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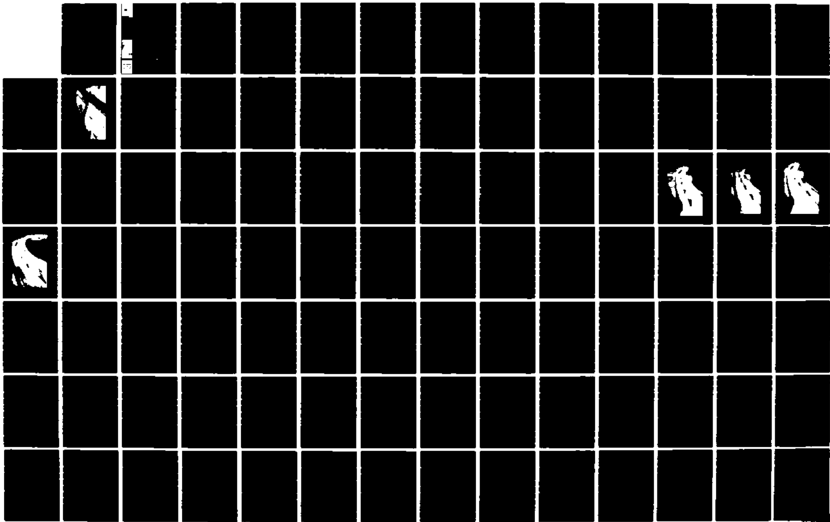

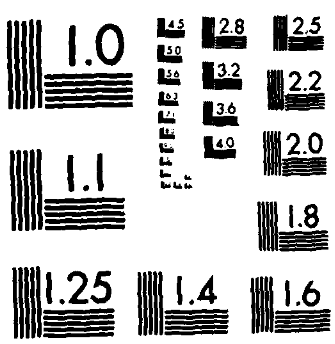

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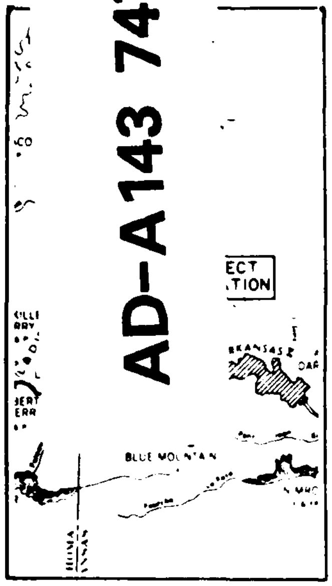

HYDRAULICS LABORATORY

(12)

TECHNICAL REPORT HL-83-20

SHOALING CONDITIONS IN LOCK AND DAM 13 POOL, ARKANSAS RIVER

Hydraulic Model Investigation

by

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Lock and Dam 13 is located at mile [illegible] on the Arkansas River. [illegible] ... [illegible] used to provide [illegible] ... [illegible] following initial operation [illegible] ... in the upstream end of lock [illegible] ... flow [illegible] ... [illegible] (Continued)

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20. ABSTRACT (Continued).

the reach just downstream of Lock and Dam 14 that would appreciably reduce the required maintenance dredging without significantly increasing water-surface elevations or velocities; determine the effectiveness of overdepth and overwidth dredging in delaying the need for required maintenance dredging; and locate the optimum site for two mooring cells upstream of Lock and Dam 14.

A movable-bed model, 1:120-scale horizontally and 1:80-scale vertically, reproduced the reach of the Arkansas River from mile 313.2 to 322.4.

Results of the study indicate that:

a. The dredging required to maintain a 250-ft channel downstream of Lock and Dam 14 could be reduced considerably by a system of dikes developed during this study (Plan H). This system reduced the required dredging following a median-year hydrograph by 63 percent and following a high-water hydrograph by 33 percent, raised water-surface elevations a maximum of 0.3 ft upstream of and 0.7 ft downstream of the dam (the maximum occurred with a flow of 230,000 cfs), and increased maximum velocities in the navigation channel by not more than 0.3 fps. This system of dikes developed a dredge-free navigation channel with a minimum width of 175 ft with both the median-year and high-water hydrographs.

b. Overwidth dredging (dredging a 400-ft-wide channel rather than a 250-ft-wide channel) in addition to the most effective dike plan tested would essentially eliminate the need for dredging to provide a 250-ft-wide navigation channel following four median-year hydrographs and reduce the quantity dredged following a high-water hydrograph by more than 50 percent. With initial overwidth dredging, the median-year hydrograph developed a navigation channel that had a minimum width of 250 ft except for a 700-ft-long section where the channel was only 175 ft wide. The high-water hydrograph developed a channel with a minimum width of 200 ft except for a 300-ft-long section where the channel was only 100 ft wide.

c. The effect of overdepth dredging (dredging a 250-ft-wide channel to el 375 rather than to el 380) was found to be about the same as that of overwidth dredging.

d. The three most downstream proposed mooring cell locations (Nos. 1-3, all located within 1.2 miles of the lock) are downstream of the point where downbound tows should cross to the right bank for a satisfactory alignment to approach the lock. A tow moored at these locations would require a downbound tow to make its approach farther out in the channel where faster velocities and adverse current directions would make it difficult for it to approach the lock. The upstream location (No. 4, located 2.3 miles from the lock) is located upstream of the crossover point and a tow moored to cells at this location would have little, if any, effect on passing tows.

PREFACE

The model investigation reported herein was conducted for the U. S. Army Engineer District, Tulsa (SWT), by the U. S. Army Engineer Waterways Experiment Station (WES) during the period April 1974 to October 1977. The study was authorized by the Office, Chief of Engineers (OCE), U. S. Army, in 2nd Indorsement dated 15 May 1973 to letter of 14 March 1973 from SWT to the U. S. Army Engineer Division, Southwestern (SWD), subject, "Authority for Proposed Model Study, McClellan-Kerr Navigation Pool 13, R.M. 308.5 to R.M. 320.0."

The investigation was conducted in the Hydraulics Laboratory of WES under the general supervision of Messrs. H. B. Simmons, Chief of the Hydraulics Laboratory, F. A. Herrmann, Jr., Assistant Chief of the Hydraulics Laboratory, and J. E. Glover, Chief of the Waterways Division. The engineer in immediate charge of the model study was Mr. J. E. Foster (retired), former Chief of the River Regulation Branch. He was assisted by Messrs. C. R. O'Dell, C. M. Noble, S. T. Mattingly, J. A. Holliday, V. E. Stewart, and H. S. Headley III. This report was prepared by Messrs. J. E. Foster, C. M. Noble, and J. E. Glover with the assistance of Mr. J. L. McGregor and Mrs. D. N. McComas.

During the course of the model study, personnel of SWD and SWT were kept informed of the progress of the study through monthly progress reports and periodic transmittal of preliminary test results. In addition, Messrs. Bruce McCartney, OCE; Tasso Schmidgall, SWD; E. B. Madden, SWD consultant; COL Anthony B. Smith, District Engineer; and E. E. Hudson, C. E. Weddle, R. D. Patterson, J. C. Maples, D. J. Sanders, A. N. Steele, K. L. Waldrie, L. D. Hogue, T. E. Horner, J. B. Henderson, and J. R. Walker, SWT, visited the model during the course of the investigation to observe tests in progress, review test results, and discuss test conditions.

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

CONTENTS

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:

Multiply	By	To Obtain
cubic feet per second	0.02831685	cubic metres per second
cubic yards	0.7645549	cubic metres
feet	0.3048	metres
feet per second	0.3048	metres per second
miles (U. S. statute)	1.609344	kilometres

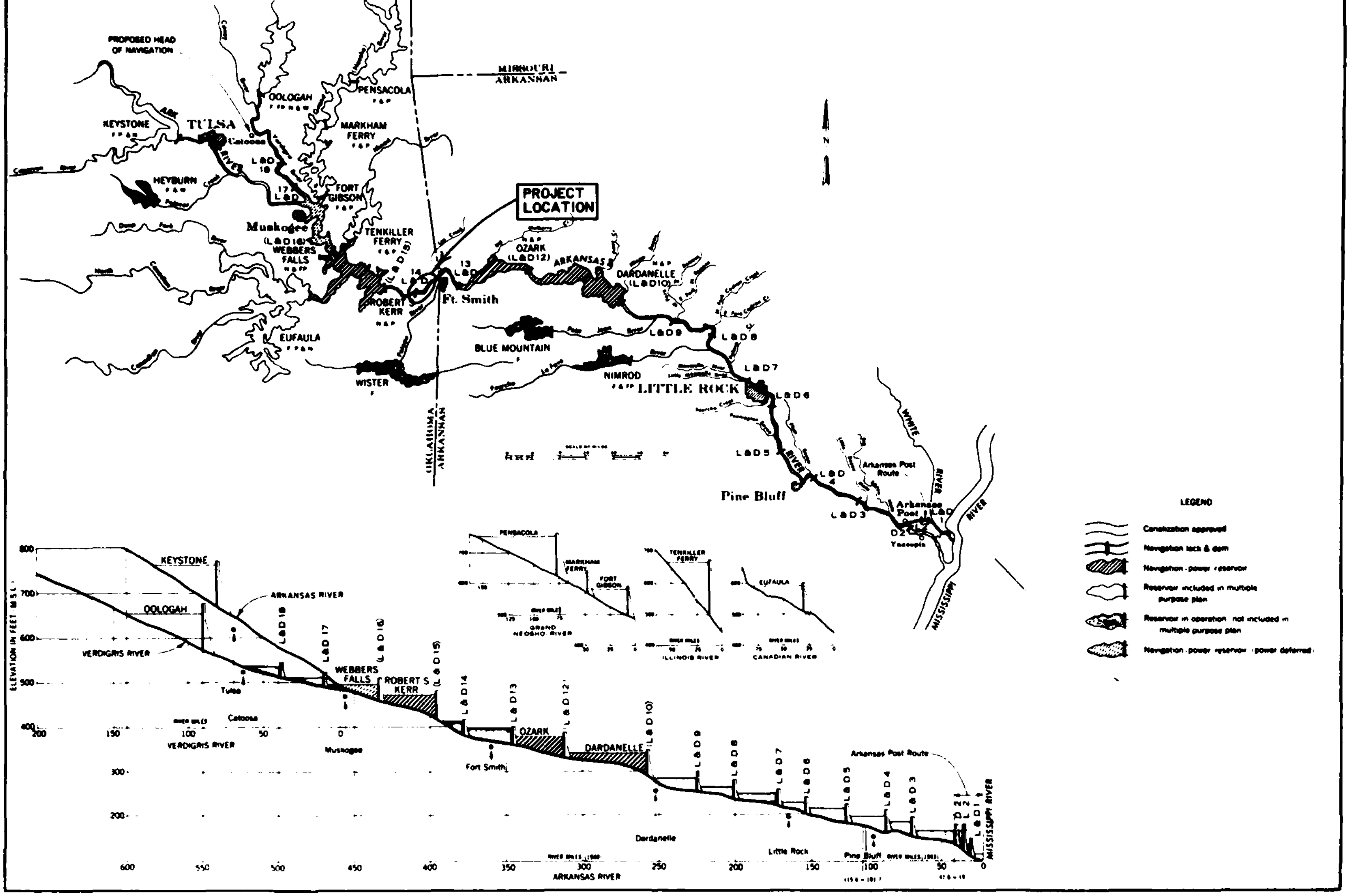

Figure 1. Location map

SHOALING CONDITIONS IN LOCK AND DAM 13 POOL, ARKANSAS RIVER

Hydraulic Model Investigation

PART I: INTRODUCTION

Arkansas River Navigation System

1. The Arkansas River Navigation System was authorized by the Congress of the United States in the ivers and Harbors Act of 24 July 1946. This system provided for t evelopment of the Arkansas River for navigation, additional flood contro , hydroelectric power generation, and other purposes. Construction of the project was begun in 1957. Navigation reached Little Rock in December 1968, Fort Smith in December 1969, and the Port of Catoosa, head of navigation, in December 1970. In 1971, Congress designated the project as the McClellan-Kerr Arkansas River Navigation System.

2. The system (Figure 1) consists of: (a) seven large upstream reservoirs that provide flood-control storage, trap sediment, and supply water for power, navigation, and other uses; (b) four high-lift locks and dams that provide depth for navigation, provide head for power, and trap some sediment; and (c) thirteen low-lift locks and dams that provide minimum 9-ft* depths for the remainder of the 448-mile navigation channel from the Mississippi River to Catoosa, Oklahoma (near Tulsa, Oklahoma). The total lift of the system is 420 ft.

Lock and Dam 13 Pool

3. Lock and Dam 13 is located on the Arkansas River at mile 292.8,** about 7 miles downstream of Fort Smith, Arkansas. The dam was

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

** All mileage cited herein refers to navigation miles except that shown in Figure 1 which is 1940 mileage.

designed to provide a minimum depth of 9 ft to Lock and Dam 14 at mile 319.7. Following initial operation of Lock and Dam 14 in January 1971, shoaling in the upstream end of Lock and Dam 13 pool became a chronic problem, occurring each time flows exceeded 50,000 cfs. In the reach from Lock and Dam 14 to Fort Smith, some 1,864,000 cu yd were dredged in 1971 and 1,273,000 cu yd were dredged in 1972. During the period August 1973 to September 1974 (following the extremely high 1973 flood), some 2,015,000 cu yd were dredged. The higher flows move large quantities of sediment through the spillway into the area just below the dam; subsequent low flows move this sediment into the navigation channel just downstream of the lock entrance. Rock in the channel downstream of the lock at about 13 ft below normal pool (Figure 2) prevented high flows from developing a deeper channel.

Purpose of Study

4. The primary purpose of this study was to develop a system of channel structures that would: (a) significantly reduce the required amount of maintenance dredging to provide a satisfactory navigation channel from Lock and Dam 14 to Fort Smith, Arkansas; (b) not appreciably increase upstream flood stages; and (c) not appreciably increase velocities in the navigation channel. Tests were added during the study to determine the effectiveness of overwidth and overdepth dredging in delaying the need for maintenance dredging and to determine the optimum location for two proposed mooring cells upstream of Lock and Dam 14.

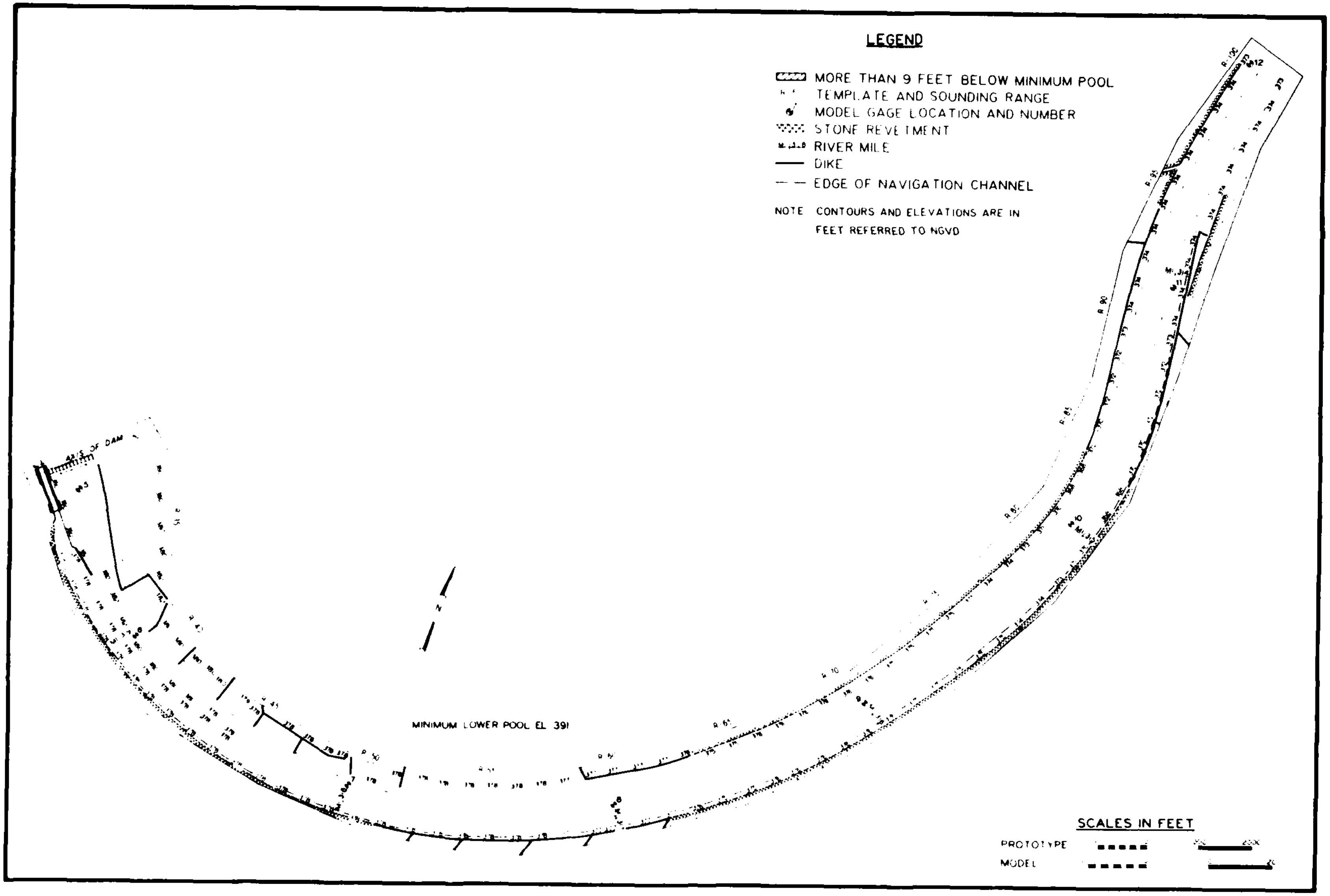

Figure 2. Elevation of bedrock within model limits

PART II: THE MODEL

Description

5. The model used in this investigation was a scale reproduction of the Arkansas River from mile 313.2 to 322.4 including Lock and Dam 14 (Figure 3) built to a horizontal scale of 1:120 and a vertical scale of 1:80. A small supplementary slope needed to provide satisfactory bed movement was incorporated in the model. The model was of the movable-bed type with fixed banks and overbank areas molded in sand-cement mortar. The bed material was crushed coal having a median diameter of about 4 mm and a specific gravity of 1.30. Bedrock and dikes were molded with crushed stone. Folded strips of mesh wire were used to simulate the roughness effect of trees and underbrush on the overbank areas. The lock, dam, and guard wall were fabricated of sheet metal; the lock gates were simulated with simple sheet-metal slide-type gates (Figure 4).

6. Overbank portions of the model were molded in accordance with data shown on topographic maps dated April 1974. Initially, the channel portion was molded to a prototype survey made during the period July-September 1972.

Appurtenances

7. Water was supplied to the model by a 10-cfs axial flow pump operating in a circulating system and was measured at the upstream end of the model by two venturi meters of different sizes to provide for accurate measurement of flow over the range of discharges to be reproduced. Water-surface elevations along the channel were measured by point gages in 12 piezometers located in the channel (Figure 3) and connected to gage buckets along the edge of the model. Water-surface elevations upstream of the dam were controlled by manipulating the gates of the dam and those downstream of the dam were controlled by an adjustable tailgate at the downstream end of the model. A graduated container

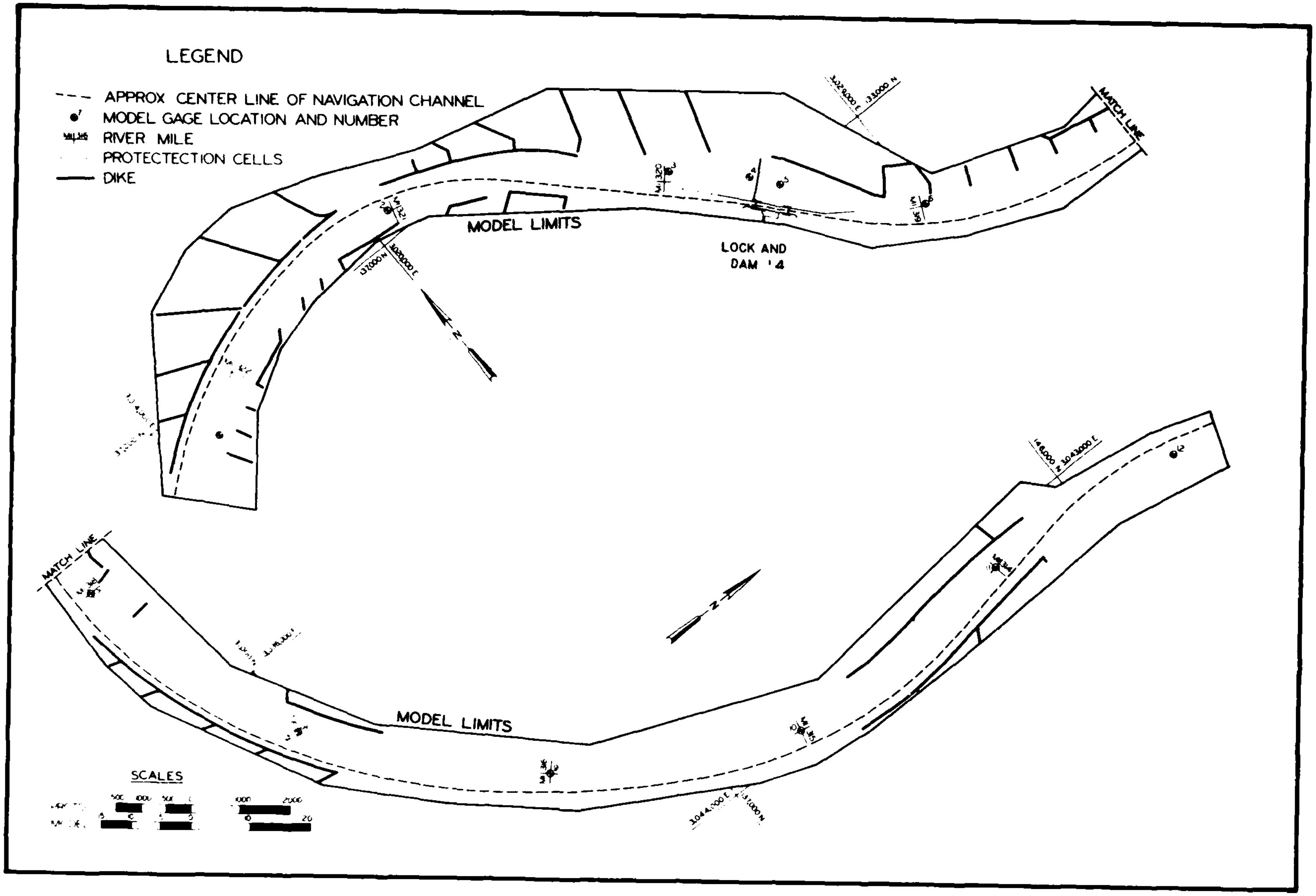

Figure 3. Model layout and gage location

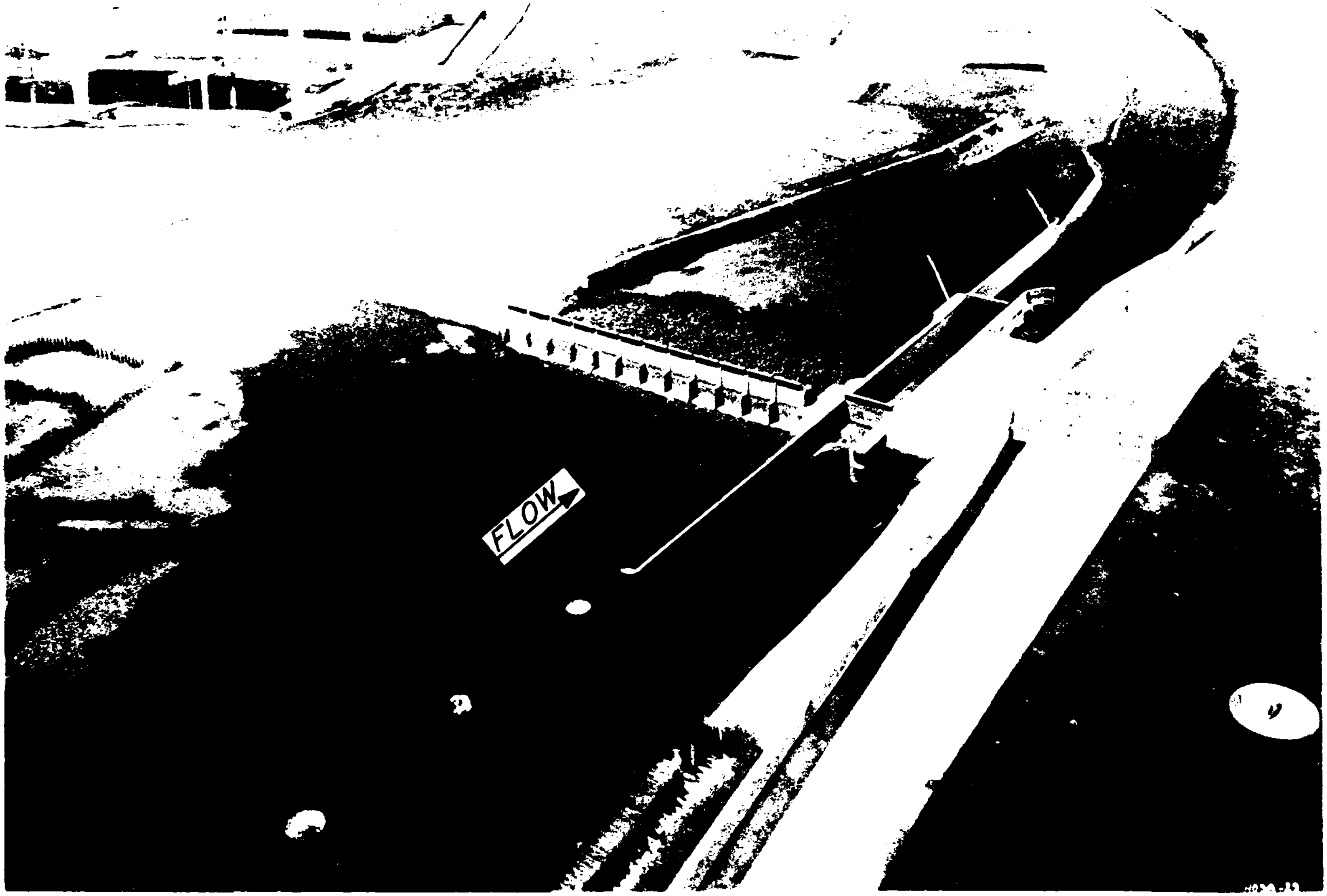

Figure 4. Lock and Dam 14 with Plan H installed

was used to measure the bed material introduced at the upstream end of the model. A sediment trap was provided at the downstream end of the model where extruded material could accumulate and be measured at the end of any specific period. A carefully graded rail was installed along each side of the channel to support sheet-metal templates used for molding the model bed prior to initiation of certain tests. These rails were also used to provide vertical control for installing structures in the model and for surveying the model bed.

8. Velocities and current directions were determined in the model by means of wooden cylinder floats weighted on one end to simulate the draft for loaded barges using the waterway (9 ft prototype). Velocities were determined by timing the travel of floats over a measured distance. Current directions were ascertained by plotting the paths of floats with respect to ranges established on the model. A model towboat and tow were used to determine and demonstrate the effects of currents on downstream tows passing a tow tied to proposed mooring cells upstream of the dam. The overall size of the passing tow was 105 by 600 ft and that of the moored tow was 105 by 340 ft.

Model Adjustment

9. Before a movable-bed model is used to test the effectiveness of proposed improvement plans, its ability to reproduce conditions similar to those that can be expected in the prototype must be demonstrated. Complete similarity between the model and prototype is seldom obtained because of the inherent distortions incorporated in the model design and in the operation of the model. Because of these dissimilarities, the degree of reliability of this type of model cannot be fully established by mathematical analysis and must be based on model verification. Verification of the model involves the adjustment of various hydraulic forces, time scale, rate of introducing bed material, and model operating techniques until the model reproduces with acceptable accuracy the changes known to have occurred in the prototype during a given period. Various scale relationships and model operating procedures established

during model verification are used in tests of various improvement plans. The degree of similarity between model and prototype data obtained during model verification is considered in the analysis of model test data.

10. Adjustment tests were initiated with the model bed molded to conditions indicated by the prototype survey of July-September 1972 (Plate 1). The model was operated using a blocked hydrograph which represented flows that occurred in the prototype between this survey and a survey taken in July 1974. These flows and the corresponding stages are shown in Plate 2. Flows from 5 July to 25 September 1973 were omitted because they were extremely low and moved very little, if any, sediment. Model dam gates 8 and 9 were closed for the period 21 November 1972 to 14 November 1973 to simulate closure of these gates in the prototype due to a tow accident. At the end of each adjustment test, the model bed was surveyed and the resulting bed configurations were compared with those of the July 1974 prototype survey (Plate 3). During the adjustment period, progressive changes were made in the discharge scale and the rate of bed material introduced until the model reproduced with a reasonable degree of accuracy the conditions indicated by the prototype survey of July 1974.

11. Verification of the model was based on the results of the final adjustment test (Plate 4) compared with the July 1974 prototype survey (Plate 3). This comparison shows that the essential trends and channel configurations were reproduced with a reasonable degree of accuracy. Bars on the inside of the model bends were from 3 to 5 ft higher than those in the prototype and the model channels on the outside of bends were from 3 to 5 ft deeper than those in the prototype. These differences were considered in the evaluation of the test results.

PART III: TESTS AND RESULTS

Test Procedure

12. The tests were conducted in three series. The first series concerned the development of modifications to the existing dike system that would significantly reduce the required amount of maintenance dredging to provide a satisfactory navigation channel from Lock and Dam 14 downstream to mile 316. This series consisted of a base test and tests of eight dike plans (Plans A-H). Two flow hydrographs were used: a median-year hydrograph (Plate 5) which was submitted by the U. S. Army Engineer District, Tulsa (SWT), as typical of what could be expected in this reach of the Arkansas River and the 1973-74 (high water) hydrograph. Generally, each plan was tested with one or more reproductions of the median-year hydrograph followed by the high-water hydrograph which for some plans was followed by another median-year hydrograph. Following each hydrograph except the first base test hydrograph, a 250-ft-wide navigation channel was dredged to el 380* downstream of the lock. Water-surface elevations upstream of the dam were controlled to normal pool (el 412) with the dam gates until all the gates were fully open. Water-surface elevations downstream of the dam were controlled with a tailgate at the downstream end of the model to a stage-discharge relationship developed on the model during the adjustment tests. Tests of most plans were initiated with the model bed molded to conditions indicated by the prototype survey of 1974 with the exception of a 250-ft-wide navigation channel dredged to el 380 downstream of the lock. Tests of the remaining plans were initiated with the model bed obtained at the end of a previous hydrograph with the exception of a 250-ft-wide navigation channel dredged to el 380 downstream of the lock. All subsequent hydrographs except for the second hydrograph of the base test were initiated with the model bed obtained at the end of the previous hydrograph after the 250-ft-wide

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* All elevations (el) cited herein are in feet referred to the National Geodetic Vertical Datum (NGVD).

navigation channel had been dredged. The second hydrograph for the base test was initiated with the model bed obtained at the end of the previous hydrograph without dredging the navigation channel. The model was surveyed following each hydrograph; however, only those surveys showing significant changes are presented in this report. Water-surface elevations, velocities, and current directions were taken for flows of 75,000 to 230,000 cfs following several tests to determine if the plan being tested would raise stages or have an adverse effect on navigation. The theoretical discharge scale was used with no supplemental slope in the model when these data were obtained.

13. The second series of tests concerned the effectiveness of overwidth and overdepth dredging in delaying the need for maintenance dredging. This series consisted of tests of three dredging plans (Plans I, J, and K). A 400-ft-wide channel to el 380 was tested with the median-year hydrograph followed by the high-water hydrograph; a 250-ft-wide channel to el 375 was tested with a median-year hydrograph followed by a high-water hydrograph; and a 400-ft-wide channel to el 380 was tested with a sequence of five median-year hydrographs. All three plans had the same dike system. Water-surface elevations were controlled at the dam and at the downstream end of the model, and the model was surveyed after each hydrograph as in the first series.

14. The third series of tests concerned the location of two proposed mooring cells upstream of Lock and Dam 14 where tows could tie up without interfering with navigation. Velocities and current directions were taken without the proposed cells and with a tow moored to the cells at the four proposed locations for flows of 110,000 and 150,000 cfs. Also time-lapse photographs were taken with a model tow going past a tow tied to the cells at each of the proposed sites. The theoretical discharge scale was used with no supplemental slope in the model when these data were obtained.

Base Test

Description

15. For the base test, the dikes existing in the prototype in 1974

were installed in the model as shown in Plate 6. Five hydrograph reproductions were conducted to determine the developments that could be expected in the test reach with existing conditions to provide a basis for comparing the effectiveness of proposed improvement plans. The median-year hydrograph was reproduced three times, followed by the high-water hydrograph, followed by another median-year hydrograph. The first hydrograph was initiated with the model bed molded to conditions indicated by the 1974 prototype survey except for a 250-ft-wide navigation channel which was dredged to el 380 downstream of the lock. Water-surface elevations, velocities, and current directions were taken for flows of 75,000, 105,000, 150,000, and 230,000 cfs after the navigation channel was dredged following the high-water hydrograph.

Results

16. Bed configurations, velocities, and current directions resulting from the base tests are presented in Plates 7-15. Relative dredging quantities and water-surface elevations for all tests are given in Tables 1 and 2, respectively. Model bed configurations (Plate 7) show the same trends that have occurred in the prototype since construction of Lock and Dam 14 (Plate 3). Bed configurations at the end of the first hydrograph (Plate 7) show a shoal just upstream of mile 319 that reduced the navigation channel to a width of about 50 ft. By the end of the second hydrograph, this shoal extended across the entire channel (Plate 8). By the end of the third hydrograph (Plate 9), the shoal in the vicinity of the dam deposited by the 1973 high water, which was included in the beginning survey, had been eroded and the shoaling upstream of mile 319 had been reduced, leaving a navigation channel 200 ft wide. The navigation channel downstream of mile 319 had a minimum width of 250 ft following the third hydrograph. The quantity of material dredged following the third hydrograph was only slightly more than 12 percent of the quantity deposited in the channel during the first hydrograph. The high-water (fourth) hydrograph left excessive deposition immediately below the dam and in the downstream lock approach channel (Plate 10). The navigation channel was reduced to a minimum width of 50 ft about mile 319.2 and 100 ft about miles 316.5 and 317.8. Dredging

following this hydrograph produced almost eleven times the quantity produced following the third hydrograph. The median-year hydrograph following the high-water hydrograph scoured in the vicinity of the dam and again deposited in the navigation channel (Plate 15). Dredging following this hydrograph produced almost four times the quantity dredged following the third hydrograph.

Plan A

Description

17. Conditions for Plan A (Plate 6) were the same as those for the base test except:

- a. The existing trail dike off the downstream end of the downstream guard wall was extended 250 ft at el 388 (5 ft below the existing trail dike).
- b. Four spur dikes were added along the left bank at miles 317.6, 317.4, 317.1, and 316.8 to el 413, 411, 409, and 407, respectively. These dikes were installed with the channel ends 800 ft* from the right bank to correspond with the channel width provided by existing dikes. The four spur dikes were oriented as follows: 317.6 and 317.4 normal to the navigation channel; 317.1 about 15 deg downstream; and 316.8 about 10 deg upstream.

18. This plan was tested with only one reproduction of the median-year hydrograph. The hydrograph was initiated with the model bed molded to the 1974 prototype survey except for a 250-ft-wide navigation channel dredged to el 380 downstream of the lock.

Results

19. A shoal area developed just downstream of the trail dike at the end of the downstream guard wall (Plate 16) as it did for the base test run 1. The trail dike extension installed for Plan A reduced the height of the deposition in the navigation channel just upstream of mile 319 about 3 ft and increased the minimum width of the navigation channel in the area from 50 to 150 ft compared with base test run 1

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* The overall width of the channel (distance between channel ends of dikes and the opposite bank) is given at normal pool (el 391 downstream of the dam).

(Plate 7 versus Plate 16). Addition of the four dikes on the left bank from mile 317.6 to 316.8 caused scouring along the right side of the channel opposite these dikes which increased the minimum width of the navigation channel in this reach from 150 to 220 ft. Dredging required to provide a 250-ft-wide navigation channel was only 37 percent of the computed quantity of material deposited in the channel during the first hydrograph of the base test (Table 1).

Plan B

Description

20. The conditions for Plan B (Plate 6) were the same as those for the base test except:

- a. The trail dike off the downstream end of the guard wall was raised from el 393 to 395 and the 250-ft extension added to this trail dike for Plan A was raised from el 388 to 390.
- b. A 100-ft extension was added to the 11 dikes on the left bank (7 existing and 4 added for Plan A). The crest of these extensions sloped downward toward the channel end with a slope of 1V on 10H. These extensions narrowed the overall channel width to 700 ft.

21. This plan was tested with two median-year hydrographs followed by one high-water hydrograph. The first hydrograph was initiated with the channel bed conditions obtained at the end of Plan A run 1 except that a 250-ft-wide navigation channel was dredged to el 380 downstream of the lock. Water-surface elevations, velocities, and current directions were taken for flows of 75,000, 150,000, and 230,000 cfs following dredging after the high-water hydrograph.

Results

22. Results of tests of Plan B are presented in Plates 17-21 and in Tables 1 and 2. These results indicate that raising the existing trail dike and extending it 250 ft decreased the deposition in the channel upstream of mile 319 over that for the base test for both the median-year (Plate 8 versus Plate 17) and the high-water (Plate 10 versus Plate 18) hydrographs. However, considerable dredging was still required

in this reach to provide a 250-ft-wide navigation channel to el 380 following the high-water hydrograph. Reducing the overall channel width by extending the seven existing dikes 100 ft and adding four dikes on the left bank produced some scour in the navigation channel opposite these dikes. This reduced deposition in the reach from mile 319 to 316.8 but caused some additional deposition in the navigation channel downstream (Plate 10 versus Plate 18 and Table 1). Scour holes developed off the end of the dikes downstream of mile 318.6 (Plate 18). The channel resulting from tests of Plan B required 79 percent less dredging following the first median-year hydrograph and 12 percent less dredging following the high-water hydrograph than did the channel resulting from the base test (Table 1). Plan B raised water-surface elevations compared with those of the base tests (Table 2) a maximum of 0.4 ft upstream and 0.3 ft downstream of the dam and increased maximum velocities in the navigation channel as much as 1.0 fps. The maximum increase in water-surface elevation occurred with a flow of 150,000 cfs. The maximum increase in velocities was from 8.3 fps for the base test (Plate 13) to 9.3 fps for Plan B (Plate 20) also with a flow of 150,000 cfs.

Plan C

Description

23. Plan C (Plate 6) was the same as Plan B except that a 100-ft extension was added to the 11 dikes on the left bank downstream of the dam. This made a total extension of 200 ft to the dikes of Plan A and reduced the overall width of the channel in the area of the dikes to 600 ft. The crest of these 200-ft extensions sloped downward toward the channel end with a slope of 1V on 20H. This plan was tested with two median-year hydrographs, followed by a high-water hydrograph, followed by another median-year hydrograph. The first hydrograph was initiated with the channel bed molded to the 1974 prototype survey with a 250-ft-wide navigation channel to el 380 downstream of the lock. Water-surface elevations, velocities, and current directions were taken for flows of

75,000, 150,000, and 230,000 cfs following the dredging after the high-water hydrograph.

Results

24. A comparison of the results of Plan C (Plates 22-27 and Tables 1 and 2) with those of Plan B indicates that extending the left bank dikes an additional 100 ft would:

a. Increase considerably the deposition in the navigation channel following the median-year hydrographs (Table 1).

b. Decrease slightly the deposition in the navigation channel following the high-water hydrograph (Table 1).

c. Develop a bar that would extend into the navigation channel at miles 319.2 and 315.9, reducing the minimum width of the navigation channel to 50 ft or less during both the median-year and high-water hydrographs (Plates 22 and 23).

d. Increase the depth of the scour holes off the end of the left bank dikes 3 to 6 ft during the high-water hydrograph (Plate 18 versus Plate 23).

e. Raise water-surface elevations as much as 0.3 ft upstream of and 0.5 ft downstream of the dam (Table 2). This maximum increase in water surface occurred with a flow of 150,000 cfs.

f. Have little effect on the maximum velocity in the navigation channel for flows of 75,000 (Plate 19 versus Plate 24) and 150,000 cfs (Plate 20 versus Plate 25) but would raise the maximum velocity in the navigation channel for a flow of 230,000 cfs from 11.7 (Plate 21) to 12.5 fps (Plate 26).

Plan D

Description

25. For Plan D (Plate 28), the 200-ft extensions to 10 of the left bank dikes added for Plan C were angled 15 deg upstream. The extension to the dike at mile 316.8 was not reoriented, since its initial placement was at about this angle. Test of Plan D was begun with the model bed configuration obtained at the end of Plan C run 4 with a 250-ft-wide navigation channel dredged to el 380 downstream of the dam. Only the high-water hydrograph was reproduced.

Results

26. Angling the 200-ft extensions to the left bank dikes caused considerable deposition in the navigation channel from mile 319.4 to 315.6 (Plate 29). Shoals developed across the entire width of the navigation channel from mile 319.4 to 319.2 and from mile 315.9 to 315.6 that left a navigation channel 2 to 3 ft above project depth. Plan D required 67 percent more dredging to provide a 250-ft-wide navigation channel to el 380 than did Plan C and 35 percent more than did the base test (Table 1).

Plan E

Description

27. Plan E (Plate 28) was the same as Plan C except:

a. Three spur dikes were installed on the left bank just downstream of the dam. The most upstream dike was installed at mile 319.6 to el 400 with the channel end 800 ft from the lock wall. The next dike was installed at mile 319.5 to el 397 with the channel end 700 ft from the lock wall. The third dike was installed at mile 319.4 to el 394 with the channel end 500 ft from the guard wall.

b. The 200-ft extensions to the seven existing dikes and the four dikes added for Plan A on the left bank were removed leaving the channel ends of these dikes 800 ft from the right bank.

c. Five dikes were installed on the left bank at miles 316.6, 316.4, 316.2, 316.0, and 315.8 to elevations of 413, 411, 409, 407, and 405, respectively. The channel ends of these dikes were 800 ft from the right bank.

28. This plan was tested with two median-year hydrographs followed by the high-water hydrograph. The first hydrograph was initiated with the channel bed molded to the 1974 prototype survey with a 250-ft-wide channel dredged to el 380 downstream of the lock. Water-surface elevations, velocities, and current directions were taken for flows of 75,000, 105,000, 150,000, and 230,000 cfs after dredging the navigation channel following the high-water hydrograph.

