HYD. 102

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BUREAU OF RECLAMATION

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HYDRAULIC LABORATORY REPORT NO. 102

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HYDRAULIC MODEL STUDIES OF COACHELLA POWER DROP STATION 290 + 00 - ALL AMERICAN CANAL PROJECT

By

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Denver, Colorado

January 21, 1942

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Branch of Design and Construction
Engineering and Geological Control
and Research Division
Denver, Colorado
January 31, 1942

Laboratory Report No. 102
Hydraulic Laboratory
Compiled By: R. R. Pomeroy

Subject: Hydraulic Model Studies of Coachella Power Drop - Station 290+00 - All-American Canal Project.

INTRODUCTION

Coachella Canal is a branch of the All-American canal system, the connection occurring at Drop No. 1, about 17 miles west of Yuma, Arizona, (figure 1). The canal crosses East Mesa, passes northwest between the Salton Sea and the Chocolate Mountains to a point near Indio, California, where it turns southwest across the Coachella Valley and then south to the Riverside-Imperial county line. The purpose of the canal is to provide water for irrigation in East Mesa and the Coachella Valley.

An abrupt change in ground elevation at Station 290+00 on the canal necessitates the construction of a drop structure. Advantage will be taken of this change in elevation to install a power unit, known as the East Mesa Power Plant, to generate electricity for the Imperial Valley.

NEED FOR MODEL STUDY

The original design called for a structure comparable in length to Drop No. 2 on the All-American Canal. Because of the smaller discharge, 2,200 second-feet as against 8,500 second-feet, it was felt that a less elaborate and shorter structure might be developed by model tests.

MODEL TESTS

A 1 to 24 scale model was constructed from the original design drawings (figure 2). The model was tested for each design using certain flow combinations.

A constant quantity representing a prototype flow of 2,200 cubic feet per second was discharged, in turn, through the spillways, through the two units of the powerhouse, and through combinations of powerhouse and spillway.

Flow conditions entering the spillways and powerhouse, down the spillways, and in the stilling pool were observed. Profiles of the water surface in the spillway were taken for design No. 2. Scour downstream from the lower warp was carefully noted for each design.

RESULTS FROM ORIGINAL DESIGN

Tests on this design disclosed that the perforated piers in the central section at the entrance of the drop structure were not properly located. These piers are built with a series of openings through them as evolved in the All-American Canal Drops, the purpose being to reduce surging in the forebay and to equalize the pressures on the two sides of the piers when a large drawdown occurs on one side. Instead of being placed adjacent to the spillways where the high velocities and consequent drawdown occur, they were located in the center of the channels leading to the two powerhouse units (figure 2). A proper relocation of these piers relieved the trouble, and they functioned as intended (figure 4).

Model tests indicated that the original design, with the exception of the above change, would operate satisfactorily (figures 4 and 5). The approach flow conditions and the conditions in the spillways were good. The induced roller in the spillway stilling pool performed in a satisfactory manner, and the amount of scour downstream from the lower warp was negligible.

DESIGN NO. 2

In visual observations of the model, it was apparent that a considerable saving in construction cost could be accomplished if the powerhouse was moved to one side in such a position that the outside powerhouse wall would replace a portion of one of the spillway training walls (figure 6). This design eliminated two costly structures, a bridge spanning one of the spillways to give access to the powerhouse, and a considerable length of the massive training wall.

At the same time the thickness of the walls of the approaches to the powerhouse was decreased, as such thickness seemed unnecessary structurally.

These changes had no detrimental effects on the performance of the structure, and it was therefore decided to work exclusively with variations of this unsymmetrical type of drop in subsequent tests.

An effort was made to eliminate one or both sets of bucket teeth and to raise the floor elevation in the bucket (figure 7). By calculation

it had been determined that the pool was too deep if a hydraulic jump were employed for dissipating the energy in the spillway flow. A temporary raised floor was installed and tried in conjunction with the two sets of dentates, one set of dentates, and alone. Removal of one or both sets of dentates was also attempted without the raised floor. Profiles were taken of the spillway and stilling-pool water surface under all these conditions. A comparison of these profiles seemed to indicate that the best solution still lay in the original stilling pool profile with both sets of bucket teeth in place (figure 8).

DESIGN NO. 3, FINAL DESIGN

Six changes were made in the third design (figure 9): (1) The total length, out to out of paving, was shortened; (2) the width of the spillway was decreased; (3) the profile of the spillway was changed; (4) the pier located on the center-line of the spillway was changed in length and shape; (5) the bucket teeth were respaced, and (6) riprap was placed on the side slopes of the canal downstream from the lower warp. Since operation of the model indicated that the length of the original design was unnecessarily great, the upstream warp was shortened from 105 feet to 70 feet. No detrimental effect was noted. The length of the downstream warp was similarly reduced from 105 feet to 78 feet 6 inches and was moved upstream 76 feet, steepening the slope of the spillway profile. A short concrete section 35 feet long, at the same cross-section as the canal itself, was added downstream from the warp. These changes reduced the total length to 369 feet 9 inches. When tested, a further reduction of length seemed possible. The length of the downstream warp was therefore reduced another 20 feet. This necessitated a change in the slope of the stilling pool floor from 12:1 to 9.87:1.

The width of the channel was decreased from 28 feet 4 inches to 26 feet 6 inches at the narrowest point opposite the powerhouse. This change was made for structural considerations only.

The profile of the spillway was changed in such a way that most of the profile would fall at a higher elevation than the corresponding points on the original profile. In this way a saving in excavation could be accomplished.

The pier located in the center of the upper end of the spillway channel was seen to be too short to straighten the flow before it reached the stilling pool. Several lengths were tried, but it was discovered

that no pier was completely satisfactory, there being a marked tendency in all cases toward the formation of a fin of water from the downstream end of the pier to the pool. A pier 70 feet in length was finally settled upon as giving the best results in this respect. The pier shape was streamlined as much as possible in order to create minimum disturbance (figure 12).

A minor change was made in the shape of the piers at the downstream end of the powerhouse. All the piers, with the exception of the one replacing a portion of the spillway wall, were made 6 feet 3 inches in length, and the downstream faces were made vertical.

The teeth in the spillway were respaced, the spaces between the teeth in the middle being made the smallest. The purpose of this was to produce better distribution of water in the pool by breaking up the fin which formed at the downstream end of the spillway pier.

Riprap, of a size equivalent to 1- to 4-foot rock on the prototype, was placed on the 1½ to 1 side slopes of the canal below the downstream warp. The riprap on the model extended downstream for a distance corresponding to 35 feet on the prototype. Negligible erosion of the sand downstream from the riprapped area indicated this to be sufficient (figure 11). The performance should be satisfactory.

