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NATIONAL DAM SAFETY PROGRAM. WILLOW BROOK DAM (INVENTORY NUMBER--ETC(U)
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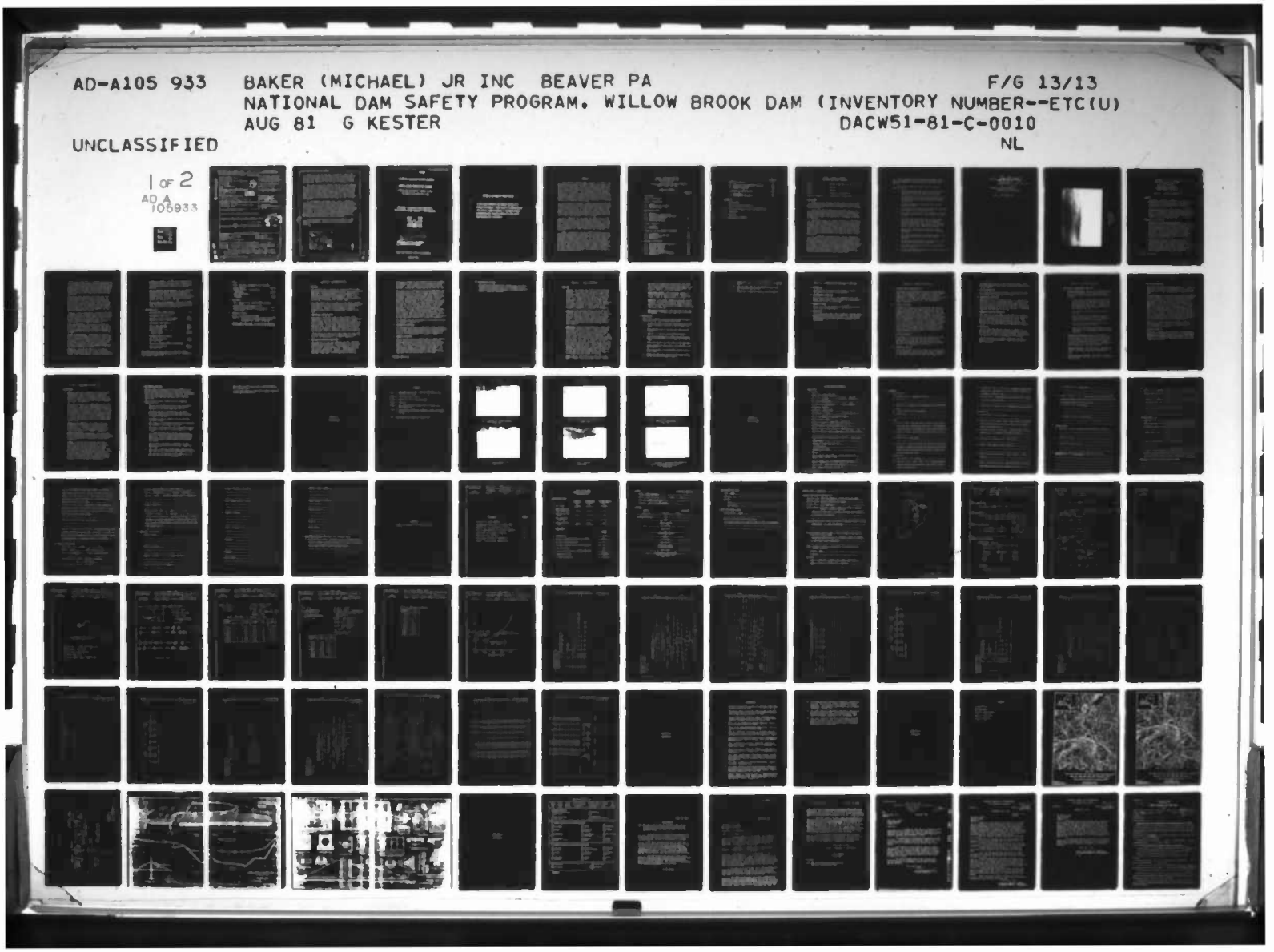

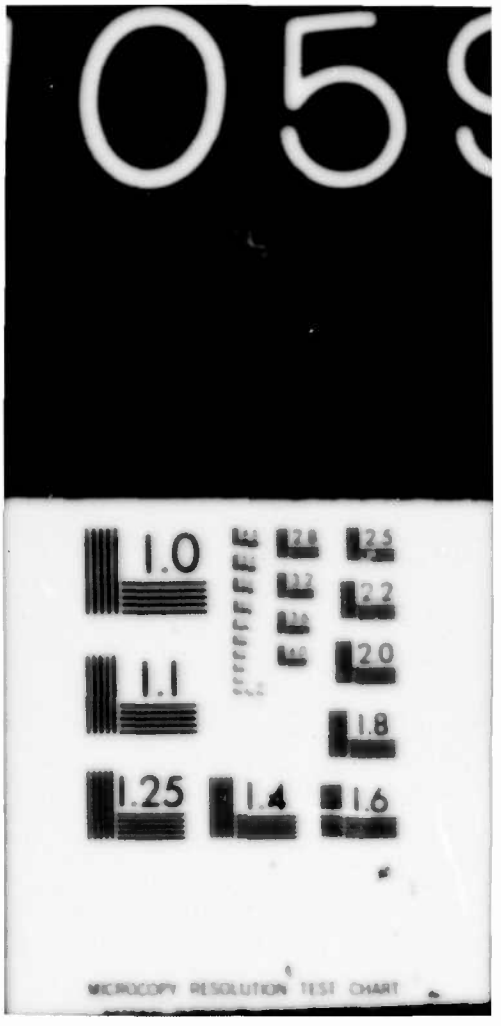
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Granville Kester, Jr

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Orange County
Lower Hudson River Basin

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.

Examination of available documents and a visual inspection of the dam and appurtenant structures did not reveal any conditions which constitute an immediate hazard to human life or property.

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Using the Corps of Engineers' screening criteria, it has been determined that the dam would be overtopped for all storms exceeding approximately 28 percent of the Probable Maximum Flood (PMF). The spillway is, therefore, adjudged as "seriously inadequate" and the dam is assessed as unsafe, non-emergency.

The classification of "unsafe" applied to a dam because of a "seriously inadequate spillway" is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that, based on an initial screening and preliminary computations, there appears to be a serious deficiency in spillway capacity, so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream.

It is therefore recommended that, within 3 months of notification of the owner, detailed hydrologic and hydraulic investigations of the structure should be undertaken to more accurately determine the site-specific characteristics of the watershed and their effects upon the overtopping potential of the dam. The results of these investigations and analyses will determine the appropriate remedial measures which will be required. In the interim, a detailed emergency action plan must be developed and implemented during periods of unusually heavy precipitation. Also, around-the-clock surveillance must be provided during these periods.

Current inspection and maintenance procedures by the owner are inadequate. Monitoring of the reservoir levels should be expanded to include readings during peak flow periods.

LOWER HUDSON RIVER BASIN

WILLOW BROOK DAM

ORANGE COUNTY, NEW YORK
INVENTORY NO. N.Y. 35

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

NEW YORK DISTRICT CORPS OF ENGINEERS

AUGUST 1981

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
WILLOW BROOK DAM
I.D. No. NY 35
DEC DAM No. 195C-450 LOWER HUDSON RIVER BASIN
ORANGE COUNTY, NEW YORK

TABLE OF CONTENTS

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Willow Brook Dam (I.D. No. NY 35)
State:	New York
County:	Orange
Stream:	Tributary of Moodna Creek
Dates of Inspection:	5 March 1981, 9 March 1981

ASSESSMENT

Examination of available documents and a visual inspection of the dam and appurtenant structures did not reveal any conditions which constitute an immediate hazard to human life or property.

Using the Corps of Engineers' screening criteria, it has been determined that the dam would be overtopped for all storms exceeding approximately 28 percent of the Probable Maximum Flood (PMF). The spillway is, therefore, adjudged as "seriously inadequate" and the dam is assessed as unsafe, non-emergency.

The classification of "unsafe" applied to a dam because of a "seriously inadequate spillway" is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that, based on an initial screening and preliminary computations, there appears to be a serious deficiency in spillway capacity, so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream.

It is therefore recommended that, within 3 months of notification of the owner, detailed hydrologic and hydraulic investigations of the structure should be undertaken to more accurately determine the site-specific characteristics of the watershed and their effects upon the overtopping potential of the dam. The results of these investigations and analyses will determine the appropriate remedial measures which will be required. In the interim, a detailed emergency action plan must be developed and implemented during periods of unusually heavy precipitation. Also, around-the-clock surveillance must be provided during these periods.

Current inspection and maintenance procedures by the owner are inadequate. Monitoring of the reservoir levels should be expanded to include readings during peak flow periods.

The following remedial measures must be completed within one year:

1. The low area of the dam crest on the left side of the spillway should be filled to the average elevation of the top of dam, 590.0 ft. M.S.L.

2. The deterioration in the spillway wingwalls should be repaired and rock riprap should be placed at the junction of the wingwalls and dam to prevent undercutting.

3. All debris should be removed from the spillway discharge channel.

4. The riprap on the upstream face should be redressed and extended to the crest of the dam.

5. The crest of the dam should be regraded and leveled to elevation 590.0 M.S.L. with a width of at least 5 feet.

6. All brush and trees should be cut off at ground level over the entire dam, and the embankment should be mowed regularly. The root systems should be removed for trees with a trunk diameter greater than 3 inches, and the resultant cavities should be backfilled, compacted, and seeded.

7. The uprooted trees should be removed, and the depressions left should be backfilled, compacted, and seeded.

8. The cracks in the spillway discharge channel walls should be repaired, and joints repointed as necessary.

9. The missing concrete caps for the masonry walls at the spillway weir should be replaced.

10. The cracks in the concrete top of the springhouse should be repaired.

11. A staff gage should be installed to monitor reservoir levels above normal pool.

SUBMITTED: _____
Granville Kester, Jr., P.E.
Vice President
MICHAEL BAKER, JR., of New York, INC.

APPROVED: _____
Colonel W.M. Smith, Jr.
New York District Engineer

DATE: 14 Aug 81

Overall View of Dam
Willow Brook Dam
I.D. No. NY 35
9 March 1981

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
WILLOW BROOK DAM
I.D. No. NY 35
DEC DAM No. 195C-450
LOWER HUDSON RIVER BASIN
ORANGE 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 and Appurtenances - Willow Brook Dam is an earthfill embankment with a concrete core wall. The dam is 540 feet long and 18.5 feet high, measured from the invert of the outlet pipe at the downstream toe to the minimum top of dam. The crest width of the dam varies from 3 feet to 4.5 feet. A concrete springhouse is located on the right side of the upstream face of the embankment, and a concrete gate house is situated at the center of the embankment. There is no internal drainage system for the dam.

A concrete spillway is located on the left[1] side of the dam. The spillway consists of a concrete, broad-crested weir and concrete training walls faced with stone. The broad-crested weir, with a length of 25 feet and breadth of 3 feet, has an inclined upstream face of about 45 degrees, and a vertical downstream face. Water passing over the weir cascades down two concrete steps, each 1

[1]Looking downstream.

foot wide by 2 feet high, to a paved masonry apron with masonry training walls. Water then passes over a rock rubble falls and through a discharge channel consisting of masonry paved bottom and sides. The masonry walls of the spillway and discharge channel are capped with concrete. The discharge channel empties into a corrugated steel culvert, 5.5 feet wide by 3.0 feet high, under the road downstream of the dam.

The outlet works consist of a 24-inch cast iron pipe placed through the center of the dam. A concrete gate house is located on the upstream side, center of the dam, containing the control for the gate on the outlet pipe. The outlet pipe exits into a channel consisting of masonry paved bottom and sides. The masonry walls are capped with concrete. The outlet works channel joins the spillway discharge channel and empties into the same corrugated steel culvert.

b. Location - Willow Brook Dam is located in the Town of Blooming Grove, Orange County, New York, on an unnamed tributary of Moodna Creek. The coordinates of the dam are N 41° 20.9' and W 74° 11.8'. The dam and reservoir are located on the U.S.G.S. 7.5 minute topographic quadrangle Monroe, New York. A Location Plan is included in Appendix E.

c. Size Classification - The height of the dam is 18.5 feet, and the reservoir volume at the top of the dam is 1061 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 - Three homes are located about 1 mile downstream of the dam. A fourth home and an apartment complex are located 1.4 and 1.5 miles, respectively, downstream of the dam. There is danger of loss of human life from large flows downstream of the dam. Therefore, Willow Brook Dam is considered to be in the "high" hazard category as defined by the Recommended Guidelines for Safety Inspection of Dams.

e. Ownership - The dam and reservoir are owned by Orange and Rockland Utilities Inc., 71 Dolson Avenue, Middletown, New York 10940. The contact person is Mr. George Begbie (Telephone 914-343-5324).

f. Purpose of the Dam - The dam was originally built to impound water for cooling steam condensers of the Orange and Rockland Electric Co. The dam and reservoir are presently used for recreational purposes.

g. Design and Construction History - Willow Brook Dam was designed by Knight, Bush and Thompson Civil Engineers and Surveyors of Monroe, New York in November, 1923. Orange and Rockland Electric Co. constructed the dam in the fall of 1925 and spring, summer, and fall of 1926. The design engineers supervised construction of the dam.

h. Normal Operating Procedures - There are no formal written operational procedures for Willow Brook Dam. The reservoir is normally maintained at the crest elevation of the spillway weir.

1.3 PERTINENT DATA

a. Drainage Area (square miles) - 1.34

b. Discharge at Dam (c.f.s.) -

Spillway at Top of Dam (Minimum)	425.0
Reservoir Drain at Normal Pool	53.0

c. Elevations (Feet M.S.L.)[2] -

Top of Dam (Average)	590.0
Top of Dam (Minimum)	588.2
Spillway Crest	585.0
Reservoir Drain (24" C.I.P.)	
Inlet Invert	570.0
Outlet Invert	569.66

d. Reservoir Surface (Acres) -

Top of Dam (Minimum)	76.0
Spillway Crest	63.4

e. Reservoir Storage Capacity (Acre-Feet) -

Top of Dam (Minimum)	1061.0
Spillway Crest	841.0

[2]All elevations are referenced to the spillway crest, elevation 585.0 feet Mean Sea Level (M.S.L.), as shown on the original design plans.

f. Dam -

Type: Earthfill embankment with concrete core wall	
Length (Feet)	540.0
Slopes (Vertical : Horizontal)	
Upstream -	1:2.2
Downstream -	1:2.1
Crest Width (Feet)	
Maximum -	4.5
Minimum -	3.0

g. Spillway -

Type: Uncontrolled, broad-crested concrete weir.	
Length of Crest Perpendicular to Direction of Flow (feet)	25.0
Width of Crest Parallel to Direction of Flow (feet)	3.0

h. Reservoir Drain -

Type: 24-inch Cast Iron Pipe
Control: Control for the gate on the outlet pipe is located in the gate house at the upstream side, center of the dam.

i. Appurtenant Structures - A concrete springhouse is located on the right upstream side of the dam.

SECTION 2: ENGINEERING DATA

2.1 GEOLOGY

Willow Brook Dam is located in a narrow portion of the Appalachian Uplands physiographic province in southeastern New York. The Geologic Map of New York (Reference 2, Appendix D) describes bedrock in the immediate area of the dam as undifferentiated sedimentary deposits of Lower Devonian and Silurian sandstones, shales, limestones and dolostones. These bedrock units are overlain by glacial till deposits of variable depth.

Although references do not show any faulting at the dam site, bedrock in the surrounding area has been extensively disrupted by faulting; normal faults are located from 1 to 3 miles to the south and northwest of the site, respectively, whereas a large northeast-southwest trending thrust fault is located about 2 miles to the east.

2.2 SUBSURFACE INVESTIGATION

The profile of the dam shown on the original plans (Appendix E) provides a general description of foundation conditions at the site, based on boring data. This profile shows that the site was overlain by deposits of clay, hardpan, and boulders, varying in thickness up to about 50 feet. A rock outcrop was reported on the left abutment, near the spillway. Bedrock is described on the profile as gneiss, shale and limestone. As shown on the field sketch in Appendix E, the outcrop shown on the original plans was also noted during the inspection.

A memorandum provided by the owner indicates that there are two limestone "caverns" located under the lake. A copy of the memorandum is included in Appendix F.

2.3 DAM AND APPURTENANT STRUCTURES

Two drawings for the dam prepared by Knight, Bush and Thompson, Civil Engineers and Surveyors, for the Orange and Rockland Electric Co., were available for review during these investigations. The drawings illustrate the original dam design features. These drawings are included in Appendix E. Copies of correspondence between Knight, Bush and Thompson and the State of New York, Department of State Engineer and Surveyor

were also provided for the inspection and are included in Appendix F. The letters discuss design and construction details and a request for a construction permit extension. They were written during construction of the dam. The dam was constructed during 1925 and 1926.

This structure is comprised of an earth embankment with a concrete core wall. The available drawings indicate that the concrete core wall is keyed into bedrock. A concrete spillway is located on the left[1] side of the structure. The spillway discharge channel consists of a masonry paved bottom and sides, and runs from the spillway, along the toe of the embankment, to the center of the dam where it joins the downstream channel. A 24-inch diameter cast iron pipe serves as the outlet for the dam. A slide gate, controlled by hand crank, is used to control flow from the outlet. The outlet and gate house are located near the center of the structure. Near the right end of the embankment is a springhouse. A pipe in the springhouse is connected to one of the two "caverns" previously mentioned. The pipe could be used as a well, but at the present time, it is unused. The other "cavern" was piped to the spring pond located downstream of the dam. A description of the limestone "caverns" is included in Appendix F.

The existing dam is illustrated by a field sketch which is included in Appendix E.

2.4 CONSTRUCTION RECORDS

No information concerning construction of the structure is available other than the previously discussed drawings and letters, and a permit application for dam construction to the New York Department of State Engineer and Surveyor (the application is included in Appendix G).

2.5 OPERATION RECORDS

The slide gate controlling discharges is opened approximately once or twice each year when the lake level rises approximately 12 inches over spillway elevation and floods the old power plant located along the lake shore. Once the lake level drops to spillway level, the gate is closed. The owner has no procedures for regular dam inspections or regular maintenance. The only known maintenance performed at this dam in the last few years was the removal of some brush from the upstream face during the winter of 1979-1980.

[1]Looking downstream.

2.6 EVALUATION OF DATA

The background information collected during the investigation was obtained from Mr. George Begbie of the Orange and Rockland Utilities Inc. Available engineering data are considered adequate and reliable for Phase I Inspection purposes.

