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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF THE CHERRY CREEK DAM OUTLET WORKS AND THE PROPOSED IRRIGATION INLET

CHERRY CREEK PROJECT, COLORADO

Hydraulic Laboratory Report Hyd. 241

RESEARCH AND GEOLOGY DIVISION

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

APRIL 29, 1948

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Laboratory Report No. 241
Hydraulic Laboratory
Compiled by: E. J. Rusho
Reviewed by: A. J. Peterka

Subject: Hydraulic model studies of the Cherry Creek Dam Outlet Works and the proposed Irrigation Inlet--Cherry Creek Project.

SUMMARY

Hydraulic model studies were made on the outlet works and on the irrigation inlet structure of Cherry Creek Dam and the results are given in this report. The model was built to a scale of 1:28 and was used to study the flow conditions in the downstream portion of the outlet conduits, in the stilling-basin, and in the irrigation inlet structure. The model was built from plans furnished by the United States Engineer Office, Denver, Colorado, except for the irrigation inlet structure which was designed by the Bureau of Reclamation.

These studies were made for the United States Engineer Department in accordance with an agreement reached between the District Engineer, United States Engineer Office, Denver, Colorado and the Chief Engineer, Bureau of Reclamation.

As the outlet works was to be constructed in two phases, the stilling-basin studies were made in two parts. In its initial phase, Figure 3, the primary purpose of Cherry Creek Dam is for flood control with a maximum total discharge through the three conduits of 6,000 second-feet at reservoir elevation 5535. The conduits are controlled by slide-gates located near the upstream end. Operation of the model, Figures 7 and 8, showed that the design of the outlet works, in general, was satisfactory.

In the final phase, Figure 4, with the reservoir also serving for irrigation storage, the center conduit is regulated by a hollow-jet valve located at the downstream end. The maximum discharge for all three conduits is 9,400 second-feet with reservoir elevation 5598 feet. Model operation, Figures 10, 11, and 12, showed that no major changes to the stilling-basin were necessary.

Minor changes in the stilling-basin were made, however, and tested. Of the various dividing walls tested, Figures 4 and 19, the original design resulted in the best-appearing basin action and it was used in the recommended design.

In the studies on the baffle piers, Figures 4 and 14, those located upstream from the original position were found to provide greater energy dissipation in the upper end of the basin and were recommended for the

prototype structure. The change in baffle pier shape and location was the only modification of the original design that was retained in the recommended stilling-basin. The recommended stilling-basin is shown in Figure 14.

Studies were also made on an irrigation canal inlet near the downstream end of the stilling-basin. It is possible that before this part of the structure is built in the field, many details of the irrigation inlet will be changed; consequently tests at this time were made only to determine the feasibility of the structure. Tests on a preliminary inlet design and a portion of the proposed canal indicated that satisfactory entrance conditions existed and that a simple structure would be sufficient to obtain irrigation water from the channel at the downstream end of the outlet works stilling-basin. Figure 23 shows the details of this structure and Figures 25 and 26 show the inlet in operation.

Motion pictures of the performance of each phase were made as the test progressed. Copies are on file in the Hydraulic Laboratory of the Bureau of Reclamation and in the United States Engineer Office, Denver, Colorado.

INTRODUCTION

Cherry Creek Dam is located on Cherry Creek 10 miles southeast of Denver, Colorado, Figure 1. It is a compacted earth structure rising 145 feet above stream bed and forms a reservoir with a maximum capacity of 250,000 acre-feet. An outlet works will release water into Cherry Creek and an overflow spillway will divert flood flows into West Tollgate Creek.

The outlet works located near the right bank consists of three conduits which pass through the base of the dam and discharge into a concrete stilling-basin. A trash rack is provided at the entrance and each conduit is controlled by slide-gates located in the gate structure.

Construction and operation of the outlet works is in two phases. In its initial phase, the primary purpose of the dam is for flood control. This phase as originally designed is shown in Figures 2 and 3. During flood control operation it is planned to hold the storage in the reservoir below 20,000 acre-feet. Thus, the maximum reservoir elevation will not exceed 5535 feet and the corresponding maximum discharge for all three of the outlet conduits is 6,000 second-feet. This is also the maximum flow that the Cherry Creek Channel can accommodate, particularly in the vicinity of Denver, Colorado.

In addition to flood control, it is planned that the final phase of the Cherry Creek Dam will provide for storage of irrigation water diverted from the Blue River. Release of irrigation water will be made through the center conduit of the outlet works. Regulation will be provided by an 84-inch hollow-jet valve located on the downstream end of a 7-foot-diameter pressure conduit installed inside the center conduit. Eventually, an irrigation canal on the right bank will take water from the downstream end of the stilling-basin, Figure 23. With the reservoir at the elevation of the spillway crest, elevation 5598, the maximum discharge of the outlet works will be 9,400 second-feet. Since the capacity of the channel below the dam is only 6,000 second-feet, however, the reservoir will be controlled to prevent higher discharges until after the channel is enlarged.

OUTLET WORKS STUDIES

Model studies were made on both the initial and final phases of operation of the outlet works. No changes in the design of the stilling-basin were made until tests on the final phase were underway. The effect of modifications to the dividing walls and to the baffle piers were then tested. Before completion of the outlet works studies on the final phase, the irrigation canal intake was installed in the model and tested to determine the relative effects of the two structures.

In the studies of the outlet works the performance of the stilling-basin was of major importance. The factors considered in determining the effectiveness of the basin were the height of waves in the channel below the apron, the velocity distribution at the end of the apron and in the channel, and scour immediately below the basin end sill. Observations and photographs were also made of the flow in the conduits, particularly in and near the transition sections at the portals.

The 1:28 Scale Model

Several factors were considered in determining the approximate model scale, but since, in the final phase, the prototype used an 84-inch hollow-jet valve, a model scale of 1:28 was selected to permit the use of a model 3-inch hollow-jet valve which was in stock at the laboratory. It was believed that a smaller valve would not make evident the problems to be considered.

The model, Figures 5, 6A, and 6B, was contained in a wooden headbox and tailbox lined with sheet metal. The three outlet conduits were constructed of sheet metal and were provided with brass slide-gates at the upstream end. Because the studies were concerned only with the outlet ends, the conduits were made shorter than the true scale lengths. However, proper model-prototype relationship of velocities at the conduit portals was obtained for any discharge by appropriate settings of the slide-gates and the water surface elevation in the headbox.

The stilling-basin floor was formed in concrete screeded to metal templates and the training walls were constructed of wood faced with sheet metal. The dividing walls and baffle piers were made of oil-treated wood. A 125-foot long section of the channel dowstream from the stilling-basin was molded in sand and the remainder was formed in concrete plastered over metal lath.

The depth of flow in the lower channel was regulated by a tailgate placed at the extreme lower end of the model. Suitable gages were employed to measure the headwater and tailwater elevations. Water to the model was supplied by a portable 6-inch pump and was measured by an orifice meter in the 8-inch line between the pump and model. A rock baffle in the headbox served to smooth out the flow from the supply pipe before it entered the conduits.

Tests On Stilling-basin

Initial phase. Operation of the stilling-basin for the initial phase, Figure 3, with one outside conduit discharging 2,275 second-feet is shown in Figure 7A and with both outside conduits discharging a total of 4,550 second-feet in Figure 7B. The center conduit discharging 1,450 second-feet is shown in Figure 8A and all three conduits discharging a total of 6,000 second-feet is shown in Figure 8B. For the flow conditions shown in Figures 7 and 8, operation of the stilling-basin was entirely satisfactory. Velocity distribution at the end of the apron was excellent for the flows tested and in no case were eddy currents objectionable, even with the unsymmetrical operation of one outside conduit, Figure 7A. Wave heights were measured in the channel about 125 feet from the end of the apron. For the 6,000 second-foot discharge they were approximately one foot high.

Scour was observed for the four flow conditions of Figures 7 and 8, and a record test was made, Figure 9, of the scour after operating one hour at 6,000 second-feet and tailwater elevation 5502.8, the most severe condition. Very little movement of the channel bed material resulted. Figure 9 shows two small deposits of sand on the downstream end of the apron close to the centerline of flow from each outside conduit. This was probably carried by bottom currents from around the end of each training wall. Erosion close to the end sill and at the end of the training walls was negligible.

As the stilling-basin performance was satisfactory and since it was believed that flow in the final phase would be more severe, it was decided to proceed to this phase before experimenting with modifications in the design.

Final phase. The center conduit was modified and an 84-inch hollow-jet valve was installed on the downstream end for the tests on the final phase, Figure 4. The maximum flow of 1,500 second-feet from the hollow-jet valve is shown in Figure 10A. Figure 10B shows one outside conduit discharging 2,275 second-feet. In Figure 11A both outside conduits are shown operating with a total flow of 6,000 second-feet and Figure 11B shows all conduits discharging a total of 9,400 second-feet. Three conduits discharging a total flow of 6,000 second-feet is shown in Figure 12A. The higher reservoir head in the final phase resulted in greater velocities from the conduits than occurred in the initial phase, but operation was still satisfactory. Stilling-basin action with the maximum discharge of

9,400 second-feet was smooth and the maximum waves in the channel were only one-half foot higher than for the lower discharge of 6,000 second-feet. Observations of the tests indicated good velocity distribution in the lower channel. This is also indicated by the appearance of the water surface in the photographs.

Scour in the channel, Figure 12B, after one hour of operation at 6,000 second-feet was slight. Sand deposits on the end of the apron were present as before and very minor erosion occurred near the end sill. Using the scour tests as a basis for judging the effectiveness of the stilling-basin, it was evident that the length of the horizontal apron of the basin could be reduced. This was substantiated in a later scour test for a discharge of 9,400 second-feet. However, tests on a shorter apron were not made since this additional length represented a margin of safety which the United States Engineers desired because of poor foundation conditions. The general stilling-basin design was consequently accepted as satisfactory. Further investigation was confined to changes in the dividing walls and baffle piers.

Baffle piers. During the tests on the initial and final phases of the stilling-basin it was noted that the original baffle piers were not fully effective because they were located too far downstream, Figure 3. In order to evaluate the effectiveness of the piers in this original position, the model was operated with all baffles removed. Flow at the downstream end of the stilling-basin appeared the same whether or not the baffles were in place. Scour was slight after one hour of operation at 6,000 second-feet, Figure 13. The only discernible difference in the erosion pattern was the absence of the sand deposits on the downstream end of the apron with the baffles removed.

As a result of the foregoing studies the second baffle pier design was installed in the model, Figure 14. As shown in the figure, two rows were used as before, but they were placed farther upstream between the dividing walls. Operation at 6,000 second-feet with the two outside conduits open is shown in Figure 15 A and with all three conduits flowing in Figure 15 B. In this position the baffles were definitely aiding in the dissipation of energy as evidenced by the increased turbulence at the upstream end of the stilling-basin. The location of the jump and the appearance of the stilling action was otherwise unchanged from the test with the first baffle pier design. Scour after one hour of operation at 6,000 second-feet and tailwater elevation 5502.8 is shown in Figure 16. Erosion was slight with small sand deposits occurring on the downstream end of the apron similar to those observed with the original baffle piers. This baffle pier design and position was considered satisfactory and it was retained in the model for the remainder of the studies.

Dividing walls. To determine the effect of the dividing walls on the operation of the stilling-basin, the first test was made with the walls removed. In Figure 17 two views are shown with the hollow-jet valve discharging 1,500 second-feet. Unstable flow in the stilling-basin is evident by the difference in the path of flow in the two photographs. This unfavorable condition showed that walls were necessary to direct the flow; consequently no additional tests were made without dividing walls.

Short walls were next installed consisting of the original walls, Figure 4, but extended only from the portals to the toe of the chute. Stable flow conditions were found in the stilling-basin with the operation of any one or two conduits and operation was satisfactory with all conduits discharging, Figure 18 A. Scour after a one hour test at 6,000 second-feet, Figure 18 B, was the same as found with the longer walls, Figure 16. A small sand deposit occurred on the apron near the left training wall.

The only objectionable feature of the operation with the short walls in place occurred when operating with any conduit closed and an adjacent conduit open. For this condition an eddy formed on the apron at the end of the dividing wall. It was caused by a cross-flow of water from the higher water surface existing downstream from the closed conduit into the lower area below the open conduit. Because of the improved appearance of the action in the basin the United States Engineers decided to use longer dividing walls.

The second dividing wall design proposed by the United States Engineers, Figure 19, was installed in the model and tested. With three conduits discharging 6,000 second-feet, Figure 20 A, flow conditions, in general, were similar to the original wall design except that water climbed the sloping sides of the piers near the upstream end as shown in Figures 20 A and 20 B. Both outside conduits operating with a total flow of 6,000 second-feet is shown in Figure 20 B. With the center conduit closed, a cross-flow resulted as with the previous test with shorter walls; however, it was much less pronounced. Due to these conditions it was decided to retain the original dividing walls for the stilling-basin.

Recommended stilling-basin. Since the performance of the original stilling-basin was satisfactory for both the initial and final phases of operation, the original design of this basin is recommended for field construction except for the shape and location of the baffle piers. The recommended basin is shown in Figure 14, and operation is shown in Figure 15, A & B. Scour after one hour operation at 6,000 second-feet is shown in Figure 16. Action of the stilling-basin for all conduits flowing a total of 9,400 second-feet is shown in Figure 21. Scour, Figure 21B, after one hour operation at 9,400 second-feet is similar to that for a discharge of 6,000 second-feet except that there are no sand deposits on the apron. Greatest depth of scour, elevation 5481, occurred just downstream from the end sill.

Tests on Conduits

Center conduit. In the initial phase of the stilling-basin, the center circular conduit changed abruptly into a rectangular section,

Figure 3, at the downstream end to provide space for installation of the hollow-jet valve in the final phase. Flow in the rectangular section for a discharge of 1,500 second-feet is shown in Figure 22A. Water climbed the side walls at this point because of the disturbance created by the sudden change from the circular to rectangular shape. The United States Engineers decided that this condition could be corrected most easily by adding fillets in the corners of the rectangular section. Model studies of this transition were felt, by the United States Engineers, to be unnecessary and it was not installed in the model.

Outside conduits. Each outside conduit had a 4° bend 60 feet upstream from the portals, Figure 2. The bends were necessary, in this design, to provide clearance for the hollow-jet valve to be placed on the center conduit in the final phase. To simplify construction these bends were represented by 4° angles in the model. It was noted in all tests that the depth of flow leaving these conduits was greater along the outside training walls. To determine whether this condition was caused by the approximation of the bend in the model, a plastic bend was built to scale, with a prototype radius of 410 feet, and installed in the left conduit. Operation of the model, Figure 22B, showed that the uneven depth of water still existed, indicating that the disturbance was caused by turning the water and not by the length of the radius of the bend. Since this was not a serious flow condition and could not be remedied without extensive changes in the prototype design, no further attempts were made at correction. The transition section in the last 30 feet of the conduits caused no apparent disturbance to the flow.

