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NATIONAL DAM INSPECTION PROGRAM. WATRES DAM NDS ID NUMBER PA-00--ETC(U)
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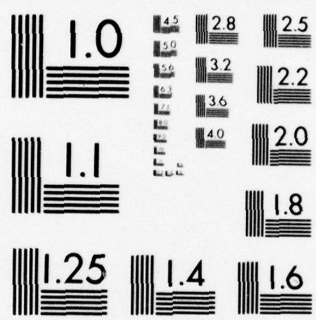


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NATIONAL BUREAU OF STANDARDS-1963-A

SUSQUEHANNA RIVER BASIN
SPRING BROOK, LACKAWANNA COUNTY

PENNSYLVANIA

# WATRES DAM

**NDS ID [redacted] PA-00451**

**DER ID [redacted] 35-81**

## PENNSYLVANIA GAS AND WATER COMPANY

Susquehanna River Basin,
Spring Brook, Lackawanna County,
Pennsylvania.

## PHASE I INSPECTION REPORT

## NATIONAL DAM INSPECTION PROGRAM



Prepared by
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
Consulting Engineers
Harrisburg, Pennsylvania 17105

DACW31-78-C-0046



For
**DEPARTMENT OF THE ARMY**
**Baltimore District, Corps of Engineers**
**Baltimore, Maryland 21203**

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LEVEL II

SUSQUEHANNA RIVER BASIN

SPRING BROOK, LACKAWANNA COUNTY

PENNSYLVANIA



# WATRES DAM

NDS ID No. PA-00451
DER ID No. 35-81

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

Prepared by


GANNETT FLEMING CORDDRY AND CARPENTER, INC.
Consulting Engineers
P.O. Box 1963
Harrisburg, Pennsylvania 17105




For

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

Contract DACW31-78-C-0046



JULY 1978

SUSQUEHANNA RIVER BASIN

SPRING BROOK, LACKAWANNA COUNTY

PENNSYLVANIA

WATRES DAM

NDS ID No. PA-00451
DER ID No. 35-81

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JULY 1978

CONTENTS



PLATES

## APPENDICES

| Appendix | Title |
|---|---|
| A | Checklist - Engineering Data. |
| B | Checklist - Visual Inspection. |
| C | Hydrology and Hydraulics. |
| D | Photographs. |
| E | Geology. |

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

## BRIEF ASSESSMENT OF GENERAL CONDITION

## AND

## RECOMMENDED ACTION

| | |
|---|---|
| Name of Dam: | Watres Dam<br>NDS ID No. PA-00451/DER ID No. 35-81 |
| Owner: | Pennsylvania Gas and Water Company |
| State Located: | Pennsylvania |
| County Located: | Lackawanna |
| Stream: | Spring Brook |
| Date of Inspection: | 7 June 1978 |
| Inspection Team: | Gannett Fleming Corddry and Carpenter, Inc.<br>Consulting Engineers<br>P.O. Box 1963<br>Harrisburg, Pennsylvania 17105 |

Based on the visual inspection, available records, calculations and past operational performance, Watres Dam is judged to be in fair condition. However, the spillway will not pass the Probable Maximum Flood (PMF) or one-half of the PMF without overtopping the dam. If Watres Dam should fail due to overtopping, the hazard to loss of life downstream from the dam would be significantly increased from that which would exist just prior to overtopping. Based on criteria established for these studies by the Department of the Army, Office of the Chief of Engineers (OCE), the spillway capacity is rated as seriously inadequate. The existing spillway can accommodate a flood with a peak inflow of 47 percent of the PMF peak inflow. If the low area of the embankment were to be restored to original grade, the existing spillway can accommodate a flood with a peak inflow of 54 percent of the PMF peak inflow. The spillway capacity would then only be rated as inadequate.

In view of the concern for safety of Watres Dam, the following measures are recommended to be undertaken by the Owner as soon as practical:

(1) Develop a detailed emergency operation and warning system for Watres Dam.

(2) Perform additional studies to more accurately ascertain the spillway capacity required for Watres Dam, as well as the nature and extent of mitigation measures required to make the spillway hydraulically adequate. Filling in the existing low area of the embankment would help increase the spillway capacity and this should be accomplished.

(3) Remove brush from the embankment slopes and perform a detailed inspection to ascertain the condition of the embankment. Surveys should be performed to determine the existing template of the embankment. The results of the survey should be evaluated to ascertain if remedial action is necessary.

(4) Provide positive drainage and good vehicular access at toe of dam to aid in assessment of seepage. Install at least eight observation wells, or other instrumentation, downstream of the axis of the dam. One well, or other instrumentation, should be located in the vicinity of seepage. The others should be at appropriate locations to determine general water level in downstream embankment. The number of wells, or other instrumentation, will be dependent on the results of the inspection recommended above. Data collected from observation wells or other instrumentation should be utilized in evaluating the stability of the structure and assessing piping potential in the future. Continue to observe wet areas and seepage downstream from dam. If conditions worsen, appropriate action should be taken to control apparent seepage with properly designed drains.

In order to correct operational, maintenance or repair deficiencies, and to more accurately assess the condition of the dam, the following are recommended to be undertaken by the Owner in a timely manner:

(1) Remove trees close to slopes.

(2) Visually monitor vegetation in spillway channel and clear vegetation when warranted.

(3) Repair deteriorated mortar in masonry joints.

(4) Remove trees close to retaining wall near spillway channel.

(5) Clear downstream channel of dead trees.

(6) Visually monitor leaks in outlet works tunnel and take remedial action, should conditions worsen.

(7) Repair concrete at downstream headwall of outlet works.

(8) Repair or replace and maintain the monitoring equipment, bent gate stem, and ladder.

(9) Investigate if the beaver dam in the downstream channel is causing the swampy conditions at toe of embankment. If it is causing this condition, it should be removed.

The following operational measures are recommended to be undertaken by the Owner:

(1) During periods of unusually heavy rains, provide round-the-clock surveillance of Watres Dam.

(2) When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system procedures.

Wat...

Submitted by:

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.

A. C. HOOKE
Head, Dam Section

Date: 31 July 1978

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
ALBERT CHARLES HOOKE
ENGINEER
No. 2201-E

Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS

G. K. WITHERS
Colonel, Corps of Engineers
District Engineer

Date: 31 Jul 78

WATRES DAM

View from Right Abutment

SUQUEHANNA RIVER BASIN

SPRING BROOK, LACKAWANNA COUNTY

PENNSYLVANIA

WATRES DAM

NDS ID No. PA-00451
DER ID No. 35-81
PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

# SECTION 1

## PROJECT INFORMATION

ABSTRACT

### 1.1 General.

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

ABSTRACT

### 1.2 Description of Project.

a. Dam and Appurtenances. Watres Dam consists of an embankment with partial concrete core wall, a broad-crested masonry gravity spillway, and an outlet works. The embankment, 135 feet high at maximum section, extends for 1,406 feet across the valley. The embankment has a 20-foot top width and varying downstream slopes which average 1V on 2.5H. The lower two-thirds of the downstream slope is either provided with riprap or stone protection. The upper part of this slope is seeded. The varying upstream slopes on the embankment are covered with riprap and average 1V on 2.4H. A reinforced-concrete core wall with grout curtain beneath is provided across the stream valley and up the left abutment along the dam axis. This core wall has a maximum height of 40 feet over the streambed. The spillway channel is excavated to the left of the hillside which forms the left abutment of the dam. The 72-foot long spillway weir is a masonry gravity structure with crest Elevation 1426.0, which is 14 feet below design top of dam. The spillway approach channel and downstream channel both have rectangular cross sections excavated in the bedrock. The spillway discharge channel descends on a varying slope, dropping 22 feet in 300 feet. It then drops on a 1V on 1H slope for about 100 feet to Panther Creek below. Panther Creek has its confluence with Spring Brook about 0.3 mile downstream. The outlet works also discharges into Panther Creek. The outlet works consists of a tunnel through the bedrock of the embankment left abutment hillside. Concrete lining and walls are provided at each end of the tunnel. A shaft near the center of the tunnel rises vertically to a valve house, located approximately at the downstream toe of embankment. Concrete plugs are provided in the tunnel upstream and downstream of the shaft. Two 30-inch diameter lines, with valves directly below the shafts, extend through both plugs. One line extends beyond the downstream plug and connects to a water supply line. Various features of the dam are shown on the Plates at the end of the report and on the Photographs in Appendix D.

b. Location. The dam is located on Spring Brook approximately 0.7 mile southwest of the Village of Spring Brook, Pennsylvania. Watres Dam is shown on USGS Quandrangle, Moscow, Pennsylvania, with coordinates N41°17'40" - W75°35'30" in Lackawanna County, Pennsylvania, and is 6 miles southeast of the Scranton/Wilkes-Barre Airport. The dam is 1.6 miles upstream of Nesbitt Reservoir, which is fed by Spring Brook. The location map is shown on Plate 1.

c. Size Classification. Large (135 feet high, 8,241 acre-feet).

d. Hazard Classification. High hazard. Downstream conditions indicate that a high hazard classification is waranted for Watres Dam (Paragraph 5.1e.).

e. Ownership. Pennsylvania Gas and Water Company, Wilkes-Barre, Pennsylvania.

f. Purpose of Dam. Water supply for the Townships of Pittston and Spring Brook, and the communities of Dupont, Laflin, Moosic, and Yatesville, Pennsylvania.

g. Design and Construction History. Watres Dam was designed by William Barnes, Chief Engineer of the Spring Brook Water Supply Company. At the time of design, this was to be the highest dam in the Commonwealth. Consequently, the Pennsylvania Water Supply Commission carefully reviewed the design and made a number of recommendations. The Owner, as the Spring Brook Water Company, concurred with all of these except with the recommendation to flatten the upstream and downstream slopes of the embankment. The Commission retained Arthur Morgan, President of the Dayton Morgan Engineering Company, Dayton, Ohio, to consult on this matter. The Spring Brook Water Company retained Leonard Metcalf of the consulting firm of Metcalf and Eddy, Boston, Massachusetts, and Daniel Moran of Moran and Proctor, foundation consultants, New York City, as consultants. A meeting in July 1921 resolved differences and construction was started soon thereafter. The tunnel was started first. It was built by Winston and Company, contractors, of Kingston, New York. The tunnel excavation was completed in 1922. Construction of the embankment and spillway was started in 1922. The reservoir started filling in the spring of 1925. Work was complete in the fall of 1925.

Some time between 1934 and 1941, the left end of the spillway weir overturned. A temporary wooden weir was constructed in that area. In 1941, the present masonry gravity weir was constructed and the previous spillway structure removed.

1.3 Pertinent Data.

a. Drainage Area. 15.4 square miles.

b. Discharge at Damsite. (cfs.)

Maximum known flood at damsite - 2,800 (estimated - August 1955).

Outlet works at maximum pool elevation - 300 (approximate).

Spillway capacity at maximum pool elevation - 10,000 (low area).

Design spillway capacity - 11,500.

c. Elevation. (Feet above msl.)

Top of dam (low area) - 1438.9.

Design top of dam - 1440.0.

Maximum pool (top of dam low area) - 1438.9.

Normal pool (spillway crest) - 1426.0.

Upstream invert outlet works - 1322.

Downstream invert outlet works - 1308.

Streambed at centerline of dam - 1305.0.

d. Reservoir Length. (Miles.)

Normal pool - 1.3.

Maximum pool - 1.8.

e. Storage. (Acre-feet.)

Normal pool (spillway crest) - 5,957.

Maximum pool (top of dam) - 8,241.

f. Reservoir Surface. (Acres.)

Normal pool (spillway crest) - 167.

Maximum pool (top of dam) - 215.

g. Dam.

Type - Earthfill with partial concrete core wall.

Length - 1,406 feet.

Height - 135 feet.

Top width - 20 feet.

Side slopes - Downstream
from El. 1440 to El. 1420 - 1V on 1.5H.
from El. 1420 to El. 1395 - 1V on 2H - 2-foot wide berm at El. 1395.
from El. 1395 to El. 1345 - 1V on 2.5H- 5-foot wide berm at El. 1345.
below El. 1345 - 1V on 2.5H.

Side slopes - Upstream
from El. 1440 to El. 1420 - 1V on 1.78H.
from El. 1420 to El. 1410 - 1V on 2H - 0.7-foot wide berm at El. 1410.
from El. 1410 to El. 1395 - 1V on 2.5H.
from El. 1395 to El. 1337 - 1V on 3H - 8-foot wide berm at El. 1337.
below El. 1337 - 1V on 1.5H.

Impervious core - Partial concrete core wall.

Zoning - Homogeneous earthfill.

Cutoff - Core wall in rock trench across center of valley and towards left abutment. At highest embankment section, top of core wall is 95 feet below top of dam.

Grout curtain - Single line across streambed, 150 feet upstream of axis. Single line beneath core wall and extending further left towards spillway.

h. Diversion and Regulating Tunnel.

Type - Tunnel in rock, partially lined with concrete. Vertical shaft, with valve house at top, at center of tunnel.

Length - 950 feet.

Closure - Concrete plug placed immediately upstream and downstream of shaft.

Access - Upstream of upstream plug - none. Between upstream and downstream plug - through shaft. Downstream of downstream plug - through exit portal at downstream end.

h. Diversion and Regulating Tunnel. (Cont'd.)

Regulating facilities - Two manually operated, rising stem, 30-inch-diameter gate valves for each of both 30-inch-diameter cast-iron pipes. Operating stands have parallel 3.25 to 1 beveled gear reducers on 3-inch-diameter 2 TPI stems. One 12-inch-diameter bypass that discharges into downstream tunnel with 12-inch-diameter rising stem gate valve. One 1-inch-diameter 3 TPI stem is connected to 12-inch-diameter handwheel on operating stand at gatehouse floor.

i. Spillway.

Type - Broad-crested weir with 1V on 6H adverse slope (width - 3.0 feet).

Length of weir - 72 feet.

Crest elevation - 1426.0.

Upstream channel - 1V on 4H adverse slope to spillway crest.

Downstream channel - Variable sloped rock channel 1-percent slope for 200 feet then changing to 20-percent slope for next 100 feet, which leads to a 1V on 1H slope extending to stream below.

j. Regulating Outlets. None, other than as noted in Paragraph 1.3h.

SECTION 2

ENGINEERING DATA

2.1 Design.

a. Data Available. Some engineering data for the dam is available for review. In 1921, the Pennsylvania Water Supply Commission prepared a report on the structure prior to issuing a permit for construction. This report resulted in some recommendations. Other consultants were employed both by the Owner and the Commission to determine a suitable design. No numerical analyses of design were available for review. A more complete history is presented in Paragraph 1.2g.

b. Design Features. The dam consists of a homogeneous earthfill embankment with a partial concrete core wall, an outlet works tunnel with pipes contained therein, and a spillway.

The embankment has a design top elevation of 1440 (Photographs A, B, C, and D). The top width is 20.0 feet. The upstream slope is protected with riprap over the entire section. On the downstream slope, riprap or stone protection is provided below Elevation 1395. Above this elevation, the downstream slope is covered with grass. The upstream slope varies from 1V on 1.78H near the top to 1V on 3H near the toe. A rockfill dam across the valley, which was originally a diversion dam during embankment construction, acts as the upstream toe of the embankment. The downstream slopes vary from 1V on 1.5H near the top to 1V on 2.5H near the toe. A two-stage stone filter is provided below Elevation 1345 at the downstream toe. Details of the profile and section are shown on Plate 3.

Cutoff facilities are provided along the axis of dam. Commencing at the right abutment, a cutoff trench excavated in earth extends for 348 feet left. This trench is 12 feet wide and is about 4 feet deep. It was backfilled with selected embankment fill. To the left of this trench, another cutoff trench was excavated in rock for 300 feet towards the left abutment. This trench starts about 120 feet right of the streambed and extends across the deepest part of the valley towards the left abutment. It stops about 160 feet right of the left embankment abutment. It is of varying depth with a 12 foot wide bottom founded in firm rock. A single line grout curtain, with holes at 16 foot maximum spacing, was provided below the trench and beyond the end of the trench towards the spillway on the left. Also, in this trench is a concrete core wall. The core wall maintains a constant elevation of 1345 across the streambed and is stepped up at irregular intervals both to the right and left of the streambed. Details of the core wall are shown on Plate 3. A second cutoff trench about 150 feet in length was excavated about 150 feet upstream of the axis of dam across the deepest part of the gorge. This trench was excavated in bedrock with a 25-foot bottom width and is about 4 feet deep. Eleven holes, on 10-foot centers, were drilled and grouted in the bottom of the trench to form a grout curtain.

The embankment is constructed of gravelly-clay. To the right of the streambed, the foundation soil is a sandy clay. The foundation soil to the left of the streambed is unknown. Rock generally lies close to the natural ground surface on this side. The nature of the rock at the site is described in Appendix E, Geology.

Access to the embankment is via an unpaved road extending along the right side of the reservoir. The access road then extends across the top of dam to the embankment left abutment. The access road then forms a wye, with one section extending along the reservoir shore to the right side of the spillway. The other section reverses direction and extends along the downstream toe of the embankment along the left abutment past the valve house until about half-way down the embankment. The road then turns leftward and extends down till it terminates near the outlet works headwall.

