UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF THE HEADWORKS AND SLUICEWAY OF WOODSTON DIVERSION DAM MISSOURI RIVER BASIN PROJECT--KANSAS

Hydraulic Laboratory Report No. Hyd-451

DIVISION OF ENGINEERING LABORATORIES

COMMISSIONER'S OFFICE
DENVER, COLORADO

July 8, 1959

FOREWORD

A movable bed model study was made of the headworks and sluiceway of Woodston Diversion Dam. The prototype structure is located on the South Fork of the Solomon River, Missouri River Basin Project, Kansas. The studies were conducted in the Hydraulic Laboratory of the Bureau of Reclamation at Denver, Colorado, during January to April 1957.

The recommended plans evolved from the study were developed through the cooperation of the staffs of the Canals and Headworks Section, Canals Branch, and the Hydraulic Laboratory. During the studies, J. A. Hufferd, R. D. Ridinger, A. J. Aisenbrey, and others frequently visited the laboratory to observe and discuss the model results and operation.

P. "F." Enger made the feasibility study to determine the possible sediment excluding devices that could be economically incorporated in the prototype design. He then made the preliminary model layout.

The entire study was conducted under the supervision of E. J. Carlson. Messrs. W. G. Allen, W. A. Lidster, and W. H. Cheng assisted considerably in taking data and making computations.

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Commissioner's Office--Denver
Division of Engineering Laboratories
Hydraulic Laboratory Branch
Hydraulic Investigations Section
Denver, Colorado
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Hydraulic model studies of the headworks and sluiceway of Woodston Diversion Dam--Missouri River Basin Project, Kansas

SUMMARY

Woodston Diversion Dam is part of the Missouri River Basin Project. It is built on the South Fork of the Solomon River in Kansas. Because sediment inflow into the headworks was a major consideration in the design, the Hydraulic Laboratory was asked to make a model study to assist in determining the final arrangement of the headworks, sluiceway, and guide walls in regard to sediment control.

Tests were made with a 1:8 scale hydraulic model. The headworks, sluiceway, and part of the river approach were represented. As a basis to compare the various arrangements tested, the model was first operated without a sediment-excluding device. The result of this run was expressed as a concentration ratio (the average sediment concentration of the sluiceway flow divided by that of the headworks). The value of this ratio for the initial run was 0.51. The operating characteristics of ten changes and one auxiliary run were studied, and concentration ratios were measured for each arrangement. Table 1 gives a description of all runs made. The effectiveness of each change has been expressed as a performance ratio. This is defined as the concentration ratio for the change divided by that of the initial run.

Change 5 was recommended to be incorporated in the final prototype design. The concentration ratio for this arrangement was 4.76, resulting in a performance 9.35 times better than the model operating without any sediment-excluding device. Figures 10 and 21 show the model of the recommended layout. Figure 2 shows the general plan and sections of the prototype structure.

INTRODUCTION

In compliance with the request of December 14, 1956, from Chief of Canals Branch, a hydraulic model study was made of the Woodston Diversion to develop a sediment control arrangement.

The sediment-excluding device incorporated in the preliminary design was evolved through the joint efforts of the Canals and Headworks Section, Canals Branch, and the Hydraulic Laboratory. From past experience with other sediment model studies and because of the debris expected in the river flow, it was decided to limit the study to curved guide walls and related structures.

The prototype of Woodston Diversion is located in Kansas on the South Fork of the Solomon River and is part of the Missouri River Basin Project. Figure 1 shows a location map.

The dam consists of an earth dike approximately 2,100 feet long, a 151-foot-long ogee spillway, an 8-foot wide sluiceway, and a 7-foot-wide headworks. The diversion works is to feed Osborne Canal which will carry irrigation water for 8,500 acres of land on the north side of the river. The general layout of the dam can be seen in Figure 2.

CONSTRUCTION AND OPERATION OF MODEL

A 1:8 scale model of Woodston Diversion Dam was constructed in an existing box. The sand available and used in this study was produced from a loosely cemented sandstone. The stone was broken down in a hammer mill. The result was a fine, uniform sand that moved well with fairly low water velocities. Figure 3 shows the comparison of the prototype and model sand settling velocities when a scale ratio of 1:8 is applied. The 50 percent sizes are almost identical in settling characteristics. It was on this basis that 1:8 was selected as the scale to be used throughout the study. Figure 4 shows the comparison of the model and prototype sediment size analyses.

To expedite the installation and the operation of the hydraulic model, it was constructed so as to appear as a mirror image of the prototype structure. Figure 5 shows the general plan of the model. Common to all runs made, the model represented structurally the headworks with its 7- by 6-1/2-foot slide gate, the sluiceway with its 8- by 18-foot radial gate, and approximately 240 feet of riverbed upstream from the diversion.

To obtain the model discharges, a statistical analysis was made from data compiled by the McCook field office for their sand load study. Data for the Years 1920 to 1948 were included in the study. The average total river discharge was 77 cubic feet per second. The average flow in the headworks, based on an operation study made in the field for the Division of Project Investigations, was 42 cubic feet per second. This left an average of 35 cubic feet per second for sluicing. The average hydrographs for the river discharge and for the flow to be diverted can be seen in Figure 6.

The model was always operated at the normal water surface elevation of 1686.5 feet just upstream of the spillway except during the auxiliary run. This elevation is 0.5 of a foot below the spillway crest. The tail water elevation maintained in the headworks was based on the assumption that the checks in the canal are too far downstream to affect the water surface at the headworks. As the entire length of the headworks was not included in the model, the tail water elevations of the curve shown in Figure 2 were corrected for friction loss.

The sediment was recirculated by a sediment pump, and its discharge was measured by means of a 2-inch plastic venturi meter. The sediment discharge was spread over the upstream end of the model by a parabolic spreader. The sediment pump, the plastic venturi meter, and spreader are shown in Figure 7.

Sand was added to the sediment pump flow until the bed had established a slope sufficient to move 125 parts per million of sediment by weight. This is the average amount as determined from the sediment discharge curve in Figure 8. The curve was computed using Schoklitsch's formula.

Samples of the sand and water being discharged through the headworks and sluiceway were taken by passing slotted troughs through the water nappes. The samples passed through conduits to calibrated tanks and the volume of the total sample was read in liters. At the bottom of the tanks were removable glass cones that retained the sediment after a major portion of the water had been drained. The sediment was then washed into centrifuge tubes where its volume was read in milliliters. The sampling tanks and the slotted trough can be seen in Figure 9.

For each sediment-excluding arrangement, a performance ratio was calculated for comparing its effectiveness to the initial run which had no excluding devices installed. The performance ratio (P_r) is defined as:

$$P_r = \frac{C_{rt}}{C_{ri}}$$

where

C_{rt} = the concentration ratio for the arrangement being tested

C_{ri} = the concentration ratio for the initial run

The concentration ratio (C_r) is defined as:

$$C_r = \frac{C_s}{C_h}$$

where

C_s = the sediment concentration in the sluiceway flow

C_h = the sediment concentration in the headworks flow

INITIAL RUN

The general plans and sections of the headworks for all changes can be seen in Figure 10. For the initial run, the guide wall was not installed.

The total river discharge set was 77 cubic feet per second with 42 cubic feet per second passing through the headworks and 35 cubic feet per second passing through the sluiceway (prototype values). Before taking data, the model was operated until the amount of sand entering was equal to that leaving.

The main current of the river continually varied in direction of approach to the headworks and sluiceway. Consequently, the concentration ratio (C_s/C_h) varied from 0.10 to 3.30. This variation was experienced during a run of approximately 100 hours. The average concentration ratio (C_s/C_h) during this run was 0.51.

Photographs of the initial arrangement in operation can be seen in Figure 11. The closeup view shows the vortices that formed in front of the sluiceway and headworks. The riverbed after the initial run can be seen in Figure 12.

CHANGE 1

For Change 1, the guide wall of the preliminary design was added to the model as shown in Figures 10 and 13. The headworks entrance was not modified. The guide wall was 0.5 of a foot higher than the normal water surface elevation. The radius of the wall was 22.5 feet, and it encompassed an arc of 90^{o}. The guide wall channel was 5 feet wide.

The model was operated for 47 hours with this arrangement installed. A strong vortex formed because of the high velocity in the guide wall channel and the offset of the headworks slide gate. As can be seen in Figure 14, the vortex was strong enough to suck air into the headworks flow. Sediment samples were taken during the run. The concentration ratio was quite low because the high vortex turbulence caused more sediment to enter the headworks. The concentration ratio (C_s/C_h) was 0.25, resulting in a performance ratio (C_{rt}/C_{ri}) of 0.49. The vortex in front of the sluice gate was not objectionable since it did not extend upstream to the headworks entrance.

Figure 15 shows that the guide wall was effective in superelevating the bed upstream from the vortex. Figure 16 shows the typical erosion pattern at the upstream end of the guide wall.

CHANGE 2

To stop the vortex, the curtain wall shown in Figure 10 was installed. The wall was 8 inches thick and extended 2 feet below the normal water surface. The bottom upstream edge of the curtain wall had an 8-inch radius to reduce turbulence and losses at the entrance. The curtain wall prevented the vortex from forming as shown by comparing Figure 17 with Figure 14. The model was operated for 5 hours with this arrangement. The concentration ratio (C_s/C_h) was 0.84, and the performance ratio (C_{rt}/C_{ri}) was 1.65.

CHANGE 3

For Change 3, the curtain wall was left as in Change 2. A sill was added to the headworks entrance to raise it 10 inches. The sill was rounded to reduce turbulence. A high level of turbulence in this area might lift the sediment into suspension just in front of the headworks. A sectional view of this arrangement can be seen in Figure 10, and Figure 18 is a photograph of the sill. The model was operated for 53 hours, during which the average concentration ratio (C_s/C_h) was 0.99. The performance ratio (C_{rt}/C_{ri}) was 1.94. The resulting bed condition in the guide wall channel may be seen in Figure 19.