CONCLUSIONS

In view of the model tests, the following changes in the original design are suggested (figure 13).

1. The powerhouse may be moved from the center of the drop structure to the side without impairing the performance of the hydraulic features, with a considerable saving structurally.

2. The total length of the structure may be reduced from 481 feet 6 inches to 349 feet 9 inches.

3. The original spacing of the bucket teeth should be changed to the spacing shown.

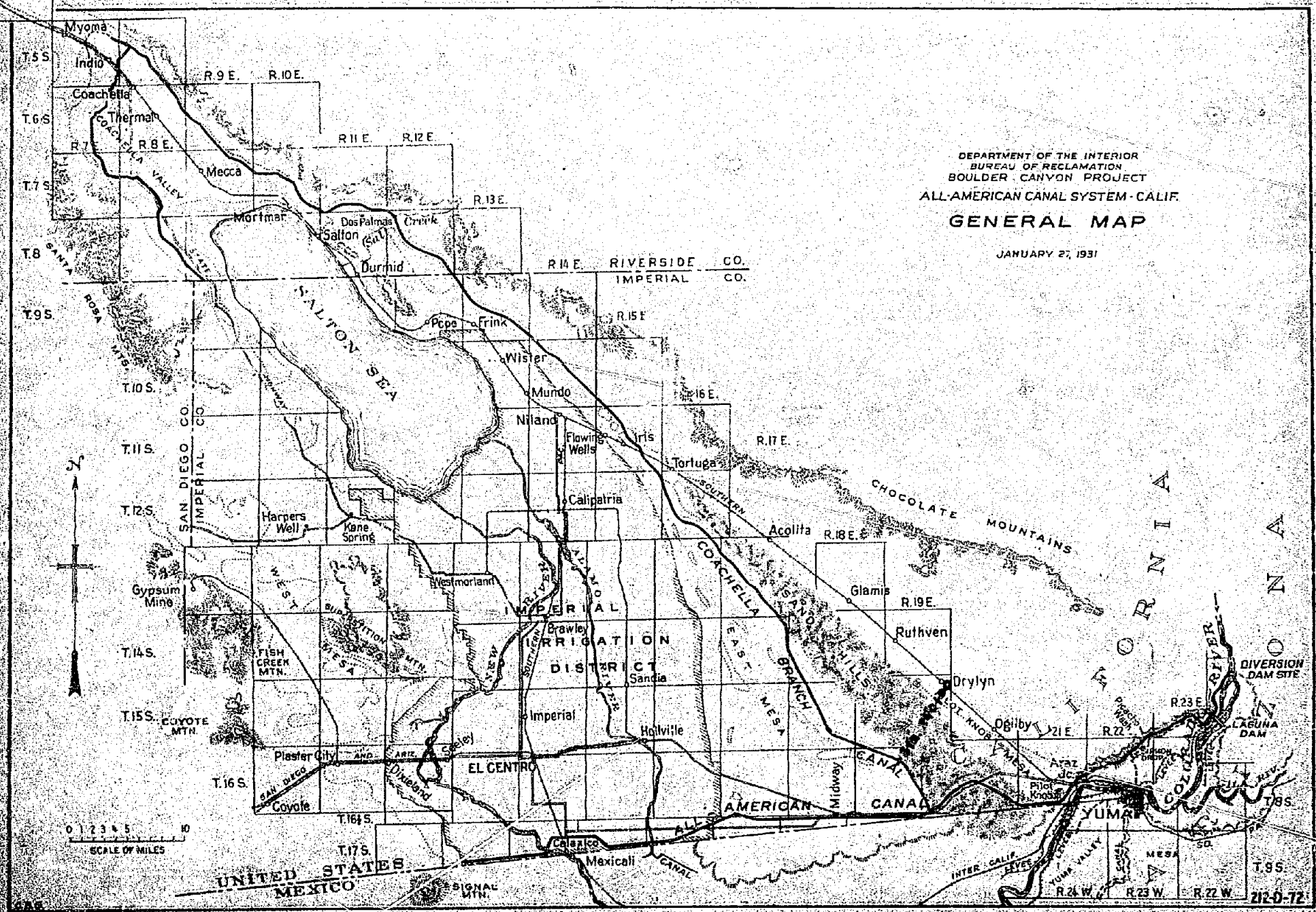
4. A pier equipped with slots should be placed next to the spillway instead of the position originally indicated.

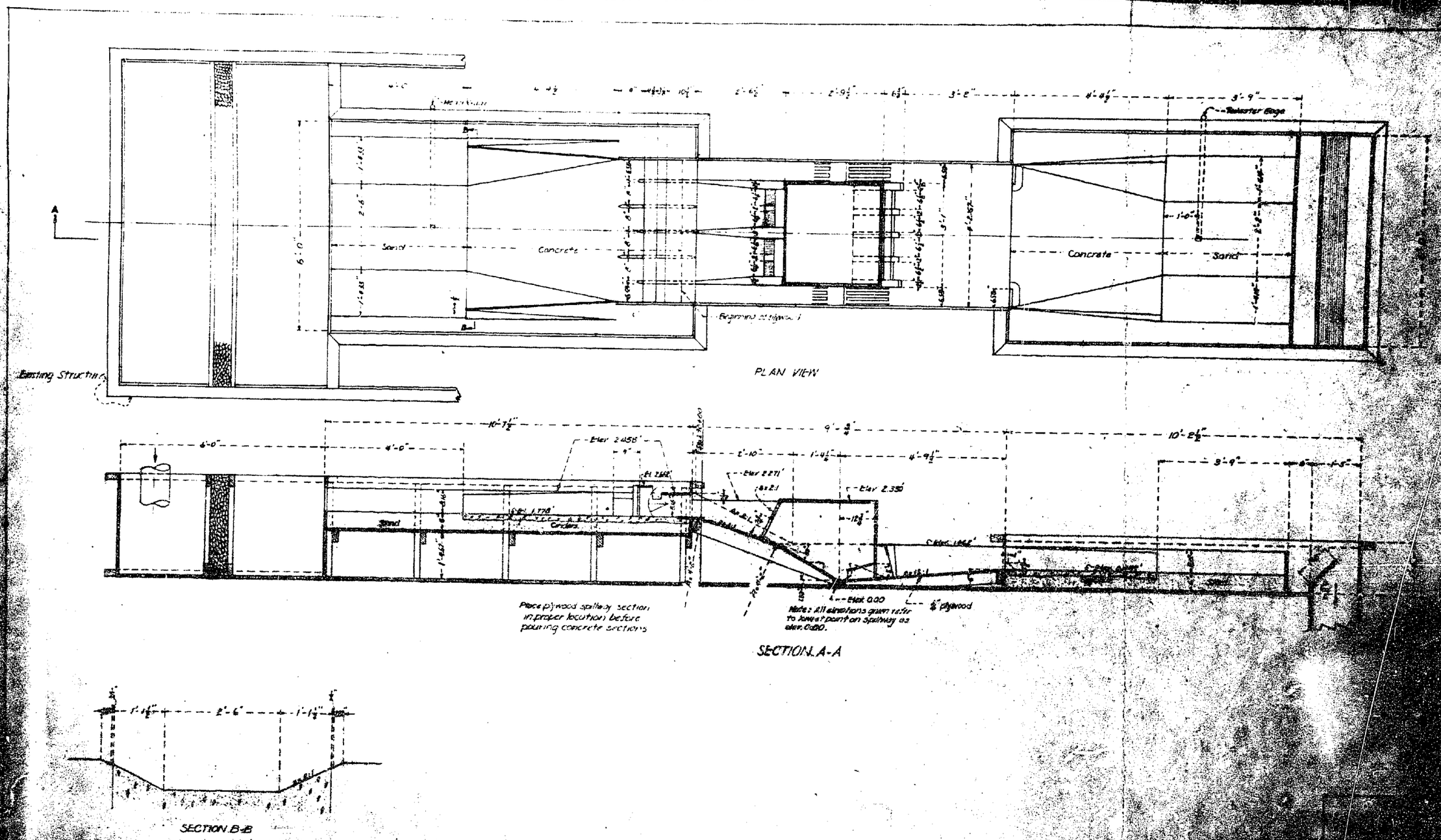
5. The width of the single spillway replacing the two spillways of the original design should be made 26 feet 6 inches in width at the narrowest point.