Results

29. Results of Plan E (Plates 30-35 and Tables 1 and 2) indicate that:

- a. Addition of three dikes on the left bank just downstream of the dam (Plan E versus Plan C) would reduce the deposition in the navigation channel just downstream of the lock for both the median-year and high-water hydrographs (Plates 22 and 23 versus 30 and 31). The dredging required to provide a navigation channel upstream of mile 319.2 for Plan E was about 45 percent of that required for Plan B and 34 percent of that required for Plan C following the second median-year hydrograph and about 53 and 85 percent, respectively, following the high-water hydrograph (Table 1).
- b. The dike modifications downstream of mile 319.2 resulted in 60 percent less deposition in the navigation channel following the second median-year hydrograph (Plan E run 2 versus Plan C run 2) and 33 percent more deposition following the high-water hydrograph (Plan E run 3 versus Plan C run 3). The total dredging required to provide a navigation channel in the test reach for Plan E was 66 percent less than that for the base test following the second median-year hydrograph and 6 percent more following the high-water hydrograph (Table 1).
- c. Water-surface elevations recorded for Plan E were as much as 0.5 ft less both upstream and downstream of the dam than for Plan C and as much as 0.3 ft more upstream of and 0.6 ft more downstream of the dam than for the base test (Table 2). The maximum difference between Plans E and C occurred with a flow of 150,000 cfs and between Plan E and the base test occurred with a flow of 230,000 cfs.
- d. Plan E would reduce the maximum velocity recorded for Plan C for a flow of 150,000 cfs from 9.6 (Plate 25) to 8.9 fps (Plate 34) and from 12.5 (Plate 26) to 11.5 fps (Plate 35) for a flow of 230,000 cfs.

Plan F

Description

30. Plan F (Plate 36) was the same as Plan E with the following modifications:

- a. The dike at mile 319.4 was extended 100 ft at the same crest elevation (394). The channel end of this dike was 400 ft from the guard wall.

b. A 100-ft extension was added to the 16 existing and proposed dikes on the left bank from mile 319 to 316.8. The crest of these extensions sloped downward toward the channel end with a 1V-on-10H slope. The channel ends of these dikes were 700 ft from the right bank.

31. This plan was tested with only the high-water hydrograph. This hydrograph was initiated with the channel bed conditions existing at the end of Plan A run 1 with a 250-ft-wide navigation channel dredged to el 380 downstream of the lock. Velocities and current directions were taken for flows at 75,000, 105,000, 150,000, and 230,000 cfs after dredging following the high-water hydrograph.

Results

32. A comparison of the results of Plan F with those of Plan E shows that:

a. Extending the dike at mile 319.4 increased the deposition 36 percent in the navigation channel upstream of mile 319.2 (Table 1).

b. Extending the 16 left bank dikes decreased the deposition 22 percent in the navigation channel from mile 319.2 to 316.8 but increased deposition 21 percent downstream of mile 316.8 (Plate 31 versus Plate 37 and Table 1).

c. The total amount dredged to provide a 250-ft-wide navigation channel downstream of the lock for Plan F was 6 percent less than that for Plan E (Table 1) and identical to that of the base test.

d. Water-surface elevations for Plan F were as much as 0.3 ft higher upstream of and 0.4 ft downstream of the dam than these for Plan E. This increase occurred with a flow of 230,000 cfs (Table 2).

e. The maximum velocity in the navigation channel for Plan F would be about 0.5 fps less than for Plan E for flows of 75,000 and 150,000 cfs but about 0.7 fps more than for Plan E for flows of 105,000 and 230,000 cfs (Plates 32-35 versus Plates 38-41).

Plan G

Description

33. For Plan G (Plate 36) the 100-ft extensions added to the last five dikes on the left bank (mile 316.6 to 315.8) were removed. Two

hydrographs were reproduced--a median-year followed by the high-water hydrograph. The median-year hydrograph was initiated with the channel bed molded to the 1974 prototype survey with a 250-ft-wide navigation channel dredged to el 380 downstream of the lock. Water-surface elevations, velocities, and current directions were taken for flows of 75,000, 105,000, 150,000, and 230,000 cfs following the dredging after the high-water hydrograph.

Results

34. A comparison of the results of Plan G (Plates 42-47 and Tables 1 and 2) with those of other plans tested indicate that Plan G would produce a better navigation channel than any of the plans previously tested. Dredging required to produce a 250-ft-wide channel to el 380 downstream of the lock following the median-year and high-water hydrographs was only 85 and 82 percent, respectively, of that required with Plan C, the next best plan tested, and only 39 and 66 percent, respectively, of that required with the base test (Table 1). The navigation channel developed with Plan G had a minimum width of 140 ft after the median-year hydrograph and 180 ft after the high-water hydrograph. Water-surface elevations with Plan G were as much as 0.3 ft higher than the base test immediately upstream of the dam and 0.2 ft higher at mile 322.2. Water-surface elevations were a maximum of 0.7 ft higher downstream of the dam than with the base test. This maximum increase in elevation occurred with a flow of 230,000 cfs (Table 2). Maximum velocities (Plates 44-47) in the navigation channel with Plan G did not exceed those for the base test by more than 0.3 fps (Plates 11-14).

Plan H

Description

35. The dike changes for Plan H (Plate 48) were designed to reduce sediment deposition in the entrance to the lock just downstream of the trail dike. Plan H was the same as Plan G except:

a. The three dikes on the left bank just downstream of the dam (miles 319.6, 319.5, and 319.4) that were added for Plan E were removed.

b. The 250-ft extension to the trail dike added for Plan A was removed.

c. Three angled dikes were installed just downstream of the dam off the lock wall, guard wall, and trail dike as shown in Plate 48. The most upstream dike, 405 ft long, was installed off the downstream end of the lock wall to el 392 at an angle of 33 deg with the lock wall. The next dike, 435 ft long, was installed off the downstream end at the guard wall to el 395 at an angle of 31 deg with the guard wall. The third dike, 320 ft long, was installed off the downstream end of the existing trail dike to el 395 at an angle of 20 deg with the trail dike (or at an angle of 28 deg with the guard wall).

36. Plan H was tested with three hydrographs--one median-year, followed by one high-water, followed by another median-year hydrograph. The first median-year hydrograph was initiated with the channel bed molded to the 1974 prototype survey with a 250-ft-wide navigation channel dredged to el 380 downstream of the lock. Water-surface elevations were taken for flows of 75,000, 105,000, 150,000, and 230,000 cfs following the dredging after the high-water hydrograph. No velocities or current directions were taken.

Results

37. A comparison of results of tests of Plan H with those of Plan G indicate that removing the 250-ft extension to the trail dike and replacing the three dikes on the left bank just downstream of the dam with three dikes off the lock wall, guard wall, and trail dike would essentially eliminate the need for dredging just downstream of the lock (to mile 319.2) for both the median-year and high-water hydrographs (Plates 49-51). Plan H reduced the required dredging between miles 319.4 and 317.8 over that required for Plan G but increased the required dredging downstream of mile 317.8 about the same amount; thus the total dredging required for Plans G and H was about the same (Table 1). The navigation channel developed with Plan H had a minimum width of 175 ft, after both the median-year and high-water hydrographs. Water-surface elevations for Plan H were the same as those for Plan G (Table 2).

Plan I

Description

38. Plan I (Plate 48) was tested to determine the effectiveness of overwidth dredging in delaying the need for maintenance dredging. Model conditions for Plan I were the same as those for Plan H except a 400-ft-wide (rather than a 250-ft-wide) navigation channel was dredged to el 380 downstream of the lock. One median-year hydrograph was reproduced followed by the high-water hydrograph. A navigation channel was not dredged following the median-year hydrograph. Following the high-water hydrograph, a 250-ft-wide channel was dredged to el 380 downstream of the lock; then an additional 150-ft width (to the left of the 250-ft-wide channel) was dredged to el 380 to determine the amount of material that was deposited in the overwidth portion of the channel.

Results

39. Results of tests indicate that the initial dredging of a 400-ft-wide channel (Plan I) rather than a 250-ft-wide channel (Plan H), in addition to the most effective dike plan tested, would essentially eliminate the need for dredging following the first median-year hydrograph (Plate 52 and Table 1) and reduce considerably the required dredging within the 250-ft-wide channel following the high-water hydrograph (Plate 50 versus Plate 53 and Table 1). Bed configurations resulting from the median-year hydrograph showed only one small area in the 250-ft-wide channel above el 382 (minimum navigation depth). This area was at mile 319 where a shoal to el 385 had developed 75 ft inside the 250-ft-wide channel for a distance of 700 ft along the channel. Bed configurations following the high-water hydrograph showed a navigation channel with a minimum width of 200 ft except at mile 319.2 where a 300-ft-long bar limited the channel width to 100 ft. Table 1 shows that the dredging required to produce a 250-ft-wide channel to el 380 after a combination of the median-year and the high-water hydrographs with initial dredging of a 400-ft-wide channel (Plan I run 2) was less than 50 percent of that required after one high-water hydrograph with initial dredging of a 250-ft-wide channel (Plan H run 2).

Plan J

Description

40. Plan J (Plate 48) was tested to determine the effectiveness of overdepth dredging in delaying the need for maintenance dredging. The model conditions for Plan J were the same as those for Plan H except a 250-ft-wide channel was dredged to el 375 (rather than to el 380) downstream of the lock. One median-year hydrograph was reproduced followed by the high-water hydrograph. Following each hydrograph a 250-ft-wide channel was dredged first to el 380, then to el 375, to determine the quantity of material that was deposited in the overdepth portion of the channel.

Results

41. Test results indicate that the initial dredging of a channel to el 375 (Plan J) rather than to el 380 (Plan H) would essentially eliminate the need for dredging following the first median-year hydrograph (Plate 54 and Table 1) and reduce considerably the required dredging following the high-water hydrograph (Plate 50 versus Plate 55 and Table 1). Bed configurations resulting from the median-year hydrograph showed only two small areas in the 250-ft-wide channel above el 382. These areas were at miles 319.2 and 319.0 and limited the channel to widths of 175 and 150 ft, respectively. Bed configurations resulting from the high-water hydrograph showed deposition in the 250-ft-wide navigation channel above el 382 at mile 319.2 which limited the navigation to a width of 150 ft and at several points downstream of mile 319.0 which limited the navigation channel to a width of 175 ft. The quantities dredged (to el 380) after the high-water hydrograph with Plan J were less than 50 percent of those dredged after Plan H (Table 1). The quantities dredged after tests of Plan J were almost identical with those after tests of Plan I.

Plan K

Description

42. Test results of Plans I and J indicated that both overwidth

and overdepth dredging would essentially eliminate the need for dredging following a single median-year hydrograph, but these tests were not designed to determine the required dredging following a series of median-year hydrographs. Plan K was designed to determine this information for overwidth dredging, but tests to determine this information for overdepth dredging were not conducted since previous tests had indicated that overwidth and overdepth were equally effective and overdepth dredging would require expensive and time-consuming rock removal. Plan K (Plate 48) was the same as Plan I, but the median-year hydrograph was reproduced five times with no dredging between the hydrographs. Following the fifth hydrograph, a 250-ft-wide channel was dredged to el 380 downstream of the lock, then an additional 150-ft width (to the left of the 250-ft-wide channel) was dredged to el 380 to determine the quantity of material deposited in the overwidth channel.

Results

43. Bed configurations resulting from the first hydrograph of Plan K (Plate 56) show that sediment was deposited in the 400-ft-wide channel from the end of the wing dike to mile 318.7 and that it extended slightly into the 250-ft-wide channel but only to el 381; thus it would not interfere with navigation. The 400-ft-wide channel downstream of mile 318.7 was not above el 380. Bed configurations resulting from the second, third, and fourth hydrographs (not presented in this report) showed little change from those for the first hydrograph except that the shoals just off the wing wall at mile 319.2 and at mile 318.7 increased slightly but would have little effect on navigation. Bed configurations for the fifth hydrograph (Plate 57) also showed little change from those for the first hydrograph except that the shoal downstream of the end of the wing dike was to el 389 in the 250-ft-wide channel, limiting the navigation channel to a width of 130 ft. The part of the shoal in the 250-ft-wide channel above el 382 was only 100 ft wide and 200 ft long, and the turbulence caused by passing tows could possibly prevent its formation. Dredging quantities listed in Table 1 show that 12 percent less material was dredged from the 250-ft-wide channel following five hydrographs which were begun with a 400-ft-wide channel (Plan K) than

following one hydrograph which was begun with a 250-ft-wide channel (Plan H).

Mooring Cell Tests

Description

44. These tests were conducted to determine the optimum location of two proposed mooring cells upstream of Lock and Dam 14 on the Arkansas River. The mooring cells are to be used for downbound tows waiting for upbound tows to clear the lock and its approach and for disabled tows to tie onto until repairs can be made. Navigation interests preferred that the cells be located close enough to see the lock signals in case their radio is out of order, but not where a tow tied to them would interfere with navigation. The model bed was molded to the prototype survey of 1974 (Plate 3). The two proposed cells with a 105-by-390-ft tow tied to them were tested at four locations on the right side of the channel--No. 1 at mile 320.4, No. 2 at mile 320.7, No. 3 at mile 320.9, and No. 4 at mile 322.0 (Plate 58). Velocities and current directions were taken with a flow of 110,000 cfs (maximum controlled flow) for existing conditions (base test) and with a tow tied to the cells at locations 1 and 2 and with a flow of 150,000 cfs (maximum navigable flow) for existing conditions and with a tow tied to the cells of all four locations. In addition, the effects of a 105-by-600-ft downbound tow passing the tow tied to the cells at each location with a flow of 150,000 cfs was recorded with time-lapse photography.

Results

45. Velocities and current directions for existing conditions and with the tow tied to the proposed cells are presented in Plates 59-67. Time-lapse photographs of the downbound tow passing the tow moored to the proposed cells at each location are presented in Photos 1-4. Test results indicate that mooring a tow to the proposed cells would reduce velocities in the area adjacent to the tow at locations 1-3 and increase the maximum velocities in the channel opposite the tow at all four locations. Observations for existing conditions indicated a downbound tow

should start crossing toward the right bank upstream of mile 321 to maintain a satisfactory alignment for the approach to the lock. Locations 1, 2, and 3 are downstream of this crossing point, and test results indicate that a tow moored to cells at any of these locations would force a downbound tow farther out into the channel where the higher velocities and the direction of currents would make it more difficult for a tow to approach the lock. Location 4 is upstream of this crossing point, and downbound tows passing this location are normally in the center of the channel; test results indicate that a tow moored to cells at this point would have little effect on passing tows and would not interfere with the tow's approach to the lock.

PART IV: DISCUSSION OF RESULTS AND CONCLUSIONS

Interpretation of Model Results

46. The limitation of the model in reproducing all of the factors affecting developments in the reach and the differences between the model and prototype indicated by the results of verification tests must be considered in the evaluation of model results. The fact that the model did not reproduce sediment in suspension must be considered. In spite of these limitations, adjustment and verification of the model were sufficient to indicate trends that can be expected under the conditions imposed for each plan or modification tested and the relative effectiveness of each plan. Dredging quantities listed in Table 1 are presented only to show relative effectiveness of the plans tested and cannot be used to determine the quantity of material to be dredged in the prototype for any particular plan.

Summary of Results and Conclusions

47. The indications and conclusions developed from the results of model tests are summarized as follows:

- a. High-water hydrographs (such as the 1973-74 hydrograph) leave heavy deposition in the area of the dam and in the navigation channel downstream of the lock. Subsequent median-year hydrographs move this deposition from the area of the dam into the channel downstream of the lock.
- b. Installing angled dikes on the left side of the channel off the lock wall, guard wall, and trail dike (as in Plan H) would essentially eliminate the need for dredging in the navigation channel upstream of mile 319.2.
- c. Extending the existing dikes downstream of the lock on the left bank 100 ft and installing nine additional dikes to limit the overall channel to a width of 700 ft at el 381 downstream to mile 316.8 and a width of 800 ft from mile 316.8 to mile 315.8 (as in Plan H) would reduce considerably the dredging required to maintain the 250-ft-wide navigation channel following both the median-year and high-water hydrographs by about 63 percent and 33 percent, respectively. The navigation channel developed by these

modifications would have a minimum width of 175 ft following both the median-year and high-water hydrographs. These modifications would raise water-surface elevations as much as 0.3 ft immediately upstream of the dam and 0.2 ft at mile 322.2. Water-surface elevations were a maximum of 0.7 ft higher downstream of the dam, and maximum velocities were not increased more than 0.3 fps over those with existing conditions. The maximum increase in elevation occurred with a flow of 230,000 cfs, and the maximum increase in velocities occurred with a flow of 105,000 cfs.

d. Extending the dikes on the left bank 200 ft (limiting the overall channel to 600 ft) as in Plan C or angling these extensions 15 deg upstream as in Plan D was counterproductive and would increase the dredging required to maintain the navigation channel.

e. Both overwidth dredging (an additional 150 ft, Plan I) and overdepth dredging (an additional 5 ft, Plan J) essentially eliminated the need for dredging following one median-year hydrograph and reduced considerably the dredging required following the high-water hydrograph. With overwidth dredging and no maintenance dredging for five years with the median-year hydrograph (Plan K), there was essentially no dredging required following the second, third, and fourth hydrographs; and the dredging required following the fifth hydrograph was only about 88 percent of that required following the first hydrograph starting with a 250-ft-wide channel (Plan H). With initial overwidth dredging the median-year hydrograph developed a navigation channel with a minimum width of 250 ft except for a 700-ft-long section where the channel was only 175 ft wide. The high-water hydrograph developed a channel with a minimum width of 200 ft except for a 300-ft-long section where the channel was only 100 ft wide.

f. Proposed mooring locations 1, 2, and 3 (0.9, 1.1, and 1.2 miles upstream of the lock and on the right bank) are downstream of the point where a tow should cross to the right bank to safely approach the lock. A 105-ft-wide tow tied to mooring cells at any of these points would force a downbound tow farther out into the channel where higher velocities and adverse currents would make it more difficult for the tow to approach the lock. Location 4 (2.3 miles upstream of the lock and on the right side of the channel) is upstream of this crossing and a tow tied to cells at this point would have little, if any, effect on passing tows.

Table 1

Navigation Channel Dredging Comparison*

Plan	Run	Hydrograph	Location in River Miles: 319.4 to 319.2	319.2 to 317.8	317.8 to 316.8	316.8 to 315.8	315.8 to 313.2	Total
Base	1	Median	--	--	--	--	--	810**
	2	Median	--	--	--	--	--	400**1210†
	3	Median	70	15	15	0	0	100
	4	High water	200	290	400	180	0	1070
	5	Median	75	60	64	173	0	372
A	1	Median	90	50	100	60	0	300
B	1	Median	50	30	45	3	42	170
	2	Median	60	10	50	0	0	300
	3	High water	160	230	280	275	0	945
C	1	Median	90	160	80	40	0	370
	2	Median	80	75	115	65	0	335
	3	High water	100	195	175	390	0	860
	4	Median	60	95	70	70	0	295
D	1	High water	270	190	340	480	160	1440
E	1	Median	110	138	65	88	0	401
	2	Median	27	55	20	33	0	135
	3	High water	85	550	405	70	30	1140
F	1	High water	115	430	315	135	75	1070
G	1	Median	60	240	7	8	0	315
	2	High water	105	350	175	75	0	705
H	1	Median	10	165	85	43	0	303
	2	High water	8	275	280	150	0	713
	3	Median	3	83	80	65	0	231
I	1	Median	--	--	--	--	--	18**
	††		--	--	--	--	--	132**
	2	High water	20†	233†	100†	0†	100†	335**353†
	††		30†	859†	478†	102†	53†	1390**1522†
J	1	Median	0	15	0	0	0	15
	‡		60	235	31	9	0	335
	2	High water	0	261	65	11	0	337
	‡		6	547	301	149	16	1019
K	5	Median	--	--	--	--	--	265‡‡
	††		--	--	--	--	--	300‡‡

* Dredging is shown to illustrate the relative effectiveness of the plans tested. The figures cannot be used to determine the quantity of material to be dredged for any particular plan. The dredged channel was 250 ft wide to el 380 unless otherwise noted.

** Dredging computed from survey.

† Total deposited during runs 1 and 2. Channel was not dredged between runs.

†† Overwidth dredging (from 250 to 400 ft).

‡ Overdepth dredging (from el 1380 to 1375).

‡‡ Total deposited during runs 1 through 5.

Table 2

Water-Surface Elevations*

Gage	Base Test Run 4	Plan B Run 3	Plan C Run 3	Plan E Run 3	Plan F Run 1	Plan G Run 2	Plan H Run 2
			Steady Flow of 75,000 cfs				
1	414.2	414.2	414.2	414.2	414.2	414.2	414.2
2	413.1	413.1	413.1	413.1	413.1	413.1	413.1
3	412.2	412.2	412.2	412.2	412.2	412.2	412.2
4	412.0	412.0	412.0	412.0	412.0	412.0	412.0
5	406.2	406.4	406.7	406.4	406.7	406.4	406.4
6	405.3	405.6	406.0	405.7	405.8	405.7	405.7
7	404.7	404.8	405.1	404.9	405.1	404.9	404.9
8	404.2	404.3	404.4	404.4	404.6	404.4	404.4
9	404.0	404.0	404.0	404.0	404.1	404.0	404.0
10	403.8	403.8	403.8	403.8	403.8	403.8	403.8
11	403.6	403.6	403.6	403.6	403.6	403.6	403.6
12**	403.5	403.5	403.5	403.5	403.5	403.5	403.5
			Steady Flow of 105,000 cfs				
1	416.8	Did Not Test	Did Not Test	416.8	416.8	416.8	416.8
2	415.0			415.0	415.0	415.0	415.0
3	413.8			413.8	413.8	413.8	413.8
4	413.5			413.5	413.5	413.5	413.5
5	410.2			410.5	410.7	410.5	410.5
6	409.2			409.5	409.6	409.5	409.5
7	408.5			408.7	408.8	408.7	408.7
8	407.9			408.1	408.2	408.1	408.0
9	407.6			407.6	407.7	407.6	407.6
10	407.3			407.3	407.3	407.3	407.3
11	407.1			407.1	407.1	407.1	407.1
12**	406.9			406.9	406.9	406.9	406.9
			Steady Flow of 150,000 cfs				
1	420.2	420.5	420.8	420.3	420.4	420.2	420.2
2	418.2	418.5	418.8	418.3	418.3	418.2	418.2
3	416.5	416.8	417.1	416.6	416.7	416.6	416.6
4	415.9	416.3	416.6	416.1	416.2	416.1	416.1
5	415.7	416.1	416.5	416.0	416.1	416.0	416.0
6	414.9	415.2	415.7	415.2	415.2	415.2	415.2
7	413.8	414.1	414.3	414.1	414.1	414.1	414.1
8	413.6	413.7	413.7	413.7	413.7	413.7	413.7
9	413.2	413.2	413.2	413.2	413.2	413.2	413.2
10	412.9	412.9	412.9	412.9	412.9	412.9	412.9
11	412.6	412.6	412.6	412.6	412.6	412.6	412.6
12**	412.4	412.4	412.4	412.4	412.4	412.4	412.4
			Steady Flow of 230,000 cfs				
1	426.4	426.6	426.7	426.6	426.7	426.6	426.6
2	424.4	424.6	424.8	424.6	424.9	424.6	424.6
3	422.2	422.5	422.7	422.5	422.8	422.5	422.3
4	421.7	422.0	422.2	422.0	422.3	422.0	422.0
5	421.4	421.7	421.9	421.7	422.0	421.8	421.8
6	420.2	420.4	420.6	420.4	420.7	420.4	420.5
7	418.2	418.4	418.8	418.8	419.0	418.9	418.9
8	417.8	417.8	417.9	417.9	418.3	418.0	418.0
9	417.4	417.4	417.4	417.4	417.4	417.4	417.4
10	416.8	416.8	416.8	416.8	416.8	416.8	416.8
11	416.4	416.4	416.4	416.4	416.4	416.4	416.4
12**	415.8	415.8	415.8	415.8	415.8	415.8	415.8

* Water-surface elevations are in feet referred to the National Geodetic Vertical Datum (NGVD).

** Water-surface elevation controlled at gage 12.

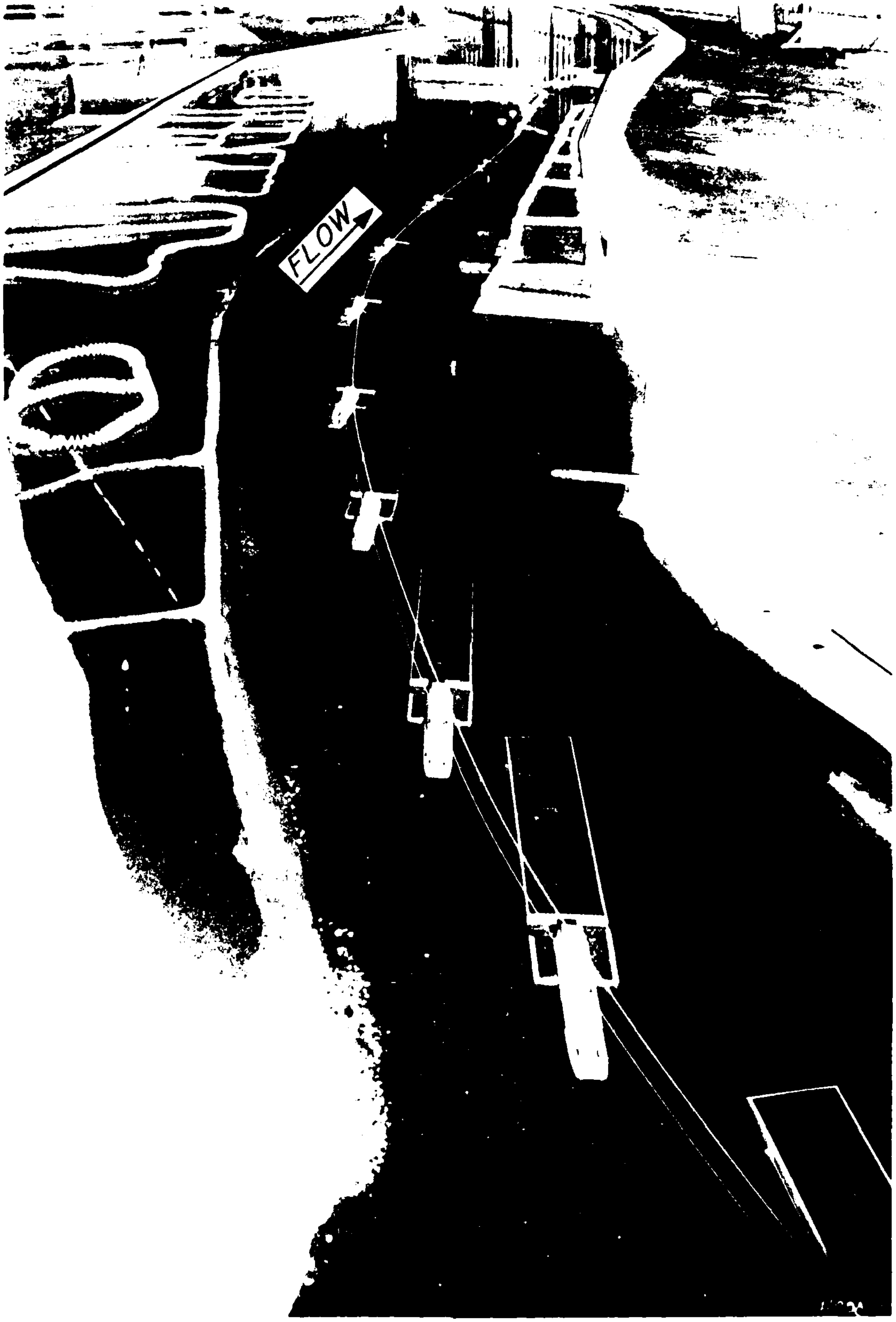


Photo 1. Path of downbound tow passing a tow tied to mooring cells at location 1; discharge 150,000 cfs

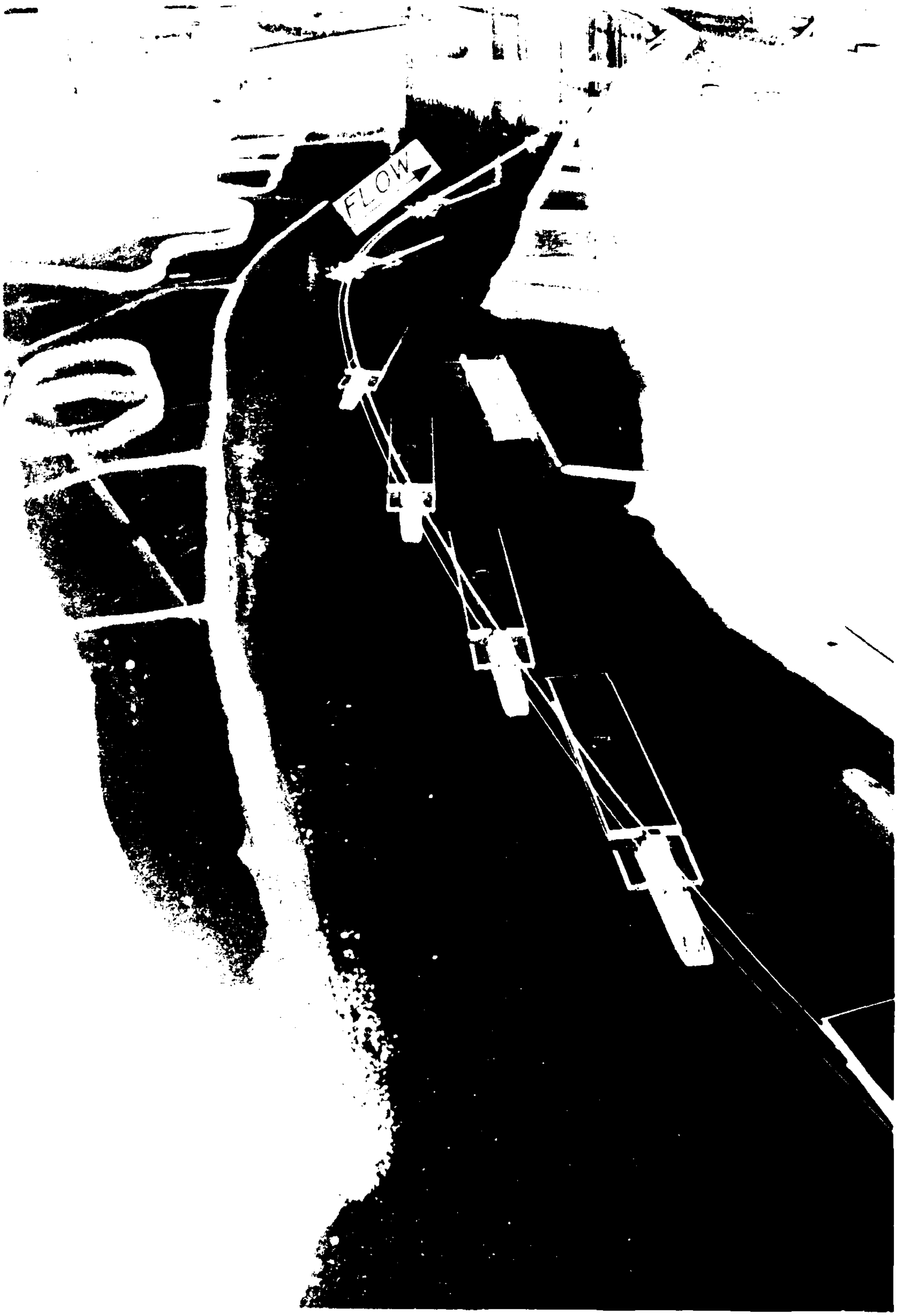


Photo 2. Path of downbound tow passing a tow tied to mooring cells at location 2; discharge 150,000 cfs

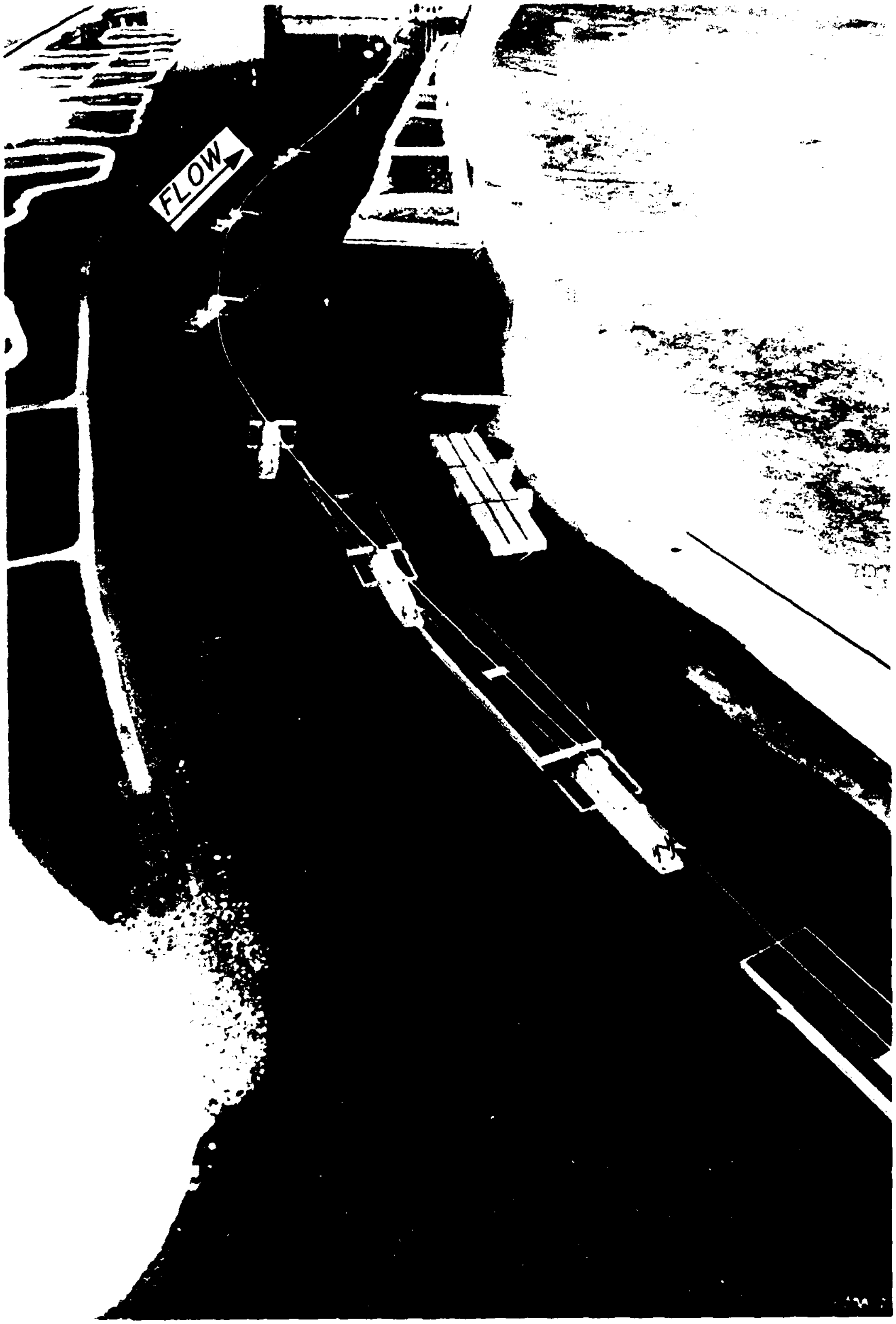


Photo 3. Path of downbound tow passing a tow tied to mooring cells at location 3; discharge 150,000 cfs

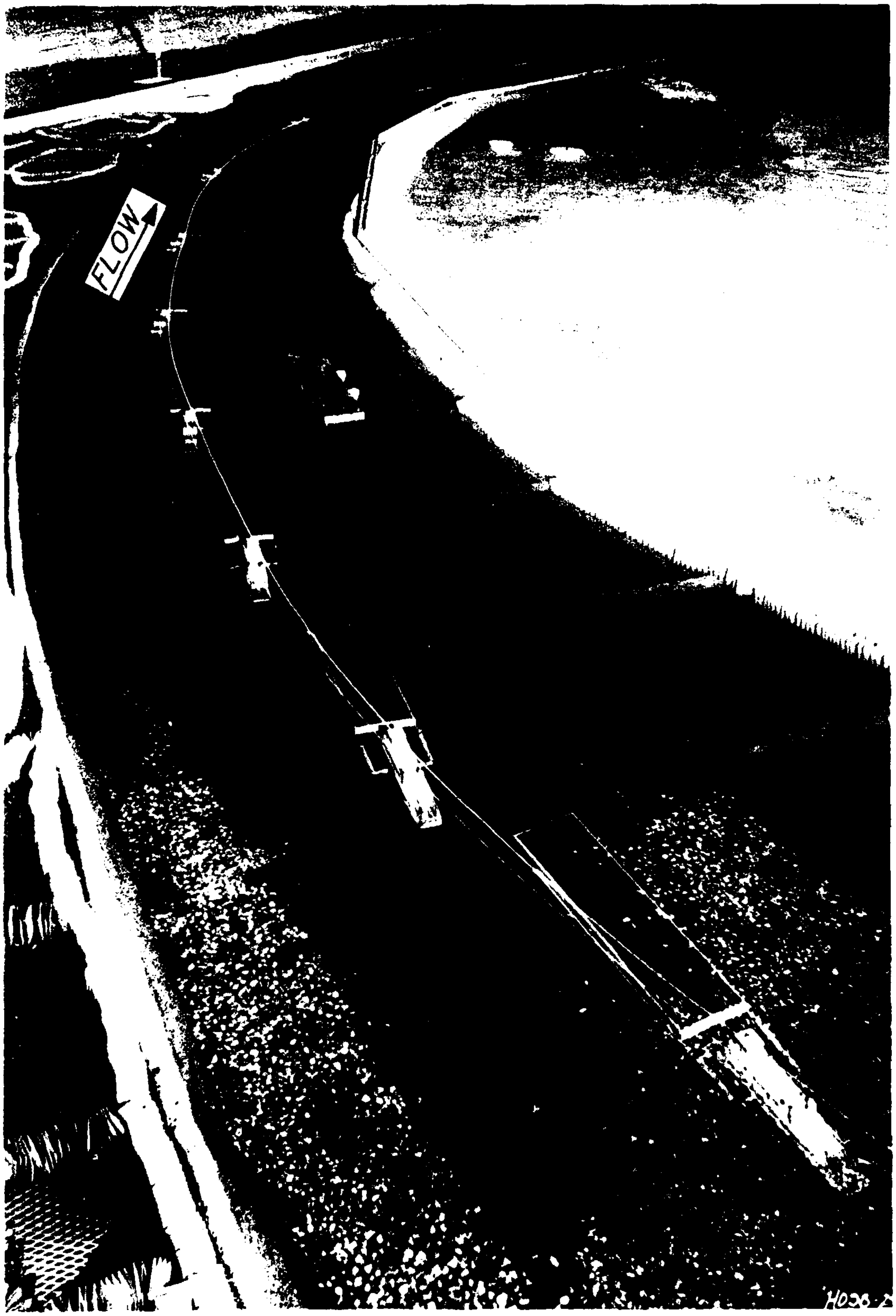


Photo 4. Path of downbound tow passing a tow tied to mooring cells at location 4; discharge 150,000 cfs

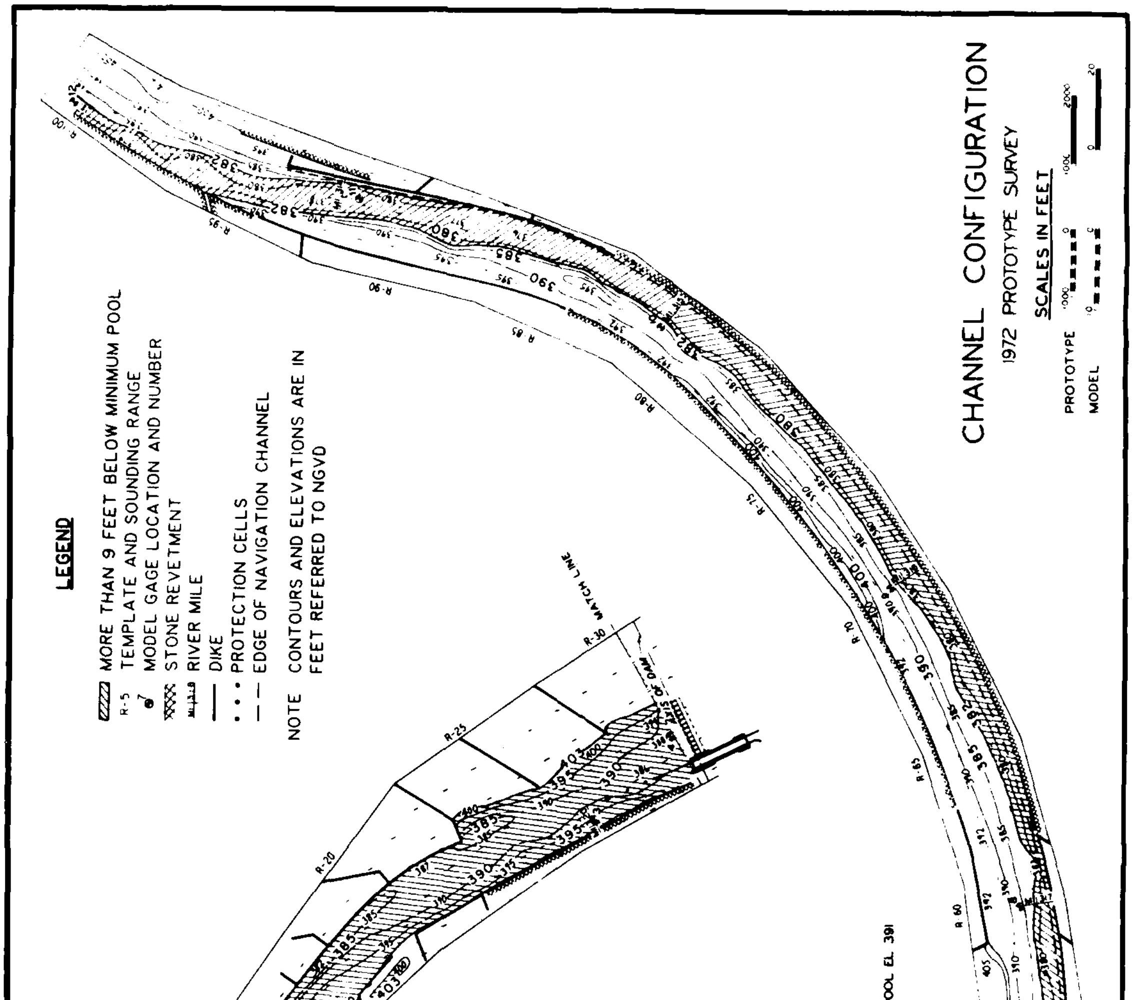
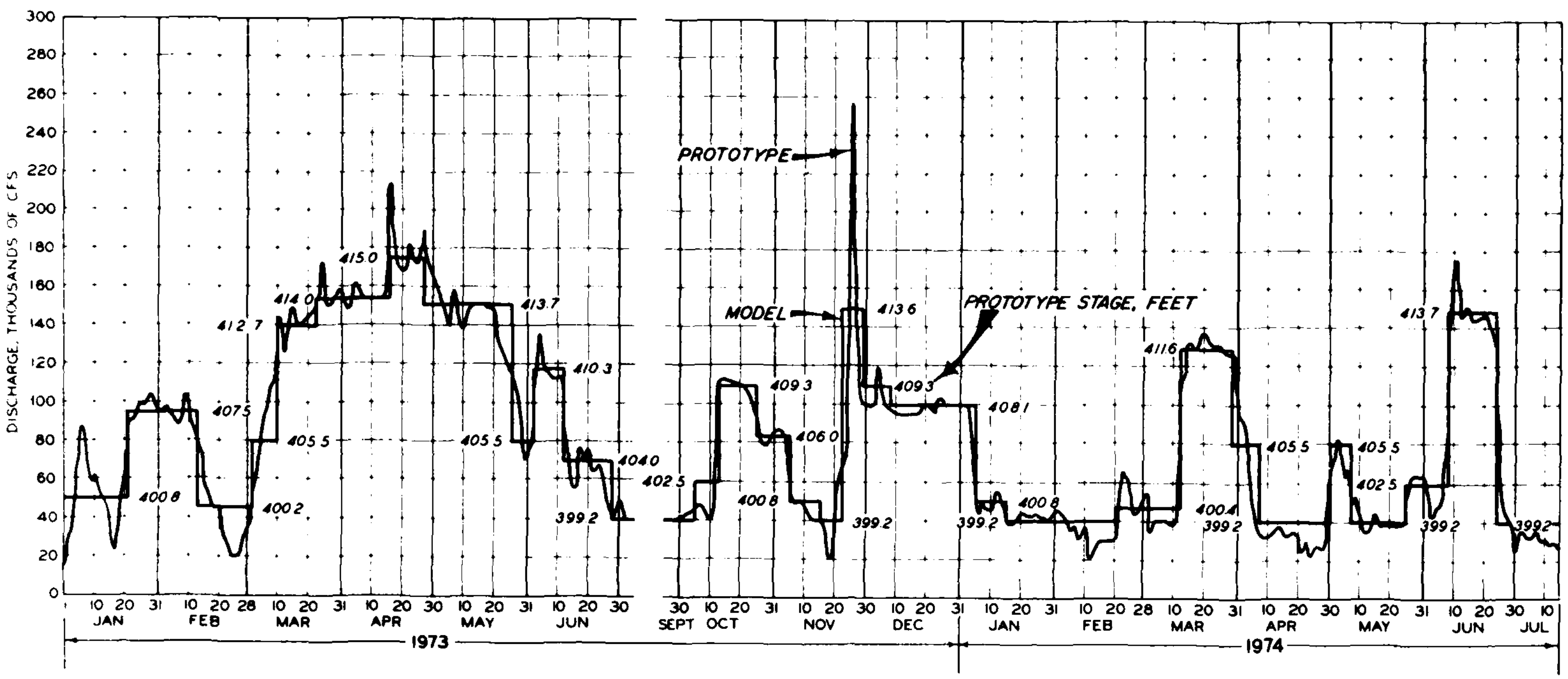

CHANNEL CONFIGURATION
1972 PROTOTYPE SURVEY
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
MATCH LINE
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE

PLATE 1



NOTE: FLOWS FROM 5 JULY 1973 TO
25 SEPTEMBER 1973 WERE OMITTED--
NO SEDIMENT MOVEMENT ON THESE
FLOWS.

