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NATIONAL DAM INSPECTION PROGRAM. LIBERTY DAM, UPPER CHESAPEAKE --ETC(U)
SEP 78 DACW31-78-C-0044

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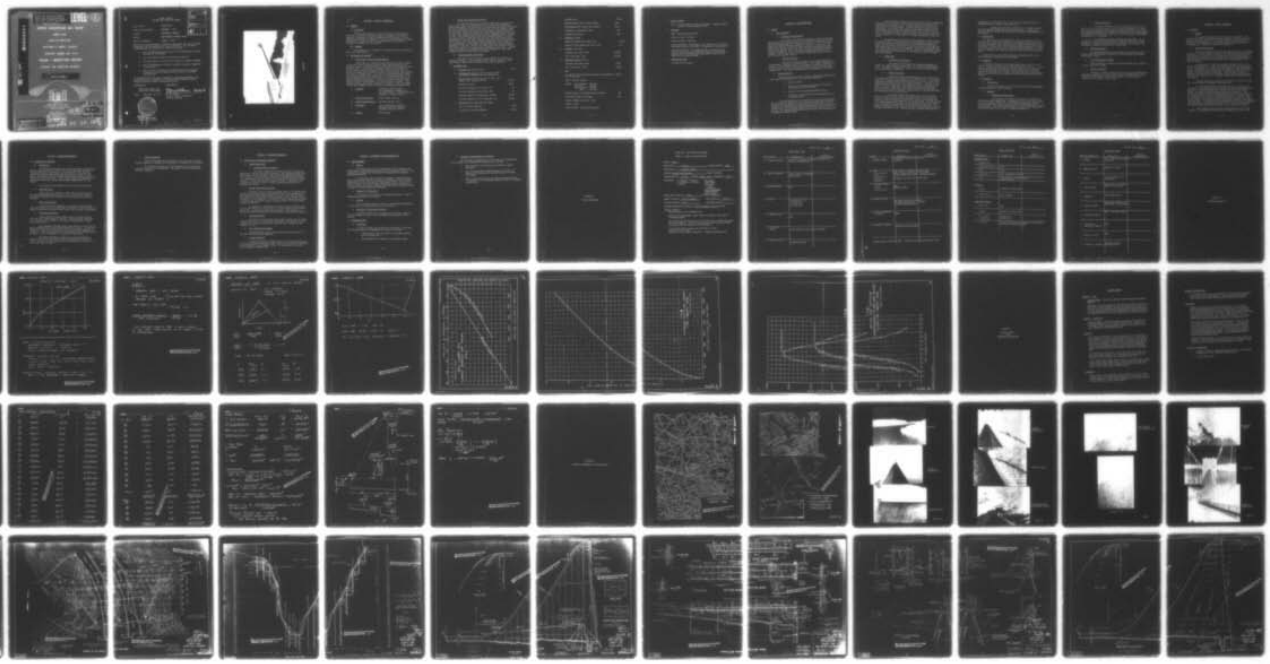

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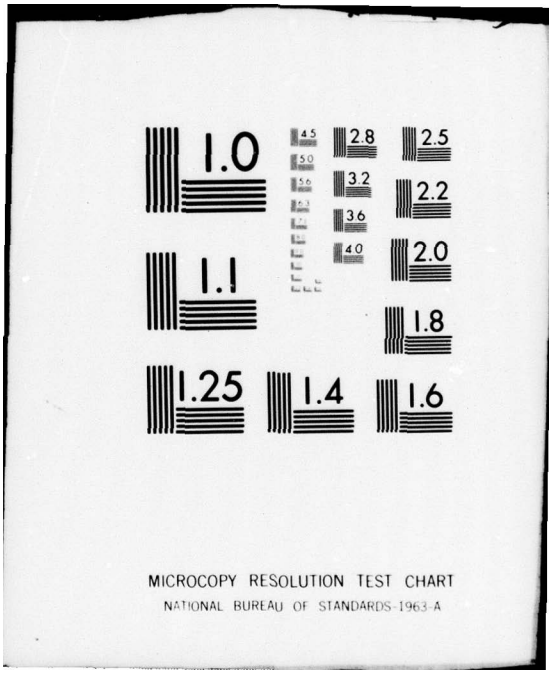
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UPPER CHESAPEAKE BAY BASIN

LIBERTY DAM

STATE OF MARYLAND

BALITMORE & CARROLL COUNTIES

INVENTORY NUMBER NDS MD-3

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

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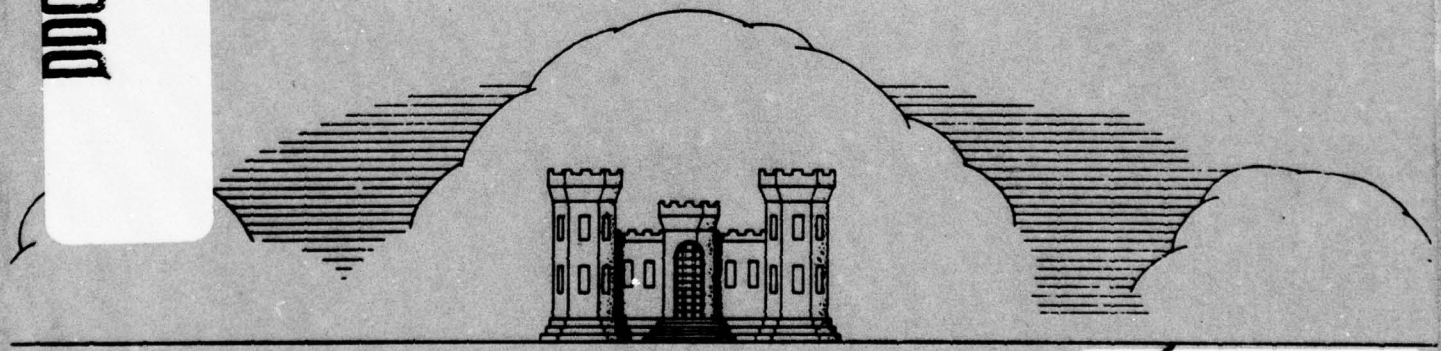


Prepared For
DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland
by
BERGER ASSOCIATES, INC
CONSULTING ENGINEERS
HARRISBURG, PA.

(12) 68 p.

(11) SEPTEMBER 1978

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam: LIBERTY DAM

State & State Number: MARYLAND - MD-3

County: BALTIMORE & CARROLL

Stream: NORTH BRANCH PATAPSCO RIVER

Date of Inspection: August 1, 1978

Based on the past performance, available engineering data and the visual inspection, the dam appears to be in good condition. The following recommendations are presented for action by the owner:

1. That consideration should be given to the installation of open gratings in the manholes.

2. That the manhole covers be provided with padlocks.

3. That the gutter in the gallery be flushed at regular intervals.

4. That the maintenance procedures include a bi-annual inspection of the gallery.

5. That a formal surveillance and downstream warning system be developed to be used during periods of heavy or prolonged precipitation.

In accordance with the Corps of Engineers' evaluation guidelines, the spillway capacity is adequate for passing the PMF (Probable Maximum Flood) peak inflow without overtopping the dam.

SUBMITTED BY:

BERGER ASSOCIATES, INC.
HARRISBURG, PENNSYLVANIA

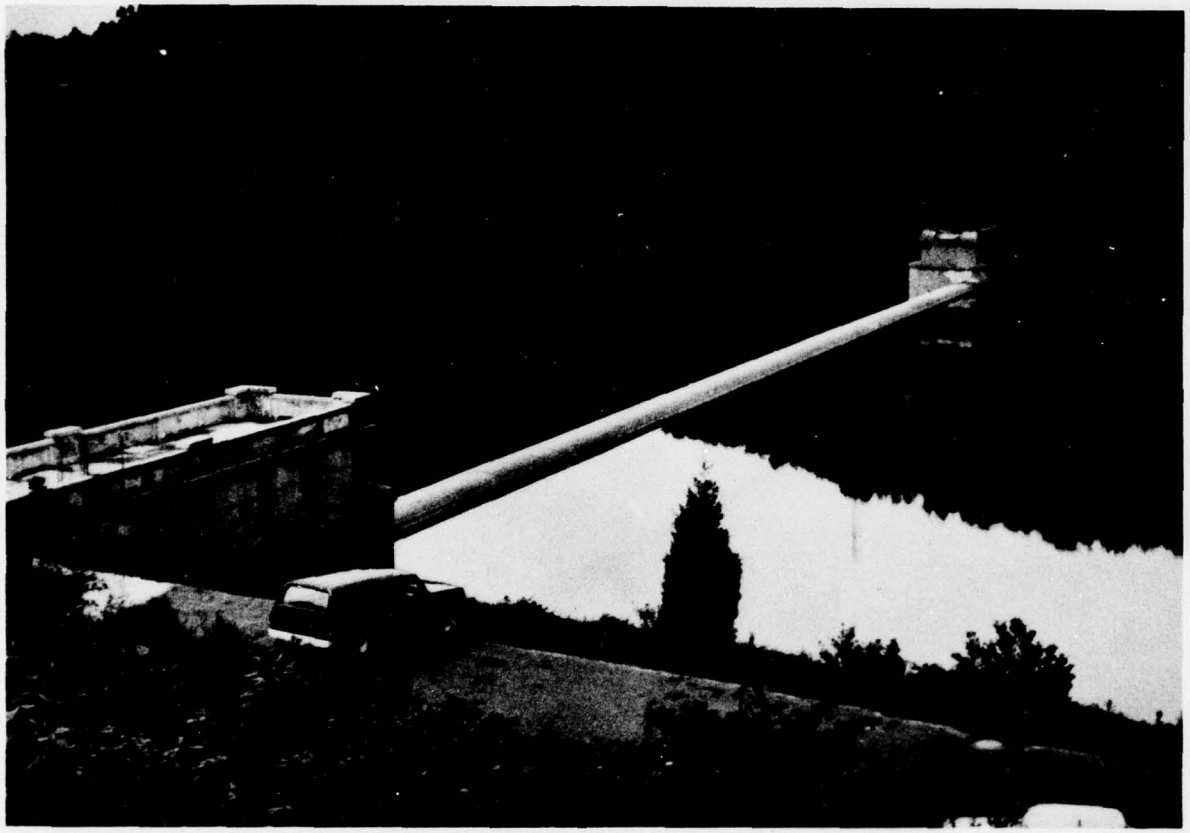
DATE: September 22, 1978

APPROVED BY:

23 Sep 78

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

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
HENDRIK JONGEMA
ENGINEER
No. 5557E



OVERVIEW

SECTION 1 - PROJECT INFORMATION

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 inspections of dams throughout the United States. Phase I Inspection and Report is limited to a review of available data, a visual inspection of the dam site and the basic hydraulic calculations to determine the adequacy of the spillway.

B. Purpose

The purpose is to determine if the dam constitutes a hazard to human life and property.

1.2 DESCRIPTION OF PROJECT

A. Description of Dam and Appurtenances

Liberty Dam is a concrete gravity dam with an overall length of 704 feet, which includes a 480 feet long overflow section. The spillway crest is at elevation 420.0 and the top of the abutments are at elevation 435.0. The original streambed elevation was at elevation 276.0, giving a hydraulic height for this structure of 159 feet. A gallery is constructed through the length of the structure (see Appendix D, Plates VII through XIII). The weir is an uncontrolled ogee section with a pool excavated below normal water for energy dissipation. The only discharge control on this structure is a 16-inch pipe with valve control located in the gallery. The actual intake for domestic water supply is located approximately 1.5 miles upstream of the dam. This intake structure (gate house) regulates the amount of water discharged in a 10 feet diameter tunnel to the City of Baltimore by gravity flow.

B.	Location:	Baltimore & Carroll County U.S. Quadrangle, Finksburg, Md. Latitude 39°-22.6', Longitude 76°-53.5' (Appendix D, Plates I and II)
C.	Size Classification:	Large (height 159 feet)
D.	Hazard Classification:	High (See Section 3.1.E)
E.	Ownership:	City of Baltimore, Maryland 600 Municipal Office Building Baltimore, Maryland 21202
F.	Purpose:	Water supply

G. Design and Construction History

The dam was designed by the City of Baltimore, Department of Public Works, Bureau of Water Supply with Dr. Abel Wolman acting as Consulting Engineer. The contractor for the dam was the Arundel Corporation. The City of Baltimore started construction of a 10 feet diameter tunnel from the North Branch Patapsco River to Baltimore in the late forties and received a permit for construction for a small diversion dam on July 7, 1948. This diversion dam was an earthfill embankment with a concrete core wall and concrete paved slopes and a hydraulic height of 13 feet and functioned as a temporary structure until the Liberty Dam would be constructed. On July 6, 1951, a permit was granted for the construction of the Liberty Dam. The original design indicated a cutoff trench on the upstream side and grouting of the underlying rock from the gallery (Appendix D, Plate X). On April 28, 1952, permit was granted to delete the cutoff trench at the upstream side (Appendix D, Plate XII). Construction was completed in September 1953 and on February 6, 1956, water flowed for the first time over the spillway.

H. Normal Operating Procedures

The dam is used for domestic water supply for the City of Baltimore, Maryland. At the intake tower, different levels of intake can be used. Water flows by gravity to the City of Baltimore.

1.3 PERTINENT DATA

A. Drainage Area (square miles)	164.0
B. Discharge at Dam Site (cubic feet per second) For hydraulic computations, see Appendix B.	
Maximum known flood at dam site in June, 1972 (Agnes) pool elevation 427.42	37,350
Warm water outlet	None
Low flow discharge at pool Elev. 420	80
Low flow discharge at pool Elev. 290	20
Spillway capacity at design Elev. 428.50	45,800
Spillway capacity at top of dam Elev. 434	96,800
C. Elevation (feet above mean sea level)	
Top of concrete abutments	435.0
Low point in hillside abutment	434.0

Spillway crest	420.0
Upstream portal invert outlet conduit	None
Downstream portal invert outlet conduit	None
Streambed at centerline of dam	276
Foundation elevation	260

D. Reservoir (miles)

Length of maximum pool (Elev. 434)	9.0(±)
Length of water supply pool (Elev. 420)	8.2

E. Storage (acre-feet)

Spillway crest (Elev. 420)	132,000
Top of dam (Elev. 434)	177,000

F. Reservoir Surface (acres)

Spillway crest (Elev. 420)	3,106
Top of dam (Elev. 434.0)	3,323±

G. Dam

For general plan and typical sections, See Appendix D, Plates VI, VII and VIII.

Type: Concrete gravity.

Length: West Abutment - 132 feet
Spillway - 480 feet
East Abutment - 92 feet
Total - 704 feet

Maximum height of abutments above streambed	159
Structural height of spillway	160

Lowest foundation at Elev. 260.0.

Cutoff: None.

Grout curtain: Grouted from gallery.

H. Outlet Conduit

Type: 10 feet diameter tunnel to Baltimore. Length 14 miles. Located 1.5 miles upstream of dam.

I. Spillway

Type: Uncontrolled ogee weir.

Length of weir: 480 feet.

Crest elevation: 420 feet.

Upstream channel: The spillway is in the center of the dam at the deepest portion of the dam. The approach is unobstructed.

Downstream channel: The discharge from the spillway flows down the ogee section with some high steps on the sides and empties into an excavated pool with concrete slab and from there into the natural stream.

J. Regulating Outlet

See Section 1.3.H above.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

A. Data Available

1. Hydrology and Hydraulics

The files of the Maryland Department of Natural Resources (DNR) contained a spillway rating curve, a storage rating curve, inflow and outflow hydrographs and a storage outflow curve. These curves and graphs were made in 1942 (see Appendix B, Plates I, II and III). The files also contained information about the design spillway discharge. Based on the drainage area of 164 square miles, the spillway discharge should be 64,000 cfs. Due to the large storage available this was reduced to 46,000 cfs, which would give a maximum pool level of 428.50 (8.5 feet over spillway crest).

2. Gravity Structure

The files of DNR contained a set of design drawings for the structure including test boring results. The original design calculations for the spillway section were available for review in the DNR files as were the length of grout holes and the amount of cement used on a daily basis. The as-built drawings were not available in the files.

B. Design Features

The spillway gravity section design calculations indicate that this structure was designed for the following conditions:

1. Reservoir empty.
2. Reservoir filled and ice pressure of 20 kips per lineal feet at elevation 420.0.
3. Reservoir filled to design elevation 428.5.
4. Siltation to elevation 370.0 and reservoir full to elevation 428.50.

This spillway section was analyzed at 10 feet high intervals and on Plate XIII, Appendix D, the results are summarized. Some reinforcement was required at the upstream face near the top due to ice pressure. All sections were analyzed assuming two-thirds of full hydrostatic uplift at the upstream side and no uplift at the toe of the section. The required sliding coefficient is shown on the drawing and is maximum at elevation 300.

The structure was poured in five foot lifts and with contraction joints at 50 feet centers. Plate XII indicates that horizontal pours were made on a 5 percent slope. Vertical contraction joints have a steel plate and a 6-inch drain. A copper waterstop was placed around the gallery. Grout holes were drilled at five feet centers from the gallery and stairs through the concrete and at least 30 feet into the rock. Drainpipes, at least 20 feet into rock, were drilled downstream of the curtain at 12.5 feet centers. Vertical construction joints are keyed.

The abutments are solid from rock foundation to the platform at elevation 420.0. Above this elevation the abutments consist of two feet thick reinforced concrete walls on the upstream and downstream sides, and these walls are connected at elevation 435.0 with beams and slab, which forms the top of the abutment. The walls are doweled into the concrete base with #5 bars at 10-inch centers. The abutment foundation is grouted and concrete walls at the end of the walls are keyed into the hillside.

C. Design Data

1. Hydrology and Hydraulics

The spillway was designed for a maximum discharge of 46,000 cfs, which requires a pool level of 8.5 feet over the spillway crest. Including the available storage, this design discharge allows for a peak inflow of 64,000 cfs.

2. Gravity Structure

Borings were taken at approximately 50 feet centers over the foundation area of the dam (Plate VIII, Appendix D). The concrete used in the structure was classified as Class 1 to Class 5, with 28-day compressive strength varying from 4,000 to 2,000 psi. The base of the abutments and the inner core of the spillway (Plate X, Appendix D) are Class 5 concrete (2,000 psi). The outside 4 feet of the spillway is Class 4 concrete (2,500 psi) and the walls and slab of the abutments have Class 2 concrete (3,500 psi). Other classes of concrete were used for the parapet and the intake tower.

The assumed weight of concrete was 150 lbs. per cubic feet, and weight of water on the sloping upstream face was taken into account. At the foundation elevation (Elev. 260.0), full hydrostatic uplift was used at the upstream side of the drain pipe. This was reduced to tailwater hydrostatic pressure at the downstream side of the drain pipe. The weight of sheet water on the spillway was neglected. The resultant forces fall within the third point of the base and the maximum sliding coefficient is .66. Maximum vertical foundation pressure was

calculated as 9 ton/square feet at the toe (full reservoir) and 12.5 ton/square feet at the heel (empty reservoir).

Design data and design criteria for the intake structure and the suspension bridge were not in the DNR files. Because this structure does not effect the dam structure, further investigations were not pursued.

2.2 CONSTRUCTION

The construction data available for review included the contract drawings, the contract specifications, two drawings indicating an alternate grouting scheme and a record with the length of grout holes and the total bags of cement used. On the original design drawings, the centerline of the gallery is shown as 15 feet from the upstream face. On the new grout scheme, this centerline is shown as 10 feet from the upstream face.

Construction of the dam was completed in September 1953, but no other records of construction were available.

2.3 OPERATION

An automatic recorder in the intake tower charts the actual pool levels. Records received from the representatives of the City indicates that the maximum pool level during the 1972 tropical storm Agnes was 427.42 and in November 1976 the pool level reached 425.7. No other records of operation were reviewed. The representatives stated that no major problems effecting the operation of the dam occurred during these storms.

2.4 EVALUATION

A. Availability

The data available for review were provided by the Department of Natural Resources (DNR), Maryland.

B. Adequacy

1. Hydrology and Hydraulics

The hydrologic and hydraulic information available for this dam was quite substantial. Hydrographs for the years 1930 to 1949 are in the design drawings and the files contained spillway rating curve, storage rating curve, inflow and outflow hydrographs and a storage outflow curve. This information enabled the review of the adequacy of the spillway based on the Corps of Engineers guidelines.

2. Gravity Structure

The design analysis for the spillway section was available for review and the assumed conditions and calculations are considered to be in accordance with accepted engineering practice. The abutment design analysis was not available for review, but the design drawings are sufficient to review the stability of these structures. The detailing appears to be acceptable.

No records of as-built drawings were available. It is assumed that actual foundation elevations will be close to the design elevations. Although the boring results plotted on the drawings were available, a geologic report was not in the files.

C. Operating Records

The operating records include automatic recorded pool levels. A good record was available reporting the use of the low flow values (last used in 1966).

D. Post Construction Changes

There have been no reported modifications made after construction was completed in 1953.

E. Seismic Stability

The dam is located in Seismic Zone 1 and it is considered that the static stability with normal safety factors is sufficient to withstand minor earthquake induced dynamic forces. No calculations or studies have been made to confirm this.

SECTION 3 - VISUAL INPSECTION

3.1 FINDINGS

A. General

The general appearance of this structure is excellent. The reservoir area and the concrete structure indicate a formally engineered and well maintained facility. The visual checklist made during the inspection is in Appendix A and photographs taken during this inspection are reproduced in Appendix D, Plates III through VI.

B. Concrete Gravity Dam

The concrete abutments and spillway appeared to be in excellent condition. The east abutment is open to the public with well maintained access roads. At the time of inspection, the pool level was about 2.5 feet below the spillway crest. An inspection of the concrete surface of the spillway shows some map cracking and some minor weathering of the concrete surface.

A manhole cover on the east abutment provides access to the inside of the abutment. A large room lies inside with a floor elevation of 420. The manhole cover access is welded down to prevent unauthorized access and indicates that inspection of the gallery is made very infrequently. Humidity inside is very high. From the level of 420.0, a gallery stair leads down to an elevation of 287 under the spillway and then under the spillway up to the other abutment where similar construction exists.

Although lighting was originally installed, the power has been cut off due to severe corrosion in the humid air.

No structural cracking was noticed during the inspection of the gallery. Some seepage of water through contraction and construction joints has occurred and deposits of calcite were noticed at several places. No actual leakage was noticed during the inspection. The relief drains appear to be functioning properly and water was running in the trough along the gallery. Approximately halfway in the lower part of the gallery is a 16-inch pipe and an 8-inch pipe with valves. These are not shown on the drawings and were presumably installed to provide a low flow outlet. According to the representatives of the City of Baltimore, these valves have not been operated since 1966. During the inspection the valves were cracked open and appear to be in operable condition.

Both abutment joints with the hillside appear to be in good condition. The downstream spillway slab is jointed very tightly with

the rock surface. Weepholes in the spillway training walls were functioning properly.

C. Appurtenant Works

The spillway is an integral part of the dam and the only regulating valves are on the 16-inch and 8-inch pipes for low flow. The intake structure or gate house is located 1.5 miles upstream of the dam. This structure has intakes at several levels, with the lowest level at elevation 320.0 where two 3-feet by 5-feet gates are located. At elevation 365.0, four gates of 3-feet by 5-feet are located. All water has to go through a 10-feet diameter concrete lined tunnel to the treatment plant at Baltimore. The water flows under gravity over a distance of approximately 14 miles. This tunnel would be the major drawdown facility for the impounded lake in an emergency. The minimum flow line (16") is not considered very effective for drawdown purposes for this large reservoir. This structure appeared to be in good condition. All gates are opened at regular intervals and are well maintained. The tower is accessible from the roadway by a suspension footbridge.

