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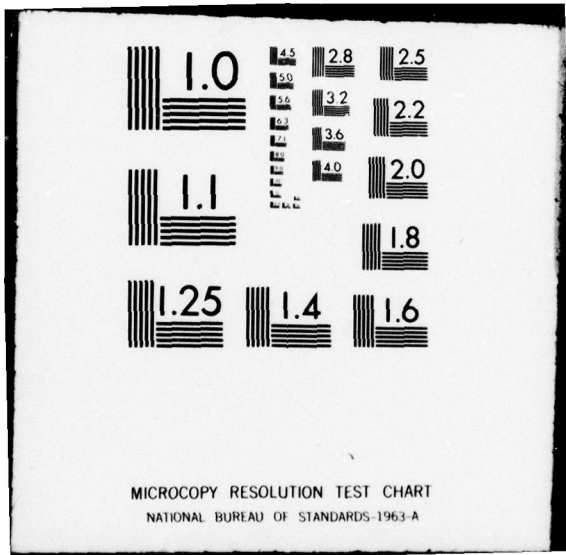
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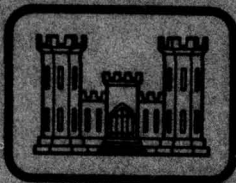




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TECHNICAL REPORT H-78-24

**NAVIGATION CONDITIONS IN ALEXANDRIA  
REACH, RED RIVER NAVIGATION PROJECT  
LOUISIANA**

Hydraulic Model Investigation

by

Louis J. Shows, John J. Franco

Hydraulics Laboratory

U. S. Army Engineer Waterways Experiment Station  
P. O. Box 631, Vicksburg, Miss. 39180

December 1978

Final Report

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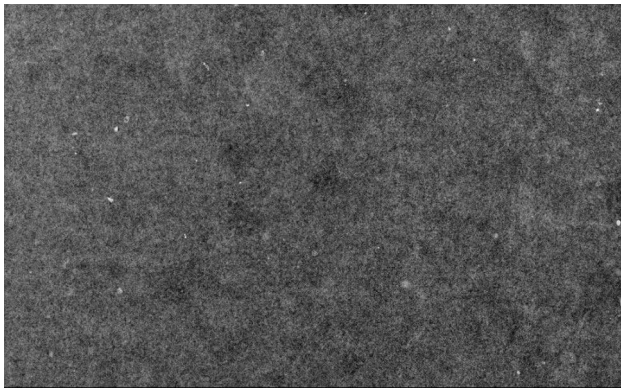
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New Orleans, Louisiana 70160

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NAVIGATION CONDITIONS IN ALEXANDRIA REACH, RED RIVER NAVIGATION PROJECT, LOUISIANA

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| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Alexandria Reach is a section of the Red River approximately 87.3 miles upstream of the junction of the Red and Mississippi Rivers. The reach is included in the Red River Navigation Project and will be about 14 miles upstream of Lock and Dam No. 2. There are five bridges in the reach within a distance of less than 2 miles. A fixed-bed model reproducing about 3.5 miles of the river in the vicinity of Alexandria, Louisiana, to an undistorted scale of 1:100 was used to determine navigation conditions through the reach and to<br>(Continued) |                       |   |

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20. ABSTRACT (Continued).

CONT → develop modifications required to eliminate any adverse conditions indicated. The model investigation was concerned principally with navigation conditions approaching and through the bridges. Results of the investigation indicated the following:

With existing conditions, navigation through the reach will tend to be hazardous, particularly for downbound tows because of the arrangement and limited width of the navigation spans, the channel and current alignment approaching the bridges, and the high-velocity currents.

→ The high-velocity currents with the water-surface elevations anticipated in the reach indicate that some scouring of the channel bed and changes in channel cross section can be expected with the completed project.

Navigation conditions through the reach with the existing bridges can be improved by modification of the revetment along the left bank in the cutoff and just downstream of the cutoff, excavation of the right bank between the two upper bridges, excavation and addition of a dike along the left bank upstream of the U. S. Highway 165 Bridge, and addition of submerged dikes along the right bank.

Navigation conditions in the lower reach would be considerably better with the replacement of the U. S. Highway 165 Bridge.

→ Navigation through the reach will tend to be hazardous because of the limited widths of spans divided by a center pier, alignment of the channel and bridge spans, and short distance between some of the spans. Satisfactory navigation conditions would require the use of tows with sufficient power and maneuverability to maintain control and alignment and widths of tows limited to 35 ft. ↑

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PREFACE

The model investigation reported herein was authorized by the Office, Chief of Engineers, U. S. Army, in 2nd indorsement dated 17 July 1973 to the Division Engineer, Lower Mississippi Valley. The study was conducted for the U. S. Army Engineer District, New Orleans (LMN), in the Hydraulics Laboratory of the U. S. Army Engineer Waterways Experiment Station (WES) during the period October 1973 to April 1976.

The investigation was conducted under the general supervision of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory, and Mr. F. A. Herrmann, Jr., Assistant Chief of the Hydraulics Laboratory, and under the direct supervision of Mr. J. E. Glover, Chief of the Waterways Division. The engineer in immediate charge of the model was Mr. L. J. Shows, Chief of the Navigation Branch, assisted by Messrs. R. T. Wooley and J. M. Ross. This report was prepared by Messrs. Shows and J. J. Franco.

During the course of the model study, representatives from LMN, Louisiana Department of Highways, and Louisiana Department of Public Works visited WES at different times to observe special model tests and discuss the results. LMN was kept informed of the progress of the study through monthly progress reports and special reports at the end of each test.

Directors of WES during the course of this investigation and the preparation and publication of this report were COL G. H. Hilt, CE, and COL John L. Cannon, CE. Technical Director was Mr. F. R. Brown.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)  
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

| <u>Multiply</u>       | <u>By</u>  | <u>To Obtain</u>        |
|-----------------------|------------|-------------------------|
| feet                  | 0.3048     | metres                  |
| miles (U. S. statute) | 1.609344   | kilometres              |
| feet per second       | 0.3048     | metres per second       |
| cubic feet per second | 0.02831685 | cubic metres per second |
| degrees (angle)       | 0.01745329 | radians                 |

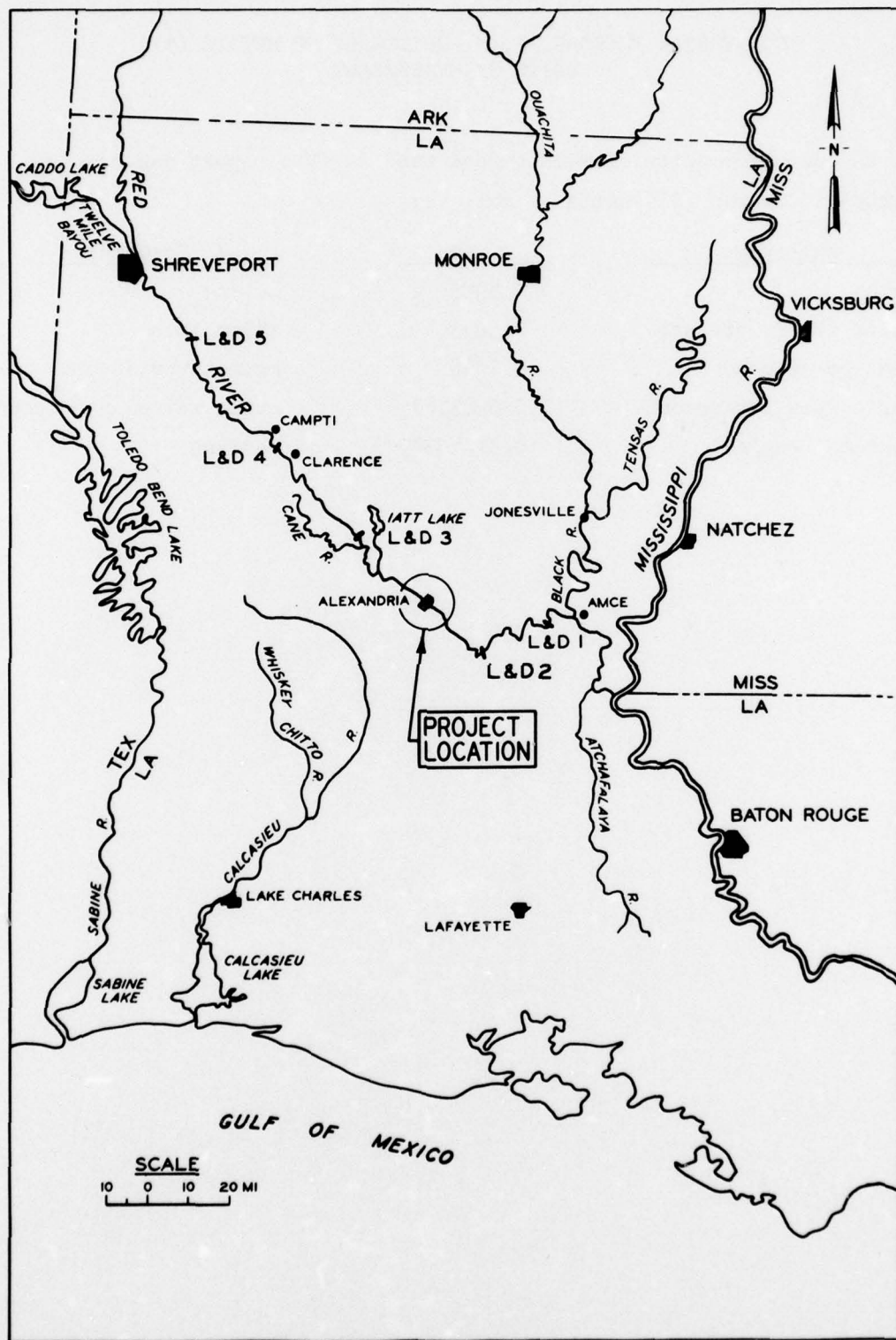


Figure 1. Location map

NAVIGATION CONDITIONS IN ALEXANDRIA REACH  
RED RIVER NAVIGATION PROJECT, LOUISIANA

Hydraulic Model Investigation

PART I: INTRODUCTION

Present Development Plan and  
Description of Prototype\*

1. As presently authorized, the Red River multipurpose project provides for the improvement of the Red River and its tributaries in Louisiana, Arkansas, Texas, and Oklahoma through the coordinated developments to serve navigation, bank stabilization, flood control, recreation, fish and wildlife, and water-quality control. The project consists of four distinct reaches: (a) Mississippi River to Shreveport, Louisiana; (b) Shreveport, Louisiana, to Dangerfield, Texas, by Twelve Mile Bayou; (c) Shreveport, Louisiana, to Index, Arkansas; and (d) Index, Arkansas, to Denison Dam, Texas. Within the first reach, the plan provides for establishing a navigable channel, approximately 227 miles\*\* long, 9 ft deep, and 200 ft wide from the vicinity of Old River by means of a system of five locks and dams, that connects with the Mississippi River through the Old River Lock and Dam (Figure 1).

2. From Denison Dam the Red River follows an easterly course along the southern edge of Oklahoma, forming the boundary between that state and Texas, and continues eastward some 47 miles farther to Index, Texas-Arkansas, forming the boundary between Texas and Arkansas. Continuing through Arkansas a short distance beyond Index to Fulton, Arkansas, the river then turns abruptly and follows a southerly course for some 77 miles to the Arkansas-Louisiana State line. The remainder of its course lies within the State of Louisiana. At Shreveport, it shifts to a southeasterly direction, for some 160 miles to its mouth at the

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\* Prototype information was obtained from John H. Overton Lock and Dam Memorandum No. 18, dated May 1977.

\*\* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

junction with the Atchafalaya and Old Rivers, 7 miles from the confluence of Old River and the Mississippi River at Red River Landing. Since 1963, flow from the Mississippi River into the Atchafalaya system has been regulated by control structures near the Mississippi River levee line where an excavated channel carries outflow to the lower Red River. A 75-ft-wide by 1,200-ft-long lock at the mouth of Old River provides for navigation between the Mississippi and the Red-Atchafalaya Rivers via the Old River channel.

3. From Alexandria to its mouth, the Red River traverses the floodplain of the Mississippi River. On the right (south) bank, from the hills above Alexandria to high ground at Moncla, Louisiana, a levee that is part of the Lower Mississippi River Levee System protects the alluvial lands south of Red River and west of Atchafalaya Floodway. From Moncla to Lake Long, a local levee provides partial protection from headwater overflows. The banks rise 35 to 40 ft above low water and in general are 700 to 800 ft apart. The slope of the water surface below Alexandria is dependent upon the stage in the Red River backwater area as affected by operation of Old River Control Structure.

4. Public Law 90-483, 90th Congress, approved 13 August 1968, authorized the construction of the "Red River Water, Louisiana, Texas, Arkansas, and Oklahoma Project," in accordance with the recommendations of the Chief of Engineers as contained in House Document No. 304, 90th Congress, 2nd Session. The Appropriations Act of 1971, approved 7 October 1970, as Public Law 91-439, provides the authority to initiate pre-construction planning from the Mississippi River to Shreveport, Louisiana, reach of the project.

#### Alexandria Reach

5. The Alexandria reach is located on the Red River approximately 87.3 miles above the junction of the Red River with the Mississippi River. The reach will be located in navigation pool 2, about 14 miles upstream from the proposed Lock and Dam 2 (John H. Overton Lock and Dam). There are five bridges within a distance of less than 2 miles in the

vicinity of the city of Alexandria, Louisiana. The two upstream bridges are located in bends of the river and the three downstream bridges are within a distance of about a half mile and in a fairly straight reach of the river. However, the navigation spans on the lower three bridges are not in line one with each other or with the river channel. The upper and lower bridges are of the swing-span type with spans of 361 ft and 302 ft, respectively, divided by the pivot piers.

#### Need for and Purpose of Model Study

6. The improvement of the Alexandria reach of the Red River involves the development of regulating structures that would provide the required channel alignment through the reach without producing currents hazardous to navigation. Navigation of the reach is complicated by the alignment of the channel, the limited width of the navigation spans at four of the bridges, the location of the spans with respect to the channel alignment, the alignment of the bridge spans (particularly of the lower three bridges), and the short distance between the three lower bridges. The problem involved the development of an adequate and stable channel for navigation with and without the replacement of the existing U. S. Highway 165 Bridge. Because of the complex nature of flow in natural streams and the requirement for navigation through the existing bridges in the Alexandria reach, an analytical analysis of the conditions that could be reasonably expected with existing conditions and proposed improvement would be extremely difficult and inconclusive. Therefore, a hydraulic model investigation of the reach was considered necessary to determine the following:

- a. The effects of Lock and Dam 2 and the proposed cutoff upstream on navigation through the reach with the existing bridges.
- b. Regulating and training structures and channel modification that might be required to provide satisfactory navigation conditions through the reach.
- c. The effect on navigation of a replacement for the existing U. S. Highway 165 Bridge.

- d. The conditions resulting from the proposed design for the Louisiana Highway Department and those concerned with planning, design, and operation of the project.

## PART II: THE MODEL

### Description

7. The model reproduced about 3.5 miles of the Red River and adjacent overbank areas beginning at about 0.5 mile downstream from the Louisiana and Arkansas Railroad bridge (L&ARR) at river mile 104\* and extending upstream about 1 mile above the Missouri and Pacific Railroad bridge (MPRR), Figure 2. The lower end of the model would be about 14 miles upstream of the proposed John H. Overton Lock and Dam. The model was of the fixed-bed type with the channel and overbank areas molded in sand-cement mortar to sheet-metal templates except for the proposed cutoff channel on the right overbank upstream of the MPRR bridge which was molded in pea rock to facilitate any adjustment of the channel that might be required. The bridges were constructed of sheet metal and assembled on a baseplate.

8. The model, except for the cutoff channel at the upstream end, was molded in accordance with a hydrographic and topographic survey completed in April 1968. The proposed cutoff channel at the upstream end of the model was molded to a cross section considered typical for that particular reach of river.

### Scale Relations

9. The model was built to an undistorted linear scale of 1:100, model to prototype, to obtain accurate reproductions of velocities, crosscurrents, and eddies that would affect navigation. Other scale ratios resulting from the linear scale ratio were: area 1:10,000, velocities and time 1:10; discharge 1:100,000; and roughness (Manning's  $n$ ) 1:2.15. Measurements of discharge, water-surface elevations, and velocities are transferable quantitatively from model to prototype equivalents by means of these scale relations.

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\* River miles are above the junction of the Red and Mississippi Rivers.

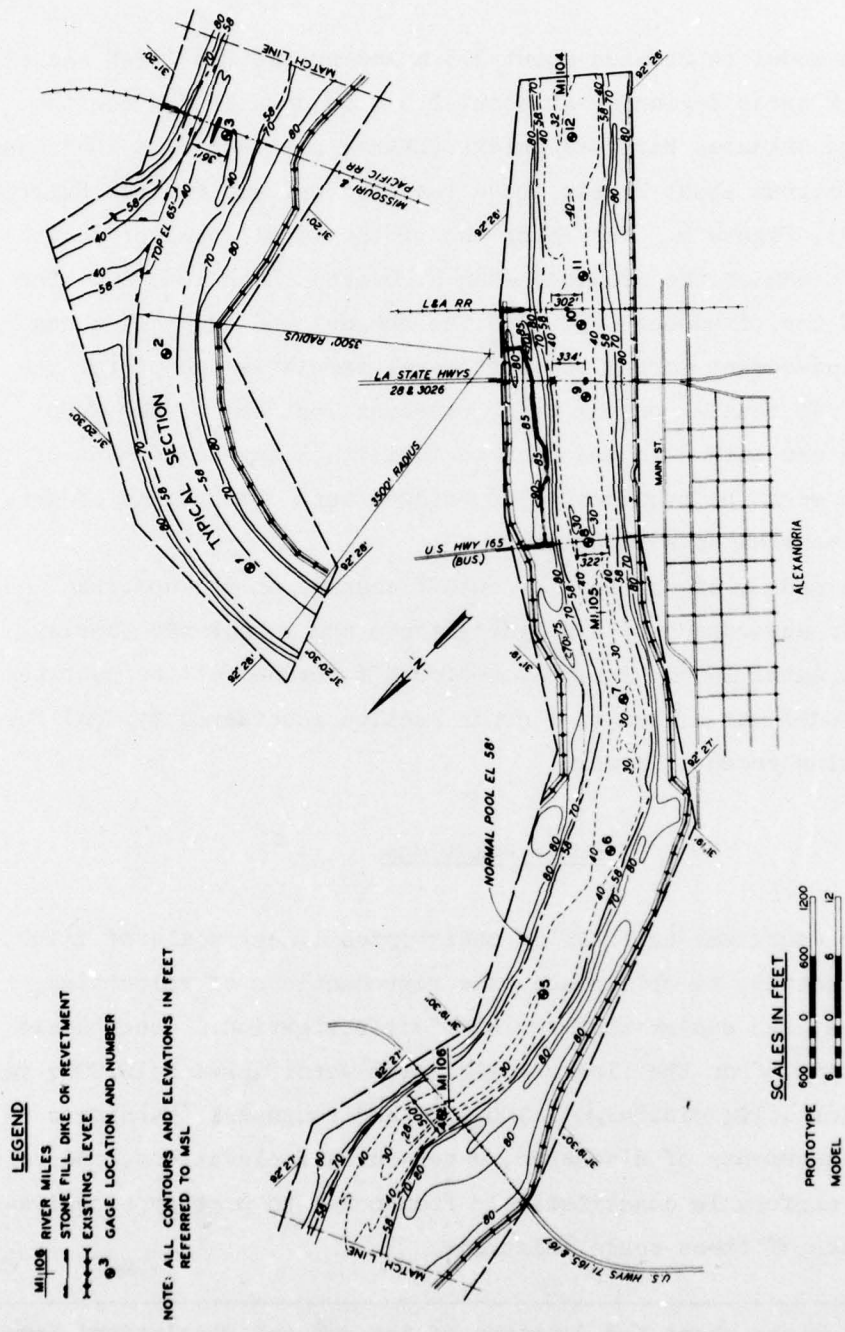


Figure 2. Model layout and location of gages



### Appurtenances

10. Water was supplied to the model from a comprehensive circulating system, and discharge was measured at the upper end of the model by means of a venturi meter. Water-surface elevations were measured by means of 10 piezometers located in the model channel and connected to a centrally located gage pit (Figure 2). Stages were controlled by introducing the desired discharge at the upper end of the model and controlling the tailwater elevations by means of a tailgate located at the lower end of the model.

11. Velocities and current directions were determined in the model by means of wooden cylinder floats weighted on one end to simulate the maximum permissible draft for loaded barges using the waterway (9 ft prototype). A model towboat and tow were used to determine and demonstrate the effects of currents on tows navigating through the bridges (Figure 3). The overall size of the towboat and tow used in this study

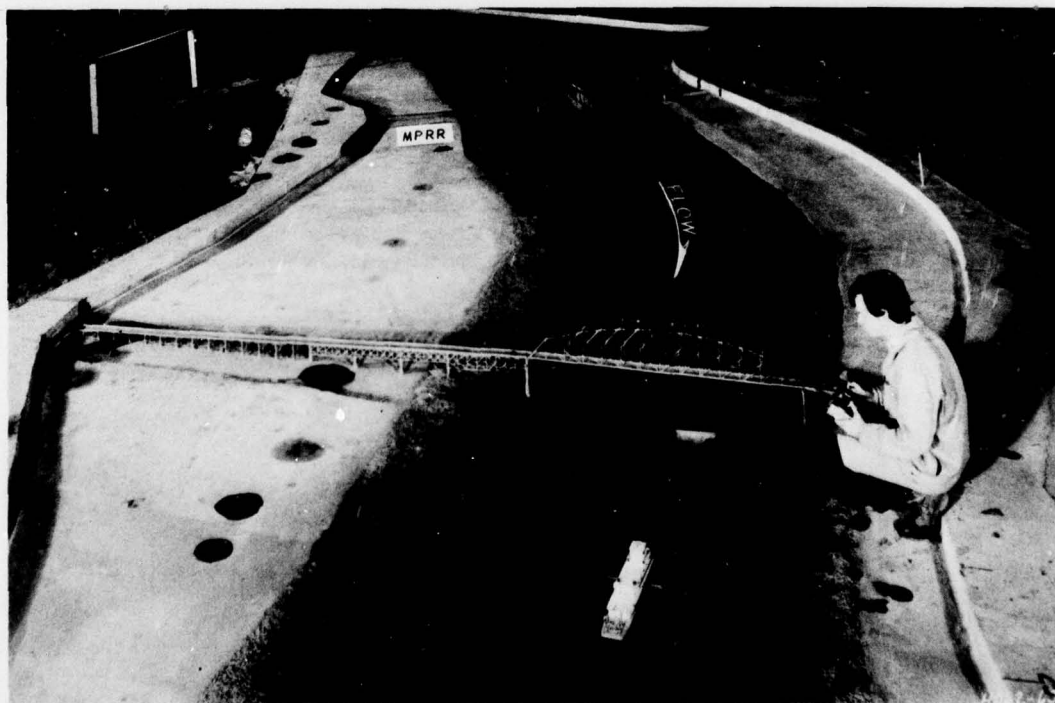


Figure 3. Remote-controlled towboat and tow in upper reach of model

was 685 ft long by 35 ft and 70 ft wide loaded to a draft of 9 ft. The towboat was propelled by two small electric motors operating from batteries located in the tow; the rudders and speed were remote-controlled. The towboat could be operated in forward or reverse with the power adjusted by means of a rheostat to a maximum speed comparable to that of the towboats expected to use the Red River waterway.

#### Model Adjustment

12. Since the model tests were based on conditions that would exist with the proposed John H. Overton Lock and Dam in place, the adjustment of the model to the existing prototype conditions was precluded. This type of adjustment was not considered necessary since the proposed improvements would involve considerable change from existing conditions. The model was constructed with a brushed cement-mortar finish to provide a roughness factor (Manning's  $n$ ) of about 0.011, which corresponds to prototype channel roughness of about 0.026. The channel roughness at the upstream end of the model, which was molded in pea rock, was somewhat greater (about 0.030). Experience with other models of this type has indicated that brushed concrete gives a very close approximation of the roughness required to reproduce prototype conditions.

### PART III: TESTS AND RESULTS

13. Tests were concerned primarily with the measurement of water-surface elevations and the study of currents and velocities, and the effects of the currents on the navigability of the model tow through the reach with existing conditions and various modifications proposed. A number of preliminary tests were made to develop modifications incorporated as part of specific plans. Little data were obtained during these tests and the results are not included in this report.

#### Test Procedure

14. Tests consisted of reproducing selected representative flows and determining current velocities and directions and observing the behavior of the model towboat and tow moving through the reach. Flows were reproduced for the base test by introducing the proper discharge and manipulating the tailgate until the computed water-surface elevations submitted by the U. S. Army Engineer District, New Orleans (LMN), for the Alexandria gage were obtained. All flows were permitted to stabilize before any data were recorded. The flows selected and used during most of the tests were as follows:

- a. Controlled flow 3,600 cfs, water-surface el 58.0,\* average annual low flow.
- b. Controlled flow 31,000 cfs, water-surface el 60.4, average annual flow.
- c. Controlled flow 50,000 cfs, water-surface el 62.8, 18 percent flow.
- d. Open riverflow 72,000 cfs, water-surface el 65.8, 10 percent flow.
- e. Open riverflow 95,000 cfs, water-surface el 69.3, 4.5 percent flow.
- f. Open riverflow 145,000 cfs (maximum navigable discharge), water-surface el 77.0, 10-year frequency flow or 1 percent flow.

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\* Elevations (el) cited herein are in feet referred to mean sea level (msl).

15. Velocities were determined by timing the travel of the floats (described in paragraph 11) over a measured distance. Current directions were ascertained by plotting the paths of the floats with respect to ranges established for that purpose. In the plots of currents in turbulent areas or where eddies or crosscurrents existed, only the main trends are shown in the interest of clarity. The effects of currents on a tow moving through the reach were determined by observation of the behavior of the model tow approaching and passing the bridges in both the upstream and downstream directions.

### Base Test

#### Description

16. The base test was conducted with the model reproducing existing prototype conditions from mile 104 at the downstream end to about mile 106.5 just upstream of the MPRR bridge. From this point to the upstream model limits, the proposed cutoff channel along the right overbank was molded in pea rock and provided a 3500-ft-radius bend along the concave bank with a typical channel cross section having a minimum navigable channel width of 300 ft (Figure 4). The purpose of this test was to determine navigation conditions with existing conditions and various discharges, to obtain data for use in developing proposed improvements, and to provide a basis for determining the effectiveness of various plan modifications.

#### Results

17. Results shown in Table 1 and Plates 1-5 indicate that with the conditions reproduced in this test, water-surface slopes and velocities would tend to be high, particularly in the reach upstream of the MPRR bridge. Maximum velocities in the reach increased to more than 12.0 fps with the 145,000-cfs flow. Velocities in the lower reach were generally lower with the maximum ranging from 8.0 to about 10.0 fps.

18. Alignments of currents in the reach were generally parallel to the bank lines. However, because of the irregular alignment of the channel, location and limited width of the navigation spans, navigation

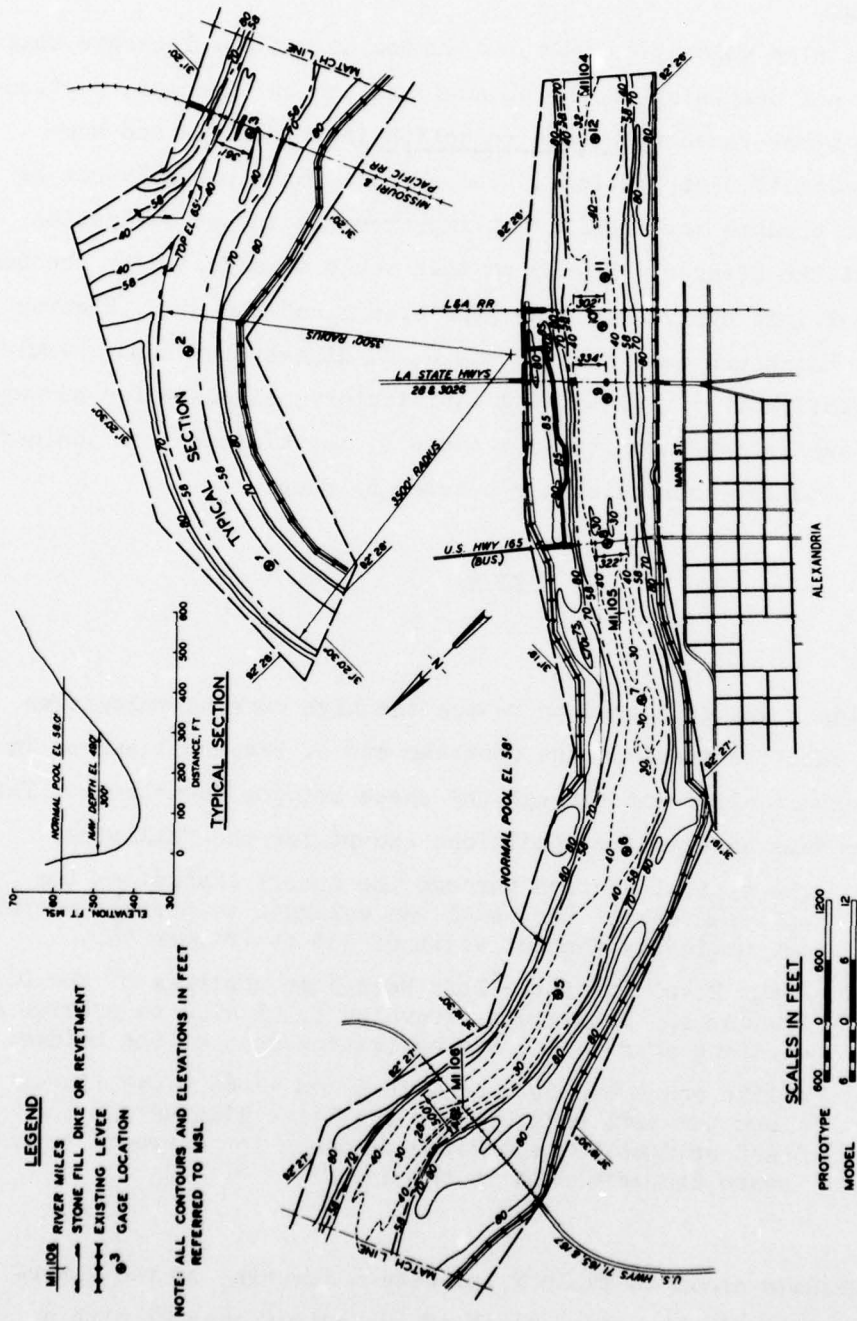


Figure 4. Existing condition with the proposed cutoff in upper reach

conditions for downbound tows would tend to be extremely difficult and hazardous at all of the bridges except at the U. S. Highways 71, 165, and 167 Bridge.

19. The high velocities measured during high flows indicate that some erosion and deepening of the channel bed can be expected, particularly in the upper reach with some reduction in velocities and some changes in velocity distributions. The effects would probably not be sufficient to produce any significant improvements in the navigation conditions at the bridges. Downbound tows would be affected by the bend in the channel just upstream of the MPRR bridge and the U. S. Highway 165 Bridge. Downbound tows passing the U. S. Highway 165 Bridge would experience difficulty in maintaining satisfactory alignment for passage through the two bridges downstream because of the alignment of the navigation spans and the short distance between bridges.

#### Plan A

##### Description

20. Plan A was developed to reduce the high current velocities through the cutoff channel at the upstream end of the model and to improve the current alignment through the three bridges downstream. This plan was the same as existing conditions except for the following:

- a. The typical section through the cutoff channel at the upstream end of the model was enlarged to provide a minimum navigable channel width of 350 ft (Figure 5).
- b. About 2,400 ft of the left bank just upstream of the U. S. Highway 165 Bridge was excavated to el 47.0 to provide a straight approach to the navigation span of the bridge.
- c. A dike about 800 ft long with a top el 65.0 was placed along the left bank between the State Highway and the L&ARR bridges to reduce the tendency for currents to move toward the left bank in the area.

