Bradley

J. N. Bradley

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF THE DIVERSION STRUCTURE - HORSETOOTH SUPPLY CONDUIT

COLORADO-BIG THOMPSON PROJECT - COLORADO

Hydraulic Laboratory Report Hyd-236

RESEARCH AND GEOLOGY DIVISION

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

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Hydraulic Laboratory
Compiled by: W. E. Wagner
Reviewed by: A. J. Peterka

Subject: Hydraulic model studies of the Diversion Structure--Horsetooth Supply Conduit--Colorado-Big Thompson Project.

SUMMARY

The hydraulic model studies described in this report were made on a 1:5 scale model to determine the operating characteristics of the grating or grizzly of the diversion structure of the Horsetooth Supply Conduit, Figure 2. The grating will be used to prevent the coarser bed load from falling in and clogging the supply conduit.

Specifically, the tests were run to determine:

a. Whether a grating length of 15 feet is sufficient to permit 12 cfs per foot of width to fall through the grating if the approach channel carries from 12 to 140 cfs per unit width.

b. The distance from the upstream edge of the supply conduit to the extreme point at which water falls through the grating for a discharge of 12 cfs per foot of width with both the Case I and Case II approach conditions shown on Figure 2.

c. The effects on the discharge through the grating when rock and gravel are being moved along the river bed and over the grating.

The model tests indicated conclusively that a grating length of 15 feet is sufficient to pass the required diversion discharge of 12 cfs per unit width for both Case I and Case II.

The required length of grating for a discharge of 12 cfs per foot of width was found to be 2.5 to 3.0 feet for Case I and 3.5 to 4.0 feet for Case II, Figure 4B and 5B and Table I.

Under the operating conditions described in this report, the movement and deposition of gravel on the grating bars had the effect of increasing the required length of grating, but a length of 15 feet, as designed, was ample to pass the design discharge of 12 cfs per unit width.

INTRODUCTION

As a part of the Colorado-Big Thompson Project, the diversion structure of the Horsetooth Supply Conduit is located on the Big Thompson River about 1-1/4 miles above the mouth of the Big Thompson Canyon, west of Loveland, Colorado, Figure 1. Transmountain diversion water, from the Colorado River Basin, enters the Big Thompson River near Estes Park, Colorado, and follows the natural river channel to the Horsetooth Diversion Structure which diverts the water through a supply conduit to the Horsetooth Feeder Canal and thence to Horsetooth Reservoir. Ultimately, it is planned to take the transmountain diversion water from the Big Thompson River a short distance below Estes Park through a conduit to Flatiron Reservoir. Water for Horsetooth Reservoir will then be supplied from Flatiron Reservoir by the Horsetooth Feeder Canal, and the Horsetooth Supply Conduit and Diversion Structure will be used only as an emergency and supplementary means of bringing water to Horsetooth Reservoir.

THE INVESTIGATION

In this report, all linear dimensions refer to prototype, and all discharges refer to prototype discharges per foot of width of river channel, unless otherwise stated.

Tests were conducted on a sectional model constructed to a geometrical scale of 1:5. The model consisted of a 7-1/2-foot wide section of the river approach channel and diversion structure, a portion of the supply conduit, and a headbox equipped with a slide gate to control the velocity of the flow in the approach channel, as shown in Figure 3.

Water, supplied to the model by two laboratory pumps, was metered through an orifice while the quantity of water diverted from the river channel through the grating was measured by means of a weir placed in the downstream end of the supply conduit.

By use of the slide gate, the model water surface, or head, could be regulated to reproduce prototype velocities for discharges varying from the minimum of 12 cfs to 140 cfs. However, model discharges equivalent to prototype discharges of more than 65 cfs could not be obtained, due to the large model scale necessary to reproduce the grid bars to a satisfactory model size. Nevertheless, by using the maximum pump discharge of 65 cfs and by regulating the model head, velocities similar to those which would exist for the maximum discharge of 140 cfs were represented in the model. In other words, a discharge of 140 cfs was assimilated in the model by using 65 cfs and increasing its velocity until the normal velocity for 140 cfs was reached.

