left(1 - \frac{8645 - 1160}{90,800}\right) = 38,000 + 701,500 = 739,500 \text{ cfs.}$$

$$Y = 37.0'$$

Flow over Northwest Road = stage - height of road above channel bed.

Stage	15.6'	35.2
Rd. height	- 7.5	- 7.5
	8.1	30.7



DAM FAILURE

NO. COBBLE MT. DAM 677

REACH 4 At Horch's Bridge (Granville Rd.) Hazard Area 4

Reach Length = 3500'; $S = 30/10,560 = .003$; $H = 5.535$

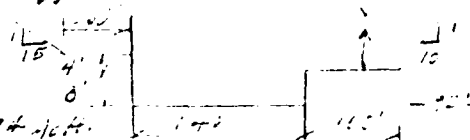
$$Q = (1.486/n) S^{1/2} A R^{2/3} = 2.3255 A R^{2/3}$$

$$\text{Dam: } L = 140' ; C = 3.4 ; Q = 3.4 L (H + H_d)^{3/2}$$

$$H = 12'; H_d = 16'; Q_1 = 22,310 \text{ cfs. over dam}$$

$$Y = 4'; H = 7.4'; Q_2 = 3,360 \text{ cfs.}; A = 43.5'$$

$$Q_T = 25,670 \text{ cfs.}; A_T = 2160'; V = 17.4 \text{ ft.}$$



$$H = 15'; H_d = 10'; Q_1 = 34,500 \text{ cfs. over dam}$$

$$Y = 7'; H = 9.4'; Q_2 = 15,500 \text{ cfs.}; A = 700 + 245 + 130 + 65 = 1140'$$

$$Q_T = 50,000 \text{ cfs.}; V = (1140 + 2160) 3500 / 45,500 = 235 \text{ ft.}$$

crest elev. = 105.11 ft

$$H = 14'; H_d = 10'; Q_1 = 27,650 \text{ cfs. over dam}$$

$$Y = 6'; H = 9.4'; Q_2 = 7,440 \text{ cfs.}; A = 600 + 130 + 120 + 30 = 880'$$

$$Q_T = 35,090 \text{ cfs.}; V = (880 + 2160) 3500 / 44,500 = 235 \text{ ft.}$$

For greater flows the dam will be submerged by tailwater

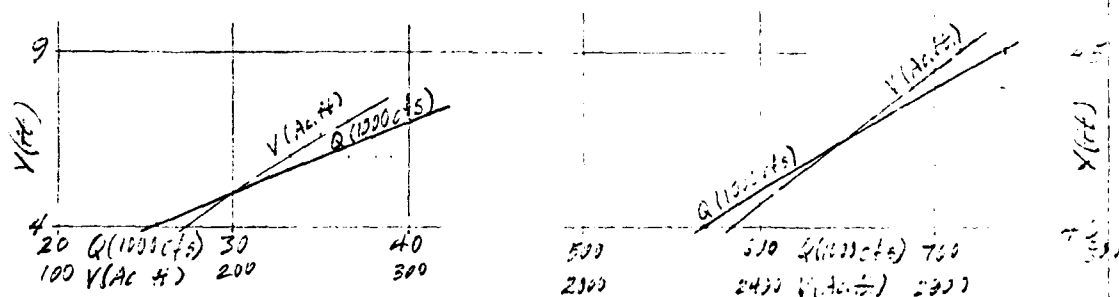
$$Q = 2.3255 A R^{2/3}; A = 1630 + 400 + 300 + 300 \times 2 + 25 \times 2 / 2; Y_2 = Y - 4.5'$$

$$Y = 44'; Q = 700,900 \text{ cfs.}; A = 34,160'; V = 2745 \text{ ft.}$$

$$Y = 45'; Q = 737,900 \text{ cfs.}; A = 35,470'; V = 2,930 \text{ ft.}$$

$$Y = 45.1'; Q = 737,500 \text{ cfs.}; A = 35,565'; V = 2,960 \text{ ft.}$$

$$Y = 40'; Q = 568,000 \text{ cfs.}; A = 24,160'; V = 2,340 \text{ ft.}$$



$$Q = 38,000 \text{ cfs.}; V = 251 \text{ ft.}; Y = 6.6'; \text{ Elev.} = 197.5; \text{ Area} = 300 \times 2 + 25 \times 2 = 172 \text{ ac.}$$

$$Q_{p2T} = 38,000 + 701,500 \left(1 - \frac{2960 - 251}{70,800}\right) = 38,000 + 691,300 = 729,300 \text{ cfs.}; Y = 44.5'$$

$$V_T = 2800 \text{ ft.}; V_{T2} = (2900 + 2340) / 2 = 2620$$

$$Q_{p2} = 3900 + 701,500 \left(1 - \frac{2970 - 251}{70,800}\right) = 3900 + 691,600 = 729,500 \text{ cfs.}; Y = 44.5'$$

$$\text{Elev.} = 257.5$$

$$\text{Area} = 4500 \times 5000 / 2 = 11,250,000$$

$$2200 \times 2000 = 4,400,000$$

$$345 \text{ ac.} + \text{Horton Rd.}$$

$$\text{Depth over top} = 44.5 - 100.0 = 160.5 \text{ ft.}$$

DAM FLOW

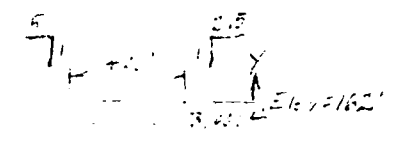
Reach 5 1500' west of Rt. 212 to Rt. 202
 Length = 1500'; S = (155-162)/700 = 0.0103; n = 0.025
 Area of 100' width = 100 - 55 = 45; 45 x 4.356 = 195.8 AC.
 Area of 200' width = 200 - 55 = 145; 145 x 4.356 = 631.6 AC.
 Rate of change = 1000/200 = 5 AC/ft.

