UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF THE SPILLWAY TIBER DAM MISSOURI RIVER BASIN PROJECT

Hydraulic Laboratory Report No. Hyd-288

ENGINEERING LABORATORIES BRANCH

DESIGN AND CONSTRUCTION DIVISION
DENVER, COLORADO

March 24, 1952

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UNITED STATES
DEPARTMENT OF THE INTERIOR
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Design and Construction Division
Engineering Laboratories Branch
Denver, Colorado
March 24, 1952

Laboratory Report No. Hyd-288
Hydraulic Laboratory Section
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Reviewed by: J. N. Bradley

Subject: Hydraulic model studies of the spillway--Tiber Dam--Missouri River Basin Project

SUMMARY

The operation of the spillway for Tiber Dam was investigated with a hydraulic model built to a scale of 1:48. The studies showed the necessity of several modifications to the spillway. The arrangement of the preliminary spillway was generally satisfactory and the discharge capacity of the overflow section was in close agreement with the designed discharge. A flow contraction at the left approach wall, Figure 7A, created a rough water surface which affected the discharge through the left spillway bay. Studies were made on four other entrance arrangements consisting of modifications to the entrance walls and backfill behind the walls. Approach E, Figure 5E, reduced the contraction and rough water surface to a satisfactory limit and was recommended for prototype construction.

Waves formed downstream from the preliminary piers, Figure 7B. Although this was not a serious disturbance, Pier No. 2, Figure 12B, was tested to determine the effect of the pier design on the wave formation. The longer pier reduced the waves, Figure 13, but the improvement did not justify the increased cost of the piers, so Pier No. 1 was retained.

The water did not spread sufficiently in passing down the spillway chute, resulting in greater flow in the center of the stilling basin than at the sides. This was most pronounced at the maximum discharge of 51,700 cfs, Figures 8A and B. Tests were made to increase the spreading of the water by using crowns, Figure 14, which resulted in the center of the chute being higher than the sides for a portion of the chute length. With the preliminary chute, Crowns Nos. 1 and 2 gave uniform distribution of flow at the maximum discharge, but the flow was concentrated at the sides of the stilling basin for lower discharges. The recommended chute, Figure 6, had a more moderate divergence of the training walls than the preliminary. By using Crown No. 3 on the recommended chute, satisfactory distribution of flow occurred at all ranges of discharge, Figures 18A and B.

With the preliminary spillway, a 1-hour erosion test at a discharge of 51,700 cfs showed an undermining of the downstream cut-off wall of the basin, Figures 9A and B. After installing the recommended entrance and chute a second scour test was run using the preliminary stilling basin. The erosion was less severe, Figure 20B, indicating that uneven flow distribution occurring with the preliminary chute contributed to the scour. Two additional erosion tests were made, one with the end sill removed and the other with 45-degree spur walls added. Scour was heavy without the end sill, Figure 21A. The erosion resulting when using the spur walls, Figure 21B, was similar to that occurring with the preliminary basin. These studies showed the preliminary basin was satisfactory and it was recommended for prototype construction.

The spillway was satisfactory, as indicated by pressure tests on the overflow section and the steep section of the chute. Water surface profiles were taken throughout the spillway and showed the training wall heights to be adequate. A discharge-capacity curve was obtained for the overflow section and is shown on Figure 26.

INTRODUCTION

Tiber Dam is a part of the Missouri River Basin Project and is located on the Marias River approximately 15 miles south of Tiber, Montana, Figure 1. The dam, 182 feet high with a crest length of 4,200 feet, is an earth-fill structure, Figure 2. The reservoir, with a capacity of 970,000 acre feet, provides irrigation water for the Marias Project, an area situated 15 miles east of the dam.

The flood control spillway at the right abutment is a concrete-lined open-channel structure, Figure 3. The overflow section at the upstream end of the spillway is controlled by three 32- by 20-foot radial gates resulting in a net crest length of 96 feet. A concrete curtain wall at the nose of the piers limits the gate openings to 20 feet and a seal prevents leakage of water between the gates and the curtain wall. The inclined chute section is 1,050 feet long, increasing in width from 108 feet at the crest to 200 feet at the stilling basin. The maximum discharge of 51,700 cfs results in a discharge of 258 cfs per foot of stilling basin width. The spillway drops 185 feet from the crest, elevation 2980, to the stilling basin, elevation 2797. A model built to a scale of 1:48 was used to study the hydraulic performance of the spillway structure.

An outlet works is located in the right abutment and to the left of the spillway, Figure 2. The conduit through the base of the dam terminates in a 14-inch hollow-jet valve for regulating the flow. The valve discharges into a stilling basin and an excavated channel leads to the river. Model studies were not made of the outlet works.

THE 1:48 SCALE MODEL

The 1:48 scale model, Figure 4, represented a portion of the reservoir area, the spillway entrance, the spillway chute, the stilling basin, and a portion of the downstream river channel. The head and tail boxes were constructed of wood and lined with sheet metal. The head box was 13 by 13.5 feet and contained reservoir topography formed of concrete plastered on metal lath. The metal lath was supported by wooden forms cut to the shape of the contours in the area. A baffle 6 inches thick and filled with 1-1/2-inch rock was located at the upstream end of the head box to quiet the flow from the inlet pipe to simulate the placid characteristics of water in a reservoir. The overflow section of the spillway, built of concrete screeded to sheet-metal templates, was placed on the downstream side of the head box. The control structure consisted of three sheet-metal gates with two wood piers and a wood curtain wall. A row of piezometers was installed along the center line of the overflow section. A point gage was placed in the head box to measure the elevation of the reservoir water surface.

The spillway chute, beginning at the overflow section and continuing to the tail box, was supported by a wooden platform covered with sheet metal. The floor of the chute, like the overflow section, was formed of concrete screeded to metal guide strips placed parallel to the flow. The training walls were made of plywood and covered with sheet metal. Piezometers were installed along the center line of the steep downstream section of the chute. The upstream section of the chute was built with a slope of 0.1312 in the model instead of the prototype slope of 0.1107. This increase in slope was necessary to give correct velocity to the flow entering the stilling basin since the friction in the model could not be made small enough to correspond to the prototype.

The tail box was 9.5 by 15.5 feet and contained the stilling basin which was connected to the lower end of the chute. The remainder of the tail box was used to reproduce 450 feet of prototype river channel. The horizontal apron of the stilling basin was built of concrete screeded to metal templates, and the chute blocks and end sill were made of wood. The channel was formed of sand, of which all passed a No. 50 sieve and was retained on a No. 100 sieve. A tailgate on the downstream end of the box was used to control the tail-water elevation which was read directly in terms of prototype elevations from a staff gage in the channel.

Water was supplied to the model from the laboratory sump by two 6-inch pumps connected in parallel. The quantity of water was measured by using an orifice meter in the supply line, and regulation was by a gate valve.

THE INVESTIGATION

Spillway No. 1--Preliminary

Description. The approach channel to the entrance of the preliminary spillway was curved, Figure 3. The terminal 130 feet of the channel at elevation 2970 was lined with concrete and had converging side walls as shown in Figure 5A. The spillway chute, starting at the overflow section, was 108 feet wide for a length of 600 feet, Figure 6. For the remaining 450 feet of length, the chute diverged uniformly to a width of 200 feet at the upstream end of the stilling basin. The stilling basin was 200 feet wide throughout its length of 167 feet with the floor at elevation 2797.

Operation. The model was operated at various discharges up to the maximum of 51, 700 cfs and the hydraulic performance of all parts of the spillway were observed. The several undesirable flow conditions which occurred were most pronounced at the maximum discharge. Starting with the reservoir area, a rough water surface and draw-down occurred at the left entrance wall for a discharge of 51, 700 cfs as shown in Figure 7A. The contraction of flow around and over the left entrance wall was caused by the near 90-degree change in direction of flow entering the spillway.

The condition of the water surface downstream from the overflow section is shown in Figure 7B. The piers caused some disturbance in the flow which is indicated by the waves spreading down the chute from the tail of each pier. The disturbance downstream from the left pier, which is the more pronounced, was increased by the uneven flow originating at the left entrance wall previously shown in Figure 7A. As the waves from the piers spread down the chute, they impinged on the training walls, overtopping the left training wall at Station 14+00, Figures 6 and 8A. The training walls then reflected the waves toward the center of the chute, so that the flow upon reaching the stilling basin was concentrated in the center, Figures 8A and B.

The preliminary model was operated for 1 hour at a discharge of 51, 700 cfs with tail-water elevation 2836, and the resulting erosion of the riverbed is shown in Figures 9A and B. The scour was greatest downstream from the end of each training wall. This is the usual case, but the erosion was increased by the uneven flow distribution originating in the chute.

The preliminary spillway tests indicated three undesirable flow conditions: (1) disturbance of the water surface in the entrance area which continued downstream, (2) uneven distribution of flow in the chute which overtopped the left training wall, and (3) an unsatisfactory scour pattern in the river channel. These problems were interrelated since a

disturbance in the flow affected the flow conditions downstream. Thus, tests on the modification to the spillway were started in the spillway entrance. Succeeding modifications were then made downstream and each acceptable solution was retained for the following tests.

Modifications

Approach studies. Approach B was the first alteration studied, Figure 5B. The modification consisted primarily in raising the height of the entrance walls as shown in the figure. The appearance of the water surface in the approach with a discharge of 51,700 cfs is shown in Figure 10A. There was some improvement over the conditions occurring with the preliminary entrance since the contraction covered less area and, being further upstream, caused less disturbance at the curtain wall.

Approach C was next tried, Figure 5C. The length of the paved section was increased 24.5 feet and the walls were lengthened a similar amount. In addition, backfill was placed to the top of the walls as shown in the figure. The contraction at the upstream end of the left wall was much less, Figure 10B, than occurred in the previous tests. The performance was considered satisfactory, but it was advisable to study similar but more economical arrangements which required less backfill.

For Approach D the same walls were used as for Approach C, but the backfill against the left wall was shortened, Figure 5D. The flow in the entrance area was smooth, Figure 11A, and there was less contraction at the left wall than had occurred with Approach C.

For Approach E, Figure 5E, the outer limit of the backfill at the left wall was placed on a curve since the corner used in Approach D would probably be damaged by large discharges through the spillway. The flow contraction at a discharge of 51,700 cfs, Figure 11B, was more pronounced than with the previous backfill arrangement, but the conditions of flow were considered satisfactory and this entrance was recommended for construction.

Pier studies. Unusually large waves formed downstream from the preliminary piers, Figure 7B, as discussed under the operation of the preliminary spillway. This disturbance was not considered objectionable to the spillway performance, but Pier No. 2 was tested to improve the conditions, if possible. Pier No. 2, Figure 12B, was similar to the preliminary pier, but it had an additional 17-foot 9-inch tapered tail added to the downstream end. The tail reduced the disturbance because the depth of water was less at the tail of the longer pier than occurred with the preliminary pier. The improvement can be observed by comparing Figure 13 with Figure 7B. However, after considering benefits with the additional cost, the designers decided that the longer piers were not justified, so Pier No. 1 was used for prototype construction.

