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NEW JERSEY STATE DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/6 13/2
NATIONAL DAM SAFETY REPORT. CANOE BROOK RESERVOIR NUMBER 2 DAM --ETC(U)
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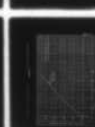
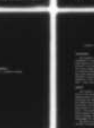
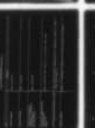
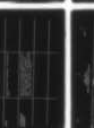
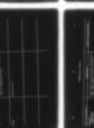
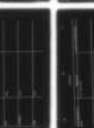
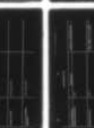
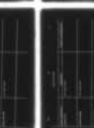
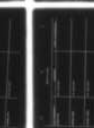
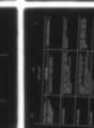
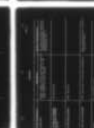
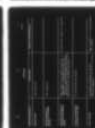
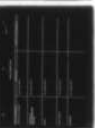
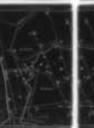
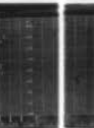
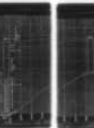
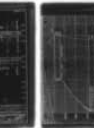
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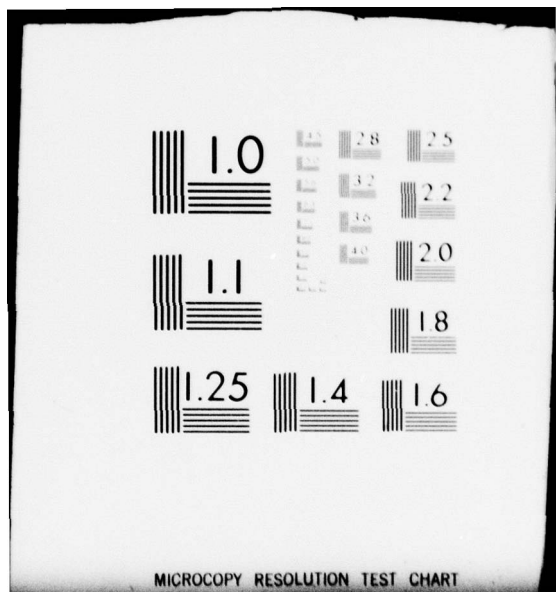
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CANOE BROOK, ESSEX COUNTY
NEW JERSEY

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CANOE BROOK RESERVOIR NO. 2 DAM NJ 00526

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

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DEPARTMENT OF THE ARMY

Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

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April, 1979

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1. REPORT NUMBER NJ00526	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Inspection Report National Dam Safety Program Canoe Brook Reservoir No. 2 Dam Essex County, N.J.		5. TYPE OF REPORT & PERIOD COVERED (9) FINAL rept.
7. AUTHOR(s) 10 Robert J. Jenny, P.E.		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Jenny-Leedshill Engineering ✓ 318 South Orange Ave. South Orange, N.J. 07079		8. CONTRACT OR GRANT NUMBER(s) 15 DACW61-78-C-0124
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, Philadelphia Custom House, 2d & Chestnut Streets Philadelphia, Pennsylvania 19106		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS (12) 830
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE (1) Apr 1979
		13. NUMBER OF PAGES 76
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) (6) National Dam Safety Report. Canoe Brook Reservoir Number 2 Dam (NJ-00526), Passaic River Basin, Canoe Brook, Essex County, New Jersey. Phase 1 Inspection Report.		
18. SUPPLEMENTARY NOTES Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dams Visual Inspection Embankments National Dam Inspection Act Report Riprap Canoe Brook Reservoir Dam #2, N.J. Structural Analysis		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in report.		

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IN REPLY REFER TO

NAPEN-D

4 MAY 1979

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Canoe Brook Reservoir No.2 Dam in Essex County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Canoe Brook Reservoir No. 2 Dam, a high hazard potential structure, is judged to be in good overall condition. Since there is no natural flow into the reservoir, the Probable Maximum Flood is simply the precipitation directly on the reservoir surface. The freeboard capacity of the reservoir is adequate to contain the Probable Maximum Precipitation. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. Within six months from the date of approval of this report, engineering studies and analyses should be performed to determine the dam's embankment and foundation condition and structural stability. This should include test borings to determine material properties relative to stability and seepage. Any remedial measures found necessary should be initiated within calendar year 1980. The embankment top and slopes should be surveyed to establish the present top elevation and width and side slopes. The maximum operating level of the reservoir should then be reviewed based on the result of the survey.

b. The following remedial actions should be completed within 30 days of the date of approval of this report:

(1) A downstream warning system in connection with Canoe Brook Reservoir No. 1 Dam should be established.

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NAPEN-D

Honorable Brendan T. Byrne

(2) Irregularities, erosion scars and areas of missing riprap on the embankment should be repaired.

c. The following remedial actions should be completed within six months of the date of approval of this report:

(1) Remove the growth of brush and trees from the dam and institute a program of regular brush removal.

(2) Initiate a program to keep records of all maintenance and operating events.

d. Within one year from the date of approval of this report alternative methods of draining the reservoir including installation of an emergency outlet should be investigated.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congresswoman Millicent Fenwick of the Fifth District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

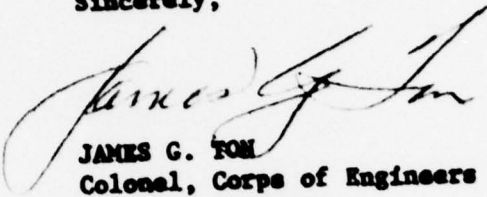
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Honorable Brendan T. Byrne

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed action taken by the State to implement our recommendations.

Sincerely,



JAMES G. TOM
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:

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P. O. Box CNO29
Trenton, NJ 08625

John O'Dowd, Acting Chief
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CANOE BROOK RESERVOIR NO. 2 DAM (NJ00526)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 29 November, 16 December 1978 and 4 January 1979 by Jenny-Leedshill Engineers, under contract to the State of New Jersey. The State, under agreement with the U. S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Canoe Brook Reservoir No. 2 Dam, a high hazard potential structure, is judged to be in good overall condition. Since there is no natural flow into the reservoir, the Probable Maximum Flood is simply the precipitation directly on the reservoir surface. The freeboard capacity of the reservoir is adequate to contain the Probable Maximum Precipitation. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. Within six months from the date of approval of this report, engineering studies and analyses should be performed to determine the dam's embankment and foundation condition and structural stability. This should include test borings to determine material properties relative to stability and seepage. Any remedial measures found necessary should be initiated within calendar year 1980. The embankment top and slopes should be surveyed to establish the present top elevation and width and side slopes. The maximum operating level of the reservoir should then be reviewed based on the result of the survey.

b. The following remedial actions should be completed within 30 days of the date of approval of this report:

(1) A downstream warning system in connection with Canoe Brook Reservoir No. 1 Dam should be established.

(2) Irregularities, erosion scars and areas of missing riprap on the embankment should be repaired.

c. The following remedial actions should be completed within six months of the date of approval of this report:

(1) Remove the growth of brush and trees from the dam and institute a program of regular brush removal.

(2) Initiate a program to keep records of all maintenance and operating events.

d. Within one year from the date of approval of this report alternative methods of draining the reservoir including installation of an emergency outlet should be investigated.

APPROVED: 

JAMES G. TOM
Colonel, Corps of Engineers
District Engineer

DATE: 4 May 79

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Canoe Brook Reservoir No. 2,
I.D. No. NJ 00526
State located: New Jersey
County located: Essex
Stream: (Off-stream pumped storage)
Date of Inspection: November 29, December 16, 1978,
and January 4, 1979

Brief Assessment of General Condition of Dam

Visual inspection of the dam indicated the embankment to be in good overall condition and without any critical signs of distress. Erosion due to wave action is a continuing problem in certain areas of the inboard slope of the embankment, and there are other erosion problems and damage of the crest and slopes due to foot traffic. The width of the crest is inordinately narrow in places.

Since there is no natural flow into the reservoir, the Probable Maximum Flood is simply the precipitation directly on the reservoir surface. The freeboard capacity of the reservoir is adequate to contain the Probable Maximum Precipitation.

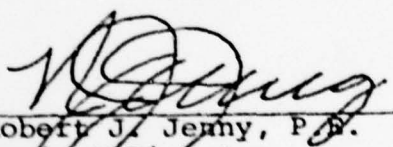
The reservoir has no spillway or emergency outlet and can be completely drained only by pumping from the reservoir into the Canoe Brook Reservoir No. 1.

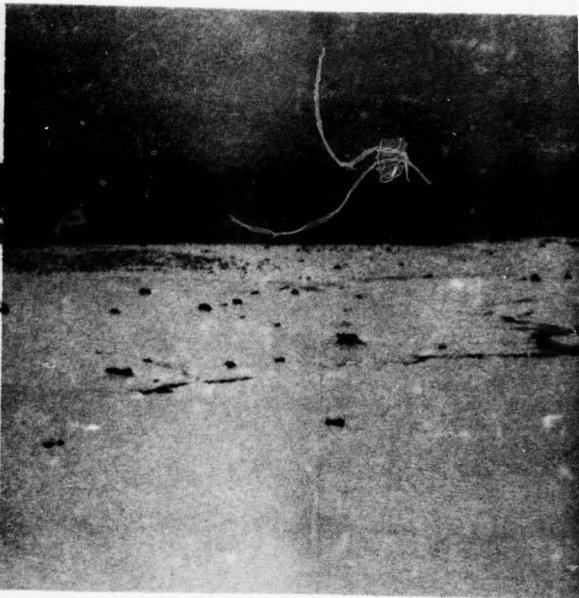
Recommendations and the urgency of their implementation are as follows:

1. In the near future, the embankment top and slopes should be surveyed to establish the present top elevation and width and side slopes.

2. Erosion scars and areas of missing riprap on the embankment should be repaired as soon as possible.
3. The maximum operating level of the reservoir should be reviewed in light of future surveys of top of dam elevations.
4. Frequent vegetation removal should become a continuing maintenance operation.
5. Seepage and stability analyses of the dam should be made in the near future.
6. A downstream warning system in connection with Canoe Brook Reservoir No. 1 Dam should be established as soon as possible.


Frank L. Panuzio, P. E.
Project Manager


Robert J. Jenny, P. E.
Project Director
New Jersey License No. 9878



View from southeast side of d





le Reservoir.

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PREFACE

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

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

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

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Canoe Brook Reservoir No. 2 Dam
Federal I.D. No. NJ 00526
New Jersey I.D. No. (None)

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The National Dam Inspection Act, Public Law 92-367, 1972, provides for the National Inventory and Inspection Program by the U. S. Army Corps of Engineers. This report has been prepared in accordance with this authority, through contract between the State of New Jersey and Jenny-Leedshill Engineers. The State of New Jersey has also entered into an agreement with the U. S. Army Engineer District, Philadelphia, to have this work performed.

b. Purpose of Inspection

The purpose of this inspection was to evaluate the general structural integrity and hydraulic adequacy of the dam, and to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project

a. Description of Dam and Appurtenances

Canoe Brook Reservoir No. 2 Dam is essentially a rolled earth-fill levee completely surrounding a reservoir. The embankment is 9,700 feet long, irregularly shaped but roughly elliptical in plan. The crest width varies from 3 to 5 feet, and side slopes are approximately 1V:2H on the inboard slope, and 1V:1-1/2H on the outboard side.

Height of the embankment varies from 7 feet to about 24 feet, but on the average is about 22 feet above the reservoir bottom. Rock riprap covers the entire inboard slope. At the time of inspection the reservoir was nearly empty, with standing water only in the northern half.