Reach 6 1500' west of Rt. 212 to Rt. 202
 Length = 1500'; S = (155-162)/700 = 0.0103; n = 0.025

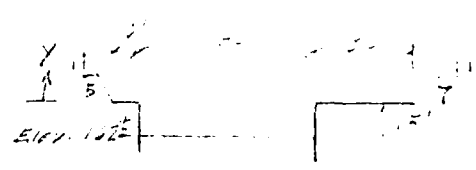
VALLEY X-SECTION

$$Q = (1.486/n) S^{2/3} A R^{2/3} = 2.437 A V^{2/3}$$

$$A = 3000 + 40Y + 3.75 Y^2$$



DAM: L = 1900'; C = 3.9
 $Q = 3.9(190)(H + H_0)^{3/2}$



$$H_0 = (39,000 / 3.9(190))^{2/3} - H$$

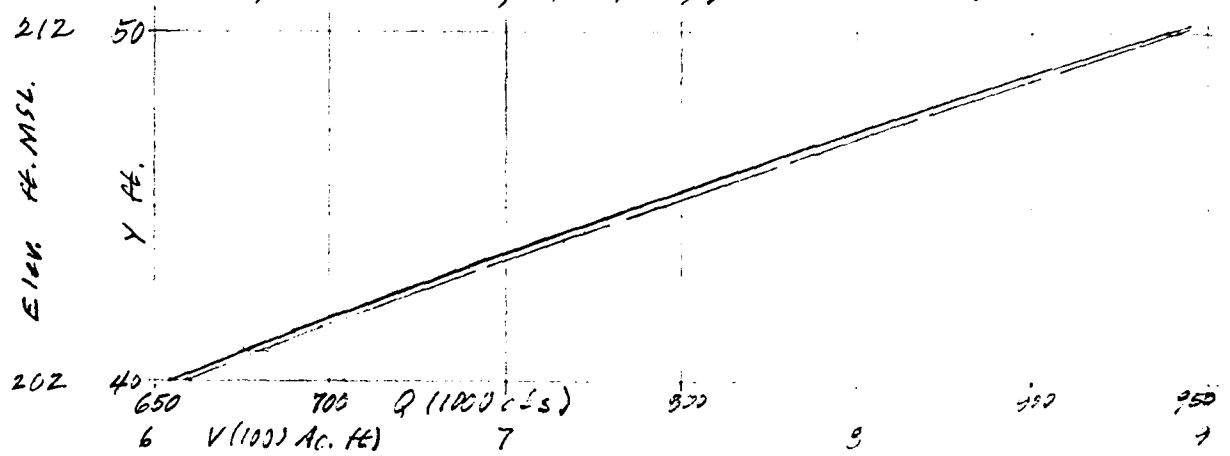
$$= 14.56 - 3.5' = 11.0'$$

$$V = 7.454(11.0 / 4.356) + (163 - 7(5)) (11.0) = 270 - 349 = 519 AC/ft.$$

H = 20'; Q = 777 cfs.

For greater flows the dam will be overtopped by tail water.
 Use Valley X-section: Q = 2.437 A V^{2/3}

Y = 40'; Q = 654,000 cfs; A = 25,000 AC; V = 360 AC/ft + 262 (40/2) = 6100 AC/ft
 Y = 50'; Q = 938,000 cfs; A = 32,375 AC; V = 1115 AC/ft + 312 (50/2) = 8915 AC/ft
 Y = 44.0'; Q = 760,300 cfs; A = 27,530 AC; V = 956 AC/ft + 252 (44/2) = 7160 AC/ft.



$Q_{p1} = 719,600 \text{ cfs}; Y = 42.9' = 204.9 \text{ V} = 6750 \text{ AC/ft.}$

$Q_{p2} = 39,000 + 691,600 (1 - \frac{6525 - 919}{90,850}) = 39,000 + 637,911 = 676,911 \text{ cfs.}$
 $V = 6300 \text{ AC/ft.}; V_{1.5} = (6300 + 6750) / 2 = 6525 \text{ AC/ft.}; Y = 42.9'$

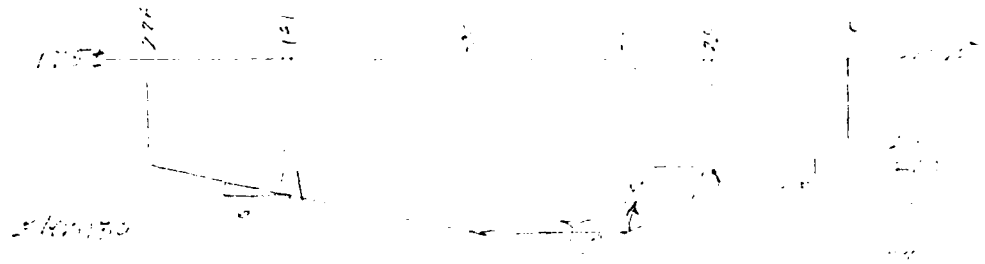
$Q_{p2} = 39,000 + 691,600 (1 - \frac{6525 - 919}{90,850}) = 39,000 + 637,911 = 676,911 \text{ cfs.}$
 $Y = 40.9' = 202.9' \text{ MSL}$

Area = $\frac{1200' \times 1000'}{5000' \times 4000'} = \frac{2.7 \text{ AC}}{2.57}$

DAV 30.12.20

Revised 7: Hydraulic Control

175' 170' 165' 155' 145' 135' 125' 115' 105' 95' 85' 75' 65' 55' 45' 35' 25' 15' 5' 0'



175' 170' 165' 155' 145' 135' 125' 115' 105' 95' 85' 75' 65' 55' 45' 35' 25' 15' 5' 0'

175' 170' 165' 155' 145' 135' 125' 115' 105' 95' 85' 75' 65' 55' 45' 35' 25' 15' 5' 0'

155' Y=25'; Q=57,500 cfs;

A=4,750

175' 170' 165' 155' 145' 135' 125' 115' 105' 95' 85' 75' 65' 55' 45' 35' 25' 15' 5' 0'

150' Y=30'; Q=56,700 cfs;

A=5,375

175' 170' 165' 155' 145' 135' 125' 115' 105' 95' 85' 75' 65' 55' 45' 35' 25' 15' 5' 0'

155' Y=30'; Q=35,360 cfs;

A=3,000

175' 170' 165' 155' 145' 135' 125' 115' 105' 95' 85' 75' 65' 55' 45' 35' 25' 15' 5' 0'

135' Y=35'; Q=123,750 cfs;

