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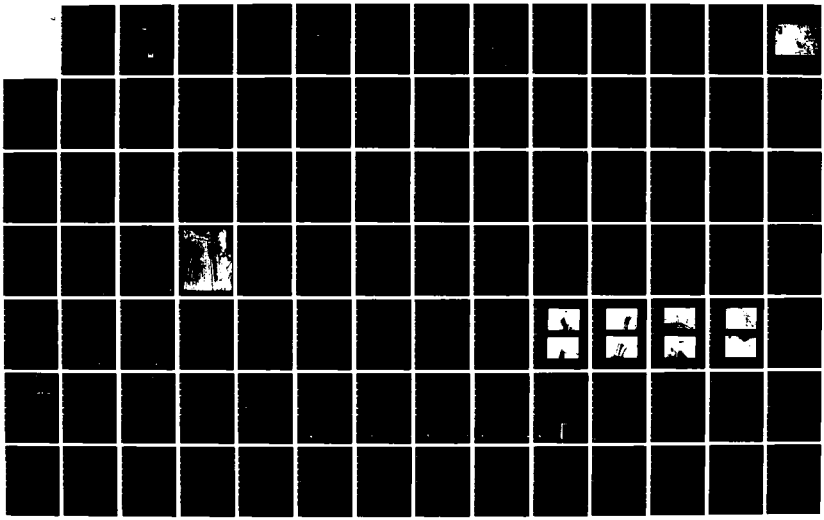

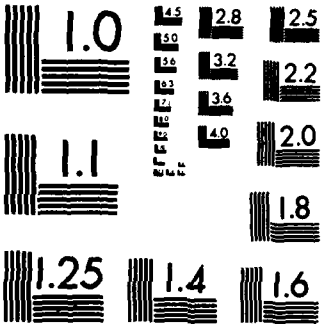

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SOUTHWESTERN COASTAL BASIN

GREENWICH, CONNECTICUT

PEMBERWICK DAM
CT 00042

PHASE 1 INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

FEBRUARY, 1980

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

DAMS, INSPECTION, DAM SAFETY,

Southwestern Coastal Basin
Greenwich, Conn.
Pemberwick Dam

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

This dam is masonry arch approx. 115 ft. long, 45 ft. high with an average top of dam width of 8 ft. The dam was built about 1867 and presently serves no function except an aesthetic one. The test flood for this dam is the Probable Maximum Flood. The test flood has an outflow discharge equal to 25,6000 cfs and will overtop the dam by 17.0 ft. in stillwater condition. The maximum outflow capacity of the spillway under a stillwater condition is 1,100 cfs, which is 4 percent of the test flood.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF
NEDED

MAR 21 1980

Honorable Ella T. Grasso
Governor of the State of Connecticut
State Capitol
Hartford, Connecticut 06115

Dear Governor Grasso:

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

A copy of this report has been forwarded to the Department of Environmental Protection, the cooperating agency for the State of Connecticut. In addition, a copy of the report has also been furnished the owner, Fairfield Associates, Inc., Greenwich, Connecticut.

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

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

Sincerely,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

SOUTHWESTERN COASTAL BASIN

GREENWICH, CONNECTICUT

PEMBERWICK DAM

CT 00042

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PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE I - INSPECTION REPORT

Identification No.:	CT 00042
Name of Dam:	Pemberwick Dam
Town:	Greenwich
County and State:	Fairfield, Connecticut
Stream:	Byram River
Date of Inspection:	November 12, 1979

BRIEF ASSESSMENT

This dam is a masonry arch approximately 115 feet long, 45 feet high with an average top of dam width of 8 feet. The dam was built about 1867 and presently serves no function except an aesthetic one.

Based on the visual inspection and past operational performance, the dam is judged to be in FAIR condition. Seepage was noted on the downstream face. The emergency outlet works are inoperable and there is no method of lowering the water level.

This dam is classified as INTERMEDIATE in size and a HIGH hazard potential structure in accordance with recommended guidelines established by the Corps of Engineers.

The test flood for this dam is the Probable Maximum Flood (PMF). The test flood has an outflow discharge equal to 25,600 cfs and will overtop the dam by 17.0 feet in a stillwater condition. The maximum outflow capacity of the spillway under a stillwater condition is 1,100 cfs, which is 4 percent of the test flood.

It is recommended that the following items be studied further: The downstream leakage, the toe and the upstream face, and the spillway capacity.

Recommendations and remedial measures that should be implemented by the Owner within one year period after receipt of this Phase I Inspection Report, are further described in Section 7.

JAMES P. PURCELL ASSOCIATES, INC.

Sudhir A. Shah

Sudhir A. Shah, P.E.
Vice-President
Connecticut P.E. No. 8012

STATE OF CONNECTICUT
SUDHIR A. SHAH
No. 8012
REGISTERED
PROFESSIONAL ENGINEER

This Phase I Inspection Report on Pemberwick Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Richard J. DiBuono

RICHARD DIBUONO, MEMBER
Water Control Branch
Engineering Division

Aramast Mahtesian

ARAMAST MAHTESIAN, CHAIRMAN
Foundation & Materials Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

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

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

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

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

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

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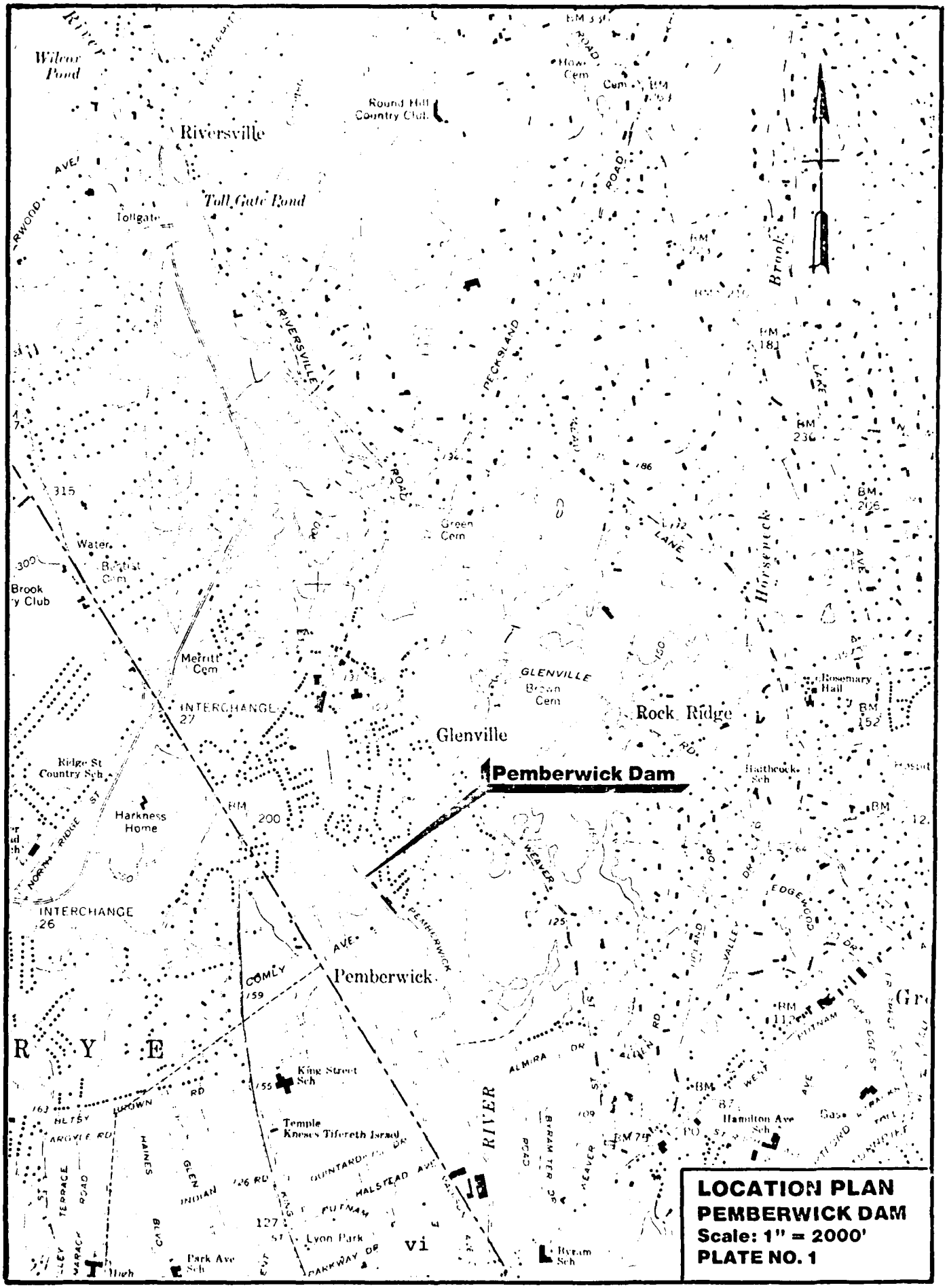
OVERVIEW PHOTO - PEMBERWICK DAM



LOCATION PLAN
PEMBERWICK DAM
Scale: 1" = 2000'
PLATE NO. 1

NATIONAL DAM INSPECTION PROGRAM

PHASE I - INSPECTION REPORT

NAME OF DAM: PEMBERWICK DAM

SECTION 1

PROJECT INFORMATION

1.1 General

a. **Authority:** Public Law 92-367, August 8, 1972, authorized the Secretary of the Army through the Corps of Engineers to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. James P. Purcell Associates, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Connecticut. Authorization and notice to proceed was issued to James P. Purcell Associates, Inc., under a letter from William E. Hodgson, Jr., Colonel, Corps of Engineers. Contract No. DACW33-80-C-0002 has been assigned by the Corps of Engineers for this work.

b. **Purpose of Inspection**

1. Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

2. Encourage and prepare the States to initiate quickly, effective dam safety programs for non-Federal dams.

3. To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. **Location:** Pemberwick Dam is located in Fairfield County, Connecticut, approximately 0.4 miles north of the village of Pemberwick on the Connecticut - New York state line (See Plate No. 1). The dam impounds water from the Byram River and is located approximately 3.5 miles upstream of Long Island Sound. The impoundment is situated in a north-south direction, with the dam

located at the southern end. The latitude is 41° -01'-42" and the longitude is 73° -39'-48".

b. **Description of Dam and Appurtenances:** The Pemberwick Dam is an arch dam, built between ledge rock abutments, creating an impoundment in the narrow gorge with nearly vertical sides. The downstream face is nearly vertical with a plan radius of 180+/- feet and is constructed of coursed ashlar masonry. The date of construction of the dam is approximately 1867.

A 63 foot long spillway is located in the center of the dam.

The outlet works, consisting of pipes through the dam, have been inoperable for many years. The high level outlet was sealed in 1978 to control leakage and the inlet for the low level outlet is suspected to be below the present sediment level.

c. **Size Classification:** The dam is classified as an INTERMEDIATE structure as per the criteria set forth in the Recommended Guidelines for the Safety Inspection of Dams by the Corps of Engineers. The impoundment storage at the top of the dam is 60 ac.-ft. (within the "small" category range of 50 to 1000 acre-feet) and the maximum height of the dam is 45 feet (within the "intermediate" category range of 40 to 100 feet). The size classification is governed by the height criteria.

d. **Hazard Classification:** The dam is classified as a HIGH hazard potential structure as per the criteria set forth in the Recommended Guidelines for the Safety Inspection of Dams by the Corps of Engineers. It is located just upstream of a residential development, a day school, and an industrial facility where failure discharge may cause the loss of more than a few lives and excessive damage due to high velocity impact from debris and flooding. The estimated water depth will inundate the school by approximately 10 feet and cause flooding of structures along the banks in the village of Pemberwick of approximately 3 to 5 feet.

The failure of an upstream dam (the American Felt Dam), located approximately 3000 feet upstream, might have a potentially hazardous effect on the Pemberwick Dam.

e. **Ownership:** The Pemberwick Dam is presently owned by Fairfield Associates, Inc., 100 Putnam Street, Greenwich, Connecticut 06830. The property was acquired in 1979 from the GAF Corporation, Wayne, New Jersey, as a development investment. Subsequent to the development of the property, the owners will be a condominium association.

f. **Operator:** The operator and caretaker for Pemberwick Dam is:

John Koslowski, Maintenance Superintendent
Fairfield Associates, Inc.
6 Glenville Street
Greenwich, CT 06830
Tel: (203) 531-1822 (mill)
531-9093 (home)

g. **Purpose of Dam:** The Pemberwick Dam impounds water from the Byram River. The original purpose of this dam is unknown, and its purpose now is only aesthetic.

h. **Design and Construction History:** The Pemberwick Dam was constructed after the Civil War in 1867. Reportedly, the dam failed in a flood of 1877 and was rebuilt shortly thereafter. No information on the extent of the damage or rebuilding is available. This dam was probably never used for power generation. No construction plans are known to be in existence.

i. **Normal Operating Procedures:** The dam, as it is presently used, requires no attention for normal operating procedures.

1.3 Pertinent Data

a. **Drainage Area:** The Pemberwick Dam is located in Fairfield County, Connecticut. The drainage basin lies 0.4 miles north of the village of Pemberwick. The basin is generally rectangular in shape having a length of 11.8 miles and an average width of 2.2 miles. The total drainage area to the dam is 26.2 square miles (see drainage basin map in Appendix D). The topography is generally rolling to moderate terrain, with elevations ranging from a high of 740 feet to 76.5 feet at the spillway crest. Stream and basin slopes are flat to moderate having average grades of 0.9 percent to 1.2 percent, respectively. The pond has a normal surface area of 5.5 acres, which is 0.03 percent of the watershed.

All elevations used in this report are based on the National Geodetic Vertical Datum (NGVD). Elevations are based on a spillway crest elevation of 76.5 feet estimated from available mapping.

b. **Discharge at Dam Site:** Discharge records are limited to estimated flows for the 1938 and 1955 storms (refer to Section 5.3 - Experience Data). Listed below are calculated discharge values for the spillway:

1. Outlet works: N/A (inoperable)

2. Maximum known flood at dam site: Estimated by unknown source to have been 3200 cfs in October 1955.

3. Spillway capacity at top of dam: 1100 cfs at elevation 80.0.

4. Spillway capacity at test flood: 15800 cfs at elevation 97.0.

5. Gated outlet capacity at normal pool elevation: N/A

6. Gated outlet capacity at test flood elevation: N/A

7. Gated outlet capacity at top of dam elevation: N/A

8. Total project discharge at top of dam: 1100 cfs at elevation 80.0.

9. Total project discharge at test flood elevation: 15800 cfs at elevation 97.0.

c. **Elevation** (Feet above NGVD)

1.	Streambed at toe of dam	35.0
2.	Bottom of cutoff	Unknown
3.	Maximum tailwater	Unknown
4.	Recreation pool	N/A
5.	Full flood control pool	N/A
6.	Spillway crest	76.5
7.	Design surcharge (original design)	Unknown
8.	Top of dam	80.0
9.	Test flood level	97.0

d. **Reservoir** (Length in Feet)

1.	Normal pool	1500

2.	Flood control pool	N/A
3.	Spillway crest pool	1500
4.	Top of dam	3000
5.	Test flood pool	3000

3. **Storage** (Acre-Feet)

1.	Normal pool	41
2.	Flood control pool	N/A
3.	Spillway crest pool	41
4.	Top of dam	60
5.	Test flood pool	223

f. **Reservoir Surface** (Acres)

1.	Normal pool	5.5
2.	Flood control pool	N/A
3.	Spillway crest	5.5
4.	Top of dam	7.0
5.	Test flood pool	11.0

g. **Dam**

1.	Type	Stone masonry arch dam
2.	Length	115 ft.
3.	Height	45 ft.
4.	Top width	8 ft.

5.	Side slopes	Upstream: Vertical above spillway Downstream: 1H:10V
6.	Zoning	Unknown
7.	Impervious core	Unknown
8.	Cutoff	Unknown
9.	Grout curtain	Unknown
h.	**Diversion and Regulating Tunnel**	N/A
i.	**Spillway**	
1.	Type	Overflow broad crested, uncontrolled weir
2.	Length of weir	63 ft.
3.	Crest elevation	76.5
4.	Gates	None
5.	U/S Channel	Natural bed
6.	D/S Channel	Natural bed, floodwall on east bank.
j.	**Regulating Outlets** (inoperable)	
1.	Invert	N/A
2.	Size	N/A
3.	Description	N/A
4.	Control mechanism	N/A

SECTION 2

ENGINEERING DATA

2.1 Design

There are no available records presenting design information for the construction of the Pemberwick Dam. A plan made during a previous inspection in 1938 is included in Appendix B of this report.

2.2 Construction

There are no available records of the construction of the dam and it appears that the above referenced drawing illustrates the "as built" condition. The high level outlet was plugged in 1978.

2.3 Operation

No formal records of operation are kept for this facility. The dam is inspected weekly by personnel from Greenwich Associates, Inc., developers of the surrounding property inclusive of the Pemberwick Dam. The dam has only an aesthetic use at this time.

2.4 Evaluation

a. **Availability:** The information noted above for this facility is available in the files of the Department of Environmental Protection, Water and Related Resources Unit, Dam Safety Engineers, State Office Building, Hartford, Connecticut, and Greenwich Associates, Inc., Greenwich, Connecticut.

b. **Adequacy:** The lack of indepth engineering data did not allow a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on the visual inspection, the dam's past performance, and sound engineering judgment.

c. **Validity:** The validity of the limited information available must be verified.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. **General:** The visual inspection of the Pemberwick Dam was conducted on November 12, 1979 and a copy of the visual inspection check list is contained in Appendix A of this report.

The following procedure was used:

1. Inspection of the upstream reach of the river which was impounded by the dam.

2. Visual inspection of the face and the top of the dam and spillway for cracks, loose stones, leakage, etc.

3. Inspection of the outlet works and other appurtenances as to their existence, location and operability.

4. Review of procedures that could be utilized in the event of an emergency situation.

5. A check of the downstream area for seepage, piping, boils or other indications of abnormal conditions. The downstream hazard potential in the event of dam failure was investigated.

6. Photographs of the general area of the dam and of specific items of note were taken and are included in Appendix C of this report.

Before the inspection, the available existing data and aerial photographs were studied and reviewed.

b. **Dam**

1. **Crest:** The top of the dam is constructed of granite capstones with no evidence of settlement or misalignment (Photo C-1). Grass is growing between some of the stones. The dam's east crest supports the gear lift mechanisms for the outlet works, and a metal pipe railing around the perimeter, which appears in good condition (Photo C-5). The western top of the dam was not accessible, but appears to be in a similar condition. The top of the dam has a width of approximately 8 feet.

2. **Upstream Face:** The upstream face of the dam is stone masonry with a vertical face above the water level at the time of the inspection, which was approximately 31 inches below the top of the dam. Grass was growing in the joints between some of the stones.

3. **Downstream Face:** The downstream face is also stone masonry with a nearly vertical face. See Appendix B for a typical cross section through the dam. Grass and small shrubs were growing in joints between some of the stone blocks. Leakage was noted from several masonry joints at and adjacent to both ends of the spillway (Photos C-3, C-4). The dam appears to be founded on bedrock.

c. **Appurtenant Structures**

1. **Spillway:** The spillway is a 63 foot long and 8 foot wide broad crested weir with a free drop of approximately 33 feet to the tailwater (Photo C-6). It is constructed of capstones which overhang the downstream face of the dam by approximately 6 inches. Water was flowing over the spillway at the time of inspection, and leakage was noted between the stone comprising the vertical ends of the spillway and the masonry dam embankment. Two logs, each approximately 15 inches in diameter and 30 feet long, were resting on the spillway crest at the time of inspection (Photo C-2). It is probable that they will wash over the crest during the next high discharge, possibly creating an impact or blockage hazard downstream.

2. **Low Level Outlet:** The information provided by the representatives of the owner, and record photographs, indicate the presence of a low level outlet located approximately in the center of the dam. The slanted gear lift mechanism on the dam's east crest apparently regulated flow through this outlet, which is suspected to lead through the dam. The present level of silt and sediment on the upstream side of the dam, and the owner, indicate that the intake is covered and, therefore, inoperable.

3. **High Level Outlet:** The high level outlet is located on the east side of the dam and was controlled by a valve attached to the vertical gear mechanism. The threaded bar for the mechanism has been sheared, rednering the valve inoperable (reportedly in the open position). The horizontal outlet pipe from the downstream face of the dam to the vertical shaft in the center of the dam was filled with concrete in 1978 by the S. E. Minor Company.

d. **Reservoir Area:** The impoundment created by the dam is a narrow flooded portion of the natural river bed. The valley walls are fairly steep at the dam and

become less steep 1500 to 2000 feet upstream. Bedrock appears to be at or near the surface. No geologic features were detected that could be expected to adversely affect the dam.

Trespassing on the dam is prohibited and the dam site is fenced and locked on the east side and fenced on the west side, reducing the potential for trespassing and vandalism. The fence on the west side has collapsed on the upstream end (Photo C-2), but protection against access to the site is still afforded.

e. **Downstream Channel:** Immediately downstream of the dam is a continuation of the steep valley walls on the west side, and a building (Mead School) and flood wall on the east side (Photo C-7). Numerous trees are overhanging the channel in this section. Further downstream, the channel is lined with riprap and is a fairly straight uniform trapezoidal channel (Photo C-8).

3.2 Evaluation

Based on the visual inspection, the Pemberwick Dam appears to be in fair condition overall, and there were no major areas of distress noted. Specific items of concern that were noted are:

The inability to draw down the pond level due to the inoperability of the outlet works.

The presence of leakage on the downstream face and the vegetative growth on the faces of the dam.

The structural integrity cannot be evaluated due to the unknown conditions within and below the dam.

SECTION 4

OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

There are presently no operational procedures for the Pemberwick Dam. It has only an aesthetic purpose at this time.

4.2 Maintenance of the Dam

There is no regular maintenance schedule for this dam. The downstream channel is lined with riprap for erosion protection and is free of vegetation growth. Upstream of the dam, the tree-lined channel has natural steeply sloping rock walls not requiring any maintenance.

4.3 Maintenance of the Operating Facilities

No maintenance of the outlet works is presently performed. The high level outlet was plugged in 1978 and the low level outlet is apparently covered with sediment and is inoperable.

4.4 Description of Any Warning System in Effect

No formal emergency or contingency plan is in effect to reduce or minimize downstream damage in emergency situations.

4.5 Evaluation

To insure the safety of the residents and industries immediately downstream, a regular inspection and maintenance program should be developed and implemented.

SECTION 5

EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General

The Pemberwick Dam, built across the Byram River, creates a narrow impoundment with a total storage capacity of 41 ac.-ft. at the spillway elevation of 76.5 or 0.03 percent of the watershed area of 26.2 square miles. Each foot of depth in the pond above the spillway crest can accommodate approximately 5.5 ac.-ft. The spillway is a 63 foot long by 8 foot wide broad crested uncontrolled weir. Stream and basin slopes are flat to moderate having average grades of 0.9 percent and 1.2 percent, respectively.

5.2 Design Data

a. Flood calculations were done by the State of Connecticut in November, 1955 and yielded a 100-year frequency flood of 3390 cfs for the Pemberwick Dam site.

