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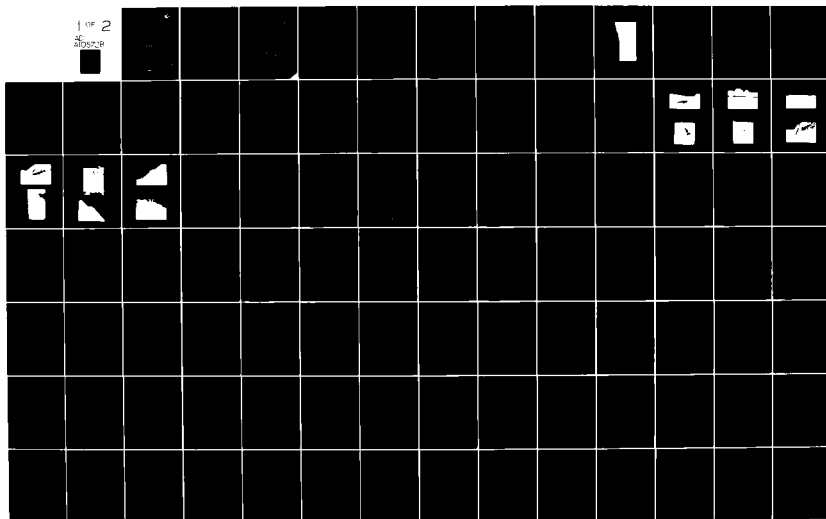
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NATIONAL DAM SAFETY PROGRAM. CHURCHTOWN DAM (INVENTORY NUMBER N--ETC(U)
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LOWER HUDSON RIVER BASIN

CHURCHTOWN DAM

COLUMBIA COUNTY, NEW YORK
INVENTORY NO. N.Y. 79

PHASE I INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM.

Churchtown Dam (Inventory Number NY. 79),
Lower Hudson River Basin, Columbia County,
New York. Phase I Inspection Report.



15) DACW51-79-C-0001

10) George /Koch/

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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. Visual inspection of this dam and engineering analyses which have been performed revealed that several serious deficiencies exist with this structure.		

Structural stability analyses, based on available information, indicate that this dam is marginally stable under normal loading conditions and is unstable when subjected to severe loading conditions (such as flood flows or ice loading). Seepage noted under and through the structure, creating wet, soft areas along the downstream toe along both ends of the dam, adversely affect the stability of the structure.

Using the Corps of Engineer's Screening Criteria for the initial review of spillway adequacy, it has been determined that the structure would be overtopped by all storms exceeding 45% of the Probable Maximum Flood (PMF). Stability analyses indicate that the dam is unstable when subjected to overtopping. A dam break analysis performed for this structure indicates that an overtopping induced dam failure would significantly increase the hazard to loss of life downstream of the dam from that which would exist just prior to failure. Therefore, the spillway is adjudged as "seriously inadequate" and the dam is assessed as "unsafe, non-emergency".

Immediately upon receipt of this notification, a system for providing around-the-clock surveillance of the dam during periods of unusually heavy precipitation should be developed and implemented. An emergency action plan for the notification of downstream residents should also be developed.

It is recommended that within 3 months of the date of notification of the owner, investigations into the deficiencies on this structure should be commenced. Studies of the structural stability and seepage problems, including subsurface and structural explorations are necessary. Information obtained should be incorporated into a detailed stability evaluation.

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PREFACE

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

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

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

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

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CHURCHTOWN DAM
I.D. No. NY 79
LOWER HUDSON RIVER BASIN
COLUMBIA COUNTY, NEW YORK

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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Churchtown Dam (I.D. No NY 79)
State Located:	New York
County:	Columbia
Watershed:	Lower Hudson River Basin
Stream:	Unnamed tributary of Taghkanic Creek
Date of Inspection:	October 29, 1980

ASSESSMENT

Visual inspection of this dam and engineering analyses which have been performed revealed that several serious deficiencies exist with this structure.

Structural stability analyses, based on available information, indicate that this dam is marginally stable under normal loading conditions and is unstable when subjected to severe loading conditions (such as flood flows or ice loading). Seepage noted under and through the structure, creating wet, soft areas along the downstream toe along both ends of the dam, adversely affect the stability of the structure.

Using the Corps of Engineer's Screening Criteria for the initial review of spillway adequacy, it has been determined that the structure would be overtopped by all storms exceeding 45% of the Probable Maximum Flood (PMF). Stability analyses indicate that the dam is unstable when subjected to overtopping. A dam break analysis performed for this structure indicates that an overtopping induced dam failure would significantly increase the hazard to loss of life downstream of the dam from that which would exist just prior to failure. Therefore, the spillway is adjudged as "seriously inadequate" and the dam is assessed as "unsafe, non-emergency".

→ Immediately upon receipt of this notification, a system for providing around-the-clock surveillance of the dam during periods of unusually heavy precipitation should be developed and implemented. An emergency action plan for the notification of downstream residents should also be developed.

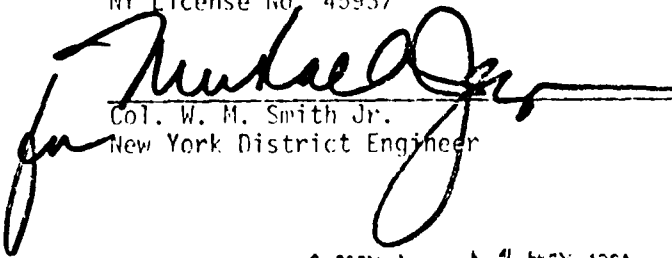
It is recommended that within 3 months of the date of notification of the owner, investigations into the deficiencies on this structure should be commenced. Studies of the structural stability and seepage problems, including subsurface and structural explorations are necessary. Information obtained should be incorporated into a detailed stability evaluation.

Additional hydrologic/hydraulic investigations are also needed to find a method to correct the spillway inadequacy. These studies should be performed in a conjunction with the stability analyses to determine the proper mitigating measures needed in response to the seriously "inadequate spillway" assessment. Remedial measures deemed necessary as a result of these investigations should be completed within 18 months.

Other deficiencies noted on this structure should also be corrected within 18 months. Among the actions required are repairing deteriorated concrete on the structure, removing trees, brush and vines growing on the dam and at the downstream toe and making the valve on the 18 inch reservoir drain pipe operable.


George Koch
Chief, Dam Safety Section
New York State Department
of Environmental Conservation
NY License No. 45937

Approved By:


Col. W. M. Smith Jr.
New York District Engineer

Date:

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OVERVIEW
CHURCHTOWN DAM
I.D. No. NY 79

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CHURCHTOWN DAM
I.D. No. NY 79
#228A-1009
LOWER HUDSON RIVER BASIN
COLUMBIA COUNTY, NEW YORK

SECTION 1: PROJECT INFORMATION

1.1 GENERAL

a. Authority

The Phase I inspection reported herein was authorized by the Department of the Army, New York District, Corps of Engineers, to fulfill the requirements of the National Dam Inspection Act, Public Law 92-367.

b. Purpose of Inspection

This inspection was conducted to evaluate the existing conditions of the dam, to identify deficiencies and hazardous conditions, to determine if these deficiencies constitute hazards to life and property, and to recommend remedial measures where required.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam

The Churchtown is a cyclopean masonry dam with an overflow spillway near the center of the structure.

The dam is 425 feet long and a maximum of 44 feet high. The crest width of the dam is 5 feet. The spillway section is 43 feet long with a crest elevation 3.8 feet below the top of the dam. There are provisions for flashboards across the spillway section but none are presently in place.

There is a gate house on the crest of the dam which contains the control mechanisms for four gates. One of these gates controls flow through a 16 inch water main leading to the chlorination plant. This gate is the only one operated regularly.

There is an 18 inch blowoff pipe through the base of the dam which was intended to act as a reservoir drain. However, the gate which controls flow through this pipe is reported to be inoperable.

b. Location

This dam is located on Reservoir Road in the Town of Taghkanic. It is approximately 3/4 mile south of the Village of Churchtown and 1 1/4 miles east of Glenco Mills.

c. Size Classification

This dam is 44 feet high and has a storage capacity of 308 acre-feet. Therefore, the dam is in the intermediate size category as defined by the "Recommended Guidelines for Safety Inspection of Dams".

d. Hazard Classification

The dam is classified as "high" hazard due to the presence of several houses downstream of the dam, as well as the damage which a dam break might cause near the Village of Glenco Mills.

e. Ownership

This dam is owned by the City of Hudson, New York. Mr. Charles Butterworth, Superintendent of Public Works, was contacted concerning the inspection. His address is 520 Warren Street, Hudson, New York 12534. His phone number is (518) 828-9458.

f. Purpose of Dam

This dam impounds a reservoir used for water supply by the City of Hudson.

g. Design and Construction History

This dam was constructed in 1908 by Hurd, Sherman & Company, Contractors. Mr. Cornelius C. Vermuele of New York designed the dam and provided construction supervision. Mr. H.E. Bishop, a former Chief Engineer of the Hudson Water Works also assisted in the design.

Leakage through the structure became a problem soon after the construction. This problem was studied in 1912 by Johnson and Fuller, Consulting Engineers, of New York and by Robert Horton, Consulting Hydraulic Engineer, of Albany. Further studies were performed in 1914 by Nicholas Hill, Consulting Engineer, of New York. He made recommendations and prepared plans for the repair of the structure. This work was performed in 1914 and consisted of the construction of a 6 inch thick reinforced concrete cutoff wall on the upstream face of the dam.

The leakage again reached unacceptable levels in 1957. The owner engaged Barker and Wheeler, Consultants, of Albany to make necessary investigations, plans and specifications for repairs. It is believed that these repairs were made and the leakage was reduced.

h. Normal Operating Procedures

There are no prescribed operating procedures for this structure. Water is withdrawn from the reservoir as required by the owner.

1.3 PERTINENT DATA

a. Drainage Area (acres) 683

b. Discharge at Dam (cfs)
Spillway at Maximum High Water (without flashboards) 758

Spillway at Maximum High Water (with flashboards) 508

c. <u>Elevation</u>	(Plan)	(USGS)	(Field)
Top of Dam	423	428	+3.8
Spillway Crest	420	425	0

d. Reservoir-Surface Area (acres)
Top of Dam 18
Spillway Crest 15

e. Storage Capacity (acre-feet)
Top of Dam 308
Spillway Crest 251

f. Dam
Type - Cyclopean masonry (concrete containing boulders at least 8 cu. ft. in size); Constructed in sections 50 feet long by 3 foot high.

Dam Length (ft) 425
Crest Width (ft) 5

g. Spillway
Type: Ungated, concrete overflow weir located near center of dam; Provisions for up to 1 foot of flashboards (2 inch pipes, 4 foot on centers)

Length: (ft) 43

h. Low-Level Outlets
Type: 16 inch water supply pipe; 18 inch blow off pipe
Control: Valve Control mechanisms located in gate house;
Valve for 16 inch pipe operable, valve for 18 inch pipe is inoperable.

i. Appurtenant Structures-Gatehouse
Brick Structure on crest of dam; contains control mechanism for 4 gates; only one of which is operated regularly.

SECTION 2: ENGINEERING DATA

2.1 GEOTECHNICAL DATA

a. Geology

The Churchtown Dam is located near the boundary of the Hudson lowlands physiographic province and the Taconic uplands physiographic province of New York State. The Hudson lowlands is an area 15 to 20 miles wide near the Hudson River which is underlain by weak sedimentary rocks. The lowlands in this vicinity have a narrow inner valley with a conspicuous terrace and gently rolling hills and ridges beyond this terrace. Rock underlying the Taconic uplands include limestones, sandstones and slates altered by faulting and folding. These mountains merge into the gently rolling hills at the edge of the Hudson lowlands. The surficial soils and features of the area are the result of glaciations during the Cenozoic Era, the last of which was the Wisconsin glaciation.

A review of the "Brittle Structures Map of the State of New York" indicates that there are no faults in the immediate vicinity of the dam. There is a high angle reverse fault approximately 1/4 mile west of the dam.

b. Subsurface Investigations

No records of any subsurface investigations performed in the vicinity of this structure could be located.

2.2 DESIGN RECORDS

No records from the original design of this structure were available. However, reports prepared both in 1912 and 1914 provided some information about the original design. The leakage problem caused concern for the stability of the structure and so these reports reviewed the structural stability computations performed by the designer, Mr. C.C. Vermuele. Further stability analyses were also performed by the engineers who prepared these reports, Mr. Nicholas Hill, who prepared the 1914 report, also designed modifications needed to repair the leakage. Plans for these modifications were available.

2.3 CONSTRUCTION RECORDS

The 1912 and 1914 reports as well as a 1905 magazine article (Engineering Record-April, 1905; see Appendix C) provide the only construction records available. These sources provide some information about the dam's foundation and about the concrete used in the structure.

2.4 OPERATIONS RECORDS

Water level readings for this reservoir are taken only when the water level drops below the spillway crest.

2.5 EVALUATION OF DATA

Data used for the preparation of this report was obtained from the Department of Environmental Conservation files and from the City of Hudson's Department of Public Works. The information available appeared to be reasonably accurate.

SECTION 3: VISUAL INSPECTION

3.1 FINDINGS

a. General

Visual inspection of the Churchtown Dam was conducted on October 29, 1980. The weather was overcast and the temperature was around 45 degrees. The water level at the time of the inspection was 0.1 feet above the spillway crest.

b. Dam

The visual inspection of the dam revealed a number of deficiencies on this structure. The most serious of these was seepage noted along the downstream toe on either side of the spillway. On the right side of the spillway, there was seepage and a soft area which extended for a distance of about 30 feet along the toe. The ground was very soft in an area which extended out about 15 feet from the toe. There was concentrated seepage noted at only one point but the total volume observed indicated that there was more than just one source of concentrated seepage. On the left side of the spillway, seepage was emerging from the downstream face of the dam. There was a wet area which extended for approximately 50 feet and covered the lower third of the downstream face. A soft wet area was noted out and away from the downstream toe on this section as well. This area extended from a point near the abutment where the seepage commenced over to the outlet channel of the spillway, a distance of about 150 feet.

Overall concrete deterioration was evident on this structure. There was spalling and surface cracking of the thin layer of concrete which covered the downstream face. More substantial structural cracking was noted on the upstream face at the right abutment. There was also concrete removal in this area. Spalling concrete was noted along the crest of the dam as well.

There was brush growing along much of the downstream toe of the dam. Some brush and vines were actually growing out of the downstream face. There were also vines growing along the upstream face at the left end of the dam.

c. Spillway

There was deteriorated concrete on the spillway. Several small voids were noted on the downstream face. There was significant concrete removal on the walls at either end of the spillway section which separate it from the nonoverflow segment of the dam. There were no stop logs in place at the time of inspection, but 2 inch diameter pipe supports, 4 feet on centers, were in place.

d. Low level Outlets

The low level outlet consists of a 16 inch diameter pipe leading to the chlorination plant downstream of the dam. The gate valve controlling flow through this pipe is operated regularly. The remaining 3 gates whose control mechanisms are located in the gate house are not regularly operated. The gate on the 16 inch pipe is closed and the pipe is cleaned once each year. Therefore, this gate is operable and the valve can be closed tightly. The gate on the 18 inch blow off pipe at the base of the dam was not operable.

e. Appurtenant Structures-Gatehouse

The gatehouse structure on the crest of the dam was in satisfactory condition.

3.2 EVALUATION OF OBSERVATIONS

Visual observations revealed several deficiencies on this structure. The following items were noted:

1. Seepage appearing on the downstream face of the dam, at the downstream toe and beyond the toe.
2. Concrete deterioration on the non-overflow section including spalling, cracking, and some concrete removal.
3. Deteriorated concrete on the walls separating the spillway section from the non-overflow section.
4. Trees, brush, and vines growing on the dam and at the downstream toe.
5. The valve on the 18 inch blow off drain pipe was not operable.

SECTION 4: OPERATION AND MAINTENANCE PROCEDURES

4.1 PROCEDURES

Water is withdrawn from the reservoir as required. The valve on the 16 in pipe leading to the chlorination plant downstream of the dam is fully closed once a year, and the pipe is cleaned. No leakage occurs through the valve during the shutdown. Water level readings are taken daily, when the pool drops below the spillway crest. No water level records are kept at other times. There are provisions for flashboards on the spillway but they are no longer used.

4.2 MAINTENANCE OF DAM

Normal maintenance is performed as required by the City of Hudson's Department of Public Works. Information in the files indicate that several times since its construction more substantial repairs have been required on this structure. Repairs were made in 1914 and again in 1957 to reduce the seepage through the dam.

4.3 WARNING SYSTEM IN EFFECT

No apparent warning system for evacuation of downstream residents is present.

4.4 EVALUATION

The operation procedures for this dam are satisfactory. Increased maintenance efforts are needed to repair the deficiencies noted in Section 3.

SECTION 5: HYDROLOGIC/HYDRAULIC

5.1 DRAINAGE AREA CHARACTERISTICS

The delineation of the contributing watershed to this dam is shown on the map titled "Drainage Area Map - Churchtown Reservoir Dam" (Appendix C). The irregular but somewhat ovalshaped east-west oriented watershed of some 683 acres is comprised of relatively underdeveloped lands consisting of open farmland and forests. Slopes are moderate to steep with the hilltops ranging from 200 to 400 feet in elevation above the reservoir. There are no other major bodies of water within the watershed.

5.2 ANALYSIS CRITERIA

The analysis of the flood water retarding capability of the dam was performed using the Corps of Engineers HEC-1 computer program, Dam Safety version, and data provided by the report titled "Lower Hudson River Basin Hydrologic Flood Routing Model" (Appendix C, ref. 4). The computer program develops an inflow hydrograph using the "Snyder Unit Hydrograph" method and then reservoir routs the hydrograph using the "modified Puls" flood routing procedure. The spillway design flood selected for analysis was the Probable Maximum Flood (PMF), in accordance with the Recommended Guidelines of the U.S. Army Corps of Engineers. The PMF event is that hypothetical storm event resulting from the most critical combination of rainfall, minimum soil retention, and direct runoff to a specific site that is considered reasonably possible for a particular watershed.

5.3 SPILLWAY CAPACITY

The 43 foot long single, ungated, concrete overflow weir is located near the center of the dam. Although provisions for flashboards exist, they were not in place at the time of inspection. Spillway flashboards, 12 inches high, have been used in the past. However, during flood events, the spillway capacity would be decreased if such flashboards remained in place. The spillway was analyzed for weir flow using a discharge coefficient, C , varying from 3.10 to 3.42. The computed discharge capacity of the spillway is 758 cfs and 508 cfs with flashboards.

The flood analysis performed for this dam indicates that the spillway without flashboards does not have sufficient capacity for discharging one-half the PMF. For this storm event, the peak inflow is 896 cfs and the peak outflow is 887 cfs. The PMF peak inflow is 1792 cfs and the peak outflow is 1783 cfs.

5.4 RESERVOIR CAPACITY

The normal water surface is at or near the spillway crest (elev. 425). The impounded capacity for this elevation is 251 acre-feet. Surge storage capacity to the top-of-dam (elev. 428.8) adds 57 acre-feet which is equivalent to a direct runoff depth of 1.0 inch over the watershed. The total storage capacity is 308 acre-feet.

5.5 FLOODS OF RECORD

The date of occurrence of the maximum flood is not known. However, for the Claverack Creek/Taghkanic Creek watershed in which this dam is located, a maximum discharge of 4960 cfs was recorded downstream of the site on

June 30, 1973. The flow gage had a contributing area of 60.6 square miles. Although no flow gage exists for the dam site, a precipitation recording gage does exist. The hourly rainfall amounts for this storm event are included in Appendix C.

5.6 OVERTOPPING POTENTIAL

Analysis using the PMF and one-half PMF storm events indicates that the dam does not have sufficient spillway capacity. The computed depths of overtopping for these two events are 0.81 feet and 0.18 feet respectively. All storm events exceeding 45% of the PMF will result in the dam being overtopped.

5.7 EVALUATION

The spillway capacity is inadequate for the peak outflow from one-half PMF and the structural stability analysis indicates the dam could fail during this same storm event. Therefore, a dam-break analysis, assuming a breaching of the dam, was performed. The analysis indicates that water surface levels downstream of the dam could reach depths which would pose a significant danger to residents. That is, dam failure resulting from overtopping would significantly increase the hazard to loss of life downstream from the dam from that which would exist just before an overtopping failure. Therefore, the spillway is adjudged as "seriously inadequate" and the dam is assessed as "unsafe, non-emergency".

SECTION 6: STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

Visual inspection of this structure revealed several deficiencies which affect the stability of this structure. There was seepage emerging at the toe of the dam on the right side of the spillway. This seepage caused a soft area beyond the toe which was about 30 feet long. On the left side of the spillway, seepage was emerging from the lower third of the downstream face in an area which extended for approximately 50 feet.

b. Data Review and Stability Evaluation

Information reviewed include two reports which contained independent stability analyses performed for this structure. These reports were prepared in response to the seepage problems on this dam. They stated that the original design assumed no uplift pressure beneath the dam, no ice load, and a water level at the spillway crest. Both reports indicated that when appropriate factors were taken into account, the dam was only marginally stable. The conclusion of both reports was that the uplift pressure had to be reduced to achieve adequate factors of safety. The construction of the 6 inch thick cutoff wall in 1914 was intended to eliminate the seepage.

A stability analysis was performed for this report in accordance with the "Recommended Guidelines for the Safety Inspection of Dams". This analysis assumed full uplift pressure on the upstream face decreasing to the tailwater pressure at the downstream face, and an ice load of 5000 pounds per linear foot. The analysis was based on a cross section of the dam shown in the 1905 magazine article (See Appendix C). Separate analyses were performed assuming a failure plane along the dam's foundation and through the middle of the structure. The results are as follows:

Case	Full Dam Section			Failure Through Middle of Dam		
	Overturning Safety Factor	Resultant in Middle Third	Sliding Safety Factor	Overturning Safety Factor	Resultant in Middle Third	Sliding Safety Factor
a. Normal conditions; water surface at spillway crest.	1.29	NO	1.05	2.08	YES	1.39
b. Case a plus an ice load of 5,000 #/ft.	1.11	NO	0.96	1.27	NO	0.94
c. 1/2 PMF flow; water surface 0.18 feet over top of dam	1.08	NO	0.87	1.46	NO	0.91
d. PMF flow; water surface 0.81 feet over top of dam	1.06	NO	0.84	1.40	NO	0.86
e. Normal con- ditions with seismic co-effi- cient of 0.10.	1.20	NO	0.81	1.96	YES	.98

These analyses indicate that the dam is marginally stable under normal conditions and would be unstable under severe loading conditions. The sliding safety factor under these conditions falls below 1.0 for both failure planes analyzed. The fact that this structure has remained in place since 1904 indicates that the actual safety factors may be higher than those calculated. Hence, the structure must be considered as being only marginally stable.

Further investigations are required to better assess the stability of the dam. Subsurface explorations and concrete cores, to obtain information about the condition of the structure and the uplift forces are required. Accurate cross sections of the dam should also be obtained. Stability analyses should then be performed using this data. Based on the results of these analyses, required modifications to the structure should be made.

c. Seismic Stability

This structure is located in Seismic Zone 2. A seismic stability analysis was performed for both failure planes, assuming a seismic coefficient of 0.1. The results of this analysis (shown on page 10) indicate that the safety factors against sliding are below 1.0 when seismic considerations are included.

SECTION 7: ASSESSMENT/RECOMMENDATIONS

7.1 ASSESSMENT

a. Safety

The Phase I inspection of the Churchtown Dam revealed seepage under and through the structure. Seepage was noted on both downstream sides of the spillway. There were soft areas which extended for more than 30 feet along the toe on either side. This seepage adversely affects the stability of the structure.

The inspection also revealed that the stability of this structure is questionable. Analyses performed indicated that the structure is only marginally stable under normal loading conditions and is unstable when subjected to severe loading conditions (such as flood flows or ice loading).

The spillway capacity for this dam has been rated as seriously inadequate since it is not capable of passing one-half the Probable Maximum Flood without overtopping the dam. Stability analyses performed indicates that under this loading condition the dam would be unstable. A dam break analysis indicates that an overtopping dam induced failure would significantly increase the hazard to loss of life downstream of the dam. Therefore, the spillway is adjudged as seriously inadequate and the dam is assessed as unsafe, non-emergency.

b. Adequacy of Information

The information which was available for the preparation of this report presented a fairly complete history of the structure. Sketches and plans which were available were design documents and did not reflect modifications made during construction. For this reason, some dimensions shown on the plans did not agree with field measurements made at the time of the inspection.

c. Need for Additional Investigations

Further investigations of the structural stability and the seepage problems on this dam are required. The studies should include subsurface and structural investigations to obtain information about the condition of the structure and its foundation. This data should then be incorporated into a detailed stability evaluation.