Chute studies. The next problem was to reduce the concentration of flow in the center of the downstream end of the chute which was objectionable at the higher discharges. Past experience had shown that by making the center of the chute higher than the edges the water would be forced to spread laterally. Such an alteration was made to the chute in the present study, Crown No. 1, Figure 14A. The distribution of the flow entering the stilling basin is shown in Figures 15A and B for discharges of 4, 150 and 51, 700 cfs. The distribution was uniform at the maximum discharge, but at the lower flows the crown spread the water excessively, causing a concentration of water at the training walls.

Crown No. 2, Figure 14B, had 32.5 feet less width at the downstream end than Crown No. 1 to reduce the spreading action of the lower flows. The performance for discharges of 4, 150 and 51, 700 cfs, Figures 16A and B, was unchanged from that occurring with Crown No. 1.

The studies with the two crowns did not prove successful in obtaining uniform flow distribution entering the stilling basin for all discharges, so the alignment of the training walls was modified, Figure 6. The point at which the training walls began to diverge was moved upstream 416 feet to Station 11+84. With the crown removed, the distribution of flow at the downstream end of the chute for the maximum flow of 51, 700 cfs, Figure 17, was more uniform than occurred with the preliminary chute without a crown. The discharge, however, was still greater in the center of the basin than at the training walls.

Crown No. 3, Figure 14C, with a center height of 1.5 feet and a length of 240 feet was next installed in the revised chute. The downstream end of the crown was at Station 17+59.7. The distribution of flow entering the stilling basin is shown in Figures 18A and B for discharges of 10, 000 and 51, 700 cfs. At the lower discharge the depth of flow was less in the center than at the sides, but the distribution was more uniform than had occurred in any previous test. Very uniform distribution resulted, however, at the maximum discharge. The water surface throughout the length of the chute was more uniform than in the tests with the preliminary chute. Since the performance of the chute arrangement was now considered satisfactory, tests were then conducted on the stilling basin.

Stilling basin studies. With the recommended approach and chute arrangement the model was operated using the preliminary stilling basin, Figure 19. The conditions of flow in the basin and channel downstream were satisfactory at the maximum discharge, Figure 20A. The erosion resulting from 1 hour of operation at a discharge of 51, 700 cfs is shown in Figure 20B. The maximum scour reached 4 feet below the apron and occurred downstream from the right training wall. The scour in the channel was less than that obtained with the test on the preliminary spillway, Figure 9. Since the same stilling basin was used in

both tests, the improvement resulted from the more uniform flow distribution obtained with the recommended chute. The stilling action of the basin, as indicated by the scour in Figure 20B, was considered adequate, but testing was continued to assure obtaining the best basin arrangement.

To determine the effectiveness of the end sill, it was removed and a 1-hour erosion test was run at a discharge of 51, 700 cfs and tail water elevation 2834. The scour in the channel was severe, Figure 21A, indicating the value of the end sill in protecting the river channel. The scour downstream from the right training wall resulted in the bed being 12 feet lower than the elevation of the apron.

The dentated end sill was installed and spur wing walls were placed on each side of the basin as shown by the dotted lines in Figure 19. Model studies made in the past using this spur wall had been successful in reducing erosion at the cut-off wall on each side of the basin. The erosion resulting from operating 1 hour at a discharge of 51, 700 cfs and tail-water elevation 2834 is shown in Figure 21B. The lowest streambed elevation occurred at the end of the spur walls where the scour was 4 feet lower than the apron elevation. The scour was quite similar to that obtained with the 90-degree wing walls shown in Figure 20B. Since the results were not improved by the addition of the spur walls, it was decided to use the preliminary basin for construction in the prototype.

The Recommended Spillway

As discussed in the tests under spillway modifications, three changes were made in the spillway structure: (1) alteration to the entrance, (2) re-alignment of the chute training walls, and (3) addition of a crown to the chute. Flow conditions throughout the spillway were then considered satisfactory, but additional data were necessary to complete the spillway tests.

Pressures and water-surface profiles. Pressures were obtained along the center line of the overflow section of the spillway. The lowest pressure that occurred, Figure 22A, was 1 foot of water below atmospheric when the gates were open 1 foot and the discharge was 3, 200 cfs. Pressures were also measured on Crown No. 3 at the points indicated in Figure 14C. The lowest pressure obtained was 1/2 foot of water above atmospheric at Piezometer No. 2. These pressures are shown in the table on Figure 14. In addition, pressures were observed along the center line of the vertical curve and steep section of the chute. The lowest pressure recorded was 1 foot of water below atmospheric with a discharge of 48, 900 cfs, Figure 22B. These tests indicated satisfactory pressure conditions existed throughout the spillway.

Water-surface profiles along each training wall throughout the length of the spillway were obtained for discharges of 35, 000 and 51, 700 cfs and these are shown in Figure 23. The water did not overtop the

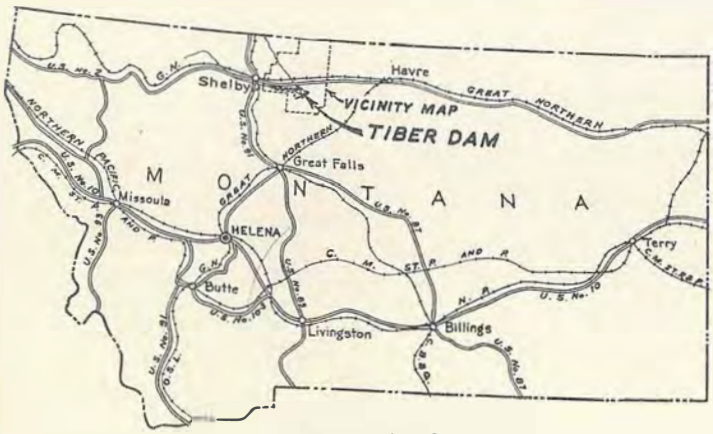
training walls at any point on the spillway. The closest approach to the top occurred along the right wall in the vicinity of Station 15+00 at the maximum discharge. Transverse water-surface profiles were taken at various discharges at five stations along the spillway, Figures 24 and 25. The transverse depth was generally uniform in the overflow section for all discharges, except for a depression in the water surface downstream from each pier, Figure 24. The depth was greater in the center of the chute at Station 11+85, 145 feet downstream from the piers, Figure 25. The depth of the water in the chute at Station 20+28.5, just upstream from the stilling basin, was slightly greater along the center line for the maximum discharge, Figure 25. These measurements of the water surfaces showed the height of the training walls to be adequate throughout the spillway.

Calibration. Discharge-capacity curves were obtained for the spillway for various conditions, Figure 26. These curves are for the discharge through three gates, with all gates opened the same amount for each curve shown on the chart. The gates should be operated symmetrically in the prototype to avoid unnecessary wave action and erosion in the river channel. The maximum gate opening is limited to 20 feet by a curtain wall whose bottom edge is at elevation 3000. Consequently, free flow can occur for only the first 20 feet of head above the crest. The maximum value of the coefficient of discharge C in the equation $Q = CLH^{3/2}$ for free flow with the water surface just free of the curtain wall is 3.28 as shown by the coefficient of discharge curve in Figure 26. With the maximum discharge of 51,700 cfs and the gate openings at 20 feet, the coefficient of discharge is 3.75 using the equation $Q = CL(H_1^{3/2} - H_2^{3/2})$ for submerged flow.

Interior - Reclamation - Denver, Colo.

FIGURE 1

VICINITY MAP



INDEX MAP

1 0 10 15
SCALE OF MILES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
LOWER MARIAS UNIT-MONTANA

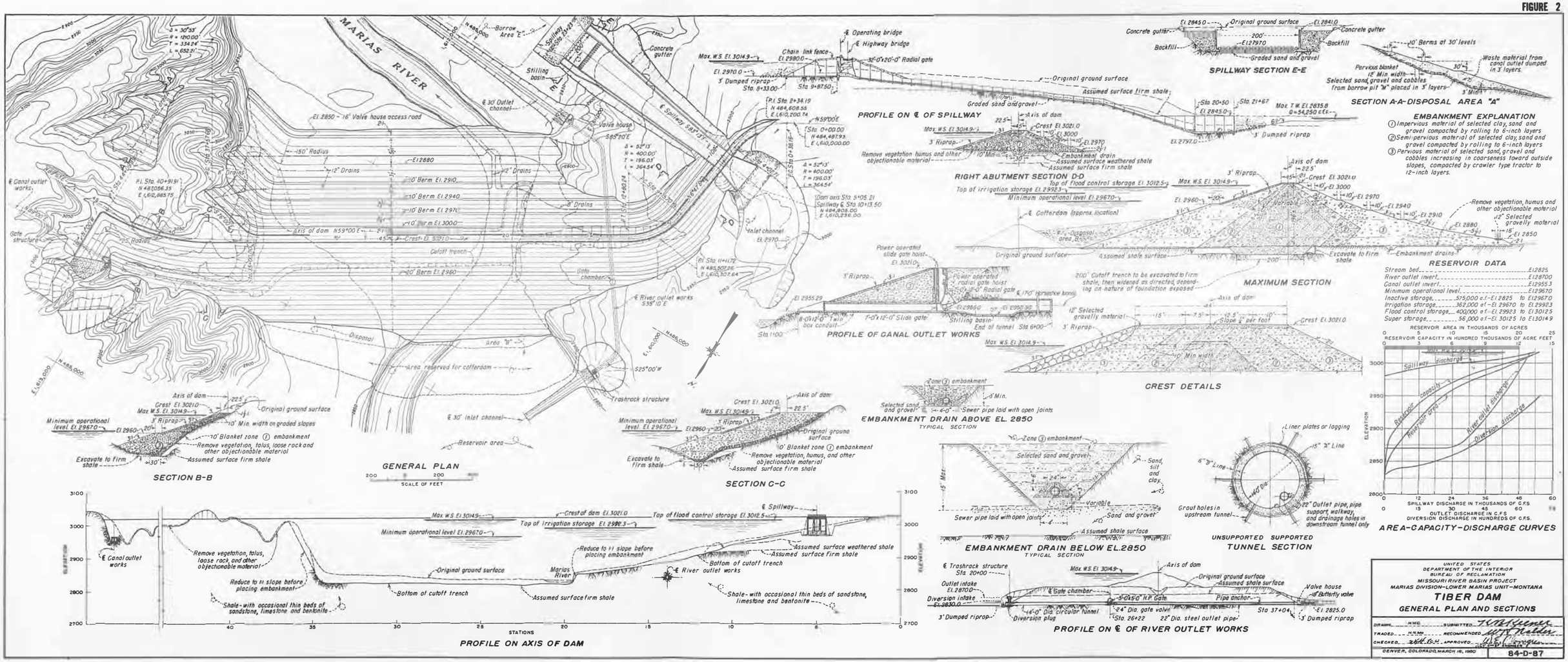
TIBER DAM

LOCATION MAP

DRAWN: R.C.R. SUBMITTED: T.W. Keener
TRACED: M.C.F. RECOMMENDED: J.W. Holder
CHECKED: RFA RCW APPROVED: W.E.P. Overview
CHIEF ENGIN. ER.

