

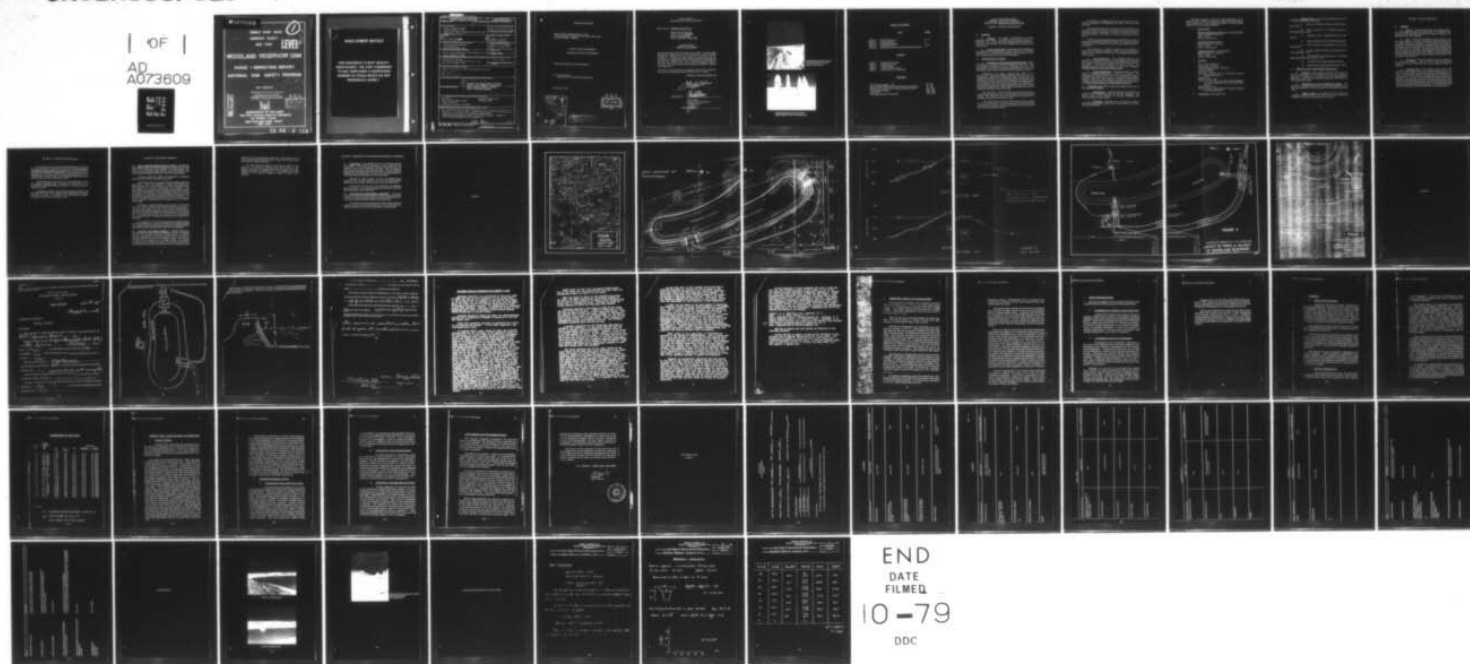
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NEW YORK STATE DEPT OF ENVIRONMENTAL CONSERVATION ALBANY F/6 13/2
NATIONAL DAM SAFETY PROGRAM. WOODLAND RESERVOIR DAM (NY00412), --ETC(U)
JUL 78 J J WILLIAMS DACW51-78-C-0035

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NATIONAL BUREAU OF STANDARDS-1963-A

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OSWEGO RIVER BASIN

ONONDAGA COUNTY

NEW YORK

LEVEL

WOODLAND RESERVOIR DAM

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

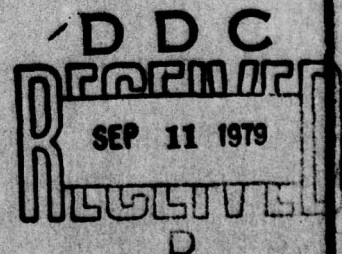
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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Inspection Report Woodland Reservoir Dam Oswego River Basin, Onondaga County, New York Inventory No. NY 412		5. TYPE OF REPORT & PERIOD COVERED Phase I Inspection Report National Dam Safety Program
7. AUTHOR(s) (10) John J. Williams		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS O'Brien and Gere Engineers 1301 Buckley Road Syracuse, New York 13221		8. CONTRACT OR GRANT NUMBER(s) (13) DACW-51-78-C-0035
11. CONTROLLING OFFICE NAME AND ADDRESS New York State Department of Environmental Conservation/ 50 Wolf Road Albany, New York 12233		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS (11) 28 Jul 78
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Department of the Army 26 Federal Plaza/ New York District, CofE New York, New York 10007		12. REPORT DATE 28 July, 1978
		13. NUMBER OF PAGES
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; Distribution unlimited. (12) 62 P.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) (6) National Dam Safety Program, Woodland Reservoir Dam (NY 412), Oswego River Basin, Onondaga County, New York, Phase I Inspection Report.		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety National Dam Safety Program Visual Inspection Hydrology, Structural Stability Woodland Reservoir Dam Onondaga County		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report provides information and analysis on the physical condition of the dam as of the report date. Information and analysis are based on visual inspection of the dam by the performing organization. Woodland Reservoir Dam was found to be in good condition. Removal of trees from the embankment was recommended. <div style="text-align: right;">393 970 <i>set</i></div>		

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

OSWEGO RIVER BASIN

Name of Dam: Woodland Reservoir Dam
County and State: Onondaga County, State of New York
Inventory Number: NY00412

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared by: O'Brien & Gere Engineers, Inc.

For: New York State
Department of Environmental Conservation

Date: July 5, 1978

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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam Woodland Reservoir Dam

State Located New York

County Located Onondaga

Stream Not Applicable

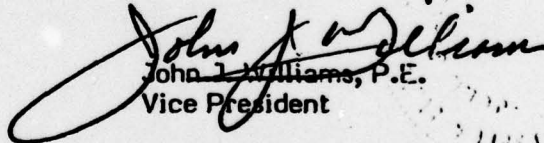
Date of Inspection June 5, 1978

ASSESSMENT OF
GENERAL CONDITIONS

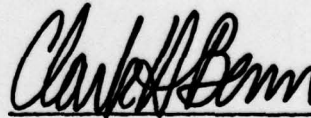
The Woodland Reservoir Dam appears to be stable. No detrimental findings were made during the visual inspection to render an unsafe assessment. However, the root systems of large trees that are growing on the downstream slope provide seepage paths through the embankment. Although these trees are impressive and add beauty to the site, they should be cut and a further investigation made to determine the extent of the root systems before additional measures are implemented.

The reservoir is provided with an adequate freeboard for storage of the 48-hour Probable Maximum Precipitation with no outflow.

O'BRIEN & GERE ENGINEERS, INC.

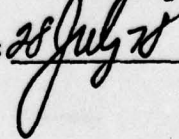

John L. Williams, P.E.
Vice President

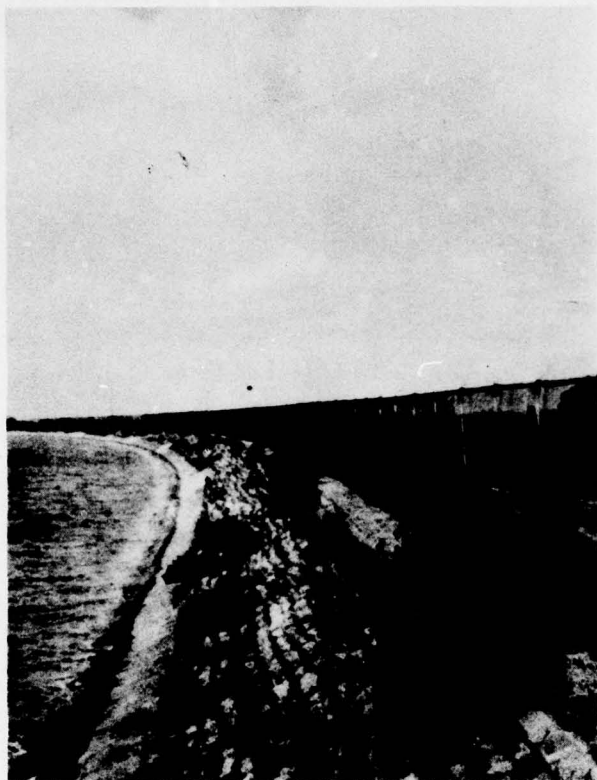
Approved by:



Clark H. Benn
Colonel, Corps of Engineers
District Engineer

Date:


28 July 78



UPSTREAM SLOPE OF DAM
STONE PAVING, GUNITE
AND VEGETATION



DOWNSTREAM SLOPE OF DAM
NORTHWEST END OF RESERVOIR

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM WOODLAND RESERVOIR DAM

SECTION I - PROJECT INFORMATION

1.1 GENERAL

a. Authority - This report is authorized by the Dam Inspection Act, Public Law 92-367, and has been prepared in accordance with contract #1467.021 between O'Brien & Gere Engineers, Inc., and the New York State Department of Environmental Conservation.

b. Purpose of Inspection - The purpose of this inspection is to evaluate the structural and hydraulic conditions of Woodland Reservoir Dam and appurtenant structures, and to determine if the Dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam, Basin and Appurtenances - Woodland Reservoir is located in central Onondaga County and is within the corporate boundary of the City of Syracuse, New York. The impoundment was formed by excavating the saddle between two hills and utilizing the excavated material to construct dikes at each end.

According to the design drawings (See Figure 3), by Howard Soule, Consulting Engineers, Woodland Reservoir Dam is a homogeneous, rolled earth embankment with an impervious clay puddle cut-off trench. The upstream slopes of the dam and bottom of the reservoir are protected by a concrete lining. The visible portion of the upstream face of the dam has a slope of 2 horizontal to 1 vertical and is paved with limestone blocks set in the concrete lining. The blocks extend below the water surface to a 10-foot berm which is located 26 feet below the top of the dam.

The Dam has a maximum height of about 36 feet and is approximately 4,200 feet long. The top width is 20 feet and is grass covered. The downstream slope is 2 horizontal to 1 vertical and is provided with two berms each 15 feet wide.

The outlet, located at the north end of the reservoir, consists of two 36 inch conduits. The North Gatehouse on the crest of the dam contains two manually operated gate valves to control discharge into the water distribution system.

The reservoir is supplied by gravity flow through two 30 inch conduits originating at Skaneateles Lake about 19 miles to the southwest.

The intake structure and South Gatehouse are located at the southeast end of the reservoir. In addition, a control structure for the supply conduits is located below the base of the dam, near each of the two gatehouses. (See Figure 4 for details of the pipe and valve layout.)

The Dam and Appurtenant Structures are owned by the City of Syracuse and operated by the Water Division. The primary purpose of the reservoir is for distribution of a treated water supply for the City of Syracuse.