Additional detailed hydrologic/hydraulic investigations are also necessary to correct the spillway discharge capacity inadequacy. These studies should consider the site specific characteristics of the watershed, such as additional surcharge storage capacity both within the drainage area and at the dam. These studies should be performed in conjunction with the stability analyses to determine the proper mitigating measures needed in response to the seriously inadequate spillway capacity.

d. Urgency

Investigations of the structural stability and seepage problems should be commenced within 3 months of the date of notification of the owner. A detailed hydrologic/hydraulic investigation should be commenced within 3 months. Remedial measures deemed necessary both as a result of these investigations and to correct the other deficiencies noted should be completed within 18 months.

7.2 RECOMMENDED MEASURES

1. Modify the structure as necessary, based on the stability analysis.
2. Take mitigating actions as necessary, based on the hydrologic/hydraulic investigation.
3. Eliminate the seepage coming under and through the dam.
4. Repair deteriorated concrete on both the spillway and the non-overflow section.
5. Remove trees, brush and vines growing on the dam and along the downstream toe.
6. Make repairs to the 18 inch reservoir drain pipe to make it operable.
7. Develop an emergency action plan for the notification of downstream residents.

APPENDIX A

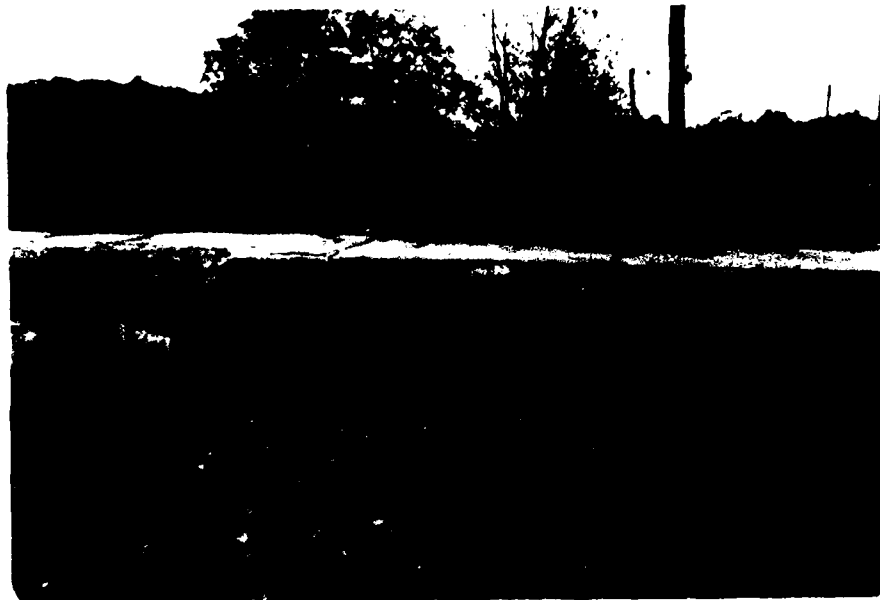
PHOTOGRAPHS



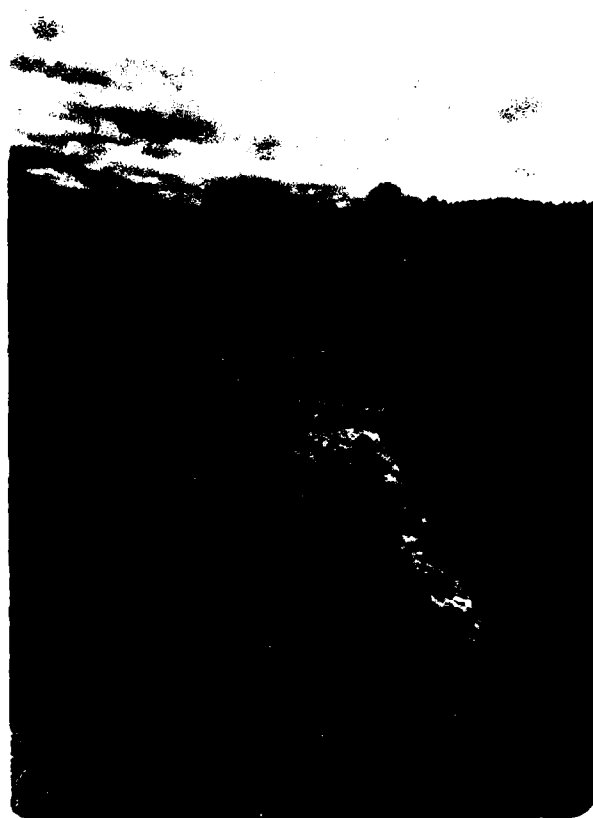
Upstream Face of Dam, Right End



Crest of Dam at Right End



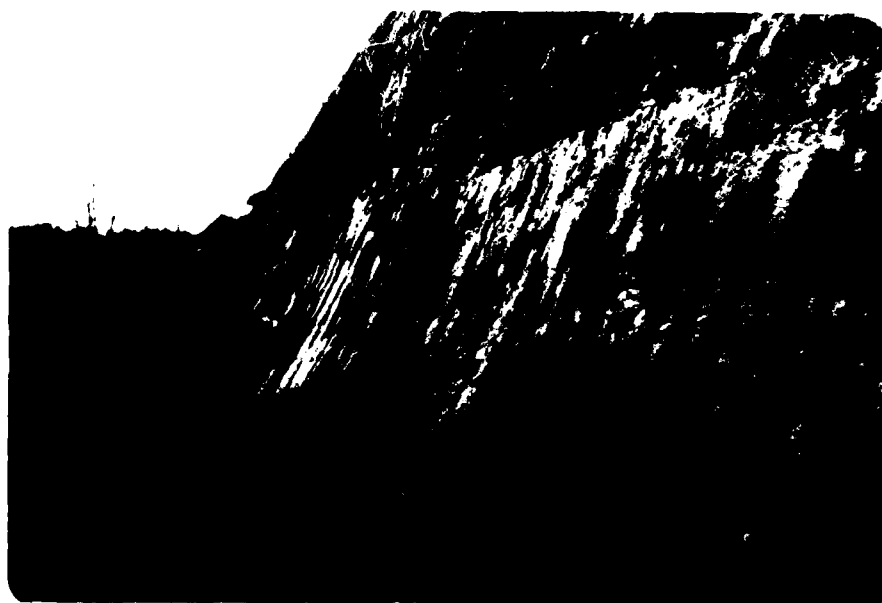
Cracks and Voids in Concrete on Upstream Face
at Right End of Dam



Crest of Dam at Left End - Note Deteriorated
Concrete



Downstream Face at Left End of Dam; Dark
Area at Base is Seepage



Close - up of Seepage at Base of Left
End of Dam



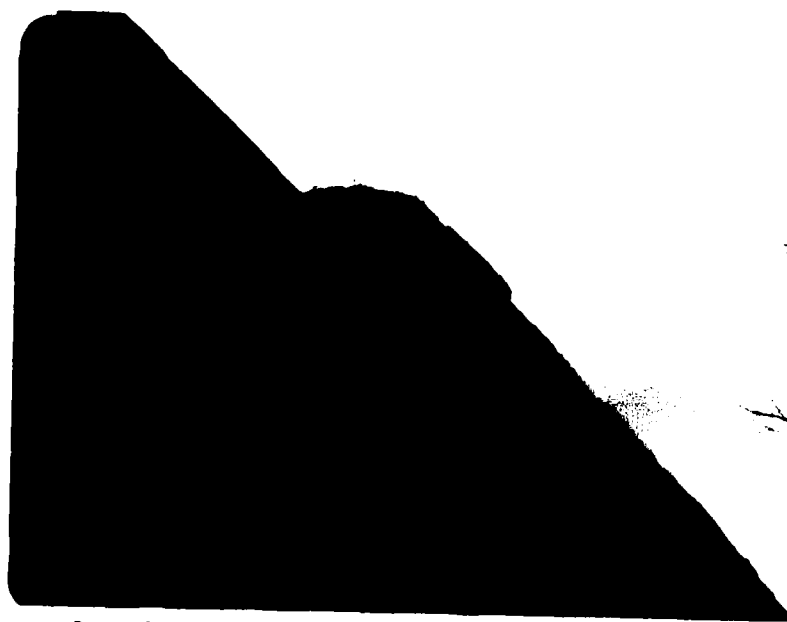
Downstream Face at Right End of Dam; Seepage
Emerging at Base



View From Crest Looking Down on Seepage
at Right End of Dam



Spillway Crest with Provisions for
Flashboards



Deteriorated Concrete Wall at Left End of Spillway



Deteriorated Concrete on Wall at Right
End of Spillway; Note Brush Growing on Downstream Face



Deteriorated Concrete on Downstream Face
of Dam

APPENDIX B

VISUAL INSPECTION CHECKLIST

VISUAL INSPECTION CHECKLIST1) Basic Data

a. General

Name of Dam CHURCHTOWN DAM
Fed. I.D. # 79 DEC Dam No. 228A-1009
River Basin LOWER HUDSON
Location: Town TAGHANIC County COLUMBIA
Stream Name _____
Tributary of TAGHANIC CREEK
Latitude (N) 42° 9.8' Longitude (W) 73° 43.2'
Type of Dam CONCRETE (CYCLOPEAN MASONRY)
Hazard Category C
Date(s) of Inspection 10/29/80
Weather Conditions OVERCAST 45°
Reservoir Level at Time of Inspection 3.7' BELOW TOP OF DAM

b. Inspector Personnel R. L. WARRENDER W. C. LYNICK

c. Persons Contacted (Including Address & Phone No.) _____

CHARLES BUTTERWORTH

CITY OF HUDSON, DEPT. OF PUBLIC WORKS

520 WARREN ST.

HUDSON, N.Y. 12534

(518) 828-9458

d. History:

Date Constructed 1904 Date(s) Reconstructed 1914

1957

Designer CORNELIUS VERMUELE, NEW YORK

Constructed By HURD, SHERMAN & COMPANY, CONTRACTORS

Owner CITY OF HUDSON

93-15-3(9/80)

4

(1) Erosion at Contact _____

(2) Seepage Along Contact _____

3) Drainage System

a. Description of System NONE

b. Condition of System _____

c. Discharge from Drainage System _____

4) Instrumentation (Monumentation/Surveys, Observation Wells, Weirs,
Piezometers, Etc.) _____

NONE

5) Reservoir

- a. Slopes WOODED & FORESTED TO EDGE
- b. Sedimentation NONE APPARENT
- c. Unusual Conditions Which Affect Dam NONE

6) Area Downstream of Dam

- a. Downstream Hazard (No. of Homes, Highways, etc.) 1 HOME & COUNTY ROAD
1 MILE DOWNSTREAM - SEVERAL HOMES IN GLENCO MILLS
- b. Seepage, Unusual Growth SEEPAGE & SOFT SPOTS FOUND BEYOND
DOWNSTREAM TOE
- c. Evidence of Movement Beyond Toe of Dam NONE
- d. Condition of Downstream Channel SATISFACTORY

7) Spillway(s) (Including Discharge Conveyance Channel)

- SINGLE OVERFLOW SECTION - LOW LEVEL PIPES - 16 INCH IS OPERABLE
- a. General GATEHOUSE CONTAINING CONTROL MECHANISM FOR 4 GATES
ONLY 1 OF WHICH IS OPERABLE; LOCATED ADJACENT TO
OVERFLOW SECTION - 16 INCH PIPE LEADS TO CHLORINATION
PLANT - CAN ACT AS RESERVOIR DRAIN
- b. Condition of ^{OVERFLOW} ~~Spillway~~ Spillway - SOME CONCRETE DETERIORATION
ON DOWNSTREAM FACE. CONCRETE BADLY DETERIORATED
ON WALLS SEPARATING SPILLWAY FROM NON OVERFLOW
SECTION
2" PIPES - 4' ON CENTER ACROSS SPILLWAY CHANNEL
CAN BE USED TO SUPPORT ~~SEEP~~ FLASH BOARDS

c. Condition of Auxiliary Spillway _____

d. Condition of Discharge Conveyance Channel BACKWATER CREATED
BY ROAD CULVERT

8) Reservoir Drain/Outlet WATER SUPPLY PIPE TO CHLORINATION BUILDING

Type: Pipe ✓ Conduit _____ Other _____

Material: Concrete _____ Metal _____ Other _____

Size: 16 INCH Length _____

Invert Elevations: Entrance _____ Exit _____

Physical Condition (Describe): _____ Unobservable _____

Material: _____

Joints: _____ Alignment _____

Structural Integrity: _____

Hydraulic Capability: _____

Means of Control: Gate ✓ Valve _____ Uncontrolled _____

Operation: Operable ✓ Inoperable _____ Other _____

Present Condition (Describe): GATE CLOSED YEARLY &

PIPE IS CLEANED

9) Structural

- a. Concrete Surfaces OVERALL SPALLING & DETERIORATION
SIGNIFICANT SPALLING OF CONCRETE ALONG CREST
- b. Structural Cracking CRACKS IN THIN LAYER OF CONCRETE ON DOWN-STREAM FACE - VINES & BRUSH GROWING ON FACE CAUSING SOME DETERIORATION
- c. Movement - Horizontal & Vertical Alignment (Settlement) NONE
- d. Junctions with Abutments or Embankments SATISFACTORY - NO SEEPAGE NOTED IN THESE AREAS
- e. Drains - Foundation, Joint, Face NONE
- f. Water Passages, Conduits, Sluices UNOBSERVABLE
- g. Seepage or Leakage LEFT SIDE OF SPILLWAY - SEEPAGE $\pm$ 4' ABOVE GROUND - 47' LONG - COMING THROUGH FACE - WET SOFT AREA BEYOND TOE ABOUT 75' LONG
RIGHT SIDE - SEEPAGE COMING BENEATH DAM - STARTING 64' FROM ABUTMENT WET AREA EXTENDS 32' & 15' OUT FROM D.S. TOE - AREA IS VERY SOFT TO WALK ON.

- h. Joints - Construction, etc. SURFICIAL DETERIORATION
PROBABLY MORE SUBSTANTIAL DETERIORATION BENEATH
THIN SURFACE LAYER OF CONCRETE
- i. Foundation _____
- j. Abutments SATISFACTORY
- k. Control Gates 1 OPERABLE - CONTROLS 16" LINE TO CHLORINATION
PLANT 3 INOPERABLE
- l. Approach & Outlet Channels NOT APPLICABLE
- m. Energy Dissipators (Plunge Pool, etc.) SATISFACTORY
- n. Intake Structures NOT OBSERVED
- o. Stability NO VISUAL EVIDENCE OF MOVEMENT
- p. Miscellaneous BRUSH GROWING AT DOWNSTREAM TOE & ON FACE
SEVERAL TREES GROWING OUT OF FACE VINES
GROWING OUT OF FACE

10) Appurtenant Structures (Power House, Lock, Gatehouse, Other)

a. Description and Condition _____

GATEHOUSE - BRICK BUILDING ON CREST - CONTAINS
CONTROL MECHANISM FOR 4 GATES
BUILDING IN GOOD CONDITION

11) Operation Procedures (Lake Level Regulation):

FLASHBOARDS NO LONGER USED REGULARLY
WATER LEVELS IN RESERVOIR TAKEN ~~BY~~ DAILY
WHEN WATER LEVEL DROPS BELOW SPILLWAY
CREST.

BRUSH IN TAILWATER AREA IS ROUTINELY
CLEARED IN THE SUMMER

APPENDIX C
HYDROLOGIC/HYDRAULIC
ENGINEERING DATA AND COMPUTATIONS

CHURCHTOWN RESERVOIR

NY - 79

1

CHECK LIST FOR DAMS
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATAAREA-CAPACITY DATA:

	(RELATIVE) Elevation (ft.)	Surface Area (acres)	Storage Capacity (acre-ft.)
1) Top of Dam	<u>3.8</u>	<u>—</u>	<u>308</u>
2) Design High Water (Max. Design Pool)	<u>N/A</u>	<u> </u>	<u> </u>
3) Auxiliary Spillway Crest	<u>N/A</u>	<u> </u>	<u> </u>
4) Pool Level with Flashboards	<u>1.0</u>	<u> </u>	<u> </u>
5) Service Spillway Crest	<u>0.0</u>	<u>15</u>	<u>251</u>

DISCHARGES

	Volume (cfs)	
1) Average Daily	<u>N/A</u>	
2) Spillway @ Maximum High Water	<u>758</u>	
3) Spillway @ Design High Water	<u>N/A</u>	
4) Spillway @ Auxiliary Spillway Crest Elevation	<u>N/A</u>	
5) Low Level Outlet	<u>N/A</u>	
6) Total (of all facilities) @ Maximum High Water	<u>758</u>	NO FLASHBOARDS
7) Maximum Known Flood	<u>N/A</u>	
8) At Time of Inspection	<u>4</u>	

CHURCHTOWN RESERVOIR

NY-79

2

CREST:

(RELATIVE)

ELEVATION: 3.8

Type: CONCRETE WEIR

Width: 6' Length: 382'

Spillover CONCRETE - SINGLE WEIR

Location NEAR CENTER OF DAM

SPILLWAY:

SERVICE

(RELATIVE)
Elevation

0.0
(USGS $\approx$ 425)
SHARP-CRESTED WEIR

Type

N/A

6'

Width

Type of Control

✓

Uncontrolled

Controlled:

FLASHBOARD PIPE SUPPORTS

EXIST ; NO FLASHBOARDS

Type

(Flashboards; gate)

H	L	Number
0-2.8'	39.6'	
2.8'-3.8'	43.6'	

Invert Material

Anticipated Length
of operating service

N/A

Chute Length

> 20'

Height Between Spillway Crest
& Approach Channel Invert
(Weir Flow)

CHURCHTOWN
RESERVOIR

NY-79

3

HYDROMETEROLOGICAL GAGES:

Type : RECORDING RAIN GAGE (NOAA INDEX #1483)

Location: NEAR DAM

Records:

Date - _____

Max. Reading - _____

FLOOD WATER CONTROL SYSTEM:

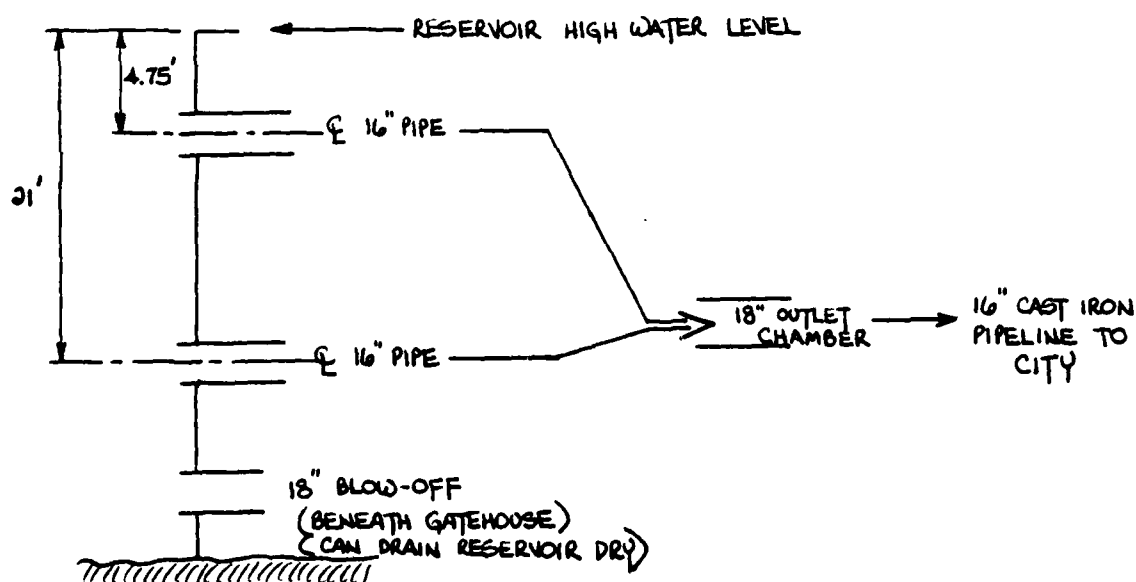
Warning System: N/A

Method of Controlled Releases (mechanisms):

WATER SUPPLY PIPE (16" DIAM.) - GATE CONTROL IN
GATE HOUSE 4 GATE STEMS EXIST - ONLY ONE
IS REGULARLY OPERATED

FROM ENGINEERING - RECORD
APRIL 1905

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CHURCHTOWN RESERVOIR
NY-79

4

DRAINAGE AREA: 1.067 SQ MI. OR 683 ACRES

DRAINAGE BASIN RUNOFF CHARACTERISTICS:

Land Use - Type: UNDEVELOPED ; OPEN FARM FIELDS & FORESTS

Terrain - Relief: MODERATE TO STEEP SLOPES ; HILLTOPS RANGE 200' TO 400'
ABOVE RESERVOIR

Surface - Soil: GRAVELS ; LOAM

Runoff Potential (existing or planned extensive alterations to existing
(surface or subsurface conditions)

N/A

Potential Sedimentation problem areas (natural or man-made; present or future)

N/A

Potential Backwater problem areas for levels at maximum storage capacity
including surcharge storage:

NONE APPARENT

Dikes - Floodwalls (overflow & non-overflow) - Low reaches along the
Reservoir perimeter:

Location: N/A

Elevation: _____

Reservoir:

Length @ Maximum Pool 1350' ≈ 0.25 (Miles)

Length of Shoreline (@ Spillway Crest) _____ (Miles)

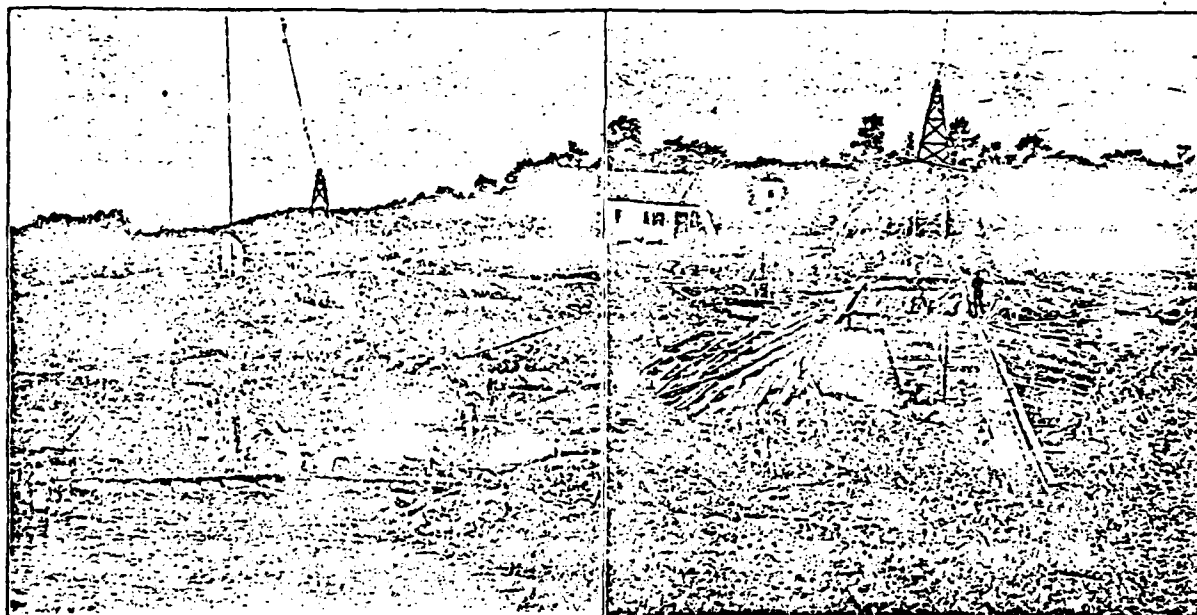
The New Gravity Water Works at Hudson, N. Y.

A storage reservoir and pipe line have just been completed at Hudson, N. Y., which furnish that city with a gravity supply from a catchment area adjoining the area at the upper end of the Roeliff Jansen Kill, on the east side of the Hudson River, which has been under consideration as a probable source of supply for New York City. Hudson is located on the east bank of the Hudson River, and the municipal water supply was formerly pumped from that stream to two open slow sand filters on a hill above the city. After passing through the filters the water flowed by gravity to a 3,200,000-gal. clear water reservoir on the same hill at an elevation of 310 ft. above the river and 175 ft. above the business portion of Hudson, and from this reservoir through the distribution system.

One of the filter beds and the clear water reservoir were designed and built in 1874 by Mr. J. B. G. Rand, and the second bed was built in 1888. Both beds and the clear water reservoir have con-

that in order to procure the daily supply a part of the river water would be pumped directly from the river into the reservoir. The conditions at the intake in the river also became unsanitary. The intake was about 800 ft. down-stream from the outlet in the river of one of the main sewers of the town, and 300 ft. upstream from another main sewer outlet, with a difference in level in the river of about 4 ft. between high and low tide. The river receives the sewage of Albany, Troy and several other cities before reaching the intake, and this, added to the local conditions, rendered the Hudson liable at all times to cause an epidemic of water-borne diseases.