D. Reservoir Area

The banks of the reservoir are wooded and no signs of erosion were noticed. The City representative stated that sedimentation has not been a problem, but no survey has been made to confirm this. The City of Baltimore owns approximately 6 percent of the watershed and controlled logging of the forests around the lake is taking place.

E. Downstream Channel

The spillway overflow ends in a concrete paved pool, 205 feet wide and 185 feet wide. The water flows from there in the natural stream which is wooded and uninhabited. The first downstream village is Daniels and approximately 14 miles downstream of the dam is Ellicott City. Dam failure would cause a high loss of life and serious economic loss in this City. The hazard classification for this dam is considered to be "High".

3.2 EVALUATION

The observed condition of this structure is considered to be excellent. No obvious signs of deterioration or an unstable condition was noticed. There are no facilities to drawdown this lake in case of an emergency. This inspection did not include an inspection of the stilling pool which is under water.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

This impoundment dam is used to supplement the water supply capacity of other sources owned by the City of Baltimore. The operational controls are not located at the dam proper, but are in an intake structure 1.5 miles upstream of the dam. The access manhole to the gallery is normally welded closed, which indicates that surveillance of the gallery is an infrequent procedure.

4.2 MAINTENANCE OF DAM

The necessary maintenance of a concrete structure is limited until aging causes deterioration. The general appearance is good, although some spalling and cracking of the spillway surface has occurred. The facilities are open to the public and the surrounding area is well maintained. The office and maintenance shop is near the dam site and daily visits to the dam are made.

4.3 MAINTENANCE OF OPERATING FACILITIES

The only operating facilities at the dam are the low flow pipes which have not been opened since 1966. All other operating facilities are located in the intake structure, 1.5 miles upstream. This structure is well maintained and all gates are in excellent condition.

4.4 WARNING SYSTEM

At present there is no formal downstream warning system in effect. The office is located at the site and daily attendance is existing.

4.5 EVALUATION

The structure is well maintained and in good condition. A formal downstream warning system should be developed for emergency use. There are no facilities for quick drawdown of the reservoir in case of an emergency. Consideration should be given to a padlocked manhole rather than welded to encourage a regular inspection of the gallery.

SECTION 5 - HYDROLOGY/HYDRAULICS

5.1 EVALUATION OF FEATURES

A. Design Data

The hydrologic and hydraulic analysis available from Maryland DNR for Liberty Dam was extensive. The files contained a spillway rating curve and a storage curve for the reservoir. The files also contained the design storm hydrograph and the flow routing for that storm. The design storm, when routed through the reservoir, produced a head of 8.5 feet on the weir. Some of these graphs are reproduced in Appendix B, which also contains the hydraulic computations for this report.

No information was available for the low flow outlet pipes.

B. Experience Data

Liberty Dam was completed in 1953, and in the period since then the maximum discharge occurred on June 22, 1972, when tropical storm Agnes produced a pool elevation of 7.42 feet above the crest of the weir.

C. Visual Observations

On the date of the inspection, no conditions were observed that would indicate that the appurtenant structures of the dam could not operate satisfactorily during a flood event, until the dam is overtopped.

D. Overtopping Potential

Liberty Dam has a total storage capacity of about 177,000 acre-feet and a total height of 159 feet. These dimensions indicate a size classification of "Large". The hazard classification is "High" (see Section 3.1.E).

The recommended Spillway Design Flood (SDF) for a dam with the above classifications is the Probable Maximum Flood (PMF). The PMF peak inflow for this site is 95,120 cfs and the total spillway capacity is 96,800 cfs. This would indicate that the potential for overtopping does not exist. Refer to Appendix B for hydraulic computations.

When routed through the reservoir, the PMF peak inflow is reduced to 76,820 cfs peak inflow, with a maximum pool elevation of 432.0. Section 6 of this report reviews the stability of the structure with a pool level of 432.0.

E. Spillway Adequacy

Since the PMF peak inflow of 95,120 cfs is less than the total spillway capacity of 96,800 cfs, the spillway is considered to be adequate.

The hydrologic analysis for this investigation was based upon existing conditions of the watershed. The effects of future development were not considered.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

A. Visual Observation

1. Concrete Gravity Structure

The visual inspection of Liberty Dam did not reveal any indication of stress or stability problems. Some leaking through joints had occurred, but at the time of this inspection, deposits had sealed these joints. The relief drains appear to be operating satisfactorily. It is recommended that the gutters in the gallery be cleaned at regular intervals. A very high moisture condition exists in the gallery and consideration should be given to install some open gratings in the abutments for airing.

B. Design and Construction Data

The files did not contain a geologic report or a discussion of allowable foundation pressure, shearing strength of the foundation rock. The resultant for the design conditions (ice, 8.5 feet head or empty) falls within the middle third of the foundation and the maximum sliding coefficient is .66 ($\Sigma H/\Sigma V$). The factor of safety against shear failure in concrete was minimal 8.5 using a friction factor of .75 and a shear strength of 300 psi.

In Appendix C, computations were made to check stability with a pool level elevation of 432, which is 3.5 feet higher than the design pool level. Because the gallery had been moved 5 feet upstream, it appears that the additional head still provides a satisfactory condition.

C. Operating Records

This dam is one of several water supply sources that are owned and operated by the City of Baltimore, Maryland. The available records indicate that no major problems have occurred since construction was completed in 1953.

D. Post Construction Changes

Records indicate that no modifications have been made to the dam after construction was completed.

E. Seismic Stability

The dam is located in Seismic Zone 1 and it is considered that the static stability with normal safety factors is sufficient to withstand minor earthquake induced dynamic forces. No calculations or studies have been made to confirm this.

SECTION 7 - ASSESSMENT AND RECOMMENDATIONS

7.1 DAM ASSESSMENT

A. Safety

The visual inspection and operational history indicate that Liberty Dam is functioning satisfactorily and is in good condition. The structure was designed and constructed in accordance with accepted engineering practice.

In accordance with the Corps of Engineers' evaluation guidelines, the spillway capacity is adequate for passing the PMF (Probable Maximum Flood) peak inflow without overtopping the dam. The short cut method indicates that the PMF peak inflow would cause a maximum pool level of 432 and a stability analysis indicates that the structure would be capable of withstanding this condition.

B. Adequacy of Information

The available information is considered sufficient to make a reasonable assessment of the project.

C. Urgency

It is considered important that the recommendations suggested in this section be implemented as soon as practical.

D. Necessity for Additional Studies

Additional studies are not required at this time. However, attention should be given to the recommendations presented in this section.

7.2 RECOMMENDATIONS

A. Facilities

In order to assure the satisfactory performance of this dam, the following items are recommended for action by the owner:

1. Installation of open gratings in the abutment manholes for air circulation.

2. The installation of padlocks on the manhole covers.

B. Operation and Maintenance Procedures

The following recommendations are presented for consideration by the owner in the operation and maintenance of the dam:

1. That the gutter in the gallery be flushed at regular intervals.

2. That the maintenance schedule include a bi-annual inspection of the gallery for possible signs of cracking and seepage.

3. That a formal surveillance and downstream warning system be developed to be used during periods of heavy or prolonged precipitation.

APPENDIX A

VISUAL INSPECTION

CHECK LIST - DAM INSPECTION PROGRAM

PHASE I - VISUAL INSPECTION REPORT

NAD NO. MD-3

NAME OF DAM Liberty HAZARD CATEGORY High

TYPE OF DAM Concrete Gravity

LOCATION Carroll and Baltimore COUNTY, MARYLAND

INSPECTION DATE 8/1/78 WEATHER Cloudy - Rain TEMPERATURE 70's

INSPECTORS: H. Jongsma, R. Houseal, R. Shireman, A. Bartlett, C. Gray — MD. D.N.R.

Dusty Moore
Jane Wagner
J. Smith
T. Moynahan

City of Baltimore

Warren Spencer
Brent Hartley

NORMAL POOL ELEVATION 420.0 AT TIME OF INSPECTION

BREAST ELEVATION 435.0 + parapet POOL ELEVATION 417.57

SPILLWAY ELEVATION 420.0 TAILWATER ELEVATION

MAXIMUM RECORDED POOL ELEVATION 427.42 (Agnes) - 425.72 (Eloise)

GENERAL COMMENTS:

City owns under 6% of watershed area.

Ellicott City Downstream - heavy losses of property, also loss of life during Agnes.

One 16-inch and one 8-inch pipe for low flow control downstream supply for plant operation. Have not been operated since late July, 1966. No special plan for operation of these valves.

Intake tower gates operated once each month at least.
Automatic gage on tower.
Contractor - The Arundel Corporation - completed September 1953.

DAM NO. NAD MD-3

VISUAL INSPECTION

OUTLET WORKS	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. INTAKE STRUCTURE	Located in reservoir upstream from dam - not part of dam operation.	
B. OUTLET STRUCTURE	10'-0" tunnel to Baltimore Gravity flow.	
C. OUTLET CHANNEL	N/A	
D. GATES	All gates 36" x 60" 2 at Elev.320 4 at Elev. 365 2 at Elev.410	
E. EMERGENCY GATE	N/A	
F. OPERATION & CONTROL	Gates opened at least every two months.	
G. BRIDGE (ACCESS)	Suspension Bridge	

DAM NO. NAD MD-3

VISUAL INSPECTION

SPILLWAY	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. APPROACH CHANNEL	The approach is directly from the reservoir.	
B. WEIR: Crest Condition Cracks Deterioration Foundation Abutments	Ogee section - concrete - uncontrolled. Slabs on ogee show some thin map cracks. Slight weathering on slabs - aggregate exposed Abutments tie into rock on both sides	
C. DISCHARGE CHANNEL Lining Cracks Stilling Basin	None Natural channel	
D. BRIDGE & PIERS	Dam spans abutment to abutment No bridge over spillway or channel Tunnel through spillway	
E. GATES & OPERATION EQUIPMENT	None	
F. CONTROL & HISTORY	Maximum flow during Agnes	

Right abutment wall below ogee - weep holes were discharging some water.

DAM NO. NAD MD-3

VISUAL INSPECTION

MISCELLANEOUS	OBSERVATIONS	REMARKS & RECOMMENDATIONS
INSTRUMENTATION		
Monumentation		
Observation Wells	None	
Weirs	None	
Piezometers	None, drainholes to tunnel	
Other	Self-automatic recording gage on intake structure	
RESERVOIR		
Slopes	Forested to waters edge	
Sedimentation	None reported	
DOWNSTREAM CHANNEL		
Condition	Good	
Slopes	Woodland to waters edge	
Approximate Population	Daniels and Ellicott City	
No. Homes	Considerable numbers of properties and families. Serious flooding during Agnes.	

DAM NO. NAD MD-3

VISUAL INSPECTION

CONCRETE/MASONRY DAM	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. SEEPAGE	None. Some calcium deposits in gallery.	
B. ABUTMENT JOINTS	Appear to be sound.	
C. DRAINS	Yes - to gallery from foundation.	
D. WATER PASSAGE	No controls at spillway. Refer to intake data.	
E. FOUNDATION	See Geologic Report.	
F. CONCRETE SURFACE	Some slight cracking and weathering - good condition.	
G. STRUCTURAL CRACKS	None - shrinkage cracks.	
H. HORIZONTAL & VERTICAL ALIGNMENTS	Good	
J. MONOLITH JOINTS	Good	
K. STAFFGAGE & RECORDER	Automatic gage for measuring W.S.L.	

APPENDIX B

HYDROLOGY/HYDRAULICS

SUBJECT LIBERTY DAM

MAXIMUM KNOWN FLOOD AT DAM SITE

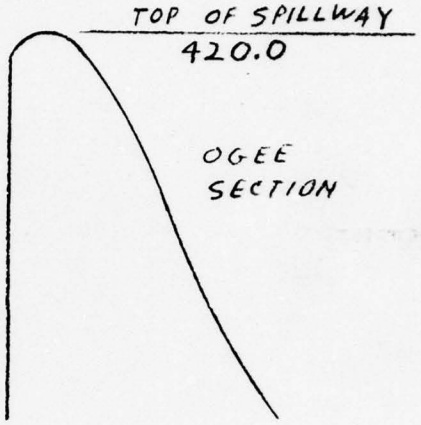
WATER DEPARTMENT RECORDS INDICATE THAT THE MAXIMUM KNOWN FLOOD SINCE CONSTRUCTION OCCURRED ON JUNE 22, 1972. AT THAT TIME THERE WAS 7.42 FT. OF HEAD ON THE WEIR.

$L = 480'$
$H = 7.42'$
$C = 3.85$

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

$= 3.85 \times 480 \times (7.42)^{3/2}$

$= 37350$ CFS



$C = 3.95$ (FIG. 249 DESIGN OF SMALL DAMS)

DESIGNER USED $C = 3.85$

USE $C = 3.85$

MINIMUM DISCHARGE OUTLET

ONE 16" DIA. PIPE AND ONE 8" DIA. PIPE, LOCATED IN GALLERY ABOUT 2' ABOVE FLOOR. ESTIMATED ELEV. = 290.0

DISCHARGE WITH WATER LEVEL AT 420

$H = 420 - 290 = 130'$
$L = 110' \pm$
$N = 0.015$

$Q = \frac{1.486}{N} \times A \times R^{2/3} \times S^{\frac{1}{2}}$

16" PIPE $Q = \frac{1.486}{0.015} \times \left(\frac{\pi \times (16/12)^2}{4}\right) \times \left((16/12)/4\right)^{2/3} \times \left(\frac{130}{110}\right)^{1/2} = 72.3$

8" PIPE $Q = \frac{1.486}{0.015} \times \left(\frac{\pi \times (8/12)^2}{4}\right) \times \left((8/12)/4\right)^{2/3} \times \left(\frac{130}{110}\right)^{1/2} = 11.4$

Q TOTAL $= 72.3 + 11.4 = 83.7$ CFS

SUBJECT LIBERTY DAM

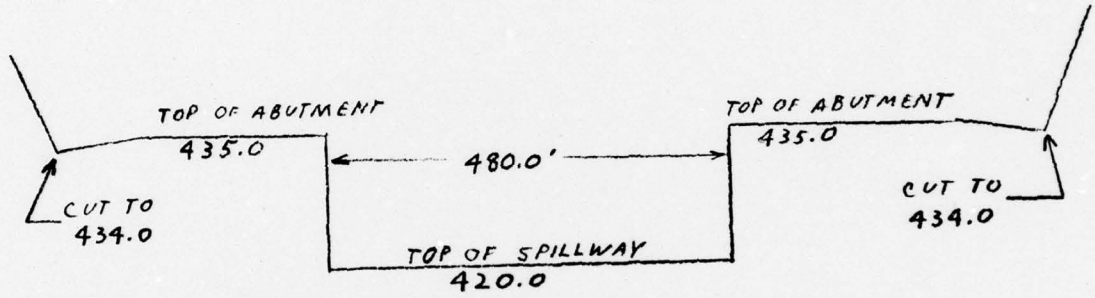
DISCHARGE AT LOW POOL. ELEV. = 300

$H = 300 - 290 = 10'$

16" PIPE $Q = \frac{1.486}{0.015} \times \left(\frac{\pi \times (16/12)^2}{4}\right) \times \left(\frac{(16/12)}{4}\right)^{2/3} \times \left(\frac{10}{110}\right)^{1/2} = 20.1$

8" PIPE $Q = \frac{1.486}{0.015} \times \left(\frac{\pi \times (8/12)^2}{4}\right) \times \left(\frac{(8/12)}{4}\right)^{2/3} \times \left(\frac{10}{110}\right)^{1/2} = 3.2$

Q TOTAL = 20.1 + 3.2 = 23.3 CFS



DISCHARGE OVER SPILLWAY

WATER LEVEL AT TOP OF DAM. ELEV. 434.0

$H = 434 - 420 = 14'$

$C = 3.85$

$L = 480'$

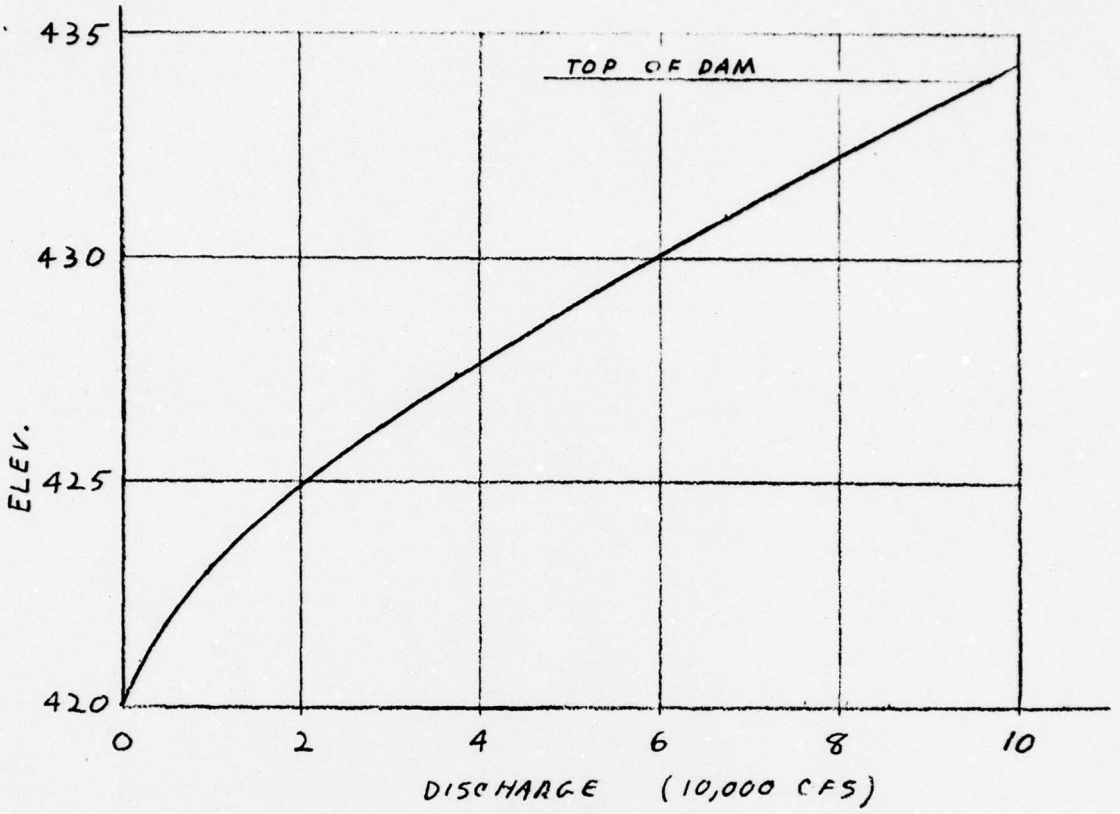
$Q = C L H^{3/2}$

$= 3.85 \times 480 \times (14)^{3/2}$

$= 96800$ CFS

SUBJECT LIBERTY DAM

SPILLWAY DISCHARGE CURVE



SIZE CLASSIFICATION

MAXIMUM STORAGE = 177,000 AC-FT ±

MAXIMUM HEIGHT = 174 FT

SIZE CLASSIFICATION IS "LARGE"

HAZARD CLASSIFICATION

ELLICOTT CITY LIES IN FLOODPLAIN DOWNSTREAM. IF DAM FAILS, LOSS OF STRUCTURES AND LIVES COULD RESULT.

USE "HIGH" HAZARD

RECOMMENDED SPILLWAY DESIGN FLOOD FOR THIS DAM IS THE PROBABLE MAXIMUM FLOOD.

SUBJECT LIBERTY DAM

PMF

DRAINAGE AREA = 164 SQ. MI.

Q = 580 CSM
ASSUME 22" RUNOFF } FROM BALT. DIST. CORPS OF ENGRS.

PMF PEAK Q = 164 x 580
= 95120 CFS

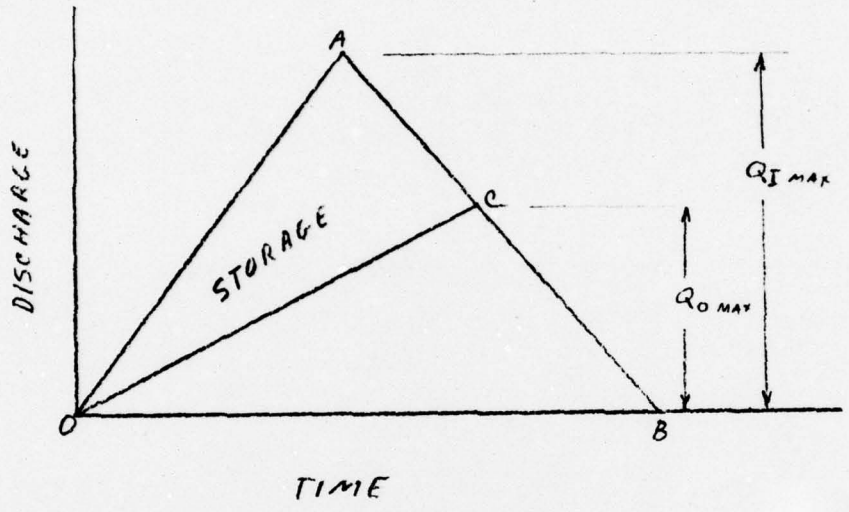
$$\frac{\text{TOTAL SPILLWAY CAPACITY}}{\text{PMF OUTFLOW}} = \frac{96800}{95120} = 102\%$$

THE SPILLWAY SHOULD PASS A FLOW EQUAL TO THE PMF PEAK INFLOW WITH ABOUT 0.2 FOOT OF FREEBOARD..