There is no natural inflow into the reservoir, and the dam contains no spillway. Water is pumped into the reservoir through an intake structure from the nearby Passaic River. Water may be pumped from the reservoir through a 16-inch pipeline to Canoe Brook Reservoir No. 1 or it can flow by gravity through a 48-inch transfer pipeline to the same reservoir. There are no low level drains.

b. Location

The dam is located in Essex County, New Jersey, north of the town of Summit in Millburn Township. It is accessible from John F. Kennedy Parkway by way of Highway 24. The location of the dam is shown on Plate 1.

c. Size Classification

The size of the dam based on its maximum height of 24 feet and 2,384 acre-feet storage capacity is intermediate. The criteria for size classification of dams are set forth in the Corps' Guidelines. An intermediate size dam is one in which the reservoir capacity is greater than 1,000 acre-feet and less than 50,000 acre-feet, and/or the maximum height is greater than 40 feet and less than 100 feet.

d. Hazard Classification

It is found that the present high hazard classification of the dam is merited, since if a breach should occur for any reason during non-flood season, the large volume released could develop a substantial size opening and a resulting large discharge. Excessive inundation and serious damage and possible loss of more than a few lives could result in Hanover Township (pop. 11,000) four miles downstream. On the other hand, during floods,

outflow from a breach in the dam would be reduced by tailwater effects of the Passaic River, and incremental effects of this reduced outflow may not be significant in the downstream areas.

e. Ownership

The dam is owned and maintained by Commonwealth Water Company, 233 Canoe Brook Road, Short Hills, New Jersey.

f. Purpose of Dam

The dam and reservoir provide storage of untreated water pumped from the Passaic River. Along with other sources, the water is used as a potable supply for general use in an extensive service area in northeastern New Jersey.

g. Design and Construction History

The dam was constructed in 1938 and has remained substantially unchanged since then except for maintenance work on the embankment.

h. Normal Operational Procedures

The reservoir is operated in conjunction with Canoe Brook Reservoir No. 1, into which all water from the Reservoir No. 2 either flows by gravity or is pumped. The maximum operating level of the reservoir is 188.5 feet elevation; however, the water level is usually maintained at a much lower level, so as to maintain a maximum water level in Reservoir No. 1. During times of water shortage, the reservoir may be very low or near empty.

1.3 Pertinent Data

- a. Drainage Area - 113.6 acres (reservoir surface area only)
- b. Discharge at Damsite - No natural discharge

- c. Elevation (ft. above MSL)
- Top Dam 193.5
 - Maximum pool 188.5
 - 48-inch diameter transfer pipe invert 174.5
 - Minimum reservoir elevation 164.54
- d. Reservoir
- Length of maximum pool 3500 feet
- e. Storage (acre-feet)
- Maximum design pool 1816
 - Top of dam 2384
- f. Reservoir surface (acres)
- Top dam 115.8
 - Maximum pool 113.6
- g. Dam
- Type Rolled earthfill
 - Length 9700 feet
 - Height Varies from 7 feet to 29 feet
 - Top width Varies from 3 feet to 5 feet
 - Side slopes 1V:2H inboard;
1V:1½H outboard
 - Zoning None
 - Imperious core None
 - Cutoff None
 - Grout curtain None
- h. Regulating Outlets
1. Type: 48 inch concrete pipe to Reservoir No. 1
Length: 780 feet
Control: 2 - 48 inch diameter butterfly valves
 2. Type: 1 - 16 inch diameter outlet pipe to Reservoir No. 1
Pump capacity: 10 mgd nominal

SECTION 2: ENGINEERING DATA

2.1 Design

a. Geological Conditions

Canoe Brook Reservoir No. 2 is located within the New Jersey Piedmont Lowland physiographic province. The regional geology of this province is discussed in Appendix C to this report.

This reservoir lies just west of the Second Watchung Mountain in the area occupied by both the Wisconsin Age glacier and Glacial Lake Passaic. Glacial Lake Passaic was formed between the Second Watchung Mountain on the east and south, the Highlands on the west and the edge of the glacier on the north. Therefore, a typical soil profile in the reservoir area is likely to consist of glacial tills on top of the bedrock, an overlying layer of relatively coarse, stratified alluvium outwash, and a topmost layer of fine sandy silt and silty fine sand which represents the fine grained "rock flour" sediments carried from the glacier as it retreated. It is these finer-grained lake deposits which form the relatively flat plain upon which the Canoe Brook Reservoirs are constructed. These sediments have a relatively low permeability which, along with a high water table, accounts for the numerous swamps, ponds and puddles seen on the flat ground around the reservoirs. In certain areas one or more of these soils may be very thin or missing while another predominates at the surface. A layer of organic deposits should be expected in the swampy areas.

No bedrock exposures were seen near the perimeter of

the reservoir embankment. However, it is known by projection that the Brunswick formation of sandstones and shales underlies Reservoir No. 2. Logs of several water wells drilled in the area between Canoe Brook No. 1 and No. 2 are shown on Plate 5 and locations of these wells are shown on Plate 6. The logs indicate soils of clay and sandy clay near the surface and bedrock between 60 to 140 feet depth.

Since the area lies within Seismic Zone 1, only minor damage may be expected from distant earthquakes. No active faults are known to exist in the immediate vicinity nor surrounding area of the dam.

b. Design History

No data are available pertaining to the original design of the dam or any subsequent maintenance work. In plan, the dam is essentially as depicted on Plate 2. Typical sections of the embankment were not available from the owner. However, based on sections of Canoe Brook Reservoir No. 1 Dam and field observations, the embankment design is believed to be as represented on Plate 3, i.e., with inboard slopes of 1V:2H, outboard slopes of 1V:1-1/2H and 5-foot top width.

No data are available on the design of any of the outlet or inlet pipes, other than the cross section of the 48-inch diameter transfer pipe connecting the reservoir with Canoe Brook Reservoir No. 1 (Plate 4). This concrete transfer pipe is elevated throughout the reach between the two reservoirs, and is protected from flotation during flooding by steel straps at regular intervals anchored to piling. The pipe has a blowout valve between the reservoirs and a butterfly valve at each reservoir embankment.

When the reservoir level falls below the invert of

the 48-inch transfer pipeline, water must be pumped to Reservoir No. 1 via a 16-inch steel pipeline. A suction pump provides 10 mgd capacity.

The inlet from Passaic River consists of a pump station, screens and two 24-inch and four 20-inch diameter steel pipelines. Flaps on the outlets of the pipes prevent backflow. Nominal pump capacity is 80 mgd and maximum is 100 mgd.

2.2 Construction

No records of construction are available. No soils tests are known to have been made of the embankment material. It was reported that the borrow material was derived from excavation within the present reservoir. Logs of nearby water wells indicate the near surface soils to be clay and sandy clay (Plates 5 and 6).

2.3 Operation

Daily records of reservoir levels and withdrawals are maintained by the owner. There are no monitoring devices or survey markers on the dam.

2.4 Evaluation

a. Availability

Data are not available on the original design or construction of the dam and no data are available on subsequent repair or maintenance work. All available data are listed in Appendix A.

b. Adequacy

Available data are insufficient to adequately evaluate the design. Calculations relating to the structural design of the dam or the stability of the as-built structure are not available. Nothing is known of construction methods, testing methods, as-built material properties, or foundation conditions.

c. Validity

The limited data that are available are believed to be valid. The plan of the dam, as represented on Plate 2 was drawn in 1963, but the date of the topographic survey is not known. The typical section of the dam, Plate 4, is inferred.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

The visual inspection of Canoe Brook Reservoir No. 2 Dam was made on November 29, 1978, and subsequent inspections made on December 16, 1978 and January 4, 1979. The reservoir was nearly empty, with the water surface elevation at the time of inspection estimated to be about 172 ft., or approximately 21 ft. below the top of the dam. Water was being pumped into the reservoir from the Passaic River and from the reservoir into Canoe Brook Reservoir No. 1 at the time of the inspection.

The visual inspection did not reveal any critical signs of distress in the dam forming the manmade compoundment. Several locations were noted where wave action or erosion along footpaths had occurred; however, in general the dam appears to have been maintained well.

Detailed inspection was made of the dam, appurtenant structures, reservoir area and the downstream channel. Descriptions of the findings of these inspections are summarized in the paragraphs which follow. The check list of visual inspection items is included in Appendix A. Geologic and foundation conditions observed at the time of the inspection are noted in greater detail in Section 2.1.

b. Dam

The dam was inspected for signs of settlement, seepage, erosion, cracking and any other evidence of undesirable behavior which might affect the stability of the structure.

To a minor extent wave action has eroded and undermined the inboard slope of the embankment on the southeastern shoreline of the reservoir (Photo 1). This has resulted in some steepening of the upper part of the slope in places (Photo 2).

The embankment crest is rather narrow in places, less than the presumed design width of 5 feet (Photo 3). This narrowness may have resulted from erosion.

Several locations were noted where troughs in the embankment have been eroded by foot traffic of persons gaining access to the reservoir for fishing. At some of these locations riprap has been dislodged from the inboard slope (Photo 4). In general, the riprap slope is well maintained.

The inboard slope and crest of the embankment were generally clean and free of vegetation growth. In certain areas, particularly on the eastern side of the reservoir, the outboard slope was covered with brush and small trees (Photo 5). The owners reportedly cut the vegetation at 5-year intervals.

No evidence of seepage could be detected. The embankment materials appear to be stiff and impermeable.

c. Appurtenant Structures

A 48-inch transfer pipeline to Canoe Brook Reservoir No. 1 passes through the embankments of both reservoirs with flow through it controlled by valves located in each embankment. At the time of the inspection the invert of the 48-inch pipe was well above the reservoir water surface so that any seepage through the embankment along the sides of the pipe when submerged could not be examined (Photo 6). The pipeline is elevated in the swampy area between the reservoirs (Photo 7).

Water from the reservoir was being pumped to Canoe

Brook Reservoir No. 1 at the time of inspection through a 16-inch pipeline, the inlet of which was submerged and could not be observed.

Water was being pumped into the reservoir from the Passaic River at the time of inspection (Photo 8). Water enters the reservoir through 6 steel pipes having flaps on their outlets to prevent backflow (Photo 9).

Washwater from the treatment plant filters is returned to the reservoir at the rate of 0.5 mgd through 16-inch and 24-inch pipelines (Photo 10).

d. Reservoir Area

The reservoir is man-made with its perimeter completely formed by earthen embankment; thus there are no natural slopes leading to the reservoir. There was standing water only in the northern, deeper, half of the reservoir. The water appeared clear, without odor and only minor debris was observed. A number of tree stumps were exposed in the southern, dry, half of the reservoir (see Overview Photo).

e. Downstream Channel

No downstream channel, as such, is associated with this dam because the embankment completely surrounds the reservoir. Discharges from the reservoir in the event of embankment failure would flow around the embankment in a direction of the lowest ground surface elevation.

In general the areas surrounding the embankment are flat and consist of wooded areas and swampland. The Passaic River is a few hundred feet outside the western and northern embankment, and the small stream, Canoe Brook, parallels the eastern embankment. The community of Florham Park lies north of the reservoir and appears to be on land which is generally higher

in elevation than the dam (Plate 1), but other houses are further downstream on the Passaic River in Hanover Township that could be endangered by flooding.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

Canoe Brook Reservoir No. 2 Dam impounds water pumped from the Passaic River. Water is normally pumped into the reservoir during the period October 1 to June 1 and is limited by minimum flow restrictions that must be maintained in the river. The maximum rate of diversion is 100 mgd. From Reservoir No. 2 water either flows by gravity into Reservoir No. 1 through a 48-inch transfer pipeline, or it is pumped at the rate of 10 mgd to Reservoir No. 1 through a 16-inch pipeline when the reservoir level falls below the invert of the 48-inch line.

From Reservoir No. 1 water is withdrawn, treated and distributed through the Commonwealth Water Company system. It may also be pumped from that reservoir to Canoe Brook Reservoir No. 3, 2 miles north of Reservoirs No. 1 and 2. The Canoe Brook Reservoirs are operated in such a manner as to maintain the maximum possible water level in Canoe Brook Reservoir No. 1 by releasing or pumping water from Reservoir No. 2. This is done to minimize the pumping head from Reservoir No. 1 into the treatment plant and to allow capacity in the Reservoir No. 2 for pumping from the Passaic River. Thus the water level in the Reservoir No. 2 is often below the maximum operating level of elevation 188.5 feet. Records of reservoir operation are kept on a daily basis.

4.2 Maintenance of Dam

The owners reportedly conduct a monthly visual inspection of the dam. One of the primary purposes of the inspection is to observe the condition of the riprap which is subject to wave erosion and dislodging by

trespassers. Riprap has apparently been regularly replaced over the years.

Other than the slab staff gage, there are no instrumentation or monitoring systems of the dam or reservoir.

The owners cut the vegetation from the embankment of the dam at 5-year intervals. They reportedly are planning to increase the frequency of such maintenance.

4.3 Maintenance of Operating Facilities

Intake and outlet facilities appear to be regularly maintained and in good working condition. The valves controlling the 48-inch transfer pipeline are reportedly operated about 50 times per year. The treatment plants have been subjected to periodic flooding of the Passaic River and the lower windows of the building have been bricked in to provide some flood protection.

4.4 Description of Warning Systems

There is no warning system or emergency contingency plan in event of failure of the dam. Neither is there any area-wide coordinated flood warning system, although it is reported that certain communities in the Passaic basin are initiating their own individual warning systems. Spring flooding of the Passaic is a frequent occurrence, and it is not unusual for flood waters to inundate the area surrounding the dam embankment.