After considerable investigation of the feasibility of constructing a new plant to filter the river water and of laying pipe lines to convey a supply from other available sources to the city, it was decided to abandon the old pumping station, erected in 1874, and to bring water from the Taughkanick Hills, which are about 13 miles from the reservoir on the hill above the city. The new supply is drawn from Claverack or Taughkanick Creek, about 15 miles from its mouth in the Hudson River. The catchment area



Construction View at the Dam Showing Contractor's Plant.

First Lift of Forms for the Concrete of the Dam.

crete bottoms, with their side slopes paved with quarry-faced granite blocks laid in cement mortar. The first bed built is 330 ft. square, and the other one is irregularly rectangular, 290 ft. long by 250 ft. wide at its broad end, built to fit the available area. The combined sand area of the two beds is about 32,000 sq. ft., and their combined capacity under normal conditions of operation was formerly 1,500,000 gal. in 24 hr.

The raw river water, which is heavily charged with sediment at certain seasons of the year, was pumped directly on the filters, as a settling basin which appears to have been included in the original design was never built. Although the surface of the sand beds was scraped several times each year, the sand had never been renewed, with the result that the capacity of the beds became reduced to about 500,000 gal. in 24 hr., and their efficiency was also greatly diminished. During the winter months the heavy ice which formed on the water in the beds rendered scraping them a difficult operation, which at times became impossible. The sand would then become so clogged

above the intake is about 50 square miles in extent, made up of mountainous country, which is sparsely inhabited and comparatively free from liability of dangerous contamination.

The new pipe line is of cast iron, and has been designed to carry 3,000,000 gal. in 24 hr. The bed and banks of the creek at the intake are solid rock, and a channel, 8 ft. wide at bottom and 5 ft. deep below the surface of the water in the creek at its normal stage, has been cut across in the bed of the creek at a slight up-stream angle. The intake is a concrete box, 6 ft. square in plan by 10 ft. deep, built in the rock of the creek bank at the lower end of the channel blasted out of the bed of the stream. The bottom of the intake is about 6 ft. below the bottom of the channel, and its side on the stream face was omitted above the channel bottom and a movable screen of vertical iron rods placed across the opening. The outlet to the pipe line is a 16-in. cast-iron pipe provided with a screen at its open end in the intake and with a gate valve just outside the intake. A 12-in. cast-iron pipe blowoff, provided with a gate

valve, is placed near the bottom of the intake.

The 13-mile pipe line has two sections, first a 5-mile length, ending in a storage reservoir built in connection with the aqueduct, and, second, an 8-mile length, leading from this reservoir to the distributing reservoir which was formerly used for a clear-water basin for the filters. The first 2 miles of the line from the intake on the creek are 16-in. pipe in two weights, one about 1,250 lb. and the other about 1,400 lb. per 12-ft. length, depending on the depth of the line below the hydraulic grade line. The remainder of the first 5 miles is 12-in. pipe in two weights, one 1,030 lb. and the other 1,200 lb. per 12-ft. length. A 12-in. pipe could have been used for all of the first 5 miles, but as the grade of the pipe, as it is laid, rises about 15 ft. above the hydraulic grade line near the end of the 16-in. pipe, pipe of that size was used in the first 2 miles and a cut, 800 ft. long, with a maximum depth of 30 ft. in hardpan, was avoided.

The storage reservoir in which the pipe from the intake terminates was made by building an overflow gravity-section masonry dam, 505 ft. long on the crest and 44 ft. in height near the center, across a narrow valley with steep sides. The dam develops a site which has a drainage area of 15½ square miles tributary to it, and provides an 82,000,000-gal. reservoir, covering a little less than 15 acres. The reservoir has abrupt banks on all sides, and with the exception of an area of about ¾ acre at one end, submerged only 4 ft., it will have a depth of 20 to 34 ft. The surface of the site was practically free from vegetation and organic matter, and was underlaid at a depth of a few inches with gravel, so the only preparation that was necessary was to plow the surface to a depth sufficient to turn the light top soil under the gravel. This was done over the whole area to an elevation of about 4 ft. above the flow line, and no trouble is anticipated from tastes or odors in the water due to organic matter.

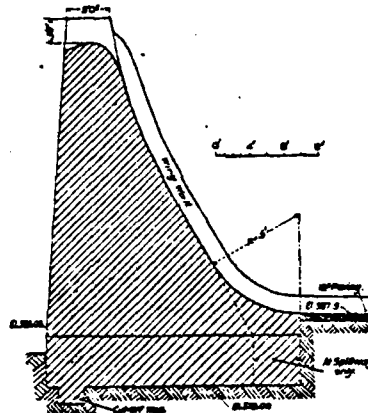
Although the whole dam was designed as an overflow structure, the 40-ft. spillway built in it toward the north end is considered capable of passing any flow that may reach the reservoir. The dam is built on solid rock, which lies at a depth of from 5 ft. to 15 ft. below the original ground surface, and construction was begun by stripping the site down to this foundation. In the soundings for the dam it was thought that rock lay within 2 ft. to 4 ft. of the surface, but when the top soil was stripped, what was considered rock in the soundings was found to be a very dense hardpan, from 3 ft. to 12 ft. deep, overlying the rock ledge.

In making the excavation for the dam the top soil was first thrown back on either side by hand. A guied derrick was then set up at the different points of the deepest cutting, and the excavated material spoiled below the site of the dam or hauled out of the trench in wagons, until a 550-ft. Lidgerwood cableway was erected longitudinally across the site. After the cableway was in place all spoil and concrete were handled in buckets on it. The small stream which formerly flowed across the site caused some trouble and had to be kept out of the trench by cofferdams on one or two occasions, but usually the work was comparatively dry.

While the excavation was in progress a stone crusher built by the Acme Road Machine Co., and a 1-yd. Ransome concrete mixer were set up adjacent to the hoisting engine and head tower of the cableway at the south end of the dam. The crusher was fitted with an elevating conveyor which delivered the broken stone to a bin over the mixer. The bin was fitted with a hopper measuring box, which discharged into the mixer. The sand and cement were also delivered on an elevated platform over the mixer built in connection with the stone bin. A 30-h.p. vertical boiler sup-

plied steam during the first part of the work, but later a 150-h.p. horizontal boiler was placed in a brick setting near the crusher and mixer, and furnished steam for all of the contractor's plant during the greater part of the dam construction.

The dam was built in 50-ft. sections, with a tongue and groove tar joint between the sections. As soon as the rock in the foundation had been stripped it was roughly leveled, and then the trench was completely filled with concrete to a sufficient depth to bring it level. The first lift of the forms was then erected, and the construction of the dam proper begun. Alternate 50-ft. sections were built at the same time. After the first lift of the forms had been filled, a 3-ft. layer of concrete was placed in one section on one day, then permitted to set a day while a 3-ft. layer was placed in an alternate section, after which another 3-ft. layer was placed in the first section, and so on. The surface of each layer was thoroughly brushed and cleaned, then wet and covered with a thin coat of 1:2 Portland cement mortar before the next layer was placed. This method of laying the concrete was followed in order that the forms might be built without exterior braces to hold them in place, and could be kept in position



Cross Section of Dam through Spillway.

by transverse rods between the sides of the sections and by the curvature of the front face of the dam, the lower forms being removed as the concrete received its set. No leaks are apparent at any of the horizontal joints, and only a slight demarcation is apparent between any of the layers.

The concrete used in the dam was mixed quite wet in the proportion of 1 part of Hudson Portland cement, 2.8 parts sand, and 5½ parts broken stone, these proportions having been found to give a slight excess of fine material. A suitable sand was not procurable in the vicinity, so a bank was opened about 2 miles from the dam. The sand from it was found to contain from 6 to 8 per cent. of loam. Thorough tests were made to discover, if possible, the effect of the presence of the loam; as good results were obtained in these tests, the sand was used. The best stone available were the glacial boulders which had been used in building stone fences in the vicinity, and after a considerable quantity of these had been used a quarry of trap rock was opened about ¼ mile from the dam, and stone from it used in the concrete to complete the work. In the early part of the work the broken stone was screened, but the greater part of the concrete was made with crusher-run broken stone, in which the largest pieces did not exceed 2½ in. in their greatest dimension.

About 7,500 cu. yd. of concrete were required in building the dam. The actual cost of mixing and placing the concrete, including the materials obtained as described, and the cost of the forms

with labor at \$1.50 per day, but exclusive of the cement, was a little more than \$3.65 per cubic yard. The 1.1 bbl. of cement used per cubic yard cost \$1.25 at a railroad station 4 miles from the dam, and that amount was hauled to the site over a pike road for 27½ cents, making the total cost of the concrete \$5.17 per cu. yd. The concrete was laid at the rate of 150 cu. yd. per day under normal conditions. Seventy-seven working days were consumed in building the forms and placing the concrete; and 146 days elapsed from the time ground was broken on the dam excavation until work on the dam was stopped on account of severely cold weather, with all but about 200 yd. of the concrete in place.

The 12-in. pipe of the line from the intake on the creek passes along the south end of the dam and the south side of the reservoir to an outlet about 6 ft. above the bottom near the upper end of the reservoir. A 6-in. branch on this pipe is laid from the dam toward the center of the reservoir where a half-bend was inserted, and the pipe built up to a point above high-water level. This branch will be used as an aerator if the water from the creek should need aeration at any time.

Water may be drawn from the reservoir through either of two 16-in. outlet pipes in the 16x18-ft. gate chamber that is built in connection with the dam. One outlet pipe has its center line 4 ft. 9 in. below the high-water level in the reservoir, and the other has its center line 21 ft. below that level. Both pipes discharge through screens in the wall of a transverse chamber in the gate chamber into an outlet chamber which is connected by an 18-in. outlet to the pipe line to the city. An 18-in. blow-off is laid through the dam beneath the gate house, and the reservoir may be drawn dry through it. All the outlet pipes are controlled by hand-operated gate valves.

The inlet to the reservoir and the outlet from it are connected by a by-pass permitting the reservoir to be entirely cut out of the system. An overflow is built in this by-pass, with its discharge at the same height as the high-water level in the reservoir, in order that the pressure on the main leading to the city may not exceed that due the head of water in the reservoir.

The 82,000,000-gal. capacity of the reservoir is about equal to 45 days' maximum consumption in the city. The normal consumption is 1,500,000 gal. per 24 hr., which is about 150 gal. per capita per day. The catchment area directly tributary to the reservoir site has given an average flow during the past two years of 1,200,000 gal. per 24 hr., with the rainfall from 3 to 6 in. below the normal, and the minimum flow to be expected from this area for any extended time is taken to be 750,000 gal. per 24-hr. The pipe line from the intake on the creek to the reservoir has been designed for a carrying capacity of 2,225,000 gal. in 24 hr., and the line from the reservoir to the city for a capacity of 3,000,000 in 24 hr. The depth of water in the reservoir, the excess of the supply over the demand and the depth below the surface at which water is fed into the reservoir are believed to produce sufficient currents and change of water to prevent any possibility of stagnation.

The pipe line from the reservoir to the city is of 16-in. cast-iron pipe in three weights, ranging from 1,250 to 1,675 lb. per 12-ft. length. No unusual difficulties were encountered in laying this part of the line nor in the line above the reservoir. The minimum depth of trench was about 5 ft., and this depth was maintained throughout the greatest part of the route. About 60 per cent. of the trench was wet, but no sheeting was required, and the water was removed with diaphragm pumps. Considerable rock cutting was required in making the trench, and two Ingersoll-Sergeant and three Rand steam drills were used in making the blast holes. Two creek crossings were made. One of them presented no difficult conditions, and the

CHURCHTOWN
DAM

pipe was laid 3 ft. below the bed of the stream. Coarse gravel was encountered at the other crossing, and pipe with flexible joints was used to avoid pumping and building cofferdams. Air valves are placed on the pipe line at all summits and blow-off pipes at all low points.

The 4,000 tons of pipe required in building the pipe line and all of the gate and air valves and the valve boxes were furnished by R. D. Wood & Co., of Philadelphia, Pa. The contract for laying the pipe and building the dam was let to Hurd, Sherman & Co., of Syracuse, N. Y.

The saving in the operation of the gravity system as compared with the operation of the old pumping plant, is about \$10,000 a year, including the salaries of three firemen and three engineers, and an average of 145 tons of coal per month. The estimated cost of rebuilding the old plant and enlarging its capacity to 3,000,000 gal. per day was \$160,000, with an estimate life of the machinery in the remodeled plant of 30 years. The cost of the new works, including all charges and construction expenses will be about \$270,000, with an estimated life of from 60 to 75 years.

While the average consumption of water per capita per day in Hudson is comparatively high, it will be difficult to reduce it to any considerable extent, owing to the peculiar conditions under which the water works system is operated. The original system was built under an act of the Legislature, which required that the works be built and operated with money obtained by a tax on the property in the city, and that water be furnished free for domestic consumption to any person paying the expense of installing a service connection. The system is still operated under that act, so the only direct income of the plant is the sale of a small percentage of the supply for commercial consumption, and the only opportunity of reducing the consumption under the present conditions is by metering the service connections of commercial consumers.

The filters are at present out of commission, but it is the intention to remodel them and filter the water from the gravity supply, and plans are now being prepared for the work. Mr. H. K. Bishop is chief engineer of the Hudson water works and the preliminary investigations, the design and construction of the new system have been carried out under his direct supervision. Mr. C. C. Vermeule, of New York, has been consulting engineer on the design and construction of the system. Mr. F. L. Getman was assistant engineer in charge of the laying of the pipe line, and Mr. H. W. Lewis was assistant engineer in charge of the construction of the dam.

PROJECT GRID

JOB CHURCHTOWN RESV. DAM NY-79		SHEET NO. 1/	CHECKED BY	DATE
SUBJECT WATERSHED PARAMETERS		COMPUTED BY WCL		DATE 12/30/80

SNYDER UNIT HYDROGRAPH:

$L = 2.01 \text{ MILES} = 10650'$

$L_{CA} = 0.909 \text{ MILES} = 4800'$

USE $C_e = 2.3$ ← FROM { CORPS OF ENGINEERS
LOWER HUDSON RIVER BASIN
HYDROLOGIC FLOOD ROUTING
MODEL

LAG TIME (HRS): $t_p = C_e (L \times L_{CA})^{0.3}$

$= 2.3 (2.01 \times 0.909)^{0.3}$

$t_p = 2.756 \text{ HRS}$

UNIT RAINFALL DURATION (HRS): $t_r = \frac{t_p}{5.5}$

$t_r = \frac{2.756}{5.5}$

$t_r = 0.501 \text{ HRS}$ ← (USE $t_r = 0.5 \text{ HRS}$)

ADJUSTED LAG TIME (HRS): $TP = t_p + 0.25(t_r - t_p)$

$= 2.756 + 0.25(0.5 - 0.501)$

$TP = 2.756$

PEAKING COEFFICIENT:

$6.40 C_p = 340$ ← FROM SUBAREA #11 (REF = SAME)

$C_p = 0.53$

SNYDER

$TP = 2.75 \text{ HRS} \quad C_p = 0.53$

PROJECT GRID

JOB CHURCHTOWN RESV. DAM		SHEET NO. 2/	CHECKED BY	DATE
SUBJECT WATERSHED PARAMETERS		COMPUTED BY WCL		DATE 12/30/80

DRAINAGE AREA:

SCALE 1:2000
1 SQ IN = 91.237 ACRES

USGS 7.5' QUAD — PLANIMETERED @ 7.44 SQ IN → 683 ACRES → 1.067 SQ. MI.

(ELEV 425) RESV. SURFACE — " @ 0.18 SQ IN → 16.5 ACRES

BASE FLOW:

INITIAL @ 1 CSM = 1 cfs/SQ MI
QRCSN = 3
RTIOR = 3

FROM: CORPS ENGINEERS
LOWER HUDSON RIVER BASIN
MODEL STUDY

LOSSES (SOIL INFILTRATION)

INITIAL = 1.0 INS.
CONSTANT = 0.05 IN/HR

USE

REF: SOIL SURVEY OF COLUMBIA COUNTY (1929)

DUTCHESS GRAVELLY LOAM }
DUTCHESS SLATE LOAM } DRAINAGE IS GOOD OR EXCESSIVE

USE
∴ SCS GROUP C

SOIL RETENTION ≈ 0.1 IN/HR

RAINFALL - PMP

REF: HMR #33

ZONE 1 INDEX PMP = 20" (200 SQ MI / 24 HR)

ADJUSTMENT FOR TIME & DA	DURATION →	6	12	24	48 (HRS)
	% OF INDEX =	111	123	132	142

LOWER LIMIT OF CHART
FOR 10 SQ MI

PROJECT GRID

JOB	CHURCHTOWN RESV. DAM	SHEET NO.	3/	CHECKED BY		DATE	
SUBJECT	STAGE - STORAGE DATA	COMPUTED BY	WCL	DATE	12/30/30		

REF: ENGINEERING RECORD - 1905	(3.067 AC-FT = 10 ⁶ GALS)	
STORAGE VOL (@ SPILLCREST) = 82 x 10 ⁶ GALS	→ 251 AC-FT	←
SURFACE AREA @ SPILLCREST = 15 ACRES		← USE
(FROM SHT 2/)	→ 16.5 ACRES	
FIELD MEASUREMENT - 10/80	SPILLCREST TO TOP DAM = 3.8'	
ΔVOL = 15 x 3.8 = 57 AC-FT		
STORAGE VOL (@ TOP DAM) = 308 AC-FT		←
APPROX. DEPTH TO BOTTOM OF RESV. @ UPSTREAM FACE OF DAM:		
H ≈ 40' → ELEV. 388.8	ELEV. 389 VOL = 1.0 AC-FT	←

PROJECT GRID

JOB CHURCHTOWN RESV. DAM		SHEET NO. 4/	CHECKED BY	DATE
SUBJECT SPILLWAY - DISCHARGES		COMPUTED BY WCL		DATE 12/31/80

WEIR FLOW: $Q = CLH^{3/2}$

$L = L' - 2(NK_p + K_n)H$ VARIES W/ H ABUTMENT CONTRACTION

$N = 0$

$L = 39.6$ $K_n = 0.2$

$C = \text{VARIES W/ H}$ USE TABLE 5-13 (KING & BRATER 5TH ED. HANDBOOK OF HYDRAULICS)

$(L = L' + 0.4H)$ 8' MODEL = #5-16

ELEV.	H	L	C	Q (cfs)
425	-0-	39.6'	3.10	—
	0.5	39.4	3.20	44
	1	39.2	3.30	129
	1.5	39	3.32	237
	2	38.8	3.36	368
	2.5	38.6	3.40	518
	2.8	38.48	3.42	616
		ΔH ($L' = 43.6$)	C	ΔQ
	3	0.2	43.52	3.3
				12 = 628
	3.5	0.7	43.32	3.3
				83 = 699
TOP DAM	3.8	1	43.2	3.3
				616 142 = 758

DISCHARGE CAPACITY -
WITH 12" FLASHBOARDS

TOP OF DAM: $Q = CLH^{3/2}$

$C = 3.1$ $L = 38.2'$

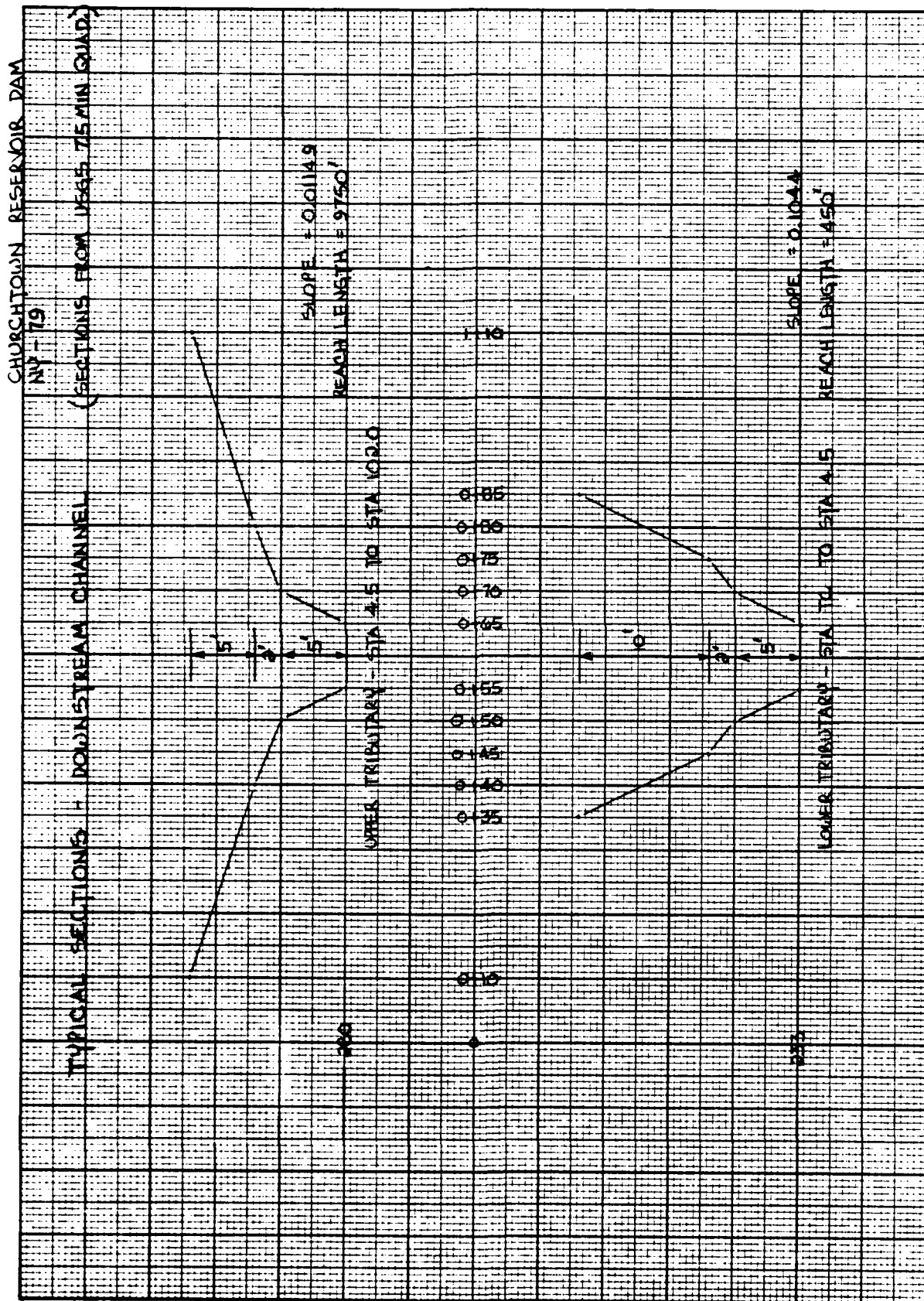
$Q = CLH^{3/2}$ $C = 3.9$ FOR $H/P = 1.8$