SECTION 3: VISUAL INSPECTION

3.1 FINDINGS

a. General - The inspection of Willow Brook Dam was conducted on 5 March 1981 during cool and cloudy weather. Light snow fell during the inspection, and temperatures ranged from 30°F to 33°F. The reservoir level was at the crest of the spillway. A follow up inspection was conducted on 9 March 1981. This inspection was made to observe the embankment without snow and to take additional pictures. Deficiencies found during the inspection will require remedial treatment. A Field Sketch of conditions found during the inspection is included in Appendix F. The complete Visual Inspection Checklist is presented as Appendix B.

b. Spillway - The upstream ends of the wingwalls are undercut and show signs of deterioration. The concrete caps for the masonry walls at the spillway weir are missing (as shown in Photo 4). In the spillway discharge channel, there are some minor cracks in the masonry walls above normal water level. A few boards were found in the channel at the rock rubble falls, and tree branches were in the channel near the confluence with the outlet works channel.

c. Embankment - The entire upstream face, crest, and downstream face are covered with brush and trees (as shown in Photos 1 and 2). There are several uprooted trees on the dam, one on the upstream face (shown in Photo 3), and three on the downstream face (see Field Sketch in Appendix E). The width at the crest of the dam varies from 3.0 feet to 4.5 feet. A footpath is worn along the upstream side of the crest. On the left side of the spillway masonry wall, the crest is eroded to the top of the concrete core wall (as shown in Photo 4). The upstream face of the dam is protected by riprap at the normal reservoir level. Some sloughing of the riprap was observed at the time of inspection. No seepage, surface cracking, or movement at the toe was observed during the inspection. The junction of the left and right abutments with natural ground appears to be in good condition. There is no internal drainage system for the dam.

d. Outlet Works - The control for the outlet pipe gate, located on top of the gate house, is rusty

but able to be operated. According to the owner, the gate was opened and closed within the last year. The gate house and outlet pipe appear to be in good condition. The outlet works channel (as shown in Photo 6) is in good condition.

e. Downstream Channel - The downstream channel is a natural stream located in a wooded, somewnat narrow valley (as shown in Photo 6). The stream slope is shallow, approximately 0.6 percent.

f. Reservoir - The slopes immediately adjacent to the reservoir are moderate and well vegetated. Sedimentation is minor, as soundings taken during the inspection indicate the reservoir depth is from 13 feet to 15 feet. There were no reservoir monitoring instruments observed.

g. Appurtenant Structures - The concrete top for the springhouse, located on the right side of the dam, is cracked.

3.2 EVALUATION

The visual inspection revealed several deficiencies in this structure. The following were noted:

1. On the left side of the spillway masonry wall, the crest is eroded to the top of the concrete core wall.

2. The upstream ends of the spillway wingwalls are undercut.

3. Debris is in the spillway discharge channel.

4. The entire upstream face, crest, and downstream face of the embankment are covered with brush and trees.

5. There are several uprooted trees on the embankment.

6. Some sloughing of the riprap on the upstream face was observed.

7. The crest width of the embankment varies from 3.0 to 4.5 feet.

8. There are some minor cracks in the masonry walls of the spillway discharge channel.

9. There are cracks in the concrete cap of the spring-house.

10. The concrete caps for the masonry walls at the spillway weir are missing.

11. There are no reservoir monitoring instruments.

SECTION 4: OPERATION AND MAINTENANCE PROCEDURES

4.1 PROCEDURES

The operation of the dam is an automatic function controlled by the crest of the spillway.

4.2 MAINTENANCE OF THE DAM

Maintenance of the dam is the responsibility of the owner. There are no formal inspection or maintenance procedures for Willow Brook Dam.

4.3 WARNING SYSTEM

There is no warning procedure or emergency action plan in the event of dam failure.

4.4 EVALUATION

It is recommended that formal inspection and maintenance procedures be developed and implemented. Maintenance items should be corrected annually. A warning system and emergency action plan should be developed and implemented.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 DRAINAGE AREA CHARACTERISTICS

Delineation of the watershed above Willow Brook Dam was made using the Monroe, New York USGS 7.5 minute quadrangles. The drainage basin is comprised of about 10% residential development, 7% lake surface, and 83% wooded land. Slopes in the reservoir are mostly moderate, about 8% to 15%. The total drainage area of Willow Brook Dam is 1.34 square miles. A Watershed Map is shown in Appendix E.

5.2 ANALYSIS CRITERIA

An hydrologic analysis of the watershed and hydraulic analysis of the dam was conducted using the U.S. Army Corps of Engineers' Flood Hydrograph Package HEC-1 DB computer program (Reference 10, Appendix D). The unit hydrograph was defined using the Snyder Unit Hydrograph Method. Estimates of Snyder hydrograph coefficients were based upon average coefficients from the Hydrologic Flood Routing Model for Lower Hudson River Basin (Reference 13, Appendix D). Rainfall losses were estimated at an initial loss of 1.0 inch and a constant loss rate of 0.1 inch per hour thereafter. The hydraulic capacity of the dam, reservoir, and spillway was determined by incorporating the Modified Puls Routing Method. All flood routings were begun with the reservoir at normal pool level. The Probable Maximum Flood (PMF) and 1/2 Probable Maximum Flood (1/2 PMF) were developed and routed through the reservoir.

5.3 SPILLWAY CAPACITY

The capacity of the spillway at the minimum top of dam (elev. 588.2 ft.) for the existing conditions was determined to be 425 cubic feet per second (c.f.s.). With the low area adjacent to the spillway filled in, the spillway capacity at the minimum top of dam (elev. 589.4 ft.) was determined to be 741 c.f.s.

5.4 RESERVOIR CAPACITY

The storage capacity of Willow Brook Dam at normal pool is 841 acre-feet. The storage capacity of the reservoir at the minimum top of dam is 1061 acre-feet. Therefore, flood control storage of the reservoir between the

spillway crest and top of dam is 220 acre-feet. This volume represents a total of 3.08 inches of runoff from the watershed.

5.5 FLOODS OF RECORD

No records concerning the effects of significant floods on the dam and spillway are available.

5.6 OVERTOPPING POTENTIAL

The peak outflow of the PMF is 2718 c.f.s. and the 1/2-PMF is 872 c.f.s. The maximum capacity of the spillway is 425 c.f.s. for existing conditions, resulting in a spillway capacity of 28 percent of the PMF. With the low area adjacent to the spillway filled in, the maximum spillway capacity is 741 c.f.s., resulting in a spillway capacity of 45 percent of the PMF.

5.7 RESERVOIR EMPTYING POTENTIAL

The reservoir can be drawn down by means of a 24-inch cast iron pipe as described in Section 1.2a. Neglecting inflow, the reservoir can be drawn down from normal pool in approximately 352 hours or 14.7 days. This is equivalent to an approximate drawdown rate of 1 foot per day, based on the hydraulic height measured from normal pool divided by the time to dewater the reservoir.

5.8 EVALUATION

It was determined that the spillway is capable of passing 28% of the PMF for existing conditions or 45% of the PMF, assuming the low area adjacent to the spillway is filled without overtopping the dam. The spillway is, therefore, judged to be "seriously inadequate".

Conclusions pertain to present conditions, and the effect of future development on the hydrology has not been considered.

SECTION 6: STRUCTURAL STABILITY

6.1 EVALUATION OF EMBANKMENT STABILITY

a. Visual Observations - No signs of potential instability were observed during the visual inspection of Willow Brook Dam. Minor problems observed which could affect the stability of the structure include:

1. A low area of the dam crest on the left side of the spillway would provide a channel for water to erode the embankment during future periods of high lake level. It appears that the embankment material at this point has been eroded away, thus exposing the top of the concrete core wall.

2. The upstream spillway wing walls have been undercut.

3. Some sloughing of the upstream riprap face has occurred, however, it did not appear, during the inspection, to be a major problem or an indication of major instability.

4. The entire dam was covered with trees and brush which should be removed.

5. Four overturned trees were observed on the embankment. The overturned trees have created depressions in the embankment which should be redressed.

b. Design and Construction Data - No design and construction information relating to stability of the embankment is available for Willow Brook Dam. A force diagram of the concrete spillway section of the dam was made for application of the dam construction permit and is included in Appendix F. No calculations of overturning or sliding stability were provided with this force diagram.

c. Operating Records - The gate valve is operated as needed to reduce the lake level approximately once a year. No formal inspections of the dam are made.

d. Post Construction Changes - No changes have been made to the dam since the completion of construction in late 1926.

6.2 STABILITY ANALYSIS

The results of previous stability analyses, if any, were not available for the embankment portion of Willow Brook Dam. As previously mentioned, a force diagram was provided for the concrete spillway portion of the dam.

The dam appears to be a relatively homogeneous embankment composed largely of sandy silt with gravel (estimated to be ML Group Soils - Unified Classification System). The original plans for Willow Brook Dam indicate a concrete core wall was placed in the center of the embankment. The top of the core wall appeared to be exposed next to the left spillway wall. Willow Brook Dam is 18.5 feet high with a crest width of 3 to 4.5 feet. The upstream slope of the embankment is 1V:2.2H while the downstream slope is 1V:2.1H. The upstream slope is protected with riprap to just above normal pool level. The crest width is varied, and a footpath is worn on the crest. The dam can be drawn down at the rate of approximately 1 foot per day and is, therefore, subject to rapid drawdown (greater than 0.5 feet drop in the reservoir level per day) as determined by hydraulic calculations made during this investigation.

There are no signs of major instability, based on the overall condition of the dam as observed during the visual inspection. Therefore, a stability analysis is not considered necessary.

6.3 SEISMIC STABILITY

This dam is located in Seismic Zone 1 which presents no hazard form earthquakes, according to the Recommended Guidelines for Safety Inspection of Dams. This determination is contingent on the requirements that static stability conditions are satisfactory and conventional safety margins exist.

SECTION 7: ASSESSMENT/RECOMMENDATIONS

7.1 ASSESSMENT

a. Safety - The Phase I Inspection of Willow Brook Dam revealed that the spillway is "seriously inadequate", based on the Corps of Engineers screening criteria. Outflows from any storm in excess of 28 percent of the PMF will overtop the dam. For this reason, the dam has been assessed as unsafe, non-emergency.

The classification of "unsafe", applied to a dam because of a "seriously" inadequate spillway", is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream from the dam.

b. Adequacy of Information - All evaluations and assessments in this report were based on field observations, conversations with the owner's representative, available engineering data, and office analyses. The information collected is considered adequate for a Phase I Inspection.

c. Need for Additional Information - Detailed hydrologic and hydraulic investigations of the structure are considered necessary to determine the appropriate mitigating measures in response to the spillway inadequacy.

d. Urgency - The detailed hydrologic and hydraulic investigations must be initiated within three months of notification to the owner. Within one year, remedial measures resulting from these investigations must be initiated with completion of these measures during the following year. In the interim, a detailed emergency action plan must be developed and implemented during periods of unusually heavy percipitation. Around the clock surveillance must also be provided during these periods. The problem areas listed below must be corrected within one year of notification.

7.2 RECOMMENDED MEASURES

Regular inspections and maintenance procedures should be developed and implemented. A thorough checklist should be compiled by the owner or the owner's representative and completed during each inspection. Maintenance items should be completed annually. The reservoir level should be monitored and some type of records maintained.

The following remedial measures must be completed within one year:

1. The low area of the dam crest on the left side of the spillway should be filled to the average elevation of the top of dam, 590.0 M.S.L.

2. The deterioration in the spillway wing walls should be repaired and rock riprap should be placed at the junction of the wing walls and dam to prevent undercutting.

3. All debris should be removed from the spillway discharge channel.

4. The riprap on the upstream face should be redressed and extended to the crest of the dam.

5. The crest of the dam should be regraded and leveled to elevation 590.0 M.S.L. with a width of at least 5 feet.

6. All brush and trees should be cut off at ground level over the entire dam and the embankment mowed regularly. The root systems should be removed for trees with a trunk diameter greater than 3 inches and the resultant cavaties backfilled, compacted, and seeded.

7. The uprooted trees should be removed, and the depressions left should be backfilled, compacted, and seeded.

8. The cracks in the spillway discharge channel walls should be repaired and joints repointed as necessary.

9. The missing concrete caps for the masonry walls at the spillway weir should be replaced.

10. The cracks in the concrete top of the springhouse should be repaired.

11. A staff gage should be installed to monitor reservoir levels above normal pool.

APPENDIX A

PHOTOGRAPHS

CONTENTS

Note: Photographs were taken on 9 March 1981.

Photo 1. Upstream Face of Dam. Concrete Cap for Springhouse and Concrete Gatehouse.
9 March 1981

Photo 2. Downstream Face of Dam
9 March 1981

Photo 3. Uprooted Tree on Upstream Slope
9 March 1981

Photo 4. Spillway
9 March 1981

Photo 5. Spillway Discharge Channel and Rock Rubble Falls below Spillway
9 March 1981

Photo 6. Confluence of Spillway Discharge Channel and Outlet Works Discharge Channel. Natural Stream Downstream of Dam.
9 March 1981

APPENDIX B

VISUAL INSPECTION CHECKLIST

VISUAL INSPECTION CHECKLIST

1) Basic Data

a. General

Name of Dam Willow Brook Dam

Fed. I.D. # NY 00035 DEC Dam No. 195C-450

River Basin Lower Hudson

Location: Town Blooming Grove County Orange

Stream Name Unnamed

Tributary of Moodna Creek

Latitude (N) 41° 20.9' Longitude (W) 74° 11.8'

Type of Dam Earthfill with concrete core wall

Hazard Category High

Date(s) of Inspection 5 March 1981, 9 March 1981

Weather Conditions Cloudy and snowy, 30° F.-33° F.

Reservoir Level at Time of Inspection 585.1 M.S.L.*

b. Inspection Personnel Terry S. Hawk, Gary W. Todd, Larry A. Diday

c. Persons Contacted (Including Address & Phone No.) 914-343-5324

George Begbie

Orange and Rockland Utilities, Inc.

71 Dolson Avenue

Middletown, NY 10940

d. History:

Date Constructed Fall of 1925 Spring, Summer, and Fall of 1926 Date(s) Reconstructed

Designer Knight, Bush, and Thompson Engineering, Monroe, NY

Constructed By Orange and Rockland Electric Co.

Owner Orange and Rockland Utilities, Inc.

*Mean Sea Level Datum

2) Embankment

a. Characteristics

(1) Embankment Material Homogenious earthfill

(2) Cutoff Type

(3) Impervious Core Concrete core wall underneath entire earth embankment.

(4) Internal Drainage System None observed

(5) Miscellaneous

b. Crest

(1) Vertical Alignment The crest varies in elevation from a low spot on the left side of the spillway, 588.2 M.S.L., to the maximum top of dam, 590.2 M.S.L. The average top of dam is elevation 590.0 M.S.L.

(2) Horizontal Alignment The crest width varies from about 3.0 ft. to 4.5 ft.

(3) Surface Cracks None observed

(4) Miscellaneous Most of the crest of the dam is covered with brush and trees. A footpath is located on the upstream side of the crest. On the left side of the spillway wall, the crest is eroded to the top of the concrete core wall.

c. Upstream Slope

(1) Slope (Estimate) (V:H) 1V:2.2H

(2) Undesirable Growth or Debris, Animal Burrows The entire upstream slope is covered with brush and trees. There is also 1 uprooted tree on the upstream face.

(3) Sloughing, Subsidence, or Depressions A depression exists from the uprooted tree. There appears to be some sloughing or subsidence of the riprap at normal pool level.

(4) Slope Protection The upstream face is protected with rock riprap to just above normal pool level.

(5) Surface Cracks or Movement at Toe Unobservable at time of inspection.

d. Downstream Slope

(1) Slope (Estimate - V:H) 1V : 2.1H

(2) Undesirable Growth or Debris, Animal Burrows The entire downstream slope is covered with brush and trees. There are also 3 uprooted trees on the downstream face.

(3) Sloughing, Subsidence or Depressions Depressions exist from the 3 uprooted trees. No sloughing or subsidence was observed.

(4) Surface Cracks or Movement at Toe None observed.

(5) Seepage None observed at time of inspection

(6) External Drainage System (Ditches, Trenches, Blanket) None observed

(7) Condition Around Outlet Structure The masonry wall with a concrete cap adequately encases the 24-in. diameter outlet pipe.

(8) Seepage Beyond Toe None observed

e. Abutments - Embankment Contact The junctions of the left and right dam abutments with natural ground appear to be in good condition, however, they are completely covered with trees and brush.

(1) Erosion at Contact None observed

(2) Seepage Along Contact None observed

3) Drainage System

a. Description of System There is no drainage system for the dam.

b. Condition of System

c. Discharge from Drainage System

4) Instrumentation (Monumentation/Surveys, Observation Wells, Weirs, Piezometers, Etc.) None observed

5) Reservoir

a. Slopes The slopes immediately adjacent to the reservoir are moderate, about 6% and are mostly well vegetated.

b. Sedimentation Sedimentation is minor. Soundings indicate the reservoir is about 13 to 15 ft. deep.

c. Unusual Conditions Which Affect Dam None observed

6) Area Downstream of Dam

a. Downstream Hazard (No. of Homes, Highways, etc.) Three homes are located about 1 mile downstream of the dam. A fourth home and an apartment complex are located 1.4 and 1.5 miles, respectively, downstream of the dam.

b. Seepage, Unusual Growth None observed

c. Evidence of Movement Beyond Toe of Dam None observed

d. Condition of Downstream Channel The downstream channel is a natural stream located in a wooded, somewhat narrow valley. The stream has some minor debris in the channel and the slope is shallow, approximately 0.6 percent.

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

a. General The rectangular shaped spillway consists of a concrete weir and concrete sides, faced with stone. The weir is broadcrested and has a length of 25 ft. and breadth of 3 ft.. The upstream face of the weir is inclined about 45° and the downstream face is vertical and has two concrete steps, each 1 ft. wide by 2 ft. high.

b. Condition of Service Spillway The spillway is in good condition with no deterioration observed. The upstream ends of the wingwalls are undermined and are showing signs of deterioration. The concrete caps for the masonry walls at the spillway crest are missing.

c. Condition of Auxiliary Spillway None observed

d. Condition of Discharge Conveyance Channel The discharge channel consists of masonry paved bottom and sides capped with concrete. The channel is in good condition with some minor cracks in the walls above normal water level. There is some debris, tree branches and boards in the channel.

8) Reservoir Drain/Outlet

Type: Pipe X Conduit _____ Other _____

Material: Concrete _____ Metal Cast Iron Other _____

Size: 24-in. diameter Length Approximately 80 feet

Invert Elevations: Entrance 570.0 M.S.L. Estimated

Exit 569.66 M.S.L.

Physical Condition (Describe): Unobservable

Material: Outlet appears to be in good condition.

Joints: Unobservable Alignment Unobservable

Structural Integrity: Structural integrity should be satisfactory

Hydraulic Capability:

Means of Control: Gate X Valve Uncontrolled

Operation: Operable X Inoperable Other

Present Condition (Describe): The control for the gate is rusty but according to the owner's representative, it has been operated within the last year. The concrete gatehouse contains the outlet gate and appears to be in good condition.

