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BUREAU OF RECLAMATION
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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF THE OVERFLOW SPILLWAY--CEDAR BLUFF DAM MISSOURI RIVER BASIN PROJECT

Hydraulic Laboratory Report No. Hyd-330

ENGINEERING LABORATORIES BRANCH

DESIGN AND CONSTRUCTION DIVISION
DENVER, COLORADO

January 17, 1952

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Laboratory Report No. HYD-330
Hydraulic Laboratory
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J. N. Bradley

Subject: Hydraulic model studies of the overflow spillway--Cedar Bluff Dam--Missouri River Basin Project

SUMMARY

The open chute spillway of Cedar Bluff Dam was investigated with two hydraulic scale models. A scale of 1:48 was used for a composite model, Figure 4, and a scale of 1:24 was used for a model of one of the 5- by 5-foot controlled sluiceways, Figure 23.

The parts of the spillway studied with the composite model were the overflow section, the uncontrolled sluiceway, the controlled sluiceways, and the stilling basin. Three tests were made on the overflow section using three piers, one pier, and no piers. Discharge capacity curves were obtained for the three conditions of flow and are shown in Figure 8 together with curves for the coefficient of discharge. The most satisfactory flow conditions occurred with all piers removed, and this arrangement was recommended for construction.

Five variations of the 14.5- by 8-foot uncontrolled sluiceway were investigated. The preliminary sluiceway, Figure 9A, had subatmospheric pressures on the roof entrance for the higher reservoir elevations and uneven flow at the lower discharges because of disturbances caused by the inclined entrance. The discharge capacity curve, Figure 11, shows a higher discharge than desired. After testing four other arrangements a satisfactory sluiceway was obtained. The recommended sluiceway is shown on Figure 13. There were no piers on the overflow section, and this sluiceway operated with satisfactory pressures for all flow conditions. The capacity was 4,000 second feet at reservoir elevation 2166, Figure 11.

Three stilling basins were tested. The preliminary stilling basin, Figure 17, had a horizontal apron at elevation 2033. Operation was only fair with a rough water surface in the river channel, while scour was moderate. The upstream end of the floor of Basin No. 2 was

raised giving a slope of 16:1 to the apron, but the operation was unsatisfactory. The recommended stilling basin, Figure 20, had the upstream end of the floor raised 5 feet higher than the downstream end. Four tests were made with this basin using combinations of two heights of chute blocks and end sills. The higher chute blocks and lower end sill gave the most satisfactory operation.

A larger model of one 5- by 5-foot controlled sluiceway was investigated on a 1:24 scale. Four roof entrance shapes were studied. Pressures on the preliminary controlled sluiceway were subatmospheric on the roof near the entrance and downstream from the gate when operated partially open, Figure 24. The recommended controlled sluiceway, Figure 26, had satisfactory pressures throughout. The entrance to the air duct was moved from the surface of the overflow section to a training wall where it had free access to the atmosphere.

INTRODUCTION

Cedar Bluff Dam in southwestern Kansas is a unit of the Missouri River Basin Project on the Smoky Hill River near the town of Ellis, Figure 1. The main purpose of the dam is for flood control, but it will also provide for irrigation of 13,000 acres of land. It is a rolled earth-fill structure 12,570 feet long having a maximum base width of 900 feet and a height above streambed of 136 feet, Figure 2. The reservoir formed has a maximum storage capacity of 768,400 acre feet.

The flood control spillway, Figure 3, which is the structure investigated in this report is located near the right abutment. The overflow section is at elevation 2166 and is 150.5 feet wide. The chute leading to the stilling basin, 400 feet downstream, increases in width to 200 feet at the stilling basin. The final spillway shows nine sluiceways through the main overflow section which serve the same purpose as gates on the crest, since they will allow for passage of flow at low heads. In this way the reservoir elevation may be held below the overflow section to allow for storage in the event of a flood. One sluiceway is an uncontrolled 14.5- by 8-foot opening in the center of the spillway, and the remaining eight are 5- by 5-foot sluiceways regulated by slide gates. The final overflow section will pass 84,700 second feet with reservoir elevation 2193 exclusive of the nine sluiceways.

The outlet works, Figure 2, for release of irrigation water consists of a high pressure conduit 66 inches in diameter, provided with a 4- by 5-foot slide gate at the downstream end which discharges into a concrete stilling basin. Model studies of the outlet works were made with a separate model and these are recorded in Laboratory Report No. HYD-245.

INVESTIGATION WITH 1:48 SCALE SPILLWAY MODEL

1:48 Scale Model

The largest model that would fit into the space available in the laboratory was constructed to a 1:48 scale. It was contained in a 12- by 14-foot head box and a 10- by 27-foot tail box connected by a 6- by 7-foot chute box, Figure 4. All boxes were of wood construction, lined on the inside with sheet metal. A portion of the reservoir upstream from the spillway was located in the head box. Topography in the reservoir was formed by plastering concrete mortar on metal lath held to the proper shape by wood supports. The overflow section, on the downstream side of the head box, was connected by a spillway chute to the stilling basin at the upstream end of the tail box. All floor sections of the spillway were made of concrete screeded to metal templates. The training walls were made of wood covered with sheet metal, and the piers, chute blocks, and end sills were made of wood. The river channel in the tail box, downstream from the stilling basin, was molded in sand having a size such that 90 percent was between a No. 8 and a No. 50 sieve.

A 6-inch pipe line from a portable pump supplied water to the model. The pipe emptied into the upstream side of the head box behind a rock baffle, which smoothed out the flow to the reservoir area. An orifice meter in the 6-inch pipe line was used to measure the flow to the model. Point gages in the head box and tail box were used to measure the water-surface elevation of the reservoir and of the tail water.

Studies of Overflow Section

Operation and pressures. The preliminary spillway overflow section is shown in Figure 5. There are two piers plus a wide center U-shaped pier, the latter providing space for a single uncontrolled sluiceway 14.5 feet wide. The net length of crest resulting from this arrangement is 116 feet. At the maximum discharge of 72,000 second feet, Figure 6, an uneven water surface appeared in the spillway chute because of fins formed by the interference of the piers with the flow over the overflow section, and by fins formed at the intersection of the flow from the sluiceway and overflow section. Spreading action of the water in the chute was satisfactory with good transverse distribution of flow occurring at the stilling basin.

Pressures on the overflow section were measured at several discharges. These pressures in feet of water plotted at various reservoir elevations are shown in Figure 7. The lowest pressure of 16 feet of water below atmospheric at Piezometer No. 3, with a reservoir elevation of 2195, was not considered serious.

The two outside piers were removed for the next operation since their only purpose was to provide support for a bridge. The overflow section then consisted of two parts having a total length of 126 feet. Considerable improvement in the rough water surface in the chute resulted from this change. The fins formed at the center pier were still present, and spreading of the flow in the chute was as satisfactory as in the original design.

The U-shape center pier was removed and a portion of the sluiceway exit was covered, Figure 6B, giving a continuous overflow section 150.5 feet in length. Operation with overflow section and sluiceway discharging was improved over the two previous tests. The water surface in the chute was not as rough, but two fins were present due to interference of the water flowing through the sluiceway with that falling over the overflow section. These fins are shown in Figure 6B with the spillway discharging 30,000 second feet. Removal of the piers had no measurable effect on the pressures on the spillway crest.

<u>Calibration</u>. Discharge capacity curves were obtained for the overflow section for each of the three lengths produced by successive removal of the piers. The uncontrolled sluiceway was blocked for these calibrations. The three rating curves obtained are shown in Figure 8 together with curves for the coefficient of discharge, C. With all piers in place, giving a net length of overflow section of 116 feet, a discharge coefficient of 4.25 was obtained at reservoir elevation 2193. The coefficient of discharge C is given by the expression $C = \frac{Q}{L\,H^{3/2}}$, where L is the minimum net length between piers and H is the total head on the crest, including velocity head of approach. With the two outside piers removed, the coefficient of discharge dropped to 4.10 and with all piers removed it became 4.03. Because of contraction and friction losses, a pier placed on an overflow section will usually cause a reduction in the coefficient of discharge; but in the present case, the coefficient of discharge showed an increase because the upstream pier noses were extremely short (distance measured from nose to crest of spillway). This same phenomenon has been experienced in the past where short nose piers were involved. Also, the first two coefficients are somewhat excessive because in computing C the minimum distance between piers was used as L

rather than the actual length at the crest (consult Figure 5). The tapering piers cause the flow to contract as it passes over the crest; thus the length of crest, as used in the usual sense, is more or less intangible in this case. The coefficient of discharge of 4.10 is correct for the free crest as a negative pressure of 16 feet of water was experienced on the face for the maximum discharge condition.

Uncontrolled Sluiceway Studies

Sluiceway No. 1--Preliminary. The preliminary sluiceway, Figure 9A, was designed to discharge 4,000 second feet at reservoir elevation 2166. The width was 14.5 feet and the invert control was at elevation 2144. A photograph of flow in the chute looking upstream for a discharge of 2,700 second feet is shown in Figure 10A. Spreading of the water in the chute was satisfactory, but a high center fin occurred in the downstream portion of the sluiceway because of entrance conditions. The feature which caused this disturbance was the 45° inclination of the bellmouth entrance.

Pressures were measured along the centerline of the invert and on the roof adjacent to the left wall, and the results are plotted in Figure 9A for four reservoir elevations. Invert pressures were greater than atmospheric for all discharges. With the reservoir elevation high enough to cause the sluiceway to run full, the roof pressures were below atmospheric and became lower with an increase in reservoir elevation. The model shows that pressures in the prototype would reach the vapor pressure of water.

A discharge capacity curve was obtained for the preliminary sluiceway, Figure 11. The discharge of 5,300 second feet at reservoir elevation 2166 was 1,300 second feet more than desired. This excess discharge was believed to result from the low pressures on the roof of the sluiceway.

Sluiceway No. 2. To give higher pressures along the roof and decrease the discharge, the length of the roof entrance was increased by the extension shown in Figure 9B. Pressures measured on the floor and roof showed little change from those of the preliminary sluiceway. A decrease in pressure occurred near the invert control, Figure 9B. Conditions of flow in the sluiceway such as the center fin were similar to those of the preceding test.

The center U-shape pier was removed and the main overflow section and sluiceway were operated together. For a total discharge of 72,000 second feet, Figure 10B, a pulsation occurred which indicated a cyclic variation in the quantity of water flowing through the sluiceway. Water from the overflow section sealed the downstream end of the sluiceway. The pulsation could be stopped by ventilating the downstream end. Therefore, the pressure in this region was definitely associated with the oscillating discharge through the sluiceway. Without ventilation the pressure in the downstream end decreased below atmospheric, causing an increase in the sluiceway discharge. The increased discharge then tended to create a back pressure which, in turn, decreased the flow through the sluiceway. This cycle was repeated over and over and was responsible for the pulsating effect.

Sluiceway No. 3. To eliminate the oscillating flow, the overflow section in the vicinity of the sluiceway was filled in as shown on Figure 12A. This left an opening 7.20 feet high at the downstream end. The sluiceway invert control remained at elevation 2144 as in the preliminary. There were no piers, so the overflow section discharge could interfere with the discharge from the sluiceway. At all discharges satisfactory conditions of flow occurred at the portal without pulsation. The restriction at the downstream end caused an increase in the pressure throughout the sluiceway with the lowest pressure amounting to atmospheric at Piezometer No. 7 with reservoir elevation 2167.01, Figure 12A. Increasing the reservoir elevation above this amount gave higher pressures in the sluiceway since the overflow discharge increased the back pressure at the downstream portal.

This arrangement was, in general, satisfactory except at low reservoir elevations when open-channel flow occurred in the sluiceway. Under these conditions, as in the preliminary, the water surface was uneven with a high center fin.

Sluiceway No. 4. The entrance was modified by moving the invert control downstream, Figure 12B. This was to eliminate the disturbance caused by the inclined bellmouth entrance. The downstream end was increased in height from 7.20 to 8 feet, and the roof section was modified to conform to the floor shape. The model was operated and smooth open-channel flow resulted. Roof pressures were acceptable, but the shape of the invert control proved to be deficient in cross section, resulting in a pressure of 13 feet of water below atmospheric at Piezometer No. 9 with reservoir elevation 2165.86, Figure 12B.

Sluiceway No. 5--Recommended. To increase the pressures, the invert control was increased in section as shown in Figure 13. The roof section was changed to a straight line, while the exit height remained at 8 feet.

Five roof entrance shapes were investigated with Sluiceway No. 5. Roof Entrance A, Figure 13A, had the roof continued in a straight line intersecting the 1:1 overflow section slope at elevation 2158. Satisfactory pressures were obtained throughout the sluiceway except for a pressure of 2 feet of water below atmospheric at Piezometer No. 6 with reservoir elevation 2166.27.

For Entrance B, a 1-foot radius was used to connect the roof and 1:1 slope, Figure 13B. Instead of increasing the pressure at Piezometer No. 6, it decreased it to 3 feet of water below atmospheric with reservoir elevation 2166.03.

For Entrance C, the 1:1 slope on the upstream face of the crest was replaced with a vertical wall, Figure 13C. Results were unsatisfactory as a pressure of 5.5 feet of water below atmospheric occurred at Piezometer No. 7 with reservoir elevation 2166.20.

A radius of 10.5 feet was employed for Entrance D as shown in Figure 13D. Pressures were higher than those for Roof Entrances A, B, and C, but at Piezometer No. 9 the pressure was 1.5 feet of water below atmospheric with reservoir elevation 2166.03.

An elliptical shape was next used for the roof entrance, Figure 13, which proved to be the recommended entrance. Pressures throughout the sluiceway were above atmospheric for all reservoir elevations. A discharge capacity curve was obtained for the recommended sluiceway, Figure 11. This sluiceway gave the required flow of 4,000 second feet with reservoir elevation 2166. Figure 14A shows the flow in the chute downstream from the sluiceway with a total discharge of 84,700 second feet. Fins originating at the portal were the only disturbances noticeable. Flow from the portal was also satisfactory when open-channel flow existed in the sluiceway, Figure 14B.

Water-surface profiles were taken in the spillway chute with the sluiceway operating at reservoir elevation 2166, Figure 15. Also shown in this figure are water-surface profiles with reservoir elevation 2193 giving a total discharge of 88,500 second feet. Distribution of flow at the downstream end of the chute was satisfactory for all flow conditions. At no time did the water overtop the training walls of the chute.

A discharge capacity curve was obtained with both the uncontrolled sluiceway and spillway operating, Figure 16. This curve is essentially Curve C of Figure 8 with the addition of the discharge through the sluiceway.

Stilling Basin Studies

Stilling Basin No. 1--Preliminary. The preliminary basin had a horizontal floor at elevation 2033, Figure 17. Chute blocks and dentated end sill were used as well as fillets at the sides of the basin. The performance is shown in Figure 18A at the maximum discharge of 84,700 second feet and tail-water elevation 2074.50. Flow was uniform across the width of the basin and the jump action was satisfactory. Flow in the river channel was turbulent with waves 3 feet high. Erosion in the channel after 1-hour operation at maximum discharge is shown in Figure 18B. Scour was moderate with a hole downstream from each training wall 9 feet below the floor of the stilling basin.

Stilling Basin No. 2. The fillets at the sides of the stilling basin were removed and the upstream end of the floor was raised, giving a slope to the floor of 16:1, Figure 17. The chute blocks were moved upstream 24.6 feet to the new intersection of the chute and floor while the end sill remained unchanged. Operation at the maximum discharge of 84,700 second feet was unsatisfactory, Figure 19, since the jump formed 50 feet downstream from the chute blocks and extended into the river channel. The end sill was all that prevented the jump from sweeping out of the basin. Because of the poor operation, a scour test was not run on this design.

Stilling Basin No. 3--Recommended. The upstream end of the basin floor was lowered to elevation 2038 making it 5 feet higher than the downstream end. This gave a slope of 24.3:1 for the floor, Figure 20. The same chute blocks (5 feet high) and end sill (12 feet high) were used for this basin as in the preceding two tests. At maximum flow of 84,700 second feet the jump formed about 40 feet downstream from the toe of the chute as shown in Figure 21A. There was a high boil over the end sill and a wave 3 feet high existed in the river channel. Scour, after 1-hour operation at maximum discharge and tail-water elevation 2074.5, was moderate with erosion down to elevation 2030 at each side of the stilling basin, Figure 21B. Three other tests were made using different combinations of chute blocks and end sill in an attempt to improve the stilling pool operation.

To reduce the high boil over the end sill, the height of the sill was lowered from 12 to 9 feet. Operation at maximum discharge, Figure 21C, showed a lower boil with 2.5-foot waves in the river channel. The scour pattern, Figure 21D, was similar to that obtained with the 12-foot end sill except the erosion at the right side of the stilling basin extended down to elevation 2024 instead of 2030.

The original 12-foot end sill was again installed, and the height of the chute blocks was increased from 5 to 7 feet for the third test. Operation at maximum discharge, Figure 22A, showed that the jump started at the toe of the chute. The boil over the end sill was higher than the previous test with the 9-foot end sill. Scour, Figure 22B, was more severe than for the previous two tests with erosion down to elevation 2023 at the left side of the basin.

