Engineering Laboratories Division
Hydraulic Laboratory Branch

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF SMALL WEIR BOX TURNOUT STRUCTURES FOR GENERAL IRRIGATION USE

COLUMBIA RIVER BASIN PROJECT, WASHINGTON

Hydraulic Laboratory Report No. Hyd-396

ENGINEERING LABORATORIES

COMMISSIONER'S OFFICE
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Laboratory Report No. Hyd-396
Hydraulic Laboratory
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Subject: Hydraulic model studies of small weir box turnout structures for general irrigation use--Columbia River Basin Project, Washington.

PURPOSE

The objective of this study was to develop simple, inexpensive, accurate, and maintenance-free turnout structures for dissipating excess flow energies, measuring the rate of flow, and releasing flows up to 5 cfs from canals or low head pipelines into farmers' ditches.

CONCLUSIONS

1. A weir box turnout with a 3-foot-wide by 4-foot-long basin, a 3-foot suppressed rectangular weir, and the plank baffle shown in Figure 10C will satisfactorily control and measure flows to 5 cfs.

2. A weir box turnout with a 3-foot-wide by 7-foot-long basin, a 3-foot suppressed rectangular weir, and the plank baffle shown in Figure 3E will control and measure flows to 5 cfs with effective heads up to 6 feet on the control gate when this gate is at the basin head wall (Figures 2 and 7). Higher effective heads are permissible when the control gates are six or more pipe diameters from the ends of the weir box inlet pipes.

3. A quiet pool on top of the cover of the submerged baffle provides an excellent location for the weir head gage.

4. The width of the basin at the weir, and hence the length of the weir crest, should be held within plus or minus 1/4 inch so that the weir tables, which are based on a 3-foot-long crest, can be used with reasonable accuracy.

5. The weir blade must be set level and be sealed to the side walls to function properly. It is important that the zero of the head gage coincide with the level of the weir blade.

6. The crest of the suppressed rectangular weir must be vented to obtain stable operation. A 1-inch pipe at each end should be adequate.

7. The head required to release 5 cfs into the turnout structure with the 15-inch control gate in the head wall fully open was 0.40 foot (Figure 8D).

8. Submerging the weir causes the discharge coefficient to deviate from the unsubmerged values at a rate somewhat less than that given in Table 12 of the Water Measurement Manual (Figure 8C).

9. A large accumulation of gravel in the weir basin had no affect on the discharge coefficient at low flows, but raised the coefficient 4.6 and 6.4 percent for 5 cfs with the 15-inch head wall gate partly closed and full open, respectively.

10. The Yakima T-baffle and a modification of it were found to be unsatisfactory at flows greater than about 2 cfs when the head differential across the control gate located in the head wall was 1 foot or more (Figures 3A, 3B, and 4).

ACKNOWLEDGMENT

The recommended weir turnout design resulted from the cooperative efforts of Bureau of Reclamation forces in the field, and in the Canals and the Hydraulic Laboratory Branches of the Assistant Commissioner and Chief Engineer's office in Denver, Colorado.

INTRODUCTION

There is a continuing need for simple, effective, and inexpensive structures to take irrigation water from supply canals, measure the rate of flow, and release the water into farmers' ditches. These turnout structures usually must regulate the flow rate, control and dissipate high velocity currents, and provide a reasonably quiet pool upstream from a measuring weir. The structures should be economical to build, simple and troublefree to operate, accurate, and as maintenance-free as is feasible. A turnout which fulfilled these requirements for small rates of flow and small heads, and known as the Yakima-type weir turnout, was developed on the Yakima Project, Washington, Figure 1. This turnout, which utilizes a Cipolletti weir for measuring the flow, was described and discussed in a field trip report dated November 14, 1951 by S. T. Larsen.

The advance of the irrigation phase of the Columbia Basin Project renewed the demands for inexpensive turnouts and the Yakima-type structure was suggested for use on the project. In some cases the flow rates and operating heads will be within the ranges known to be satisfactory for the Yakima-type structures, but in many other cases the discharges and heads will be much greater. To handle the more severe operating conditions it appeared that the structures would have to be enlarged, or that design changes would have to be made. The most severe condition anticipated is a 5 second-foot flow with a 6-foot head differential across the control valve. This head differential is the elevation difference between the water surface in the head box and that in the weir pool.

As previously mentioned, the Yakima-type turnout uses a Cipolletti weir for the flow measurement. In order to use standard discharge tables for a Cipolletti weir the basin must have a width about two and one-half times the weir length, a length about four times the weir length, and a depth below the weir crest about equal to the maximum head on the crest. This means that a turnout using a Cipolletti weir must be relatively large for the discharge passed. A reduction in the structure size for a given turnout capacity was sought as a means of reducing the cost per structure, and, after considering various types of weirs and their basin requirements, it was determined that a rectangular suppressed weir would permit the narrowest structure. The basin length would be a function of the effectiveness of a system of baffles in distributing and quieting the flow as it entered the basin.

Preliminary considerations suggested that two structures would be needed to gain the utmost economy in the field installations. One would be intended for flows up to 2 cfs at heads not greater than 1 foot. The other would be intended for discharges up to 5 cfs and heads up to 6 feet. It was subsequently determined by laboratory tests that the smaller structure, as finally developed, would be satisfactory for discharges up to 5 cfs with head differentials up to 3 feet, and that the same structure would be satisfactory for heads of more than 6 feet provided the control gate was placed in the inlet pipe well upstream from the basin, instead of on the basin head wall. A discussion of the laboratory tests on the weir box turnout using the suppressed rectangular weir, and of the results obtained by the tests, is presented in this report.

INVESTIGATION

Description of Full-sized Model

For the turnout quantities considered for the Columbia Basin Project, the field structures are not large, being about 3 feet wide and less than 12 feet long. The laboratory model was therefore made full size, and it consisted of a 15-inch inlet pipe, a head box containing a 15-inch square-leafed irrigation gate, and a combination stilling pool and measuring weir basin (Figure 2). A 12-inch gate valve upstream of the 15-inch inlet pipe, and the 15-inch irrigation gate on the head box wall provided regulation of the rate of flow and control of the head at the turnout structure. Baffles were placed in the upstream end of the basin to disperse the jet issuing from the gate to provide smooth flow to the measuring weir. The measuring weir was of the rectangular suppressed type with a machined metal blade. The blade extended across the full width of the basin and was mounted at the top of the upstream face of the movable wall which was used to form the downstream end of the basin. A tailgate farther downstream in the model permitted raising the water surface so that the weir could be submerged. Water was supplied to the model through the central laboratory supply system which contained Venturi meters for measuring the rate of flow. After passing through the model the water was returned to the laboratory reservoir and was recirculated. Suitable instruments such as piezometers, manometers, and staff gages were provided for measuring the water depths and heads.

The same basic model was used for the development of two structures; i.e., the 2 cfs and the 5 cfs turnouts. The difference in the two turnouts lay in the design of the baffle covers and the length of the weir pools. Most of the tests were conducted with the 15-inch irrigation gate mounted on a wall of the head box which formed the head wall of the weir basin. This arrangement provided the highest flow velocities and the most difficult flow control problems. Moreover, this was the location most likely to be used in the field structures because of the nearness of the regulating gate to the weir gage. Near the end of the test program the gate was removed and the pipeline was extended through the head box so that the weir basin was supplied directly from the pipeline. Flow and head regulation in the tests with this type of entrance were accomplished with the 12-inch gate valve 10 feet upstream from the model basin, and with a second gate valve in the permanent laboratory water supply system.

Turnout Structure for 5 cfs with a 6-foot Head Differential on Control Gate

Preliminary Tests--T-baffle

The T-shaped baffle of the Yakima turnouts was tested in the model basin (Figures 2 and 3A). Fairly good flow conditions occurred in the pool at discharges to about 2 cfs and head differentials up to 1 foot across the gate. At 1.4 cfs the water-surface fluctuation in the pool downstream of the baffle was 1/2 inch measured from the peak of the waves to the bottom of the troughs (Figure 4A). With 3.0 cfs at a 1-foot head differential, the baffle was not adequate and there was considerable eddying and boiling in the pool (Figure 4B). In addition water overtopped the horizontal baffle arm and spilled into the weir pool. These tests showed that better baffling was required if discharges of 5 cfs were to be measured satisfactorily.

Development of Baffle

Modified T-baffle. The Yakima T-baffle was modified by adding a horizontal 4-inch-wide shelf to the upstream face of the upright, cutting a 4-inch-high by 6-inch-wide opening at the bottom of the upright, and placing a cover over the area from the head wall to the horizontal T-board (Figure 3B). Somewhat better flow was obtained with this baffle, but it was still not considered satisfactory.

Wide center board with side wall deflectors and cover. A baffle was suggested in which the flow was made to pass through side passages of known area, and then caused to flow inward in a manner intended to produce energy dissipation and improve flow distribution (Figure 3C). A wall 3/4 inch thick, 27 inches long, and extending 19 inches upward from the floor to a submerged cover was placed in the basin in front of the gate opening. Water flowed around each side of the wall and was then deflected inward toward the passage center line by baffles placed at the side walls and a short distance downstream. The submerged cover extended 4 feet downstream from the head wall and was tightly sealed to the head box and basin walls. The length of the basin was increased from 4 feet to 7 feet by moving the weir wall downstream. Better flow was obtained with this baffle than with the previous designs and a discharge of 5 cfs could be passed without extreme turbulence (Figure 5). Less turbulence occurred when the control gate was partly opened than when it was opened all the way (Figures 5B and 5A). Changes in the width of the center obstruction and in the size and shape of the side wall deflectors changed the flow pattern to some degree, but did not produce acceptable conditions. Removal of the side wall baffles slightly improved the flow conditions when the gate was at or near the full open position. The head loss across the baffle was found to be high and a differential of more than 1 foot was required to pass 5 cfs when the 15-inch gate was full open.

Pool for head gage. It was believed that if a quiet pool could be created in the structure, a staff gage could be installed in it and rapid and accurate measurements could be made of the head on the weir. Such a pool was formed near the upstream end of the weir basin by placing a 2 x 8 timber on edge across the upper surface of the submerged cover (Figure 5C). The bottom of the 2 x 8 was notched at three places to permit communication between the water in the weir basin and in the measuring pool. When the cover length was reduced from 4 feet 0 inches to 2 feet 4 inches, considerably different heads were indicated in the pool at any given discharge with the gate operated full open or partly closed. When the cover length was changed to 3 feet 6 inches the readings became more consistent so that at 5 cfs the indicated head with the full open gate was only 0.026 feet greater than with the partly open gate. This degree of accuracy was considered adequate for the structures.

Plank baffles with submerged cover. A baffle made of three vertical 2 x 8 timbers, spaced 1 inch apart and extending 19 inches up from the floor to the submerged cover, produced good flow and permitted a discharge of 5 cfs at a head differential of 0.43 feet. Another baffle made of four 2 x 6 timbers, spaced 1 inch apart, in conjunction with the sealed submerged cover, produced somewhat better flow (Figures 3D and 6A and B), and a 5 cfs flow required a head differential on the gate of only 0.40 feet. Head measurements on the staff gage at 5 cfs differed by less than 0.005 feet when the gate was operated at the full open or partly closed position.