$H = 1.8 \rightarrow L = 38.9$

$Q = (3.9)(38.9)(1.8)^{3/2} = 366$

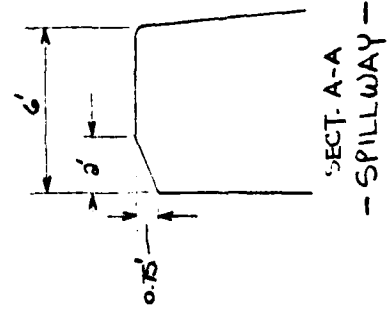
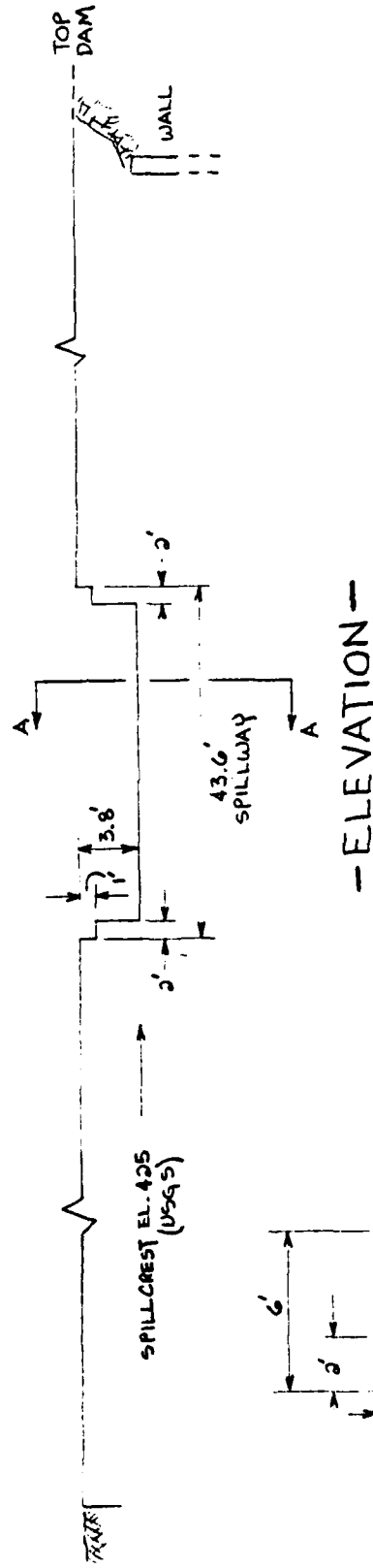
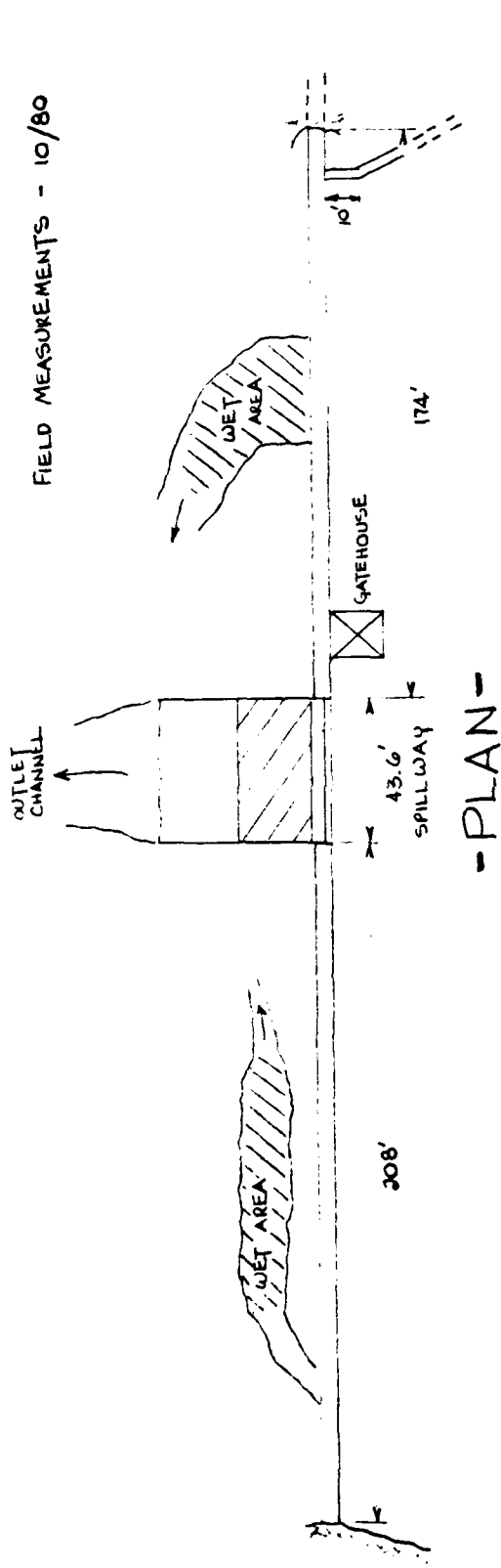
$+ 142$

$Q = 508 \text{ cfs}$



CHURCHTOWN RESV. DAM
NY-79

FIELD MEASUREMENTS - 10/80

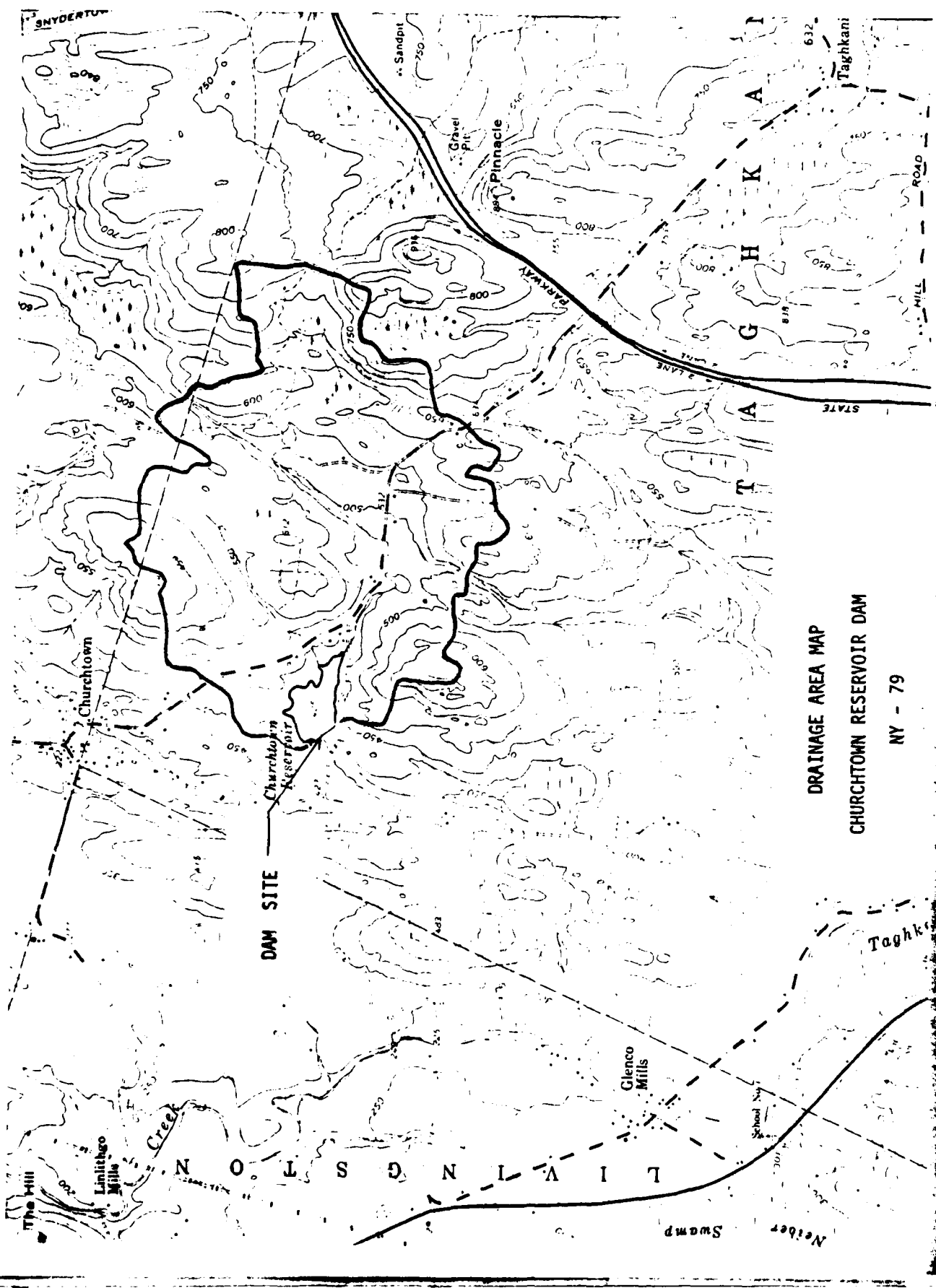


HOURLY PRECIPITATION @ RECORDING GAGE (NOAA INDEX #1483) - CHURCHTOWN RESERVOIR
(CITY OF HUDSON)

STORM EVENT : JUNE 30, 1973

DATE	AM												PM												TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	
6/28												.10		.02											0.12
6/29						-	.60	.46	.04	-	.06	-	.01	.07	.02	.39	.16	.12	.01	.07	.01	.04	.09	.15	2.30
6/30	.07	.53	.15	1.06	.65	.05	-																		2.92

CHURCHTOWN RESERVOIR DAM
NY-79



DRAINAGE AREA MAP
CHURCHTOWN RESERVOIR DAM

NY - 79

32
33
34
35
36
37
38
39
40
41
42
43
44

K		I		LOCATION		CHANNEL ROUTING OF HYDROGRAPH TO STATION TC		I	
K1									
Y									
Y1									
Y6									
Y7									
Y7									
K									
A									
A									
A									
A									
A									

233

65

233

55

238

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75

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0.04

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PREFACE

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

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

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

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

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT BASIN
ROUTE HYDROGRAPH TO DAM
ROUTE HYDROGRAPH TO UPTRB
ROUTE HYDROGRAPH TO LOWTRB
END OF NETWORK

 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 26 FEB 79
 MODIFIED FOR MONEYJELL APR 79

 NEW YORK STATE
 DEPT OF ENVIRONMENTAL CONSERVATION
 FLOOD PROTECTION BUREAU

RUN DATE 01/21/81

NY-75

CHURCHTOWN RESERVOIR DAM
 DEC - 1009 LH -- TACHKANIC CREEK

LOWER HUDSON RIVER BASIN
 COLUMBIA COUNTY
 SNYDER UH

JOB SPECIFICATION

NO	NHR	AMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
150	0	30	0	0	0	0	0	0	0
			JOPEP	IWT	LRDPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED

RTICS= 0.45 0.46 0.50 1.00
 NPLAN= 1 NRTIO= 4 LRTO= 1

***** SUR-AREA RUNOFF COMPUTATION *****

INFLOW HYDROGRAPH -- DAM

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

HYDROGRAPH DATA

IMYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	1.07	0.	1.07	0.	0.	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.	20.00	111.00	123.00	132.00	142.00	0.	0.

TRSPC COMPUTED BY THE PROGRAM IS 0.800

LOSS DATA

LRDPT	STARR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRIL	CNSTL	ALSHX	RTIMP
0	C.	0.	1.00	0.	0.	1.00	1.00	0.05	0.	0.02

UNIT HYDROGRAPH DATA

TP= 2.75 CP=0.53 NTA= 0

RECESSION DATA

STRTO= 1.00 SRTCSN= 3.00 RTICR= 3.00
 APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 5.99 AND R= 6.87 INTERVALS

UNIT HYDROGRAPH 40 END-OF-PERIOD ORDINATES, LAG= 2.73 HOURS, CP= 0.53 VOL= 1.00									
9.	33.	66.	100.	124.	133.	124.	107.	92.	80.
69.	60.	52.	45.	39.	33.	25.	25.	21.	19.
16.	14.	12.	10.	9.	8.	7.	6.	5.	4.
4.	3.	3.	2.	2.	2.	2.	1.	1.	1.

END-OF-PERIOD FLOW

MO.DA	HR.M4	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	PR.FN	PERIOD	RAIN	EXCS	LOSS	COMP C
1.01	0.30	1	0.00	0.00	0.20	1.	1.02	14.00	76	1.07	1.04	0.02	322.

1.02	10.33	0.10	0.14	0.32	119.	1.04	0.	149	0.	0.	0.
1.02	11.00	0.10	0.14	0.32	126.	1.04	0.30	145	0.	0.	0.
1.02	11.33	0.10	0.14	0.02	136.	1.04	1.00	146	0.	0.	0.
1.02	12.03	0.16	0.14	0.02	143.	1.04	1.30	147	0.	0.	0.
1.02	12.33	0.39	0.86	0.02	155.	1.04	2.00	148	0.	0.	0.
1.02	13.03	0.49	0.96	0.02	185.	1.04	2.30	149	0.	0.	0.
1.02	13.30	1.07	1.04	0.02	239.	1.04	3.00	150	0.	0.	0.
SUM 22.72 20.40 2.32 27963.											
(577.)(518.)(55.)(791.82)											

CFS	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
1792.	1792.	1395.	559.	194.	27972.
CMS	51.	40.	16.	6.	752.
INCHES		12.16	19.49	20.32	20.32
MM		306.99	494.53	516.16	516.16
AC-FT		692.	1108.	1156.	1156.
TOTALS CU M		853.	1367.	1426.	1426.

HYDROGRAPH AT STA BASIN FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	4.	9.	13.	18.	21.	23.	23.	23.	21.	21.	21.
19.	15.	13.	11.	9.	8.	7.	6.	6.	6.	6.	6.
6.	7.	8.	9.	10.	10.	11.	11.	11.	11.	12.	12.
13.	15.	24.	30.	37.	42.	49.	54.	54.	54.	58.	58.
61.	64.	70.	83.	108.	145.	193.	250.	311.	311.	388.	388.
439.	607.	776.	806.	787.	735.	670.	597.	523.	523.	523.	523.
455.	395.	305.	269.	235.	207.	182.	160.	140.	140.	140.	140.
123.	105.	91.	68.	59.	51.	44.	38.	33.	33.	33.	33.
28.	24.	21.	15.	12.	10.	8.	6.	4.	4.	4.	4.
3.	2.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

CFS	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
800.	800.	628.	251.	87.	12587.
CMS	23.	18.	7.	2.	356.
INCHES		5.47	8.77	9.14	9.14
MM		139.05	222.72	232.27	232.28
AC-FT		311.	499.	520.	520.
TOTALS CU M		384.	615.	642.	642.

HYDROGRAPH AT STA BASIN FOR PLAN 1, RTIO 2

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	4.	8.	13.	18.	22.	23.	23.	23.	22.	22.	22.
20.	17.	15.	13.	11.	10.	8.	7.	6.	6.	6.	6.
6.	7.	8.	9.	10.	10.	11.	11.	11.	12.	12.	12.
13.	15.	19.	24.	31.	38.	44.	50.	55.	55.	55.	55.
63.	66.	71.	85.	110.	148.	198.	256.	318.	318.	386.	386.
507.	617.	793.	824.	805.	751.	685.	610.	532.	532.	532.	532.
467.	407.	356.	274.	241.	212.	187.	164.	143.	143.	143.	143.
124.	108.	93.	80.	69.	60.	52.	45.	39.	39.	33.	33.
29.	25.	21.	18.	15.	13.	10.	8.	7.	7.	4.	4.
3.	2.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

CFS	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
120.	120.	100.	400.	100.	100.
CMS					
INCHES					
MM					
AC-FT					
TOTALS CU M					

[illegible]

7.	10.	/	J.
5.00	9.35		
142.14	237.67		
318.	532.		
393.	656.		
			324.
			5.35
			237.44
			532.
			656.

HYDROGRAPH AT STA BASIN FOR PLAN 1, RTIC-3

[illegible]

CFS
 CHS
 INCHES
 MM
 AC-FT
 TFOIS CU M

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL	VOLUME
89b.	65d.	279.	97.	1396.	
25.	20.	3.	3.	356.	
	6.08	9.74	10.16	10.16	
	154.49	247.47	258.08	258.09	
	346.	554.	578.	578.	
	427.	684.	713.	713.	

HYDROGRAPH AT STA BASIN FOR PLAN 1, RTIO 4

1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
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CFS
 CMS
 INCHES
 1/4"
 AC-FT
 3/4"

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
792.	1395.	559.	194.	27572.
51.	40.	16.	6.	752.
	12.16	19.49	20.32	516.18
	308.99	494.93	516.16	516.18
	692.	1108.	1156.	1156.
	853.	1367.	1426.	1426.

[illegible]

HYDROGRAPH PLOTTING

425.4	425.4	425.2	425.2	425.1	425.1	425.1
425.1	425.1	425.1	425.1	425.1	425.1	425.1
425.1	425.1	425.2	425.2	425.3	425.3	425.4
425.5	425.6	425.6	425.7	425.9	426.0	426.4
427.0	427.3	427.7	428.1	428.7	428.6	428.1
427.8	427.2	427.0	426.8	426.7	426.4	426.2
426.1	426.0	425.9	425.9	425.7	425.6	425.5
425.5	425.4	425.4	425.3	425.3	425.2	425.2
425.1	425.1	425.1	425.1	425.1	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0

PEAK OUTFLOW IS 743. AT TIME 43.50 HOURS

CFS	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL	VOLUME
CMS	743.	617.	250.	87.		12560.
INCHES	21.	17.	7.	2.		356.
MM		5.38	8.73	9.14		9.15
AC-FT		136.55	221.65	232.28		232.29
THOUS CU M		306.	496.	520.		520.
		377.	612.	642.		642.

STATION DAM PLAN 1, RATIO 2
END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW		STORAGE		STAGE	
C.	0.	C.	0.	C.	0.
0.	0.	251.	251.	425.0	425.0
0.	0.	251.	251.	425.0	425.0
0.	0.	251.	251.	425.0	425.0
0.	0.	251.	251.	425.0	425.0
17.	17.	252.	252.	425.0	425.0
9.	9.	254.	254.	425.0	425.0
11.	11.	252.	252.	425.0	425.0
44.	44.	253.	253.	425.0	425.0
376.	376.	253.	253.	425.0	425.0
619.	619.	254.	254.	425.0	425.0
159.	159.	252.	252.	425.0	425.0
43.	43.	252.	252.	425.0	425.0
12.	12.	253.	253.	425.0	425.0
2.	2.	254.	254.	425.0	425.0
0.	0.	255.	255.	425.0	425.0
		256.	256.	425.0	425.0
		257.	257.	425.0	425.0
		258.	258.	425.0	425.0
		259.	259.	425.0	425.0
		260.	260.	425.0	425.0
		261.	261.	425.0	425.0
		262.	262.	425.0	425.0
		263.	263.	425.0	425.0
		264.	264.	425.0	425.0
		265.	265.	425.0	425.0
		266.	266.	425.0	425.0
		267.	267.	425.0	425.0
		268.	268.	425.0	425.0
		269.	269.	425.0	425.0
		270.	270.	425.0	425.0
		271.	271.	425.0	425.0
		272.	272.	425.0	425.0
		273.	273.	425.0	425.0
		274.	274.	425.0	425.0
		275.	275.	425.0	425.0
		276.	276.	425.0	425.0
		277.	277.	425.0	425.0
		278.	278.	425.0	425.0
		279.	279.	425.0	425.0
		280.	280.	425.0	425.0
		281.	281.	425.0	425.0
		282.	282.	425.0	425.0
		283.	283.	425.0	425.0
		284.	284.	425.0	425.0
		285.	285.	425.0	425.0
		286.	286.	425.0	425.0
		287.	287.	425.0	425.0
		288.	288.	425.0	425.0
		289.	289.	425.0	425.0
		290.	290.	425.0	425.0
		291.	291.	425.0	425.0
		292.	292.	425.0	425.0
		293.	293.	425.0	425.0
		294.	294.	425.0	425.0
		295.	295.	425.0	425.0
		296.	296.	425.0	425.0
		297.	297.	425.0	425.0
		298.	298.	425.0	425.0
		299.	299.	425.0	425.0
		300.	300.	425.0	425.0
		301.	301.	425.0	425.0
		302.	302.	425.0	425.0
		303.	303.	425.0	425.0
		304.	304.	425.0	425.0
		305.	305.	425.0	425.0
		306.	306.	425.0	425.0
		307.	307.	425.0	425.0
		308.	308.	425.0	425.0
		309.	309.	425.0	425.0
		310.	310.	425.0	425.0
		311.	311.	425.0	425.0
		312.	312.	425.0	425.0
		313.	313.	425.0	425.0
		314.	314.	425.0	425.0
		315.	315.	425.0	425.0
		316.	316.	425.0	425.0
		317.	317.	425.0	425.0
		318.	318.	425.0	425.0
		319.	319.	425.0	425.0
		320.	320.	425.0	425.0
		321.	321.	425.0	425.0
		322.	322.	425.0	425.0
		323.	323.	425.0	425.0
		324.	324.	425.0	425.0
		325.	325.	425.0	425.0
		326.	326.	425.0	425.0
		327.	327.	425.0	425.0
		328.	328.	425.0	425.0
		329.	329.	425.0	425.0
		330.	330.	425.0	425.0
		331.	331.	425.0	425.0
		332.	332.	425.0	425.0
		333.	333.	425.0	425.0
		334.	334.	425.0	425.0
		335.	335.	425.0	425.0
		336.	336.	425.0	425.0
		337.	337.	425.0	425.0
		338.	338.	425.0	425.0
		339.	339.	425.0	425.0
		340.	340.	425.0	425.0
		341.	341.	425.0	425.0
		342.	342.	425.0	425.0
		343.	343.	425.0	425.0
		344.	344.	425.0	425.0
		345.	345.	425.0	425.0
		346.	346.	425.0	425.0
		347.	347.	425.0	425.0
		348.	348.	425.0	425.0
		349.	349.	425.0	425.0
		350.	350.	425.0	425.0
		351.	351.	425.0	425.0
		352.	352.	425.0	425.0
		353.	353.	425.0	425.0
		354.	354.	425.0	425.0
		355.	355.	425.0	425.0
		356.	356.	425.0	425.0
		357.	357.	425.0	425.0
		358.	358.	425.0	425.0
		359.	359.	425.0	425.0
		360.	360.	425.0	425.0
		361.	361.	425.0	425.0
		362.	362.	425.0	425.0
		363.	363.	425.0	425.0
		364.	364.	425.0	425.0
		365.	365.	425.0	425.0
		366.	366.	425.0	425.0
		367.	367.	425.0	425.0
		368.	368.	425.0	425.0
		369.	369.	425.0	425.0
		370.	370.	425.0	425.0
		371.	371.	425.0	425.0
		372.	372.	425.0	425.0
		373.	373.	425.0	425.0
		374.	374.	425.0	425.0
		375.	375.	425.0	425.0
		376.	376.	425.0	425.0
		377.	377.	425.0	425.0
		378.	378.	425.0	425.0
		379.	379.	425.0	425.0
		380.	380.	425.0	425.0
		381.	381.	425.0	425.0
		382.	382.	425.0	425.0
		383.	383.	425.0	425.0
		384.	384.	425.0	425.0
		385.	385.	425.0	425.0
		386.	386.	425.0	425.0
		387.	387.	425.0	425.0
		388.	388.	425.0	425.0
		389.	389.	425.0	425.0
		390.	390.	425.0	425.0
		391.	391.	425.0	425.0
		392.	392.	425.0	425.0
		393.	393.	425.0	425.0
		394.	394.	425.0	425.0
		395.	395.	425.0	425.0
		396.	396.	425.0	425.0
		397.	397.	425.0	425.0
		398.	398.	425.0	425.0
		399.	399.	425.0	425.0
		400.	400.	425.0	425.0

CFS
 CHS
 INCHES
 AC-FT
 THOUS CU YD

STATION DAY, PLAN 1, RATIC 3
END-OF-PERIOD HYDROGRAPH COORDINATES

OUTLINE

[illegible]

STORAGE

[illegible]

STAGE

[illegible]

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422
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FANCL ROUTING OF HYDROGRAPH TO STATION 4.5									
ISTAQ	ICDIP	ICGIV	ITAPE	JPLT	JURT	INAME	ISTAGE	IAUTO	
0	1	0	C	0	C	1	0	0	

PUTTING DATA													
AVG	IRFS	ISAME	IOPT	IPWP	LSTR	WSTPS	WSTDL	LAG	ANSKK	X	TSK	STGRA	ISPRAT
0.	1	1	0	0	0	4	0	0	0.	0.	0.	0.	0

INSTPS	INSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
4	0	0	0	0	0	0	0

QN(1)	QJ(2)	QJ(3)	ELAVT	ELMAX	RLPTH	SEL
0.0400	0.0400	0.0400	250.0	300.0	9750.	0.01149

10.00	292.00	40.00	287.00	50.00	285.00	55.00	280.00	65.00	280.00
70.00	285.00	40.00	287.00	112.00	292.00				

STORAGE	0.	2.60	5.70	9.30	13.39	18.04	24.62	33.70	45.63	60.58
	78.49	99.37	122.69	146.25	169.82	193.38	216.94	240.50	264.06	287.62
OUTFLOW	0.	43.19	139.05	280.20	466.78	714.24	1078.33	1564.02	2209.96	3036.10
	4134.38	5474.21	7252.52	9415.60	11843.25	14520.52	17435.43	20578.10	23940.15	27514.35
STAGE	280.00	281.05	282.11	283.16	284.21	285.26	286.32	287.37	288.42	289.47
	290.53	291.58	292.63	293.68	294.74	295.79	296.84	297.89	298.95	300.00
FLOW	0.	43.19	139.05	280.20	466.78	714.24	1078.33	1564.02	2209.96	3036.10
	4134.38	5474.21	7252.52	9415.60	11843.25	14520.52	17435.43	20578.10	23940.15	27514.35

STATION 10T3A. PLAN 1. PTVF 1

廣州自由黨黨部

CHURCHTOWN
RESERVOIR
DAM

OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIOS APPLIED TO FLOWS
				0.45	0.46	0.50	1.00	
HYDROGRAPH AT	BASIN	1.07 (-0.00)	1	80% (22.53)	82% (23.34)	89% (25.37)	1792% (50.74)	
ROUTED TO	DAM	1.07 (0.12E 25)	1	74% (21.04)	76% (21.55)	83% (25.10)	178% (50.49)	
ROUTED TO	UPTRB	1.07 (-0.00)	1	74% (21.01)	76% (21.54)	83% (24.93)	140% (50.57)	
ROUTED TO	LOUTRB	1.07 (-0.00)	1	74% (20.99)	76% (21.52)	80% (24.91)	190% (50.97)	

CHURCHTOWN RESERVOIR DAM

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1

RATIO CF PMF	MAXIMUM RESERVOIR W.S. ELEV	ELEVATION STORAGE OUTFLOW	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM	TIME OF MAX OUTFLOW HOURS	TYPE OF FAILURE HOURS
0.45	425.00	251.	425.00	428.80	0.	43.50	0.
0.46	425.00	251.	425.00	428.80	0.	43.50	0.
0.50	425.00	251.	425.00	428.80	0.	43.50	0.
1.00	425.00	251.	425.00	428.80	0.	43.50	0.

