UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDY OF THE MASONVILLE SIPHON TURNOUT STRUCTURE--HORSETOOTH FEEDER CANAL--COLORADO-BIG THOMPSON PROJECT, COLORADO

Hydraulic Laboratory Report No. Hyd.-237

RESEARCH AND GEOLOGY DIVISION

HYD 237

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

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Branch of Design and Construction
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Laboratory Report No Hyd 237
Hydraulic Laboratory
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Subject: Hydraulic model study of the Masonville Siphon turnout structure--Horsetooth Feeder Canal--Colorado-Big Thompson Project, Colorado.

PURPOSE OF STUDY

The purpose of this study was to develop, by hydraulic model testing, a satisfactory stilling-well and weir basin for a turnout structure which would release supplemental water to the Union Ditch from the Masonville Siphon in the Horsetooth Feeder Canal near Masonville, Colorado.

CONCLUSIONS

It was concluded that:

1. The stilling-well design, developed by this model study (Figures 2B and C) will dissipate satisfactorily the energy in the water released from the Masonville Siphon to the Union Ditch.

2. The baffle wall between the stilling-well and weir basin will produce tranquil flow in the weir basin, and permit reasonably accurate reading of the staff gage indicating the head on the Cipolletti measuring-weir.

3. There is a possibility of cavitation occuring in the pipeline immediately downstream from the valve controlling the turnout flow, since the maximum capacity of the valve is 32 cfs and throttling of the valve will be required when the normal discharge of 25 cfs is being released.

4. If the pipeline immediately downstream from the control valve is vented there will be no cavitation, but air will be drawn into the pipeline and released in the stilling-well. The action will increase the surface roughness in the well, but should not prove objectionable.

RECOMMENDATIONS

It was recommended that:

1. The flow passages of the turnout structure be constructed to conform with those shown on Figures 2B and C (recommended design).

2. An air-vent at least 2 inches in diameter with a bellmouth entrance to prevent noise, be placed in the top of the supply pipe immediately downstream from the control valve (Figure 2C). Some provision be made to prevent this vent being blocked, accidentally or otherwise, by persons or objects covering the entrance.

3. Since the structure is unlike any used previously, the performance of the prototype should be checked by design and laboratory personnel.

ACKNOWLEDGMENT

The design of the turnout structure for the Masonville Siphon, evolved from the tests described in this report, was developed through the collaboration of engineers in the Canals Division and Hydraulic Laboratory.

INTRODUCTION

General

The Horsetooth Feeder Canal, a part of the distribution system of the Colorado-Big Thompson Project, extends from Flatiron Reservoir southwest of Loveland, Colorado, to Horsetooth Reservoir 3 miles due west of Fort Collins, Colorado. Its purpose is to convey water north to the Horsetooth Reservoir for storage and distribution. Approximately 7 miles north of the canal heading, near the small town of Masonville, a siphon will be provided to cross the valley at Buckhorn Creek (Figure 1). A structure known as the Masonville Siphon turnout and located near the low point in this siphon will supply supplemental water to the Union Ditch which crosses its course at this point. The static head at the turnout will be about 115 feet making it necessary to dissipate, or change to nondestructive form, the kinetic energy of the water taken from the siphon barrel before the water is released into the Union Ditch. Though the maximum capacity of the structure is about 32 cfs, its normal release will be about 25 cfs.