   To supplement this data, U.S.G.S. topographic maps (scale 1"=2000') were utilized to develop hydrologic parameters such as drainage areas, reservoir surface areas, basin length, time of concentration and other runoff characteristics. Elevation-storage relationships for the reservoir were approximated. Surcharge storage was computed using U.S.G.S. maps. Some of the pertinent hydraulic design data was obtained and/or confirmed by actual field measurements at the time of the visual field inspection.

b. Outflow values (routing procedures) and dam overtopping analyses were computed in accordance with the guidelines developed by the Corps of Engineers. Judgment was used in calculating final values outlined in this report, which are quite approximate and should not be considered a substitute for actual detailed analysis.

5.3 Experience Data

Historical data for recorded discharges at the dam site is limited to the following approximations derived in 1955 from an unknown source:

July and September 1938 - 2400 cfs
October 1955 - 3200 cfs

From the spillway capacity and dam overtopping analysis calculations, both of these floods overtopped the dam by at least 2 feet.

5.4 Test Flood Analysis

Recommended Guidelines for the Safety Inspection of Dams by the Corps of Engineers were used for the selection of the "Test Flood". This dam is classified as a HIGH hazard and an INTERMEDIATE size structure. Guidelines indicate that the Probable Maximum Flood (PMF) be used as the test flood for these classifications. The watershed has a total area of 26.2 square miles. Snyder's lag was calculated to be 7.31 hours and a Snyder peaking coefficient of 0.625 was used. The 200 square miles - 24 hour Probable Maximum Precipitation (PMP) is 22 inches. The flood hydrograph package, HEC-1 computer program, developed by the Corps of Engineers was utilized to develop the inflow hydrograph, route the flood through the reservoir, and for the dam overtopping analysis. A test flood inflow equal to the PMF was calculated to be 25600 cfs. The inflow of 1/2 PMF is 12800 cfs.

The spillway capacity is hydraulically inadequate to pass the test flood (PMF) and overtopping of the dam will occur. The maximum outflow capacity of the spillway without overtopping the dam is 1100 cfs. This corresponds to 4 percent of the test flood and a storage above the spillway level of 19 ac.-ft. The maximum outflow discharge value for the test flood is 25600 cfs corresponding to a depth of flow over the top of the dam of 17.0 feet and a storage above the spillway level of 182 ac.-ft. The outflow value for 1/2 PMF is 12800 cfs. A spillway rating curve and a reservoir surface area - capacity curve are included in Appendix D of this report.

There are no operating outlet works and all flow must be discharged over the spillway or top of the dam. Storage for impending flood conditions cannot be provided if the pool level is high.

5.5 Dam Failure Analysis

This dam is classified as a high hazard structure. Failure discharge can cause damage due to high velocities, impact from debris, and flooding to over 5 residential homes, a school and a commercial building. The calculated dam failure discharge is 8350 cfs at a pool level equal to the top of the dam. At this level, the prefailure flow in the downstream channel will be 1100 cfs corresponding to a depth of flow of approximately 5 feet. Failure will produce a water surface level of approximately 11.5 feet immediately downstream from the dam. The failure discharge will affect downstream areas for a distance of 3000 feet from the dam. At this distance the water surface level will be approximately 1 to 2 feet above normal observations. Beyond 3000 feet, the effects of the failure discharge will be reduced as it enters an unnamed pond. Water surface elevations due to the failure of the dam are listed in Appendix D. Probable consequences including the prime impact areas, are also listed in Appendix D.

SECTION 6

EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observation

The visual inspection revealed no signs of major physical distress in the structure. However, leakage was noted on the downstream face.

6.2 Design and Construction Data

There is insufficient design and construction data to permit a formal evaluation of stability.

6.3 Post-Construction Changes

No post-construction design data pertinent to the embankment or foundation is available. It is believed that the original dam failed in October 1877 and the present dam rebuilt shortly thereafter. The extent of the damage due to the failure or information concerning the rebuilding is unavailable.

The high level outlet was sealed in 1978. The low level outlet is suspected to be below the present sediment level.

6.4 Seismic Stability

The dam is in Seismic Zone 1 and, hence, does not require evaluation for seismic stability according to the Corps of Engineers Recommended Guidelines.

SECTION 7

ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. **Condition:** Based on the visual inspection, past performance and hydraulic/hydrologic evaluation, the Pemberwick Dam and appurtenances are judged to be generally in FAIR condition. Items of concern that should be addressed as a result of this inspection are listed in Sections 7.2 and 7.3.

b. **Adequacy of Information:** The absence of existing engineering data did not allow for definitive review. Therefore, the adequacy of the dam is based on visual inspection, past performance history, and engineering judgment.

c. **Urgency:** The recommendations and remedial measures described below should be implemented by the owner within one year after receipt of this Phase I Inspection Report.

7.2 Recommendations

It is recommended that the owner engage a qualified registered engineer to carry out the following actions:

a. A detailed hydraulic-hydrologic investigation to determine the need and means of increasing the discharge capacity of the project.

b. The pond be lowered and the upstream face be visually inspected, and the toe checked for potential undermining.

7.3 Remedial Measures

a. **Operational and Maintenance Procedures**

1. The vegetation should be removed from the joints and the joints re-pointed on the faces and top of the dam.

2. The two logs should be removed from the spillway crest as soon as possible.

3. The trees overhanging the channel downstream of the dam should be removed.

4. The damaged fence on the west abutment should be repaired.

5. The seepage on the downstream face should be monitored to note any change from the existing conditions.

6. The low level outlet should be brough back to an operating condition to allow the pond to be lowered.

7. Institute a program of annual periodic technical inspection with special emphasis on the joint between the dam and the rock abutments at the valley walls.

8. Develop a formal flood warning and surveillance plan, including round-the-clock monitoring during heavy precipitation.

7.4 Alternatives

Remove the dam.

APPENDIX A

INSPECTION CHECK LIST

INSPECTION CHECK LIST

PARTY ORGANIZATION

PROJECT PEMBERWICK DAM

DATE NOVEMBER 12, 1979

TIME 10:00 AM - 12:00

WEATHER PARTLY SUNNY

W.S. ELEV. _____ U.S. _____ DN.S.

PARTY:

1. R. JOHNSTON, JPPA
2. R. LYON, JPPA
3. G. SALZMAN, CWDD
4.
5.
6. D. KNABEL - GREENWICH ASSOC.
7.
8.
9.
10.

PROJECT FEATURE	INSPECTED BY	REMARKS
1. Hydraulics	R. Johnston	
2. Structural	R. Lyon	
3. Geotechnical	G. Salzman	
4.		
5.		
6.		
7.		
8.		
9.		
10.		

INSPECTION CHECK LIST

PROJECT PEMBERWICK DAM DATE 11-12-79

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED		CONDITION
DAM EMBANKMENT		
Crest Elevation	80.0	GOOD - STONE CREST
Current Pool Elevation	76.5	GOOD - 31" BELOW CREST
Maximum Impoundment to Date		
Surface Cracks		NONE OBSERVED
Pavement Condition		GRASS GROWING BETWEEN STONES
Movement or Settlement of Crest		NONE OBSERVED
Lateral Movement		NONE OBSERVED
Vertical Alignment		GOOD
Horizontal Alignment		GOOD
Condition at Abutment and at Concrete Structures		GOOD
Indications of Movement of Structural Items on Slopes		NONE OBSERVED
Trespassing on Slopes		NOT PERMITTED
Vegetation on Slopes		MINOR - GRASS & SM. SHRUBS IN JOINTS
Sloughing or Erosion of Slopes or Abutments		NONE OBSERVED
Rock Slope Protection - Riprap Failures		N/A
Unusual Movement or Cracking at or near Toes		TOE NOT VISIBLE - UNDERWATER
Unusual Embankment or Downstream Seepage		LEAKS AT AND ADJACENT TO SPILLWAY SILL EDGES
Piping or Boils		NONE OBSERVED
Foundation Drainage Features		NONE OBSERVED
Toe Drains		NONE OBSERVED
Instrumentation System		NONE OBSERVED

INSPECTION CHECK LIST

PROJECT PEMBERWICK DAM DATE 11-12-79

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
CUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	ENTIRE RIVER BED - UNDERWATER
b. Intake Structures	
Low Level Outlet	NOT VISIBLE - SUSPECTED TO BE CONTROLED BY THE SLANTED GEAR LIFT ON THE TOP OF THE DAM. INTAKE SUSPECTED TO BE BELOW PRESENT SILT LEVEL AND INOPERABLE.
High Level Outlet	SURFACE INTAKE OPEN. LOWER INTAKE NOT VISIBLE. VERTICAL GEAR STEM ON INOPERABLE (SHEARED SHAFT).

INSPECTION CHECK LIST

PROJECT PEMBERWICK DAM DATE 11-12-79

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - TRANSITION & CONDUIT	
Low Level Outlet	TYPE AND CONDITION UNKNOWN.
High Level Outlet	A VERTICAL SHAFT LEADS FROM THE SURFACE AND LOWER INTAKE TO A 36" PIPE WHICH EXTENDS HORIZONTALLY TO THE DOWNSTREAM FACE OF THE DAM. PLUGGED WITH CONCRETE IN 1978.

INSPECTION CHECK LIST

PROJECT PEMBERWICK DAM DATE 11-12-79

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
Structure	NOT VISIBLE. 12 INCH OUTLET VALVE ON DOWNSTREAM FACE OF DAM FOR HIGH LEVEL OUTLET WAS REMOVED AND OUTLET SEALED WITH CONCRETE IN 1978. LOW LEVEL OUTLET WAS APPARENTLY A PIPE OUTLETTING THROUGH THE FACE OF THE DAM.
Channel	SEE SPILLWAY DISCHARGE CHANNEL.

INSPECTION CHECK LIST

PROJECT PEMBERWICK DAM DATE 11-12-79

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	ENTIRE RIVER BED - UNDER WATER
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir	
General Condition of Granite	GOOD
Rust or Staining	N/A
Spalling	NONE OBSERVED
Any Visible Reinforcing	NONE OBSERVED
Any Seepage or Efflorescence	SPILLWAY FLOWING - NONE VISIBLE
Drain Holes	NONE OBSERVED
c. Discharge Channel	ENTIRE RIVERBED - UNDERWATER
General Condition	GOOD
Loose Rock Overhanging Channel	NONE OBSERVED
Trees Overhanging Channel	YES
Floor of Channel	UNDERWATER - APPARENTLY ROCK
Other Obstructions	BUILDING AND SURROUNDING CONCRETE WALL ON LEFT SLOPE

APPENDIX B

ENGINEERING DATA

APPENDIX B-1

DESIGN, CONSTRUCTION AND MAINTENANCE RECORDS AND LOCATION

Mr. Victor J. Galgowski
Dam Safety Engineer
Water and Related Resources Unit
Department of Environmental Protection
State of Connecticut
State Office Building
Hartford, Connecticut 06115

Greenwich Associates, Inc.
100 Putnam Green
Greenwich, Connecticut 06830

APPENDIX B-2

COPIES OF PAST INSPECTION REPORTS

BUCK & BUCK

ENGINEERS

98 WADSWORTH STREET, HARTFORD, CONNECTICUT 06106

JAMES A. THOMPSON
ROBINSON W. BUCK
LAWRENCE F. BUCK

HENRY WOLCOTT BUCK
1931-1965
ROBINSON D. BUCK
1935-1959

COMM. 5713-131

June 13, 1978

Mr. Victor Galgowski,
Superintendent of Dams,
Department of Environmental Protection,
State Office Building,
Capitol Avenue,
Hartford, Connecticut 06115

WATER RESOURCES
UNIT
RECEIVED
JUN 16 1978
ANSWERED
REFERRED
FILED

Reference: "American Felt Dam"
Byram River, Greenwich

Dear Vic:

We inspected the subject dam on May 19, 1978 and found the dam to be in good condition and apparently safe. There is a slight leak at spillway level in the west abutment, but the leak is very minor and nothing to be concerned about. The dam is a cut stone masonry arch, founded on ledge rock. Most probably the abutments also bear against ledge rock. The dam is basically a run of the river type structure which can be overtopped without danger to the dam.

I checked the Corps of Engineers "Flood Plain Information Study" of the Byram River, prepared in 1964 and found that the subject dam is called the "Aerotec" dam in that report. The Corps study indicates the dam will be overtopped by a 10-year flood. The study also indicates the downstream channel will contain a flood flow of 4,300 cfs, which is equal to the flood of record, which occurred in October of 1955.

Although the dam itself is in good condition, we found some of its appurtenances in bad shape. The protective railing which surrounds the east abutment is rusting at the base of each post and a large section on the downstream side has broken off. The gate mechanism operating wheel has been broken, the stem is badly rusted and it's most probable that the mechanism is inoperable. A gate and section of pipe that had been installed in the old "pipe head race" has broken off, reportedly due to heavy ice loads this last Winter, and water is spewing freely from the broken pipe. Downstream owners expressed concern about the flow from this pipe, but it is being deflected by a ledge outcropping and is causing no damage.

Reproduced from best available copy.

In summary, the structure is in good condition and appears to be safe. Some of its appurtenances need improvement, but they are all non-structural maintenance type items. The owner should be notified of these conditions.

Sincerely yours,

BUCK & BUCK

James A. Thompson

James A. Thompson

JAT:fb

No. [illegible]

WATER RESOURCES COMMISSION
SUPERVISION OF DAMS
INVENTORY DATA

42

Inventoried By [illegible]

Date 3-8-[illegible]

Name of Dam or Pond Comly Av Dam [illegible] DAM

Code No. [illegible] (R B & W DAM)

Nearest Street Location [illegible]

Town ~~[illegible]~~ Greenwich

U.S.G.S. Quad. Greenville

Name of Stream BYRAM RIVER

Owner A. G.H.F.

Address 1361 Alps Road
Wayne, NJ 07470

Photo shows large high stone dam 30'

[illegible] G.A.F.

Pond Used For INDUSTRIAL USES DA-65-605M

Dimensions of Pond: Width _____ Length _____ Area 3 AC

Total Length of Dam 150 Length of Spillway 30'

Location of Spillway [illegible] of Dam

Height of Pond Above Stream Bed 35' [illegible] 15' [illegible] 20' [illegible]

Height of Embankment Above Spillway [illegible]

Type of Spillway Construction Stone & Conc

Type of Dike Construction Stone & Conc

Downstream Conditions Factory just Below [illegible]

Summary of File Data [illegible]

Remarks Should have file on this check as to condition

Would Failure Cause Damage? To Factory Class B

1867

Reproduced from best available copy.

COPY

TOWN OF GREENWICH
CONNECTICUT

DEPT. OF PUBLIC WORKS

September 5, 1950

Mr. W. H. Lehmberg
American Felt Co.
Glenville, Conn.

Re: Masonry Arch Dam - Byram River
North of Comly Ave.

Dear Mr. Lehmberg:

It was fortunate for my purposes you mentioned the other day that your company now owns the R.B & W. dam and that you had drawn down the water for the purpose of repairing a gate. The foundation of this dam has bothered me for several years not knowing whether or not undercutting had occurred at the foundation in the tailwater pool. This pool was pumped out and photographs taken Sept. 1st, a set of same being enclosed. I had previously attempted to test the foundation by probing with long poles from a raft but as you can readily realize this was not entirely satisfactory. You will note that the photographs show no undercutting of the foundation at the toe of the dam. I would suggest that whenever opportunity affords, say in periods of five to ten years, that the pool be de-watered and the foundation examined.

The ledge rock on the west abutment apparently is in better condition than that on the east due apparently to the inclination of the stratification.

I did not examine the ashlar masonry joints closely since the whole area was slippery and I did not care to fall and break a leg. As suggested to you over the telephone I think it would be to your company's interest to examine the pointing to determine to what depth it has deteriorated. This is a semi-arch type dam and if the pointing deteriorates materially, it would be possible over a period of time, through the accumulation of smaller movements, to bring about a condition that might impair the safety of the dam. If the mortar has deteriorated or is washed out entirely to a considerable depth I would suggest you look into the possibility of making repairs by the gunite process. As you know, by this process mortar is shot into the structure at considerable velocity. I would believe also that this process would do as good or a better job and at less cost than the usual hand methods of pointing.

I understand that now diving is not permitted from the dam. You will note in the photographs a sizeable boulder approximately in the center of the pool; it is a wonder that some boy did not break his neck in the past.

You will understand of course that my principal interest in this structure is due to feeling that the Town has some responsibility to the inhabitants in the Cosberwick flood plain below the dam as well as damage to Town roads and bridges.

Yours very truly,

Joseph W. Cone
Commissioner

Reproduced from best available copy.

JWC:CB
cc. State Bd. of Dams

RECORD PHOTOGRAPH FROM
PREVIOUS DAM INSPECTION
SEPTEMBER 5, 1950

S. E. MINOR & CO., INC.
CIVIL ENGINEERS
GREENWICH, CONN.

56-1-1
from Mr Cadwell's Office

December 15, 1938

COPY

Drainage Commission
Town Hall
Greenwich, Conn.

Re: Byram River Dams

Gentlemen:-

At the request of your Commission, representing the Town of Greenwich, and other interested parties, an inspection was made November 2, 1938 of three dams on the Byram River by a committee of this Board consisting of Messrs. Palmer, Blair and Cone, with particular reference to loss or damage in the Pemberwick flood area should these dams break away.

A study of the watershed to determine probable maximum run-off was made by the writer and field data was obtained under his supervision.

The dams under consideration, in order following downstream, are commonly known as the:- Reynolds Dam, Felt Co. Dam, and R. B. & W. Dam, owned respectively by Grace V. A. Reynolds, The American Felt Co. and Russell, Burdsall & Ward Bolt & Nut Co.

Watershed.

Watershed tributary to the Felt Co. dam is 27.35 sq. mi. and to the R. B. & W. dam 27.75 sq. mi., both approximate. Water is diverted from the watershed at two points; by New York City on the west branch of the Byram at the State Line and on the east branch by the Greenwich Water Co. above Old Mill Road.

Estimated flood flow on July 23, 1938 and Sept. 21, 1938, both of the same magnitude, was approximately 2000 cubic feet per second. Had both tunnels been closed, the flow would have been

approximately 2200 c.f.s.

The watershed, from a runoff viewpoint, is undeveloped. Quicker runoff with higher flood stages is to be expected in the future due to swamp clearance and drainage, construction of storm drains, buildings, pavements, and other impervious surfaces.

Using the Fuller formula with a watershed constant of 60 and time frequency of 1000 a maximum rate of runoff is obtained of 5200 cubic feet per second or more than twice the flood flow of the floods of July and September. This is not an unreasonable flood to expect sometime in the future, particularly considering the comparatively small area of the watershed. Had the center of the hurricane of September passed along the Byram watershed, this flow would have been obtained.

Plans.

No construction plans of the dams are known to be in existence. The Reynolds and Felt Co. dams are evidently by their appearance quite old. The original R. B. & W. dam quite likely failed in the flood of October 9, 1877 when precipitation was 9.7 inches in 10.5 hours at White Plains, N. Y. It is reasonable to presume the present R. B. & W. dam was built shortly thereafter.

Back profiles of sections of dams at maximum height were obtained by sounding from a boat with an iron rod through water and silt, consequently sections are approximate. Condition of toe of R. B. & W. dam was investigated in the same manner.

Reynolds Dam.

This dam is a typical dry rubble overflow dam with vertical

face, originally with a tight-line and probably an impact platform. Abutments are against ledge rock. Headrace ends in a wooden bulkhead in poor condition. Old mill has been razed. The pond formed by the dam is shallow due to silting and impounds about 5 acre feet.

The dam is a small affair in poor condition and unless repaired will go out during some freshet. Failure will be comparatively slow; the dam will not give way all at once. For this reason and since only a small amount of water is retained by the dam, no serious harm will be done.

Felt Co. Dam.

This dam is located 1700'± below the Reynolds dam and 3300'± above the R. B. & N. dam. Principal dimensions are as follows:-

Crest length	200'±
Spillway length	49'
Maximum height at spillway	30'
Top width at spillway	13'
Bottom width at spillway	19'±
Freeboard	4.75 Aver.
Area of pond	2.6± Ac.
Capacity of pond (silted)	6± Ac. ft.

The dam is constructed of cement rubble masonry with a vertical face. The back, as nearly as could be determined by soundings, is stepped. The spillway section is arched in plan with a face radius of 85'. The east abutment has considerable mass and is backed by a retaining wall, perpendicular to the dam, with heavy fill in back of retaining wall and between dam and mill building. The west abutment has not sufficient mass nor is the plan proper to take arch thrust. Consequently the dam should be considered as a gravity section disregarding arch action.

Impact of overflow at spillway is taken by exposed ledge rock and there is no danger of concealed underscour. It is believed the main portion of the dam is on ledge rock. The extreme ends may not be.

The spillway is inadequate. The crest was topped by a few inches during the floods of 1938. If spillway length remains the same and crest length is held to 185' by building up ends, it is probable a future flood would have a still water height of about 2.5' above crest of dam and about 7.3 above spillway. Length of spillway should be increased by extending same to the west.

Under the conditions stated above and considered as a gravity section, the resultant of forces acting on the dam falls well outside the middle third and while the dam is theoretically safe against overturning, there is probable tension in masonry in the back of the dam. There is not the margin of safety indicated by good practice, particularly when the condition of the masonry in the interior of the dam is unknown. The dam can be strengthened by additional masonry along the downstream face.

Trees have been allowed to grow on and close to the dam. This should not be allowed account of root action.

There is a collecting trough along the east portion of the dam to take overtopping. If this was not included in the original design, it was built as the result of some experience in the past. The bottom of this trough should be paved to prevent scouring.

If the building on the downstream side of the west end of

the dam is to be protected, a similar trough should be constructed along the west portion of the dam.

An extraordinary flood would probably cut around the ends of the dam, particularly the west end. This might result in progressive undermining of the ends of the dam and final failure. To prevent this, ends of dam should be raised and carried back into solid ground.

There is a leak through the bottom of the sluiceway under the easterly portion of the spillway. This should be repaired. The old sluiceway in the western portion of the dam is not used and should be closed with masonry.

The fact that a dam has stood for a long period of years should not of itself give assurance the dam will withstand all future floods. To refute this idea there is the evidence, throughout New England, of numerous neglected dams that have failed. An old dam requires frequent and thorough maintenance. Moreover, it is quite probable the particular watershed has not been subject to a serious flood condition for a period far beyond the memory of the oldest inhabitant.

To place the dam in better condition the following is recommended:- Lengthen spillway - Additional masonry to increase section - Remove trees - Pave east collecting trough - Construct similar trough along west end - Build up ends of dam to prevent end scour - Repair leak - Close up old sluiceway - Careful maintenance.

The volume impounded by this dam is small, the distance to the R. B. & W. dam is 3300 feet mostly still water, area

of the R. B. & W. pond is 5.5± acres, surge would flatten out quickly and still water level at the R. B. & W. dam would be only slightly raised. Should the dam fail, loss or damage would be confined to the American Felt Co. and the Pemberwick flood plain would not suffer loss or damage.

R. B. & W. Dam. (PEMBERWICK)

This dam is located 3300'± below the Felt Co. dam and immediately above the flood plain section of "Pemberwick". Principal dimensions are as follows:-

Crest length	115'
Spillway length	63'
Maximum height at spillway	41'
Top width at spillway	8'
Bottom width at spillway	17'±
Freeboard	3.5
Area of pond	5.5± Ac.
Capacity of pond (silted)	29± Ac. ft.

