Grand Coulee Feeder Canal Weir

PAP 49

STANDARD FORM NO. 64

Office Memorandum • UNITED STATES GOVERNMENT

Memorandum Denver, Colorado

TO : Chief, Canals Branch DATE: December 7, 1953

Attention: H. K. Brickey

FROM : Chief, Engineering Laboratories

SUBJECT: Results of hydraulic model studies on the Grand Coulee Feeder Canal check weir--Columbia Basin Project

The hydraulic model studies to determine the required length, shape, elevation, and location of the weir for checking up the water depth in the Grand Coulee Feeder Canal have been completed. Due to the urgent need for the data, the test results were informally communicated to the designers as the tests progressed. This memorandum constitutes the formal report summarizing the complete program.

The Model

The studies were conducted on a 1:24 scale model that consisted of a head box, the equivalent of 480 feet of canal, the transition and weir structure, and 288 feet of rectangular chute (Figure 1). Water was supplied to the model through the main laboratory supply system which contained calibrated venturi meters for measuring the flow rate. The depth of water in the model canal was measured by suitably positioned point gages. Piezometers were placed in the downstream face of the left wall of the final design weir so the pressures acting on this surface could be measured. Tests were also made to determine if a pier on the nose section of the weir would provide aeration to the nappe at the higher rates of flow.

Preliminary Design

Weir. The preliminary weir with the crest at elevation 1555.87 backed up the water in the canal to elevations 1558.12 and 1562.58 at Station 88+50 for discharges of 3,200 and 16,000 cfs, respectively. Complete aeration of the nappe occurred at flows through 9,600 cfs. A roll of water which occupied considerable space under the nappe was formed by the nappe impinging on the floor. The small roll formed at 3,200 cfs may be seen through the nappe in Figure 2A. At 13,600 and 16,000 cfs the underside of the nappe was completely occupied by this roll and there was no aeration at any point along the weir (Figure 2B).

Raised floor downstream from weir. To avoid a reduction in discharge due to the weir becoming submerged at high flows, a certain distance was needed from the weir crest to the floor at the weir base. However, if less height were needed than that provided in the preliminary design, the entire structure could be built farther upstream in the canal, thereby replacing the already damaged canal section and obviating the otherwise necessary and costly lining repairs. To determine the effect of less height, the model was altered by raising the floor of the rectangular chute the equivalent of 1.71 feet and by uniformly sloping the floor at the foot of the weir from the elevation of the canal invert at the nose section to the elevation of the chute floor at the chute entrance (Figure 1). The weir crest was retained at elevation 1555.87. With the raised floor installed, the water surface in the canal at Station 88+50 was at elevations 1558.14 and 1562.89 at discharges of 3,200 and 16,000 cfs, respectively. This showed no appreciable elevation change at 3,200 cfs. However, at 16,000 cfs the water surface was 0.31 feet higher than with the original floor.

Additional runs were made with the raised floor, but with the weir crest lowered 1 foot to elevation 1554.87. Canal water surface elevations of 1557.04 and 1562.13 were obtained at discharges of 3,200 and 16,000 cfs.

Canal transition. The relatively sharp outward breaks in the canal side slopes where the structure widens to provide an approach to the weir caused a large eddy on each side of the channel (Figures 1 and 2C).

Final Design

Weir. Because it was desirable to pass the high flows at a somewhat lower canal water surface than was possible with the initial design, a new design was prepared in which the weir length was increased from 263 to 290 feet, and in which a straight transverse nose was used in place of the round one (Figure 3). It was necessary to raise the elevation of the weir because the low flows had to be checked up to a minimum elevation, and the longer weir would pass a given discharge at less head. The timber top of the weir crest was set at elevation 1556.26. The position of the structure was shifted upstream 60 feet along the canal to place it nearer the upstream end of the damaged lining where the construction cost would be less. A long, slow warp was used on the side slopes to provide approach area to the weir. The laboratory model was modified to conform to this new design (Figure 4A).

This design, with the model weir representing elevation 1556.26, required canal water surfaces of 1558.21 and 1562.73 at Station 88+00 to pass 3,200 and 16,000 cfs, respectively (Figure 4B and C). Taking into account the 0.10-foot higher elevation of the measuring station at 88+00 than at Station 88+50 (due to the slope of the canal), the water depth in the canal is found to be about the same as with the initial weir design. The operation of the weir at flows of 6,400 and 9,600 cfs is shown in Figure 5A and B, respectively.

Aeration of the nappe was the same as in the initial design and was complete at discharges up through 9,600 cfs. At higher flows the roll at the weir base filled the space under the nappe (Figure 6A and B).