The spillway is located to the left of the embankment (Plate 3). The centerline of spillway is about 160 feet left of the left end of embankment. The spillway and spillway channel are separated from the embankment by high natural ground. The spillway weir is a 72-foot long masonry gravity structure with a crest elevation of 1426.0 (Plate 4 and Photograph G). The crest is 3 feet wide and slopes toward the reservoir such that the upstream edge is 6 inches below the crest. The back and front face of the structure, which is founded in rock, are slightly battered. A masonry apron extends along the downstream side of the spillway weir. The apron is about 2 feet below the crest and extends for 5 feet downstream. The walls of the spillway approach channel and the spillway channel are near vertical rock cuts. The short approach channel consists of an excavated surface through the natural materials. The spillway channel is excavated into bedrock. The channel downstream from the weir is on a 0.5 percent grade for 200 feet, then on a 20-percent grade for the next 100 feet (Photograph H). Below this point, the channel drops about 100 feet on about a 100-percent grade to Panther Creek below (Photograph I). Panther Creek flows into Spring Brook about 0.3 mile downstream of the spillway.

On the right bank of the spillway channel, at the toe of the 100-percent grade, is a masonry retaining wall (Photograph J). This wall is about 30 feet long and is about 18 feet high at the highest section. Apparently, this wall is used to retain a natural earthen section of the hillside.

The outlet works consists of a tunnel, excavated in rock, in the left abutment hillside. The tunnel is about 120 feet right of the left end of the embankment and is almost normal to the axis. The upstream invert of the tunnel is at Elevation 1322 and the downstream invert is at Elevation 1308. A reinforced-concrete portal is provide on the upstream end. The upstream end of the tunnel is provided with reinforced-concrete lining until the natural rock is of such quality that concrete lining is no longer required. The clear opening at this end is a horseshoe-shaped area, 9 feet wide by 9.3 feet high. A steel screen is provided in the upstream portal. The tunnel terminates downstream at a reinforced-concrete headwall with a clear rectangular opening 10 feet wide by 5 feet high (Photograph F and Plate 6). Approximately 120 feet of the most downstream section of tunnel is lined with the reinforced concrete and it maintains the rectangular cross section. Upstream of the downstream concrete lining, the tunnel changes abruptly to a horseshoe-shaped section excavated in the natural bedrock. This section, excavated in the bedrock, continues upstream to the concrete lining near the upstream portal. A vertical access shaft extends from the natural ground surface approximately at downstream toe of embankment to the tunnel. This shaft is reinforced concrete lined and has a clear diameter of 12.7 feet. The tunnel was originally used for diversion purposes. After completion of the embankment, concrete plugs were placed in the tunnel directly upstream and downstream of the shaft. Two 30-inch diameter cast-iron pipes extend through the upstream plug and terminate at the upstream side of the plug. A valve house is provided atop the shaft (Plate 6 and Photograph B). The valve stems extend down to the two 30-inch gate valves, connected in series on each pipe. The pipes then extend through the downstream concrete plug. The left pipe terminates at the downstream side of the plug. The right pipe extends almost to the end of the tunnel, where it deflects right and connects to a 30-inch diameter water supply line leading from the dam. Directly below the shaft, in the valve chamber, a 12-inch diameter cast-iron pipe, with valve, is provided. This pipe extends from a tap between the valves on the left pipe through the downstream plug, where it terminates. A 4-inch diameter cast-iron pipe extends through the top of the upstream plug. This pipe taps into a 14-inch diameter cast-iron pipe which extends vertically to the valve house. It is used as a floatwell.

2.2 Construction.

a. Data Available. At the time of construction, the Watres embankment was the highest in the Commonwealth. Because of this, the Pennsylvania Water Supply Commission was quite concerned with the construction methods utilized. Frequent inspections were made by the Commission. Inspection reports and construction specifications are on file. Other data was available from the Owner's files.

b. Construction Considerations.

As originally designed, the embankment would have had three core walls. These walls would have been parallel to the axis of dam. The longest would have been constructed along the axis. The other two, which would have extended across only the deepest part of the valley, would have been 150 feet upstream and 75 feet downstream of the axis. Excavation of the trench for the upstream core wall revealed poor quality seamy rock. The grout holes in this trench required 299 bags of cement. With the approval of the Pennsylvania Water Supply Commission, the plans were changed to provide one core wall along the axis of dam, where the quality of rock was much better. Because of the nature of the material at the downstream end of the tunnel, the original plan to provide a valve house at the downstream end of tunnel was modified to provide a shaft for the gate stems in approximately the center of the tunnel.

The periodic inspections by the Commonwealth during construction resulted in a number of recommendations which were implemented by the Owner. It was recommended that all large stones be removed from the embankment earthfill. It was also recommended that the thickness of the earthfill layers, which were being placed 18 to 20 inches thick, before compaction, be reduced to 6 inches, as required by the permit issued by the Commonwealth. The inspection also recommended that frozen earthfill, placed at the end of a construction season, be removed and replaced with good quality earthfill.

The original spillway was an excavated rock channel with control section. During the final Commonwealth construction inspection in 1925, it was discovered that the Owner had constructed an erodable earth dike about 100 feet upstream of the control section. The top of dike was about 5 feet higher than the control section invert. The Owner reported that there had been fairly serious seepage through the rock upstream of the control section. The Commonwealth objected to the erodable dike. The Owner then proposed to construct a concrete weir with crest at present spillway crest elevation and an erodable earthfill dike with top elevation 2 feet above the new crest. With the Commonwealth's approval, these features were constructed in 1926. In November 1926, the erodable earthfill dike washed out and was never replaced.

In summary, it appears that reasonable care was exercised during construction of Watres Dam.

As was noted in Paragraph 1.2g, the spillway weir overturned and a new masonry gravity weir was constructed in 1941. No construction data was available for this modification.

2.3 Operation. No formal records of operation were reviewed. Based on information from the Owner, all structures as presently constructed have performed satisfactorily. As was noted in Paragraph 1.2g, the original spillway had structural problems. It has since been replaced. The Owner's records indicate that the depth of water over the spillway was 4.75 feet during the flood of May, 1942 and 5.5 feet during Tropical Storm Diane in 1955.

2.4 Other Investigations. During 1955, Thomas Wiggin, Consulting Engineer, New York City, performed a hydraulic and hydrologic analysis to determine the existing capability of the dam to pass flood flows. No modifications to the dam resulted from that study.

2.5 Evaluation

a. Availability. Engineering data was provided by the Division of Dams and Encroachments, Bureau of Water Quality Management, Department of Environmental Resources, Commonwealth of Pennsylvania, and by the Owner, Pennsylvania Gas and Water Company. The Owner made available an engineer, the caretaker, and a valve crew for information and operating demonstrations during the visual inspection. The Owner also researched his files for additional information upon request of the inspection team.

b. Adequacy. The type and amount of design data and other engineering data is limited, and the assessment must be based on the combination of available data, visual inspection, performance history, hydrologic assumptions, and hydraulic assumptions.

c. Validity. There is no reason to question the validity of the available data.

# SECTION 3

## VISUAL INSPECTION

3.1 Findings.

a. General. Watres Dam appears to be in fair condition. There are some deficiencies as noted below.

b. Embankment. The upstream slopes above the normal reservoir level appear to be in good condition, except for brush growing over the upper half of the exposed slope (Photograph D). The riprap appeared in good condition, with hardly any evidence of weathering. A survey performed for this inspection revealed that the lowest point on top of embankment is 1.1 feet below design elevation. The low area extends over 600 feet of the top. The left end of the low area is about 350 feet right of the left end of the embankment. The downstream slope was heavily overgrown with brush (Photographs A and C), except at the toe near the streambed. The toe in this area is rock fill. The abutment line was indistinct because of the heavy and, in some areas, impenetrable growth. One cross section of the embankment was surveyed for the inspection. To gain access to areas of the embankment, a path had to be cut with a machete. Because of the brush, many of the features shown on the section supplied by the Owner could not be seen. The surveyed cross section indicates that the embankment is somewhat steeper near the top than the Owner's cross section indicates. The survey revealed that the upper 20 feet of embankment is 1V on 1.3H or steeper. As changes in slope could not be observed, the survey data cannot be considered definitive. Most of the embankment could not be observed. The toe of embankment, at the streambed, was swampy (Photograph E). Two seepage areas were observed. About 30 feet downstream of the toe, on the right, clear water was seeping from the hillside at about 1 gpm. About 60 feet downstream of the toe, on the left side of the streambed, clear water was seeping at 2 to 3 gpm. Flowing water could be heard running through the rock fill at toe of dam. Access to the toe was through the woods from an access road about 200 feet to the left. Trees were growing adjacent to the rock fill at the toe. There did not appear to be any permanent watercourse from the swampy area at the toe to the stream.

c. Spillway. Mortar is missing for up to a 2-inch depth from some joints in the weir and downstream apron (Photograph G). There is a small amount of vegetation in the channel immediately downstream of the weir (Photograph H). The stream below the spillway channel has dead trees strewn across it (Photograph I). The masonry retaining wall on the right bank in this area has deteriorated motar, with grass growing in some joints (Photograph J). A brown-colored leaching was observed over the lower half. Trees are growing close to this wall.

d. Outlet Works. The stem for the floatwell intake valve in the valve house is bowed. The floatwell does not function. The ladder from the valve house which extends down the vertical shaft is rusting. The concrete tunnel lining near the downstream end of the tunnel has 1-inch diameter hole through which water is leaking. The top of the headwall at the downstream end of tunnel is severely deteriorated, with the reinforcing steel being exposed over all the top (Photograph F). The operation of the downstream valve on the left pipe was observed. It required four men 30 minutes to open the valve 8 inches. The Owner requested that the valve not be opened more to avoid getting sediment in the water transmission line on the right. No problems were noted with the valve operation. This valve leaked.

3.2 Evaluation.

a. Embankment. Brush on the upstream slope is undesirable. The brush on the downstream slope is of general concern. The Owner stated that the embankment had been cleared of brush three years previously. Problems occurring on the embankment would not be observable. The Owner warned the inspection crew repeatedly that poisonous snakes were very prevalent in the area. In the thick brush, they would be a definite hindrance to an investigation of suspected problems. Because of the brush, the visual inspection cannot be considered definitive. Seepage from the dam has been reported in almost all the periodic inspections by the Commonwealth. The descriptions in the inspection reports are insufficient to determine if these seepage areas are the same as the areas noted during this inspection. The flow from the right of the stream is noted in one inspection report as being from drain pipes which extend from the core wall. Another inspection report indicated that springs in the right hillside were discovered, during embankment construction. It was the inspector's opinion that the water heard flowing through the rock fill at the toe of embankment was related to the water seeping from the left side of the streambed. Water flowing through the rock fill had not been reported in previous inspections. Positive drainage of the swampy area at the toe would aid in assessing the seepage condition. A good vehicular access road to this area would also be of benefit to make inspections easier and quicker. Because of its potential seriousness, the seepage is of some concern. Trees adjacent to the embankment are undesirable. The reason for the discrepancies in cross section data is unknown. The low areas in the embankment indicate the embankment has settled.

During the 1930 inspection by the Commonwealth, it was noted that the embankment had settled 1.7 feet and that it was in the process of being raised to design level. If the apparent top embankment slope of 1V on 1.3H is verified by a future survey, the slope should be restored to design template.

b. Spillway. The deterioration of the mortar is not sufficiently serious to be of concern. The vegetation downstream of the weir is too small to create problems at present. The trees in the downstream channel, while not desirable, present no significant hazard to the dam. Trees adjacent to the retaining wall are undesirable. Long-term neglect of the deteriorating mortar could prevent the spillway from acting as a watertight structure.

c. Outlet Works. The inoperable floatwell presents no hazard to the dam. However, if operable it would be an aid, in assessing the seepage downstream. The rusting ladder could eventually be a hazard to personnel. The leakage observed in the tunnel presents no significant hazard to the dam. The deteriorated headwall does not present a hazard to the dam.

d. Reservoir Area. No conditions were observed in the reservoir area which might present a significant hazard to the dam.

e. Downstream Channel. A beaver dam is located in the downstream channel, but it presents no significant hazard to the dam. It may, however, be related to the swampy conditions observed at the toe of the embankment.

## SECTION 4

## OPERATIONAL PROCEDURES

4.1 Procedure. The reservoir is maintained at spillway crest, Elevation 1426.0, with excess inflow discharging over the spillway and into Panther Creek. Panther Creek flows into Spring Brook, which flows into Nesbitt Reservoir 2.5 stream miles downstream. A 30-inch dismeter cast-iron water transmission line drains water from the Watres Dam outlet works tunnel, which enters the reservoir at Elevation 1322. On the average, 18 mgd flow in the gravity transmission line to Pittston and Spring Brook Townships, and to the communities of Dupont, Laflin, Moosic, and Yatesville. All these communities consume an average of 14 mgd. The average excess of 4 mgd flows to Gardner Creek upstream of Gardner Creek Dam. Streamflows in Spring Brook can be increased by releases from Watres Dam. A 30-inch diameter cast-iron water supply line, which is separate from the transmission line, discharges into the outlet works tunnel. The tunnel discharges into Panther Creek, which flows into Spring Brook and thence into Nesbitt Reservoir. Since streamflow is usually augmented only when Nesbitt Reservoir is below spillway crest elevation, the downstream valve on the Watres water supply line is usually closed. The upstream emergency shutoff valve on this line is usually fully open. The downstream valve on the water supply line is not normally opened fully, as this would cause sediment to also enter the water transmission line. Apparently, the 12-inch diameter bypass line, which taps off the water supply line, is not operated frequently.

4.2 Maintenance of Dam. The dam is visited daily by two cartakers who record the reservoir elevation. Weekly reports are mailed to the Owner's Engineering Department. This information is used by the Engineering Department for regulating flows in the distribution system. The caretakers are also responsible for observing the general condition of the dam and appurtenant structures and reporting any changes or deficiencies to the Owner's Engineering Department. A Pennsylvania Gas and Water Company engineer makes a formal inspection of the dam each year, and the records are filed and used for determining priority of repairs. Informal inspections are also made when the engineer is on the site for other reasons. The caretakers are also responsible for maintenance of Spring Brook Intake, Nesbitt Dam, Maple Lake Dam, Covey Swamp Dam, and Fort Tuna Creek Dam.

4.3 Maintenance of Operating Facilities. Valve stems and gears are lubricated frequently. The general condition of the operating facilities seemed good. A few items were not adequately maintained as noted in Section 3. According to the Owner, there is no regular maintenance schedule, but maintenance of items is performed when deemed necessary.

4.4 Warning Systems in Effect. The Owner furnished the inspection team with a chain of command diagram for Watres Dam and a generalized emergency notification list that is applicable for all of the Pennsylvania Gas and Water Company dams. The Owner said that during periods of heavy rainfall, available personnel are dispatched to the dams to observe conditions. All company vehicles are equipped with radios, and the personnel can communicate with each other and with a central control facility. Evaluation of risk is made by the Owner's Engineering Department. The Owner's Engineering Department is also responsible for notification of emergency conditions to the local authorities. Detailed emergency operational procedures have not been formally established for Watres Dam, but are as directed by the Owner's Engineering Department.

4.5 Evaluation. The operational procedures appear satisfactory. However, in order to ensure proper operation, the upstream valve on the water supply line and the valve on the bypass line should be fully opened and closed at least once a year. The maintenance of the operating equipment is good. The maintenance of the embankment is poor. The procedures used by the Owner for inspecting the dam are adequate, but some needed repairs have not been made. In general, the warning system is adequate, but it would be more effective if it were more detailed.

SECTION 5

HYDROLOGY AND HYDRAULICS

5.1 Evaluation of Features.

a. Design Data.

(1) No hydrologic and hydraulic analyses for the original Watres Dam design were available for review. The spillway capacity has been estimated several times for the various construction modifications that have evolved.

(2) In the recommended guidelines for safety inspec-tion of dams, the Department of the Army, Office of the Chief of Engineers (OCE), established criteria for rating the capacity of spillways. The recommended spillway design flood for the size (large) and hazard potential (high) classification of Watres Dam is the Probable Maximum Flood (PMF). If the dam and spillway are capable of passing the PMF without over-topping failure, the spillway capacity is rated as inadequate. If the dam and spillway are capable of passing one-half of the PMF without overtopping failure, the spillway capacity is not rated as seriously inadequate. A spillway capacity is rated as seriously inadequate if all of the following conditions exist:

(a) There is a high hazard to loss of life from large flows downstream of the dam.

(b) Dam failure resulting from overtopping would significantly increase the hazard to loss of life down-stream from the dam from that which would exist just before overtopping failure.

(c) The dam and spillway are not capable of passing one-half of the PMF without overtopping failure.

(3) In 1955, Thomas H. Wiggin, Consulting Engineer, New York, rated the spillway capacity. Since no spillway mod-ifications have been made from the time the computations were made, the rating curve is still valid and is acceptable. With-out freeboard, the spillway design capacity is 11,500 cfs. However, low spots exist in the crest of the embankment that reduce the capacity of the spillway to 10,000 cfs at the point of initial overtopping of the dam.