This is an arch dam, between ledge rock abutments, in a narrow gorge with nearly vertical sides. Face of dam is vertical and face radius of arch is 180'±. Face masonry is coursed ashlar and is a wonderful piece of work. Entire visible portion of dam is on ledge rock. As nearly as could be determined by sounding with iron rods from a boat in the spillway pool, overflow impact is taken by ledge rock and there was no underscouring of the dam that could be found by prodding.

Still water height over spillway during recent floods was 4.3'±. The entire length of the dam acts as an overflow dam during floods with no danger of end scour.

The dam is safe in its present condition and will withstand

any flood it is reasonable to expect.

The stability of this type of dam, among other things, depends on tight contact with gorge walls and constant inter-contact of the various sections of the dam; and of course, as with any dam, underscouring must be prevented. Consequently this dam must be inspected periodically to determine (1) that gorge walls are not softening and that no leaks are developing around ends or along bottom; (2) that mortar in masonry joints has not seriously deteriorated and is in good condition; (3) that underscouring is not taking place.

It is recommended that the spillway pool be dewatered during the next low water stage of the river to determine by visual inspection the exact condition of the dam and foundation at the toe in the pool, and to determine whether or not repairs are necessary.

Conclusion.

It is our opinion that:-

The Reynolds dam is in poor condition and will fail during some freshet but the Pemberwick Section will not suffer loss or damage on account of such failure.

The Felt Co. dam may fail during some future flood but the Pemberwick Section will not suffer loss or damage on account of such failure.

The R. B. & W. dam is safe at present and will not

fail under the action of any flood it is reasonable to expect, provided the dam is maintained in good condition.

Yours very truly,

State Board of Civil Engineers

By _____
Joseph T. Cone
Member for Fourth District

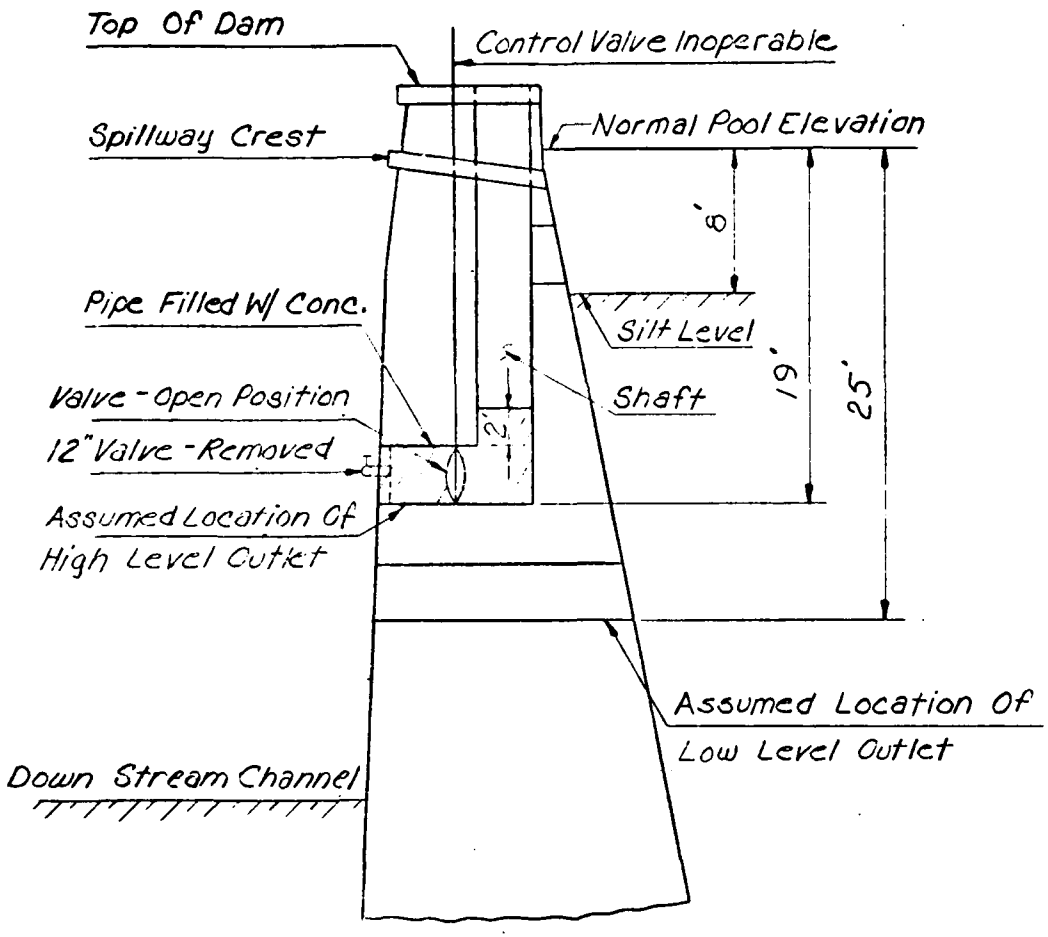
Concurred in _____
Shepard B. Palmer
Member for Second District

COPY

_____
Clarence E. Blair
Member for Third District

APPENDIX B-3

RECORD DRAWINGS AND SKETCHES



NOTE:

All Dimensions Shown Are Plus Or Minus

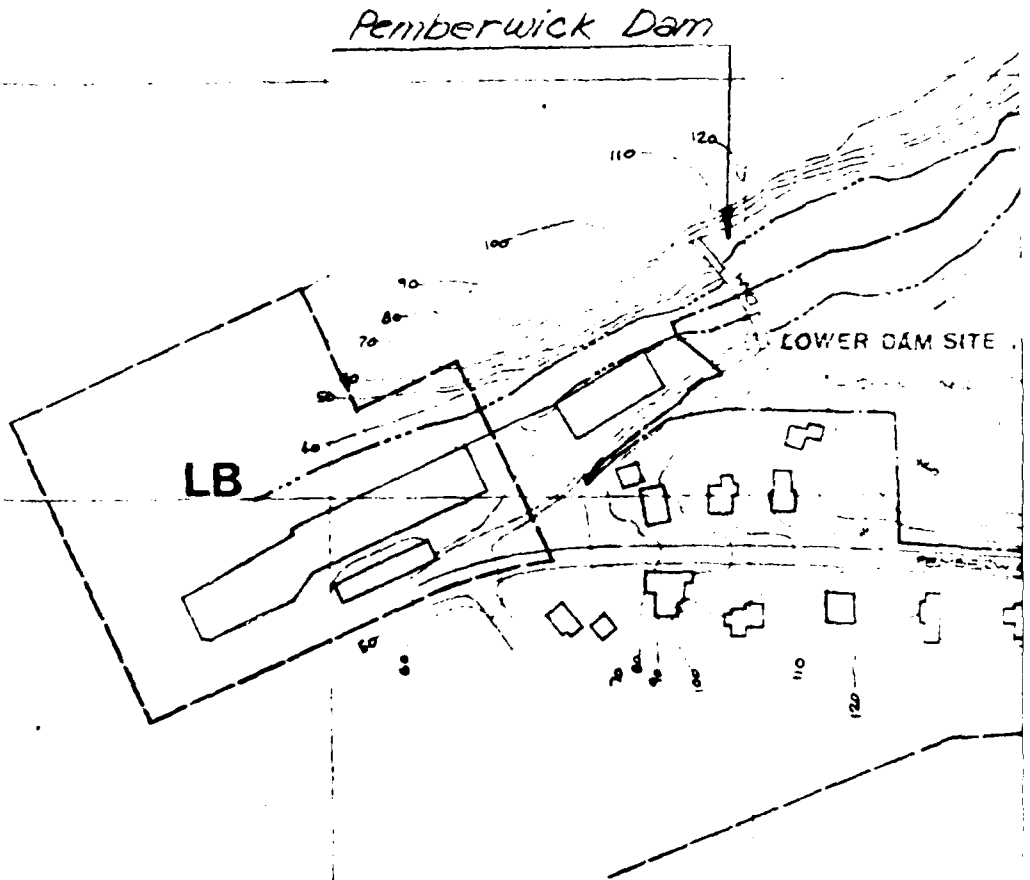
SECTION SHOWING OUTLETS

SCALE : 1" = 10'

PEMBERWICK DAM

JAMES P. PURRELL ASSOCIATES, INC.

ENGINEERS • ARCHITECTS • PLANNERS



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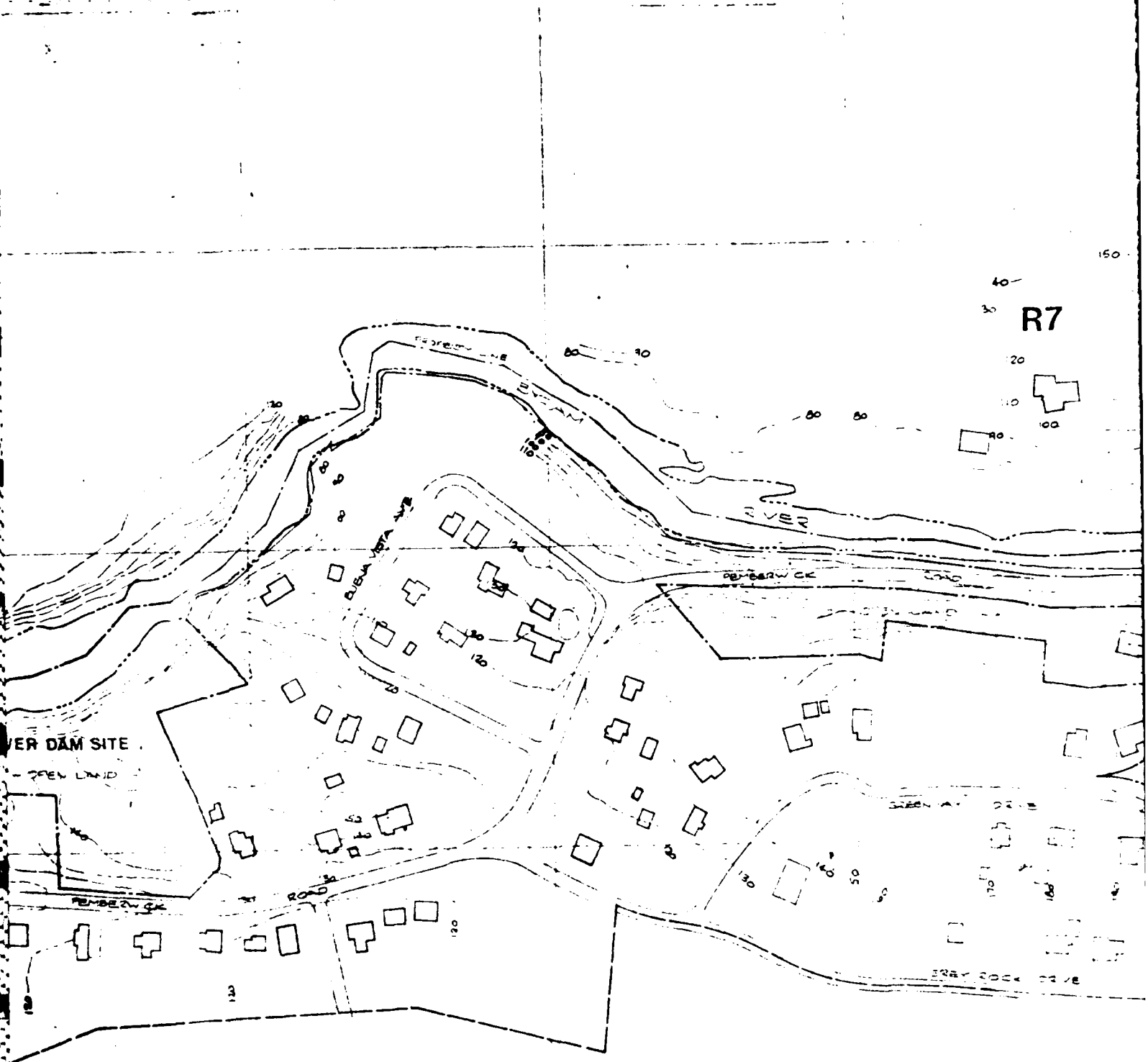
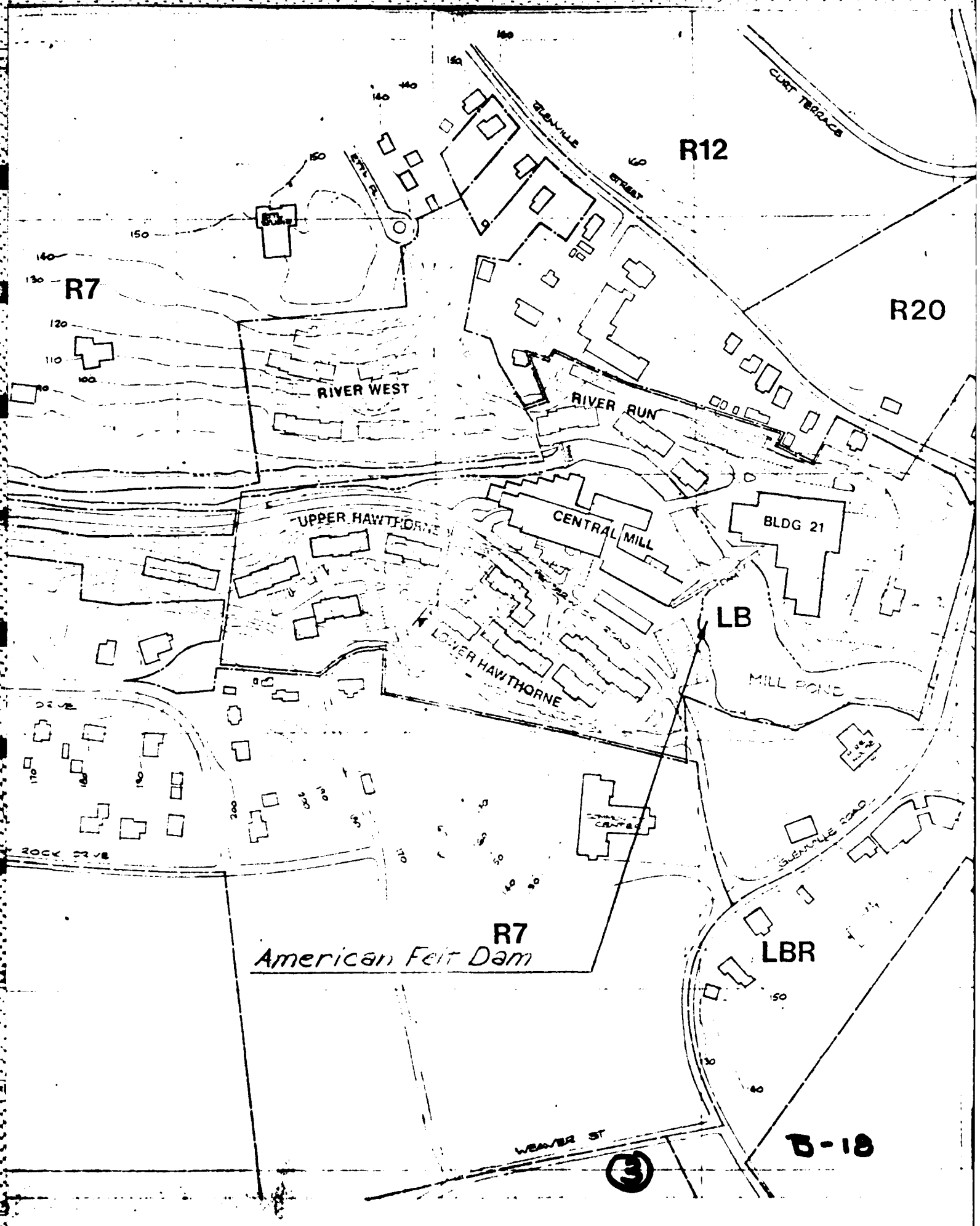
B-18