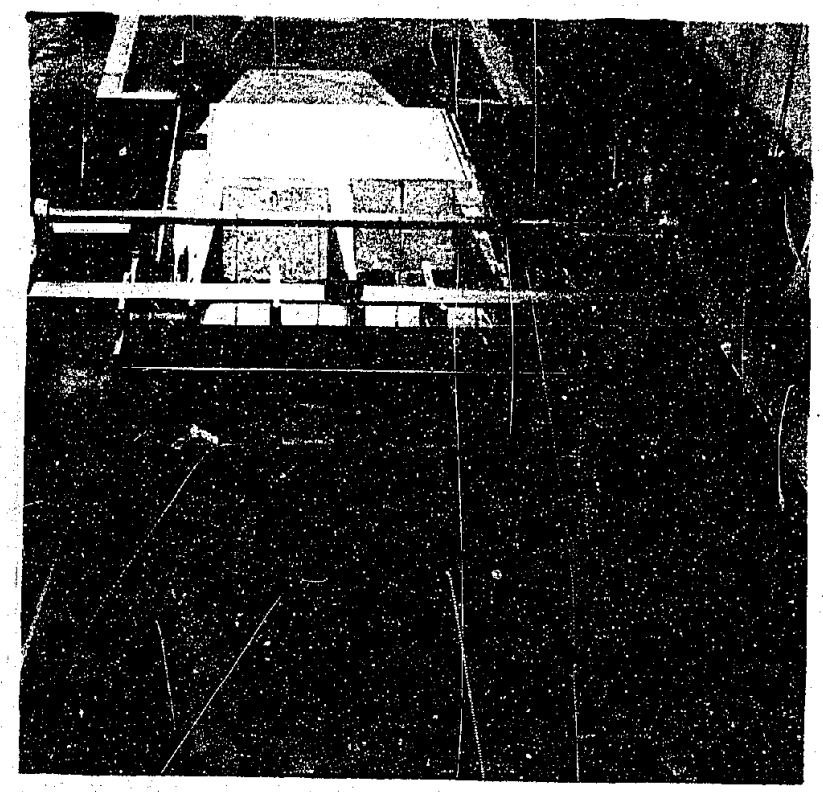
6. Riprap, 1 to 4 feet in size, should be placed on the side slopes of the canal at the downstream end of the lower concrete section, the length of the riprapped section to be determined in the field.

7. The walls of the channels leading to the powerhouse units should be reshaped and made thinner as shown.

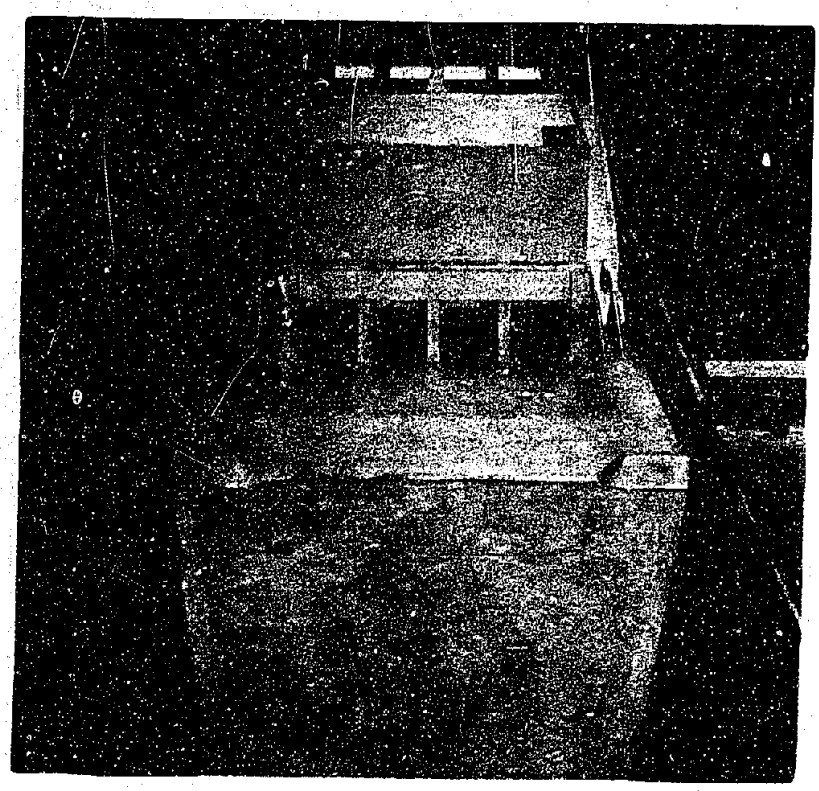
8. The piers at the downstream end of the powerhouse should be reshaped as shown.


DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
BOULDER CANYON PROJECT
ALL-AMERICAN CANAL SYSTEM - CALIF.
GENERAL MAP
JANUARY 27, 1931
T. 4 S.
T. 5 S.
T. 6 S.
T. 7 S.
T. 8
T. 9 S.
T. 10 S.
T. 11 S.
T. 12 S.
T. 14 S.
T. 15 S.
T. 16 S.
T. 16½ S.
T. 17 S.
T. 9 S.
R. 7 E.
R. 8 E.
R. 9 E.
R. 10 E.
R. 11 E.
R. 12 E.
R. 13 E.
R. 14 E.
R. 15 E.
R. 16 E.
R. 17 E.
R. 18 E.
R. 19 E.
R. 21 E.
R. 22
R. 23 E.
R. 24 W.
R. 23 W.
R. 22 W.
RIVERSIDE CO.
IMPERIAL CO.
SAN DIEGO CO.
IMPERIAL CO.
Myoma
Indio
Coachella
Thermal
COACHELLA VALLEY
Mecca
Mortmar
Dos Palmas
Salton
Salt Creek
Durmid
SALTON SEA
SANTA ROSA MTS.
Pope
Frink
Wister
Mundo
Niland
Flowing Wells
Iris
Tortuga
Calipatria
Harpers Well
Kane Spring
Westmorland
Gypsum Mine
WEST MESA
SUPERSTITION MTN.
FISH CREEK MTN.
COYOTE MTN.
Plaster City
SAN DIEGO AND ARIZ.
Dixieland
Coyote
Seeley
EL CENTRO
Brawley
IMPERIAL IRRIGATION DISTRICT
Imperial
Sandia
Holtville
Calexico
Mexicali
ALL-AMERICAN CANAL
SOUTHERN PACIFIC
COACHELLA BRANCH
EAST MESA
Midway
Acolita
Glamis
Ruthven
Drylyn
Ogilby
Araz Jc.
Pilot Knob
PILOT KNOB MESA
CHOCOLATE MOUNTAINS
YUMA
COLORADO RIVER
DIVERSION DAM SITE
LAGUNA DAM
YUMA VALLEY
INTER CALIF. RIVER
MESA
SIGNAL MTN.
UNITED STATES
MEXICO
CALIFORNIA
ARIZONA
SCALE OF MILES
0 1 2 3 4 5 10
212-D-72
Revised 4
Revised 5


Existing Structure
Sand
Concrete
Beginning of spillway
Tailwater Gage
PLAN VIEW
Elev 2.458'
Elev 2.271'
Elev 2.350'
Elev 1.778'
Cinders
Elev 0.00
Place plywood spillway section in proper location before pouring concrete sections
Note: All elevations given refer to lowest point on spillway as elev. 0.00.
¾" plywood
SECTION A-A
SECTION B-B