##### Results

21. Results shown in Table 2 indicate a lowering of the water-surface elevations in the upper reach of the cutoff channel with a considerable reduction in water-surface slope from those obtained with

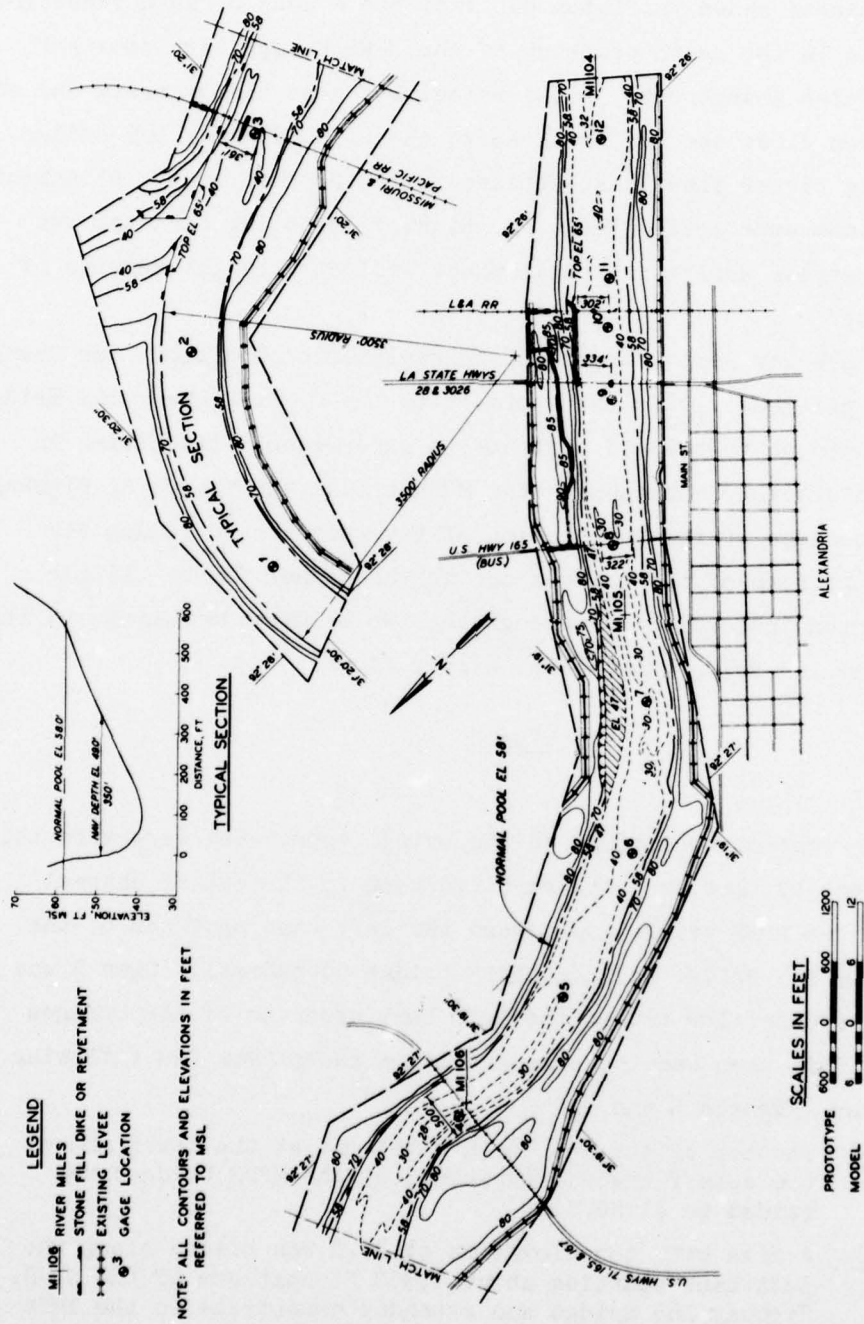


Figure 5. Plan A

the base test. Only local changes in water-surface elevations occurred in the reach downstream of the cutoff.

22. Results shown in Plates 6-8 indicate a considerable reduction in velocities in the reach upstream of the MPRR bridge with somewhat lower velocities downstream. Local velocities near the upstream end of the excavation along the left bank above the U. S. Highway 165 Bridge were slightly higher than those obtained with the base test. Alignments of the currents approaching the U. S. Highway 165 Bridge and the two bridges downstream were better than those indicated by the results of the base test.

23. There was some improvement in navigation conditions for downbound tows, particularly in the approach to the U. S. Highway 165 Bridge. However, downbound tows would continue to experience difficulties in making a satisfactory approach to the MPRR bridge and the U. S. Highway 165 Bridge because of the orientation of tows after negotiating the bends just upstream of the bridges during the higher flows. Little change occurred in conditions through the two bridges downstream of the U. S. Highway 165 Bridge during the higher flows.

#### Plan B

##### Description

24. Navigation conditions in the bridge approaches were affected to some extent by flow over the revetted bank in the cutoff channel upstream of the MPRR bridge and toward the left bank upstream of the U. S. Highway 165 Bridge and the L&ARR bridge downstream. Plan B was designed to reduce flow toward the left bank upstream of the bridges mentioned. This plan was the same as plan A except for the following modifications (Figures 6 and 7):

- a. The top of the left bank revetment at the lower end of the cutoff channel (upstream of the MPRR bridge) was raised to el 80.0.
- b. A dike with top elevation at 80.0 was placed along the left bank starting about 1,350 ft upstream of the U. S. Highway 165 Bridge and extended downstream to the left pier of the navigation span of the bridge.



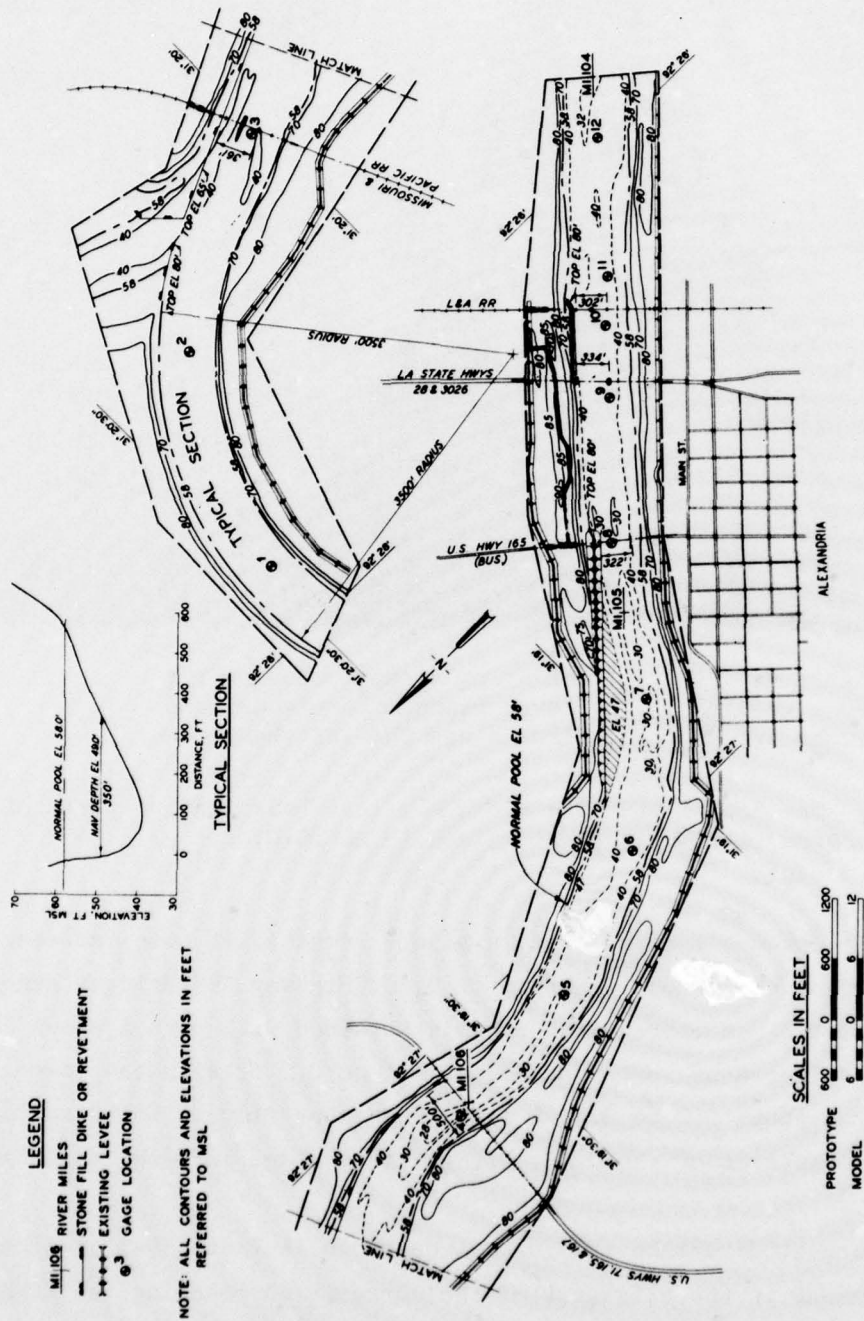


Figure 6. Plan B

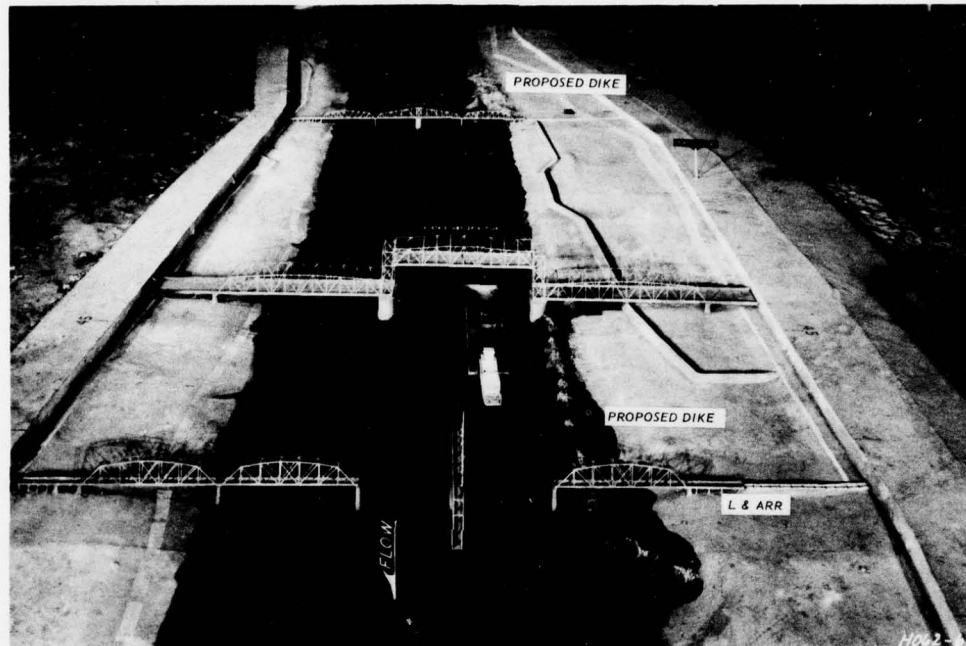


Figure 7. Plan B (looking upstream), showing the three bridges in the lower reach of the model and the two proposed dikes along the left bank

- c. The top of the dike along the left bank just upstream of the L&ARR bridge was raised to el 80.0.

#### Results

25. The changes incorporated in plan B resulted in some increase in water-surface elevations upstream of U. S. Highway 165 Bridge (gage 8) as shown in Table 3 compared with results obtained with plan A shown in Table 2. The increases were in order of 0.1 to 0.2 ft with the lower flows and from about 0.2 to 0.4 ft with the higher flows. Water-surface elevations downstream of the U. S. Highway 165 Bridge were not affected appreciably.

26. Current direction and velocities shown in Plates 9-11 indicate some improvement in the alignment of the currents approaching the MPRR bridge, the U. S. Highway 165 Bridge, and the two bridges downstream compared with the results of tests with plan A. There were some

increases in the velocities of the currents approaching the bridges, particularly with the higher flows which were affected by the higher structures.

27. Although navigation conditions were somewhat better with plan B than with plan A, downbound tows would continue to experience considerable difficulties in making a satisfactory and safe approach to the MPRR and U. S. Highway 165 Bridges during the higher flows. No serious difficulties should be encountered in the reach by upbound tows having sufficient power to negotiate the high-velocity currents.

### Plan C

#### Description

28. Plan C was the same as plan B except for the following (Figure 8):

- a. The right bank upstream of U. S. Highways 71, 165, and 167 Bridge was excavated to el 47.0 beginning at the right pier of the navigation span and extending upstream about 1,800 ft. The excavation was on a curve having a radius of 4,500 ft.
- b. The right bank upstream and downstream of the U. S. Highway 165 Bridge was excavated to el 47.0 forming a straight line about 50 ft landward of the right pier of the navigation span. The excavation extended about 1,250 ft upstream of the bridge and about 800 ft downstream.

#### Results

29. Results shown in Table 4 indicate that the modifications of plan C had little effect on water-surface elevations through the reach compared with the results of the test of plan B.

30. Except for some lowering of velocities upstream of the MPRR bridge with the 145,000-cfs flow, there was little change in current directions and velocities from those obtained with plan B (Plates 12-14). Navigation conditions were not affected appreciably except that there was a strong tendency for downbound tows to be grounded along the lower end of the revetment downstream of the cutoff channel after passing through the MPRR bridge.



## Plan D

### Description

31. Plan D was the same as plan C except for the following (Figure 9):

- a. The cutoff channel upstream of the MPRR bridge was realigned with the left bank place on a radius of 3,268 ft.
- b. The left bank revetment between the MPRR bridge and the U. S. Highways 71, 165, and 167 Bridge was moved slightly riverward and realigned to tie in with the existing left bank line approaching the lower bridge.
- c. Three 100-ft-long submerged dikes with crests at el 47.0 were placed along the left bank revetment starting about 600 ft downstream of the MPRR bridge. The first dike was angled about 30 deg toward the downstream, the other two dikes were normal to the bank line, and each dike was spaced 600 ft and 500 ft from the next dike upstream.
- d. Four 300-ft-long submerged dikes with crest at el 47.0 were placed along the right bank starting about 2,750 ft upstream of the U. S. Highway 165 Bridge. The first dike was angled about 45 deg toward the downstream and the other three were placed normal to the bank line. The spacings between dikes were 500 ft, 500 ft, and 600 ft starting from the upstream dike.
- e. The right bank in the vicinity of the U. S. Highway 165 Bridge was restored to existing conditions.
- f. The slope of the excavated left bank upstream of the U. S. Highway 165 Bridge was reduced to 1V on 4H and the upper end flared landward to form a smooth transition with the existing bank line.

### Results

32. Results shown in Table 5 indicate a general increase in water-surface elevations upstream of the U. S. Highway 165 Bridge with this plan compared with the base test. The increase in water-surface elevations varied from about 0.1 ft with the low flows to as much as 1.0 ft with the 145,000-cfs flow.

33. Results shown in Plates 15-20 indicate velocities to be generally high except during the lower flows. Velocities in the approach to the MPRR bridge varied from about 6.0 fps with the 31,000-cfs flow to about 10.6 fps with the 145,000-cfs flow. Velocities in the reach in

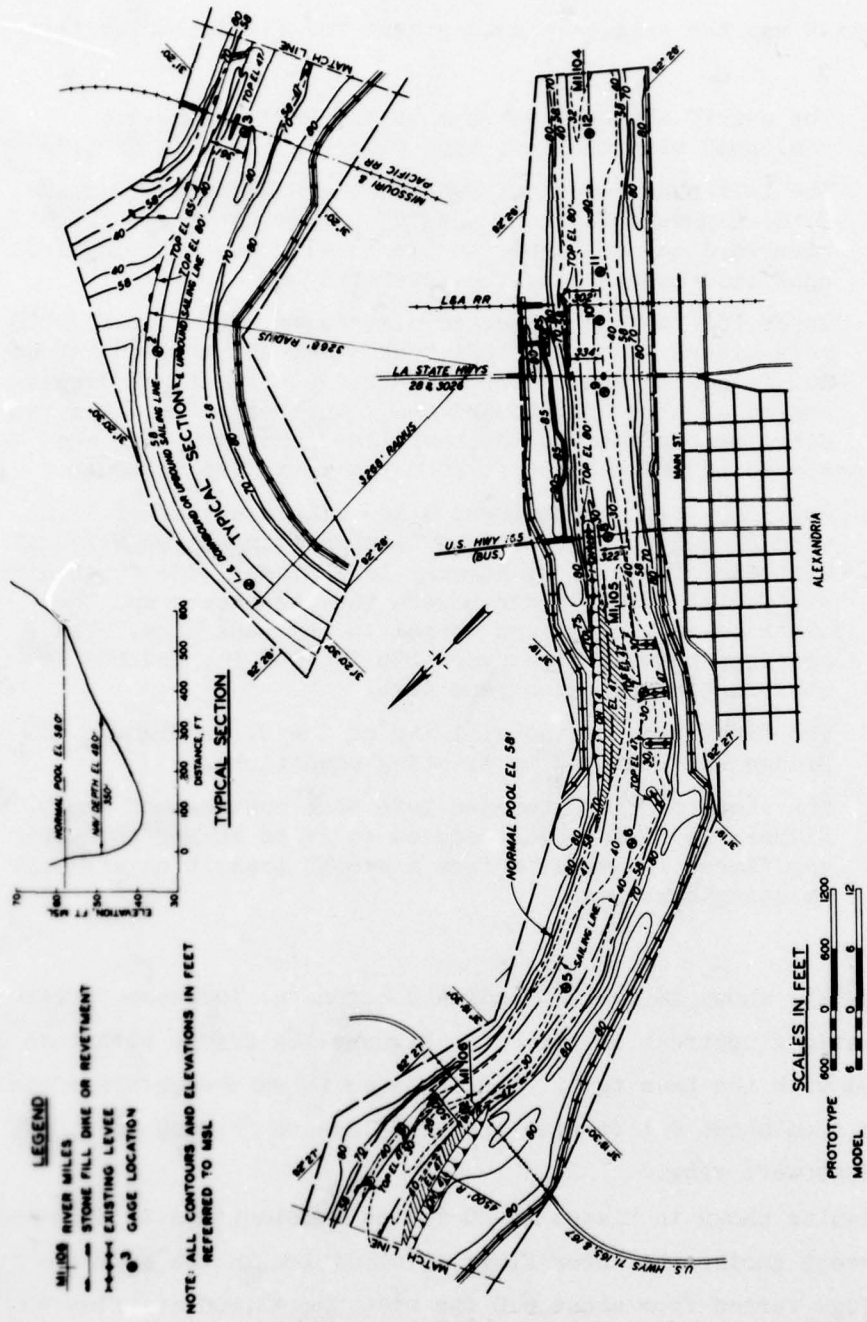


Figure 9. Plan D

the vicinity of the U. S. Highway 165 Bridge were somewhat lower than in the vicinity of the MPRR bridge during the lower flows and somewhat higher during the higher flows. Velocities just downstream of the U. S. Highway 165 Bridge reached a maximum of 11.0 fps with the 145,000-cfs flow and somewhat less farther downstream. Velocities were generally higher than those measured with plan C but considerably lower than those obtained with the base test except in the reach downstream of the U. S. Highway 165 Bridge with the 95,000- and 145,000-cfs flows.

34. Alignments of currents shown in Photos 1-3 and Plates 15-20 were generally parallel to the bank lines with considerable improvement in the alignment of currents approaching and moving through the bridges. Because of the improvements in the alignment of the currents, downbound tows could approach the U. S. Highways 71, 165, and 167 Bridge and the U. S. Highway 165 Bridge with considerably less difficulty than with plan C.

35. Because of the high-velocity currents during the higher flows, navigation conditions for downbound tows could be hazardous in the approaches to the MPRR and the U. S. Highway 165 bridges unless proper alignment is maintained. Upbound tows with sufficient power to overcome the high-velocity currents could navigate the reach without serious difficulties, using either the right or left sailing line indicated in Figure 9. Two-way traffic could be maintained in the reach during the lower flows but conditions would be generally better with the downbound tow using the left sailing line and upbound tows using the right sailing line (Photos 4-6). Two-way navigation would be affected by the tendency for downbound tows using the left sailing line to be moved toward the right sailing line just downstream of U. S. Highways 71, 165, and 167 Bridge; this tendency increased with an increase in discharge. Downbound tows using the right sailing line would tend to be grounded along the right bank below the bridge when attempting to turn back to the left after negotiating the bend.

36. Downstream of the U. S. Highway 165 Bridge, navigation conditions were affected by the alignment of the navigation spans of the two bridges, the short distance between the bridges, and the current

alignment through the reach. There was a strong tendency for a down-bound tow using the left sailing line to hit the pivot pier of the L&ARR bridge and to hit the right pier of the Louisiana State Highways 28 and 3026 Bridge when using the right sailing line. With tows having adequate power, it might be possible to maintain two-way traffic with extreme caution upstream of the U. S. Highway 165 Bridge with flows up to about 95,000 cfs and downstream of the bridges with flows up to about 50,000 cfs. Navigation conditions were based on tows 35 ft wide and 685 ft long. Wider tows would experience considerably more difficulties and conditions could be extremely hazardous except during low flows.

#### Plan E

##### Description

37. Plan E was the same as plan D except for the following modifications (Figure 10):

- a. The existing U. S. Highway 165 Bridge and the dike along the left bank tying in with the left pier of the existing navigation span were removed.
- b. Piers simulating the piers of the proposed replacement bridge for the U. S. Highway 165 Bridge were placed in the model about 500 ft upstream of the existing bridge. The replacement bridge had a clear 303-ft-wide navigation span.
- c. Protection cells were placed on the upstream side of the piers on the navigation spans of the MPRR and the L&ARR bridges as shown in Figure 10.

##### Results

38. Results of test of plan E indicate only small local differences in water-surface elevations from those obtained during the test of plan D (Table 6). Current directions and velocities shown in Plates 21-26 and Photo 7 indicate that there was little change from those obtained with plan D except in the reach in the vicinity of the U. S. Highway 165 Bridge. Velocities in the reach downstream of the U. S. Highway 165 replacement bridge were somewhat lower than those with plan D, particularly with the higher flows. The reduction was caused by the removal





of the dike along the left bank upstream of the location of the existing bridge (removed). Velocities increased through the reach with an increase in discharge and ranged from about 9.7 to 10.6 fps in the upper reach and from about 7.9 to 9.8 fps in the lower reach with flows from 72,000 to 145,000 cfs. Some local disturbance in the alignment of the currents was caused by the protection cells placed upstream of the piers of the navigation spans of the railroad bridges.

39. Navigation conditions in the upper reach and through the MPRR bridge and the U. S. Highways 71, 165, and 167 Bridge were about the same as those with plan D. Navigation conditions through the replacement U. S. Highway 165 Bridge were somewhat better than with the existing bridge and a better approach could be made to the next two bridges downstream (Photo 8). However, because of the high-velocity currents and limited width of the navigation spans on the L&ARR bridge, conditions would tend to be hazardous during the higher flows. It is possible to maintain two-way traffic through the reach with flows up to about 95,000 cfs, provided downbound tows use the left sailing line and maintain adequate control. Caution would be required, particularly when passing in the bend just downstream of the U. S. Highways 71, 165, and 167 Bridge, because of the tendency for downbound tows to be moved toward the right sailing line. One-way traffic would require downbound tows to use the left sailing line with flows above 95,000 cfs, but upbound tows could navigate either sailing line with flows up to 145,000 cfs. Navigation conditions in the reach are based on tows 35 ft wide and 685 ft long.

#### Plan F

##### Description

40. Plan F was the same as plan E except that the turn spans and pivot piers on the MPRR and L&ARR bridges were removed and replaced with a lift span having clear dimensions of 315 and 250 ft, respectively. Protection cells on the upstream side of the two bridges were shifted toward the navigation channel as shown in Figure 11.

##### Results

41. Results shown in Table 7 indicated only small local differences



in water-surface elevations from those obtained during the test of plan E. Current direction and velocities shown in Plates 27-30 indicate that there was little change from those obtained with plan E except in the lower reach in the vicinity of the L&ARR bridge where velocities were somewhat higher, particularly with the higher flows, due mostly to the removal of the pivot pier on the bridge. Velocities increased through the reach with an increase in discharge from 50,000 to 145,000 cfs and ranged from about 7.6 to 10.5 fps in the upper reach and from about 6.4 to 11.1 fps in the lower reach. Local disturbances in flow caused by the protection cell at the upper and lower railroad bridges were reduced considerably with the removal of the pivot piers.

42. Navigation conditions through the reach were generally similar to those with plan E. However, the number of barges that could be moved through the reach safely was increased from three to six 35- by 195-ft barges based on a tow size of 70 by 685 ft. Upbound and downbound tows of that size could move through the reach without difficulty with all flows tested. There was a strong tendency for the downbound tow to be moved toward the bridge pier on the right side of the navigation span of the proposed U. S. Highway 165 replacement bridge, particularly with the higher flows. Downbound tows moving near the right bank downstream of the U. S. Highways 71, 165, and 167 Bridge could encounter difficulty in becoming properly aligned for passage through the proposed bridge. Two-way navigation could be maintained through the reach without difficulty with the lower flows. With flows of 72,000 cfs and higher, conditions would tend to be hazardous for tows attempting to pass in the bend just downstream of the U. S. Highways 71, 165, and 167 Bridge and in the upper approach to the replacement (U. S. Highway 165) bridge.

#### Plan G

##### Description

43. This plan was the same as plan F except that the four submerged dikes along the right bank just upstream of the proposed

U. S. Highway 165 Bridge were removed and four new dikes with crest at el 80.0 were placed along the right bank starting 2,070 ft upstream of the proposed bridge (Figure 12). The dikes were 160, 170, 190, and 160 ft long, from upstream to downstream, placed normal to the bank line and spaced 420, 450, and 690 ft apart starting from the upstream dike.

#### Results

44. Results shown in Table 8 indicate that the modifications of plan G produced only small differences in water-surface elevations from those obtained with plan F. Current directions and velocities shown in Plates 31 and 32 indicate that velocities in the vicinity of the proposed new bridge were as much as 1.0 fps higher with the 50,000-cfs flow to about 1.9 fps higher with the 145,000-cfs flow than those obtained with plan F. Maximum velocities in the vicinity ranged from about 5.3 fps with the 31,000-cfs flow to about 12.5 fps with the 145,000-cfs flow. Current alignments were about the same as those with plan F except that they were more concentrated in the approach and through the navigation span of the proposed bridge.

45. Navigation conditions through the reach were about the same as those with plan F except in the upstream approach to the new bridge. The tendency for downbound tows to be moved toward the pier on the right side of the navigation span of the new bridge was reduced considerably, and tows could move through this reach and pass through the two lower bridges without serious difficulties. Some difficulties could be experienced with two-way traffic along the right side of the channel below U. S. Highways 71, 165, and 167 Bridge and in the approach to the new bridge, particularly during the higher flows.

#### Plan H

##### Description

46. Plan H was based on the results of preliminary tests conducted in an effort to improve navigation conditions in the bend downstream of the U. S. Highways 71, 165, and 167 Bridge and in the upper approach to the proposed new U. S. Highway 165 Bridge. This plan was the same as



plan G except for the following (Figure 13):

- a. The right bank in the bend just downstream of the U. S. Highways 71, 165, and 167 Bridge was excavated to el 47.0 along a 2,000-ft radius.
- b. The length of the first dike on the right bank just upstream of the proposed new bridge was increased to about 190 ft.
- c. A fifth dike about 200 ft long with top el 80.0 was placed along the right bank 370 ft upstream of the dike nearest the proposed new bridge.

#### Results

47. Results of tests shown in Table 9 indicated only small local differences in water-surface elevations from those obtained during the test of plan G. Plates 33-37 indicate that there was little change in current directions and velocities from those obtained with plan G except with the high flows in the reach approaching the proposed new bridge. Velocities in the reach were somewhat lower than those with plan G, particularly with the 145,000-cfs flow, and ranged from about 4.8 fps with the 31,000-cfs flow to about 11.2 fps with the 145,000-cfs flow. Velocities in the upper reach were about the same as those obtained with plan E, and ranged from about 6.4 fps with the 31,000-cfs flow to about 10.4 with the 95,000- and 145,000-cfs flows in the upper approach to the MPRR bridge.

48. Satisfactory navigation conditions were indicated with all flows tested provided that tows maintain proper control and alignment when approaching the bridges (Photos 9-14). Downbound and upbound tows could approach and pass through the MPRR and the U. S. Highways 71, 165, and 167 bridges along either side of the navigation channel without difficulty. However, there was a tendency for downbound tows with limited steerage to be grounded along the right bank downstream of the highway bridge or hit the right bank dikes farther downstream. Navigation conditions for upbound and downbound tows maintaining proper control and alignment should experience no serious difficulties in navigating through the lower three bridges. Two-way traffic could be maintained under most conditions provided that downbound tows use the sailing line along the left side of the channel (Photos 15-17).





Caution would be required for downbound tows in the reach just downstream of the U. S. Highways 71, 165, and 167 bridge and in the upper approach to U. S. Highway 165 replacement bridge during the higher flows because of the tendency mentioned above.

## PART IV: DISCUSSION OF RESULTS AND CONCLUSIONS

### Limitations of Model Results

49. Analysis of the results of this investigation is based principally on a study of the effects of the bridge piers and regulating structures on water-surface elevations, current directions, and velocities in the navigation channels, and the effects of resulting currents on the behavior of the model towboat and tow (685 ft long by 35 ft and 70 ft wide). In evaluating test results, consideration should be given to the fact that small changes in direction of flow or in velocities are not necessarily changes produced by a change in plan, since several floats introduced at the same point may follow slightly different paths and move at somewhat different velocities. Current directions shown in plates were taken with floats submerged to a depth of 9 ft (prototype) and are more indicative of currents that will affect the movement of tows than surface currents shown in the photographs.

50. Because of the small model scale, it was difficult to reproduce accurately the hydraulic characteristics of the prototype structures or to measure water-surface elevations within an accuracy greater than  $\pm 0.1$  ft (prototype). The model was of the fixed-bed type with semi-fixed areas located at the upper end of the model and was not designed to simulate the movement of sediment in the prototype; therefore the changes in channel configurations and slopes that can be expected from changes in regulating and training structures could not be developed naturally.

51. It should be considered that the model was constructed to reproduce conditions indicated by a survey completed in April 1968, except in the cutoff upstream of the MPRR bridge which was based on typical cross sections that were later modified. Also, the model was operated by reproducing water-surface elevations computed by the LMN based on the anticipated changes that could be expected downstream. Any appreciable differences between the computed values and those that will actually occur after completion of project could have a significant

effect on conditions in the reach. The high velocities measured during the tests indicate that some deepening of the channel can be expected during high flows which would tend to reduce velocities to less than those indicated by the model results.

#### Summary of Results and Conclusions

52. The following conclusions and indications were developed during the investigation:

- a. Navigation conditions in the reach reproduced in the model for the base test would tend to be hazardous, particularly for downbound tows, because of the arrangement and limited width of some of the bridge spans, channel and current alignment approaching the bridges, and high-velocity currents during the higher flows.
- b. High-velocity currents, particularly in the upper reach, indicate that some scouring and changes in channel cross section can be expected during the early stages of development.
- c. Navigation conditions approaching the MPRR bridge and between that bridge and the U. S. Highways 71, 165 and 167 Bridge could be improved by raising the left bank revetment to above the maximum navigable flow, realignment of the revetment between the two bridges, and some excavation along the right bank.
- d. Navigation conditions in the approach to the existing U. S. Highway 165 Bridge could be improved by excavation to realign the left bank upstream of the bridge, addition of a long longitudinal dike between the excavation and the bridge, and addition of submerged dikes along the left bank in the bend upstream of the bridge.
- e. Satisfactory navigation conditions could be developed with most flows and the modifications included in plan D. Downbound tows would have to use the left sailing line with flows of more than 50,000 cfs even with one-way traffic. Some flanking might be required during the higher flows.
- f. Navigation conditions in the lower reach would be considerably better with the replacement of the existing U. S. Highway 165 Bridge and modifications included in plan E. With this plan, two-way traffic for 35-ft-wide tows is possible through the reach with flows up to about 95,000 cfs provided downbound tows use the left sailing line.

- g. Satisfactory navigation conditions during most flows could be developed for tows up to 70 ft in width with the modifications of plan F.
- h. With plan H, two-way traffic with 70-ft-wide tows could be maintained through the reach with flows up to about 72,000 cfs, provided downbound tows use the left sailing line. With the higher flows, two-way traffic could be hazardous in the reach just downstream of U. S. Highways 71, 165, and 167 Bridge and in the upper approach to the replacement bridge (U. S. Highway 165). Conditions approaching the replacement bridge were better with this plan than those with plan F.
- i. Navigation conditions for downbound tows with limited power and maneuverability will tend to be hazardous through this reach because of the high-velocity currents indicated with the conditions tested, short distance between bridges, and the alignment of the channel approaching the bridges. No serious difficulties were indicated for upbound tows with sufficient power to overcome the effects of the high-velocity currents.
- j. Changes in the tailwater elevation and in the channel configurations caused by erosion of the bed and deposition of sediment could produce navigation conditions that would be somewhat different from those indicated by the model results.

Table 1  
Water-Surface Elevations, ft msl  
Base Test

| Gage<br>No. | Discharge, cfs |               |               |               |                |
|-------------|----------------|---------------|---------------|---------------|----------------|
|             | <u>3,600</u>   | <u>31,000</u> | <u>50,000</u> | <u>95,000</u> | <u>145,000</u> |
| 1           | 58.2           | 62.4          | 65.8          | 73.0          | 80.5           |
| 2           | 58.1           | 61.6          | 64.5          | 71.4          | 79.0           |
| 3           | 58.0           | 60.7          | 63.4          | 70.4          | 78.2           |
| 4           | 58.0           | 60.7          | 63.4          | 70.2          | 78.0           |
| 5           | 58.0           | 60.6          | 63.3          | 70.0          | 77.8           |
| 6           | 58.0           | 60.5          | 63.1          | 69.8          | 77.6           |
| 7           | 58.0           | 60.4          | 62.9          | 69.5          | 77.3           |
| 8           | 58.0*          | 60.4*         | 62.8*         | 69.3*         | 77.0*          |
| 9           | 58.0           | 60.3          | 62.8          | 69.2          | 76.9           |
| 10          | 58.0           | 60.3          | 62.7          | 69.0          | 76.7           |
| 11          | 57.9           | 60.2          | 62.5          | 68.8          | 76.5           |
| 12          | 57.9           | 60.1          | 62.5          | 68.8          | 76.5           |

\* Controlled elevation.