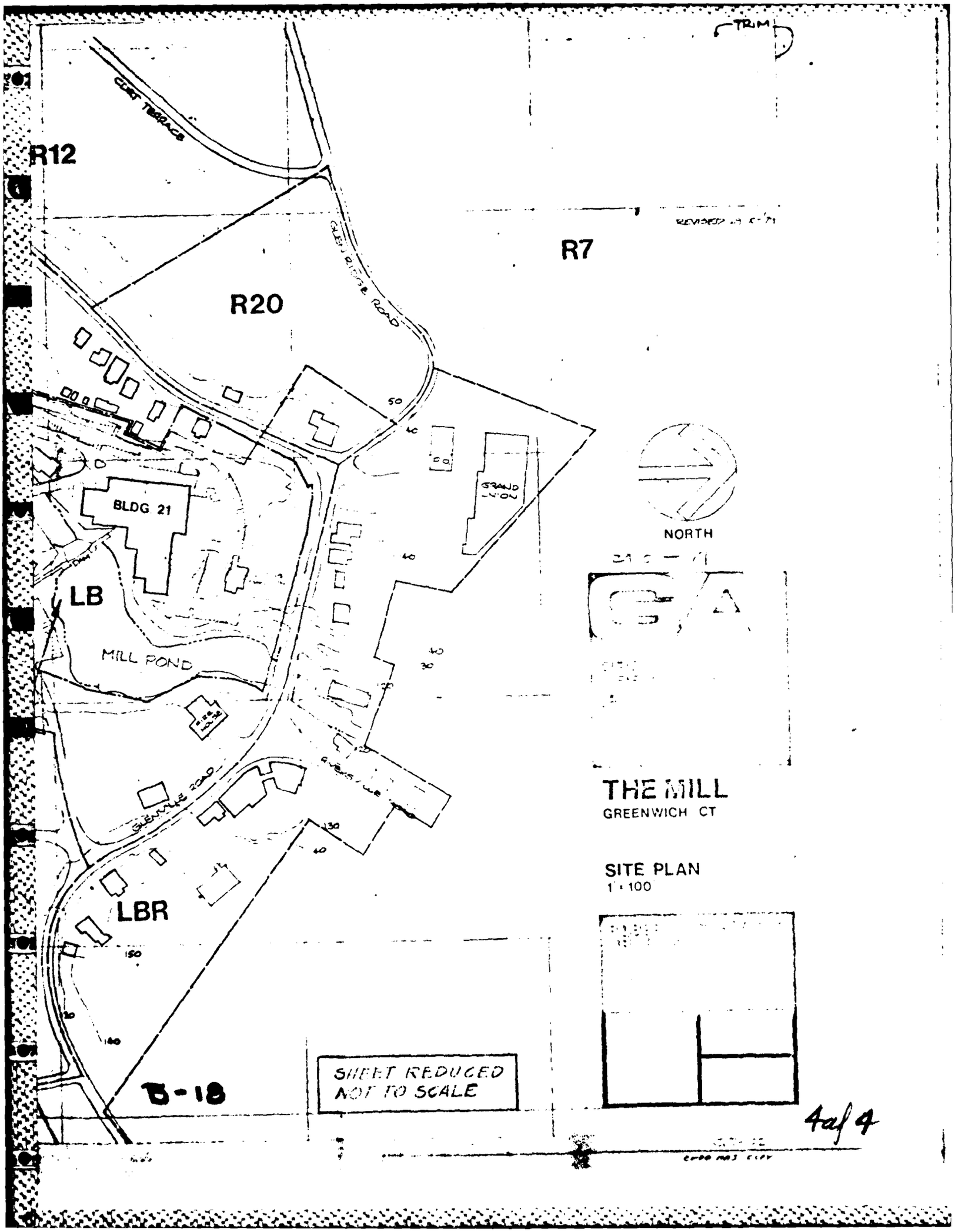
1

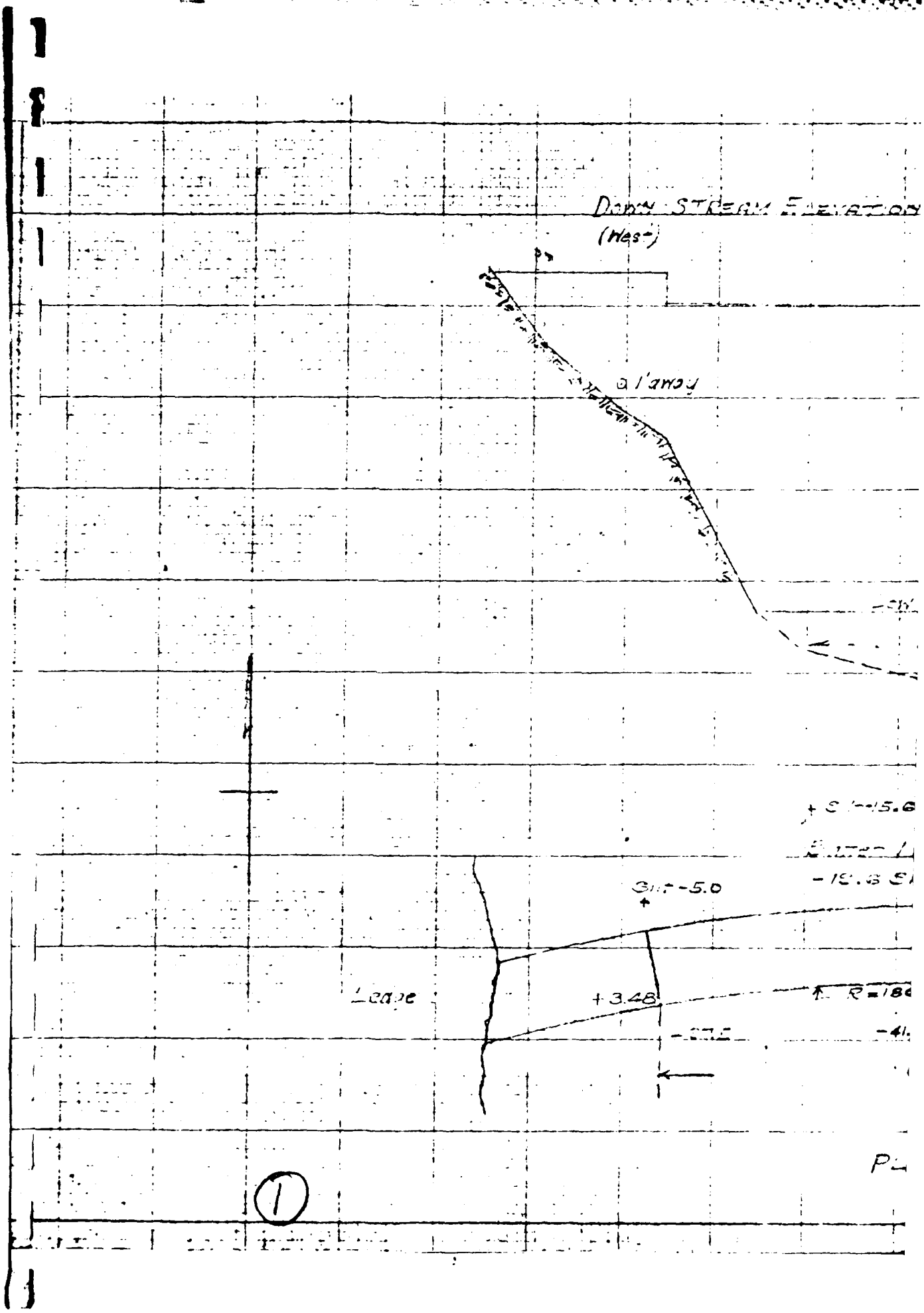


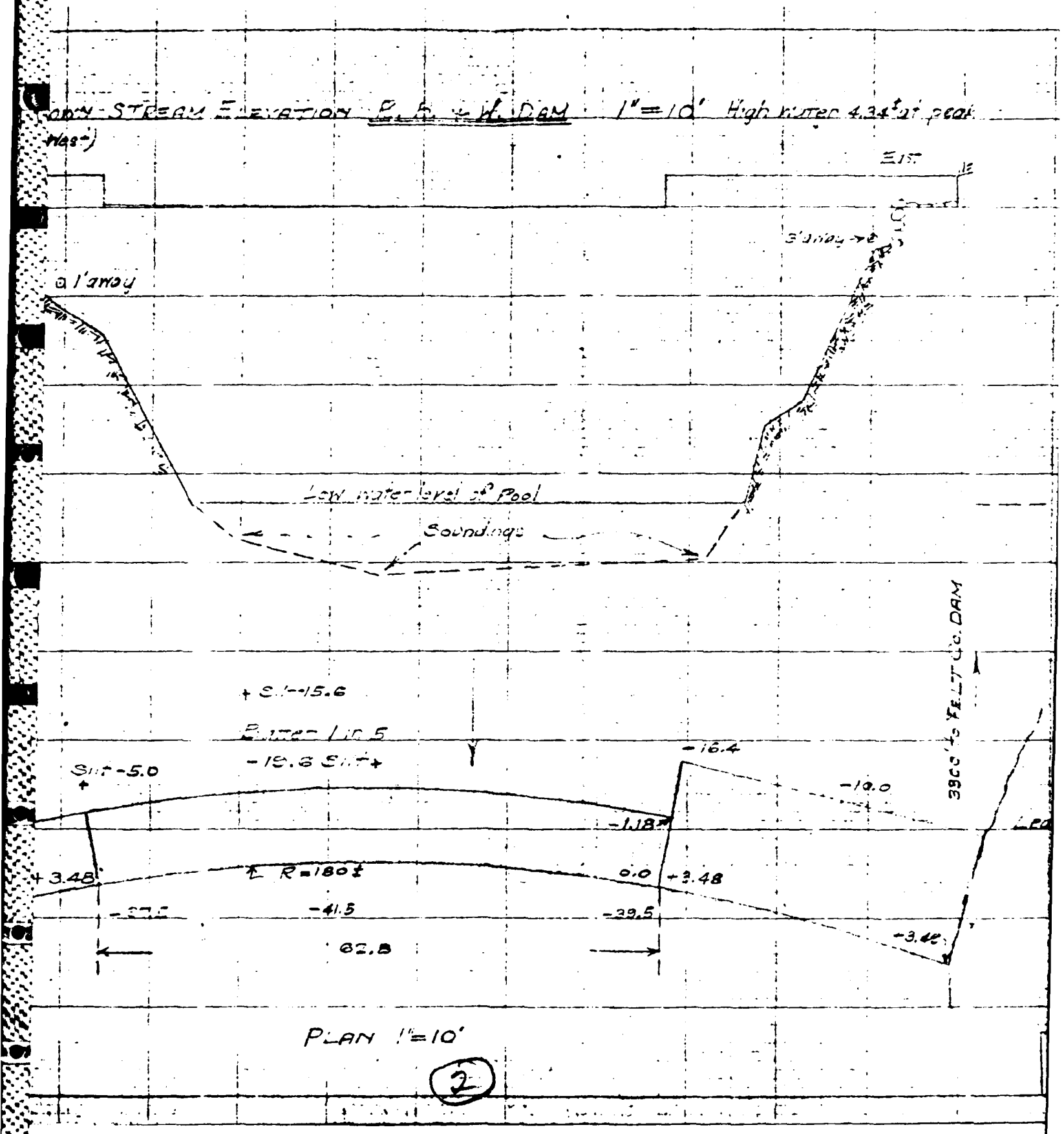
R12

B-18 (2)

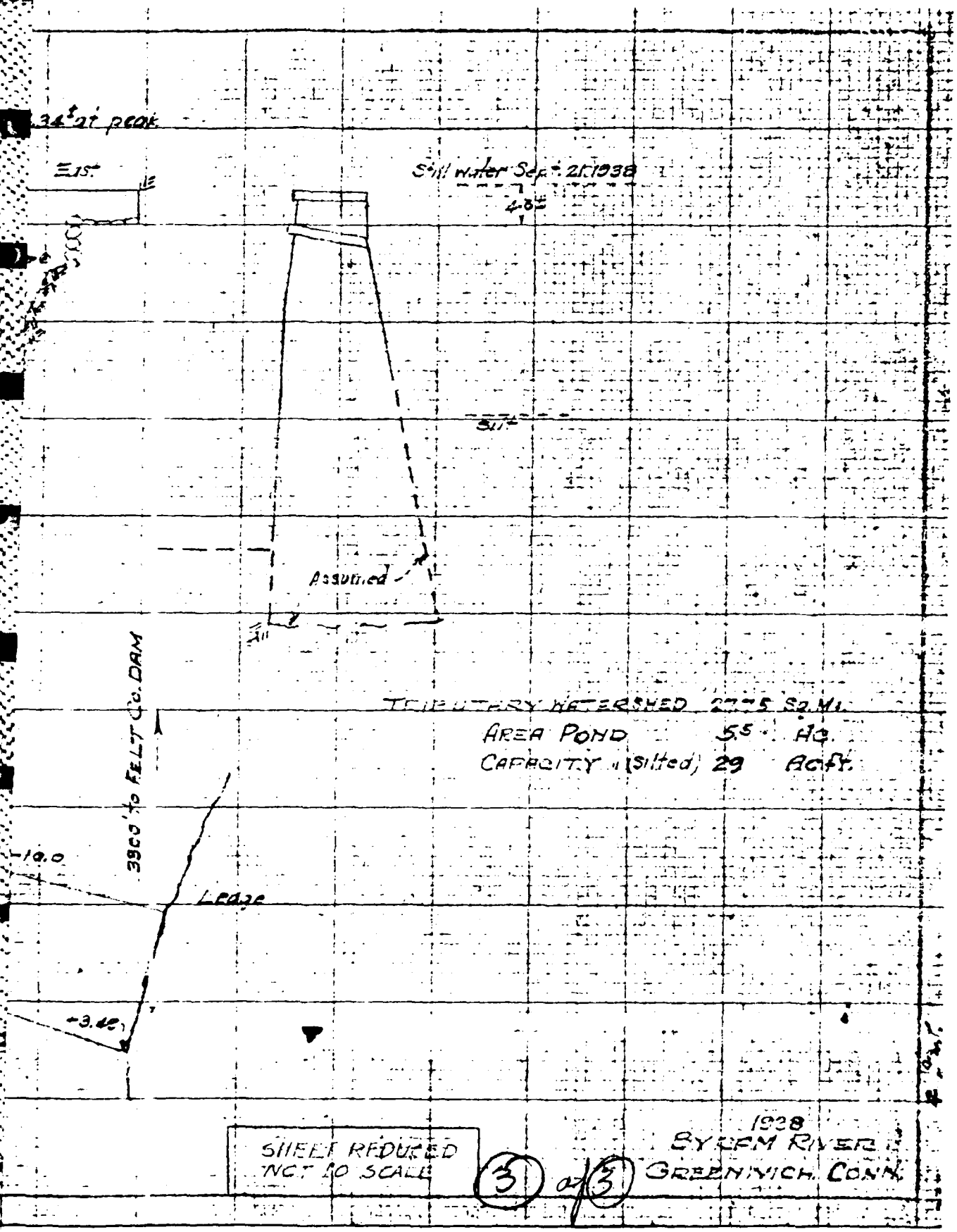

R12
R20
R7
RIVER WEST
RIVER RUN
UPPER HAWTHORNE
CENTRAL MILL
BLDG 21
LB
LOWER HAWTHORNE
MILL POND
R7
American Felt Dam
LBR
WEAVER ST
B-18
3


TRIM
CLIFF TERRACE
R12
R7
R20
GLEN RIDGE ROAD
BLDG 21
GRAND UNION
NORTH
LB
MILL POND
GLENVILLE ROAD
LBR
THE MILL
GREENWICH CT
SITE PLAN
1" = 100
SHEET REDUCED
NOT TO SCALE
B-18
4 of 4


DOWN STREAM ELEVATION
(West)
Gut -5.0
+3.48
Ledge
1



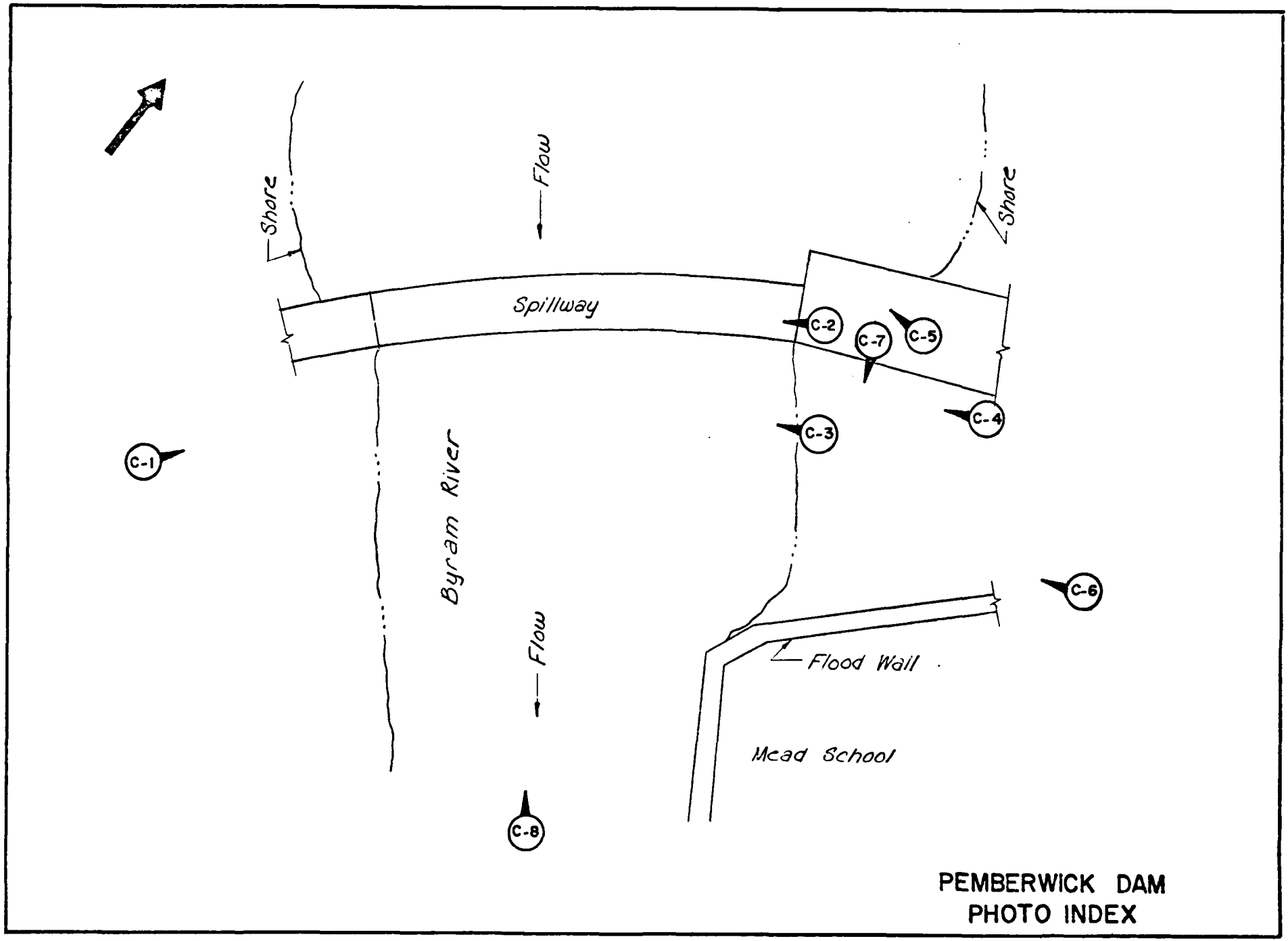
STREAM ELEVATION R.R. + W. DAM 1"=10' High water 4.34± at peak
West
East
3' away
1' away
Low water level of Pool
Soundings
+ Silt -15.6
Batter 1 in 5
-19.6 Silt +
Silt -5.0
-16.4
-10.0
-1.18
+3.48
R=180±
0.0
+3.48
-41.5
-39.5
-3.48
62.8
3900' to FELT Co. DAM
PLAN 1"=10'
2



.34± at peak
Still water Sept. 21, 1938
Assumed
3800' to FELT Co. DAM
TRIBUTARY WATERSHED 27.75 Sq. Mi.
AREA POND 5.5 Ac.
CAPACITY (Silted) 29 Ac.ft.
Ledge
SHEET REDUCED NOT TO SCALE
1938
BYRAM RIVER
GREENWICH, CONN.
3 of 3

APPENDIX C

PHOTOGRAPHS

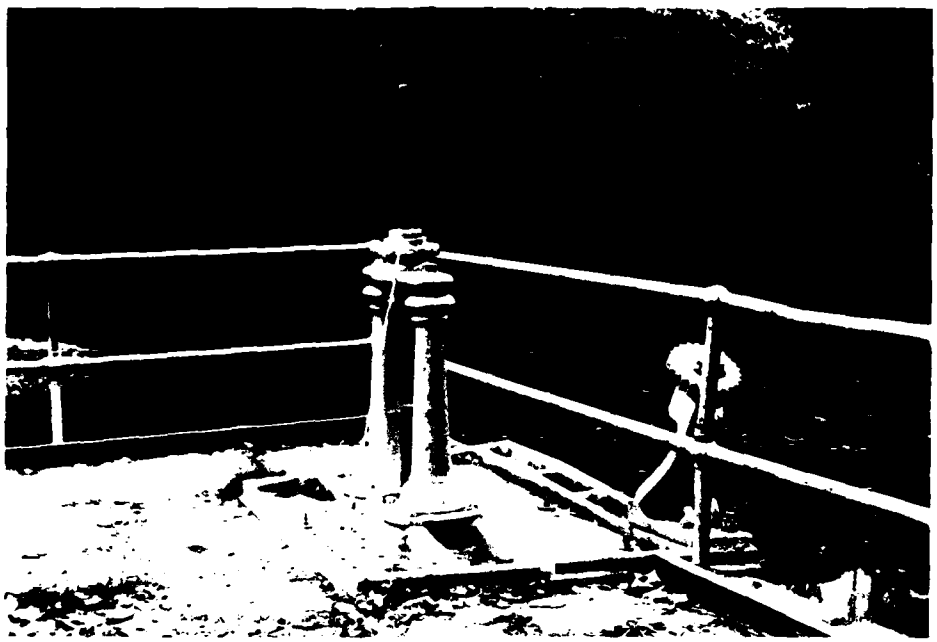

Shore
Flow
Shore
Spillway
C-2
C-7
C-5
C-4
C-3
C-1
Byram River
C-6
Flood Wall
Flow
Mead School
C-8
PEMBERWICK DAM
PHOTO INDEX