HIGH-WATER HYDROGRAPH

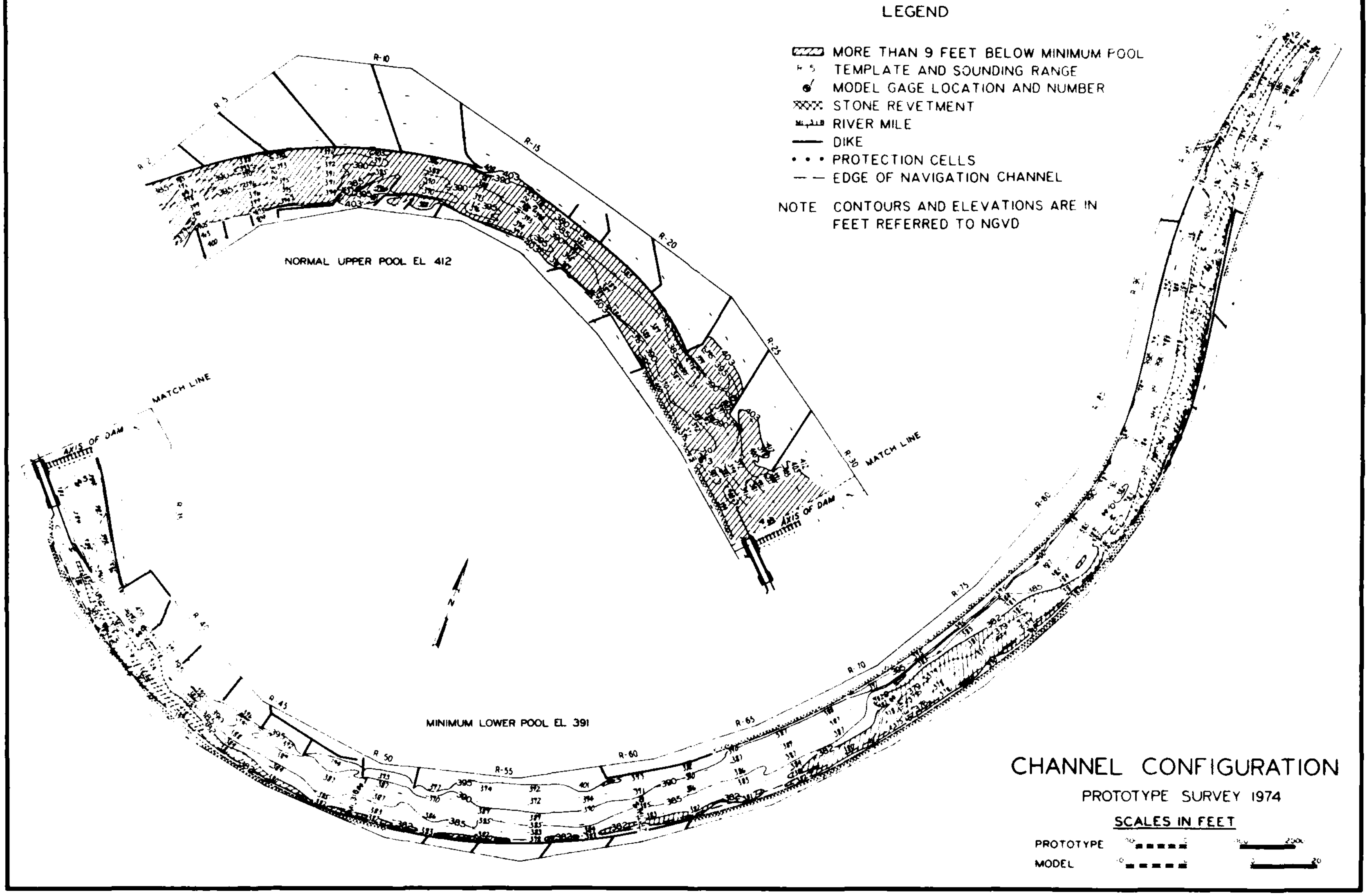

LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE
MATCH LINE
AXIS OF DAM
AXIS OF DAM
R-5
R-10
R-15
R-20
R-25
R-30
R-45
R-50
R-55
R-60
R-65
R-70
R-75
R-80
CHANNEL CONFIGURATION
PROTOTYPE SURVEY 1974
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 3

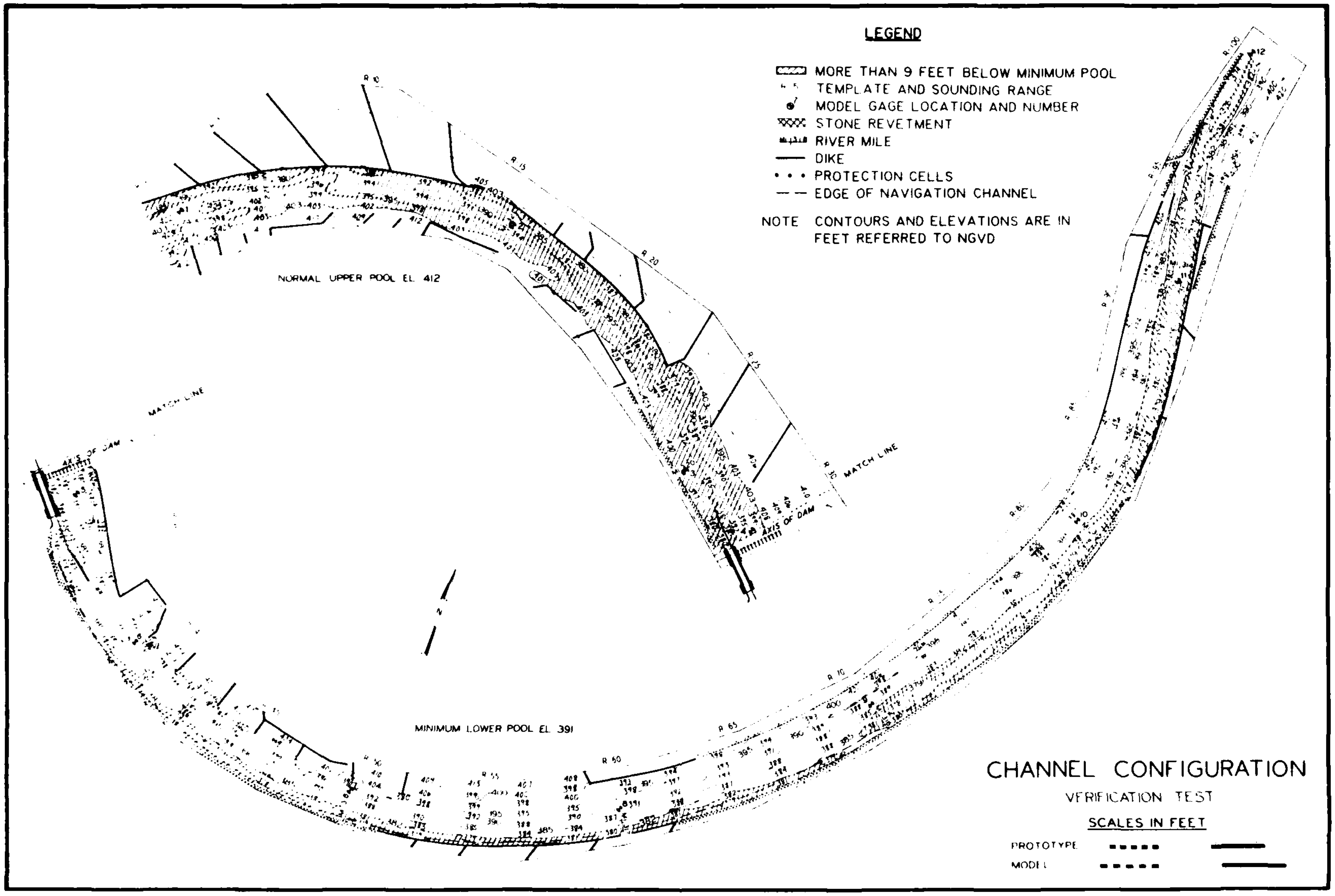
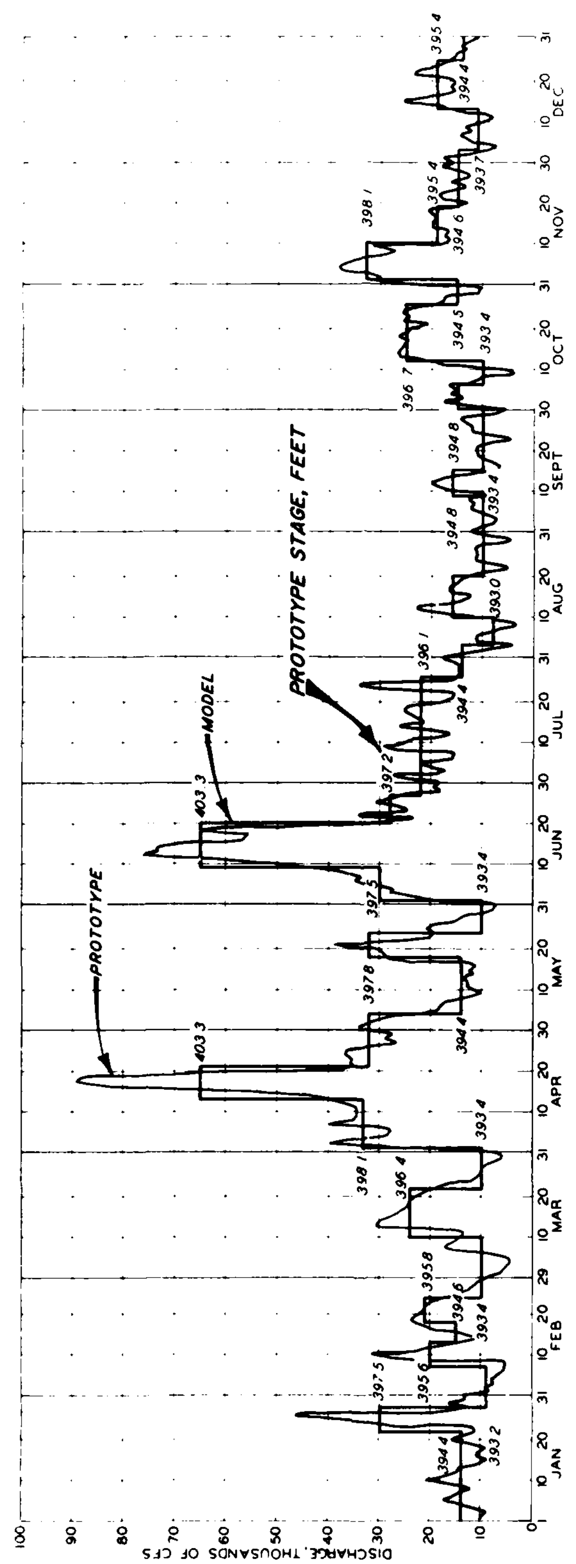

LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE
MATCH LINE
AXIS OF DAM
AXIS OF DAM
CHANNEL CONFIGURATION
VERIFICATION TEST
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 4



MEDIAN-YEAR HYDROGRAPH

PLATE 5

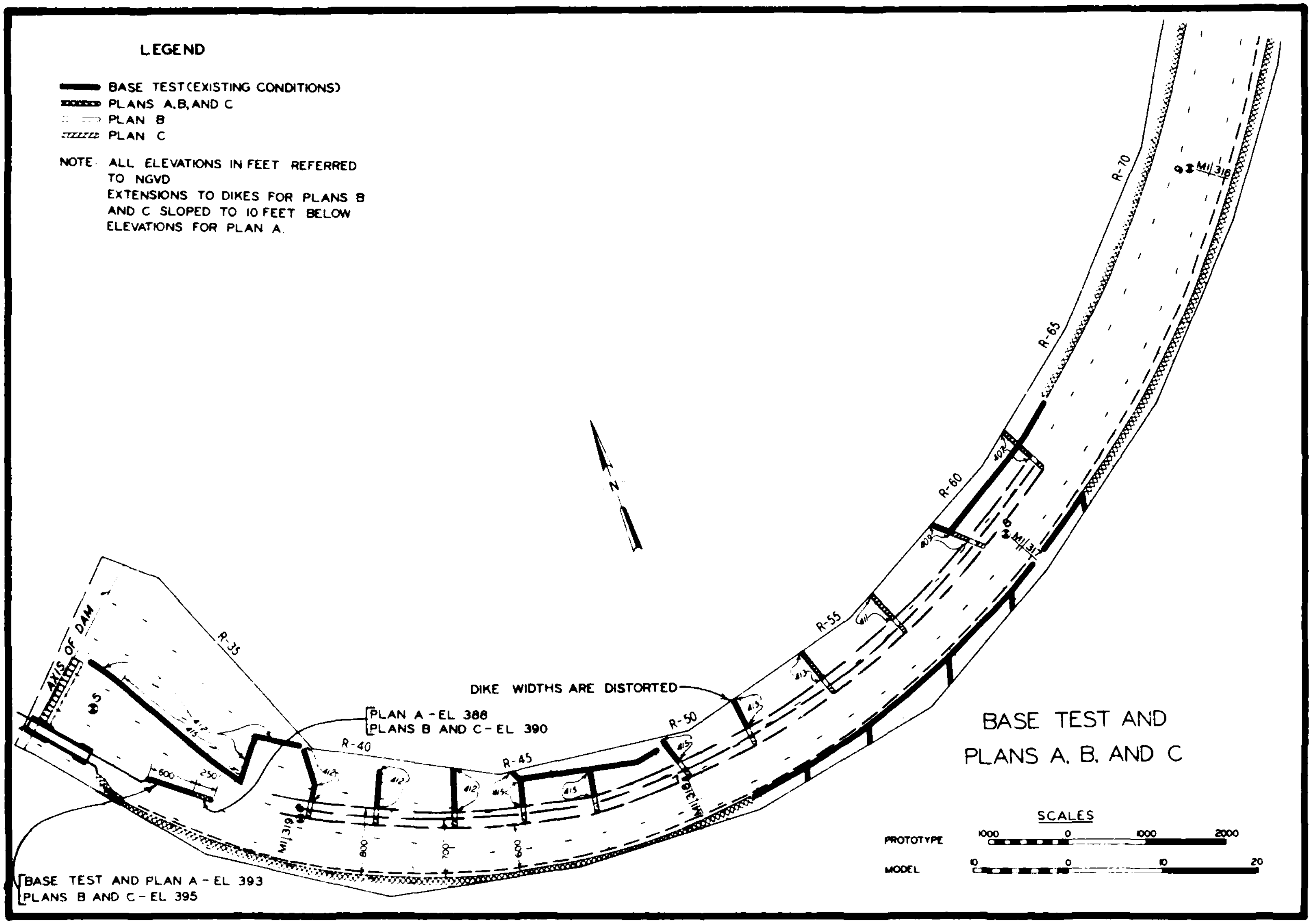
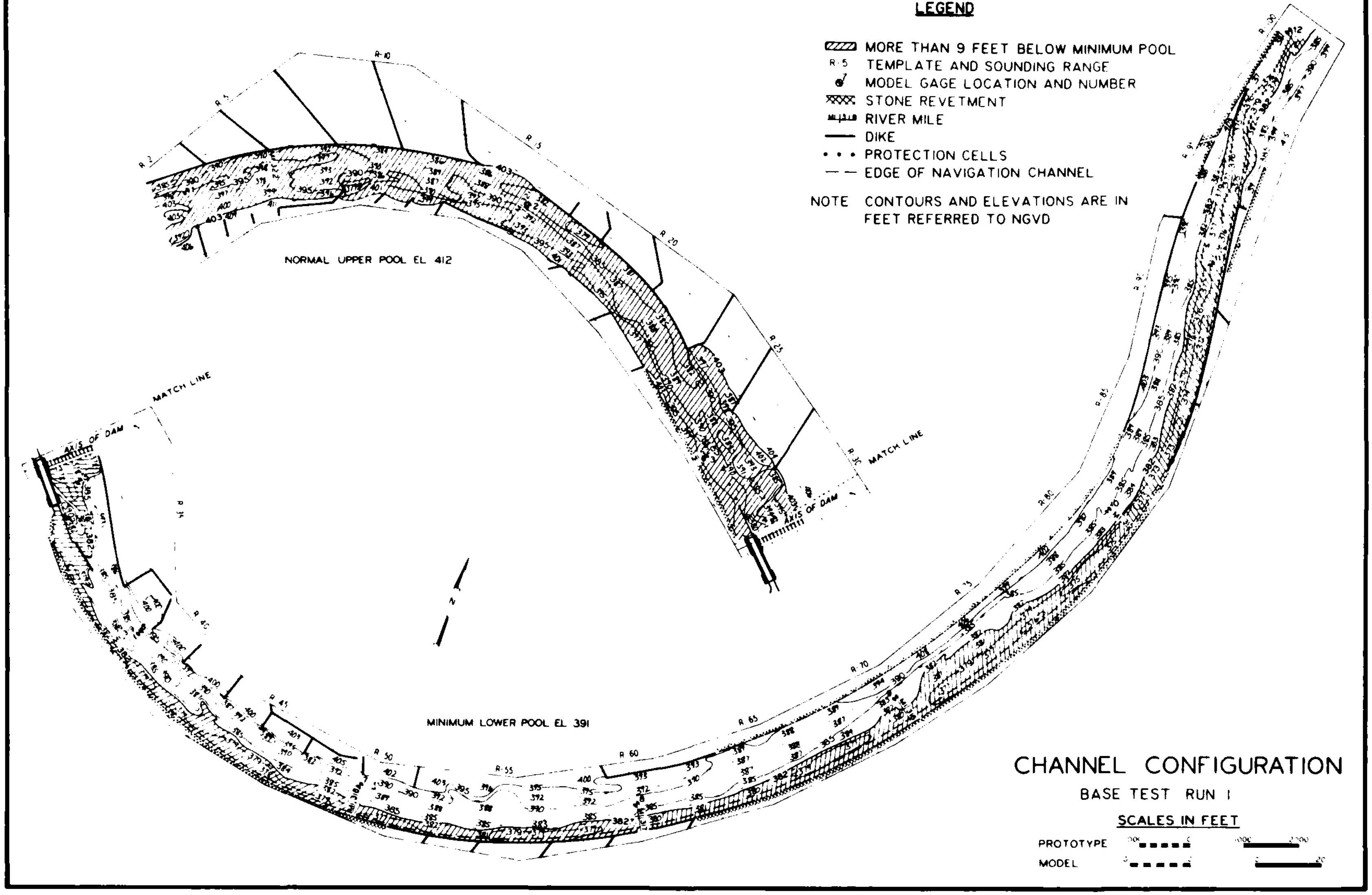

LEGEND
BASE TEST (EXISTING CONDITIONS)
PLANS A, B, AND C
PLAN B
PLAN C
NOTE: ALL ELEVATIONS IN FEET REFERRED TO NGVD
EXTENSIONS TO DIKES FOR PLANS B AND C SLOPED TO 10 FEET BELOW ELEVATIONS FOR PLAN A.
DIKE WIDTHS ARE DISTORTED
PLAN A - EL 388
PLANS B AND C - EL 390
BASE TEST AND PLAN A - EL 393
PLANS B AND C - EL 395
AXIS OF DAM
R-35
R-40
R-45
R-50
R-55
R-60
R-65
R-70
MI 316
MI 317
MI 318
MI 319
N
BASE TEST AND
PLANS A, B, AND C
SCALES
PROTOTYPE
1000 0 1000 2000
MODEL
10 0 10 20

PLATE 6



CHANNEL CONFIGURATION

BASE TEST RUN 1

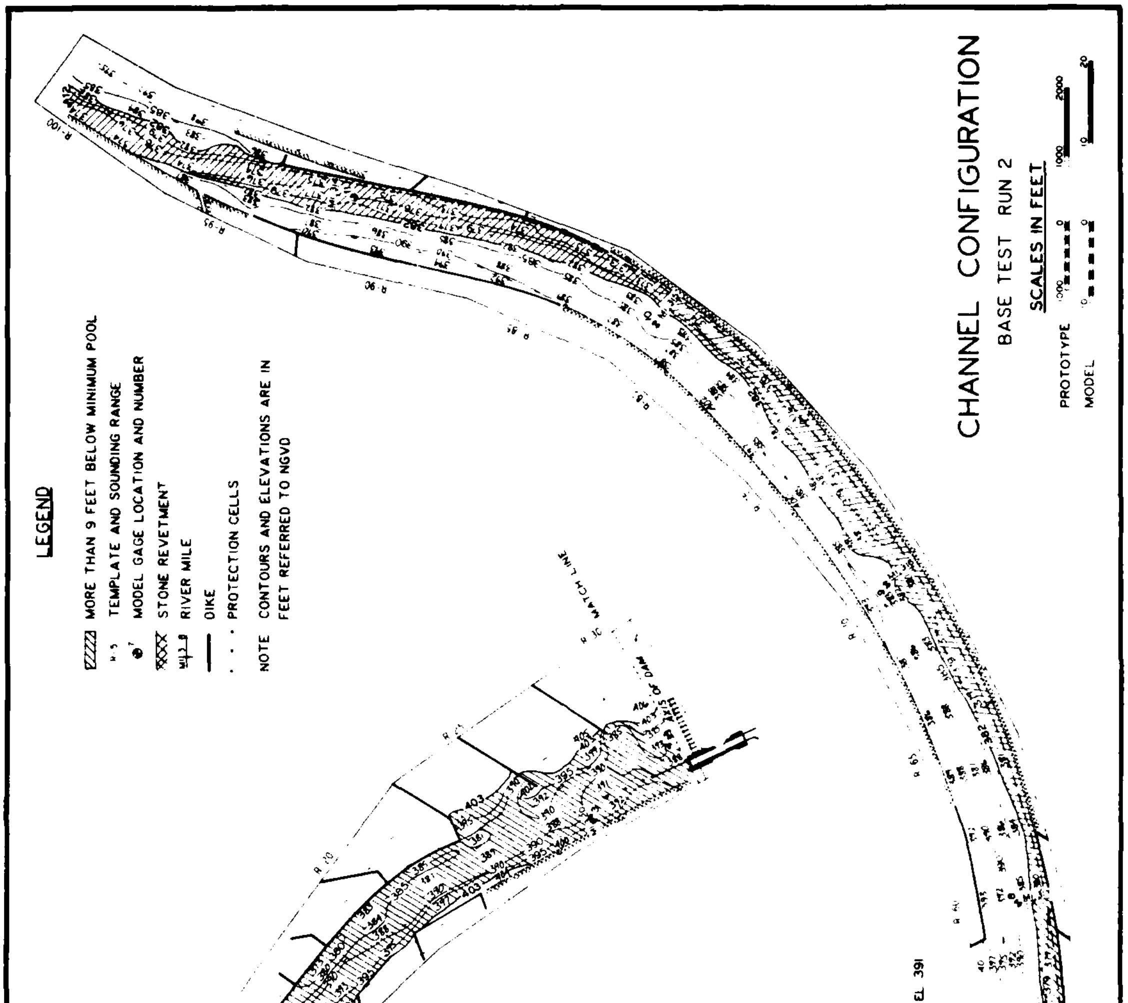
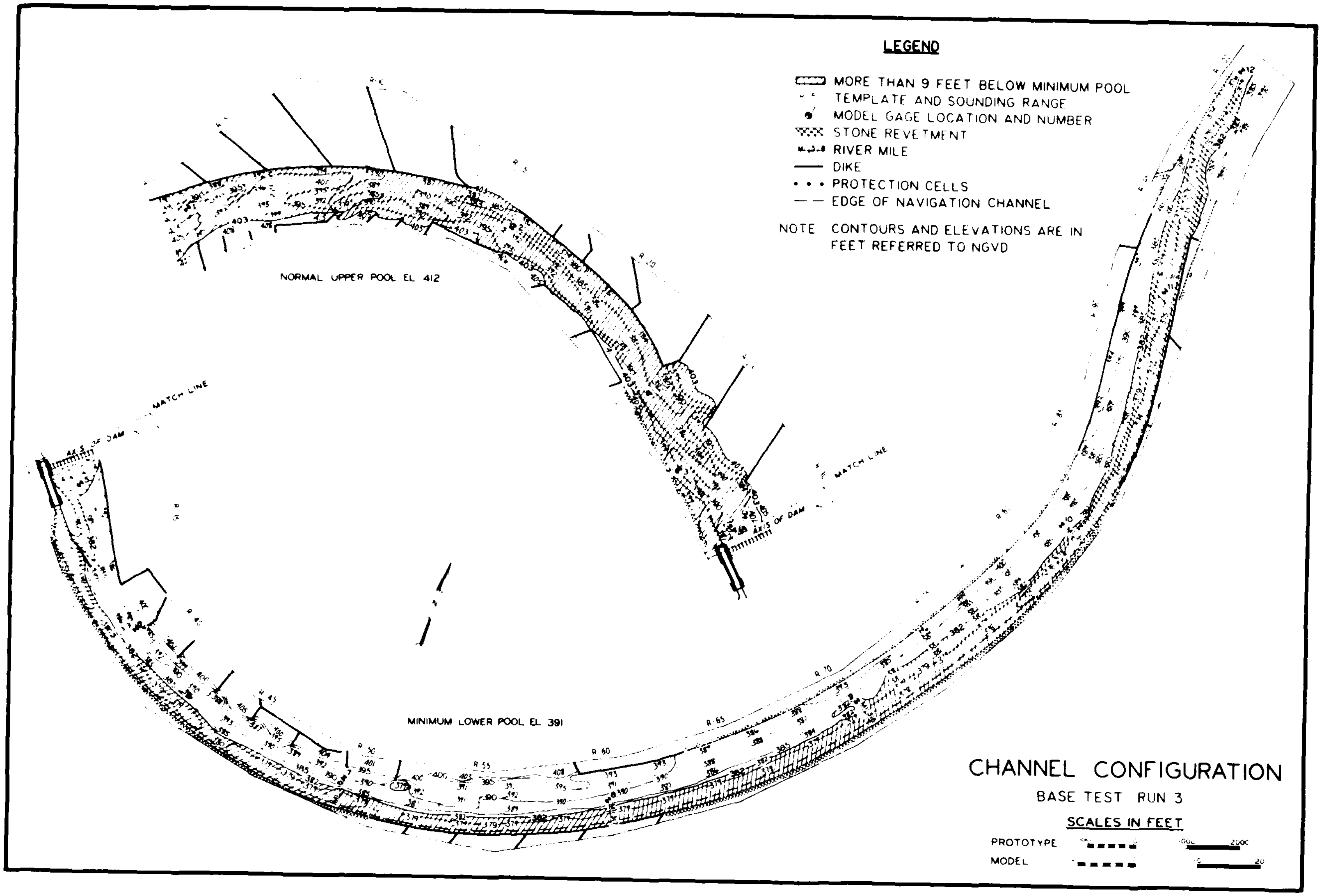
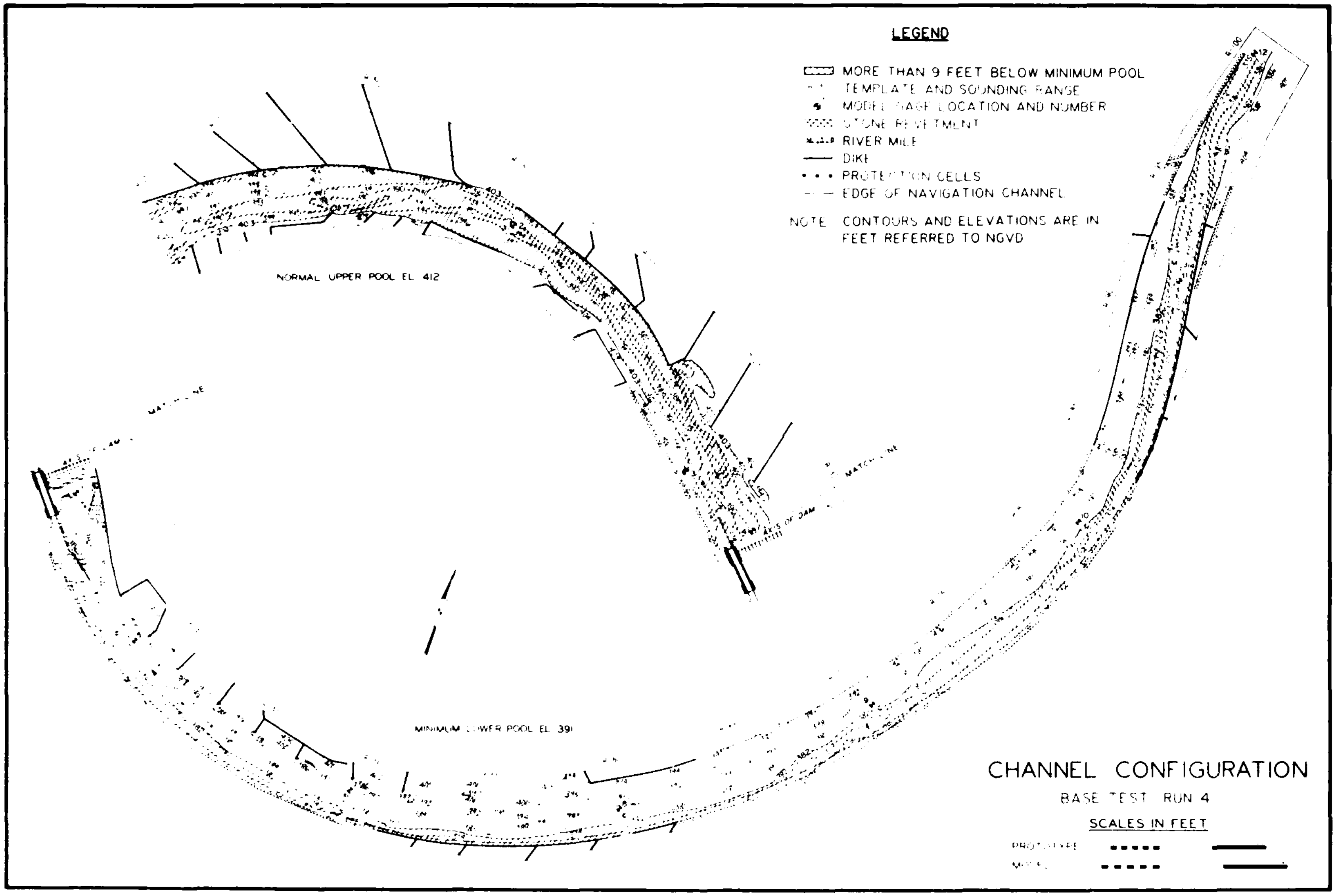

LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
CHANNEL CONFIGURATION
BASE TEST RUN 2
SCALES IN FEET
PROTOTYPE
MODEL
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE

PLATE 8


LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE
AXIS OF DAM
MATCH LINE
AXIS OF DAM
CHANNEL CONFIGURATION
BASE TEST RUN 3
SCALES IN FEET
PROTOTYPE
MODEL



CHANNEL CONFIGURATION

BASE TEST RUN 4

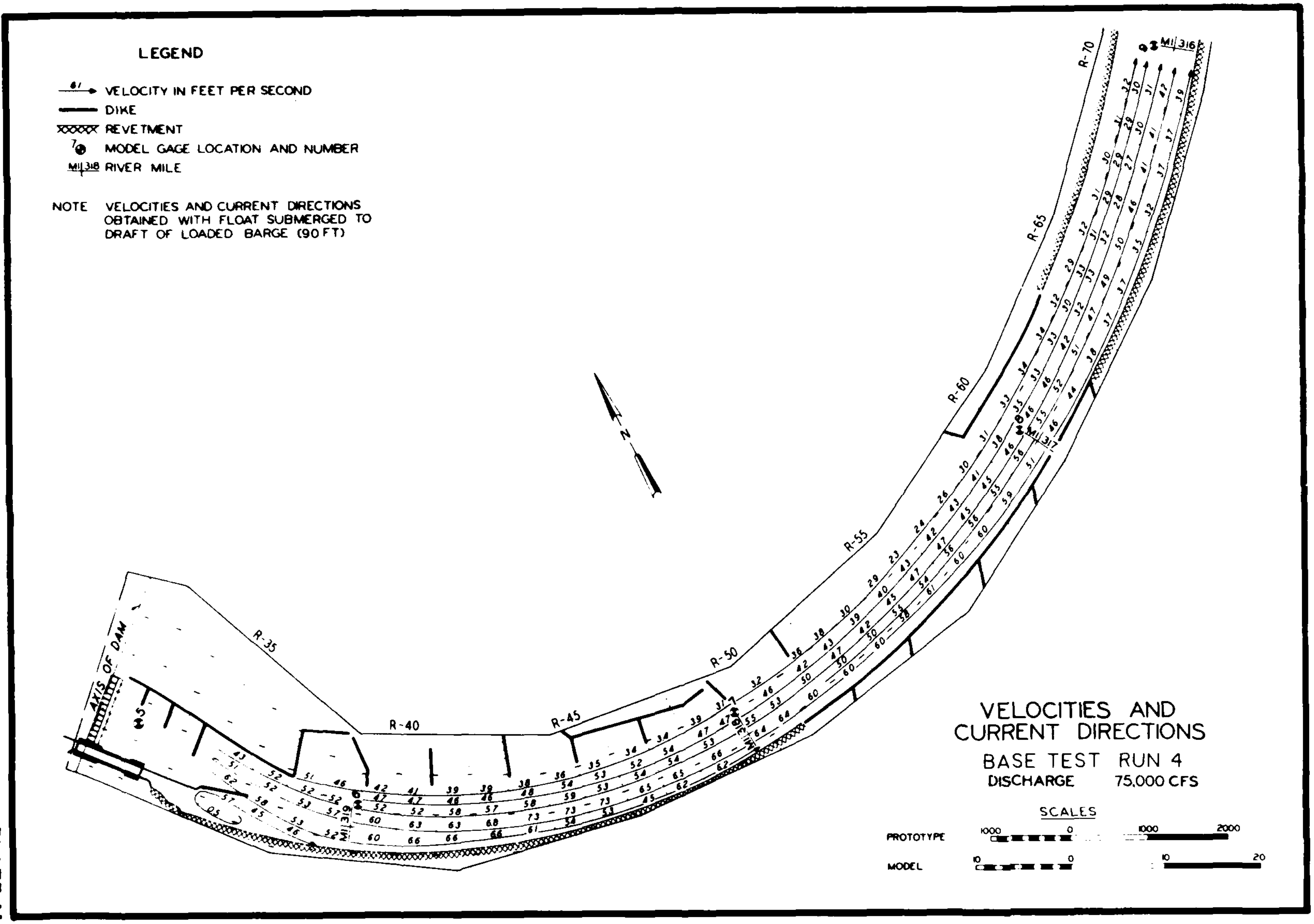
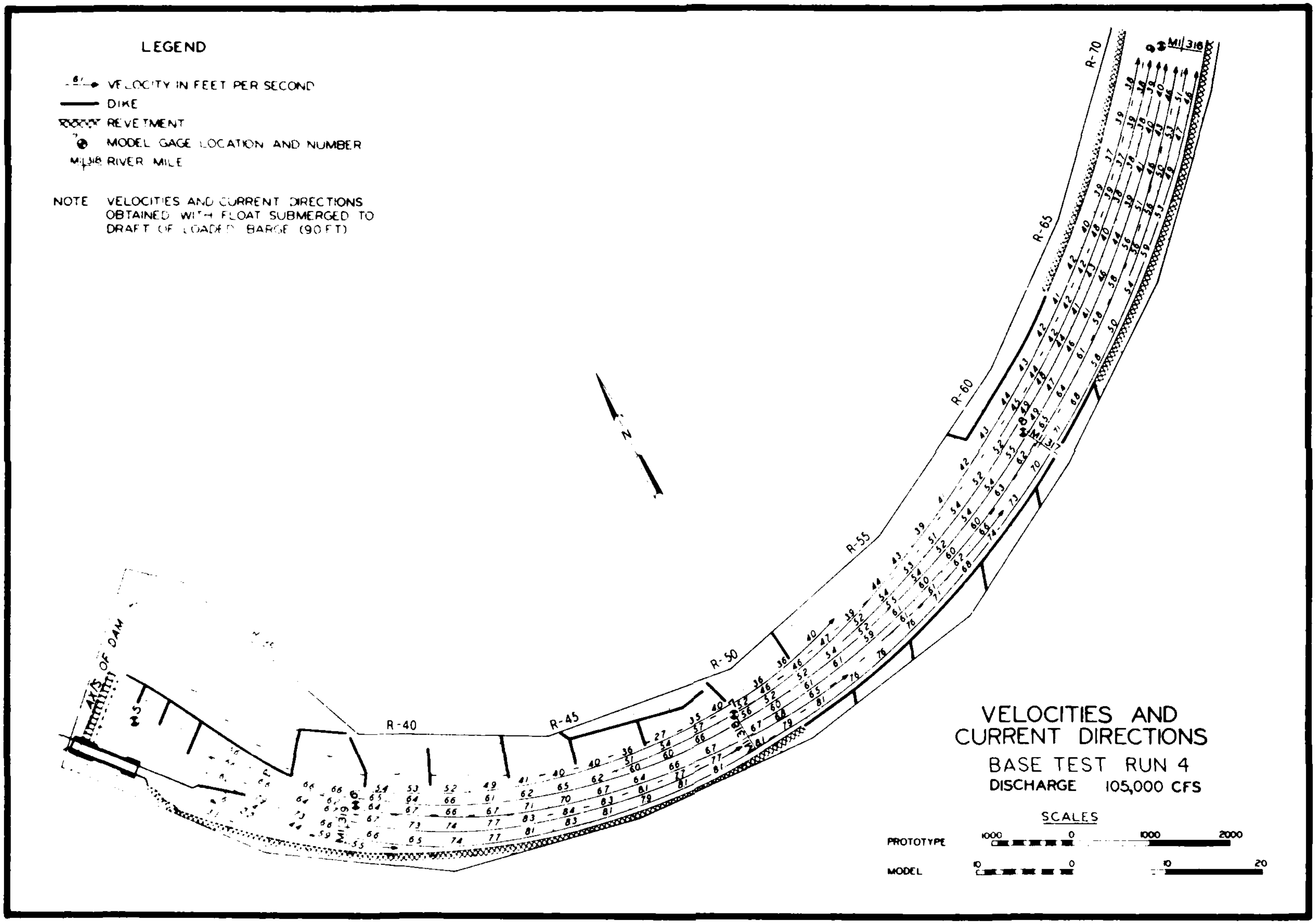
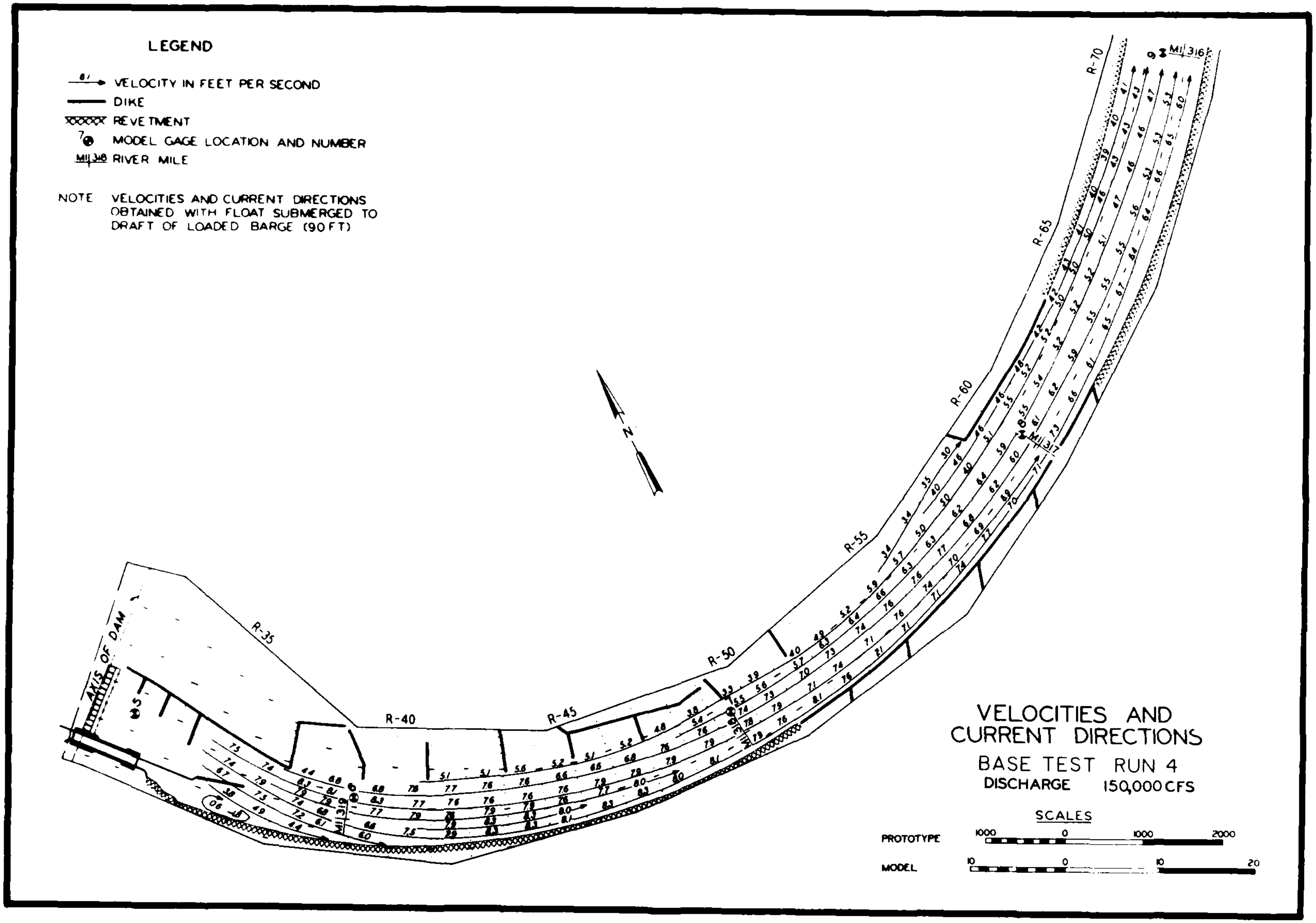
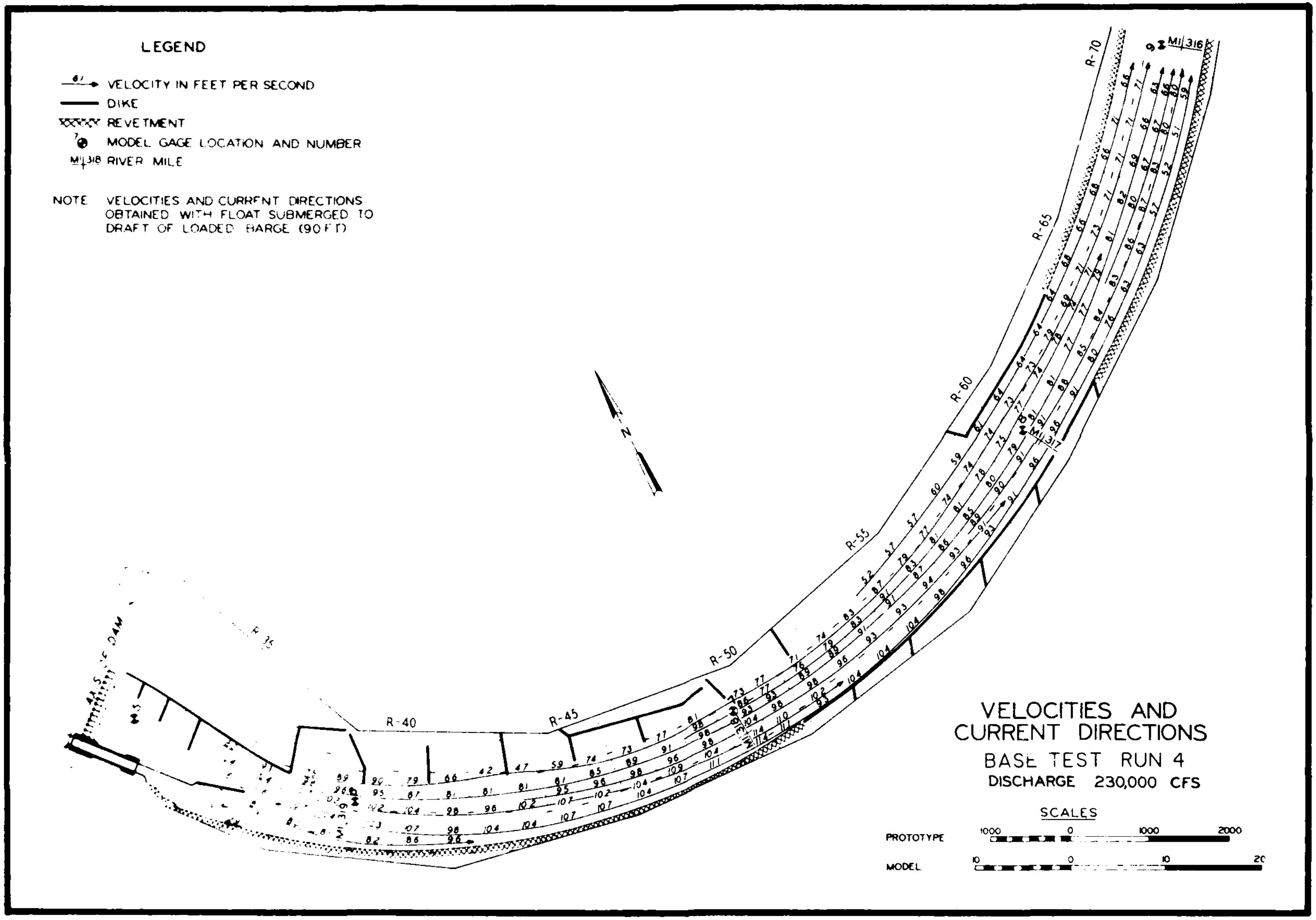
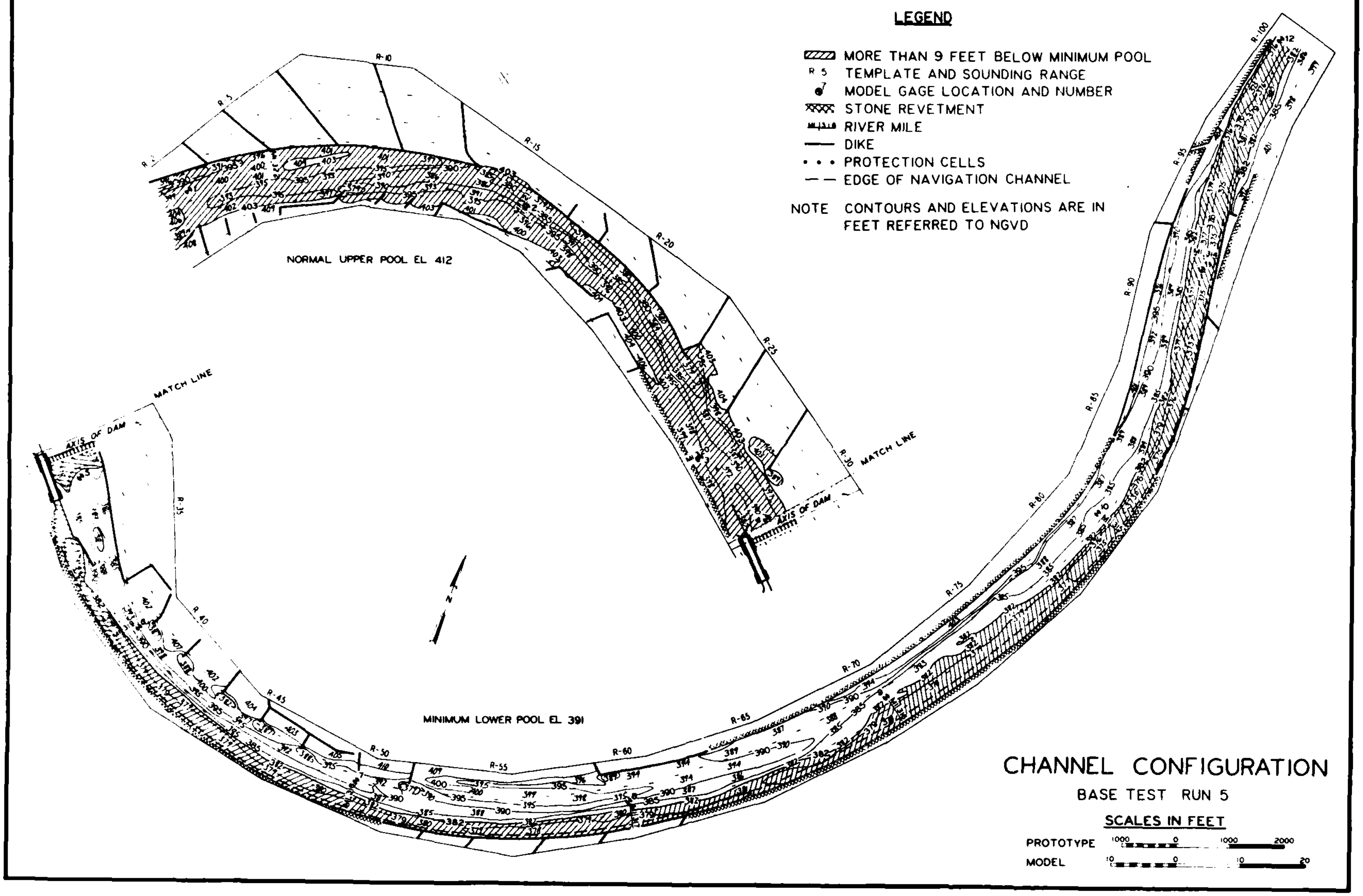

LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
MI 318 RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (90 FT)
AXIS OF DAM
R-35
R-40
R-45
R-50
R-55
R-60
R-65
R-70
MI 316
N
VELOCITIES AND CURRENT DIRECTIONS
BASE TEST RUN 4
DISCHARGE 75,000 CFS
SCALES
PROTOTYPE
MODEL
1000
0
1000
2000
10
0
10
20

PLATE 11


LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
R-70
R-65
R-60
R-55
R-50
R-45
R-40
AXIS OF DAM
N
MI 318
MI 317
MI 316
MI 319
VELOCITIES AND CURRENT DIRECTIONS
BASE TEST RUN 4
DISCHARGE 105,000 CFS
SCALES
PROTOTYPE
MODEL


LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (90 FT)
R-35
R-40
R-45
R-50
R-55
R-60
R-65
R-70
AXIS OF DAM
MI 316
N
VELOCITIES AND CURRENT DIRECTIONS
BASE TEST RUN 4
DISCHARGE 150,000 CFS
SCALES
PROTOTYPE
MODEL

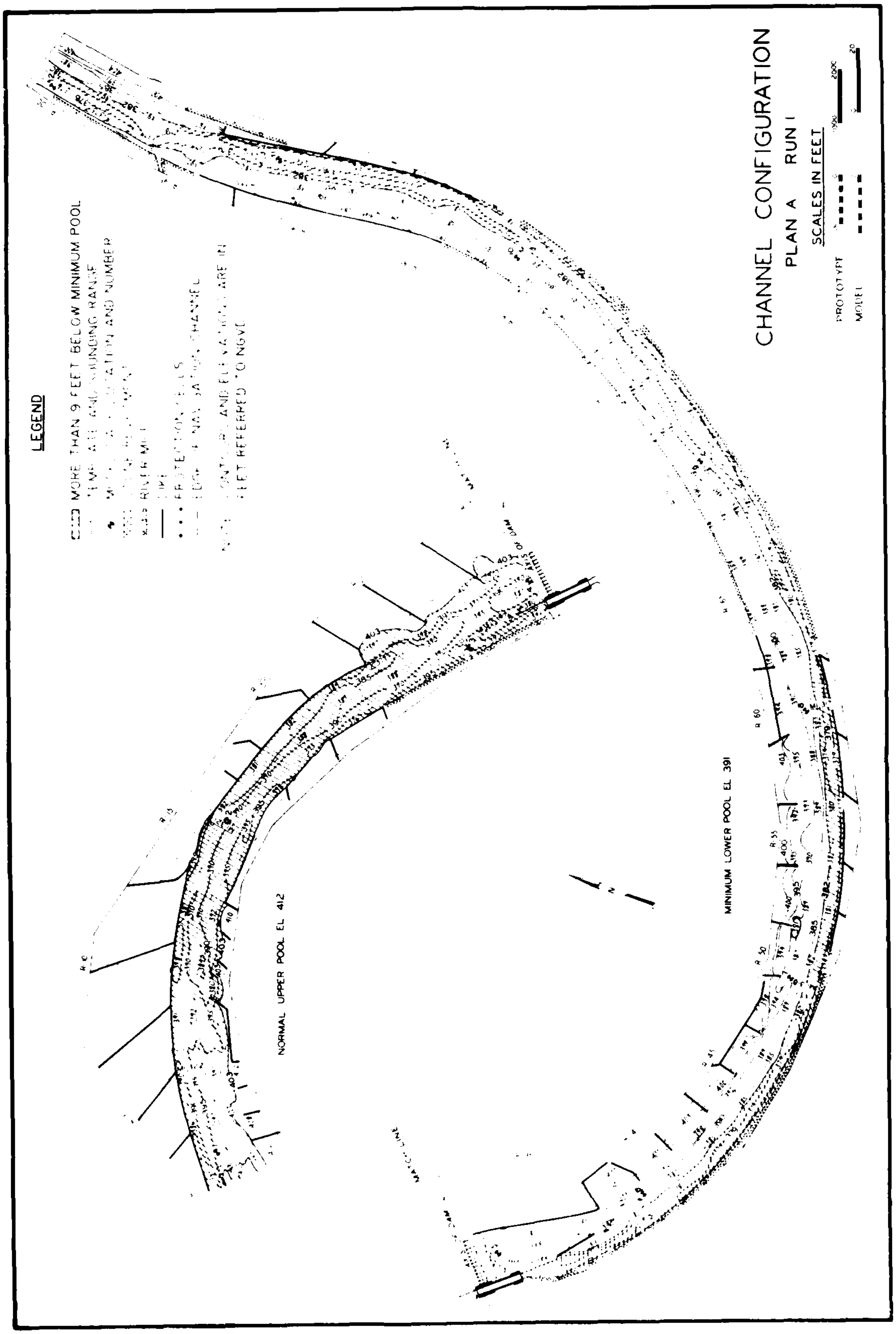

LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
MI 318 RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
R-40
R-45
R-50
R-55
R-60
R-65
R-70
MI 316
MI 317
N
VELOCITIES AND CURRENT DIRECTIONS
BASE TEST RUN 4
DISCHARGE 230,000 CFS
SCALES
PROTOTYPE
MODEL
1000 0 1000 2000
10 0 10 20

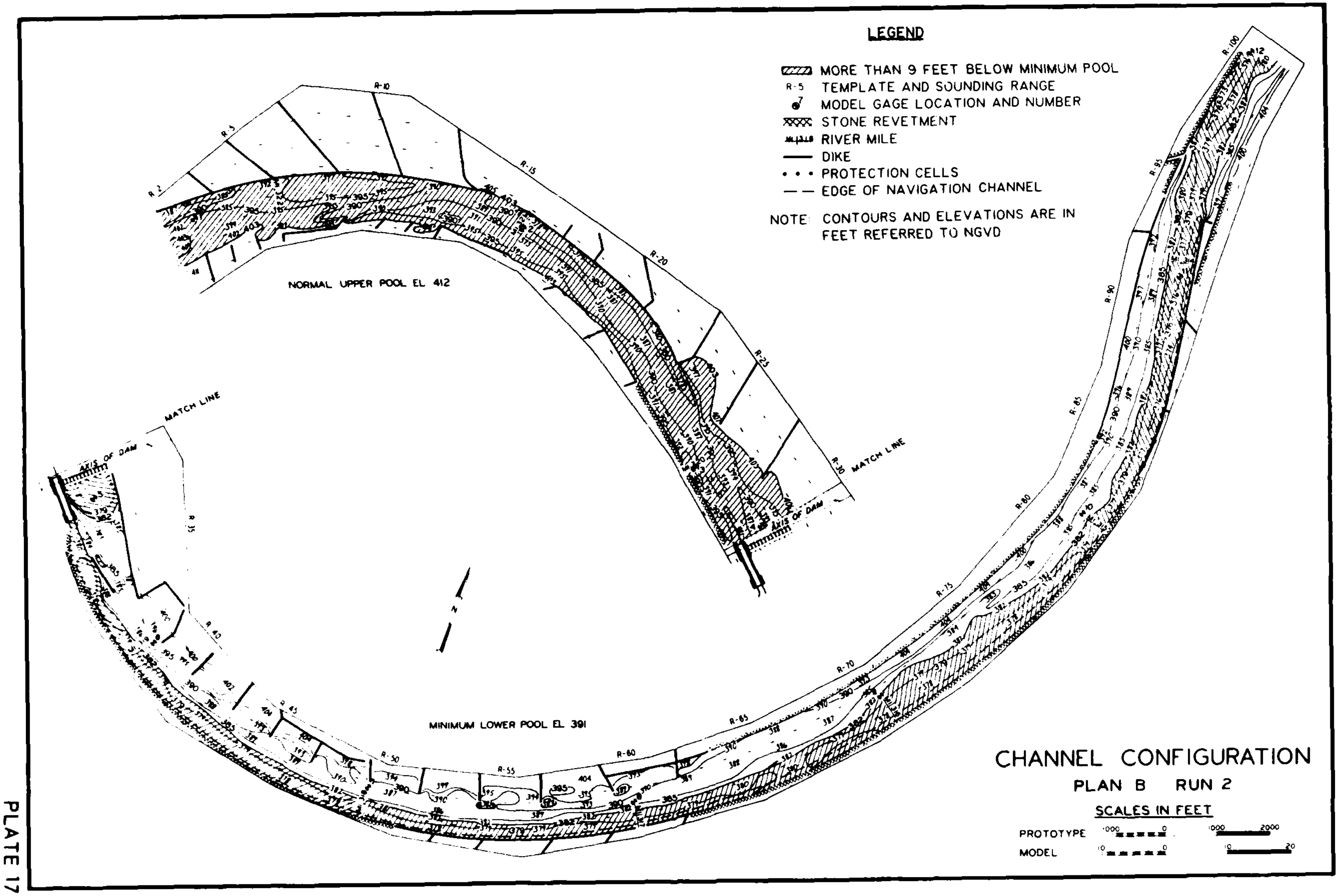


CHANNEL CONFIGURATION

BASE TEST RUN 5

PLATE 15


CHANNEL CONFIGURATION
PLAN A RUN I
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
RIVER MILE
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391


LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE
AXIS OF DAM
R-5
R-10
R-15
R-20
R-25
R-30
R-35
R-40
R-45
R-50
R-55
R-60
R-65
R-70
R-75
R-80
R-85
R-90
R-95
R-100
CHANNEL CONFIGURATION
PLAN B RUN 2
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 10 0 10 20

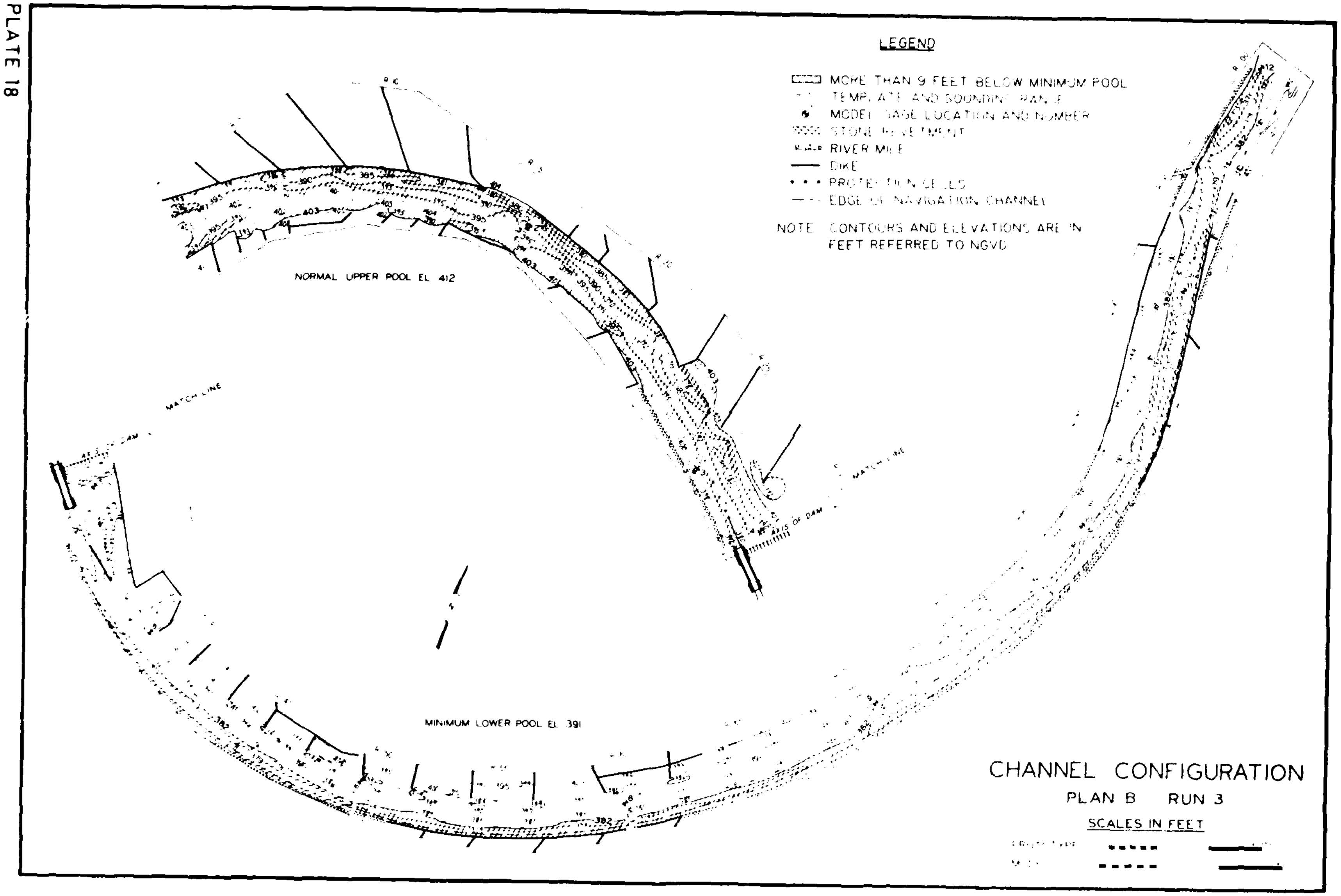
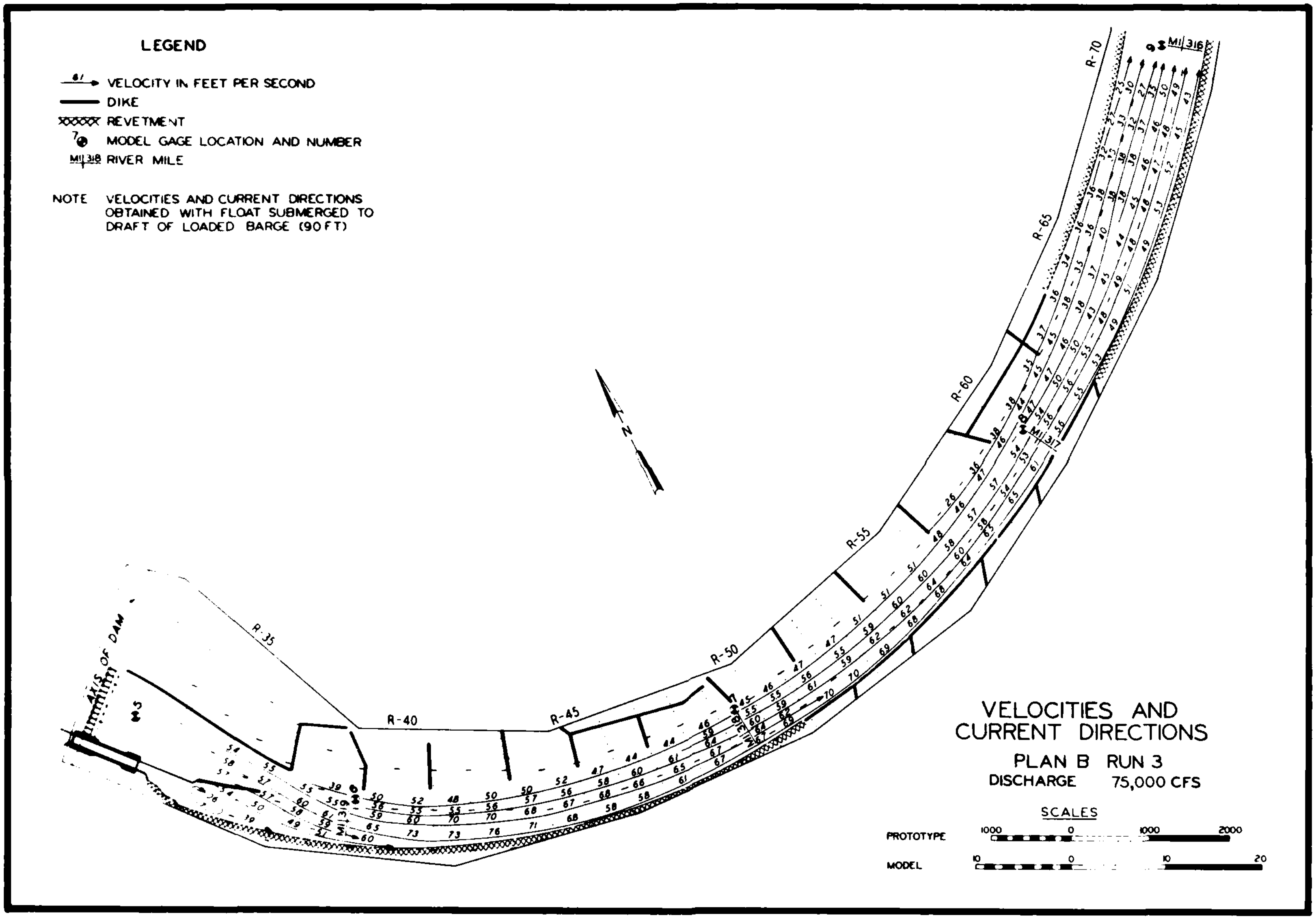

LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
MODEL GAGE LOCATION AND NUMBER
RIVER MILE
DIKE
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE
AXIS OF DAM
CHANNEL CONFIGURATION
PLAN B RUN 3
SCALES IN FEET

PLATE 18



LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
MI 318 RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (90 FT)
VELOCITIES AND CURRENT DIRECTIONS
PLAN B RUN 3
DISCHARGE 75,000 CFS
SCALES
PROTOTYPE
MODEL
AXIS OF DAM
R-35
R-40
R-45
R-50
R-55
R-60
R-65
R-70
MI 316
MI 317
MI 318
N

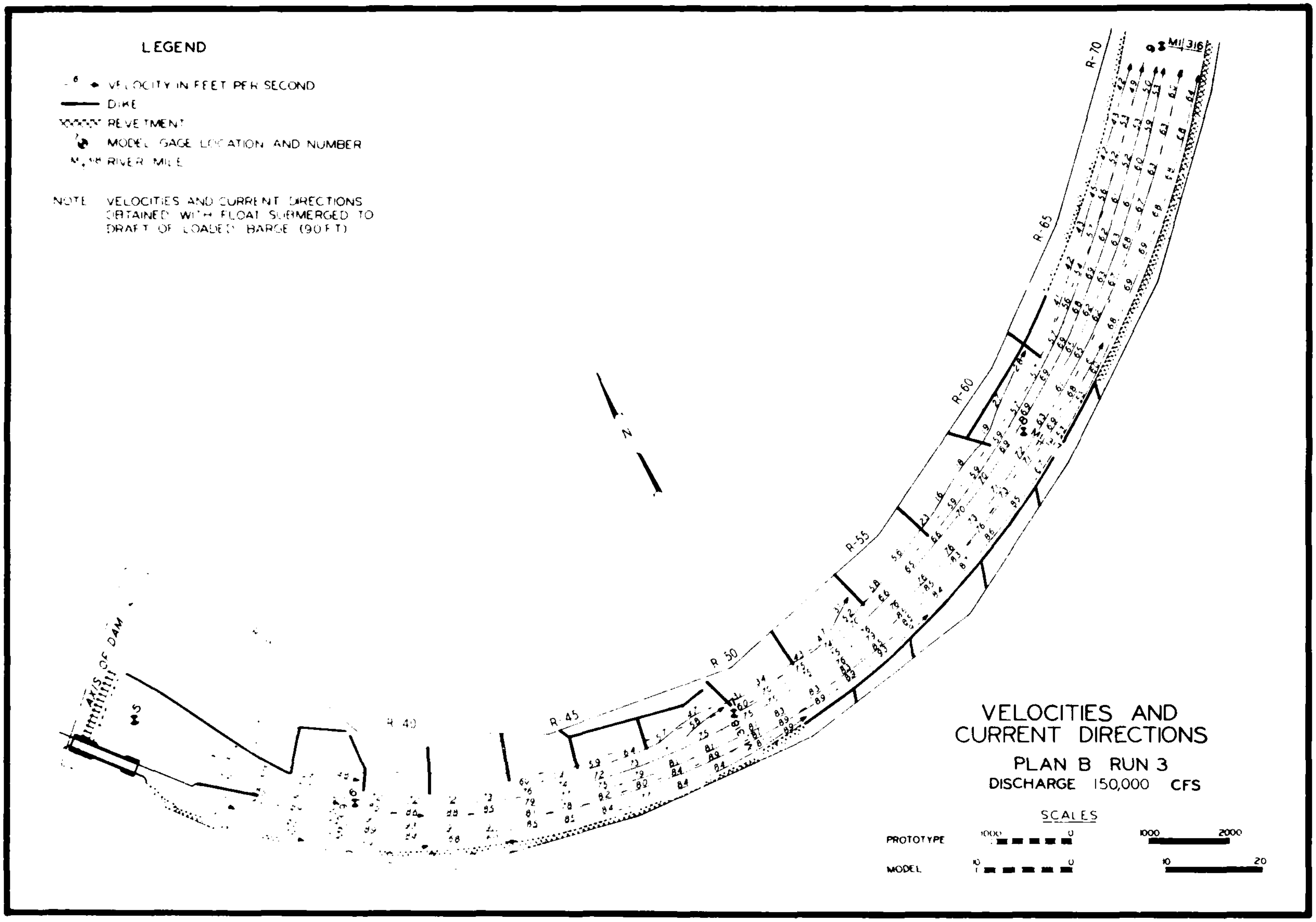
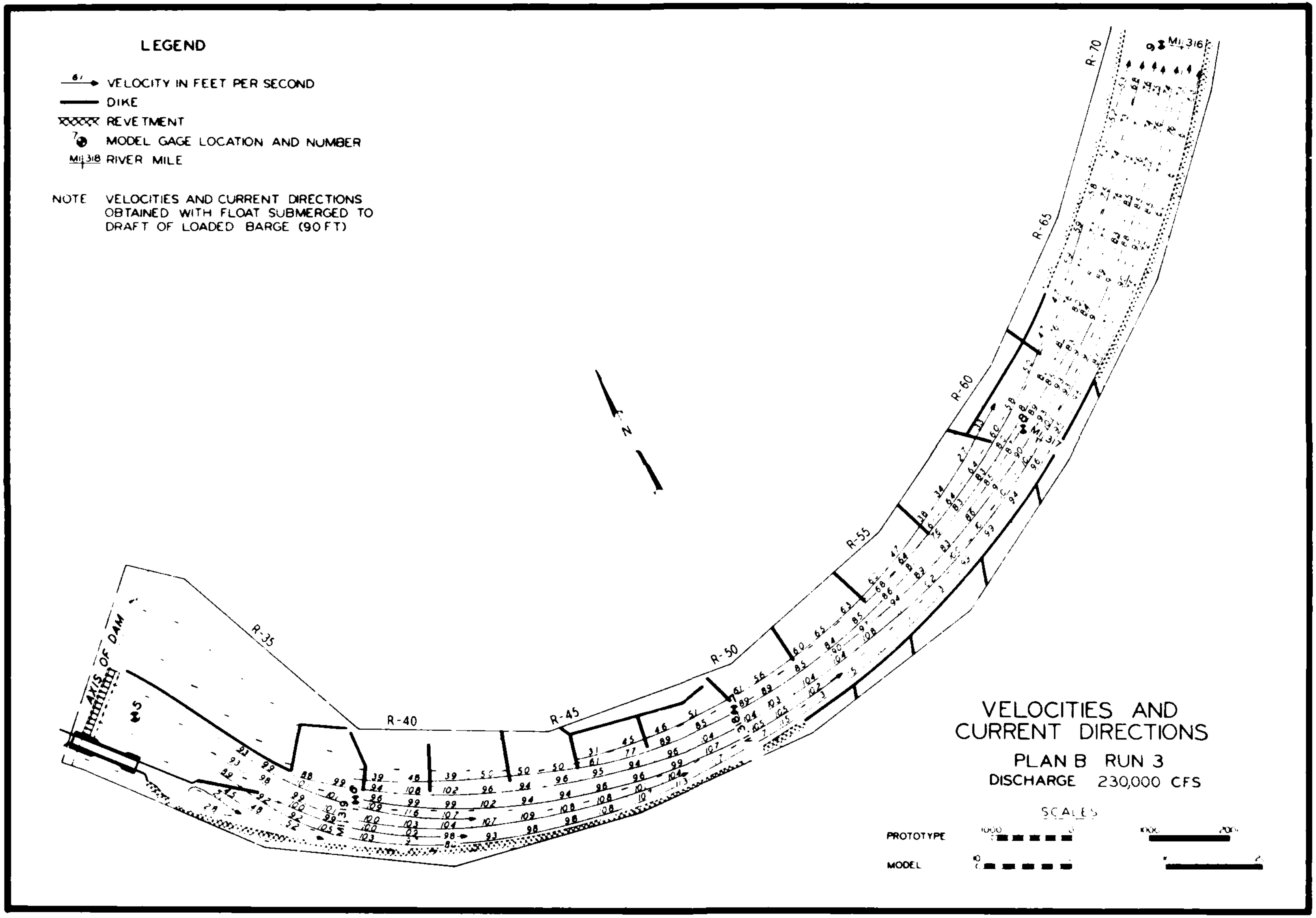
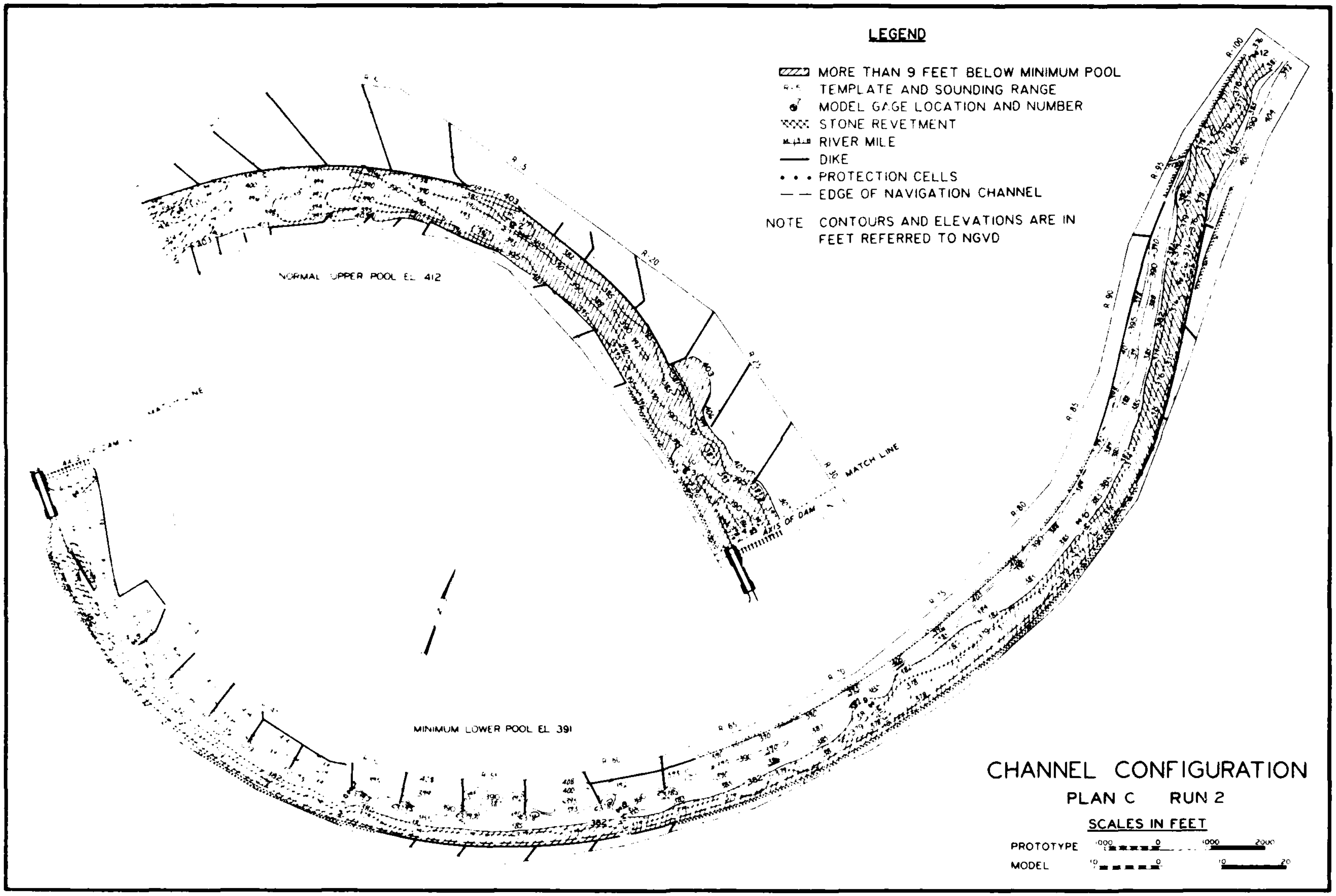
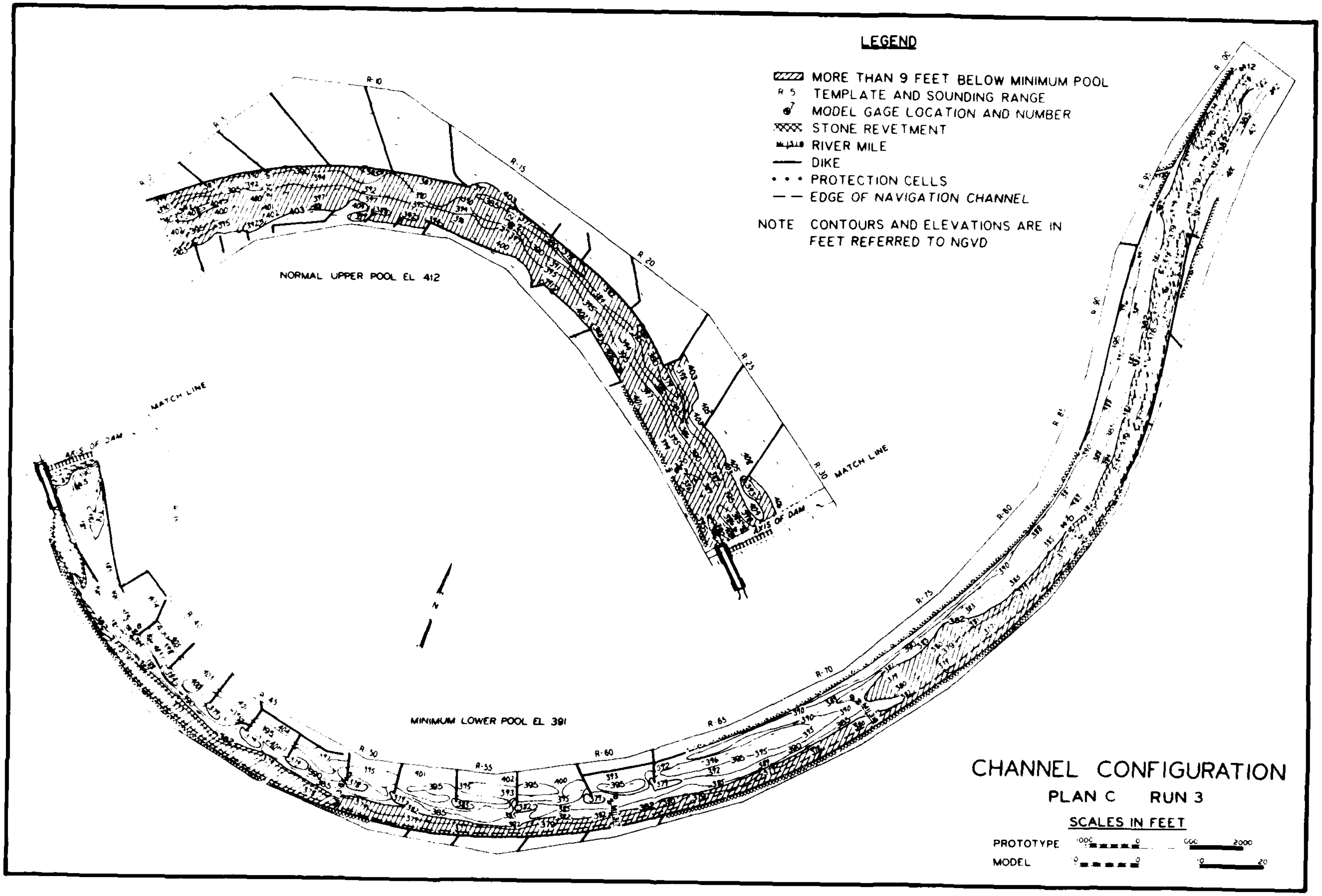

LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
N
AXIS OF DAM
R-70
R-65
R-60
R-55
R 50
R 45
R 40
MI 316
VELOCITIES AND CURRENT DIRECTIONS
PLAN B RUN 3
DISCHARGE 150,000 CFS
SCALES
PROTOTYPE
1000
0
1000
2000
MODEL
10
0
10
20

PLATE 20


LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
MI 318 RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (90 FT)
R-35
R-40
R-45
R-50
R-55
R-60
R-65
R-70
AXIS OF DAM
MI 316
MI 317
MI 319
N
VELOCITIES AND CURRENT DIRECTIONS
PLAN B RUN 3
DISCHARGE 230,000 CFS
SCALES
PROTOTYPE
MODEL


LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE
AXIS OF DAM
CHANNEL CONFIGURATION
PLAN C RUN 2
SCALES IN FEET
PROTOTYPE
MODEL