Pier on weir nose section. A pier was placed in the center of the weir nose section to determine if the nappe could be aerated at flows greater than 9,600 cfs (Figure 6C). A small amount of aeration occurred in the form of bubbles that were carried into the roll and nappe. The aeration was confined to the portions of the weir lying within 25 feet of the nose (Figure 6C). The bubbles did not constitute real aeration of the nappe, and the pier was considered not effective. The canal water surface elevation at Station 88+00 rose 0.21 foot to elevation 1562.94 when the pier was installed and 16,000 cfs was flowing. Any such increase in the canal depth at high rates of water flow was undesirable. It was therefore recommended that the pier not be used.

Pressures on weir wall. The data obtained from the six piezometers placed in the left weir wall are tabulated below. Table 1 gives the values without the pier. Table 2 gives the values with the pier installed.

Table 1

PIEZOMETRIC PRESSURES WITHOUT PIER--
EFFECTIVE WATER SURFACE ELEVATIONS

Piezometer		Discharge--cfs 3,200	6,400	9,600	13,800	16,000
Station:	El 1554.76	Aerated	Aerated	1553.58	1553.34	1555.76
89+30	El 1546.26	Do	Do	1549.04	1552.40	1552.64
Station:	El 1554.76	Do	Do	Aerated	1556.72	1558.52
89+90	El 1546.26	Do	Do	1551.99	1555.88	1557.44
Station:	El 1554.76	Do	Do	Aerated	1556.00	1558.28
90+50	El 1546.26	Do	Do	1551.49	1554.75	1556.72

Weir crest elevation 1556.24

Table 2

PIEZOMETRIC PRESSURES WITH PIER--
EFFECTIVE WATER SURFACE ELEVATIONS

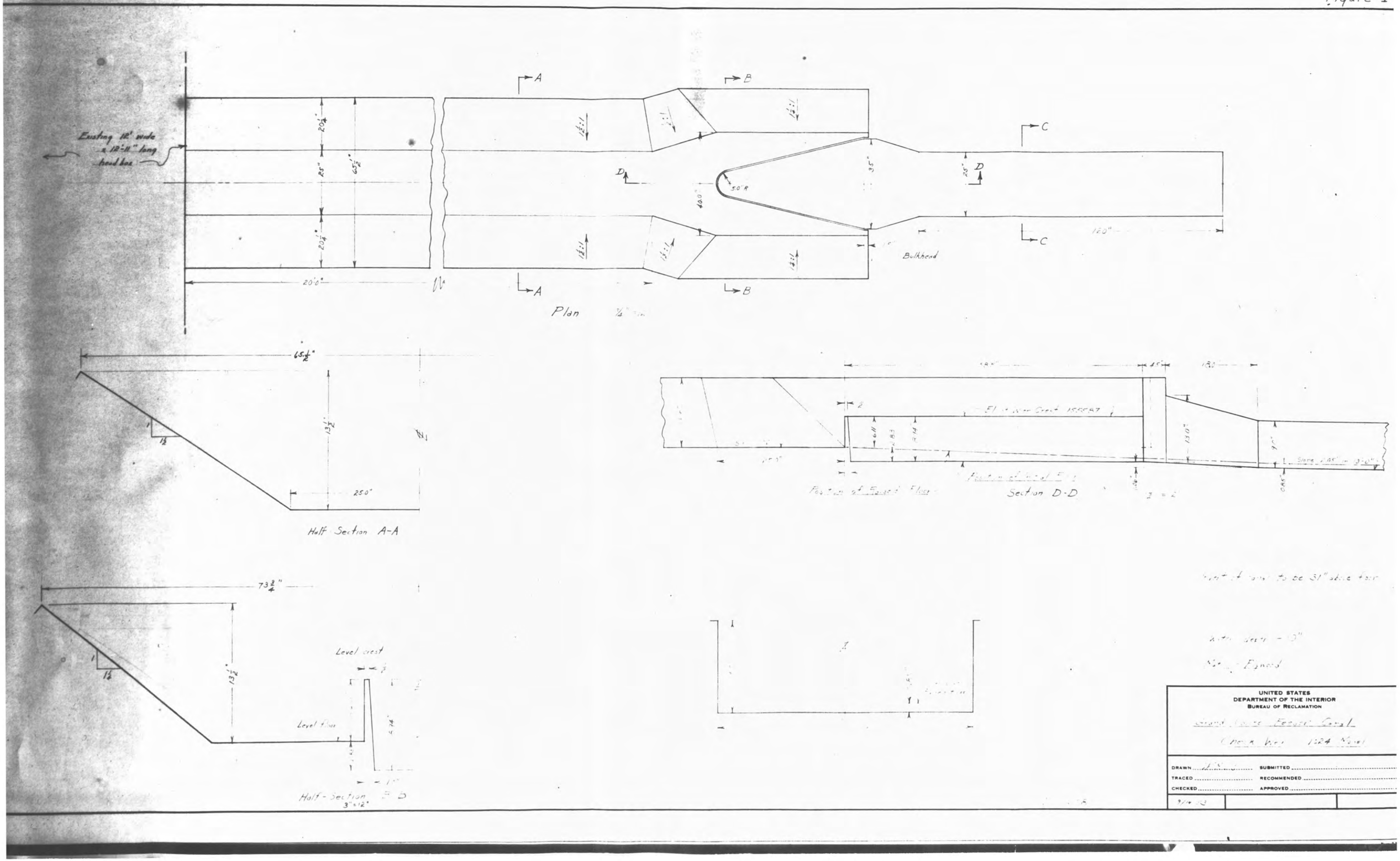
Piezometer		Discharge--cfs 3,200	6,400	9,600	13,800	16,000
Station:	El 1554.76	Aerated	Aerated	1555.04	1555.16	1554.92
89+30	El 1546.26	Do	Do	1549.16	1551.20	1552.28
Station:	El 1554.76	Do	Do	Aerated	1557.51	1559.48
89+90	El 1546.26	Do	Do	1551.92	1555.52	1557.32
Station:	El 1554.76	Do	Do	Aerated	1556.36	1558.40
90+50	El 1546.26	Do	Do	1551.56	1554.85	1556.84

