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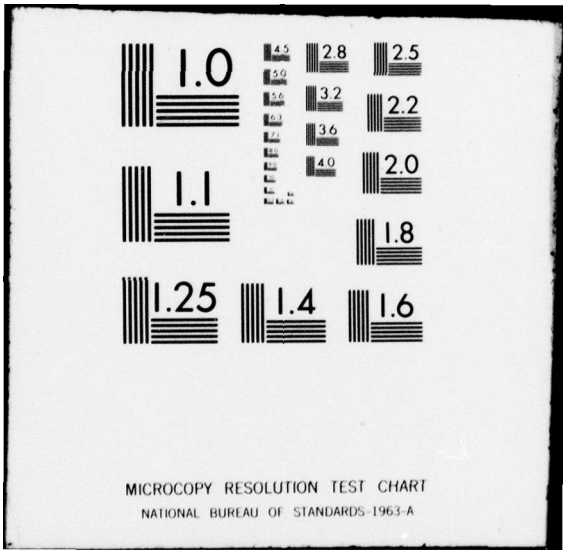
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LEVEL II

DELAWARE RIVER BASIN
WILD CREEK, CARBON COUNTY

PENNSYLVANIA
ID NO. PA.00608

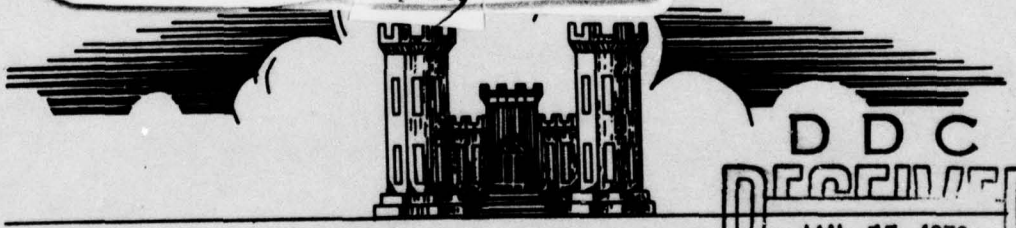
(10) John H. /Frederick, Jr.
William S. /Gardner

PENN FOREST DAM

(15) DACW31-78-C-0048

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

(6) National Dam Inspection Program. Penn Forest Dam (National I.D. Number PA-00608), Delaware River Basin, Wild Creek, Carbon County, Pennsylvania. Phase I Inspection Report.



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

(11) JUNE 1978

(12) 91 p.

LEVEL II

DELAWARE RIVER BASIN

PENN FOREST DAM
CARBON COUNTY, PENNSYLVANIA
NATIONAL I.D. NO. PA 00608

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Prepared by:

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Plymouth Meeting, Pennsylvania 19462

Submitted to:

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

June 1978

Contract DACW31-78-C-0048

PHASE I REPORT

NATIONAL DAM INSPECTION PROGRAM

Name of Dam: Penn Forest Dam
County Located: Carbon County
State Located: Pennsylvania
Stream: Wild Creek
Coordinates: Latitude 40° 55.8' Longitude 75° 33.8'
Date of Inspection: 26 April 1978

Penn Forest Dam developed a large sinkhole on its upstream face and turbid seepage downstream during the first filling of the reservoir in 1960. As a result, this facility has undergone intensive study and remedial work. Although various investigators differ as to the probable cause, it is generally conceded that some form of piping mechanism led to incipient failure of the dam.

Although the reservoir has been full for over ten years with no reoccurrence of these events, it is recognized that this zoned dam has no filter system and is susceptible to piping The Owner, therefore, continues to employ Gannett, Fleming, Corddry and Carpenter, Inc. of Harrisburg, Pennsylvania to monitor the performance of the dam and assess the significance of the numerous piezometer and weir readings that they maintain. Detailed evaluation of these data is beyond the scope of this current inspection. It is important, however, to note that continual monitoring and evaluation of this latent defect is important to the overall safety of the dam.

At the time of inspection, the reservoir was full and the dam appeared to be in good condition. This facility is designed to pass the probable maximum flood and is observed by staff personnel on a regular basis. The historical problem and some slope deformation near the intake structure are currently being assessed by a qualified engineering consulting firm.

However, there is concern about the apparent creep movement of the downstream face of the dam and water seepage

on the dam face in the vicinity of the sinkhole. It is recommended that instrumentation be installed to monitor the creep area and an investigation should be made of this area to determine its significance to the dam integrity.

Of less concern is the seepage at the downstream toe of the dam and at the left downstream abutment. It is recommended that the additional seepage areas be added to any on-going observation and monitoring program at the dam to detect any possibly changes in the seepage as described in Section 7.2 of the report.

for John H. Frederick, Jr., P.E.
Maryland Registration 7301

Jun 30, 1978
Date

W S Gardner

William S. Gardner, P.E.
Penna. Registration 43002E

6/30/78
Date

APPROVED BY:

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

11 Jul 78
Date

OVERVIEW
PENN FOREST DAM, CARBON COUNTY, PENNSYLVANIA

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
PENN FOREST DAM
NATIONAL I.D. #PA 00608

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. Penn Forest Dam is a zoned earth and rock fill embankment with a central core of impervious materials extending down to the rock surface and a low central concrete core wall also founded within rock. The dam is approximately 1,930 feet long and 145 feet high at the original streambed. A reinforced concrete chute spillway for overflow discharge is located on the right abutment. The intake structure is located upstream on the left abutment and a concrete lined tunnel beneath the abutment contains a 48-inch pipe to the operating discharge facility of the dam. Release of water through this facility is controlled by valves in the intake tower and a valve at the downstream outlet.

A concrete tunnel 12 feet in diameter was used for stream diversion during construction. This tunnel was closed off after installation of a 36-inch diameter pipe within the tunnel. This pipe can be used for emergency drawdown of the reservoir.

b. Location. Penn Forest Dam is located at about the confluence of Wild Creek and Hell Creek that is approximately 1,000 feet north of the south boundary of Penn Forest Township in Carbon County, Pennsylvania. This location is about 2.5 miles upstream from Wild Creek Dam. The dam site and reservoir are shown on the USGS Quadrangle, Pohopoco Mountain,

Pennsylvania at coordinates N 40° 55.8', W 75° 33.8'. A Regional Location Plan of Penn Forest Dam and Reservoir is enclosed as Plate 1 in Appendix E.

c. Size Classification. Consistent with a maximum height of 145 feet and a reservoir capacity of 19,980 acre-feet, the dam is classified as "Large".

d. Hazard Classification. Consistent with the occurrence of inhabited structures immediately below Wild Creek Dam (approximately 2.5 miles downstream from Penn Forest Dam), and the certain destruction of Wild Creek Dam and loss of the City of Bethlehem's entire water supply, a "High Hazard" classification is assigned.

e. Ownership. Bethlehem Authority.

f. Purpose of Dam. Water supply for Bethlehem and nearby communities.

g. Design and Construction History. A construction permit was first issued for Penn Forest Dam on April 10, 1946 by the Water and Power Resources Board of the Pennsylvania Department of Forest and Waters. It was stipulated that detailed plans, specifications, and supporting documents be submitted for review and that written approval was necessary before construction could proceed. On December 27, 1948 a petition for a time extension of the construction permit was presented before the Board and identified that test borings in the dam area, evaluation of proposed borrow pits, a geologic report and a preliminary report on the necessary grouting program were completed. It also stated that negotiations for a model test of the spillway were underway.

The final design of Penn Forest Dam was completed for the Owner by Morris Knowles, Inc. of Pittsburgh, Pennsylvania in 1955. A construction permit was issued on November 14, 1955 by the Water and Power Resources Board. Penn Forest Dam was constructed in the period from July, 1956 to September, 1958. After construction, the outlet valves were left open to allow Wild Creek Reservoir located downstream to fill, and the impoundment of water behind Penn Forest Dam was begun in late March, 1959.

h. Normal Operation Procedure. At present, Penn Forest Dam is operated with water impounded up to the spillway crest at elevation 1,000. Previously, due to repairs and engineering studies of the performance of the dam, the reservoir was

operated at elevations as low as 940. Water is drawn from Penn Forest Reservoir to maintain the minimum required stream flow below Wild Creek and also to replenish the water drawn off from Wild Creek Reservoir for water supply. Consequently, Penn Forest Reservoir is drawn down in periods of drought.

Verbal reports indicate the maximum seasonal drawdown is on the order of 15 feet. The operational draw of water is taken through the 48-inch pipe and regulation is accomplished by the valve at the outlet.

1.3 Pertinent Data.

a. Drainage Area. Approximately 16.5 square miles.

b. Discharge at Damsite.

Maximum known flood at damsite - 243 cfs estimated[1]
Outlet works outlet at normal pool elevation - rating curve in "Record Plans - January, 1959" for operational discharges
reported discharge of 425 cfs at 65 percent valve opening
Blow-off outlet at normal pool elevation - no rating curve
Spillway discharge at maximum design pool - 12,000 cfs
Maximum spillway capacity - 14,400 cfs estimated
Total discharge capacity - greater than 14,800 cfs

c. Elevation. (ft. above MSL)[2]

Top of Dam - 1,015.0
Maximum pool - design surcharge - 1,012.4
Maximum pool of record - 1,000.92 (March 28, 1978)
Upstream portal invert-diversion tunnel - 876.6
- outlet pipe -878.1
Downstream portal invert-diversion tunnel - 866.0
- outlet pipe - 867.5
Streambed at downstream toe of dam - 870
Maximum tailwater - no rating curve

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(1) Flow over spillway March 28, 1978.

(2) Data from Record Plans, January, 1959.

d. Reservoir. (miles)

Length of maximum pool - 1.6±
Length of normal pool - 1.5±

e. Storage. (acre-feet)

Spillway crest - 19,980
Top of Dam - 27,669

f. Reservoir Surface. (acres)

Spillway Crest - 462
Top of Dam - 563

g. Dam Details.

Type - Rolled earth and rock fill with impervious soil core extending to rock and concrete cutoff wall.
Length - 1,930 feet
Height - 145 feet
Crest Width - 30 feet
Side Slopes - Upstream - 2:1(H:V) above elevation 1,000
2.5:1(H:V) below elevation 1,000
3:1(H:V) below elevation 970
3.5:1(H:V) below elevation 940

- Downstream - 2:1(H:V) above elevation 990
2.5:1(H:V) below elevation 990
3:1(H:V) below elevation 950

Zoning - Impervious fill core
Rolled coarse fill outer zones
Rock fill downstream toe
Cofferdam and rock fill toe at upstream
Riprap on upstream slope
Impervious Core - Rolled impervious fill, 30 feet wide at dam crest and with 1:1 side slopes down to rock surface
Cutoff - Concrete cutoff wall founded 3 feet below rock surface and extending 7 feet into impervious core
Grout Curtain - Single line grout curtain injected through cutoff to lowest drilled elevation of 800. Grout holes 80 to 130 feet deep with longer holes on abutments. Supplemental grout holes upstream in valley bottom area.

h. Diversion and Regulating Tunnel.

Type - 12 feet diameter reinforced concrete
Length - 816 feet
Closure - Bulkheaded and filled with concrete for 300 feet through impervious fill core - 36-inch CIP installed in tunnel
Access - Open at downstream end
Regulating Facilities - Two gate valves in series at outlet

i. Spillway.

Type - Triangular crested weir
Length of Weir - 85 feet
Crest Elevation - 1,000.0 feet
Gates - None
Upstream Channel - Forebay with reinforced concrete walls and floor slab 8 feet below spillway crest, about 250 feet long and 85 feet wide
Spillway Chute - Reinforced concrete chute, narrowing from 85 feet to 40 feet wide through 154 feet, at 10.4 percent grade, walls 10 feet high, stilling basin increases in width to 90 feet.

j. Regulating Outlets.

Type - 48-inch RCP in 12 feet diameter semicircular tunnel
Length - Tunnel 930 feet
- Pipe 1,080± feet
Intake Elevations - 949.7 and 901.2
Intake Regulation - Two 42-inch gate valves at each intake level and one 48-inch sluice gate at pipe intake
Outlet Regulation - 48-inch Howell-Bunger valve
Access - Access chamber to tunnel on downstream left abutment

SECTION 2
ENGINEERING DATA

2.1 Design.

a. Data Available. A detailed summary of engineering data on Penn Forest Dam is presented in the checklist, attached as Appendix A. As-built data on Penn Forest Dam is contained within a set of Record Plans containing 32 sheets plus 13 supplemental drawings, all dated January, 1959. These drawings were obtained for review from the Pennsylvania Department of Environmental Resources (DER). Additional data pertaining to the design, construction and subsequent studies at Penn Forest Dam were obtained from the DER files, the Corps of Engineers, and from Gannett, Fleming, Corddry and Carpenter, Inc. of Harrisburg, Pennsylvania, Consultants to the Owner.

Principal documents containing pertinent data are:

1. "Petition of Bethlehem Municipal Authority for Extension of Time . . .", December 27, 1948.
2. Application of the Bethlehem Authority for the construction of Penn Forest Dam, September 27, 1955.
3. "Report upon the Application of Bethlehem Authority", November 3, 1955.
4. Construction Permit for Penn Forest Dam, issued November 14, 1955.
5. "Dam Rises At Bethlehem", by Jerry Pratt, Constructioneer, October 21, 1957.
6. Mason and Hanger-Silas Mason Company, Inc. letter to Bethlehem Authority, March 24, 1961.
7. "Report on Penn Forest Dam", E. D'Appolonia Associates, December 24, 1962.
8. Letter Report, Gannett, Fleming, Corddry and Carpenter, Inc., February 20, 1963.
9. "Report of Inspections Penn Forest Dam", Gannett, Fleming, Corddry and Carpenter, Inc., October, 1967.
10. Bethlehem Authority letter to Gannett, Fleming, Corddry and Carpenter, Inc., October 6, 1967.

11. Gannett, Fleming, Corddry and Carpenter, Inc. letter to Bethlehem Authority, March 8, 1968.

12. Gannett, Fleming, Corddry and Carpenter, Inc. letter to Bethlehem Authority, May 20, 1968.

13. Gannett, Fleming, Corddry and Carpenter, Inc. letter to Bethlehem Authority, October 7, 1969.

14. "Penn Forest Dam, Status of Investigation for Period November, 1969 to January, 1975", Gannett, Fleming, Corddry and Carpenter, Inc. February, 1975.

15. Miscellaneous memoranda, letters, visual inspection reports and photographs.

16. "Beltzville Dam and Reservoir, Design Memorandum 1, Hydrology and Hydraulics", U.S. Army Engineer District, Philadelphia, 1963.

Within this data there are references to, but no documentation of, physical and strength properties of embankment materials, engineering analyses of embankment stability, spillway capacity and design criteria, construction specifications and detailed documentation of the dam construction. References are also made to several additional engineering reports that were not readily available.

b. Design Features. The principal design features of Penn Forest Dam are illustrated on Plates 2 through 6 in Appendix E. The locations of the test borings that were drilled for the design studies of the dam together with columnar boring logs are presented on Plate 7 of Appendix E. These drawings show the embankment to have a maximum height on the order of 145 feet from a streambed elevation on the order of 870 to a design crest elevation of 1,015. A concrete core wall founded on the rock surface along the axis of the dam extends at least 7 feet into the impervious soil core and a single-line grout curtain was constructed extending through the core wall.

A central impervious core zone having a minimum width of 30 feet was to be constructed of materials described as lean clay/sandy clay/clayey silt/and clayey sand. The drawings show the foundation area of the dam within the impervious core zone to be excavated to the rock surface. The outer zones of the dam were to be constructed of rolled coarse fill with materials from the designated borrow pits expected to be silty sand with gravel. A limited drainage system is designed

for the stream valley bottom area beneath the toe of the downstream coarse fill zone.

Rock fill toes are shown at the upstream and downstream sides of the dam. Embankment slopes vary from 2:1 (H:V) to 3.5:1(H:V) as shown on Plate 3. A three foot cover of stone riprap overlying a one foot thick filter bed of sand and gravel is shown on the upstream face of the dam. The application report indicated that a safety factor of 1.5 was estimated for the embankment design.

A reinforced concrete tunnel 12 feet in diameter is located beneath the dam approximately 250 feet to the east of the original streambed. This tunnel was used for stream diversion during the dam construction. At the conclusion of the construction, a 36-inch diameter pipe with shutoff valves at the downstream outlet was installed in the tunnel which was then bulkheaded shut. The water intake structure is on the left abutment approximately 600 feet upstream from the dam axis.

Within the intake structure, intake levels are at elevations 949.7 and 901.2. A semi-circular tunnel 12 feet in diameter beneath the left abutment of the dam contains a 48-inch diameter pipe for the operating water flow from reservoir. This outlet facility is controlled by gate valves and a sluice gate in the intake structure and a 48-inch Howell-Bunger valve at the downstream outlet.

A reinforced concrete chute spillway is located on the right abutment of the dam. The spillway chute is oriented towards the center of the valley and makes an angle of about 60 degrees with the axis of the dam. The crest of the spillway is at elevation 1,000 and consists of a steel plate armored obtuse angle formed by the intersection of the chute slab with the inclined forebay floor slab. The crest is 85 feet long and through a distance of 154 feet, the chute narrows to a width of 40 feet.

Through the forebay, a curve is made such that the forebay extends approximately 250 feet upstream in a direction normal to the dam axis. The walls of the forebay are of a cantilever design with the floor slab of the forebay at elevation 992. The spillway chute is at a gradient of 10.4 percent and is formed by gravity retaining walls. Cantilever retaining walls form the sides of the stilling basin having a discharge weir at elevation 906.3. The water flows from the stilling basin into a wasteway channel containing two

weirs to create stilling pools. The end of the wasteway channel discharges water into Wild Creek at elevation 852.3.

2.2 Construction.

The available documents concerning the construction of Penn Forest Dam consist of a series of letters from the Owner to the State summarizing the progress of work on the dam. A representative from the designer was at the site throughout the period of construction. Related correspondence during this period refers to a testing program documenting the compaction of the rolled earth fill embankment. However, this data is not readily available. There are occasional memos reporting on construction site visits by personnel from the State. In July, 1956 such a visit reported that red shale of poor quality was exposed in the foundation excavation in the valley floor. Another such memo in October, 1957 made reference to some problems with the grouting but supplied no further details.

2.3 Operation Data.

A minimum flow requirement of 1.32 cfs into Wild Creek is stated in the construction permit for the dam, together with the requirement that a weir be constructed to measure stream flow with measurements periodically reported to the State. Other than this requirement, it was expected that water would be released from Penn Forest Reservoir as needed for consumption. However, as the water level in the reservoir approached the spillway crest elevation on its initial filling in 1960, a sinkhole developed on the upstream slope of the dam at about elevation 995 and at a location approximately 400 feet east from the spillway. At about this time, turbid water was observed seeping from the junction of the dam and the right abutment and from the toe of the dam near the right abutment.

Grouting with bentonite was reportedly performed to stop the seepage and numerous drill holes were left open as observation wells. Subsequently, the operation of Penn Forest Dam was limited to a maximum pool at elevation 960. Reference is made to a series of borings drilled in 1962 but no further documentation was available. A major instrumentation program was commenced in 1964 in which 60 test borings were drilled and 166 piezometers were installed at various locations through the dam and abutments. The locations of these borings are shown on Plates 8, 9 and 10 of Appendix E. A program of incrementally raising the pool elevation

concurrent with monitoring the observation wells and piezometers was then started.

As a result of the monitoring and analysis, the decision was made in November, 1968 to operate Penn Forest Dam with the reservoir at elevation 1,000. This recommendation was based on the conclusion that no adverse conditions existed within the dam structure.

The monitoring of the dam was continued until the present time. A report issued in 1975 after several years of "normal" operation of the dam concluded that no detrimental conditions existed. Based on the monitoring information, conclusions about the conditions of water flow through the dam, such as illustrated on the cross-section in Plate 11 of Appendix E, which is taken in the vicinity of the sinkhole, were developed.

Documents in the DER file through this period identify that a major servicing of the Howell-Bunger valve was performed. Extensive repairs to the riprap in the drawdown and operating discharge channels were necessary after a period of high-volume discharge from both of these facilities.

2.4 Other Investigations.

Within the DER file, reference is made to undisturbed samples of the dam materials that were taken from borings drilled in the 1964 program and subsequently tested. It was mentioned that a report of the stability conditions of Penn Forest Dam was prepared. This report was not readily available. Related studies in March of 1968 reported that no appreciable settlement was observed at the location of the borings drilled during the 1964 program.

2.5 Evaluation.

a. Availability. The Department of Environmental Resources provided their files containing drawings, correspondence, permits and reports which provided the bulk of the data reproduced in this report and studied for this investigation. Also reviewed was information selectively provided by Gannett Fleming Corddry and Carpenter, Inc., and Corps of Engineers, Philadelphia District. The Owner's representatives were available to provide verbal information and operational data about the current operation of the dam.

b. Adequacy. In general, the adequacy of the available design data varied throughout different aspects of the design, construction and performance of Penn Forest Dam. Data detailing the subsurface investigations and material testing is inadequate

to support any evaluation of design analyses of the dam. The record plans appear to be a reasonably accurate representation of the configuration of the dam. However, minor discrepancies may exist such as the 1968 observation of a difference in core wall elevation at the spillway wall that was thought to represent settlement. Subsequent investigation concluded that this difference was a discrepancy in the record plans.

Additional data whose availability was limited to statements in the Application Report were the results of the model test that was performed to evaluate the spillway capacity. Due to the variable adequacy of data, the final assessments of this investigation pertaining to the design and construction of Penn Forest Dam must be based largely upon the visual inspection.

Considerable data is available regarding the performance of the dam. However, it is noted that most of the data relates to the sinkhole development, the underlying rock, and the integrity of the grout curtain. Data in this respect is considered to be adequate. Mention is made that conditions within the embankment possibly contributed to the sinkhole and observations and data in this respect are inadequate. The seemingly unbalanced availability of data appears to provide an inadequate basis for an objective evaluation of the performance of the dam. Thus, other interpretations of the performance history of the dam that would be made as part of this investigation must be based primarily upon the visual inspection.

c. Validity. In general, there is no reason to question the validity of the available data. It is noted from this inspection and also within the available documents that disintergration of shale rock within the rock toe of the dam is occurring. These observations could be an important qualification to any evaluation wherein the rock toe becomes of importance to the integrity of the dam.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. The observations and comments of the field inspection team are contained in the checklist enclosed herein as Appendix B and are summarized and evaluated as follows. In general, the outward appearances indicated that the dam and its appurtenances were construced in accordance with the plans and are well maintained.

b. Dam. During the visual survey, no indication or evidence was observed of major distortions in alignment or grade that would be indicative of significant movement of the embankment or foundation. The horizontal alignment of the dam crest appeared to be straight and undistorted. There are gentle vertical undulations on the order of ±0.3 feet were observed together with a gentle tilting of the dam crest downward toward the upstream side of the dam. Of special note was a broad shallow dip in the dam crest in the vicinity of the sinkhole area. Numerous wellpoints and piezometers were installed in this area. Also, there was a slight area of different colored riprap rock on the upstream face either as a result of different rock source or from grout staining. The grass growth on the downstream slope of the dam is, in places, lush indicating an unusual presence of water. Grass also covers most of the rock toe area.

The tile pipe on the downstream slope berms was observed to be compressed in the horizontal plane with the upstream side of the pipe having been pushed inward. This distortion was accompanied by cracking of the pipe and the concrete flashing between the pipe and the surface of the berm. There was also evidence of void spaces existing beneath the pipe. Such distortions were especially prevalent in the sinkhole vicinity.

In the observation trenches that were previously dug on the downstream face of the dam at about elevation 970 there is a lush growth of grass together with soft ground and standing water. In the westernmost of these trenches, there is visible and audible water seepage on the upstream face of the trench at a distance of about 3 feet below the face of the dam. There was evidence of similar seepage but no observations of seepage in the other two trenches located further to the east.

Clear running seepage was observed at several locations on the downstream side of the dam. Near the right abutment and just below the dam toe there is a marshy area that is fed by seepage from at least three discrete locations along the access road normal to the dam. Slight seepages were observed in the gutter and in the access road at the dam toe. At about the original streambed location at the dam toe there is a major leakage where several sections of the gutter drain were removed and a trench was excavated for about 15 feet into the dam toe. This leakage flows into the gutter and then across a measuring weir that appeared to be in a state of disrepair. Documents in the DER file indicate that the weir was installed in conjunction with the 1964 monitoring program. Leakage was also observed slightly downstream from the dam toe in the vicinity of this measuring weir. Water flowing from the weep holes around the diversion tunnel outlet appeared to have a greater volume than the water flow observed in the tunnel. Water was also flowing from the weep holes at the operating discharge outlet. Additional seepage was observed downstream from the dam on the left abutment of the valley. A small seep of clear water was also observed at the left wall of the stilling basin. The flow rate at these seeps was difficult to estimate during the visual inspection.