The structures for Woodland Reservoir were designed by Howard Soule, Consulting Engineers, in 1892. Construction began in 1893 and was completed in 1894 with full operation beginning the following year.

b. Size Classification - The Woodland Reservoir was designed for a storage volume of 121 million gallons (370 acre-feet) at the maximum operating pool elevation of 620 feet above mean sea level (MSL). The maximum height of the dam is 36 feet. The structure is in the small size category as defined by the Recommended Guidelines for Safety Inspection of Dams.

c. Hazard Classification - Woodland Reservoir is located within a residential neighborhood of the City of Syracuse. The topography surrounding the dam is such that overtopping or failure of the dam would cause flood waters to be directed toward adjacent dwellings resulting in severe damage to property and loss of life. Therefore, the structure is in the high hazard category as defined by the Recommended Guidelines for Safety Inspection of Dams.

1.3 PERTINENT DATA (from information supplied by the City of Syracuse, Water Division.)

a. Drainage Area - Woodland Reservoir is isolated from surface runoff by drainage ditches and the local topography. The surface area of the reservoir at maximum operating pool (Elevation 620.6) is about 14 acres.

b. Discharges - Discharge from the reservoir is accomplished through manually operated gate valves located in the North and South Gatehouses.

Woodland Reservoir is used for water distribution and is dependent upon discharge through gated conduits from Skaneateles Lake; construction of an emergency spillway for flood control apparently was not considered necessary.

c. Reservoir Data

Maximum Operating Pool (Reservoir at Elevation 620.6)

Length - 1,750 feet (maximum)

Area - 14 acres

Volume - 370 acre-feet

Top of Dam (Elevation 626.6)

Length - 1,750 feet (maximum)

Area - 14 acres

Volume - 454 acre-feet

Maximum Pool (PMF - Elevation 622.6)

Length - 1,750 feet (maximum)

Area - 14 acres

Volume - 398 acre-feet

d. Dam Data

Type - earth embankment

Top elevation - 626.6 feet

Original ground elevation - 590.6 feet

Length - 4,200 feet

Top width - 20 feet

Side Slopes - upstream slope 2 : 1 (horizontal : vertical)
downstream slope 2 : 1

Zoning - none

Impervious core - none

Cutoff - 14-foot thick clay puddle cutoff extending 5 feet into embankment and 13 feet into foundation soil

Grout curtain - none

Reservoir lining - basin lined with 9 inches of concrete and 1½ inches of gunite

e. Outlet Works - See Section 1.3.b.

f. Engineering Data - The information available for review of Woodland Reservoir Dam included:

- 1) Sections of Woodland Reservoir, dated November 10, 1892.
- 2) Plan of Conduit Line to Woodland Reservoir, dated September 15, 1908.
- 3) Topographic Map - Woodland Reservoir, dated July 1917
- 4) Layout of Pipes & Valves at Woodland Reservoir.
- 5) Plan & Section of 6" Underdrain at Toe of the Embankment.
- 6) A report entitled "Relining of Woodland Reservoir with Gunite - 1932."
- 7) DAM REPORT by the Conservation Commission, State of New York, dated August 2, 1917.
- 8) A report by B.K. Hough, Consulting Engineer.
- 9) Water levels from piezometers installed in 1964.

1.4 OPERATING AND MAINTENANCE PROCEDURES

a. Operation - Under normal conditions, the reservoir is used for water supply and is maintained at the maximum operating pool level. Drawdown of the reservoir can be accomplished by opening a 16 inch diameter overflow conduit along with the three water distribution mains.

b. Maintenance of Dam and Operating Facilities - The facilities at Woodland Reservoir are under daily surveillance by a work crew assigned to the site and repairs are performed as the need arises.

c. Warning System - No system for flood warning is currently in effect, but the water surface elevation is continually monitored at the Water Department's control center.

SECTION 2 - VISUAL INSPECTION

2.1 FINDINGS

a. General - The field inspection of the Woodland Reservoir embankment took place on June 5, 1978. The reservoir water surface elevation was about 620 feet MSL during the inspection. No underwater areas were inspected.

b. Dam - The entire downstream slope and crest of the dam is grass covered. There was no indication of slope misalignments or seepage along the downstream toe and slope at the time of inspection. During the inspection, no discharge was observed in the catch basin which collects flow from the drain system installed along the northwest toe of the slope. Evergreen trees with diameters as large as 3 feet are growing in the downstream slope between the North Gatehouse and the access road. Grass, small bushes and vines are growing between the stone masonry blocks on the upstream face around the entire reservoir.

c. Gatehouses - The brick masonry structures appeared to be in excellent condition. The gate valves within the structures appeared to be well maintained, but were not operated during the inspection.

d. Reservoir Area - The natural ground west of the reservoir slopes upward to an elevation about 60 feet above crest of dam. The slope is covered with deep grass and appeared stable at the time of the inspection. Runoff from this slope is intercepted by a drainage ditch. A brick masonry standpipe has been constructed on the top of this hill with an asbestos cement overflow pipe which discharges into Woodland Reservoir. The northeastern portion of the basin is cut into the gently undulating summit of a hill which slopes away from the basin towards the northeast. The remaining perimeter generally slopes away from the embankment and is grass covered.

SECTION 3 - HYDROLOGY/HYDRAULICS

The design flood used for the Woodland Reservoir structure is the Probable Maximum Flood (PMF), according to the Recommended Guidelines for Safety Inspection of Dams. The reservoir surface at the maximum operating level (Elevation 620.6) comprises the entire drainage area. Therefore, the PMF was considered equivalent to the adjusted 48-hour Probable Maximum Precipitation (PMP) which would raise the reservoir water surface about 2 feet.

The embankment is provided with 6 feet of freeboard above the maximum operating pool. Therefore, no difficulty is to be anticipated in adequately storing the rainfall of a storm less than or equal to the PMP.

A drawdown analysis was performed assuming discharge into the distribution mains with a starting water surface elevation of 620 feet and no inflow. According to the calculations, complete drawdown of the reservoir would take 7 days.

SECTION 4 - STRUCTURAL STABILITY

4.1 VISUAL OBSERVATIONS AND DATA REVIEW - Although the Dam appeared stable at the time of inspection, the existence of large trees on the downstream slope represent a potential hazard: the trees could be uprooted by high winds, or the root systems of the trees may provide seepage paths that could lead to future piping.

Extensive repairs and a number of investigations of Woodland Reservoir Dam have been undertaken since 1894.

According to the report entitled "Relining Woodland Reservoir with Gunitite - 1932" (See Appendix), in January 1932 seepage was observed flowing from the northwest toe of the downstream slope. The reservoir was drained, piezometers were installed in the embankment, the concrete lining was inspected and pressure tested and a full scale leakage test was performed to determine the source of seepage. The conclusion of this investigation was that, sic, "the concrete lining was structurally sound but very soft and porous." The reservoir was subsequently lined with about 1½ inches of gunitite and a 6-inch underdrain installed along the northwest toe of the downstream slope.

B.K.Hough, Consulting Engineer, was retained in 1964 by the City of Syracuse to evaluate the embankment conditions in connection with a new school to be built in the vicinity of Woodland. A subsurface investigation program consisting of soil borings, laboratory testing and piezometer installations was undertaken by the consultant. Mr. Hough concluded that the reservoir and its embankments were in good condition. Excerpts from this report are included in the Appendix.

It is significant to note that the piezometers installed during the 1964 investigation have been monitored and the readings recorded on a regular basis by City personnel. Evaluation of this data indicates that all piezometers have been essentially dry since installation.

4.2 GEOLOGY AND SEISMIC STABILITY - Woodland Reservoir is located within the Erie-Ontario physiographic province, a relatively low, flat area bordering Lake Erie and Lake Ontario. The simple erosional topography is modified by glacial drift in the form of drumlins, shoreline deposits and recessional moraines. The reservoir is formed by the enclosure of a saddle between two drumlins deposited during the Pleistocene Epoch. The glacial till which forms the foundation of the dam was excavated from the saddle area and

utilized as fill for embankment construction. The basement rock, a thinly bedded Silurian dolomite, varies in depth from 20 feet to 40 feet below the original groundline.

No fault zones are known to exist in the vicinity of the reservoir. The structure is located within Seismic Zone 2 of the Seismic Zone Map of Contiguous States, and it appears that static stability conditions are satisfactory. No earthquakes have been recorded of any significant magnitude within 50 miles of the reservoir.

SECTION 5 - ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

5.1 ASSESSMENT - The Woodland Reservoir embankment appears to be stable. No evidence of seepage or unusual settlement was observed at the time of inspection. However, large trees (up to 50 feet tall) are growing in the northwest slope. This is a potential problem since the roots of trees have been known to provide a path of seepage through embankments. Further, high winds could uproot the trees, thus removing large portions of the embankment.

Although the stone masonry riprap on the upstream face appeared to be in good condition, the vines and bushes growing between the stone blocks could eventually loosen the riprap facing.