PLAN 1 STATION LPTRB

RATIO	MAXIMUM FLOW, CFS	MAXIMUM STAGE, FT	TIME HOURS
0.45	742.	285.3	43.50
0.46	761.	285.4	43.50
0.50	880.	285.7	43.50
1.00	1800.	287.8	43.00

PLAN 1 STATION LC*TRB

RATIO	MAXIMUM FLOW, CFS	MAXIMUM STAGE, FT	TIME HOURS
0.45	741.	235.8	43.50
0.46	760.	235.9	43.50
0.50	830.	236.1	43.50
1.00	1800.	237.8	43.00

	K	1	LWTRB	CHANNEL ROUTING OF	BREACH	TO STATION TC
33	K	1				1
34	K1					
35	Y		1			
36	Y1	1				
37	Y6	0.04	0.04	233	280	450 0.1544
38	Y7	35	250	45	50	238 .55
39	Y7	70	238	75	85	250
40	K	99				
41	A					
42	A					
43	A					
44	A					
45	A					

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS
RUNOFF HYDROGRAPH AT BASIN
ROUTE HYDROGRAPH TO DAM
ROUTE HYDROGRAPH TO UPTRB
ROUTE HYDROGRAPH TO LOWTRB
END OF NETWORK

FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAH SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79
MODIFIED FOR HONEYWELL APR 79

RUN DATE 02/24/81

AY-79

CHURCHTOWN RESERVOIR DAM
DEC - 1009 LH -- TACHKANIC CREEK

LOWER HUDSON RIVER BASIN
COLUMBIA COUNTY
SNYDER UN

NEW YORK STATE
DEPT OF ENVIRONMENTAL CONSERVATION
FLOOD PROTECTION BUREAU

NC NHR IOAY NMIN IHR IMIN METRC IPLT IPRT NSTAN
150 0 30 0 0 0 0 0
JOPER NNT LROPT TRACE
5 0 0 0

JOB SPECIFICATION

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTID= 4 LRTID= 1
RTICS= 0.45 0.46 0.50 1.00

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH -- DAM
ISTAQ ICOMP IECON ITAPF JPLT JPRT INAME ISTAGE IAUT0
BASIN 0 0 0 0 0 0 1 0 0

HYDROGRAPH DATA
IMVGC IUNG TAREA SNAP TRSDA TRSPC RATIO ISNOW ISAME LOCAL
1 1 1.07 0. 0. 1.07 0. 0. 0. 0. 1 0 0

PRECIP DATA

SPFE PMS R6 R12 R24 R48 R72 R96
0. 20.00 111.00 123.00 132.00 142.00 0. 0.

TRSPC COMPUTED BY THE PROGRAM IS 0.800

LOSS DATA
LROPT STRKR DLTKR RTIOL ERAIN STAKS RTIOK STRTL CNSTL ALSHX RTIMP
0 0. 0. 1.00 0. 0. 1.00 1.00 0.03 0. 0.02

UNIT HYDROGRAPH DATA
TP= 2.75 CP=0.53 NTA= C

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 5.99 AND R= 6.87 INTERVALS
STRTQ= 1.00 QRCSN= 3.00 RTICR= 3.00
RECESSION DATA

UNIT HYDROGRAPH 40 END-OF-PERIOD ORDINATES, LAG= 2.73 HOURS, CP= 0.53 VOL= 1.00
9. 33. 66. 100. 124. 133. 124. 107. 92. 80.
69. 60. 52. 45. 38. 33. 29. 25. 21. 19.
16. 14. 12. 10. 9. 8. 7. 6. 5. 4.
4. 3. 3. 2. 2. 2. 2. 1. 1. 1.

MO-DA MR-MN PERIOD RAIN EXCS LOSS COMP Q MO-DA MR-MN PERIOD RAIN EXCS LESS COMP Q
1.01 0.30 1 0.00 0.00 1. 1.02 14.00 76 1.07 1.04 0.02 322.
1.01 1.00 2 0.00 0.00 1. 1.02 14.30 77 1.33 1.31 0.02 429.

END-OF-PERIOD FLOW

1.01	2.30	0.00	0.00	0.00	1.02	15.30	79	1.62	1.40	0.02	690.
1.01	3.00	0.00	0.00	0.00	1.02	16.00	80	5.13	5.10	0.02	662.
1.01	3.30	0.00	0.00	0.00	1.02	16.30	81	1.24	1.22	0.02	1086.
1.01	4.00	0.00	0.00	0.00	1.02	17.00	82	1.24	1.22	0.02	1333.
1.01	4.30	0.00	0.00	0.00	1.02	17.30	83	0.98	0.95	0.02	1560.
1.01	5.00	0.00	0.00	0.00	1.02	18.00	84	0.98	0.95	0.02	1724.
1.01	5.30	0.00	0.00	0.00	1.02	18.30	85	0.07	0.03	0.02	1752.
1.01	6.00	0.00	0.00	0.00	1.02	19.00	86	0.07	0.03	0.02	1749.
1.01	6.30	0.00	0.00	0.00	1.02	19.30	87	0.07	0.03	0.02	1634.
1.01	7.00	0.00	0.00	0.00	1.02	20.00	88	0.07	0.03	0.02	1488.
1.01	7.30	0.00	0.00	0.00	1.02	20.30	89	0.07	0.03	0.02	1326.
1.01	8.00	0.00	0.00	0.00	1.02	21.00	90	0.07	0.03	0.02	1163.
1.01	8.30	0.00	0.00	0.00	1.02	21.30	91	0.07	0.03	0.02	1014.
1.01	9.00	0.00	0.00	0.00	1.02	22.00	92	0.07	0.03	0.02	686.
1.01	9.30	0.00	0.00	0.00	1.02	22.30	93	0.07	0.03	0.02	774.
1.01	10.00	0.00	0.00	0.00	1.02	23.00	94	0.07	0.03	0.02	678.
1.01	10.30	0.00	0.00	0.00	1.02	23.30	95	0.07	0.03	0.02	595.
1.01	11.00	0.00	0.00	0.00	1.03	C.30	96	0.07	0.03	0.02	523.
1.01	11.30	0.00	0.00	0.00	1.03	1.00	97	0.	0.	0.	461.
1.01	12.00	0.00	0.00	0.00	1.03	1.30	98	0.	0.	0.	405.
1.01	12.30	0.00	0.00	0.00	1.03	2.00	99	0.	0.	0.	356.
1.01	13.00	0.00	0.00	0.00	1.03	2.30	100	0.	0.	0.	311.
1.01	13.30	0.00	0.00	0.00	1.03	3.00	101	0.	0.	0.	270.
1.01	14.00	0.00	0.00	0.00	1.03	3.30	102	0.	0.	0.	234.
1.01	14.30	0.00	0.00	0.00	1.03	4.00	103	0.	0.	0.	202.
1.01	15.00	0.00	0.00	0.00	1.03	4.30	104	0.	0.	0.	175.
1.01	15.30	0.00	0.00	0.00	1.03	5.00	105	0.	0.	0.	151.
1.01	16.00	0.00	0.00	0.00	1.03	5.30	106	0.	0.	0.	130.
1.01	16.30	0.00	0.00	0.00	1.03	6.00	107	0.	0.	0.	112.
1.01	17.00	0.00	0.00	0.00	1.03	6.30	108	0.	0.	0.	97.
1.01	17.30	0.00	0.00	0.00	1.03	7.00	109	0.	0.	0.	84.
1.01	18.00	0.00	0.00	0.00	1.03	7.30	110	0.	0.	0.	72.
1.01	18.30	0.00	0.00	0.00	1.03	8.00	111	0.	0.	0.	62.
1.01	19.00	0.00	0.00	0.00	1.03	8.30	112	0.	0.	0.	54.
1.01	19.30	0.00	0.00	0.00	1.03	9.00	113	0.	0.	0.	46.
1.01	20.00	0.00	0.00	0.00	1.03	9.30	114	0.	0.	0.	39.
1.01	20.30	0.00	0.00	0.00	1.03	10.00	115	0.	0.	0.	33.
1.01	21.00	0.00	0.00	0.00	1.03	10.30	116	0.	0.	0.	27.
1.01	21.30	0.00	0.00	0.00	1.03	11.00	117	0.	0.	0.	22.
1.01	22.00	0.00	0.00	0.00	1.03	11.30	118	0.	0.	0.	18.
1.01	22.30	0.00	0.00	0.00	1.03	12.00	119	0.	0.	0.	14.
1.01	23.00	0.00	0.00	0.00	1.03	12.30	120	0.	0.	0.	8.
1.01	23.30	0.00	0.00	0.00	1.03	13.00	121	0.	0.	0.	6.
1.02	0.	0.00	0.00	0.00	1.03	13.30	122	0.	0.	0.	4.
1.02	0.30	0.00	0.00	0.00	1.03	14.00	123	0.	0.	0.	3.
1.02	1.00	0.00	0.00	0.00	1.03	14.30	124	0.	0.	0.	3.
1.02	1.30	0.00	0.00	0.00	1.03	15.00	125	0.	0.	0.	2.
1.02	2.00	0.00	0.00	0.00	1.03	15.30	126	0.	0.	0.	2.
1.02	2.30	0.00	0.00	0.00	1.03	16.00	127	0.	0.	0.	2.
1.02	3.00	0.00	0.00	0.00	1.03	16.30	128	0.	0.	0.	2.
1.02	3.30	0.00	0.00	0.00	1.03	17.00	129	0.	0.	0.	1.
1.02	4.00	0.00	0.00	0.00	1.03	17.30	130	0.	0.	0.	1.
1.02	4.30	0.00	0.00	0.00	1.03	18.00	131	0.	0.	0.	1.
1.02	5.00	0.00	0.00	0.00	1.03	18.30	132	0.	0.	0.	1.
1.02	5.30	0.00	0.00	0.00	1.03	19.00	133	0.	0.	0.	1.
1.02	6.00	0.00	0.00	0.00	1.03	19.30	134	0.	0.	0.	1.
1.02	6.30	0.00	0.00	0.00	1.03	20.00	135	0.	0.	0.	1.
1.02	7.00	0.00	0.00	0.00	1.03	20.30	136	0.	0.	0.	1.
1.02	7.30	0.00	0.00	0.00	1.03	21.00	137	0.	0.	0.	1.
1.02	8.00	0.00	0.00	0.00	1.03	21.30	138	0.	0.	0.	1.
1.02	8.30	0.00	0.00	0.00	1.03	22.00	139	0.	0.	0.	0.
1.02	9.00	0.00	0.00	0.00	1.03	22.30	140	0.	0.	0.	0.
1.02	9.30	0.00	0.00	0.00	1.03	23.00	141	0.	0.	0.	0.
1.02	10.00	0.00	0.00	0.00	1.03	23.30	142	0.	0.	0.	0.
1.02	10.30	0.00	0.00	0.00	1.03	24.00	143	0.	0.	0.	0.
1.02	11.00	0.00	0.00	0.00	1.03	24.30	144	0.	0.	0.	0.
1.02	11.30	0.00	0.00	0.00	1.03	25.00	145	0.	0.	0.	0.
1.02	12.00	0.00	0.00	0.00	1.03	25.30	146	0.	0.	0.	0.
1.02	12.30	0.00	0.00	0.00	1.03	26.00	147	0.	0.	0.	0.
1.02	13.00	0.00	0.00	0.00	1.03	26.30	148	0.	0.	0.	0.
1.02	13.30	0.00	0.00	0.00	1.03	27.00	149	0.	0.	0.	0.
1.02	14.00	0.00	0.00	0.00	1.03	27.30	150	0.	0.	0.	0.
1.02	14.30	0.00	0.00	0.00	1.03	28.00	151	0.	0.	0.	0.
1.02	15.00	0.00	0.00	0.00	1.03	28.30	152	0.	0.	0.	0.
1.02	15.30	0.00	0.00	0.00	1.03	29.00	153	0.	0.	0.	0.
1.02	16.00	0.00	0.00	0.00	1.03	29.30	154	0.	0.	0.	0.
1.02	16.30	0.00	0.00	0.00	1.03	30.00	155	0.	0.	0.	0.
1.02	17.00	0.00	0.00	0.00	1.03	30.30	156	0.	0.	0.	0.
1.02	17.30	0.00	0.00	0.00	1.03	31.00	157	0.	0.	0.	0.
1.02	18.00	0.00	0.00	0.00	1.03	31.30	158	0.	0.	0.	0.
1.02	18.30	0.00	0.00	0.00	1.03	32.00	159	0.	0.	0.	0.
1.02	19.00	0.00	0.00	0.00	1.03	32.30	160	0.	0.	0.	0.
1.02	19.30	0.00	0.00	0.00	1.03	33.00	161	0.	0.	0.	0.
1.02	20.00	0.00	0.00	0.00	1.03	33.30	162	0.	0.	0.	0.
1.02	20.30	0.00	0.00	0.00	1.03	34.00	163	0.	0.	0.	0.
1.02	21.00	0.00	0.00	0.00	1.03	34.30	164	0.	0.	0.	0.
1.02	21.30	0.00	0.00	0.00	1.03	35.00	165	0.	0.	0.	0.
1.02	22.00	0.00	0.00	0.00	1.03	35.30	166	0.	0.	0.	0.
1.02	22.30	0.00	0.00	0.00	1.03	36.00	167	0.	0.	0.	0.
1.02	23.00	0.00	0.00	0.00	1.03	36.30	168	0.	0.	0.	0.
1.02	23.30	0.00	0.00	0.00	1.03	37.00	169	0.	0.	0.	0.
1.02	24.00	0.00	0.00	0.00	1.03	37.30	170	0.	0.	0.	0.
1.02	24.30	0.00	0.00	0.00	1.03	38.00	171	0.	0.	0.	0.
1.02	25.00	0.00	0.00	0.00	1.03	38.30	172	0.	0.	0.	0.
1.02	25.30	0.00	0.00	0.00	1.03	39.00	173	0.	0.	0.	0.
1.02	26.00	0.00	0.00	0.00	1.03	39.30	174	0.	0.	0.	0.
1.02	26.30	0.00	0.00	0.00	1.03	40.00	175	0.	0.	0.	0.
1.02	27.00	0.00	0.00	0.00	1.03	40.30	176	0.	0.	0.	0.
1.02	27.30	0.00	0.00	0.00	1.03	41.00	177	0.	0.	0.	0.
1.02	28.00	0.00	0.00	0.00	1.03	41.30	178	0.	0.	0.	0.
1.02	28.30	0.00	0.00	0.00	1.03	42.00	179	0.	0.	0.	0.
1.02	29.00	0.00	0.00	0.00	1.03	42.30	180	0.	0.	0.	0.
1.02	29.30	0.00	0.00	0.00	1.03	43.00	181	0.	0.	0.	0.
1.02	30.00	0.00	0.00	0.00	1.03	43.30	182	0.	0.	0.	0.
1.02	30.30	0.00	0.00	0.00	1.03	44.00	183	0.	0.	0.	0.
1.02	31.00	0.00	0.00	0.00	1.03	44.30	184	0.	0.	0.	0.
1.02	31.30	0.00	0.00	0.00	1.03	45.00	185	0.	0.	0.	0.
1.02	32.00	0.00	0.00	0.00	1.03	45.30	186	0.	0.	0.	0.
1.02	32.30	0.00	0.00	0.00	1.03	46.00	187	0.	0.	0.	0.
1.02	33.00	0.00	0.00	0.00	1.03	46.30	188	0.	0.	0.	0.
1.02	33.30	0.00	0.00	0.00	1.03	47.00	189	0.	0.	0.	0.
1.02	34.00	0.00	0.00	0.00	1.03	47.30	190	0.	0.	0.	0.
1.02	34.30	0.00	0.00	0.00	1.03	48.00	191	0.	0.	0.	0.
1.02	35.00	0.00	0.00	0.00	1.03	48.30	192	0.	0.	0.	0.
1.02	35.30	0.00	0.00	0.00	1.03	49.00	193	0.	0.	0.	0.
1.02	36.00	0.00	0.00	0.00	1.03	49.30	194	0.	0.	0.	0.
1.02	36.30	0.00	0.00	0.00	1.03	50.00	195	0.	0.	0.	0.
1.02	37.00	0.00	0.00	0.00	1.03	50.30	196	0.	0.	0.	0.
1.02	37.30	0.00	0.00	0.00	1.03	51.00	197	0.	0.	0.	0.
1.02	38.00	0.00	0.00	0.00	1.03	51.30	198	0.	0.	0.	0.
1.02	38.30	0.00	0.00	0.00	1.03	52.00	199</				

1.02	11.30	71	0.16	0.14	0.02	136.	1.04	1.00	146	0.	0.	0.
1.02	12.00	72	0.16	0.14	0.02	143.	1.04	1.30	147	0.	0.	0.
1.02	12.30	73	0.89	0.86	0.02	125.	1.04	2.00	148	0.	0.	0.
1.02	13.00	74	0.89	0.86	0.02	135.	1.04	2.30	149	0.	0.	0.
1.02	13.30	75	1.07	1.04	0.02	239.	1.04	3.00	150	0.	0.	0.

SUP 22.72 20.40 2.32 27963.
(577.)(518.)(59.)(791.82)

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
1792.	1395.	559.	194.	27972.
51.	40.	16.	6.	792.
CFS	12.16	19.49	20.32	20.32
CMS	308.99	494.93	516.16	516.16
INCHES	692.	1108.	1156.	1156.
MM	893.	1367.	1426.	1426.
AC-FT				
TH-OLS CU H				

HYDROGRAPH AT STA BASIN FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	17.	15.	13.	11.	9.	8.	21.	23.	23.	21.	21.	21.
6.	7.	8.	9.	10.	10.	10.	10.	11.	11.	12.	12.	12.
13.	15.	18.	24.	30.	37.	43.	43.	49.	54.	58.	58.	58.
61.	70.	83.	108.	145.	193.	250.	250.	250.	311.	388.	388.	388.
489.	600.	702.	806.	876.	935.	970.	970.	970.	997.	997.	997.	997.
456.	395.	343.	268.	235.	207.	182.	160.	140.	138.	140.	140.	140.
122.	91.	79.	63.	59.	51.	44.	38.	33.	33.	33.	33.	33.
28.	24.	21.	17.	15.	12.	10.	8.	6.	6.	6.	6.	6.
3.	2.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
806.	628.	251.	87.	12587.
23.	18.	7.	2.	336.
CFS	5.47	8.77	9.14	9.14
CMS	139.05	222.72	232.27	232.27
INCHES	311.	499.	520.	520.
MM	384.	615.	642.	642.
AC-FT				
TH-OLS CU H				

HYDROGRAPH AT STA BASIN FOR PLAN 1, RTIO 2

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	17.	15.	13.	11.	10.	8.	22.	23.	23.	22.	22.	22.
6.	7.	8.	9.	10.	10.	10.	10.	11.	11.	12.	12.	12.
13.	15.	18.	24.	31.	38.	44.	44.	50.	55.	59.	59.	59.
63.	71.	85.	110.	148.	198.	256.	256.	256.	318.	396.	396.	396.
500.	613.	718.	824.	805.	751.	685.	610.	610.	610.	610.	610.	610.
467.	407.	356.	274.	241.	212.	187.	164.	164.	164.	164.	164.	164.
124.	108.	93.	69.	60.	52.	45.	39.	39.	39.	39.	39.	39.
29.	25.	21.	18.	15.	13.	10.	8.	7.	7.	7.	7.	7.
3.	2.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
824.	642.	257.	89.	12867.
23.	18.	7.	3.	364.
CFS				
CMS				

AC-FT
T-OLS CU M

692. 1108. 1156.
853. 1367. 1426.

HYDROGRAPH ROUTING

ROUTED OUTFLOW - SPILLCREST ELEV 425 - USGS - WITH BREACH
 ISTAQ ICOMP IECN ITAPE JPLT JPR1 INAME ISTAGE I AUTO
 DAM 1 0 0 0 1 0 0

ROUTING DATA
 IRES ISAME IDPT IPMP LSTR
 0. 1 1 0 C 0

NSPTS NSTOL LAG AMSKK X TSK STORA ISPRAT
 1 0 0 0. 0. -425. -1

STAGE	425.00	425.50	426.00	426.50	427.00	427.50	427.80	428.00	428.50	429.00
FLOW	0.	44.00	129.00	237.00	368.00	518.00	616.00	628.00	699.00	758.00

CAPACITY= 1. 251.

ELEVATION= 389. 425.

CREL	SPWID	COQM	EXPW	ELEV	COQL	CAREA	EXPL
425.0	0.	0.	0.	0.	0.	0.	0.

DAM DATA

TOPEL	COQD	EXPD	DAMWID
428.8	3.1	1.5	382.

DAM BREACH DATA

BRWID	Z	ELRM	TFAIL	WSEL	FAILEL
44.	0.	400.00	0.50	425.00	428.80

STATION DAM, PLAN 1, RATIC 1

END-OF-PERIOD HYDROGRAPH ORIGINATES

OUTFLOW		STORAGE	
0.	0.	251.	251.
0.	0.	251.	251.
0.	0.	251.	251.
0.	0.	251.	251.
1.	4.	251.	251.
17.	15.	251.	251.
17.	16.	251.	251.
8.	8.	251.	251.
11.	14.	251.	251.
12.	17.	251.	251.
56.	76.	251.	251.
470.	686.	251.	251.
366.	324.	251.	251.
603.	94.	251.	251.
136.	107.	251.	251.
39.	32.	251.	251.
10.	7.	251.	251.
10.	1.	251.	251.
2.	1.	251.	251.
0.	0.	251.	251.

THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF 0.010 HOURS DURING BREACH FORMATION. DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF 0.500 HOURS. THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH. INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

46% x PMF

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	COMPUTED BREACH HYDROGRAPH (CFS)	ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
43.500	0.	761.	761.	0.	0.	0.
43.510	0.010	857.	820.	37.	37.	0.
43.520	0.020	954.	926.	28.	65.	0.
43.530	0.030	1050.	1060.	-9.	56.	0.
43.540	0.040	1147.	1214.	-68.	-12.	-0.
43.550	0.050	1243.	1385.	-142.	-154.	-0.
43.560	0.060	1340.	1568.	-228.	-382.	-0.
43.570	0.070	1436.	1761.	-325.	-707.	-1.
43.580	0.080	1533.	1962.	-429.	-1136.	-1.
43.590	0.090	1629.	2168.	-538.	-1675.	-1.
43.600	0.100	1726.	2382.	-656.	-2331.	-2.
43.610	0.110	1822.	2599.	-777.	-3107.	-3.
43.620	0.120	1919.	2818.	-900.	-4007.	-3.
43.630	0.130	2015.	3038.	-1023.	-5030.	-4.
43.640	0.140	2111.	3260.	-1149.	-6179.	-5.
43.650	0.150	2208.	3490.	-1282.	-7461.	-6.
43.660	0.160	2304.	3683.	-1378.	-8839.	-7.
43.670	0.170	2401.	3867.	-1466.	-10305.	-8.
43.680	0.180	2497.	4052.	-1555.	-11860.	-10.
43.690	0.190	2594.	4233.	-1639.	-13499.	-11.
43.700	0.200	2690.	4412.	-1722.	-15221.	-13.
43.710	0.210	2787.	4592.	-1806.	-17026.	-14.
43.720	0.220	2883.	4768.	-1884.	-18911.	-16.
43.730	0.230	2980.	4948.	-1968.	-20879.	-17.
43.740	0.240	3076.	5124.	-2047.	-22927.	-19.
43.750	0.250	3173.	5303.	-2131.	-25057.	-21.
43.760	0.260	3269.	5480.	-2211.	-27268.	-23.
43.770	0.270	3365.	5669.	-2304.	-29572.	-24.
43.780	0.280	3462.	5847.	-2385.	-31937.	-26.
43.790	0.290	3558.	5823.	-2265.	-34221.	-28.
43.800	0.300	3655.	5801.	-2146.	-36367.	-30.
43.810	0.310	3751.	5781.	-2029.	-38397.	-32.
43.820	0.320	3848.	5762.	-1914.	-40311.	-33.
43.830	0.330	3944.	5745.	-1800.	-42111.	-35.
43.840	0.340	4041.	5729.	-1688.	-43799.	-36.
43.850	0.350	4137.	5714.	-1577.	-45376.	-38.
43.860	0.360	4234.	5700.	-1466.	-46842.	-39.
43.870	0.370	4330.	5687.	-1357.	-48200.	-40.
43.880	0.380	4427.	5676.	-1249.	-49449.	-41.
43.890	0.390	4523.	5665.	-1142.	-50590.	-42.
43.900	0.400	4619.	5655.	-1035.	-51625.	-43.
43.910	0.410	4716.	5645.	-929.	-52554.	-43.
43.920	0.420	4812.	5636.	-824.	-53378.	-44.
43.930	0.430	4909.	5628.	-719.	-54098.	-45.
43.940	0.440	5005.	5620.	-615.	-54713.	-45.
43.950	0.450	5102.	5613.	-512.	-55224.	-46.
43.960	0.460	5198.	5607.	-408.	-55633.	-46.
43.970	0.470	5295.	5601.	-306.	-55939.	-46.
43.980	0.480	5391.	5595.	-204.	-56142.	-46.
43.990	0.490	5488.	5589.	-102.	-56244.	-46.
44.000	0.500	5584.	5584.	0.	-56244.	-46.