In the fourth test the 7-foot chute blocks were retained and the 9-foot end sill installed. Operation at maximum discharge, Figure 22C, showed that the jump started at the chute blocks with a moderate boil over the end sill. Waves were 2 feet high in the river channel. Erosion, Figure 22D, was moderate with the maximum scour extending down to elevation 2030 at the end of each training wall. From the results of these tests, the basin with 7-foot chute blocks and 9-foot end sill was selected as the recommended arrangement.

INVESTIGATION WITH 5- BY 5-FOOT SLUICEWAY

1:24 Scale Model

After completion of the 1:48 scale model studies it was decided to install eight 5- by 5-foot gate-controlled sluiceways through the overflow section. A model built to a scale of 1:24 was used for investigating these sluiceways, Figure 23. A 3- by 3-foot head box representing a section of the reservoir was constructed of wood and lined with sheet metal. Water was supplied to the head box by a 6-inch pipe, and flow was quieted by a rock baffle in the head box. An orifice meter in the 6-inch supply pipe was used to measure the water supplied by a portable pump. The model consisted of a portion of the main overflow section including one 5- by 5-foot sluiceway and gate built of plastic. Wood, lined with sheet metal, was used for the crest and training walls.

5- By 5-foot Sluiceway Studies

Controlled Sluiceway No. 1--Preliminary. The sluiceways are 5-foot-square conduits with invert slope = 0.01 and the invert entrance at elevation 2134.82. Control of the flow is provided by slide gates about 40 feet downstream from the bellmouth entrances. The preliminary sluiceway was provided air, on the downstream side of the gate, by an air duct leading from the downstream face of the overflow section. Piezometers were installed along the length of the sluiceway roof and in the floor downstream from the gate, Figure 24. Three piezometers were also installed along the left side of the curved entrance.

The model was operated throughout the range of reservoir elevations with the slide gate 1/3, 2/3, and fully open, while pressures were recorded on all piezometers. With the gate fully open all pressures were above atmospheric except for a small area of the roof entrance. The lowest pressure obtained was 3.5 feet of water below atmospheric at Piezometer No. 3 with reservoir elevation 2167, Figure 24. At partial gate openings, for all reservoir elevations, the pressures in the sluiceway upstream from the gate were above atmospheric. Pressures below atmospheric, however, occurred downstream from the gate, when the reservoir elevation was high enough to allow flow over the overflow section, due to sealing of the air-vent entrance. The minimum pressure was 13 feet of water below atmospheric at Piezometer No. 8 with the gate two-thirds open and reservoir elevation 2174.2, Figure 24.

Controlled Sluiceway No. 2. The air-duct entrance was moved from the overflow face to a training wall where it had free access to the atmosphere, so that the subatmospheric pressures could be relieved in the sluiceway downstream from the gate. The only portion of the sluiceway having low pressures because of the shape was the roof entrance. The remaining tests were made on three different roof-entrance curves. An elliptical roof-entrance curve was used for Sluiceway No. 2 as in the preliminary, but the new curve increased the height of entrance. The lowest pressure obtained trying various operating conditions was 4 feet of water below atmospheric at Piezometer No. 3 with reservoir elevation 2165.1, Figure 25.

Controlled Sluiceway No. 3. The variation of the pressures on the two roof entrances indicated a flatter ellipse would give higher pressures, so a flat ellipse was used starting with a 1/2-foot radius, Figure 25. Operation showed that pressures at Piezometers No. 3 and 4 were above atmospheric, but with reservoir elevation 2165.4, a pressure of 4 feet of water below atmospheric occurred at Piezometer No. 1, Figure 25. Considerable variation in pressures occurred along the length of the curve as with the two previous tests. A direct method was used to determine the roof-entrance shape by removing the roof and measuring the water surface profile with reservoir elevation at 2166.

Controlled Sluiceway No. 4--Recommended. An 8-foot radius was used for the roof entrance since this conformed very nearly to the measured water surface, Figure 25. Pressures were observed for various reservoir elevations and gate openings throughout the sluiceway. Entrance pressures were above atmospheric except for a pressure of 0.7 foot of water below atmospheric at Piezometer No. 5 with reservoir elevation 2147.4, Figure 25. The remainder of the sluiceway pressures were above atmospheric for all reservoir elevations and gate openings, Figure 26. The air duct supplied air to the sluiceway when the gate was partially open and when the downstream end of the sluiceway was sealed by flow from the overflow section. Flow through the sluiceway only with the slide gate one-third open is shown in Figure 27A. Flow with the gate one-third open together with discharge over the overflow section is shown in Figure 27B. In the second case, back pressure causes the tunnel to flow full. Similar operating conditions are shown in Figures 28A and 28B with the gate two-thirds open. With flow over the spillway, Photograph B, air is drawn into the water by lowering of the pressure on the downstream side of the gate.

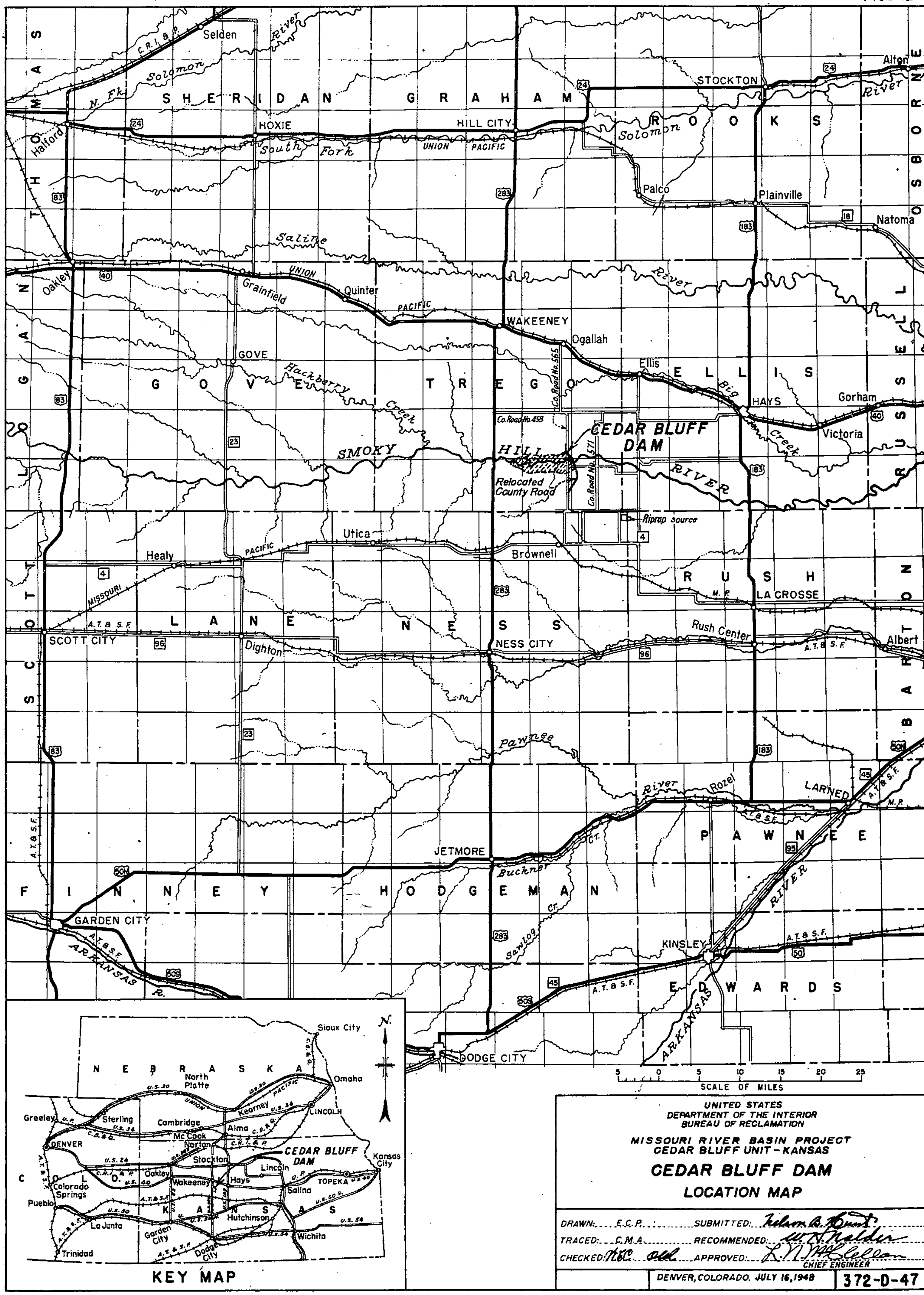
The photographs on Figures 27 and 28 show the air pipe leading to the sluiceway with a 1/4-inch orifice fitted to the top of the pipe. The pressure drop across the orifice was measured by the gage shown connected to the air pipe by a rubber tube. This gage was developed in the laboratory to measure small pressure differentials. It consists of a float within a cylinder, Figure 29. A change in pressure differential of H feet of water between the outside and inside of the float causes a float movement of MH. M is the multiplication in movement and is equal to the ratio of Area C to Area D. The model indicated that the maximum air required by the prototype sluiceway will be 216 cubic feet of air per minute with reservoir elevation 2174.3 and the gate two-thirds open. As the air duct in the model was exceptionally small, the air flow in the prototype is expected to exceed the above value.

A discharge capacity curve was obtained for the 5- by 5-foot sluiceway for gate openings of 1/3, 2/3, and fully open, Figure 30. In making the calibration the condition of flow over the main crest for reservoir elevations above 2166 was duplicated in the 1:24 scale model. This caused back pressure on the sluiceway portal and is reflected in a decrease in sluiceway discharge at higher reservoir elevations as shown by the rating curves.

1:48 Scale Model

5- by 5-foot sluiceway studies. The eight 5- by 5-foot sluiceways were installed in the 1:48 spillway model to observe the flow in the chute with these controlled sluiceways and the center uncontrolled sluiceway operating. At reservoir elevation 2166, with all sluiceways operating, Figures 31A and 31B, flow was satisfactory with good distribution down the spillway chute. Satisfactory operation also occurred with the main overflow section discharging together with the sluiceways.

FIGURE I



SHERIDAN
GRAHAM
ROOKS
THOMAS
OSBORNE
LOGAN
GOVE
TREGO
ELLIS
RUSSELL
SCOTT
LANE
NESS
RUSH
BARTON
FINNEY
HODGEMAN
PAWNEE
EDWARDS
Selden
STOCKTON
Alton
HOXIE
HILL CITY
Halford
Palco
Plainville
Natoma
Oakley
Grainfield
Quinter
WAKEENEY
Ogallah
GOVE
Ellis
HAYS
Gorham
Victoria
CEDAR BLUFF DAM
Co. Road No. 565
Co. Road No. 458
Co. Road No. 571
Relocated County Road
Riprap source
Utica
Healy
Brownell
LA CROSSE
SCOTT CITY
Dighton
NESS CITY
Rush Center
Albert
Rozel
LARNED
JETMORE
GARDEN CITY
KINSLEY
DODGE CITY
N. Fk. Solomon River
Solomon River
South Fork
Saline River
Hackberry Creek
Big Creek
SMOKY HILL RIVER
Pawnee River
Buckner Cr.
Sawlog Cr.
ARKANSAS R.
ARKANSAS RIVER
C.R.I. & P.
UNION PACIFIC
MISSOURI PACIFIC
A.T. & S.F.
M.P.
SCALE OF MILES
5 0 5 10 15 20 25
KEY MAP
NEBRASKA
KANSAS
COLORADO
Sioux City
Omaha
North Platte
Kearney
LINCOLN
Greeley
Sterling
Cambridge
Alma
Mc Cook
Norton
DENVER
Stockton
Oakley
CEDAR BLUFF DAM
Lincoln
Kansas City
Colorado Springs
Wakeeney
Hays
TOPEKA
Salina
Pueblo
La Junta
Garden City
Hutchinson
Dodge City
Wichita
Trinidad
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
CEDAR BLUFF UNIT - KANSAS
CEDAR BLUFF DAM
LOCATION MAP
DRAWN: E.C.P.
SUBMITTED:
TRACED: C.M.A.
RECOMMENDED:
CHECKED:
APPROVED:
CHIEF ENGINEER
DENVER, COLORADO. JULY 16, 1948
372-D-47

