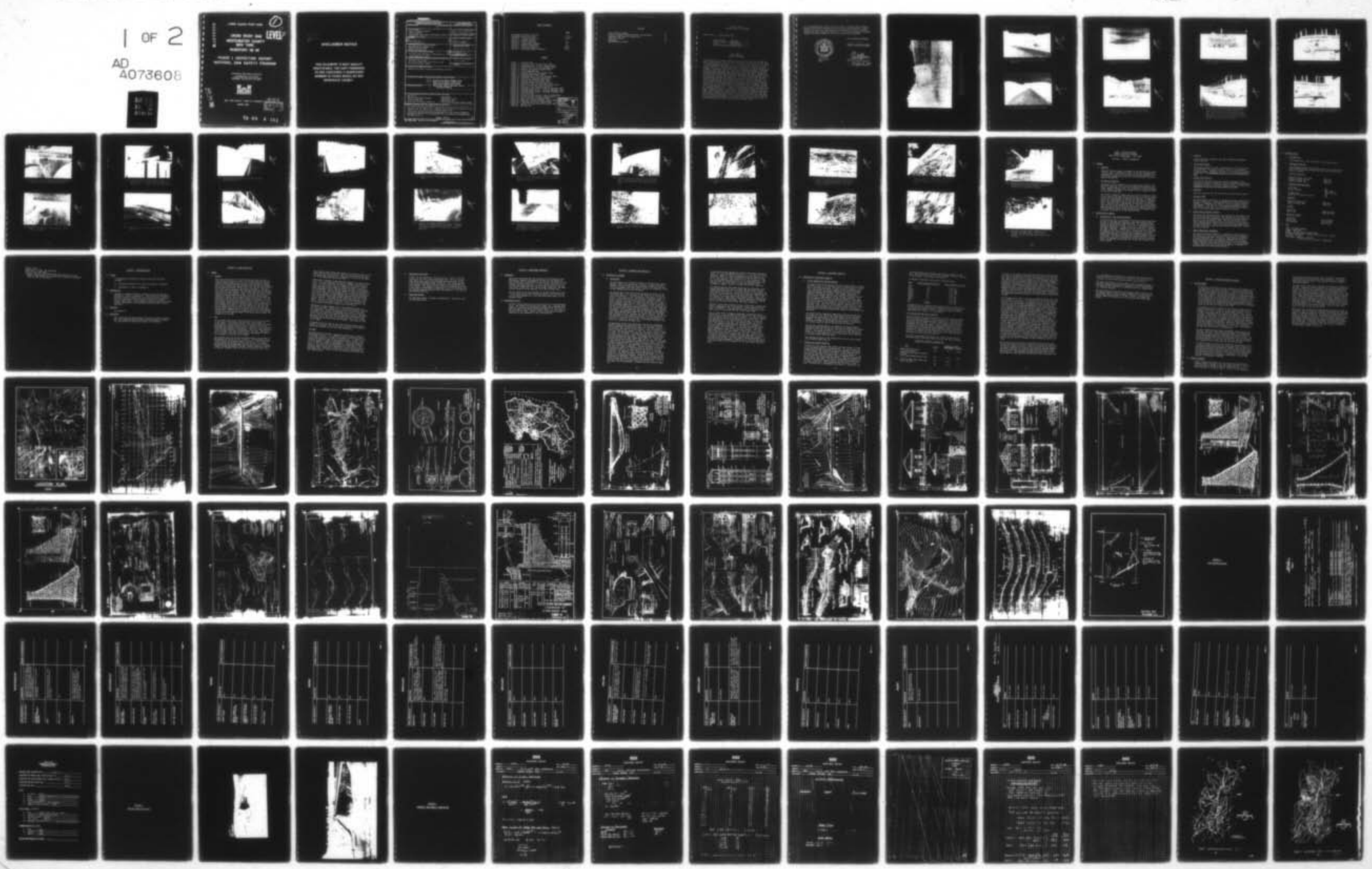
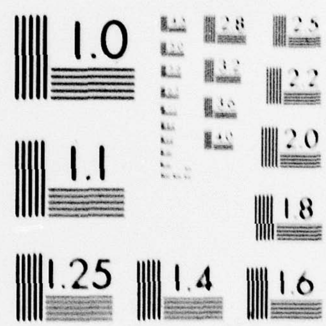
AD-A073 608 NEW YORK STATE DEPT OF ENVIRONMENTAL CONSERVATION ALBANY F/G 13/2
NATIONAL DAM SAFETY PROGRAM. CROSS RIVER DAM (ID NUMBER NY38), --ETC(U)
SEP 78 J B STETSON DACW51-78-C-0035

UNCLASSIFIED NL

1 OF 2
AD
A073608





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

LOWER HUDSON RIVER BASIN

CROSS RIVER DAM
WESTCHESTER COUNTY
NEW YORK
INVENTORY Nº 38

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED

CONTRACT NO. DACW 51-78-C-0035

NEW YORK DISTRICT CORPS OF ENGINEERS

AUGUST 1978

DISCLAIMER NOTICE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)

Phase I Inspection Report
Cross River Dam
Lower Hudson River Basin, Westchester County, N.Y.
Inventory No. NY 38

5. TYPE OF REPORT & PERIOD COVERED

Phase I Inspection Report
National Dam Safety Program

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

(10) John B. Stetson

8. CONTRACT OR GRANT NUMBER(s)

(15) DACW-51-78-C-0035

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Dale Engineering Company, Inc.
Bankers Trust Building
Utica, New York 13501

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

(12) 129 p.

11. CONTROLLING OFFICE NAME AND ADDRESS

New York State Department of Environmental Conservation/ 50 Wolf Road
Albany, New York 12233

12. REPORT DATE

(11) 19 September 1978

13. NUMBER OF PAGES

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

Department of the Army
26 Federal Plaza/ New York District, CofE
New York, New York 10007

15. SECURITY CLASS. (of this report)

UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; Distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

(6) **National Dam Safety Program. Cross River Dam (ID Number NY38), Lower Hudson River Basin, Cross River, Westchester County, New York. Phase I Inspection Report.**

18. SUPPLEMENTARY NOTES

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

Dam Safety	Cross River
National Dam Safety Program	Westchester County
Visual Inspection	Cross River Dam
Hydrology, Structural Stability	City of New York Water Supply System

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

This report provides information and analysis on the physical condition of the dam as of the report date. Information and analysis are based on visual inspection of the dam by the performing organization.

Cross River Dam has significant deterioration of the concrete structure, spalling of concrete on the downstream face, and leaks in the masonry dam and gate valve.

393 970

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

TABLE OF CONTENTS

FIGURES

APPENDIX

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam Cross River NY38

State Located New York
County Located Westchester
Stream Cross River
Date of Inspection July 27, 1978

ASSESSMENT OF GENERAL CONDITIONS

Cross River Dam is a large cyclopean masonry gravity dam built in 1906 as a water supply reservoir for the City of New York. On the basis of this Phase I visual examination and analysis, it is concluded that the dam is in need of a more thorough and detailed investigative evaluation. After 70 years of service, this dam is severely showing its age and its structural integrity is somewhat in question. The structure has not undergone any major improvement or repair since 1906 other than replacement of the stilling basin and pump house which were damaged by the storm of October 15-18, 1955. Substantial cracking (the source of which should be determined) has occurred near the top of the dam in a storage room (bastion). This area is within the dam above the waterline and under the roadway that goes over the dam. The concrete surface of the dam has deteriorated significantly in many locations. A number of lengthy surface cracks have been located. Wetness on the downstream surface (the source of which should be determined) is in evidence. Seepage into the valve pit below the dam has been noted as well as possible seepage on the south abutment area. Large calcified seepage deposits have been found on the downstream surface. In addition, the hydrologic analysis indicates that the dam's spillway is not capable of passing the Probable Maximum Flood (PMF). The spillway is currently capable of passing 88 percent of the PMF. The stability computation indicates an unsatisfactory factor of safety when uplift forces are considered. The spillway flood stage from the 1/2 PMF may also be of sufficient height to add enough pressure on the bastion wall to cause collapsing of the wall and failure of the road above.

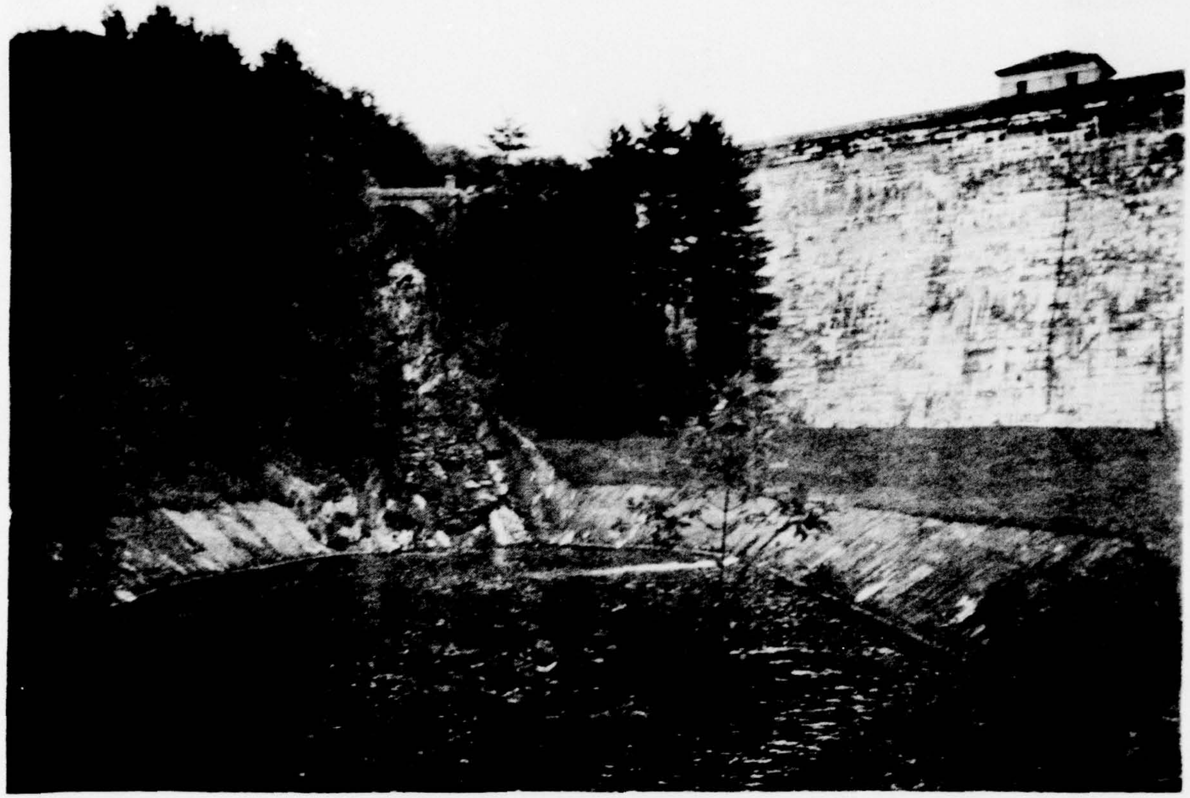
It is recommended that further studies be made to determine the structural integrity of the dam. Non-destructive testing of the dam section is recommended as well as field investigations and engineering studies to further evaluate the dam's structural stability. The bastion area should be properly repaired to provide safety for use of the road on top of the dam.

Dale Engineering Company

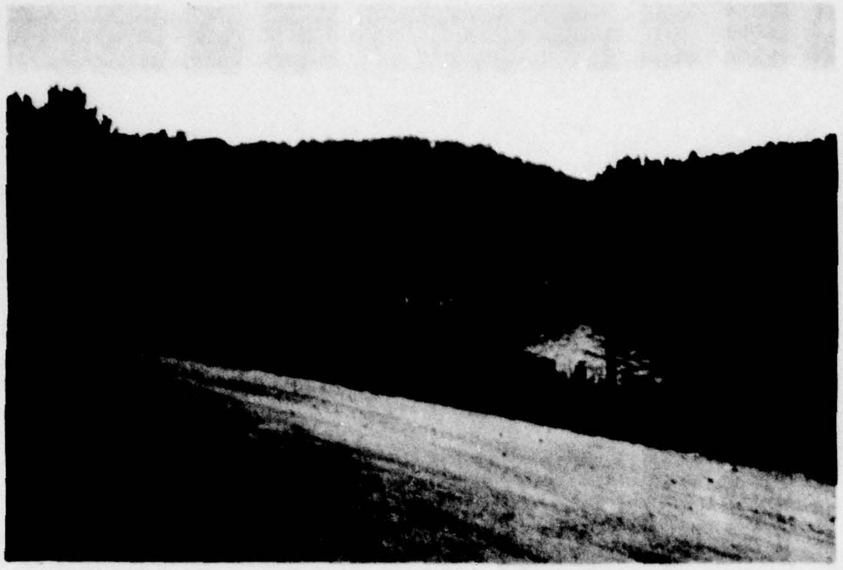
John B. Stetson, President

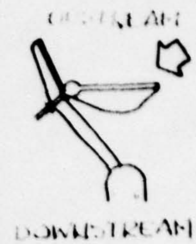
Approved By:
Date:

Col. Clark H. Benn
New York District Engineer
19 September 1978

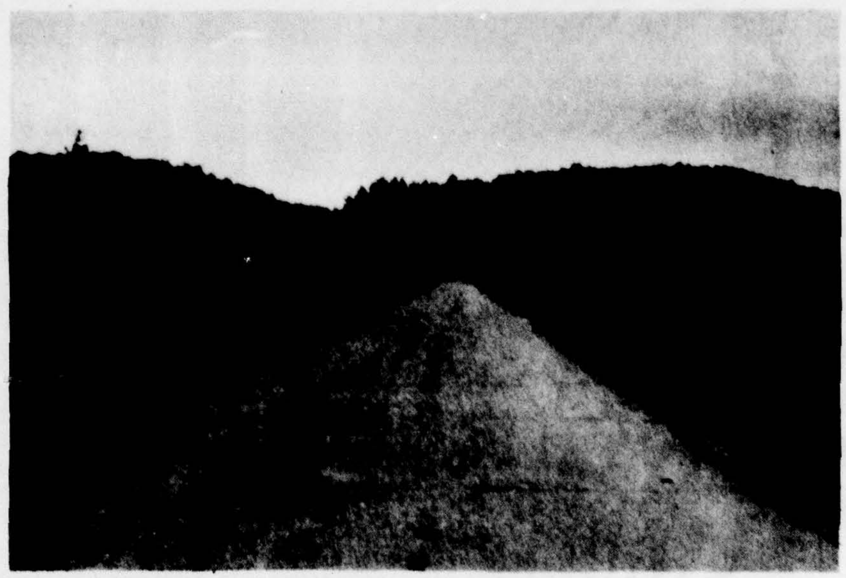


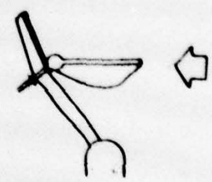
Overview of dam showing concrete block faced cyclopean masonry structure constructed in 1906. Side channel rock spillway is founded on north abutment.



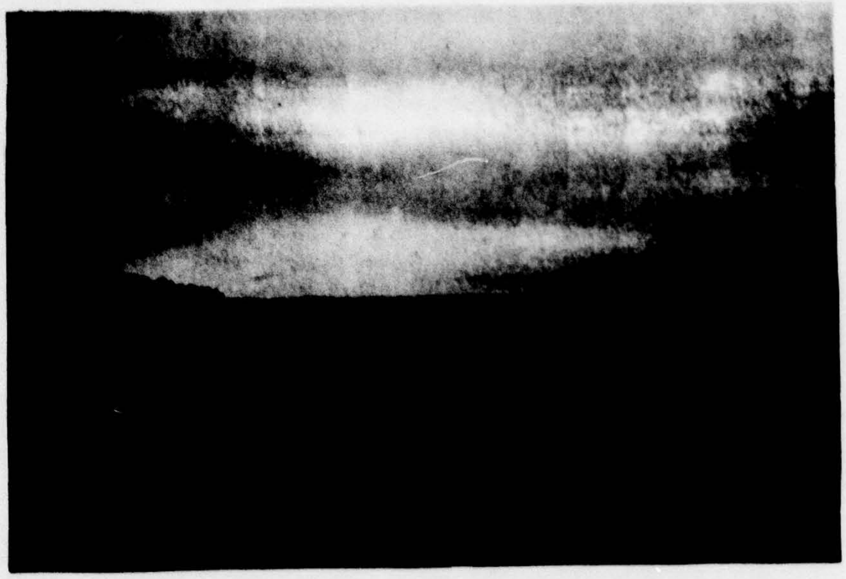


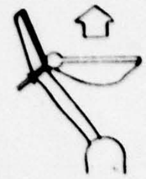
1. View across face of dam from south abutment.



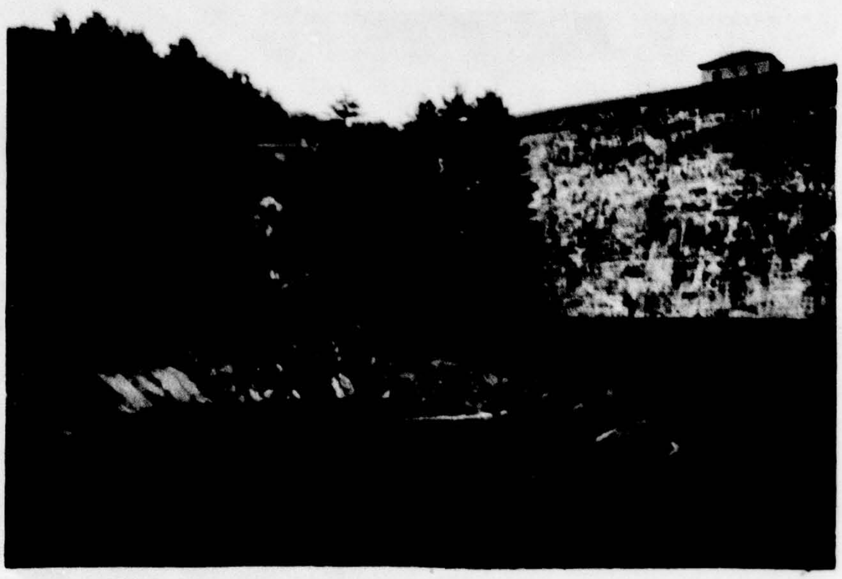


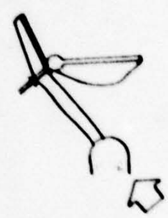
2. View of road across top of dam.



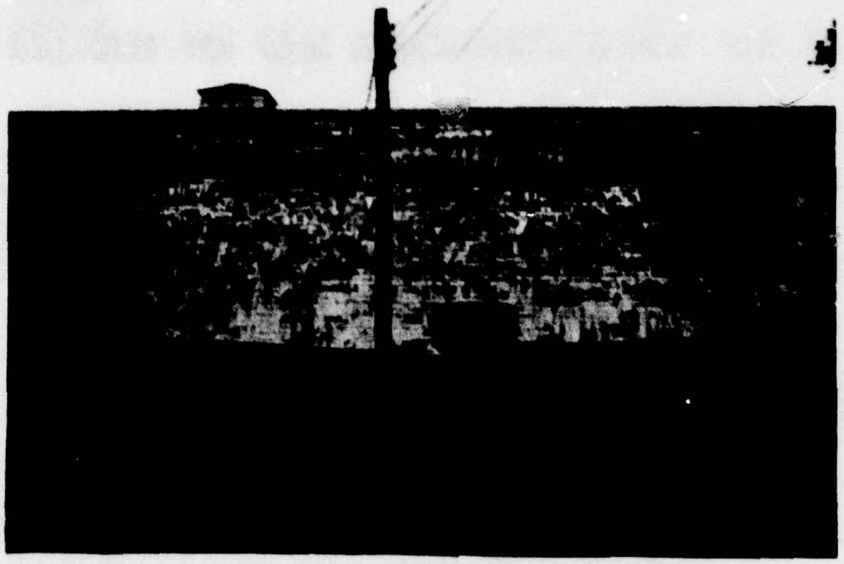


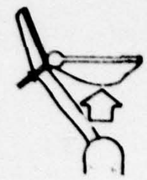
3. View of reservoir and upstream runoff terrain.



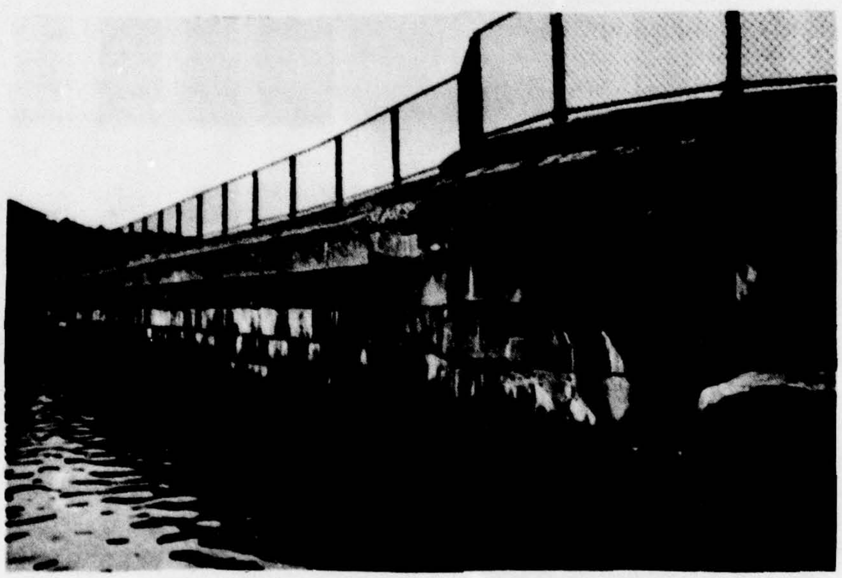


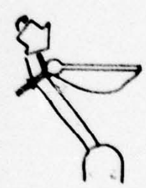
4. Overview photo again. Stilling basin in foreground constructed after flood of October, 1955.



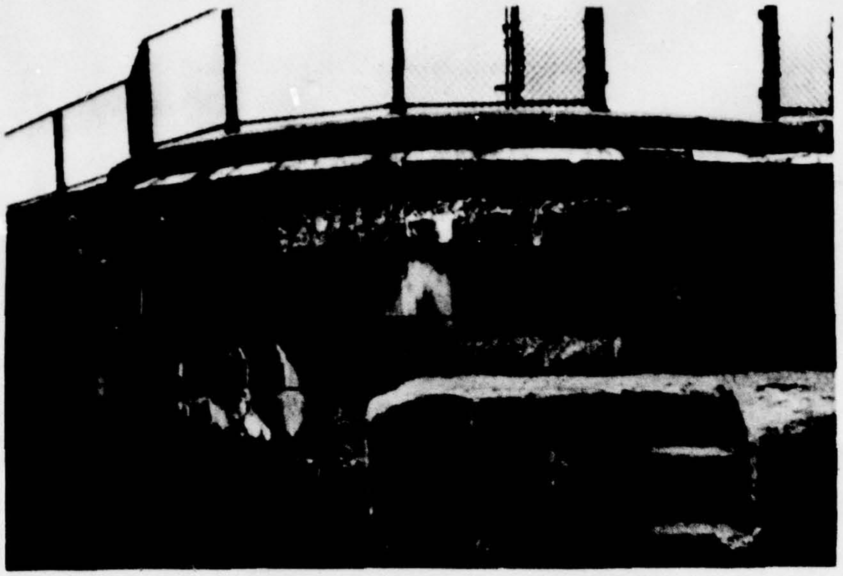


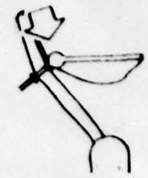
5. View of center section of downstream face of dam.



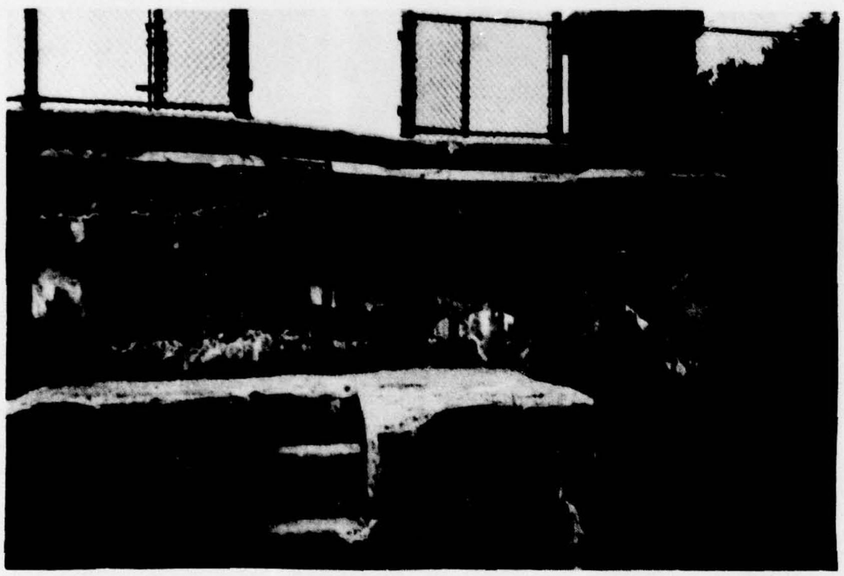


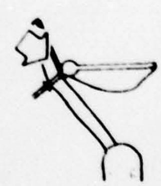
6. View across front of dam from spillway weir location. Circular portion of structure contains bastion room within dam. Floor of room is 0.66 feet above spillway. Room previously used to store flashboards which are no longer in use. Notice cracks in bastion area.



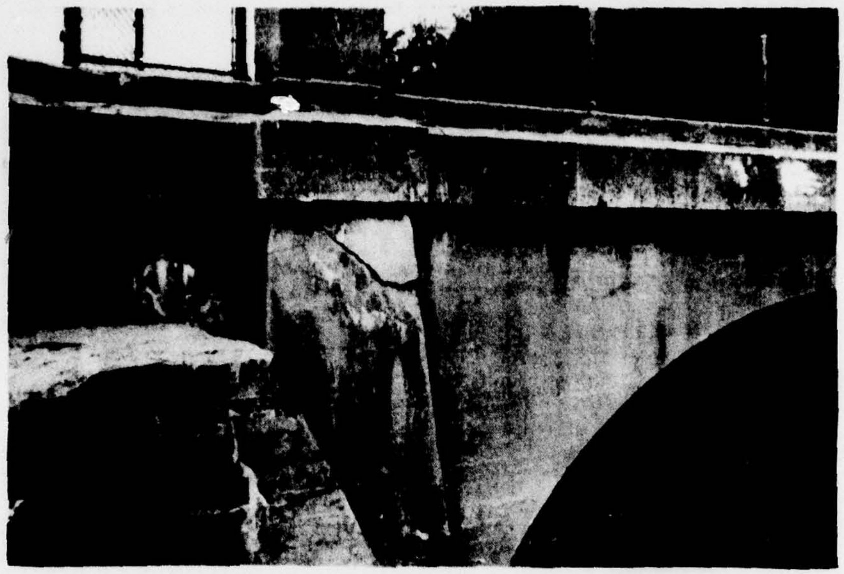


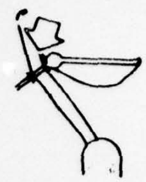
7. View of bastion area. Notice severe cracks.



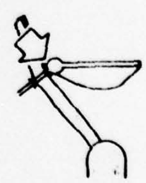


8. Closeup of bastion's right side showing extensive fracture of non-reinforced concrete wall sections.

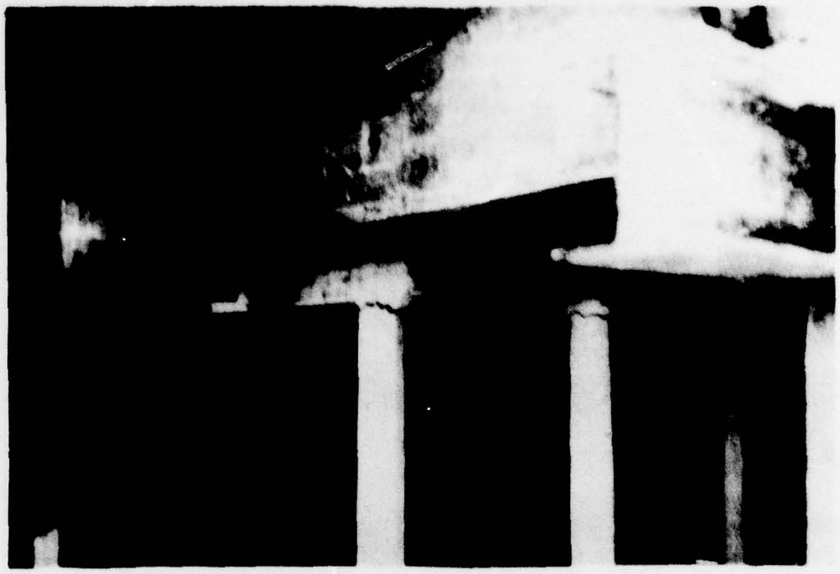




9. Detail of bridge abutment wall showing in right portion of picture No. 8.

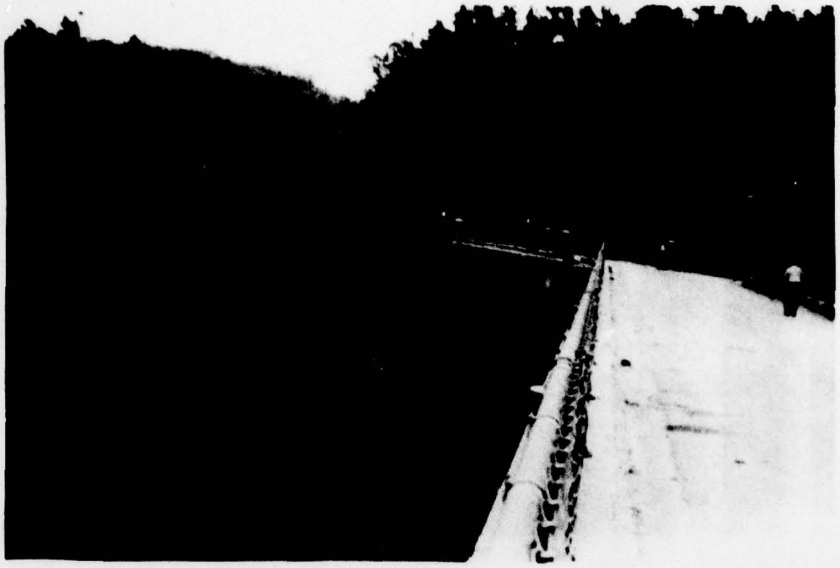


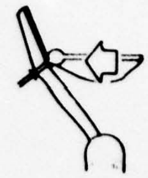
10. Detail of fracture in picture No. 8 to right of ladder.



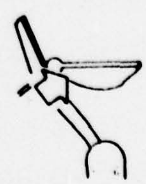
11. Picture taken through window shown in picture No. 8. Notice all columns are sheared off. Columns are non-reinforced.

12. Road surface and repaired curb area above bastion.

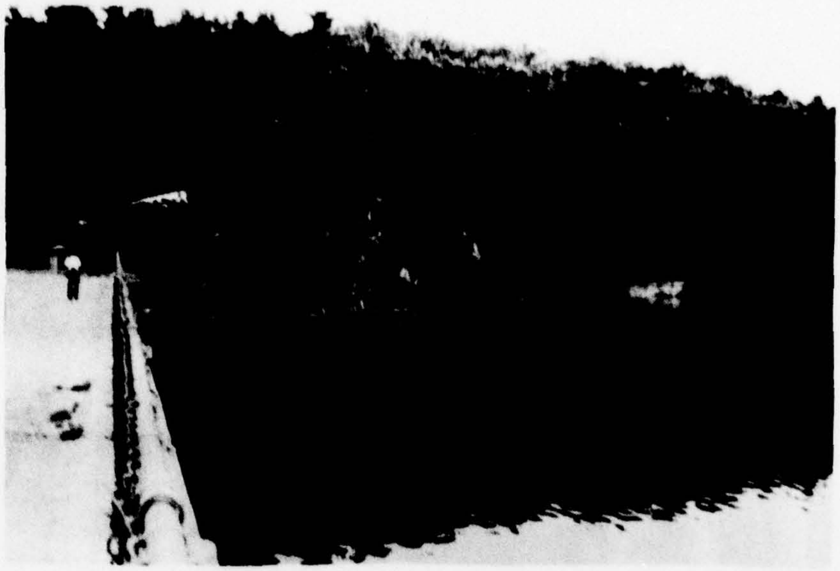


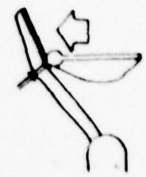


13. View across dam and of spillway bridge near bastion area.

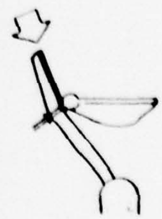


14. Detail of spalling of concrete facing on south side of downstream face of dam.

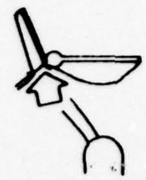




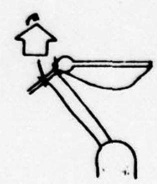
15. View of side channel spillway weir.



