UNITED STATES

DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

- - - - - -

MEMORANDUM TO CHIEF DESIGNING ENGINEER

SUBJECT: HYDRAULIC MODEL STUDIES

FOR THE DESIGN OF THE AGENCY VALLEY SPILLWAY

By

JOHN B. DRISKO, ASSISTANT ENGINEER

- - - - - -

Under direction of

E. W. LANE, RESEARCH ENGINEER

AND

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HYD 4.2

TECHNICAL MEMORANDUM NO. 506

Denver, Colorado

January 17, 1936

(PRICE $4.30)

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ACKNOWLEDGEMENTS

The studies discussed in this memorandum were made by the hydraulic research department of the United States Bureau of Reclamation in its Arapahoe Street laboratory in Denver, Colorado. At the time these tests were made, Mr. E. W. Lane, Research Engineer, was in charge of the research department. The construction and testing was under the general supervision of W. M. Borland, Associate Engineer, and the author. H. M. Martin and L. R. Brooks, Junior Engineers, handled the construction; J. M. Buswell and F. L. Panuzio, Junior Engineers, conducted the tests, and the latter assisted in the preparation of the report. The report was prepared under the general surveillance of J. E. Warnock, Research Engineer.

All engineering work of the Bureau of Reclamation is under J. L. Savage, Chief Designing Engineer, and R. F. Walter, Chief Engineer. All activities of the Bureau are under the direction of Dr. Elwood Mead, Commissioner.

A. SUMMARY

As a result of model tests, the open channel spillway for the Agency Valley earth dam, as originally proposed, was shown to be unsatisfactory. The flow down the chute, in the model, was very irregular and the hydraulic jump action in the stilling pool was very turbulent. Changes in the design of the chute, just below the gates, greatly improved the flow in the chute; steepening the side walls of the pool and increasing the pool length made possible the formation of a relatively quiet hydraulic jump.

This report describes the model tests carried out and the results obtained.

B. PROJECT

The proposed Agency Valley Dam is an earth-fill dam situated on the north fork of the Malheur River, about 60 miles west of Vale, Oregon, (figure 1). The maximum predicted flood flow of 11,700 c.f.s. will be passed by a gate-controlled open-channel spillway in the rim of the reservoir at the right-hand end of the dam, (figure 2). The spillway will have a total length of about 700 feet, from reservoir to river, and the drop from reservoir level to tailwater for the maximum predicted flood will be 74 feet. Figure 4 is the estimated tailwater curve, or river rating curve below the spillway.

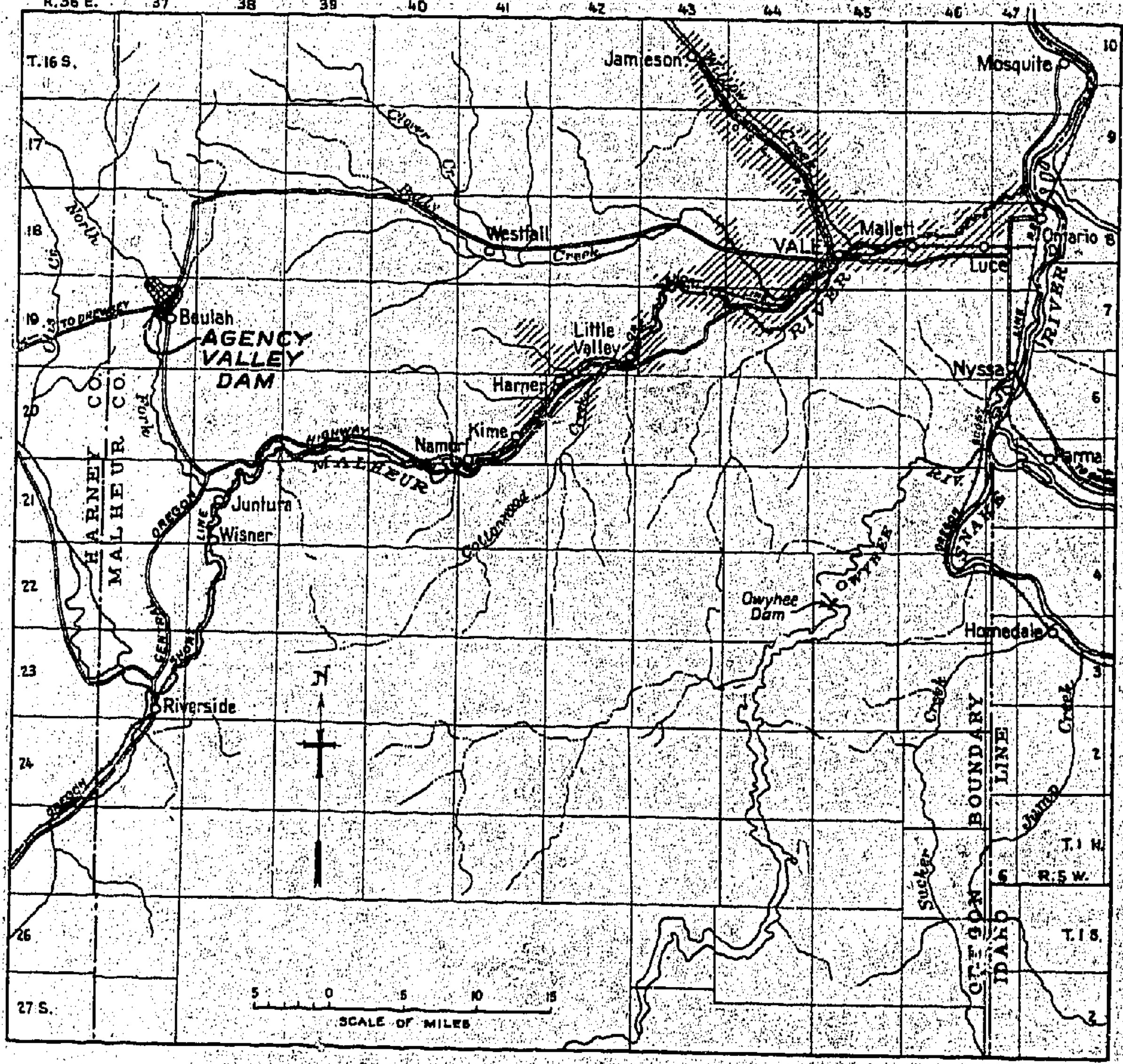
To insure the satisfactory operation of the structure and to investigate certain variations of the design, a model of the spillway was tested in the Denver laboratory of the U. S. Bureau of Reclamation.

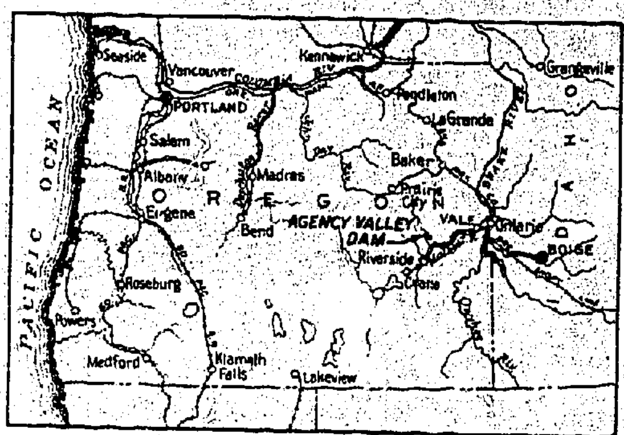
C. LABORATORY

The Denver laboratory of the U. S. Bureau of Reclamation is housed in the basement of the Old Custom House in Denver, (figure 3). The water used for models is recirculated; the system includes a 6-inch centrifugal pump which feeds twin head-tanks for supplying the models, and return flumes which bring the water back to the 90° V-notch measuring weir and the pump sump.

The fact that members of the design staff were able to keep in close touch with the laboratory staff and were able to visit the laboratory and observe the model in operation was of great value in expediting the work.

FIG 1
DRAWING No. 1





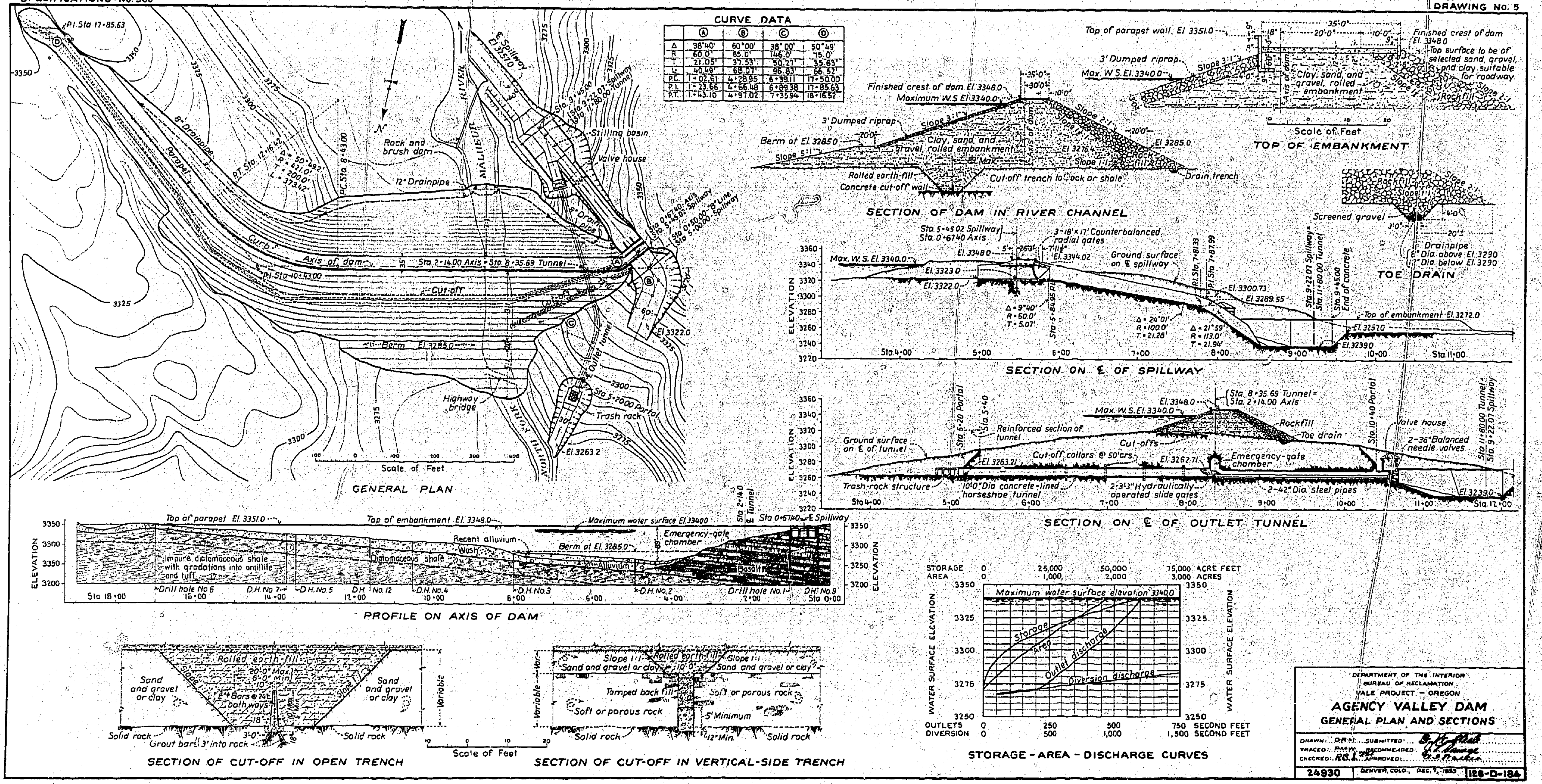
INDEX MAP

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT – OREGON

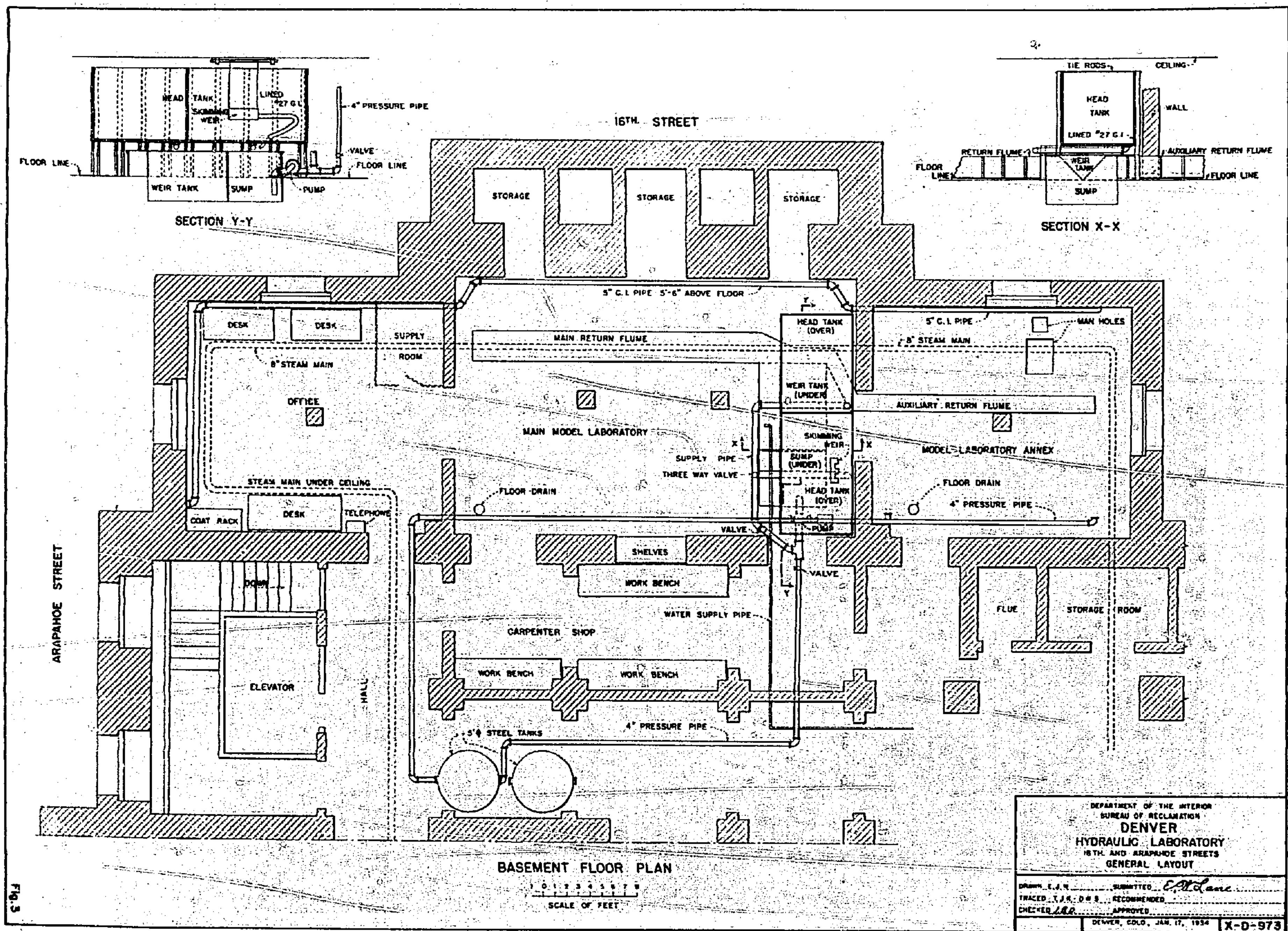
AGENCY VALLEY DAM
LOCATION MAP

DRAWN W.L.K.	SUBMITTED [signature]
TRACED C.B.G.	RECOMMENDED [signature]
CHECKED [signature]	APPROVED [signature]