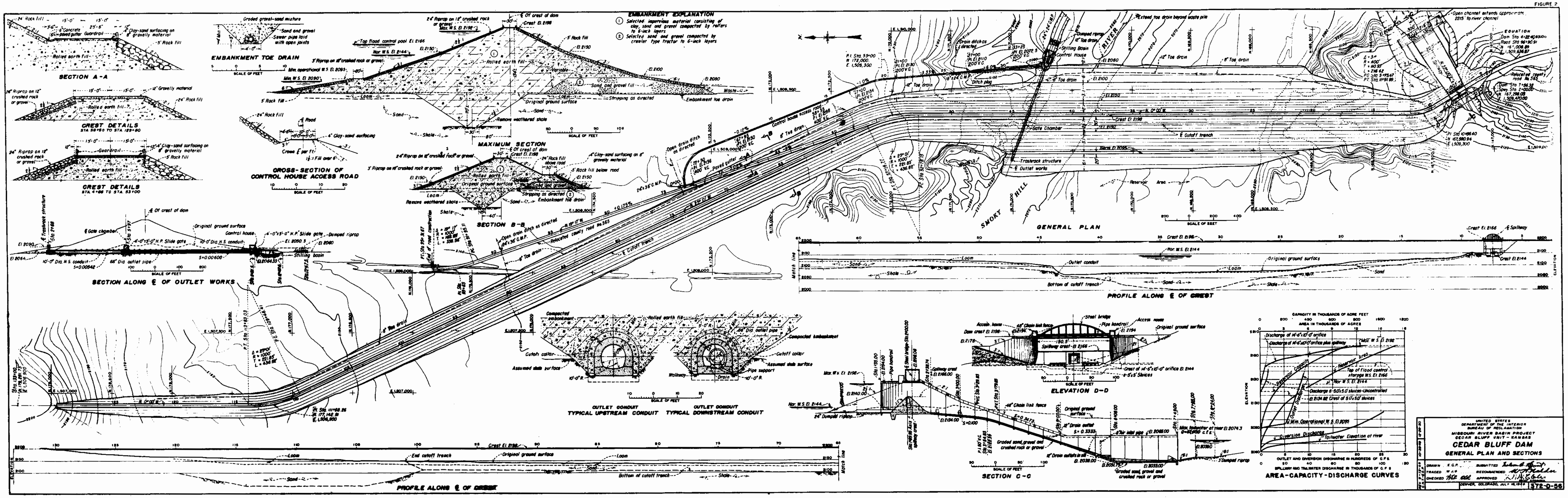


FIGURE 7
EMBANKMENT EXPLANATION
① Selected impervious material consisting of clay, sand and gravel compacted by rollers to 6-inch layers
② Selected sand and gravel compacted by crawler type tractor to 6-inch layers
SECTION A-A
CREST DETAILS
CREST DETAILS
EMBANKMENT TOE DRAIN
CROSS-SECTION OF CONTROL HOUSE ACCESS ROAD
MAXIMUM SECTION
SECTION B-B
SECTION ALONG ℄ OF OUTLET WORKS
GENERAL PLAN
SMOKY HILL RIVER
PROFILE ALONG ℄ OF CREST
OUTLET CONDUIT TYPICAL UPSTREAM CONDUIT
OUTLET CONDUIT TYPICAL DOWNSTREAM CONDUIT
ELEVATION D-D
SECTION C-C
AREA-CAPACITY-DISCHARGE CURVES
PROFILE ALONG ℄ OF CREST
UNITED STATES
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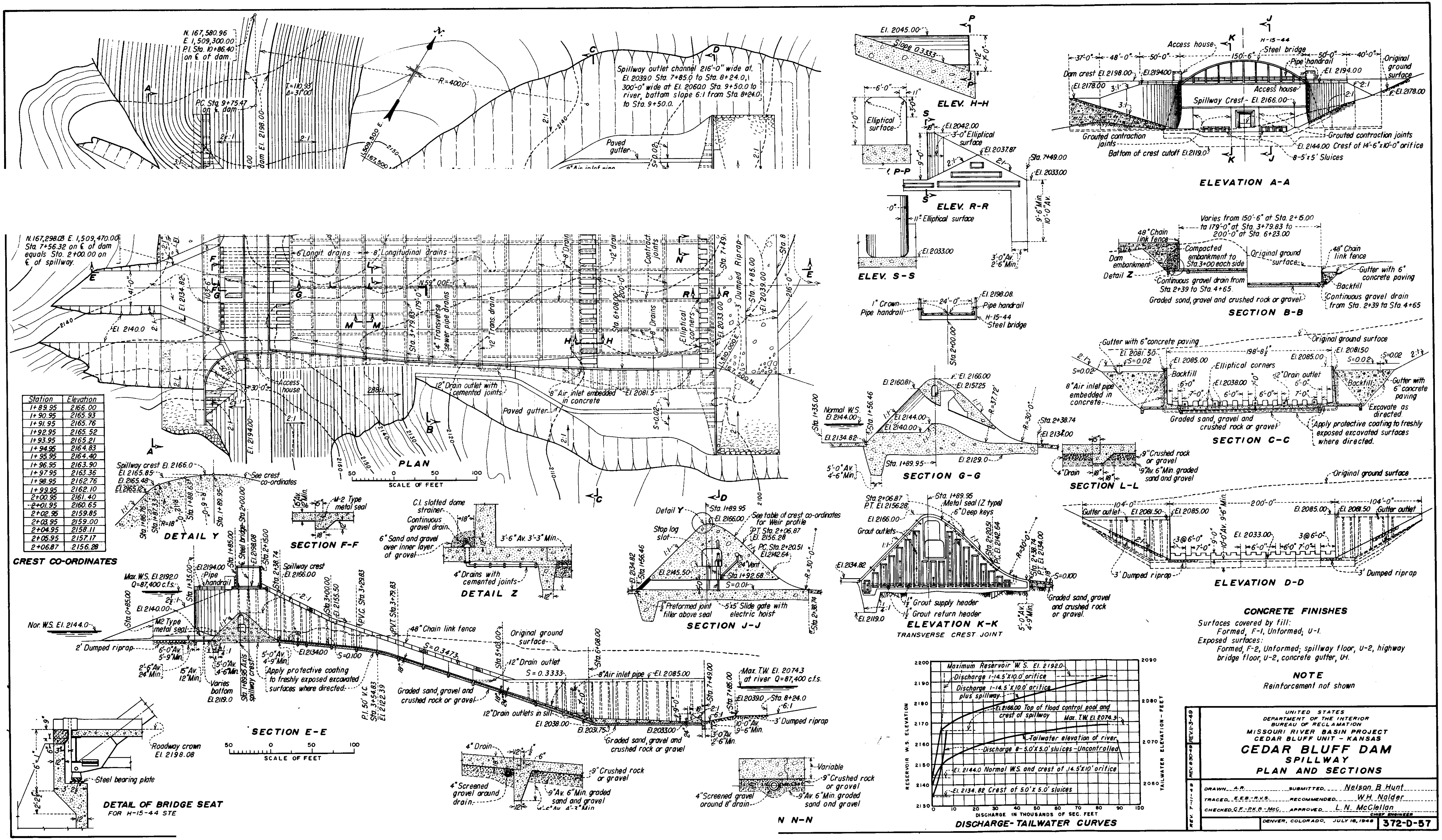
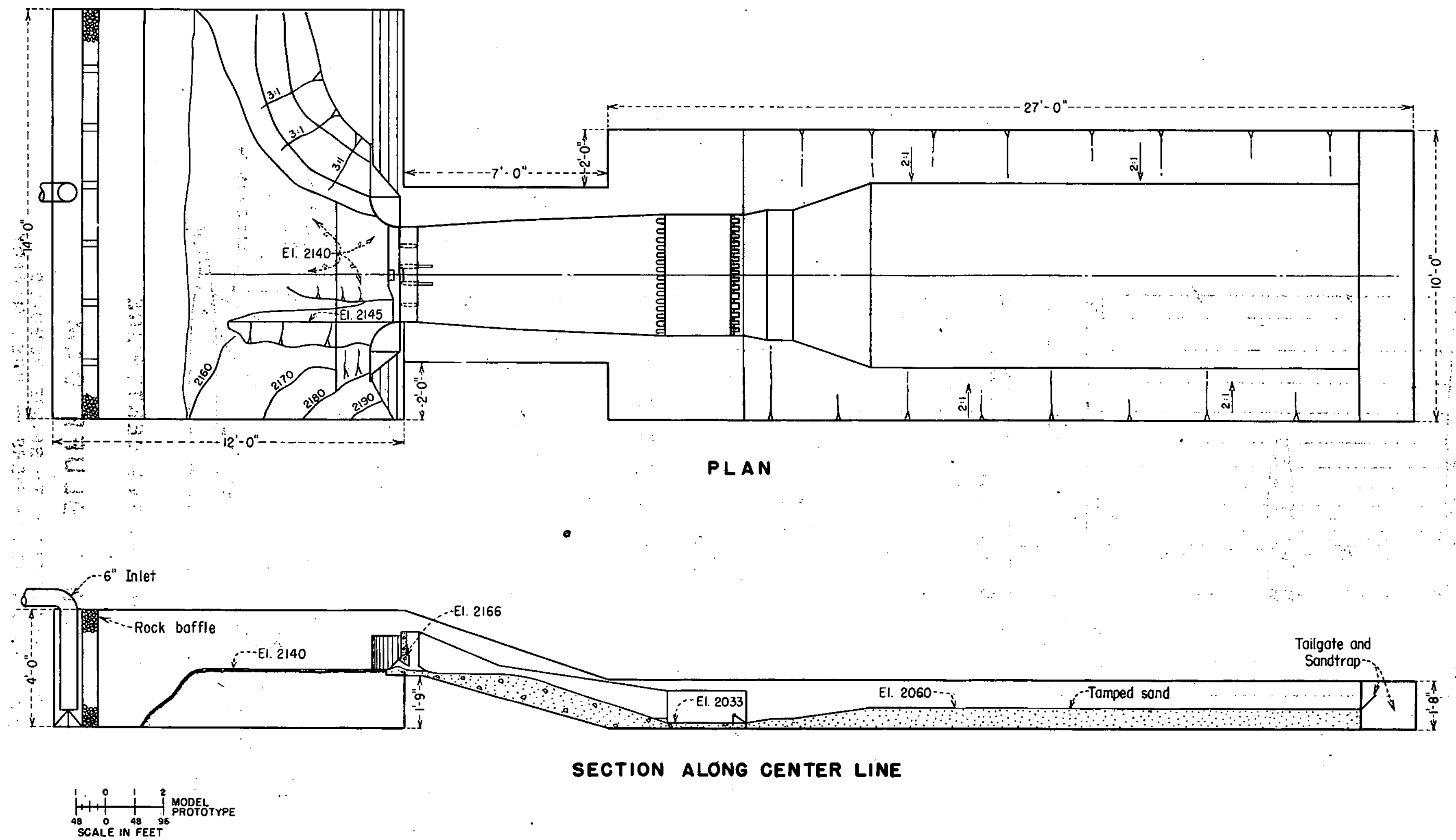
MISSOURI RIVER BASIN PROJECT
CEDAR BLUFF UNIT - KANSAS
CEDAR BLUFF DAM
GENERAL PLAN AND SECTIONS
DRAWN E.G.P.
TRACED W.J.S.
CHECKED
SUBMITTED
RECOMMENDED
APPROVED
DENVER, COLORADO, JULY 18, 1949
372-D-56

FIGURE 3



CREST CO-ORDINATES

Station	Elevation
1+89.95	2166.00
1+90.95	2165.93
1+91.95	2165.76
1+92.95	2165.52
1+93.95	2165.21
1+94.95	2164.83
1+95.95	2164.40
1+96.95	2163.90
1+97.95	2163.36
1+98.95	2162.76
1+99.95	2162.10
2+00.95	2161.40
2+01.95	2160.65
2+02.95	2159.85
2+03.95	2159.00
2+04.95	2158.11
2+05.95	2157.17
2+06.87	2156.28

