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NAVIGATION CONDITIONS AT ALICEVILLE LOCK AND DAM, MISSISSIPPI AND ALABAMA TOMBIGBEE RIVER

Hydraulic Model Investigation

by

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Aliceville Lock and Dam will be the second navigation structure proposed for the development of navigation on the Tennessee-Tombigbee Waterway. The lock will be along the left bank of the Tombigbee River about 333 miles above the mouth of the Mobile River, which is at the foot of Government Street in Mobile, Alabama, or approximately 67 miles above the proposed Gainesville Lock and Dam. The structures will include one lock with clear chamber dimensions of 110 by 600 ft and a dam consisting of a gated spillway and a fixed-crest overflow weir
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20. ABSTRACT (Continued).

designed to maintain during low flows a minimum upper pool at el 136.0 extending upstream about 32 miles to the proposed Columbus Lock and Dam.

A fixed-bed model reproducing about 2.8 miles of the Tombigbee River channel and adjacent overbank to an undistorted scale of 1:100 was used to determine navigation conditions with the proposed design and to develop such modification as might be required to eliminate conditions that would adversely affect navigation using the lock. The model was also used to determine conditions that might be expected during construction of the lock and dam with the proposed construction plan. Results of the investigation revealed the following: (a) satisfactory navigation conditions in the upper lock approach could be developed with modification of the excavation along the left bank of the approach channel and excavation of the right bank in the bend near the upper end of the approach channel; (b) navigation conditions in the lower lock approach could be improved considerably with a dike angled riverward along the right side of the approach channel; (c) two-way traffic in the second bend upstream of the upper lock approach would be difficult and hazardous during the higher flows; (d) recommended changes to the original plan would have little effect on water-surface elevations in the reach or on conditions that could be expected during construction of the lock and dam.

PREFACE

The model investigation reported herein was authorized by the Office, Chief of Engineers, U. S. Army, in an indorsement dated 15 May 1972 to the Division Engineer, U. S. Army Engineer Division, South Atlantic. The study was conducted for the U. S. Army Engineer District, Mobile, in the Hydraulics Laboratory of the U. S. Army Engineer Waterways Experiment Station (WES) during the period June 1972 to September 1976.

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

During the course of the model study, Messrs. W. Odom, A. F. Baer, B. Felder, and F. Thompson of the U. S. Army Engineer District, Mobile (SAM) visited WES at different times to observe special model tests and discuss the results. SAM was kept informed of the progress of the study through monthly progress reports and special reports at the end of each test.

Directors of WES during the course of the investigation and the preparation and publication of this report were COL L. A. Brown, CE, BG E. D. Peixotto, CE, COL G. H. Hilt, CE, and COL John L. Cannon, 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
feet	0.3048	metres
miles (U. S. statute)	1.609344	kilometres
square miles (U. S. statute)	2.589988	square kilometres
cubic feet per second	0.02831685	cubic metres per second
feet per second	0.3048	metres per second
degrees (angle)	0.01745329	radians

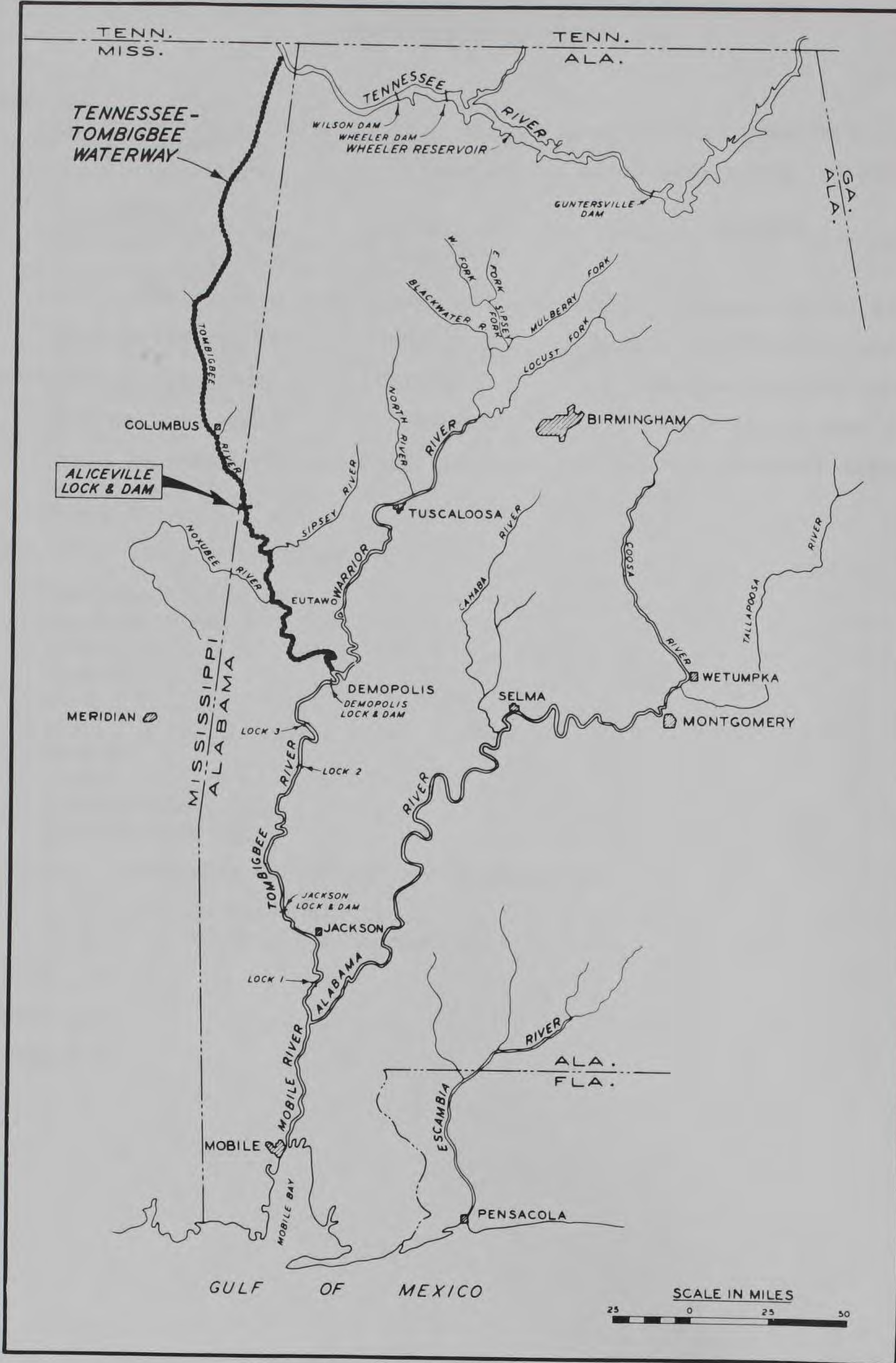

Figure 1. Location map

NAVIGATION CONDITIONS AT ALICEVILLE LOCK AND DAM, MISSISSIPPI AND ALABAMA, TOMBIGBEE RIVER

Hydraulic Model Investigation

PART I: INTRODUCTION

Location of Proposed Lock and Dam and Description of Prototype*

1. Aliceville Lock and Dam is proposed for construction in west central Alabama on the Tombigbee River, about 1 mile** southwest of Pickersville in Pickens County, Alabama (Figure 1). The lock will be constructed in the left overbank about 332.7 river miles above the Mobile River mouth which is at the foot of Government Street in Mobile, Alabama, or approximately 115.7 miles above the confluence of the Tombigbee and Warrior Rivers and 119.5 miles above Demopolis Lock and Dam. The dam will be placed across the main river channel adjacent to the lock. This lock and dam will be the second navigation structure proposed for the development of the Tennessee-Tombigbee Waterway. The structure is designed to maintain, during low flows, a minimum upper pool extending upstream to the proposed Columbus Lock and Dam at mile 342.2.

2. The Tombigbee River above the proposed Aliceville Dam site drains a 5,785 square-mile area or 29 percent of the 20,100 square miles for the Tombigbee River basin. The drainage area lies within the Coastal Plains with elevations ranging from about 1000 ft† at the highest point to 96 ft at the damsite. The Tombigbee River is formed at the junction of the East and West Forks near Amory, Mississippi, and flows

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* Prototype information was obtained from Aliceville Lock and Dam, Tombigbee River, Mississippi and Alabama, Design Memorandum No. 4.

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

† All elevations (el) cited herein are in feet referred to mean sea level (msl).

59 miles nearly due south to Columbus, Mississippi, thence 23 miles southeast to the Aliceville Dam site.

3. The ridge separating the Tennessee River from the headwaters of the Tombigbee is about 15 miles south of the Tennessee River in extreme northeast Mississippi. The ridge divides the waters of Yellow Creek, which flows northward into the Tennessee River, from the waters of Mackeys Creek, which flows southward to the East Fork of the Tombigbee. The proposed Tennessee-Tombigbee project will cut a channel through this divide to el 395.0 and connect these rivers for navigation by means of locks and dams. At low stages, the Tombigbee River varies in width from 75 ft at its source to 400 ft at Demopolis. The principal tributaries of the Tombigbee River above the Aliceville Dam site are the East and West Forks which form the stream, the Buttahatchee and Tibbee Rivers, and Luxapalila Creek.

Present Plan of Improvement and Development

4. The Tennessee-Tombigbee project, first authorized in the 1946 River and Harbor Act, consists of three reaches: the River Section, the Canal Section, and the Divide Section. The River Section will consist of a 173-mile-long reach of river which will extend up the Tombigbee River from Demopolis, Alabama, to Amory, Mississippi, and will involve straightening the river channel and building conventional locks and dams near Gainesville and Aliceville, Alabama, and Columbus and Aberdeen, Mississippi. The Canal Section will consist of a 45-mile-long canal that will parallel the Tombigbee River on the east from near Amory to Mackeys Creek near Old Bay Springs in the southwest corner of Tishomingo County, Mississippi, and will involve the construction of a canal, by excavation and levees, with five locks. The Divide Section will consist of a 40-mile-long canal that will extend from Bay Springs to the Yellow Creek arm of Pickwick Lake on the Tennessee River near the common boundary of Mississippi, Alabama, and Tennessee, involving a 27-mile-long cut through the Divide separating the Tombigbee and Tennessee Basins. The River Section will be a minimum of 9 ft deep,

and the Canal and Divide Sections will be 12 ft deep. The bottom width will be 300 ft except in the actual Divide Cut, where it will be 280 ft. The lock chambers, with clear dimensions of 110 by 600 ft, will have a depth of 15 ft over the miter gate sills, corresponding to the new locks on the connecting waterways. The locks will provide a total lift of 341 ft to overcome the difference in elevation between Demopolis Lake on the Tombigbee River and Pickwick Lake on the Tennessee River.

5. The major portion of the prospective commerce consists of upbound movement of commodities which are normally moved in bulk. Virtually all the upbound commerce originates in the immediate trade areas of the Gulf ports or at industries or producing areas along the Gulf Intracoastal Waterway. Upbound traffic originating at New Orleans or west thereof would terminate generally along the upper Tennessee River; traffic originating at Mobile or ports to the east, owing to the greater distance advantage in comparison with the Mississippi River, would be distributed over a much broader area along the Ohio and the upper Mississippi Rivers and tributaries. Similarly, a large part of the downbound traffic would terminate along the Gulf coast or be exported through the ports of Mobile or New Orleans. Shippers and receivers along the Warrior River, principally Tuscaloosa and Birmingham, would also contribute an appreciable volume of traffic to the waterway.

Description of Proposed Structures

6. Aliceville Lock and Dam (Figure 2) is designed to maintain a normal upper pool at el 136.0. The navigation lock will provide clear chamber dimensions of 110 ft wide and 600 ft long with 670 ft between the center lines of the gate pintles. The dam will consist of a gated spillway to be located in the river channel and an adjacent 150-ft-long overflow weir located on the right overbank. The gated spillway crest will be at el 111.0, the overflow weir crest at el 135.5. The dam will be connected to the lock on the left bank with a 115.5-ft-long abutment wall with top el 146.0. The overflow weir will be connected to the right bank with a 115-ft-long abutment wall with top el 146.0.

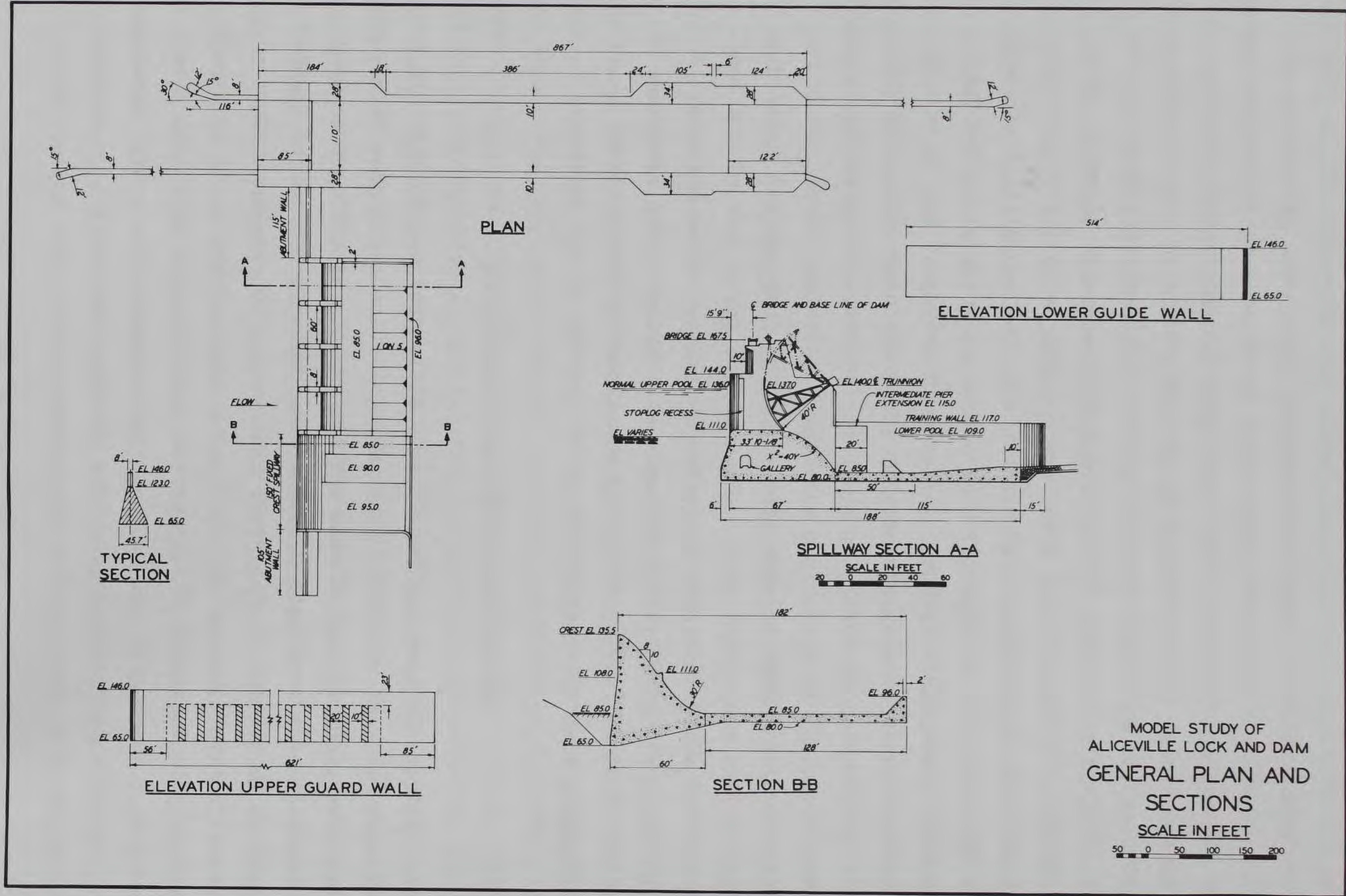


Figure 2. General plan and sections

A public use area with top el 146.0 will be located on the right bank adjacent to the dam. An overflow earth-fill dike, access road, will connect the public use area to high ground on the right overbank. A non-overflow access road will connect the lock to high ground on the left overbank. The upper approach to the lock will be excavated to el 123.0 along the left bank and the upper approach to the overflow weir will be excavated to el 130.5 along the right bank. The river channel downstream of the lock will be excavated to provide a 300-ft bottom width at el 96.0.

Need for, Scope, and Purpose of Model Study

7. The general design of Aliceville Lock and Dam was based on sound theoretical design practice and experience with similar structures. However, navigation conditions vary with location and flow conditions upstream and downstream of a structure, and an analytical study to determine the hydraulic effects that can reasonably be expected to result from a particular design is both difficult and inconclusive. Thus, a comprehensive model study was considered necessary to investigate conditions that could be expected with the proposed design and to develop modifications required to ensure satisfactory navigation conditions.

8. The locations of the lock and dam were fixed at the time the model study was undertaken. Therefore, the specific purpose of the model was not only to investigate navigation conditions in the bends upstream and downstream of the lock and in the lock approaches and flow conditions and discharge distribution at the dam with various riverflows, but also to develop modifications that might be required to eliminate any undesirable conditions. In addition, the model was used to determine stages, current directions, and velocities with the lock and dam in place, to demonstrate to navigation interests the conditions resulting from the proposed design, and to satisfy these interests of its acceptability from a navigation standpoint. The model was also used to determine conditions that could be expected during construction of the lock and dam with the proposed construction plan.

PART II: THE MODEL

Description

9. The model reproduced about 2.75 miles of the Tombigbee River, extending about 8500 ft upstream of the dam to about 6000 ft downstream of the dam including the adjacent overbanks areas. Also included were the navigation lock, the gated- and fixed-crest sections of the dam, and the diversion canal on the right overbank (Figure 3). The model was of the fixed-bed type, with the channel and overbank areas molded in sand-cement mortar to sheet metal templates. Portions of the model, where changes in bank alignments and channel configurations could be anticipated, were molded in pea gravel to permit modifications that might be required to provide satisfactory conditions. The lock, dam crest, and piers were fabricated of sheet metal. The dam gates were simulated schematically with simple sheet-metal slide-type gates.

10. The model was molded to the hydrographic and topographic survey dated February 1972. Overbank areas were molded to a maximum elevation of 140.0, which was considered sufficient for the reproduction and investigation of flows that would affect navigation.

Scale Relations

11. The model was built to an undistorted linear scale ratio of 1:100, model to prototype, to obtain accurate reproduction of velocities, crosscurrents, and eddies that would affect navigation. Other scale ratios resulting from the linear scale ratio were as follows:

Area	1:10,000
Velocity	1:10
Time	1:10
Discharge	1:100,000
Roughness (Manning's n)	1:2.15

Measurements of discharges, water-surface elevations, and current velocities can be transferred quantitatively from model to prototype equivalents by means of these scale relations.

Figure 3. View of the model showing the arrangement of the lock and dam with the original plan

Appurtenances

12. Water was supplied to the model by means of a 10-cfs axial flow pump operating in a circulating system; the discharge was controlled and measured at the upper end of the model by means of a valve and a venturi meter. Water-surface elevations were measured by means of 10 piezometer gages located in the model channel and connected to a centrally located gage pit (Figure 4). For control riverflows, upper pool stages were controlled at the dam by opening and closing the slide gates; for open riverflows, tailwater elevations were controlled by means of a tailgate located at the lower end of the model.

13. Velocities and current directions were obtained in the model by means of wooden cylindrical floats weighted on one end so that they would be submerged to the depth of a loaded barge. Two model towboats

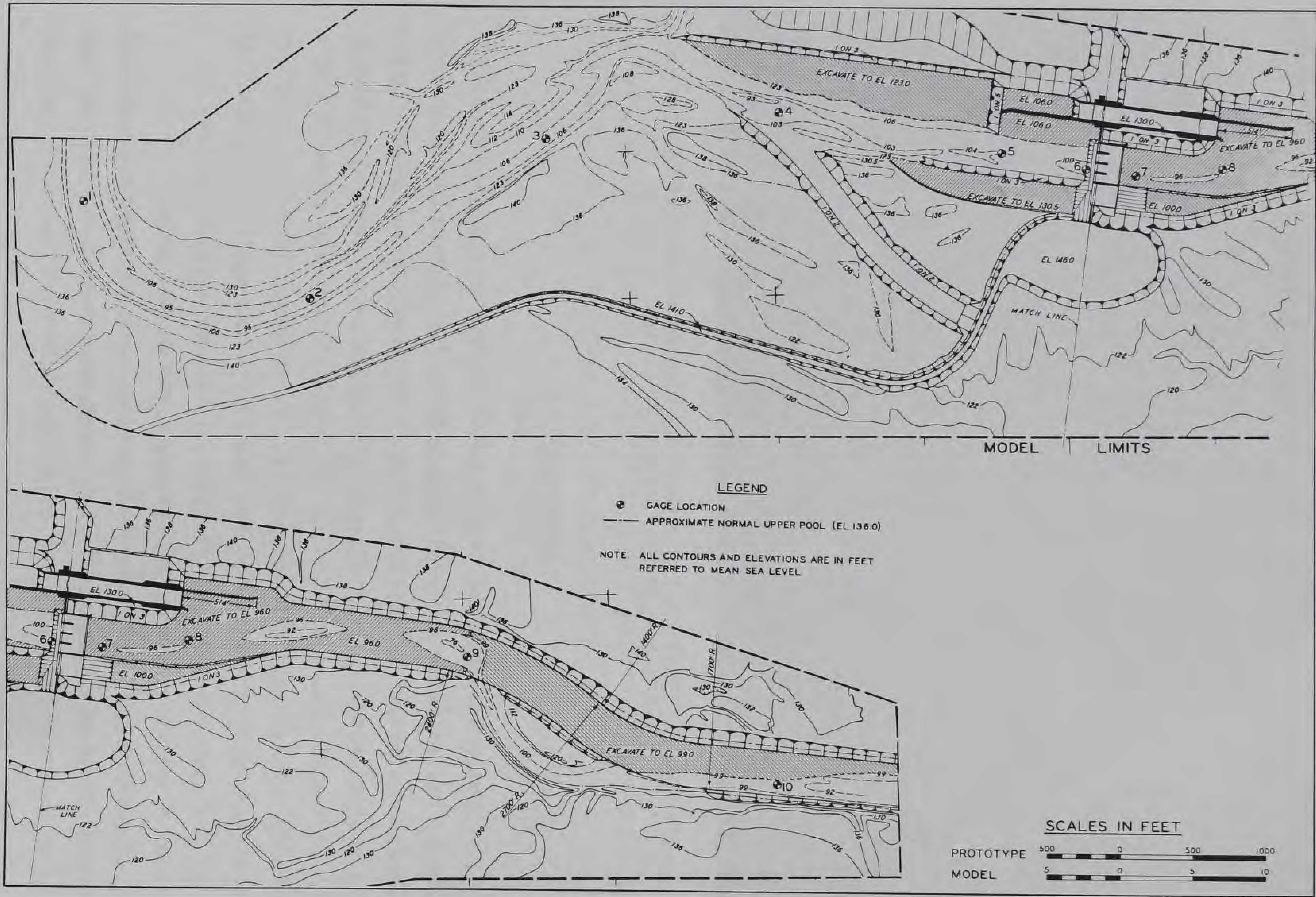


Figure 4. Model layout and gage locations

and tows (Figure 5) were used to determine and demonstrate the effects of currents on tows approaching and leaving the lock and while moving through the bends upstream and downstream of the lock. Each towboat was equipped with twin screws and propelled by two small electric motors operating from batteries located in the model tow; the rudders and speed of the towboat were remote-controlled. The power of the towboat was adjusted by means of a rheostat to a maximum speed comparable to that of towboats expected to use the Tennessee-Tombigbee Waterway.

Figure 5. Remote-controlled towboat and tow in the upper lock approach

Model Adjustment

14. Inclusion of the proposed plans in the initial model construction precluded adjustment of the model to the existing prototype conditions. This type of adjustment was not considered necessary since the proposed improvements would involve considerable change from

existing conditions. The model was constructed with a brushed-cement mortar finish to provide a roughness factor (Manning's n) of about 0.0135, which corresponds to a prototype channel roughness of about 0.029. Based on experience with other models of this type, brushed concrete gives a close approximation of the roughness required to reproduce prototype conditions.

PART III: TESTS AND RESULTS

15. Tests on the model were concerned primarily with the study of flow patterns, measurement of velocities and water-surface elevations, and behavior of the model tows moving in the lock approaches and in the reaches upstream and downstream. Since the worst conditions, as far as navigation was concerned, were obtained in the model during the higher river stages with uncontrolled riverflows, no tests were conducted to determine the effects of dam gate operation during controlled flows other than with all spillway gates open the same.

Test Procedures

16. Tests were conducted by reproducing stages and discharges with the computed tailwater elevations for the improved channel furnished by the U. S. Army Engineer District, Mobile, as follows:

- a. A controlled riverflow of 30,000 cfs at normal upper pool el 136.0.
- b. Maximum flow at which normal pool el 136.0 could be maintained at the dam (53,000 cfs).
- c. An intermediate flow (4-1/2-year frequency, 85,000 cfs) tailwater el 142.1 at the dam.
- d. Maximum navigable flow (8-year frequency, 114,000 cfs), tailwater el 144.4 at the dam.
- e. Revised maximum navigable flow (12-year frequency, 125,000 cfs), tailwater el 144.7 at the dam.

The controlled riverflow was reproduced by introducing the proper discharge, setting the tailwater elevation for the discharge, and manipulating the dam gate openings until the required upper pool elevation was obtained. Uncontrolled riverflows were reproduced by introducing the proper discharge with dam gates fully open and manipulating the tailgate to obtain the proper tailwater elevation below the dam. All stages were permitted to stabilize before any data were recorded. Current directions were determined by plotting the paths of the wooden floats (paragraph 13) with respect to ranges established for that purpose, and velocities were measured by timing the travel of the floats over known distances. No data were obtained with the model tow other than the observations of its behavior in the bends and the lock approaches. Flow distributions through the gated spillway were based on velocity measurements in each gate bay.

17. Most of the modifications were developed during preliminary tests. Data obtained during these tests were sufficient only to assist in the development of a plan that appeared to provide the improvements required. Results of the preliminary tests are not included in this report.

Original Plan

Description

18. The original plan proposed for the lock and dam and the channel just upstream and downstream of the dam are shown in Figure 6 and include the following principal features:

a. A nonnavigable gated spillway, located across the river channel, containing five 8-ft-wide piers and four 60-ft gate bays with gate sills at el 111.0. A 150-ft-long overflow weir section with crest at el 135.5 located to the right of the gated spillway. A 115-ft-long nonoverflow abutment wall, top el 146.0, connected the right end of the overflow weir to the right bank. A 115.5-ft-long nonoverflow abutment wall, top at el 146.0, connected the left end of the dam to the lock.

b. A navigation lock with clear chamber dimensions of 110 ft by 600 ft located along the left overbank. The lock had a 514-ft-long, nonported lower guide wall and a 621-ft-long ported, buttress type, upper guard wall. Tops of lock walls were at el 146.0. The upper guard wall contained seventeen 20-ft-wide ports with top of ports at el 123.0.

c. A nonoverflow dike (access road), top el 148.0, connected the lock to high ground on the left overbank.

d. A public use area with top el 146.0 located on the right overbank adjacent to the dam abutment wall. The public use area was connected to high ground on the right overbank by a 7200-ft-long overflow dike and access road with top el 141.0.