4.5 Evaluation of Operational Adequacy

There is presently no way to lower or drain the reservoir other than by gravity flow or pumping into Canoe Brook Reservoir No. 1 and thence through the owner's water distribution system. This condition imposes a limitation on emergency operational flexibility. Maintenance of the inlet and outlet facilities appears

to be good, and maintenance of the embankment is reasonably good.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

As already stated, Canoe Brook Reservoir No. 2 Dam is classified as high hazard and intermediate in size. In accordance with the Corps of Engineers', the "Recommended Guidelines for Safety Inspection of Dams," the Spillway Design Flood (SDF) is the Probable Maximum Flood (PMF).

Canoe Brook Reservoir No. 2 is contained within a man-made dike that is continuous for the entire circumference of the reservoir. The height of the dike varies from a minimum of about seven feet to a maximum of about twenty-four feet. Water is supplied to the reservoir by pumping from Passaic River. Hence reservoir storage is completely controlled except for contributions that occur as precipitation directly on the reservoir surface.

Canoe Brook Reservoir No. 2 is shown in plan on Plate 2. It is reported by the owner that the maximum operating water surface elevation of the reservoir is 188.5 feet. The capacity of the reservoir at this maximum operating level is reported by the owners to be 1816 acre-feet. The surface area of the reservoir is 113.6 acres. The top elevation of the impounding dike is reported by the owners to be 193.5 feet; hence, embankment freeboard above the maximum operating level is 5.0 feet. The reservoir has no spillway. The storage capacity curve for Canoe Brook Reservoir No. 2 is shown on Plate D-1, Appendix D.

The Probable Maximum Flood (PMF) entering the reservoir is the Probable Maximum Precipitation (PMP) with no reduction allowance for infiltration. The PMP was calculated using Hydrometeorological Report No. 33 with a Hop Brook reduction factor of 0.80 for misalignment of the storm. With concurrence of the Corps, PMP values for a 10 square mile drainage basin were used even though the reservoir surface area is 0.18 square miles. The cumulative PMP for various durations is shown in the following tabulation. Calculations supporting these figures are presented in Appendix D.

<u>Duration, Hours</u>	<u>PMP, Feet</u>
6	1.7
12	1.8
24	2.0
48	2.1

Under the assumption that the freeboard of the reservoir is 5.0 feet, the embankment design is capable of containing the 48-hour PMP.

Drawings obtained from the owner and discussions with the owner indicate there are no drains for the reservoir. Assuming there are no drains, the only means of emptying the reservoir is via gravity flow or pumping to Canoe Brook No. 1 Reservoir. In the event that Reservoir No. 1 is full, then deliveries out of Reservoir No. 2 can only be at the rate that water is being delivered to customers out of Reservoir No. 1. This rate is reported to average about 60 acre-feet per day. Assuming this average rate, the reservoir could be drained in about 30 days.

b. Experience Data

Reservoir elevation records are available for Canoe Brook Reservoir No. 2. The reservoir is maintained at its lowest water surface elevation whenever possible so that water can be diverted from Passaic River into the

system and so that the water surface in Canoe Brook Reservoir No. 1 can be maintained at hydraulically favorable high levels. During high runoff months, Reservoir No. 2 is normally above its minimum level because Reservoir No. 1 is frequently near its maximum level. There is no evidence that the embankment has ever been overtopped.

c. Visual Observations

Other than the company's treatment facilities, there are no developments around or immediately downstream of the reservoir. The Passaic River nearly borders the reservoir on two sides and Canoe Brook closely parallels a third side. Terrain between the reservoir and the two streams is gently sloping and heavily wooded.

Some areas along the reservoir side of the embankment are slightly irregular due to wave action. The fetch of the reservoir is about 0.6 miles.

d. Overtopping

The design reservoir freeboard above the maximum operating level is adequate to contain the PMP without overtopping. Assuming the reservoir can be drained at the rate of 60 acre-feet per day, the reservoir level can be lowered at the rate of about 0.5 feet per day.

Because the PMP can be completely contained within the freeboard storage the embankment design should be considered as hydrologically adequate.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The embankment appears to be in generally good condition. Slopes are reasonably uniform and the in-board riprap, with minor exceptions, is well maintained. Wave action has cut the southeastern embankment to a minor degree. No vertical deflections in the crest could be detected, but the crest in some places is only about 3 feet wide, possibly due to erosion.

Vegetation growth on the outboard slopes is a potential problem in some areas.

b. Design and Construction Data

Almost nothing is known of the design or construction of the dam. Although slopes visually appear uniform, the true cross-sectional configuration is not known. Nothing is known of as-built embankment materials. No hydraulic or hydrologic computations are known to exist.

c. Operating Records

The daily measurements of water levels made by the owner provide a good record of the reservoir operation.

The lack of instrumentation to detect seepage or adverse pore pressures does not appear to be a serious inadequacy in view of the apparently negligible seepage losses.

Of some concern is the lack of any recent surveys

to determine the present top of dam elevation and side slopes. Such surveys are needed to assess the adequacy of the freeboard and the structural stability of the embankment slopes.

d. Post-Construction Changes

No major post-construction changes are known to have been made. Routine maintenance plus deformation and erosion over the years have undoubtedly resulted in some deviations from the design configuration of the embankment.

e. Seismic Stability

The dam is located in Seismic Zone 1 in which it may generally be assumed that there is no hazard from earthquake, provided static stability conditions are satisfactory and conventional safety margins exist. Static stability conditions of the dam are unknown and must be determined by future analyses.

SECTION 7: ASSESSMENT, RECOMMENDATIONS
AND PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety

At the elevation of the top of the dam as indicated from available data, the freeboard is adequate to contain the Probable Maximum Precipitation falling on the reservoir surface.

The width of the crest is inordinately narrow in places. Side slopes appear to be reasonably uniform and to conform to presumed design slopes.

The growth of vegetation at certain places on the outboard embankment is undesirable and could lead to piping problems if unchecked.

b. Adequacy of Information

Data are insufficient to evaluate the stability of the dam, since almost nothing is known of the design or construction methods. It is not known when the embankment was last surveyed, so that the crest elevation and side slopes are not known with certainty. Information on the inlet and outlet structures and on the operation of the reservoir are generally adequate.

c. Urgency

A survey of the dam and seepage and stability analyses should be performed in the near future. Vegetation removal should also be started in the near future.

Irregularities and eroded surfaces on the crest and slopes should be repaired as soon as possible.

Alternative methods of draining the reservoir should be investigated in the future.

d. Necessary for Additional Data/Evaluation

Corps of Engineers Guidelines require that, in general, seepage and stability analyses should be on record for all dams in the high hazard category. It is recommended that soil borings and laboratory tests should be performed to determine pertinent physical properties of the embankment and foundation materials so that seepage and stability analyses can be made.

A survey of the dam, including top of dam elevation, side slopes and outlet locations is needed to assess the structural integrity of the dam and the danger of overtopping at low points along the crest in event of a Probable Maximum Flood.

7.2 Remedial Measures

a. Alternatives

It is recommended that the owner investigate alternative methods of draining the reservoir, including installation of an emergency outlet.

b. Operation and Maintenance Procedures

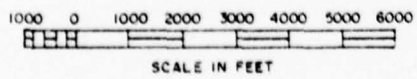
It is recommended that the owner perform the following operation and maintenance work:

1. Repair any erosion scars, deformations and settlement areas as indicated by a survey of the embankment, so that the embankment top elevation, width of top and angle of slope conform to the original design.

2. Remove the growth of brush and trees from the dam and institute a program of regular brush removal.
3. Keep records of all maintenance and operating events.
4. The maximum operating level of the reservoir should be reviewed in light of future surveys of top of dam elevations.
5. A warning system should be implemented in cooperation with downstream authorities and should be coordinated with Canoe Brook Reservoir No. 1.