Weir crest elevation 1556.24

Canal transition. Smoother flow was obtained at the change in section of the canal when the long warped side slopes were used in place of the relatively sharp breaks of the initial design (Figures 5C and 2C). However, somewhat greater upward boils occurred at the head wall at the downstream end of the transition when the final warped slopes were used.

Walter H. Price

Figure 1



Existing 12' wide x 12'-11" long head box
Plan
Bulkhead
Half Section A-A
Section D-D
Level crest
Level floor
Half-Section B-B
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DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DRAWN
TRACED
CHECKED
SUBMITTED
RECOMMENDED
APPROVED

Figure 2

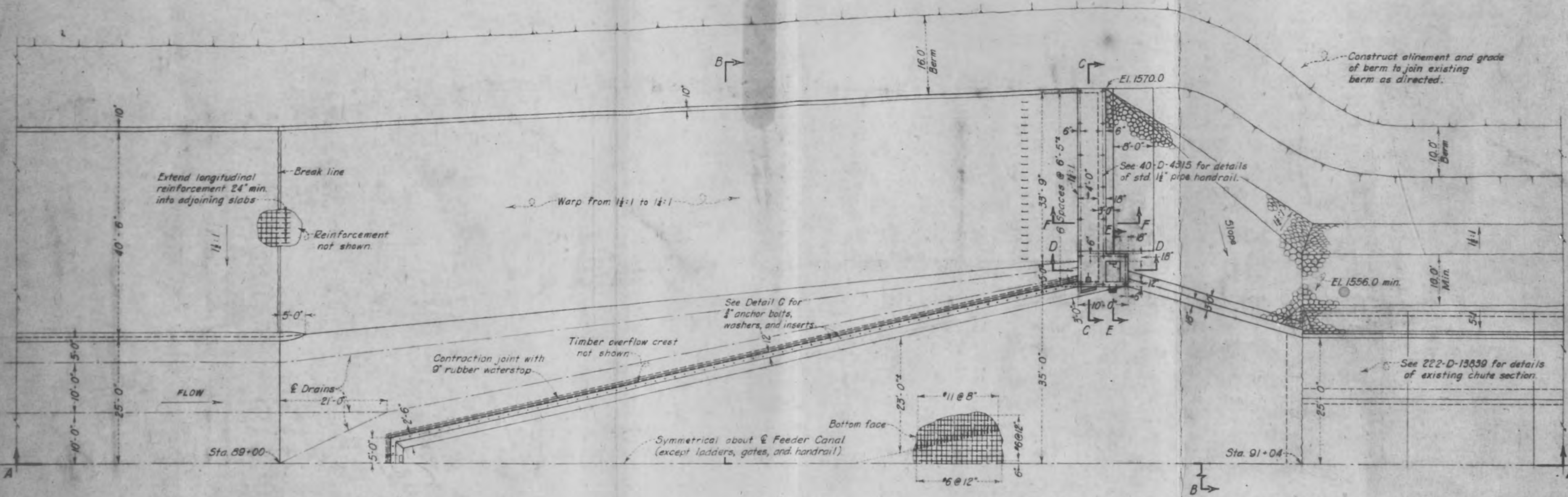
A. Q = 3,200 cfs

B. Q = 16,000 cfs

C. Large eddies occur where the canal widens for the weir
Q = 16,000 cfs

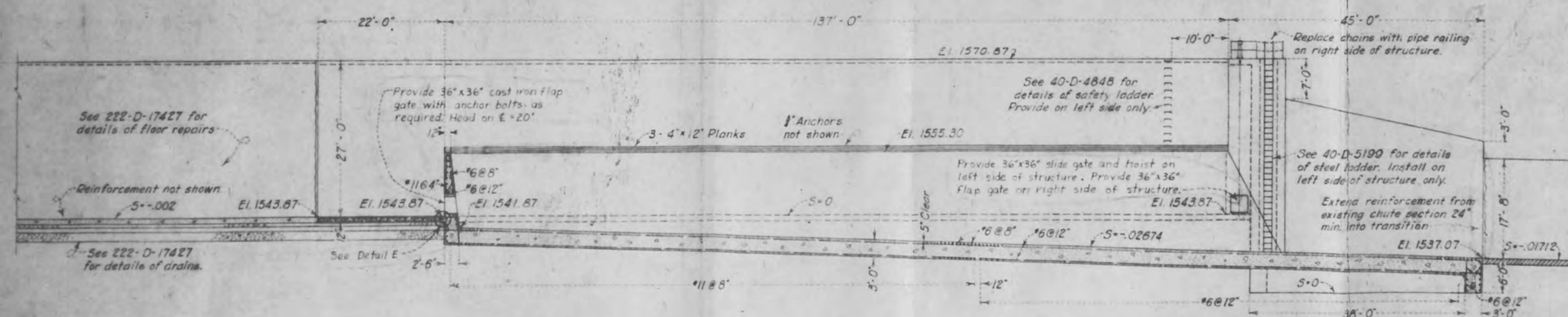
1:24 MODEL GRAND COULEE FEEDER CANAL CHECK WEIR
Flow Conditions with 2 and 10 pumps operating - Preliminary Design

Figure 3



HALF PLAN

SCALE OF FEET



SECTION A-A