9) Structural - Not Applicable

a. Concrete Surfaces

b. Structural Cracking

c. Movement - Horizontal & Vertical Alignment (Settlement)

d. Junctions with Abutments or Embankments

e. Drains - Foundation, Joint, Face _____

f. Water Passages, Conduits, Sluices _____

g. Seepage or Leakage _____

h. Joints - Construction, etc. _____

i. Foundation _____

j. Abutments _____

k. Control Gates _____

l. Approach & Outlet Channels _____

m. Energy Dissipators (Plunge Pool, etc.) _____

n. Intake Structures _____

o. Stability _____

p. Miscellaneous _____

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

a. Description and Condition A concrete structure, containing a spring-house, is located on the right upstream side of the dam. The concrete top for this structure is cracked in several places.

APPENDIX C

HYDROLOGIC/HYDRAULIC DATA AND COMPUTATIONS

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject: WILLOW BROOK DAM — S.O. No.
APPENDIX G - HYDROLOGIC / — Sheet No. of
HYDRAULIC CALCULATIONS: — Drawing No.
Computed by — Checked by — Date

SUBJECT	PAGE

CHECK LIST FOR DAMS
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

AREA-CAPACITY DATA:

		Elevation (ft.)	Surface Area (acres)	Storage Capacity (acre-ft.)
1)	Top of Dam	588.2	76.0	1,061
2)	Design High Water (Max. Design Pool)	--	--	--
3)	Auxiliary Spillway Crest	--	--	--
4)	Pool Level with Flashboards	--	--	--
5)	Service Spillway Crest	585.0	63.4	841

DISCHARGES

		Volume (cfs)
1)	Average Daily	5 - 10
2)	Spillway @ Maximum High Water - Top of Dam -	425
3)	Spillway @ Design High Water	--
4)	Spillway @ Auxiliary Spillway Crest Elevation	--
5)	Low Level Outlet	55
6)	Total (of all facilities) @ Maximum High Water	478
7)	Maximum Known Flood	Unknown
8)	At Time of Inspection	5 - 10

CREST: ELEVATION: 588.2 ft.

Type: Earth Embankment

Width: 3 ft. to 4.5 ft. Length: 540 ft.

Spillover Broad-crested weir

Location 100 ft. from left abutment

SPILLWAY:

SERVICE		AUXILIARY
585.0 ft.	Elevation	None
Broad-crested weir	Type	
	Width	

Type of Control

X	Uncontrolled	

Controlled:

--	Type (Flashboards; gate)	
--	Number	
--	Size/Length	
	Invert Material	
	Anticipated Length of Operating Service	
--	Chute Length	
1.3 ft.	Height Between Spillway Crest & Approach Channel Invert (Weir Flow)	

HYDROMETEROLOGICAL GAGES:

Type: None

Location:

Records:

Date:

Max. Reading:

FLOOD WATER CONTROL SYSTEM:

Warning System: None

Method of Controlled Releases (mechanisms):

24" blow-off pipe at toe of dam controlled by a valve in the gatehouse

DRAINAGE AREA: 1.34 sq. mi.

DRAINAGE BASIN RUNOFF CHARACTERISTICS:

Land Use - Type: About 10% residential, 7% lake surface, 83% wooded

Terrain - Relief: Moderate, about 8% to 15% slopes

Surface - Soil: Poor permeability

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

There were no known plans for altering the existing runoff patterns at the time of the inspection.

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

None observed. All slopes well-vegetated.

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

Orange and Rockland Utilities, Inc. building is subject to flooding if the reservoir rises substantially.

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

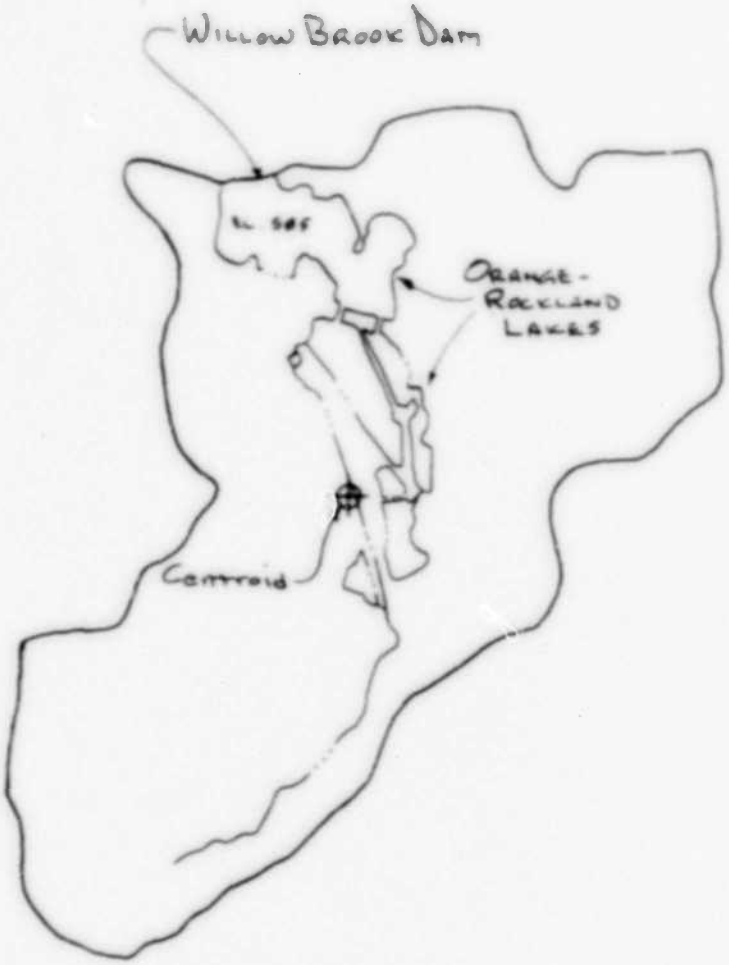
Location: None

Elevation:

Reservoir:

Length @ Maximum Pool 5,500 ft. (Top of Dam El. 590.0 M.S.L.)

Length of Shoreline (@ Spillway Crest) 15,000 ft.



N

1"=2000'

WILLOW BROOK DAM
DRAINAGE AREA MAP

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS
Box 280
Beaver, Pa. 15009

Subject N.Y. Dam Insp. S.O. No. 13990.00-A9A-03
Willow Brook Dam Sheet No. 6 of 29
(Orange-Rockland Lakes) Drawing No.
Computed by [illegible] Checked by [illegible] Date 1/14/81

Drainage Area

Monroe Quad – 20.09/3 = 9.36 in² = 859.5 Ac. = 1.34 mi²

Surface Areas

Lakes @ el 565 – 2.07/3 = 0.69 in² = 63.4 Ac. = 0.10 mi²
el 600 – 4.00/3 = 1.33 in² = 122.4 Ac. = 0.19 mi²
el 620 – 7.00/3 = 2.33 in² = 214.3 Ac. = 0.33 mi²

Watershed Lengths

L = 13,650 ft. = 2.59 mi
Lc = 4,500 ft. = 0.85 mi

$C_T = 2.0$ $C_p = 0.63$
$T_p = C_T (L \cdot L_{ca})^{0.3}$
$= 2.0(2.59 \cdot .85)^{0.3}$
$= 2.53$

ADJUSTMENT FOR T_r USING A DURATION INTERVAL OF 30 MIN.

$T_{rr} = T_p + \frac{D_r - D_p}{4}$

$= 2.53 + \frac{.5 - .46}{4}$

$T_{rr} = 2.54$

PRECIPITATION DATA

HMR-33 Zone 1

PMP 24 hr. – 200 mi² = 21.5 inches
D.A Less than 10 mi²

Duration	% of 200 mi²	Inches
6 hr. PMP	111	23.9
12 hr. "	123	26.4
24 hr. "	133	28.6
48 hr. "	142	30.5

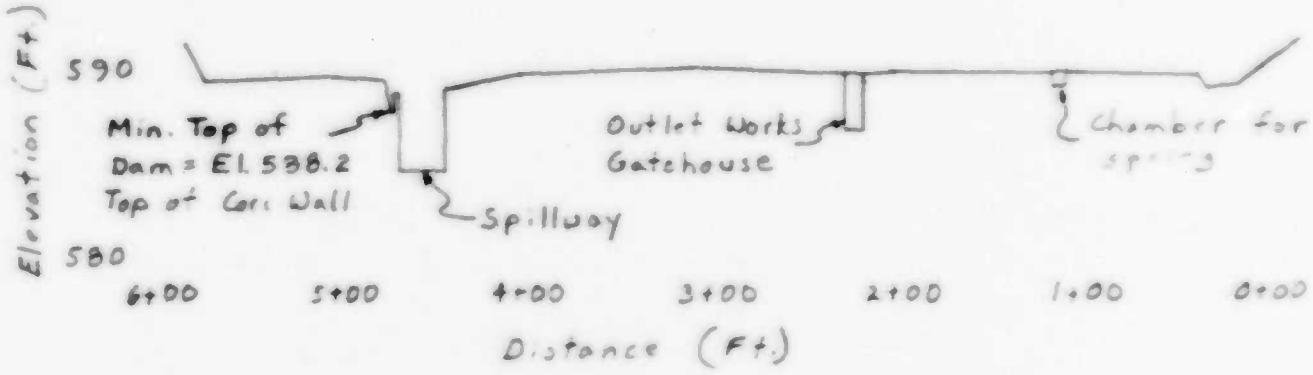
TP-40

100 YR – 24 hr. Rainfall – 7.5 inches
" 12 hr. " – 6.4 "
" 6 hr. " – 5.3 "

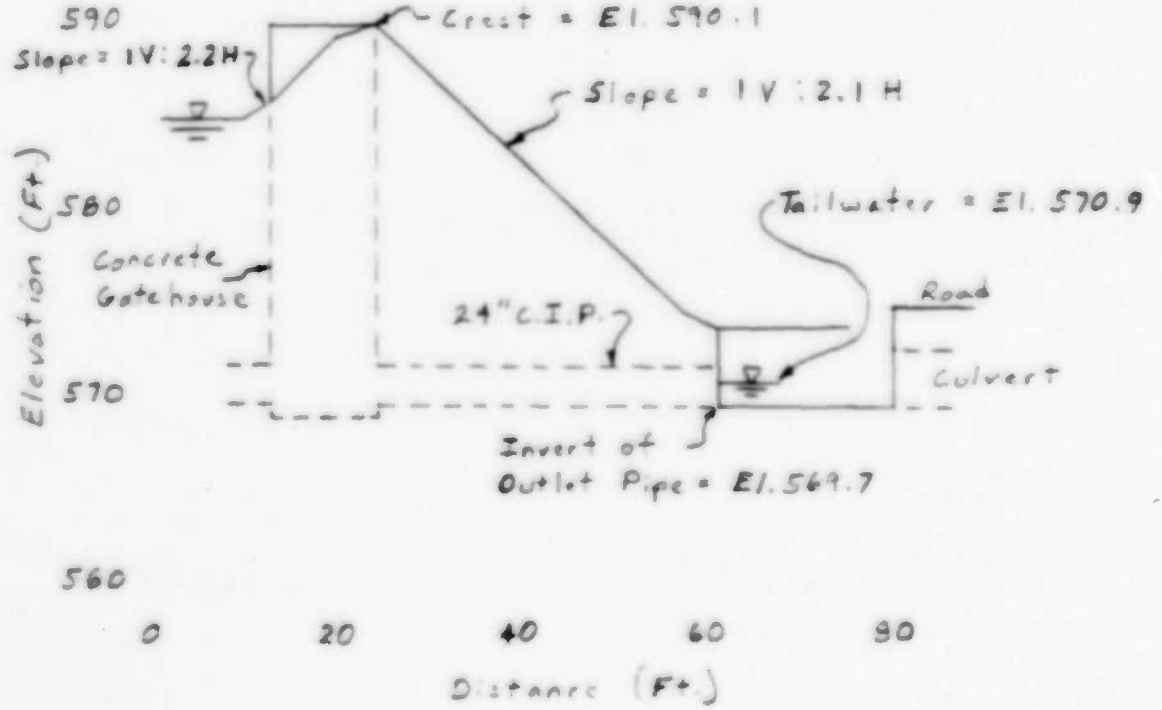
MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS
Box 280
Beaver, Pa. 15009

Subject: New York Dam
Willow Brook Dam
S.O. No.
Sheet No. 7 of 29
Drawing No.
Computed by LAD Checked by GWT Date 3/12/91

TOP OF DAM PROFILE



TYPICAL DAM CROSS SECTION AT STA. 2+14



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THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject: New York Dam — S.O. No.
Willow Brook Dam — Sheet No. 8 of 39
Spillway Rating — Drawing No.
Computed by: ED — Checked by: GWT — Date: 3/12/91

Weir Flow

$Q = CLH^{3/2}$

$L = 25'$

Breadth = 3'

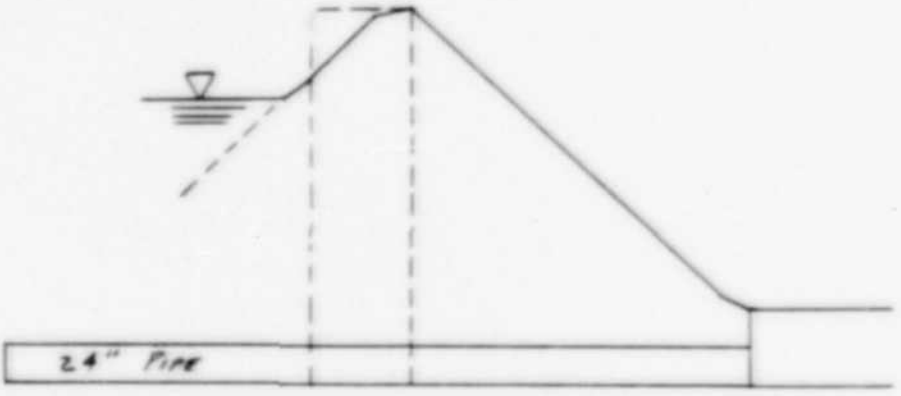
C varies with H, Kings and Brater Handbook Table 5-3 and 5-4 Fig 5-40

H varies from 0.2 Ft to 8.0 Ft

Elevation (Ft.)	H (Ft)	C	L (Ft.)	Q (cfs)
585.0	0		25.0	0
585.2	0.2	2.4	25.0	5.4
585.6	0.6	2.7	25.0	31.4
586.0	1.0	2.7	25.0	67.5
587.0	2.0	2.7	25.0	190.9
588.0	3.0	2.9	25.0	376.7
589.0	4.0	3.1	25.0	620.0
590.0	5.0	3.3	25.0	922.4
591.0	6.0	3.3	25.0	1212.5
592.0	7.0	3.3	25.0	1527.9
593.0	8.0	3.3	25.0	1866.8

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS
Box 280
Beaver, Pa. 15009

Subject: WILLOW BROOK DAM — S.O. No.
24-IN. CAST IRON PIPE RATING — Sheet No. 9 of 29
Drawing No.
Computed by GWT — Checked by LAO — Date 3-18-81



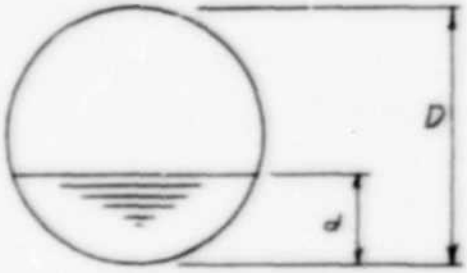
OUTLET PIPE IS 24" CAST IRON PIPE
INLET ELEV. 570.00 FT.
OUTLET ELEV. 569.66 FT.
LENGTH = 80 FT.
SPILLWAY CREST ELEV. 585.0 FT.

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject: WILLOW BROOK DAM I — S.O. No.
24" ∅ CAST IRON PIPE RATING — Sheet No. 10 of 29
Drawing No.
Computed by GWT — Checked by GD — Date 3-18-81

"DESIGN OF SMALL DAMS" PAGES 558 AND 559 ✓



D = DIA. PIPE
d = DEPTH OF WATER
S = PIPE SLOPE

$S = \frac{570.00 - 569.66}{80} = 0.0043$ ✓

n = 0.013 ✓

$\frac{d}{D} = \frac{1}{2} = .5$ TABLE B-2 $1.3955 = \frac{Q_n}{D^{8/3} S^{1/2}} = \frac{Q}{2^{8/3}}$ Q = 7.89 C.F.S. ✓

$\frac{d}{D} = \frac{1}{2} = .5$ TABLE B-3 $.232 = \frac{Q_n}{D^{8/3} S^{1/2}} = \frac{Q(.013)}{(2)^{8/3}(.0043)^{1/2}}$ Q = 7.43 C.F.S. ✓

$\frac{d}{D} = \frac{1.5}{2} = .75$ TABLE B-2 $3.0607 = \frac{Q_n}{D^{8/3}} = \frac{Q}{2^{8/3}}$ Q = 17.31 C.F.S. ✓

$\frac{d}{D} = \frac{1.5}{2} = .75$ TABLE B-3 $.422 = \frac{Q_n}{D^{8/3} S^{1/2}} = \frac{Q(.013)}{(2)^{8/3}(.0043)^{1/2}}$ Q = 13.52 C.F.S. ✓

Subcritical Flow controls

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS
Box 280
Beaver, Pa. 15009

Subject: Willow Brook Dam — S.O. No.
24-in Cast Iron Pipe Rating — Sheet No. 11 of 29
Drawing No.
Computed by GWT — Checked by GAD — Date 3-18-81

Orifice Flow

$Q = CA(2gH)^{.5}$

$Q = 15.12 (H)^{.5}$ /

$A = \pi R^2 = \pi (1)^2 = 3.14$ /

$g = 32.2$ ft/sec^2 /

H varies from 1.5 to 17.2 Ft /

C = 0.6 from Table 4-6 Pg. 4-92 /

Reated + King

Head Measured To Center of Pipe

Elevation (Ft)	C	A (Sq. Ft)	g^2 (Ft/Sec)	H (Ft)	Q (cfs)
573.0	.6	3.14	64.4	2.0	21.38 /
574.0	.6	3.14	64.4	3.0	26.19 /
576.0	.6	3.14	64.4	5.0	33.81 /
578.0	.6	3.14	64.4	7.0	40.00 /
580.0	.6	3.14	64.4	9.0	45.36 /
582.0	.6	3.14	64.4	11.0	50.15 /
584.0	.6	3.14	64.4	13.0	54.52 /
586.0	.6	3.14	64.4	15.0	58.56 /
588.2	.6	3.14	64.4	17.2	62.71 /

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject: Willow Brook Dam — S.O. No.
24-in Cast Iron Pipe Rating — Sheet No. 12 of 29
Drawing No.
Computed by GWT — Checked by GAD — Date 3-18-81