CHANGE 4

For this run, the rounded sill was replaced with the sharp-edged, overhanging sill shown in Figures 10 and 20. The sill had a 15-inch overhang. The guide wall and curtain wall were not changed. The model was operated for 25 hours with this arrangement. The average concentration ratio (C_s/C_h) was 1.54, and the performance ratio (C_{rt}/C_{ri}) was 3.02. As can be seen in Figure 20, the bed deposits reached the level of the overhanging sill with a slight deposit on the sill towards the end nearest the sluiceway.

CHANGE 5 (Recommended Design)

For Change 5, the elevation of the channel bottom downstream from the headworks slide gate was raised to elevation 1680.30. This increased the difference in elevation between the headworks and sluiceway channels to 3.30 feet. The sharp-edged sill had a 21-inch overhang and was 6 inches above the headworks floor elevation. The depth of skim of the curtain wall was decreased to 1.5 feet. Figure 10 shows the sectional view of this change. The model was operated for 29 hours, during which samples were obtained. The average concentration ratio (C_s/C_h) was 4.76, and the performance ratio (C_{rt}/C_{ri}) was 9.35. These ratios were the best obtained throughout the study for average discharges. As can be seen in Figure 21, there was no deposit of sand on the overhanging sill. On the basis of these high ratios, this arrangement was recommended for incorporation into the final design.

CHANGE 6

For Change 6, everything was left the same as in Change 5 except that the sluice gate was moved 3 feet 4 inches upstream. This was done to erode the bed to a lower elevation beneath the headworks lip. Figure 22 shows the model after 50 hours' operation. The bed was lower, but the minor vortex in front of the sluice gate was closer to the headworks and caused sand to be entrained in the headworks flow. The concentration ratio (C_s/C_h) dropped to 2.94, and the performance ratio (C_{rt}/C_{ri}) was 5.76.

CHANGE 7

For Change 7, the guide wall channel width was increased to 6 feet 6 inches. This was done in hopes that the turbulence would be reduced without sufficient velocity reduction to raise the bed above the lip elevation of the headworks. The sluiceway gate was left in the same location as for Change 6. The radius of the guide wall was 21 feet and it encompassed an arc of 73°. The guide wall was curved to meet the sluiceway wall tangentially. The model was operated for 46 hours with this arrangement installed. The concentration ratio (C_s/C_h) was 1.23, and the performance ratio (C_{rt}/C_{ri}) was 2.41. Figure 23 shows the model in operation. Note the large vortex caused by the sluiceway. This vortex, along with the general rising of the bed, contributed to the higher concentration ratio. The resulting bed condition in the guide wall channel may be seen in Figure 24.

CHANGE 8

For Change 8, everything was the same as in Change 7 except the sluiceway gate was moved back to its original position. The sectional view of the headworks for this arrangement can be seen in Figure 10. The model was operated 26 hours, during which samples were taken. The average concentration ratio (C_s/C_h) was 1.72, and the performance ratio (C_{rt}/C_{ri}) was 3.38. The condition of the guide wall channel bed can be seen in Figure 25. Note that the curtain wall was removed so as to get a better photograph of the sand that piled up on the upstream edge of the overhanging sill.

CHANGE 9

This change is the same as Change 5, but the guide wall encompassed an arc of only 68°. The wall was curved to meet the sluiceway wall tangentially, and the model was operated for 32 hours with this arrangement. Samples were taken, and the concentration ratio (C_s/C_h) was 2.63. The performance ratio (C_{rt}/C_{ri}) was 5.15. The values for these ratios were considerably lower than for Change 5. Figure 26(a) shows the bad approach conditions of the bed caused by the short wall length. Figure 26(b) shows the bed in the guide wall channel after the run.

CHANGE 10

At the request of the Canals and Headworks Section, the arrangement of Change 9 was operated with 2 feet of stoplogs in the headworks. Figure 27(a) shows these stoplogs in place below the curtain wall. This was done to give a greater elevation difference between the sluiceway flow and headworks flow. The model was operated for 26 hours. The average concentration ratio (C_s/C_h) was 2.17, and the performance ratio (C_{rt}/C_{ri}) was 4.25. The condition of the bed can be seen in Figure 27(b).

AUXILIARY RUN

An auxiliary run was made with the same arrangement as in Change 9, but the headworks discharge was increased to 161 cubic feet per second, which is the maximum for the design of Osborne Canal. The sluiceway discharge was set at 35 cubic feet per second. The model was operated for 18 hours. The average concentration (C_s/C_h) ratio was 7.14, and the performance ratio (C_{rt}/C_{ri}) was 14.0.

CONCLUSIONS AND RECOMMENDATIONS

Table 1 shows the comparison of all runs made with the model. Change 5 had the best concentration ratio for average flow conditions. As can be seen from the performance ratio (C_{rt}/C_{ri}), this arrangement was about nine times more effective in excluding sediment than the initial run. By comparing Change 5 with Change 9, it can be seen that the length of the guide wall has a definite effect on the performance ratio. The second sharp-edged sill with the long guide wall, Change 5, was almost two times more effective than with the shorter length wall, Change 9. As can be seen from the summary data of the auxiliary run, the arrangement of Change 5 was highly effective for the maximum canal discharge. The arrangement as studied in Change 5 was recommended as a basis for the final prototype design. The headworks entrance width just upstream of the gate was 7 feet in the model. In the final prototype design, it was 8 feet 2 inches. The orifice created by installing the curtain wall did not control for the average discharges studied, and it was deemed unnecessary to alter this dimension in the model. This additional width should decrease the turbulence and make the sediment-excluding device more effective.

To reduce the amount of degradation and the amount of sand passing through the headworks, the reservoir water surface should be maintained as low as possible during low water requirement in early years. During the nonirrigation season, the headworks should be closed and as much water as possible should be passed through the sluiceway.

Based on this model study, the arrangement as studied in Change 5 will exclude approximately 3,000 tons of sediment per year. This value was computed as follows:

<u>Discharges as determined from the operation study</u>

Headworks (Q_h) = 42 cfs

Sluiceway (Q_s) = 35 cfs

Total river (Q_r) = 77 cfs

From Figure 8, the total river sand load is 26 tons per day.

Converting to concentration (ppm by weight):

$$C_R = \frac{(26\ t/d)\ (2,000\ lb/t)\ (10^6)}{(24\ hr/d)\ (3,600\ sec/hr)\ (77\ ft^3/sec)\ (62.4\ lb/ft^3)}$$

C_R = 125 ppm by weight

From model study:

$$C_r = \frac{C_s}{C_h} = 0.51 \qquad \ldots (1)$$

$$C_s = 0.51\ C_h \qquad \ldots (1a)$$

By writing solids equation:

$$Q_R C_R = Q_s C_s + Q_h C_h \qquad \ldots (2)$$

And solving Equations (1) and (2) simultaneously:

$$C_h = 161 \text{ ppm by weight}$$

Tons of water that would flow through the headworks per year:

$$T_W = \frac{(42\ ft^3/sec)\ (62.4\ lb/ft^3)\ (3{,}600\ sec/hr)\ (24\ hr/d)\ (365\ d/yr)}{2{,}000\ lb/ton}$$

$$T_W = 41.4 \times 10^6 \text{ tons/yr}$$

Since water year is 7 months:

$$T_W = 24.1 \times 10^6 \text{ tons/water yr}$$

The sediment passing through headworks without any excluding devices is:

$$T_s = \frac{(24.1 \times 10^6 \text{ tons/yr})\ (161 \text{ ppm by wt})}{(10^6)}$$

$$T_s = 3{,}880 \text{ tons/yr}$$

For the arrangement as studied in Change 5:

$$C_r = \frac{C_s}{C_h} = 4.76 \qquad \ldots (3)$$

$$C_s = 4.76\ C_h \qquad \ldots (3a)$$

Solving Equations (2) and (3) simultaneously:

$$C_h = 46 \text{ ppm by wt}$$

The sediment passing through the headworks for the arrangement studied in Change 5:

$$T_s = \frac{24.1 \times 10^6 \text{ tons/yr} \times 46 \text{ ppm by wt}}{10^6}$$

$$T_S = 1,110 \text{ tons/yr}$$

The amount of sediment excluded is:

$$3,880 - 1,110 = 2,770 \text{ tons/yr}$$

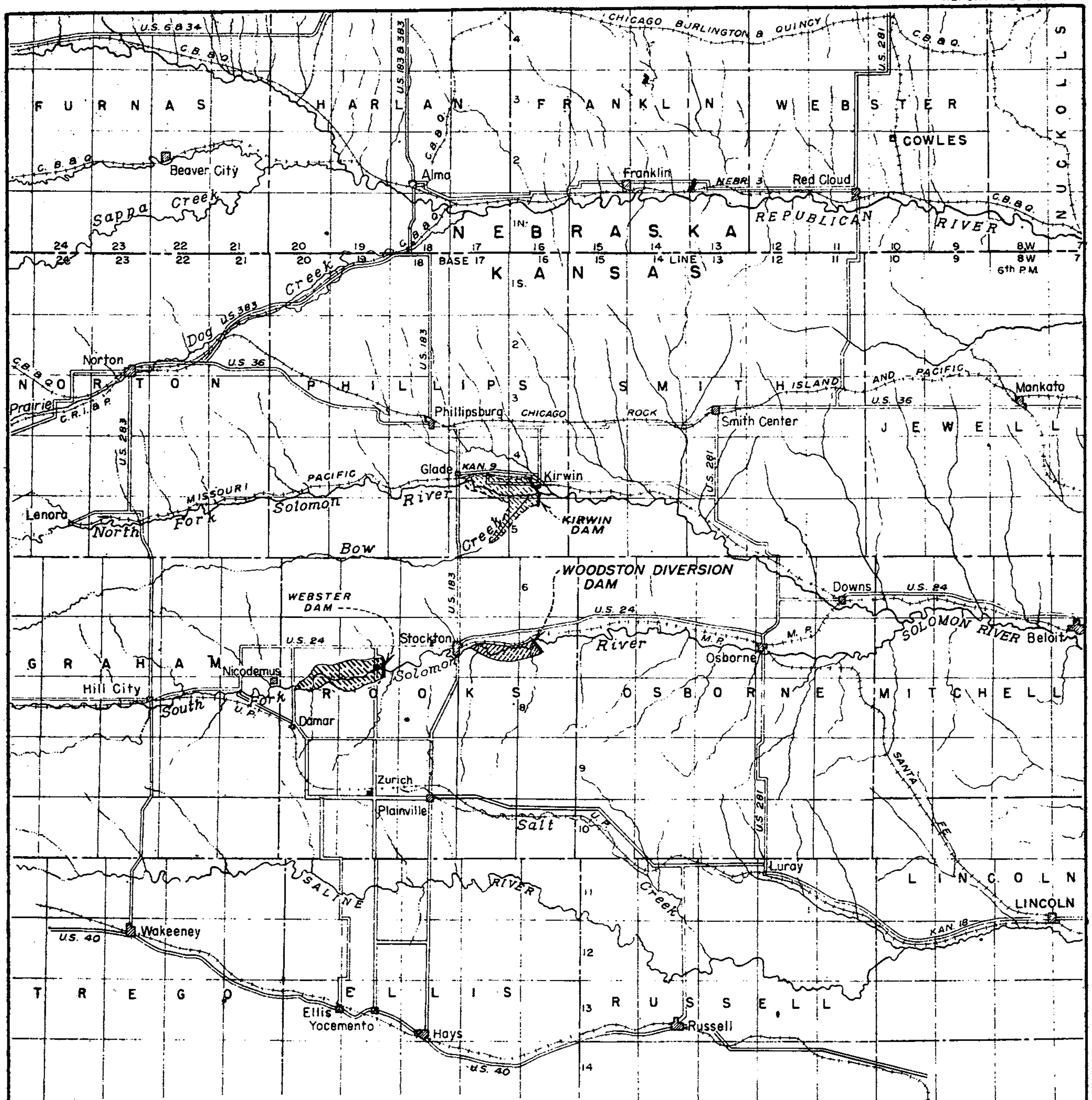
Table 1

SUMMARY OF MODEL DATA

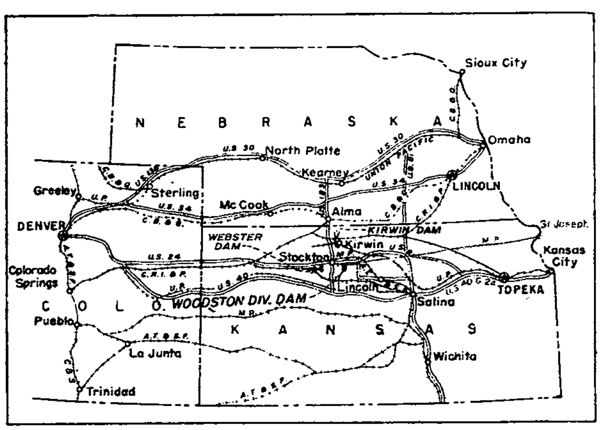
Run or change 1/	Guide wall channel width (A, Fig. 10)	Arc of curved guide wall (α)	Curve between guide wall and sluiceway wall	Sluice gate moved upstream	Concentration ratio 5/ (C_s/C_h)	Performance ratio 5/ (C_{rt}/C_{ri})	Type of sill	Operation time (hours)	Depth of skim of curtain wall
Initial	None	None	No	No	0.51	1.00	None	100	None
1	5'	90°	No	No	0.25	0.49	None	47	None
2	5'	90°	No	No	0.84	1.65	None	5	2'
3	5'	90°	No	No	0.99	1.94	Rounded	53	2'
4	5'	90°	No	No	1.54	3.02	Sharp overhang	25	2'
5	5'	90°	No	No	4.76	9.35	Sharp overhang	29	1.5'
6	5'	90°	No	Yes	2.94	5.76	Sharp overhang	50	1.5'
7	6'6"	73°	Yes	Yes	1.23	2.41	Sharp overhang	46	1.5'
8	6'6"	73°	Yes	No	1.72	3.38	Sharp overhang	26	1.5'
9	5'	68°	Yes	No	2.63	5.15	Sharp overhang	32	1.5'
10	5'	68°	Yes	No	2.17	4.25	4/ Sharp overhang	26	1.5'
Auxiliary 3/	5'	68°	Yes	No	7.14	14.00	Sharp overhang	18	1.5'

1/ Arrangements for all runs can be seen in Figure 10.
2/ Discharge for initial run through 10 in headworks = 42 cfs--in sluiceway = 35 cfs.
3/ Discharge in headworks = 161 cfs--discharge in sluiceway = 35 cfs.
4/ Two feet of stop logs in headworks.
5/ Ratios defined on pages 5 and 6.

FIGURE 1
REPORT HYD. 541



5 0 5 10 15 20 25
SCALE OF MILES



KEY MAP

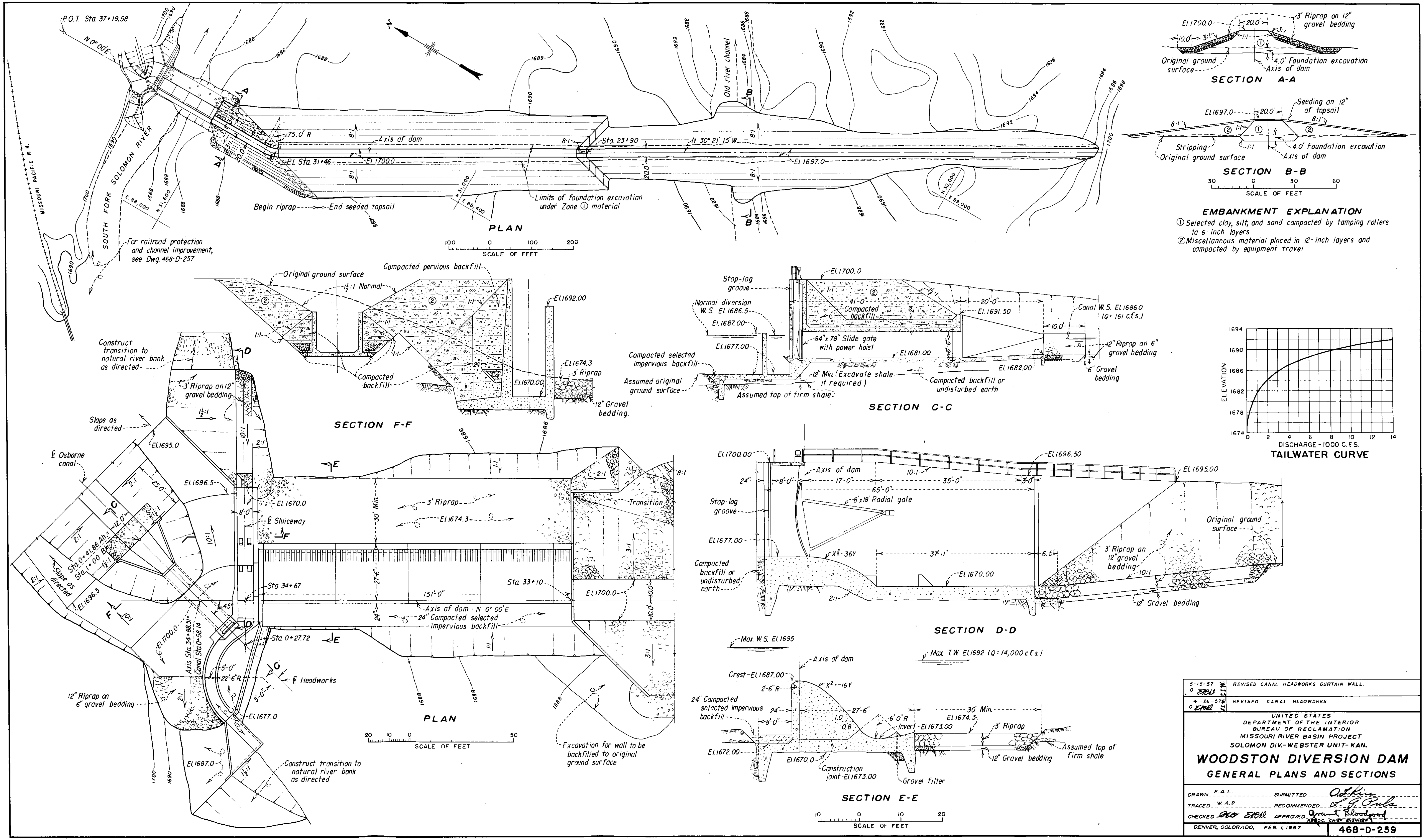
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
SOLOMON DIV. - WEBSTER UNIT - KAN.