24926 | DENVER, COLO. DEC. 7, 1933 | 126-D-180



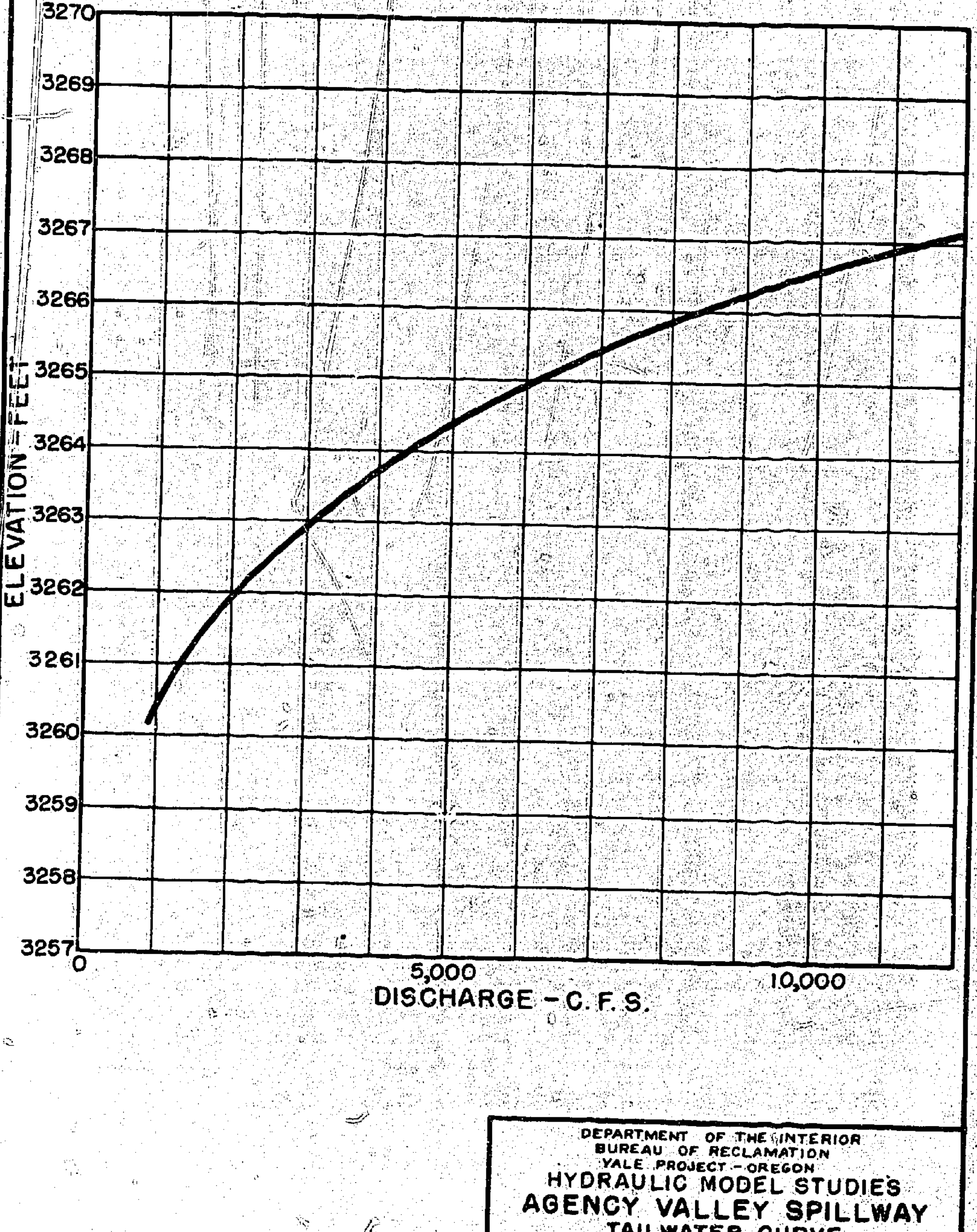
	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Δ	38°40'	60°00'	38°00'	50°49'
R	60.0'	65.0'	146.0'	75.0'
T	21.05'	37.53'	50.27'	35.63'
L	40.49'	68.07'	96.83'	66.52'
P.C.	1+02.61	4+28.95	6+39.11	17+50.00
P.I.	1+23.66	4+66.48	6+89.38	17+85.63
P.T.	1+43.10	4+97.02	7+35.94	18+16.52



SECTION Y-Y
HEAD TANK
SKIMMING WEIR
LINED #27 G.I.
4" PRESSURE PIPE
VALVE
FLOOR LINE
WEIR TANK
SUMP
PUMP
16TH. STREET
STORAGE
SECTION X-X
TIE RODS
CEILING
WALL
LINED #27 G.I.
RETURN FLUME
AUXILIARY RETURN FLUME
WEIR TANK
SUMP
ARAPAHOE STREET
5" C.I. PIPE 5'-6" ABOVE FLOOR
DESK
SUPPLY ROOM
MAIN RETURN FLUME
8" STEAM MAIN
OFFICE
MAIN MODEL LABORATORY
STEAM MAIN UNDER CEILING
COAT RACK
TELEPHONE
FLOOR DRAIN
HEAD TANK (OVER)
WEIR TANK (UNDER)
SUPPLY PIPE
THREE WAY VALVE
SUMP (UNDER)
PUMP
VALVE
5" C.I. PIPE
MAN HOLES
AUXILIARY RETURN FLUME
MODEL LABORATORY ANNEX
4" PRESSURE PIPE
SHELVES
WORK BENCH
WATER SUPPLY PIPE
CARPENTER SHOP
DOWN
ELEVATOR
HALL
5'⌀ STEEL TANKS
FLUE
STORAGE ROOM
BASEMENT FLOOR PLAN
SCALE OF FEET
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DENVER
HYDRAULIC LABORATORY
16TH. AND ARAPAHOE STREETS
GENERAL LAYOUT
DRAWN E.J.R.
SUBMITTED
TRACED T.J.R., D.H.S.
RECOMMENDED
CHECKED
APPROVED
DENVER, COLO., JAN. 17, 1934
X-D-973

Fig.3

FIGURE 4



DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YALE PROJECT - OREGON
HYDRAULIC MODEL STUDIES
AGENCY VALLEY SPILLWAY
TAILWATER CURVE

DRAWN J.B.D. . . . SUBMITTED J. M. Bradley
TRACED D.W.S. . . . RECOMMENDED J. C. Warnick
CHECKED J.M. . . APPROVED J. L. Savage

DENVER, COLO., 12-1[illegible]-35 126-D-366

Testing.

During the period of testing of the model, two test-crews were working, on two shifts. Each crew consisted of one junior engineer and two laborers. Comparative tests of the stilling pool design were run at the maximum predicted discharge of 11,700 c.f.s. Tests of the transition below the gates were run at various discharges, as frequently a set-up which was satisfactory at maximum flow was ineffective at low flows.

D. MODEL

The Agency Valley Spillway model was built to a scale of 1:30. This gave the largest model which could be accommodated in the laboratory. The model was constructed with a substructure of wood and a lining of sheet metal, (figure 5). Warped surfaces, which were often changed, were constructed variously of sheet metal, concrete on expanded metal lath, and plaster of paris. The stilling pool was set inside a larger sand box, which enabled a study of the erosion below the pool.

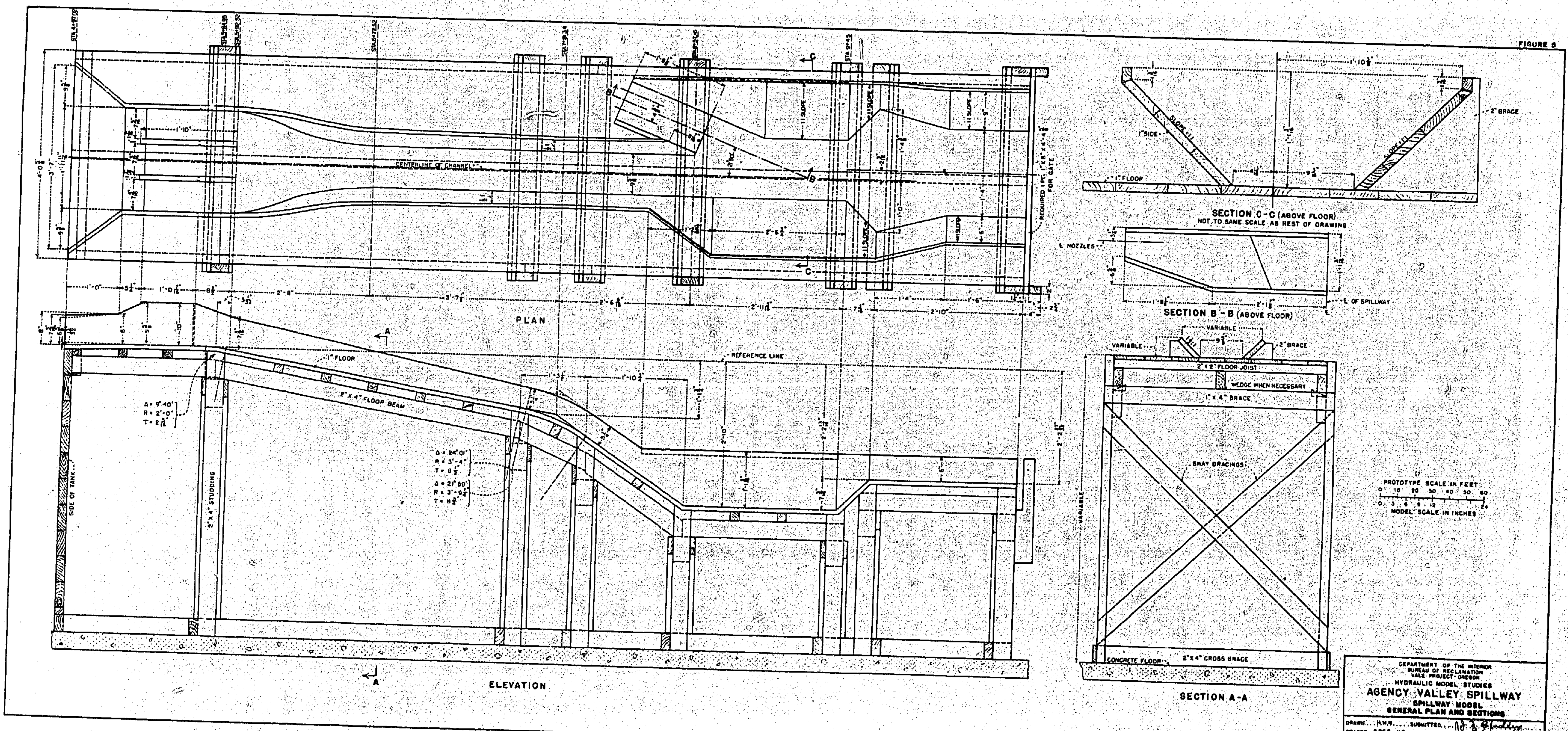
The slope of the chute, in the model, was slightly greater than the designed slope of the prototype. This expedient was necessary to counteract the relatively greater roughness of the model, and to obtain proper velocities at entrance to the stilling pool. The value of Kutter's n used in designing the prototype was n = .010; the same value was used for the model.

E. ORIGINAL DESIGN

The original spillway design, (figure 6), was not satisfactory. The transition just below the headgates was on a steep slope, and the flow down the chute was extremely irregular. The transition caused the flow to pile up in the center of the flume just below the transition, and to ride up on the sides of the flume down toward the stilling pool, as shown on plate I. The stilling pool was very turbulent, and the waves splashed high on the sloping sides.

The transition below the gates and the upper end of the chute was redesigned so as to create an hydraulic jump at the head of the chute. Extensive studies were then made to improve the flow conditions down the chute. After the chute conditions were settled, the pool was changed by making the side slopes m[illegible] steeper. This greatly improved the action in the pool and increased the effectiveness of sills and other devices used in the pool.

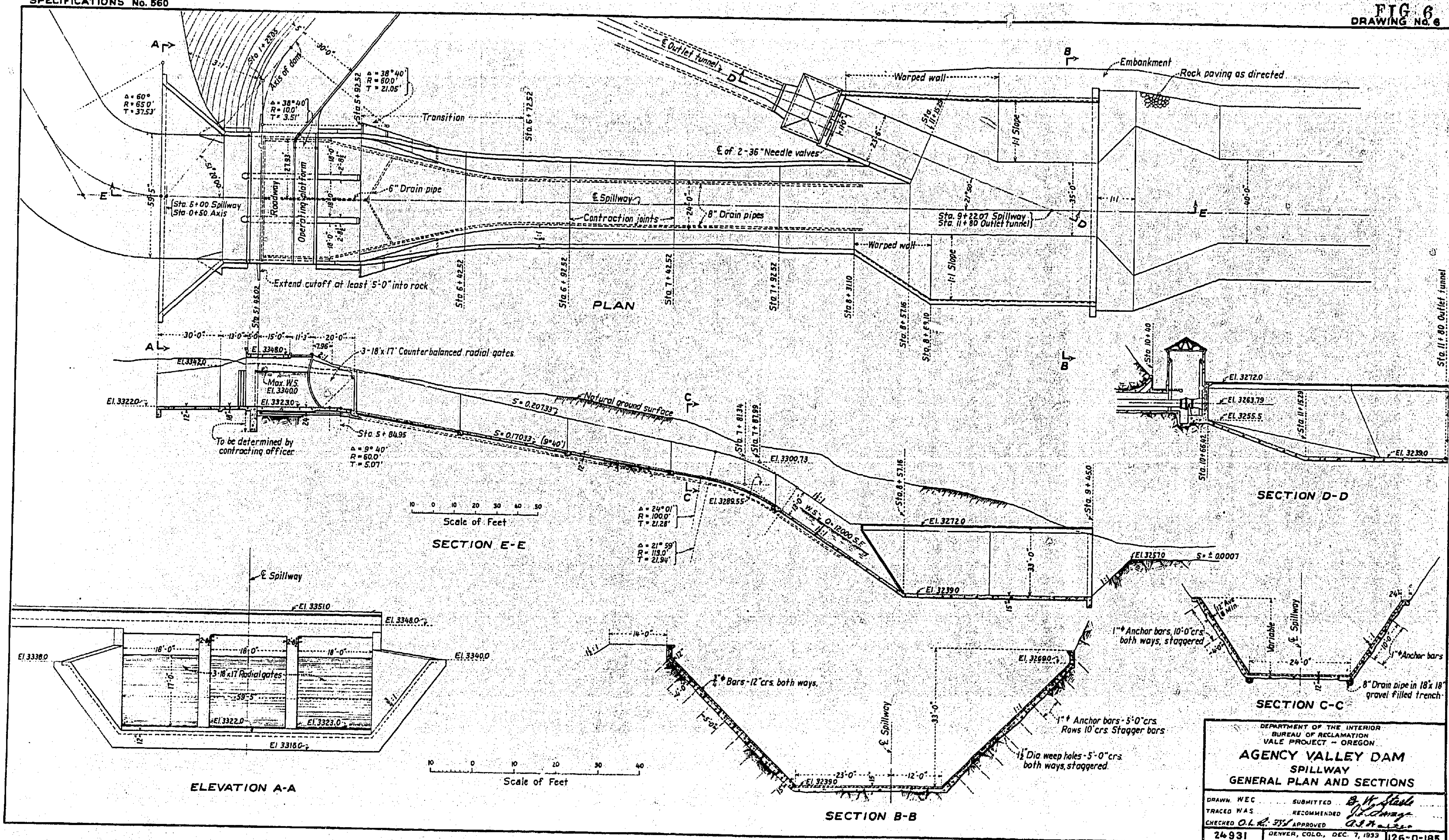
FIGURE 5



DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT-OREGON
HYDRAULIC MODEL STUDIES
AGENCY VALLEY SPILLWAY
SPILLWAY MODEL
GENERAL PLAN AND SECTIONS