Pipe Flow

$$Q = \frac{A(2gH)^{1/2}}{[1 + K_e + K_o + K_c(L)]^{1/2}}$$

$$= \frac{3.14(64.4H)^{1/2}}{[1 + .78 + 0 + .0124(80)]^{1/2}}$$

$Q = 15.13\ H^{1/2}$ /

$A = \pi R^2 = 3.14$ /
$g = 32.2$ Ft/sec² /
H VARIES AND IS MEASURED FROM / THE TOP OF PIPE ELEV AT THE OUTLET
$L = 80$ Ft.
K_e (K_e) = .78 Pg. 5.5-6 / SCS NEH-5
K_o (K_o) = 0 Pg 5.5-10 / SCS NEH-5
K_c (K_c) = 0.0124 Pg 5.5-6 / SCS NEH-5
$n = 0.013$ /

TOP OF 24" PIPE AT OUTLET = ELEV. 571.66 Ft. /

ELEVATION (Ft)	H (Ft)	Q (CFS)
573.0	1.34	17.5 /
574.0	2.34	23.1 /
576.0	4.34	31.5 /
578.0	6.34	38.1 /
580.0	8.34	43.7 /
582.0	10.34	48.7 /
584.0	12.34	53.2 /
586.0	14.34	57.3 /
588.2	16.54	61.5 /

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject: WILLOW BROOK DAM — S.O. No.
24" IN PIPE RATING SUMMARY — Sheet No. 13 of 29
Drawing No.
Computed by GWT — Checked by LAD — Date 3-18-81

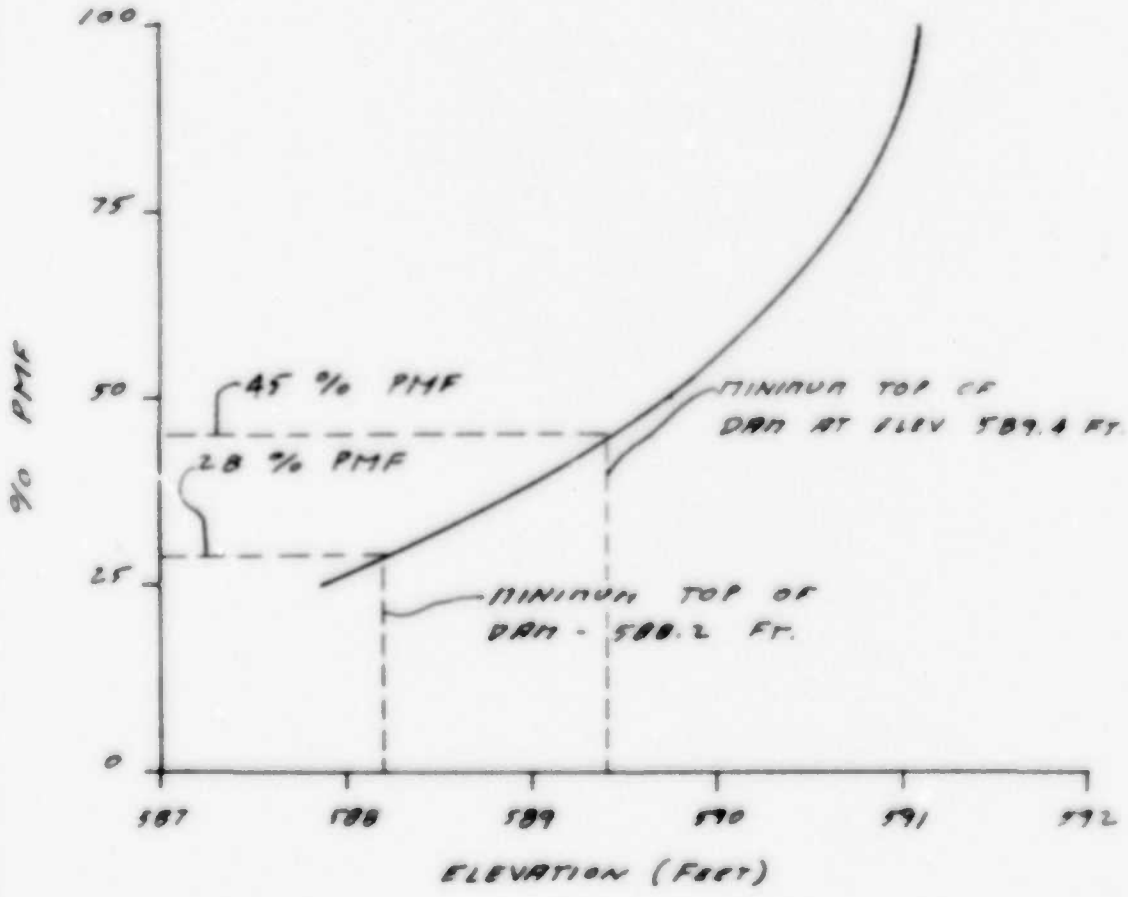
24" PIPE RATING SUMMARY

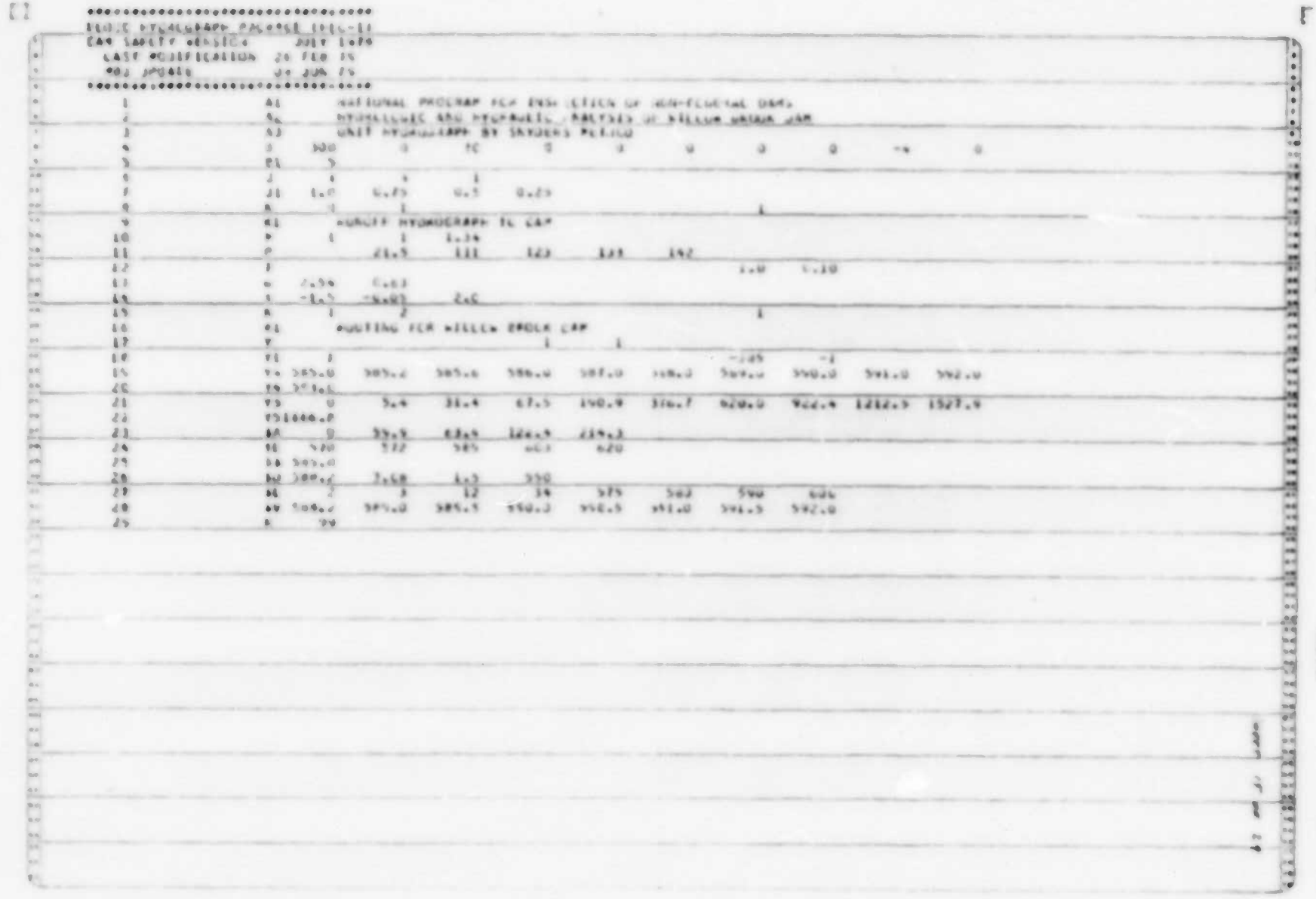
ELEVATION (FT)	Q (CFS)
570.0	0
571.0	7.4
571.5	13.5
573.0	17.5
574.0	23.1
576.0	31.5
578.0	38.1
580.0	43.7
582.0	48.7
584.0	53.2
586.0	57.3
588.2	61.5

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject: Willow Brook Dam — S.O. No.
Spillway Capacity Analysis — Sheet No. 14 of 29
Drawing No.
Computed by GWT — Checked by LAD — Date 5/6/81





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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION        JULY 1978
  LAST MODIFICATION  26 FEB 79
  NEW UPDATE         29 APR 79
**********

RUN  DATE 03/13/81
     TIME    15.27

                    NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
                    HYDROLOGIC AND HYDRAULIC ANALYSES OF MILLER DAM, OHIO
                    UNIT HYDROGRAPH BY SNYDER'S METHOD

                                    JOB SPECIFICATION
                      NW     NMIN     METRIC     IDAY      IHR      MIN      IPLT     IPRT    ASTAR
                      100        0         10        0        0        0        0        0       -9        0
                                                  JSPLT    JPRT   INAME    ISTAG
                                                      1        0        0        0        0

                                    MULTI-PLAN ANALYSES TO BE PERFORMED
                                      NPLAN= 1  RATIO= 1  LRATIO= 1
                      RTIOS=   1.20    0.85    0.50    0.25

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

                                    SUB-AREA RUNOFF COMPUTATION

                    RUNOFF HYDROGRAPH IS CAR

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

                                    HYDROGRAPH DATA
                      IHYDG     IUHG    TAREA    SNAP   TRSDA   TRSPC   RATIO   ISAME   LOCAL
                          1        1    1.39     0.0     1.39    0.0     0.0        0       0       0

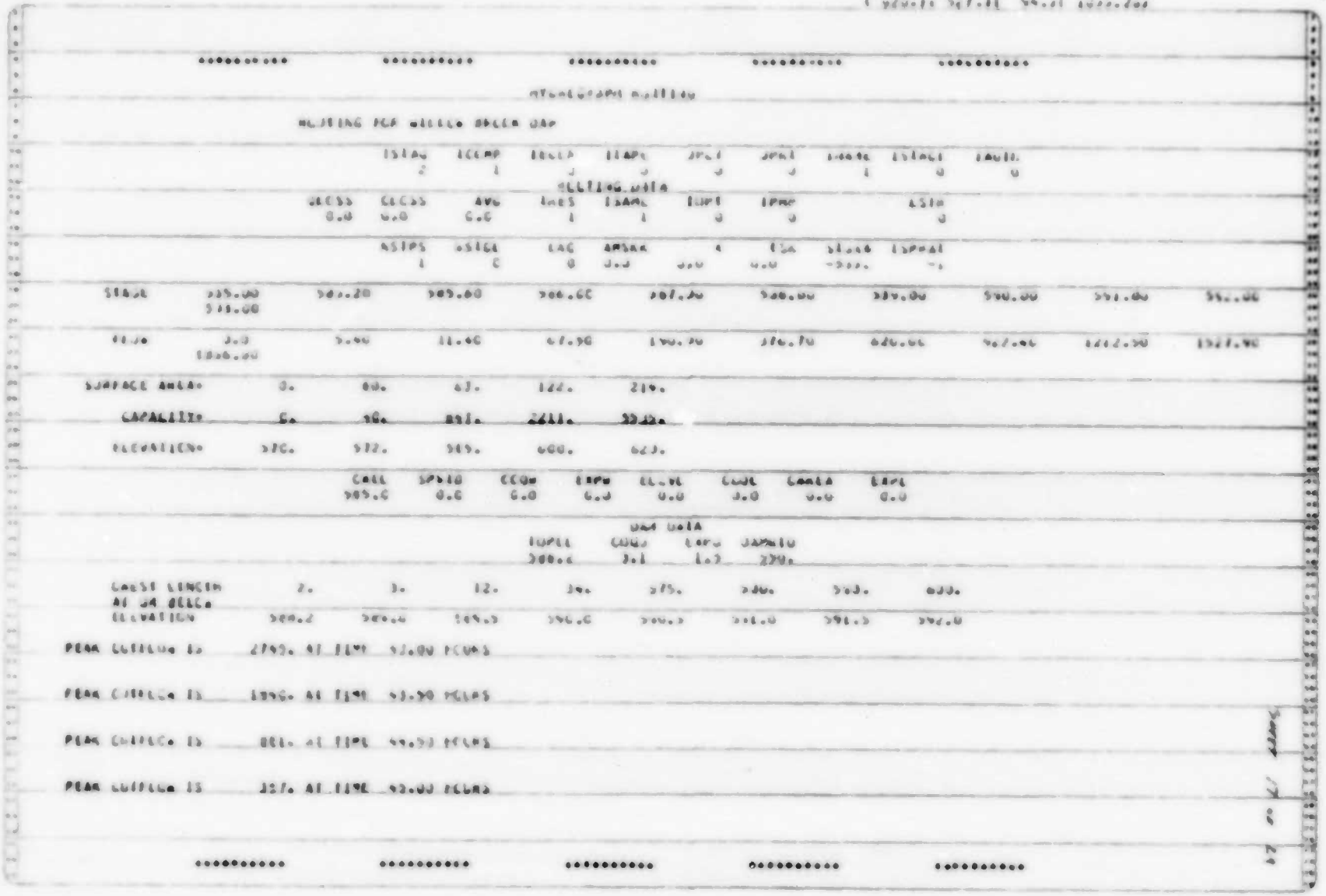
                                    PRECIP DATA
                                SPFE     PAS      RE      F12     F24     F48     F72     F96
                                 0.0   21.50   116.00   121.00   132.50   142.00    0.3     3.0
IMSBL COMPLETED BY THE PROGRAM IS 0.300

                                    LOSS DATA
                      LRUPT   STRKR    DLTKR    RTIOL    ERAIN    STRKS    RTIOL    STRTL    CNSTL    ALSMX    RTIMP
                          2     0.0      0.0      1.00     0.0      0.0      1.00     1.00     0.010    0.0      0.0