C-1 EAST CREST AND SPILLWAY - LOOKING FROM SLOPE ABOVE WEST CREST

C-2 WEST CREST - LOOKING FROM EAST CREST

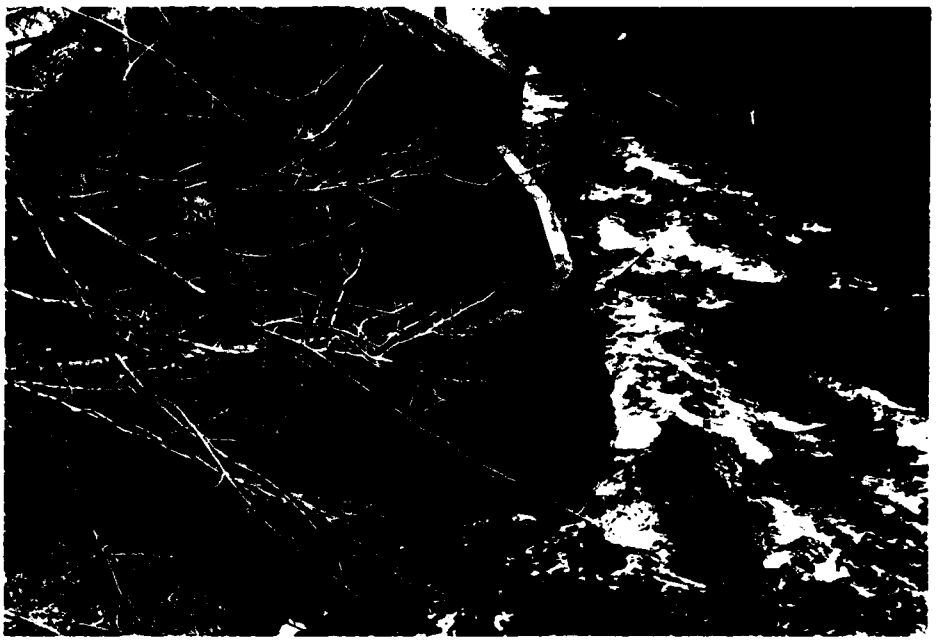
C-3 LEAKAGE AT DOWNSTREAM FACE OF WEST CREST

C-4 SPILLWAY AND LEAKAGE AT EAST END OF SPILLWAY



C-5 OUTLET WORKS CONTROL MECHANISM

C-6 SPILLWAY - LOOKING FROM DOWNSTREAM ON EAST BANK

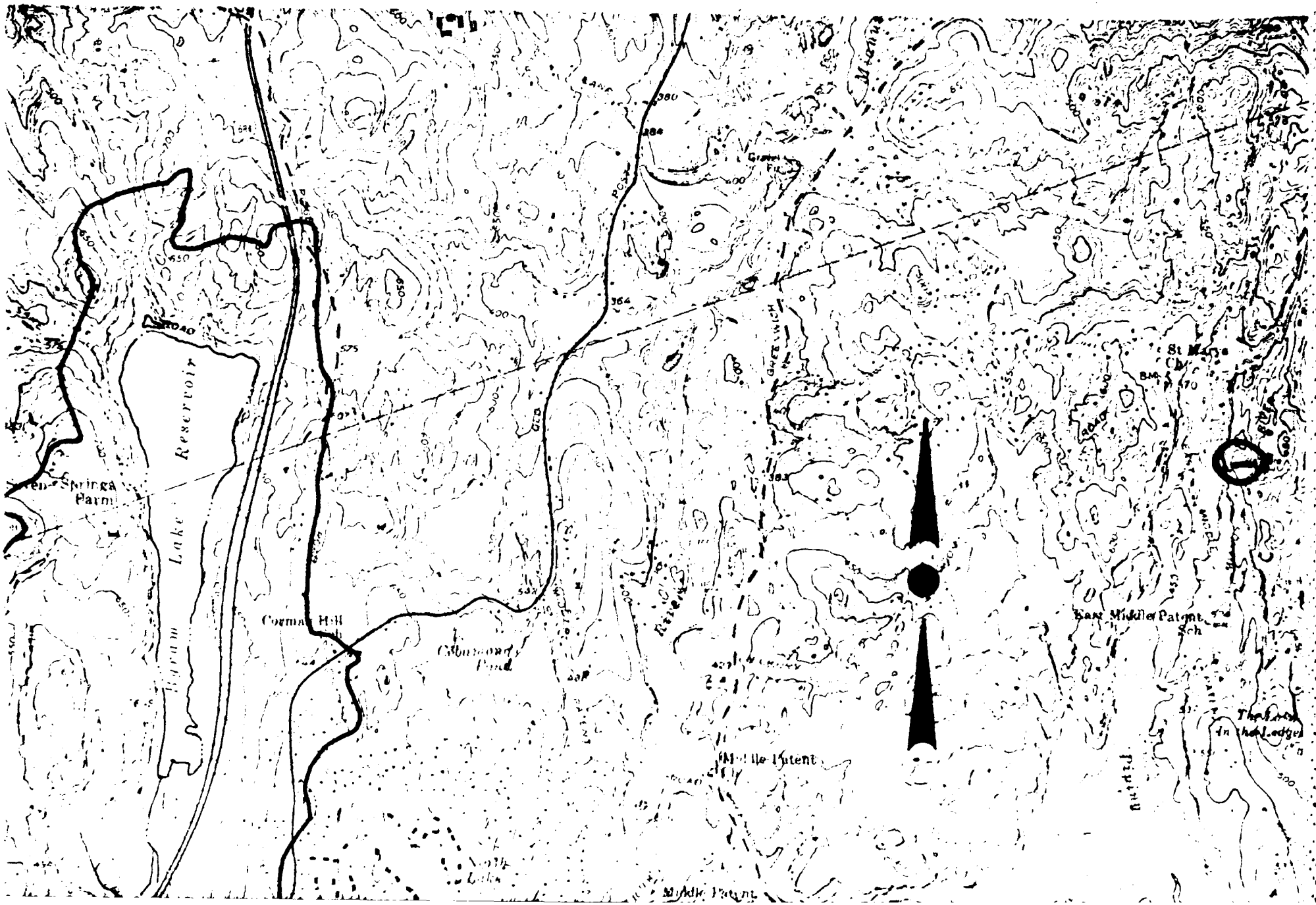


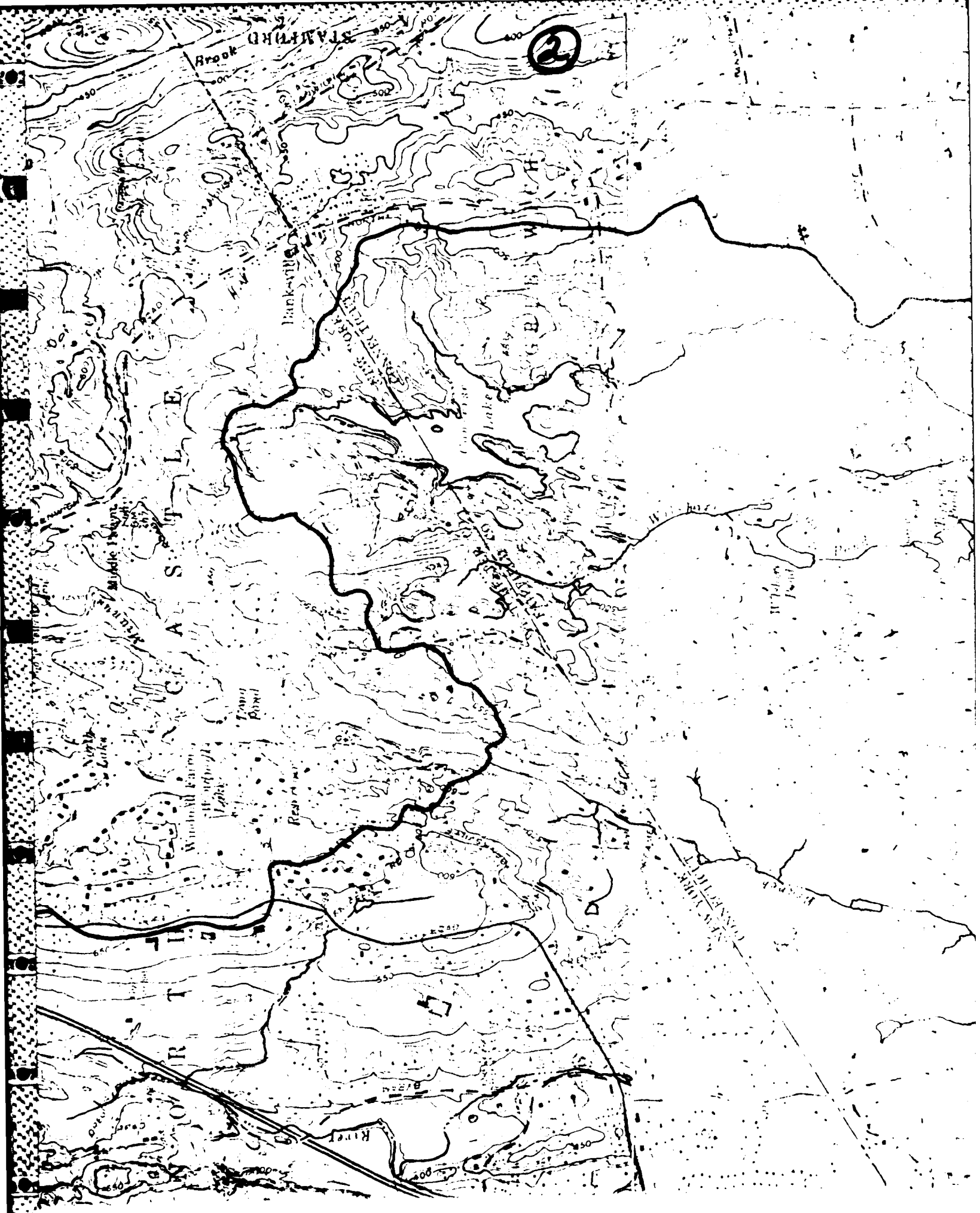
C-7 MEAD SCHOOL AND FLOODWALL - LOOKING FROM EAST CREST

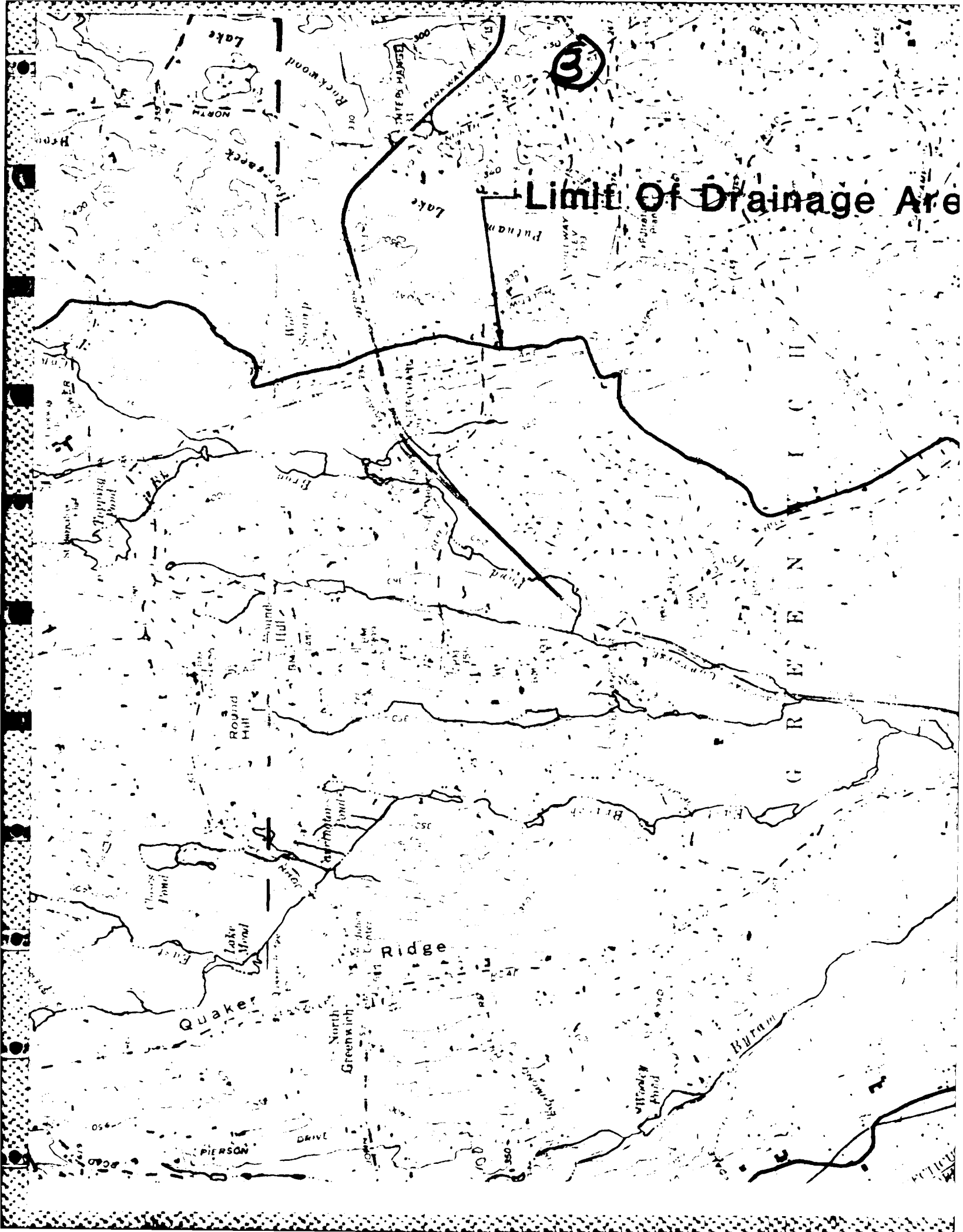
C-8 DOWNSTREAM CHANNEL - LOOKING NORTH FROM COMLY AVENUE

APPENDIX D

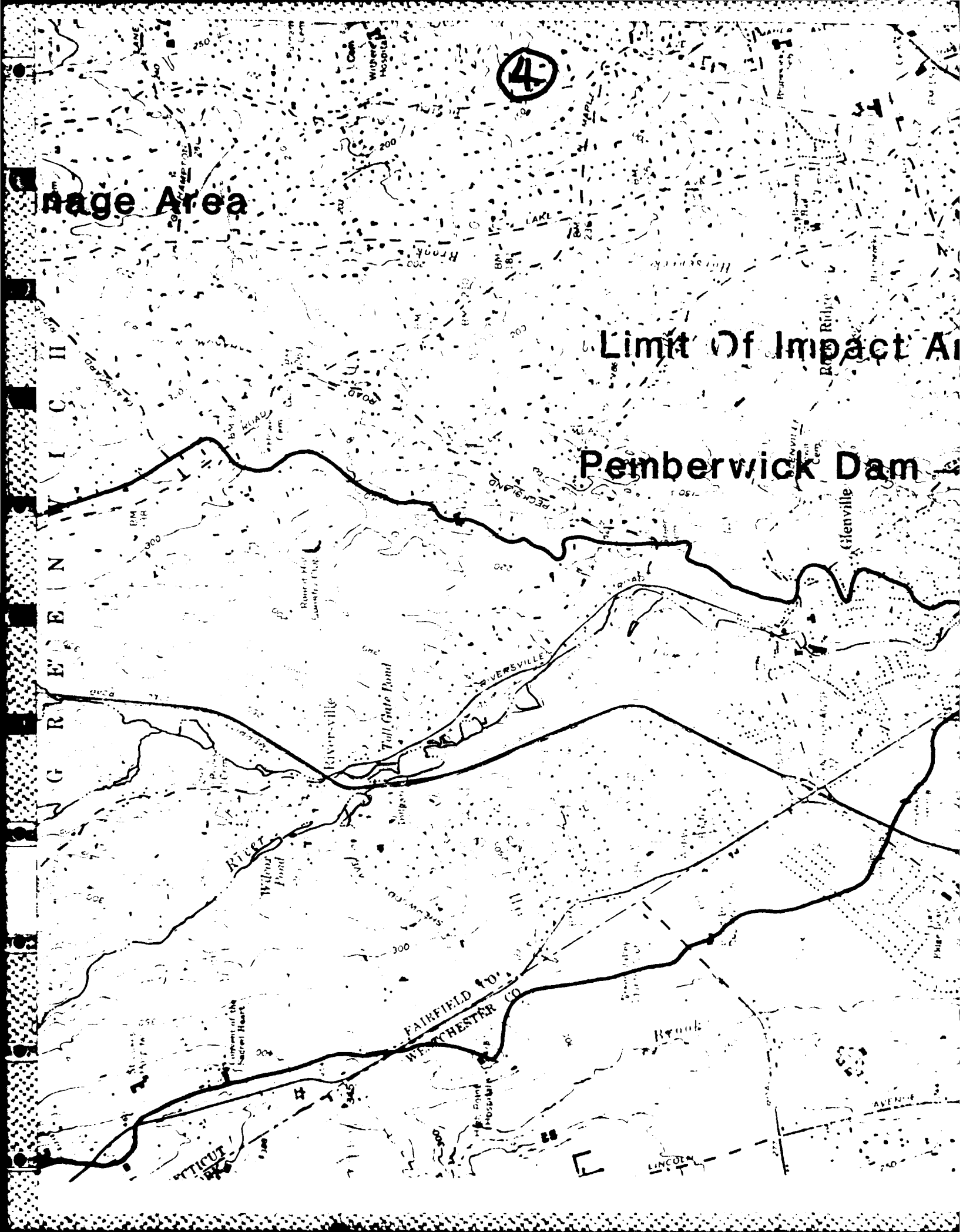
HYDROLOGIC AND HYDRAULIC COMPUTATIONS

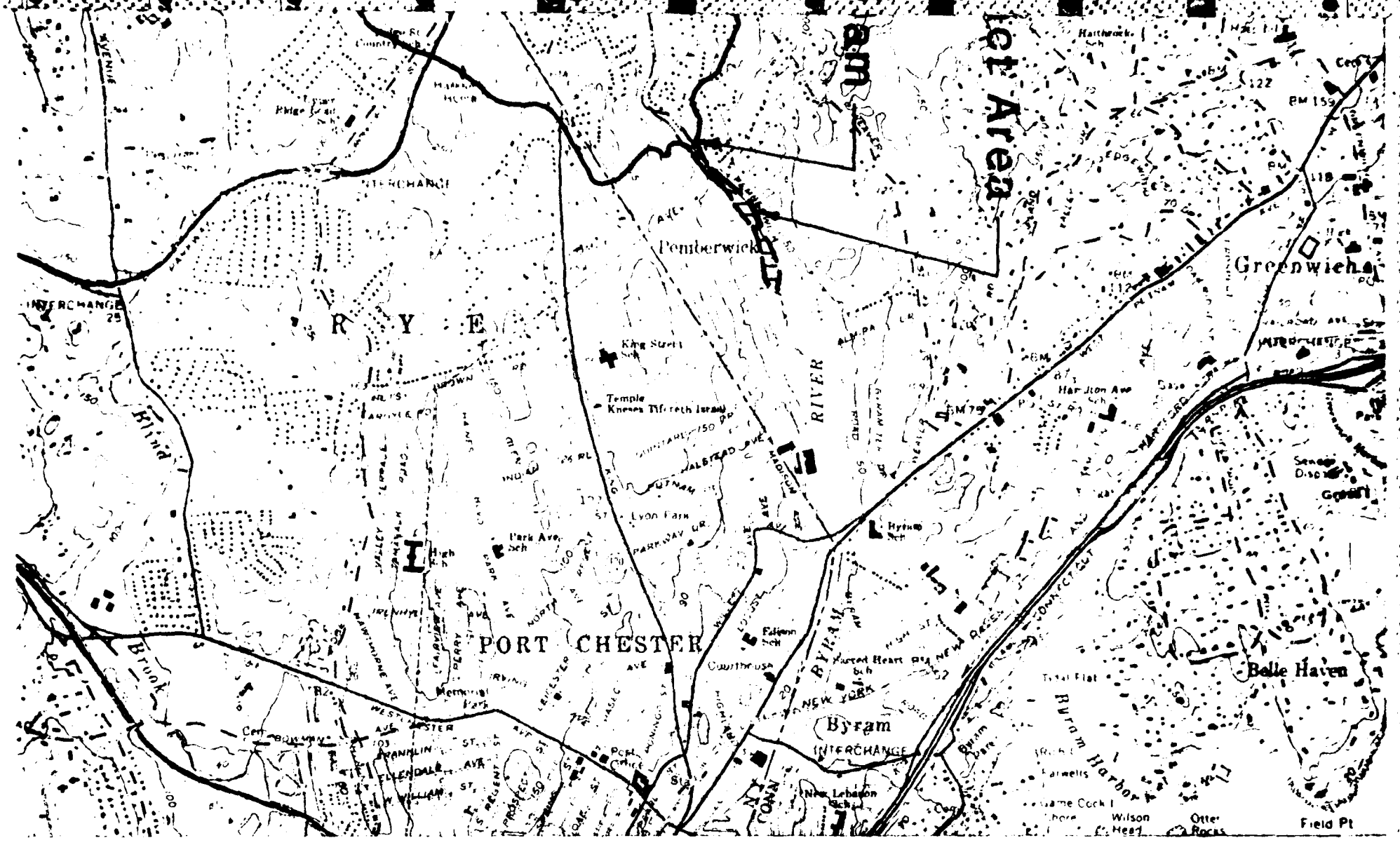

Lake Reservoir
Springs Farm
Corman Hill
Cobamondy Pond
Middle Patent
East Middle Patent
St Marys Ch
Piping
Middle Patent


2
STAMFORD
Brook
Banksville
Middle Patent
Lake
River

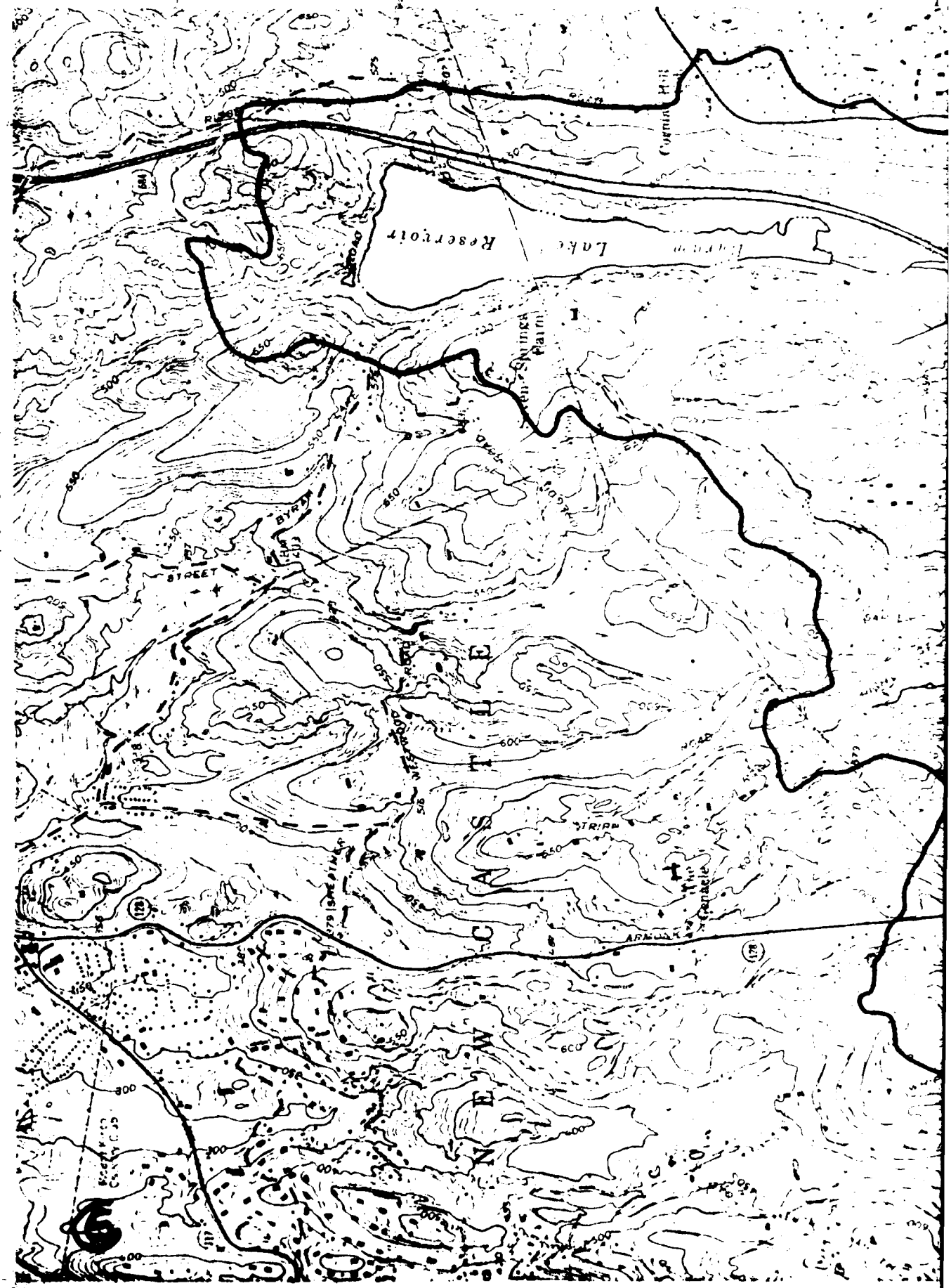


Limit Of Drainage Are
Lake
Rockwood
Putnam
Round Hill
Ridge
Quaker
North Greenwich
Byram
PIERSON
DRIVE

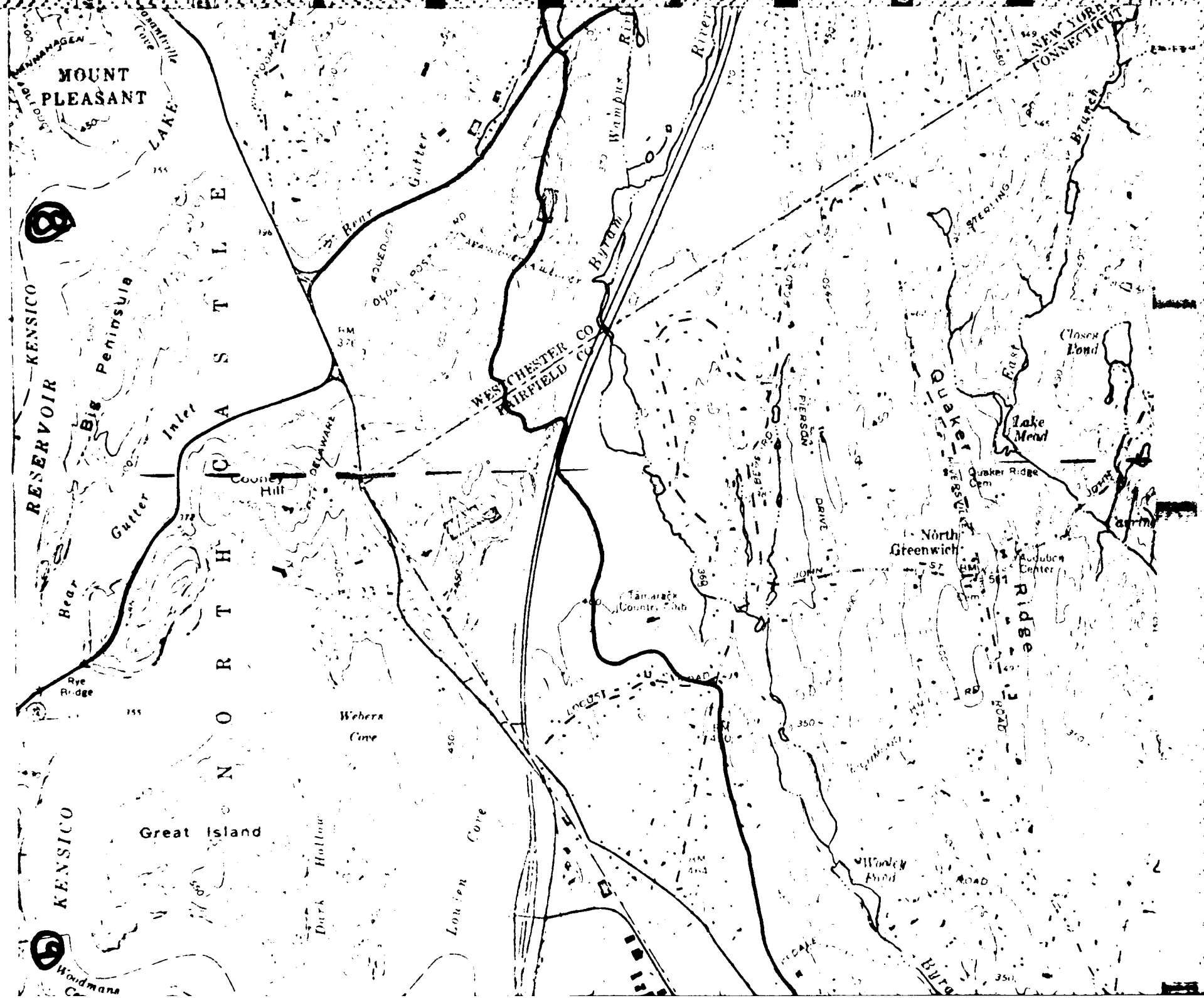

4
nage Area
Limit Of Impact Ar
Pemberwick Dam
Glenville
Riverville
Toll Gate Pond
RIVERSVILLE
RIVER
Wilson Pond
FAIRFIELD CO.
WESTCHESTER CO.
Convent of the Sacred Heart
Brook
LINCOLN
AVENUE