IRRIGATION INLET STUDIES

Installation of the irrigation inlet, Figure 24, was made in the model before completion of the studies on the final phase of the outlet works stilling-basin. The irrigation canal stilling-basin was not installed in the model since these tests were made only to determine whether a satisfactory inlet could be provided at the downstream end of the outlet works stilling-basin. Consequently, tests were run only to record the performance of the structure as originally designed and to obtain calibration curves for the inlet crest and radial gate.

Test Data

The irrigation canal and inlet structure as installed in the model is shown in Figure 24 A & B. With the hollow-jet valve discharging 1,500 second-feet photographs were taken of flow in the irrigation outlet. In Figure 25 two views are shown with the radial gate of the inlet open 4 feet and in Figure 26 two views are shown with the gate fully open. Choppy waves were present on the water surface at the entrance to the inlet and a depressed water surface or drawdown existed around the upstream end of the left training wall, due to the contraction in the flow. This drawdown increased with high flows into the irrigation canal. Depth of flow in the curve downstream from the entrance was greater on the outside of the bend and some degree of superelevation should be used in a final design. The vertical side walls were overtopped for discharges greater than 1,300 second-feet making this the limit of capacity of the canal. Small diamond pattern waves existed on the water surface of the bend and throughout the length of the canal.

Water surface profiles were taken in the canal, Figure 27, for discharges of 500 second-feet and 1,000 second-feet both with the control gate 4 feet open and fully open. For a discharge of 1,000 second-feet with the gate open 4 feet, the depth of flow entering the channel was below critical and increased with distance downstream. For the other three flows the depth was above critical at the entrance and decreased with distance downstream.

Crest and Gate Calibration

A discharge capacity curve for free crest and various gate openings was obtained from the model, Figure 28. The elevation of the water surface upstream from the canal inlet, or, the head, was determined by point gage. Discharge through the irrigation canal was measured by means of a V-notch weir placed at the downstream end of the canal. At full-gate opening, 955 second-feet could be passed by the irrigation canal before any flow went down Cherry Creek Channel. Reason for this can be seen from Figure 29, as at elevation 5495, which is zero flow for Cherry Creek, the discharge of the irrigation inlet is 955 second-feet for free crest.

WAR DEPARTMENT

FIGURE 1

CORPS OF ENGINEERS, U. S. ARMY

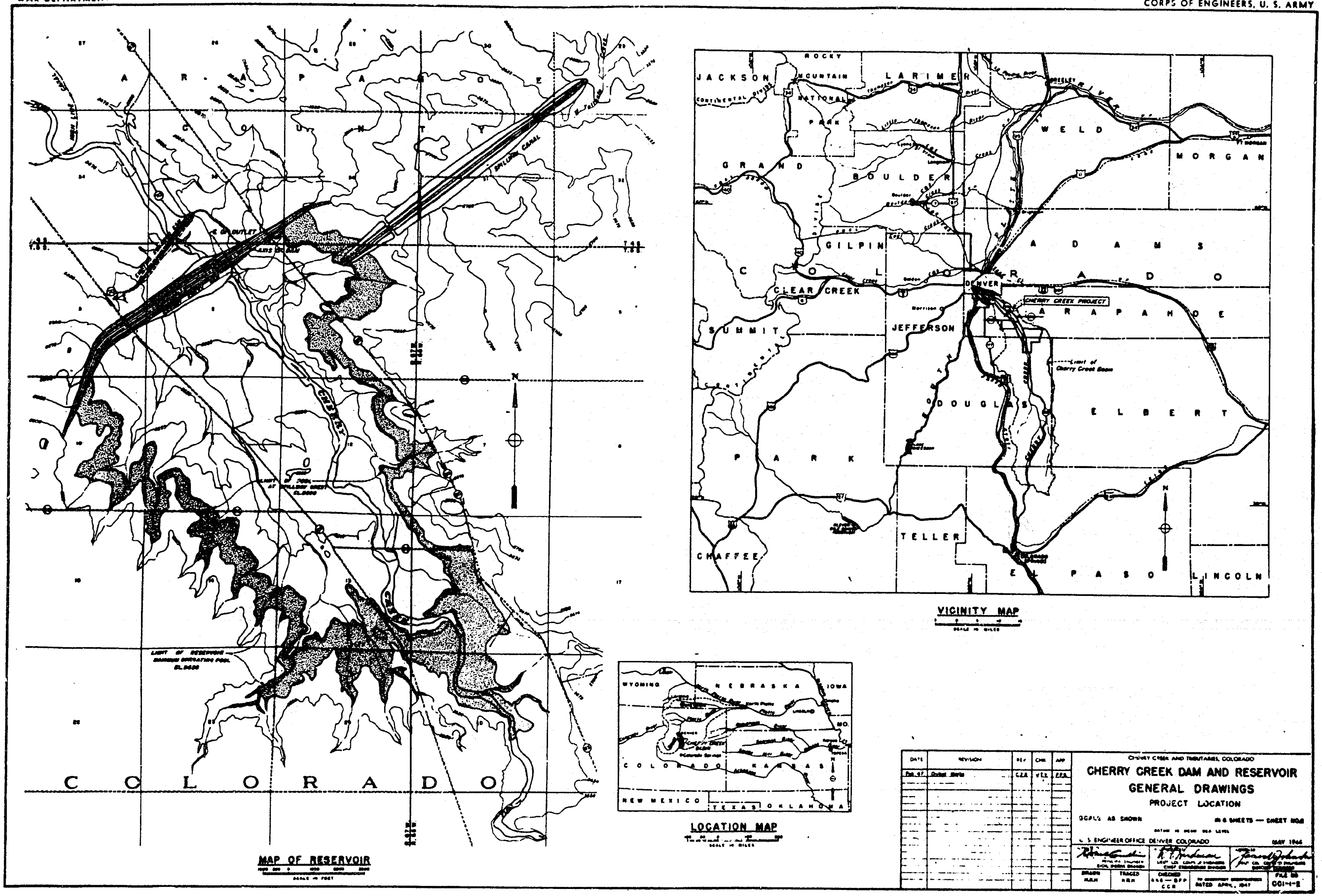


FIGURE 2

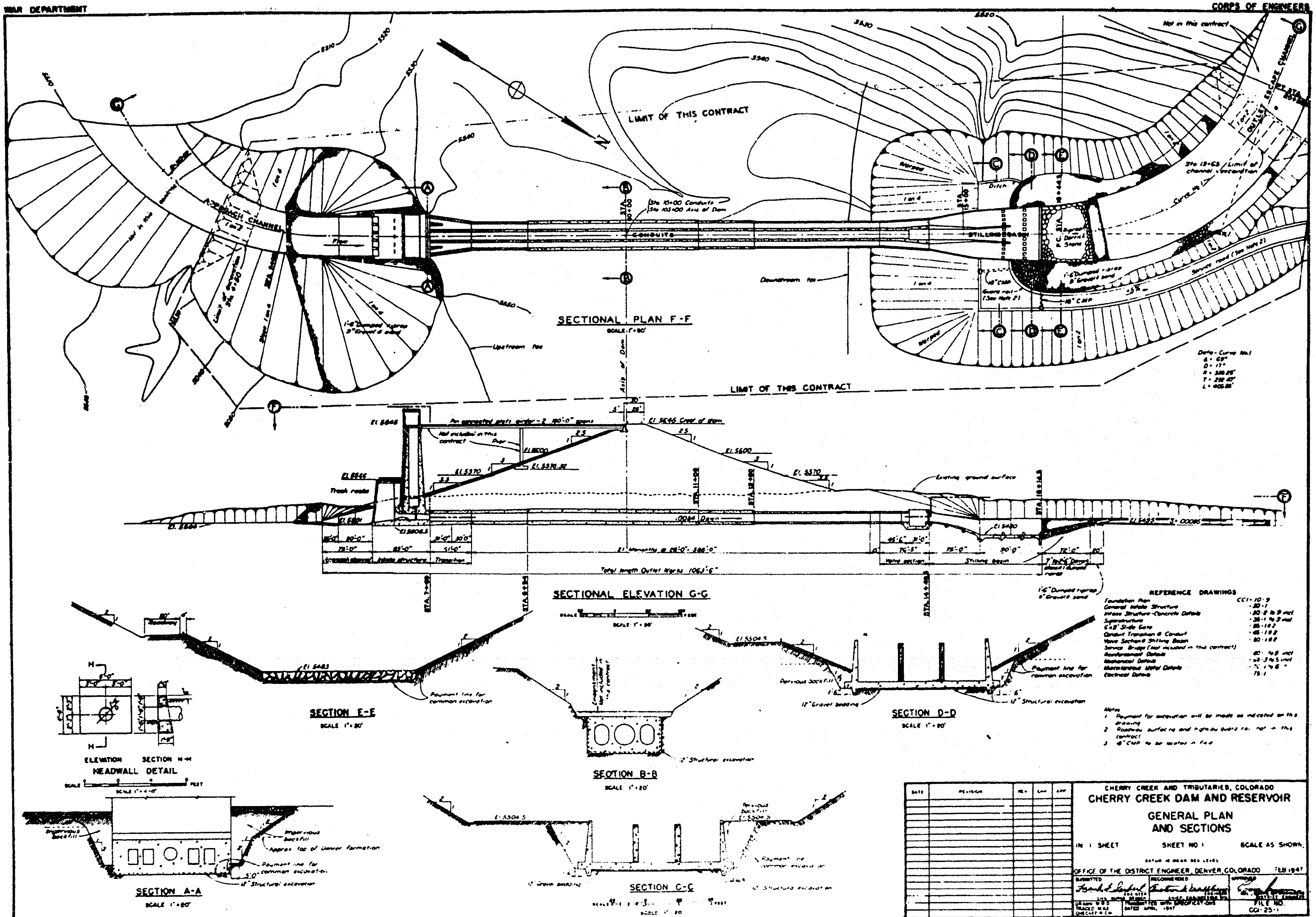
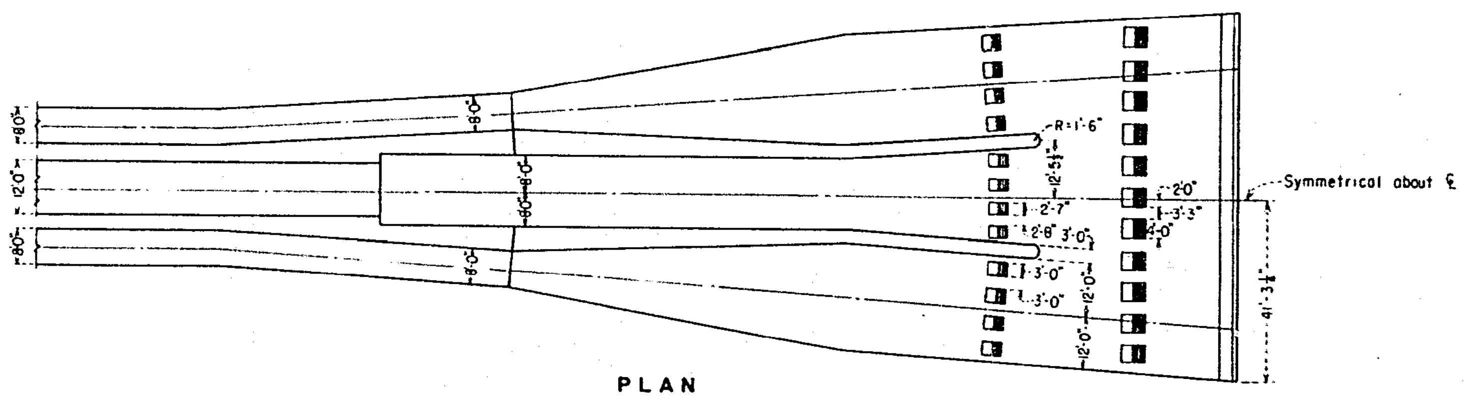
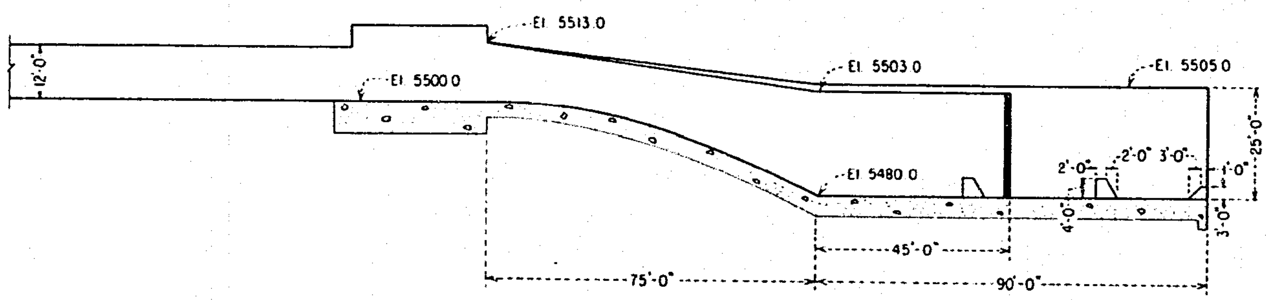

WAR DEPARTMENT
CORPS OF ENGINEERS
LIMIT OF THIS CONTRACT
APPROACH CHANNEL
CONDUITS
STILLING BASIN
Downstream toe
Upstream toe
SECTIONAL PLAN F-F
Axis of Dam
ESCAPE CHANNEL
OUTLET
Not in this contract
El. 5646 Crest of dam
El. 5600
El. 5570
Trash racks
Existing ground surface
Total length Outlet Works 1063'-6"
SECTIONAL ELEVATION G-G
REFERENCE DRAWINGS
SECTION E-E
SECTION D-D
SECTION B-B
SECTION A-A
SECTION C-C
HEADWALL DETAIL
ELEVATION
SECTION H-H
Payment line for common excavation
Pervious backfill
Impervious backfill
12" Gravel bedding
12" Structural excavation
CHERRY CREEK AND TRIBUTARIES, COLORADO
CHERRY CREEK DAM AND RESERVOIR
GENERAL PLAN AND SECTIONS
IN 1 SHEET
SHEET NO. 1
SCALE AS SHOWN
OFFICE OF THE DISTRICT ENGINEER, DENVER, COLORADO
FEB 1947
FILE NO.
CCI-25-1