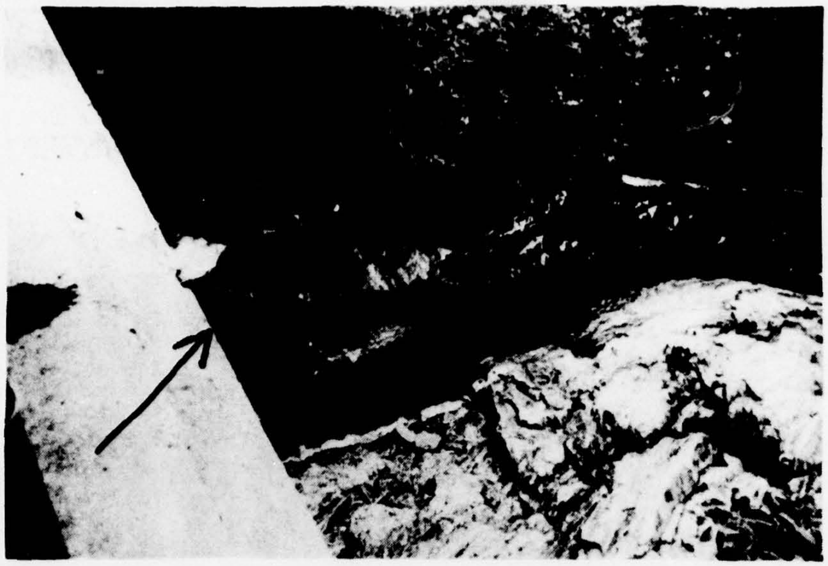
16. View down spillway side channel.

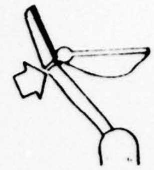


17. View at face of spillway weir founded on rock.

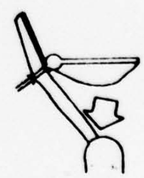


18. Detail of seepage under spillway concrete through the weathered rock joint. Seepage noted at a number of locations in spillway weir.

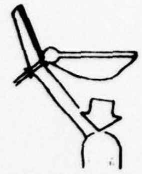




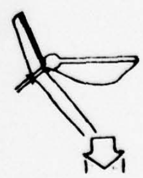
19. Detail of spillway side wall below bridge. Notice cavity in sidewall due to high discharge pressures.



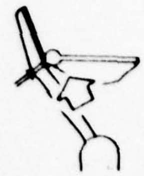
20. **Flow from reservoir in stilling basin and Croton Water Supply reservoir. Notice stilling basin slab construction joint has heaved 4 - 6 inches.**



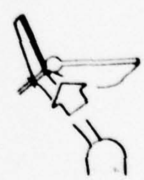
21. Seepage from wall in valve pit behind dam. Seepage discharges into stilling basin in picture No. 20 through small pipe.



22. Stream channel downstream of stilling basin.

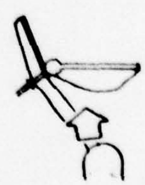


23. Downstream face of dam at north abutment.

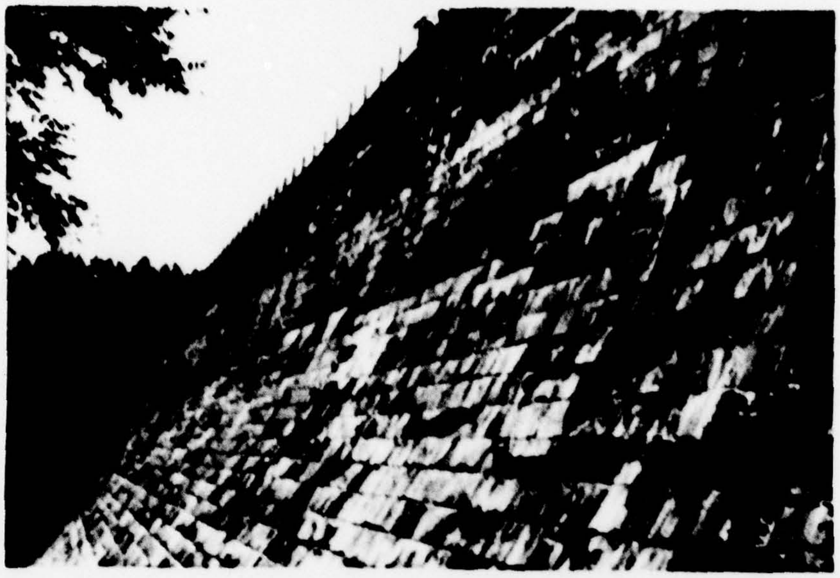


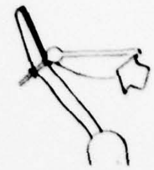
24. Detail of spalling on face of dam.

25. View of extensive spalling and surface crack on downstream face of dam above location of north abutment toe and valley section.

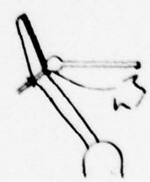


26. View of same area from a distance.

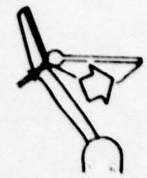




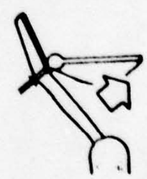
27. View of spalling and surface cracks on downstream face of dam above location of south abutment toe and valley section.



28. Detail of extensive calcium depositions found at numerous locations on downstream face of dam.



29. Heavy grassed area in center of picture between face of dam and tree line is location of suspected seepage.



30. Closeup of same area. Notice fern plants and other heavy vegetative growth. Area very wet with some minor erosion.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM - CROSS RIVER ID# - NY38

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority

Authority for this report is provided by the National Dam Inspection Act, Public Law 92-367 of 1972. It has been prepared in accordance with a contract for professional services between Dale Engineering Company and The New York State Department of Environmental Conservation.

b. Purpose of Inspection

The purpose of this inspection is to evaluate the structural and hydraulic condition of the Cross River Dam and appurtenant structures, owned by New York City, and to determine if the dam constitutes a hazard to human life or property and to transmit findings to the State of New York.

This Phase I inspection report does not relieve an owner or operator of a dam of the legal duties, obligations or liabilities associated with the ownership or operation of the dam. In addition, due to the limited scope of services for these Phase I investigations, the investigators had to rely upon the data furnished to them. Therefore, this investigation is limited to visual inspection, review of data prepared by others, and simplified hydrologic, hydraulic and structural stability evaluations where appropriate. The investigators do not assume responsibility for defects or deficiencies in the dam or in the data provided.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances

The Cross River Dam is constructed of cyclopean masonry and faced on both its upstream and downstream sides with concrete blocks. The dam is approximately 1,226 feet long. The greatest depth of foundation below the river bed is 37.7 feet. The height is 170 feet above foundation. Length at the top is 986 feet. Length of spillway is 240 feet. Thickness at the top of the dam is 23 feet. Thickness at the base is 116.3 feet. The spillway is situated on the northwest end of the structure and discharges into a side channel spillway which discharges down a bedrock channel into the Cross River. The dam and spillway are founded entirely on rock. Two 48-inch iron pipes, provided with valves, located in the gate house, are embedded in the lower part of the dam to control the flow of water.

b. Location

Cross River Dam is located in the Town of Bedford, Westchester County, New York.

c. Size Classification

The maximum height of the dam is approximately 133 feet above the old river bed. The storage volume of the dam is approximately 41,000 acre feet. Therefore, the dam is in the large size category as defined by the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification

Cross River, the receiving stream from the impoundment flows through the Village of Katonah, a sizeable residential development. Therefore, the dam is in the high hazard category as defined by the Recommended Guidelines for Safety Inspection of Dams.

e. Ownership

The dam is owned by The City of New York, Bureau of Water Supply.

f. Purpose of Dam

The dam presently functions as a standby water supply reservoir for the City of New York. During periods when flow from the Delaware Aqueduct is inadequate, the reservoir is used to augment flows to meet demands. Flow from the Croton System supplements the water supply going to the City. It is reported that the Croton System is used in this manner approximately 2 months of the year.

g. Design and Construction History

The Cross River Dam and Reservoir was designed by the Aqueduct Commission of the City of New York. The contract for construction of the Cross River Dam was awarded on June 20, 1905 and the reservoir was put in service on May 1, 1908. The flood of October 15-18, 1955, caused extensive damage to the stilling basin at the bottom of the spillway chute. This stilling basin was subsequently reconstructed along with a pumping station which has been built close to the toe of the dam.

h. Normal Operational Procedures

The Cross River Dam and Reservoir is operated by the Bureau of Water Supply of the City of New York with Croton Division headquarters in Katonah, New York. The dam is under constant surveilance by Bureau personnel and is periodically inspected by the City. Normal operation consists of adjusting the flow in the discharge lines to maintain a full head at the spillway. During high demand periods, the pump station at the base of the dam is operated to discharge water into the Delaware Aqueduct.

1.3 PERTINENT DATA

a. Drainage Area

The drainage area of the Cross River is 28.4 square miles.

b. Discharge at Dam Site

Flow discharge records are available at this site in the form of daily 9:00 AM spillway readings available from Croton Division Office in Katonah.

Computed Discharges:

Ungated spillway, top of dam	25273 cfs
Ungated spillway, 1/2 PMF	13516 cfs
Ungated spillway, PMF	28532 cfs

c. Elevation (feet above MSL)

Top of dam	340
Design discharge	340.5 (PMF)
	336.5 (1/2 PMF)
Spillway crest	330
Stream bed at centerline of dam	210

d. Reservoir

Length of maximum pool	22500 feet
Length of normal pool	17000 feet

e. Storage

Top of dam	39700 acre feet
Normal pool	32000 acre feet

f. Reservoir Surface

Top of dam	Not estimated
Maximum pool	Not estimated
Spillway pool	899.2 acres

g. Dam

Type - Cyclopean masonry.
Length - 1226 feet.
Height - 105 feet above finished grade.
Freeboard between normal reservoir and top of dam - 10 feet.
Top width - 23 feet.
Side slopes - Vertical - upstream.
1/2 horizontal to 1 vertical - downstream.

Zoning - None.
Impervious - No core. Not applicable.
Grout Curtain - Not known.
Spillway - 240 feet side channel ogee weir section into a side channel trough leading to a spillway chute founded on rock which flows into the stilling basin.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The information available for review of the Cross River Dam included:

1) The plans included in this report are Figures 2 through 25.

2) References 2, 3 and 5 in Appendix E.

2.2 CONSTRUCTION

Information regarding the dam's construction was obtained from Reference 2, 3 and 5 in Appendix E. These sources of information provide a narrative description of the salient points relating to the dam's construction and of project milestones of the work process (news items). Limited technical data was obtained in these sources. No detailed field engineering data was found in these references.

2.3 OPERATION

See Section 4.

2.4 EVALUATION

The limited data reviewed indicates the dam was carefully constructed. The information obtained was considered adequate to enable the investigators to perform this Phase I investigation.

SECTION 3 - VISUAL INSPECTION

3.1 SUMMARY

a. General

The visual inspection of Cross River Dam took place on July 27, 1978 and again on August 2, 1978. The second inspection was performed to make further study of areas of concern with Mr. George Koch, Chief of Dam Safety for New York State and Messrs. Anthony Barbero and Jerome Caspe, Administrators for the Dam Safety Program for the New York District of the Corps of Engineers. Over the years, the dam has undergone continued maintenance by the New York City Bureau of Water Supply. Two incidents effecting the dam were reported to the dam inspection team. On October 18, 1955, a flood stage of 4.49 feet above the spillway crest was measured when a significant rainfall event severely eroded the stilling basin and destroyed a pumping station located close to the basin. The discharge from this storm event was estimated to be 3650 cfs. A second incident, which occurred sometime prior to 1965, caused structural damage to the roof of a bastion chamber and upstream wall of the dam above the waterline near the north end of the dam. The bastion chamber was used to store stop planks for the spillway. The structural damage consists of severe cracking of the upstream concrete wall, buckling of the roadway curb on top of the dam and cracking of the columns and beams in the bastion which support the roadway across the dam.

b. Dam

The cyclopean masonry dam visually conforms to the plans provided in the report. The massive structure has a large amount of deterioration of the concrete facing. The bastion area, previously mentioned, has complete fracture of wall sections and interior nonreinforced concrete column elements. Seepage is also suspected along the south abutment. Photographs 1 and 2 are views across the top of the dam. The road is maintained by the Town. Reportedly, salt is spread on the road during winter. Photographs 12 and 13 are close-ups of portions of the roadway.

The concrete facing of the dam has deteriorated as can be seen in Photographs 14, 23, 24, 25, 26, 27 and 28. In Photographs 23 and 24 the surface of the dam was noted to be moist. This condition could be caused by absorbed moisture from rainfall or seepage. Photographs 25 and 26 show where spalling has occured up to eight inches in depth (estimated), forming a surface crack up to the top of the dam. Another crack line occurs on the south side of the dam. Both of these cracks have formed at the quarter points of the downstream face of the dam very near the location where the abutment meets the valley section. Photograph 28 shows calcium deposits on the downstream face of the dam.

Photographs 6 through 11 show extensive damage to the bastion chambers. It is not known what caused this movement and cracking to occur. Possible causes for this damage are frost heave, thermal expansion, creep, pore pressure, foundation movement, reservoir head, vehicular traffic loads and seismic activity. The fracture and displacements seem to indicate expansion along the longitudinal axis of the dam. The bastion area being a circular (relatively) thin walled structure is the weakest point in the dams longitudinal axis and is between the south abutment and the north ends bridge arch. Expansion forces seem to have pushed the front wall of the bastion area out. Fractured column joints show movement to the North. Lateral torsion failures were visible in the roads floor beams. The cause of these fractures is not known, however, the most prevalent explanation appears to be frost heave.

Photograph 21 shows seepage flow in the underground valve pit at the toe of the dam. From this pit a drain pipe discharges into the stilling basin. The outflow location of this pipe is the small pipe shown in the center of Photograph 20 to the left of the construction joint and to the right of the larger reservoir discharge outlet. At the time of the second inspection an excavation had been made next to the valve pit exposing the leak at the surface. The excavation was found to be full of water. The source of flow is not known.

Photographs 29 and 30 show an area near the south abutment where seepage is suspected. At time of second inspection the ground exhibited more wetness than at the first observation.

c. <u>Spillway</u>

The ogee concrete spillway is founded on exposed rock as shown in Photographs 10 and 17. At a number of points, seepage was noted, one of these locations is shown in Photograph 18. It appears to be through the weathered rock at the concrete contact surface. The spillway approach is shown in Photograph 15, while the downstream chute of bedrock is shown in Photograph 4. Photograph 19 shows a cavity in the south side spillway below the bridge which is suspected to have occurred due to weathering of rock and high velocity discharge flows. The new stilling basin, shown in Photograph 21, shows where the left portion of the slab has moved vertically from the right portion.

d. Appurtenant Structures

A minor leak was observed in the valve pit at a joint. This was repaired at the time of the second inspection. The pit area has a leak coming from a pipe sleeve through the concrete wall at the location of the southeast corner of the pit. All valves appeared to be operable with significant discharge coming through the low level outlets. The pumping station, which is located below the dam in the center of Photograph 5, allows the city to divert flows into the Delaware Aqueduct from the Cross River Reservoir. The floor of the pump house was dry.

e. Downstream Channel

The downstream channel is shown in Photograph 22. Below this area lies the Muscoot Dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

Operational procedures were not observed by the inspection team. The dam and reservoir are owned by the New York City Bureau of Water Supply and are maintained by the staff of the Croton Division located in Katonah, New York. It is the staffs responsibility to maintain and operate the facility under the direction of the central office in New York City. During normal conditions, the water surface elevation of the reservoir is at the spillway crest.

Control valves in the valve chamber can either discharge into the stilling basin which flows into Croton Reservoir and to New York via the Croton Aqueduct or to the pump house which pumps into the Delaware system.

4.2 MAINTENANCE OF DAM

The dam is maintained by the Croton Division full-time maintenance staff. The Croton Division Operations Center has a complete staff capable in operation and maintenance engineering for the facility. While the dam is continually maintained, there is no individual at the dam site full-time. There is also no flood warning system in operation (to the knowledge of the investigations).

SECTION 5 - HYDROLOGY AND HYDRAULICS

5.1 EVALUATION OF FEATURES

a. Design Data

For this report, no information relevant to the hydrologic and/or hydraulic design for the dam was available. Analysis provided in Appendix C was performed utilizing information obtained from construction documents and other general sources of information listed in the reference section of this report.

The massive wall of the Cross River Dam spans the valley of the Cross River which is a tributary of the Croton River forming the Cross River Reservoir. The drainage area contributing to the reservoir is 29.8 square miles. The volume of impoundment water is mainly a function of the natural watershed although a number of small reservoirs and ponds lie upstream of the reservoir. The reservoir augments flows into the Croton System through the Muscoot and Croton Dams downstream. For the purpose of this investigation, the dam and spillway were analyzed with respect to their flood control potential and to determine their adequacy under rare flooding conditions. This potential was assessed through the development of the Probable Maximum Flood (PMF) for the watershed and the subsequent routing of the PMF through the reservoir system. The PMF is that hypothetical flow induced by the most critical combination of precipitation, minimum infiltration losses, and concentration of run-off at a specific location, that is considered reasonably possible for a particular drainage area.

The hydrologic analysis was performed using the unit hydrograph method to develop the flood hydrograph. For the dam's location little hydrologic information was found from available studies. At the dam site the floods of record include: storm of October 18, 1955; Hurricane Diane, August 17, 1955, and a prior storm of August 12, 1955. The USGS gage at the dam site recorded 11 inches of rain on October 16, 17 and 18. No information was available to determine the frequency of this event. An isohyetal map of this event was obtained from the Lower Hudson Report [Ref. 7]. Three hour rainfall precipitation data from a gage north of the basin was used to evaluate the unit hydrograph derived for this study. The Bureau of Water Supply measured the spillway discharges that morning at 9:00 AM of October 18. The recording was 4.49 feet of flow, 2.49 feet over the 2-foot flashboards. This was computed to be equal to a discharge of 3650 cfs. Reconstitution of the event yielded a discharge of 6907 cfs into the reservoir and 3282 cfs over the structure. The computed time of peak discharge was at 9:00 AM on October 18. No effort was made to calibrate the model (i.e. loss rates) to the measured discharge. These results indicate the unit hydrograph is reasonable. Additional work on this reconstruction could evaluate the reservoir stage-storage relationship at the beginning of the event, evaluate loss rate functions, etc. It is felt that the unit hydrograph is adequate for this scope of analysis.

In preparing the unit hydrograph, Clark's coefficients were estimated. For the Clark Method, values of Tc = 7.0 and R = 5.30 were computed. Snyder's CT was later checked from the computer program's derivation of Snyder parameters Tpr and Cp and a CT value of 1.75 was computed. This value of CT is very reasonable. The New York District recommends CT of 2.0 for mountainous areas and rolling hills which are typical of the area; whereas Chow recommends a general value of 1.2 [Ref. 10] for this condition.

The Probable Maximum Flood (PMF) hydrograph was determined using Probable Maximum Precipitation rainfall data obtained in Hydrometeorlogical Report No. 51. An index rainfall of 24.0 inches for a 200 square mile area for a period of 24 hours was adopted for the analysis. Both the PMF and 1/2 PMF were evaluated. The 1/2 PMF was assumed to be approximately the Standard Project Flood (SPF) in utilizing the U.S. Army Corps of Engineers Hydrologic Engineering Center's Computer Program UHCOMP. The peak discharge for the PMF was 31,726 cfs and for the 1/2 PMF (SPF) was 16,145 cfs.

Hydraulic studies were performed on the spillway weir assuming weir control (submergence was not evaluated). These computations are shown in Appendix C. Only the 240 foot long spillway was considered active in routing the PMF and 1/2 PMF (SPF) flows.

The U.S. Army Corps of Engineers Hydrologic Engineering Center's Program HEC-1, using the Modified Puls Method for flood routing was used to evaluate the structure and reservoir. Peak flow discharges were reduced to 28,532 for the PMF and 13,516 for the SPF. The spillway capacity is 25, 273 cfs and the spillway is capable of passing 88 percent of the PMF. The reductions were not significant. The computed stage-discharge relationship in Appendix C indicates that the dam, which is in the large dam classification, may be topped with a PMF event. In addition, the 1/2 PMF (SPF) would discharge 6.6 feet of flow over the spillway. This flow depth would be of sufficient height to flood the bastion chamber putting additional pressure on the wall sections. Based on the concern for failure of a roadway, additional work needs to be done in further investigations at which time the hydrologic analysis work should be refined. This work should include determination of possible spillway submergence, preparation of a new spillway rating curve and evaluation of the capacity of the open channel spillway chute.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations And Data Review

The major portion of the masonry dam and spillway appears to retain structural stability at this time, with no indication of misalignment, significant settlement or other structural movement. However, considerable structural cracking of the concrete elements comprising the bastion chamber constructed as part of the dams northerly abutment has occurred. This chamber immediately underlies the roadway crossing along the top of the dam, and the bastion floor is approximately at the spillway elevation. The dam's downstream face shows a considerable number of areas where surface spalling of the concrete has occurred, and at the time of the field inspection, the surface of various spalled sections was damp and/or wet. Calcified seepage deposits were noted at a few locations. What appears to be a vertical surface cracking of the downstream face was noted near the upper portion of the dam, at approximately the quarter-length points inward at both abutment toe locations.

The ground surface immediately downstream from the dam generally was found to be dry, except for ground wetness noted in an area approximately one-quarter of the dams length from the southerly abutment. Foliage and ground cover in this area is very heavy, defining the extent of the ground surface effected. A section 50 to 100 feet along the face of the dam could be involved.

The concrete spillway bears on a foundation of exposed bedrock. Seepage was observed from the construction joint between the poured concrete and the rock foundation. The spillway chute consists of bedrock. No seepage was noted to be occurring at the end section of the dam (in and adjacent to the spillway chute) which underlies the storage chamber mentioned above.

Some leakage was noted in the below-ground valve pit area located just below the downstream toe.

b. Geology and Seismic Stability

The New York State Geologic Map (1970) indicates the dam is sited in an area whose bedrock is Fordham Gneiss. The gneiss crops out beneath the spillway, along the valley wall opposite to and north of the spillway, and comprises the whole of the downstream channel bed from the spillway to the pool below. Foliation generally strikes east-west and dips steeply, 60 to 90 degrees north. A number of small, very tight folds are present. Some minor amounts of garnet grains were noted. The biotite, hornblende and amphibolite portions of the gneiss weather readily and may yield rotted zones or seams in the rock. Such weathered zones were noted in the area. Permeability of unweathered sound gneiss is relatively low.

The State Geologic map indicates several faults present in the area. None are known to exist in the immediate vicinity of the dam or the spillway. See Geologic Map Figure 26.

Earthquakes recorded for the area are tabulated below:

Date	Intensity-Modified Mercalli	Location Relative to Dam
1885	III	6 mi. W
1937	II	8 mi. SW
1938-1	III	5 mi. SSW
1938-2	III	5 mi. SSW
1938-3	II	6 mi. S
1964-1	II	5 mi. SW
1964-2	II	5 mi. SW
1964-3	V	5 mi. SW
1967	V	8 mi. SW
1972	unknown	8 mi. SW

Although this area is designated as being in Zone 1 of the Seismic Probability Map, the New York State Geological Survey believes this area should be upgraded to Zone 2. Convention assumes no earthquake hazard for a Zone 1 or 2 designation.

c. Data Review and Stability Evaluation

Design drawings applicable to stability evaluations made available for this study are limited to dam cross-sections. Soil/rock properties and upstream/downstream water conditions utilized for the dam design are not known. As part of the present study, stability evaluations have been performed. Actual properties of the sites foundation soils and rock and the groundwater conditions in the area have not been determined; where data was lacking, simplifying conservative assumptions have been applied. The conditions for a reservoir at spillway elevation with ice, and for flow overtopping the dam by one foot, have been studied.

The analysis performed (See Appendix D) indicate unsatisfactory stability against overturning and sliding for the forces assumed.

RESULTS OF STABILITY COMPUTATIONS

	CASE	UPLIFT	FACTORS OF SAFETY OVERTURNING	FACTORS OF SAFETY SLIDING
I.	Water level and ice at spillway elevation, downstream subsurface at ground surface,	YES	1.2	0.88
	uplift acts beneath base of dam.	NO	2.9	1.60
II.	Stability where water level tops dam by one foot.	YES	1.06	---
		NO	2.40	---

Critical to the analysis and resulting indication of stability are the items of uplift water pressures acting on the base of the dam and relative permeabilities of the sites foundation soil and rock. The analysis uplift force was based on a full headwater hydrostatic pressure acting on the dams upstream corner and a full tailwater hydrostatic pressure (for the condition of a water surface at the elevation of the downstream ground surface) acting at the dams downstream corner. Uplift pressures were assumed to vary linearly between the dams upstream and downstream corners, and act upon 100 percent of the dam base. The resulting uplift force represents a condition that is, to the analysis, very significant in arriving at the computed dangerously low factors of safety against overturning/sliding.

The assigned uplift force is felt to be conservative but also could be too great or too small. The prediction of uplift acting on the base of a gravity dam which is supported on rock, without having information on the permeability/seepage properties of the foundation rock stratum and upstream/downstream earth overlying the rock, represents an engineering analysis area of great uncertainty. If the permeability of the rock stratum foundation is very high, the uplift pressure on the dams upstream corner could be less than a hydrostatic pressure computed on the basis of a full headwater elevation. The full headwater hydrostatic pressure is felt to be reasonable where the permeability of the rock foundation is very low compared to the permeability of soil in back of the dam. If the rock is layered and jointed, the uplift computed assuming a linear variation of pressures and a resulting force acting only on an area equal to the dam base could be too low. However, if the rock is very sound and impermeable, seepage would be very low and uplift pressures of significance would require a long period of time to develop. Similarly, within the masonry itself (say near the base of the dam) hydrostatic pressures from permeating headwater potentially causing the same effect as uplift at the base of the dam could require a considerable period of time before reaching a significant magnitude. A conclusion drawn from these latter conditions is that the computed uplift shown in the reports stability analysis may not exist at present and only develop at some future time.

Due to of the critical nature of the uplift force acting on this dam and the related very critical question of structural stability, it would be prudent to perform a field investigation and engineering study as necessary to properly determine the underdam seepage and uplift pressures, and ascertain the resulting effect on the dams stability. The necessary engineering geology field investigation would include subsurface explorations such as borings to obtain undisturbed rock samples and to determine the geologic and engineering character and properties of the rock, and installing instruments for determining seepage gradients and pressures.

The field explorations can also extend to the area where seepage is presently suspected (see section (a) above), to more fully evaluate the condition and if necessary to develop plans for a remedy (such as a grouting program).

The poor structural condition of the storage chamber underlying the dam roadway adjacent to the spillway apparently is not yet having a structurally adverse effect on the dam. Repairs to damaged components should be undertaken, and the area kept under close observation.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

On the basis of the Phase I visual examinations and analysis, it is concluded that the Cross River Dam is in need of a more thorough and detailed investigative evaluation. The cyclopean masonry dam which is approximately 105 feet above grade is a large dam in the high hazard category. The Village of Katonah is located downstream of the dam as well as the Muscoot and New Croton Reservoirs. The facility which was put into service in 1908 is now 70 years old. A visual inspection of the dam indicates the dam is showing its age. It reportedly has not undergone any major improvements or repair since its construction other than replacement work from the damages caused by the storm of October 15-18, 1955.

Considerable structural cracking of the concrete elements has occurred sometime prior to 1965 in an area comprising the bastion chamber. This area is above the normal water elevation. It has not been ascertained what has caused this damage. Frost heave is suspected. Reportedly, the cracks in this portion of the dam have worsened over the years. The Bureau of Water Supply has shored up the interior of the bastion chamber with structural steel members. However, this condition presents a distinct safety hazard to those using the roadway across the dam. Additional reservoir head on the dam acting alone or in combination with other loads could cause failure and collapse of the roadway in this area. Some damage to the dam from this failure is also possible.

The dam's downstream face shows considerable surface spalling of concrete. Vertical cracks are distinguishable at the downstream face quarter prints. Surface wetness has been noted as well as calcified seepage deposits on the downstream face of the dam. The ground surface has been found to be dry except for one area along the south abutment. A leak into the valve pit area was uncovered. Some seepage has been noted under the concrete spillway.

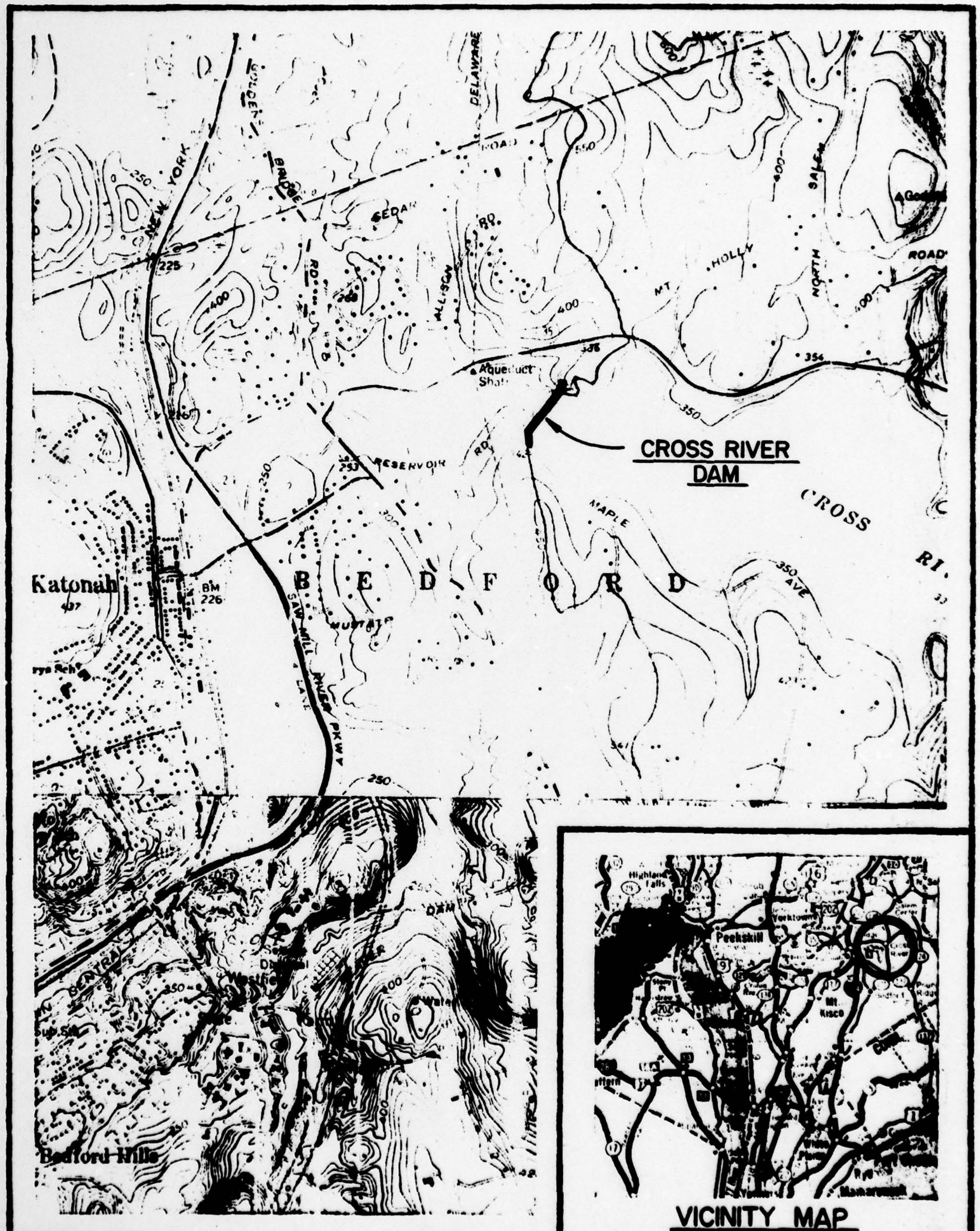
A stability analysis indicates the dam has an unsatisfactory factor of safety against overturning and sliding when uplift forces are considered. Hydrologic and hydraulic analysis indicate the 1/2 PMF discharge would have a sufficient stage to flood the bastion chamber and apply additional lateral load on the structure threatening collapse of the road in that area. The analysis also indicates that the dam would be overtopped by a PMF event. The spillway capacity is 88 percent of the PMF.