Clogging of plank baffles. The possibility of the plank baffles acting as trashracks and becoming clogged with weeds was considered, and a test was made in which a 5-gallon can of leafy pondweed and water stargrass was slowly emptied into the head box of the model while 5 cfs was flowing through the fully opened gate. None of the weeds caught on the baffle and all were carried through the weir basin and out of the structure (Figure 6C). Clogging was still considered a possibility, however, because papers, tumbleweeds, and other large foreign objects could easily enter the main canal and be carried into the turnouts. If clogging should occur, the baffle would be difficult to clean because of the sealed cover over the area upstream from the planks. This portion of the cover was therefore removed to provide an opening for the removal of debris. A 2 x 12 was placed on edge on the cover above the baffle planks to prevent water from splashing into the head measuring pool. The flow in the weir basin was adversely affected by the removal of the upstream portion of the cover and the head readings in the measuring pool for a 5 cfs flow differed by about 1 inch at the full open and the partly open gate settings. Several minor revisions to the baffle planks and spacings failed to produce any significant flow improvement.

Recommended plank baffle. A nonwatertight, removable cover over the baffle cleanout opening (Figure 3E) produced nearly as good flow in the weir basin as the watertight cover. The difference in head indicated at the staff gage for a 5 cfs flow with the gate full and partly open was 0.025 feet (Figures 7 and 8A). Boils occasionally occurred in the basin when the gate was at or near the full open position, but they were considered not frequent enough to be detrimental to the over-all performance (Figure 7A).

The relation of the rate of flow and the head on the weir, as measured in the staff gage pool, is shown in Figure 8A for conditions where the gate is full open with the minimum head, and where the gate is partly opened with a 6-foot head differential. The test points with the fully opened gate and with the partly opened gate at discharges greater than 2 cfs closely agree with the values given for a 3-foot suppressed weir in Table 8 of the 1953 edition of the Bureau of Reclamation Water Measurement Manual (Figure 8A). At flows less than 2 cfs the head reading is about 0.017 foot less for partial gate openings than for full openings. This deviation from the Table 8 curve at partial gate openings with flows less than 2 cfs was at first of some concern, but the designers decided that new weir tables would be prepared for these structures, and there would be no need for developing a weir having a more nearly constant coefficient. The plank baffle and submerged cover design shown in Figure 3E is therefore considered suitable for field structures. The relation of the coefficient of discharge to the head on the weir for this turnout design is shown in Figure 8B and the relation of head loss to the rate of flow with the gate full open is shown in Figure 8D.

Study of Turnout Operation

Effect of submerging weir. The change in discharge coefficient resulting from submerging the weir was determined by raising the tailgate of the model. At slight submergences the coefficient was greater than without submergence, and at greater submergences the coefficient decreased (Figure 8C). This is in general agreement with the submergence data presented in Table 12 of the Bureau of Reclamation Water Measurement Manual, which tabulates the correction to be applied to the discharge indicated by the measured weir head (Figure 8C). The test data for the turnout structure, when presented in the same form as that in the above table, is somewhat higher than the table values at the higher submergences.

Effect of sand deposits in basin. Considerable quantities of dirt and sand may enter the weir basins from the canals, and by deposition due to winds. These accumulations might become large in structures that are not periodically maintained or are operated continuously for long periods of time. The effect of such deposits upon the accuracy of the flow measurements was determined by placing pea gravel in the model. The material deposited in field structures will no doubt be much smaller than pea gravel and may in most cases be washed away under normal operating conditions. However, it was desirable to ascertain what the effect of such deposits would be on the efficiency of the weir so the use of the larger material was satisfactory. Three bushels of gravel were placed in the basin at the foot of the weir in the first test. Check readings were taken after several hours of operation had elapsed to stabilize the position of the gravel (Figure 9A). At low flows the coefficient was unchanged and at 5 cfs the coefficient was slightly increased. More gravel was added to bring the gravel deposit up to the weir crest. After 4 hours operation at 5 cfs with a 6-foot head differential on the control gate readings were again taken. The coefficient remained unchanged at the low flows but was 4.6 percent higher than initially at 5 cfs with a 6-foot head differential on the control gate, and 6.4 percent higher at 5 cfs with the gate fully opened. The gravel deposit at the end of the test is shown in Figure 9B.

Effect of air vents at weir. The two air vents placed just downstream of the weir blade and below its crest (Figure 2) were kept open in all preceding tests. When these vents were closed, unstable flow occurred at the crest, particularly at the higher discharges, because intermittent venting occurred through the nappe. When the air vents were reopened steady flow resumed. The vents are therefore considered essential for satisfactory operation of the measuring weir and should be included in all prototype structures, and be arranged so as to be nonclogging.

Turnout Structure for 2 cfs with 1-foot Head Differential on Control Gate

Development of Design

It seemed possible to decrease the size of the turnout structure for the smaller discharges and gate differentials, and tests were made to determine what changes would be practical. The tests showed that for the 2 cfs structure the baffle cover could be shortened 1 foot on the downstream end, and the cleanout cover upstream of the baffle planks could be removed. The height, size, and spacing of the baffles, and the position of the cover were left unchanged (Figures 10A and 3E). The width of the basin was retained at 3 feet because this was considered the minimum practical size for construction and maintenance purposes. The flow conditions produced by this design at 2 cfs were excellent, and it appeared that the 7-foot-long basin could be shortened to 5 feet. Excellent flow occurred with the 5-foot-long basin and the design was further simplified by removing the portion of the cover downstream from the measuring pool (Figure 10B). Good flow persisted and the basin was shortened to 4 feet.

Recommended design. The 4-foot-long by 3-foot-wide basin with the four 2 x 6 planks spaced 1 inch apart, and with the short submerged cover and measuring pool constitutes the recommended design for the 2 cfs, 1-foot head differential turnout structure (Figure 10C). Flow conditions in the basin, and head measurements in the measuring pool, were excellent at the design conditions (Figures 11 and 13A).

Adopted Designs for 5 cfs with Head Differential Limits of 3 and 6 Feet on Control Gate

Extension of Tests on 2 cfs Turnout Structure

5 cfs with a 3-foot head differential limit on control gate. The recommended design of the 2 cfs structure was subjected to progressively increased discharges to find the practical operating limits and to obtain data for calibration curves. The flow at 3 cfs with the gate fully opened (minimum head), and at 3 cfs with the gate partly closed and a head differential of 3 feet, was satisfactory (Figures 12A and B). At 5 cfs with a 3-foot head differential the flow was somewhat turbulent with either full open or partly closed gate, but not so disturbed that reasonable flow measurements could not be made (Figures 12C and D). The relation of the rate of flow to the head on the weir (measured in the staff

gage pool) is shown in Figures 13A and B. The values given in Table 8 of Water Measurement Manual are also shown on these figures. A deviation of the test points from the table values was noted, particularly in the case with a 6-foot head on the control gates. The relation of the discharge coefficient to the head on the weir is shown in Figure 13C. On the basis of these tests it was the designers' opinion that the 2 cfs structure could be used without change for flows up to 5 cfs with head differentials on the control gate to 3 feet. This design is therefore incorporated in the Type 1 and Type 2 structures shown in Figure 16 (Drawing No. 40-D-5315). A table, based upon the test data, was prepared to show the discharges at a suitable range of heads on the weir (Figure 16). Vertical columns appear in the table for differential heads on the control gate (y) of 0.25, 1, 2, and 3 feet in accord with the deviations shown in Figures 13A, B, and C.

<u>5 cfs with a 6-foot head differential on the control gate.</u> The discharge coefficient with 5 cfs and a head differential on the gate greater than 3 feet deviated too much to be acceptable when the gate was located in the head wall of the basin (Figures 13C and 2). The model was therefore modified by removing the gate at the basin head wall and by extending the 15-inch conduit through the head box to the basin (Figure 2). This arrangement represented the case where the turnout control is at, or near, the canal bank and the flow enters the weir basin through the filled 15-inch inlet pipe. The rate of flow to the basin was controlled with the 12-inch valve in the line 10 feet upstream from the weir basin, and the desired head differential on this valve could be set by adjusting this valve and a second valve farther upstream in the supply line. Tests were made at flows of 3 and 5 cfs with the 12-inch valve full open, and with the valve partly closed, with head differentials of 3 and 6 feet (Figure 14). Quite good performance was obtained and the test data is shown in Figure 15 for the condition where no air enters the vent in the pipe line below the valve (Figure 2). The design is therefore incorporated in the Type 3 structure shown in Figure 16 (Drawing No. 40-D-5315). There was little difference between the curves for the various test conditions, and only one tabular column was required for the Type 3 structure (Figure 16).

<u>Effect of air vent below pipeline control valve.</u> An additional test was made in which the 4-inch air vent in the pipeline just downstream of the 12-inch gate valve (Figure 2) was opened, and the gate was subjected to upstream heads up to 8 feet. The discharge-to-head relationship at the weir remained unchanged, but at the higher heads a hydraulic jump occurred in the pipeline and trouble was experienced in the basin with air that was entrained in the jump. Much of the air surfaced in the open area between the head wall and the baffle planks and waves were created which carried through the basin. The remaining air passed under the cover and surfaces in the weir pool where it created additional waves. These small choppy waves communicated with the water in the measuring pool and caused undesirable surface fluctuations. It was concluded that air vents should not be provided below the gates of the Type 3 structures and that this type structure should not be used in settings where there is danger of cavitation below the throttling valve.

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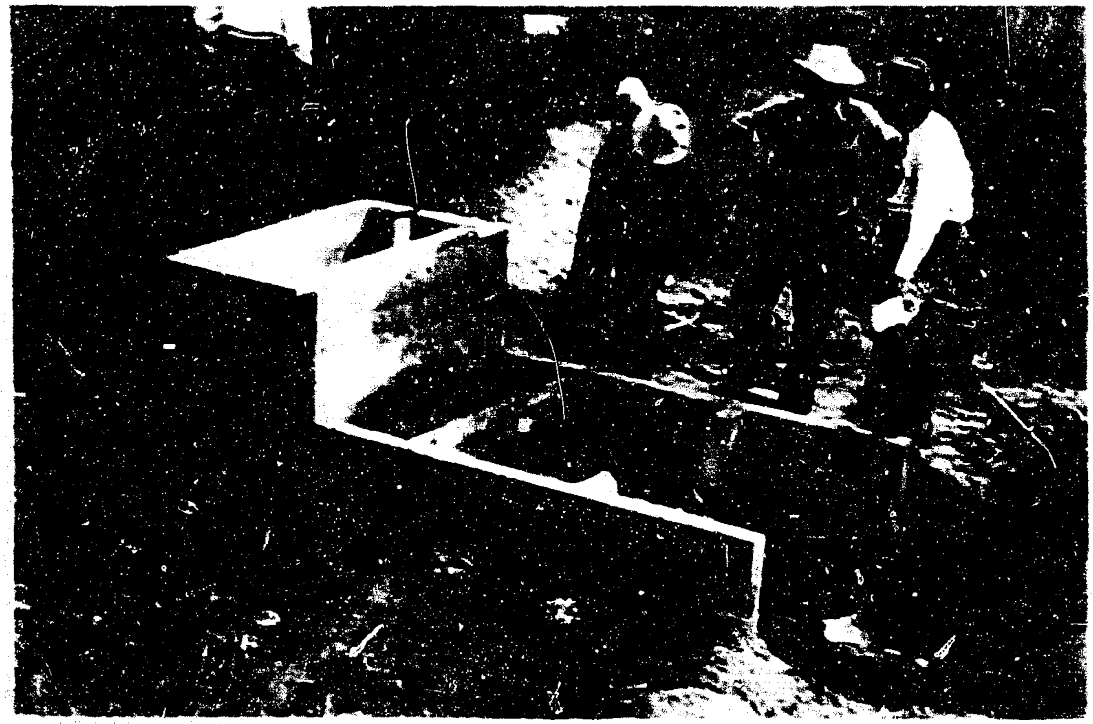