CHANNEL CONFIGURATION
PLAN C RUN 3
SCALES IN FEET

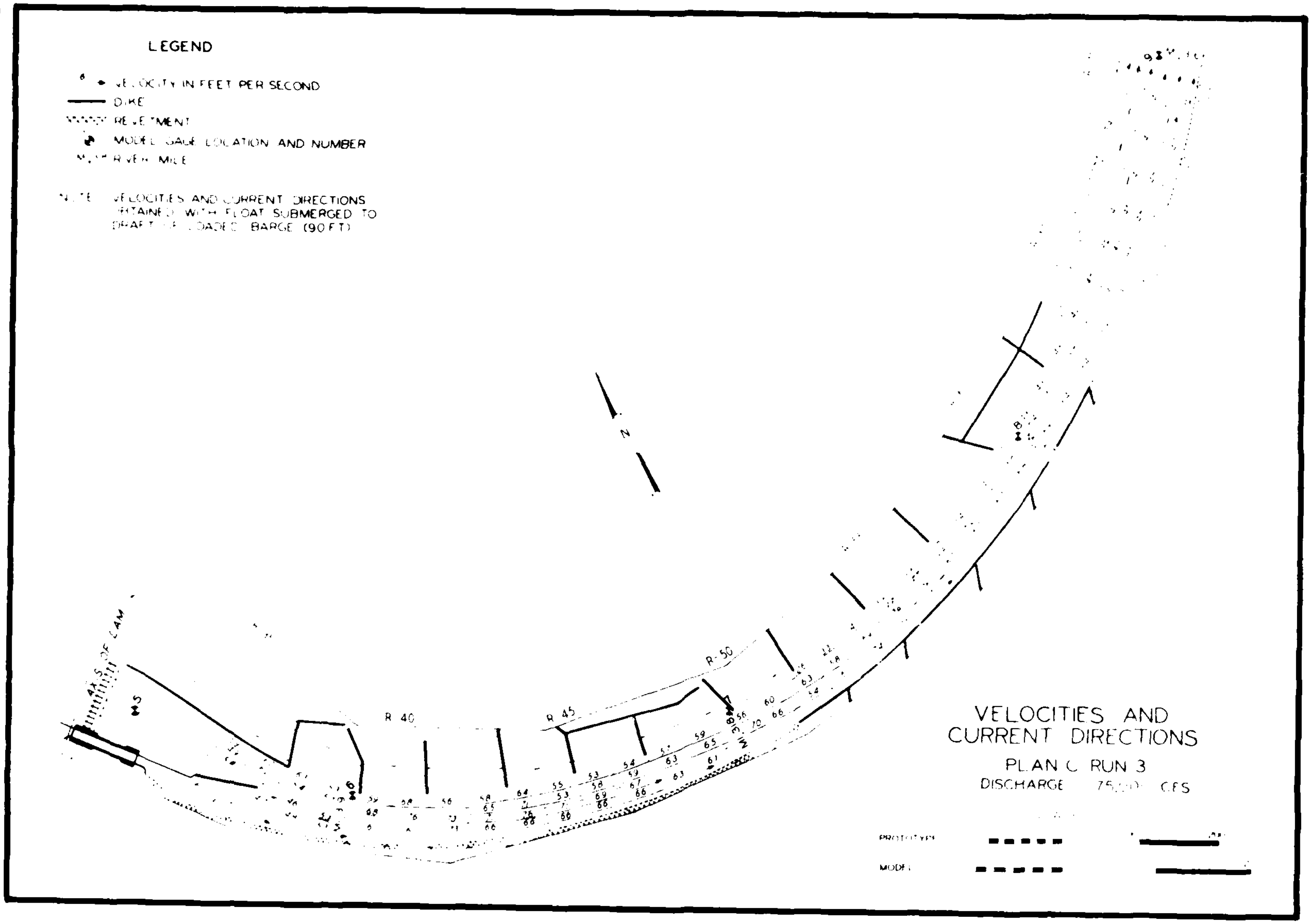
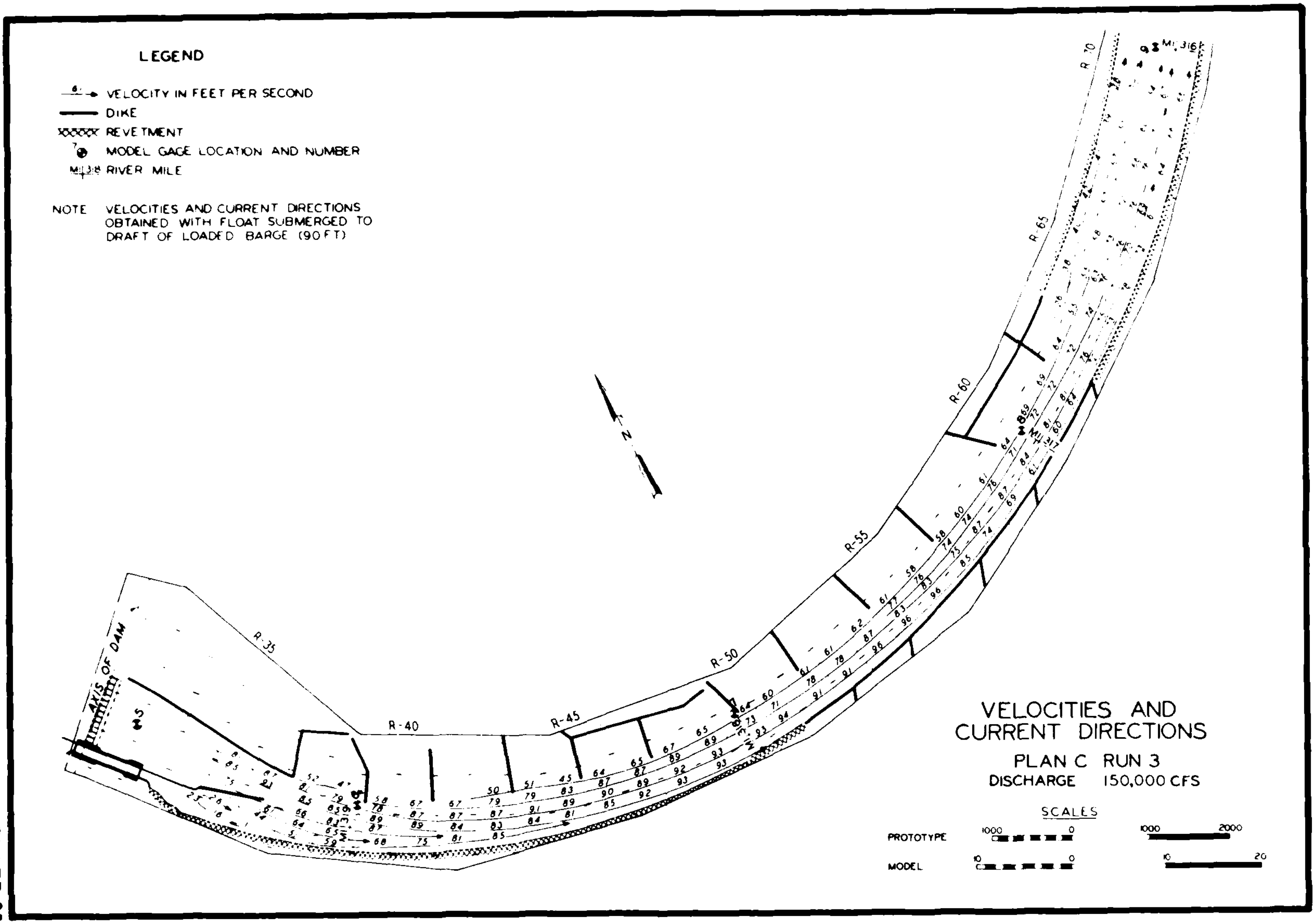

LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS
OBTAINED WITH FLOAT SUBMERGED TO
DRAFT OF LOADED BARGE (9.0 FT)
R 40
R 45
R-50
VELOCITIES AND
CURRENT DIRECTIONS
PLAN C RUN 3
DISCHARGE 75,000 CFS
PROTOTYPE
MODEL

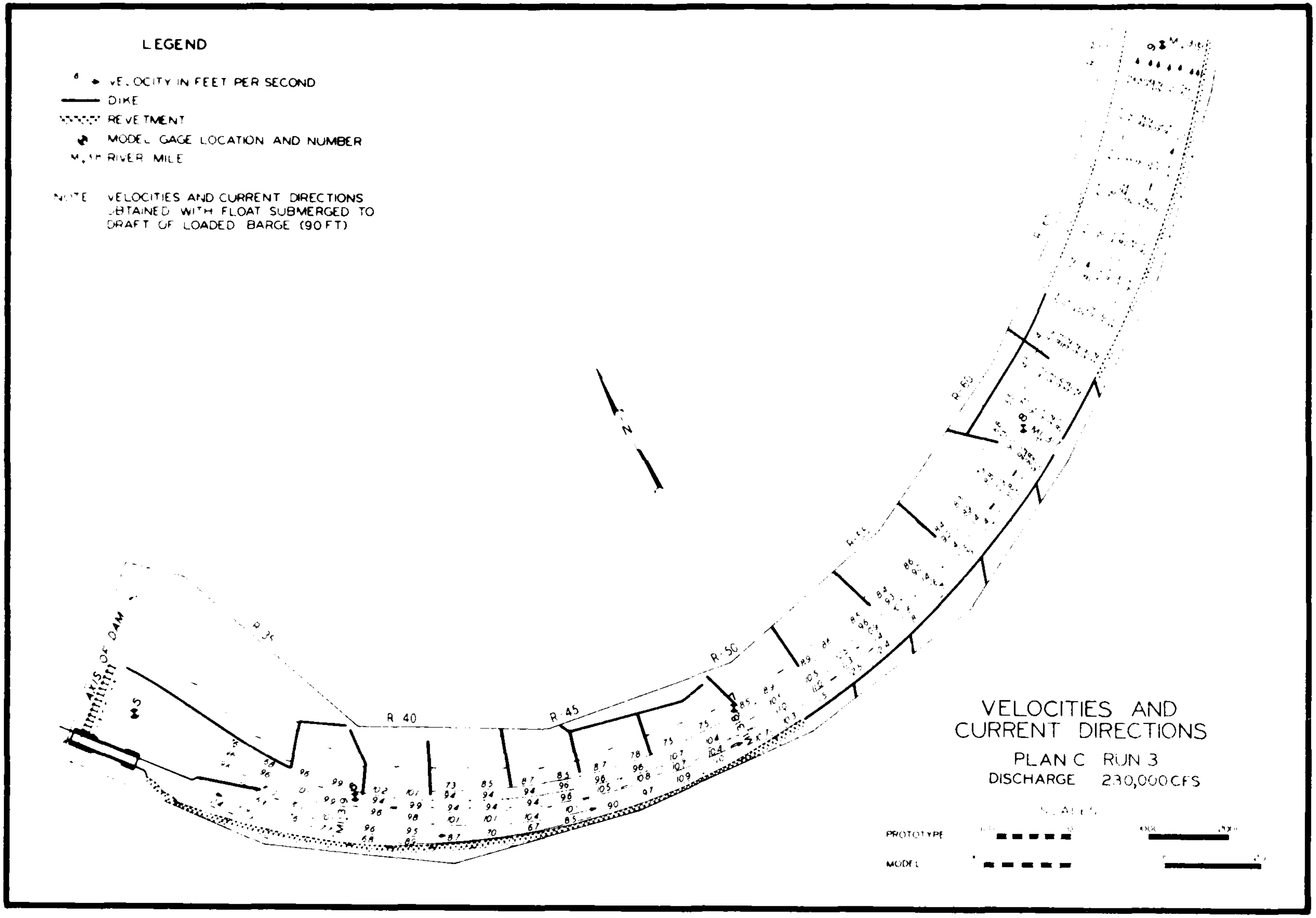
PLATE 24



VELOCITIES AND CURRENT DIRECTIONS

PLAN C RUN 3

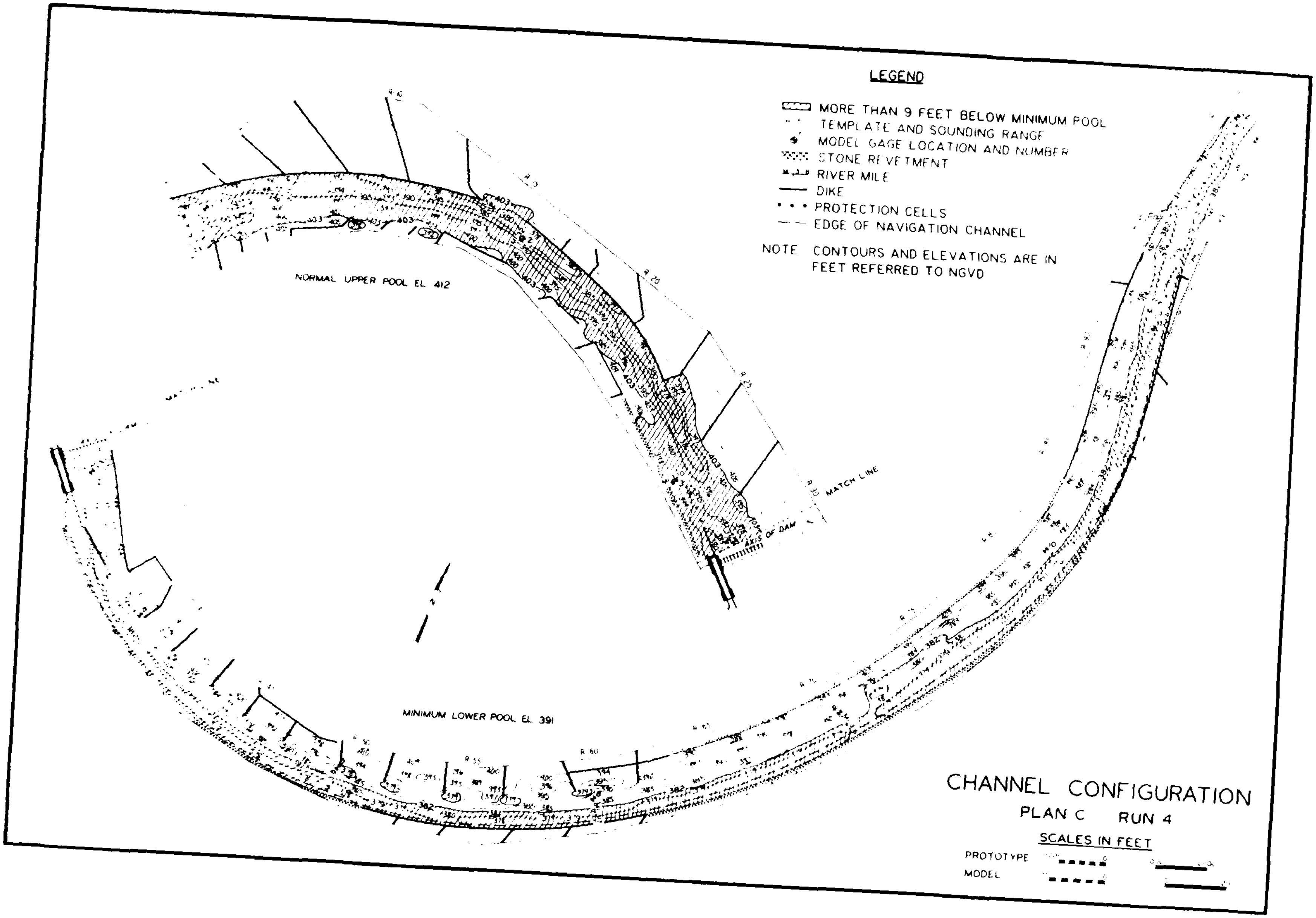
DISCHARGE 150,000 CFS



VELOCITIES AND CURRENT DIRECTIONS

PLAN C RUN 3

DISCHARGE 230,000 CFS



CHANNEL CONFIGURATION
PLAN C RUN 4

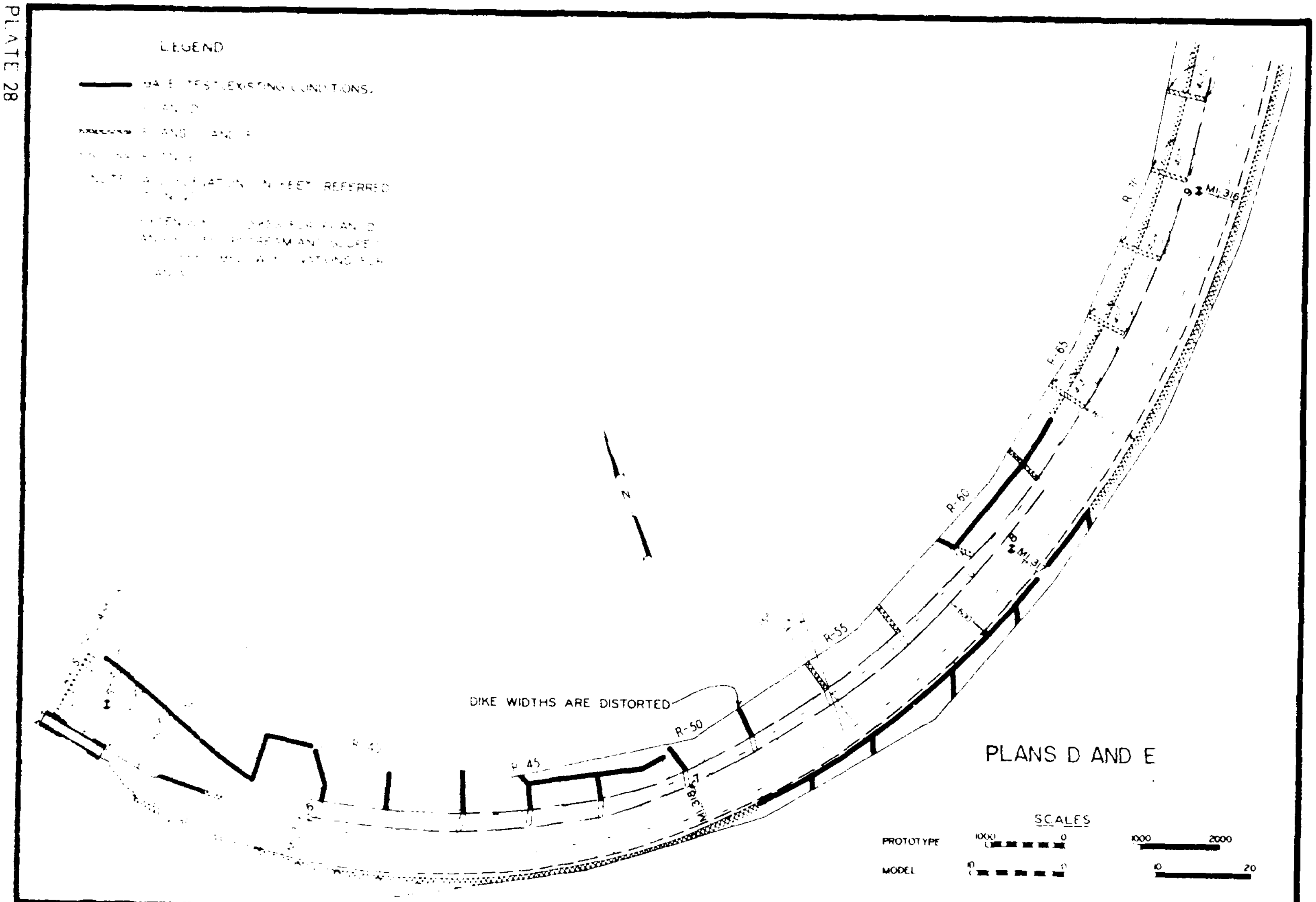
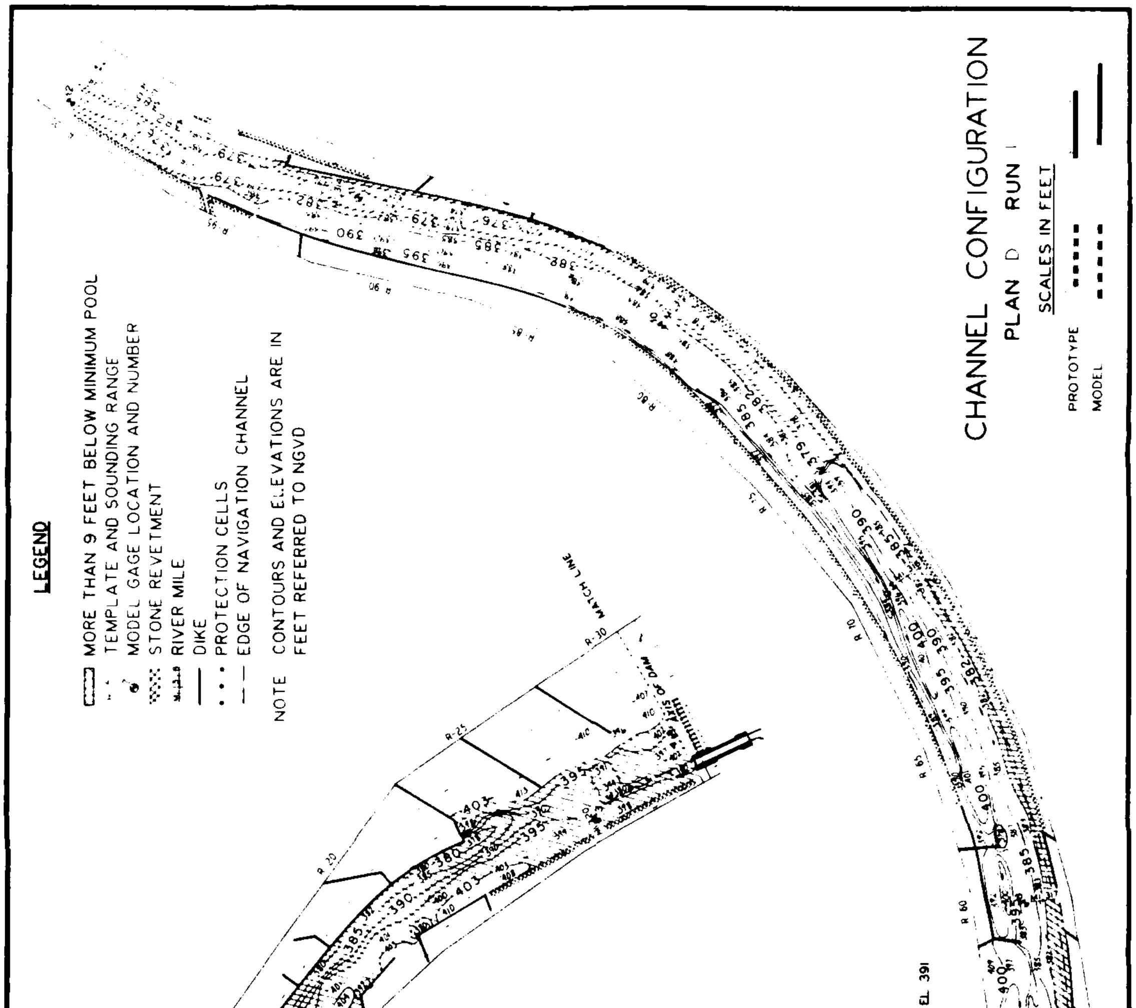

LEGEND
BASE TEST (EXISTING CONDITIONS)
DIKE WIDTHS ARE DISTORTED
R-45
R-50
R-55
R-60
R-65
MI 316
MI 31
PLANS D AND E
SCALES
PROTOTYPE
MODEL
1000
0
2000
10
20

PLATE 28


CHANNEL CONFIGURATION
PLAN D RUN 1
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE
AXIS OF DAM

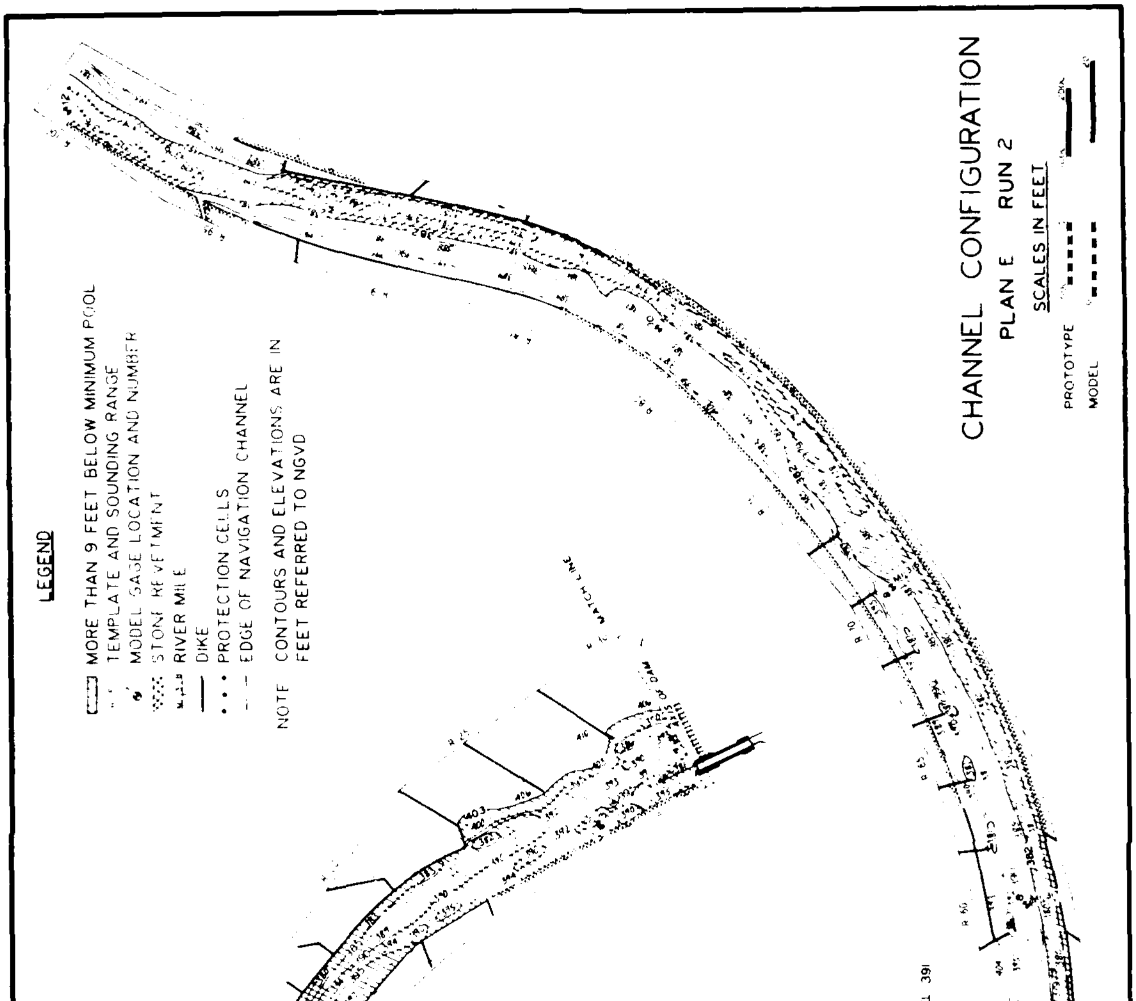
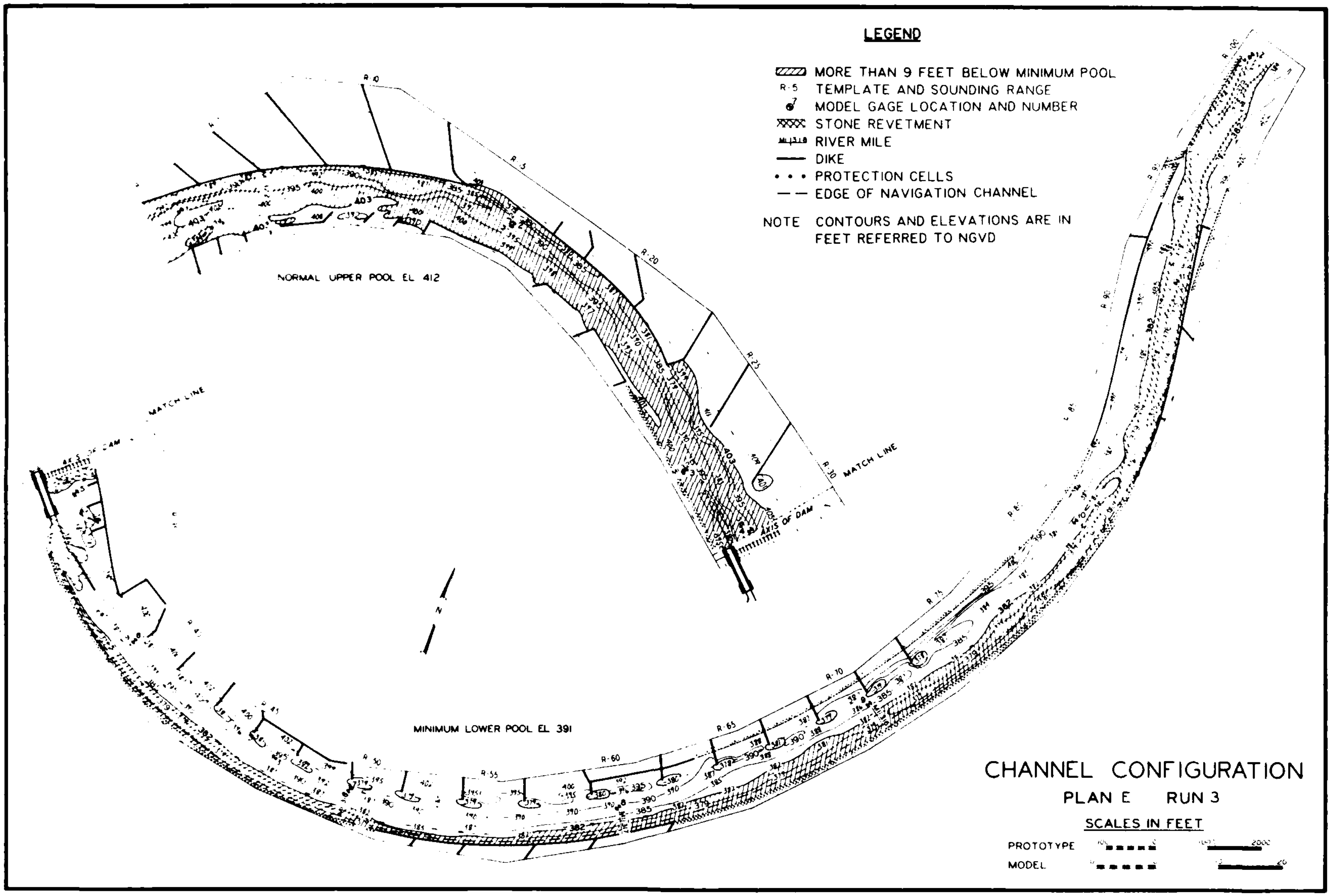

CHANNEL CONFIGURATION
PLAN E RUN 2
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
MATCH LINE
MINIMUM LOWER POOL EL 391
NORMAL UPPER POOL EL 412

PLATE 30



CHANNEL CONFIGURATION

PLAN E RUN 3

SCALES IN FEET

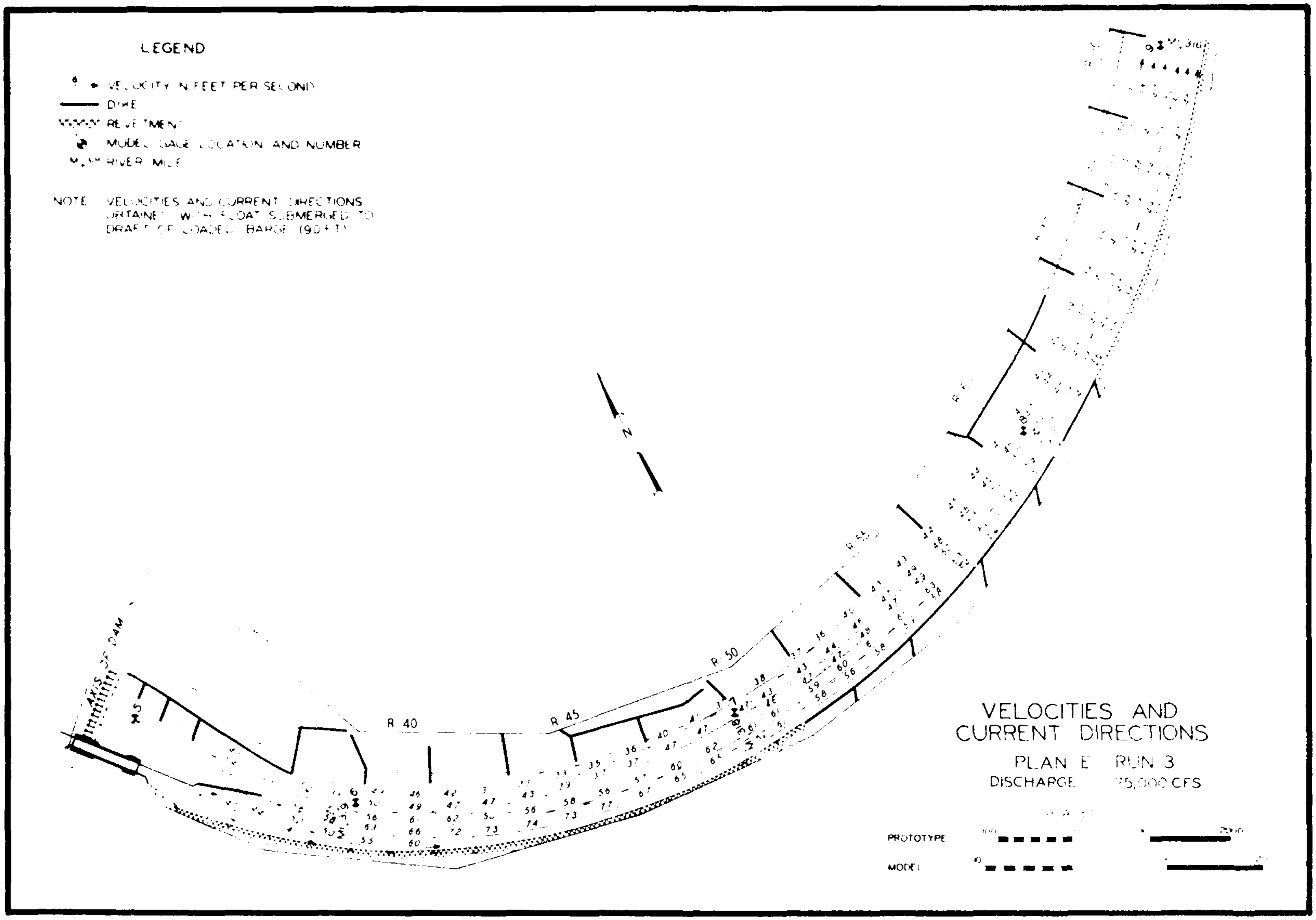
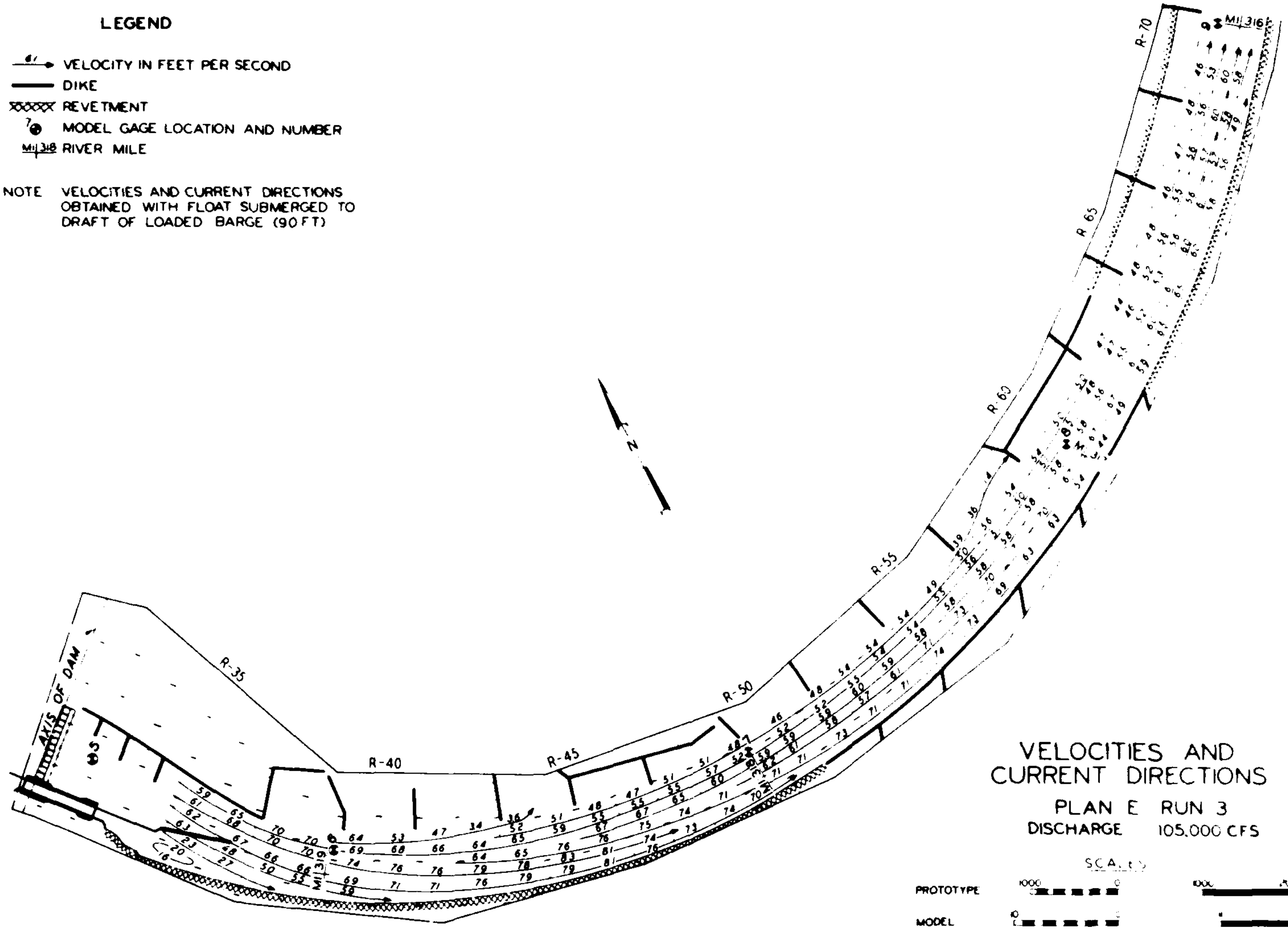

LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
AXIS OF DAM
R 40
R 45
R 50
N
VELOCITIES AND CURRENT DIRECTIONS
PLAN E RUN 3
DISCHARGE 75,000 CFS
PROTOTYPE
MODEL

PLATE 32



LEGEND

- VELOCITY IN FEET PER SECOND
- DIKE
- REVETMENT
- MODEL GAGE LOCATION AND NUMBER
- MI 318 RIVER MILE

NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (90 FT)

VELOCITIES AND CURRENT DIRECTIONS

PLAN E RUN 3

DISCHARGE 105,000 CFS

SCALES

PROTOTYPE

MODEL

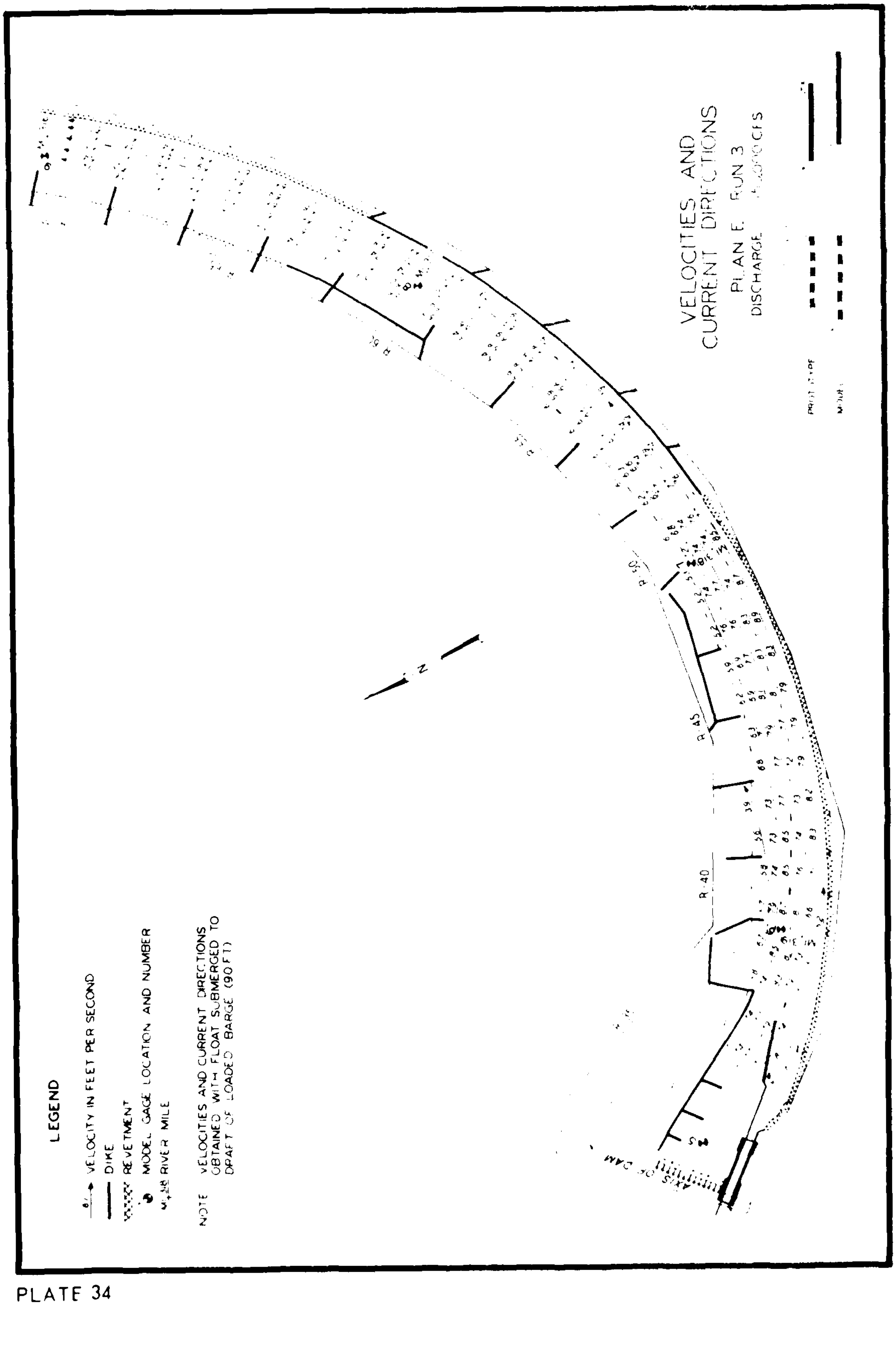
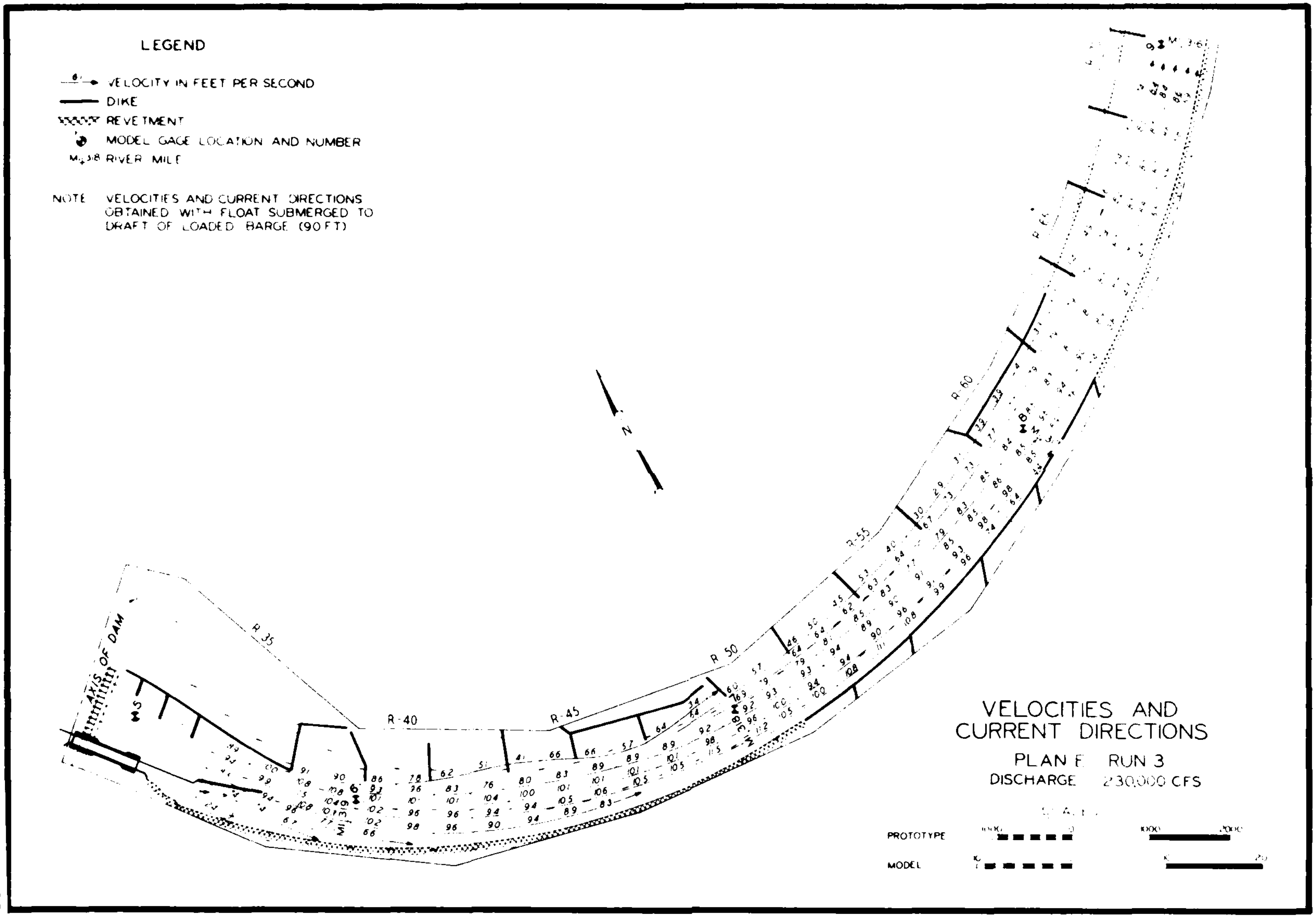