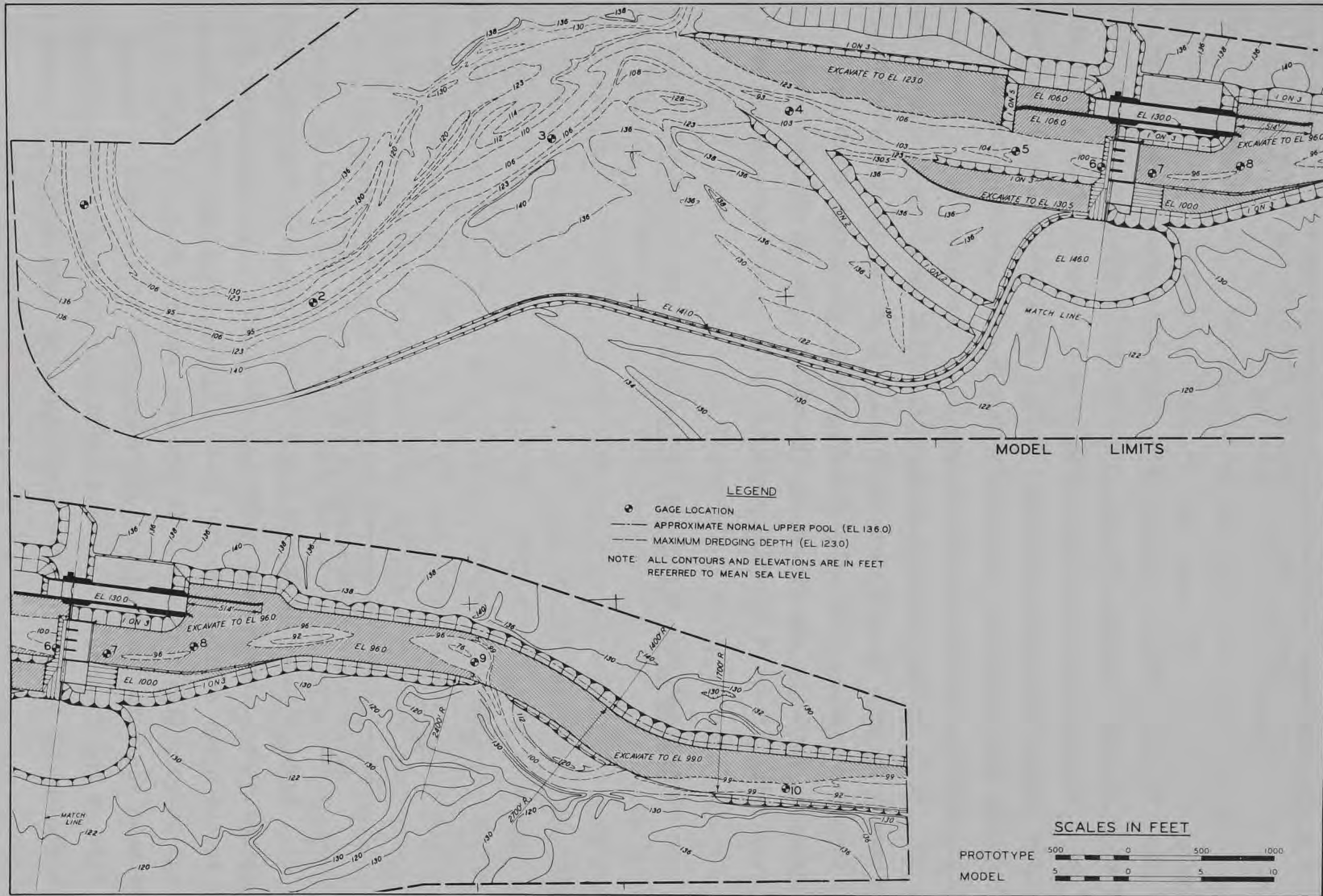


Figure 6. Original plan

e. The upper approach to the lock was excavated to el 123.0.

f. The upper portion of the diversion canal that would be used during construction of the lock and dam was left in place.

Results

19. Results shown in Table 1 indicated that the drop in water-surface elevation through the dam (gages 6 and 7) was about 0.6 ft with the open riverflows tested. The total drop in water-surface elevation from the end of the upper guard wall to the lower end of the lock (gages 5-8) ranged from about 0.7 ft with the 53,000-cfs flow to about 0.8 ft with the 85,000- and 114,000-cfs flows.

20. Distribution of flow through the gated spillway was generally good except through the gate bay near the lock which was considerably less than the average (see tabulation below). The lower discharge through that gate bay was caused by the offset between the lock and spillway which affected the alignment of currents approaching the gate bay.

Discharge Distribution in Percent of Total Flow

Gate Bay	Discharge 53,000 cfs
1	21.1
2	26.4
3	26.3
4	25.8
Weir	0.4

Note: Gate bays numbered from left to right.

21. Results shown in Plates 1-4 indicate that with the lower flows the alignment of currents was generally parallel to the bank lines except in the upper approach to the lock. During the higher flows (85,000 cfs and above), flow from the left overbank moved across the neck of the upper bend and into the channel just downstream of the bend. Some of the flow in the channel in the bend moved over the right overbank near the lower end of the bend. This condition increased with an increase in

stage and discharge. There was a small tendency for currents in the upper approach to the lock to move away from the left bank across the lock approach, mostly during the lower flows. The highest velocities in the upper reach and in the upper lock approach were obtained with the 53,000-cfs flow. Maximum velocities were about 6.4 fps in the upper reach and about 5.0 fps in the lock approach.

22. Currents from the spillway channel angled toward the left bank across the lower lock approach just downstream of the end of the lock wall, and a counterclockwise eddy formed along the guide wall. The angle of the currents moving toward the left bank decreased an with increase in river stage and discharge. Maximum velocities of the currents moving across the lower lock approach ranged from less than 3.0 fps with the lower flows tested to about 4.8 fps with the 85,000-cfs flow. A clockwise eddy formed downstream of the overflow weir to the right of the spillway during flows up to 85,000 cfs. The intensity of the eddy decreased with an increase in stage and discharge.

23. Navigation conditions upstream of the upper lock approach were generally satisfactory for one-way traffic during most flows. With the 114,000-cfs discharge, flow moving from the channel in the upper bend toward the right overbank would produce currents hazardous for downbound tows moving around the bend. Conditions were also difficult and hazardous for downbound tows within the upper lock approach because the tows tended to move riverward before reaching the end of the upper guard wall. This condition was attributed to the shallow depths in the approach channel and the effect of tows on the currents within the approach. Some difficulties were indicated for upbound tows approaching the lower guide wall because of the effects of currents moving toward the left bank and eddy currents along the guide wall which combined to rotate the tow counterclockwise, moving the head of the tow away from the guide wall.

Plan A

Description

24. Plan A was designed to improve navigation conditions in the

lock approaches and to determine the effects of reducing the length of the lower guide wall. The plan was the same as the original plan except for the following modifications (Figure 7):

a. Two circular cells were placed upstream of the end of the upper guard wall and in line with the lock side of the wall. The cells were placed 75 ft on centers with the first cell placed 75 ft from the end of the wall. The bottom of the channel between the end of the guard wall and the first cell was raised to el 123.0.

b. The length of the lower guide wall was reduced from 514 ft to 400 ft.

c. A 125-ft-long rock dike was placed along the right side of the lower lock approach channel starting 50 ft from the end of the riverside lock wall. The dike was angled about 30 deg riverward of the alignment of the wall.

Results

25. Results shown in Table 2 indicate practically no change in water-surface elevations compared with those obtained with the original plan. The cells placed upstream of the end of the upper guard wall had little effect on the alignment and velocity of currents in the upper approach to the lock (Plates 5 and 6). There was some increase in the flow moving toward the lock side of the upper guard wall and through the ports in the wall, but the increase was not sufficient to have any significant effect on currents in the approach.

26. There was some reduction in the velocity of currents moving toward the left bank across the lower lock approach and some improvement in the alignment of currents. The eddy along the lock side of the lower guide wall was smaller in size and intensity because of the rock dike to the right of the approach channel.

27. Navigation conditions for downbound tows were about the same as those with the original plan. Tows approaching the lock would experience difficulties in making a satisfactory approach because of the tendency for the tows to be moved riverward before reaching the cells upstream of the guard wall. Navigation conditions in the lower lock approach were considerably better than with the original plan. The tendency for the head of an upbound tow to be moved away from the lower guide wall was small and no serious difficulties were indicated.

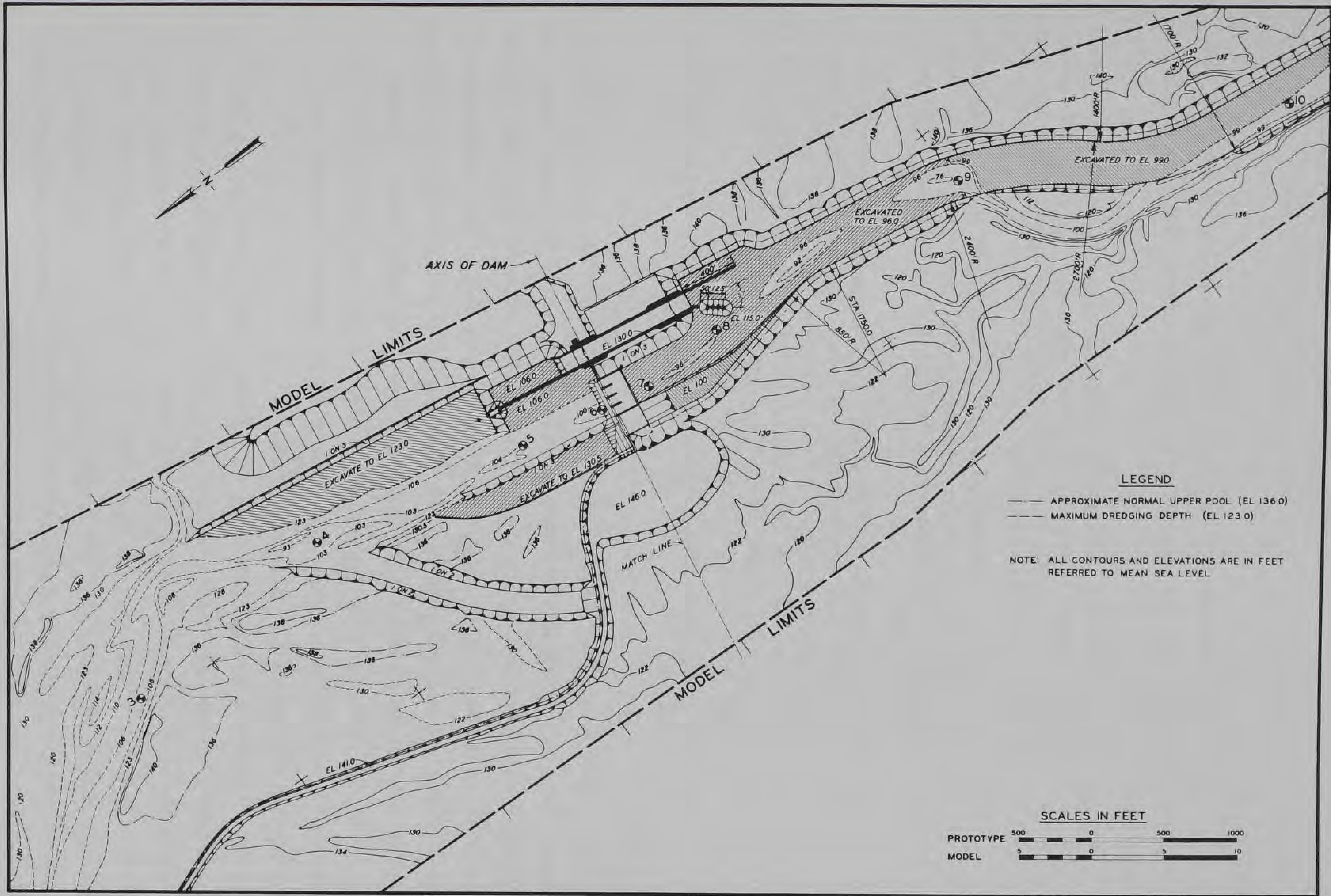


Figure 7. Plan A

Plan B

Description

28. Plan B was designed to improve navigation conditions in the upper lock approach and was the same as plan A except for the following modifications (Figure 8):

- a. A 450-ft-long earth-fill dike was placed as an extension to the upper guard wall. The approach side of the dike was in line with the lock side of the guard wall and had a top elevation of 146.0.
- b. The width of the excavation of the right bank upstream of the overflow weir was reduced by moving the toe of the excavated bank riverward and in line with the right end of the weir.
- c. The excavation of the right bank downstream of the overflow weir was modified by placing the toe of the slope of the excavated bank in line with the right end of the weir and then curving on a radius of 750 ft. The radius of the bend in the right bank line opposite the end of the lower guide wall was reduced from 850 ft to 600 ft.
- d. The rock dike downstream of the lock river-side wall was removed.

Results

29. Water-surface elevations shown in Table 2 indicate increases of about 0.1 to 0.2 ft above those obtained with the original plan with 30,000-cfs flow and about the same with the 53,000-cfs flow except for a lowering of about 0.3 ft just upstream of the dam. The difference in water-surface elevations across the dam (gages 6 and 7) with the latter flow was 0.4 ft which was about 0.2 ft lower than with the original plan. The difference in water-surface elevations from the end of the upper guard wall to the lower end of the lock (gages 5 and 8) was 0.7 ft, the same as that with the original plan.

30. Except for some decrease in current velocities along the earth-filled dike, there was little or no change in the alignment and velocity of currents in the upper lock approach from those obtained with plan A (Plates 7 and 8). Currents in the lower lock approach were affected by the realignment of the right bank and removal of the rock dike which caused a greater concentration of the total flow toward the left bank,

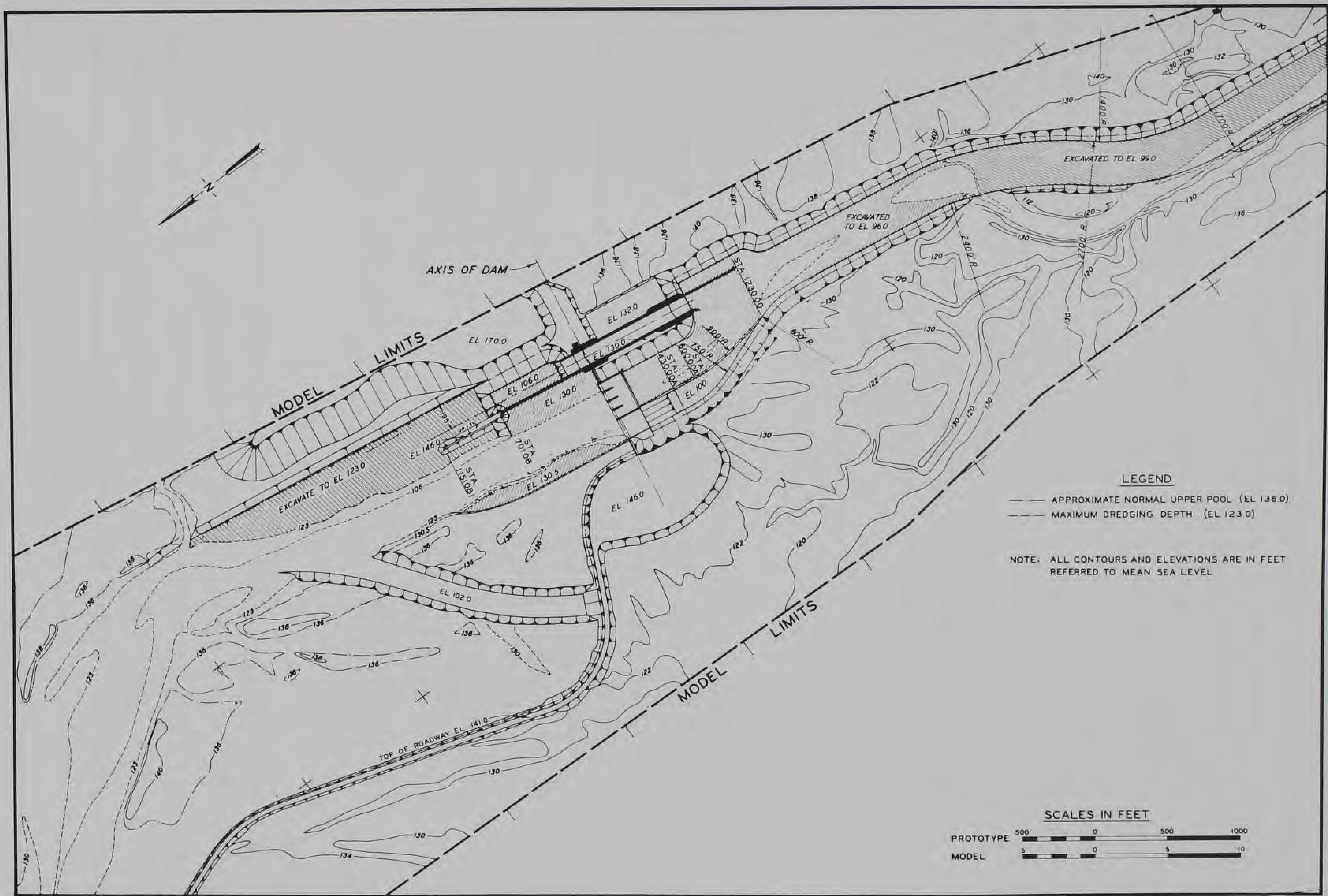


Figure 8. Plan B

particularly with the 30,000-cfs discharge. Velocities of currents moving across the lower lock approach were somewhat higher than those with plan A, varying from about 4.0 fps with the lower flow to about 3.2 fps with the 53,000-cfs flow.

31. Navigation conditions for downbound tows approaching the lock were somewhat better than those with plan A, but tows would have to approach close along the left bank to avoid the effects of the outdraft near the upper end of the dike. Navigation conditions in the lower lock approach were about the same as those with the original plan and not as good as those with plan A. Upbound tows approaching the lock would tend to be rotated counterclockwise by currents moving across the approach, causing the head of the tow to be moved away from the guide wall.

Plan C

Description

32. Plan C was the same as plan B except for the following modifications designed to provide better navigation conditions in the upper and lower lock approaches (Figure 9):

- a. The earth-fill dike extending upstream of the end of the upper guard wall was removed.
- b. The upper lock approach channel was deepened to el 118.0 over a 200-ft bottom width along the left bank.
- c. The right bank just downstream of the dam was modified to provide a 1200-ft straight alignment angled to the left and then bending to the right on a radius of 1700 ft.
- d. The alignments of the left and right banks downstream of the lower lock approach were also modified as shown in Figure 9.

Results

33. Water-surface elevations shown in Table 2 indicate little difference from those obtained with the original plan except just below the dam (gage 7) where the water level was about 0.3 ft lower with the 53,000-cfs flow. The difference in the water-surface elevations across the dam (gages 6 and 7) was about 0.8 ft. The water-surface elevation near the lower end of the lock (gage 8) was about 0.2 ft higher than

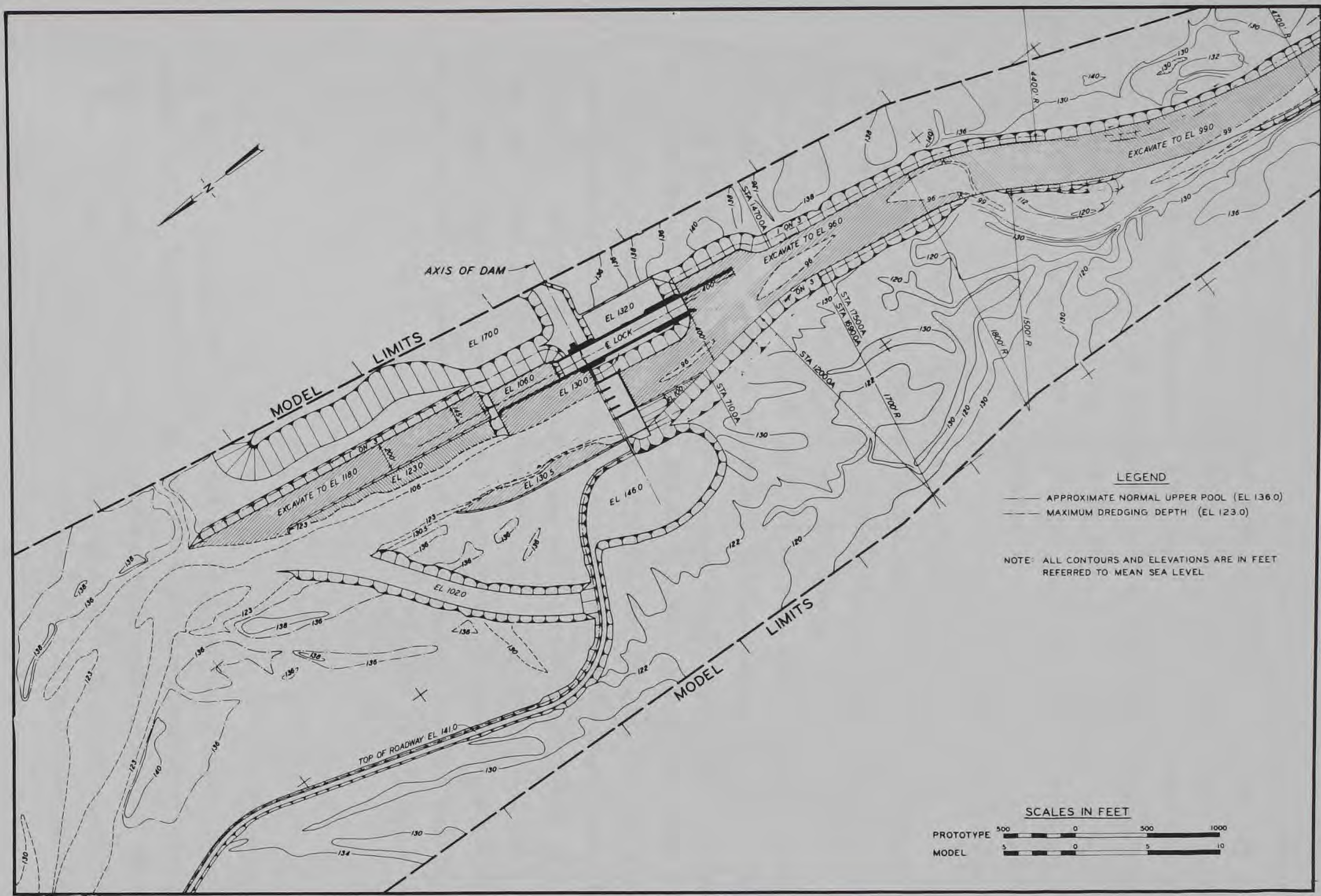


Figure 9. Plan C

that just below the dam and only about 0.1 ft lower than that with the original plan.

34. Current directions and velocities shown in Plates 9 and 10 indicate only small differences from those obtained in the upper lock approach with the original plan. The alignment of the currents moving toward the left bank across the lower lock approach channel was about the same as that with the original plan but velocities were higher, ranging from 3.2 fps with the 30,000-cfs flow to about 4.3 fps with the 53,000-cfs flow. The size and intensity of the eddy along the lower guide wall also were greater.

35. Navigation conditions in the upper lock approach were considerably better than those with any of the other plans tested, and no serious difficulties were indicated for tows properly aligned within the approach channel. Downbound tows would have to enter the approach channel from along the left side of the bend upstream to avoid the effects of the currents moving toward the river side of the approach channel. Navigation conditions for upbound tows approaching the lock were about the same as those with the original plan in that currents moving toward the left bank and the eddy along the guide wall tended to rotate the tow counterclockwise. A satisfactory approach could be made by attaching a line to the guide wall to prevent the head of the tow from being moved away from the wall. Navigation conditions in the reach downstream of the lower lock approach were generally good, and no serious difficulties were indicated for two-way traffic in the reach reproduced in the model.

Plan D

Description

36. Plan D was designed to facilitate the movement of tows into the upper lock approach channel from the bend upstream and to reduce the tendency for the head of upbound tows to be moved away from the lower guide wall. This plan was the same as plan C except for the following modifications (Figure 10):

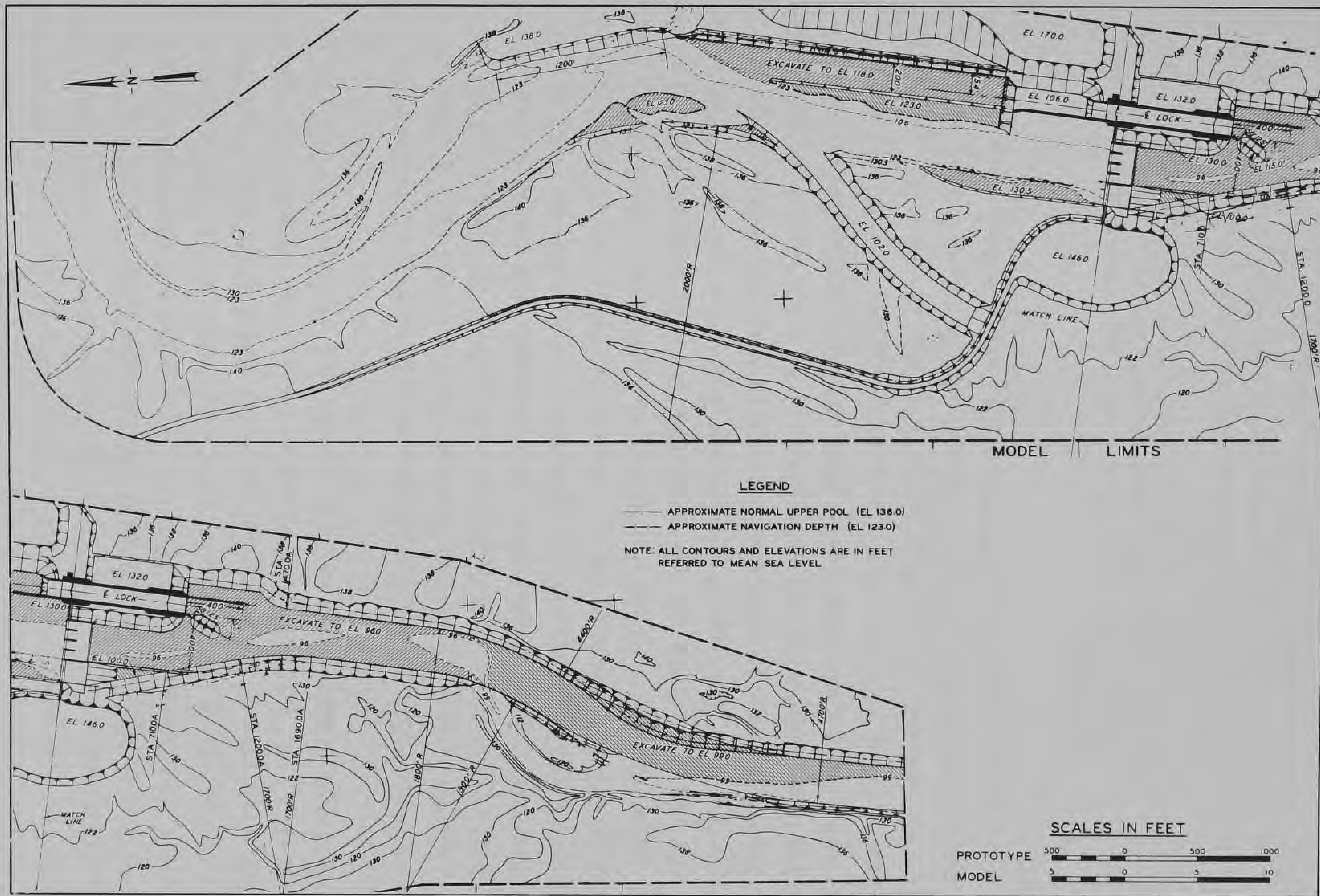


Figure 10. Plan D

a. A 1200-ft-long earth-fill dike was placed along the left overbank just upstream of the upper approach to the lock with crest at el 138.0.

b. The right bank forming the convex side of the bend just upstream of the approach was excavated to el 123.0 on a radius of 2000 ft.

c. A 125-ft-long rock dike was placed along the right side of the lower lock approach starting 50 ft from the lower end of the lock riverward wall and angled about 30 deg riverward.