Table 2  
Water-Surface Elevations, ft msl  
Plan A

| Gage<br>No. | Discharge, cfs |               |                |
|-------------|----------------|---------------|----------------|
|             | <u>31,000</u>  | <u>95,000</u> | <u>145,000</u> |
| 1           | 61.6           | 72.1          | 79.9           |
| 2           | 61.2           | 71.3          | 79.0           |
| 3           | 60.8           | 70.6          | 78.4           |
| 4           | 60.7           | 70.2          | 77.9           |
| 5           | 60.6           | 70.0          | 77.7           |
| 6           | 60.5           | 69.8          | 77.5           |
| 7           | 60.4           | 69.7          | 77.5           |
| 8           | 60.3           | 69.4          | 77.1           |
| 9           | 60.3           | 69.3          | 77.0           |
| 10          | 60.2           | 69.0          | 76.7           |
| 11          | 60.1           | 68.8          | 76.5           |
| 12          | 60.1*          | 68.8*         | 76.5*          |

\* Controlled elevation.

Table 3  
Water-Surface Elevations, ft msl  
Plan B

| Gage<br>No. | Discharge, cfs |               |                |
|-------------|----------------|---------------|----------------|
|             | <u>31,000</u>  | <u>95,000</u> | <u>145,000</u> |
| 1           | 61.8           | 72.4          | 80.2           |
| 2           | 61.4           | 71.6          | 79.4           |
| 3           | 60.9           | 70.8          | 78.7           |
| 4           | 60.8           | 70.4          | 78.2           |
| 5           | 60.7           | 70.3          | 78.0           |
| 6           | 60.6           | 69.9          | 77.8           |
| 7           | 60.5           | 69.9          | 77.7           |
| 8           | 60.4           | 69.3          | 77.0           |
| 9           | 60.3           | 69.3          | 77.0           |
| 10          | 60.2           | 69.0          | 76.6           |
| 11          | 60.1           | 68.8          | 76.5           |
| 12          | 60.1*          | 68.8*         | 76.5*          |

\* Controlled elevation.

Table 4  
Water-Surface Elevations, ft msl  
Plan C

| Gage<br>No. | Discharge, cfs |               |                |
|-------------|----------------|---------------|----------------|
|             | <u>31,000</u>  | <u>95,000</u> | <u>145,000</u> |
| 1           | 61.7           | 72.5          | 80.2           |
| 2           | 61.3           | 71.6          | 79.4           |
| 3           | 60.9           | 70.9          | 78.8           |
| 4           | 60.7           | 70.5          | 78.4           |
| 5           | 60.7           | 70.3          | 78.1           |
| 6           | 60.6           | 70.1          | 77.9           |
| 7           | 60.5           | 70.0          | 77.8           |
| 8           | 60.4           | 69.3          | 77.0           |
| 9           | 60.3           | 69.3          | 77.0           |
| 10          | 60.2           | 69.0          | 76.6           |
| 11          | 60.1           | 68.8          | 76.5           |
| 12          | 60.1*          | 68.8*         | 76.5*          |

\* Controlled elevation.

Table 5  
Water-Surface Elevations, ft msl  
Plan D

| Gage<br>No. | Discharge, cfs |               |               |               |               |                |
|-------------|----------------|---------------|---------------|---------------|---------------|----------------|
|             | <u>3,600</u>   | <u>31,000</u> | <u>50,000</u> | <u>72,000</u> | <u>95,000</u> | <u>145,000</u> |
| 1           | 58.1           | 62.4          | 65.7          | 69.6          | 73.3          | 80.8           |
| 2           | 58.0           | 61.7          | 64.8          | 68.6          | 72.3          | 80.0           |
| 3           | 58.0           | 61.0          | 63.9          | 67.4          | 71.2          | 79.0           |
| 4           | 58.0           | 60.9          | 63.7          | 67.2          | 70.9          | 78.6           |
| 5           | 58.0           | 60.8          | 63.6          | 67.0          | 70.7          | 78.4           |
| 6           | 58.0           | 60.7          | 63.4          | 66.8          | 70.5          | 78.2           |
| 7           | 57.9           | 60.5          | 63.1          | 66.3          | 69.9          | 77.6           |
| 8           | 57.9           | 60.3          | 62.7          | 65.8          | 69.3          | 76.9           |
| 9           | 57.9           | 60.3          | 62.7          | 65.8          | 69.3          | 76.9           |
| 10          | 57.9           | 60.2          | 62.6          | 65.5          | 69.0          | 76.6           |
| 11          | 57.9           | 60.1          | 62.5          | 65.4          | 68.8          | 76.5           |
| 12          | 57.9*          | 60.1*         | 62.5*         | 65.4*         | 68.8*         | 76.5*          |

\* Controlled elevation.

Table 6  
Water-Surface Elevations, ft msl  
Plan E

| Gage<br>No. | Discharge, cfs |               |               |               |               |                |
|-------------|----------------|---------------|---------------|---------------|---------------|----------------|
|             | <u>3,600</u>   | <u>31,000</u> | <u>50,000</u> | <u>72,000</u> | <u>95,000</u> | <u>145,000</u> |
| 1           | 58.1           | 62.4          | 65.7          | 69.6          | 73.3          | 80.8           |
| 2           | 58.0           | 61.7          | 64.8          | 68.6          | 72.3          | 80.0           |
| 3           | 58.0           | 61.0          | 63.8          | 67.4          | 71.2          | 79.0           |
| 4           | 58.0           | 60.9          | 63.7          | 67.2          | 70.9          | 78.6           |
| 5           | 58.0           | 60.8          | 63.6          | 67.0          | 70.7          | 78.3           |
| 6           | 58.0           | 60.7          | 63.4          | 66.8          | 70.5          | 78.1           |
| 7           | 57.9           | 60.5          | 63.1          | 66.3          | 69.8          | 77.6           |
| 8           | 57.9           | 60.3          | 62.7          | 65.8          | 69.4          | 76.9           |
| 9           | 57.9           | 60.3          | 62.7          | 65.8          | 69.4          | 76.9           |
| 10          | 57.9           | 60.2          | 62.6          | 65.5          | 69.0          | 76.6           |
| 11          | 57.9           | 60.1          | 62.5          | 65.4          | 68.8          | 76.5           |
| 12          | 57.9*          | 60.1*         | 62.5*         | 65.4*         | 68.8*         | 76.5*          |

\* Controlled elevation.

Table 7  
Water-Surface Elevations, ft msl  
Plan F

| Gage<br>No. | Discharge, cfs |               |               |               |                |
|-------------|----------------|---------------|---------------|---------------|----------------|
|             | <u>31,000</u>  | <u>50,000</u> | <u>72,000</u> | <u>95,000</u> | <u>145,000</u> |
| 1           | 62.4           | 65.7          | 69.6          | 73.3          | 80.8           |
| 2           | 61.7           | 64.8          | 68.6          | 72.2          | 80.0           |
| 3           | 61.0           | 63.9          | 67.4          | 71.1          | 79.0           |
| 4           | 60.9           | 63.7          | 67.2          | 70.9          | 78.6           |
| 5           | 60.8           | 63.6          | 67.0          | 70.7          | 78.3           |
| 6           | 60.7           | 63.4          | 66.8          | 70.5          | 78.1           |
| 7           | 60.5           | 63.1          | 66.3          | 69.8          | 77.6           |
| 8           | 60.3           | 62.8          | 65.8          | 69.4          | 76.9           |
| 9           | 60.3           | 62.7          | 65.8          | 69.4          | 76.9           |
| 10          | 60.2           | 62.6          | 65.5          | 69.0          | 76.6           |
| 11          | 60.1           | 62.5          | 65.4          | 68.8          | 76.5           |
| 12          | 60.1*          | 62.5*         | 65.4*         | 68.8*         | 76.5*          |

\* Controlled elevation.

Table 8  
Water-Surface Elevations, ft msl  
Plan G

| Gage<br>No. | Discharge, cfs |               |               |               |                |
|-------------|----------------|---------------|---------------|---------------|----------------|
|             | <u>31,000</u>  | <u>50,000</u> | <u>72,000</u> | <u>95,000</u> | <u>145,000</u> |
| 1           | 62.4           | 65.7          | 69.6          | 73.4          | 80.9           |
| 2           | 61.7           | 64.9          | 68.6          | 72.3          | 80.1           |
| 3           | 61.0           | 64.0          | 67.4          | 71.2          | 79.1           |
| 4           | 60.9           | 63.7          | 67.2          | 70.8          | 78.7           |
| 5           | 60.8           | 63.7          | 67.0          | 70.8          | 78.4           |
| 6           | 60.7           | 63.5          | 66.8          | 70.6          | 78.2           |
| 7           | 60.4           | 63.0          | 66.2          | 69.7          | 77.5           |
| 8           | 60.3           | 62.8          | 65.8          | 69.4          | 76.8           |
| 9           | 60.3           | 62.7          | 65.8          | 69.4          | 76.9           |
| 10          | 60.2           | 62.6          | 65.5          | 69.0          | 76.7           |
| 11          | 60.1           | 62.5          | 65.4          | 68.8          | 76.5           |
| 12          | 60.1*          | 62.5*         | 65.4*         | 68.8*         | 76.5*          |

\* Controlled elevation.



Table 9  
Water-Surface Elevations, ft msl  
Plan H

| Gage<br>No. | Discharge, cfs |        |        |        |         |
|-------------|----------------|--------|--------|--------|---------|
|             | 31,000         | 50,000 | 72,000 | 95,000 | 145,000 |
| 1           | 62.4           | 65.7   | 69.6   | 73.4   | 80.9    |
| 2           | 61.7           | 64.9   | 68.6   | 73.3   | 80.1    |
| 3           | 61.0           | 64.0   | 67.4   | 71.2   | 79.1    |
| 4           | 60.9           | 63.7   | 67.2   | 70.8   | 78.7    |
| 5           | 60.8           | 63.7   | 67.0   | 70.8   | 78.4    |
| 6           | 60.7           | 63.5   | 66.8   | 70.6   | 78.3    |
| 7           | 60.4           | 63.0   | 66.2   | 69.6   | 77.6    |
| 8           | 60.3           | 62.8   | 65.8   | 69.4   | 76.8    |
| 9           | 60.3           | 62.7   | 65.8   | 69.4   | 76.9    |
| 10          | 60.2           | 62.6   | 65.5   | 69.0   | 76.7    |
| 11          | 60.1           | 62.5   | 65.4   | 68.8   | 76.5    |
| 12          | 60.1*          | 62.5*  | 65.4*  | 68.8*  | 76.5*   |

---

\* Controlled elevation.

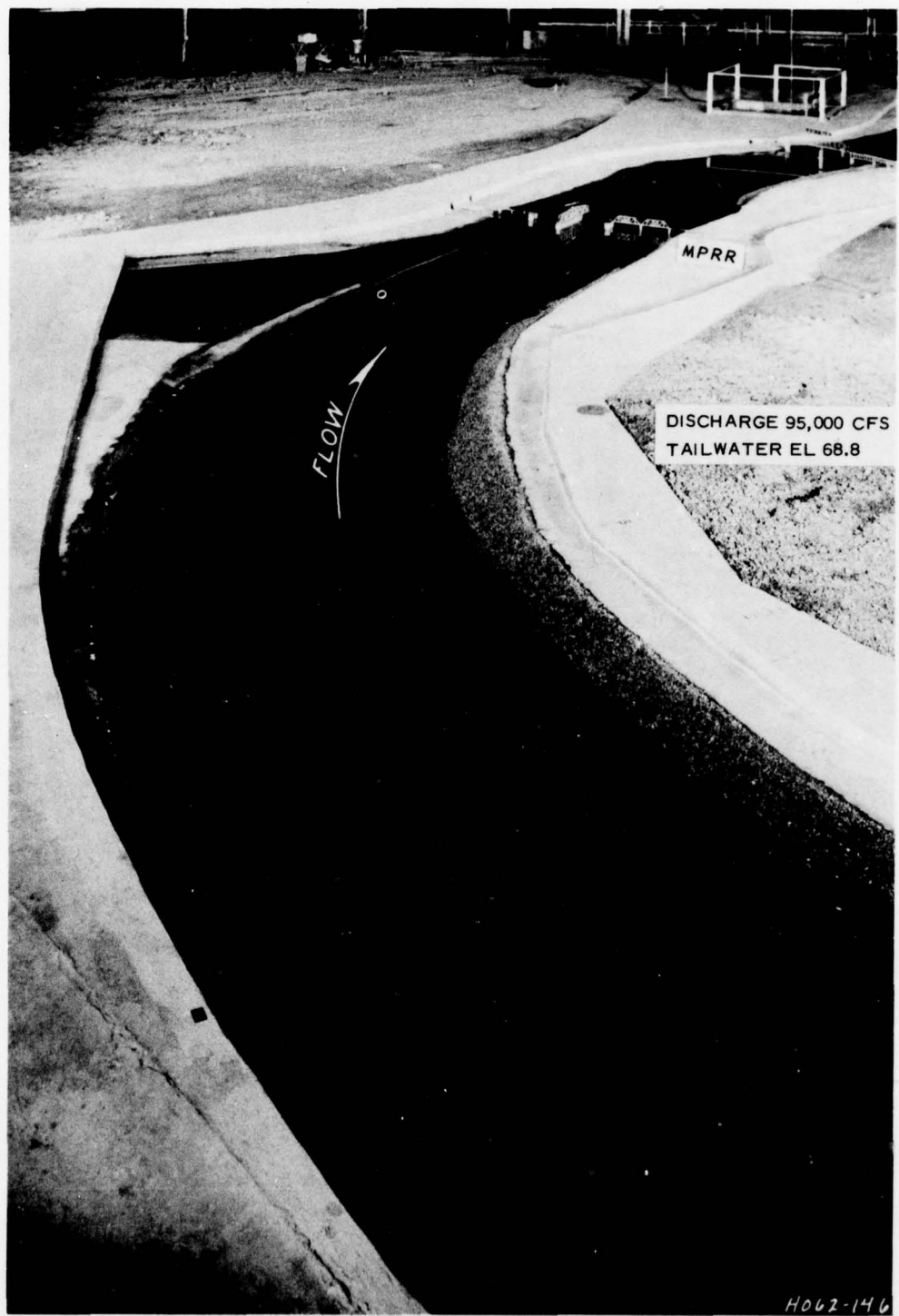
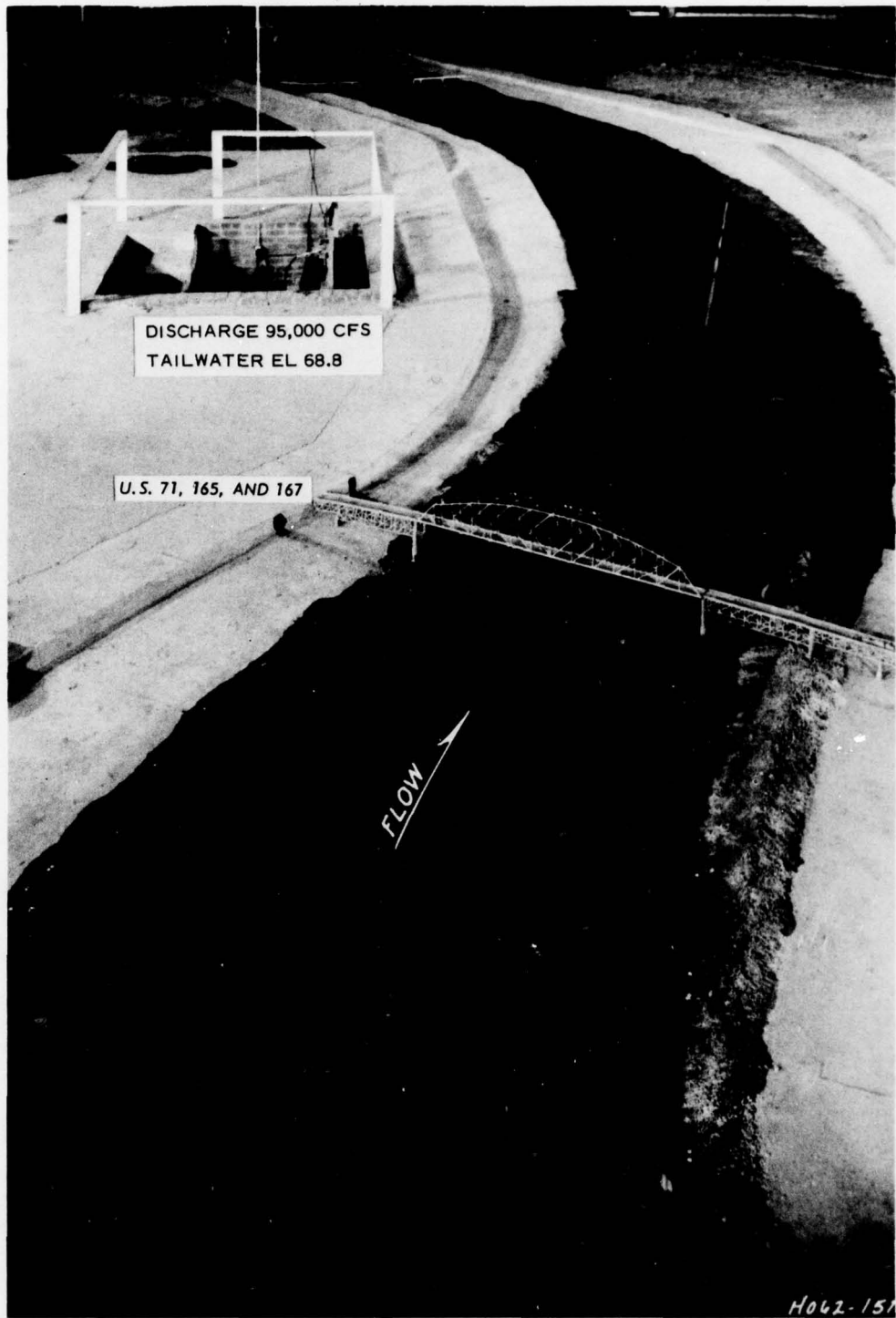


Photo 1. Plan D; surface currents through the cutoff channel and in the approach to the MPRR bridge. Note tendency for currents to concentrate toward the left bank



DISCHARGE 95,000 CFS  
TAILWATER EL 68.8

U.S. 71, 165, AND 167

FLOW

H062-151

Photo 2. Plan D; surface currents in the vicinity of the U. S. Highways 71, 165, and 167 Bridge. Note tendency for currents to move away from the left bank in the bend downstream of the bridge

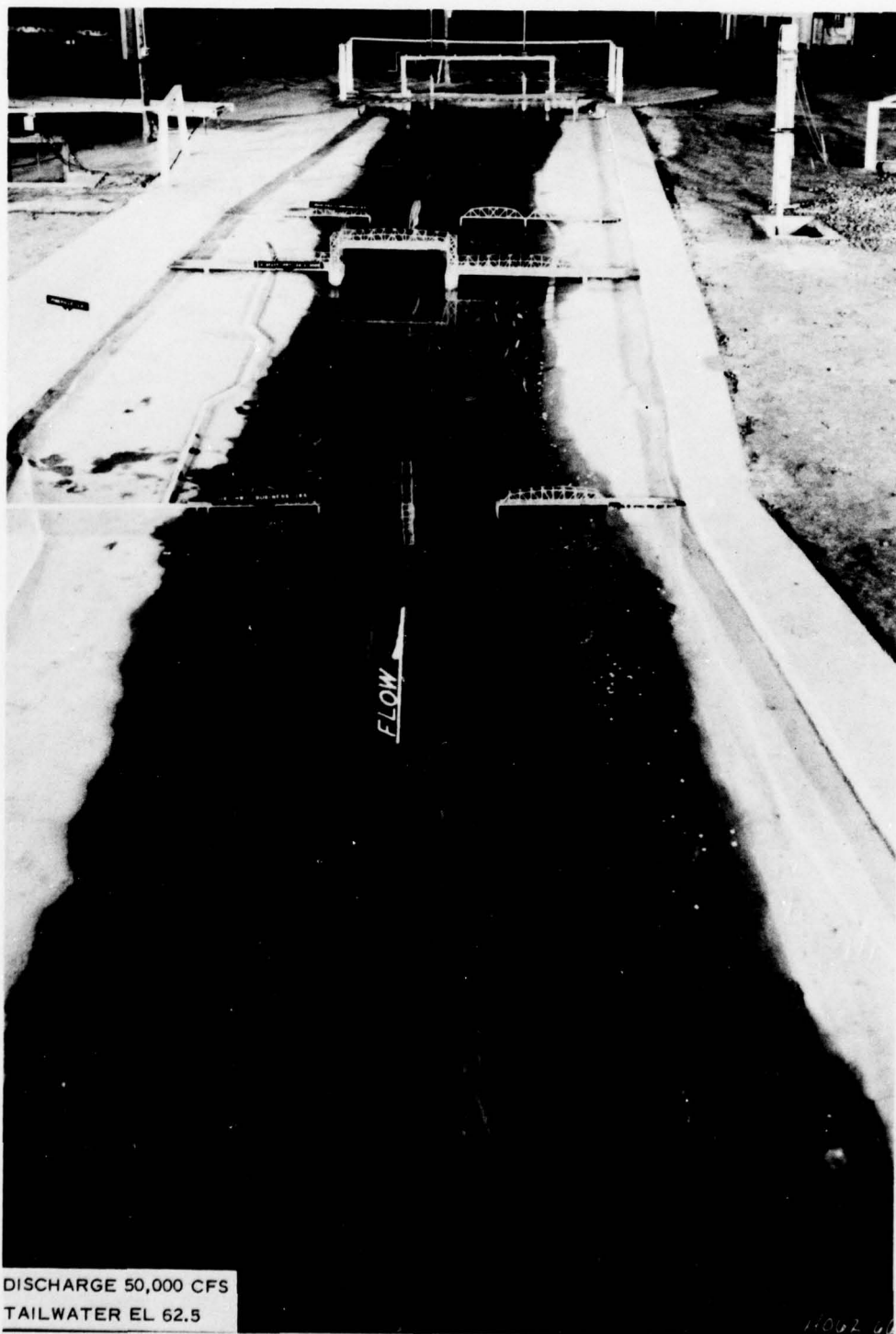


Photo 3. Plan D; surface currents approaching and downstream of U. S. Highway 165 Bridge. Note alignment of the currents downstream of the first bridge



Photo 4. Plan D; paths of tows in upper reach. Note orientation of downbound tow navigating the bend and the tendency for the tow to be moved toward the left bank as it approaches the MPRR bridge

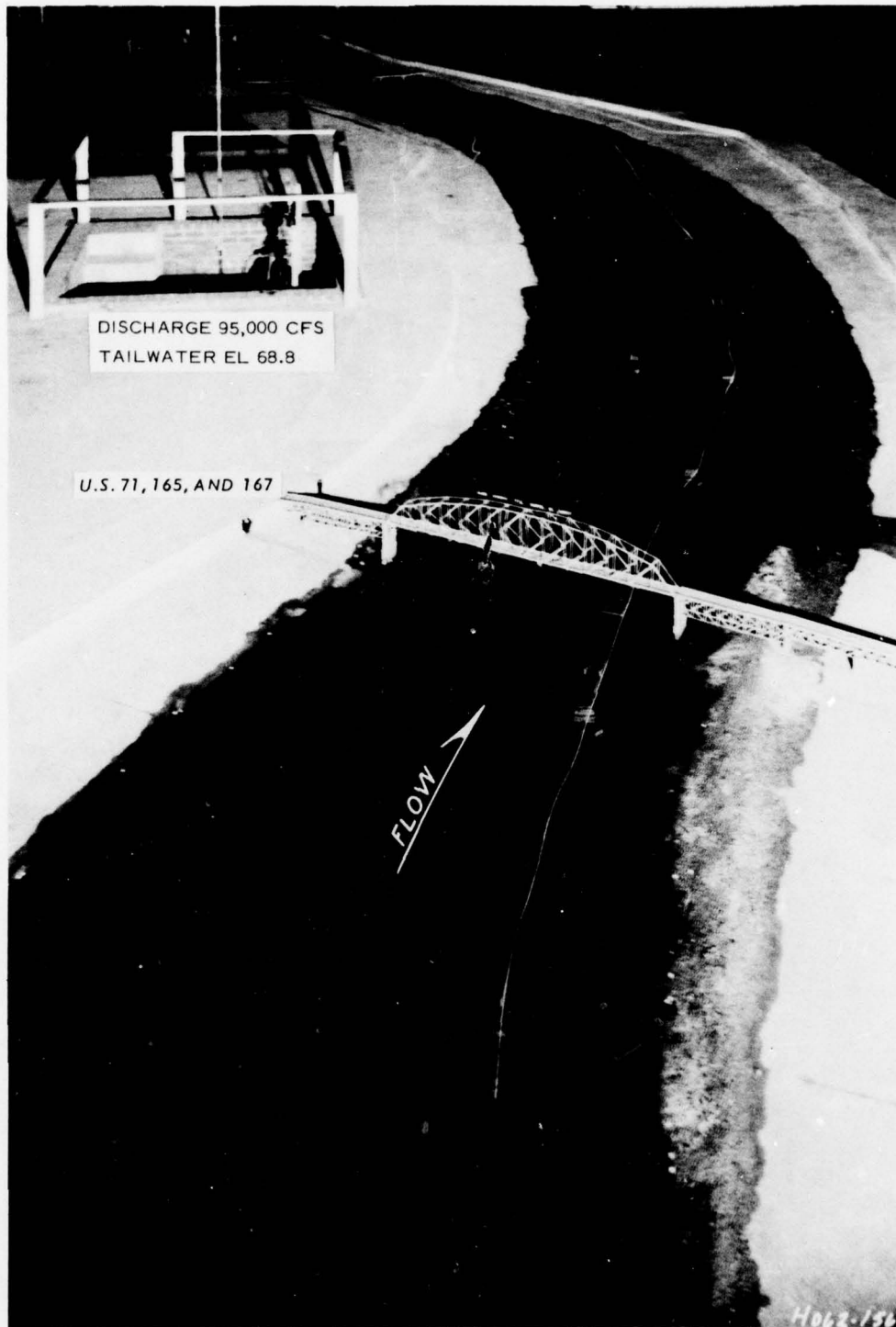


Photo 5. Plan D; paths of tows navigating the reach upstream and downstream of the U. S. Highways 71, 165, and 167 Bridge. Note tendency for downbound tow to be moved to the right in the bend just downstream of the bridge

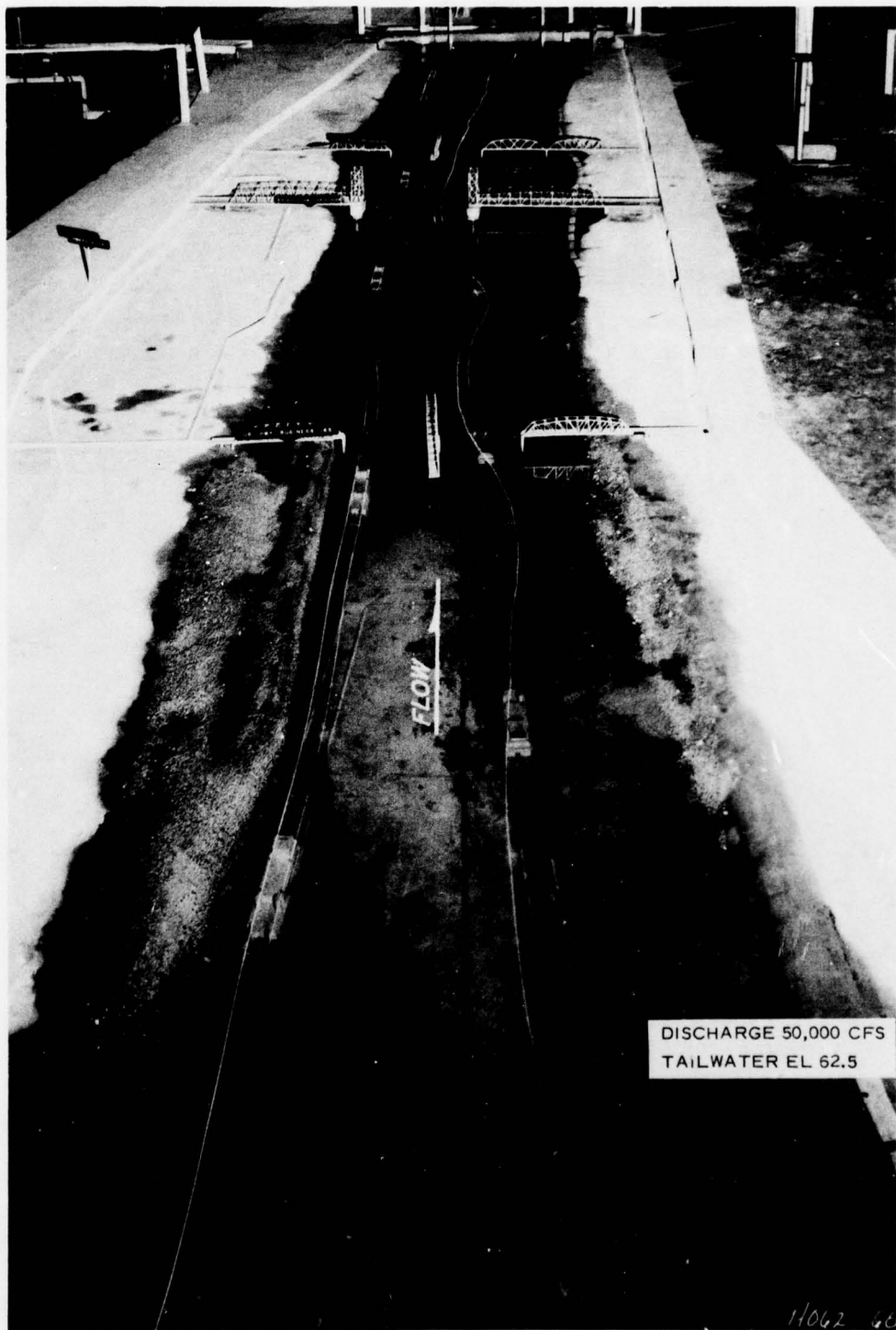


Photo 6. Plan D; paths of tows navigating the lower reach from above the U. S. Highway 165 Bridge. Note alignment of paths of tows for two-way traffic through the bridges

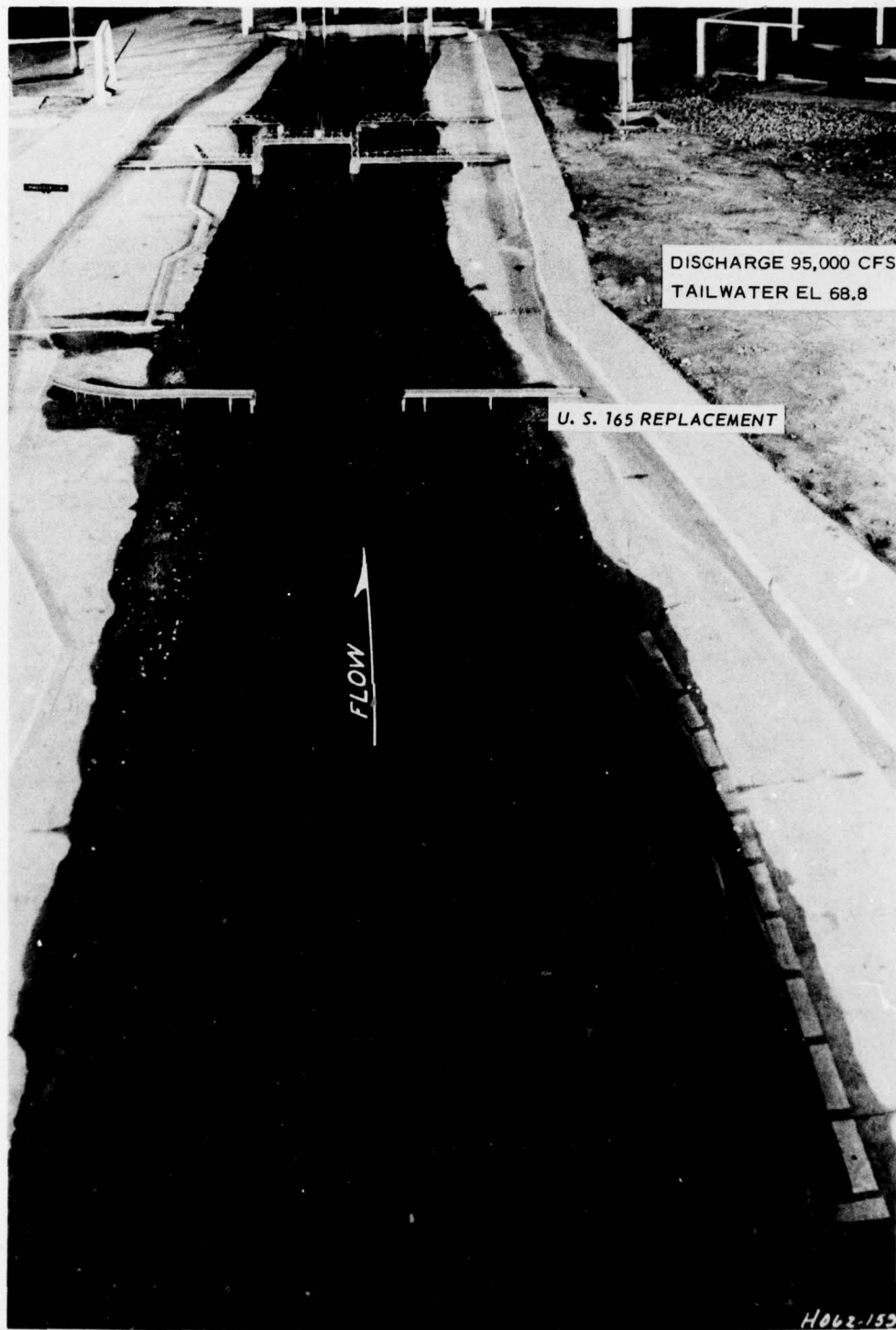


Photo 7. Plan E; surface currents through the lower reach from upstream of the proposed U. S. Highway 165 replacement bridge



