UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF TURNOUT STRUCTURE--EAST LOW CANAL--COLUMBIA BASIN PROJECT, WASHINGTON

Hydraulic Laboratory Report No. Hyd-322

ENGINEERING LABORATORIES BRANCH

DESIGN AND CONSTRUCTION DIVISION
DENVER, COLORADO

August 11, 1952

CONTENTS

	Page
Summary	1
Introduction	2
The 1:16.52 Scale Model	2
The Investigation	2
Tests of Transition Sections	2
Transition No. 1--Preliminary	2
Transition No. 2	3
Transition No. 3	3
Transition No. 4	4
Transition No. 5--Recommended	4
Calibration Tests	5

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Design and Construction Division
Engineering Laboratories Branch
Denver, Colorado
August 11, 1952

Laboratory Report No. Hyd-322
Hydraulic Laboratory Section
Compiled by: E. J. Rusho
P. F. Enger
Checked and
Reviewed by: A. J. Peterka
J. N. Bradley

Subject: Hydraulic model studies of turnout structure--East Low Canal Columbia Basin Project, Washington

SUMMARY

This report describes studies made to improve the entrance flow conditions to a Parshall flume located just downstream from a lateral turnout at Station 1543+52.5 on the East Low Canal of the Columbia Basin Project, Washington, Figure 1. The turnout is a double box culvert controlled by two slide gates. Flow enters the Parshall flume after passing through a transition section connecting the box culvert and flume. As a result of these studies using a 1:16.52 scale model, Figure 4, it was found necessary to modify the transition section to obtain satisfactory entrance conditions at the Parshall flume, since poor entrance conditions result in inaccurate discharge determination.

Flow was unsatisfactory in the preliminary transition with both gates opened equally as a surge of 0.75 foot occurred at the upstream flume gage for the maximum discharge. Four additional transition sections were tested, all having a length of 30 feet instead of the 20 feet used in the preliminary. The recommended transition No. 5, Figure 13, gave satisfactory flow conditions with a surge of 0.15 foot at the upstream flume gage for a discharge of 360 cfs. The surge increased slightly at lower discharges. Both a float and a fixed baffle across the upper portion of the transition reduced the surge for intermediate flows but did not prove helpful at the maximum discharge, so they were not recommended.

With one gate of the box culvert closed the flow was unsatisfactory at all discharges and could not be improved by modifying the transition unless the length was increased a prohibitive amount. Since one-gate operation could not be provided for it is recommended that all operation be with both gates opened an equal amount.

Calibration of the model flume was made using two-gate operation and the results showed agreement with the discharge formula for a Parshall flume of the same size. However, since the installation in this case is not according to standard practice it is recommended the flume be calibrated in the field.

INTRODUCTION

The lateral turnout at Station 1543+52.5 of the East Low Canal of the Columbia Basin Project, Washington, Figure 1, consists of a double box culvert controlled by two 72- by 72-inch slide gates, Figure 2. Design and construction of the lateral was undertaken after completion of the East Low Canal and culvert turnout. A Parshall flume was required for measuring the discharge in the lateral and it was necessary to connect the flume to the culvert with a short transition section, Figure 3.

To obtain reliable measurements of the discharge by use of the Parshall flume smooth flow is necessary in the transition section and flume for all discharges including the maximum of 360 cfs. A model study was made of the structure to assure satisfactory conditions of flow. The model included a reservoir section representing the East Low Canal, the double box culvert, the transition section, and the flume to the throat section. With aid of the studies the transition was altered until the flow was considered satisfactory.

The 1:16.52 Scale Model

A scale of 1:16.52 was used for the model of this lateral on the East Low Canal of the Columbia Basin Project, Washington. The portion of the lateral simulated by the model was the box culvert turnout with two regulating gates, a transition section, and the upstream section of a 12-foot Parshall flume, Figure 4. An existing head box of wood lined with sheet metal was used to represent the East Low Canal. The box culvert was connected to the side of the head box and had two sheet-metal slide gates on the upstream side. The culvert transition section and flume were constructed of plywood.

Water for the tests was measured by a laboratory Venturi meter in the supply line. The water-surface elevation in the head box was read with a hook gage in a stilling-well located outside the head box. The head-water elevation was maintained constant at the normal depth of water in the main canal for all flows in the lateral. Changes in discharge were made by adjusting the slide-gate openings at the head of the culvert. During the tests, the flow in the transition section and flume was photographed, wave heights in the flume were recorded, and water-surface elevations were taken in the head box and flume.

THE INVESTIGATION

Tests of Transition Sections

Transition No. 1--Preliminary. The preliminary transition had a length of 20 feet which increased in width from 13 feet 1 inch at the portal of the culvert to 18 feet 4-3/4 inches at the entrance to the Parshall flume, Figure 5. In the first test, an open channel was used instead of the divided box culvert to determine whether the covered culvert section would have any effect on flow through the flume. The resulting depth of flow in the open channel showed that at higher discharges the culvert would run full and under pressure, so the culvert was installed to assure true representation of prototype conditions.

The first operation tests were made with the left gate of the box culvert closed. At a discharge of 360 and 180 cfs, Figures 6A and B, the flow was unsatisfactory because of the standing wave downstream from the right gate. This created an uneven water surface, the velocity distribution was not uniform across the width of the flume, and large water-surface fluctuations occurred at the flume gage. This test showed that satisfactory flow could not be obtained with one-gate operation. The remaining discussion in this report is on tests made with both gates opened equally.

With both gates open, the step produced a standing wave in the transition section and in the converging section of the Parshall flume. The transverse distribution of flow was also unsatisfactory in the flume. A water-surface fluctuation of 0.75 foot occurred at the upstream flume gage for a discharge of 360 cfs. As the discharge was decreased the waves became smaller. The fluctuation at the gage was 0.40 foot for a discharge of 180 cfs. The flow conditions for these two discharges are shown in Figures 7A and B.

Transition No. 2. Transition No. 2, Figure 8, had a length of 30 feet or 10 feet more than the preliminary transition. At a discharge of 360 cfs with both gates open, the wave action in the transition and flume, Figure 9A, was similar to that which occurred in Transition No. 1. The longer transition length reduced the fluctuation of the water surface at the upstream flume gage. At a discharge of 360 cfs, the surge was 0.60 foot. The greater transition length decreased the surge at the gage but the wave action was still unsatisfactory, so the step at the upstream end of the transition was modified.

Transition No. 3. For Transition No. 3, Figure 10, a 2:1 slope replaced the vertical step. Operation at a discharge of 360 cfs with both gates open, Figure 9B, showed an improvement over that obtained with Transitions No. 1 and 2. The change in the step reduced the wave heights, although a small water-surface depression occurred in the central area of the transition section as shown in the photograph. The surge at the upstream flume gage was 0.20 foot at a discharge of 360 cfs and apparently was caused by an unstable condition created by the water-surface depression. This surge remained approximately the same for all discharges between 360 and 180 cfs.

Two sets of blocks, Types A and B, Figure 10, were installed and tested on the 2:1 slope. Type A consisted of four blocks 18 inches wide, equally spaced, while Type B consisted of six blocks 12 inches wide similarly installed on the slope. The operation was generally similar for both types of blocks. While the addition of the blocks did not change the flow distribution, the depression in the central area of the transition section was more pronounced with an increase in the amplitude of the surge at the upstream flume gage. Since the blocks caused poorer operation, they were not tried again in any of the transitions tested.