During the inspection it was observed that about one foot of settlement had occurred adjacent to the left spillway wall over a distance of approximately 40 to 50 feet upstream from the dam axis. In this vicinity, some minor wave erosion of the crushed rock backfill behind the left forebay wall was also observed.

c. Appurtenant Structures. At the time of the inspection, not more than one inch of water was flowing over the spillway. This spillway flow was observed to be reasonably smooth and uniform over the crest and down the spillway channel. Some minor concrete spalling was observed at occasional joints in the floor slab of the spillway and in the spillway walls. The spillway walls were observed to be in a straight line and showed no evidence of displacement or rotation. Throughout the spillway structure, minor shrinkage cracks were observed together with occasional scaling, pop-outs, and erosion of concrete. It was noted that concrete deterioration and occurrence of cracking appeared to be more severe around the stilling basin where calcium carbonate precipitate was also observed.

The intake structure was examined and the accessible portions were found to be in generally good condition but with

some minor cracking and erosion of the concrete, particularly around the reservoir water line. It was noted, however, that the grating and stop-log guides were rusted such that operation of these facilities may present difficulty. It was also noted that the reservoir slope adjacent to the intake structure showed evidence of instability. The Owner's representative (see Appendix B) reported that erosion and sliding had occurred in this area and that Gannett Fleming Corddry and Carpenter, Inc., is performing an engineering investigation of this slope and will report to the Owner in the near future.

The water discharge tunnel appeared to be in reasonably good condition. The floor of this tunnel is unconcreted and at several locations the concrete arch was undercut for a distance of about 4 inches at the floor level. There are frequent transverse cracks, some of which appear to be construction joints, together with longitudinal cracks at the crown of the tunnel. These cracks were frequently denoted by calcium carbonate stalactites together with occasional staining of the concrete. Frequent leakage was observed in the tunnel that varied in quantity from barely perceptible seepage to a constant stream of water. In general, the frequency of cracking and seepage is greater upstream of the dam centerline. Occasional pipe supports in the tunnel exhibited local concrete deterioration.

The outlet structure enclosing the 48-inch Howell-Bunger valve appeared to be in generally good condition. The valve was exercised and all controls appeared to be operational.

The 12-foot diameter concrete diversion tunnel was closed approximately 250 feet into the dam. The concrete in the tunnel is generally in good condition with only infrequent leakages. At two locations, it appeared that an insignificant amount of soil fines had extruded into the tunnel through cracks in the concrete. Some calcium carbonate precipitate was observed at the end of the tunnel near the bulkhead. The 36-inch pipe supported on cradles within this tunnel appeared to be in good condition.

The two series gate valves appeared to be clean and well maintained. It was reported that these valves are periodically exercised. The riprap lined channels below both the service and emergency outlets appeared to be in good condition.

d. Reservoir. Except for the vicinity of the intake structure, the reservoir slopes were observed to be stable and of moderate inclination. The slopes were generally grass-covered for a distance of about 20 feet from the operating

water level (elevation 1,000) with forested land beyond. There was no evidence of significant siltation or debris accumulation that would affect the flood storage or the operation of the dam. A small area of slope sloughing was observed in the upper end of the reservoir.

e. Downstream Channel. The concrete structures in the wasteway channel immediately below the stilling basin were observed to be in generally good condition. Some of the exposed rock in this channel, however, is disintegrated and is probably producing the sediment accumulation observed further downstream. In the natural stream channel, the side slopes are of moderate to steep inclination with well-established forest growth at the edges of the stream banks.

Penn Forest Dam is located approximately 2.6 miles upstream from Wild Creek Dam which supplies all of Bethlehem's water. Wild Creek Dam is located 2000 feet above the high water line of Beltzville Dam.

3.2 Evaluation.

The visual survey of the dam disclosed no evidence of apparent past or present movement of sufficient magnitude to indicate instability of the dam embankment. The observations of the cracked gutter drains and together with the seepage into the observation trenches, however, may indicate a down slope creep of a portion of the downstream face of the dam. The observations of apparent vertical disorientation of the dam crest could represent a general settlement of the dam embankment as well as local settlement of backfill against the spillway structure. From the information in the DER file, it is apparent that most of the seeps noted in this survey were previously observed and have been gauged. The clarity of the seepage indicates that piping is not presently occurring within the dam.

SECTION 4
OPERATION PROCEDURES

4.1 Procedures.

The maximum reservoir level is maintained at elevation 1,000 by reservoir inflow passing over the spillway. Water is withdrawn from Penn Forest Reservoir as needed to maintain the available supply in Wild Creek Reservoir, further downstream. This withdrawal of water is regulated at the Howell-Bunger valve. It was not apparent that the flow through Wild Creek is presently monitored to assure that the minimum required flow is maintained. However, the most recent evaluation of the seepage conditions reported that the total flow from the seeps is approximately equivalent to the minimum required stream flow. It is understood that there are no formal written procedures for the operation of Penn Forest Dam.

4.2 Maintenance of Dam.

The dam is maintained and patrolled by the Owner's personnel.

4.3 Maintenance of Operating Facilities.

The valves and enclosing structures are maintained as needed. The valve-control mechanisms are periodically lubricated and show evidence of good maintenance.

4.4 Warning Systems in Effect.

There are no formal warning systems or procedures established to be followed during periods of exceedingly heavy rainfall. The Owner maintains a staff who regularly patrol the area and are in radio contact with their operating base at the Control Building, immediately downstream from Wild Creek Dam. During periods of high precipitation, the dam and reservoir water level are monitored several times daily.

4.5 Evaluation.

It is believed that the current operating procedures adequately serve the function of Penn Forest Dam and are consistent with the operating equipment at the dam. A formal monitoring and warning procedure should be formulated and followed.

SECTION 5
HYDROLOGY-HYDRAULIC

5.1 Evaluation of Features.

a. Design Data. The hydraulic design of the spillway for Penn Forest Dam was evaluated by a hydraulic model test that is referred to in the permit application report. The spillway design was reported to have a discharge capacity of 12,000 cfs at a head of 12.4 feet. A more recent evaluation of the hydraulic and hydrologic characteristics of the watershed and spillway was performed by the Corps of Engineers. As cited in these documents and determined from the latest USGS mapping, the watershed for Penn Forest Reservoir is approximately 16.5 square miles, fan-shaped and approximately 6.1 and 3.8 miles in width and length, respectively. Elevations in the watershed range from 2,060 in the upper reaches on Stony Ridge Mountain to 1,000 at the normal reservoir pool level. The watershed area is mountainous and dissected by narrow stream valleys at steep gradients. This area is greater than 90 percent wooded and approximately 50 percent of the watershed is owned by the Bethlehem Authority. Over the years, the watershed characteristics have not appreciably changed. No information was reviewed concerning future growth of the area.

Approximately 3,500 feet upstream from the reservoir on Wild Creek is a small private pond and dam. The pond has a surface area of about 2 acres and is reported to be about 9 feet deep. At the time of the inspection there was less than 1 foot of freeboard at its retaining dam. During an extreme event, this pond is not expected to have a significant influence on the Penn Forest Reservoir. In addition, a diversion from Tunkhannock Creek discharges water into a tributary of the reservoir. This diversion is through a 30-inch pipe and is similarly not considered to be significant during an extreme event.

The model test reported a spillway discharge of 12,000 cfs at a head of 12.4 feet, leaving 2.6 feet of design freeboard at the dam. The Corps of Engineers study (Section 2.1, Reference No. 16) concluded that the PMF inflow into Penn Forest Reservoir would be 16,800 cfs and, by routing, the peak discharge from Penn Forest Dam would be 12,000 cfs.

b. Experience Data. Rainfall records and reservoir

water level readings are maintained by the Owner. Within recent record, maximum depth of flow over the spillway of 0.92 feet occurred on March 28, 1978, corresponding to an estimated 243 cfs. On January 28, 1976, a water depth of 0.91 feet (estimated to be 239 cfs) resulted from a two-day rainfall of 4.3 inches.

c. Visual Observations. As presented in Appendix B, no features were observed in the reservoir or downstream channel that would adversely affect the hydrologic and hydraulic conditions. However, localized settlement adjacent to the spillway appears to have lowered the effective crest elevation of the dam by as much as one foot. Based upon the conditions in the adjacent woodlands, it is considered unlikely that debris would accumulate in the reservoir and possibly clog the spillway.

d. Overtopping Potential. Based upon the Corps of Engineers studies, the spillway at Penn Forest Dam is judged to be capable of passing the PMF without overtopping. Consistent with the apparent settlement at the spillway wall, the estimated effective freeboard in this event is at least 1.6 feet. During the PMF, the tailwater is estimated to be 100 feet or more below the spillway crest and the dam crest is accessible during times of flood.

Penn Forest Dam is located approximately 0.8 miles upstream from Wild Creek Reservoir. Between these two, there are no habitated buildings and all of the land is owned by the Bethlehem Authority. Thus, the loss of life in the event of a large flow from Penn Forest Dam is considered to be minimal. However, the Corps of Engineers study concluded that failure of Penn Forest Dam would precipitate a failure of Wild Creek Dam and loss of the water supply for the City of Bethlehem.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. The visual observations did not reveal evidence of any significant existing embankment stability problems. However, the condition of the gutter drains, especially in the vicinity of the sinkhole area, indicates that down slope creep might have occurred. The seepage located in the old observation trenches could result from an unusually high phreatic surface within the dam that, in turn, could be contributing to the creep movement. This seepage observation contrasts with the phreatic surface estimated from the piezometer readings shown on Plate 11 in Appendix E.

The water seepage observed at the toe of the dam and at the stilling basin is consistent with documented observations of Penn Forest Dam since 1961. The clarity of the seepage water indicates that piping or erosion within the dam is not presently occurring. However, the seepage observed downstream of the left abutment was not previously recorded in the available files.

b. Design and Construction Data. Although the overall design of Penn Forest Dam appears to be adequate, there are details of the dam design that cannot be confirmed. The geology and soil investigation reports together with reports of testing on the dam embankment and foundation materials and the subsequent stability analyses of the embankment were not available for review. Considering the soil types that are locally available and the brief references within the DER files, it is believed that the basic proportioning of the dam constitutes a reasonable design.

However, it is noted that the design shows internal drainage only in the area at the bottom of the former stream valley and there is no apparent outlet from this drain. Notably absent in the design of the dam are filter layers between the impervious zone and the downstream coarse fill zone and between the coarse fill and rock toe, as well as beneath the rock toe. Neither is there any indication that the designated borrow areas contained materials of a gradation that would preclude soil particle migration between the different zones. The drawings indicate that the foundation for the impervious core was excavated to the rock surface but

do not give any indication of treatment to the rock surface or removal of any mantle of broken and pervious rock, especially upstream from the concrete cutoff.

Penn Forest Dam was designed with a single-line grout curtain to be injected through pipes cast into the cutoff wall. Additional grouting was performed upstream from the cutoff in the valley bottom area. Other than a description of the grout holes ranging in length from from 80 to 130 feet with the longer holes at the abutments and the shorter holes in the valley bottom extending down to elevation 800, design details of the grout curtain are unavailable.

In general, the design of the appurtenant structures appears to be adequate to insure the integrity of the dam. It is noted that the valves for the emergency drawdown are located at the downstream side of the dam. This is considered of minor importance since the pipe is located within the 12 foot diameter tunnel such that any leakage from the pipe would not directly affect the downstream portion of the dam.

c. Operating Records. Of significance to the operation of Penn Forest Dam is the history of the "sinkhole" and related phenomena that are described in Section 2.3 above. Reports of subsequent observations concluded that no adverse conditions existed within the dam that would preclude its full operation. Mention is made of the highly fractured rock noted in borings in both abutments and that apparently minor breaks in the grout curtain developed and subsequently self-sealed. One of these breaks is located in the left abutment area and could be related to the seepage observed downstream from the dam at this location.

As noted in the available documents, apparently several other seeps developed shortly after the sinkhole incident. Most of these seeps are still flowing and were observed during the visual inspection of Penn Forest Dam. Monitoring of these seepages indicated a flow rate on the order of 1.3 cfs, or about equivalent to the required discharge from the dam.

Other details of the dam performance were noted in the available files. Correspondence in 1967 mentions water seepage in the observation trenches on the downstream face of the dam. It was conjectured that this seepage is related to a perched water condition on top of layers of impervious fill that may have been placed in the downstream coarse fill zone

of the dam. There was no other treatment of this observation within the DER files on Penn Forest Dam.

In 1968 it was reported that the top of the core wall was about 9 inches below the top of the spillway wall whereas the Record Plans indicate that these two walls were to be built to the same elevation. A subsequent investigation involving the digging of a test trench adjacent to this area concluded that differential settlement between the two walls had not occurred.

The surface elevations adjacent to the wellpoints installed in the 1964 program were resurveyed in 1968. Within the DER files, a general statement is made that comparing the two sets of elevations indicated that Penn Forest Dam had not experienced any appreciable amount of settlement.

It was verbally reported that the reservoir slope adjacent to the intake structure has been periodically sloughing and eroding into the reservoir. This is the area in which a stability investigation is presently in progress. This instance does not appear to present a threat to the integrity of Penn Forest Dam. However, a loss of materials in this area, such as through a slide, could remove the lateral support from one side of the intake structure.

d. Post-Construction Changes. Aside from the repair and remedial construction and installation of piezometers, there were no reports nor is there any evidence that modification or alterations were made to the dam.

e. Seismic Stability. Penn Forest Dam is located in Seismic Zone I. As stated in the recommended guidelines for safety inspection for dams, 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. Thus, the same qualifications to the static stability of Penn Forest Dam also apply to the condition of seismic stability.

SECTION 7
ASSESSMENT/REMEDIAL PROCEDURES

7.1 Dam Assessment.

a. Safety. The visual inspection and the long-term performance of Penn Forest Dam indicates that the dam embankment and foundation is now performing in a way that does not present any obvious safety hazard. Clear water seepage is now being experienced downstream from the dam. The condition of the seepage does not now indicate any hazard to the integrity of the dam nor any hazardous condition within the dam. Of some concern is the apparent down slope creep and seepage on the downstream face of the dam. While these conditions do not present a hazard to the integrity of the dam, the possibility exists for the development of a hazardous condition.

The hydraulic and hydrologic analyses conducted by the Corps of Engineers in conjunction with the Beltzville Dam project indicates that Penn Forest Dam will not be overtopped by a PMF event. Thus, the spillway capacity of Penn Forest Dam is, by definition, "Adequate".

b. Adequacy of Information. The information available is such that the assessment of the stability of the dam embankment must be based in large measure upon the visual inspection. A previous engineering study reviewed addressed adequately the hydrologic and hydraulic conditions of Penn Forest Dam.

c. Urgency. It is considered that the recommendations presented below be implemented as soon as practicable.

d. Necessity of Additional Studies. Although the data did not include summaries of the stability analyses of the embankment that were performed in conjunction with the design of Penn Forest Dam or in conjunction with the 1964 investigation program at the dam, the visual inspection of the embankment does not indicate that additional studies of major magnitude are needed. However, additional studies should be performed as needed to implement the remedial measures.

7.2 Remedial Measures.

a. Alternatives. It is believed the down slope creep potential and water seepage on the downstream face of the dam require additional assessment. A monitoring program to detect movements should be established and maintained in the area of

slope creep. Applicable systems would consist of acoustic emissions monitoring or more conventional instrumentation such as settlement stakes, alignment stakes and borehole inclinometers.

Alternatively, an investigation should be conducted to synthesize and, if necessary, supplement available data and reevaluate the long-term stability of the embankment under the prevailing piezometric conditions. Depending upon the results of such investigations, repairs may or may not be indicated.

A program of periodic inspection of seepage in the downstream left abutment area should be implemented. In conjunction with this program, the previously noted seep flows around the dam should also be observed. Photographs and a written evaluation of the seeps (incluidng gaging or an estimate of the seepage rate) should be periodically made and compared with the previous observations. In conjunction with this program, measurements should be made in the area of the 18-inch flume downstream in Wild Creek to detect if any gross changes in seepage rate occur. This program is recommended as an alternate to refurbishing the previously installed weirs to measure seepage flow.

A similar periodic inspection program of the soil intrusion into the diversion tunnel should be implemented. Photographs and a written evaluation of the tunnel conditions should be made and compared with the documentations from previous inspections. A significant change in soil extrusion would indicate the necessity for remedial measures.

As noted, the slide conditions of the intake structure are being investigated. Whatever remedial measures are recommended in that study report should be implemented.

b. Operation and Maintenance Procedures. A formal procedure for observation and warning during periods of exceptionally high precipitation should be developed and implemented. Otherwise, the maintenance and operation of the dam as presently performed may be continued. However, written procedures for this operation and maintenance are recommended to assure continuity of these programs.

APPENDIX

A

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM *Penn Forest Dam*

ID # *Pa. 00608*

ITEM	REMARKS
AS-BUILT DRAWINGS	*"Plans for Penn Forest Dam and Reservoir" prepared by Morris Knowles, Inc. Pittsburgh, Pennsylvania. Set of 32 drawings with 13 supplemental drawings, all marked "Record Plan - January, 1959", available at Pennsylvania Department of Environmental Resources, Harrisburg.*
REGIONAL VICINITY MAP	*Sheet 1 of 32 of record plans.*
CONSTRUCTION HISTORY	*Periodic letters from Bethlehem Authority to State from July, 1956 to September, 1958 and other letters and memoranda describing construction progress in State files.*
TYPICAL SECTIONS OF DAM	*Sheet 4 of 32 of record plans.*
OUTLETS - PLAN	*Diversion: Sheet 5 of 32/Service: Sheet 15 and 17 of 32*
DETAILS	*Diversion: Sheet 6 of 32 and Supplemental drawing No. 4/Service: Sheet 16 of 32*
CONSTRAINTS	
DISCHARGE RATINGS	*Outlet valve - Drawing B-18489, Record Plan, January, 1959*
RAINFALL/RESERVOIR RECORDS	*Maintained by Owner.*

ITEM	REMARKS
DESIGN REPORTS	*Not available.*
GEOLOGY REPORTS	*Published geologic literature and maps. Geology report for design studies not available.*
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	*Not available.* *Calculation of stability during drawdown, dated 11-12-55, in State file.*
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	*Borings and Test Pits - locations, elevations and column logs of borings - Record Plan - January, 1959 - Sheet 31 of 32.*
POST-CONSTRUCTION SURVEYS OF DAM	*None available.*
BORROW SOURCES	*Locations of borrow areas and test pits - Record Plans - January, 1959 - Sheet 32 of 32.*

ITEM	REMARKS
MONITORING SYSTEMS	*None installed in conjunction with dam construction.*
MODIFICATIONS	*None made.*
HIGH POOL RECORDS	*Available at Chemical facility, below Wild Creek Dam.*
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	*Investigation of dam materials and stability cited in State file but not available. Numerous reports of seepage conditions of dam were prepared, some of which are available in State file and from Gannett Fleming Corddry and Carpenter, Inc., Harrisburg.* *"Beltzville Dam and Reservoir, Design Memorandum No. 1, Hydrology and Hydraulics", U.S. Army Engineer District, Philadelphia, December 1963.*
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	*"Sink hole" developed in May, 1960, in upstream face about 5' below design pool level. Investigations, studies and reports were performed since then.*
MAINTENANCE OPERATION RECORDS	*Maintained by Owner/Operator.*

ITEM	REMARKS
SPILLWAY PLAN SECTIONS	*Sheet 7 of 32 of Record Plans.*
DETAILS	*Sheets 8, 9, 10 of 32 and Supplemental Drawing Nos. 2, 6, 7 of Record Plans.*
OPERATING EQUIPMENT PLANS & DETAILS	*Outlet valve - Sheet 16 of 32 and Supplemental Drawing No. 9 of Record Plans.* *Intake - Sheets 17, 18, 19, 20, 21, 22, 23 of 32 and Supplemental Drawing No. 10 of Record Plans.*

APPENDIX

B

CHECK LIST
VISUAL INSPECTION
PHASE I

Name Dam *Penn Forest Dam* County *Carbon* State *Pennsylvania* National ID # *Pa. 00608*

Type of Dam *Rolled Earth and Rock* Hazard Category *I (HIGH)*

Date(s) Inspection *4/26/78* Weather *Hazy* Temperature *60°±*

Pool Elevation at Time of Inspection *1,000.1* M.S.L. Tailwater at Time of Inspection *852* M.S.L.

Inspection Personnel:

John H. Frederick, Jr. (Geotechnical) *Robert E. Griffith, Jr. (Structural)* *Richard E. Mabry (Geotechnical)*

Mary F. Beck (Hydrologist) *Vincent McKeever (Hydrologist)*

Raymond S. Lambert (Geologist)

Richard E. Mabry Recorder

Remarks:

Inspection team was accompanied by J. DeFebbo and A. Broody of the Pennsylvania, Department of Environmental Resources, Reading regional office.