FIGURE 3



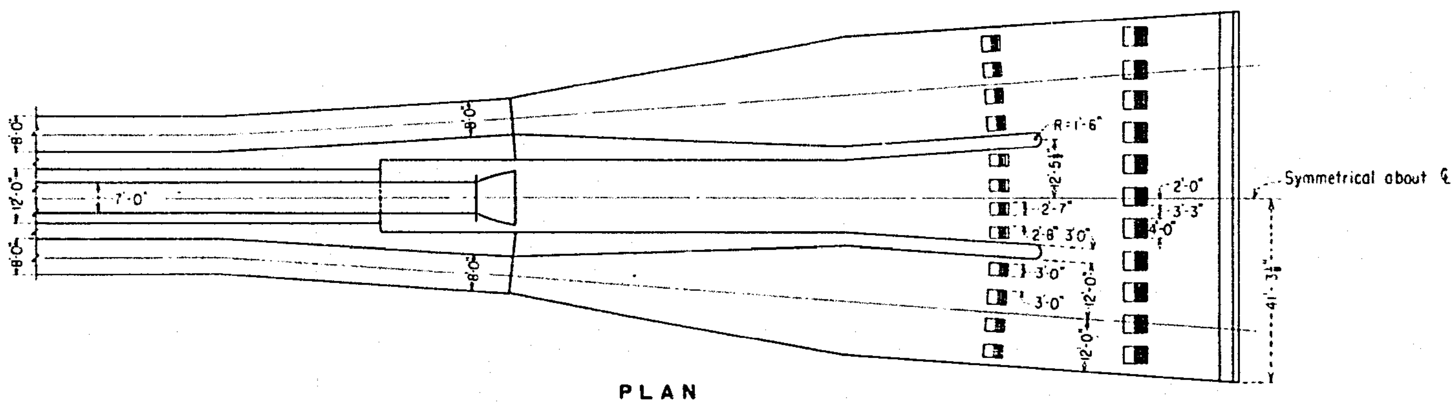
PLAN



SECTION ON ℄

CHERRY CREEK DAM AND RESERVOIR
OUTLET WORKS AND STILLING BASIN
INITIAL PHASE

FIGURE 4



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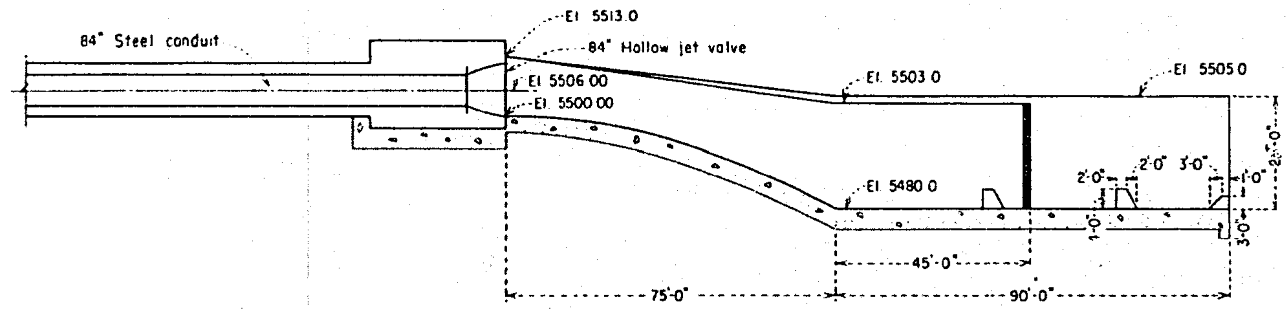
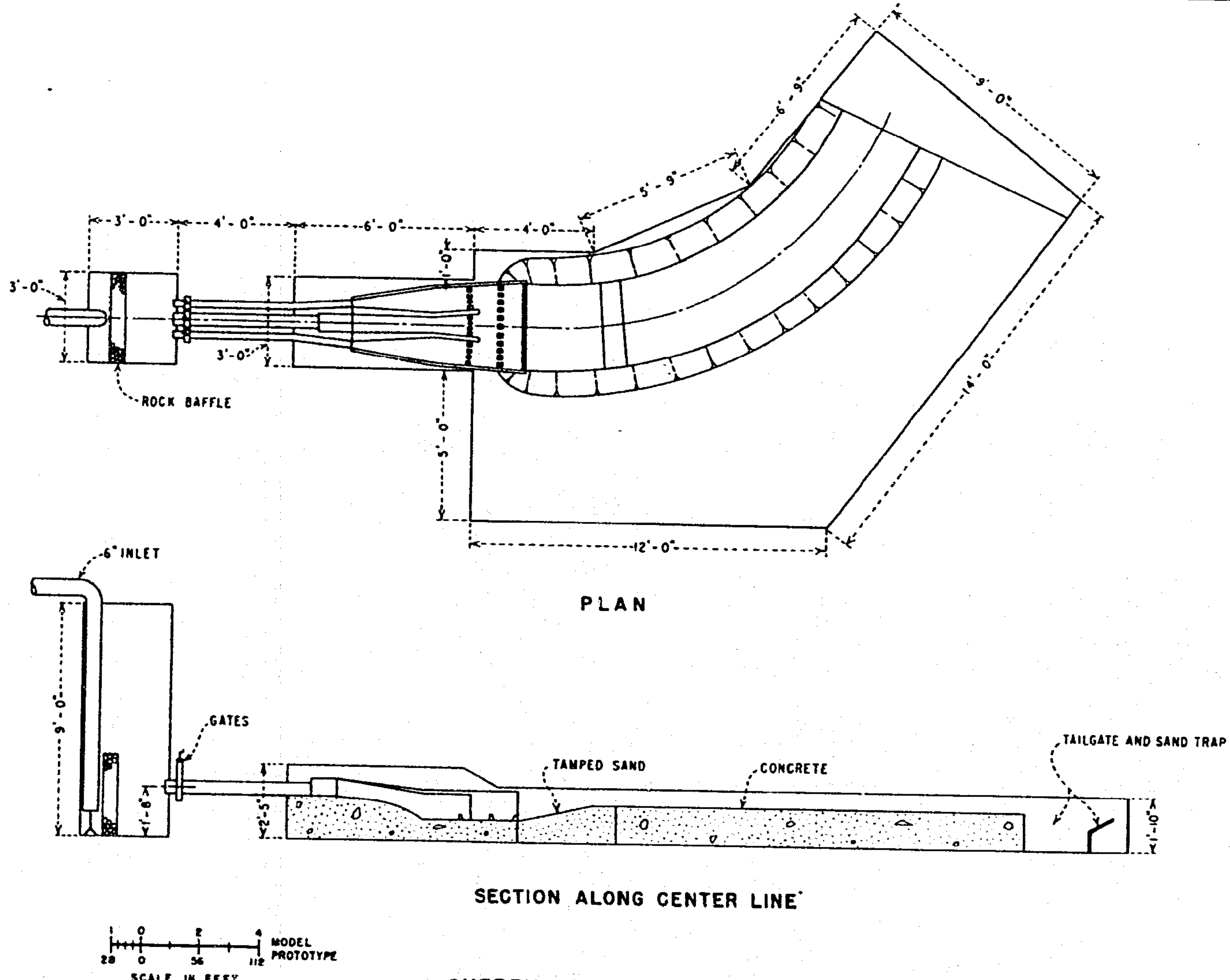


