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PRELIMINARY LABORATORY INVESTIGATION OF SECTION 32 HARD POINT.(U)
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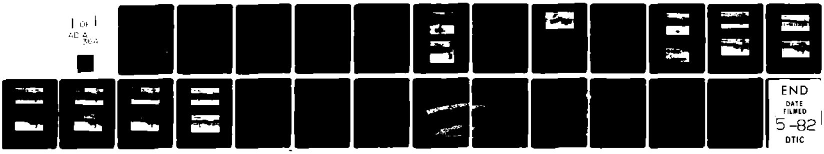

P. L. 93–251 SECTION 32 DEMONSTRATION PROJECTS STUDY

MRD HYDRAULIC LABORATORY SERIES
REPORT NO. 8
PRELIMINARY

PRELIMINARY LABORATORY INVESTIGATION OF SECTION 32 HARD POINT

MEAD HYDRAULIC LABORATORY
MEAD, NEBRASKA

U. S. ARMY ENGINEER DISTRICT, OMAHA
MISSOURI RIVER DIVISION, OMAHA
OCTOBER 1978

DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS

PRELIMINARY LABORATORY INVESTIGATION

OF SECTION 32 HARD POINTS

Conducted at

MEAD HYDRAULIC LABORATORY

MEAD, NEBRASKA

U.S. Army Engineer District, Omaha, Nebraska

Missouri River Division, Omaha, Nebraska

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PRELIMINARY LABORATORY INVESTIGATION
OF SECTION 32 HARD POINTS

INTRODUCTION

This report describes a series of preliminary tests of a short duration model study conducted on erosion control structures at the Mead Hydraulic Laboratory under the authority of P.L. 93-251, Section 32. The specific erosion control structures investigated were hard points. Hard points are two-part structures consisting of a spur and a root (~~see plate~~ 1). The spur is placed directly on the channel bank to stop streamflow erosion at that point. The root provides a tie from the spur into the bank to prevent the structure from being outflanked by bank erosion.

This is the eighth report prepared for model studies at the Mead Hydraulic Laboratory. The model study was conducted by personnel of the Omaha District Corps of Engineers under the direct supervision of the Channel Stabilization and Hydraulics Sections of the Omaha District and under the general supervision of the Missouri River Division. This report was prepared by Mr. Eugene E. Matson and Mr. Bill J. Berry, Jr.

PURPOSE OF STUDY

Through P.L. 93-251, Section 32 authority, Demonstration Projects are to be constructed to develop economical erosion-control structures which do not have a significant adverse ecological impact and which will either retain or improve the existing riverine fish and wildlife habitat.

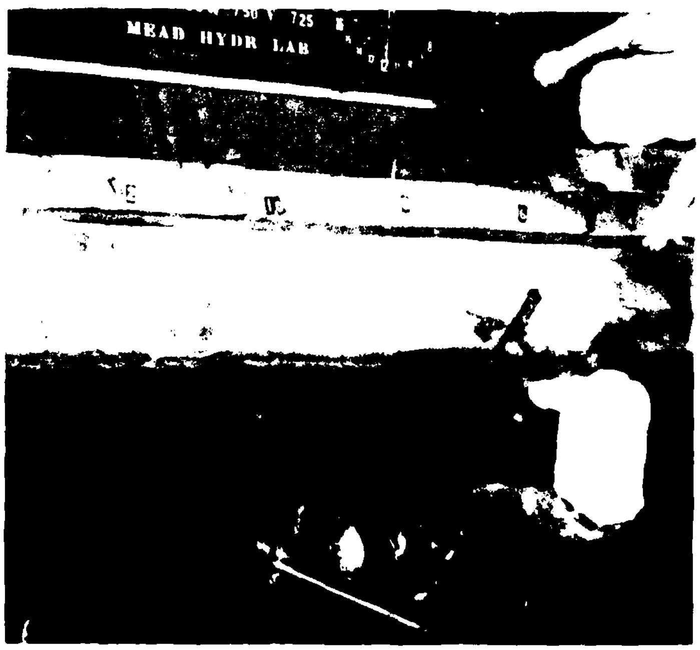
These model tests were preliminary to a more extensive study on hard points and were conducted to determine the effect of a single hard point structure on the bank and stream bed utilizing an L-Head or dike extension with varying orientations of the root section.

One test was also conducted to determine the effect of a pair of hard point structures.

MODEL LAYOUT

The channel of the test model had a top width of 7 feet with an average depth of 0.25 feet. The test area was along the right bank of a reach which was approximately 40 feet long. The test structure was located at station 6.0, six feet downstream from the entrance to the test area. An additional 25 feet was provided at each end of the test area to avoid entrance and exit effects. Finely ground walnut shells were used as the bed material for the model test. Crushed limestone rock with a median size of approximately 2.7 mm. was used as the structure riprap. For a more detailed description of the bed material and operating procedures, see MRD HYDRAULIC LABORATORY SERIES REPORT NO. 1.

Photograph 1. Leveling test bank by using a male template fixed to a carriage on a rail traverse.



Photograph 2. Excavation of the root trench into the right bank.

TEST PROCEDURES

The test procedures utilized to insure repeatable conditions and uniform data collection were as follows:

1. The channel bank in the test area was completely rebuilt before each test. It was shaped to the desired configuration by pulling a male template back and forth across the bank material. See photo 1. The template was mounted on a carriage which rolled along a system of uniform elevation railing. This resulted in a berm with a top elevation of 1.500 feet, a top width of 1.6 foot, a length of 20 feet, and a bank slope of 1 vertical to 2 horizontal.

2. A trench for the hard point root was then cut in the bank and the rock structure was built by placing the crushed limestone riprap into the trench. See photo 2.

3. The berm was then gridded with .05 ft. wide lines using a white powder. The grid lines were spaced 1.0 ft. by 0.4 ft. with the larger spacing parallel to the channel. This grid system served as a reference to measure bank erosion while the model was in operation. See photo 3.

4. The run information sign was set up and the clock which measured elapsed time of run was set to zero hours.

5. To prevent premature bank erosion, water was added very slowly to the model.

6. The model water surface elevation at the control, 25 feet upstream from Station 6.0, was held constant at 1.360 feet during all runs.

7. Photographs of the model were taken at the start and the end of each test run.

8. After the model was filled and a run was ready to begin, the time-lapse camera was started (time intervals of 20 seconds were used during the first two hours, 70 seconds during the night, and 20 seconds during the drain-down period).

9. The model discharge was controlled during each run so as to provide an average flow of about 0.73 c.f.s. See Table I.

ANALYSIS OF THE MODEL RESULTS.