ESTIMATED QUANTITIES

Concrete	2,600 Cu. Yds.
Reinforcement steel	360,000 Lbs.

NOTES

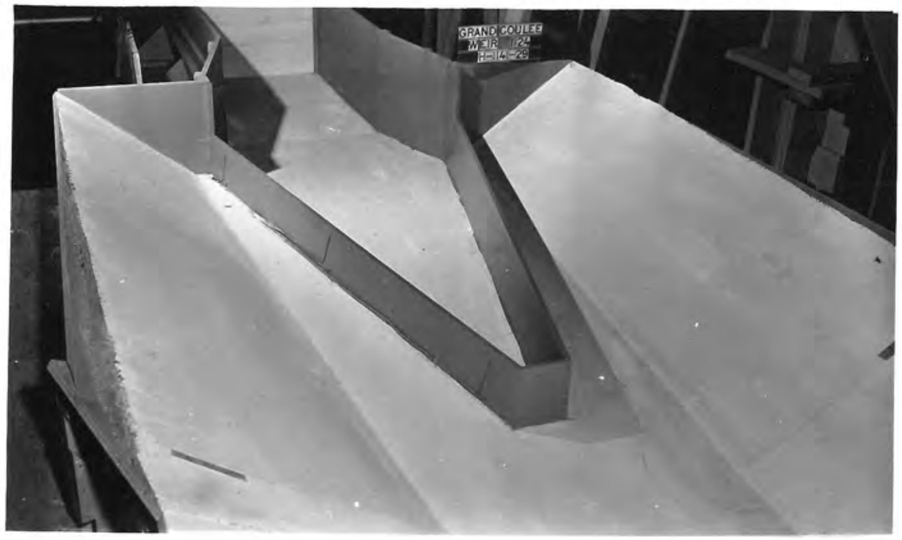
Unless otherwise shown, place reinforcement so that the clear distance between face of concrete and nearest reinforcement is 1½" for #5 bars and less, and 2" for #6 bars and greater; except provide a clear distance from face of concrete placed against earth or rock of 2" where slab thickness is 9" or less, and 3" where slab thickness is greater than 9".
Lap all bars 20 diameters at splices, unless otherwise shown.
Concrete design based on a compressive strength of 3,000 pounds per square inch.
Vary thickness of concrete uniformly between dimensions shown.
Place entire structure on undisturbed earth foundation, thoroughly compacted backfill, or as otherwise shown.
All details and sections except Sec. A-A shown on 222-D-1743

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLUMBIA BASIN PROJECT - WASHINGTON
FEEDER CANAL - STA. 89+00 TO STA. 91+04
OVERFLOW CONTROL STRUCTURE
PLAN AND SECTION

REV. 10-12-53 J.O.G. - G.H.J.