Transition No. 4. An inclined floor 25 feet long, Figure 11, was installed for Transition No. 4. The training walls were parallel, giving a constant width of 18 feet 4-3/4 inches to the transition but making an abrupt increase in width at the culvert portal. The length of the transition remained at 30 feet. Appearance of the flow at a discharge of 360 cfs with both gates open is shown in Figure 12A. The water surface was flat without standing waves, both in the transition and the upstream portion of the Parshall flume. The surge at the upstream flume gage was 0.20 foot, the same as occurred with Transition No. 3. The abrupt increase in width at the portal caused unsatisfactory flow in this region.

Float A, Figure 11, was placed 9 feet downstream from the tunnel portal. The surging action was not eliminated by the float, but was reduced in amplitude.

A baffle placed in the transition was next tested as a means of reducing the surge. Baffle "A", Figure 11, was installed in the position shown. At a discharge of 360 cfs, Figure 12B, the surge at the upstream flume gage was 0.20 foot. Flow conditions in the transition and Parshall flume were improved for discharges from 100 to 360 cfs, but the designers considered the extra cost of the baffle to be too great for the improvement obtained.

Transition No. 5--Recommended. The same floor shape was used for Transition No. 5, Figure 13, as was used for Transition No. 4. The side walls diverged the same as in Transitions No. 2 and 3. At a discharge of 360 cfs, Figure 14, the surge at the upstream flume gage was 0.15 foot and remained at this value down to a discharge of 230 cfs. For lower flows the surge was greater, with the maximum of 0.40 foot occurring at a discharge of 170 cfs. As shown in the figure, the water surface was smooth with good distribution in the transition and upstream section of the flume. Performance was the best obtained with any of the transitions tested.

The test using Float A, Figure 11, with Transition No. 4 was repeated with Transition No. 5. The surging action was reduced in amplitude but not eliminated by the float. This method for obtaining smooth flow conditions was not considered satisfactory.

Baffle "A," Figure 11, was installed in the same position as in the test with Transition No. 4. The maximum surge which occurred at a flow of 170 cfs was reduced, but at a discharge of 360 cfs, the surge was 0.25 foot which was greater than obtained at this discharge without the baffle.

The smaller Baffle "B," Figure 13, was next installed in the two positions shown. In each position the baffle reduced the surge in the flume and gave good flow distribution with low discharges. However, at a discharge of 360 cfs, the water flowing over the top of the baffle caused an increase in the surge.

From all the tests, Transition No. 5 gave the best results over the entire range of discharge. Baffles in the transition section decreased the surge at low flows, but caused a greater surge at the higher discharges. From these considerations and the cost of baffles, Transition No. 5 without baffles was recommended for construction.

Calibration Tests

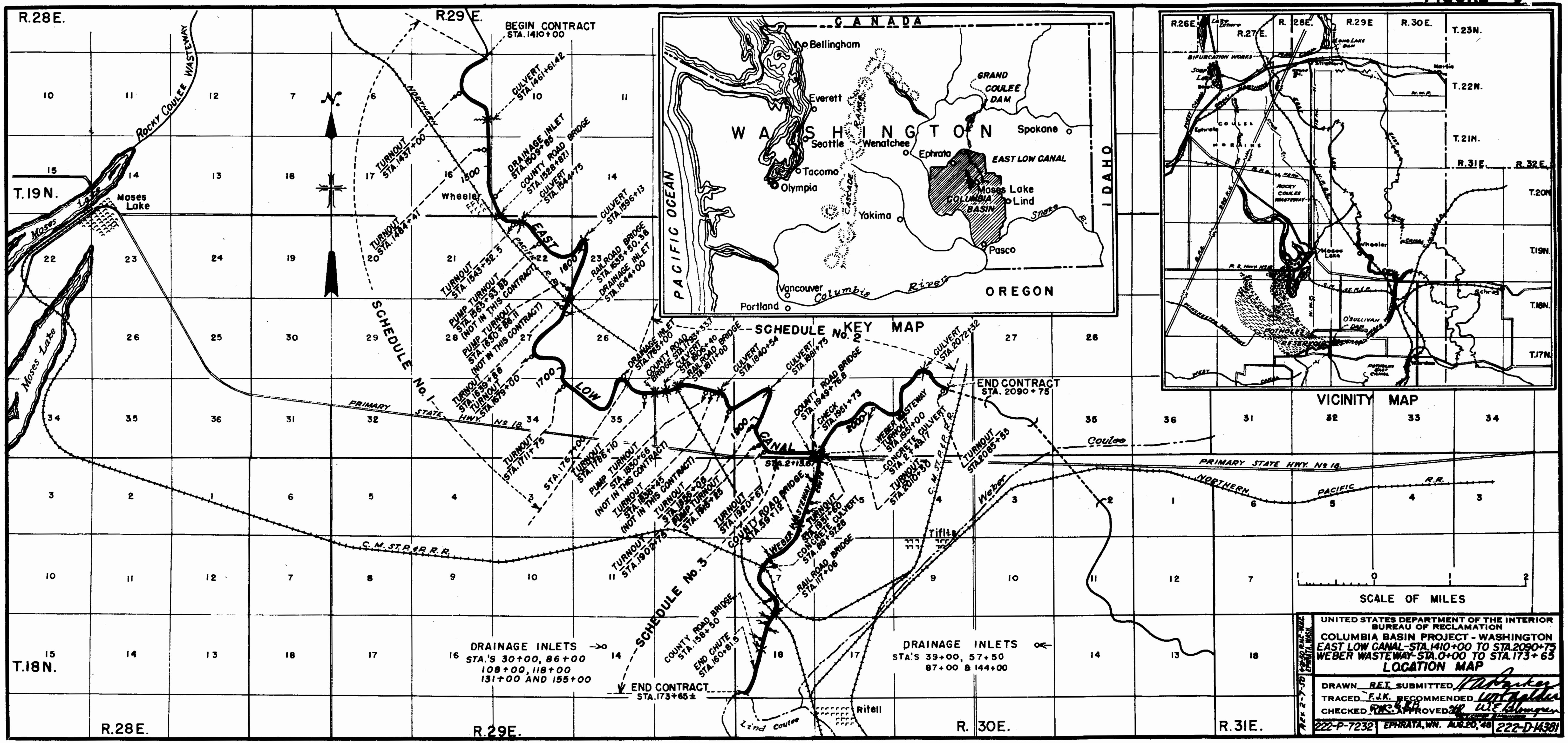
Model calibration was made of the slide gates on the box culvert for a constant water-surface elevation in the canal. The discharge-capacity curve obtained is shown on Figure 15.