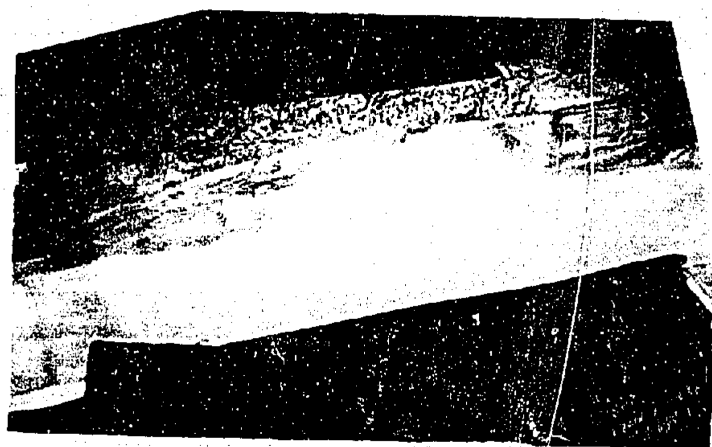
DRAWN ... H.N.N. ... SUBMITTED ...
TRACED ... S.P.C.S., H.S. ... RECOMMENDED ...
CHECKED ... ... APPROVED ...
DENVER, COLO., NOV. 21, 1933
128-D-387

FIG. 6


DRAWING No. 6
PLAN
SECTION E-E
ELEVATION A-A
SECTION B-B
SECTION C-C
SECTION D-D
Scale of Feet
Axis of dam
Transition
Roadway
Operating platform
6" Drain pipe
℄ Spillway
Contraction joints
8" Drain pipes
℄ Outlet tunnel
℄ of 2-36" Needle valves
Warped wall
Embankment
Rock paving as directed
1:1 Slope
Sta. 5+00 Spillway
Sta. 0+50 Axis
Sta. 9+22.07 Spillway
Sta. 11+80 Outlet tunnel
Extend cutoff at least 5'-0" into rock
3-18'x17' Counterbalanced radial gates
Max. W.S. El. 3340.0
Natural ground surface
To be determined by contracting officer
S = 0.20733
S = 0.17033
S = ± 0.0007
W.S. Q = 12000 S.F.
El. 3272.0
El. 3239.0
3-18'x17' Radial gates
El. 3351.0
El. 3348.0
El. 3340.0
El. 3338.0
El. 3322.0
El. 3323.0
El. 3316.0
1/4" ϕ Bars - 12" crs. both ways.
1" ϕ Anchor bars - 5'-0" crs. Rows 10' crs. Stagger bars
1 1/2" Dia. weep holes - 5'-0" crs. both ways, staggered.
1" ϕ Anchor bars, 10'-0" crs. both ways, staggered
8" Drain pipe in 18"x18" gravel filled trench
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT - OREGON
AGENCY VALLEY DAM
SPILLWAY
GENERAL PLAN AND SECTIONS
DRAWN W.E.C.
TRACED W.A.S.
CHECKED O.L.
SUBMITTED
RECOMMENDED
APPROVED
24931
DENVER, COLO., DEC. 7, 1933
126-D-185

A. IRREGULAR FLOW DOWN CHUTE.

B. STILLING POOL ACTION.
LOOKING UPSTREAM.



C. FLOW DOWN CHUTE.

ORIGINAL DESIGN WITH MAXIMUM DISCHARGE.

F. TRANSITION STUDIES

The original transition below the gates produced very unsatisfactory flow conditions down the chute, as shown in plate I. The first alteration tried was a more abrupt contraction of the throat transition, as shown in plate II. Although only a temporary set-up which served to indicate the type of further studies to be made, this design caused an hydraulic jump to form just below the piers at maximum flow, which effectively prevented the formation of undesirable standing waves or irregularities in the chute flow. This set-up did not create a jump at low flows, and hence was not given further consideration. The headgate and transition structure in the model was then rebuilt so that various layouts could be readily constructed and tested. Numerous designs, all of a similar nature, and differing only in dimensions and proportions, were tried, and the design shown in figure 7 evolved and was adopted. Other designs having a longer length of depressed floor were found to give better flow conditions than the design chosen, but were discarded because of the cost of the extra excavation and construction involved. Plate III shows one set-up tried, and plate IV shows the final design.

G. STILLING POOL STUDIES

Pool A

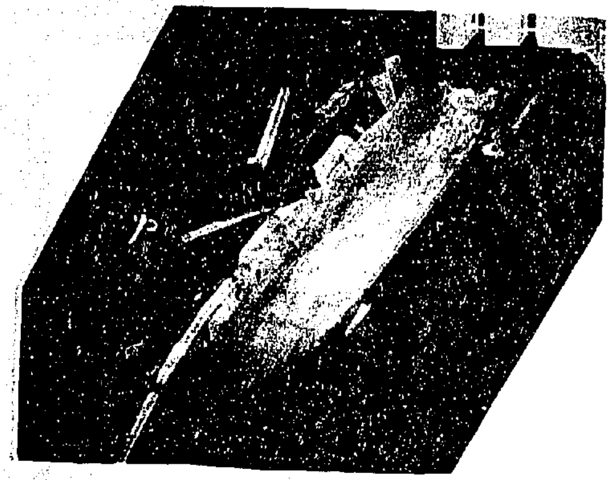
The water in the original unsymmetrical pool, (figure 2), as observed during the testing of the transition, was very turbulent, and a side roller (vertical axis) invariably formed.

Pool B

The pool was rebuilt to have a symmetrical trapezoidal cross section, (Pool B, figure 8). Various tests with this set-up showed that it, too, was unsatisfactory, because of the great turbulence and the high splash. Tests on this pool were made with several layouts, which included a stepped apron, sills, and several kinds of upturned bucket, where the chute enters the pool. Plates V and VI show some of the variations which were tried.

The different devices produced various effects, but none quieted the water sufficiently to form an acceptable pool.

In general, the hydraulic jump which forms in a stilling pool having a deep trapezoidal cross section is not satisfactory. The entering jet of water is narrow, and the greater top width of the pool encourages the formation of rollers having vertical axes at the sides of the pool. These rollers are unstable, they splash high on the sloping sides of the pool and produce a very agitated



A. CHUTE SHOWING SMOOTHER FLOW CONDITION.

B. CLOSE-UP OF TRANSITION SHOWING FORMATION OF HYDRAULIC JUMP.

MODIFIED DESIGN OF TRANSITION WITH MAXIMUM DISCHARGE.

A. LOOKING UP THE CHUTE.

B. LOOKING DOWN ON CONTRACTION AND STEP WHICH FORM THE TRANSITION.

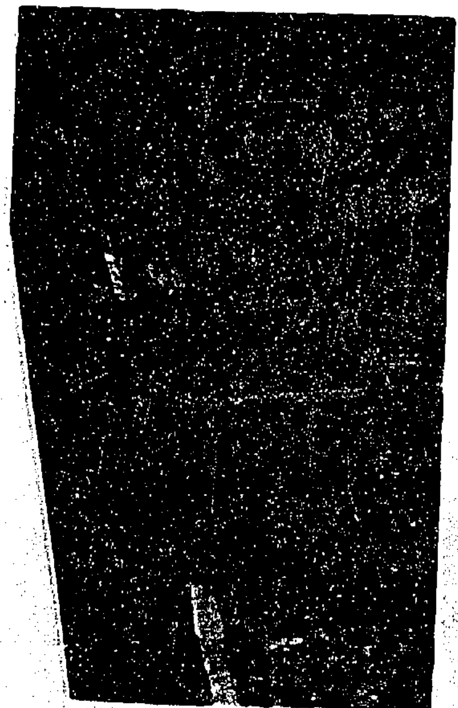
C. MAXIMUM DISCHARGE. JUMP FORMED WELL UPSTREAM OF TRANSITION; SMOOTH FLOW DOWN CHUTE.

D. DISCHARGE 2,740 SECOND-FEET.

ANOTHER MODIFICATION OF TRANSITION DESIGN.

A. DISCHARGE 11,700 SECOND-FEET.

B. DISCHARGE 7,900 SECOND-FEET.



C. DISCHARGE 3,940 SECOND-FEET.

D. DISCHARGE 1,460 SECOND-FEET.

FINAL DESIGN OF TRANSITION

A. SET-UP.

B. MAXIMUM DISCHARGE.

POOL "B" WITH HIGH STEPPED APRON.

C. SET-UP.

D. MAXIMUM DISCHARGE.

POOL "B" WITH LOW STEPPED APRON AND DENTATED SILL.

A. SET-UP.

B. MAXIMUM DISCHARGE.

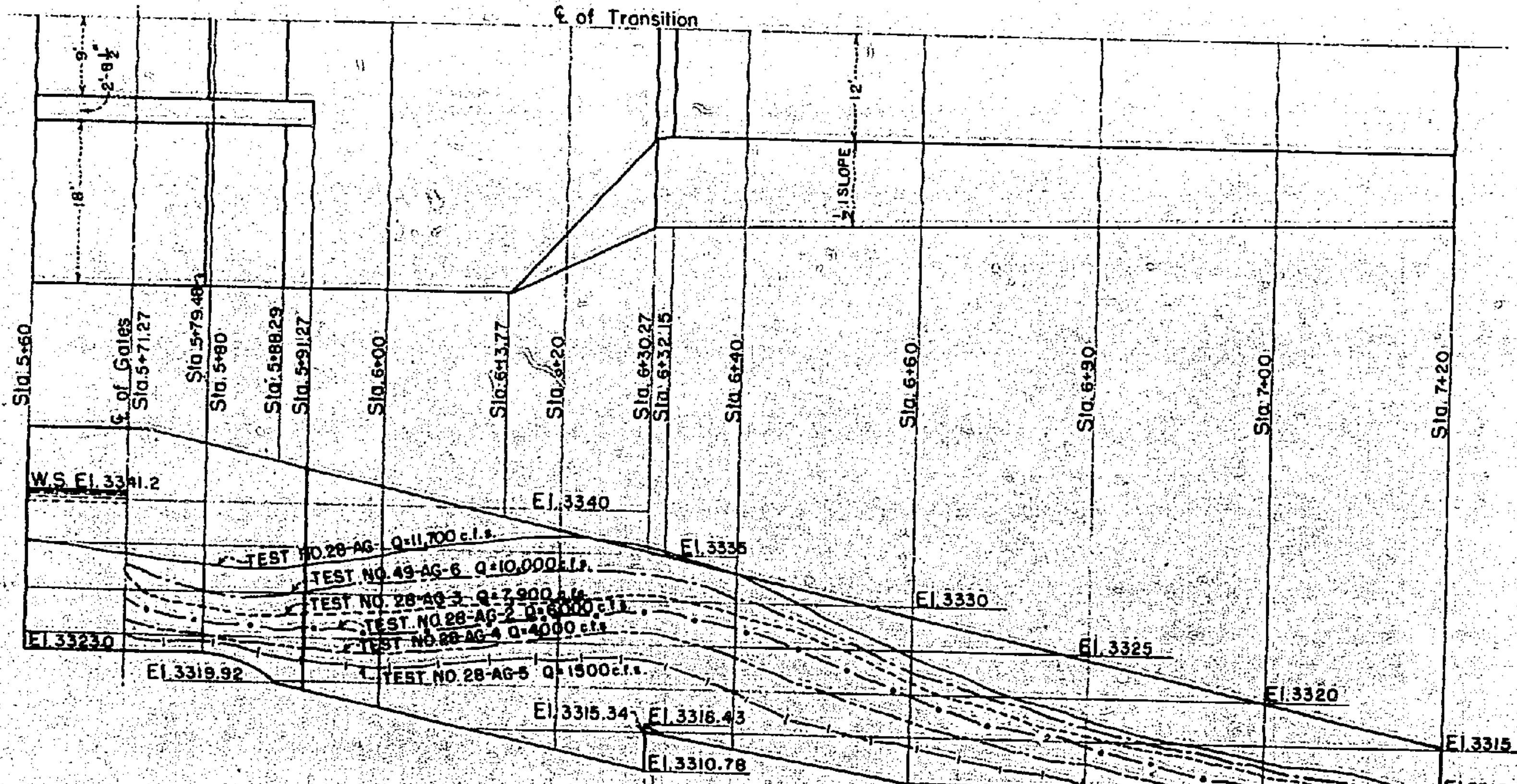
POOL "B" WITH DEPRESSED BUCKET AND DENTATED SILL.

C. SET-UP.

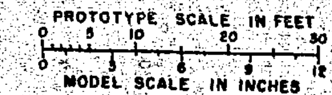
D. MAXIMUM DISCHARGE.

POOL "C" WITH NO APRON OR SILL.