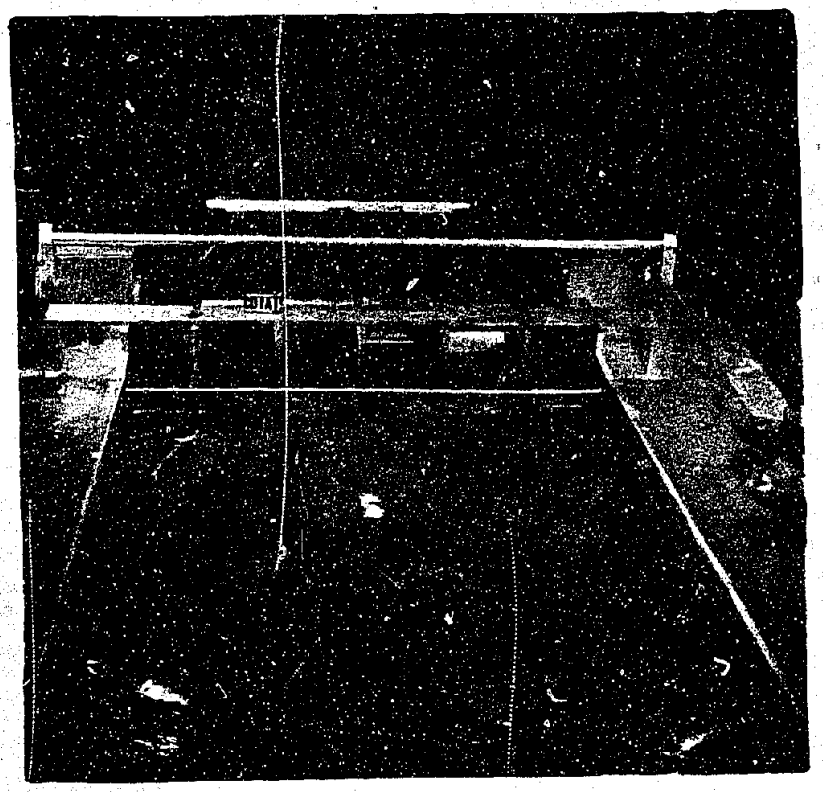


VIEW OF MODEL LOOKING DOWNSTREAM



VIEW OF MODEL LOOKING UPSTREAM

ORIGINAL DESIGN

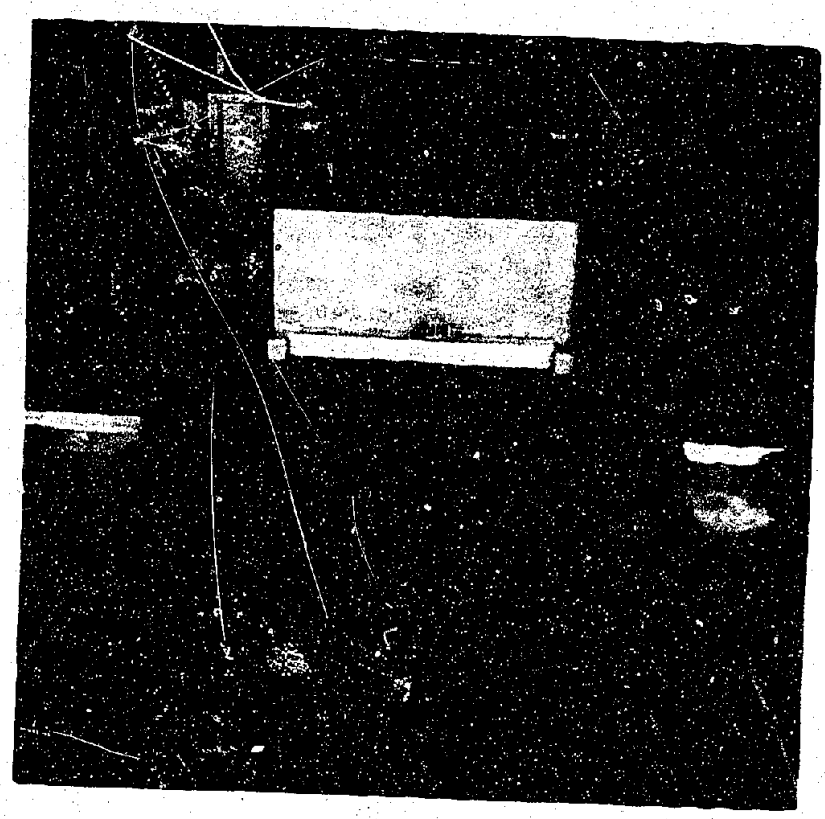


FLOW OF 2200 SECOND-FEET ENTERING POWERHOUSE

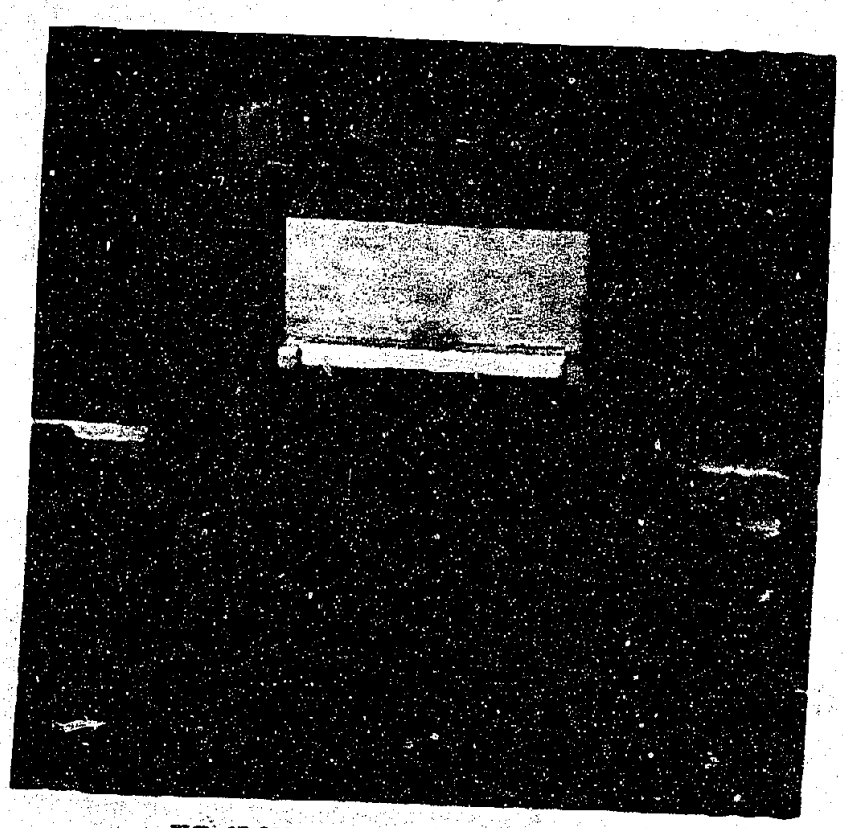
FLOW OF 2200 SECOND-FEET ENTERING SPILLWAYS