QVF*

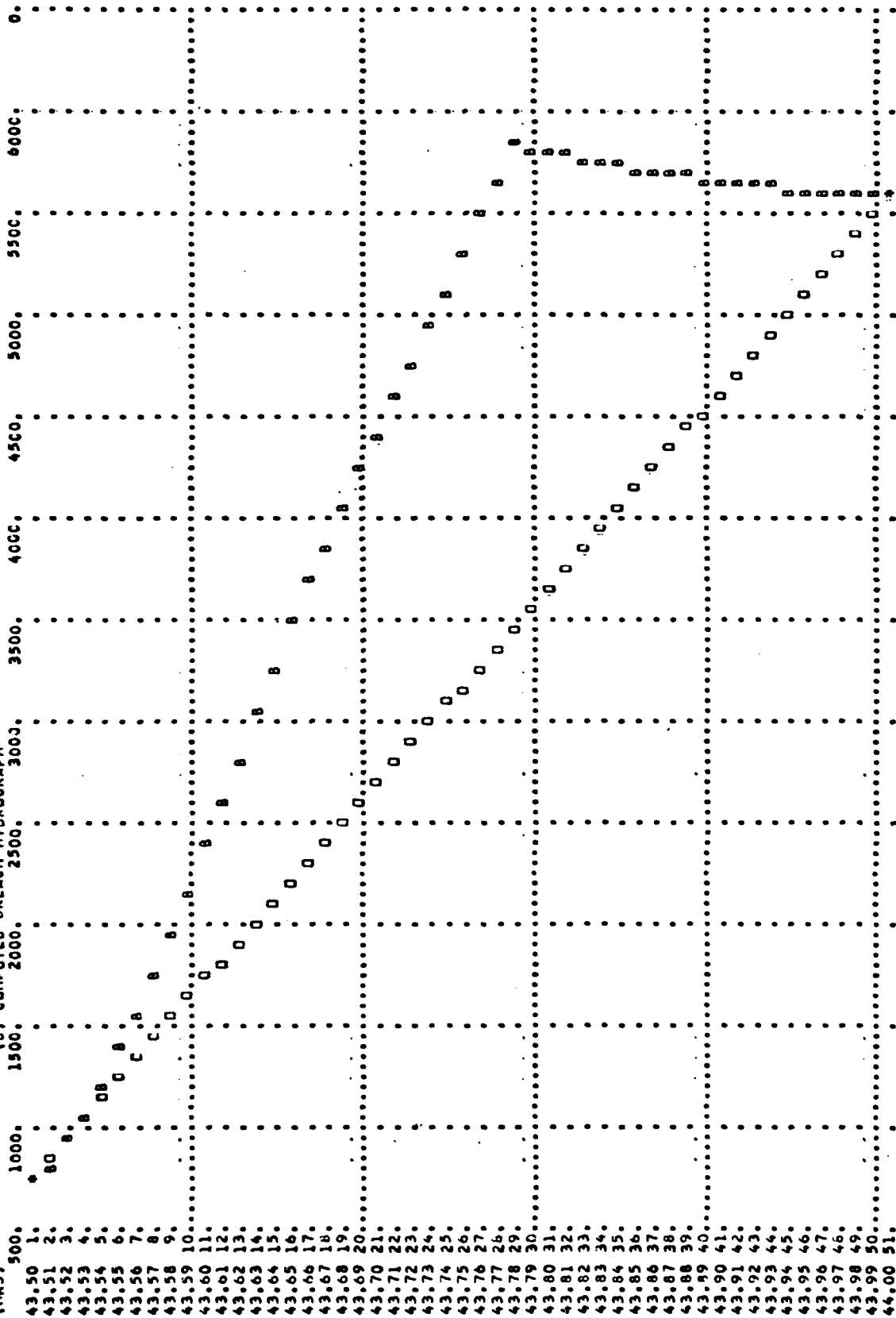
STATION DAM

TIME (HRS)

(A) POINTS AT NORMAL TIME INTERVAL

(C) INTERPOLATED BREACH HYDROGRAPH

(B) COMPUTED BREACH HYDROGRAPH



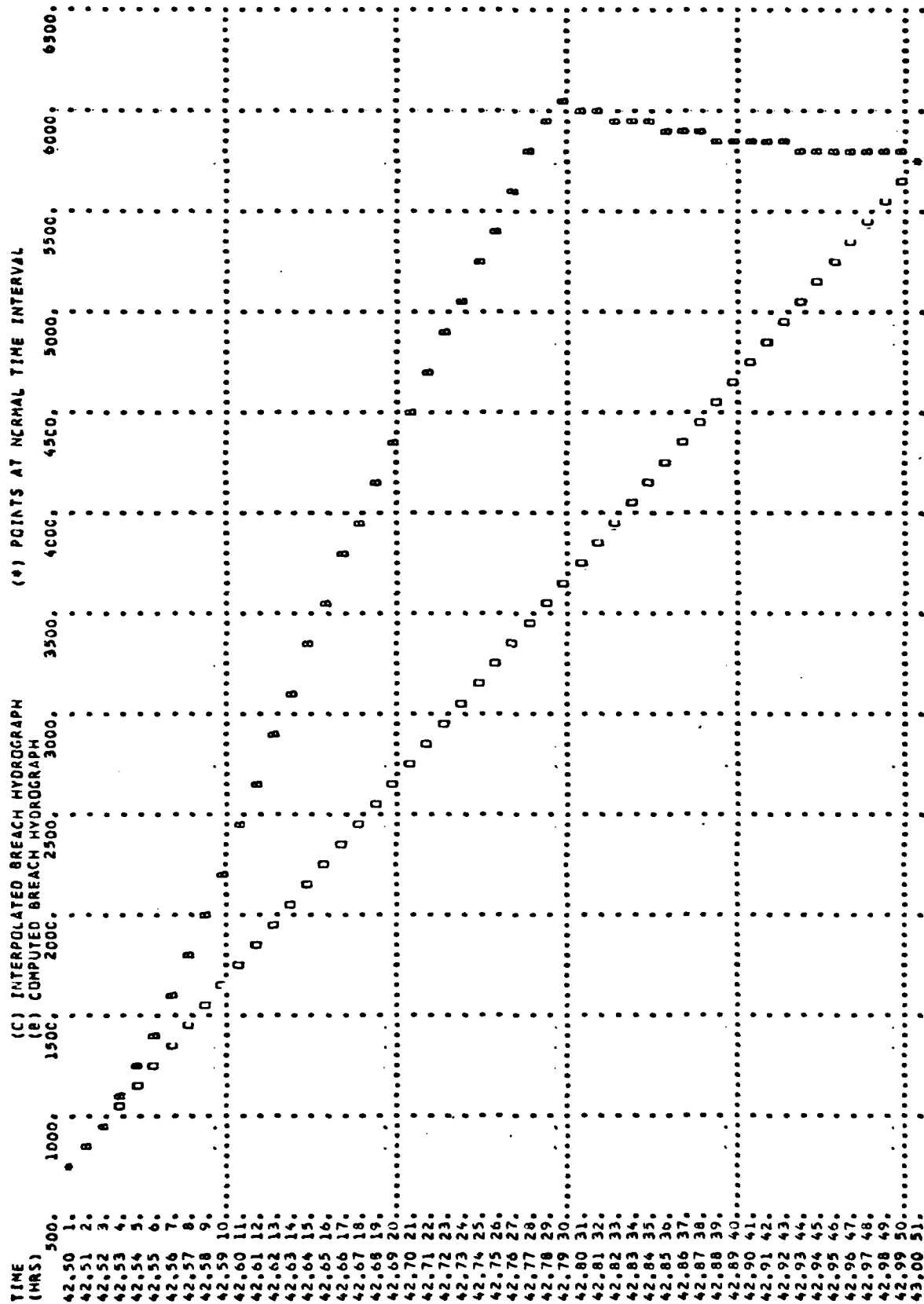
46% x PMF

THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF 0.010 HOURS DURING BREACH FORMATION. DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF 0.500 HOURS. THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH. INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	COMPUTED BREACH HYDROGRAPH (CFS)	ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)	50% x PMF
42.500	0.010	765.	765.	0.	0.	0.	
42.510	0.010	865.	830.	35.	35.	0.	
42.520	0.020	965.	940.	25.	60.	0.	
42.530	0.030	1065.	1077.	-12.	49.	0.	
42.540	0.040	1165.	1234.	-69.	-20.	-C.	
42.550	0.050	1266.	1409.	-144.	-164.	-C.	
42.560	0.060	1366.	1599.	-232.	-396.	-C.	
42.570	0.070	1466.	1796.	-330.	-727.	-1.	
42.580	0.080	1566.	2002.	-436.	-1163.	-1.	
42.590	0.090	1666.	2213.	-547.	-1710.	-1.	
42.600	0.100	1766.	2429.	-662.	-2372.	-1.	
42.610	0.110	1866.	2651.	-785.	-3157.	-3.	
42.620	0.120	1967.	2876.	-909.	-4066.	-3.	
42.630	0.130	2067.	3101.	-1034.	-5100.	-4.	
42.640	0.140	2167.	3325.	-1158.	-6258.	-5.	
42.650	0.150	2267.	3555.	-1288.	-7546.	-6.	
42.660	0.160	2367.	3780.	-1413.	-8959.	-7.	
42.670	0.170	2467.	3969.	-1501.	-10460.	-9.	
42.680	0.180	2568.	4155.	-1588.	-12048.	-10.	
42.690	0.190	2668.	4341.	-1673.	-13721.	-11.	
42.700	0.200	2768.	4522.	-1754.	-15475.	-13.	
42.710	0.210	2868.	4704.	-1836.	-17311.	-14.	
42.720	0.220	2968.	4883.	-1915.	-19226.	-16.	
42.730	0.230	3068.	5062.	-1993.	-21219.	-18.	
42.740	0.240	3168.	5241.	-2072.	-23291.	-19.	
42.750	0.250	3269.	5418.	-2150.	-25441.	-21.	
42.760	0.260	3369.	5598.	-2230.	-27671.	-23.	
42.770	0.270	3469.	5780.	-2311.	-29982.	-25.	
42.780	0.280	3569.	5971.	-2402.	-32384.	-27.	
42.790	0.290	3669.	6044.	-2475.	-34758.	-29.	
42.800	0.300	3769.	6017.	-2248.	-37006.	-31.	
42.810	0.310	3870.	5993.	-2124.	-39130.	-32.	
42.820	0.320	3970.	5971.	-2001.	-41131.	-34.	
42.830	0.330	4070.	5951.	-1881.	-43012.	-36.	
42.840	0.340	4170.	5932.	-1762.	-44774.	-37.	
42.850	0.350	4270.	5915.	-1645.	-46419.	-38.	
42.860	0.360	4370.	5899.	-1529.	-47947.	-40.	
42.870	0.370	4470.	5884.	-1414.	-49361.	-41.	
42.880	0.380	4571.	5871.	-1300.	-50661.	-42.	
42.890	0.390	4671.	5859.	-1188.	-51849.	-43.	
42.900	0.400	4771.	5847.	-1076.	-52925.	-44.	
42.910	0.410	4871.	5837.	-966.	-53891.	-45.	
42.920	0.420	4971.	5827.	-856.	-54747.	-45.	
42.930	0.430	5071.	5818.	-747.	-55493.	-46.	
42.940	0.440	5172.	5810.	-638.	-56132.	-46.	
42.950	0.450	5272.	5802.	-531.	-56663.	-47.	
42.960	0.460	5372.	5795.	-424.	-57086.	-47.	
42.970	0.470	5472.	5789.	-317.	-57403.	-47.	
42.980	0.480	5572.	5783.	-211.	-57614.	-48.	
42.990	0.490	5672.	5778.	-105.	-57719.	-48.	
43.000	0.500	5772.	5772.	0.	-57719.	-48.	

NOVF*

STATION DAM



50% x PMF

THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF 0.010 MCLRS CLURING BREACH FORMATION.
 DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF 0.500 HOURS.
 THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH.
 INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	COMPUTED BREACH HYDROGRAPH (CFS)	ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
40.500	0.010	766.	766.	0.	0.	C.
40.510	0.010	839.	839.	36.	36.	C.
40.520	0.020	983.	958.	25.	61.	C.
40.530	0.030	1091.	1103.	-12.	49.	C.
40.540	0.040	1200.	1268.	-68.	-19.	-C.
40.550	0.050	1308.	1445.	-137.	-156.	-C.
40.560	0.060	1416.	1635.	-219.	-375.	-C.
40.570	0.070	1525.	1840.	-316.	-691.	-C.
40.580	0.080	1633.	2054.	-421.	-1112.	-1.
40.590	0.090	1742.	2274.	-533.	-1645.	-1.
40.600	0.100	1850.	2498.	-648.	-2293.	-2.
40.610	0.110	1958.	2725.	-766.	-3060.	-3.
40.620	0.120	2067.	2956.	-890.	-3949.	-3.
40.630	0.130	2175.	3190.	-1015.	-4964.	-4.
40.640	0.140	2283.	3423.	-1140.	-6104.	-5.
40.650	0.150	2392.	3655.	-1264.	-7368.	-6.
40.660	0.160	2500.	3891.	-1391.	-8759.	-7.
40.670	0.170	2609.	4124.	-1516.	-10274.	-8.
40.680	0.180	2717.	4318.	-1601.	-11875.	-10.
40.690	0.190	2825.	4509.	-1684.	-13559.	-11.
40.700	0.200	2934.	4699.	-1765.	-15323.	-13.
40.710	0.210	3042.	4883.	-1841.	-17165.	-14.
40.720	0.220	3151.	5070.	-1919.	-19084.	-16.
40.730	0.230	3259.	5252.	-1993.	-21077.	-17.
40.740	0.240	3367.	5435.	-2067.	-23145.	-15.
40.750	0.250	3476.	5617.	-2142.	-25286.	-21.
40.760	0.260	3584.	5799.	-2215.	-27501.	-23.
40.770	0.270	3692.	5981.	-2289.	-29790.	-25.
40.780	0.280	3801.	6168.	-2368.	-32157.	-27.
40.790	0.290	3909.	6362.	-2452.	-34610.	-29.
40.800	0.300	4018.	6408.	-2391.	-37001.	-31.
40.810	0.310	4126.	6381.	-2255.	-39255.	-32.
40.820	0.320	4234.	6356.	-2121.	-41377.	-34.
40.830	0.330	4343.	6333.	-1990.	-43367.	-36.
40.840	0.340	4451.	6313.	-1862.	-45229.	-37.
40.850	0.350	4559.	6295.	-1736.	-46965.	-39.
40.860	0.360	4668.	6279.	-1611.	-48576.	-40.
40.870	0.370	4776.	6265.	-1488.	-50064.	-41.
40.880	0.380	4885.	6252.	-1367.	-51431.	-43.
40.890	0.390	4993.	6241.	-1248.	-52679.	-44.
40.900	0.400	5101.	6231.	-1129.	-53808.	-44.
40.910	0.410	5210.	6222.	-1012.	-54820.	-45.
40.920	0.420	5318.	6215.	-896.	-55717.	-46.
40.930	0.430	5427.	6208.	-782.	-56498.	-47.
40.940	0.440	5535.	6203.	-668.	-57166.	-47.
40.950	0.450	5643.	6198.	-555.	-57720.	-48.
40.960	0.460	5752.	6194.	-442.	-58163.	-48.
40.970	0.470	5860.	6191.	-331.	-58494.	-48.
40.980	0.480	5968.	6188.	-220.	-58713.	-49.
40.990	0.490	6077.	6187.	-110.	-58823.	-49.
41.000	0.500	6185.	6185.	0.	-58823.	-49.

PMF

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FORMULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO	1	RATIO	2	RATIO	3	RATIO	4	RATIOS APPLIED TC FLOWS
					0.45		0.46		0.50		1.00	
HYDROGRAPH AT	BASIN	1.07 (-0.00)	1	(	806. 22.83)	(	824. 23.34)	(	896. 25.37)	(	1792. 50.74)	(
ROUTED TO	DAM	1.07 (0.12E 25)	1	(	743. 21.04)	(	5584. 158.12)	(	5772. 163.46)	(	6185. 175.15)	(
ROUTED TO	UPTRB	1.07 (-0.00)	1	(	742. 21.01)	(	3538. 100.20)	(	3660. 103.65)	(	4087. 115.73)	(
ROUTED TO	LOWTRB	1.07 (-0.00)	1	(	741. 20.99)	(	3501. 100.84)	(	3684. 104.31)	(	4112. 116.43)	(

CHURCHTOWN
 RESERVOIR
 DAM

[w/ BREACH]

CHURCHTOWN RESERVOIR DAM [w/ BREACH]

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	ELEVATION STORAGE OUTFLOW	INITIAL VALUE 425.00 251. 0.	SPILLWAY CREST 425.00 251. 0.	TOP OF DAM 428.80 308. 758.	TIME OF FAILURE HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
RATIO CF PMF 0.45 0.46 0.50 1.00	MAXIMUM RESERVOIR W.S. ELEV 428.72 428.81 428.82 428.85	MAXIMUM STORAGE AC-FT 307. 308. 308. 309.	MAXIMUM OUTFLOW CFS 743. 5847. 6044. 6408.	DURATION OVER TOP HOURS 0. 0.52 0.54 0.56	43.50 43.78 42.79 40.80	43.50 43.78 42.79 40.80	43.50 43.78 42.79 40.80

PLAN 1 STATION LPT88

RATIO	MAXIMUM FLOW, CFS	MAXIMUM STAGE, FT	TIME HOURS
0.45	742.	285.3	43.50
0.46	3538.	285.9	44.50
0.50	3660.	290.1	43.50
1.00	4087.	290.5	41.50

PLAN 1 STATION LCTR8

RATIO	MAXIMUM FLOW, CFS	MAXIMUM STAGE, FT	TIME HOURS
0.45	741.	235.8	43.50
0.46	3561.	239.5	44.50
0.50	3684.	239.6	43.50
1.00	4112.	240.0	41.50

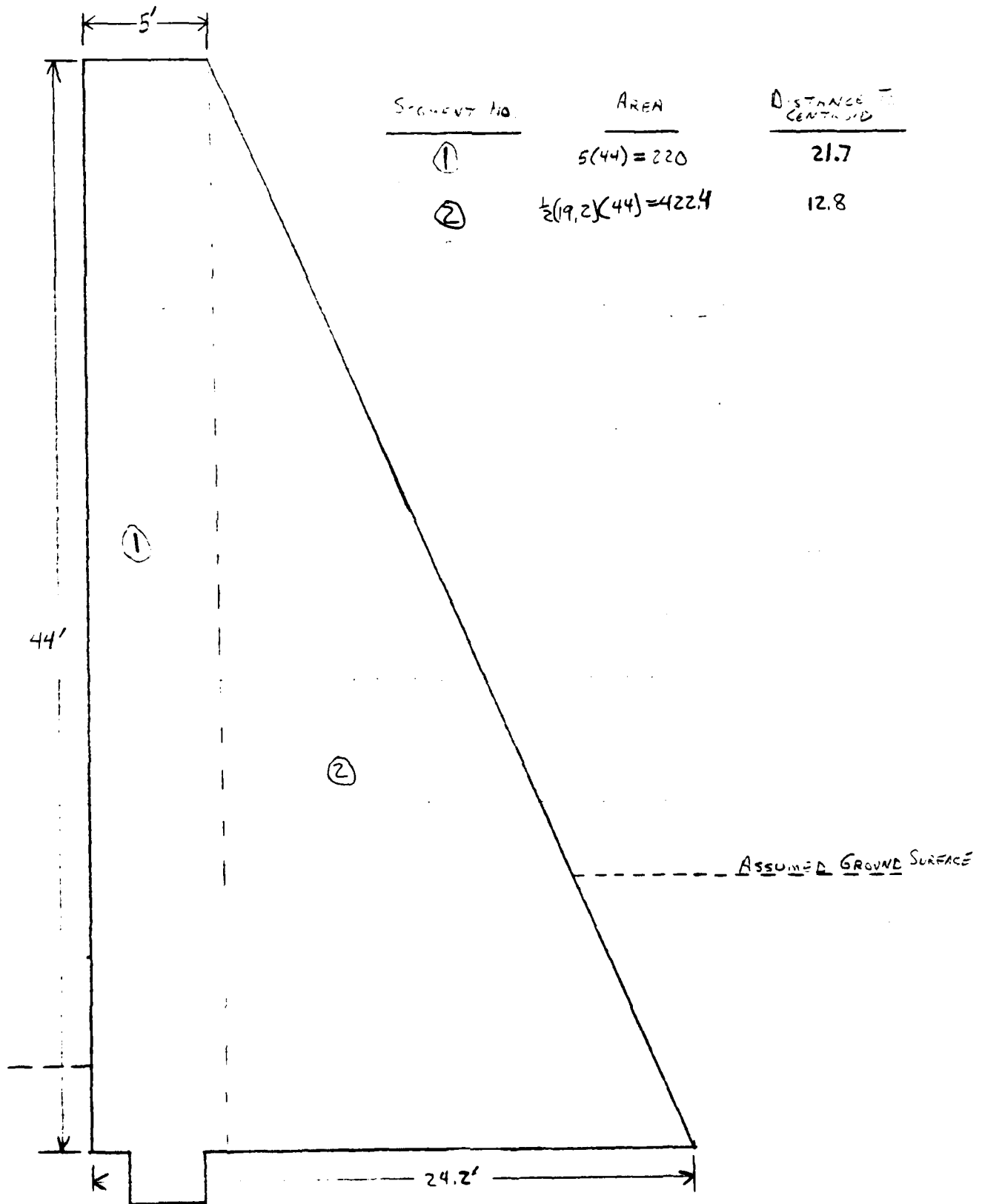
APPENDIX D
STABILITY COMPUTATIONS

STRUCTURAL STABILITY ANALYSIS CONDITIONS

1. Normal conditions; water surface at spillway crest.
2. Same as #1 plus ice load of 5,000 pounds per linear foot.
3. Flood flows - water surface at top of dam.
4. 1/2 PMF flow - water surface 0.18 feet above crest of dam.
5. PMF flow - water surface 0.81 feet above crest of dam.
6. Normal conditions; with seismic coefficient of 0.1.

CHURCHTOWN DAM

SCALE 1" = 5'



PROJECT GRID

JOB	SHEET NO.	CHECKED BY	DATE
CHURCH TOWN DAM	1		
SUBJECT	COMPUTED BY		DATE
STRUCTURAL STABILITY ANALYSIS	RLW		2/23/81

ANALYZE 2 CONDITIONS

1. FULL DAM SECTION

2. MID DAM SECTION - ASSUME A FAILURE ALONG JOINT BETWEEN BLOCKS

FOR FULL DAM SECTION

CALCULATE SHEARING RESISTANCE OF KEY

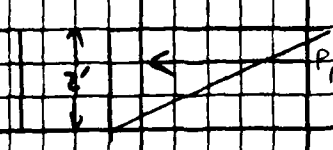
1. COMPUTE SHEAR STRENGTH OF CONCRETE

ASSUME 2000 PSI CONCRETE

SHEAR STRENGTH = $2\sqrt{f'_c} = 2\sqrt{2000} = 89.44 \text{ PSI}$

$$\frac{(\text{STRENGTH})(\text{AREA/FOOT})}{1000 \text{ LB/K}} = \frac{(89.44 \text{ PSI})(932 \text{ IN}^2/\text{FT})}{1000 \text{ LB/K}} = 38.64 \text{ K/FT}$$

CALCULATE PASSIVE RESISTANCE AVAILABLE



$$P_p = \frac{1}{2}(30)(0.55)(2)^2 = 0.33 \text{ K/FT}$$

USE THIS VALUE FOR SHEAR KEY RESISTANCE

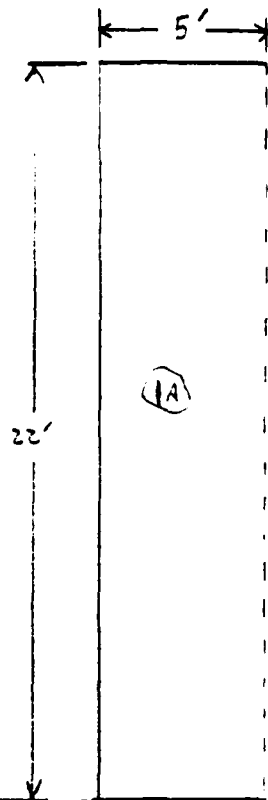
STABILITY ANALYSIS PROGRAM - WORK SHEET

FULL DAM SECTION

<u>INPUT ENTRY</u>		<u>ANALYSIS CONDITION</u>				
		1	2	3	4	5
Unit Weight of Dam (K/ft ³)	0	0.15				
Area of Segment No. 1 (ft ²)	1	220				
Distance from Center of Gravity of Segment No. 1 to Downstream Toe (ft)	2	21.7				
Area of Segment No. 2 (ft ²)	3	422.4				
Distance from Center of Gravity of Segment No. 2 to Downstream Toe (ft)	4	12.8				
Area of Segment No. 3 (ft ²)	5					
Distance from Center of Gravity of Segment No. 3 to Downstream Toe (ft)	6					
Base Width of Dam (Total) (ft)	7	24.2				
Height of Dam (ft)	8	44				
Ice Loading (K/L ft.)	9		5.0			
Coefficient of Sliding	10	0.60				
Unit Weight of Soil (K/ft ³) (deduct 18)	11	0.55				
Active Soil Coefficient - Ka	12	.33				
Passive Soil Coefficient - Kp	13	3.0				
Height of Water over Top of Dam or Spillway (ft)	14			3.8	3.98	4.61
Height of Soil for Active Pressure (ft)	15	3.5				
Height of Soil for Passive Pressure (ft)	16	13.0				
Height of Water in Tailrace Channel (ft)	17	13.0				
Weight of Water (K/ft ³)	18	0.0624				
SHEAR KEY RESISTANCE	52	.333				
Area of Segment No. 4 (ft ²)	19					
Distance from Center of Gravity of Segment No. 4 to Downstream Toe (ft)	20					
Height of Ice Load or Active Water (ft) (does not include 14)	46	40.2				
Seismic Coefficient (g)	50					
<u>RESULTS OF ANALYSIS</u>						
Factor of Safety vs. Overturning		1.29	1.11	1.09	1.08	1.06 1.20
Distance From Toe to Resultant		6.51	2.93	2.42	2.23	1.55 4.89
Factor of Safety vs. Sliding		1.05	0.96	0.87	0.87	0.84 0.81

CHURCHTOWN DAM
SECTION TAKEN AT MIDPOINT
AND SPILLWAY SECTION

SCALE 1"=50'



MIDPOINT
SEGMENT NO.