7.2 REMEDIAL MEASURES

A more in depth investigation of the dam should be performed to determine whether the dam is safe for normal operations. At this time, more data is needed to make this determination. It is obvious the dam is in need of repair. Repairs to the components of the bastion should be done as soon as possible, and the area should continue to be kept under close observation. The owner should determine the cause of the extensive structural damage in the bastion chamber.

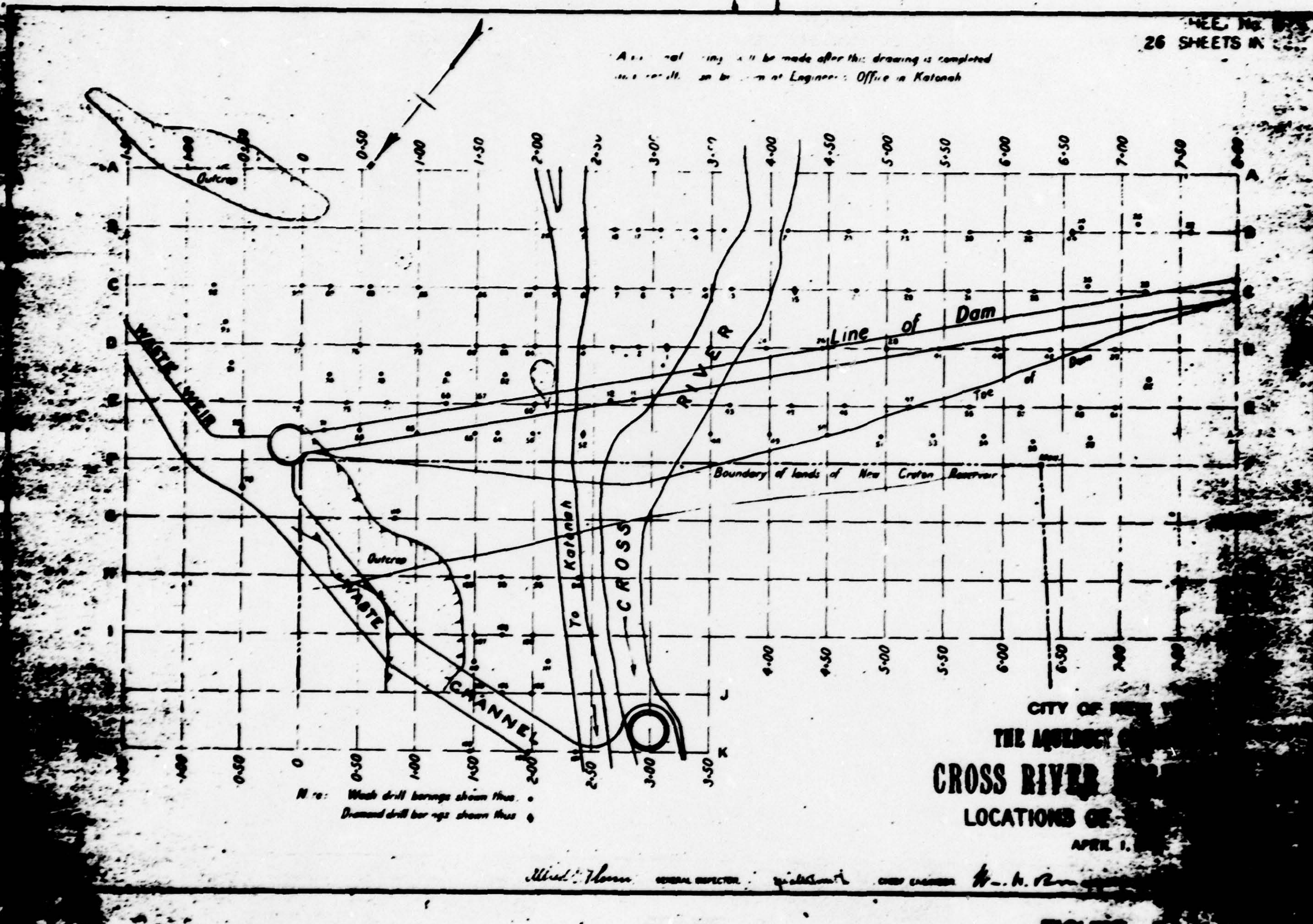
The owner should take steps to evaluate the structural integrity of the dam. A number of testing agencies are currently employing non-destructive testing (NDT) techniques to evaluate concrete structures. Characteristics such as compressive strength, modules of elasticity, voids, honeycombing, cracking, cement matrix loss, and loss of bond between paste and aggregate can be identified from NDT data. These data provide information on possible damage, deterioration, or faulty construction. One NDT method, provided by a division of the Portland Cement Association, called the micro seismic technique, permits concrete members to be inspected from one side only (See Appendix F). It is believed that the structural integity of the dam could be evaluated using NDT. Selective cores would have to be taken as part of this effort.

Additional field investigations and engineering studies related to structural stability should be conducted to determine the cause and extent of underdam seepage and resulting uplift pressures and their effect on the dam's stability. An engineering geology field investigation should be conducted. This investigation should include subsurface explorations, such as borings, to obtain undisturbed rock samples and to determine the geologic and engineering properties of the rock. Instruments should be installed to determine seepage gradients and pressures. The work should be extended to all areas where seepage is suspected.



LOCATION PLAN

FIGURE 1



26 SHEETS IN
Outcrop
Line of Dam
Toe of Dam
RIVER
CROSS
To Katonah
Boundary of lands of New Croton Reservoir
Outcrop
WASTE WEIR
WASTE CHANNEL
Note: Wash drill borings shown thus
Diamond drill borings shown thus
CITY OF
THE AQUEDUCT
CROSS RIVER
LOCATIONS OF
APRIL 1.
GENERAL INSPECTOR
CHIEF ENGINEER

FIGURE 2

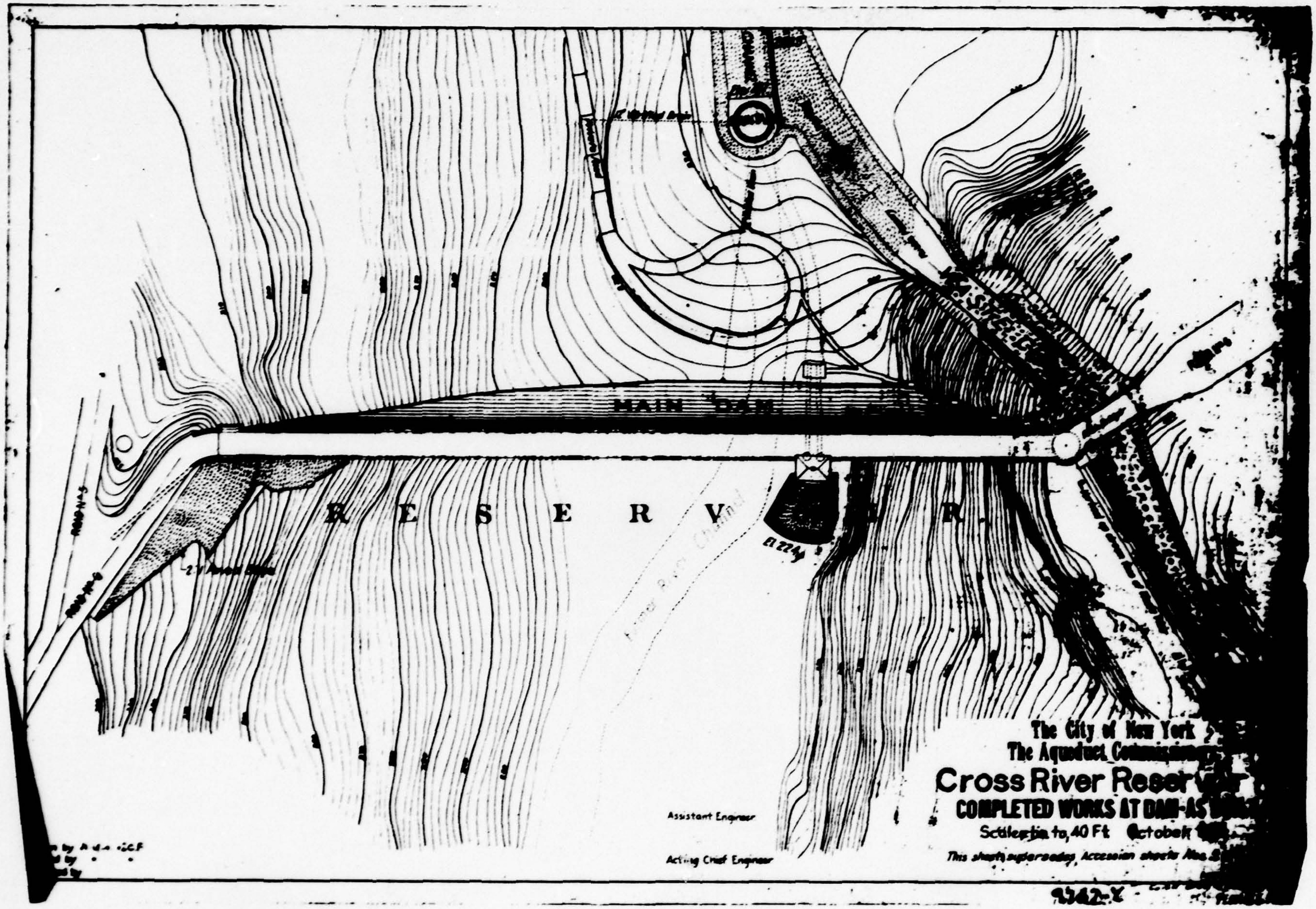

MAIN DAM
RESERVOIR
El. 224
Assistant Engineer
Acting Chief Engineer
The City of New York
The Aqueduct Commissioners
Cross River Reservoir
COMPLETED WORKS AT DAM-AS BUILT
Scale: 1 in. to 40 Ft. October
9342-X

FIGURE 3

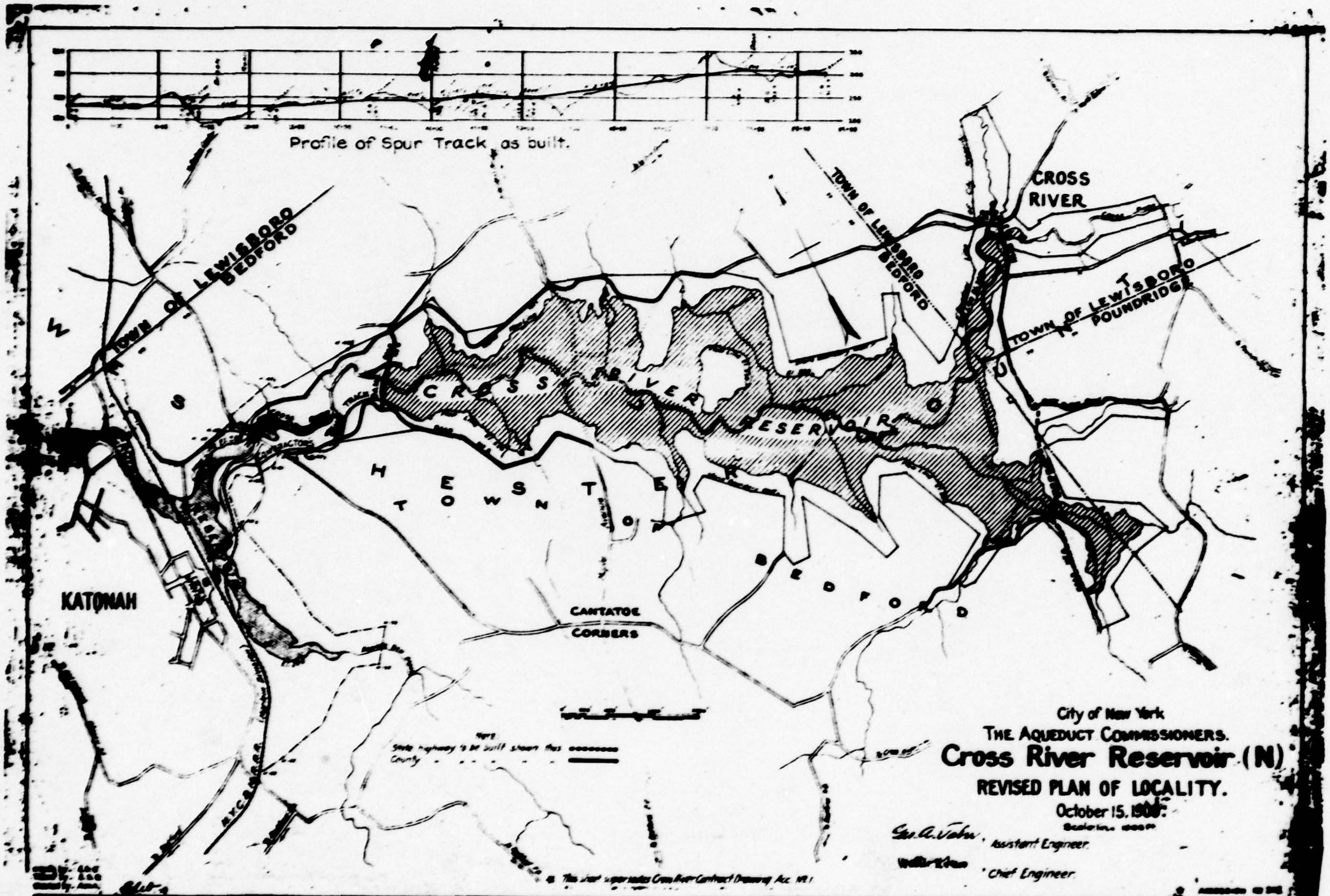

Profile of Spur Track as built.
CROSS RIVER
TOWN OF LEWISBORO
BEDFORD
TOWN OF LEWISBORO
POUNDRIDGE
CROSS RIVER RESERVOIR
TOWN OF BEDFORD
WESTCHESTER
KATONAH
CANTATOE CORNERS
City of New York
THE AQUEDUCT COMMISSIONERS.
Cross River Reservoir (N)
REVISED PLAN OF LOCALITY.
October 15, 1906.
Assistant Engineer.
Chief Engineer.

FIGURE 4

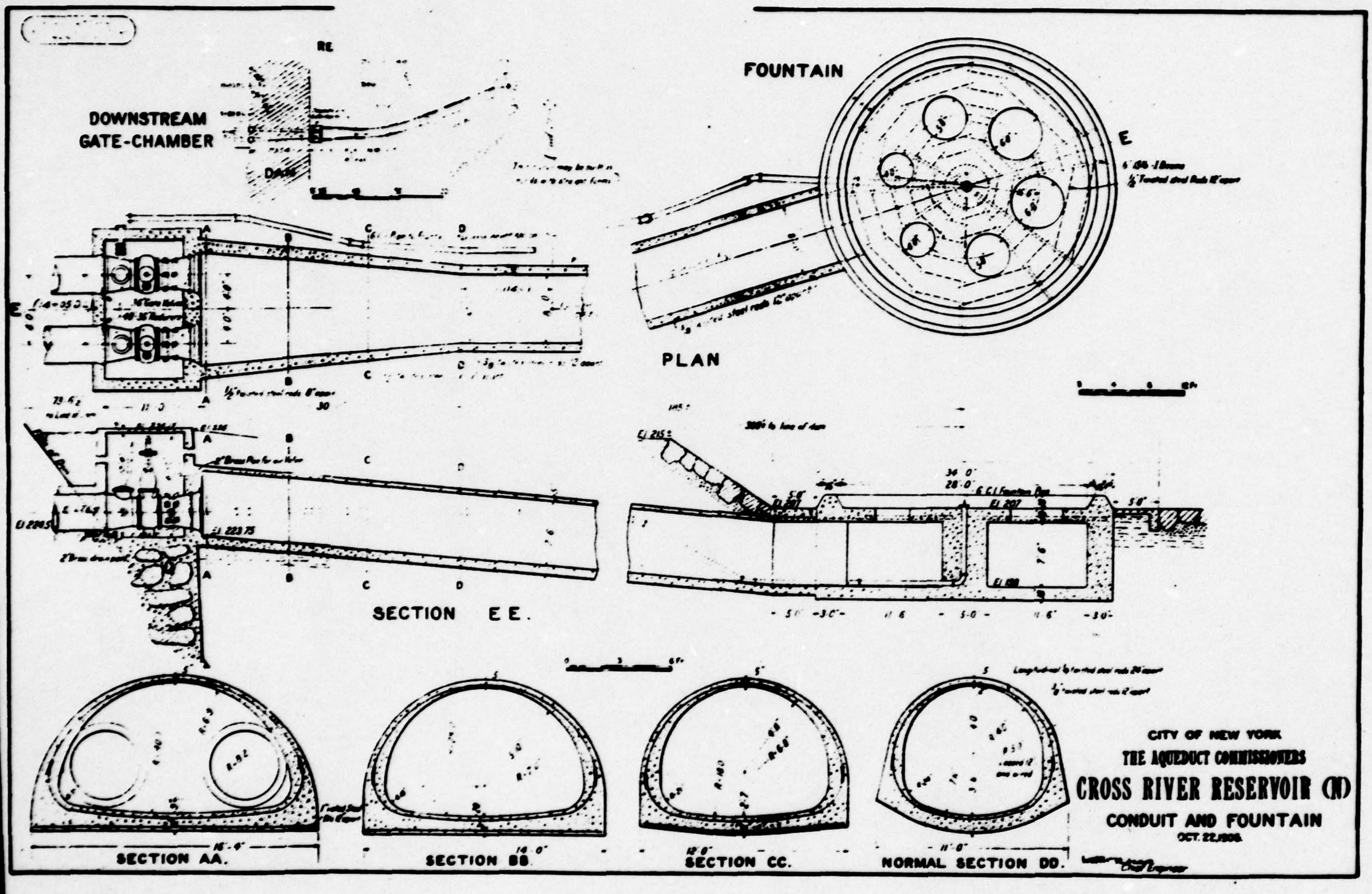

DOWNSTREAM
GATE-CHAMBER
FOUNTAIN
PLAN
SECTION E E.
SECTION AA.
SECTION BB.
SECTION CC.
NORMAL SECTION DD.
CITY OF NEW YORK
THE AQUEDUCT COMMISSIONERS
CROSS RIVER RESERVOIR (N)
CONDUIT AND FOUNTAIN
OCT. 22, 1908.

FIGURE 5

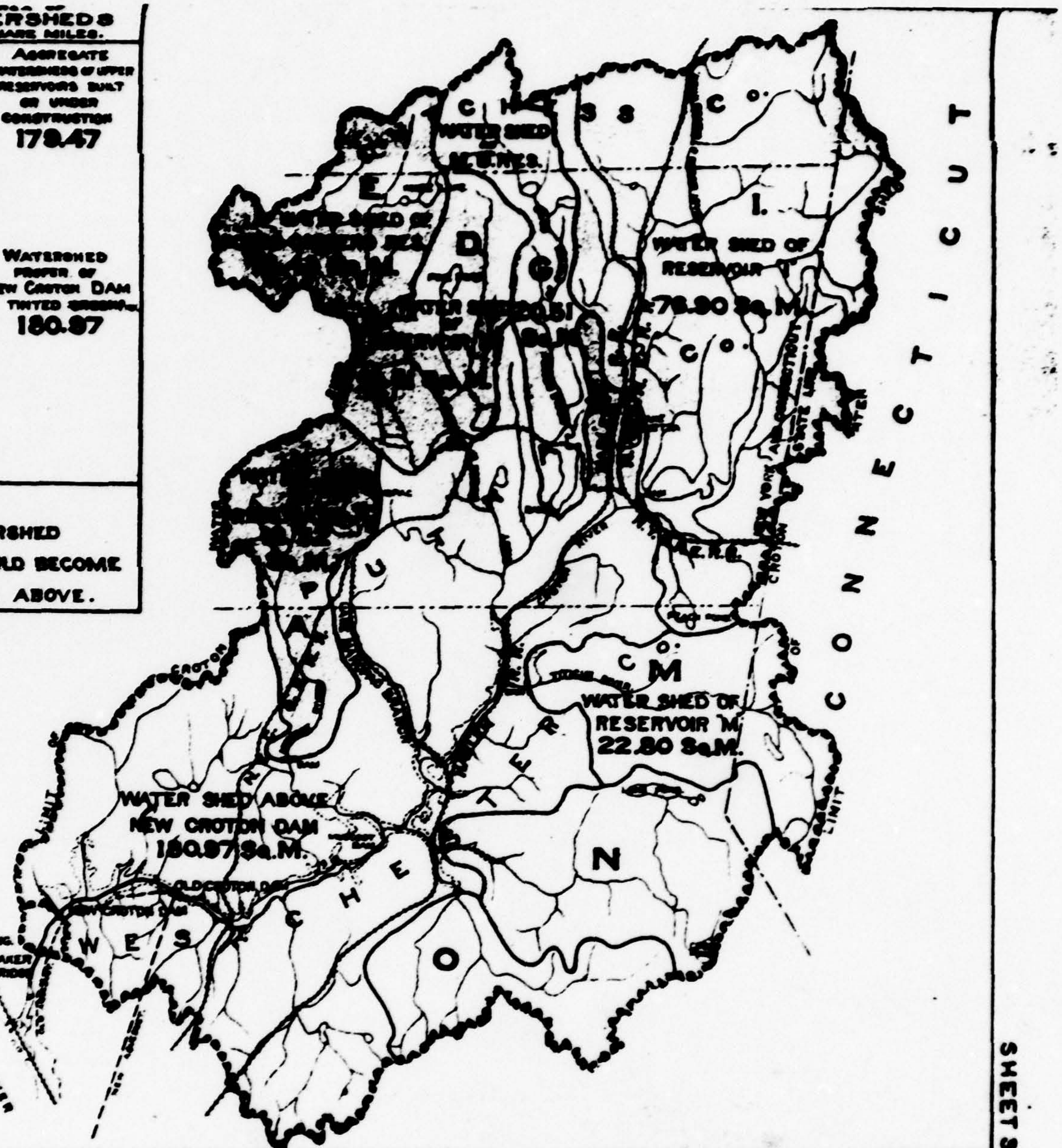
	Reservoirs	Area of Watersheds in Square Miles	
E	Boyds Corners .... Built	21.43	Aggregate watersheds of upper reservoirs built or under construction 179.47
D	Carmel .... Under Construction	19.51	
G	Middle Branch .... Built	20.51	
I	East Branch .... Built	78.90	
M	Titicus .... Under Construction	22.80	
A	Amawalk .... "	18.32	
N	.... Contemplated	29.47	Watershed proper of New Croton Dam tinted green 180.97
O	.... "	17.30	
	Between the upper Dams and the old Croton Dam	112.58	
	From old Croton Dam to the New Croton Dam	21.62	
	Total area of the water shed above the New Croton Dam	360.44 *	

If Reservoirs N and O were built the watershed proper of the New Croton Dam would become 134.20 Square Miles instead of 180.97 as above.

* This area is based on the survey of 1888.

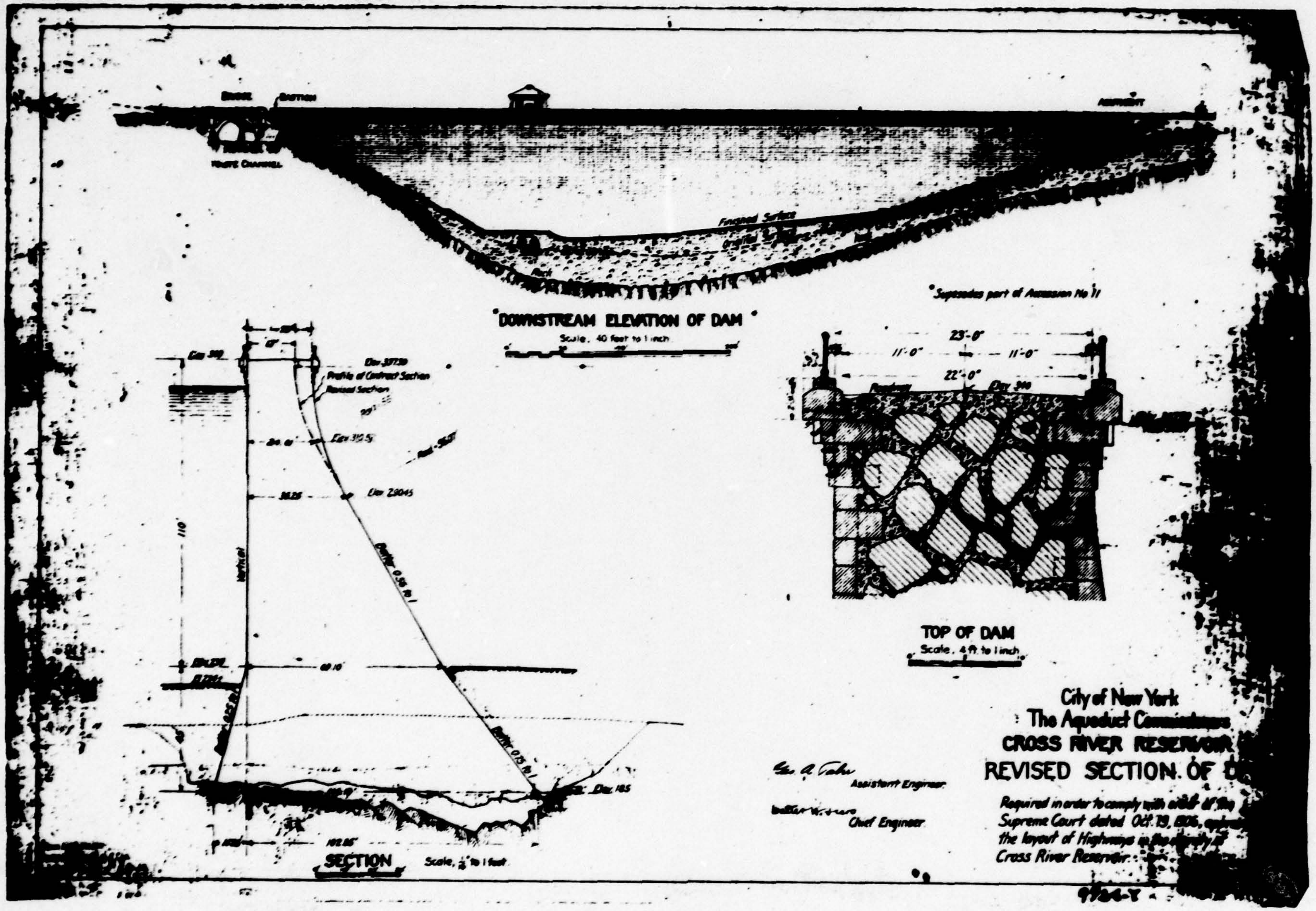
The Aqueduct Commissioners Map Showing Croton Water Shed and Subdivisions Corresponding to the Various Dams

A. Fteley
Chief Engineer



SHEET 3

FIGURE 6



BRIDGE
BASTION
WASTE CHANNEL
ABUTMENT
Finished Surface
Rock
DOWNSTREAM ELEVATION OF DAM
Scale, 40 feet to 1 inch
Supersedes part of Accession No 11
23'-0"
11'-0"
11'-0"
22'-0"
Roadway
Elev 340
TOP OF DAM
Scale, 4 ft. to 1 inch
Elev 340
Elev 337.30
Profile of Contract Section
Revised Section
Elev 310.5
Elev 290.45
Vertical
Batter 0.56 to 1
Batter 0.75 to 1
110
Elev 185
102.85
SECTION
Scale, 1/8" to 1 foot
City of New York
The Aqueduct Commissioners
CROSS RIVER RESERVOIR
REVISED SECTION OF D
Assistant Engineer
Chief Engineer
Required in order to comply with order of the Supreme Court dated Oct. 19, 1906, approving the layout of Highways in the vicinity of Cross River Reservoir.

FIGURE 7

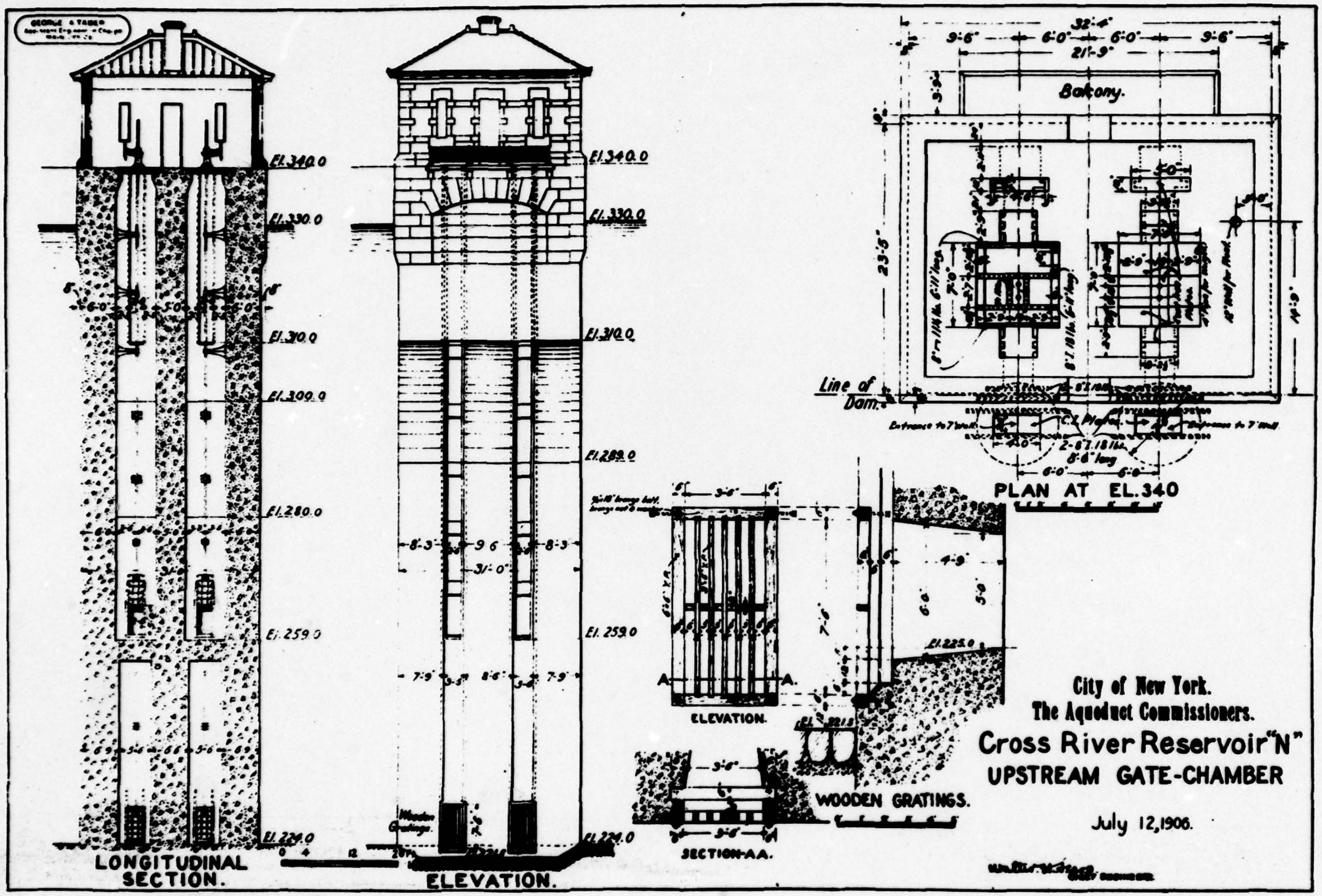

LONGITUDINAL SECTION.
ELEVATION.
PLAN AT EL. 340
ELEVATION.
SECTION-AA.
WOODEN GRATINGS.
Balcony.
Line of Dam.
El. 340.0
El. 330.0
El. 310.0
El. 300.0
El. 289.0
El. 280.0
El. 259.0
El. 224.0
El. 225.0
32'-4"
9'-6"
6'-0"
21'-9"
23'-5"
14'-9"
31'-0"
City of New York.
The Aqueduct Commissioners.
Cross River Reservoir "N"
UPSTREAM GATE-CHAMBER
July 12, 1906.