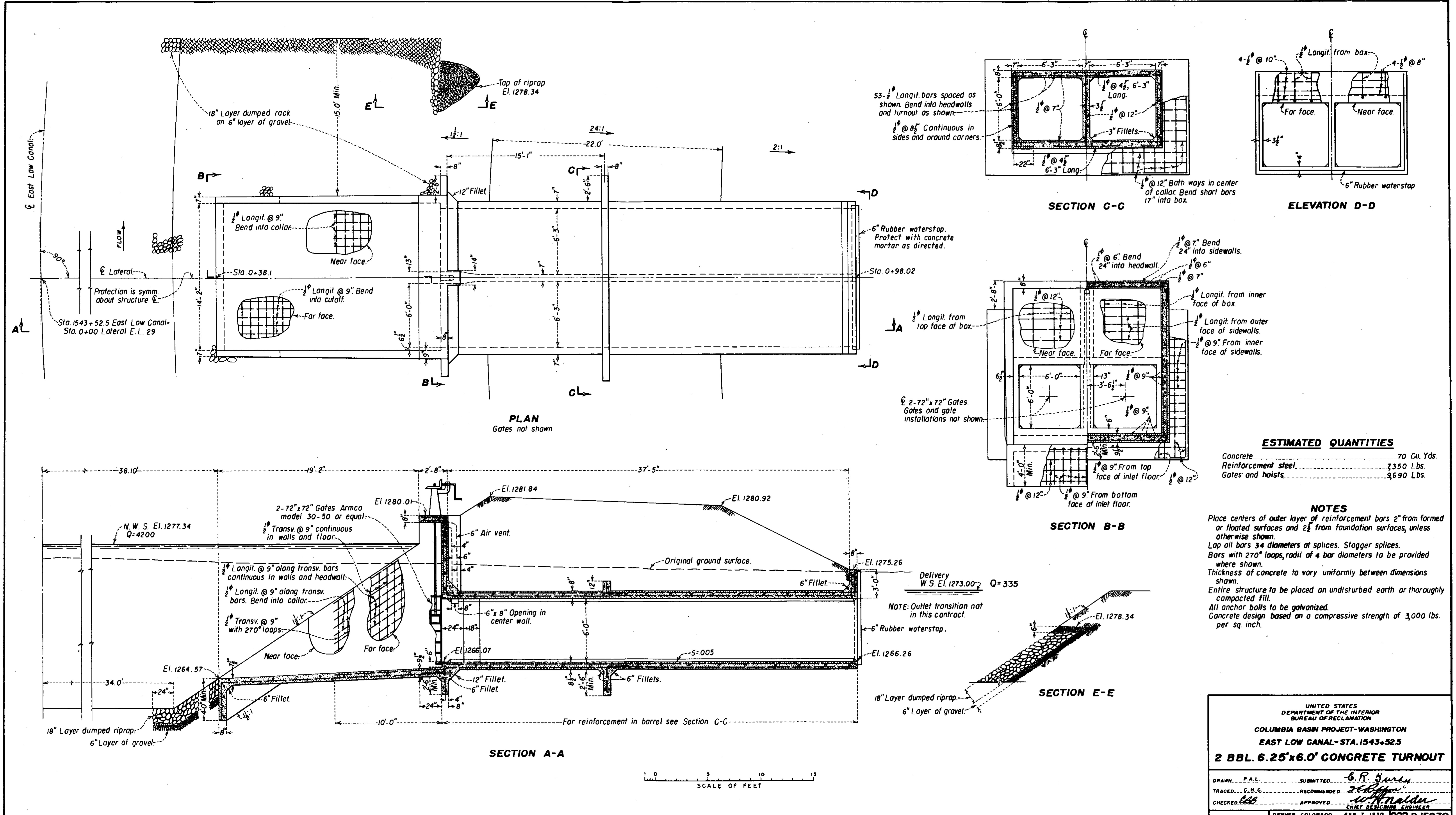
Standard discharge formulas given for Parshall flumes are for recommended installations in which a minimum length of straight approach is required. Even though the Parshall flume with Transition No. 5 will operate satisfactorily the flow in the short approach will differ from that in an approach of proper length. Therefore, the use of standard formulae or model calibration is not recommended in this case, instead the flume should be rated in place.

Installation of Parshall flumes or other water-measuring devices in this manner should be avoided whenever possible and the recommended straight length of approach should be provided upstream so that standard ratings are applicable. Futhermore, measuring devices not constructed to standard practice are always subject to question by persons and authorities not familiar with them. This often results in the construction of additional measuring equipment as a check on the original which in the end is not economical design.

Interior - Reclamation - Denver, Colo.

FIGURE 1


R.28E.
R.29E.
R.30E.
R.31E.
T.19N.
T.18N.
BEGIN CONTRACT
STA. 1410+00
END CONTRACT
STA. 2090+75
END CONTRACT
STA. 173+65±
EAST LOW CANAL
SCHEDULE No. 1
SCHEDULE No. 2
SCHEDULE No. 3
ROCKY COULEE WASTEWAY
Moses Lake
Wheeler
Tiflis
Ritell
Lind Coulee
Weber Wasteway
PRIMARY STATE HWY. No 18.
NORTHERN PACIFIC R.R.
C. M. ST. P. & P. R.R.
DRAINAGE INLETS
STA.'S 30+00, 86+00
108+00, 118+00
131+00 AND 155+00
DRAINAGE INLETS
STA.'S 39+00, 57+50
87+00 & 144+00
KEY MAP
CANADA
WASHINGTON
OREGON
IDAHO
PACIFIC OCEAN
Bellingham
Everett
Seattle
Tacoma
Olympia
Wenatchee
Ephrata
Yakima
Spokane
Moses Lake
Lind
Pasco
Vancouver
Portland
GRAND COULEE DAM
EAST LOW CANAL
COLUMBIA BASIN
Columbia River
VICINITY MAP
SCALE OF MILES
UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLUMBIA BASIN PROJECT - WASHINGTON
EAST LOW CANAL-STA.1410+00 TO STA.2090+75
WEBER WASTEWAY-STA.0+00 TO STA.173+65
LOCATION MAP
DRAWN R.E.T. SUBMITTED
TRACED F.J.K. RECOMMENDED
CHECKED APPROVED
222-P-7232
EPHRATA, WN. AUG.20, '48
222-D-14381



ESTIMATED QUANTITIES

Concrete	70 Cu. Yds.
Reinforcement steel	7,350 Lbs.
Gates and hoists	9,690 Lbs.

