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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC MODEL STUDIES OF BARTLEY DIVERSION DAM

PROGRESS REPORT NO. 3 ON GENERAL STUDIES OF HEADWORKS AND SLUICEWAY STRUCTURES

MISSOURI RIVER BASIN PROJECT, NEBRASKA

Hydraulic Laboratory Report No. Hyd-384

ENGINEERING LABORATORIES

OFFICE OF THE ASSISTANT COMMISSIONER AND CHIEF ENGINEER
DENVER, COLORADO

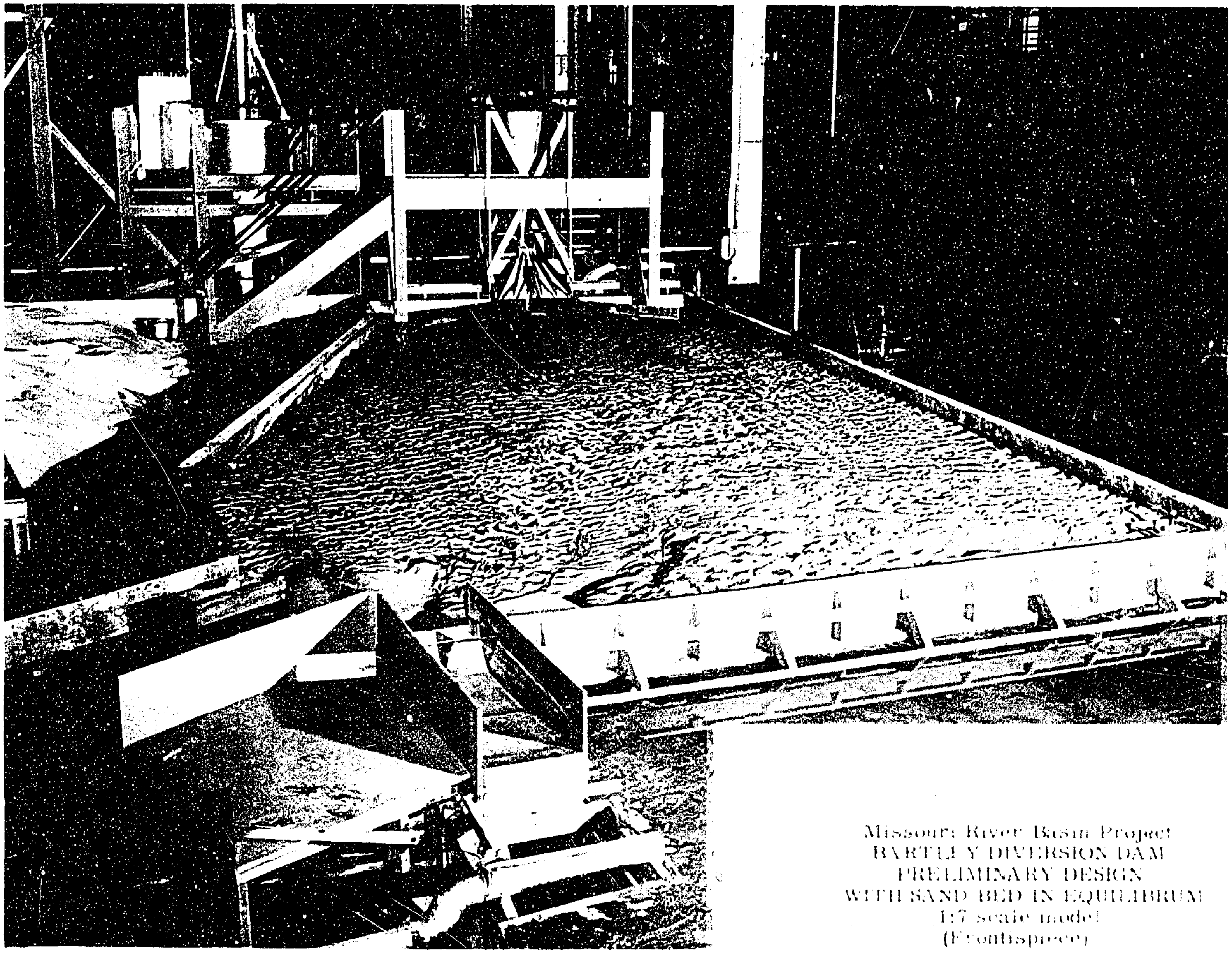
February 23, 1954

FOREWORD

Hydraulic model studies of the headworks and sluiceway of Bartley Diversion Dam, Missouri River Basin Project, were conducted in the Hydraulic Laboratory of the Bureau of Reclamation at Denver, Colorado, during May, June, and July of 1952.

The final plans evolved from this study were developed through the cooperation of the staffs of the Diversion Works Section and the Hydraulic Laboratory. During the course of the model study, A. W. Kidder, J. A. Hufferd, and others of the Diversion Works Section frequently visited the laboratory to observe the model operation and to discuss test results.

The study was conducted by the writer, P. "F." Enger, and was under the supervision of E. J. Carlson.



Missouri River Basin Project
BARTLEY DIVERSION DAM
PRELIMINARY DESIGN
WITH SAND BED IN EQUILIBRUM
1:7 scale model
(Frontispiece)

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Office of the Assistant Commissioner
and Chief Engineer
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Denver, Colorado
February 23, 1954

Laboratory Report No. Hyd-384
Hydraulic Laboratory
Compiled by: P. F. Enger
Checked by: R. A. Dodge
Reviewed by: E. J. Carlson

Subject: Hydraulic model studies of Bartley Diversion Dam--Progress Report No. 3 on general studies of headworks and sluiceway structures--Missouri River Basin Project, Nebraska

SUMMARY

A 1:7 undistorted scale hydraulic model was used to study the headworks and sluiceway of Bartley Diversion Dam of the Missouri River Basin Project. Tests were conducted to develop a design that would pass the maximum amount of sediment through the sluiceway, thus keeping as much sediment as possible from entering Bartley Canal headworks.

A feasible design was determined and additional tests were conducted to help determine the most favorable operating procedure to use with the prototype.

The preliminary design and six changes were studied. Comparison of designs was made from concentrations of sand in the sluiceway and headworks. The sediment distribution was improved from the preliminary design, in which most of the sediment passed through the headworks, to a recommended design in which the concentration of sediment in the sluiceway was approximately seven times as great as the concentration of sediment in the headworks for the test conditions. For a summary of test results see Table 1. The various designs tested are shown in Figures 3 and 13. Each change resulted in an improvement over the preliminary design. Change 4, shown in Figure 13, proved to be the most favorable when removal of sediment and cost of construction was considered.

From the model studies of Superior-Courtland Diversion Dam, Hydraulic Laboratory Report No. Hyd-275, it was known that guiding the flow in the area immediately upstream from the headworks and sluiceway provided an effective method of using sluicing water. Therefore, in all models tested, walls to guide the flow were used. The recommended design, Figure 13, consists of two guide walls forming a curve past the headworks. Changes 1 and 2 had two guide walls installed, while Change 3 incorporated a skimming weir with the guide walls of Change 2, and Changes 5 and 6 incorporated a sluicing tunnel with the guide walls of Change 4.

The tests to help determine the best operating procedure to use with the prototype, indicated the sluicing action was effective for a wide range of sluicing discharges, Figure 20. The tests also indicated that occasional intermittent sluicing with a comparatively large discharge was desirable.

INTRODUCTION

With the increasing demand for water diverted from alluvial streams, the problem of sediment control has become of major importance. The removal of coarse sediment carried into canals by diverted water has become a major item in the operation and maintenance costs of many canals. On some of the larger projects elaborate and costly desilting works have been built. On small projects the cost of elaborate structures is not justified, and simpler and cheaper means of eliminating the sediment from the canals must be found. In a general study program of the sediment control problem, models of Superior-Courtland and Republic Diversion Dams were built and tested in the Bureau of Reclamation Hydraulic Laboratory at Denver, Colorado. Continuing sediment control studies, a 1:7 scale model of the headworks and sluiceway of Bartley Diversion Dam was built and tested.

Bartley Diversion Dam, located in Nebraska on the Republican River, Figure 1, will consist of two compacted earth dikes, approximately 2,100 feet long and 18 feet high, a 700-foot-wide overflow spillway, two 10-foot-wide sluice gates, and two 10-foot-wide head gates to Bartley Canal, Figure 2. Bartley Canal, which has a design discharge of 130 cfs and a length of approximately 19.8 miles, will serve about 7,030 acres of irrigable land on the south side of the river. The 1:7 scale model studied included one sluiceway, Bartley Canal headworks, and a length of the Republican River channel upstream from the dam.

The scope of the model study was limited. However, by taking advantage of previous studies, Superior-Courtland and Republic Diversion Dams*, a good sluicing action was obtained.

CONSTRUCTION AND OPERATION OF THE MODEL

As shown in Figure 3, the 1:7 scale model was built in an existing box which was constructed of wood and lined with sheet metal and which measured approximately 29 by 76 feet. The sluiceway and headworks of the model were built of sheet metal on a wooden framework. The river channel upstream from the headworks was sand which was allowed to assume a natural slope for the discharge and sediment

* Hydraulic Laboratory Reports No. Hyd-275 and Hyd-316.

load used. As no studies were made with water running over the spillway, a vertical wall was placed along the spillway axis. A photograph of the model may be seen in Figure 4a and in the frontispiece.

A sediment feeding system consisting of a 14-cubic-foot hopper, a vibrating trough, and a vaned sand chute, Figure 5, maintained a continual discharge of sand into the simulated river. The sand used was obtained from a loosely cemented sandstone ground in a hammer mill. The mean diameter of the sand was approximately 0.2 mm with 90 percent passing the 40-mesh and 10 percent being retained on the 100-mesh U.S. standard screens (0.43 to 0.15 mm). The size analysis curve of the model sand may be seen in Figure 6, and the relationship between the settling velocities of the sand in the model and prototype may be seen in Figure 7. Figure 8 shows photomicrographs of the model sand and washed Republican River sand. Size comparison can be made from the 1-mm rectangular grid shown on the photographs. The main requirement for the model sediment was that it would move similar to the bed sediment of the prototype with the discharge and velocity obtainable in the model. Previous tests on the Superior-Courtland model indicated that the fine sand would move satisfactorily under relatively low discharges.

Water was supplied by a portable pump. The discharge was measured with a venturi orifice meter and controlled by means of a valve near the head box. Flow through the headworks and sluiceway was controlled by radial gates. The discharge through the headworks was measured with a V-notch weir and the difference between this and the total discharge through the venturi orifice meter gave the discharge through the sluiceway.

The total water and sand discharge into the model was held constant and the model was operated until a state of equilibrium was reached, or as much sand and water was leaving the model as was entering it. Samples of the sand and water being discharged through the sluiceway and headworks were taken by passing a sharp-edged trough, shown in Figures 4a and 9, through the nappes. The water discharged from the trough into a short conduit and into calibrated collecting tanks, Figure 4b. The tanks were calibrated to read the total amount of water and sand in liters, and at the bottom of the tanks small removable glass funnels were calibrated to read the number of grams of sand that settled to the bottom of the tank.

A total discharge of 97.5 cfs was used for all tests. For comparison tests the approximate division of water was 60 cfs diverted through the Bartley Canal headworks and 37.5 cfs utilized as sluicing water. The "Sand Load Study for Bartley Diversion Dam," prepared by the Kansas River District, indicated 37.5 cfs will be available for sluicing purposes approximately 70 percent of the time that the canal is in operation. These studies also indicated that a discharge equal to, or less than, the 60 cfs will be diverted to Bartley Canal approximately 78 percent of the time it is in operation, see Figures 10 and 11.

Tests were made of the recommended design in which the division of flow between the headworks and sluiceway was varied while the total discharge in the river was maintained constant at 97.5 cfs. Tests were also made of intermittent sluicing with the recommended design.

The water surface elevation in the river upstream from the headworks was held at approximately 2352.5 feet for tests conducted on all changes. The water surface in the river was read by a staff gage located outside the guided flow area.

All tests were conducted with the water and sediment discharge entering the model held constant. A concentration of sand in the stream flow of 474 ppm, by weight, was used for the studies. The sediment feed was set by regulating the vibrating trough sand feeder, Figure 5, with a rheostat.

During the testing it was found that the concentrations passing the headworks and sluiceway varied with time. This was believed due to the continually shifting channel of the river bed and the fact that sand approached the guide walls in waves. Samples of the discharge through the headworks and sluiceway were taken simultaneously at varying intervals. The samples were averaged, and the concentration of sand in the headworks and sluiceway in ppm by weight was calculated.

Data recorded included water and sediment discharge into the model, water surface elevations of the reservoir, the length of time the model was run, and the water and sediment distribution through the headworks and sluiceway. When a system of intermittent sluicing was used, the time of sluicing and sampling was also recorded.

THE INVESTIGATION

Changes of the preliminary model were made to utilize two phenomena in sediment transportation: The first being that contact sediment load concentrates on the inside of a curved open channel, and the second being that the concentration of the sand and larger fractions of suspended sediment is greatest near the bed of a channel and decreases with increasing elevation.

Preliminary Design

The first test was made with the headworks and sluiceway arranged as shown in Figure 3. A total discharge of 97.5 cfs was used; 60.2 cfs was diverted to the headworks and 37.3 cfs was used as sluicing water. The headwater elevation was held at approximately 2352.48 feet, and the model was operated for 84 hours. A photograph of the model before operation and a photograph of the model during operation may be seen in the frontispiece and Figure 4a, respectively.