The analysis of the model results was based on (a) visual comparisons of the channel contour maps, (b) data extracted from scour hole contour maps, (c) still photos, and (d) time-lapse photography taken when the model was in operation for each of the various runs. In evaluating the test results, it should be kept in mind that a very small number of model tests were conducted. Because the model was unverified, it is difficult to translate accurately the model data to prototype structures.

Photograph 3. Marking procedure for the horizontal reference lines on the test bank. Note hard point structure in place.

TABLE I

OBSERVED MODEL PARAMETERS

Run No.	Discharge c.f.s.	Slope 10^{-4}	Run Time Hours
2	.723	9.94	19.5
3	.732	7.56	20.0
4	.734	7.59	19.0
5	.733	8.17	19.5
6	.728	6.28	22.25
7	.731	7.93	19.75
8	.730	6.88	21.50

The channel maps are contour charts of the channel bed. Reproductions of the channel maps are not shown in this report. These contour charts showed the general channel characteristics of size and shape of bed scour and the structure effects on local erosion. The scour hole contour maps were extracted from the channel maps to show local effects of the hard point structures. See plate 2. The data which were extracted from the scour hole contour maps were plotted on graphs so as to detect changes and evaluate trends associated with the different structure variations. See plate 3.

The still photographs show structure placement, rock dispersal of the hard point root, and the limits of bank erosion. The shape of the scour hole, bed dunes and channel configurations are also shown in the still photographs. See photographs 6 through 17.

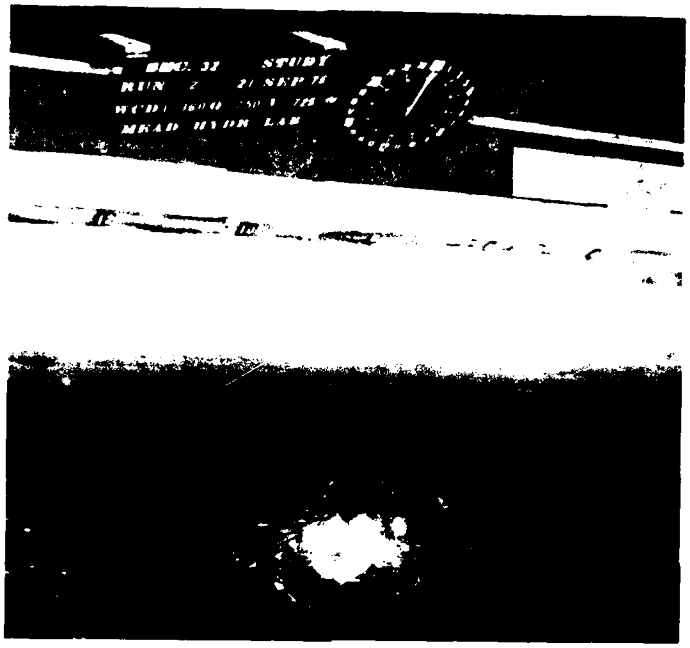
The time-lapse film shows the progress of bank erosion and hard point rock dispersal during each model run. This film revealed that bank erosion occurred for approximately the first 10 hours of run time and then held fairly constant for the remainder of the run time. The slow-motion film indicates the surface flow patterns around the hard point structures. The scallop upstream from the hard point structure and the eddy round-out downstream from the hard point structure occurred in all of the test runs.

The channel contour maps indicated that the overall channel configurations generally remained the same through all of the test runs. That is, the bar buildup on the left side of the channel, the deep channel area through the center of the reach, and the sediment deposit along the right side of the channel represent typical conditions which existed in all of the model runs. Photographs 4 through 17 show in detail the before and the after situations for each model run.

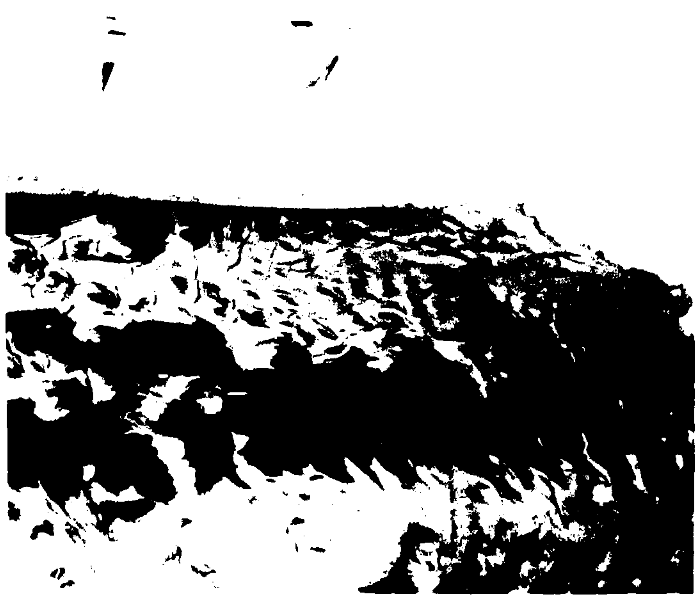
Test run 2 had no hard point structures positioned in the right channel bank. This run was used to determine the amount of bank area which would be removed by erosion without any type of protection. At the upstream end of this run (station 1.7), the flow expanded off the end of the fixed rock revetted slope and caused the right bank erosion to extend to station 6.5. See photos 4 and 5 and plate 2. Station 6.0 was, therefore, selected as the location for the various hard point structures in the forthcoming model tests.

The layouts of the different hard point structures are shown on plate 2 and in photographs 6 through 17. For test runs 3, 7, and 8, the hard point structures were constructed out to the edge of the channel bank. For test runs 4, 5, and 6, the hard point structures were extended 0.5 foot further into the channel. This was done in an attempt to determine if this would decrease the amount of bank erosion which occurred downstream from the hard point structures.