FIGURE 8

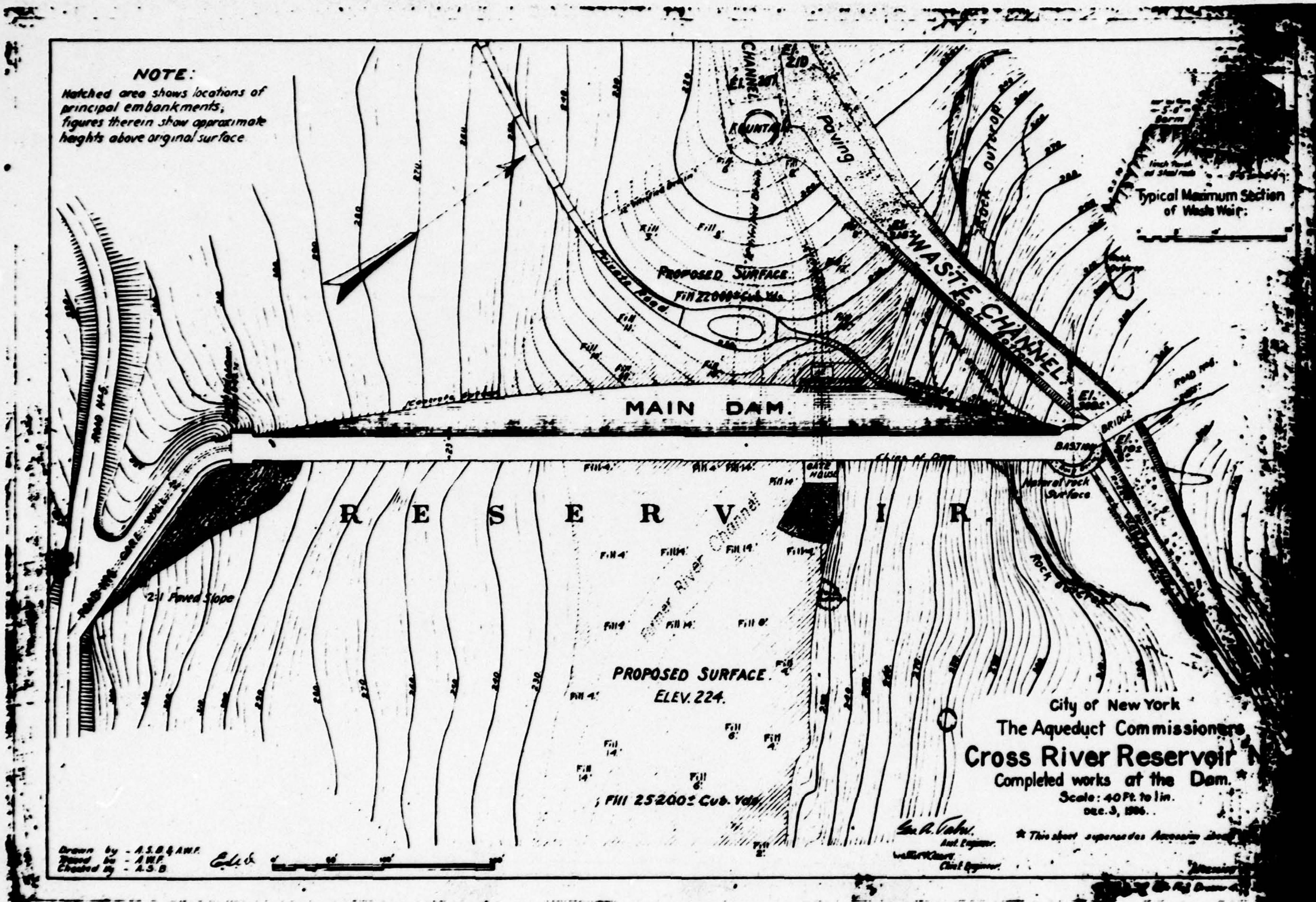

NOTE:
Hatched area shows locations of principal embankments; figures therein show approximate heights above original surface
MAIN DAM.
R E S E R V O I R
WASTE CHANNEL
Paving
CHANNEL
FOUNTAIN
Rock outcrop
Typical Maximum Section of Waste Weir:
PROPOSED SURFACE.
Fill 22000± Cub. Yds.
Private Road
BRIDGE
Natural rock Surface
Gate House
2:1 Paved Slope
PROPOSED SURFACE.
ELEV. 224.
Fill 25200± Cub. Yds.
Croton River Channel
City of New York
The Aqueduct Commissioners
Cross River Reservoir
Completed works at the Dam.*
Scale: 40 Ft. to 1 in.
Dec. 3, 1906.
Drawn by - A.S.B. & A.W.F.
Traced by - A.W.F.
Checked by - A.S.B.

FIGURE 9

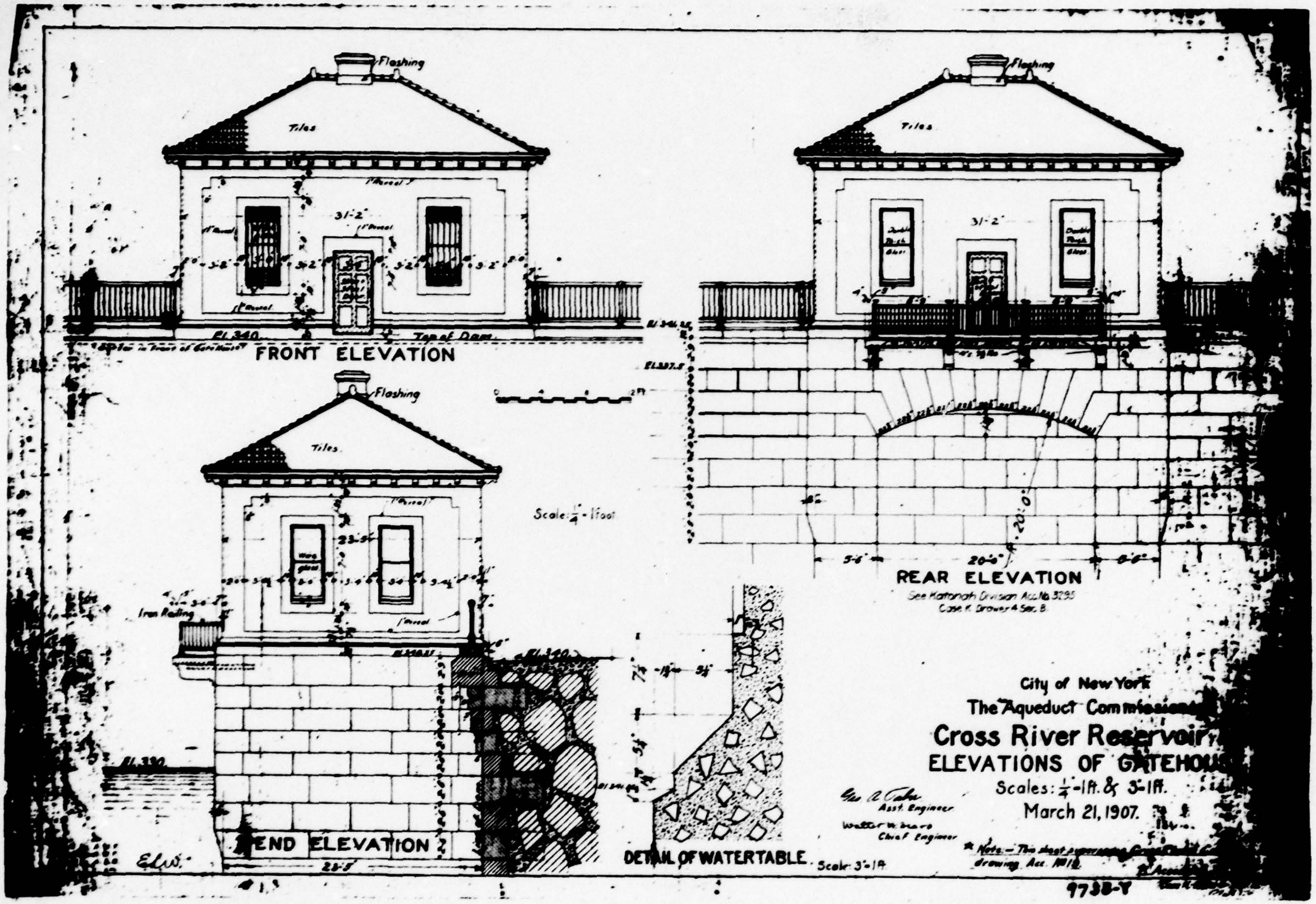

Flashing
Tiles
31'-2"
FRONT ELEVATION
Top of Dam
Flashing
Tiles
31'-2"
REAR ELEVATION
See Katonah Division Acc.No. 3295
Case K Drawer 4 Sec. B
Flashing
Tiles
Scale: 1/4 - 1 foot
Iron Railing
El. 330
END ELEVATION
DETAIL OF WATERTABLE
Scale: 3 - 1 ft.
City of New York
The Aqueduct Commissioners
Cross River Reservoir
ELEVATIONS OF GATEHOUSE
Scales: 1/4 - 1 ft. & 3 - 1 ft.
March 21, 1907.
Asst. Engineer
Chief Engineer
9738-Y

FIGURE 10

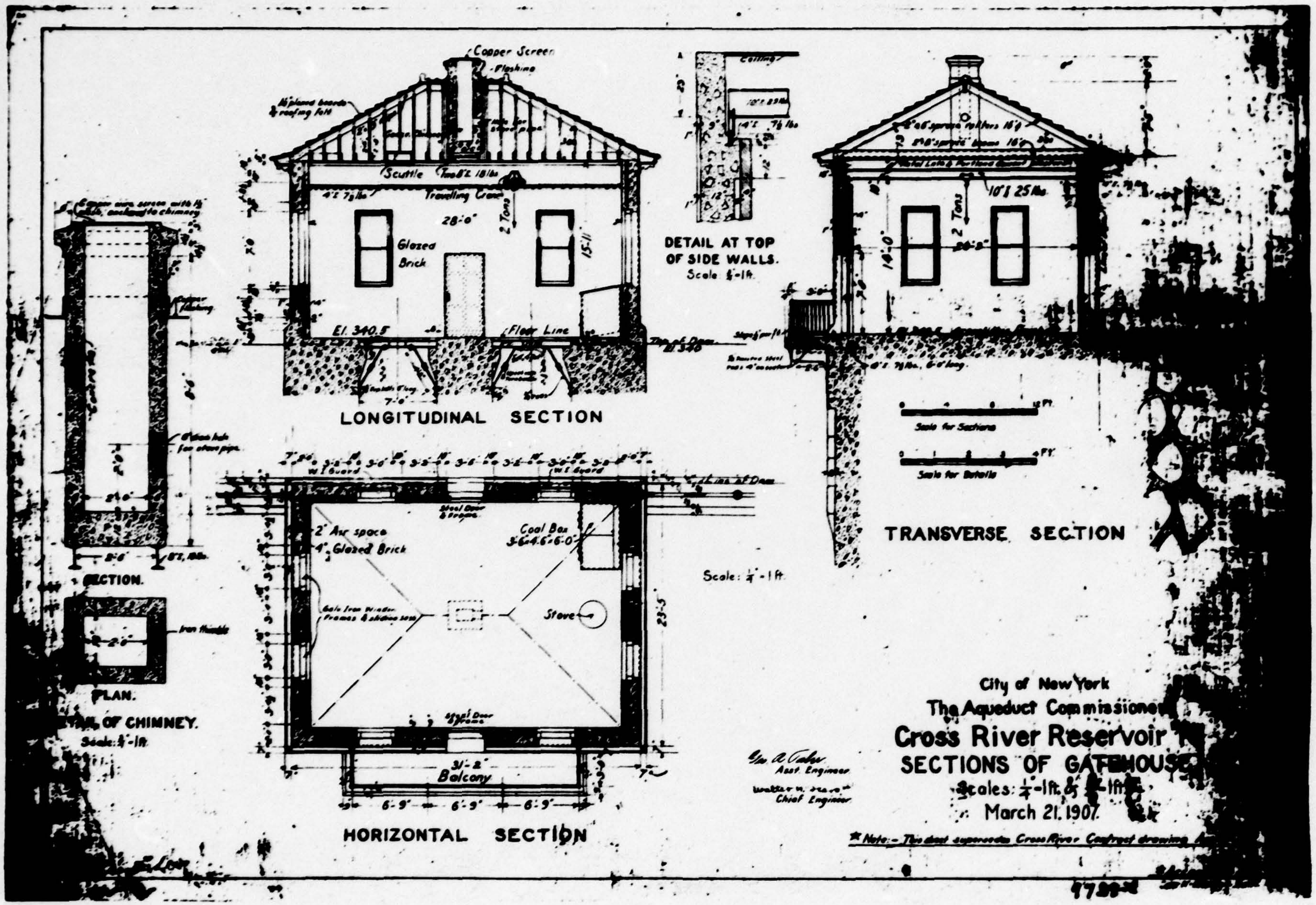

Copper Screen
Flashing
Scuttle
Travelling Crane
28'-0"
2 Tons
Glazed Brick
15'-11
El. 340.5
Floor Line
LONGITUDINAL SECTION
DETAIL AT TOP OF SIDE WALLS.
Scale: ½"-1ft.
10"I 25 lbs
2 Tons
14'-0
TRANSVERSE SECTION
Scale for Sections
Scale for Details
SECTION.
PLAN.
DETAIL OF CHIMNEY.
Scale: ½"-1ft.
2" Air space
4" Glazed Brick
Coal Box
3'-6"×4'-6"×6'-0"
Stove
23'-5
31'-2"
Balcony
6'-9"
6'-9"
6'-9"
HORIZONTAL SECTION
Scale: ¼"-1ft.
City of New York
The Aqueduct Commissioners
Cross River Reservoir
SECTIONS OF GATEHOUSE
March 21, 1907
Asst. Engineer
Chief Engineer

FIGURE 11

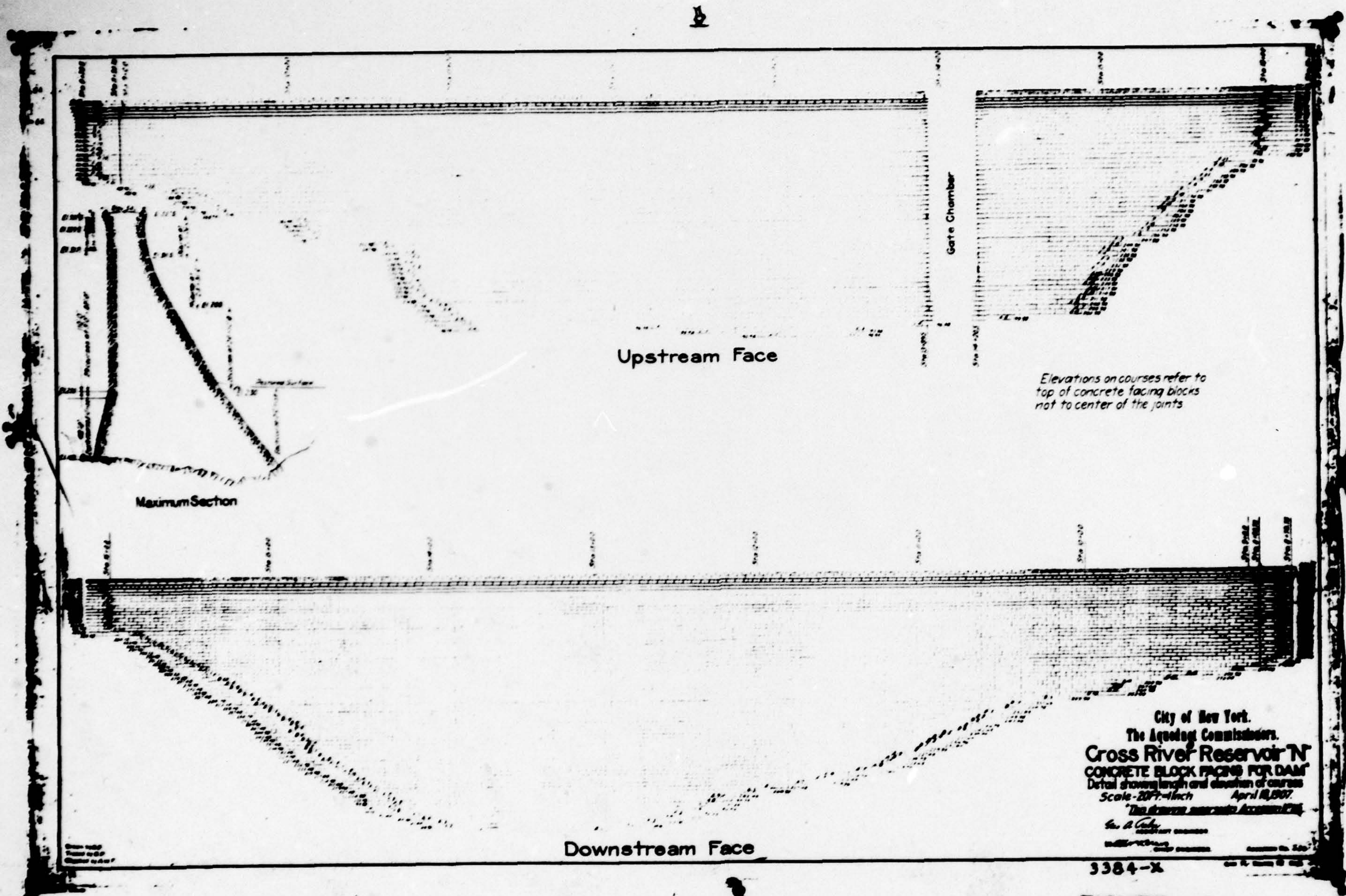

Gate Chamber
Upstream Face
Elevations on courses refer to top of concrete facing blocks not to center of the joints
Maximum Section
Downstream Face
City of New York.
Cross River Reservoir "N"
CONCRETE BLOCK FACING FOR DAM
Scale - 20 Ft. = 1 Inch
April 18, 1907.
3384-X

FIGURE 12

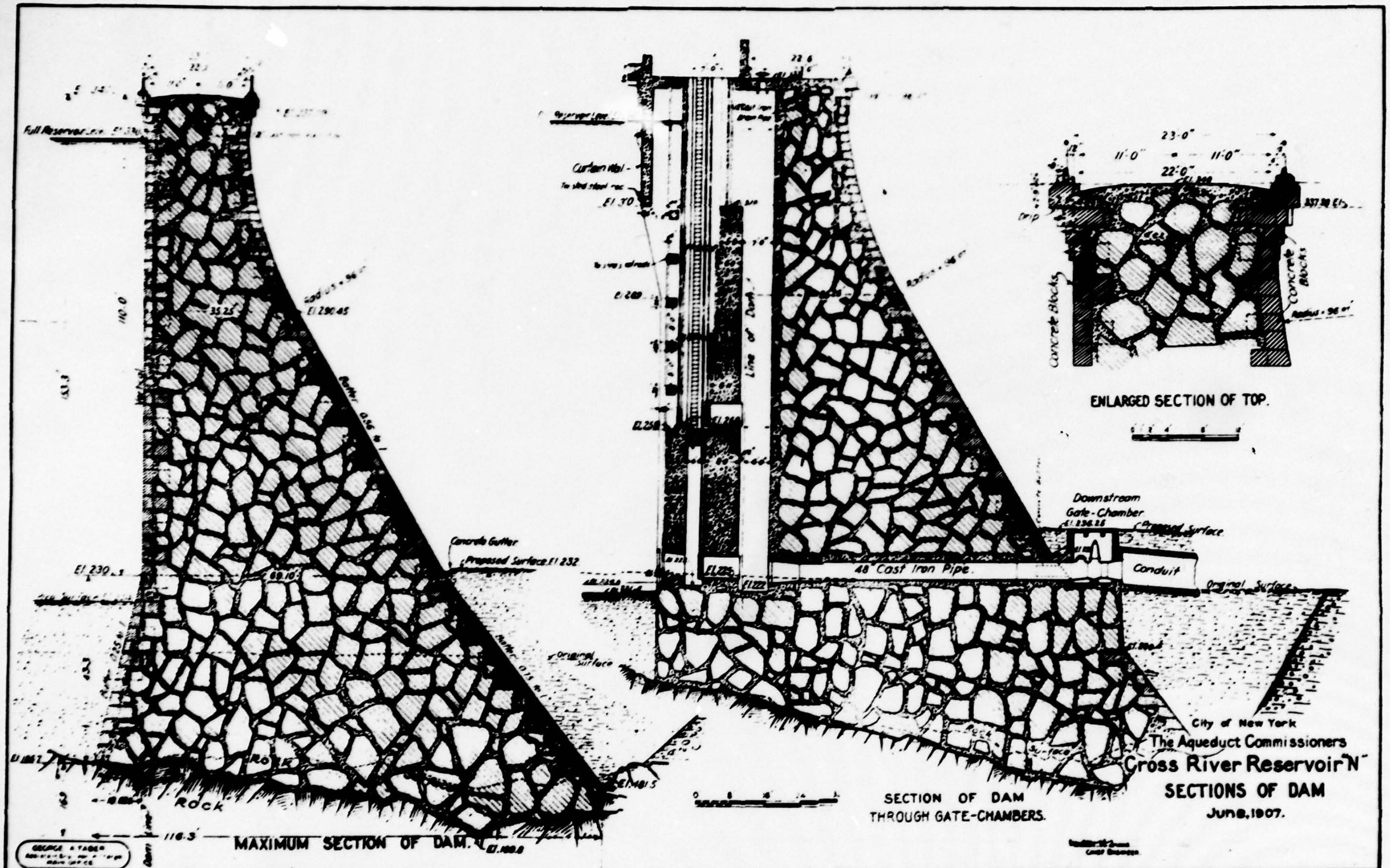

Full Reservoir
Curtain Wall
Concrete Gutter
Proposed Surface El 232
El 230
Original Surface
Rock
Line of Dam
48" Cast Iron Pipe
Downstream Gate-Chamber
Proposed Surface
Conduit
Original Surface
23'-0"
11'-0"
11'-0"
22'-0"
Drip
Concrete Blocks
Concrete Blocks
ENLARGED SECTION OF TOP.
MAXIMUM SECTION OF DAM.
SECTION OF DAM
THROUGH GATE-CHAMBERS.
City of New York
The Aqueduct Commissioners
Cross River Reservoir "N"
SECTIONS OF DAM
June, 1907.

FIGURE 13

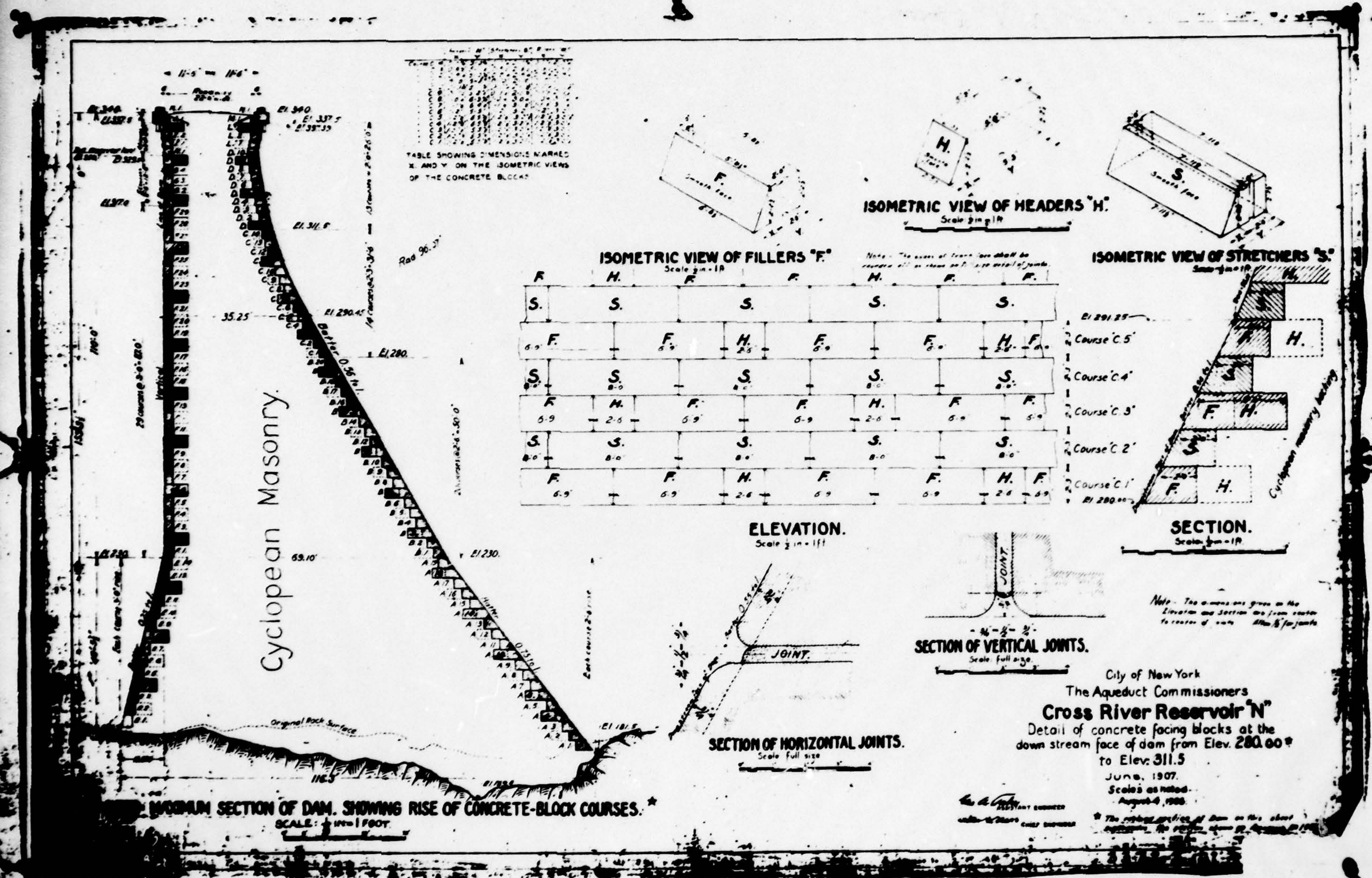
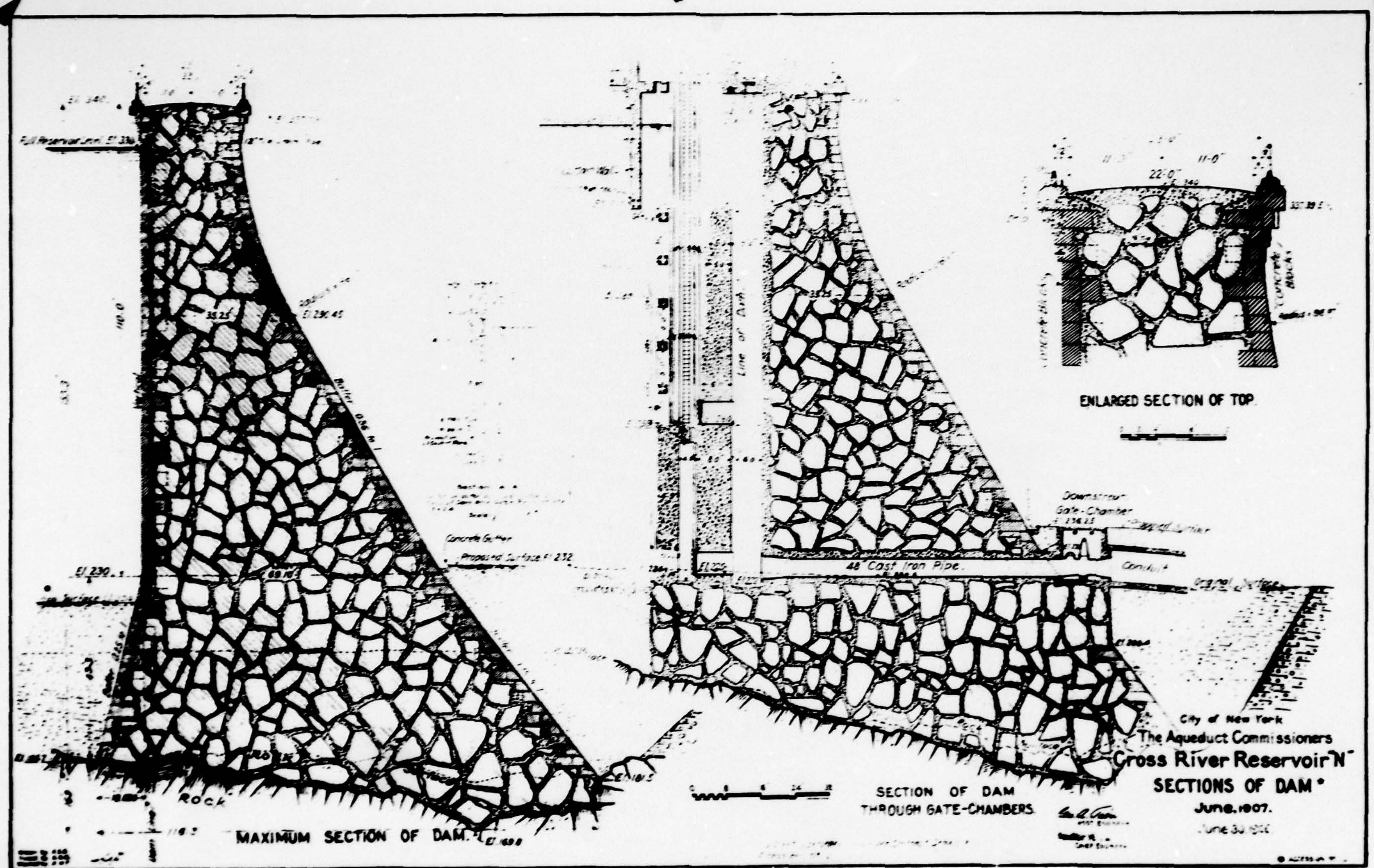
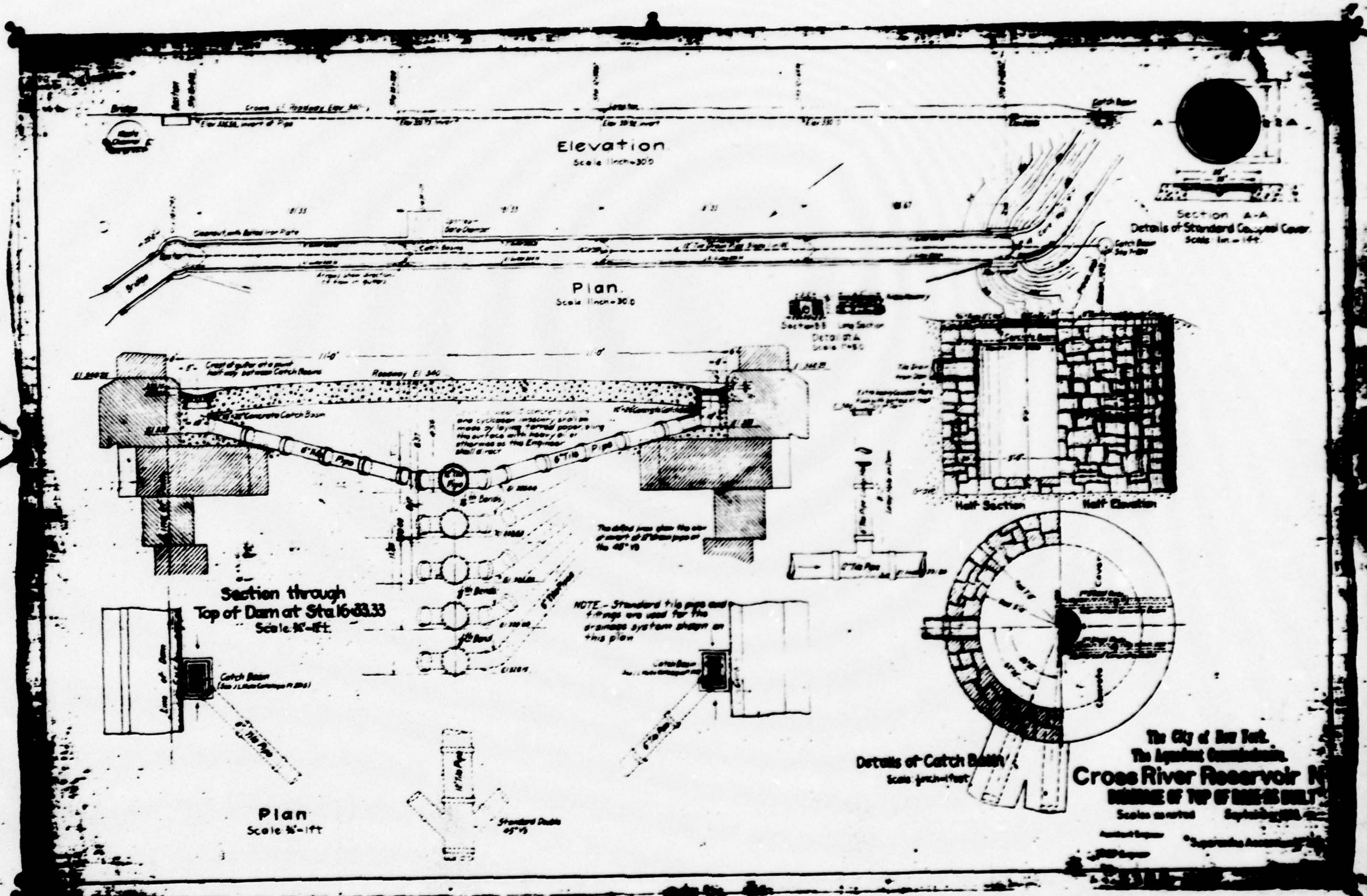

Cyclopean Masonry.
TABLE SHOWING DIMENSIONS MARKED X AND Y ON THE ISOMETRIC VIEWS OF THE CONCRETE BLOCKS
ISOMETRIC VIEW OF FILLERS "F."
ISOMETRIC VIEW OF HEADERS "H."
ISOMETRIC VIEW OF STRETCHERS "S."
ELEVATION.
Scale ½ in = 1 ft
SECTION.
Cyclopean masonry backing
Course C.1
Course C.2
Course C.3
Course C.4
Course C.5
SECTION OF HORIZONTAL JOINTS.
Scale full size
SECTION OF VERTICAL JOINTS.
Scale full size
JOINT.
Original Rock Surface
Batter 0.56 to 1.
MAXIMUM SECTION OF DAM. SHOWING RISE OF CONCRETE-BLOCK COURSES.*
City of New York
The Aqueduct Commissioners
Cross River Reservoir "N"
Detail of concrete facing blocks at the down stream face of dam from Elev. 280.00* to Elev. 311.5
June, 1907.
Scales as noted.