After a few hours of model operation, it became apparent that sand bars were building up in front of the headworks. A sand bar first built up in front of Gate 2, Figure 3. As may be seen in Figure 12a, the sluiceway had very little effect on flow conditions near Gate 2. With continued operation, a sand bar built up in front of Gate 1. A photograph of the sand bars that formed after 84 hours of operation is shown in Figure 12b.

After equilibrium was reached, samples of the discharge through the sluiceway and headworks were taken at varying intervals. From the samples it was observed that the amount of sediment drawn through the sluiceway varied a great deal with the direction of the approach channel to the sluiceway and headworks. When the major part of the flow came from the direction of the spillway and flowed past the area in front of the sluiceway before entering the headworks, the concentration of sediment passing through the sluiceway was about equal to the concentration passing through the headworks. However, when the channel shifted and the major portion of the flow came down the right bank, looking downstream, and past the headworks before entering the sluiceway most of the sediment was swept through the headworks. As the approach channel was continually shifting, the concentration varied considerably. An average over the 84-hours showed the concentration of sediment passing through the headworks to be 1,020 ppm, by weight, and the concentration of sediment passing through the sluiceway to be 135 ppm, by weight, Table 1. The resulting ratio of concentration of sediment in the sluiceway to concentration of sediment in the headworks was 0.13. The average concentration of sediment being discharged from the model was 681 ppm. It will be noticed that the concentration of sediment which was discharged from the model was somewhat higher than the 474 ppm which was fed into the model, Table 1. The high concentration of sediment being discharged was probably due to lack of equilibrium of the slope of the bed in the early stages of the test.

Change 1

To improve the sediment concentrations, curved guide walls were installed. Various arrangements of curved guide walls had been tested on previous models to take advantage of the fact that contact sediment load concentrates on the inside of a curve. Using data from previous tests, the walls forming a curve past the headworks, shown in Figure 13, were designed. The area between the walls was filled with sand to elevation 2348.00 feet, and the test discharge of 97.5 cfs was set. Approximately the same division of discharges was used as in the preliminary design; 58.0 cfs was diverted to the canal and 39.5 cfs was used as sluicing water. The headwater elevation was held at approximately 2352.53 feet.

The model was operated for 51-1/2 hours at the preceding conditions. During operation, samples were taken of the water and sediment in the sluiceway and headworks. The samples indicated an improvement over the preliminary design. The average concentration of sediment in the headworks dropped from the preliminary design value of 1,020 to 603 ppm, while the sediment concentration in the sluiceway increased from 135 to 250 ppm. These sediment concentrations resulted in an average of 460 ppm and improved the ratio of sediment concentration in the sluiceway to sediment concentration in the headworks from 0.13 to 0.41.

After a few hours of model operation, a sand bar began to build up in front of Gate 2. Apparently high sediment concentration occurred near the guide wall which approached Gate 2. To determine the amount of sediment being discharged from each headworks gate, a number of integrated samples were taken of each gate. The samples taken from Gate 2 were found to contain a sediment concentration of 716 ppm, while those taken from Gate 1 were found to contain a sediment concentration of 492 ppm. Throughout the model operation of Change 1, the area in front of Gate 1 did not accumulate a sediment bar.

Photographs showing the model in operation and the condition of the sand bed between the guide walls of Change 1 may be seen in Figure 14. It may be noticed, from a study of the photograph showing the model in operation, Figure 14a, that a large percentage of the confetti and consequently the surface current follows the wall leading to Gate 2.

Change 2

Change 2, as shown in Figure 13, was the same general layout as Change 1, however it was modified to cause the flow to enter the area between the guide walls with less turbulence. A 2:1 side slope was added near the right guide wall and a small radius was included on the end of the left wall. Other dimensions were changed slightly, but the general lay-out of Change 1 was used. The area between the guide walls was filled to elevation 2348.00 feet, while the remainder of the sand bed was left unchanged. The total discharge of 97.5 cfs was set; 59.7 cfs was diverted to the headworks, while 37.8 cfs continued through the sluiceway. The headwater elevation was held at approximately 2352.51 feet, and the model was operated continuously for 34 hours.

Change 2 resulted in a concentration ratio, Cs/Ch, of 1.6. The average sediment concentration in samples taken from the headworks was 367 ppm, and the average sediment concentration in samples taken from the sluiceway was 588 ppm. The average sediment concentration in the water leaving the model was 453 ppm, which was slightly lower than the 474 ppm which was being added to the water entering the model.

Although the division of sediment was improved, it was noted that a sand bar built up in front of Gate 2 in a manner similar to that of Change 1. To determine any change in the sediment concentration going through the gates, each headworks gate was sampled separately. The resulting data indicated a sediment concentration of 489 ppm passing Gate 2 and a sediment concentration of 246 ppm passing Gate 1. The sand bar, which formed in front of Gate 2, may be seen in the photograph of Figure 15b. The photograph, Figure 15a, shows the model in operation; confetti on the surface of the water outlines the surface flow pattern.

Change 3

In an attempt to eliminate the sand bar from building up in front of Gate 2, a skimming weir was utilized. As may be seen in Figure 13, Change 2 was modified to test the skimming weir. The weir was placed parallel to the left wall and in front of the headworks. Using a length of 28.15 feet, an elevation of 2351.16 feet was calculated for the top of the weir. After the weir was in place the channel between the walls and between the weir and the headworks was filled with sand to elevation 2348.00 feet, and the river discharge of 97.5 cfs was set. The water was divided in a manner similar to preceding tests; 58.8 cfs through the headworks and 38.7 cfs through the sluiceway. The headwater elevation was held at approximately 2352.49 feet, and the model remained in continuous operation for 24 hours.

No improvement over Change 2 was indicated when samples were taken. As may be seen in the photographs of Figure 16, the sand bar built up over the top of the skimming weir and in front of the headworks. The concentration ratio was 1.6, the same as that of Change 2. However, the average concentration of sediment leaving the model increased from 453 ppm to 481 ppm. As no improvement over the concentrations of Change 2 was noted, the headworks gates were not sampled separately. By observing the sand bar which built up in front of each gate, it is believed that the concentrations passing each headworks gate were approximately equal.

Change 4 (Recommended Design)

As shown in Figure 13, Change 4 consisted of two curved walls forming a channel past the headworks. The wall with the shortest radius, 30 feet, was farthest from the headworks. The distance between the walls was constant at 12 feet, and their top elevation was 2353.00 feet. Sand was placed in the area between the walls to elevation 2348.00 feet, and the test discharge of 97.5 cfs was set. Approximately the same discharge division as previously used was set; 58.7 cfs was diverted to the headworks and 38.8 cfs was used as sluicing water. The reservoir elevation was held at approximately 2352.54 feet, and the model was operated for 49 hours.

Samples of the water and sediment being discharged from the model were taken during operation. The samples indicated an improvement of sediment concentrations in the sluiceway and headworks. The average concentration of sediment passing the sluiceway was 830 ppm while the average concentration of sediment passing the headworks was 124 ppm. The two preceding concentrations resulted in an average sediment concentration in the water being discharged from the model of 405 ppm and a ratio, Cs/Ch, of 6.69.

The concentration ratio, resulting from Change 4, indicated a substantial improvement over previous designs tested. The area in front of the headworks remained free from sediment bars, as shown in Figure 17. Sediment deposited on the inside of the curve near the guide wall farthest from the headworks, while the area near the headworks was left relatively clear of sediment. At the end of the guide walls a good deal of scour occurred as shown in Figure 17a. The scour indicated that it would be advisable to pave the area near the ends of the guide walls.

Although the improved conditions resulting from Change 4 were considered satisfactory for design purposes, it was decided to try two additional designs that were proposed to determine the effect of using a tunnel which would separate the sluicing water from the canal water before it reached the canal headworks.

Change 5

For the first tunnel test the guide walls of Change 4 were left in place, and a tunnel fitting between the guide walls was added. The tunnel portal was approximately 31 feet upstream from the sluice gates and as may be seen from a study of Figure 13, the elevation of the tunnel bottom was placed at 2348.00 feet and the tunnel roof at elevation 2349.50 feet. The tunnel was constructed of 15 gauge sheet metal, and the roof had no appreciable thickness. The area upstream from the tunnel and between the guide walls was leveled at elevation 2348.00 feet, and the operating discharge of 97.5 cfs was set. The water was divided approximately the same as in preceding tests; 39.5 cfs was used as sluicing water, and 58.0 cfs was diverted through Bartley Canal headworks. The reservoir elevation was held at approximately 2353.57 feet, and the model was operated for 6-1/2 hours.

Samples taken during the operation indicated a sediment concentration in the water coming from the headworks of 115 ppm while that coming from the sluiceway was 901 ppm. The average concentration of sediment leaving the model for the above conditions was 433 ppm, and the resulting concentration ratio was 7.83.

The tunnel created some turbulence near its entrance similar to that shown in Figure 18b. The turbulence probably aided in lifting sediment over the tunnel, which deposited on the tunnel roof and in front of the headworks, Figure 18a. The sediment deposit was quite sizable, and it is believed that the sediment, after reaching equilibrium, would continue through the headworks and thus increase the concentration going into the canal.

As Change 5 would be more expensive to construct than Change 4, no further tests were conducted.

Change 6

The tunnel used in Change 5 was shortened for Change 6. The guide walls of Change 4 were left in place, and the tunnel entrance was moved to the center line of the headworks. A floor was placed at the end of the guide walls at elevation 2348.00 feet to simulate a paved condition to aid in observing scour. The resulting design of Change 6 may be seen in Figure 13. The area in front of the tunnel was leveled to elevation 2348.00 feet, and the operating discharge of 97.5 cfs was set. 39.0 cfs was used as sluicing water, 58.5 cfs was diverted through Bartley Canal headworks, and the reservoir elevation was held at approximately 2352.53 feet. The model was operated at these conditions for 24 hours.

As in Change 5 a large sediment deposit formed on the tunnel roof, Figure 19a, indicating higher sediment concentrations would occur through Gate 1 when the sediment deposit reached equilibrium. The average concentration of sediment which passed the headworks during the operation was 168 ppm, and that which passed the sluiceway was 808 ppm.

The average sediment concentration discharged from the model for the preceding conditions was 424 ppm, and the resulting concentration ratio 4.81. Turbulent conditions near the tunnel entrance were present as in the previous design. In the photograph of Figure 18b a vortex may be seen near the guide wall and above the tunnel entrance.

The photograph in Figure 19b shows the area at the end of the guide walls after 24 hours of operation. The floor which was placed at the end of the guide walls, to simulate a paved condition, may be seen. There were sand deposits on the floor and some scour occurred near its edge.

Varied Discharge Ratios and Intermittent Sluicing Tests

As Change 4 resulted in satisfactory operation for the discharge ratio tested, tests were made to determine the optimum discharge ratio and to determine the value of intermittent sluicing. These tests may be of benefit in determining the best method to operate the prototype structure. Gate settings similar to those expected in the field were used for testing discharge ratios.

The first test consisted of varying the ratio of water being discharged through the headworks and sluiceway while the total discharge of the river was held at 97.5 cfs. Besides the discharge ratio previously tested, three additional discharge ratios were tested. Each additional ratio was held while Change 4 was operated for approximately 8 hours. Results of these tests may be seen in the graph of Figure 20. The tests indicated that the sluice gate was effective for small sluicing discharges. A concentration resulted in the sluiceway approximately twice as high as that in the headworks when the discharge in the headworks was four times that in the sluiceway. As the discharge in the sluiceway increased and that in the headworks decreased, the concentration of sediment in the water going through the sluiceway increased rapidly. This continued until the discharges through the sluiceway and headworks were approximately equal. At equal discharges the concentration of sediment going through the sluiceway was approximately eight times that going through the headworks. Changing the discharge ratio beyond the points of equal discharge appeared to have little effect on the concentration ratio. Due to the length of time that would be required for the model river bed to re-establish equilibrium if another total discharge were to be tested, additional tests along this line were not made.

Tests to determine the value of intermittent sluicing were conducted. For the intermittent sluicing tests the model was set so that the headwater elevation was held at approximately 2352.5 feet and so that the discharge was 38.8 cfs in the sluiceway and 58.7 cfs in the headworks. After establishing the discharges, the sluice gate was completely opened and left open for 22 minutes*. After the sluice gate had been open for 22 minutes, it was completely closed until the headwater elevation reached 2352.5 feet, and the previous discharge ratio was established. The model was then operated for 45 minutes after which the complete operation was repeated. During the time of sluicing, samples were integrated in a manner that included the complete sluicing period. The samples indicated that during the sluicing period the concentration ratio of sediment in the sluiceway to sediment in the headworks, Cs/Ch, decreased to a value of approximately four, and the water discharge through the headworks decreased by approximately 15 percent. As the water storage area in the model did not include the full width or length of the storage area in the prototype, the decrease in canal discharge in the prototype would be less. While the sluice gate was open, a sand bar built up in the area immediately under the sluice gate and on the apron to the river channel. Immediately after the headwater was raised to 2352.5 feet and the sluice gate was set for the test discharge ratio, the concentration of sediment in the sluiceway nappe became quite high. As shown in Figure 21, the sediment concentration in the sluiceway and headworks both reached a maximum approximately 2 minutes after the sluice gate was reopened. The sediment concentrations decreased to their average values in approximately 20 minutes. Although the concentration of sediment in both the sluiceway and headworks increased, the increase was by far the larger in the sluiceway. A study of Figure 21 reveals the sluiceway concentration increased to approximately 4,500 ppm, which is an increase of 442 percent over the normal concentration of 830 ppm, while the headworks concentration increased to approximately 170 ppm, which is an increase of 37 percent over the normal concentration of 124 ppm. Figure 22, which shows the concentration ratio plotted against the time after sluicing, indicates that for approximately 18 minutes after the sluice gate was reopened the concentration ratio, Cs/Ch, was above the normal of 6.69.