Results

37. Water-surface elevations shown in Table 3 indicate only small differences from those obtained with the original plan. In general, there were increases in stages of 0.1 to 0.2 ft in the upper reach of the model (gages 1-3) with the 85,000-cfs flow and a slight lowering in stages downstream of the dam. Water-surface elevation was 0.3 ft lower just downstream of the dam (gage 7), the same as with plan C, and only 0.1 ft lower farther downstream (gages 8 and 9). Tests with the 125,000-cfs flow, considered the maximum navigable flow as modified, were not conducted with the original plan and a comparison could not be made. The difference in the water-surface elevations upstream and downstream of the dam (gages 6 and 7) varied from about 0.3 ft with the 125,000-cfs flow to about 0.8 ft with the 53,000-cfs flow. The difference in water-surface elevation of 0.8 ft across the dam with the 53,000 cfs flow is probably not a true indication of the effect of the structure since the difference in water level between gage 6 just upstream of the dam and gage 8 some distance downstream of the dam was only 0.5 ft.

38. The distribution of flow through the dam shown in the tabulation on page 29 indicates some decrease in the flow thorugh the gate bay near the lock with the 53,000-cfs flow compared with the original plan. This change is attributed to the increase in the flow through the ports of the upper guard wall. Flow through the three gate bays away from the lock was fairly well distributed, particularly with the 85,000-cfs flow.

Discharge Distribution in Percent of Total Flow Through the Dam		
Gate Bay	Discharge, cfs	
	53,000	85,000
1	18.0	20.6
2	26.9	26.2
3	27.9	26.2
4	26.8	26.2
Weir	0.4	0.8

Note: Gate bays numbered from left to right. Some of the 85,000-cfs flow bypassed the dam on the right overbank.

39. Current directions and velocities shown in Plates 11 and 12 indicate little difference in the alignment and velocity of currents in the upper lock approach from those obtained with plan C. In the bend just upstream, currents moved toward the right with an increase in the size of the eddy along the left bank upstream of the lock approach channel. Currents in the upper lock approach with the higher flows, 85,000 cfs and 125,000 cfs (Plates 13 and 14), were generally straight and parallel with the left bank. Velocities in the upper approach channel with the 85,000-cfs flow were somewhat higher than those obtained with the original plan. With the higher discharges, a considerable amount of the flow in the bend farthest upstream moved out of the channel and across the right overbank near the lower end of the bend and was replaced by flow from the left overbank.

40. In the reach downstream of the lock, currents were generally parallel to the bank lines. With the 125,000-cfs discharge, there was considerable flow toward and over the left overbank in the first bend just downstream of the lower lock approach channel. The alignment of the currents moving toward the left bank across the lower lock approach with the lower flows was better than with plan C, and the eddy along the lower guide wall was reduced in size and intensity. There was no appreciable change in the alignment of currents across the lower lock

approach with the 85,000- and 125,000-cfs flows compared with the lower flows.

41. Navigation conditions in the lock approaches were considerably better than those with plan C and no serious difficulties were indicated with any of the flows tested. Upbound and downbound tows could pass in the bend upstream of the upper lock approach with little tendency for downbound tows to be moved riverward of the approach channel even when passing along the right side of the upbound tow (Photo 1). Two-way traffic could be maintained in the upper bend during within-bank flows but downbound tows would have to flank around the bend to avoid being moved toward and against the bank. During the higher flows, downbound tows would be affected by flow from the bend toward and over the right overbank and conditions would tend to be hazardous for two-way traffic.

42. Good navigation conditions were indicated in the lower lock approach and two-way traffic could be maintained with all of the flows tested (Photo 2). The tendency for upbound tows approaching the lower guide wall to be rotated counterclockwise was practically eliminated. No difficulties were indicated for two-way traffic downstream of the lower lock approach, and tows could approach or leave the lock from either side of the channel (Photo 3).

Plan E

Description

43. Plan E was designed to provide additional suitable backfill material required for the project without adversely affecting navigation conditions in the upper lock approach. This plan was the same as plan D except for the following (Figure 11):

a. The left bank along the upper lock approach was excavated to a bottom elevation of 118.0 for a distance of 585 ft landward of the lock-side of the upper guard wall and the excavation extended about 2150 ft upstream of the end of the wall. From that point, the excavated bank was angled toward the river channel and upstream to tie in with the natural bank near the upper end of the lock approach channel.

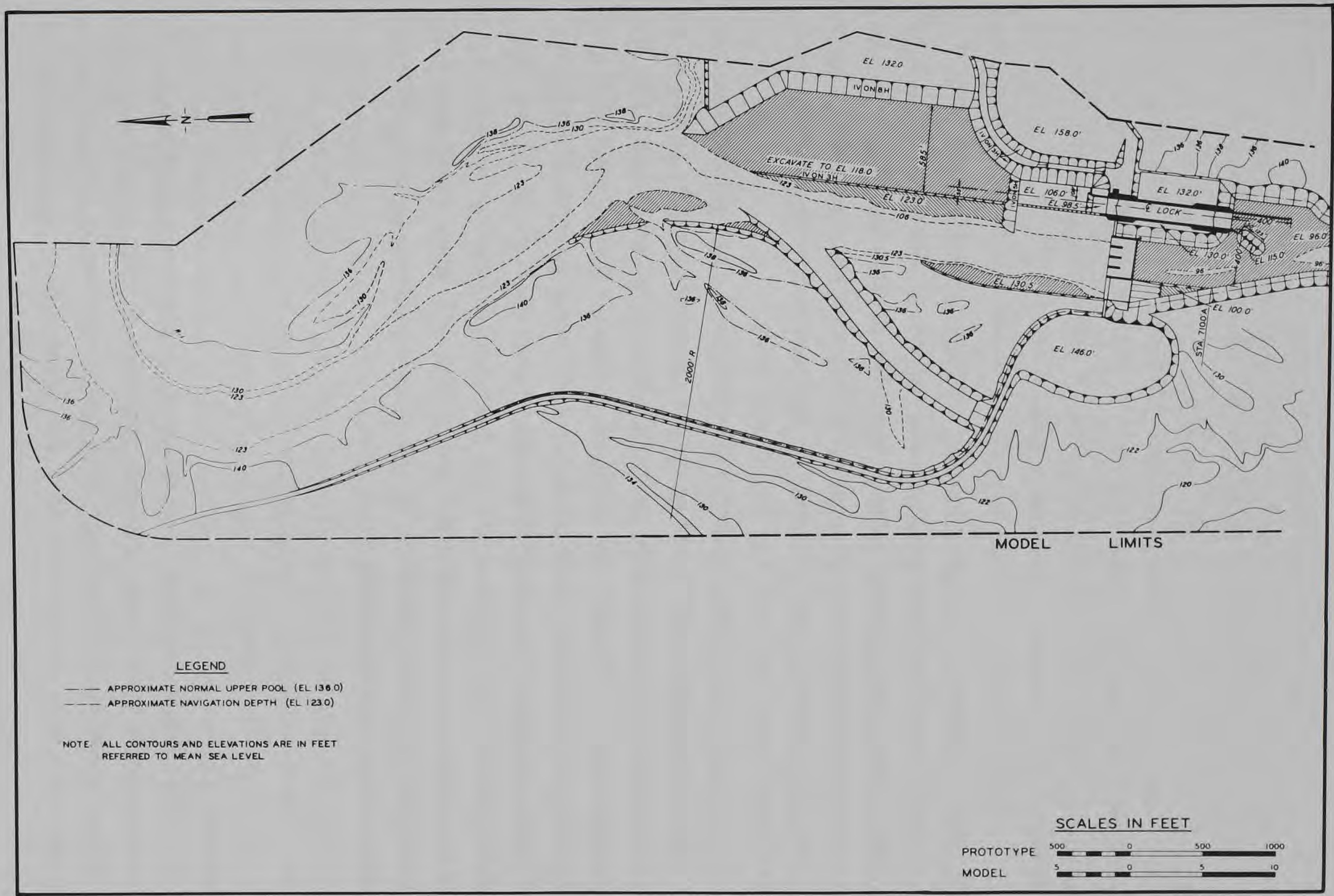


Figure 11. Plan E

b. The overbank to the left of the excavated area outlined in "a" above was excavated to el 132.0 and extended as far left as the model limits.

c. The earth-fill dike along the left bank upstream of the upper end of the lock approach channel was removed.

Results

44. Water-surface elevations shown in Table 4 indicate only small differences from those obtained with plan D. Results indicated a slight tendency for stages to be higher upstream of the dam with plan E but only about 0.1 ft with the 53,000-cfs flow.

45. Current directions and velocities shown in Plates 15 and 16 indicated an increase in the amount of flow moving to the left toward the excavated area and an increase in the amount of flow moving back to the right across the approach channel upstream of the end of the upper guard wall. Velocities in the upper lock approach were somewhat higher than those with plan D, particularly in the crosscurrents near the end of the upper guard wall with the 53,000-cfs flow.

46. Navigation conditions for downbound tows approaching the lock with this plan would be difficult and hazardous because of the alignment of the currents in the approach, particularly the outdraft near the end of the guard wall. To avoid the effects of the outdraft, tows would have to approach the guard wall from a considerable distance landward of the wall and be in danger of grounding along the left bank just upstream of the end of the wall. If the turn toward the guard wall is started too far upstream to avoid hitting the left bank, downbound tows would tend to be moved riverward by the crosscurrents and be in danger of hitting the end of the wall.

Plan F

Description

47. Plan F was designed to eliminate the hazardous navigation conditions in the upper lock approach indicated with plan E by modification of the excavation of the left bank just upstream of the lock and along the right bank in the bend near the upper end of the approach

channel. This plan was the same as plan E except for the following (Figure 12):

- a. The lower end of the excavation along the left bank near the end of the upper guard wall was flared on a straight line forming an angle of 33 deg to the left of the lock center line, increasing the maneuver area available landward of the guard wall.
- b. The excavation of the right bank in the bend near the upper end of the approach channel was increased from a bottom elevation of 123.0 to el 118.0 to reduce the amount of flow moving toward the upper lock approach channel.

Results

48. The effects of plan F on water-surface elevations were generally small and about the same as those with plans D and E except for local differences (Table 5). The difference in the water-surface elevations upstream and downstream of the dam (gages 6 and 7) ranged from about 0.9 ft with the 53,000-cfs flow to only about 0.3 ft with 125,000-cfs flow.

49. Current directions and velocities shown in Plates 17 and 18 indicate some improvements in the alignment of the currents in the bend near the upper end of the lock approach channel with no significant change in the approach channel compared with plan E. Velocities near the end of the upper guard wall were somewhat lower with plan F, and the alignment of currents moving toward the guard wall was generally better. Velocities in the approach to the lock with the 85,000-cfs flow were lower than those with the 53,000-cfs flow, particularly along the left side of the channel. The alignment of the currents in the approach channel with the 125,000-cfs flow was about the same as that with the 53,000- and 85,000-cfs flows but velocities were considerably lower.

50. Navigation conditions in the upper lock approach were considerably better than those with plan E, and no serious difficulties were indicated for tows approaching or leaving the lock. Downbound tows could make a satisfactory approach to the lock from either side of the channel in the bend just upstream of the upper end of the approach channel, and two-way traffic could be maintained upstream of the end of the guard wall (Photo 4).

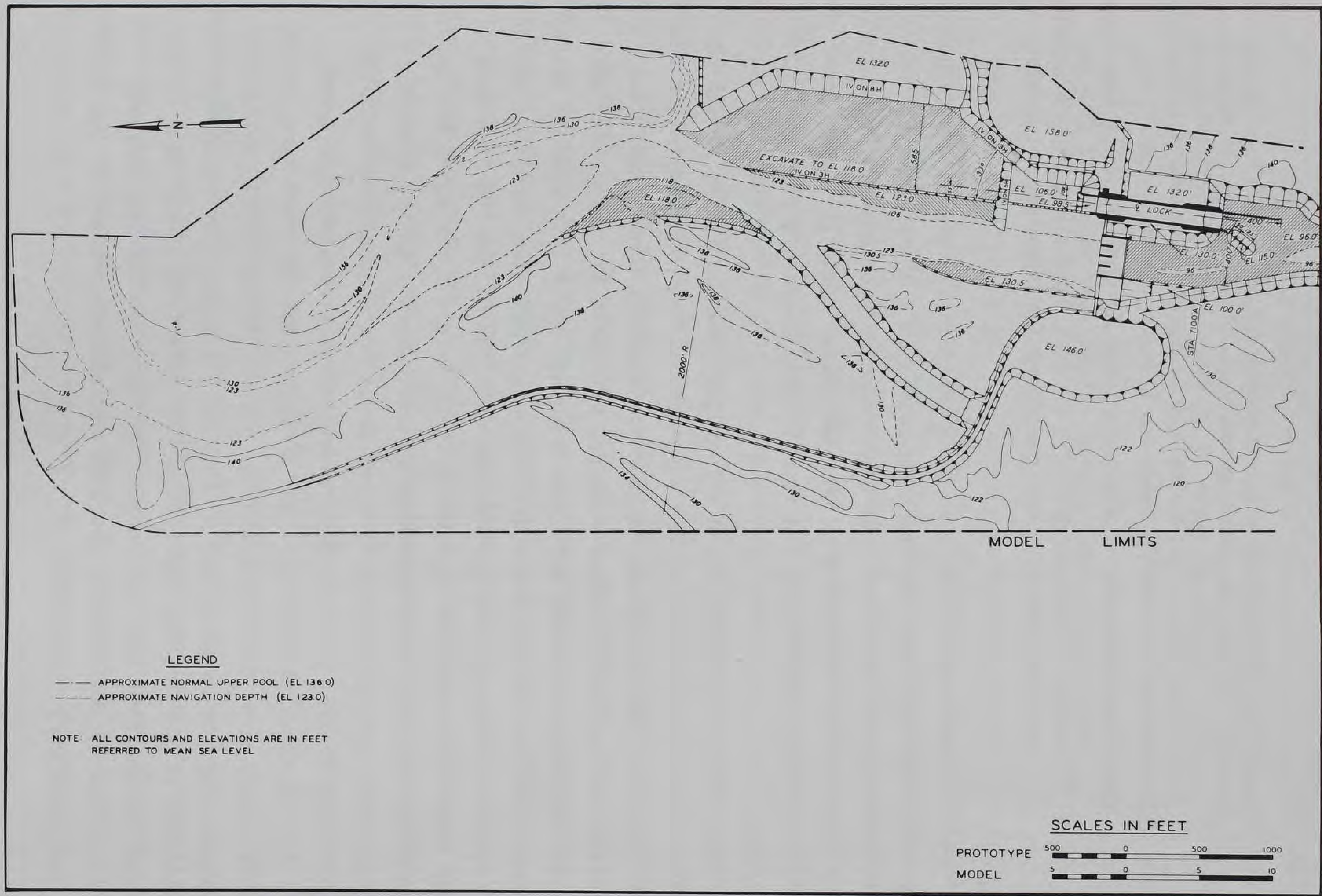


Figure 12. Plan F

Plans F-1 and F-2

Description

51. Tests of plans F-1 and F-2 were conducted to determine the effects on navigation conditions of reducing the amount of excavation along the left bank upstream of the end of the guard wall. These plans were the same as plan F except as follows:

a. Plan F-1. The excavation along the left bank of the lock approach was not extended as far upstream and the amount of excavation was reduced by about 30 percent as shown in Figure 13.

b. Plan F-2. The excavation along the left bank was not extended as far upstream as that in plan F-1 and the amount of excavation was reduced by about 50 percent of the amount in plan F. The low overbank area along the left bank upstream of the end of the lock approach channel was filled to el 138.0 (Figure 14).

Results

52. Results shown in Table 6 indicate that the modifications in the amount of excavation along the lock upper approach channel had little or no effect on water-surface elevations. Reduction of the amount of excavation with plans F-1 and F-2 lessened the amount of flow moving to the left side of the lock approach channel and the crosscurrents near the end of the upper guard wall (Plates 21 and 22). Velocities in the lock approach channel with plans F-1 and F-2 were slightly higher than those with plan F, but the alignment of the currents was much better and generally parallel to the alignment of the approach channel with the 53,000-cfs flow.

53. Navigation conditions in the upper lock approach with either plan F-1 or plan F-2 were satisfactory and generally as good as those with plan F. Two-way traffic could be maintained from the bend upstream of the lock approach with most flows. Downbound tows moving close along the left bank tended to ground in the shallow area just upstream of the end of the approach channel with plan F-1; this tendency was eliminated with the fill placed along the left bank in plan F-2. As with all of the other plans tested, two-way traffic would be difficult and hazardous

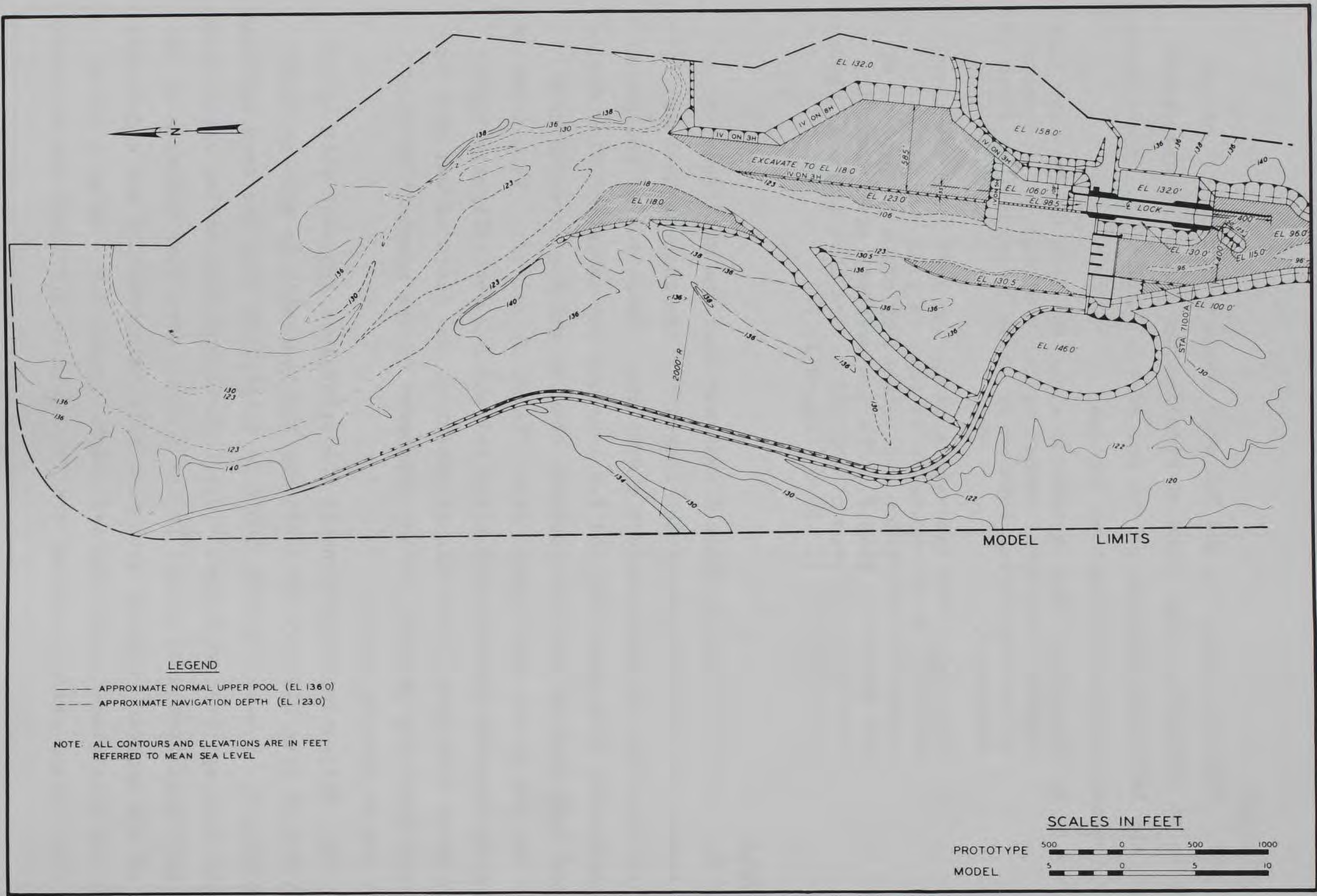


Figure 13. Plan F-1

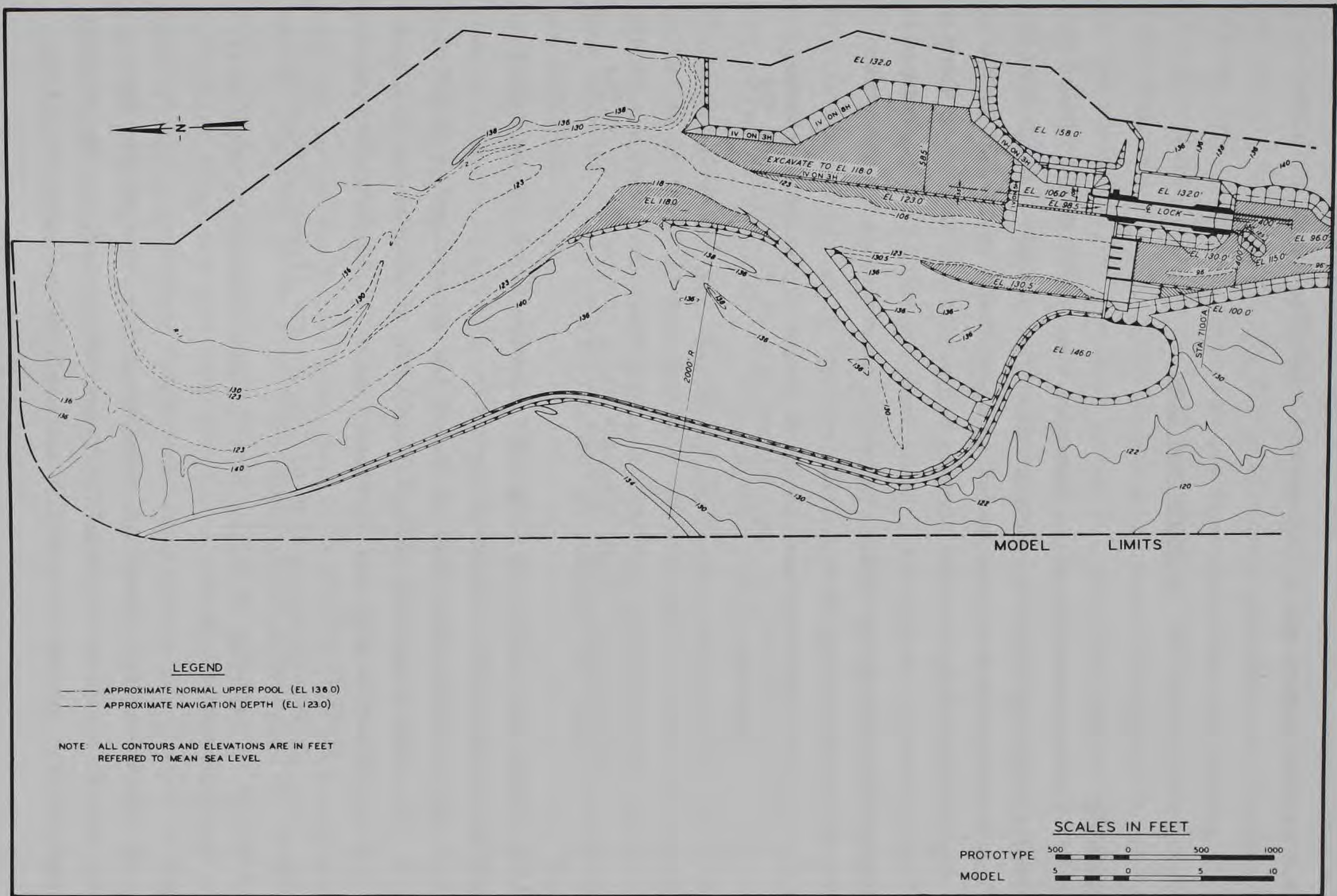


Figure 14. Plan F-2

in the second bend upstream of the lock approach during higher flows because of flow moving out of the channel toward and over the right overbank.

Construction Plan

Description

54. Tests were conducted to determine conditions that could be expected in the reach during construction of the project. As proposed, the lock and dam would be constructed in a one-stage earth-fill cofferdam with the riverflow diverted through a bypass canal excavated along the right overbank. Accordingly, tests were conducted that reproduced conditions existing in the prototype before construction is undertaken except for the following (Photo 5, Plate 23):

a. The cofferdam was installed across the existing channel with the top of the upstream side at el 149.0 and the downstream side at el 147.5.

b. The diversion canal was excavated along the right overbank to a bottom width of 150 ft and el 102.0.

c. The material excavated from the diversion canal was stockpiled on the right overbank along the left side of the canal and adjacent to the cofferdam.

55. Tests were conducted with the following flows and tailwater elevations based on the unimproved channel:

a. A within-bank flow of 30,000 cfs with tailwater el 127.9.

b. Near bank-full flow of 43,000 cfs with tailwater el 135.6.

c. Channel with some overbank flow of 53,000 cfs with tailwater el 138.3.

d. Cofferdam design flow of 100,000 cfs (7-year frequency) with tailwater el 143.8.

e. Flood flow of 127,000 cfs (13-year frequency) with tailwater el 144.8.

Results

56. Water-surface elevations obtained during tests of the construction plan are shown in Table 7. These results indicate differences in water-surface elevations from the upper end to the lower end of the

diversion canal (gages 4-10) varying from 2.2 ft with the 30,000-cfs flow to 1.2 ft with the 53,000-cfs flow; with the higher flows of 100,000 cfs and 127,000 cfs, the differences were about 1.2 ft and 2.0 ft, respectively. Water-surface elevations near the upstream side of the cofferdam (gage A) ranged from 144.5 to 146.2 with the higher flows and from 144.3 to 145.7 on the downstream side (gage 8). Based on these results, the freeboard on the upstream side of the cofferdam would vary from 4.5 ft for the cofferdam design flow to 2.8 ft for the 127,000-cfs flood flow. On the downstream side, the freeboard would vary from 3.2 ft to 1.8 ft for the two flows, respectively. The model did not reproduce all of the low overbank area to the right of the diversion canal.

57. Results shown in Plates 23-27 indicate that the distribution of flow and velocities within the diversion canal are affected by the alignment of currents entering the canal and by the bend downstream of the entrance. The highest float velocities were obtained with the 30,000-cfs flow and the 127,000-cfs flood flow which reached a maximum of 10 fps in the bend downstream of the entrance. Current directions and velocities in the bend with the 100,000- and 127,000-cfs flows were also affected by flow along the right overbank moving toward and into the diversion canal.

58. Spot velocities taken within about 3 ft of the bottom of the channel (Plates 28 and 29) are more indicative of the erosive effects that could be expected on the bed and banks of the diversion canal than are the float velocities. The highest velocities were measured with the 30,000-cfs flow and ranged from about 5.5 to 6.4 fps within the bend and in the reach just downstream of the bend. The amount of protection required in the diversion channel would depend on the characteristics of the soil forming the bed and banks of the canal. Although velocities along the left bank near the entrance to the canal were not as great as those farther downstream, the tendency for erosion of the junction between the existing channel and canal could be greater because of the turbulence and deposition that would tend to occur on the opposite side. Any appreciable erosion of the point at the junction could

seriously affect the alignment and velocity of currents downstream and cause deterioration of the diversion channel.

59. The movement of sediment into and within the diversion canal was traced in the model by means of a lightweight plastic material moving along the bottom of the channel. The movement of the material and areas where deposition might tend to occur are indicated in Plates 30 and 31. The movement of sediment and deposition will depend on flow conditions, maintenance of channel alignment and cross section, and amount of sediment movement in the reach. Generally, some scouring can be expected along the concave side of a bend with deposition forming a sandbar on the convex side.