Owner's representative was Larry Enstrom, Assistant Forester

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	*N/A*	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	*N/A*	
DRAINS	*N/A*	
WATER PASSAGES	*N/A*	
FOUNDATION	*N/A*	

CONCRETE/MASONRY DAMS

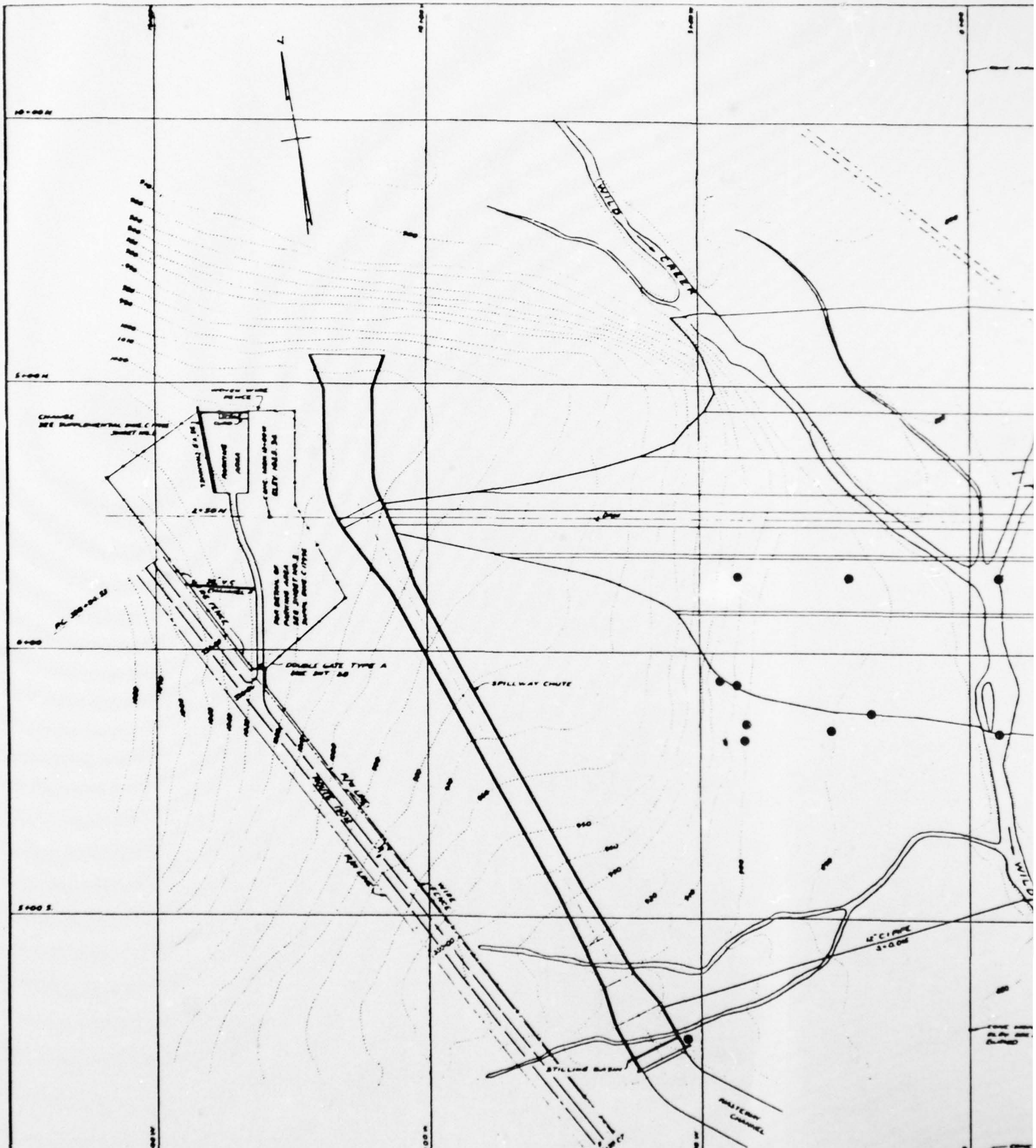
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	*N/A*	
STRUCTURAL CRACKING	*N/A*	
VERTICAL AND HORIZONTAL ALIGNMENT	*N/A*	
MONOLITH JOINTS	*N/A*	
CONSTRUCTION JOINTS	*N/A*	

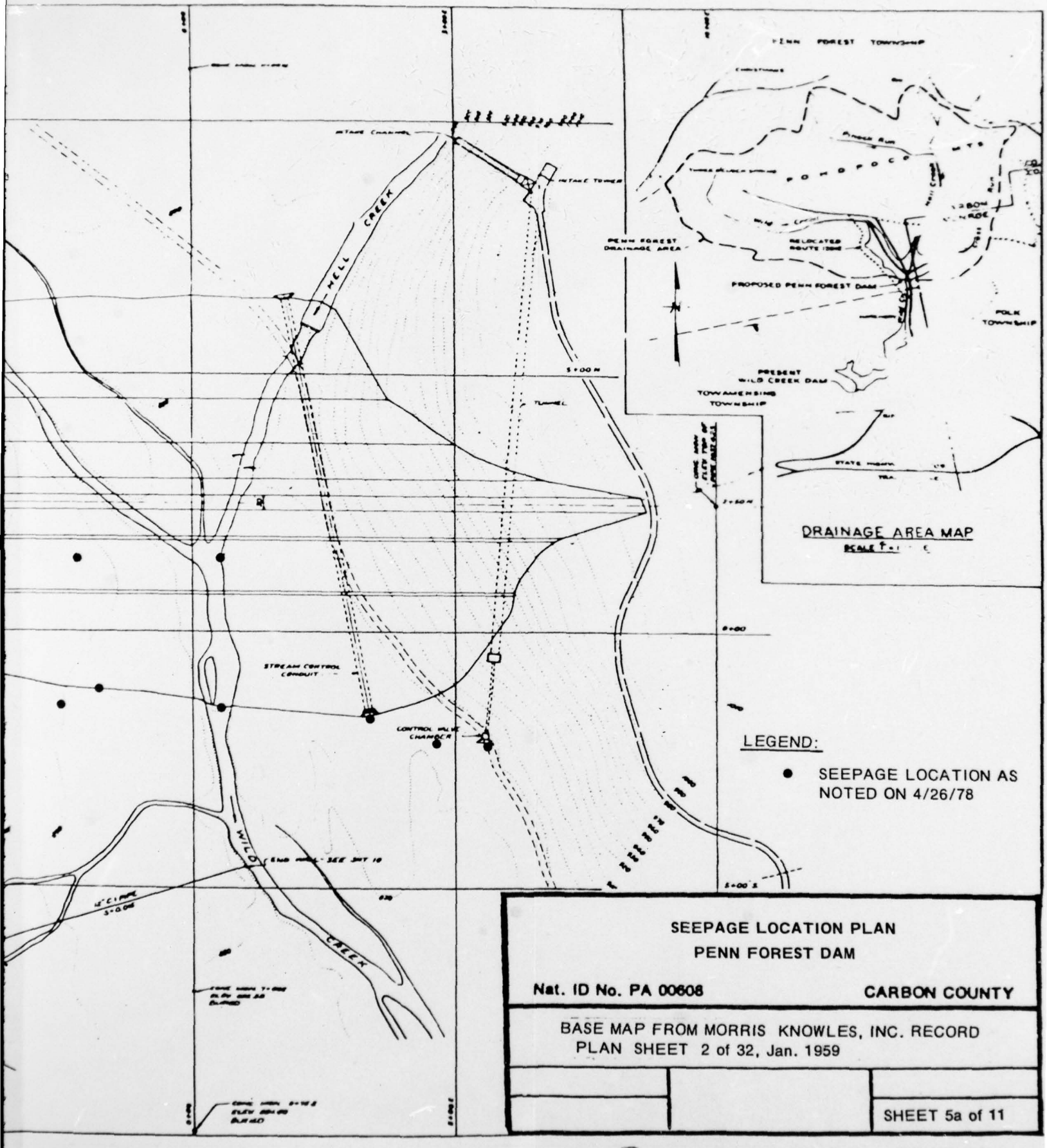
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	*None observed*	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	*None observed*	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	*Cracked and distorted tile drain gutters on downstream slope berms, especially in area of reported "sink hole" (See Photo No.9) possibly indicating compression movement laterally and down slope. Occasional cracks in concrete "flashing" and void spaces around gutters. Reservoir slope instability adjacent to intake structure (See Photo No. 1).*	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	*Horizontal alignment of crest is straight. There are several broad shallow undulations along dam crest (50' to 100' long and about ±.3' maximum depth). There is a noticeable depression in crest in vicinity of "sink hole". Throughout the dam crest there is a general transverse tilt downward toward the upstream side of the dam.*	
RIPRAP FAILURES	*Rip-rap in generally good condition - no bumps or scalloping - color change noted in "sink hole" vicinity (See Photo No. 7) - occasional pieces of shale in riprap.*	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ROCK TOE	*Vegetation growing over most of rock toe area of dam with some "bare" areas of rock showing (See Photo No. 2 and 8).*	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	*Occasional cracking of tile drain gutter at abutment. Minor wave erosion of crushed rock backfill at left forebay wall. Possible embankment/backfill settlement of about 1' at left spillway crest wall exposing top of core wall at spillway crest and extending about 40' upstream.*	
ANY NOTICEABLE SEEPAGE	*Numerous clear water seeps - lush grass growth on downstream dam slope in "sink hole" vicinity and in observation trenches. Standing water and marshy ground in all observation trenches at about Elevation 970 and visible and audible seepage in western most trench at "sink hole" vicinity. Major seepage and marshy area at toe and right abutment. Slight seep into joint in toe gutter and then out of another joint several sections away. Slight seep in road at toe of dam (See Photo No. 8). Major leakage at toe - trench previously dug and sections of gutter removed to pick up leakage. Major leakage below toe to right of diversion tunnel. Also water flowing from weepholes at drawdown outlet structure (barely discernable in Photo No. 4). Seepage from downstream left abutment near valley floor. Small seep at left wall of stilling basin.*	
STAFF GAGE AND RECORDER	*Measuring scale on wall at spillway crest - measurements also made at intake structure.*	
DRAINS	*See Item 3 above.*	


10+00 N
5+00 N
0+00
5+00 S
WILD CREEK
SPILLWAY CHUTE
STILLING BASIN
DOUBLE GATE TYPE A
WIRE FENCE
WILD



SEEPAGE LOCATION PLAN
PENN FOREST DAM

Nat. ID No. PA 00608 **CARBON COUNTY**

BASE MAP FROM MORRIS KNOWLES, INC. RECORD PLAN SHEET 2 of 32, Jan. 1959

SHEET 5a of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	*Concrete crown structure in tunnel with unconcreted floor of tunnel. Floor covered with sand and gravel - tunnel muck possibly - and freely flowing water. Some undercutting of tunnel lining (up to 4") at floor level. Numerous cracks in lining - mostly transverse to tunnel but some longitudinal cracks at crown. Most cracks were leaking - some cracks and holes had constant streams of water flowing. Leakage frequently accompanied with C_aCO_3 precipitate (See Photo No. 10) and some brown/black staining and soil deposits. Leakage most frequent at about dam centerline and above. CIP and thrust block behind intake structure as well as RCP through tunnel appear in good condition. No exceptional seepage at upstream end of tunnel. Some local deterioration of concrete pipe supports.*	
INTAKE STRUCTURE	*Inspected portion of structure above water - concrete work and timber roof framing in good condition - some erosion at reservoir water line. Grating and stop log guides are rusting - minor crack where inlet section joins main body of structure - investigation of adjacent slope stability in progress by others at time of visual inspection.*	
OUTLET STRUCTURE	*Structure in good condition (See Photo No. 4). Void between concrete apron and right wall. Minor separation between walls and building structure. Spray valve exercised.*	
OUTLET CHANNEL	*Rip-rap in good condition downstream from spray valve.*	
EMERGENCY GATE	*Structure at outlet appears to be in good condition (See Photo No. 3). Water flowing from weep holes appears to be in greater volume than water in tunnel. Some erosion under rip-rap in channel. Tandem gate valves at downstream end of pipe reported to be operated and appeared to be well mainteined. Tunnel is in generally good condition up to bulkhead (about 300 feet). Some minor transverse cracking and staining on wall with some soil intrusion. Some C_aCO_3 at bulkhead and at water seeps.*	

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	*Erosion of protective paint coating on steel armor plate of weir. Concrete in generally good condition - uniform water flow.*	
APPROACH CHANNEL	*Water in channel precluded inspection of slab. Cantilever side walls in generally good condition with minor shrinkage cracking. Expansion joint material eroded in upper several feet of wall. Minor scaling and "D" line cracking on top of walls. Longitudinal cracks at each joint on top of water stop terminal. Alignment generally good but with offsets up to 1" at top of some expansion joints. 1" separation at exposed anti-seepage flange and spillway wall and torn waterstop.*	
DISCHARGE CHANNEL	*Uniform flow of water down channel. Slab alignment is good with no evidence of uplift, warpage, or buckling. Shrinkage cracks at centers of all panels and erosion at expansion joints. Gravity side walls in generally good condition with good alignment. Numerous shrinkage cracks and many key joints sheared. Spalling on top of wall and at occasional construction joints. More deterioration at panels adjacent to stilling basin with horizontal and vertical cracks up to 1/8" and with some C_aCO_3 deposits. Counterfort walls of stilling basin in good alignment and condition. Minor cracking at junction of wall and counterfort. Large spall at junction with gravity wall. Occasional popouts and scaling and erosion at joints at spillway discharge. Numerous cracks and fair concrete condition. Good alignment. Large seeps of clear water.*	
BRIDGE AND PIERS	*N/A*	

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	*N/A*	
APPROACH CHANNEL	*N/A*	
DISCHARGE CHANNEL	*N/A*	
BRIDGE AND PIERS	*N/A*	
GATES AND OPERATION EQUIPMENT	*N/A*	

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	*None*	
OBSERVATION WELLS	*See Piezometers, below*	
WEIRS	*Weir at gutter drain at dam toe in state of disrepair. Other wiers referred to in previous reports are destroyed or in disrepair.*	
PIEZOMETERS	*Reported 275 piezometers and observation wells are installed and monitored twice monthly with measurements sent to Garnett Fleming Corddry and Carpenter, Inc., Harrisburg, Pennsylvania.*	
OTHER	*None observed*	

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS

SLOPES *Reservoir slopes (except near Intake Structure) are stable and of moderate inclination. Slopes are generally grass covered for 20' back from water (Elevation 1000) and wooded beyond. Small area of sloughing in upper end of reservoir. No evidence of significant debris that could enter water.*

SEDIMENTATION *Minimal sedimentation in upper reaches of reservoir expected to have negligible effect on storage.*

Small pond (about 2 acres) above reservoir on Wild Creek. Pond has maximum depth on order of 9' and is not expected to have a significant effect on hydrologic conditions.

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	*Some disintegration of rock of downstream channel is producing sediment accumulation further downstream.*	
SLOPES	*Moderate to steep with timber growing to edge of bank.*	
APPROXIMATE NO. OF HOMES AND POPULATION	*No houses between Penn Forest Dam and Wild Creek Dam immediately downstream. One rural highway below Penn Forest Dam.*	

APPENDIX

C

PENN FOREST DAM
CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: *90 percent wooded, mountainous*

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): *1,000 Ft. (19,980 Ac-Ft.)*

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): *1,014 Ft. (7,175 Ac-Ft.)*

ELEVATION MAXIMUM DESIGN POOL: *1,012.4 Ft.*

ELEVATION TOP DAM: *1,014 Ft. (field observation) 1,015 Ft. (design)*

SPILLWAY

a. Elevation *1,000 Ft.*

b. Type *Sharp crest weir with concrete chute*

c. Width *N/A*

d. Length *85 Ft.*

e. Location Spillover *Right abutment*

f. Number and Type of Gates *None*

OUTLET WORKS: (Water Supply)

a. Type *48-inch RCP*

b. Location *Left abutment*

c. Entrance inverts *900*

d. Exit inverts *875*

e. Emergency draindown facilities *36" CIP located in stream diversion tunnel*

HYDROMETEOROLOGICAL GAGES:

a. Type *Standard rain gauge*

b. Location *Chemical Building 2.8 miles downstream*

c. Records *Maintained at Chemical Building and sent to Weather Service*

MAXIMUM NON-DAMAGING DISCHARGE: *Not determined*

DAM SAFETY ANALYSIS
HYDROLOGIC/HYDRAULIC DATA

Date: 5/15/78
By: MFB
Sheet 2 of 5

DAM Penn Forest Dam Nat. ID No. PA 609 DER No. 13-85

	ITEM/UNITS	Permit/Design Files (A)	Calc. from Files/Other (B)	Calc. from Observations (C)
1.	Min. Crest Elev., ft.	1015 ft.		1014 ft.
2.	Freeboard, ft.	2.6 ft		1.6 ft
3.	Spillway(1) Crest Elev, ft.	1000 ft.		
3a.	Secondary(2) Crest Elev, ft.	N/A		
4.	Max. Pool Elev., ft.			1012.4 ft.
5.	Max. Outflow(3), cfs	12,000 cfs	12,000 cfs	
6.	Drainage Area, mi^2	16.5 $mile^2$	16.1 $mile^2$	15.9 $mile^2$
7.	Max. Inflow(4), cfs		16,800 cfs	
8.	Reservoir Surf. Area,	462 Ac		462 Ac
9.	Flood Storage(5) Ac-Ft			7175 Ac-Ft
10.	Inflow Volume, ft^3			

Reference all figures by number or calculation on attached sheets:

Example: 3A - Drawing No. xxx by J. Doe, Engr., in State File No. yyyy.

NOTES:

(1) Main emergency spillway.

(2) Secondary ungated spillway.

(3) At maximum pool, with freeboard, ungated spillways only.

(4) For columns B and C, use PMF.

(5) Between lowest ungated spillway and maximum pool.

Date: 5/15/78
By: MFB
Sheet 3 of 5

HYDROLOGIC/HYDRAULIC CALCULATIONS (cont.)

Item (from sheet 2)	Source
2A, 5A, 6A	Application Report, Nov. 3, 1955
6C, 8C	USGS Maps Pohopoco Mountain (1970) Christmans (1970)
5B, 6B, 7B	OCE Design Memorandum No. 2 Beltzville Dam and Reservoir Hydrology and Hydraulics
2C, 4C, 1C, 9C	See Sheet 4 of 5

BY MFB DATE 5/30/78 Rev. 6/23/78 SUBJECT Penn Forest Dam SHEET 4 OF 5

CHKD. BY DATE JOB No.

Spillway Discharge

Length = 85 ft

C = coefficient of discharge, estimated from statements contained Nov. 3, 1935 Application Report = 3.24 (assumed constant)
Study made by McPherson & Strausser

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

if $Q = 12{,}000$ cfs

$12{,}000 = 85 \times 3.24 \times H^{3/2}$

$H = 12.4$ ft

Maximum Head (existing conditions) = 14 ft. (See Appendix B sheet 5)
∴ Freeboard = 14 - 12.4 = 1.6 ft.
(top of dam 1014 ft., min. crest elevation)

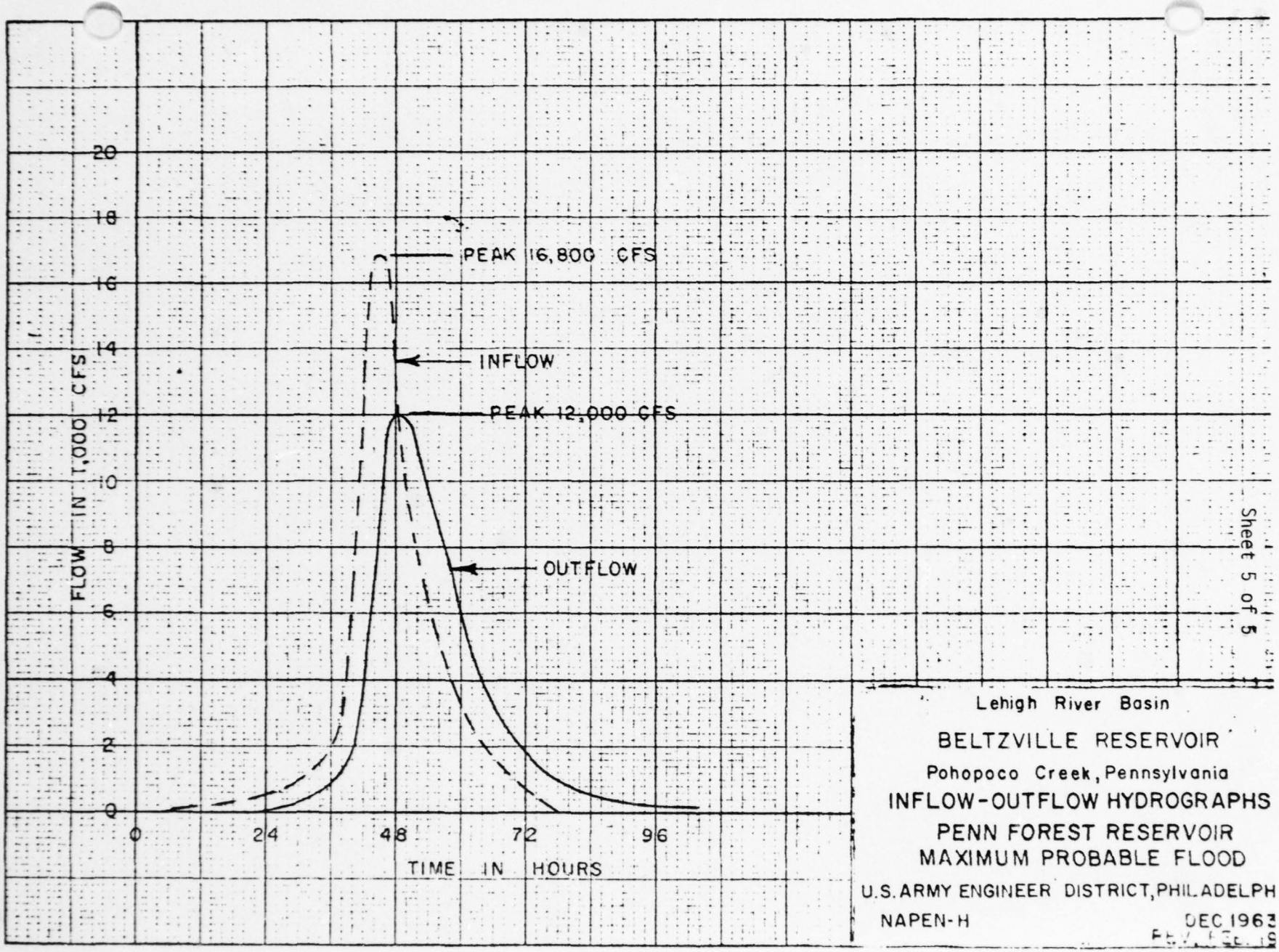
CONCLUSION: PENN FOREST WILL PASS PMF WITHOUT OVERTOPPING

Flood Storage

Surface Area of Reservoir at elev. 1000 = 462 Ac
Surface Area of Reservoir at elev. 1015 = 563 Ac

Distance between Spillway Crest and Minimum Crest elev. - 14 ft (field checked)

Flood (or Surcharge) Storage 7195 Ac-Ft



Sheet 5 of 5

Lehigh River Basin

BELTZVILLE RESERVOIR

Pohopoco Creek, Pennsylvania

INFLOW-OUTFLOW HYDROGRAPHS

PENN FOREST RESERVOIR

MAXIMUM PROBABLE FLOOD

U.S. ARMY ENGINEER DISTRICT, PHILADELPH

NAPEN-H

DEC 1962

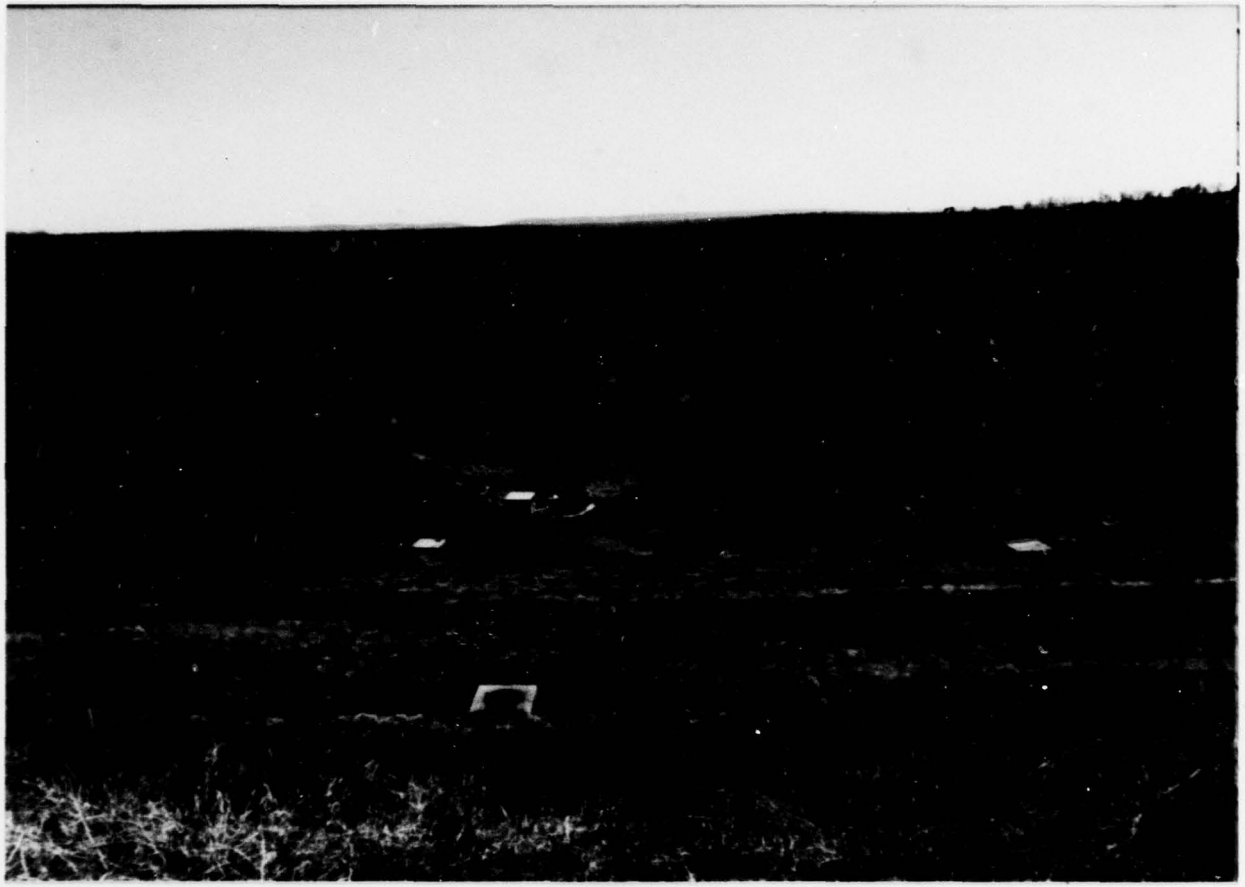
PLATE 45

APPENDIX

D

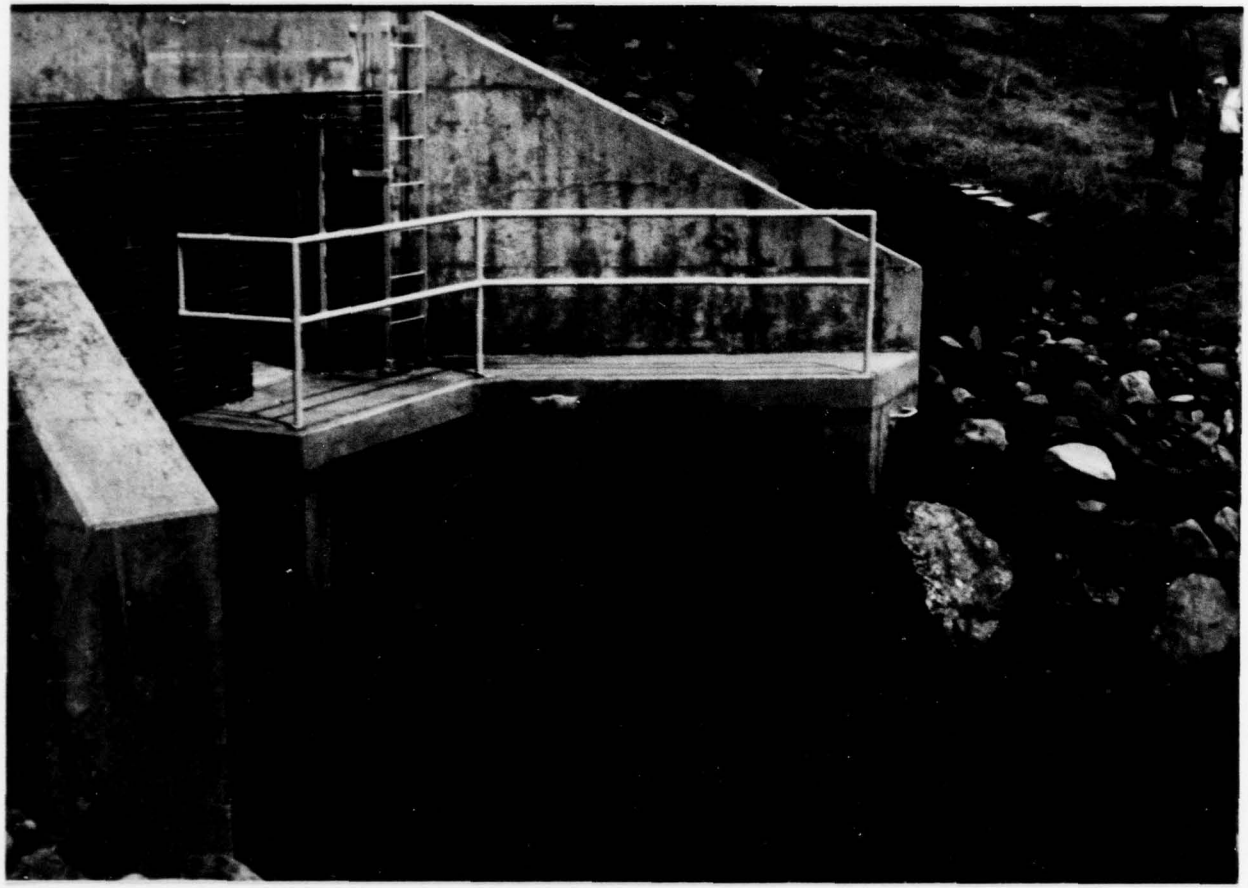
VIEW OF INTAKE TOWER AND RESERVOIR BANK UPSTREAM
FROM LEFT DAM ABUTMENT.