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* Times are indicated as model time.

CONCLUSIONS

As a result of the model study, the arrangement shown as Change 4 in Figure 13 was adapted in design of the prototype structure. This arrangement resulted in a ratio of the concentration of sediment in the sluicing water to the concentration of sediment in the water passing Bartley Canal headworks of 6.69, when the headwater elevation was 2352.54 feet and the discharge in the headworks and sluiceway were respectively 58.7 cfs and 38.8 cfs. This sediment ratio indicates a substantial improvement over the preliminary design.

All records possible should be kept regarding sediment concentrations, sediment deposits, discharges, and operating procedure until the best results of operation are obtained in the prototype structure. Methods of operating the prototype based on the operation studies given in this report and on visual observation and tests on the prototype should be used. The model tests indicate that equal amounts of water through the headworks and sluiceway give good results, however, with a small percent of the total discharge going through the sluiceway a substantial portion of the sediment load was removed. When excess water is available, the sluice gate should occasionally be completely opened for intermittent sluicing of the complete system.

Tests on the prototype to verify the model study by taking sediment samples on the prototype operating under conditions similar to those for which the model was tested would be a valuable contribution to the design of future diversion structures.

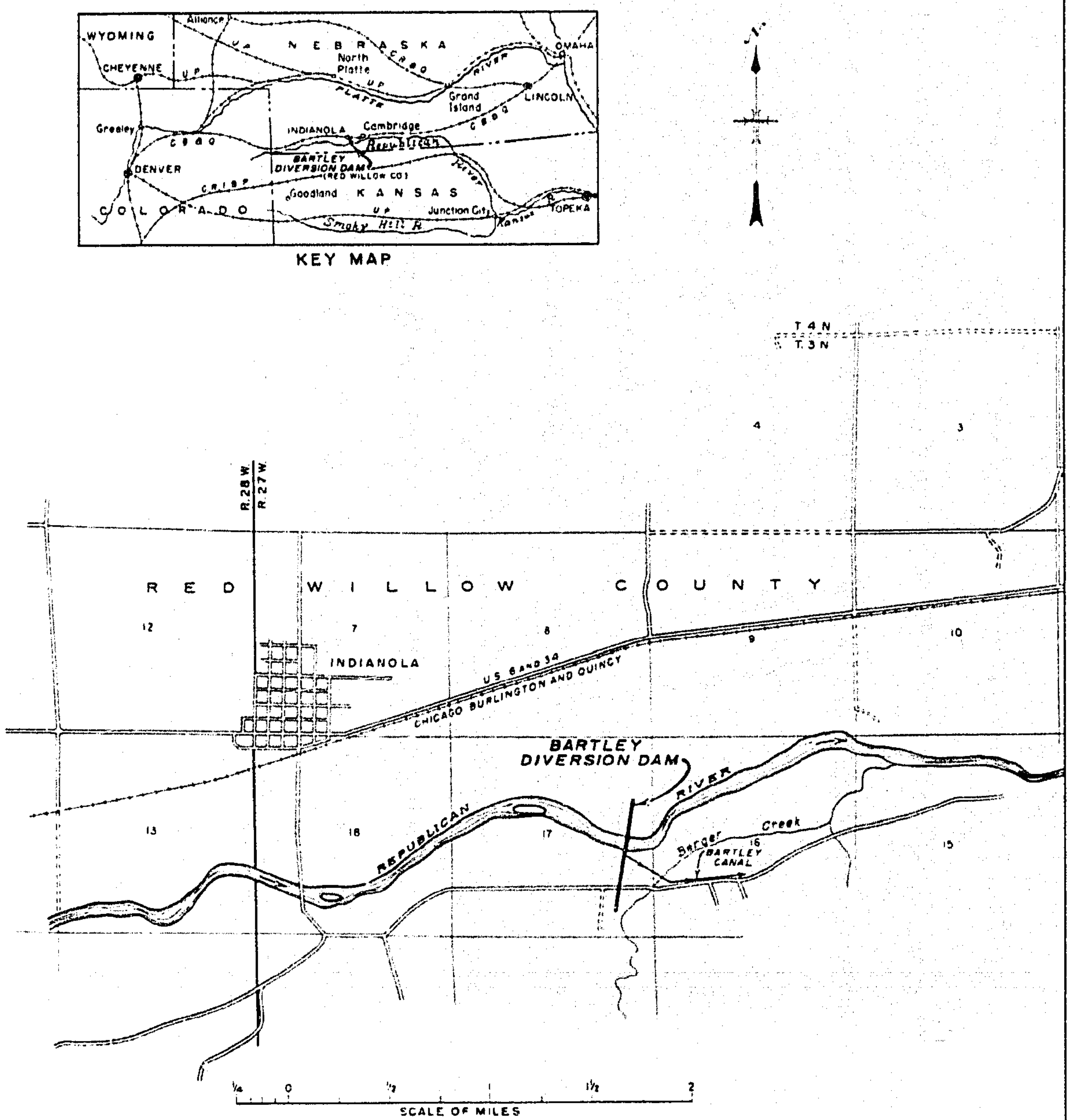
TABLE I

Missouri River Basin Project
BARTLEY DIVERSION DAM
Hydraulic Properties
Data from 1:7 scale model

Change No.	Hw el	Operation Time (hr)	Qs	Qh	Cs	Ch	Ci	Ct	Cs/Ch
Preliminary design	2352.48	84	37.3	60.2	135	1,020	474	681	0.13
1	2352.53	51-1/2	39.5	58.0	250	603	474	460	0.41
2	2352.51	34	37.8	59.7	588	367	474	453	1.60
3	2352.49	24	38.7	58.8	622	389	474	481	1.60
4	2352.54	49	38.8	58.7	830	124	474	405	6.69
5	2352.57	6-1/2	39.5	58.0	901	115	474	433	7.83
6	2352.53	24	39.0	58.5	808	168	474	424	4.81

Hw el = average headwater elevation.
Qs = average discharge through sluiceway cfs (prototype).
Qh = average discharge through headworks cfs (prototype).
Cs = average sediment concentration in sluiceway ppm by weight.
Ch = average sediment concentration in headworks ppm by weight.
Ci = concentration of sediment being added to the model ppm by weight.
Ct = average sediment concentration discharged from model ppm by weight.

FIGURE 1



UNITED STATES
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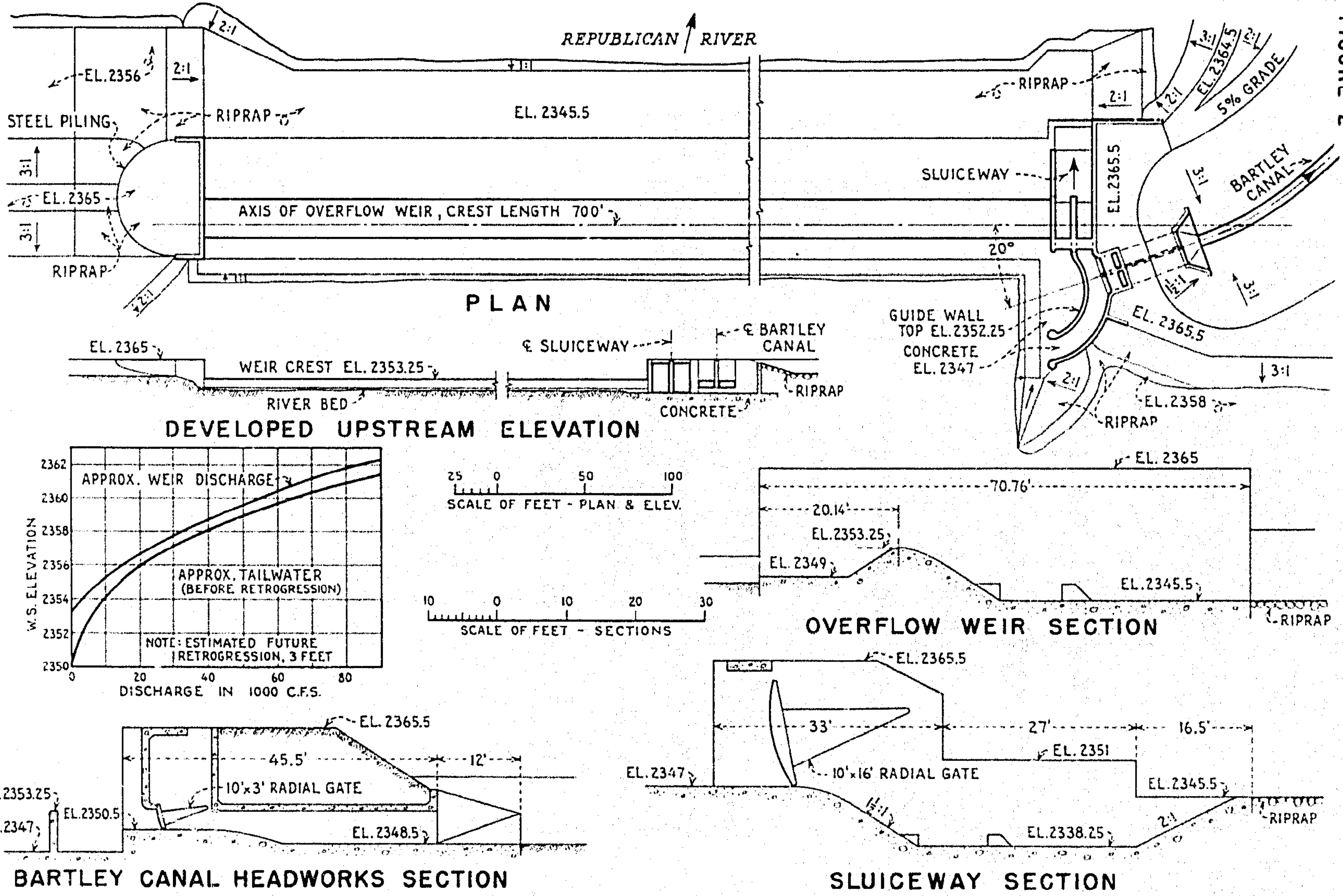
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
FRENCHMAN-CAMBRIDGE DIVISION-RED WILLOW UNIT-NEBR.

BARTLEY DIVERSION DAM
LOCATION MAP

DRAWN B.E.N. SUBMITTED A.B. Reese
TRACED G.M.A. RECOMMENDED K.B. Keener
CHECKED ... APPROVED W.E. Blomgren
ASST. CHIEF ENGINEER
DENVER, COLORADO, APRIL 2, 1952
328-D-1418