A=5,800

175' 170' 165' 155' 145' 135' 125' 115' 105' 95' 85' 75' 65' 55' 45' 35' 25' 15' 5' 0'

145' Y=15'; Q=19,460 cfs;

A=1,920

175' 170' 165' 155' 145' 135' 125' 115' 105' 95' 85' 75' 65' 55' 45' 35' 25' 15' 5' 0'

140' Y=10'; Q=9,000 cfs;

A=600

175' 170' 165' 155' 145' 135' 125' 115' 105' 95' 85' 75' 65' 55' 45' 35' 25' 15' 5' 0'

For major bridge restoration $Q = 1.47 \times 10^6$ cfs

K = 1.05; $100 \times 1.05 = 105$

$1.47 \times 10^6 = 1.47 \times 10^6$

175' Y=20'; A=5,000; $H_v = 1.8$; $H_t = 7.5$; Q=50,000 cfs

165' Y=30'; A=5,200; $H_v = 1.8$; $H_t = 8.5$; Q=14,000 cfs

155' Y=35'; A=5,300; $H_v = 2.1$; $H_t = 9.5$; Q=15,000 cfs

170' Y=40'; A=7,520; $H_v = 2.2$; $H_t = 7.5$; Q=130,000 cfs

155' Y=45'; A=5,500; $H_v = 2.3$; $H_t = 10$; Q=200,000 cfs

155' Y=25'; A=4,000; $H_v = 1.6$; $H_t = 7$; Q=97,500 cfs

South Meadow Road Bridge overpass; also Silver Is.

$Q = 2.1 \times 10^6$ cfs

$Q = A \sqrt{2g} (H_v - H_t)$

$H_v = 0.5$ K=1.2

155' Y=16'; Q=9,500 cfs; A=1,000; $H_v = 1.5$; $H_t = 1.5$

155' Y=11'; Q=4,700 cfs; A=500; $H_v = 1.5$; $H_t = 1.5$

125' Y=21'; Q=11,700 cfs; A=1,000; $H_v = 1.5$; $H_t = 1.5$

150' Y=6'; A=300; $H_v = 2$; Q=3,540 cfs

160' Y=16'; A=800; $H_v = 4$; Q=12,570 cfs

170' Y=26'; A=1300; $H_v = 7$; Q=26,250 cfs

175' Y=31'; A=1500; $H_v = 8$; Q=33,300 cfs

Thru city: $n = .040$; $s = .001$; $Q = 1.17489 \times 10^6$ cfs

155' MSY Y=10'; Q=46,700 cfs; A=13,600; $H_v = 1.5$; $H_t = 1.5$

165' Y=15'; Q=140,600 cfs; A=27,375; $H_v = 1.5$; $H_t = 1.5$

165' Y=20'; Q=293,200 cfs; A=41,700; $H_v = 1.5$; $H_t = 1.5$

175' Y=30'; Q=631,700 cfs; A=72,000; $H_v = 1.5$; $H_t = 1.5$

150' Y=5'; Q=7,350 cfs; A=3,400; $H_v = 1.5$; $H_t = 1.5$

170' Y=25'; Q=467,400 cfs; A=56,575; $H_v = 1.5$; $H_t = 1.5$

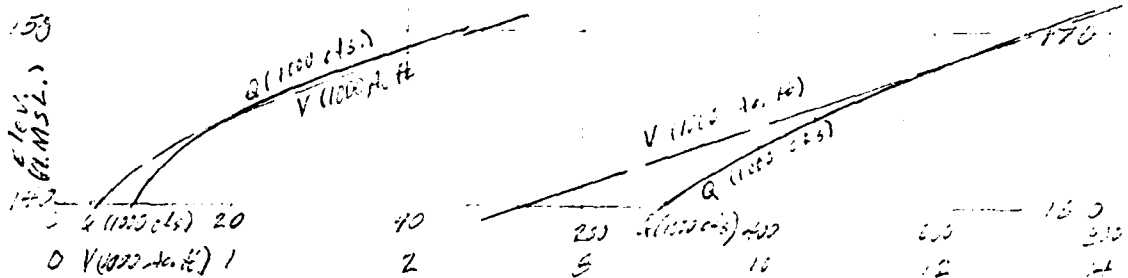
DAM FAILURE

Region T: Fork Interpolation

NO. 1052 LE. AIT. DAM 4/17

Flow at Head Volume

Elev. 140	150	160	170
$A = 90 \times \frac{2.79}{4.76} = 42.4$	$\frac{2.79}{4.76} = 403.40$	$\frac{4.76}{6.50} = 570.40$	$\frac{4.76}{6.50} = 570.40$
$V = (403.40 + 570.40) \times 1.0$	$V = (570.40 + 570.40) \times 1.0$	$V = (570.40 + 570.40) \times 1.0$	$V = (570.40 + 570.40) \times 1.0$
$V_{140} = 76(1.0) = 76.0$	$V = 403.40 \text{ Ac. ft.}$	$V = 570.40 \text{ Ac. ft.}$	$V = 570.40 \text{ Ac. ft.}$
$V_{150} = 76 + 76 = 152$	$V_{160} = 736.3 \text{ Ac. ft.}$	$V_{170} = 1,140.8 \text{ Ac. ft.}$	
$= 241.3 \text{ Ac. ft.}$			



$$Q = 39,111 \text{ cfs}; V = 2,050 \text{ Ac. ft.}; \text{Elev.} = 143.6 \text{ ft. MSL}$$

$$Q_{01} = 677,500 \text{ cfs}; V = 12,800 \text{ Ac. ft.}; \text{Elev.} = 169.4 \text{ ft. MSL}$$

$$Q_{p2} = 39,111 + 639,500 \left(1 - \frac{12,800 - 2,050}{90,800}\right) = 39,111 + 563,900 = 603,011 \text{ cfs}; \text{Elev.} = 167.9$$

$$V = 11,350 \text{ Ac. ft.}; V_{p2} = (11,350 - 12,800)/2 = 12,375 \text{ Ac. ft.}$$

$$Q_{p2} = 39,111 + 639,500 \left(1 - \frac{12,375 - 2,050}{90,800}\right) = 39,111 + 566,300 = 605,411 \text{ cfs}; \text{Elev.} = 168.0 \text{ ft. MSL}$$