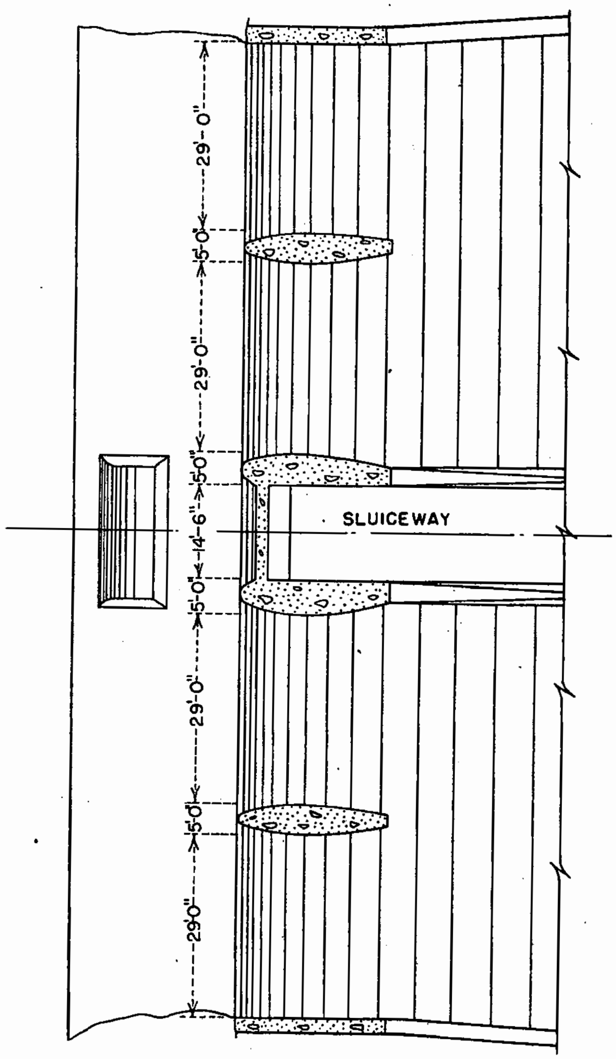


CEDAR BLUFF DAM

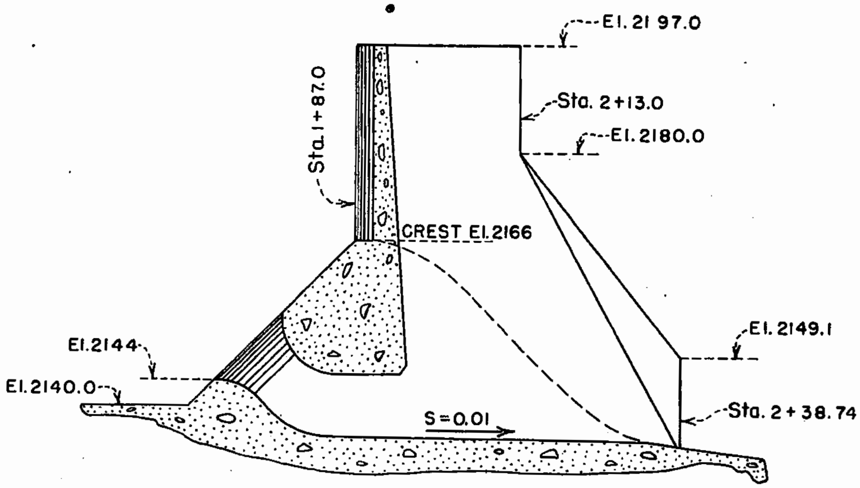
MODEL LAYOUT

1:48 SCALE MODEL

FIGURE 4



PLAN



SECTION ALONG CENTERLINE

CEDAR BLUFF DAM

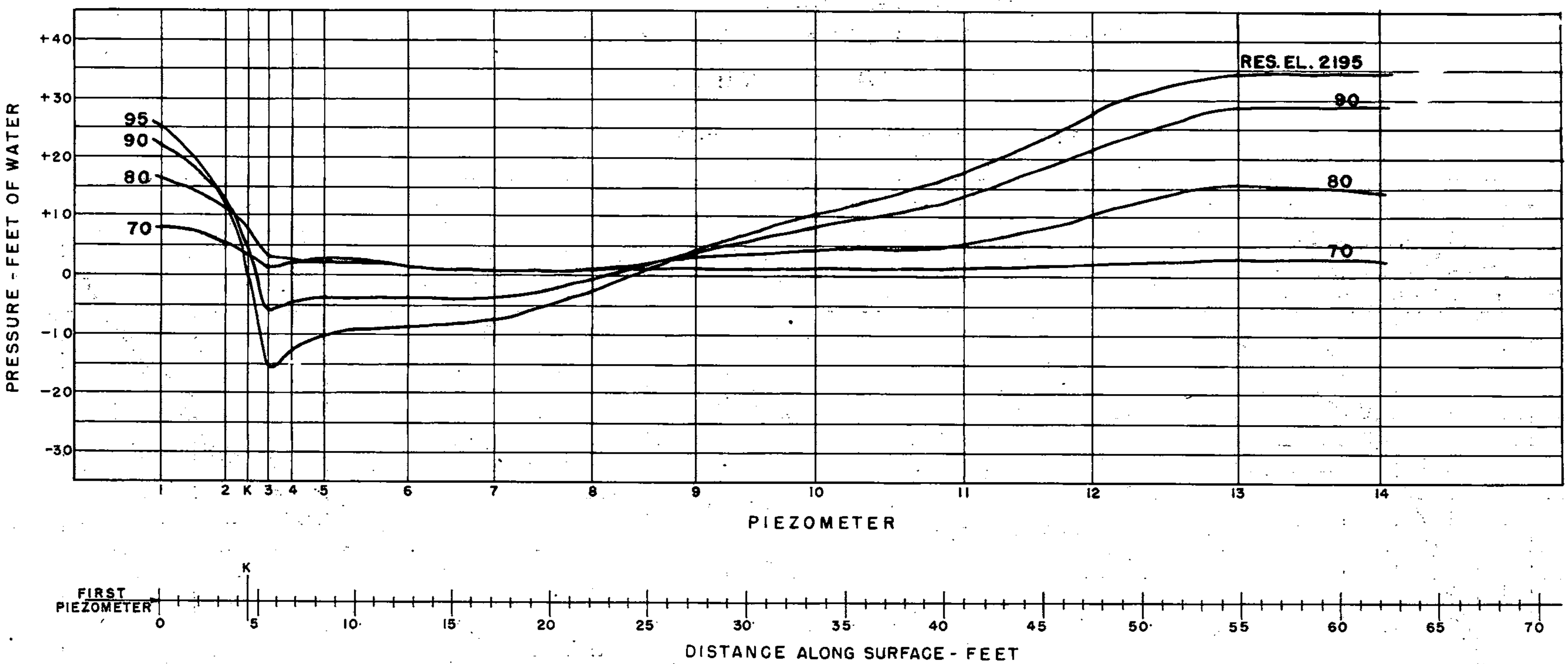
SPILLWAY CREST WITH BRIDGE REMOVED
SHOWING LOCATION OF PIERS — PRELIMINARY

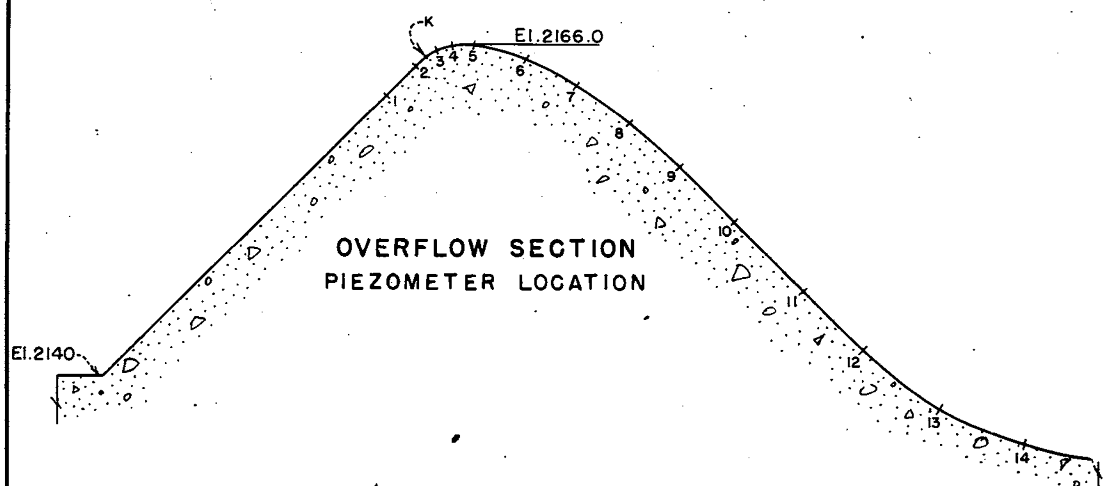
FIGURE 6

A. Piers in place, 116 feet crest length
Discharge 72,000 second-feet

B. Piers removed, 150.5 feet crest length
Discharge 30,000 second-feet

Preliminary Overflow Section
CEDAR BLUFF DAM
1:48 Scale Model Study





CEDAR BLUFF DAM
PRESSURES ON OVERFLOW SECTION
1:48 SCALE MODEL STUDY

FIGURE 7

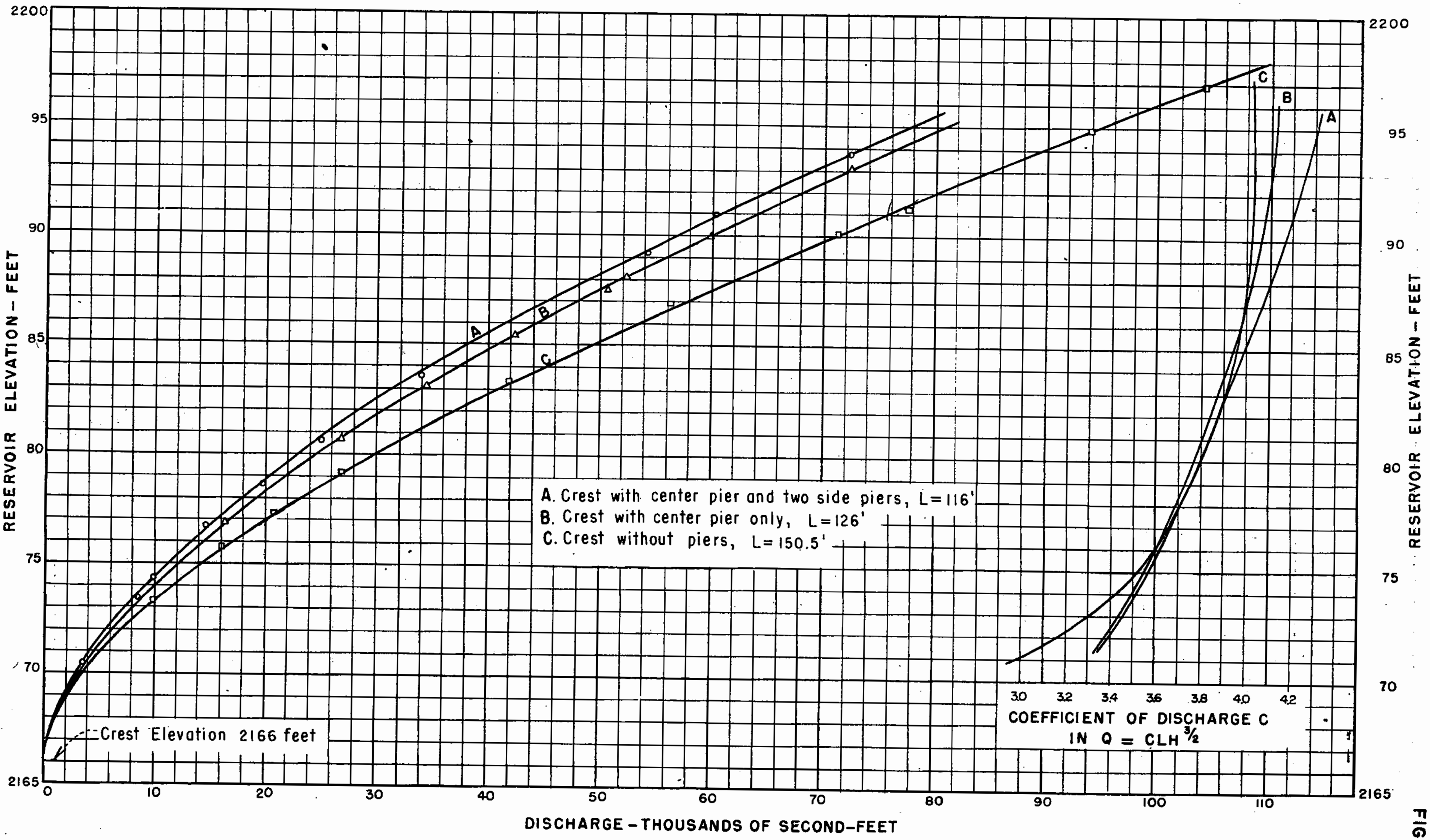
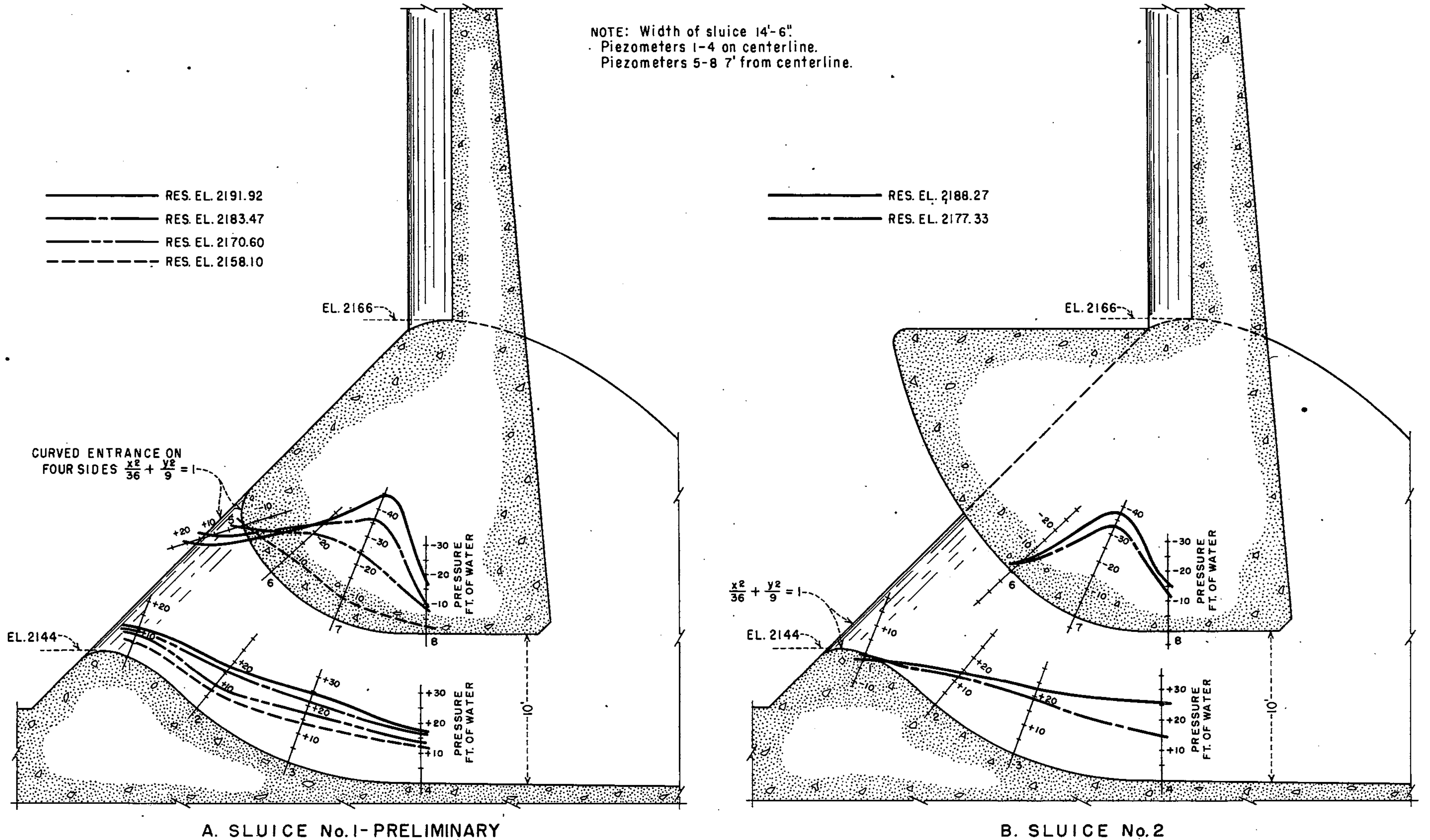