MISSOURI RIVER BASIN PROJECT

BARTLEY DIVERSION DAM

GENERAL PLAN AND SECTIONS

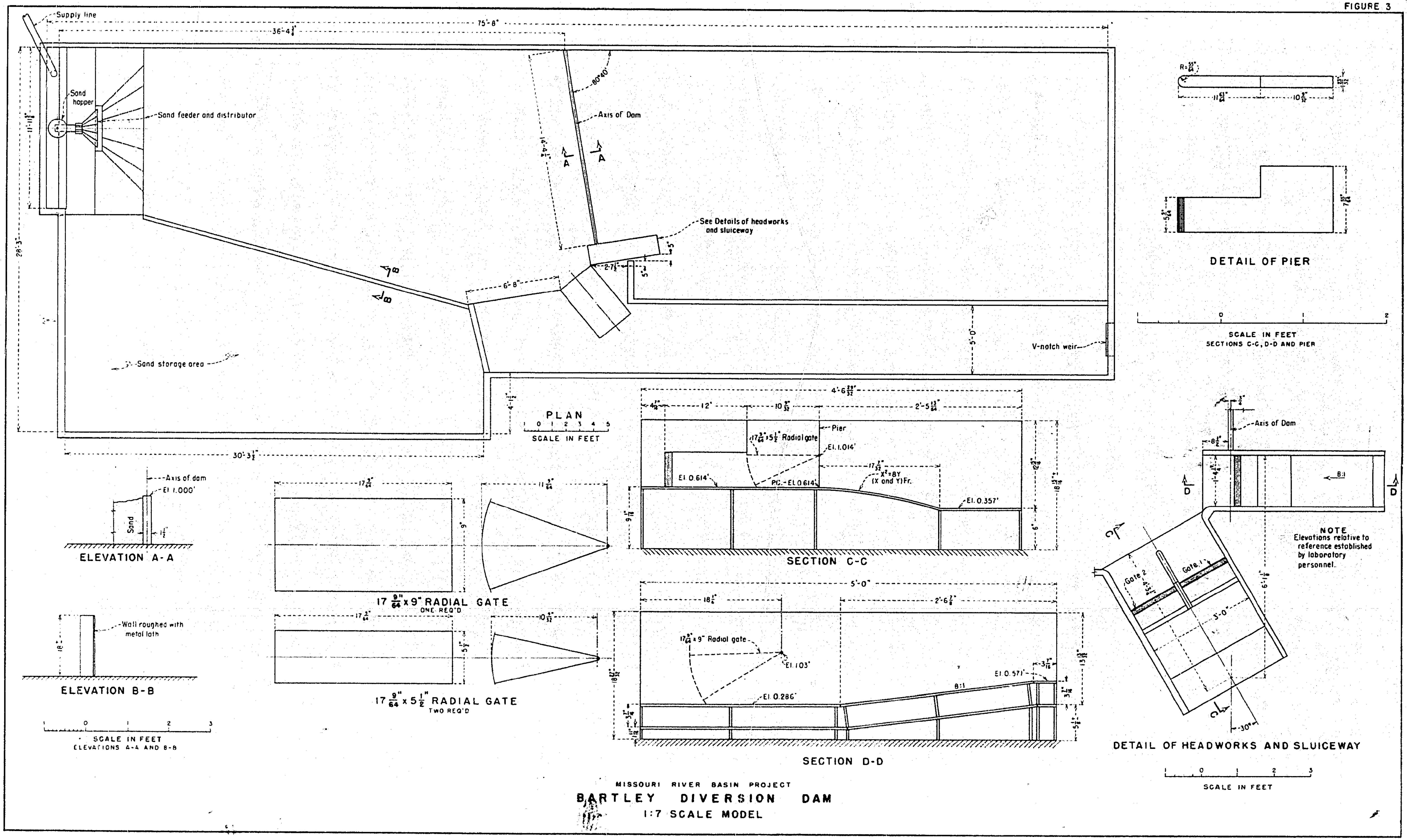


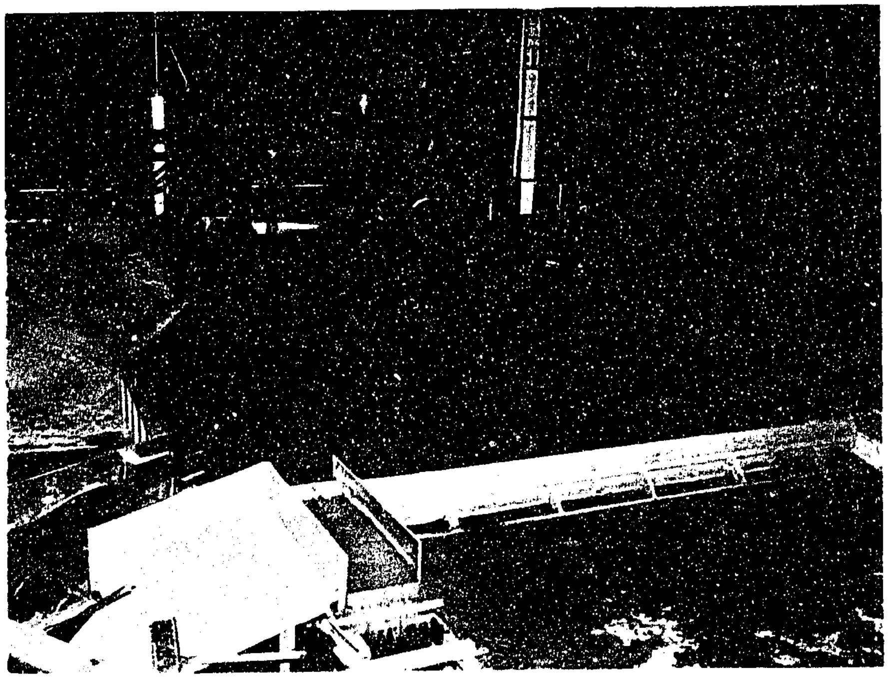
FIGURE 3

MISSOURI RIVER BASIN PROJECT

BARTLEY DIVERSION DAM

1:7 SCALE MODEL

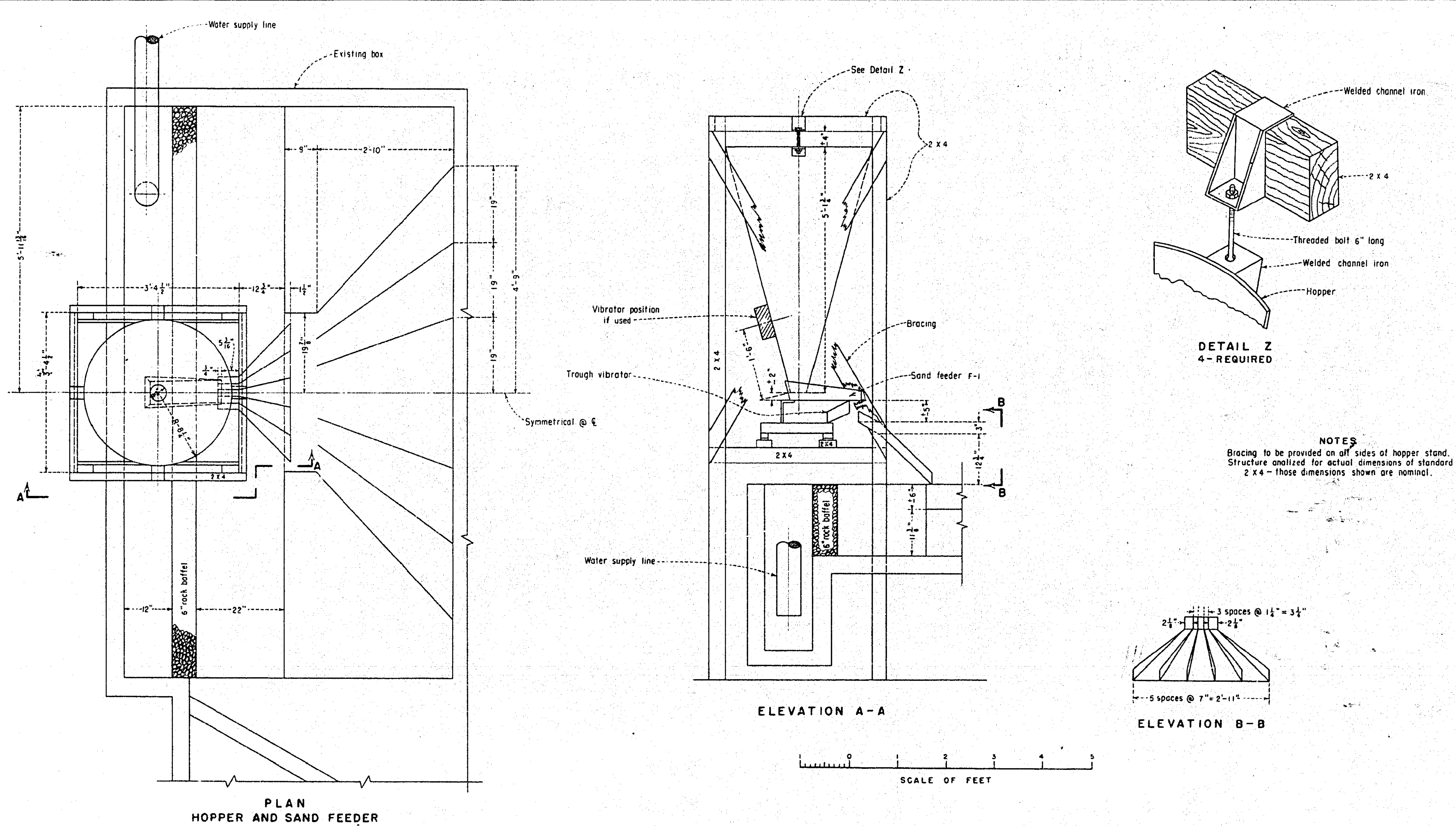
Figure 4



(a) Preliminary design in operation - total discharge 97.5 cfs; discharge diverted to Bartley Canal 60.2 cfs; discharge used for sluicing 37.3 cfs.

(b) Calibrated collecting tanks.

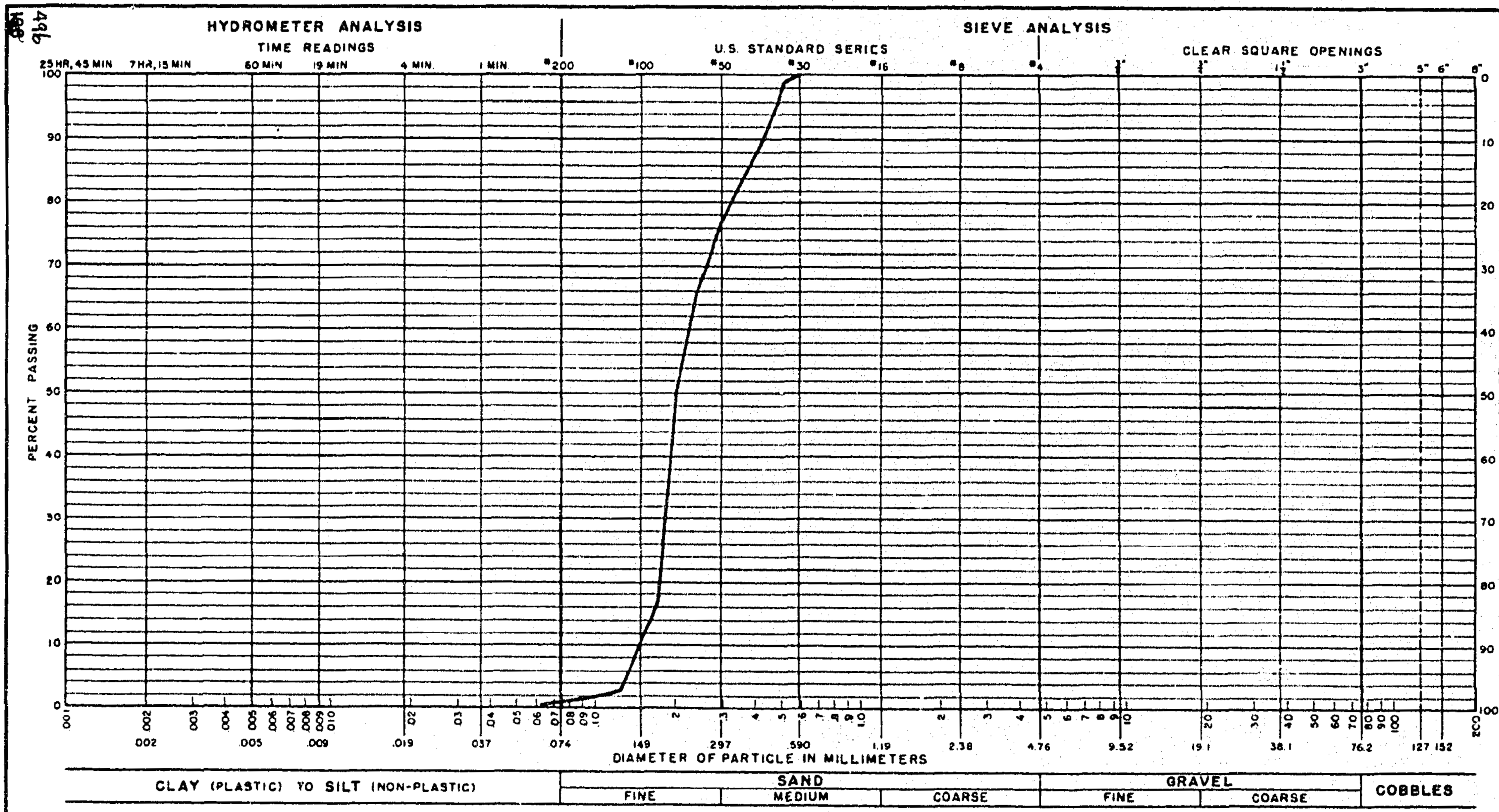
Missouri River Basin Project
BARTLEY DIVERSION DAM
PRELIMINARY DESIGN AND COLLECTING TANKS
1:7 scale model



MISSOURI RIVER BASIN PROJECT

BARTLEY DIVERSION DAM

SAND FEEDING SYSTEM



NOTES:

Sand used in 1:7 hydraulic model study of Bartley diversion dam.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