SUBJECT LIBERTY DAM

ROUTING OF PMF BY C. OF E. SHORT CUT METHOD

VOLUME OF PMF = 22" RUNOFF
= 97,055 CFS-DAYS
= 192,306 AC-FT

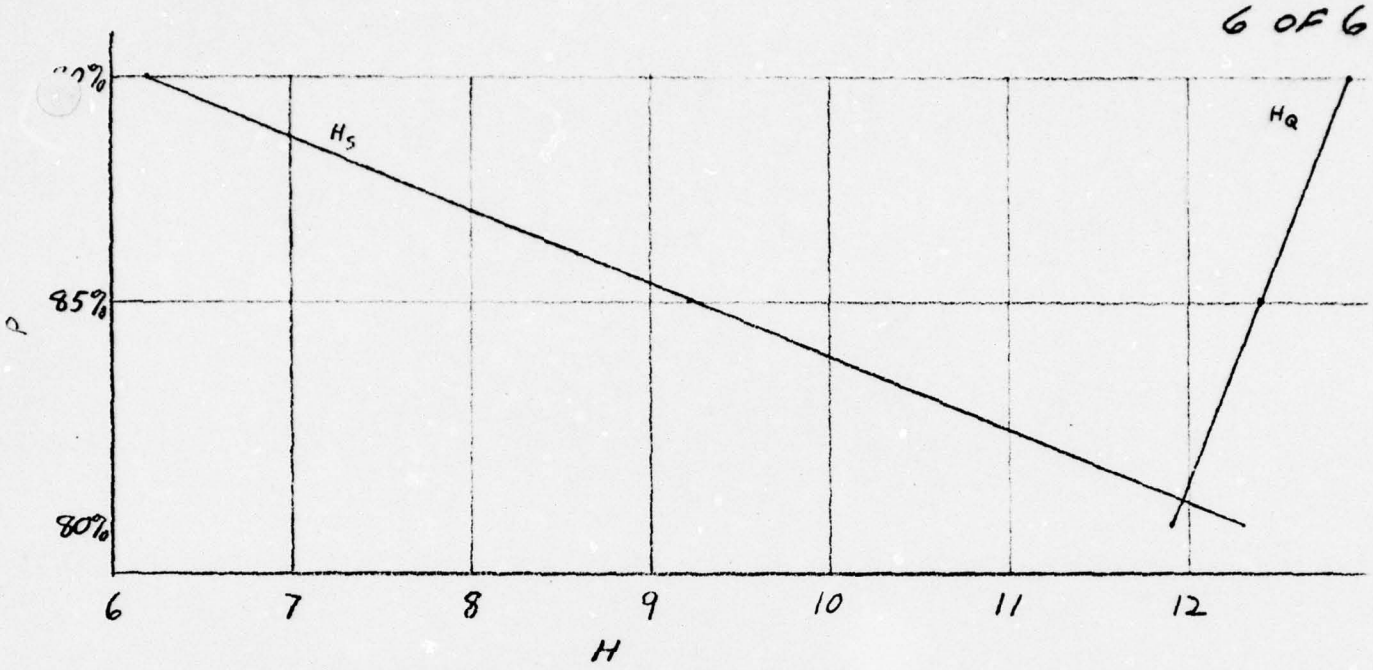


$$\frac{\Delta AOC}{\Delta AOB} = \frac{\Delta AOB - \Delta COB}{\Delta AOB} = 1 - \frac{\Delta COB}{\Delta AOB}$$

$$\frac{\Delta AOC}{\Delta AOB} = 1 - \frac{T\,P\,Q_{I\,MAX}/2}{T\,Q_{I\,MAX}/2} = 1 - P$$

$$\Delta AOC = (1-P)\,\Delta AOB \qquad \Delta AOB = 192,306 \text{ A-F}$$

P =	ΔAOC = (A-F)	H_S =	Q_O = (CFS)	H_Q =
90%	19230.6	6.2	85608	12.9
80%	38461.2	12.3	76096	11.9
85%	28845.9	9.2	80852	12.4



MAX. HEAD = 11.95 USE 12'

MAX. POOL ELEV. = 420 + 12 = 432.0'

MAX. DISCHARGE OVER SPILLWAY = 76820 CFS

PLATE I

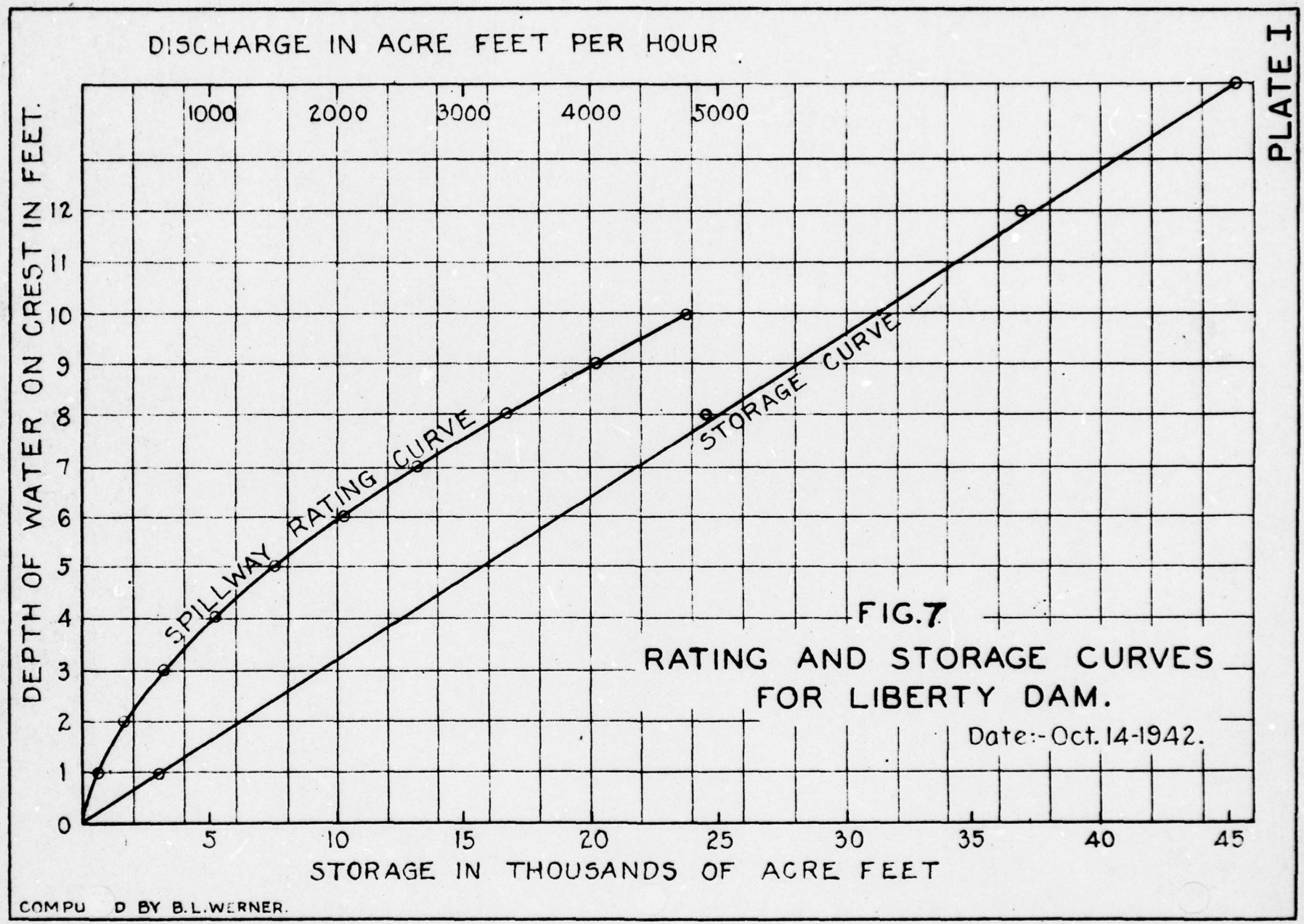
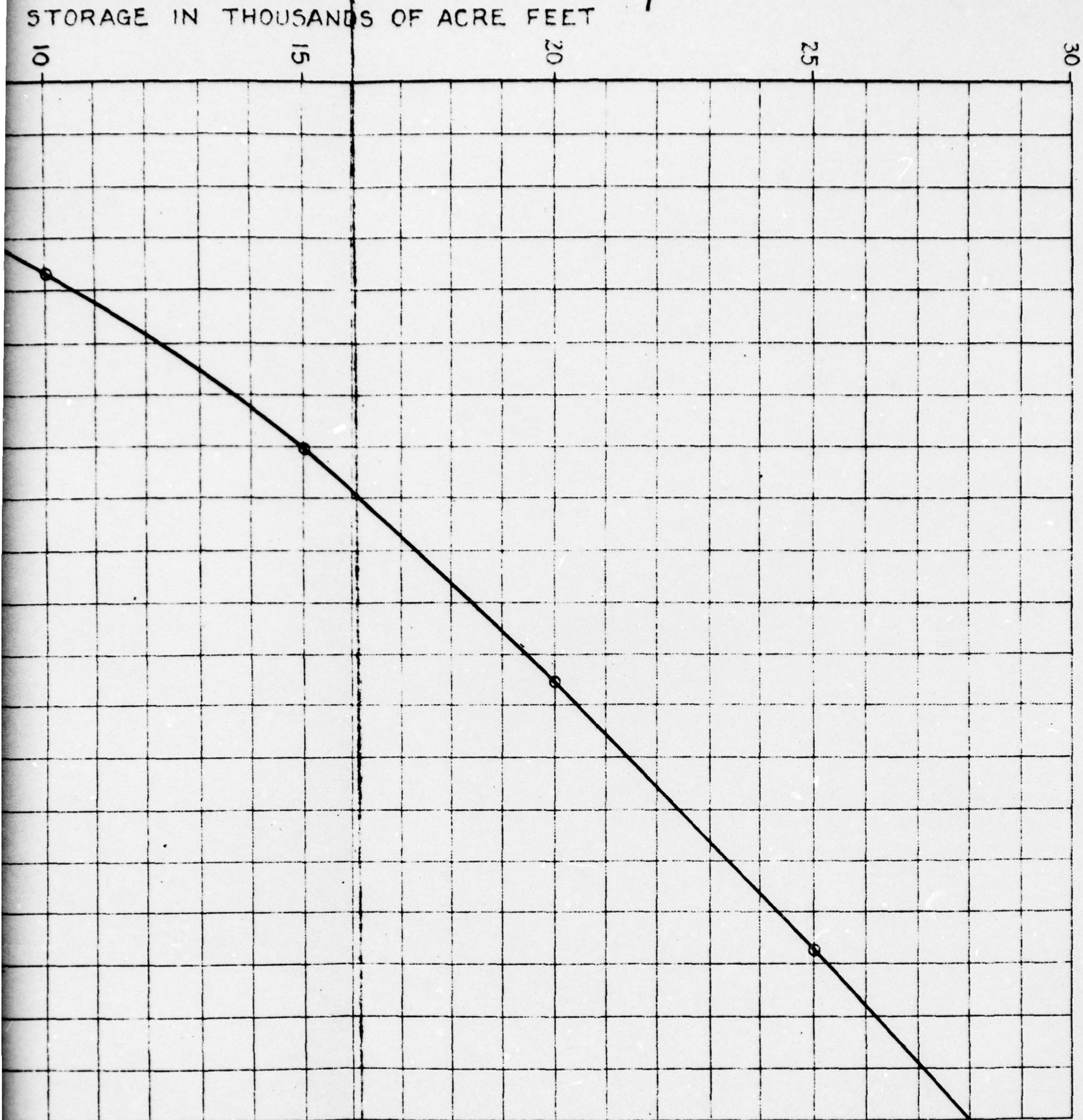


FIG. 7

RATING AND STORAGE CURVES FOR LIBERTY DAM.

Date:- Oct. 14-1942.

COMPU D BY B.L.WERNER.


STORAGE IN THOUSANDS OF ACRE FEET
10
15
20
25
30

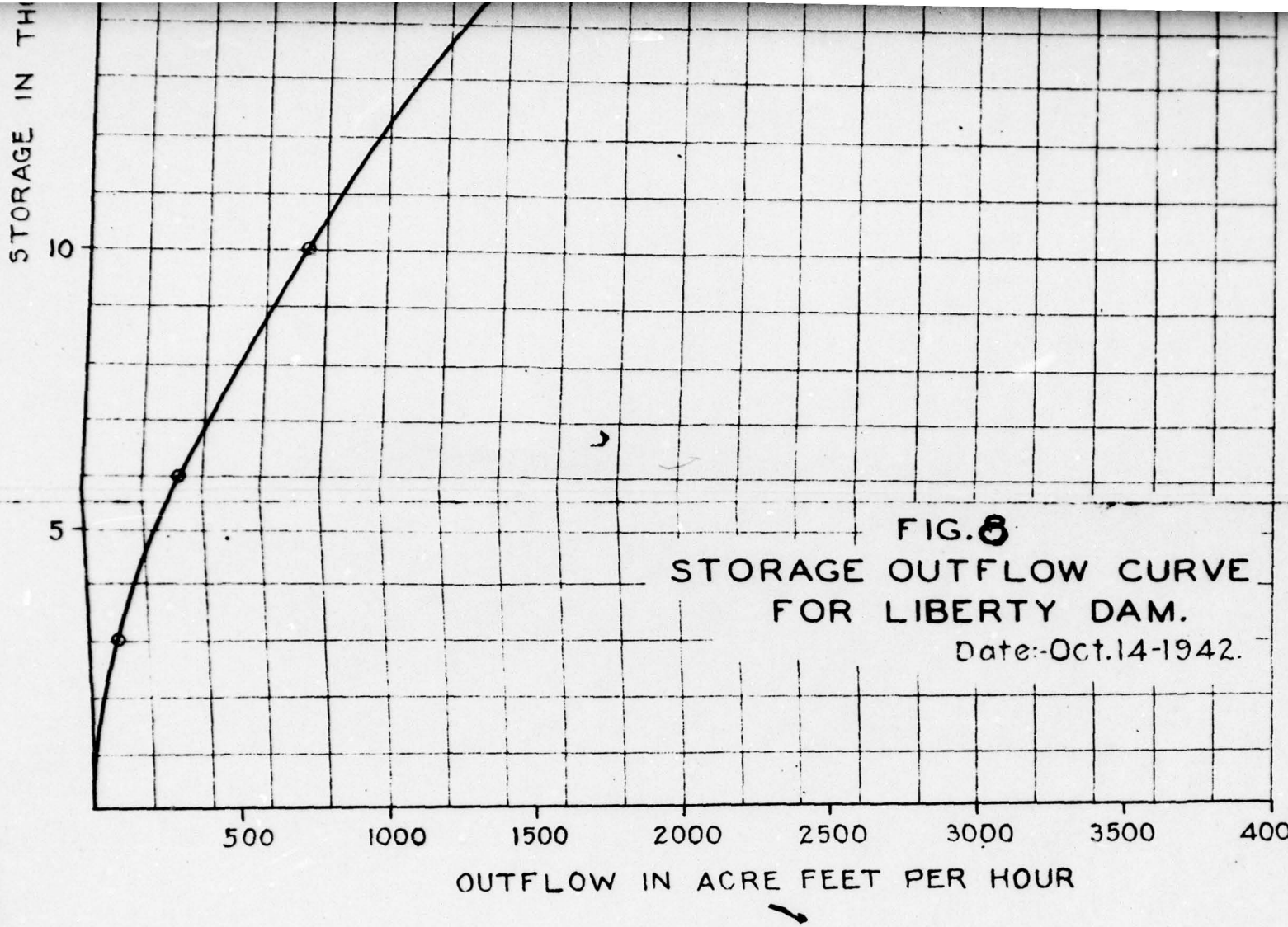


FIG. 8
STORAGE OUTFLOW CURVE
FOR LIBERTY DAM.
Date:-Oct.14-1942.

PLATE II

COMPUTED BY B.L.WERNER.

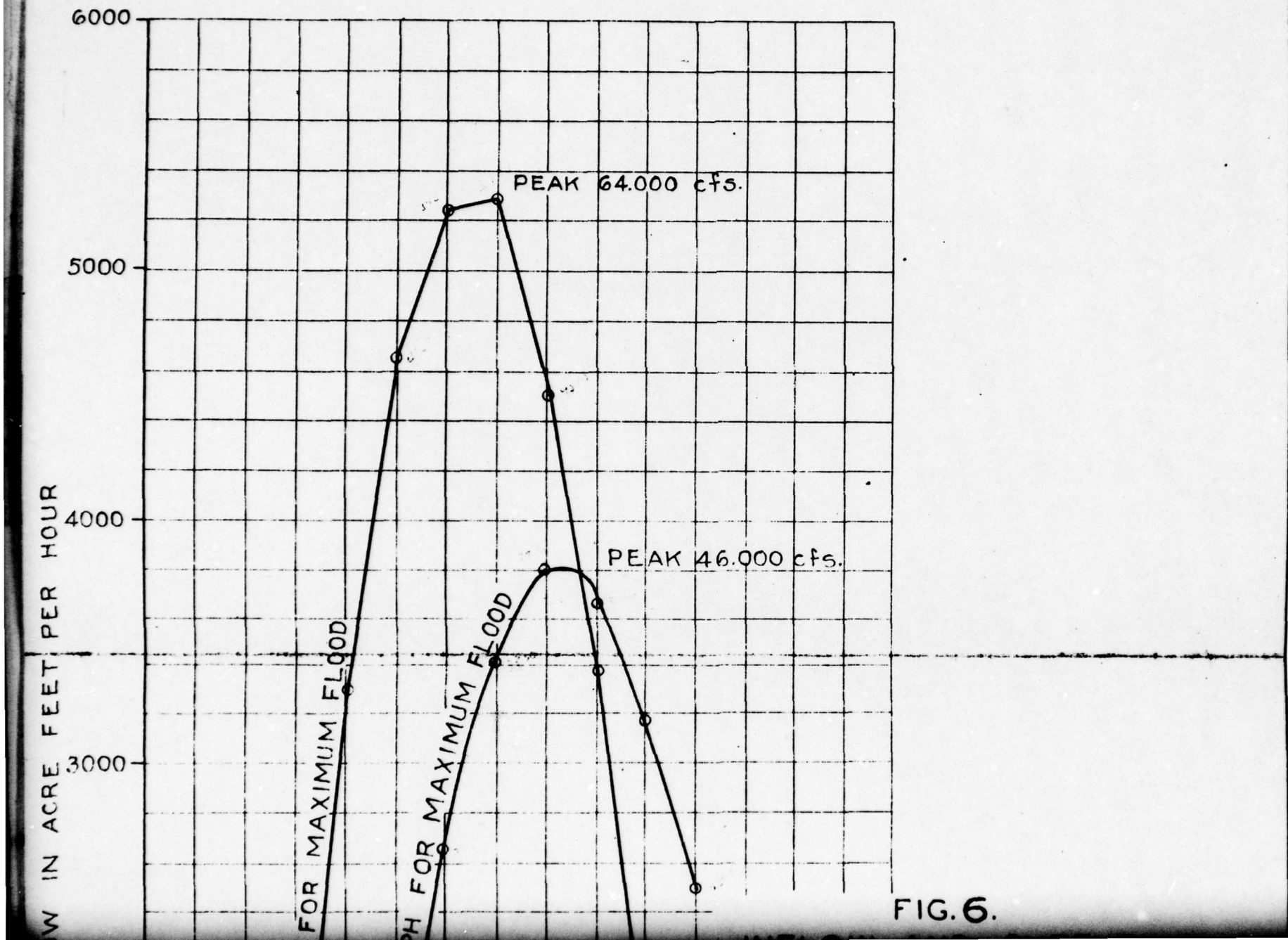

6000
5000
4000
3000
PEAK 64.000 cfs.
PEAK 46.000 cfs.
FOR MAXIMUM FLOOD
H FOR MAXIMUM FLOOD
W IN ACRE FEET PER HOUR

FIG. 6.

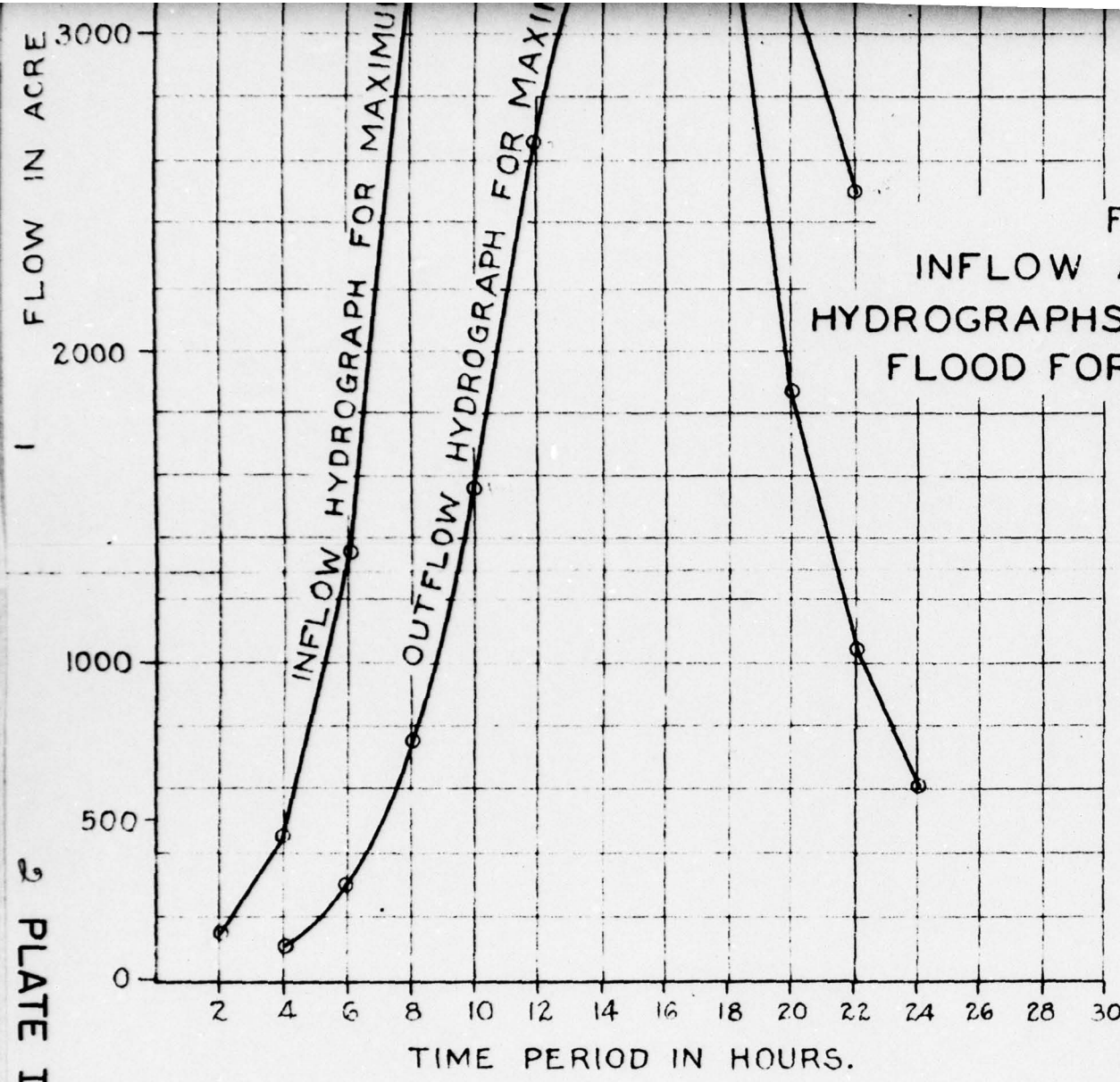


FIG. 6.

INFLOW AND OUTFLOW HYDROGRAPHS OF SPILLWAY DESIGN FLOOD FOR LIBERTY DAM.

Date:-Oct. 14-1942.

PLATE III

COMPUTED BY B.L. WERNER.

APPENDIX C

GEOLOGIC REPORT
AND
STRUCTURAL CALCULATIONS

GEOLOGIC REPORT

Bedrock - Dam

Formation Name: Piney Run Formation (undifferentiated ultramafic member).

Lithology: The rocks mapped as "UM" (Ref.1) include ultramafic and mafic rocks, which consist "entirely of schistose rock, rich in chlorite, talc and amphibole and commonly bearing some plagioclase". At the exposures near the dam the schistosity is generally obscure, and amphibole appears to be more plentiful than chlorite and talc.

Bedrock - Reservoir

Formation Names: Sykesville Formation, Morgan Run Formation and Piney Run Formation. All of these formations are complexes of metamorphic rocks including gneiss, schist, quartz schist, quartzite, amphibolite and altramafic rocks.

Structure

The origin and structure of the ultramafic rocks of Maryland has been a subject of widely differing interpretations. The latest is that they are a block of former oceanic crust which was detached and slid, as a submarine landslide, into a trough where muds and sands were accumulating. Later, the whole mass was compressed, folded, and metamorphosed several times, changing the muds and sands to schist and quartzite enclosing the schistose ultramafic rock.

The schistosity strikes N30° to 35°E and dips 60° to 75°NW. The rock is strongly jointed. The following joint directions were measured at two outcrops at the east side of the dam:

N 0°E, 80°W; N35°E, 58°NW; N40°E, 45°NW; N 0°E, 70°E; N20°E, 25°SE; N30°E, 40°SE; N40°E, 48°SE: N55°E, Vertical; N65°E, 48°NW; N75°E, 60°NW; N75°E, 80°NW; N80°E, 60°NW; N15°W, 52°SW; N30°W, 66° SW; N25°W, 75°NE; N65°W, Vertical; N60°W, 80°NE.