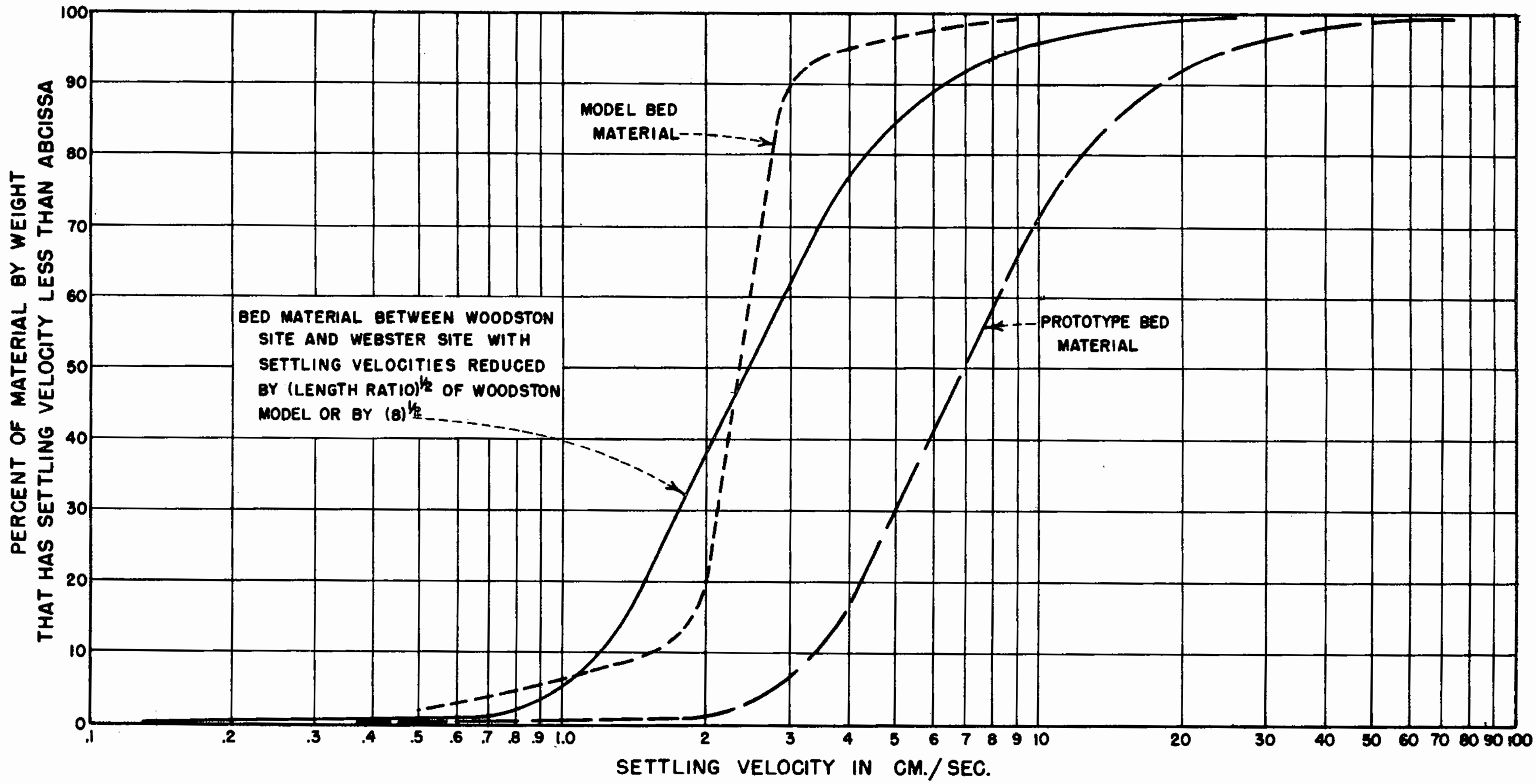
WOODSTON DIVERSION DAM

LOCATION MAP

DRAWN E.L.W. SUBMITTED O.L. Rice
TRACED V.M.M. RECOMMENDED L.G. Puls
CHECKED O.T.L. E.R.M. APPROVED Grant Bloodgood ASSOC. CHIEF ENGINEER
DENVER, COLORADO, FEB. 1, 1957

468-D-258


PLAN
SCALE OF FEET
P.O.T. Sta. 37+19.58
N 0° 00' E
MISSOURI PACIFIC R.R.
SOUTH FORK SOLOMON RIVER
Axis of dam
75.0' R.
P.I. Sta. 31+46
El. 1700.0
Sta. 23+90
N 30° 21' 15" W
El. 1697.0
Old river channel
Begin riprap
End seeded topsoil
Limits of foundation excavation under Zone ① material
For railroad protection and channel improvement, see Dwg. 468-D-257
SECTION A-A
El. 1700.0
3' Riprap on 12" gravel bedding
Original ground surface
4.0' Foundation excavation
Axis of dam
SECTION B-B
El. 1697.0
Seeding on 12" of topsoil
Stripping
Original ground surface
4.0' Foundation excavation
EMBANKMENT EXPLANATION
① Selected clay, silt, and sand compacted by tamping rollers to 6-inch layers
② Miscellaneous material placed in 12-inch layers and compacted by equipment travel
SECTION F-F
Original ground surface
Compacted pervious backfill
1½:1 Normal
Compacted backfill
El. 1692.00
El. 1674.3
3' Riprap
El. 1670.00
12" Gravel bedding.
SECTION C-C
Stop-log groove
Normal diversion W.S. El. 1686.5
El. 1687.00
El. 1677.00
El. 1700.0
Compacted backfill
El. 1691.50
84" x 78" Slide gate with power hoist
El. 1681.00
El. 1682.00
Canal W.S. El. 1686.0 (Q = 161 c.f.s.)
12" Riprap on 6" gravel bedding
6" Gravel bedding
Compacted selected impervious backfill
Assumed original ground surface
12" Min. (Excavate shale if required)
Assumed top of firm shale
Compacted backfill or undisturbed earth
TAILWATER CURVE
ELEVATION
DISCHARGE - 1000 C.F.S.
Construct transition to natural river bank as directed
3' Riprap on 12" gravel bedding
Slope as directed
℄ Osborne canal
El. 1695.0
El. 1696.5
El. 1670.0
℄ Sluiceway
3' Riprap
El. 1674.3
30' Min.
Transition
Sta. 34+67
Sta. 33+10
151'-0"
El. 1700.0
Axis of dam - N 0° 00' E
24" Compacted selected impervious backfill
Sta. 0+27.72
Sta. 0+41.86 Ah.
Sta. 1+00 Bk.
El. 1700.0
Axis Sta. 34+88.51± Canal Sta. 0+58.14
22'-6" R
℄ Headworks
El. 1677.0
12" Riprap on 6" gravel bedding
El. 1687.0
Construct transition to natural river bank as directed
Excavation for wall to be backfilled to original ground surface
SECTION D-D
El. 1700.00
Axis of dam
8' x 18' Radial gate
El. 1696.50
El. 1695.00
Stop-log groove
El. 1677.00
$X^2 = 36Y$
El. 1670.00
Compacted backfill or undisturbed earth
Original ground surface
3' Riprap on 12" gravel bedding
12" Gravel bedding
SECTION E-E
Max. W.S. El. 1695
Max. T.W. El. 1692 (Q = 14,000 c.f.s.)
Axis of dam
Crest - El. 1687.00
$X^2 = -16Y$
24" Compacted selected impervious backfill
El. 1672.00
El. 1670.0
Construction joint - El. 1673.00
Invert - El. 1673.00
El. 1674.3
30' Min.
3' Riprap
12" Gravel bedding
Gravel filter
Assumed top of firm shale
5-15-57 REVISED CANAL HEADWORKS CURTAIN WALL.
4-26-57 REVISED CANAL HEADWORKS
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
SOLOMON DIV. - WEBSTER UNIT - KAN.
WOODSTON DIVERSION DAM
GENERAL PLANS AND SECTIONS
DRAWN E.A.L.
TRACED W.A.P.
CHECKED
SUBMITTED
RECOMMENDED
APPROVED
ASSOC. CHIEF ENGINEER
DENVER, COLORADO, FEB. 1, 1957
468-D-259