GRADATION TEST

MISSOURI RIVER BASIN PROJECT

BARTLEY DIVERSION DAM

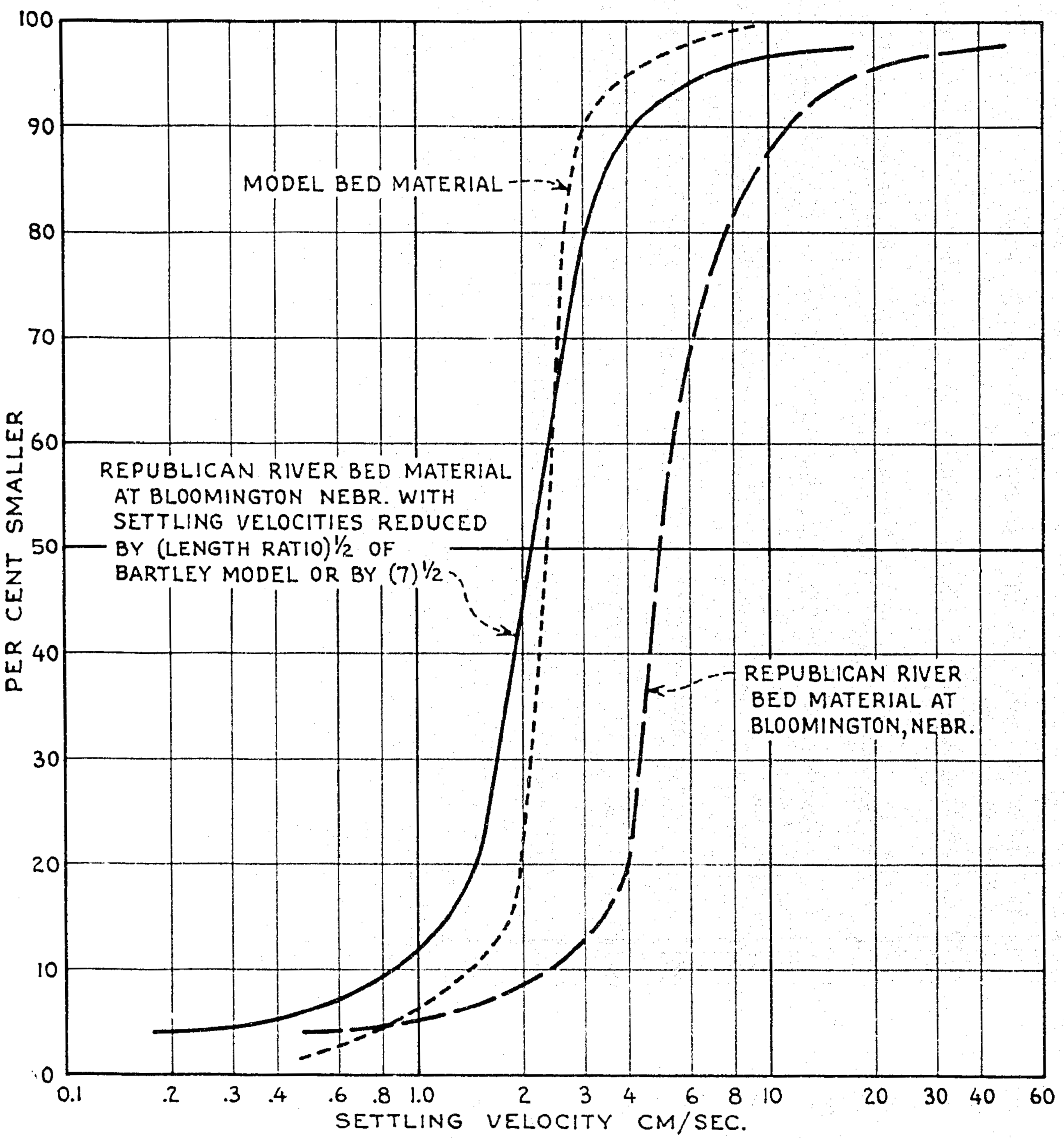
SIZE ANALYSIS CURVE

MODEL SAND

DRAWN CHECKED DATE

FIGURE 6

FIGURE 7

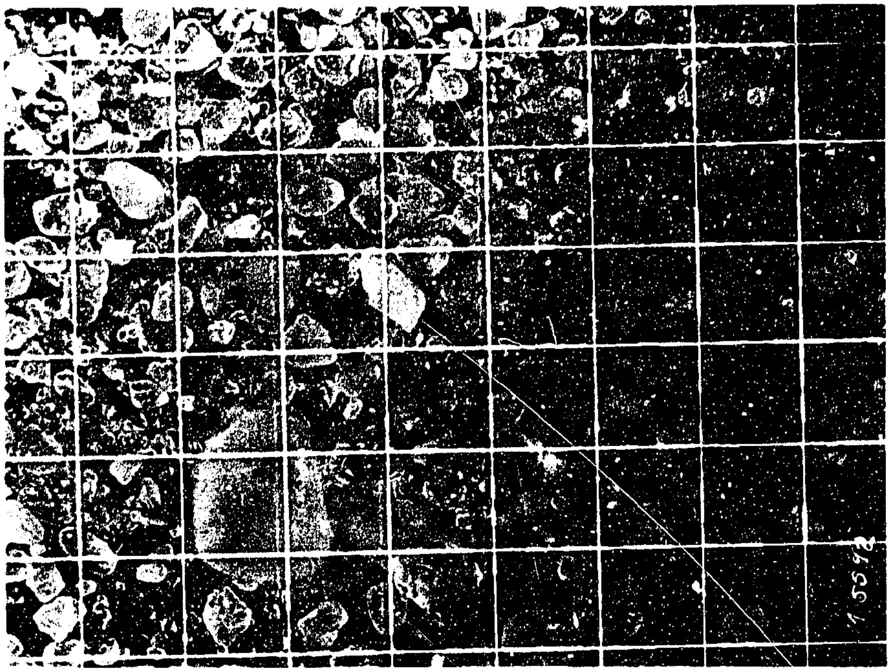


MISSOURI RIVER BASIN PROJECT

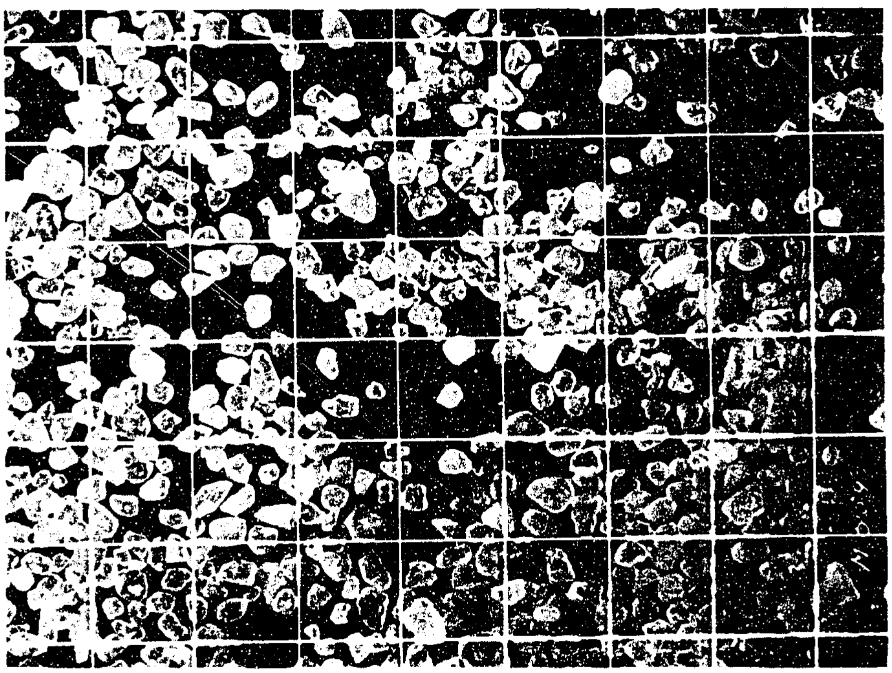
BARTLEY DIVERSION DAM

COMPARISON OF SAND SETTLING VELOCITIES

Figure 8

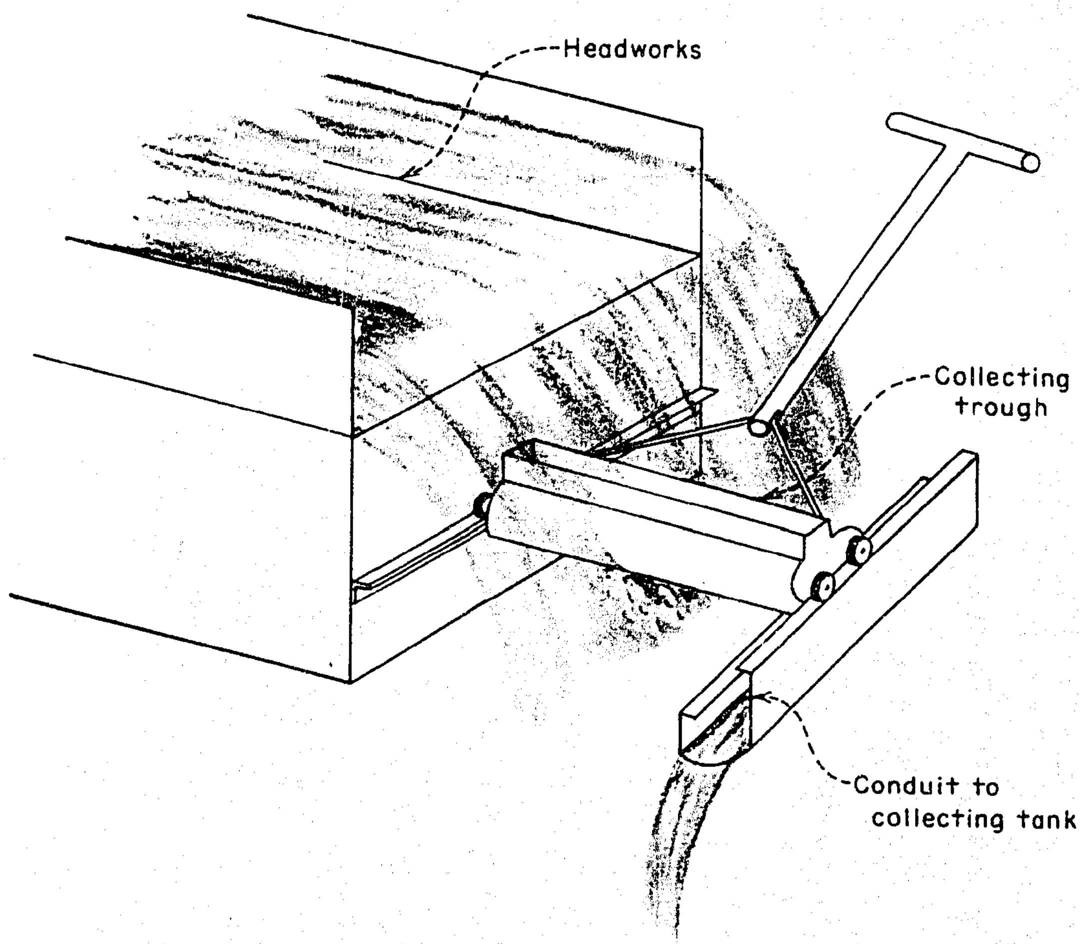


(a) Republican River bed sand



(b) Model sand

Missouri River Basin Project
BARTLEY DIVERSION DAM
REPUBLICAN RIVER AND MODEL SAND
1:7 scale model