A. Weir box turnout with Cipolletti weir

B. Weir pool, upper part of T-baffle, and Cipolletti weir - Flow about 0.5 cfs.

WEIR BOX TURNOUT STUDIES
Field installation - Yakima-type Turnout

FIGURE 2
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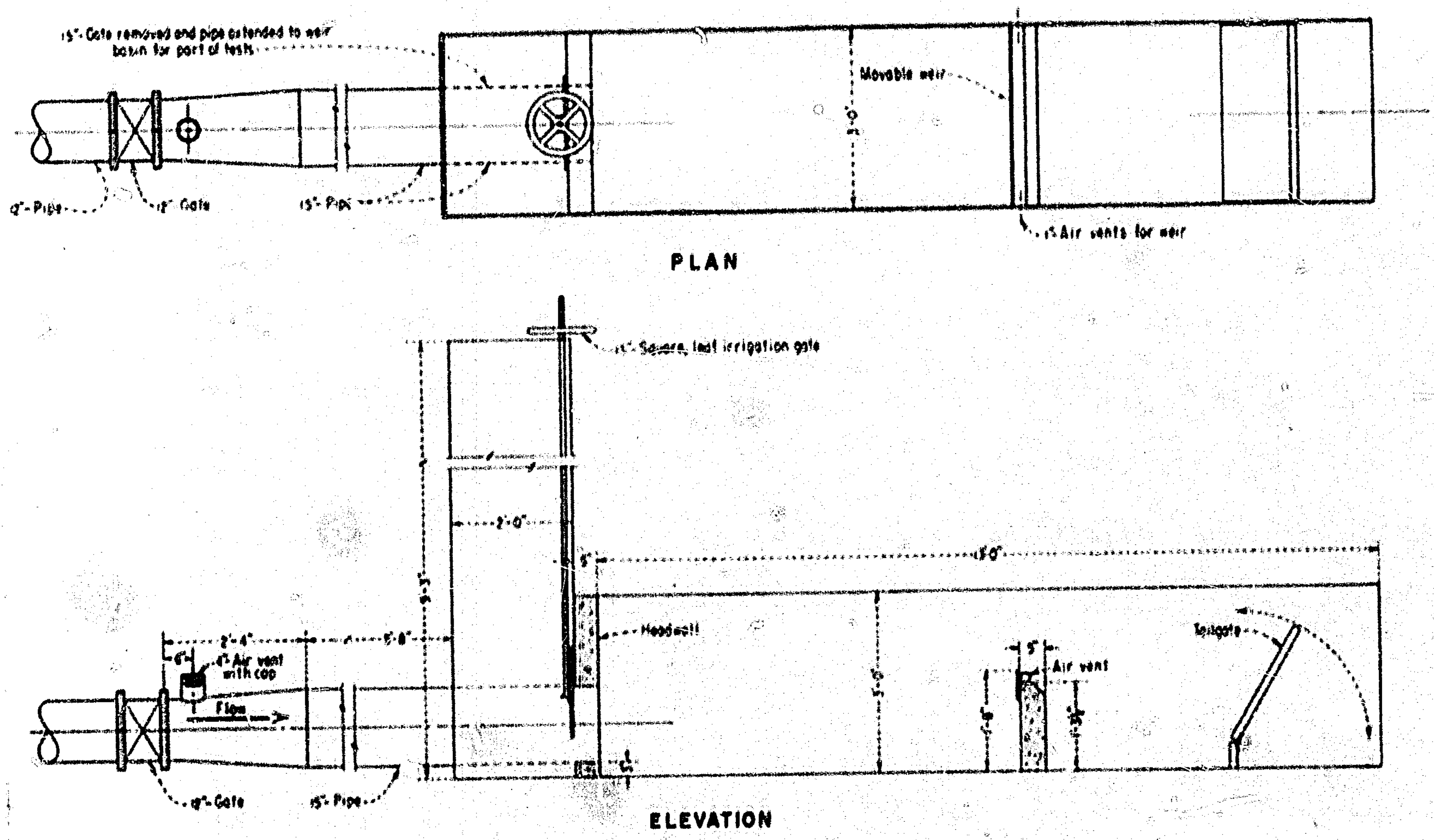
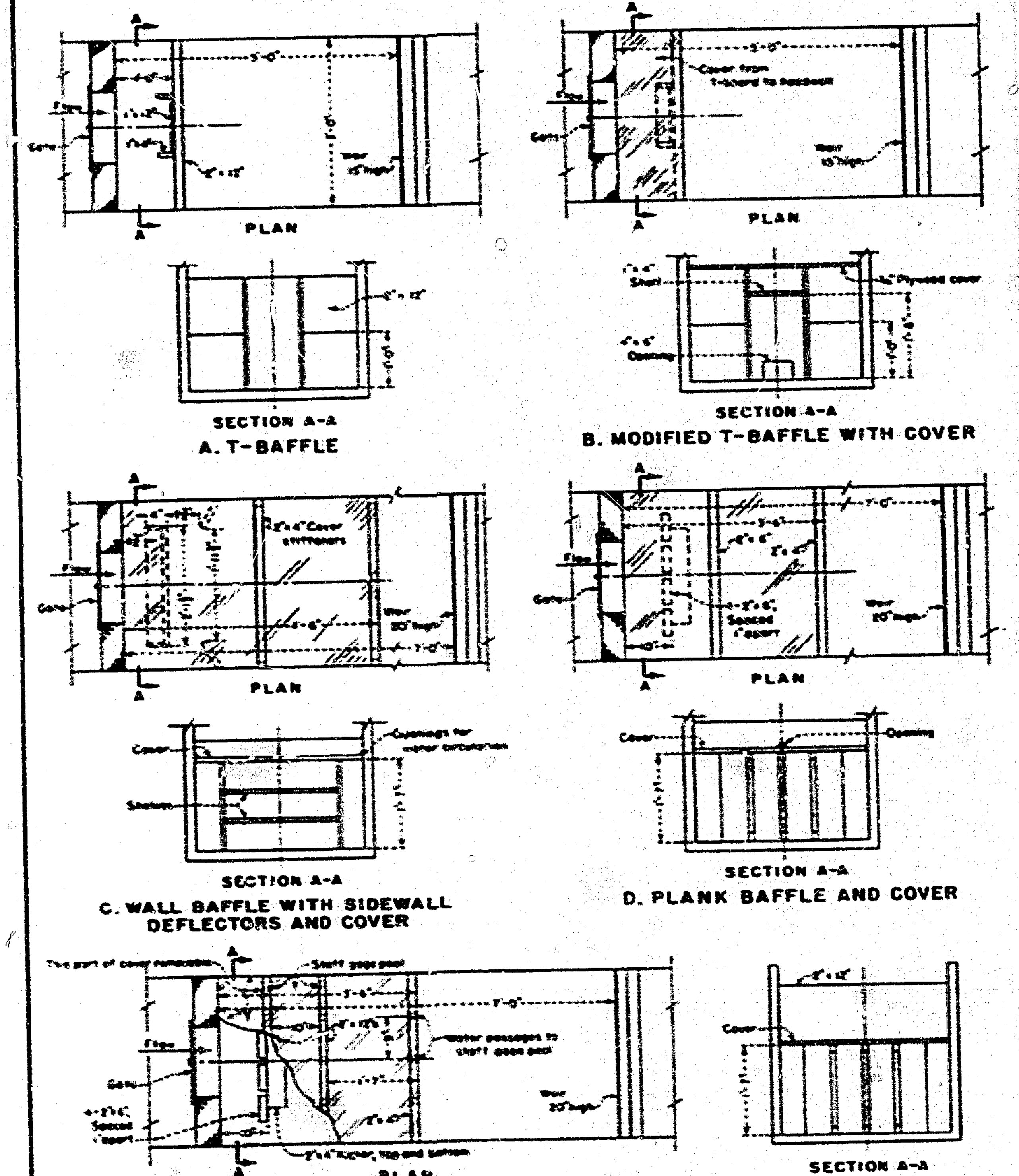