FIGURE 7



FINAL TRANSITION DESIGN



DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT-OREGON
HYDRAULIC MODEL STUDIES

AGENCY VALLEY SPILLWAY

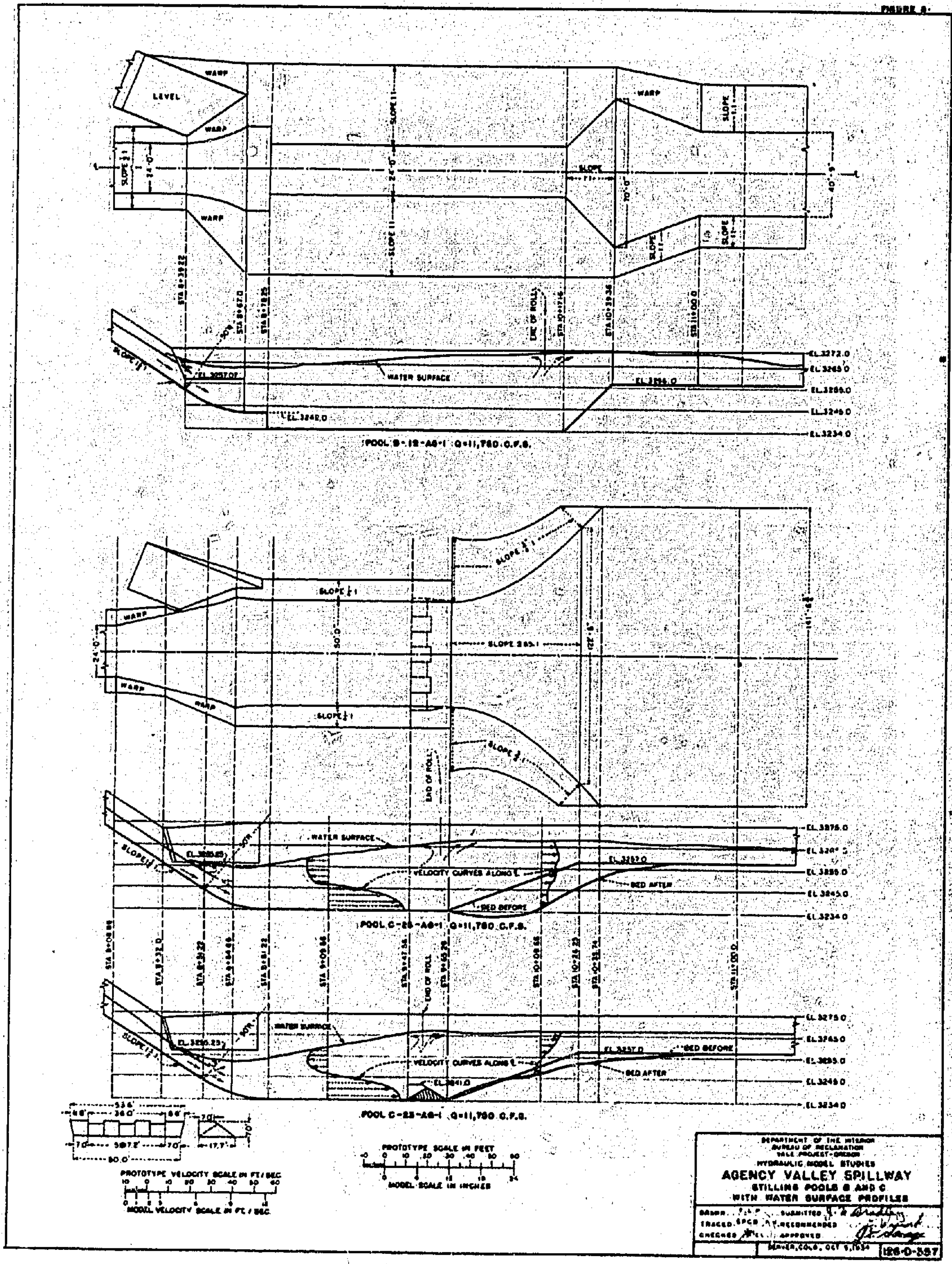
FINAL TRANSITION DESIGN WITH WATER SURFACE PROFILES FOR VARIOUS DISCHARGES

DRAWN C.H.M. SUBMITTED J. N. Bradley
TRACED J.O.K.-F.P.C. RECOMMENDED J. E. Warnock
CHECKED P.B.H. APPROVED J. L. Savage

DENVER, COLO. AUG. 3, 1934

126-D-356

FIGURE 8


WARP
LEVEL
SLOPE ½:1
24'-0"
SLOPE 1:1
70'-0"
40'-9"
END OF ROLL
WATER SURFACE
EL. 3272.0
EL. 3256.0
EL. 3242.0
EL. 3234.0
POOL B-12-AG-1 Q=11,750 C.F.S.
SLOPE 285:1
50'-0"
SLOPE 2½:1
VELOCITY CURVES ALONG ℄
BED AFTER
BED BEFORE
EL. 3275.0
EL. 3257.0
EL. 3250.25
EL. 3241.0
POOL C-25-AG-1 Q=11,750 C.F.S.
PROTOTYPE VELOCITY SCALE IN FT./SEC.
MODEL VELOCITY SCALE IN FT./SEC.
PROTOTYPE SCALE IN FEET
MODEL SCALE IN INCHES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT-OREGON
HYDRAULIC MODEL STUDIES
AGENCY VALLEY SPILLWAY
STILLING POOLS B AND C
WITH WATER SURFACE PROFILES
DRAWN
SUBMITTED
TRACED
RECOMMENDED
CHECKED
APPROVED
DENVER, COLO., OCT. 5, 1934
126-D-357

water surface in the pool and in the channel downstream.

Pool C

The pool was then changed to have a greater bottom width and much steeper side slopes, (Pool C, figure 8). The lower end of the chute, at the entrance to the pool, was flared slightly to help produce a wider, shallower jump. The flare was rather short and did not spread the water completely, as may be seen from figure 9, but practical considerations prevented utilizing a longer, more gradual flare.

Several types of devices were tried with this improved pool, which will be discussed presently. Plates VI and VII illustrate this pool and its performance.

Bare Pool

The bare stilling pool, with a smooth floor, gave excessive erosion in the tailway or lead-off channel, as may be seen on figure 8. Plate VI shows the pool before a test, and during the test.

Stepped Apron

A small stepped apron at the upper end of the pool (as on figure 13, tests 46 and 49) seemed, unaccountably, to improve the action of the pool. The difference in the pools with and without this stepped apron could scarcely be measured, and was purely a matter of visual observation, which, unfortunately, is subject to personal variations.

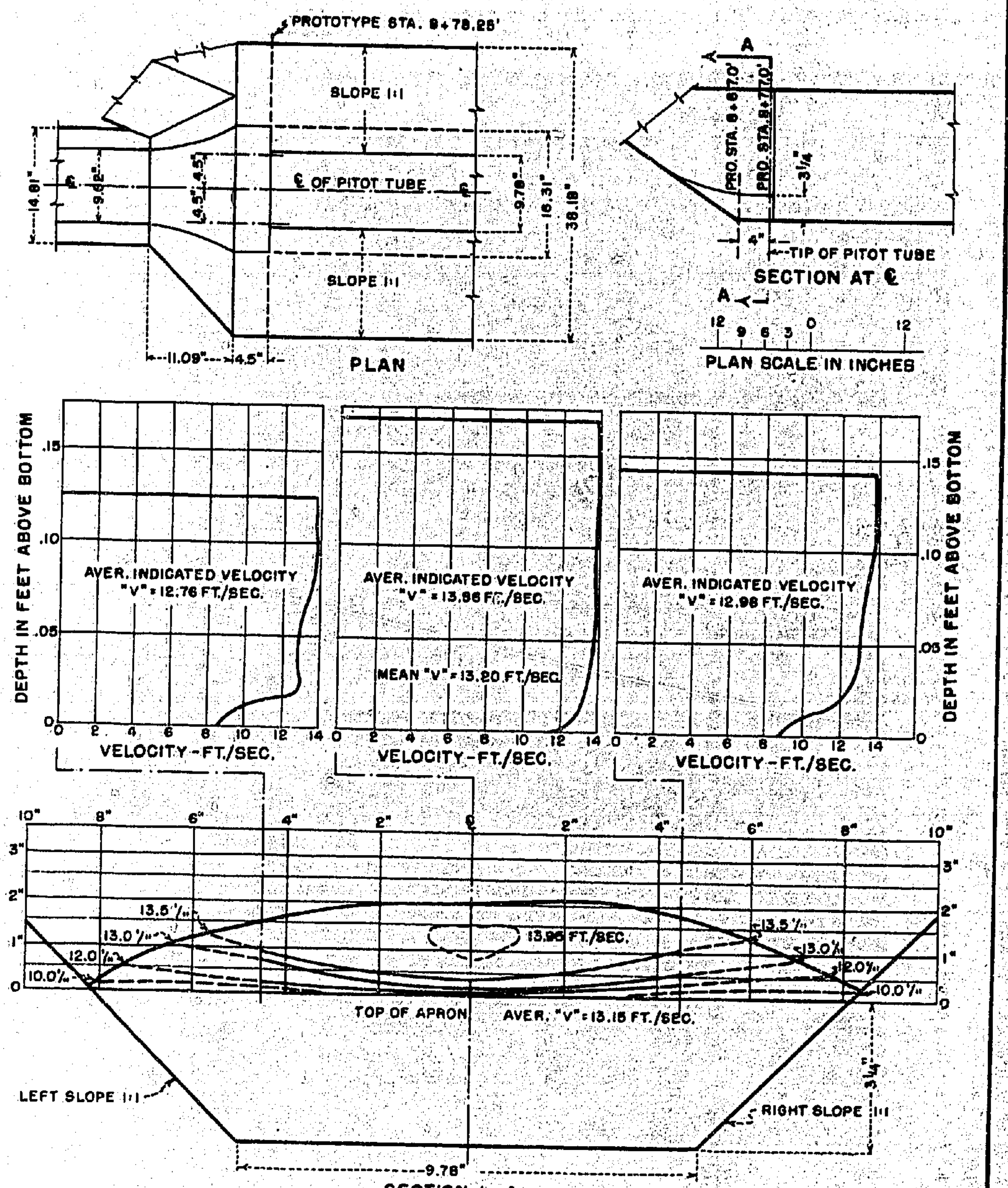
Upturned Bucket

Several tests were run with curved buckets installed at the bottom of the chute - a depression in the floor of the stilling pool, with a turn-up at its downstream end as on figure 10 and plate VII. This set-up produced a very turbulent pool with a great deal of boiling, which was caused by the rising water from the turned-up part of the bucket. Apparently, the upturned bucket is best suited to conditions of high tailwater, which do not exist for this spillway.

Diffuser Sill

A diffuser sill at the bottom of the chute did not seem to reduce the erosion in the lead-off channel as much as other devices.

FIGURE 9



SECTION A-A

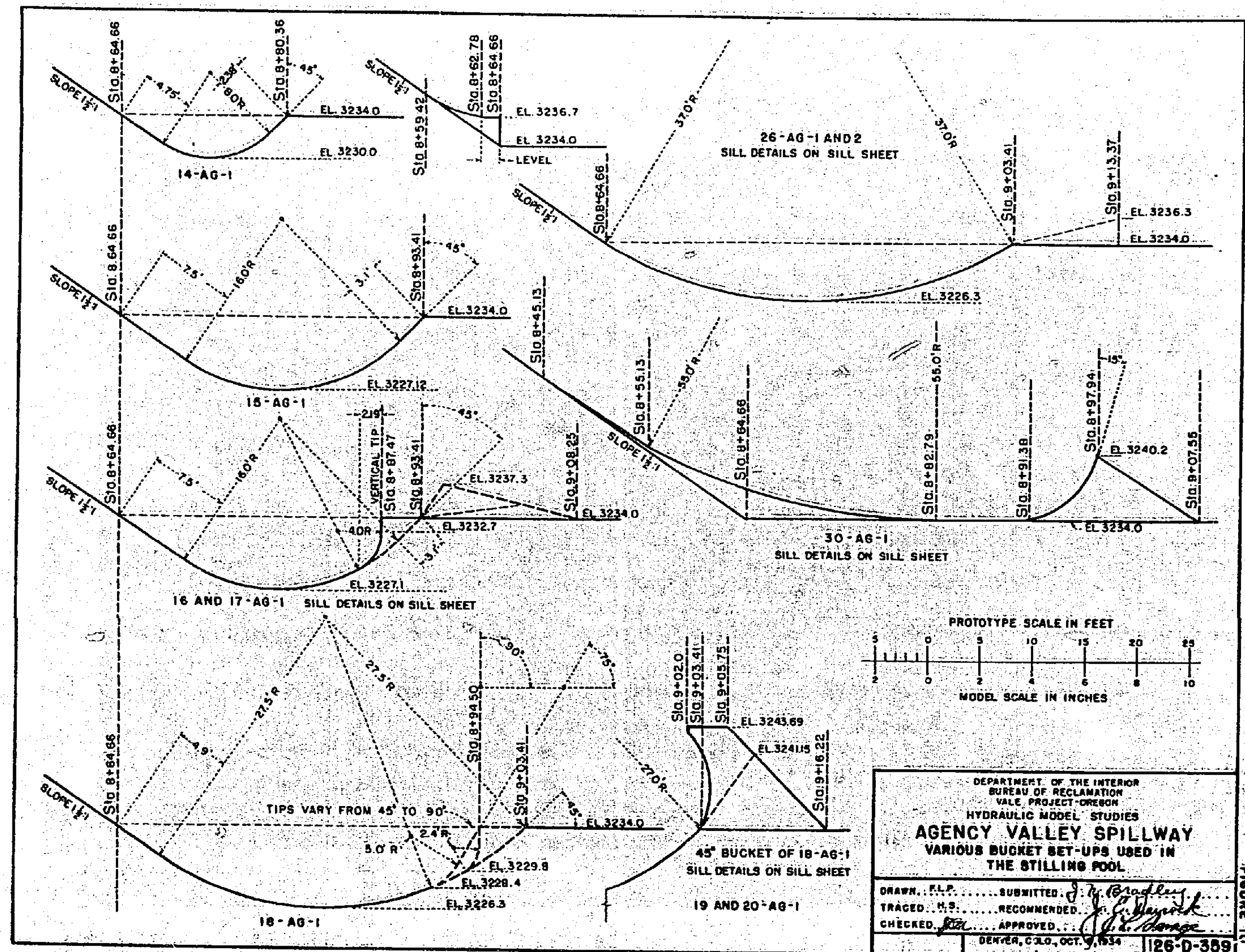
NOTES

1. These measurements for model Q = 2.31 c.f.s.
2. Model scale is 1:30.
3. Velocity traverses taken with pitot tube.
4. Average cross-sectional velocity determined from area and discharge.
5. Velocity contours shown at odd intervals.
6. Plotted from measurements of Test II-AG-1.

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT-OREGON
HYDRAULIC MODEL STUDIES
AGENCY VALLEY SPILLWAY
VELOCITY AND FLOW DISTRIBUTION AT TIP OF THE STEPPED APRON

DRAWN F.L.P. SUBMITTED J. N. Bradley
TRACED H.S.-D.W.S. RECOMMENDED E. Wernick
CHECKED ... APPROVED ...

DENVER, COLO., OCT. 15, 1934 | 126-D-356

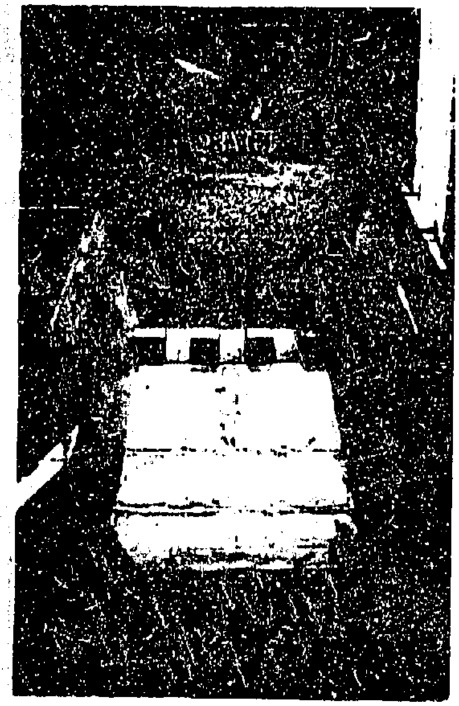


DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT-OREGON
HYDRAULIC MODEL STUDIES

AGENCY VALLEY SPILLWAY
VARIOUS BUCKET SET-UPS USED IN THE STILLING POOL

DRAWN F.L.P. ...... SUBMITTED J. N. Bradley
TRACED H.S. ...... RECOMMENDED J. E. Warnock
CHECKED ...... APPROVED J. L. Savage
DENVER, COLO., OCT. 9, 1934 — 126-D-359

FIGURE 10



A. SET-UP.

B. MAXIMUM DISCHARGE.

POOL "C" WITH DENTATED SILL.