DENVER, COLORADO, MARCH 16, 1950 | 84-D-74

FIGURE 2


MARIAS RIVER
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SCALE OF FEET
PROFILE ON ℄ OF SPILLWAY
SPILLWAY SECTION E-E
SECTION A-A-DISPOSAL AREA "A"
EMBANKMENT EXPLANATION
① Impervious material of selected clay, sand and gravel compacted by rolling to 6-inch layers
② Semi-pervious material of selected clay, sand and gravel compacted by rolling to 6-inch layers
③ Pervious material of selected sand, gravel and cobbles increasing in coarseness toward outside slopes, compacted by crawler type tractor to 12-inch layers.
RIGHT ABUTMENT SECTION D-D
MAXIMUM SECTION
RESERVOIR DATA
Stream bed ..... El 2825
River outlet invert ..... El 2870.0
Canal outlet invert ..... El 2955.3
Minimum operational level ..... El 2967.0
Inactive storage ..... 575,000 a.f.-El 2825 to El 2967.0
Irrigation storage ..... 362,000 a.f.-El 2967.0 to El 2992.3
Flood control storage ..... 400,000 a.f.-El 2992.3 to El 3012.5
Super storage ..... 56,000 a.f.-El 3012.5 to El 3014.9
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RESERVOIR CAPACITY IN HUNDRED THOUSANDS OF ACRE FEET
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OUTLET DISCHARGE IN C.F.S.
DIVERSION DISCHARGE IN HUNDREDS OF C.F.S.
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PROFILE ON ℄ OF RIVER OUTLET WORKS
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
MARIAS DIVISION-LOWER MARIAS UNIT-MONTANA
TIBER DAM
GENERAL PLAN AND SECTIONS
DENVER, COLORADO, MARCH 16, 1960
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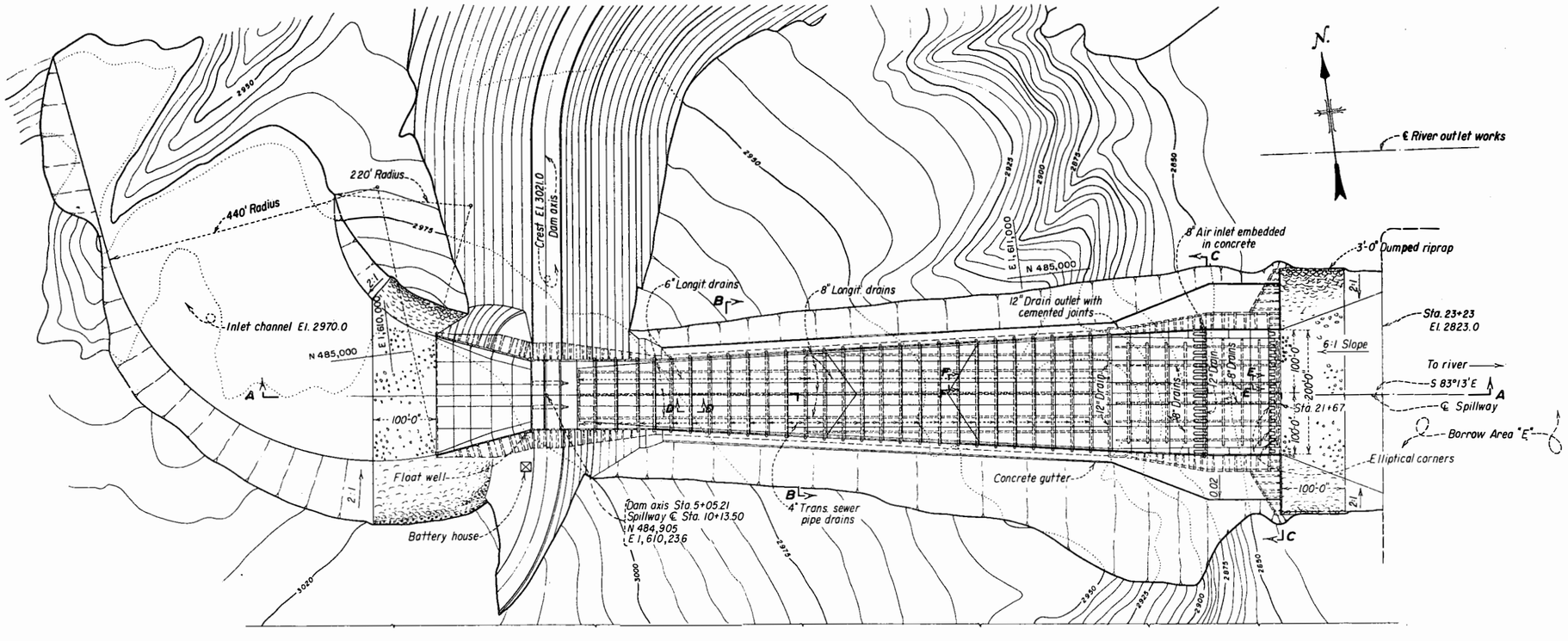
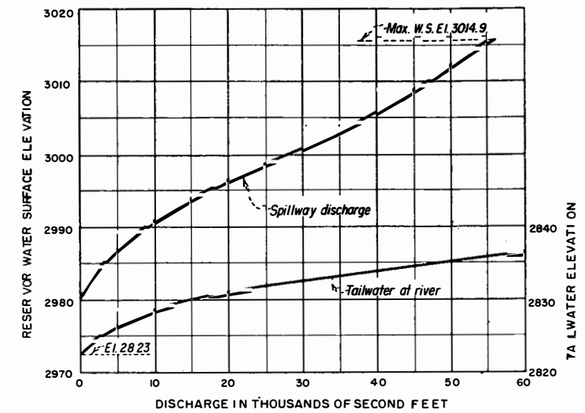
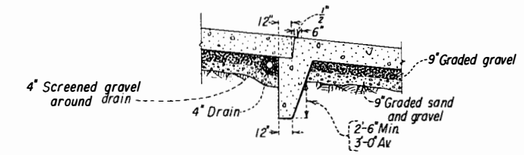


PLAN

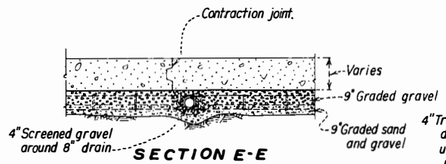
SCALE OF FEET



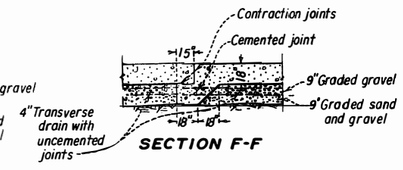
DISCHARGE-TAILWATER CURVES



SECTION D-D



SECTION E-E



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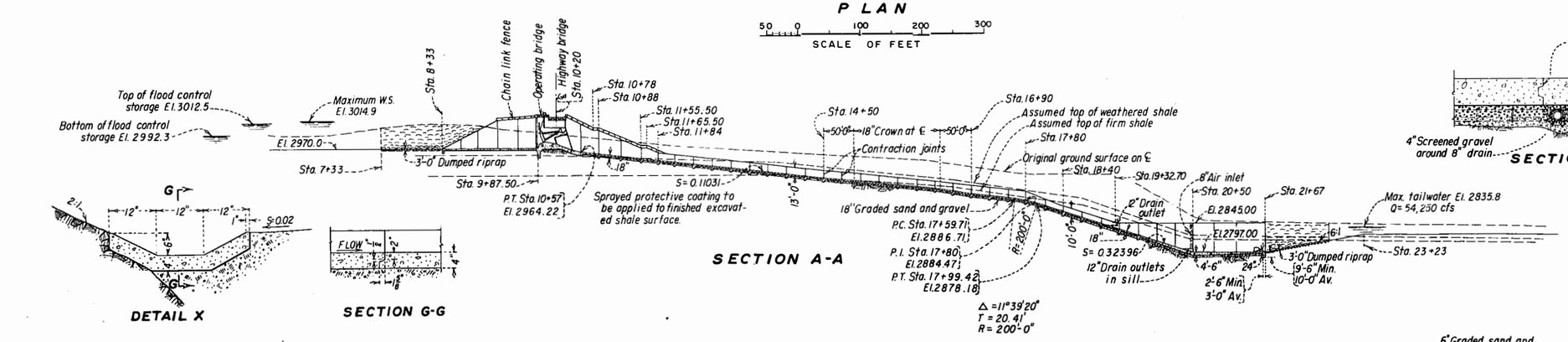
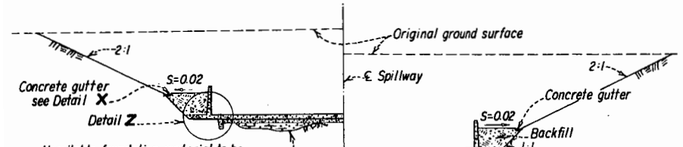
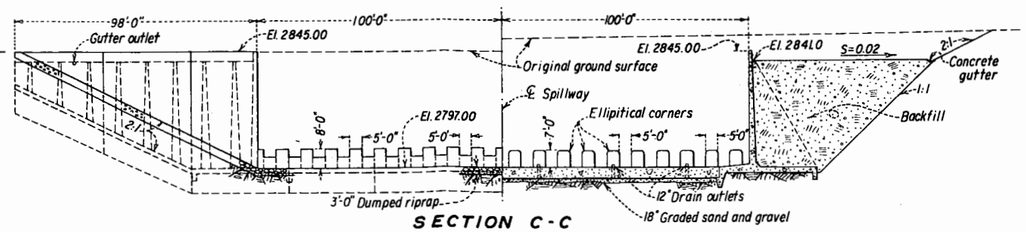


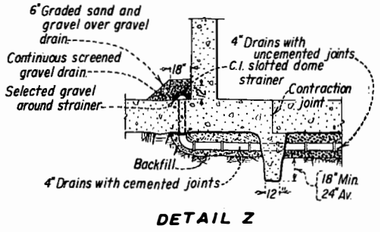
SECTION A-A



SECTION B-B



SECTION C-C



DETAIL Z

CONCRETE FINISHES

Surfaces covered by fill:
Formed, F1, Unformed, U1.
Exposed surfaces:
Formed, F2, Unformed: spillway floor, U2; highway bridge floor, U2; concrete gutter, U2.

NOTES

Apply one coat of sealing compound to one side of contraction joints.
Reinforcement, electrical conduits, and apparatus not shown.
All concrete in spillway will be designed for 3000 lbs. per sq. inch compressive strength at 28 days.