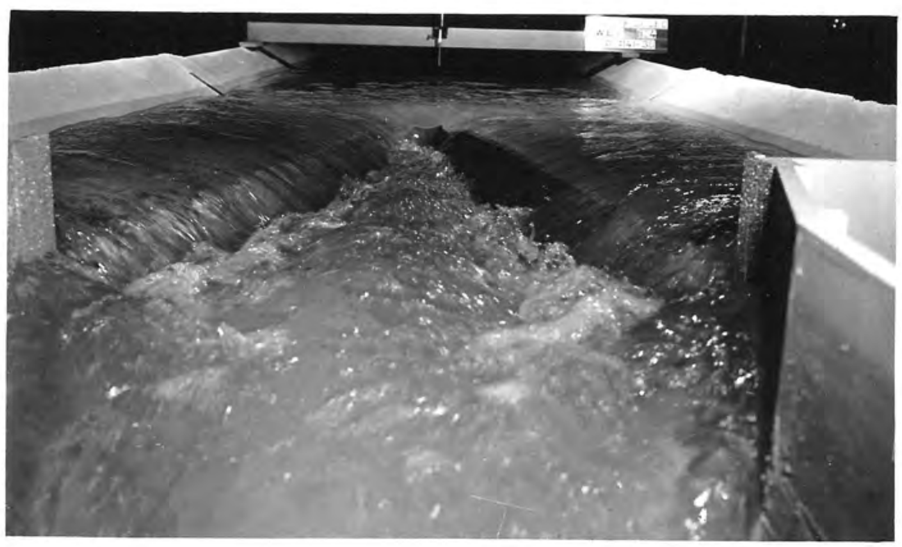
DRAWN A.C.C. SUBMITTED A.G. Bryce
TRACED RECOMMENDED O.T. Rice
CHECKED G.H.J. W.E.B. APPROVED W.E. Blomgren
DENVER, COLORADO SEPTEMBER 12, 1953
SHEET 1 OF 2
222-D-17429

Figure 4



A. 290-foot weir with straight nose & warped transition sidewalls

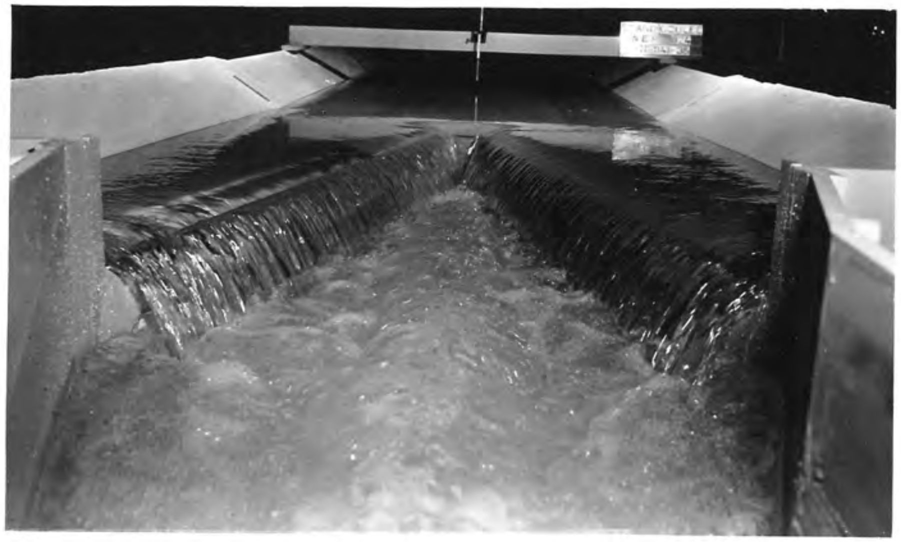
B. Q = 3,200 cfs



C. Q = 16,000 cfs

1:24 MODEL GRAND COULEE FEEDER CANAL CHECK WEIR
Flow Conditions with 2 and 10 pumps operating - Final Design

Figure 5



A. 6,400 cfs

B. 9,600 cfs

C. Smaller eddies occur with the warped transition walls than with the initial walls (see Figure 2C). Q = 16,000 cfs.

1:24 MODEL GRAND COULEE FEEDER CANAL CHECK WEIR
Flow Conditions with 4, 6, and 10 pumps operating - Final Design