PHOTO NO. 1



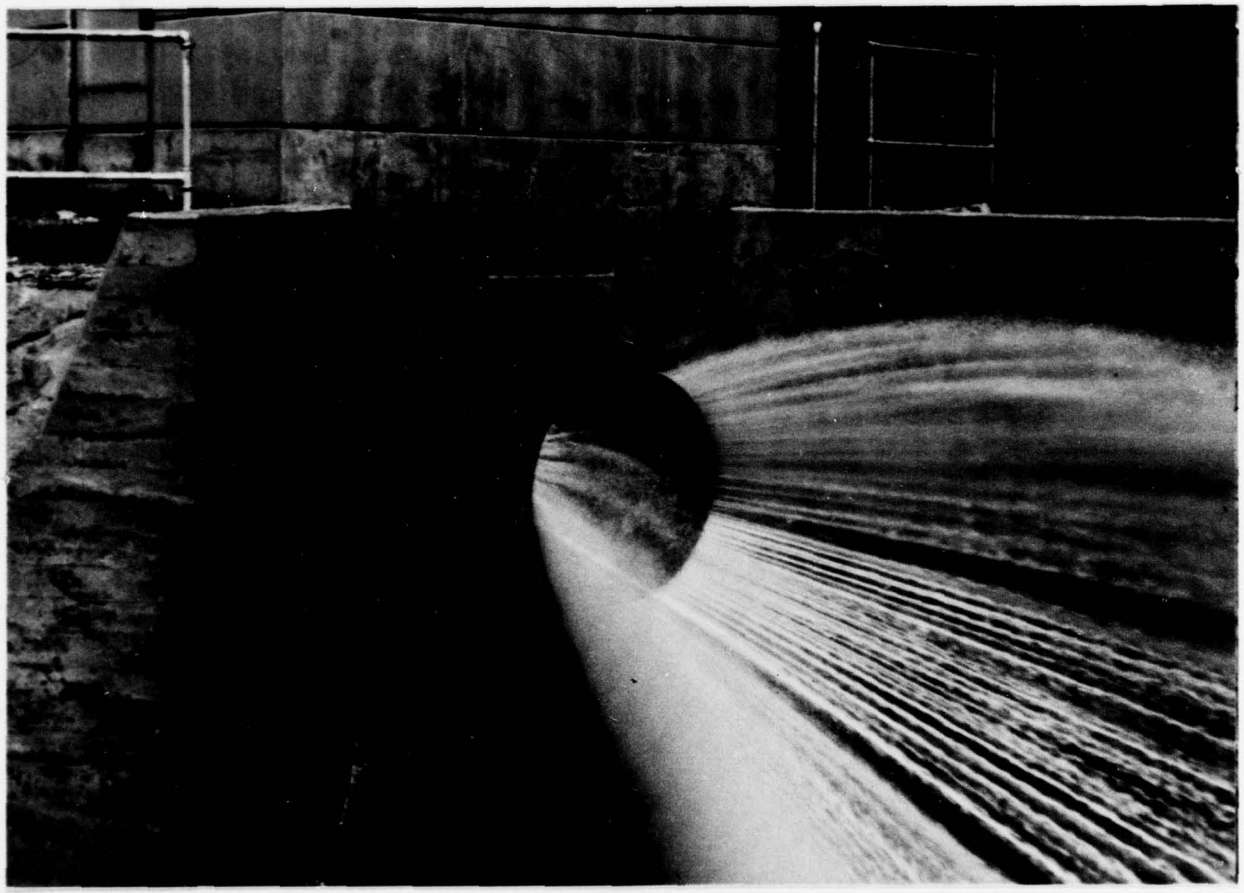
VIEW LOOKING DOWNSTREAM FROM CREST OF DAM SHOWING DOWNSTREAM DAM SLOPE WITH BERM GUTTERS IN FOREGROUND, OPERATING DISCHARGE STRUCTURE AND CHANNEL IN CENTER, AND DRAWDOWN DISCHARGE STRUCTURE AND CHANNEL IN RIGHT CENTER.

PHOTO NO. 2



DRAWDOWN DISCHARGE STRUCTURE WITH 36-INCH OUTLET PIPE
(See Photo No. 2 for orientation).

PHOTO NO. 3

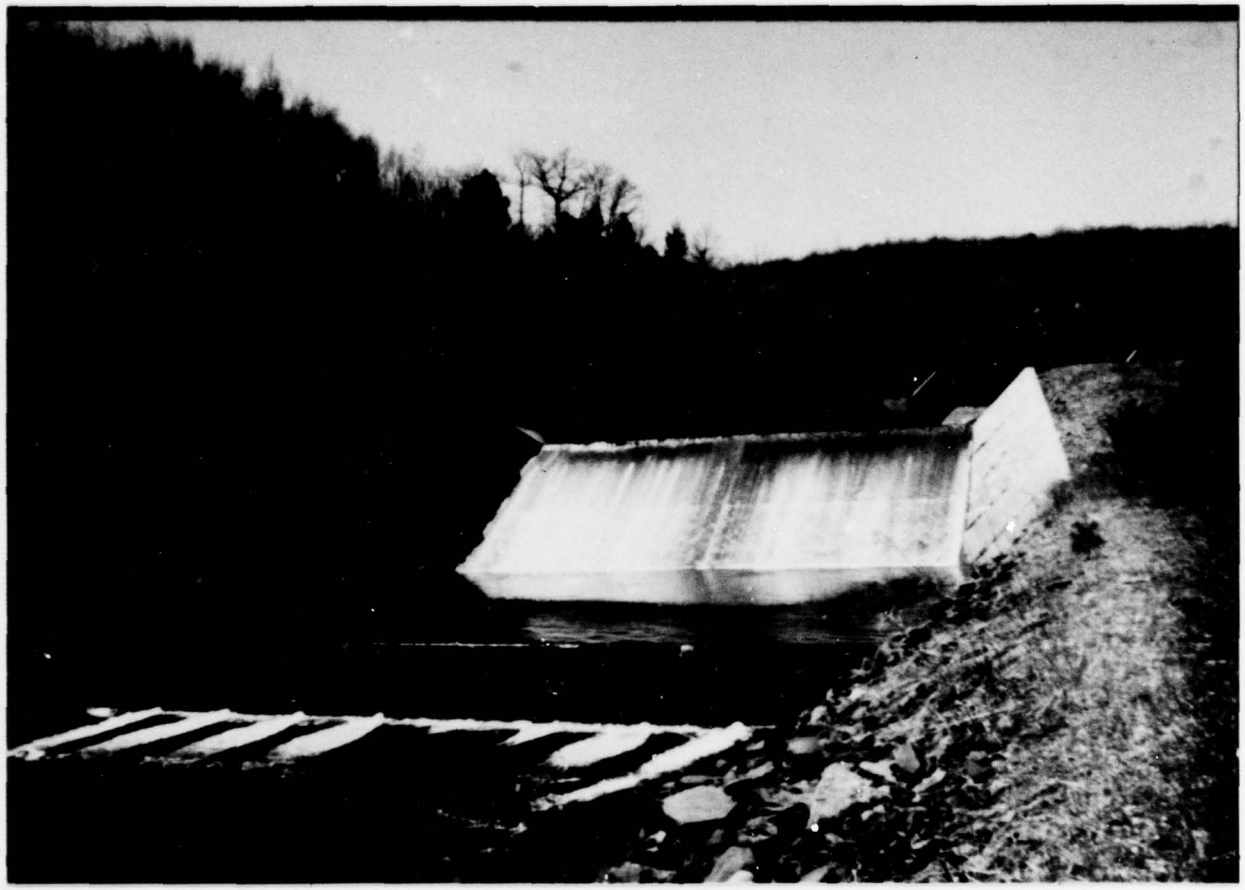


OPERATING DISCHARGE STRUCTURE WITH 48-INCH SPRAY VALVE.
(See Photo No. 2 for orientation).

PHOTO NO. 4

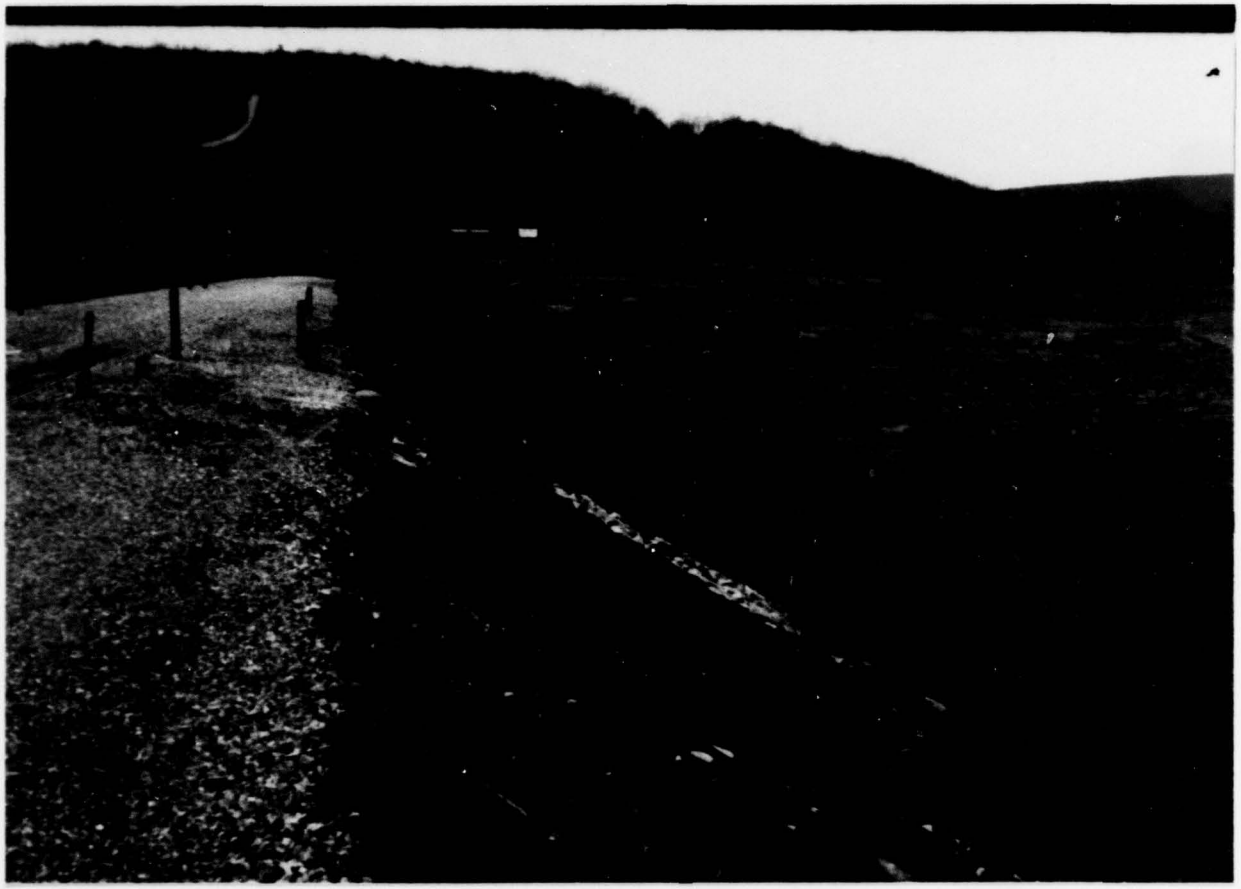
VIEW OF SPILLWAY CREST LOOKING DOWNSTREAM

PHOTO NO. 5



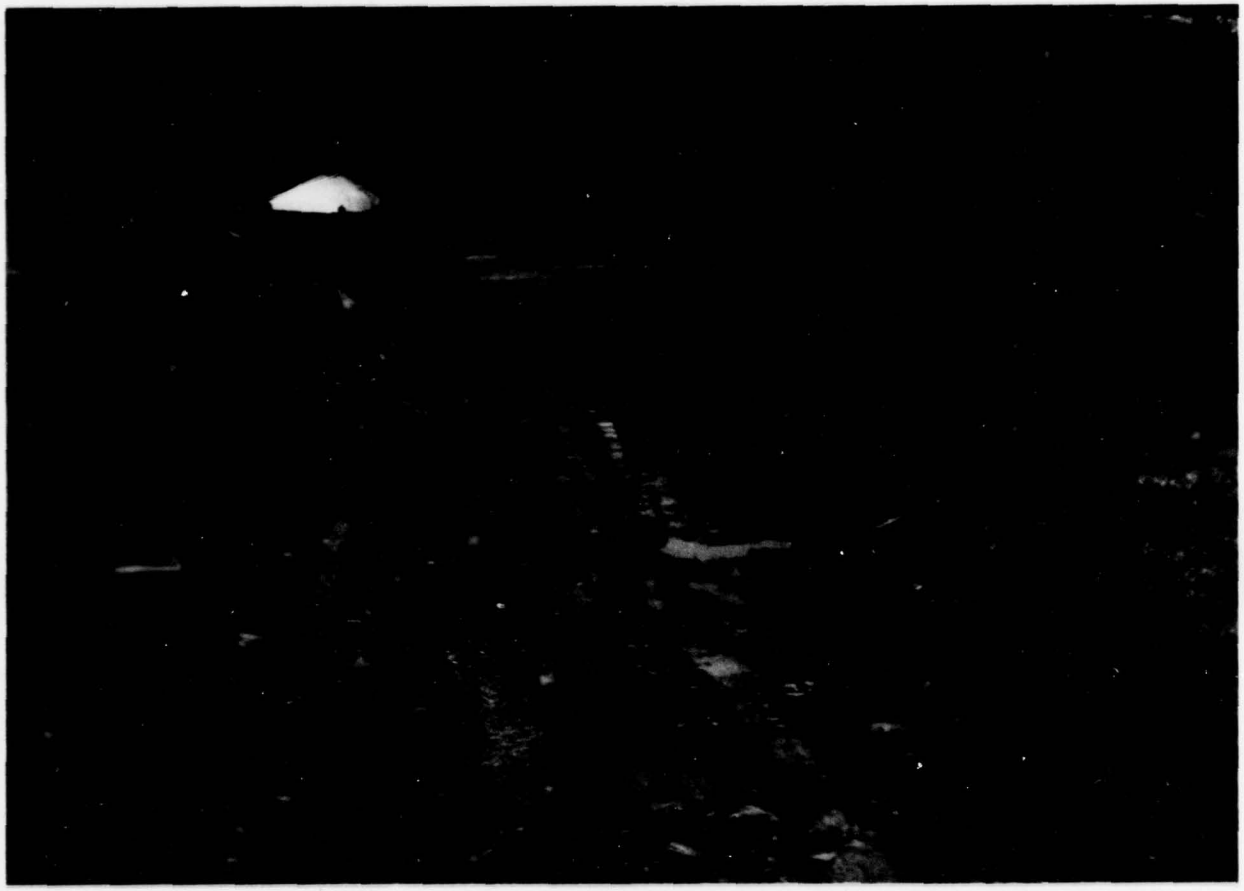
VIEW OF STILLING BASINS

PHOTO NO. 6



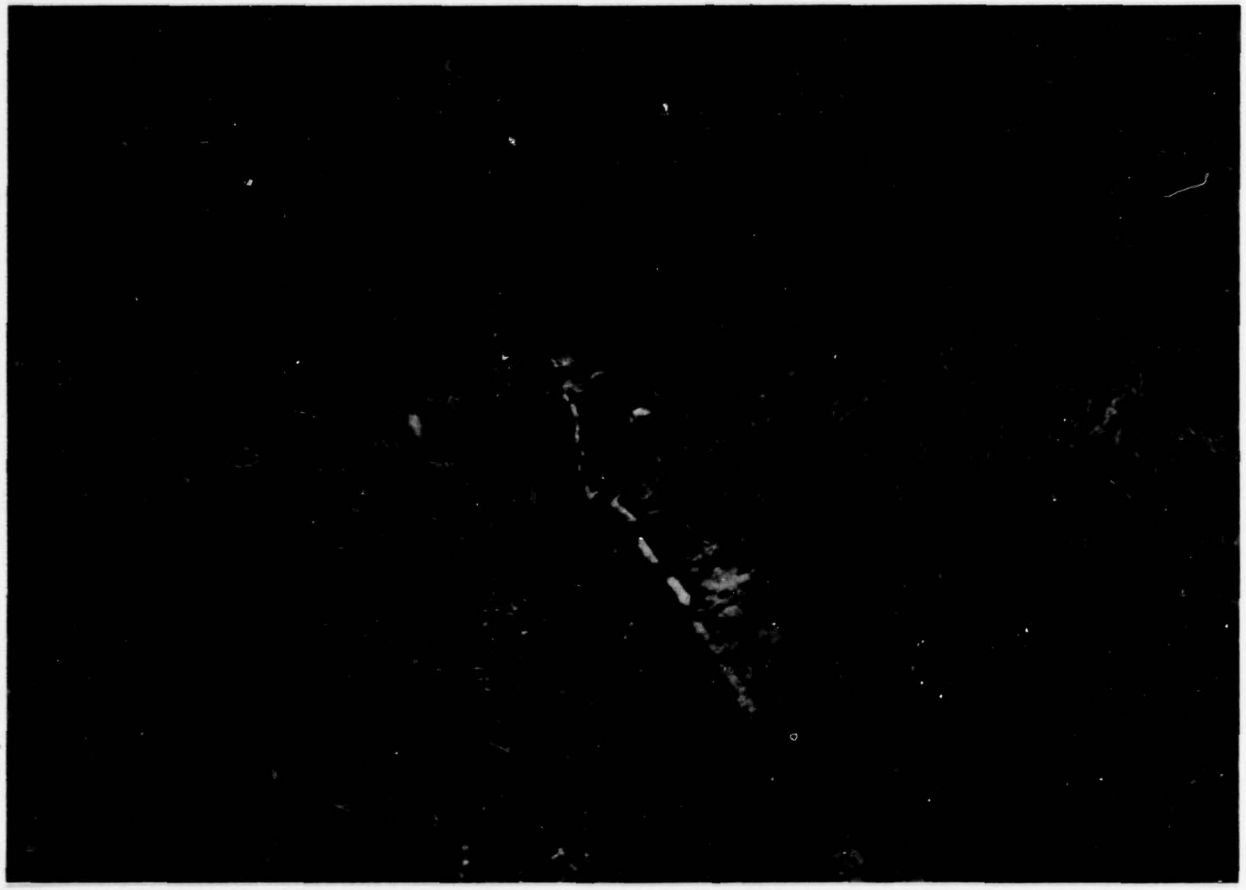
VIEW OF CREST AND UPSTREAM SLOPE OF DAM LOOKING TOWARD RIGHT ABUTMENT. NOTE CONDITION OF RIPRAP AND DAM CREST, DIFFERENT COLOR RIPRAP POSSIBLY INDICATING "SINK HOLE" REPAIR, AND PIEZOMETER LOCATIONS.

PHOTO NO. 7



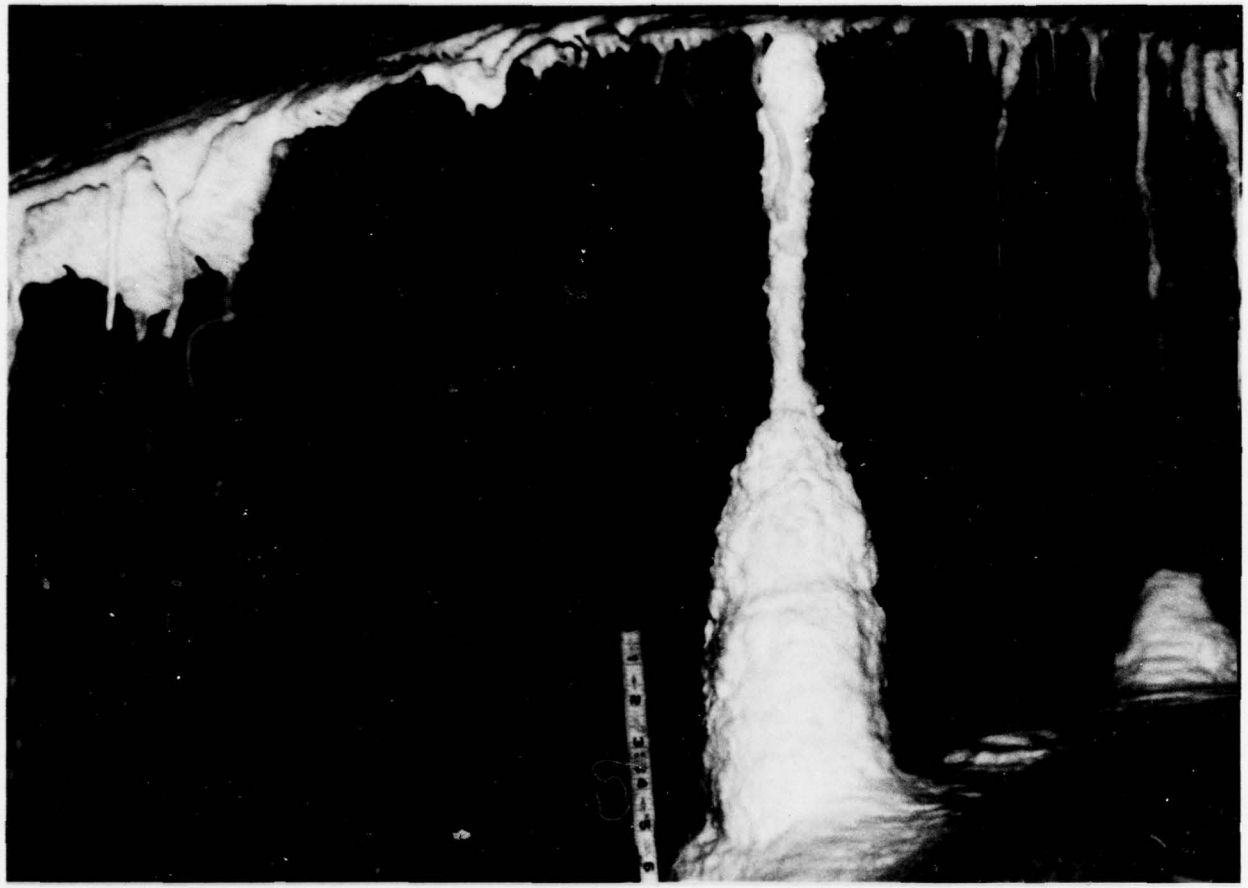
DOWNSTREAM TOE OF DAM SHOWING SEEPAGE AREA IN ACCESS ROAD AND TILE GUTTER DRAIN, PLUME FROM SPRAY VALVE IN BACKGROUND (See Photo No. 2 for orientation), AREA OF TOE SEEPAGE INTO GUTTER DRAIN IN HIGH LEFT CENTER.