FIGURE 8

CEDAR BLUFF DAM

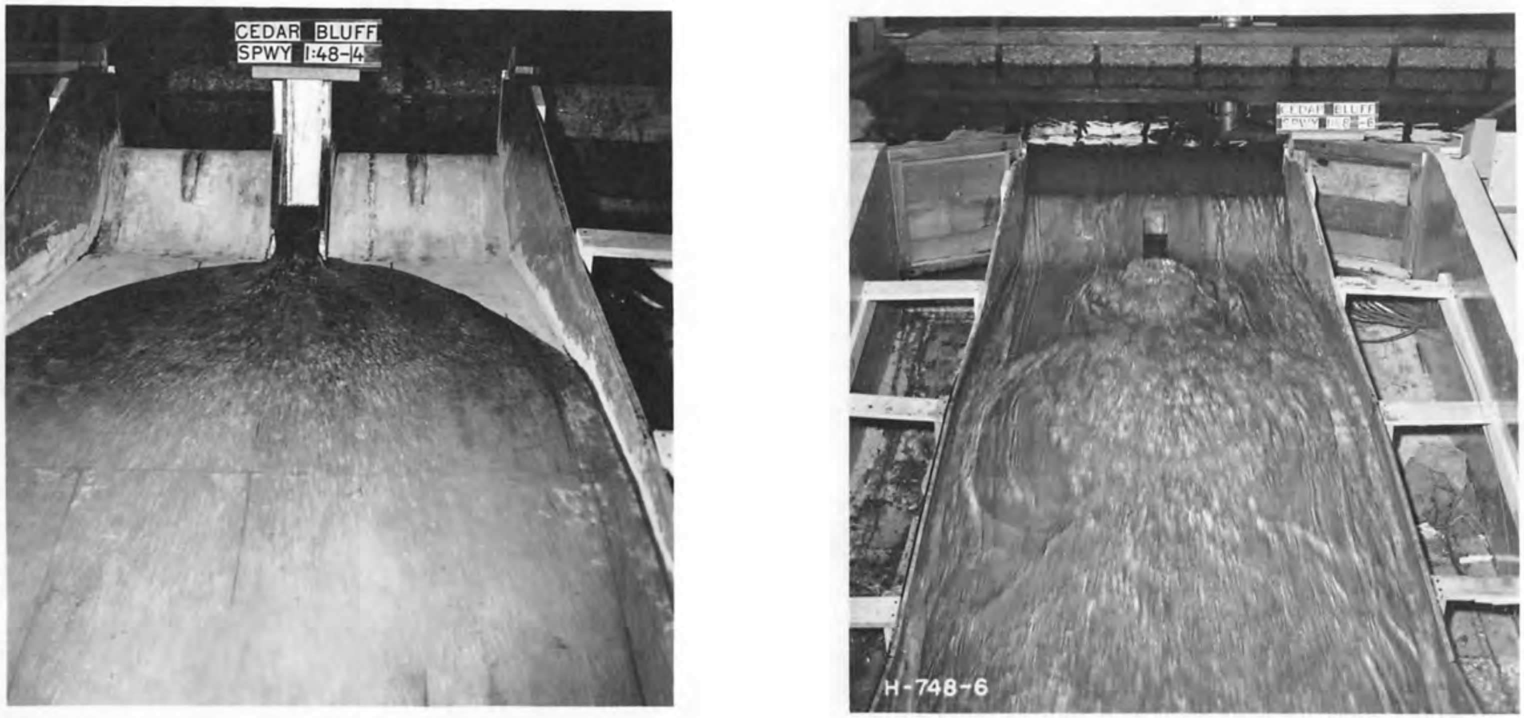
SPILLWAY DISCHARGE CAPACITY CURVES

WITH SLUICEWAYS CLOSED



CEDAR BLUFF DAM
PRESSURES IN SLUICEWAY
1:48 SCALE MODEL STUDY

FIGURE 9

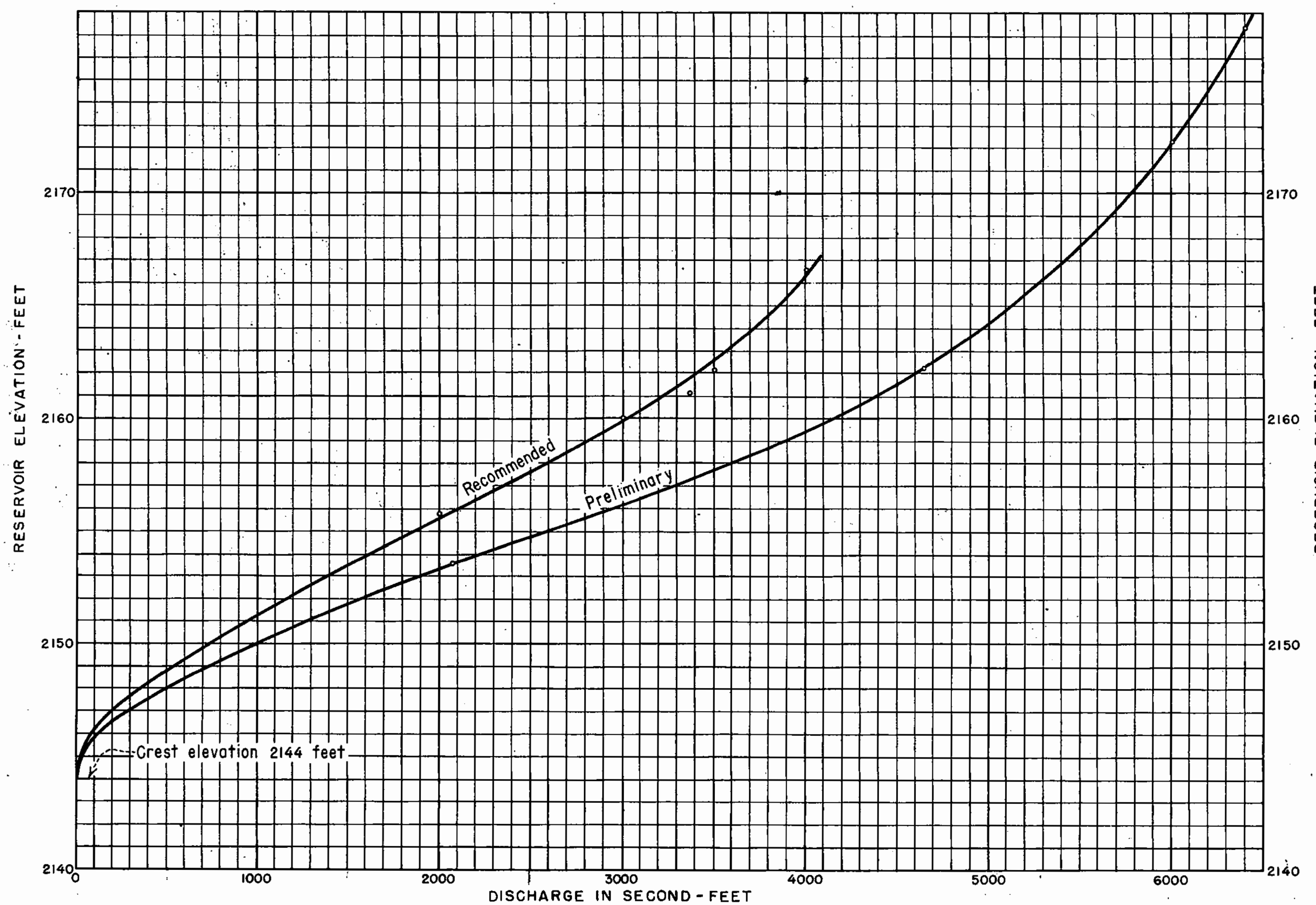


A. Piers in place--Discharge 2,700 second-feet

B. Piers removed--Discharge 72,000 second-feet

Preliminary Uncontrolled Sluiceway
CEDAR BLUFF DAM
1:48 Scale Model Study

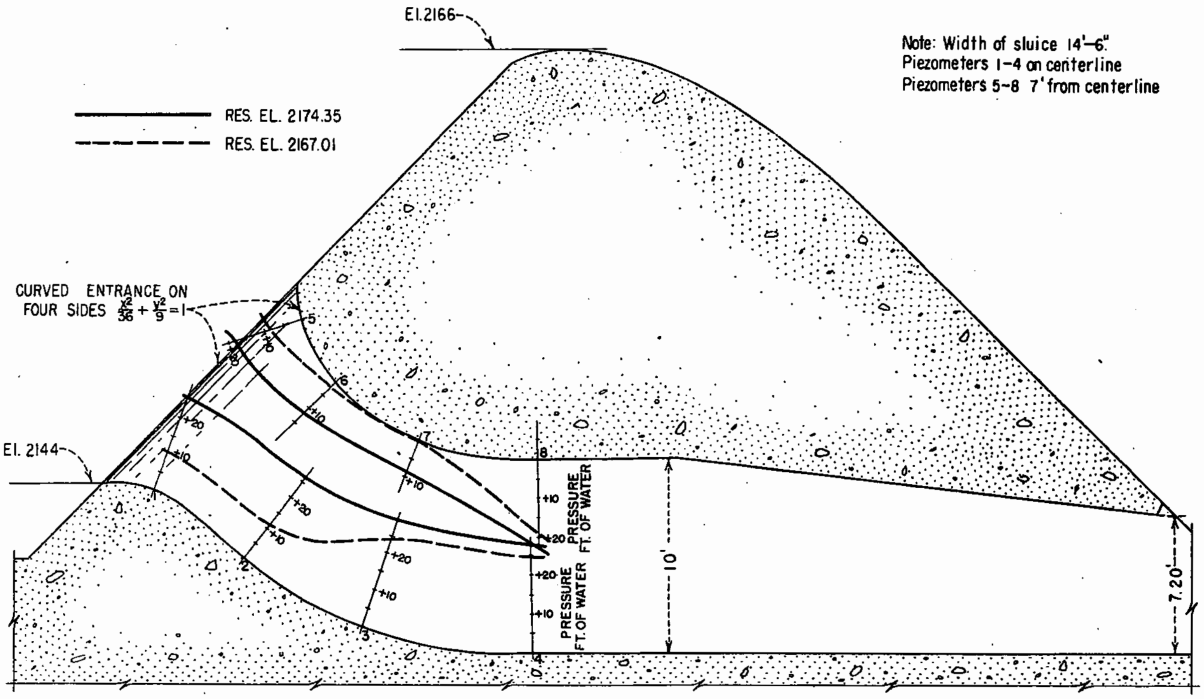
FIGURE 10



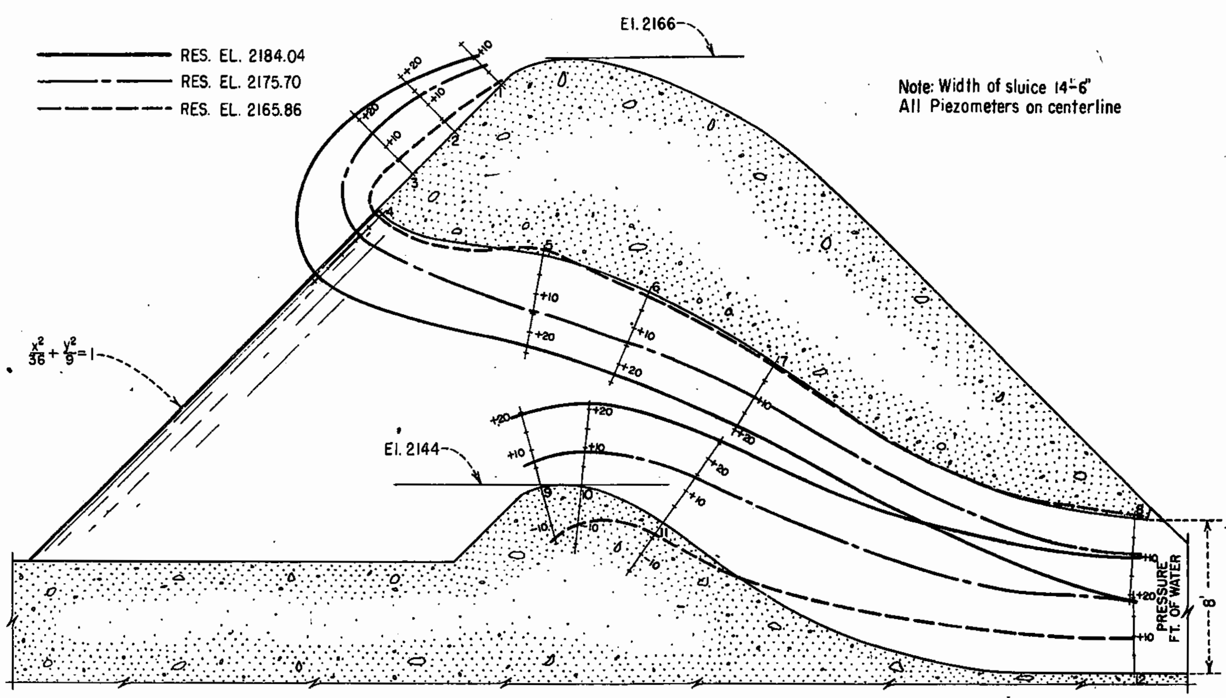
CEDAR BLUFF DAM

SLUICEWAY DISCHARGE CAPACITY

FIGURE 11



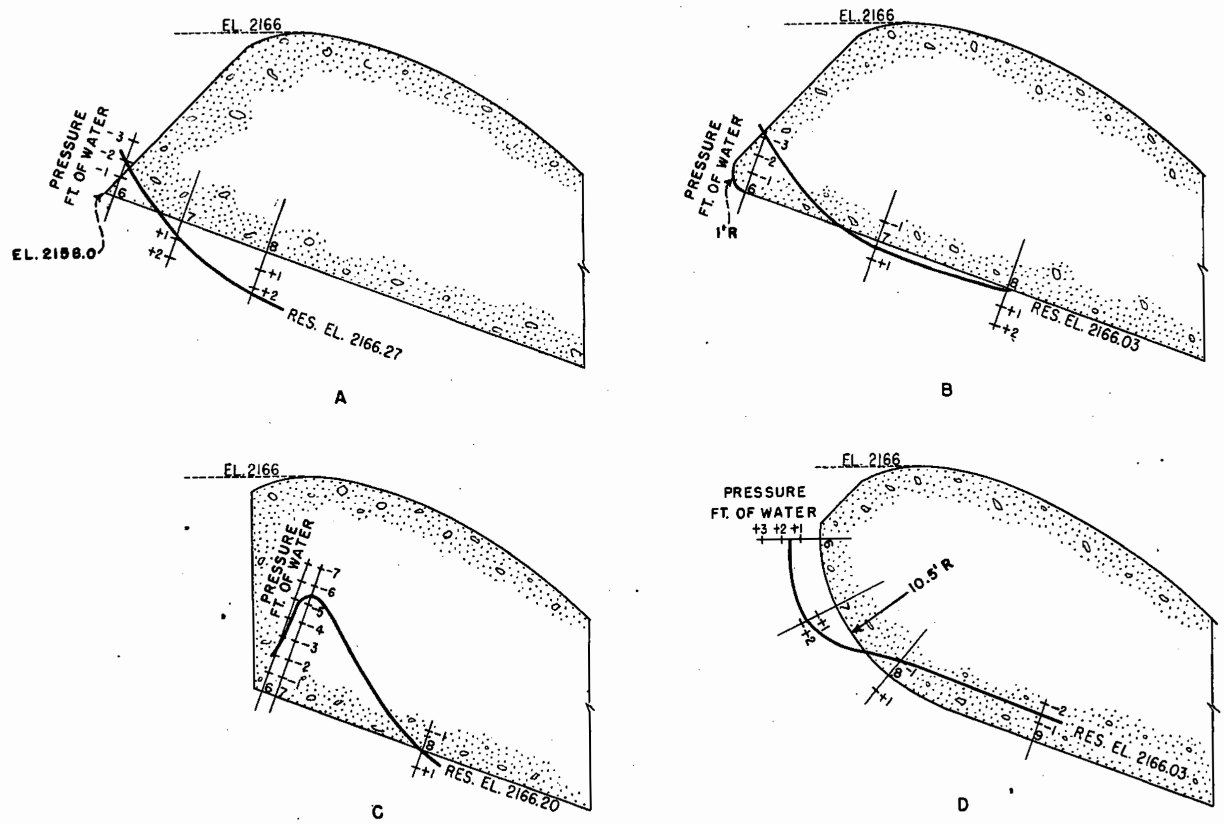
A. SLUICE No. 3



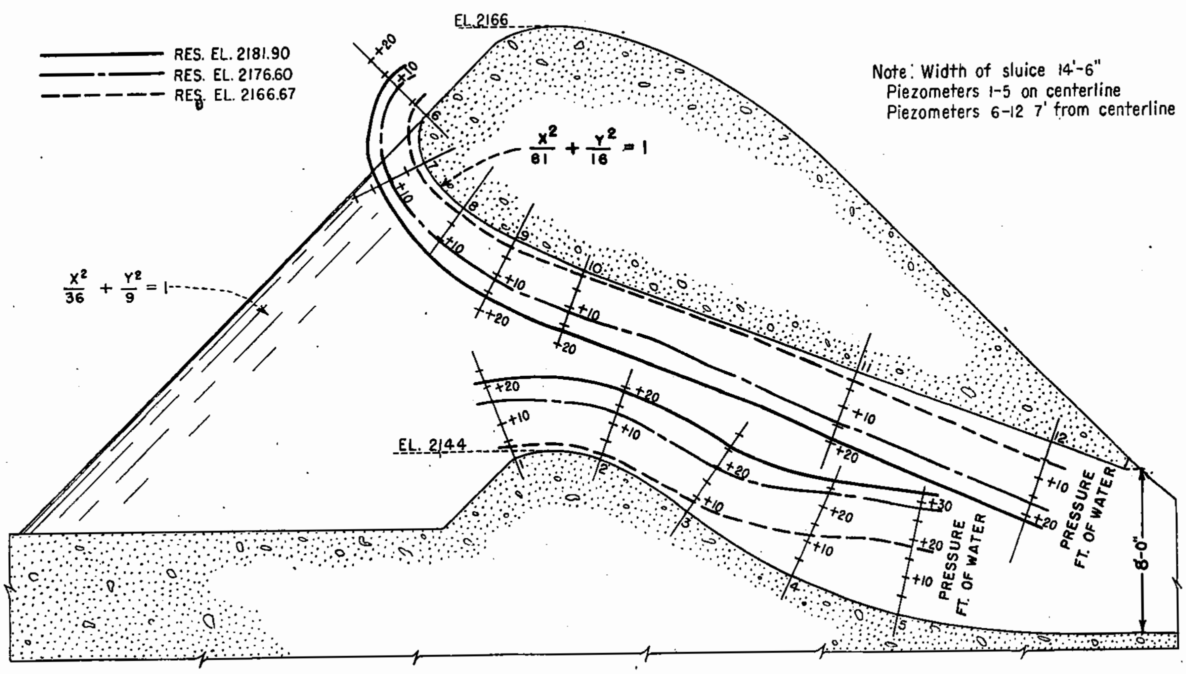
B. SLUICE No. 4

CEDAR BLUFF DAM
PRESSURES IN SLUICEWAY
1:48 SCALE MODEL STUDY

FIGURE 13



UPPER ENTRANCE DESIGNS INVESTIGATED FOR SLUICE No. 5

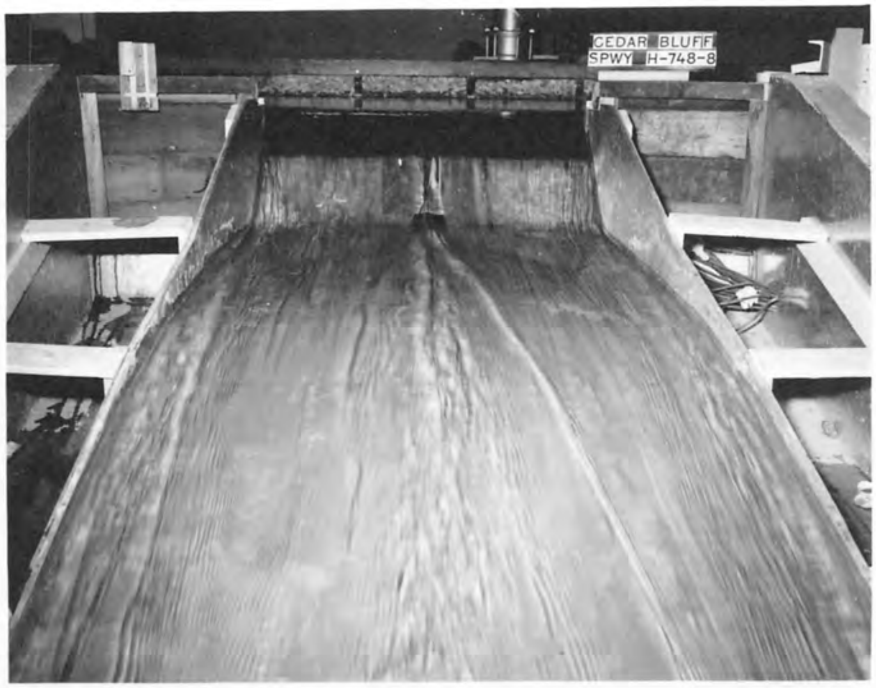


SLUICE No. 5-RECOMMENDED

CEDAR BLUFF DAM

PRESSURES IN SLUICEWAY

1:48 SCALE MODEL STUDY

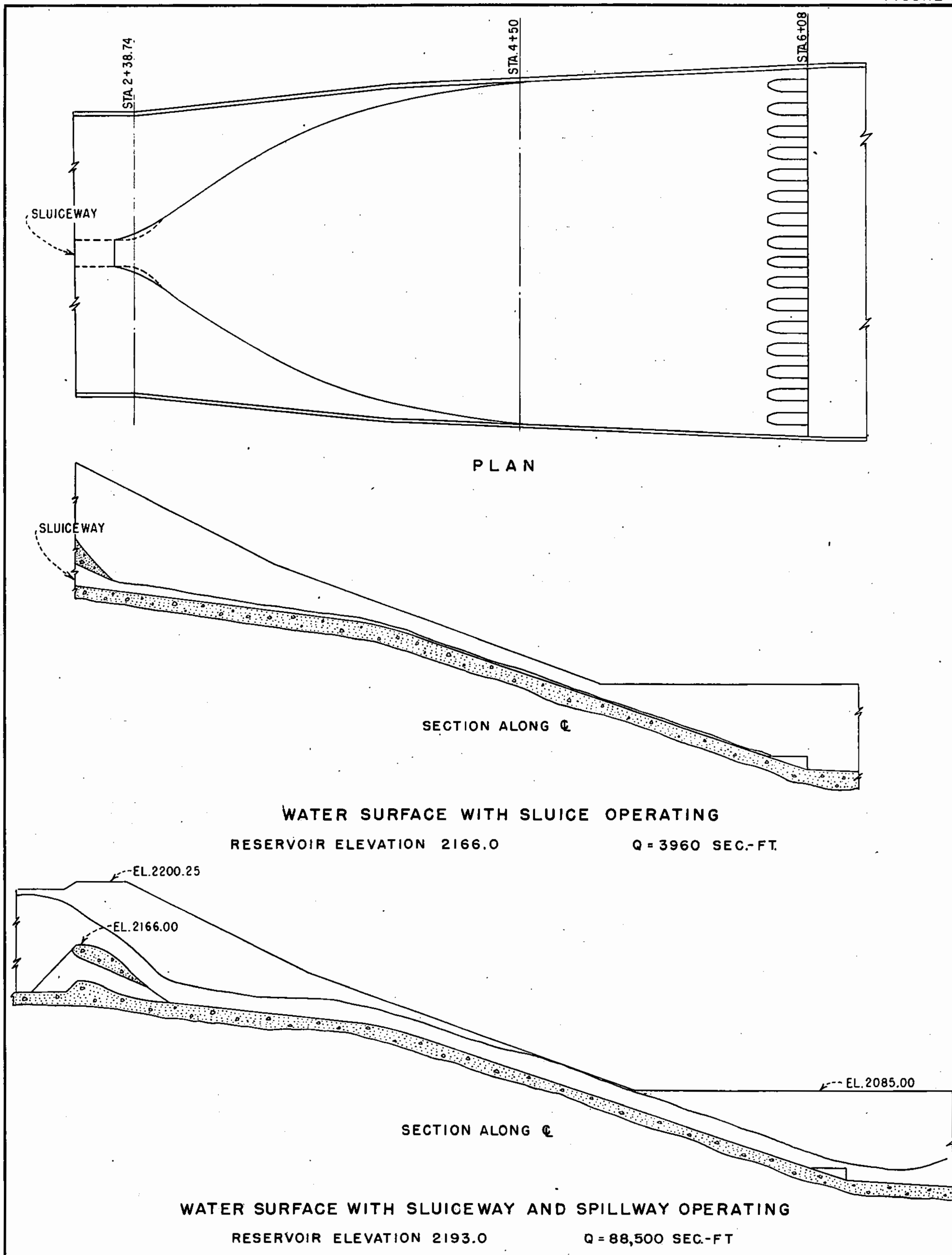


A. Discharge 84,700 Second-feet

B. Discharge 2,880 Second-feet

Recommended Sluiceway
CEDAR BLUFF DAM
1:48 Scale Model Study

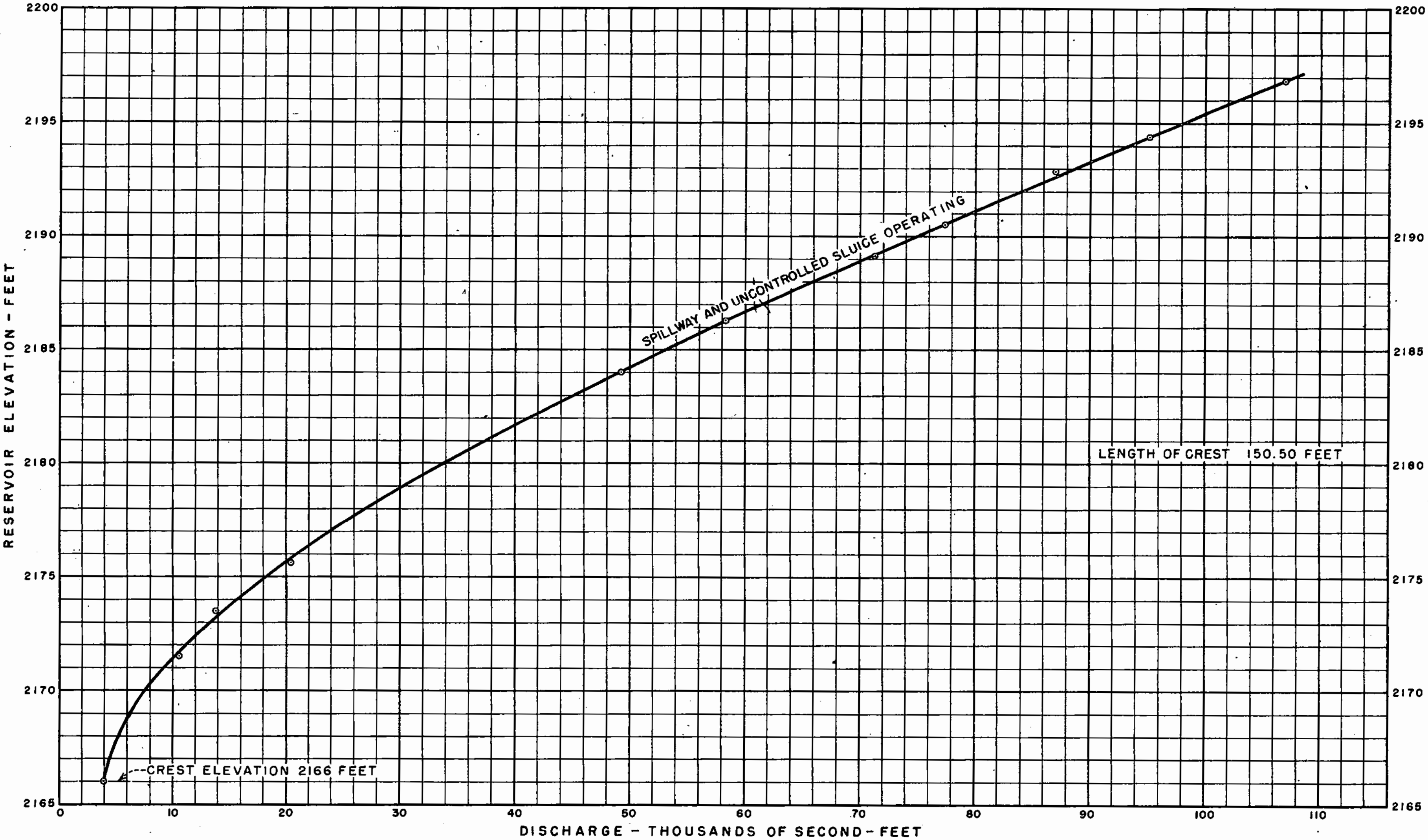
FIGURE 15



CEDAR BLUFF DAM

WATER SURFACE PROFILES

1:48 SCALE MODEL STUDY

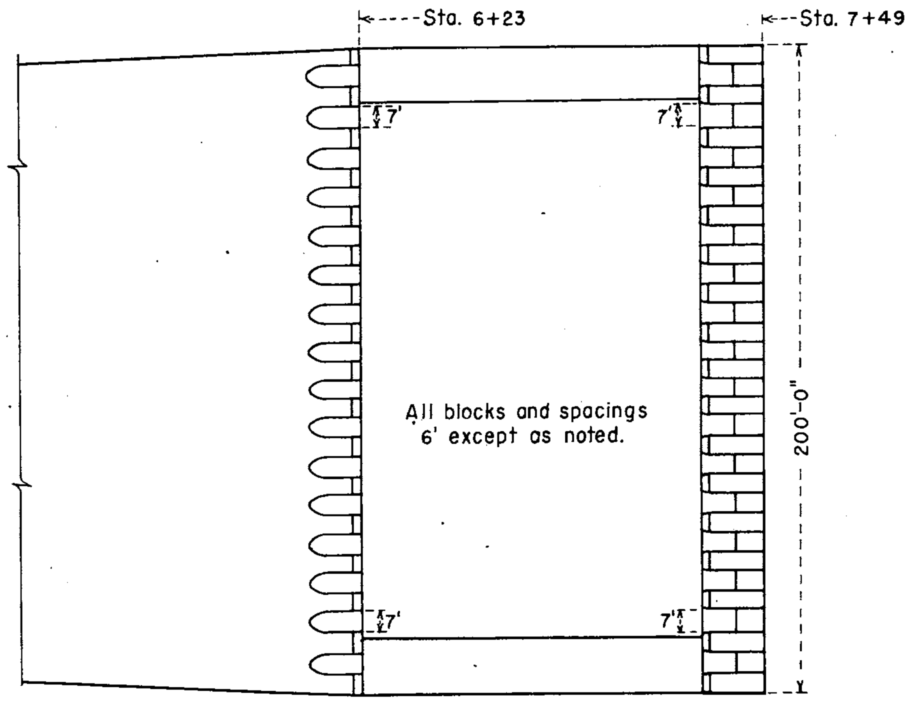


CEDAR BLUFF DAM

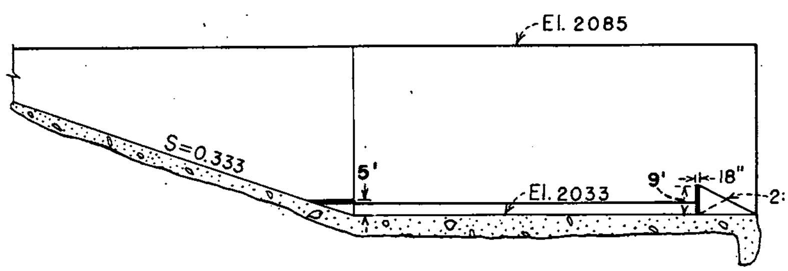