AREA

DISTANCE TO
CENTROID

1A

$$5(22) = 110$$

12

2A

$$\frac{1}{2}(9.5)(22) = 104.5$$

6.3

SPILLWAY
SEGMENT NO.

AREA

DISTANCE TO
CENTROID

1

$$5(44) = 220$$

27.3

2

$$\frac{1}{2}(25)(10.5) = 131.2$$

21.3

3

$$(10.5)(18.5) = 194.5$$

19.5

4

$$\frac{1}{2}(14)(10.5) = 74.4$$

9.5

5

$$(14)(8.5) = 121.5$$

7.1

STABILITY ANALYSIS PROGRAM - WORK SHEET
SPILLWAY SECTION

<u>INPUT ENTRY</u>		<u>ANALYSIS CONDITION</u>					
		1	2	3	4	5	6
Unit Weight of Dam (K/ft ³)	0	0.15					
Area of Segment No. 1 (ft ²)	1	220					
Distance from Center of Gravity of Segment No. 1 to Downstream Toe (ft)	2	27.3					
Area of Segment No. 2 (ft ²)	3	131.2					
Distance from Center of Gravity of Segment No. 2 to Downstream Toe (ft)	4	21.3					
Area of Segment No. 3 (ft ²)	5	199.5					
Distance from Center of Gravity of Segment No. 3 to Downstream Toe (ft)	6	19.5					
Base Width of Dam (Total) (ft)	7	29.7					
Height of Dam (ft)	8	40.2					
Ice Loading (K/L ft.)	9		5				
Coefficient of Sliding	10	0.60					
Unit Weight of Soil (K/ft ³) (deduct 18)	11	0.55					
Active Soil Coefficient - Ka	12	0.33					
Passive Soil Coefficient - Kp	13	3.0					
Height of Water over Top of Dam or Spillway (ft)	14			3.8	3.98	4.61	
Height of Soil for Active Pressure (ft)	15	3.5					
Height of Soil for Passive Pressure (ft)	16	13.0					
Height of Water in Tailrace Channel (ft)	17	13.0					
Weight of Water (K/ft ³)	18	0624					
Area of Segment No. 4 (ft ²)	19	74.4					
Distance from Center of Gravity of Segment No. 4 to Downstream Toe (ft)	20	9.5					
Height of Ice Load or Active Water (ft) (does not include 14)	46	40.2					
Seismic Coefficient (g)	50						0.1
SHEAR KEY RESISTANCE	58	0.333					
<u>RESULTS OF ANALYSIS</u>							
AREA SEGMENT 5	21	121.5					
DIS. TO CENT.	22	7.1					
Factor of Safety vs. Overturning		1.80	1.59	1.60	1.59	1.57	1.70
Distance From Toe to Resultant		19.66	16.45	16.60	16.45	15.74	18.22
Factor of Safety vs. Sliding		3.54	3.23	2.99	2.97	2.89	2.67

STABILITY ANALYSIS PROGRAM - WORK SHEET

FAILURE PLANE IN MIDDLE OF DAM

INPUT ENTRY		ANALYSIS CONDITION					
		1	2	3	4	5	6
Unit Weight of Dam (K/ft ³)	0	0.15					
Area of Segment No. 1 (ft ²)	1	110					
Distance from Center of Gravity of Segment No. 1 to Downstream Toe (ft)	2	12					
Area of Segment No. 2 (ft ²)	3	104.5					
Distance from Center of Gravity of Segment No. 2 to Downstream Toe (ft)	4	6.3					
Area of Segment No. 3 (ft ²)	5						
Distance from Center of Gravity of Segment No. 3 to Downstream Toe (ft)	6						
Base Width of Dam (Total) (ft)	7	14.5					
Height of Dam (ft)	8	22					
Ice Loading (K/L ft.)	9		5				
Coefficient of Sliding	10	.60					
Unit Weight of Soil (K/ft ³) (deduct 18)	11	.055					
Active Soil Coefficient - Ka	12	.33					
Passive Soil Coefficient - Kp	13	3.0					
Height of Water over Top of Dam or Spillway (ft)	14			3.8	3.98	4.61	
Height of Soil for Active Pressure (ft)	15						
Height of Soil for Passive Pressure (ft)	16						
Height of Water in Tailrace Channel (ft)	17						
Weight of Water (K/ft ³)	18	.0624					
Area of Segment No. 4 (ft ²)	19						
Distance from Center of Gravity of Segment No. 4 to Downstream Toe (ft)	20						
Height of Ice Load or Active Water (ft) (does not include 14)	46	18.2					
Seismic Coefficient (g)	50						0.1
<u>RESULTS OF ANALYSIS</u>							
Factor of Safety vs. Overturning		2.08	1.27	1.49	1.46	1.40	1.92
Distance From Toe to Resultant		6.45	2.65	4.05	3.94	3.54	6.09
Factor of Safety vs. Sliding		1.39	.94	0.92	0.91	0.86	0.98

APPENDIX E

REFERENCES

APPENDIX
REFERENCES

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- 2) B.B. Eissler, Low - Flow Frequency Analysis of Streams in New York - Bulletin 74, U.S. Geological Survey, 1979.
- 3) Engineering Record; Volume 51, No. 13, "The New Gravity Water Works at Hudson, NY" April 1, 1905.
- 4) T.S. George and R.S. Taylor; Lower Hudson River Basin Hydrologic Flood Routing Model; for the Department of the Army, New York District Corps of Engineers; Water Resources Engineers, Inc. January 1977.
- 5) N.S. Hill Jr., Report on Condition of Dam, March 27, 1914.
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AD-A105 728

NEW YORK STATE DEPT OF ENVIRONMENTAL CONSERVATION ALBANY F/8 13/13
NATIONAL DAM SAFETY PROGRAM. CHURCHTOWN DAM (INVENTORY NUMBER N--ETC(U)
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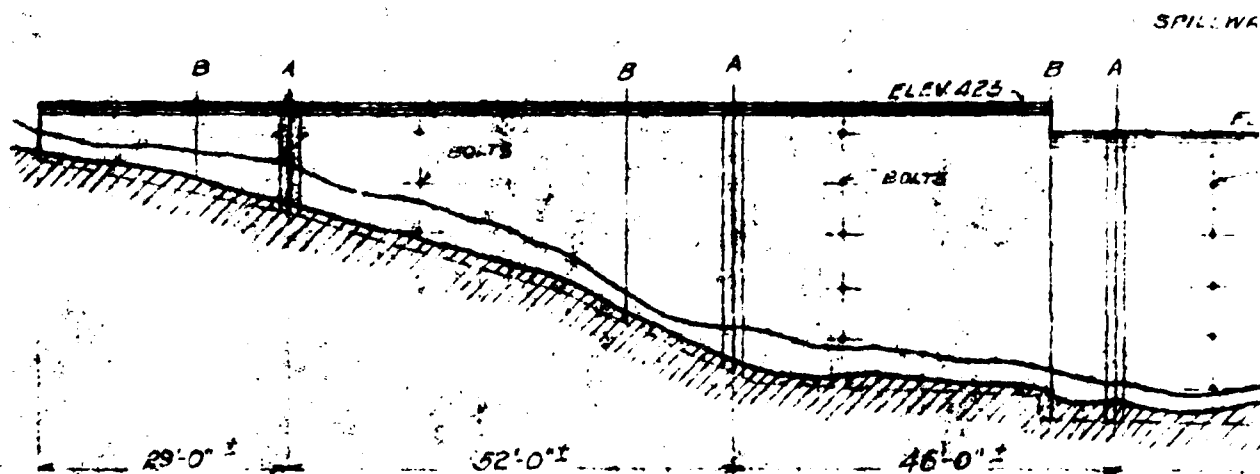
U.S. Army Corps of Engineers:

- 8) HEC-1 Flood Hydrograph Package - Dam Safety Version, September 1978.

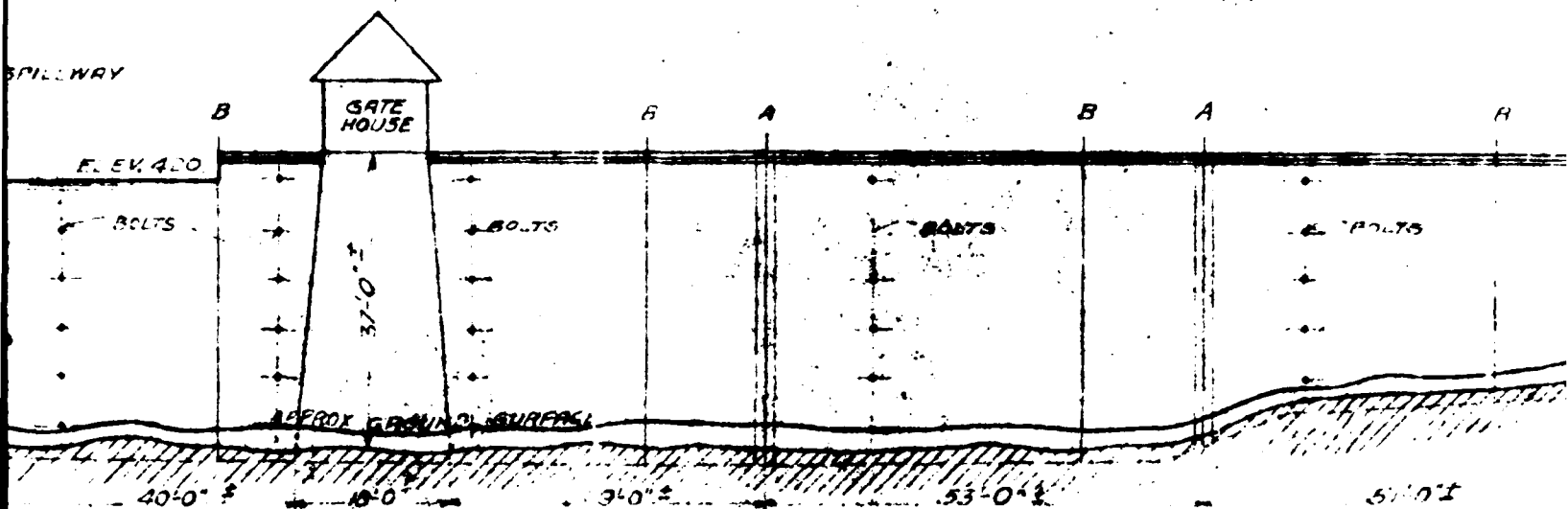
Engineering Manual 1110-2-1405; Flood-Hydrograph Analysis and Computations,
August 1959.
- 10) U.S. Department of Agriculture, Soil Conservation Service; National Engineering Handbook; Section 4-Hydrology, August 1972.
- 11) U.S. Department of Commerce; Weather Bureau; Hydrometeorological Report No. 33: Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24, and 48 Hours, April 1956.
- 12) U.S. Geological Survey, Water Resources Data for New York - 1979; Volume 1 - Excluding Long Island.

APPENDIX F

REFERENCES

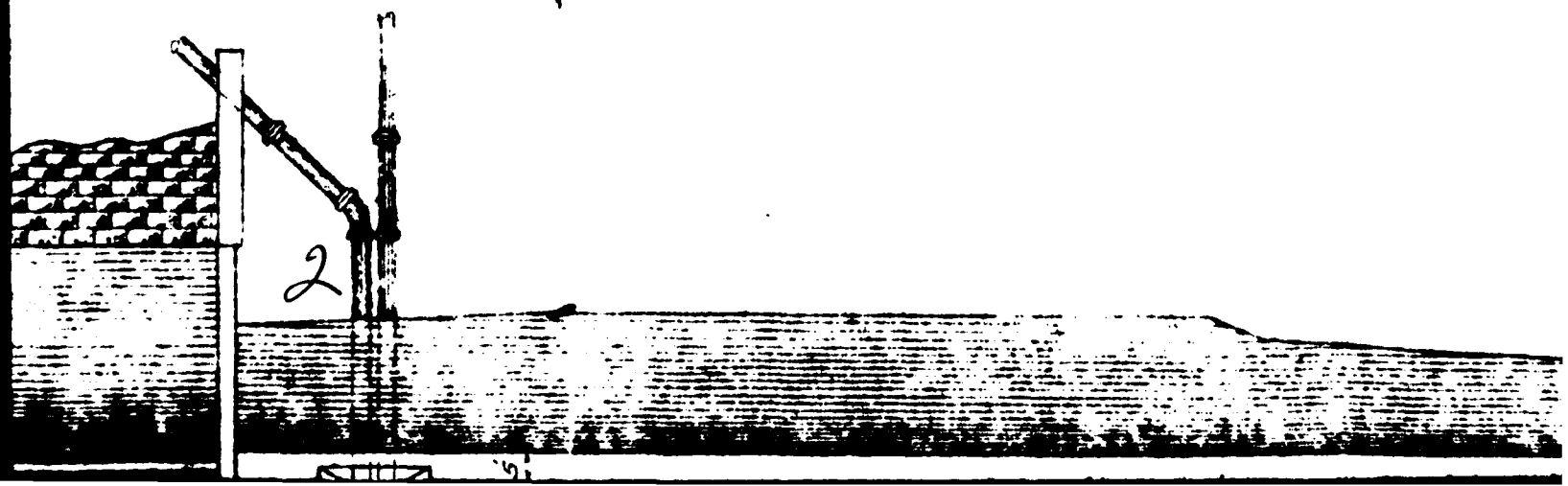


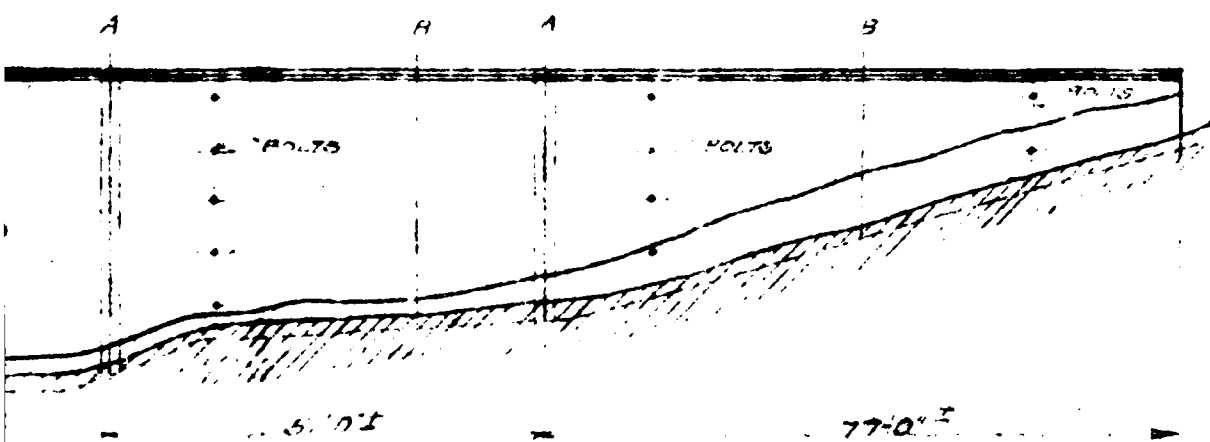
A. Ind.
in a
B. Ind.
for



Indicates approximate location of construction joints in cut off wall.

Indicates approximate location of present expansion joints in dam.



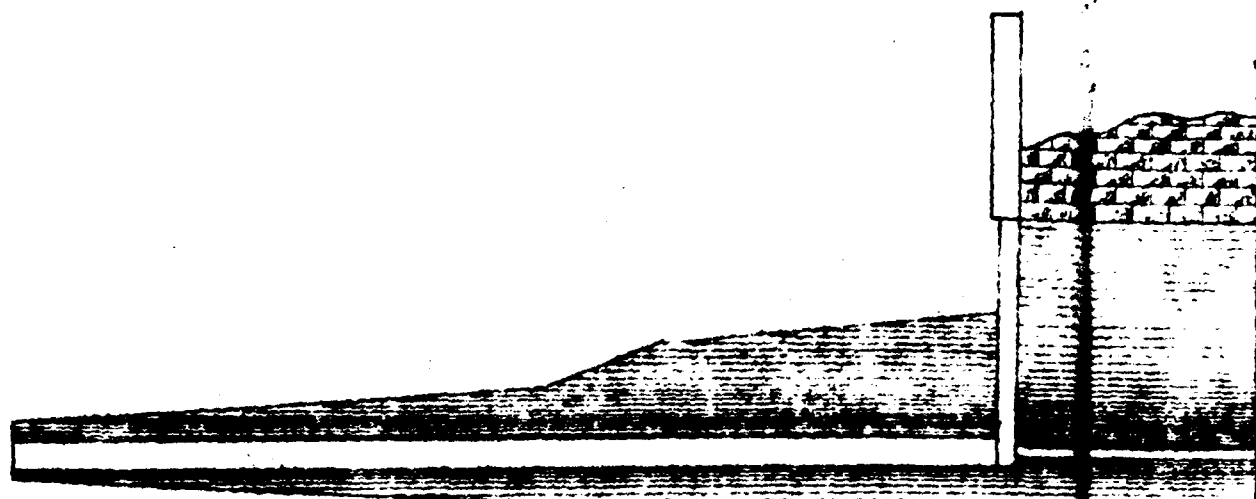


29'-0"

52'-0"

46'-0"

A. Indio
in cu
B. Indio
joint



40'-0"

167'-0"

4

40'-0"

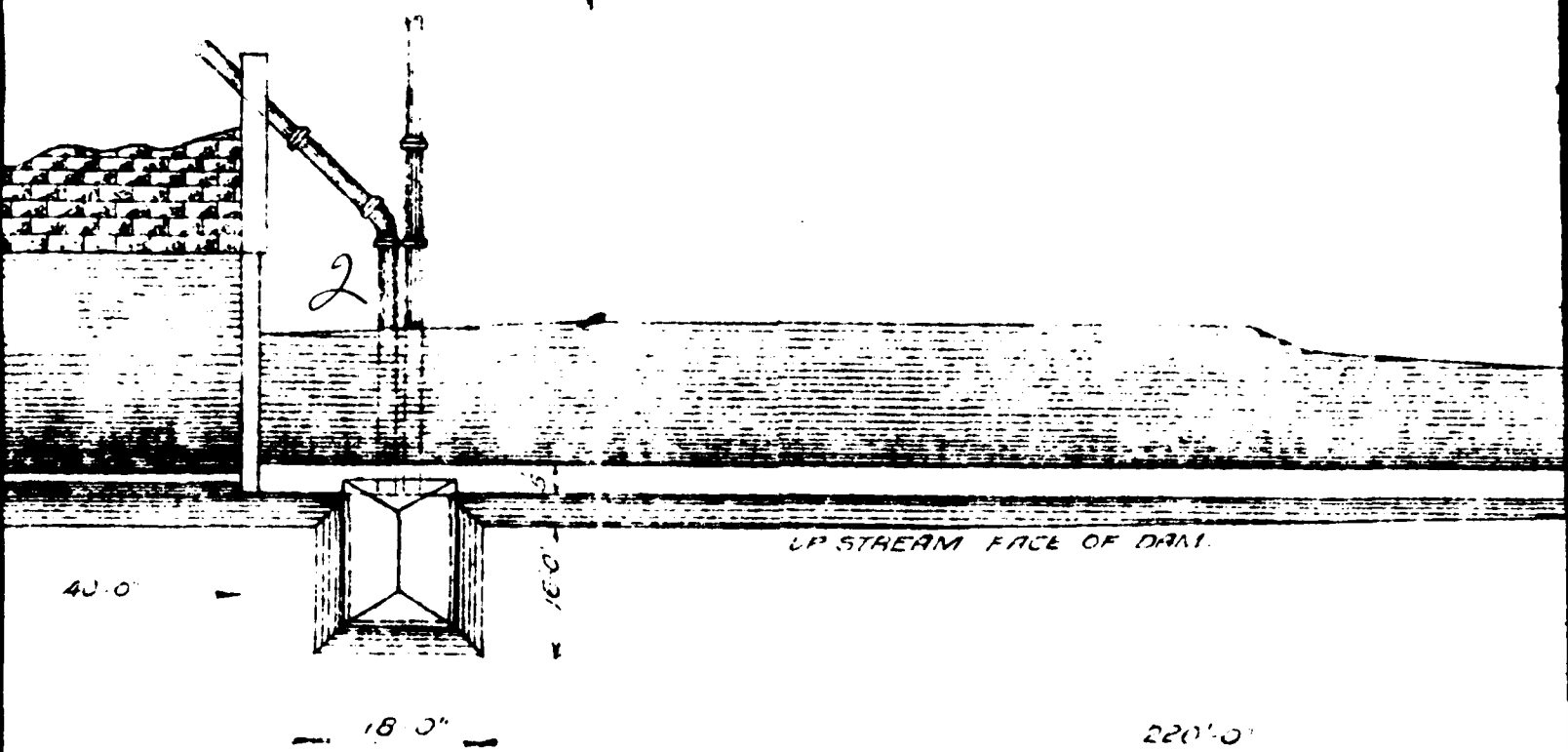
10'-0"

3'-0"

53'-0"

51'-0"

- A. Indicates approximate location of construction joints in cut off wall.
- B. Indicates approximate location of present expansion joints in dam.



162

STATE OF NEW YORK
CONSERVATION COMMISSION
DIVISION OF INLAND WATERS
Albany, N. Y.

This is to certify that this plan with the accompanying specifications for
No. 1009 Lower Reservoir Watershed have been received at
Chief Engineer
Albany, N. Y.

This is to certify that by resolution of this Commission under and in accordance
with the provisions of Section 21 of the Conservation Law, the above mentioned plan and specifications
approved.

CONSERVATION COMM

5.05

77-0'

3

STATE OF NEW YORK
CONSERVATION COMMISSION
DIVISION OF INLAND WATERS

Albany, N. Y.