PHOTO NO. 8



CONDITION OF TILE GUTTER DRAIN IN LOWER DOWNSTREAM SLOPE BERM (El. 950) IN VICINITY OF "SINK HOLE" AREA. NOTE PIEZOMETER HOUSINGS ON BERM.

PHOTO NO. 9

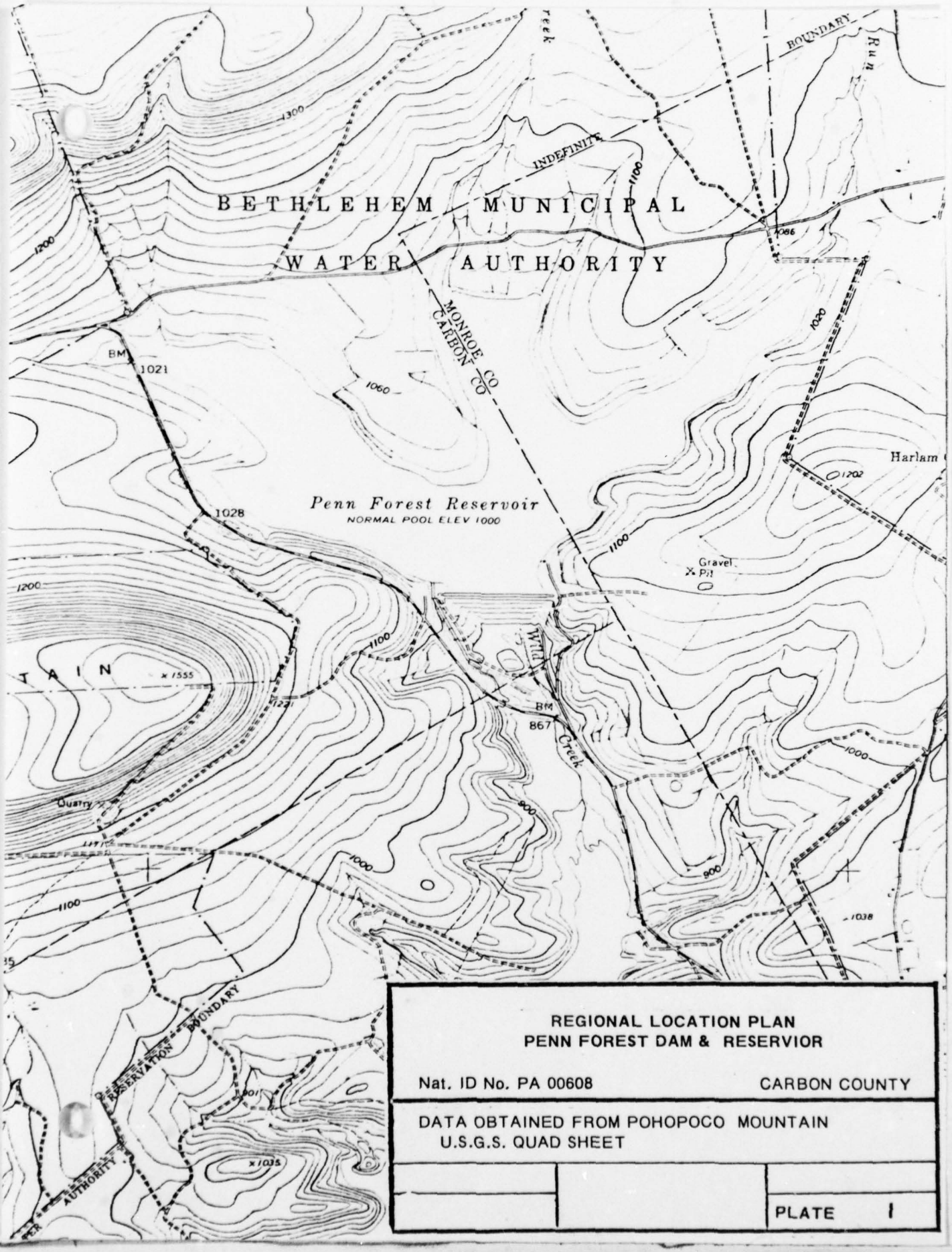


CALCIUM CARBONATE PRECIPITATE FORMATION OVER 54-INCH CONCRETE INTAKE PIPE IN INTAKE TUNNEL. NOTE PRECIPITATE ACCUMULATION ALONG CRACK IN TUNNEL ROOF.

PHOTO NO. 10

APPENDIX

E

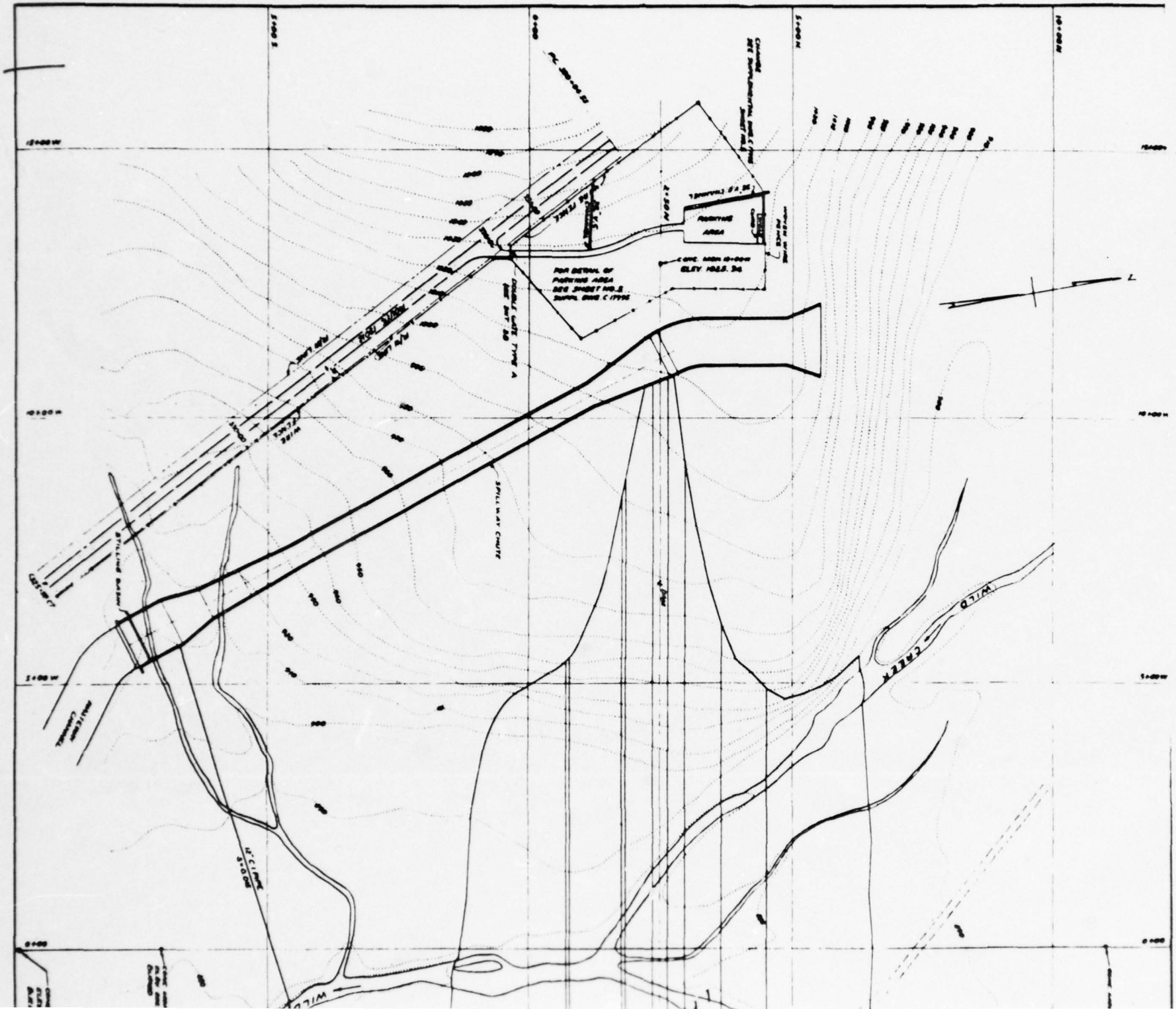


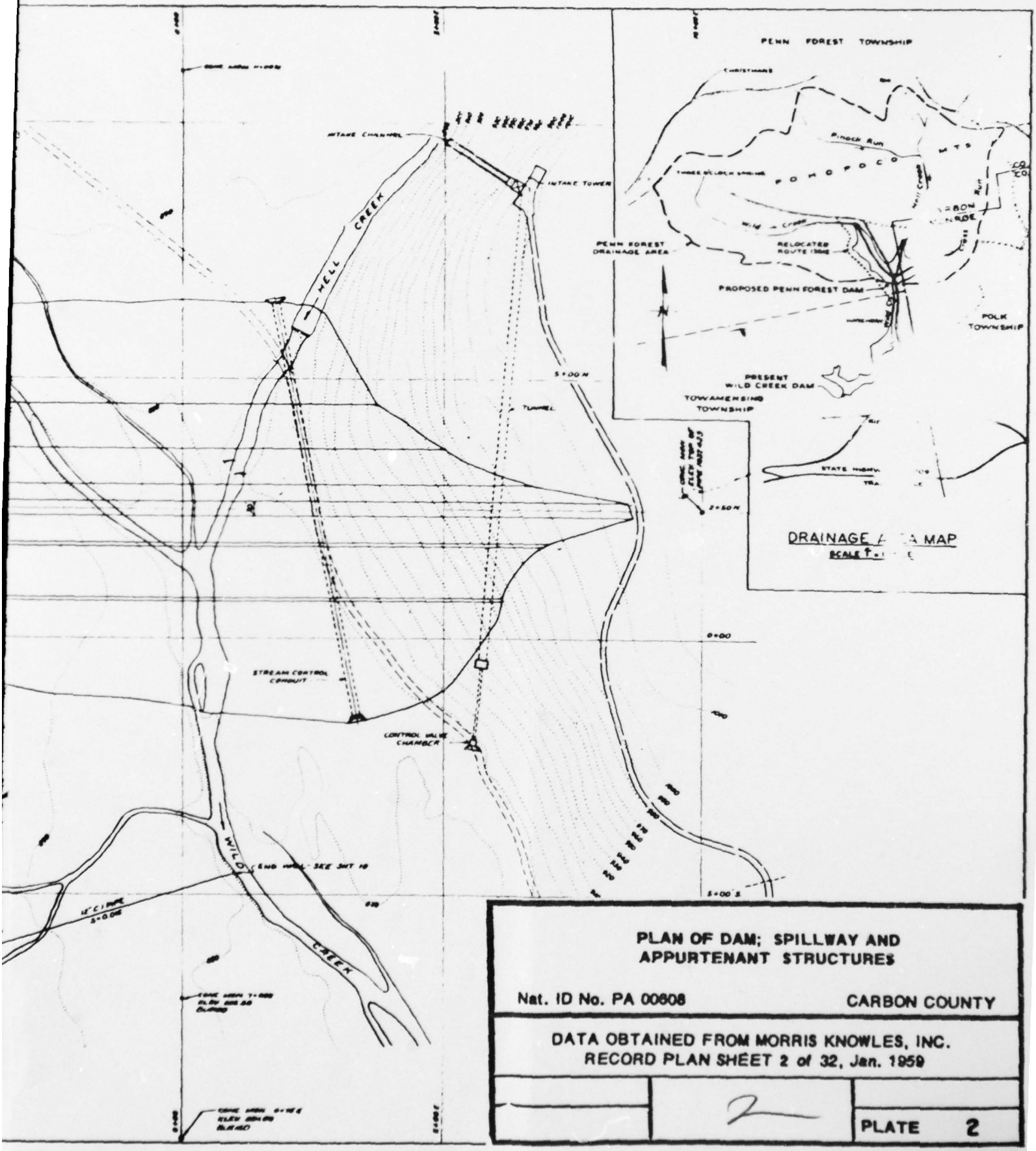
REGIONAL LOCATION PLAN
PENN FOREST DAM & RESERVIOR

Nat. ID No. PA 00608 CARBON COUNTY

DATA OBTAINED FROM POHOPOCO MOUNTAIN
U.S.G.S. QUAD SHEET

PLATE 1


SPILLWAY CHUTE
STILLING BASIN
CREEK
WILLOW



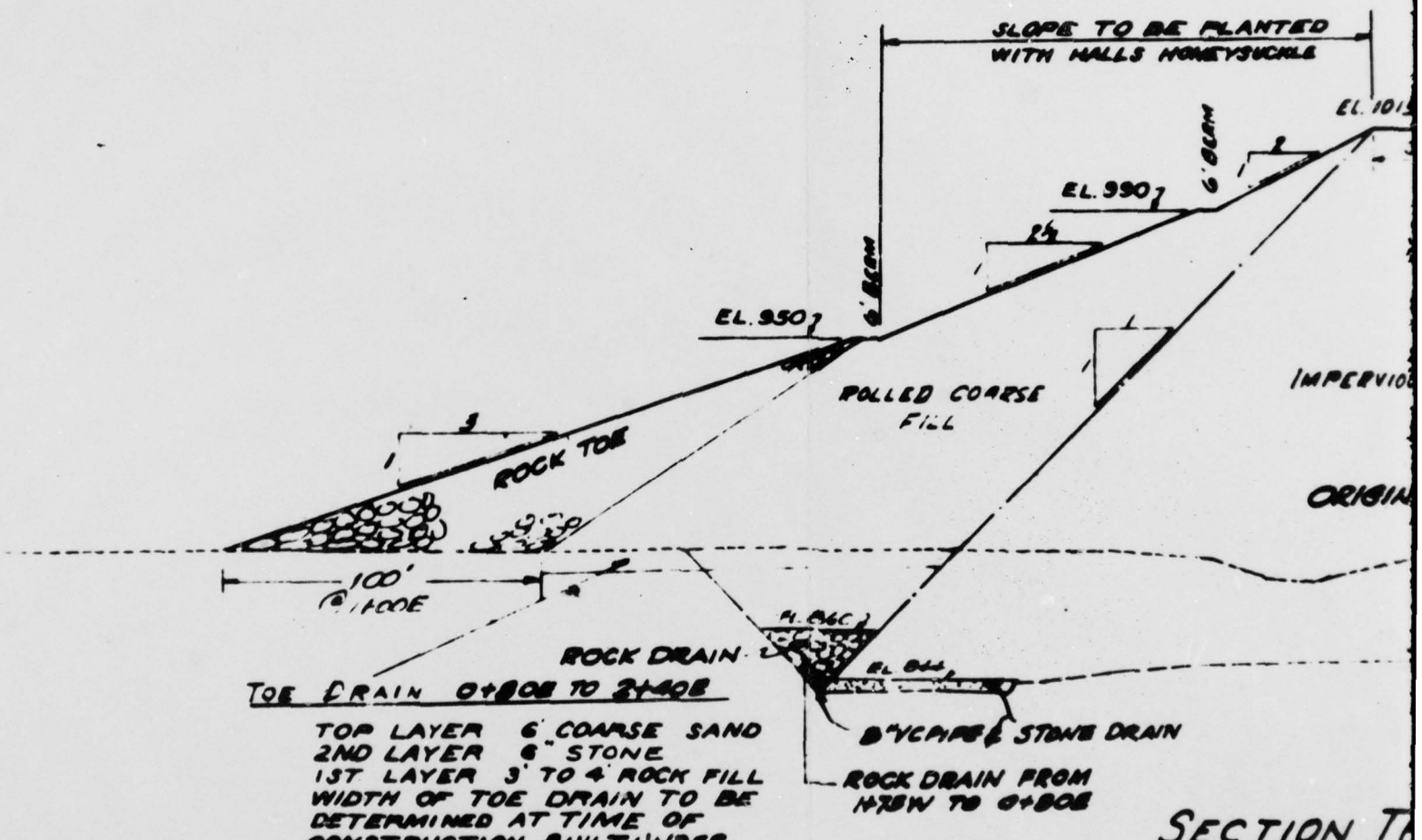
PLAN OF DAM; SPILLWAY AND APPURTENANT STRUCTURES

Nat. ID No. PA 00608 — CARBON COUNTY

DATA OBTAINED FROM MORRIS KNOWLES, INC.
RECORD PLAN SHEET 2 of 32, Jan. 1959

2

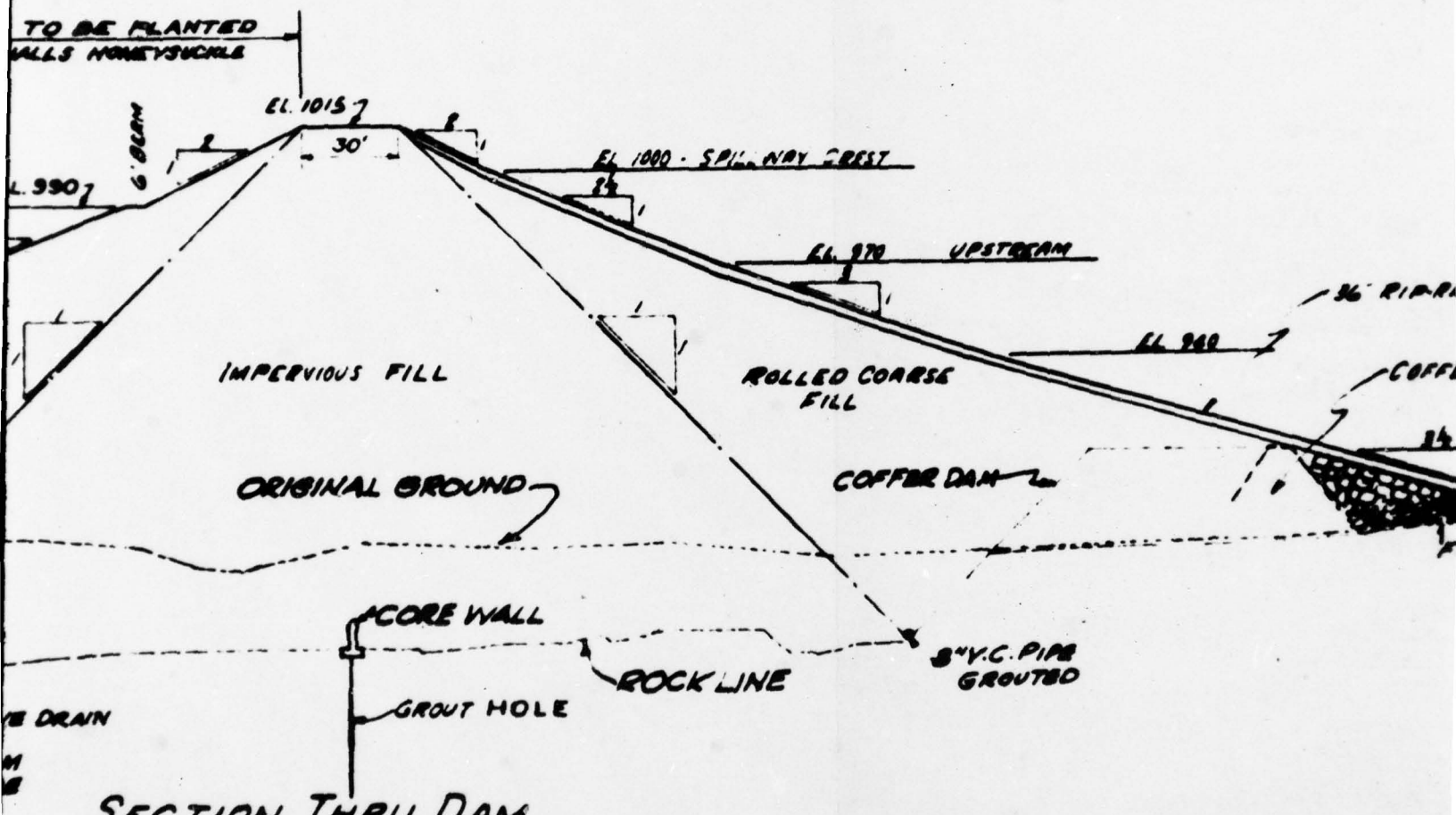
PLATE 2



TOE DRAIN 0+80E TO 2+40E

TOP LAYER 6" COARSE SAND
2ND LAYER 6" STONE
1ST LAYER 3' TO 4' ROCK FILL
WIDTH OF TOE DRAIN TO BE
DETERMINED AT TIME OF
CONSTRUCTION, BUILT UNDER
COARSE FILL

SECTION TH
AT COORDINA
(TYPI
SCALE

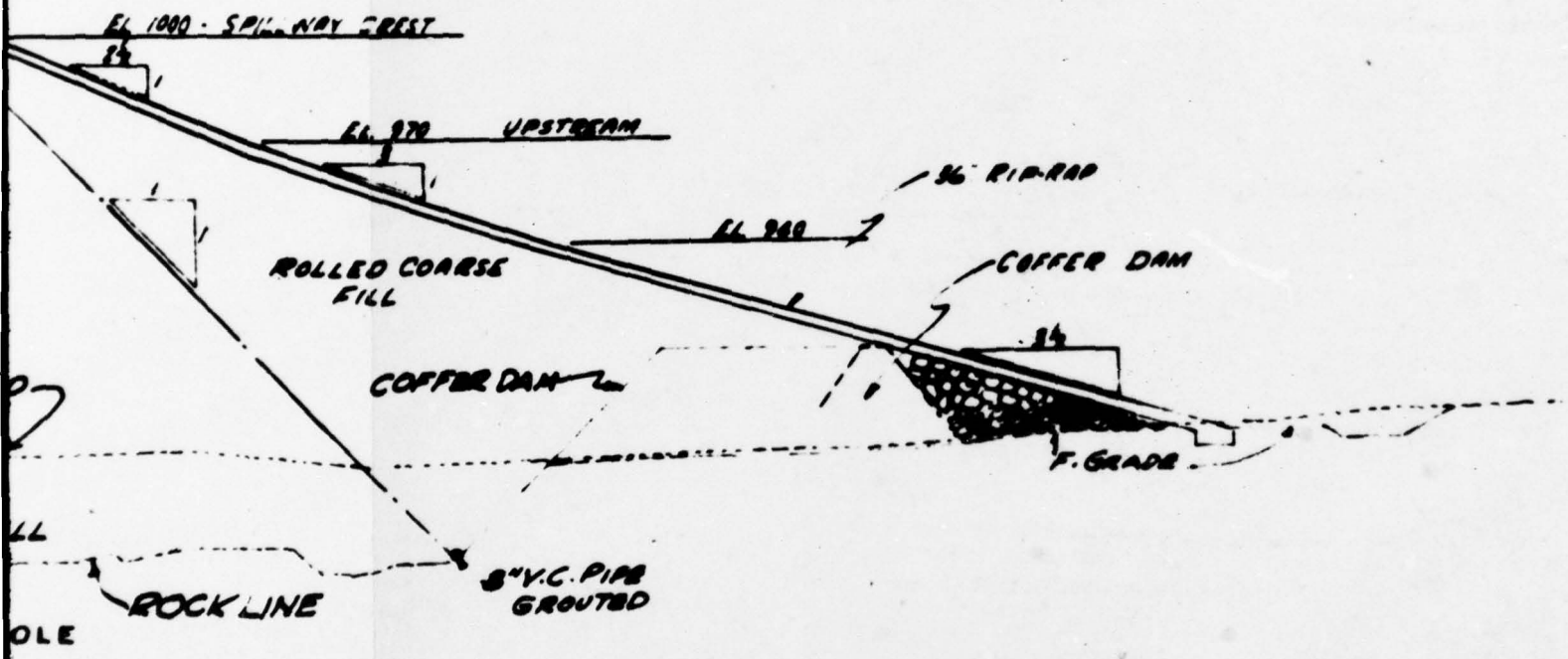


SECTION THRU DAM AT COORDINATE 1+00W

(TYPICAL)