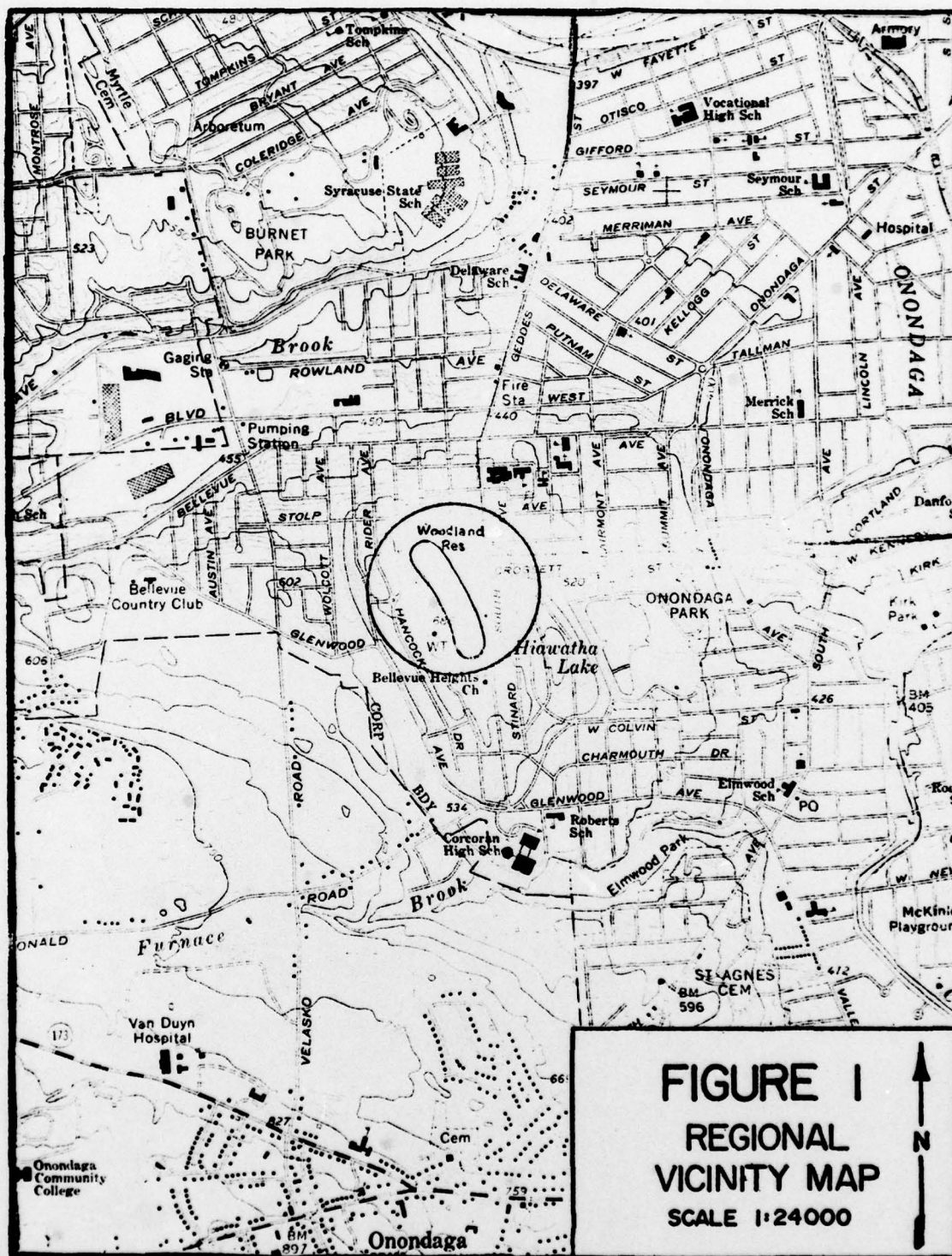
The structures for the outlet works associated with Woodland Reservoir appear to be in good condition, and should not adversely affect the safety of the embankment.

5.2 RECOMMENDATIONS/REMEDIAL MEASURES - The large trees on the downstream slope should be cut near the ground surface. A further investigation should be made to determine the extent of the root system before additional measures are implemented.

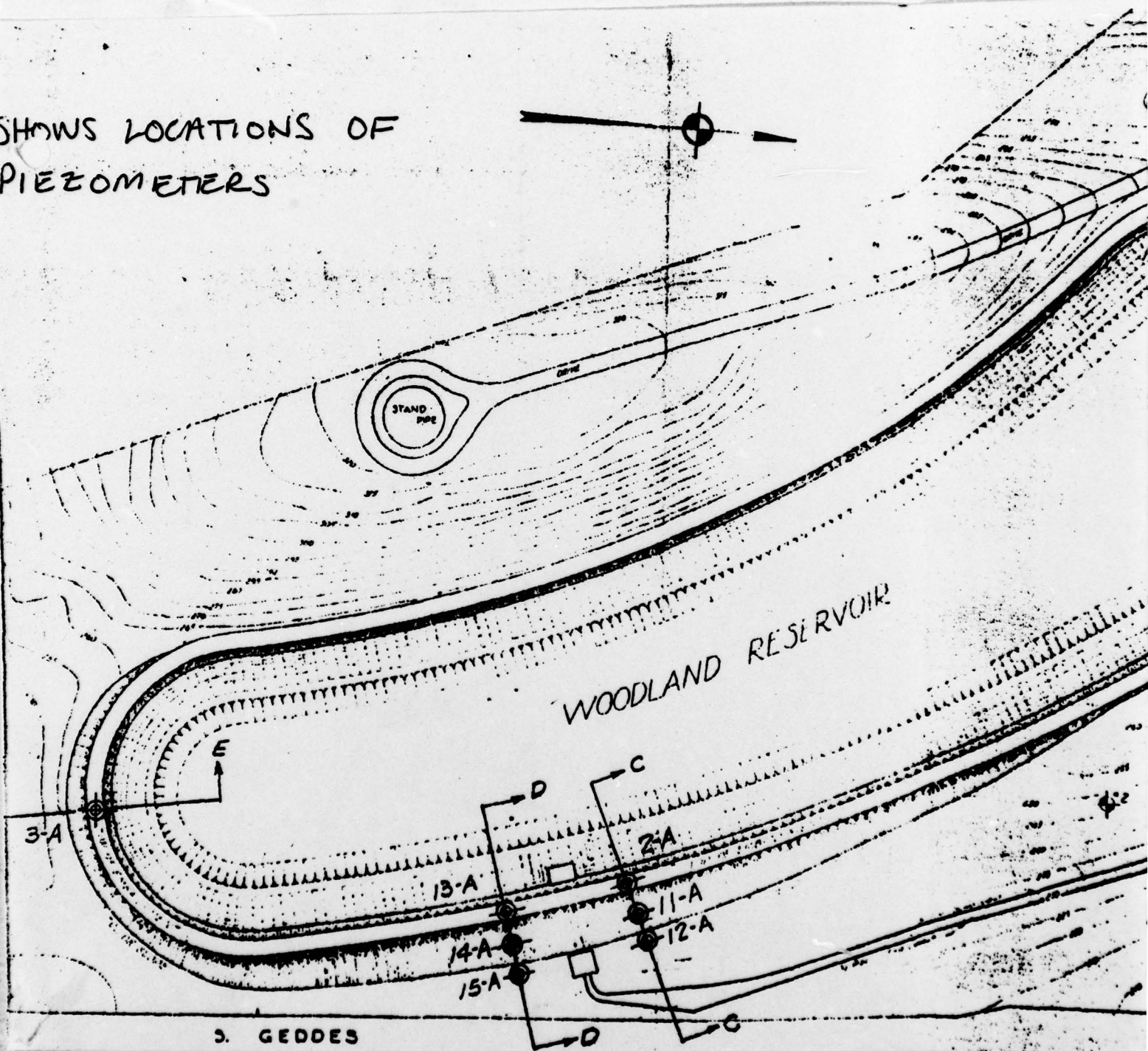
The shrubs and vines growing on the upstream slope should be pulled or cut and the root systems destroyed. The cavities should be cleaned and filled to grade with an appropriate binding material.

FIGURES

16



SHOWS LOCATIONS OF
PIEZOMETERS



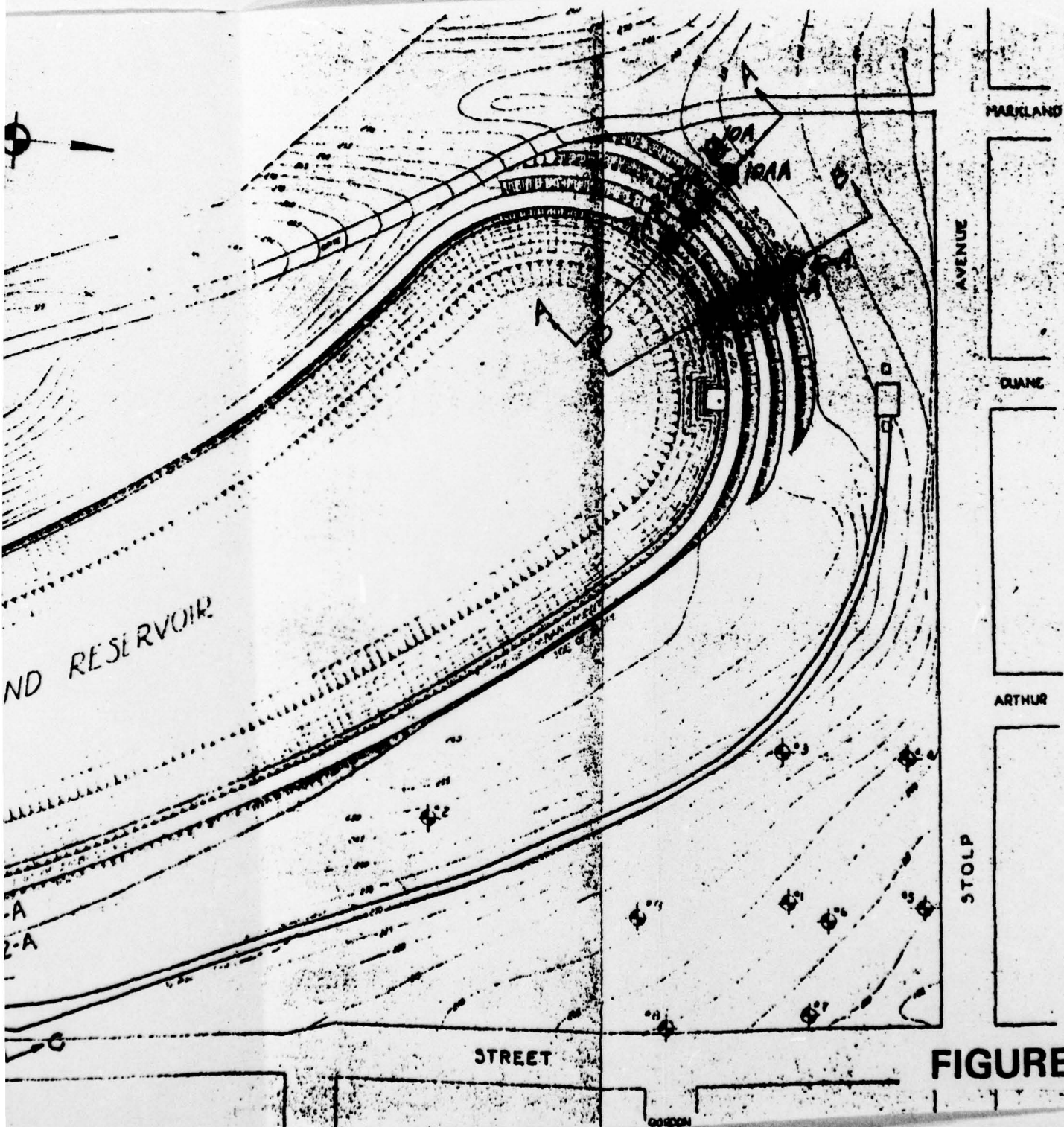


FIGURE 2

ELEVATION - MSL

640

620

600

580

FLOW LINE

SLOPE 2:1

9" CONCRETE

SLOPE 2:1

12" BLOCK

Clay
Puddle

20'