FIGURE 14



3376-X

FIGURE 15



Elevation
Scale 1 inch = 30 ft
Plan.
Scale 1 inch = 30 ft
Section A-A
Details of Standard Cesspool Cover.
Section through
Top of Dam at Sta 16+33.33
Scale 3/8" = 1 ft.
NOTE - Standard tile pipe and fittings are used for the drainage system shown on this plan
Half Section
Half Elevation
Details of Catch Basin
Plan
Scale 3/8" = 1 ft.
The City of New York.
The Aqueduct Commission.
Cross River Reservoir N

FIGURE 16

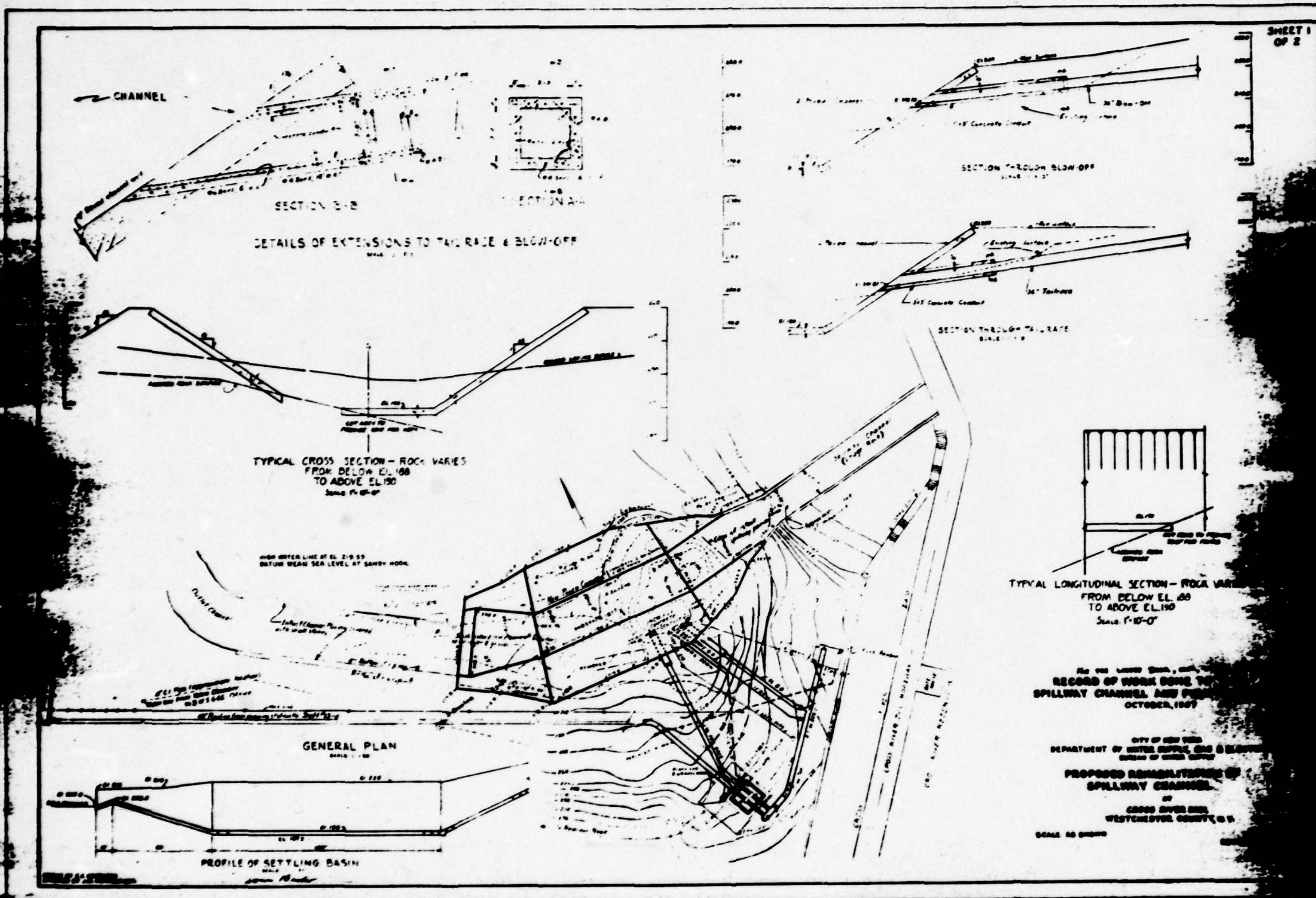
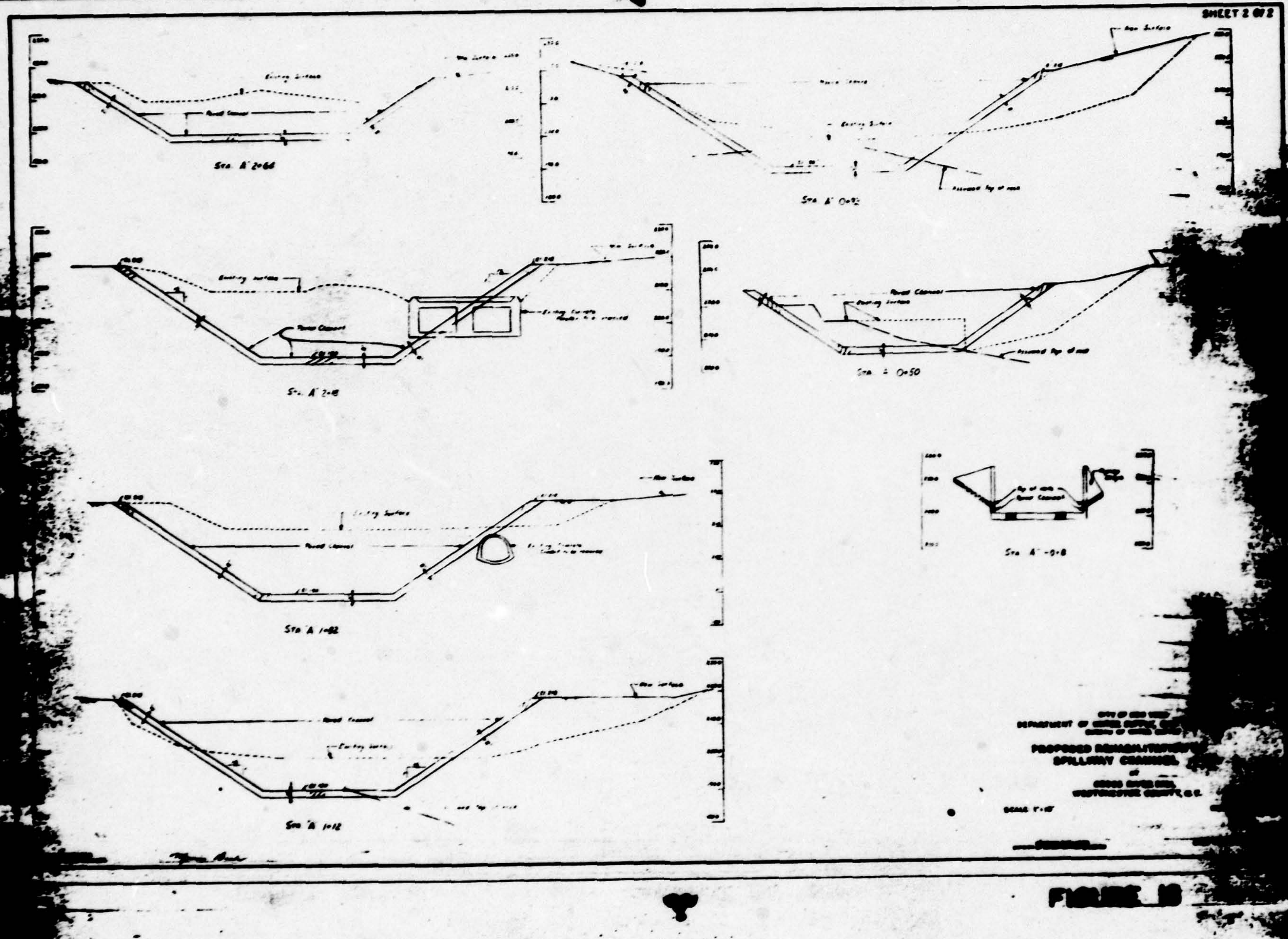

SHEET 1 OF 2
CHANNEL
SECTION B-B
SECTION A-A
DETAILS OF EXTENSIONS TO TAILRACE & BLOW-OFF
SECTION THROUGH BLOW-OFF
SECTION THROUGH TAILRACE
TYPICAL CROSS SECTION - ROCK VARIES FROM BELOW EL. 188 TO ABOVE EL. 190
HIGH WATER LINE AT EL. 219.55
DATUM MEAN SEA LEVEL AT SANDY HOOK
Outlet Channel
GENERAL PLAN
PROFILE OF SETTLING BASIN
TYPICAL LONGITUDINAL SECTION - ROCK VARIES FROM BELOW EL. 188 TO ABOVE EL. 190
Scale: 1"=10'-0"
SPILLWAY CHANNEL
DEPARTMENT OF
SPILLWAY CHANNEL

FIGURE 17


SHEET 2 OF 2
Sta. A' 2+64
Sta. A' 0+92
Sta. A' 2+18
Sta. A 0+50
Sta. A 1+82
Sta. A' -0+8
Sta. A 1+12
PROPOSED REHABILITATION
SPILLWAY CHANNEL

Survey of Croton System 6
Cross River Reservoir

C Picha 11/3/77

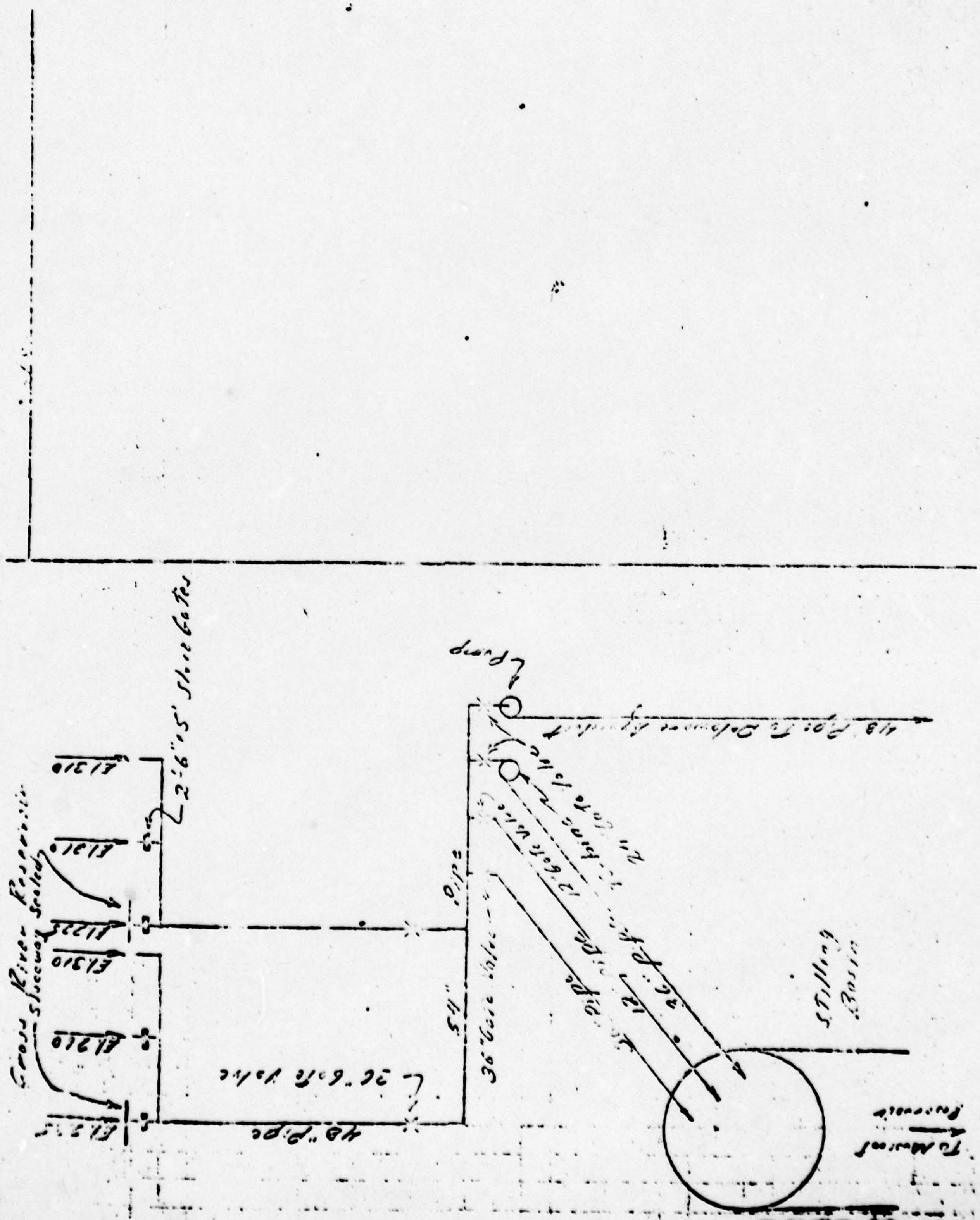
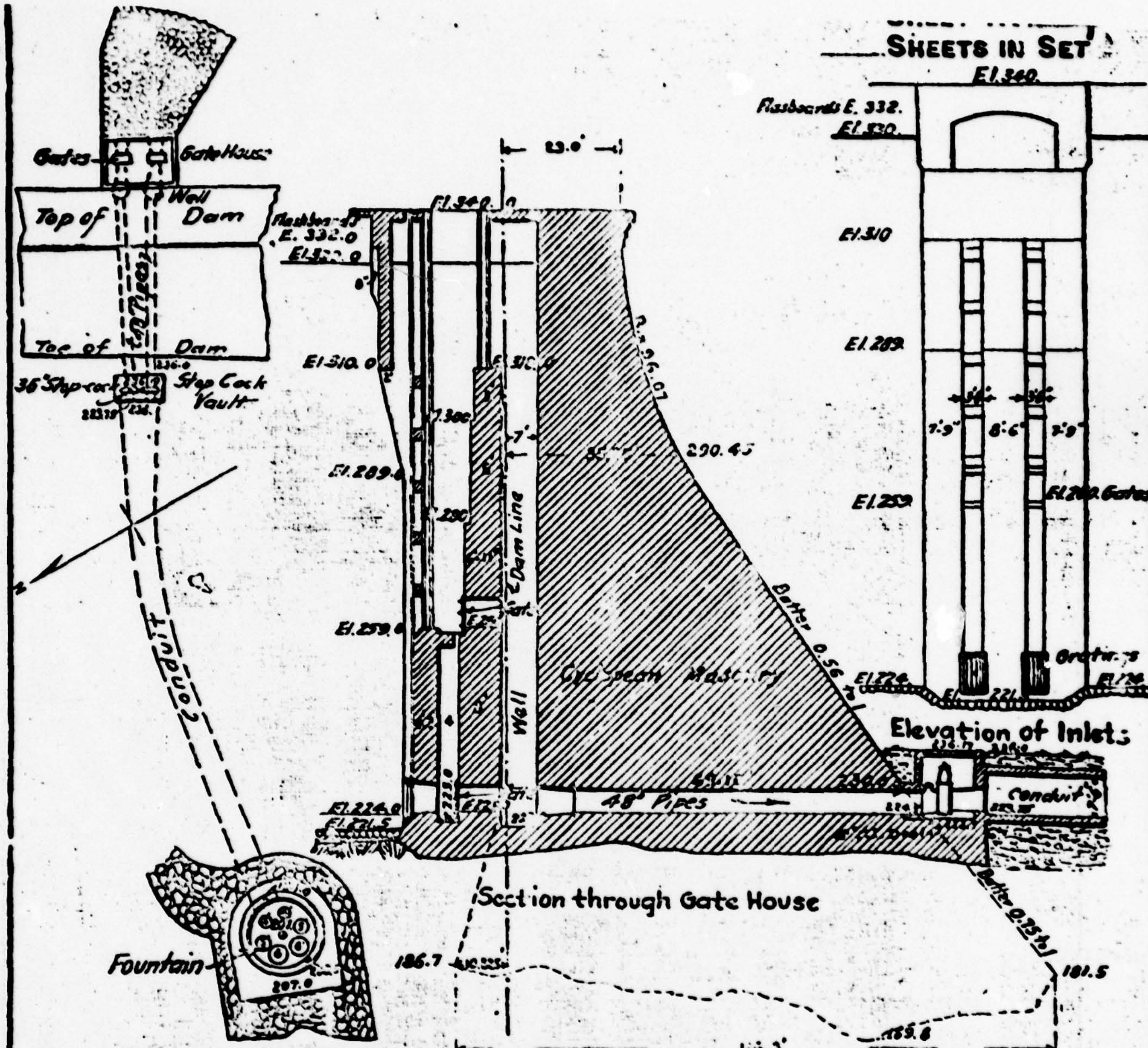


FIGURE 20.

SHEETS IN SET



Inlets			Outlets			Gates			Stop-cocks			Remarks
Number	Shape and Dimension	Elev. of Invert	Number	Shape and Dimension	Elev. of Invert	Number	Size	Elev. of Invert	Number	Diam.	Elev. of Invert	NOTE. These Elevations refer to Croton Datum which is 3.[illegible] ft. lower than City Datum.
2	6' × 3'6"	224.5				2	2'6" × 5'	250	2	36"	225.	El. of Flashboards 332.0 / El. of Spillway 330.0 / Length do. 240.0 / El. lip of Fountain 208.5 / Length of Masonry Dam 773.75 / Conduit has varying Section. See Sheet #16 / Length of Earth Dam 206.72
						2	2'6" × 5'	225				
			1	Conduit	133.							
				Fountain Outlet								
2	31' × 5'6"	250.	2	6" diam								
			2	5" "	207							
			2	4" "								
			6	Fount.								

CITY OF NEW YORK

THE AQUEDUCT COMMISSIONERS

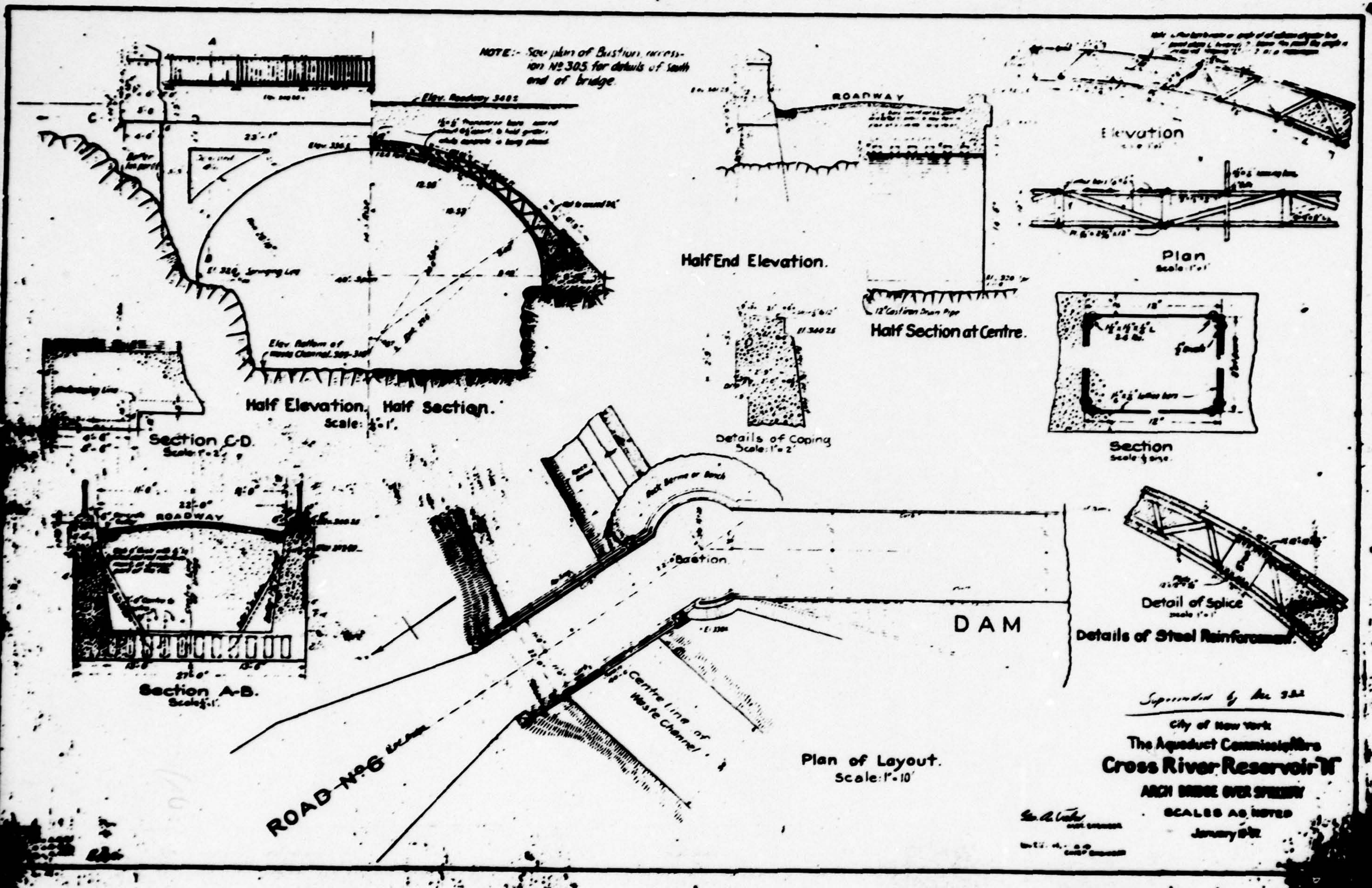
RESERVOIR "N"

CROSS RIVER DAM

FIGURE 10

Drawn by A.S.F.
Traced by S.F.
Checked by

ACCESSION No.



NOTE:- See plan of Bastion, accession No 305 for details of south end of bridge.
Half Elevation. Half Section.
Section C-D.
Section A-B.
ROADWAY
Half End Elevation.
Details of Coping
Half Section at Centre.
Elevation
Plan
Section
Bastion
DAM
Detail of Splice
Details of Steel Reinforcement
Centre line of Waste Channel
Plan of Layout.
Scale: 1"=10'
ROAD No 6
City of New York
The Aqueduct Commissioners
Cross River Reservoir
ARCH BRIDGE OVER SPILLWAY
SCALES AS NOTED

FIGURE 21

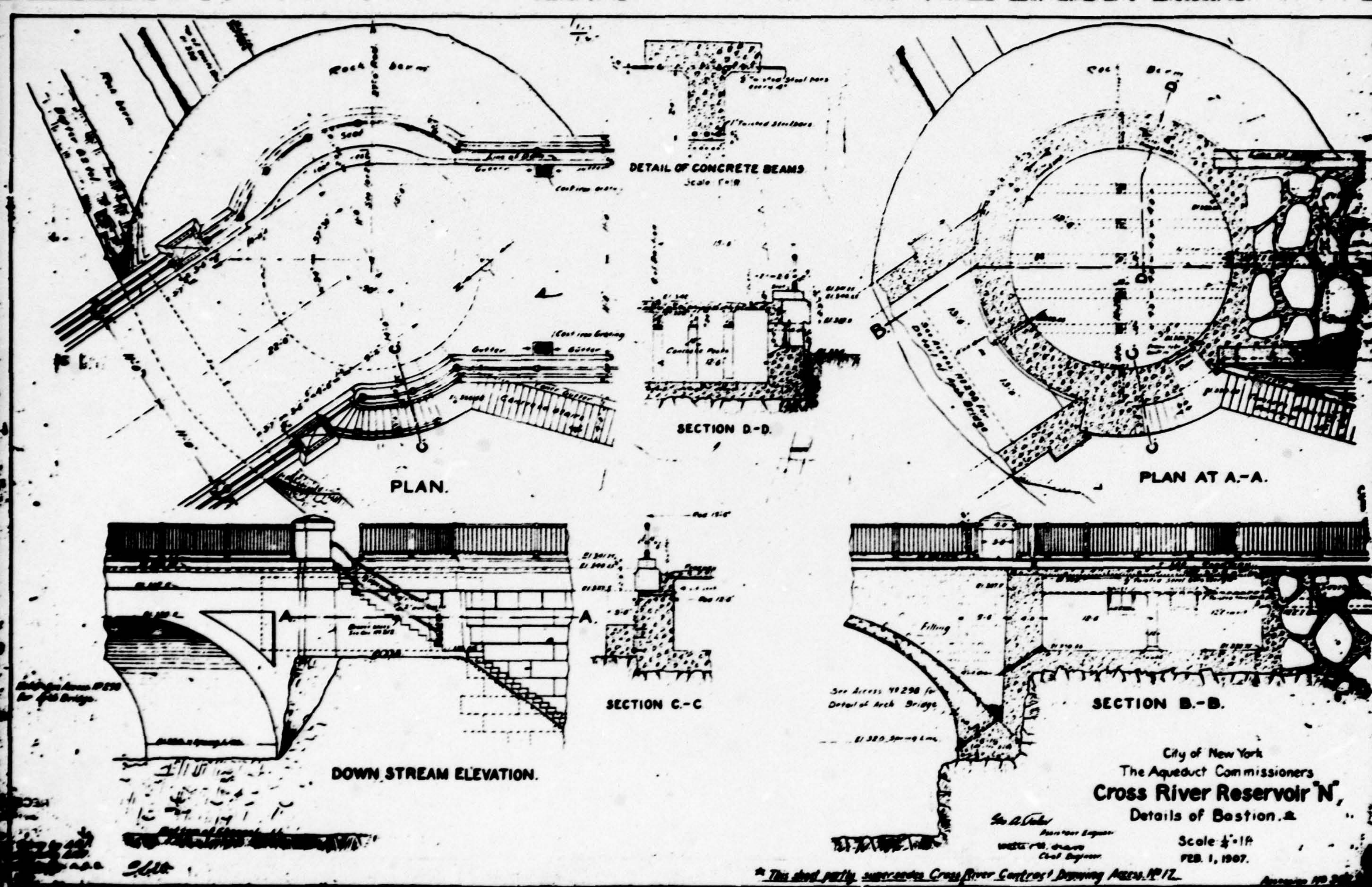
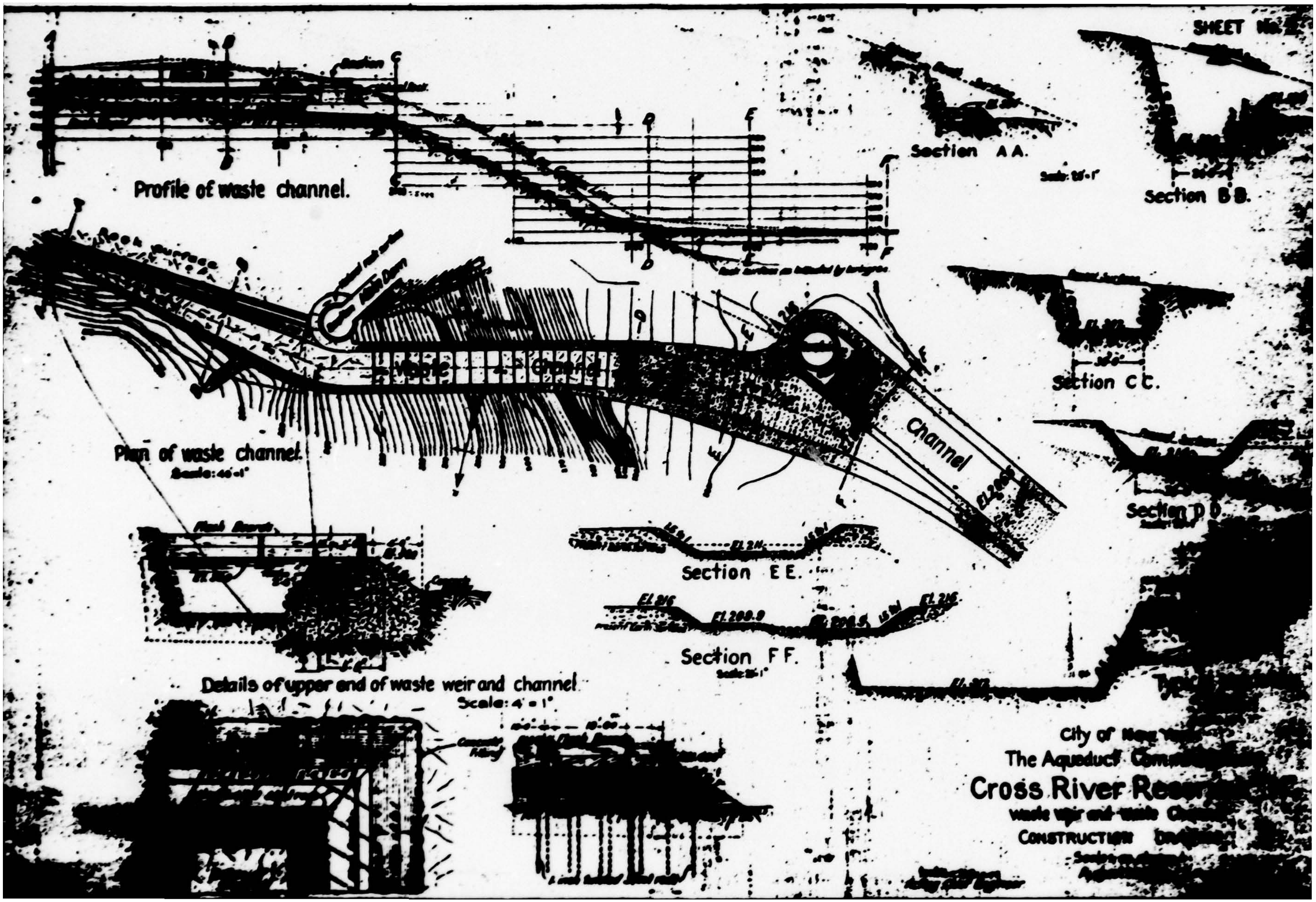

DETAIL OF CONCRETE BEAMS
PLAN.
SECTION D.-D.
PLAN AT A.-A.
SECTION C.-C
SECTION B.-B.
DOWN STREAM ELEVATION.
City of New York
The Aqueduct Commissioners
Cross River Reservoir "N",
Details of Bastion.
Scale ½"=1ft
FEB. 1, 1907.
This sheet partly supersedes Cross River Contract Drawing Access. No 12.