ORIGINAL DESIGN

FIGURE 5

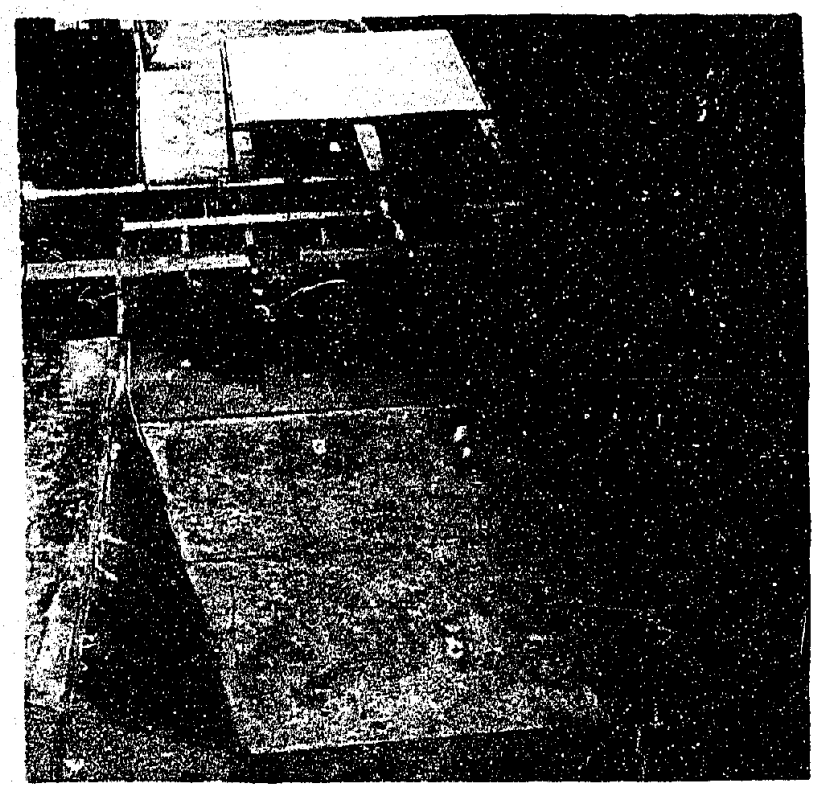


FLOW OF 2200 SECOND-FEET THROUGH POWERHOUSE



FLOW OF 2200 SECOND-FEET THROUGH SPILLWAYS

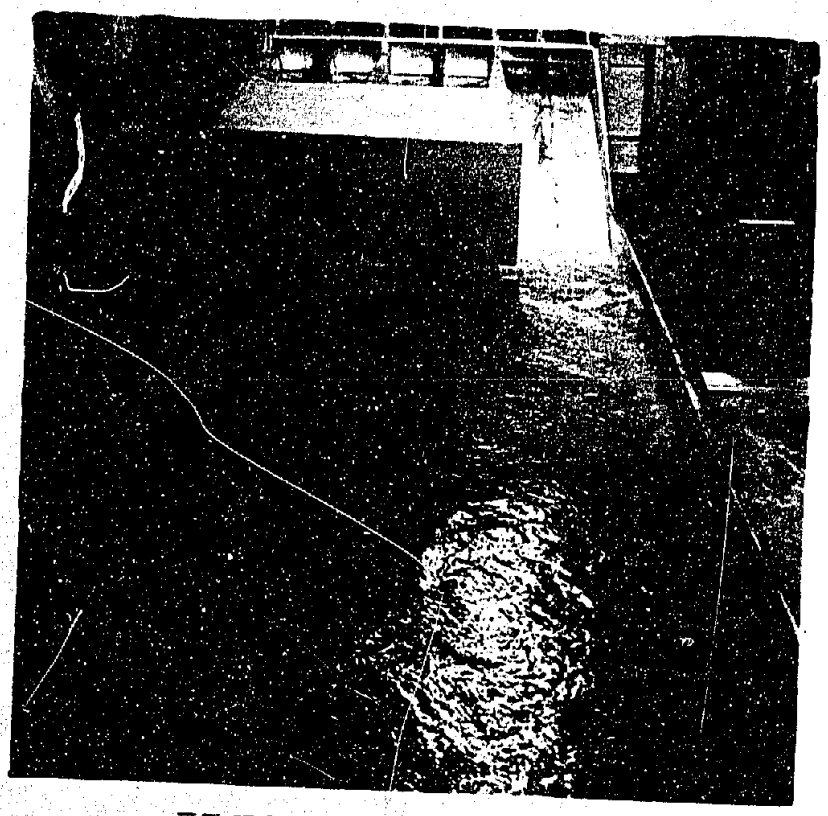
ORIGINAL DESIGN



VIEW OF MODEL LOOKING DOWNSTREAM

VIEW OF MODEL LOOKING UPSTREAM

DESIGN NO. 2

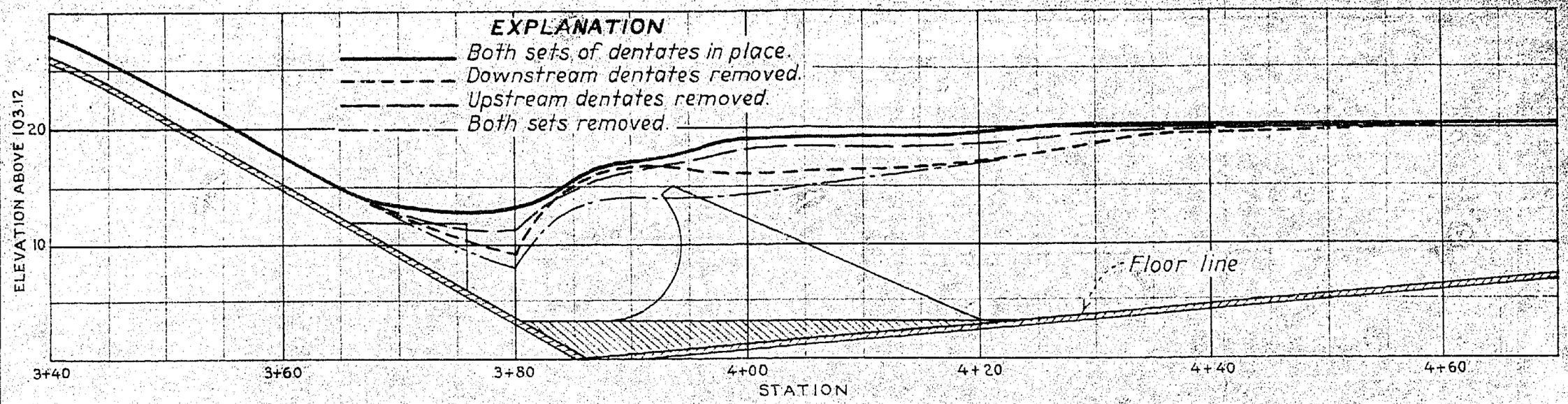


FLOW OF 2200 SECOND-FEET THROUGH SPILLWAY
BOTH SETS OF BUCKET TEETH IN PLACE

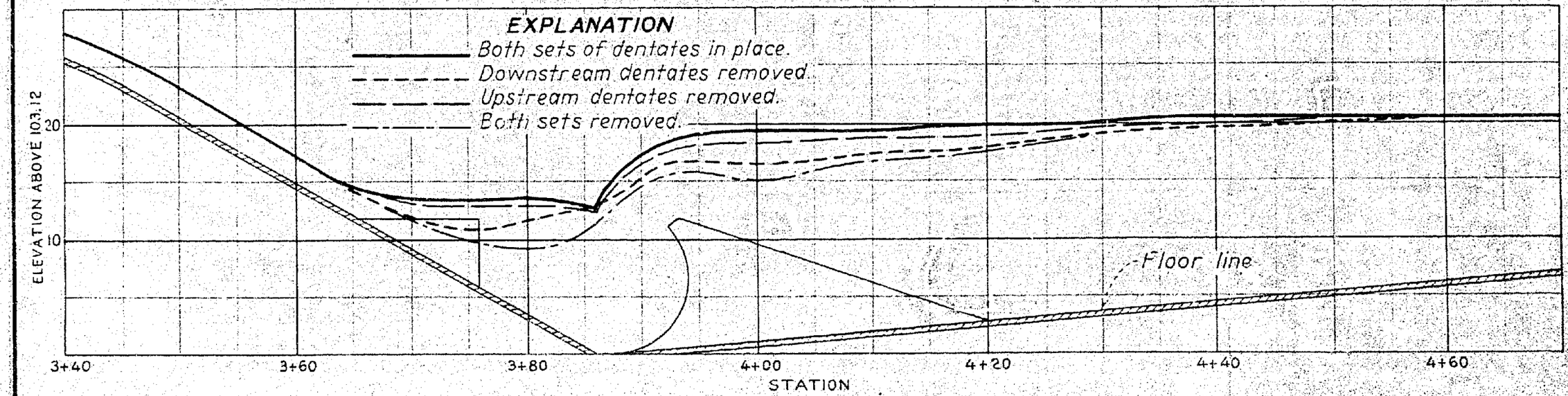
FLOW OF 2200 SECOND-FEET THROUGH SPILLWAY
BOTH SETS OF TEETH REMOVED - RAISED FLOOR

DESIGN NO. 2

FIGURE 8



MAXIMUM WATER SURFACE - RAISED FLOOR - Q = 2200 c.f.s.