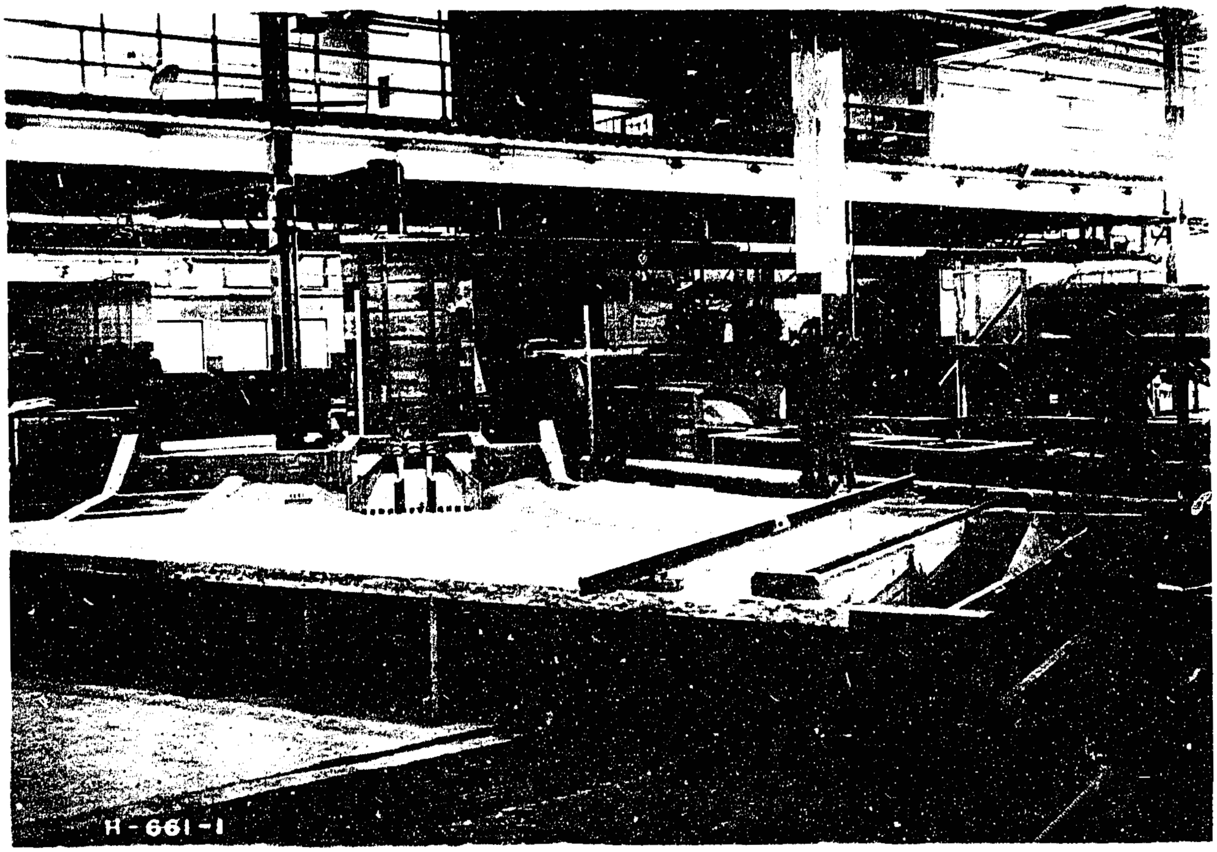
SECTION ON ℄

CHERRY CREEK DAM AND RESERVOIR
OUTLET WORKS AND STILLING BASIN
FINAL PHASE



CHERRY CREEK OUTLET WORKS
1:28 MODEL

FIGURE 5

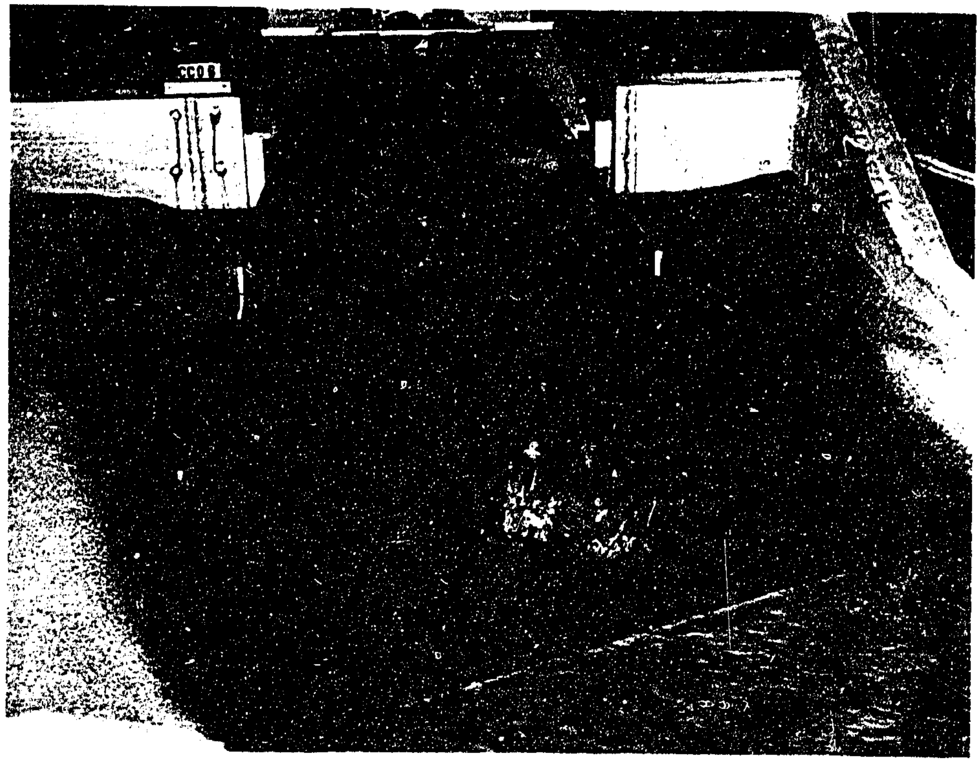


A. Completed model

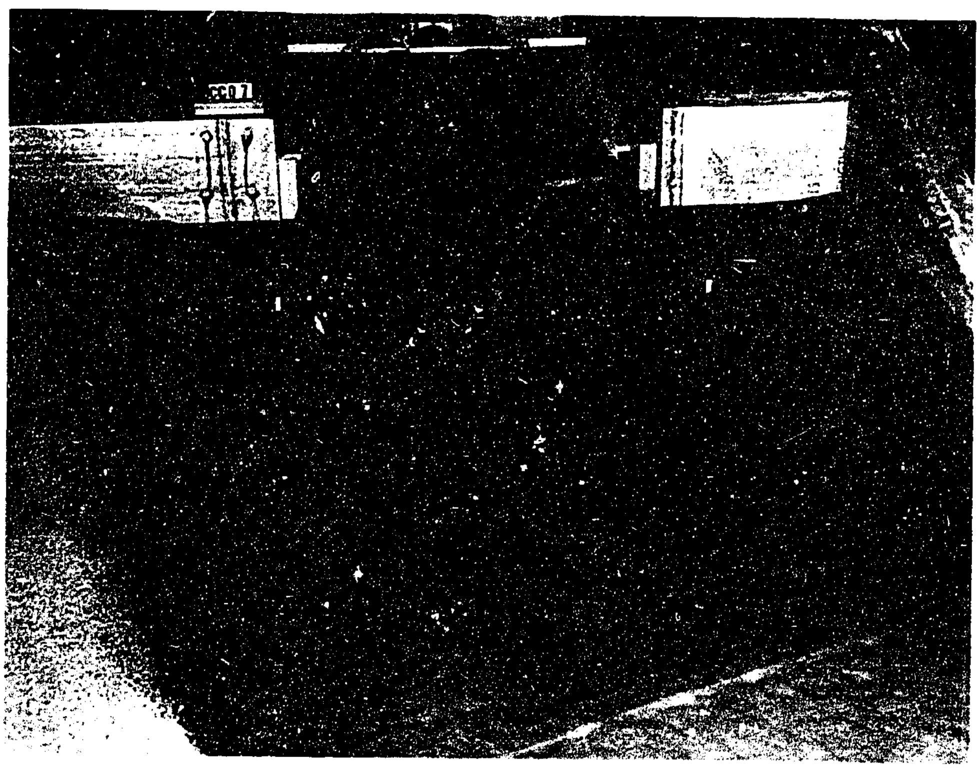
B. Stilling-basin

MODEL, CHERRY CREEK OUTLET WORKS, ORIGINAL DESIGN, INITIAL PHASE

FIGURE 7



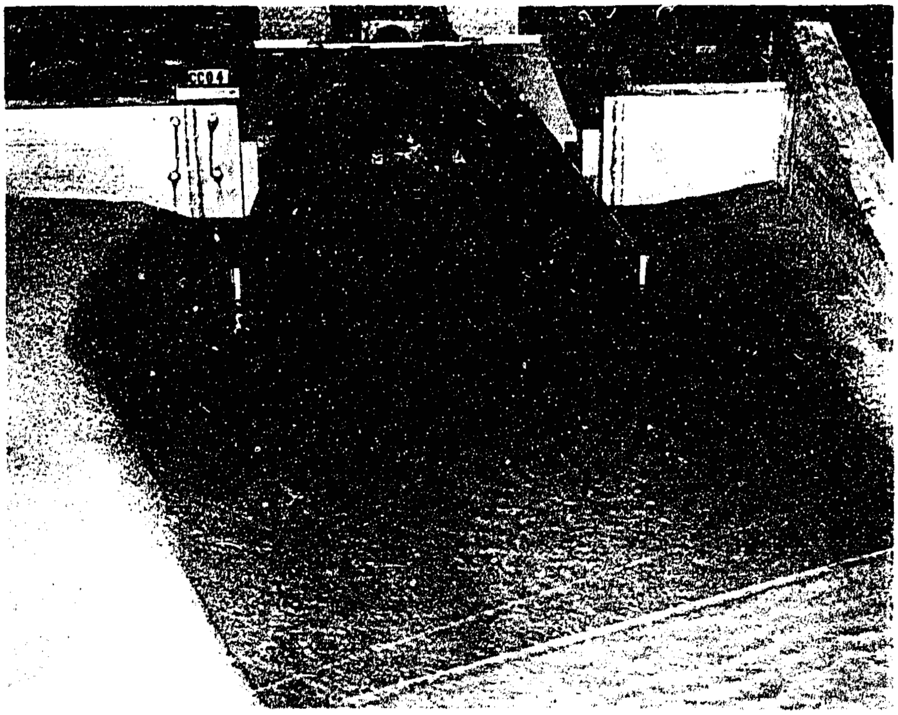
A. Left conduit discharging 2,275 second-feet



B. Both outside conduits operating - 4,550 second-feet

1:28 MODEL, CHERRY CREEK STILLING-BASIN, ORIGINAL DESIGN, INITIAL PHASE

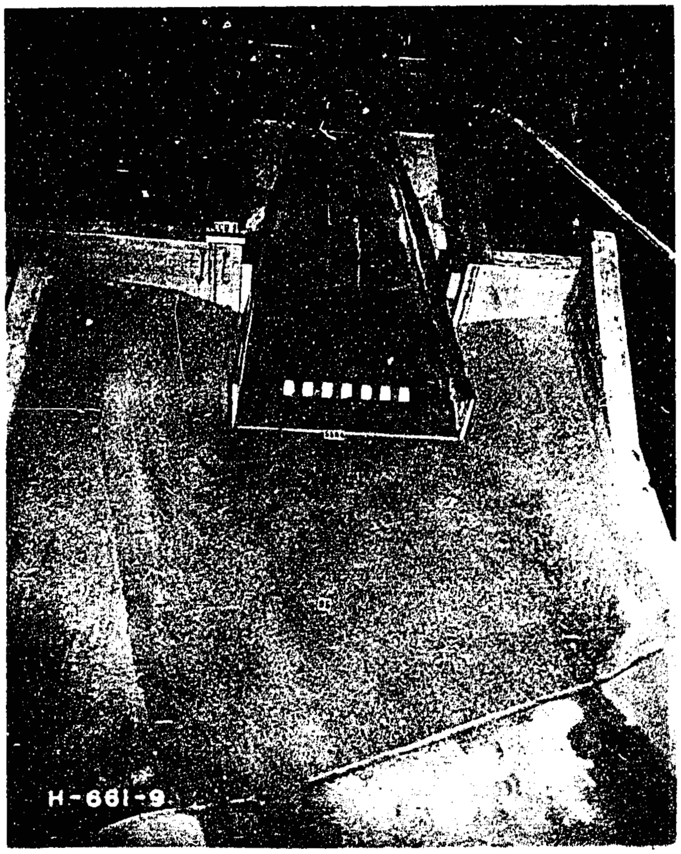
FIGURE 8



A. Center conduit discharging 1,450 second-feet

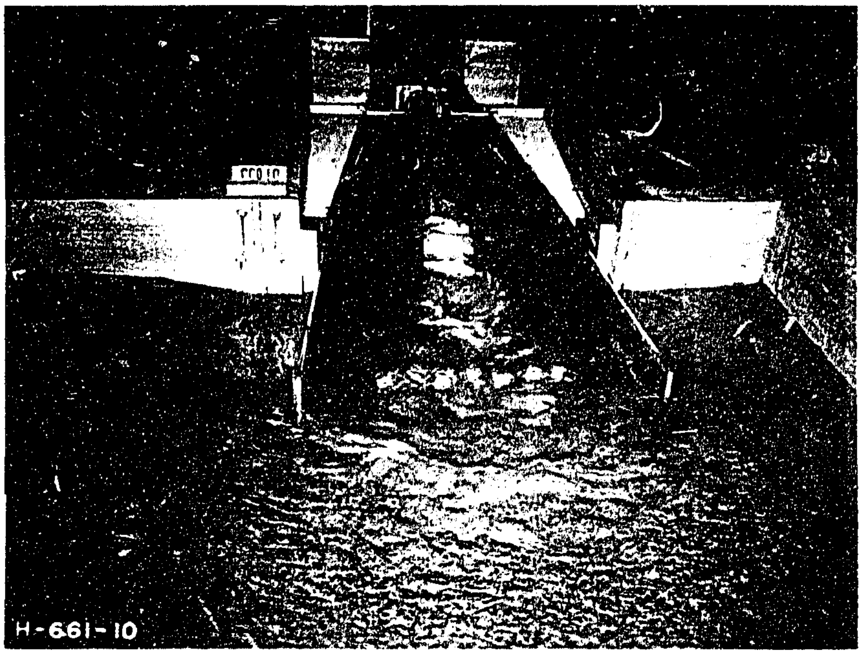
B. All conduits operating - 6,000 second-feet

1:28 MODEL, CHERRY CREEK STILLING-BASIN, ORIGINAL DESIGN, INITIAL PHASE

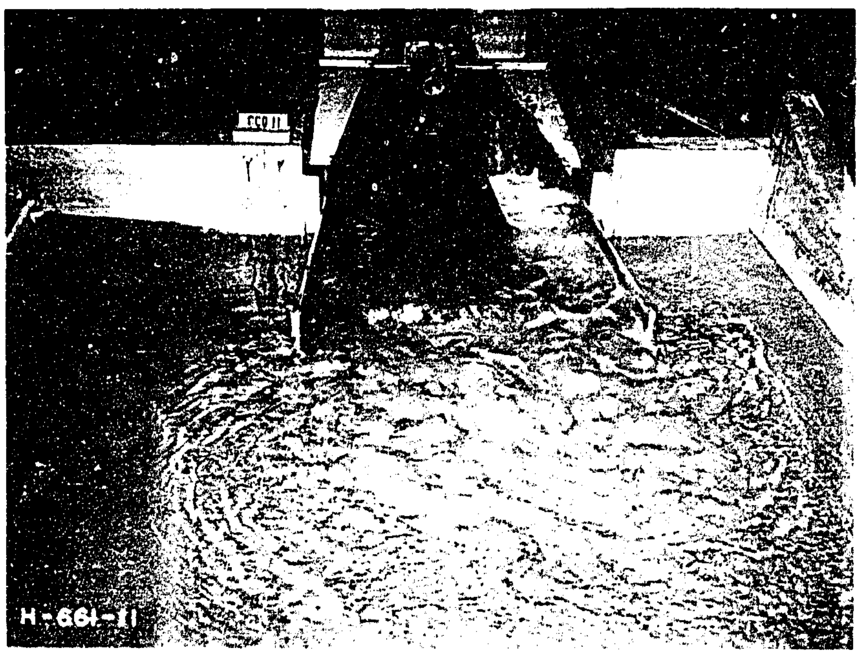


Scour after 1 hour operation 3 conduits discharging
6,000 second-feet, tailwater elevation 5502.8

1:28 MODEL, CHERRY CREEK STILLING-BASIN, ORIGINAL DESIGN, INITIAL PHASE

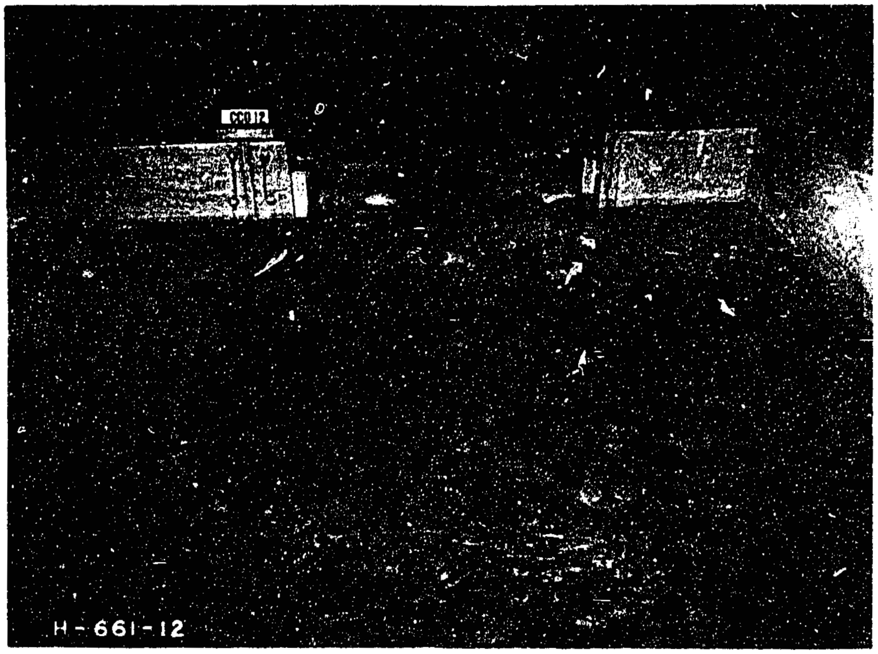


A. Hollow-jet valve discharging 1,500 second-feet

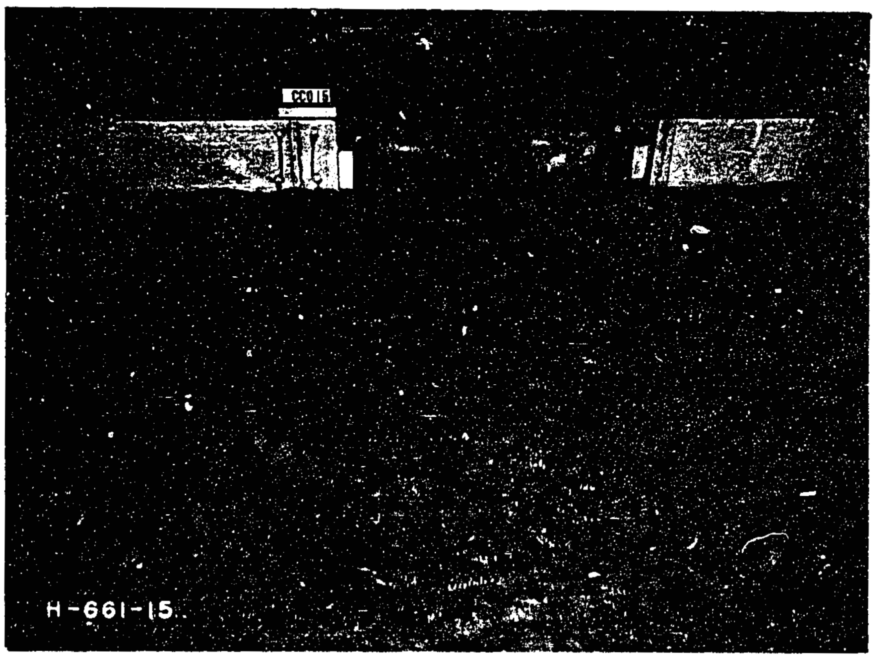


B. Left conduit discharging 2,275 second-feet

1:28 MODEL, CHERRY CREEK STILLING-BASIN, ORIGINAL DESIGN, FINAL PHASE



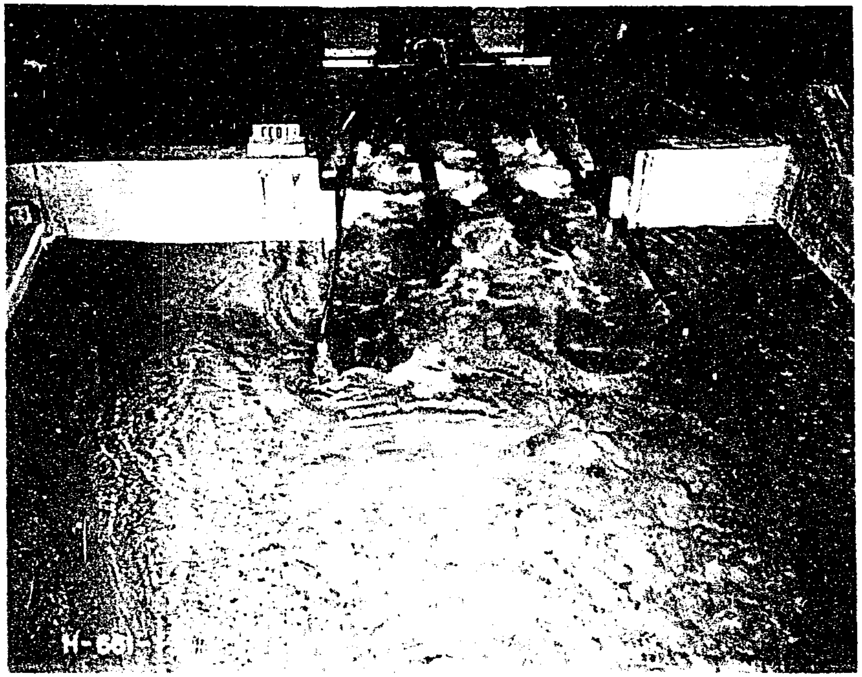
A. Both outside conduits operating - 6,000 second-feet