SPILLWAY DISCHARGE CAPACITY WITH SLUICEWAY OPEN

RECOMMENDED

FIGURE 16

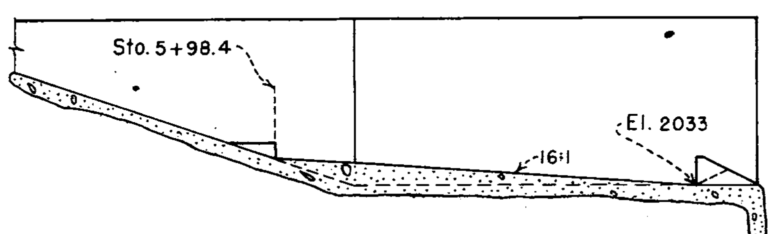


PLAN



SECTION ALONG ℄

BASIN NO. 1 PRELIMINARY



Basin width, chute blocks, end sill and dentates same as basin No. 1.

SECTION ALONG ℄

BASIN NO. 2

CEDAR BLUFF DAM
STILLING BASINS
1:48 SCALE MODEL STUDY

A. Discharge 84,700 Second-feet

B. Scour after 1 Hour

Preliminary Stilling Basin
CEDAR BLUFF DAM
1:48 Scale Model Study

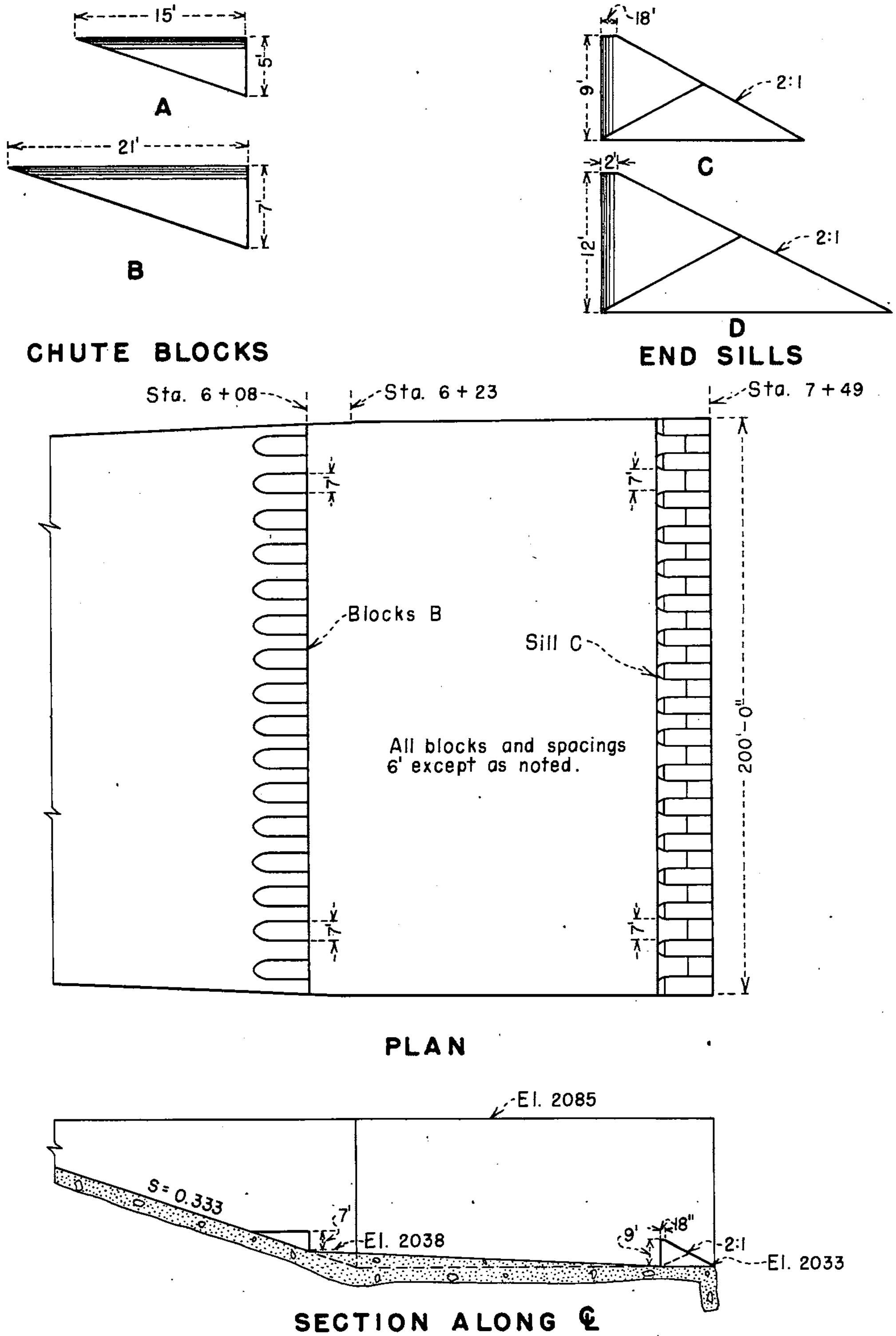
FIGURE 18

Discharge 84,700 Second-feet

Stilling Basin No. 2
CEDAR BLUFF DAM
1:48 Scale Model Study

FIGURE 19

FIGURE 20

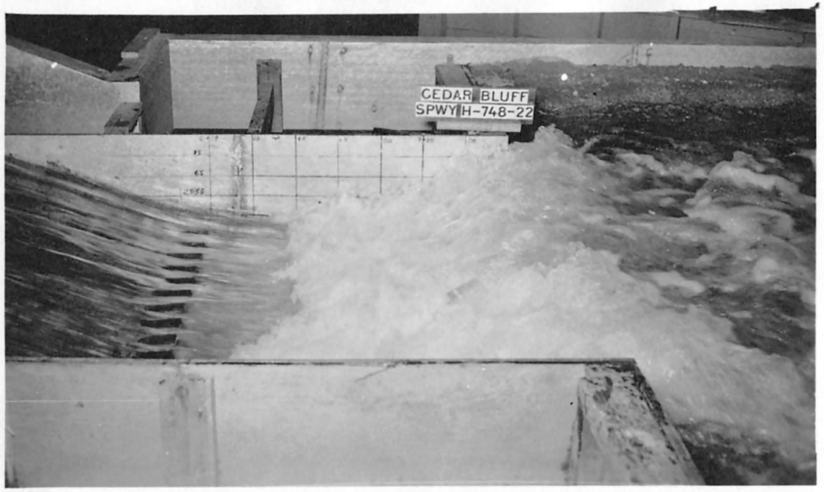


BASIN NO. 3 RECOMMENDED

CEDAR BLUFF DAM

STILLING BASINS

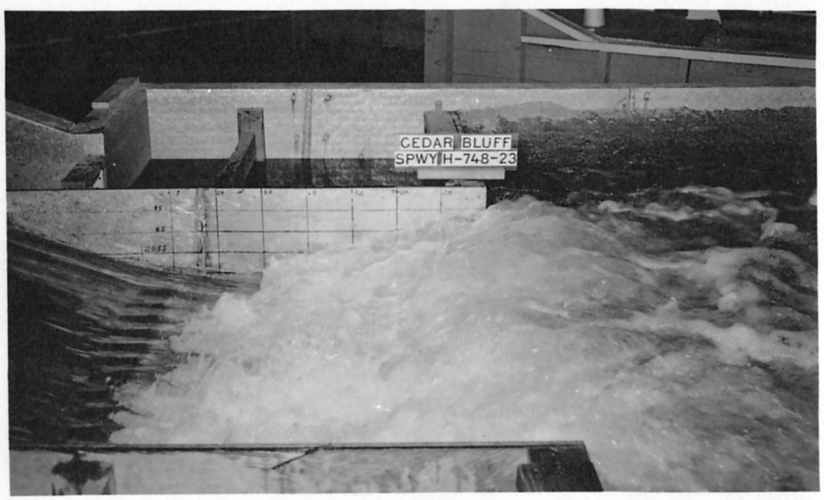
1:48 SCALE MODEL STUDY



A. Operation

B. Scour

HEIGHT CHUTE BLOCKS 5 FEET, END SILL 12 FEET



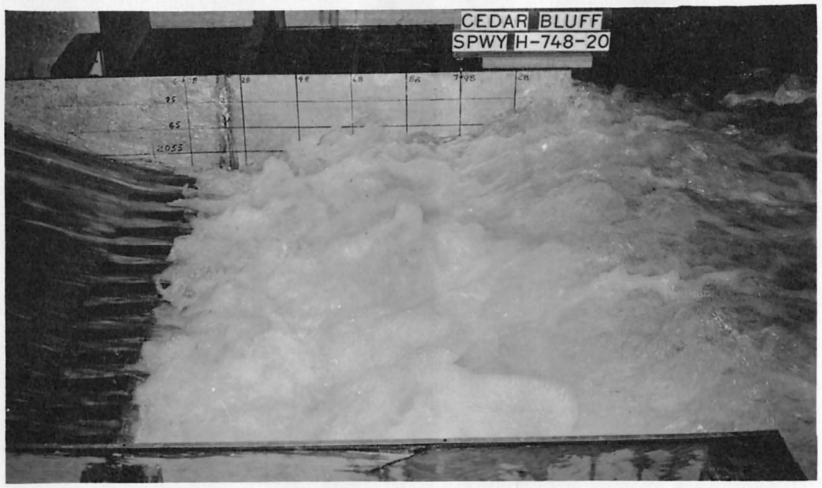
C. Operation

D. Scour

HEIGHT CHUTE BLOCKS 5 FEET, END SILL 9 FEET

Operation at 84,700 Second-feet and Scour after 1 Hour--Basin No. 3
CEDAR BLUFF DAM
1:48 Scale Model Study

FIGURE 21



A. Operation

B. Scour

HEIGHT CHUTE BLOCK 7 FEET, END SILL 12 FEET

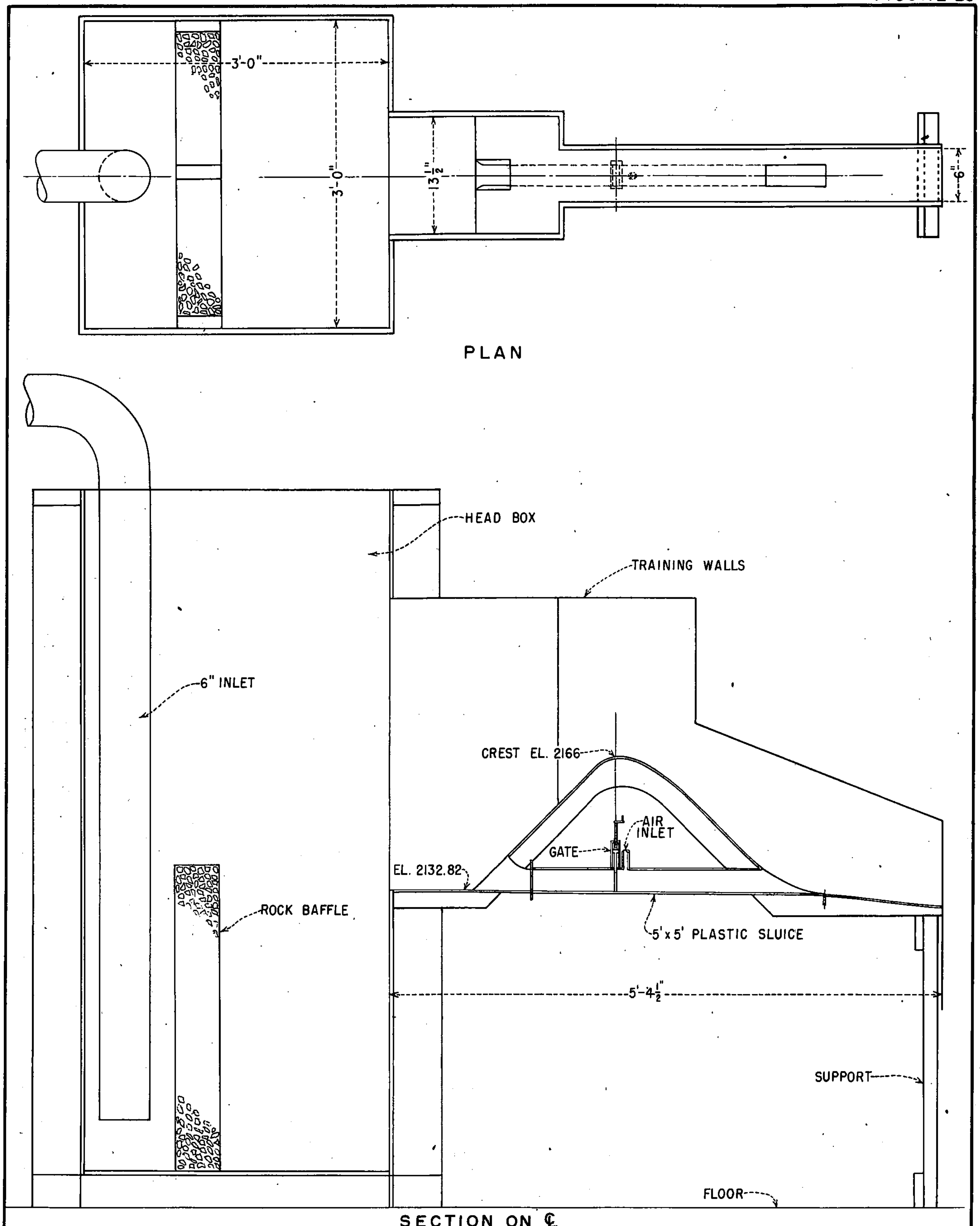
C. Operation

D. Scour

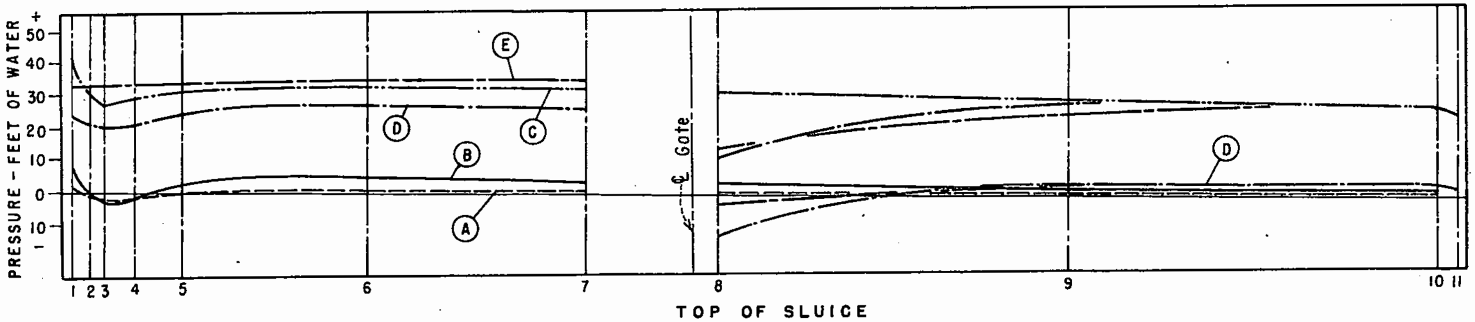
HEIGHT CHUTE BLOCK 7 FEET, END SILL 9 FEET