Stage at R202:

$$\text{Base flow stage: } S = 0.0020 \text{ Elev. } 14.6 \text{ ft. } 2(7600) = 165.9 \text{ MSL}$$

Failure stage: $S = 0.001$ Elev. = $165.04 \text{ ft. } 7600 = 175.6 \text{ MSL}$
due to large area of dike flow from river

Depth over R202 NE of bridge: $104 - 104 = 0$ ft. dike
 $176 - 104 = 72$ ft. failure

Depth over main of RR bridge: $143.6 - 144 = 4.6$ ft. dike
 $168.0 - 144 = 24.0$ ft. failure

D.M. FALDAE

Recon. of Highway Bridge to carry 100 ft. wide

Assume 10% of waterway for bridge piers

$$S = 24.17 (50.0) = 1208.6$$

Let X = section

$$A_1 = 600 + 1.5X + 1.5X^2$$

$$A_2 = 4200 + 24X + 2.25X^2$$

$$A_3 = 4.31 + 452.5X_2 + 2.25X_2^2$$

$$Q = (1.486/n) S^{2/3} A R^{4/3} = 0.917 A R^{4/3}$$

$$Y = 20'; Q = 119,200 cfs; A = 4,200; EL = 124.3$$

$$Y_1 = 15'; Q = 73,415 cfs; A = 2,130; EL = 126$$

$$Y_2 = 5'; Q = 9,522 cfs; A = 1,350; EL = 141$$

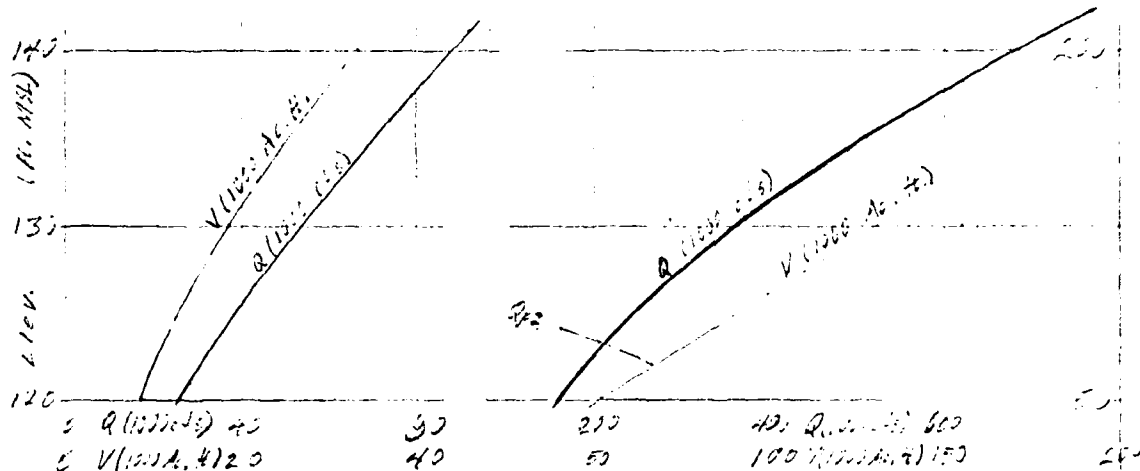
$$Y_2 = 40'; Q = 373,500 cfs; A = 32,270; EL = 76$$

$$Y_2 = 60'; Q = 621,500 cfs; A = 43,130; EL = 142$$

$$Y_2 = 80'; Q = 762,200 cfs; A = 50,430; EL = 208$$

$$Y_2 = 20'; Q = 189,800 cfs; A = 13,500; EL = 156$$

$Q = 77,315$ at $Y = 15'$
Relative total



$$Q_2 = 39,111 cfs; V = 12,500 ft/sec; EL = 124.3' MSL$$

$$Q_{p1} = 604,800 cfs; V = 192,500 ft/sec > 95,800 \therefore \text{develop stage - temporary}$$

$$\text{Elev.} = 155; V = 67,000 ft/sec; Q = 192,500 cfs; Q_{p2} = 59,111 + 566,900 \left(1 - \frac{67,000 - 12,500}{95,800}\right) = 266,500 cfs$$

$$\text{Elev.} = 160; V = 83,300 ft/sec; Q = 228,000 cfs; Q_{p2} = 59,111 + 566,900 \left(1 - \frac{83,300 - 12,500}{95,800}\right) = 162,500 cfs$$

$$\text{Elev.} = 159.5; V = 77,000 ft/sec; Q = 212,000 cfs; Q_{p2} = 59,111 + 566,900 \left(1 - \frac{77,000 - 12,500}{95,800}\right) = 202,200 cfs$$

$$\text{Elev.} = 157.5; V = 76,000 ft/sec; Q = 212,000 cfs; Q_{p2} = 59,111 + 566,900 \left(1 - \frac{76,000 - 12,500}{95,800}\right) = 203,400 cfs$$

$$\therefore \text{EL} = 157.4; Q = 202,000 cfs$$

DAM FAILURE

McC. CURRENT DAM 14.7

Reach 8 cont. Flood control from this reach as a reservoir with hydro. outlet control at Westfield - Westfield town line.

check time constraints:

$$\text{Durational surge: } T = 125/12.47 = 12(5.9, 0.9) / 931,100$$

$$T = 52,047 \text{ sec.} = 14.5 \text{ hrs}$$

Time to crest to max flow reach = L/V

$$t = (945 + 16,400) / (373,500 / 30,000) = 25.7 - 12.24 = 13.46 \text{ min.}$$

$$t = 35 \text{ min.}$$

$$T/t = 14.5(60)/35 = 25.3 \text{ OK to use steady state hydraulics}$$

Stage capacity:

$$\text{Elev. 100 } A = 0$$

$$\text{Elev. 150 } A = 3105 \text{ AC.}$$

$$\text{Elev. 200 } A = 6237 \text{ AC.}$$

$$V = A \cdot H = 51,750 \text{ AC} \cdot \text{ft}$$

$$V = A \cdot H = 209,557 \text{ AC} \cdot \text{ft}$$

$$\text{check } \Delta V = (A_2 - A_1) \cdot H = 50(3105 + 6237) = 234,300 \text{ AC} \cdot \text{ft}$$

$$\text{Elev. 156 } Q_{p2T} = 308,600 + 570,700 \left(1 - \frac{45,000 - 93,000}{70,000}\right) = 308,600 - 257,600 = 54,000 \text{ cfs.}$$

$$\text{Elev. 191 } Q_{p2T} = 308,600 + 570,700 \left(1 - \frac{166,500 - 93,000}{90,000}\right) = 308,600 + 109,700 = 418,300 \text{ cfs.}$$

$$\text{Elev. 137.5 } Q_{p2} = \frac{510,000 \text{ cfs}}{1.5} = 308,600 + 201,400$$