Overburden

Soil cover was thin, generally less than five feet on the steep valley sides. Core boring logs indicate that the bedrock was not deeply weathered. Iron staining and broken core was noted in only the top five to ten feet, in most holes.

Aquifer Characteristics

In ultramafic rock ground water movement is entirely along fractures, as the rock itself is impermeable. At relatively shallow depths these fractures are tight and ground water movement is limited.

Discussion

Bedrock of this type is generally considered to be of excellent quality foundation material for heavy structures. The ultramafics were formerly identified (Carrol Co. Geologic Map) as serpentinite. This term is misleading as it implies a large percentage of serpentine, a relatively soft mineral. Very little serpentine, or talc, is present in the rock at the dam. The rock is schistose, but is not easily split along the schistosity, except in a few local zones.

No data could be found in the shearing strength of this rock, but it should be similar to unweathered mica schist. A stereographic plot of the joint directions shows a fairly random distribution. Of 18 directions measured, only two had strikes close to parallel to the dam and dips of less than 45°. These joints were noted to have distinctly undulating surfaces. It is concluded, therefore, that there are probably no available joint surfaces which would facilitate failure by sliding.

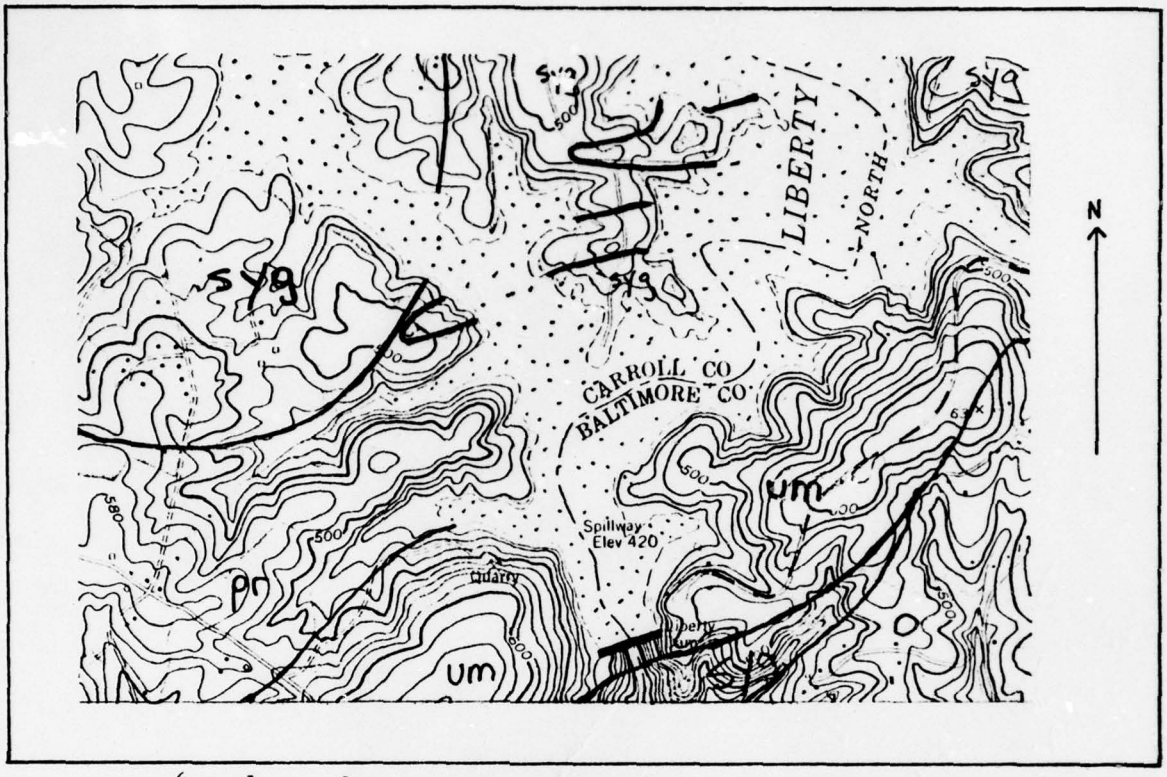
Leakage through fractures in the bedrock below the grout curtain is unlikely to occur in more than minor quantities. Continued leakage would not cause any solution or deterioration of the rock.

Sources of Information

1. Crowley, William P., unpublished geologic map of the Finksburg Quadrangle, on file, Maryland Geologic Survey.

2. Core borings in file.

GEOLOGIC MAP - LIBERTY DAM



(geology from manuscript map, Md. Geol. Surv.)

KEY

O	Oella Fm.
syg	Sykesville Fm.
um	undifferentiated ultramafics
pr	Peters Creek Fm.- Piney Run Member

SCALE 1:24000

1 0 1 MILE

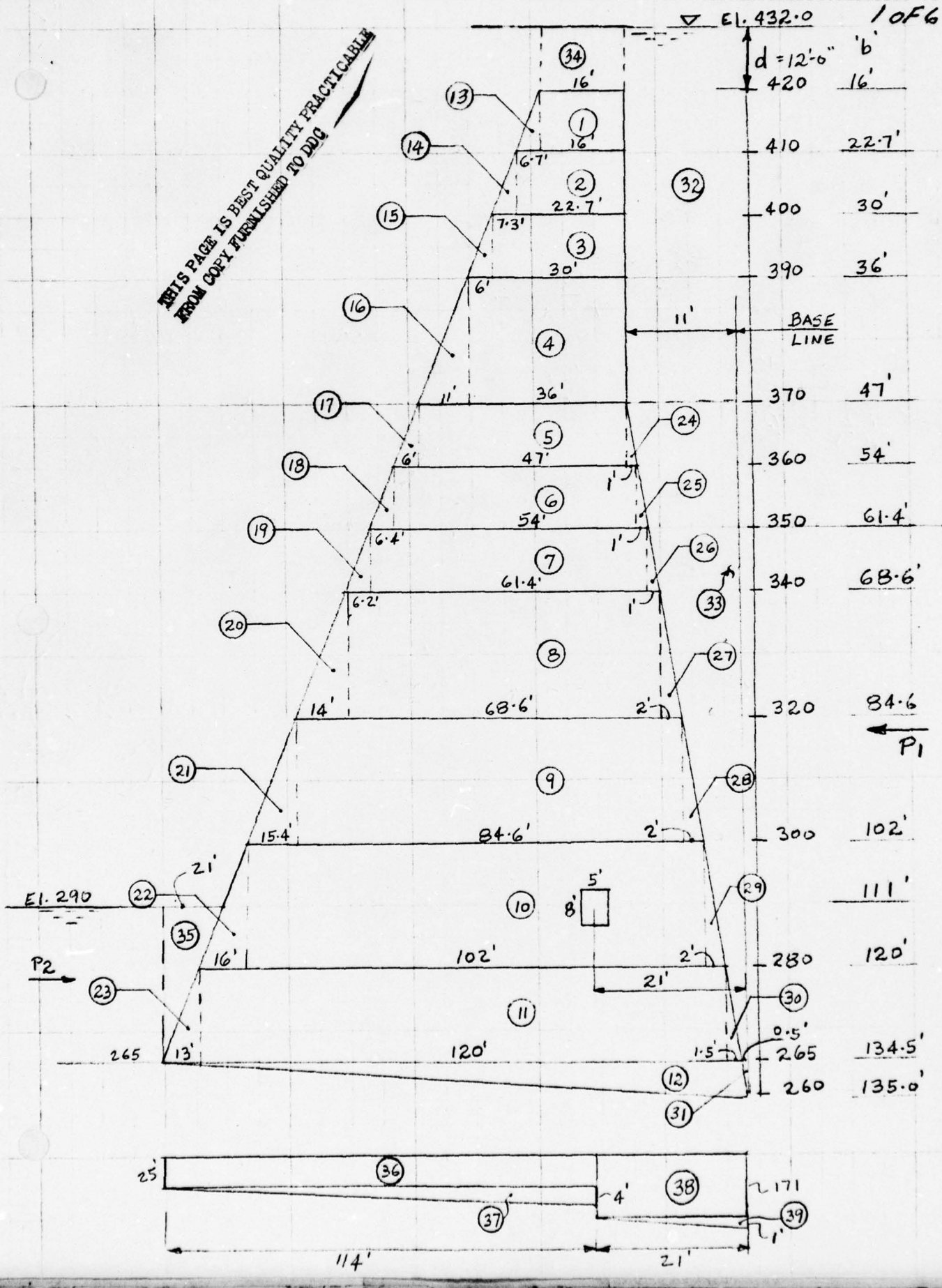
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS

SUBJECT

PROJECT



SUBJECT

FROM ORIGINAL COMPUTATIONS

	WT. LBS.	L.A. FROM ℄		MOM ABOUT ℄
(1)	24,000	19'	=	456,000
(2)	34,050	22·35'	=	761,018
(3)	45,000	26·0'	=	1,170,000
(4)	108,000	29·0'	=	3,132,000
(5)	70,500	34·5'	=	2,432,250
(6)	81,000	37·0'	=	2,997,000
(7)	92,100	39·7'	=	3,656,370
(8)	205,800	42·3	=	8,705,340
(9)	253,800	48·3	=	12,258,540
(10)	306,000	55·0'	=	16,830,000
(11)	270,000	62·0'	=	16,740,000
(12)	50,437	44·67'	=	2,253,020
(13)	5,025	29·23'	=	146,881
(14)	5,475	36·13'	=	197,812
(15)	4,500	43·0'	=	193,500
(16)	16,500	50·67'	=	836,055
(17)	4,500	60·0'	=	270,000
(18)	4,800	66·13'	=	317,424
(19)	4,650	72·47'	=	336,985
	1586.137	(46·46')		73,690,195 #

SUBJECT _____ PROJECT _____ 3 OF 6

	WT. LBS.	L.A.		MOM ABOUT P_2
From Pg. 2.	1,586,137	(46.46)		73,690,195'*
(20)	21,000	81.27'	=	1,706,670
(21)	23,100	95.73'	=	2,211,363
(22)	24,000	111.33	=	2,671,920
(23)	14,625	126.33'	=	1,847,576
(24)	750	10.67'	=	8,002
(25)	750	9.67'	=	7,252
(26)	750	8.67'	=	6503
(27)	3,000	7.33'	=	21,990
(28)	3,000	5.33'	=	15,990
(29)	3,000	3.33'	=	9,990
(30)	1,687	1.50	=	2,530
-(31)	-188	0.17'	=	-32
- GALLERY	-6,000	21	=	-126,000
	1,675,611	(48.98')		82,073,951'*
WATER (32)	42,625	5.5	=	234,438
(33)	37,812	3.67'	=	138,770
(34)	12,000	19'	=	228,000
(35)	16,406	128'	=	2,099968
	1,784,454	(47.51')		84,775,126'*

Uplift Forces

		Vert. Lbs.	L.A.	Mom. at P_E
(36)	$25' \times 114' \times 62.5$ =	178,125	78' =	13,893,750'#
(37)	$\frac{1}{2}(4)(114)(62.5)$ =	14,250	59' =	840,750'#
(38)	$171 \times 21 \times 62.5$ =	224,438	10.5' =	2,356,594'#
(39)	$\frac{1}{2}(1)(21)(62.5)$ =	656	7' =	4594'#
		417,469#	(40.95')	17,095,688'#

AT MAX. FLOW

	V	Mom.	
NET VERT: ↓	1,784,454#	84,775,126'#	
↑ Uplift.	417,469#	17,095,688	
↓ NET	1,366,985#	(49.51')	67,679,438'#

OVERTURNING

$0.5wh(h+2d) = 31.25 \times 160[160+24] = 920,000$#

Mom. Arm $= \frac{h+3d}{h+2d} \times \frac{h}{3} = \left(\frac{160+36}{160+24}\right)\left(\frac{160}{3}\right) = 56.81'$

$\therefore$ Mom = 52,266,667'#

$P_2 = \frac{1}{2}wh^2 = 31.25(25)^2 = 19531$#

Mom = $19531\left(\frac{1}{3} \times 25 + 5\right) = 260,417$'#

$\therefore$ Net. H = 920,000 − 19,531 = 900,469#

Net O.T. Mom = 52,266,667 − 260,417 = 52,006,250'#

$\therefore$ Resultant: from P_E (At Max Flow) $= \frac{67,679,438 + 52,006,250}{1,366,985} = 87.55'$

$\frac{2}{3}$(base) $= \frac{2}{3}(135) = 90' > 87.55'$

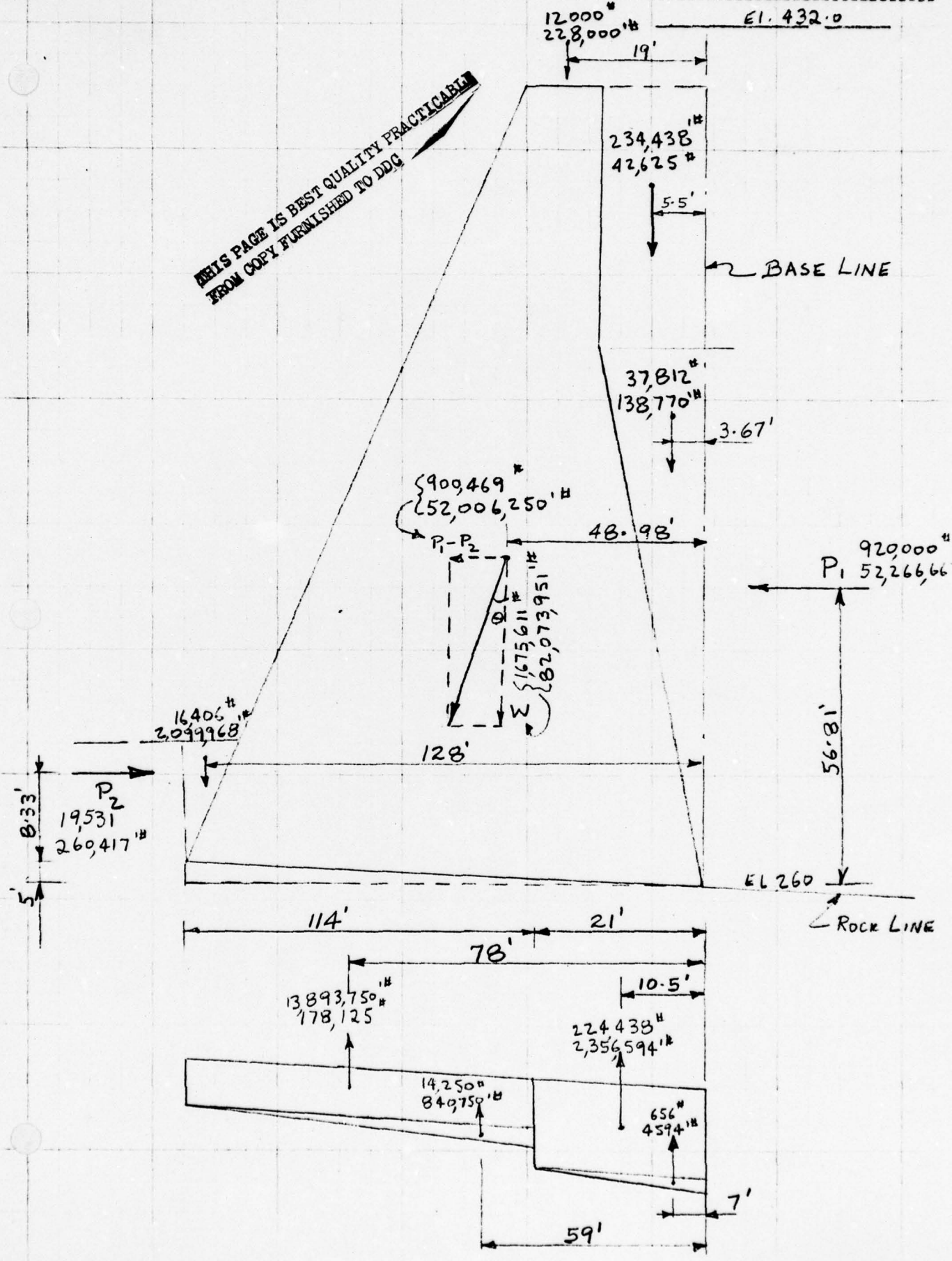
ecc $= \frac{1}{2}(135) - 87.55 = 20.05'$

$\therefore$ No tension develops @ the toe.

SUBJECT

PROJECT

5 OF 6



$\tan \phi = \frac{900,469}{1,675,611} = 0.5374 = 28.253°$

Shear Friction Factor $= \frac{(1,675,611 \times 0.75) + (135 \times 144 \times 300)}{900,469} = 7.87$

Max. Pressures:

$p = \frac{W}{L}\left(1 \pm \frac{6e}{L}\right)$

$e = 20.05'$

$\therefore p(\text{Toe}) = \frac{1,675,611}{135}\left[1 + \frac{6 \times 20.05'}{135}\right]$

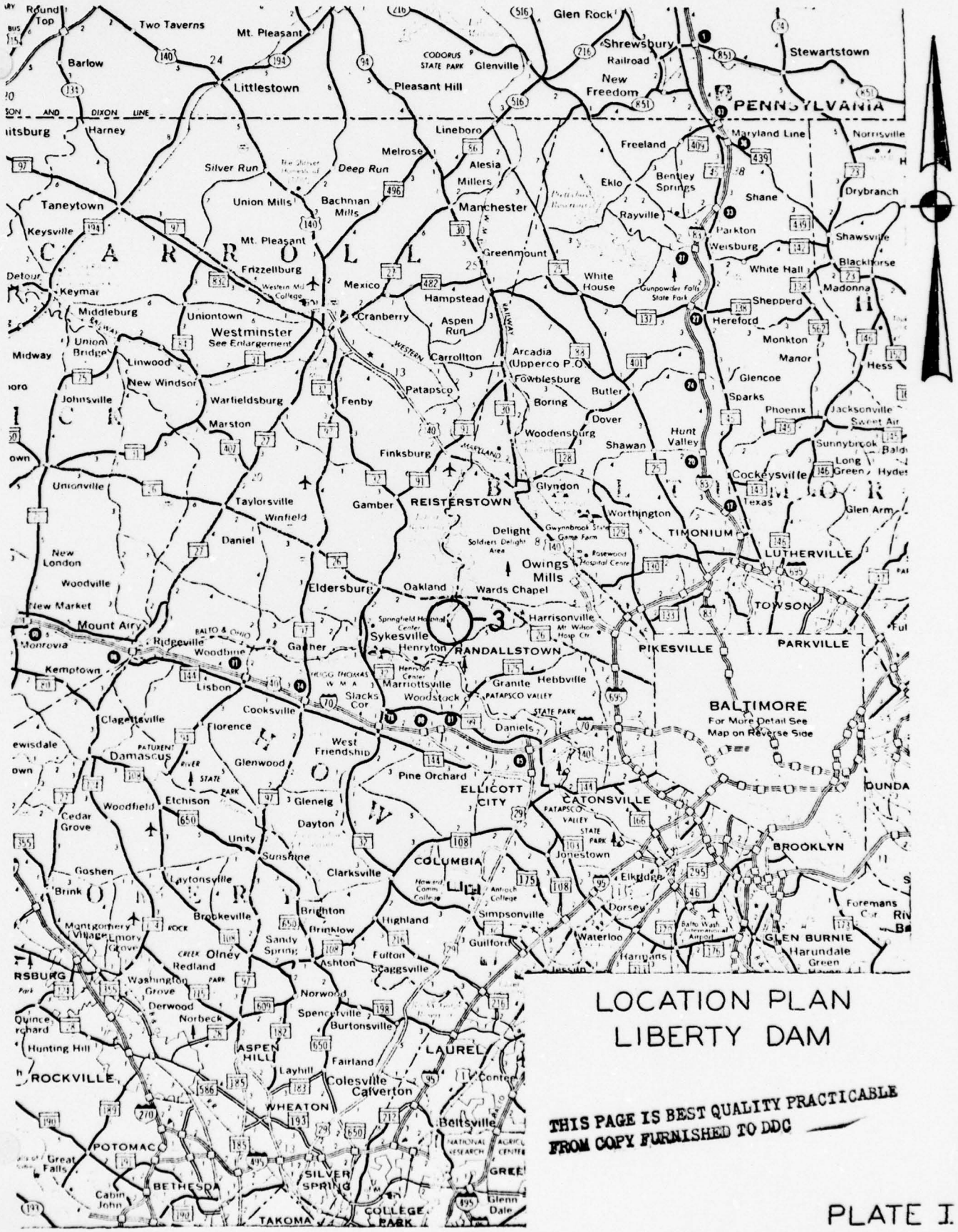
$= 12,412 \times (1 + 0.891)$

$= 23,472$ psf

Heel $p = 12,412(1 - 0.891) = 1,352$ psf

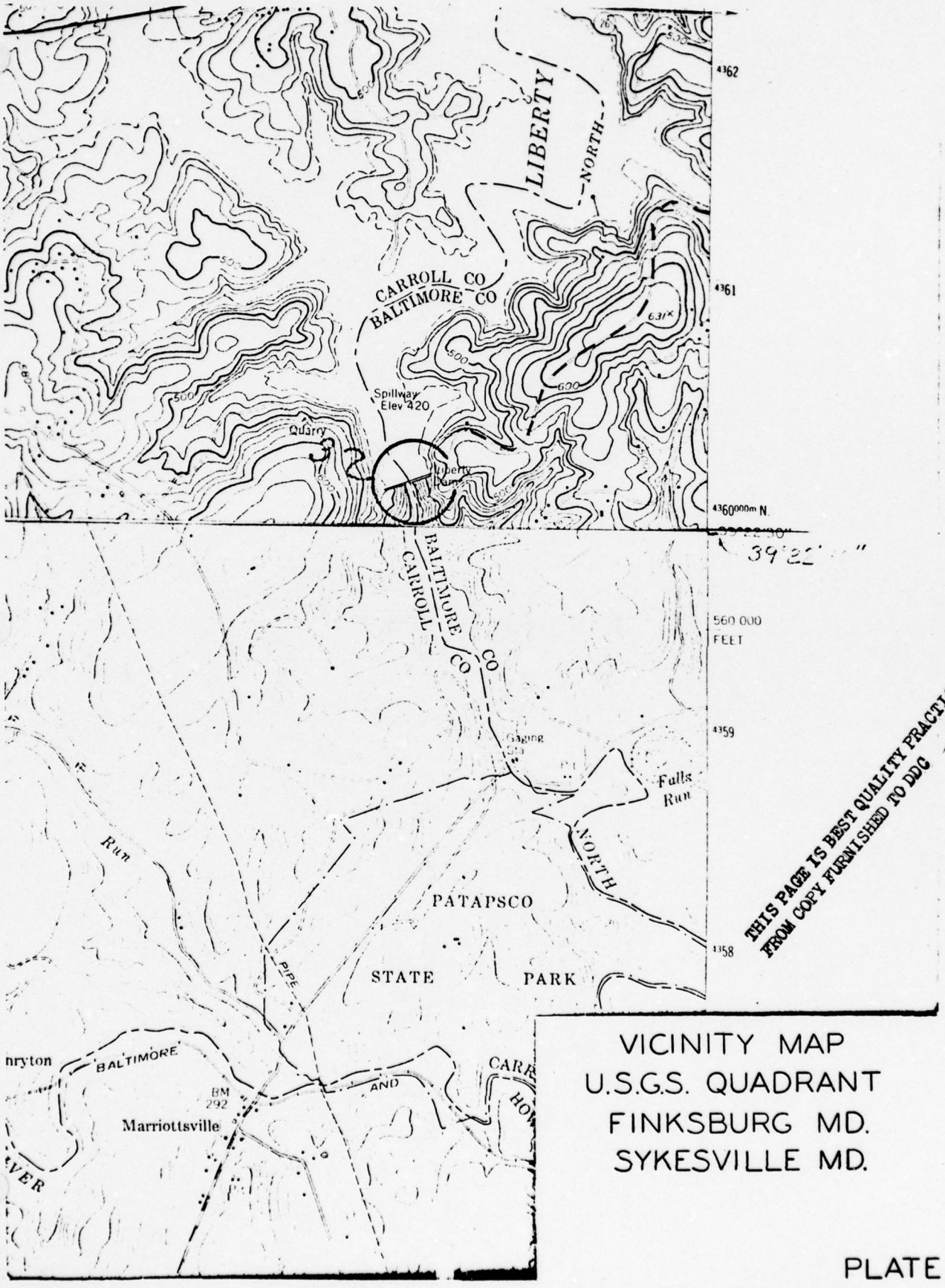
APPENDIX D

LOCATION, PHOTOGRAPHS & DESIGN DRAWINGS



LOCATION PLAN
LIBERTY DAM

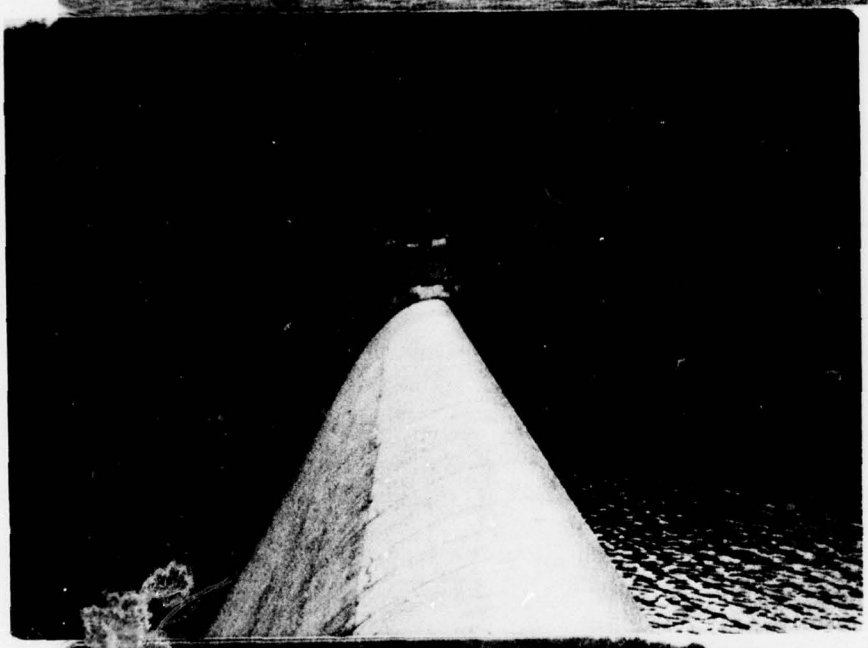
PLATE I.