PART IV: DISCUSSION OF RESULTS AND CONCLUSIONS

Limitation of Model Results

60. The analysis of the results of this investigation is based principally on a study of (a) the effects of various plans and modifications on water-surface elevations, current directions, and velocities, and (b) the effects of resulting currents on the behavior of the model towboat and tow. In evaluating test results, consideration should be given to the fact that small changes in direction of flow or in velocities are not necessarily changes produced by a modification in plan since several floats introduced at the same point may follow a different path and move at slightly different velocities because of pulsating currents and eddies. Current directions and velocities shown in the plates were obtained with floats submerged to a depth of a loaded barge (9 ft prototype) and are indicative of the currents that would affect the behavior of tows.

61. The small scale of the model made it difficult to reproduce accurately the hydraulic characteristics of the prototype structures or to measure water-surface elevations within an accuracy of ±0.1 ft prototype. Also, it should be considered that the model limits did not include all of the floodway areas covered by the higher flows. The model was of the fixed-bed type and was not designed to simulate the movement of sediment in the prototype; therefore changes in channel configurations and slopes resulting from changes in the channel bed and banks that might be caused by the structures or changes in flow conditions could not be developed naturally in the model. The movement of lightweight material was used in the model to provide a very general indication of the movement of sediment that could be expected through the diversion canal in its initial condition and cannot be considered as an accurate simulation of conditions that might occur in the prototype.

Summary of Results and Conclusions

62. The following results and conclusions were developed during this investigation:

a. Navigation conditions in the second bend upstream from the lock would be affected by the relatively short radius of the bend and flow moving from the channel toward the right overbank during the higher flows. Two-way traffic could be maintained in the bend during most of the within-bank flows but downbound tows would have to flank around the bend under most conditions. With flows above bank-full, two-way traffic would be very difficult and hazardous.

b. Navigation conditions in the upper lock approach with the original plan would tend to be difficult and hazardous because of the strong tendency for downbound tows to be moved riverward as they approached the end of the upper guard wall.

c. Satisfactory navigation conditions in the upper lock approach could be developed by increasing the depth of the approach channel and excavation of the right bank in the bend upstream of the lock approach channel as in plan D.

d. Excavation of the left bank to provide backfill material for the project would tend to increase the flow moving to the left into the excavated area and then back riverward, producing an outdraft near the end of the upper guard wall which would adversely affect navigation. Modification of the excavation near the lock to provide additional maneuver area landward of the upper guard wall as in plan F would permit downbound tows to avoid the outdraft and make a satisfactory approach to the lock. Navigation conditions in the upper approach would be better without the excavation as in plan D or with the reduced excavation of plans F-1 and F-2.

e. Navigation conditions in the lower lock approach with the original plan would be affected by currents moving toward the left bank across the approach and the eddy along the lower guide wall that would tend to move the head of upbound tows away from the wall. The effects of these currents could be eliminated or reduced sufficiently to provide satisfactory conditions with a short rock dike placed along the right side of the approach and angled riverward as in plan D.

f. The maximum difference in water-surface elevation across the dam was about 0.9 ft which occurred with the 53,000-cfs flow. This difference was not affected appreciably by changes in plans.

g. The distribution of flow through the gated spillway was reasonably good except for the gate bay nearest the lock which was affected by flow through the ports in the upper guard wall and the offset between the lock and spillway.

h. With the construction plan tested, sufficient freeboard would be provided with the cofferdam design flow (100,000 cfs) during construction of the lock and dam. With the 127,000-cfs flow, the freeboard would be about 3.2 ft on the upstream side and about 1.8 ft on the downstream side.

i. Protection required in the diversion canal during construction would depend on the erodibility of the bed and banks and could be affected by the amount of sediment moved into the canal. The left bank of the canal near the upper end should be maintained to prevent changes in the currents and deterioration of the diversion channel downstream.

Table 1

Water-Surface Elevations, ft msl, Original Plan

Gage No.	Discharge, cfs			
	30,000	53,000	85,000	114,000*
1	136.3	137.1	143.8	146.1
2	136.2	136.7	143.5	145.9
3	136.1	136.6	143.4	145.7
4	136.1	136.4	143.3	145.6
5	136.0	136.2	143.0	145.3
6	136.0**	136.0	142.7	145.0
7	124.4**	135.4**	142.1**	144.4**
8	124.7	135.5	142.2	144.5
9	124.5	135.4	142.2	144.5
10	124.3	135.2	142.0	144.2

* Maximum navigable flow based on 1-ft freeboard at the upper guard wall.

** Controlled elevations based on improved channel.

Table 2

Water-Surface Elevations, ft msl, Plans A, B, and C

Gage No.	Discharge, cfs					
	Plan A		Plan B		Plan C	
	30,000	53,000	30,000	53,000	30,000	53,000
1	136.3	137.0	136.4	137.0	136.4	137.1
2	136.2	136.6	136.3	136.6	136.2	136.7
3	136.1	136.5	136.3	136.6	136.1	136.6
4	136.1	136.4	136.2	136.4	136.1	136.4
5	136.0	136.2	136.1	136.1	136.0	136.2
6	136.0*	136.0	136.0*	135.7	136.0*	135.9
7	124.4	135.4	124.5	135.3	124.5	135.1
8	124.6	135.5	124.7	135.4	124.6	135.4
9	124.5	135.4	124.5	135.3	124.5	135.3
10	124.3*	135.2*	124.3*	135.2*	124.3*	135.2*

* Controlled elevations based on improved channel.

Table 3

Water-Surface Elevations, ft msl, Plan D

Gage No.	Discharge, cfs 30,000	53,000	85,000	125,000
1	136.4	137.2	144.0	145.7
2	136.2	136.8	143.7	145.6
3	136.1	136.6	143.5	145.4
4	136.1	136.4	143.4	145.4
5	136.0	136.3	143.0	145.2
6	136.0*	135.9	142.6	145.0
7	124.5	135.1	142.1	144.7*
8	124.6	135.4	142.2	144.8
9	124.5	135.3	142.2	144.7
10	124.3*	135.2*	142.0*	144.6

* Controlled elevations based on improved channel.

Table 4

Water-Surface Elevations, ft msl, Plan E

Gage No.	Discharge, cfs 30,000	53,000
1	136.3	137.1
2	136.3	136.8
3	136.2	136.7
4	136.1	136.5
5	136.1	136.4
6	136.0*	136.0
7	124.5	135.1
8	124.6	135.4
9	124.4	135.4
10	124.3*	135.2*

* Controlled elevations based on improved channel.

Table 5

Water-Surface Elevations, ft msl, Plan F

Gage No.	Discharge, cfs 30,000	53,000	85,000	125,000
1	136.3	137.1	143.9	145.5
2	136.3	136.7	143.7	145.4
3	136.2	136.6	143.5	145.3
4	136.1	136.5	143.4	145.3
5	136.1	136.4	142.9	145.2
6	136.0*	136.1	142.6	145.0
7	124.5	135.2	142.1	144.7
8	124.6	135.4	142.2	144.8
9	124.5	135.4	142.2	144.7
10	124.3*	135.2*	142.0*	144.6*

* Controlled elevations based on improved channel.

Table 6

Water-Surface Elevations, ft msl, Plans F-1 and F-2

Gage No.	Discharge, cfs Plan F-1 53,000	Plan F-2 53,000
1	137.1	137.1
2	136.7	136.7
3	136.6	136.6
4	136.4	136.4
5	136.4	136.4
6	136.0	136.0
7	135.1	135.1
8	135.4	135.4
9	135.3	135.3
10	135.2*	135.2*

* Controlled elevations based on improved channel.

Table 7

Water-Surface Elevations, ft msl

Construction Plan

Gage No.	Discharge, cfs 30,000	43,000	53,000	100,000	127,000
1	130.8	137.4	140.0	145.6	147.1
2	130.5	137.2	139.6	145.4	146.9
3	130.4	137.1	139.6	145.3	146.9
4	130.1	136.9	139.5	145.3	146.8
A	129.6	136.3	138.9	144.5	146.2
6	Inside cofferdam	--	--	--	--
7	Inside cofferdam	--	--	--	--
8	129.3	136.2	138.8	144.3	145.7
9	128.5	136.0	138.8	144.1	145.3
10	127.9*	135.6*	138.3*	143.8*	144.8*

Note: Gage A was a temporary gage located in the center of the diversion canal along the axis of the dam. No adjustment made in discharge to compensate for the flow over that portion of the right overbank not reproduced in the model.

* Controlled elevations based on natural channel.

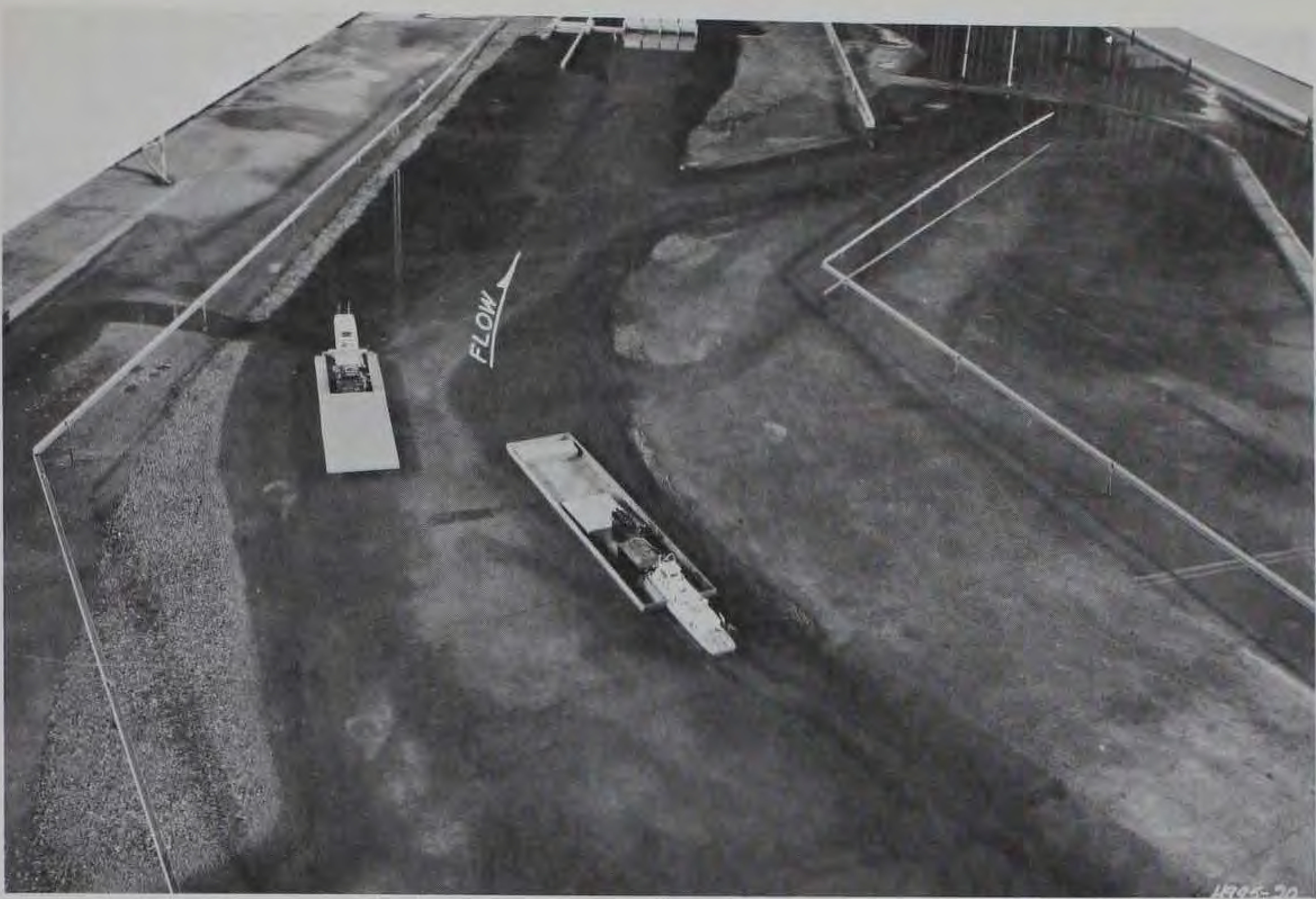
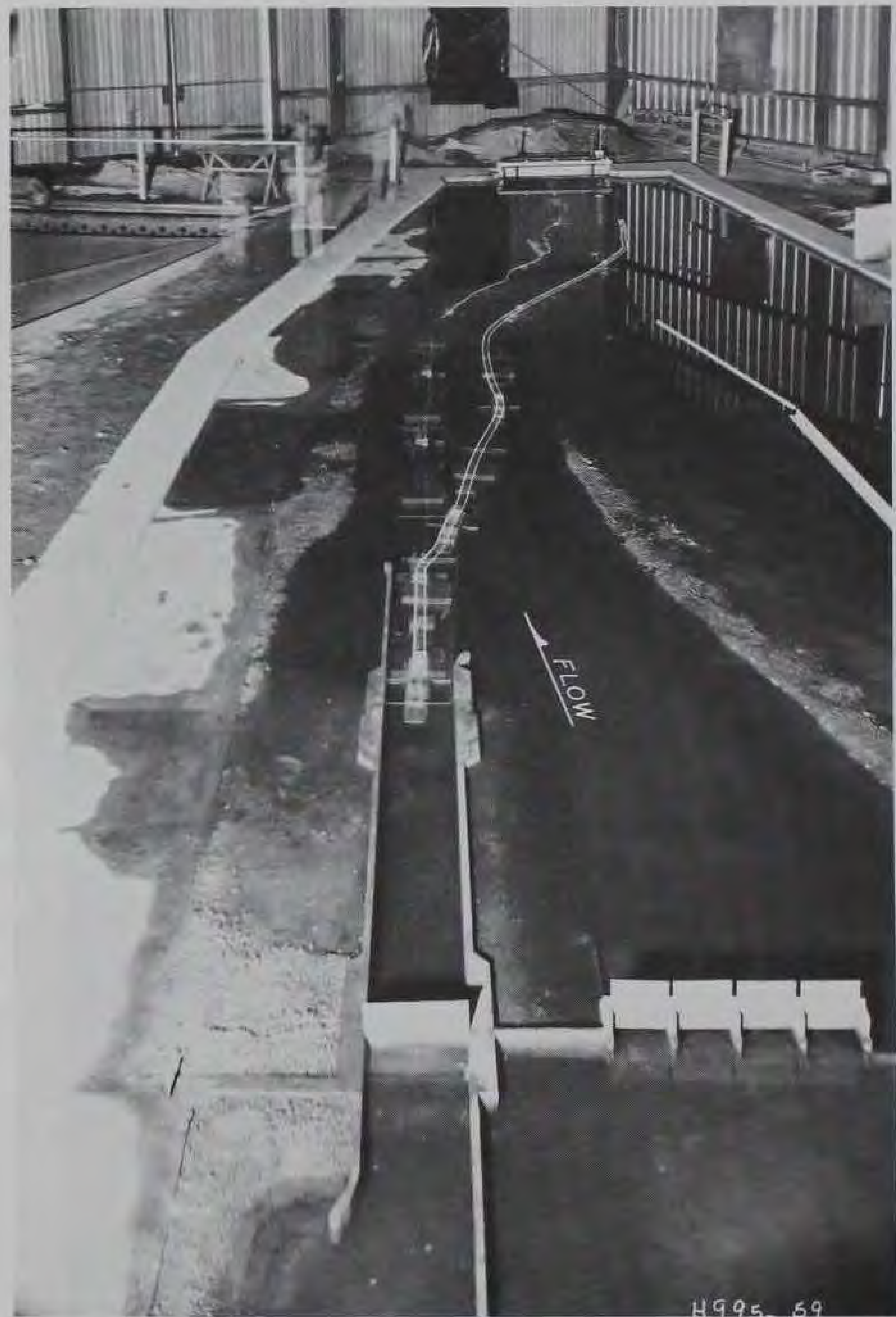


Photo 1. Plan D, 53,000-cfs flow. Relative positions of upbound and downbound tows passing near the upper end of the lock approach channel

Photo 2. Plan D, 53,000-cfs flow. Relative positions of upbound and downbound tows passing within the lower lock approach

a. Upbound tow approaching the lock from the right side of the channel



b. Upbound tow approaching the lock from the left side of the channel

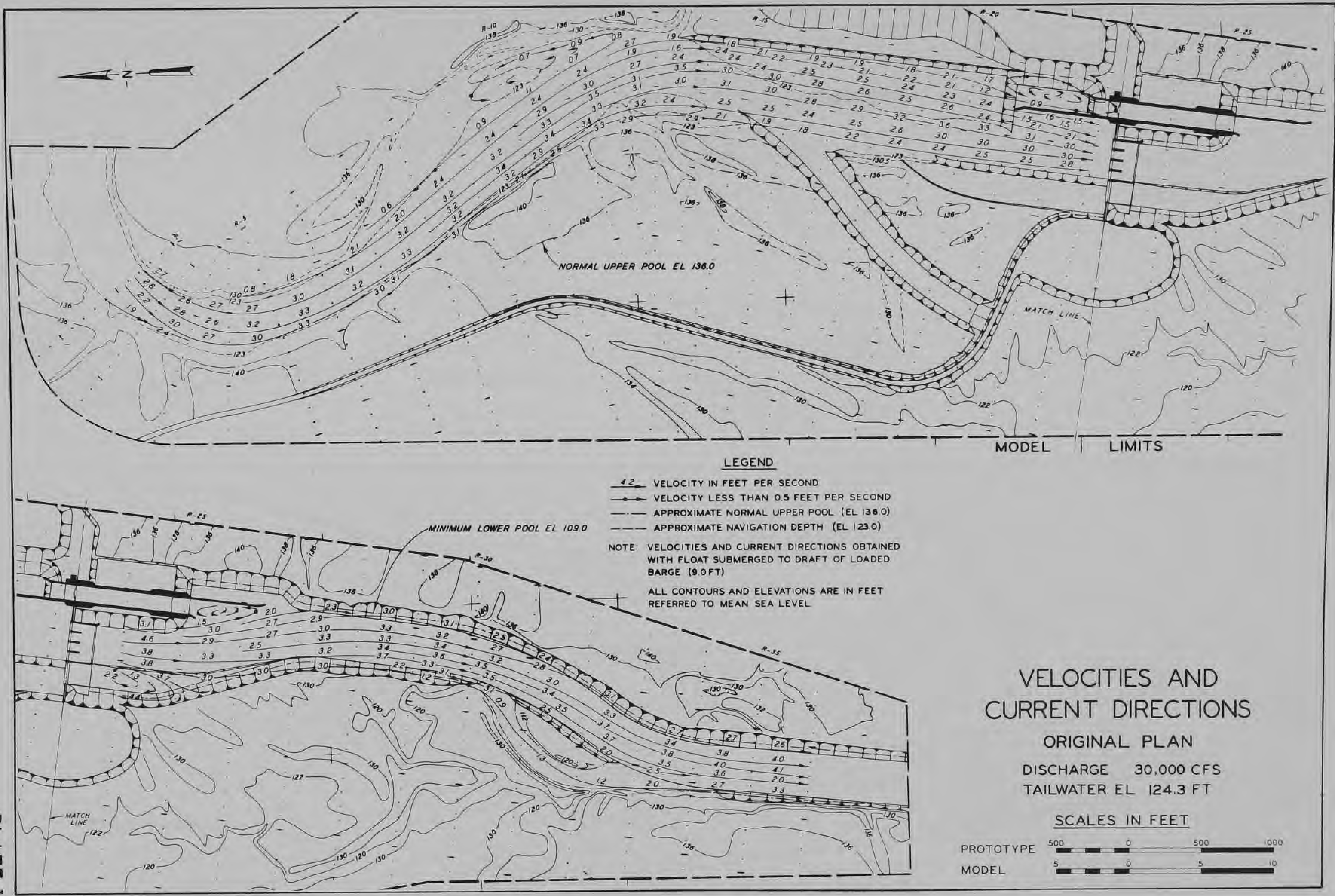
Photo 3. Plan D, 53,000-cfs flow. Typical paths of upbound and downbound tows passing within the lower lock approach

a. Downbound tow approaching the lock from left side of channel

b. Downbound tow approaching the lock from right side of channel

Photo 4. Plan F, 53,000-cfs flow. Typical paths of upbound and downbound tows passing within upper approach channel

Photo 5. Construction plan, 30,000-cfs flow. Surface currents near the entrance and just downstream of the diversion canal during construction of lock and dam. Note concentration of surface currents along the left bank near the upper end of diversion canal



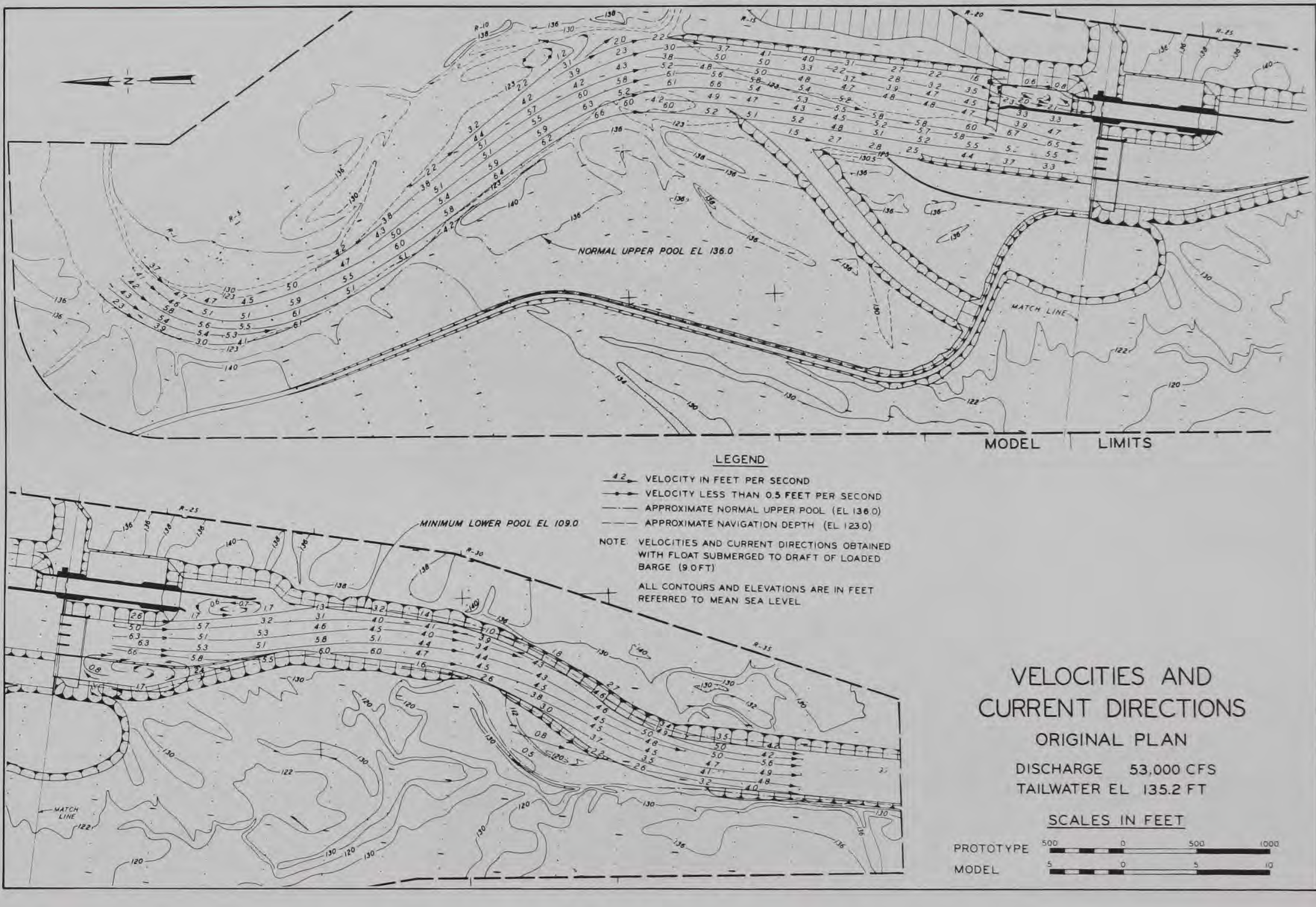
VELOCITIES AND CURRENT DIRECTIONS

ORIGINAL PLAN

DISCHARGE 30,000 CFS

TAILWATER EL 124.3 FT

PLATE 2



LEGEND

4.2 — VELOCITY IN FEET PER SECOND

—•— VELOCITY LESS THAN 0.5 FEET PER SECOND

—·— APPROXIMATE NORMAL UPPER POOL (EL 136.0)

— — APPROXIMATE NAVIGATION DEPTH (EL 123.0)