Westfield River & Little River proposed dam at

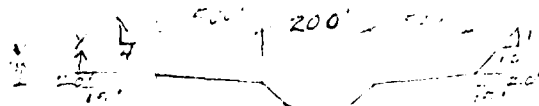
Little River at RR bridge proposed dam at 157.7

Rec'd + written int Springfield Nov 10 7. Atkinson's

$$R \rightarrow a, b \quad \log_2 11 = 193260 \times 10^{-5} = 25.15007 \times 10^{-2} \quad n = 10^4$$

$$\dot{q} = (1.42 \times 10^5) S^{-1} AR^{2/3} = 1.257 AR^{2/3}$$

Valley X-Section:



$$H = 20 \cdot \left(\frac{1}{2} \right)^{3/2} + 20 \cdot (2) + \frac{1}{2} \cdot (10)^2 = 20$$

$$+ 7Y^2 + 1230Y + 10 = Y^2 = 1000 + 1230Y + 7Y^2$$

$$y = 0'; \Delta = 115.75049; \alpha = 16.0''; \gamma = 7.05144 \pm$$

$$Y = 10; R = 254,600 \text{ (5)}; A = 23,70 \text{ (5)}; V = 12; \sigma = 0,46 \text{ (5)}$$

$$Y = 15; \bar{r} = 34\% \text{ } 400 \text{ } 15; A = 35,575; V = 15,000 \text{ } 15,000$$

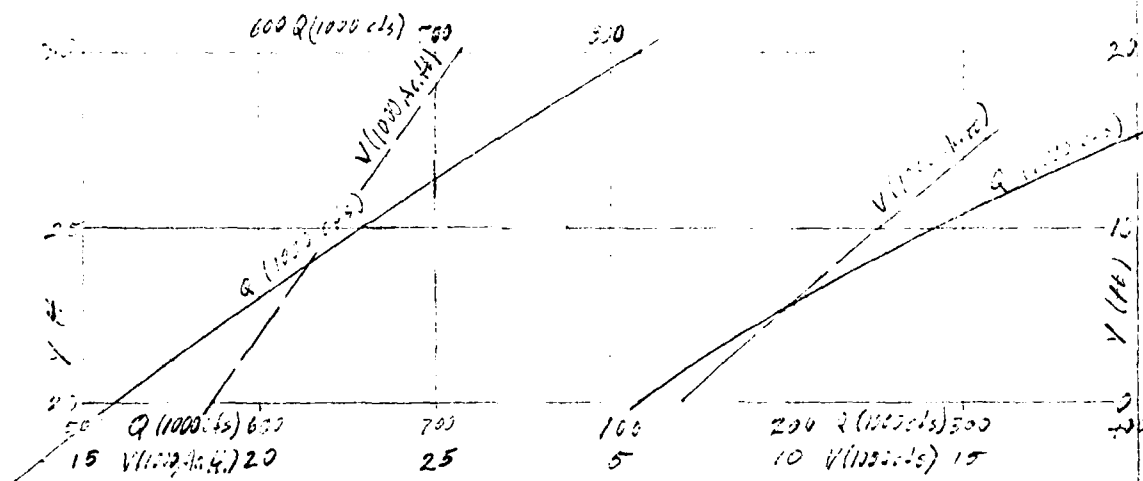
$$Y = 11.2 \quad Q = 503 \quad 602 \quad 4 \quad A = 32 \quad 27^{10} \quad N = 13 \quad 340 \quad 422$$

$$y = 30, \quad y' = 916, \quad y'' = 12,699, \quad y''' = 53,741, \quad y^{(4)} = 25,074,000$$

$$Y = 25 \text{ (in \%)} \quad \text{and} \quad \text{var}(Y) = 50 \text{ (in \%)}^2, \quad \rho = 20 \text{ (in \%)}^2 \text{ (in \%)}^2$$

$$x = 20, \quad G = 510, \quad 200 \cdot 20 \cdot 4 = 160,000, \quad V = 15,000,000$$

$$Y_1 = 17.2; \quad \hat{A} = 39.100 \quad c(5); \quad \hat{A} = 6, 10:5^{(H)}; \quad Y = 2, 430, \dots$$



$$Q_{2T} = 328,601 + 201,400 \left(1 - \frac{13,450 - 13,340}{90,800}\right) = 308,601 + 192,000 = 499,601 \text{ lbs}$$

$$V = 18,100 \text{ Ac. ft.} \quad V_{\text{ave}} = (13,100 + 13,400)/2 = 16,275 \text{ Ac. ft.}$$

$$Q_{F2} = 308,600 + 201,400 \left(1 - \frac{18,275 - 13,340}{90,800}\right) = 308,600 + 133,522 = 442,122 \text{ cfb}; V = 12.5 \text{ A/cf.}$$

$$Q_{\text{NET}} = 39,000 + 171,000(1 - \frac{10,100 - 2,932}{23,500}) = 39,000 + 157,500 = 196,500 \text{ J/g} = 47.5 \text{ kJ/g}$$

$$V = 7,900 \text{ A.C. } \checkmark; \quad I_{\text{ave}} = (750) + 12,100 \checkmark = 9,950 \text{ A.C. } \checkmark$$

$$Q_{0.2} = 39,200 + (71,506(1 - \frac{9950 - 2920}{90,506})) = 39,051 + 17,991 = 155,500 \text{ lbs} = 7.3'$$

DRY FILLER ... 13/17
 REMAINING ...