C. SET-UP.

D. MAXIMUM DISCHARGE.

POOL "C" WITH DEPRESSED BUCKET AT FOOT OF SLOPE

Dentated Sill

Several designs of dentated sills and groups of baffle piers were included in the gamut of tests, and gave good results. When properly located, they produced a good-looking jump in the pool, and kept the erosion of the tailway at a minimum. Figures 11 and 12 show the various sills studied, and plate VII illustrates a sill in action.

Triangular Sill

It was found that a plain triangular sill at the end of the pool produced excellent results. Large blocks at the ends of the sill next to the pool walls were necessary to prevent the erosion caused by a side roller forming in the flaring part of the tailway.

Pool D

As a result of the tests made up to this point, a design (Pool D) was submitted for further test. This design provided a shorter pool and included a gradual flare from pool to tailway, (figure 13). As before, this pool was investigated with a stepped apron and with various sills. The results obtained were parallel to those given by Pool C, and are shown on figure 13.

Diffuser Sill

One test was run with a diffuser sill placed close to the foot of the chute. The jump action in the pool was satisfactory, but the erosion below the sill was unsymmetrical and somewhat excessive, (plate VIII).

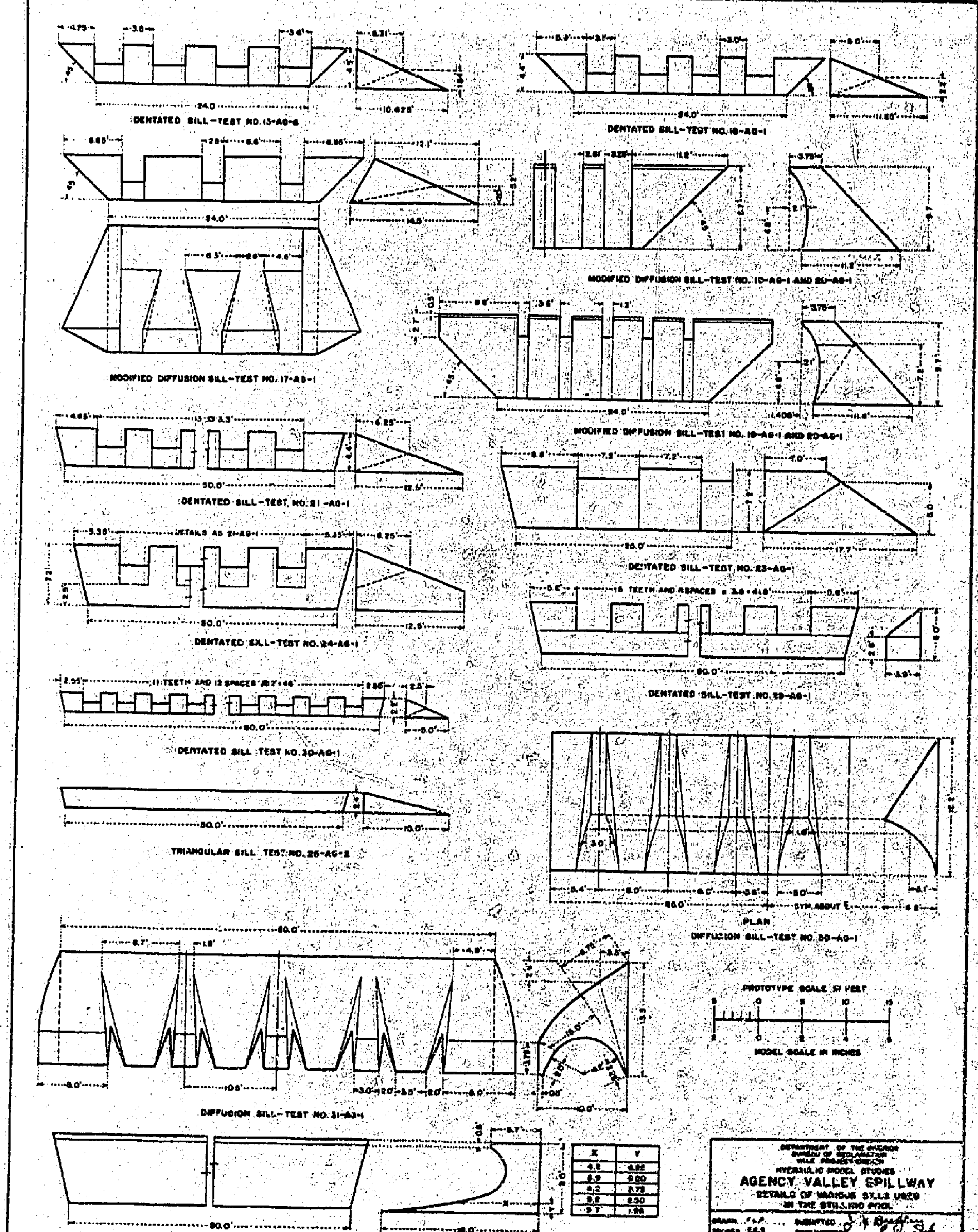
Final Design

There seemed to be little difference between the effectiveness of a plain triangular sill and a dentated sill. The plain sill was recommended because of its lesser cost. Figure 14 shows the final prototype design. Plates VIII and IX illustrate this pool in action.

Outlet Works

The floor under the jets which discharge from the outlet nozzles was studied carefully, and a layout proposed which caused a minimum of splash and was thought to be exposed to the least impact from the free jets. Figure 15 shows the original design and the revised layout, and figure 16 shows how the jets flow over it.

FIGURE 11


DENTATED SILL-TEST NO. 15-AG-6
DENTATED SILL-TEST NO. 16-AG-1
MODIFIED DIFFUSION SILL-TEST NO. 17-AG-1
MODIFIED DIFFUSION SILL-TEST NO. 10-AG-1 AND 20-AG-1
MODIFIED DIFFUSION SILL-TEST NO. 18-AG-1 AND 20-AG-1
DENTATED SILL-TEST NO. 21-AG-1
DENTATED SILL-TEST NO. 23-AG-1
DENTATED SILL-TEST NO. 24-AG-1
DENTATED SILL-TEST NO. 25-AG-1
DENTATED SILL-TEST NO. 30-AG-1
TRIANGULAR SILL-TEST NO. 26-AG-2
PLAN
DIFFUSION SILL-TEST NO. 30-AG-1
DIFFUSION SILL-TEST NO. 31-AG-1
BAFFLE SILL-TEST NO. 9F, 29-AG-25
PROTOTYPE SCALE IN FEET
MODEL SCALE IN INCHES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT-OREGON
HYDRAULIC MODEL STUDIES
AGENCY VALLEY SPILLWAY
DETAILS OF VARIOUS SILLS USED
IN THE STILLING POOL

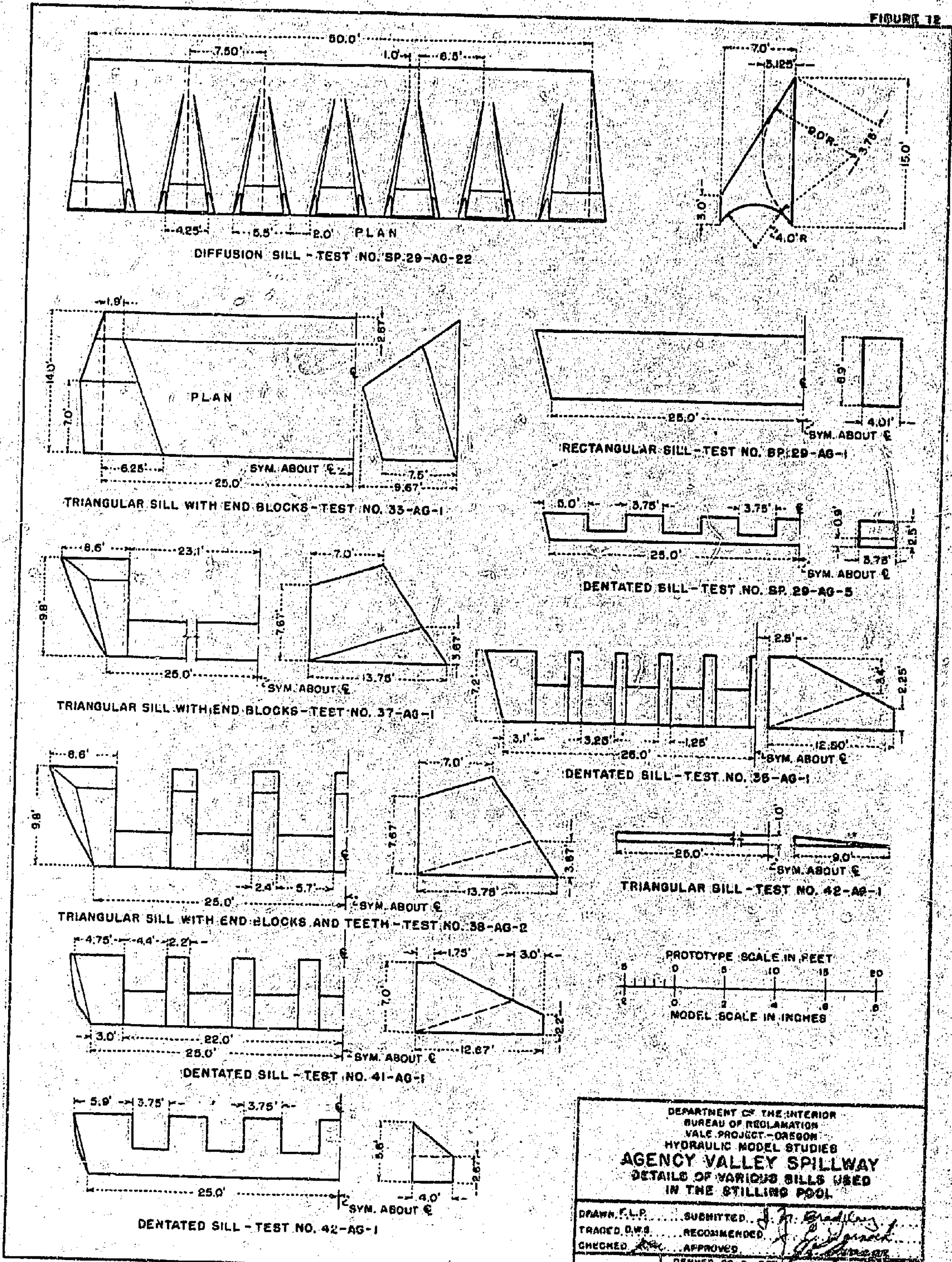
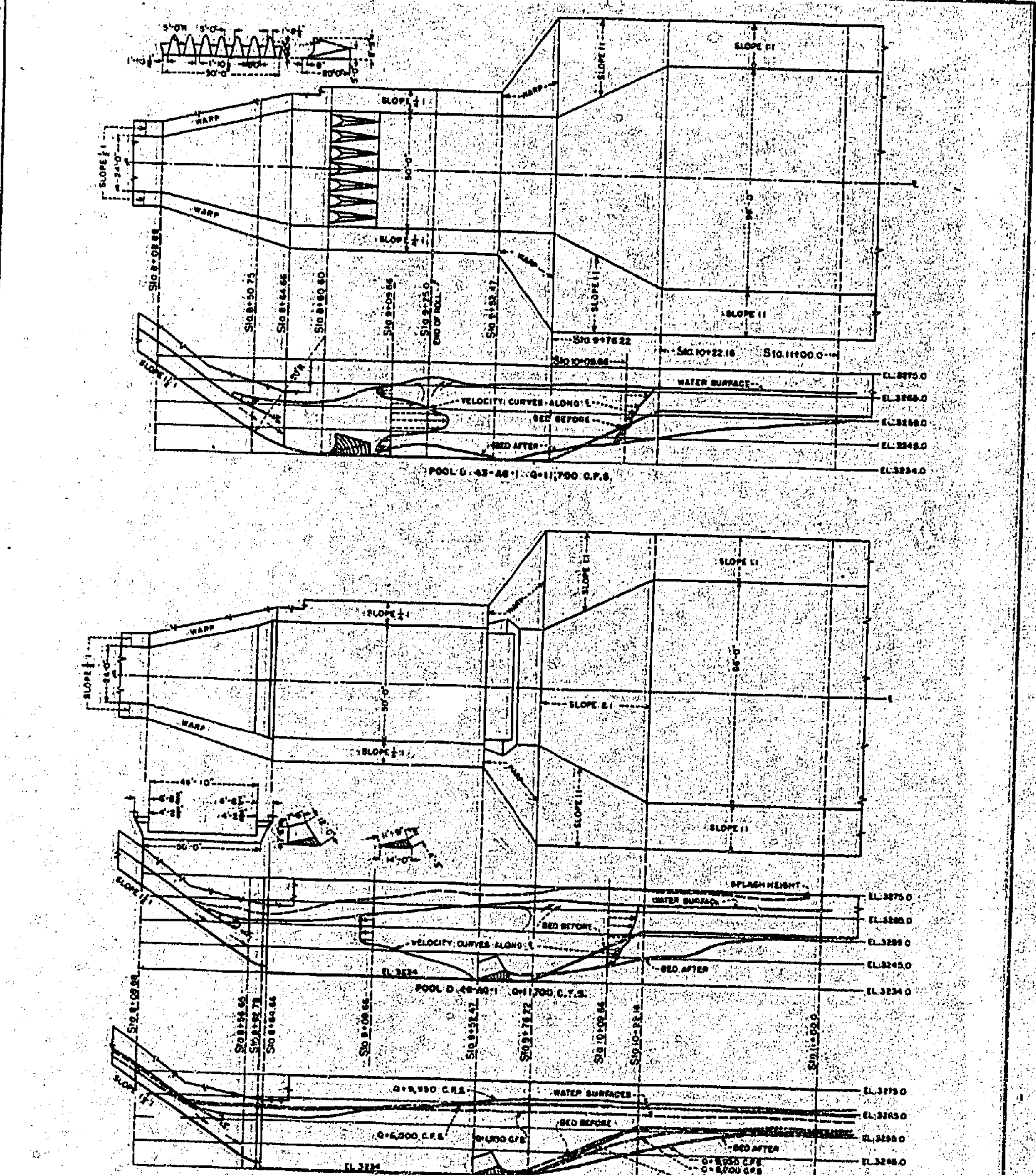
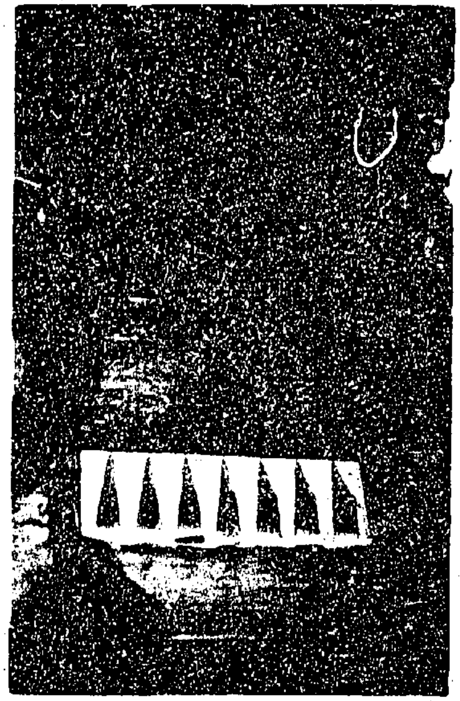