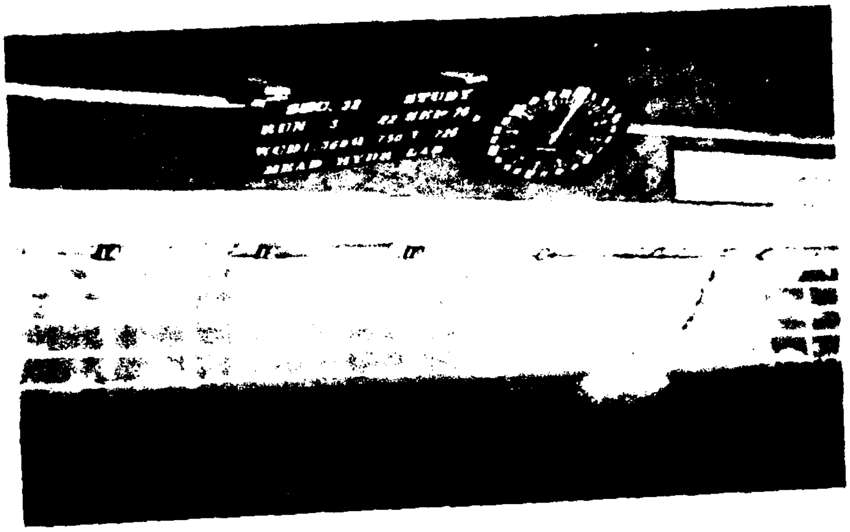
Runs 3 through 8 (plate 2) indicate the amount of bank erosion, which occurred in run 2, was considerably reduced by a hard point structure located at station 6. Runs 4, 5, and 6 had more bank area saved than the other runs.



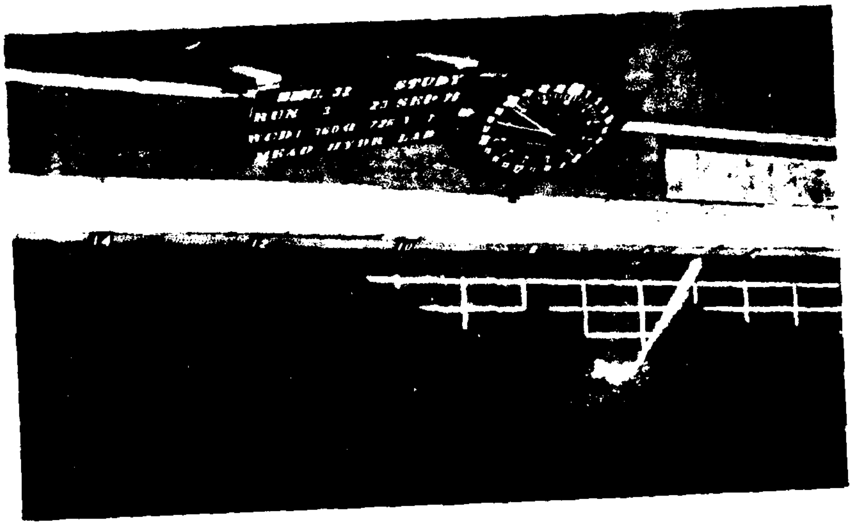
Photograph 4. Test bank arrangement prior to run 2. Notice that this run had no hard point structure.



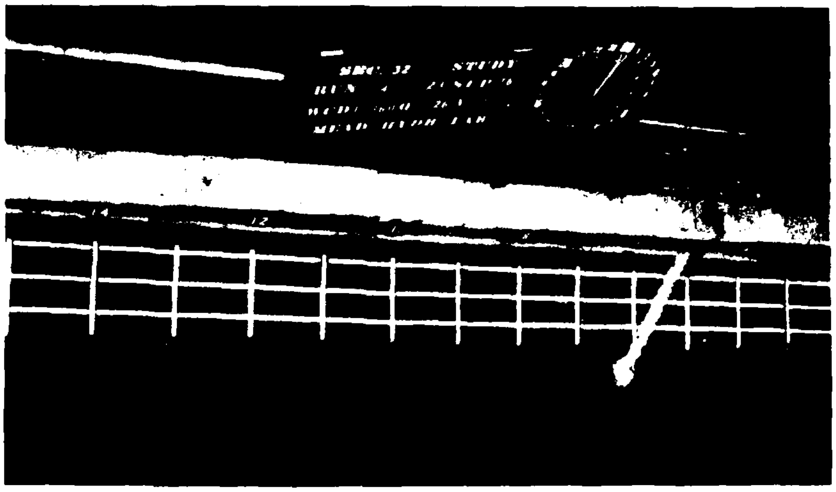
Photograph 5. Resulting channel bed and bank configurations at the end of run 2.



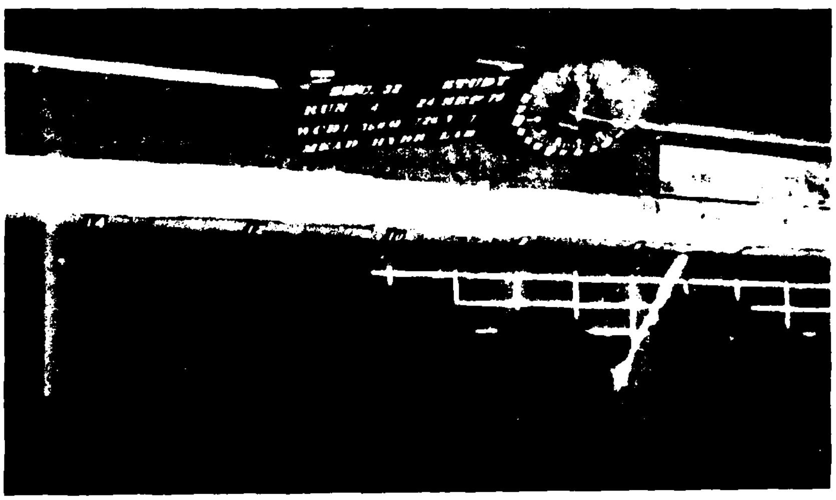
Photograph 6. Test bank arrangement prior to run 3.



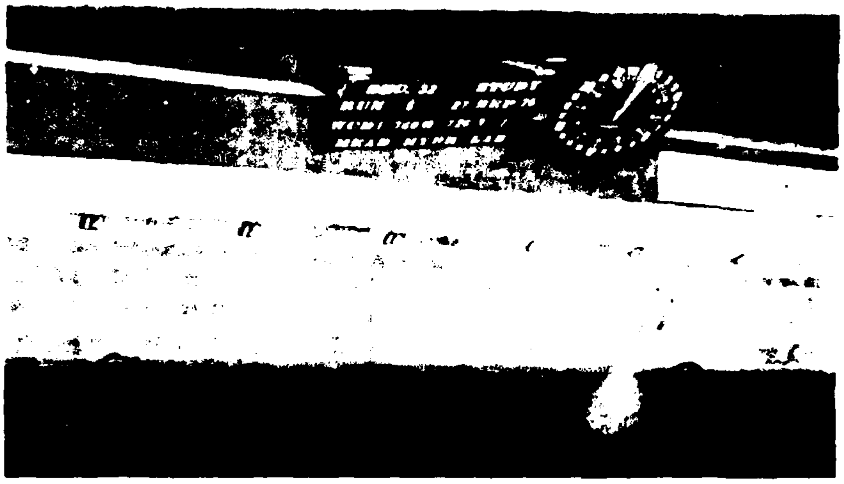
Photograph 7. Resulting channel bed and bank configurations at the end of run 3.