SCALE 1" = 30'

TYPICAL PENN FO
Nat. ID No. PA 00808
DATA OBTAINED RECORD PLA



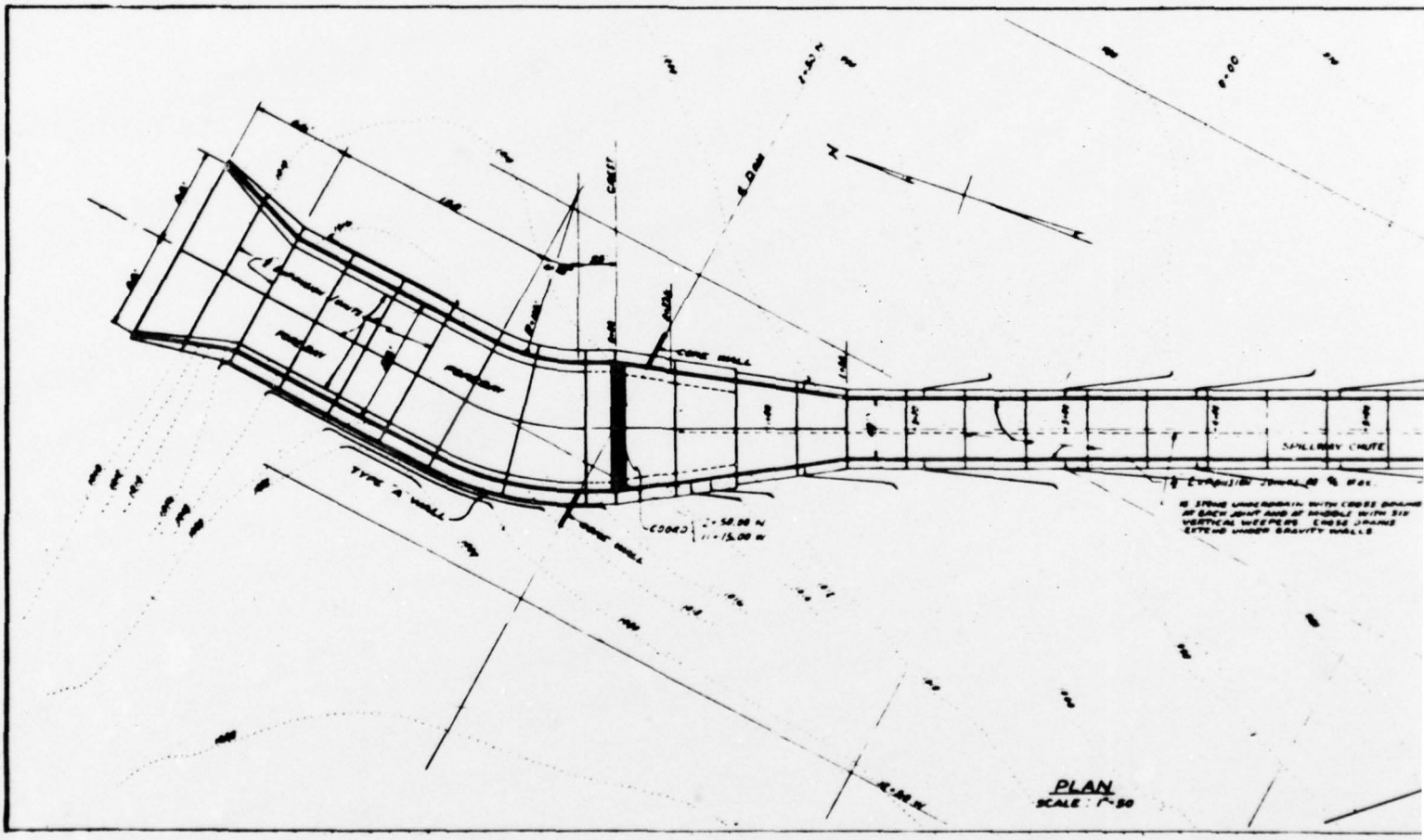
TYPICAL EMBANKMENT SECTION
PENN FOREST DAM & RESERVIOR

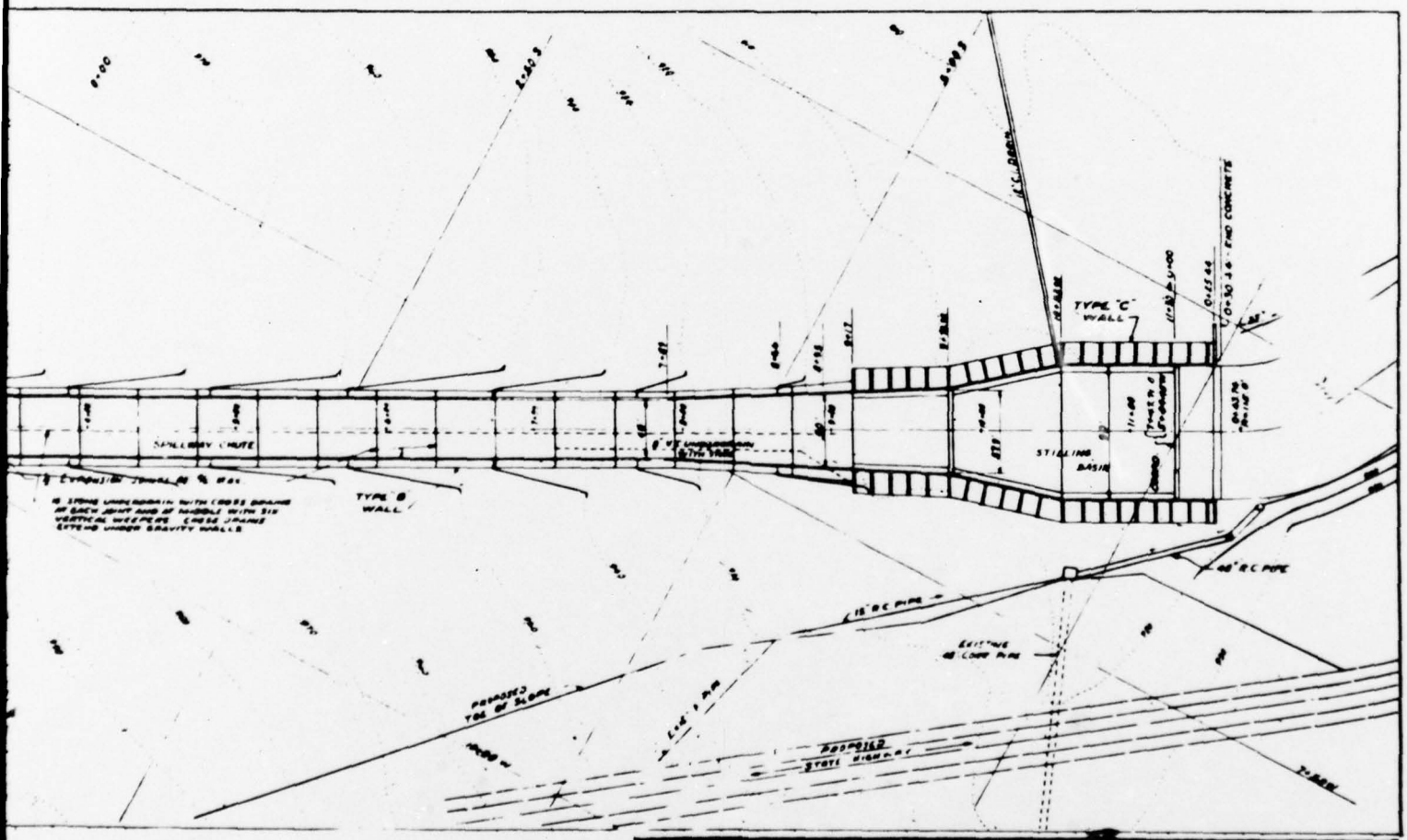
Nat. ID No. PA 00808 CARBON COUNTY

DATA OBTAINED FROM MORRIS KNOWLES, INC.
RECORD PLAN SHEET 4 of 32, Jan. 1968

PLATE 3

3


CREST
CORE WALL
SPILLWAY CHUTE
TYPE 'A' WALL
PLAN
SCALE : 1"=50

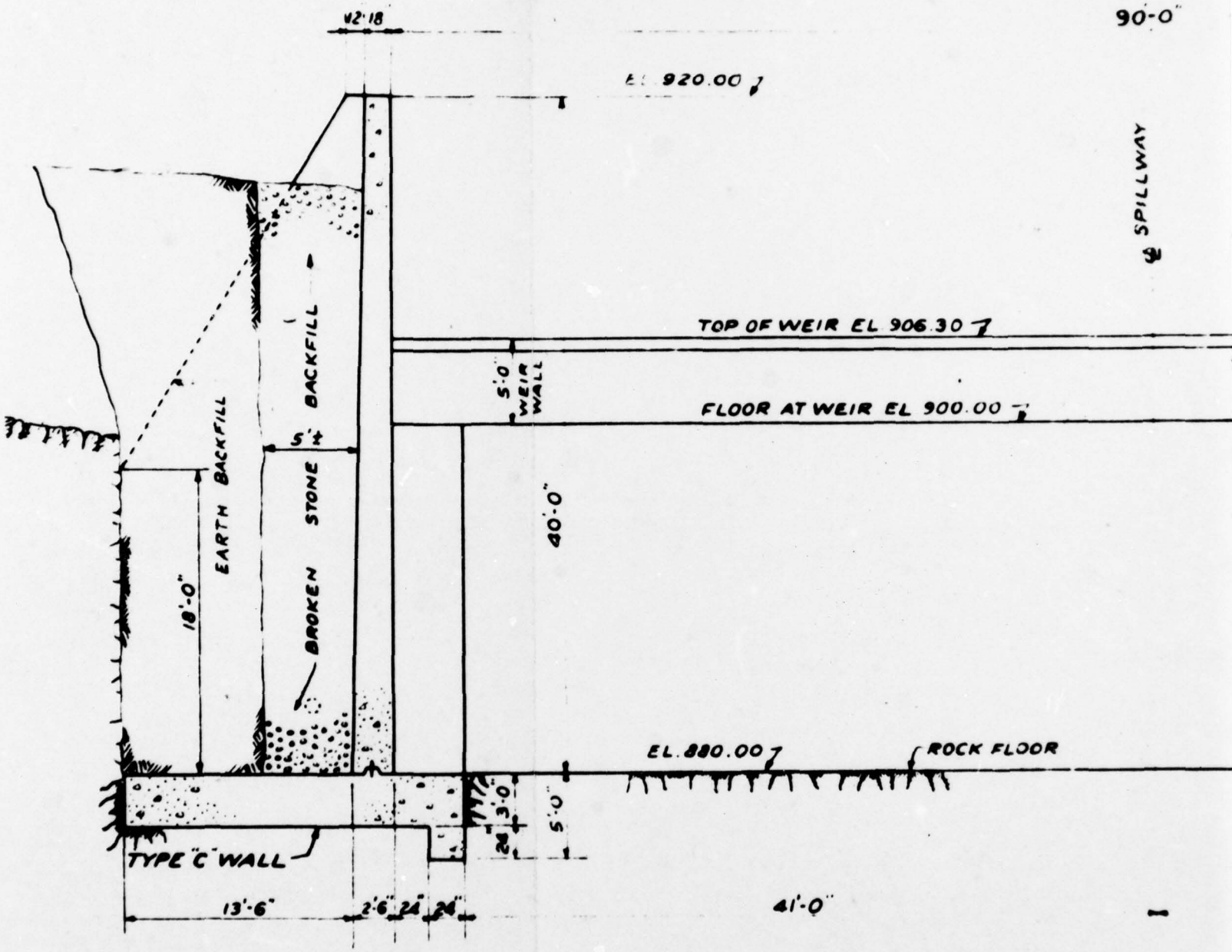


SPILLWAY CHUTE PLAN
PENN FOREST DAM & RESERVIOR

Nat. ID No. PA 00608 — CARBON COUNTY

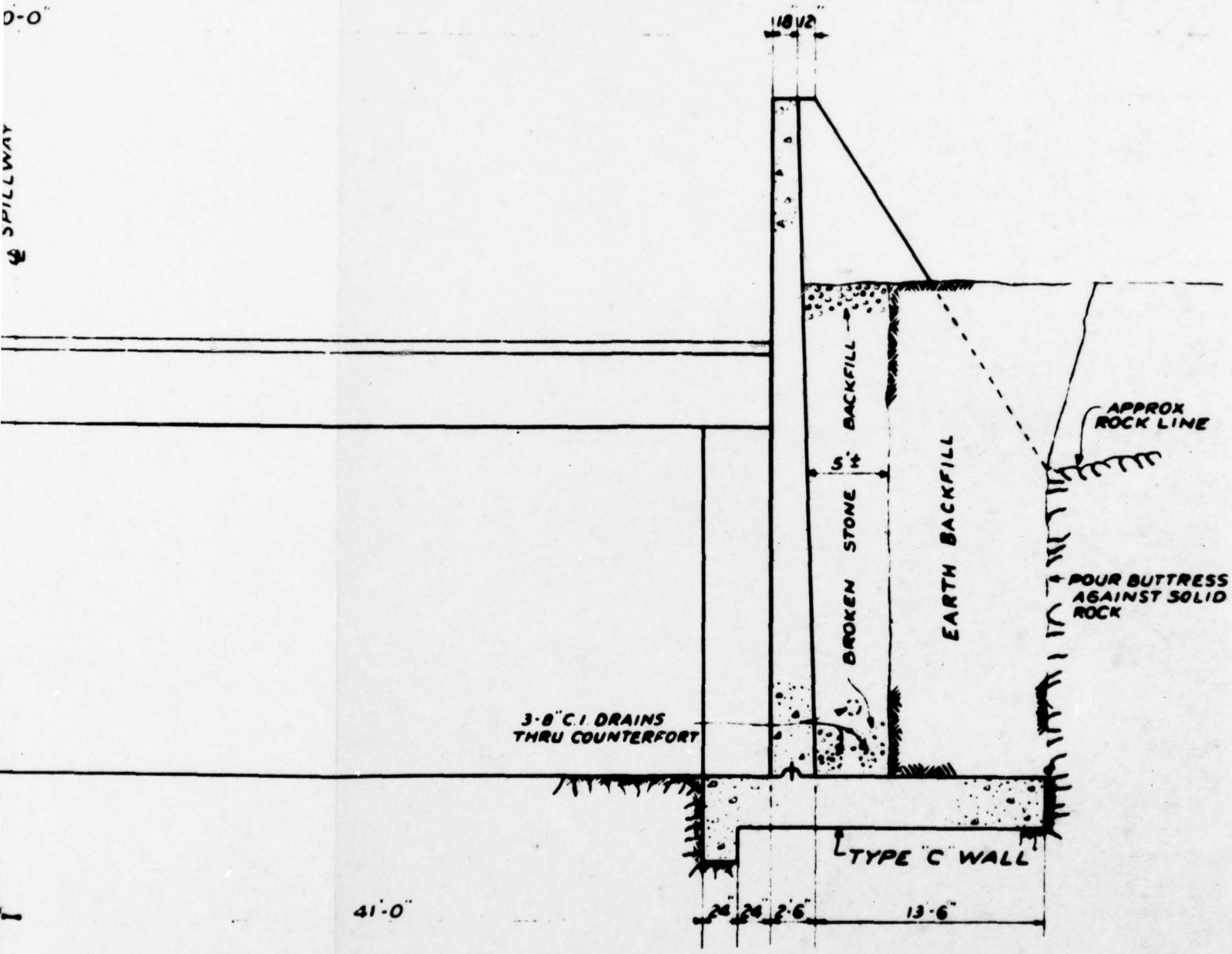
DATA OBTAINED FROM MORRIS KNOWLES, INC.
RECORD PLAN SHEET 7 of 32, Jan. 1959

PLATE 4



SECTION THRU STILL

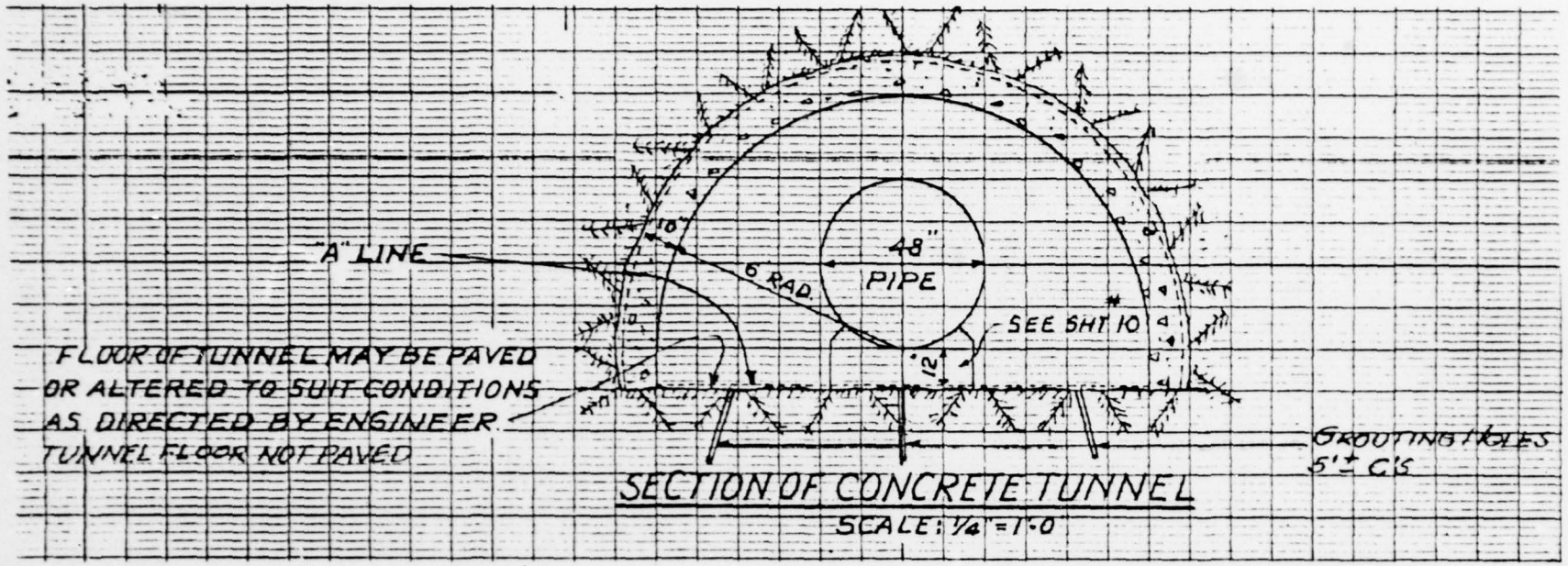
(LOOKING SOUT



STILLING BASIN

SOUTH)

SECTION THRU STILLING BASIN (LOOKING SOUTH) PENN FOREST DAM & RESERVIOR
Nat. ID No. PA 00808 — CARBON COUNTY
DATA OBTAINED FROM MORRIS KNOWLES, INC. RECORD PLAN SHEET 8 of 32, Jan. 1959
PLATE 5



SECTION OF CONCRETE TUNNEL

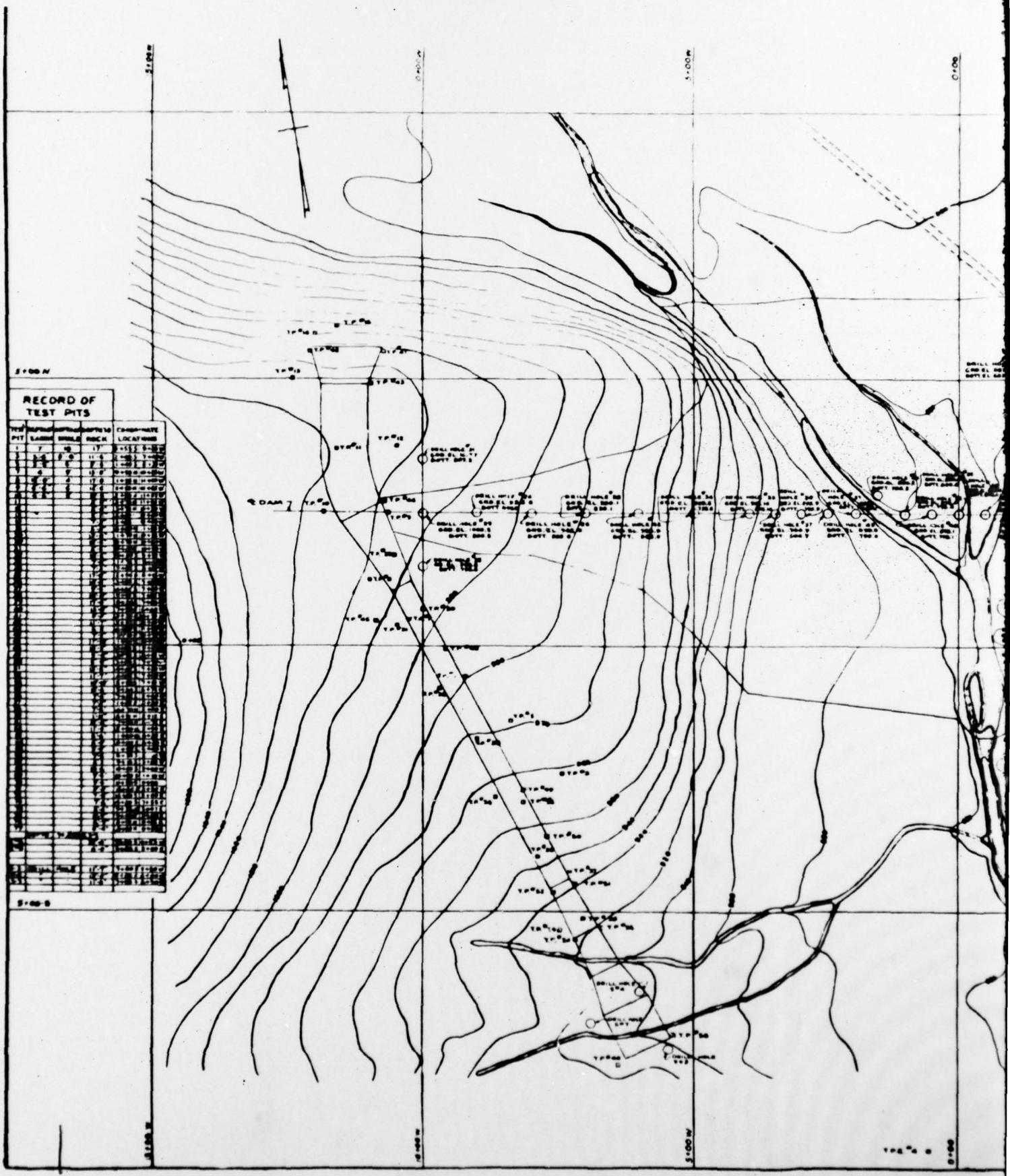
SCALE: 1/4" = 1'-0"