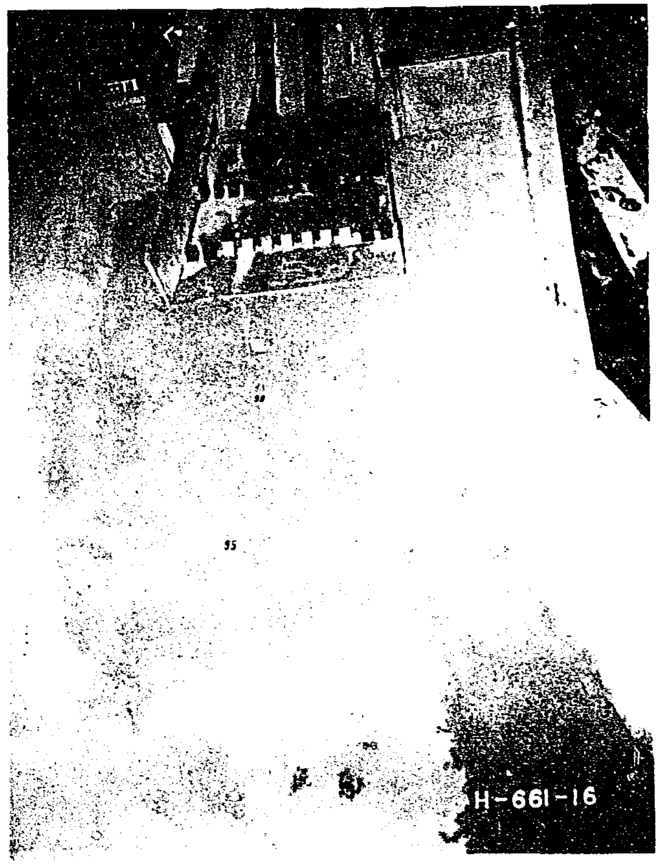


B. All conduits operating - 9,400 second-feet

1:28 MODEL, CHERRY CREEK STILLING-BASIN, ORIGINAL DESIGN, FINAL PHASE

FIGURE 12





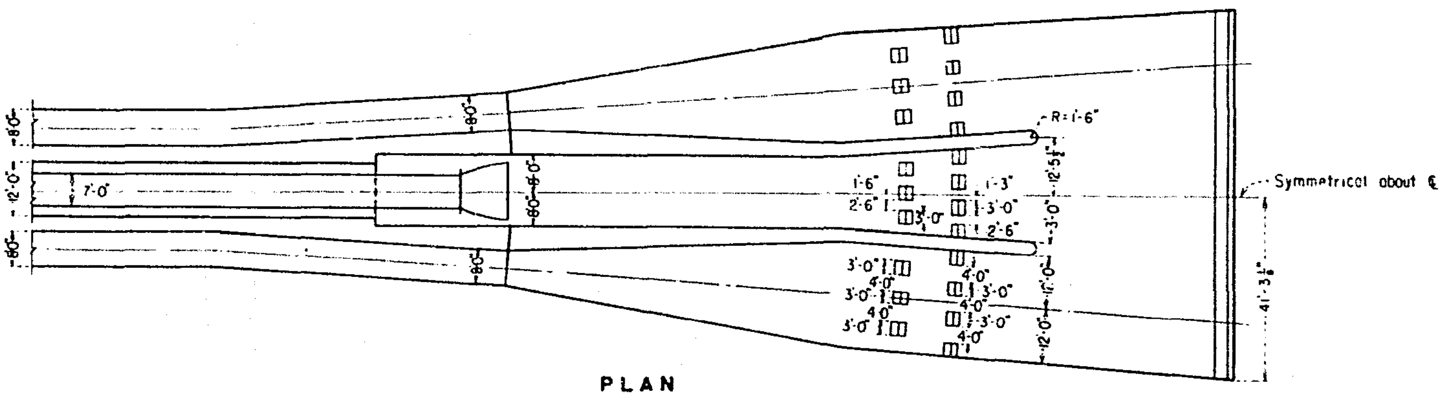
A. All conduits operating - 6,000 second-feet

B. Scour after 1 hour operation, 3 conduits discharging 6,000 second-feet. Tailwater elevation 5502.8.

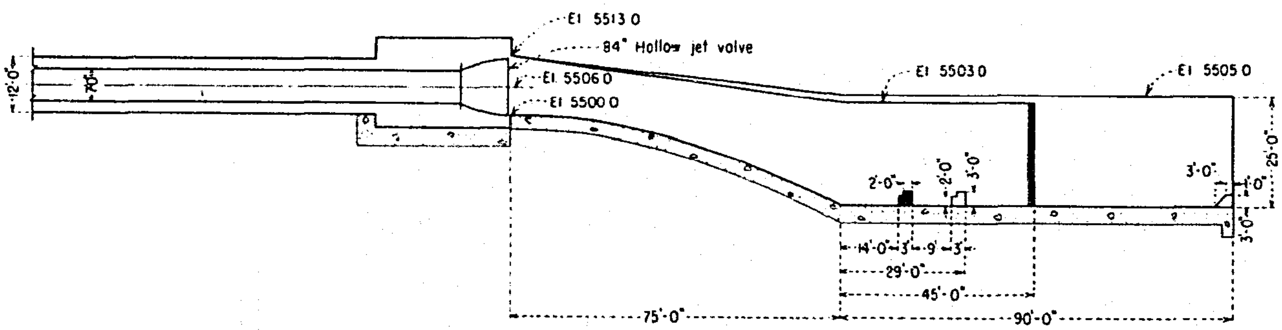
1:28 MODEL, CHERRY CREEK STILLING-BASIN, ORIGINAL DESIGN, FINAL PHASE

Scour after one hour operation, 3 conduits discharging 6,000 second-feet, tailwater elevation 5502.8.

1:28 MODEL, CHERRY CREEK STILLING-BASIN, ORIGINAL DESIGN, FINAL PHASE, BAFFLE PIERS REMOVED



PLAN

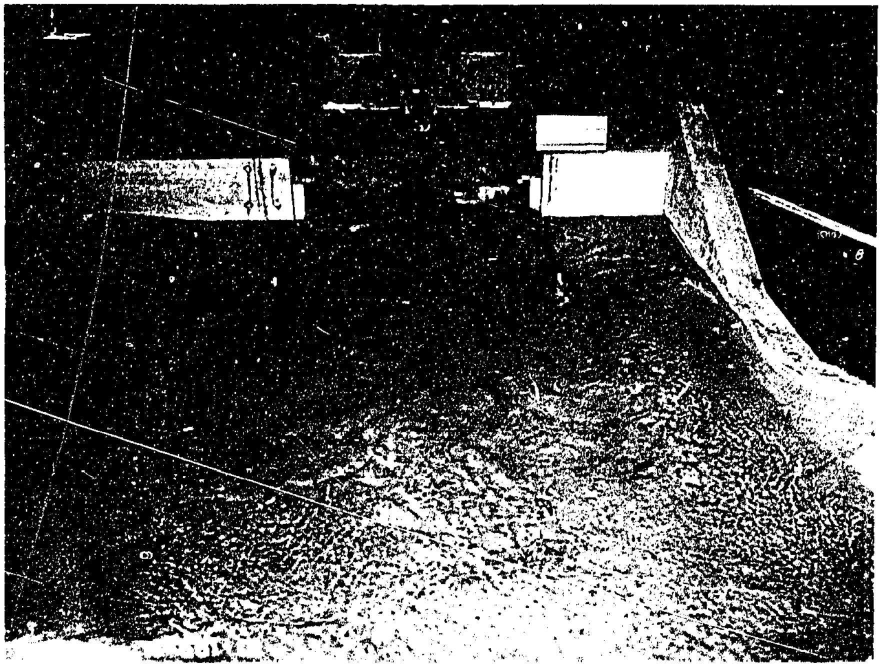


SECTION ON ℄

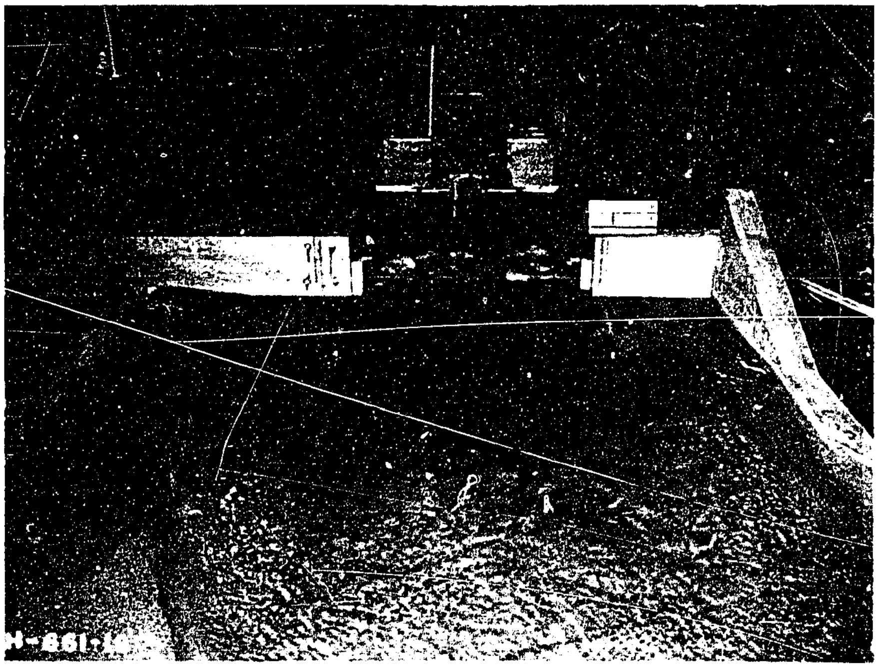
CHERRY CREEK DAM AND RESERVOIR

OUTLET WORKS AND STILLING BASIN
SECOND BAFFLE PIER DESIGN
RECOMMENDED STILLING BASIN DESIGN

FIGURE 14



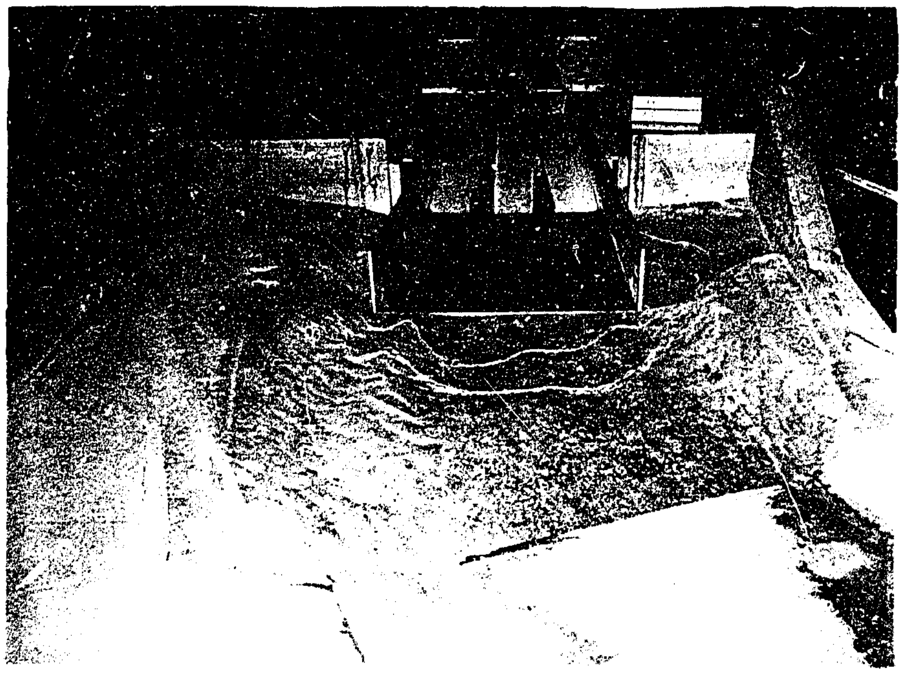
A. Both outside conduits operating - 6,000 second-feet



B. All conduits operating - 6,000 second-feet

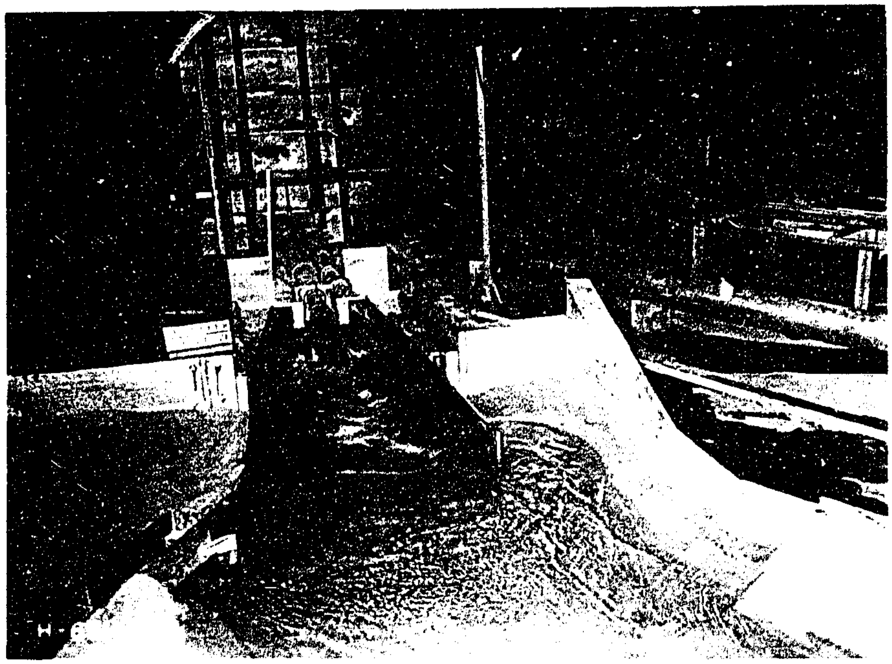
1:28 MODEL, CHERRY CREEK STILLING-BASIN,
SECOND BAFFLE PIER DESIGN, FINAL PHASE

FIGURE 16

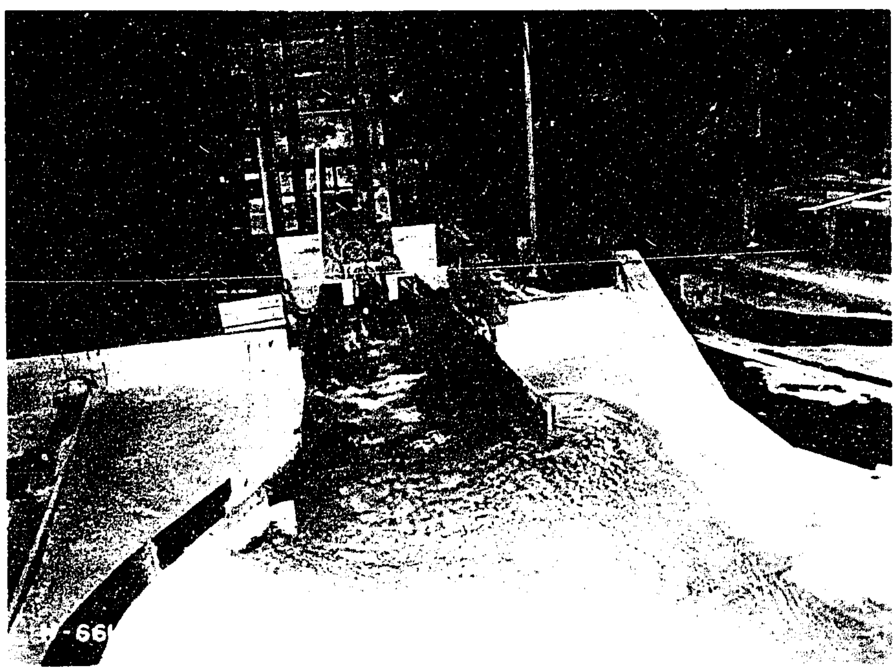


Scour after one hour operation, 3 conduits discharging
6,000 second-feet, tailwater elevation 5502.8