SECTION

ELEVATION - MSL

640

620

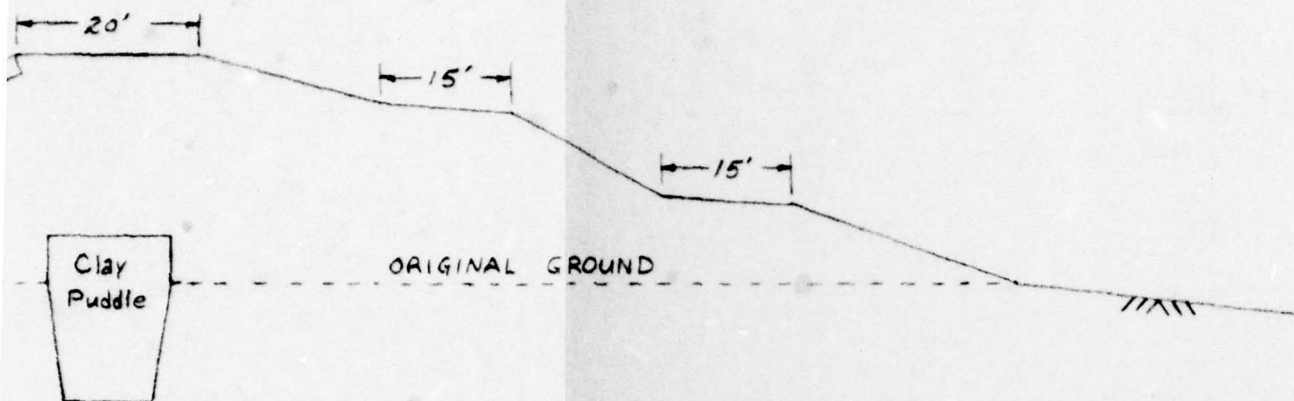
600

580

Clay
Puddle

20'

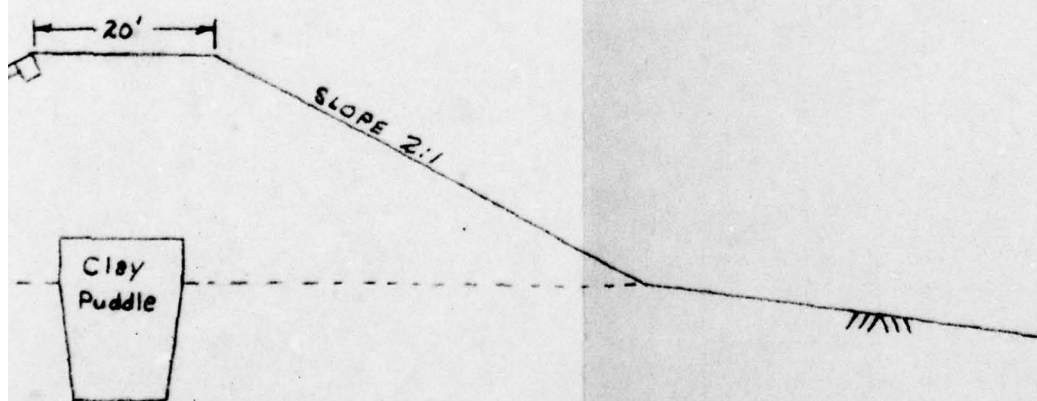
SECTION



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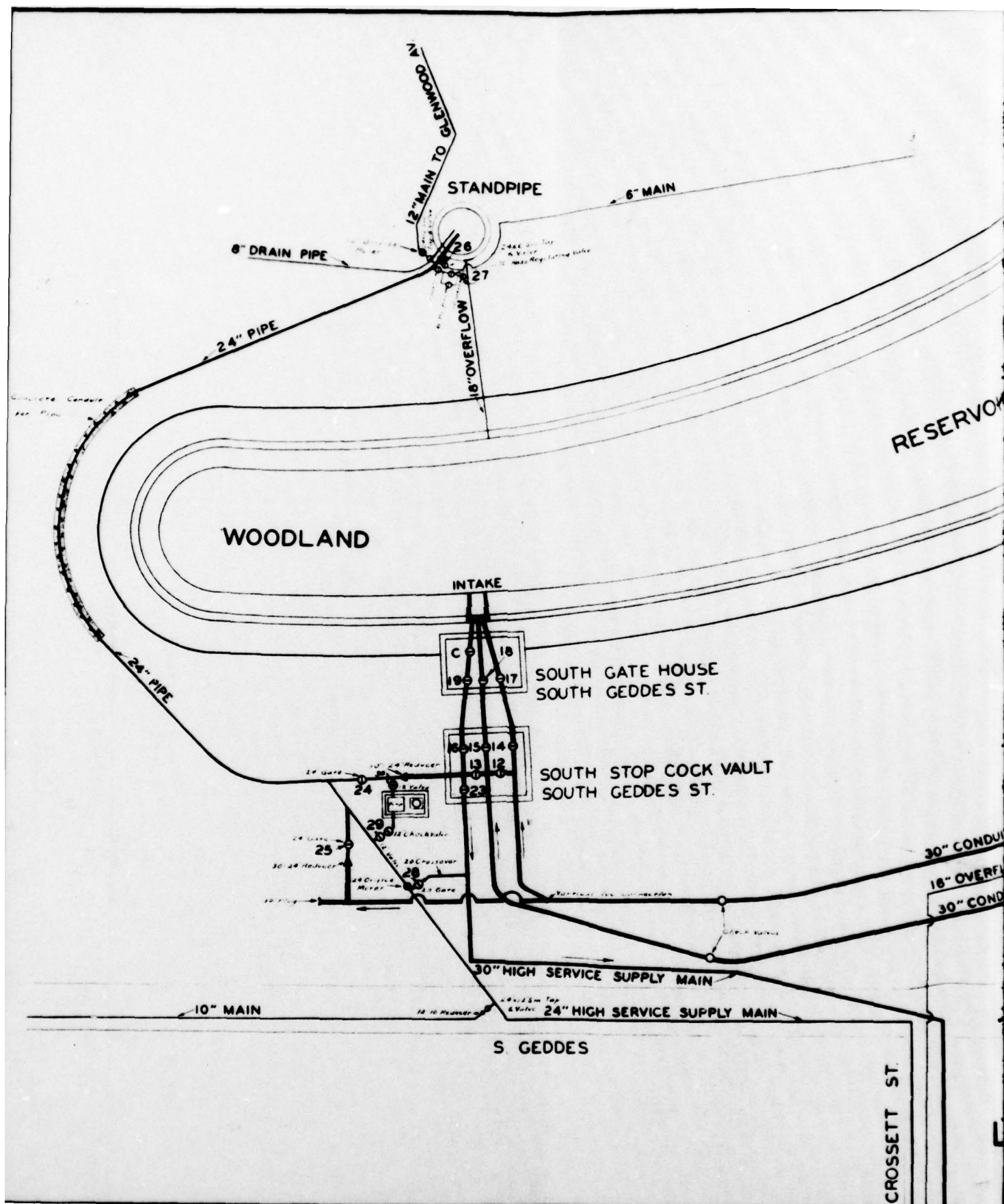
Information for this sketch obtained from "CROSS SECTION OF THE WOODLAND RESERVOIR, Howard Soule, Consulting Engineer, Nov. 10, 1892.