UNITED STATES
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BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
MARIAS DIVISION - LOWER MARIAS UNIT - MONTANA

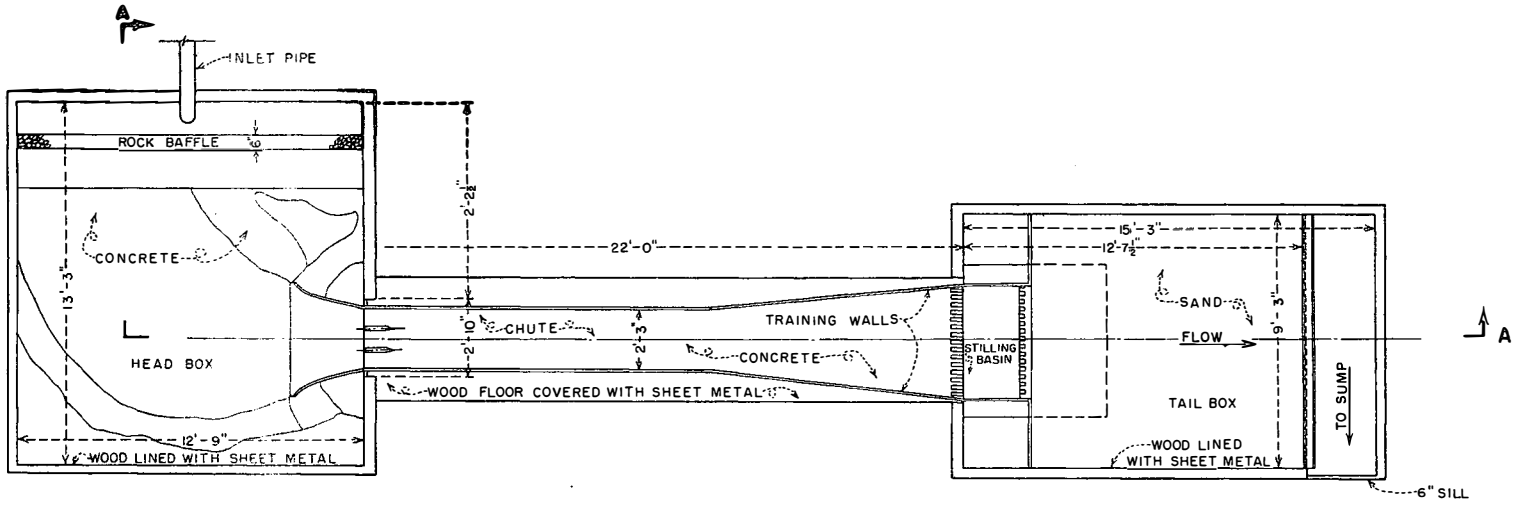
TIBER DAM

SPILLWAY
PLAN AND SECTIONS

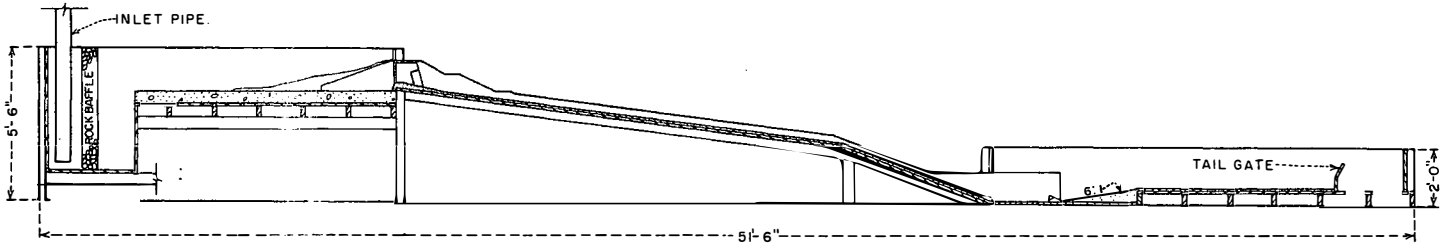
DRAWN J.E.B. T.V.C. SUBMITTED T. V. M. Greener
TRACED E.N.K. RECOMMENDED W. H. Nalder
CHECKED V.C. A.M.A. APPROVED W. E. Warren
Asst. CHIEF ENGINEER