1:28 MODEL, CHERRY CREEK STILLING-BASIN,
SECOND BAFFLE PIER DESIGN, FINAL PHASE

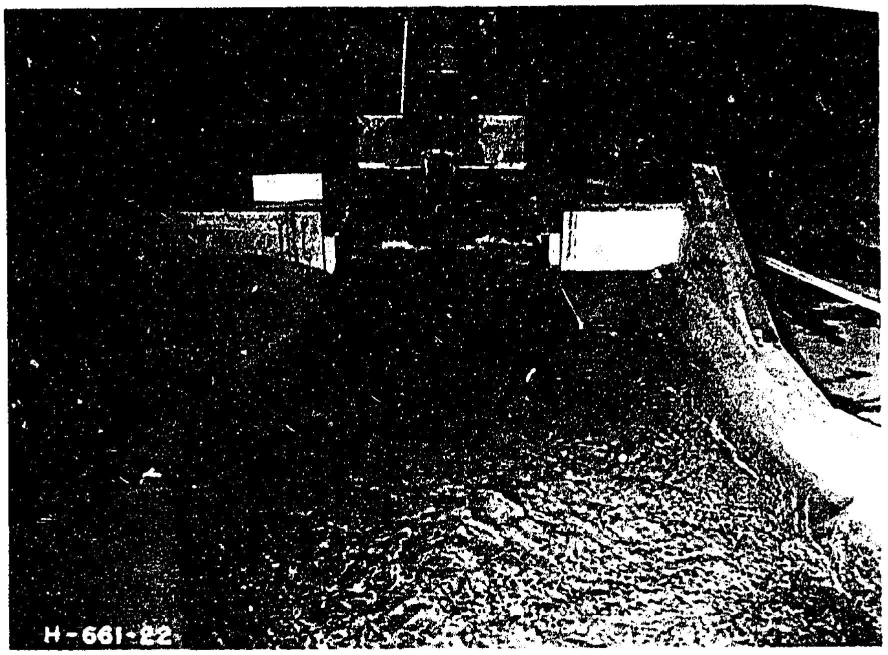


A. Hollow-jet valve discharging 1,500 second-feet.
Flow is along centerline of basin.

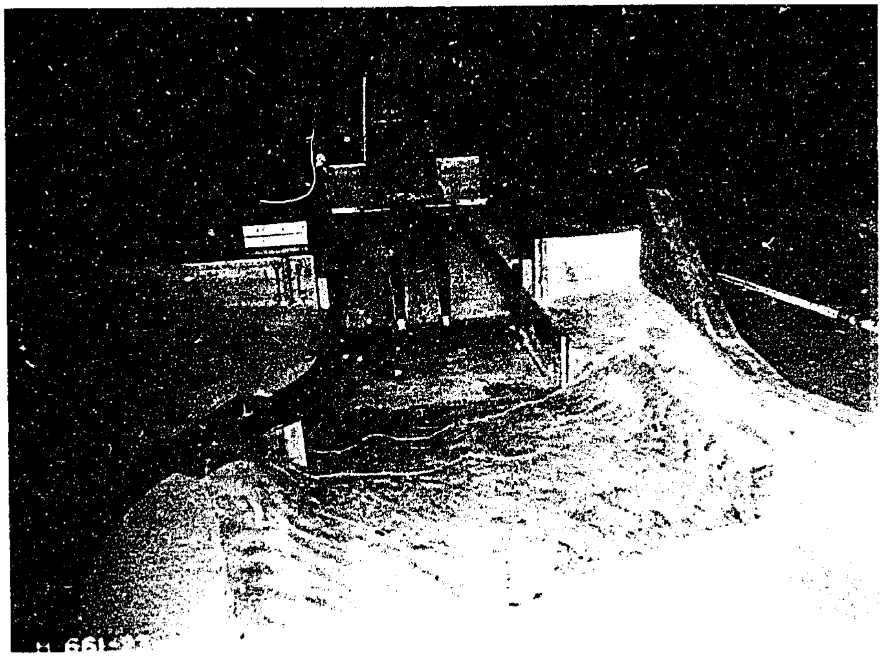


B. Hollow jet valve operating - 1,500 second-feet.
Flow is to the right of basin centerline.

1:28 MODEL, CHERRY CREEK SPILLING-BASIN, NO DIVIDING WALLS, FINAL PHASE



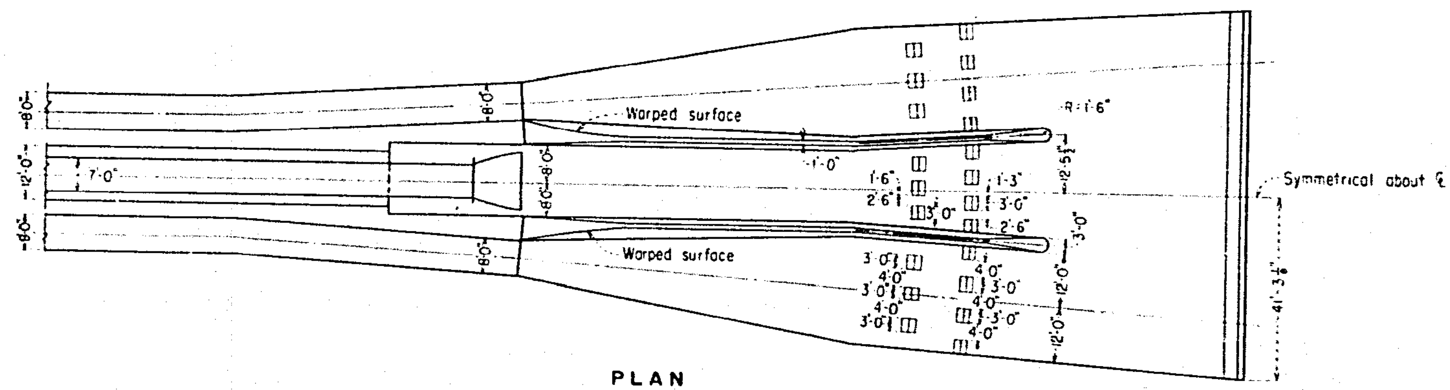
A. All conduits operating - 6,000 second-feet



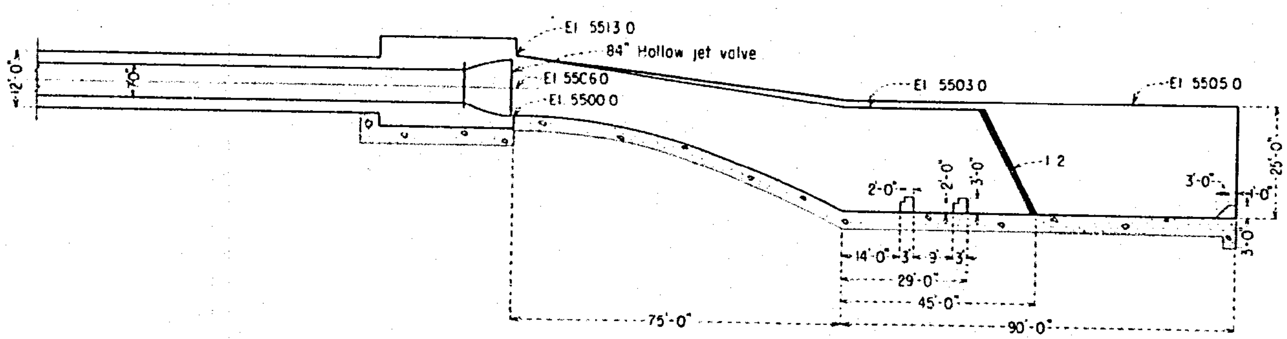
B. Scour after 1 hour operation, 3 conduits discharging 6,000 second-feet. Tailwater elevation 5502.8.

1:28 MODEL, CHERRY CREEK STILLING-BASIN, SHORT DIVIDING WALLS, FINAL PHASE

FIGURE 19



PLAN



SECTION ON ℄

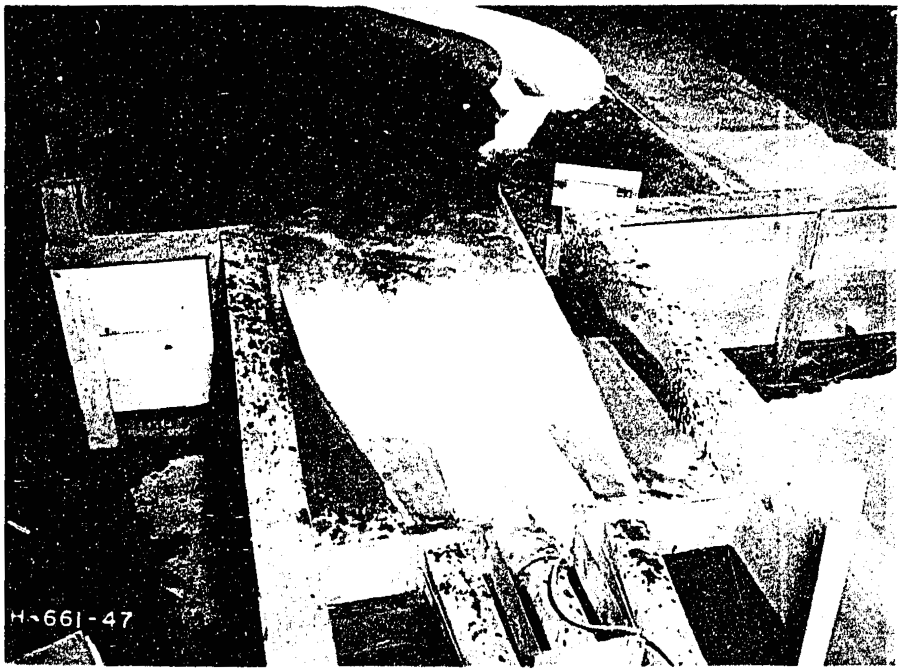
CHERRY CREEK DAM AND RESERVOIR
OUTLET WORKS AND STILLING BASIN
SECOND DIVIDING WALL DESIGN

FIGURE 20

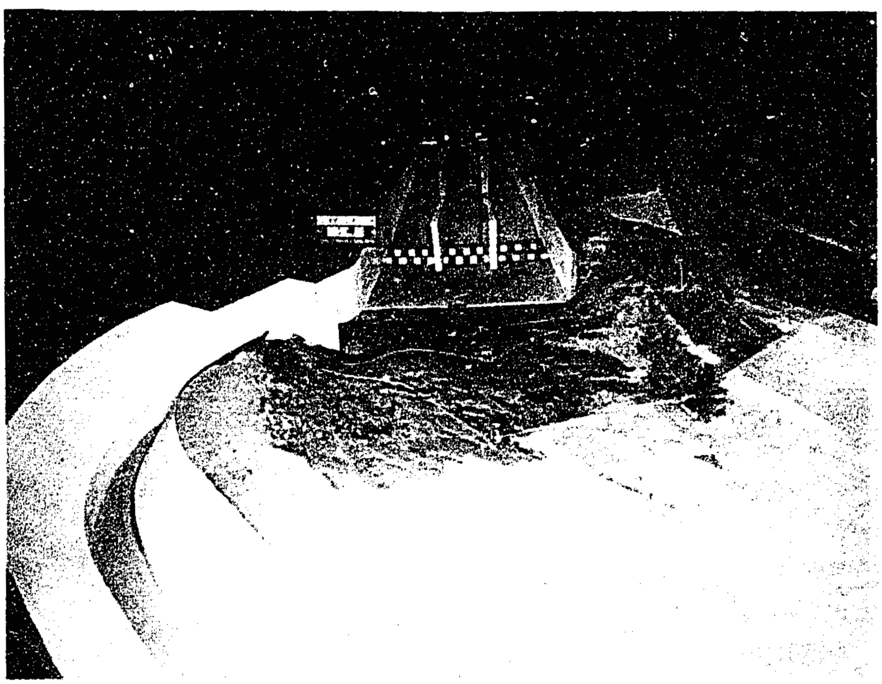
A. All conduits operating - 6,000 second-feet

B. Both outside conduits operating - 6,000 second-feet

1:28 MODEL, CHERRY CREEK STILLING-BASIN, SECOND DIVIDING WALL DESIGN, FINAL PHASE



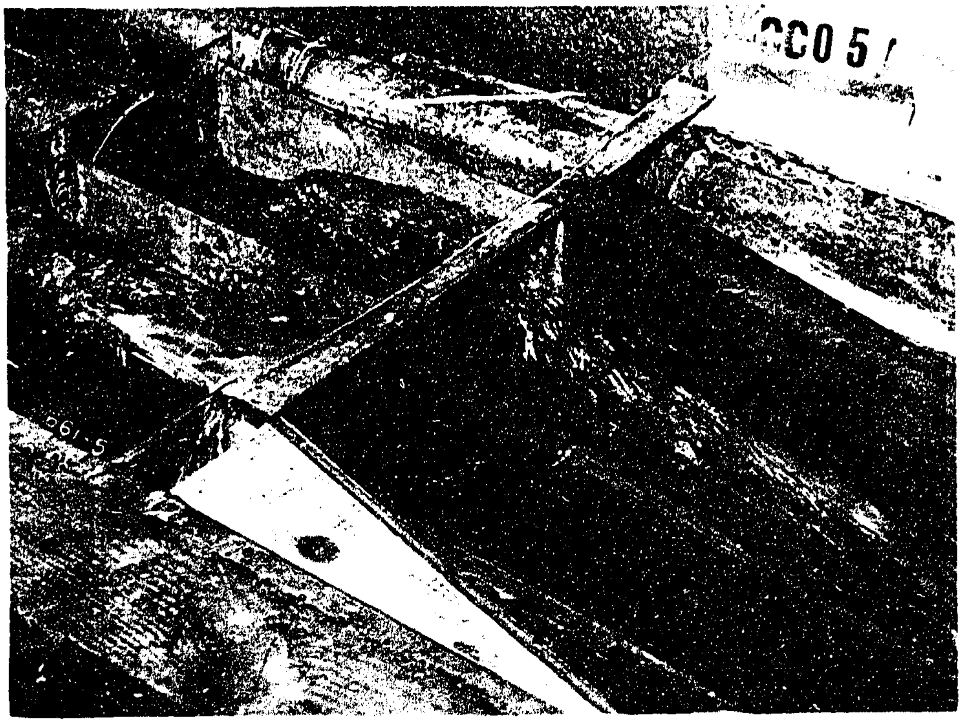
A. All conduits discharging - 9,400 second-feet