July 11, 1914

with the accompanying specifications for the work to be done at the above named place and specifications were this day

Alfred B. Hill

Surveyor General

Albany, N. Y. 10
of the City of New York and the County of Albany, with the work to be done at the above named place and specifications were this day

CONSERVATION COMMISSION

DRAWING No 104-1

REPAIRS TO CHURCHTOWN DAM
CITY OF HUDSON N.Y.
CHURCHTOWN DAM
PLAN AND ELEVATION

Nicholas S. Hill Jr.
Consulting Engineer

107 William St.

Scale 1" = 20'

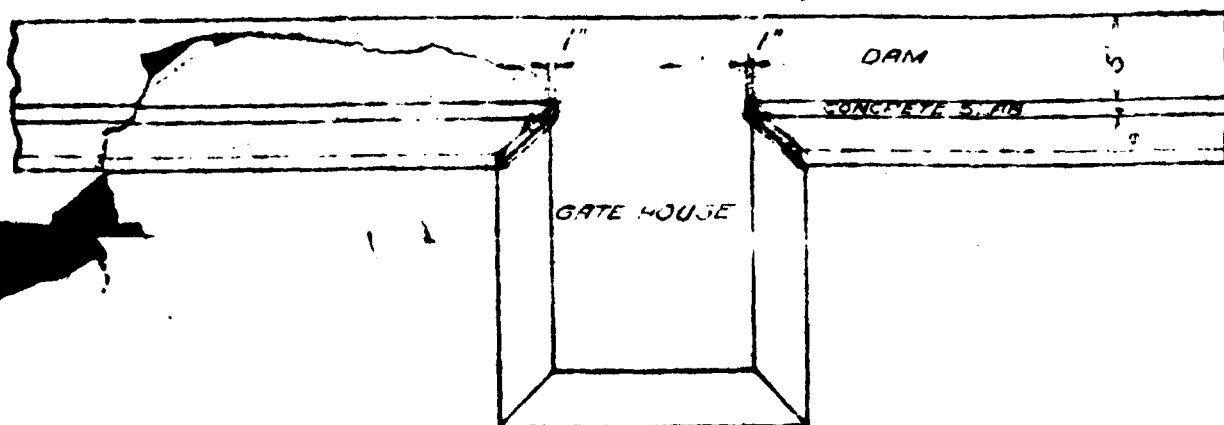
Date July 3, 1914. New York

Drawn by
Checked by

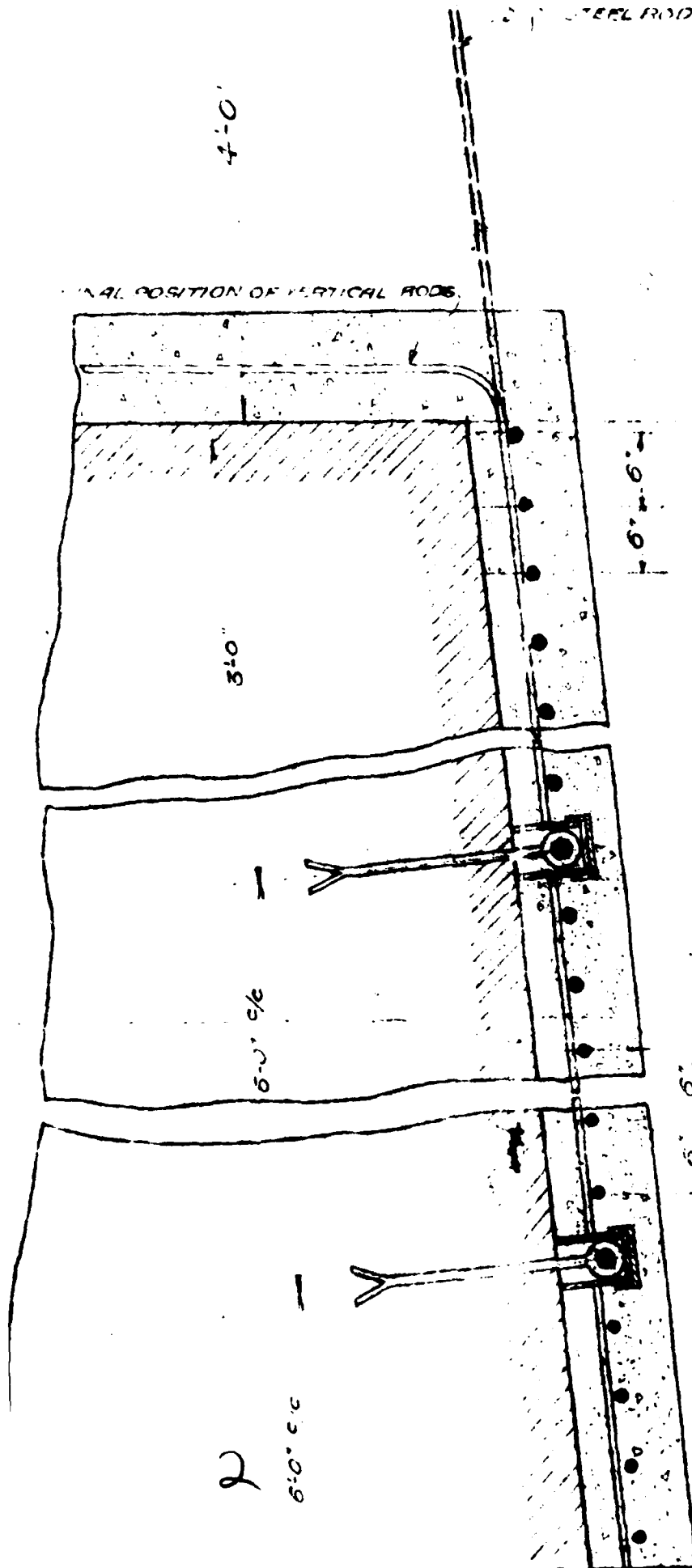
COPPER STRIP $\frac{1}{8}$ " THICK BENT
AS SHOWN



CONSTRUCTION JOINT DETAIL
SCALE 2" = 1'-0"



SKETCH SHOWING CONNECTION OF
CONCRETE SLAB AND GATE HOUSE
(NOT TO SCALE)



STEEL RODS SPACED 6" APART

15'-0" 1 1/2" Ø STEEL RODS SPACED 6" APART

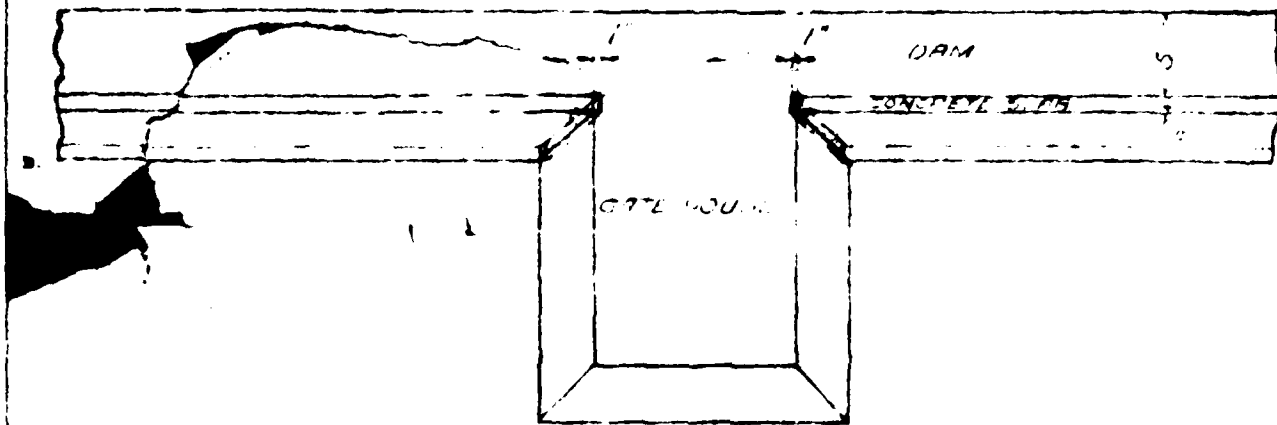
22'-0" STEEL RODS SPACED 6" APART

DETAILS OF REINFORCED CONCRETE
SCALE 1" = 1'-0"

DETAILS & REINFORCING 3
SCALE 1" = 1'-0"

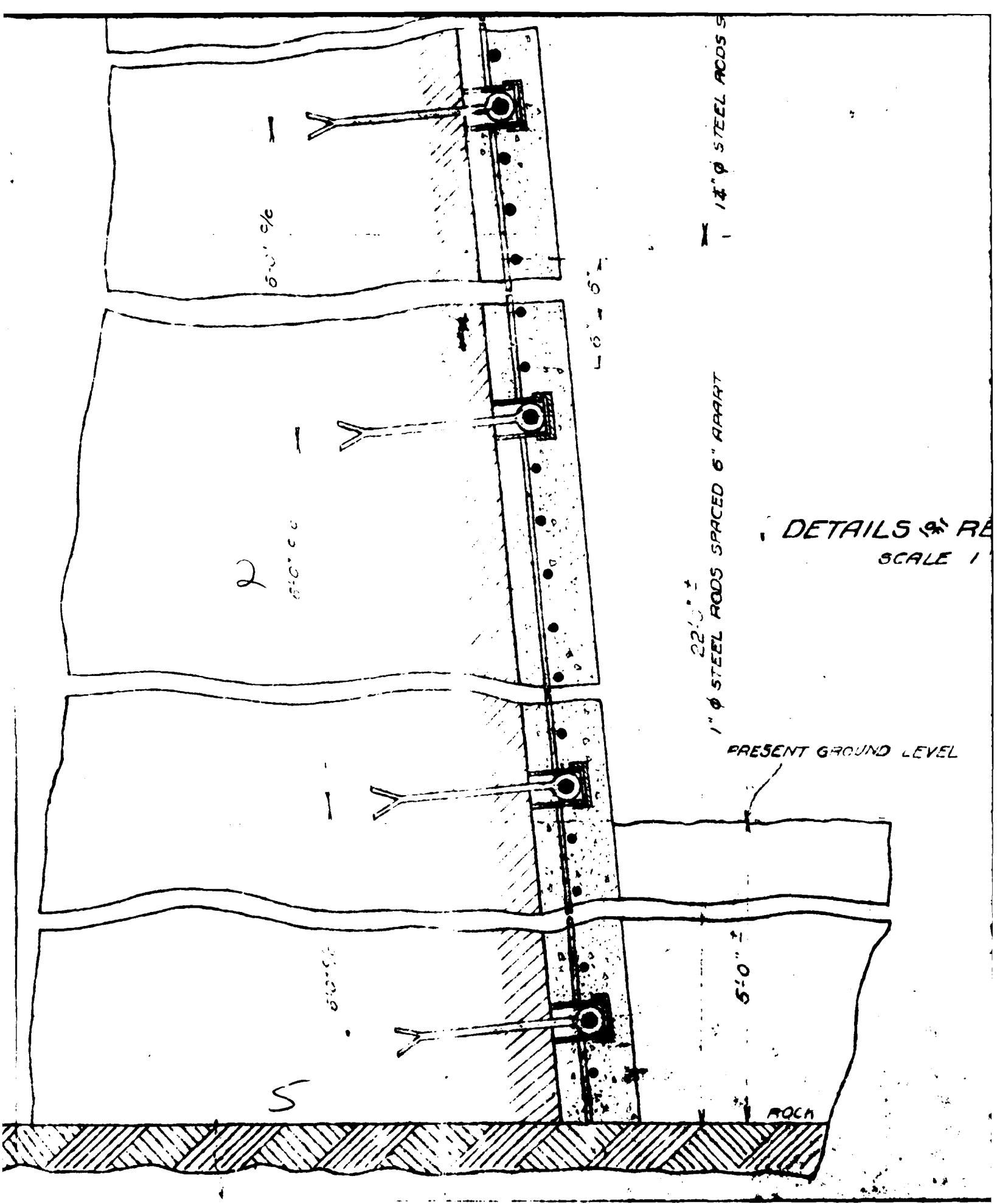
STATE OF NEW YORK
CONSERVATION COMMISSION

ORIGINAL



SKETCH SHOWING CONNECTION OF
CONCRETE SLAB AND GATE HOUSE
(NOT TO SCALE)

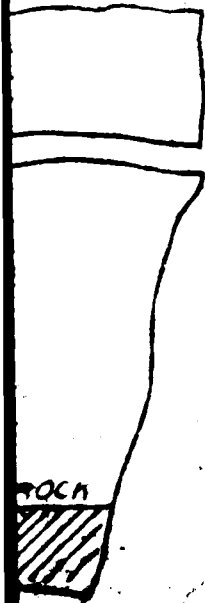




DETAILS & REINFORCING 3

SCALE 1" = 1'-0"

ENT GROUND LEVEL



STATE OF NEW YORK
 CONSERVATION COMMISSION
 DIVISION OF INLAND WATERS
 Albany, N. Y.

July 11 1914

This is to certify that the plan, with the accompanying specifications, for reconstructing and conserving the
 No. 1009 Dam, in the Watershed, have been examined and approved.

Albany, N. Y., July 11 1914

Inspector Docks and Dams

Conservation Commission

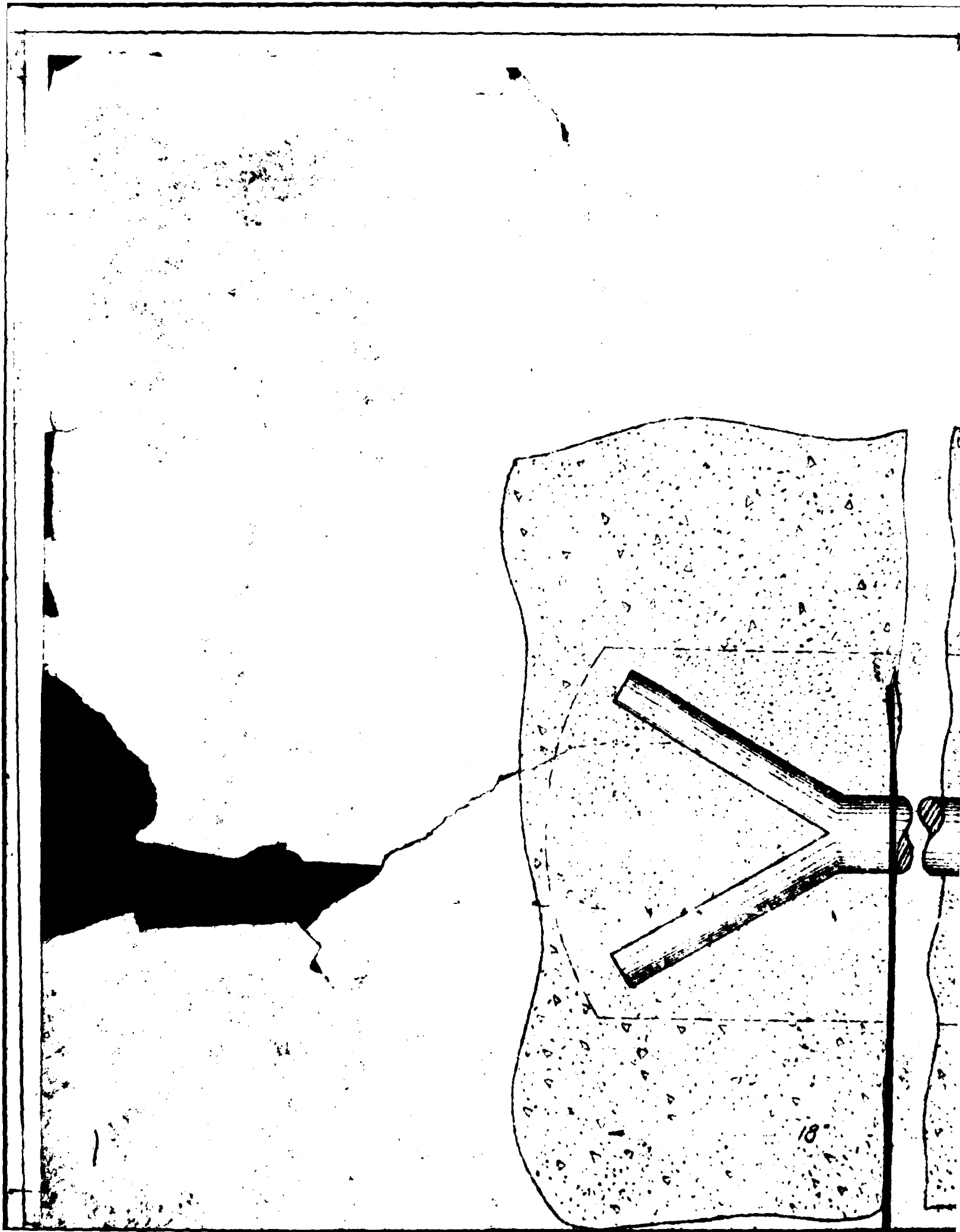
DRAWING No 104-2

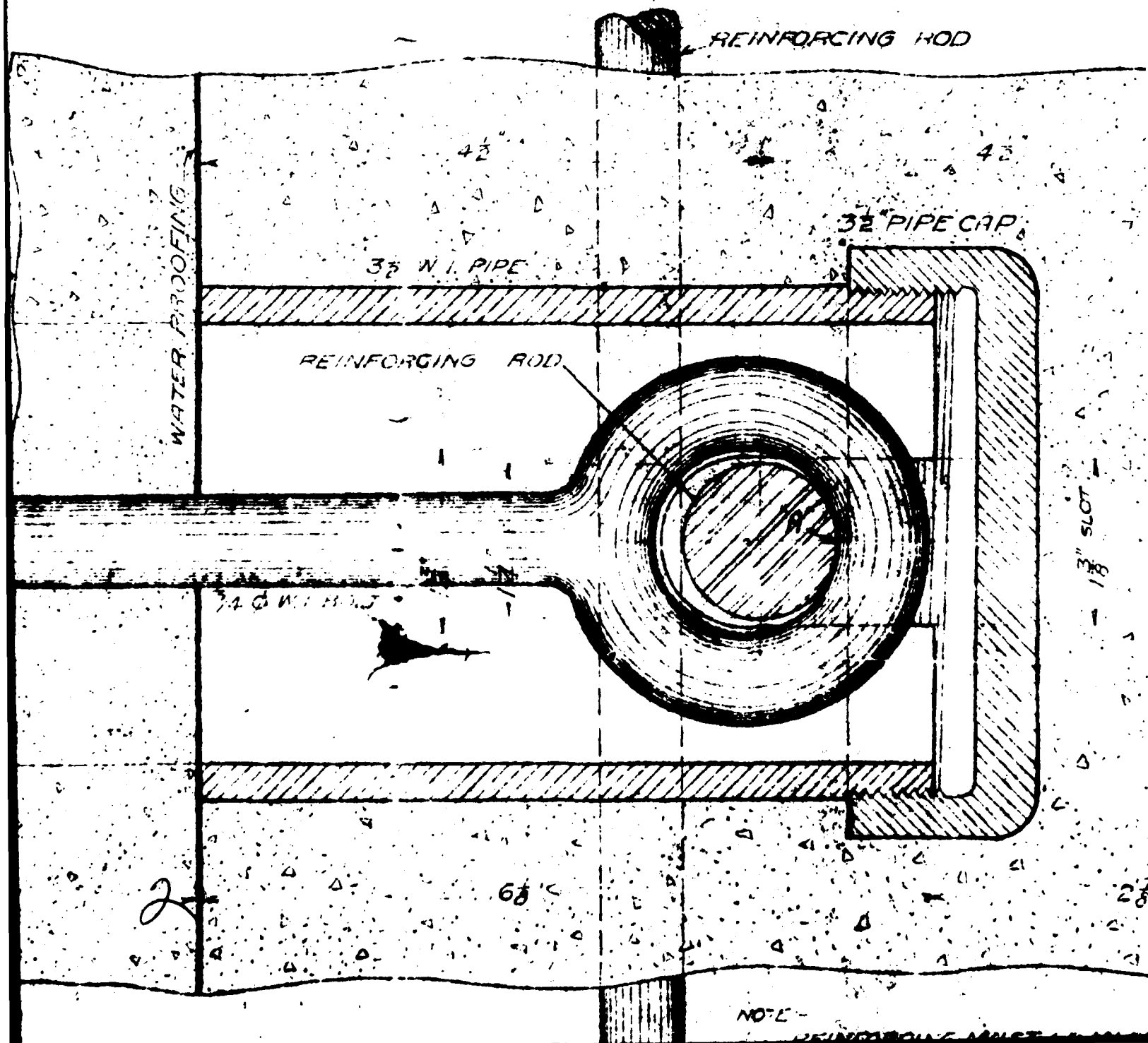
REPAIRS TO CHURCHTOWN DAM
 CITY OF HUDSON N. Y.
 DETAILS & REINFORCING
 AND CONSTRUCTION JOINTS

Nicholas S. Hill, Jr.,
 Consulting Engineer,

Scale 2" = 1'-0" 100 William St,
 Date July 8, 1914 New York.

Drawn by C.B.
 Checked by G.H.

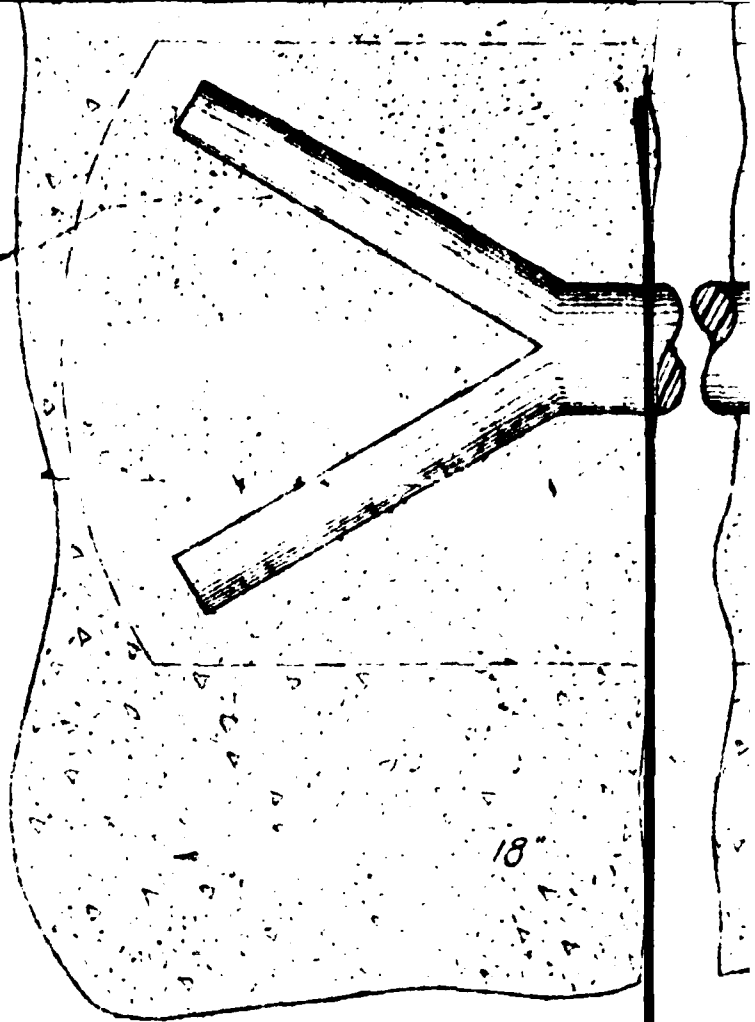




REINFORCING ROD

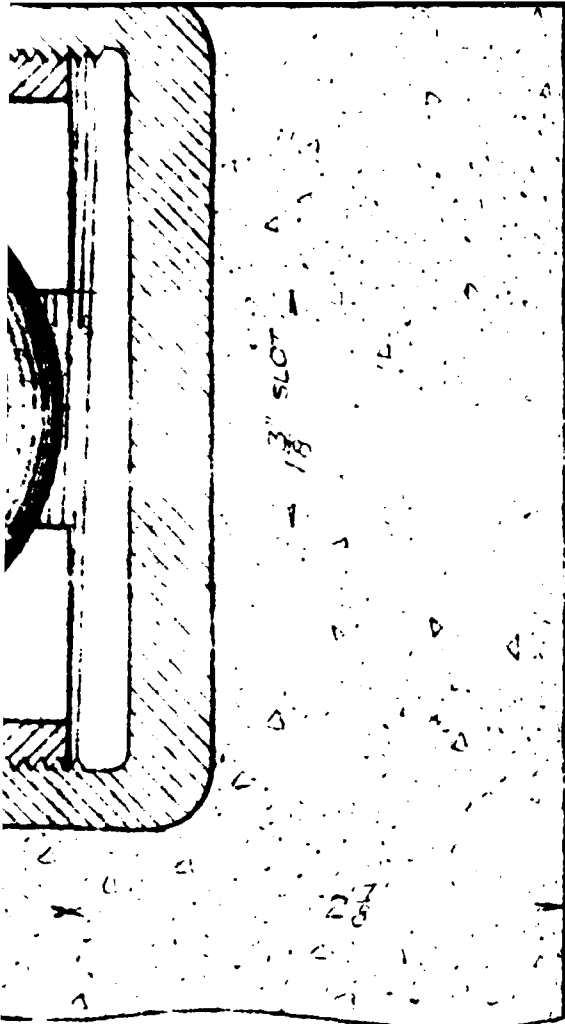
42
3/2" PIPE CAP

3" SLOT



1

4



REINFORCING MUST BE IN CONTACT
WITH CONCRETE AT POINT 'A'

3

OFFICE OF THE
ENGINEERING COMMISSION
CITY OF NEW YORK
ALBANY, N. Y.
July 11, 1914
The accompanying specifications for reinforcing steel
have been examined and approved.
By: *Nicholas S. Hill, Jr.*
Chief Engineer
The City of New York
The following is a copy of the specifications for reinforcing steel
as shown on plan and section of the dam, and is to be used in
the construction of the dam.
RESERVATION COMMISSION

DRAWING NO 104-3

REPAIRS TO CHURCHTOWN DAM
CITY OF HUDSON N.Y.
DETAILS OF BOLTS HOLDING
REINFORCING STEEL TO DAM

6

Nicholas S. Hill, Jr.,
Chief Engineer

Scale: Full Size
Date: July 11, 1914

Monticelli, N.Y.
New York

Drawn by: C.
Checked by: J.

END

DATE
FILMED

11-81

DTIC