(4) The Owner estimated that approximately half of the watershed belongs to Pennsylvania Gas and Water Company. Most of the watershed remains undeveloped. Hydrologic analysis for this study was based on existing conditions, and the effects of future development of the watershed were not considered.

(5) Compton Dam is 4.4 stream miles upstream of Watres Reservoir (Photograph K). At the damsite, the drainage area is 1.0 square mile. The dam itself is an earthfill embankment 19 feet high with a spillway at the right abutment. At spillway crest elevation, the reservoir has a surface area of 3 acres and the reservoir contains 49 acre-feet. During the inspection of Watres Dam, a brief field visit was made to Compton Dam and the dimensions of the spillway were obtained. The spillway is an ogee-shaped concrete weir 27 feet long (Photograph L). The spillway crest is 4.0 feet below top of embankment. The reservoir is used for recreation purposes by the Jewish Community Center, which is situated on the left abutment hillside. Except for the spillway dimensions, data concerning the dam was obtained from Bulletin No. 5 "Water Resources Bulletin - Dams, Reservoirs and Natural Lakes", published by the Bureau of Engineering, Pennsylvania Department of Forests and Waters. Subsequent calculations (Appendix C) indicate that the spillway discharge capacity is 800 cfs and that the reservoir would contain 62 acre-feet with pool at top of dam. The component of the Watres PMF at the Compton damsite is estimated at 3,080 cfs. The method of obtaining the component of the PMF was by transposing the PMF flow at Watres Dam. Considering the effects of the available surcharge storage at Compton Dam, the spillway can pass, without overtopping the dam, a flood of equal duration of the PMF and with a peak flow of 830 cfs. This is 27 percent of the PMF peak inflow. The total capacity of Compton Reservoir is 62 acre-feet. This is less than 3 percent of the available surcharge storage at Watres Dam. Therefore, failure of Compton Dam would not, by itself, cause overtopping of Watres Dam. Because Compton Dam is far upstream of Watres Reservoir and because it has small spillway capacity and minimal storage, it was estimated that the dam would have negligible effects on major flood inflows to Watres Reservoir.

b. Experience Data. For this study, the PMF was obtained from the curve of PMF peak flow vs. drainage area for Region 2 of the Susquehanna River Basin.[1] The PMF peak was estimated to be 27,410 cfs. The volume of the inflow hydrograph was adjusted to approximate 26 inches of runoff over the entire watershed.

In May 1942, a head of 4.75 feet was reported on the spillway crest. The estimated discharge was 2,480 cfs. The highest discharge of record was reported during the runoff associated with Tropical Storm Diane in August 1955. According to the caretaker, the water level was 5.5 feet

(1) Obtained from the Baltimore District, Corps of Engineers.

over the spillway crest, which corresponds to a discharge of about 2,800 cfs.

c. Visual Observations. On the date of the inspection, no conditions were observed that would indicate that the spillway capacity would be significantly reduced during a flood occurrence.

d. Overtopping Potential. For an occurrence of the PMF, the peak inflow of 27,410 cfs is greater than the spillway capacity of Watres Dam. A check of the surcharge storage effect of Watres Reservoir shows that the surcharge storage available is insufficient to contain an inflow with a peak flow of 27,410 cfs without overtopping the dam (Appendix C).

3. Downstream Conditions. About 1 mile downstream of Watres Dam, there are a few homes on the right overbank of Spring Brook. However, as these homes are at least 140 feet higher than the stream, they would probably not be flooded by large flows from Watres Dam. Spring Brook flows into Nesbitt Reservoir about 2.5 stream miles below Watres Dam. At the approximate juncture of Spring Brook and the reservoir, Pennsylvania Route No. 502 crosses the reservoir on a low bridge. This bridge would not provide any mitigating effects for floodflows in Spring Brook. A Phase 1 Inspection Report for Nesbitt Dam has been prepared. The downstream conditions noted in the report indicate that a high hazard classification is warranted for Nesbitt Dam. In the report, it is also estimated that the failure of Watres Dam would cause the overtopping of Nesbitt Dam. Therefore, the downstream conditions indicate that a high hazard classification is warranted for Watres Dam.

f. Spillway Adequancy.

(1) The existing spillway will not pass the PMF without overtopping the dam. One-half of the PMF inflow is 13,705 cfs and is greater than the spillway capacity. A check of the surcharge storage effect of Watres Reservoir shows that the surcharge storage available is insufficient to contain an inflow with a peak flow of 13,705 cfs without overtopping the dam (Appendix C).

(2) The maximum tailwater is estimated to be Elevation 1,320 at the spillway capacity of 10,000 cfs. At maximum pool elevation, there is a difference of about 120 feet between headwater and tailwater. If Watres Dam should fail due to overtopping, the hazard to loss of life downstream from the dam will be significantly increased from that which would exist just prior to overtopping.

(3) Based on established OCE criteria as outlined in Paragraph 5.1a(2), the spillway capacity of Watres Dam is rated as seriously inadequate. Considering the effects of the surcharge storage of 2,284 acre-feet, the spillway discharge capacity of 10,000 cfs can accommodate a flood with a peak inflow of 12,920 cfs for a storm of the same duration as the PMF. This is 47 percent of the PMF peak inflow.

(4) If the low area of the embankment were to be raised up-to-grade, which could be considered a maintenance task, the spillway capacity of Watres Dam can be increased to 11,500 cfs. This would allow accommodation of a flood with a peak inflow of approximately 14,690 cfs or 54 percent of the PMF peak inflow. The spillway capacity of Watres Dam would then only be rated as inadequate.

## SECTION 6

## STRUCTURAL STABILITY

### 6.1 Evaluation of Structural Stability.

a. Visual Observations.

(1) General. The visual inspection of the dam resulted in a number of observations relevant to structural stability. These observations are listed herein for various features.

(2) Embankment. Seepage was observed at the toe of embankment and survey data, acquired for this inspection, revealed differences between the existing embankment template and the design template. A detailed description and evaluation of these conditions are in Paragraphs 3.1b. and 3.2a., respectively.

(3) Spillway. Deterioration of mortar in joints was observed in the spillway weir, masonry apron, and downstream retaining wall. A detailed description and evaluation of these conditions are in Paragraphs 3.1c. and 3.2b., respectively.

b. Design and Construction Data. No record of design data or stability analysis was available for review. In the report upon the application of the Spring Brook Water Supply Company to obtain a construction permit for Watres Dam, the Pennsylvania Water Supply Commission was concerned about the design slopes of the embankment, as was noted in Paragraph 1.2g. No mention was made of the spillway weir stability in the report. Based on data available for review, there is no record of numerical analyses for either of these features.

Analysis of the embankment stability is beyond the scope of this study. Also, sufficient data would have to be acquired before the analysis could be performed.

After the original spillway weir overturned, approximately 10 years after its construction, a new spillway weir was constructed in 1941. No stability analysis for this structure was available for review.

The existing spillway weir crest elevation is approximately 2 feet above the invert elevation of the downstream spillway channel. Stability analyses are not usually performed on structures this small. From a review of the cross section of this structure, it is judged that it should be stable under the anticipated loading conditions. Failure of the spillway weir, while perhaps creating a hazard downstream, would not create a hazard to the embankment.

c. Operating Records. No formal records of operation were reviewed. Evidence of some instability on the embankment was noted in the periodic inspections performed by the Commonwealth. As was noted in Paragraphs 3.1b. and 3.2a., a detailed inspection of the embankment was not able to be performed for this inspection.

d. Postconstruction Changes. As noted herein, there is sufficient information available on all modifications made to Watres Dam.

e. Seismic Stability. Watres Dam is located in Seismic Zone 1. Normally it can be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake loading. However, since there are no formal static stability analyses, and since there is the potential of earthquake forces moving or cracking the concrete core wall, the theoretical seismic stability of Watres Dam cannot be assessed.

## SECTION 7

## ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety.

(1) Based on visual inspection, available records, calculations, and past operational performance, Watres Dam is judged to be in fair condition. However, deficiencies of varying degree of importance were noted. A summary of the features and observed deficiencies is listed below:

| Feature and Location | Observed Deficiencies |
|---|---|
| Embankment: | |
| Upstream and downstream slopes | Brush on slopes. |
| Top of dam | Settlement. |
| Slopes | Differs from design; top portion of downstream slope is too steep. |
| Downstream slopes | Trees too close. |
| Downstream toe | Seepage and swampy area, lack of access. |
| Spillway: | |
| Masonry joints | Deteriorated mortar. |
| Channel | Vegetation. |
| Downstream channel | Dead trees across channel. |
| Retaining wall | Trees too close. |
| Outlet Works: | |
| Tunnel | Leaks. |
| Downstream headwall | Deteriorated concrete. |
| Valve house and valve chamber in tunnel | Rusting ladder, bent gate stem, inoperable monitoring equipment. |
| Downstream Channel: | Beaver dam. |

(2) The overtopping potential analysis shows that the dam will be overtopped by the PMF and one-half PMF. Based on OCE criteria, as outlined in Paragraph 4.1a(2), the existing spillway capacity is rated as seriously inadequate. The existing spillway can accommodate a flood with a peak inflow of 47 percent of the PMF peak inflow. If the low area of the embankment were to be restored to original grade, the existing spillway can accommodate a flood with a peak inflow of 54 percent of the PMF peak inflow. The spillway capacity would then only be rated as inadequate.

(3) Because of the low height of the spillway weir, no analysis was performed to calculate its stability. It was judged that it would be stable under maximum loading conditions.

b. Adequacy of Information. The information available is such that a total assessment of the dam cannot be inferred from the information available. The embankment could not be inspected in sufficient detail.

c. Urgency. The recommendations in Paragraph 7.2 should be implemented as soon as practical or in a timely manner as noted.

d. Neccessity for Further Investigations. In order to accomplish some of the remedial measures outlined in Paragraph 7.2, further investigations will be required.

7.2 Recommendations and Remedial Measures.

a. In view of the concern for safety of Watres Dam, the following measures are recommended to be undertaken by the Owner as soon as practical:

(1) Develop a detailed emergency operation and warning system for Watres Dam.

(2) Perform additional studies to more accurately ascertain the spillway capacity required for Watres Dam, as well as the nature and extent of mitigation measures required to make the spillway hydraulically adequate. Filling in the existing low area of the embankment would help increase the spillway capacity and this should be accomplished.

(3) Remove brush from the embankment slopes and perform a detailed inspection to ascertain the condition of the embankment. Surveys should be performed to determine the existing template of the embankment. The results of the survey should be evaluated to ascertain if remedial action is necessary.

(4) Provide positive drainage and good vehicular access at toe of dam to aid in assessment of seepage. Install at least eight observation wells, or other instrumentation, downstream of the axis of the dam. One well, or other instrumentation, should be located in the vicinity of the seepage. The others should be at appropriate locations to determine general water level in downstream embankment. The number of wells, or other instrumentation, will be dependent on the results of the inspection recommended above. Data collected from observation wells or other instrumentation should be utilized in evaluating the stability of the structure and assessing piping potential in the future. Continue to observe wet areas and seepage downstream from dam. If conditions worsen, appropriate action should be taken to control apparent seepage with properly designed drains.

b. In order to correct operational, maintenance or repair deficiencies, and to more accurately assess the condition of the dam, the following are recommended to be undertaken by the Owner in a timely manner.

(1) Remove trees close to slopes.

(2) Visually monitor vegetation in spillway channel and clear vegetation when warranted.

(3) Repair deteriorated mortar in masonry joints.

(4) Remove trees close to retaining wall near spillway channel.

(5) Clear downstream channel of dead trees.

(6) Visually monitor leaks in outlet works tunnel and take remedial action should conditions worsen.

(7) Repair concrete at downstream headwall of outlet works.

(8) Repair or replace, and maintain the monitoring equipment, bent gate stem and ladder.

(9) Investigate if the beaver dam in the downstream channel is causing the swampy conditions at toe of embankment. If it is causing this condition, it should be removed.

c. The following operational measures are recommended to be undertaken by the Owner:

(1) During periods of unusually heavy rains, provide round-the-clock surveillance of Watres Dam.

(2) When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system procedures.

SUSQUEHANNA RIVER BASIN

SPRING BROOK, LACKAWANNA COUNTY

PENNSYLVANIA

WATRES DAM

NDS ID No. PA-00451
DER ID No. 35-81

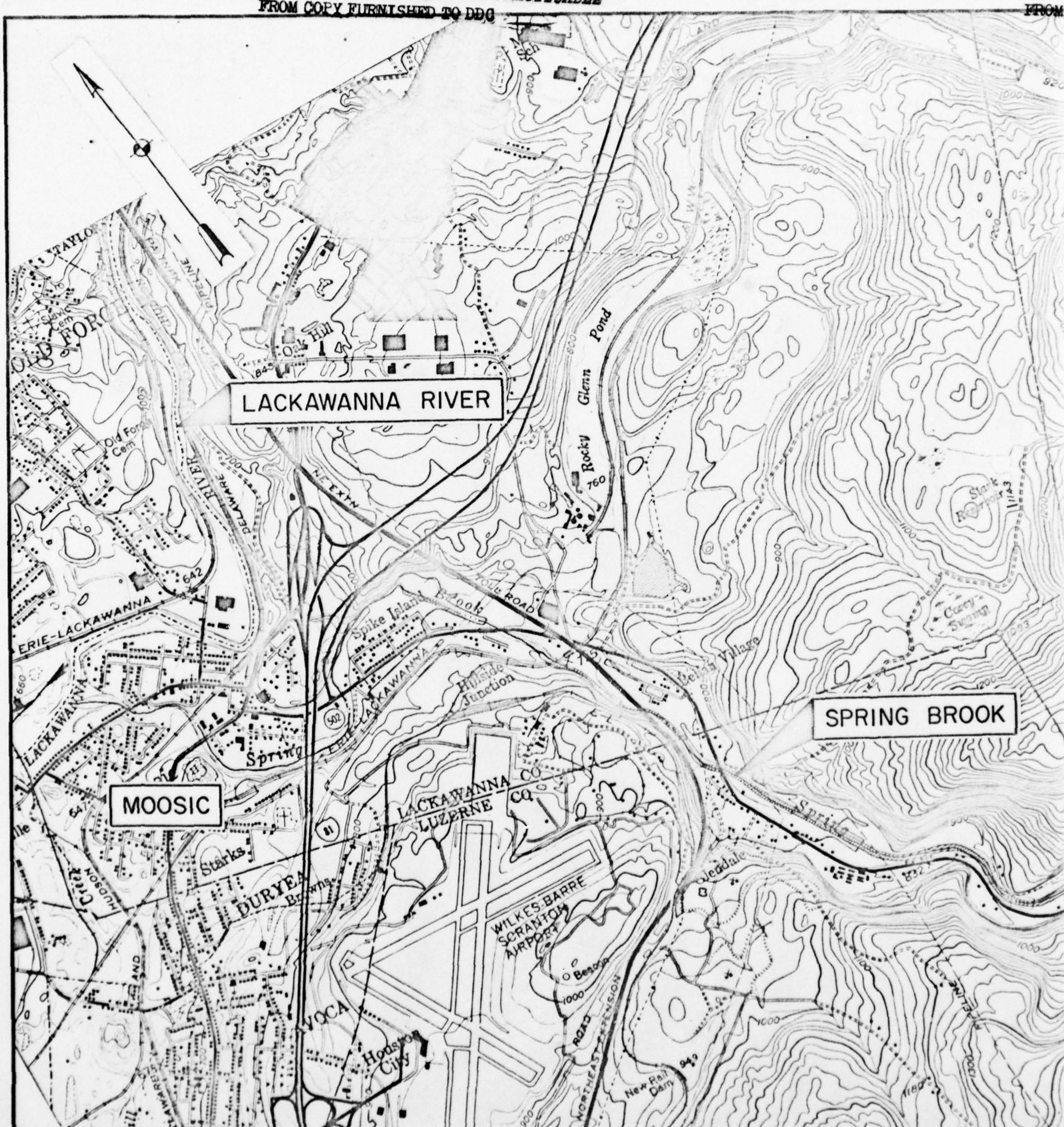
PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JULY 1978

# PLATES


LACKAWANNA RIVER
SPRING BROOK
MOOSIC
ERIE-LACKAWANNA
LACKAWANNA
Rocky Glenn Pond
Spike Island Brook
Hillside Junction
LACKAWANNA CO
LUZERNE CO
WILKES-BARRE SCRANTON AIRPORT
DURYEA
Starks
AVOCA
Houston City
Glendale
NORTHEAST EXTENSION
New Rail Dam
Beacon
Oak Hill
TOLL ROAD
DELAWARE
HUDSON
Mill Creek
Spring
Old Forge Cem