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

VELOCITIES AND CURRENT DIRECTIONS

ORIGINAL PLAN

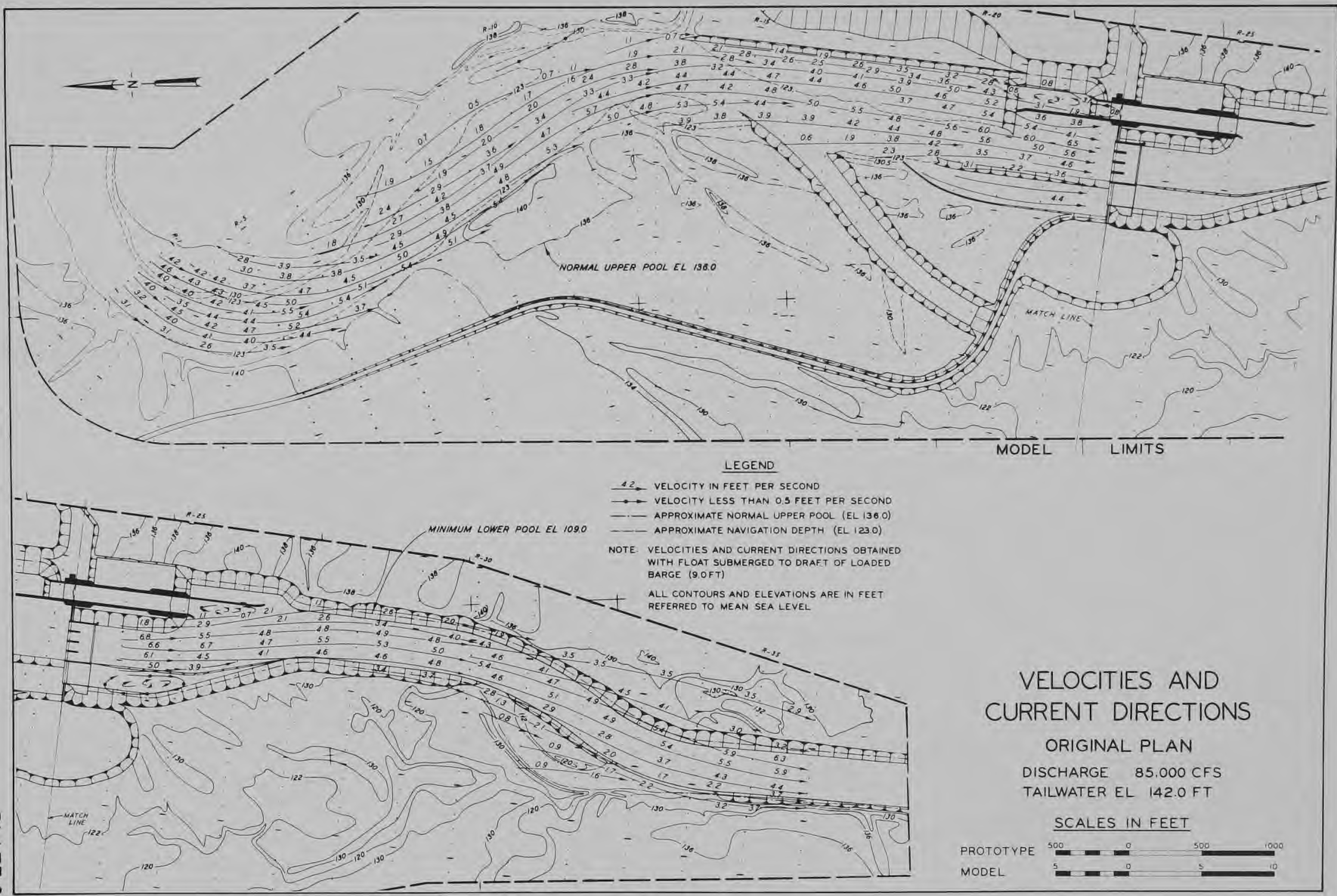
DISCHARGE 53,000 CFS

TAILWATER EL 135.2 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10



VELOCITIES AND CURRENT DIRECTIONS

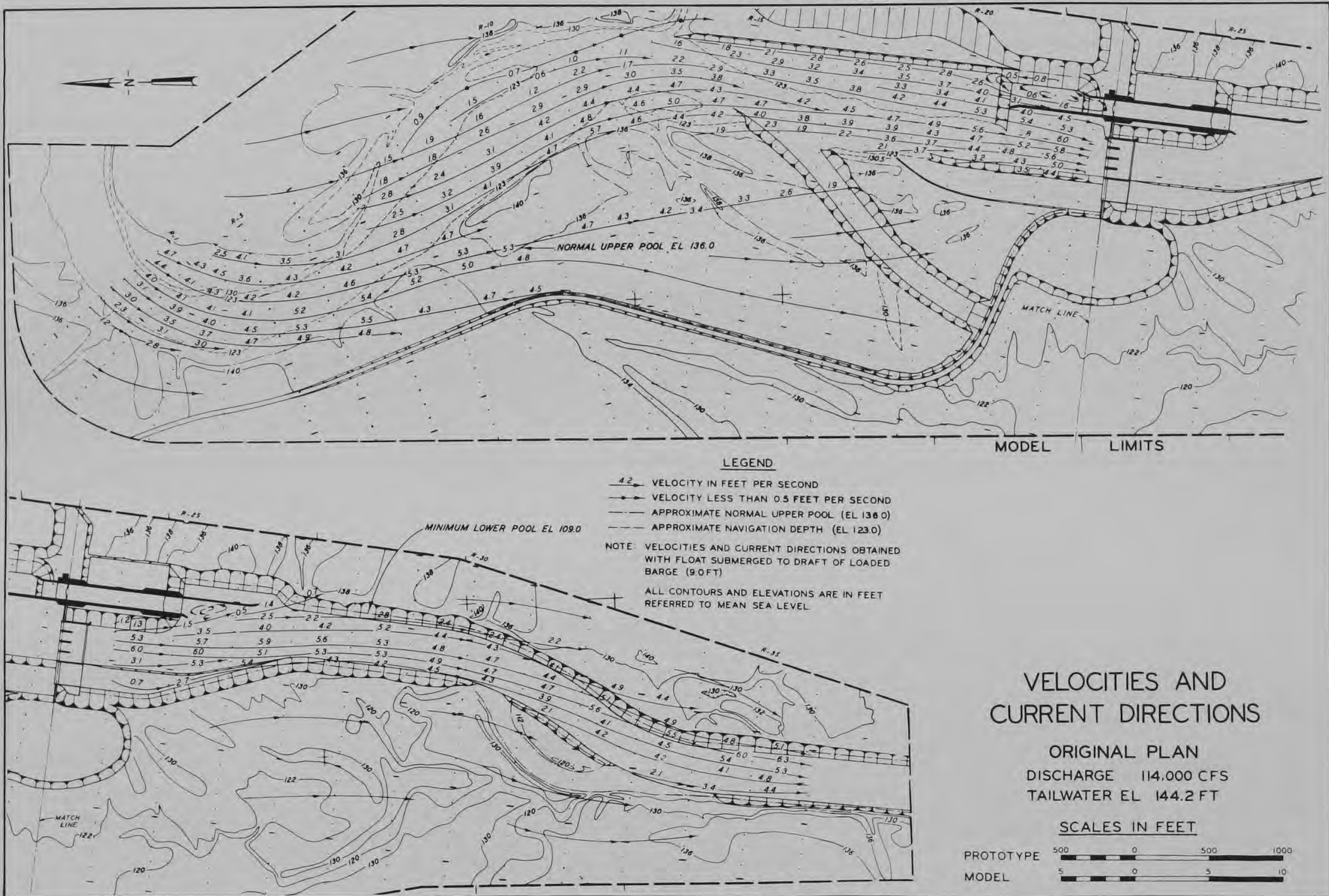
ORIGINAL PLAN

DISCHARGE 85,000 CFS

TAILWATER EL 142.0 FT

PLATE 3

PLATE 4

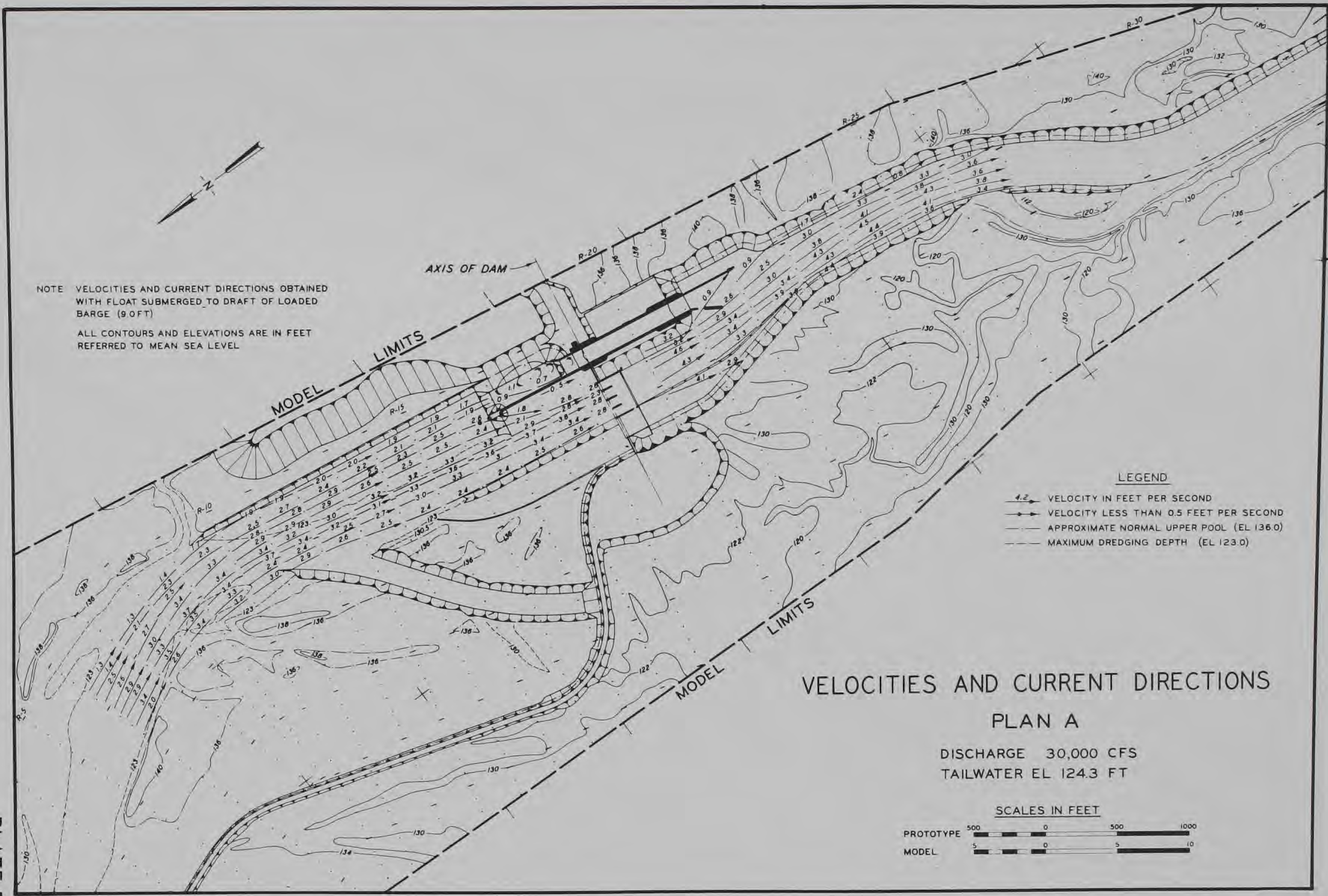


VELOCITIES AND CURRENT DIRECTIONS

ORIGINAL PLAN

DISCHARGE 114,000 CFS

TAILWATER EL 144.2 FT



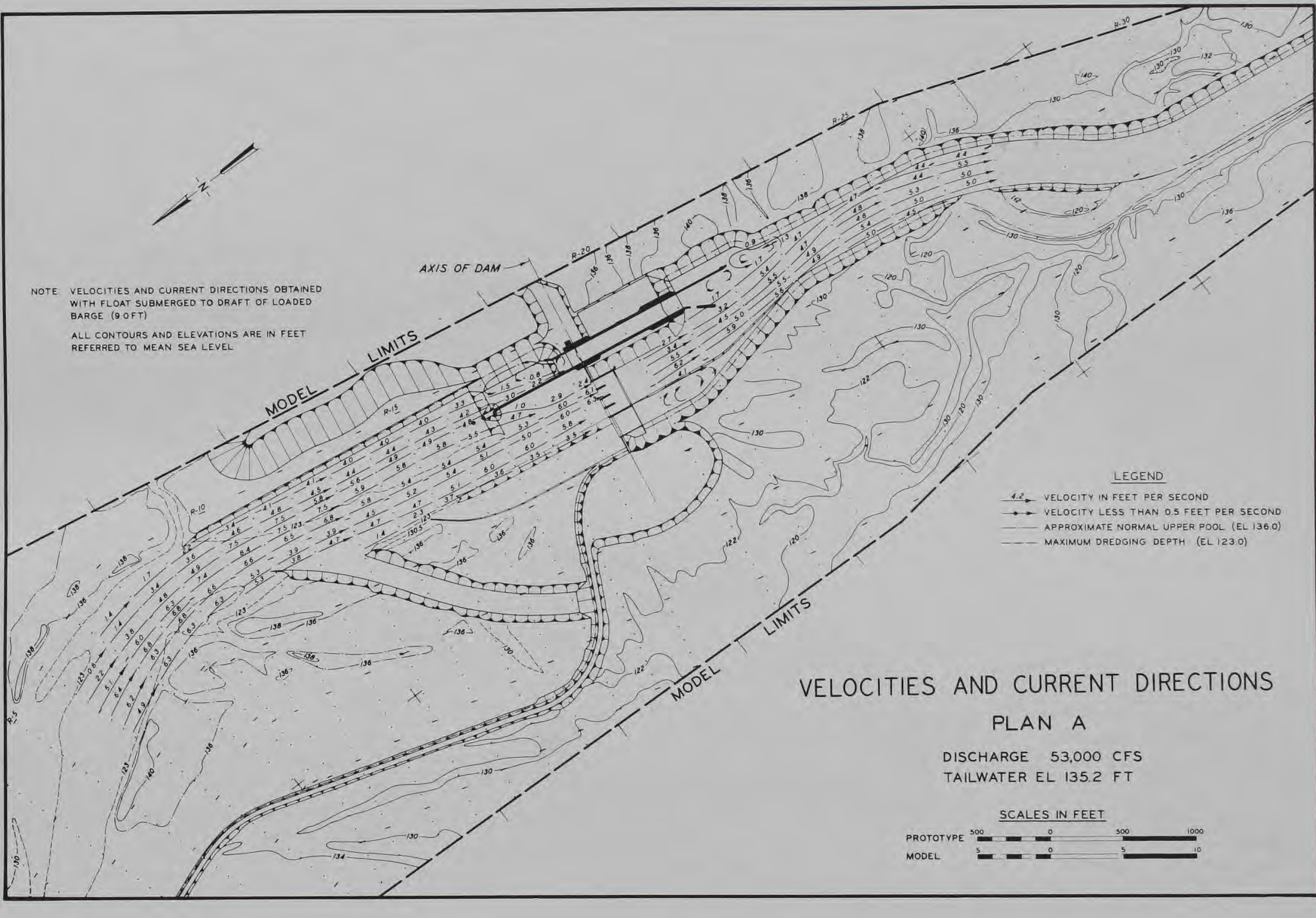
VELOCITIES AND CURRENT DIRECTIONS

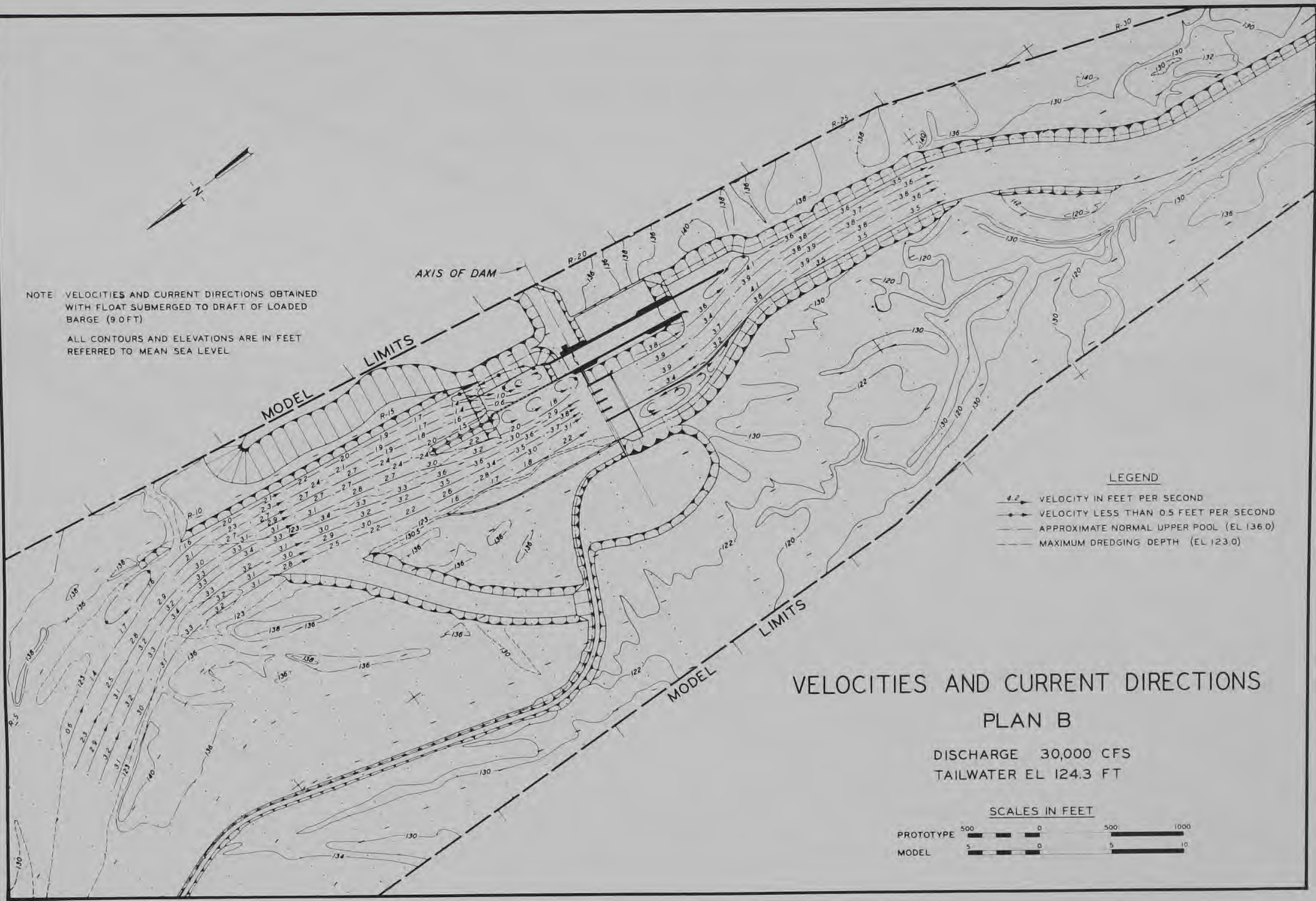
PLAN A

DISCHARGE 30,000 CFS

TAILWATER EL 124.3 FT

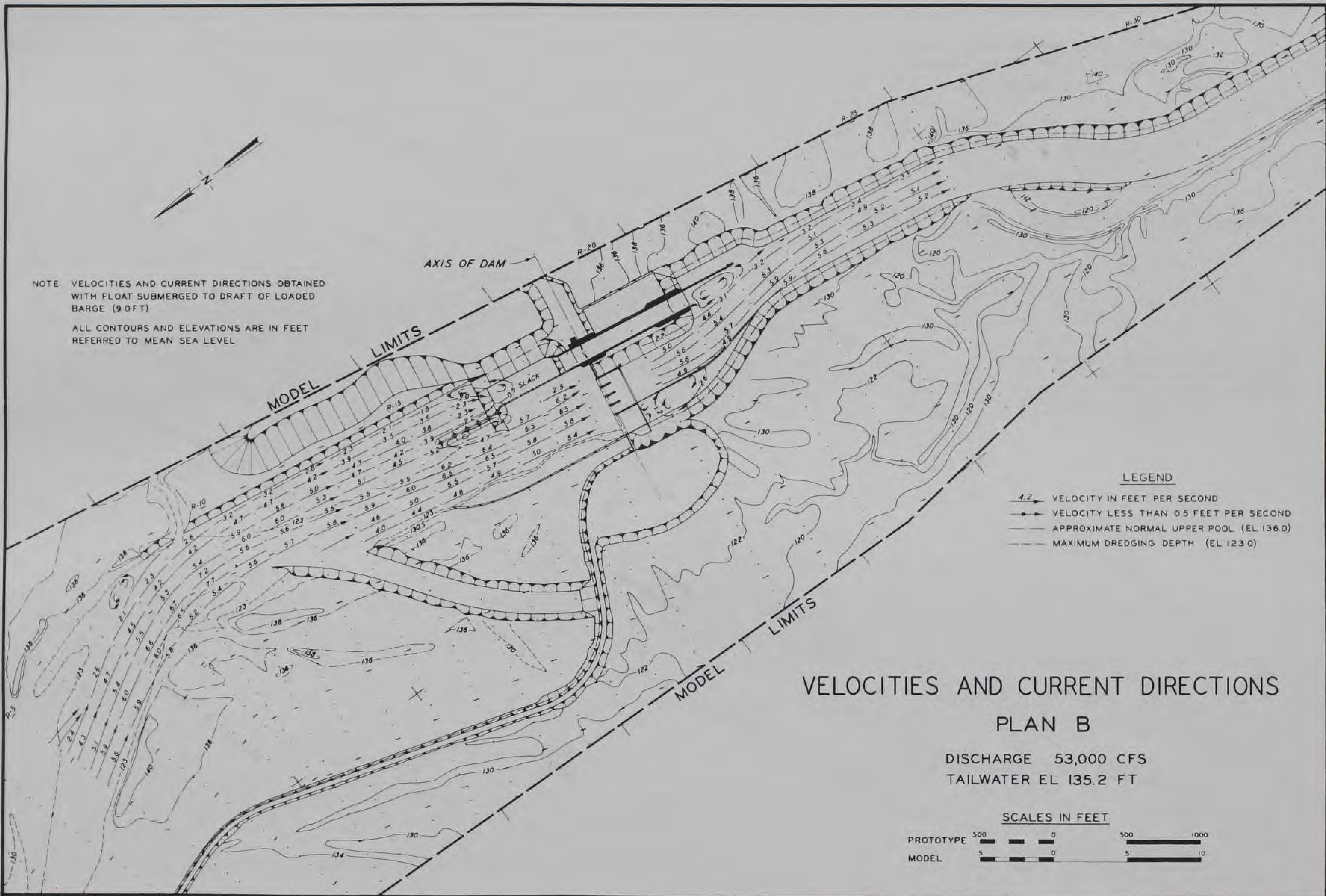
PLATE 5


NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
AXIS OF DAM
MODEL LIMITS
MODEL LIMITS
N
R-5
R-10
R-15
R-20
R-25
R-30
LEGEND
4.2 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
APPROXIMATE NORMAL UPPER POOL (EL 136.0)
MAXIMUM DREDGING DEPTH (EL 123.0)
VELOCITIES AND CURRENT DIRECTIONS
PLAN A
DISCHARGE 53,000 CFS
TAILWATER EL 135.2 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10



NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
AXIS OF DAM
MODEL LIMITS
MODEL LIMITS
LEGEND
4.2 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
APPROXIMATE NORMAL UPPER POOL (EL 136.0)
MAXIMUM DREDGING DEPTH (EL 123.0)
VELOCITIES AND CURRENT DIRECTIONS
PLAN B
DISCHARGE 30,000 CFS
TAILWATER EL 124.3 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

PLATE 7



VELOCITIES AND CURRENT DIRECTIONS
PLAN B

DISCHARGE 53,000 CFS
TAILWATER EL 135.2 FT

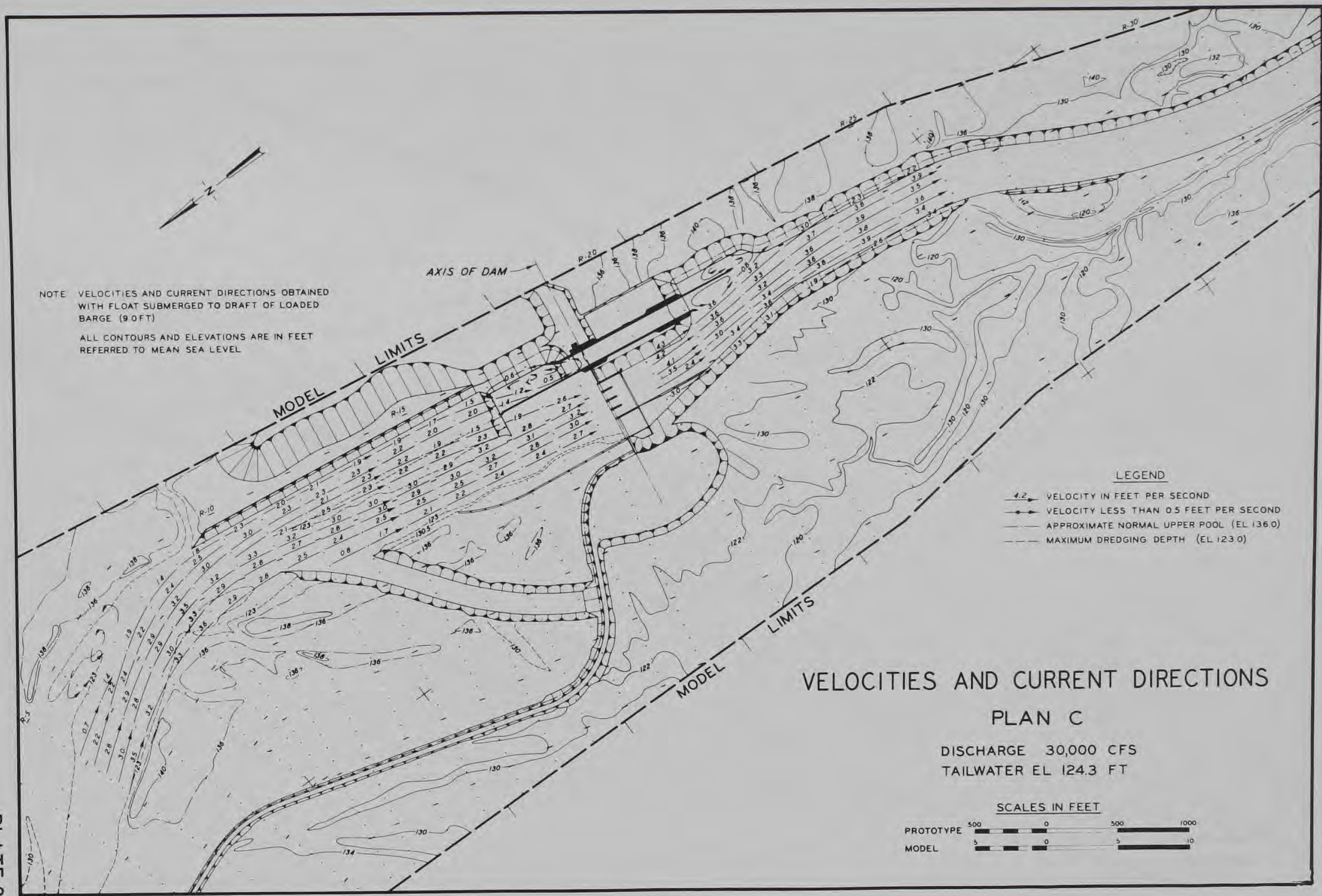
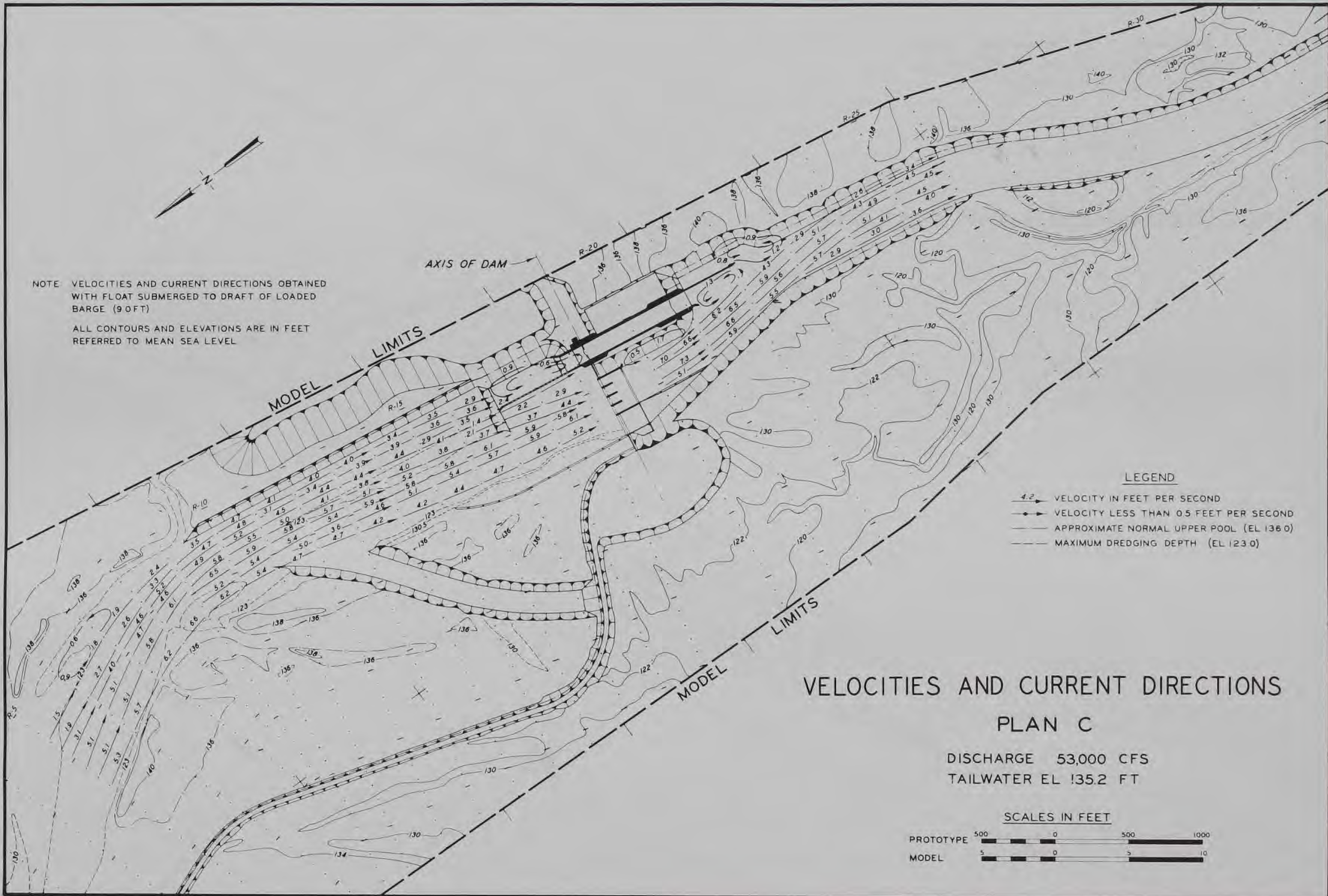

NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
AXIS OF DAM
MODEL LIMITS
MODEL LIMITS
LEGEND
4.2 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
APPROXIMATE NORMAL UPPER POOL (EL 136.0)
MAXIMUM DREDGING DEPTH (EL 123.0)
VELOCITIES AND CURRENT DIRECTIONS
PLAN C
DISCHARGE 30,000 CFS
TAILWATER EL 124.3 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

PLATE 9

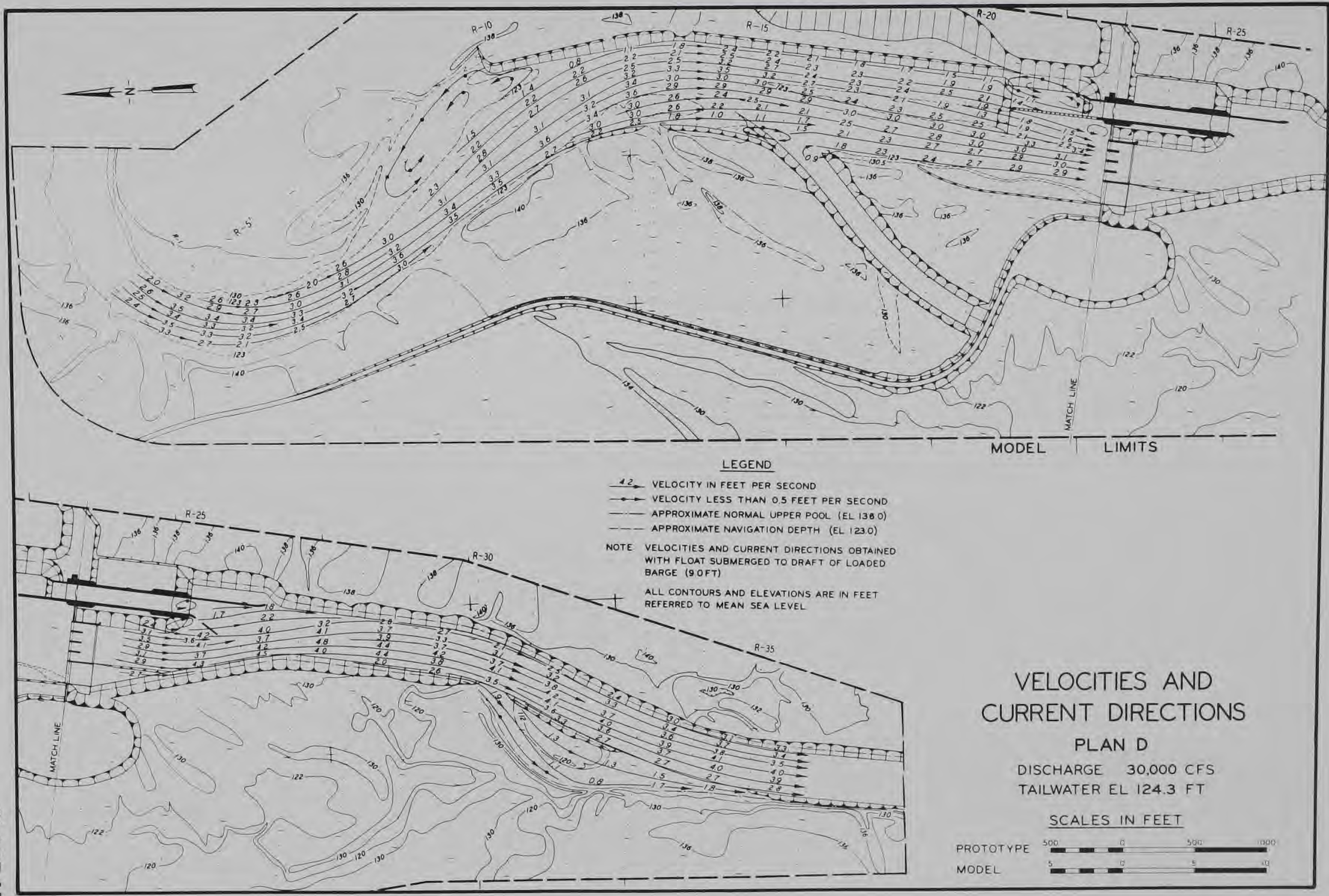


VELOCITIES AND CURRENT DIRECTIONS

PLAN C

DISCHARGE 53,000 CFS

TAILWATER EL 135.2 FT



LEGEND

4.2 → VELOCITY IN FEET PER SECOND
—•→ VELOCITY LESS THAN 0.5 FEET PER SECOND
—·— APPROXIMATE NORMAL UPPER POOL (EL 138.0)
— — APPROXIMATE NAVIGATION DEPTH (EL 123.0)

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

VELOCITIES AND CURRENT DIRECTIONS

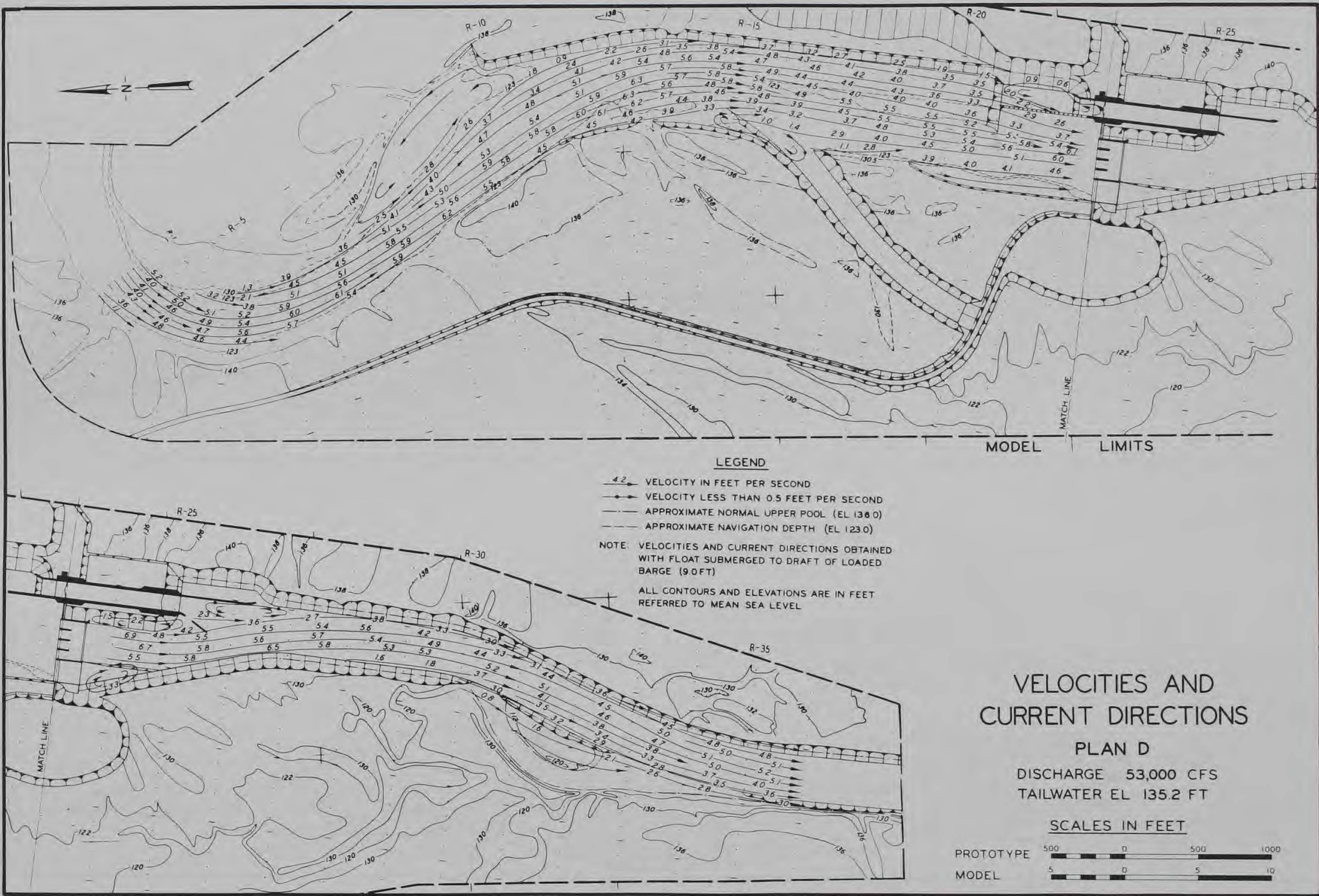
PLAN D

DISCHARGE 30,000 CFS
TAILWATER EL 124.3 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

PLATE 11



LEGEND

4.2 VELOCITY IN FEET PER SECOND

VELOCITY LESS THAN 0.5 FEET PER SECOND

APPROXIMATE NORMAL UPPER POOL (EL 138.0)

APPROXIMATE NAVIGATION DEPTH (EL 123.0)

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

VELOCITIES AND CURRENT DIRECTIONS

PLAN D

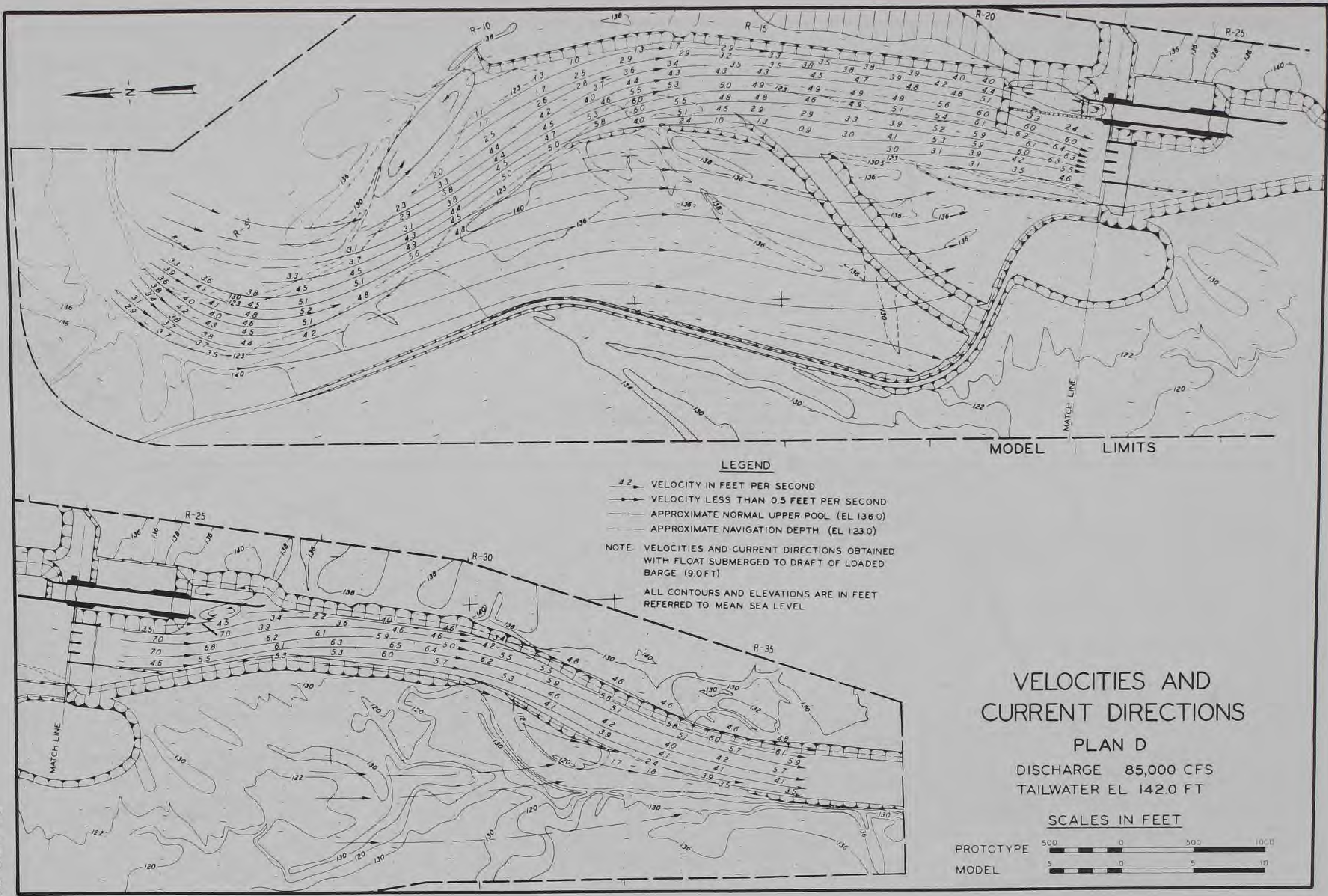
DISCHARGE 53,000 CFS

TAILWATER EL 135.2 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10



LEGEND

4.2 VELOCITY IN FEET PER SECOND

VELOCITY LESS THAN 0.5 FEET PER SECOND

APPROXIMATE NORMAL UPPER POOL (EL 136.0)

APPROXIMATE NAVIGATION DEPTH (EL 123.0)

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

VELOCITIES AND CURRENT DIRECTIONS

PLAN D

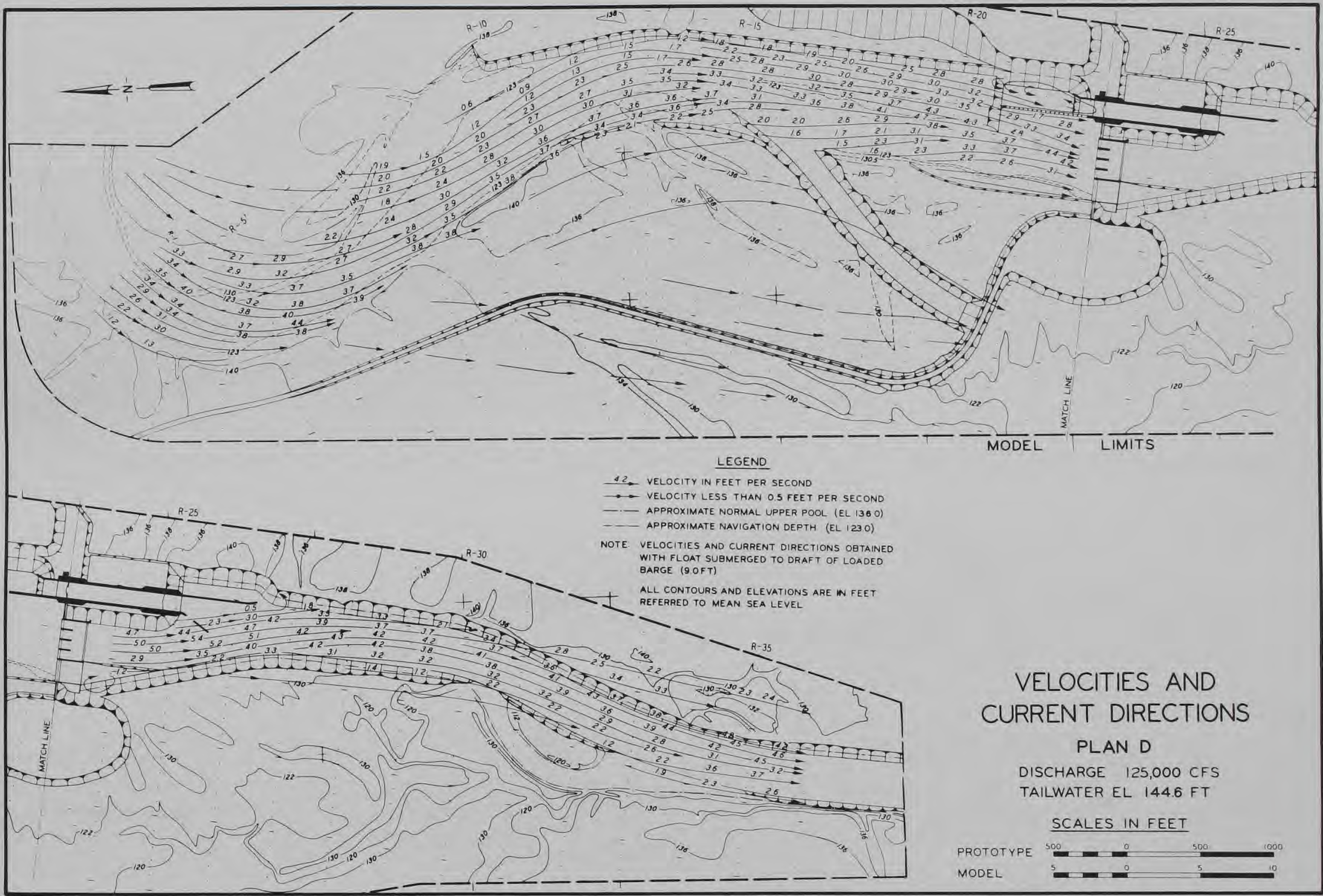
DISCHARGE 85,000 CFS
TAILWATER EL 142.0 FT

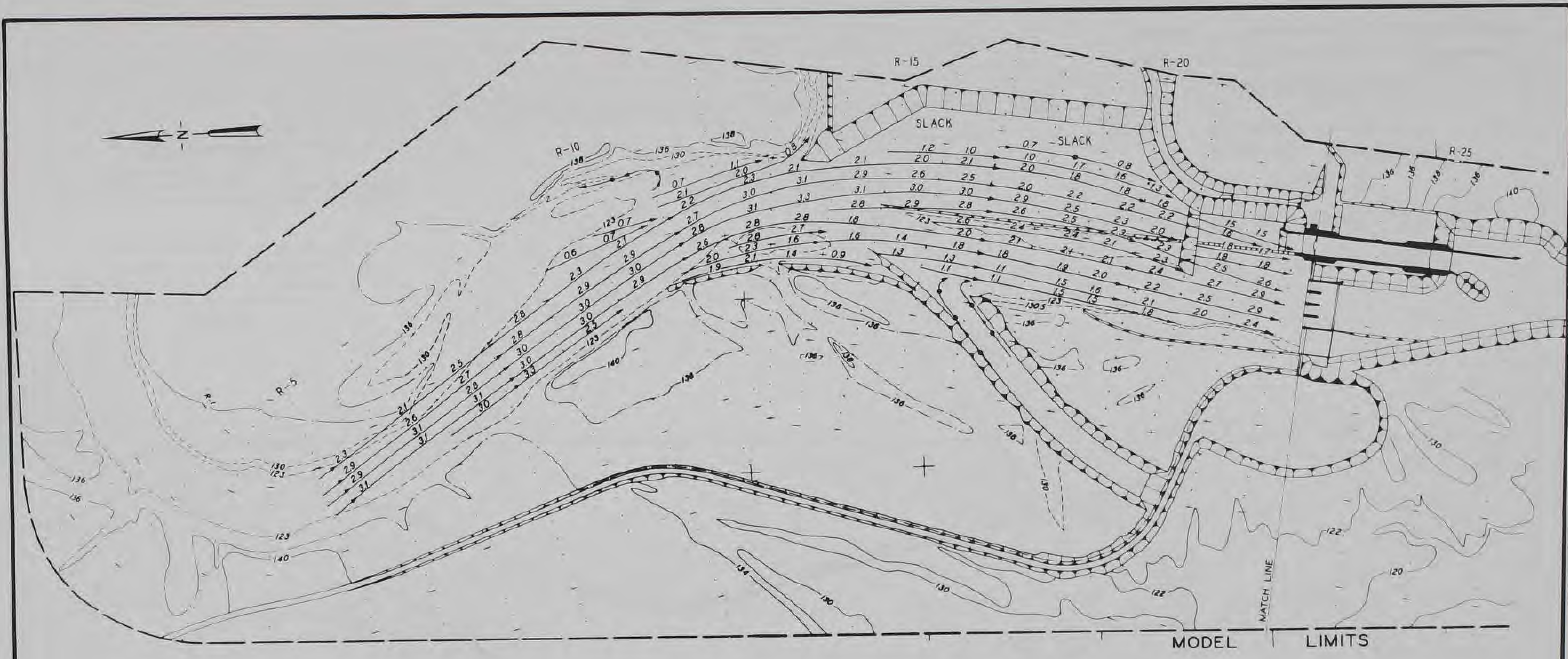
SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

PLATE 13


MODEL LIMITS
MATCH LINE
LEGEND
4.2 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
APPROXIMATE NORMAL UPPER POOL (EL 138.0)
APPROXIMATE NAVIGATION DEPTH (EL 123.0)
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
VELOCITIES AND CURRENT DIRECTIONS
PLAN D
DISCHARGE 125,000 CFS
TAILWATER EL 144.6 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10



LEGEND

4.2 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
APPROXIMATE NORMAL UPPER POOL (EL 136.0)
APPROXIMATE NAVIGATION DEPTH (EL 123.0)

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

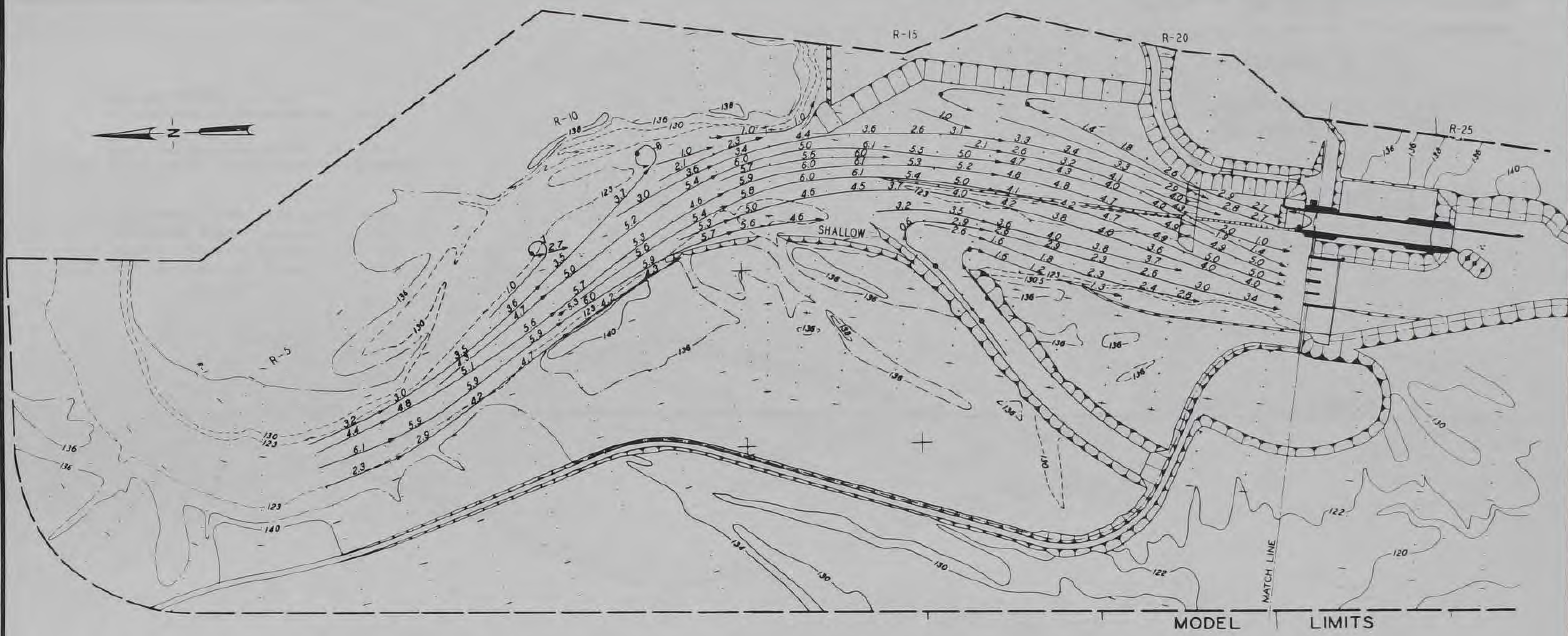
VELOCITIES AND CURRENT DIRECTIONS

PLAN E

DISCHARGE 30,000 CFS
TAILWATER EL 124.3 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10



LEGEND

4.2 → VELOCITY IN FEET PER SECOND
—•→ VELOCITY LESS THAN 0.5 FEET PER SECOND
—·— APPROXIMATE NORMAL UPPER POOL (EL 136.0)
– – – APPROXIMATE NAVIGATION DEPTH (EL 123.0)

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

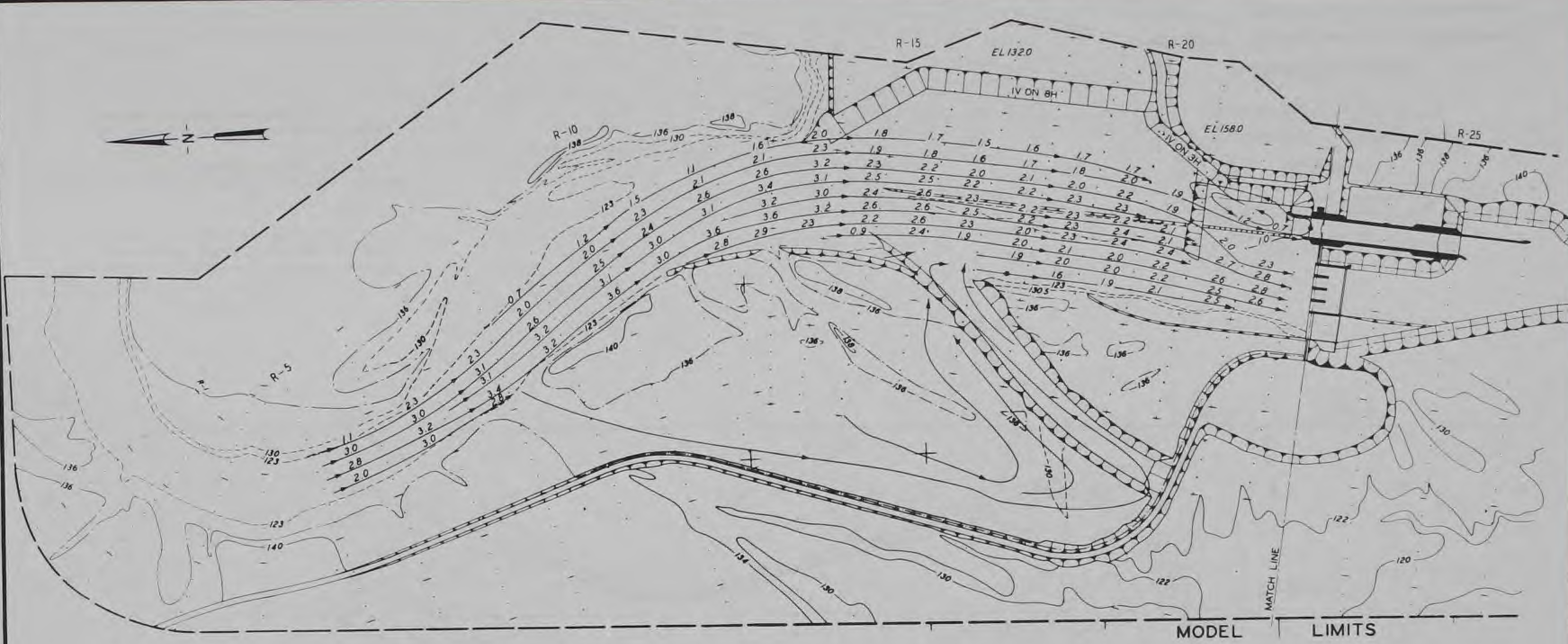
VELOCITIES AND CURRENT DIRECTIONS

PLAN E

DISCHARGE 53,000 CFS
TAILWATER EL 135.2 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10