DENVER, COLORADO, MARCH 6, 1950

84-D-93



PLAN

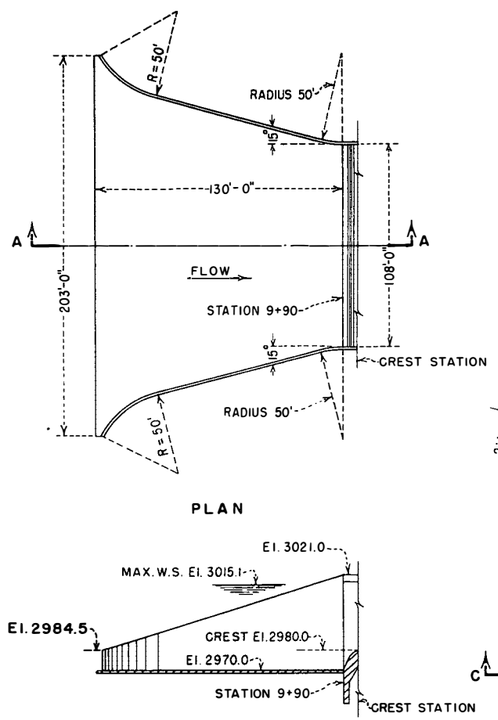


SECTION A-A

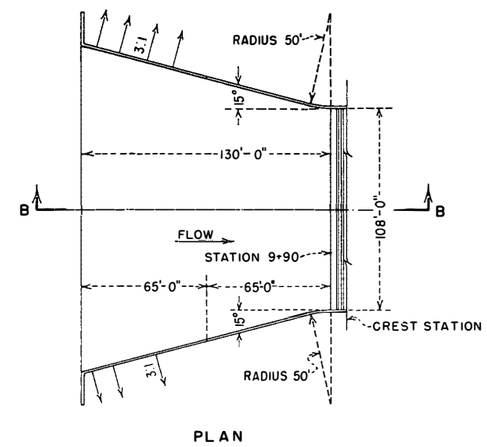
TIBER DAM SPILLWAY
HYDRAULIC MODEL STUDIES
MODEL ARRANGEMENT
MODEL SCALE 1:48

FIGURE 4

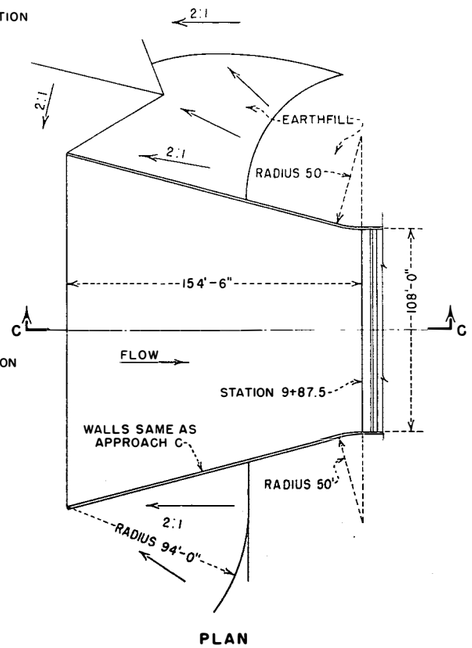
FIGURE 5



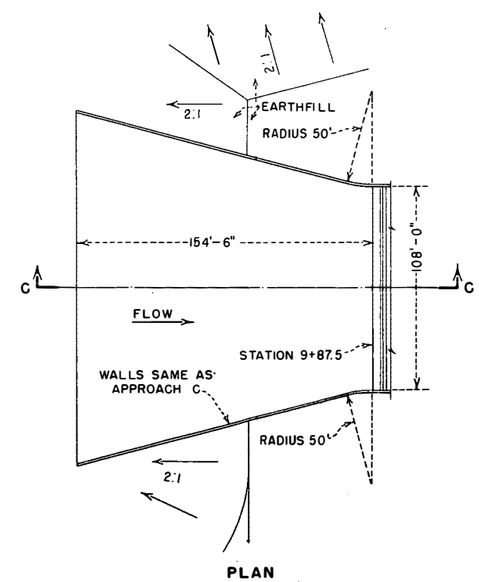
A - PRELIMINARY APPROACH



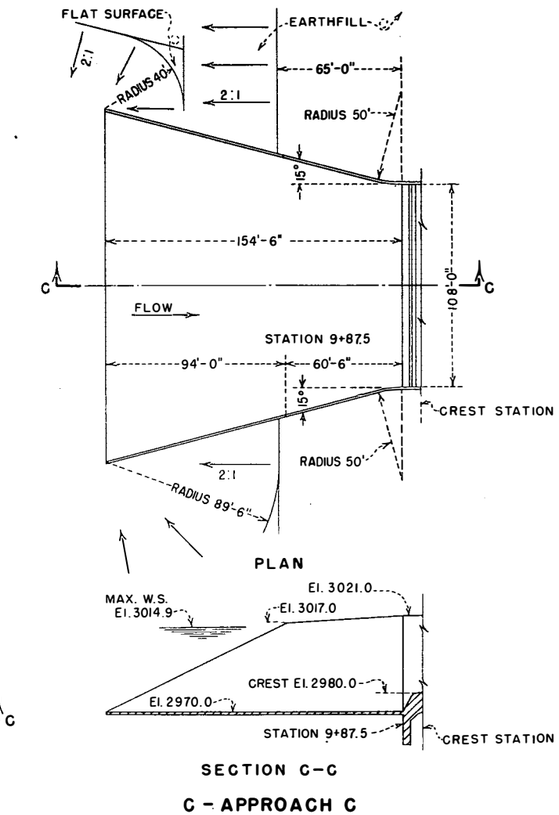
B - APPROACH B



E - RECOMMENDED APPROACH

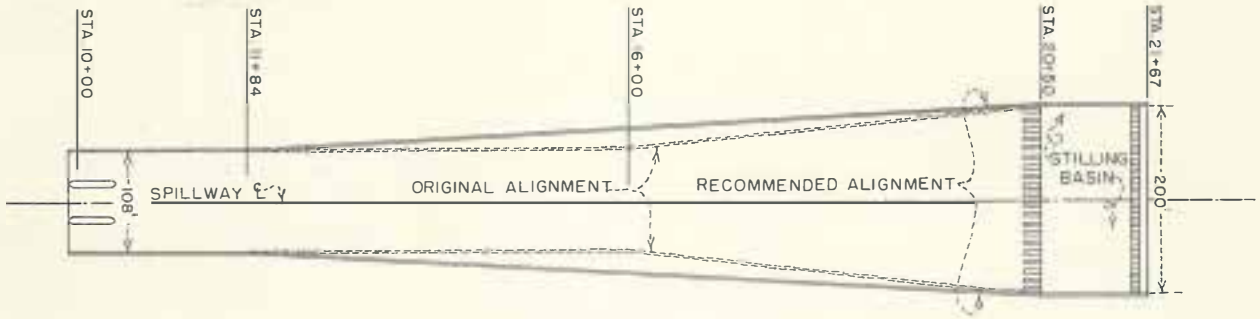


D - APPROACH D

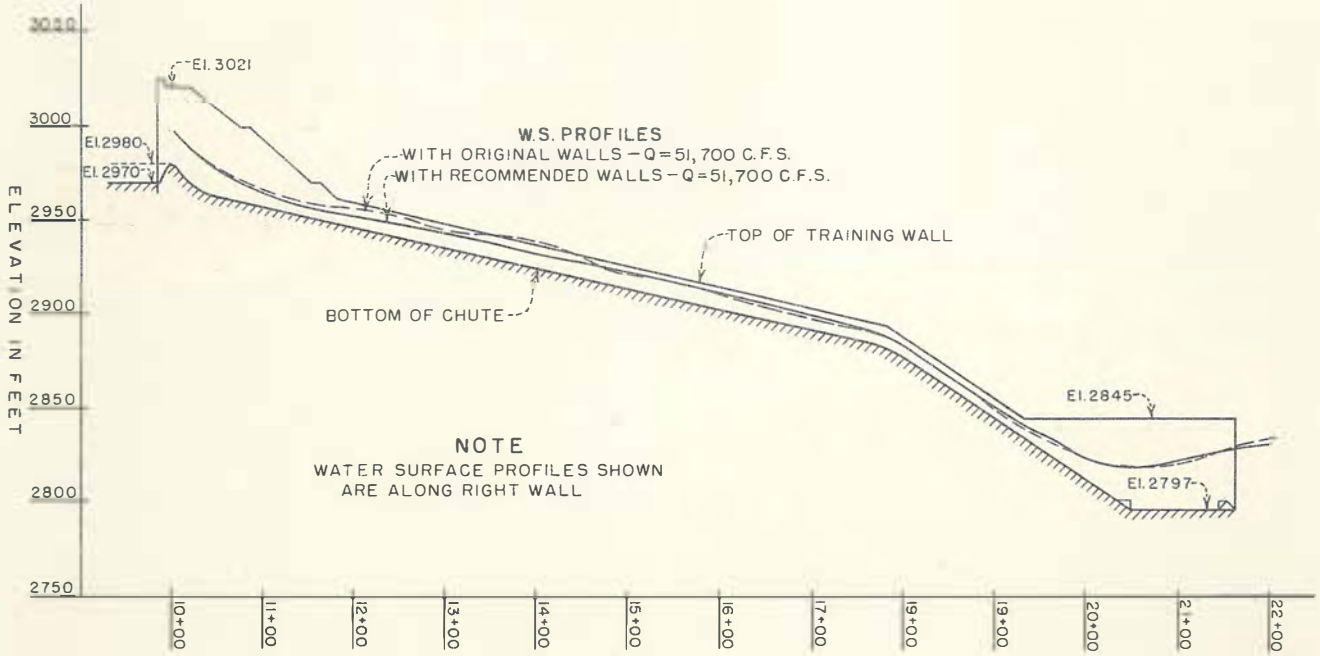


C - APPROACH C

TIBER DAM SPILLWAY
HYDRAULIC MODEL STUDIES
SPILLWAY APPROACHES
MODEL SCALE 1:48



PLAN



PROFILE

TIBER DAM SPILLWAY
CHUTE TRAINING WALLS
1:48 SCALE MODEL STUDY

FIGURE 6

A. Reservoir & Approach

B. Overflow Section & Piers

Discharge 51,700 c.f.s.

SPILLWAY NO. 1 - PRELIMINARY
TIBER DAM
1:48 Scale Model Study

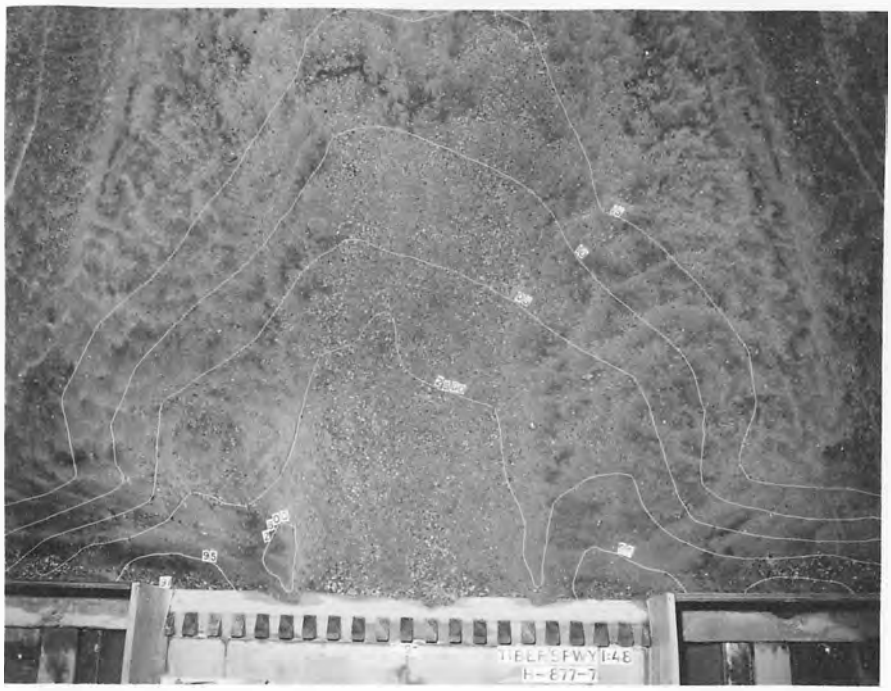
FIGURE 8

A. Spillway chute

B. Stilling basin

Discharge 51,700 c.f.s.

SPILLWAY NO. 1 - PRELIMINARY
TIBER DAM
1:48 Scale Model Study



A. Downstream view

B. Upstream view

**Scour after 1 hour at 51,700 c.f.s.
and tailwater elevation 2836**

**SPILLWAY NO. 1 - PRELIMINARY
TIBER DAM
1:48 Scale Model Study**

A. Approach B Discharge 51, 700 c.f.s.

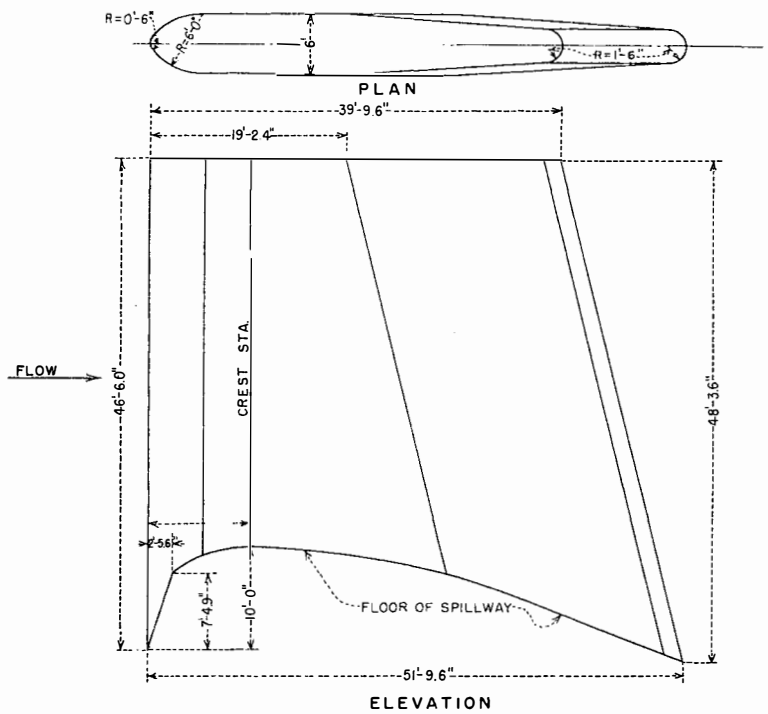
B. Approach C Discharge 51, 700 c.f.s.

APPROACH B and C
TIBER DAM
1:48 Scale Model Study

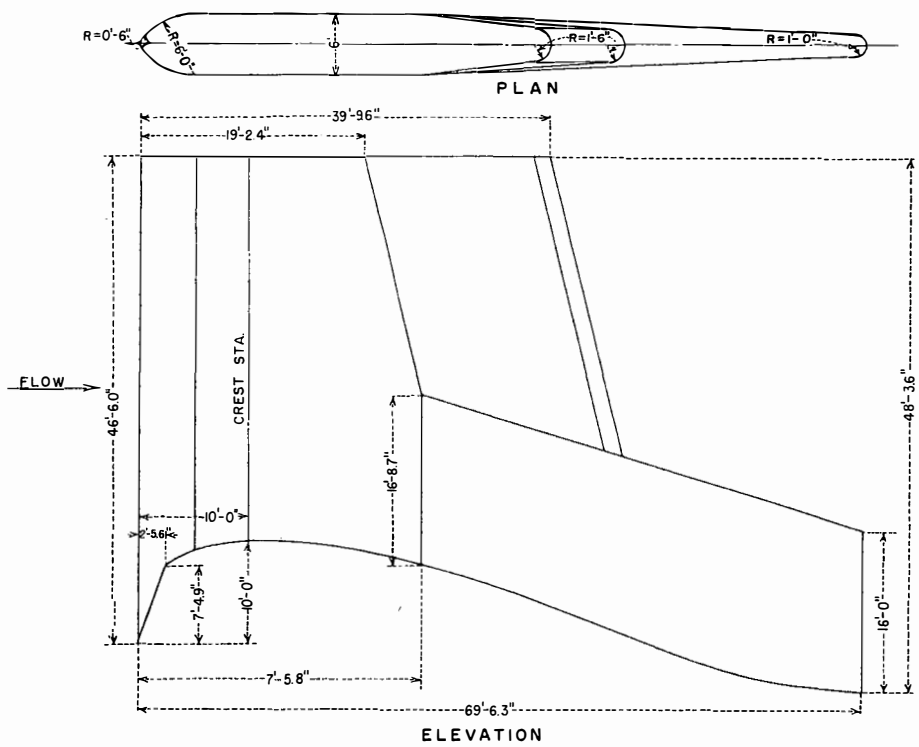
A. Approach D Discharge 51, 700 c. f. s.

B. Approach E Recommended, Discharge 51, 700 c. f. s.

APPROACH D and E
TIBER DAM
1:48 Scale Model Study



A. PRELIMINARY PIER NO. 1

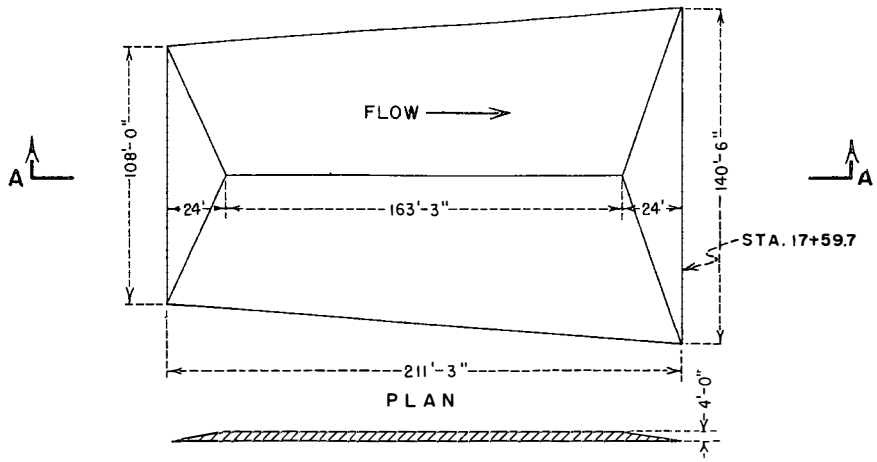


B. ALTERNATE PIER NO. 2

TIBER DAM SPILLWAY
HYDRAULIC MODEL STUDIES
PIERS
MODEL SCALE 1:48

Discharge 51,700 c.f.s.