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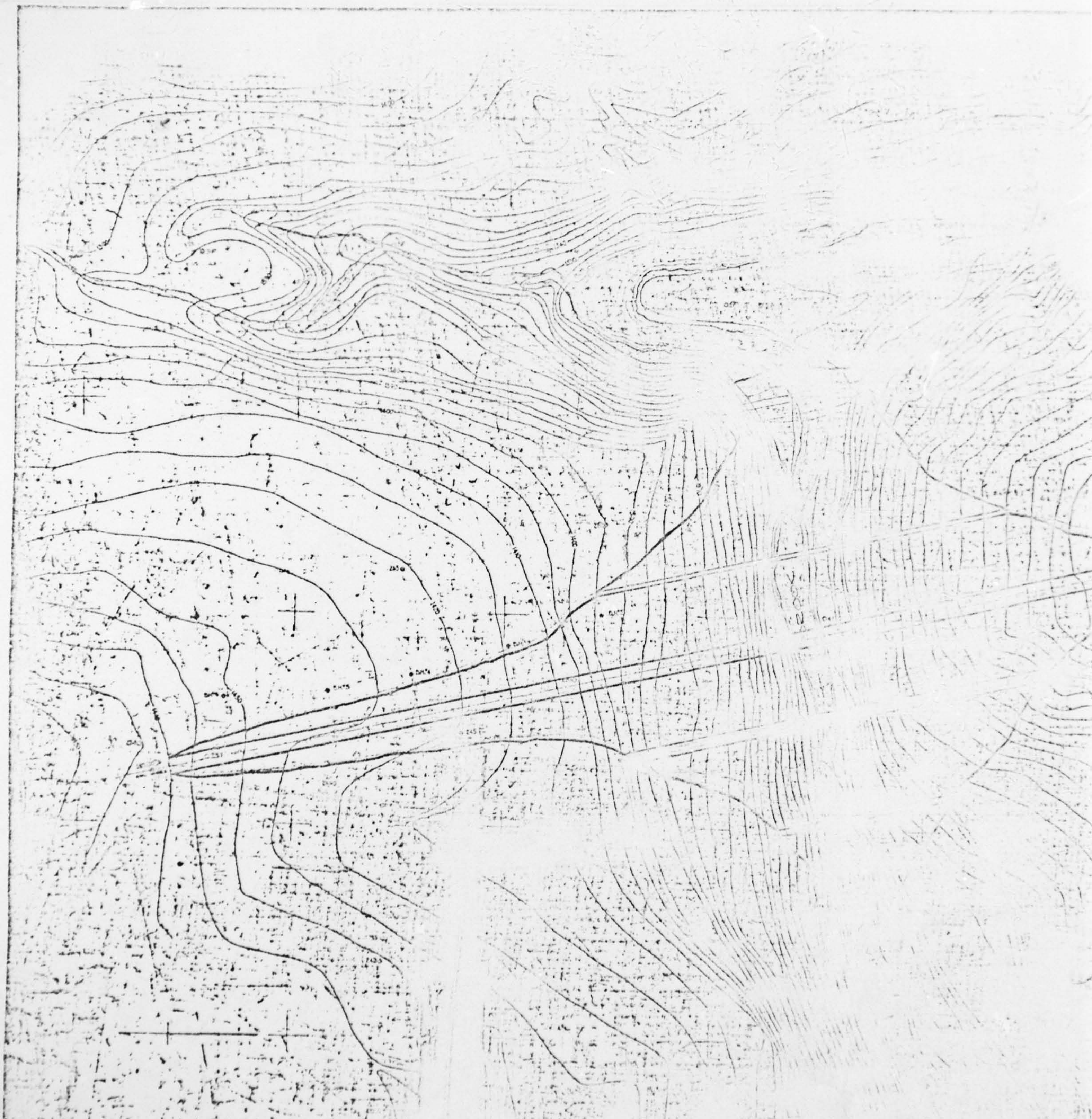
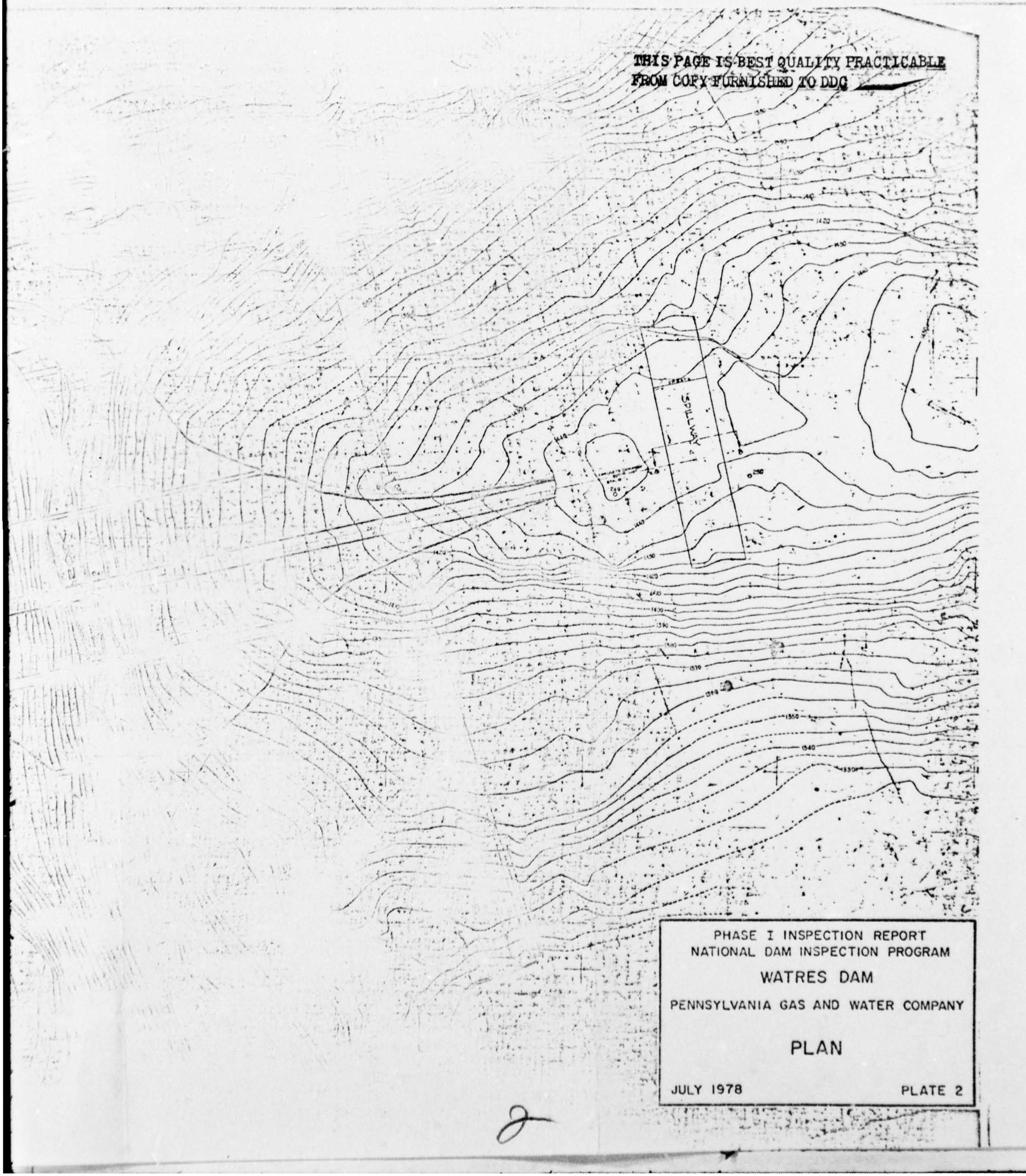
NESBITT DAM
SPRING BROOK
WATRES DAM
Nesbitt
Reservoir
Spring
Brook
Watres
Reservoir
Rockdale
Benjamin Pond
Spring Brook
Pinnacle Hill
Panther
Creek
Creek


PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
WATRES DAM
PENNSYLVANIA GAS AND WATER COMPANY
LOCATION MAP
JULY 1978
PLATE 1
2000 0 2000
SCALE 1 IN. = 2000 FT.
DAM
Watres
Reservoir
Rockdale
Spring Brook Corners
Spring Brook
Welch Cr
Benjamin Pond
Rattlesnake
S P R I N G B R O O K
BM 1592
Brook

4





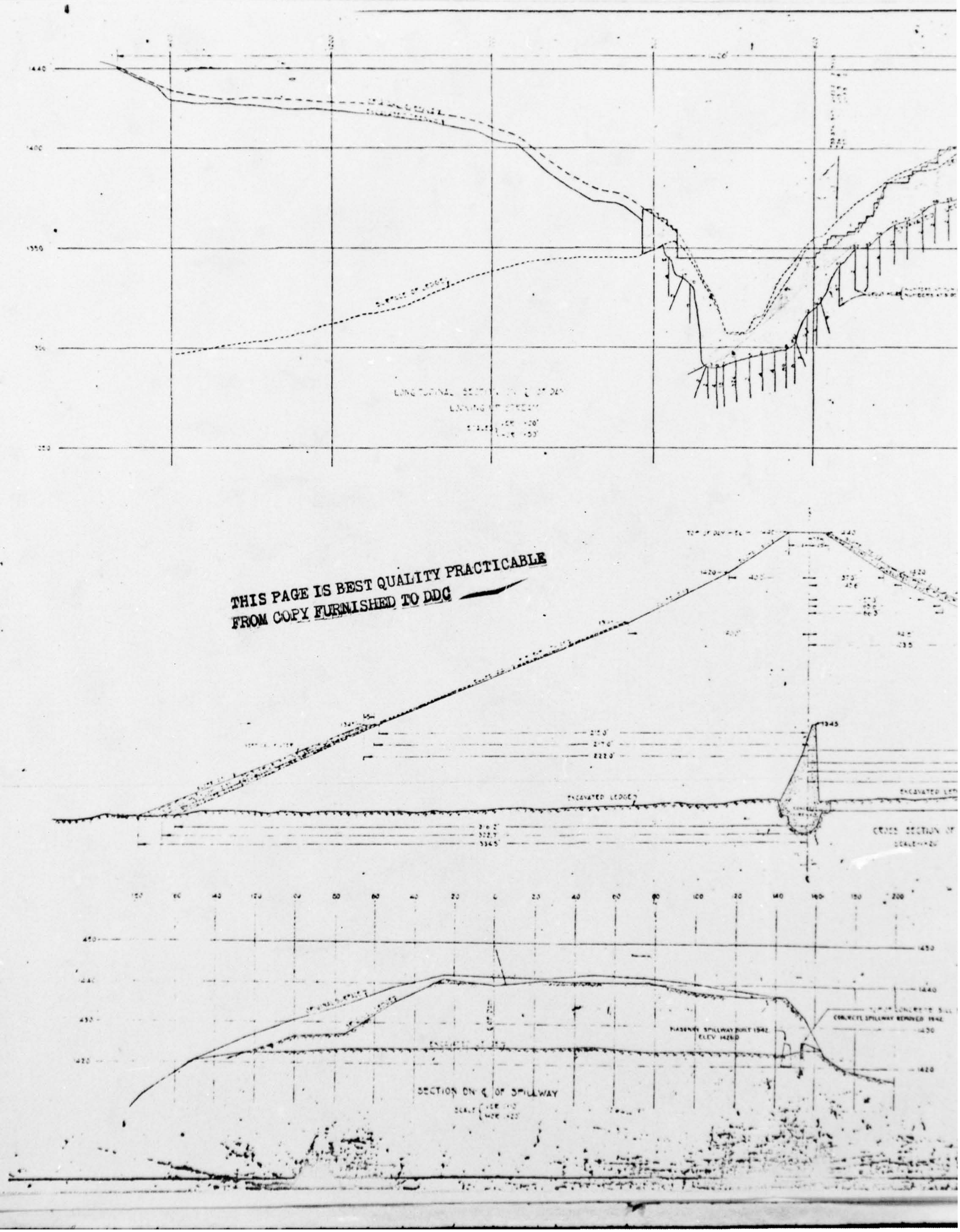

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

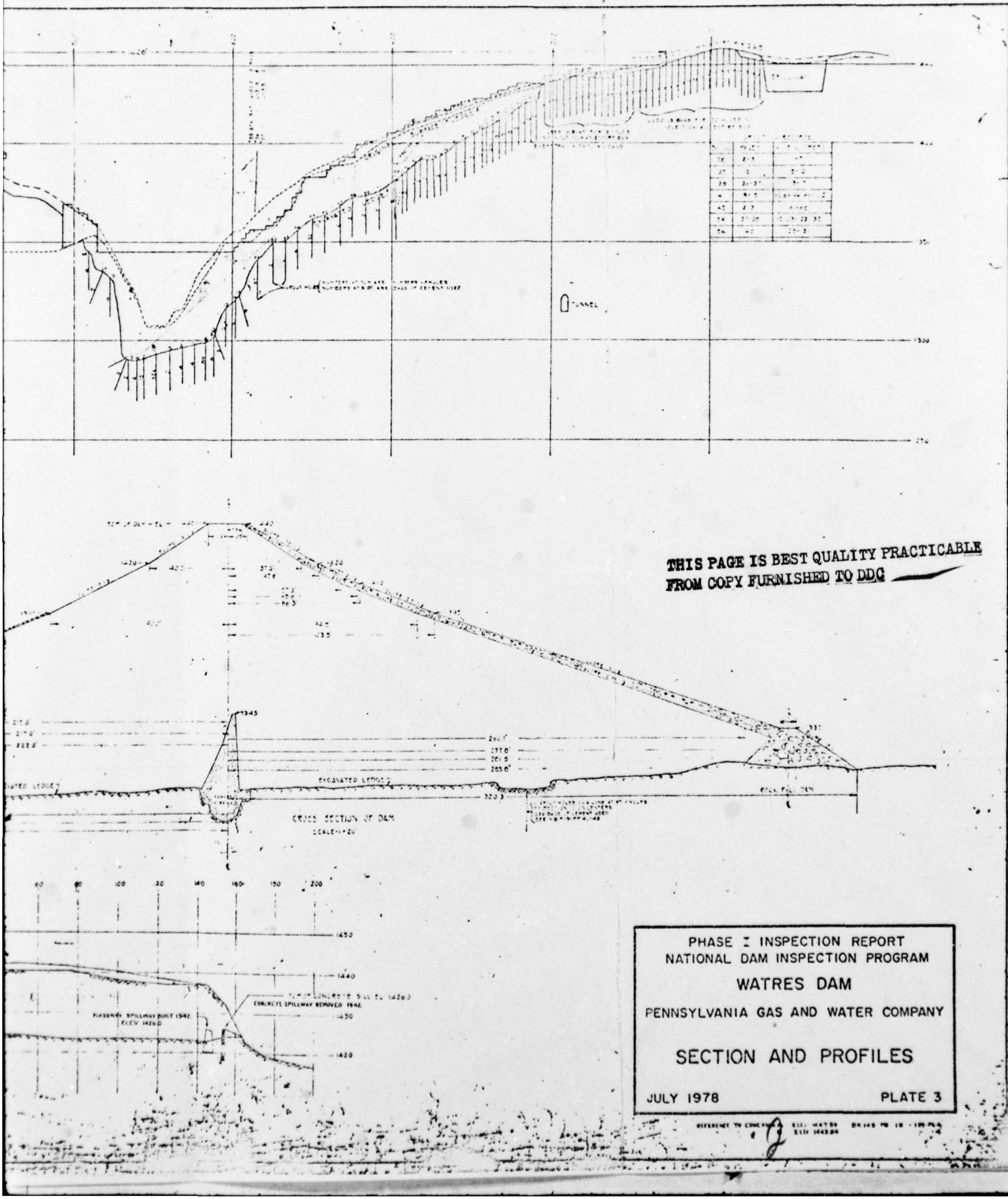
WATRES DAM

PENNSYLVANIA GAS AND WATER COMPANY

PLAN

JULY 1978 PLATE 2


1440
1400
1350
SURFACE OF LEDGE
EXCAVATED LEDGE
1345
CROSS SECTION OF
1450
1440
1430
1420
MASONRY SPILLWAY BUILT 1942
ELEV 1426.0
CONCRETE SPILLWAY REMOVED 1942
SECTION ON ℄ OF SPILLWAY






PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

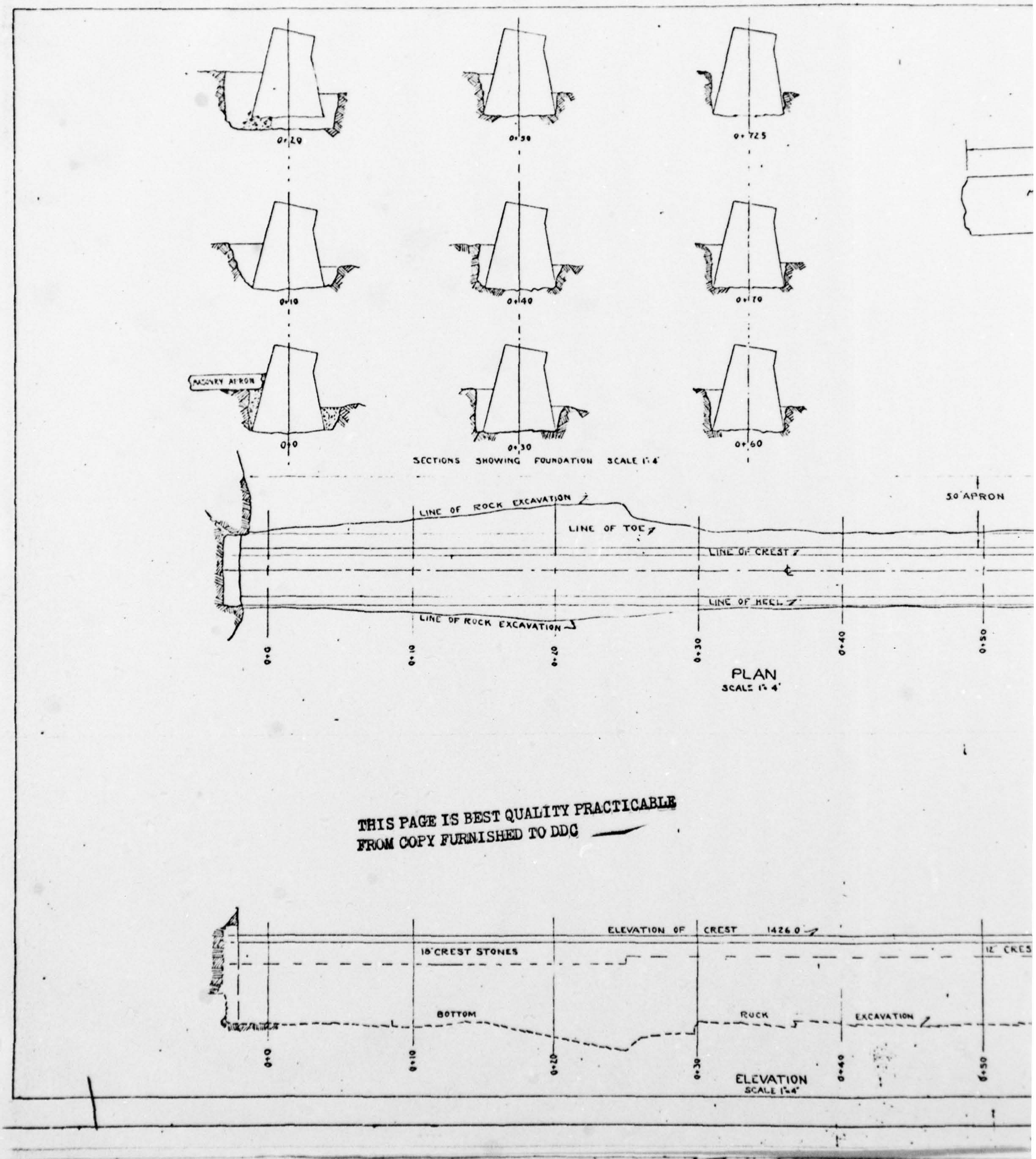
WATRES DAM

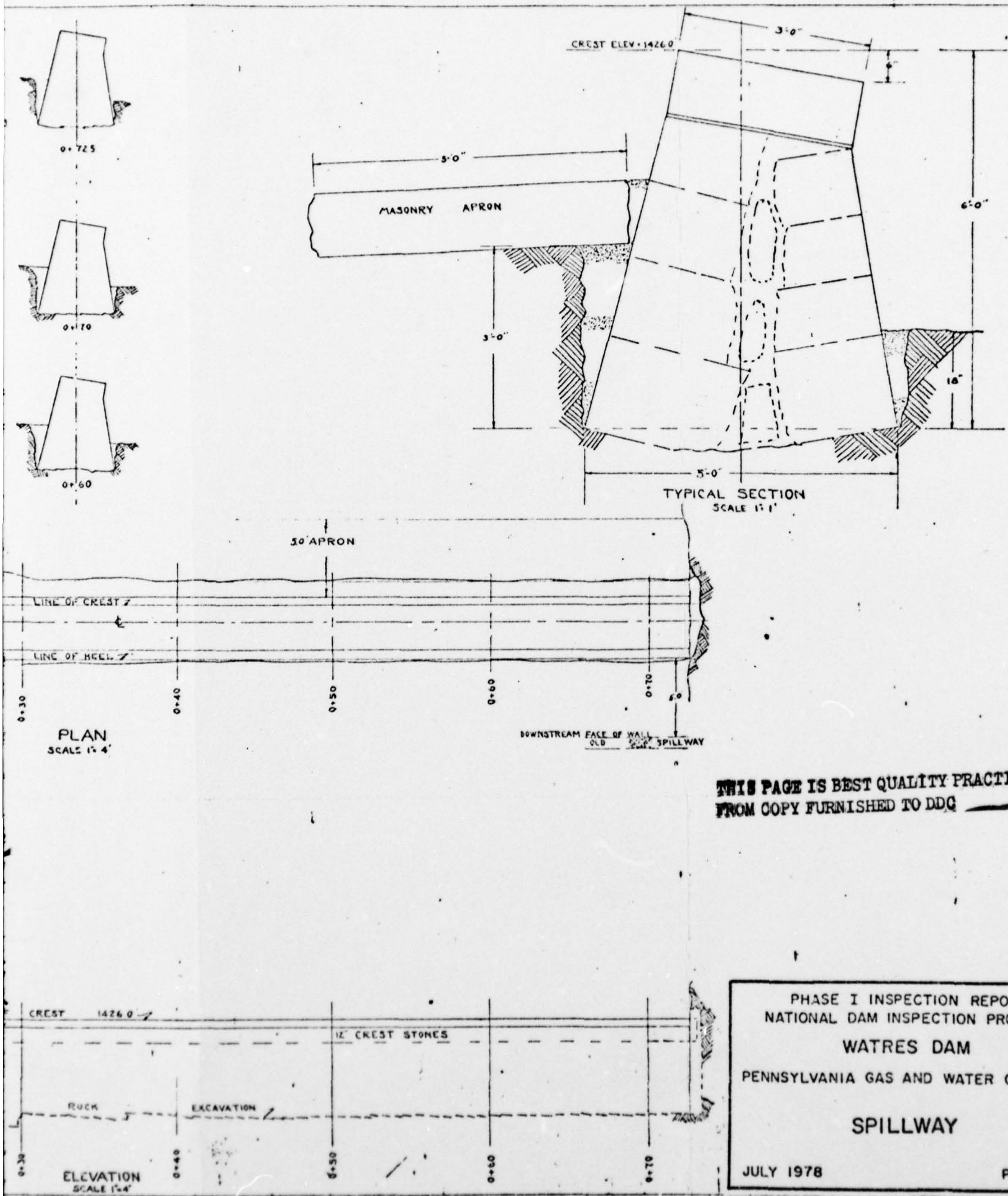
PENNSYLVANIA GAS AND WATER COMPANY

SECTION AND PROFILES

JULY 1978

PLATE 3


0+20
0+50
0+725
0+10
0+40
0+70
MASONRY APRON
0+0
0+30
0+60
SECTIONS SHOWING FOUNDATION SCALE 1"=4'
LINE OF ROCK EXCAVATION
LINE OF TOE
LINE OF CREST
LINE OF HEEL
LINE OF ROCK EXCAVATION
50' APRON
0+0
0+10
0+20
0+30
0+40
0+50
PLAN
SCALE 1"=4'
ELEVATION OF CREST 1426.0
18" CREST STONES
12" CRES
BOTTOM
ROCK
EXCAVATION
0+0
0+10
0+20
0+30
0+40
0+50
ELEVATION
SCALE 1"=4'

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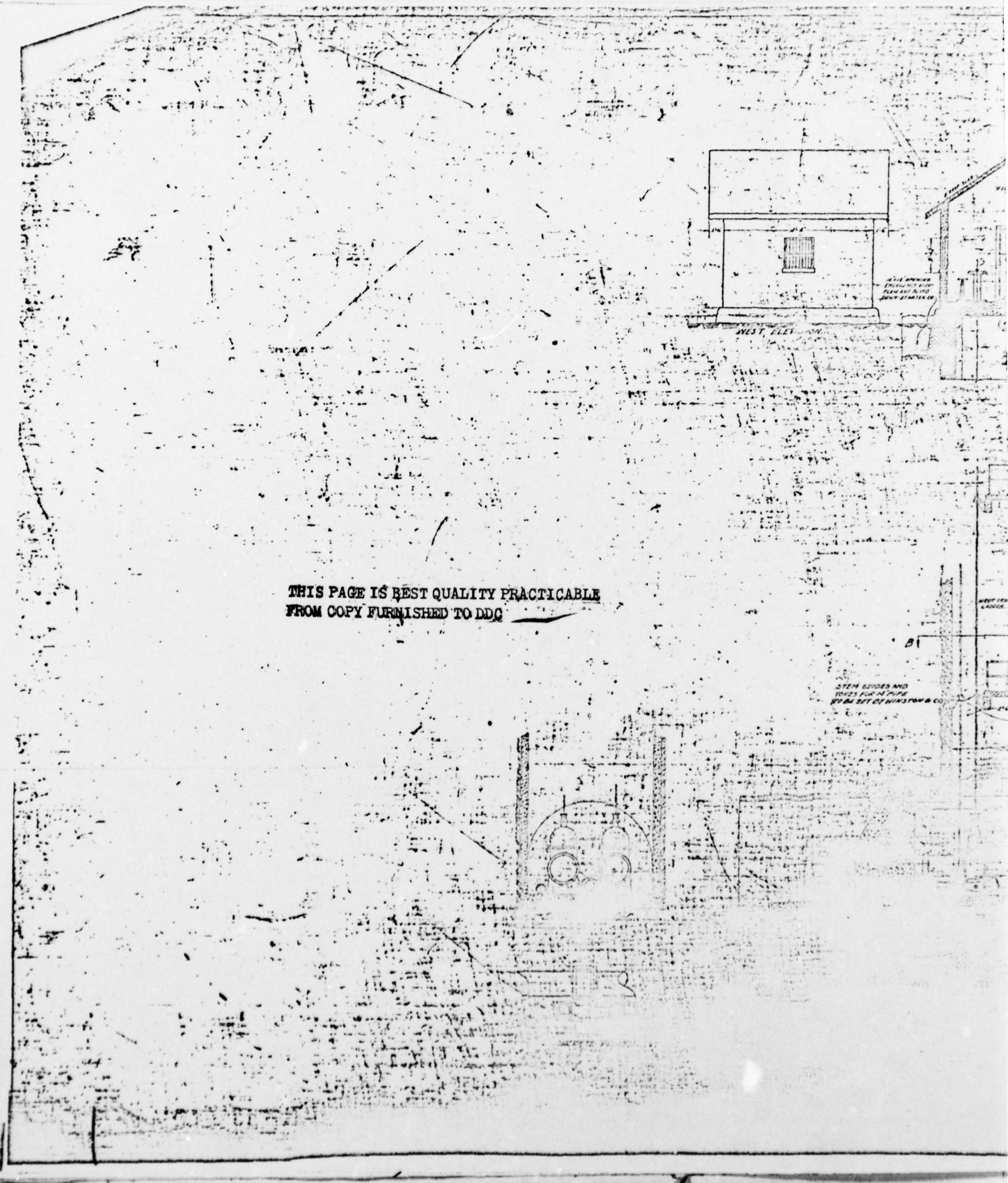
NATIONAL DAM INSPECTION PROGRAM