VELOCITIES AND
CURRENT DIRECTIONS
PLAN E RUN 3
DISCHARGE
LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
AXIS OF DAM
R 40
R 45
R 50

PLATE 34


LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
AXIS OF DAM
N
VELOCITIES AND
CURRENT DIRECTIONS
PLAN F RUN 3
DISCHARGE 230,000 CFS
PROTOTYPE
MODEL

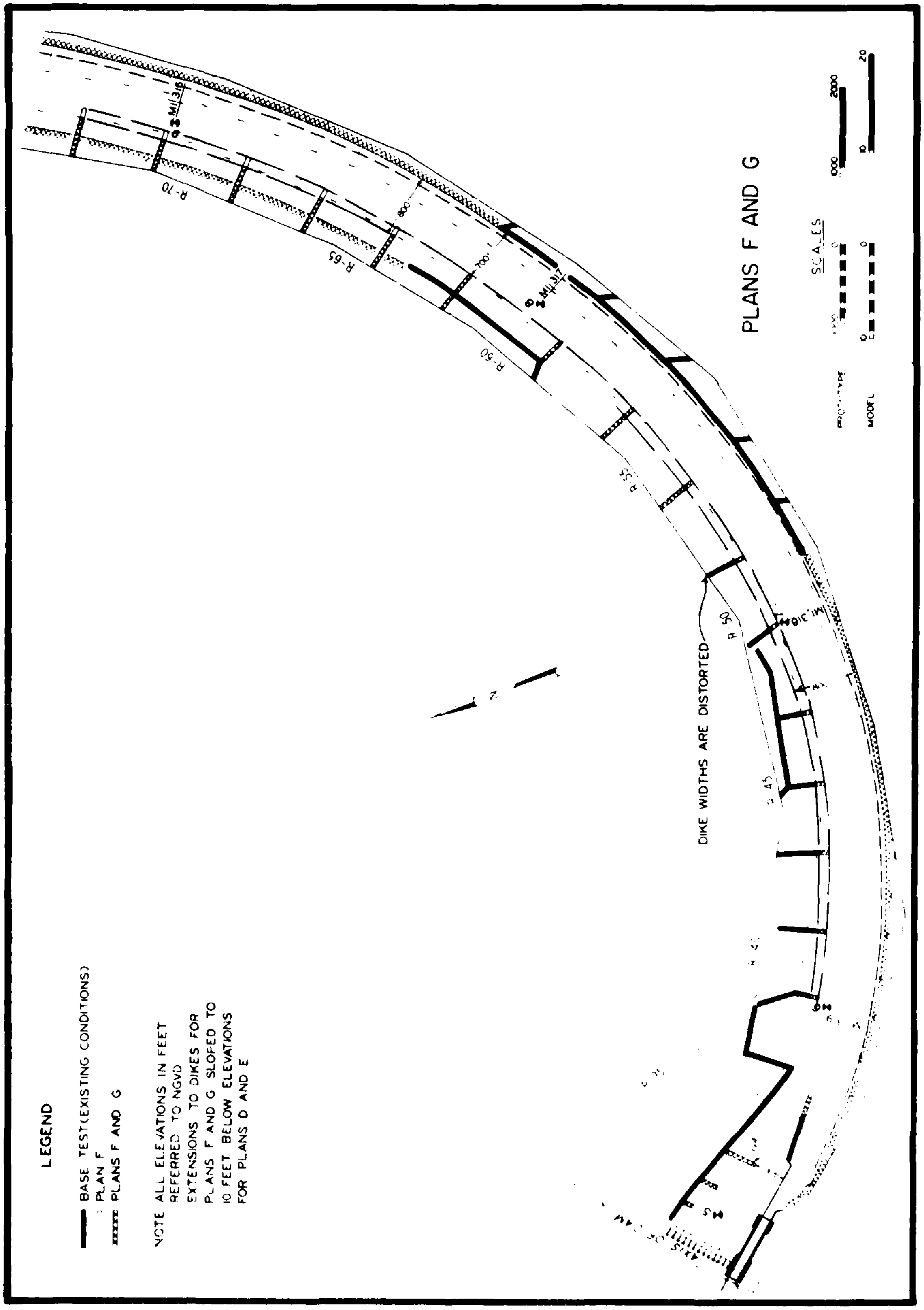

PLANS F AND G
LEGEND
BASE TEST (EXISTING CONDITIONS)
PLAN F
PLANS F AND G
NOTE: ALL ELEVATIONS IN FEET REFERRED TO NGVD
EXTENSIONS TO DIKES FOR PLANS F AND G SLOPED TO 10 FEET BELOW ELEVATIONS FOR PLANS D AND E
SCALES
PROTOTYPE
MODEL
1000
0
1000
2000
10
0
10
20
DIKE WIDTHS ARE DISTORTED
R-70
R-65
R-60
R-55
R-50
R-45
MI 316
MI 317
MI 318
800'
700'
N

PLATE 36

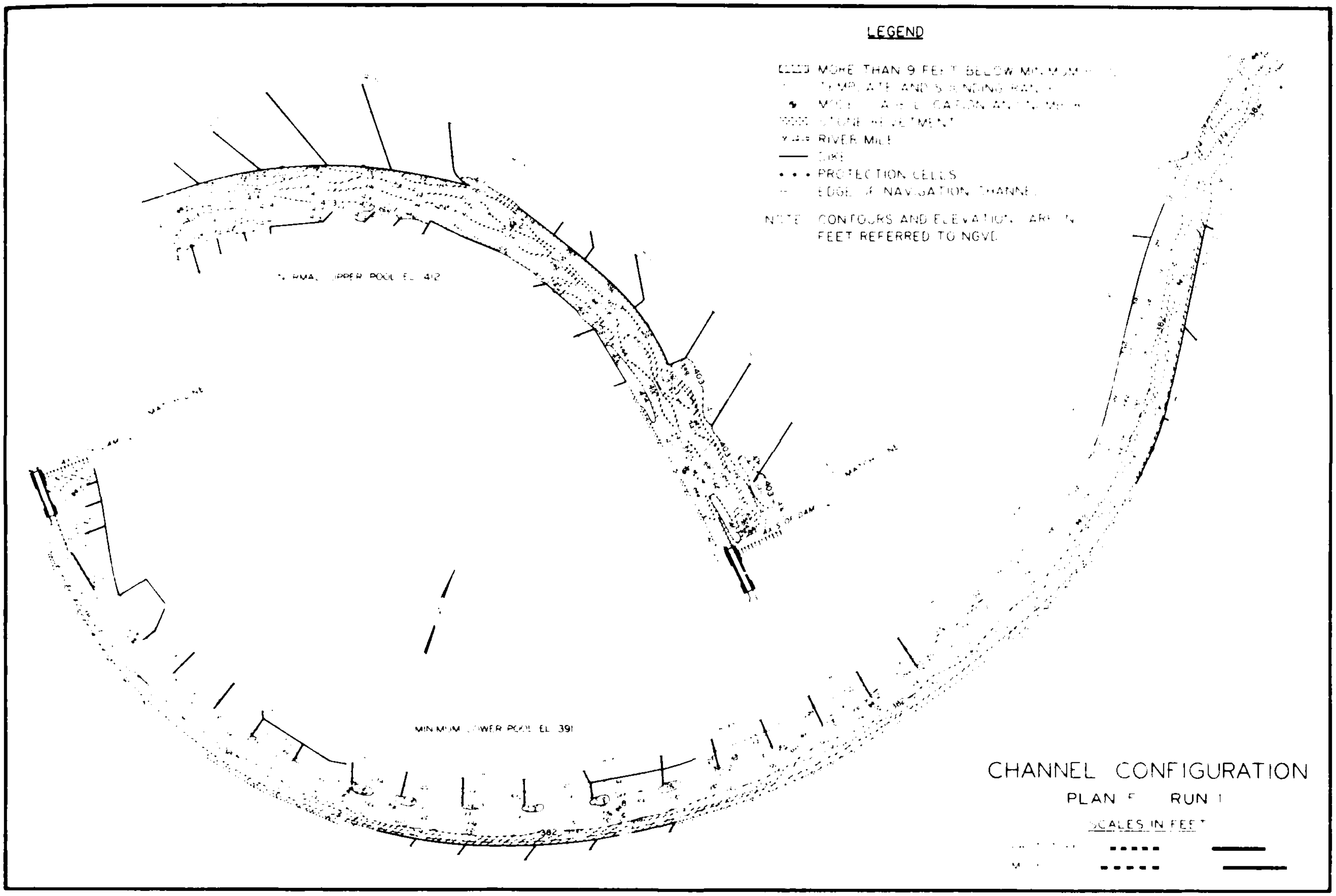
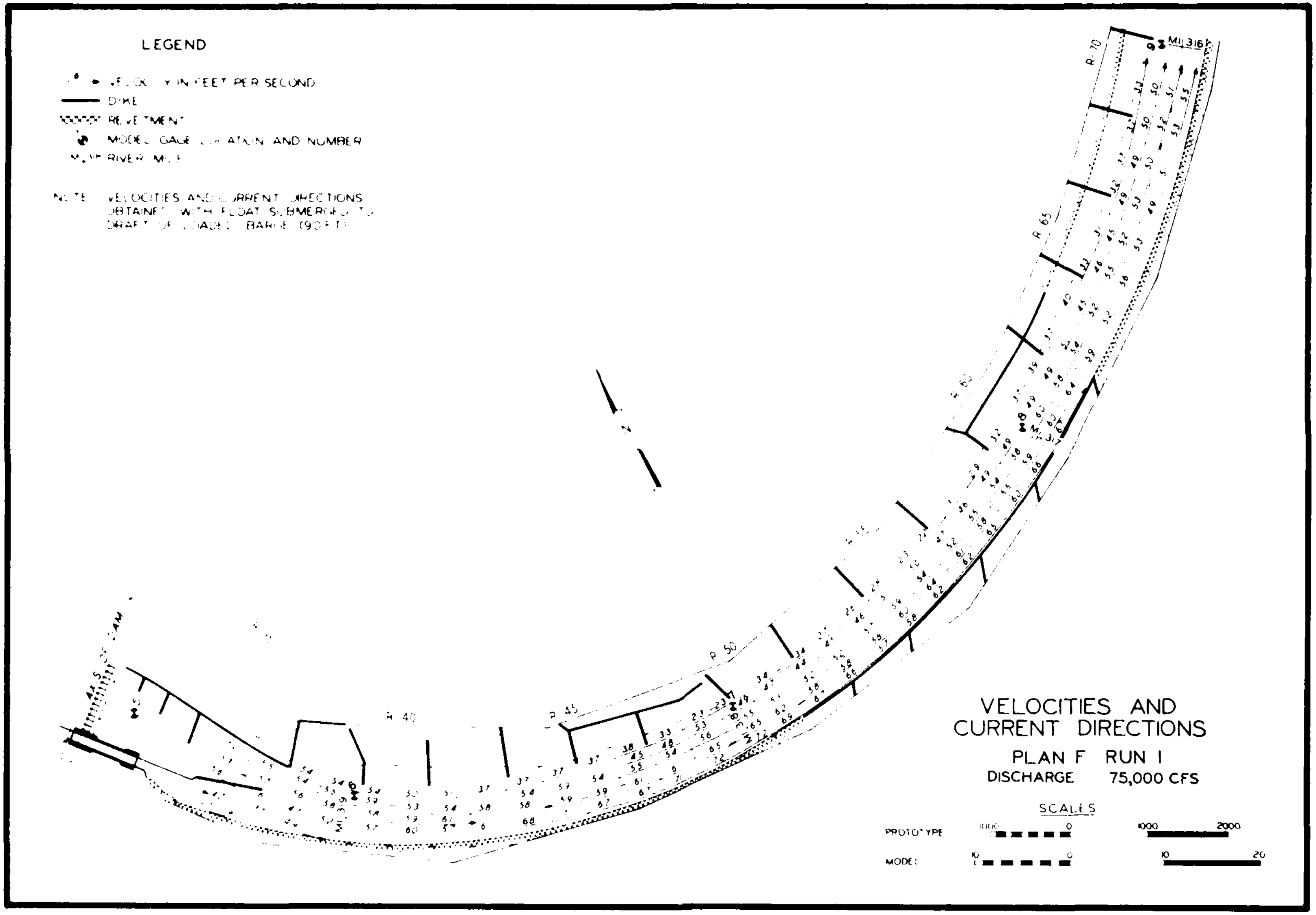
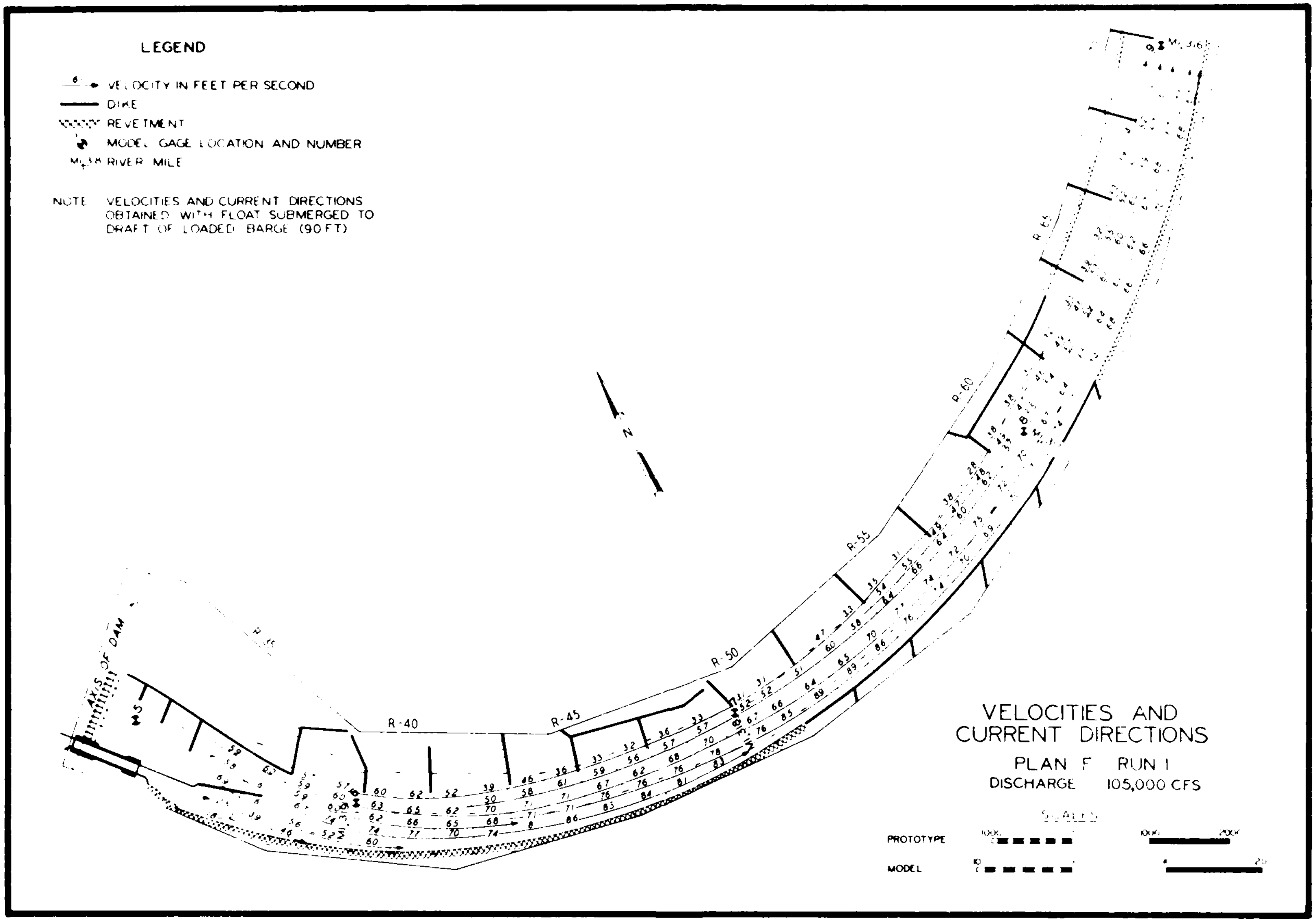

LEGEND
RIVER MILE
PROTECTION CELLS
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
MINIMUM LOWER POOL EL 391
CHANNEL CONFIGURATION
SCALES IN FEET

PLATE 37


LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
RIVER MILE
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
VELOCITIES AND CURRENT DIRECTIONS
PLAN F RUN I
DISCHARGE 75,000 CFS
SCALES
PROTOTYPE
MODEL
R 70
R 65
R 60
R 50
R 45
R 40
M1.316
M1.317


LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
AXIS OF DAM
R-40
R-45
R-50
R-55
R-60
R-65
N
VELOCITIES AND CURRENT DIRECTIONS
PLAN F RUN 1
DISCHARGE 105,000 CFS
PROTOTYPE
MODEL

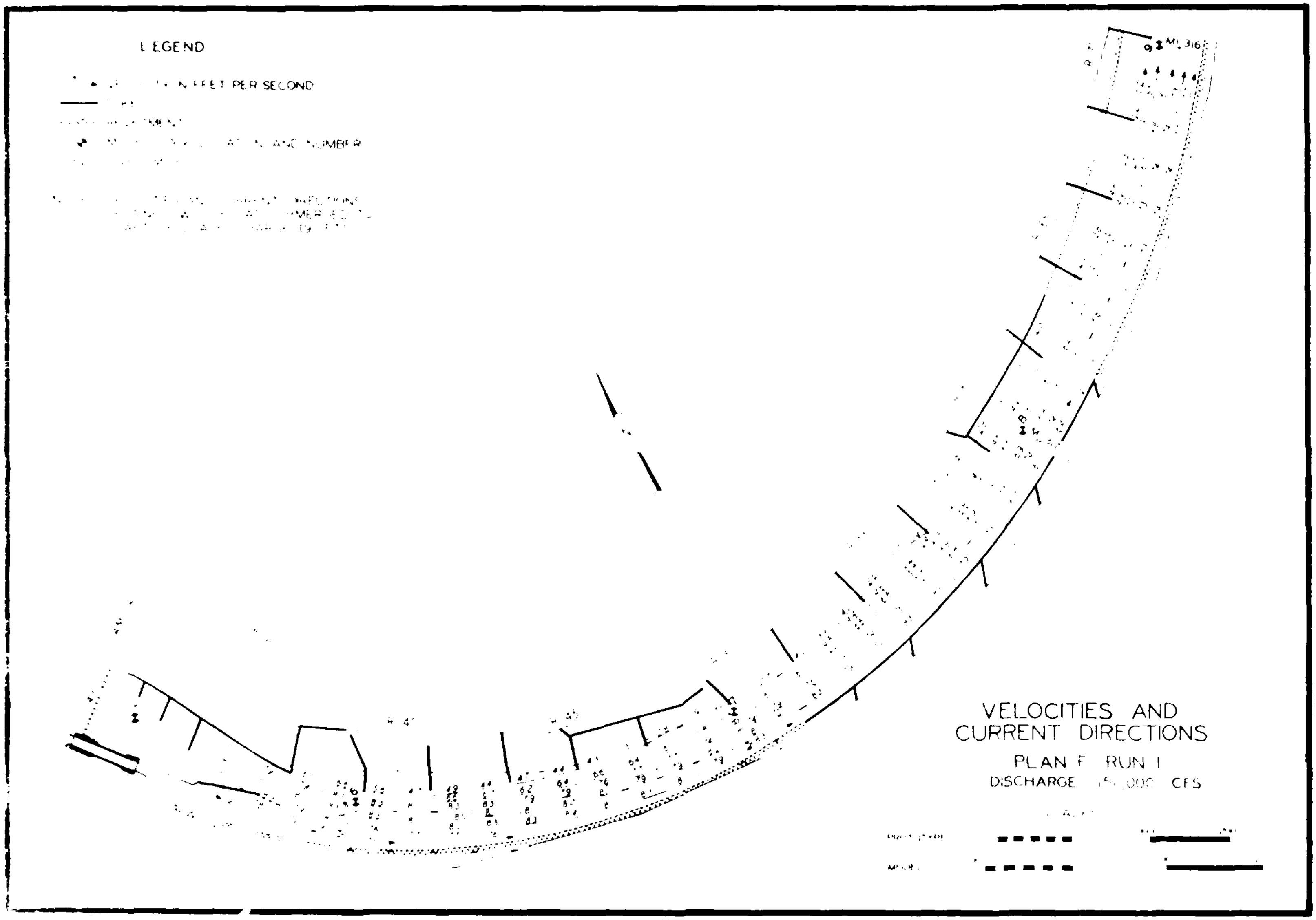

LEGEND
FEET PER SECOND
NUMBER
ML 316
VELOCITIES AND
CURRENT DIRECTIONS
PLAN F RUN 1
DISCHARGE CFS

PLATE 40

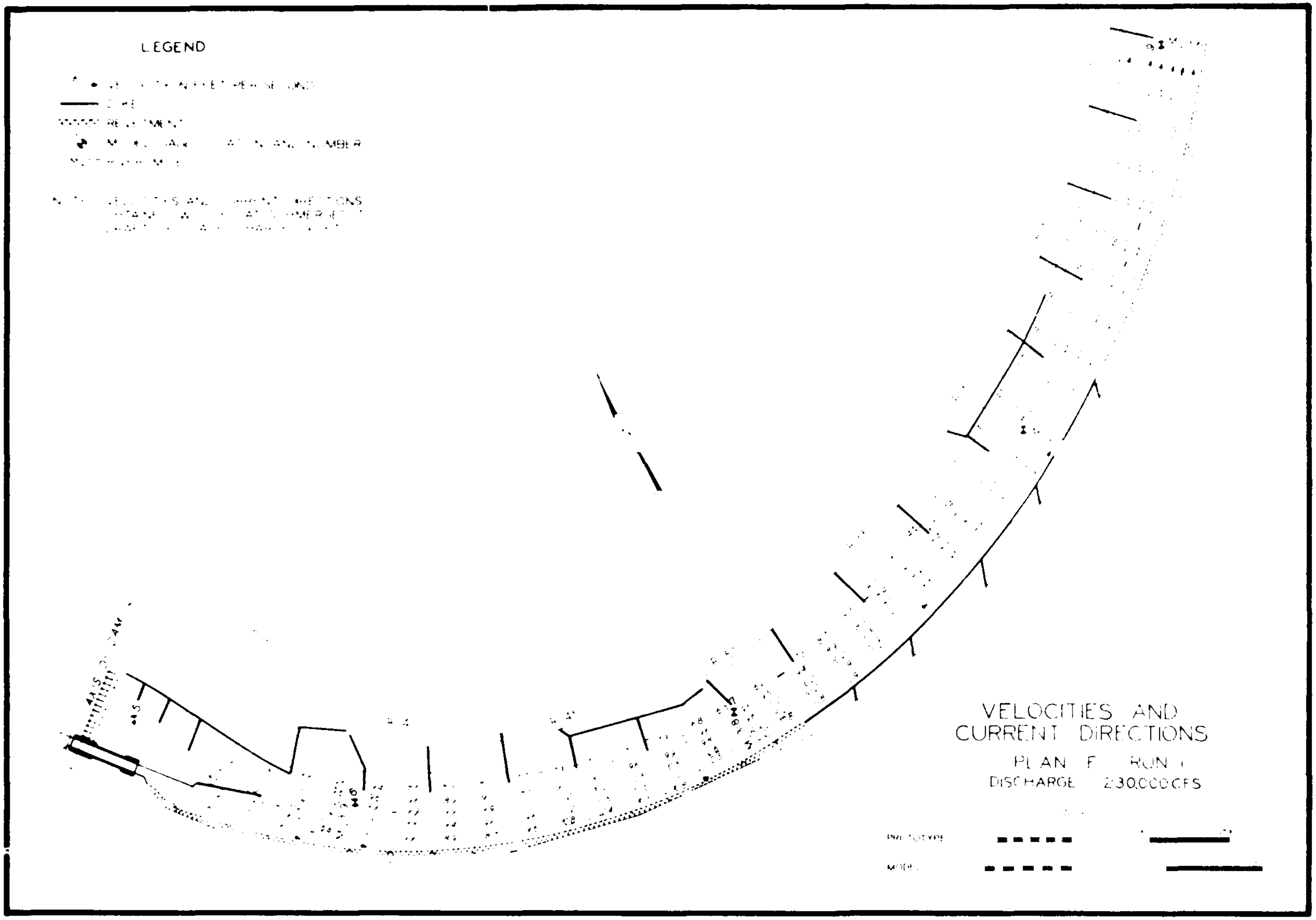
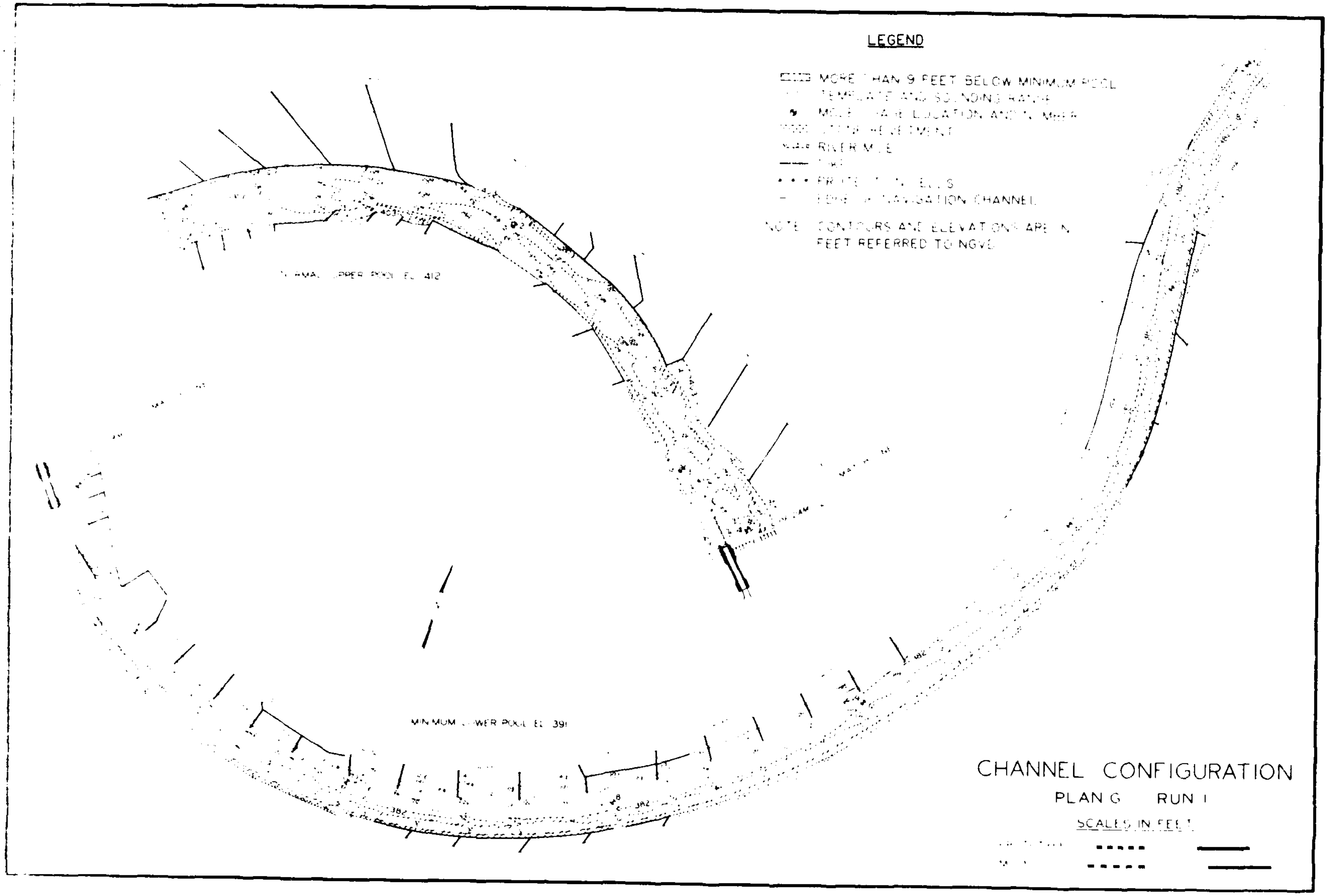
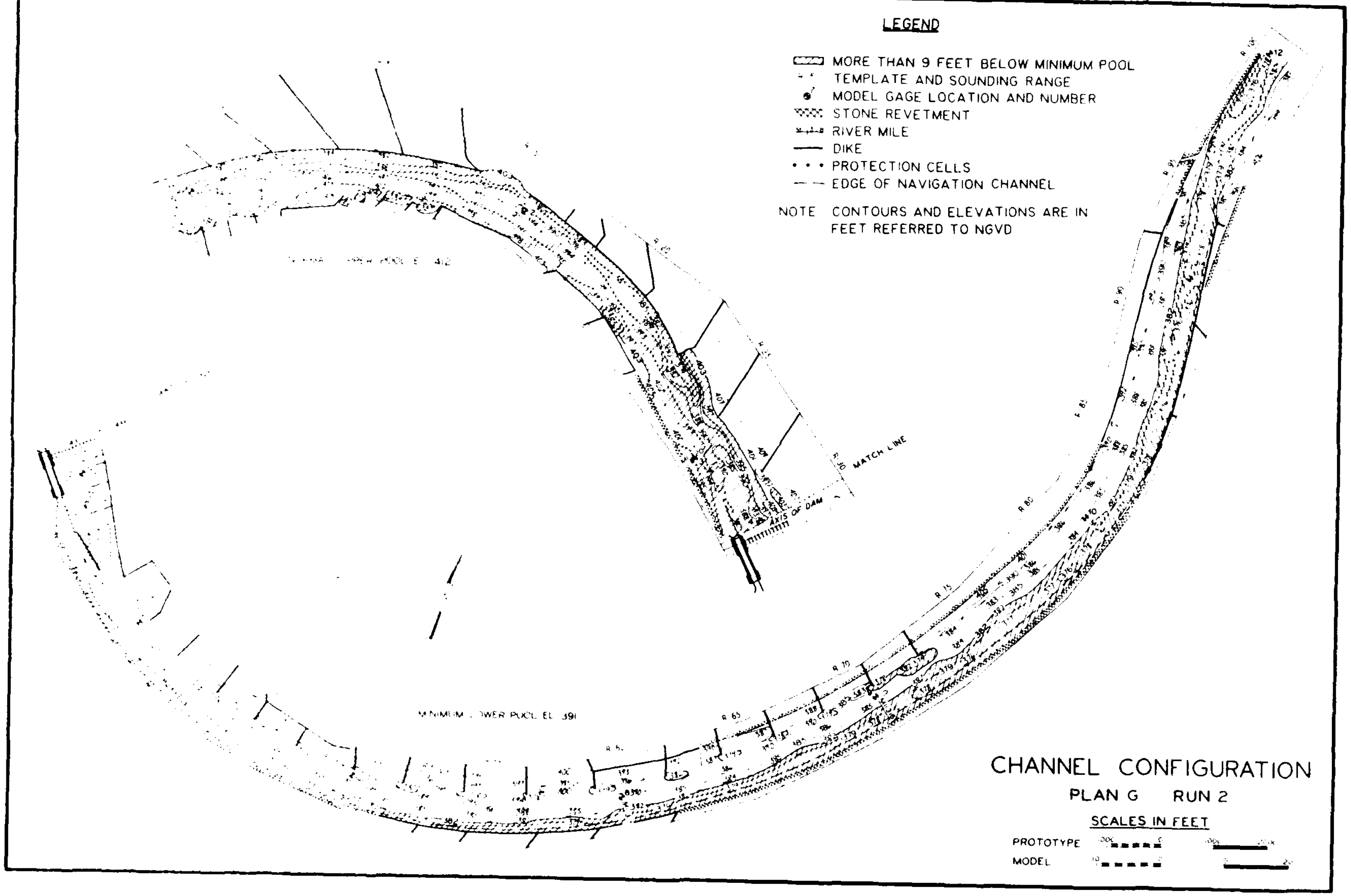

LEGEND
VELOCITIES AND
CURRENT DIRECTIONS
PLAN F RUN 1
DISCHARGE 230,000 CFS

PLATE 41


LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
RIVER MILE
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
MINIMUM LOWER POOL EL 391
CHANNEL CONFIGURATION
PLAN G RUN 1
SCALES IN FEET


LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
MATCH LINE
AXIS OF DAM
MINIMUM LOWER POOL EL 391
CHANNEL CONFIGURATION
PLAN G RUN 2
SCALES IN FEET
PROTOTYPE
MODEL

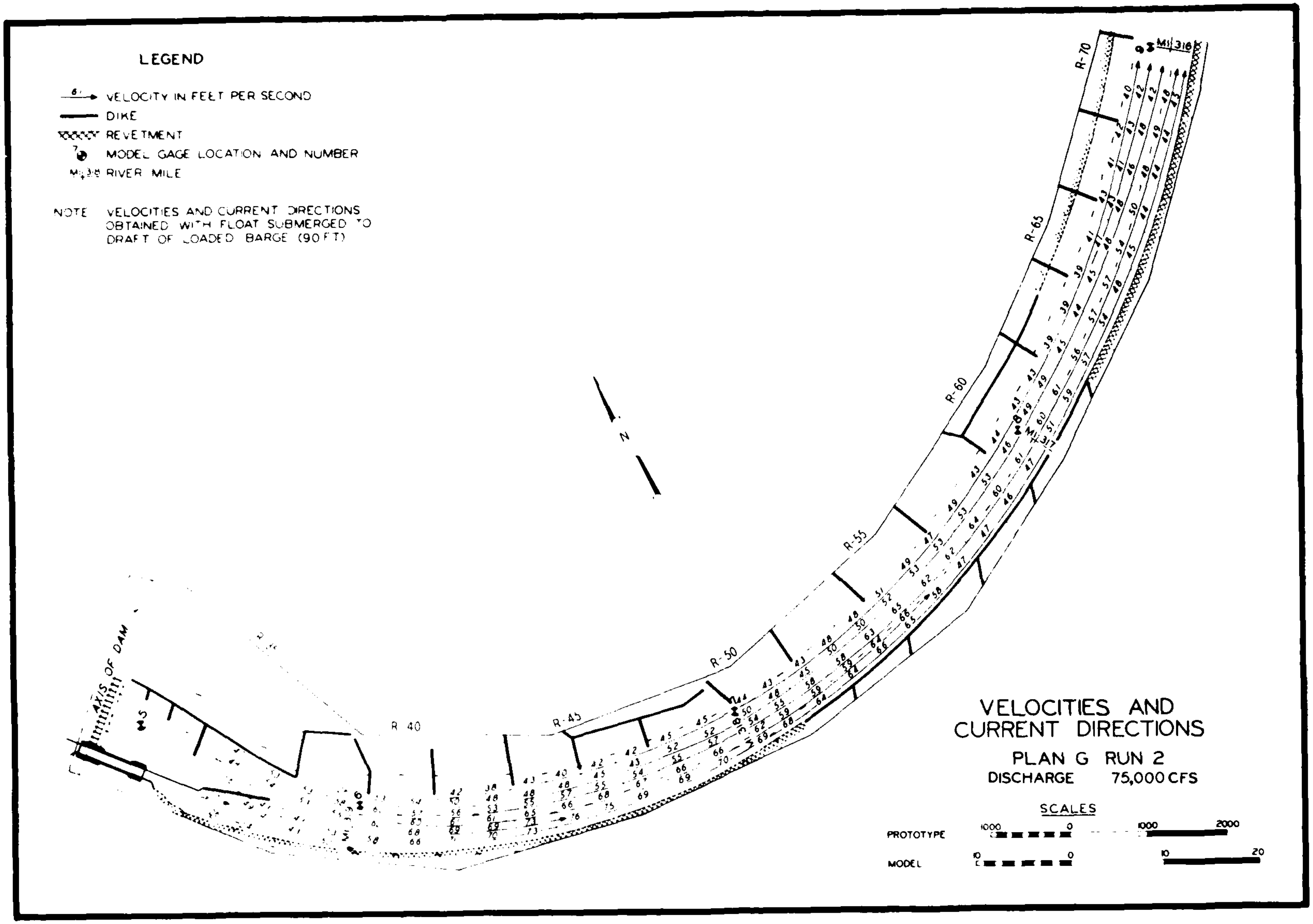

LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
R-70
R-65
R-60
R-55
R-50
R-45
R 40
N
AXIS OF DAM
MI 318
MI 317
VELOCITIES AND CURRENT DIRECTIONS
PLAN G RUN 2
DISCHARGE 75,000 CFS
SCALES
PROTOTYPE
MODEL
1000
0
1000
2000
10
0
10
20

PLATE 44

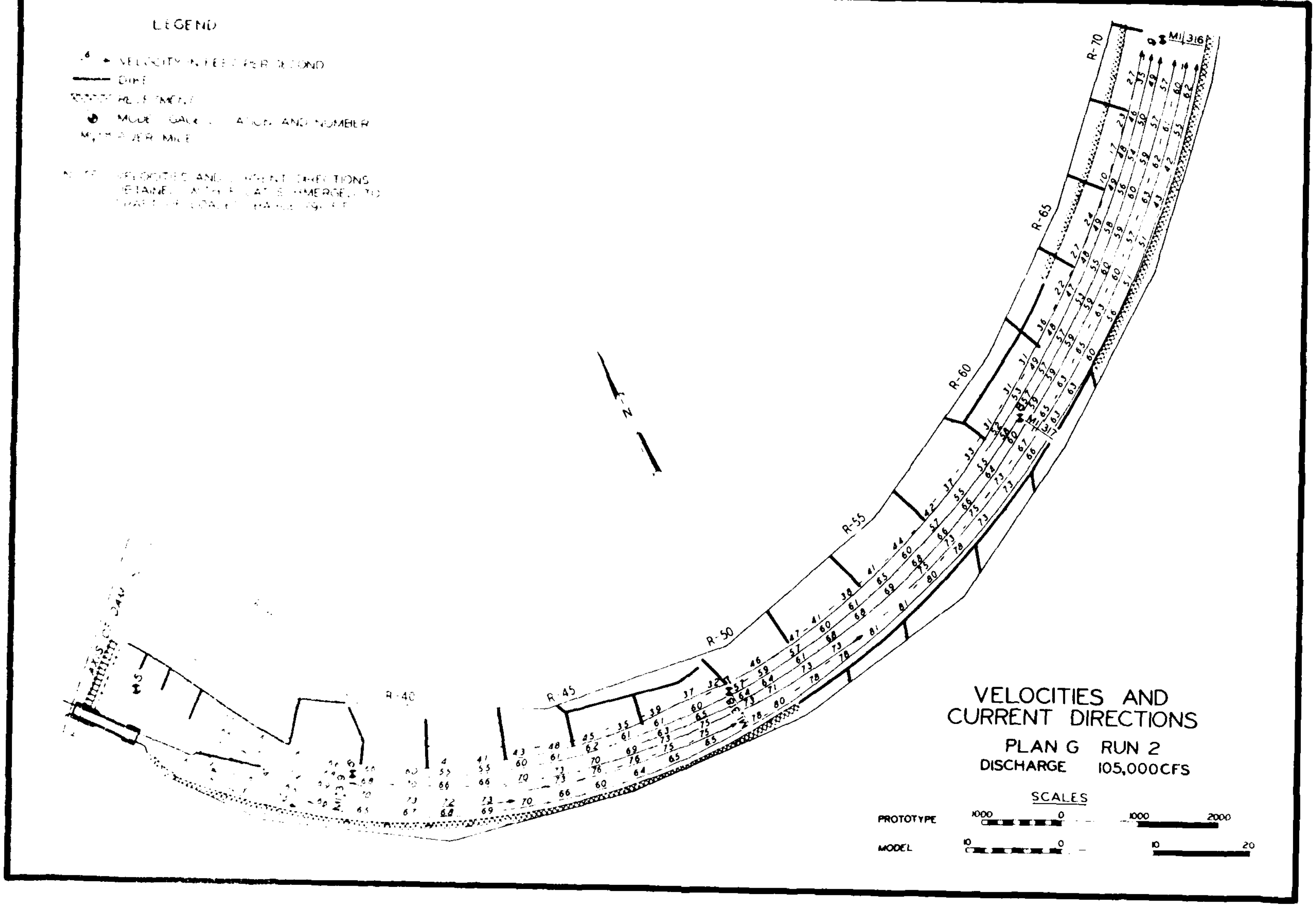
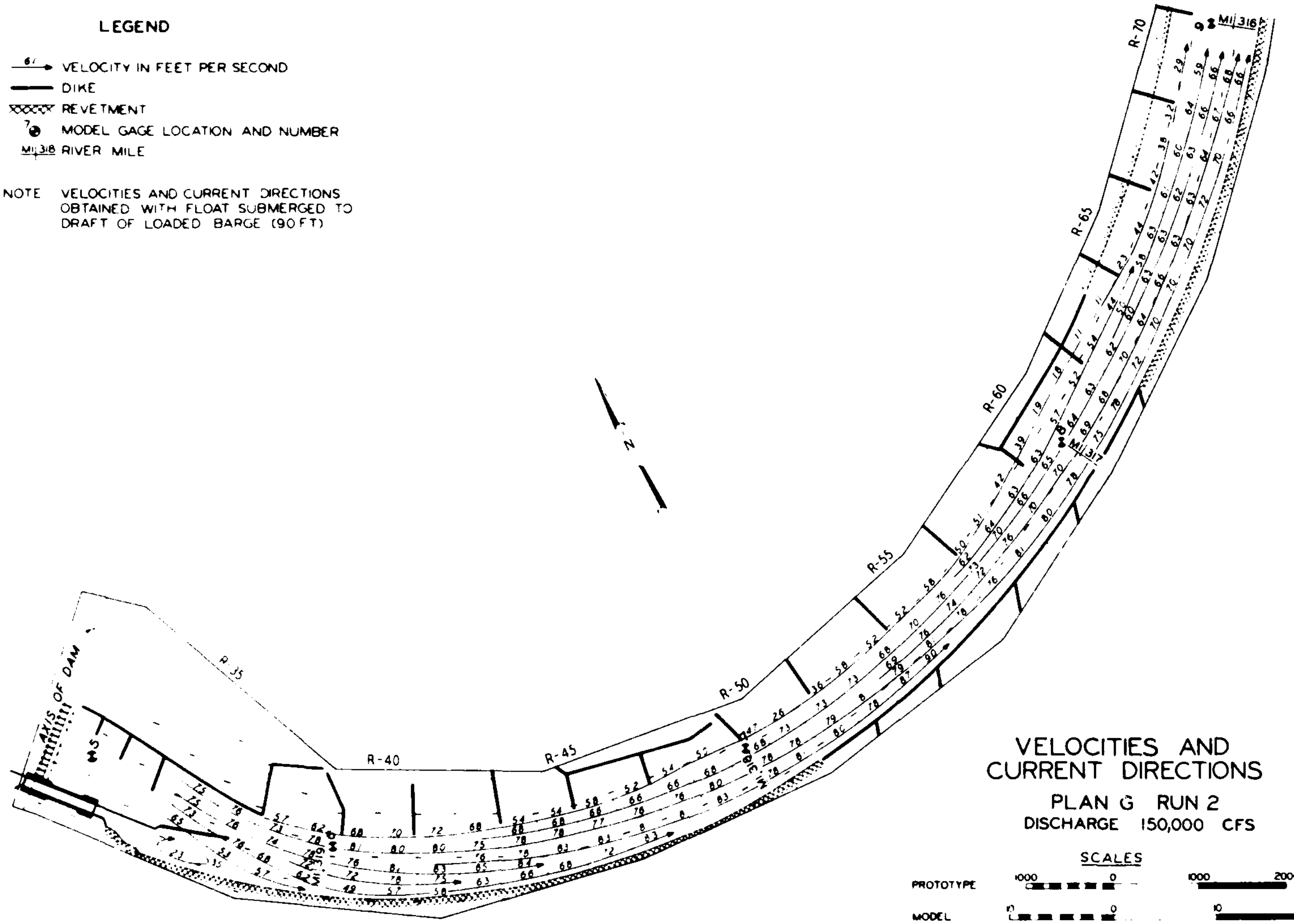