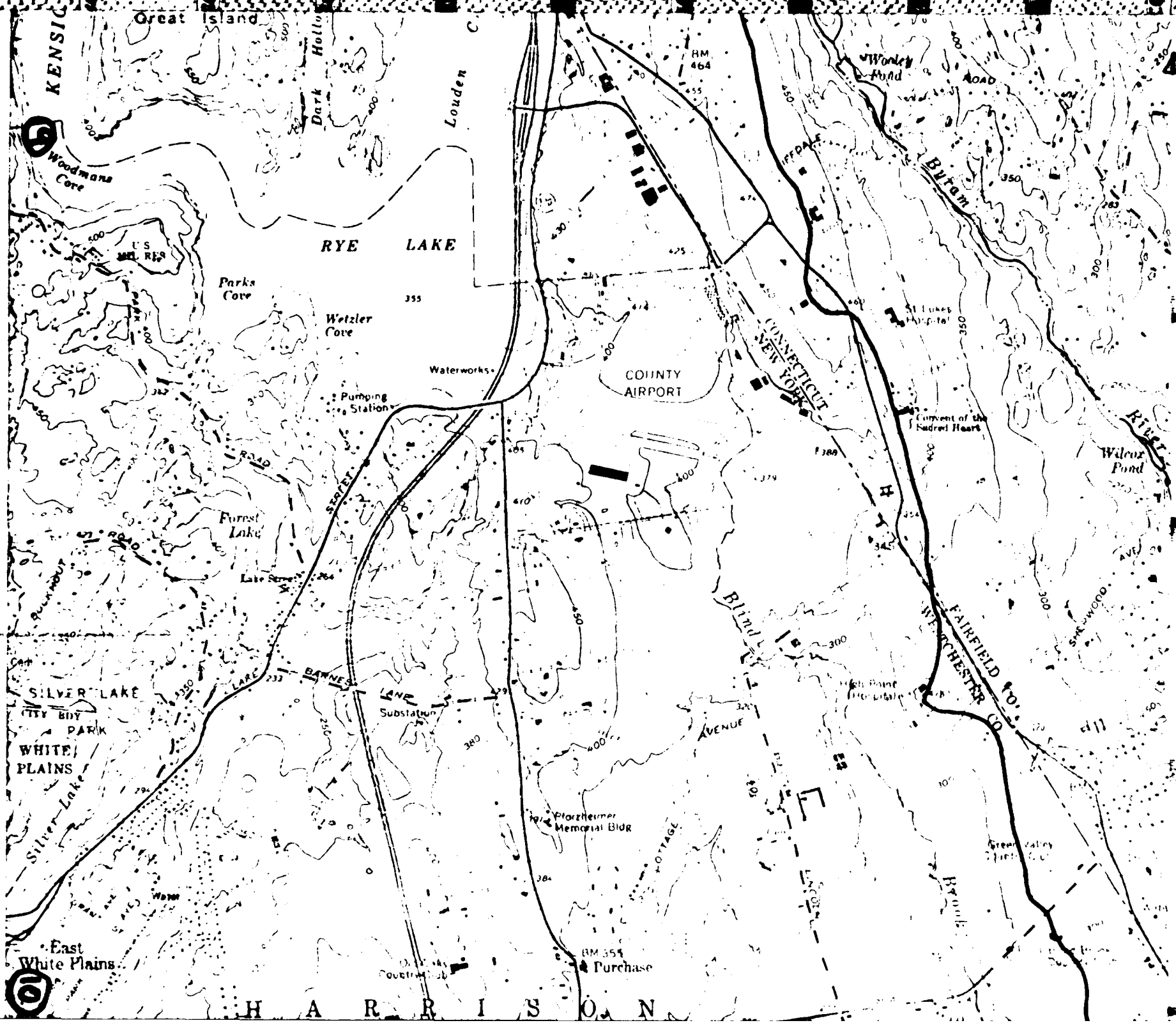


Area
Pemberwick
Greenwich
RYE
PORT CHESTER
Byram
Belle Haven
Byram Harbor
Field Pt
Wilson Head
Otter Rocks
Tidal Flat
Farwells
Game Cock I
Shore
INTERCHANGE
Blind Brook
Temple Knesses Tifereth Israel
King Street Sch
Lyon Park
Park Ave Sch
High Sch
Memorial Park
Courthouse
Edison Sch
Sacred Heart Sch
New Lebanon Sch
Hamilton Ave Sch
Hyram Sch
Haithrock Sch
Sewage Disposal
Cem
Port Office
Sta
NEW YORK
NEW HAVEN
CONNECTICUT
RIVER
BYRAM

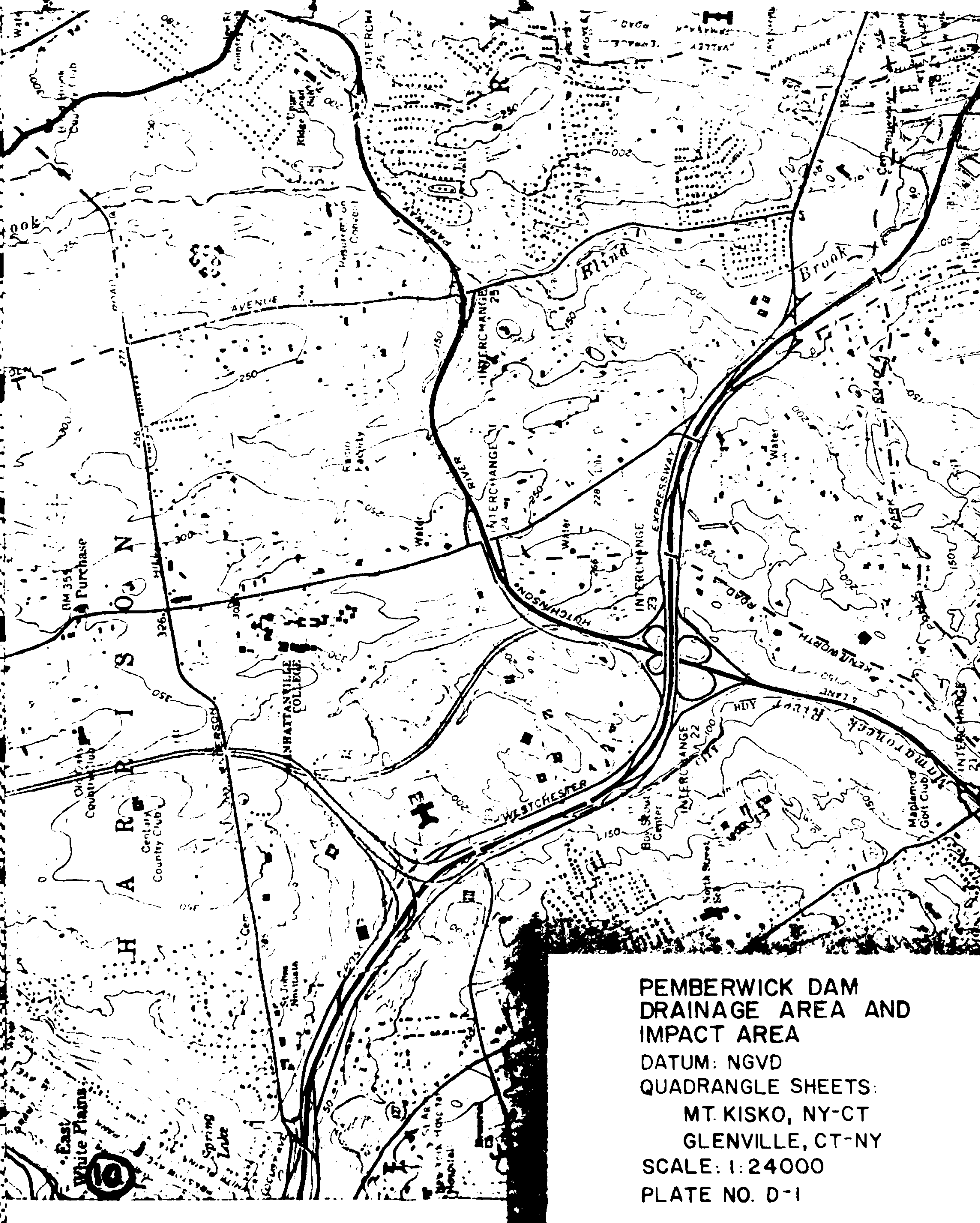

Lake Reservoir
Cognac Hill
Springs Farm
STREET
BYRAM
ROAD
TRIPP
ARMONK
The Grenadier
NEW CASTLE

Wampus Lake Reservoir
Wampus
Wampus Sch
Armonk
Armonk
Whippoorwill Sch
MOUNT PLEASANT
MOUNT PLEASANT
LAKE
NEW YORK
CONNECTICUT
N O R T H
River


MOUNT PLEASANT
LAKE
KENSICO
RESERVOIR
Big Peninsula
Inlet
Bear Gutter
Bear Gutter
NORTH CASTLE
Cooney Hill
Rye Bridge
Great Island
KENSICO
Webers Cove
Dark Hollow
Louden Cove
Woodmans
WESTCHESTER CO
FAIRFIELD CO
Byram River
Wampus River
NEW YORK
CONNECTICUT
Branch
East
Closes Pond
Lake Mead
Quaker Ridge
Quaker Ridge Cem
North Greenwich
Audubon Center
Tamarack Country Club
PIERSON DRIVE
LOCUST ROAD
Wooley Pond
ROAD
Byram



Great Island
KENSIC
Dark Hollow
Louden C
Woodmans Cove
RYE LAKE
U S MIL RES
Parks Cove
Wetzler Cove
Waterworks
Pumping Station
COUNTY AIRPORT
CONNECTICUT
NEW YORK
Wooley Pond
ROAD
Byram
River
St Lukes Hospital
Convent of the Sacred Heart
Wilcox Pond
Forest Lake
Lake Street
ROAD
STREET
BUCKHOUT
Blind
FAIRFIELD CO
WESTCHESTER CO
SHERWOOD
AVE
High Point Hospitale
SILVER LAKE
CITY BDY
PARK
WHITE PLAINS
Silver Lake
LAKE
BARNES
LANE
Substation
AVENUE
Pforzheimer Memorial Bldg
COTTAGE
Green Valley
Brook
East White Plains
BM 355
Purchase
H A R R I S O N



PEMBERWICK DAM
DRAINAGE AREA AND
IMPACT AREA
DATUM: NGVD
QUADRANGLE SHEETS:
MT. KISKO, NY-CT
GLENVILLE, CT-NY
SCALE: 1:24000
PLATE NO. D-1

```
12.00 60.............I.........................................................................
13.00 61.          IO        .         .         .         .         .         .         .         .         .         .
14.00 62.         I  .         .         .         .         .         .         .         .         .         .         .
15.00 63.        I   .         .         .         .         .         .         .         .         .         .         .
16.00 64.       I    .         .         .         .         .         .         .         .         .         .         .
17.00 65.      I     .         .         .         .         .         .         .         .         .         .         .
18.00 66.     IO     .         .         .         .         .         .         .         .         .         .         .
19.00 67.     I      .         .         .         .         .         .         .         .         .         .         .
20.00 68.    I       .         .         .         .         .         .         .         .         .         .         .
21.00 69.    I       .         .         .         .         .         .         .         .         .         .         .
22.00 70..IO.........................................................................................
23.00 71. I          .         .         .         .         .         .         .         .         .         .         .
 0.00 72. I          .         .         .         .         .         .         .         .         .         .         .
 1.00 73. I          .         .         .         .         .         .         .         .         .         .         .
 2.00 74.I           .         .         .         .         .         .         .         .         .         .         .
 3.00 75.I           .         .         .         .         .         .         .         .         .         .         .
```

HYDROLOGIC AND HYDRAULIC ANALYSIS
SUMMARY SHEET

Dam Pemberwick Dam

Test Flood PMF

INFLOW HYDROGRAPH DEVELOPMENT

Drainage Area 26.2 sq. mi.

Probable Maximum Precipation
24 hour - 200 square mile PMP 22 inches

Initial Railfall Loss 0 Inch
Uniform Railfall loss .1 Inch

Snyder's Lag 7.31 hours
Snyder's Peaking Coefficient .625

Test Flood Inflow 25600 CFS

PMF Inflow 25600 CFS

RESERVOIR ROUTING AND DAM OVERTOPPING

Test Flood Outflow 25600 CFS

Spillway Capacity at Top of Dam 1100 CFS
4 % of Test Flood

Flow Over Spillway at Test Flood 15800 CFS

Spillway Crest Elevation 76.5 Feet
Top of Dam Elevation 80.0 Feet
Test Flood Elevation 97.0 Feet

FINAL

```
*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
*********************************
    1              A1      DAM SAFETY ANALYSIS-JOB NO. 79-905/02-ERJ
    2              A2      PEMBERWICK DAM-GREENWICH-CONN
    3              A3      12-05-79
    4              B     75       1       0       0       0       0       0       2       0       0
    5              B1     5
    6              J      1       2       1
    7              J1    .5      1.       0       0       0       0       0       0       0
    8              K      0       1       0       0       0       0       1       0
    9              K1      COMPUTATION OF PMF-DEVELOPMENT OF INFLOW HYDROGRAPH
   10              M      1       1    26.2       0    26.2       0       0       0       1
   11              P      0      22     100     114     124     132
   12              T      0       0       0       0       0       0       0      .1
   13              W   7.31    .625
   14              X    1.5     .05     2.0
   15              K      1       1       0       0       0       0       1
   16              K1      ROUTING INFLOW HYDROGRAPH THRU LAKE-OVERTOPPING ANALYSIS
   17              Y      0       0       0       1       1
   18              Y1     1       0       0       0       0       0      -1       0
   19              $A   5.5     8.5    11.5
   20              $E  76.5      85      95
   21              $$  76.5      63     2.7     1.5
   22              $D  80.0     2.7     1.5      52
   23              K     99
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

```
RUNOFF HYDROGRAPH AT          1
ROUTE HYDROGRAPH TO           1
END OF NETWORK
```

```
*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
*********************************

RUN  DATE0 12/06/79.
     TIME0 15.04.40.


                    DAM SAFETY ANALYSIS-JOB NO. 79-905/02-ERJ
                    PEMBERWICK DAM-GREENWICH-CONN
                    12-05-79

                                  JOB SPECIFICATION
          NQ     NHR    NMIN    IDAY     IHR    IMIN   METRC    IPLT    IPRT   NSTAN
          75       1       0       0       0       0       0       2       0       0
                                JOPER     NWT   LROPT   TRACE
                                    5       0       0       0


                          MULTI-PLAN ANALYSES TO BE PERFORMED
                              NPLAN= 1 NRTIO= 2 LRTIO= 1
           RTIOS=    .50   1.00


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

                              SUB-AREA RUNOFF COMPUTATION

              COMPUTATION OF PMF-DEVELOPMENT OF INFLOW HYDROGRAPH

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

                                  HYDROGRAPH DATA
          IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
              1       1   26.20    0.00   26.20    0.00   0.000       0       1       0

                                    PRECIP DATA
                  SPFE     PMS      R6     R12     R24     R48     R72     R96
                  0.00   22.00  100.00  114.00  124.00  132.00    0.00    0.00
TRSPC COMPUTED BY THE PROGRAM IS  .831

                                    LOSS DATA
       LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
           0    0.00    0.00    1.00    0.00    0.00    1.00    0.00     .10    0.00    0.00

                                  UNIT HYDROGRAPH DATA
                              TP=  7.31    CP= .63    NTA=  0

                                  RECESSION DATA
                        STRTQ=    1.50    QRCSN=     .05    RTIOR= 2.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 8.40 AND R= 6.66 INTERVALS

          UNIT HYDROGRAPH 40 END-OF-PERIOD ORDINATES, LAG=   7.28 HOURS, CP=  .63  VOL= 1.00
       69.      253.      505.      789.     1073.     1300.     1435.     1472.     1379.     1204.
     1036.      891.      767.      660.      568.      488.      420.      362.      311.      268.
```

1.01	1.00	1	.01	0.00	.01	1.
1.01	2.00	2	.01	0.00	.01	1.
1.01	3.00	3	.01	0.00	.01	1.
1.01	4.00	4	.01	0.00	.01	1.
1.01	5.00	5	.01	0.00	.01	1.
1.01	6.00	6	.01	0.00	.01	1.
1.01	7.00	7	.03	0.00	.03	1.
1.01	8.00	8	.03	0.00	.03	1.
1.01	9.00	9	.03	0.00	.03	1.
1.01	10.00	10	.03	0.00	.03	1.
1.01	11.00	11	.03	0.00	.03	1.
1.01	12.00	12	.03	0.00	.03	1.
1.01	13.00	13	.12	.02	.10	2.
1.01	14.00	14	.14	.04	.10	8.
1.01	15.00	15	.18	.08	.10	25.
1.01	16.00	16	.45	.35	.10	79.
1.01	17.00	17	.17	.07	.10	184.
1.01	18.00	18	.13	.03	.10	324.
1.01	19.00	19	.01	0.00	.01	478.
1.01	20.00	20	.01	0.00	.01	627.
1.01	21.00	21	.01	0.00	.01	743.
1.01	22.00	22	.01	0.00	.01	809.
1.01	23.00	23	.01	0.00	.01	820.
1.02	0.00	24	.01	0.00	.01	771.
1.02	1.00	25	.12	.02	.10	686.
1.02	2.00	26	.12	.02	.10	600.
1.02	3.00	27	.12	.02	.10	529.
1.02	4.00	28	.12	.02	.10	475.
1.02	5.00	29	.12	.02	.10	437.
1.02	6.00	30	.12	.02	.10	413.
1.02	7.00	31	.43	.33	.10	420.
1.02	8.00	32	.43	.33	.10	490.
1.02	9.00	33	.43	.33	.10	641.
1.02	10.00	34	.43	.33	.10	879.
1.02	11.00	35	.43	.33	.10	1204.
1.02	12.00	36	.43	.33	.10	1598.
1.02	13.00	37	1.83	1.73	.10	2130.
1.02	14.00	38	2.19	2.09	.10	2957.
1.02	15.00	39	2.74	2.64	.10	4215.
1.02	16.00	40	6.95	6.85	.10	6299.
1.02	17.00	41	2.56	2.46	.10	9448.
1.02	18.00	42	2.01	1.91	.10	13345.
1.02	19.00	43	.18	.08	.10	17492.
1.02	20.00	44	.18	.08	.10	21305.
1.02	21.00	45	.18	.08	.10	24138.
1.02	22.00	46	.18	.08	.10	25583.
1.02	23.00	47	.18	.08	.10	25577.
1.03	0.00	48	.18	.08	.10	24155.
1.03	1.00	49	0.00	0.00	0.00	21792.
1.03	2.00	50	0.00	0.00	0.00	19171.
1.03	3.00	51	0.00	0.00	0.00	16676.
1.03	4.00	52	0.00	0.00	0.00	14469.
1.03	5.00	53	0.00	0.00	0.00	12537.
1.03	6.00	54	0.00	0.00	0.00	10843.
1.03	7.00	55	0.00	0.00	0.00	9358.
1.03	8.00	56	0.00	0.00	0.00	8059.
1.03	9.00	57	0.00	0.00	0.00	6934.
1.03	10.00	58	0.00	0.00	0.00	5966.
1.03	11.00	59	0.00	0.00	0.00	5133.
1.03	12.00	60	0.00	0.00	0.00	4417.
1.03	13.00	61	0.00	0.00	0.00	3800.
1.03	14.00	62	0.00	0.00	0.00	3270.
1.03	15.00	63	0.00	0.00	0.00	2813.
1.03	16.00	64	0.00	0.00	0.00	2420.
1.03	17.00	65	0.00	0.00	0.00	2082.
1.03	18.00	66	0.00	0.00	0.00	1791.
1.03	19.00	67	0.00	0.00	0.00	1541.
1.03	20.00	68	0.00	0.00	0.00	1326.
1.03	21.00	69	0.00	0.00	0.00	1140.
1.03	22.00	70	0.00	0.00	0.00	981.
1.03	23.00	71	0.00	0.00	0.00	840.
1.04	0.00	72	0.00	0.00	0.00	719.
1.04	1.00	73	0.00	0.00	0.00	615.
1.04	2.00	74	0.00	0.00	0.00	525.
1.04	3.00	75	0.00	0.00	0.00	448.
		SUM	24.14	20.86	3.28	349564.
			(613.)	(530.)	(83.)	(9898.55)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	25583.	23580.	13076.	4852.	349342.
CMS	724.	668.	370.	137.	9892.
INCHES		8.37	18.57	20.67	20.67
MM		212.65	471.69	525.08	525.08
AC-FT		11693.	25936.	28871.	28871.
THOUS CU M		14423.	31992.	35612.	35612.

```
*OMF*
                                    STATION     1

                    INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)
        0.     4000.     8000.    12000.    16000.    20000.    24000.    28000.        0.        0.        0.        0.        0.
                                                                                                   PRECIP(L) AND EXCESS(X)
        0.        0.        0.        0.        0.        0.        0.        0.        8.        6.        4.        2.        0.
  1.00  1I         .         .         .         .         .         .         .         .         .         .         .         L
  2.00  2I         .         .         .         .         .         .         .         .         .         .         .         L
  3.00  3I         .         .         .         .         .         .         .         .         .         .         .         L
  4.00  4I         .         .         .         .         .         .         .         .         .         .         .         L
  5.00  5I         .         .         .         .         .         .         .         .         .         .         .         L
  6.00  6I         .         .         .         .         .         .         .         .         .         .         .         L
  7.00  7I         .         .         .         .         .         .         .         .         .         .         .         L
  8.00  8I         .         .         .         .         .         .         .         .         .         .         .         L
  9.00  9I         .         .         .         .         .         .         .         .         .         .         .         L
 10.00 10I.........................................................................................................................L
 11.00 11I         .         .         .         .         .         .         .         .         .         .         .         L
 12.00 12I         .         .         .         .         .         .         .         .         .         .         .         L
 13.00 13I         .         .         .         .         .         .         .         .         .         .         .        LX
 14.00 14I         .         .         .         .         .         .         .         .         .         .         .        LX
 15.00 15I         .         .         .         .         .         .         .         .         .         .         .        LX
 16.00 16I         .         .         .         .         .         .         .         .         .         .         .       LXX
 17.00 17I         .         .         .         .         .         .         .         .         .         .         .        LX
 18.00 18.I        .         .         .         .         .         .         .         .         .         .         .        LX
 19.00 19.I        .         .         .         .         .         .         .         .         .         .         .         L
 20.00 20..I.......................................................................................................................L
 21.00 21. I       .         .         .         .         .         .         .         .         .         .         .         L
 22.00 22. I       .         .         .         .         .         .         .         .         .         .         .         L
 23.00 23. I       .         .         .         .         .         .         .         .         .         .         .         L
  0.00 24. I       .         .         .         .         .         .         .         .         .         .         .         L
  1.00 25. I       .         .         .         .         .         .         .         .         .         .         .        LX
  2.00 26. I       .         .         .         .         .         .         .         .         .         .         .        LX
  3.00 27.I        .         .         .         .         .         .         .         .         .         .         .        LX
  4.00 28.I        .         .         .         .         .         .         .         .         .         .         .        LX
  5.00 29.I        .         .         .         .         .         .         .         .         .         .         .        LX
  6.00 30.I.........................................................................................................................LX
  7.00 31.I        .         .         .         .         .         .         .         .         .         .         .       LXX
  8.00 32.I        .         .         .         .         .         .         .         .         .         .         .       LXX
  9.00 33. I       .         .         .         .         .         .         .         .         .         .         .       LXX
 10.00 34. I       .         .         .         .         .         .         .         .         .         .         .       LXX
 11.00 35.  I      .         .         .         .         .         .         .         .         .         .         .       LXX
 12.00 36.   I     .         .         .         .         .         .         .         .         .         .         .       LXX
 13.00 37.    I    .         .         .         .         .         .         .         .         .         .         .LXXXXXXXXX
 14.00 38.      I  .         .         .         .         .         .         .         .         .         .       LXXXXXXXXXXX
 15.00 39.         .I        .         .         .         .         .         .         .         .         .    LXXXXXXXXXXXXXX
 16.00 40.................I.........................................................LXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 17.00 41.         .         .   I     .         .         .         .         .         .         .         .     LXXXXXXXXXXXXX
 18.00 42.         .         .         .  I      .         .         .         .         .         .         .        LXXXXXXXXXX
 19.00 43.         .         .         .         .   I     .         .         .         .         .         .         .        LX
 20.00 44.         .         .         .         .         .  I      .         .         .         .         .         .        LX
 21.00 45.         .         .         .         .         .         I         .         .         .         .         .        LX
 22.00 46.         .         .         .         .         .         .   I     .         .         .         .         .        LX
 23.00 47.         .         .         .         .         .         .   I     .         .         .         .         .        LX
  0.00 48.         .         .         .         .         .         I         .         .         .         .         .        LX
  1.00 49.         .         .         .         .         .   I     .         .         .         .         .         .         L
  2.00 50.........................................I.........................................................................L
  3.00 51.         .         .         .         . I       .         .         .         .         .         .         .         L
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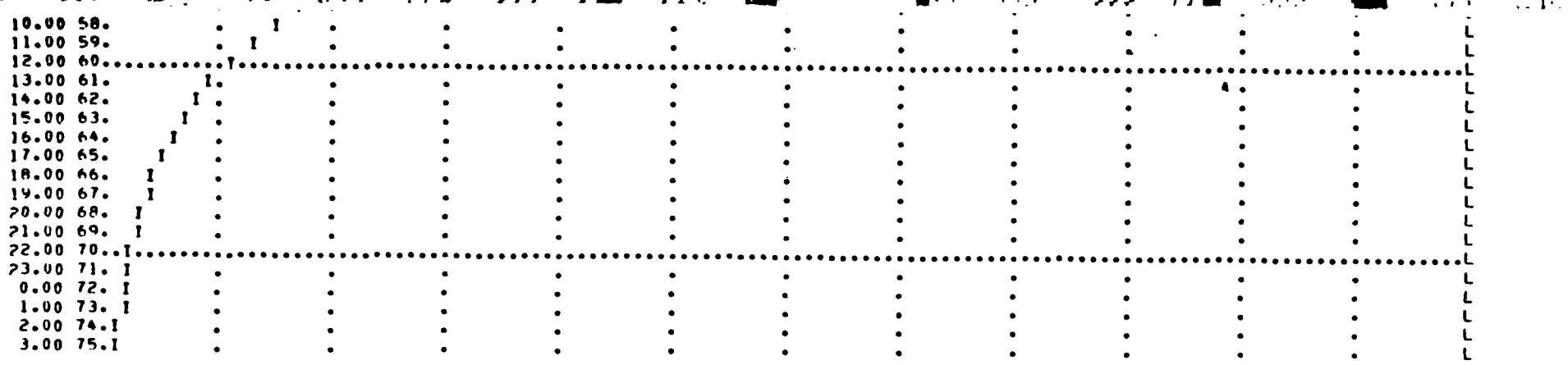
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20.00 68.
21.00 69.
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23.00 71.
0.00 72.
1.00 73.
2.00 74.
3.00 75.