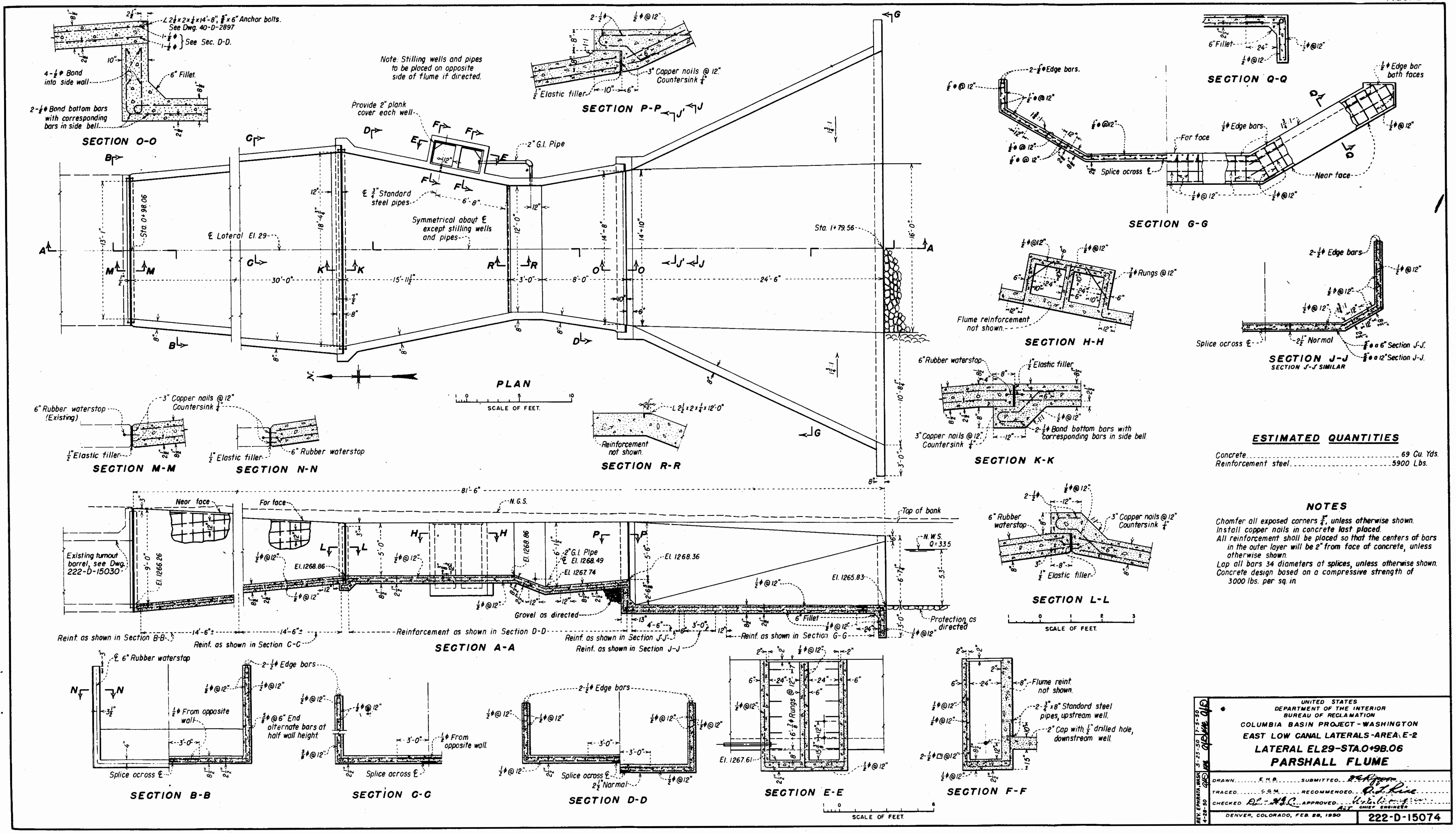
NOTES

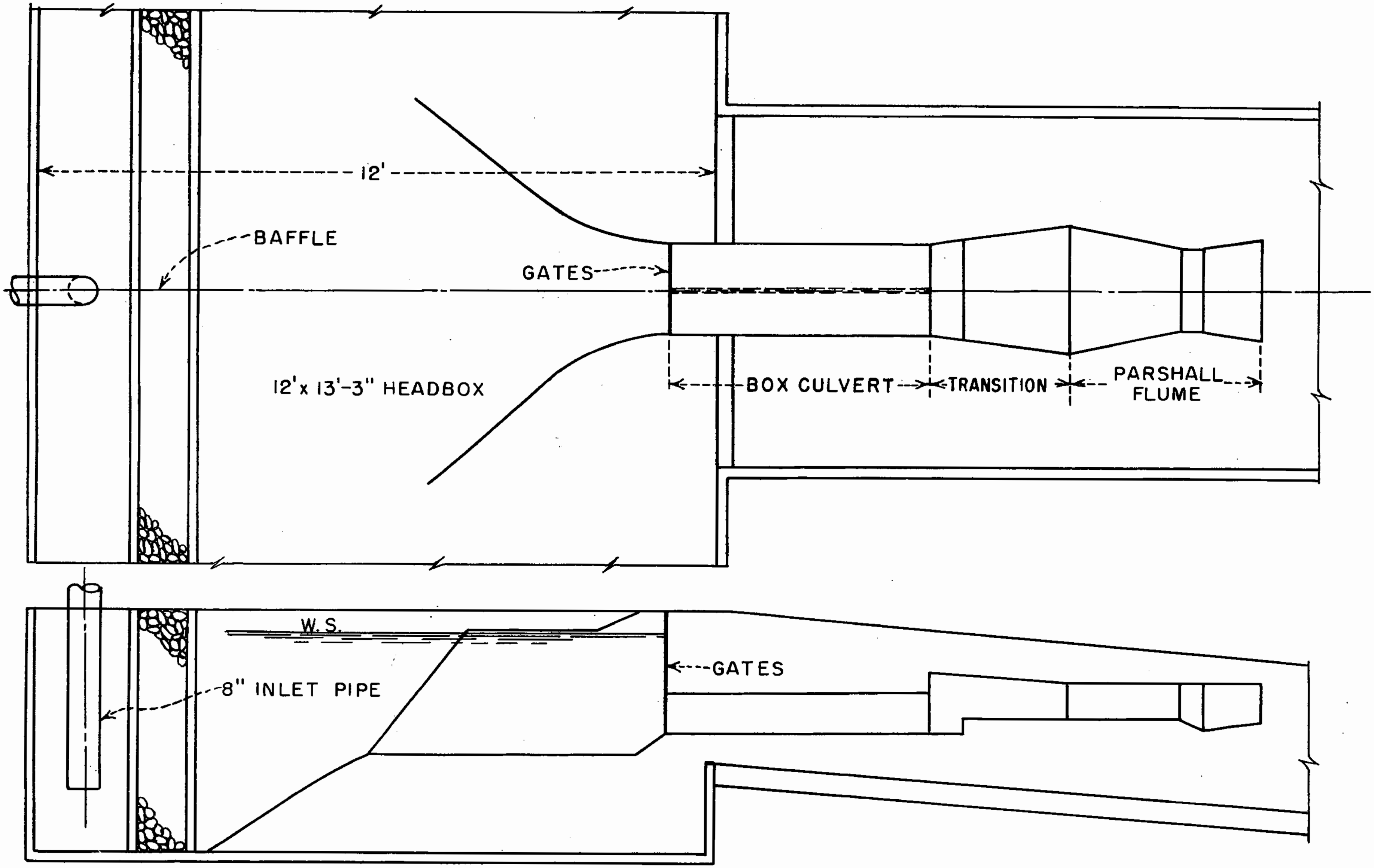
Place centers of outer layer of reinforcement bars 2" from formed or floated surfaces and 2½" from foundation surfaces, unless otherwise shown.
Lap all bars 34 diameters at splices. Stagger splices.
Bars with 270° loops, radii of 4 bar diameters to be provided where shown.
Thickness of concrete to vary uniformly between dimensions shown.
Entire structure to be placed on undisturbed earth or thoroughly compacted fill.
All anchor bolts to be galvanized.
Concrete design based on a compressive strength of 3,000 lbs. per sq. inch.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLUMBIA BASIN PROJECT-WASHINGTON
EAST LOW CANAL-STA. 1543+52.5
2 BBL. 6.25'x6.0' CONCRETE TURNOUT

DRAWN P.A.L. SUBMITTED
TRACED C.H.C. RECOMMENDED
CHECKED APPROVED CHIEF DESIGNING ENGINEER
DENVER, COLORADO. FEB. 7, 1950 222-D-15030