Photograph 8. Test bank arrangement prior to run 4.

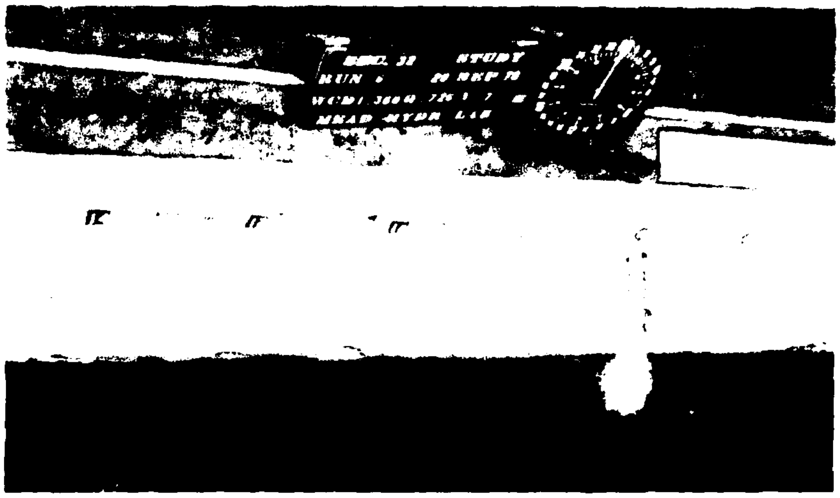


Photograph 9. Resulting channel bed and bank configurations at the end of run 4.



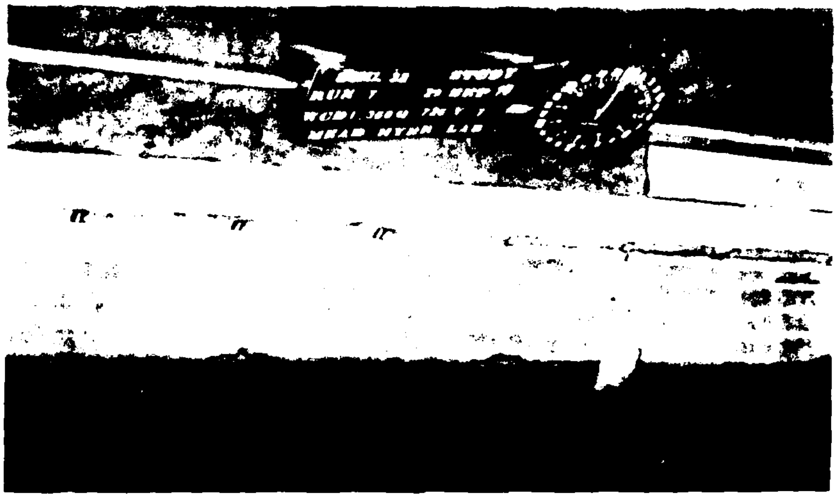
Photograph 10. Test bank arrangement prior to run 5.

Photograph 11. Resulting channel bed and bank configurations at the end of run 5.



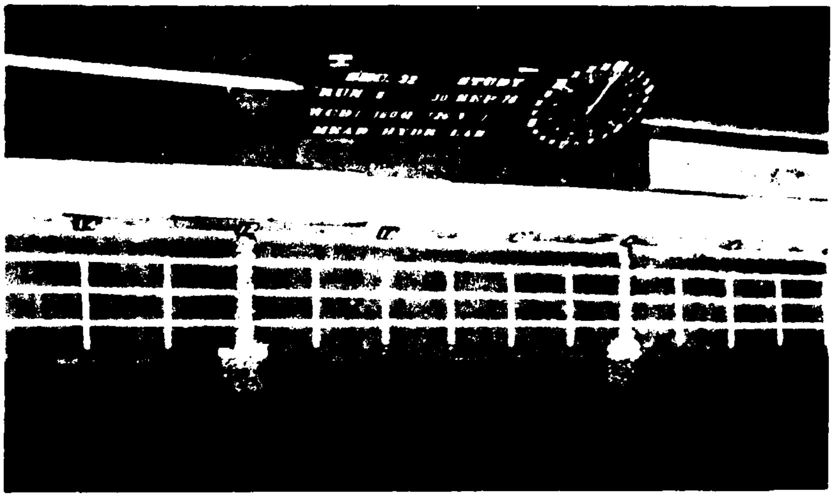
Photograph 12. Test bank arrangement prior to run 6.

Photograph 13. Resulting channel bed and bank configuations at the end of run 6.

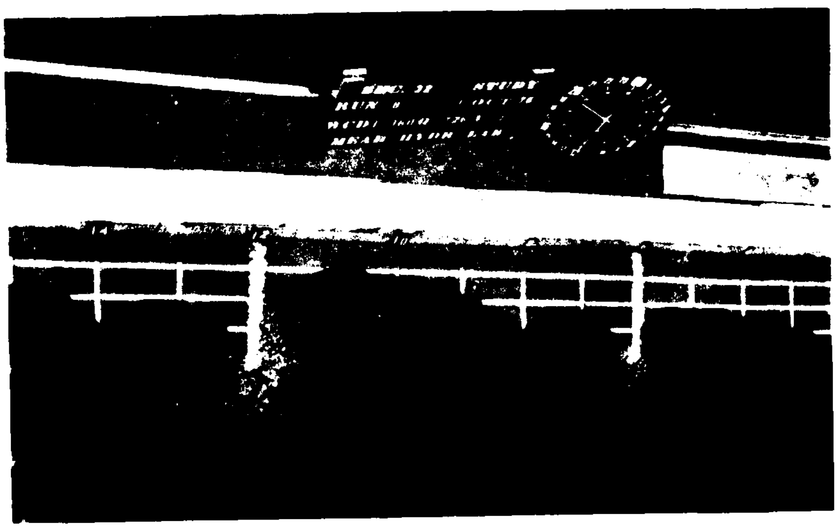


Photograph 14. Test bank arrangement prior to run 7.

Photograph 15. Resulting channel bed and bank configurations at the end of run 7.



Photograph 16. Test bank arrangement prior to run 8.



Photograph 17. Resulting channel bed and bank configurations at the end of run 8.