... 13/17

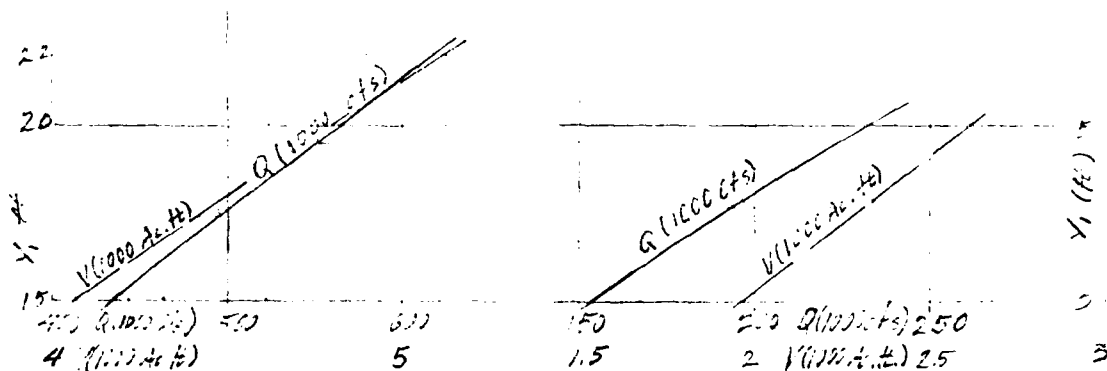
$$Q = 1000 \text{ cfs} \quad A = 2.1 \text{ ft}^2$$

$$V = 1000 \text{ cfs}$$

$$H = 1000 \text{ cfs} \quad A = 2.1 \text{ ft}^2$$

$$+ 2.1 \text{ ft}^2 + 3.1 \text{ ft}^2 = 5.2 \text{ ft}^2 \quad \text{X-section power line east of dam.}$$

$Y_1 = 5.9$; $Q = 53,000$ cfs; $A = 1,000$ ft²; $V = 53$ ft/s
 $Y = 5$; $Q = 100,000$ cfs; $A = 2.1$ ft²; $V = 47,619$ ft/s
 $Y = 2$; $Q = 313,000$ cfs; $A = 27.1$ ft²; $V = 11,550$ ft/s
 $Y_1 = 5$; $Q = 153,400$ cfs; $A = 15,713$ ft²; $V = 9,763$ ft/s
 $Y_1 = 10$; $Q = 323,000$ cfs; $A = 15,710$ ft²; $V = 20,553$ ft/s
 $Y_1 = 5$; $Q = 231,740$ cfs; $A = 14,213$ ft²; $V = 16,299$ ft/s
 $Y_1 = 10$; $Q = 436,500$ cfs; $A = 22,113$ ft²; $V = 19,736$ ft/s
 $Y_1 = 2.4$; $Q = 196,400$ cfs; $A = 12,650$ ft²; $V = 15,525$ ft/s



$$Q_{p27} = 38,000 + 158,000 \left(1 - \frac{2.730 - 9.50}{93,800}\right) = 38,000 + 155,900 = 193,900 \text{ cfs. } Y_1 = 2.7$$

$$V = 2310 \text{ Ac. ft.} \quad V_{avg} = (2310 + 2330)/2 = 2320 \text{ Ac. ft.}$$

$$Q_{p2} = 38,000 + 158,000 \left(1 - \frac{2.720 - 9.50}{93,800}\right) = 38,000 + 155,900 = 193,900 \text{ cfs.}$$

Peak W.S. Elev. at ... 23 + 3 = 26 ft M.S.L.
 Deck at ... 93 ft M.S.L.
 Peak W.S. Elev. at ... 15 + 23 + 3 = 41 ft M.S.L.
 Top of dike at ... 76.2 ft M.S.L.
 Top of conc. wall at ... 76.2 ft M.S.L.

DAN F. 12-25-55

12-25-55 12:15 PM

Design of Memorial Drive Bridge over Spring Creek

Water Velocity

$$A = 1.77 \times 10^4 \text{ ft}^2$$

$$S = 0.0001 = 0.0022$$

$$n = 0.025$$

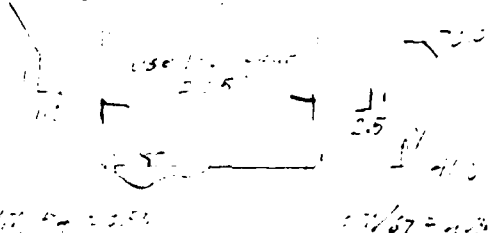
$$Q = (1.486/n) S^{2/3} A^{2/3} = 2.795 \times 10^3 \text{ cfs}$$

$$V = 11.45 \text{ ft/sec}; Q = 30,000 \text{ cfs}; A = 2,700 \text{ ft}^2$$

$$V = 31.07 \text{ ft/sec}; Q = 143,000 \text{ cfs}; A = 4,600 \text{ ft}^2$$

$$S_{100} = 0.0001$$

$$S_{100} = 0.0001$$



Flood area behind lake

possible inlet of Eastern States Exposition

$$6000' \times 300' = 200 \text{ Ac.}$$

Memorial Drive road surface elevation north of bridge
at River st. = 61.3'

DAM FAILURE

0.00 CABLE MT. JAN 15-17

AT SPRINGFIELD ON CONNECTICUT RIVER

Flow to Lock:

Springfield Lock

Normal flow from lock to river discharge: 39,000 cfs

Normal flow from Connecticut River at Windsor Locks: $\frac{16,000}{54,000 \text{ cfs}}$

Total flow:

After failure peak is reached

17,000

Total flow:

210,000 cfs

Hydraulic Control at Springfield - Long Run in the

Valley X-Section (T/B file # 4545 TQ)

$S = 1/1000$ $n = 0.015$

$$A_1 = 802(21)^{3/4} + 300y + \frac{1}{2}y^2$$

$$= 12,600 + 300y + \frac{1}{2}y^2$$

$$A_2 = 2,600 + 13,600 + 1156 + 1592 \frac{1}{2}y^2 + 300y + \frac{1}{2}y^2$$

$$= 27,356 + 966y + 66y^2$$

NP=

$$Q = (1.486/n) S^{1/2} AR^{2/3} = 2.9293 AR^{2/3}$$

$$y_1 = 20' \quad Q = 270,400 \text{ cfs}$$

$$y_1 = 17' \quad Q = 240,200 \text{ cfs}$$

$$y_1 = 10' \quad Q = 161,200 \text{ cfs}$$

$$y_1 = 14.5' \quad Q = 210,100 \text{ cfs}$$

$$y_1 = 5' \quad Q = 113,500 \text{ cfs}$$

$$y_1 = 1' \quad Q = 80,900 \text{ cfs}$$

$$y_1 = 0' \quad Q = 73,500 \text{ cfs}$$

$$A = 25,013 \text{ ft}^2$$

$$A = 16,700 \text{ ft}^2$$

$$A = 13,400 \text{ ft}^2$$

$$A = 12,600 \text{ ft}^2$$

Elev. = 57.5'

This indicates that hydraulic slope is less than $1/10,000$ at low flows. The skew is 54,200 cfs is not a significant flow.