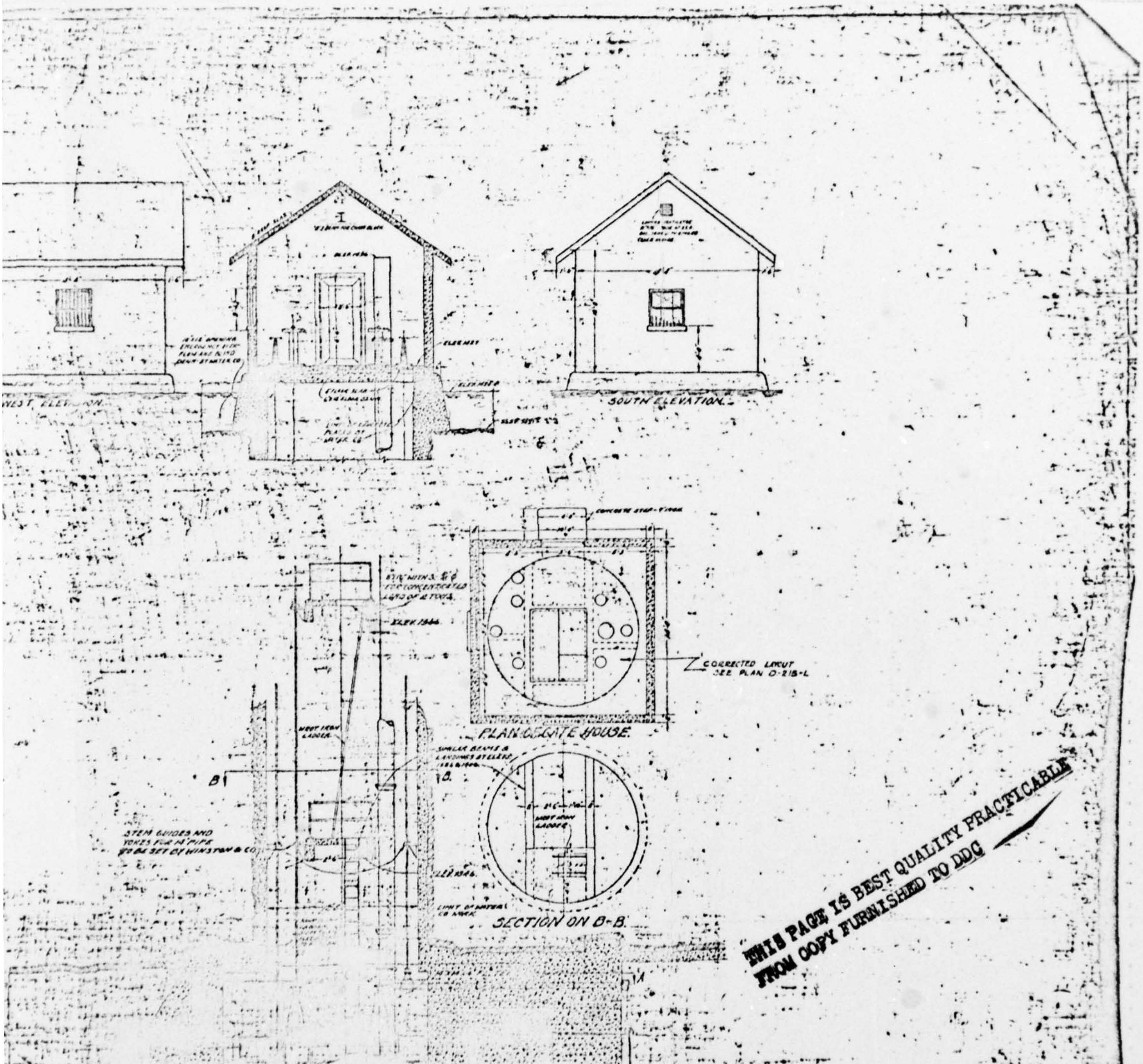
WATRES DAM

PENNSYLVANIA GAS AND WATER COMPANY

SPILLWAY

JULY 1978 PLATE 4


B1
STEM GUIDES AND
YOKES FOR 14" PIPE
TO BE SET BY WINSTON & CO






PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

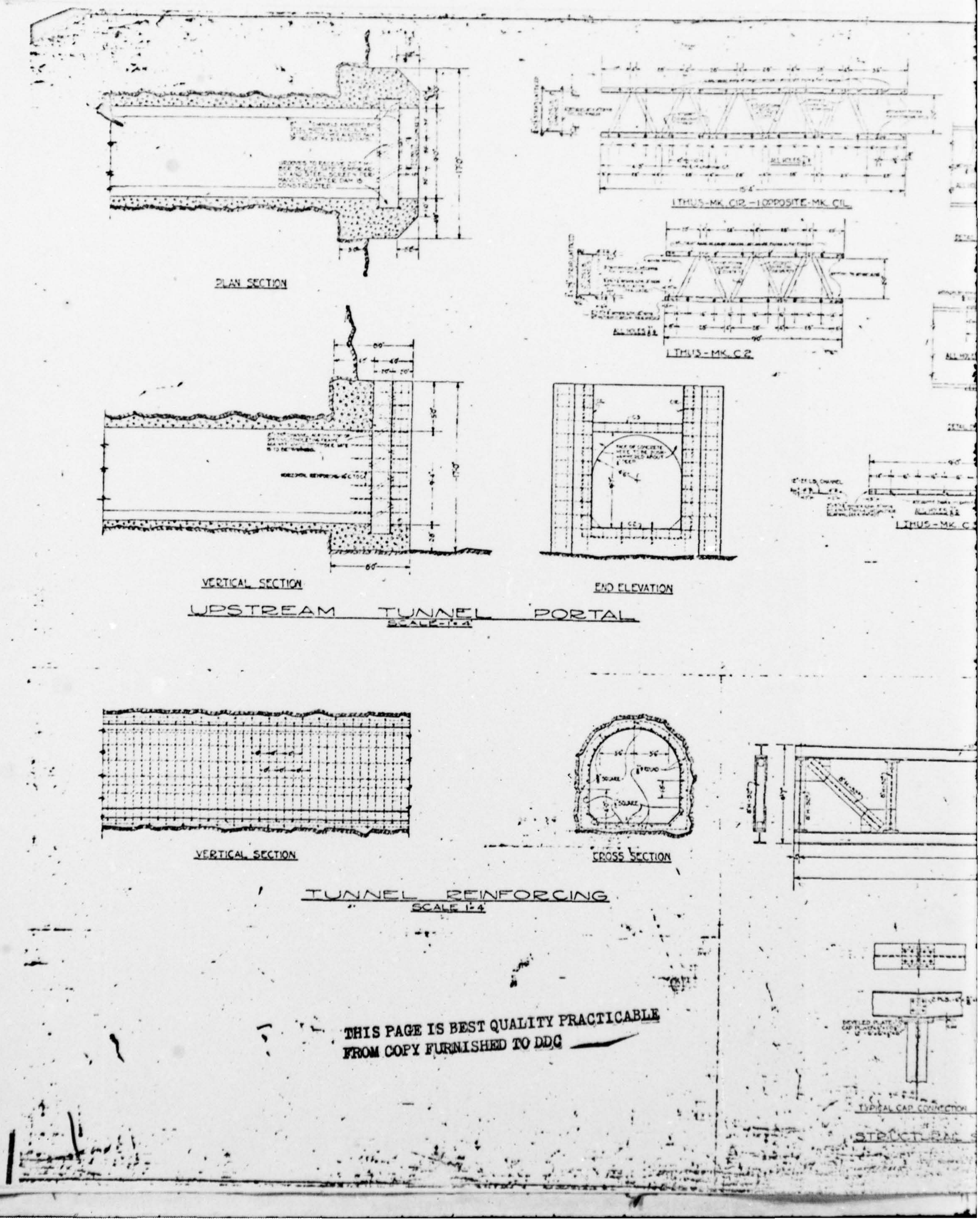
WATRES DAM

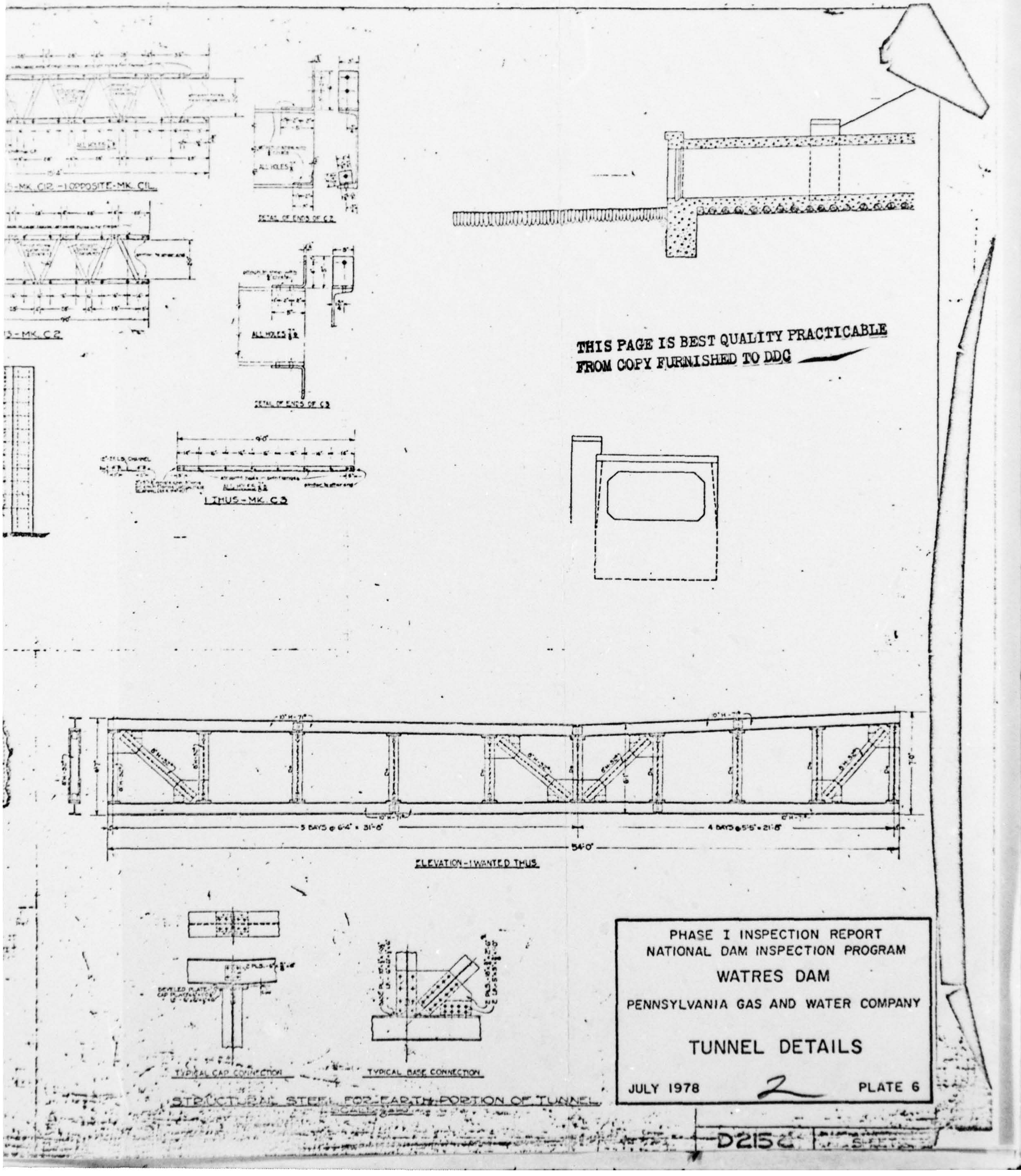
PENNSYLVANIA GAS AND WATER COMPANY

VALVE HOUSE

JULY 1978 PLATE 5

2


PLAN SECTION
VERTICAL SECTION
END ELEVATION
UPSTREAM TUNNEL PORTAL
SCALE 1"=4'
VERTICAL SECTION
CROSS SECTION
TUNNEL REINFORCING
SCALE 1"=4'
1 THUS-MK. C1R - 1 OPPOSITE-MK. C1L
1 THUS - MK. C2
ALL HOLES
TYPICAL CAP CONNECTION






PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

WATRES DAM

PENNSYLVANIA GAS AND WATER COMPANY

TUNNEL DETAILS

JULY 1978 — 2 — PLATE 6

SUSQUEHANNA RIVER BASIN

SPRING BROOK, LACKAWANNA COUNTY

PENNSYLVANIA

WATRES DAM

NDS ID No. PA-00451
DER ID No. 35-81

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JULY 1978

# APPENDIX A

## CHECKLIST - ENGINEERING DATA

CHECKLIST

ENGINEERING DATA

DESIGN, CONSTRUCTION, AND OPERATION
PHASE I

NAME OF DAM: Watres Dam

NDS ID NO.: 451 DER ID NO.: 35-81

Sheet 1 of 4

| ITEM | REMARKS |
|---|---|
| AS-BUILT DRAWINGS | Construction drawings of original structure and subsequent modifications available. |
| REGIONAL VICINITY MAP | Project is shown on Moscow, Pennsylvania - Quadrangle Sheet N4115 - W7530/7.5, 1946 Photorevised 1969. |
| CONSTRUCTION HISTORY | Built 1922-1925. Tunnel constructed by John E. Robertson. Embankment constructed by Winston and Company. Modified 1926 and 1941. |
| TYPICAL SECTIONS OF DAM | Design sections available of original structure and modifications. |
| OUTLETS:<br>Plan<br>Details<br>Constraints<br>Discharge Ratings | Plan and details available. Discharge ratings from Owner's files. |

ENGINEERING DATA



| ITEM | REMARKS |
|---|---|
| RAINFALL/RESERVOIR RECORDS | May 1942 rainfall amounts and crest elevation of reservoir. |
| DESIGN REPORTS | None. |
| GEOLOGY REPORTS | 1921 permit report on design has general geologic description. |
| DESIGN COMPUTATIONS:<br>Hydrology and Hydraulics<br>Dam Stability<br>Seepage Studies | 1921 estimates of hydrology and hydraulics. No stability analyses or seepage studies. |
| MATERIALS INVESTIGATIONS:<br>Boring Records<br>Laboratory<br>Field | 1921 permit report results of bore holes and two test pits dug at right hillside on center line of dam and at borrow pit. Comments in 1921 permit report about material encountered during tunnelling operation for diversion tunnel. |
| POSTCONSTRUCTION SURVEYS OF DAM | None. |

| ITEM | REMARKS |
| --- | --- |
| BORROW SOURCES | Material obtained from onsite. Borrow pit located on hill upstream of dam. |
| MONITORING SYSTEMS | Observation wells in left hillside between embankment and spillway. |
| MODIFICATIONS | 1926 concrete weir 12 inches higher than spillway channel crest and erodable embankment 2 feet higher than the concrete weir were constructed in spillway channel. 1941 masonry spillway crest constructed across existing spillway channel near the existing concrete crest to Elevation 1426. An apron of stone 5 feet wide was laid along the downstream face of the crest to prevent erosion of the softer rock in the channel. The old concrete crest was cut down and removed. |
| HIGH POOL RECORDS | May 1942 crest elevation of reservoir and August 1955 crest elevation of reservoir. |
| POSTCONSTRUCTION ENGINEERING STUDIES AND REPORTS | None. |
| PRIOR ACCIDENTS OR FAILURE OF DAM:<br>Description<br>Reports | 1941 spillway weir in rock spillway channel - left side collapsed into channel, and middle portion of the crest wall was reported to be leaning downstream. |

ENGINEERING DATA



| ITEM | REMARKS |
|---|---|
| MAINTENANCE AND OPERATION RECORDS | No detailed operation records. |
| SPILLWAY:<br>Plan<br>Sections<br>Details | Construction drawings of original structure and subsequent modifications. |
| OPERATING EQUIPMENT:<br>Plans<br>Details | Plans and cross sections available; no equipment details. |
| PREVIOUS INSPECTIONS<br>Dates<br>Deficiencies | 1925 dam crest 6 inches higher than shown on plans irregular spillway crest elevation on rock; leakage on the left hillside to a depth of 1-9/16 inches on a 90° V-notch weir; springs on right hill found on site of dam during construction; earth embankment not shown on plans found 100 feet upstream of spillway crest-embankment is 5 feet higher than spillway crest elevation; curtain wall under downstream end of tunnel outlet was undermined during construction and was being repaired at time of inspection.<br>1926 seepage at foot of right hill-flow from two pipes from back of core wall-flow decreases with time-discharge from right pipe of 12 quarts per 60 seconds and from left pipe of 12 quarts per 15 seconds; 5-foot earth dike remains in spillway channel.<br>1927 seepage less than at last inspection; no evidence of settlement of dam crest-crest is 4 to 12 inches higher than shown on plans; concrete weir 12 inches higher than |

| ITEM | REMARKS |
|---|---|
| PREVIOUS INSPECTIONS (Con't.) | design crest elevation and erodable embankment 2 feet higher than the concrete weir were constructed in August 1926-the embankment and considerable rock on the downstream side of the hill were washed away by a flood in November 1926. |
| | 1928 slide of rock placed on downstream embankment below drainage ditch in center portion of dam; downstream end of channel is eroding on the right side; water from spillway was running over natural ground back into the eroded channel; timber repairs were made to end of tunnel outlet and side walls from undermining of outlet during |
| | construction.<br>1929 smaller amount of seepage on the right and left hills; rock slide on downstream face of dam has been cleared to a depth of 12 to 15 feet-exposed gravel fill is to be regraded, covered with loam, and reseeded; narrow excavation in rock near left side of spillway channel has been |
| | made in an effort to confine erosion; downstream end of tunnel outlet has been repaired.<br>1930 embankment of dam has settled a maximum of 1.7 feet on day of inspection, fill was being replaced on the crest to restore it to the original elevation.<br>1932 brush and young trees on both slopes of the embank- |
| | ment near the crest; considerable flow of water on the bottom of the construction conduit-seepage may be from hillside; a small stream was noted emerging from near the toe of the embankment along the right hillside.<br>1934 one crack noted in spillway crest; several old minor slumps on downstream face at mid-height; seepage from springs in gutters along right hillside intersection; flow |
| | from drains at right end of toe into pool.<br>1941 considerable erosion and minor slumps were observed over a length of about 600 feet at right end of dam; a swampy spot exists at toe about 600 feet from right end of dam; slight leakage was noted to left of swampy area at several places along intersection of hillside and |

ENGINEERING DATA

Sheet 4b of 4

| ITEM | REMARKS |
|---|---|
| PREVIOUS INSPECTIONS (Con't.) | embankment; left end of spillway weir wall has collapsed into channel and has been replaced by a temporary wooden structure-the middle portion of the crest wall is leaning downstream; some disintegration of concrete was noted at lower end of outlet conduit. |
| | 1943 considerable erosion exists on the downstream face over a length of about 600 feet at right end of embankment; a swampy spot exists at toe 600 feet from right end of embankment; wet condition at left end along intersection of hillside and embankment; loose stone in wasteway channel below spillway apron; slight disintegration was |
| | observed on outlet end of floor of conduit.<br>1957 poor general appearance and maintenance.<br>1965 fair appearance. |
| | |
| | |
| | |

CHECKLIST

ENGINEERING DATA

HYDROLOGY AND HYDRAULICS

NAME OF DAM: Watres NDS ID NO.: PA-00451 DER ID NO.: 35-81

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): Elevation 1426.0

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): Elevation 1440 - varies across dam.

ELEVATION MAXIMUM DESIGN POOL: Elevation 1435

ELEVATION TOP DAM: Elevation 1440 varies across dam.

SPILLWAY CREST:

a. Elevation Elevation 1426.0
b. Type Masonry, broad-crested with 6" adverse fall over the width of the crest.
c. Width 3 feet
d. Length 73 feet
e. Location Spillover 200 feet left of left abutment of dam embankment.
f. Number and Type of Gates None.

OUTLET WORKS:

a. Type Cast-iron pipe through construction diversion tunnel.
b. Location Near left abutment.
c. Entrance Inverts
d. Exit Inverts
e. Emergency Draindown Facilities 2 - 30-inch cast-iron pipes.

HYDROMETEOROLOGICAL GAGES:

a. Type None.
b. Location None.
c. Records None.

MAXIMUM NONDAMAGING DISCHARGE: 10,000 cfs.

SUSQUEHANNA RIVER BASIN

SPRING BROOK, LACKAWANNA COUNTY

PENNSYLVANIA

WATRES DAM

NDS ID No. PA-00451
DER ID No. 35-81

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JULY 1978

# APPENDIX B

# CHECKLIST - VISUAL INSPECTION

CHECKLIST

VISUAL INSPECTION

PHASE I

Name of Dam: Watres County: Lackawanna State: Pennsylvania

NDS ID No.: PA-00451 DER ID No.: 35-81

Type of Dam: Earth with concrete wall cutoff Hazard Category: High

Date(s) Inspection: 7-8 June 1978 Weather: Overcast Temperature: 65°

Soil Conditions: Moist

Pool Elevation at Time of Inspection: 1426.1 msl/Tailwater at Time of Inspection: 1403.5* msl

* 300 feet downstream of spillway crest in spillway channel.

Inspection Personnel:

| | |
|---|---|
| D. R. Ebersole (GFCC) | J. Skoritowski (PG&W) |
| W. E. Seip (GFCC) | D. R. Kaufman (PG&W) |
| J. Crouse (GFCC) | J. Chernesky (PennDER) |

A. Whitman (GFCC) Recorder

EMBANKMENT

Sheet 1 of 2

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|---|---|---|
| SURFACE CRACKS | None. | |
| UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE | None. | |
| SLOUGHING OR EROSION:<br>Embankment Slopes<br>Abutment Slopes | None. | |
| CREST ALIGNMENT:<br>Vertical<br>Horizontal | Horizontal - straight<br>Vertical - surveyed varies from Elevation 1438.9 to 1440.9 | |
| RIPRAP FAILURES | None. | |

EMBANKMENT



| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|---|---|---|
| JUNCTION OF EMBANKMENT WITH:<br>Abutment<br>Spillway<br>Other Features | No observable defects. | |
| ANY NOTICEABLE SEEPAGE | At toe of embankment-at old streambed-boggy area with two visible seeps. One 30 feet downstream of toe from right hill-1 gpm clear. Another 60 feet downstream from bottom-2 or 3 gpm clear. | Water can be heard flowing through rock toe. Access to toe only through woods. |
| STAFF GAGE AND RECORDER | None. | |
| DRAINS | Toe drain - see "ANY NOTICEABLE SEEPAGE" ABOVE. | |
| VEGETATION | Upstream slope - large bushes on upper half of exposed, riprapped slope.<br>Downstream - completely overgrown. | Recorder walked abutment line-with difficulty. Abutment line is indistinct with trees adjacent, two inspectors, one with machete, required to take rod down for section stadia. Not a thorough inspection. |

OUTLET WORKS

Sheet 1 of 1

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|---|---|---|
| CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT | Downstream tunnel lining has a 1-inch diameter hole with about 5 gpm leak. Other leaks in rock tunnel. | |
| INTAKE STRUCTURE | None. | |
| OUTLET STRUCTURE | Concrete on top of headwall deteriorated completely with rebar totally exposed. | VALVE HOUSE: Bent floatwell valve stem. Rusting ladder. Floatwell inoperable. |
| OUTLET CHANNEL | See "DOWNSTREAM CHANNEL" Sheet B-8. | |
| EMERGENCY GATE | Four men opened left downstream 30-inch valve 8 inches in 30 minutes. - No deficiencies. | Owner requested opening stop after 8 inches to prevent sediment from entering right transmission line. |

UNGATED SPILLWAY

Sheet 1 of 1

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|---|---|---|
| CONCRETE WEIR | Mortar missing for about 2-inch depth from some joints. | |
| APPROACH CHANNEL | Reservoir. Approach is cut in natural materials with natural rock vertical walls. No deficiencies. | |
| DISCHARGE CHANNEL | Cut in rock with near vertical rock walls. Mortar missing from areas of joints in stone apron. | Channel at toe of near vertical drop has trees across it. Channel near weir has a small amount of vegetation. |
| BRIDGE AND PIERS | None. | |
| RETAINING WALL | On right bank downstream end of spillway channel. Deteriorated mortar with grass growing in some joints. Brown-colored leaching over lower half. | Wall in generally overgrown area. |

## INSTRUMENTATION

Sheet 1 of 1

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|---|---|---|
| MONUMENTATION/SURVEYS | Not observed. | |
| OBSERVATION WELLS | On left abutment of embankment - Pipes protruding from ground - on centerline alignment. | May be grout pipes. |
| WEIRS | None. | |
| PIEZOMETERS | None. | |
| OTHER | None. | |

RESERVOIR AND WATERSHED

Sheet 1 of 1

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|---|---|---|
| SLOPES | No steep slopes or visible movement observed. | |
| SEDIMENTATION | Owner reports no problems. | |
| WATERSHED DESCRIPTION | Mostly wooded. Sparse development along roads. | |
| | | |
| | | |

## DOWNSTREAM CHANNEL

Sheet 1 of 1

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|---|---|---|
| CONDITION:<br>Obstructions<br>Debris<br>Other | Beaver dam below tunnel (approximately 300 feet). | |
| SLOPES | Right overbank is flat and wooded. Left overbank not observed. | |
| APPROXIMATE NUMBER OF HOMES AND POPULATION | None observed. | |
| | | |
| | | |

SUSQUEHANNA RIVER BASIN

SPRING BROOK, LACKAWANNA COUNTY

PENNSYLVANIA

WATRES DAM

NDS ID No. PA-00451
DER ID No. 35-81

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JULY 1978

# APPENDIX C

# HYDROLOGY AND HYDRAULICS

**GANNETT FLEMING CORDDRY AND CARPENTER, INC.**
**HARRISBURG, PA.**

SUBJECT WATRES DAM (35-81) FILE NO. 7613.1P
HYDROLOGY AND HYDRAULICS ANALYSIS SHEET NO. 1 OF 6 SHEETS
FOR USCE - BALTIMORE DISTRICT
COMPUTED BY JMK DATE 6/16/78 CHECKED BY PvdG DATE 6/30/78



CLASSIFICATION

HIGH HAZARD, SINCE DOWNSTREAM POPULATION IS 50, AND FAILURE OF THE DAM COULD RESULT IN MORE THAN A FEW LIVES LOST AND EXCESSIVE ECONOMIC LOSS

LARGE SIZE, SINCE HEIGHT = 131 FEET AND CAPACITY = 10,939 AC-FT

REFERENCE : "RECOMMENDED GUIDELINES FOR SAFETY INSPECTION OF DAMS," p. D-8

SPILLWAY DESIGN FLOOD (SDF)
THE SDF SHOULD BE THE PMF (FROM p D-12 OF "REC. GUIDELINES...")

HYDROLOGY AND HYDRAULICS ANALYSIS
REFERENCE : PHASE I PROCEDURE PACKAGE

II. A. 2. PMF INFLOW HYDROGRAPH NOT AVAILABLE
a. BALTIMORE CONTACT, MIKE KANOWITZ, RECOMMENDS OBTAINING PMF PEAK FROM CURVE
b. FROM CURVE OF SUSQUEHANNA RIVER BASIN, REGION 2, AND DRAINAGE AREA = 15.4 SQ.MI, PMF = 1,780 CFS/SQ.MI. × 15.4 SQ.MI. = 27,412 CFS, SAY 27,410 CFS

EFFECT OF UPSTREAM RESERVOIRS

COMPTON RESERVOIR, DRAINAGE AREA = 1.0 SQ.MI. AND SURFACE AREA = 3 ACRES, IS UPSTREAM OF WATRES RESERVOIR ON SPRING BROOK. A FIELD CHECK OF COMPTON RESERVOIR DURING THE VISUAL INSPECTION TRIP TO WATRES RESERVOIR REVEALED THAT COMPTON RESERVOIR IS TOO SMALL TO HAVE ANY APPRECIABLE EFFECT FOR THE PHASE I INSPECTION OF WATRES DAM. FOR THE PURPOSES OF THIS STUDY, NO UPSTREAM RESERVOIRS EXIST, BUT SEE SHEET 6 FOR STORAGE VOLUME CHECK FOR FAILURE OF COMPTON DAM.

B. ABILITY OF SPILLWAY TO PASS THE PMF
1. CAPACITY OF SPILLWAY
FROM THE FIELD SURVEY CONDUCTED DURING THE VISUAL INSPECTION OF THE DAM, A LOW AREA EXISTS ON THE EMBANKMENT CREST AT ELEVATION 1,438.9'. SINCE THE SPILLWAY CREST ELEVATION IS 1,426.0', THE MAXIMUM HEAD ON THE SPILLWAY BEFORE OVERTOPPING OF THE EMBANKMENT IS 1,438.9' - 1,426.0' = 12.9'.

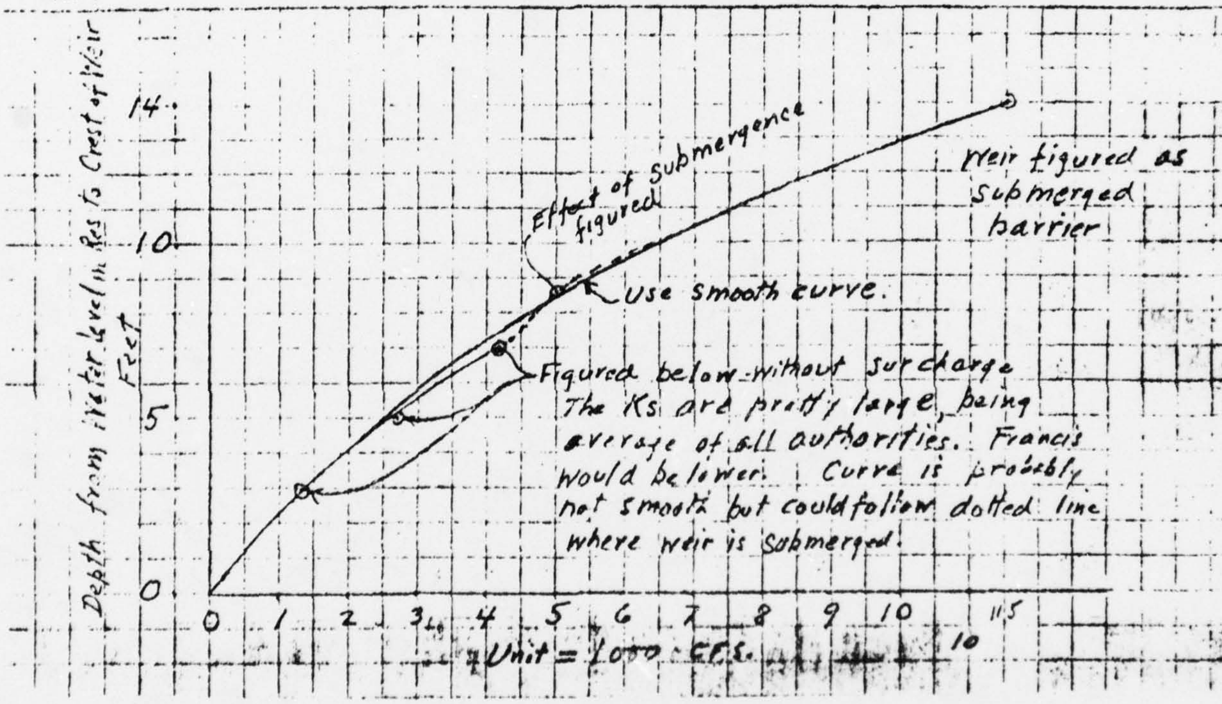
THOMAS H. WIGGIN, CONSULTING ENGINEER, 90 BROAD STREET, NEW YORK, NEW YORK, RATED THE SPILLWAY CHANNEL ON COMPUTATION SHEETS DATED JAN 27, 1955. AN EXCERPT OF HIS WORK IS REPRODUCED ON THE FOLLOWING PAGE. SINCE THE DAM AND SPILLWAY HAVE NOT BEEN MODIFIED SINCE THEN, THE RATING CURVE IS STILL VALID.

SP 11860A

THOS. H. WIGGIN CONSULTING ENGINEER 90 BROAD STREET, N. Y. CITY

Watres Spillway

SHEET NO. 19 COMPUTER T. H. Wiggin DATE Jan. 27, 1955




AT THE PRESENT CONDITION AVAILABLE HEAD OF 12.9 FEET, THE SPILLWAY DISCHARGE = 10,000 CFS
AT THE DESIGN ELEVATION HEAD OF 14.0 FEET, THE SPILLWAY DISCHARGE = 11,500 CFS

3. THE PMF PEAK FLOW IS GREATER THAN THE SPILLWAY CAPACITY (27,410 > 10,000)

b. ROUTING OF THE PMF IS NOT AVAILABLE

(1.) THE SPILLWAY WILL PASS (10,000/27,410) = 0.365 · p = 36.5 % OF THE PMF PEAK

(2.) INCLUSIVE 3 METHOD TO ESTIMATE THE STORAGE EFFECT OF THE RESERVOIR

(a) TRIANGULAR SHAPE FOR PMF HYDROGRAPH

(b) FROM THE GRAPH OF TOTAL TIME VS. D.A. FOR THE SUSQUEHANNA RIVER BASIN, TOTAL TIME = 31.5 HOURS

— CHECK INCHES OF RUNOFF PRODUCED BY THE PMF PEAK AND THE TOTAL TIME —

RUNOFF VOLUME = ½ bh = ½ (31.5 HOURS)(27,410 CFS) = 431,708 CFS-HOURS

SP 11860A

$431,708 \frac{FT^3}{SEC} \times HOURS \times \frac{3,600\ AC\text{-}SECS}{43,560\ FT^2\text{-}HRS} \times \frac{12\ IN}{1\ FT} = 428,140\ AC\text{-}IN$

DRAINAGE AREA = 15.4 SQ. MI × (640 ACRES / SQ. MI.) = 9,856 ACRES

RUNOFF AMOUNT = $\frac{428,140\ AC\text{-}IN}{9,856\ ACRES}$ = 43.4 INCHES

SINCE 43.4 INCHES OF RUNOFF IS A HIGH VALUE FOR THE PMF, REDUCE THE INCHES OF RUNOFF TO 26, AS PER THE INSTRUCTIONS OF THE BALTIMORE CONTACT, MIKE KANOWITZ. FROM THE PMF PEAK AND THE VOLUME OF RUNOFF PRODUCED BY 26 INCHES OF RUNOFF OVER THE DRAINAGE AREA, CALCULATE THE EQUIVALENT TOTAL TIME OF PMF HYDROGRAPH.

$VOL = \frac{1}{2} bh; \quad b = \frac{2\,VOL}{h}$

VOL = 26" RUNOFF × 9,856 ACRES = 256,256 AC-INCHES

$256,256\ AC\text{-}IN \times \frac{1\ FT}{12\ IN} \times \frac{43,560\ FT^2\text{-}HRS}{3,600\ AC\text{-}SECS} = 258,391\ CFS\text{-}HRS$

$b = \frac{2\,VOL}{h} = \frac{2 \times 258,391\ CFS\text{-}HRS}{27,410\ CFS} = 18.9\ HOURS$

$1-p = 1 - 0.365 = 0.635 = \frac{\Delta AOC}{\Delta AOB}$

$\Delta AOB = \frac{1}{2} bh = VOL = 256,256\ AC\text{-}IN \times (1 FT/12 IN) = 21,355\ AC\text{-}FT$

SUBSTITUTING, $\Delta AOC = (1-p)\,\Delta AOB = (0.635)(21,355) = 13,560\ AC\text{-}FT$

REQUIRED STORAGE = $\Delta AOC$ = 13,560 AC-FT

(c) INCREMENTAL STORAGE AVAILABLE BETWEEN NORMAL POOL ELEVATION AND MAXIMUM POOL ELEVATION

NORMAL POOL ELEVATION = SPILLWAY CREST ELEVATION = 1,426.0'
MAXIMUM POOL ELEVATION = TOP OF DAM ELEVATION = 1,438.9'
DESIGN MAX. POOL ELEV. = DESIGN TOP OF DAM ELEV. = 1,440.0'

FROM OWNER'S RESERVOIR STORAGE CURVE,

RESERVOIR STORAGE AT MAXIMUM POOL ELEV. (H = 12.9') = 99,500,000 $FT^3$
= 2,284 AC-FT

RESERVOIR STORAGE AT DESIGN MAX. POOL ELEV. (H = 14.0') = 108,500,000 $FT^3$
= 2,491 AC-FT

STORAGE REQUIRED = 13,560 AC-FT > STORAGE AVAILABLE = 2,284 AC-FT

C. PROCEDURES FOR DETERMINATION OF ADEQUATE / INADEQUATE SPILLWAY CAPACITY

2. STORAGE REQUIRED FOR THE PMF IS GREATER THAN THE STORAGE AVAILABLE

a. ETL 1110-2- STATES THREE CONDITIONS THAT MUST EXIST BEFORE THE SPILLWAY CAPACITY IS CONSIDERED TO BE SERIOUSLY INADEQUATE. CHECK CONDITION "C."

SP 11860A

(IS THE SPILLWAY ABLE TO PASS ½ PMF W/O OVERTOPPING FAILURE ?)

b. REPEAT CALCULATIONS FOR ½ PMF PEAK

½ PMF PEAK = ½(27,410) = 13,705 CFS

II, B. ABILITY OF SPILLWAY TO PASS ½ PMF



1. CAPACITY OF SPILLWAY = 10,000 CFS

3. ½ PMF PEAK FLOW IS GREATER THAN THE SPILLWAY CAPACITY (13,705 > 10,000)

b. ROUTING OF ½ PMF IS NOT AVAILABLE

(1.) THE SPILLWAY WILL PASS (10,000/13,705) = 0.730 = p = 73.0% OF ½ PMF PEAK

(2.) INCLOSURE 3 METHOD TO ESTIMATE THE STORAGE EFFECT OF THE RESERVOIR

(a) TRIANGULAR SHAPE FOR ½ PMF HYDROGRAPH

(b) SAME AS BEFORE, EXCEPT THAT PEAK IS NOW 13,705 CFS

$1-p = 1-0.73 = 0.270 = \frac{\Delta AOC}{\Delta AOB}$

$\Delta AOB = \frac{1}{2}bh = \frac{1}{2}(18.9 \text{ HOURS})(13,705 \text{ CFS}) = 129,512$ CFS-HOURS

SUBSTITUTING, $\Delta AOC = (0.270)(\Delta AOB) = (0.270)(129,512) = 34,968$ CFS-HOURS

∴ 34,968 CFS-HOURS IS REQUIRED TO PASS ½ PMF W/O OVERTOPPING

$34,968 \frac{FT^3}{SEC} \times \text{HOURS} \times \frac{3,600 \text{ AC-SECS}}{43,560 \text{ FT}^2\text{-HRS}} = 2,890$ AC-FT

(c) INCREMENTAL STORAGE AVAILABLE BETWEEN NORMAL POOL ELEVATION AND MAXIMUM POOL ELEVATION - SEE SHEET 3 - = 2,284 AC-FT

STORAGE REQUIRED = 2,890 AC-FT > STORAGE AVAILABLE = 2,284 AC-FT

C. PROCEDURES FOR DETERMINATION OF ADEQUATE/INADEQUATE SPILLWAY CAPACITY

2. STORAGE REQUIRED IS GREATER THAN STORAGE AVAILABLE

a. ETL 1110-2-

① THERE IS A HIGH HAZARD OF LOSS OF LIFE FROM LARGE FLOWS DOWNSTREAM OF DAM

② CHECK TAILWATER AT INSTANT BEFORE OVERTOPPING OCCURS

③ THE DAM AND SPILLWAY ARE NOT CAPABLE OF PASSING ½ PMF WITHOUT OVERTOPPING FAILURE

b. TAILWATER AT INSTANT BEFORE OVERTOPPING OCCURS

SPILLWAY CAPACITY DISCHARGE = 10,000 CFS. FROM HEC-2 COMPUTER RUN USING A USGS TOPO SHEET CROSS-SECTION DOWNSTREAM OF DAM,

TAILWATER DEPTH @ Q = 10,000 CFS IS 10.9 FEET

TOP OF DAM ELEVATION = 1,440.0'

HEIGHT OF DAM = 131'

**GANNETT FLEMING CORDDRY AND CARPENTER, INC.**
**HARRISBURG, PA.**

SUBJECT: WAITES DAM (35-81) — HYDROLOGY AND HYDRAULICS ANALYSIS
FILE NO. 7613.1P
SHEET NO. 5 OF 6 SHEETS
FOR: USCE - BALTIMORE DISTRICT
COMPUTED BY: JMC DATE 6/19/78 CHECKED BY PvdG DATE 6/30/78

BOTTOM OF DAM ELEVATION = 1,309.0'

TAILWATER DEPTH = 10.9'

TAILWATER ELEVATION = 1,319.9'

TOP OF DAM ELEV - TAILWATER ELEV. = 1,440.0 - 1,319.9' = 120.1'

PERCENT OF PMF THAT SPILLWAY CAN PASS
GENERAL FORMULA

$$\% \text{ OF PMF THAT SPILLWAY CAN PASS} = \frac{Q_T}{Q_{PMF}} \times 100\%,$$

WHERE $Q_T = Q_{SPILLWAY} + 2S/\Delta t$,

$S = \sum_{i=1}^{n} S_i$ FOR UPSTREAM RESERVOIR CASES,

AND $T$ = EQUIVALENT TOTAL TIME OF PMF HYDROGRAPH

$$\% \text{ OF PMF} = \frac{10{,}000 + \left(\frac{2\times(2{,}284)\text{ AC-FT}}{18.9\text{ HOURS}} \times \frac{43{,}560\text{ FT}^2\text{-HRS}}{3{,}600\text{ AC-SECS}}\right)}{27{,}410} \times 100\%$$

$$= \frac{10{,}000 + 2{,}924}{27{,}410} \times 100\%$$

% OF PMF = 47%

SPILLWAY CAPACITY THAT COULD BE REALIZED IF THE EMBANKMENT ELEVATION WAS BROUGHT UP TO THE DESIGN ELEVATION OF 1,440.0' IS 11,500 CFS. THE RESERVOIR STORAGE AT ELEVATION 1,440.0' IS 2,491 AC-FT.

% OF PMF THAT SPILLWAY CAN PASS WITH INCREASED SPILLWAY CAPACITY

$$= \frac{11{,}500 + \left(\frac{2\times(2{,}491)\text{ AC-FT}}{18.9\text{ HOURS}} \times \frac{43{,}560\text{ FT}^2\text{-HRS}}{3{,}600\text{ AC-SECS}}\right)}{27{,}410} \times 100\%$$

$$= \frac{11{,}500 + 3{,}190}{27{,}410} \times 100\%$$

% OF PMF THAT SPILLWAY CAN PASS WITH INCREASED SPILLWAY CAPACITY = 54%

STORAGE VOLUME CHECK FOR FAILURE OF COMPTON DAM

CAPACITY OF COMPTON RESERVOIR = 16,000,000 GALLONS = 49 AC-FT*

SURCHARGE STORAGE CAPACITY OF WATRES RESERVOIR = 2,284 AC-FT (SHEET 3)

SINCE THE SURCHARGE STORAGE CAPACITY OF WATRES RESERVOIR IS MUCH GREATER THAN THE CAPACITY OF COMPTON RESERVOIR, WATRES DAM SHOULD BE ABLE TO WITHSTAND A FAILURE OF COMPTON DAM WITHOUT BEING OVERTOPPED, DISREGARDING OTHER INFLOW AND OUTFLOW TO WATRES RESERVOIR.

* REFERENCE: "DAMS, RESERVOIRS, AND NATURAL LAKES," WATER RESOURCES BULLETIN NO. 5, COMMONWEALTH OF PENNSYLVANIA, DEPARTMENT OF FORESTS AND WATERS, 1970.

# Compton Dam

FIND EQUIVALENT RADIUS OF RESERVOIR

3 ACRES @ NORMAL POOL = $\pi r^2 = 3 \times 43560$

$r = 204'$

USE 1V ON 5H SLOPES - THEY APPEARED FLAT

4.0' SPILLWAY CREST TO TOP OF DAM

$r_{\text{TOP OF DAM}} = 204 + 5 \times 4 = 224$

$\text{AREA}_{\text{TOP OF DAM}} = \pi r^2 = \frac{\pi \times 224^2}{43560} = 3.6 \text{ ACRES}$

SURCHARGE STORAGE = $\frac{(3 + 3.6)}{2} \times 4 = 13.2$ ACRE-FT

SAY 13 ACRE-FT

TOTAL STORAGE = 13 + 49 = 62 ACRE-FT

TOTAL SURCHARGE STORAGE AT WATRES = 2,284 ACRE-FT

$\frac{62 \times 100}{2284} = 2.7\%$

∴ SHOULD COMPTON DAM FAIL, WATRES DAM WOULD NOT BE OVERTOPPED

Compton Spillway

$Q = CLH^{3/2}$

$= 3.7 \times 27 \times 4^{3/2} = 799.2 \text{ CFS} \approx 800 \text{ CFS}$

DETERMINE COMPONENT OF WATRES PMF AT COMPTON DAM

$Q = 27,410 \left(\frac{1}{154}\right)^{0.8} = 3075.3 \text{ CFS} \approx 3080 \text{ CFS}$

COMPUTE HYDROGRAPH ASSUMING 26 INCHES RUNOFF

VOLUME = $1 \text{ mi}^2 \times 640 \text{ ACRES/mi} \times \frac{26 \text{ INCHES}}{12 \text{ INCHES/FT}} = 1387 \text{ ACRE-FT}$

$= 60,403,200 \text{ FT}^3$

$S = \frac{Q \times \text{TIME}}{2}$ $\quad T = \frac{2S}{Q} = 39222.9 \text{ SEC}$

$= 10.9 \text{ HRS}$

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT: COMPTON DAM
HYDRAULICS AND HYDROLOGY
FILE NO. ____ SHEET NO. ____ OF ____ SHEETS
FOR: WATRES DAM
COMPUTED BY: ABT DATE 6/27/78 CHECKED BY: LudG DATE 6/30/78

DETERMINE EFFECT OF SURCHARGE STORAGE AVAILABLE

$$Q = Q_{SPILLWAY} + \frac{2 \times S_{SURCHARGE}}{T}$$

$$= 800 + 2 \times \frac{13 \times 43560}{39,223 \text{ sec}}$$

$$= 800 + 28.8 \text{ cfs}$$

$$= 829 \text{ cfs} \approx 830 \text{ cfs}$$

$$\frac{830 \times 100}{3080 \text{ cfs}} = 26.9 \approx \underline{\underline{27\%}}$$

DISTANCE UPSTREAM OF WATRES = 4.4 STREAM MILES

STORAGE – NEGLIGIBLE

∴ IGNORE COMPTON IN WATRES PMF CALCULATIONS.

SUSQUEHANNA RIVER BASIN

SPRING BROOK, LACKAWANNA COUNTY

PENNSYLVANIA

WATRES DAM

NDS ID No. PA-00451
DER ID No. 35-81

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JULY 1978

# APPENDIX D

# PHOTOGRAPHS

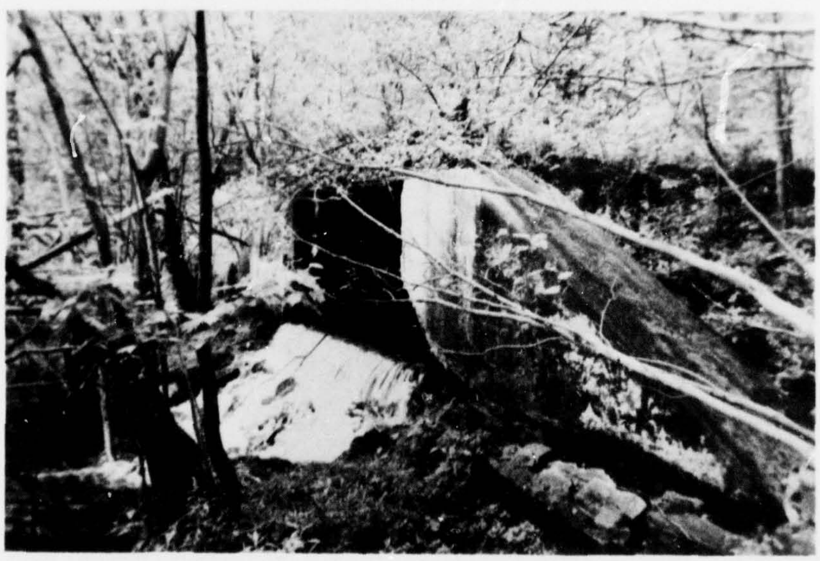
A. Embankment at Right Abutment

B. Valve House and Top of Dam
Looking Towards Right Abutment

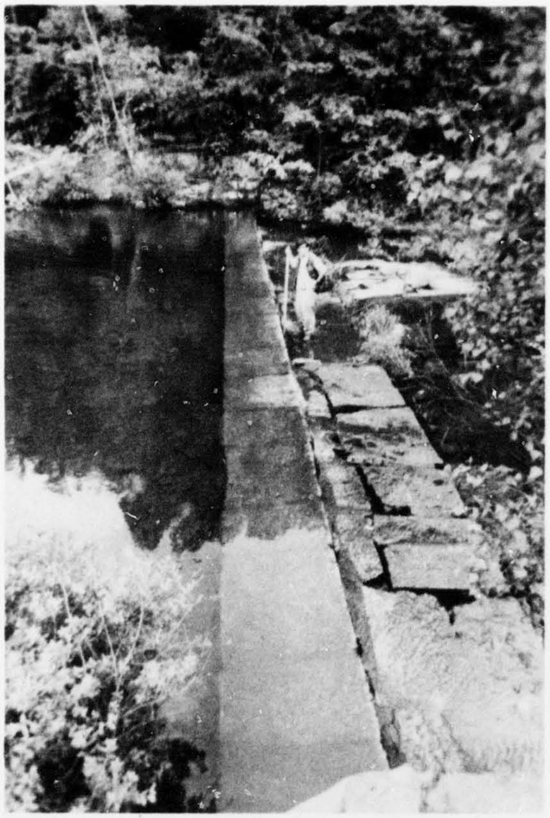
C. Brush on Downstream Slope of Embankment

D. Riprap on Upstream Slope of Embankment

E. Seepage at Toe of Dam



F. Headwall at Downstream End of Outlet Works Tunnel



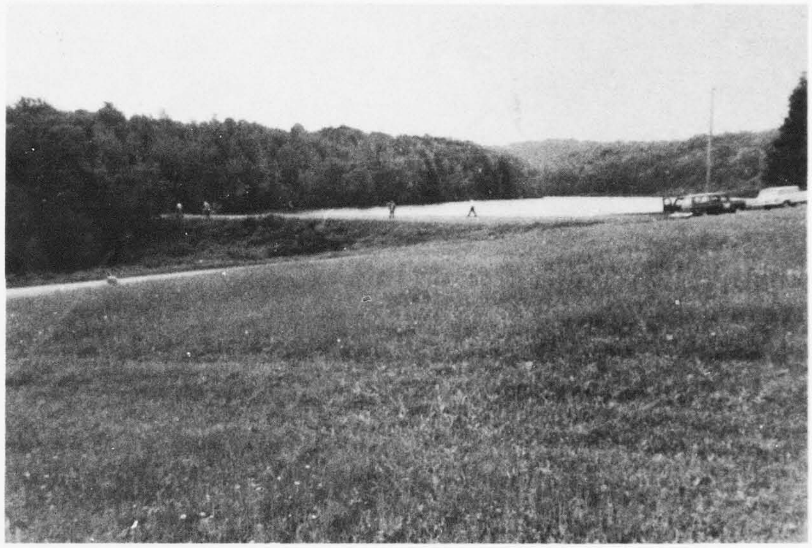
G. Spillway Crest

H. Spillway — Looking Upstream

WATRES DAM

I. Downstream End of Spillway Channel
Looking Upstream

J. Retaining Wall on Right Bank of
Downstream End of Spillway Channel



K. Compton Dam — Upstream of Watres Dam
Looking Upstream

L. Compton Dam — Upstream of Watres Dam — Spillway at Right Abutment of Dam

SUSQUEHANNA RIVER BASIN

SPRING BROOK, LACKAWANNA COUNTY

PENNSYLVANIA

WATRES DAM

NDS ID No. PA-00451
DER ID No. 35-81

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# APPENDIX E

# GEOLOGY

WATRES DAM

APPENDIX E

GEOLOGY

1. General Geology. The damsite and reservoir are located in Lackawanna County. Lackawanna County was completely covered with ice during the last continental glaciation of Pleistocene time. The general direction of ice movement was S 35° - 40° W. Glacial drift covers the entire County, except where subsequent erosion has removed it. Thick deposits of glacial outwash occur in many places along the Lackawanna River, and are 50 to 100 feet thick near Dickson, Scranton, and Moosic.

The only important structural feature in Lackawanna County is the Lackawanna Syncline, which traverses the County in a southwesterly direction. The syncline enters the County at the northeast corner as a narrow shallow trough, gradually deepens and broadens toward the southwest, and reaches its maximum development in Luzerne County. The rock formations exposed range from the post-Pottsville formations (youngest) through the Pottsville, Mauch Chunk shale, Pocono sandstone to the Damascus formation of the Catskill group (oldest). The rim rocks, the Pottsville formation and Pocono sandstone, have dips that rarely exceed 10° to 20° and form a rather simple syncline. The core rocks, the post-Pottsville formations, are folded into a series of minor anticlines and synclines which trend about N70° E. The rock in the northwestern and southeastern parts of the County, outside of the limits of the Lackawanna Syncline, are generally horizontally stratified.

The Lackawanna River, in general, follows the axis of the Lackawanna Syncline. Southeast of the Lackawanna River, the rise in terrain is quite gradual and the crests of the high mountains are several miles from the Lackawanna River. Streams, such as Roaring Brook, Stafford Meadow Brook, and Spring Brook, have cut deep canyons through the mountains and follow a tortuous course to their confluence with the Lackawanna River near Scranton, Pennsylvania. Northwest of Lackawanna River, the mountains rise abruptly to a sharp ridge which in most places is somewhat higher than the country to the northwest. Consequently, most of the drainage in this part of the County flows westward by way of Tunkhannock Creek. A few small tributary streams, however, such as Leggetts Creek, flow eastward from this area into Lackawanna River. In the area of interest, the Lackawanna River streambed is founded in post-Pottsville formations. Proceeding uphill from the river, the older Pottsville formation, Mauch Chunk shale, Pocono sandstone, and Catskill continental group are encountered in turn. The tributary streams, in flowing down the mountains, have generally cut through or around the hard sandstone and conglomerate members, and have eroded their streambed into the softer shales and glacial till. The Catskill continental group of rocks underlies the greater part of Lackawanna County.

2. Site Geology. Watres Dam and Reservoir are sited in Catskill sandstone and shale formations southeast of the Lackawanna syncline. At the damsite, Spring Brook is cutting a gorge through a ridge of hard green and red sandstone. The site was investigated by means of core borings and test pits. The sandstone stratifications are quite thick with lenses of red and gray sandy shale. At the damsite, the stratifications have a dip of approximately 30 degrees to the right and downstream. From reports of engineers of the Pennsylvania Water Supply Commission, who inspected the site both before and during construction, it is learned that rock was exposed with almost vertical walls in the narrow gorge of the stream channel to a height of 25 to 30 feet above the streambed. To the left of the channel gorge, the sidewall rock rises sharply to the top of sandstone strata and then follows the natural slope. The bedrock is covered by only 6 inches to 2 feet of sandy clay overburden to a point well beyond and above the elevation of the top of dam at the left end of the dam. To the right of the natural stream channel, the rock in the sidewall of the gorge rises to a height of about 50 feet above the stream surface, at which point the top of the stratification is reached and from there follows the natural downward slope of the stratification. At the right end of the dam, the sandstone bedrock is located about 65 feet below the top of dam. The bedrock is covered by sandy clay overburden.

A 40-foot high concrete core wall was constructed across the gorge section of the foundation. The core wall was keyed into the rock foundation and sidewalls of the gorge. To the left of the gorge, a 12-foot wide cutoff trench was excavated to firm rock. Seamy, open joint sandstone was removed and a core wall constructed in the trench to top of ground or to a minimum height of 6 feet. The rock upstream of the core wall was drilled on 16-foot centers and grouted on a split spacing. The grout take was heavy in certain areas. To the right of the gorge, a 12-foot wide inspection trench was excavated about 4 feet into the sandy clay overburden without use of a concrete core wall.

The concrete-lined tunnel was excavated in red and green sandstone under the left abutment of the embankment. The spillway is founded in sandstone to the left of the left end of the embankment.