Although the depth and quantity of water was considerably less than that for 140 cfs, this variance was on the safe side for the purpose of these studies, since if 12 cfs would pass through the grating for a given channel discharge and velocity, a greater quantity of water would certainly pass through at a greater channel depth and the same velocity.

Average velocities in each case were determined from pitot-tube measurements made at 0.6 of the depth measured from the water surface.

Description and Results of Tests

Two conditions of the approach channel were studied: Case I, in which the bottom of the approach channel upstream from the diversion structure is 5 feet below the level of the structure grating, and Case II, the ultimate condition, in which the approach channel is filled with gravel to the level of the diversion structure, Figure 2. Thus, in Case II, there is the possibility of bed load, consisting of rocks and gravel, being deposited on the grating and thereby reducing its ability to pass the required quantity of water to the conduit.

The model was first constructed to represent Case I conditions, and two tests were made using discharges of 12 cfs and 65 cfs to determine the amount of water diverted from the river channel to the conduit and to observe the flow conditions over the grating. Results of these tests are shown in Table I and Figure 4.

The model was then modified to represent Case II conditions by placing a wood platform level with the upstream end of the grating and extending upstream to the headbox, Figure 5A. As in Case I, tests were made using discharges of 12 and 65 cfs, Figures 5B and 5C. To determine the effect of rock and gravel which might be deposited on the grating, gravel representing 1-1/4- to 10-inch rock in the prototype was slowly dropped in the upstream approach channel. The approach channel carried a discharge of 12 cfs and gravel was added until the grating was practically covered, Figure 6A. As the discharge in the approach channel was increased, the gravel had a tendency to move downstream on the grating bars until the total area between the bars, through which the water could flow, was sufficient to pass the quantity of water flowing in the approach channel.

The discharge in the approach channel was then increased to 65 cfs, without adding more gravel. The flow conditions at this discharge and the amount of gravel remaining on the grating was observed, Figure 6C. After the higher discharge of 65 cfs, the only gravel remaining on the grating were those wedged between the grating bars, Figure 6D.

In all the above tests, the required quantity of water, 12 cfs, passed through the grating.