The Turnout Structure

The turnout structure evolved from the tests described in subsequent parts of this report contained a supply system, stilling-well, weir basin, and measuring-weir (Figure 5). The water supply for this structure was released from the crown of the siphon barrel into the stilling-well through a 12-inch pipe containing a 12-inch gate valve for control. This pipe extended vertically down into a stilling-well 9 feet wide, 4 feet long, and 16.5 feet deep, discharging its flow on to a 2- by 2- by 1-foot high pedestal located on the floor. The pipe, with its vertical axis 1 foot from the upstream wall of the well, terminated 1 foot above the top surface of the pedestal. The downstream wall of the well contained fifteen 1-foot-square openings arranged in three tiers of five each on 20-inch centers both vertically and horizontally, with the bottom tier 10 feet above the floor of the well. This wall formed the upstream end of a weir basin, 9 feet wide, 12 feet long, and 6 feet 6 inches deep, having its floor flush with the bottom of the openings of the lower tier. The water passes from the openings in the wall, through the weir basin, over a 4-foot 6-inch Cipolletti weir, located in the downstream wall, 3 feet 9 inches above the floor, and thence into the main ditch.

INVESTIGATION

Description of Model

The model used for the study of the Masonville Siphon turnout structure was constructued to a 1 to 6 scale (Figure 3A). It was contained in a wooden box lined with sheet metal. The well with a movable floor was constructed as part of the box. Wooden walls were arranged within the box to represent those of the full-sized structure. The baffle wall between the stilling-well and weir basin was constructed of plywood and held in place by screws to facilitate changing its design. A small Cipolletti weir of thin sheet metal was attached to the downstream wall of the weir basin to represent the prototype installation. A straight length of 2-inch ID pipe, with a sliding sleeve at the upper end to facilitate placing the discharge end at different elevations, was used to represent the supply conduit. This arrangement differed from the prototype in that the model elbow was above the water surface, but this difference has no significant effect so far as the test results were concerned. A trapezoidal section of concrete-lined channel downstream from the model weir represented the inlet to the Union Ditch. No study was made of flow conditions in this section of the model since they were assumed to have no influence upon the operation of the turnout structure.

Testing of Model

Nearly all of the tests conducted on the model were of a qualitative nature consisting mainly of visual observations of the flow conditions in the stilling-well and weir basin for various changes in design. No calibration tests were made since a standard Cipolletti weir was to be used in the full-sized structure. Discharges corresponding to 25 and 32 cubic feet per second were used in most cases since these were to be the normal and probable maximum quantities released. Specific tests at smaller discharges were not made since the flow conditions became more tranquil as the quantity decreased.

Original Design

In the original design (Figure 2A) the elbow exit of the 12-inch line was 10 feet above the floor of the stilling-well and the wall between the well and weir basin contained one 2-1/2- by 4-foot opening for conveying the water from the well to the basin. When the end of the 2-inch line in the model was placed in a position corresponding to the exit of the elbow, the flow in the well was very turbulent as evidenced by large boils and surges at the surface. This turbulence was carried directly into the weir basin through the large opening in the baffle wall (original design, Figure 2B). The water flowing through this opening was concentrated in the center of the weir basin and upon striking the downstream wall of the basin was directed upwards causing a turbulent boiling surface at the corners. This action and other undesirable surface turbulence occurred in the basin (Figure 3B). It was estimated that the length of the basin would have to be increased three or four times to obtain satisfactory flow over the weir with this design. Since this change was considered uneconomical and satisfactory action was questionable, other changes were considered. It was believed that much of the objectionable flow action could be eliminated by altering the supply pipe and revising the flow passage in the baffle wall. The model tests were continued on this basis.

Extension of Inlet Pipe and Baffle Modification

The model was revised by extending the pipe to within 2 feet (prototype) of the well floor. The flow conditions were improved, but excessive turbulence still continued through the baffle opening into the weir basin. To suppress this condition and to break up the heavy concentration of flow through the single opening, the baffle was modified by replacing this opening by twelve slots 6 inches high and 28 inches wide (Design 2, Figure 2B). Substantial improvement of flow in the weir basin was brought about by the extension of the pipe and the modification of the baffle (Figure 3C). However, the velocity through the twelve slots in this design was still of such magnitude that the flow in the weir basin was more turbulent than desired. Moreover, the upper slots in this wall were not submerged adequately, and the water flowing through them had sufficient velocity to cause a surface roller, indicating the need for further alteration.