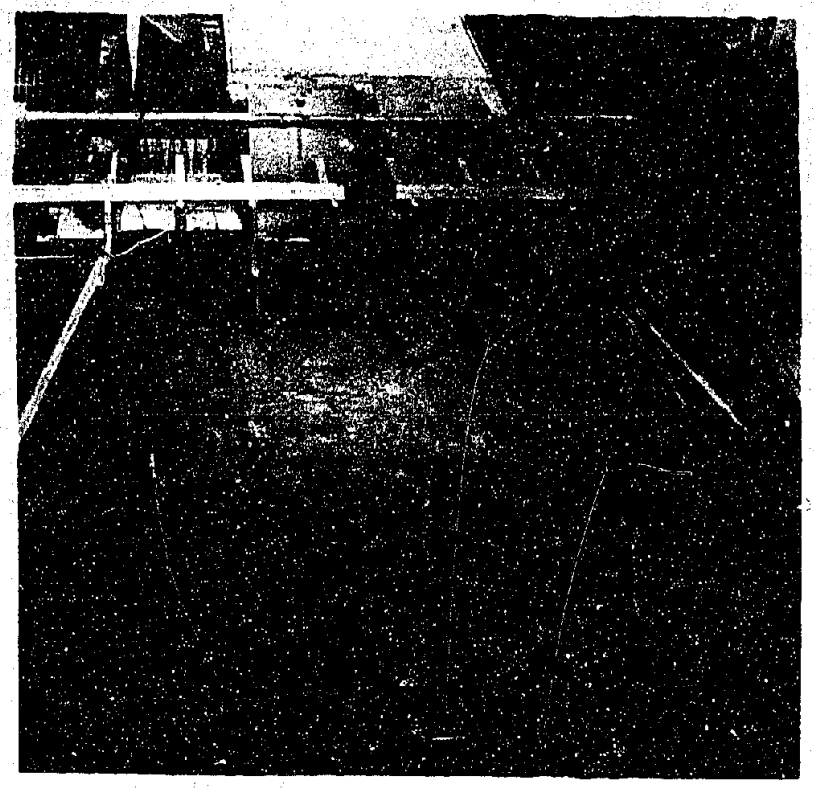
MAXIMUM WATER SURFACE - ORIGINAL FLOOR ELEVATION - Q = 2200 c.f.s.

WATER SURFACE PROFILES - SPILLWAY CHANNEL - TEST 2

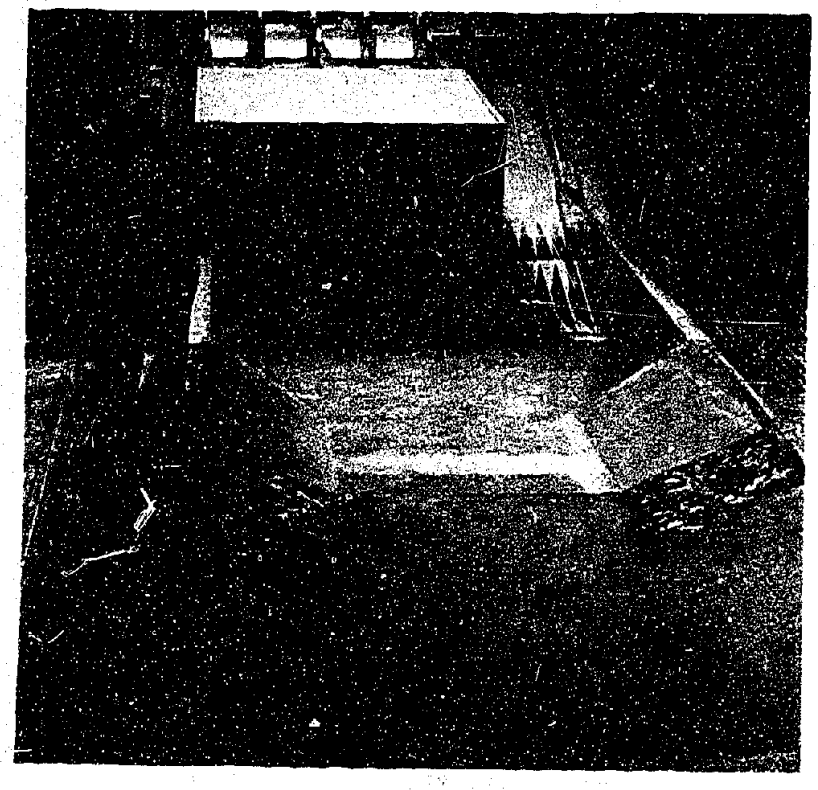
COACHELLA POWER DROP

1 : 24 MODEL

5-12-41 - R.R.P.