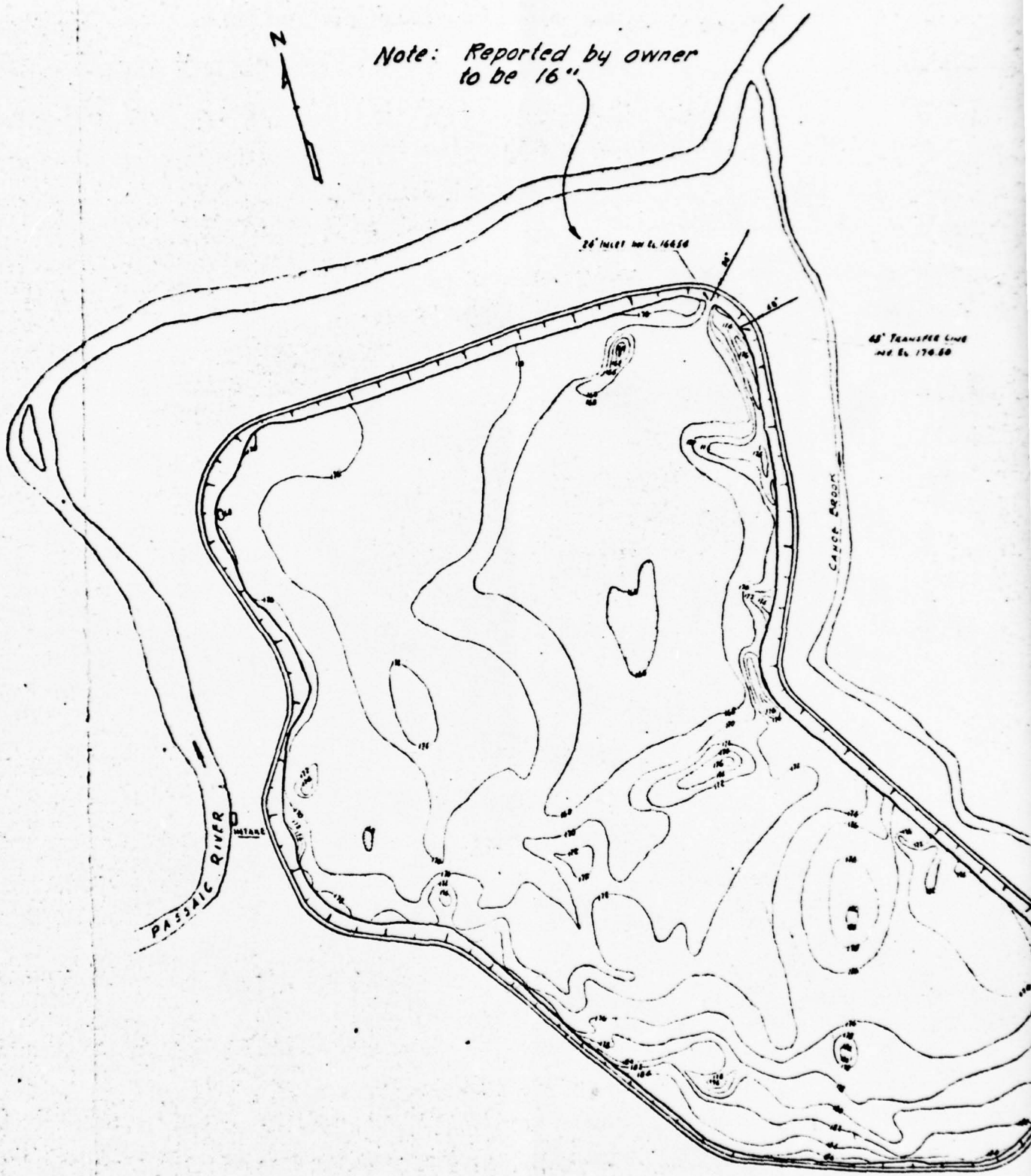
CANOE BROOK DAM NO. 2

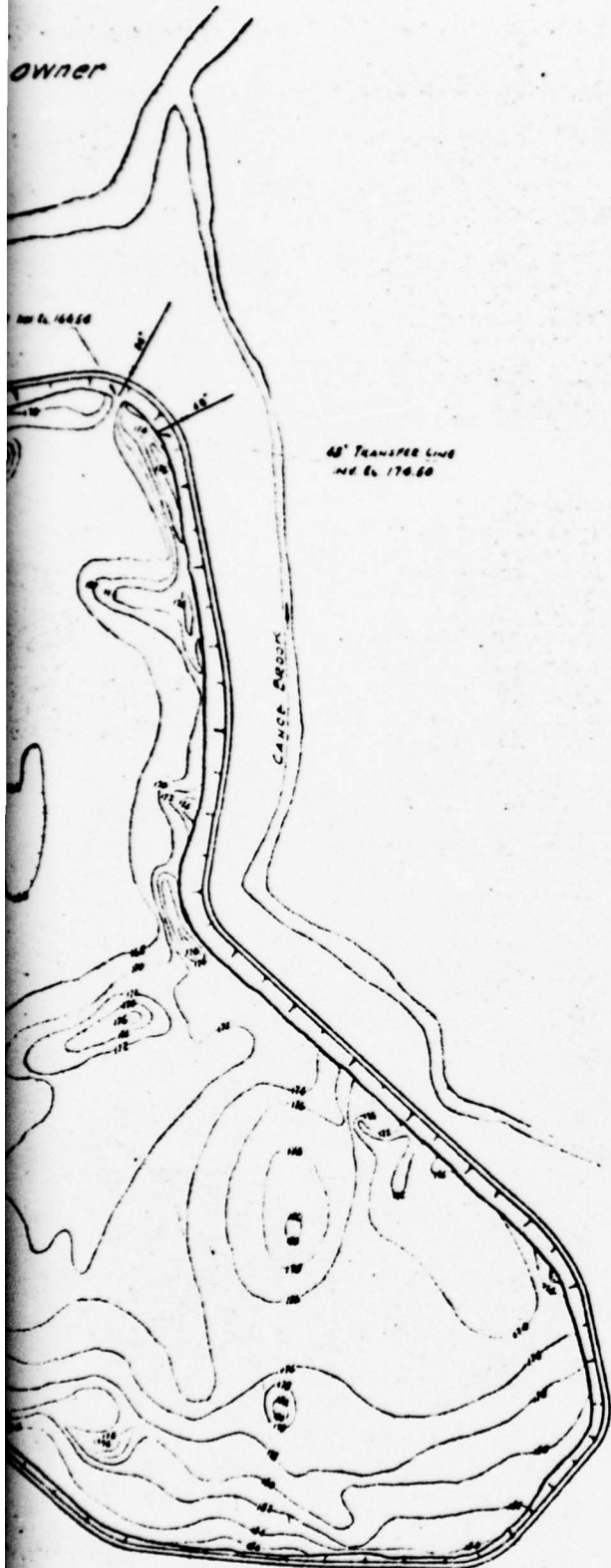


VICINITY MAP

JENNY-LEEDSHILL

JANUARY 1979





48' TRANSFER LINE
H.E. EL. 170.00

- NOTES:
- ① ELEVATIONS SHOWN ARE U.S.G.S. TO CONVERT TO CANOE BROOK DATUM SUBTRACT 3.5 FEET.
 - ② FOR STASH SURVEY FIELD DATA SEE DNG. NO. 69 1068R

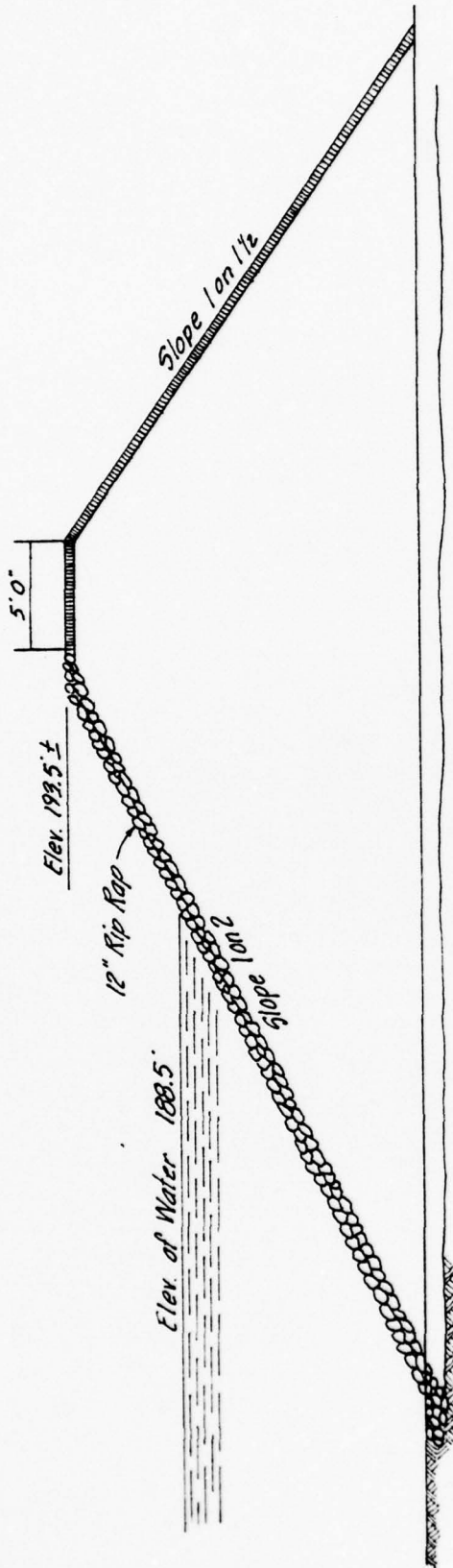
2

REVISIONS	CANOE BROOK STATION RESERVOIR N° 2 CONTOURS
	COMMONWEALTH WATER COMPANY SUMMIT, N. J.
	AMERICAN WATER WORKS SERVICE COMPANY, INC. <small>THREE PENN CENTER PLAZA PHILADELPHIA 3 PA.</small>
	SCALE: 1" = 200'-0" USE DIMENSIONS ONLY
	DRAWN BY J.P.M. DATE: 11-16-63 CHECKED BY <i>[Signature]</i>
	APPROVED <i>[Signature]</i> PROJECT _____ INSP BY _____
	USE APPROVED DRAWINGS ONLY FOR CONSTRUCTION PURPOSES 69 1049

TYPICAL SECTION
CANOE BROOK DAM NO. 2

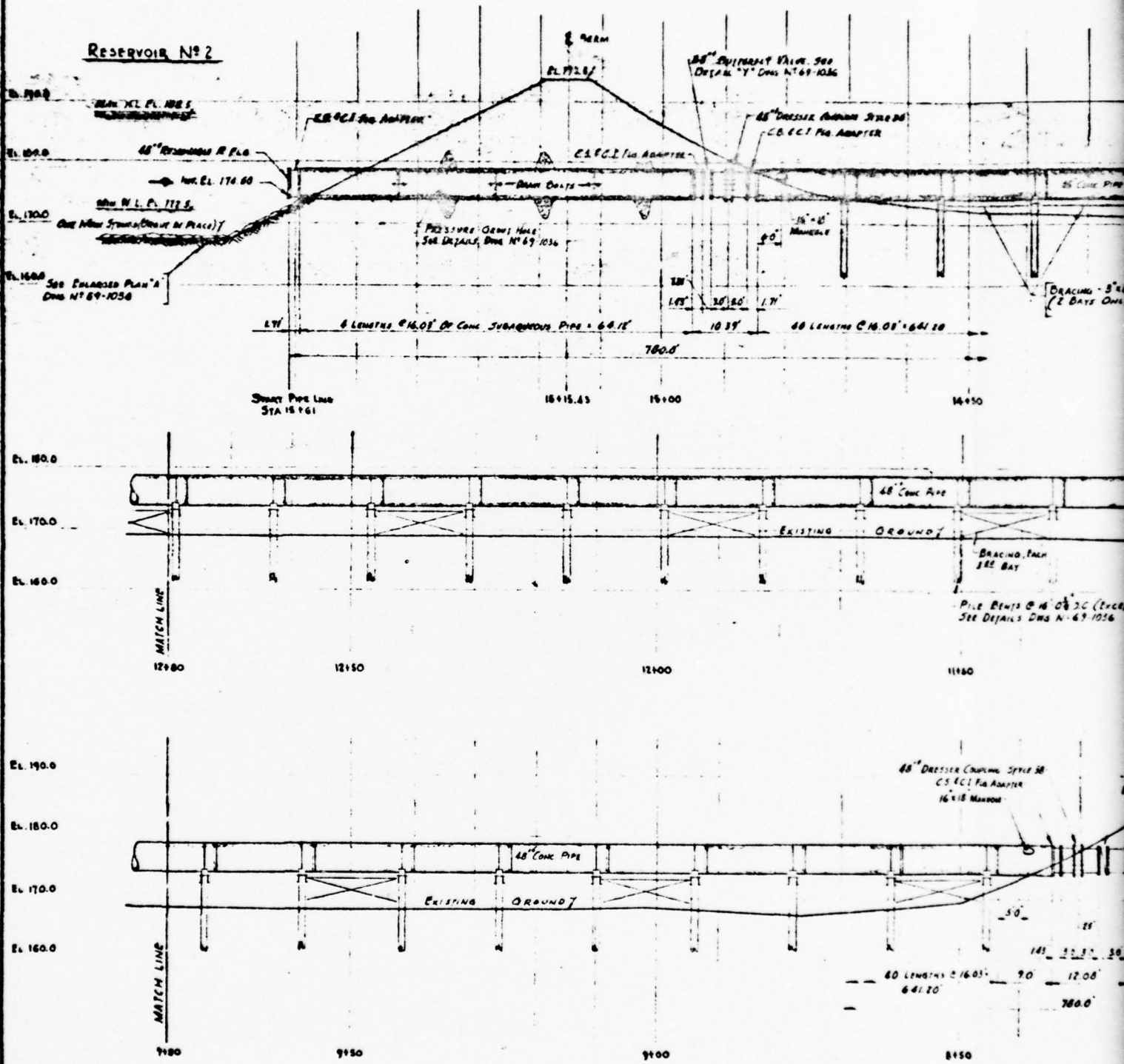
JANUARY 1979

JENNY - LEEDSHILL



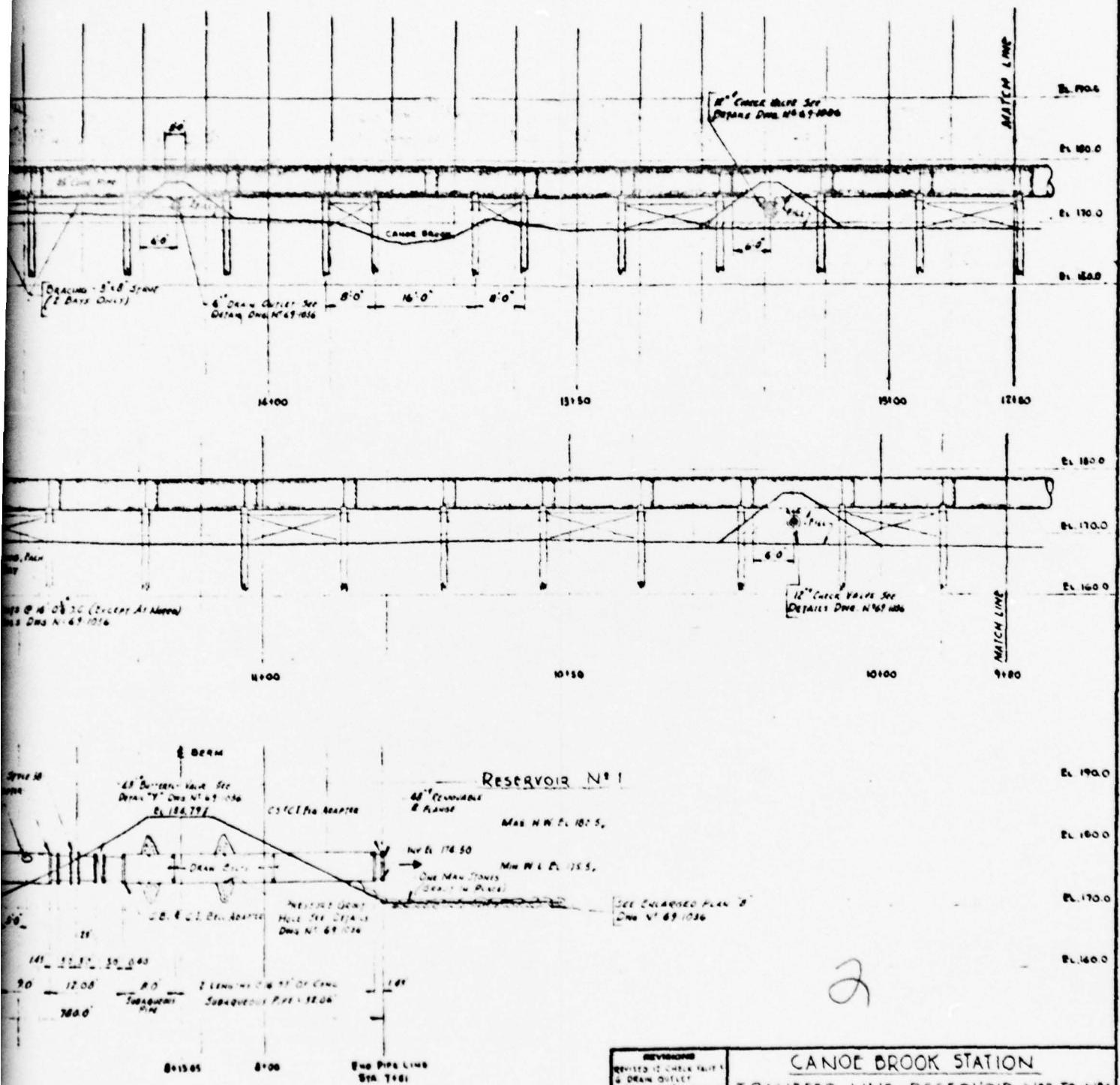
Note: Based on typical section of
Canoe Brook Dam No. 1,
plus field observations and
information from owner.