Table 1

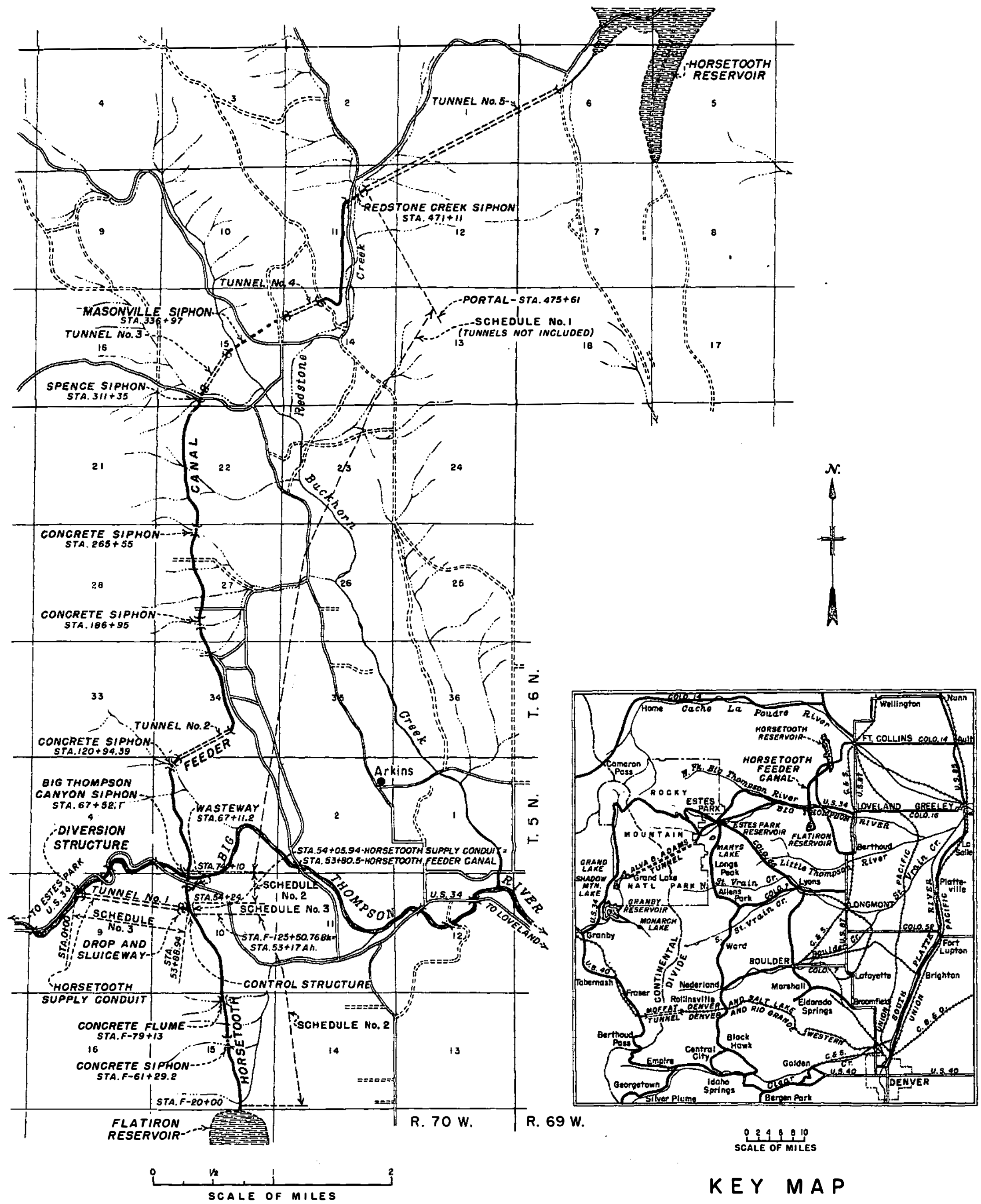
Test No	Q_p* (Approach channel)	Normal V in ft/sec for Q_p	Normal V in ft/sec for 140 cfs	V at which test was made	Gravel on grating	Distance** in ft	Q_p* (Conduit)
			Case I				
1	12	1.62	--	1.62	No	2-1/2 to 3	12
2	65	5.16	7.9	7.9	No	--	47***
			Case II				
3	12	12.5	--	12.5	No	3-1/2 to 4	12
4	12	12.5	--	12.5	Yes	Varied	12
5	65	24.6	33.5	33.5	No	--	44***
6	65	24.6	33.5	33.5	Yes	--	41***

*Prototype discharge.

**Distance from the upstream edge of the supply conduit to the extreme point at which water falls through the grating, shown as distance "X" on Figure 2.