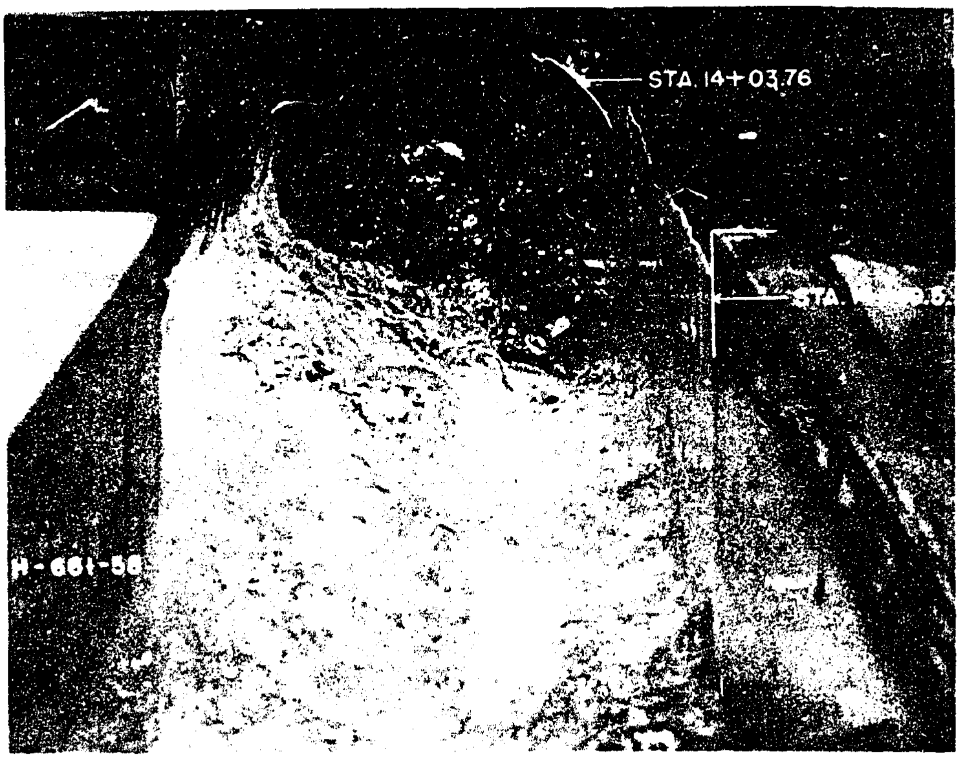
B. Scour after 1 hour operation, 3 conduits discharging 9,400 second-feet. Tailwater 5505.3

1:28 MODEL, CHERRY CREEK STILLING-BASIN, RECOMMENDED DESIGN

FIGURE 22



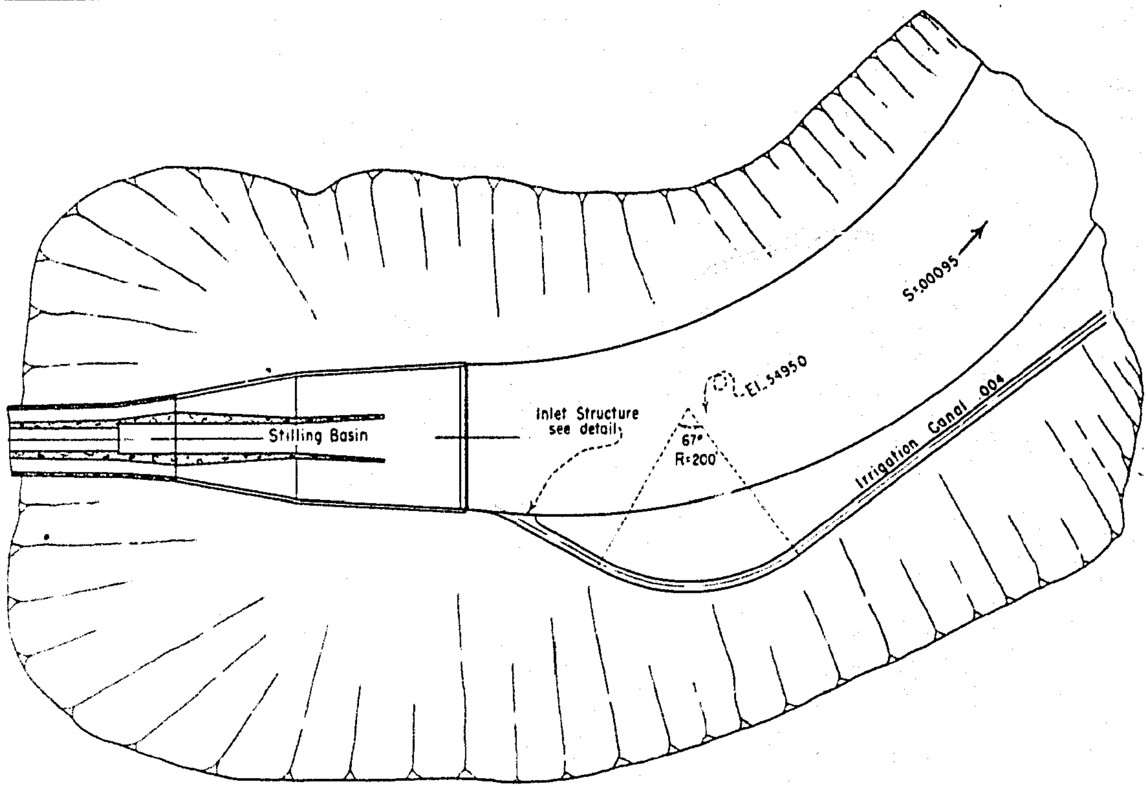
A. Flow near portal of center conduit - Initial phase, discharge 1,500 second-feet



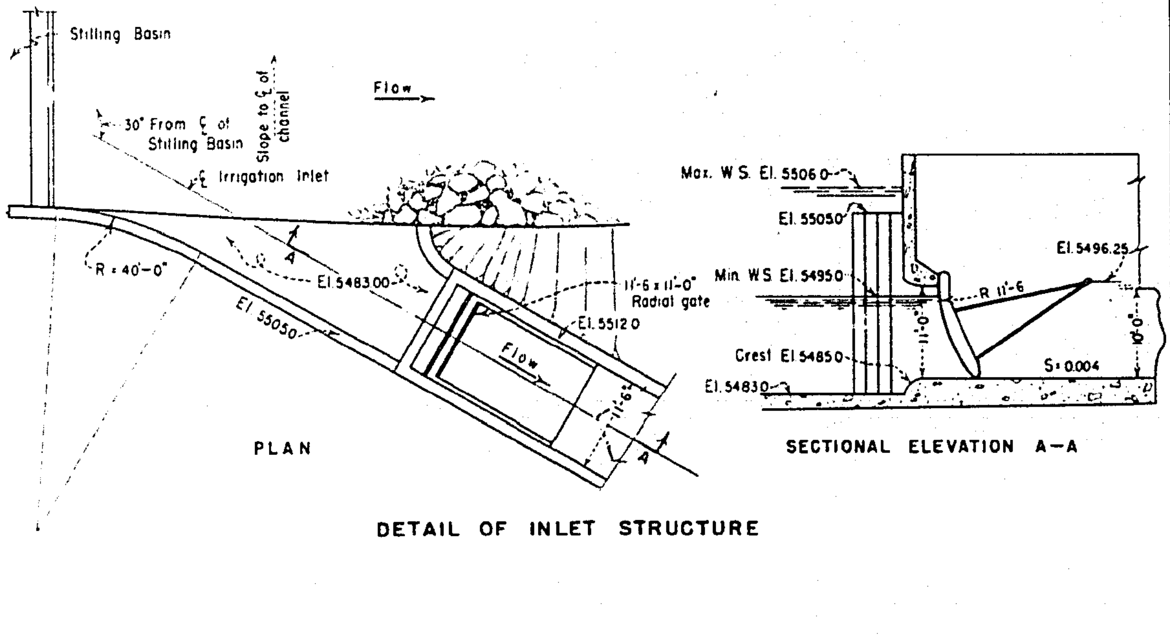
B. Flow in downstream section of left conduit with roof removed, discharge 2,275 second-feet. 1/20,000 sec. exposure.