OVN

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

1.	1.	1.	1.	1.	0.	0.	0.	0.	0.
0.	0.	1.	4.	13.	40.	92.	162.	239.	314.
372.	405.	410.	386.	343.	300.	265.	238.	219.	206.
210.	245.	320.	439.	602.	799.	1065.	1478.	2107.	3150.
4724.	6673.	8746.	10652.	12069.	12791.	12789.	12077.	10896.	9586.
8338.	7234.	6268.	5421.	4679.	4029.	3467.	2983.	2567.	2208.
1900.	1635.	1407.	1210.	1041.	896.	770.	663.	570.	490.
420.	360.	308.	263.	224.					

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	12791.	11790.	6538.	2426.	174671.
CMS	362.	334.	185.	69.	4946.
INCHES		4.19	9.29	10.34	10.34
MM		106.33	235.85	262.54	262.54
AC-FT		5846.	12968.	14435.	14436.
THOUS CU M		7211.	15996.	17806.	17806.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 2

1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	2.	8.	25.	79.	184.	324.	478.	627.
743.	809.	820.	771.	686.	600.	529.	475.	437.	413.
420.	490.	641.	879.	1204.	1598.	2130.	2957.	4215.	6299.
9448.	13345.	17492.	21305.	24138.	25583.	25577.	24155.	21792.	19171.
16076.	14469.	12537.	10843.	9358.	8059.	6934.	5966.	5133.	4417.
3800.	3270.	2813.	2420.	2082.	1791.	1541.	1326.	1140.	981.
840.	719.	615.	525.	448.					

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	25583.	23580.	13076.	4852.	349342.
CMS	724.	668.	370.	137.	9892.
INCHES		8.37	18.57	20.67	20.67
MM		212.65	471.69	525.07	525.08
AC-FT		11693.	25936.	28871.	28871.
THOUS CU M		14423.	31992.	35612.	35612.

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

HYDROGRAPH ROUTING

ROUTING INFLOW HYDROGRAPH THRU LAKE-OVERTOPPING ANALYSIS

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

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

SURFACE AREA= 6. 9. 12.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
76.5	63.0	2.7	1.5	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
80.0	2.7	1.5	52.

STATION 1, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	1.	6.	24.	69.	139.	219.	296.
360.	399.	411.	393.	353.	310.	273.	244.	223.	209.
208.	234.	300.	410.	567.	761.	1014.	1413.	2031.	3026.
4567.	6500.	8582.	10515.	11982.	12761.	12812.	12153.	10996.	9687.
8433.	7318.	6344.	5489.	4740.	4084.	3516.	3026.	2605.	2243.
1931.	1663.	1433.	1235.	1067.	920.	792.	682.	587.	506.
434.	372.	319.	273.	233.					

STORAGE

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	1.	2.	3.	5.	7.	8.
9.	10.	10.	10.	9.	9.	8.	7.	7.	7.
6.	7.	8.	10.	13.	16.	20.	25.	30.	39.
50.	64.	78.	90.	100.	104.	105.	101.	93.	85.
77.	70.	63.	57.	52.	47.	43.	39.	35.	32.
30.	27.	25.	23.	21.	18.	17.	15.	13.	12.
11.	10.	9.	8.	7.					

STAGE

76.5	76.5	76.5	76.5	76.5	76.5	76.5	76.5	76.5	76.5
76.5	76.5	76.5	76.5	76.6	76.8	77.1	77.4	77.7	77.9
78.1	78.3	78.3	78.2	78.1	78.0	77.9	77.8	77.7	77.6
77.6	77.7	78.0	78.3	78.7	79.2	79.8	80.5	81.3	82.5
84.0	85.6	87.1	88.5	89.4	89.9	90.0	89.5	88.8	87.9
87.0	86.2	85.5	84.8	84.1	83.5	83.0	82.5	82.0	81.6
81.2	80.9	80.5	80.2	79.9	79.6	79.3	79.0	78.8	78.6
78.4	78.2	78.0	77.9	77.7					

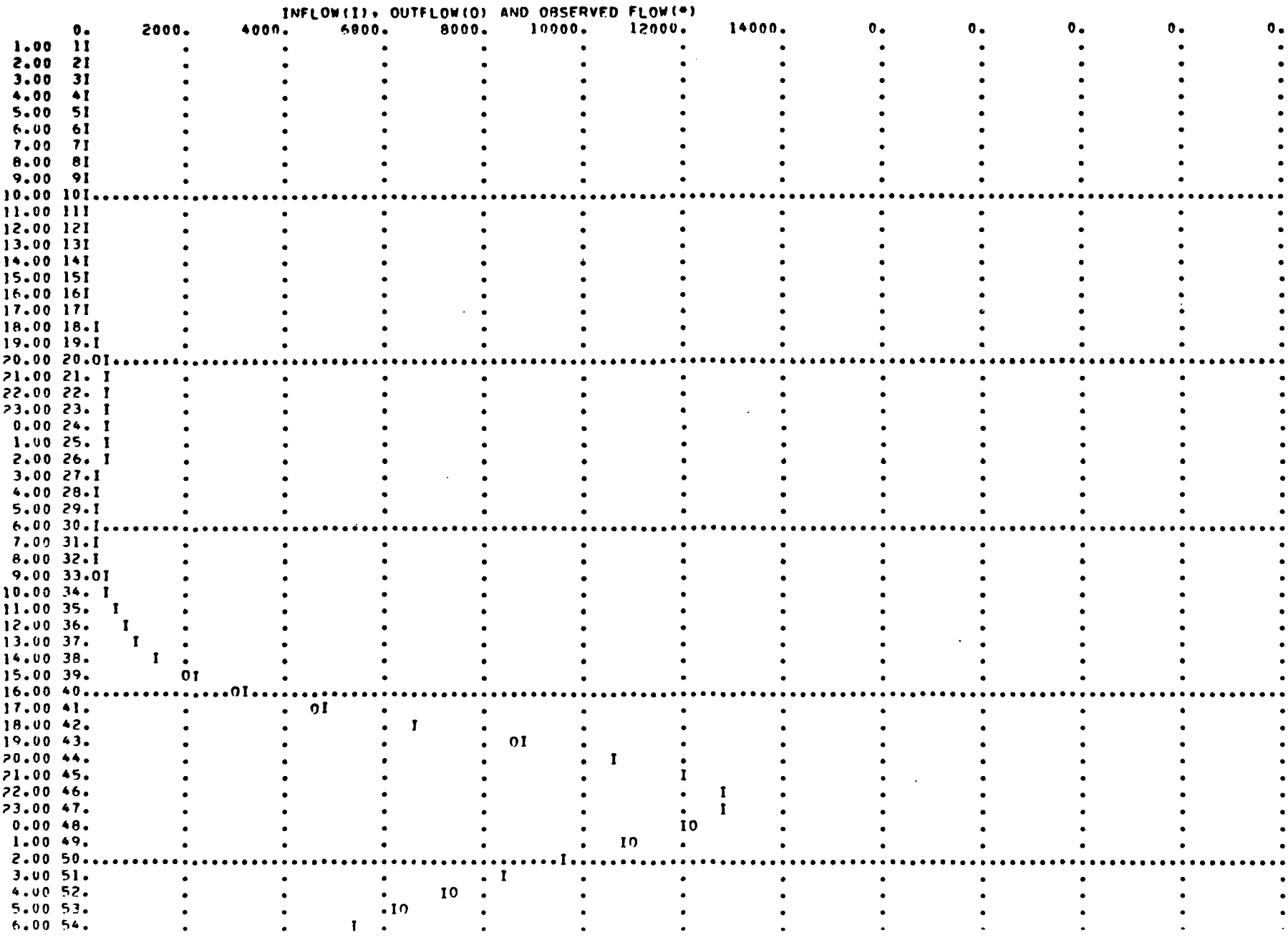
PEAK OUTFLOW IS 12812. AT TIME 47.00 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	12812.	11801.	6537.	2425.	174586.
CMS	363.	334.	185.	69.	4944.
INCHES		4.19	9.28	10.33	10.33
MM		106.42	235.80	262.41	262.41
AC-FT		5852.	12965.	14429.	14429.
THOUS CU M		7218.	15993.	17797.	17797.

OVF

STATION 1

INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)



OVN

STATION 1, PLAN 1, RATIO 2

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	3.	14.	53.	148.	288.	445.	599.
724.	800.	821.	784.	703.	616.	542.	485.	444.	417.
416.	471.	606.	830.	1144.	1551.	2062.	2863.	4083.	6085.
9165.	13037.	17186.	21047.	23971.	25524.	25622.	24302.	21982.	19363.
16852.	14622.	12674.	10964.	9468.	8156.	7020.	6042.	5200.	4476.
3852.	3316.	2854.	2457.	2116.	1822.	1569.	1351.	1165.	1008.
864.	740.	634.	542.	464.					

STORAGE

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	1.	3.	5.	8.	11.	14.
16.	17.	17.	16.	15.	14.	13.	12.	11.	11.
11.	11.	14.	17.	22.	26.	31.	37.	47.	61.
82.	106.	131.	155.	172.	182.	182.	174.	160.	145.
129.	116.	104.	93.	84.	75.	68.	61.	55.	50.
45.	41.	37.	34.	31.	29.	26.	24.	22.	20.
18.	16.	14.	13.	11.					

STAGE

76.5	76.5	76.5	76.5	76.5	76.5	76.5	76.5	76.5	76.5
76.5	76.5	76.5	76.6	76.7	77.0	77.4	77.9	78.4	78.8
79.1	79.3	79.4	79.3	79.1	78.9	78.7	78.5	78.4	78.3
78.3	78.5	78.8	79.4	80.1	80.7	81.4	82.3	83.5	85.2
87.6	90.1	92.6	94.7	96.2	96.9	97.0	96.3	95.2	93.8
92.4	91.1	89.9	88.8	87.8	86.8	86.0	85.2	84.5	83.9
83.3	82.8	82.3	81.8	81.4	81.1	80.7	80.4	80.1	79.8
79.5	79.2	78.9	78.7	78.5					

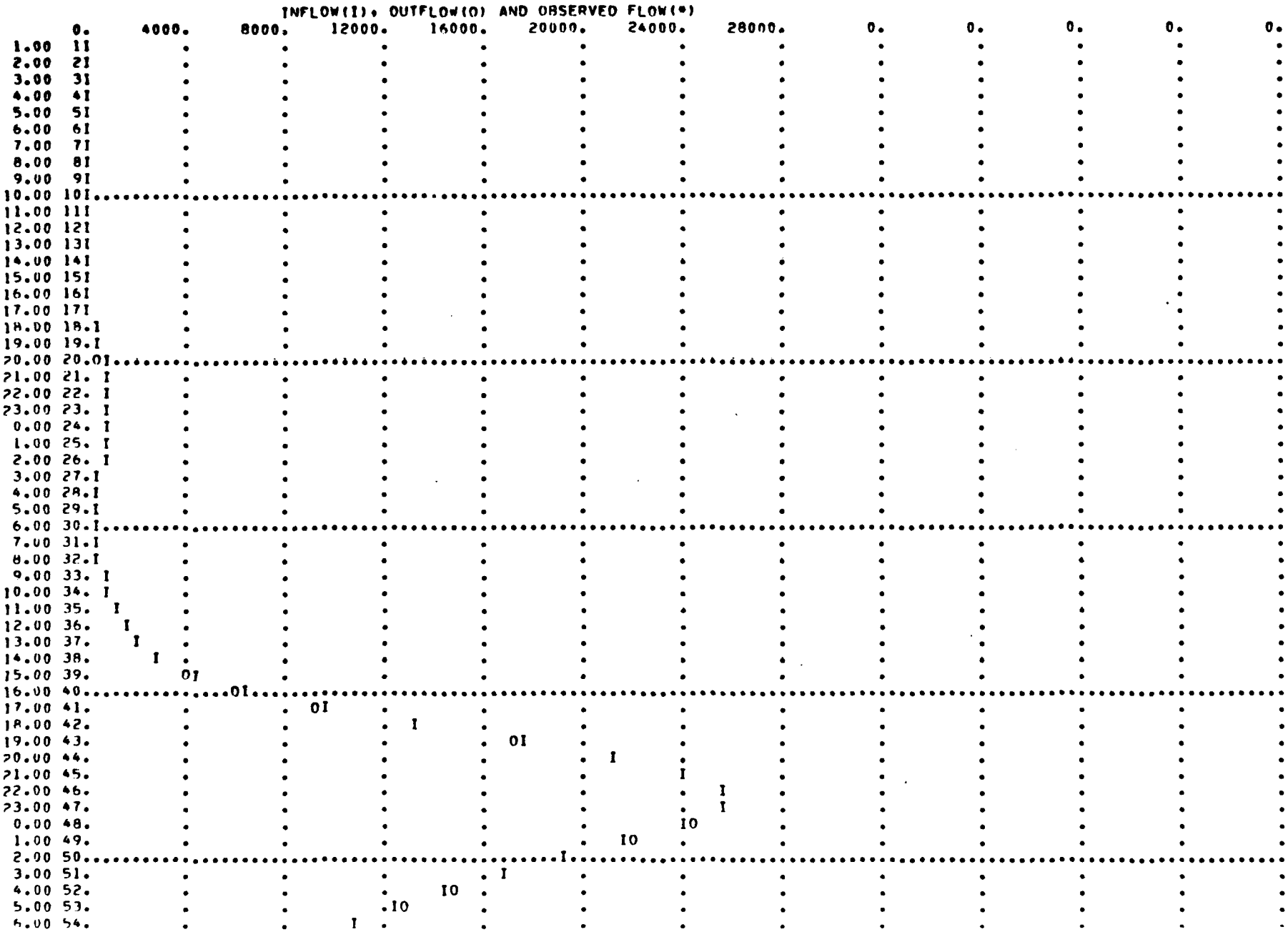
PEAK OUTFLOW IS 25622. AT TIME 47.00 HOURS

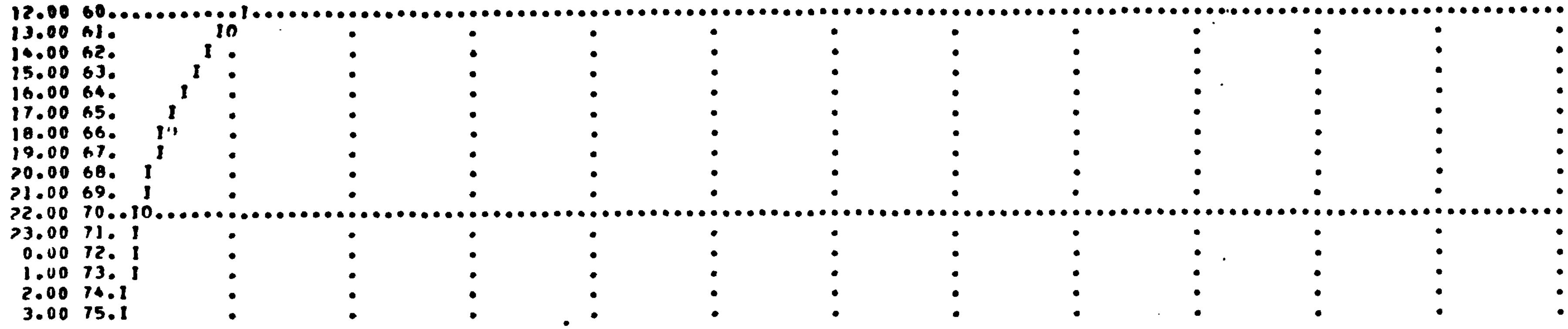
	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	25622.	23601.	13074.	4850.	349205.
CMS	726.	668.	370.	137.	9888.
INCHES		8.38	18.57	20.66	20.66
MM		212.84	471.63	524.87	524.87
AC-FT		11703.	25932.	28860.	28860.
THOUS CU M		14435.	31987.	35598.	35598.

OVF

STATION 1

INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)

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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY 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	RATIOS APPLIED TO FLOWS RATIO 1 .50	RATIO 2 1.00
HYDROGRAPH AT	1	26.20	1	12791.	25583.
	(	67.86)	(	362.21)(	724.42)(
ROUTED TO	1	26.20	1	12812.	25622.
	(	67.86)	(	362.79)(	725.52)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	76.50	76.50	80.00
STORAGE	0.	0.	21.
OUTFLOW	0.	0.	1114.

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
.50	89.96	9.96	105.	12812.	27.00	47.00	0.00
1.00	97.00	17.00	182.	25622.	35.00	47.00	0.00

A. Size Classification

Height of dam = 45 ft.; hence intermediate

Storage capacity at top of dam (elev. 80.0) = 60 AC-FT.; hence small

Adopted size classification intermediate

B.i) Hazard Potential

This dam is located upstream of Pemberwick, an urbanized area. Residential homes are located along the downstream channel. Mead School and a commercial building also are located along the channel.

ii) Impact of Failure of Dam at Maximum Pool (Top of Dam)

It is estimated from the "rule of thumb" failure hydrograph, that the following adverse impacts are a possibility by the failure of this dam.

a) Loss of homes Over 5;
b) Loss of buildings 1-2;
c) Loss of highways or roads None;
d) Loss of bridges None;

The failure profile can affect a distance of 3000 feet from the dam.

C. Hazard Potential Classifications

HAZARD	SIZE	TEST FLOOD RANGE
High	Intermediate	PMF

Adopted Test Flood = PMF = 1010 CSM

= 26500 CFS

D. Overtopping Potential

Drainage Area 16,777 Acres = 26.2 sq. miles

Spillway crest elevation = 76.5 NGVD

Top of Dam Elevation = 80.0 NGVD

Maximum spillway discharge

Capacity without overtopping of dam = 1100 CFS
"test flood" inflow discharge = 26500 CFS
"test flood" outflow discharge = 26500 CFS

PEMBERWICK DAM

Dam Failure Analysis

1. Failure discharge with pool at top of dam (elev. 80.0) = 8350 CFS
2. Depth of water in reservoir at time of failure = 36 ft.
3. Maximum depth of flow downstream of dam = 11.5 ft.
4. Water surface elevation just downstream of dam at time of failure) = 51.5 NGVD

The failure discharge of 8350 CFS will enter and flow downstream 3,000 feet until the brook enters a pond on Byram River. Valley storage in this 3,000 foot length of brook is substantial in reducing the discharge. Also due to roughness characteristics, obstructions and frictional losses, it is very likely that the unsteady dam failure flow will dissipate its wave and kinetic energy and thus convert to steady and uniform flow obeying Manning's formulae 3000 feet downstream. The failure profile will have the following hydraulic characteristics:

DISTANCE FROM THE DAM	WATER SURFACE ELEVATION NGVD	REMARKS
0'	80.0	Upstream of dam
0'	51.5	Downstream of dam
1000'	41.5	
2000'	31.5	
3000'	10.0	@ Pond

Beyond 3,000 feet _____ failure discharge will flow in the below given channel characteristics:

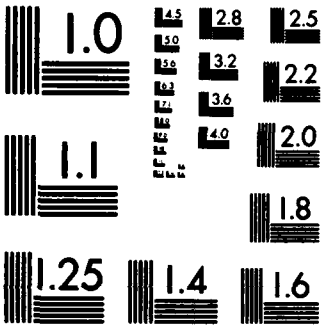
Q = 3158 CFS; S = .007

n = 0.05 ; b = 300 ; d = 3±

Side slopes = 1V or 2H.

AD-A142 702 NATIONAL DAM INSPECTION PROGRAM PEMBERWICK DAM (CT 00042) SOUTHWESTERN CO..(U) CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV FEB 80 2/2

UNCLASSIFIED FFG 13/13 NL



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

"Rule of Thumb Guidance for Estimating Downstream Dam Failure Analysis"

DATA

Name of Dam Pemberwick Dam

Location North of Pemberwick, CT.

Drainage Area 26.2 sq. mi., Top of Dam 80.0 NGVD

Spillway Type Overflow-broad crest, Crest of Spillway 76.5 NGVD

Surface Area @ Crest Elev. 5.5 Acres = .009 sq. mi.

Pool Bottom Near Dam = 44 ± NGVD

Assumed Side Slopes of Embankments = 1:1

Depth of Pool at Dam (Yo) = 36 Feet

Mid-Height Elev. 62 NGVD

Length of Dam at Crest = 115 Feet

Length of Dam at Mid-Height = 93 Feet

% of Dam Length at Mid-Height = W_b = 23 Feet

Step 1

Storage (S) at time of failure 60 Ac-FT
(Equal to top of dam)

Step 2

Peak Failure Discharge
$Q_{pl} = 8/27\ W_b \sqrt{g}\ Yo^{3/2}$

$= 1.68\ W_b\ Yo^{3/2} =$ 8346 cfs

Failure is assumed to coincide with pool elevation at top of dam.

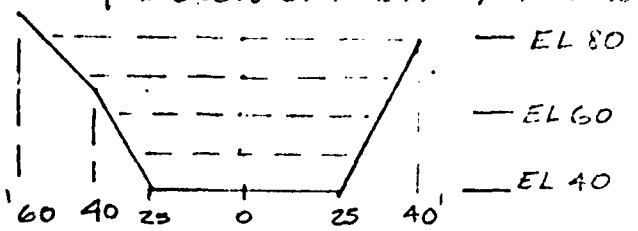
No Name Pond is located 3000 feet downstream of Pemberwick dam. There is a 35 foot drop into No Name pond which will cause the dissipation of wave and kinetic energy of the failure discharge. Approximately, the water surface elevations between Pemberwick dam and No Name pond will be as given on Dam Failure Analysis. The increase of depth in No Name pond due to failure of Pemberwick dam is estimated to be 1-2 feet.