These runs had structures which extend 0.5 feet further riverward than the other runs. Of these three runs, the structures with angled roots had more bank area protected than the structure whose root was perpendicular to the channel bank. However, the angled root structures had more rock accumulated on the underwater slope than did the perpendicular root structure. See plate 2.

The slow-motion portion of the time-lapse movie indicated that the eddy areas were larger when the structures were placed 0.5 feet further riverward from the channel bank. These structures also had larger and deeper scour holes associated with them. See plate 2. The larger scour holes were created by the increased channel velocities caused by the constriction of the channel from the longer hard point structures. These longer structures had more area of hard point structure exposed to the flow in the channel and, consequently, used a larger amount of riprap to protect the underwater slope. See plate 2. Plots of scour hole lengths, widths, and depths downstream from the ends of the hard point structures are shown on plate 3. The bank erosion line and scour hole angles are also shown on plate 3.

CONCLUSIONS

The following conclusions were developed as a result of this preliminary model investigation.

The angled placement of the rock and the 0.5 foot riverward extension for the hard point structures of runs 4 and 5 resulted in somewhat larger scour holes than runs 6 and 7 which had perpendicular structure roots. Runs 4 and 5 also had the most bank area protected from erosion; however, these two runs had the largest area of rock dispersal on the underwater slope of hard point structure. This shows that the greater the area of the hard point structure under attack from channel flows the greater the amount of rock dispersal on the underwater slope.

The effect of the 0.5 foot riverward extension of a perpendicular root structure can be seen in the comparison of run 6 with run 7. The extension of the structure in run 6 protects more bank area downstream but uses a greater quantity of rock to armor the upstream slope of the hard point structure. The channel constriction caused by the hard point extension increases the channel velocities and, thus, results in a larger and deeper scour hole.

The effect of a pair of hard point structures compared to a single hard point structure can be seen in the comparison of run 7 to run 8. The pair of structures have considerable more bank area protected than the single structure. There is only a small difference in the amount of rock used on the underwater hard point slope between the pair of structures and the single structure. Therefore, more bank can be protected from erosion and not much of an increase in the amount of rock per structure will occur with the pair of hard point structures.

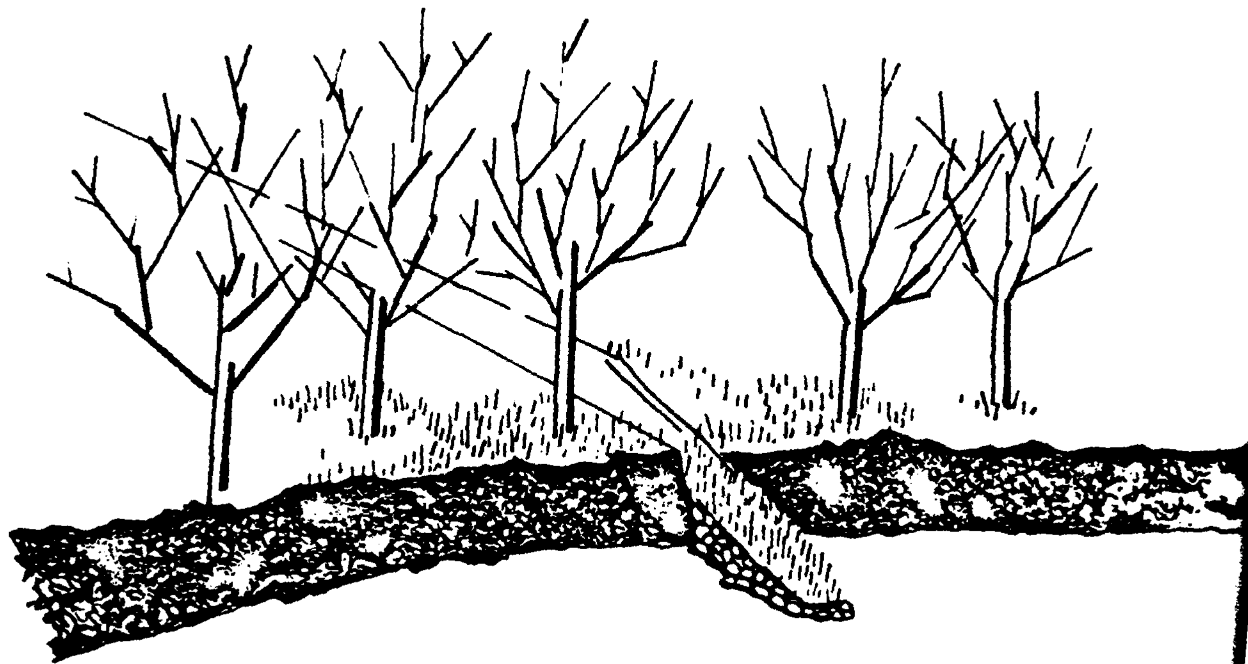
These conclusions would indicate that the hard point structures which have angled root placements have advantages and disadvantages over structures with perpendicularly placed roots. The apparent advantage is the increased amount of channel bank which is protected from erosion. The apparent disadvantage if that more rock is used to armor the underwater slope of the hard point structure with the angled root placement.

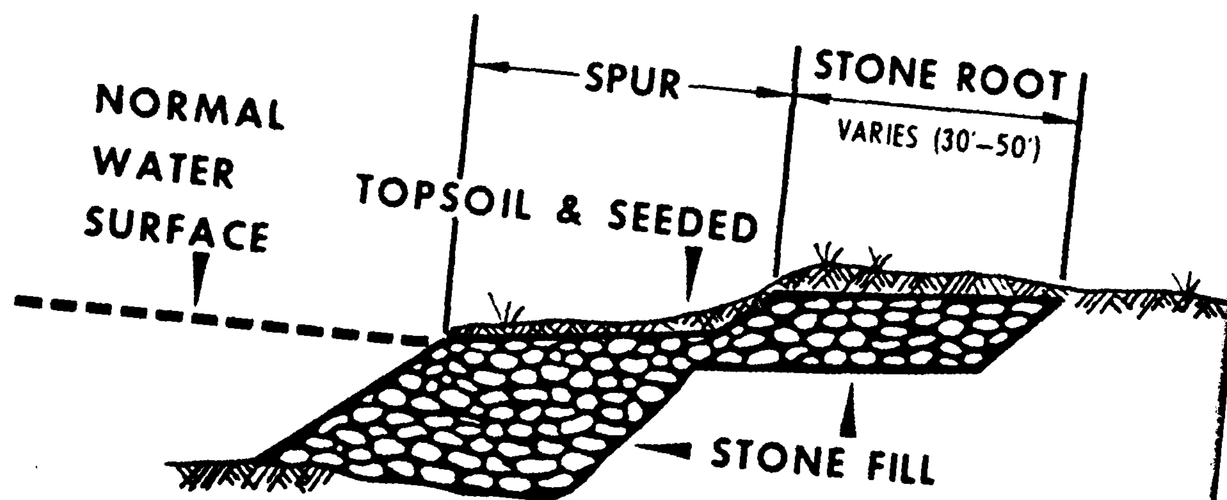
These conclusions also would indicate that a pair of hard point structures have advantages over a single structure. The advantage is that more bank can be protected from erosion and with not much of an increase in the amount of rock used on the underwater slope per hard point structure.