***Approximations only since flow over measuring weir was extremely turbulent.

FIGURE I



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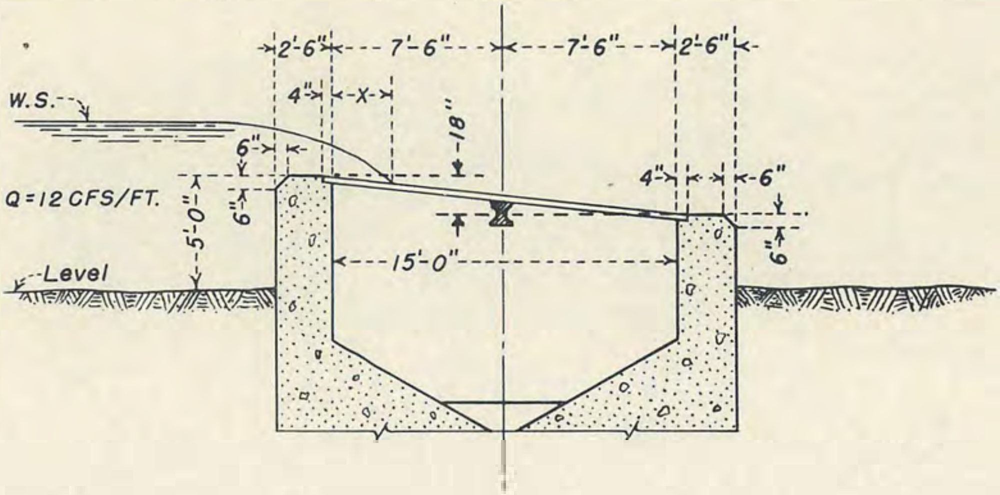
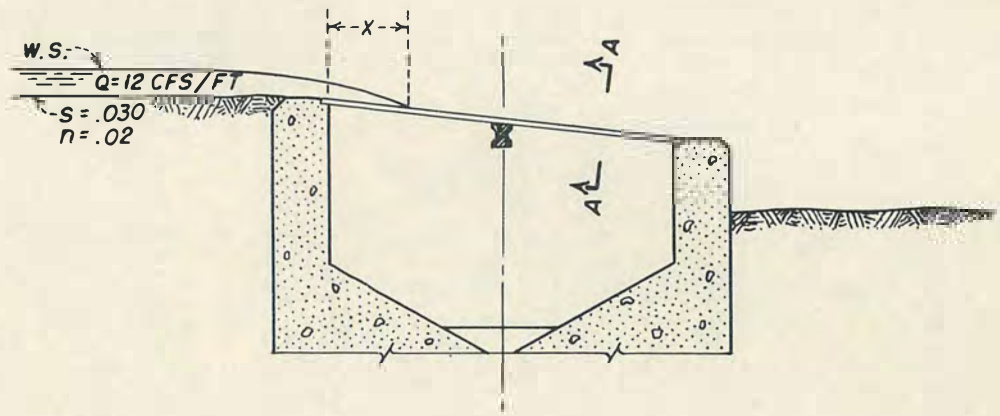
HORSETOOTH FEEDER CANAL
LOCATION MAP