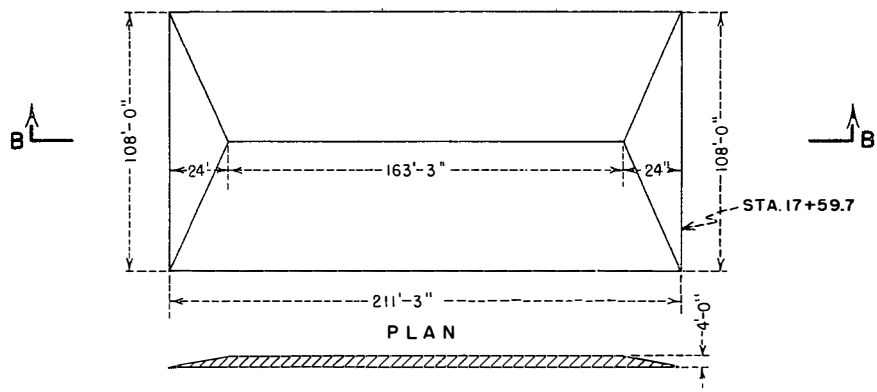
PIER NO. 2
TIBER DAM
1:48 Scale Model Study



PLAN

SECTION A-A

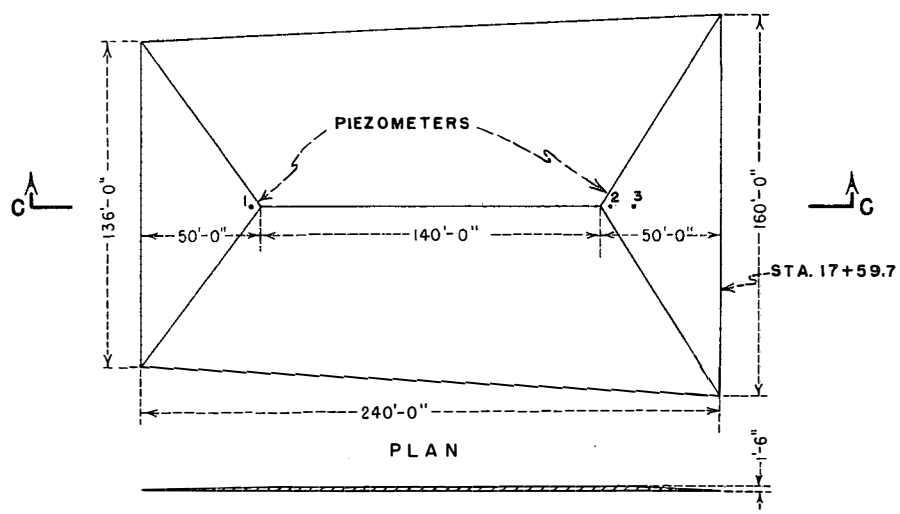
A. CROWN NO. 1



PLAN

SECTION B-B

B. CROWN NO. 2



PLAN

SECTION C-C

C. CROWN NO. 3

PRESSURES ON CROWN NO. 3

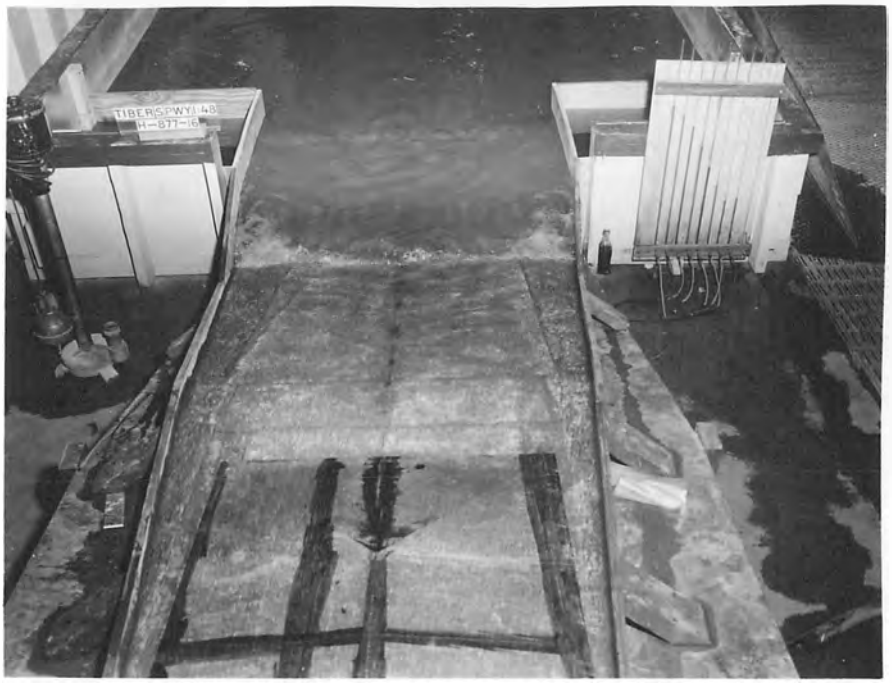
DISCH.	51,700	30,000	10,000
PIEZ.	PRESSURE FT. OF WATER		
1	4	3	1.6
2	1	.5	.5
3	2	1.2	.8

TIBER DAM SPILLWAY
HYDRAULIC MODEL STUDIES
CHUTE CROWNS
MODEL SCALE 1:48

A. Discharge 4150 c.f.s.

B. Discharge 51,700 c.f.s.

PRELIMINARY CHUTE WITH CROWN NO. 1
TIBER DAM
1:48 Scale Model Study



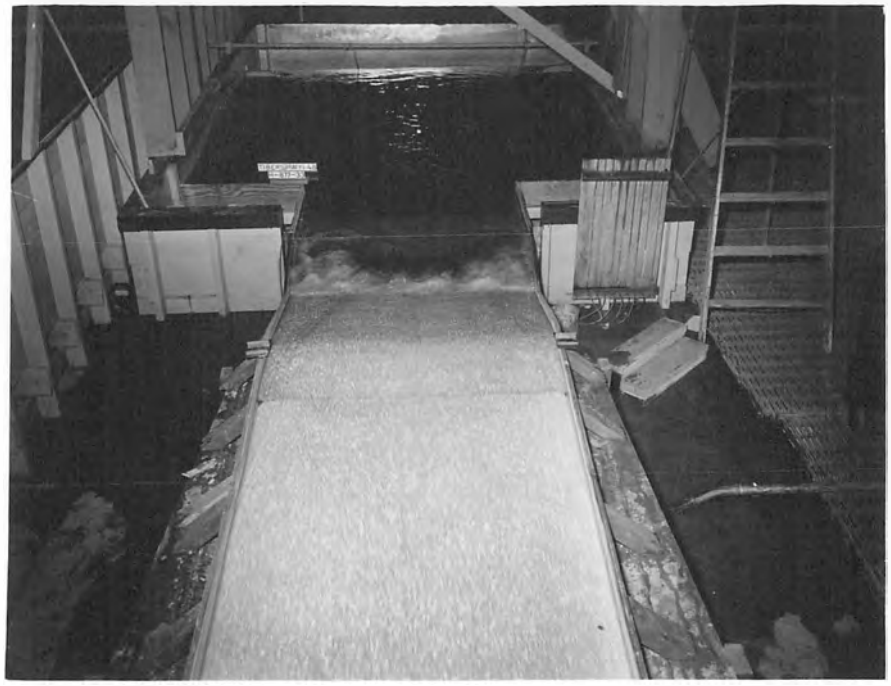
A. Discharge 4,150 c.f.s.

B. Discharge 51,700 c.f.s.

PRELIMINARY CHUTE with CROWN NO. 2
TIBER DAM
1:48 Scale Model Study

Discharge 51, 700 c. f. s.

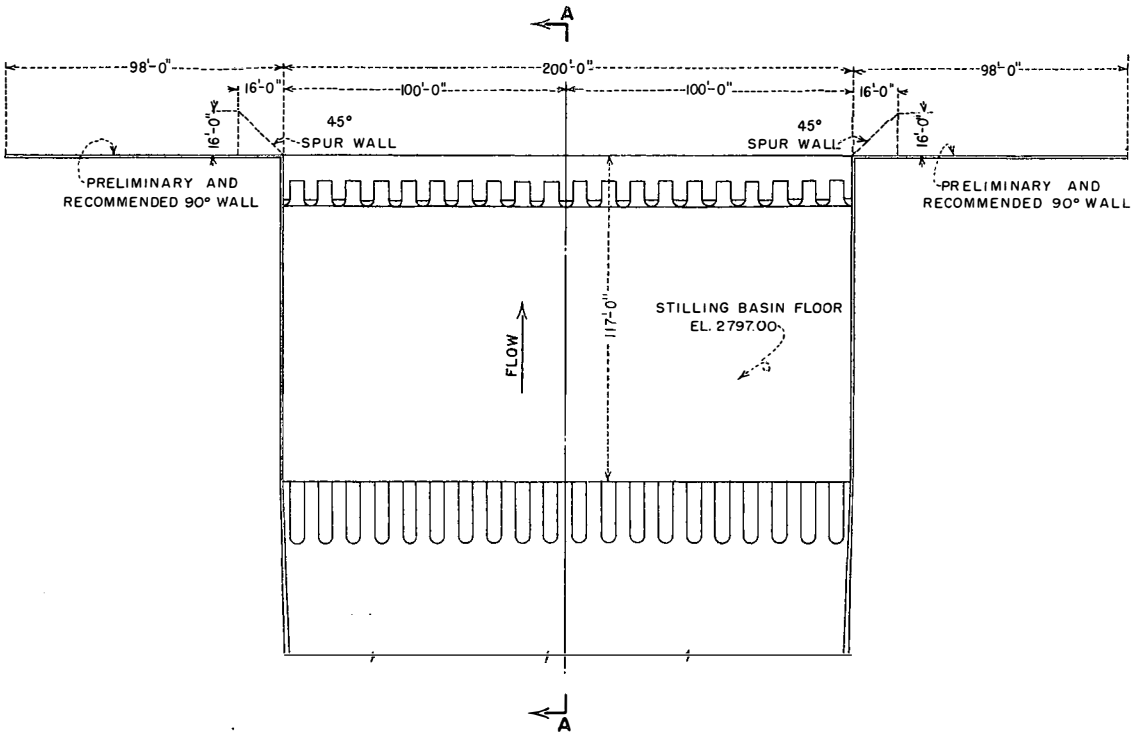
RECOMMENDED CHUTE WITHOUT CROWN
TIBER DAM
1:48 Scale Model Study



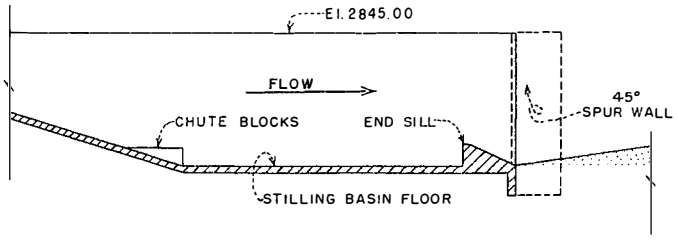
A. Discharge 10,000 c.f.s.