FIGURE 22


SHEET No.
Profile of waste channel.
Section A A.
Section B B.
Section C C.
Section D D.
Plan of waste channel.
Scale: 40'=1"
Channel
Section E E.
Section F F.
Details of upper end of waste weir and channel
Scale: 4' = 1"
City of New York
The Aqueduct Commission
Cross River Reservoir
waste weir and waste channel
CONSTRUCTION DRAWING

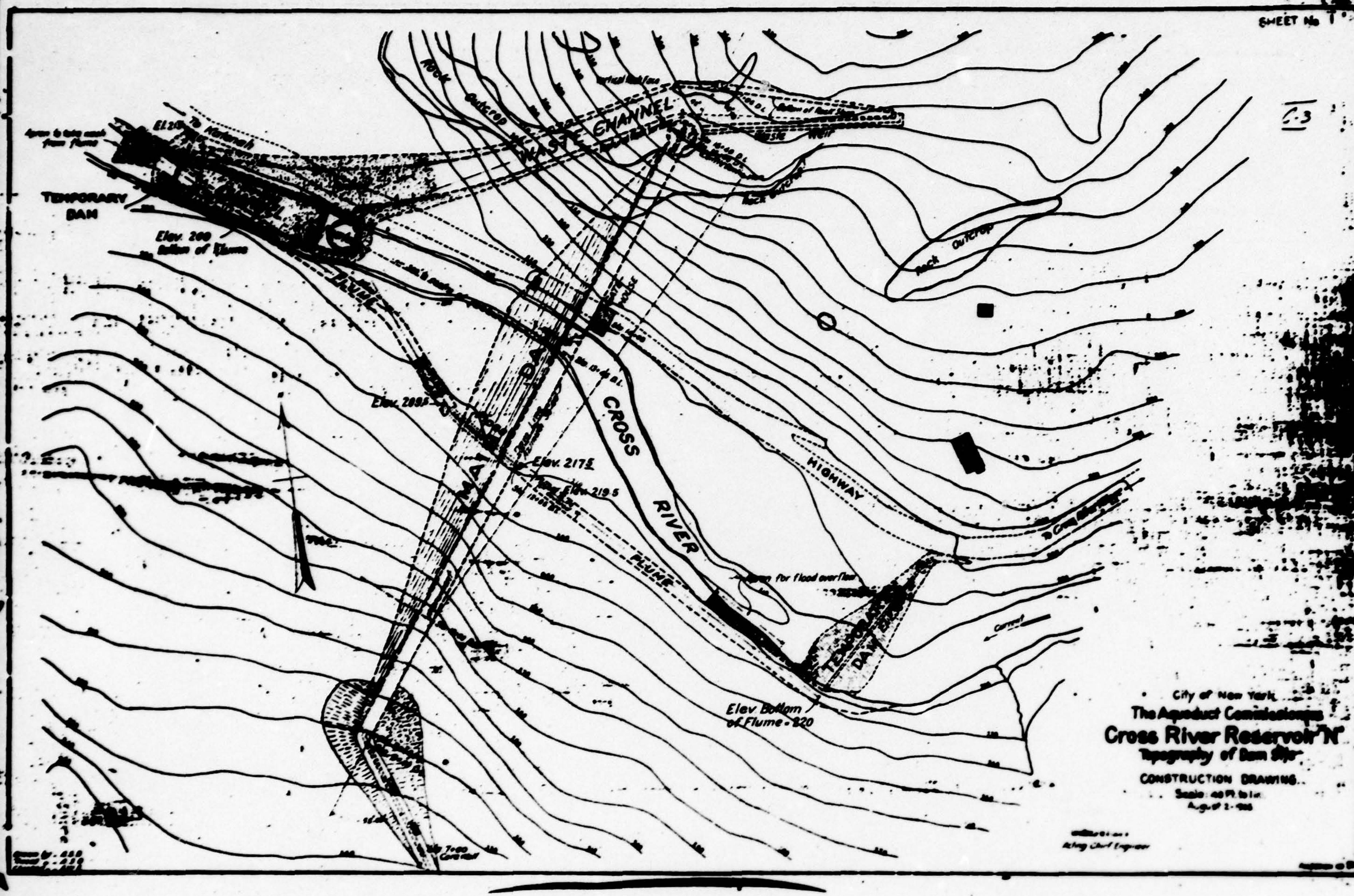
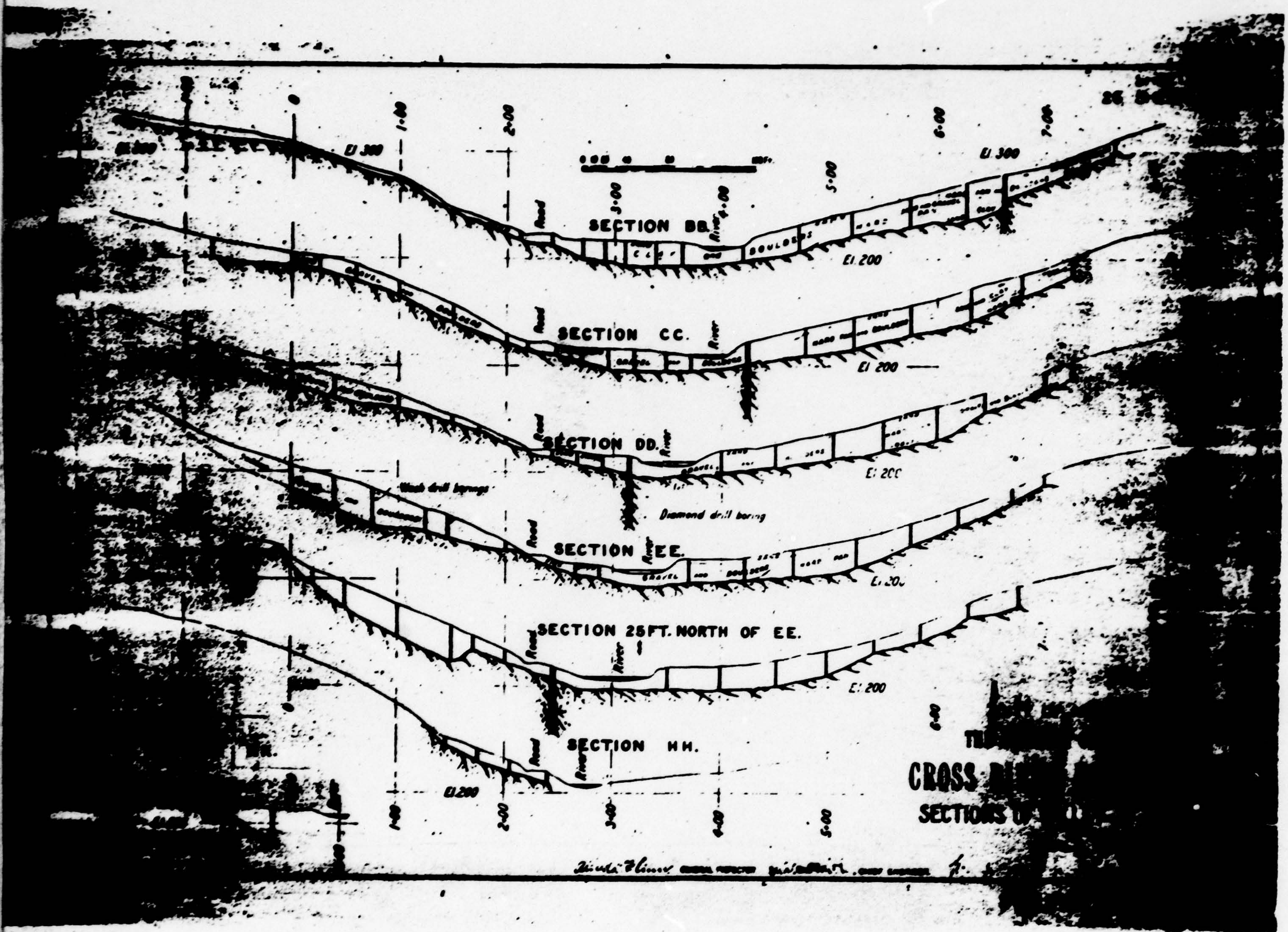
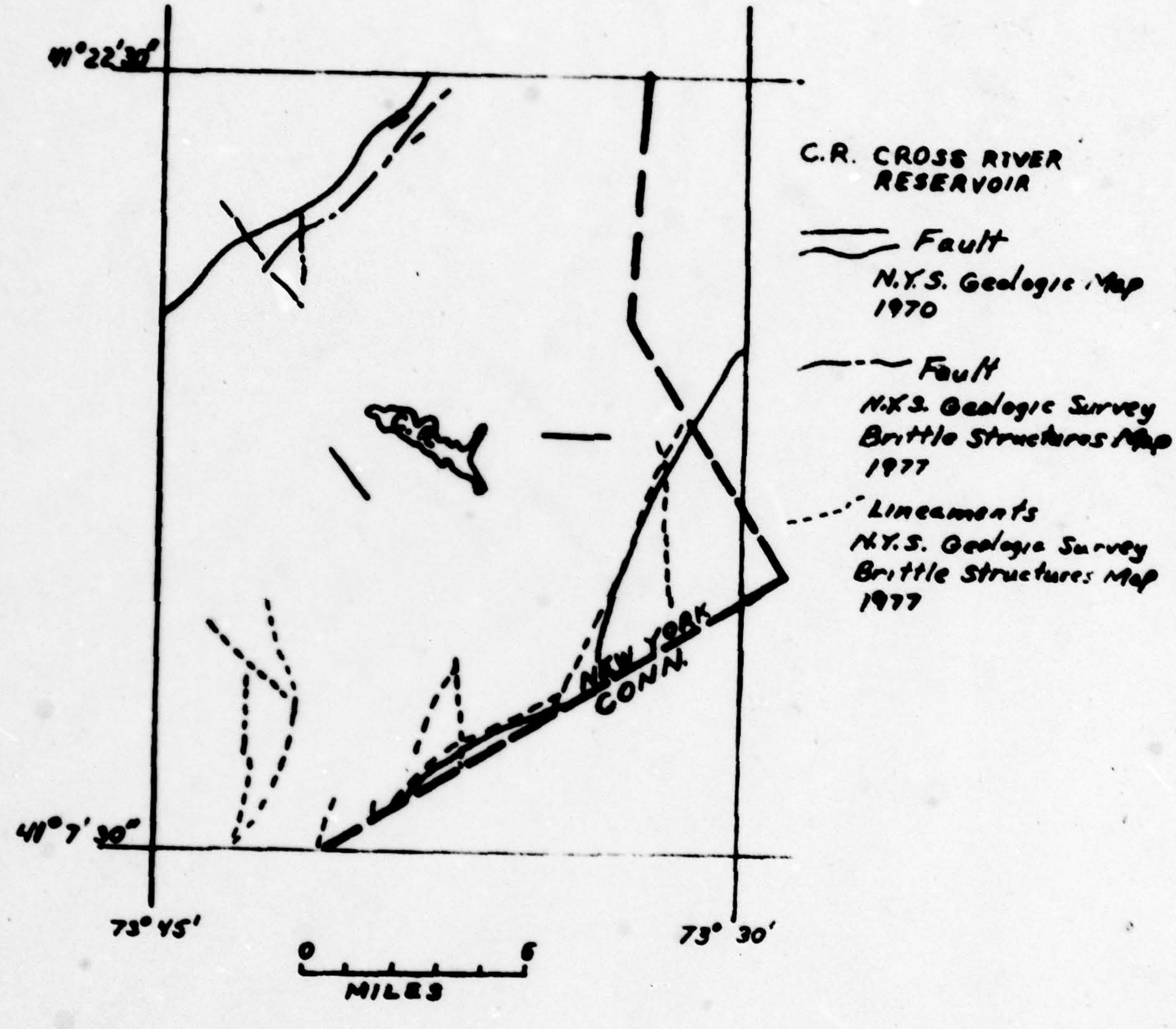

SHEET No
TEMPORARY DAM
Elev. 200 Bottom of Flume
WASTE CHANNEL
Rock Outcrop
CROSS RIVER
HIGHWAY
FLUME
Elev. 217±
Elev. 219.5
Elev Bottom of Flume - 220
City of New York
The Aqueduct Commissioners
Cross River Reservoir "N"
Topography of Dam Site
CONSTRUCTION DRAWING
Acting Chief Engineer

FIGURE 24


SECTION BB.
SECTION CC.
SECTION DD.
SECTION EE.
SECTION 25FT. NORTH OF EE.
SECTION HH.
Road
River
BOULDERS
El. 300
El. 200
Wash drill borings
Diamond drill boring
0
1+00
2+00
3+00
4+00
5+00
6+00
7+00
CROSS
SECTIONS



GEOLOGIC MAP

FIGURE 26

APPENDIX A

FIELD INSPECTION REPORT

CHECK LIST
VISUAL INSPECTION

PHASE 1

Name Dam CROSS RIVER County WESTCHESTER State NEW YORK ID # NY 38

Type of Dam MASONRY Hazard Category HIGH

Date(s) Inspection JULY 27, 1978 Weather CLOUDY Temperature 75°

AND AUGUST 2, 1978

Pool Elevation at Time of Inspection 329.96 M.S.L. Tailwater at Time of Inspection --

Inspection Personnel:

* B. COLWELL DALE ENGINEERING COMPANY

N. F. DUNLEVY DALE ENGINEERING COMPANY

F. W. BYSZEWSKI DALE ENGINEERING COMPANY

D. F. McCARTHY DALE ENGINEERING COMPANY (JULY 27 INSPECTION ONLY)

* H. S. MUSKATT DALE ENGINEERING COMPANY

JOHN BYRNES, KATONAH SECTION ENGR., N.Y.C. BOARD OF WATER SUPPLY

CARL PECKA, CROTON DIVISION ENGR., N.Y.C. BOARD OF WATER SUPPLY (OFFICE CONFERENCE)

* ANTHONY BARBERO, JERRY CASPE, CORPS OF ENGINEERS, NEW YORK DISTRICT

* GEORGE KOCH, CHIEF DAM SAFETY, STATE OF NEW YORK D.E.C.

N. F. DUNLEVY Recorder

* PRESENT ONLY AT SECOND INSPECTION ON AUGUST 2, 1978

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	Suspected seepage below dam. South abutment area very wet with substantial amount of fern plant growth. Extensive amounts of dampness at numerous locations on downstream face.	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	South abutment exhibits large area with wetness.	
DRAINS	No drains observed from dam. Drain from valve pit discharging due to valve leaks.	
WATER PASSAGES	N/A	
FOUNDATION	Only observed spillway foundation where seepage was occurring at joint of spillway concrete and rock. The seepage follows in weathered seams in gneiss.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Two large surface cracks on downstream face at location of abutment with the valley sections on either side. Extensive spalling of downstream surface.	
STRUCTURAL CRACKING	Bastion areas has severe cracking. Complete fracture of non-reinforced columns and wall sections above water line. Portions at top half have moved as much as 3 inches to the north.	
VERTICAL & HORIZONTAL ALIGNMENT	Vertical uplift movement of the roadway near the bastion.	
MONOLITH JOINTS (CYCLOPEAN MASONRY)	A number of joints have severely deteriorated between masonry elements.	
CONSTRUCTION JOINTS	No problem area observed. No joints observed.	
STAFF GAGE OF RECORDER	None.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	N/A.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	N/A.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	N/A.	
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	N/A.	
RIPRAP FAILURES	N/A.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	N/A.	
ANY NOTICEABLE SEEPAGE	N/A.	
STAFF GAGE AND RECORDER	N/A.	
DRAINS	N/A.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Good condition. Some horizontal cracks. Leakage between concrete and foundation rock. Follows weathered seams in gneiss. Joint in center is spread slightly.	Grout. Under certain conditions freeze-thaw may lead to cracking of concrete.
APPROACH CHANNEL	None.	
DISCHARGE CHANNEL	Rock. Bedded, foliated rock. Under bridge south spillway wall has a rock cavity, possibly from discharge or from construction. Cavity shows considerable weathering along seams in gneiss.	Cavity should be filled and surface above cavity covered to lessen potential rock-fall along foliation which could weaken bridge foundation.
BRIDGE AND PIERS	Good condition. Except bastion area next to bridge.	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	None.	
APPROACH CHANNEL	None.	
DISCHARGE CHANNEL	None.	
BRIDGE AND PIERS	None.	
GATES AND OPERATION EQUIPMENT	None.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Valve leaks and another leak into the valve pit at southeast corner in concrete wall at location of pipe.	Outlet pipe is cast iron.
INTAKE STRUCTURE	None.	
OUTLET STRUCTURE	Pipe discharging into stilling pool. No problems at outlet location. Some leaks noted above in valve pit.	
OUTLET CHANNEL	Is stilling basin; see photographs.	Original basin destroyed in flood of October, 1955.
EMERGENCY GATE	None.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	No problems.	
SLOPES	No problems.	
APPROXIMATE NO. OF HOMES AND POPULATION	Downstream is Muscoot Dam. A number of homes are reported to be in the area. The Village of Katonah is approximately 1 mi. below dam, about 20 ft. above normal water levels.	A Town road crosses the bridge. The road is used as a schoolbus route and there are a significant number of people who use the reservoir for fishing.

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER	None.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Rock outcropping along backs of reservoir. Drainage area slopes above reservoir.	
SEDIMENTATION	None observed.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE 1

NAME OF DAM Cross River

ID # NY 38

ITEM	REMARKS
AS-BUILT DRAWINGS	See this report.
REGIONAL VICINITY MAP	See this report.
CONSTRUCTION HISTORY	See this report.
TYPICAL SECTIONS OF DAM	See this report.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS	See this report.
RAINFALL/RESERVOIR RECORDS	None.

ITEM	REMARKS
DESIGN REPORTS	Not available.
GEOLOGY REPORTS	Not available.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Not available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Not available.
POST-CONSTRUCTION SURVEYS OF DAM	Not available.
BORROW SOURCES	Not available.

ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	None.
HIGH POOL RECORDS	None.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None known to inspection team.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None.
MAINTENANCE OPERATION: RECORDS	See N.Y.C. Board of Water Supply

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	See this report.
OPERATING EQUIPMENT PLANS & DETAILS	See this report.

CHECK LIST
HYDROLOGIC & HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 29.80 sq. mi.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 329.55

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 329.55

ELEVATION MAXIMUM DESIGN POOL: 340.00

ELEVATION TOP DAM: 340.00

CREST:

a. **Elevation** 329.55
b. **Type** Concrete capped weir on rock into chute spillway.
c. **Width** 4 feet
d. **Length** 240.00
e. **Location Spillover** North abutment.
f. **Number and Type of Gates** None.

OUTLET WORKS: (Drawdown)

a. **Type** Conduit pipes (see this report)
b. **Location** Center section of dam.
c. **Entrance Inverts** 224.00
d. **Exit Inverts** 205 ±
e. **Emergency Draindown Facilities** None other than outlet works.

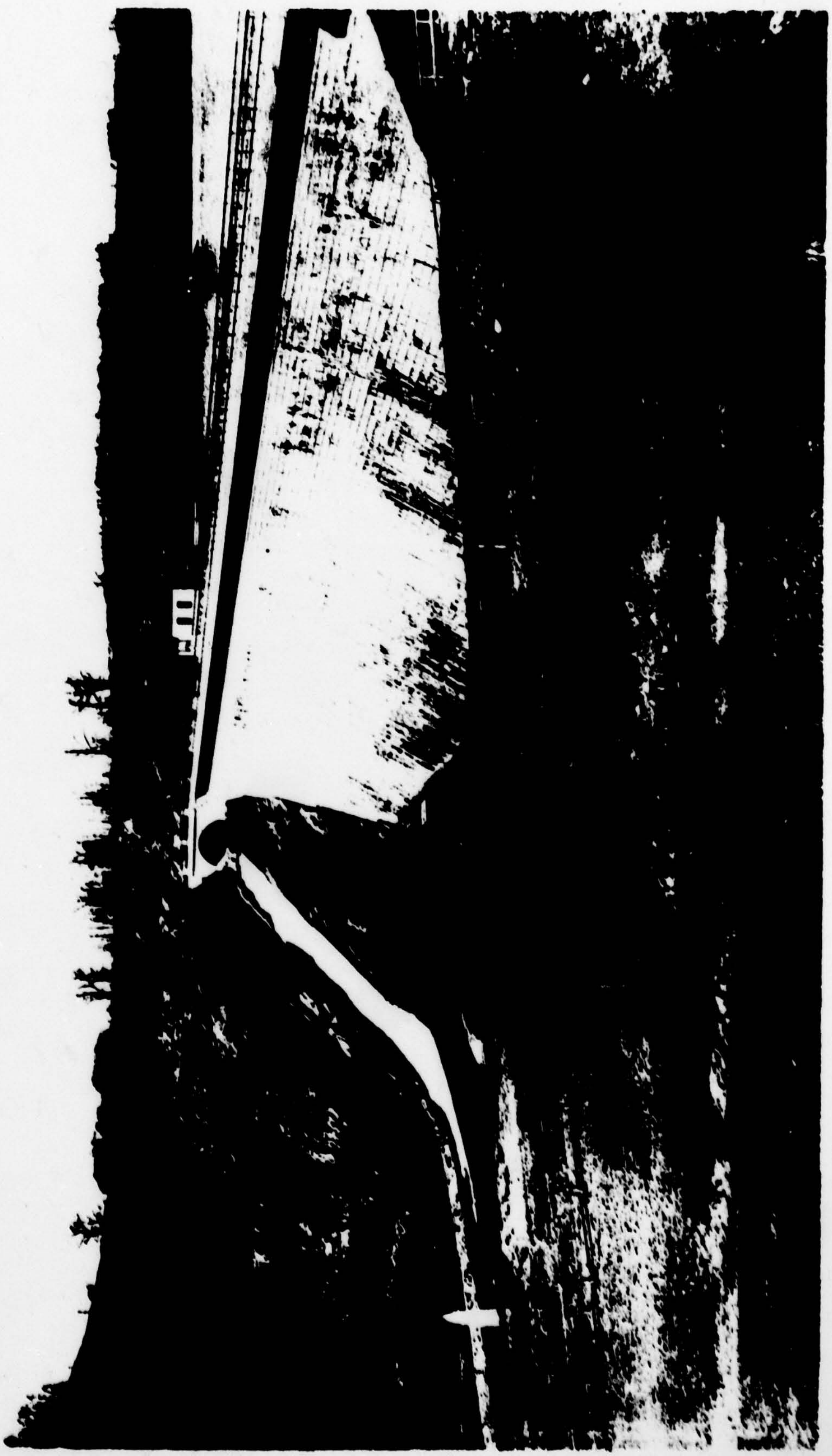
HYDROMETEOROLOGICAL GATES:

a. **Type** None
b. **Location** None
c. **Records** None

MAXIMUM NON-DAMAGING DISCHARGE: ----

APPENDIX B

PREVIOUS INSPECTION REPORTS



APPENDIX C

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

DALE

DESIGN BRIEF

DESIGNED BY: NFD — DATE: 8.7.78
CHECKED BY: — PAGE: C-1 OF:
PROJECT NO.: 2210 — SHORT TITLE: NY DAM INSPECTION
DESIGN SUBJECT: CROSS RIVER DAM — REF. DWGS.:

ESTIMATE OF CLARK'S PARAMETERS

ESTIMATE OF T_C (BPR)

$T_C = (11.9\,L^3/H)^{.385} = ((11.9 \times 7 \times 5280)/700)^{.385} = 11.95$ HRS

SCS

$L = \dfrac{l^{.8}(S+1)^{.7}}{1900\,Y^{.5}} = \dfrac{(36,960)^{.8}(3.89+1)^{.7}}{1900\,(1.9)^{.5}}$ $\qquad S = \dfrac{1000}{CN} - 10 = 3.89$

$= \dfrac{13710.6}{2622} = 5.23$

$T_C = L/.6 = 5.23/.6 = 8.71$

NORTH ATLANTIC DIV WATER RESOURCES STUDY (FEB 72)

$T_C + R = 10\,(c)\,(DA/S)^{.25} = 10\,(1.80)\,(27.8/100)^{.25}$
$T_C + R = 13.2$ HRS

$R/T_C + R = .40 \qquad R = 5.3 \qquad T_C = 7.9$

$L = 7$ MI
$\Delta H = 700$ ft
EST $\Delta H_{10-85} = 600$ ft

$S = 100$

DALE

DESIGN BRIEF

DESIGNED BY NFD | DATE 8.7.78
CHECKED BY | PAGE C-2 OF
PROJECT NO. 2210 SHORT TITLE NY DAM INSPECTIONS
DESIGN SUBJECT CROSS RIVERS DAM | REF. DWGS.

ESTIMATE OF SNYDER'S PARAMETERS

640 C_P =
C_P = 0.60
C_T =

$t_p = C_t (L \times L_{ca})^{0.3}$
$5.93 = C_t (10.966 \cdot 5.473)^{0.3}$
$5.93 = C_t (60.02)^{0.3}$
$5.93 = C_t (3.4)$
$C_t = 1.75$

$t_r = t_p / 5.5 =$

$t_{pr} = t_p + 0.25 (t_R - t_r)$
$6.41 = t_p + 0.25 (3.0 - \frac{t_p}{5.5})$

$6.41 = t_p + (.75 - .045 t_p)$
$6.41 = t_p + .75 - .045 t_p$
$5.66 = .955 t_p$
$5.93 = t_p$

SUMMARY OF PARAMETERS

CLARK'S
BPR T_c = 11.95
SCS (CN METHOD) T_c = 8.71
NORTH ATLANTIC DIV T_c = 7.90

SNYDER'S
t_{pr} =
C_p =

$R/(T_c + R)$ =

DALE

DESIGN BRIEF

DESIGNED BY H.D. | DATE A-5 4, 1978
CHECKED BY | PAGE C-3 OF
PROJECT NO. 2210 | SHORT TITLE N.Y. STATE DAM INSPECTION
DESIGN SUBJECT CROSS RIVER | REF. DWGS.

CROSS RIVER DAM
D-A-D RELATIONSHIP*

Area	Duration	Depth	%
10 mi²	6 HR	26.0	100
10	12	30.0	125
10	24	33.0	138
10	48	36.5	152
10	72	38.0	158
200	6	17.5	73
200	12	20.8	86
200	24	24.0	100
200	48	27.5	115
200	72	29.3	122
1000	6	12.5	52
1000	12	15.7	65
1000	24	19.5	81
1000	48	22.5	94
1000	72	23.5	98

PMP INDEX RAINFALL - 24.0 inches

RATIOS FOR PROJECT AREA FOR DURATIONS: (29.8 sq. mi)

6 HR	96
12 HR	111
24 HR	124
48 HR	139
72 HR	146

* from "Hydrometeorological Report No. 51"

DALE

DESIGN BRIEF

DESIGNED BY N.FO   DATE 8.4.78

CHECKED BY   PAGE C-4 OF

PROJECT NO. 7210   SHORT TITLE NY DAM INSPECTION

DESIGN SUBJECT CROSS RIVERS DAM   REF. DWGS.

D-A-D RELATIONSHIPS

DURATION   DEPTH   % OF INDEX

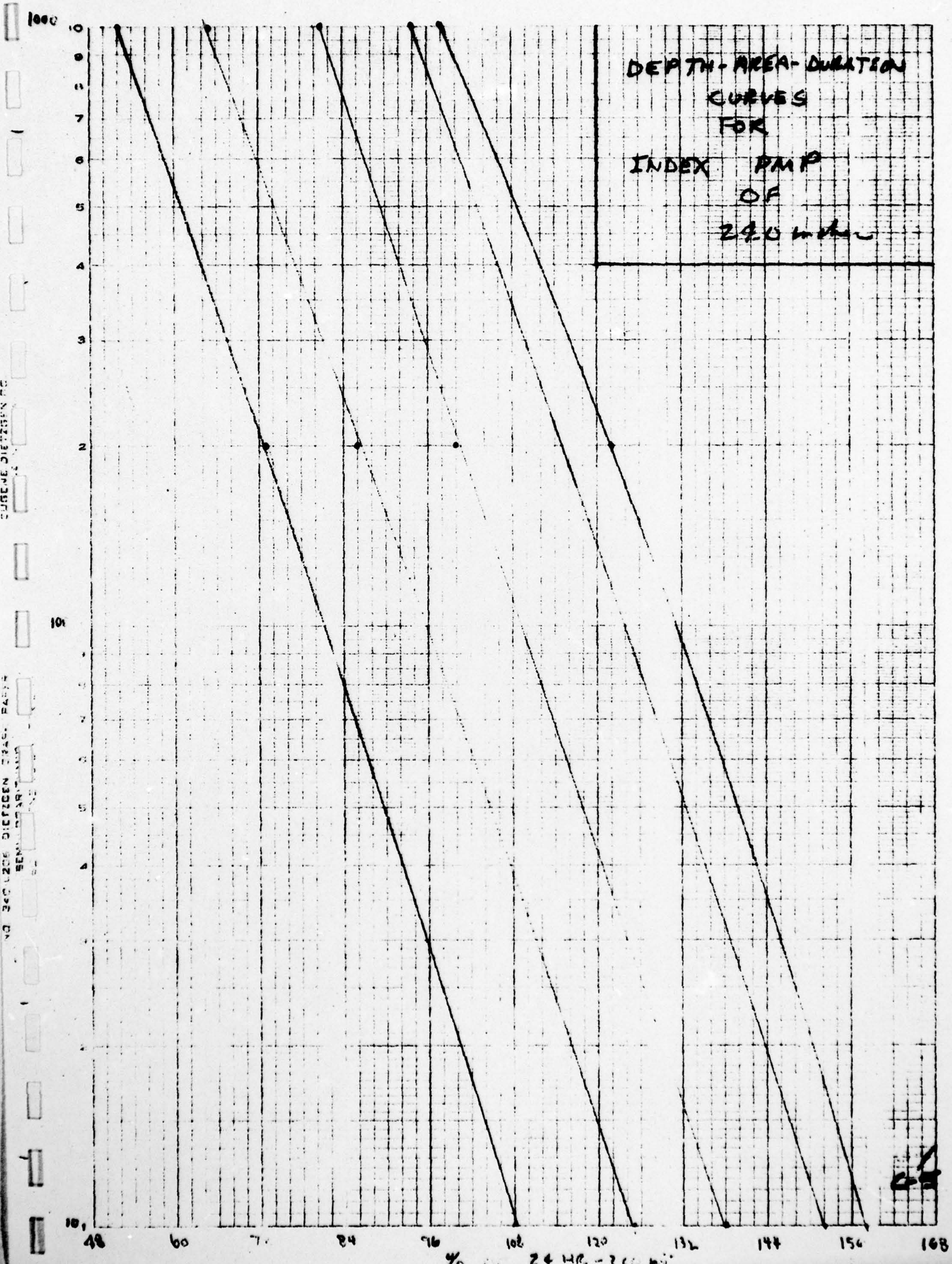
BASE FLOW

2.0 cfs

LOSS RATES

INITIAL LOSS = 1.0

CONSTANT LOSS =



DEPTH-AREA-DURATION
CURVES
FOR
INDEX PMP
OF
240 inches
1000
10
9
8
7
6
5
4
3
2
101
10,
48
60
72
84
96
108
120
132
144
156
168
% of 24 HR. - 200 mi

DALE

DESIGN BRIEF

DESIGNED BY NFD | DATE 8.5.78
CHECKED BY | PAGE 66 OF
PROJECT NO. 2210 | SHORT TITLE
DESIGN SUBJECT CROSS RIVER DAM | REF. DWGS.

UNIT HYDROGRAPH VERIFICATION
WITH STORM OF OCT 1955

ASSUMED BASE FLOW OF 60 CFS
OVER SPILLWAY. WITH FLASHBOARDS
FLOW DEPTH IS 2.00 FEET AS
ANTECEDENT CONDITION. FLASHBOARDS MAY HAVE
BEEN LOST DURING STORM.

RAINFALL FROM LOWER HUDSON STUDY GAGE
#24 WAS USED FOR RAINFALL DISTRIBUTION

TOTAL RAINFALL AT GAGE #24 IS 10.5 in.

TOTAL RAINFALL AT DAM WAS 11.0 in.