WEIR BOX TURNOUT STUDIES

LABORATORY MODEL

FULL SIZE

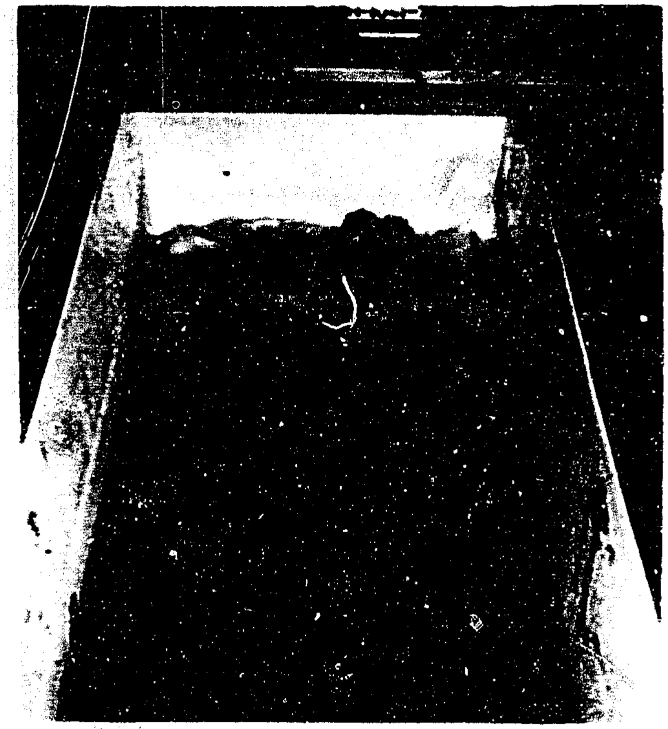
FIGURE 3



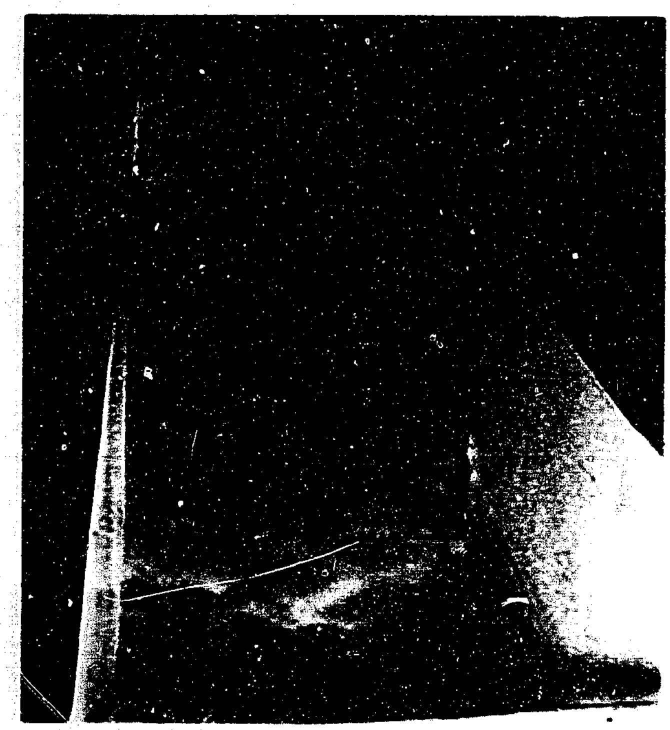
WEIR BOX TURNOUT STUDIES

BAFFLES FOR 5 CFS TURNOUT WITH 6 FOOT HEAD DIFFERENTIAL ON CONTROL GATE

FULL SIZE MODEL



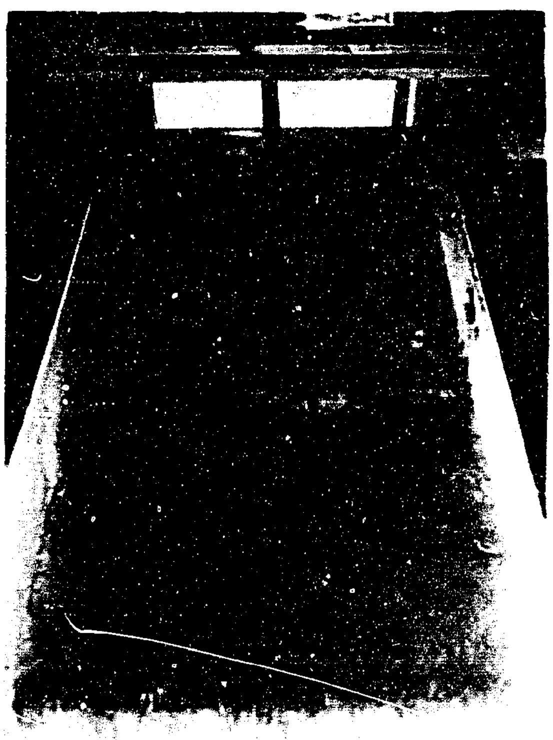
A. 1.4 cfs with 1 foot head on control gate



B. 3 cfs with 1 foot head on control gate

WEIR BOX TURNOUT STUDIES
Flow conditions - 5 foot long weir basin with Yakima-type T-baffle
Full size model

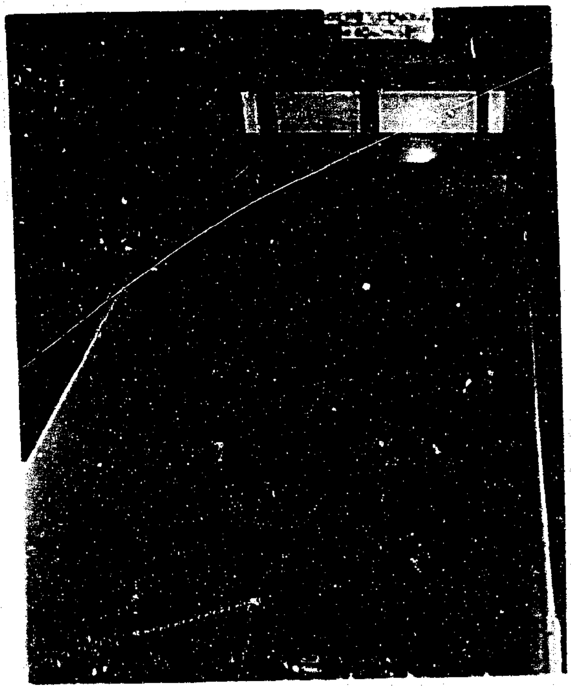
A. 5 cfs with 1.67 foot head differential on full-open 15 inch control gate



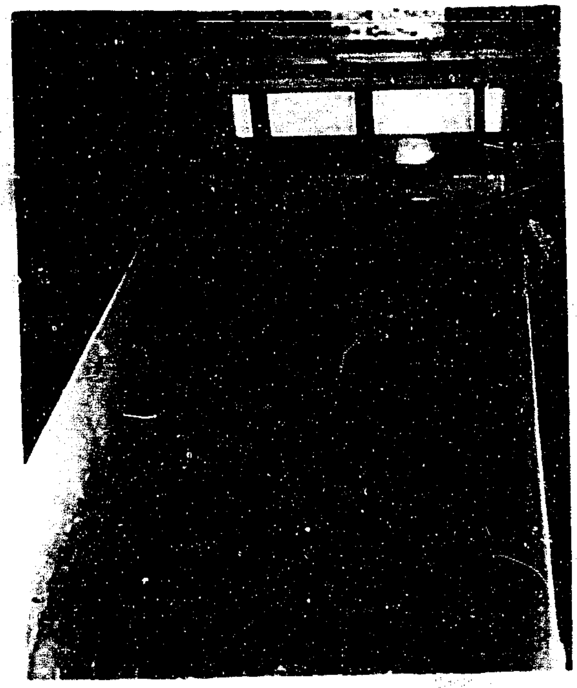
B. 5 cfs - 6.16 foot head differential on 15 inch control gate 5.5" open

C. 5 cfs - 1.14 foot head differential on full open 15 inch control gate. 2 x 8 on top of cover forms quiet measuring pool.

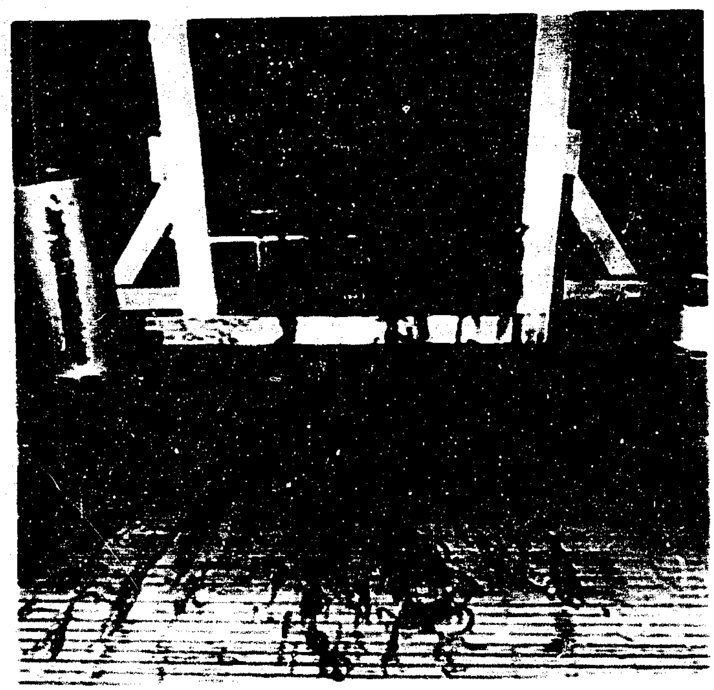
WEIR BOX TURNOUT STUDIES
Flow conditions - 7 foot long weir basin with wide center plank baffle, sidewall deflectors, and submerged cover.
Full size model



A. 5 cfs - 0.54 foot head differential on full open 15 inch control gate.

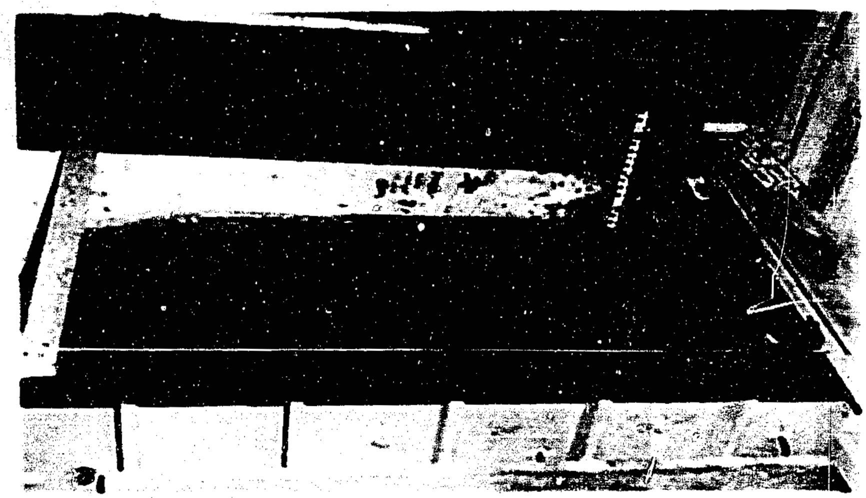


B. 5 cfs - 6.16 foot head differential on 15 inch control gate 5.2 inches open.

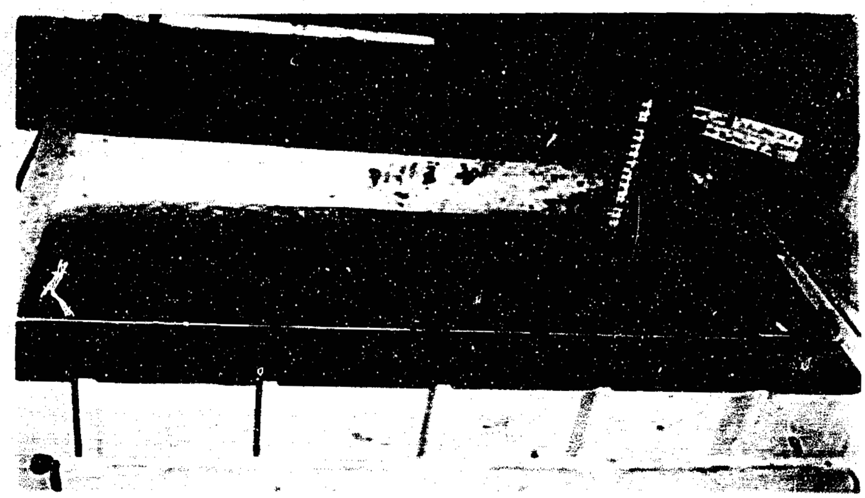


C. Leafy Pond Weed and Water Starr Grass put through the turnout. None was retained on baffle.

WEIR BOX TURNOUT STUDIES
Flow conditions - 7 foot long weir basin with 4 vertical 2 x 6 planks and watertight submerged cover.
Full size model