B. Discharge 51,700 c.f.s.

RECOMMENDED CHUTE WITH CROWN NO. 3
TIBER DAM
1:48 Scale Model Study



PLAN



SECTION A-A

TIBER DAM SPILLWAY
HYDRAULIC MODEL STUDIES
STILLING BASIN
MODEL SCALE 1:48

A. Discharge 51,700 c.f.s.

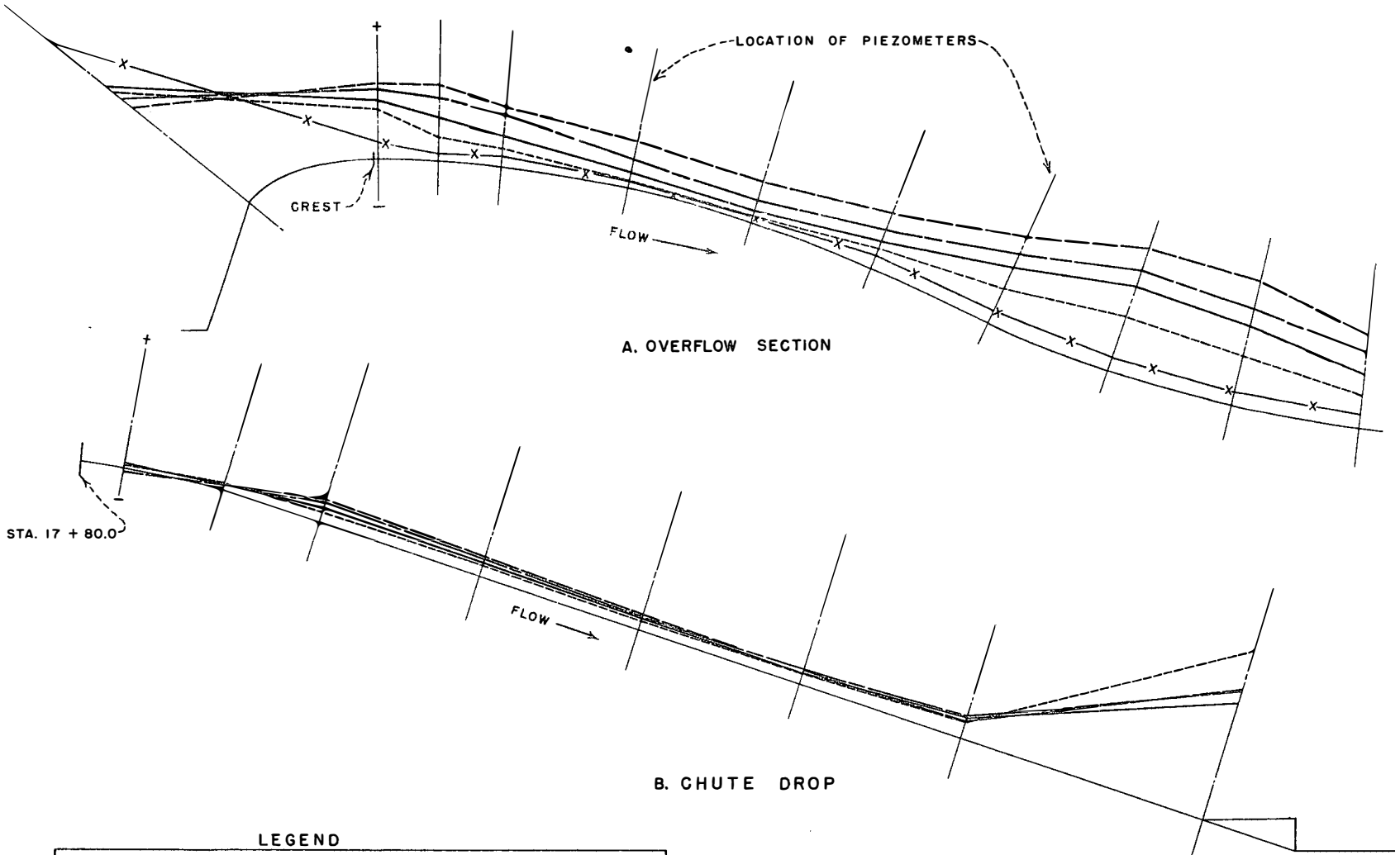
B. Scour after 1 hour discharge of 51,700 c.f.s. T.W. El. 2834

PRELIMINARY STILLING BASIN - RECOMMENDED
TIBER DAM
1:48 Scale Model Study

A. End sill removed, scour after 1 hour discharge of 51,700 c.f.s. T.W. El. 2834

B. 45° spur walls, scour after 1 hour discharge of 51,700 c.f.s. T.W. El. 2834

PRELIMINARY STILLING BASIN
SCOUR WITHOUT SILL AND WITH SPUR WING WALLS
TIBER DAM
1:48 Scale Model Study



LEGEND

———	3 GATES OPENED	20 FEET	Q = 48,900 C.F.S.
———	3 GATES OPENED	15 FEET	Q = 38,200 C.F.S.
———	3 GATES OPENED	10 FEET	Q = 29,100 C.F.S.
———	3 GATES OPENED	5 FEET	Q = 15,200 C.F.S.
——x——	3 GATES OPENED	1 FOOT	Q = 3,200 C.F.S.