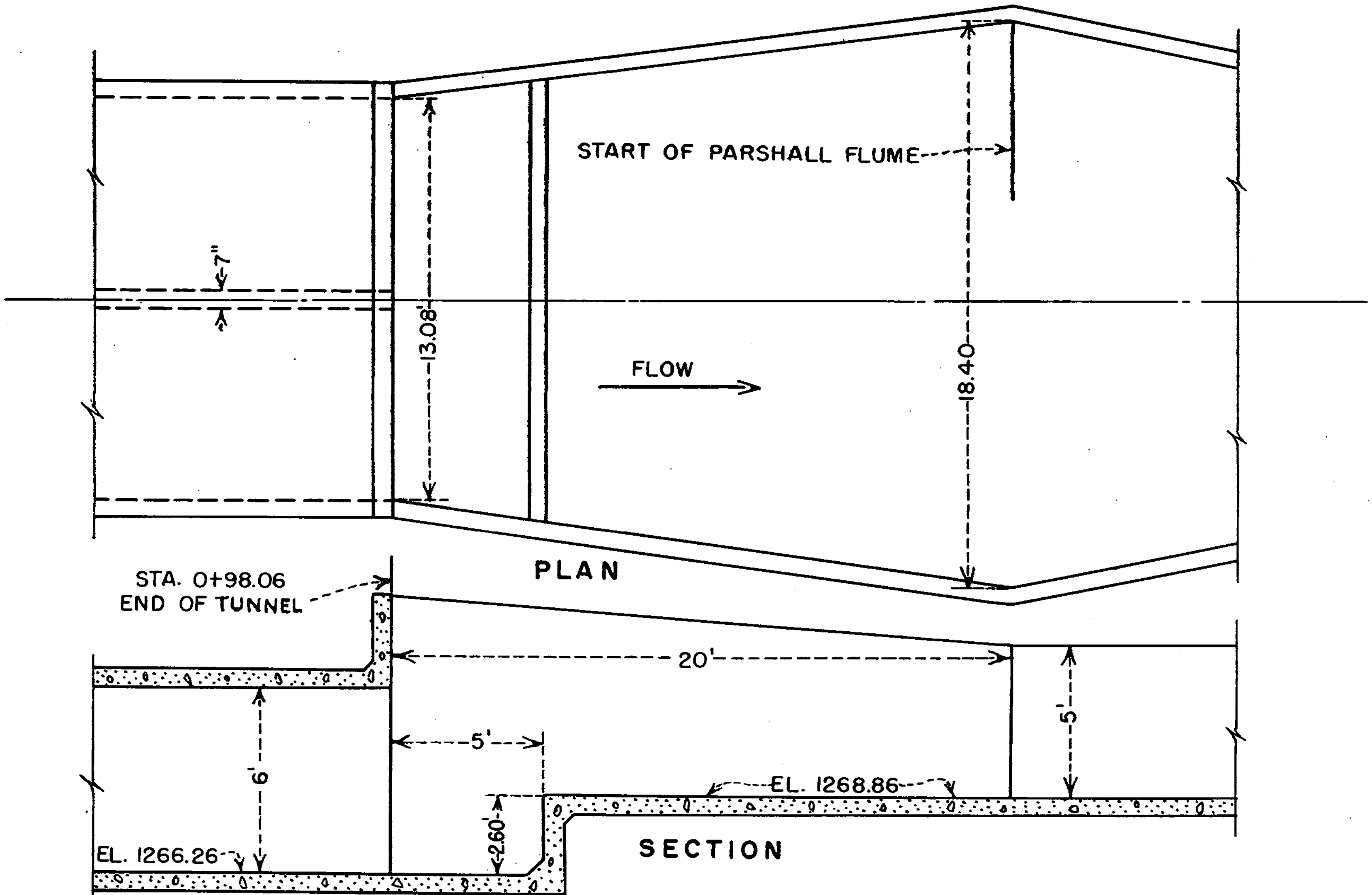
FIGURE 3


SECTION O-O
SECTION P-P
SECTION Q-Q
SECTION G-G
SECTION H-H
SECTION J-J
SECTION J'-J' SIMILAR
SECTION K-K
SECTION L-L
SECTION M-M
SECTION N-N
SECTION R-R
PLAN
SCALE OF FEET
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
SECTION E-E
SECTION F-F
Note: Stilling wells and pipes to be placed on opposite side of flume if directed.
Provide 2" plank cover each well
Symmetrical about ℄ except stilling wells and pipes
ESTIMATED QUANTITIES
Concrete 69 Cu. Yds.
Reinforcement steel 5900 Lbs.
NOTES
Chamfer all exposed corners ¾", unless otherwise shown.
Install copper nails in concrete last placed.
All reinforcement shall be placed so that the centers of bars in the outer layer will be 2" from face of concrete, unless otherwise shown.
Lap all bars 34 diameters at splices, unless otherwise shown.
Concrete design based on a compressive strength of 3000 lbs. per sq. in.
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLUMBIA BASIN PROJECT - WASHINGTON
EAST LOW CANAL LATERALS - AREA E-2
LATERAL EL29 - STA.0+98.06
PARSHALL FLUME
DENVER, COLORADO, FEB. 28, 1950
222-D-15074