RESERVOIR N^o 2



- NOTES:**
- ① CONCRETE PIPE SHOWN SHADED
 - ② ELEVATIONS SHOWN ARE U.S.S. TO CORRECT TO CANADIAN DATUM SUBTRACT 2.5 FEET

PLEASE READ →



RESERVOIR N^o 1

MAX. H.W. EL. 187.5,
MIN. H.L. EL. 175.5,
ONE MAIN TOWER
(DEATH PLATE)

SEE ENLARGED PLAN 'B'
Dwg. N^o 69-1036

SHADED
8.5 To Convert To
GRAVIT. S.F. FEET

2

<p>REVISIONS</p> <p>REVISED TO CHECK TIGHT DRAIN OUTLET J.P.M. 1/2/63</p> <p>REMOVED WALKWAY J.P.M. 1/2/63</p>	<p>CANOE BROOK STATION TRANSFER LINE-RESERVOIR N^o 2 TO N^o 1 PROFILE</p>	
	<p>COMMONWEALTH WATER COMPANY SUMMIT, N.J.</p>	
	<p>AMERICAN WATER WORKS SERVICE COMPANY, INC. THREE FIFTH AVENUE PLAZA PHILADELPHIA 5, PA.</p>	
	<p>SCALE: 1" = 10' 0" DRAWN BY J.P.M. APPROVED A.C.C.</p> <p>DATE: 8-28-63 CHECKED BY E.W.O. PROJECT: A 10111800 BY E.P.H.</p>	
<p>USE APPROVED DRAWINGS ONLY FOR CONSTRUCTION PURPOSES</p>		<p>69-1035</p>