Modifications Leading to the Recommended Design

A study of flow conditions in the stilling-well of the original design, the design with modifications to the inlet pipe and baffle wall, and a review of the results of tests conducted previously on a similar model, indicated that improvement would be obtained by making five changes. These changes included: (1) making the stilling-well 2 feet deeper, (2) placing a 2- by 2-foot pedestal 1-foot high on the stilling-well floor directly beneath the discharge pipe, (3) lowering the discharge pipe until it was within 1 foot of the pedestal, (4) changing the openings through the baffle wall from twelve slots to fifteen 1-foot-square openings, and (5) extending the weir basin downstream 3 feet. It was reasoned that a better distribution of flow within the well would result from increasing the depth of the stilling-well; that additional dissipation of energy would result from placing a pedestal on the stilling-well floor and placing the end of the inlet pipe near its top surface; that more openings distributed over the area of the baffle wall would improve flow into the weir basin; and that increasing the length of the weir basin would improve approach conditions to the weir. The more uniform velocity distribution given by these changes would certainly tend to give the desired improvement.

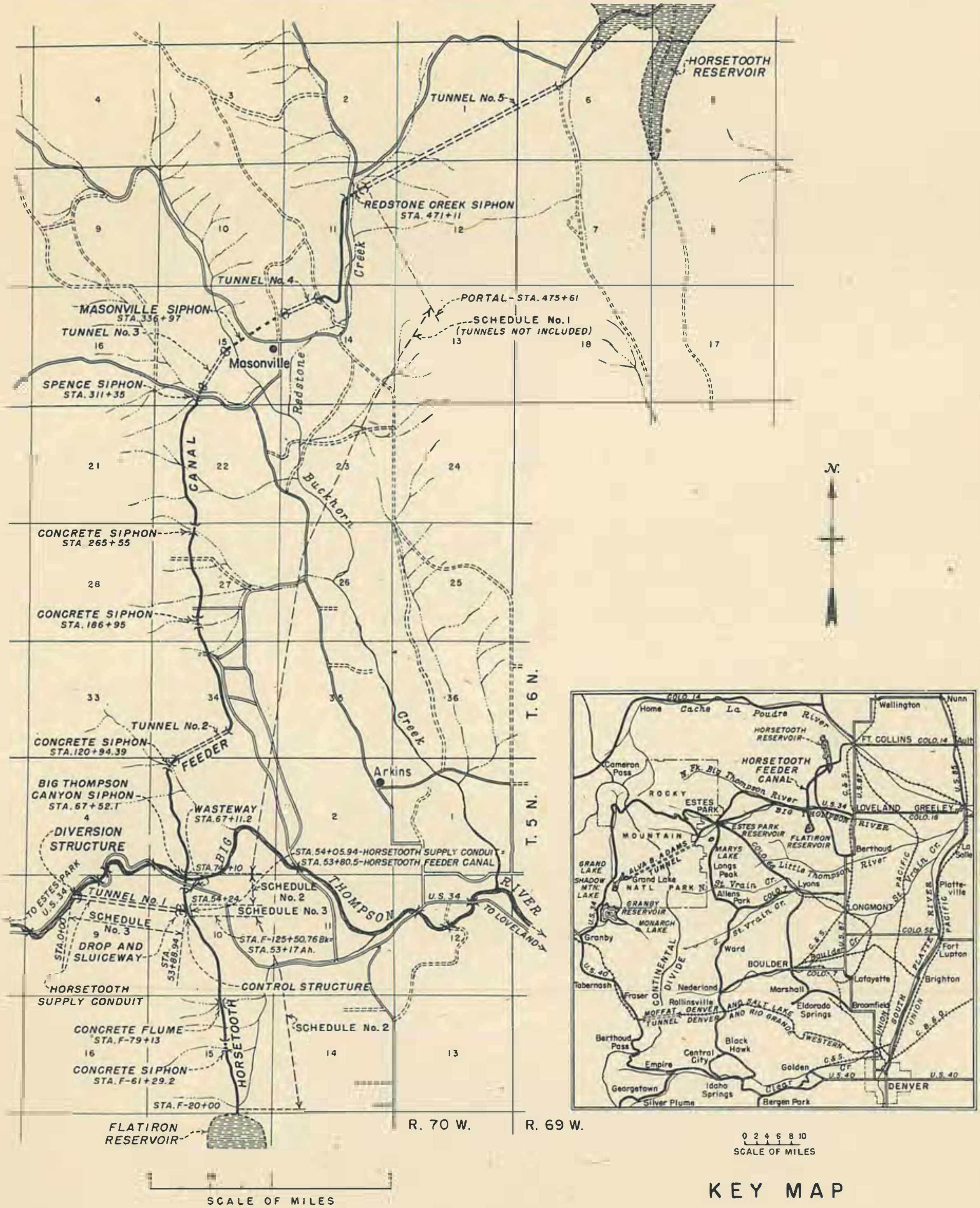
It was expected that the flow from the pipe would strike the pedestal where it would be deflected horizontally and spread radially toward the walls of the stilling-well. The jet upon leaving the pedestal would be exposed both on the top and bottom to the relatively slow moving water in the stilling-well, and it was reasoned that additional dissipation of energy would take place because of this condition. It was expected also that placing the inlet pipe near the pedestal would aid the deflection and radial spreading of the jet.