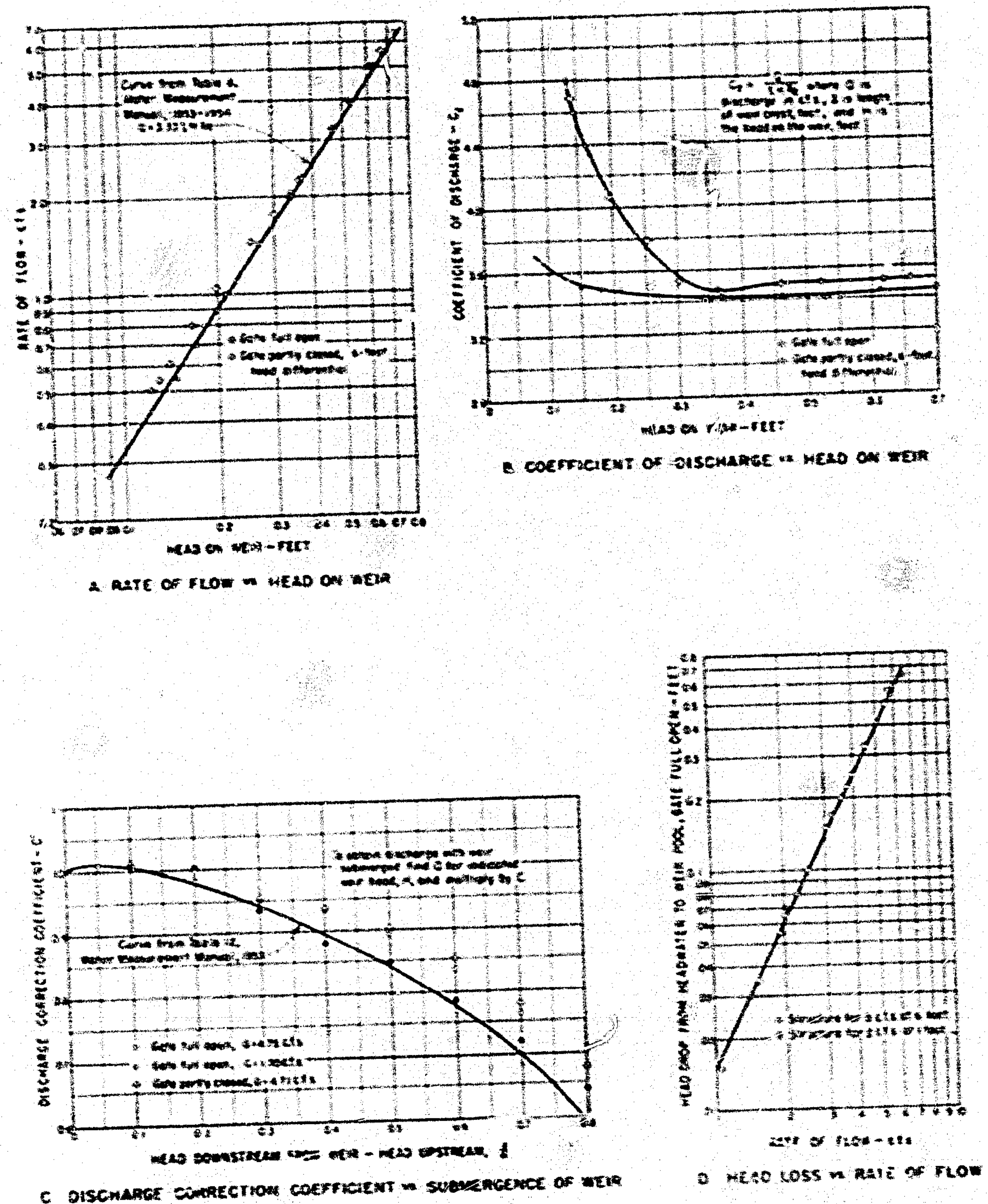


A. 5 cfs - 0.40 foot head differential on full open 15 inch control gate.



B. 5 cfs - 6.0 foot head differential on 15-inch control gate 5.2 inches open

WEIR BOX TURNOUT STUDIES
Flow conditions - 7 foot long basin, 5 cfs-6 foot head turnout structure with recommended plank baffle, submerged cover, and removable cleanout
Full size model



A. RATE OF FLOW vs HEAD ON WEIR

B. COEFFICIENT OF DISCHARGE vs HEAD ON WEIR

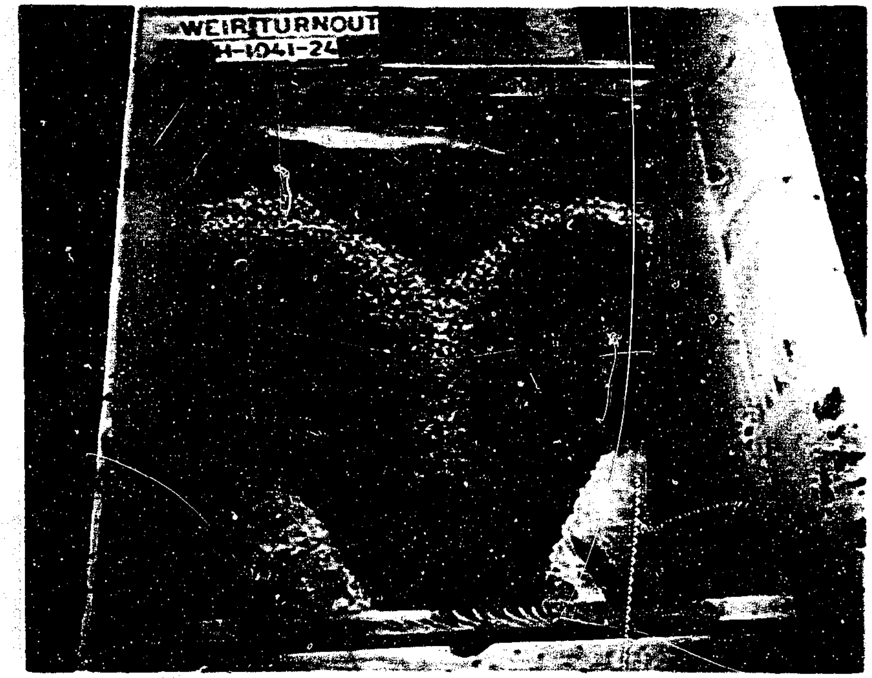
C. DISCHARGE CORRECTION COEFFICIENT vs SUBMERGENCE OF WEIR

D. HEAD LOSS vs RATE OF FLOW

WEIR BOX TURNOUT STUDIES

PERFORMANCE CURVES—RECOMMENDED STRUCTURE FOR 5 CFS WITH 6 FOOT HEAD DIFFERENTIAL ON CONTROL GATE

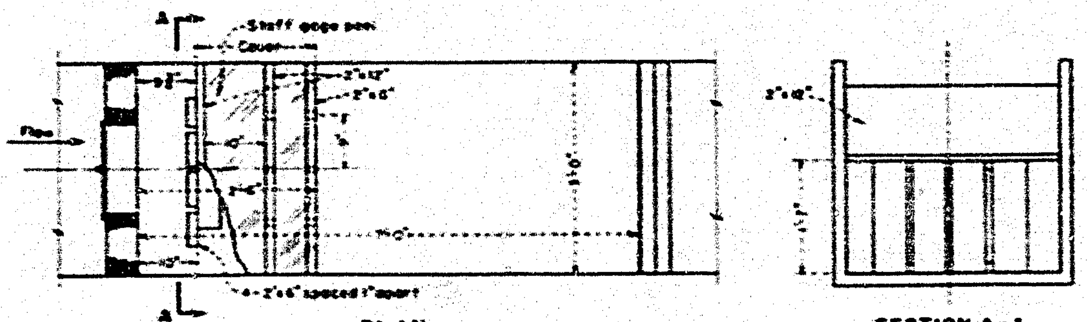
FULL SIZE MODEL



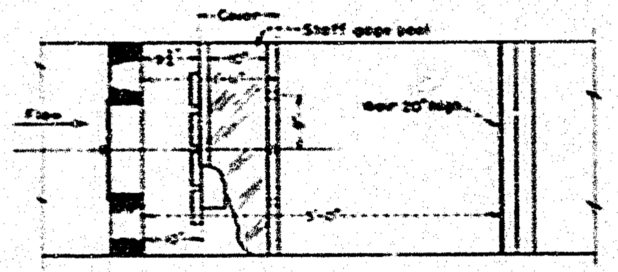
A. Pattern assumed by 3 bushels of pea gravel after 2.3 hour run at 5 cfs with full open control gate.

B. Pattern assumed after more gravel was added to that shown in "A" and after 4 hour run at 5 cfs with 6 foot head differential on control gate.

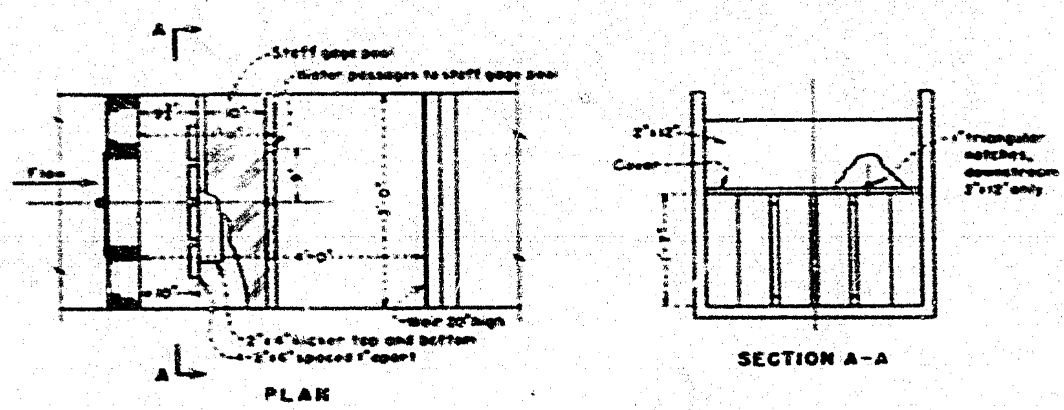
WEIR BOX TURNOUT STUDIES
Gravel deposits used in tests
Full size model