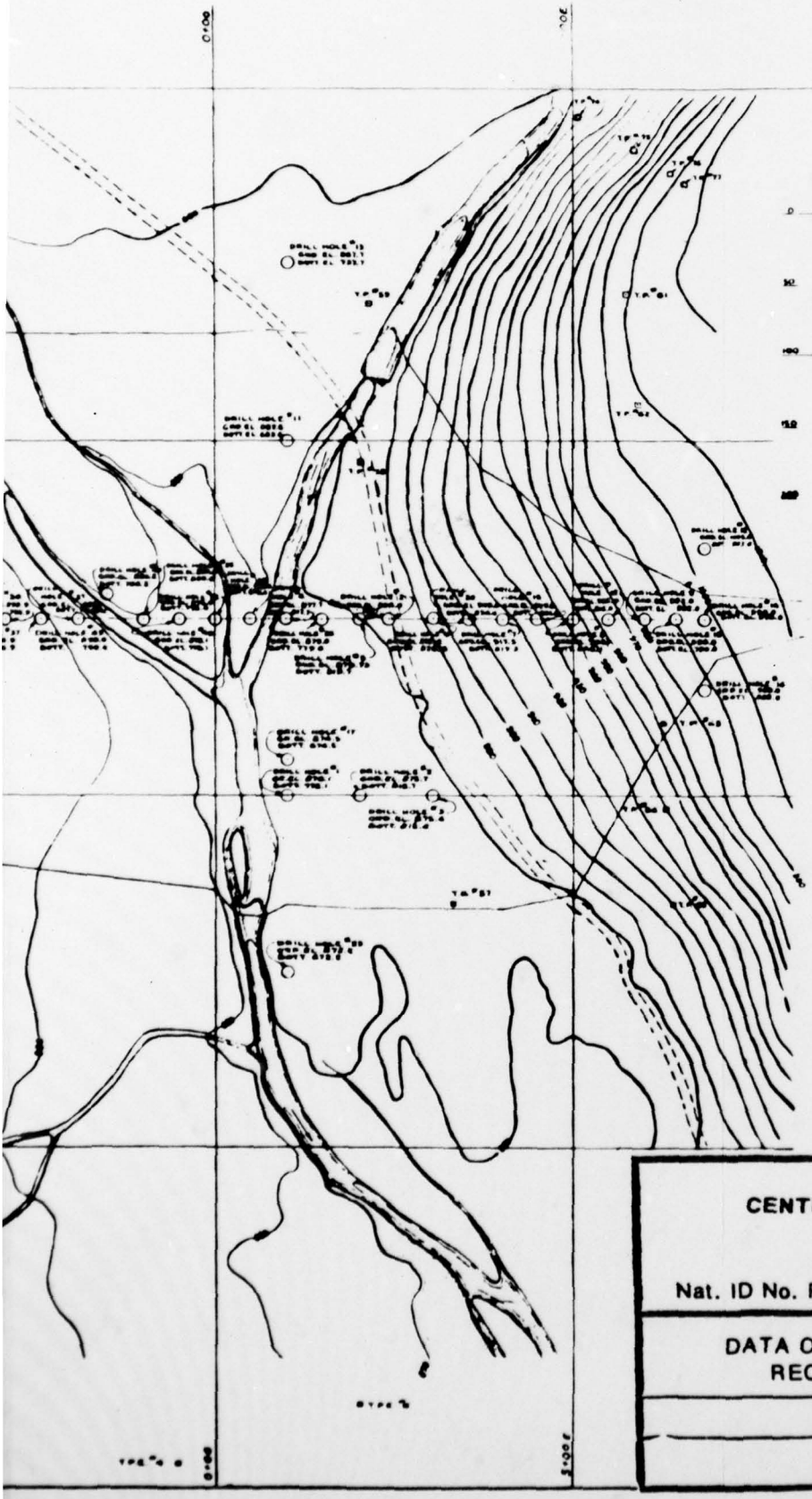
SECTION OF CONCRETE TUNNEL RUNNING
FROM CONTROL TOWER TO EXIT VALUE
PENN FOREST DAM & RESERVIOR

Nat. ID No. PA 00608 CARBON COUNTY

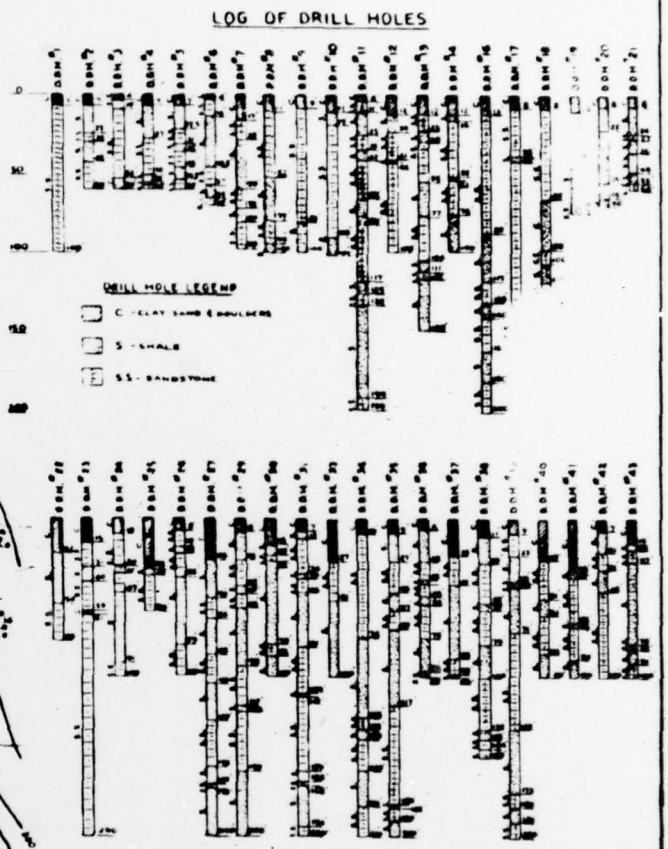
DATA OBTAINED FROM MORRIS KNOWLES, INC.
RECORD PLAN SHEET 15 of 32, Jan. 1959

PLATE 6


RECORD OF
TEST PITS
DAM 1



LOG OF DRILL HOLES



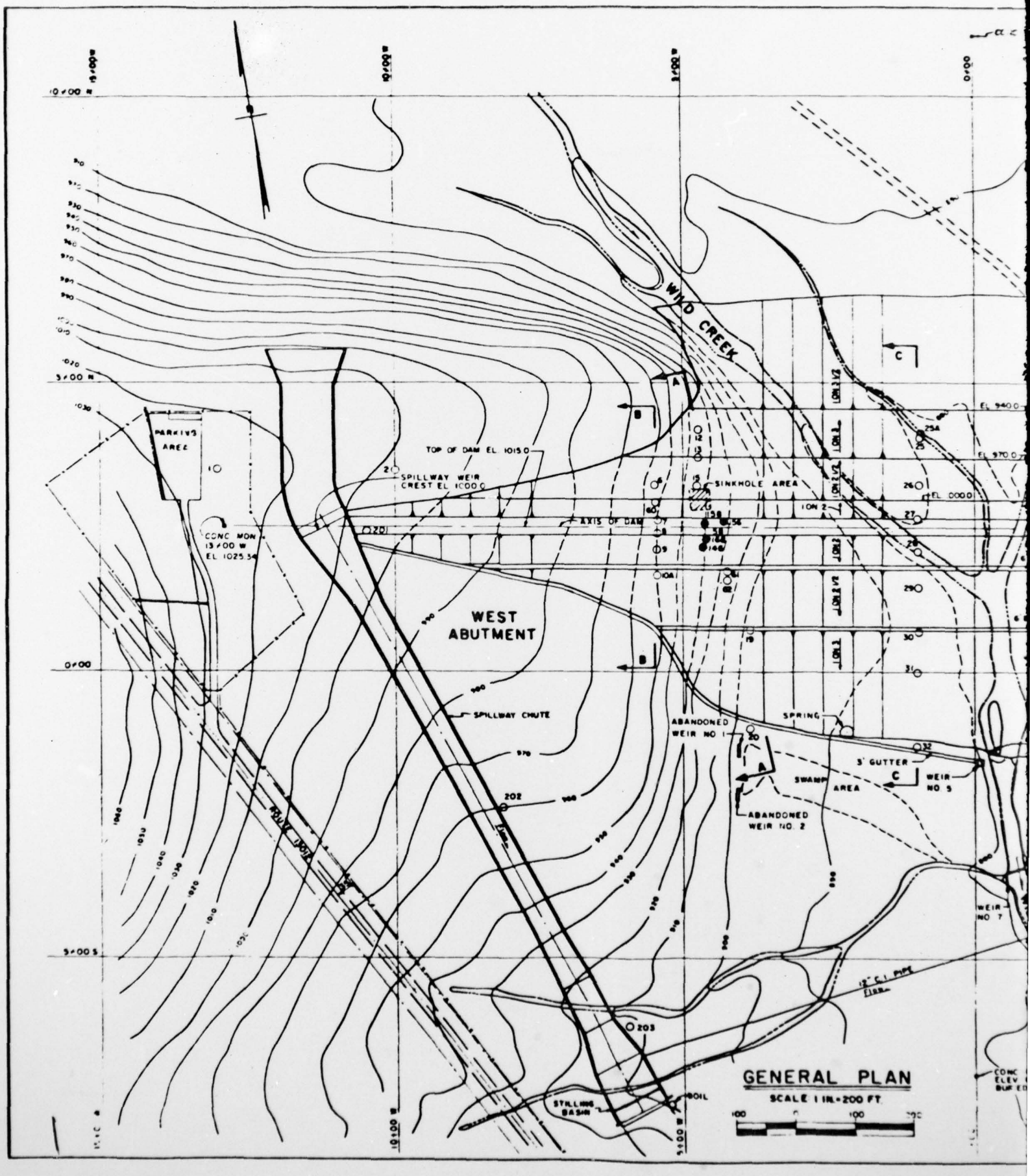
CENTERLINE TEST BORING LOCATION PLAN
PENN FOREST DAM & RESERVIOR

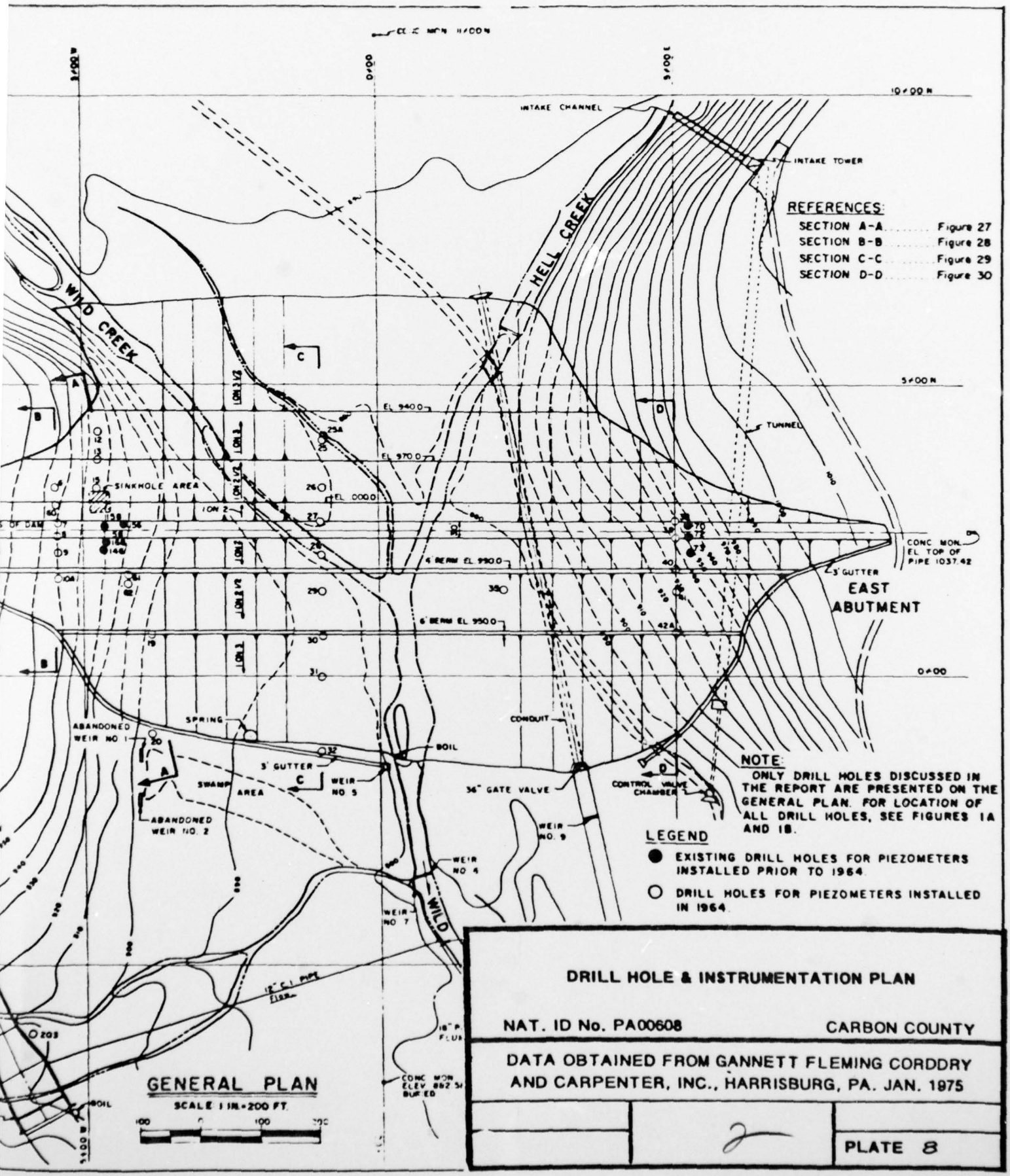
Nat. ID No. PA 00608 — CARBON COUNTY

DATA OBTAINED FROM MORRIS KNOWLES, INC.
RECORD PLAN SHEET 31 of 32, Jan. 1959

2

PLATE 7


WILD CREEK
TOP OF DAM EL 1015.0
SPILLWAY WEIR
CREST EL 1000.0
SINKHOLE AREA
AXIS OF DAM
PARKING AREA
CONC MON
13+00 W
EL 1025.34
WEST
ABUTMENT
SPILLWAY CHUTE
ABANDONED
WEIR NO 1
SPRING
3' GUTTER
SWAMP
AREA
WEIR
NO 5
ABANDONED
WEIR NO. 2
WEIR
NO 7
12" CI PIPE
EL 9400
EL 9700
EL 0000
STILLING
BASIN
BOIL
GENERAL PLAN
SCALE 1 IN.=200 FT.



REFERENCES:

SECTION A-A	Figure 27
SECTION B-B	Figure 28
SECTION C-C	Figure 29
SECTION D-D	Figure 30

NOTE:
ONLY DRILL HOLES DISCUSSED IN THE REPORT ARE PRESENTED ON THE GENERAL PLAN. FOR LOCATION OF ALL DRILL HOLES, SEE FIGURES 1A AND 1B.

LEGEND

- ● EXISTING DRILL HOLES FOR PIEZOMETERS INSTALLED PRIOR TO 1964.
- ○ DRILL HOLES FOR PIEZOMETERS INSTALLED IN 1964.

GENERAL PLAN
SCALE 1 IN.=200 FT.

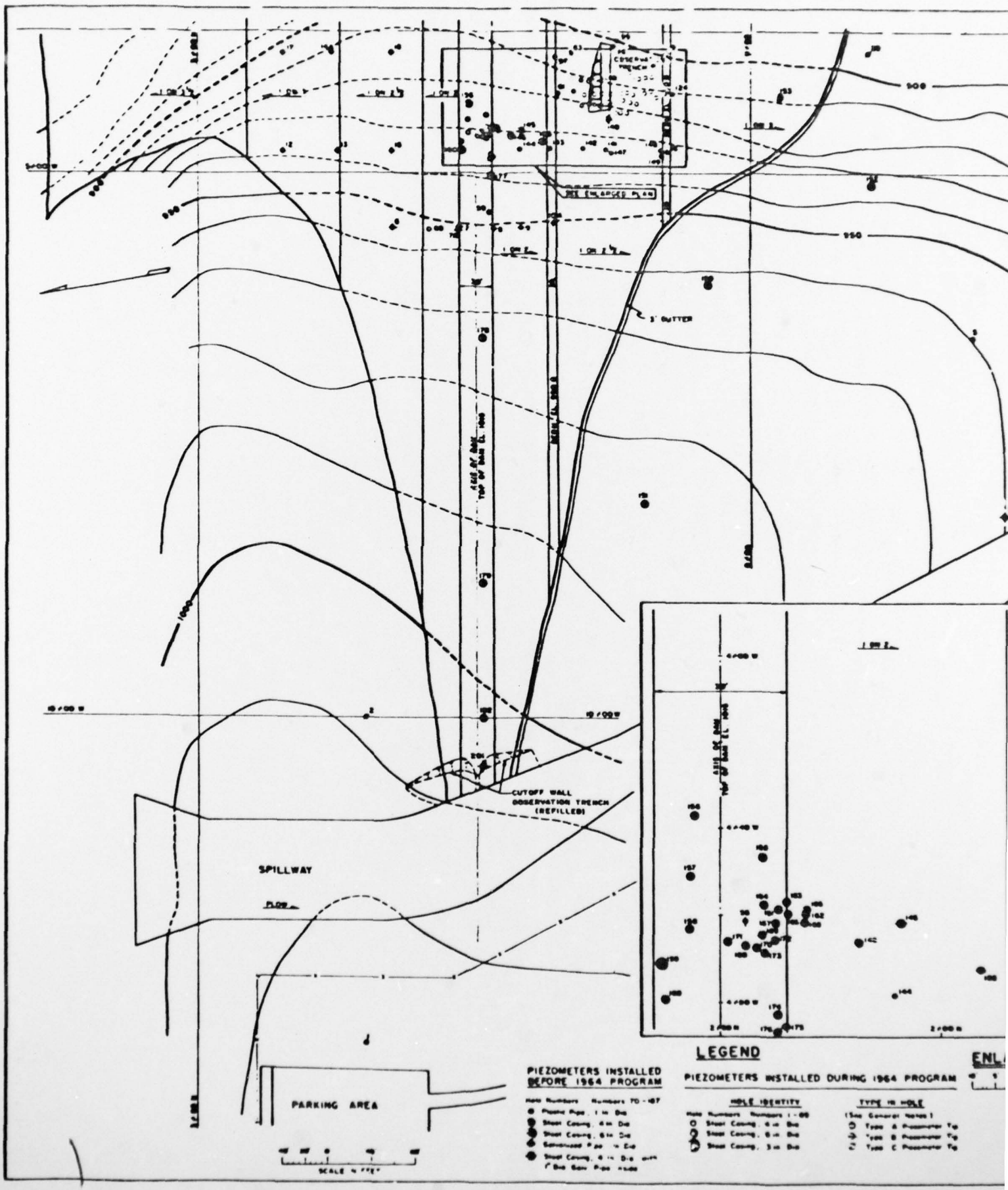
DRILL HOLE & INSTRUMENTATION PLAN

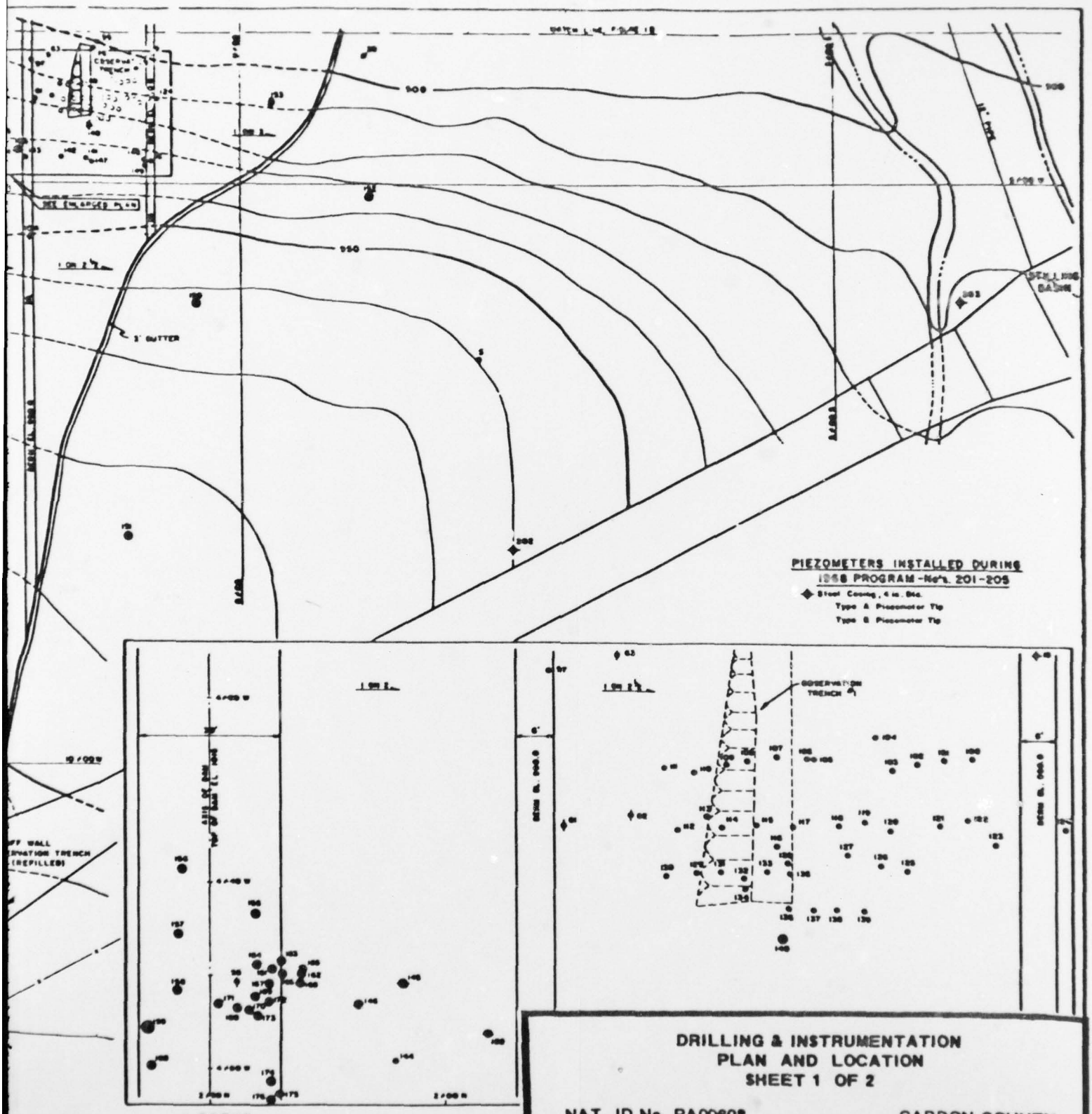
NAT. ID No. PA00608 — CARBON COUNTY

DATA OBTAINED FROM GANNETT FLEMING CORDDRY AND CARPENTER, INC., HARRISBURG, PA. JAN. 1975

2

PLATE 8


CUTOFF WALL
OBSERVATION TRENCH
(REFILLED)
SPILLWAY
PARKING AREA
SCALE
LEGEND
PIEZOMETERS INSTALLED BEFORE 1964 PROGRAM
PIEZOMETERS INSTALLED DURING 1964 PROGRAM
HOLE IDENTITY
TYPE IN HOLE