Future studies to investigate this type of erosion control should include bends with varying flow velocities to provide different attack conditions on the hard point structures and their integral bank area. Other hard point shapes should also be considered. The effects of structure overtopping should also be investigated. The previously mentioned conditions should also be investigated for a field of hard point structures.

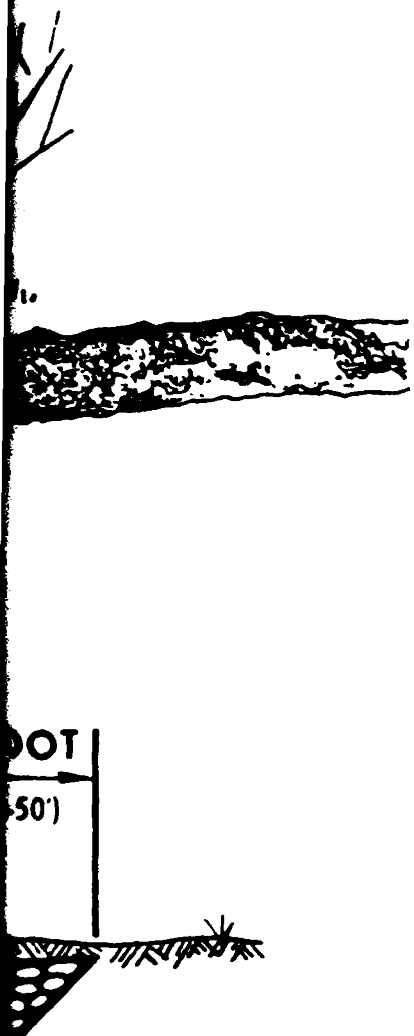
The time-lapse film is also available for viewing.

APPENDIX





TYPICAL SECTION



SECTION 32 DESIGN STUDY

EROSION CONTROL USING HARD POINTS

TYPICAL SECTION

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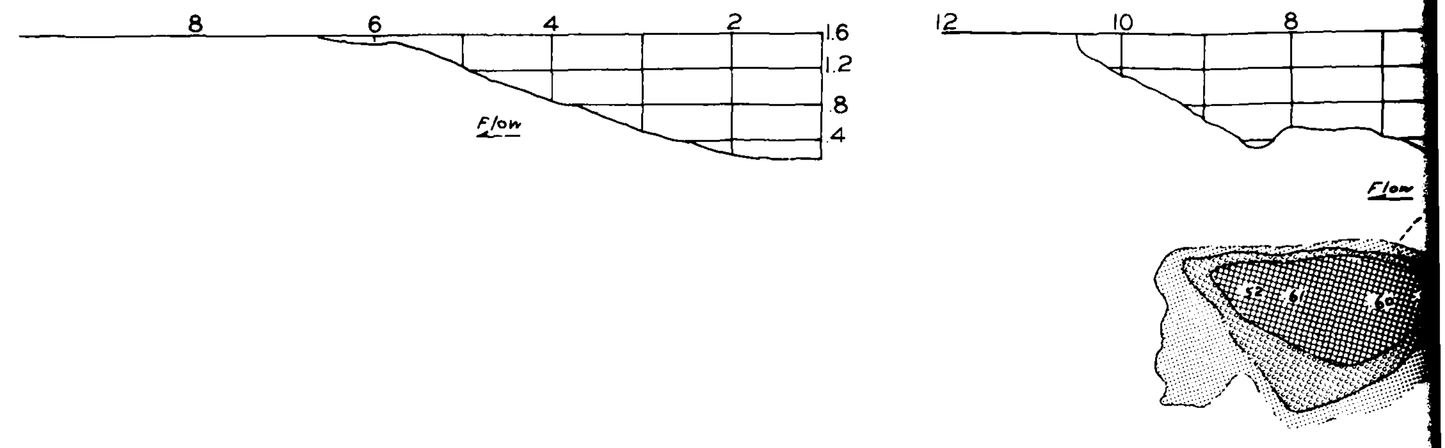
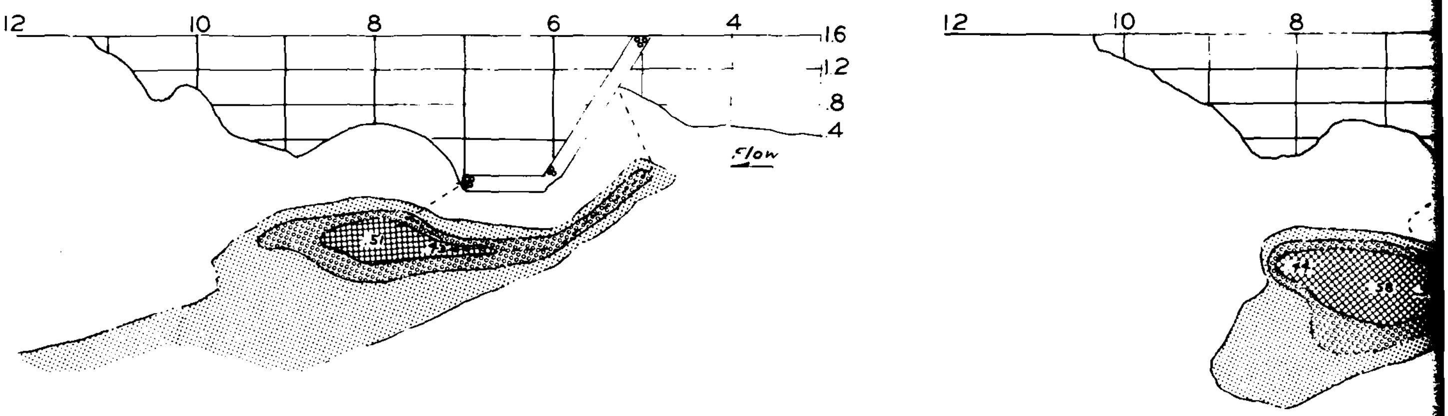
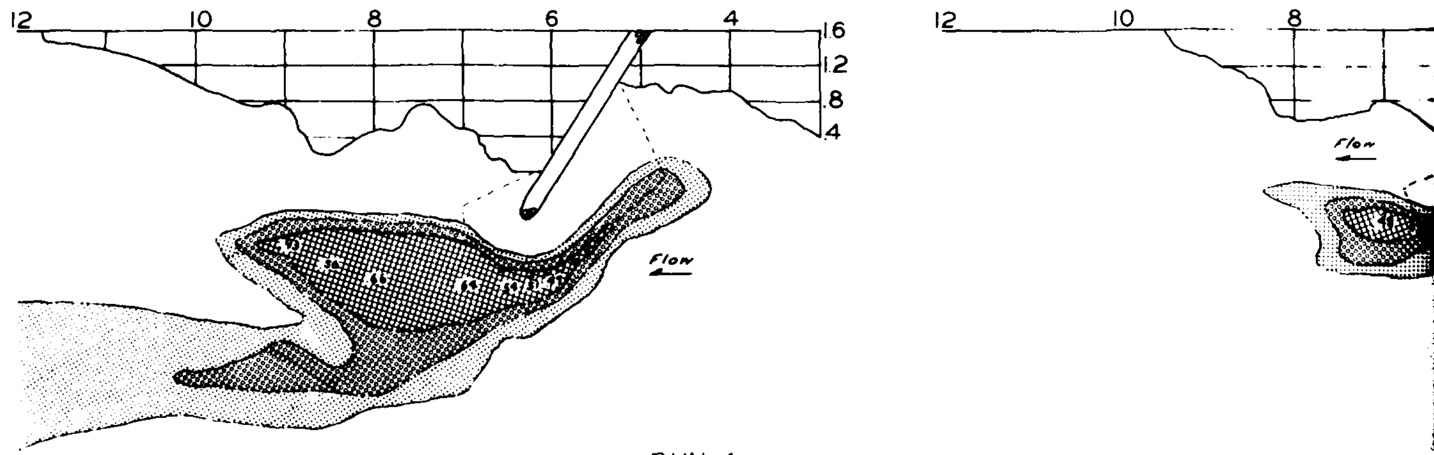
PLATE I 2