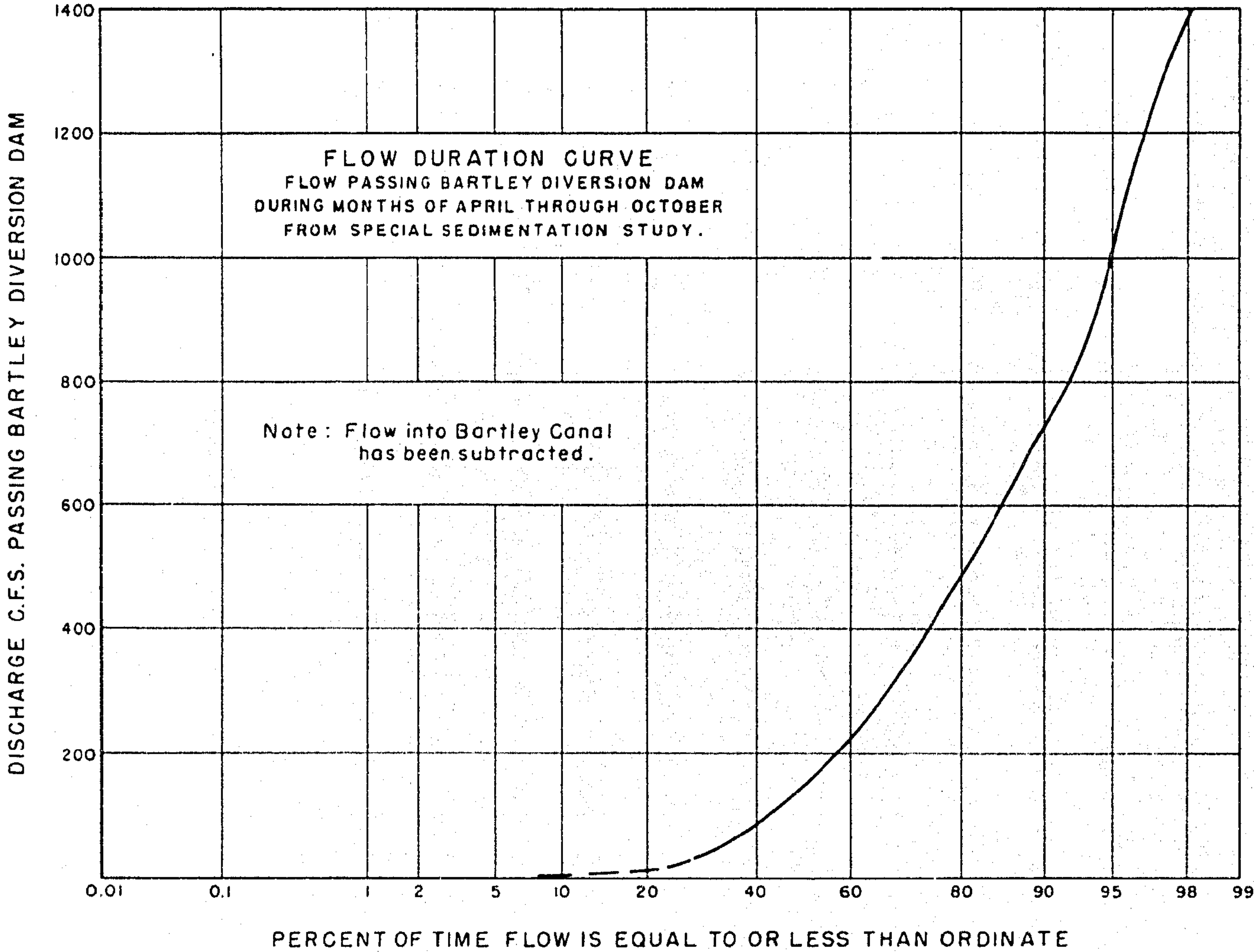


MISSOURI RIVER BASIN PROJECT

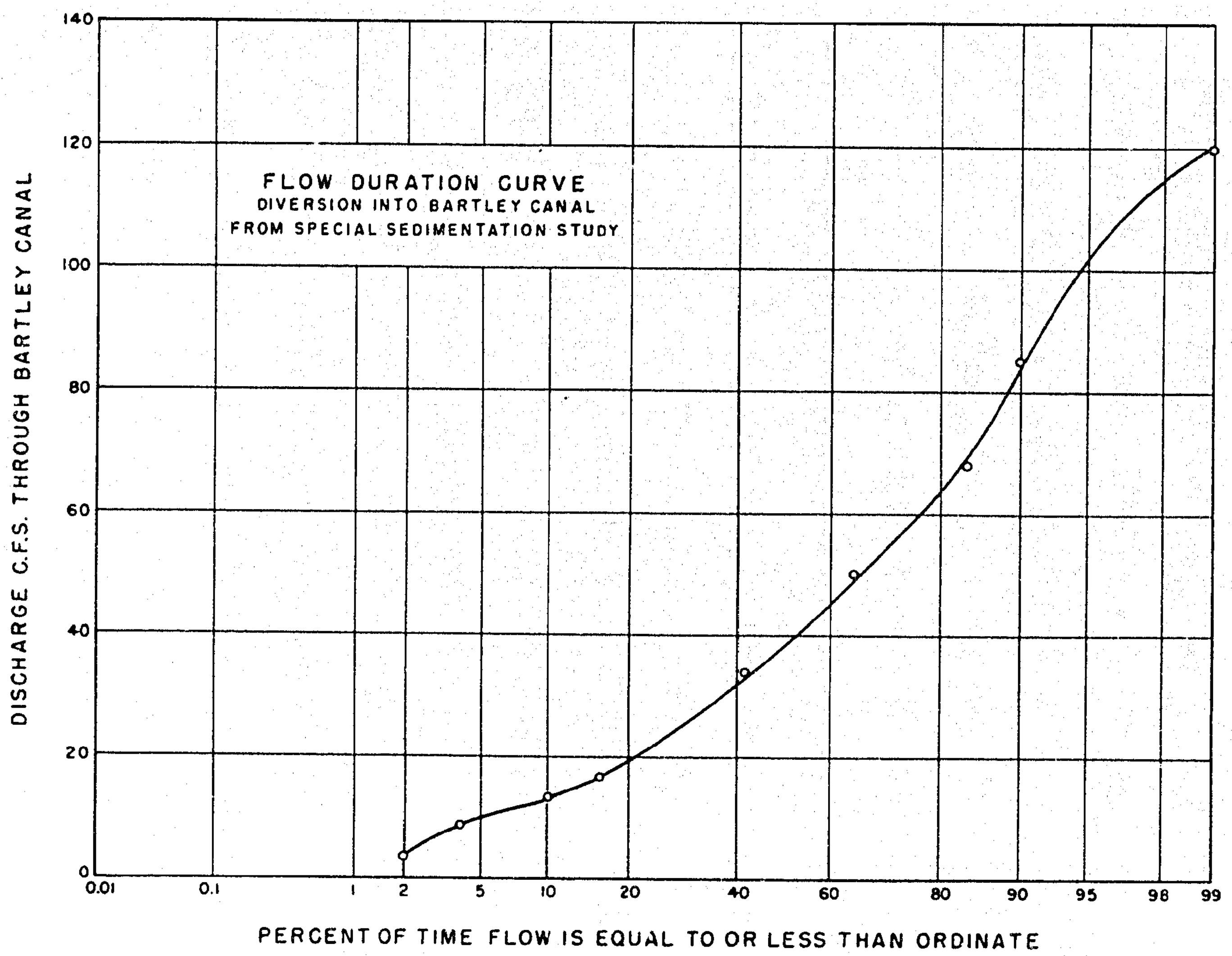
BARTLEY DIVERSION DAM

SEDIMENT SAMPLING SYSTEM

FIGURE 10
REPORT HYD. 384



MISSOURI RIVER BASIN PROJECT
BARTLEY DIVERSION DAM
FLOW PASSING BARTLEY DIVERSION DAM



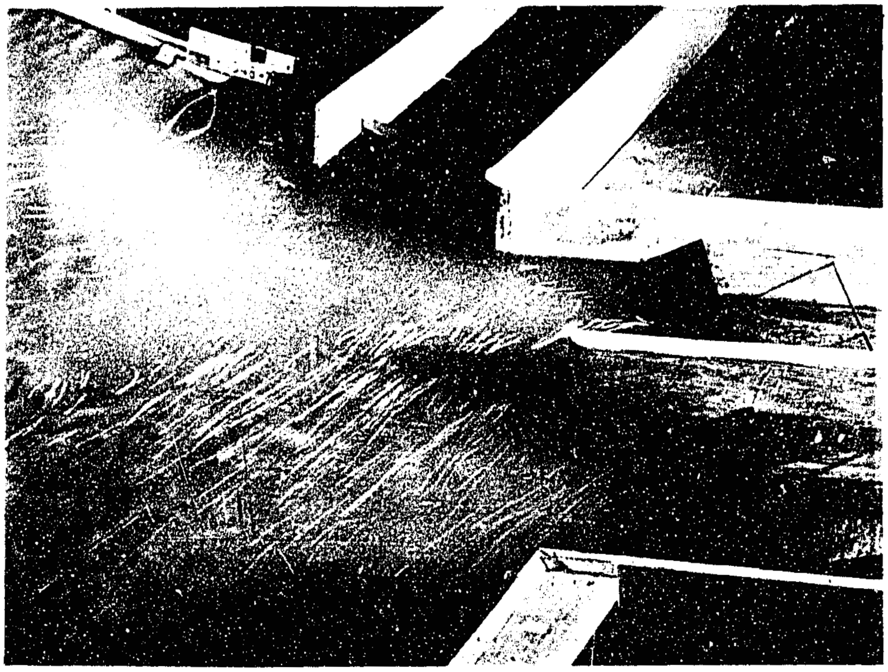
MISSOURI RIVER BASIN PROJECT

BARTLEY DIVERSION DAM

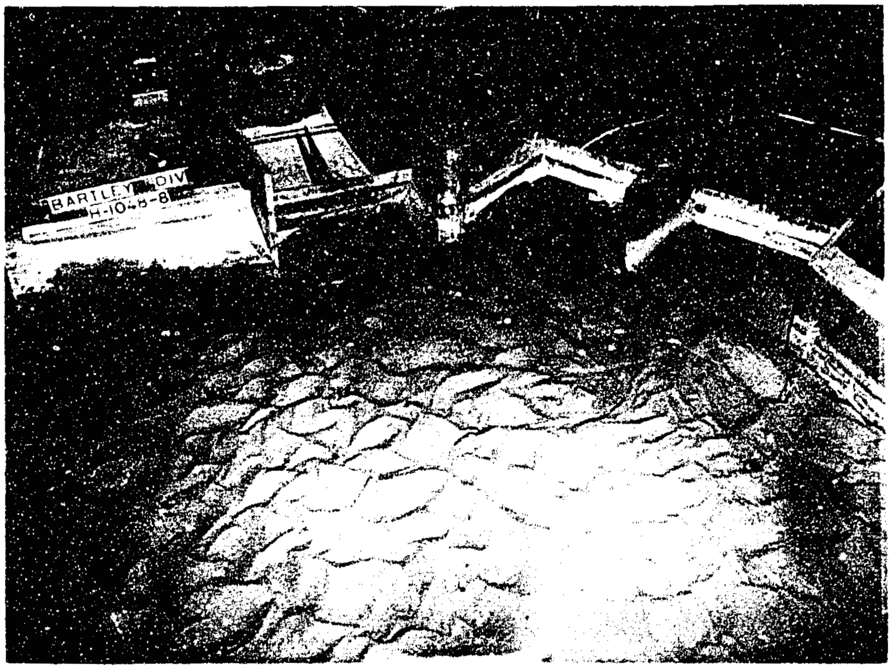
FLOW DIVERTED TO BARTLEY CANAL

FIGURE 11
REPORT HYD. 384

Figure 12

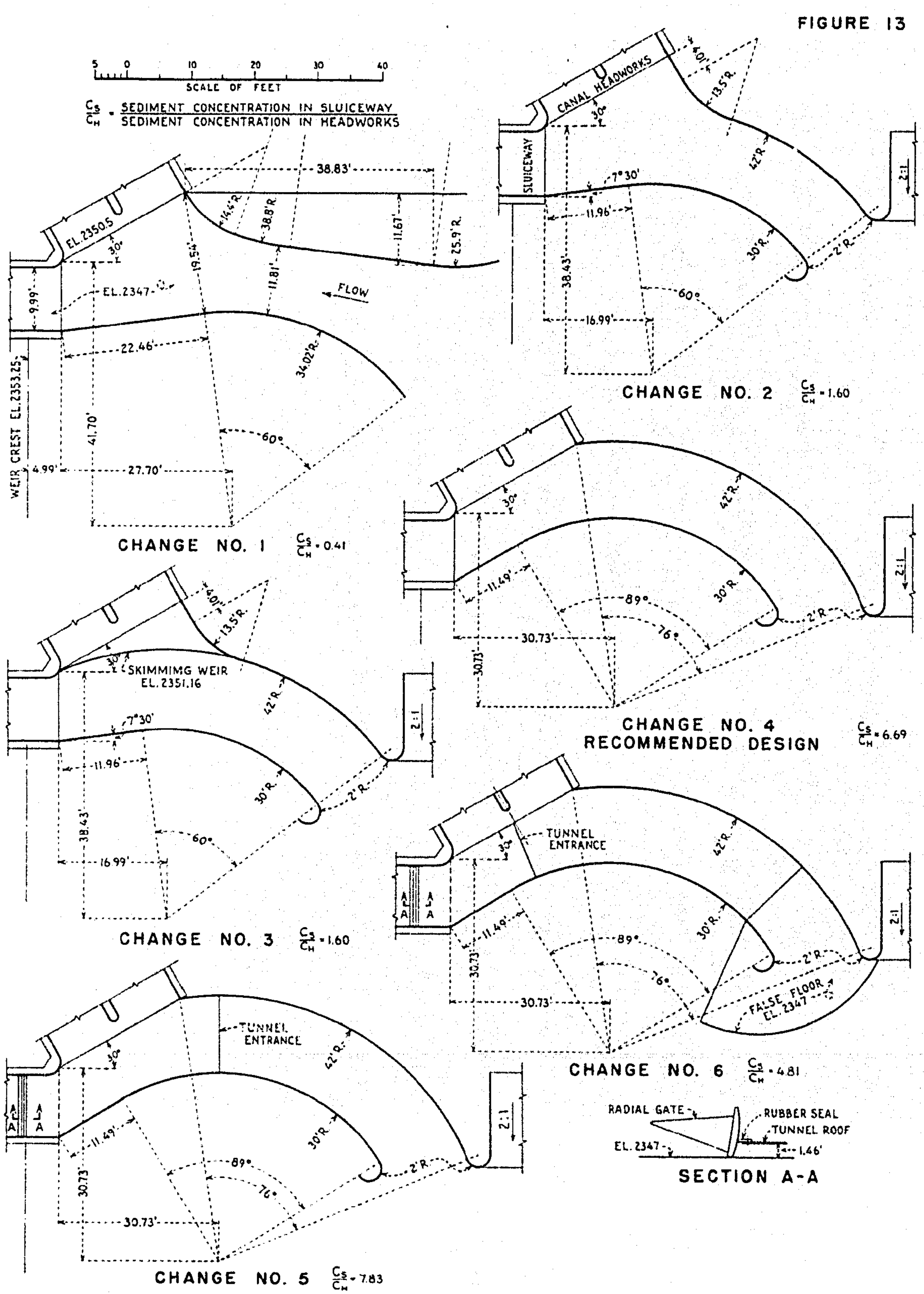


(a) Model in operation - total discharge 97.5 cfs discharge through headworks 60.2 cfs; discharge through sluiceway 37.3 cfs. White streaks are confetti on the water surface.



(b) Model after 84 hrs. operation at the above conditions.

Missouri River Basin Project
BARTLEY DIVERSION DAM
PERFORMANCE OF PRELIMINARY DESIGN
1:7 scale model



MISSOURI RIVER BASIN PROJECT

BARTLEY DIVERSION DAM

MODEL CHANGES

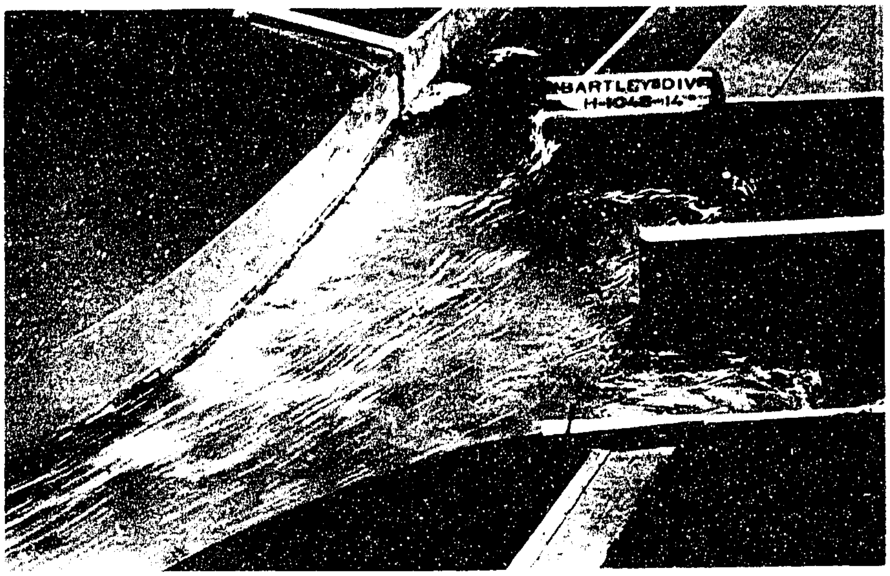
DATA FROM 1:7 SCALE MODEL

(a) Model in operation - total discharge 97.5 cfs; discharge through headworks 58.0 cfs; discharge through sluiceway 39.5 cfs.