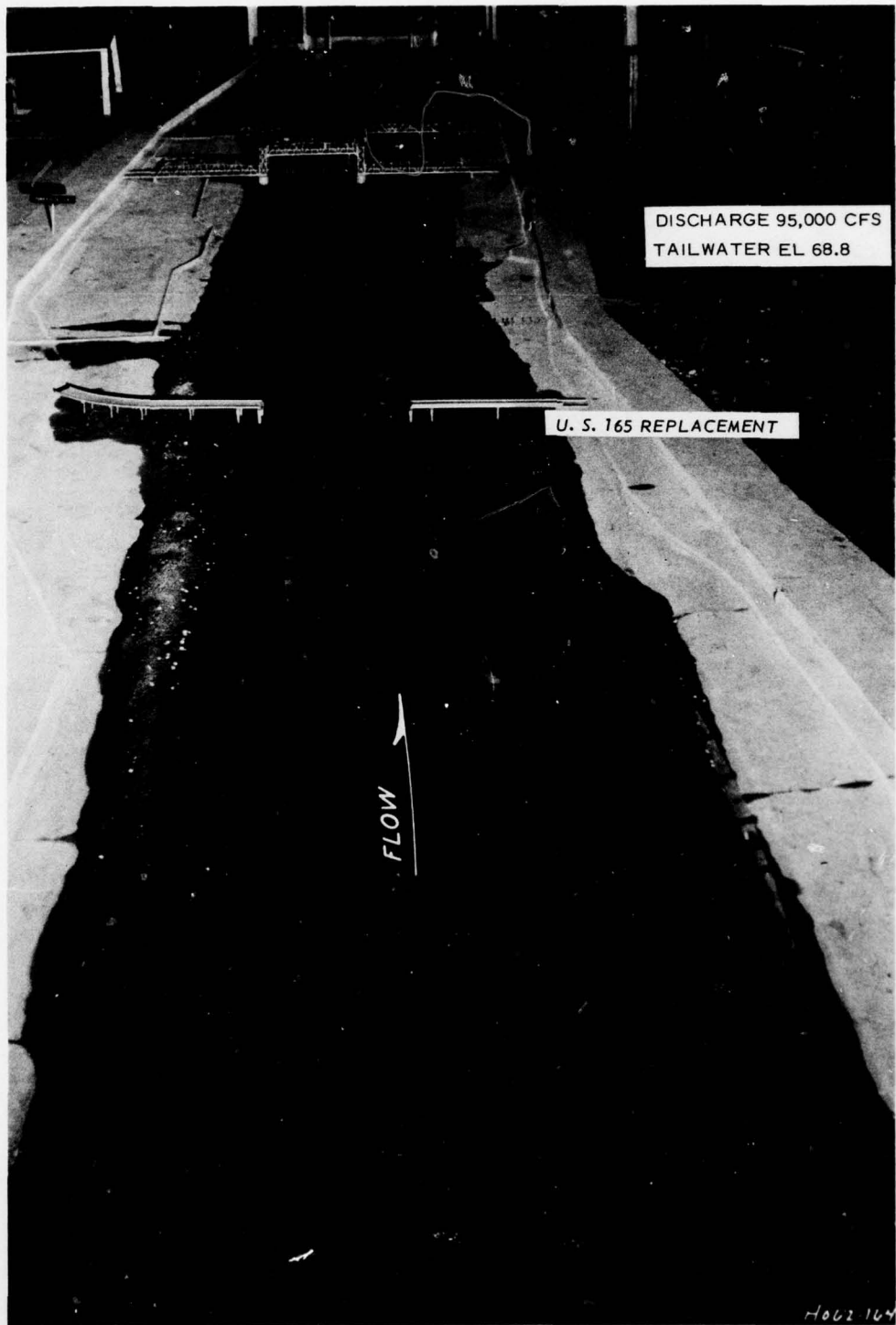


Photo 8. Plan E; paths of upbound and downbound tows navigating the lower reach. Irregular alignment of the path of the upbound tow is attributed to limited power on the towboat

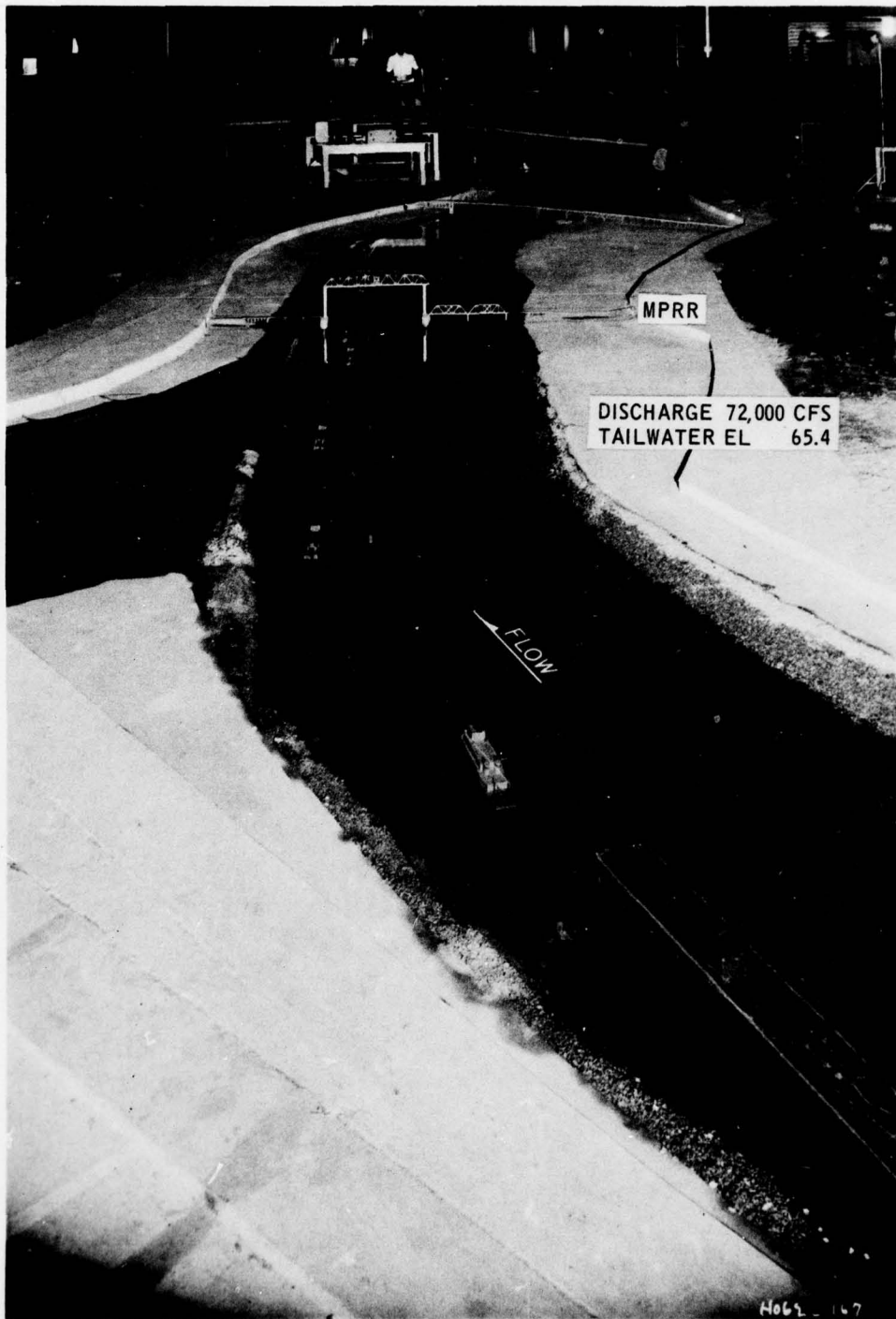


Photo 9. Plan H; Discharge 72,000 cfs, Tailwater el 65.4. Path of downbound tow approaching and passing through the MPRR bridge from along the left side of the navigation channel

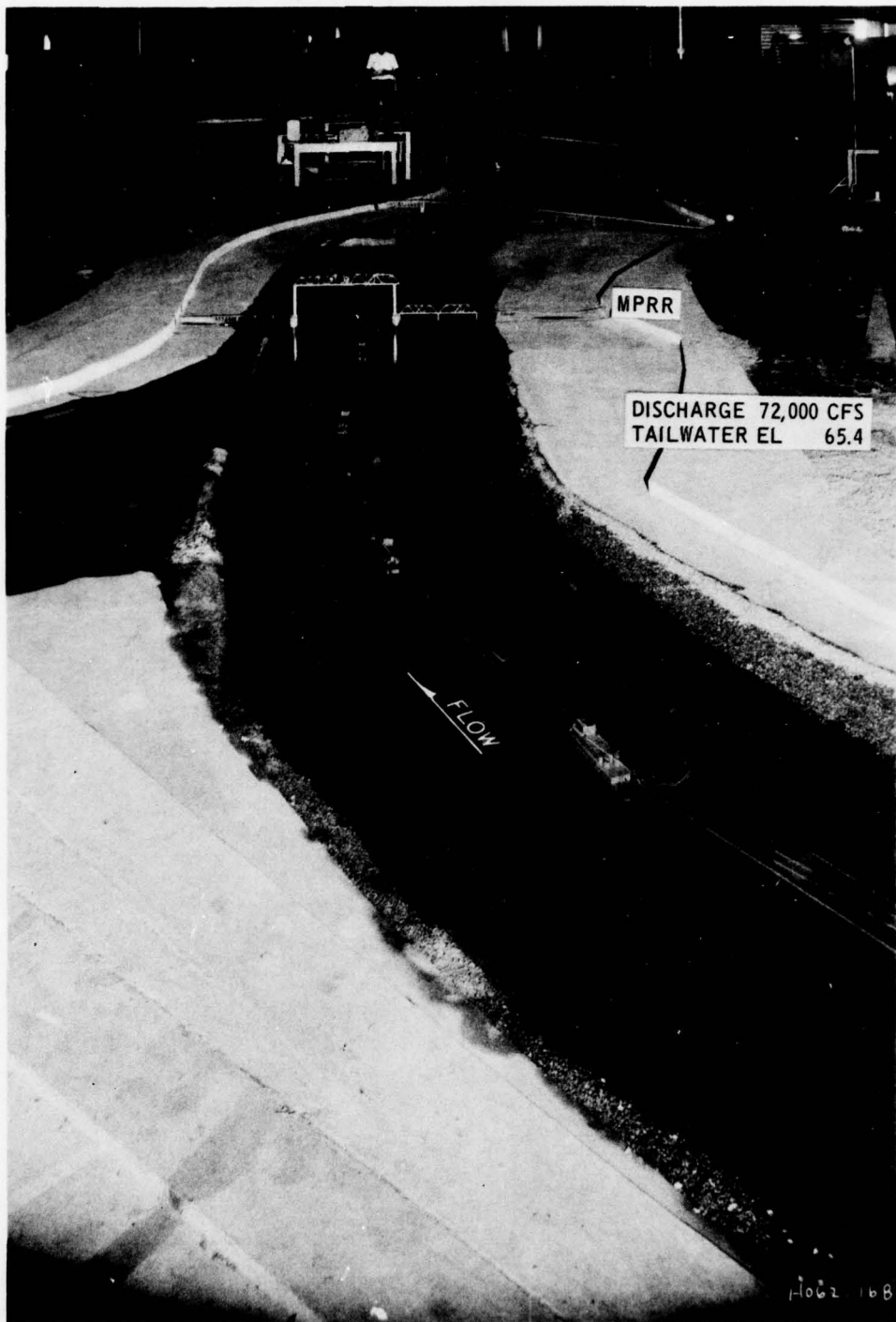


Photo 10. Plan H; Discharge 72,000 cfs, Tailwater el 65.4.  
Path of downbound tow approaching and passing through the  
MPRR bridge from along the right side of the navigation  
channel

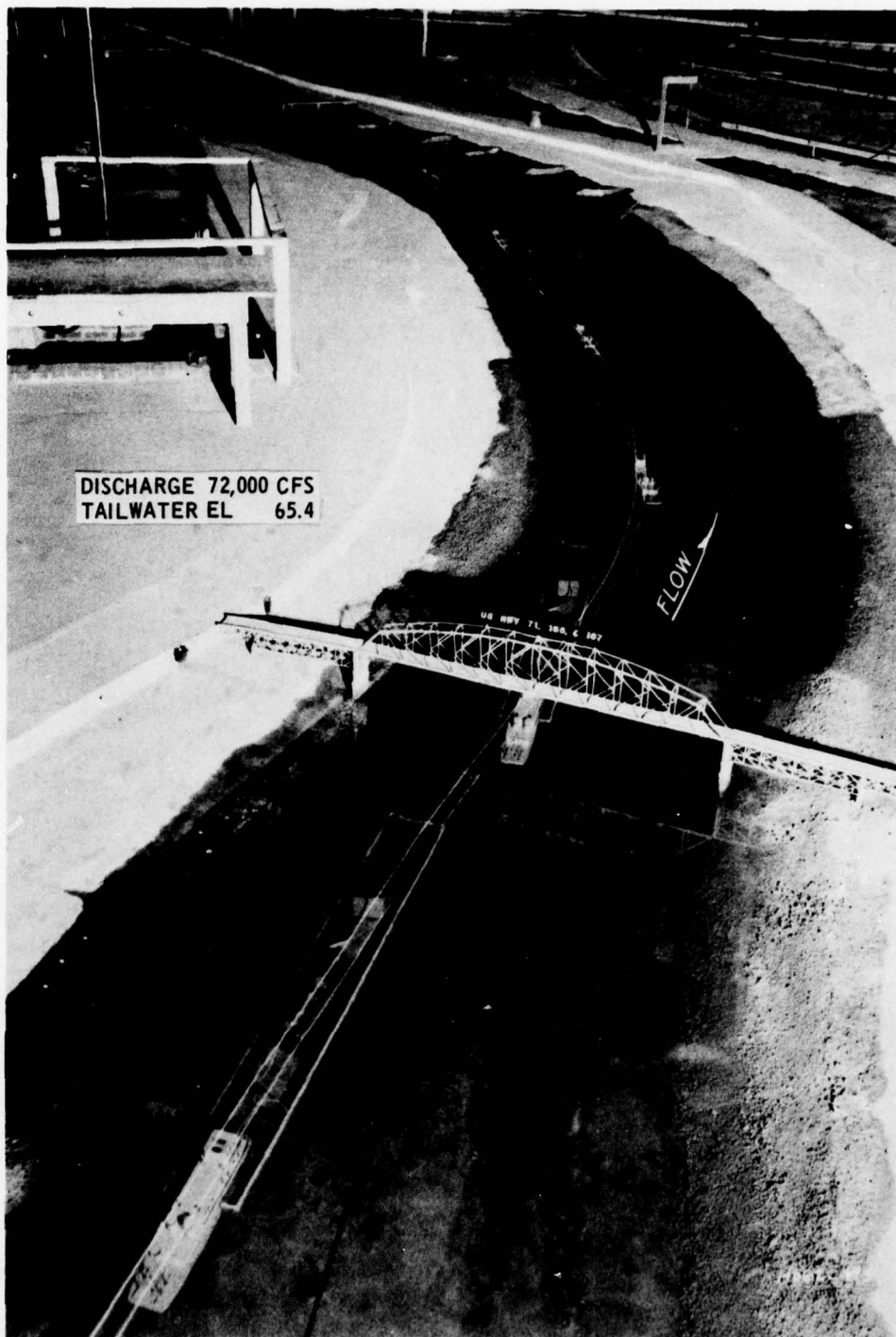


Photo 11. Plan H; Discharge 72,000 cfs, Tailwater el 65.4. Path of downbound tow passing through the U. S. Highways 71, 165, and 167 Bridge and moving along the left bank downstream. Note tendency for tow to be moved to the right after passing the bridge

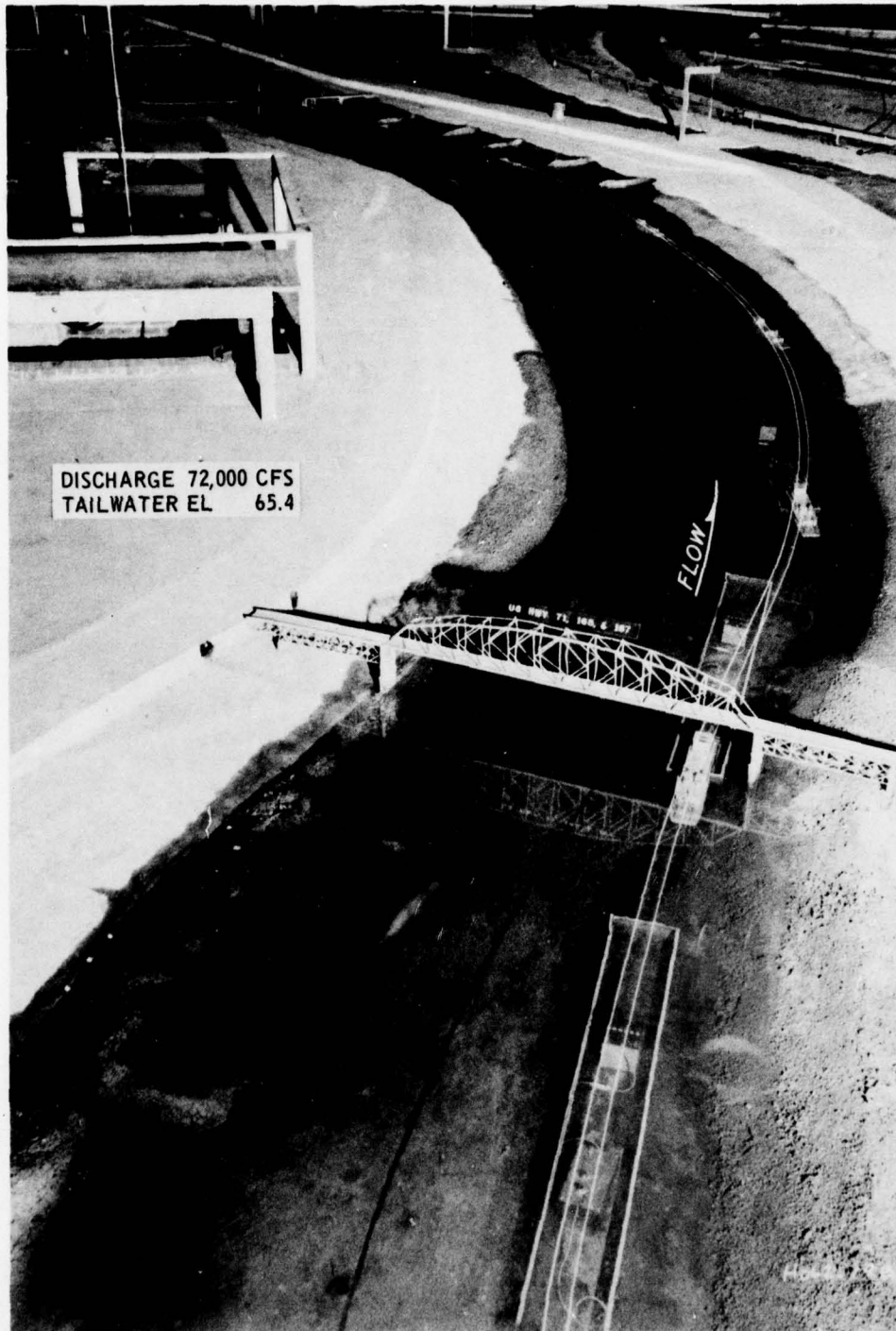


Photo 12. Plan H; Discharge 72,000 cfs, Tailwater el 65.4  
Path of downbound tow passing through the right side of the  
Highways 71, 165, and 167 Bridge span. Note tendency for  
the tow to be moved toward the right bank downstream of the  
bridge

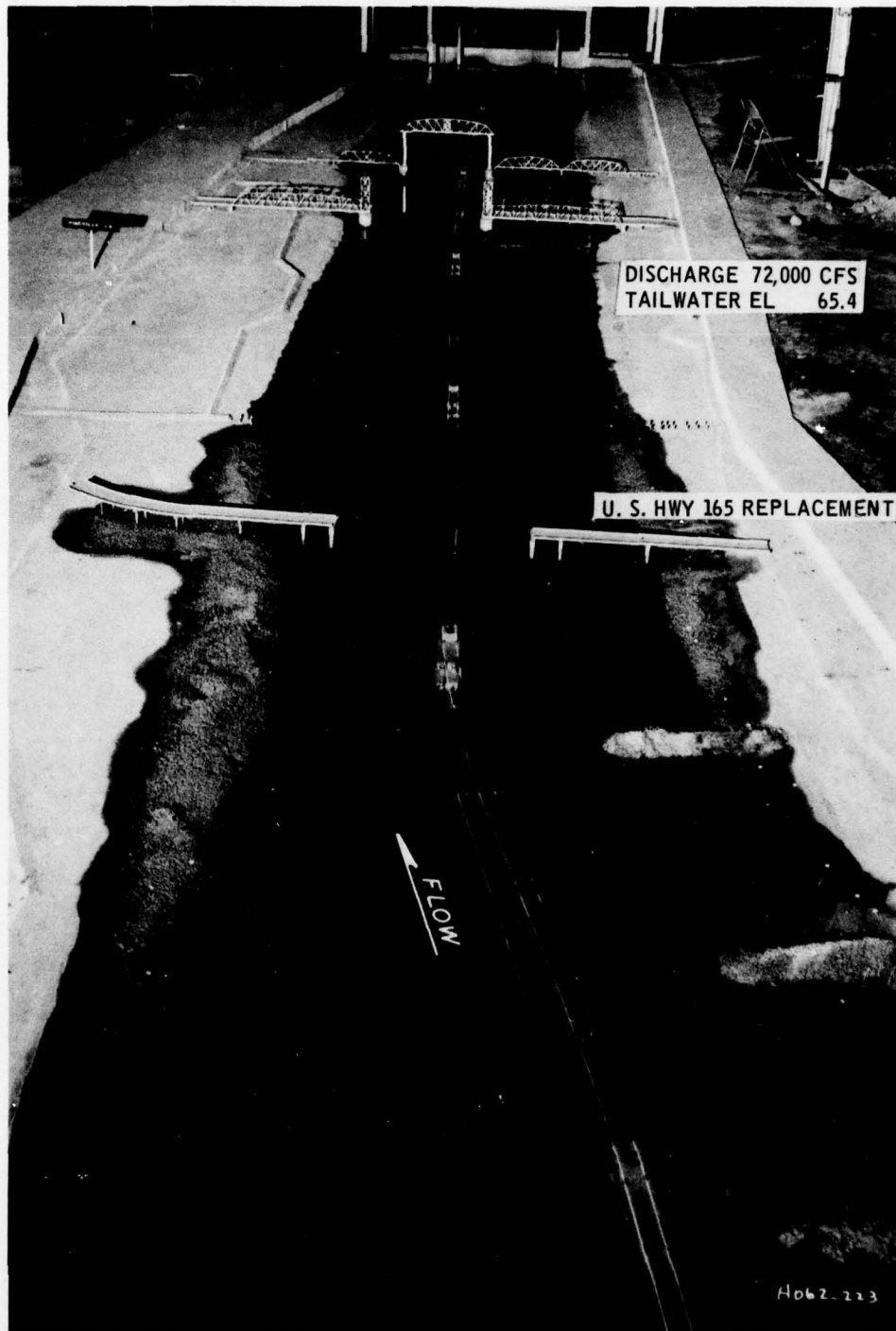


Photo 13. Plan H; Discharge 72,000 cfs, Tailwater el 65.4. Path of downbound tow approaching and passing through the bridges in the lower reach along the right side of the navigation channel



Photo 14. Plan H; Discharge 72,000 cfs, Tailwater el 65.4. Path of downbound tow approaching and passing through the bridges in the lower reach along the left side of the navigation channel. Note tendency for tow to be moved to the left after passing the U. S. Highway 165 replacement bridge

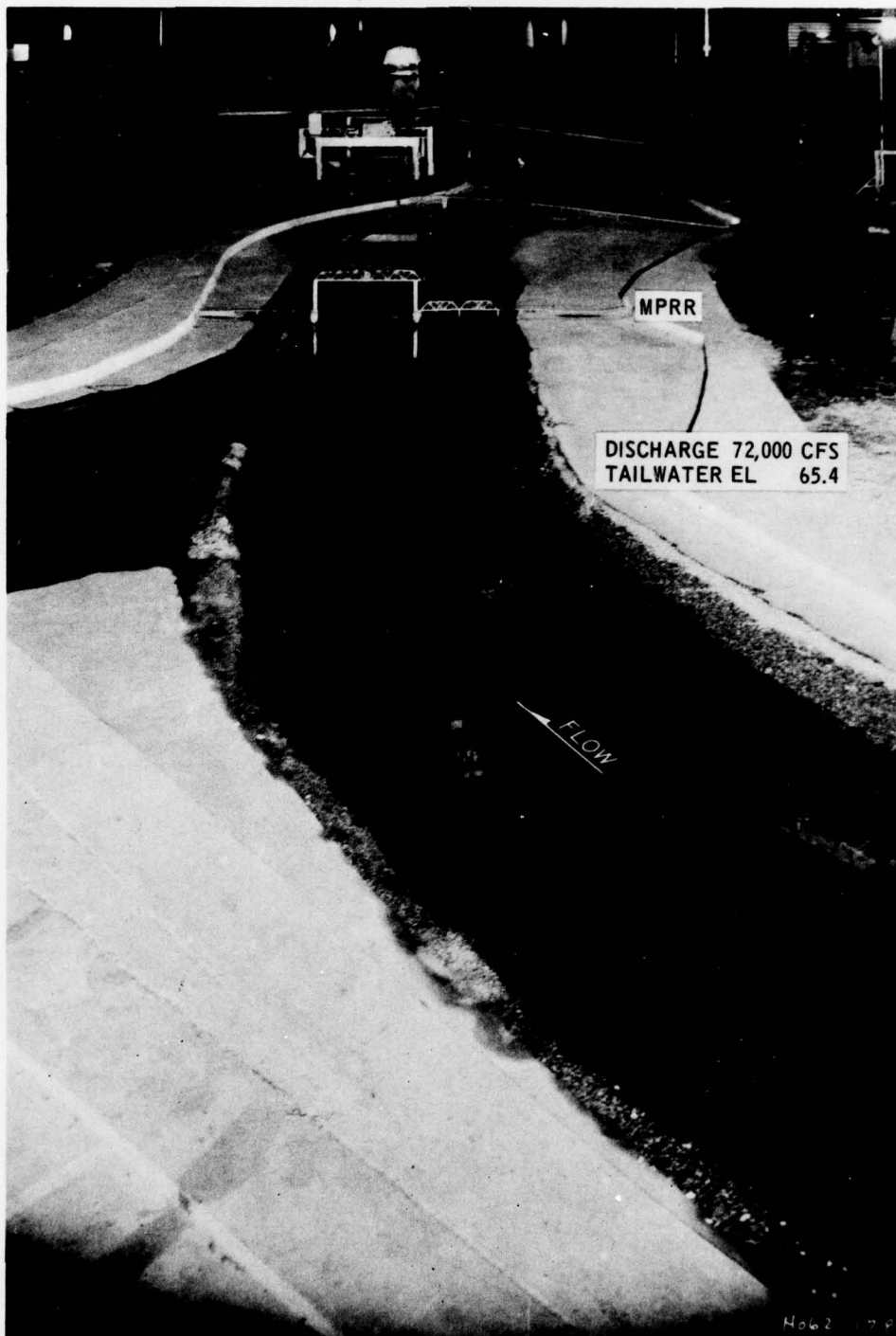


Photo 15. Plan H; Discharge 72,000 cfs, Tailwater el 65.4. Paths of upbound and downbound tows passing in the upper reach. Note orientation and tendency for the downbound tow to be moved toward the left bank in the bend upstream of the MPRR bridge



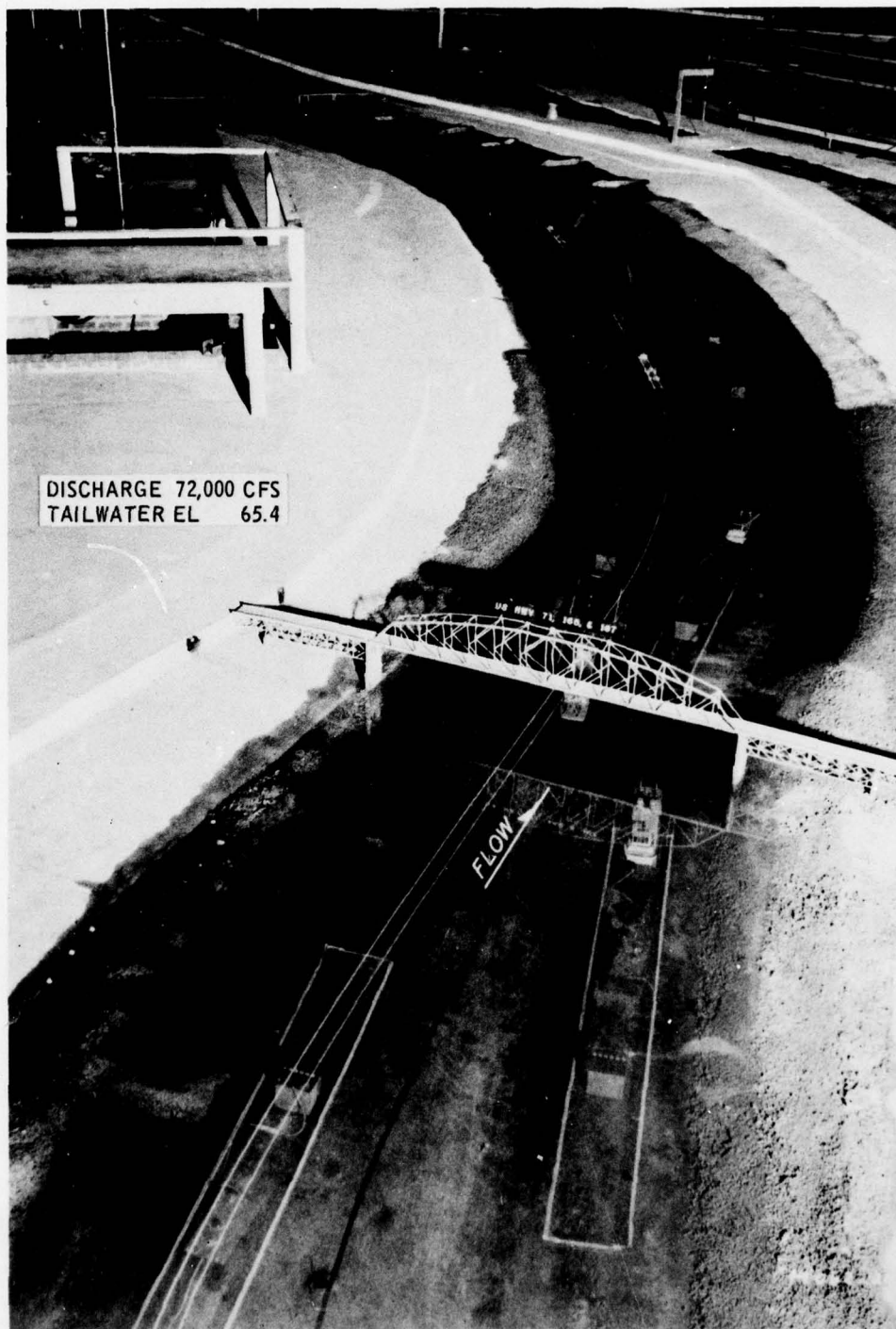
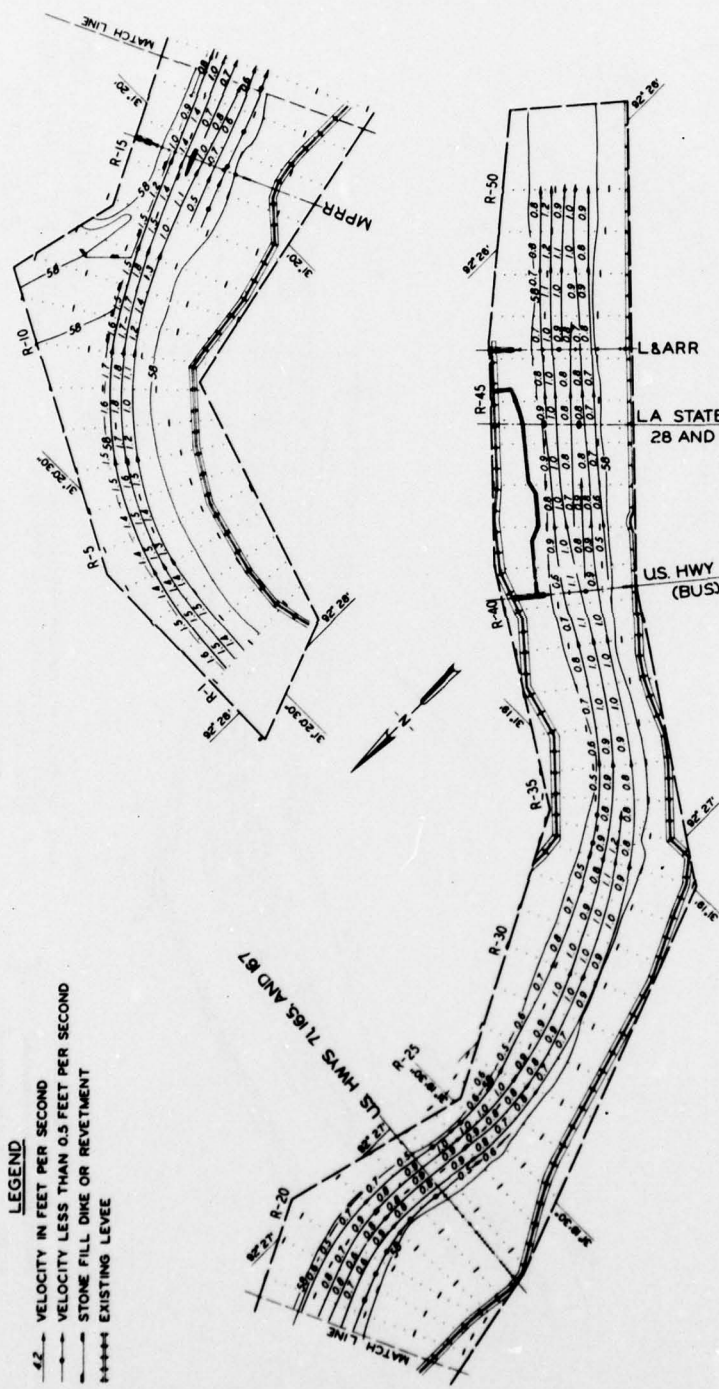