A. PLANK BAFFLE WITH COVER DOWNSTREAM



B. SHORT DOWNSTREAM COVER AND 5'-0" POOL



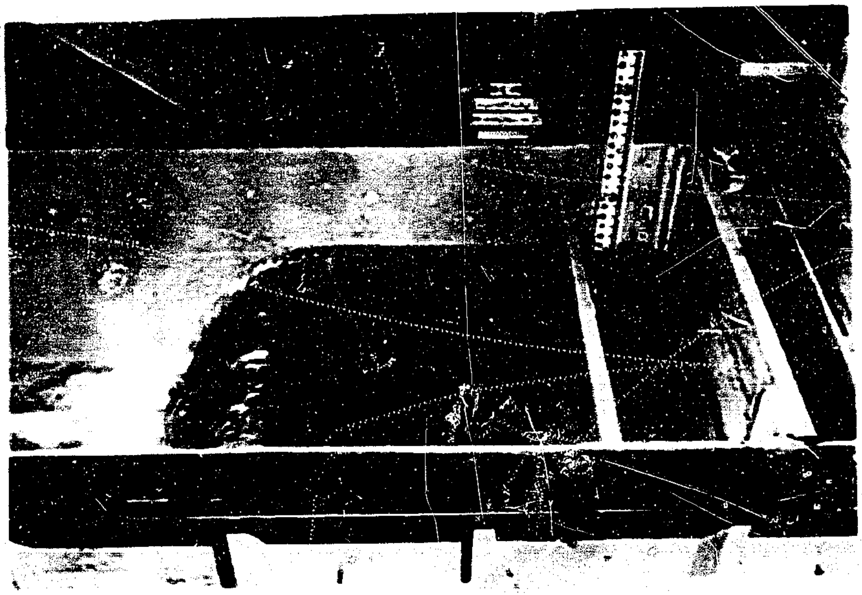
C. RECOMMENDED PLANK BAFFLE, SHORT COVER, AND 4'-0" POOL

WEIR BOX TURNOUT STUDIES

BAFFLES FOR 2 CFS TURNOUT WITH 1 FOOT HEAD DIFFERENTIAL LIMIT ON CONTROL GATE

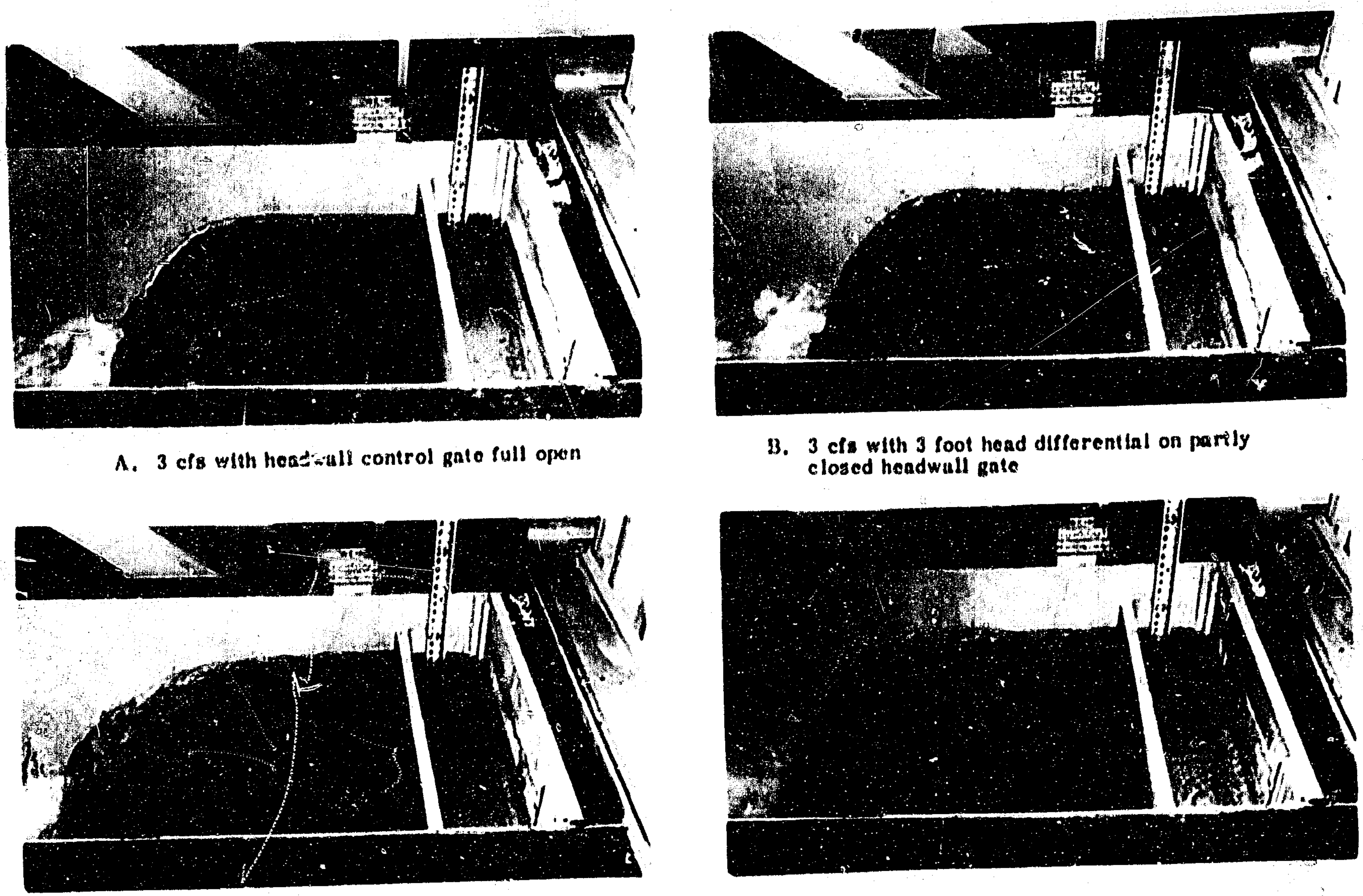
FULL SIZE MODEL

A. 2 cfs - full open 15 inch control gate



B. 2 cfs - 1 foot head differential on control gate

WEIR BOX TURNOUT STUDIES
Flow conditions - Recommended 2 cfs - 1 foot head turnout structure
with plank baffle and short cover
Full size model



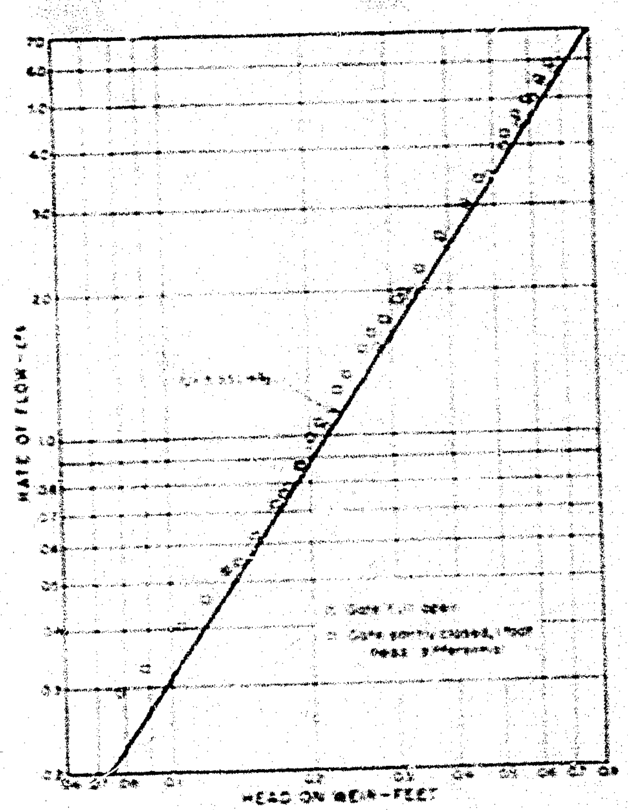
A. 3 cfs with headwall control gate full open

B. 3 cfs with 3 foot head differential on partly closed headwall gate

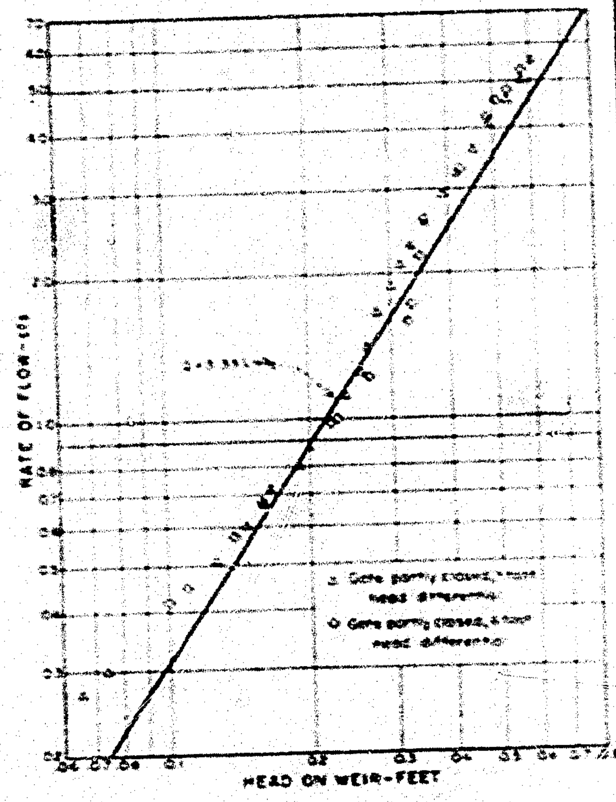
C. 5 cfs with headwall control gate full open

D. 5 cfs with 3 foot head differential on partly closed headwall gate

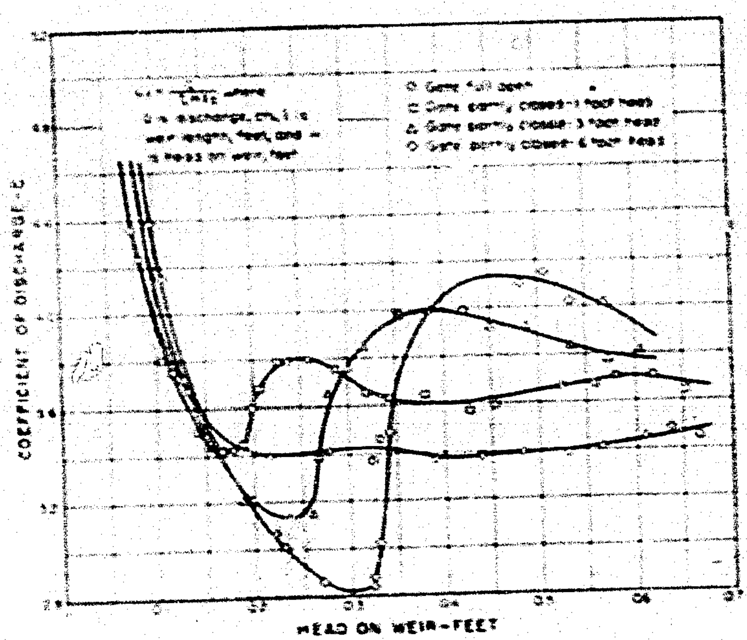
WEIR BOX TURNOUT STUDIES
Flow conditions with 3 and 5 cfs flows in 2 cfs turnout structure with control gate on weir basin headwall
Full size model