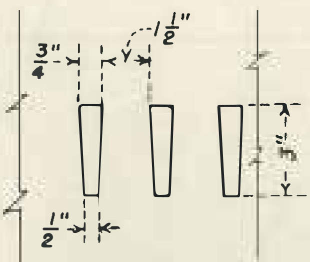
FIGURE 2



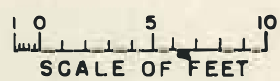
CASE I



CASE II



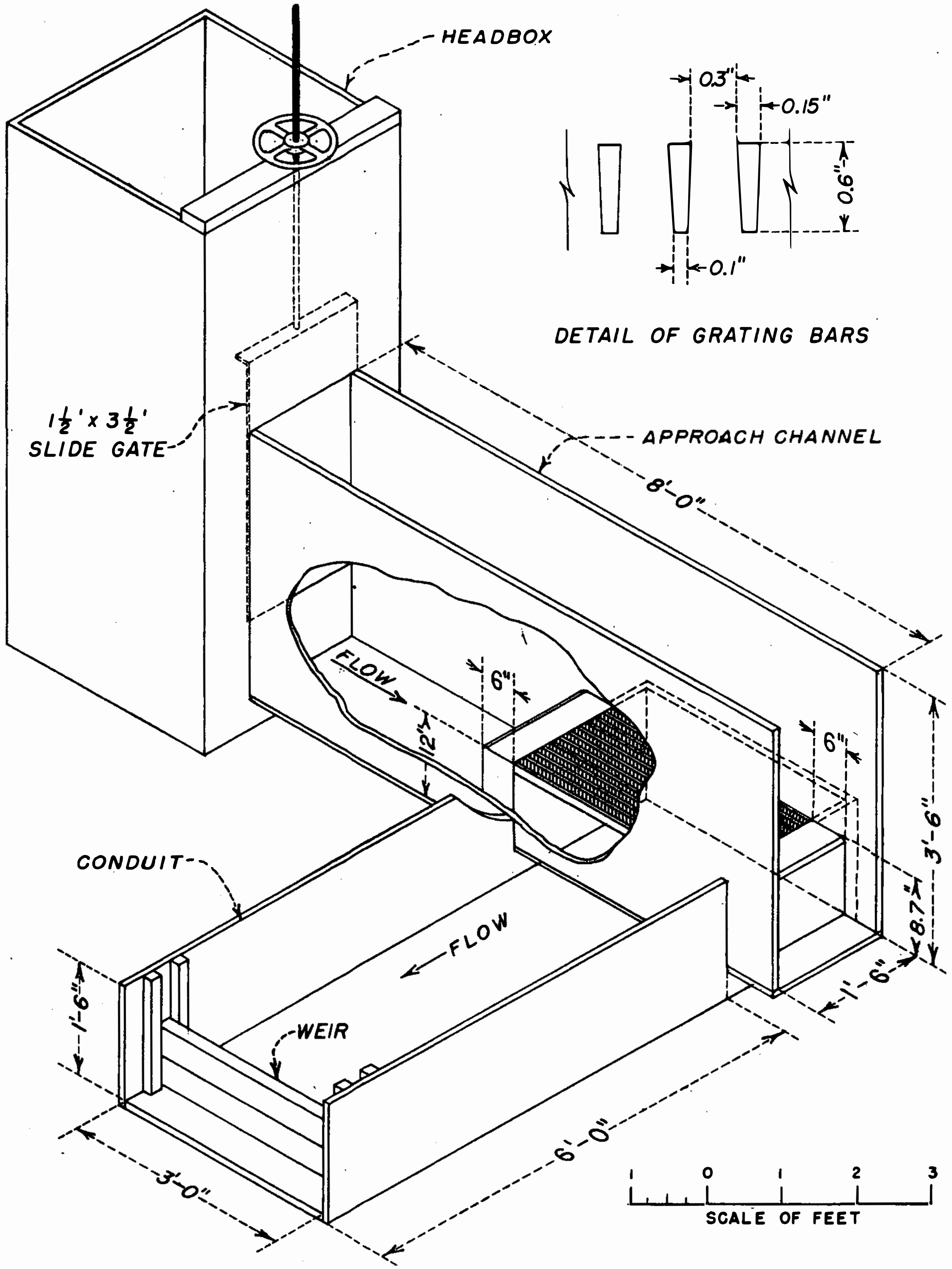
SECTION A-A



COLORADO-BIG THOMPSON PROJECT

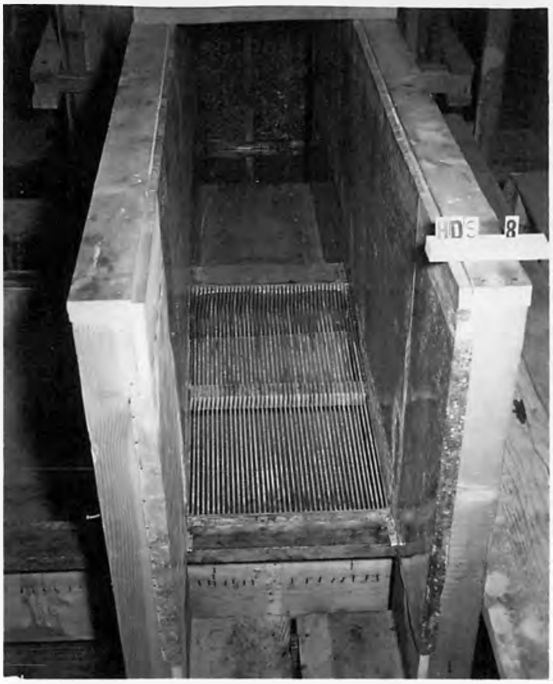
HORSETOOTH SUPPLY CONDUIT
DIVERSION STRUCTURE

R.D.R. 7-12-47



HYDRAULIC MODEL
HORSETOOTH SUPPLY CONDUIT
DIVERSION STRUCTURE
MODEL SCALE 1:5