LEGEND
VELOCITIES AND
CURRENT DIRECTIONS
PLAN G RUN 2
DISCHARGE 105,000CFS
SCALES
PROTOTYPE
MODEL
R-70
R-65
R-60
R-55
R-50
R-45
R-40
MI 316
MI 317

PLATE 45

LEGEND

- VELOCITY IN FEET PER SECOND
- DIKE
- REVETMENT
- MODEL GAGE LOCATION AND NUMBER
- MI 318 RIVER MILE

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



VELOCITIES AND CURRENT DIRECTIONS

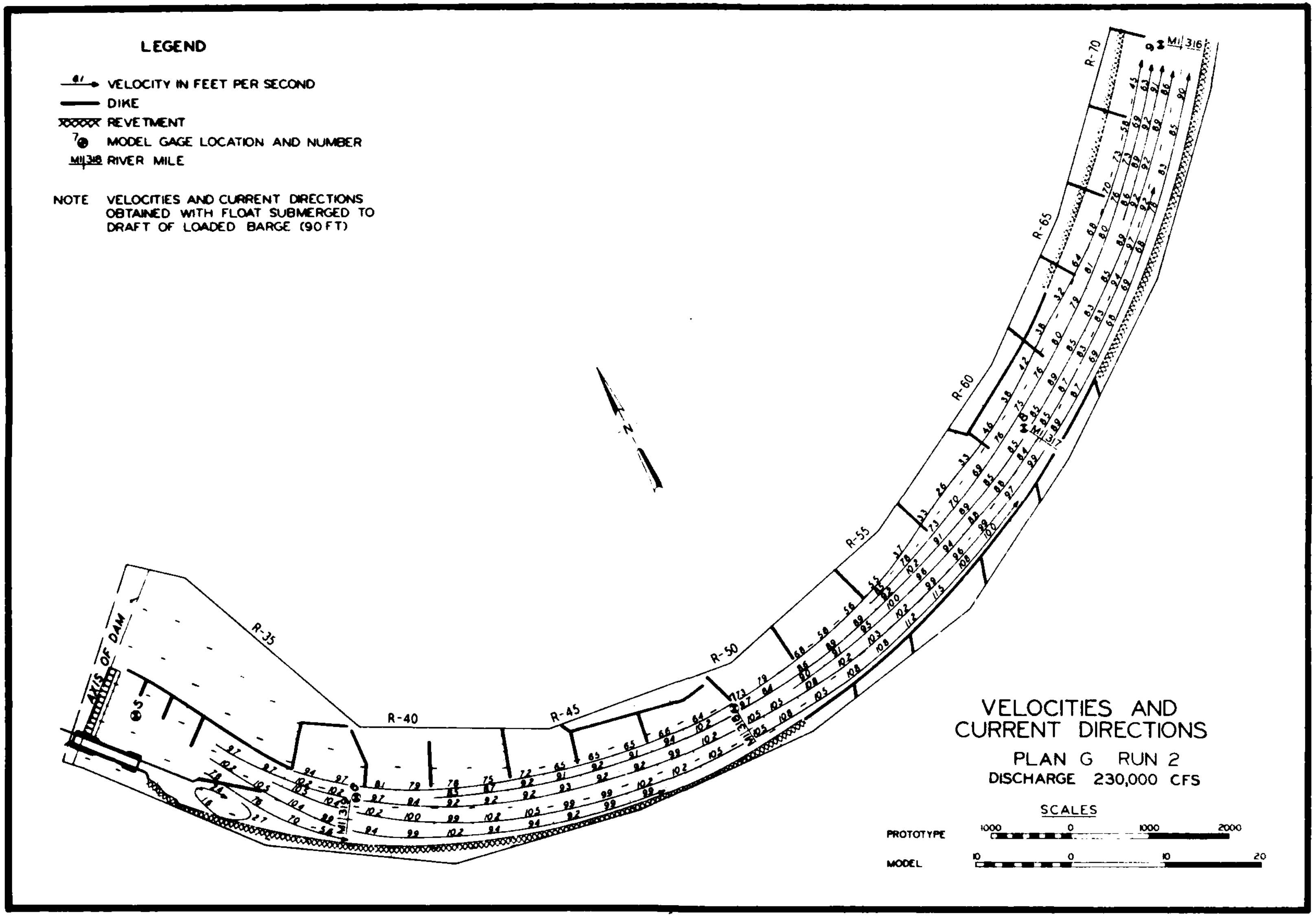
PLAN G RUN 2

DISCHARGE 150,000 CFS

SCALES

PROTOTYPE 1000 0 1000 2000

MODEL 10 0 10 20


LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
MI 318 RIVER MILE
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (90 FT)
VELOCITIES AND CURRENT DIRECTIONS
PLAN G RUN 2
DISCHARGE 230,000 CFS
SCALES
PROTOTYPE
MODEL
AXIS OF DAM
R-35
R-40
R-45
R-50
R-55
R-60
R-65
R-70
MI 316
N

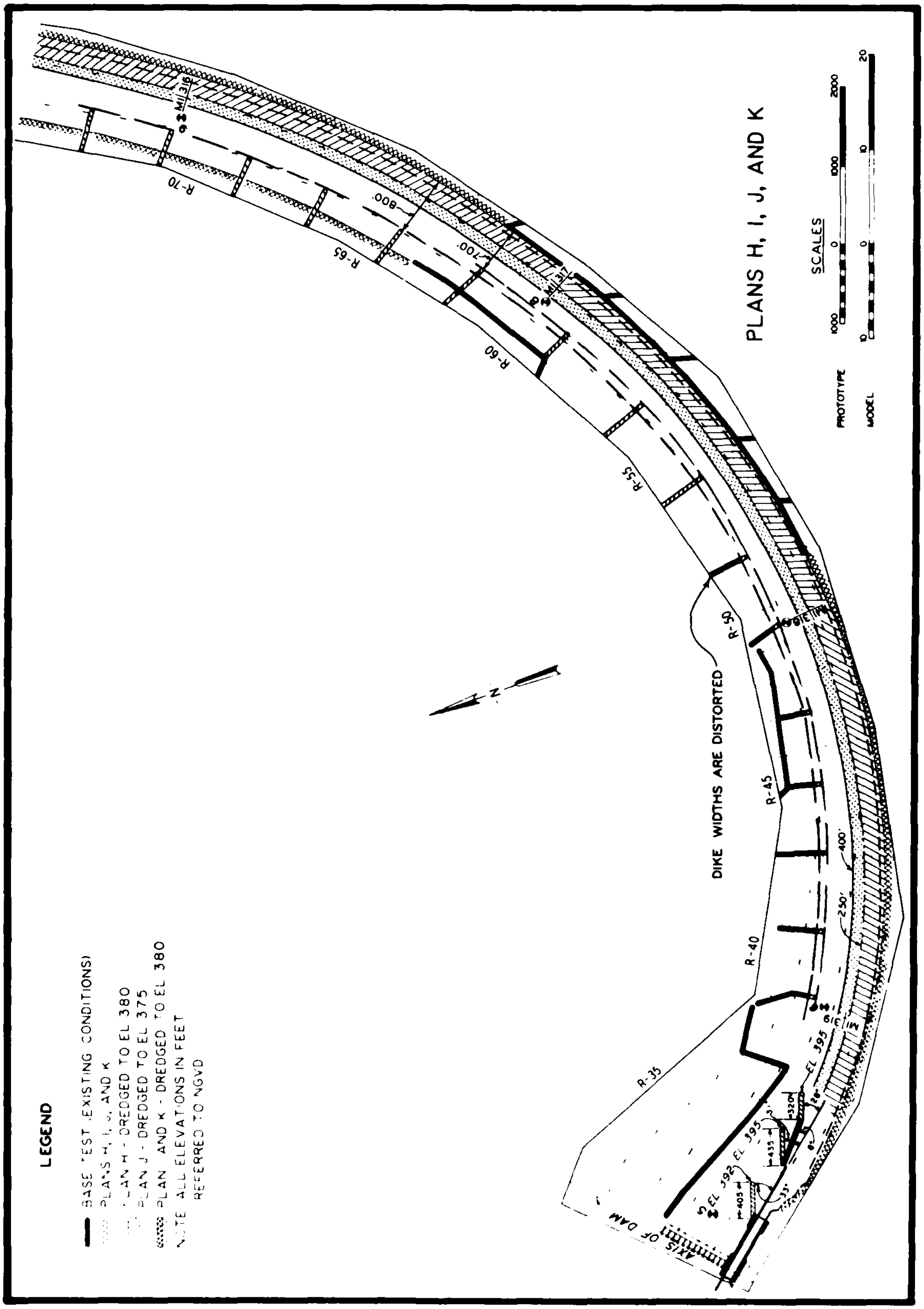
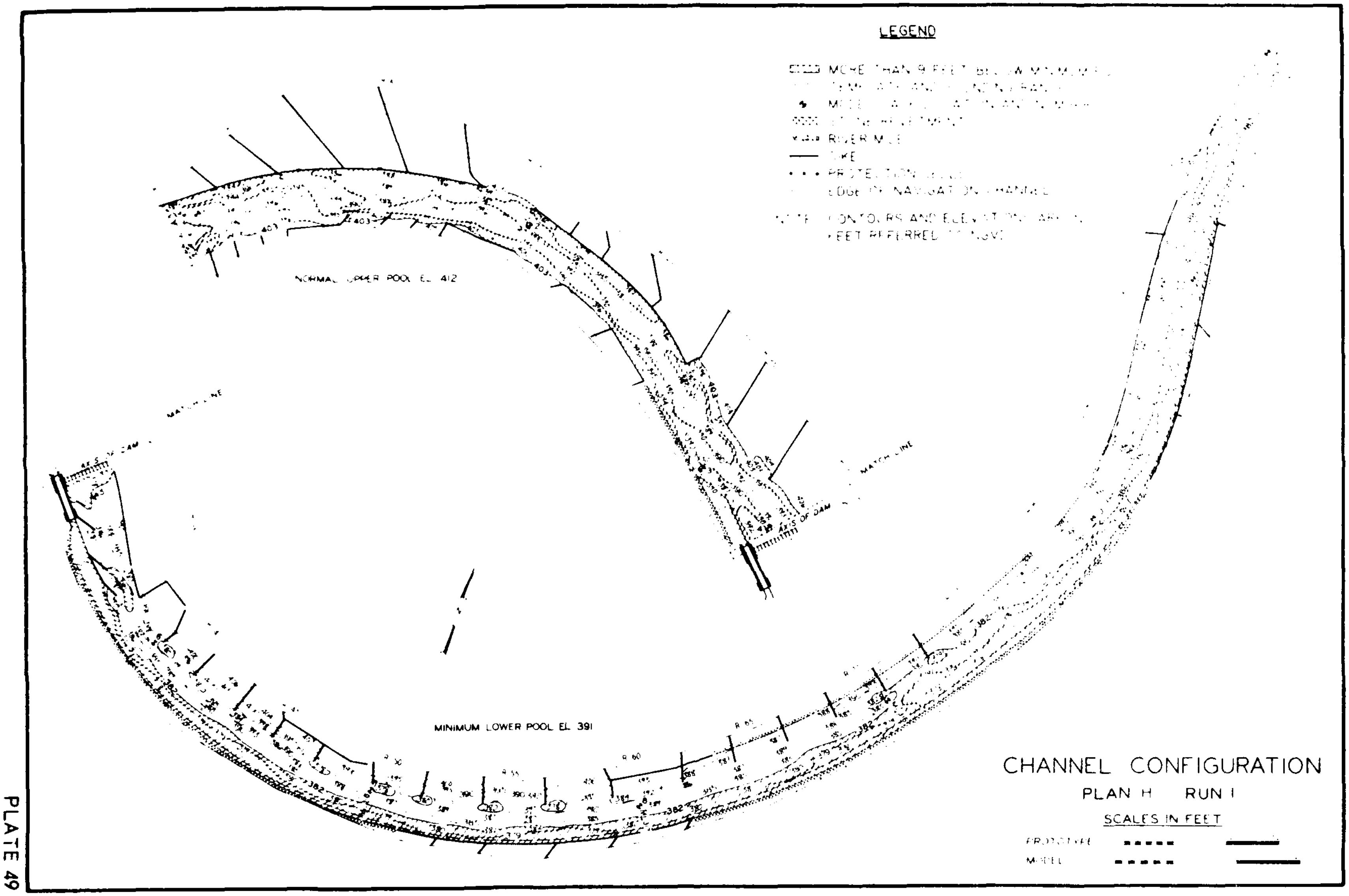

PLANS H, I, J, AND K
SCALES
PROTOTYPE
MODEL
1000
0
1000
2000
10
0
10
20
LEGEND
BASE TEST (EXISTING CONDITIONS)
PLANS H, I, J, AND K
PLAN H - DREDGED TO EL 380
PLAN J - DREDGED TO EL 375
PLAN I AND K - DREDGED TO EL 380
NOTE ALL ELEVATIONS IN FEET
REFERRED TO NGVD
DIKE WIDTHS ARE DISTORTED
N
R-35
R-40
R-45
R-50
R-55
R-60
R-65
R-70
800'
700'
400'
250'
EL 395
EL 392
AXIS OF DAM
MI 316
MI 317

PLATE 48



CHANNEL CONFIGURATION

PLAN H RUN I

PLATE 49

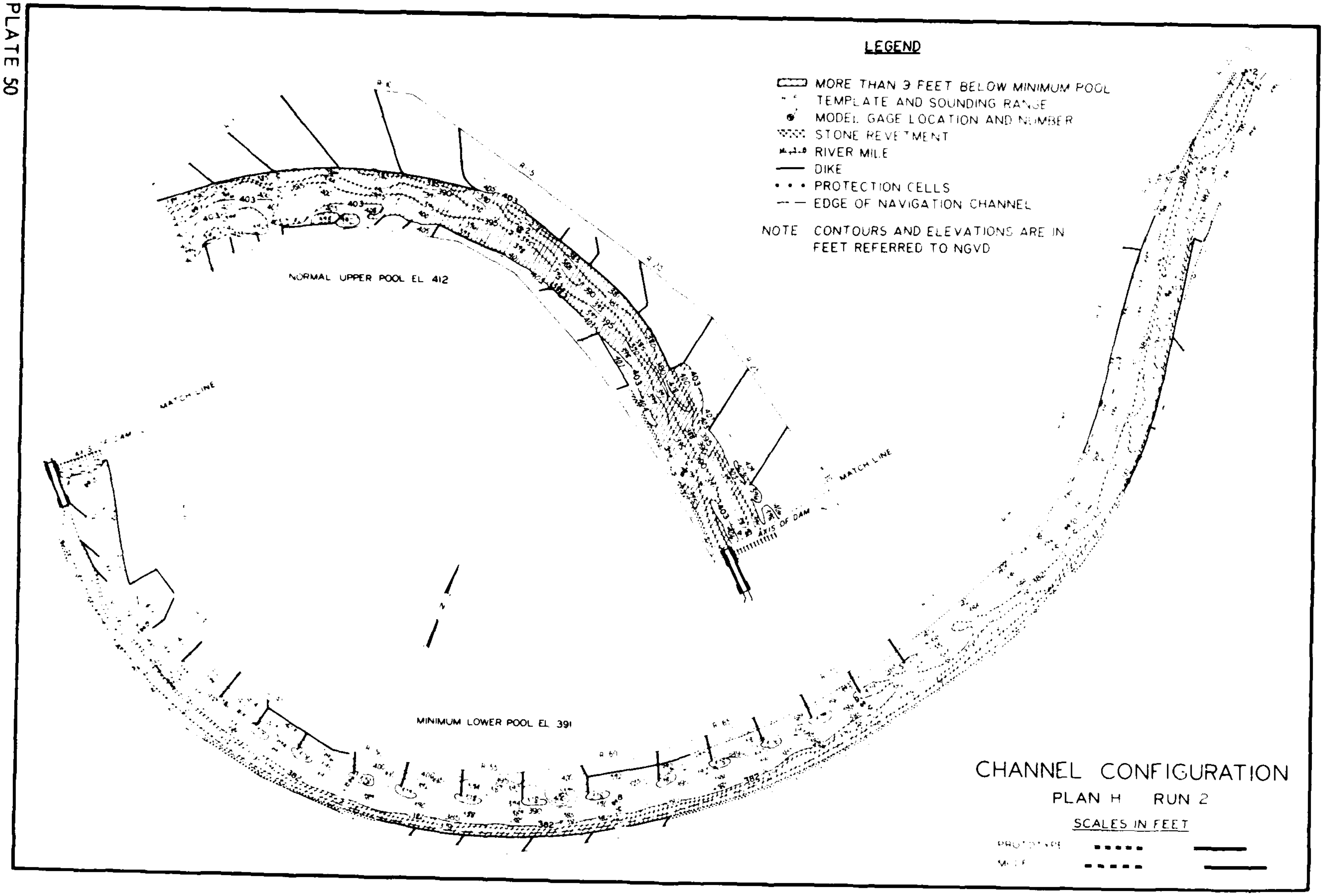
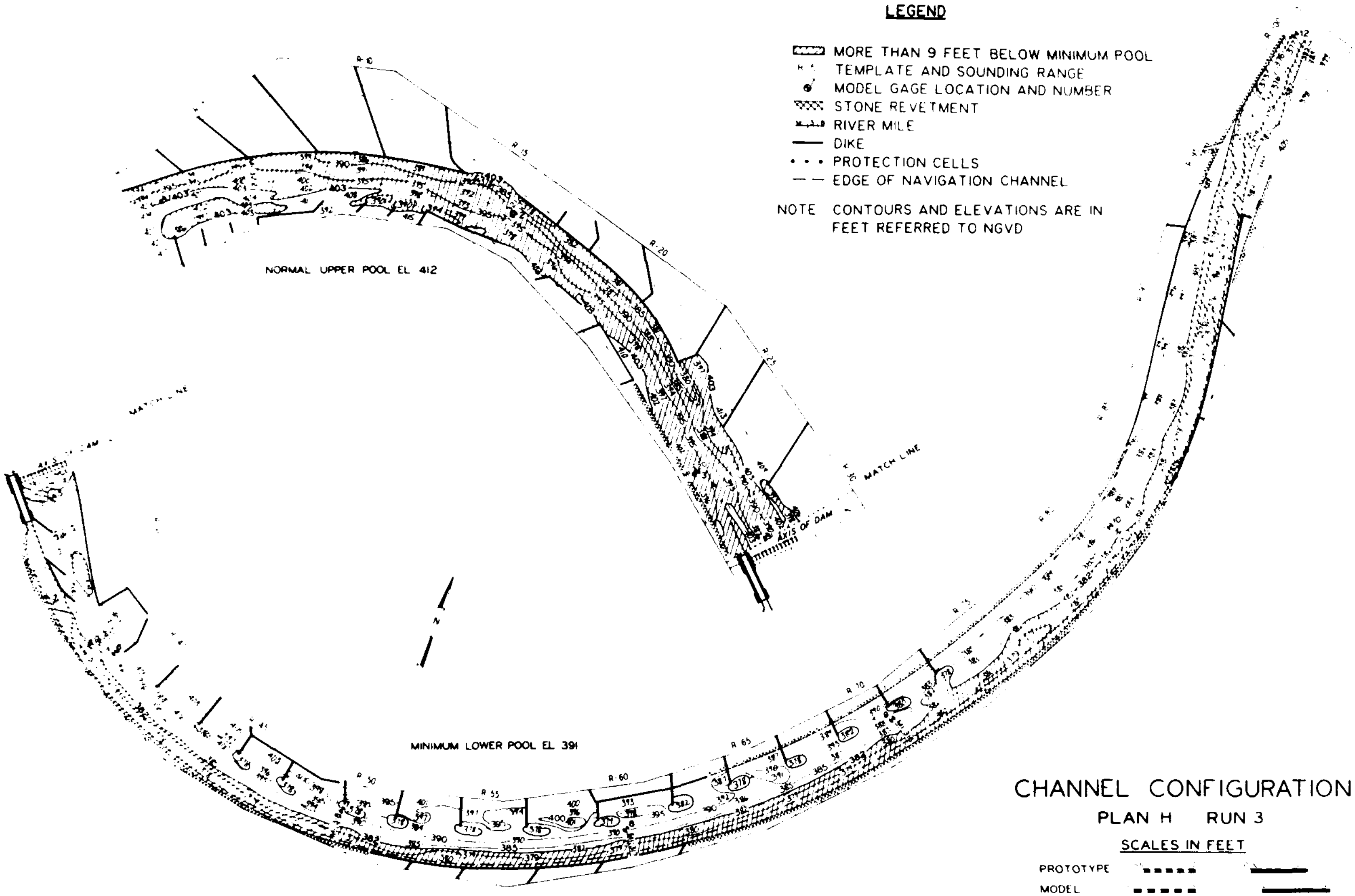

LEGEND
MORE THAN 3 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE
MATCH LINE
AXIS OF DAM
CHANNEL CONFIGURATION
PLAN H RUN 2
SCALES IN FEET

PLATE 50



CHANNEL CONFIGURATION

PLAN H RUN 3

SCALES IN FEET

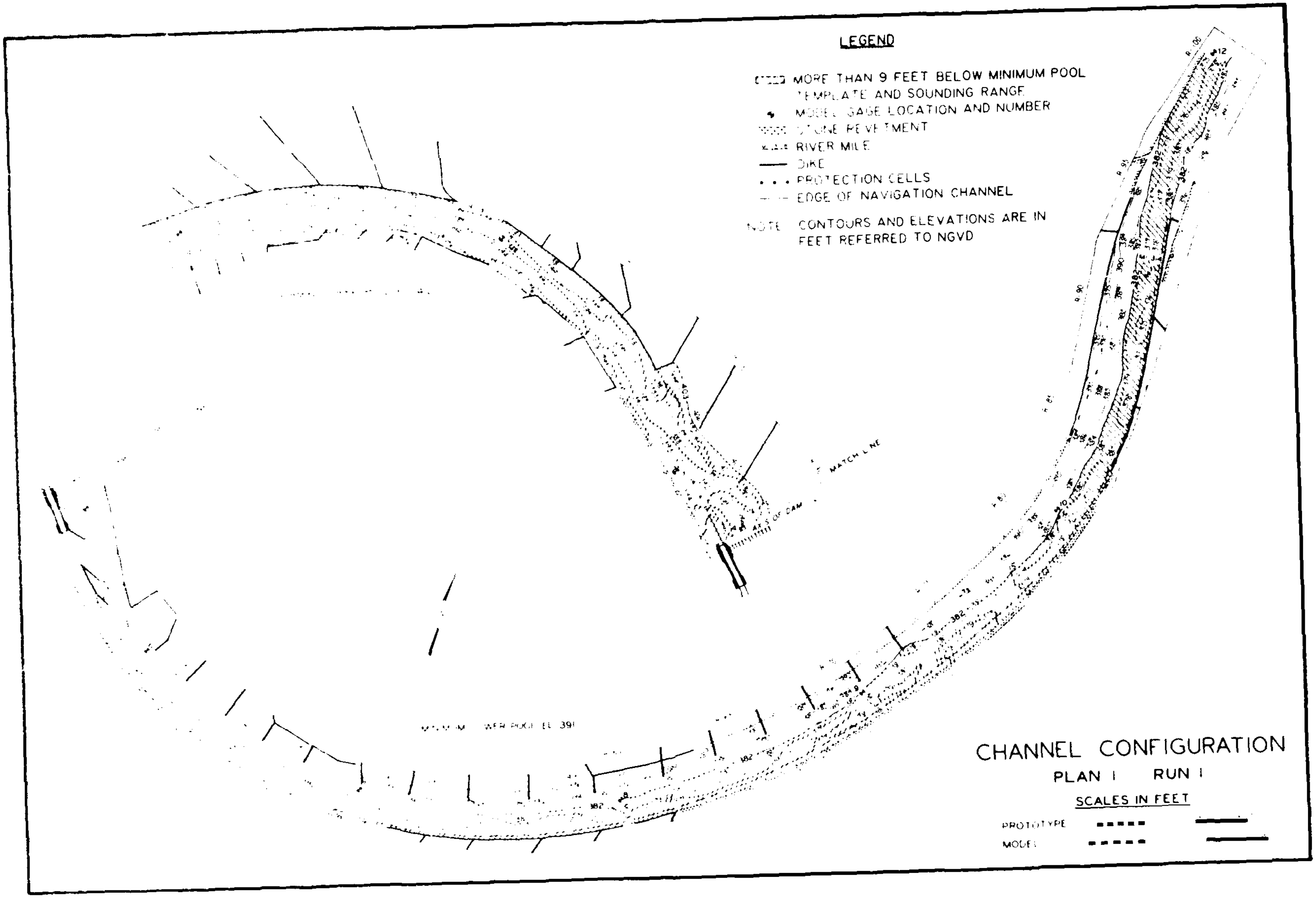
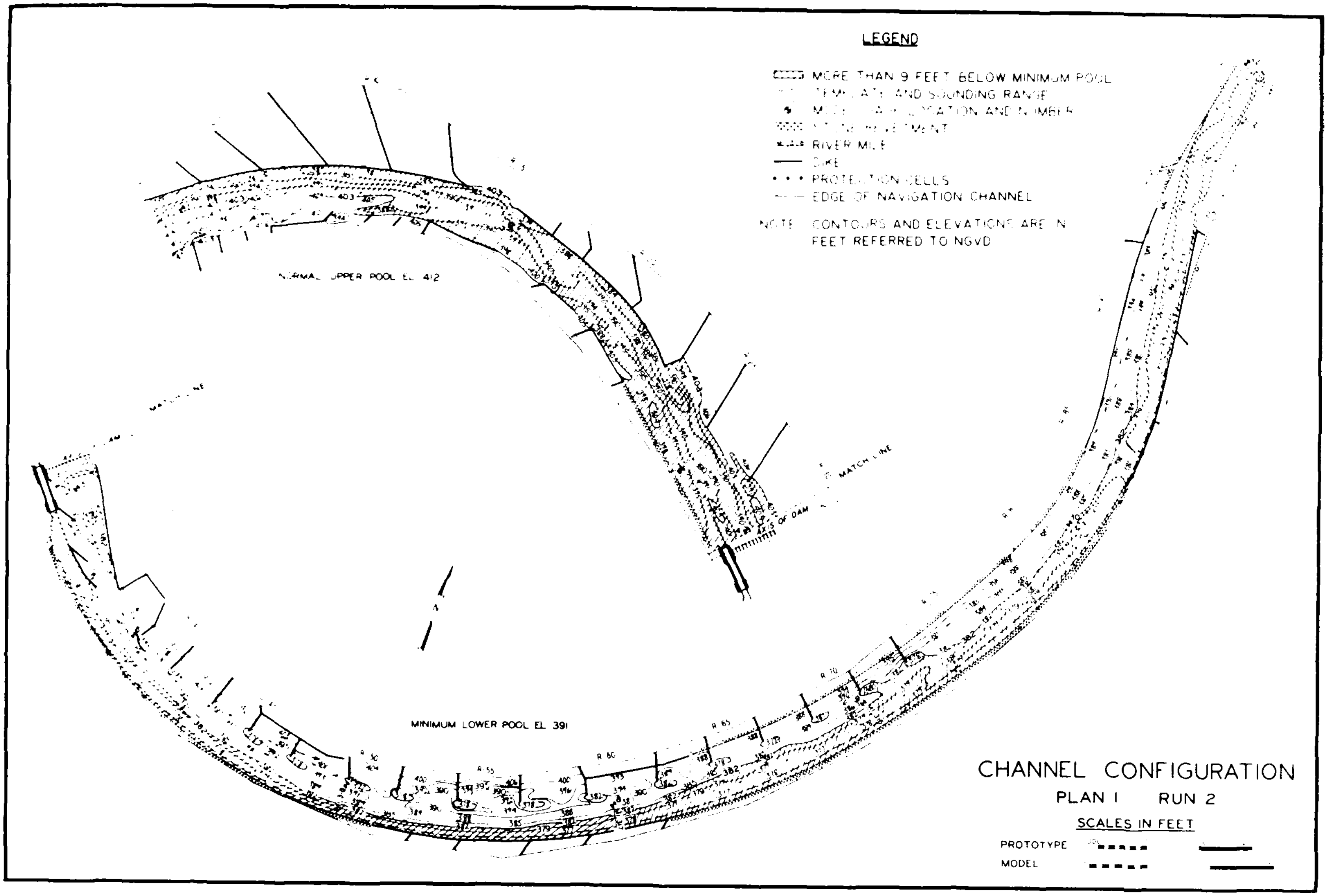
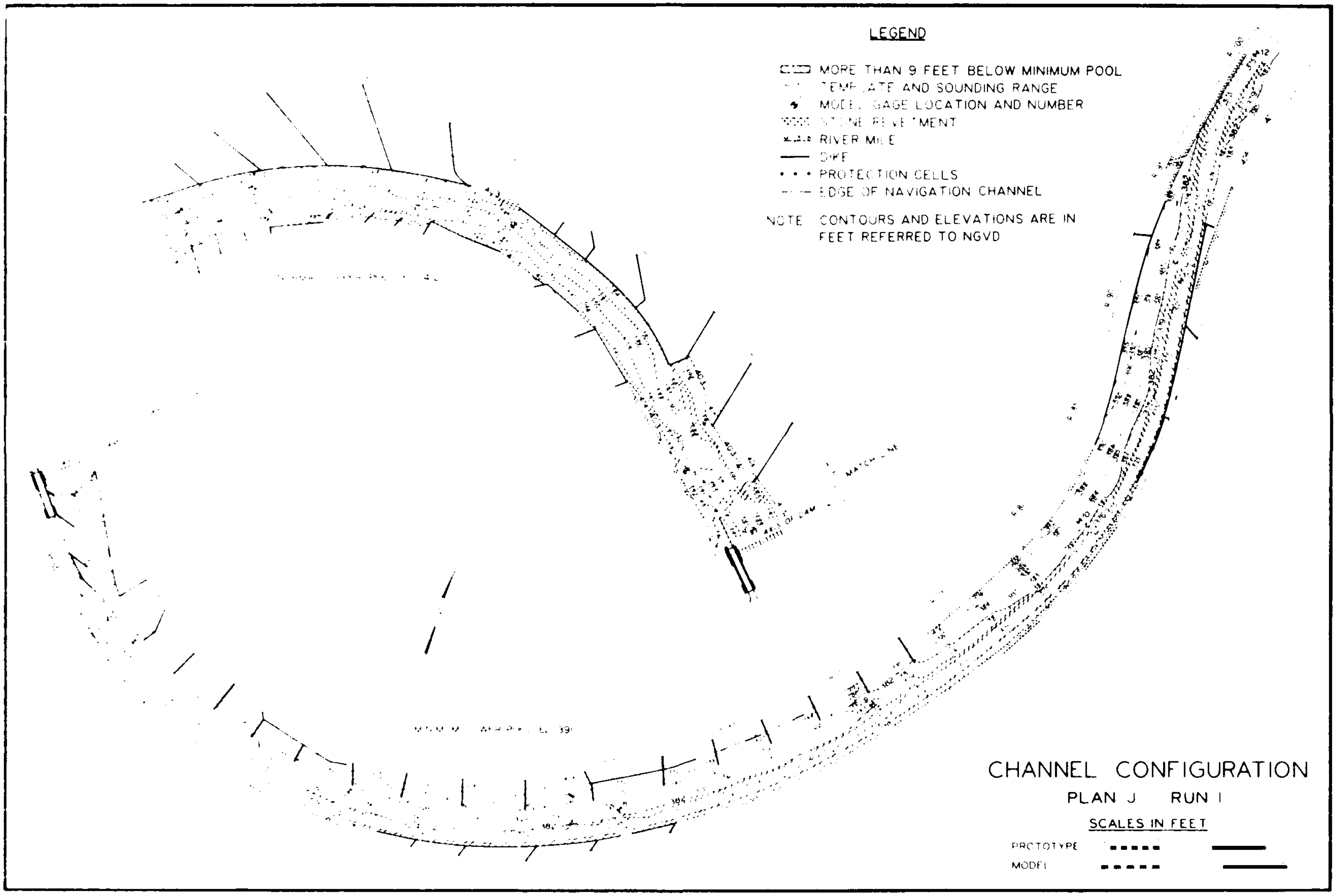
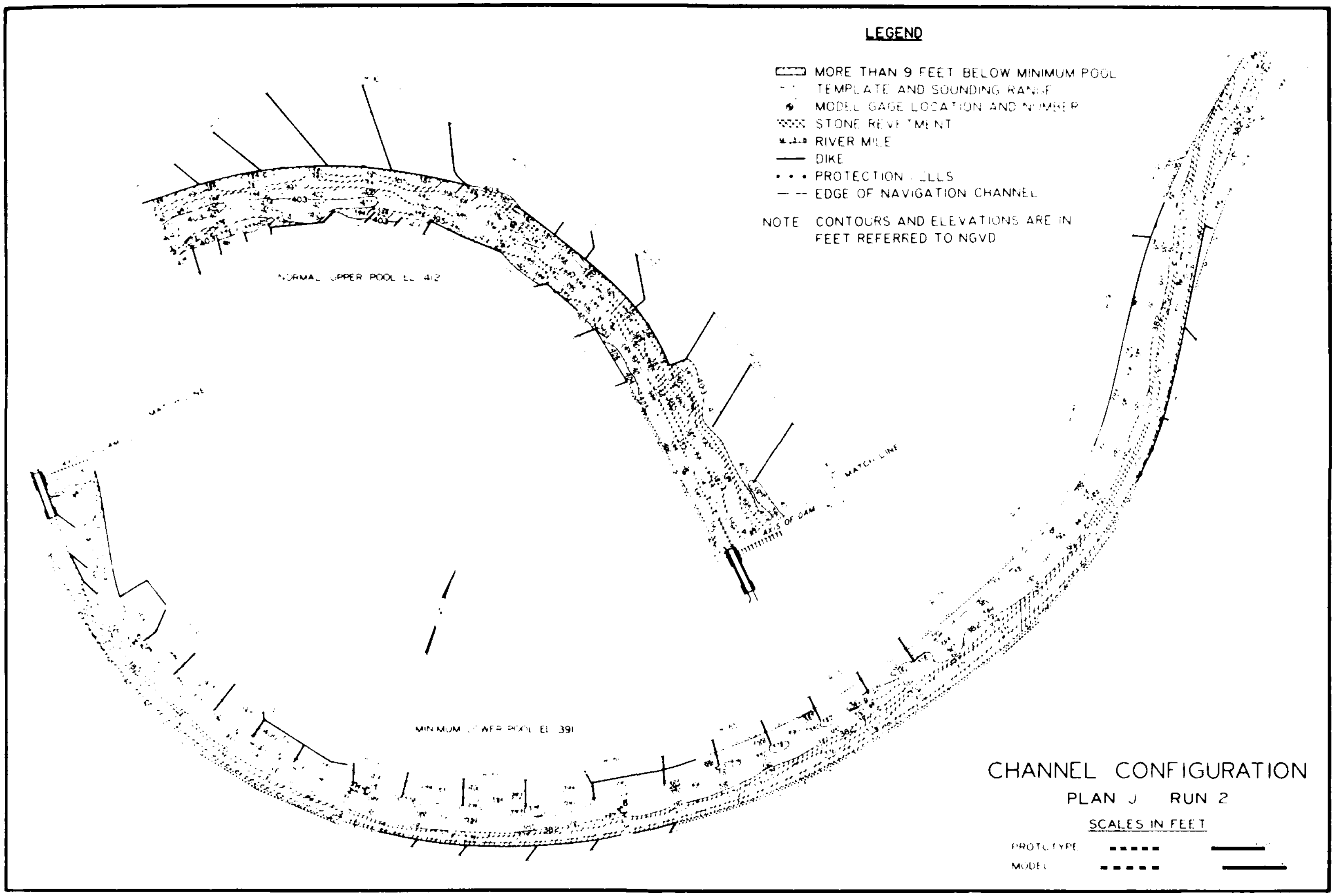

LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
MATCH LINE
CHANNEL CONFIGURATION
PLAN 1 RUN 1
SCALES IN FEET
PROTOTYPE
MODEL

PLATE 52

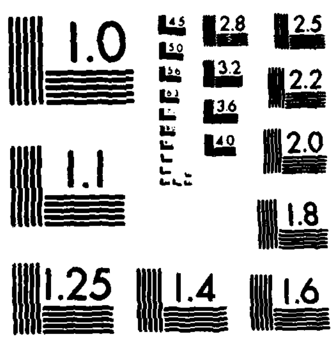

LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
RIVER MILE
DIKE
EDGE OF NAVIGATION CHANNEL
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE
CHANNEL CONFIGURATION
PLAN I RUN 2
SCALES IN FEET
PROTOTYPE
MODEL


LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
CHANNEL CONFIGURATION
PLAN J RUN 1
SCALES IN FEET
PROTOTYPE
MODEL


LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE
AXIS OF DAM
CHANNEL CONFIGURATION
PLAN J RUN 2
SCALES IN FEET
PROTOTYPE
MODEL

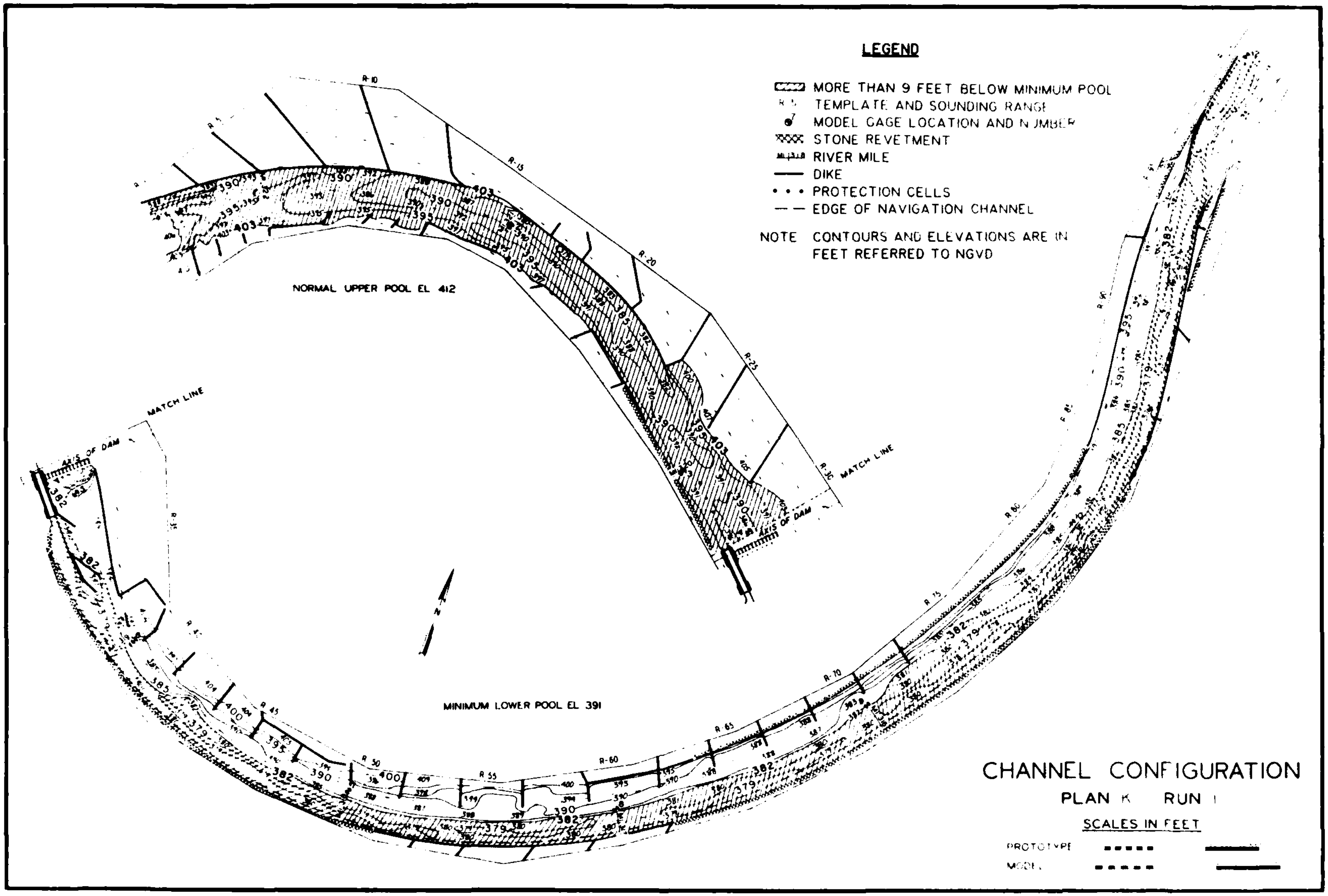
AD-A143 747 SHOALING CONDITIONS IN LOCK AND DAM 13 POOL ARKANSAS RIVER HYDRAULIC MODE..(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS HYDRA.. 2/2