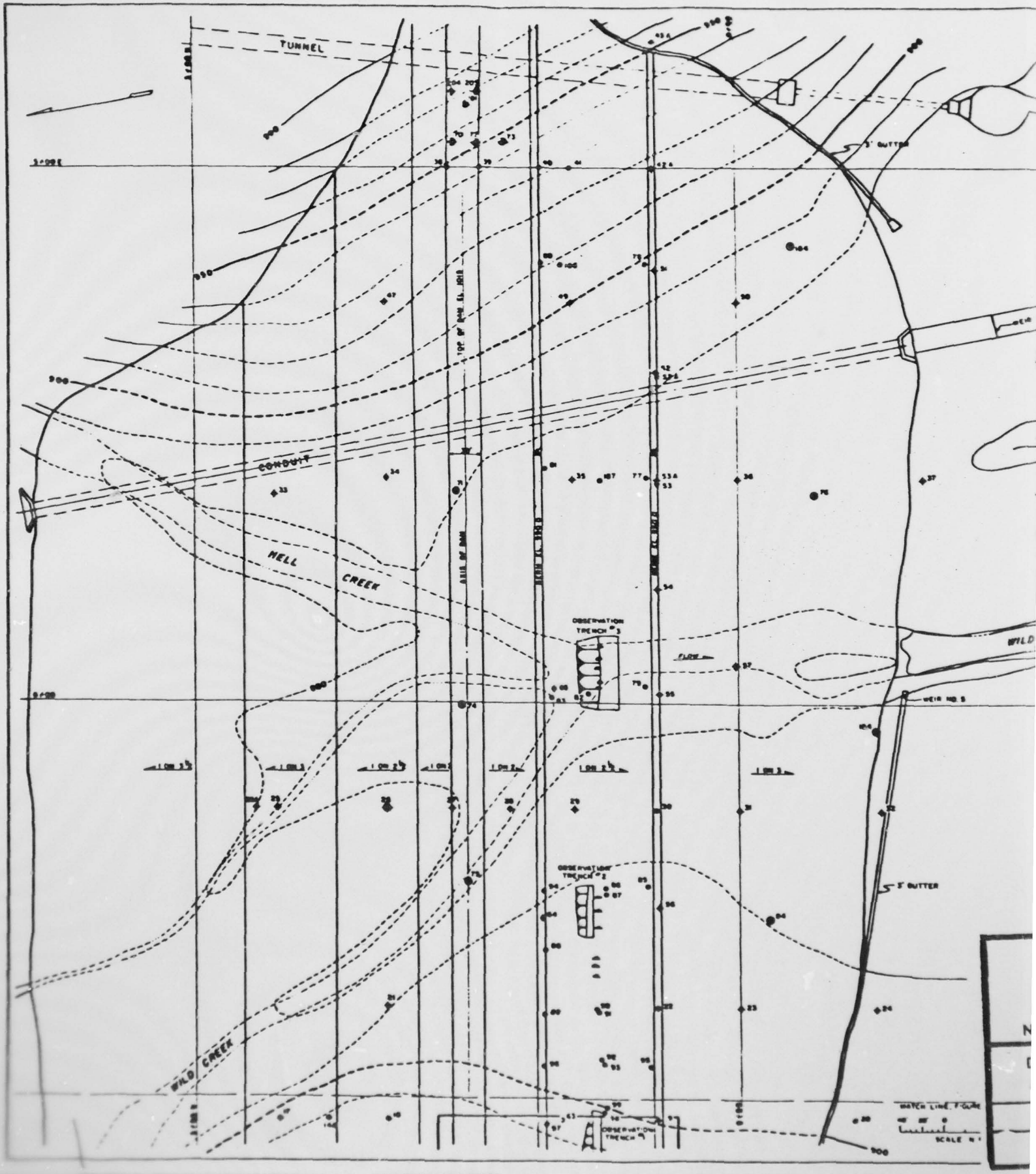


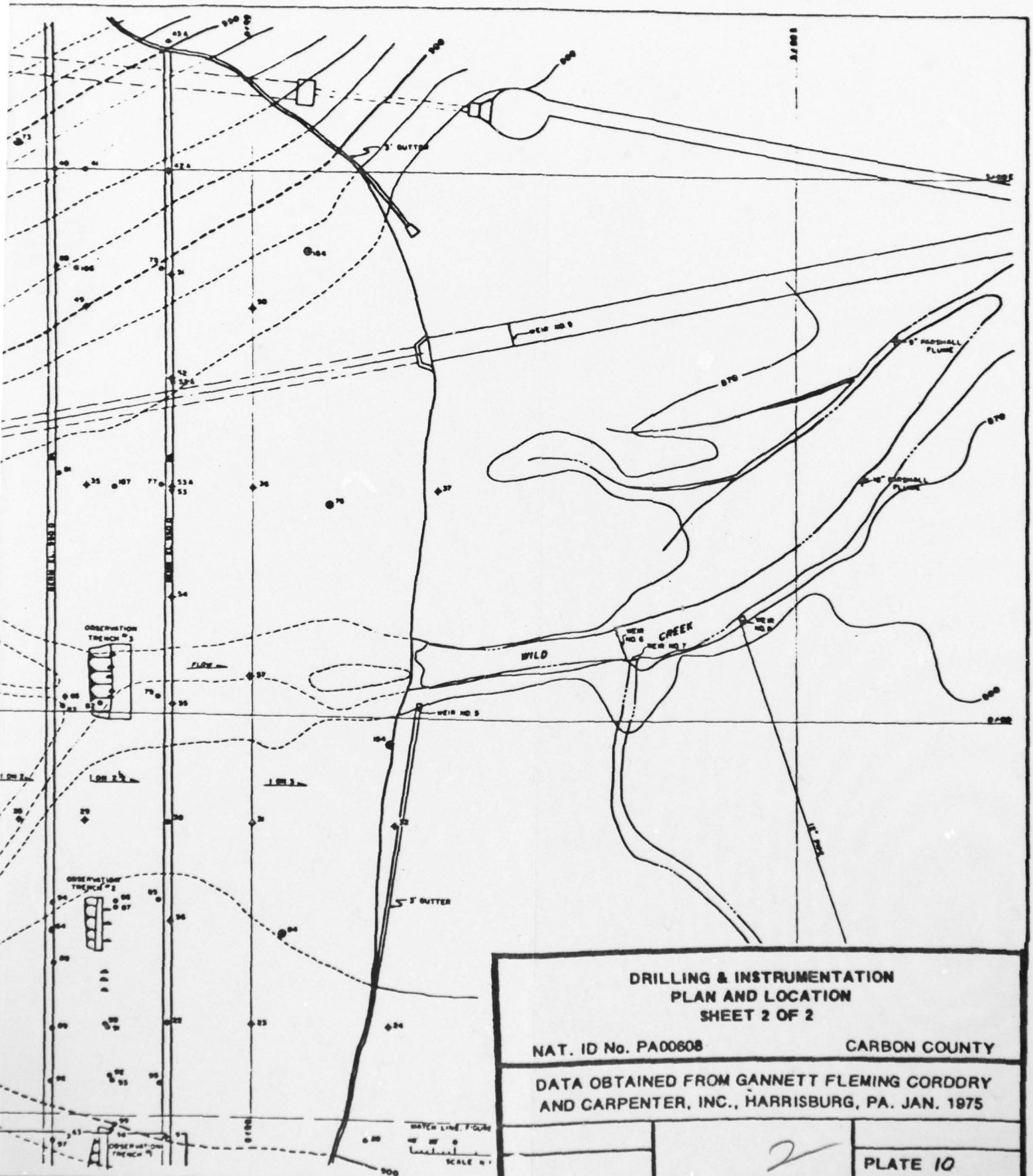
DRILLING & INSTRUMENTATION PLAN AND LOCATION
SHEET 1 OF 2

NAT. ID No. PA00608 — CARBON COUNTY

DATA OBTAINED FROM GANNETT FLEMING CORDDRY AND CARPENTER, INC., HARRISBURG, PA. JAN. 1975

PLATE 9


TUNNEL
CONDUIT
HELL CREEK
WILD CREEK
OBSERVATION TRENCH
WEIR NO. 5
3' GUTTER
FLOW
WATER LINE, FOUR
SCALE



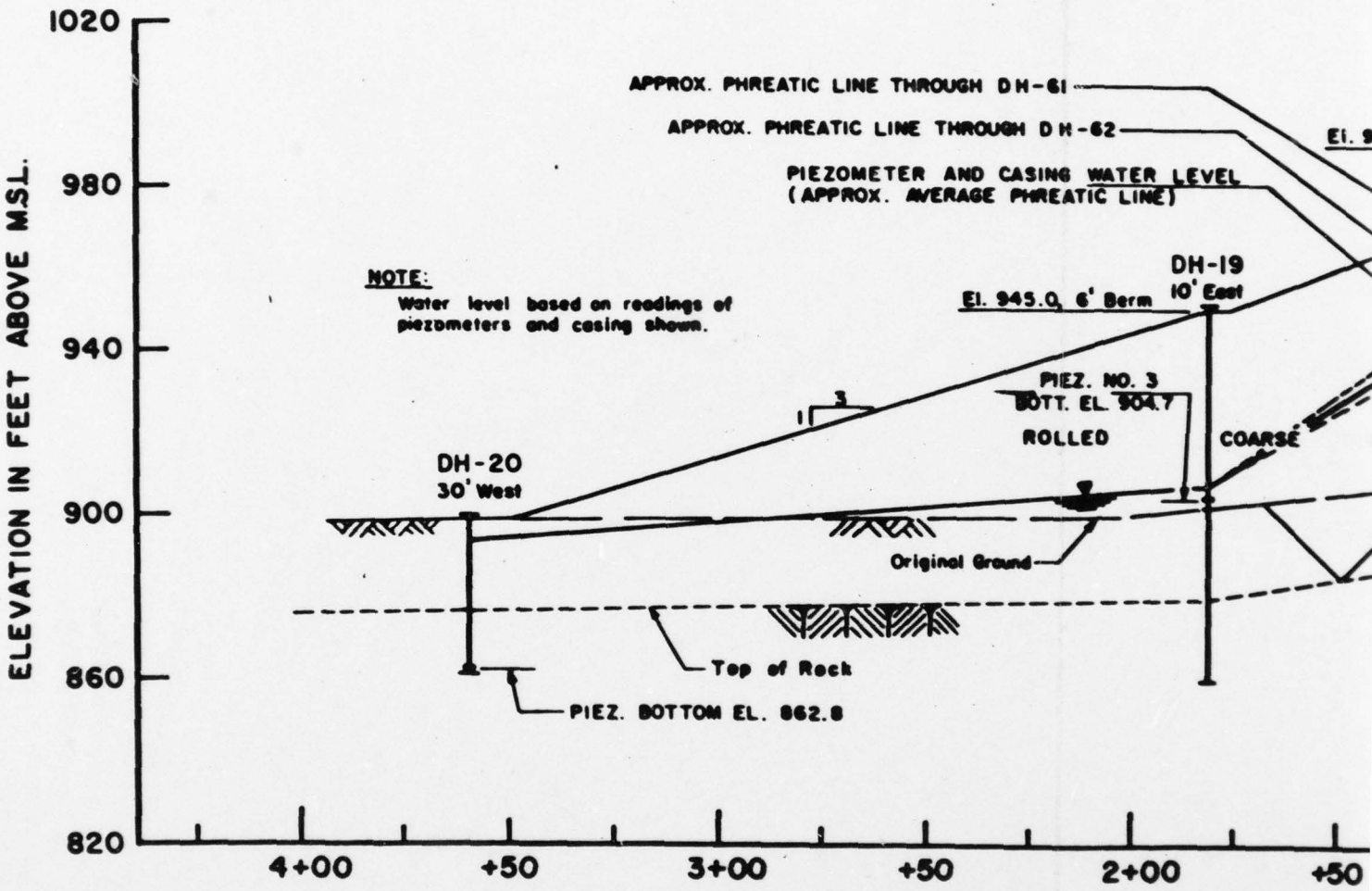
DRILLING & INSTRUMENTATION
PLAN AND LOCATION
SHEET 2 OF 2

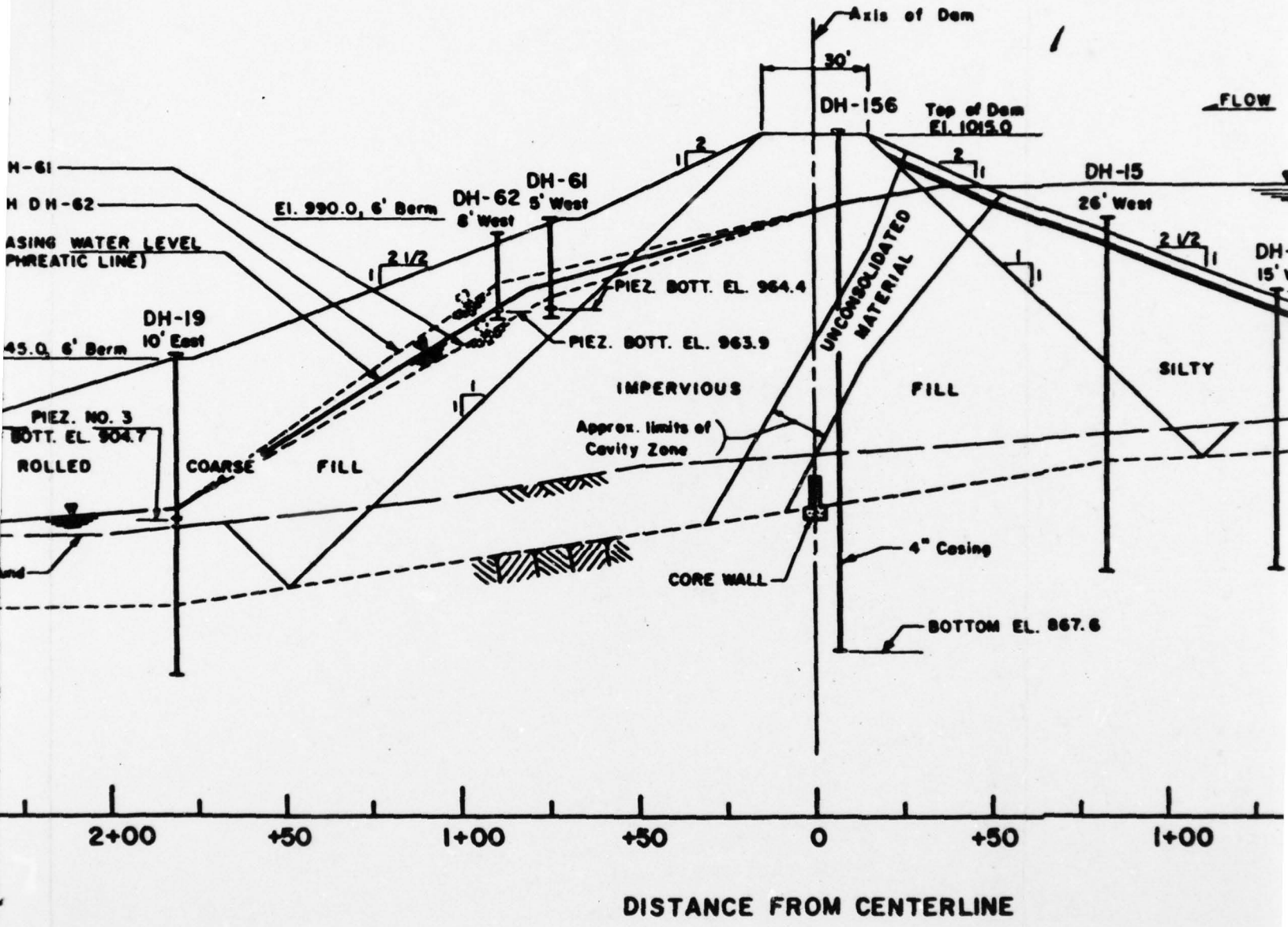
NAT. ID No. PA00608 — CARBON COUNTY

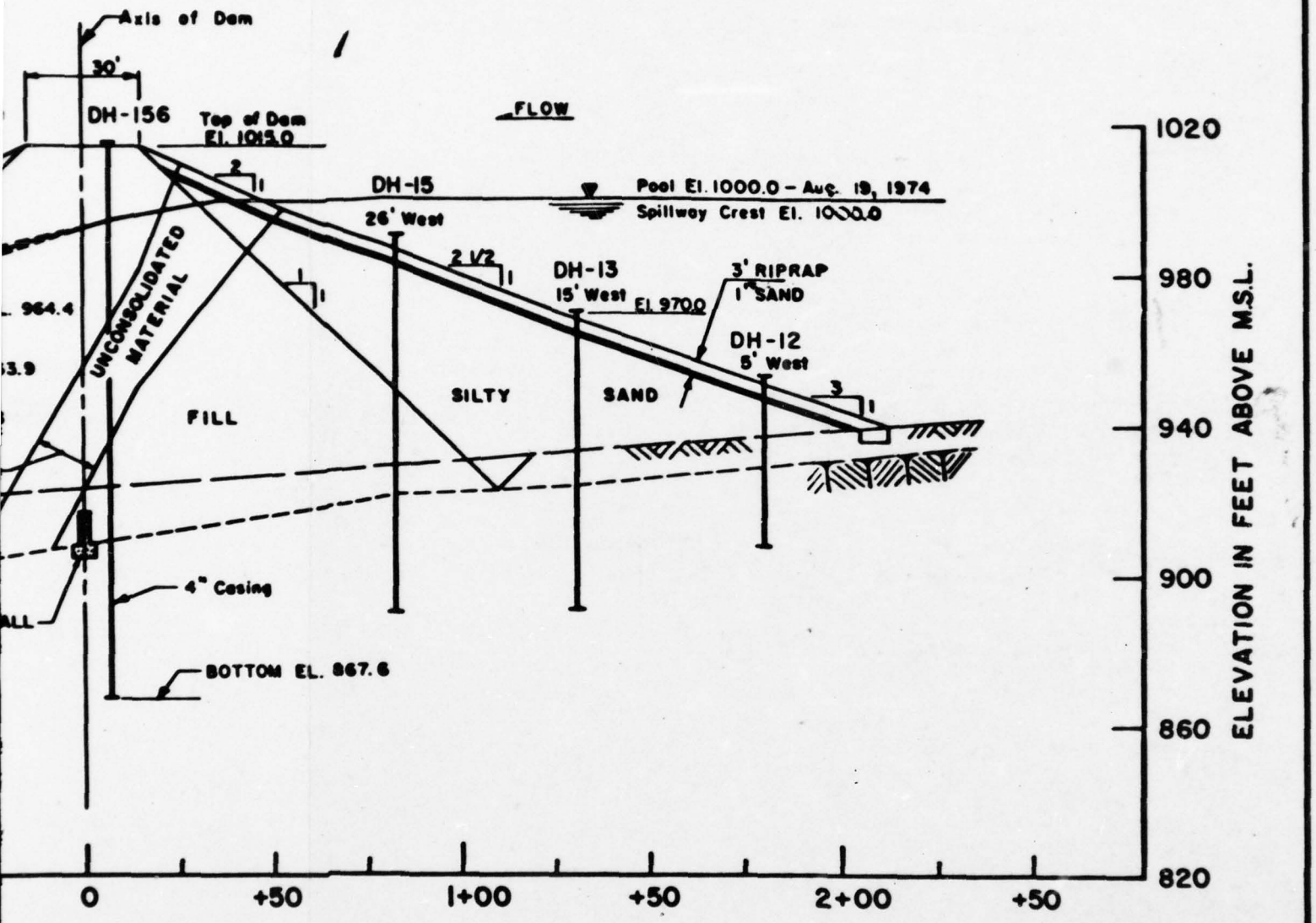
DATA OBTAINED FROM GANNETT FLEMING CORDDRY AND CARPENTER, INC., HARRISBURG, PA. JAN. 1975

2

PLATE 10


1020
980
940
900
860
820
ELEVATION IN FEET ABOVE M.S.L.
APPROX. PHREATIC LINE THROUGH DH-61
APPROX. PHREATIC LINE THROUGH DH-62
PIEZOMETER AND CASING WATER LEVEL
(APPROX. AVERAGE PHREATIC LINE)
NOTE:
Water level based on readings of piezometers and casing shown.
DH-19
10' East
El. 945.0, 6' Berm
PIEZ. NO. 3
BOTT. EL. 904.7
ROLLED
COARSE
3
1
DH-20
30' West
Original Ground
Top of Rock
PIEZ. BOTTOM EL. 862.8
4+00
+50
3+00
+50
2+00
+50


Axis of Dam
30'
DH-156
Top of Dam
El. 1015.0
FLOW
H-61
H DH-62
ASING WATER LEVEL
PHREATIC LINE)
El. 990.0, 6' Berm
DH-62
6' West
DH-61
5' West
2 1/2
1
2
DH-15
26' West
2 1/2
1
DH-19
10' East
45.0, 6' Berm
PIEZ. BOTT. EL. 964.4
PIEZ. BOTT. EL. 963.9
UNCONSOLIDATED MATERIAL
IMPERVIOUS
FILL
SILTY
PIEZ. NO. 3
BOTT. EL. 904.7
ROLLED
COARSE
FILL
Approx. limits of
Cavity Zone
4" Casing
CORE WALL
BOTTOM EL. 867.6
2+00
+50
1+00
+50
0
+50
1+00
DISTANCE FROM CENTERLINE



E FROM CENTERLINE

TYPICAL SECTION SECTION A-A IN VICINITY OF STATION 4+40 W

NAT. ID No. PA00608 CARBON COUNTY

DATA OBTAINED FROM GANNETT FLEMING CORDDRY AND CARPENTER, INC., HARRISBURG, PA. JAN. 1975

3

PLATE 11

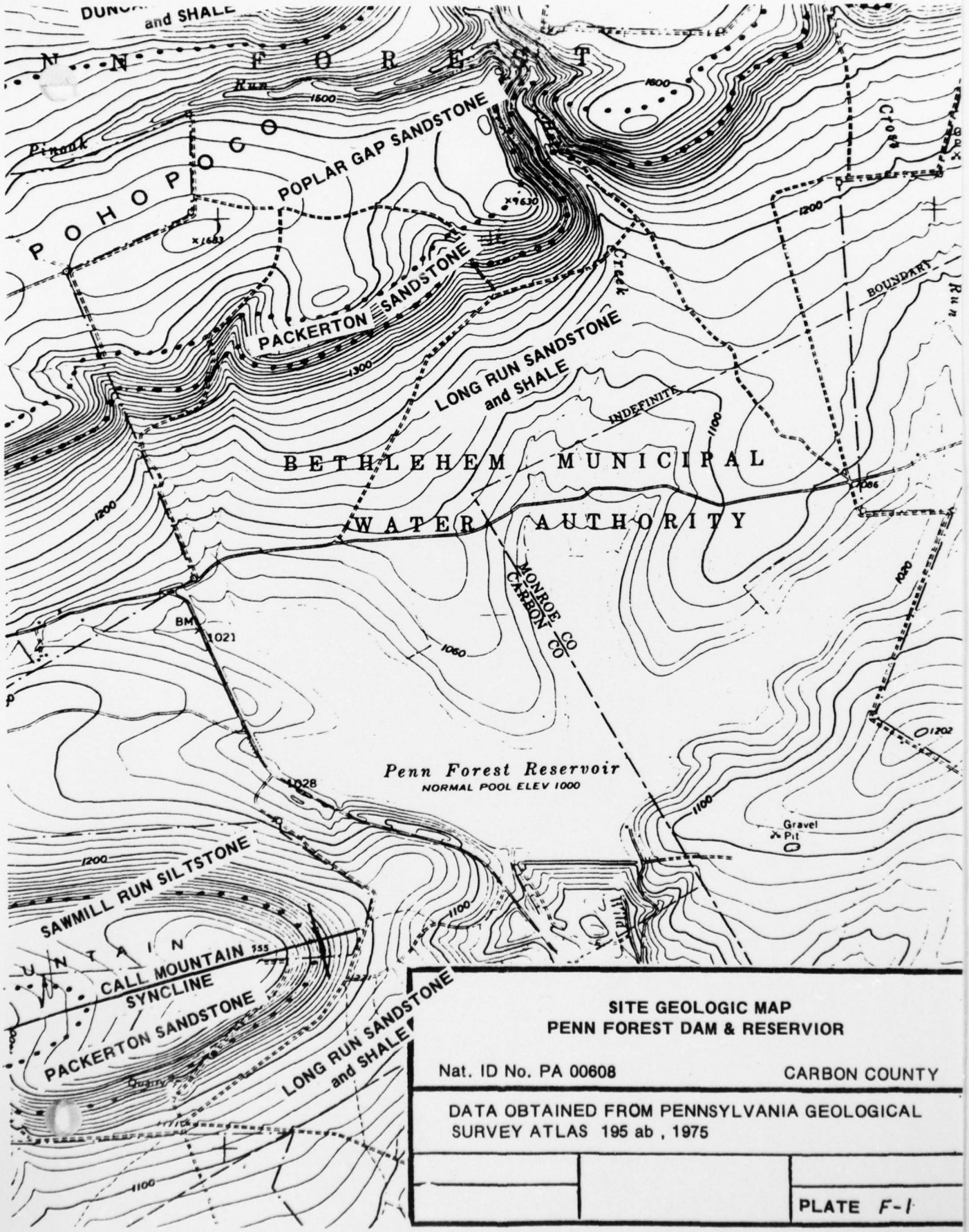
APPENDIX

F

PENN FOREST DAM
SITE GEOLOGY

The Penn Forest Dam is located in the Appalachian Mountain section of the Valley and Ridge Physiographic Province. As shown in Plate F-1, the dam is situated on the nose and parallel to the axis of the Call Mountain syncline. Rock types in the area consist of fine- to medium-grained sandstone, siltstone and shale of the Long Run member of the Catskill Formation of Upper Devonian age. Bedrock bedding strikes east/northeast and dips 10 to 15 degrees to the north. Rock jointing strikes to the north with high angle dips and with near east-west strikes with high angle southerly dips. The Long Run member is characterized by moderate infiltration capacities, but higher capacities may locally occur from fracturing due to localized folding.

This region of Pennsylvania was glaciated during Pleistocene time and the dam lies near the southern border of glacial deposits. No glacial deposits are found in the immediate dam area, but glacial till is found along most of the reservoir shoreline.



SITE GEOLOGIC MAP
PENN FOREST DAM & RESERVIOR

Nat. ID No. PA 00608 CARBON COUNTY

DATA OBTAINED FROM PENNSYLVANIA GEOLOGICAL SURVEY ATLAS 195 ab , 1975

PLATE F-1