MISSOURI RIVER BASIN PROJECT

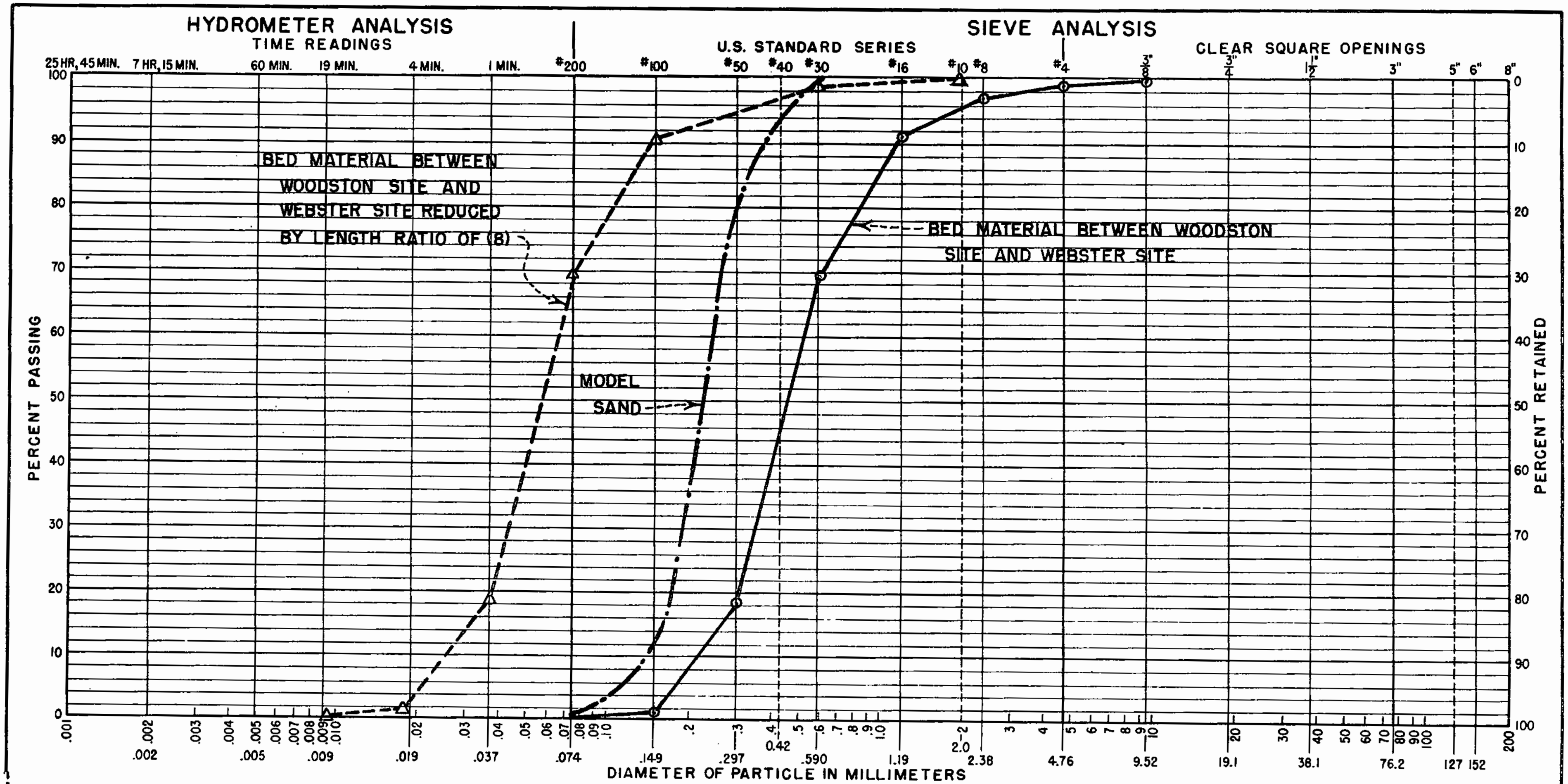
WOODSTON DIVERSION DAM

SEDIMENT CONTROL STUDIES

SETTLING VELOCITIES OF MODEL AND PROTOTYPE SEDIMENT

1:8 SCALE HYDRAULIC MODEL

FIGURE 3
REPORT HYD. 451



MISSOURI RIVER BASIN PROJECT

WOODSTON DIVERSION DAM

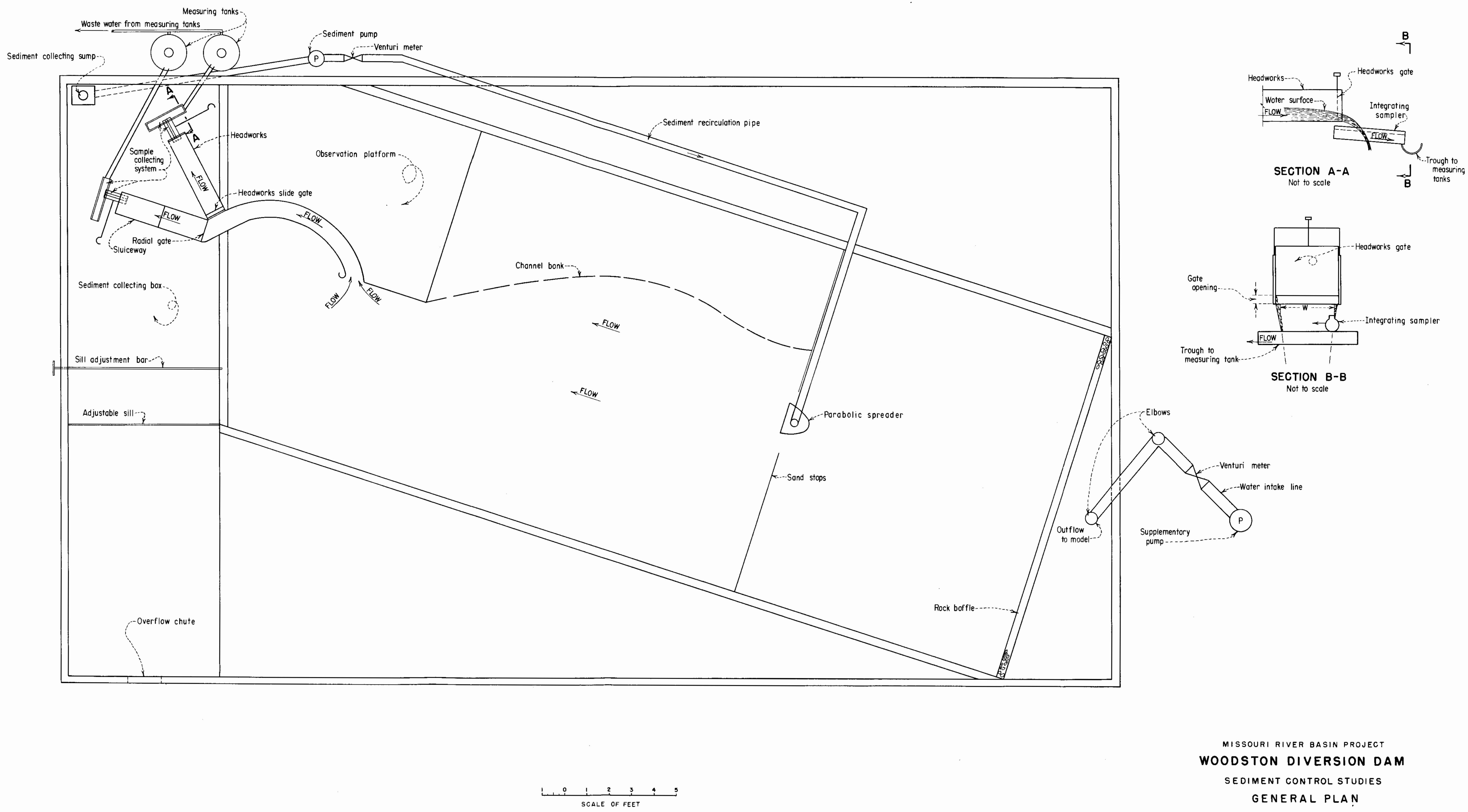
SEDIMENT CONTROL STUDIES

SIZE ANALYSIS CURVES OF MODEL AND PROTOTYPE BED SEDIMENT

1:8 SCALE HYDRAULIC MODEL

611

FIGURE 4
REPORT HYD. 451



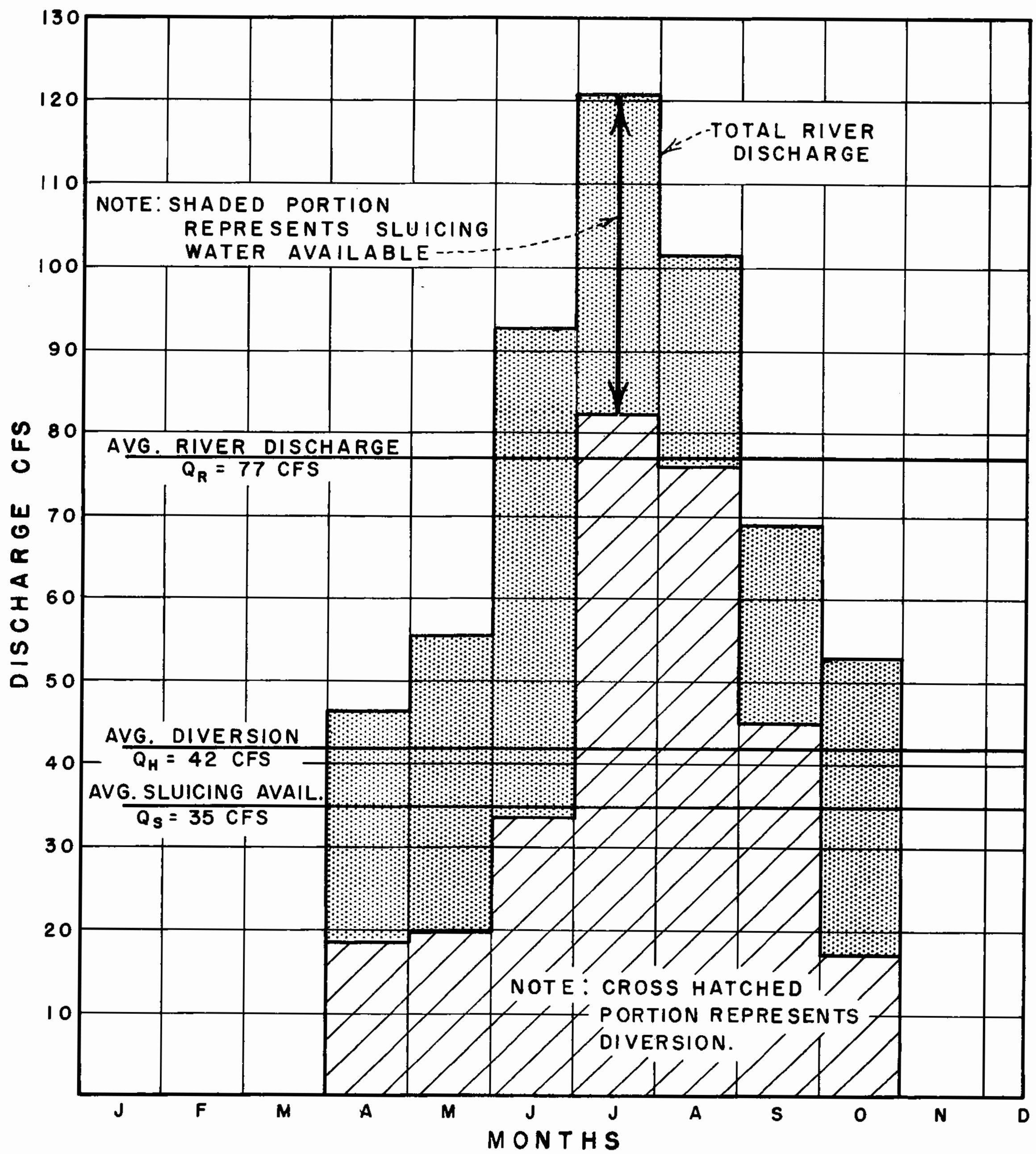
MISSOURI RIVER BASIN PROJECT

WOODSTON DIVERSION DAM

SEDIMENT CONTROL STUDIES

GENERAL PLAN

1:8 SCALE HYDRAULIC MODEL



MISSOURI RIVER BASIN PROJECT

WOODSTON DIVERSION DAM

SEDIMENT CONTROL STUDIES