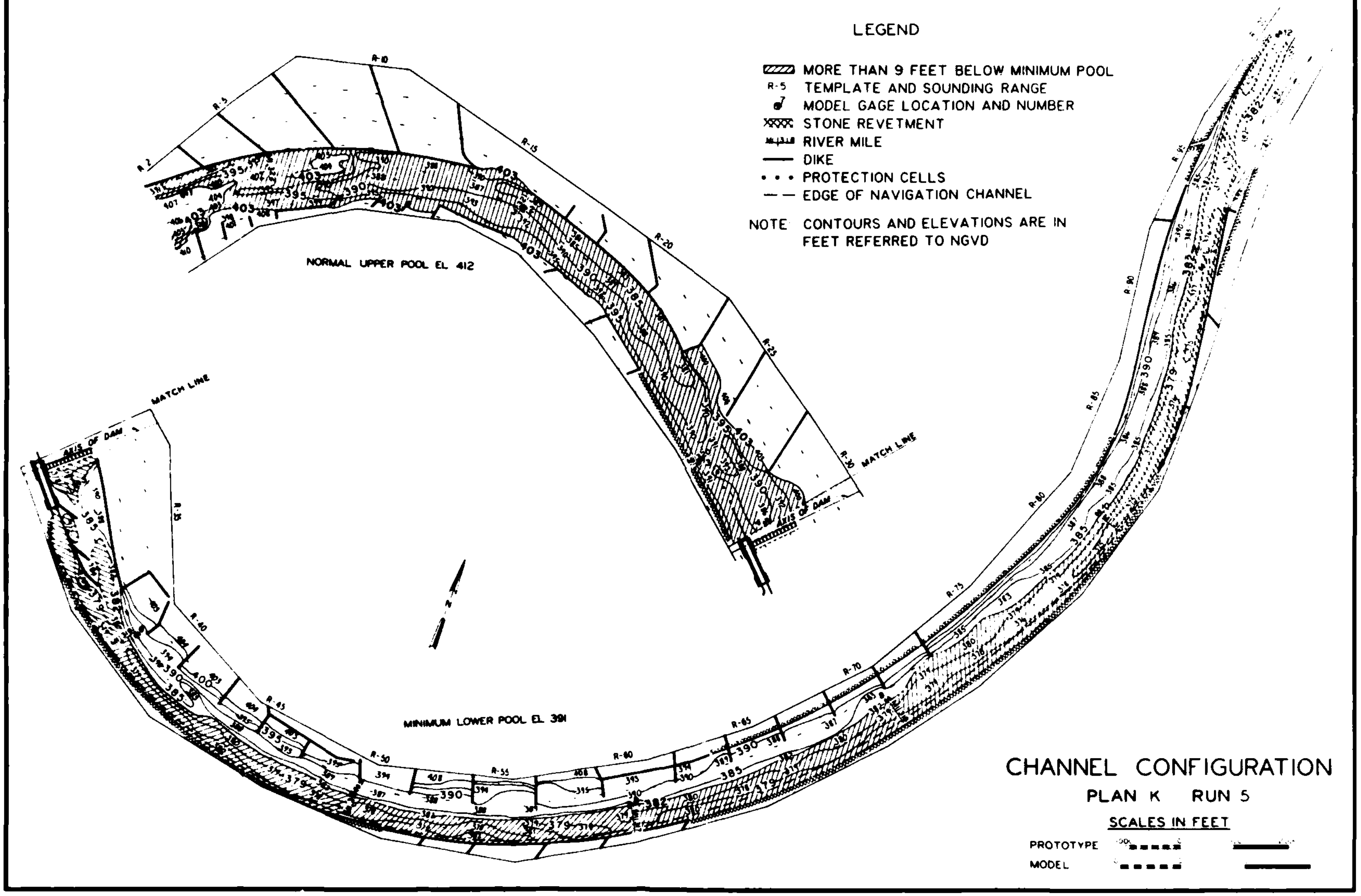
UNCLASSIFIED J E FOSTER ET AL. NOV 83 WES/TR/HL-83-20 F/G 13/2 NL

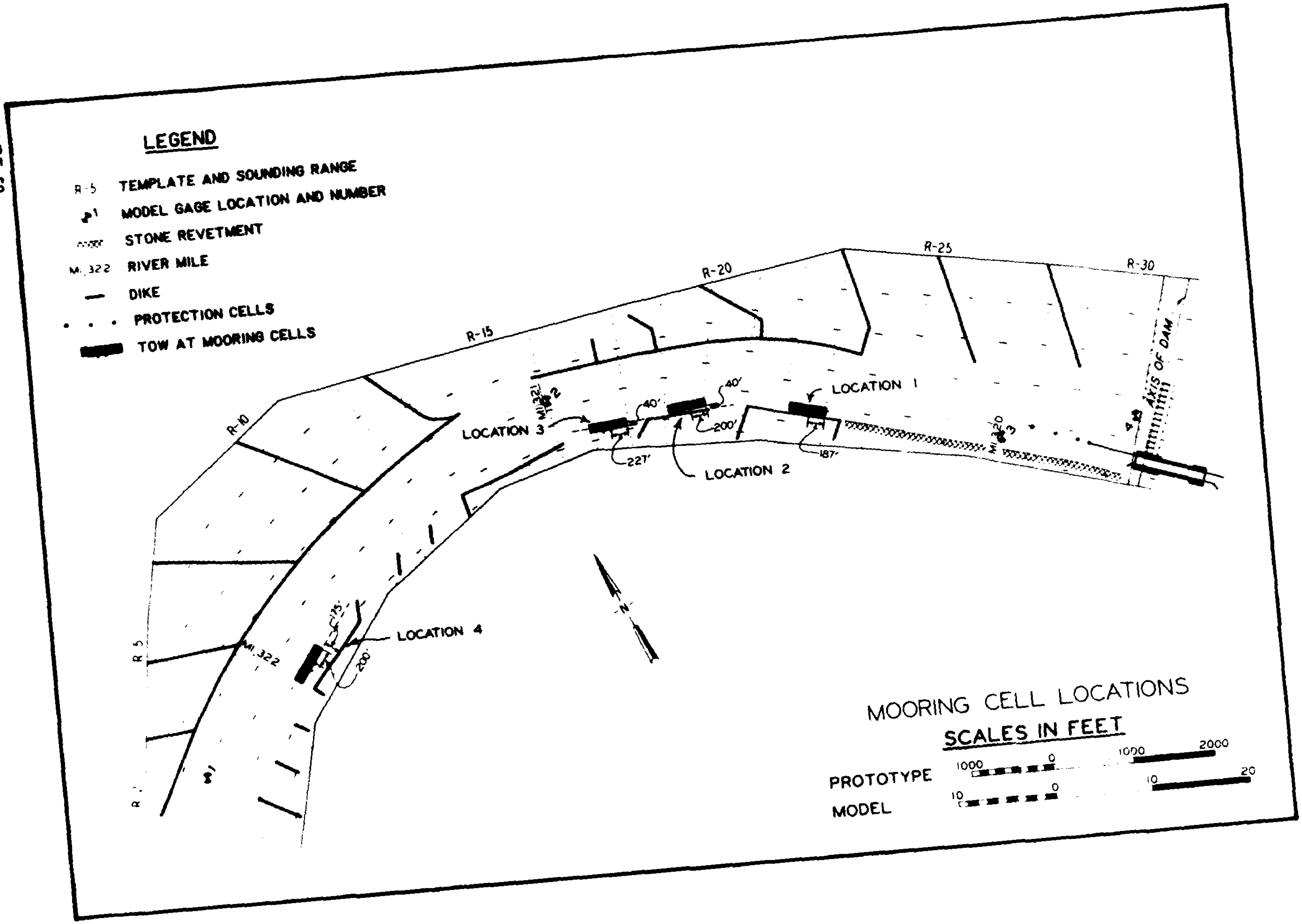


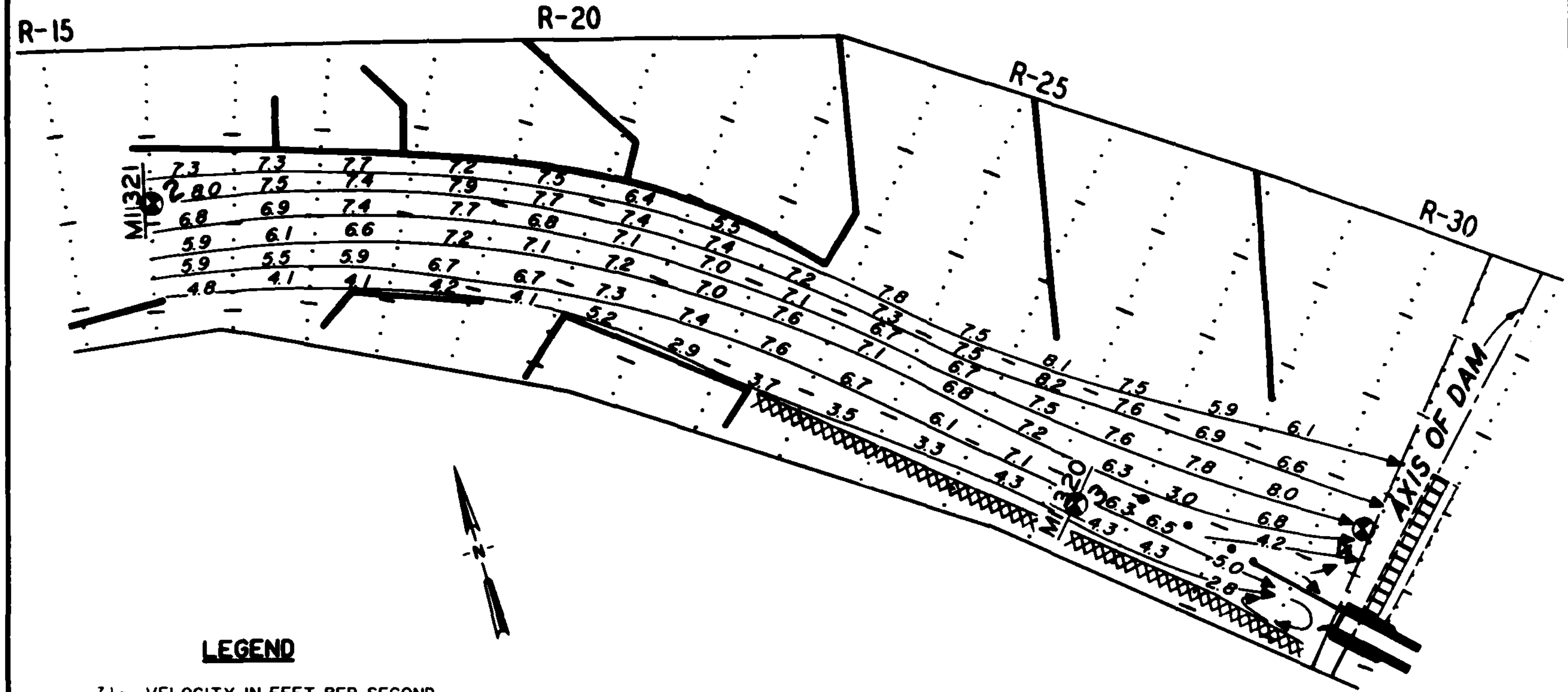
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

PLATE 56


LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE
MATCH LINE
AXIS OF DAM
AXIS OF DAM
CHANNEL CONFIGURATION
PLAN K RUN 1
SCALES IN FEET
PROTOTYPE
MODEL


LEGEND
MORE THAN 9 FEET BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
RIVER MILE
DIKE
PROTECTION CELLS
EDGE OF NAVIGATION CHANNEL
NOTE CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NORMAL UPPER POOL EL 412
MINIMUM LOWER POOL EL 391
MATCH LINE
MATCH LINE
AXIS OF DAM
AXIS OF DAM
CHANNEL CONFIGURATION
PLAN K RUN 5
SCALES IN FEET
PROTOTYPE
MODEL


LEGEND
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
STONE REVETMENT
MI. 322 RIVER MILE
DIKE
PROTECTION CELLS
TOW AT MOORING CELLS
R-10
R-15
R-20
R-25
R-30
AXIS OF DAM
LOCATION 1
LOCATION 2
LOCATION 3
LOCATION 4
187'
200'
40'
40'
227'
175'
200'
MI. 321
MI. 320
MI. 322
R-5
N
MOORING CELL LOCATIONS
SCALES IN FEET
PROTOTYPE
MODEL
1000
0
1000
2000
10
0
10
20



LEGEND

- 7.1 → VELOCITY IN FEET PER SECOND
- DIKE
- XXXX REVETMENT
- ⊗ MODEL GAGE LOCATION AND NUMBER
- MI 322 RIVER MILE
- • • • PROTECTION CELLS

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

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

BASE TEST

MILES 321.0 TO 319.7

DISCHARGE 110,000 CFS

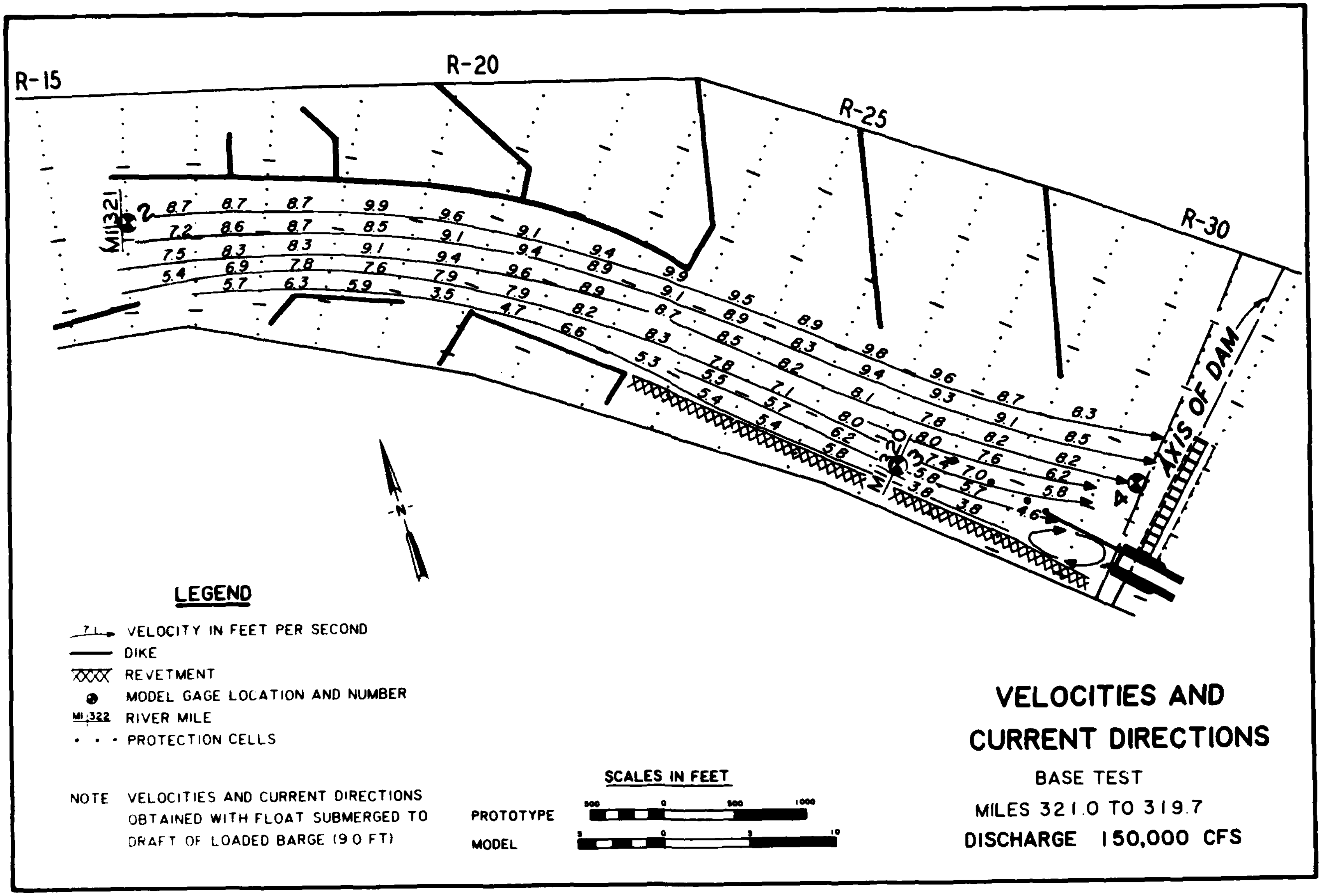
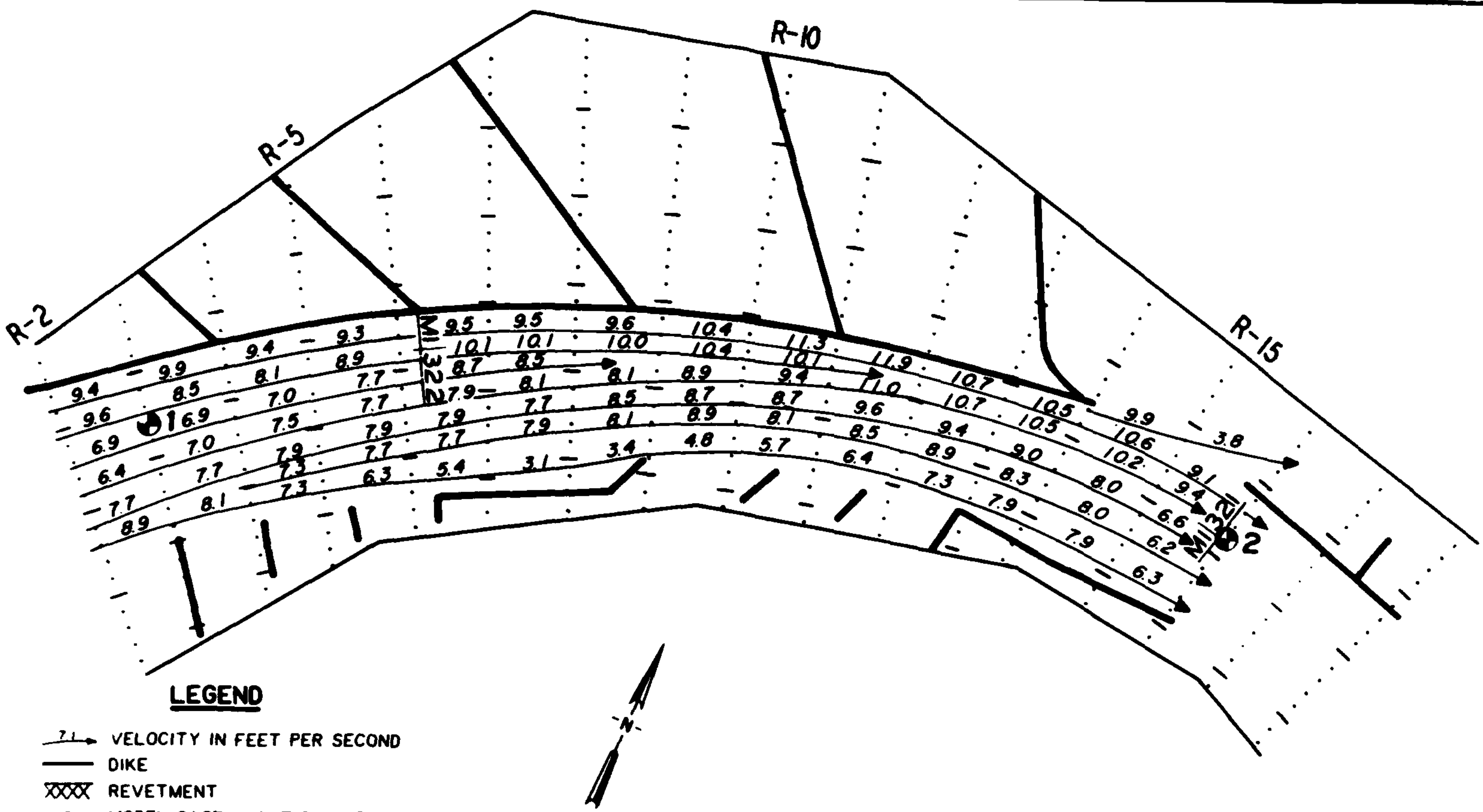

R-15
R-20
R-25
R-30
AXIS OF DAM
N
LEGEND
VELOCITY IN FEET PER SECOND
DIKE
REVETMENT
MODEL GAGE LOCATION AND NUMBER
MI 322 RIVER MILE
PROTECTION CELLS
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
SCALES IN FEET
PROTOTYPE
MODEL
VELOCITIES AND CURRENT DIRECTIONS
BASE TEST
MILES 321.0 TO 319.7
DISCHARGE 150,000 CFS

PLATE 60



LEGEND

- VELOCITY IN FEET PER SECOND
- DIKE
- REVETMENT
- MODEL GAGE LOCATION AND NUMBER
- MI 322 RIVER MILE

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

SCALES IN FEET

PROTOTYPE 500 0 500 1000

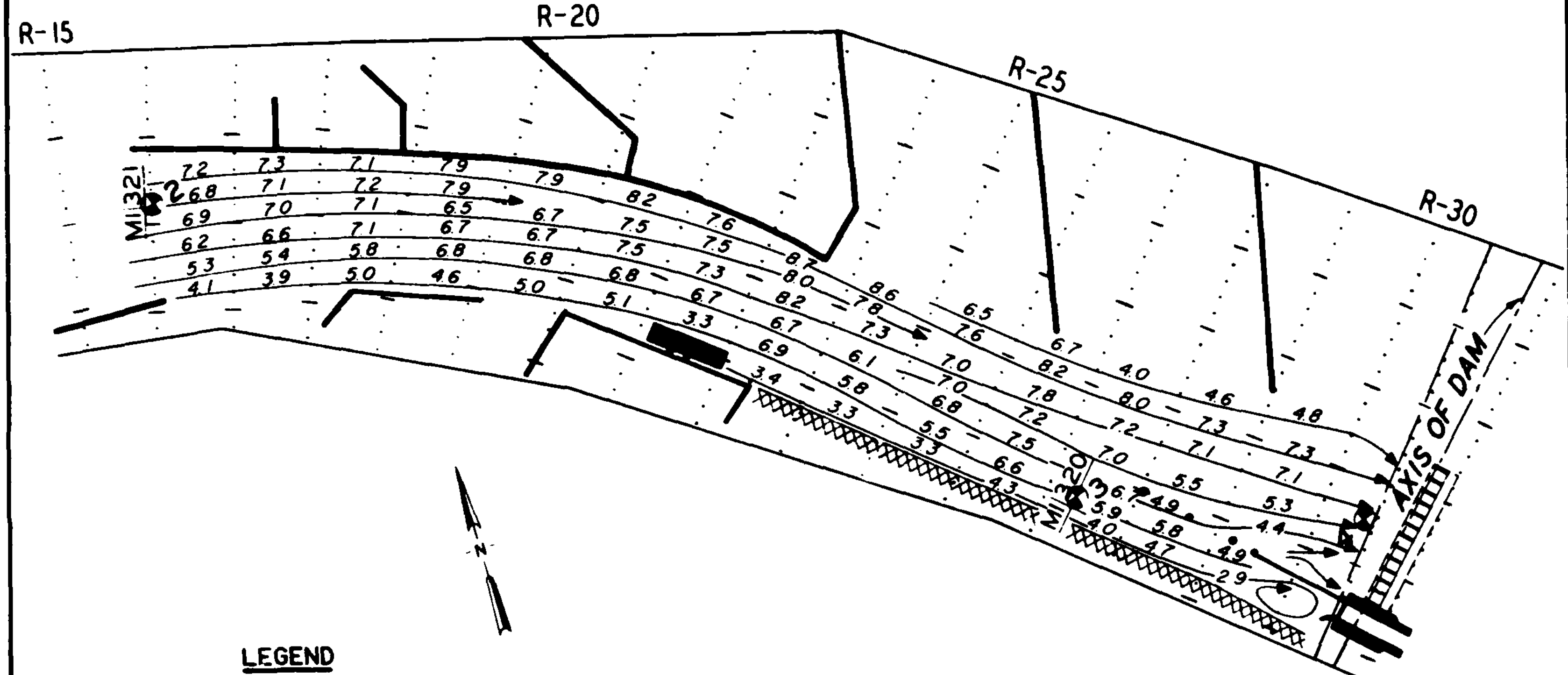
MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

BASE TEST

MILES 322.4 TO 321.0

DISCHARGE 150,000 CFS



LEGEND

- VELOCITY IN FEET PER SECOND
- DIKE
- REVETMENT
- MODEL GAGE LOCATION AND NUMBER
- MI 322 RIVER MILE
- TOW AT MOORING CELLS
- PROTECTION CELLS

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

SCALES IN FEET

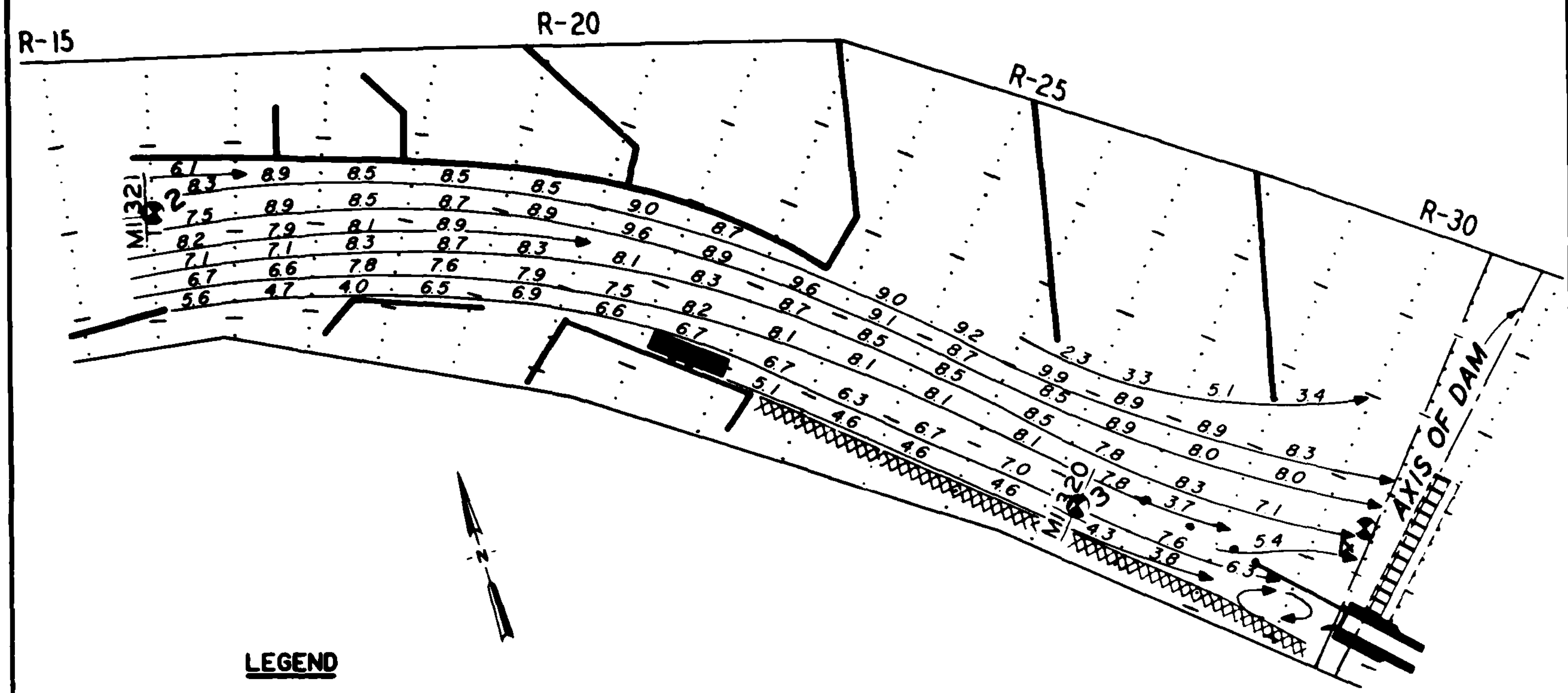
PROTOTYPE 100 500 1000

MODEL 5 5 0

VELOCITIES AND CURRENT DIRECTIONS

TOW AT MOORING FACILITIES
PROPOSED LOCATION I
DISCHARGE 110,000 CFS

PLATE 62



LEGEND

- 7.1 → VELOCITY IN FEET PER SECOND
- DIKE
- REVETMENT
- MODEL GAGE LOCATION AND NUMBER
- MI 322 RIVER MILE
- TOW AT MOORING CELLS
- PROTECTION CELLS

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

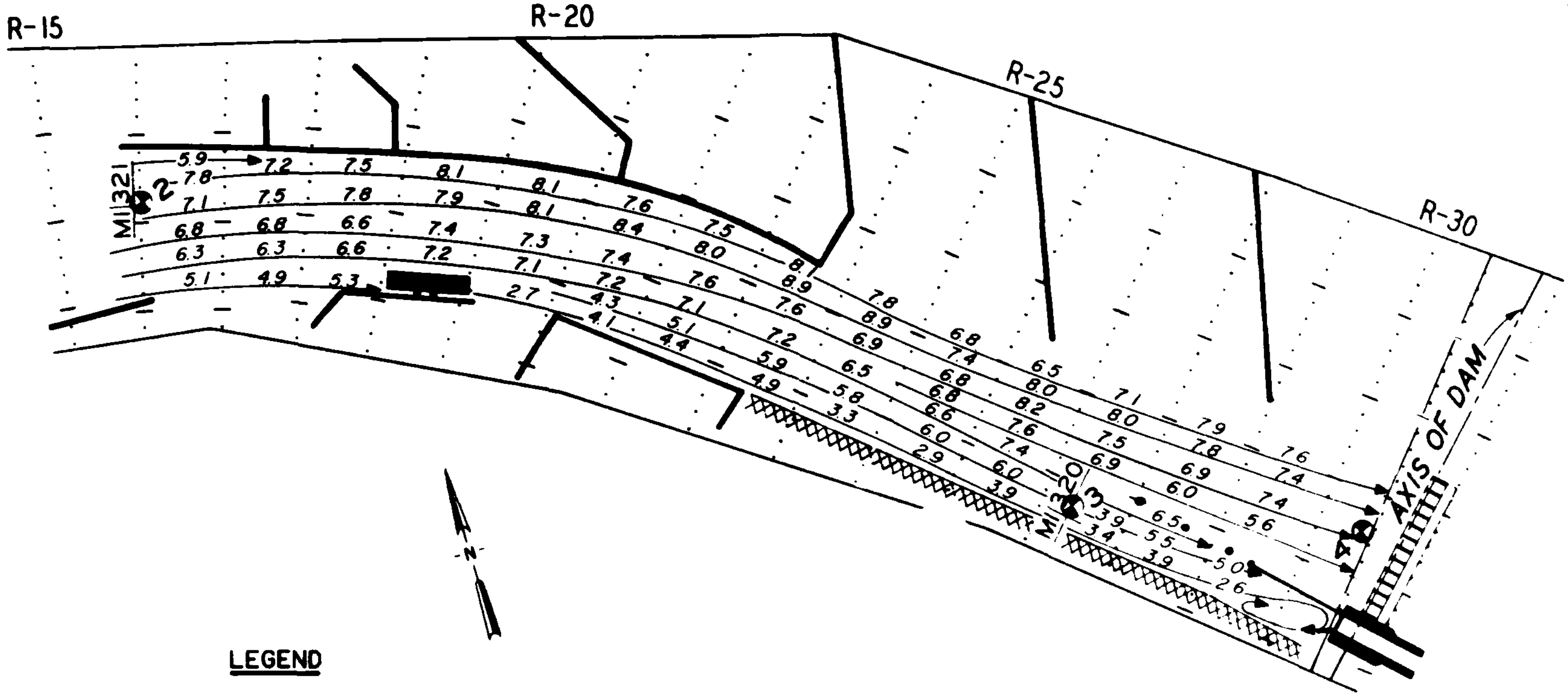
SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

TOW AT MOORING FACILITIES
PROPOSED LOCATION 1
DISCHARGE 150,000 CFS



LEGEND

- 7.1 → VELOCITY IN FEET PER SECOND
- DIKE
- REVETMENT
- MODEL GAGE LOCATION AND NUMBER
- MI 322 RIVER MILE
- TOW AT MOORING CELLS
- PROTECTION CELLS

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

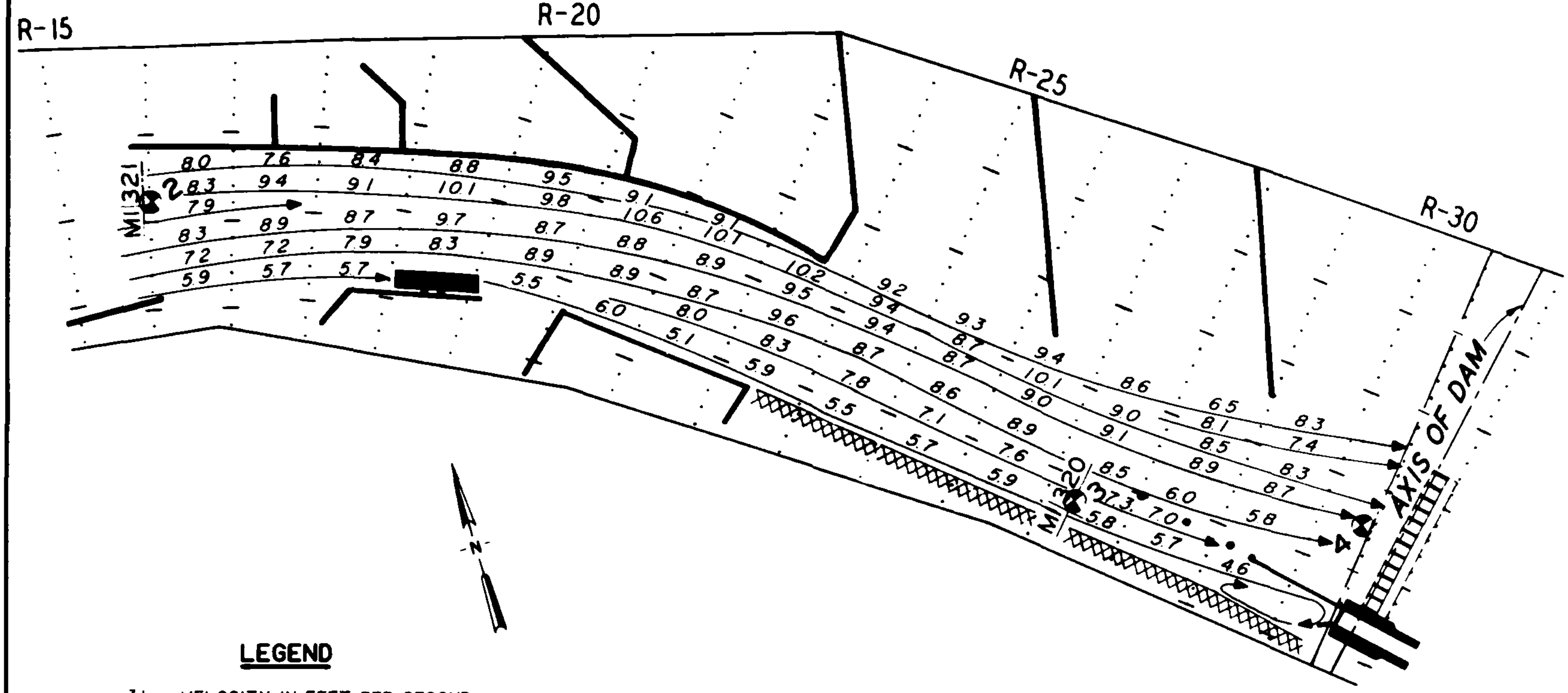
SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

TOW AT MOORING FACILITIES
PROPOSED LOCATION 2
DISCHARGE 110,000 CFS



LEGEND

- 7.1 → VELOCITY IN FEET PER SECOND
- DIKE
- REVETMENT
- MODEL GAGE LOCATION AND NUMBER
- MI 322 RIVER MILE
- TOW AT MOORING CELLS
- • • • PROTECTION CELLS

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

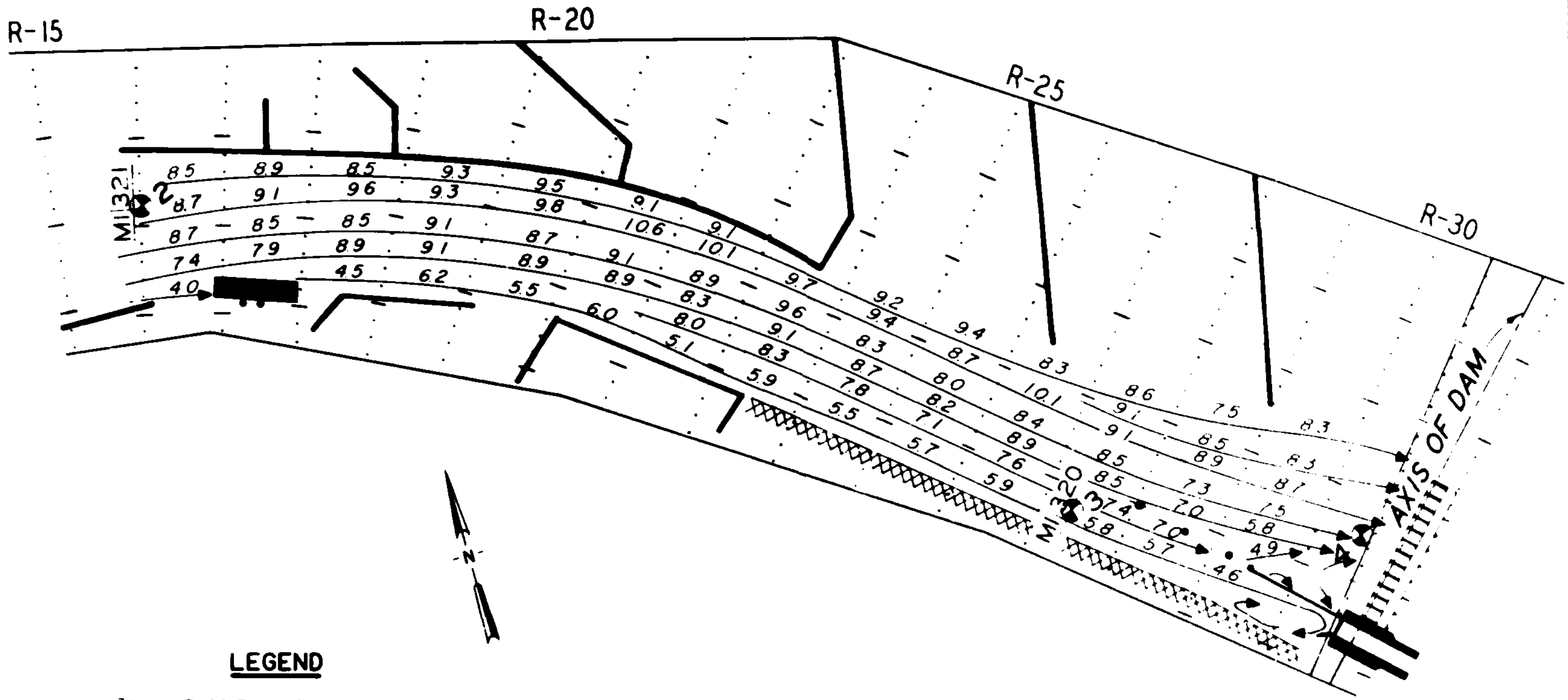
SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

TOW AT MOORING FACILITIES
PROPOSED LOCATION 2
DISCHARGE 150,000 CFS



LEGEND

- VELOCITY IN FEET PER SECOND
- DIKE
- REVETMENT
- MODEL GAGE LOCATION AND NUMBER
- MI 322 RIVER MILE
- TOW AT MOORING CELLS
- PROTECTION CELLS

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

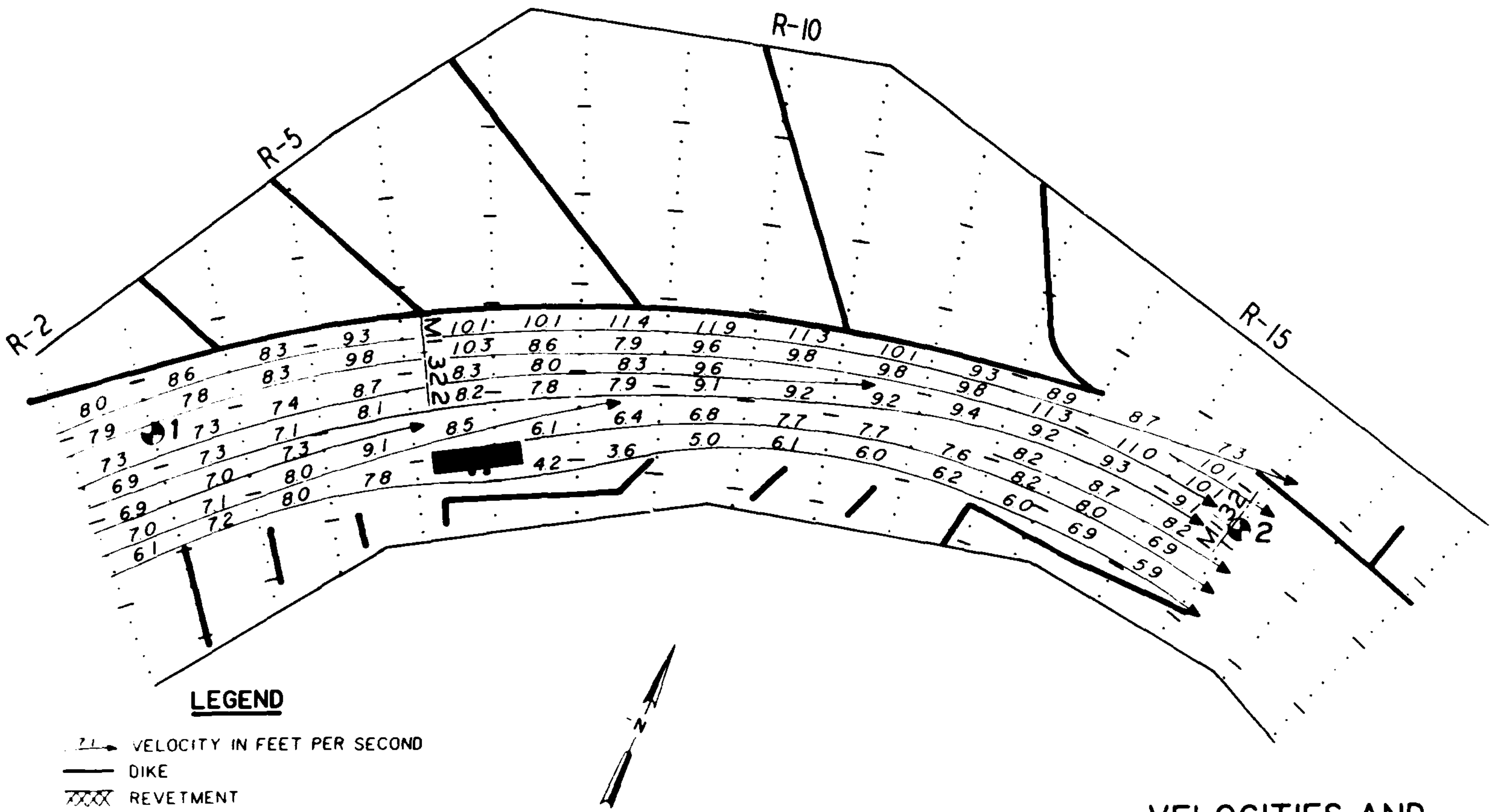
SCALES IN FEET

PROTOTYPE

MODEL

VELOCITIES AND CURRENT DIRECTIONS

TOW AT MOORING FACILITIES
PROPOSED LOCATION 3
DISCHARGE 150,000 CFS



LEGEND

- 7.1 → VELOCITY IN FEET PER SECOND
- DIKE
- REVETMENT
- MODEL GAGE LOCATION AND NUMBER
- MI 322 RIVER MILE
- TOW AT MOORING CELLS

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

SCALES IN FEET

PROTOTYPE

MODEL

VELOCITIES AND CURRENT DIRECTIONS

TOW AT MOORING FACILITIES
PROPOSED LOCATION 4
DISCHARGE 150,000 CFS

END

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