Photo 16. Plan H; Discharge 72,000 cfs, Tailwater el 65.4. Paths of upbound and downbound tows passing in the reach upstream and downstream of the U. S. Highways 71, 165, and 167 Bridge. Note tendency for the downbound tow to be moved toward the right after passing the bridge (same as in Photo 11)



Photo 17. Plan H; Discharge 72,000 cfs, Tailwater el 65.4. Paths of upbound and downbound tows passing in the approach and through the bridges in the lower reach. Note tendency for the downbound tow to be moved to the left after passing U. S. Highway 165 replacement bridge (same as in Photo 14)



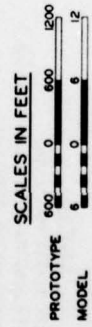
# VELOCITIES AND CURRENT DIRECTIONS

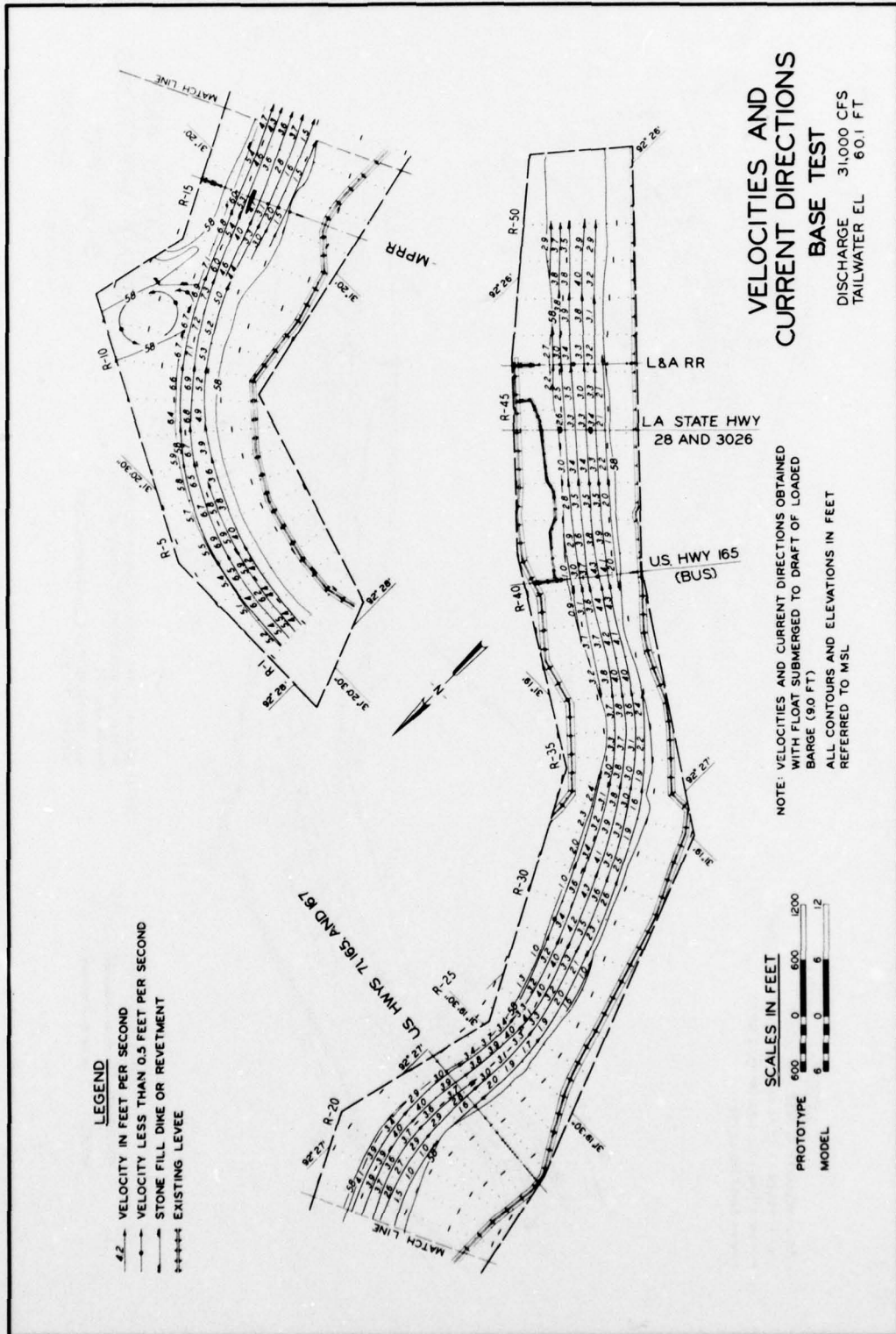
**BASE TEST**  
 DISCHARGE 3,600 CFS  
 TAILWATER EL 57.9 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (30 FT)  
 ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL

## LEGEND

- VELOCITY IN FEET PER SECOND
- - - VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- EXISTING LEVEE





**LEGEND**

- 0.2 — VELOCITY IN FEET PER SECOND
- 0.5 — VELOCITY LESS THAN 0.5 FEET PER SECOND
- — — STONE FILL DIKE OR REVETMENT
- +++++ EXISTING LEVEE

**VELOCITIES AND CURRENT DIRECTIONS  
BASE TEST**

DISCHARGE 31,000 CFS  
TAILWATER EL 60.1 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL

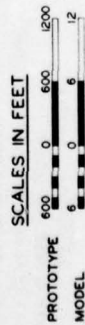
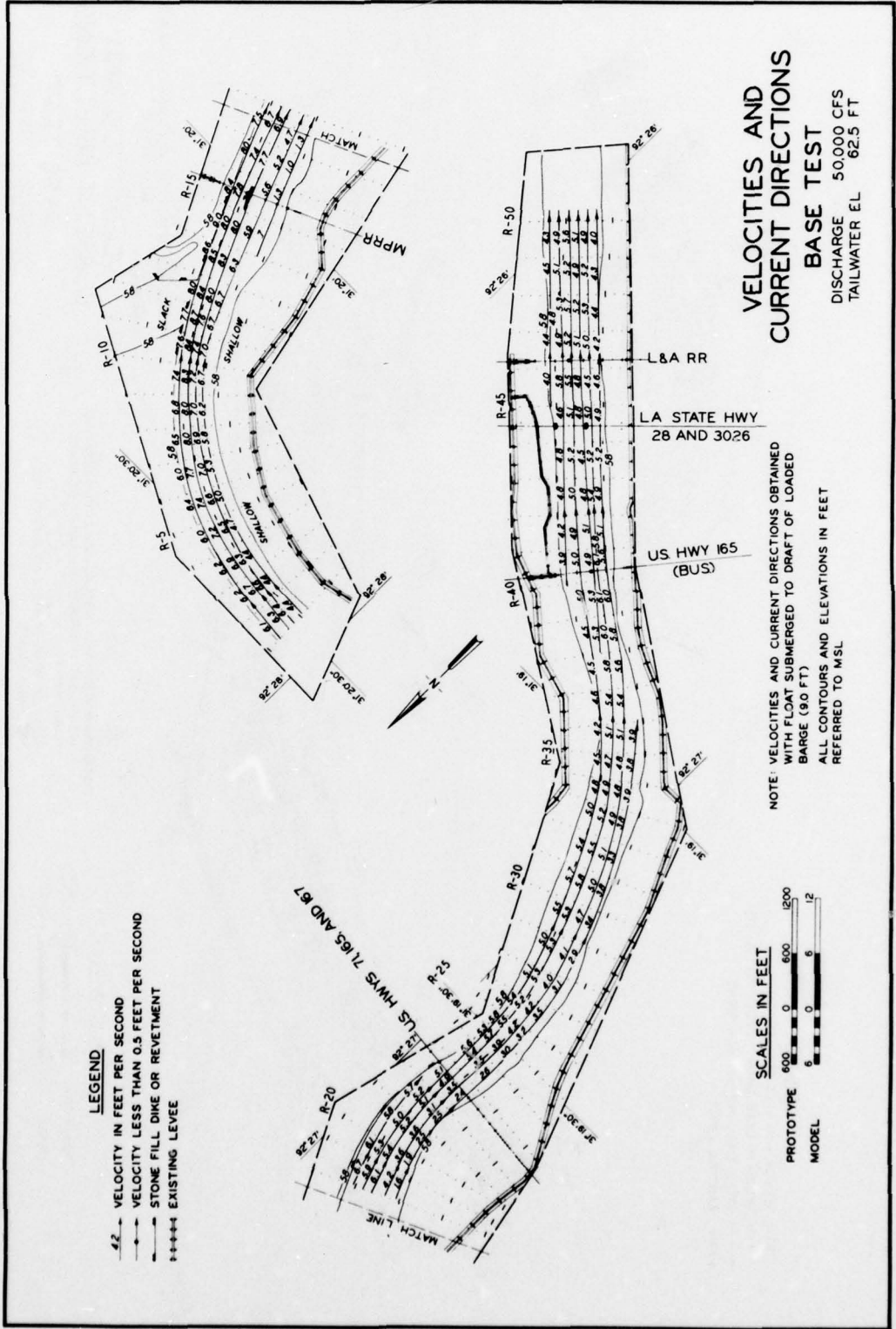


PLATE 2



**LEGEND**

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- EXISTING LEVEE

**SCALE IN FEET**

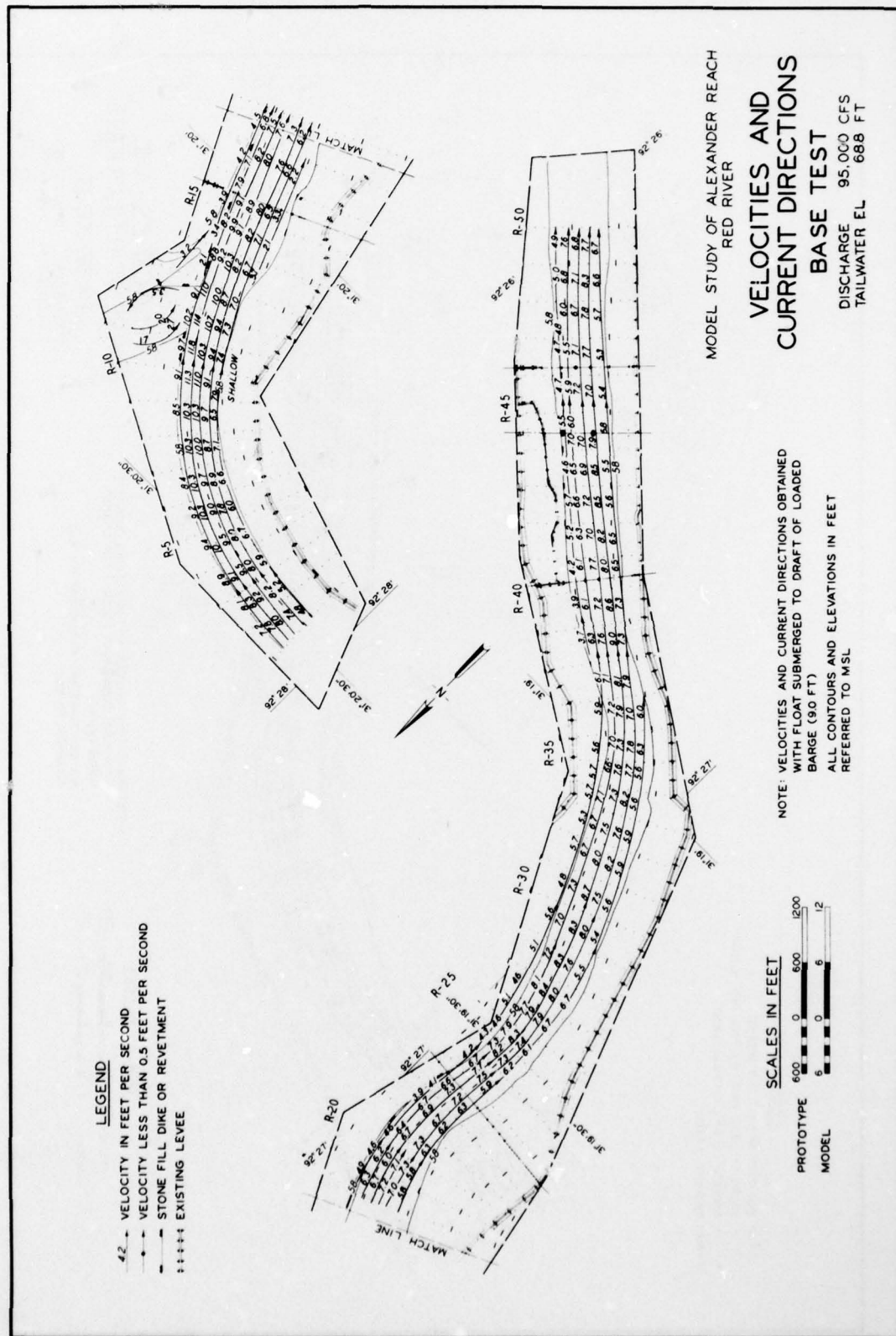


NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)  
 ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL

**VELOCITIES AND CURRENT DIRECTIONS**

**BASE TEST**

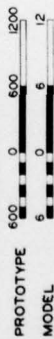
DISCHARGE 50,000 CFS  
 TAILWATER EL 62.5 FT



**LEGEND**

- 4.2 → VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- +++++ EXISTING LEVEE

**SCALES IN FEET**



NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (90 FT)  
 ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL

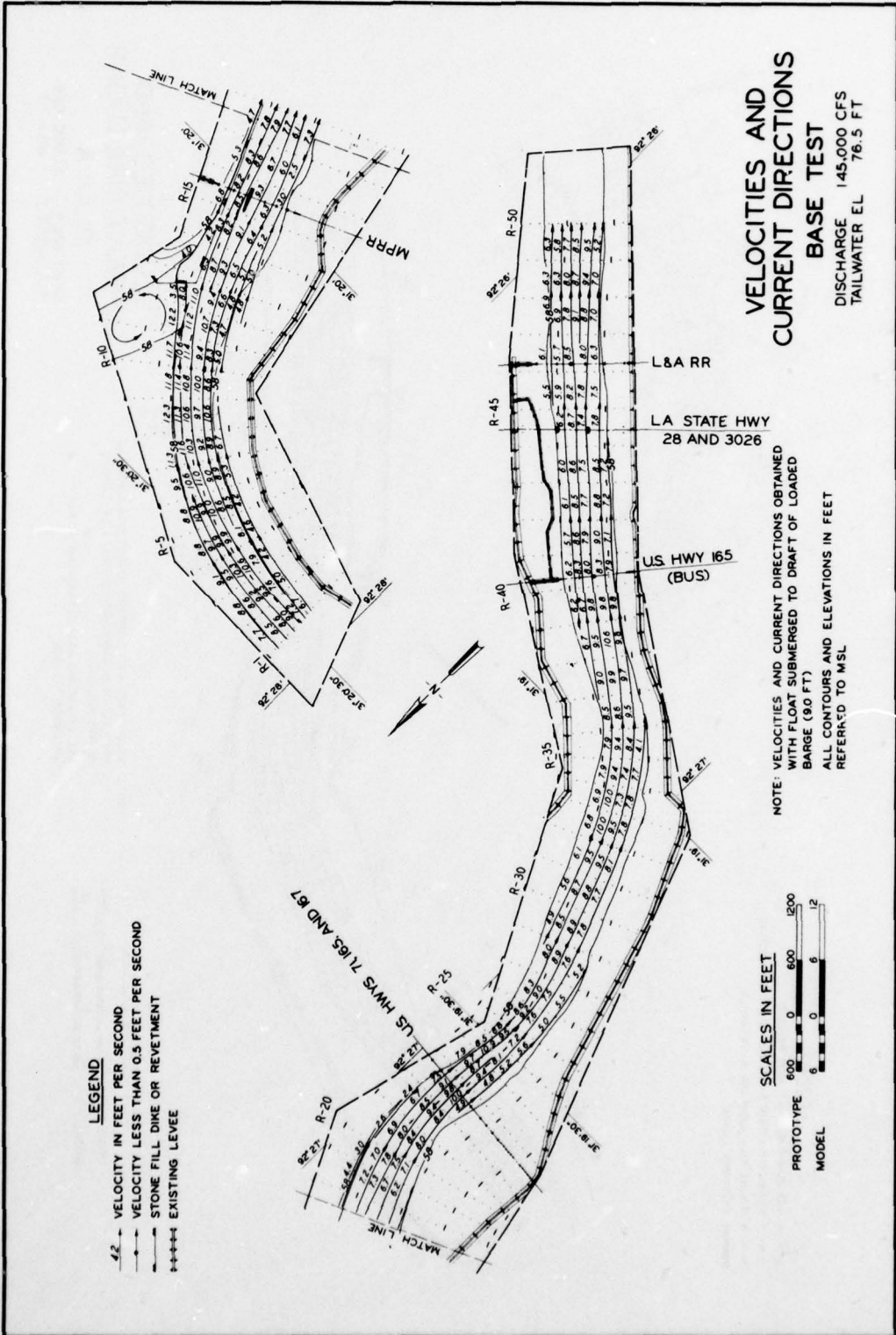
MODEL STUDY OF ALEXANDER REACH  
 RED RIVER

**VELOCITIES AND CURRENT DIRECTIONS**

**BASE TEST**

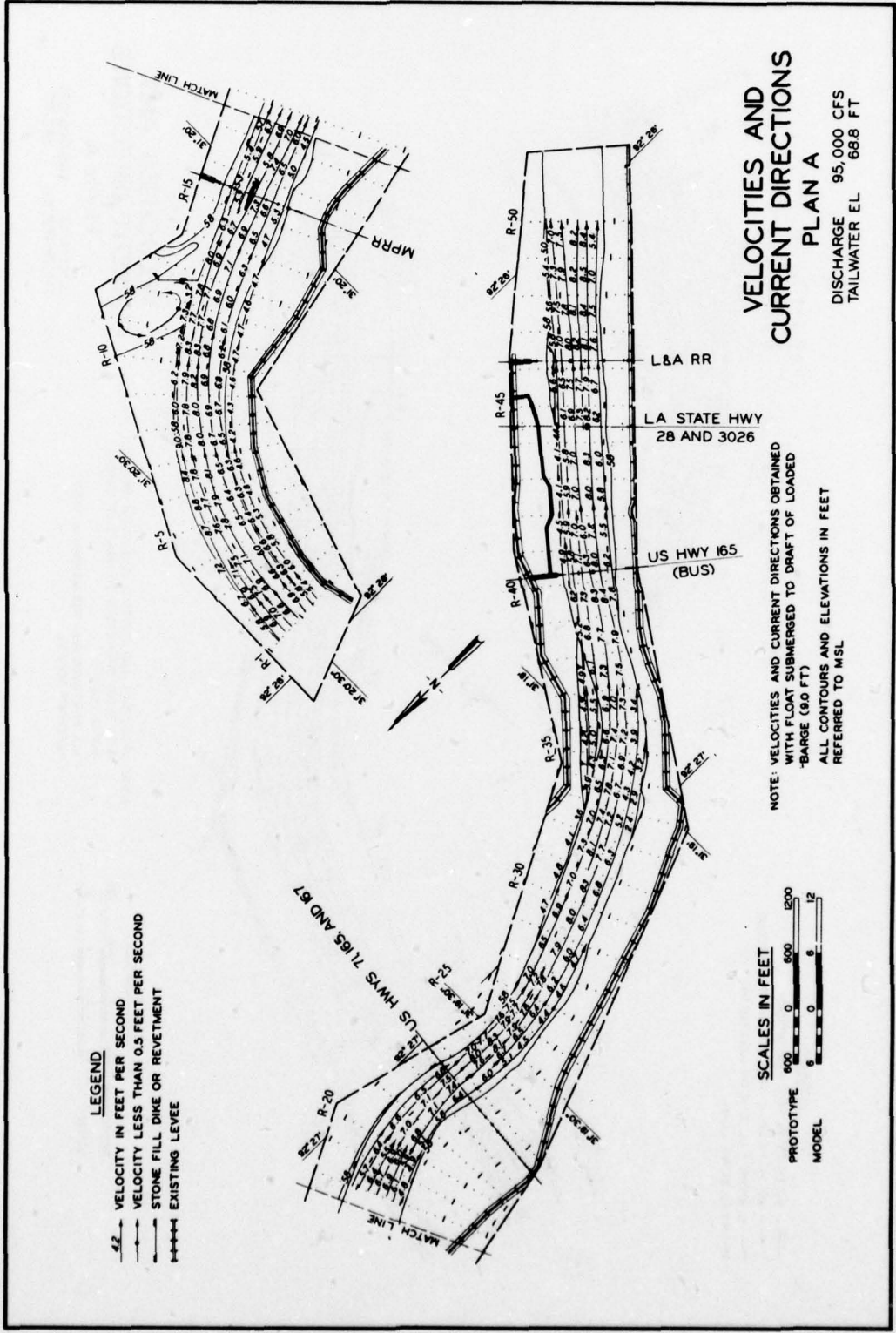
DISCHARGE 95,000 CFS  
 TAILWATER EL 688 FT

PLATE 4









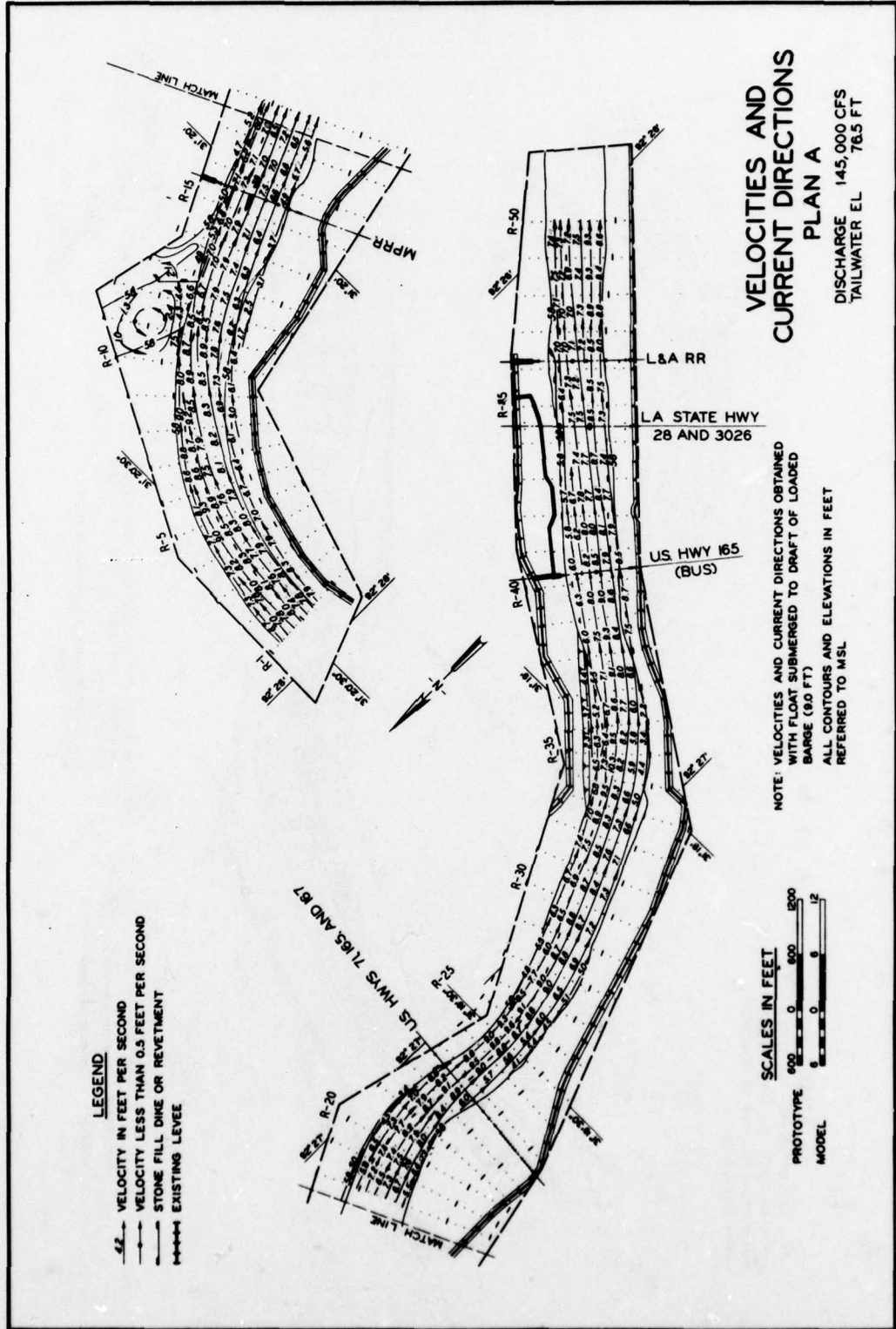
# VELOCITIES AND CURRENT DIRECTIONS PLAN A

DISCHARGE 95,000 CFS  
TAILWATER EL 688 FT

- LEGEND**
- VELOCITY IN FEET PER SECOND
  - - - VELOCITY LESS THAN 0.5 FEET PER SECOND
  - STONE FILL DIKE OR RETENTION
  - EXISTING LEVEE

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (80 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL





**LEGEND**

- 0.2— VELOCITY IN FEET PER SECOND
- 0.5— VELOCITY LESS THAN 0.5 FEET PER SECOND
- +—+— STONE FILL DIKE OR REVETMENT
- +—+— EXISTING LEVEE

**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN A**

DISCHARGE 145,000 CFS  
TAILWATER EL 76.5 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED  
WITH FLOAT SUBMERGED TO DRAFT OF LOADED  
BARGE (300 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET  
REFERRED TO MSL

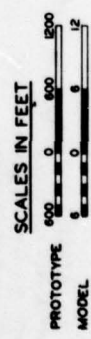
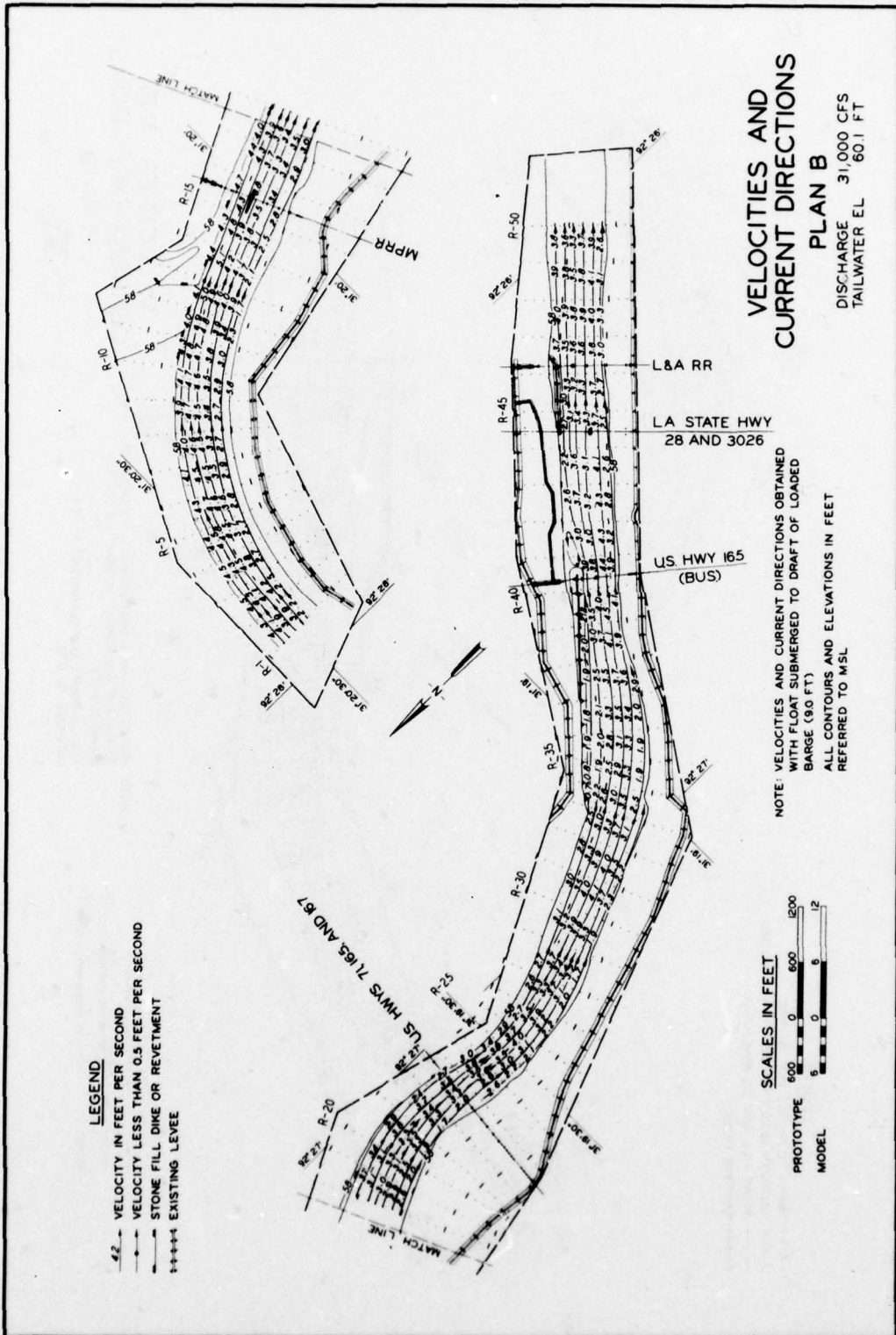