DAM FAILURE

At S-Hyfield on Connecticut River

Flow to head

Before failure 1917

Cobble Dam spillway test discharge = 38,000 cfs

Ave. flow connected after failure 1917 = 15,000 cfs

Total flow

53,000 cfs

At failure rate as indicated:

Total flow

$\frac{15,000}{53,000}$ cfs

Connecticut River stage - including dam failure

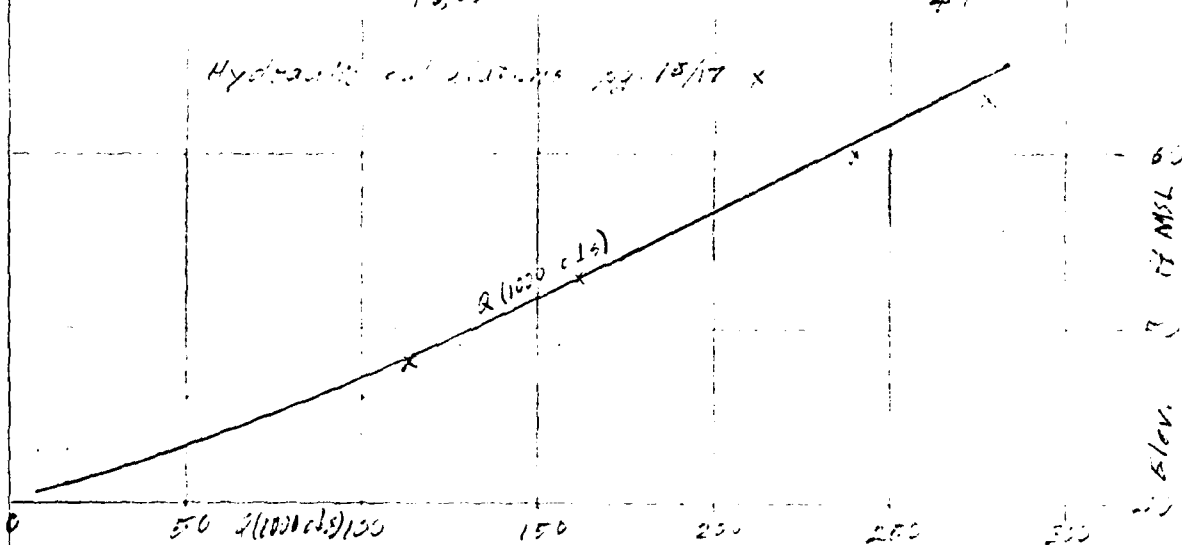
Surface Water Supply and Water Flowing Down

Q	Stage
232,000	11.5
174,000	10.53
156,000	10.01
100,000	7.04
15,000	

Flow

65 feet (100,000 cfs)
54 feet (15,000 cfs)