AVERAGE HYDROGRAPHS 1920-1948, SOUTH FORK SOLOMON RIVER AND DIVERTED FLOWS

1:8 SCALE HYDRAULIC MODEL

(a) Sediment pump and 2-inch venturi meter

(b) Parabolic spreader

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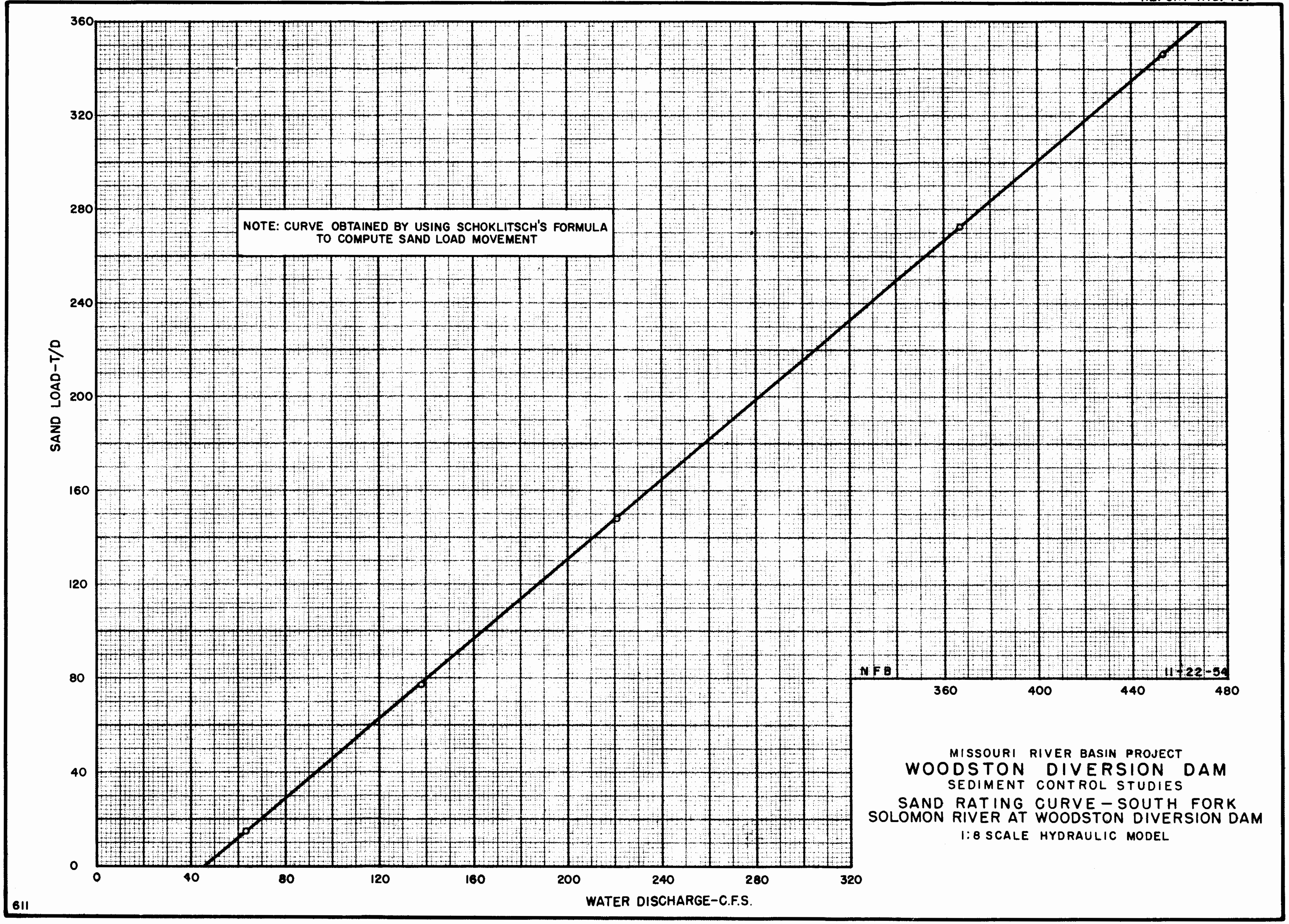
WOODSTON DIVERSION DAM
Sediment Control Study
1:8 Scale Hydraulic Model

Sediment recirculating system



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WOODSTON DIVERSION DAM
SEDIMENT CONTROL STUDIES
SAND RATING CURVE – SOUTH FORK
SOLOMON RIVER AT WOODSTON DIVERSION DAM
1:8 SCALE HYDRAULIC MODEL

(a) Sediment samplers for headworks and sluiceway

(b) Collecting tanks for sediment samples

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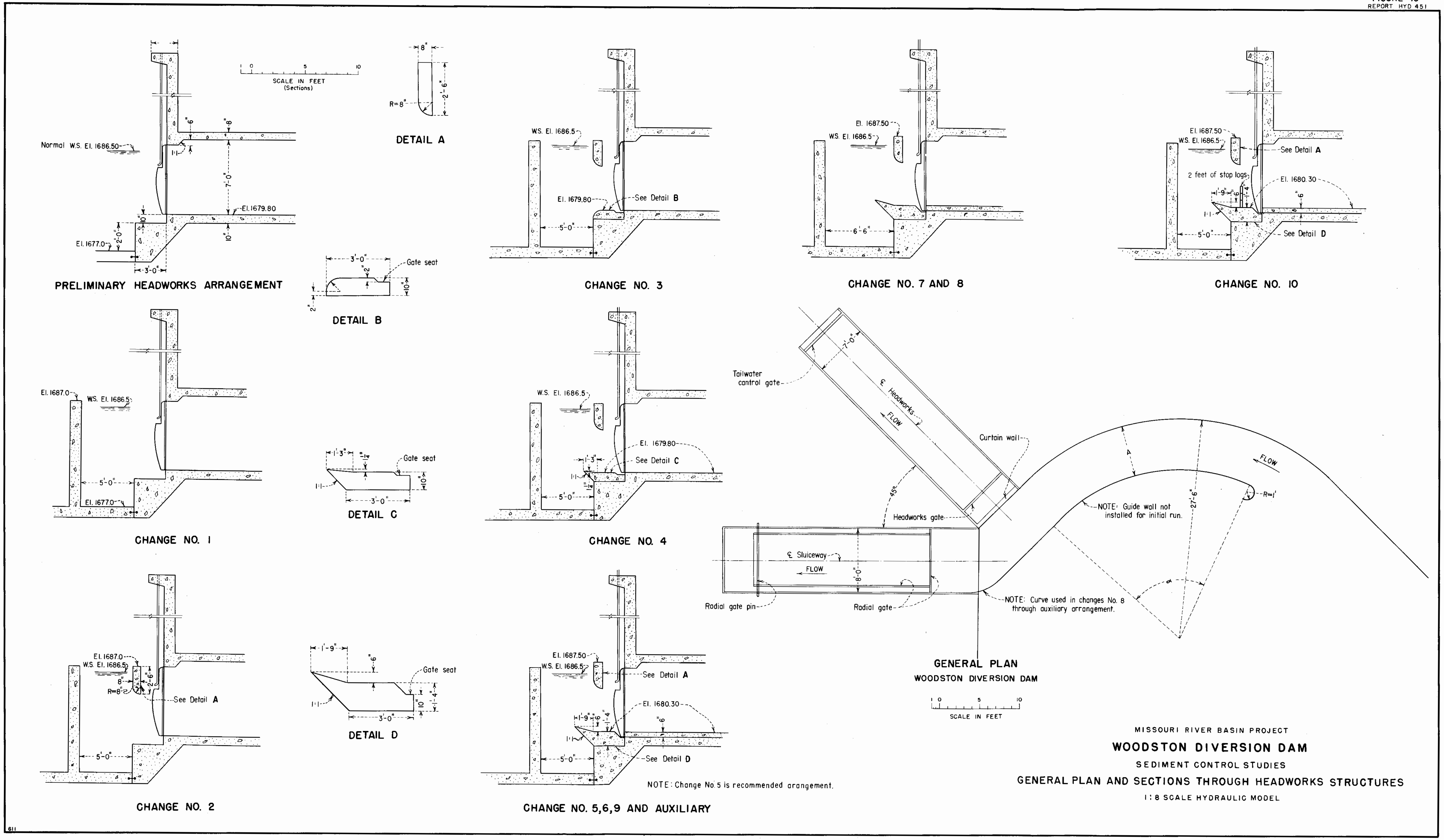
1:8 Scale Hydraulic Model