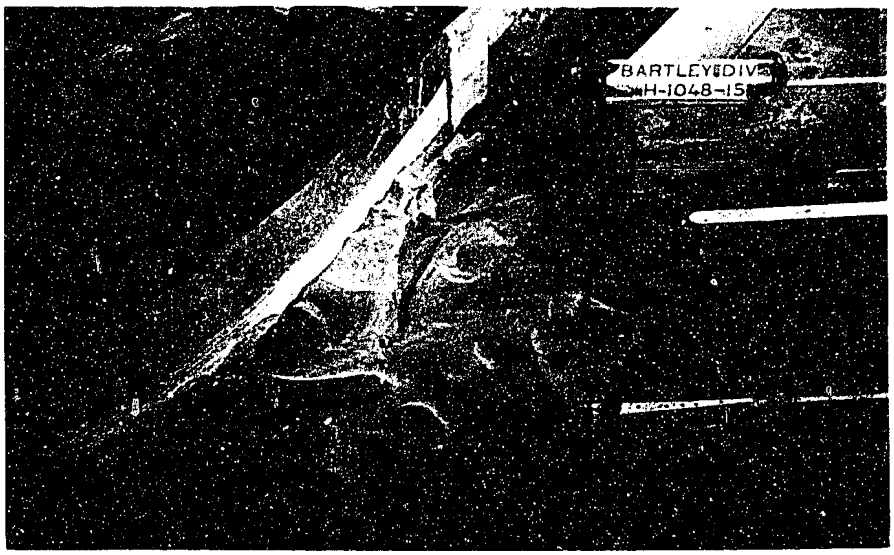
(b) Model after 51.5 hrs. of operation at the preceding conditions.

Missouri River Basin Project
BARTLEY DIVERSION DAM
PERFORMANCE OF CHANGE 1
1:7 scale model

Figure 14



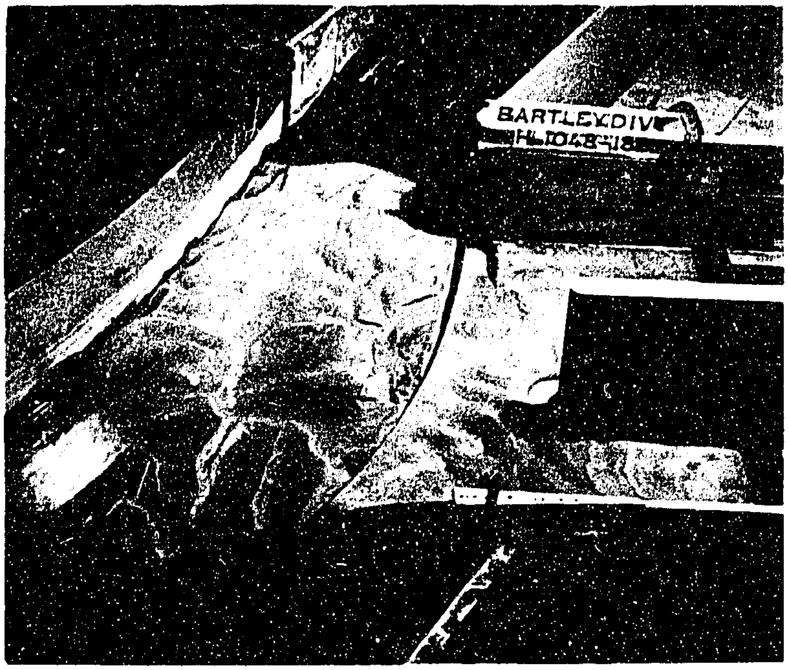
(a) Model in operation - total discharge 97.5 cfs; discharge through headworks 59.7 cfs; discharge through sluiceway 37.8 cfs.



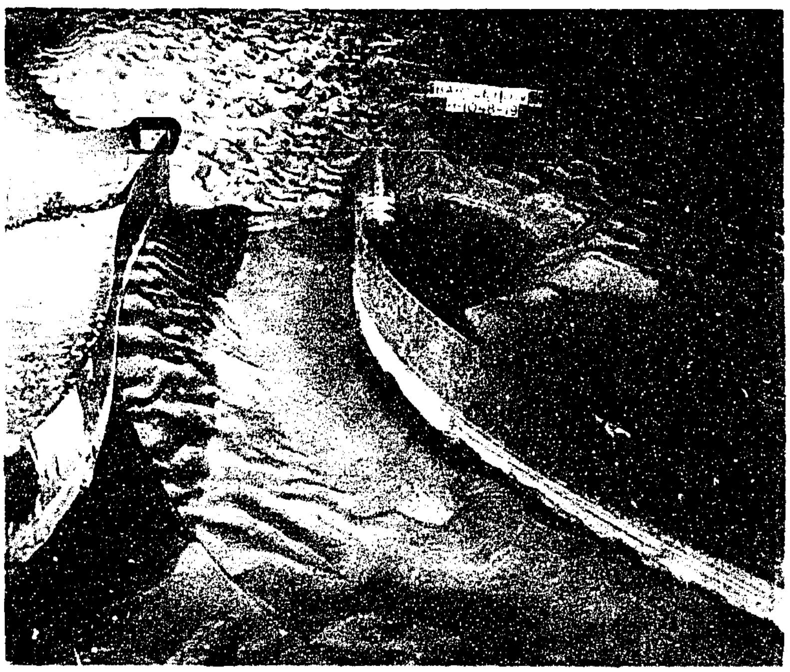
(b) Sediment pattern after 34 hrs. of operation at the above conditions - note sand bar on the headworks floor in the foreground.

Missouri River Basin Project
BARTLEY DIVERSION DAM
PERFORMANCE OF CHANGE 2
1:7 scale model

Figure 16

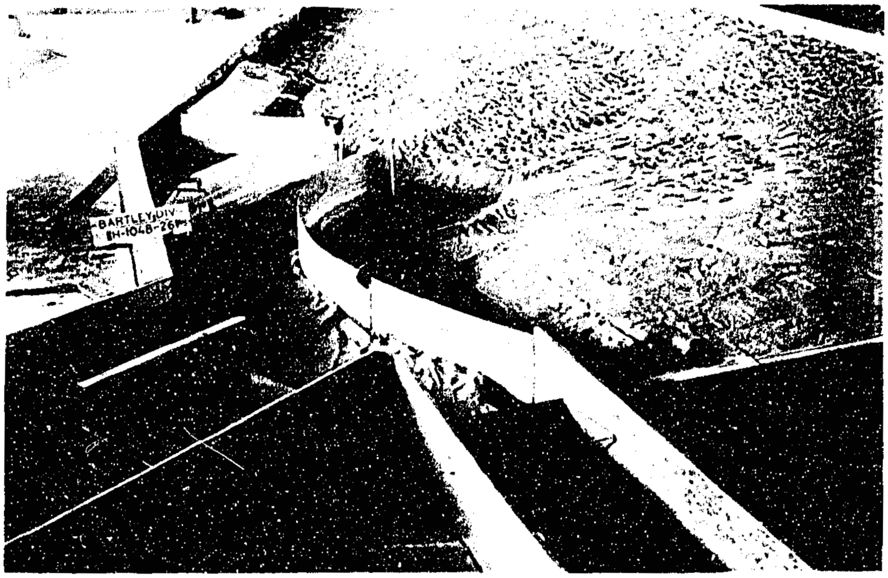


(a) Sand bars that built up in front of the headworks after 24 hours of operation at the test conditions.

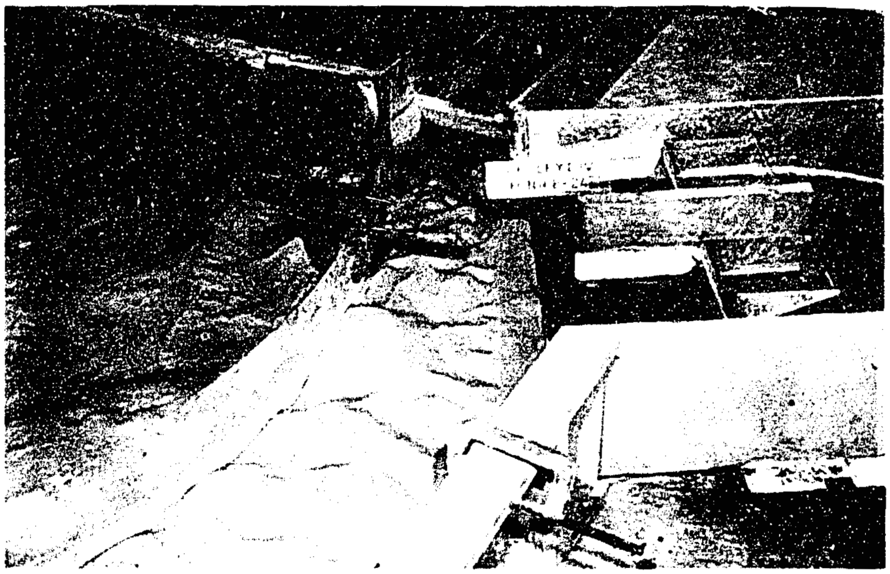


(b) Sediment pattern between the guide walls - note bar formed over skimming weir and scour near end of outer guide wall.

Missouri River Basin Project
BARTLEY DIVERSION DAM
PERFORMANCE OF CHANGE 3
1:7 scale model



(a) General scour pattern after 49 hours operation at the test conditions - note erosion near end of guide wall.

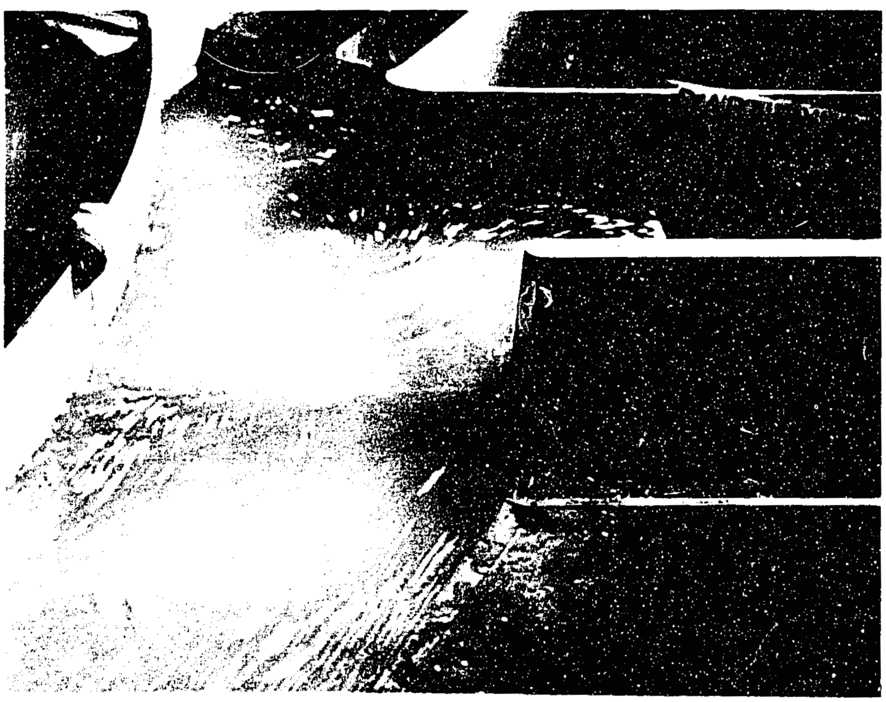


(b) Scour pattern between guide walls near the headworks - note area in front of the headworks gates is relatively clear of sand bars.

Missouri River Basin Project
BARTLEY DIVERSION DAM
PERFORMANCE OF CHANGE 4
1:7 scale model

Figure 18

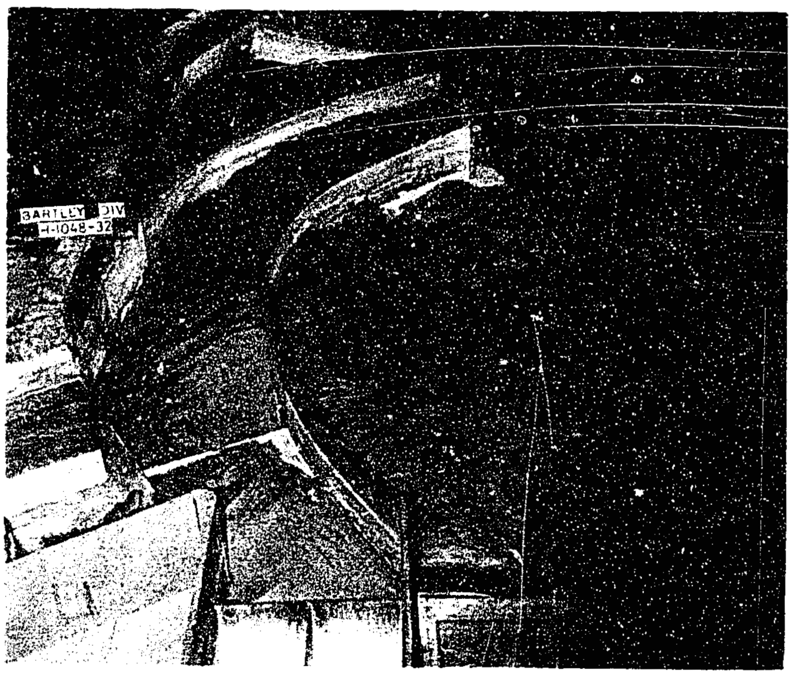
(a) Change 5 - sediment deposits on top of the tunnel after 6.5 hrs. operation - total discharge 97.5 cfs; discharge diverted to Bartley Canal 58.0 cfs; discharge used for sluicing 39.5 cfs.