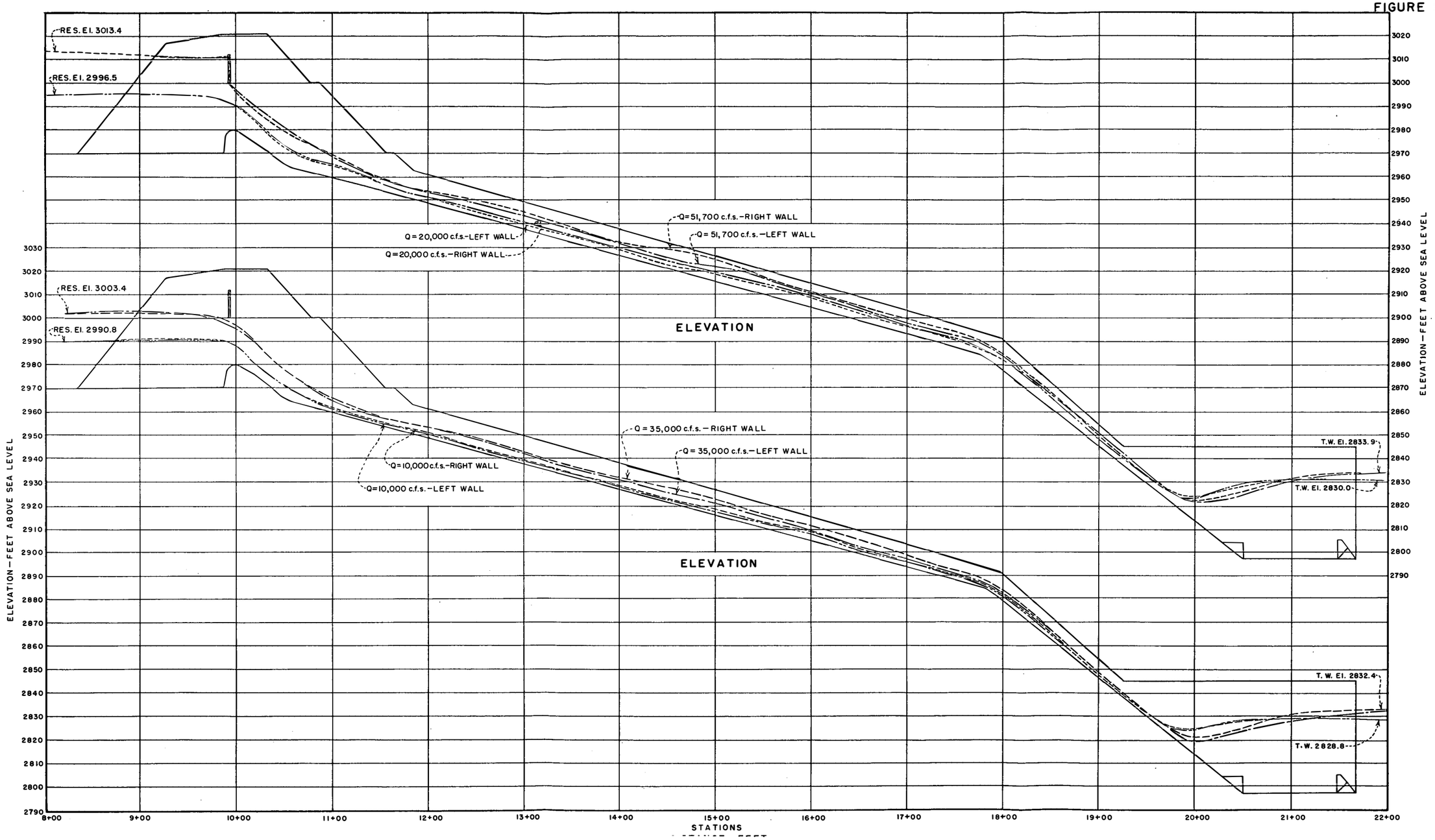
0 10 20 30

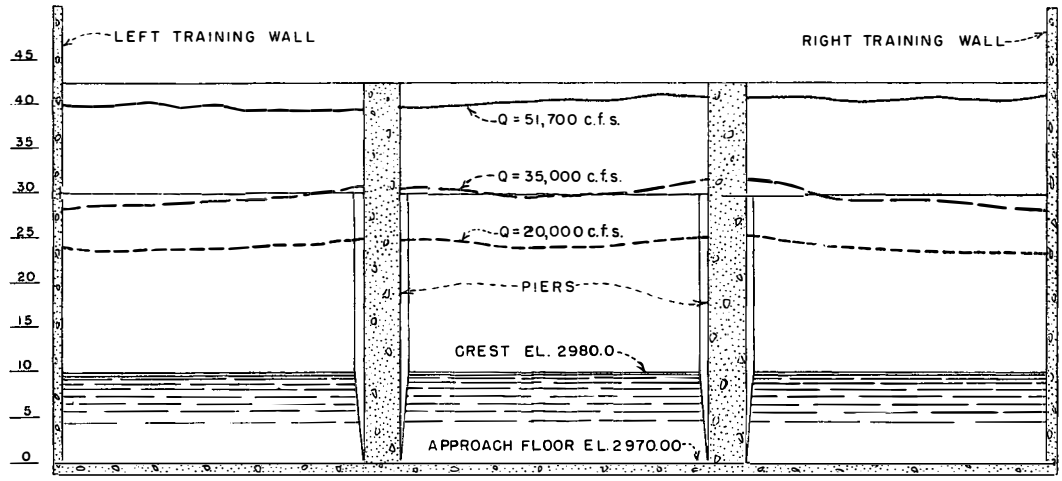
PRESSURE SCALE IN FEET OF WATER

TIBER DAM SPILLWAY
HYDRAULIC MODEL STUDIES
PIEZOMETRIC PRESSURES
MODEL SCALE 1:48
RECOMMENDED SPILLWAY

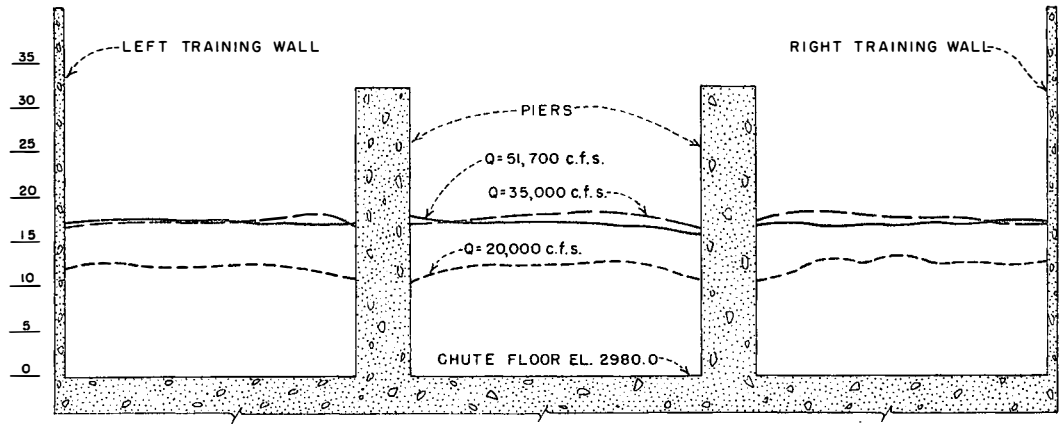
FIGURE 22

FIGURE 23

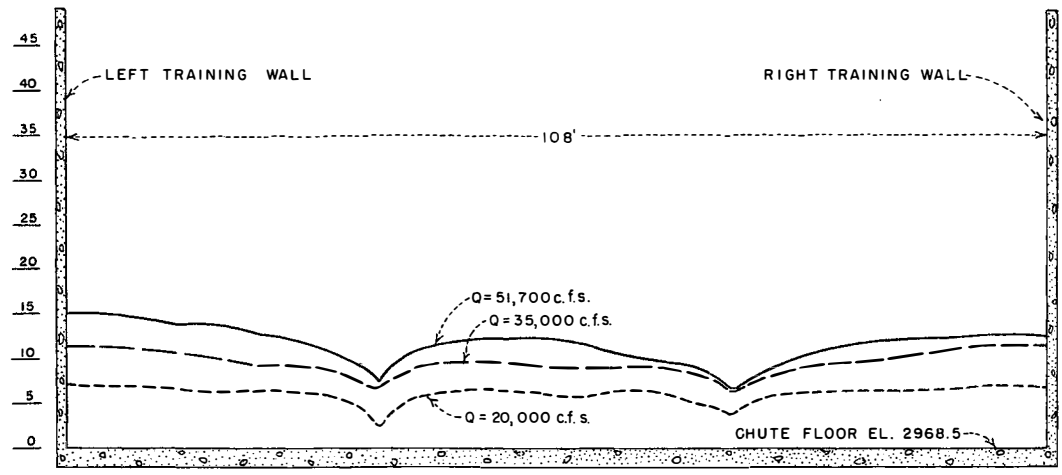

RES. El. 3013.4
RES. El. 2996.5
Q=51,700 c.f.s.-RIGHT WALL
Q=51,700 c.f.s.-LEFT WALL
Q=20,000 c.f.s.-LEFT WALL
Q=20,000 c.f.s.-RIGHT WALL
ELEVATION
RES. El. 3003.4
RES. El. 2990.8
Q=35,000 c.f.s.-RIGHT WALL
Q=35,000 c.f.s.-LEFT WALL
Q=10,000 c.f.s.-RIGHT WALL
Q=10,000 c.f.s.-LEFT WALL
T.W. El. 2833.9
T.W. El. 2830.0
ELEVATION
T.W. El. 2832.4
T.W. 2828.8
ELEVATION—FEET ABOVE SEA LEVEL
STATIONS
8+00
9+00
10+00
11+00
12+00
13+00
14+00
15+00
16+00
17+00
18+00
19+00
20+00
21+00
22+00



PROFILES AT STA. 9+90



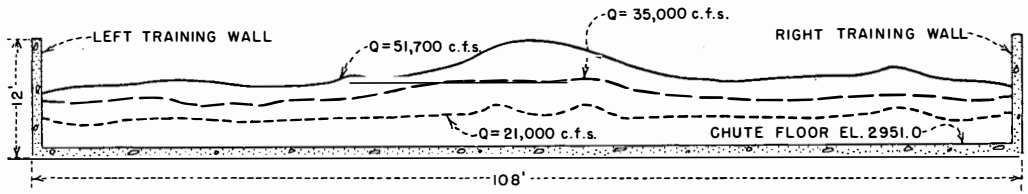
PROFILES AT STA. 10+00



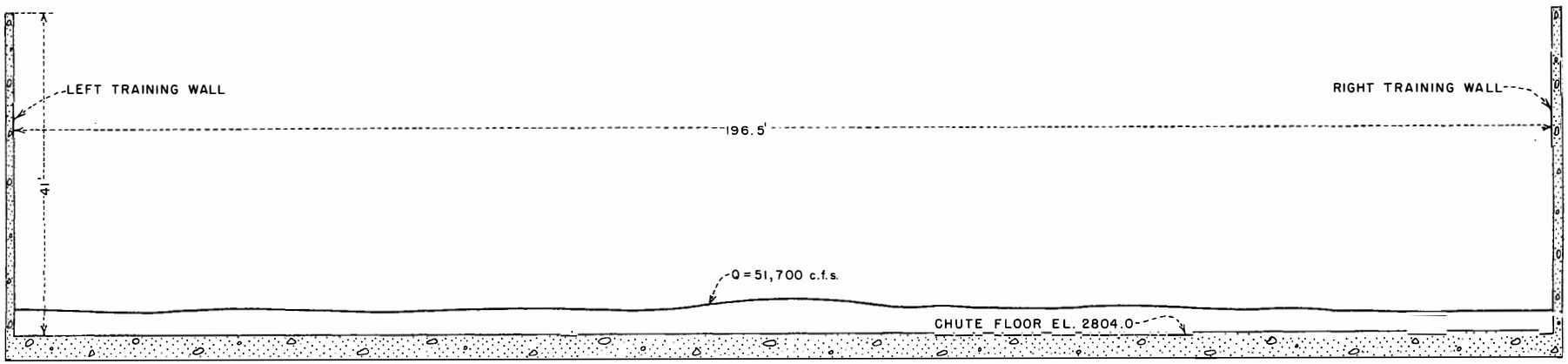
PROFILES AT STA. 10+51.8

TIBER DAM SPILLWAY
HYDRAULIC MODEL STUDIES
WATER SURFACE PROFILES
MODEL SCALE 1:48
RECOMMENDED SPILLWAY

FIGURE 25



PROFILES AT STA. 11+84



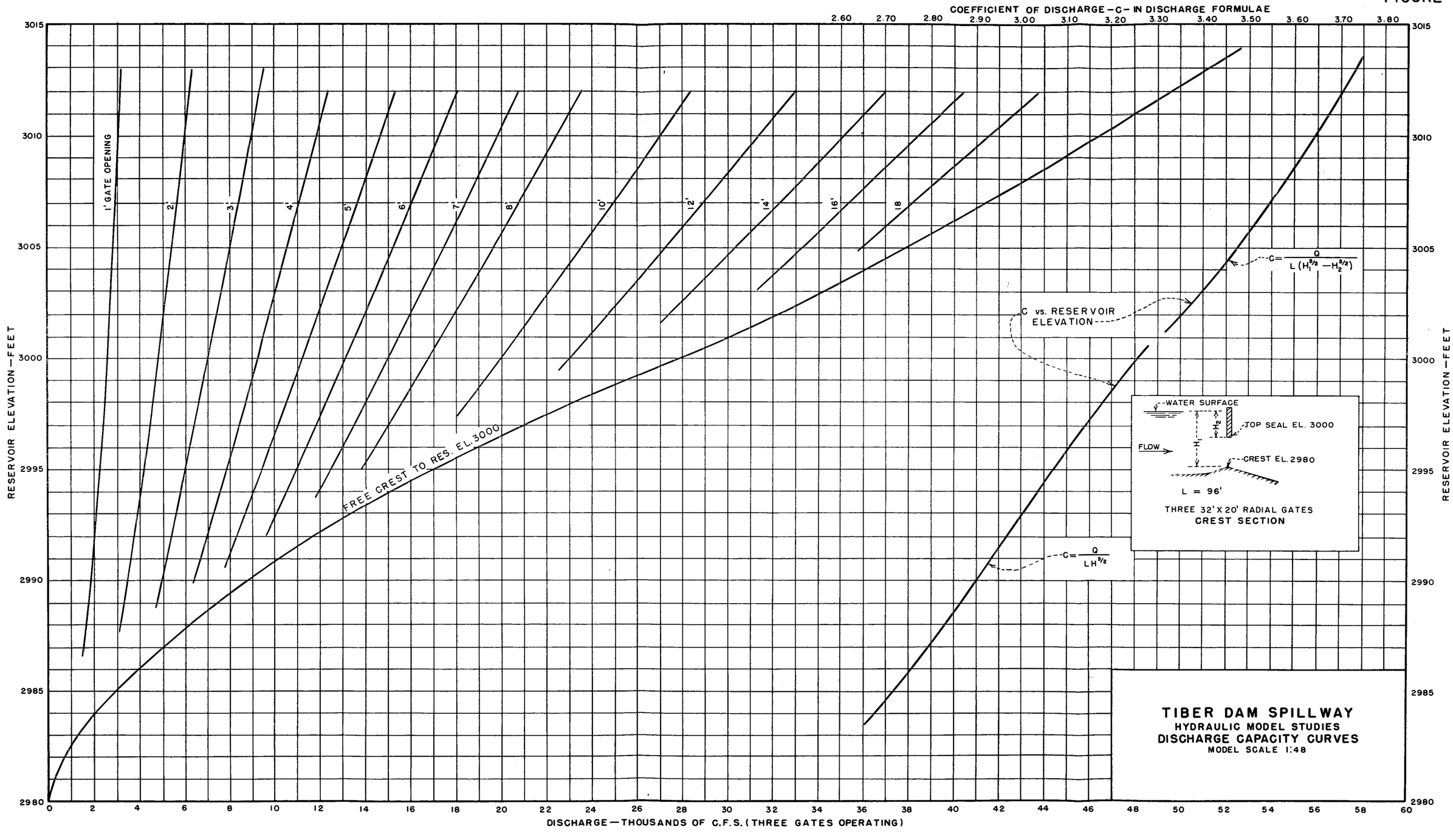
PROFILE AT STA. 20+28.5

NOTE

Sta. 20+28.5 where these profiles were measured is just upstream from the upper limit of the hydraulic jump at maximum discharge.

TIBER DAM SPILLWAY
HYDRAULIC MODEL STUDIES
WATER SURFACE PROFILES
MODEL SCALE 1:48
RECOMMENDED SPILLWAY

FIGURE 26


COEFFICIENT OF DISCHARGE—C— IN DISCHARGE FORMULAE
2.60 2.70 2.80 2.90 3.00 3.10 3.20 3.30 3.40 3.50 3.60 3.70 3.80
RESERVOIR ELEVATION—FEET
3015 3010 3005 3000 2995 2990 2985 2980
1' GATE OPENING
2'
3'
4'
5'
6'
7'
8'
10'
12'
14'
16'
18
FREE CREST TO RES. EL. 3000
C vs. RESERVOIR ELEVATION
$C = \frac{Q}{L(H_1^{3/2} - H_2^{3/2})}$
$C = \frac{Q}{LH^{3/2}}$
WATER SURFACE
TOP SEAL EL. 3000
FLOW
CREST EL. 2980
H_2
H_1
L = 96'
THREE 32' X 20' RADIAL GATES
CREST SECTION
TIBER DAM SPILLWAY
HYDRAULIC MODEL STUDIES
DISCHARGE CAPACITY CURVES
MODEL SCALE 1:48
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
DISCHARGE—THOUSANDS OF C.F.S. (THREE GATES OPERATING)