Sediment Sampling System



MISSOURI RIVER BASIN PROJECT

WOODSTON DIVERSION DAM

SEDIMENT CONTROL STUDIES

GENERAL PLAN AND SECTIONS THROUGH HEADWORKS STRUCTURES

1:8 SCALE HYDRAULIC MODEL

(a) Looking downstream towards headworks and sluiceway

(b) Vortices in front of sluiceway and headworks

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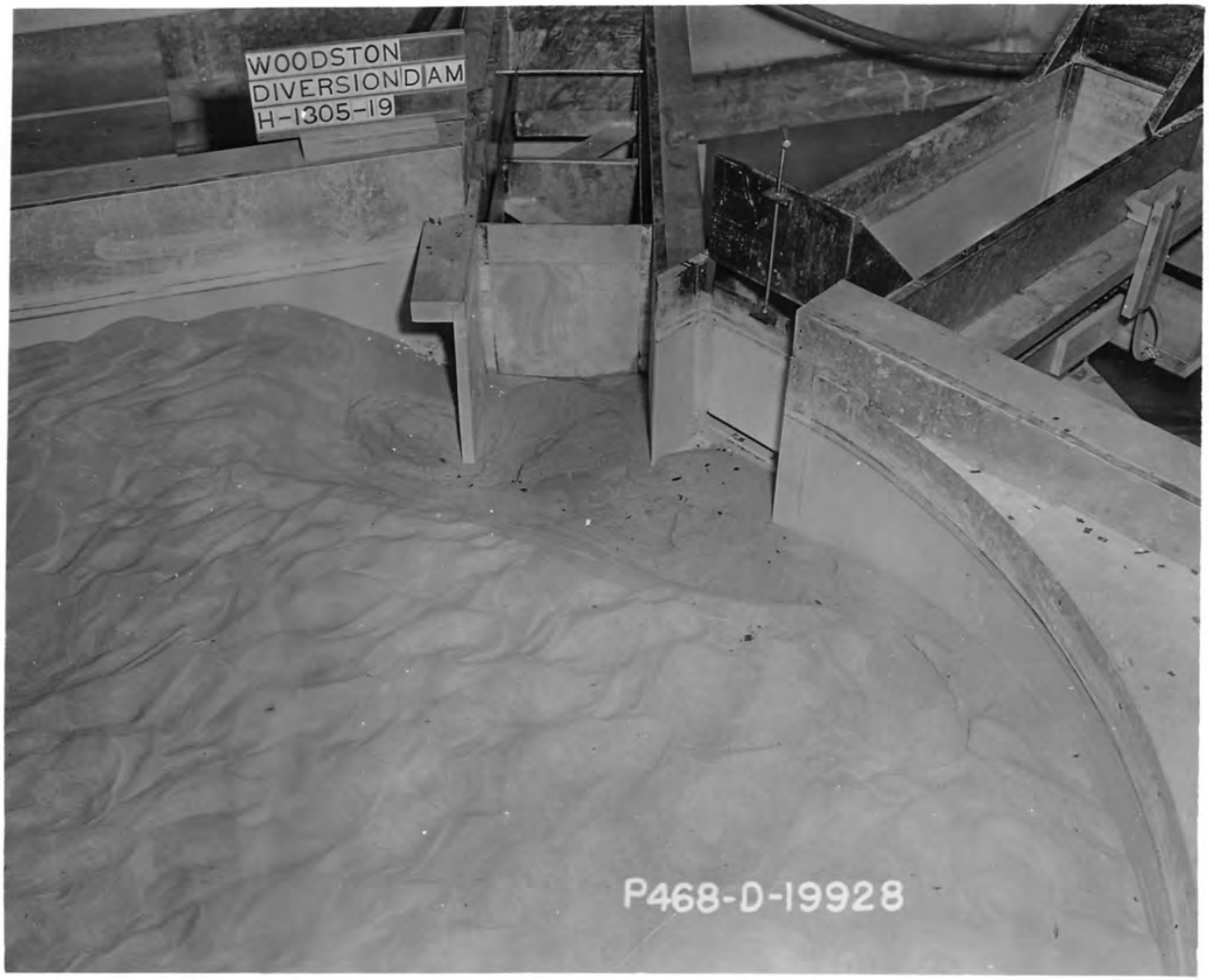
1:8 Scale Hydraulic Model



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1:8 Scale Hydraulic Model

Downstream view of river bed in front of headworks and sluiceway after 100 hours operation with initial arrangement

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Guide wall installed prior to operation of Change 1

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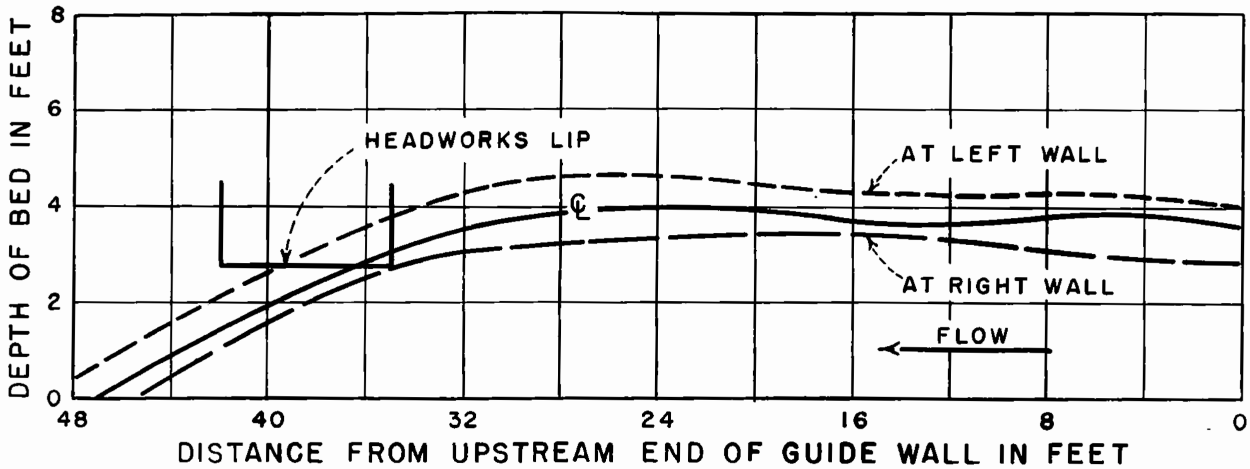
Vortices in front of headworks and sluiceway
during operation of Change 1



(a) Bed profiles measured at 27th hour of operation

(b) Guide wall channel bed after 47 hours operation

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Condition of guide wall channel bed - Change 1

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Typical erosion pattern at upstream end of guide wall

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Curtain wall in front of headworks to prevent vortex--Change 2

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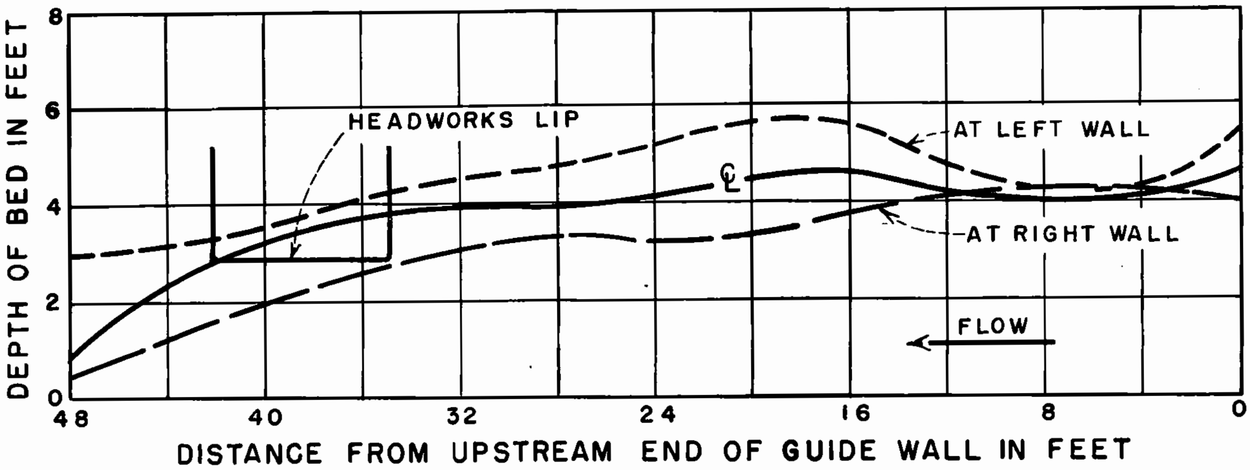
1:8 Scale Hydraulic Model

Rounded headworks' sill installed for Change 3



(a) Bed profiles measured at 28th hour of operation

(b) Guide wall channel bed after 53 hours operation

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Condition of guide wall channel--Change 3

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Slight sand bar piled on top of sharp edged sill
after 25 hours operation of Change 4

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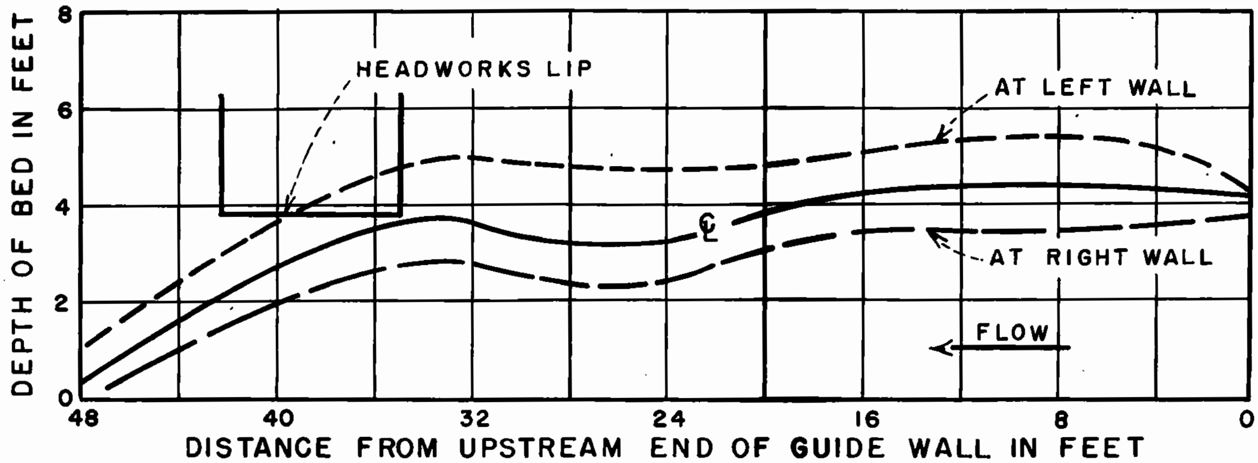
1:8 Scale Hydraulic Model

Condition of guide wall channel bed after 29 hours operation of Change 5 (recommended arrangement).