Hydraulic calculation 1917 x

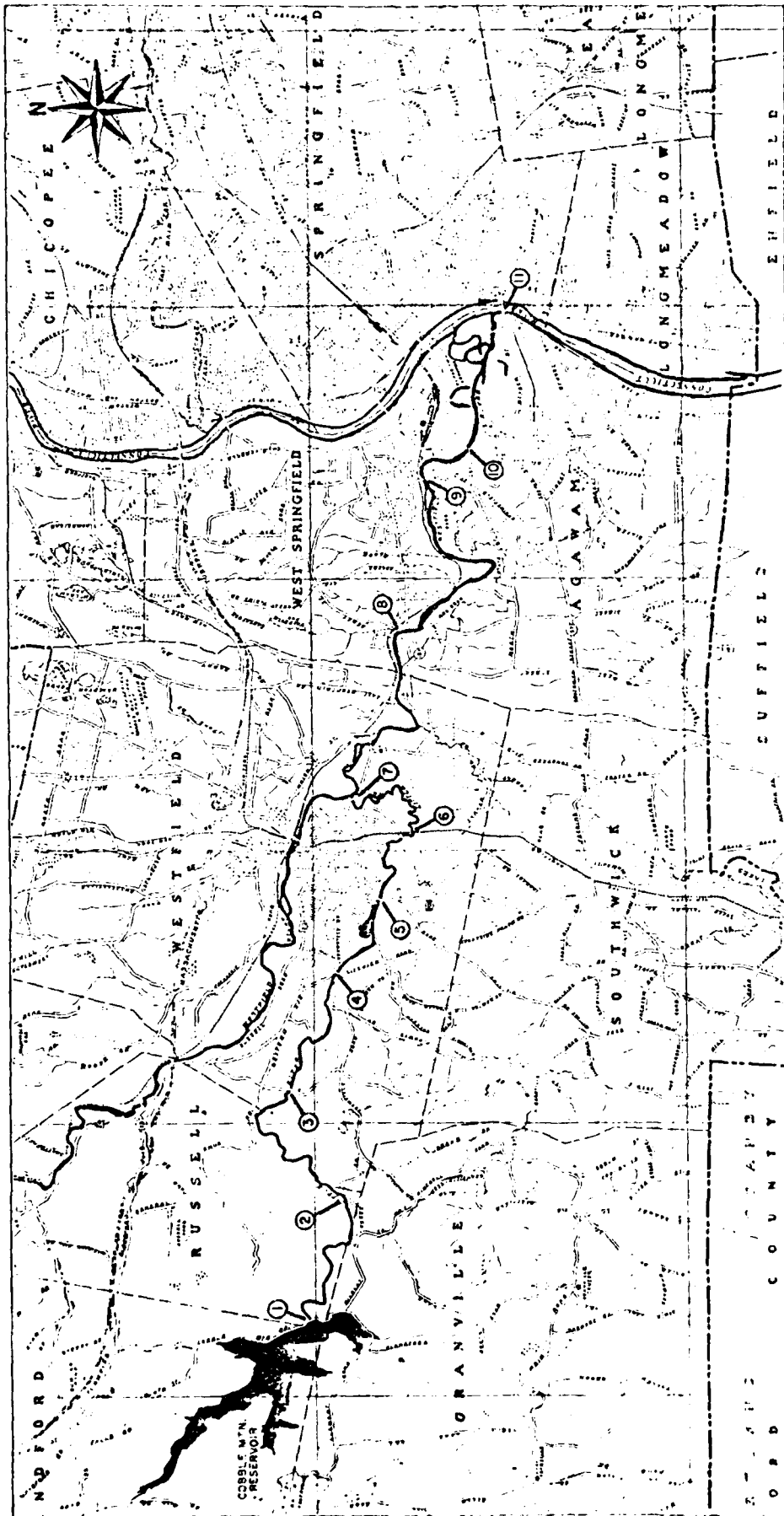


Q = 54,000 cfs Elev = 43.7

Q = 210,000 cfs Elev = 57.7

DOWNSTREAM IMPACTS OF DAM FAILURE

Map Dist. from Dam	Before dam failure Flood stage Elev.	Depth After Flood Stage	After dam failure Flood stage Elev.	Depth After Flood Stage	Comments
1 0 Dam	35,000 19	—	904,000 91	—	
2 10,000 Intake dam	35,000 19	—	904,000 90	70 1	Power station flooded by dam failure
3 31,500 Air Inlet Road	35,000 16	6 2 250 ft.	302,000 38	31 6 400 ft.	
4 44,000 Horseshoe bridge	35,000 7 Elev. 199	3 5 100 ft.	724,000 45 Elev. 237	41 110 400 ft.	Mill at dam damaged by dam failure
5 52,500 Route 202 Bridge	35,000 11 Elev. 164	—	674,000 41 Elev. 176	12 153 257 ft.	Dam 3 yds. damaged by dam failure
6 53,000 Railroad Bridge	35,000 11 Elev. 149	5 400 ft.	605,000 Elev. 108	24 600 ft.	Concrete dam 20 ft. lower than dam level to City Hall, by failure to 10 ft. from highway.
7 61,000 East Main St.	35,000 Elev. 125	3 800 ft.	216,000 Elev. 157	35 300 ft.	Dam 10 ft. lower than failure floods to 10 ft. from
8 5,700 Dewey St.	35,000 20	3 12	194,000 35	15 30	
9 110,200 Front St.	35,000 14	—	194,000 26	—	
10 116,000 Apawamut	35,000 11	—	194,000 31	11 210	Failure flood is 2 ft. above flood dike
11 124,000 South End Bridge	35,000 Elev. 94	—	212,000 Elev. 56	—	Failure flood is 10 ft. above flood dike



TIGHE & BOND / S.C.I.
CONSULTING ENGINEERS
125 WASHINGTON ST., SUITE 200
SPRINGFIELD, MASS. 01103

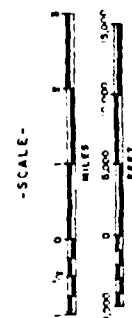
U.S. ARMY ENGINEER DIVISION
CORPS OF ENGINEERS
WASHINGTON, D.C. 20315

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION AND DOWNSTREAM HAZARD MAP

COBBLE MOUNTAIN RESERVOIR DAM (MA 00068) RUSSELL
HAMPSHIRE COUNTY MASSACHUSETTS

SCALE AS NOTED
DATE MARCH 1980



FROM GENERAL HIGHWAY MAP,
HAMPSHIRE COUNTY

- | | |
|----------------------------------|---|
| ① : COBBLE MTH. RESERVOIR DAM | ⑦ : 69,000' D.S. EAST MAIN ST., RTE. 20 |
| ② : 14,600' D.S. INTAKE DAM | ⑧ : 88,700' D.S. DEWEY STREET |
| ③ : 31,500' D.S. NORTHWEST ROAD | ⑨ : 110,200' D.S. FRONT STREET |
| ④ : 44,100' D.S. NORTON'S BRIDGE | ⑩ : 116,000' D.S. AGAWAM BRIDGE |
| ⑤ : 52,000' D.S. ROUTE U.S. 202 | ⑪ : 129,000' D.S. SOUTH END BRIDGE |
| ⑥ : 53,600' D.S. RAILROAD BRIDGE | |

APPENDIX E

INFORMATION AS CONTAINED IN THE
NATIONAL INVENTORY OF DAMS



INVENTORY OF DAMS IN THE UNITED STATES

STATE	DIVISION	CONGR DIST	CONGR COUNTY	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE
MA	2	13	01	CORBLE MOUNTAIN RESERVOIR DAM	42° 07.6	72° 53.6	15 NOV 79

POPULAR NAME	NAME OF FOUNDMENT
	CORBLE MOUNTAIN RESERVOIR

REACH BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	POPULATION
01	LITTLE RIVER	WESTFIELD	35000

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FEET)	HYDRAULIC HEIGHT (FEET)	MAXIMUM FLOODING CAPACITY (ACRES)	MAXIMUM FLOODING CAPACITY (CFS)	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	POPULATION
WUG	1931	5	267	250	90000	70000	WESTFIELD	35000

REMARKS
DO 1070 PIELING ADY

SPILLWAY	MAXIMUM OVERFLOW (CFS)	VOLUME OF DAM (CY)	POWER CAPACITY (KW)	NAVIGATION LOCKS
730	135	20000	33.0	33.0

OWNER	ENGINEERING BY	CONSTRUCTION BY
SPRINGFIELD WATER DEPT	HAZEN & WHIPPLE	CITY OF SPRINGFIELD

DESIGN	REGULATORY AGENCY	OPERATION	MAINTENANCE

INSPECTION BY	INSPECTION DATE	AUTHORITY FOR INSPECTION
1304 & BOND DIV SCT	15 NOV 79	PUBLIC LAW 92-367

REMARKS
DO 1070 PIELING ADY

DO 1070 PIELING ADY

ATE
MED