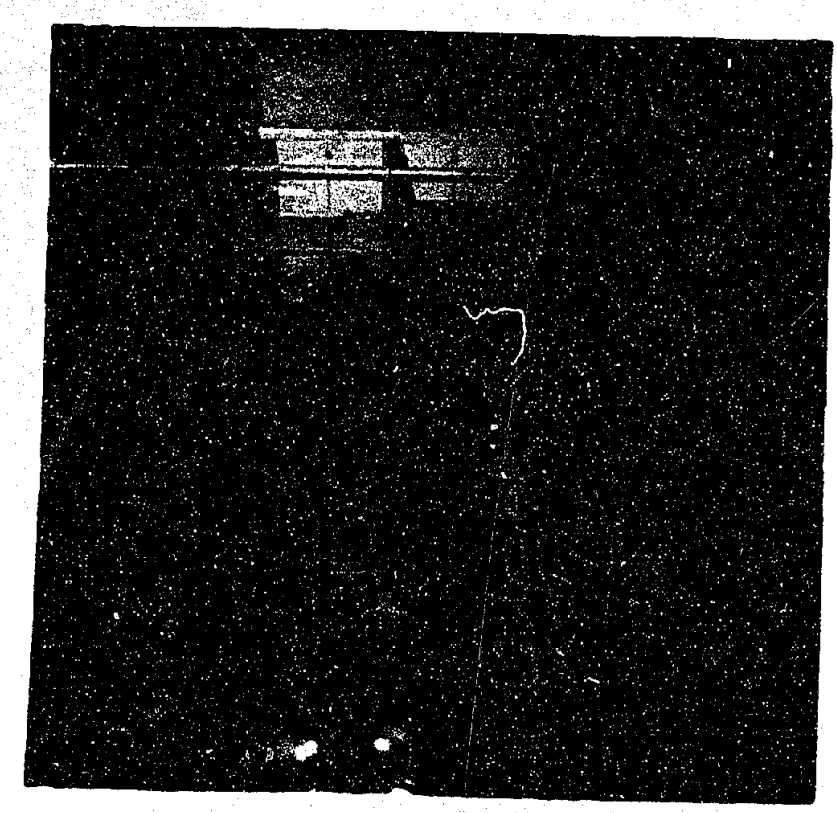
VIEW OF MODEL LOOKING DOWNSTREAM



VIEW OF MODEL LOOKING UPSTREAM

FINAL DESIGN

FLOW OF 2200 SECOND-FEET ENTERING POWERHOUSE



FLOW OF 2200 SECOND-FEET ENTERING SPILLWAYS

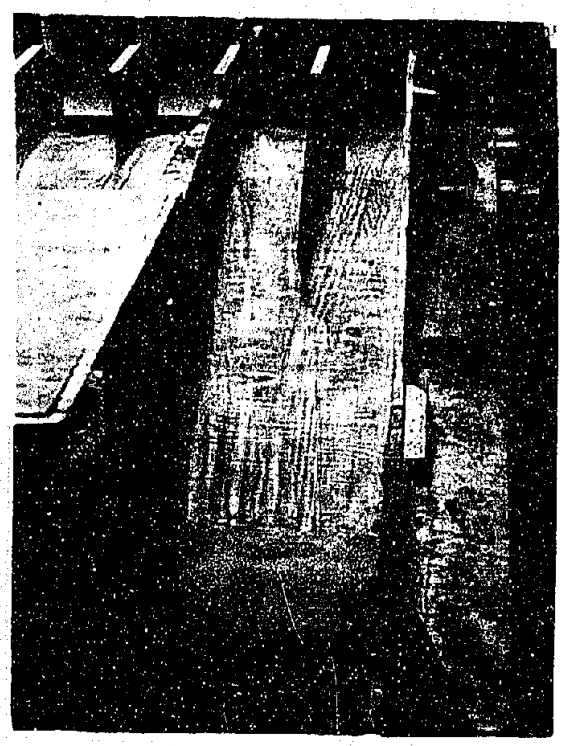
FINAL DESIGN

FIGURE 11

FLOW OF 2200 SECOND-FEET THROUGH POWERHOUSE

FLOW OF 2200 SECOND-FEET THROUGH SPILLWAY

FINAL DESIGN

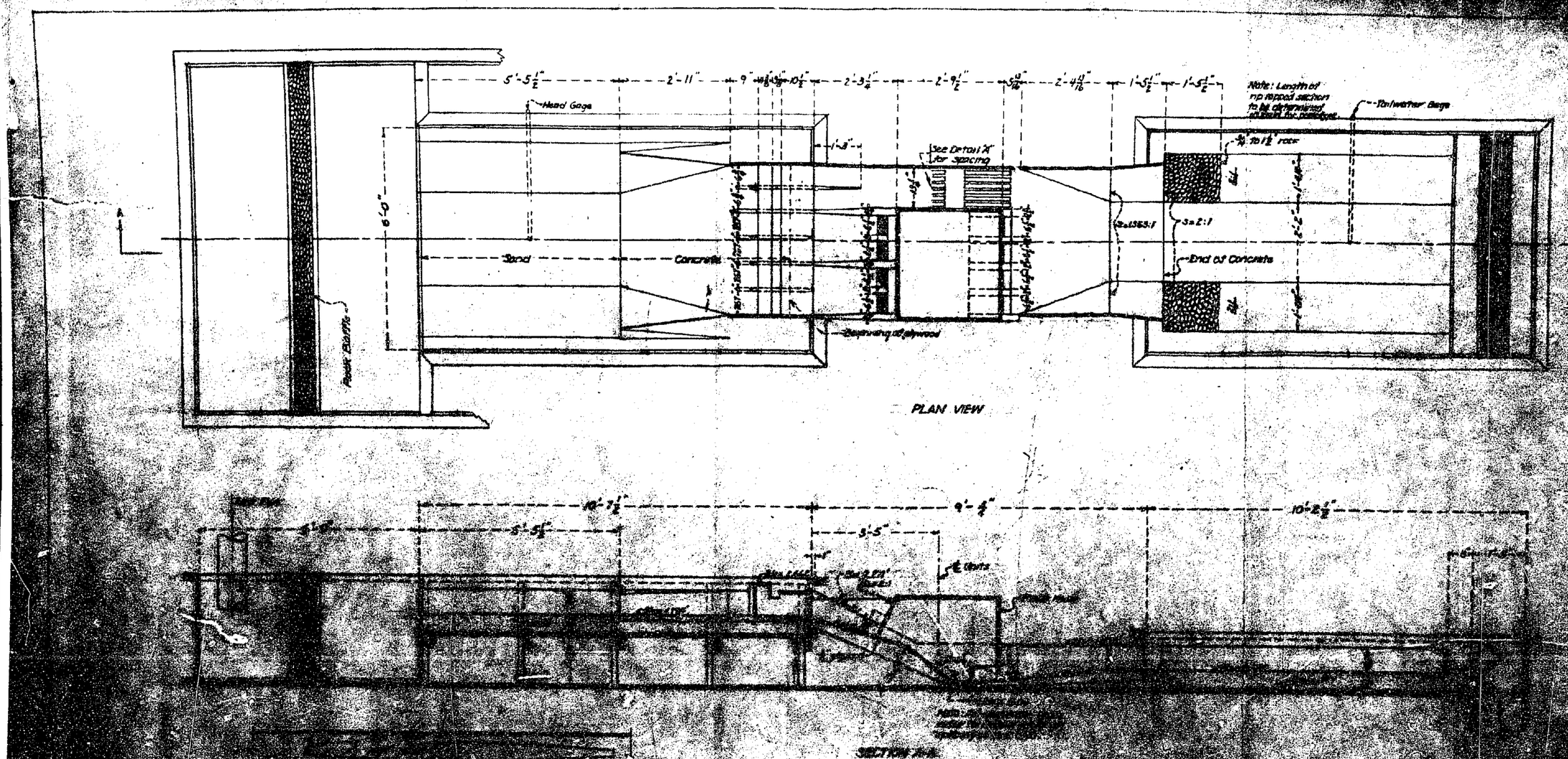


FLOW OF 2200 SECOND-FEET THRU
SPILLWAY WITH BOTH GATES OPEN

FLOW OF 2200 SECOND-FEET DIVIDED
BETWEEN ONE UNIT OF POWERHOUSE
AND ADJACENT SPILLWAY

FLOW OF 2200 SECOND-FEET DIVIDED
BETWEEN ONE UNIT OF POWERHOUSE
AND OPPOSITE SPILLWAY

FINAL DESIGN


Head Gage
Tailwater Gage
See Detail "A" for spacing
Sand
Concrete
Beginning of plywood
Power Outlets
Note: Length of rip rapped section to be determined on field for passage.
End of Concrete
S=2:1
PLAN VIEW
SECTION A-A