SECTION B-B



SECTION D-D

FIGURE 3
TYPICAL SECTIONS



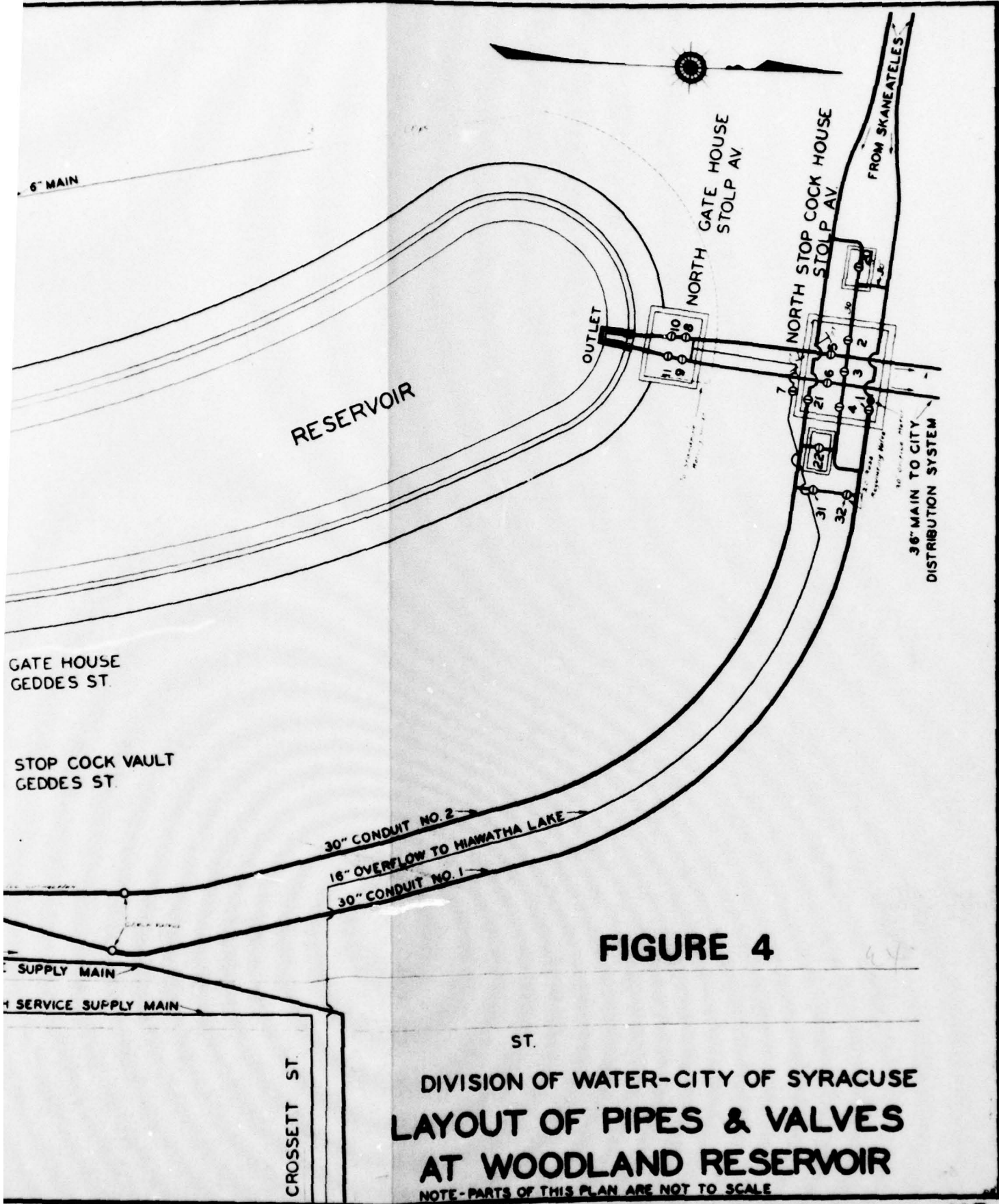


FIGURE 4

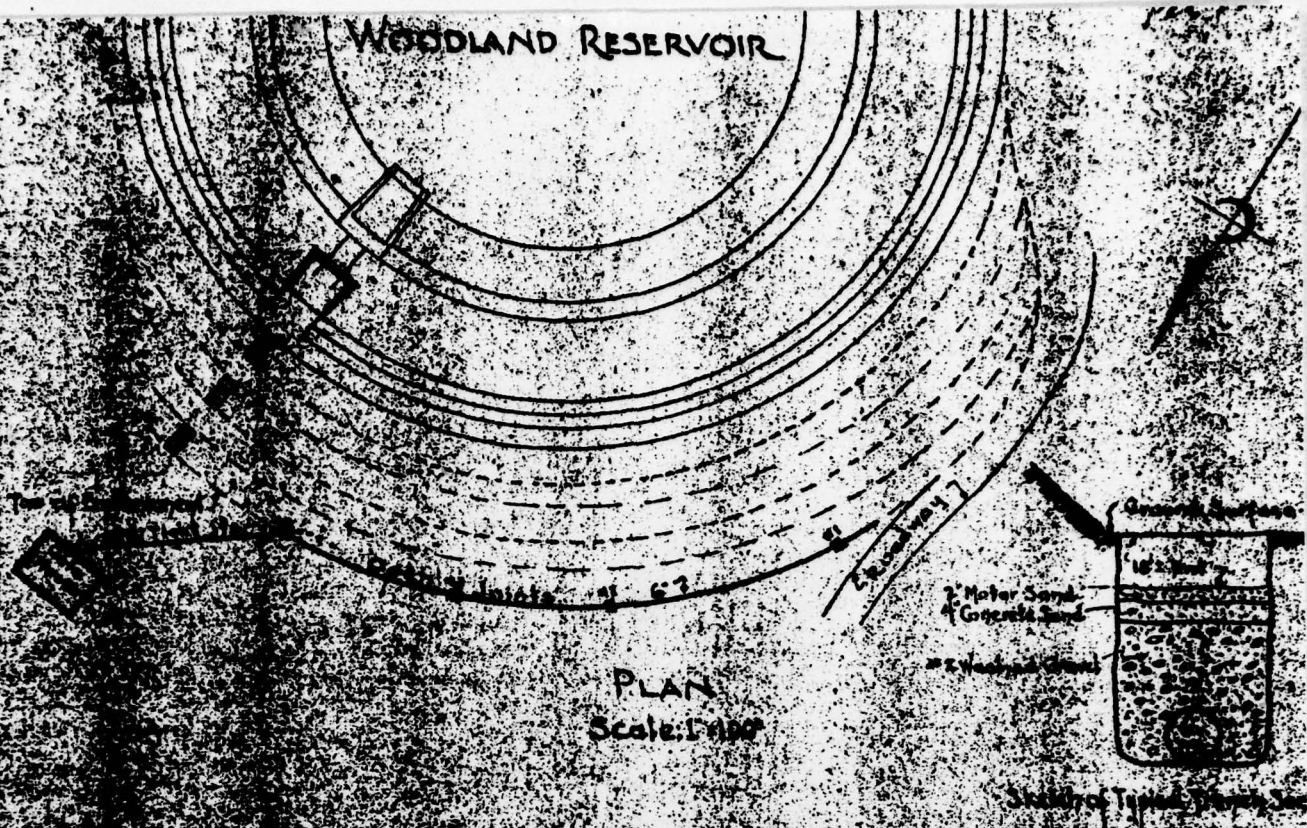


FIGURE 5

CITY OF SYRACUSE, DIVISION OF WATER
DEPT. OF ENGINEERING

**GUNDER DRAIN AT TOE OF THE
EMBANKMENT AT WOODLAND
RESERVOIR**

SCALE AS INDICATED - APPROVED
DRAWN BY A.S.B.
CHECKED BY A.S.B.
APPROVED

APPENDIX

Q

For use by the State of New York

NOTICE: After filling out one of these forms as completely as possible for each dam in your district, return it at once to the Conservation Commission, Albany.

STATE OF NEW YORK
CONSERVATION COMMISSION
ALBANY

DAM REPORT

342 George

August 2, 1917
(Date)

CONSERVATION COMMISSION,

DIVISION OF WATERS.

GENTLEMEN:

I have the honor to make the following report in relation to the structure known as
the Woodhatch Syracuse Reservoir Dam.

This dam is situated upon the Ted from Skaneateles Lake by the
in the City of Syracuse, Onondaga County,
about 2 1/2 from the Village or City of Center of City
(State distance)

The distance stream from the dam, to the stream
(Up or down) (Give name of nearest important stream or of a bridge)
is about stream
(State distance)

The dam is now owned by City of Syracuse
(Give name and address in full)
and was built in or about the year 1891, and was extensively repaired or reconstructed
during the year embankments are earth masonry line

As it now stands, the spillway portion of this dam is built of embankments are earth masonry line
(State whether of masonry, concrete or timber)
and the other portions are built of embankments are earth masonry line
(State whether of masonry, concrete, earth or timber with or without rock fill)

As nearly as I can learn, the character of the foundation bed under the spillway portion
of the dam is clay and under the remaining portions such
foundation bed is clay

(In the space below, make a third sketch showing other conspicuous objects in the vicinity.)

Standpipe

Center Lines

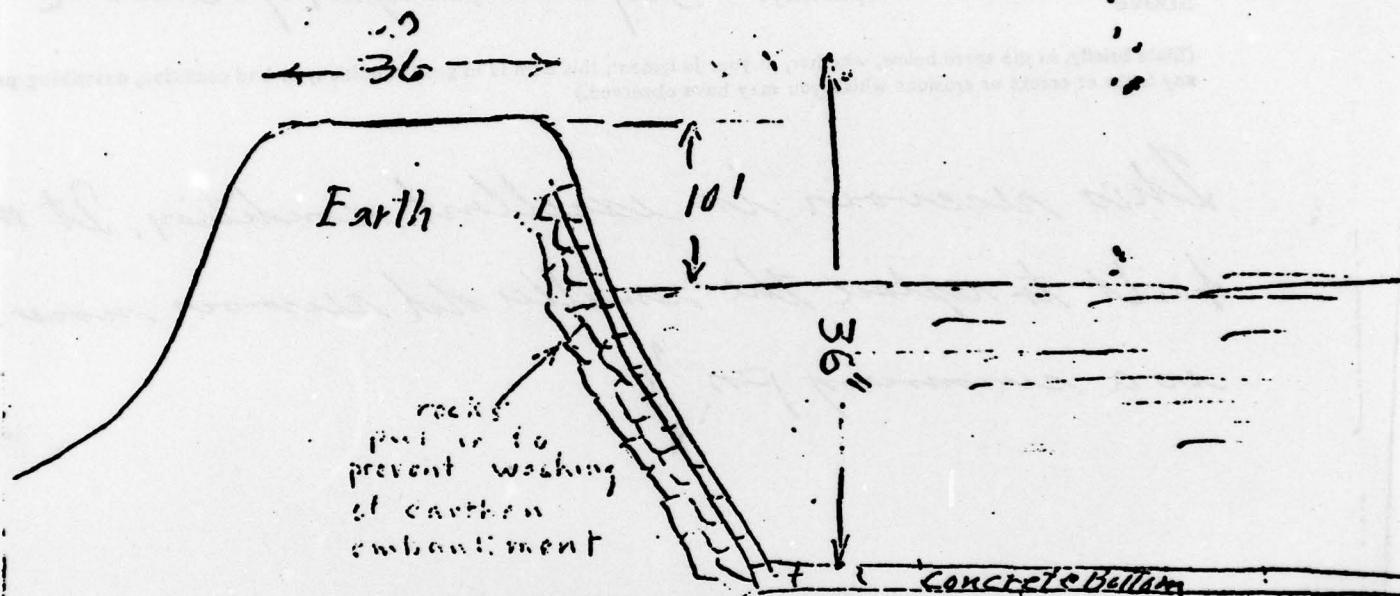
Masonry lined

Concrete base

Gate House

Stake

Space below, make one sketch showing the form and dimensions of a cross section through the spillway or waste-weir of this dam and outline the abutment, and a second sketch showing the same information for a cross section through the other portion of the dam. Show particularly the greatest height of the dam above the stream bed, its thickness at the top, and thickness at the bottom, nearly as you can learn.)



The total length of this dam is.....feet. The spillway weir portion, is about.....feet long, and the crest of the spillway is about.....feet below the abutment.

The number, size and location of discharge pipes, waste pipes or gates which may for drawing off the water from behind the dam, are as follows: *Water is drawn off by conduits one 30" two 36" and 24"*

At the time of this inspection the water level above the dam was.....ft. below above the crest of the spillway. *36 ft max depth of reservoir*

(State briefly, in the space below, whether, in your judgment, this dam is in good condition, or bad condition, describing any leaks or cracks or erosions which you may have observed.)

This reservoir in excellent condition. It is built to replace the smaller old reservoir now used as a swimming pool.

Reported by *Vernon L. Schell*
(Signature)

P. & Charles M. J.
(Address—Street and number, P. O. Box or R. F. D. route)

P.O. Box 177
(Name of place)

Aug 7 1915

RELINING WOODLAND RESERVOIR WITH GUNITE - 1932

Woodland Reservoir was constructed in the years 1892 to 1895, and was put into operation in the latter year. It was lined with 9" of concrete on the bottom and slopes up to the berm, 12" of concrete on the berm, and the upper slope was lined with 6" of concrete faced with one foot of Onondaga Limestone masonry. In construction or expansion joints were provided. Each day's pouring was joined to the preceding day's work in irregular lines without special effort being made to secure a bond.

American Hydraulic Cement was used, the specifications calling for a compressive strength of concrete of 100 lbs. per square inch.

After this reservoir had been in operation for a year, it was drained and cleaned. It was never completely emptied again until 1932.

In January 1932 a small stream of water was observed flowing from the toe of slope, at the northwest corner of the reservoir, at a point where the artificial embankment in this reservoir has a maximum height of about 40 feet. While some signs of moisture had been observed in this section in previous years, it was attributed to ground water as it disappeared in dry weather. The amount of water which appeared in January was considerably greater than previously experienced for this time of the year, and it was therefore decided to investigate to determine if it was leakage from the bowl. Test holes were dug at the toe of slope and in the outside berm, both showing evidence of water in the embankment. As a further check 2" pipes were driven at intervals thru the center of the embankment by means of a wash drill to a depth of about 40 feet. All of these test pipes showed water in the embankment, the ones in the northwest corner showing that water existed in the embankment within 18 feet of the top. From this evidence, it seemed conclusive that there was seepage thru the embankment and that the embankment was partly saturated. Such a condition was considered dangerous and it was decided to drain the reservoir immediately to at least one-half depth to relieve the pressure on the banks and thereby minimize the possibility of a failure of this clay embankment which would certainly result in a large loss to neighboring property, and possible loss of life. This draining operation was started on January 30 and on February 9 the level in the reservoir had reached the elevation of the inside berm, leaving a depth of approximately 15 feet in the bowl. The water was held at this elevation until the spring months in order to protect the lining as much as possible against frost action.