C
T/5A

28

RESERVOIR #2
EDGE

42

33

SANDY CLAY

SAND

CLAY

SAND - CLAY BOULDERS

CLAYEY SAND

C. SAND & GVL.

200

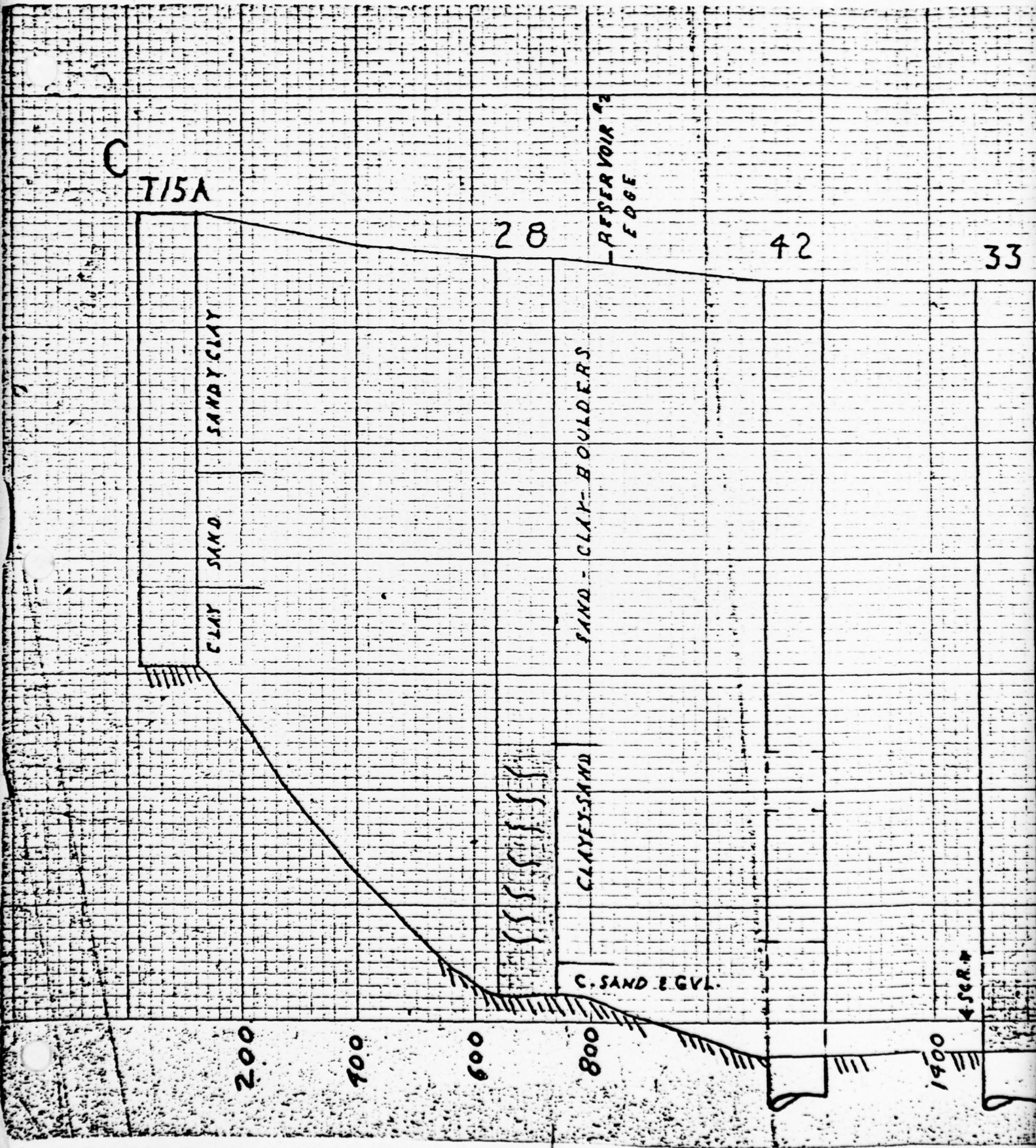
700

600

800

1400

← SCR. →



33

41

KELLY 5

RESERVOIR
EDGE

BLUE CLAY

CLAY

SANDY CLAY

SAND-CLAY-BOULDERS

SAND, CLAY & BOULDERS

CLAYEY FINE SAND

BLUE CLAY

GRAVEL

SAND & GRAVEL

SCREEN

RED CLAY-SAND & GRAVEL

10-14-18

1900

CHARLES BRUNING COMPANY
CROSS SECTION 10x10

SANDSTONE

SHALE

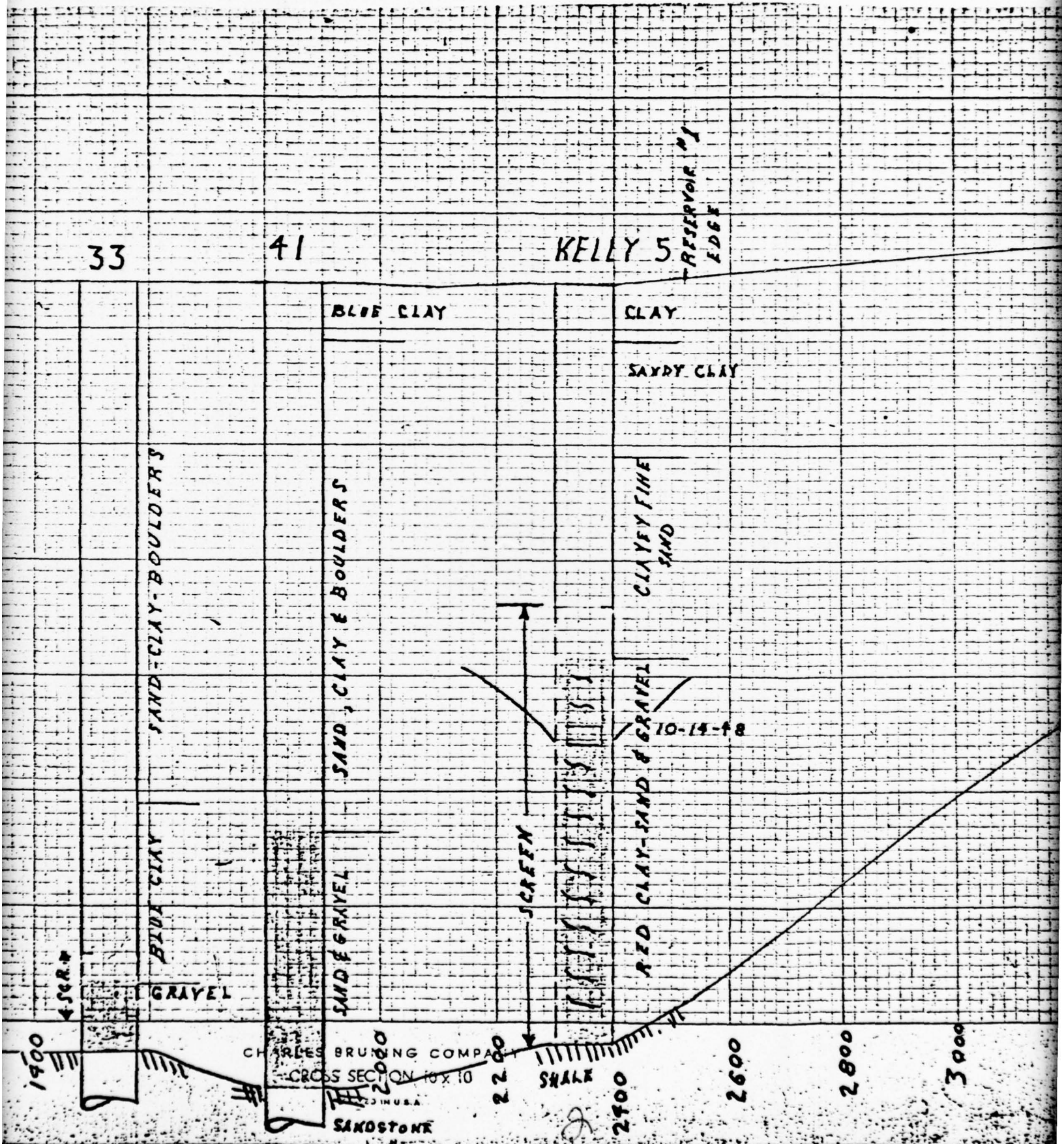
2200

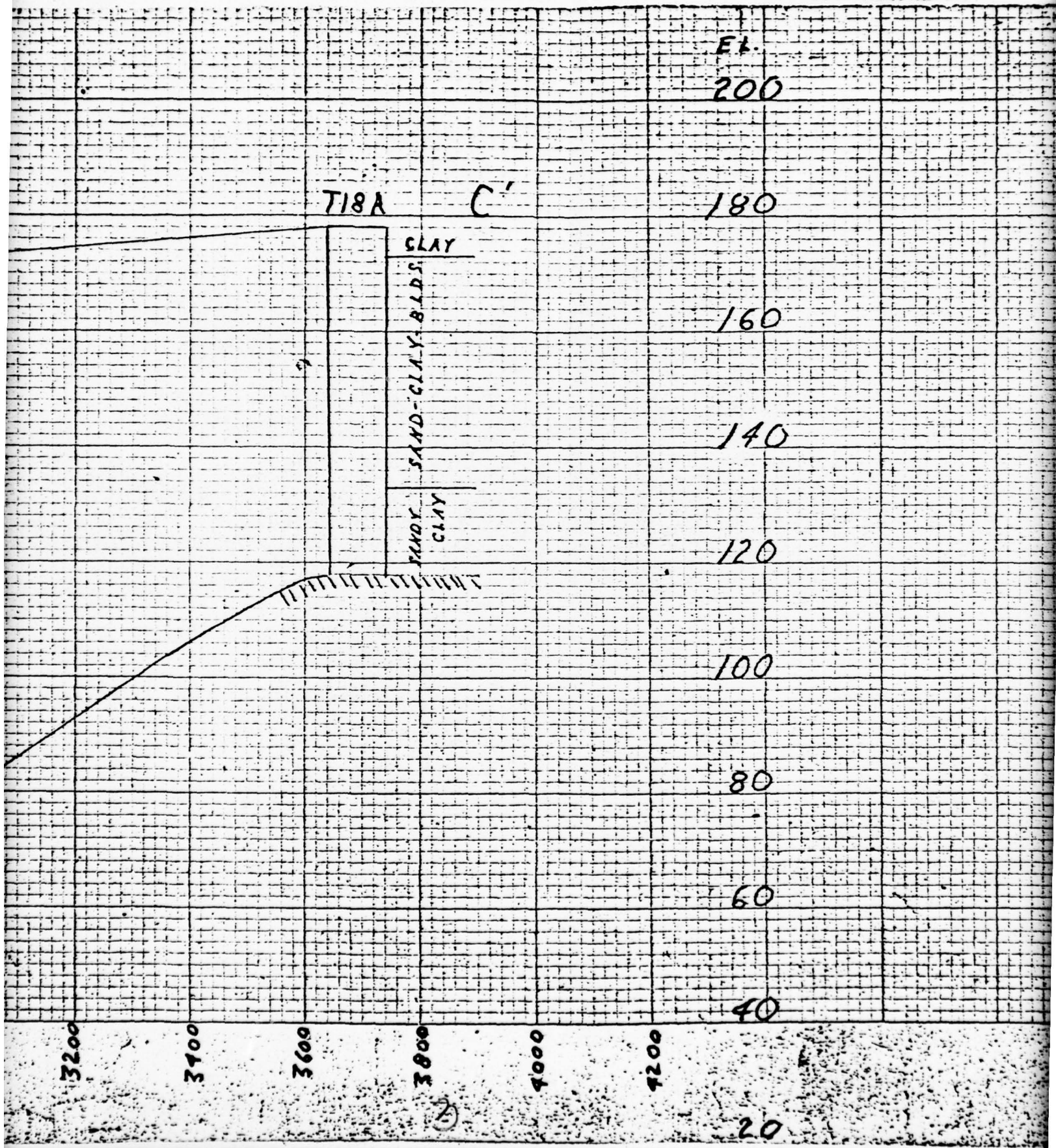
2500

2600

2800

3000





CANOE BROOK WELLS

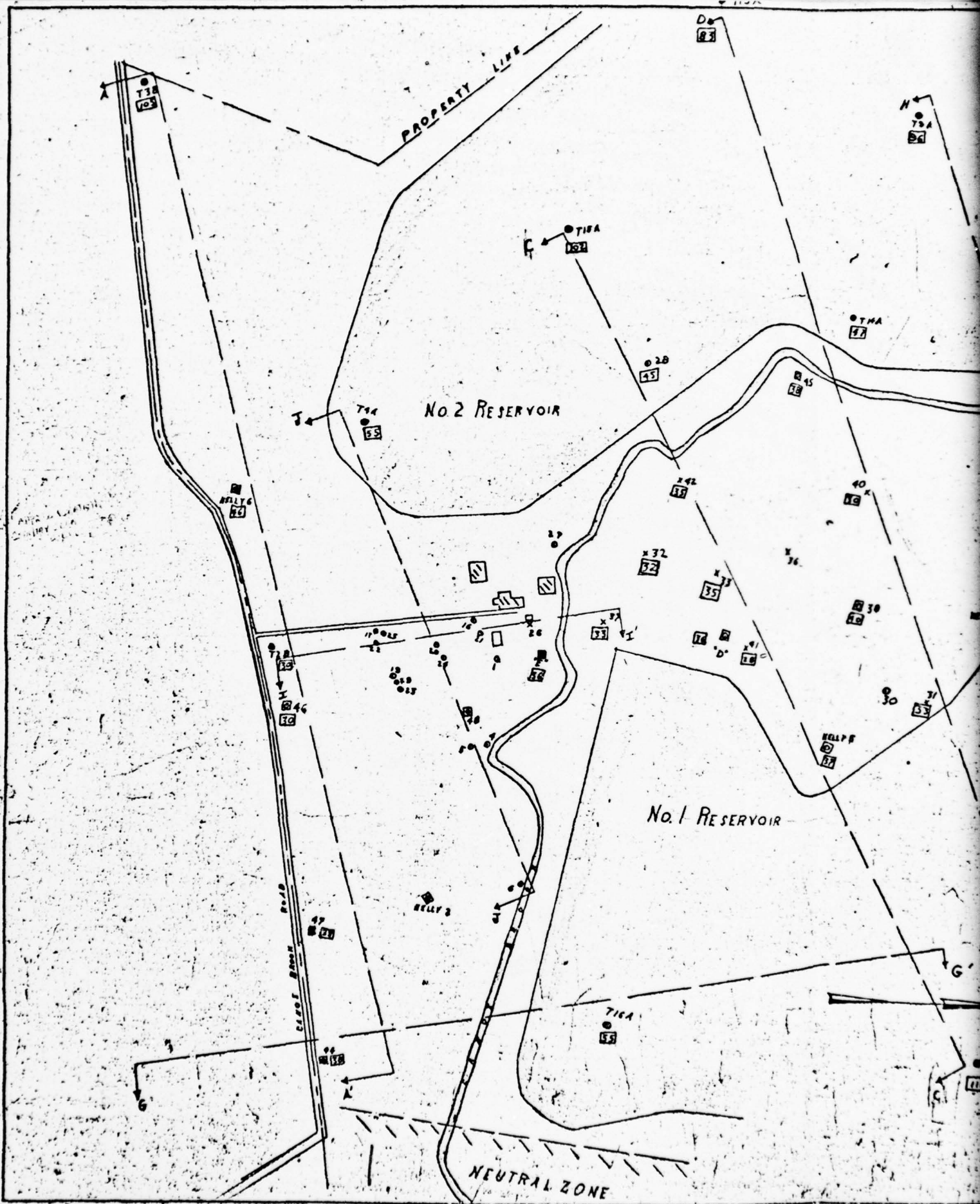
FIG. 6 - SEE FIG. 5

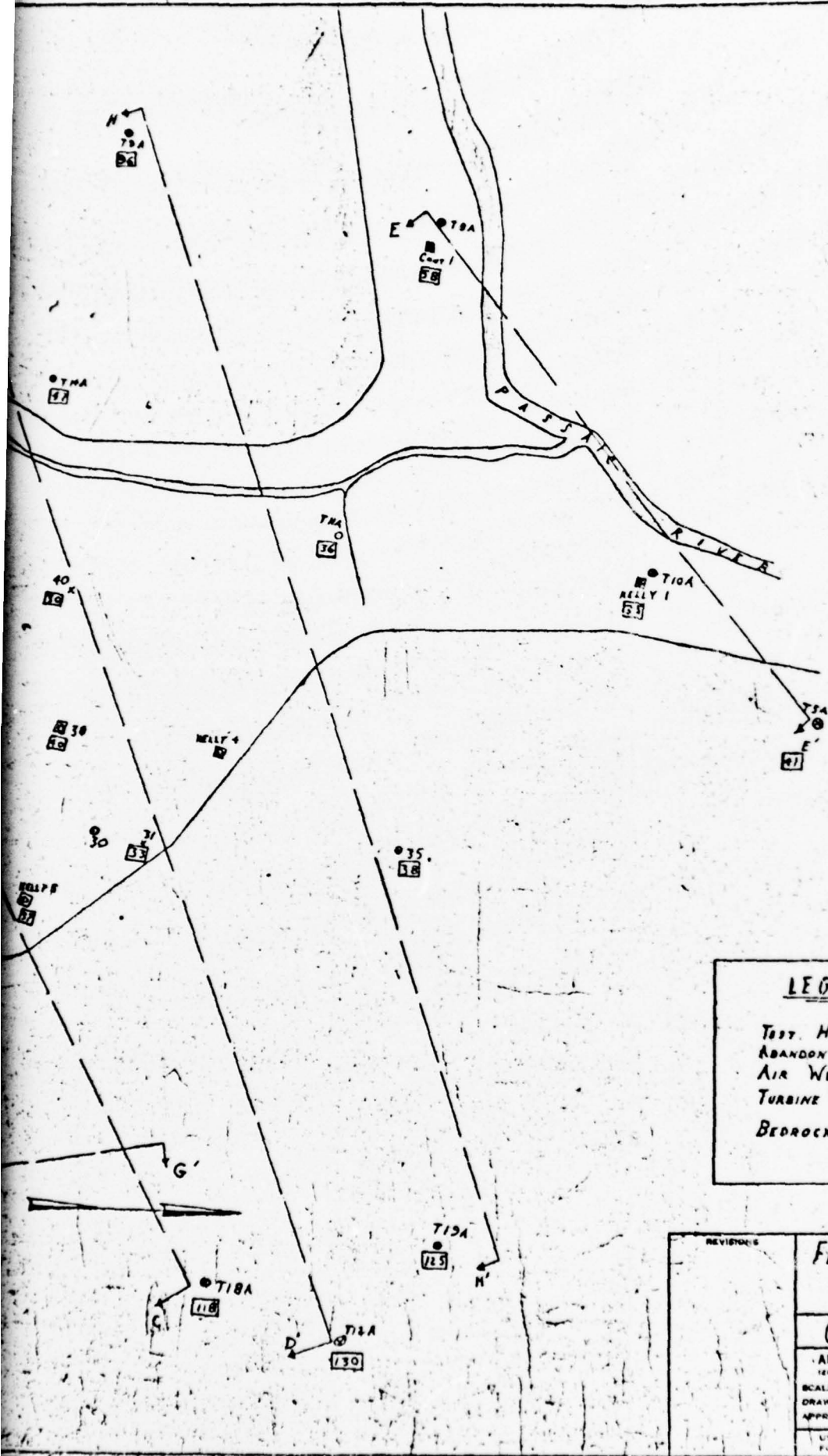
SECTION C-C'

HORIZONTAL SCALE
1" = 200'

VERTICAL SCALE 1" = 20'

69-842H





LEGEND

TEST HOLE ----- ○

ABANDON WELL ----- ○

AIR WELL ----- X

TURBINE WELL ----- □

BEDROCK ELEVATION ----- □

2

REVISIONS	<p>FIG. 5 WELLS AT THE CANOE BROOK STATION - SEE FIG. 6 FOR CROSS SECTIONS</p> <p>COMMONWEALTH WATER CO.</p> <p>AMERICAN WATER WORKS SERVICE COMPANY, INC. 121 SOUTH BRIDGE STREET PHILADELPHIA 7, PA.</p> <p>SCALE 1"=200' USE DIMENSIONS ONLY</p> <p>DRAWN BY RAR DATE 7-1-55 CHECKED BY</p> <p>APPROVED PROJECT P-89 INSP BY</p> <p>USE APPROVED DRAWINGS ONLY FOR CONSTRUCTION PURPOSES</p>	
	<p>69-845</p>	

APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

CHECK LIST - ENGINEERING, CONSTRUCTION
MAINTENANCE DATA

Check List
Visual Inspection
Phase 1

Name Dam Canoe Brook No. 2 County Essex State New Jersey Coordinator NJDEP
Coordinates - 40° 44' 30" N
74° 21' 30" W

Date(s) Inspection Nov. 29, 1978
Dec. 16, 1978 Weather Overcast Temperature 40° F.
Jan. 4, 1979

Pool Elevation at Time of Inspection 172' ± M.S.L. Tailwater at Time of Inspection N/A M.S.L.