A. RATE OF FLOW VS. HEAD ON WEIR



B. RATE OF FLOW VS. HEAD ON WEIR



C. COEFFICIENT OF DISCHARGE VS. HEAD ON WEIR

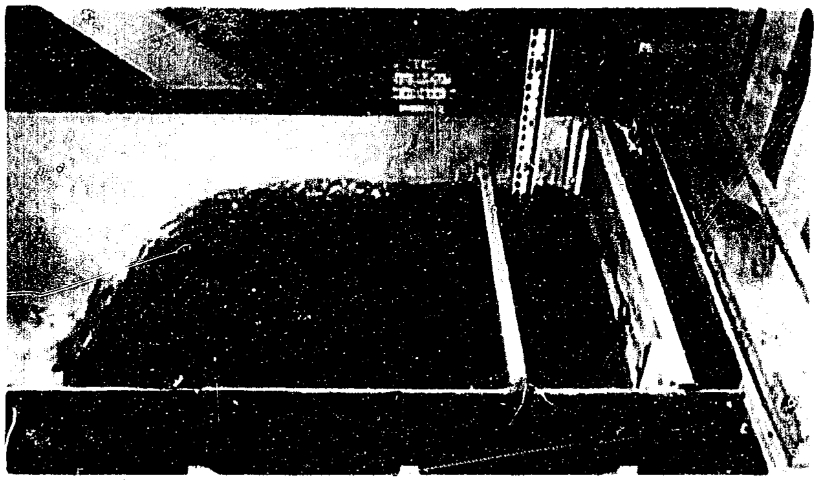
WEIR BOX TURNOUT STUDIES

PERFORMANCE CURVES — RECOMMENDED STRUCTURE FOR 2 CFS
WITH 1 FOOT MAXIMUM HEAD DIFFERENTIAL LIMIT ON CONTROL GATE

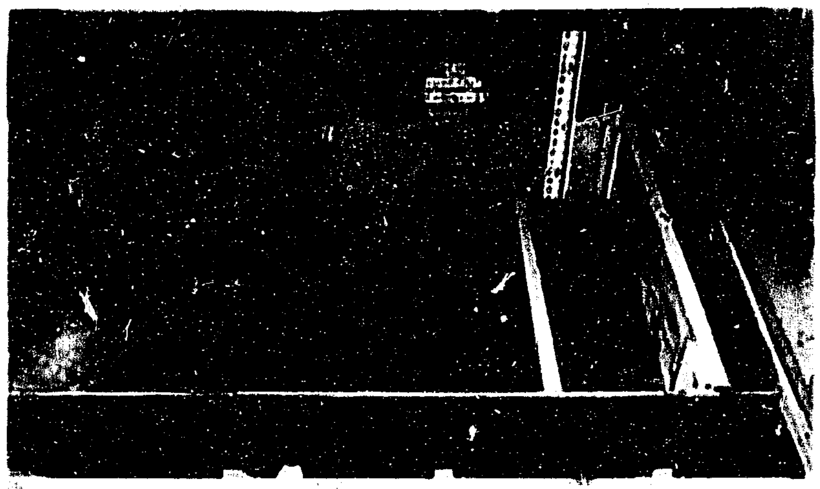
FULL SIZE MODEL

A. 3 cfs with pipeline gate valve full open

B. 3 cfs with 6 foot head differential on partly closed pipeline gate valve

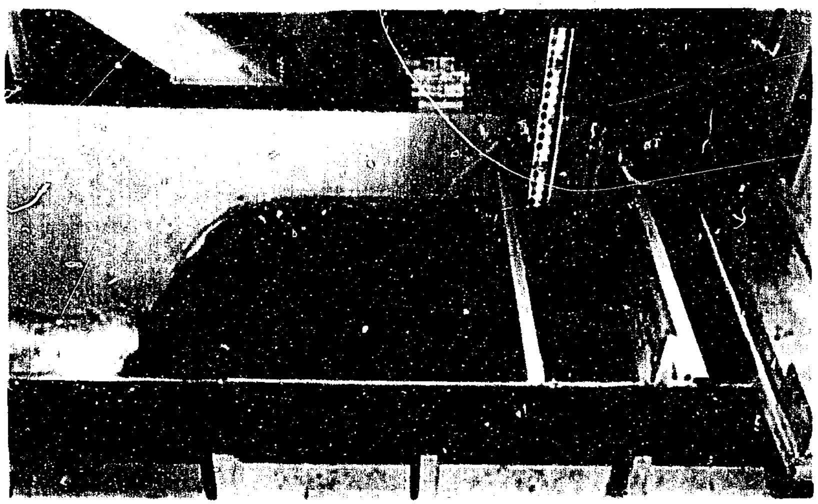


C. 5 cfs with pipeline gate valve full open



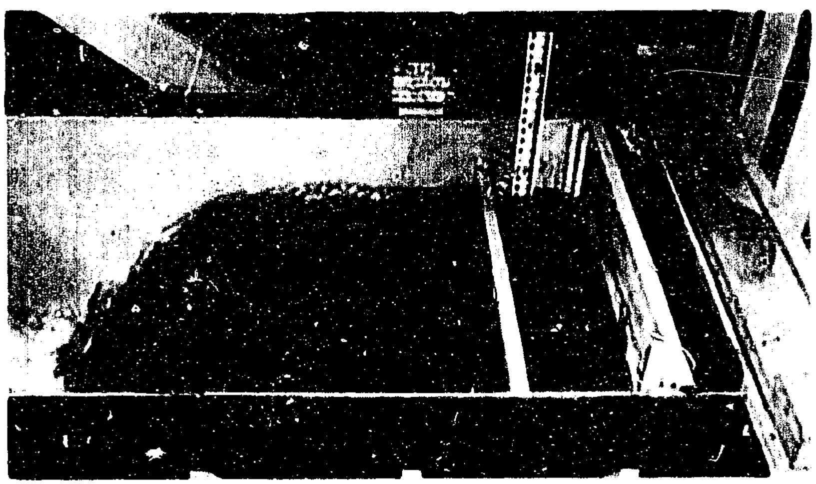
D. 5 cfs with 6 foot head differential on partly closed pipeline gate valve.

WEIR BOX TURNOUT STUDIES
Flow conditions - 3 and 5 cfs flows in 2 cfs turnout structure with control gate in pipeline 10 feet upstream of weir basin headwall
Full size model

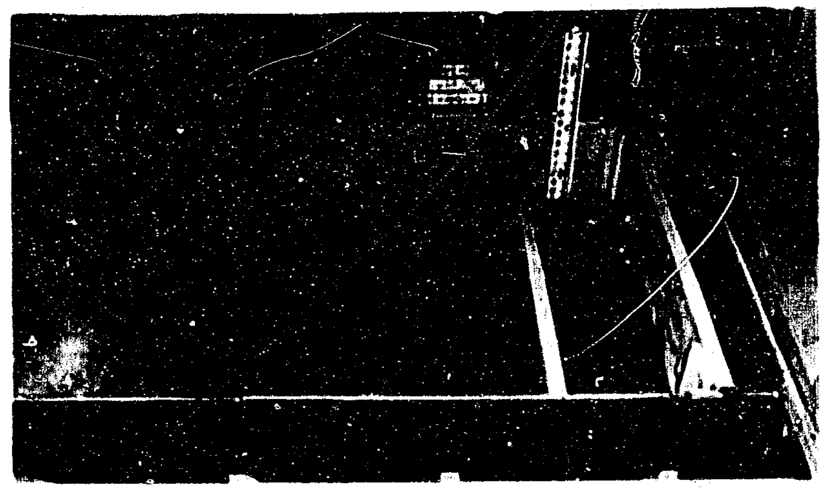


A. 3 cfs with pipeline gate valve full open

B. 3 cfs with 6 foot head differential on partly closed pipeline gate valve

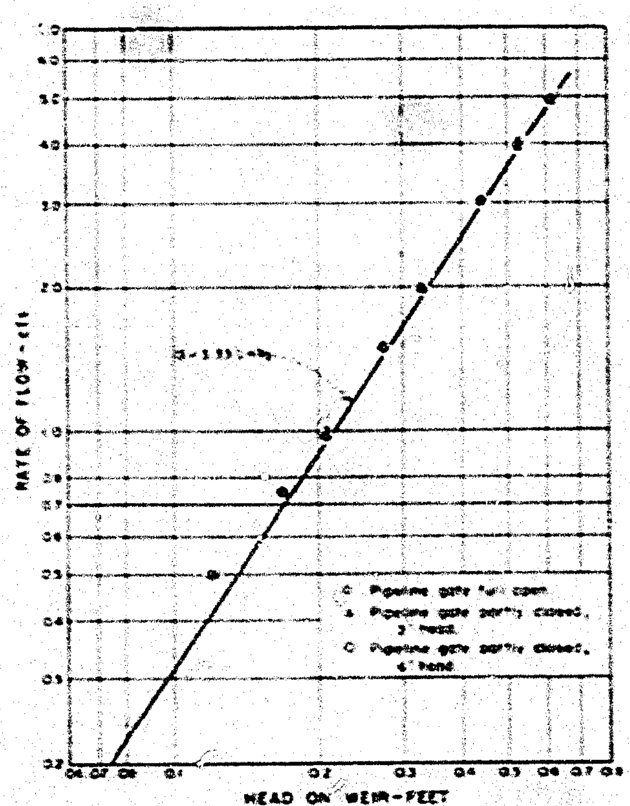


C. 5 cfs with pipeline gate valve full open

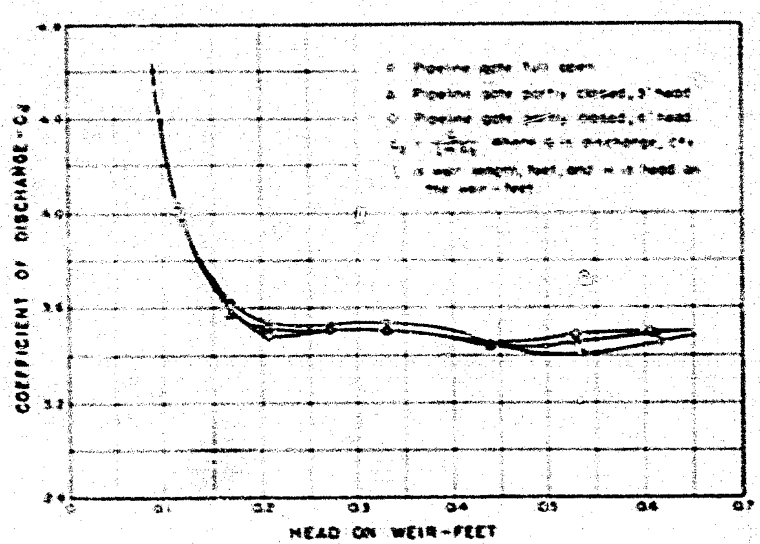


D. 5 cfs with 6 foot head differential on partly closed pipeline gate valve.

WEIR BOX TURNOUT STUDIES
Flow conditions - 3 and 5 cfs flows in 2 cfs turnout structure with control gate in pipeline 10 feet upstream of weir basin headwall
Full size model