LEGEND

4.2 — VELOCITY IN FEET PER SECOND
—•— VELOCITY LESS THAN 0.5 FEET PER SECOND
—·— APPROXIMATE NORMAL UPPER POOL (EL 138.0)
—+— APPROXIMATE NAVIGATION DEPTH (EL 123.0)

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

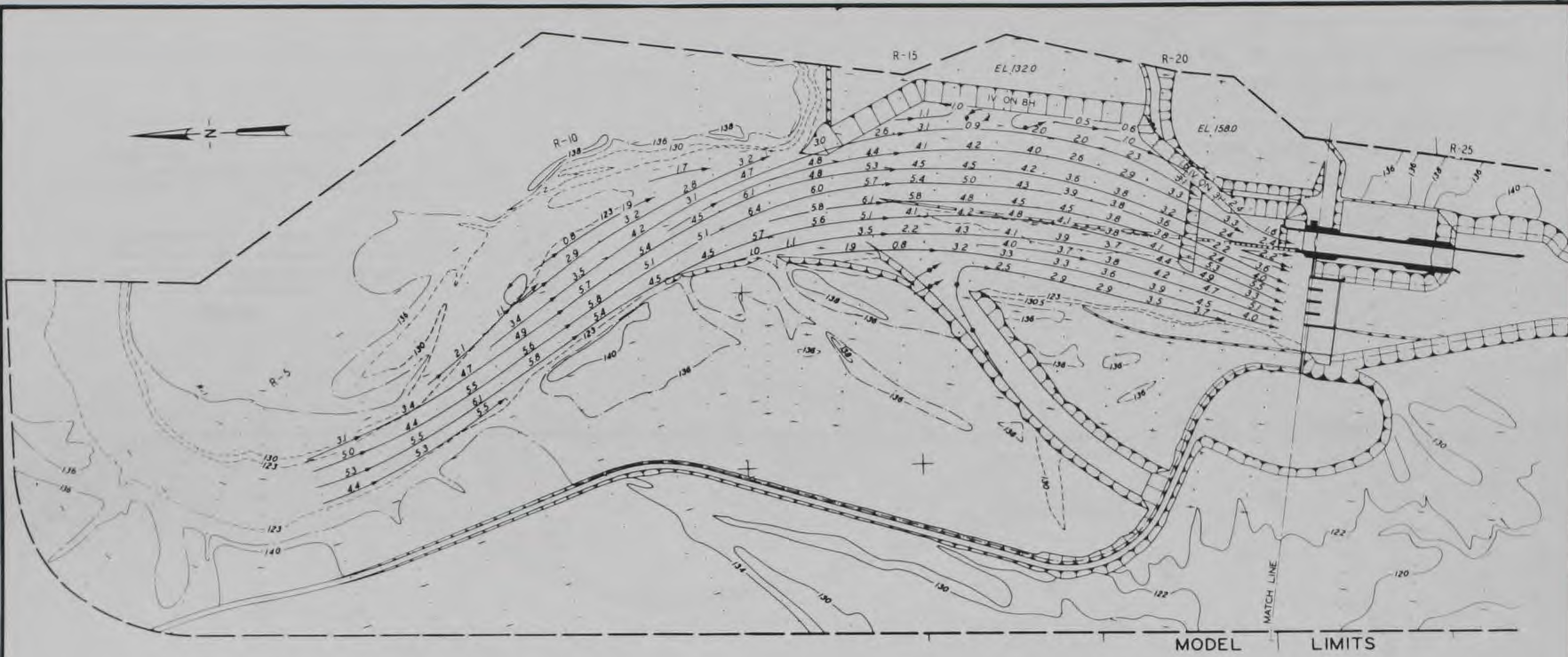
VELOCITIES AND CURRENT DIRECTIONS

PLAN F

DISCHARGE 30,000 CFS
TAILWATER EL 124.3+ FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10



LEGEND

- 4.2 VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- APPROXIMATE NORMAL UPPER POOL (EL 136.0)
- APPROXIMATE NAVIGATION DEPTH (EL 123.0)

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

VELOCITIES AND CURRENT DIRECTIONS

PLAN F

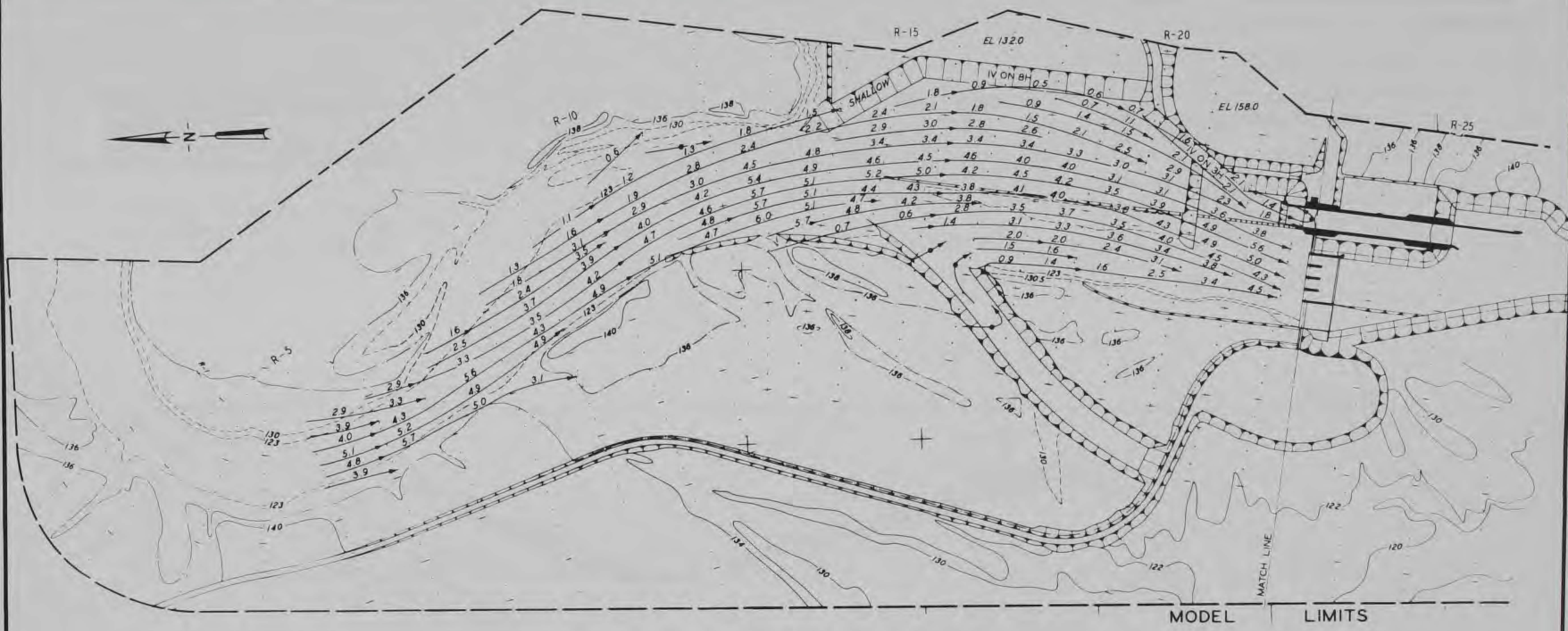
DISCHARGE 53,000 CFS

TAILWATER EL 135.2 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- APPROXIMATE NORMAL UPPER POOL (EL 136.0)
- APPROXIMATE NAVIGATION DEPTH (EL 123.0)

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

VELOCITIES AND CURRENT DIRECTIONS

PLAN F

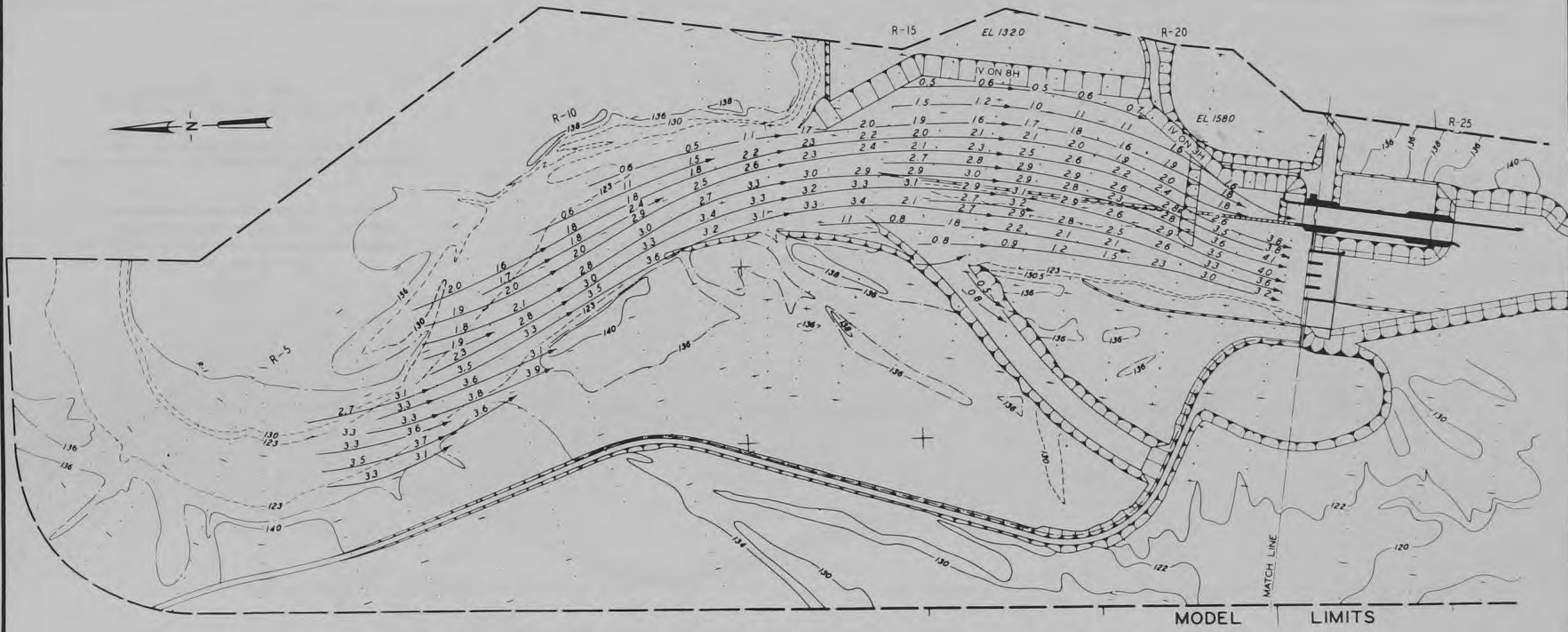
DISCHARGE 85,000 CFS

TAILWATER EL 142.0 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10



LEGEND

4.2 → VELOCITY IN FEET PER SECOND
—•→ VELOCITY LESS THAN 0.5 FEET PER SECOND
—·— APPROXIMATE NORMAL UPPER POOL (EL 136.0)
— — APPROXIMATE NAVIGATION DEPTH (EL 123.0)

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

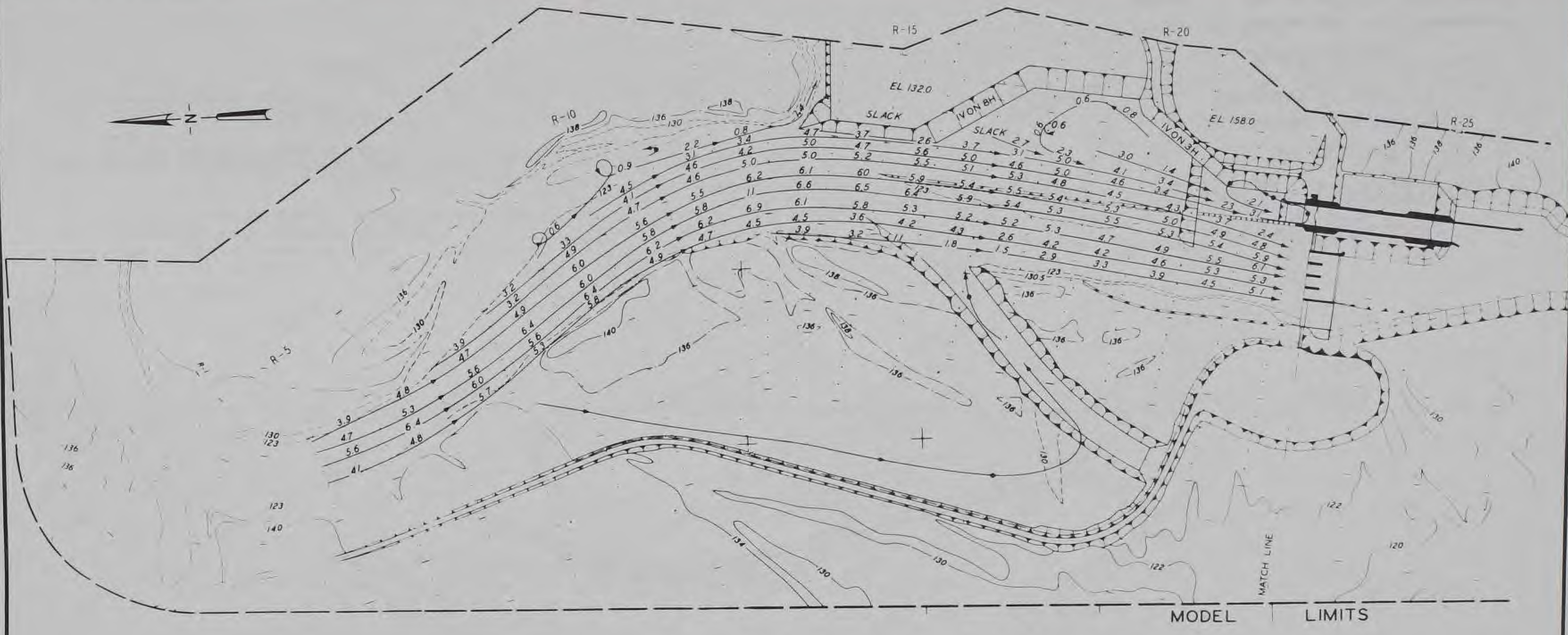
VELOCITIES AND CURRENT DIRECTIONS

PLAN F

DISCHARGE 125,000 CFS
TAILWATER EL 144.6 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10



LEGEND

4.2 — VELOCITY IN FEET PER SECOND

—•— VELOCITY LESS THAN 0.5 FEET PER SECOND

—·— APPROXIMATE NORMAL UPPER POOL (EL 136.0)

– – – APPROXIMATE NAVIGATION DEPTH (EL 123.0)

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

VELOCITIES AND CURRENT DIRECTIONS

PLAN F-1

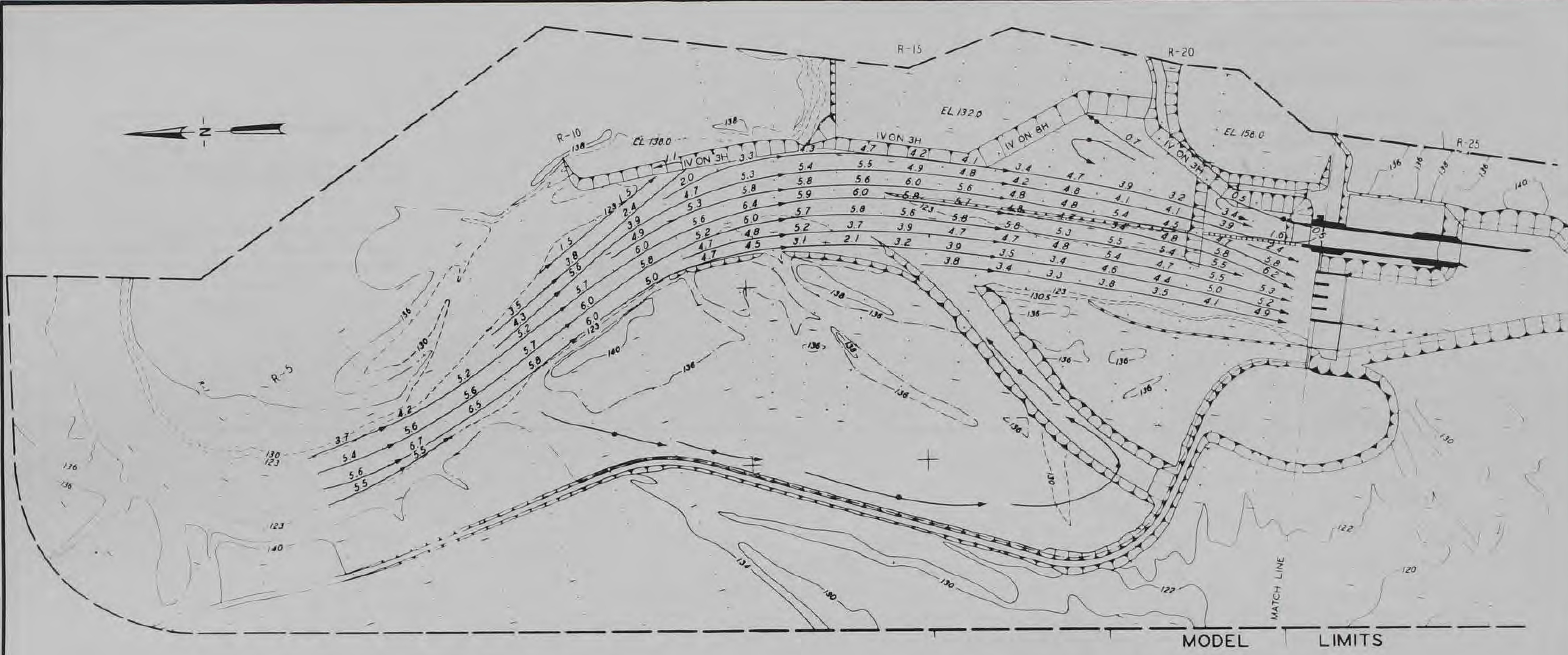
DISCHARGE 53,000 CFS

TAILWATER EL 135.2 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10



LEGEND

4.2 → VELOCITY IN FEET PER SECOND

—•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

—·— APPROXIMATE NORMAL UPPER POOL (EL 136.0)

— — APPROXIMATE NAVIGATION DEPTH (EL 123.0)

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

VELOCITIES AND CURRENT DIRECTIONS

PLAN F-2

DISCHARGE 53,000 CFS

TAILWATER EL 135.2 FT

SCALES IN FEET

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

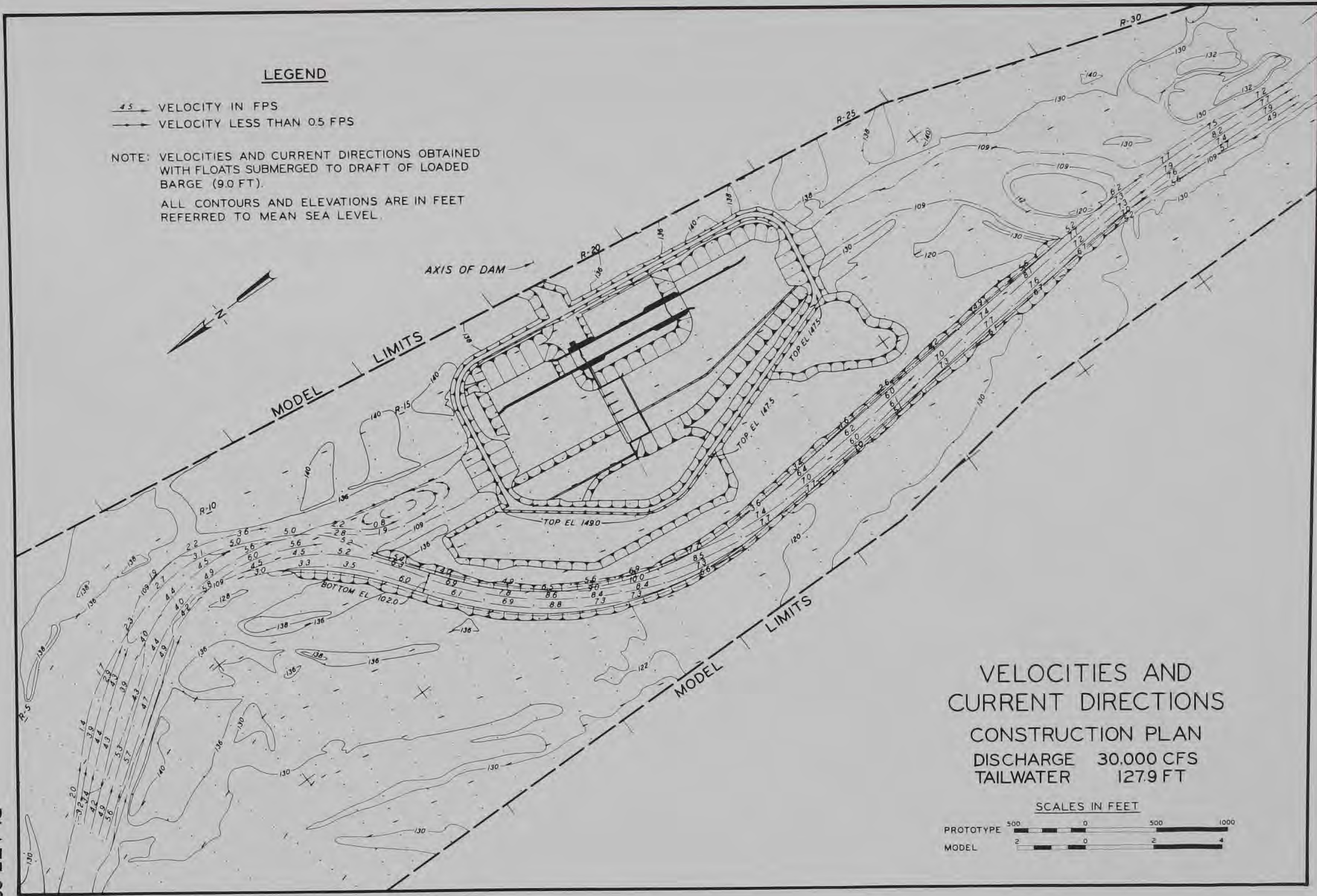
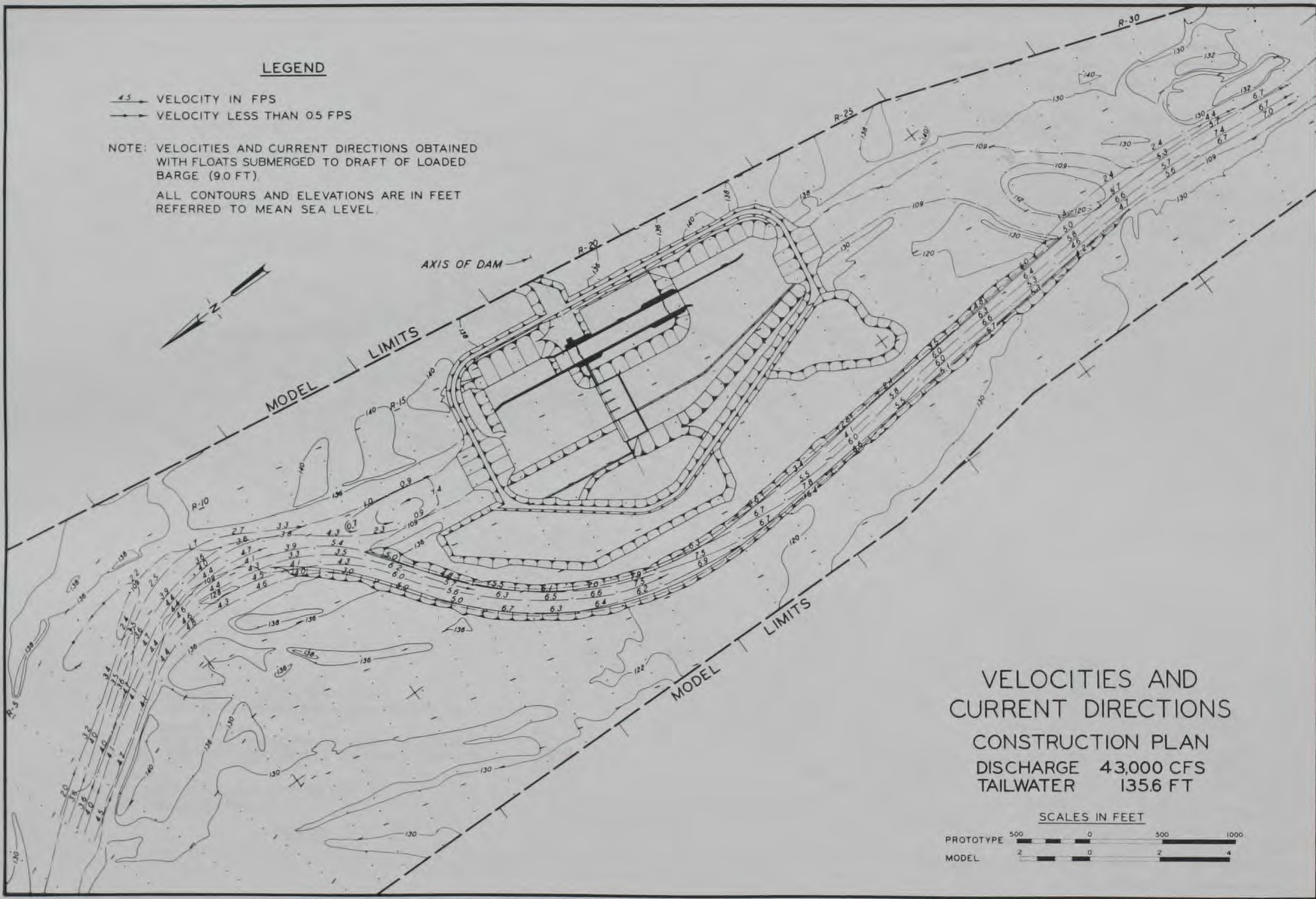
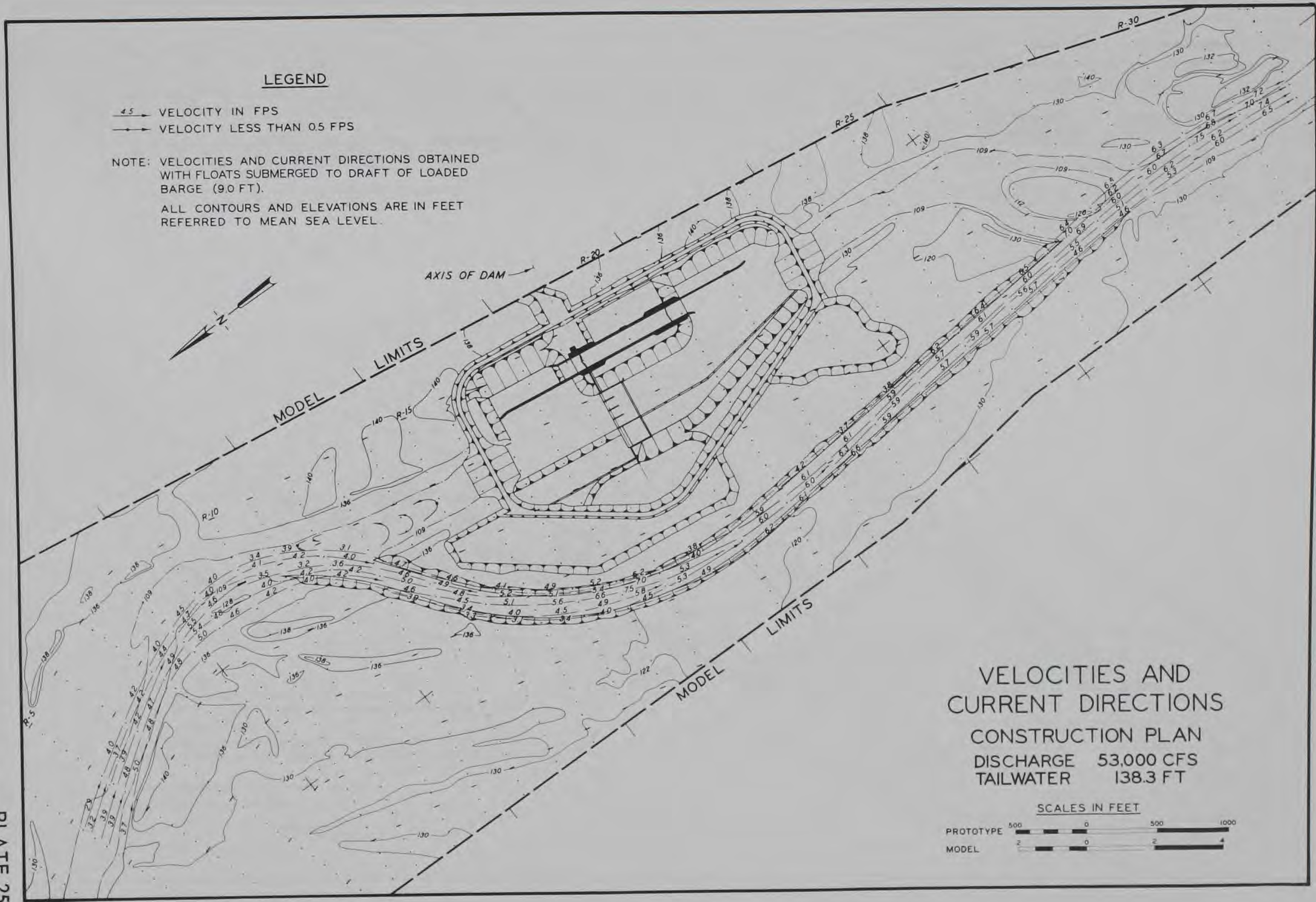