RUN 2

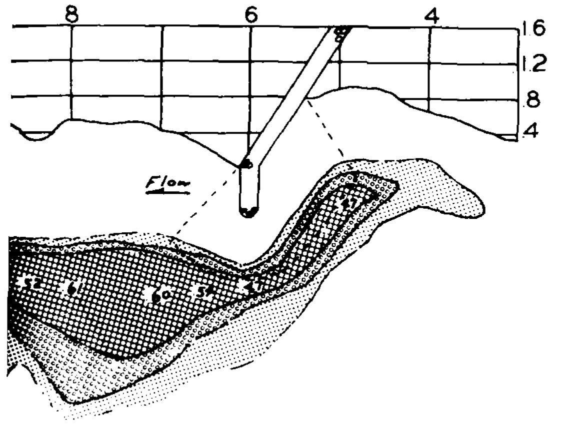


RUN 3

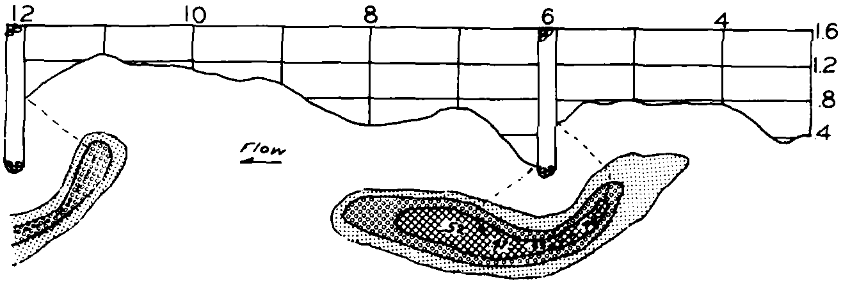


RUN 4

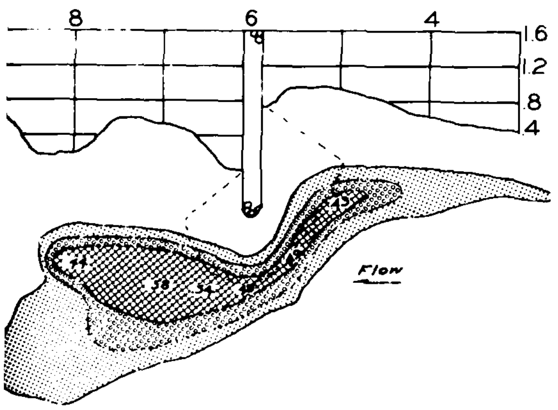
/



RUN 5



RUN 8



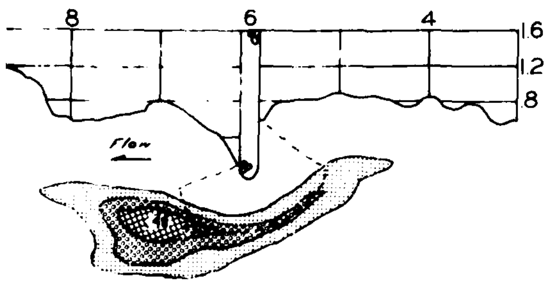
RUN 6

LEGEND:

- OVER .42 FEET
- .36 - .42 FEET
- .30 - .36 FEET
- .24 - .30 FEET

NOTES:

1. VALUES WITHIN THE SCOUR HOLES ARE MEASURED DEPTHS.
2. NUMBERS ALONG THE GRID ARE REFERENCE POINTS IN FEET.



RUN 7

SECTION 32 DESIGN STUDY

EROSION CONTROL USING HARD POINTS

RESULTS OF TEST RUNS

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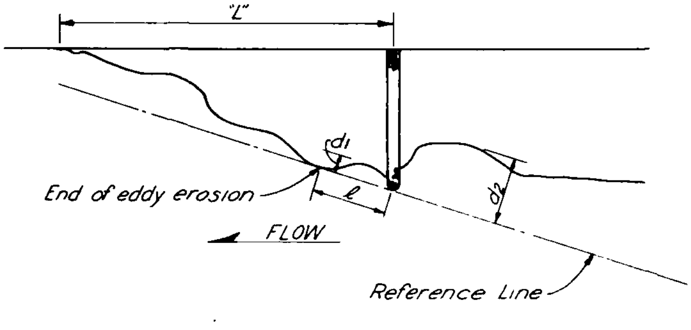
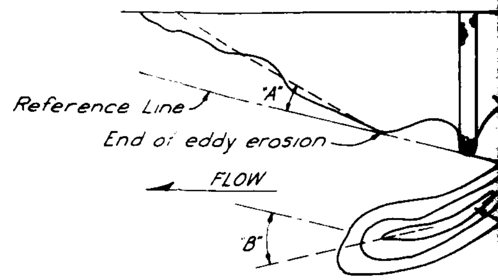
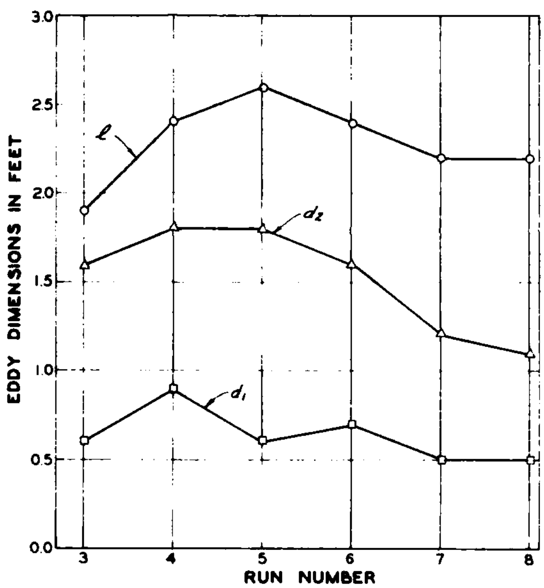
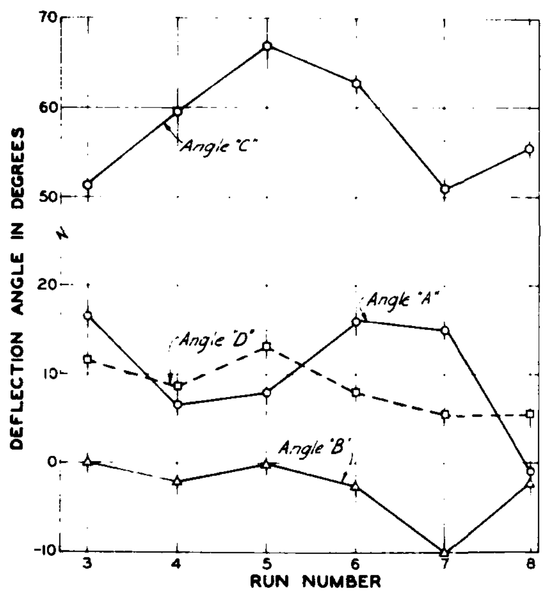

"L"
d1
End of eddy erosion
ℓ
d2
FLOW
Reference Line

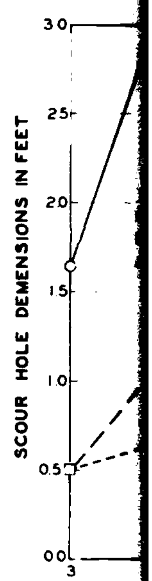
KEY

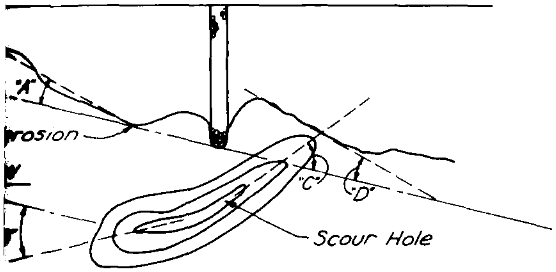

Reference Line
"A"
End of eddy erosion
FLOW
"B"

KEY

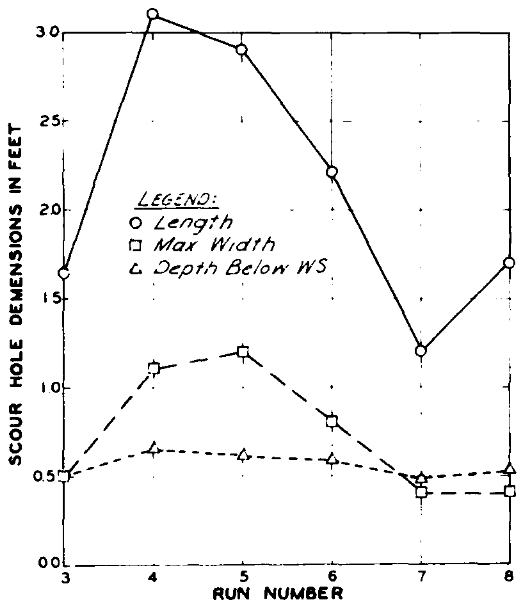

EDDY DIMENSIONS IN FEET
RUN NUMBER
ℓ
d2
d1
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3
4
5
6
7
8

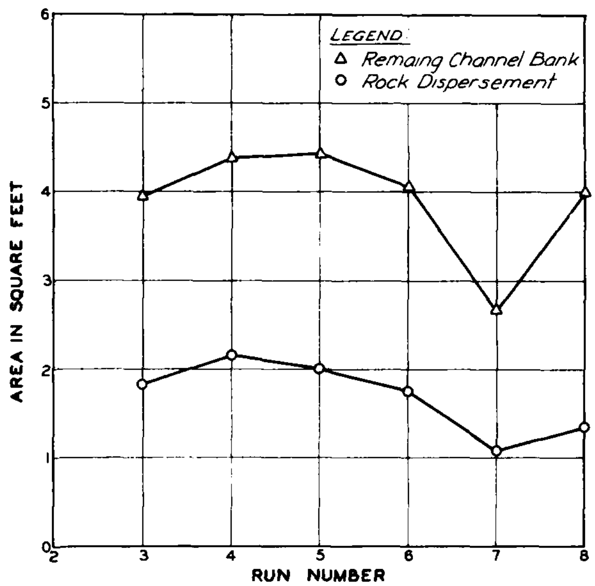

DEFLECTION ANGLE IN DEGREES
RUN NUMBER
Angle "C"
Angle "A"
Angle "D"
Angle "B"
70
60
50
20
10
0
-10
3
4
5
6
7
8


SCOUR HOLE DEMENSIONS IN FEET
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3



KEY





SECTION 32 DESIGN STUDY

EROSION CONTROL USING HARD POINTS

STRUCTURE EFFECTS ON LOCAL EROSION

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
OCT 1978

DATE
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