                                    UNIT HYDROGRAPH DATA
                                  TP= 2.00    CP=0.63    NTA= 0

                                    RECESSION DATA
                                STRTQ=   -1.00    QRCSN=   -0.05    RTIOR= 2.00

                      UNIT HYDROGRAPH 21 END-OF-PERIOD ORDINATES, LAG=  2.00 HOURS, CP= 0.63  VOL= 1.00
                      17.      66.     172.     110.     213.     219.     188.     199.     119.      93.
                      70.      44.      25.      38.      33.      27.      19.      15.      11.      10.
                       8.       5.       5.       5.       4.       3.       2.
```



PEAK FIELD AND STORAGE BOND IP PERMITS SUPPORT FOR MULTIPLE PLANETARY ECONOMIC COMPUTATIONS
FIELDS IN SQUARE FEET PER SQUARE FOOTAGE METERS PER ASSEMBLY
AREA IN SQUARE METERS FOOTAGE ALLOCATION

OPERATION	STATION	AREA	PLAN	RATIO 1 $.00	RATIO 2 C.C7	RATIOS APPLIED TO FIELDS RATIO 3 W.TW	RATIO 4 A.C2
PSYCHOGRAPHIC AI	1 1	1.49 1.071	1 1	4860. 81.0814	4192. 66.7544	1970. 40.5081	713. 20.4214
POWTEN IN	2 1	1.49 1.071	1 1	4792. 77.7214	1898. 30.1081	994. 20.4511	371. 10.0814

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

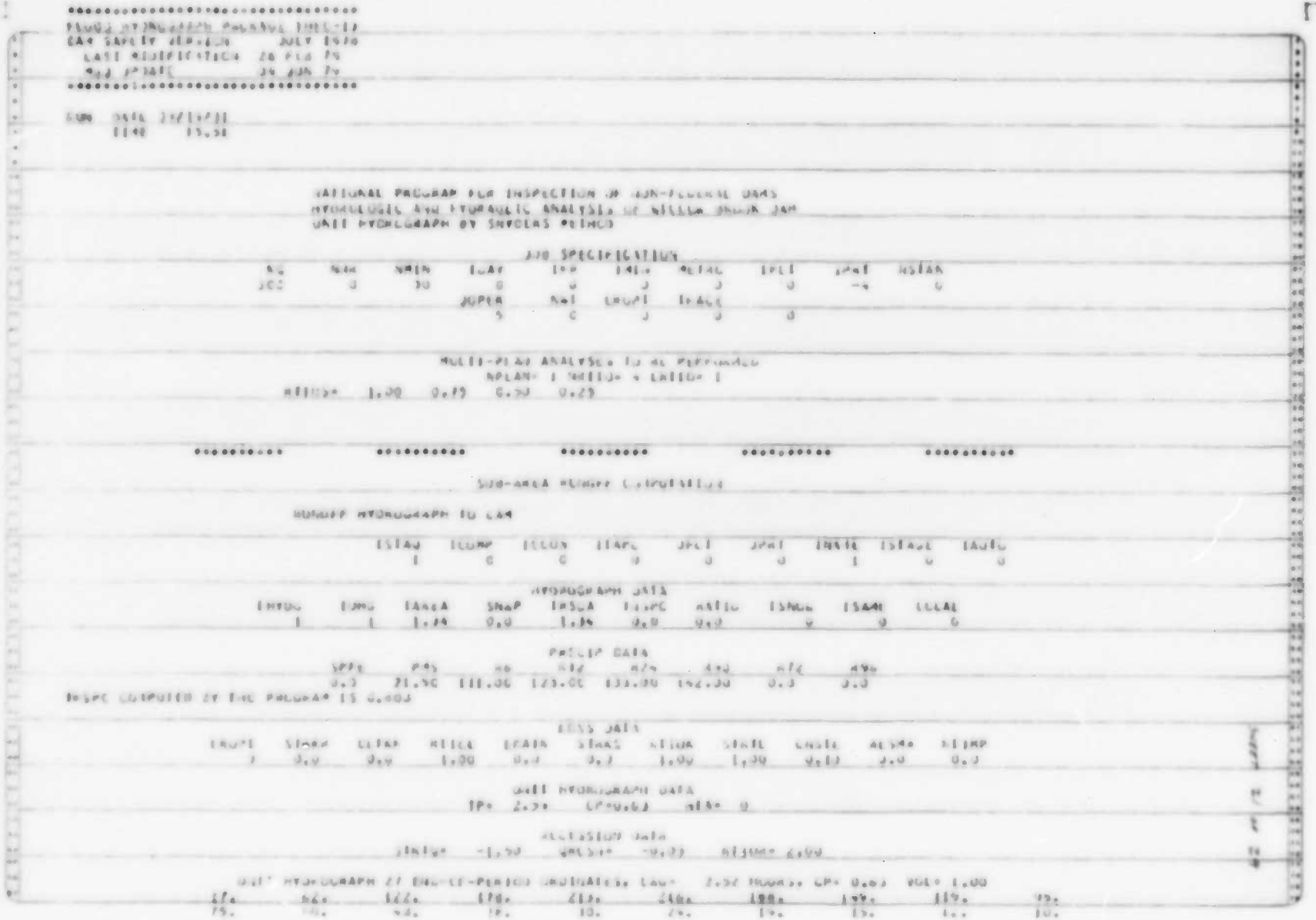
	ELEVATION	INITIAL VALUE 989.00	SPILLWAY CREST 992.00	TOP OF DAM 998.20
	STORAGE	0.0.	0.0.	0.0.
	OUTFLOW	0.	0.	0.

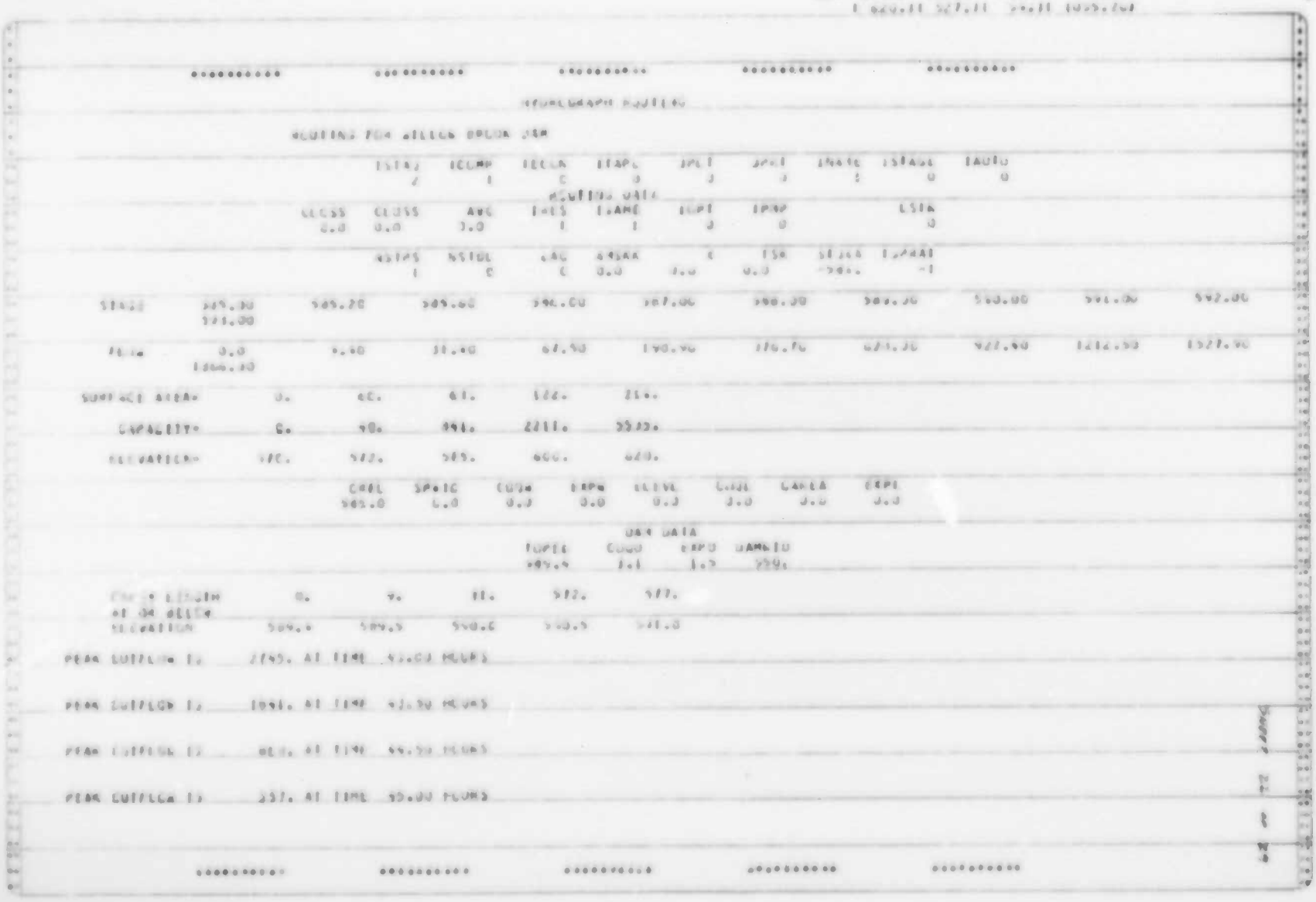
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	991.69	0.69	1292.	4797.	11.00	92.00	0.0
0.75	990.93	0.93	1201.	4040.	10.00	91.50	0.0
0.50	989.77	0.57	1148.	0.0.	7.50	90.50	0.0
0.25	987.82	0.0	1039.	0.	0.0	95.00	0.0

EXISTING CONDITIONS

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
CAM SAFETY VERSION        JULY 1978
  LAST MODIFICATION  28 FEB 79
  RUN UPDATE         01 JUN 79
**********
    1                 A1       NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
    2                 A2       HYDROLOGIC AND HYDRAULIC ANALYSIS OF EXISTING SPRAGUE DAM
    3                 A3       UNIT HYDROGRAPH BY SNYDER'S METHOD
    4                 B    300      0      30      3      3      3      0      0     -4      0
    5                 B1     5
    6                 J     1      4      1
    7                 J1   1.0    0.75    0.5    0.25
    8                 K     0      1                                          1
    9                 O1       OUTLET HYDROGRAPH TO DAM
   10                 M     2      1    1.34
   11                 P           21.2     111     123     133     142
   12                 T                                                   1.0    0.16
   13                 R    2.56    0.61
   14                 E    -1.5   -0.03     2.6
   15                 K     1      2                                          1
   16                 O1       ROUTING FOR SILVER SPRING DAM
   17                 T                                  1      1
   18                 T1    1                                             -585     -1
   19                 T2  585.0   585.2   585.6   586.0   587.0   588.0   589.0   590.0   591.0   592.0
   20                 T2  593.0
   21                 T5    3      5.0     11.0    67.5    190.9   376.7   620.0   922.0  1212.3  1527.9
   22                 T5 1864.8
   23                 IA    0     99.9    91.9    124.5   219.3
   24                 IL   570     572     585     630     620
   25                 LS  585.0
   26                 KK  589.0    1.04    1.0     550
   27                 KL    0       0      31      272     577
   28                 KK  589.0   589.5   590.0   590.5     591
   29                 *     99
```

REVISING LOW MASS ADJACENT TO THE SPILLWAY IS FILED IN.





PEAK FLOW AND STORAGE (EXCLUDING BASEFLOW) FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

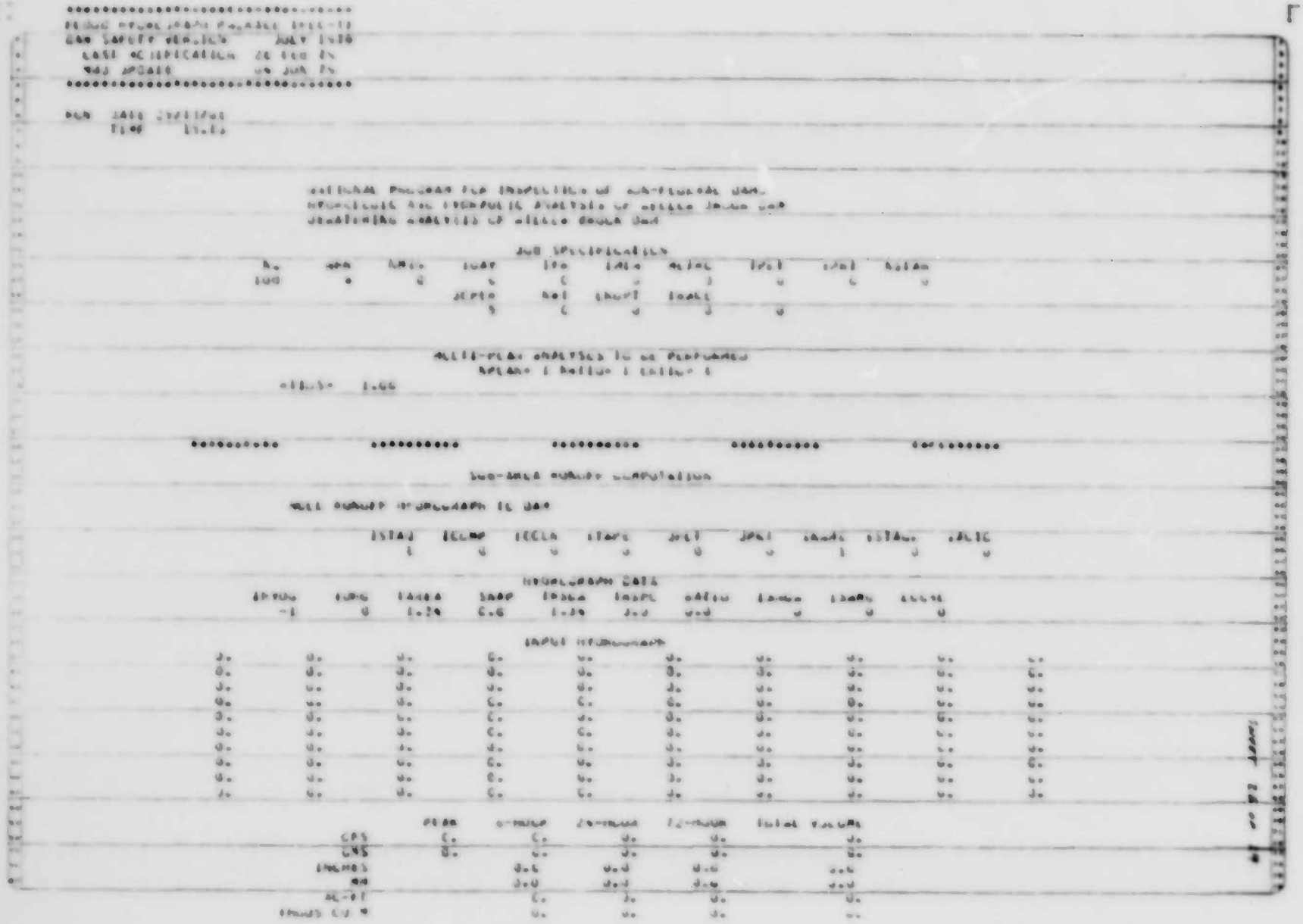
OPERATION	STATION	AREA	PLAN	RATIO 1 1.00	RATIO 2 0.75	RATIO 3 0.50	RATIO 4 0.25
HYDROGRAPH AT	1	1.19	1	2900.	2193.	1449.	712.
	1	3.071	1	81.8314	62.1514	41.0381	20.1911
ROUTED TO	2	1.39	1	2745.	1891.	948.	227.
	1	3.671	1	77.7781	53.5554	26.8411	6.4311

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	593.00	582.00	597.00
STORAGE	861.	861.	1133.
OUTFLOW	0.	0.	861.

RATIO OF PMF	MAXIMUM RESERVOIR W.S. ELEV.	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	598.44	1.44	1210.	6152.	3.00	53.00	0.0
0.75	598.15	1.15	1200.	5091.	0.00	43.00	0.0
0.50	596.79	0.79	1159.	3666.	0.00	44.00	0.0
0.25	387.69	0.0	1094.	2216.	0.00	52.00	0.0

NORMAL FLOW DEAM ABSENT TO SPILLWAY IS FAILED IN.



HYDROGRAPH AT STA [illegible] 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.	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.	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
CFS	0.	0.	0.	0.	0.
CMS	0.	0.	0.	0.	0.
INCHES		0.0	0.0	0.0	0.0
MM		0.0	0.0	0.0	0.0
AC-FT		0.	0.	0.	0.
THOUS CU M		0.	0.	0.	0.

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

HYDROGRAPH ROUTING

ROUTING [illegible] DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.0	0.0	0.0	1	1	0	0		0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.0	0.0	0.0	-585.	-1

STAGE	572.30	577.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	580.00	[illegible]	[illegible]
	586.00	588.20								
FLOW	0.0	7.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]								

SURFACE AREA=	0.	10.	[illegible]	[illegible]	[illegible]
CAPACITY=	0.	40.	[illegible]	[illegible]	[illegible]
ELEVATION=	570.	572.	585.	600.	620.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
585.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

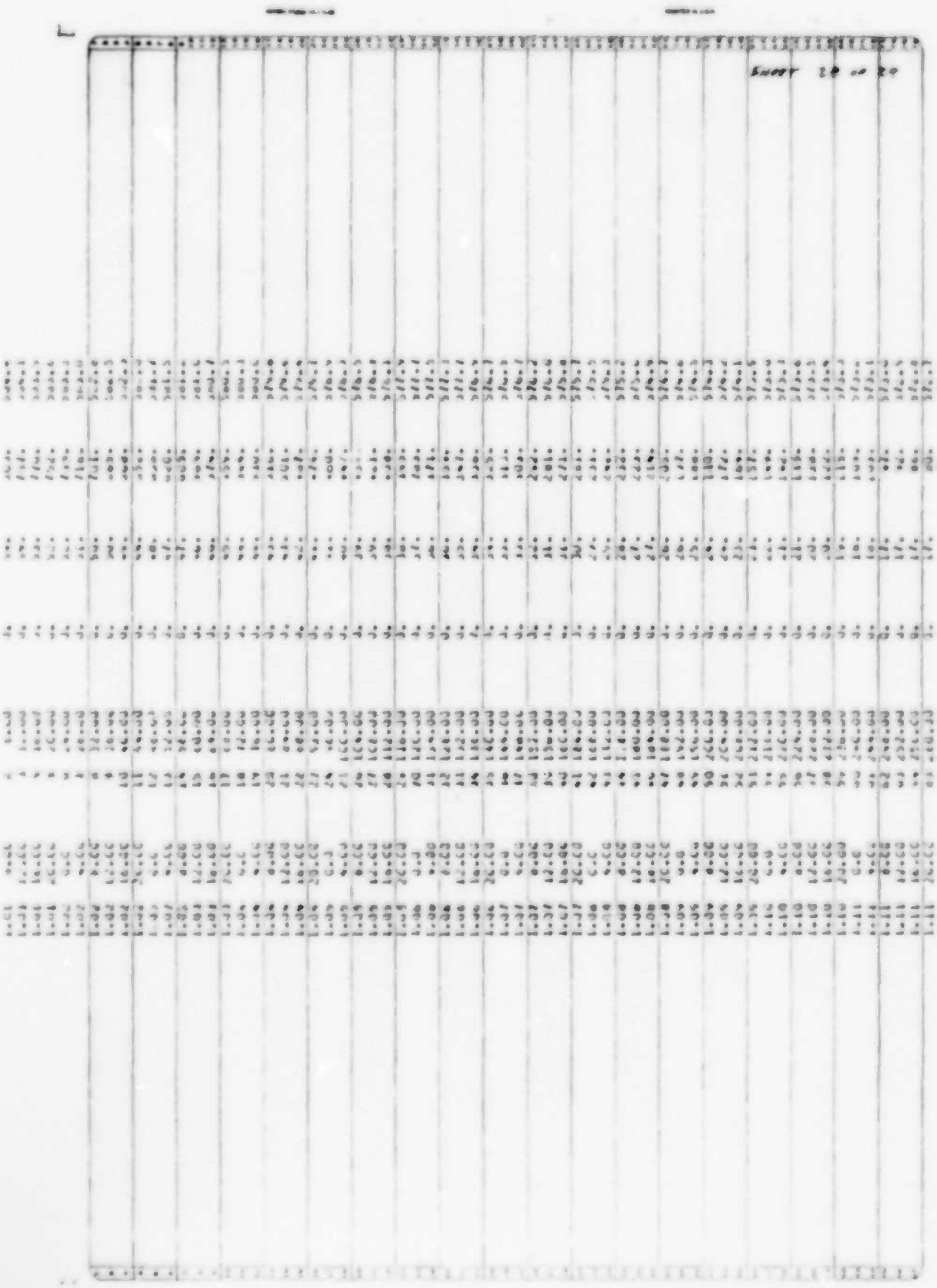
DAM DATA

TOPEL	COQD	EXPD	DAMWID
588.2	[illegible]	1.5	[illegible]

STATION 2, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

MO.DA	HR.MN	PERIOD	HOURS	INFLOW	OUTFLOW	STORAGE	STAGE
[illegible]	[illegible]	1	[illegible]	0.	[illegible]	[illegible]	[illegible]



1.12	12.00	69	276.00	0.	16.	30.	[illegible]
1.12	16.00	70	280.00	0.	15.	30.	[illegible]
1.12	20.00	71	284.00	0.	15.	49.	[illegible]
1.13	0.0	72	288.00	0.	15.	40.	[illegible]
1.13	4.00	73	292.00	0.	15.	36.	[illegible]
1.13	8.00	74	296.00	0.	15.	30.	[illegible]
1.13	12.00	75	300.00	0.	19.	24.	[illegible]
1.13	16.00	76	304.00	0.	19.	23.	[illegible]
1.13	20.00	77	308.00	0.	16.	20.	[illegible]
1.14	0.0	78	312.00	0.	16.	16.	[illegible]
1.14	4.00	79	316.00	0.	16.	14.	[illegible]
1.14	8.00	80	320.00	0.	10.	8.	[illegible]
1.14	12.00	81	324.00	0.	8.	5.	[illegible]
1.14	16.00	82	328.00	0.	6.	3.	[illegible]
1.14	20.00	83	332.00	0.	5.	1.	[illegible]
1.15	0.0	84	336.00	0.	2.	0.	[illegible]
1.15	4.00	85	340.00	0.	0.	0.	[illegible]
1.15	8.00	86	344.00	0.	0.	0.	[illegible]
1.15	12.00	87	348.00	0.	0.	0.	[illegible]
1.15	16.00	88	352.00	0.	0.	0.	[illegible]
1.15	20.00	89	356.00	0.	0.	0.	[illegible]
1.16	0.0	90	360.00	0.	0.	0.	[illegible]
1.16	4.00	91	364.00	0.	0.	0.	[illegible]
1.16	8.00	92	368.00	0.	0.	0.	[illegible]
1.16	12.00	93	372.00	0.	0.	0.	[illegible]
1.16	16.00	94	376.00	0.	0.	0.	[illegible]
1.16	20.00	95	380.00	0.	0.	0.	[illegible]
1.17	0.0	96	384.00	0.	0.	0.	[illegible]
1.17	4.00	97	388.00	0.	0.	0.	[illegible]
1.17	8.00	98	392.00	0.	0.	0.	[illegible]
1.17	12.00	99	396.00	0.	0.	0.	[illegible]
1.17	16.00	100	400.00	0.	0.	0.	[illegible]

PEAK OUTFLOW IS [illegible] AT TIME [illegible] HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	39.	30.	32.	29.	2089.
CMS	1.	1.	1.	1.	59.
INCHES		3.23	1.07	4.10	11.36
MM		6.79	27.13	104.24	288.79
AC-FT		10.	105.	293.	683.
THOUS CU M		22.	129.	361.	1113.