Operation at 84,700 Second-feet and Scour after 1 Hour--Basin No. 3
CEDAR BLUFF DAM
1:48 Scale Model Study

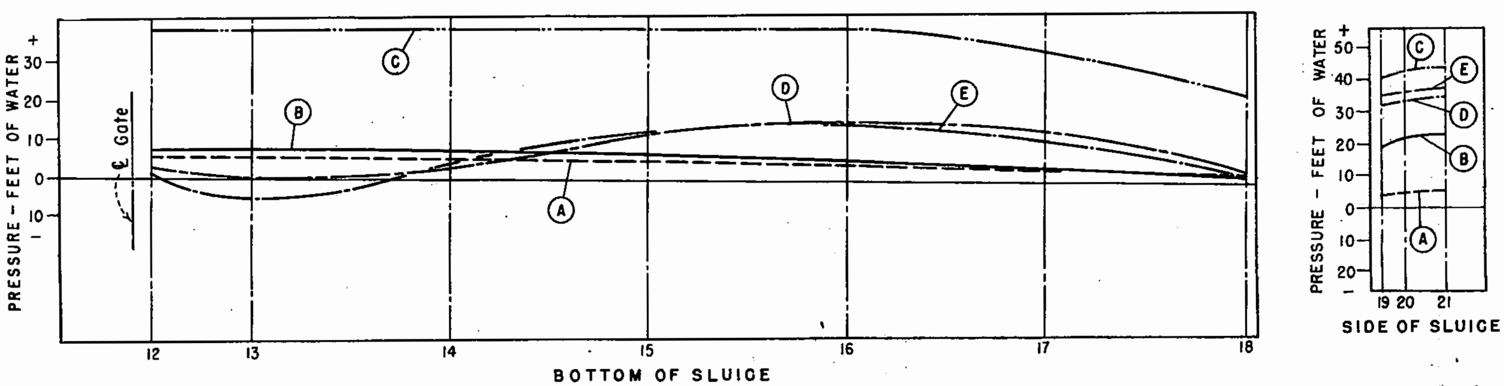
FIGURE 22



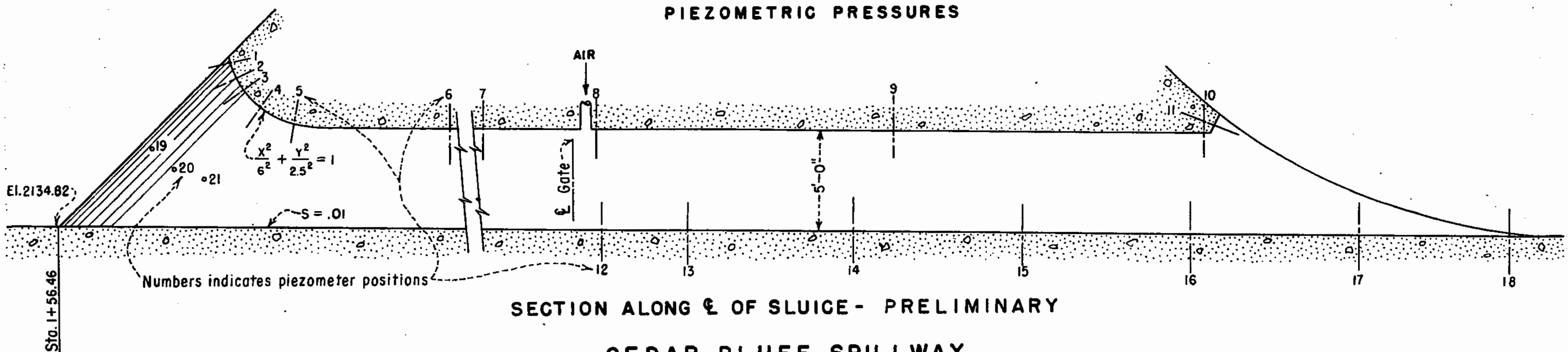
CEDAR BLUFF DAM
5' x 5' SLUICE
1:24 SCALE MODEL



CURVE	SYMBOL	RESERVOIR WATER SURFACE	DISCHARGE SEC.-FT.	GATE OPENING PERCENT
A	– – – –	2144.9	395	100
B	———	2167.0	875	100
C	—··—··—	2188.4	5250	100
D	—·—·—	2174.2	1500	67
E	—— ——	2176.0	1520	33



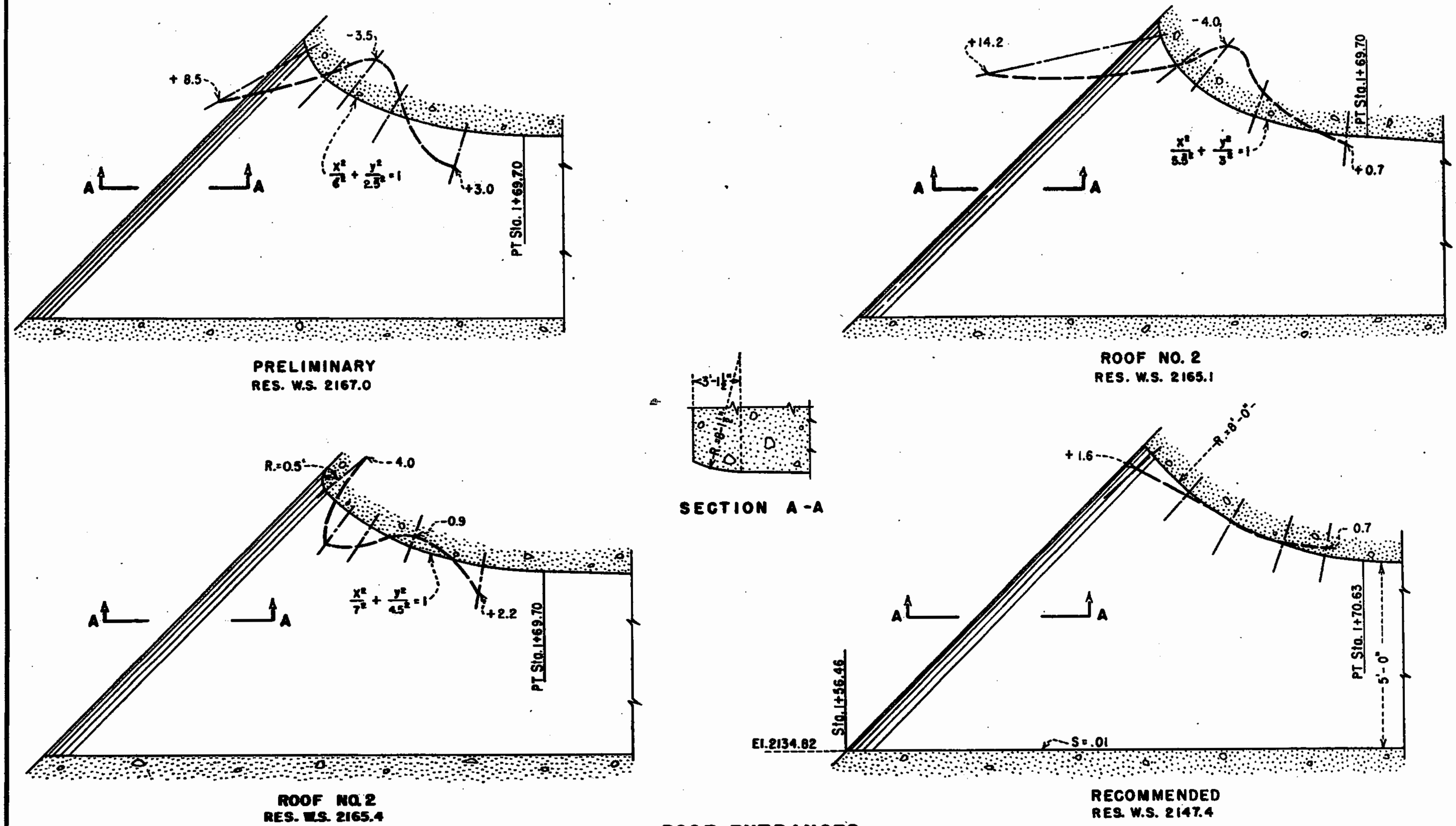
PIEZOMETRIC PRESSURES



SECTION ALONG € OF SLUICE - PRELIMINARY

CEDAR BLUFF SPILLWAY
5 X 5 FLOOD CONTROL SLUICE
1:24 HYDRAULIC MODEL

FIGURE 24



ROOF ENTRANCES

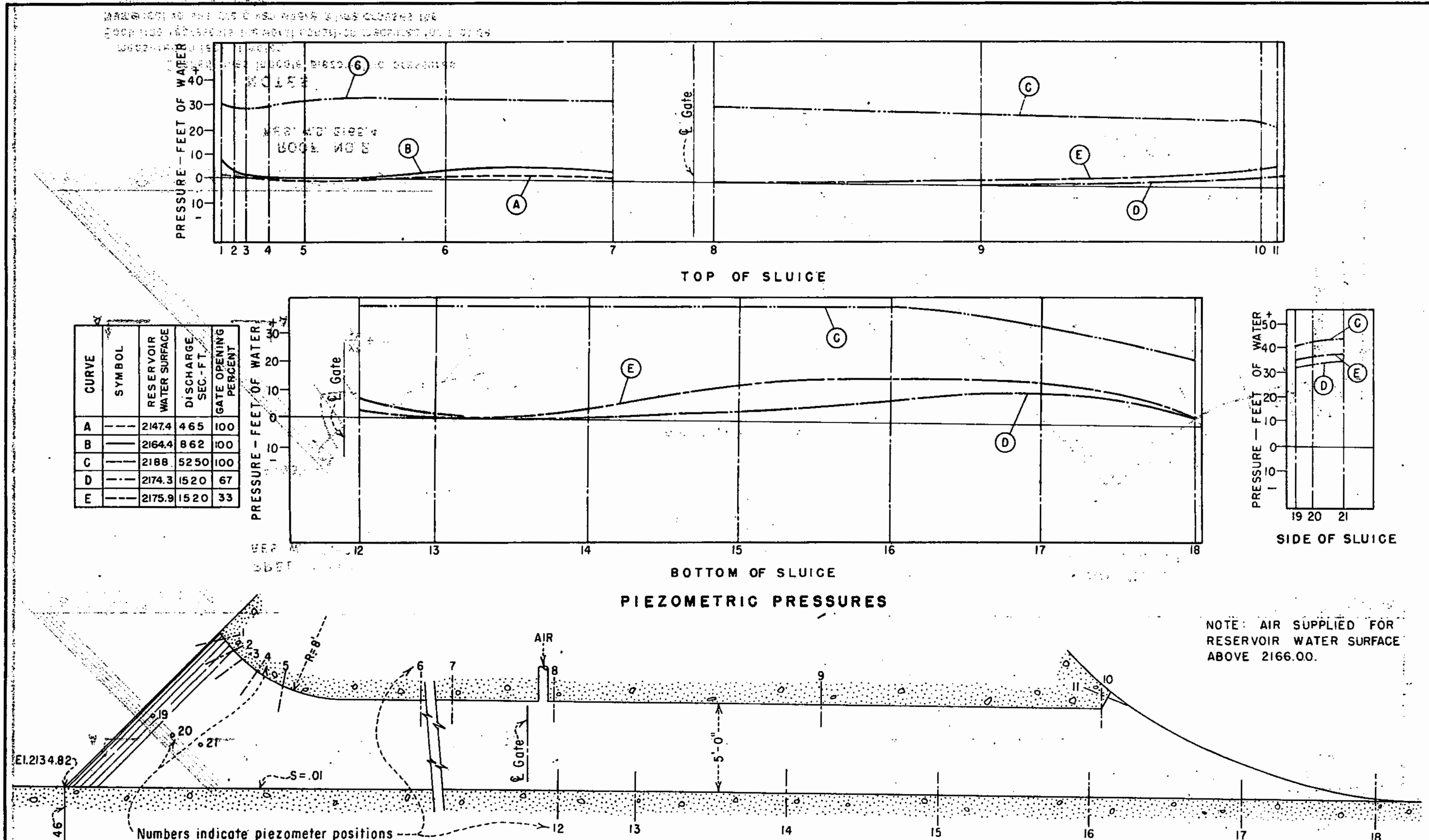
NOTES

Dashed lines indicate piezometric pressures measured in feet of water.
Each line represents the worst condition measured for that design.
Numerical values are given where a line crosses the appropriate piezometer.

CEDAR BLUFF DAM
5X5 FLOOD CONTROL SLUICE
1:24 HYDRAULIC MODEL

5-27-49

FIGURE 25



CURVE	SYMBOL	RESERVOIR WATER SURFACE	DISCHARGE SEC.-FT.	GATE OPENING PERCENT
A	----	2147.4	465	100
B	——	2164.4	862	100
C	—·—	2188	5250	100
D	—··—	2174.3	1520	67
E	— — —	2175.9	1520	33