Inspection Personnel:
(November 29, 1978)
Robert C. Gaffin
Philip L. Wagner
(December 16, 1978)
Dennis J. Lachel
Frank L. Paruzio
(January 4, 1979)
Robert J. Jenny
Alan L. Slaughter

Philip L. Wagner Recorder

Owner Representatives:
(November 29, 1978)
Karl Lutz
D. H. Edwards

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEEPAGE OR LEAKAGE	Not Applicable	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Not Applicable	
DRAINS	Not Applicable	
WATER PASSAGES	Not Applicable	
FOUNDATION	Not Applicable	

CONCRETE/MASONRY DAYS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Not Applicable	
STRUCTURAL CRACKING	Not Applicable	
VERTICAL AND HORIZONTAL ALIGNMENT	Not Applicable	
MONOLITH JOINTS	Not Applicable	
CONSTRUCTION JOINTS	Not Applicable	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	
SLOUGHING OR EROSION OF EMBANKMENT AND ADJUTENT SLOPES	Minor sloughing at several locations in embankment. Embankment erosion is occurring along paths made by persons gaining access to reservoir for fishing. Wave erosion on southeast shoreline.	Eroded areas should be repaired.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	No discernable deviations	
RIPRAP FAILURES	Occasional sloughing of riprap. One bald area 10 ft. by 20 ft. at north end of reservoir.	Have stockpile of riprap material for repair.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VEGETATION	Shrubs, weeds, briars, and grasses heavily cover outboard on eastern side of dam. Large trees have been removed.	All trees and brush should be removed and grasses and other vegetation should be periodically cut.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Not Applicable.	
ANY NOTICEABLE SEEPAGE	None observed.	
STAFF GAGE AND RECORDER	Slab staff gage on southeast embankment.	Owner maintains daily records of reservoir level.
DRAINS	No embankment drains.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	48-inch concrete transfer pipeline appeared to be in good condition.	
INTAKE STRUCTURE	Two 24-inch and four 20-inch pipelines from pump station on Passaic River with capacity of 80 to 100 mgd. Venturi tubes broken off in blowoff standpipe.	Pumping water at time of inspection
OUTLET STRUCTURE	16-inch suction pump and pipeline near northeast end of reservoir was submerged. 48-inch transfer pipeline outlet was above water. No evidence of prior seepage around pipeline.	Butterfly valves in 48-inch transfer pipeline reportedly operated about 50 times per year.
OUTLET CHANNEL	Not Applicable	
EMERGENCY GATE	Not Applicable	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Not Applicable	
APPROACH CHANNEL	Not Applicable	
DISCHARGE CHANNEL	Not Applicable	
BRIDGE AND PIERS	Not Applicable	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Not Applicable	
APPROACH CHANNEL	Not Applicable	
DISCHARGE CHANNEL	Not Applicable	
BRIDGE AND PIERS	Not Applicable	
GATES AND OPERATION EQUIPMENT	Not Applicable	

INSTRUMENTATION

VISUAL EXAMINATION MONUMENTATION/SURVEYS	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
None		
OBSERVATION WELLS	None	Owner pumps from a number of water wells in vicinity
WEIRS	None	
PIEZOMETERS	None	
OTHER	None	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Not applicable	
SEDIMENTATION	Pump intake at Passaic River has screens. Mud cracks and tree stumps in exposed part of reservoir floor.	
DEBRIS	None observed.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
<p>CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)</p>	<p>Passaic River on west side, Canoe Brook on east side. Swampy conditions locally, some wooded areas.</p>	
<p>SLOPES</p>	<p>Area surrounding embankment is generally flat.</p>	
<p>APPROXIMATE NO. OF HOMES AND POPULATION</p>	<p>Less than 10 structures immediately downstream, most of which appear to be at elevations higher than the reservoir. Water treatment plant in immediate vicinity. Town of Hanover 4 miles downstream contains more than 20 structures.</p>	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	"Canoe Brook Station, Reservoir No. 2, Contour", Scale 1" = 200', 1963 (See Plate 2)
REGIONAL VICINITY MAP	U. S. G. S. topographic maps (See Plate 1)
CONSTRUCTION HISTORY	Little available. Reported to be constructed in 1938.
TYPICAL SECTIONS OF DAM	Not available. Typical section prepared for this report (See Plate 3).
HYDROLOGIC/HYDRAULIC DATA	Elevation- capacity curve furnished by owner (See Plate D-1, Appendix D)
OUTLETS - PLAN - DETAILS -CONSTRAINTS -DISCHARGE RATINGS	"Canoe Brook Station, Transfer Line-Reservoir No. 2 to No. 1, Profile", Scale 1" = 10' -0", 6-28-63 (See Plate 4)
RAINFALL/RESERVOIR RECORDS	Daily reservoir levels available.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
DESIGN REPORTS	None available
GEOLOGY REPORTS	None available
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None available (See Plates 5 & 6 for water well logs)
POST-CONSTRUCTION SURVEYS OF DAM	"Canoe Brook Station, Reservoir No. 2, Contours", Scale 1" = 200', 1963 (See Plate 1)
BORROW SOURCES	Borrow for embankment reported to be from reservoir excavation.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
SPILLWAY-PLAN -SECTIONS -DETAILS	Not Applicable
OPERATING EQUIPMENT PLANS & DETAILS	None available except for 48-inch transfer pipeline (See Plate 4)
MONITORING SYSTEMS	Staff gage only
MODIFICATIONS	Not available
HIGH POOL RECORDS	Daily records not made available for this study but are available at owner's office.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None available
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None reported

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM

REMARKS

MAINTENANCE
OPERATION
RECORDS

Monthly inspections of embankment by owner's personnel

APPENDIX B
PHOTOGRAPHS



Photo 1 - Southeastern shoreline in area subject to most severe wave action. (11-29-78)



Photo 2 - Southern embankment, showing wave-cut inboard slope. (11-29-78)

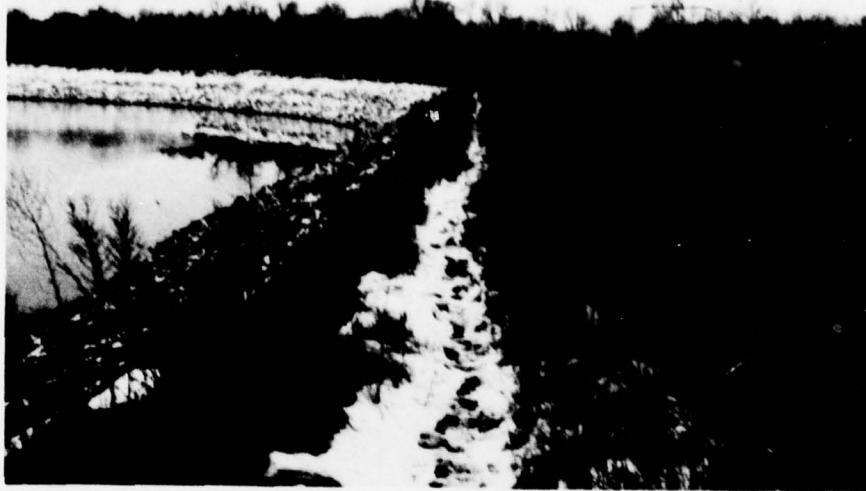


Photo 3 - Northwestern embankment looking west,
showing narrow crest width. (11-29-78)



Photo 4 - Dislodged riprap on northern
inboard slope. (11-29-78)



Photo 5 - Eastern embankment looking north,
showing vegetation growth on outboard slope.
(11-29-78)

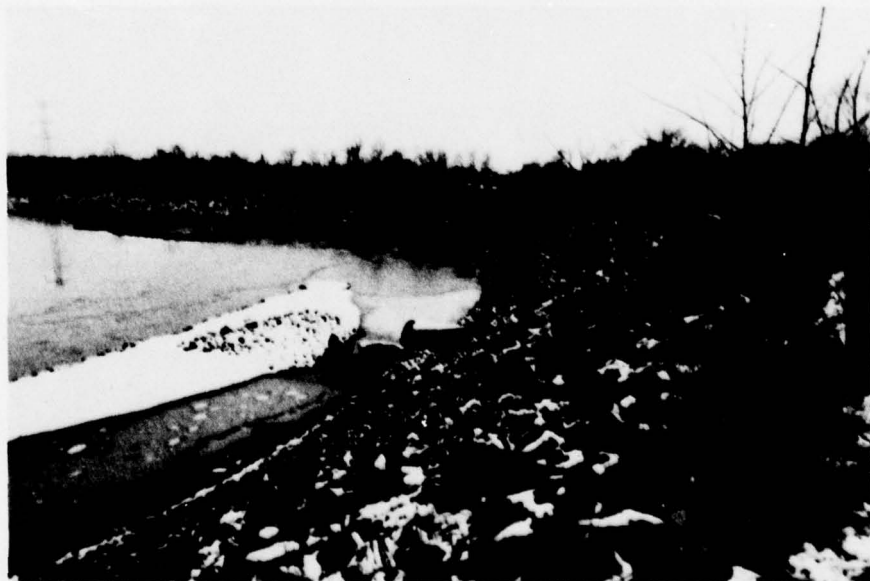


Photo 6 - Inlet of 48-inch transfer pipeline
connecting Canoe Brook Reservoirs Nos. 1 and 2.
(11-29-78)



Photo 7 - Elevated portion of 48-inch transfer pipeline, looking toward Canoe Brook Reservoir No. 1. (11-29-78)



Photo 8 - Passaic River at intake structure. Pump station to left of weir. (11-29-78)



Photo 9 - Outlet pipes from Passaic
River pump station. (11-29-78)



Photo 10 - Outlet pipes for return flow of
washwater from treatment plant filters.
(11-29-78)

APPENDIX C

REGIONAL GEOLOGY - PIEDMONT LOWLANDS

REGIONAL GEOLOGY - PIEDMONT LOWLANDS

Physiography

The Piedmont Lowlands Province of New Jersey lies northwest of a line approximately between Trenton and Perth Amboy and southeast of an approximate line between Milford on the Delaware River and Mahwah near the New York State border. Physiographically, the province is situated between the predominantly Precambrian age New Jersey Highlands Province to the northwest and the typically unconsolidated Cretaceous age and younger sediments of the Coastal Plain Province to the southeast. (See Figure C-1).

Bedrock

The Piedmont Lowlands, encompassing about one-fifth of the state, is characterized by northwestward dipping bedrock composed of interbedded red shales, siltstones and sandstones of Triassic and Jurassic age and igneous basalt extrusions (lava flows) and diabase intrusions of Jurassic age. The sedimentary rocks have been eroded to a broad southeastward sloping piedmont plain. The northwest border of the province is a northeast-southwest trending fault zone (Ramapo Fault) which truncates the sedimentary beds. Total vertical displacement on the fault may reach 10,000 feet.

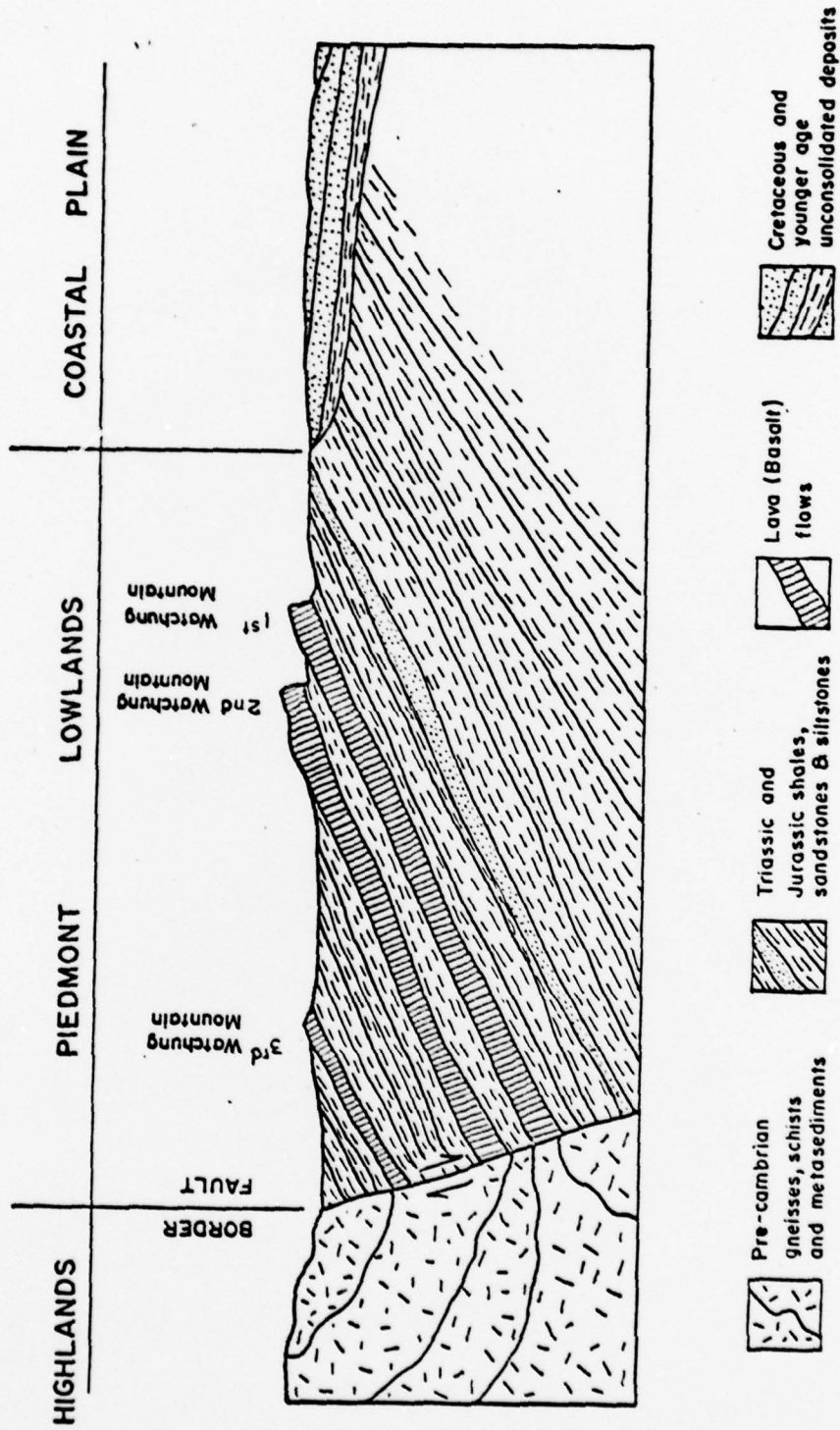
The gently rolling lowland topography of the piedmont lowlands is pierced by long asymmetric ridges of hard

and resistant igneous rocks which were intruded into or on top of the sedimentary sequences. With the subsequent erosion of the softer sedimentary rocks, these igneous formations have been left standing, often in bold relief, up to 400 ft. above the surrounding plains. The igneous bodies composed of diabase and basalt form the Palisades along the Hudson River and the three Watchung Mountain ridges of the central Piedmont. The ridges are all steeper on the southeast with gentle dip slopes to the northwest.