FIGURE 12
PLAN
DIFFUSION SILL - TEST NO. SP.29-AG-22
PLAN
TRIANGULAR SILL WITH END BLOCKS - TEST NO. 33-AG-1
SYM. ABOUT ℄
RECTANGULAR SILL - TEST NO. SP.29-AG-1
DENTATED SILL - TEST NO. SP. 29-AG-5
TRIANGULAR SILL WITH END BLOCKS - TEST NO. 37-AG-1
DENTATED SILL - TEST NO. 36-AG-1
TRIANGULAR SILL WITH END BLOCKS AND TEETH - TEST NO. 38-AG-2
TRIANGULAR SILL - TEST NO. 42-AG-1
DENTATED SILL - TEST NO. 41-AG-1
DENTATED SILL - TEST NO. 42-AG-1
PROTOTYPE SCALE IN FEET
MODEL SCALE IN INCHES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT - OREGON
HYDRAULIC MODEL STUDIES
AGENCY VALLEY SPILLWAY
DETAILS OF VARIOUS SILLS USED IN THE STILLING POOL
DRAWN F.L.P. SUBMITTED
TRACED D.W.S. RECOMMENDED
CHECKED APPROVED
DENVER, COLO., OCT 15, 1934

FIGURE 19


SLOPE 1:1
WARP
50'-0"
WATER SURFACE
VELOCITY CURVES ALONG ℄
BED BEFORE
BED AFTER
EL. 3275.0
EL. 3234.0
SPLASH HEIGHT
WATER SURFACES
PROTOTYPE VELOCITY SCALE IN FT./SEC.
MODEL VELOCITY SCALE IN FT./SEC.
PROTOTYPE SCALE IN FEET
MODEL SCALE IN INCHES
HYDRAULIC MODEL STUDIES
AGENCY VALLEY SPILLWAY
STILLING POOL-D
WITH WATER SURFACE PROFILES

A. MAXIMUM DISCHARGE.



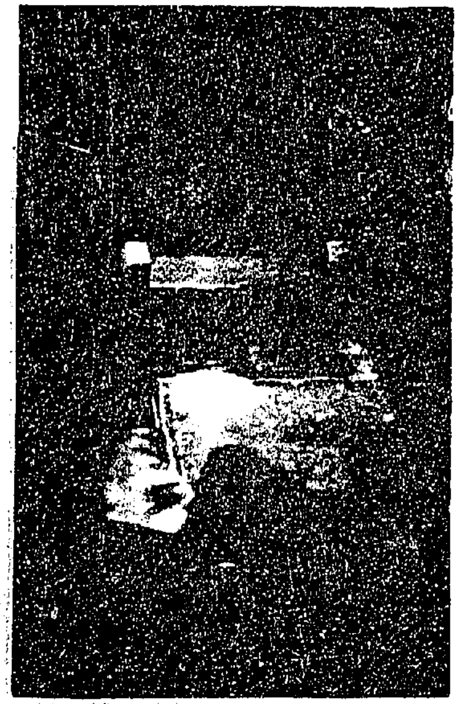
B. AFTER 75-MINUTE RUN.

POOL "D" WITH DIFFUSER SILL.

C. DISCHARGE 1,970 SECOND-FEET.

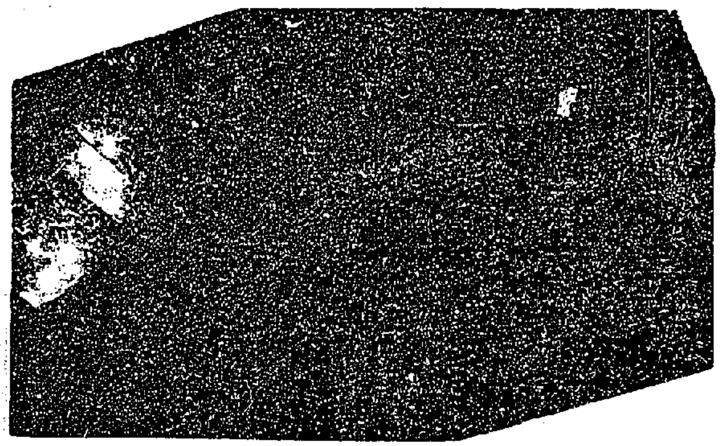
D. DISCHARGE 6,010 SECOND-FEET.

POOL "D" - FINAL DESIGN.



A. SET-UP.

B. MAXIMUM DISCHARGE.



C. LOOKING UPSTREAM TOWARD POOL
AFTER A 75-MINUTE RUN AT MAXIMUM DISCHARGE.

FINAL DESIGN OF STILLING POOL.

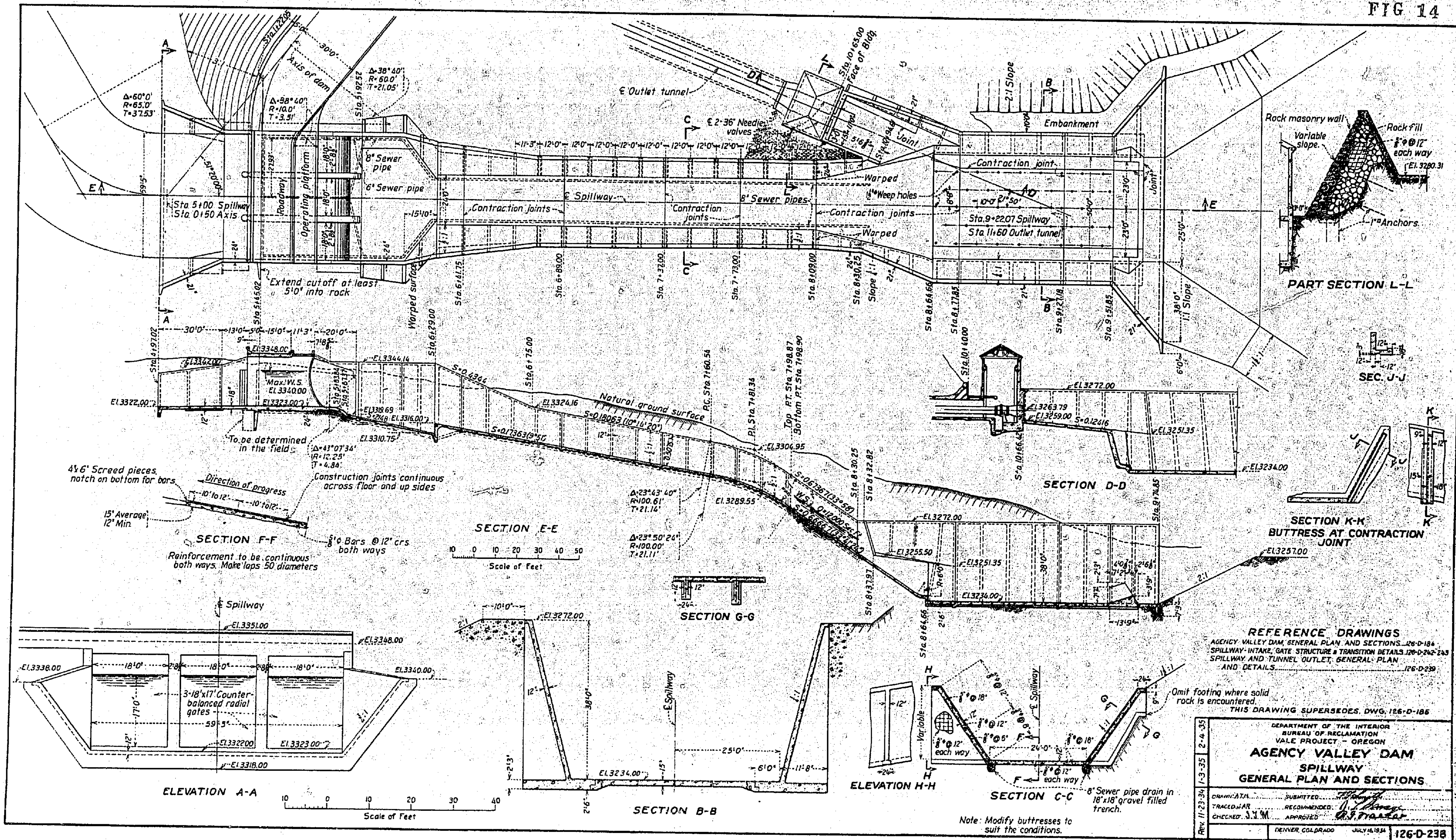
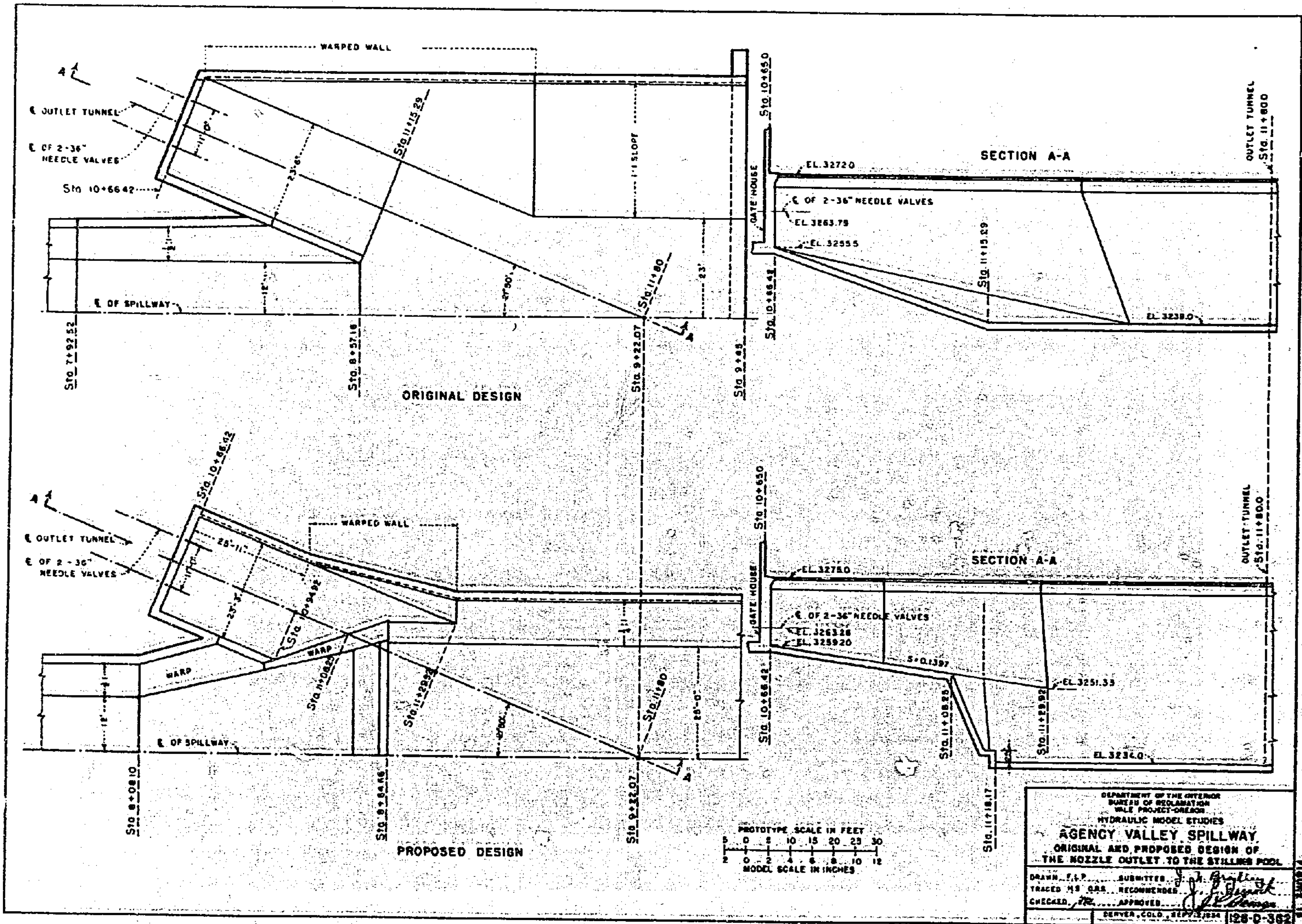
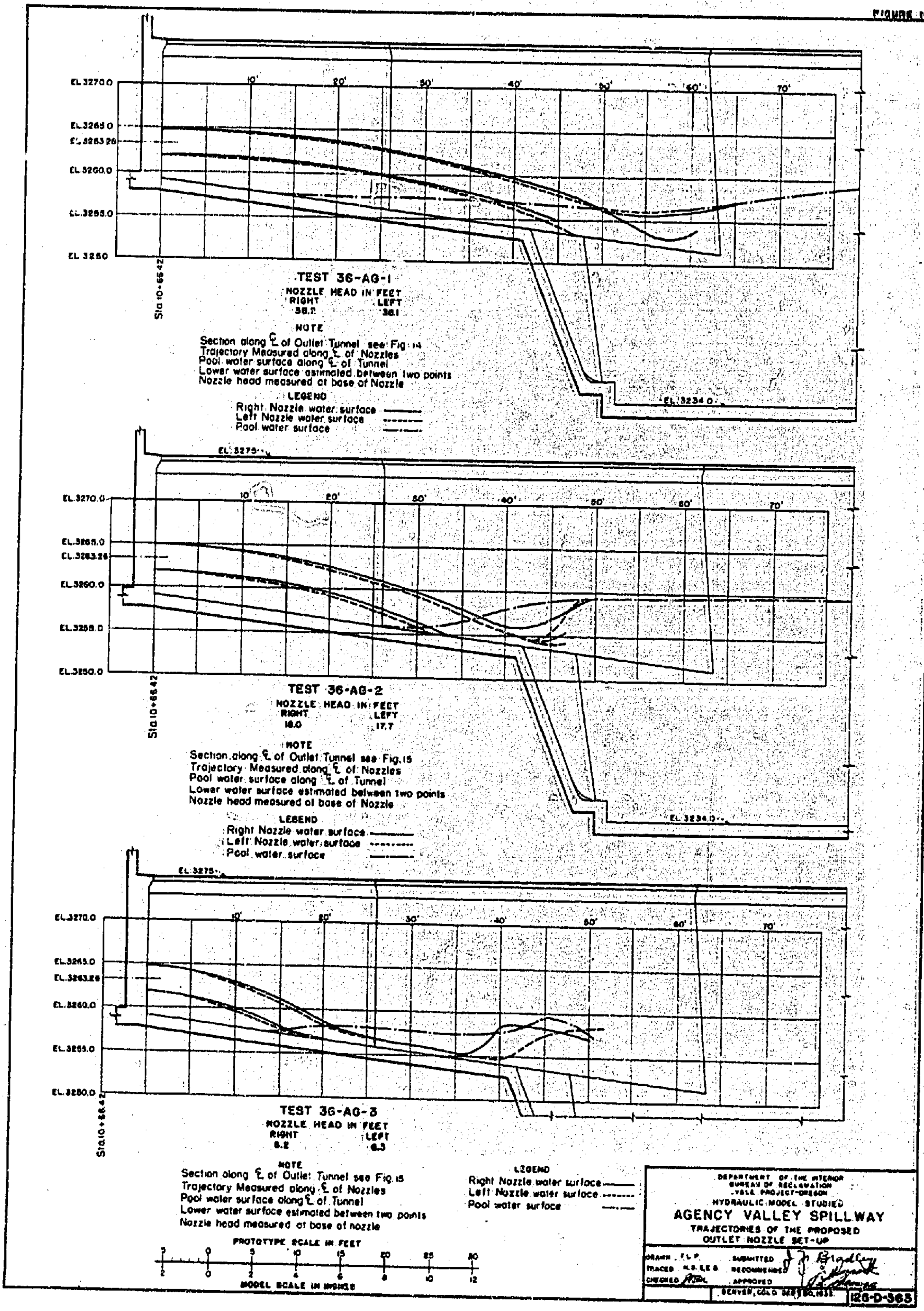