....

APPENDIX D

REFERENCES

REFERENCES

1. University of the State of New York, Geology of New York, Education Leaflet 20, 1966.

2. Broughton, John G. and others, "Geologic Map of New York - Lower Hudson Sheet," New York State Museum and Science Service, Map and Chart Series No. 15, 1970.

3. Soil Conservation Service, Soil Interpretations Inventory Analysis and Erosion Control - Orange County, New York, U.S. Dept. of Agriculture, January 1972.

4. Chow, Ven Te, Handbook of Applied Hydrology, McGraw - Hill Book Company, New York, 1964.

5. Chow, Ven Te, Open Channel Hydraulics, McGraw - Hill Book Company. New York, First Edition, 1959.

6. HMR 33, "Seasonal Variations of Probable Maximum Precipitation, East of the 105th Meridian for Areas 10 to 1000 Square Miles and Durations of 6 to 48 Hours," (1956).

7. King, Horace Williams and Brater, Ernest F., Handbook of Hydraulics, Fifth Edition, McGraw - Hill Book Company, New York, 1963.

8. Soil Conservation Service, "National Engineering Handbook - Section 4, Hydrology," U.S. Department of Agriculture, 1964.

9. Soil Conservation Service, "National Engineering Handbook - Section 5, Hydraulics," U.S. Department of Agriculture.

10. U.S. Army, Hydrological Engineering Center, "Flood Hydrograph Package (HEC-1), Dam Safety Investigations, Users Manual," Corps of Engineers, Davis, California, September 1978.

11. U.S. Army, "Inventory of United States Dams," Corps of Engineers, 9 September 1978.

12. U.S. Army, Office of the Chief of Engineers, "Appendix D, Recommended Guidelines for Safety Inspection of Dams," National Program of Inspection of Dams, Volume 1, Corps of Engineers, Washington, D.C., May 1975.

13. George, Thomas S. and Taylor, Robert S., Hydrologic Flood Routing Model For Lower Hudson River Basin, Water Resources Engineers, Inc., 8001 Forbes Place, Suite 312, Springfield, Virginia, January 1977.

14. U.S. Army, Office of the Chief of Engineers, Engineering Circular EC-1110-2-163 (Draft Engineering Manual), "Spillway and Freeboard Requirements for Dams, Appendix C, Hydrometeorological Criteria and Hyetograph Estimates," (August 1975).

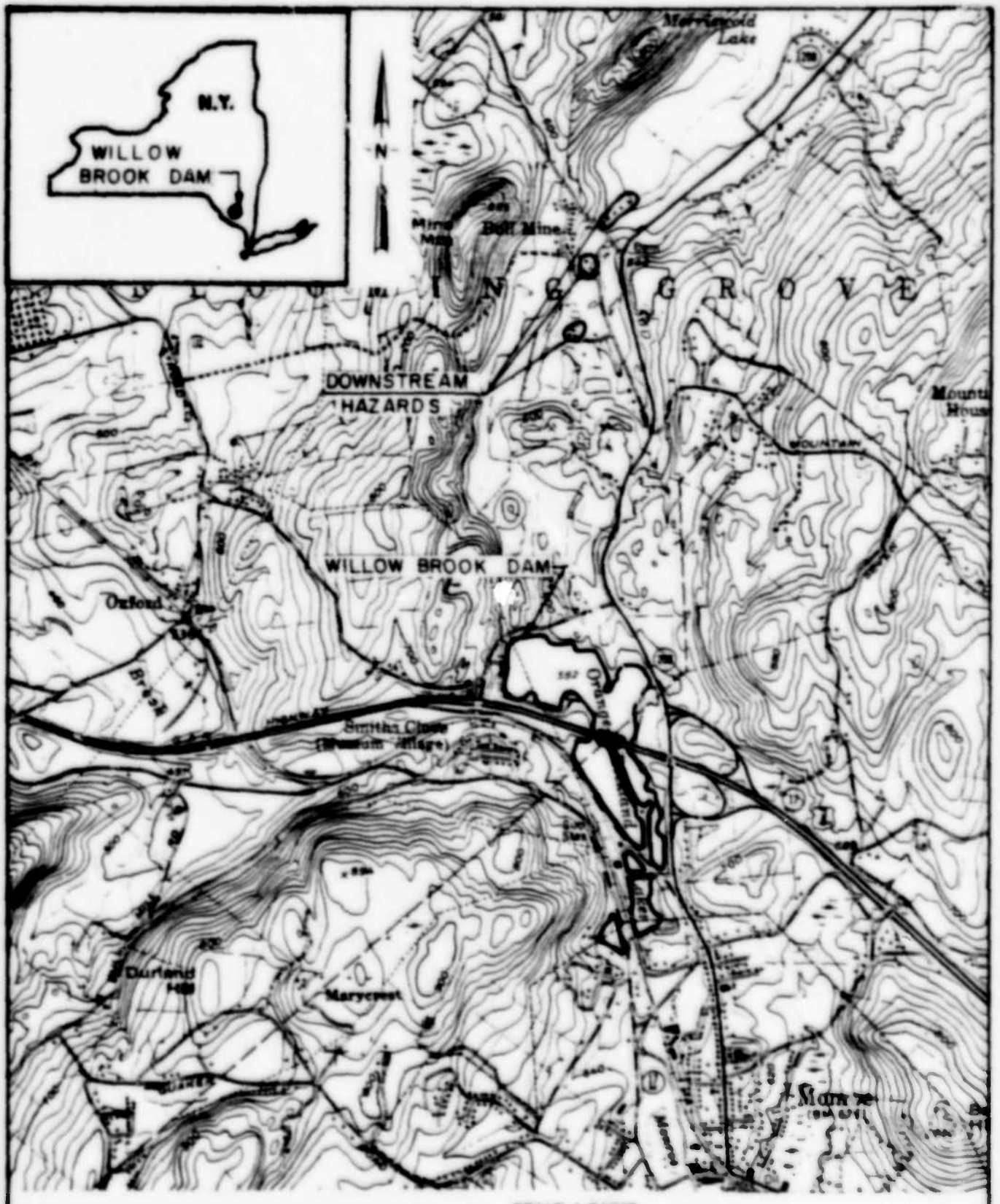
15. U.S. Army, Office of the Chief of Engineers, Engineering Circular EC-1110-2-188, "Engineering and Design, National Program of Inspection of Non-Federal Dams," Corps of Engineers, Washington, D.C., 30 December 1977.

16. U.S. Army, Office of the Chief of Engineers, Engineer Technical Letter No. ETL 1110-2-234, "Engineering and Design, National Program of Inspection of Non-Federal Dams, Review of Spillway Adequacy," Corps of Engineers, Washington, D.C., 10 May 1978.

APPENDIX E

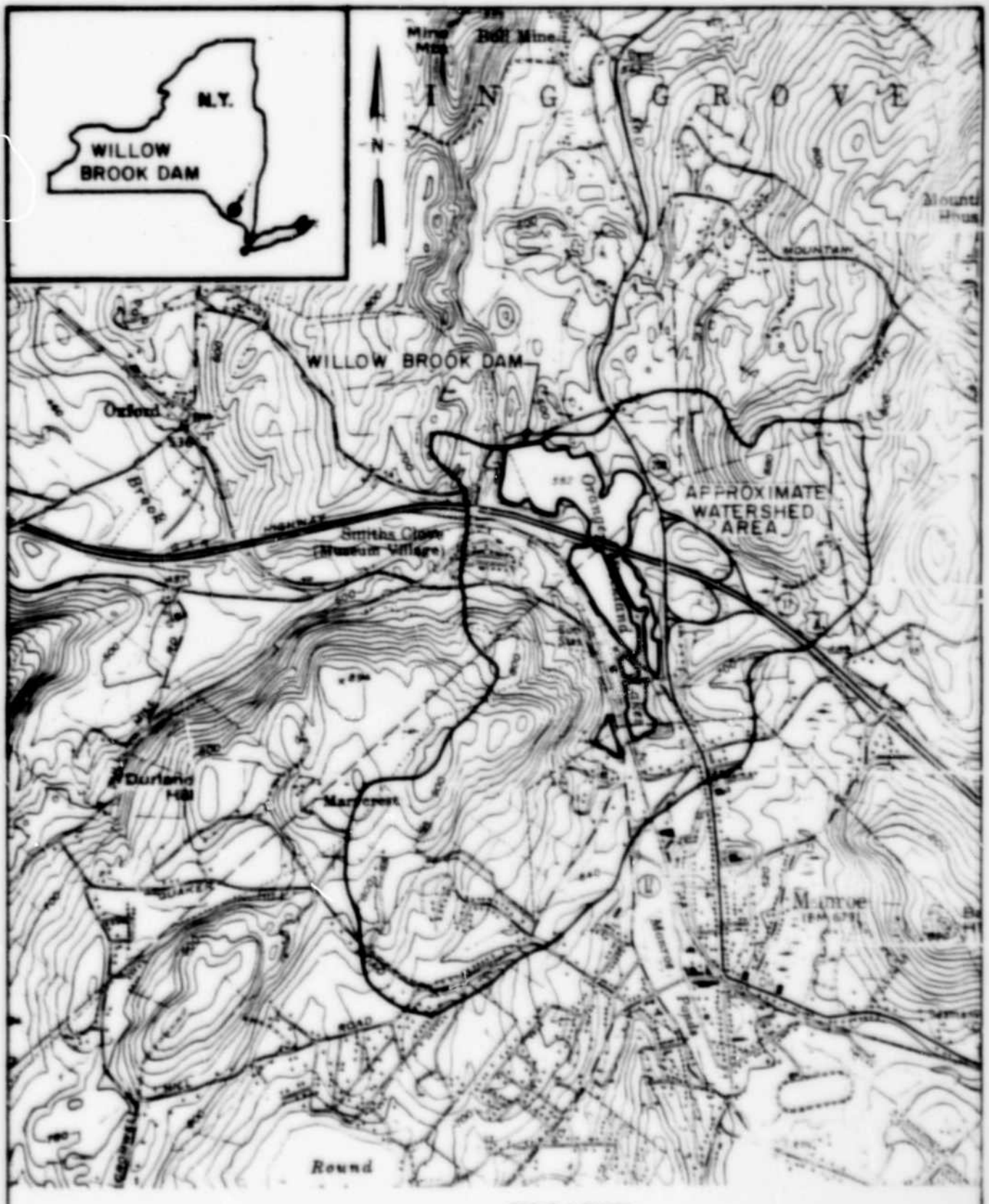
DRAWINGS

CONTENTS



REFERENCES:
1. U.S.G.S. 7.5' MONROE, N.Y. QUADRANGLE 1957

LOCATION PLAN
WILLOW BROOK DAM



REFERENCES:
1. U.S.G.S. 7.5' MONROE, N.Y. QUADRANGLE. 1957

WATERSHED MAP
WILLOW BROOK DAM

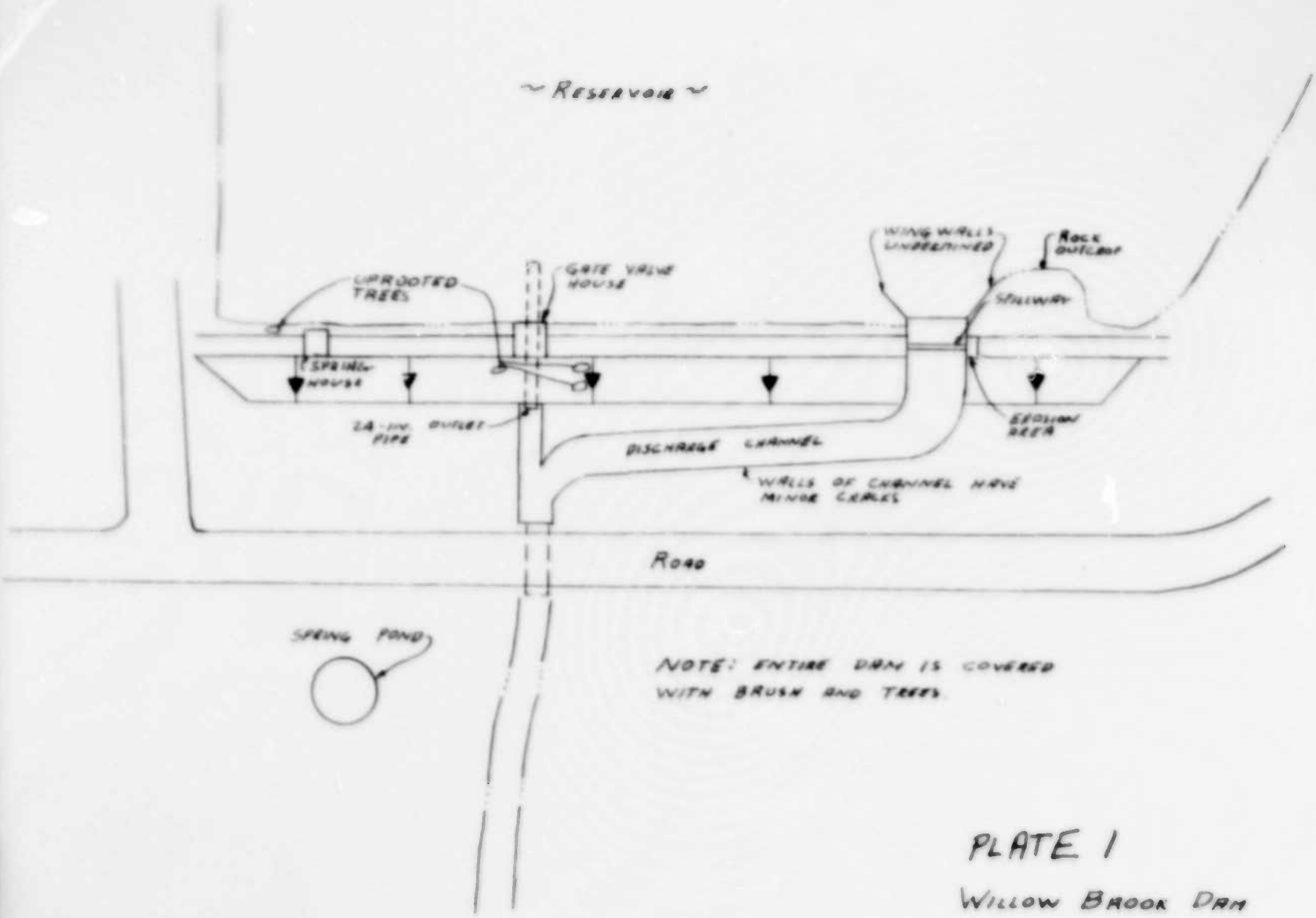
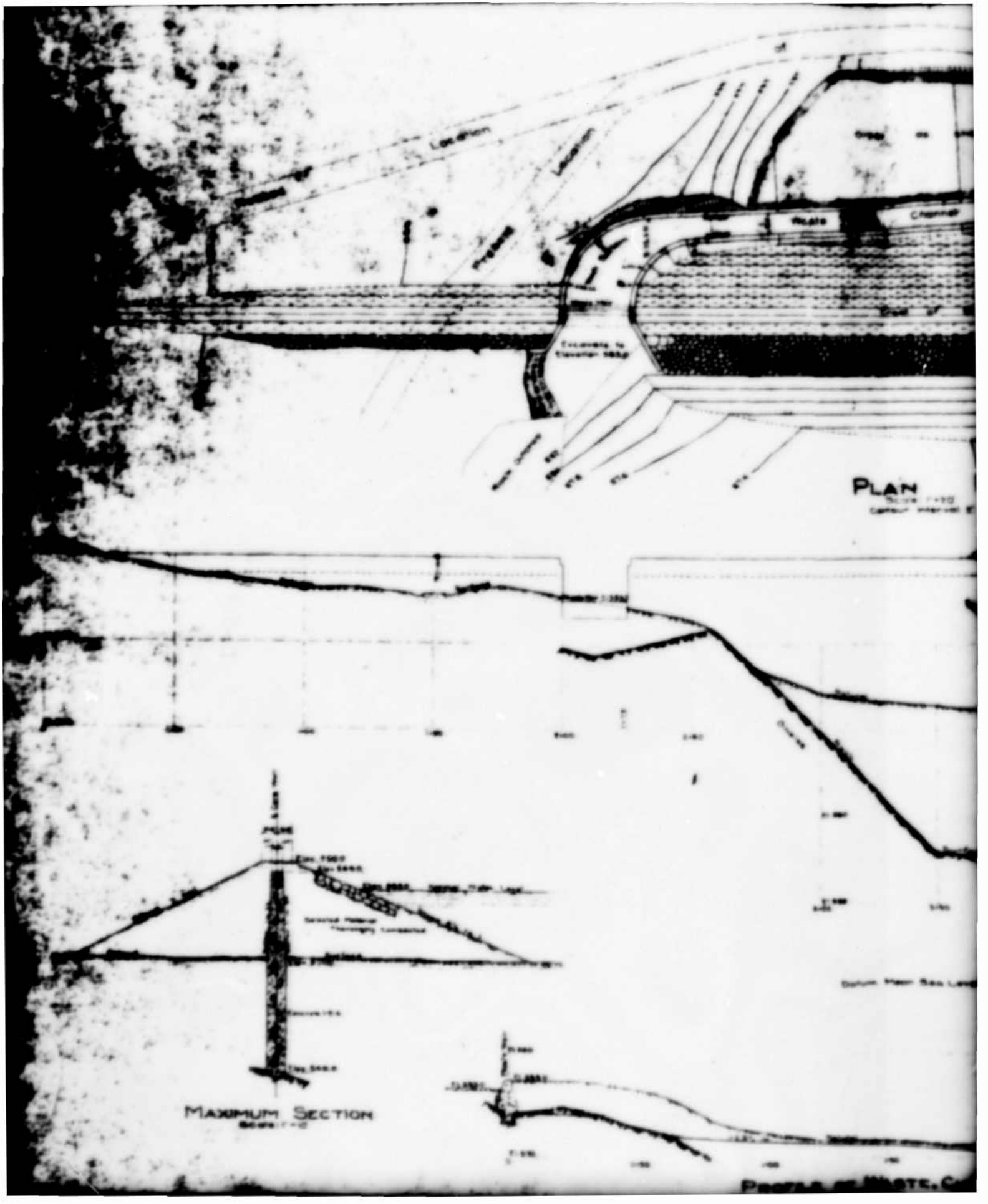
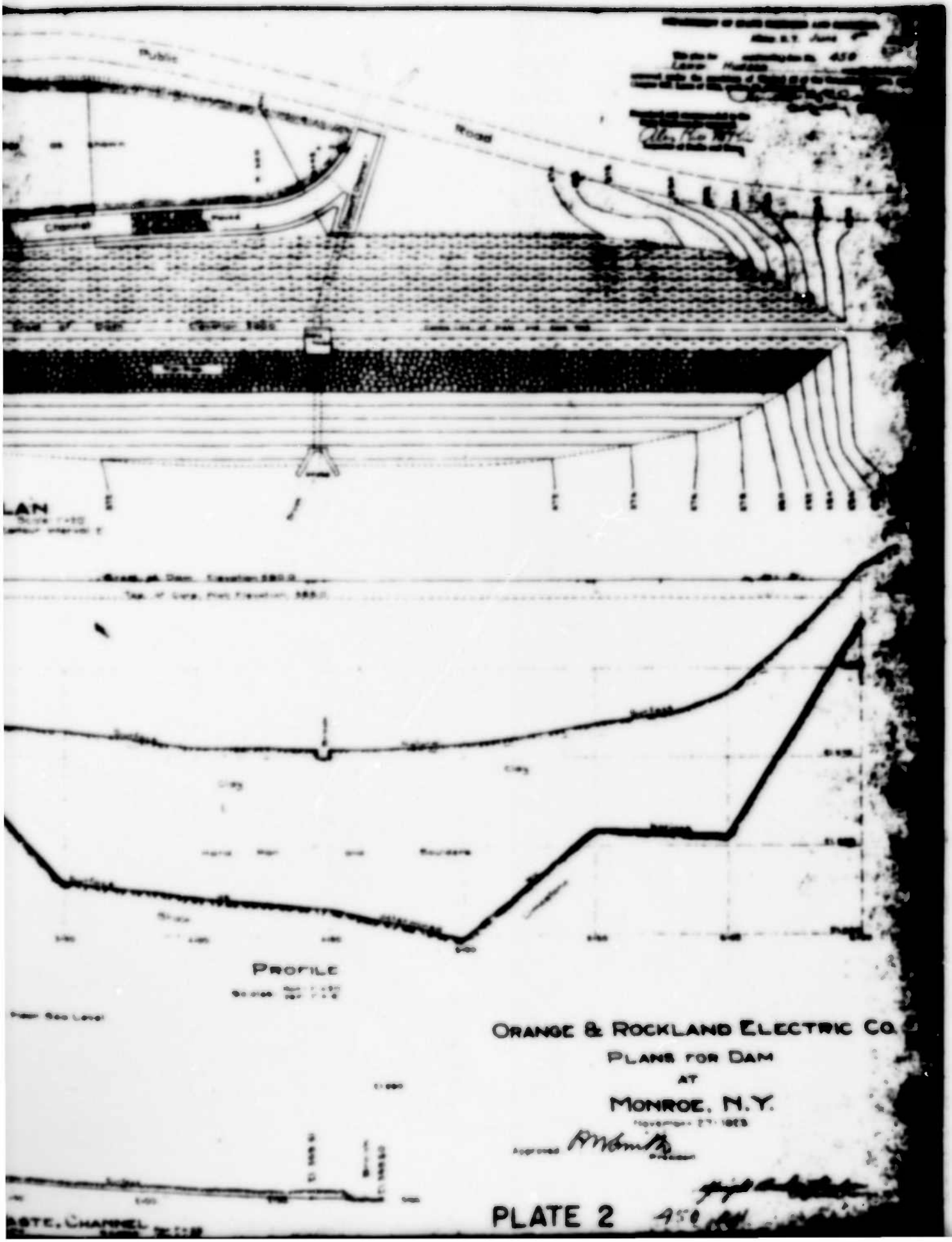