Overburden

The Pleistocene Age Wisconsin continental glacier has smoothed and filled approximately the northern half of the province. The terminal moraine of the glacier extends from Perth Amboy to Summit then northward to Morris Plains. North of the morainal line the soils characteristically consist of glacial tills overlying the bedrock with scattered overlying stratified outwash deposits. At least three large glacial lakes occupied portions of the area north of the moraine at different periods, resulting in a relatively flat topography composed predominantly of silts and clays.

South of the terminal moraine, most of the overburden consists of alluvial deposits overlying a more highly developed weathered transition zone on top of the bedrock. Some highly weathered tills of pre-Wisconsin glaciation can be found on the top of intervalley ridges. Much of the alluvium is glacial outwash.



SCHEMATIC CROSS-SECTION OF
 NEW JERSEY PIEDMONT LOWLANDS
 PHYSIOGRAPHIC PROVINCE

JENNY / LEEDSHILL
 JANUARY 1979

APPENDIX D

HYDROLOGIC & HYDRAULIC COMPUTATIONS

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Reservoir surface only

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 188.5 feet

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): No flood control pool

ELEVATION MAXIMUM DESIGN POOL: 188.5 feet

ELEVATION TOP DAM: 193.5 feet

CREST: _____

- a. Elevation 193.5 feet
- b. Type Earth
- c. Width 3 to 5 feet
- d. Length 9700 feet
- e. Location Spillover None
- f. Number and Type of Gates None

OUTLET WORKS: _____

- a. Type 1-48" Dia. transfer outlet and 1-16" Dia. suction outlet.
- b. Location Both near northwest corner of reservoir.
- c. Entrance inverts 174.5 feet (16" Dia. unknown)
- d. Exit inverts 174.5 feet (16" Dia. unknown)
- e. Emergency draindown facilities None

HYDROMETEOROLOGICAL GAGES: Not known

- a. Type _____
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE: Not applicable

Jan 78:214 CANOE BROOK No 2

- (1) Canoe Brook No. 2 is near boundary between Zone 1 and Zone 6. Use average of the precipitation values for the two zones. ✓
- (2) Drainage basin area is 0.15 square miles. Use precipitation values for a 10-square mile basin. ✓
- (3) Precipitation values from HMR # 33 - see page D-3

ALL SEASON ENVELOPE S

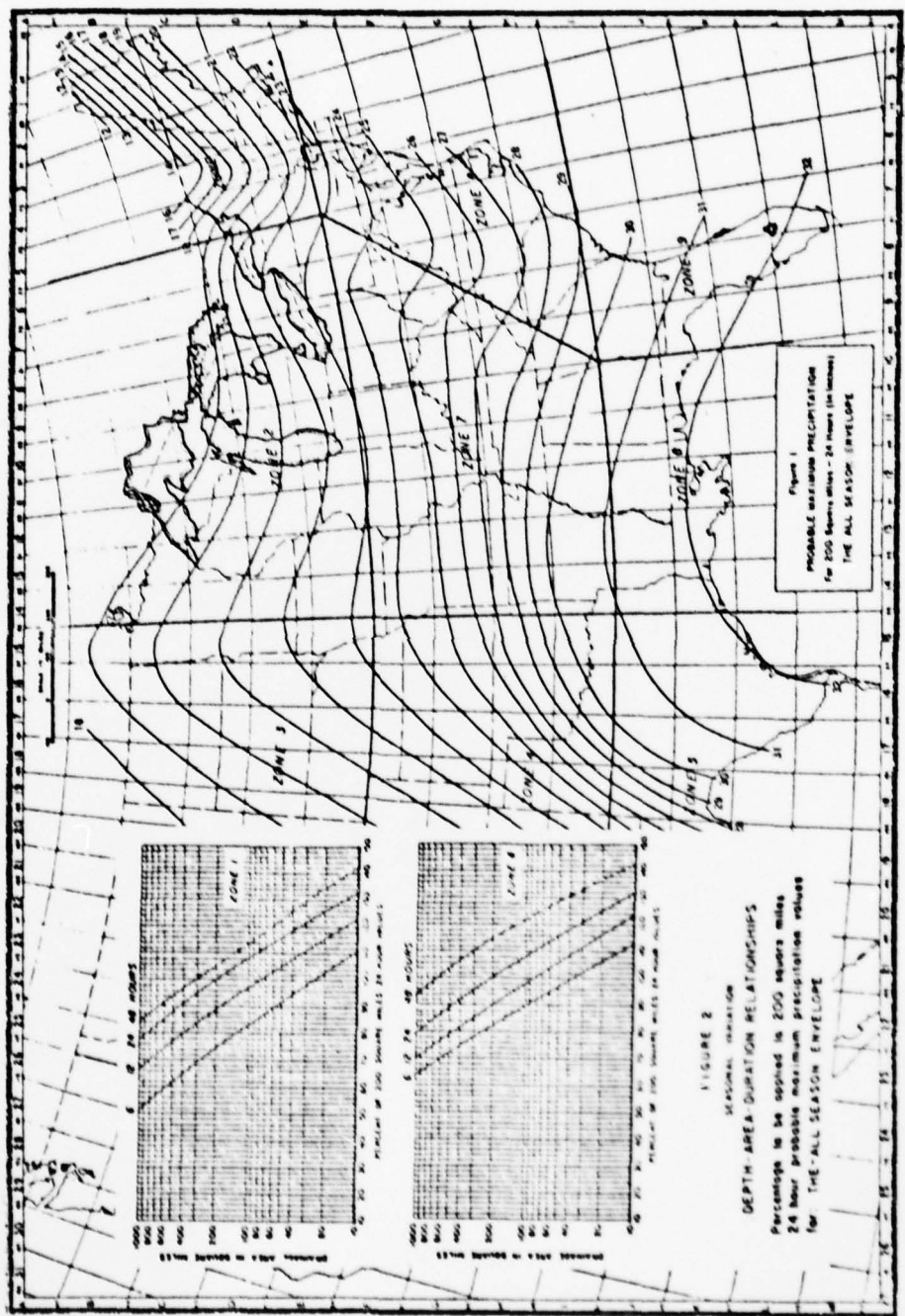
200 mi ² , 24 HR PPT	ZONE	PERCENT FOR 10 mi ² BASIN			
		6HR	12HR	24HR	48HR
22.4"	6	113	123	132	142
	1	111	122	133	142
	Avg.	112	123	133	142

ZONES 1 & 6 AVERAGE PMP VALUES FOR CANOE BROOK No. 2:

Duration, HRS	6	12	24	48
PMP	25.1"	27.6"	29.8"	31.8"
PMP reduced by Hops Brook factor (0.80)	20.1"	22.0"	23.8"	25.4"

✓ As instructed by COS

NATIONAL WEATHER SERVICE



Thu

781229

CANOE BROOK No. 2

302-03

Drawdown:

Assume discharges out of Reservoir No. 2. to Reservoir No. 1 is at the average rate water is being delivered to customers out of Reservoir No. 1, 60 acre-feet per day.

From a maximum design operating pool, time required to drain is:

$$1816/60 = 30.3 \text{ days}$$

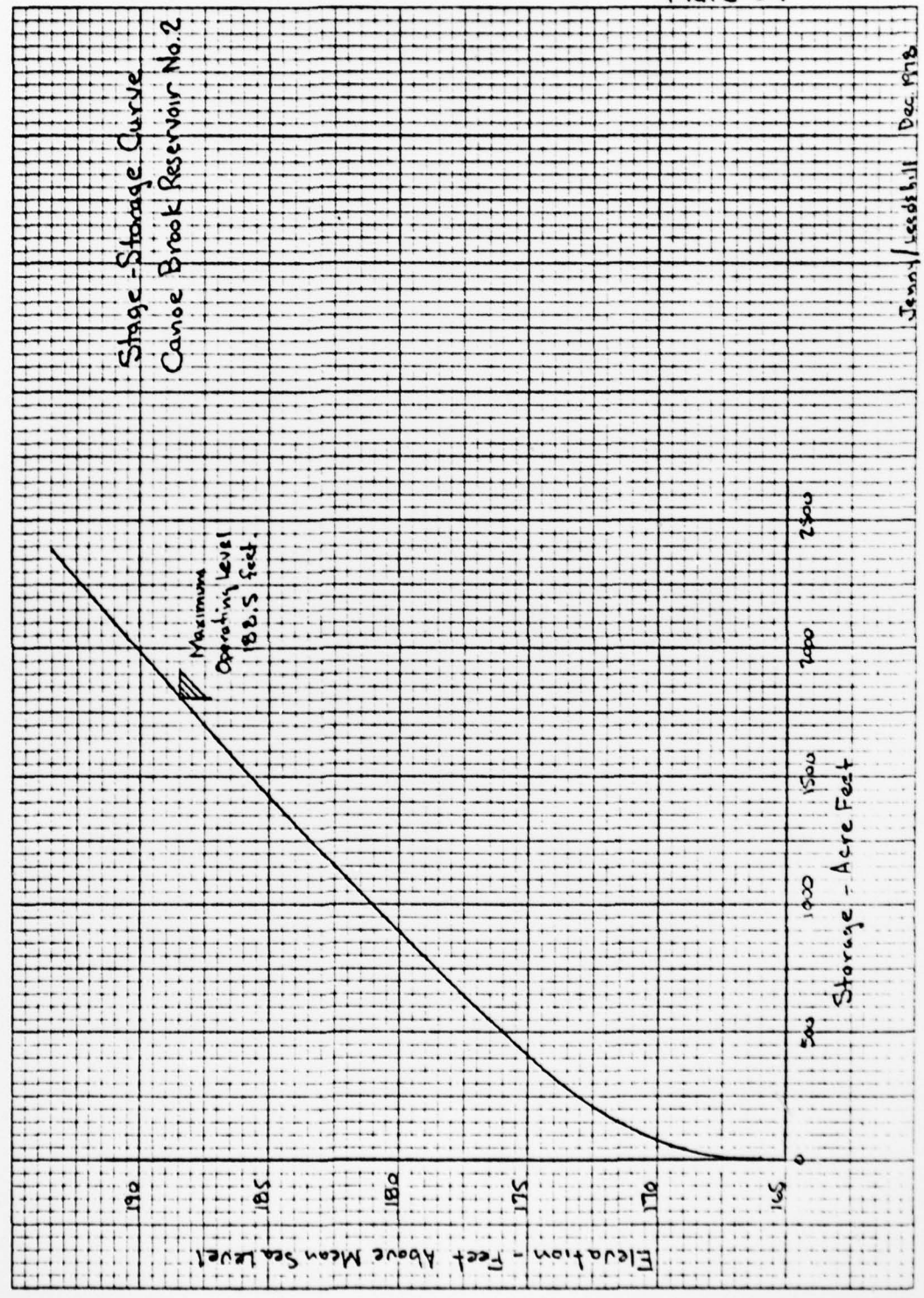
Say 30 days





Plate D-1

Stage-Storage Curve
Canoe Brook Reservoir No. 2



Jenny Leedsbill Dec. 1978