LEGEND
4.5 VELOCITY IN FPS
VELOCITY LESS THAN 0.5 FPS
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT).
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL.
AXIS OF DAM
MODEL LIMITS
MODEL LIMITS
TOP EL 149.0
TOP EL 147.5
TOP EL 147.5
BOTTOM EL 102.0
R-5
R-10
R-15
R-20
R-25
R-30
N
VELOCITIES AND CURRENT DIRECTIONS
CONSTRUCTION PLAN
DISCHARGE 30,000 CFS
TAILWATER 127.9 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 2 0 2 4

PLATE 24


LEGEND
4.5 VELOCITY IN FPS
VELOCITY LESS THAN 0.5 FPS
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT).
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL.
AXIS OF DAM
MODEL LIMITS
MODEL LIMITS
R-5
R-10
R-15
R-20
R-25
R-30
N
VELOCITIES AND CURRENT DIRECTIONS
CONSTRUCTION PLAN
DISCHARGE 43,000 CFS
TAILWATER 135.6 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 2 0 2 4

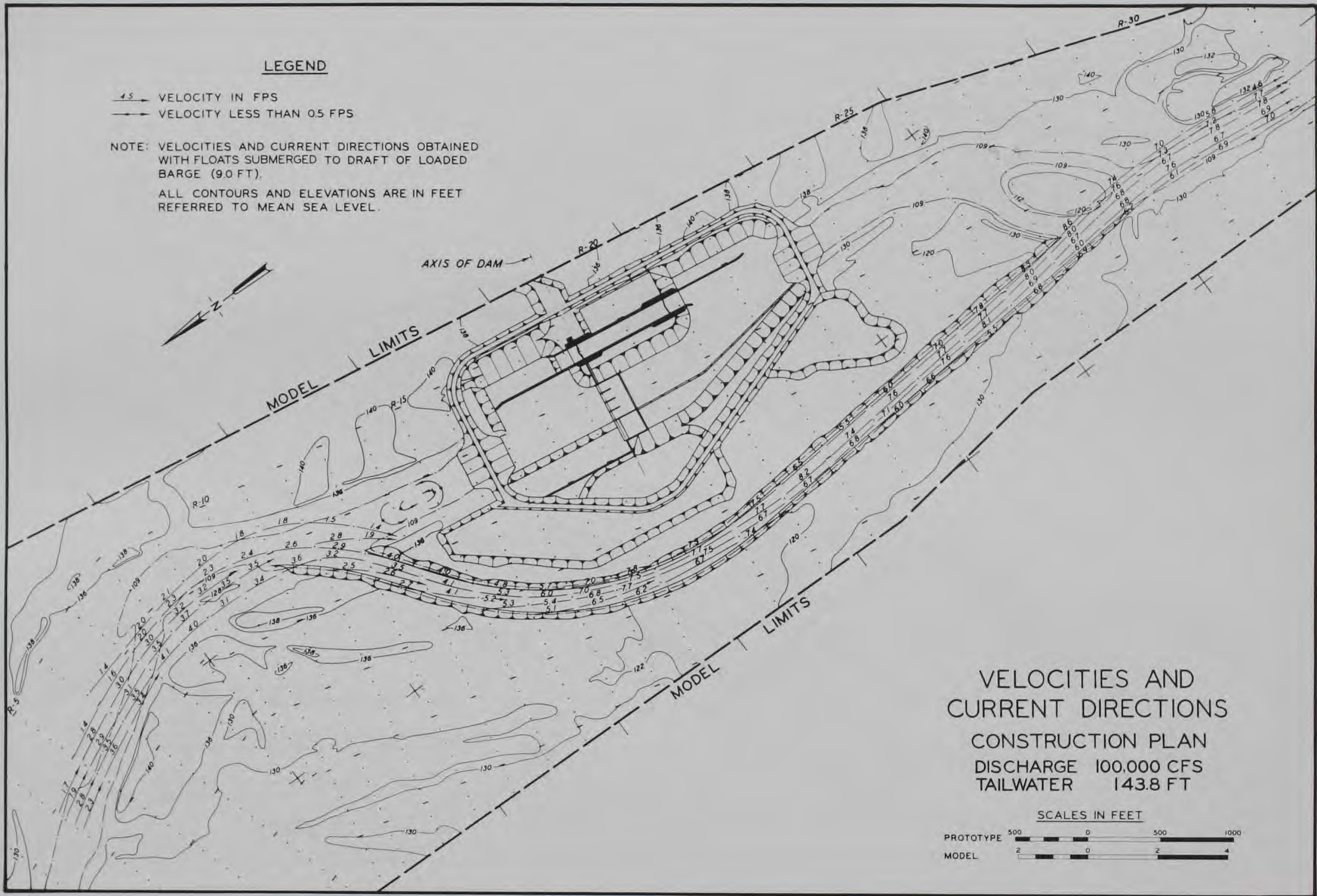


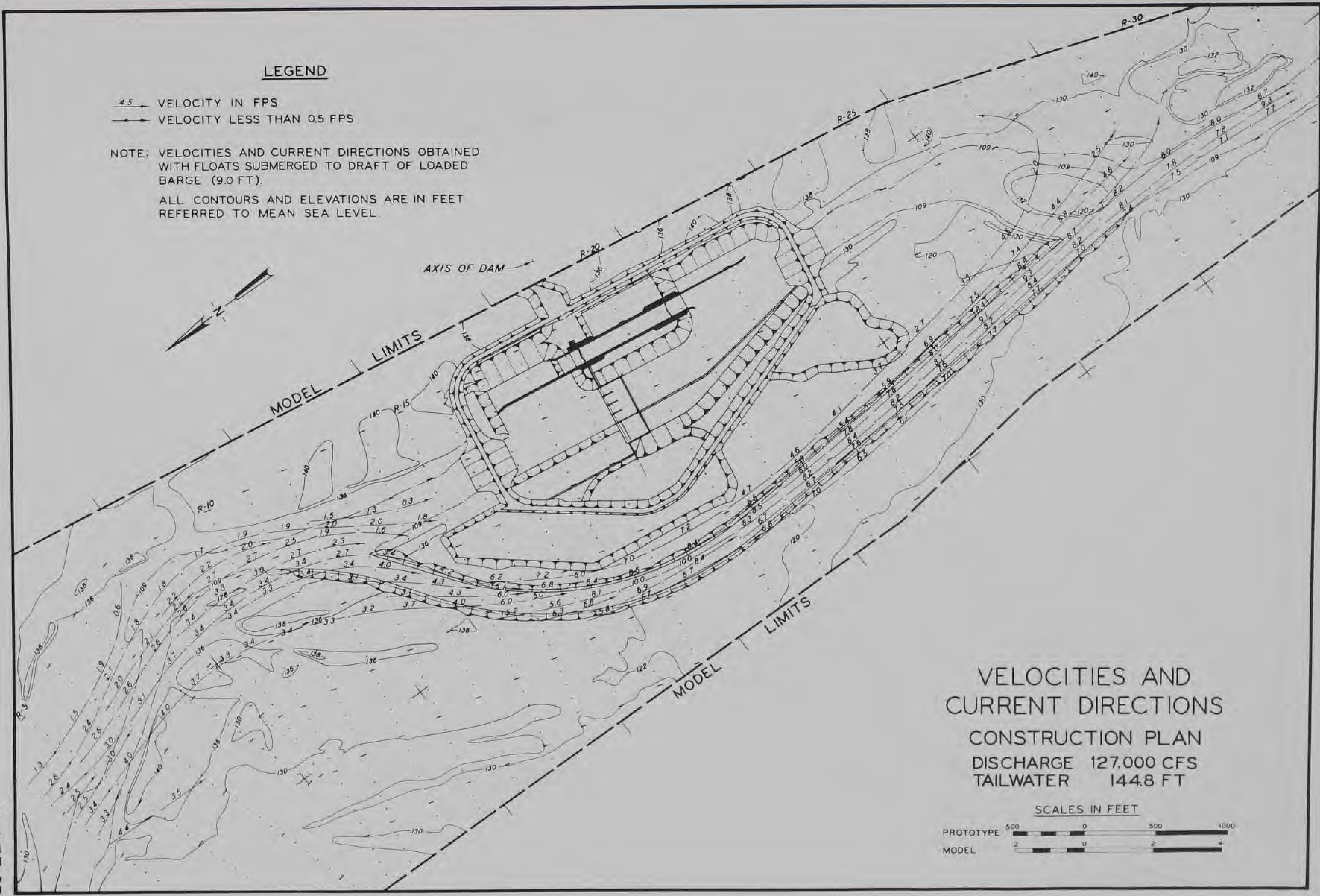
VELOCITIES AND CURRENT DIRECTIONS

CONSTRUCTION PLAN

DISCHARGE 53,000 CFS

TAILWATER 138.3 FT


LEGEND
4.5 VELOCITY IN FPS
VELOCITY LESS THAN 0.5 FPS
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOATS SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT).
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL.
AXIS OF DAM
MODEL LIMITS
MODEL LIMITS
R-5
R-10
R-15
R-20
R-25
R-30
N
VELOCITIES AND CURRENT DIRECTIONS
CONSTRUCTION PLAN
DISCHARGE 100,000 CFS
TAILWATER 143.8 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 2 0 2 4



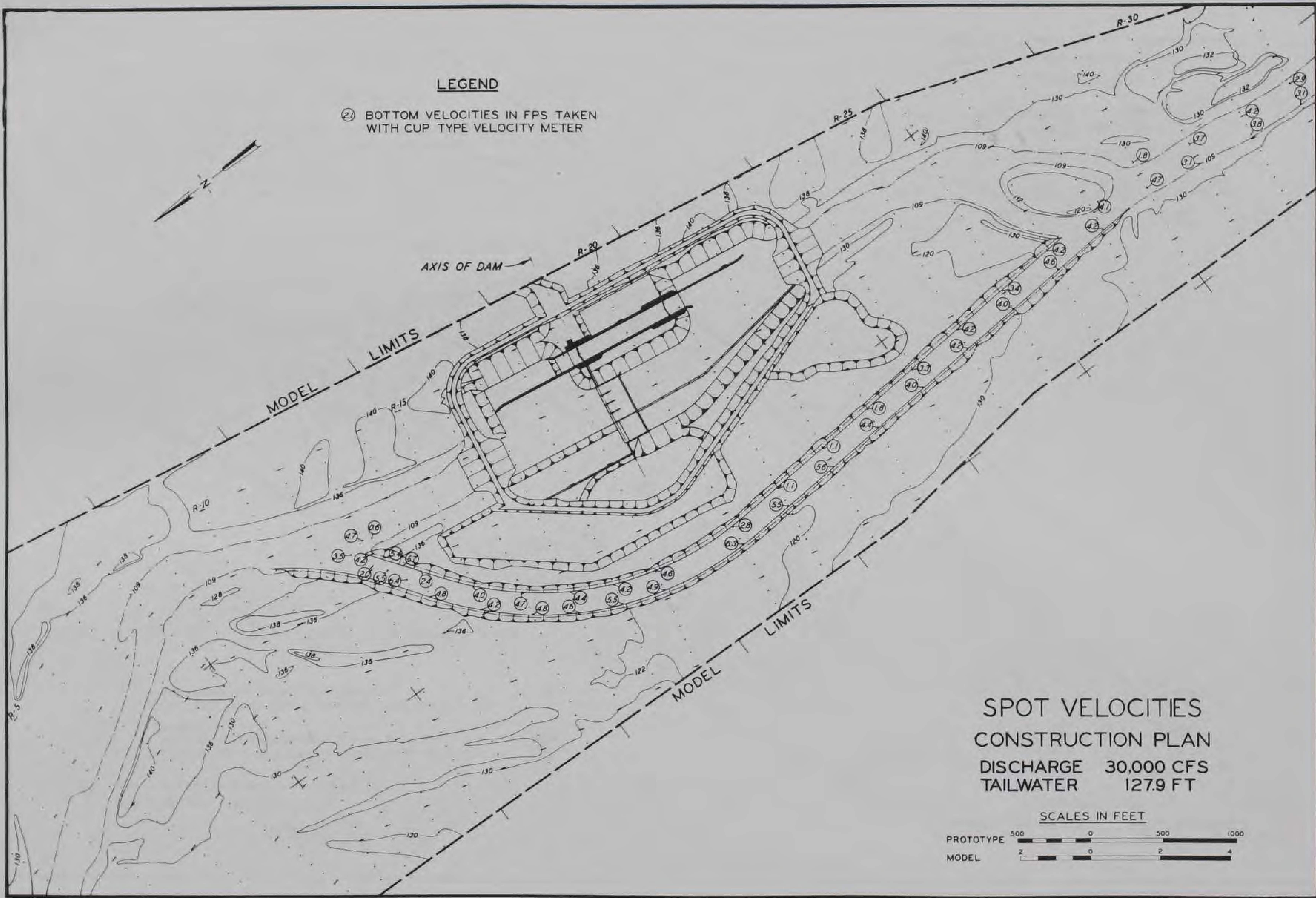
VELOCITIES AND CURRENT DIRECTIONS

CONSTRUCTION PLAN

DISCHARGE 127,000 CFS

TAILWATER 144.8 FT

PLATE 28


LEGEND
(2.1) BOTTOM VELOCITIES IN FPS TAKEN WITH CUP TYPE VELOCITY METER
N
AXIS OF DAM
MODEL LIMITS
MODEL LIMITS
R-5
R-10
R-15
R-20
R-25
R-30
SPOT VELOCITIES
CONSTRUCTION PLAN
DISCHARGE 30,000 CFS
TAILWATER 127.9 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 2 0 2 4

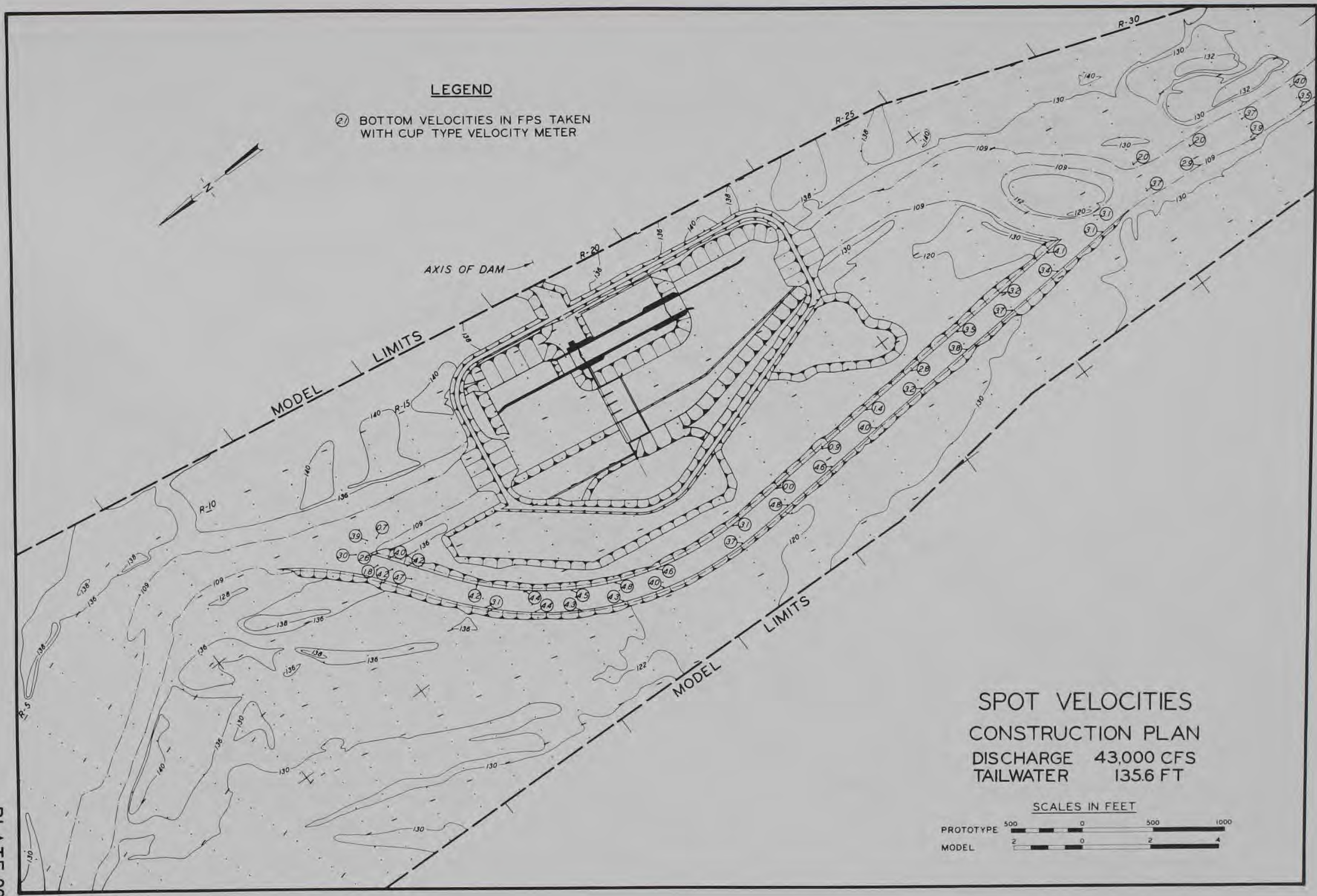
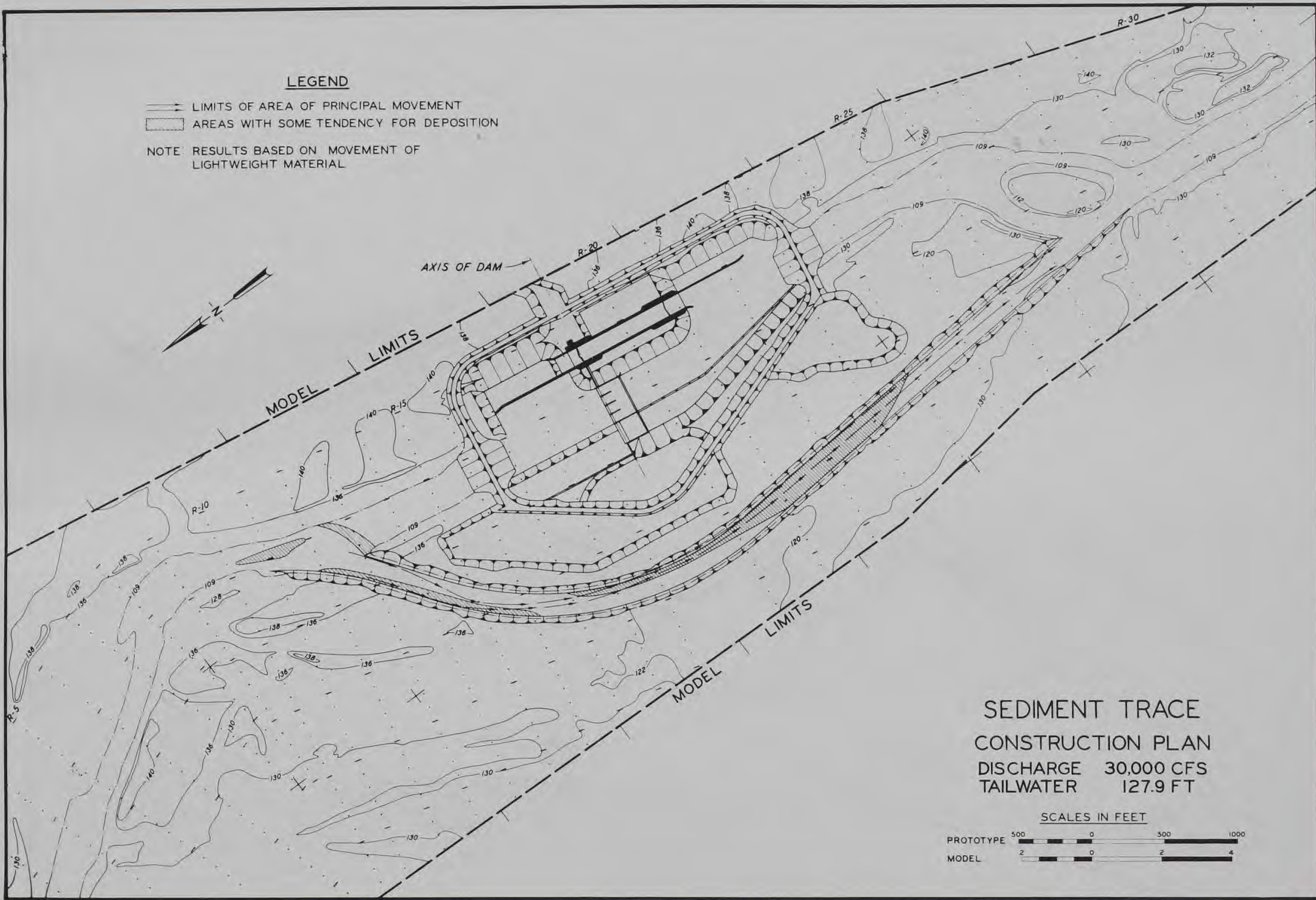

LEGEND
(21) BOTTOM VELOCITIES IN FPS TAKEN WITH CUP TYPE VELOCITY METER
N
AXIS OF DAM
MODEL LIMITS
MODEL LIMITS
R-5
R-10
R-15
R-20
R-25
R-30
SPOT VELOCITIES
CONSTRUCTION PLAN
DISCHARGE 43,000 CFS
TAILWATER 135.6 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 2 0 2 4

PLATE 29



SEDIMENT TRACE
CONSTRUCTION PLAN
DISCHARGE 30,000 CFS
TAILWATER 127.9 FT

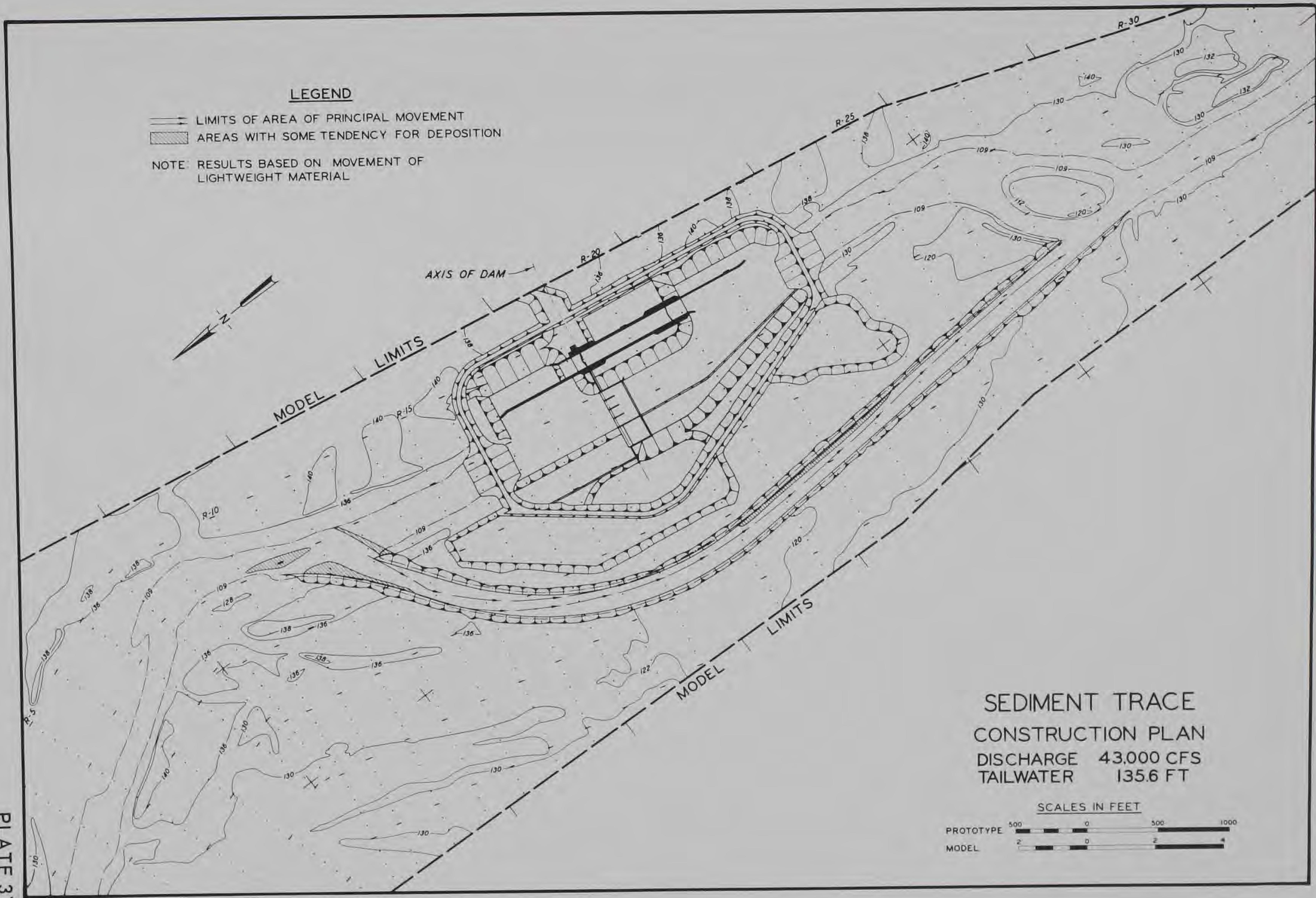

LEGEND
LIMITS OF AREA OF PRINCIPAL MOVEMENT
AREAS WITH SOME TENDENCY FOR DEPOSITION
NOTE: RESULTS BASED ON MOVEMENT OF LIGHTWEIGHT MATERIAL
N
AXIS OF DAM
MODEL LIMITS
MODEL LIMITS
R-5
R-10
R-15
R-20
R-25
R-30
109
120
130
136
138
140
SEDIMENT TRACE
CONSTRUCTION PLAN
DISCHARGE 43,000 CFS
TAILWATER 135.6 FT
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 2 0 2 4

PLATE 31