LOSS RATE Initial 1.0 in.
Continuous 0.1 in/hr

	CFS	Time
UHCOMP. Peak (prior to reservoir routing)	6907	16/13
HEC-1 Peak (after routing)	3282	16/19
Measurement at dam — (depth of flow 4.5') $Q = 3.3 \cdot 240 \cdot 3.0$	4150	16/19
HEC-1 flow at measurement time	3282	16/19

DALE

DESIGN BRIEF

DESIGNED BY HED

DATE 8.5.78

CHECKED BY

PAGE C-7 OF

PROJECT NO. 2710

SHORT TITLE

DESIGN SUBJECT CROSS RIVER DAM

REF. DWGS.

THE LIMITED DATA AVAILABLE FOR THIS VERIFICATION INDICATES THAT THE CLARK UNIT HYDROGRAPH PARAMETERS AND THE LOSS RATE PARAMETERS ARE EXCEPTABLE. MORE WORK COULD BE PERFORMED GIVEN TIME TO COLLECT SUFFICIENT DATA TO REFINE THIS ANALYSIS. THE DATA PROVIDED HEREIN IS THEREFORE ESTIMATED TO BE CLOSE ENOUGH TO COMPUTED 1/2 PMF AND PMF DISCHARGES.

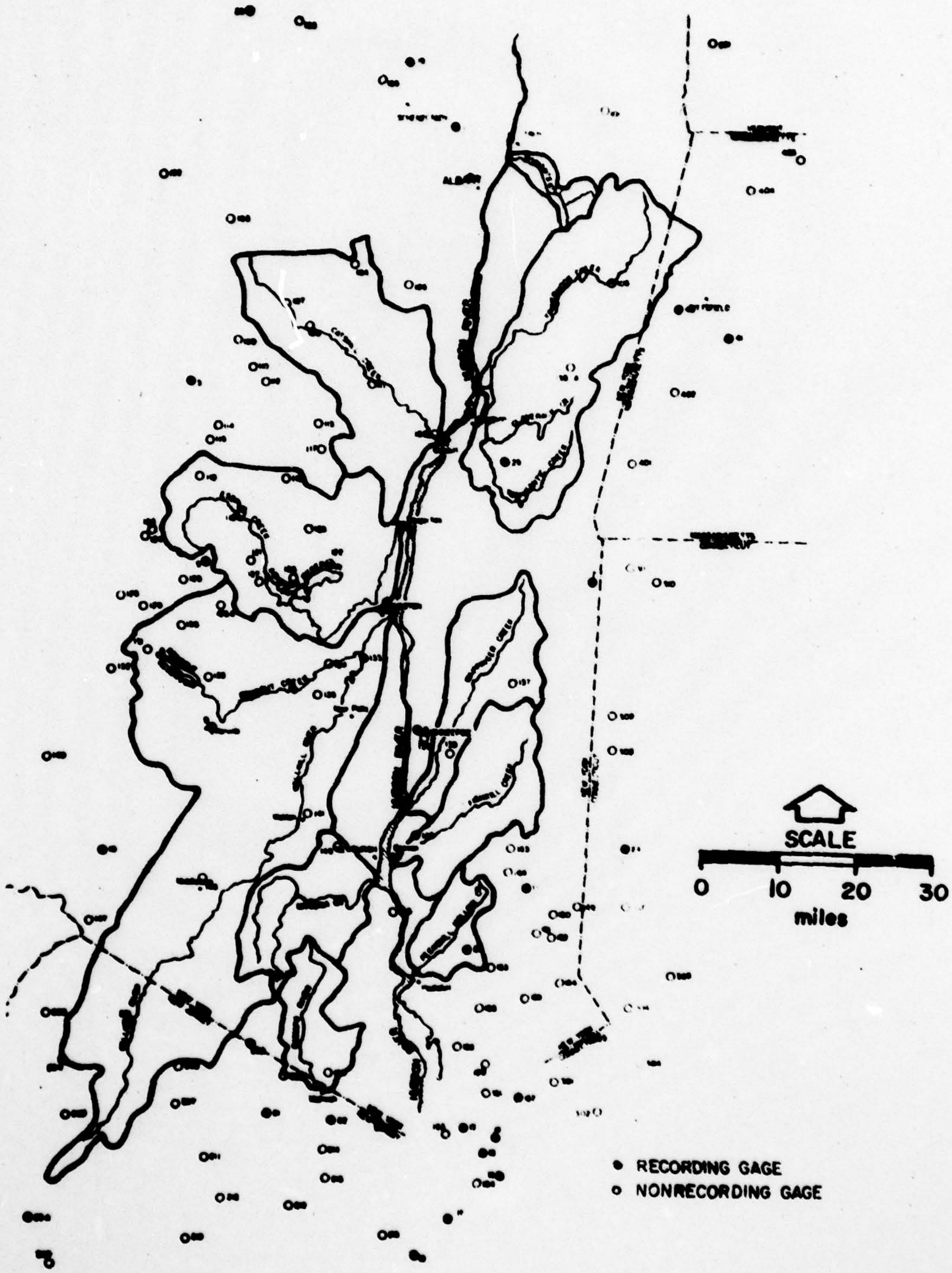


FIGURE 7. PRECIPITATION GAGING STATIONS

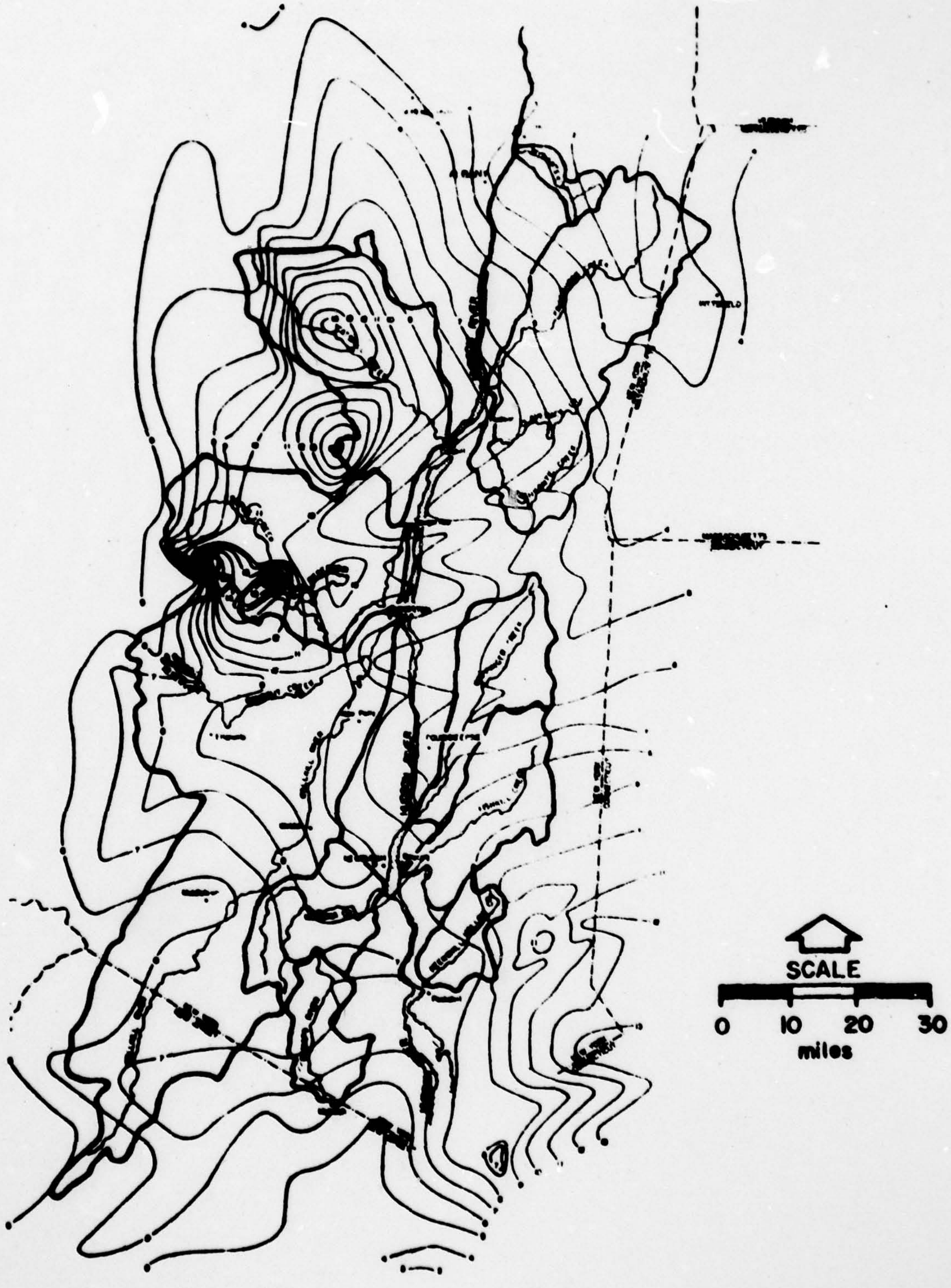


FIGURE 11. TOTAL RAINFALL (INCHES) 14-18 OCTOBER 1955

-44-

C-9

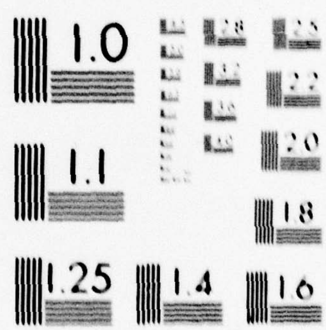
AD-A073 608 NEW YORK STATE DEPT OF ENVIRONMENTAL CONSERVATION ALBANY F/G 13/2
NATIONAL DAM SAFETY PROGRAM. CROSS RIVER DAM (ID NUMBER NY38), --ETC(U)
SEP 78 J B STETSON DACW51-78-C-0035

UNCLASSIFIED NL

2 OF 2

AD
A073608

END
DATE
FILMED
10-79
DDC



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

TABLE 7
3-HOUR RAINFALL DISTRIBUTION (Cont'd)

OCTOBER 1955

Gage \ Hour	14							15								16								17			
	6	9	12	15	18	21	24	3	6	9	12	15	18	21	24	3	6	9	12	15	18	21	24	3	6	9	12
3			.04	.07	.15	.44	.15	.06	.05	.28	.36	.35	.41	.80	1.12	.93	.76	.10	.08	.09	.14	.18	.13	.09	.10	.10	
5	.15	.35	.60	.90	1.50	2.60	1.10	.43	.20	.87	2.00	.80	1.50	1.65	1.10	1.30	.45	.20	.35	.27	.15	.08	.11	.23	.08	.03	
6			.02	.08	.01	.03	.08	.03	.14	.80	1.10	.09	.40	1.85	1.75	INCOMPLETE											
7				.06	.08	.11	.24	.20	.35	.40	.70	.10		.07	.38	.27	.58	.18	.03	.19	.10	.10	.01	.11	.06	.12	
8				.07	.04	.13	.10	.11	.03	.25	.86	.19	.36	.85	1.13	.92	.31	.09	.21	.18	.06	.05	.08	.03	.10	.17	.03
9			.09	.30	.56	.80	.29	.11	.04	.11	.90	1.95	1.25	1.25	.39	.43	.12	.02	.06	.09	.14	.22	.07	.04	.07	.10	
10			.04	.31	.72	1.18	.61	.08	.01		.19	.76	1.00	1.08	.42	.13	.02	.05	.15	.10	.05	.05		.04	.09	.06	
11			.12	.20	.55	.60	.40	.07	.05	.53	1.04	.16	1.40	1.60	1.45	.82	.03		.05			.10		.01	.19	.15	.02
12		.07	.02	.26	.55	.44	.38	.07	.01	.20	.48	.79	.88	1.20	1.20	.45	.02	.03	.05	.02		.10	.05	.05	.10	.27	.21
13		.05	.13	.92	.92	.17	.06		.04	.24	.42	1.28	2.33	.15	.64	.05		.04	.42	.01			.09	.07	.13	.02	
14		.06	.10	.50	.40	.09	.03	.02	.06	.19	.51	.88	1.32	.35	.67	.04	.01	.05	.66	.04			.09	.13	.07		
15		.07	.14	.82	.70	.10	.03		.05	.24	.37	.73	2.41	.29	.55	.03	.06	.41	.69	.01			.14	.15	.11		
16		.04	.16	.71	.89	.23	.04	.01	.04	.10	.23	.51	1.18	.83	.36	.21	.08	.07	1.92	.10	.02		.04	.23	.09		
17				.47	.80	.05						.16	.78	.05	.19	.11	.03	.99	.08	.36			.14	.19	.01		
21		.06	.08	.82	1.40	.44	.02	.06	.02			.48	.28	.06	.66	.20	.24	.06	.07	.23	.10	.04		.02	.16	.04	
23				.41	1.21	.28	.04			.04	.05	.38	.46	.48	.29	.29		.04	.14	.16	.01	.03		.09	.27	.06	
24		.14	.12	.40	.74	1.05	.42	.23	.35	.65	.20	.20	1.05	2.05	1.50	.70	.05	.05	.11	.02	.02	.02			.32	.11	.03

OCT 1955

...low spillway... Plus (...

...GE: RESERVOIRS

NEW CROTON

COOT Contents	CROTON Elev. Spillway is the Permanent Flashboard 201.56	CROTON Contents
4,914		
5,705	201.56	28,110
47	48	49
5425	-0.70	7585
5425	-0.70	7585
5427	-0.71	7577
5409	-0.74	7555
5397	-0.77	7532
5393	-0.78	7525
5481	-0.56	7690
5545	-0.40	27810
5605	-0.25	27922
5645	-0.15	27997
5665	-0.10	28035
5677	-0.07	28057
5685	-0.05	28072
5699	-0.04	28090
5896	+0.46	[illegible]
7741	+3.84	31043
7195	+2.92	30318
6740	+2.23	[illegible]
6452	+1.72	29394
6307	+1.41	29160
6207	+1.19	28794
[illegible]	+1.05	[illegible]
6053	+0.91	28783
6058	+0.85	29139
6029	+0.78	[illegible]
5958	+0.68	28613
5954	+0.60	[illegible]
5934	+0.55	[illegible]
5917	+0.51	[illegible]
5925	+0.53	[illegible]
6198	+1.17	[illegible]

...riod beginning at 8 A.M.

...based on actual ...

...in million gallons

ORIGINAL

DAILY RECORD OF [illegible] (Inches)

[illegible] WATERSHED

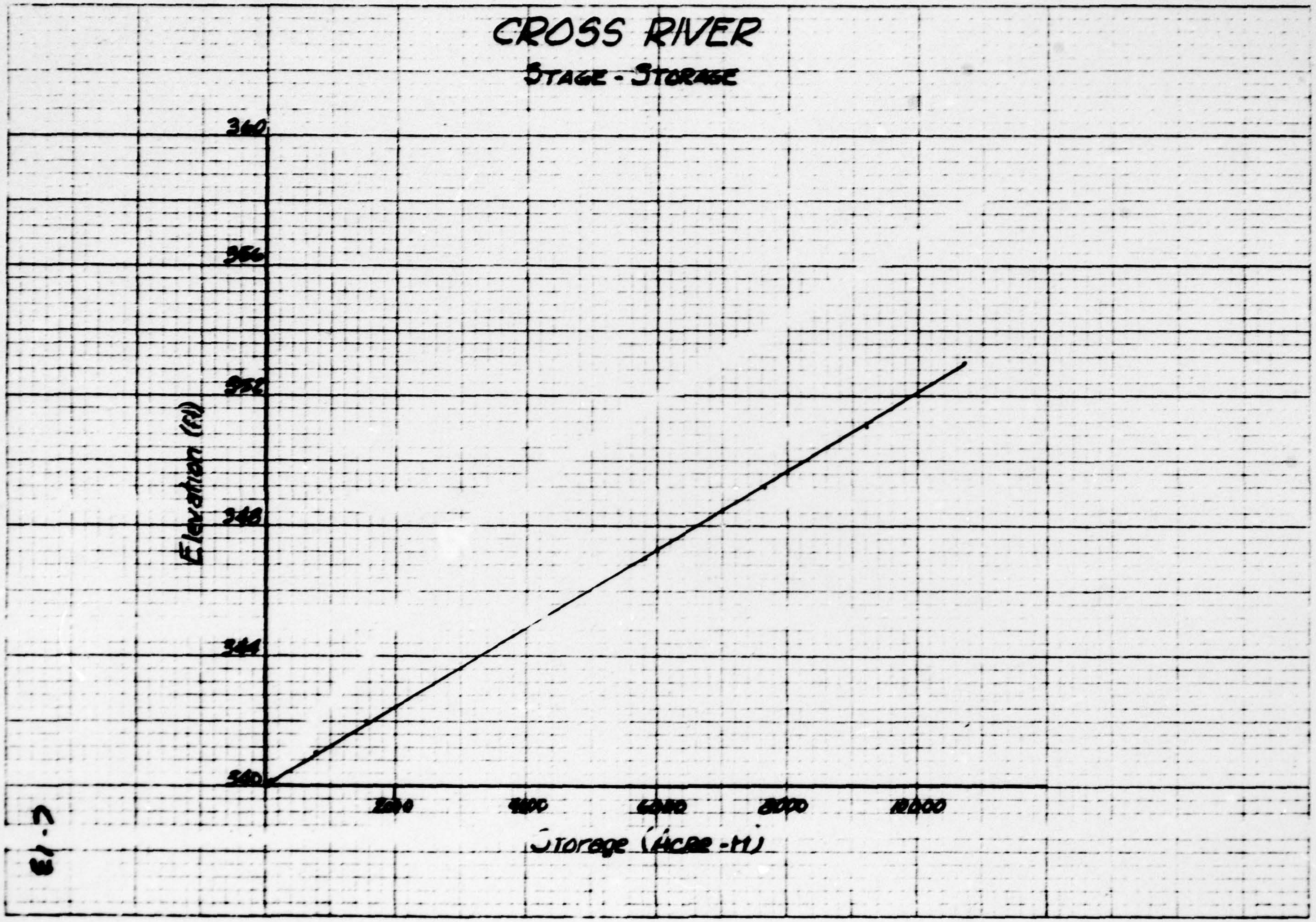
CATSKILL - CROTON DIVISION

MONTH. OCTO. [illegible]

DATE	[illegible]	Boyds Corner	West Branch	Middle Branch	East Branch	Croton Falls	Titicus	Cross River	Amawalk	Croton Lake	DAILY AVERAGE	TOTAL FOR WEEK	TOTAL
[illegible]												1.177	[illegible]
1												1.177	[illegible]
2													
3													
4													
5	[illegible]	[illegible]	0.[illegible]	0.53	0.[illegible]	0.[illegible]	0.[illegible]	0.40	0.33	0.56	0.50[illegible]		
6	[illegible]	[illegible]	1.[illegible]	0.97	0.[illegible]7	1.[illegible]	0.[illegible]	0.[illegible]	1.10	1.58	1.1[illegible]		
7	[illegible]	[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.41	0.28	0.[illegible]		
8	[illegible]	[illegible]	0.11	0.13	0.[illegible]7	0.[illegible]7	0.[illegible]3	0.14	0.05	0.27	0.1[illegible]	1.882	4[illegible]
9													
10													
11													
12													
13	[illegible]	[illegible]	[illegible]	0.0[illegible]	0.[illegible]	0.[illegible]		0.[illegible]		0.01	0.0[illegible]		
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.65	2.20	2.7[illegible]		
15		[illegible]	[illegible]	0.[illegible]	0.[illegible]	[illegible]	[illegible]	0.[illegible]	5.95	6.10	7.0[illegible]	[illegible]	[illegible]
16		[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.46	0.46	0.[illegible]		
17		[illegible]	0.[illegible]	0.[illegible]	0.[illegible]		0.[illegible]	0.[illegible]	0.05		0.0[illegible]		
18			[illegible]	0.2[illegible]	0.[illegible]	0.0[illegible]	0.[illegible]	0.[illegible]	0.01	0.03	0.1[illegible]		
19			[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible]			0.0[illegible]		
20													
21													
22												0.777	5[illegible]
23													
24			[illegible]	[illegible]	[illegible]	0.[illegible]	[illegible]	0.[illegible]	0.22	0.19	0.[illegible]		
25													
26													
27													
28													
29		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.[illegible]	1.37	0.80	0.[illegible]	0.901	[illegible]
30		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.27	[illegible]	[illegible]		
31											0.0[illegible]	[illegible]	[illegible]
Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13.92	[illegible]	[illegible]	[illegible]	[illegible]

R[illegible]

C-1[illegible]


CROSS RIVER
STAGE - STORAGE
Elevation (Ft)
360
356
352
348
344
340
2000
4000
6000
8000
10000
Storage (Acre-Ft)

```
UNIT GRAPH AND HYDROGRAPH COMP JULY 1966 (REVISED AUGUST 1974)
YDROLOGIC ENGINEERING CENTER (HEC)
AVIS,CA


--- OPERATIONS AVAILABLE ---

IME INT = SET TIME INTERVAL OF ALL COMPUTATIONS
UNIT H  = COMPUTE UH BY INPUT, CLARK, OR SNYDER
RAIN    = INPUT RAIN AND LOSS RATE DATA
UNOFF   = INPUT BASEFLOW, COMPUTE & PRINT HYDROGRAPH
PNT     = PRINT UNIT HYDROGRAPH ONLY
STOP    = STOP EXECUTION OF PROGRAM

USER MUST SELECT OPERATION DESIRED
MAY RETURN TO ANY OPERATION


SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)      1
ENTER TIME INTERVAL(MIN)=  180.

SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)      2
ENTER DRAINAGE AREA (SQMI) =     29.80
SELECT 1-3 (1=INPUT UH, 2=CLARK, 3=SNYDER )        2
ENTER NUMBER OF TIME-AREA ORDINATES (0=NONE)=      0
ENTER CLARKS TC AND R (HRS) =         7.90        5.30

     TP        CP        TC        R

     6.41      0.5[illegible]4     7.90      5.30

SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)      3
ENTER RATIO  IMPERVIOUS =          0.00
SELECT 1-3 ( 1=RAIN, 2=SPS, 3=PMS )        1
ENTER NUMBER PERIODS OF RAIN =     21
ENTER RAINFALL (IN/TIME INT) =
      0.14      0.12      0.40      0.74      1.05      0.42      0.2[illegible]      0.35
      0.65      0.02      0.20      1.05      2.05      1.50      0.7[illegible]      0.05
      0.05      0.11      0.02      0.02      0.02
ENTER STORM TOTAL (0=SUM OF RAIN) (IN) =          11.00
SELECT 1-3 (1=INIT+CONST, 2=ACUM LOSS, 3=SCS)        1
ENTER INITIAL LOSS(IN), CONSTANT LOSS(IN/HR) =      1.00        0.10

SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)      4
ENTER A TITLE PLEASE -   CROSS RIVER OCT 1955
ENTER STRTQ,QRCSN,AND RTIOR =         60.00    60.00     1.00

 HR MIN   RAIN   LOSS EXCESS   UNIT HG    RECSN      FLOW
  3   0   0.16   0.16   0.00     460.       60.        60.
  6   0   0.13   0.13   0.00    1439.       60.        60.
  9   0   0.44   0.44   0.00    1750.       60.        60.
 12   0   0.82   0.47   0.35    1214.       60.       224.
 15   0   1.17   0.30   0.87     679.       60.       971.
 18   0   0.47   0.30   0.17     379.       60.      2004.
 21   0   0.26   0.26   0.00     212.       60.      2252.
```

24	[illegible]0	0.39	0.30	0.09	119.	60.	1693.
27	[illegible]C	0.72	0.30	0.42	67.	60.	1316.
30	[illegible]0	0.02	0.02	0.00	37.	60.	1342.
33	[illegible]C	0.22	0.22	0.00	21.	60.	1195.
36	[illegible]0	1.17	0.30	0.87	12.	60.	1201.
39	[illegible]0	2.28	0.30	1.98		60.	2649.
42	[illegible]0	1.67	0.30	1.37		60.	5303.
45	[illegible]	0.78	0.30	0.48		60.	6907.
48	[illegible]0	0.06	0.06	0.00		60.	6213.
51	[illegible]0	0.06	0.06	0.00		60.	4271.
54	[illegible]0	0.12	0.12	0.00		60.	2526.
57	[illegible]0	0.02	0.02	0.00		60.	1439.
60	[illegible]0	0.02	0.02	0.00		60.	831.
63	[illegible]0	0.02	0.02	0.00		60.	489.
66	[illegible]0					60.	301.
69	[illegible]C					60.	196.
72	[illegible]0					60.	131.
75	[illegible]C					60.	87.
78	[illegible]0					60.	66.
81	[illegible]0					60.	60.
84	[illegible]0					60.	60.
87	[illegible]0					60.	60.
90	[illegible]0					60.	60.
93	[illegible]0					60.	60.
96	[illegible]0					60.	60.
TOTAL		11.00	4.40	6.60	6396.	1920.	44146.

SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)

****
HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01
****

CROSS RIVER DAM
RESERVOIR ROUTING OVER STRUCTURE OF STORM OF OCT. 1955
INCLUDES SERVICE SPILLWAY ONLY

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
30	1	0	0	0	0	0	0	0	0

JOPER	NWT
3	0

**********   **********   **********   **********   **********

SUB-AREA RUNOFF COMPUTATION

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
0	0	0	0	0	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	0	29.00	0.0	0.0	0.0	0.0	0	0	0

INPUT HYDROGRAPH

60.	60.	60.	224.	971.	2004.	2252.	1693.	1316.	1342.
1195.	1201.	2649.	5303.	6907.	6213.	4271.	2526.	1439.	831.
409.	301.	196.	131.	87.	66.	60.	60.	60.	60.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	6907.	4645.	1819.	1460.	44027.
INCHES		1.45	2.27	2.29	2.29
AC-FT		2304.	3611.	3640.	3640.

**********   **********   **********   **********   **********

HYDROGRAPH ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
0	1	0	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.0	0.0	1	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.0	0.0	0.0	-1.

STORAGE=	0.	770.	1540.	2310.	3080.	3850.	4620.	0.	0.	0.
OUTFLOW=	0.	800.	2260.	4153.	6394.	8935.	11746.	0.	0.	0.

TIME	EOP STOR	AVG IN	EOP OUT
1	58.	60.	60.
2	58.	60.	60.
3	58.	60.	60.
4	64.	142.	67.
5	106.	598.	110.
6	215.	1408.	224.
7	366.	2128.	381.
8	492.	1973.	512.
9	571.	1505.	593.
10	629.	1329.	654.
11	678.	1269.	705.
12	717.	1198.	745.
13	809.	1925.	875.
14	1047.	3976.	1325.
15	1413.	6105.	2028.
16	1756.	6568.	2799.
17	1939.	5242.	3255.
18	1958.	3399.	3282.
19	1853.	1983.	3039.
20	1718.	1135.	2684.
21	1559.	660.	2306.
22	1412.	395.	2018.
23	1277.	249.	1761.
24	1154.	164.	1529.
25	1046.	109.	1323.
26	950.	77.	1141.
27	867.	63.	985.
28	797.	60.	850.
29	735.	60.	763.
30	679.	60.	706.
SUM			36831.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3282.	2894.	1518.	1228.	36831.
INCHES		0.98	1.89	1.92	1.92
AC-FT		1436.	2997.	3045.	3045.

********** ********** ********** ********** **********

RUNOFF SUMMARY, AVERAGE FLOW

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	0	6987.	4645.	1819.	1468.	29.80
ROUTED TO	0	3282.	2894.	1518.	1228.	29.80

```
OLNFF
00100 A  CROSS RIVER DAM
0110 A RESERVOIR ROUTING OVER STRUCTURE OF STORM OF OCT. 1955
0120 A INCLUDES SERVICE SPILLWAY ONLY
0130 B     30         1
0140 I      3
0150 K      0
0160 O     -1               29.8
00170 O    60        60        60       224       971      2004      2252      1693      1316      1302
0180 O   1195      1201      2649      5303      6987      6213      4271      2526      1439       831
0190 O    409       301       196       131        87        66        60        60        60        60
0200 K      1
0210 Y                                    1
0220 1      1                                                         -1
0230 2              770      1540      2300      3080      3850      4620
0240 3              800      2260      4153      6394      8935     11746
0250 K     99
0260 A
0270 A
0280 A
```

```
DAVIS,CA


--- OPERATIONS AVAILABLE ---

TIME INT = SET TIME INTERVAL OF ALL COMPUTATIONS
UNIT H   = COMPUTE UH BY INPUT, CLARK, OR SNYDER
RAIN     = INPUT RAIN AND LOSS RATE DATA
RUNOFF   = INPUT BASEFLOW, COMPUTE & PRINT HYDROGRAPH
PNT      = PRINT UNIT HYDROGRAPH ONLY
STOP     = STOP EXECUTION OF PROGRAM

USER MUST SELECT OPERATION DESIRED
MAY RETURN TO ANY OPERATION


SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)      1
ENTER TIME INTERVAL(MIN)=  180.


SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)      2
ENTER DRAINAGE AREA (SQMI) =     29.80
SELECT 1-3 (1=INPUT UH, 2=CLARK, 3=SNYDER )       2
ENTER NUMBER OF TIME-AREA ORDINATES (0=NONE)=     0
ENTER CLARKS TC AND R (HRS) =        7.90      5.30

      TP       CP       TC       R

    6.41    0.584    7.90    5.30


SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)      3
ENTER RATIO  IMPERVIOUS =        0.00
SELECT 1-3 ( 1=RAIN, 2=SPS, 3=PMS )        3
ENTER PMS INDEX RAINFALL (IN) = 24.00
ENTER R6,R12,R24,R48,R72,R96 =      96.00   111.00   124.00   139.00   146.00
ENTER TRSPC AND TRSDA (SQMI) =            0.00       29.80
SELECT 1-3 (1=INIT+CONST, 2=ACUM LOSS, 3=SCS)        1
ENTER INITIAL LOSS(IN), CONSTANT LOSS(IN/HR) =      1.00       0.10


SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)      4
ENTER A TITLE PLEASE -   CROSS RIVER PMF
ENTER STRTQ,QRCSN,AND RTIOR =       60.00    60.00     1.00

 HR MIN  RAIN  LOSS EXCESS  UNIT HG    RECSN     FLOW
  3   0  0.06  0.06  0.00     468.      60.       60.
  6   0  0.06  0.06  0.00    1439.      60.       60.
  9   0  0.18  0.18  0.00    1750.      60.       60.
 12   0  0.18  0.18  0.00    1214.      60.       60.
 15   0  0.77  0.62  0.15     679.      60.      130.
 18   0  1.56  0.30  1.26     379.      60.      865.
 21   0  0.09  0.09  0.00     212.      60.     2136.
 24   0  0.09  0.09  0.00     119.      60.     2447.
 27   0  0.52  0.30  0.22      67.      60.     1794.
 30   0  0.52  0.30  0.22      37.      60.     1392.
```

33	0	1.50	0.30	1.20	21.	60.	1833.
36	0	1.50	0.30	1.20	12.	60.	3286.
39	0	6.35	0.30	6.05		60.	7293.
42	0	12.89	0.30	12.59		60.	18537.
45	0	0.78	0.30	0.48		60.	31447.
48	0	0.78	0.30	0.48		60.	31726.
51	0	0.03	0.03	0.00		60.	21747.
54	0	0.03	0.03	0.00		60.	12743.
57	0	0.08	0.08	0.00		60.	7266.
60	0	0.08	0.08	0.00		60.	4092.
63	0	0.36	0.30	0.06		60.	2344.
66	0	0.73	0.30	0.43		60.	1612.
69	0	0.04	0.04	0.00		60.	1487.
72	0	0.04	0.04	0.00		60.	1275.
75	0					60.	802.
78	0					60.	391.
81	0					60.	242.
84	0					60.	158.
87	0					60.	115.
90	0					60.	91.
93	0					60.	77.
96	0					60.	70.
99	0					60.	65.
102	0					60.	60.
105	0					60.	60.
TOTAL		29.22	4.88	24.34	6398.	2100.	157824.

```
SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)        1
ENTER TIME INTERVAL(MIN)=  180.

SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)        2
ENTER DRAINAGE AREA (SQMI) =      29.80
SELECT 1-3 (1=INPUT UH, 2=CLARK, 3=SNYDER )          2
ENTER NUMBER OF TIME-AREA ORDINATES (0=NONE)=       0
ENTER CLARKS TC AND R (HRS) =          7.90        5.30

       TP        CP       TC        R

    6.41    0.584     7.90     5.30

SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)        3
ENTER RATIO  IMPERVIOUS =          0.00
SELECT 1-3 ( 1=RAIN, 2=SPS, 3=PMS )          2
ENTER SPS INDEX RAINFALL (IN) = 12.00
ENTER TRSPC AND TRSDA (SQMI) =               1.00       29.80
SELECT 1-3 (1=INIT+CONST, 2=ACUM LOSS, 3=SCS)         1
ENTER INITIAL LOSS(IN), CONSTANT LOSS(IN/HR) =       1.00         0.10

SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)        4
ENTER A TITLE PLEASE -   CROSS RIVER SPF
ENTER STRTQ,QRCSN,AND RTIOR =        60.00    60.00     1.00
```