Because there was inadequate time to determine the individual merits of each of these changes in decreasing the turbulent action in the stilling-well and weir basin, the changes were all incorporated in the model for the final series of tests (Figure 2, recommended design).

It is to be inferred that the pedestal functioned as planned for the water surface in the stilling-well was very smooth, and that the end of the pipe being nearer the surface of the pedestal gave a better distribution of velocity in the well. The fifteen 1-foot-square openings in the baffle provided more area than the slots of Design 2, thus water flowed from the well to the weir basin at lower velocities. In this design the openings were arranged to obtain complete submergence of the top row. This change gave a lower entrance velocity and with an extension of the wier basin, provided a greater distance in which the dissipation of energy could take place. Even with these modifications, some surface roughness was observed in the basin directly downstream from the baffle wall. Since this appeared to be caused by flow through the upper openings, a horizontal sill extending outwards 1 foot and the full width of the basin was placed above these openings to suppress the upward movement of flow (Figure 2C). This modification resulted in a marked improvement in surface conditions. The sill was inclined at various slopes to determine optimum position, but it appeared to function best when set horizontally.

In the design of the prototype stilling-well to allow clearance for the bolts in the flanged elbow leading down into the well, the pipe centerline was set 1 foot 6 inches out from the upstream wall. This changed the pedestal from a 2-foot square to a rectangle 2 feet by 2 feet 6 inches (Figure 5). This change was not tested but there should be no adverse flow conditions resulting from this alteration.

A final change in the model was made when it was learned that the model weir was 9 inches (prototype) below the elevation required to give the designed weir-basin depth. This change gave further improvement in flow conditions within the structure and additional tests were considered unnecessary. Flow conditions for the final design, including the 9-inch rise in weir elevation but not the 6-inch change in the supply pipe location, are shown in Figure 4.