PART SECTION L-L
SEC. J-J
SECTION D-D
SECTION K-K
BUTTRESS AT CONTRACTION JOINT
SECTION F-F
Reinforcement to be continuous both ways. Make laps 50 diameters
SECTION E-E
Scale of Feet
SECTION G-G
ELEVATION A-A
3-18'x17' Counter-balanced radial gates
SECTION B-B
ELEVATION H-H
SECTION C-C
8" Sewer pipe drain in 18"x18" gravel filled trench.
Note: Modify buttresses to suit the conditions.
Omit footing where solid rock is encountered.
REFERENCE DRAWINGS
AGENCY VALLEY DAM, GENERAL PLAN AND SECTIONS 126-D-186
SPILLWAY-INTAKE, GATE STRUCTURE & TRANSITION DETAILS 126-D-242-243
SPILLWAY AND TUNNEL OUTLET, GENERAL PLAN AND DETAILS 126-D-239
THIS DRAWING SUPERSEDES DWG. 126-D-186
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT - OREGON
AGENCY VALLEY DAM
SPILLWAY
GENERAL PLAN AND SECTIONS
DENVER, COLORADO JULY 16, 1934
126-D-238

Figure 18



WARPED WALL
€ OUTLET TUNNEL
€ OF 2-36" NEEDLE VALVES
Sta 10+66.42
Sta 11+15.29
1:1 SLOPE
23'-6"
11'-0"
23'
12'
21'
€ OF SPILLWAY
Sta 7+92.52
Sta 8+57.16
Sta 9+22.07
Sta 11+80
Sta 9+45
Sta 10+65.0
ORIGINAL DESIGN
SECTION A-A
EL. 3272.0
GATE HOUSE
€ OF 2-36" NEEDLE VALVES
EL. 3263.75
EL. 3255.5
Sta 10+66.42
Sta 11+15.29
EL. 3238.0
OUTLET TUNNEL
Sta 11+80.0
25'-11"
23'-2"
WARP
Sta 10+94.92
Sta 11+08.25
Sta 11+29.92
Sta 11+80
28'-0"
PROPOSED DESIGN
Sta 8+08.10
Sta 8+84.46
EL. 3275.0
EL. 3263.26
EL. 3259.20
S=0.1397
EL. 3251.35
EL. 3234.0
Sta 11+18.17
PROTOTYPE SCALE IN FEET
MODEL SCALE IN INCHES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT-OREGON
HYDRAULIC MODEL STUDIES
AGENCY VALLEY SPILLWAY
ORIGINAL AND PROPOSED DESIGN OF THE NOZZLE OUTLET TO THE STILLING POOL
DRAWN F.L.P.
TRACED H.S. O.R.S.
CHECKED
SUBMITTED
RECOMMENDED
APPROVED
DENVER, COLO.
128-D-362

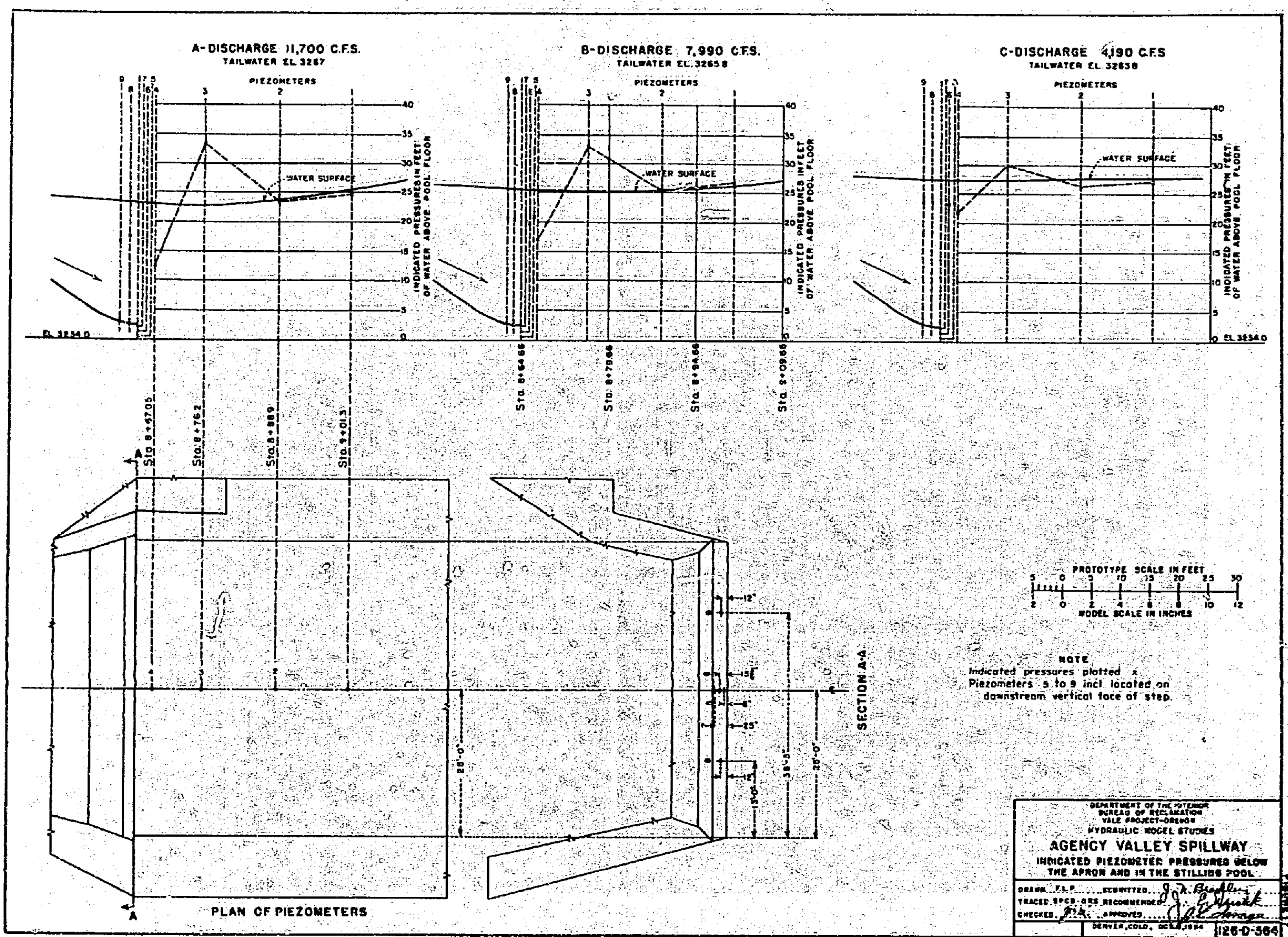

EL. 3270.0
EL. 3265.0
EL. 3263.26
EL. 3260.0
EL. 3255.0
EL. 3250
10'
20'
30'
40'
50'
60'
70'
Sta. 10+66.42
EL. 3234.0
EL. 3275
TEST 36-AG-1
NOZZLE HEAD IN FEET
RIGHT 36.2
LEFT 38.1
NOTE
Section along ℄ of Outlet Tunnel see Fig. 14
Trajectory Measured along ℄ of Nozzles
Pool water surface along ℄ of Tunnel
Lower water surface estimated between two points
Nozzle head measured at base of Nozzle
LEGEND
Right Nozzle water surface
Left Nozzle water surface
Pool water surface
TEST 36-AG-2
NOZZLE HEAD IN FEET
RIGHT 18.0
LEFT 17.7
NOTE
Section along ℄ of Outlet Tunnel see Fig. 15
Trajectory Measured along ℄ of Nozzles
Pool water surface along ℄ of Tunnel
Lower water surface estimated between two points
Nozzle head measured at base of Nozzle
LEGEND
Right Nozzle water surface
Left Nozzle water surface
Pool water surface
TEST 36-AG-3
NOZZLE HEAD IN FEET
RIGHT 6.2
LEFT 6.3
NOTE
Section along ℄ of Outlet Tunnel see Fig. 15
Trajectory Measured along ℄ of Nozzles
Pool water surface along ℄ of Tunnel
Lower water surface estimated between two points
Nozzle head measured at base of nozzle
LEGEND
Right Nozzle water surface
Left Nozzle water surface
Pool water surface
PROTOTYPE SCALE IN FEET
5 0 5 10 15 20 25 30
2 0 2 4 6 8 10 12
MODEL SCALE IN INCHES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT-OREGON
HYDRAULIC MODEL STUDIES
AGENCY VALLEY SPILLWAY
TRAJECTORIES OF THE PROPOSED
OUTLET NOZZLE SET-UP
DRAWN F.L.P.
TRACED
CHECKED
SUBMITTED
RECOMMENDED
APPROVED
DENVER, COLO.
128-D-363

Pressures Below Stepped Apron

One test included measurements of the pressure on the downstream side of the stepped apron, and on the pool floor immediately below. These pressures were not greatly different from the depth of water (figure 17) and should cause no anxiety.

H. HEAD ON GATES

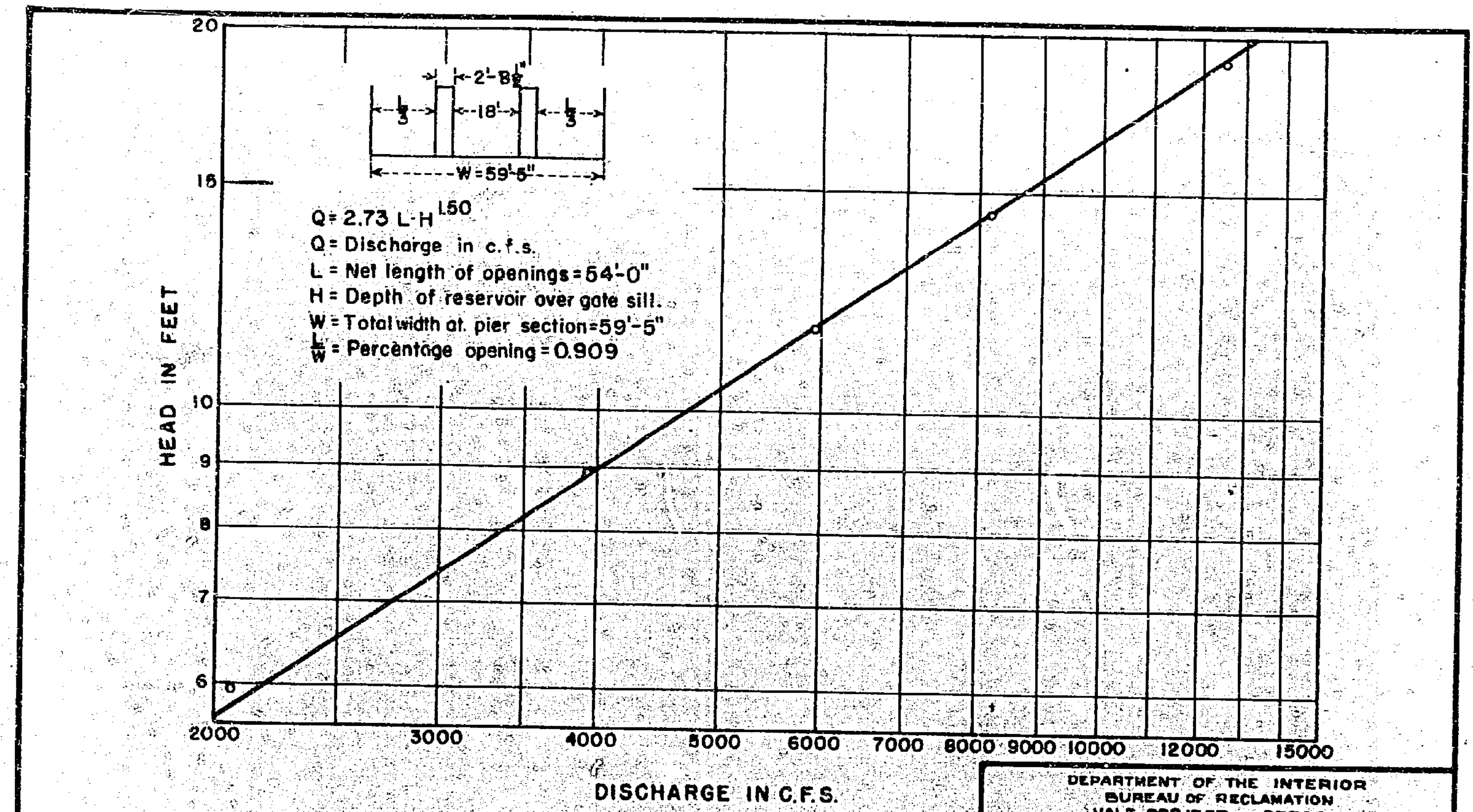
Measurements of the discharge through the model for varying heads on the gates showed the discharge relationship to be $Q = 2.73\ LH^{3/2}$. The line does not fall exactly on the measured points (figure 18) but a more accurate line would have given an exponent differing from 3/2, which means that the coefficient could not be dimensionless, but would vary with the size of the structure.



A-DISCHARGE 11,700 C.F.S.
TAILWATER EL. 3267
B-DISCHARGE 7,990 C.F.S.
TAILWATER EL. 3265.8
C-DISCHARGE 4,190 C.F.S.
TAILWATER EL. 3263.8
PIEZOMETERS
WATER SURFACE
INDICATED PRESSURES IN FEET OF WATER ABOVE POOL FLOOR
EL. 3234.0
Sta. 8+67.05
Sta. 8+76.2
Sta. 8+88.9
Sta. 9+01.3
Sta. 8+64.66
Sta. 8+78.66
Sta. 8+94.66
Sta. 9+09.66
SECTION A-A
PLAN OF PIEZOMETERS
PROTOTYPE SCALE IN FEET
MODEL SCALE IN INCHES
NOTE
Indicated pressures plotted x
Piezometers 5 to 9 incl. located on downstream vertical face of step.
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT-OREGON
HYDRAULIC MODEL STUDIES
AGENCY VALLEY SPILLWAY
INDICATED PIEZOMETER PRESSURES BELOW THE APRON AND IN THE STILLING POOL
DENVER, COLO.
126-D-564

FIGURE 17

FIGURE 16



DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VALE PROJECT - OREGON
HYDRAULIC MODEL STUDIES
AGENCY VALLEY SPILLWAY
HEAD-DISCHARGE RELATION THROUGH GATES

DRAWN E.C.R.-V.L.S. SUBMITTED J. N. Bradley
TRACED J.O.K. RECOMMENDED J. E. Warnock
CHECKED J.O.K. APPROVED J. L. Savage

DENVER, COLO. JUNE 1934 126-D-365

APPENDIX

APPENDIX

SUMMARY OF TESTS

Tests	Set-up Studied	Description of Set-up
1 to 10	Transition Below the Gates	Studies of Designs to Study an Hydraulic Jump
No Formal Tests	Stilling Pool Design A	Unsymmetrical Trapezoidal Pool
12 to 20	Stilling Pool Design B	Symmetrical Trapezoidal Pool
21 to 36 29 to 33	Stilling Pool Design C	Steep-sided Pool
34 to 50	Stilling Pool Design D	Steep-sided Pool, Shorter with Warped Surfaces Downstream
11	Measurement of Velocity at tip of Apron	
36	Studies of Flow from Outlet Nozzles	
44	Measurements of Head vs. Discharge for Gates	
47	Measurement of Pressures Below Apron and in Stilling Pool.	