HR	MIN	RAIN	LOSS	EXCESS	UNIT HG	RECSN	FLOW
3	0	0.01	0.01	0.00	468.	60.	60.
6	0	0.01	0.01	0.00	1439.	60.	60.
9	0	0.03	0.03	0.00	1750.	60.	60.
12	0	0.03	0.03	0.00	1214.	60.	60.
15	0	0.10	0.10	0.00	679.	60.	60.
18	0	0.20	0.20	0.00	379.	60.	60.
21	0	0.02	0.02	0.00	212.	60.	60.
24	0	0.02	0.02	0.00	119.	60.	60.
27	0	0.05	0.05	0.00	67.	60.	60.
30	0	0.05	0.05	0.00	37.	60.	60.
33	0	0.13	0.13	0.00	21.	60.	60.
36	0	0.13	0.13	0.00	12.	60.	60.
39	0	0.45	0.37	0.08		60.	97.
42	0	0.91	0.30	0.61		60.	460.
45	0	0.08	0.08	0.00		60.	1078.
48	0	0.08	0.08	0.00		60.	1225.
51	0	0.35	0.30	0.05		60.	878.
54	0	0.35	0.30	0.05		60.	600.
57	0	0.94	0.30	0.64		60.	767.
60	0	0.94	0.30	0.64		60.	1368.
63	0	3.30	0.30	3.00		60.	3677.
66	0	6.70	0.30	6.40		60.	9365.
69	0	0.58	0.30	0.28		60.	15919.
72	0	0.58	0.30	0.28		60.	16145.
75	0	0.02	0.02	0.00		60.	11154.

```
  78   0  0.02  0.02  0.00                     60.    6589.
  81   0  0.05  0.05  0.00                     60.    3777.
  84   0  0.05  0.05  0.00                     60.    2140.
  87   0  0.17  0.17  0.00                     60.    1224.
  90   0  0.35  0.30  0.05                     60.     736.
  93   0  0.03  0.03  0.00                     60.     495.
  96   0  0.03  0.03  0.00                     60.     348.
  99   0                                       60.     214.
 102   0                                       60.     103.
 105   0                                       60.      82.
 108   0                                       60.      71.
 111   0                                       60.      66.
 114   0                                       60.      63.
 117   0                                       60.      62.
 120   0                                       60.      61.
 123   0                                       60.      61.
 126   0                                       60.      60.
 129   0                                       60.      60.

TOTAL     16.76  4.68 12.08      6398.      2580.   79866.


SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)      1
ENTER TIME INTERVAL(MIN)=  180.


SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)      2
ENTER DRAINAGE AREA (SQMI) =     29.80
SELECT 1-3 (1=INPUT UH, 2=CLARK, 3=SNYDER )        2
ENTER NUMBER OF TIME-AREA ORDINATES (0=NONE)=      0
ENTER CLARKS TC AND R (HRS) =        7.90      5.30

      TP       CP       TC        R

    6.41   0.584     7.90     5.30


SELECT 1-6 (1=TIME INT,2=UNIT H,3=RAIN,4=RUNOFF,5=PNT,'6=STOP)      3
ENTER RATIO  IMPERVIOUS =        0.00
SELECT 1-3 ( 1=RAIN, 2=SFS, 3=PMS )        1
ENTER NUMBER PERIODS OF RAIN =     21
ENTER RAINFALL (IN/TIME INT) =
```

CROSS RIVER
WEIR FLOW PROGRAM

GIVE C,L

3.33 240.00
GIVE ELEVATION TO START FLOW AND HEIGHT 330 20

ELEV	331	FT	DISCHARGE	799.	CFS
ELEV	332	FT	DISCHARGE	2260.	CFS
ELEV	333	FT	DISCHARGE	4153.	CFS
ELEV	334	FT	DISCHARGE	6394.	CFS
ELEV	335	FT	DISCHARGE	8935.	CFS
ELEV	336	FT	DISCHARGE	11746.	CFS
ELEV	337	FT	DISCHARGE	14801.	CFS
ELEV	338	FT	DISCHARGE	18084.	CFS
ELEV	339	FT	DISCHARGE	21578.	CFS
ELEV	340	FT	DISCHARGE	25273.	CFS
ELEV	341	FT	DISCHARGE	29157.	CFS
ELEV	342	FT	DISCHARGE	33222.	CFS
ELEV	343	FT	DISCHARGE	37460.	CFS
ELEV	344	FT	DISCHARGE	41865.	CFS
ELEV	345	FT	DISCHARGE	46429.	CFS
ELEV	346	FT	DISCHARGE	51149.	CFS
ELEV	347	FT	DISCHARGE	56018.	CFS
ELEV	348	FT	DISCHARGE	61033.	CFS
ELEV	349	FT	DISCHARGE	66189.	CFS
ELEV	350	FT	DISCHARGE	71482.	CFS

DALE

DESIGN BRIEF

DESIGNED BY: NFO
DATE: 8-6-78
CHECKED BY:
PAGE: C-29 OF
PROJECT NO.: 2210
SHORT TITLE: Dam Simplification [illegible]
DESIGN SUBJECT: Crois River Dam
REF. DWGS.

SPILLWAY CAPACITY ANALYSIS

	UHCOMP (above dam)		HEC-1 (at dam)	
PMF	31226	CFS	28532	CFS
				depth of flow over spillway
½ PMF	16145	CFS	13814	CFS
				depth of flow over spillway

Assumed only weir flow over spillway. Did not compute capacity of side-discharge spillway and investigate possibility of weir submergence.

```
******************************
HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01
******************************
                    CROSS RIVER DAM
                     RESERVOIR ROUTING OVER STRUCTURE OF PMF
                    INCLUDES SERVICE SPILLWAY ONLY

                                        JOB SPECIFICATION
                          NQ   NHR  NMIN  IDAY   IHR  IMIN METRC  IPLT  IPRT NSTAN
                          30     3     0     0     0     0     0     0     0     0
                                           JOPER    NWT
                                               3      0


        *********      *********      *********      *********      *********

                                   SUB-AREA RUNOFF COMPUTATION
                           ISTAQ  ICOMP  IECON  ITAPE   JPLT   JPRT  INAME
                               0      0      0      0      0      0      0

                                          HYDROGRAPH DATA
                 IHYDG   IUHG  TAREA   SNAP  TRSDA  TRSPC  RATIO  ISNOW  ISAME  LOCAL
                    -1      0  29.00    0.0    0.0    0.0    0.0      0      0      0

                                          INPUT HYDROGRAPH
      60.      130.      865.     2136.     2447.     1794.     1392.     1833.     3206.     7293.
   18537.    31447.    31726.    21747.    12743.     7264.     4092.     2344.     1612.     1407.
    1275.      802.      391.      242.      158.      115.       91.       77.       70.       65.

                                PEAK    6-HOUR   24-HOUR   72-HOUR   TOTAL VOLUME
                       CFS    31726.    31507.    16056.     6544.       157523.
                    INCHES                9.06     21.05     24.51         24.59
                     AC-FT               15671.    33451.    38957.        39075.


        *********      *********      *********      *********      *********

                                        HYDROGRAPH ROUTING
                           ISTAQ  ICOMP  IECON  ITAPE   JPLT   JPRT  INAME
                               0      1      0      0      0      0      0
                                           ROUTING DATA
                                 QLOSS  CLOSS    AVG   IRES  ISAME
                                   0.0    0.0    0.0      1      0

                           NSTPS  NSTDL    LAG  AMSKK      X    TSK   STORA
                               1      0      0    0.0    0.0    0.0     -1.
```

STORAGE	0.	770.	1540.	2310.	3080.	4620.	6160.	7700.	9240.	10780.
OUTFLOW	0.	800.	2260.	4153.	6394.	11746.	18004.	25273.	33220.	41065.

TIME	EOP STOR	AVG IN	EOP OUT
1	58.	60.	60.
2	65.	95.	60.
3	160.	490.	166.
4	453.	1301.	471.
5	846.	2292.	944.
6	1002.	2121.	1392.
7	1122.	1593.	1460.
8	1151.	1613.	1523.
9	1359.	2560.	1910.
10	2010.	5290.	3415.
11	3720.	12915.	8619.
12	6443.	24992.	19404.
13	8332.	31507.	28532.
14	8060.	26737.	27131.
15	6521.	17245.	19771.
16	4934.	10805.	13040.
17	3676.	5679.	8466.
18	2751.	3210.	5436.
19	2113.	1970.	3660.
20	1710.	1550.	2670.
21	1459.	1301.	2107.
22	1245.	1039.	1700.
23	1023.	597.	1200.
24	830.	317.	913.
25	679.	200.	705.
26	554.	137.	575.
27	450.	103.	460.
28	366.	84.	380.
29	298.	74.	310.
30	245.	68.	255.
SUM			156061.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	28532.	27032.	16300.	6404.	156061.
INCHES		8.69	20.35	24.29	24.40
AC-FT		13800.	32347.	38604.	38911.

**********　　**********　　**********　　**********　　**********

RUNOFF SUMMARY, AVERAGE FLOW

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	0	31726.	31507.	16056.	6544.	29.00
ROUTED TO	0	28532.	27032.	16300.	6404.	29.00

```
00100 A  CROSS RIVER DAM
0110 A  RESERVOIR ROUTING OVER STRUCTURE OF SPF
0120 A  INCLUDES SERVICE SPILLWAY ONLY
0130 B     30       3
0140 1      3
0150 K      0
0160 M     -1              29.8
00170 M     60      97     460    1078    1225     878     600     767    1568    3677
0180 M   9365   15919   16145   11154    6509    3777    2140    1224     736     495
0190 M    308     214     103      82      71      66      63      61      61      60
0200 K      1
0210 Y                              1
0220 1      1                                              -1
0230 2      0     770    1540    2310    3080    4620    6160    7700    9240   10780
0240 3      0     800    2260    4153    6394   11746   18004   25273   33220   41865
0250 K     99
0260 A
0270 A
0280 A
```

[illegible]
UPDATED AUG 74
CHANGE NO. 01
****

CROSS RIVER DAM
RESERVOIR ROUTING OVER STRUCTURE OF SPF
INCLUDES SERVICE SPILLWAY ONLY

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
30	3	0	0	0	0	0	0	0	0

JOPER	NWT
3	0

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
0	0	0	0	0	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	0	29.00	0.0	0.0	0.0	0.0	0	0	0

0 INPUT HYDROGRAPH

60.	97.	446.	1070.	1225.	870.	600.	767.	1560.	3677.
9365.	15919.	16145.	11154.	6509.	3777.	2140.	1224.	736.	495.
340.	214.	103.	82.	71.	66.	63.	61.	61.	60.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	16145.	16032.	8596.	3280.	79003.
INCHES		5.00	10.73	12.29	12.34
AC-FT		7954.	17050.	19525.	19617.

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
0	1	0	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.0	0.0	1	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.0	0.0	0.0	-1.

STORAGE=	0.	770.	1540.	2310.	3080.	4620.	6160.	7700.	9240.	10780.
OUTFLOW	0.	800.	2260.	4153.	6394.	11746.	18084.	25273.	33228.	41865.

TIME	EOP STOR	AVG IN	EOP OUT
1	58.	60.	60.
2	62.	79.	64.
3	109.	279.	113.
4	253.	769.	263.
5	440.	1152.	466.
6	577.	1052.	599.
7	608.	739.	631.
8	619.	684.	643.
9	734.	1168.	763.
10	1111.	2623.	1446.
11	2098.	6521.	3632.
12	3716.	12642.	8683.
13	4983.	16032.	13239.
14	5050.	13650.	13516.
15	4269.	8072.	10527.
16	3343.	5183.	7309.
17	2564.	2959.	4893.
18	1965.	1682.	3305.
19	1522.	900.	2226.
20	1199.	616.	1613.
21	960.	422.	1160.
22	783.	201.	825.
23	638.	159.	663.
24	513.	93.	533.
25	413.	77.	429.
26	333.	69.	346.
27	272.	65.	282.
28	223.	62.	232.
29	186.	61.	193.
30	157.	61.	163.
SUM			78735.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	13516.	13378.	8128.	3246.	78735.
INCHES		4.18	10.15	12.16	12.29
AC-FT		6637.	16130.	19327.	19531.

**********   **********   **********   ********+**   **********

RUNOFF SUMMARY, AVERAGE FLOW

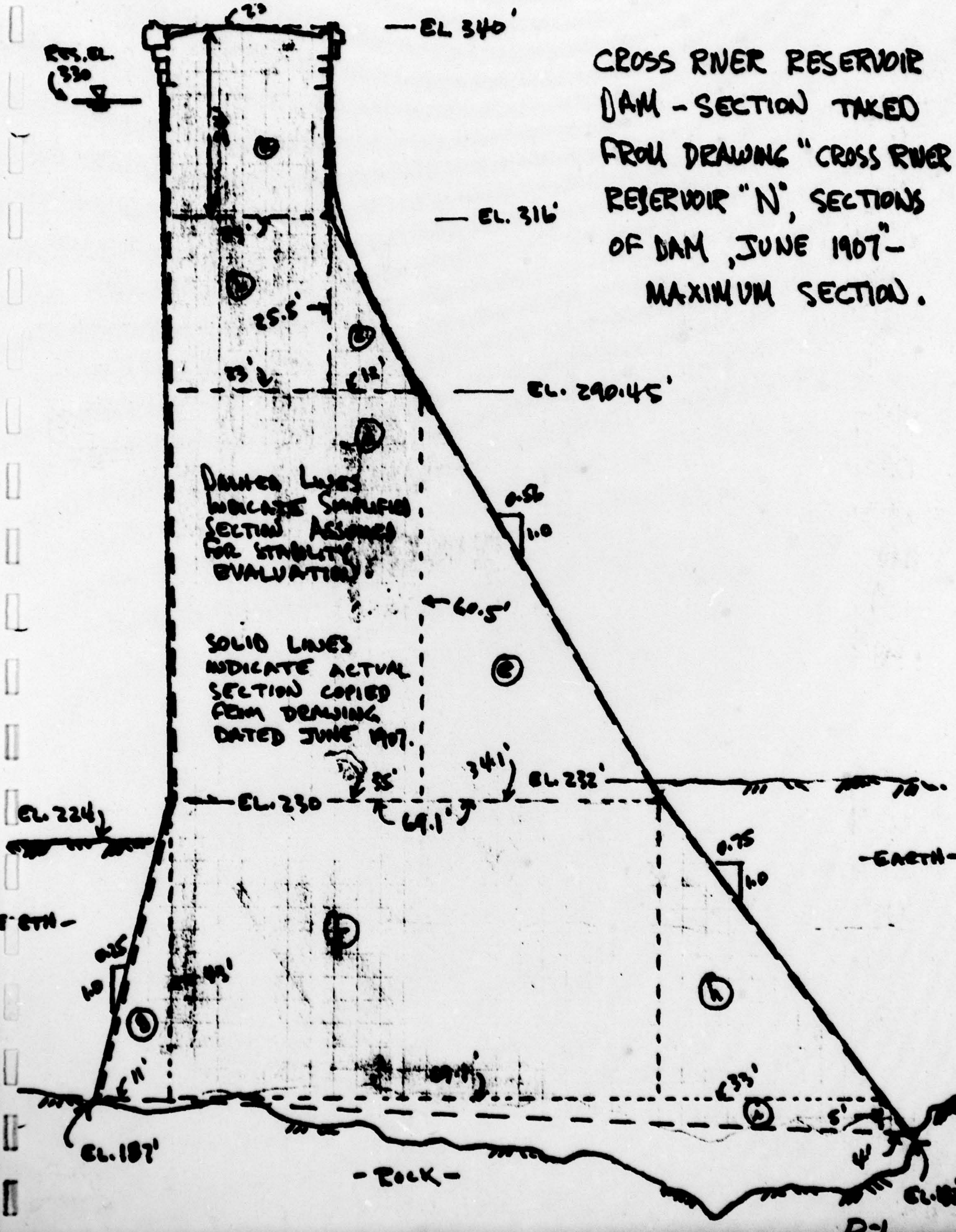
		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	0	16145.	16032.	8596.	3280.	29.00
ROUTED TO	0	13516.	13378.	8128.	3246.	29.00

```
0LNHF+
00100 A CROSS RIVER DAM
0110 A RESERVOIR ROUTING OVER STRUCTURE OF PMF
0120 A INCLUDES SERVICE SPILLWAY ONLY
0130 B     30       3
0140 1      3
0150 K
0160 N     -1            29.8
0170 N     60     130     865    2136    2447    1794    1392    1833    3206    7293
0180 N  18537   31447   31726   21747   12743    7266    4092    2344    1612    1087
0190 N   1275     802     391     242     150     115      91      77      70      65
0200 K      1
0210 Y                              1
0220 1      1                                              -1
0230 2            770    1540    2310    3080    4620    6160    7700    9240.  10780
0240 3            800    2260    4153    6394   11746   18004   25273   33220   41065
0250 K     99
0260 A
0270 A
0280 A
0SAVE
```

APPENDIX D

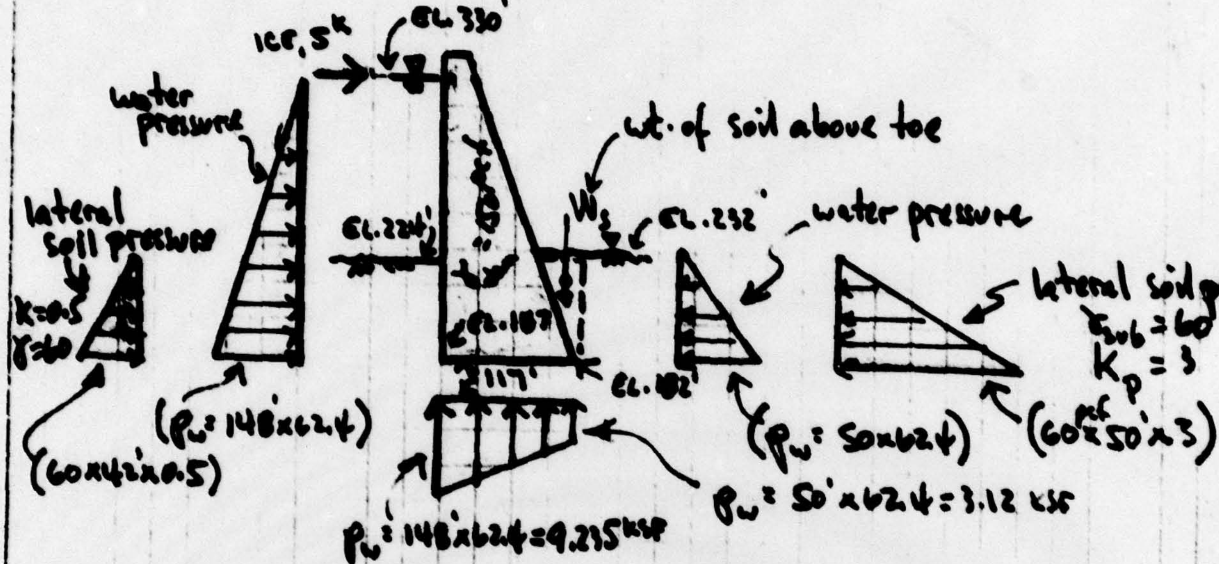
STABILITY ANALYSIS

CROSS RIVER RESERVOIR DAM - SECTION TAKEN FROM DRAWING "CROSS RIVER RESERVOIR "N", SECTIONS OF DAM, JUNE 1907" - MAXIMUM SECTION.



STABILITY – OVERTURNING & SLIDING

I. Assume following conditions
- WL and ice at spillway elevation (ref. sketch, elev. 330)
- downstream subsurface WL at ground surface
- uplift acts beneath base of dam



A. OVERTURNING

Forces causing overturning about toe = horiz. water press + horiz. soil press + ice + uplift

Moments about toe causing overturning

horiz. water pressure = $148' \times 62.4 \times \frac{148'}{2} \times \frac{148'}{3}$ = 33,715 $^{'k}$

horiz. Soil ~~pressure~~ = $42' \times 60 \times 0.5 \times \frac{42}{2} \times \frac{42}{3}$ = 371 $^{'k}$

ice = 5000# × 148' = = 740 $^{'k}$

uplift water press = $(3.12^{ksf} \times 117' \times \frac{117'}{2}) + (9.235 - 3.12^{ksf})(\frac{117}{2} \times \frac{2}{3} \times 117)$

= 21,355$^{'k}$ + 27,926$^{'k}$ = 49,280$^{'k}$

Total overturning (without uplift) = 34,825$^{'k}$

Total overturning (with uplift) = 84,105$^{'k}$

(CONT'D)

Forces resisting overturning about toe — mass of dam + horiz. water pressure (downstream) + horiz. soil pressure + weight soil above toe

<u>Moments about toe resisting overturning</u>

mass of dam (ref. sketch of section) = [(23' × 24' ⓐ × 94.5' × .150 pcf) + ...
+ (23' × 25.5' ⓑ × 94.5' × .150) + (1/2 × 25.5 × 12 ⓒ × 79.1 × .150) + ...
+ (35' × 60.5' ⓓ × 88.5' × .150) + (1/2 × 60.5 × 34.1 ⓔ × 59.7 × .150) + ...
+ (69.1 × 43 ⓕ × 71.5 × .150) + (1/2 × 43 × 11 ⓖ × 109.8 × .150) + ...
+ (1/2 × 43 ⓗ × 33 × 26 × .150) + (1/2 × 5 × 102 ⓘ × 38 × .150)] = 95,284 'K

horiz. soil pressure (passive) (γ_{sub} = 60 pcf, k_p = 3) = (60 pcf × 50' × 3 × 1/2 × 50 × 50/3) = 3,750 'K

horiz. water pressure = (50' × 62.4 pcf × 50/2 × 50/3) = 1,300 'K

soil above toe = (1/2 × 50 × 37 × 60 pcf × 37/3) = 685 'K

Total resistance to overturning;
including soil above toe = 101,019 'K
neglecting soil above toe = 100,334 'K

FS against overturning, including uplift, neglecting soil above toe

$$= \frac{100,334}{84,105} = 1.2 \pm$$

FS against overturning, neglecting uplift

$$= \frac{100,334}{34,825} = 2.9 \pm$$

B. <u>SLIDING</u>

Forces causing sliding ~ horiz. soil pressure behind dam + horiz. water pressure behind dam

horiz. soil pressure $= \left(60 \times 42 \times 0.5 \times \frac{42}{2}\right) = 26.5^k$

water pressure : $\left(148 \times 62.4 \times \frac{148}{2}\right) = 683.4^k$

Total $= 710^k$ (no ice)
$= 715^k$ (with ice)

Forces resisting sliding — soil and water pressure (lateral) behind dam + friction along base

horiz. soil pressure $= 60 \times 50 \times 3 \times \frac{50}{2} = 225^k$

horiz. water pressure $= 50 \times 62.4 \times \frac{50}{2} = 78^k$

friction along base $= f\,[\text{downward wt.} - \text{uplift}]$

where wt. downward of dam $= [(23 \times 24 ⓐ \times .150) + (23 \times 25.5 ⓑ \times .150) +$
$+ (\frac{1}{2} \times 25.5 ⓒ \times 12 \times .150) + (35 \times 60.5 ⓓ \times .150) + (\frac{1}{2} \times 60.5 ⓔ \times .150) +$
$+ (69.1 ⓕ \times 43 \times .150) + (\frac{1}{2} \times 43 ⓖ \times 11 \times .150) + (\frac{1}{2} \times 43 ⓗ \times 33 \times .150) +$
$+ (\frac{1}{2} \times 5 ⓘ \times 102 \times .150)] = 1142^k$

where wt. soil above toe $= (37 \times 50 \times \frac{1}{2} \times 60) = 55.5^k$

Total $= 1197.5^k$

where uplift $= \left(\frac{9.235 + 3.12}{2}\right)(117') = 722.8^k$ (ksf, ksf)

assume $f = 0.6$

friction $= (0.6)[1197.5 - 722.8] = 475^k$

FS against sliding $= \frac{225 + 78 + 475}{715} = \frac{778}{715} = 0.83 \pm$ (with uplift)

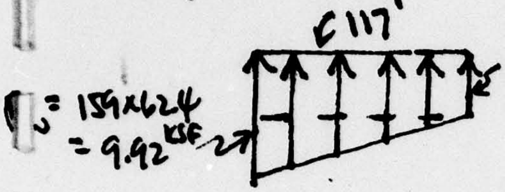
$= \frac{225 + 78 + 809}{715} = 1.6 \pm$ (no uplift)

II. Stability where WL tops dam one foot ~
water pressure behind dam increases, uplift increases

moments about toe (causing)

- horiz. water pressure = $\left(159' \times 62.4\,\text{pcf} \times \frac{159}{2} \times \frac{159}{3}\right) = 41{,}805^{1K}$

- uplift pressure at base changes to



moment $= \left(3.12^{KSF} \times 117 \times \frac{117}{2}\right) + (9.92 - 3.12)\left(\frac{117}{2} \times \frac{2}{3} \times 117\right)$
$= 21{,}355 + 31{,}028 = 52{,}383^{1K}$

- soil pressure (as for case I) $= 371^{1K}$

Total overturning moment $= 94{,}559^{1K}$

moments resisting overturning (as for case I) $= 100{,}334^{1K}$

FS against overturning $= \frac{100334}{94{,}559} = 1.06 \pm$ (with uplift)

$= \frac{100{,}334}{42{,}175} = 2.4 \pm$ (no uplift)

Sliding computation not perform since Case I results already unsatisfactory.

APPENDIX E

REFERENCES

APPENDIX E

REFERENCES

1. Department of the Army, Office of the Chief of Engineers. National Program of Investigation of Dams; Appendix D: Recommended Guidelines for Safety Inspection of Dams, 1976

2. Edward Wegmann: The Design and Construction of Dams, John Wiley and Sons (1918)

3. Charles H. Weidner: Water for a City - Rutgers University Press (1974)

4. The University of the State of New York - The State Education Department - State Museum and Science Service - Geological Survey: Geological Map of New York (1970)

5. John F. Cowan: Report to the Aqueduct Commission 1895-1907

6. U.S. Nuclear Regulatory Commission: Design Basis Floods for Nuclear Power Plants, Regulating Guide 1.59, Revision 2, August 1977

7. Water Resources Engineers, Inc., Lower Hudson River Basin, Hydrologic Flood Routing Model, January 1977

8. Linsley and Franzini: Water Resources Engineering, Second Edition, McGraw-Hill (1972)

9. Louis C. Schreiner and John T. Riedel: Hydrometeorological Report No. 51, U.S. Department of Commerce, National Oceanic and Atmospheric Administration National Weather Service, Office of Hydrology; Silver Springs, Maryland, September 1976

10. Ven Te Chow: Handbook of Applied Hydrology, McGraw-Hill, 1964

11. The Hydrologic Engineering Center: Computer Program 723-X6-L2010, HEC-1 Flood Hydrograph Package, User's Manual, Corps of Engineers, U.S. Army, 609 Second Street, Davis, California 95616, January 1973

12. The Hydrologic Engineering Center, Art Pabst: Computer Program UHCOMP, Unpublished, Corps of Engineers, U.S. Army, 609 Second Street, Davis, California 95616

13. North Atlantic Regional Water Resources Study Coordinating Committee: Appendix C, Climate, Meteorology and Hydrology, February 1972

14. Soil Conservation Service (Engineering Division): Urban Hydrology for Small Watersheds, Technical Release No. 55, U.S. Department of Agriculture, January 1975

15. H.W. King, E.F. Brater: Handbook of Hydraulics, McGraw-Hill, 5th Edition, 1963

16. Ven Te Chow: Open Channel Hydraulics, McGraw-Hill, 1959

17. Bureau of Reclamation, United States Department of the Interior, Design of Small Dams: A Water Resources Technical Publication, Third Printing, 1965

18. The Hydrologic Engineering Center, Regional Frequency Studies Upper Delaware and Hudson River Basins, New York District, November 1974

19. "Permeability Pore Pressure, and Uplift in Gravity Dams", by Roy W. Carlson, Transactions ASCE, Volume 122, 1957

20. Scotford, David M., 1956, Metamorphism and axial-plane folding in the Poundridge area, New York: Geological Society of America Bull., Volume 67, Page 1155-1198

21. New York State Geologic Survey Brittle Structures Map, 1977

APPENDIX F

NON-DESTRUCTIVE TESTING

construction technology laboratories
a Division of the PORTLAND CEMENT ASSOCIATION
5420 Old Orchard Road, Skokie, Illinois 60076 • Area Code 312 / 966-6200

August 15, 1978

Mr. Neal Dunlevy
Dale Engineering Company
Bankers Trust Building
Utica, New York 13501

<u>CONCERNS</u>: Inspection of Concrete Gravity Dams

Dear Mr. Dunlevy:

As discussed in our telephone conversation earlier today, I am enclosing a copy of information describing our nondestructive testing capabilities. In addition, I am enclosing a copy of the Construction Technology Laboratory Review describing specific jobs where this procedure has been employed.

In discussions with other members of our staff, I have determined that it is possible to measure internal hydrostatic pressure acting to reduce vertical compressive stresses in the concrete. We can develop a proposal to do work such as this.

As discussed, I would suggest that the dam you described be thoroughly evaluated using the pulse echo method of nondestructive testing. In addition, selective cores should be taken. Based on results of these findings, it should be possible to make recommendations for measures to assure continued safety of the dam.

We would be pleased to make a proposal for doing detailed evaluation of concrete dams.

Sincerely yours,

W. G. Corley, Director
Engineering Development Department

WGC/cag

Enclosure

construction technology laboratories

a Division of the PORTLAND CEMENT ASSOCIATION
5420 Old Orchard Road, Skokie, Illinois 60076
Area Code 312 / 966-6200

THE MICROSEISMIC TECHNIQUE OF NONDESTRUCTIVE TESTING

Microseismic techniques employing low frequency mechanical energy are used to detect, locate, and photographically record physical and mechanical discontinuities within solids. Concrete strength and modulus as well as the presence and orientation of surface and internal cracking can be determined.

Microseismic testing is based on Snells' Law of Reflection and Refraction of mechanical energy. Briefly, this physical law states that as a mechanical wave propagates through a material with a velocity V_1, a portion of that energy will be reflected as a second material is encountered. The wave will be reflected from the second material having a lower velocity V_2. The ratio of the reflected energy to the energy introduced is directly proportional to the ratio of velocities. For example, when a concrete to air interface is encountered approximately 90% of the energy is reflected. This is based on relative velocities of 15,000 ft/sec for concrete and 1,100 ft/sec for air. Should the discontinuity be filled with water, then a concrete to water interface is encountered and approximately 70% of the energy is reflected.

An electronic timing circuit is used to measure, in micro-seconds, the time used for the mechanical wave to enter the solid, propagate to the rear wall, and reflect back to the entry surface. When the distance the wave has traveled is known, a distance versus time relationship can be established and a compressional wave velocity V_c can be calculated. This value of V_c can then be used to determine an insitu compressive strength, (f_c') for the con-crete. This compressive strength is derived from established correlation charts or from correlations with concrete cores taken from the structure in question. In addition, a shear wave velocity V_s is calculated from the time measurement. Combining V_c and V_s, calculated values for Poissons Ratio and Young's Modulus, E_c, can be made.

A visualization of the reflected energy on a cathode ray tube makes possible, in some cases, the identification of internal discontinuities. For example, "ring down time" of the initial reflection will usually differentiate cracks from voids. Second and third reflections are used to identify microcracking, excessive air, and softening of the cement matrix.

The test equipment is portable and includes the following:

1) Visual display read out
2) Time and signal measuring device
3) Electro/mechanical transducer
4) Constant energy mechanical wave producer
5) Couplant

Test sequence includes the following procedure:

1) Select test locations
2) Prepare area
3) Apply couplant to transducer
4) Seal transducer to test surface
5) Produce mechanical wave at the test surface

Records including the following are obtained:

1) Visual display records electro/mechanical energy transfer
2) Time and signal is measured
3) Visual display is activated
4) Test data is displayed
5) Film type record is made (if necessary)

Further information can be obtained from:

Dr. W. Gene Corley, Director
Engineering Development Department
Portland Cement Association
5420 Old Orchard Road
Skokie, Illinois 60077
Phone: 312-966-6200, Ext. 413