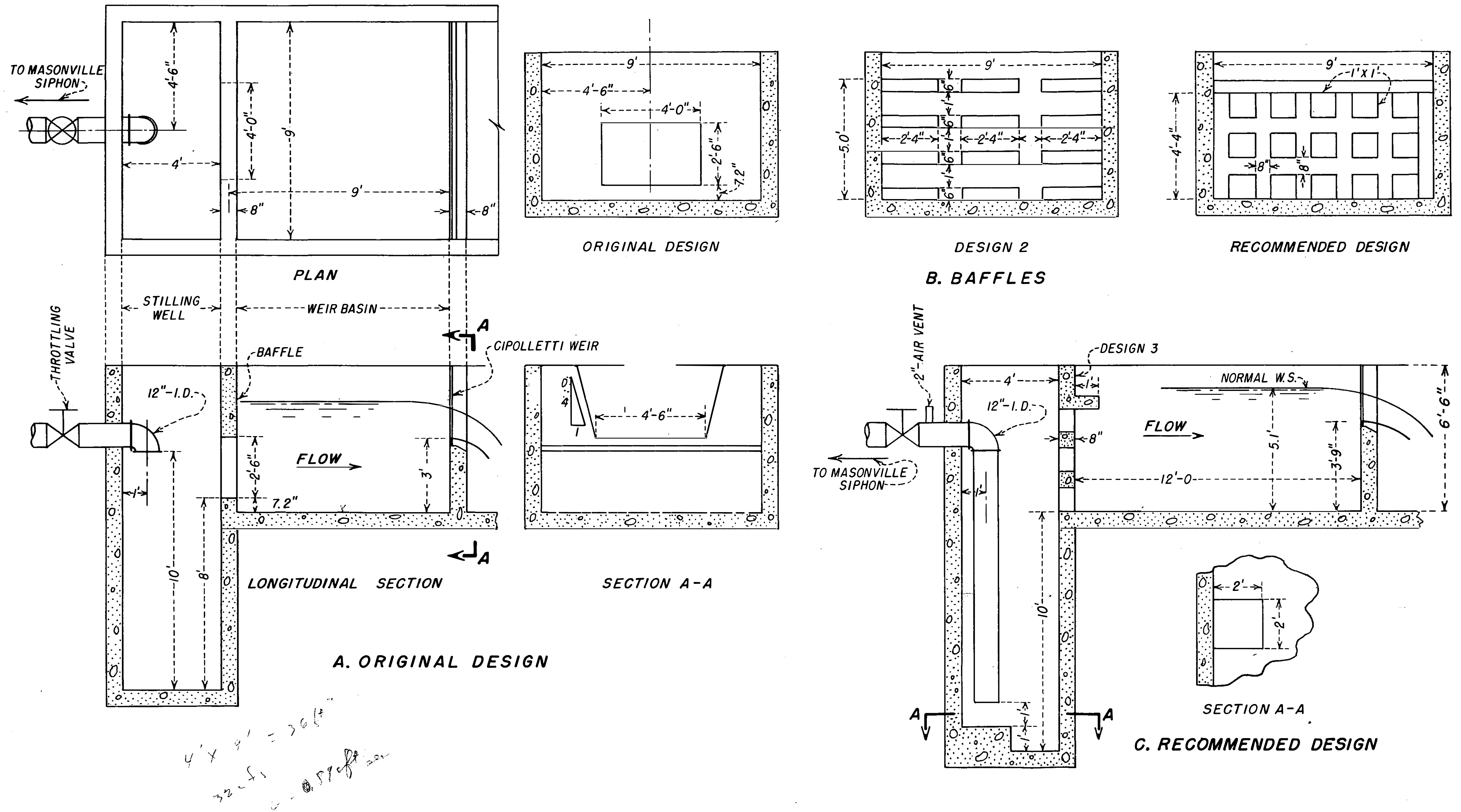
KEY MAP

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

COLORADO - BIG THOMPSON PROJECT — COLO.