EAST LOW CANAL LATERAL
TURNOUT AND PARSHALL FLUME
1:16.52 SCALE MODEL

FIGURE 4



EAST LOW CANAL LATERAL
TRANSITION SECTION No. 1
PRELIMINARY

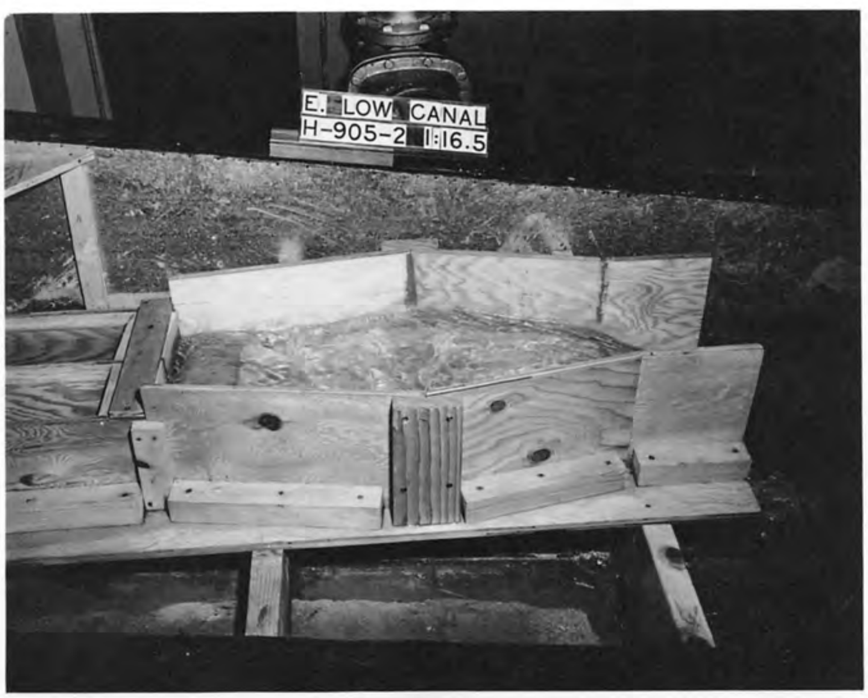
FIGURE 5

A. Discharge 360 cfs--Note standing wave and uneven distribution of flow.

B. Discharge 180 cfs--Wave is smaller

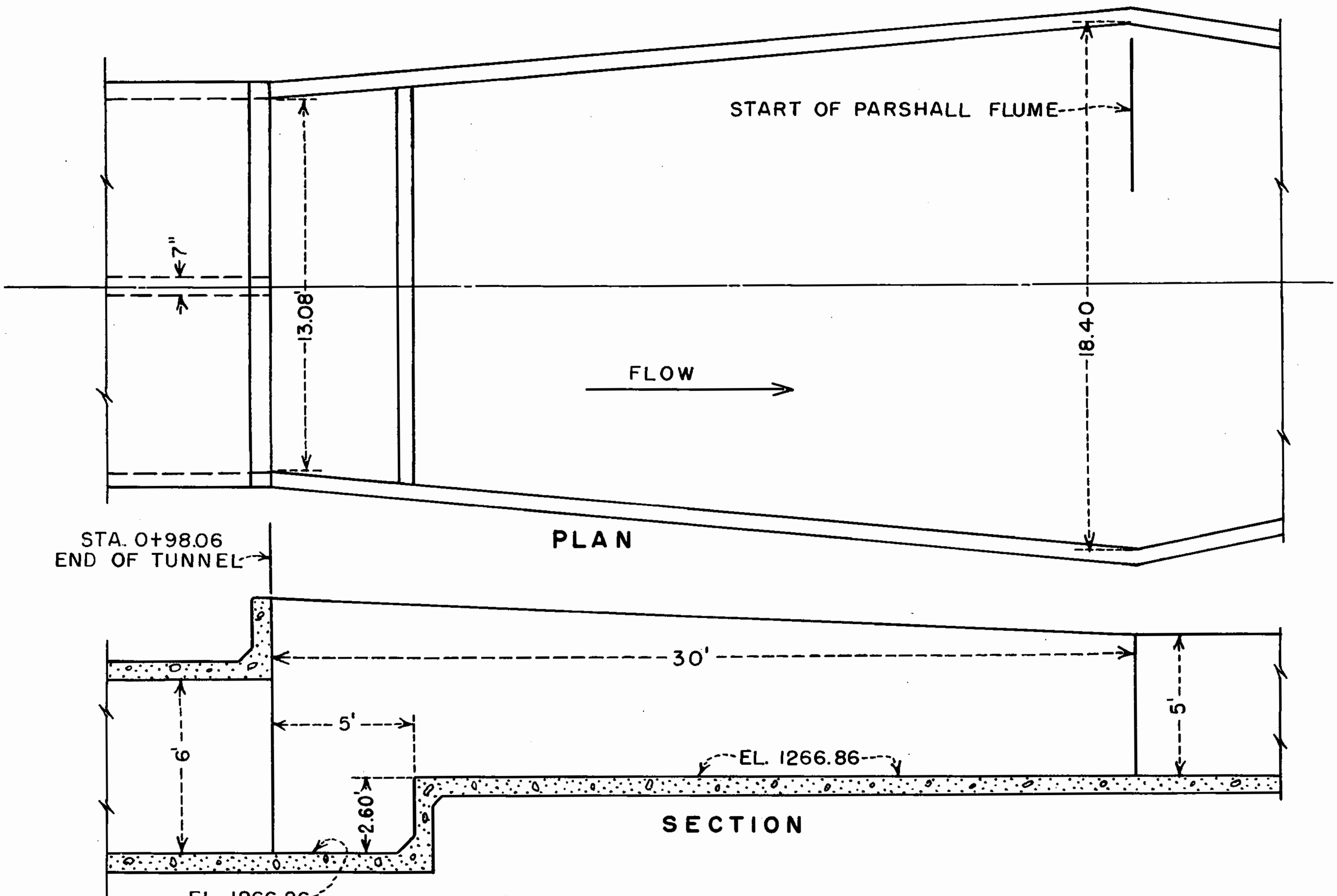
EAST LOW CANAL LATERAL
Transition No. 1 - Preliminary
Operation with Left Gate Closed

A. Discharge 360 cfs--Note standing waves



B. Discharge 180 cfs--Waves slightly smaller

EAST LOW CANAL LATERAL
Transition No. 1 - Preliminary
Operation with Both Gates Open



EAST LOW CANAL LATERAL
TRANSITION SECTION No. 2

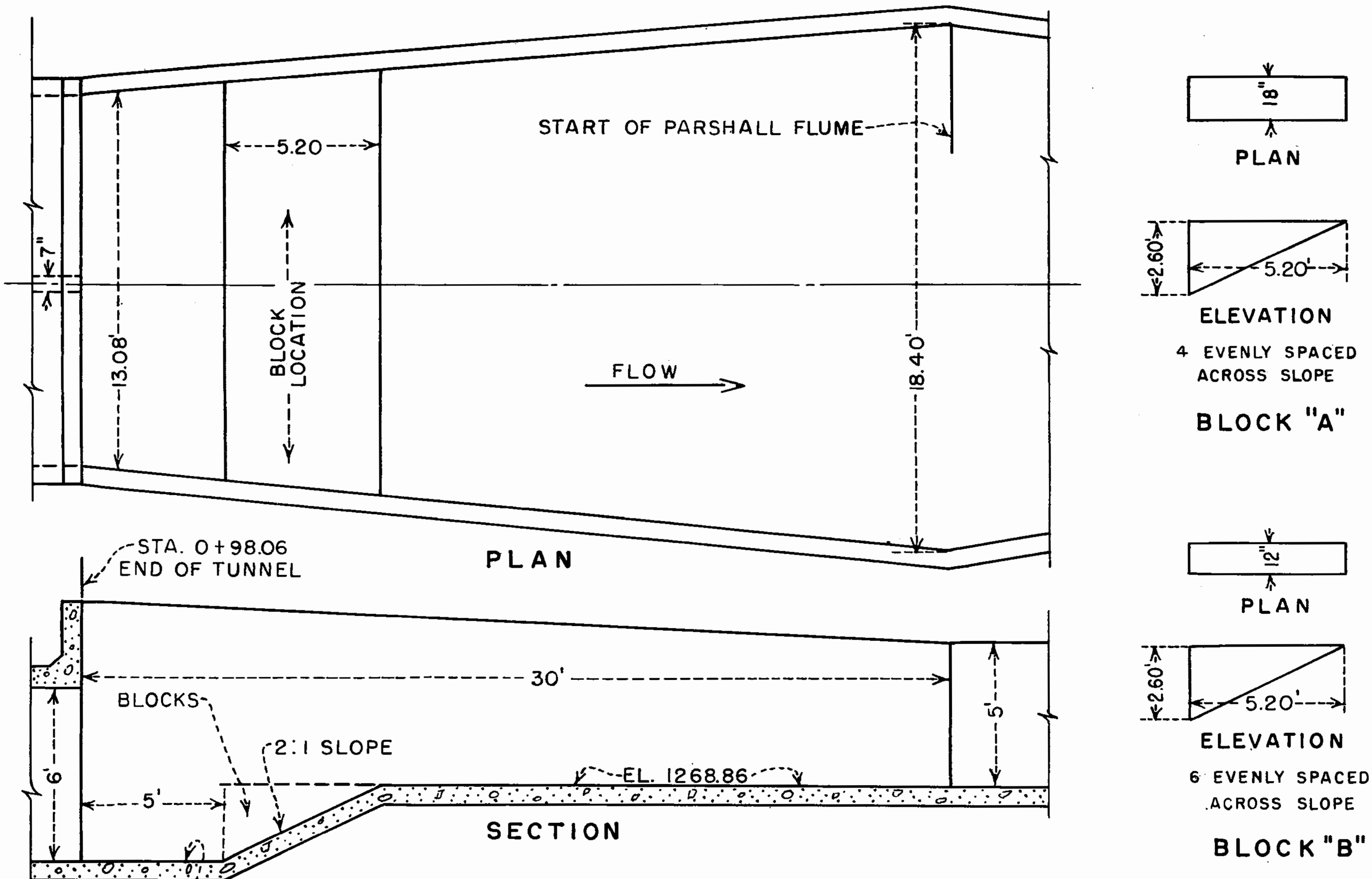
FIGURE 8

429

A. Transition No. 2, Discharge 360 cfs.

B. Transtion No. 3 - No blocks, Discharge 360 cfs.

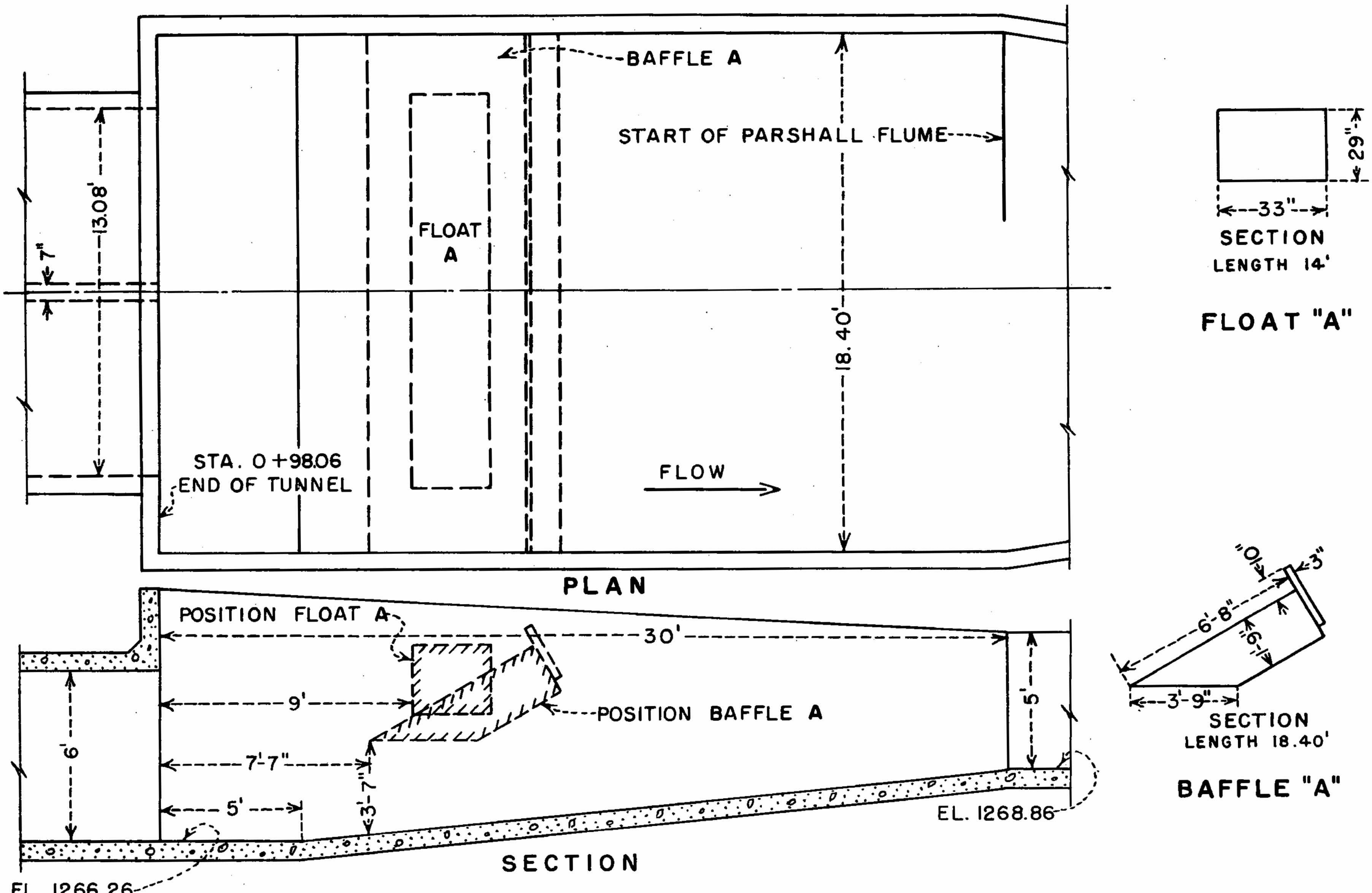
EAST LOW CANAL LATERAL
Transitions No. 2 and No. 3
Operation with Both Gates Open



EAST LOW CANAL LATERAL

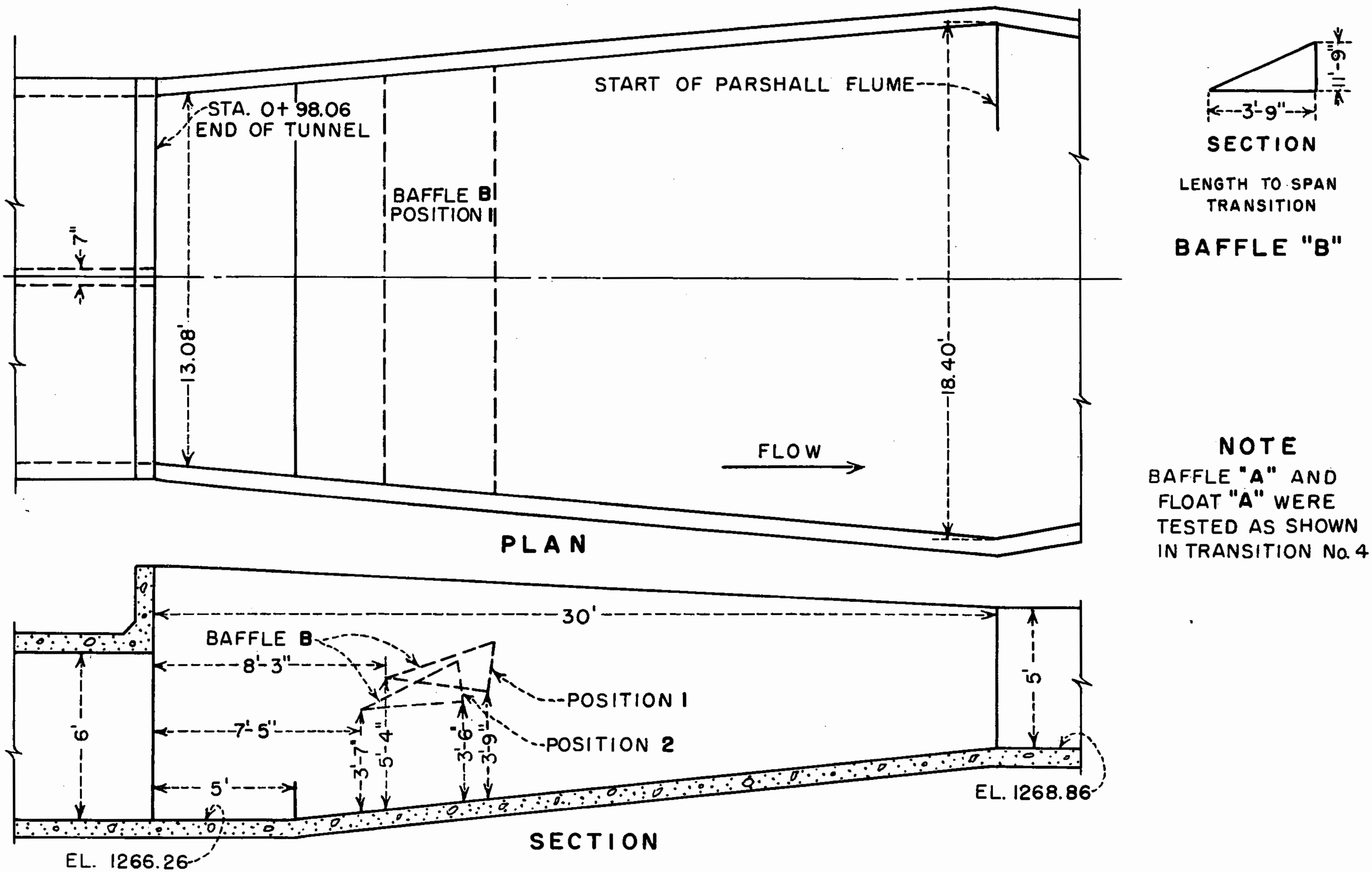
TRANSITION SECTION No. 3

FIGURE 10



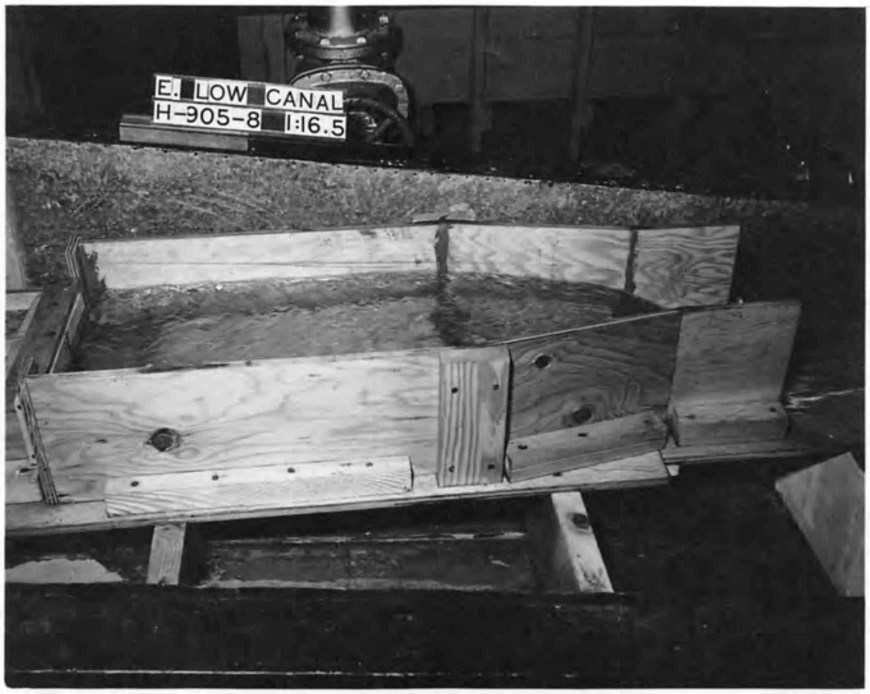
EAST LOW CANAL LATERAL

FIGURE 11



EAST LOW CANAL LATERAL
TRANSITION SECTION No. 5

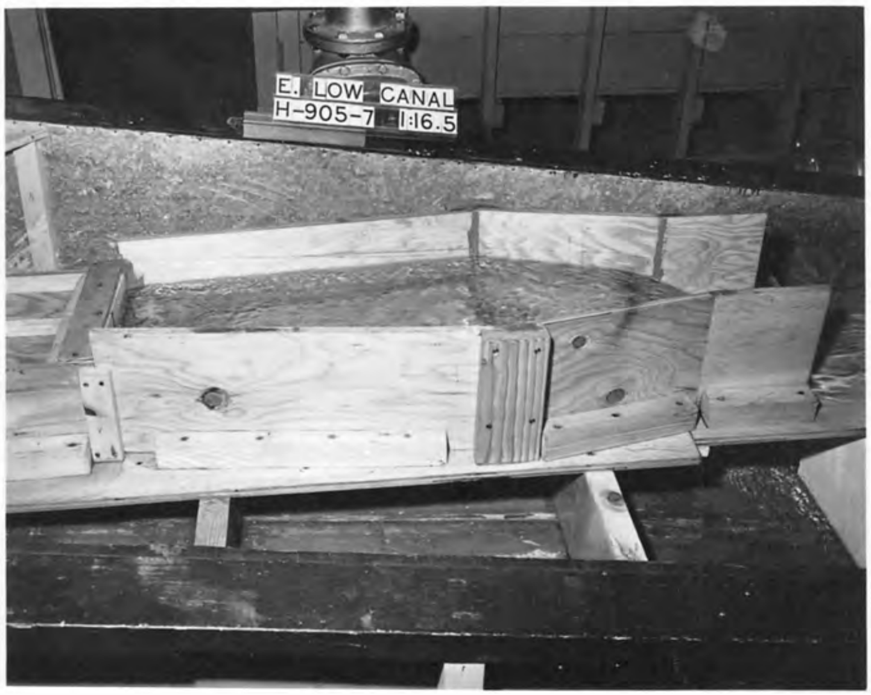
FIGURE 13



A. Without baffles

B. Baffle "A" installed

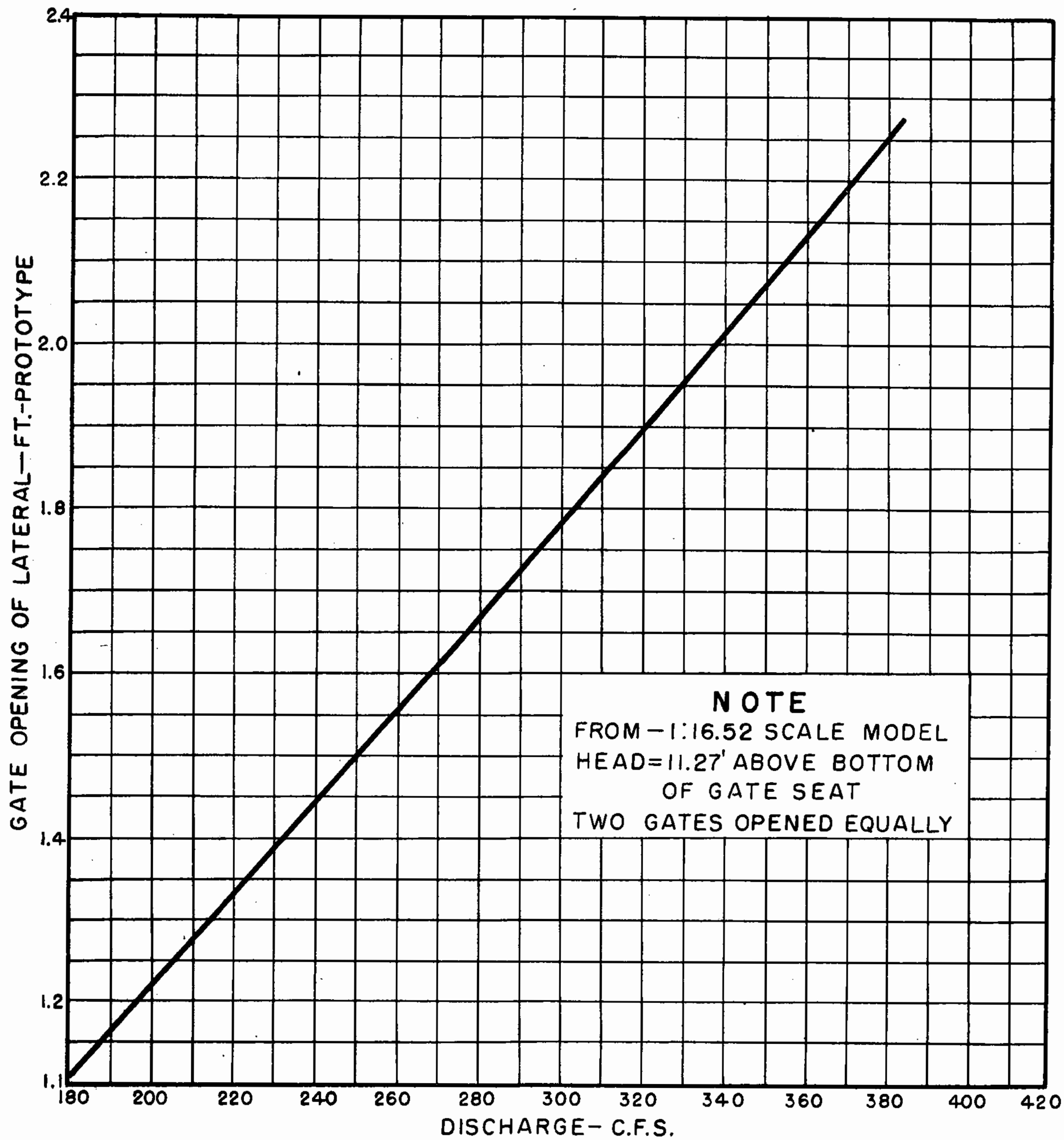
Discharge 360 cfs
EAST LOW CANAL LATERAL
Transition No. 4.
Operation with Both Gates Open



Discharge 360 cfs--Note uniform water surface.

EAST LOW CANAL LATERAL
Transition No. 5 - Recommended
Without Baffles or Float
Operation with Both Gates Open

FIGURE 15



EAST LOW CANAL LATERAL
DISCHARGE CAPACITY
2–6x6 GATES

429