1:28 MODEL, CHERRY CREEK OUTLETS

FIGURE 23



GENERAL PLAN



PLAN

SECTIONAL ELEVATION A—A

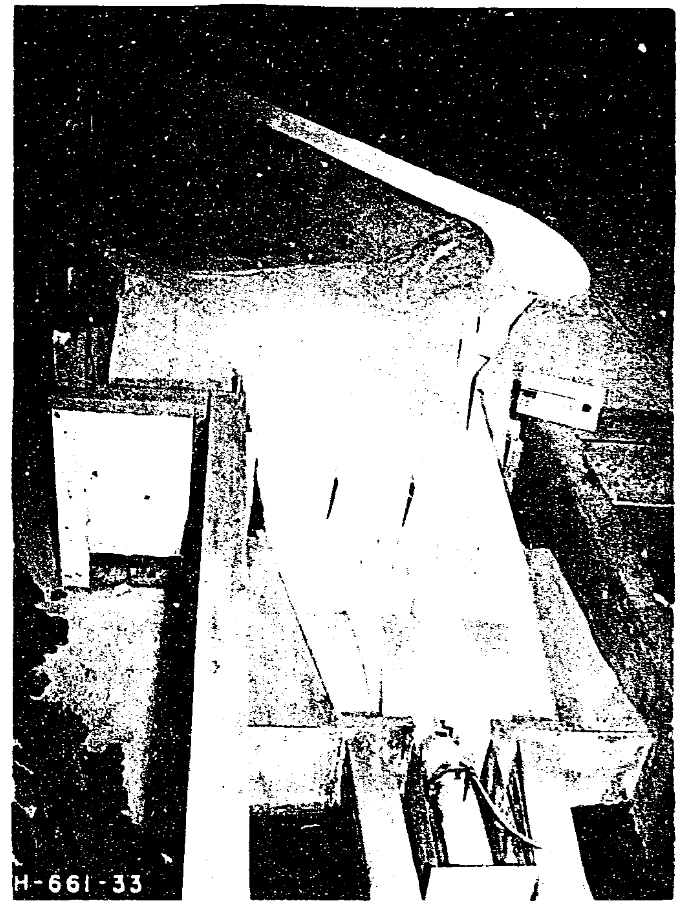
DETAIL OF INLET STRUCTURE

CHERRY CREEK DAM AND RESERVOIR

IRRIGATION INLET STRUCTURE

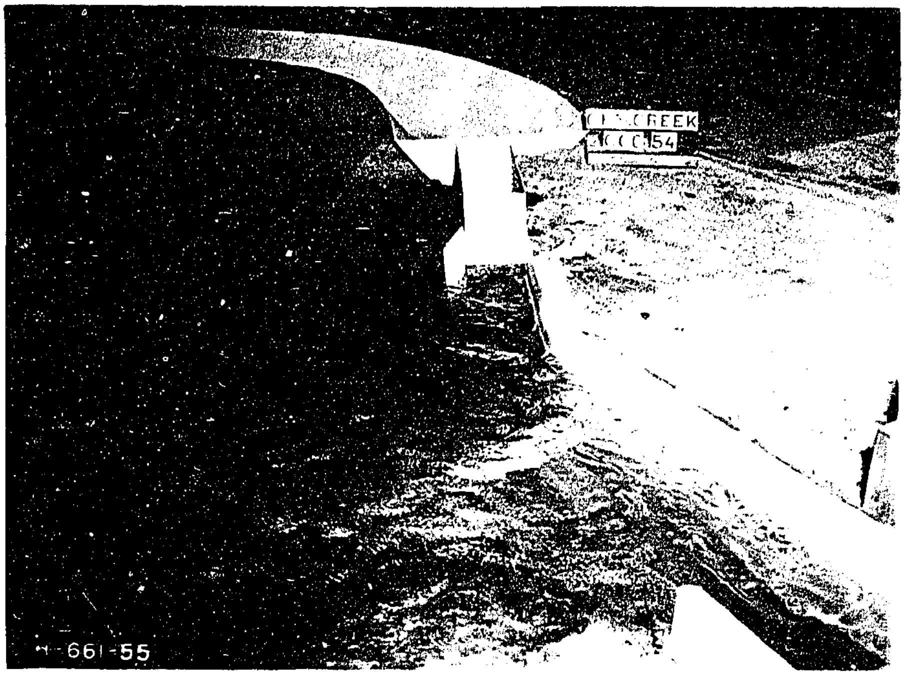
FIGURE 24

A. Looking upstream

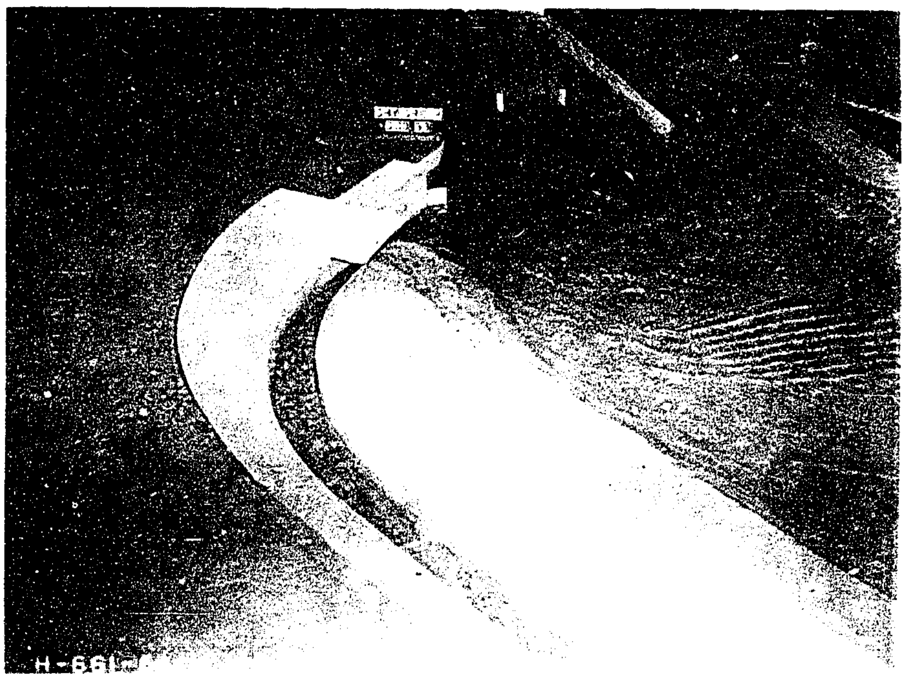


B. Looking downstream

1:28 MODEL, CHERRY CREEK OUTLET WORKS, IRRIGATION INLET INSTALLATION ON RIGHT BANK



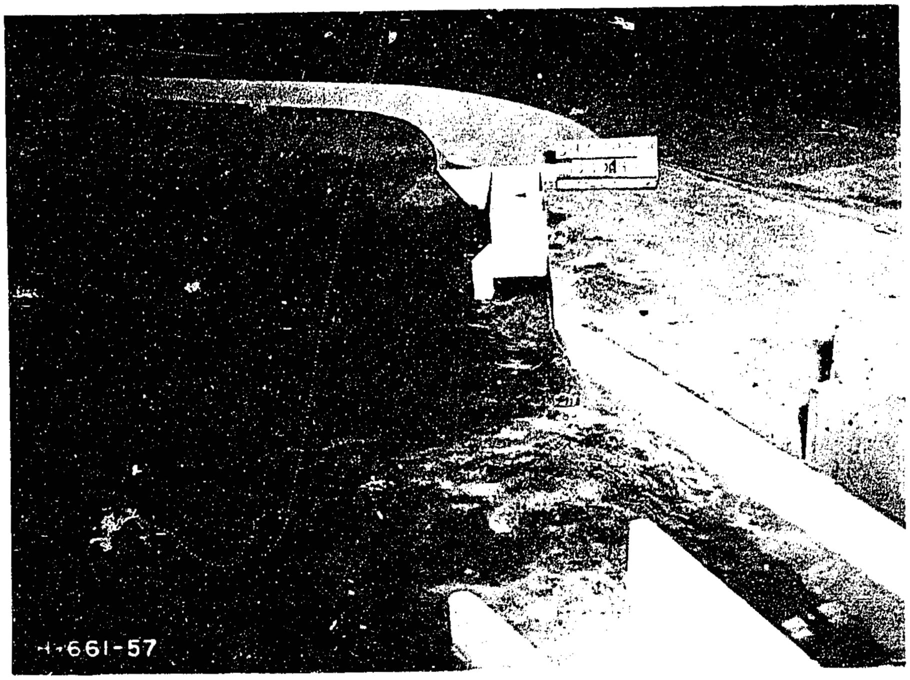
A. Flow conditions at entrance



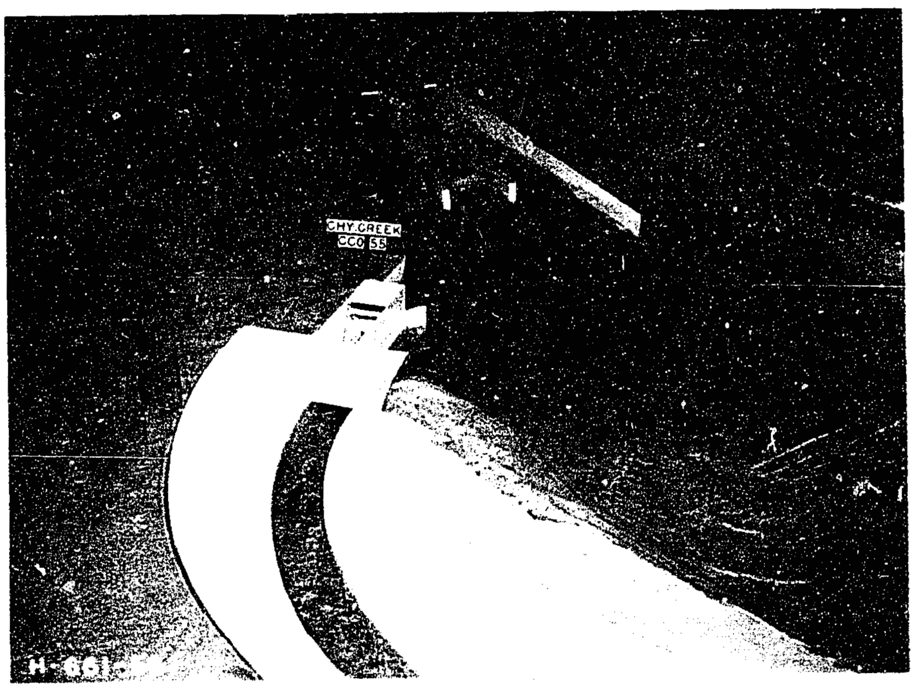
B. Flow conditions in the canal

CANAL DISCHARGE 750 SECOND-FEET - 4-FOOT GATE OPENING. HOLLOW-JET VALVE DISCHARGING 1,500 SECOND-FEET, TAILWATER ELEVATION 5497.6

1:24 MODEL, CHERRY CREEK IRRIGATION INLET



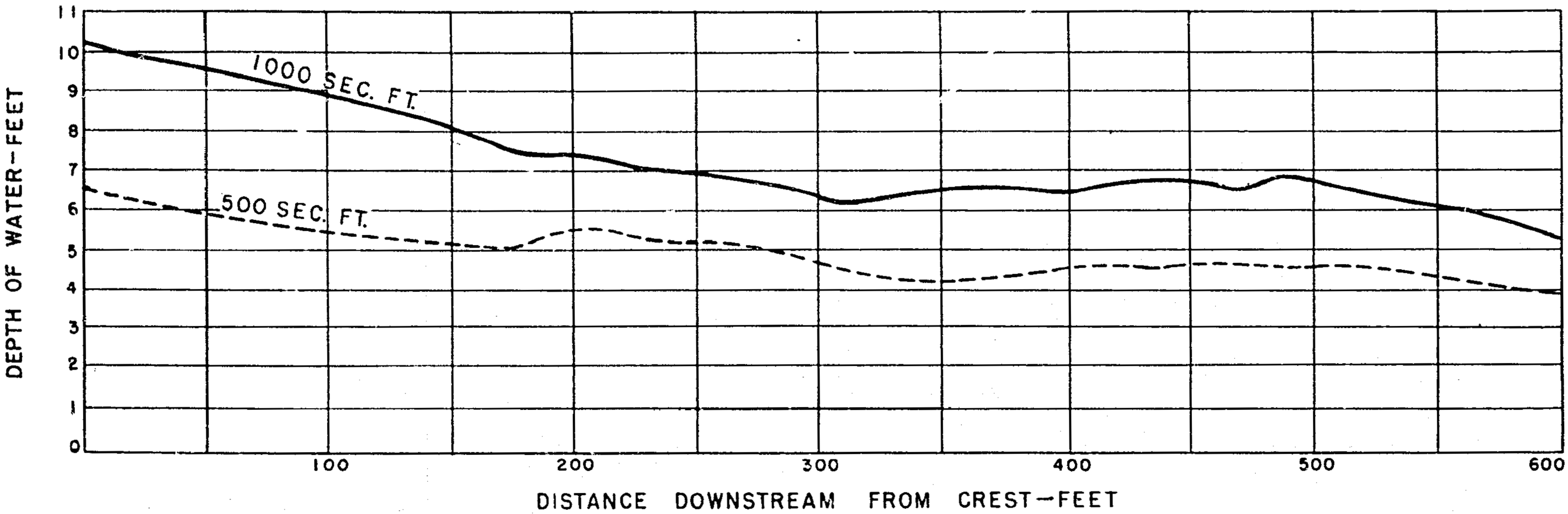
A. Flow at entrance is affected slightly by contraction



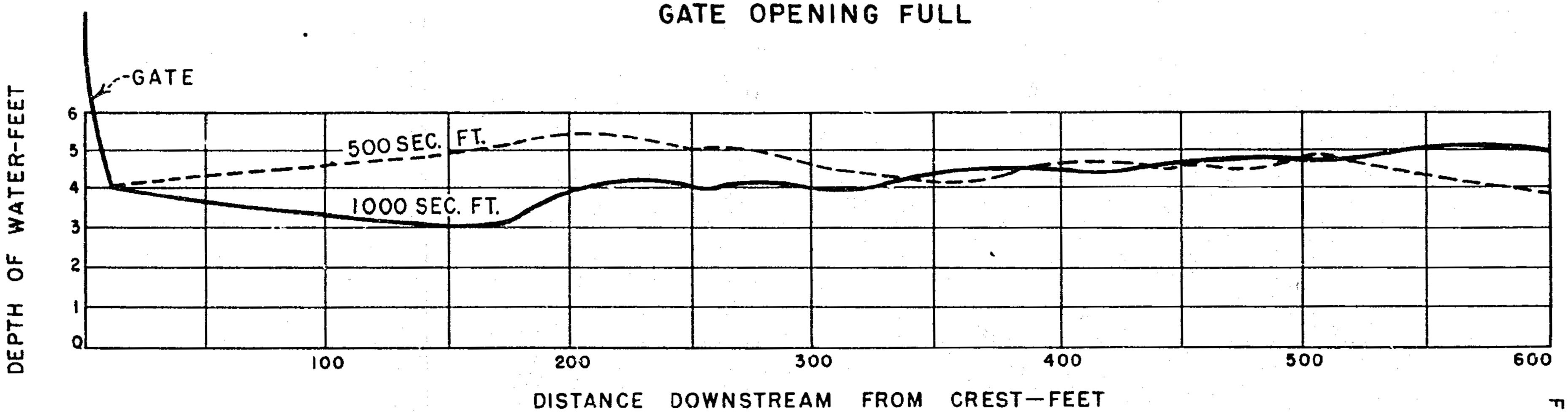
B. Flow in canal is concentrated along outside of bend

CANAL DISCHARGE 1,200 SECOND-FEET - GATE FULLY OPEN. HOLLOW-JET VALVE DISCHARGING 1,500 SECOND-FEET, TAILWATER ELEVATION 5496.3

1:28 MODEL, CHERRY CREEK IRRIGATION INLET



GATE OPENING FULL

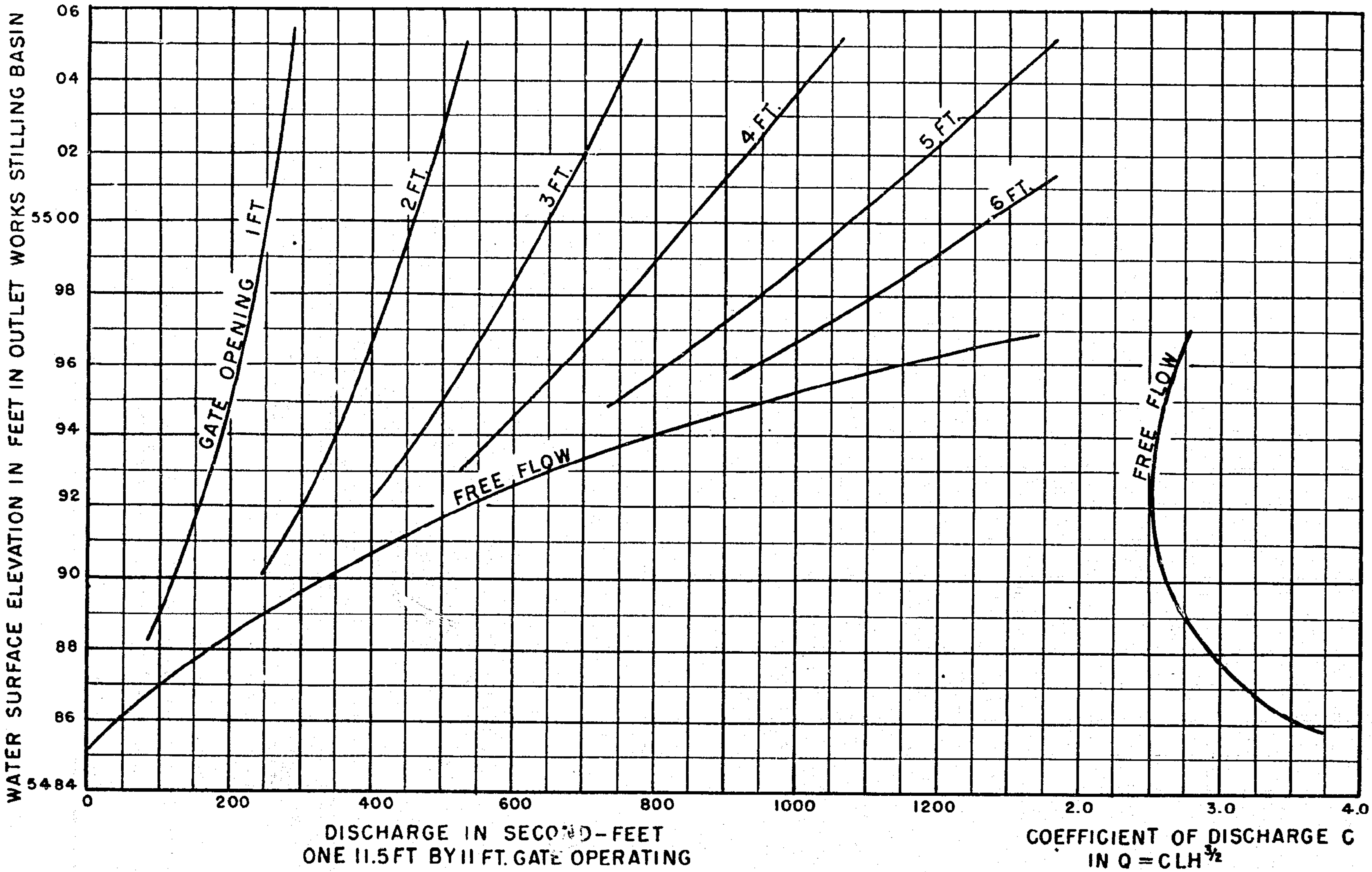


GATE OPENING 4 FEET

WATER SURFACE PROFILES IN IRRIGATION CANAL

CHERRY CREEK DAM.. 1:28 MODEL

FIGURE 27



IRRIGATION. INLET DISCHARGE CAPACITY CURVES

CHERRY CREEK DAM

FIGURE 28