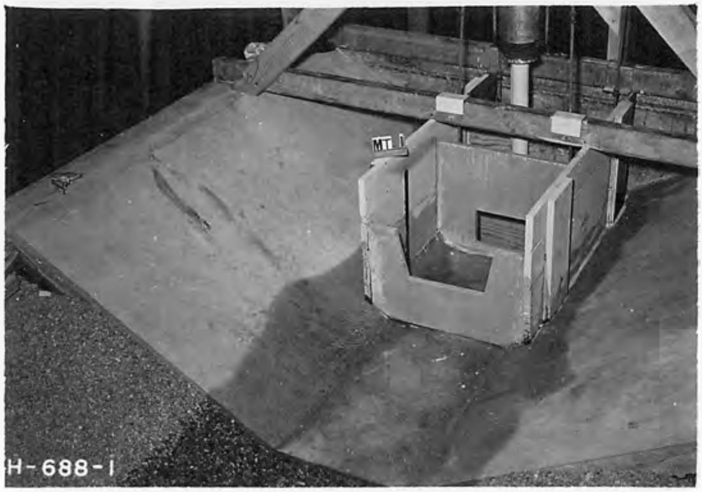
HORSETOOTH FEEDER CANAL

LOCATION MAP



COLORADO BIG THOMPSON PROJECT
HORSE TOOTH FEEDER CANAL
MASONVILLE SIPHON TURNOUT

FIGURE 3



A. Original Design-Flow of 0 cfs

B. Original Design-Flow of 32 cfs

C. Design 2-Flow of 32 cfs

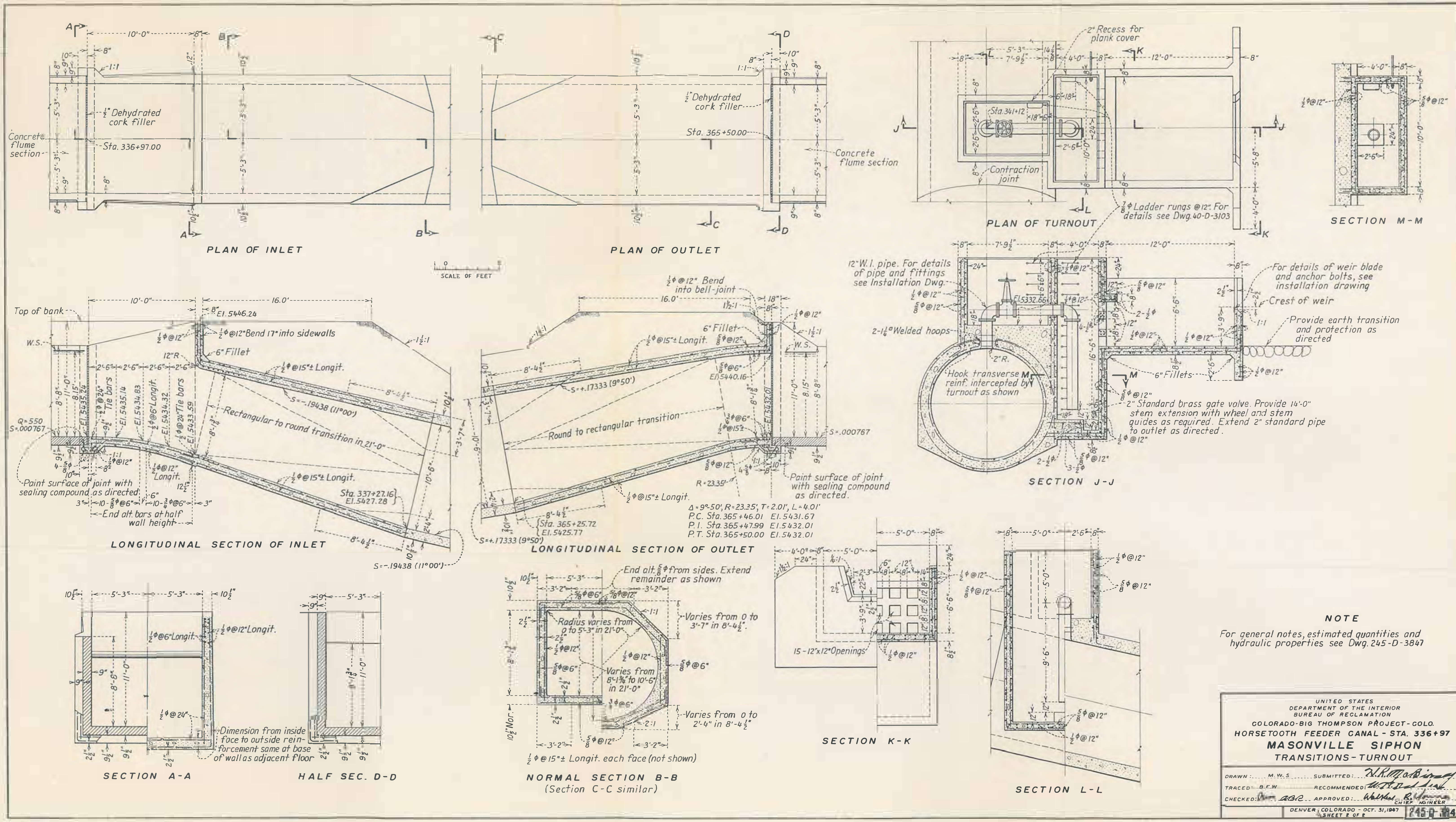
Flow Conditions in Weir Basin
MASONVILLE SIPHON TURNOUT
1:6 Model