About April 1st the level was again lowered until all of the water had been drained from the bowl which was accomplished about the middle of the month.

When the depth of water in the reservoir was about two feet, the State Conservation Department removed all of the fish in the reservoir by means of nets transporting these fish to neighboring lakes. Hundreds of perch and lesser amounts of white fish and bass were removed.

Cleaning operations were begun at once by the Water Division using its own men. A layer of about 2½" of silt, mud and sea weed covered the lower slopes and bottom. This was scraped with a truck and wooden scraper to the Geddes Street gate house where it was flushed thru the 30" and 24" high service feeder to Onondaga Creek. Final cleaning was accomplished by men with brooms by May 20. The cleaning operation required about ten men per day.

A careful inspection of the lining was then made to determine its condition. It was found that the old concrete, in general, had deteriorated but little, most of its surface being smooth and intact. However, it was found to be very porous and soft. In most places it could be removed with the use of a pick only. A 6" core was bored from the lining and inserted in the end of a 6" cast iron pipe which was sealed tight and a pressure applied corresponding to a maximum pressure on the bottom of the reservoir. This test showed that there was an appreciable seepage of water thru the lining under this pressure.

The worst condition was at the angle formed by the lower slope in the berm where some settlement of the upper slope had caused the inside edge of the berm to raise, leaving a crack at this angle varying in thickness from a small fraction of an inch to the thickness of a man's hand. This condition was worst opposite the point in the northwest corner where water had been observed breaking out of the ground at the toe of slope. Moreover, there was a hollow space beneath the berm indicating settlement or wash. Such a condition was also observed immediately south and north of the upper Geddes Street gate house. At a point just north of this gate house it had been noted for years that there was an unusual amount of ground water breaking out of this side hill toward Geddes Street, it being especially noticeable in the check valve chambers of the conduits located in this area. It is probable that at least some of this water was leakage.

In the late Fall of 1931 leakage tests were run on Woodland Reservoir by closing all of the gates on the inlet and outlets and measuring the drop in the reservoir, correction being made for evaporation and rainfall. By this test it was found that leakage existed to the extent of 200,000 to 250,000 gallons per day. This test, with the evidence obtained by inspection of the lining, showed that the embankment of this reservoir is not impervious.

A study was now begun of the best method of repairing the reservoir lining to insure water-tightness at reasonable cost. Based on our experience in lining the new Westcott Reservoir, a gunite lining for Woodland was favored by the engineers, but it was felt that investigation of other waterproofing methods costing less should be made. A great deal of study was therefore given to the various waterproofing materials on the market for this kind of work and waterproof engineers and contractors were invited to investigate the condition of the lining and to give their opinion as to the practicability and cost of waterproofing the reservoir. Various materials and methods were considered, including emulsified asphalt, membrane waterproofing, hot asphalt, and various powdered metal treatments.

There seemed to be a great deal of difference of opinion on the subject of waterproofing. None of these concerns were able to show a single job in this country where their process had been used successfully on a job of anything of the magnitude of Woodland Reservoir. The estimated cost for the various treatments varied from five cents to ten cents per square foot. While this was substantially cheaper than a gunite lining there was no assurance that any of these waterproofings would be effective for more than ten years, whereas it is commonly conceded that the life of a good gunite lining is indefinite, easily exceeding 50 years, and it was therefore decided to gunite the reservoir.

Inasmuch as considerable experience had been gained by the City in the lining of Westcott Reservoir and in the research work which the Water Division did in the winter of 1930-31, and as there was a desire to employ local labor as much as possible, it was decided to do this work with the City's own forces employing a minimum number of experienced workmen and gunmen until such time as City men had become sufficiently familiar with this work to give good production and quality. Two or three men of the Division forces were already experienced, having worked on various small gunite jobs which the City had done since the lining of Westcott Reservoir.

It was necessary to rent equipment for such a large job and bids were therefore asked on the rental of six of the E-2 Cement Guns and sufficient compressor capacity to furnish not less than 1450 cubic feet of free air per minute. Other miscellaneous equipment pertaining to the guns such as hose, nozzles, mixers, etc., were included in the bid. The Cement Gun Company of Allentown, Pennsylvania, were low bidders on this equipment, furnishing four large horizontal, slow speed, electrically driven, air compressors, with the other equipment specified, and two mechanics for operating the compressors and servicing all of the equipment. Contracts were let to low bidders on materials as follows:

Cement - D. J. Salisbury, Inc., Syracuse, N. Y.

Sand - B. D. Hyde, Solvay, N. Y.

Mesh & Expansion Belts - Paragon Plaster Co., Syracuse, N. Y.

Copper Expansion Joint - T. Talbot & Sons, Syracuse, N. Y.

Plastic joint material was bought from the Central City Roofing

Alfa Cement was manufactured at Jamesville, N. Y.

Mesh - manufactured by Wickwire-Spencer Co.

The bid on cement and sand called for delivery at the reservoir grounds.

It was decided to apply a lining of $1\frac{1}{2}$ " thickness on the concrete and an average thickness of $1\frac{1}{4}$ " on the stone. The lining was to extend to within 10 feet of the top of the reservoir measured along the slope. It was not thought necessary to line this area as it is above the high water line, and subject to splash only.

2. RESERVOIR DESIGN AND CONSTRUCTION

The reservoir is located in the southwest section of the city as shown in Fig. 1 on the facing page of this report and forms an important part of the municipal water supply system. City records indicate that the reservoir was built in 1894. It has been continuously in service ever since, a period of some 70 years.

The reservoir has a capacity of about 125 million gallons. The overall length is roughly 1750 feet; the width, 400 feet, and the depth of water, about 35 feet.

Existing site topography* and orientation of the reservoir are shown in Fig. 2. Construction drawings indicate that the site was originally a saddle from which the flow of surface water was respectively to the north and the south. The reservoir was formed by making an excavation in the saddle area and utilizing the excavated material to construct dikes at either end. It appears that there was an approximate balance of cut and fill and that all embankment material was obtained from the site. Thus the reservoir bottom and all cut and embankment slopes are in or of essentially the same material. This material is glacial till as is more fully described in later sections of this report.

The dikes are of homogeneous cross section and were originally constructed without provision for internal or toe drainage. The plans indicate that a core trench with puddled backfill was constructed along the centerline of the embankment sections. The embankments were reportedly compacted by use of a grooved roller but details on the size and weight of the roller do not appear in the records. Embankment side slopes as well as cut slopes are 1 on 2 except as

* All detailed topographic plans and embankment cross sections appearing in this report show elevations referenced to the City of Syracuse datum. To convert these elevations to U. S. G. S. datum (MSL) add 360.02 ft.

modified by berms. Embankments and cut sections were constructed to provide for about 5 ft. freeboard above the normal reservoir level.

The entire bottom and sides of the reservoir are paved with concrete, the upper section of which is faced with hand placed, mortared stone riprap. It appears that this lining was expected to serve as a watertight membrane and that this accounts for lack of provision for drainage in the embankments themselves. It may further be noted that the lining was constructed directly on the earth surfaces of the bottom and sides without an underlying, pervious drainage course.

Since its original construction, the reservoir has been modified in some respects as required to meet various situations which developed during reservoir operation. In 1938 a break in the lining on the north dike reportedly occurred. Seepage through the embankment with outcrop on the landside slope was observed at that time. The lining was repaired and a pipe drain installed at the landside toe of the embankment. No further trouble at this location has since been observed and it is reported that little if any flow issues from the drain. At about the same time while the reservoir was empty or being emptied, a section of lining on the west-erly side of the reservoir was heaved by pressure of water seeping from the hillside on which the standpipe is located. An intercepting drain was installed along the foot of the hill-side slope and the lining repaired. There has been no known trouble at this location since. Repairs to the lining have been required on a number of other occasions but these reportedly did not include installation of any form of drainage.

There is some question in the minds of those operating the reservoir whether the lining is now or has ever been completely watertight. This doubt is supported by occasional measurements of inflow and outflow made at times when no known breaks in the lining existed. These measurements although admittedly not of a highly precise nature, have given evidence of leakage.

3. FIELD INVESTIGATIONS

Several investigations have recently been made at the reservoir site for various purposes as described below.

a. Investigation for Southwest Junior High School.

In March 1964, borings were made in the northeasterly corner of the property to investigate conditions affecting construction of the proposed Southwest Junior High School. These were designated borings #1 to 9 inclusive. Their locations are shown in Fig. 2. While this investigation did not include examination of the reservoir embankments, it provided information on certain site features of interest in this report. For this reason, the driller's logs of these borings have been included in Appendix 1.

b. Investigation of Reservoir Embankment

The purpose of the investigation undertaken by the writer was to determine the nature and condition of the materials in the reservoir embankments and the embankment foundations. Although the initial plan was to make this investigation by means of both test pit excavations and borings, agreement was reached with the City Engineer during the course of the work that borings alone would be sufficient. Fifteen borings designated 1-A to 15-A inclusive, were eventually made at locations shown in Fig. 2. The driller's logs of all these borings will be found in Appendix 2 of this report.

Borings 1-A, 2-A and 3-A were made in the period Oct. 28 to Nov. 5, 1964 to constitute a preliminary investigation which could be used as a guide in planning the remainder of the work. These three borings located respectively in the north, east and south dikes, were drilled through the embankments, the underlying natural soil formations and well into the bedrock beneath.

Borings 4-A to 15-A inclusive were made in the summer of 1965. These were for the dual purpose of investigation of embankment and foundation conditions and also for installation of piezometers as subsequently described.

Information obtained from these borings will be found not only in the driller's logs but also on the embankment cross sections presented in Figs. 3, 4 and 5. Reference to these figures will facilitate comparison of data such as penetration resistance values for samples at varying depths from the several different borings which were made in each section.

b. FINDINGS

a. Natural Site Formations

Aside from the reservoir itself, the most conspicuous site feature is the elongated hill or knoll on which the standpipe is located. This hill, which rises to a height of about 60 ft. above the water level in the reservoir, is a drumlin. Although no borings were made in the hill, it is known from the regional geology that such formations are composed of glacial till, an extremely strong, compact, unsorted but relatively well graded mixture of sand, silt and clay with scattered gravel and occasional boulders.

The remainder of the City-owned property is a larger, less well defined drumloid land form, a formation which is also composed of glacial till.

The borings indicate that the till rests directly on the bedrock. Since both the ground and rock surfaces have significant slope, the depth to rock varies considerably. However, the overburden as a whole is relatively shallow. The depth from original grade to rock probably does not greatly exceed about 35 ft. at any point and in general is closer to about 20 ft.

The bedrock has been identified as belonging to the Bertie Formation. This formation is composed of thin-bedded, slabby, siliceous, dolomitic limestone. For a depth of 5 to 10 ft. the rock is believed to be somewhat weathered. It is probable that the weathered rock interval is considerably more pervious than the till and that it functions as an underdrain or aquifer.

b. Reservoir Embankments

The embankments were constructed with glacial till material taken from on-site excavations. Textural characteristics of this material are indicated by the gradation

urves in Appendix 3. The till may be classified as a well graded sandy Silt with little to some clay, scattered gravel and occasional boulders.