PLATE 8



**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN B**

DISCHARGE 31,000 CFS  
TAILWATER EL 60.1 FT

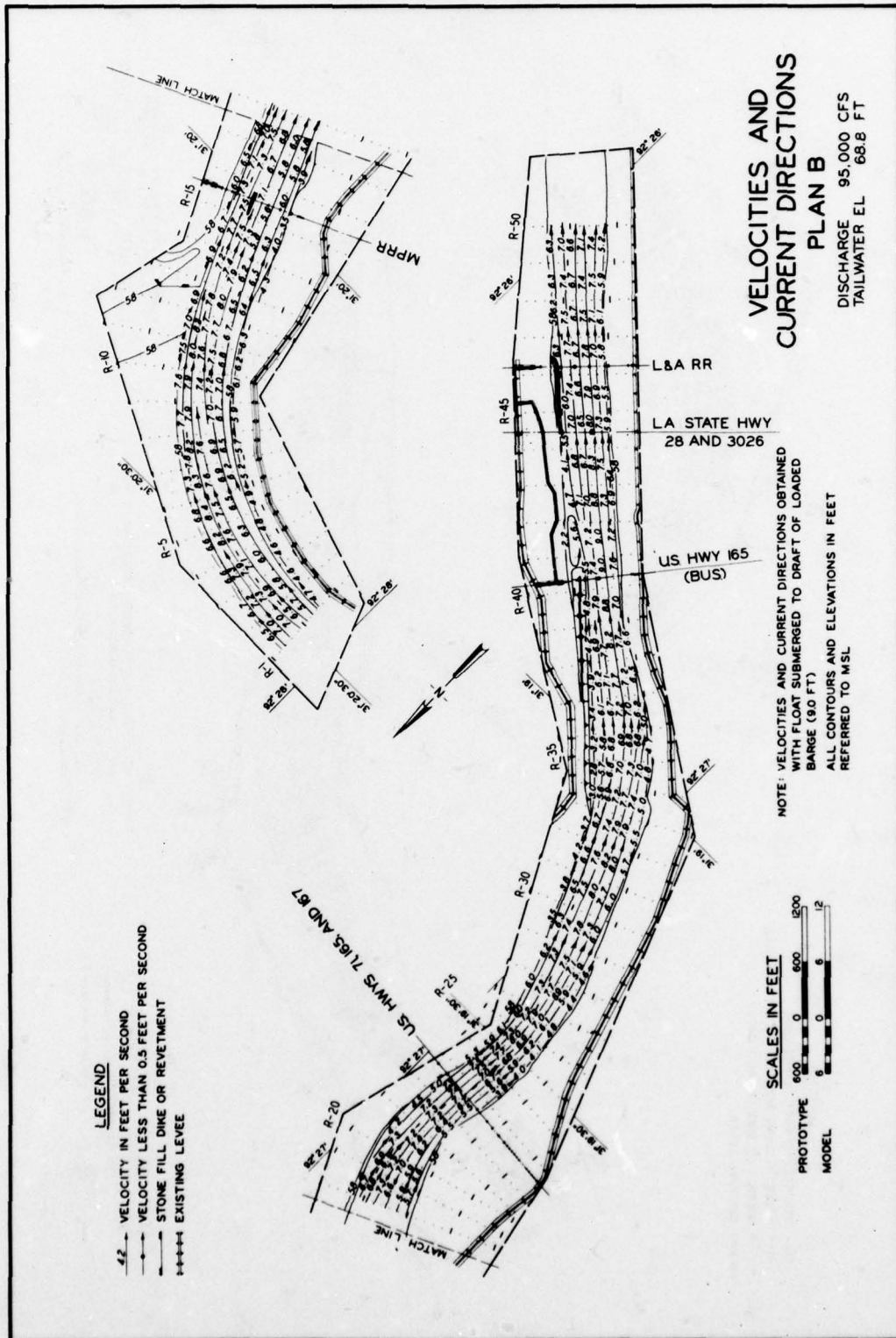
**LEGEND**

- 0.2 — VELOCITY IN FEET PER SECOND
- 0.5 — VELOCITY LESS THAN 0.5 FEET PER SECOND
- — — STONE FILL DIKE OR REVETMENT
- +++++ EXISTING LEVEE

**SCALES IN FEET**



NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED  
WITH FLOAT SUBMERGED TO DRAFT OF LOADED  
BARGE (90 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET  
REFERRED TO MSL



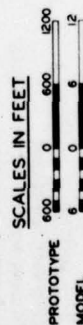
**LEGEND**

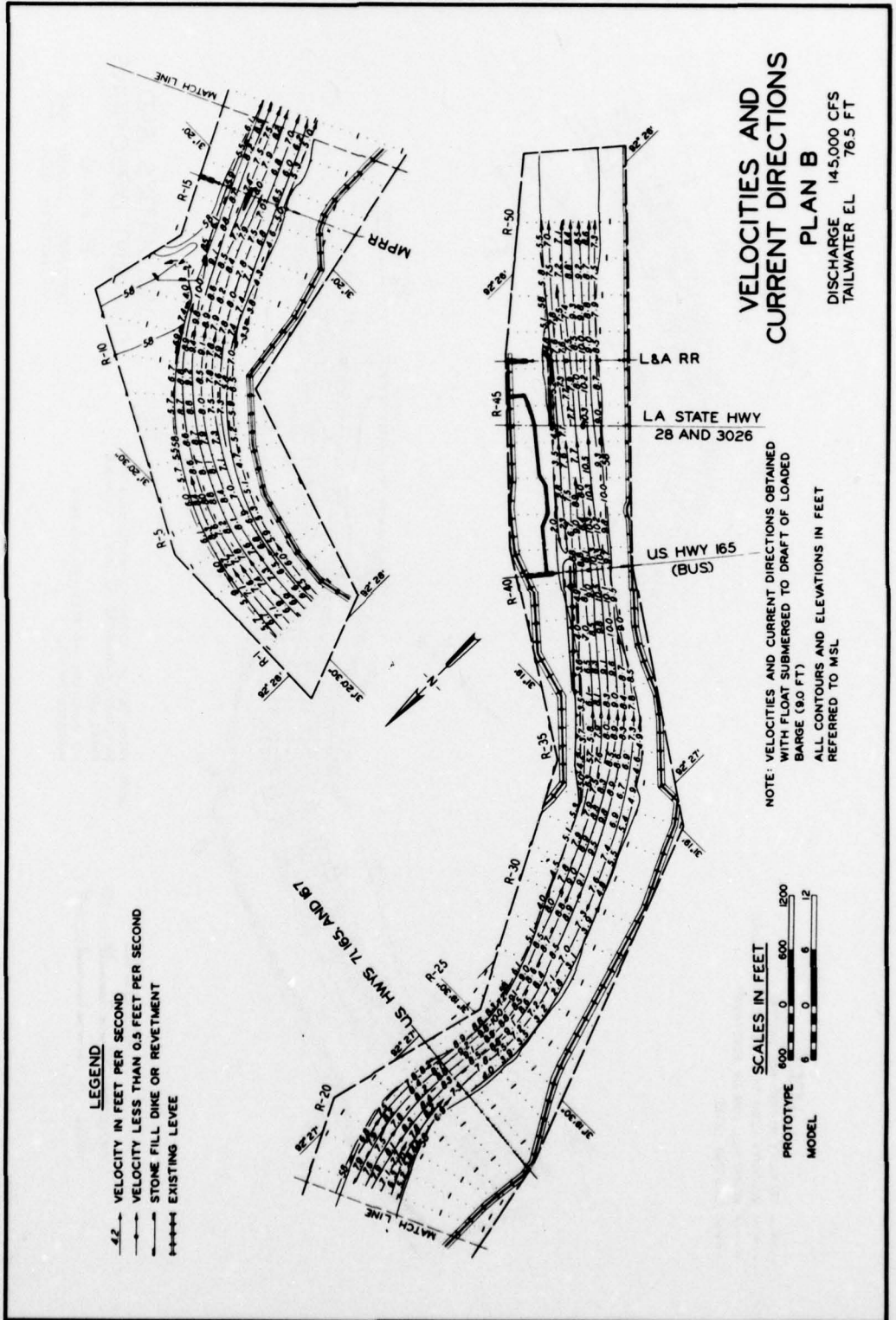
- VELOCITY IN FEET PER SECOND
- - - VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- +++++ EXISTING LEVEE

**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN B**

DISCHARGE 95,000 CFS  
TAILWATER EL 68.8 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED  
WITH FLOAT SUBMERGED TO DRAFT OF LOADED  
BARGE (10 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET  
REFERRED TO MSL





# VELOCITIES AND CURRENT DIRECTIONS PLAN B

DISCHARGE 145,000 CFS  
TAILWATER EL 76.5 FT

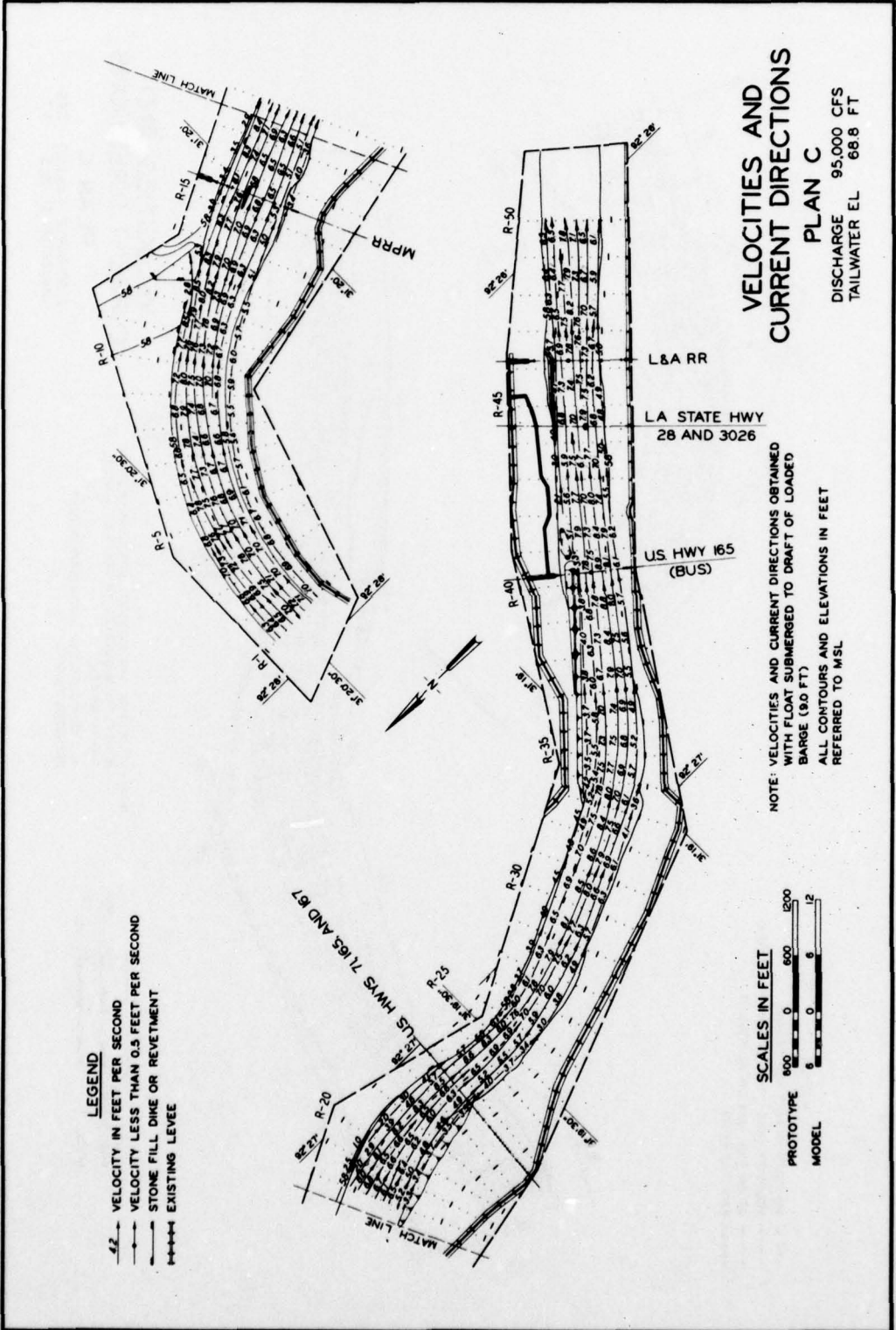
### LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- EXISTING LEVEE



NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL





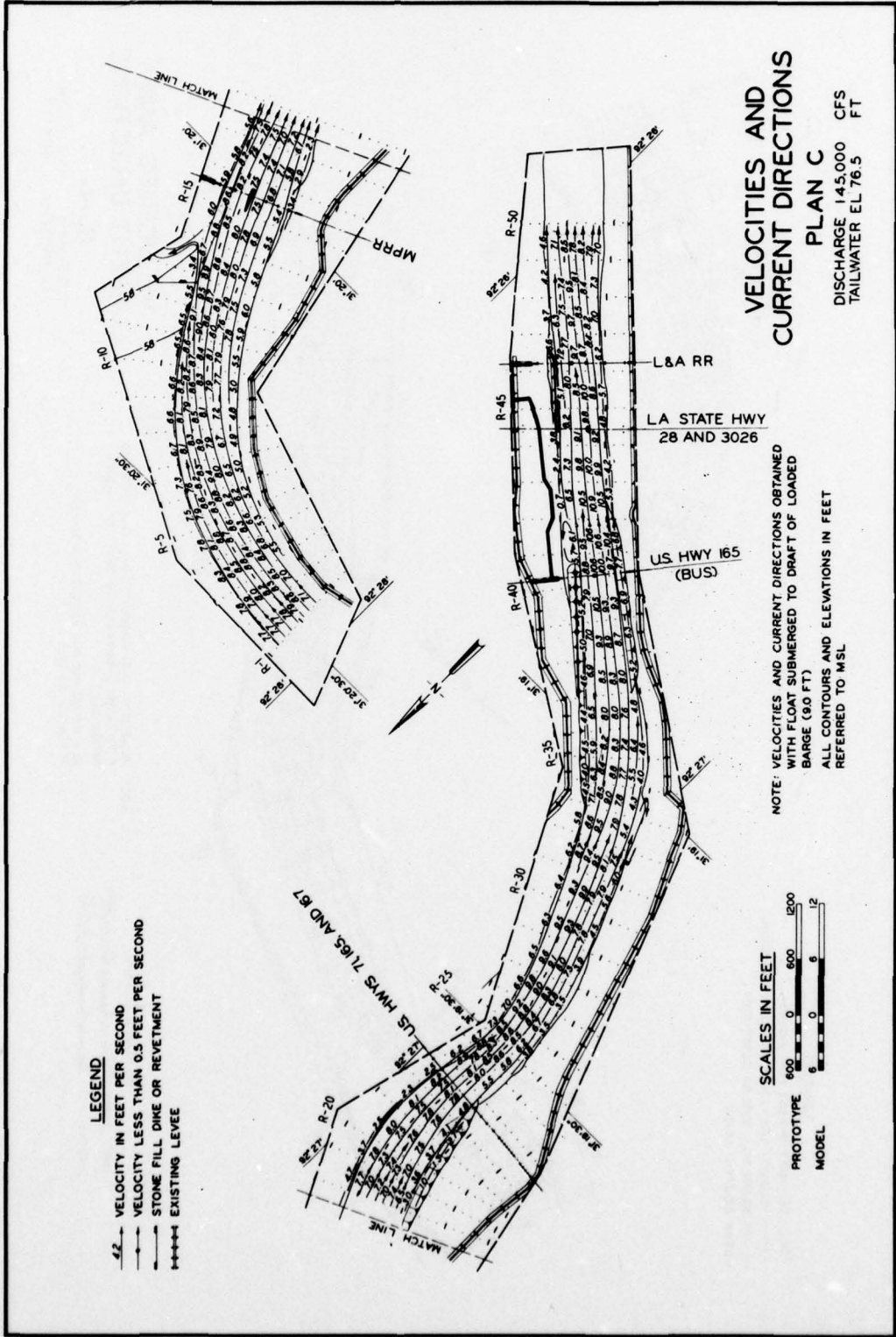
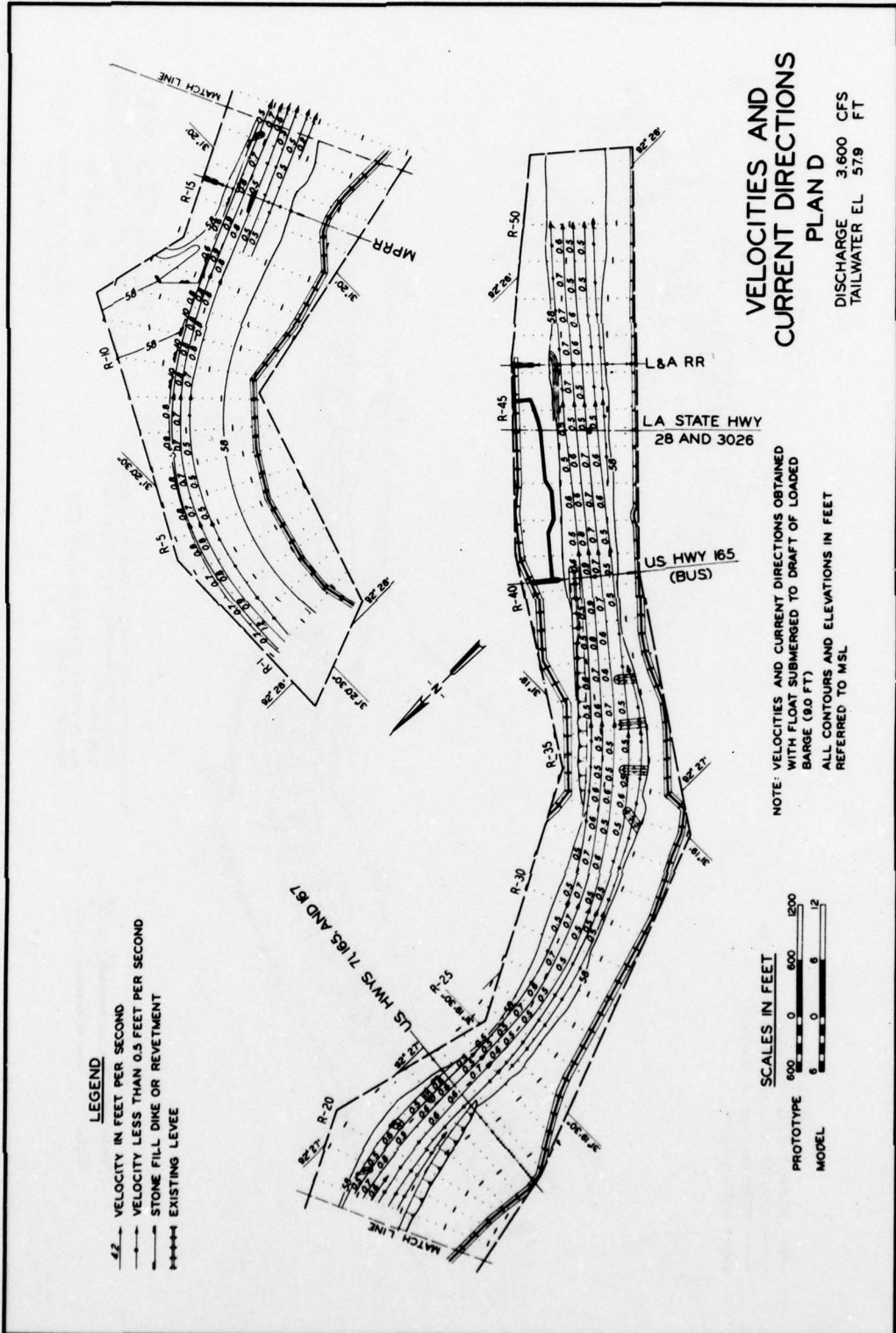


PLATE 14





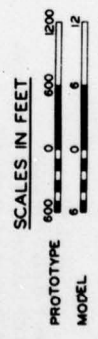
**LEGEND**

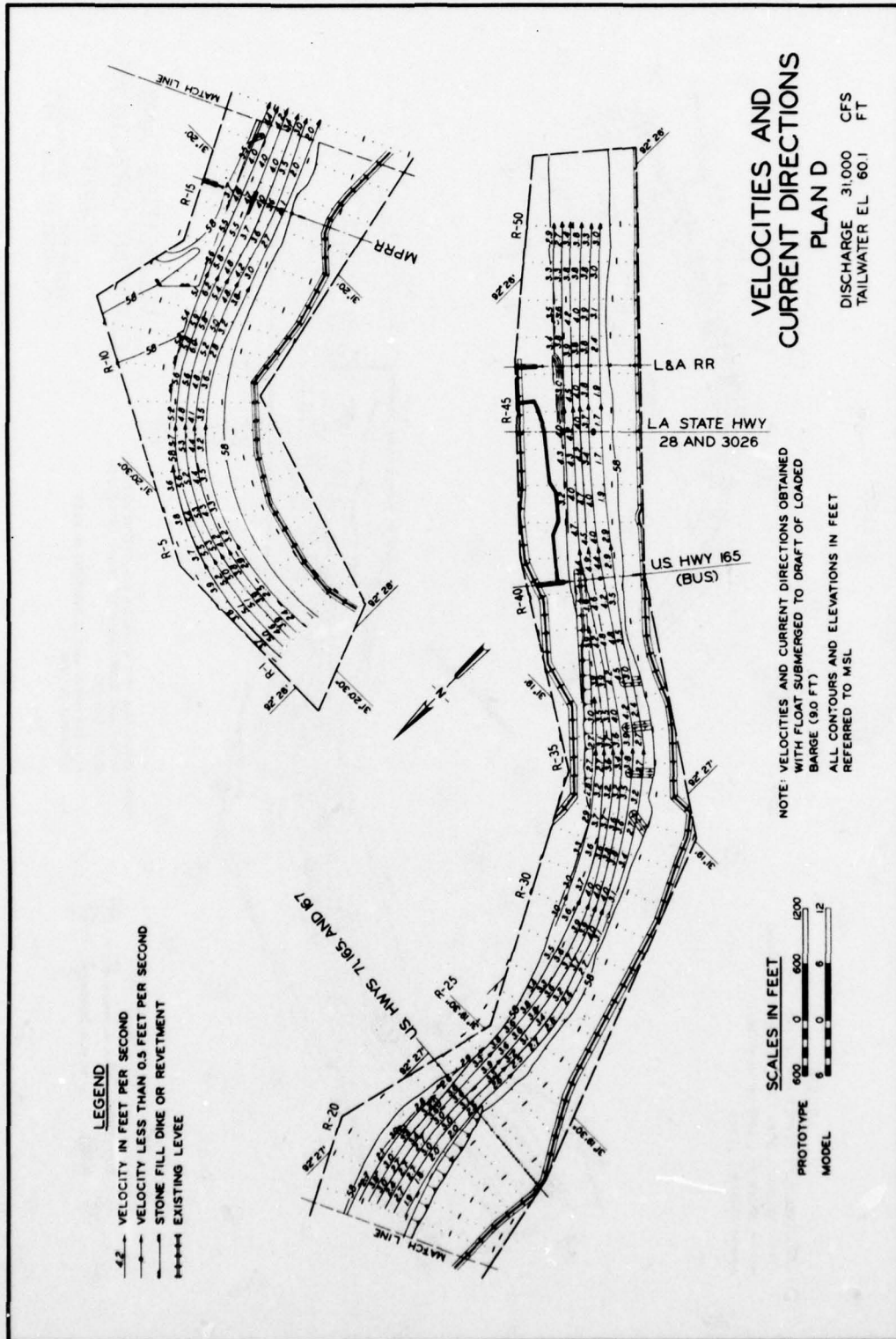
- VELOCITY IN FEET PER SECOND
- - - VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- EXISTING LEVEE

**VELOCITIES AND CURRENT DIRECTIONS  
PLAN D**

DISCHARGE 3,600 CFS  
TAILWATER EL. 579 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL



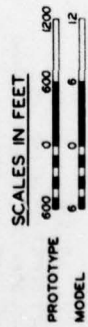


**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN D**

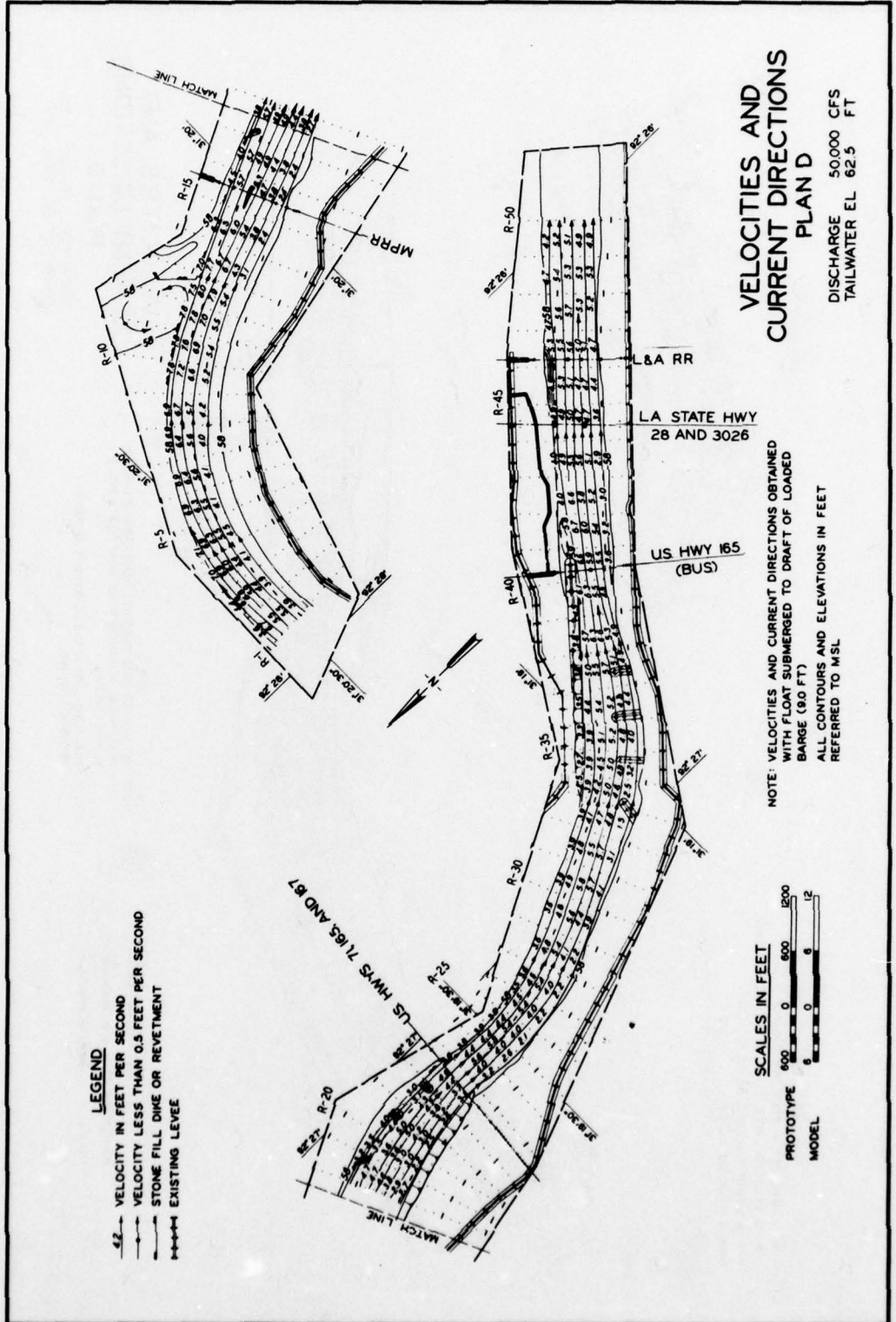
DISCHARGE 31,000 CFS  
TAILWATER EL. 60.1 FT

**LEGEND**

- VELOCITY IN FEET PER SECOND
- - - VELOCITY LESS THAN 0.5 FEET PER SECOND
- +— STONE FILL DIKE OR REVETMENT
- +++++ EXISTING LEVEE



NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (90 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL



**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN D**

DISCHARGE 50000 CFS  
TAILWATER EL 62.5 FT

**LEGEND**

- VELOCITY IN FEET PER SECOND
- - - VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- EXISTING LEVEE

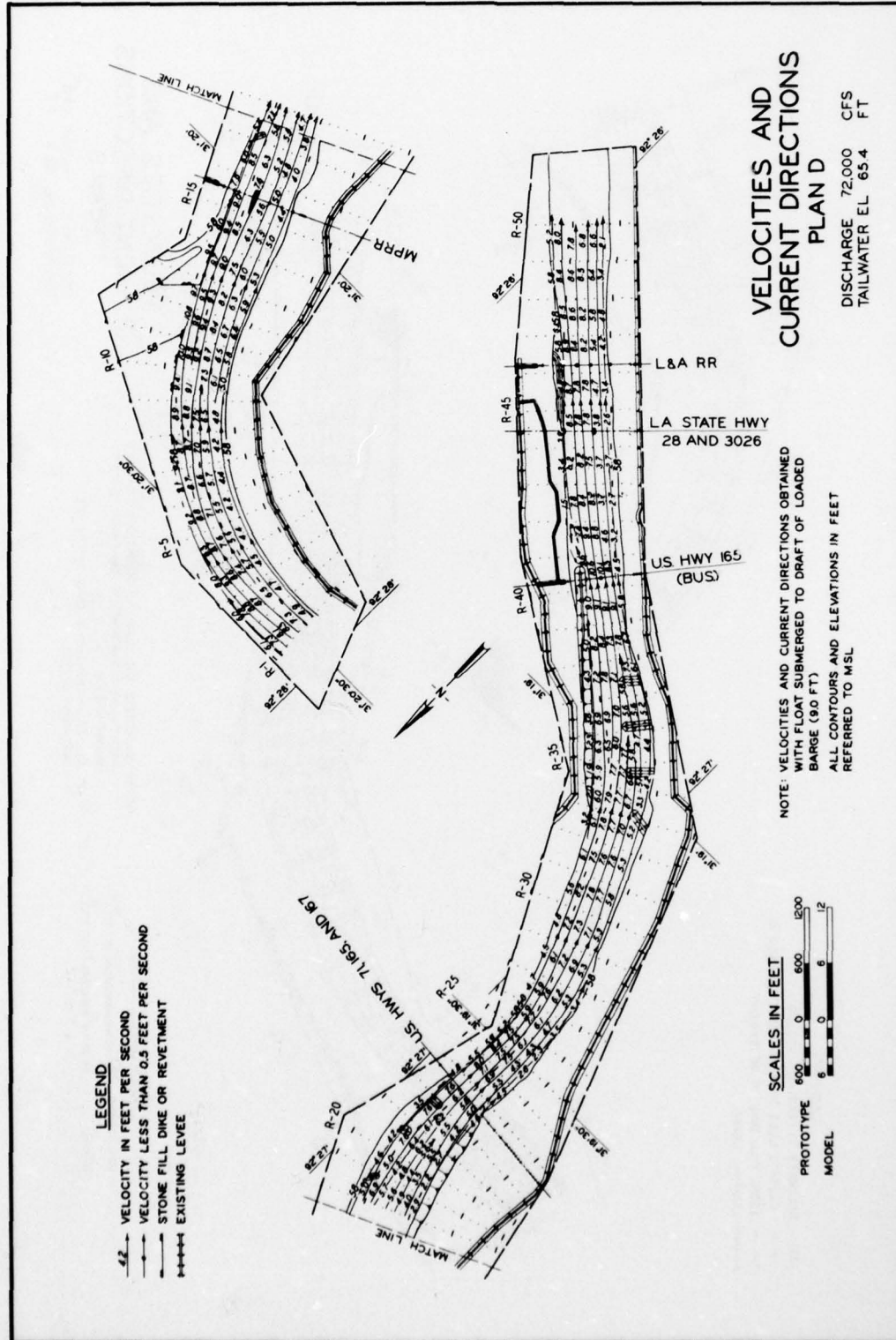
**SCALES IN FEET**

PROTOTYPE 0 600 1200

MODEL 0 6 12

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)

ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL



**LEGEND**

- VELOCITY IN FEET PER SECOND
- - - VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- EXISTING LEVEL

**VELOCITIES AND CURRENT DIRECTIONS  
PLAN D**

DISCHARGE 72,000 CFS  
TAILWATER EL. 65.4 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (30 FT). ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL.

