Coastal and Hydraulics Laboratory

ERDC/CHL TR-02-6

US Army Corps
of Engineers®
Engineer Research and
Development Center

Red River Waterway, John H. Overton Lock and Dam

Navigation Alignment Conditions, Hydraulic Model Investigation

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Preface

The model investigation reported herein was conducted for the U.S. Army Engineer District (USAED), Vicksburg, and authorized by DA Form 2544, Order No. LMNED-80-1, dated 2 October 1979, to the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS. The study was conducted by the Coastal and Hydraulics Laboratory (CHL), ERDC, during the period October 1979 through 1993.

In addition to this fixed-bed navigation model study, physical model studies and a numerical model studies were conducted at ERDC. The additional studies included a fixed-bed navigation model study conducted prior to major changes to the design[1] and a hydraulic moveable-bed model study.[2]

During the course of the model study, representatives of the USAED, Vicksburg, and other navigation interests visited ERDC at different times to observe special model experiments and to discuss the results of those experiments. The USAED, Vicksburg, was informed of the progress of the study by monthly reports and special presentations at the conclusion of each experiment.

This report is being published by members of the staff of CHL, formed in October 1996 with the merger of the ERDC Coastal Engineering Research Center and the Hydraulics Laboratory. Mr. Tom Richardson is the Director of CHL, and Mr. Thomas Pokrefke is Deputy Director.

The first-line review of this report was conducted by Dr. Sandra Knight, Chief, CHL's Navigation Branch. The principal investigator in immediate charge of the model study was Mr. Donald C. Wilson, assisted by Messrs. Ronald T. Wooley, E. Johnson, and Messes. D. P. George and P. S. Van Norman. This report was prepared by Messrs. Wilson and Wooley.

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[1] Lewis J. Showes and John J. Franco. (1979). "Navigation conditions at John H. Overton Lock and Dam, Red River," Technical Report HL-79-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

[2] Randy A. McCollum. (1989). "Red River Waterway, John H. Overton Lock and Dam; Report 3, Sedimentation conditions hydraulic model investigation," