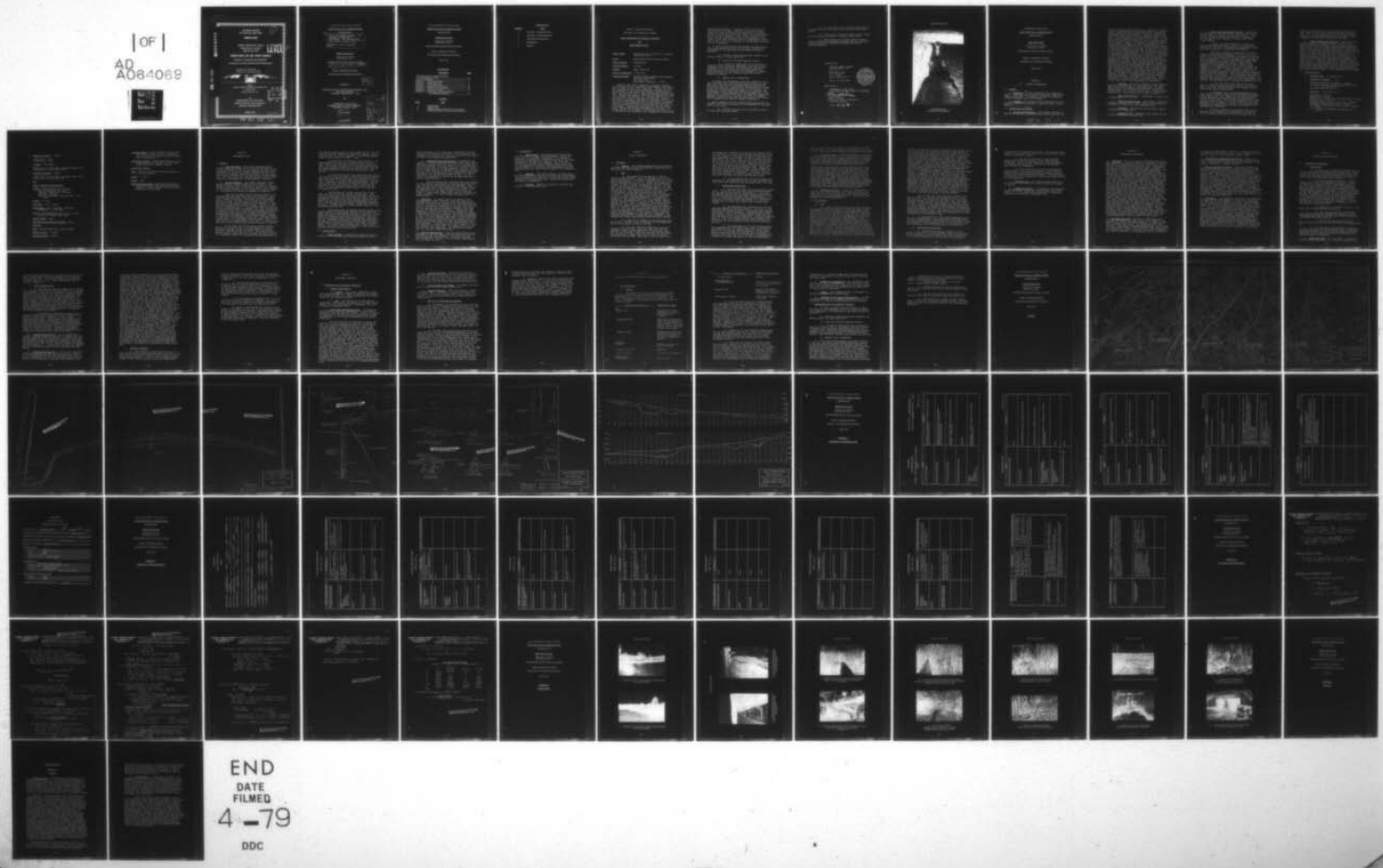
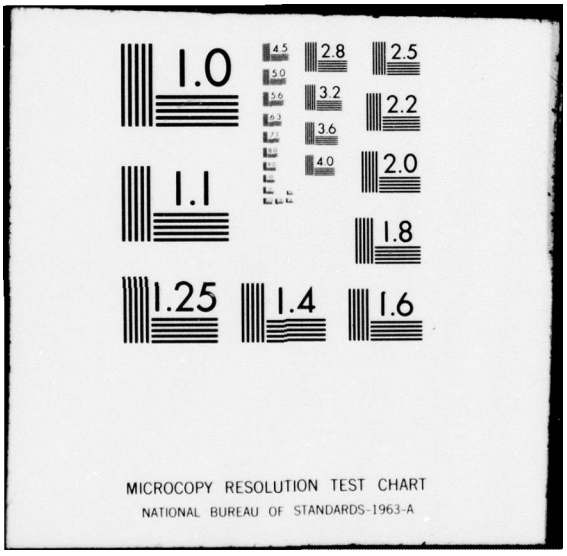
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SUSQUEHANNA RIVER BASIN
DEEP HOLLOW RUN, LUZERNE COUNTY

PENNSYLVANIA

DEEP HOLLOW DAM

NDS ID NO. PA-00549
DER ID NO. 40-3

LEVEL II

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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Contract No. DACW31-78-C-0046

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

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

JUNE 1978

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SUSQUEHANNA RIVER BASIN

DEEP HOLLOW RUN, LUZERNE COUNTY

PENNSYLVANIA

(6) National Dam Inspection Program. Deep Hollow Dam (NDS ID-PA-00549) (DER ID-40-3), Pennsylvania Gas and Water Company. Susquehana River Basin, Deep Hollow Run, Luzerne County, Pennsylvania. Phase I Inspection Report.

DEEP HOLLOW DAM

NDS ID No. PA-00549
DER ID No. 40-3

PENNSYLVANIA GAS AND WATER COMPANY

(15) DACW31-78-C-0076

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

(12) 85 p.

Prepared by

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

For

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Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

(11) JUNE 1978

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SUSQUEHANNA RIVER BASIN

DEEP HOLLOW RUN, LUZERNE COUNTY

PENNSYLVANIA

DEEP HOLLOW DAM

NDS ID No. PA-00549
DER ID No. 40-3

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

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2	General Plan.
3	Proposed Reconstruction (Not Constructed).
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APPENDICES

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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:	Deep Hollow Dam (NDS ID No. PA-00549; DER ID No. 40-3)
Owner:	Pennsylvania Gas and Water Company
State Located:	Pennsylvania
County Located:	Luzerne
Stream:	Deep Hollow Run
Date of Inspection	23 May 1978
Inspection Team:	Gannett Fleming Corddry and Carpenter, Consulting Engineers P.O. Box 1963 Harrisburg, Pennsylvania 17105

Based on the visual inspection, available records, calculations and past operational performance, Deep Hollow Dam is judged to be in fair condition. However, the overall condition of the dam and appurtenant structures has deteriorated to the extent that general rehabilitation is due. The spillway will not pass the Probable Maximum Flood (PMF) without overtopping. The spillway capacity and storage available from maintaining a reduced pool level are sufficient to prevent overtopping by one-half the PMF. If Deep Hollow 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. Computations indicate that the PMF inflow would overtop the concrete nonoverflow by 0.6 foot. Although the dam has a number of structural deficiencies, it is believed to be improbable that overtopping to the extent

indicated would result in complete failure of this concrete gravity arch dam. Based on the criteria established for these studies by the Department of the Army, Office of the Chief of Engineers (OCE), the dam and spillway are rated as adequate. The existing spillway combined with the available storage from maintaining a pool level 10 feet below spillway crest can accomodate a flood with a peak inflow of 52 percent of the PMF peak flow without any overtopping.

In order to reduce existing hazards for Deep Hollow Dam in the immediate future, 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 Deep Hollow Dam.

(2) Clear the spillway approach channel.

(3) In order to reduce the risk of failure at high pool levels or during overtopping, the Owner should investigate the foundation conditions where the dam is founded on soil, and design and implement proper remedial measures that are found to be necessary to prevent potential piping of the foundation materials and/or erosion by overflow.

(4) Repair roof in gatehouse.

To ensure the satisfactory long-term condition of the dam, the Owner should perform additional studies to more accurately ascertain the discharge capacity required for Deep Hollow Dam, and he should study alternates and develop a plan for structural rehabilitation of the project. Continued lack of maintenance and repair will accelerate the development of more potentially hazardous conditions. The study should include determination of foundation conditions, condition of concrete in the dam, and extent of remedial measures required to make the dam hydraulically and structurally adequate under maximum loading conditions.

Before remedial work for rehabilitating the project is complete, the following measures are recommended to be undertaken by the Owner:

(1) Maintain the pool level at elevation 1108.8 (10 feet below spillway crest).

(2) Visually monitor the two areas along the toe of the dam and the three wet areas located further downstream.

(3) Provide round-the-clock surveillance of Deep Hollow Dam during periods of unusually heavy rains.

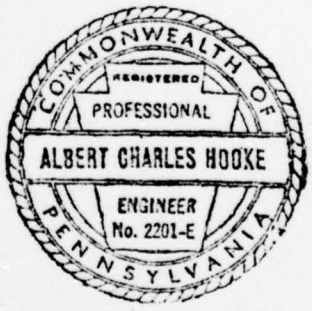
(4) When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system procedures.

Submitted by:

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.

A. C. HOOKE
Head, Dam Section

Date: 19 July 1978

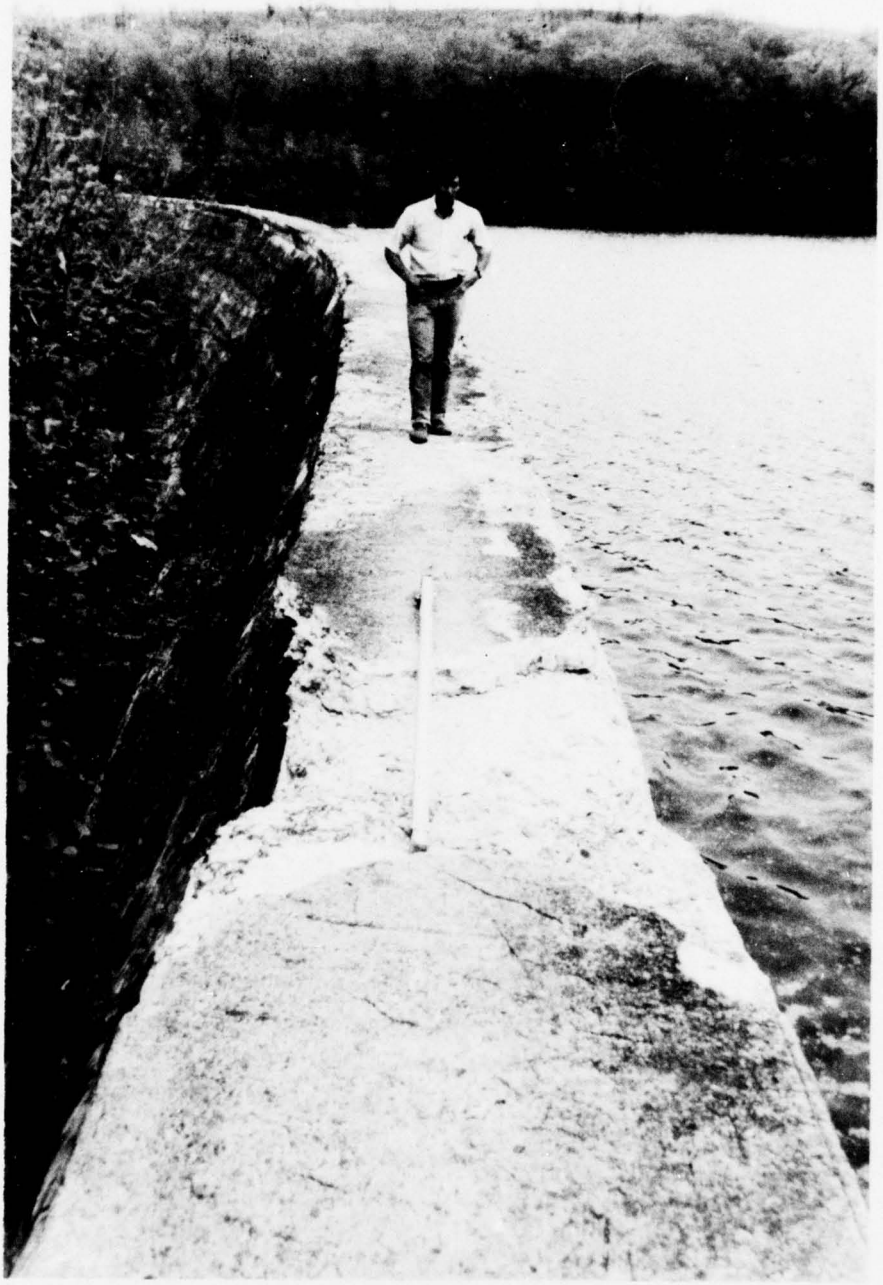


Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS

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

Date: 31 Jul 78



Deep Hollow Dam
Looking from Left Abutment

SUSQUEHANNA RIVER BASIN

DEEP HOLLOW RUN, LUZERNE COUNTY

PENNSYLVANIA

DEEP HOLLOW DAM

NDS ID No. PA-00549
DER ID No. 40-3

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

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. The primary features of Deep Hollow Dam are a curved concrete gravity section, two

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straight concrete gravity sections, a spillway, a concrete gravity retaining wall and an outlet works. The curved concrete gravity section begins at the left abutment and continues across the valley for a distance of about 660 feet. This section has a maximum height of about 45 feet and is curved upstream with a radius of 819 feet. At the right end of the curved section, a low, straight concrete gravity section begins. This section extends downstream for a distance of about 120 feet at a deflection of 57 degrees from the projection of the chord joining the ends of the curved section. At the end of this straight section, a 57-degree deflection to the right is made to tie a final 90-foot long straight section into the hillside adjacent to the Lehigh Valley Railroad. The 32-foot long spillway is located near the center of this final reach. Beginning at the right abutment of the dam, a concrete gravity retaining wall extends upstream along the railroad for a distance of 370 feet. This wall retains the railroad embankment and, with the first straight section of the dam, forms the boundaries of the spillway approach channel. The spillway is a broad-crested weir that is 2 feet lower than the top of dam. The spillway crest is almost flush with the ground surface. The top of the railroad embankment retaining wall is 1 foot higher than the top of the dam. The outlet works consists of two 16-inch diameter-pipes at the base of the dam located near the center of the curved section. A gatehouse at the toe of the dam shelters two 16-inch gate valves for each pipe. Various features of the dam are shown the Plates at the end of the report and on the Photographs in Appendix D.

b. Location. The dam is located on Deep Hollow Run about 0.6 mile upstream its confluence with Mill Creek. Deep Hollow Dam is shown on USGS Quadrangle, Pittston, Pennsylvania, with coordinates N41°15'30" - W75°47'30" in Luzerne County and is about 3 miles east of Wilkes-Barre, Pennsylvania. The location map is shown on Plate 1.

c. Size Classification. Intermediate (45 Feet high, 740 acre-feet).

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

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

f. Purpose of Dam. Emergency water supply for the city of Wilkes-Barre, Pennsylvania.

g. Design and Construction History. Deep Hollow Dam was built in 1907 and 1908 by the Spring Brook Water Supply Company to augment existing water supply. The dam was designed and constructed under the supervision of John Lance, Chief Engineer of Spring Brook Water Supply Company.

In 1914, the Pennsylvania Water Supply Commission performed hydrologic, hydraulic, and stability analyses for the dam. The Commission concluded that the dam was satisfactory in design and performance.

Records of inspections performed by the Pennsylvania Water Supply Commission from 1914 to 1929 indicate that the concrete underwent a progressive deterioration in that period and that leakage through the dam became considerable. In 1929, the Commission recommended to the Scranton Spring Brook Water Service Company that plans be made for repairing the dam. Repairs were proposed by the Scranton Spring Brook Water Service Company to be accomplished in 1933, which satisfied the Commission. In 1933, a 1-year extension for making the repairs was granted. In 1935, Thomas H. Wiggin, Consulting Engineer, prepared a report outlining the proposed repairs for Deep Hollow Dam. The proposed repairs were to be performed in two stages. The first stage consisted of grouting the construction joints to eliminate leakage. The second stage involved a program for major rehabilitation of the dam. The proposed plan of repairs was approved in 1935.

In 1935, the first stage repairs were made. About 420 holes were drilled and groute ed in the top 14 feet of the dam. Reports indicate that leakage through the dam was reduced considerably.

In September 1942, the Scranton-Spring Brook Water Service Company received bids to perform the second stage repair work, and a permit for the work was issued by the Pennsylvania Water and Power Resources Board in October of that year. Details of this second stage repair work are shown on Plate 3. In 1943, before any work was undertaken, the Contractor refused to do the work, and an extension for completion of the work was granted by the Commonwealth authorities.

The only information available for the period from 1944 to the present is correspondence indicating that the second stage repairs were never made, and, ap-

parently, that the water level has been maintained at a level about 10 feet lower than the spillway crest since 1944. In 1964, the Pennsylvania Gas and Water Company indicated to Commonwealth authorities that there were no immediate plans for reconstruction of the dam.

h. Normal Operational Procedure. The water level in the reservoir of Deep Hollow Dam is normally kept about 10 feet below spillway crest. The pool level is maintained by the two 16-inch diameter pipes discharging excess inflow into the channel downstream from the dam. Water in the channel travels downstream to a canal located about 1,700 feet from the dam. This canal, which also is fed from a small diversion structure on Mill Creek, carries the water to Laurel Run No. 2 Reservoir. This reservoir stores the water for emergency purposes. The Owner said that water for distribution is withdrawn from Laurel Run No. 2 Reservoir only on an average of about twice a year. A control structure is located in the canal where Deep Hollow Run feeds the canal. During periods of high outflow from Deep Hollow Dam, the control structure would allow excess water to overflow and continue along the natural stream channel to the confluence of Mill Creek.

1.3 Pertinent Data.

a. Drainage Area. 0.9 square mile.

b. Discharge at Damsite. (cfs.)

Maximum known flood at damsite - unknown.
Emergency drawdown line at maximum pool elevation - 75 (approximate).
Spillway capacity - 260

c. Elevation. (Feet above msl.)

Top of dam - 1120.8.
Maximum pool - 1120.8.
Normal pool (10 feet below spillway crest)- 1108.8.
Spillway crest- 1118.8.
Upstream intake invert outlet works - 1078.8.
Downstream invert outlet works - 1078.8.
Streambed at centerline of dam - 1079.0 (approximate).
Top of railroad embankment retaining wall - 1121.8.

d. Reservoir Length. (Miles.)

Normal pool - 0.44.
Maximum pool - 0.51.

e. Storage. (Acre-feet.)

Normal pool (10 feet below spillway crest)- 240.
Maximum pool (top of dam)- 740.

f. Reservoir Surface (Acres.)

Normal pool (10 feet below spillway crest)- 38.4.
Maximum pool (top of dam)- 45.

g. Dam.

Type - Concrete gravity arch.

Length - Dam and spillway - 873 feet.
Arch nonoverflow - 660 feet.
Straight nonoverflow - 181 feet.
Spillway - 32 feet.
Railroad embankment retaining wall - 370 feet.

Height - 45 feet.

Top Width - Dam - 4 feet.

Side Slopes - Dam - upstream - vertical.
Downstream - 1V on 0.58H.

Cutoff - Dam penetrates rock 1.5 to 2.0 feet, except for 28-foot long reach.

Grout Curtain - None.

h. Diversion and Regulating Tunnels. None.

i. Spillway.

Type - Broad-crested weir (width 2 feet).

Length of Weir - 32 feet.

Crest Elevation - 1118.8.

Upstream Channel - Mild adverse slope to spillway crest. Channel unlined. Bounded on left by dam and on right by railroad embankment retaining wall.

Downstream Channel - Steep slope curving to left. Joins outlet works channel 300 feet downstream from dam. Channel unlined.

j. Regulating Outlets.

Type - Two 16-inch diameter cast-iron pipes on 4.75-foot centers.

Length - 71 feet.

Access - None.

Regulating Facilities - Two manually operated nonrising stem 16-inch gate valves with exposed 3 to 1 gear reducers for each pipe in gatehouse at toe of dam.

SECTION 2

ENGINEERING DATA

2.1 Design.

a. Data Available. Very little engineering data was available for review for the original structures. In a study performed in 1914 by the Pennsylvania Water Supply Commission, an account of design concepts, geology, construction and design features was prepared for the structures from interviews with the Owner and by visual inspection. The 1914 study also included analyses of hydrology, hydraulics, and stability of the principal features.

b. Design Features. The primary features of Deep Hollow Dam are a curved concrete gravity section, two straight concrete gravity sections, a spillway, a concrete gravity retaining wall, and an outlet works. The locations of the various features of the project are shown on Plate 2. A discussion on geology is presented in Appendix E.

The curve concrete gravity section begins at the left abutment and continues across the valley for a distance of about 660 feet. The section is curved upstream with a radius of 819 feet. The right end of the curved section is about 100 feet from the right hillside. The top width of the curved concrete gravity section is 4 feet, and the maximum height is about 45 feet. The top of the dam is at Elevation 1120.8. The upstream face is vertical, and the downstream face is vertical for 2 feet and then has a slope of 1V on 0.58H. According to available information, the curved portion of the dam is founded completely on a conglomerate rock except for a 28-foot long reach located 73 feet from the right end. This 28-foot reach is founded on stiff clay. The foundation level for the curved section varies from 2 to 13 feet below original ground, and it is into rock for an average depth of 1.5 feet. A profile along the axis of the curved gravity section is shown on Plate 4.

At the right end of the curved concrete gravity section is a monolith that is 8 feet square at its top. The first straight section of the dam meets the curved portion of the dam at this monolith. The first straight section extends downstream for a distance of about 120 feet at a deflection angle of 57 degrees from the projection of

the chord joining the ends of the curved section. The section has the same geometry as the curved section, and it rests entirely on a rock foundation. The maximum exposed height of this section is about 7 feet.

At the end of the first straight section, a 57-degree deflection angle to the right is made to tie a final 90-foot long straight section into the right hillside. This section is similar to the other sections, but its maximum exposed height is only about 2 feet. The 32-foot long spillway is located near the center of this section.

At the location where the second straight section ties into the right hillside, a concrete gravity retaining wall begins and extends upstream for a distance of 370 feet. This wall is 1 foot higher than the top of the dam, and it retains an adjacent railroad embankment. The retaining wall has a top width of 2 feet, a vertical back face and an inclined front face with a slope of 1V on 0.33H. It has a maximum exposed height of 11 feet and is founded on rock.

The spillway is 32 feet long and has a 2-foot wide crest that is at the original ground level. The crest is 2 feet lower than the top of the dam. The spillway approach channel has a gentle adverse slope, and it is bounded on the left by the first straight section of the dam and on the right by the railroad embankment retaining wall. The spillway outlet channel is steep and curves to the left. It meets the main stream channel about 300 feet downstream from the dam.

The outlet works is located near the center of the curved section of the dam and consists of two 16-inch diameter cast-iron pipes through the base of the dam. Control facilities are two 16-inch gate valves for each line located in a gatehouse near the toe of the dam. The inlet ends of the pipes extend 18 feet upstream from the heel of the dam. Available information indicates that the pipes are encased in concrete from their inlet ends to the gatehouse. The 16-inch lines discharge into a small outlet channel. The outlet channel is founded on rock and has low concrete training walls on each side.

2.2 Construction.

a. Data Available. Construction data available for review for the original structures was limited to infor-

mation contained in the 1914 report prepared by the Pennsylvania Water Supply Commission. That information was obtained by interviews with the Owner, and it gives details of some of the construction operations.

b. Construction Considerations. Information contained in the 1914 report by the Pennsylvania Water Supply Commission indicates that the quality of the foundation rock was excellent, and that joints in the rock were cleaned and filled prior to placing concrete. However, there were no investigations to determine the character of underlying strata. Near the right end of the curved section of the dam, a rock foundation was not reached and a 28-foot long section of the dam was founded on clay. In this reach, the foundation is from 12 to 15 feet below the origional ground surface.

The 1914 report also indicates that the aggregate for the concrete was obtained by crushing sandstone quarried from the hillside above the left abutment. They also reported from visual inspection that proper care had not been exercised in making construction joints. This was apparently in the upper 10 feet of the structure which, in later years, leaked badly enough to warrant the present drawdown. No joint leakage was found with the existing pool.

2.3 Operation. No formal records of operation were available for review. However, inspection reports and correspondence provided information on the performance of the dam. Throughout the period of its life when the water level in the dam was maintained at spillway crest level, the dam suffered from considerable leakage in the upper section and concrete disintegration. Construction was completed in 1908 and by 1914 leakage through the upper construction joints was reported. The condition worsened in the following years and repairs were first recommended in 1929. In 1935, measures were taken to reduce the leakage by drilling and grouting the top 14 feet of the dam. Although information indicates that this operation was at least partially successful, no other rehabilitation was ever performed. In anticipation of major repairs in 1944, the reservoir was drawn down. The repairs were not carried through, and, apparently, the reservoir has been kept at a low pool level ever since.

2.4 Other Investigations. Plans and specifications were developed in 1942 to rehabilitate Deep Hollow Dam and to increase the spillway capacity. The actual work was never undertaken. Details of the proposed rehabilitation work are shown on Plate 3.

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 are 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. The general appearance of this project indicated that the project features have deteriorated with age and are in need of repair.

b. Dam.

(1) The concrete of the dam was in various stages of deterioration. About 20 percent of the top of the curved portion of the dam was disintegrated to a 3-inch depth (Photographs C, D, and E). Almost all of the top of the two straight sections of the dam was disintegrated to a depth of about 3 inches (Photographs G and H). In general, about 80 percent of the downstream face of the left half of the dam was scaled to an average depth of 2 inches (Photograph D). The downstream face of the right half of the dam was scaled and disintegrated over most of its surface to an average depth of 10 inches (Photographs C and K). A more detailed description of the condition of the concrete on the downstream face is presented in Appendix B. The exposed portion of the upstream face of the dam had deterioration of a more local nature (Photographs A and B). About 10 percent of the exposed surface had scaling, spalling, or disintegration to an average depth of 6 inches. However, some areas were more deteriorated. At the right end of the curved section of the dam, a 25-foot reach was disintegrated to a depth of about 18 inches (Photograph F). In this reach a 2-inch diameter cable that was embedded in the concrete is exposed. The concrete deterioration is generally more advanced at the construction joints, particularly near the top of the dam.

(2) There was no seepage on the downstream face of the dam. The pool level on the date of the inspection was 11.8 feet below the top of the dam.

(3) Five wet areas were observed in the area downstream from the dam. About 200 feet from the left abutment, a small spring emerged at a rock outcrop about 150 feet from the dam. About 325 feet from the left abutment, there was a swampy area from 75 feet to 150 feet downstream from the dam. There was no flow of water, and

the swampy area appeared to be an area of natural runoff concentration. At a low area located about 450 feet from the left abutment, there was soft area located about 120 feet downstream from the dam. A slight, clear flow was observed at this area. About 500 feet from the left abutment, there was a 5-foot diameter wet area located about 20 feet from the toe of the dam. There was no flow of water from the area, and the ground between the wet area and toe of the dam was not abnormally soft. About 600 feet from the left abutment, another 5-foot diameter wet area was located about 30 feet from the toe of the dam. This area is shown on Photograph J. Although no flow of water was observed, the ground between the wet area and the toe of the dam was softer than adjacent areas.

(4) It was observed that the forest begins immediately at the downstream toe of the dam, and that some large vines are growing on the downstream face of the dam.

c. Appurtenant Structures.

(1) The spillway crest is at the original ground level. The concrete on the crest was cracked and uneven, and one section was missing (Photograph H). The spillway approach channel was completely overgrown with 2-inch to 4-inch diameter mixed hard woods (Photographs E, G, H, and I). The spillway discharge channel was irregular and overgrown with heavy forest (Photograph H). The outlet channel was not lined, but several rock outcrops were visible.

(2) The gatehouse had a large hole in the roof that was apparently caused by vandals. The valves in the gatehouse were partially buried in earth and were covered with straw to prevent freezing. The exposed gear reducers were rusted. One of the 16-inch diameter lines was discharging water prior to the inspection. During the inspection, the valve on the other line was fully opened (Photograph L). The valve operated easily and was opened in a few minutes by the caretaker without using the reduction gearing.

(3) The downstream half of the railroad embankment retaining wall had scaling over about 75 percent of its exposed face to an average depth of 2 inches (Photograph I). The upstream half was generally in good condition except that near the upstream end a horizontal construction joint near the top of the wall was weathered to a depth of 4 inches, and about 0.5 inch of differential

movement was measured. Concrete at construction joints was generally more deteriorated than the other areas, and several small trees were growing in the construction joints.

d. Reservoir Area. The slopes adjacent to the reservoir are generally mild and are covered with hardwoods. No evidence was visible of creep, rockslides or landslides. The Owner indicated that sedimentation is not a problem from the standpoint of reduced reservoir capacity. The watershed is owned by the Pennsylvania Gas and Water Company and is undeveloped. At one time an earth lined flume brought additional inflow into the reservoir from another watershed. While it was operable, it increased the effective watershed area by about 0.6 square mile. The flume was abandoned some years ago. The inspection team examined the intake area of the abandoned flume to verify that it no longer contributes any inflow to the reservoir (Photograph M). The intake structure no longer exists and the flume is overgrown with the trees and brush. The Owner also said that at several locations along the flume the sides are broken down and that no inflow could be carried into the reservoir of Deep Hollow Dam.

e. Downstream Channel. There is a short outlet channel for the outlet works. The bottom is bedrock and each side has a low training wall. The outlet channel flows into the natural stream channel. The stream flows through the forest unobstructed.

3.2 Evaluation.

a. Dam.

(1) Based on descriptions of the dam contained in previous inspection reports, it does not appear that the condition of the concrete on this downstream face of the dam has deteriorated greatly since the pool level was lowered in the early 1940's. For example, the inspection report filed in 1941 indicates that peeling off about 1 foot of the downstream surface would produce a sound concrete surface. Similarly, a report in 1934 indicates disintegration on the downstream face had occurred to a maximum depth of 9 inches. During this study the greatest average disintegration over a large area was estimated to be about 10 inches. The previous inspection reports indicate that the active period of disintegration of the downstream face corresponds to the period when the reservoir was maintained at the spillway crest and when the upper level of the dam was leaking. Apparently, when the upper level of the

dam was grouted and the pool was lowered, and leaking ceased and the rate of disintegration decreased substantially. It is reasonable to assume that the condition of the downstream face has resulted primarily from freeze-thaw cycles during the period of leakage. Consequently, it appears that the situation has been nearly stable for about the last 35 years. The condition of the upstream face is less certain because only the top one-fourth of the surface could be examined. A report in 1942 indicates that a visual inspection of the upstream face was made when the reservoir was drawn down and that the concrete was disintegrated at all of the construction joints. However, in this inspection, no leakage was observed anywhere on the downstream surface. Based on the visual inspection and previous inspection reports, it appears that deterioration of the concrete is continuing but at a slow rate. Poorly made construction joints near the top of the dam have apparently been the root of most of the problems that have been experienced. The concrete at some of these joints has deteriorated to the extent that there might be some blocks of concrete near the top of the dam that are separated from the bulk of the dam by cracks. However, the lack of leakage, uniform horizontal and vertical alignment, and lack of cracks indicates that the structural integrity of most of most of the dam has probably been maintained.

(2) Of the five areas that were observed, only the two closest to the dam are considered to be of general concern. The others are situated at locations that indicate probable sources of water other than flow under the dam. Of the two wet areas closest to the dam, the one of greater concern is the one located about 600 feet from the left abutment. Although no flow of water was observed, the ground between this wet area and the toe of the dam was softer than adjacent areas. The location of this wet area corresponds to the location where the foundation of the dam is reported to be founded on clay.

(3) The growth of trees along downstream toe of the dam is undesirable. Roots from trees have been known to cause problems along the foundations of structures. The vines growing on the downstream face of the dam will probably accelerate local disintegration of the concrete.

b. Appurtenant Structures

(1) The spillway approach channel is overgrown to the extent it would probably reduce the capacity of the spillway. Though unlined, the outlet channel has rock outcrops nearby that indicate that little erosion

would result from spillway discharge. The spillway itself is such a minor structure that it has little overall importance to the dam as a whole.

(2) The hole in the roof of the gatehouse could allow access for vandals to the valve operating mechanisms. The valves are apparently operated regularly to maintain the pool level. The rust on the exposed gear reducers is undesirable.

(3) The condition of the railroad embankment retaining wall is not very significant. It has not yet deteriorated to the extent of being considered unsatisfactory, but some maintenance is needed. Continued growth of the trees in the construction joints will cause accelerated deterioration.

c. Reservoir Area. No conditions were observed in the reservoir area that might present significant hazard to the dam.

d. Downstream Channel. No conditions were observed in the downstream channel that might present significant hazard to the dam. Additional discussion on downstream conditions is presented in Paragraph 5.1e..

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedure. As far as could be determined from available information, the water level in the reservoir has been maintained at approximately Elevation 1108.8 since 1944. This is 10 feet below spillway crest level. The reservoir has been maintained at this level because a proposed rehabilitation of the dam in 1942 was never undertaken. The pool level is maintained by withdrawing excess inflow through two 16-inch diameter cast-iron pipes at Elevation 1078.8 that discharge into a small outlet channel near the toe of the dam. Flow through the cast-iron pipes is regulated by valves located in a gatehouse at the toe of the dam. Each pipe has two 16-inch gate valves. The upstream valve on each line is normally open, and the downstream valve is used to regulate flow. The caretaker visits the dam daily and checks the reservoir level. Unless otherwise directed by the Owner's Engineering Department, the caretaker adjusts the valves according to his judgement so that the normal pool elevation is maintained. The caretaker has been on the job for 36 years. Outflow from the dam travels down the natural stream channel to a canal located about 1,700 feet downstream from the dam. This canal is fed by the outflow from Deep Hollow Dam and also by a small diversion structure located on Mill Creek. The canal carries the water to Laurel Run No. 2 Reservoir, which stores the water for emergency purposes. The Owner said that water in this reservoir is withdrawn for distribution only on an average of twice a year. During periods of high outflow from Deep Hollow Dam, a control structure that is located along the canal where Deep Hollow Run enters it allows any excess water to spill back into the natural stream channel. The excess water then continues downstream to the confluence of Mill Creek.

4.2 Maintenance of Dam. The dam is visited daily by a caretaker who checks the water level in the reservoir and adjusts the valves as he deems necessary in order to maintain the normal pool level. He reports the water level each day to the Owner's Engineering Department, and he makes a written weekly report. The caretaker is also responsible for observing the general condition of the dam and reporting any unusual conditions. No maintenance work is performed

on the dam or appurtenant structures. A Pennsylvania Gas and Water Company engineer makes a formal inspection of the dam each year, and the records are kept on file.

4.3 Maintenance of Operating Facilities. There is no known regular maintenance program for the operating facilities. Maintenance of valves and discharge channel is apparently performed as deemed necessary.

4.4 Warning Systems in Effect. The Owner furnished the inspection team with a chain of command diagram for Deep Hollow Dam and a generalized emergency notification list that is applicable for all 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 located in Wilkes-Barre. However, the caretaker uses a privately owned vehicle that is not equipped with a radio. 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 Deep Hollow Dam, but are as directed by the Owner's Engineering Department.

4.5 Evaluation. As discussed in Section 3, the operational procedure that is used appears to have nearly stabilized the condition of the concrete in the dam, and its present rate of deterioration appears to be slow. However, maintenance of the dam has been almost nonexistent since about 1935. As a short term solution, the operation and inspection procedures are considered satisfactory because the reservoir level is normally kept at a level about 25 percent lower than the design level and because the condition of the dam is checked at regular intervals. However, the combined operation and maintenance procedures presently used are not satisfactory for long term operation of the dam. Neglect of needed maintenance causes accelerated deterioration of structures and encourages development of potentially hazardous conditions. In general, the warning system is adequate, but it is not in sufficient detail for Deep Hollow Dam when its overall condition is considered.

SECTION 5

HYDROLOGY AND HYDRAULICS

5.1 Evaluation of Features.

a. Design Data.

(1) No hydrologic or hydraulic analyses for the original Deep Hollow Dam design were available for review. In the 1914 report by the Pennsylvania Water Supply Commission the spillway capacity was reported to be 235 cfs, but no back-up computations were available for review.

(2) In the recommended guidelines for safety inspection 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 (intermediate) and hazard potential (high) classification of Deep Hollow Dam is the Probable Maximum Flood (PMF). If the dam and spillway are not capable of passing the PMF without overtopping 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 downstream 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) The Deep Hollow Run watershed is owned by the Pennsylvania Gas and Water Company and is undeveloped. Hydrologic analysis for this study was based on existing conditions and the effects of future development of the watershed were not considered.

b. Experience Data. For this report, a PMF peak flow previously calculated for a potential reservoir site

on Fall Brook was transposed to the Deep Hollow Run watershed. The PMF peak flow was estimated to be 2,860 cfs at Deep Hollow Dam. The spillway capacity was estimated for this study at 260 cfs. These computations are included in Appendix C.

c. Visual Observations.

(1) The spillway approach channel is an unlined earth channel excavated near the right abutment of the dam. It is bounded on the left by the straight concrete gravity section of the dam and on the right by a concrete retaining wall for the Lehigh Valley Railroad embankment. Between the retaining wall and the dam, the spillway approach channel is overgrown with dense brush and 2 to 4-inch saplings. The spillway outlet channel is also overgrown. Photographs G and H show the extent of the growth. These conditions would have the effect of reducing the spillway capacity to some extent. However, for this study the spillway capacity was determined as if the approach and outlet channels were cleared.

(2) As originally constructed, water was diverted into Deep Hollow Reservoir from an adjacent watershed (0.6 square mile) by means of a small intake structure and a flume. The masonry intake structure had washed away and the clay-lined flume is overgrown with brush and small trees. A representative of the Pennsylvania Gas and Water Company informed the inspection team that the flume was also caved in at several locations beyond the intake structure. Therefore, the flume no longer can convey any inflow into Deep Hollow Reservoir. Photograph M shows the intake area of the flume.

d. Overtopping Potential. For an occurrence of the PMF, the peak inflow of 2,860 cfs is greater than the spillway capacity of Deep Hollow Dam. A check of the surcharge storage effect of Deep Hollow Reservoir shows that the surcharge storage available is insufficient to contain an inflow with a peak flow of 2,860 cfs without overtopping the dam (Appendix C.). Calculations indicate that the dam would be overtopped by about 0.6 foot of water by a PMF inflow.

e. Downstream Conditions. A plan of the area downstream from Deep Hollow Dam is shown on Plate 1. About 0.1 mile downstream from the dam, the Deep Hollow Run valley is traversed by two 66 kv transmission lines that are owned by the Pennsylvania Power and Light Company. The

lines are strung on wooden poles and could be affected by a failure of Deep Hollow Dam. At a distance of 0.3 mile downstream from the dam, a concrete diversion structure with a weir overflow diverts water to the Laurel Run No. 2 intake of the Pennsylvania Gas and Water Company. Large discharges would overtop the diversion structure and flow down the Deep Hollow Run valley to the confluence of Mill Creek, 0.7 mile downstream of the dam. Downstream from the confluence, there is a reach of Mill Creek that flows through an uninhabited, densely wooded valley. Interstate Route 81 crosses Mill Creek 1.7 miles downstream from Deep Hollow Dam, and the stream runs through the embankment in twin box culverts, each of which is 16.5 feet wide, 11.2 feet high and 300 feet long. Downstream from Interstate Route 81, Mill Creek passes under Pennsylvania Route 315. This opening is very large and would pose almost no restriction to flow. The first structure that would be affected by a failure of Deep Hollow Dam is located along Pennsylvania Route 315. The Pocono Downs racetrack facilities are situated just downstream of the Pennsylvania Route 315 bridge, about 2.3 miles downstream from Deep Hollow Dam. Beyond the racetrack, Mill Creek winds through 1.3 miles of strip mines before entering the northeast end of the City of Wilkes-Barre, Pennsylvania. If Deep Hollow Dam failed, the embankment of Interstate Route 81 could decrease or increase the hazard to human life or property. If the Interstate Route 81 embankment did not fail as a result of a failure of Deep Hollow Dam, the hazard to human life and property would decrease. If the Interstate Route 81 embankment did fail as a result of a failure of Deep Hollow Dam, the hazard to human life and property could increase. The mechanics of the interaction between the failure of Deep Hollow Dam and the embankment of Interstate Route 81 are complex and beyond the scope of this study. Therefore, it cannot be assumed that the hazard to human life and property resulting from a failure of Deep Hollow Dam would be reduced by the existence of the highway embankment. Consequently, the downstream conditions indicate that a high hazard classification is warranted for Deep Hollow Dam.

f. Spillway Adequacy.

(1) The spillway of Deep Hollow Dam will not pass the PMF without overtopping the dam by 0.6 foot. One-half of the PMF inflow is 1,430 cfs and is greater than the spillway capacity. A check of the surcharge storage effect of Deep Hollow Reservoir using the reduced pool

level as normal pool elevation shows that the surcharge storage available is sufficient to contain an inflow with a peak flow of 1,430 cfs without overtopping the dam. (Appendix C).

(2) The maximum tailwater is estimated to be Elevation 1082.0 at the spillway capacity of 260 cfs. At maximum pool elevation there is a difference of about 39 feet between headwater and tailwater. If Deep Hollow 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) As discussed in Paragraph 6.1f., it is believed that the dam is capable of passing a flow of 0.6 foot over its entire length with possibly some damage to the disintegrated concrete but not complete failure.

(4) Based on established OCE criteria as outlined in Paragraph 5.1a.(2), the dam and spillway of Deep Hollow Dam are rated as adequate. Considering the effects of the surcharge storage of 500 acre-feet the spillway discharge capacity of 260 cfs can accomodate a flood with a peak inflow of 1,490 cfs for a storm of the same duration as the PMF without any overtopping. This is 52 percent of the PMF peak inflow.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations.

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

(2) Dam. The concrete of the dam was deteriorated. The location and extent of the deteriorated areas of the dam are described in Paragraph 3.1b. and evaluated in Paragraph 3.2a..

b. Design and Construction Data. No records of design data or stability computations for the original structures were available for review. However, a stability analysis for the curved gravity section of the dam was performed in 1914 by the Pennsylvania Water Supply Commission.

The 1914 analysis was reviewed to assess the stability of the curved gravity section of Deep Hollow Dam. This analysis assumed headwater at top of dam, concrete weight of 145 pounds per cubic foot, uplift varying uniformly from zero at the toe to two-thirds of full upstream water pressure at the heel of the dam, and zero tailwater. The results of the analysis were that the resultant is outside the middle third but within the base, about 6 feet from the toe. Toe pressure and resistance to sliding were found to be within acceptable limits. The calculations were reviewed and the results appear to be satisfactory. It should be noted, however, that the concrete is deteriorated to various stages, and if the reduced section were used, the resultant would be located slightly closer to the downstream toe of the section. OCE guidelines on overturning recommend that the resultant be within the middle third of the base. Although the resultant is outside the middle third, it is within the base, and considering that the dam is founded almost entirely on rock and that the toe pressures and resistance to sliding are within acceptable limits, the resultant being outside the middle third is not considered to be a significant deviation from the recommended guidelines.

c. Operating Records. There was no information reviewed that gave any indication that stability problems have occurred for the dam during its operational history. However, the reservoir pool level has been maintained about 10 feet below spillway crest since the early 1940's in accordance with the current permit for Deep Hollow Dam.

d. Post-Construction Changes. No changes have been made to Deep Hollow Dam since construction.

e. Seismic Stability. Deep Hollow 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.

f. Ability to Withstand Overtopping.

(1) Preliminary calculations indicate that Deep Hollow Dam would be overtopped by the PMF by about 0.6 foot over its whole length. A structural analysis was made in this study for the overtopping condition. A tailwater depth of 4 feet was assumed because the shape of the downstream valley would cause a tailwater concentration near the maximum section of the dam. Only the bottom of the curved concrete gravity section was considered, and no allowance was made for any section reduction due to concrete deterioration. The stability analysis based on these assumptions indicates that the toe pressure and sliding factor would be within acceptable limits. The resultant is outside the middle third, but it is located within the base, about 6.5 feet from the toe.

(2) Although the analysis described above indicates that the dam might withstand overtopping by the PMF without failure, there are two additional factors to consider. The first factor is that although the dam is known to be founded upon a hard sound conglomerate rock, there were no investigations of the strata underlying the top of the foundation. It is also known that a 28-foot long reach of the dam, near the right end of the curved section of the dam was founded on stiff clay, 13 to 15 feet below natural ground level. It should also be noted that a soft, wet area was observed downstream from the toe in the vicinity of this reach. At higher pool levels, this could be of concern. The second factor of importance is the condition of the concrete. The concrete at the horizontal and vertical construction joints in the upper 10 feet of the dam is badly weathered to considerable depths, the downstream surface of the dam has deteriorated over large areas to a maximum

average depth of 10 inches, the surface at the top of dam is badly disintegrated, and the condition of most of the upstream face is unknown.

(3) Apparently most of the above conditions were created during the early life of the dam and have not progressed greatly since then. A water level was maintained at spillway crest for 36 years with leakage problems in the upper areas of the dam, but no other concern. If the dam were structurally rehabilitated, no concern would be felt for several feet of overtopping. Even in its present condition, it is believed to be capable of passing a flow of 0.6 foot over its entire length with possibly some damage to the disintegrated concrete, but no complete failure.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety.

(1) Based on the visual inspection, available records, calculations and past operational performance, Deep Hollow 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
Dam:	
Top of dam	Disintegration over 20 percent of area to average depth of 3 inches.
Downstream face	Scaling and disintegration over 80 percent of area; average depth left half of dam is 2 inches; average depth right half of dam is 10 inches.
Upstream face	Scaling, Spalling, and disintegration over 10 percent of exposed area to average depth of 6 inches.
Spillway:	
Crest	Uneven, cracked, one section missing.
Approach channel	Overgrown.
Outlet channel	Irregular and overgrown.
Outlet Works:	
Gatehouse	Hole in roof

Feature and Location	Observed Deficiencies
Exposed gears	Rusted.
Retaining Wall:	
Downstream half	Scaling over 75 percent of area to average depth of 2 inches.
Upstream end	Crack at horizontal construction joint with differential movement.
Construction Joints	Small trees growing in joints.

(2) The overtopping potential analysis shows that Deep Hollow Dam will be overtopped by the PMF, but not by one-half the PMF provided that the reduced pool level is taken as normal pool elevation. Computations indicate that the PMF inflow would overtop the concrete nonoverflow by 0.6 foot. Although the dam has a number of structural deficiencies, it is believed to be improbable that overtopping to the extent indicated would result in complete failure of this concrete gravity arch dam. Based on OCE criteria, as outlined in Paragraph 5.1a.(2), the dam and spillway are rated as adequate. The existing spillway, combined with the available storage from maintaining a reduced pool level, can accommodate a flood with a peak inflow of 52 percent of the PMF peak inflow without any overtopping.

(3) Review of the 1914 stability computations for the dam indicates that for the condition of maximum loading before overtopping, the resultant is slightly outside the middle third of the base, but the factor of safety for sliding and the toe pressure are within acceptable limits.

(4) There are two factors that could affect the structural stability of the dam and its ability to resist maximum loading and some overtopping. One factor is the foundation condition under the 28 feet of structure that is founded on stiff clay as well as a general idea as to the thickness of the conglomerate that the rest of the dam is resting upon. The other factor is the deteriorated condition of the concrete. If the questions relative to the foundation are resolved and necessary remedial work performed, and the concrete structurally

rehabilitated, it would be immaterial as to whether the spillway is enlarged or the PMF flow allowed to overtop the entire dam.

b. Adequacy of Information. The information available is such that an assessment of the condition of the dam can be inferred from the combination of visual inspection, past performance, and computations performed prior to and as part of this study.

c. Urgency. The recommendations in Paragraph 7.2 should be implemented as noted herein.

d. Necessity 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 order to reduce existing hazards for Deep Hollow Dam in the immediate future 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 Deep Hollow Dam.

(2) Clear the spillway approach channel.

(3) In order to reduce the risk of failure at high pool levels or during overtopping, the Owner should investigate the foundation conditions where the dam is founded on soil, and design and implement proper remedial measures that are found necessary to prevent potential piping of the foundation materials and erosion by overflow.

(4) Repair roof in gatehouse.

b. To ensure the satisfactory long-term condition of the dam, the Owner should perform additional studies to more accurately ascertain the discharge capacity required for Deep Hollow Dam and he should study alternates and develop a plan for rehabilitation of the project. Continued lack of maintenance and repair will accelerate the development of more potentially hazardous conditions. The study should include determination of foundation conditions, condition of concrete in the dam, and extent of remedial measures required to make the dam hydraulically and structurally adequate under maximum loading conditions.

c. Before remedial work for rehabilitating the project is complete, the following measures are recommended to be undertaken by the Owner:

(1) Maintain the pool level at elevation 1108.8 (10 feet below spillway crest).

(2) Visually monitor the two wet areas along the toe of the dam and the three wet areas located further downstream.

(3) Provide round-the-clock surveillance of Deep Hollow Dam during periods of unusually heavy rains.

(4) 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

DEEP HOLLOW RUN, LUZERNE COUNTY

PENNSYLVANIA

DEEP HOLLOW DAM

NDS ID No. PA-00549
DER ID No. 40-3

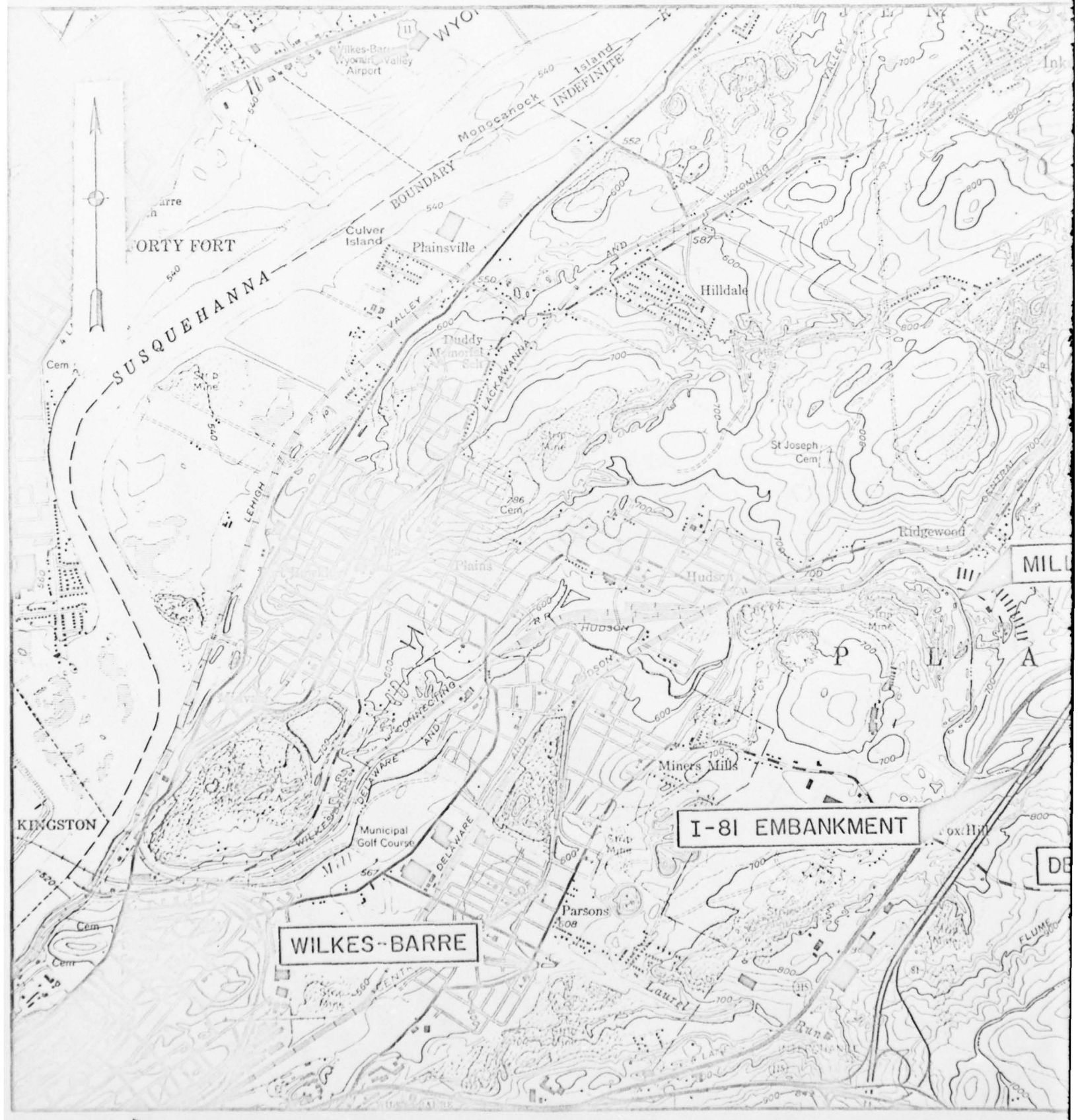
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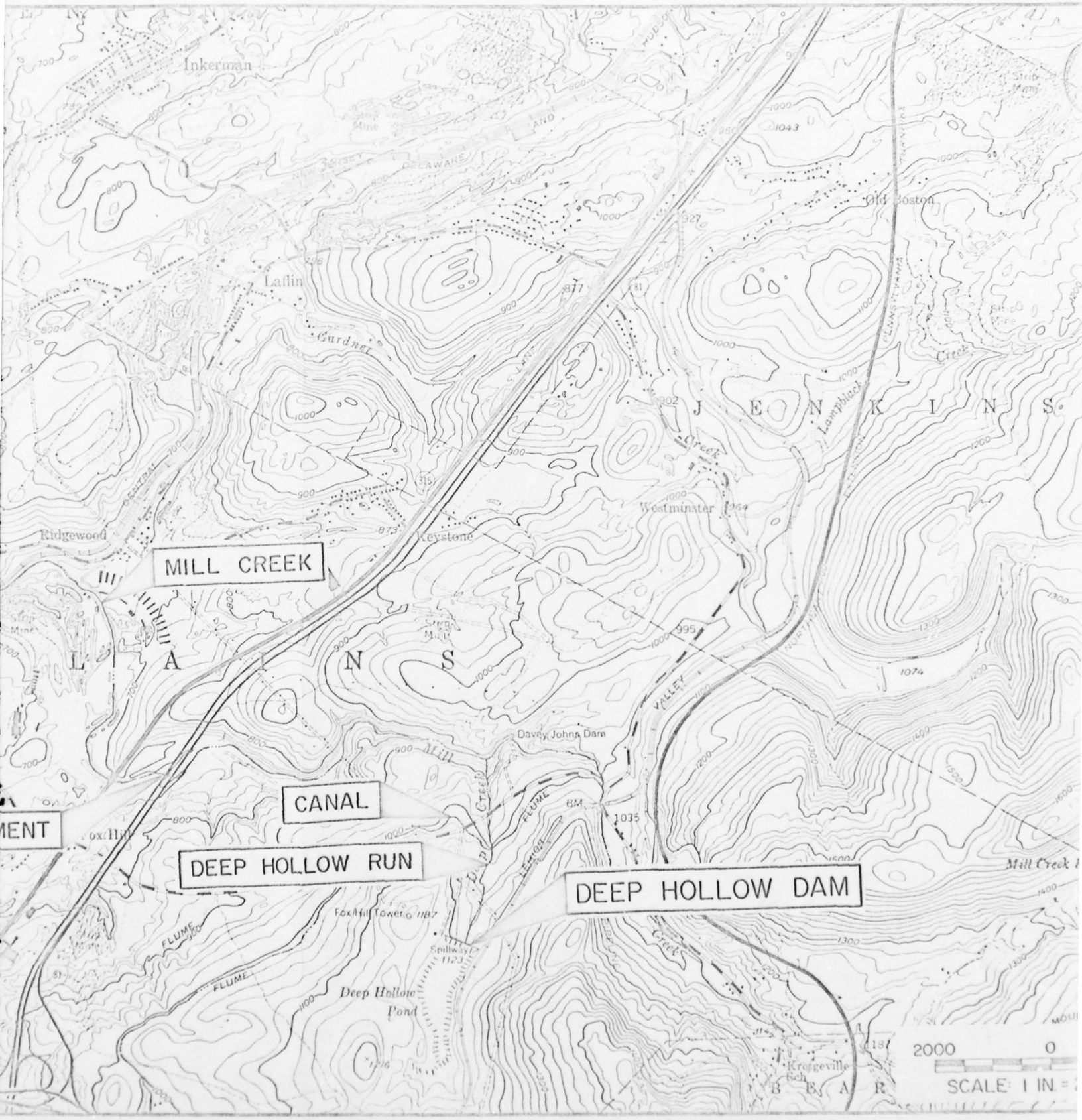
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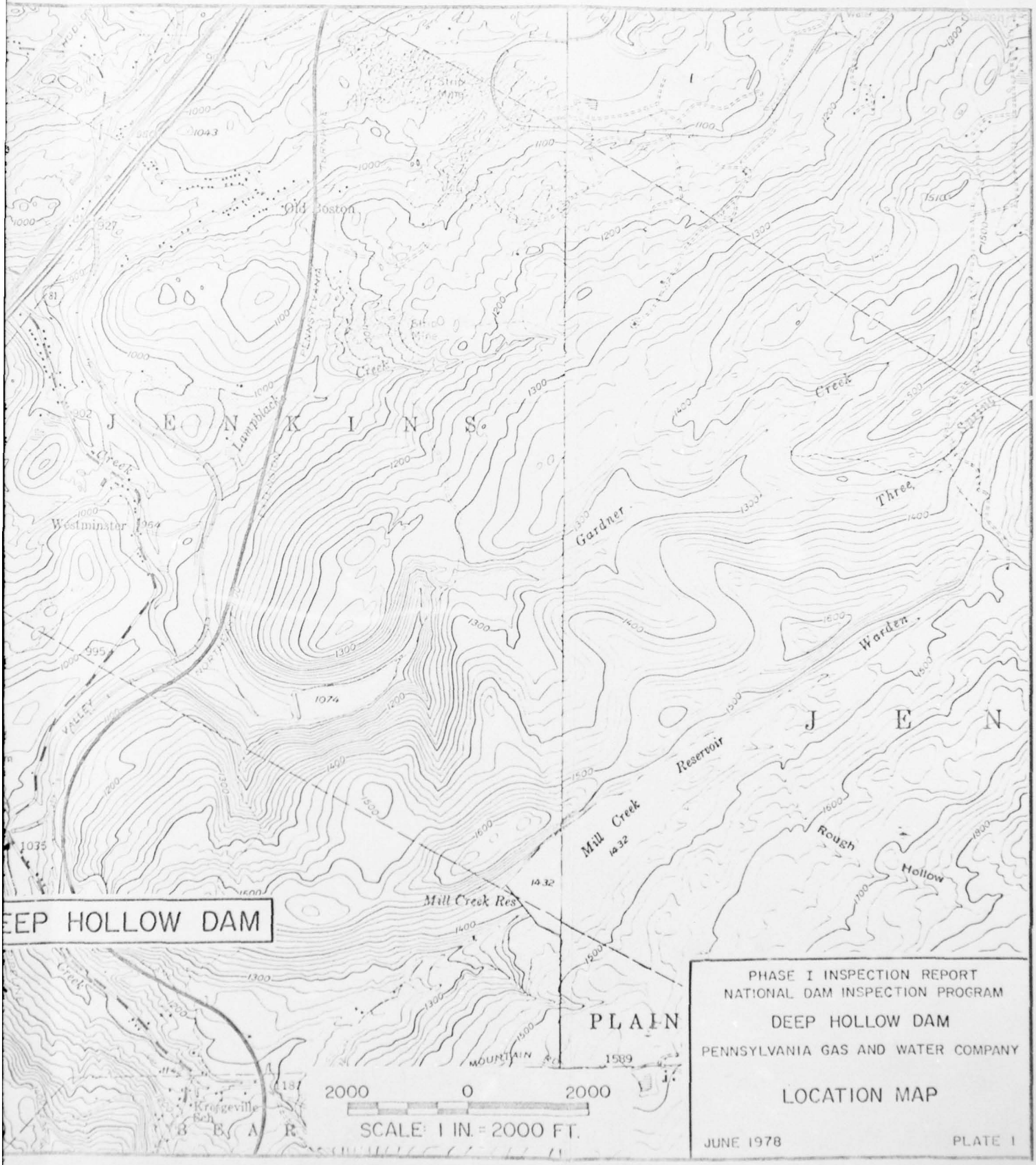
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PLATES


I-81 EMBANKMENT
WILKES-BARRE
KINGSTON
ORTY FORT
Plainsville
Culver Island
Hilldale
Duddy Mountain
Plains
Hudson
Miners Mills
Parsons
Municipal Golf Course
Wilkes-Barre Wyoming Valley Airport
Ridgewood
St Joseph Cem
SUSQUEHANNA
BOUNDARY
Monocanock Island
INDEFINITE
LEHIGH
LACKAWANNA
DELAWARE
WYOMING
VALLEY
HUDSON
CONNECTING
Laurel Run
FLUME


Inkerman
Laflin
Gardner
Ridgewood
Keystone
Westminster
Old Boston
Creek
Lamplack
MILL CREEK
L A N S
J E N K I N S
CANAL
DEEP HOLLOW RUN
DEEP HOLLOW DAM
Davey Johns Dam
Mill
Creek
FLUME
VALLEY
Deep Hollow
Pond
Foxhill Tower
Spillway
1123
Kregeville
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DEEP HOLLOW DAM

PENNSYLVANIA GAS AND WATER COMPANY

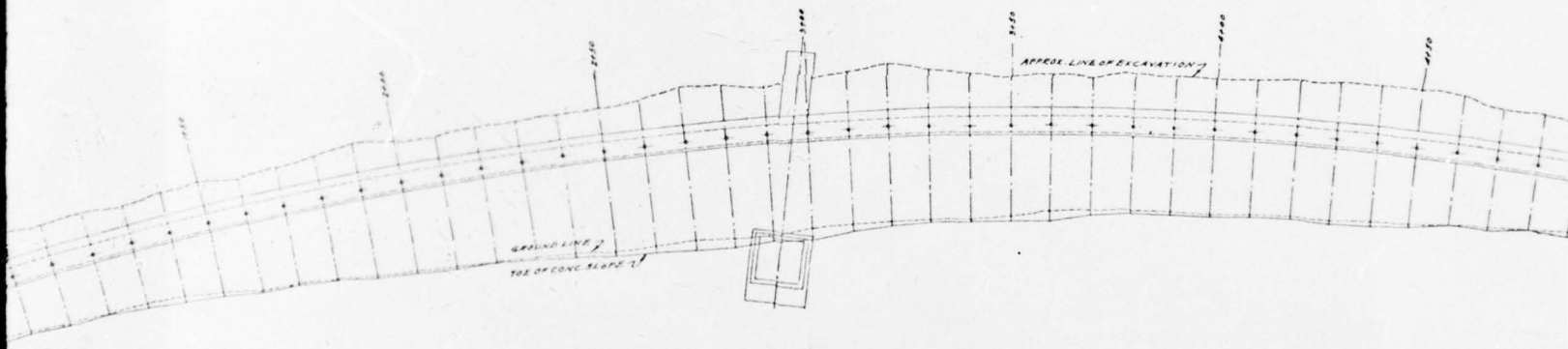
LOCATION MAP

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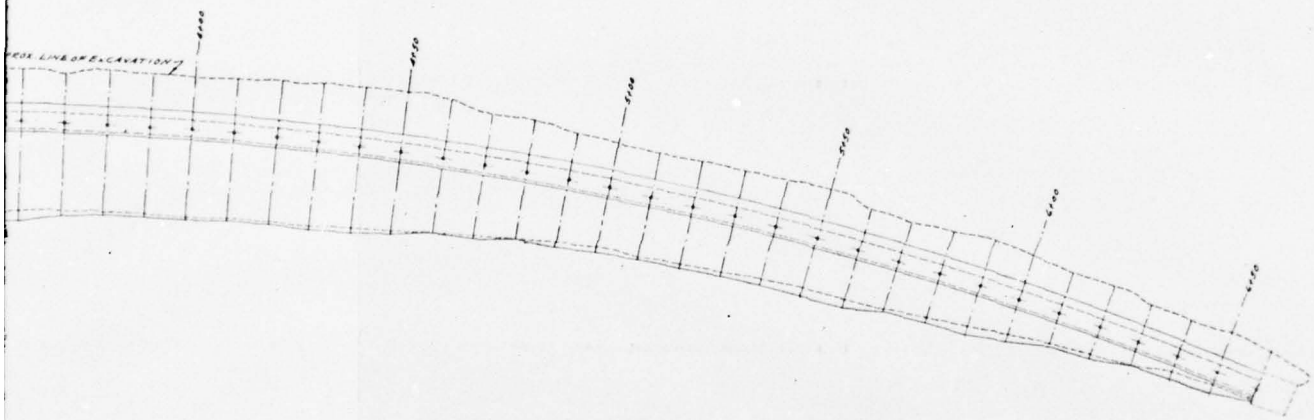
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GENERAL PLAN

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DEEP HOLLOW DAM

PENNSYLVANIA GAS AND WATER COMPANY

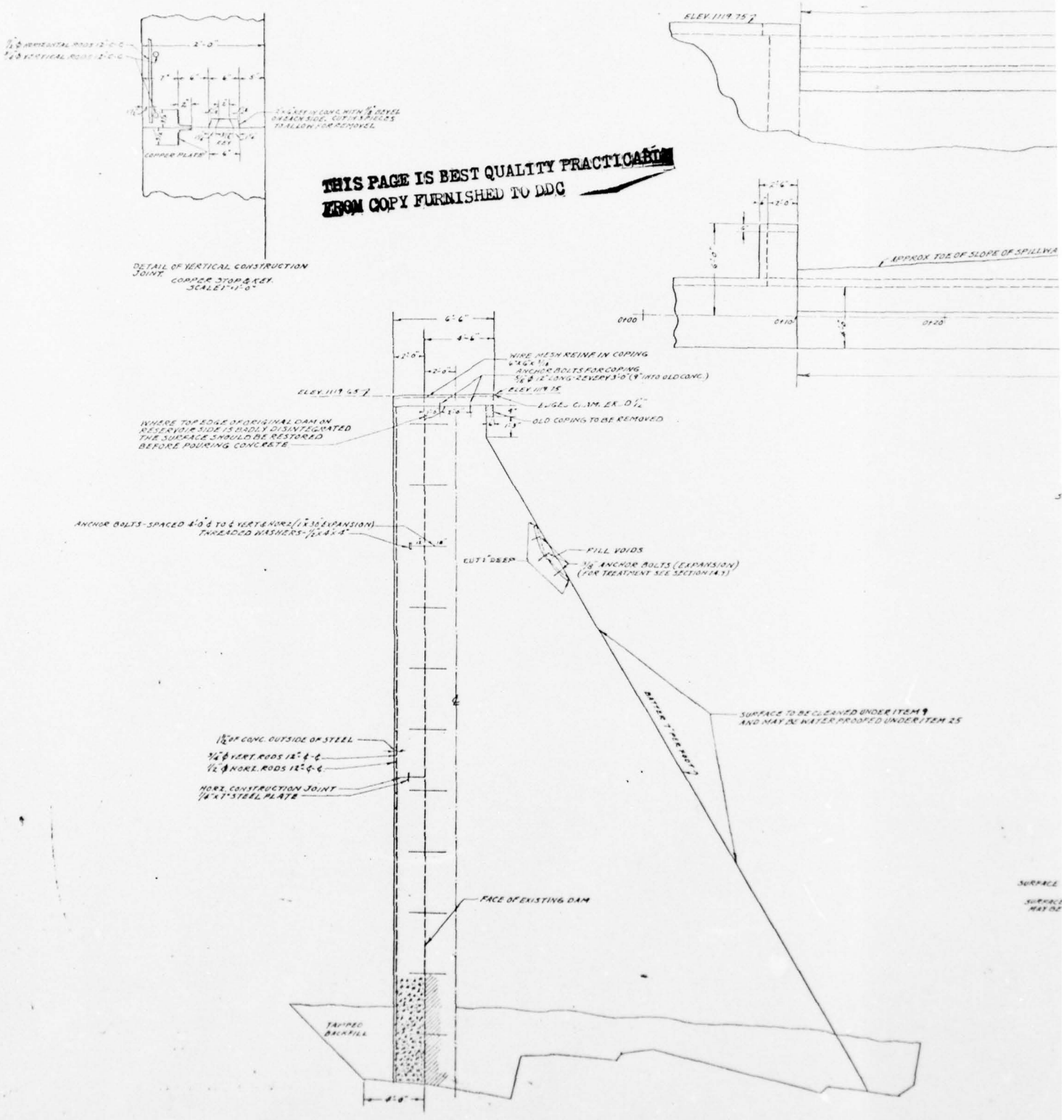
GENERAL PLAN

JUNE 1978 PLATE 2

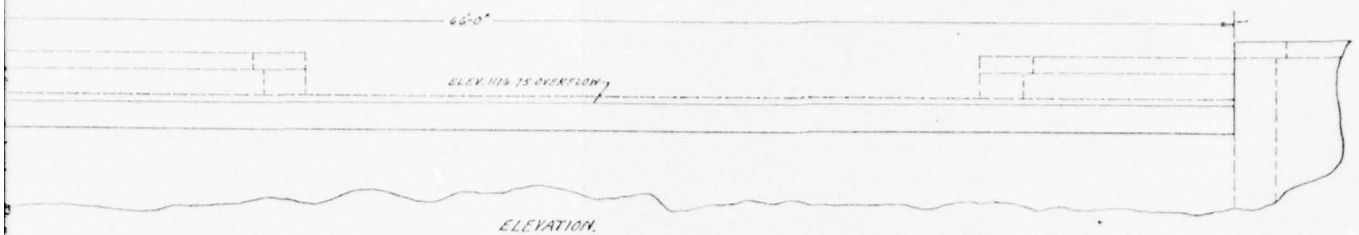
APPROVED:
William T. Barnes
CHIEF ENGR.
Thos. W. Leggin
Pulicani
ENGR.

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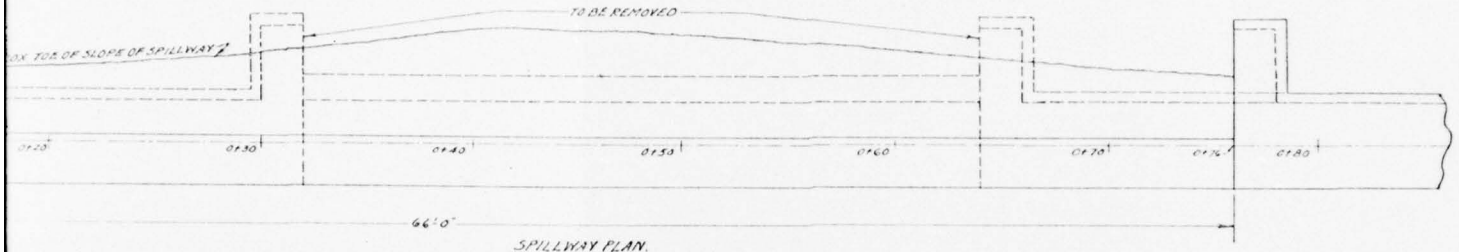
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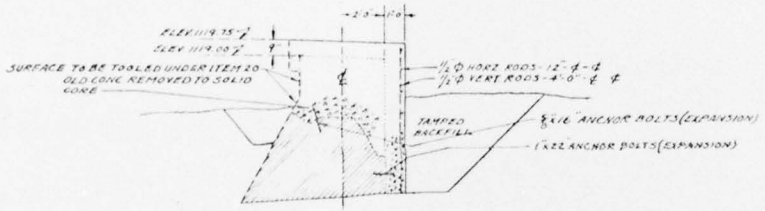
TYPICAL SECT. (STA 2+80) MAIN DAM.



ELEVATION.

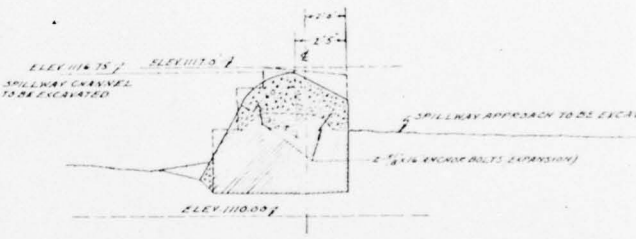


SPILLWAY PLAN.



TYPICAL FOR (0+90 TO 1+11) AND FOR SPILLWAY 10' AT EITHER END OF NEW SPILLWAY.

TYPICAL SECT. (STA 1+10) WING WALL

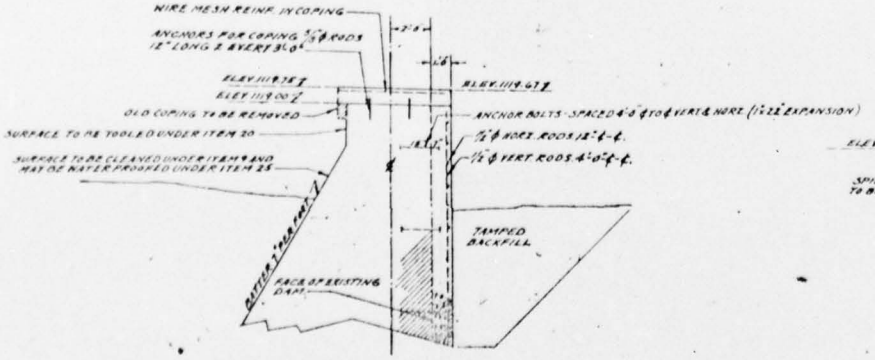


TYPICAL SECT. (STA 0+50) SPILLWAY.

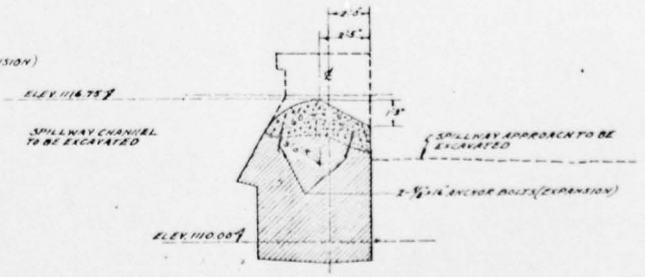
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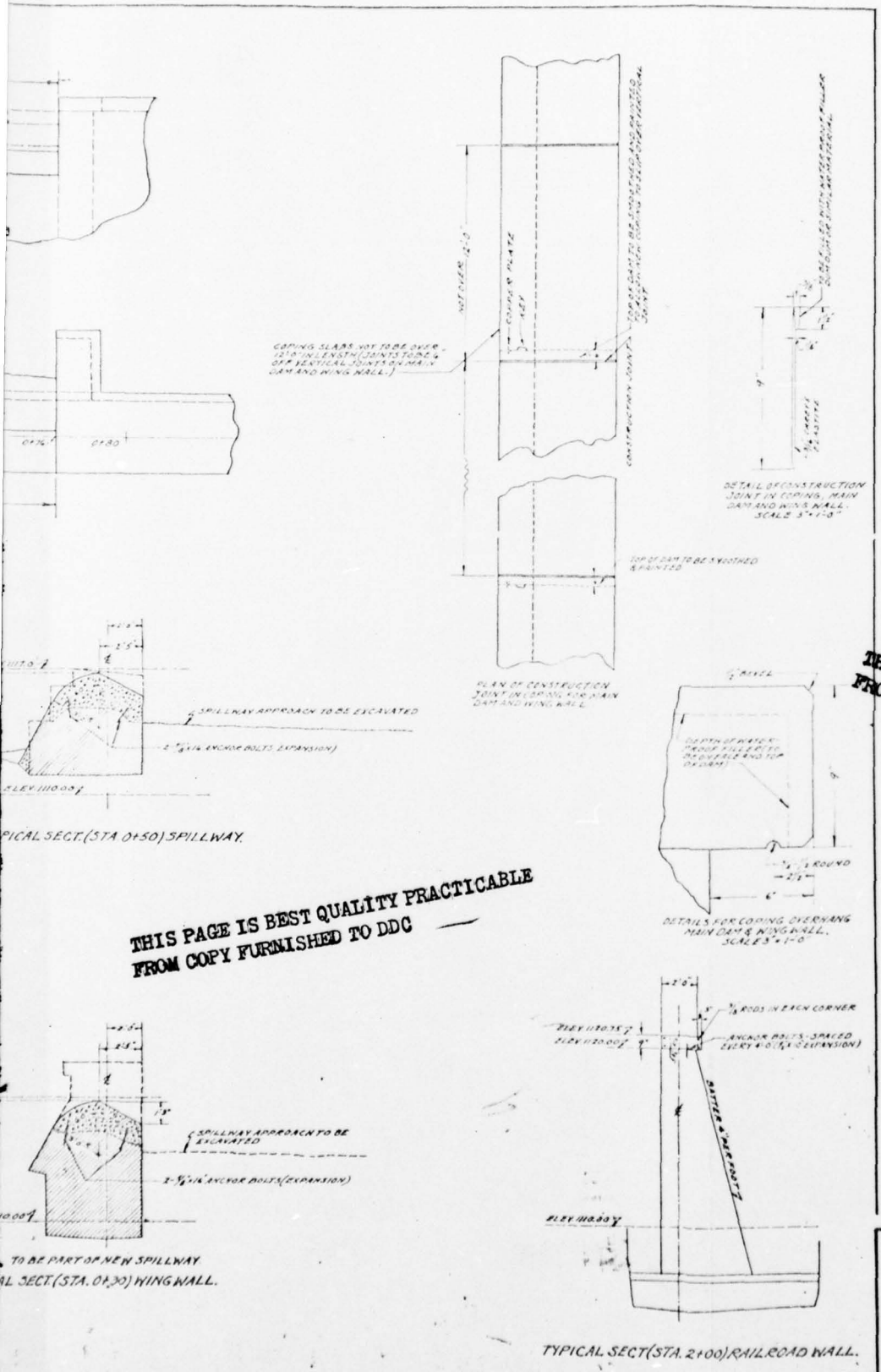


TYPICAL FOR (STA. 0+00 TO 0+90)
TYPICAL SECT. (0+50) WING WALL.



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APPROVED:
CHIEF ENGR.
CONSULTING



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RECONST — HOLLOW DAM
PLAN & ELEVATION — TYPICAL SECTIONS — STRUCTURES
D-211-1

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

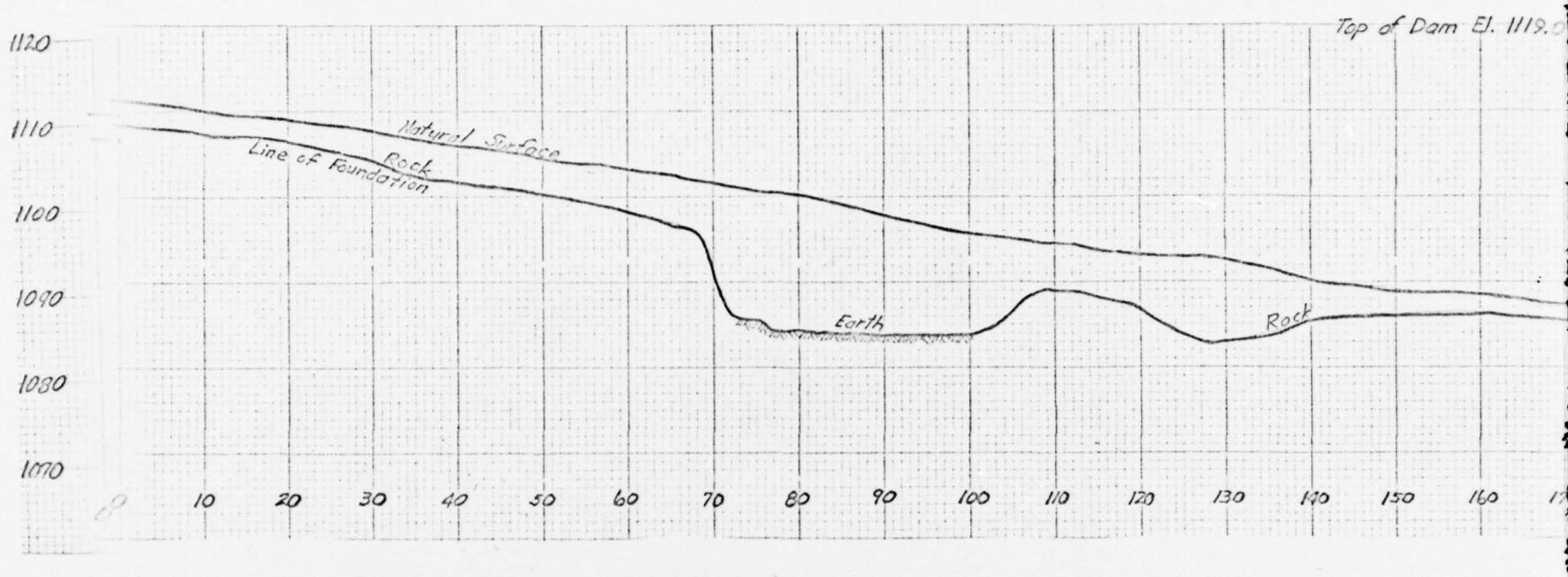
DEEP HOLLOW DAM

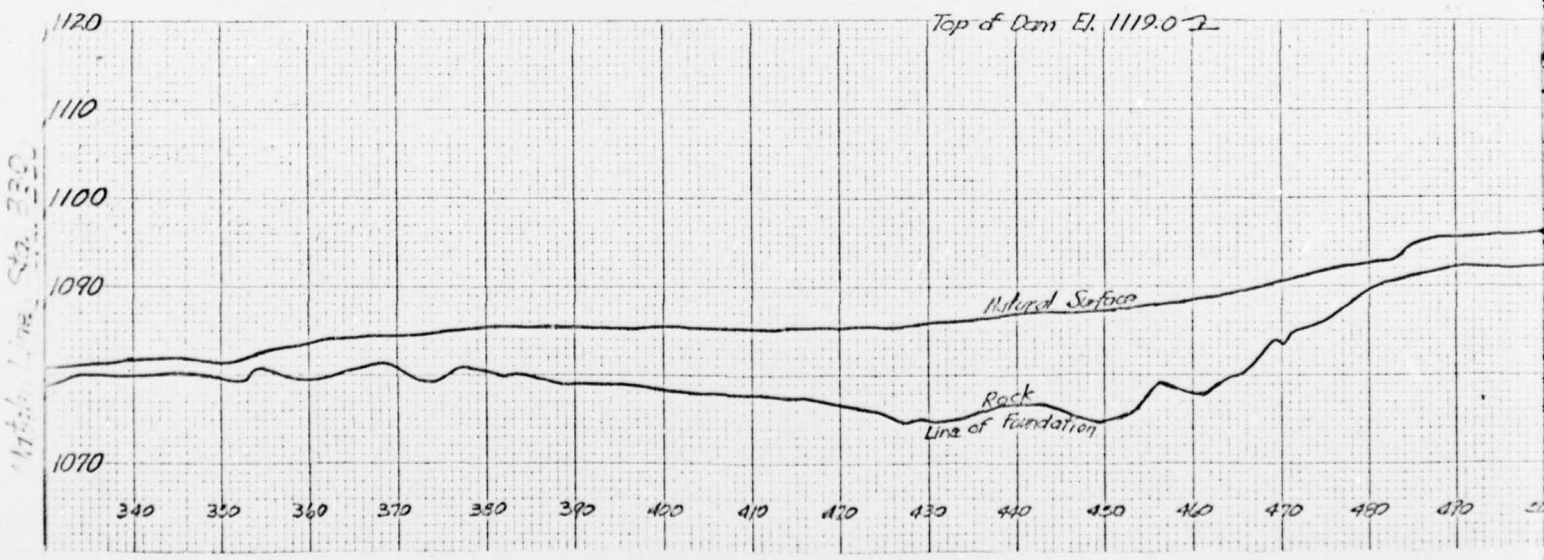
PENNSYLVANIA GAS AND WATER COMPANY

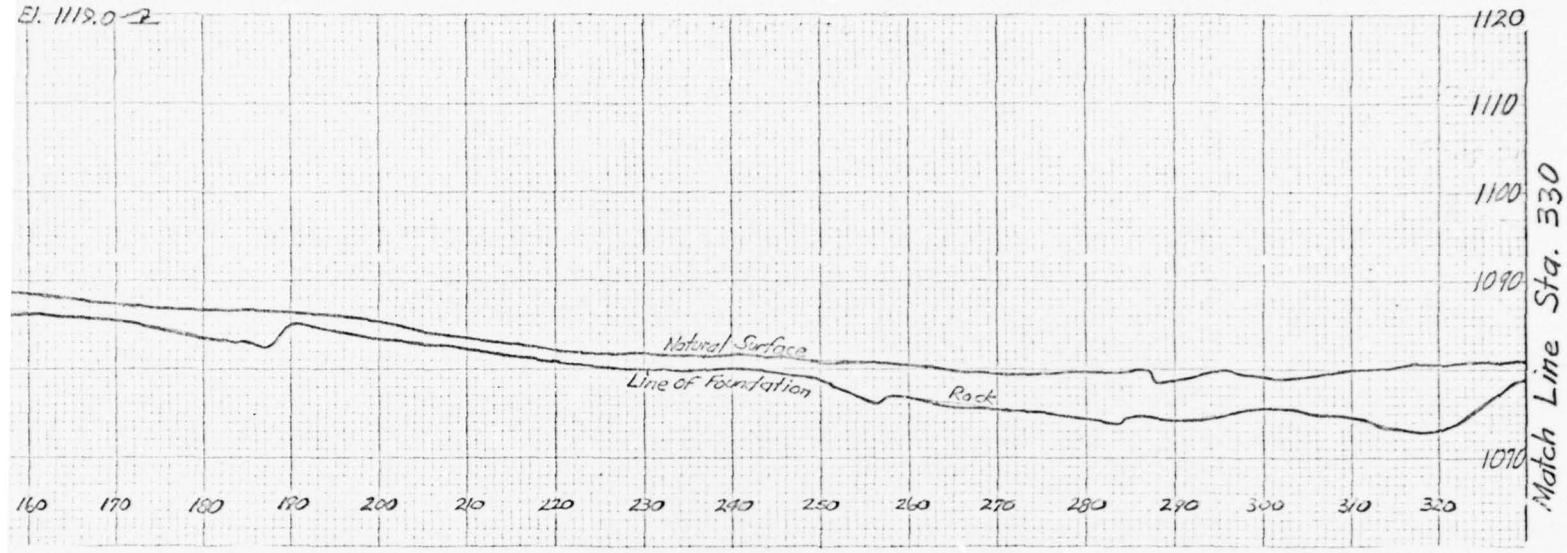
PROPOSED RECONSTRUCTION
(NOT CONSTRUCTED)

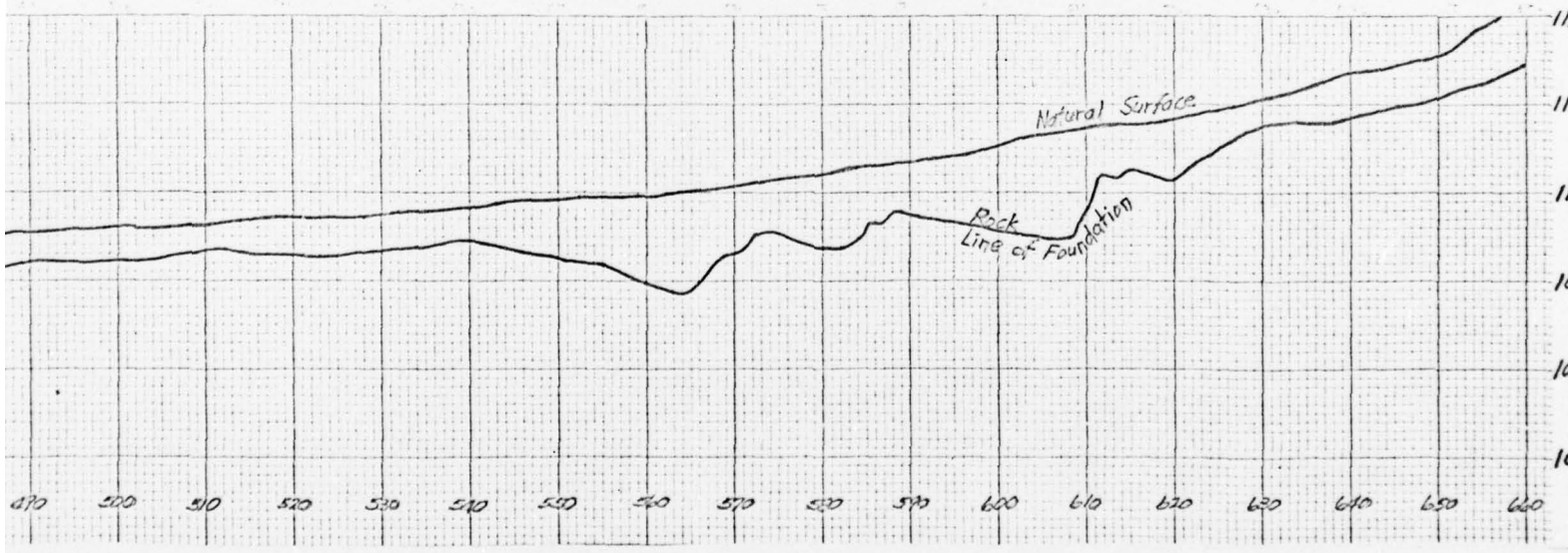
JUNE 1978 PLATE 3

3


Top of Dam El. 1119.0
1120
1110
1100
1090
1080
1070
Natural Surface
Rock
Line of Foundation
Earth
Rock
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160


Top of Dam El. 1119.0
1120
1110
1100
1090
1070
Natural Surface
Rock
Line of Foundation
340
350
360
370
380
390
400
410
420
430
440
450
460
470
480
490





PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEEP HOLLOW DAM

PENNSYLVANIA GAS AND WATER COMPANY

PROFILE ALONG AXIS OF
CURVED GRAVITY SECTION

JUNE 1978 PLATE 4

SUSQUEHANNA RIVER BASIN

DEEP HOLLOW RUN, LUZERNE COUNTY

PENNSYLVANIA

DEEP HOLLOW DAM

NDS ID No. PA-00549
DER ID No. 40-3

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

APPENDIX A

CHECKLIST - ENGINEERING DATA

CHECKLIST

ENGINEERING DATA

DESIGN, CONSTRUCTION, AND OPERATION
PHASE I

NAME OF DAM: Deep Hollow Dam

NDS ID NO.: PA-00549 DER ID NO.: 40-3

Sheet 1 of 4

ITEM	REMARKS
AS-BUILT DRAWINGS	Foundation profile dated 1914; drawings for proposed reconstruction dated 1942.
REGIONAL VICINITY MAP	Project is shown on Pittston, Pennsylvania. Quadrangle Sheet N4115 - W7545/7.5, 1947, Photo revised 1969.
CONSTRUCTION HISTORY	Constructed 1907-1908 by Spring Brook Water Supply Company. Repaired 1935.
TYPICAL SECTIONS OF DAM	Available.
OUTLETS: Plan Details Constraints Discharge Ratings	Plan available. Details available by description. No discharge ratings.

ENGINEERING DATA

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	None.
DESIGN REPORTS	Permit application report for proposed rehabilitation.
GEOLOGY REPORTS	General geologic description in 1914 report.
DESIGN COMPUTATIONS: Hydrology and Hydraulics Dam Stability Seepage Studies	1914 hydraulic analysis of spillway and stability analysis of dam.
MATERIALS INVESTIGATIONS: Boring Records Laboratory Field	None.
POSTCONSTRUCTION SURVEYS OF DAM	None.

ENGINEERING DATA

ITEM	REMARKS
BORROW SOURCES	Aggregate for concrete obtained by crushing sandstone quarried from left hillside.
MONITORING SYSTEMS	None.
MODIFICATIONS	1935: Drilling and grouting of joints in top 14 feet of dam.
HIGH POOL RECORDS	None.
POSTCONSTRUCTION ENGINEERING STUDIES AND REPORTS	1914: Evaluation of stability of dam and hydraulics of spillway.
PRIOR ACCIDENTS OR FAILURE OF DAM: Description Reports	None.

ENGINEERING DATA

ITEM	REMARKS
MAINTENANCE AND OPERATION RECORDS	No detailed operation records.
SPILLWAY: Plan Sections Details	Plan and sections available from proposed reconstruction drawings.
OPERATING EQUIPMENT: Plans Details	Descriptions available.
PREVIOUS INSPECTIONS Dates Deficiencies (Continued on Sheet A-5)	1919: Some seepage through concrete joints; leakage at right end of spillway wall. 1920: Crest of dam disintegrating from spillway to 75 feet from right end of arch; downstream face scaling at construction joints; estimated leakage 100,000 gpd. 1921: Same as 1920. 1923: Same as 1920. 1925: Same as 1920. 1927: Same as 1920 but concrete disintegration progressing.
	1929: Concrete disintegrated to depth of 6 inches; repairs suggested. 1930: Flow along toe of dam, seepage through dam. 1931: Repairs recommended. 1932: Same as above.

ENGINEERING DATA

ITEM	REMARKS
Previous Inspections (Continued from Sheet A-4)	1933: Same as above; no repairs made. 1936: Leakage reduced by grouting. 1941: Deep disintegration at top of dam; downstream face disintegrated to maximum depth of 15 inches;
	left spillway approach wall badly disintegrated; brush growing in waste channel. 1964: Concrete deteriorated.

CHECKLIST

ENGINEERING DATA

HYDROLOGY AND HYDRAULICS

NAME OF DAM: Deep Hollow Dam NDS ID NO.: PA-00549 DER ID NO.: 40-3

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): Elevation 1108.8

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): Elevation 1120.8

ELEVATION MAXIMUM DESIGN POOL: Elevation 1120.8

ELEVATION TOP DAM: Elevation 1120.8

SPILLWAY CREST:
- a. Elevation 1118.8
- b. Type Broad crested weir.
- c. Width 2 feet
- d. Length 32 feet
- e. Location Spillover Right abutment.
- f. Number and Type of Gates None.

OUTLET WORKS:
- a. Type Two 16-inch cast-iron pipes.
- b. Location Near center of curved section of dam.
- c. Entrance Inverts Elevation 1078.8.
- d. Exit Inverts Elevation 1078.8.
- e. Emergency Draindown Facilities Pipes described above.

HYDROMETEOROLOGICAL GAGES:
- a. Type None
- b. Location None
- c. Records None

MAXIMUM NONDAMAGING DISCHARGE: Unknown.

SUSQUEHANNA RIVER BASIN

DEEP HOLLOW RUN, LUZERNE COUNTY

PENNSYLVANIA

DEEP HOLLOW DAM

NDS ID No. PA-00549
DER ID No. 40-3

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

APPENDIX B

CHECKLIST - VISUAL INSPECTION

CHECKLIST

VISUAL INSPECTION

PHASE I

Name of Dam: Deep Hollow Dam County: Luzerne State: Pennsylvania

NDS ID No.: PA-00549 DER ID No.: 40-3

Type of Dam: Concrete Gravity Hazard Category: High

Date(s) Inspection: 23 May 1978 Weather: Clear Temperature: 70°

Pool Elevation at Time of Inspection: 1109.0 msl/Tailwater at Time of Inspection: 1079.0 msl

Note: Pool was 11.8 feet below top of dam.

Inspection Personnel:

D. Wilson (GFCC)	D. Ebersole (GFCC)	C. Kresge (PG&W)
W. Seip (GFCC)	D. Kaufman (PG&W)	Also present were representatives
D. Wolf (GFCC)	J. Skoritowski (PG&W)	from PennDER and OCE

D. Wilson (GFCC) Recorder

CONCRETE/MASONRY DAMS

Sheet 1 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE (Continued on Sheet B-9)	1. Downstream face of dam had no seepage. 2. Sta. 2+00: Small spring at rock outcrop 150 feet downstream from dam.	1. Pool level was 11.8 feet below top of dam. 2. Source unknown; could be independent from reservoir.
JUNCTION OF STRUCTURE WITH: Abutment Embankment Other Features	1. Left abutment - outcrops of gray sandstone. 2. Right abutment - outcrops of sound conglomerate.	1. Rock was hard and sound.
DRAINS	None.	
WATER PASSAGES	None other than outlet works.	
FOUNDATION	No evidence of foundation problems.	Many rock outcrops in area.

CONCRETE/MASONRY DAMS

Sheet 2 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SURFACES: Surface Cracks Spalling (Continued on Sheet B-9)	1. Crest of curved section: about 20% of crest disintegrated to 3-inch depth. 2. Crest of straight sections: all of crest disintegrated to 3-inch depth.	
STRUCTURAL CRACKING	None.	
ALIGNMENT: Vertical Horizontal	No irregularities.	
MONOLITH JOINTS	Monolith joints are construction joints.	
CONSTRUCTION JOINTS	Concrete deterioration is generally more advanced at construction joints.	
STAFF GAGE OR RECORDER	None.	

OUTLET WORKS

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Not applicable.	
INTAKE STRUCTURE	None.	
OUTLET STRUCTURE	Large hole in roof of gatehouse.	Caused by vandalism.
OUTLET CHANNEL	Rock bottom, low concrete walls each side.	
EMERGENCY GATE	Two 16-inch gate valves on each CIP	Valves located underground. Opened easily.

UNGATED SPILLWAY

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Weir crest is cracked and uneven; one section missing.	Pool level 9.8 feet below weir level.
APPROACH CHANNEL	Completely overgrown with 2-inch to 4-inch hardwoods (oak, maple, birch, and poplar).	Channel is unlined.
DISCHARGE CHANNEL	Heavy forest cover; irregular; no lining.	
BRIDGE AND PIERS	None.	

INSTRUMENTATION

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER	None.	

RESERVOIR AND WATERSHED

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Slopes mild; no evidence of instability; some rock outcrops.	
SEDIMENTATION	No major problem reported by Owner.	
WATERSHED DESCRIPTION	Owned and controlled by PG&W; no development; hardwood cover.	

DOWNSTREAM CHANNEL

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION: Obstructions Debris Other	1. Rt. 81 embankment located about 1.7 miles downstream. 2. Rt. 315 embankment downstream from Rt. 81.	1. Embankment has twin box culverts; each is 16.5' wide x 11.2' high x 300' long. 2. Large opening.
SLOPES	No undue erosion.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	No houses between dam and Rt. 81. First populated area is at Pocono Downs Race Track. Wilkes-Barre is about 4 miles downstream.	

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE (Continued from Sheet B-2)	3. Sta. 3+00 to 3+40: Generally swampy area from 75 feet to 150 feet downstream from dam. 4. Sta. 4+50: Soft spot and slight clear flow 120 feet downstream from dam. 5. Sta. 5+00: 5-foot diameter wet area 20 feet from toe of dam. 6. Sta. 6+00: 5-foot diameter wet area 30 feet from toe.	3. No flowing water; appears to be natural runoff concentration. 4. Soft spot located at natural low area. 5. No flow of water; not abnormally soft between wet area and toe of dam. 6. No flow of water; ground between wet area and toe of dam was softer than adjacent areas.
CONCRETE SURFACES (Continued from Sheet B-3) (Continued on Sheet B-10)	3. Downstream face of dam: Sta. 0+00 to 3+00: 80% of face has scaling to depth of 1"-2". Sta. 3+00 to 3+50: Same scaling plus 150 s.f. disintegrated to 12" maximum depth near top. Sta. 3+50 to 4+50: increase in depth of scaling. Sta. 4+50 to 6+60: average depth of scaling estimated at 10" - 12". General: Woods and brush start at toe of dam; occasional vines growing on downstream face; downstream face has scaling of variable depth over 80% of area.	

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SURFACES (Continued from Sheet B-9)	4. Upstream face of dam: concrete deterioration is of a local nature. Estimate 10% of area has scaling, spalls, or disintegration to average depth of 6". At right end of curved section a 25-foot length has disintegration to a maximum depth of 18". Also had 2-inch cable exposed at this area.	
RAILROAD EMBANKMENT RETAINING WALL	1. Near upstream end: wide crack at construction joint near top; weathered to 4" depth. 2. Downstream half of wall: scaling over 75% of area to average depth of 2". 3. Construction joints are generally more weathered than other areas.	1. 1/2" differential movement; not serious if it fails. 2. Maximum depth of scaling about 6". 3. Several small trees growing in construction joints.

SUSQUEHANNA RIVER BASIN

DEEP HOLLOW RUN, LUZERNE COUNTY

PENNSYLVANIA

DEEP HOLLOW DAM

NDS ID No. PA-00549
DER ID No. 40-3

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

APPENDIX C

HYDROLOGY AND HYDRAULICS

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

SUBJECT Deep Hollow Dam FILE NO. 7613.12
Hydrology and Hydraulics SHEET NO. 1 OF 6 SHEET
FOR USCE - Baltimore
COMPUTED BY DAW DATE 7-78 CHECKED BY _____ DATE _____

Classification

The hazard classification is high since the downstream population is 27 - ref. Recommended Guidelines for Safety Inspection of Dams, p D-9

The size classification is intermediate since the height equals 40 feet and the capacity is 230 million gallons - ref. same, p D-8

Spillway Design Flood

The spillway design flood should be the PMF for a high hazard dam of intermediate size. - ref, same, p D12

Hydrology and Hydraulics Analysis

Assume "best possible" conditions

1. no flashboards
2. no inflow from flume
3. normal pool is 10' below spillway crest

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

SUBJECT Deep Hollow Dam FILE NO. 7613.11
Hydrology and Hydraulics SHEET NO. 2 OF 6 SHEET
FOR USCE - Baltimore
COMPUTED BY DAW DATE 6/1/73 CHECKED BY EFM DATE

REFERENCE: Phase 1 Procedure Package

II.A. Deep Hollow Dam is ideally situated.

2. The PMF inflow hydrograph is not available.

a. Apply PMF for Fall Brook to Deep Hollow Dam by using the ratio of the drainage areas to the 0.8 power - ref. Baltimore - Mr. Michael Kanowitz
Deep Hollow - 0.9 Mi^2, Fall Brook - 4.14 Mi^2 @ 9700 cfs

$$PMF_{Deep\ Hollow} = 9700(0.9/4.14)^{0.8}$$

$$= 9700(0.295)$$

$$PMF = 2860\ cfs$$

B. Ability of spillway to pass the PMF

1. assume "best possible" conditions.
that is restoring spillway to L = 32' 1914 report
h = 2' "
C = 2.85 std. Handbook, Merritt
and removing obstructions to flow as noted in the inspection report.
$Q = CLH^{3/2} = \underline{258\ cfs}$

3. The PMF peak flow is greater than the spillway capacity.

b. The routing of the PMF is unavailable.

(i.) Percent of PMF which is capable of passing the spillway.

$$P = \frac{\text{SPILLWAY CAPACITY}}{\text{PMF Peak}} = 9\ \%$$

(2.) Estimate of storage effect of the reservoir.
(Reference: Inclosure 3)
Volume of PMF = 24" of runoff from 0.9 Mi^2
$0.9 \times 640 \times 2 = 1152$ Acre-ft. = 13,939 cfs-hrs
$b = (2 \cdot 13939) \div 2860 = 9.75$ hrs.

SP 11860A

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$\Delta AOC = (1-P)\Delta AOB$ (Ref. Incl 3 p 1)
$= (1-.09) \cdot 1152$
$= 1048$ Ac.-Ft.

Total Capacity of Reservoir @ Top of Dam = 741 Ac-Ft. (1914 Report)

∴ Storage required is greater than storage available even if the reservoir is totally dry just prior to the storm.

C.2.4. adequacy of Spillway
ETL 1110-2- states that three conditions must exist before spillway capacity is considered to be seriously inadequate. Check condition "C" - Ability of spillway to pass ½ PMF without overtopping.
b. repeat calculations for ½ PMF = ½(2860) = 1430 cfs

II.B. Ability of Spillway to pass ½ PMF
1. Spillway Capacity is 258 cfs
3. ½ PMF is greater than Spillway Capacity
1430 > 258
b. routing of ½ PMF is not available
1. the spillway will pass $(258/1430) \cdot 100 = 18.0\%$ of ½ PMF Peak
2. Inclosure 3 Method used to estimate the storage effect of the reservoir.
$(1-0.18)(0.9 \times 640 \times 1)$ = 472 Ac.-Ft. = Storage Req'd.

Estimate Storage Available

Assume that a right circular cone with 5H on 1V side slopes will adequately model the reservoir volume

∴ $\Delta r = 5\ \Delta H$

@ Top of Dam $A = 45$ Acres $= \pi r^2$ ∴ $r = 789.9'$
@ Spillway Crest $r = r - 2 \times 5 =$ $779.9'$ ∴ $A = 43.37$ Acres
@ Spillway Crest -10' $r = r - 12 \times 5 =$ 729.9 ∴ $A = 38.42$ Acres

Surcharge Storage $= 12 \times \left(\frac{A_1 + A_2}{2}\right) = 6(45 + 38.42) = 500.5$ Acre-Ft.

500.5 > 472 ∴ Deep Hollow Dam Spillway is not seriously inadequate when the normal pool is 10' below spillway crest.

SP 1185GA

© Tailwater depth at instant before overtopping occurs

Spillway Capacity = 258 cfs
Tailwater depth @ Q = 258 cfs = 2.05 ft. HEC-2 run

Top of Dam Elev. = 1120.8
Height of Dam = 40 ft.
Bottom of Dam Elev = 1080.8
Tailwater Elev = 1082.0
Top of Dam - Tailwater Elev = 38.8 ft.

Percent of PMF which will pass spillway

$$\% = \frac{\text{Spillway Cap} + \frac{2.5}{T}}{\text{PMF Peak}} \times 100$$

Storage Estimate

Assume that a right circular cone with 5H on 1V side slopes will adequately model the volume of Deep Hollow reservoir.

$\therefore \Delta r = 5\Delta x$

@ Top of Dam $A = 45 \text{ Acres} = \pi r^2$
$r = 789.9\,a'$

@ Spillway Crest $r = r - 2.5 = 779.90'$ $\therefore A = 43.87$ Acres
@ Spillway Crest -10' $r = r - 5.12 = 729.90'$ $\therefore A = 38.42$ Acres

$\therefore$ Surcharge $= 12 \cdot \left(\frac{A_1 + A_2}{2}\right) = 6(45 + 38.42) = 500.5$ Acre-ft.

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$$\frac{258. + \frac{2 \cdot 500.5 \times \frac{43560}{3600}}{9.75}}{2860} \times 100 = 52.4\ \%$$

$\therefore Q_{max} = 0.524 \times 2860 = 1500$ cfs for a storm of the same duration as the PMF

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

SUBJECT Deep Hollow Dam FILE NO. 7613.14
Hydrology and Hydraulics SHEET NO. 6 OF 6 SHEET
FOR USCE - Baltimore
COMPUTED BY DAW DATE 6-78 CHECKED BY EFM DATE 7-78

1. Determine Elev.-Outflow
Starting at spillway crest - 10', or normal pool

$$Q = 2.85 \cdot 32 (H-10)^{3/2} + 3.09 \cdot 841 (H-12)^{3/2}$$

2. Determine Storage

$$\text{Storage} = H\left(\frac{38.42 + \pi(729.90+5H)^2 \frac{1}{43560}}{2}\right)$$ see page 4

H ft.	A Acres	Surcharge Storage Acre-Ft	Outflow cfs	$O + \frac{2S}{T}$ cfs
0	38.42	0	0	0
5	41.10	198.80	0	493.4
10	43.87	411.44	0	1021.2
12	45.0	500.51	258	1500.3
12.5	45.28	523.15	12793	2577.8
13	45,57	545.94	3072.6	4427.6
13.5				

3. Calculate Overtopping at PMF = 2860 cfs

$$H = 12.5 + \frac{(2860 - 2577.8)}{2(4427.6 - 2577.8)} = 12.5 + .07 = 12.6'$$
or 0.6' over top of dam

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SUSQUEHANNA RIVER BASIN

DEEP HOLLOW RUN, LUZERNE COUNTY

PENNSYLVANIA

DEEP HOLLOW DAM

NDS ID No. PA-00549
DER ID No. 40-3

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

APPENDIX D

PHOTOGRAPHS

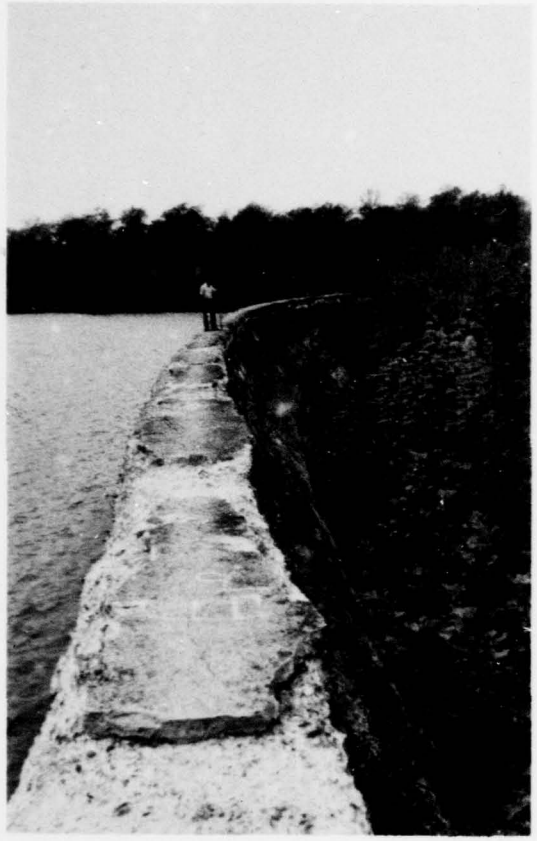
DEEP HOLLOW DAM



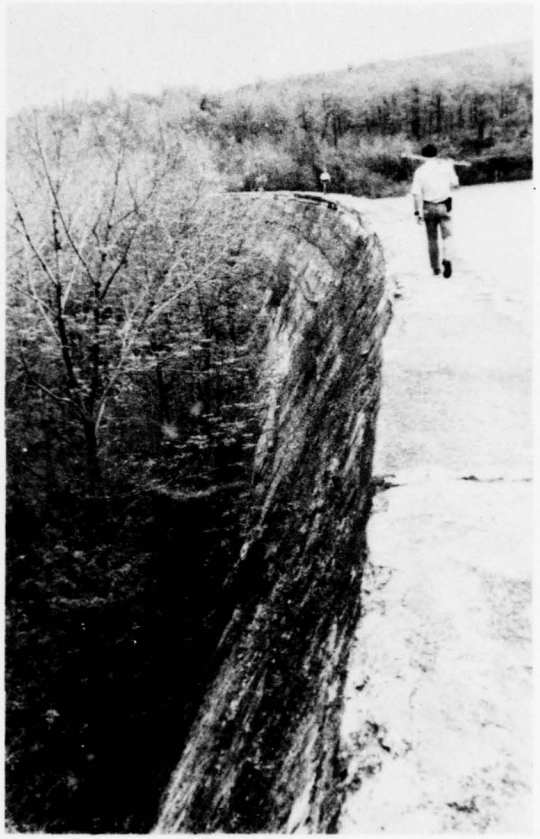
A. Upstream Face of Curved Concrete Gravity Section
Near Left Abutment



B. Upstream Face of Curved Concrete Gravity Section
Near Right Abutment



C. Crest and Downstream Face of Curved Concrete Gravity Section Near Right End



D. Crest and Downstream Face of Curved Concrete Gravity Section Near Left Abutment



E. Right End of Curved Concrete Gravity Section. Spillway Approach Channel is in Background at Center.



F. Concrete Disintegration Along the Upstream Face of the Curved Concrete Gravity Section at Right End



G. View Along Straight Concrete Gravity Section.
Looking from Right End of Curved Concrete Gravity Section.
Spillway Approach Channel on Right.



H. 32-Foot Wide Spillway.
Spillway Approach Channel is on Right.
Spillway Outlet Channel is on Left.



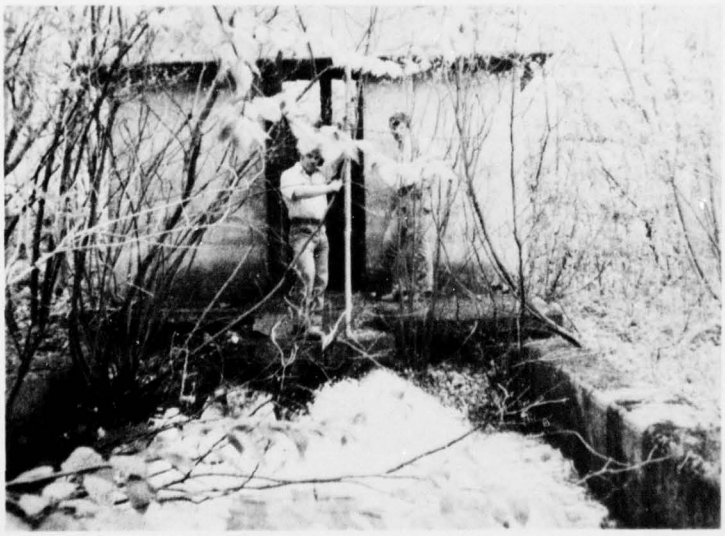
I. Railroad Embankment Retaining Wall.
Spillway Approach Channel on Right.



J. Wet Area Downstream from Dam
Located About 600 Feet from Left Abutment.



K. Downstream Face of Curved Concrete Gravity Section



L. Gatehouse and Outlet Channel with Both 16-Inch Outlet Pipes in Operation



M. Intake Area of Abandoned Flume.
The Masonry Intake Structure
Has Been Completely Washed Away.



N. Conduits Through I-81 Highway Embankment
1.5 Miles Downstream from Dam

SUSQUEHANNA RIVER BASIN

DEEP HOLLOW RUN, LUZERNE COUNTY

PENNSYLVANIA

DEEP HOLLOW DAM

NDS ID No. PA-00549
DER ID No. 40-3

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JUNE 1978

APPENDIX E

GEOLOGY

DEEP HOLLOW DAM

APPENDIX E

GEOLOGY

1. General Geology. The damsite and reservoir are located in Luzerne County. The rock formations exposed in Luzerne County range from the post-Pottsville formations, of Pennsylvanian Age, down to the Onondaga formation, of Middle Devonian Age. The Wisconsin terminal moraine crosses the southern part of the County, and the greater part of the County is covered by glacial drift. Extensive deposits of glacial outwash occur along the Susquhanna River and less extensive deposits along the smaller streams.

Nearly all of Luzerne County lies in the Valley and Ridge Province in which nearly all the rocks have been strongly folded. In going from north to south across the County, five major folds are encountered, all of which trend northeast. The first of these is a shallow syncline on the crest of North Mountain, forming the Mehoopany coal basin. The second is the Milton Anticline, which exposes the Portage group in the northwestern part of the County and gradually flattens out toward the northeast. The third and most pronounced is the Lackawanna Syncline, which originates in Lackawanna County to the north, and has preserved the post-Pottsville formations throughout the Wyoming Valley. The maximum depth of this syncline is reached in the vicinity of Wilkes-Barre and Plymouth. The double rim of this syncline is formed by the resistant Pottsville formations and Pocono sandstone, separated by the less resistant Mauch Chunk shale. The fourth fold is the Berwick (Montour) Anticline, which exposes a few feet of the Onondaga formation in the vicinity of Beach Haven. This fold reaches its maximum development farther west and only the eastern portion reaches Luzerne County. The fifth major fold comprises a series of anticlines and synclines forming the Eastern Middle Anthracite Field in the vicinity of Hazelton. The synclinal basins in this region are relatively shallow and there are large areas from which all coalbeds have been eroded.

The general dips of the region vary from 0° to 40°, and the maximum dips are found on the rims and within the synclinal coal basins. The relatively soft post-Pottsville beds in their cores are severely folded and contorted

with numerous minor faults. The northern and easternmost parts of the County border the Appalachian Plateau Providence and are characterized by horizontal, or nearly horizontal strata. The Catskill continental group of rocks underlies those parts of Luzerne County that are outside of the five major folds.

2. Site Geology. In the area of interest, the Susquhanna River represents the approximate axis of the Lackawanna Syncline. The dam and reservoir are located east of the Susquehanna River in the relatively gentle slope of the left descending limb, looking downstream, of the Syncline. Deep Hollow Run, a tributary of Mill Creek, has cut through the Mauch Chunk shale formations, in the area of the damsite, and is flowing over a hard, gray Pottsville conglomerate. Beyond the immediate streambed, the valley bottom and abutments are covered by a sandy clay overburden.

From construction reports, obtained by Pennsylvania Water Supply Commission engineers in the initial 1914 inspection of the dam, all but 28 feet of the 863 foot length of concrete dam is founded upon the hard, gray conglomerate. A 28-foot section of dam, located 73 feet from the right end of the arch, is founded upon a stiff clay. The top of conglomerate was located from 2 feet below natural gound in the valley to over 13 feet in the abutments. The stiff clay layer upon which the 28 feet of dam is founded, was located from 13 to 15 feet below natural ground. The conglomerate was reported to be of such good quality that it was only found necessary to remove from 1 to 2 feet of weathered rock to obtain a good, firm rock foundation. The rock foundation was reported to have been thoroughly cleaned and roughened and all surface joints filled with an expanding mortar prior to concrete placement.