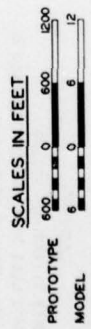
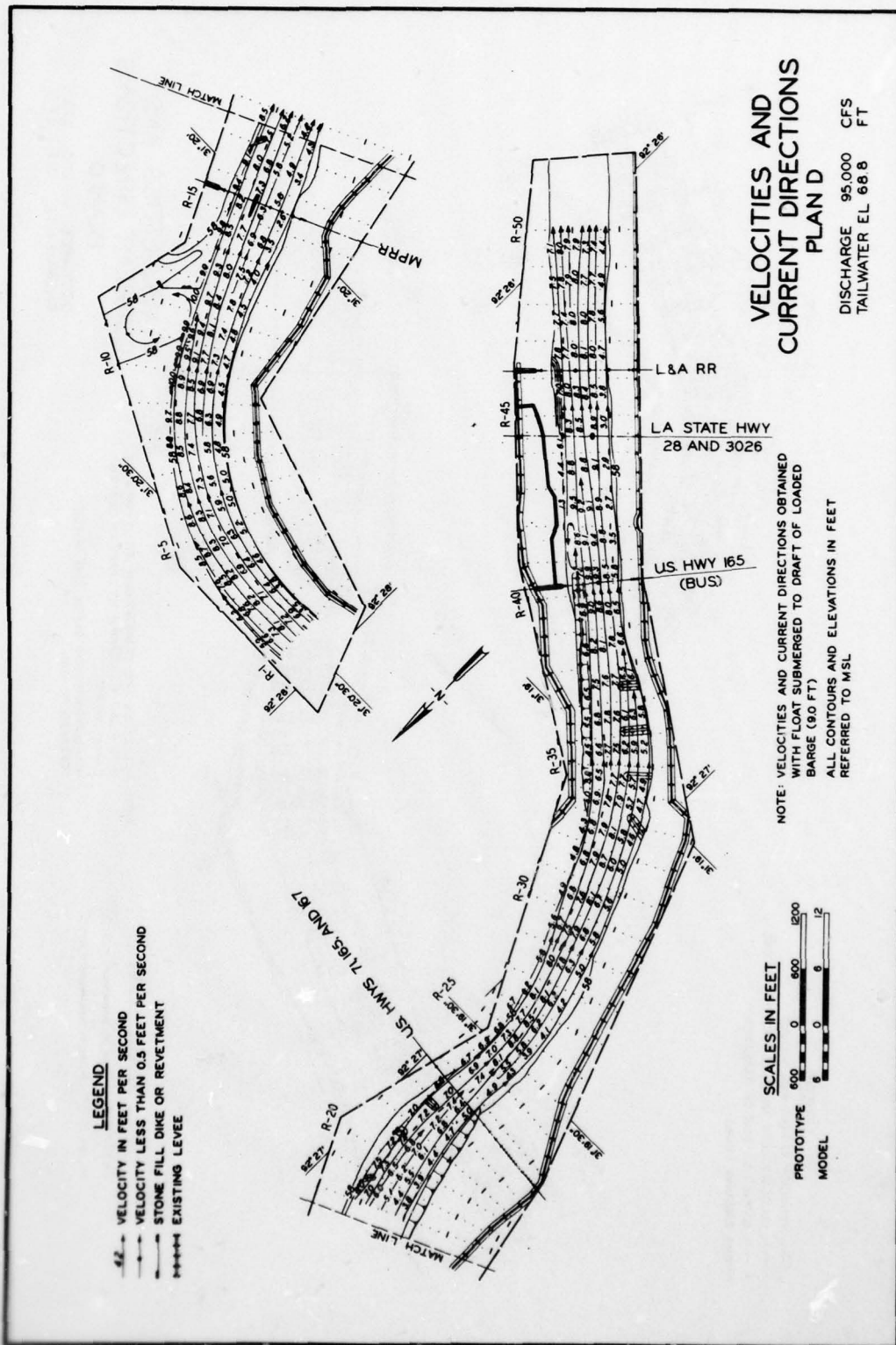


PLATE 18



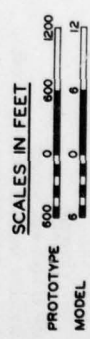
**LEGEND**

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- EXISTING LEVEE

**VELOCITIES AND CURRENT DIRECTIONS PLAN D**

DISCHARGE 95,000 CFS  
TAILWATER EL 68.8 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL



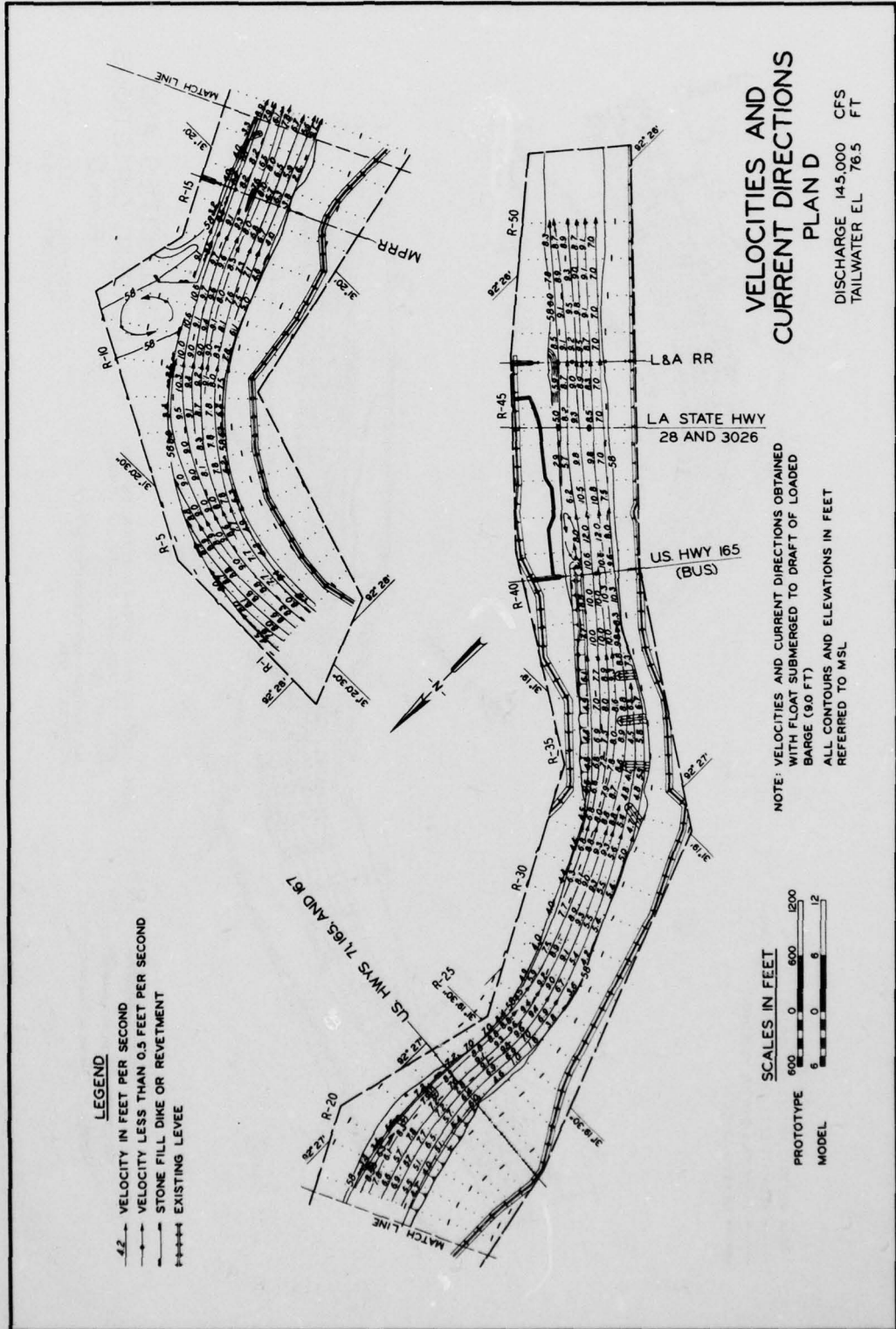
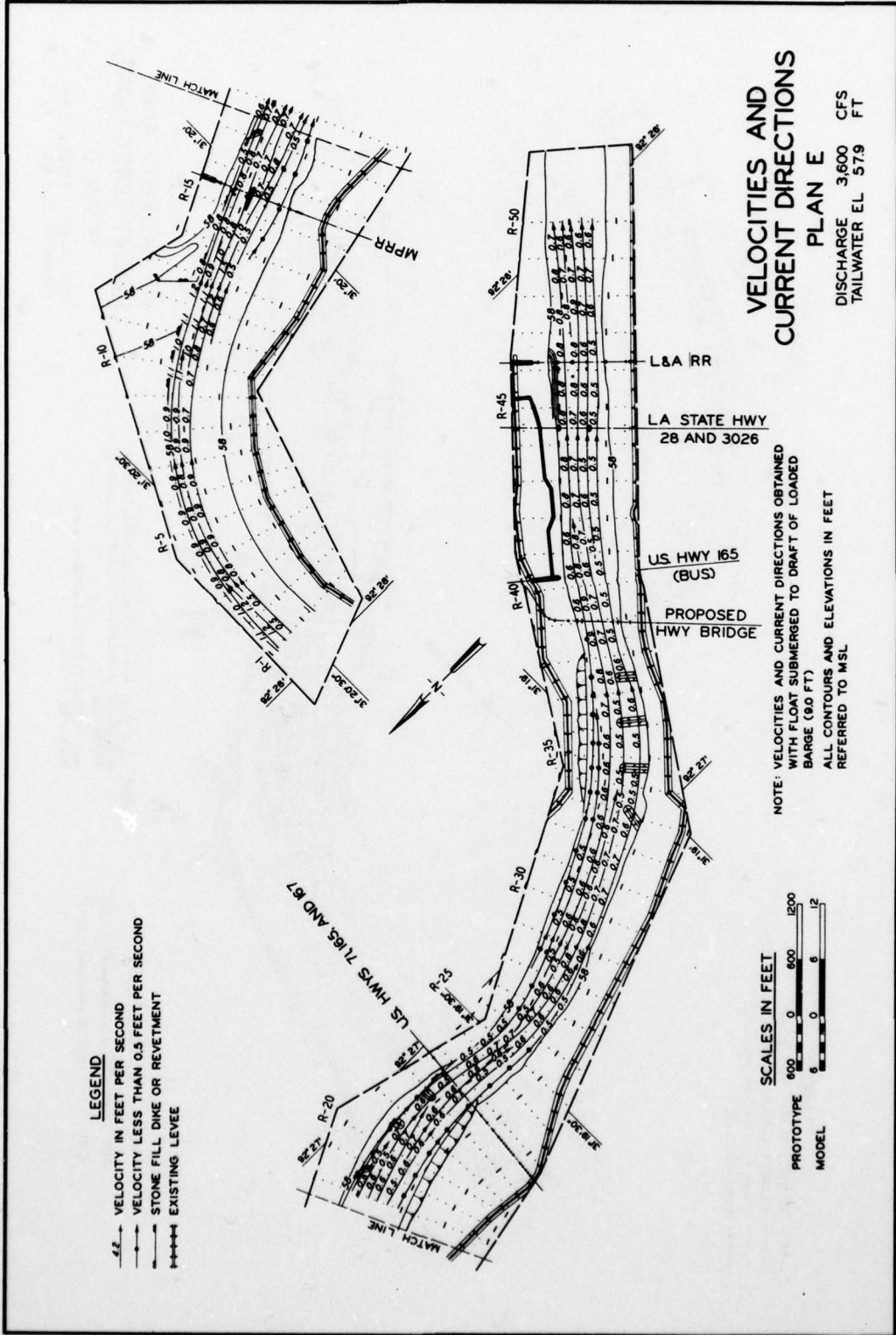


PLATE 20



**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN E**

DISCHARGE 3,600 CFS  
TAILWATER EL 57.9 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED  
WITH FLOAT SUBMERGED TO DRAFT OF LOADED  
BARGE (10 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET  
REFERRED TO MSL

**LEGEND**

- - - VELOCITY IN FEET PER SECOND
- - - VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- ==== EXISTING LEVEE

**SCALES IN FEET**

PROTOTYPE 0 600 1200

MODEL 0 6 12

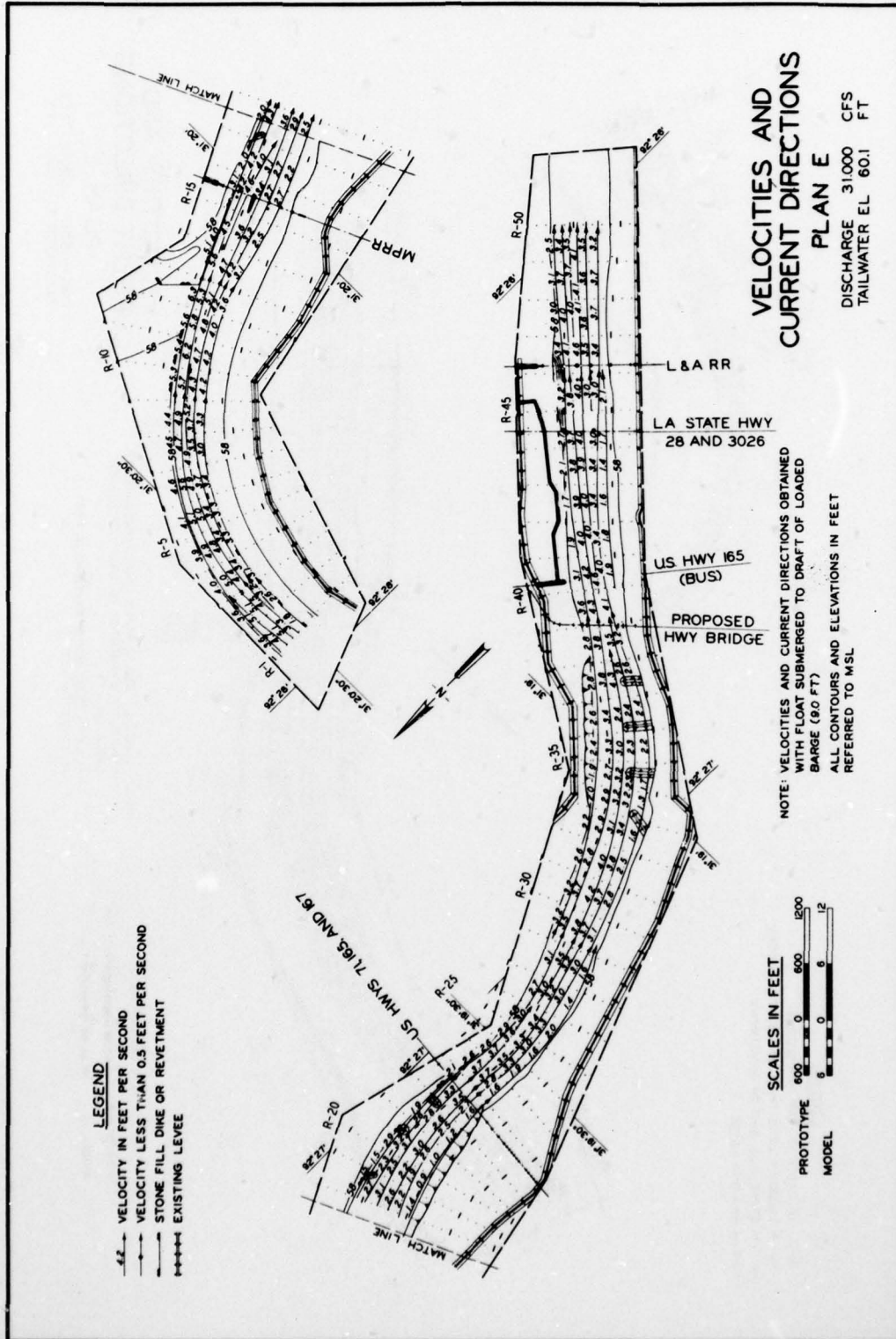
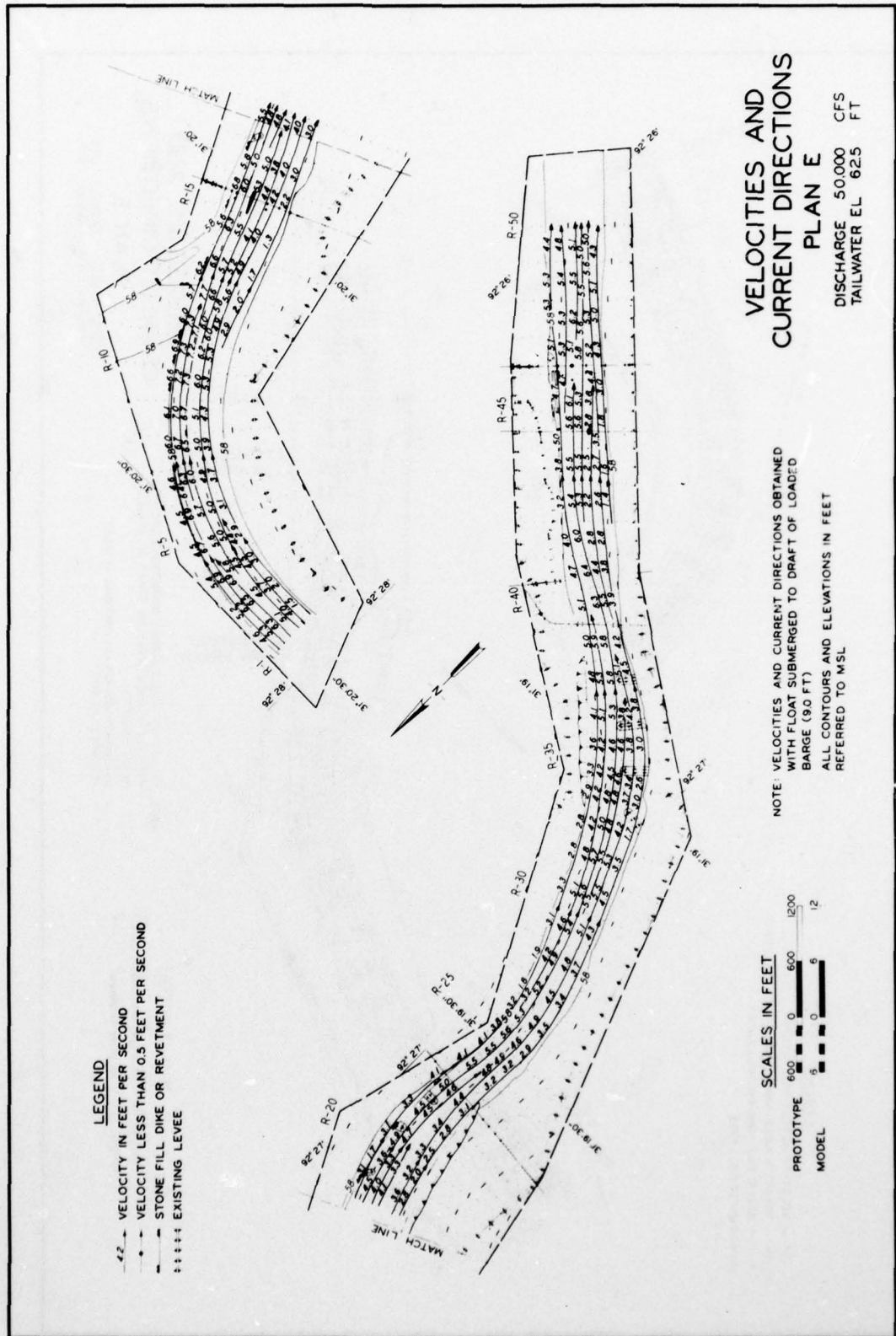
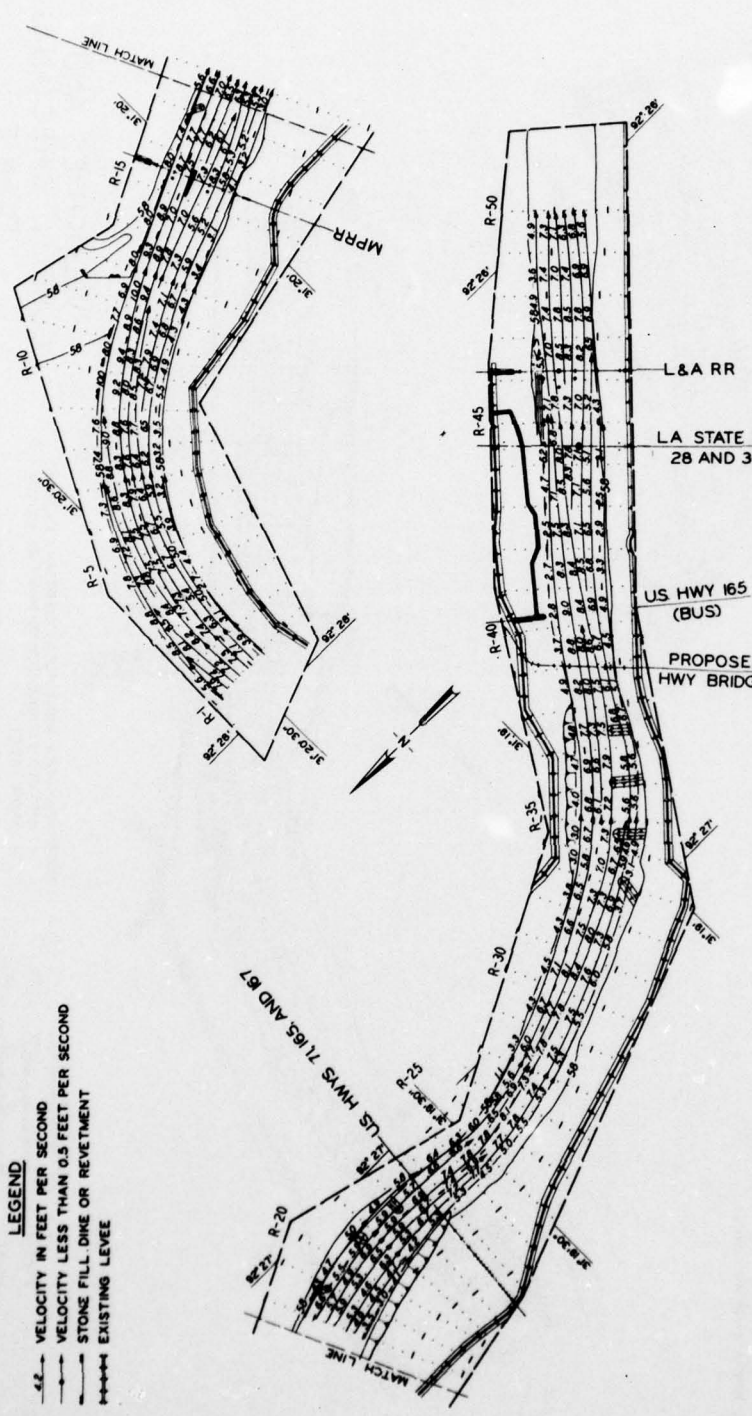


PLATE 22









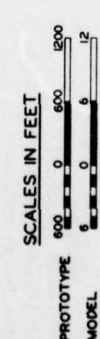
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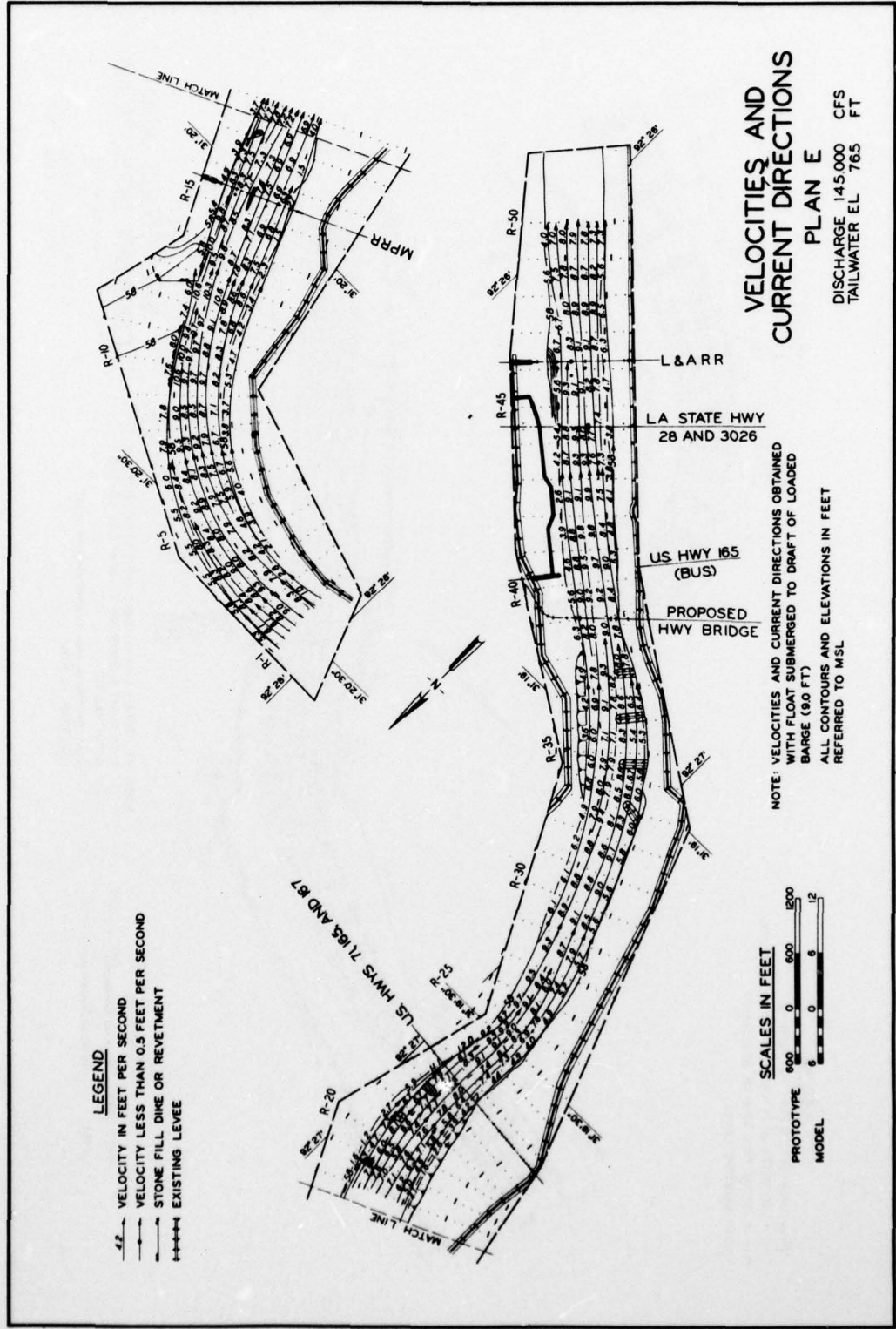
- 4.2- VELOCITY IN FEET PER SECOND
- - - VELOCITY LESS THAN 0.5 FEET PER SECOND
- - - STONE FILL, DIKE OR REVETMENT
- - - EXISTING LEVEE

**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN E**

DISCHARGE 95,000 CFS  
TAILWATER EL. 688 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (60 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL





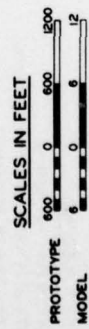
**LEGEND**

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- EXISTING LEVEE

**VELOCITIES AND CURRENT DIRECTIONS  
PLAN E**

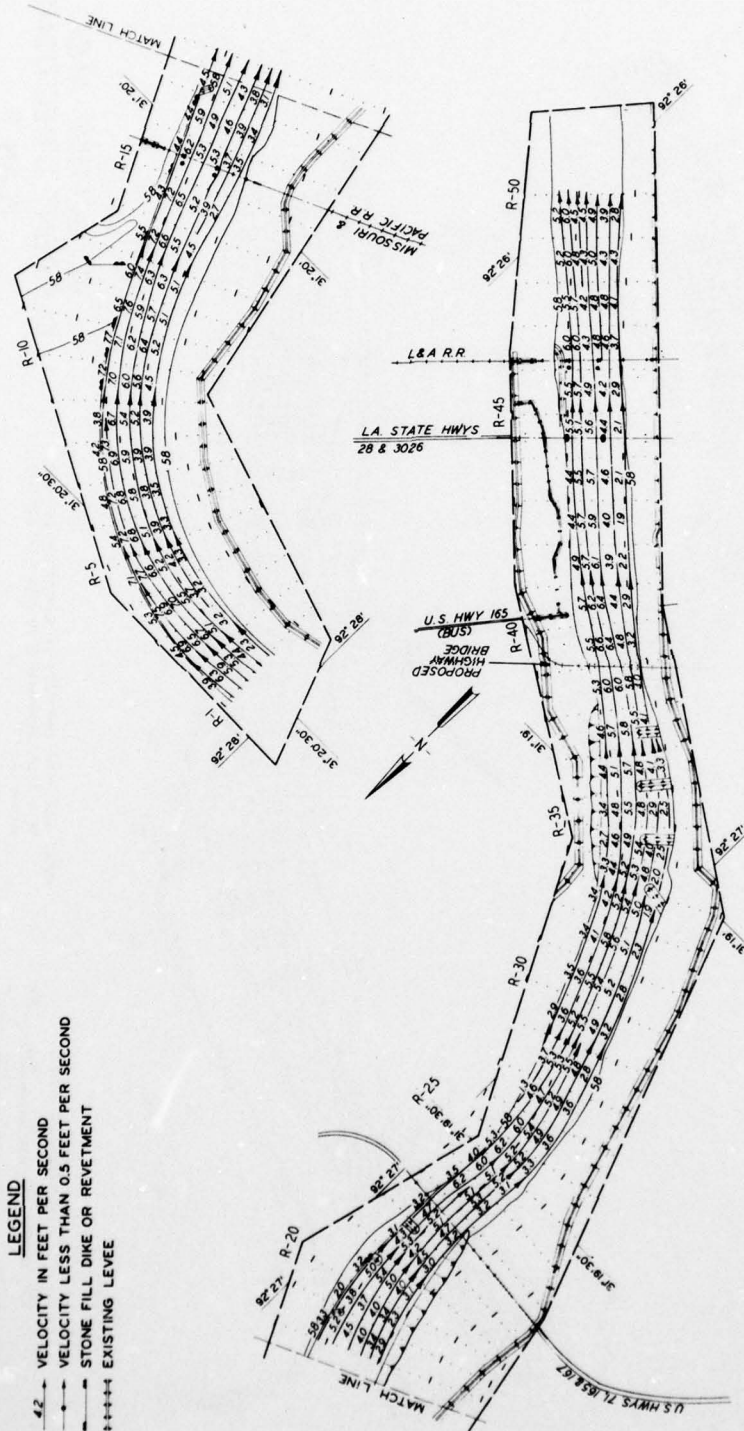
DISCHARGE 145,000 CFS  
TAILWATER EL 76.5 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (80 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL



**LEGEND**

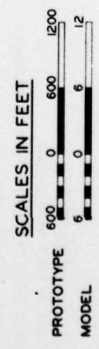
- 4.2 VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- +++++ EXISTING LEVEE

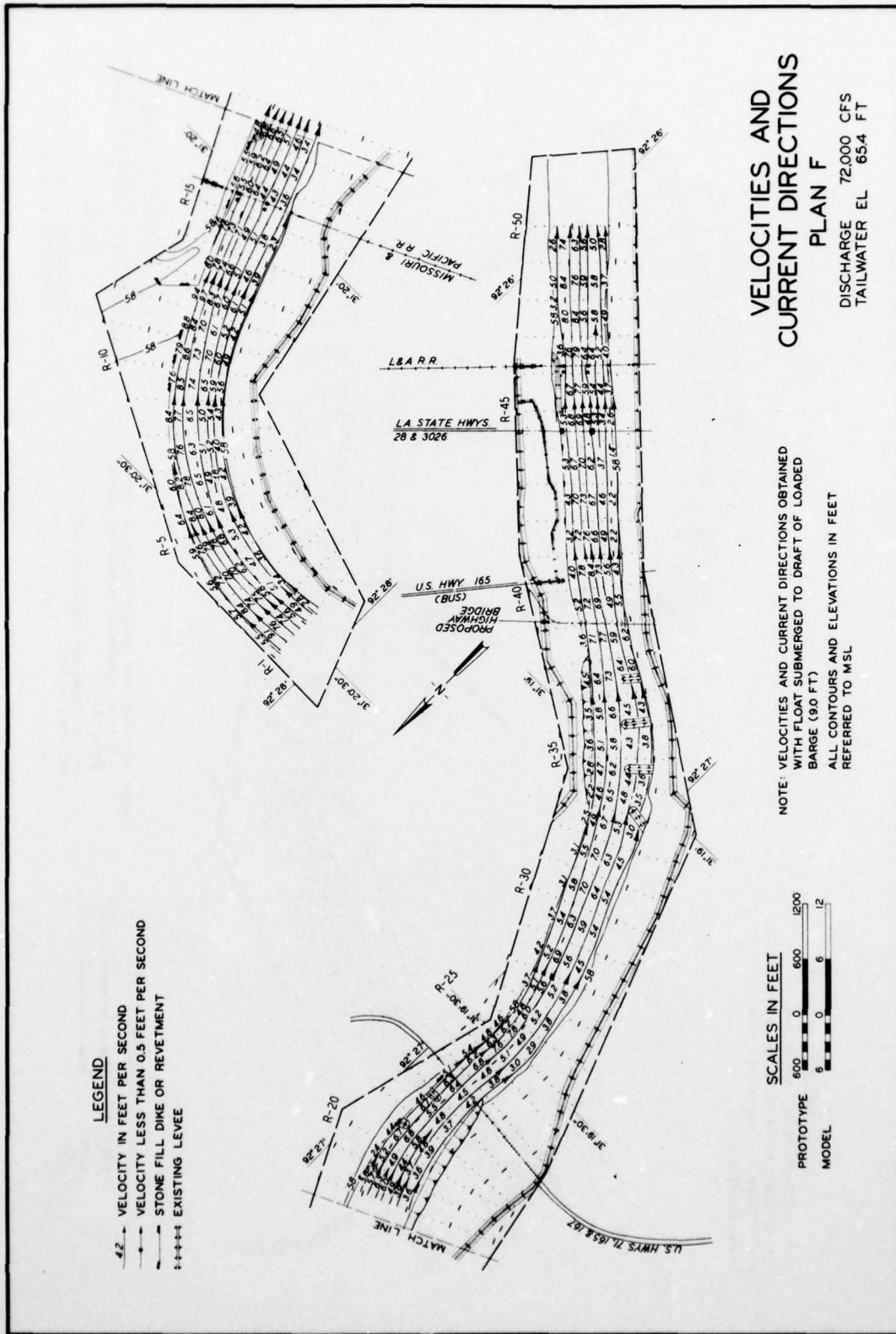


**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN F**

DISCHARGE 50,000 CFS  
TAILWATER EL 62.5 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED  
WITH FLOAT SUBMERGED TO DRAFT OF LOADED  
BARGE (9.0 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET  
REFERRED TO MSL





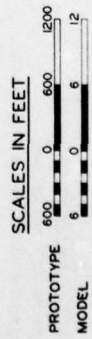
**LEGEND**

- 4.2 — VELOCITY IN FEET PER SECOND
- 7.2 — VELOCITY LESS THAN 0.5 FEET PER SECOND
- — — STONE FILL DIKE OR REVETMENT
- +++++ EXISTING LEVEE