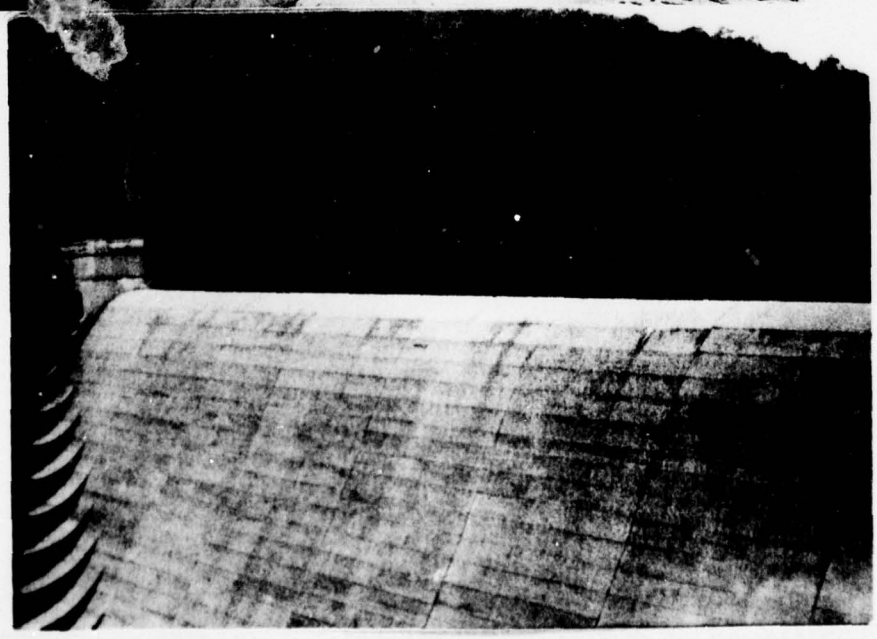
VICINITY MAP
U.S.G.S. QUADRANT
FINKSBURG MD.
SYKESVILLE MD.

PLATE II

Reservoir

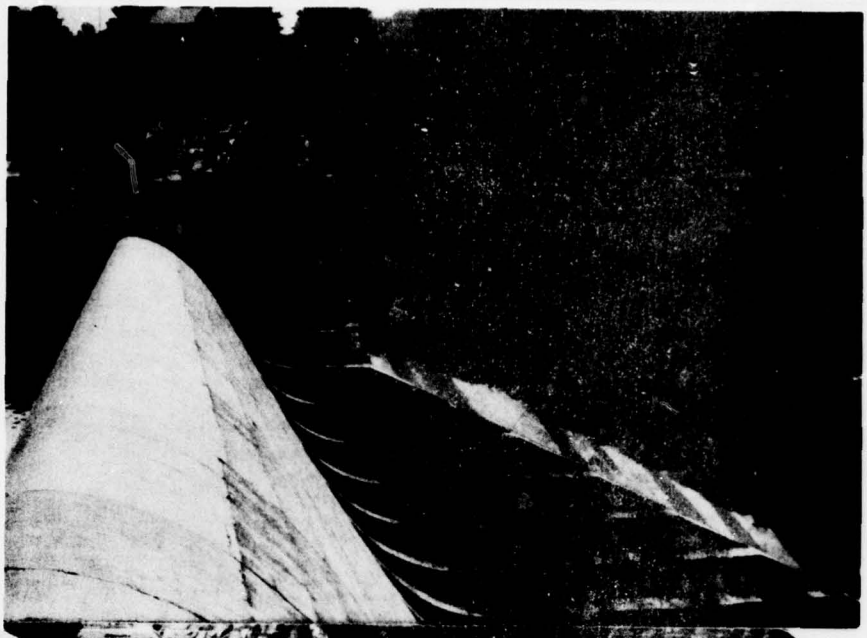


Spillway
Looking West

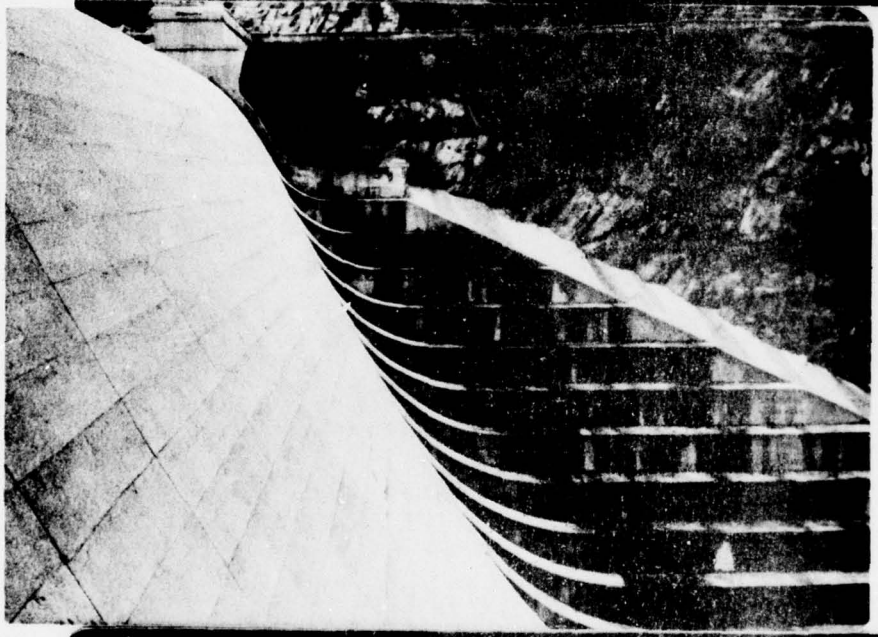


Spillway Surface

PLATE III



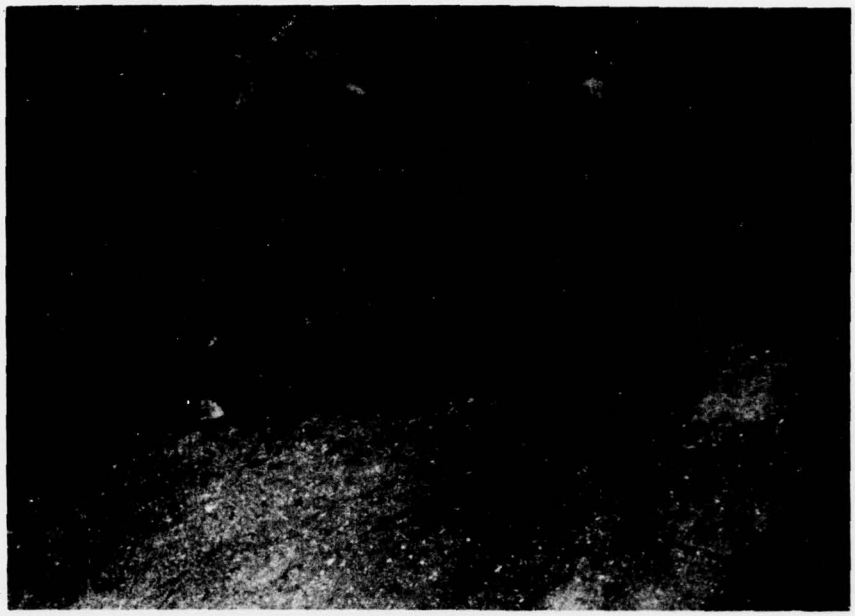
Spillway
Looking East



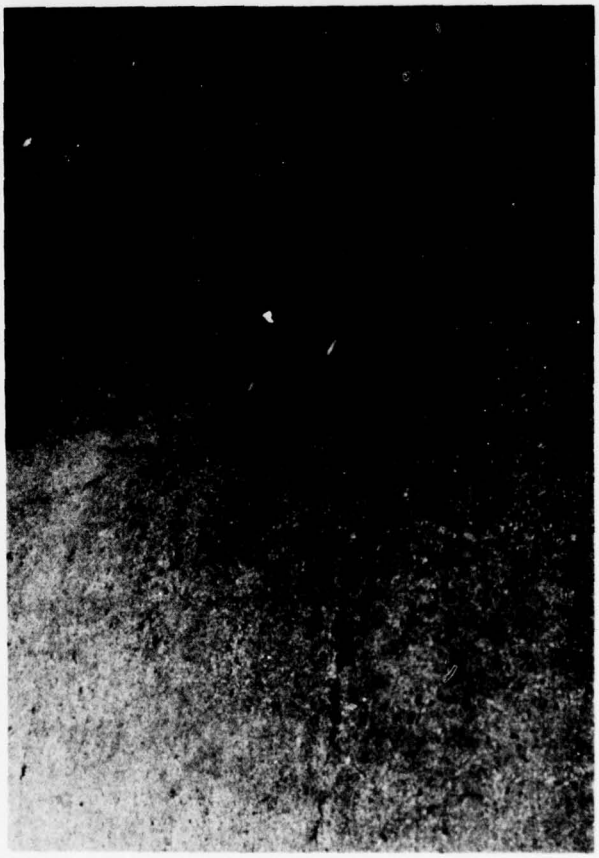
Spillway Surface

West Spillway Wall
& Downstream Channel

PLATE IV

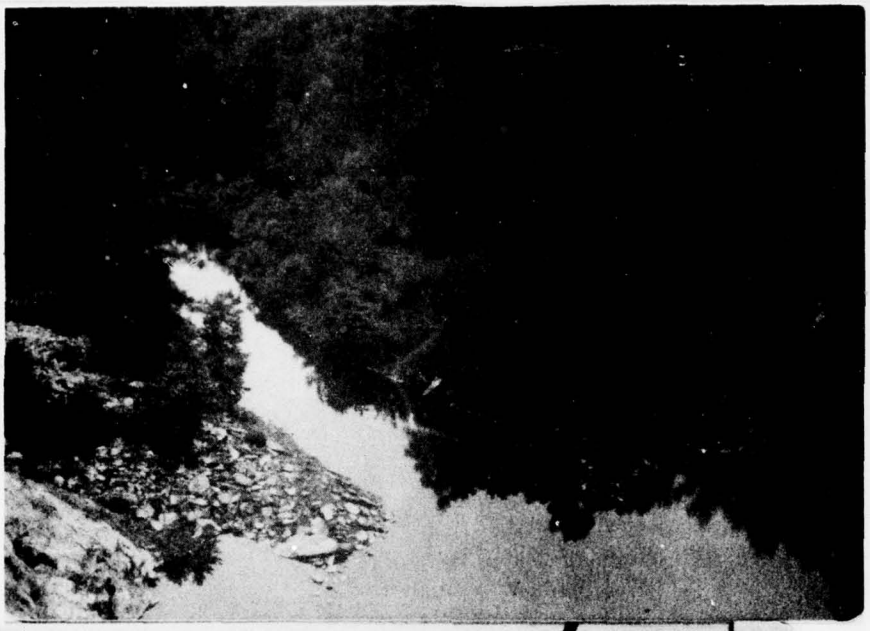


West Spillway
Wall Abutment Joint



Spillway Joints

PLATE V

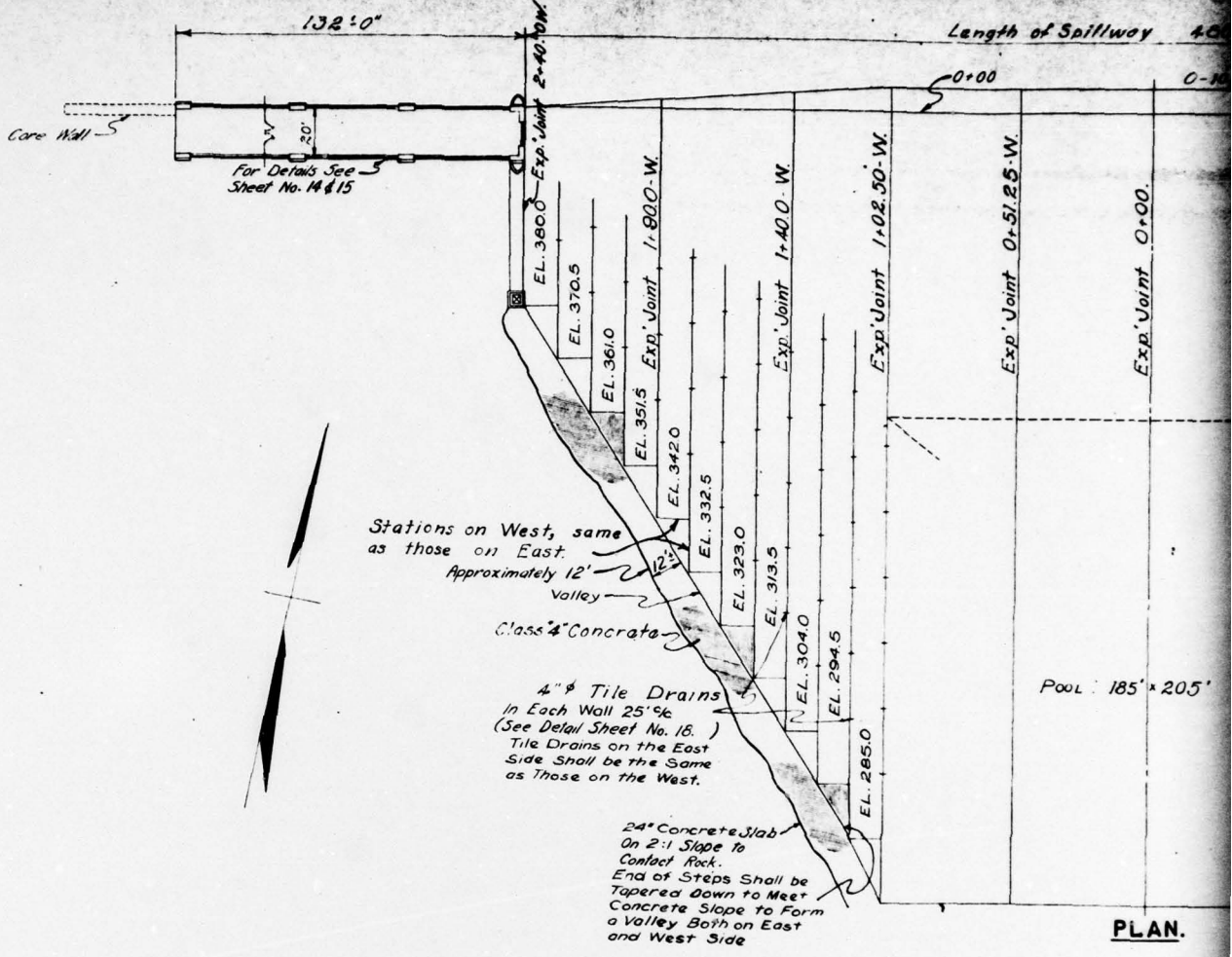


Downstream
Channel

Intake Tower

Bridge To
Intake Tower

PLATE VI



PLAN.

0 20 40 60

Scale: 1"=30'

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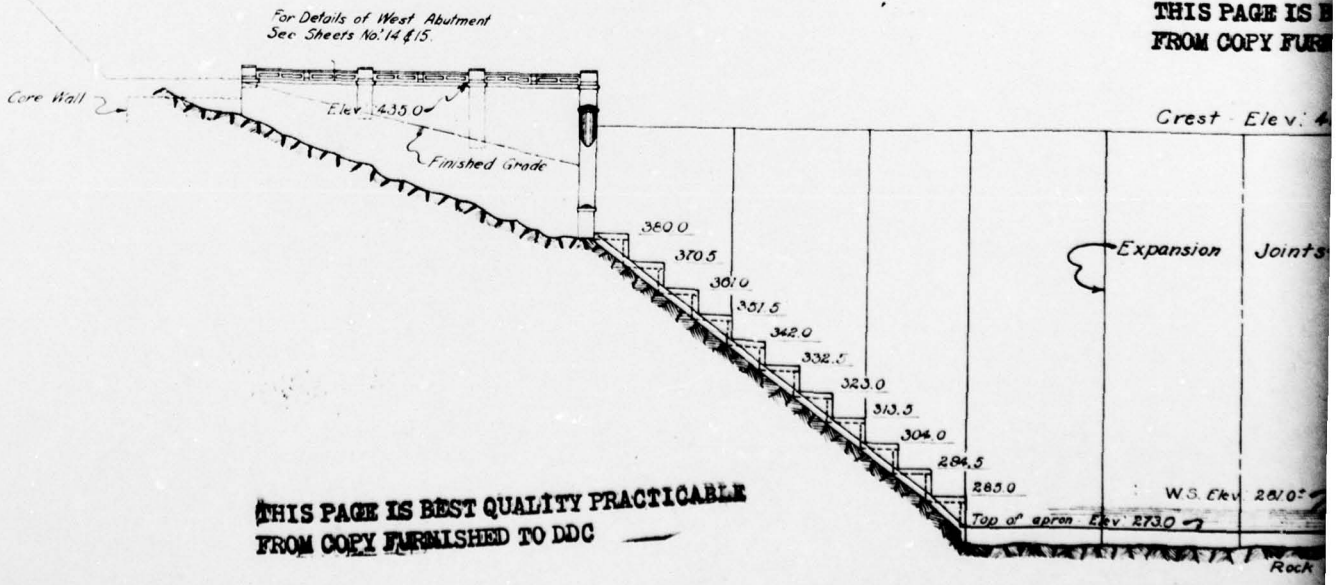

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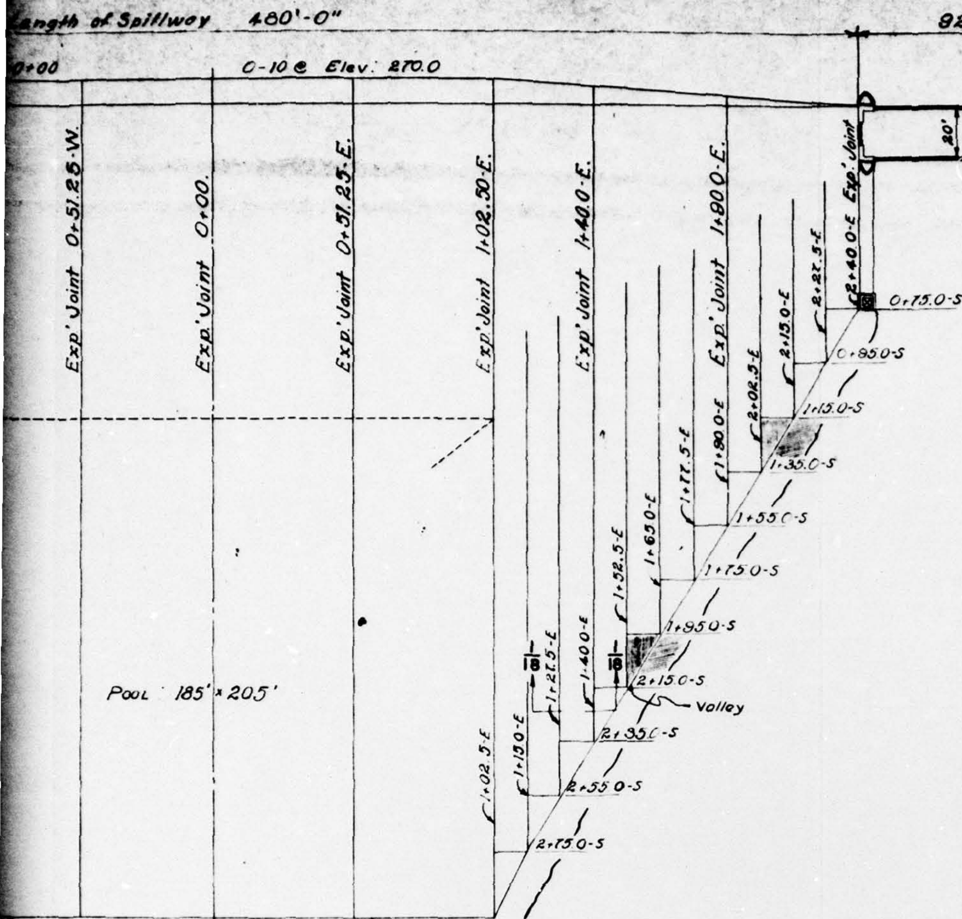
Length of Spillway 480'-0"
92'-0"
0+00
0-10 ℄ Elev: 270.0
Exp' Joint 0+51.25-W.
Exp' Joint 0+00
Exp' Joint 0+51.25-E.
Exp' Joint 1+02.50-E.
Exp' Joint 1+40.0-E.
Exp' Joint 1+80.0-E.
Exp' Joint 2+40.0-E
20'
Core Wall
For Details See
Sheet No. 16 & 17.
0+75.0-S
0+85.0-S
1+15.0-S
1+35.0-S
1+55.0-S
1+75.0-S
1+85.0-S
2+15.0-S
2+35.0-S
2+55.0-S
2+75.0-S
3+00-S
2+27.5-E
2+15.0-E
2+02.5-E
1+90.0-E
1+77.5-E
1+65.0-E
1+52.5-E
1+40.0-E
1+27.5-E
1+15.0-E
1+02.5-E
1/18
Valley
Pool: 185' x 205'

PLAN.