FIGURE 4



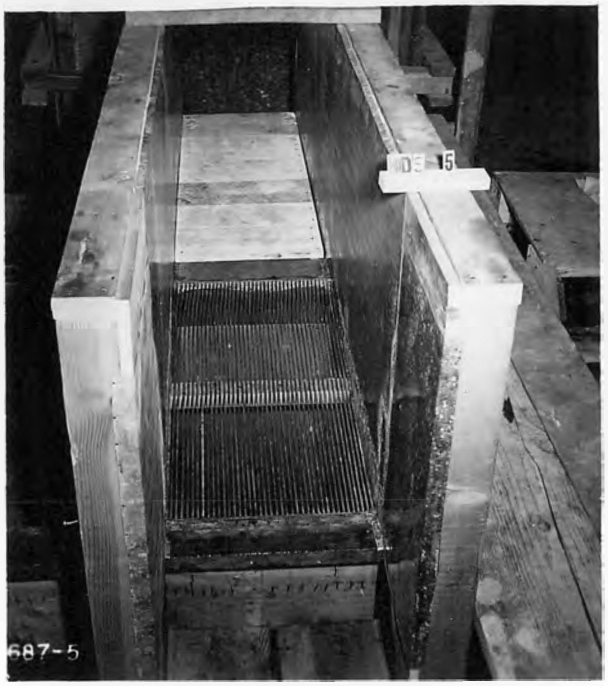
A. Case I - Looking upstream at sectional model of approach channel and grating

B. Case I - Flow conditions at grating
Discharge = 12 cfs per ft of width
Velocity = 1.62 ft per sec

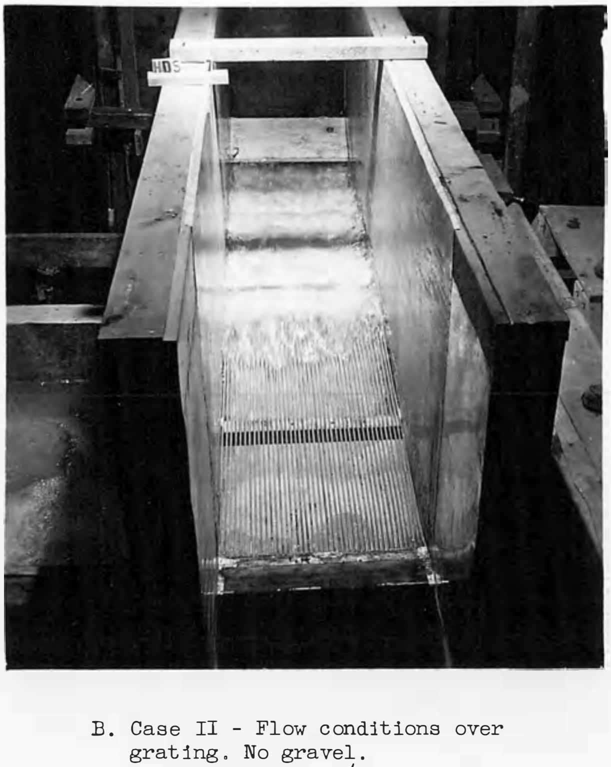
C. Case I - Flow conditions at grating
No gravel. Discharge = 65 cfs/ft of width. Velocity = 7.9 ft per sec.