(a)

(b)

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1:8 Scale Hydraulic Model

Condition of guide wall channel bed after 50 hours operation of Change 6

Figure 23

Missouri River Basin Project
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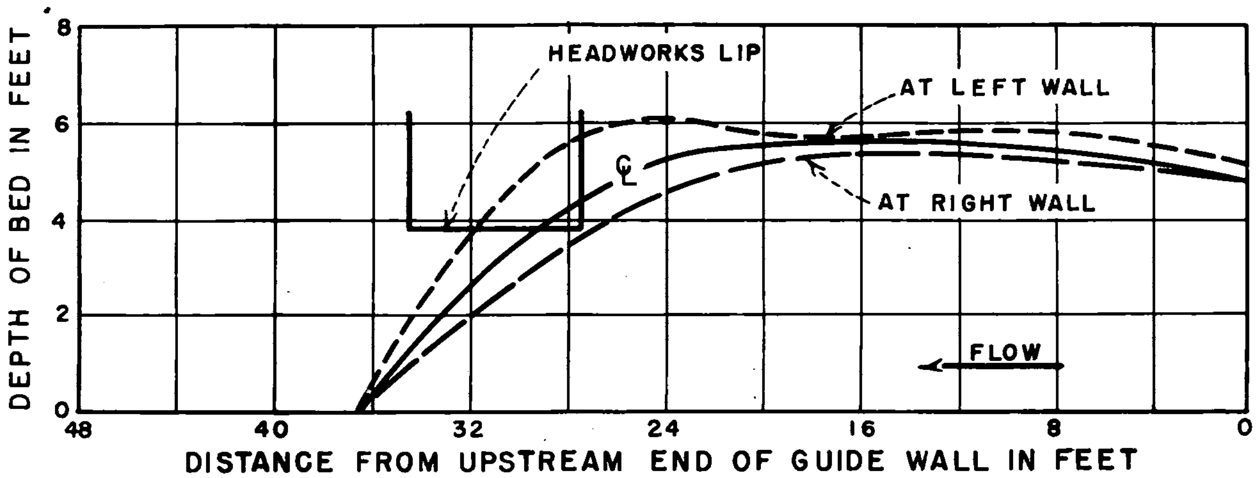
Sediment Control Study
1:8 Scale Hydraulic Model

Model in operation--Change 7



(a)

(b)

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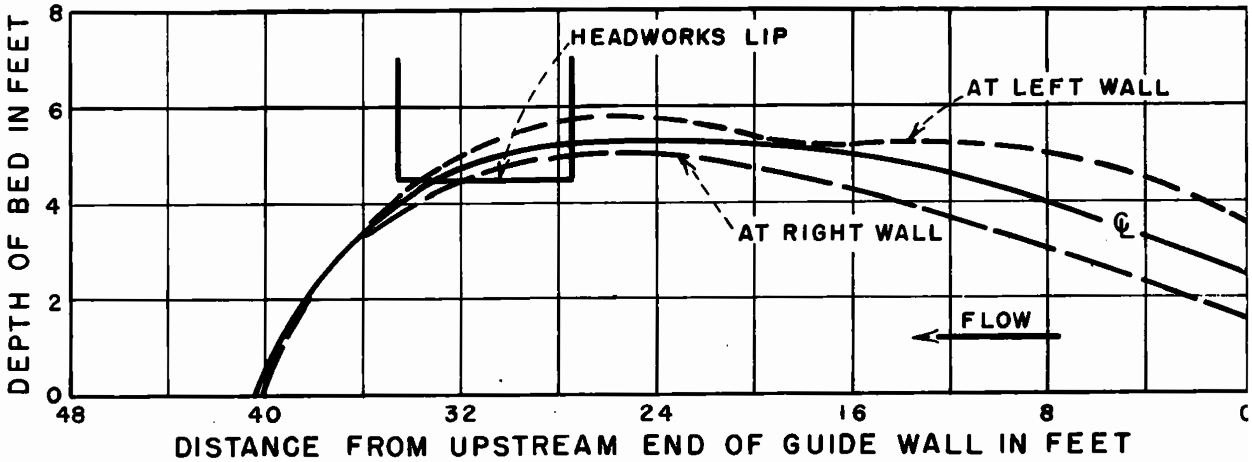
Condition of guide wall channel bed after 46 hours operation of Change 7



(a)

(b)

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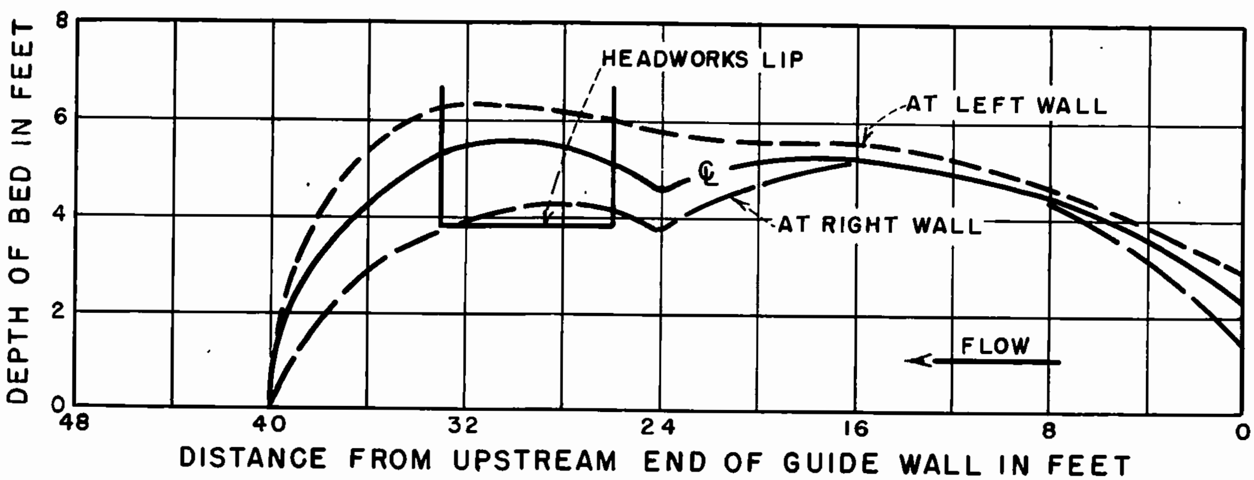
Condition of guide wall channel bed after 26 hours operation of Change 8

(a)



(b)

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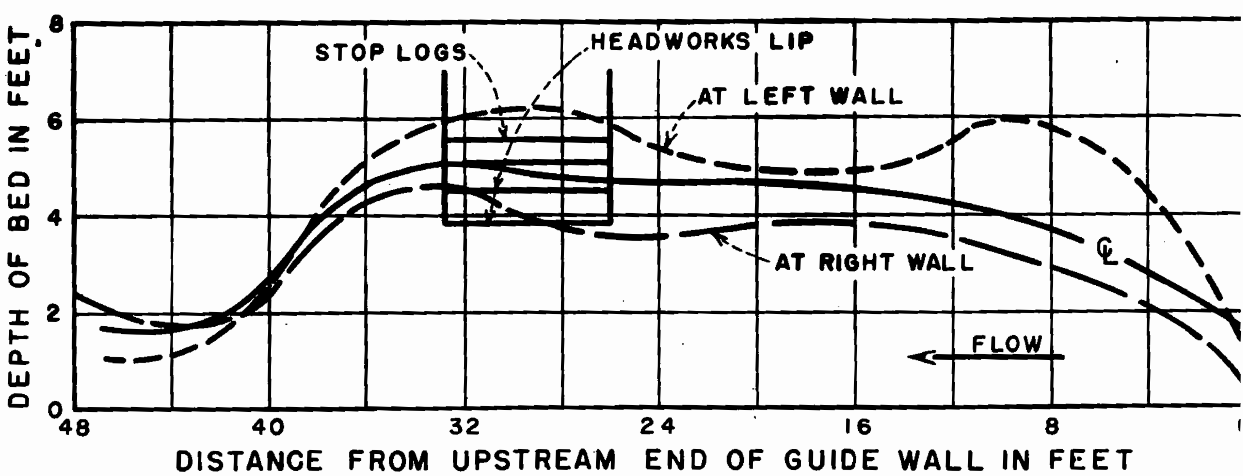
Condition of guide wall channel bed after 32 hours operation of Change 9

(a) Stop logs in place below curtain wall



(b) Condition of guide wall channel bed after 26 hours operation

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