0' 20' 40' 60' 80' 100'
Scale: 1" = 30'

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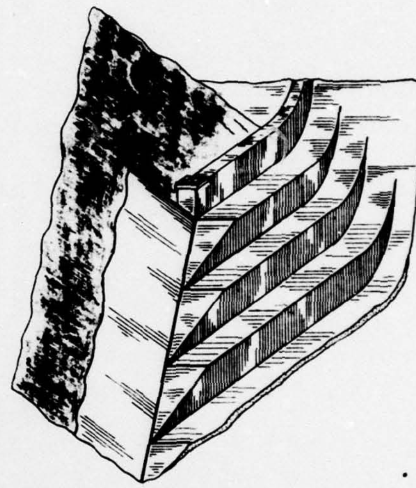

ISOMETRIC VIEW OF SPILLWAY STEPS

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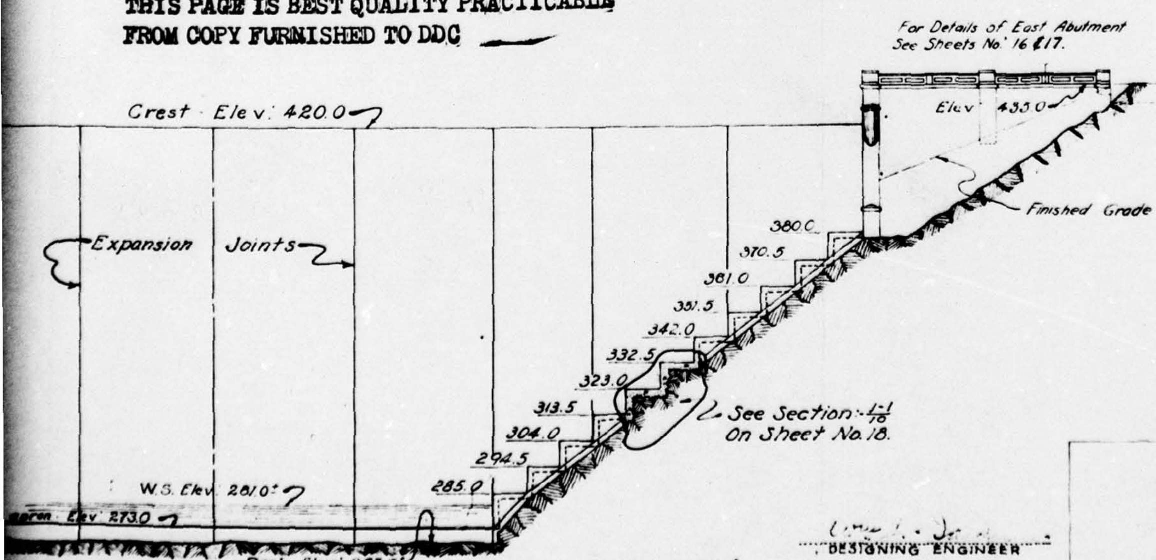


ELEVATION.

Permit No. 8, July 6, 1951.
Joseph F. Singewald, Jr., Director

PLATE VII

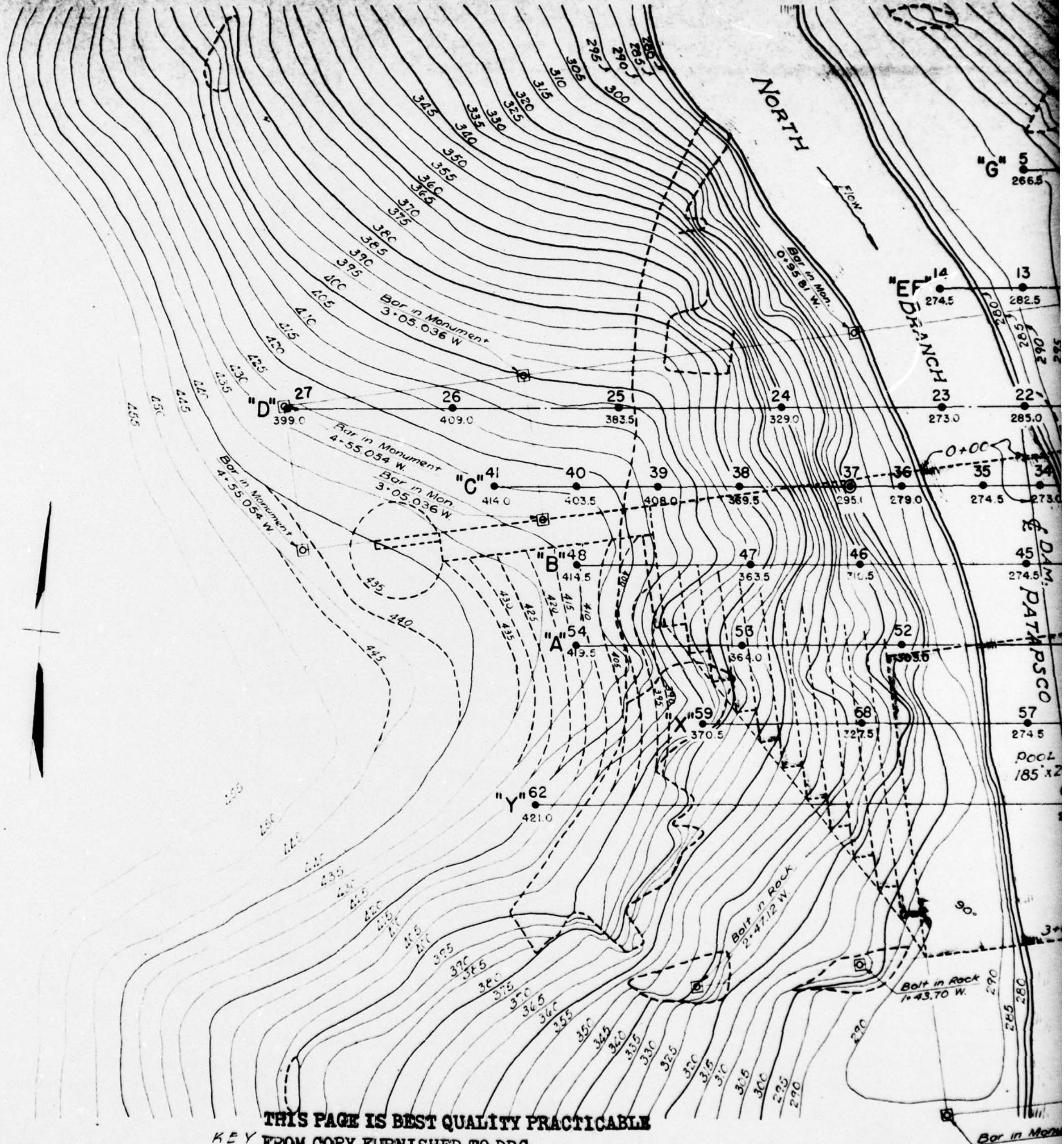
CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
BUREAU OF WATER SUPPLY
PLANT IMPROVEMENT DIVISION

LIBERTY DAM

PLAN AND ELEVATION

SHEETS IN SET - 42 — SHEET NO. 10
SCALE: - 1" = 30'-0" — DATE - MAY 1, 1951

DESIGNING ENGINEER
DIRECTOR OF PUBLIC WORKS
CONSULTING ENGINEER
PRINCIPAL ASSOCIATE ENGR.
WATER ENGINEER



NORTH BRANCH PATAPSCO
FLOW
"G" 5
266.5
"EF" 14
274.5
13
282.5
Bar in Mon.
0+95.81 W.
Bar in Monument
3+05.036 W.
"D" 27
399.0
26
409.0
25
383.5
24
329.0
23
273.0
22
285.0
Bar in Monument
4+55.054 W.
Bar in Mon.
3+05.036 W.
"C" 41
414.0
40
403.5
39
408.0
38
389.5
37
295.0
36
279.0
35
274.5
34
273.0
0+00
Bar in Monument
4+55.054 W.
"B" 48
414.5
47
363.5
46
45
274.5
"A" 54
419.5
53
364.0
52
57
274.5
"X" 59
370.5
68
327.5
POOL
"Y" 62
421.0
Bolt in Rock
2+47.12 W.
Bolt in Rock
1+43.70 W.
90°
Bar in Mon.

KEY

- = Existing Contours
- = Proposed Contours
- = Rock Outcrop.
- 2 = Lines Of Borings.
- 51 = 8" Borings.
- = Concrete Reference Monuments.

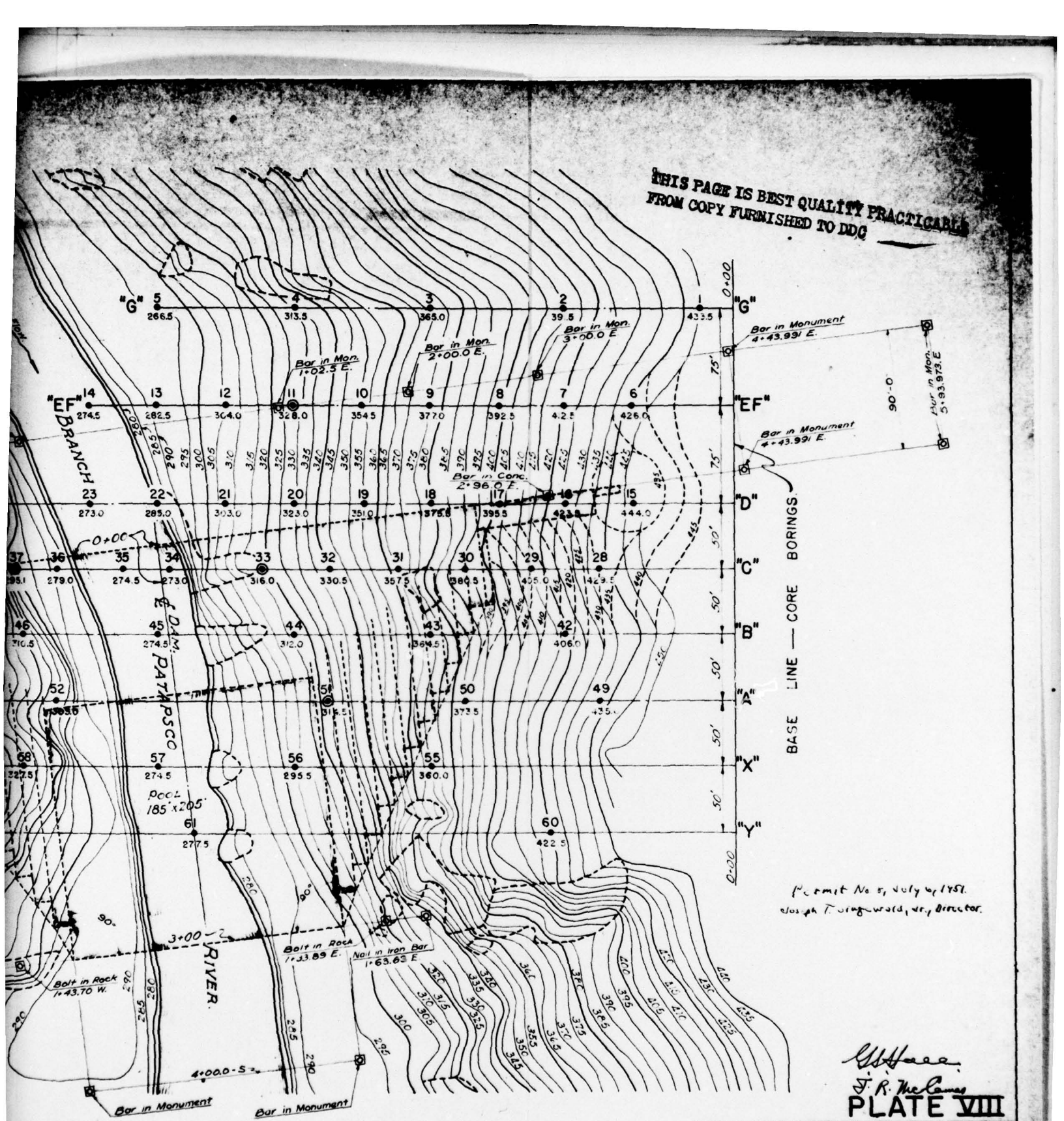
Note:- Elevations At Core Borings Denote Top Of Rock.

0 20 40 60 80 100' 150

Scale: 1" = 40'-0"

TOPOGRAPHY AND CORE BORINGS.

DRAWN BY Harry Kastner
TRACED BY H. Kastner
CHECKED BY



Permit No 5, July 6, 1951.
Joseph T. Singewald, Jr., Director.

J. R. McComas

PLATE VIII

KEY TO SECTION NUMBERS :-
Example :- SECTION :- 15-15/10 = Section Number. = Sheet No. Section is Taken.

AND CORE BORINGS.

DESIGNING ENGINEER

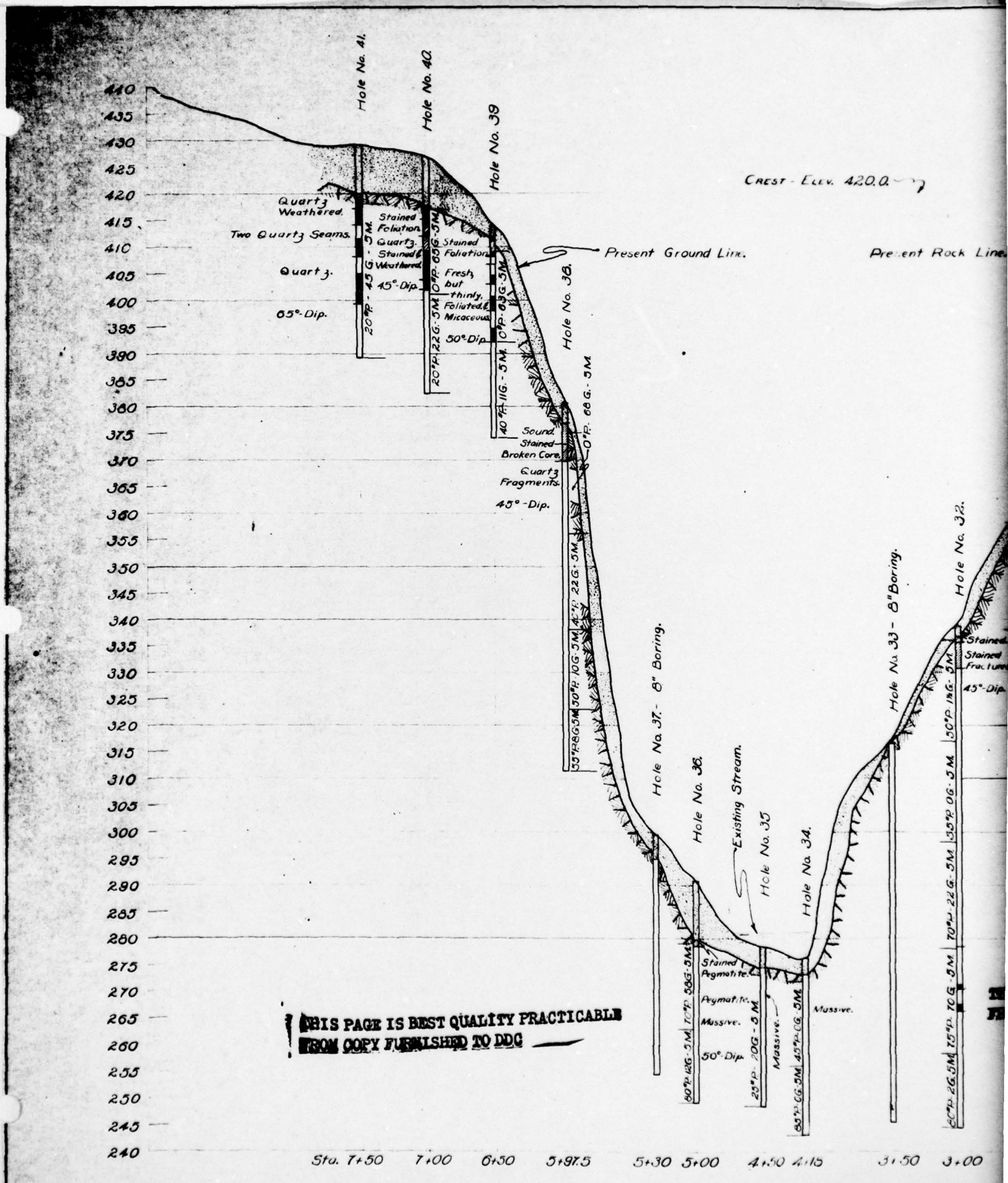
DIRECTOR OF PUBLIC WORKS

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
BUREAU OF WATER SUPPLY
PLANT IMPROVEMENT DIVISION

LIBERTY DAM
GENERAL PLAN & TOPOGRAPHY

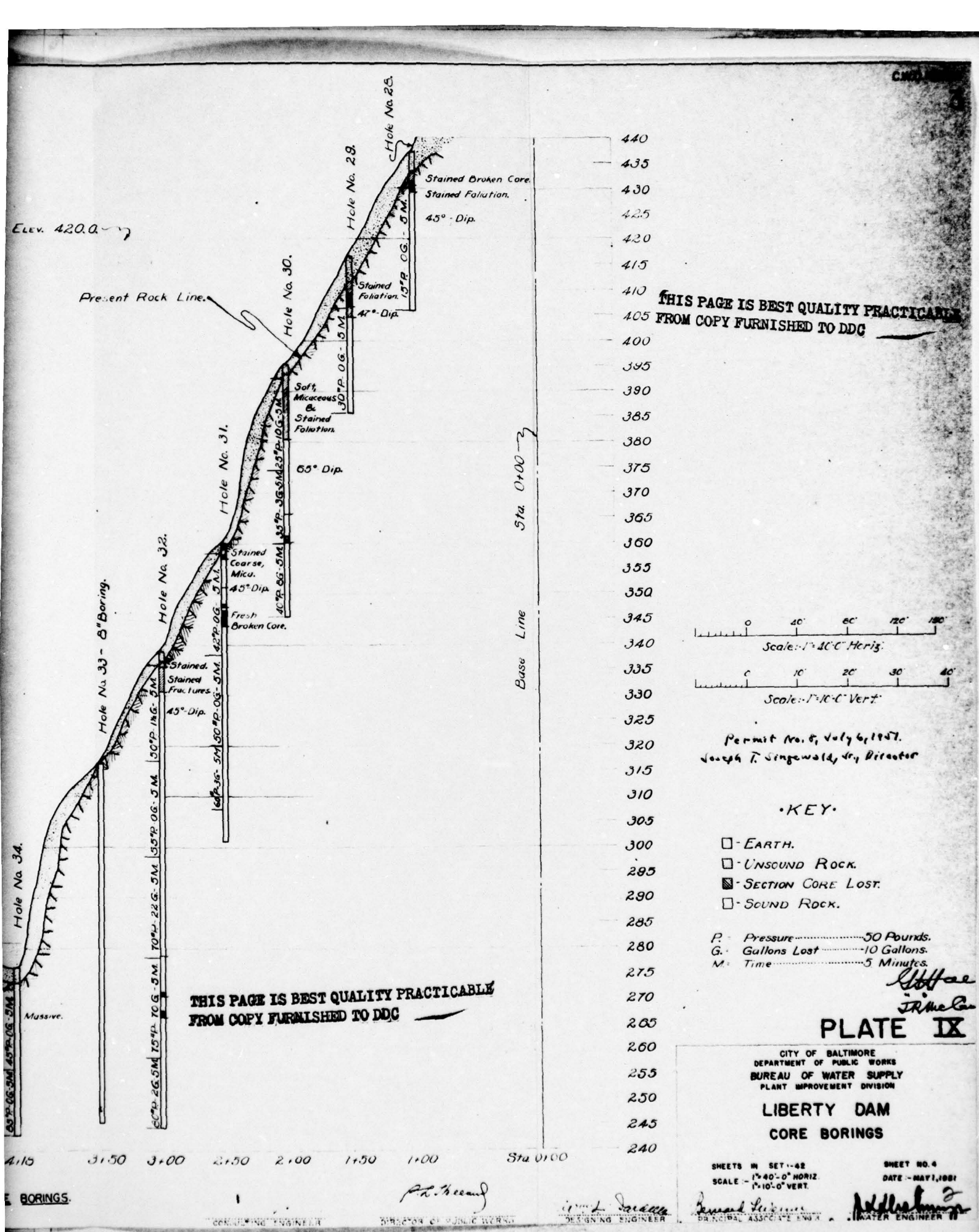
SHEETS IN SET :- 42 SHEET NO. 1
SCALE :- 1" = 40'-0" DATE :- MAY 1, 1951

CHIEF ENGINEER



Drawn By Chm. U.S. Army Engrs.

PROFILE LINE "C" CORE BORINGS.



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Scale:- 1" = 40'-0" Horiz.

Scale:- 1" = 10'-0" Vert.

Permit No. 6, July 6, 1957.
Joseph T. Singewald, Jr., Director

KEY

- Earth.
- Unsound Rock.
- Section Core Lost.
- Sound Rock.

P. - Pressure ..... 50 Pounds.
G. - Gallons Lost ..... 10 Gallons.
M. - Time ..... 5 Minutes.

PLATE IX

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
BUREAU OF WATER SUPPLY
PLANT IMPROVEMENT DIVISION

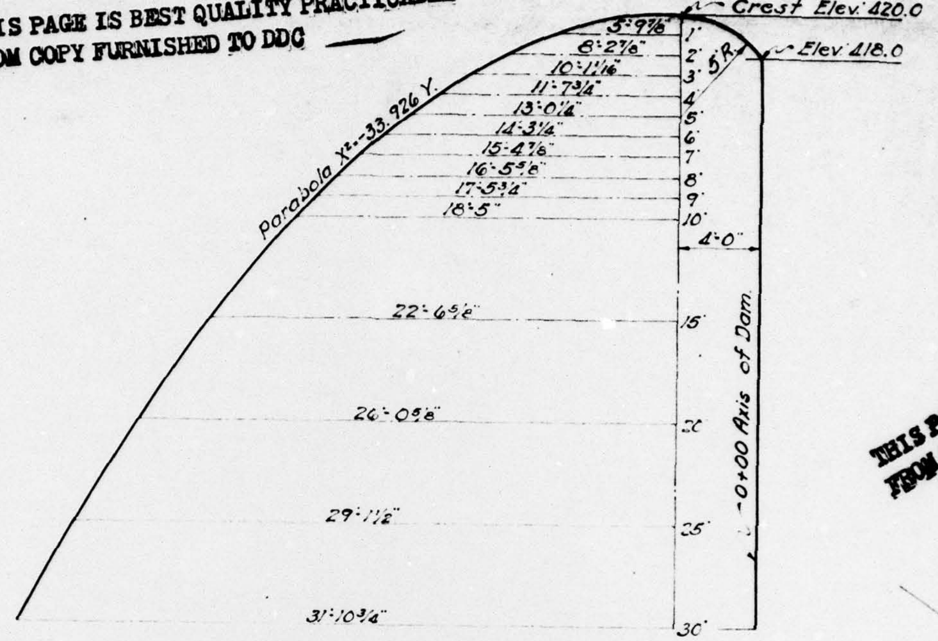
LIBERTY DAM
CORE BORINGS

SHEETS IN SET :- 42
SCALE :- 1" = 40'-0" HORIZ.
1" = 10'-0" VERT.