The in-place density or compactness of the embankment material may be judged in several ways. One is by reference to the standard penetration resistance values obtained in each sampling operation in each boring. These values appear in the driller's logs and on the graphic logs of borings in Figs. 3, 4 and 5 of the text. Another index of compaction is found in the unit dry weight and unconfined compressive strength values for the Shelby tube samples which were taken at intervals in some of the borings. These values also are given in Figs. 3, 4 and 5. To organize these data so that their significance becomes more apparent, a tabulation of test values is presented in Fig. 6. In this tabulation, the values are listed in descending order of shearing strength.

After careful analysis of both the standard penetration resistance values and the laboratory test data, it has been concluded that embankment compaction on the whole is reasonably good. There are some indications in fact, that the embankments are about as compact as the undisturbed ground on which they were constructed. Within each embankment section which was investigated there are random variations in density and water content but this is true of most embankments. Considering the data for all the different sections, there is an indication that the material in the landside toe of the north dike is somewhat less compact than that at any other single location.

No evidence of seepage through any embankment section was found. In fact no positive evidence of a phreatic or free water surface either due to seepage or the natural ground water table was found. It is therefore concluded that at the present time the lining is reasonably watertight and that groundwater is seeping through the weathered zone at the surface of the bedrock formation.

TABULATION OF TEST DATA

Sample No.	Sample depth, ft.	q_u	γ_{dry}	w	Location	
					Section	Dike
3-A	5 - 6	4.49	136	9.1	A-A	N. dike
1-A	42 $\frac{1}{2}$ -44 $\frac{1}{2}$	4.03	125	11.1	B-B	N. dike
4-A	20 - 21 $\frac{1}{2}$	3.16	135	8.9	A-A	N. dike
2-A	12 $\frac{1}{2}$ -14 $\frac{1}{2}$	3.1	132	10.5	C-C	E. dike
5-A	32 $\frac{1}{2}$ -34 $\frac{1}{2}$	3.1	127	10.7	E-E	S. dike
1-A	42 $\frac{1}{2}$ -44 $\frac{1}{2}$	2.37	127	10.4	B-B	N. dike
1-A	5 - 6	2.02	98	23.6	A-A	N. dike
1-A	22 $\frac{1}{2}$ -24 $\frac{1}{2}$	2.0	132	10.7	C-C	E. dike
1-A	20 - 21	2.0	134	10.5	A-A	N. dike
7-A	25 - 26	1.72	139	10.2	A-A	N. dike
1-A	12 $\frac{1}{2}$ -14 $\frac{1}{2}$	1.6	120	13.3	E-E	S. dike
9-A	15 - 16	1.48	126	12.5	A-A	N. dike
1-A	15 - 17	1.30	126	12.0	B-B	N. dike
3-A	10 - 11	1.15	129	9.2	A-A	N. dike
1-A	30 - 31	1.05	116	17.4	A-A	N. dike
1-A	5 - 6 $\frac{1}{2}$	0.96	114	15.0	A-A	N. dike
1-A	15 - 16 $\frac{1}{2}$	0.89	116	14.6	A-A	N. dike
1-A	10 - 11 $\frac{1}{2}$	0.88	121	12.4	A-A	N. dike
1-A	15 - 16 $\frac{1}{2}$	0.79	119	14.9	A-A	N. dike
10-A	10 - 11	0.63	109	18.7	A-A	N. dike
10-A	10 - 11	0.52	102	22.9	A-A	N. dike

Notation:

q_u = unconfined compressive strength, tons per sq. ft.

γ_{dry} = unit dry weight, lbs. per cu. ft.

w = water content, dry wt. basis, percent.

c. PRESENT AND FUTURE SECURITY OF RESERVOIR

a. Present Condition

Because of its construction as described above, the reservoir is dependent for its present and future security on the integrity of the lining. As long as the lining remains at least as watertight as it is now, there need be no question as to the security of the embankments and the reservoir as a whole.

If a break in the lining should occur, water will begin to seep into the ground behind the lining. Where the sides of the reservoir are in a cut section, it is unlikely that this would create a hazardous condition. If the break occurred at an embankment section, however, the embankment would be required to function like an earth dam constructed without any outer lining. Despite the fact that the embankments are constructed of reasonably impervious material which on the whole is strong and well compacted, they could not remain stable indefinitely under these conditions. The embankment section at the point of the break would gradually become saturated, seepage outcrop at the landside toe would occur and in time softening and sloughing of toe material would begin. It is inconceivable that any such development would go unnoticed for such a length of time that a complete failure of the embankment could occur, hence there is no occasion for alarm or immediate, emergency action. However, this possibility should be recognized and given consideration as noted below. Incidentally, it should be noted that the most vulnerable section of embankment is not the North dike as has been assumed by some, but the East dike in the vicinity of the South Gate House. Both embankment sections are of about the same height but the base width of the North dike is considerably greater than that of the East dike because of the berm construction at the former. The overall or average slope of the landside face of the North dike is therefore flatter and the time required for saturation of the embankment would be greater than at the East dike.

With respect to the future security of the reservoir, sole reliance on observing seepage outcrop at the landside toe of the embankments is inadvisable for several reasons. For one thing, by the time the outcrop was observable, some damage to the embankment might have occurred. As a case in point, it is just possible that the somewhat looser present condition of the material at the landside toe of the north dike which was found in the recent investigation is due in part to seepage caused by the break in the lining which occurred in 1938. Secondly, if and when seepage outcrop occurs it would become imperative to empty the reservoir in whole or part as rapidly as possible. To do so would be to run the risk of causing a major failure of a large section of the lining due to the effect of what is termed sudden drawdown. This might be the result of back pressure due to a high ground water condition or to reverse seepage from a zone of saturation in the embankment. It may be well to note at this point the need for lowering the reservoir level very gradually in any future maintenance operations.

b. Possible Provisions for Future

1) Construction of Improved Type of Lining

Various alternative methods for assuring the security of the reservoir in the future are discussed and evaluated below. The first of these is to attempt in one of several ways to provide insurance against a break in the lining. The present lining, being made of concrete, is of a brittle nature and is therefore incapable of deforming or stretching without cracking. Much more flexible types of membrane material are now available. A study to select any one particular type has not been attempted in the course of this investigation as it would be quite time-consuming and is somewhat outside the scope of the writer's assignment. It may be noted however, that the newly constructed Eastern Reservoir was provided with an asphalt lining and that there is some trend toward use of such linings in water supply reservoirs. The cost of placing an asphalt lining

over the present concrete lining in the Woodland Reservoir would be in the neighborhood of \$500,000 based on unit prices for the work at the Eastern Reservoir. If any such operation were to be attempted, it would be highly advisable to provide a pervious underdrainage course at the same time so as to eliminate the present danger of damage due to sudden draw down.

2) Construction of Toe Drainage System

A second approach to the problem would be in some way to insure that even if a break in the lining were to occur, the embankments would not be weakened or damaged. If this could be accomplished, the only consequence of a break in the lining would be wastage of water. Protection of earthen embankments against the effects of seepage can be achieved through construction of an adequate system of toe drains. This is a standard provision in all unlined earth dams, large or small, and procedures for accomplishing this purpose are very well established. This solution to the problem at Woodland could probably be achieved at a cost of about \$100,000 or possibly less.

3) Piezometers as Seepage Detection System

A third approach is to provide in some way for detection of leakage long before damage to the embankments can occur. One method of doing this is to install devices known as piezometers at strategic points in the embankments. These devices can be used to obtain an immediate indication of a rise or fluctuation in the position of the phreatic or free water surface. Since such an installation is relatively inexpensive and provides an immediate benefit, piezometers were installed in all fifteen bore holes in the embankments during the course of the present investigation. Details on the construction of these devices and their locations in the embankments are given in Appendix 4. Water Department personnel have been instructed in the use of the piezometers and this system is now in operation.

7. CONCLUSIONS AND RECOMMENDATIONS

The recently completed investigation has lead the writer to conclude that the reservoir and its embankments are in good condition. The possibility of a sudden failure of any section of the reservoir is limited to the chance of the occurrence of such an unlikely and unpredictable event as a major earthquake.

The reservoir is however, subject to the possibility of damage due to a break in the lining. It is impossible to predict whether a major break will ever occur or if so, when. In the event of a break, seepage through the adjacent embankment section would occur. Observation of seepage outcrop would give warning of trouble in time for the reservoir to be emptied and repaired.

In order to eliminate the necessity for reliance on detection of seepage outcrop, one of two alternative procedures might be followed. The first is to undertake a major reconstruction of the lining using some form of flexible membrane rather than a brittle material such as concrete. For an asphalt lining such as the one recently constructed for the Eastern Reservoir, the estimated cost is in the neighborhood of \$500,000. The second alternative is to protect the embankments with a complete and adequate toe drainage system so that seepage could occur without threat to the security of the reservoir. The cost of this type of protection is estimated to be about \$100,000.

Both of these alternates are relatively expensive especially when viewed with the realization that the chances of their being urgently required are very remote. One cannot lose sight of the fact that the reservoir as originally constructed has been in service for seventy years and that on the only known occasion when trouble due to a break in the lining occurred, the observations of Water Department employees sufficed to prevent any serious damage. It is

possible and seemingly quite advisable however to facilitate such observations by installation of devices which will give an indication of seepage before it actually outcrops at the toe of the embankments. For this reason, a number of piezometers were installed during the course of the investigation and these devices are now in operation.

The writer's final conclusion is therefore that with the installation of the piezometers and with the continuing observations of the Water Department employees as a safeguard, the future security of the reservoir is sufficiently assured to eliminate the need for any major new construction or repairs.

B. K. HOUGH, CONSULTING ENGINEER

B. K. Hough
B. K. Hough
Engineer
N. Y. 18,275



FIELD INSPECTION
REPORT

Check List
Visual Inspection
Phase 1

Name Dam Woodland Reservoir Dam County Onondaga State New York Coordinators _____

Date(s) Inspection 6/5/78 Weather Partly Cloudy Temperature 70° F

Pool Elevation at Time of Inspection 620 M.S.L. Tailwater at Time of Inspection ----- M.S.L.

Inspection Personnel:

Mr. George Elias Mr. James Ryan

Mr. David Campbell _____

Mr. Steven Snider _____

Mr. Steven Snider Recorder

Accompanied by:

Mr. Richard Kunder - Chief Engineer, City of Syracuse, Water Division

Mr. Anthony Boldino - Foreman of Reservoirs, City of Syracuse, Water Division

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None noted	None
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None noted	None
SLOUGHING OR EROSION OF EMBANKMENT AND ADJUTENT SLOPES	None noted	None
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	No problems noted	None
RIPRAP FAILURES	None noted. Small bushes and vines are growing between the stone blocks.	The vegetation should be removed.