SECTION ALONG ℄ OF SLUICE-RECOMMENDED

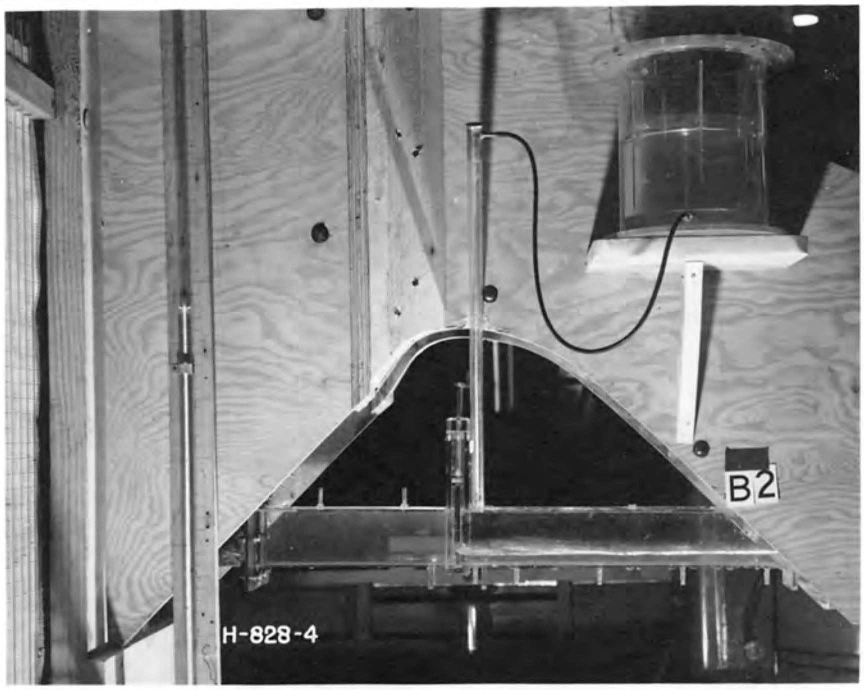
CEDAR BLUFF SPILLWAY

5 X 5 FLOOD CONTROL SLUICE

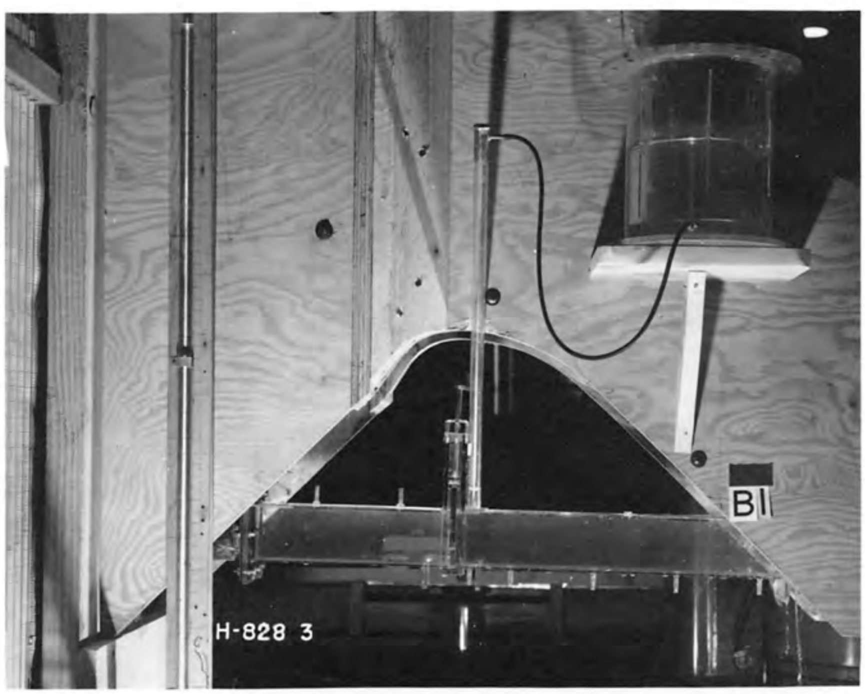
1:24 HYDRAULIC MODEL

FIGURE 26

FIGURE 27

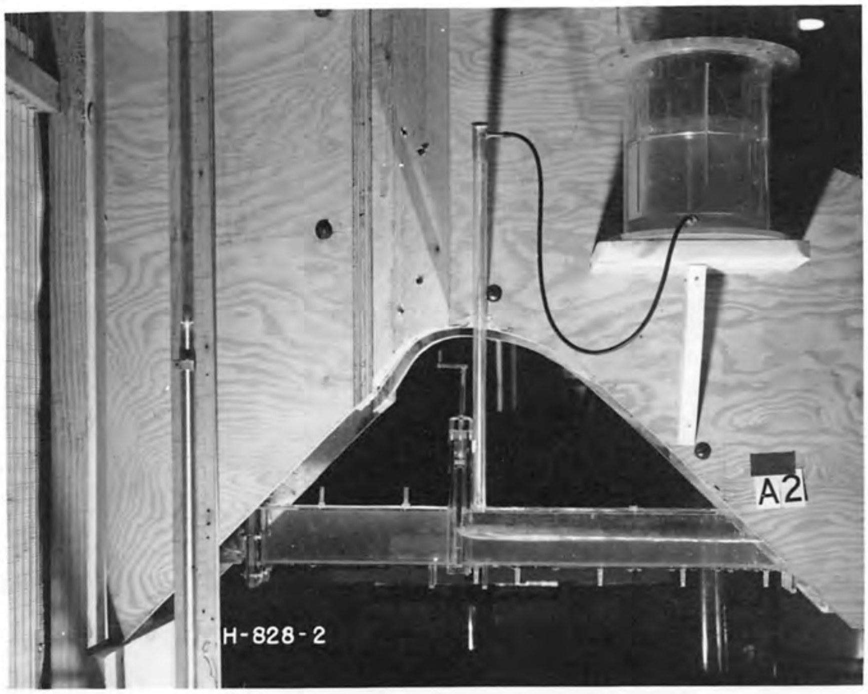


A. **Gate 1/3 open, Reservoir Elevation 2164.4**
Flow through sluice only

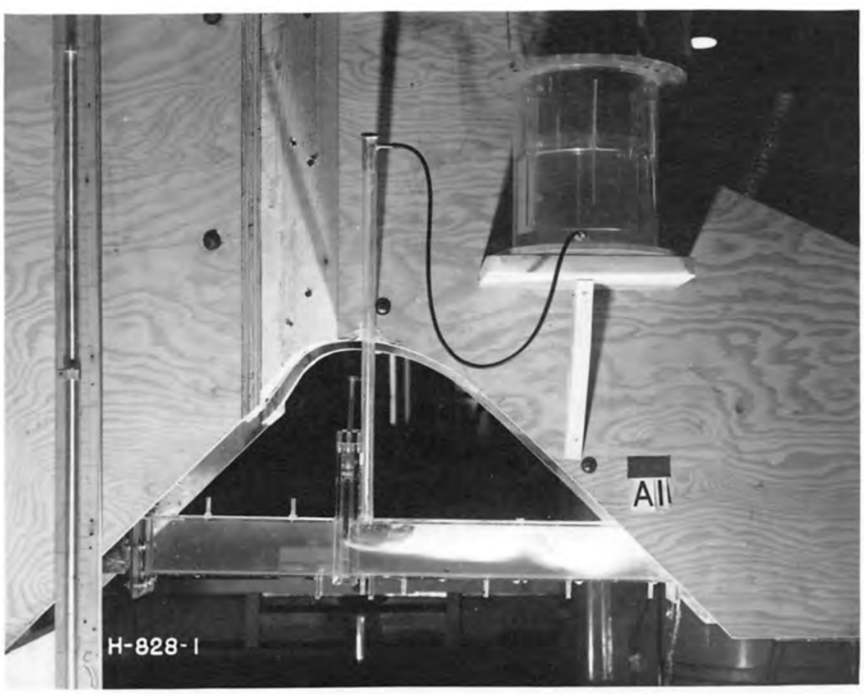


B. **Gate 1/3 open, Reservoir Elevation 2188.0**
Flow through sluice and overflow section

CEDAR BLUFF DAM
5 feet by 5 feet Sluice--Recommended
1:24 Scale Model Study

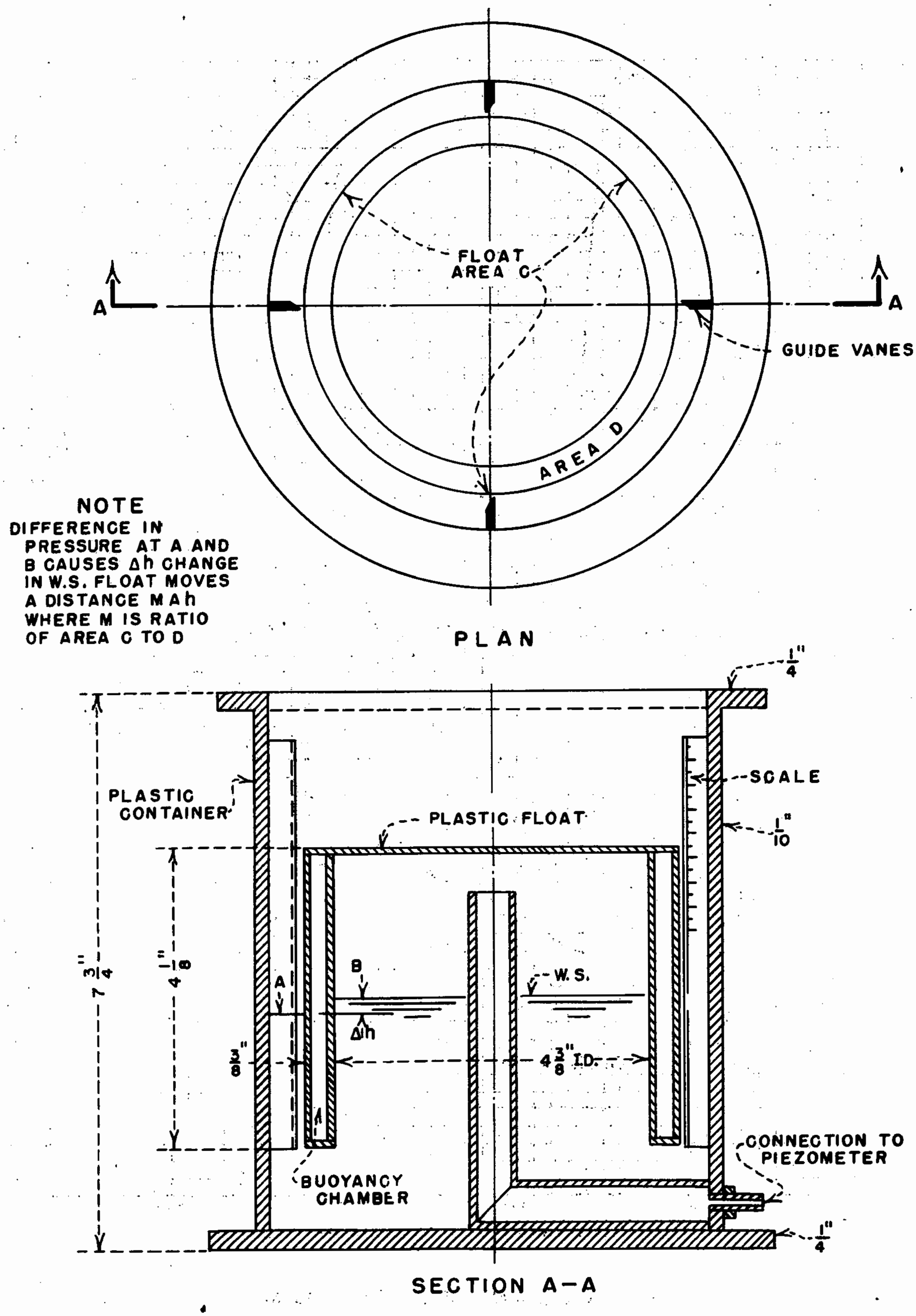


A. Gate 2/3 open Reservoir Elevation 2165.0
Flow through sluice only

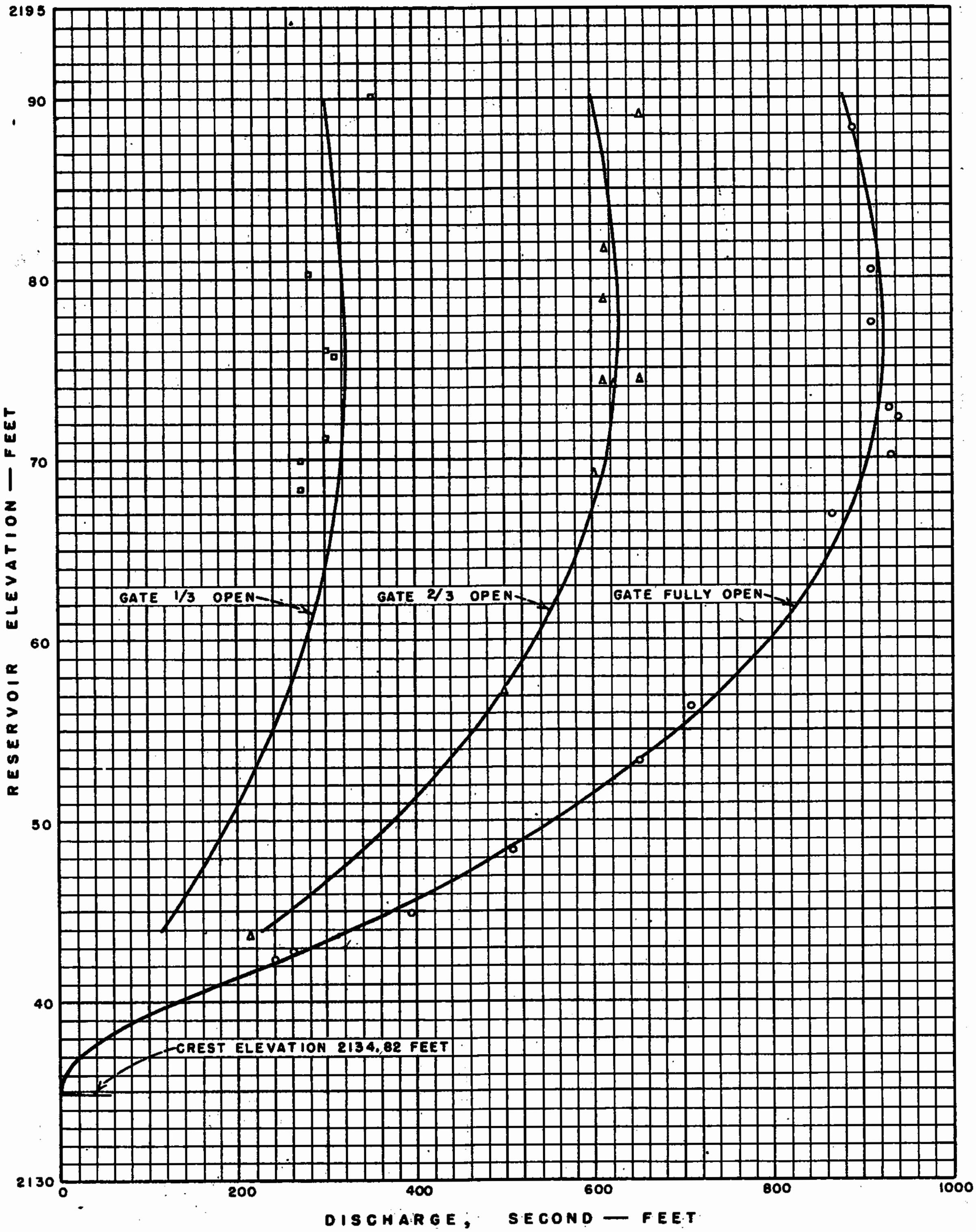


B. Gate 2/3 open, Reservoir Elevation 2174.3
Flow through sluice and overflow section

CEDAR BLUFF DAM
5 feet by 5 feet Sluice-Recommended
1:24 Scale Model Study



CEDAR BLUFF DAM
SENSITIVE DIFFERENTIAL GAGE

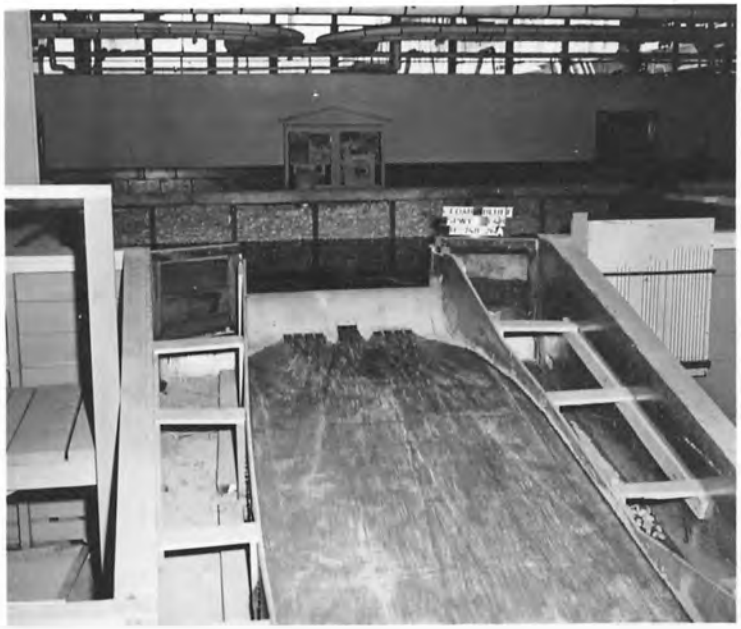


CEDAR BLUFF DAM

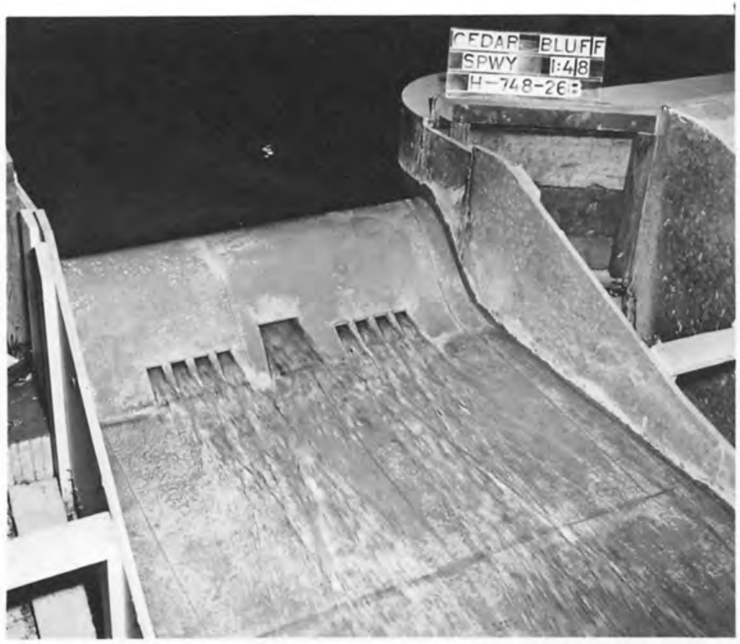
DISCHARGE CAPACITY

ONE, 5' X 5' CONTROLLED SLUICE

1:24 SCALE MODEL



A. **Reservoir Elevation 2166**
Discharge 11,040 second-feet



B. **Reservoir Elevation 2166**
Discharge 11,040 second-feet

Recommended Entrance, 8, 5 feet by 5 feet Sluices
And Center Sluice Operating
CEDAR BLUFF DAM
1:48 Scale Model Study