**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN F**

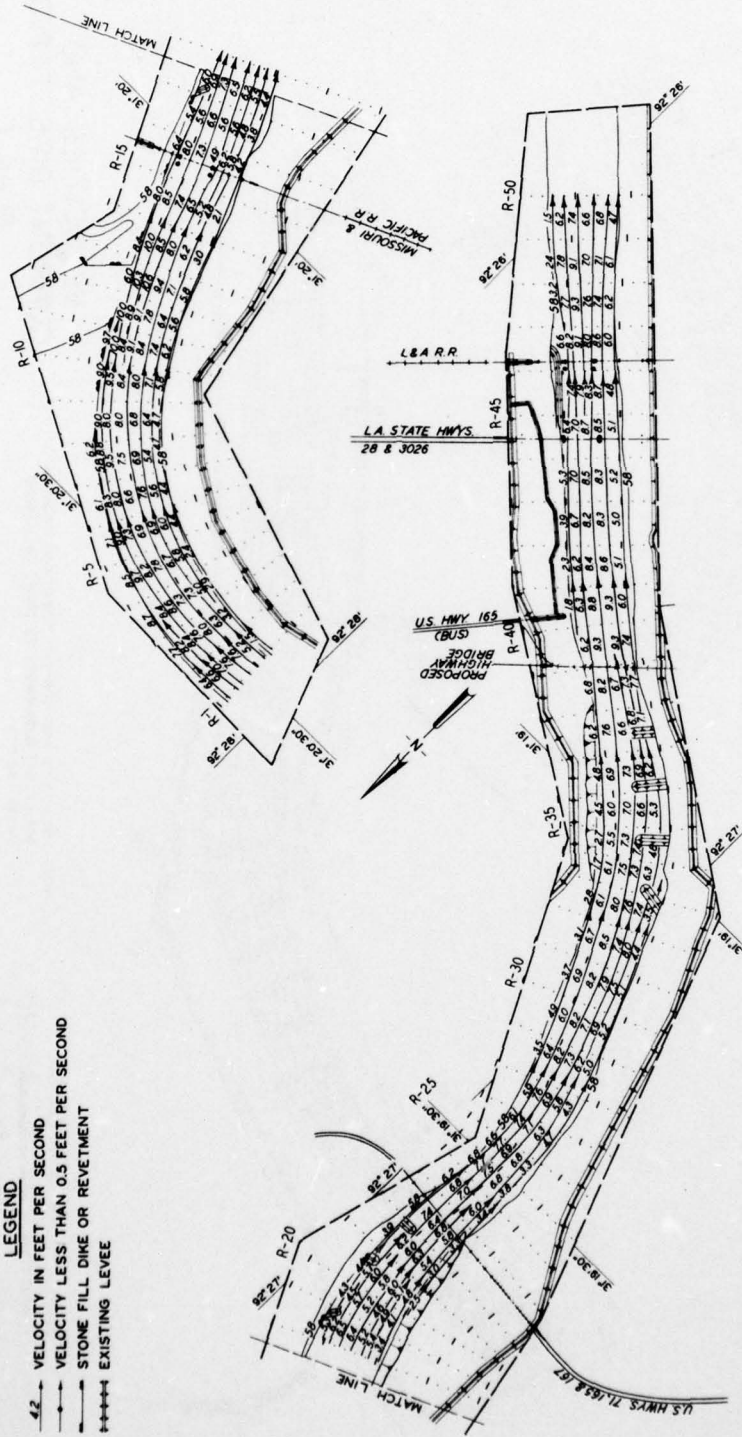
DISCHARGE 72,000 CFS  
TAILWATER EL 65.4 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL



**LEGEND**

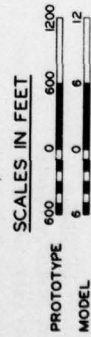
- 0.2 — VELOCITY IN FEET PER SECOND
- 0.5 — VELOCITY LESS THAN 0.5 FEET PER SECOND
- — — STONE FILL DIKE OR REVETMENT
- — — EXISTING LEVEE

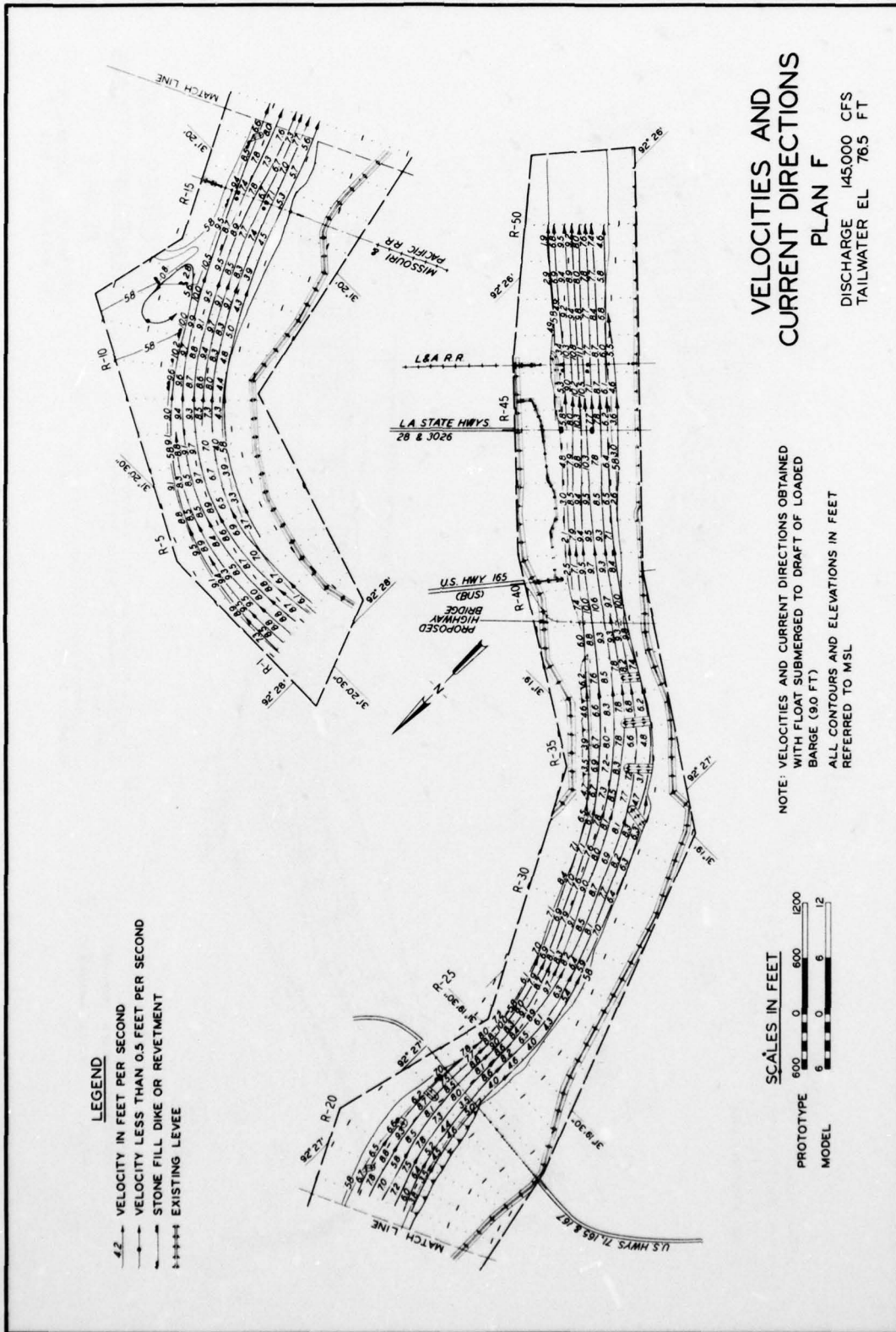


**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN F**

DISCHARGE 95,000 CFS  
TAILWATER EL 68.8 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED  
WITH FLOAT SUBMERGED TO DRAFT OF LOADED  
BARGE (8.0 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET  
REFERRED TO MSL





**LEGEND**

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- ◆— EXISTING LEVEE

**SCALES IN FEET**

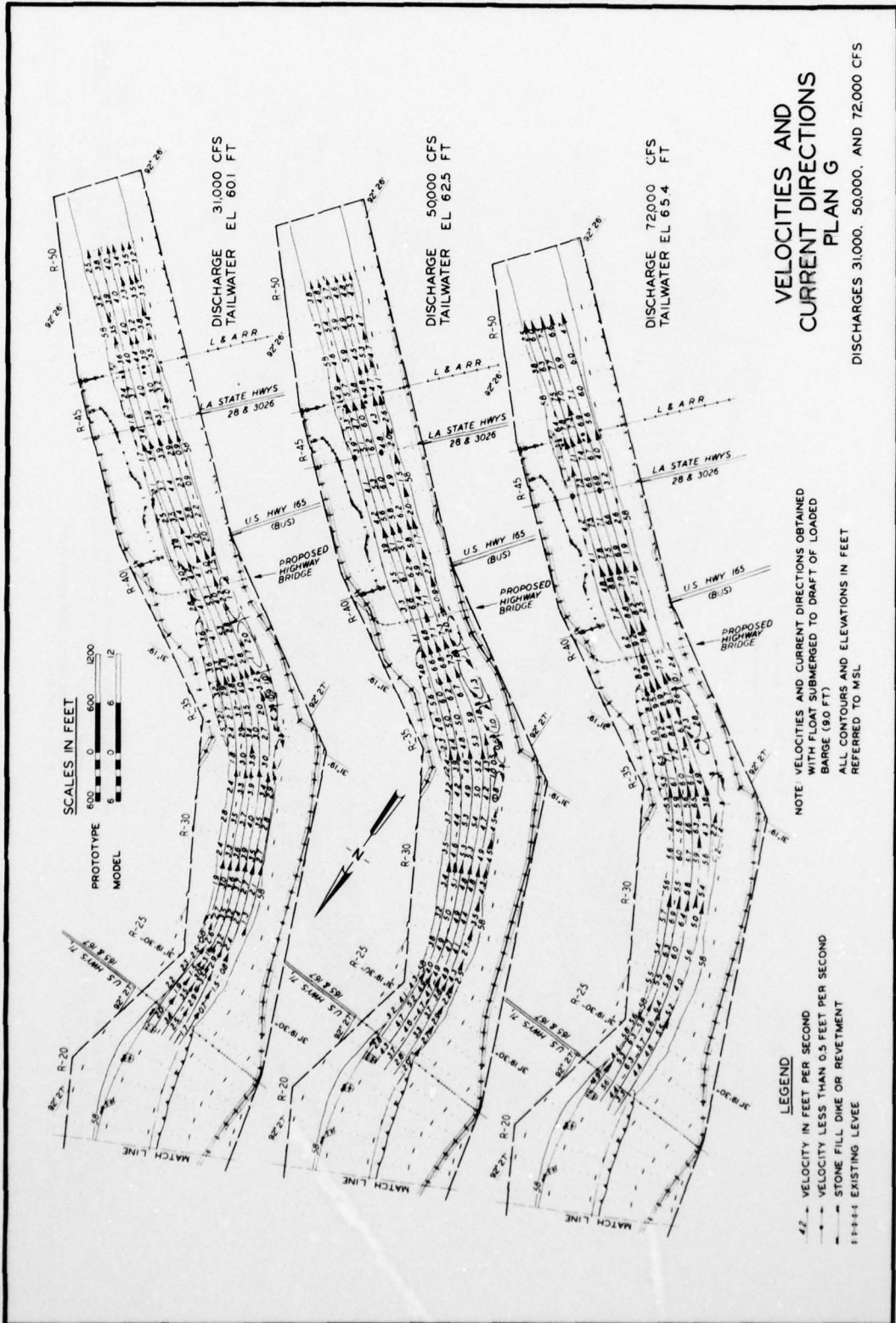


NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)  
 ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL

**VELOCITIES AND CURRENT DIRECTIONS  
 PLAN F**

DISCHARGE 145,000 CFS  
 TAILWATER EL 76.5 FT







AD-A064 397

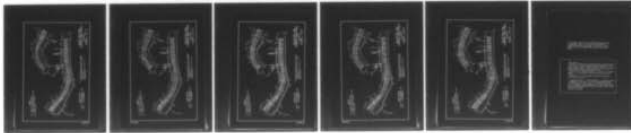
ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/G 17/7  
NAVIGATION CONDITIONS IN ALEXANDRIA REACH, RED RIVER NAVIGATION--ETC (U)  
DEC 78 L J SHOWS, J J FRANCO

UNCLASSIFIED

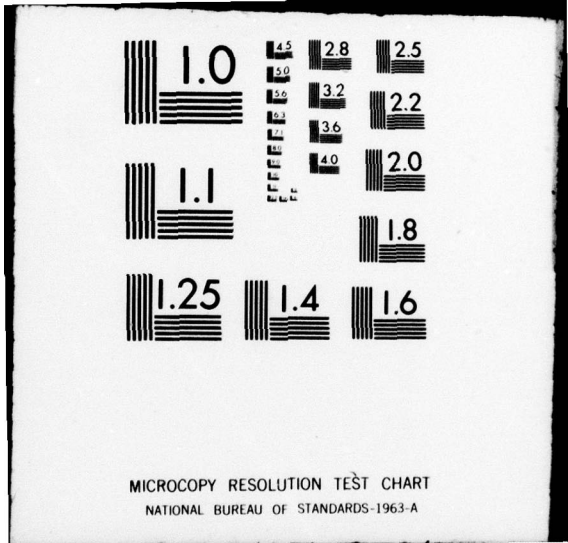
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NL

2 of 2  
AD  
A064 397

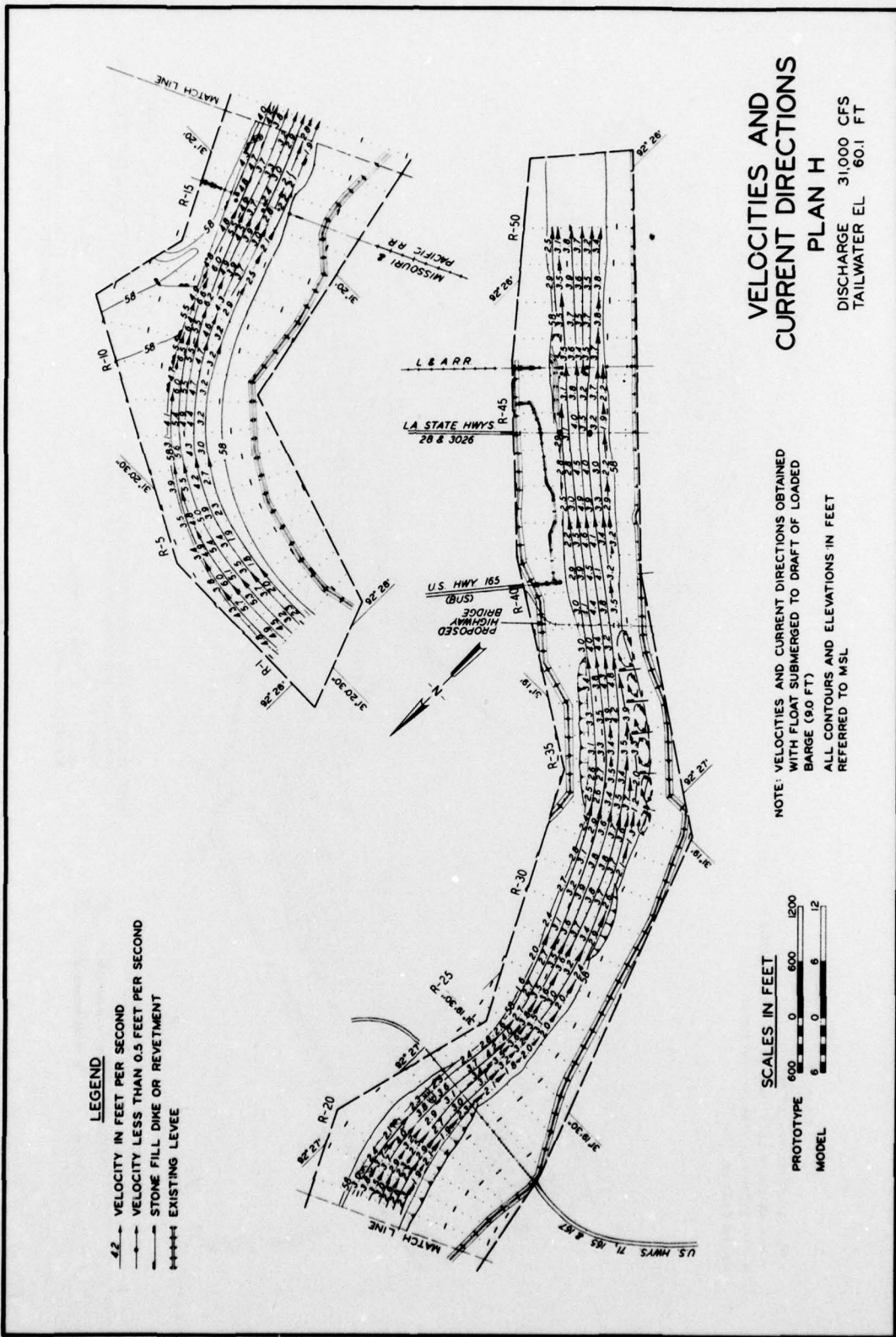


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DDC



MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

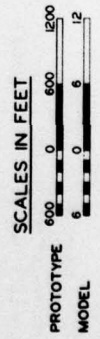
- LEGEND**
- VELOCITY IN FEET PER SECOND
  - - - VELOCITY LESS THAN 0.5 FEET PER SECOND
  - STONE FILL DIKE OR REVETMENT
  - +++++ EXISTING LEVEE



**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN H**

DISCHARGE 31,000 CFS  
TAILWATER EL 60.1 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL



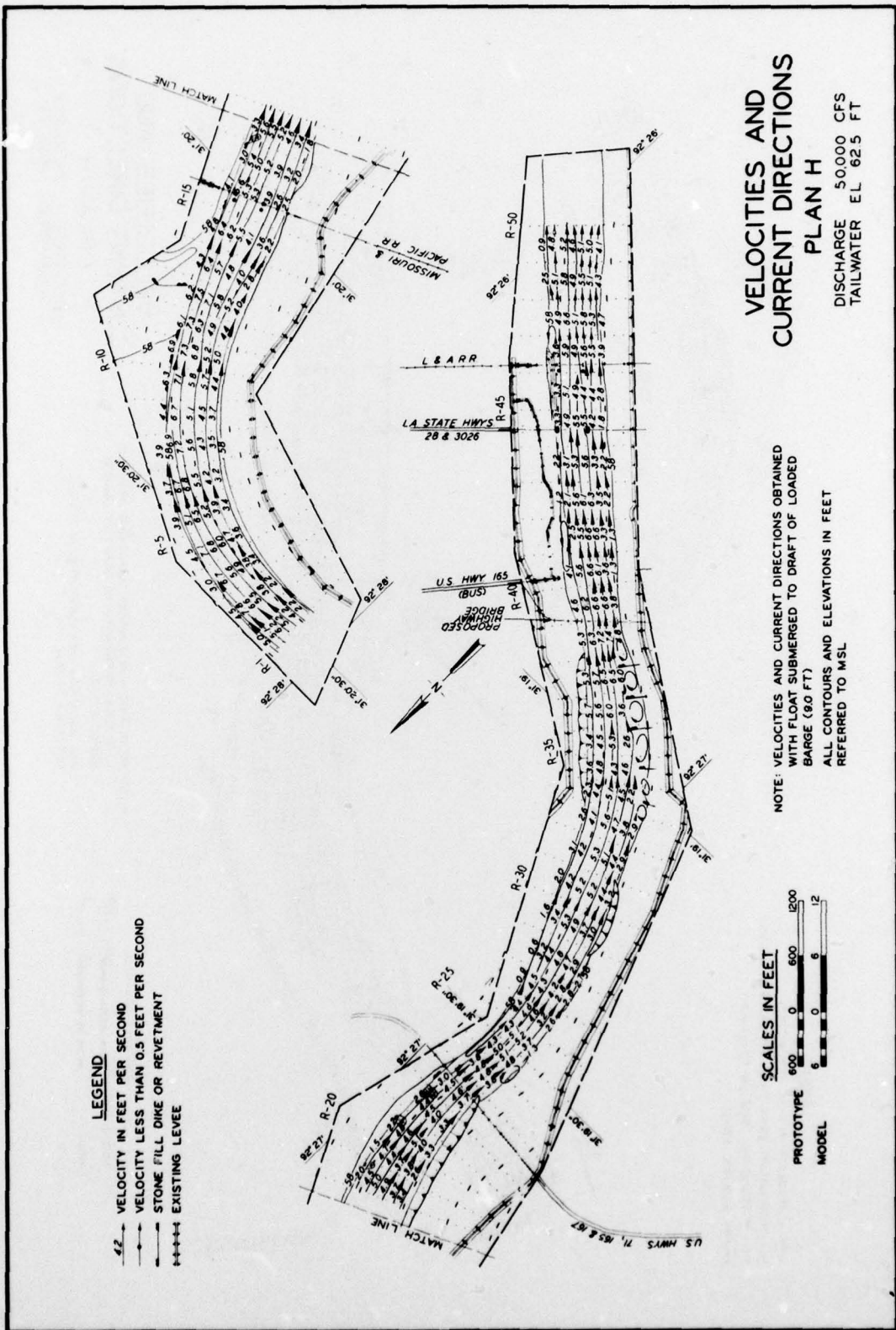
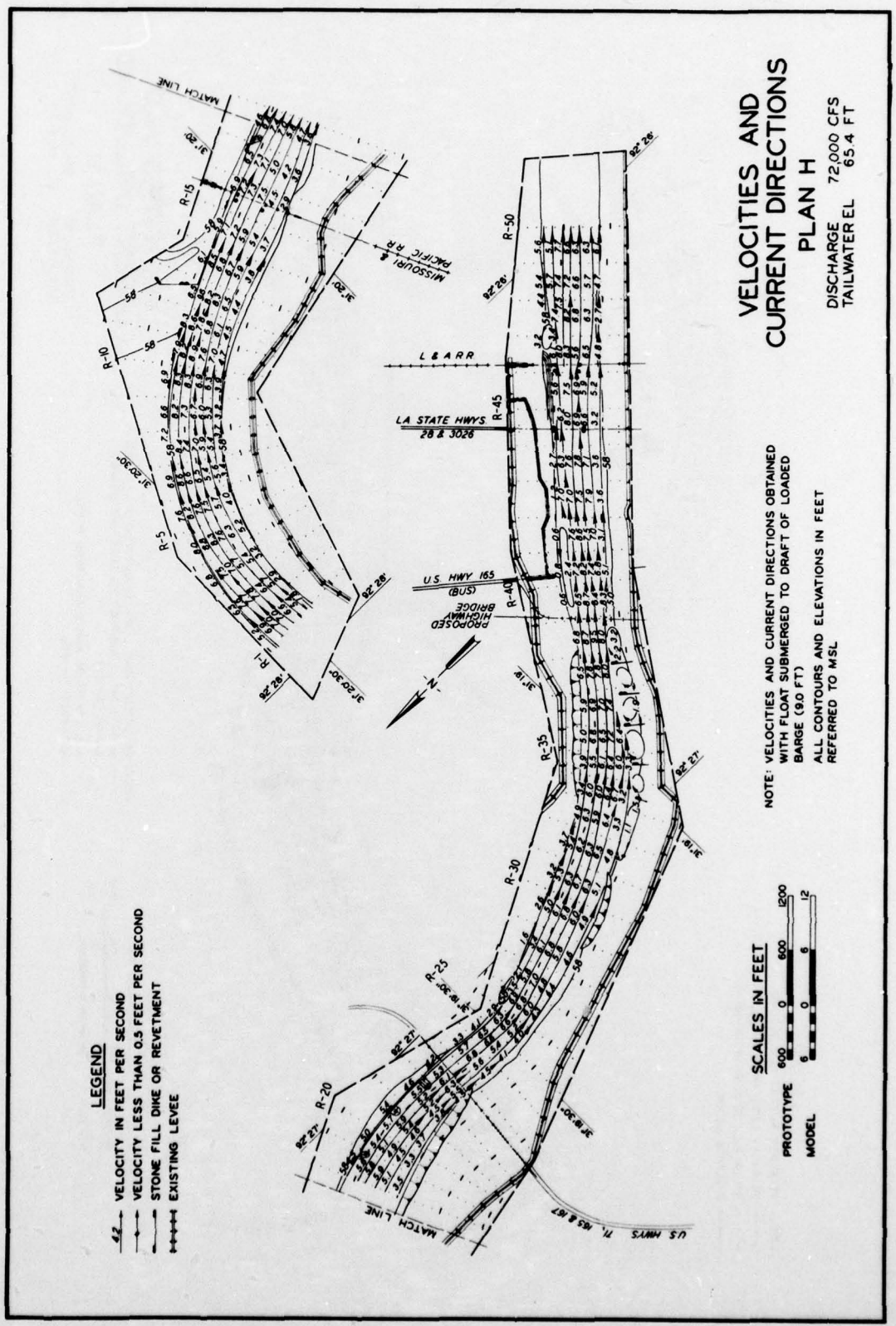


PLATE 34

**LEGEND**

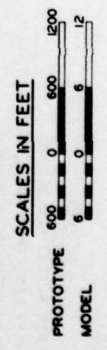
- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- EXISTING LEVEE

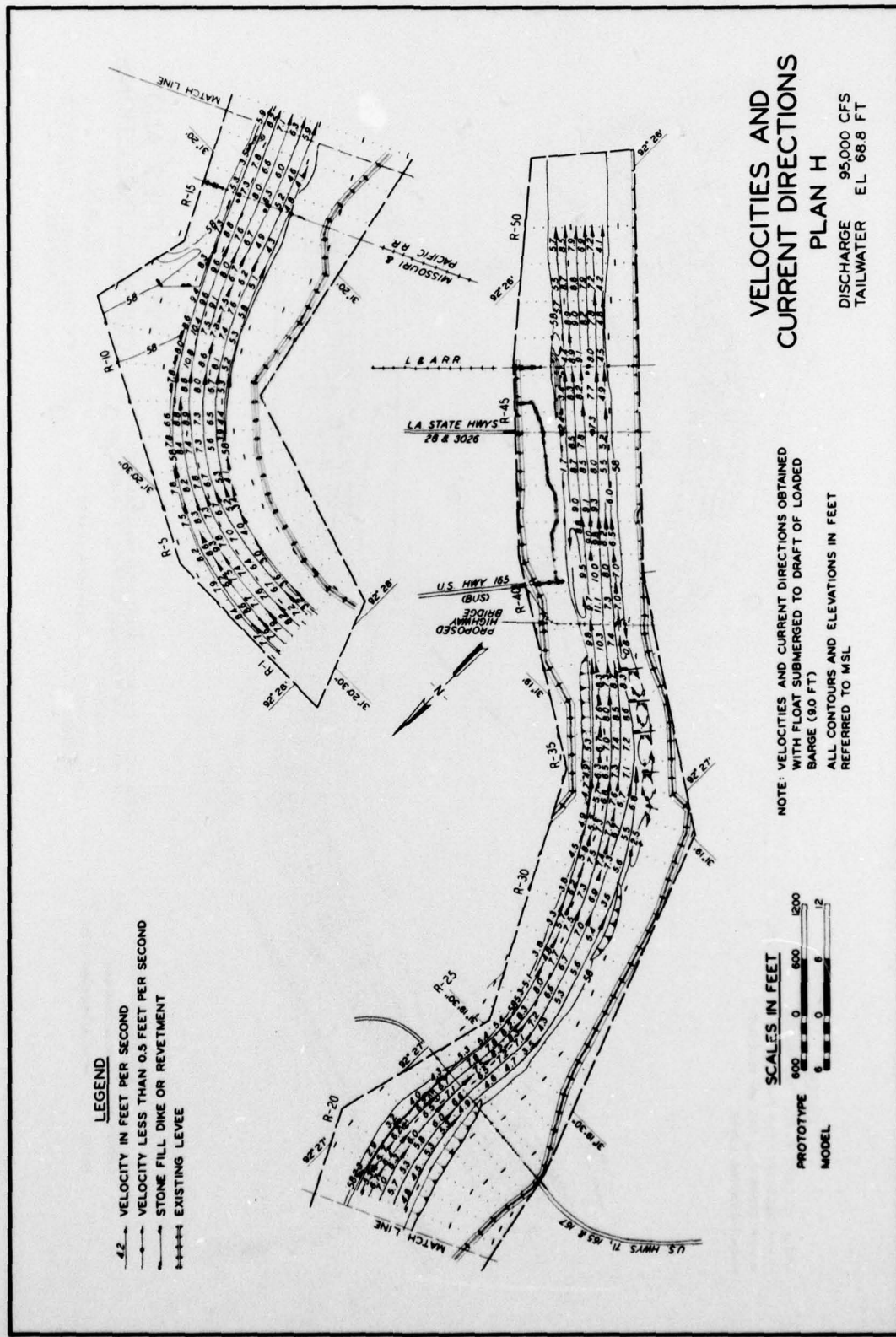


**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN H**

DISCHARGE 72,000 CFS  
TAILWATER EL 65.4 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED  
WITH FLOAT SUBMERGED TO DRAFT OF LOADED  
BARGE (80 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET  
REFERRED TO MSL





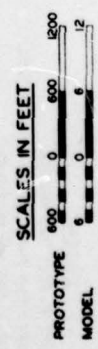
**LEGEND**

- 4.2 VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- EXISTING LEVEE

**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN H**

DISCHARGE 95,000 CFS  
TAILWATER EL 68.8 FT

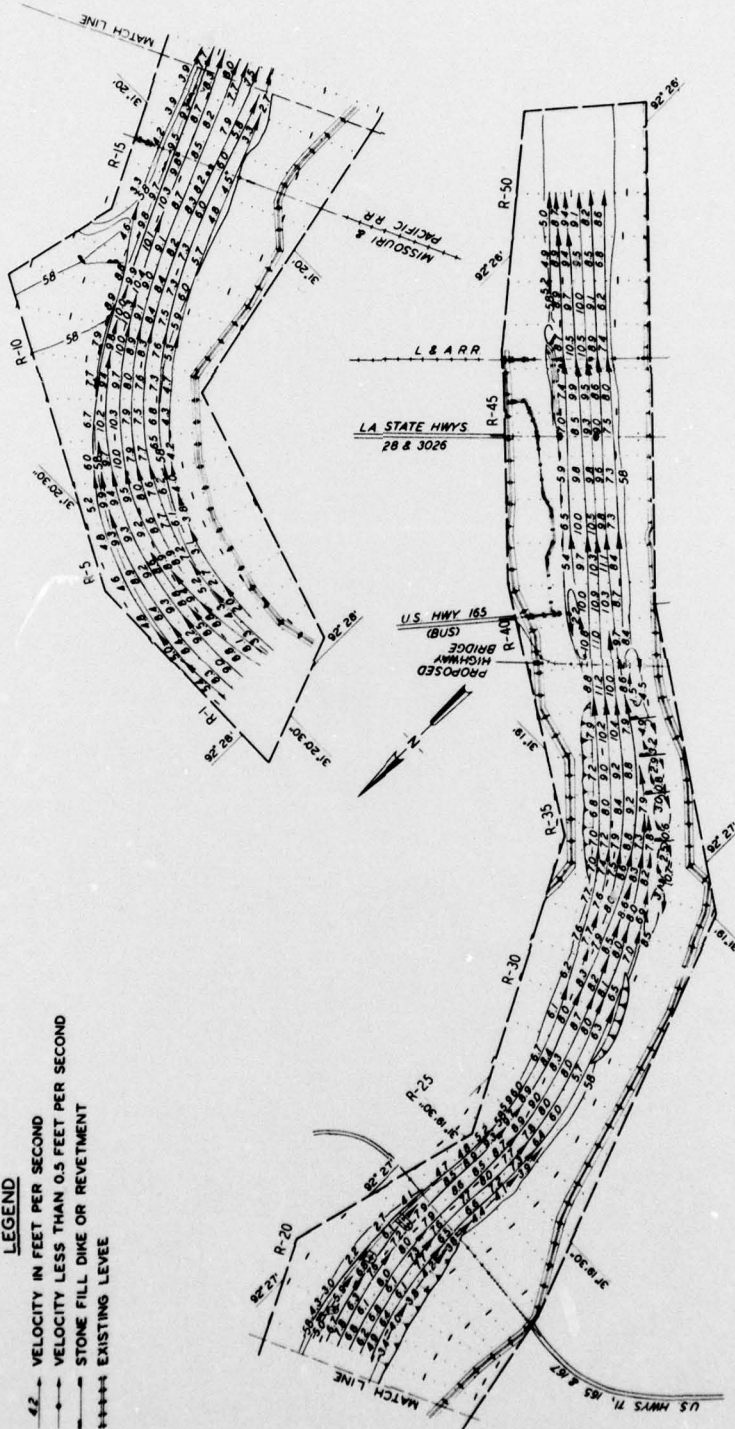
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (80 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET REFERRED TO MSL





**LEGEND**

- 4.2 — VELOCITY IN FEET PER SECOND
- 0.5 — VELOCITY LESS THAN 0.5 FEET PER SECOND
- — — STONE FILL DIKE OR REVETMENT
- — — EXISTING LEVEE



**VELOCITIES AND  
CURRENT DIRECTIONS  
PLAN H**

DISCHARGE 145,000 CFS  
TAILWATER EL 765 FT

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED  
WITH FLOAT SUBMERGED TO DRAFT OF LOADED  
BARGE (8.0 FT)  
ALL CONTOURS AND ELEVATIONS IN FEET  
REFERRED TO MSL



In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Shows, Louis J

Navigation conditions in Alexandria Reach, Red River Navigation Project, Louisiana; hydraulic model investigation / by Louis J. Shows, John J. Franco. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.

38, [22] p., 37 leaves of plates : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; H-78-24)

Prepared for U. S. Army Engineer District, New Orleans, New Orleans, Louisiana.

1. Alexandria Reach. 2. Fixed-bed models. 3. Hydraulic models. 4. Navigation conditions. 5. Red River Navigation Project. I. Franco, John J., joint author. II. United States. Army. Corps of Engineers. New Orleans District. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; H-78-24.  
TA7.W34 no.H-78-24