SHEET NO. 4
DATE :- MAY 1, 1958

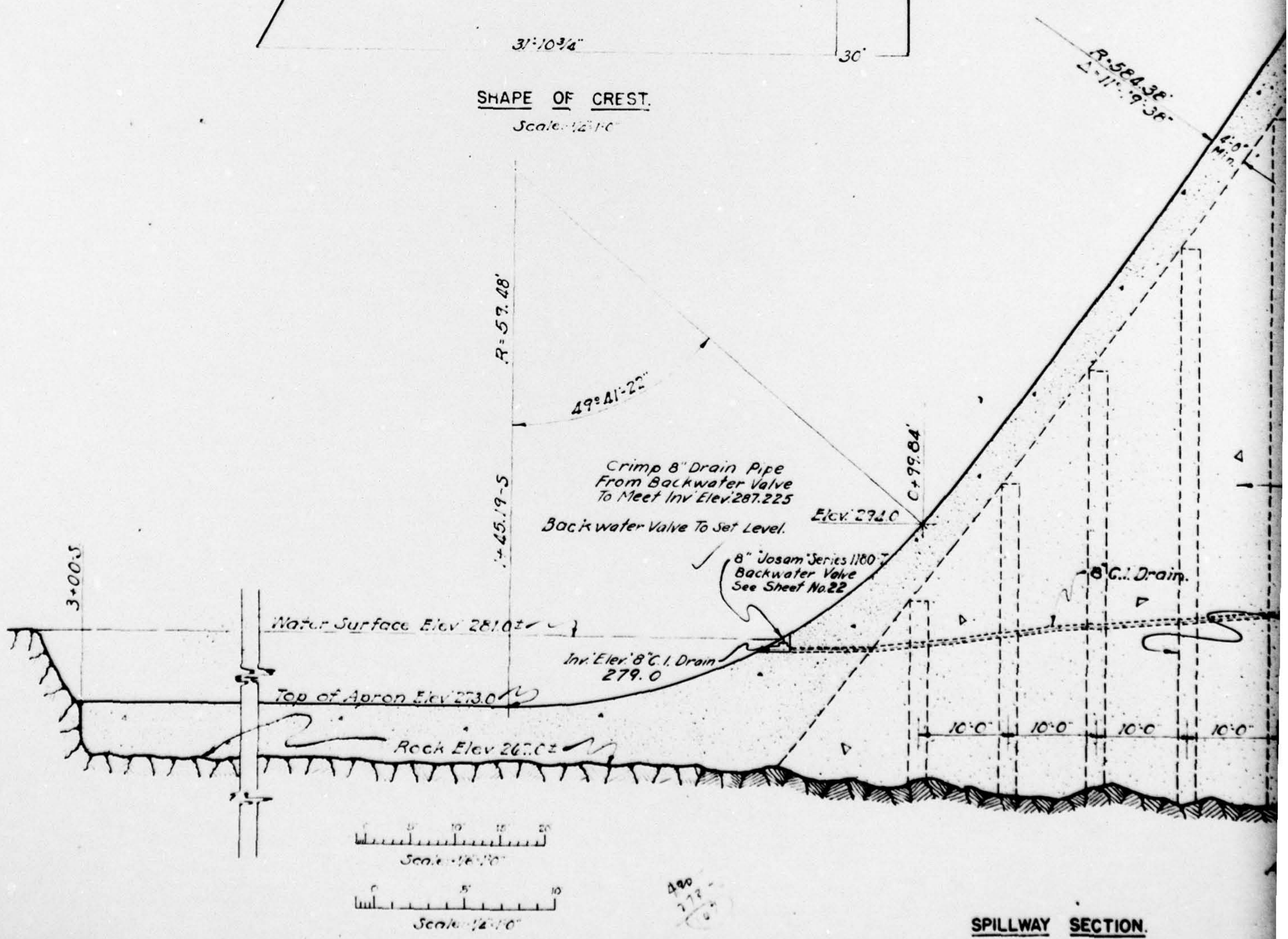
CONSULTING ENGINEER
DIRECTOR OF PUBLIC WORKS
DESIGNING ENGINEER
PRINCIPAL ASSOCIATE ENGR.
WATER ENGINEER II

E BORINGS.



SHAPE OF CREST.

Scale: 1/2" = 1'-0"


R = 584.38'
4'-0" Min.
R = 57.48'
49°41'22"
Crimp 8" Drain Pipe
From Backwater Valve
To Meet Inv Elev. 287.225
Backwater Valve To Set Level.
C+99.84
Elev. 292.0
8" Josam Series 1160-T
Backwater Valve
See Sheet No. 22
8" C.I. Drain.
3+00.5
1+45.19.5
Water Surface Elev. 281.0±
Inv. Elev. 8" C.I. Drain
279.0
Top of Apron Elev. 273.0
Rock Elev. 267.0±
10'-0"
10'-0"
10'-0"
10'-0"

Scale: 1/8" = 1'-0"

Scale: 1/2" = 1'-0"

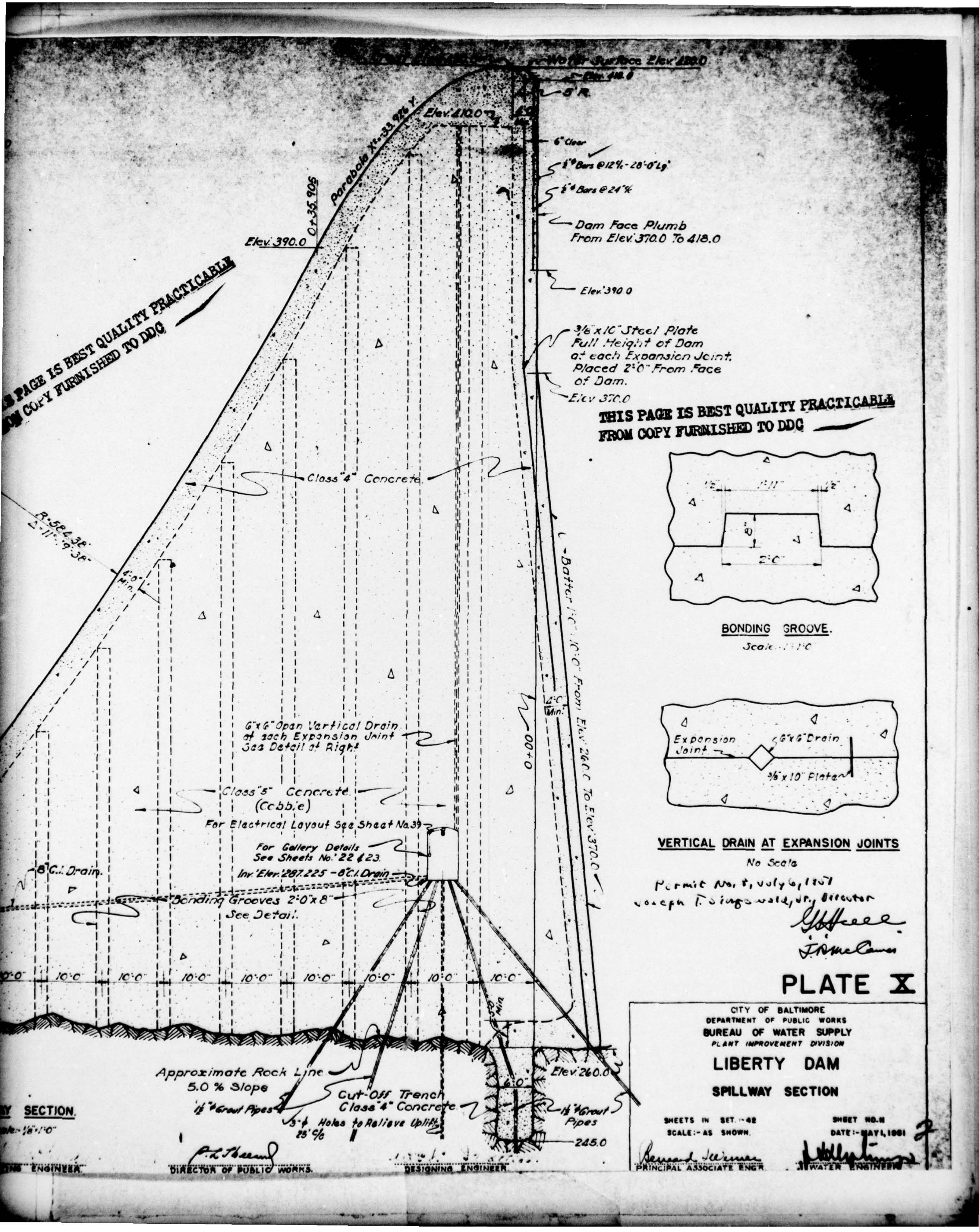
Scale: 1" = 1'-0"

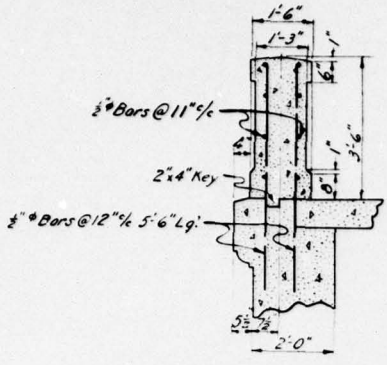
SPILLWAY SECTION.

Scale: 1/8" = 1'-0"

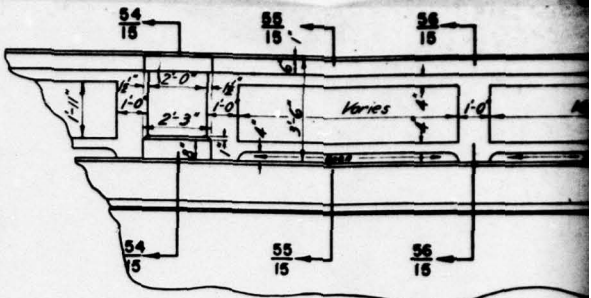
DRAWN BY
TRACED BY
CHECKED BY

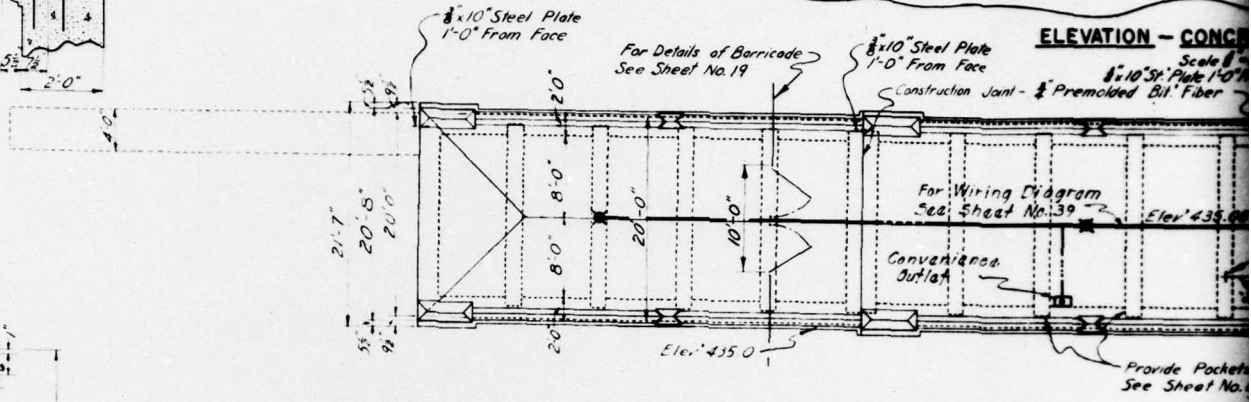
CONSULTING ENGINEERS



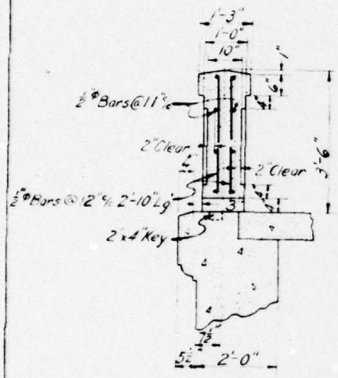


SECTION 54-54 / 15
Scale ⅜"=1'-0"





ELEVATION – CONCR
Scale ⅜"
⅜"x10" St. Plate 1'-0"

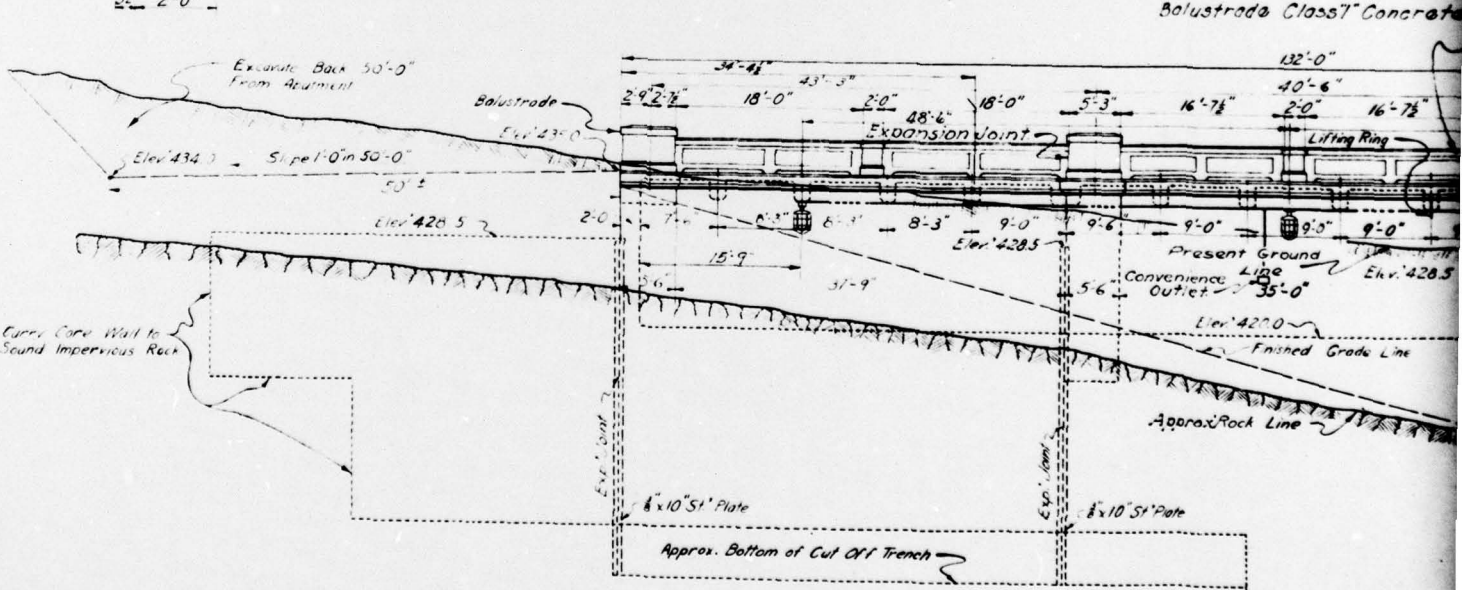


SECTION 55-55 / 15
Scale ⅜"=1'-0"

Note:- For Typical Abutment Section See Sheet No. 17.

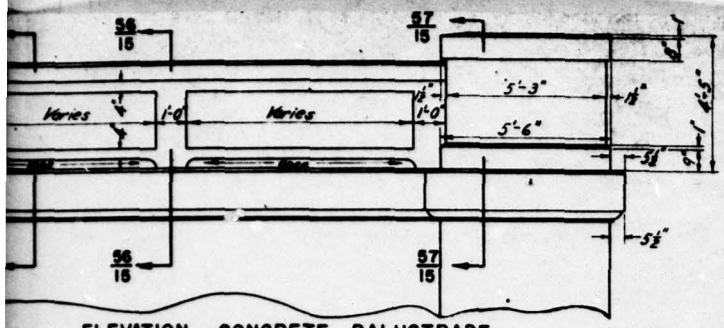
Note:- For Surfacing of Floors See Item No. 18 of Specifications.

PLAN OF WEST ABUTMENT
Scale ⅛"=1'-0"

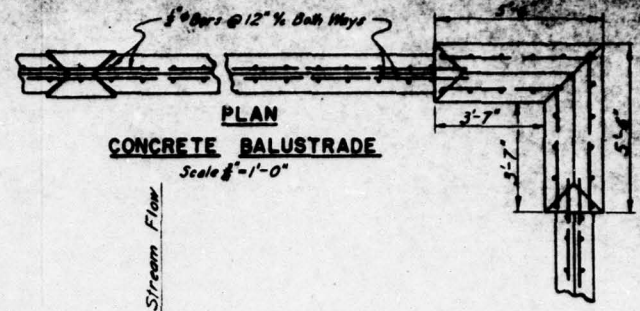


DRAWN BY W. C. Wantland
TRACED BY W. Saunders Jr.
CHECKED BY W. C. Wantland

ELEVATION OF WEST ABUTMENT
Scale ⅜"=1'-0"

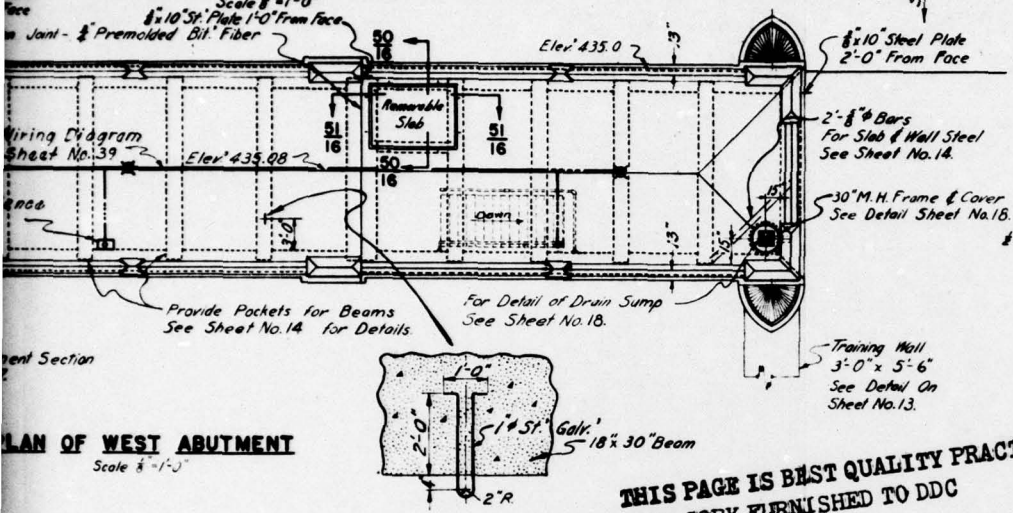


ELEVATION — CONCRETE BALUSTRADE
Scale ½"=1'-0"

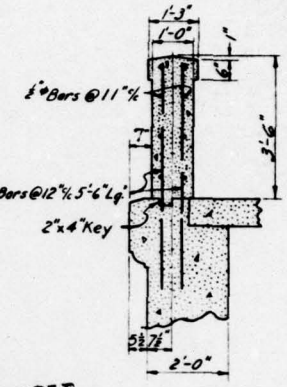


PLAN
CONCRETE BALUSTRADE
Scale ½"=1'-0"

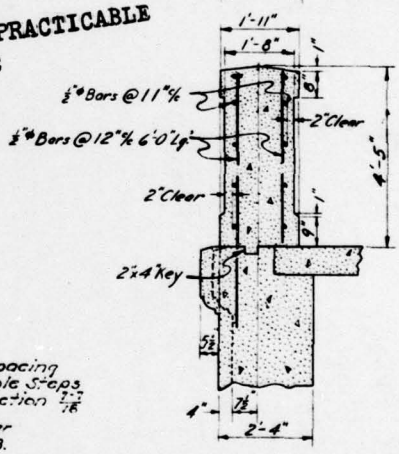
Stream Flow



LIFTING RING DETAIL
Scale ½"=1'-0"
2-Req'd.
(1 in East & 1 in West Abutment.)



SECTION 56-56/15
Scale ½"=1'-0"



SECTION 57-57/15
Scale ½"=1'-0"

PLAN OF WEST ABUTMENT
Scale ⅛"=1'-0"

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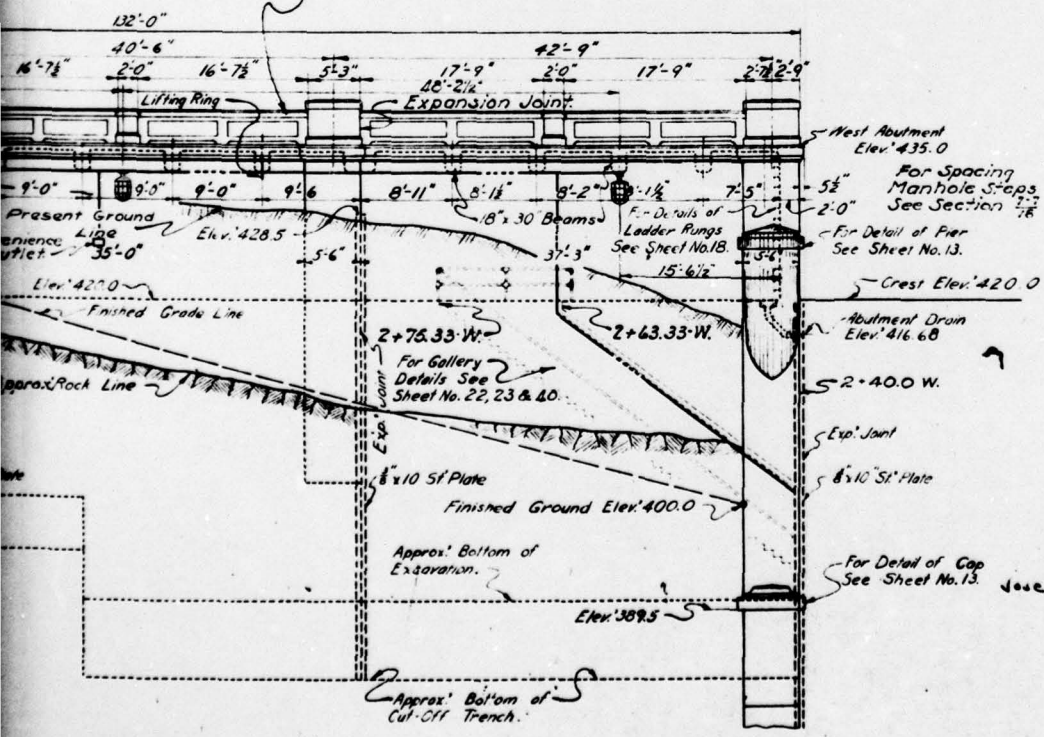
Balustrade Class "A" Concrete (1 in East & 1 in West Abutment.)