BY FCB DATE 11/22/79 SUBJECT DAM INSPECTION STUDIES SHEET NO 1 OF 4
CHKD. BY ERJ DATE 1/15/80 JOB NO [illegible]

DOWNSTREAM W.S.E.L. COMPS

PEMBERWICK DAM

SECTION – 0+00 (DOWNSTREAM FACE OF DAM)



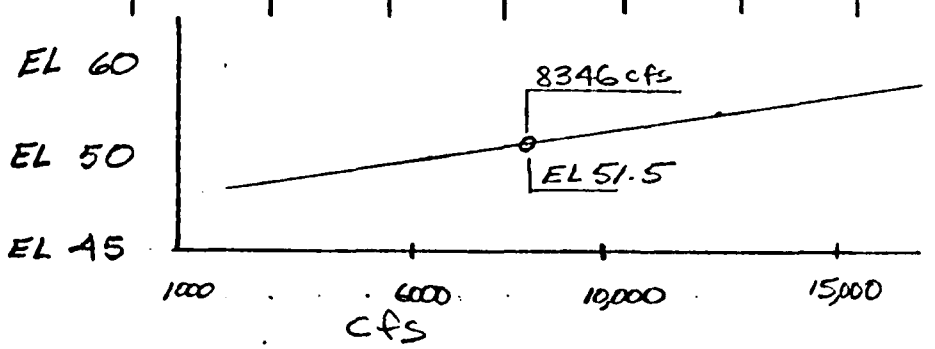
$n = .05$

$S = .01\,^1/_1$ $\quad Q_{P1} = 8346$ cfs

FIND DEPTH & STORAGE FOR Q_{P1}

$Q = 1.486/n \; A R^{2/3} S^{1/2}$

ELEV	AREA	WP	R	$R^{2/3}$	S	$S^{1/2}$	1.486	n	Q
60	1200	95	12.63	5.42	.01	0.1	29	.72	19,330
50	550	72	7.64	3.88	.01	0.1	29	.72	6340
55	875	83.5	10.48	4.79	.01	0.1	29	.72	12,454



DEPTH @ DOWNSTREAM FACE OF DAM EQUAL TO 11.5' OR EL 51.5

NEXT DOWNSTREAM SECTION AT 10+00

STORAGE DOES NOT CHANGE

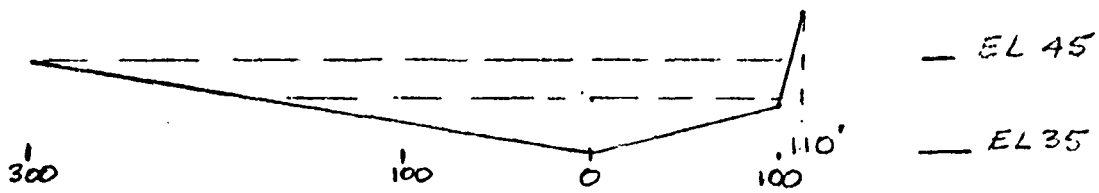
PURCELL ASSOCIATES

BY FCB DATE 11/27/79 SUBJECT DAM INSPECTION STUDIES SHEET NO 2 OF 4
CHKD. BY ERJ DATE 1/15/80 JOB NO 79-9[illegible]

DOWNSTREAM WSEL COMP'S

PEMBERWICK DAM

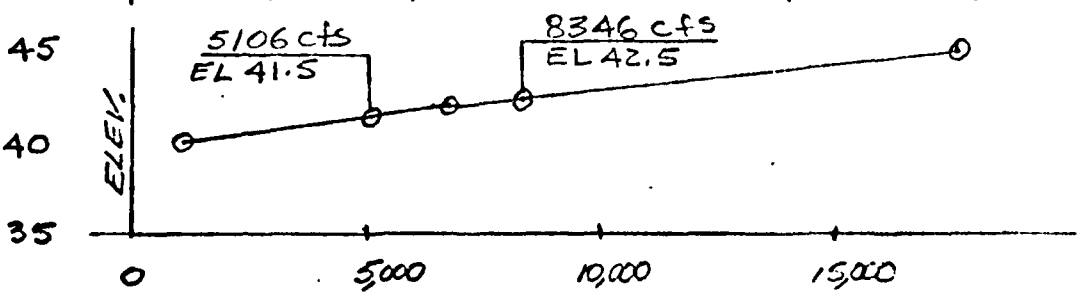
SECTION - 10+00 DOWNSTREAM OF DAM



$n = .05$

$S = .01^{1/1}$ $\quad QP_1 = 8346$ cfs

ELEV	AREA	WP	R	$R^{2/3}$	$S^{1/2}$	$1.486/n$	Q	DEPTH
EL 45	2025	405	5	2.92	.1	29.72	17,599	10'
EL 42	987	282	3.5	2.3	.1	29.72	6,762	7'
EL 40	500	200	2.5	1.84	.1	29.72	1093	5'



$V_1 = \frac{11.5+7.5}{2} \times \left(\frac{300+62}{2} \times 1000 \div 43560\right) \times 1/2 = 19.8$ Ac-ft. (4.16)

19.8 > 51 SECTION OK $\quad S = 51$

Q_{P2} (TRIAL) $= Q_{P1}\left(1 - V_1/S\right) = 5106$ cfs

$V_2 = \frac{11.5+6.5}{2} \times 4.16 \times 1/2 = 18.7$ Ac-ft

$Q_{P2} = Q_{P1}\left(1 - V_{AVE}/S\right) = 5196$ cfs

STAGE-DISCHARGE = 5196 WSEL = 41.5^t D = 6.5'

NEXT DOWNSTREAM SECTION AT 20+00

PURCELL ASSOCIATES

BY FCB DATE 11/27/79 SUBJECT DAM INSPECTION SHEET NO 3 OF 4
CHKD. BY ERJ DATE 1/15/80 STUDIES JOB NO 79-9[illegible]

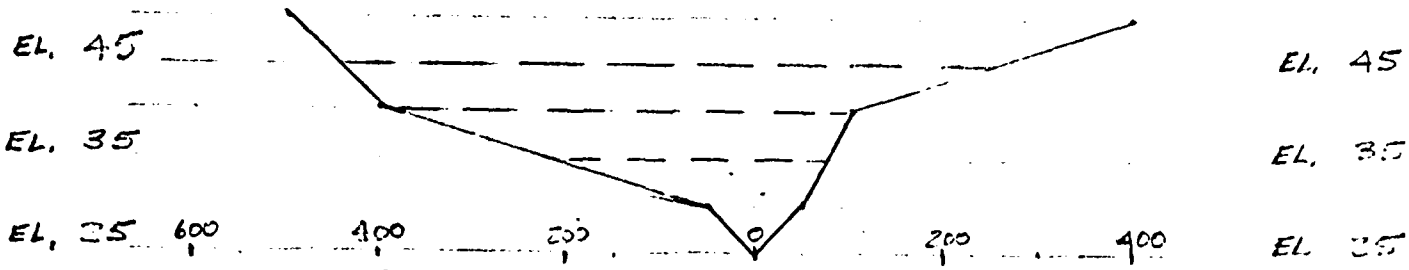
DOWNSTREAM W.S.EL. COMPUTATIONS

NAME OF DAM: PEMPERWICK

SECTION LOCATION: 20[illegible]' DOWNSTREAM OF DAM

USING : $Q = 1.486/n \, A \, R^{2/3} S^{1/2}$

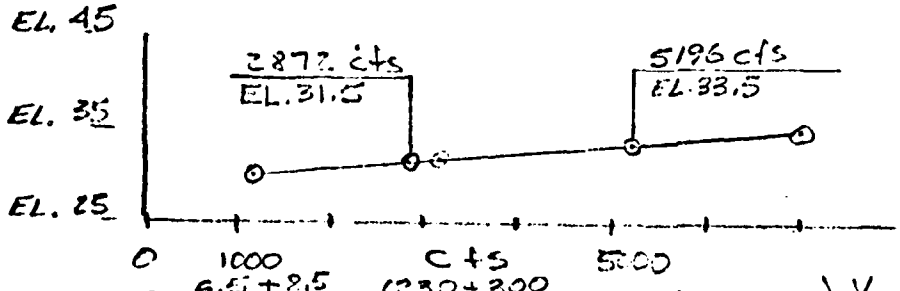
WHERE: $n = 0.05$ $S = \text{SLOPE} = 0.007^{1/1}$



CHANNEL SECTION

$Q_{P_1} = 5196$ cfs STORAGE (S) 51 Ac-ft.

ELEV	AREA	W.P.	R	$R^{2/3}$	$S^{1/2}$	1.486/n	Q	DEPTH
35	1188	325	3.66	2.37	.083	29.72	7001	10
40	1688	525	3.22	2.18	.083	29.72	9071	15
30	250	100	2.5	1.84	.083	29.72	1136	5



$V_1 = \frac{6.5+8.5}{2} \times \left(\frac{230+300}{2} \times 1000 \div 43{,}560\right) 1/2 = 22.8$ Ac-ft

Q_{P2} (TRIAL) $= Q_{P1}(1 - V_1/S) = 2872$ cfs

$V_2 = 6.5 \times \left(\frac{160+300}{2} \times 1000 \div 43{,}560\right) 1/2 = 17.2$ $V_{AVE} = 20.0$

$Q_{P2} = Q_{P1}\left(1 - \frac{V_{AVE}}{S}\right) = 3158$ cfs

STAGE DISCHARGE = 3158 cfs ELEV = 31.5 OR A D = 6.5'

NEXT DOWNSTREAM SECTION 1000 ft.

PURCELL ASSOCIATES

BY FCB DATE 11/27/77 SUBJECT DAM INSPECTION STUDIES SHEET NO 4 OF 4
CHKD. BY ERJ DATE 1/15/80 JOB NO 79-905

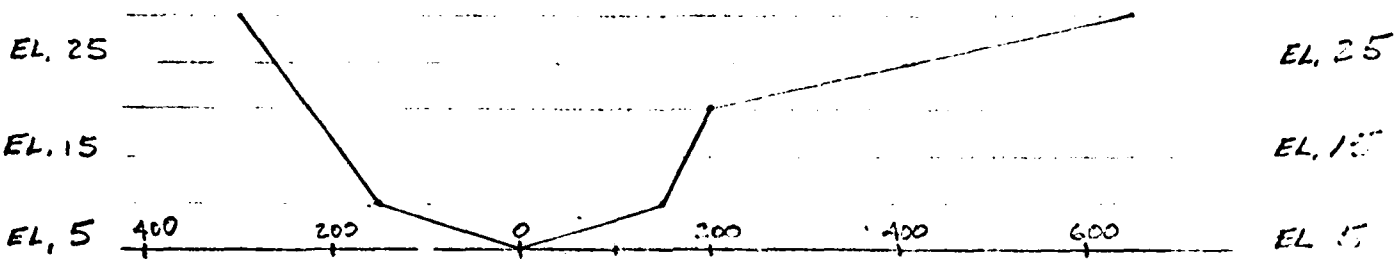
DOWNSTREAM W.S.EL. COMPUTATIONS

NAME OF DAM: PEMBERWICK

SECTION LOCATION: 3000' DOWNSTREAM OF DAM [illegible]

USING: $Q = 1.486/n \, A \, R^{2/3} S^{1/2}$

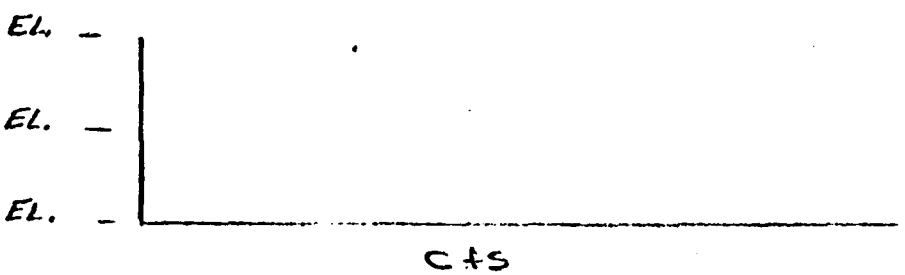
WHERE: n = 0.05 S = SLOPE = .007 1/1



CHANNEL SECTION

Q_{P_1} = 3158 STORAGE (S) 51

ELEV.	AREA	WP	R	$R^{2/3}$	$S^{1/2}$	1.486/n	Q	DEPTH
10	750	300	2.5	1.84	.083	29.72	*3408	5
						29.72		
						29.72		



* ELEVATION 10 IS APPROXIMATELY EQUAL TO Q_{P2} 3158 cfs. THEREFOR THE FAILURE DISCHARGE WILL DISAPPATE AT THE POND CAUSING A 1 TO 2 FOOT RISE IN THE POND WSEL

STAGE DISCHARGE = _____ ELEV = _____ OR A D = _____

NEXT DOWNSTREAM SECTION N/A ft.

PURCELL ASSOCIATES

RATING CURVE DEVELOPMENT

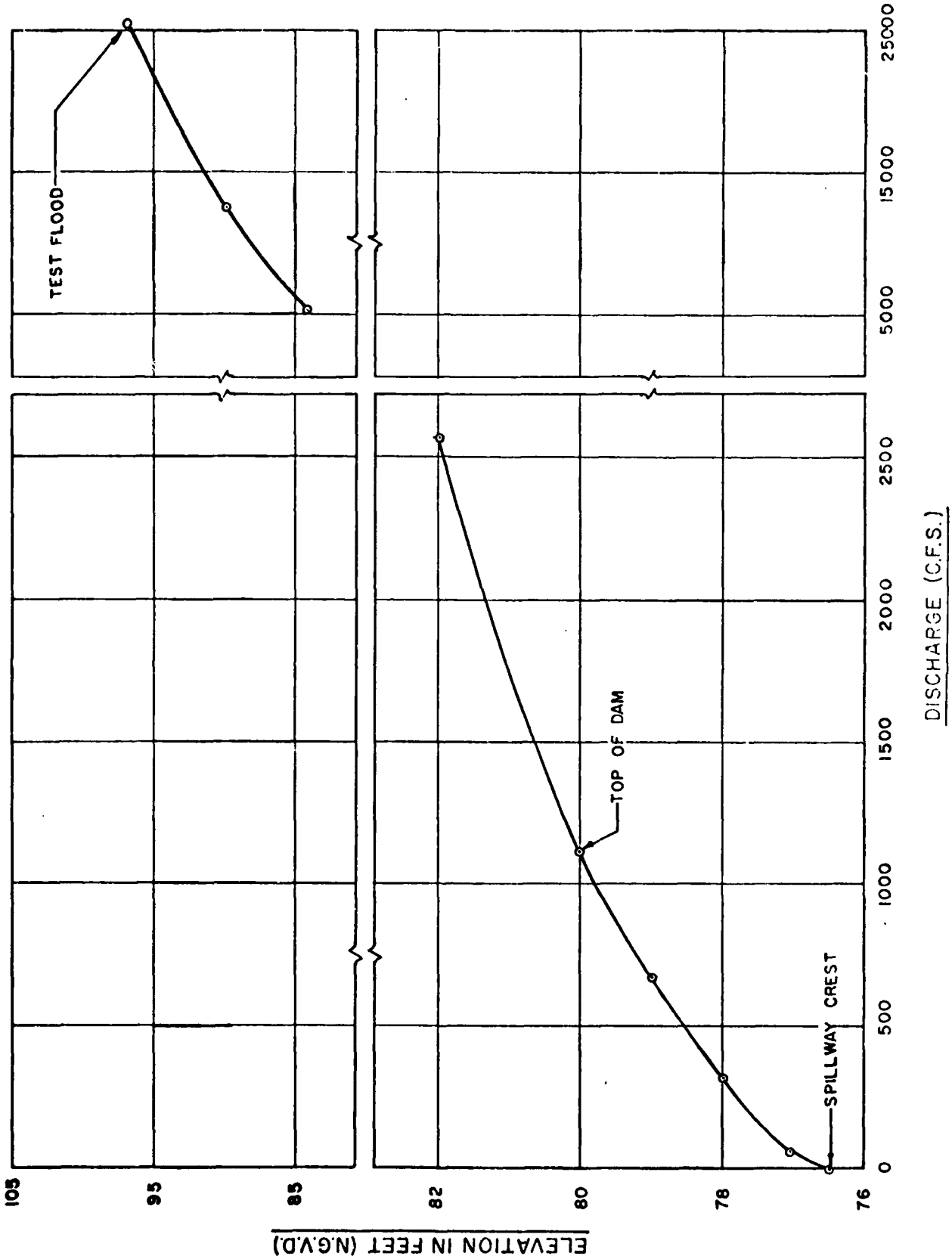
Pemberwick Dam

Spillway

$$Q = C\ L\ H^{2/3}$$

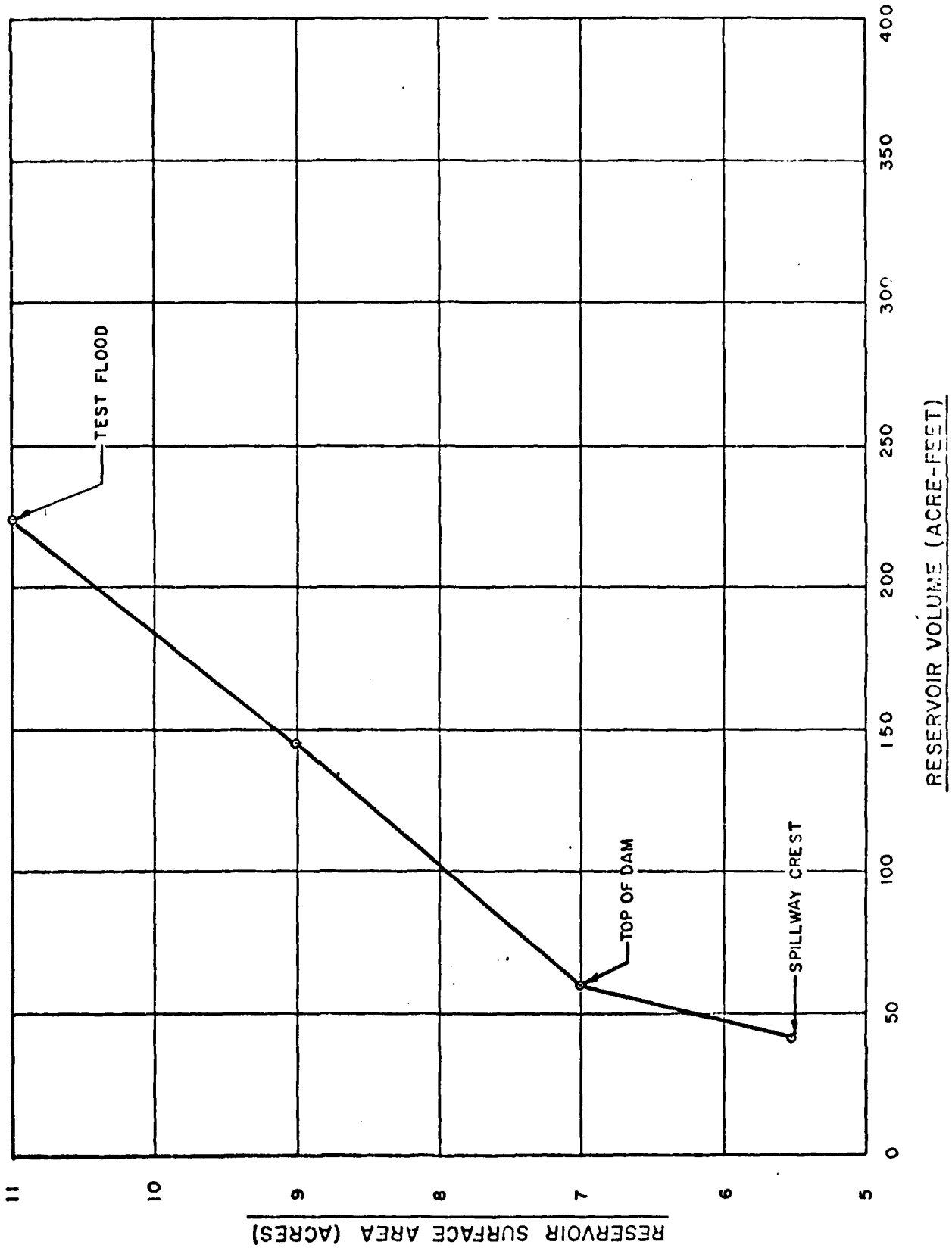
$C = 2.70$

$L = 63$ feet



PEMBERWICK DAM

SPILLWAY RATING CURVE



PEMBERWICK DAM
RESERVOIR AREA-CAPACITY CURVE

APPENDIX E

INFORMATION AS CONTAINED IN THE

NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

STATE	IDENTITY NUMBER	DIVISION	STATE	COUNTY	CONGR DIST.	STATE	COUNTY	CONGR DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY MO YR
CT	42	NED	CT	001	04				PEMBERWICK DAM	4101.7	7339.8	20DEC79

POPULAR NAME	NAME OF IMPOUNDMENT
RAHN DAM	BYRAM RIVER

REGION	BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	DIST FROM DAM (MI.)	POPULATION
01	07	BYRAM RIVER	PEMBERWICK	1	1000

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FT.)	HYDRAULIC HEIGHT (FT.)	IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	IMPOUNDING CAPACITIES NORMAL (ACRE-FT.)	DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
VAPGOT	1867	O	45	45	60	41	NED	N	N	N	N	

REMARKS
23-AESTHETIC 21-STONE MASONARY

D/S HAS	SPILLWAY CREST LENGTH	SPILLWAY TYPE	SPILLWAY WIDTH (FT.)	MAXIMUM DISCHARGE (FT.)	VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (MW)	POWER CAPACITY PROPOSED (MW)	NAVIGATION LOCKS NO	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
1	115	U	63	1100	2200											

OWNER	ENGINEERING BY	CONSTRUCTION BY
FAIRFIELD ASSOCIATES INC		

REGULATORY AGENCY DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
		CT DEPT ENVIR PROT	CT DEPT ENVIR PROT

INSPECTION BY	INSPECTION DATE DAY MO YR	AUTHORITY FOR INS
JAMES P PURCELL ASSOCIATES INC	12NOV79	PL-92-367

REMARKS

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12.00 60.............I.......................................................................
13.00 61.         IO        .        .        .        .        .        .        .        .        .        .
14.00 62.        I .        .        .        .        .        .        .        .        .        .        .
15.00 63.       I  .        .        .        .        .        .        .        .        .        .        .
16.00 64.      I   .        .        .        .        .        .        .        .        .        .        .
17.00 65.     I    .        .        .        .        .        .        .        .        .        .        .
18.00 66.    IO    .        .        .        .        .        .        .        .        .        .        .
19.00 67.    I     .        .        .        .        .        .        .        .        .        .        .
20.00 68.   I      .        .        .        .        .        .        .        .        .        .        .
21.00 69.   I      .        .        .        .        .        .        .        .        .        .        .
22.00 70..IO.......................................................................................
23.00 71. I        .        .        .        .        .        .        .        .        .        .        .
 0.00 72. I        .        .        .        .        .        .        .        .        .        .        .
 1.00 73. I        .        .        .        .        .        .        .        .        .        .        .
 2.00 74.I         .        .        .        .        .        .        .        .        .        .        .
 3.00 75.I         .        .        .        .        .        .        .        .        .        .        .
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END

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8 84

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