EMBANKMENT

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION OF

DOWNSTREAM SLOPE

Large evergreen trees up to 3 feet in diameter growing on slope.

Cut trees and remove stumps.

JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM

N/A

ANY NOTICEABLE SEEPAGE

A23

None noted

None

STAFF GAGE AND RECORDER

N/A

DRAINS

Catch basin into which toe drain discharges was dry.

None

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	N/A	
INTAKE STRUCTURE	No problems noted	None
OUTLET STRUCTURE	No problems noted	None
OUTLET CHANNEL	N/A	
EMERGENCY GATE	N/A	

INSTRUMENTATION

VISUAL EXAMINATION MONUMENTATION/SURVEYS	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
	N/A	
OBSERVATION WELLS	Riser pipes of piezometers are well maintained.	City personnel monitor water levels on a regular basis.
WEIRS	N/A	
PIEZOMETERS	N/A	
OTHER		

RESERVOIR

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION OF

SLOPES

No problems noted

None

SEDIMENTATION

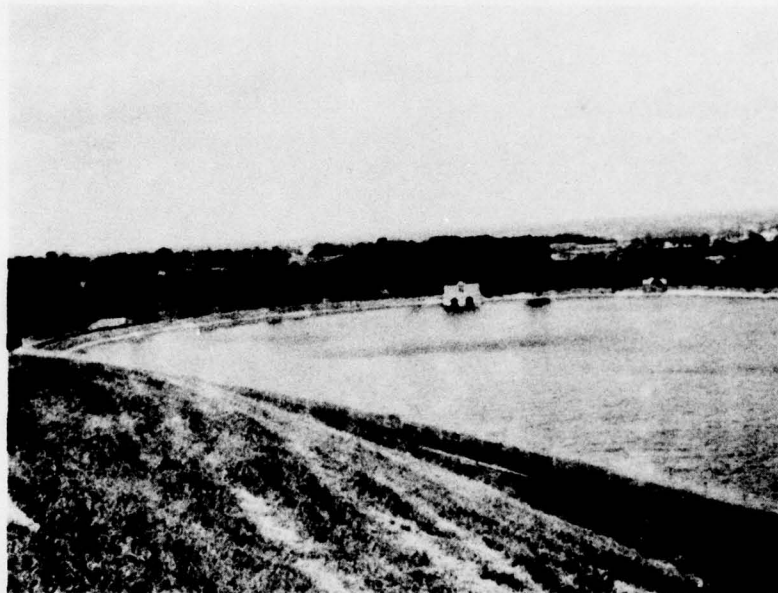
None noted

None

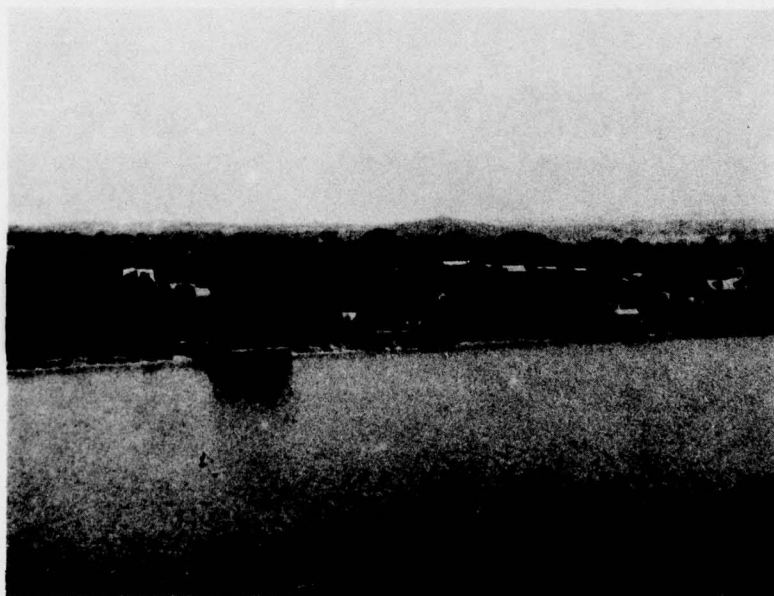
ITEM	REMARKS
DESIGN REPORTS	Woodland Reservoir Dam was completed in 1894. No construction records are available.
GEOLOGY REPORTS	None available
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available
A27	
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None
POST-CONSTRUCTION SURVEYS OF DAM	Topographic Map of Woodland, dated July 1917. Too large for inclusion in this report.
BORROW SOURCES	On-site material used for embankment.

ITEM	REMARKS
MONITORING SYSTEMS	Personnel from the City of Syracuse, Water Division operate and monitor the operation of the reservoir.
MODIFICATIONS	The reservoir was lined with gunite and provided with a toe drain in 1932. A description of these repairs is included in the Appendix.
HIGH POOL RECORDS	None available
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	An inspection was made in 1917. (See Appendix) An evaluation of the cause of seepage was performed in 1932. (See Appendix) An analysis of embankment conditions was initiated in 1964. (See Appendix)
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None noted
MAINTENANCE OPERATION RECORDS	None available

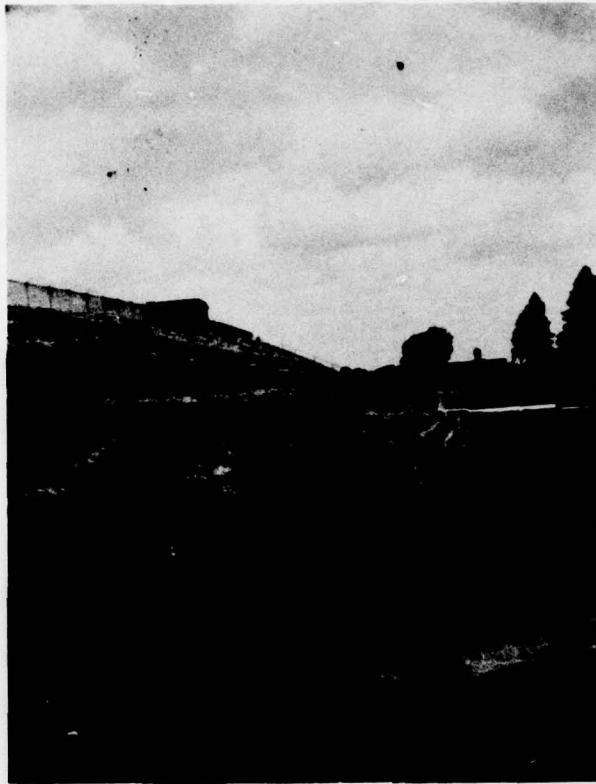
PHOTOGRAPHS



NORTH GATEHOUSE



SOUTH GATEHOUSE



DOWNSTREAM SLOPE OF DAM
SOUTHEAST END
OF RESERVOIR

HYDROLOGIC/HYDRAULIC CALCULATIONS

NAME OF CLIENT N.Y. Dept. of Environmental Conservation

PROJECT Woodland Reservoir, Syracuse, N.Y.

PMP HYDROLOGY

DRAINAGE AREA - none

RESERVOIR AREA \approx 14 acres

6-Hour 10 sq. mile PMP = 22"
Zone = 1

The drainage area is considered equal to the reservoir area. Since the surface area is less than 10 sq. miles, no reduction reflecting basin size is included.

A reduction of 20% is included to account for imperfect fit of basin and storm isohyets.

$$\therefore 6\text{-Hour PMP} = 17.6''$$

$$48\text{ Hour PMP} = 1.27(17.6) = 22.4''$$

Since no inflow or outflow is considered, the 48 Hour PMP is applied to the reservoir.

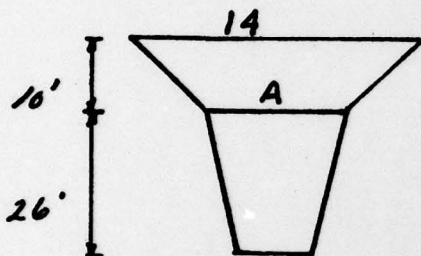
DRAWDOWN CALCULATION

Reservoir Capacity - 121 million gallons (370 acre-feet)

Surface Area - 14 acres

Depth - 36 feet

Assume area at bottom of basin is 6 acres.



$$\frac{(14+A)}{2} 10 + \frac{(A+6)}{2} 26 = 370$$

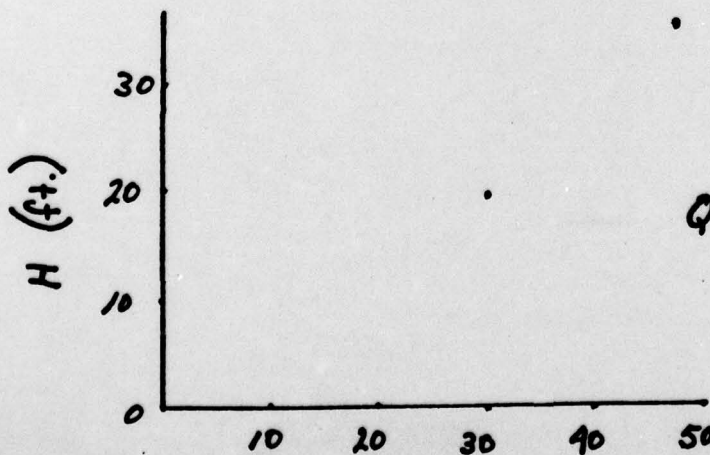
$$A = 12.33 \text{ acres}$$

Max. Discharge @ Normal Pool is about 30 MGD

$$Q_{NP} = 46.3 \text{ cfs}$$

Assume $Q \propto \sqrt{H}$

$$46.3 = C(36)^{1/2} \Rightarrow C = \frac{46.3}{6} = 7.72$$



JUSTIN & COURTNEY, INC.
Division of O'Brien & Gere Engineers, Inc.
PHILADELPHIA, PA

SHEET NO. 3 OF 3

DATE 6/16/78

NAME OF CLIENT N.Y. Dept. of Environmental Conservation

COMP. BY S.H.S.

PROJECT Woodland Reservoir, Syracuse, N.Y.

CHECKED BY _____

H (FT.)	Q (CFS)	Q _{AVE} (CFS)	A (ACRES)	V (A.F.)	T (HRS.)
36	43.6	43.3	14 13.6	67.9	19.0
31	43.0	41.2	13.17 12.75	63.8	18.7
26	39.4	37.0	12.33 11.60	69.6	22.8
20	34.5	32.2	10.87 10.26	51.3	19.3
15	29.9	27.2	9.65 9.04	45.2	20.1
10	24.4	20.9	8.44 7.83	39.2	22.7
5	17.3	8.7	7.22 6.61	33.1	46.0
0	0		6		

$\Sigma T = 168.6 \text{ H.}$

$\approx 7 \text{ Days}$