(b) Change 6 - water surface showing vortex near tunnel entrance - total discharge 97.5 cfs; discharge being diverted to Bartley Canal 58.5 cfs; discharge being used as sluicing water 39.0 cfs.

Missouri River Basin Project
BARTLEY DIVERSION DAM
PERFORMANCE OF CHANGES 5 AND 6
1:7 scale model

(a) Sediment deposits on tunnel roof-after 24 hours operation at the test conditions - note sand bar in front of headworks gate.



(b) Scour near end of guide wall - note floor in position at end of guide wall.

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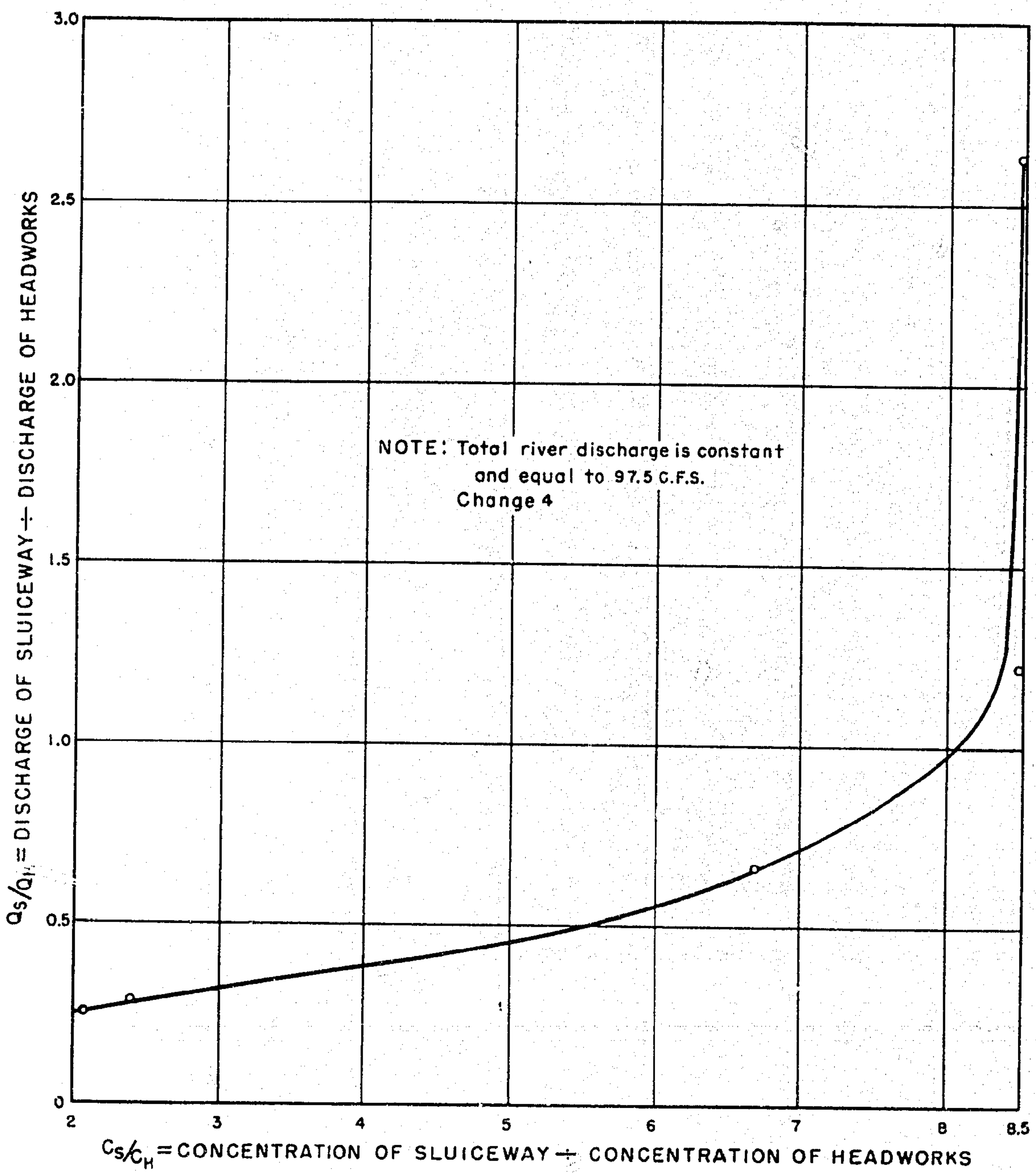
BARTLEY DIVERSION DAM
PERFORMANCE OF CHANGE 6
1:7 scale model



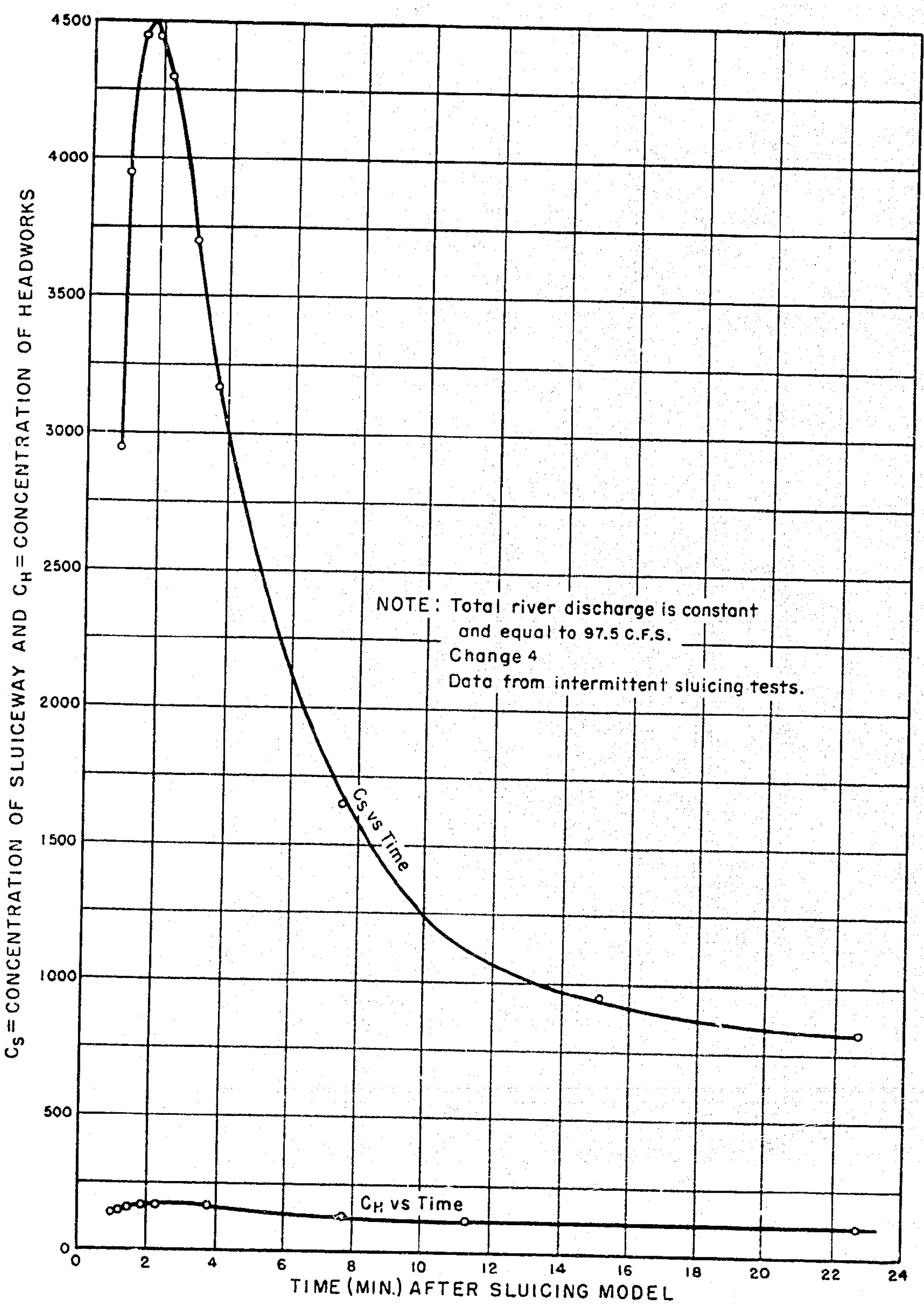
MISSOURI RIVER BASIN PROJECT

BARTLEY DIVERSION DAM

CONCENTRATION RATIO VERSUS DISCHARGE RATIO

DATA FROM 1:7 SCALE MODEL

496

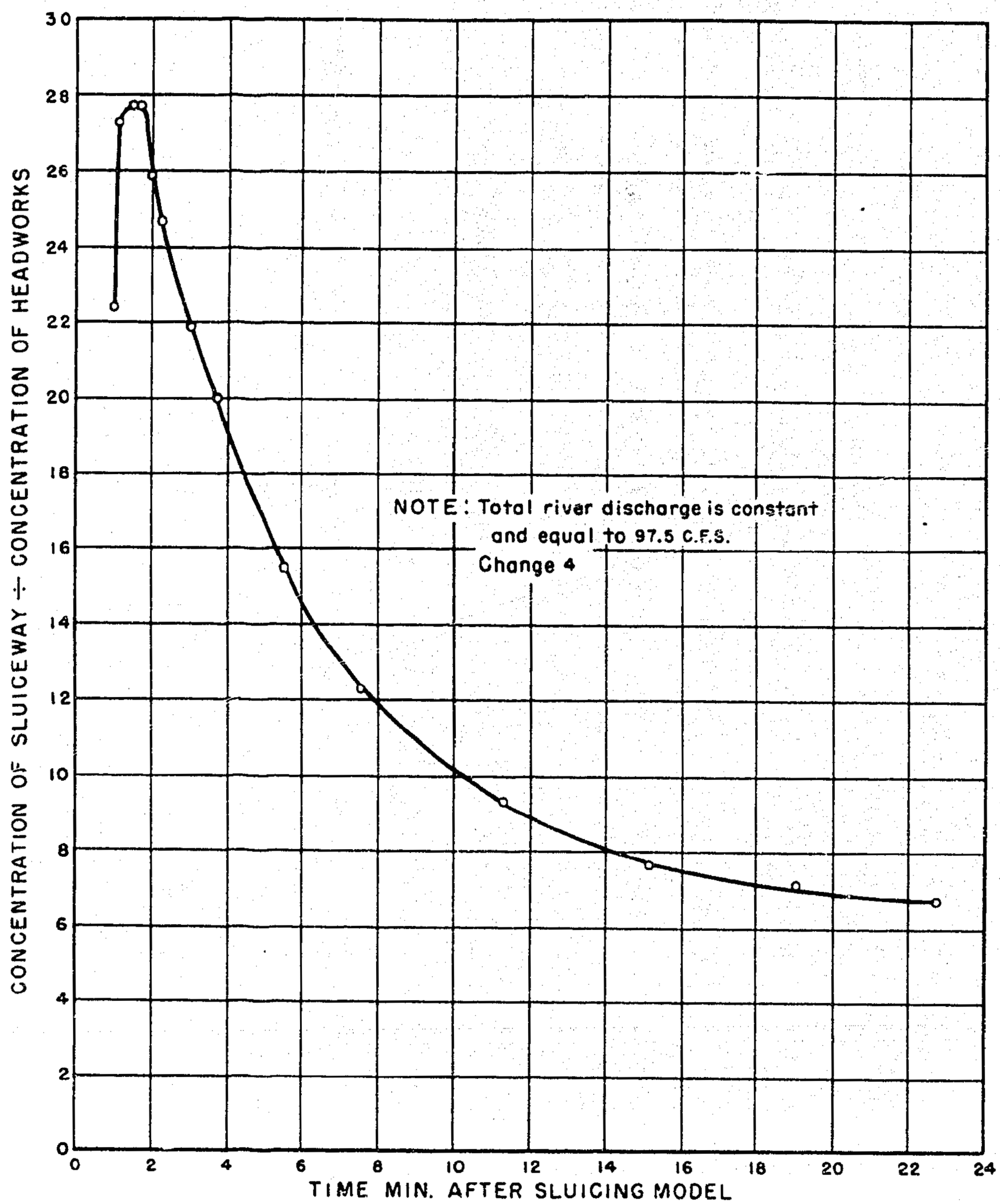


MISSOURI RIVER BASIN PROJECT

BARTLEY DIVERSION DAM

CONCENTRATION VERSUS TIME AFTER SLUICING

DATA FROM 1:7 SCALE MODEL



MISSOURI RIVER BASIN PROJECT

BARTLEY DIVERSION DAM

CONCENTRATION RATIO VERSUS TIME AFTER SLUICING

DATA FROM 1:7 SCALE MODEL