0 5' 10' 15' 20' 25' 30'
Scale ⅛"=1'-0"

0 1' 2' 3' 4' 5' 6' 7' 8' 9' 10'
Scale ⅛"=1'-0"

0 1' 2' 3' 4' 5' 6' 7'
Scale ½"=1'-0"

Permit No. 5, July 6, 1951.
Joseph T. Singewald, Jr., Director

PLATE XI

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
BUREAU OF WATER SUPPLY
PLANT IMPROVEMENT DIVISION

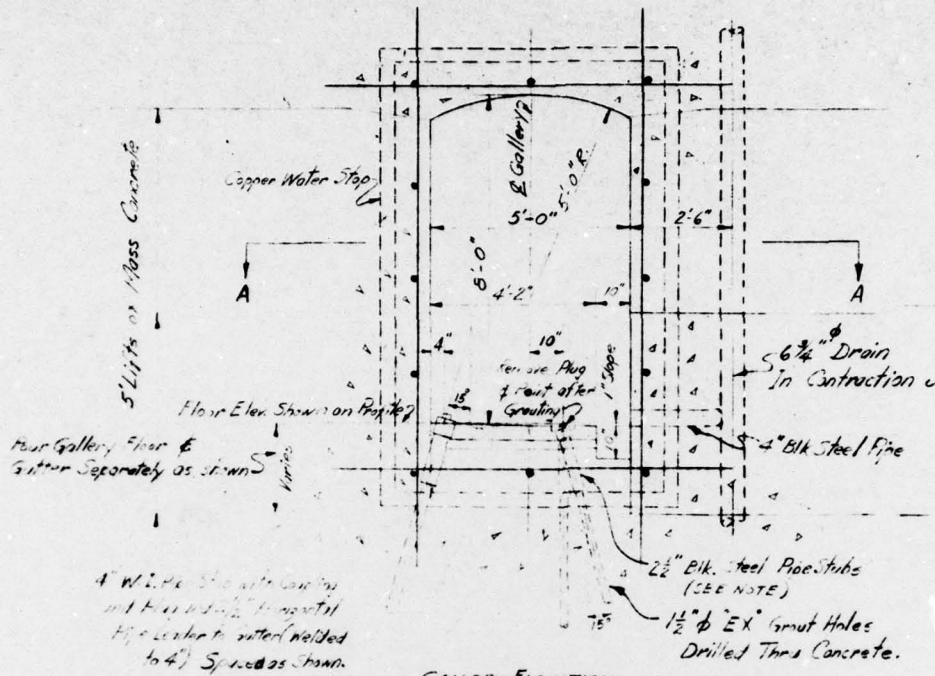
LIBERTY DAM

WEST ABUTMENT — PLAN & ELEVATION

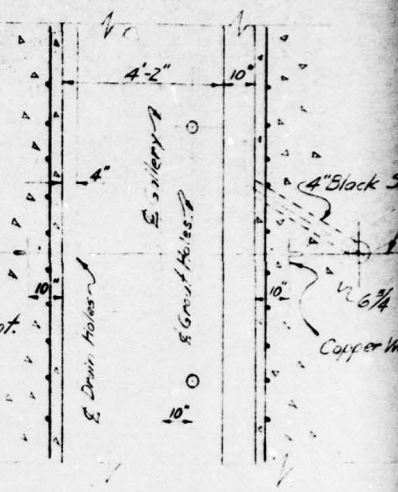
SHEETS IN SET - 42
SCALE: AS SHOWN

DESIGNING ENGINEER
DIRECTOR OF PUBLIC WORKS
CONSULTING ENGINEER

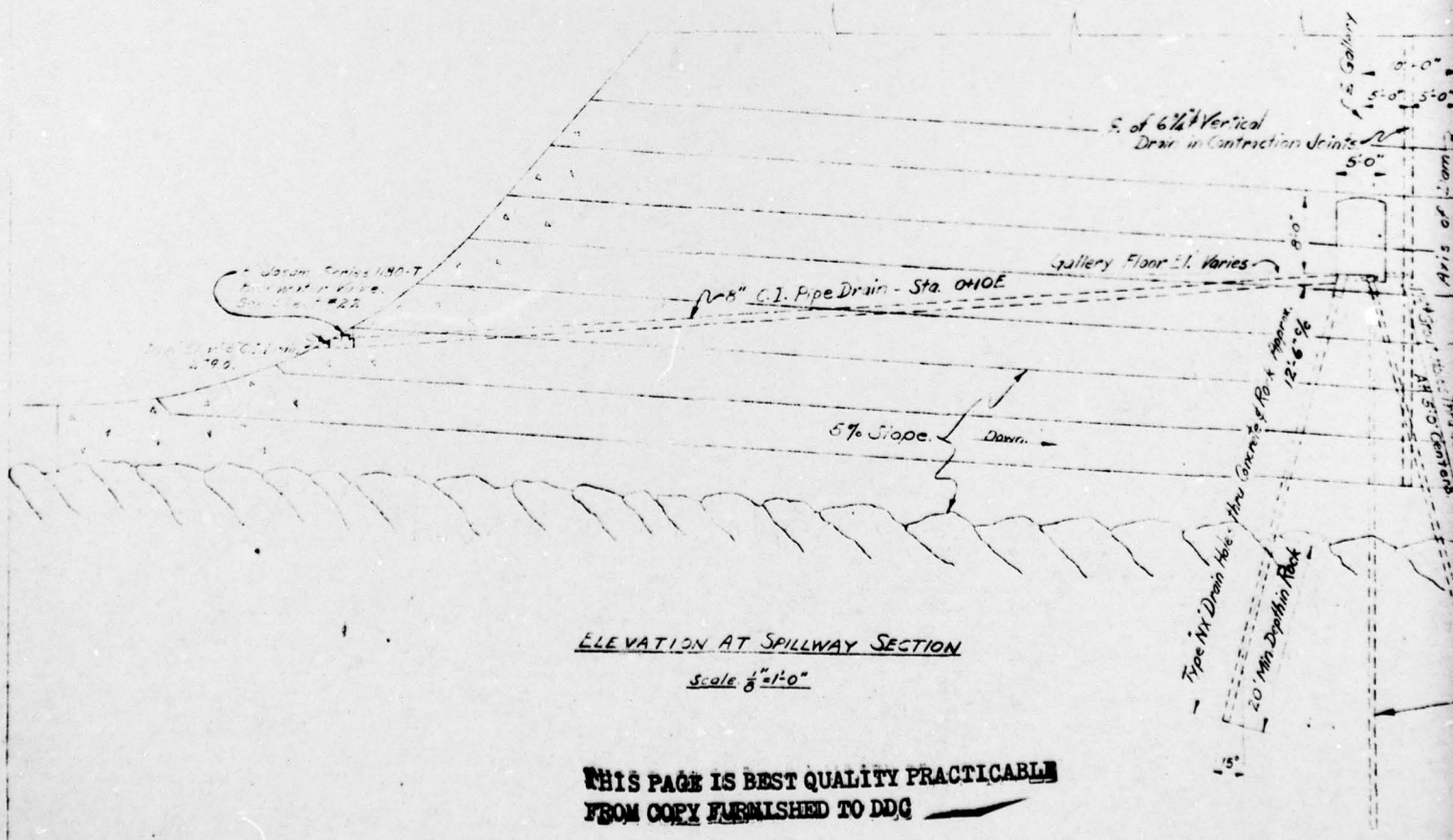
ELEVATION OF WEST ABUTMENT
Scale ⅛"=1'-0"



GALLERY ELEVATION
Scale: ½"=1'-0"



SECTION A-A AT CONTRACTION JOINT
Scale ½"=1'-0"

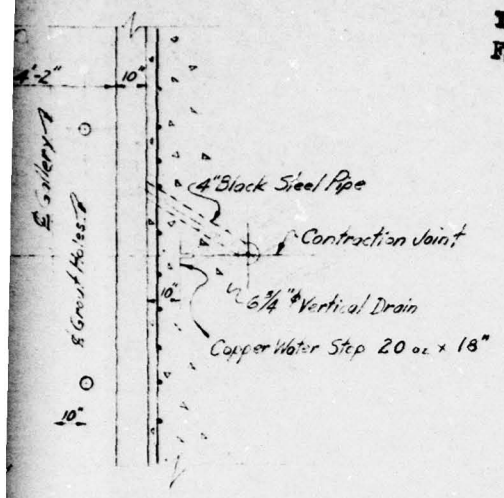


ELEVATION AT SPILLWAY SECTION
Scale ⅛"=1'-0"

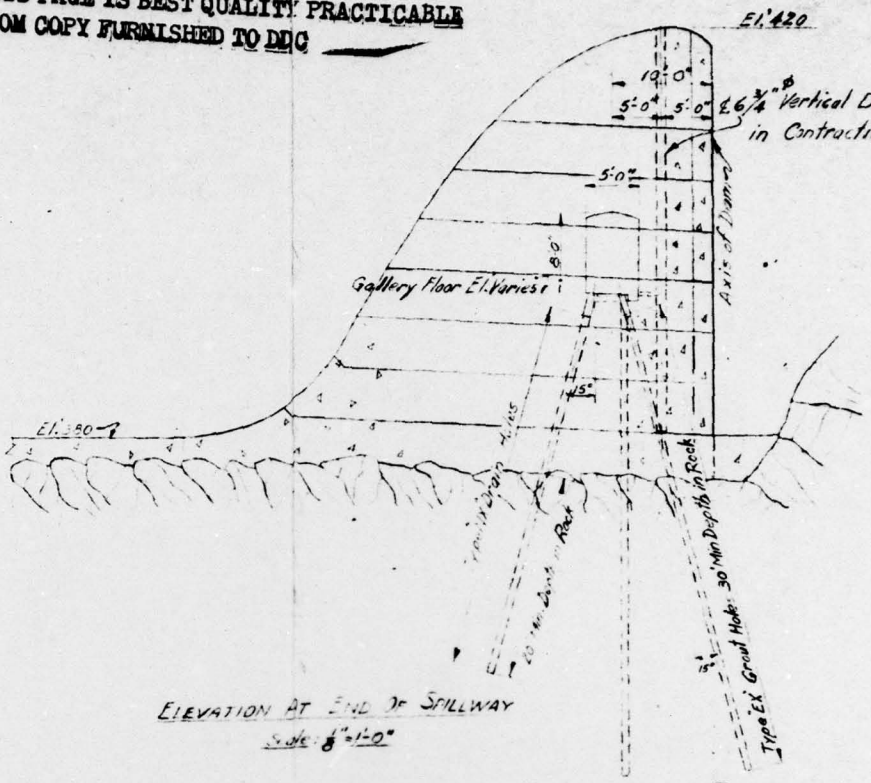
DRAWN BY
TRACED BY
CHECKED BY

C.W.O.-18860

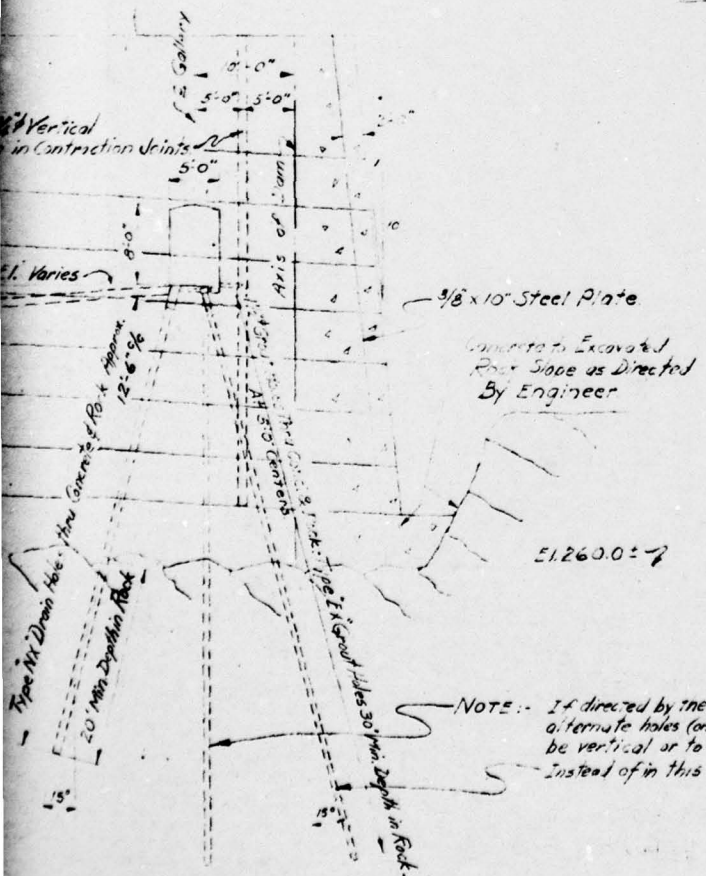
3

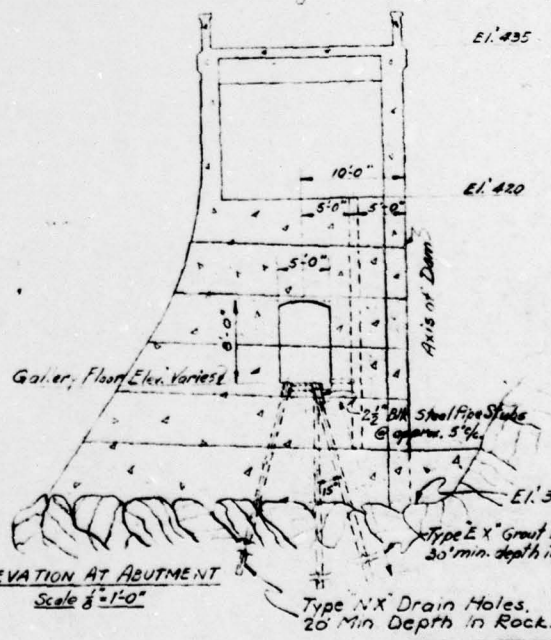


9-A AT CONTRACTION JOINT
Scale ¼"=1'-0"



ELEVATION AT END OF SPILLWAY
Scale ⅛"=1'-0"





ELEVATION AT ABUTMENT
Scale ⅛"=1'-0"

NOTE:- If directed by the Engineer alternate holes (one site) may be vertical or to other inclination instead of in this direction.

PLATE XII

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
BUREAU OF WATER SUPPLY
PLANT IMPROVEMENT DIVISION

LIBERTY DAM

ALTERNATE GROUTING SCHEME

SHEETS IN SET -
SCALE - As Shown.
SHEET NO. - 11-A.
DATE - Aug 17, 1932

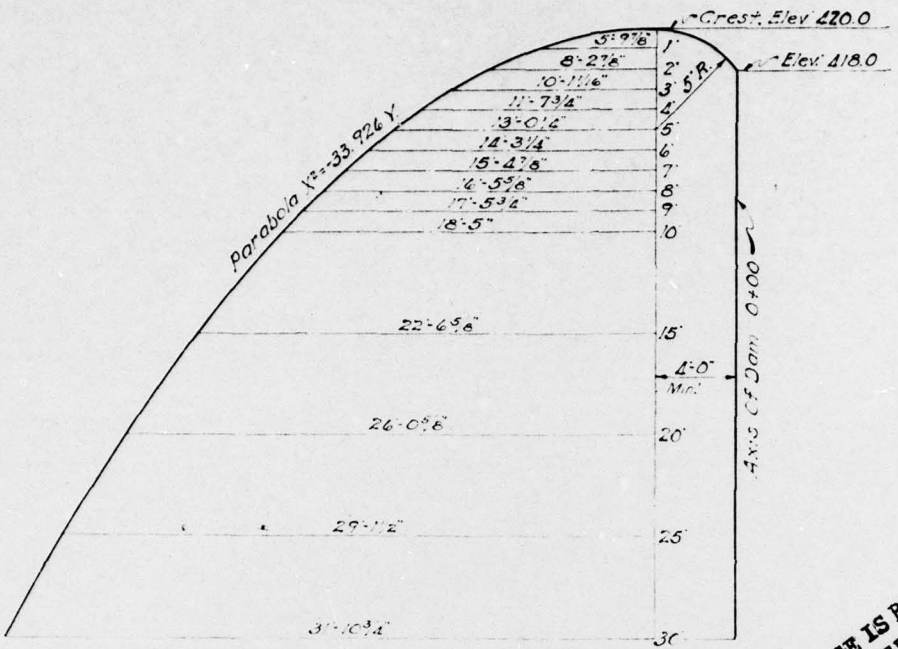
Walter Lasseter
DESIGNING ENGINEER

DIRECTOR OF PUBLIC WORKS

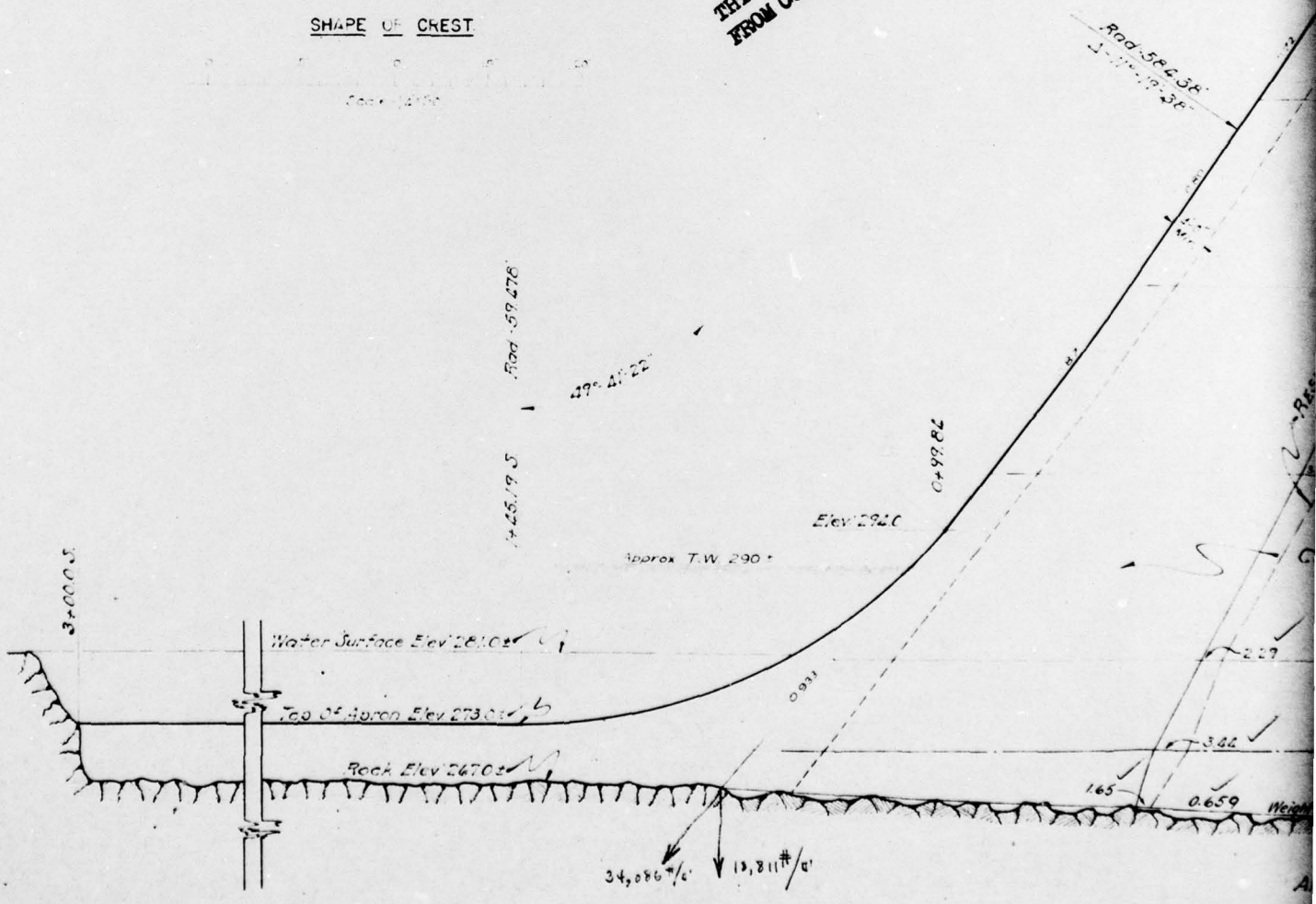
CONSULTING ENGINEER

DEPUTY WATER ENG'R

WATER ENGINEER



SHAPE OF CREST



STRESS DIAGRAM OF SPILLWAY SECTION.

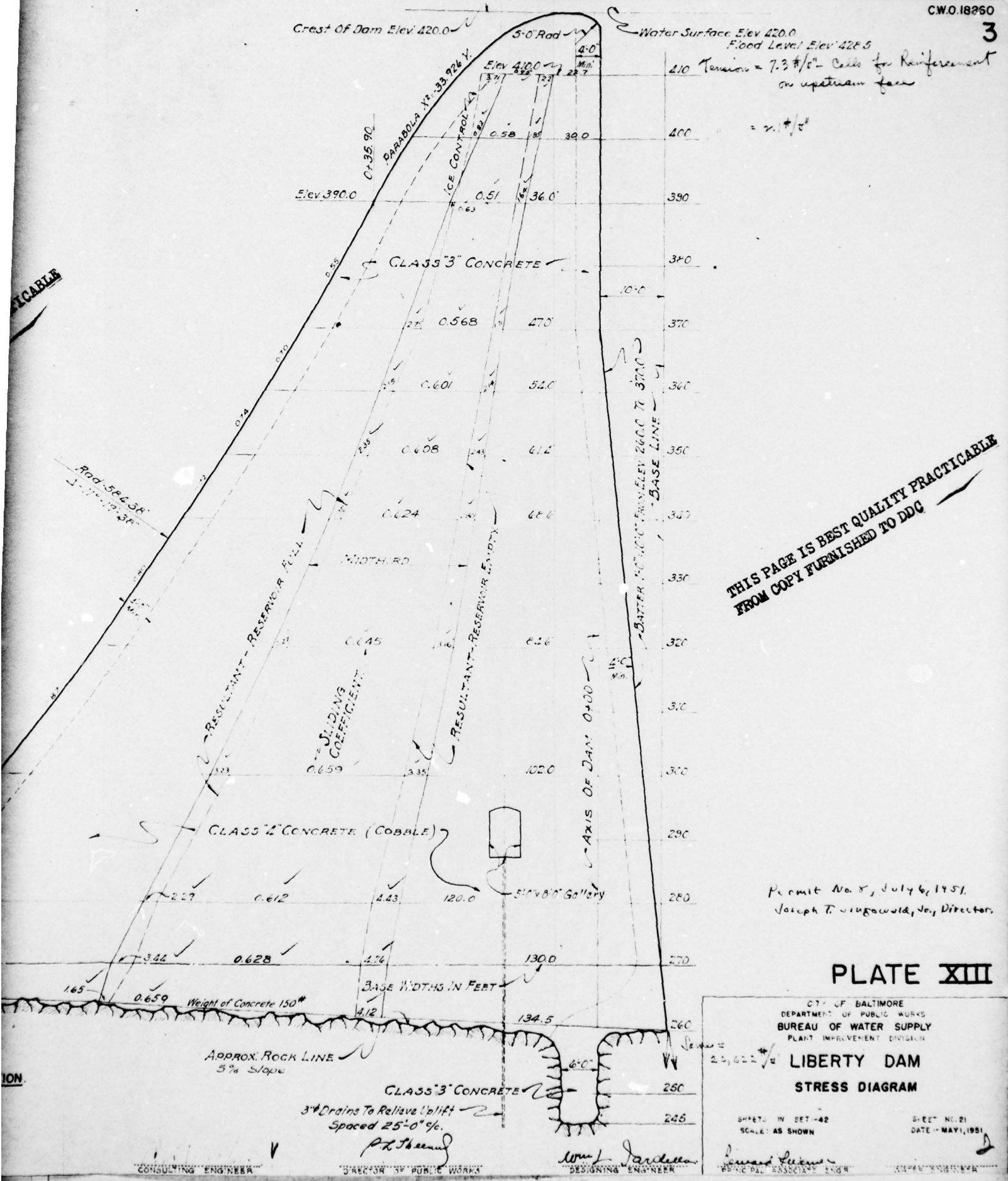
0 5' 10' 15' 20' 25' 30'
Scale: 1"=10'-0"

DRAWN BY C.A. Biondo
TRACED BY
CHECKED BY

CONSULTING

C.W.O. 18260

3



Permit No. 8, July 6, 1951.
Joseph T. Ringgold, Jr., Director.

PLATE XIII

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
BUREAU OF WATER SUPPLY
PLANT IMPROVEMENT DIVISION

LIBERTY DAM
STRESS DIAGRAM

SHEETS IN SET - 42
SCALE: AS SHOWN
SHEET NO. 21
DATE - MAY 1, 1951

CONSULTING ENGINEER | DIRECTOR OF PUBLIC WORKS | DESIGNING ENGINEER | PRINCIPAL ASSOCIATE ENGR | CHIEF ENGINEER