A. Recommended Design-Flow of 32 cfs

B. Recommended Design-Flow of 25 cfs

Flow Conditions in Weir Basin-Recommended Design
MASONVILLE SIPHON TURNOUT
1:6 Model

FIGURE 5


PLAN OF INLET
PLAN OF OUTLET
PLAN OF TURNOUT
SECTION M-M
SECTION J-J
LONGITUDINAL SECTION OF INLET
LONGITUDINAL SECTION OF OUTLET
SECTION A-A
HALF SEC. D-D
NORMAL SECTION B-B
(Section C-C similar)
SECTION K-K
SECTION L-L
SCALE OF FEET
½" Dehydrated cork filler
Concrete flume section
Sta. 336+97.00
Sta. 365+50.00
2" Recess for plank cover
Contraction joint
⅝ϕ Ladder rungs @12". For details see Dwg. 40-D-3103
12" W.I. pipe. For details of pipe and fittings see Installation Dwg.
For details of weir blade and anchor bolts, see installation drawing
Crest of weir
Provide earth transition and protection as directed
2-1⅛"ϕ Welded hoops
Hook transverse reinf. intercepted by turnout as shown
2" Standard brass gate valve. Provide 14'-0" stem extension with wheel and stem guides as required. Extend 2" standard pipe to outlet as directed.
Top of bank
Rectangular to round transition in 21'-0"
Round to rectangular transition
Paint surface of joint with sealing compound as directed
End alt. bars at half wall height
Sta. 337+27.16 El. 5427.28
Δ = 9°-50', R = 23.35', T = 2.01', L = 4.01'
P.C. Sta. 365+46.01 El. 5431.67
P.I. Sta. 365+47.99 El. 5432.01
P.T. Sta. 365+50.00 El. 5432.01
Dimension from inside face to outside reinforcement same at base of walls as adjacent floor
End alt. ⅝ϕ from sides. Extend remainder as shown
Radius varies from 0 to 5'-3" in 21'-0"
Varies from 0 to 3'-7" in 8'-4½"
Varies from 8'-1⅜" to 10'-6" in 21'-0"
Varies from 0 to 2'-4" in 8'-4½"
½ϕ @ 15"± Longit. each face (not shown)
15 - 12"x12" Openings
NOTE
For general notes, estimated quantities and hydraulic properties see Dwg. 245-D-3847
UNITED STATES
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COLORADO-BIG THOMPSON PROJECT - COLO.
HORSETOOTH FEEDER CANAL - STA. 336+97
MASONVILLE SIPHON
TRANSITIONS - TURNOUT
DRAWN: M.W.S. SUBMITTED:
TRACED: B.F.W. RECOMMENDED:
CHECKED: APPROVED:
CHIEF ENGINEER
DENVER, COLORADO - OCT. 31, 1947
SHEET 2 OF 2
245-D-3848