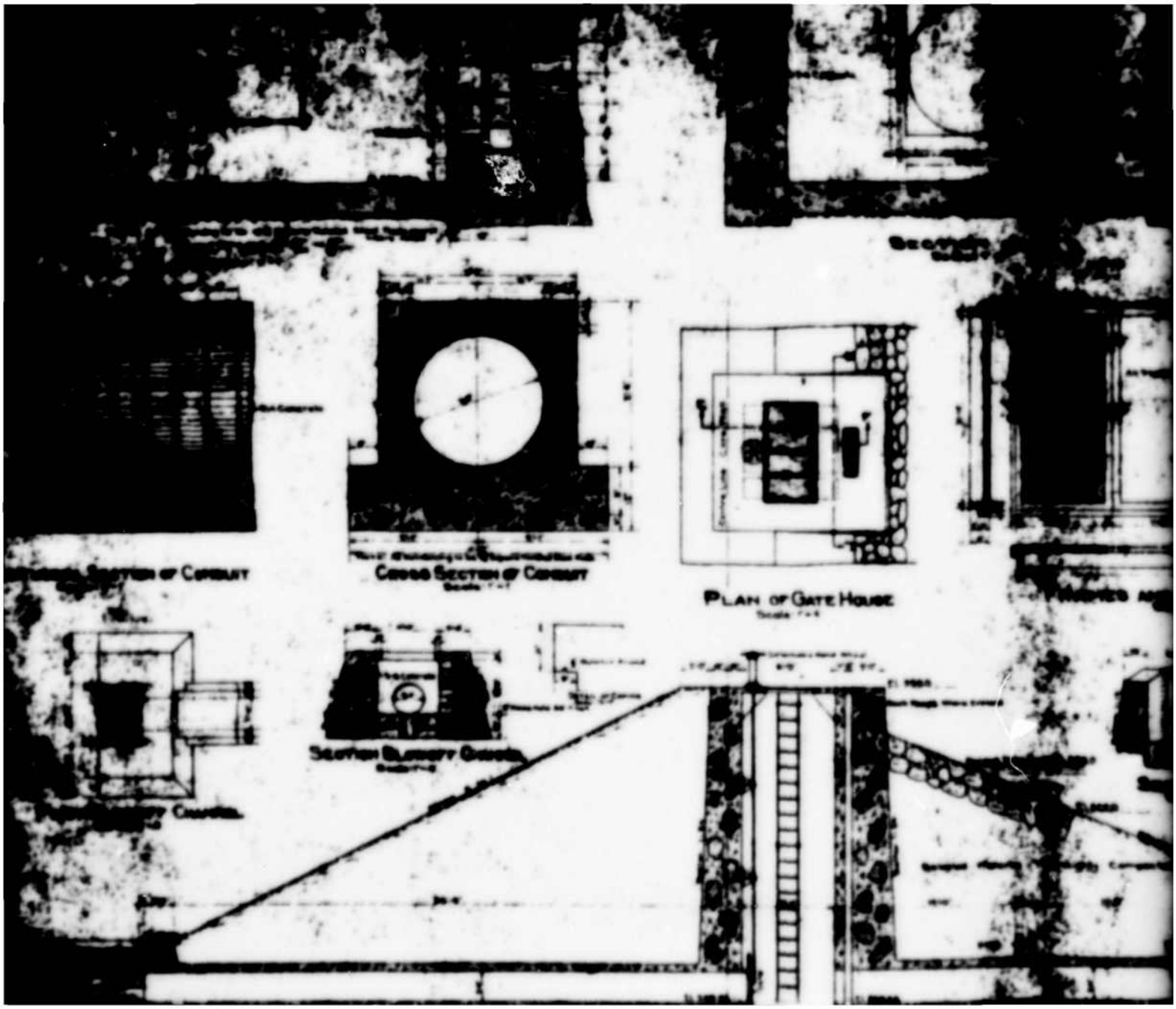
PLATE 1

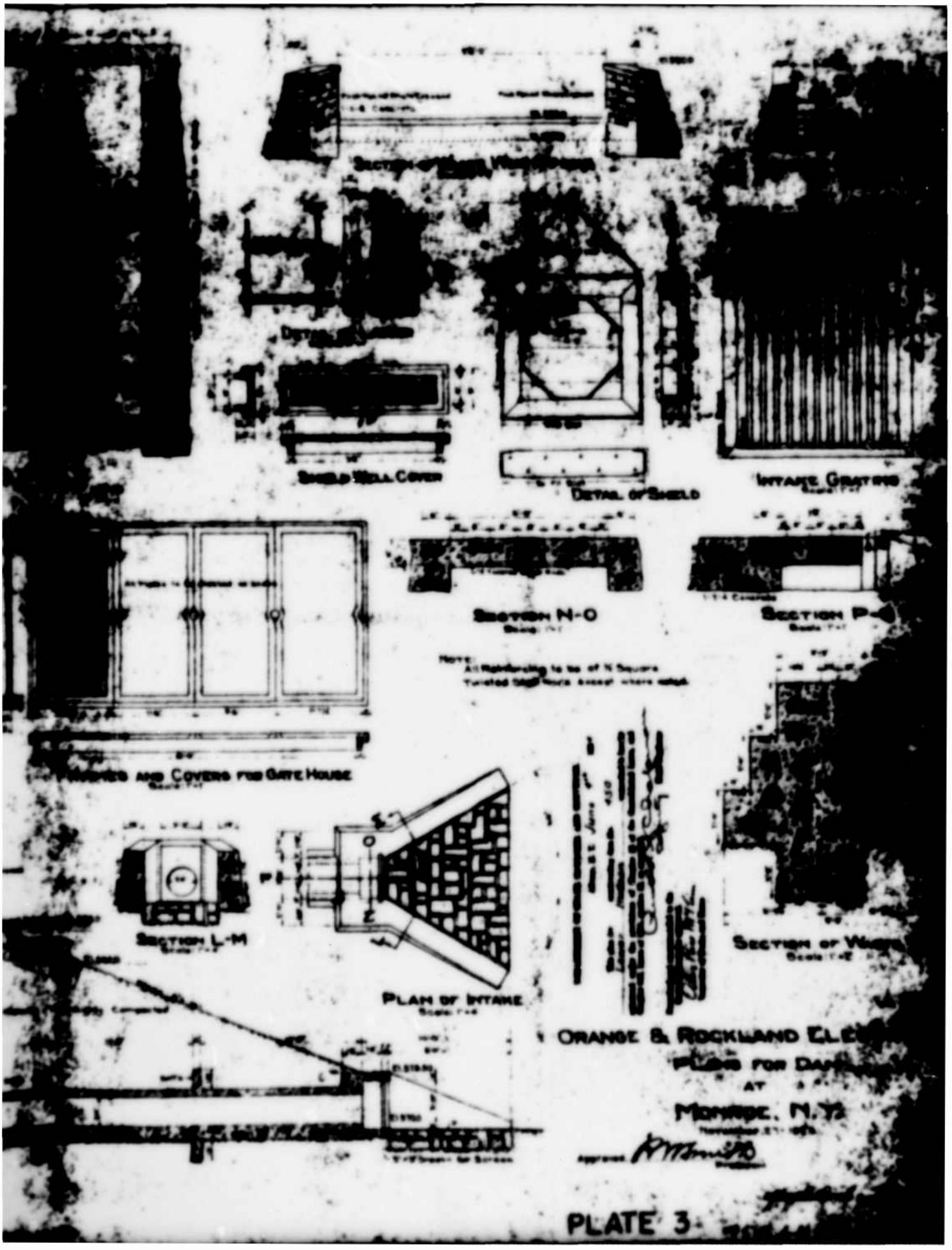
WILLOW BROOK DAM

FIELD SKETCH


PLAN
MAXIMUM SECTION


Public
Road
PROFILE
ORANGE & ROCKLAND ELECTRIC CO.
PLANS FOR DAM
AT
MONROE, N.Y.
PLATE 2


Cross Section of Conduit
Plan of Gate House


Shield Wall Cover
Detail of Shield
Intake Gratings
Section N-O
Section P-
Section L-M
Plan of Intake
Section of
Orange & Rockland Elec
at
Monroe, N.Y.
PLATE 3

APPENDIX F

BACKGROUND DOCUMENTS

DEC DAM INSPECTION REPORT

RB	CTY	YR. AP.	DAM NO.	INS. DATE	USE	TYPE
31	36	24	456	05 07 77	23	1

AS BUILT INSPECTION

1 Location of Spillway and outlet	1 Elevations
1 Size of Spillway and outlet	1 Geometry of Non-overflow section

GENERAL CONDITION OF NON-OVERFLOW SECTION 1

1 Settlement	1 Cracks	1 Deflections
1 Joints	2 Surface of Concrete	1 Leakage
1 Undermining	1 Settlement of Embankment	2 Crest of Dam
2 Downstream Slope Trees	2 Upstream Slope	2 Toe of Slope

Trees

GENERAL CONDITION OF SPILLWAY AND OUTLET WORKS 1

2 Auxiliary Spillway	2 Service or Concrete Spillway	2 Stilling Basin
2 Joints	2 Surface of Concrete	2 Spillway Toe
2 Mechanical Equipment	2 Plunge Pool	2 Drain

11 Maintenance	18 Hazard Class
3 Evaluation	15 Inspector

COMMENTS:

July 27, 1954

MEMORANDUM

RE: Telephone conversation with Peter Bush, Monroe Village Engineer regarding description of the underground caverns under the large Orange and Rockland lake.

When we were excavating for a foundation for the dam, we went down to a depth of over 50' before we found solid rock and near the bottom there were two streams of water running in the footing excavation.

Mr. Bush made numerous tests to determine if one cavern had any connection with the other cavern and tests proved that they were entirely separate. We planned and constructed separate outlets from those caverns so that the outlet from one cavern was piped across the highway and through a concrete box where a gate valve was placed, and the pipe continued to the spring, around which a wall was built at that same time.

The other cavern was securely sealed and a pipe and concrete masonry extended to the top of the dam so that a deep well pump could be connected to that source, which was tested at that time and found to be good for drinking purposes. The capacity of this cavern is 20 gallons per minute continuous flow.

R. W. Smith

March 25, 1933

Clarke and Rapuano
145 East 32nd Street
New York City, N. Y.

Attention: Mr. Charles Macdonald

Dear Mr. Macdonald:

Since my return from the south, I have noticed a raft out in the middle of our lake, with some canvas wind protectors around it and upon inquiry I am informed that your men are drilling a test hole in our lake, to ascertain underwater conditions and that the hole is down some sixty odd feet as of last week-end.

We are quite concerned with what you are doing because of conditions that exist of which we believe you are not aware and they are as follows:

Our lakes, as you may know, were built primarily for power plant purposes so it was necessary for us to purchase several farms in order to obtain possession of the valley where the lake is located. Our engineers, Knight, Dush & Thompson, drilled a number of test holes across the valley to ascertain the underground conditions before making their drawings for the construction of the dam, which was afterward built to impound the water of the stream going down through the valley.

In order to have a tight dam it was necessary for us to first remove the earth across the valley and then remove the limestone to a depth in the lowest places of more than 50' in order to reach the granite rock formation upon which to start the foundation of the dam.

Of course we knew that there was a large spring bubbling over with nearly 400 gallons of water per minute below the proposed site of the dam and when we had excavated to the hard rock, we found two streams of underground water, each of which had no relation to the stream passing through the meadow. One of these streams was sealed off tight and

connected with the stand pipe that goes up through the core of our dam. The measurement of that stream, together with the time it took to raise the water level in our stand pipe until it became stationary, indicated that there was an underground reservoir holding sufficient water for a small village.

The other stream of water could not be trapped into the lake and that stream is still running and coming to the surface in the above mentioned spring. This spring was temporarily dry when our pumps were operating to keep the excavation downtered and we thought it a good time to clean the muck out of the spring and build a well around it. This we did and we were surprised to find some mastodon bones, including some teeth, in the muck of the spring, which indicated that that animal went there for a drink of water thousands of years ago, became mired in the water and died.

We are telling you of this reservoir and spring because of the remote possibility that your drilling through the bed of our lake might provide a passage of water from our lake into the underground reservoir or into the spring below the lake, in which case we might lose the lake.

Yours very truly,

CHARLES R. MACDONALD ELECTRIC COMPANY

R. W. Smith,
President

RWS/bhz

cc: Mr. J. S. Bixby, District Engineer,
New York State Highway Dept.

STATE OF NEW YORK
DEPARTMENT OF STATE ENGINEER AND SURVEYOR
EASTERN DIVISION
JOURNAL BLDG.
ALBANY

Subject:

Dam No. 450, L.H.,
Monroe.

July 23, 1926.

Hon. Roy G. Finch,
State Engineer,
Albany, N. Y.

Dear Sir:-

On July 16, 1926, Mr. T. S. Bailey of this department made an inspection of the dam being built on Willow Brook, near Monroe. Mr. Bush, the engineer in charge, informed him that work had been resumed early in May and would be completed about November 1, 1926.

The excavation is practically 90% complete for the core wall. A small amount of excavation remains to be done in the core wall foundation near the west side of the valley, where the limestone is being removed down to the gneiss.

The backfill of the foundation trench is about 70% complete. 186 feet of core wall is completed to grade. Excavation for the spillway and waste channel is in progress. The blow-off conduit is being concreted. No embankment has been done. A section of the waste channel, about 30 feet long, below the blow-off conduit, has been lined, as shown on the plans.

Mr. Bailey reports that the dam is being constructed strictly in accordance with the approved plans, and the foundation is excavated in every case to satisfactory material.

Very truly yours,

E. Bushnell

Division Engineer.

KNIGHT, BUSH & THOMPSON

CIVIL ENGINEERS AND SURVEYORS

TELEPHONE 22 F 2 — MONROE, N. Y.

OFFICE STATE ENG.
SEP 29 1925
REFD TO Mr. Finch
ANSD

September 26th, 1925.

Dam 450, T. H.
Monroe.

Mr. Roy G. Finch,
State Engineer,
Albany, N. Y.
Dear Sir;-

Replying to your letter of the 21st inst., concerning the work done at Willow Brook dam, we have to state that prior to suspension of work in February, 1924, about three hundred feet of excavation for the corewall had been made and about one hundred feet of corewall, varying in height from twelve to twenty feet, had been placed. The depth of excavation in rock, from natural surface to foundation, varied from three to eighteen feet. No concrete was placed until solid rock, free from faults, fissures and seams, was reached.

The rock bottom is partly limestone and partly hard black shale.

When work was suspended the excavation flooded and remained so until about two weeks ago when pumps were put in operation to remove the water.

On the 21st inst, work was resumed and has consisted, principally, of removing the debris and material which sloughed in due to the flooding, and the continuation of excavating.

A short section of the bottom is about ready for the corewall and concreting will be resumed some time next week.

As to the various materials encountered in making the excavation, they are clearly shown by the boring sheet furnished your inspector, Mr. Kellog, when he visited the work on July 7th, last.