LOG OF TESTS - - - AGENCY VALLEY SPILLWAY

Test and Run No.	Discharge	Feature Studied	Description of Set-up	Remarks
1-AG-1	11,700	Original design	Design A - Original design of transition and pool as submitted for testing.	Design very poor from gates on through pool; flow very bubbly and splashy; a great deal of water splashed over the sides.
2-AG-1, 2 and 3		Transition below gates	Experimented with the transition in an attempt to find a set-up that would form a jump and smooth out the flow down the chute.	
3-AG-1	11,340	Transition below gates	Transition with curved contracted warp.	Jump at very end of piers; side splash very high; flow beyond transition very rough.
3-AG-2	9,000	Transition below gates	Transition with curved contracted warp.	Flow characteristics similar to 3-AG-1
4-AG-1	11,310	Transition below gates	Transition with long curved warp.	
4-AG-2	8,480	Transition below gates	Transition with long curved warp.	
5-AG-1	11,450	Transition below gates	Transition similar to 4-AG-1.	Flow characteristics similar to 4-AG-1.
6-AG-1	11,450	Transition below gates	Transition with straight warp and Ogee sill at end.	
6-AG-2	2,740	Transition below gates	Transition with straight warp and Ogee sill at end.	Flow very good; small irregularities probably due to unsymmetrical construction.

LOG OF TESTS - - - AGENCY VALLEY SPILLWAY (Cont.)

Test and Run No.	Discharge	Feature Studied	Description of Set-up	Remarks
7-AG-1	11,450	Transition below gates	Transition with sloping floor and abrupt change of section from rectangular to trapezoidal.	
7-AG-2	3,650	Transition below gates	Transition with sloping floor and abrupt change of section from rectangular to trapezoidal.	
8-AG-1	11,450	Transition below gates	Transition with sudden drop below gates, and sill at beginning of sudden contraction.	
8-AG-2	3,600	Transition below gates	Transition with sudden drop below gates, and sill at beginning of sudden contraction.	Jump and flow conditions very good.
8-AG-3	11,450	Transition below gates	Same as 8-AG-1, except that slight ogee has been placed below contraction.	
8-AG-4	2,000	Transition below gates	Same as 8-AG-3.	
9-AG-1	12,000	Transition below gates	Transition with ogee drop below gates and wing walls 45 degrees at contracted section.	Jump begins a little above the downstream end of piers; flow in chute very good.
9-AG-2	5,920	Transition below gates	Same as 9-AG-1.	Conditions same as above.

LOG OF TESTS - - - AGENCY VALLEY SPILLWAY (Cont.)

Test and Run No.	Discharge	Feature Studied	Description of Set-up	Remarks
10-AG-1	12,000	Transition below gates	Same as 9-AG-1, except wing walls have horizontal fins, and are warped.	Fins cut down bubbling action at beginning of contracted section, but flow down chute is rougher than without.
10-AG-2	12,000	Transition below gates	Same as 10-AG-1, except that fins are removed.	Flow conditions very good, flow fairly uniform throughout channel.
11-AG-1	12,000	Flow into pool.	Velocity measurements at downstream end of apron at approach to stilling pool.	
12-AG-1	11,720	Pool, Design B	Pool design B with apron H = 8.1' L = 11.25'. (Nomenclature for aprons: H = Height of apron, L = distance apron extends horizontally downstream from toe of original chute).	Apron too *high*; flow very turbulent and water splashed over both sides for entire length of pool; flow unsymmetrical with sideward as well as forward movement, more forward movement on one side than on other; water backed up into nozzles.
13-AG-1	11,750	Pool, Design B	Same as 12-AG-1, except sand bin has been added below pool.	Pool conditions very bad; flow very turbulent with water splashing over the sides; side slopes washed down in very short time.
13-AG-2	11,750	Pool, Design B	Pool design B with Rehbock sill 4.2' high at end of pool.	Flow very bad; sill causes an enormous boil directly over it; flow symmetrical at beginning of roll; very little erosion.

LOG OF TESTS - - - AGENCY VALLEY SPILLWAY (Cont.)

Test and Run No.	Discharge	Feature Studied	Description of Set-up	Remarks
13-AG-3	11,750	Pool, Design B	Pool design B with pool bare (no sill or apron).	Flow better than previous tests, but jump still drowned; erosion greatly increased; water at nozzles much lower than in 13-AG-1.
13-AG-4	11,750	Pool, Design B	Same as 13-AG-3, except tailrace widened.	No change in water surface noted; one wall went out immediately.
13-AG-5	11,750	Pool, Design B	Same as 13-AG-4 with apron 2.3' high.	Pool very rough; very swift velocities through tailrace; depth of pool lower due to lower tailwater.
13-AG-6	11,750	Pool, Design B	Same as 13-AG-5 with Rehbock sill 4.2' high, at end of pool.	Conditions very much better; boil directly over sill; practically no movement of material.
14-AG-1	11,690	Pool, Design B	Pool design B with bucket 4.1' deep at end of chute and Rehbock sill 4.22' high.	Bucket too small; seemed to have no effect.
15-AG-1	11,740	Pool, Design B	Same as 14-AG-1, but with bucket 6.9' deep.	Appears to be the same as 14-AG-1.
16-AG-1	11,740	Pool, Design B	Same as 15-AG-1, but with vertical tip at end of bucket.	Bucket causes fountain at low flows, fountain disappears at high flows; radius of bucket seems too small.
17-AG-1	11,740	Pool, Design B	Same as 15-AG-1, except Rehbock sill was moved to downstream side of bucket.	Water surface very bad; water hits sill and forms fountain.

LOG OF TESTS - - - AGENCY VALLEY SPILLWAY (Cont.)

Test and Run No.	Discharge	Feature Studied	Description of Set-up	Remarks
18-AG-1	11,740	Pool, Design B	Same as 14-AG-1, except with bucket 7.7' deep; slope of tip varied from 45 to 90 degrees. Radius of bucket 28.1'.	When angle of tip is 90 degrees, vertical fountain flow is caused; from 90 to 45 fountain flow becomes less, leaving more energy to be dissipated by sill, which causes jump to form; although pool is roughest with vertical fountain flow, the maximum amount of energy is dissipated.
19-AG-1	11,700	Pool, Design B	Pool design B with bucket the same as 18-AG-1 and toothed sill 9.2' high at lower side of bucket.	Flow in front part of pool bad; water boils way up and is backed up above nozzles; water quiet in lower end of pool.
20-AG-1	11,740	Pool, Design B	Same as 19-AG-1, except notches cut clear through sill.	Less boil than 19-AG-1 due to more velocity getting past sill; considerable erosion in tailrace.
21-AG-1	11,740	Pool, Design C	Pool design C with Rehbock sill 4.4' high and 62 feet downstream from bottom of chute.	Pool action is good, but sill too far upstream; water splashes over entire length of pool; jet does not spread much when entering pool. Tailwater above normal.
22-AG-1	11,740	Pool, Design C	Same as 21-AG-1, except sill moved to end of pool 88 feet downstream from bottom of chute.	Not much change from 21-AG-1. Tailwater above normal.

LOG OF TESTS - - - AGENCY VALLEY SPILLWAY (Cont.)

Test and Run No.	Discharge	Feature Studied	Description of Set-up	Remarks
23-AG-1	11,740	Pool, Design C	Pool design C with Rehbock sill 7.2' high at end of pool; same as 22-AG-1, except for height of sill.	Not as good as small sill; pool rough and very foamy; fountain action over sill; water splashed back over nozzles; very little erosion, however, so final results very good.
24-AG-1	11,690	Pool, Design C	Pool design C with apron 2.7' high, L = 0, and Rehbock sill 4.4' high on block 2.5' high at end of pool.	Water surface looks much better than any previous run; walls of pool should be made higher, water splashes over them a great deal; very little erosion.
25-AG-1	11,740	Pool, Design C	Pool design C with pool bare.	Flow very rough; looks about the same as previous runs, except run 24-AG-1; erosion very bad at end of pool.
26-AG-1	11,700	Pool, Design C	Pool design C with bucket at lower end of chute 7.65' deep and 38.75' long.	Not at all satisfactory; bucket forced water nearly straight up.
26-AG-2	11,700	Pool, Design C	Same as 26-AG-1 with triangular sill at lower side 3.15' high.	Water from chute does not spread full width of pool, chute should flare sooner; fountain flow caused by bucket makes pool very rough and causes water to splash over the sides.
27-AG-1	11,740	Transition below gates	Transition design as submitted by design section.	Roll in center starts just upstream from end of piers; side rolls unsymmetrical and varying.

LOG OF TESTS - - - AGENCY VALLEY SPILLWAY (Cont.)

Test and Run No.	Discharge	Feature Studied	Description of Set-up	Remarks
27-AG-2	6,000	Transition below gates	Same as 27-AG-1, except warps changed slightly.	Flow rough at step, but good down chute; jump in no danger of going out.
28-AG-1	11,700	Transition below gates	Final transition design; same as 27-AG-2, except for sill 1.1' high on step at end of transition.	Flow through transition fairly smooth; jump washes out from between the piers at intervals; pond elevation not affected.
28-AG-2	5,950	Transition below gates	Same as 28-AG-1.	Flow in pool rather rough, but jump stays at end of piers; flow rough in chute due to drop in sill.
28-AG-3	7,900	Transition below gates	Same as 28-AG-1.	Pool rather rough; flow down chute fair.
28-AG-4	3,940	Transition below gates	Same as 28-AG-1.	Flow improves from Q's less than 6,000; flow down chute fair.
28-AG-5	1,460	Transition below gates	Same as 28-AG-1.	Flow the best, except for maximum Q.
29-AG-1	11,740	Pool, Design C	Pool design C with apron 2.65' high, L = 0; sill 1' high, 45.8' downstream; toothed sill 3.6' high on 2.5' block, 88 feet downstream.	Pool looked good; very rough.

LOG OF TESTS - - - AGENCY VALLEY SPILLWAY (Cont.)

Test and Run No.	Discharge	Feature Studied	Description of Set-up	Remarks
30-AG-1	11,760	Pool, Design C	Pool design C with baffle piers set on triangular block 26.7' downstream from toe of chute; curved fillet at toe of chute; small dentated sill 2.5' high at end of pool.	Pool very good; erosion not excessive.
31-AG-1	11,700	Pool, Design C	Pool design C with apron 2.65' high L = 0; diffuser sill 10.2' high at end of pool.	
32-AG-1	11,740	Pool, Design C	Same as 24-AG-1, except sill moved upstream 15.6'.	A roller type of pool; pool rough with bubbling action at end of pool; splashes over sides occasionally.
33-AG-1	11,700	Pool, Design C	Pool design C with apron 2.65' high and triangular sill with end blocks at end of pool.	Pool rather rough, but not much splash.
34-AG-1	11,710	Pool, Design D	Pool design D with apron 2.65' high L = 0; Rehbock sill 4.4' high, 73.75' downstream from toe of chute.	Does not look as good as some of the previous runs; considerable erosion.
34-AG-2 to 15		Pool Design D	Trial runs on various set-ups; no measurements made.	

LOG OF TESTS - - - AGENCY VALLEY SPILLWAY (Cont.)

Test and Run No.	Discharge	Feature Studied	Description of Set-up	Remarks
35-AG-1	11,710	Pool, Design D	Same as 34-AG-1, except for sill; dentated sill 7.2' high and 88 feet downstream from toe of chute.	Side roller action; pool rough and splashy; bubbles and splashes over the sides at end of the pool; expansion at end of pool too sudden.
36-AG-1, 2, and 3		Outlet nozzles	Experimented with and made measurements on nozzles for various heads.	
37-AG-1	11,710	Pool, Design D	Same as 34-AG-1, except for sill; triangular sill with end blocks 88 feet downstream from toe of chute.	Side roller type of pool; low bubbling action at end of pool with occasional splashing over the sides.
38-AG-1	11,710	Pool, Design D	Same as 37-AG-1, except bottom of sand bed in sand instead of stone.	Final result good; material stayed well in center of flume and filled in nicely back of sill.
38-AG-2	11,710	Pool, Design D	Same as 38-AG-1 with five teeth placed between end blocks.	
39-AG-1	11,690	Pool, Design D	Pool design D with apron 2.65' high, L = 0; Rehbock sill 4.4' high on 2.5' block 88' downstream from toe of chute; bottom of sand bed not covered with slab.	Pool good though more boil than 38-AG-2.
40-AG-1	11,690	Pool, Design D	Same as 39-AG-1, except for sill; dentated sill 7.2' high used.	Pool conditions good, but looks worse than 39-AG-1.

LOG OF TESTS - - - AGENCY VALLEY SPILLWAY (Cont.)

Test and Run No.	Discharge	Feature Studied	Description of Set-up	Remarks
41-AG-1	11,710	Pool, Design D	Same as 40-AG-1, except new dentated sill 7.0' high used.	Side roller type of action with considerable bubbling at end of pool; pool quite rough with occasional splashing over the sides.
42-AG-1	11,710	Pool, Design D	Pool design D with apron 2.65' high L = 0; flat triangular sill 1.0' high 36.4' downstream from toe of chute; triangular toothed sill 3.30' high on 2.65' block, 87.5' downstream from toe of chute.	Side roller type pool; flow looks good; erosion considerable, does not look as good as previous runs.
43-AG-1	11,710	Pool, Design D	Pool design D with curved fillet at toe of chute and diffuser sill placed 15.9' downstream from toe of chute.	Pool good with small bubbling fountains over the sill; foamy roller exists ahead of sill; flow slightly unsymmetrical; sand washed upstream to back of sill; water splashed over sides occasionally.
44-AG-1 2, 3, & 4		Head vs. discharge		Measurement of discharge and head on the gates.
45-AG-1	11,710	Pool, Design D	Pool design D with apron 2.65' high L = 0; Rehbock sill 4.7' high on 2.5' block, 87.5' downstream from toe of chute.	Pool fair; quite a boil over sill; very little splash over sides; sand built in back of sill.
46-AG-1	11,710	Pool, Design D	Same as 45-AG-1, except for sill; triangular sill with end blocks.	Pool fair with side rollers; pool surges occasionally and splashes over the sides; pool quite rough when surging.

LOG OF TESTS - - - AGENCY VALLEY SPILLWAY (Cont.)

Test and Run No.	Discharge	Feature Studied	Description of Set-up	Remarks
47-AG-1, 2, & 3		Pressures in pool.	Pressure investigations on floor of pool and downstream face of apron.	
48-AG-1	11,700	Pool, Design D	Same as 45-AG-1, except no sill.	Pool very rough and apparently too short; water splashes over the sides and boil extends downstream into sand bed.
49-AG-1 2 3 4 5	7,990 6,010 3,990 1,970 9,970	Pool, Design D	Final design; same as 46-AG-1.	Pool looks good for most flows, although unsymmetrical for some of the smaller discharges.
49-AG-6	9,970	Transition below gates	Final transition design, same as 28-AG-1.	Jump formed nicely; flow through transition and down chute very good.
50-AG-1 to 8		Pool final design	Pictures taken for various flows in final design.	