D. Case I - Overall view of model
Discharge = 65 cfs/ft of width
Velocity = 7.9 ft per sec.

HORSETOOTH DIVERSION STRUCTURE
1:5 SCALE MODEL



A. Case II - Approach to grating raised to assimilate future **approach** conditions.

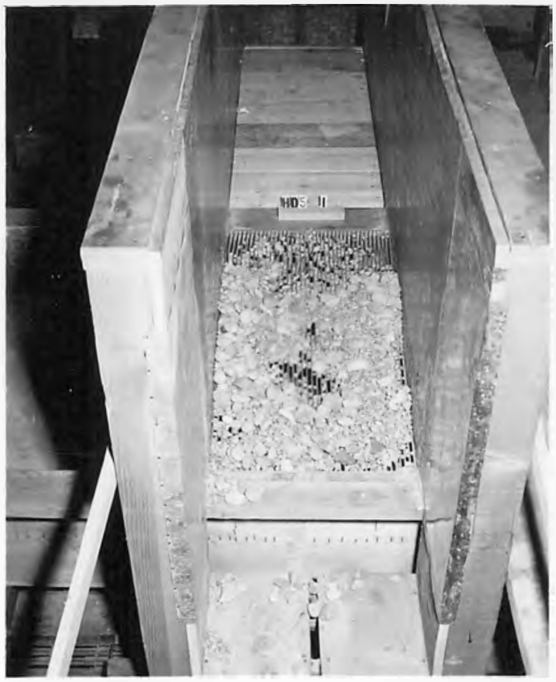


B. Case II - Flow conditions over grating. No gravel.
Discharge = 12cfs/ft of width
Velocity = 12.5 ft/sec

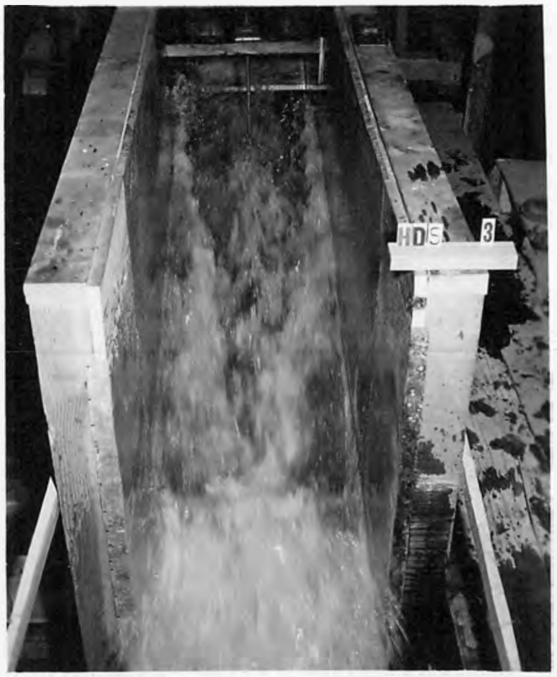
C. Case II - Flow conditions over grating. No Gravel. Discharge = 65 cfs/ft of width. Velocity = 33.5 ft/sec

HORSETOOTH DIVERSION STRUCTURE
1:5 SCALE MODEL

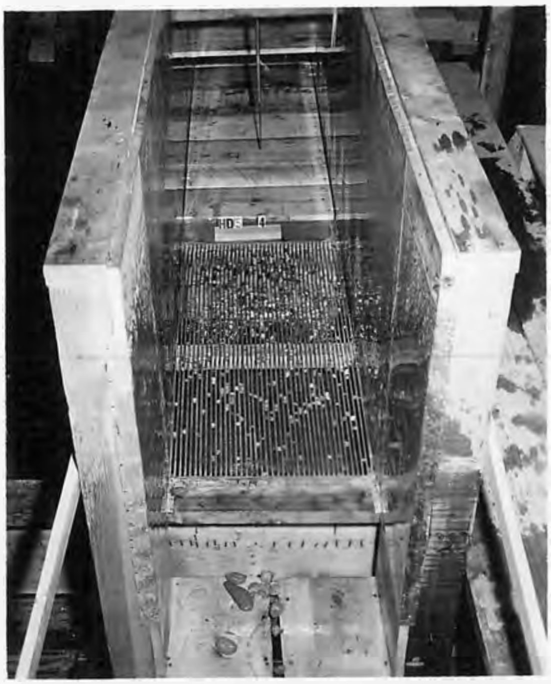
A. Case II - Flow conditions with gravel deposit on grating. Discharge = 12 cfs/ft of width. Velocity = 12.5 ft/sec



B. Case II - Gravel distribution on grating after discharge of 12 cfs/ft of width and velocity of 12.5 ft/sec



C. Case II - Flow conditions over grating and gravel deposit. Discharge = 65 cfs/ft of width Velocity = 33.5 ft/sec



D. Case II - Only gravel that wedged in grating remains after discharge of 65cfs/ft of width and velocity of 33.5 ft/sec.

HORSETOOTH DIVERSION STRUCTURE
1:5 SCALE MODEL