No cross-sections, to determine quantities, are taken as the work is being done directly by the Orange & Rockland Electric Co., the owner, hence we have no record, other than the boring sheet, of the depths and classifications of the various materials encountered. However, from our observations of the banks, we have found the boring sheet to be quite reliable as to classifications and depths.

We would ask that you kindly extend the time of the permit for construction from November 1st, 1925, the original date, to November 1st, 1926, as it will not be possible, with the plant and equipment being used, to complete the work this season.

Should you require further information concerning the work we will be glad to furnish it; also, we would be pleased to have your inspector visit the work soon.

Very truly yours,

Knight, Bush & Thompson

KNIGHT, BUSH & THOMPSON

CIVIL ENGINEERS AND SURVEYORS

TELEPHONE 88 F 3 MONROE N.Y.

OFFICE OF STATE ENGINEER
AUG -5 1925
REFD TO Mr. Kane
ANSD

August 4th, 1925.

Mr. Roy G. Finch,
State Engineer,
Albany, N. Y.
Dear Sir;-

Replying to your letter of July 28th, concerning grubbing at the dam site of the Willow Brook Dam, Dam No. 450, L. Hudson, we wish to report that the excavating is being done with a drag-line excavator and the width of the excavation is much greater than would be the case were it being done by vertical trenching. The tops of the slopes of the excavation fall very near the toe of the proposed embankment, i. e. not much of the embankment will fall outside of the limits of the excavation. However, we assure you, wherever grubbing and removal of top soil are necessary it shallbe done.

Concerning the materials encountered in making the exdavation, we furnished your inspector, Mr. Kellog, with a classification sheet showing the various materials and their depths; this sheet, we believe, furnishes the information requested.

Very truly yours,

Knight Bush Thompson

STATE OF NEW YORK

DEPARTMENT OF

State Engineer and Surveyor

ALBANY

Received Feb 2 - 1924 - June 4 1924 Dam No. 450 L Hudson Watershed

Disposition Approved June 4 - 1924 Serial No. 565

Site inspected

Foundation inspected

Structure inspected

Application for the Construction or Reconstruction of a Dam

Application is hereby made to the State Engineer, Albany, N. Y., in compliance with the provisions of Chapter LXV of the Consolidated Laws and Chapter 647, Laws of 1911, Section 22 as amended, for the approval of specifications and detailed plans, marked Orange & Rockland Electric Co., Plans for Dam at Monroe, N. Y.

herewith submitted for the {construction / reconstruction} of a dam located as stated below. All provisions of law will be complied with in the erection of the proposed dam.

1. The dam will be on Willow Brook branch of Moodna Creek in the town of Blooming Grove, County of Orange and 1 5/8 mile northwesterly from the Village of Monroe
(Give exact distance and direction from a well-known bridge, dam, village, main cross-roads or mouth of a stream)

2. The name and address of the owner is Orange & Rockland Electric Co., Monroe, N. Y.

3. The dam will be used for impounding water for cooling steam condensers

4. Will any part of the dam be built upon or its pond flood any State lands? No.

5. The watershed at the proposed dam draining into the pond to be formed thereby is 1.36 square miles.

6. The proposed dam will have a pond area at the spillcrest elevation of seventy-four acres and will impound 25,000,000 cubic feet of water.

7. The lowest part of the natural shore of the pond is twelve (12) feet vertically above the spillcrest and everywhere else the shore will be at least five feet above the spillcrest. at junct. embankment and natural shore

8. The maximum known flow of the stream at the dam site was ----- cubic feet per second on ----------
(Date)

9. State if any damage to life or to any buildings, roads or other property could be caused by any possible failure of the proposed dam. Damage to roads and bridges, slight damage to few buildings probable; damage to life improbable

10. The natural material of the bed on which the proposed dam will rest is (clay, sand, gravel, boulders, granite, shale, slate, limestone, etc.) Corewall on Gneiss, Shale and Limestone; embankment on clay and hardpan.

AD-A105 933 BAKER (MICHAEL) JR INC BEAVER PA F/G 13/13
NATIONAL DAM SAFETY PROGRAM. WILLOW BROOK DAM (INVENTORY NUMBER--ETC(U)
AUG 81 G KESTER DACW51-81-C-0010
UNCLASSIFIED NL

2 OF 2
AD A 105933

END
DATE FILMED
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clay and

11. The material of the right bank, in the direction with the current, is gravel ; at the spillcrest elevation this material has a top slope of 3 inches vertical to a foot horizontal on the center line of the dam, a vertical thickness at this elevation of 6 feet, and the top surface extends for a vertical height of 20 feet above the spillcrest.

12. The material of the left bank is hardpan ; has a top slope of 1 1/2 inches to a foot horizontal, a thickness of 5 feet, and a height of to top of mountain feet

13. State the character of the bed and the banks in respect to the hardness, perviousness, water bearing, effect of exposure to air and to water, uniformity, etc. The bed of the valley is a layer of soil about 1ft. deep, a layer of impervious blue clay about 10 ft. deep and a layer of clay, gravel and boulders about 8 ft. deep overlaying the rock which at the left bank is gneiss, middle shale and left bank limestone.

14. If the bed is in layers, are the layers horizontal or inclined? inclined . If inclined what is the direction of the slope relative to the center line of the dam and the inches vertical to a foot horizontal? The limestone at the right bank is inclined about 3":1' downward upstream

15. What is the thickness of the layers? From two to six feet.

16. Are there any porous seams or fissures? Yes, in the limestone.

17. WASTES. The spillway of the above proposed dam will be 25 feet long in the clear; the waters will be held at the right end by a corewall and bank the top of which will be 5 feet above the spillcrest, and have a top width of 6 feet; and at the left end by a corewall and bank the top of which will be 5 feet above the spillcrest, and have a top width of 6 feet.

18. There will be also for flood discharge a pipe 24 inches in diameter and the bottom will be 15.17 feet below the spillcrest, a sluice or gate 2 feet wide in the clear by 2 feet high, and the bottom will be 15.17 feet below the spillcrest.

19. APRON. Below the proposed dam there will be an apron ~~MADE~~ of natural ledge rock feet long, feet wide and feet thick. The downstream side of the apron will have a thickness of feet for a width of feet.

20. PLANS. Each application for a permit of a dam over 12 feet in height must be accompanied by a location map and complete working drawings of the proposed structure. Each drawing should have a title giving the parts shown, the name of the town and county in which the dam site is located, and the name of the owner and of the engineer.

The location map (U. S. Geological Quadrangle or other map) should show the exact location of the proposed dam; of buildings below the dam which might be damaged by any failure of the dam; of roads adjacent to or crossing the stream below the dam, giving the lowest elevation of the roadway above the stream bed and giving the shape, the height and the width of stream openings; and of any embankments or steep slopes that any flood could pass over. Also indicate the character and use made of the ground.

The complete working drawings should give all the dimensions necessary for the calculations of the stability of the structure, and all the information asked for below under "Sketches." There may be attached to the plans any written reports, calculations, investigations or opinions that may aid in showing the data and method used by the designer.

21. SKETCHES. For small and unimportant structures, if plans have not been made, on the back sheet of this application make a sketch to scale for each different cross-section at the highest point; showing the height and the depth from the surface of the foundation, the bottom width, the top width (for a concrete or masonry spill at 18 inches below the crest), the elevation of the top in reference to the spillcrest, the length of the section, and the material of which the section is to be constructed. Mark each section with a capital letter. Also sketch a plan; show the above sections by their top lines, giving the mark and the length of each; the openings by their horizontal dimensions; and the abutments by their top width and top lengths from the upstream face of the spillcrest and give the elevation of the top in reference to the spillcrest.

22. ELEVATIONS. Also give the elevations, if possible from the Mean Sea Level, of at least two permanent Bench Marks; of the spillcrest for any existing dam on the proposed dam site, at the middle and at both ends of the spill; and of the spillcrest for the above proposed dam.

23. SAMPLES. When so instructed, send samples of the materials to be used in the construction of the proposed dam, using shipping tags which will be furnished. For sand one-half a cubic foot is desired; for cement, three pints; and for the natural bed, twenty cubic inches.

24. INSPECTION. State how inspection is to be provided for during construction Construction to be done under supervision of Knight, Bush & Thompson, Engineers.

Note: The corewall is to be carried down to solid rock foundation and extend into the rock at each end.

MEMORANDUM FOR MR. A. R. McKIM, INSPECTOR OF DOCKS AND DAMS

I have examined the section submitted by Knight, Bush & Thompson for the spillway of the proposed dam to be built by the Orange & Rockland Electric Company at Willow Brook near Monroe, N.Y.

I have figured this section for stability and sliding under the following conditions:

Height of water 4 feet over crest.

No weight figured for water on crest.

Uplift of one quarter the total head at the upstream face of the dam, diminishing to zero at the downstream face.

No back pressure from water below dam.

Masonry 140 pounds per cubic foot.

Under these conditions I find the resultant pressure to be 3.2 feet from the downstream face. This is 0.45 feet inside the middle third. The coefficient of sliding is 0.477 under the same conditions.

H. E. Brainard

Assistant Engineer.

L. H. Nourse

April 24, 1924.

Dam at Monroe, N.Y.
Orange and Rockland Electric Co.

Sheet No 2.
Slab over gate house.

Assume concrete slab to be self supporting
Assume brackets to support load on chk. plates.

Let w = live load + dead load per square ft.

Slab. Span 6', effective d = 5", total d = 5"
reinforcement = 1/2" bars 5" cts = 0.60" per ft.

$M = \frac{wl^2}{8} = \frac{w \times 6.0 \times 12}{8} = 54w.$

$A_{steel} = \frac{M}{f_s j d}$, $w = \frac{0.60 \times 14000 \times \frac{7}{8}}{54} = 426^{\#}$ per sq ft —

assume wt of slab = 50#
Slab is good for 376# live load

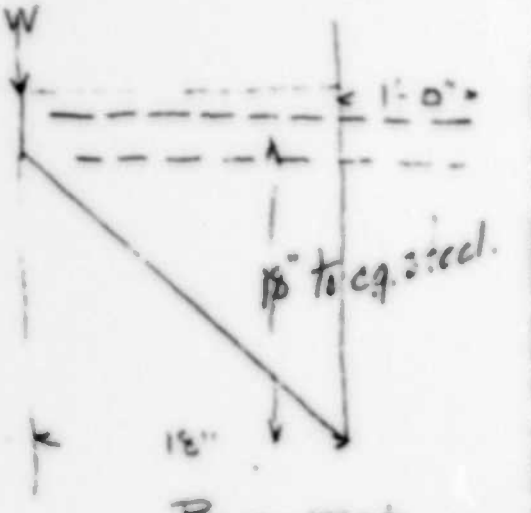
Brackets.

Area of chk. pl supported by each bracket = 2.25' × 1.5 = say 3.4 sq ft

$3.4w \times 1.5 = (4 \times 0.25 \times 16000) \times 1.5$
$w = 4700^{\#}$ per sq ft

Bond stress = 80#/sq in.

$3.4 \times 1.5 = 1.5 \times (4 \times 80 \times 12)$
$3.4w = 4320^{\#}$
$w = 1270^{\#}$ per sq ft (live and dead)



Bracket.

Benedict, June, 1924.

Dam at Monroe. N.Y.
Orange and Rockland Elec. Co.

Sheet 2. Section of conduit.
Water Surface Max. El. 589 } Max head 20'
Invert of culvert El. 569.66 Emp El. 52.9 }

Intensity of pressure due to 20 head. 1250# per square ft.

total pres. tending to cause rupture of side walls.

$\frac{1250^{\#} \times d}{2}$. $\frac{1250 \times 2.17}{2}$ = 1360# per lin ft of pipe.

Resistance to rupture. 2-⅞ bars = $2 \times 0.14^{\square} \cdot 16000^{\#} = 4490^{\#}$
Side bars as shown are amply strong.

Culvert empty. Earth pressure El. 590 - El 572 = 18' (est) = 1350#/sq'
Assume beam, d. 4½", sp. in. 2'

Area steel required. $\frac{1360 \times 2 \times 12^3}{\frac{7}{8} \times 14000 \times 4.5} = \frac{106}{630} = 0.172^{\square"}$

on acct arch action of culvert, bars are O.K.

Benedict. June 1924.

KNIGHT, BUSH & THOMPSON

CIVIL ENGINEERS AND SURVEYORS

TELEPHONE 28 F 2 MONROE, N. Y.

April 21st, 1924.

Mr. Arnold G. Chapman,
Deputy State Engineer,
Albany, N. Y.

Dam No. 450 Lower Hudson,
Monroe.

Dear Sir:-

We are sending you herewith a sketch showing a revised section for the waste weir or spillway of the Willow Brook Dam, proposed to be built by the Orange & Rockland Electric Co., near Monroe, N. Y.

This section is designed to meet the requirements set forth in your letters of February 7th and March 4th, 1924; i. e., maximum crest or overflow 4 feet; uplift pressure at upstream edge equal to one-quarter of the maximum head (4/10) and diminishing uniformly to zero at the downstream edge; no downthrust due to weight of water on crest of weir; no back pressure on downstream face and weight of masonry assumed to be 140 pounds per cubic foot. The area of the section shown on the accompanying sketch does not include the foundation bond key, nor has any deduction been made for the rounding of the corners of the steps on the downstream side.

Should this section meet with your approval, we would ask that you please return the plans submitted so that we may correct them to agree with this revision.

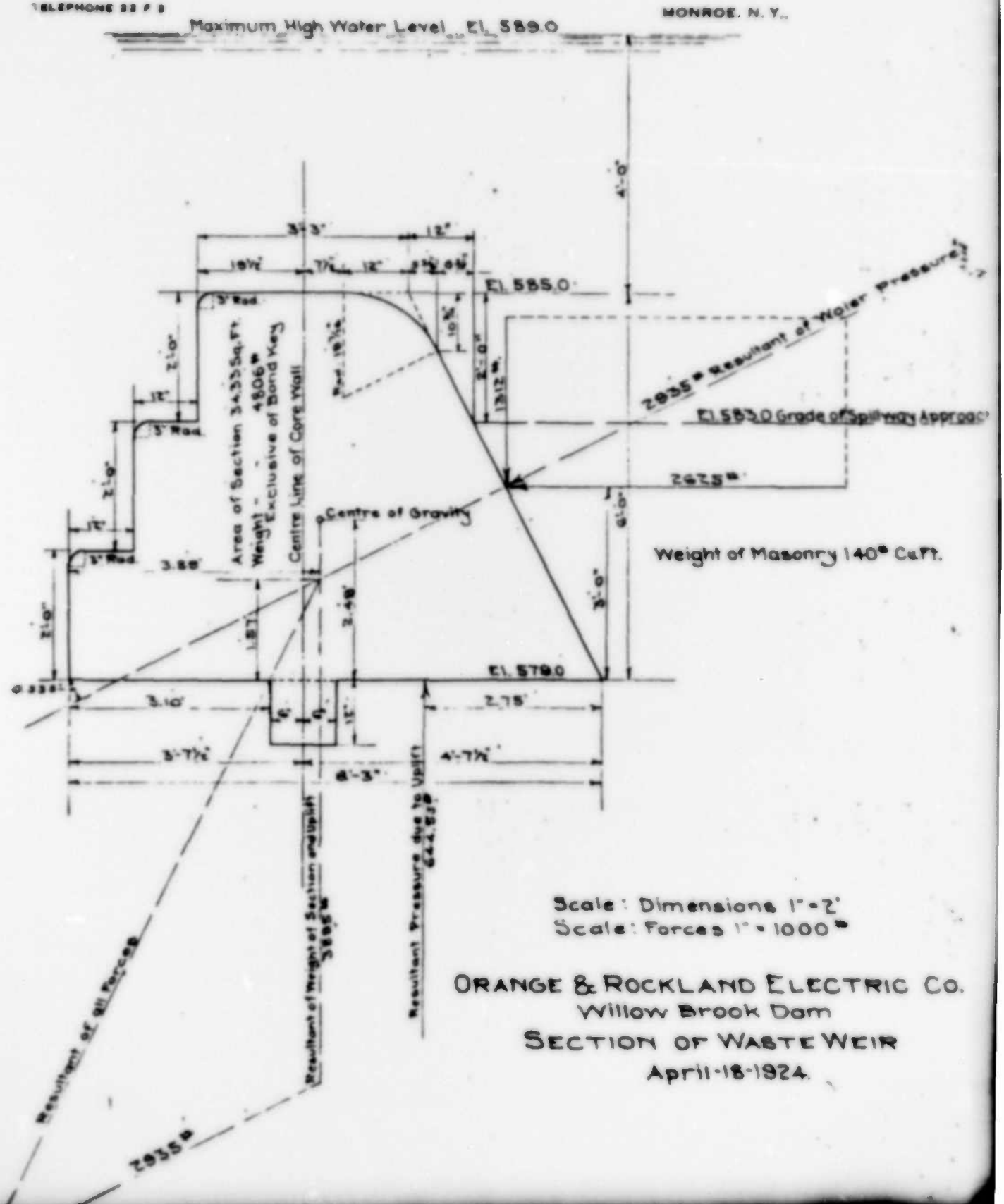
Very truly yours,

Knight, Bush & Thompson

KNIGHT, BUSH & THOMPSON

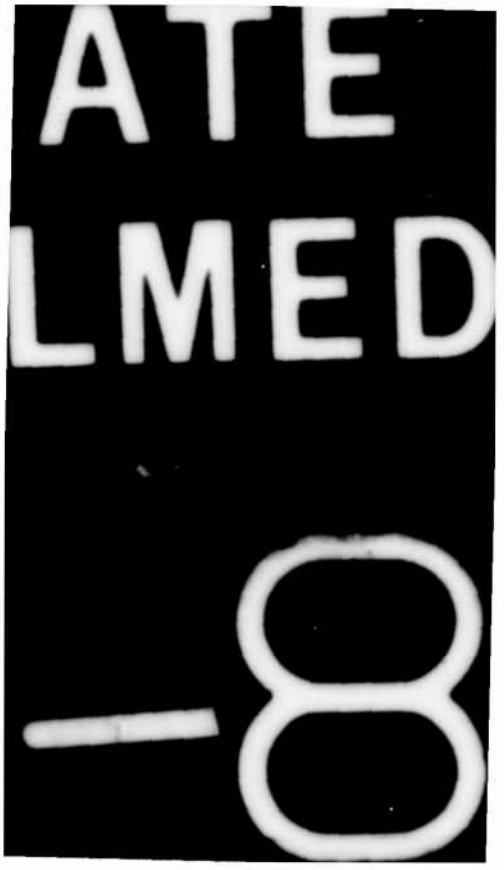
CIVIL ENGINEERS AND SURVEYORS

TELEPHONE 33 F 3 — MONROE, N. Y.



Scale: Dimensions 1" = 2'
Scale: Forces 1" = 1000#

ORANGE & ROCKLAND ELECTRIC CO.
Willow Brook Dam
SECTION OF WASTE WEIR
April-18-1924.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