A. RATE OF FLOW VS. HEAD ON WEIR

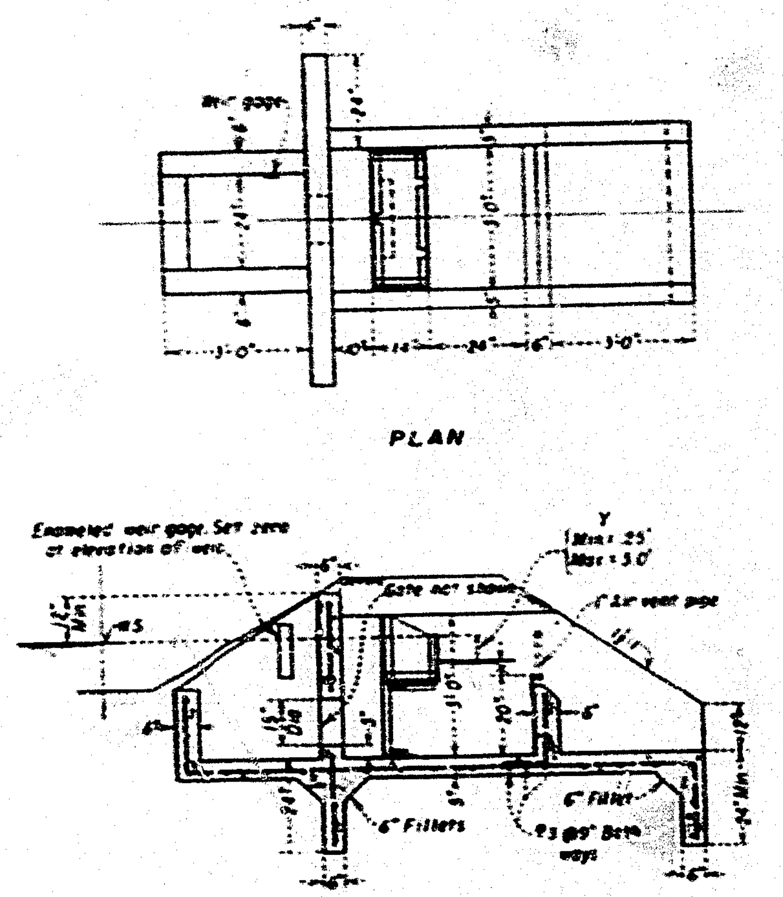


B. COEFFICIENT OF DISCHARGE VS. HEAD ON WEIR

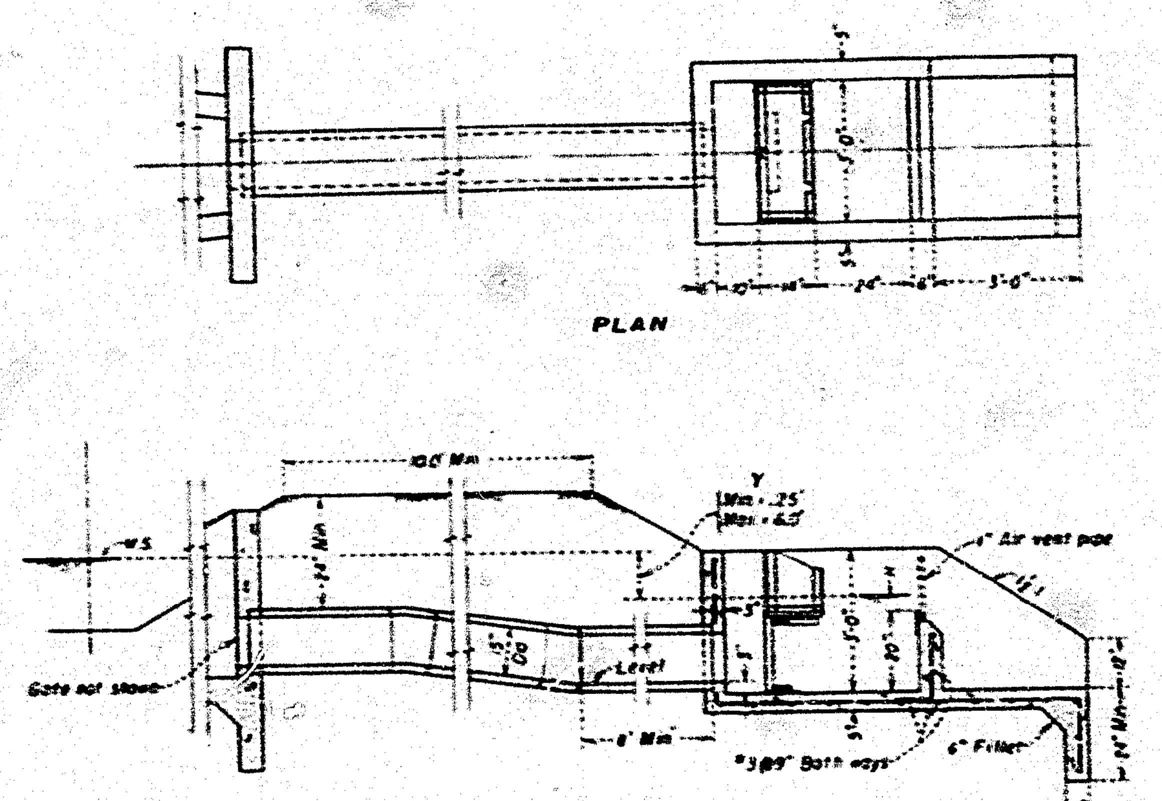
WEIR BOX TURNOUT STUDIES

PERFORMANCE CURVES — RECOMMENDED STRUCTURE FOR 2 CFS WITH CONTROL GATE IN UPSTREAM PIPELINE

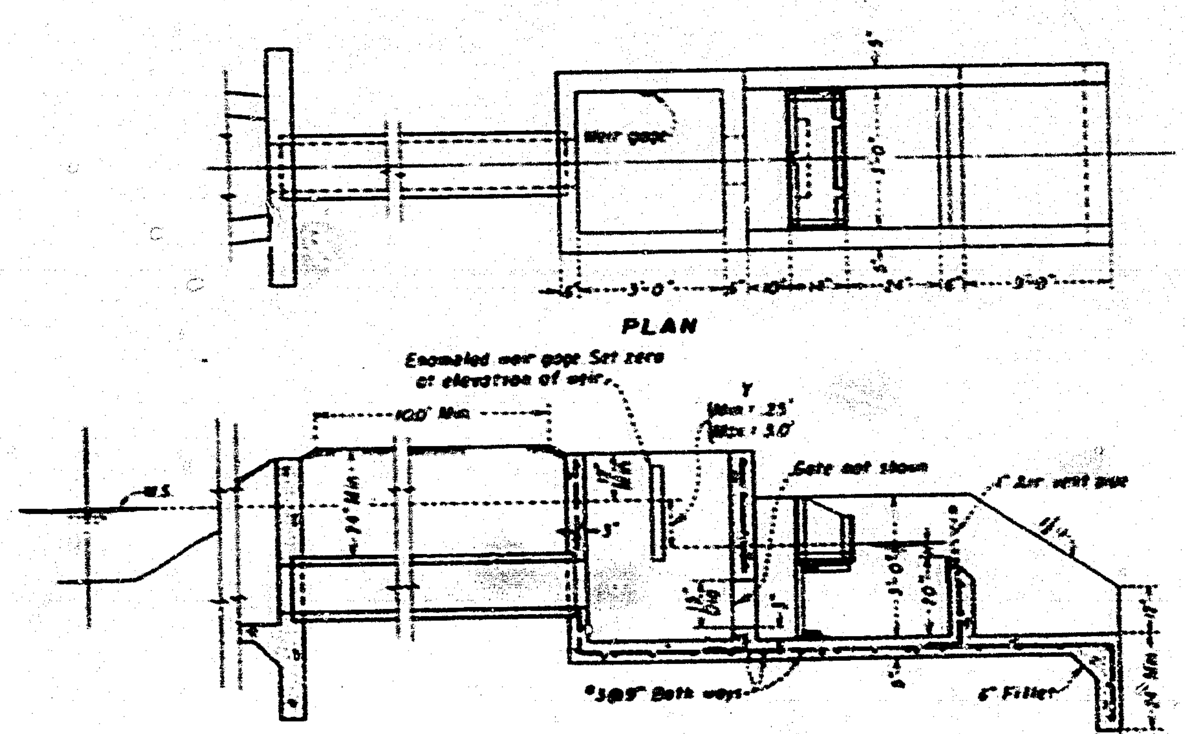
FULL SIZE MODEL



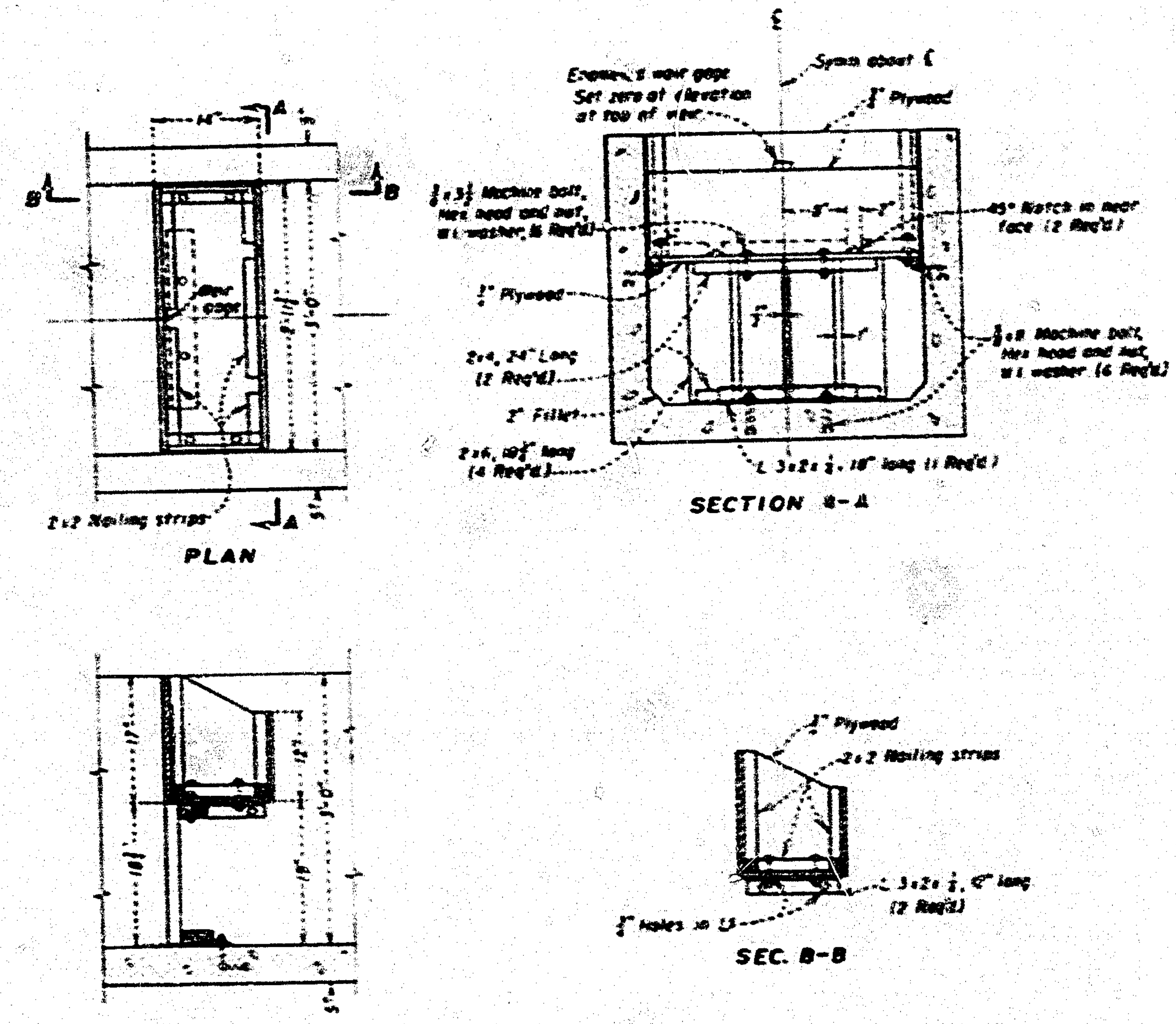
LONGITUDINAL SECTION
TYPE 1



LONGITUDINAL SECTION
TYPE 3



LONGITUDINAL SECTION
TYPE 2



DETAIL OF BAFFLE AND STILLING WELL

TABLE OF DISCHARGE

HEAD H, FEET	Q, c.f.s. TYPE 1 AND 2 — VALUES OF Y, FEET: .25	1.0	2.0	3.0	Q c.f.s. TYPE 3
.10	.39	.39	.39	.39	.39
.12	.48	.48	.48	.48	.48
.14	.58	.58	.58	.58	.58
.16	.68	.68	.65	.68	.68
.18	.80	.80	.78	.78	.78
.20	.94	.97	.88	.88	.90
.22	1.08	1.17	1.03	.99	1.05
.24	1.23	1.36	1.26	1.13	1.20
.26	1.39	1.55	1.49	1.31	1.37
.28	1.55	1.70	.71	1.57	1.55
.30	1.72	1.87	1.91	1.90	1.73
.32	1.90	2.04	2.10	2.18	1.91
.34	2.08	2.21	2.28	2.41	2.09
.36	2.27	2.41	2.46	2.64	2.27
.38	2.46	2.61	2.67	2.87	2.45
.40	2.65	2.81	2.88	3.10	2.64
.42	2.85	3.02	3.10	3.33	2.83
.44	3.05	3.26	3.32	3.57	3.02
.46	[illegible]	3.50	3.54	3.80	3.22
.48	3.50	3.73	3.77	4.05	3.43
.50	3.73	3.97	4.00	4.25	3.65
.52	3.96	4.20	4.24	4.50	3.87
.54	4.20	4.45	4.48	4.73	4.10
.56	4.45	4.72	4.72	5.00	4.34
.58	4.70	5.00	5.00		4.58
.60	5.00				4.83
.62					5.00

NOTES

All reinforcement in monolithic concrete shall be placed in the center of the slab, unless otherwise shown.
All exposed bolts to be galvanized.
See 40-C-71 for details of weir gage.
See 40-D-3732 for details of weir blade.
Plywood to be Douglas Fir, exterior type, grade A-B, commercial standard CS 45-48, U.S.D.C.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
STANDARD DESIGN

3.0 FOOT WEIR BOX
MAXIMUM Q=5 C.F.S.

40-D-5315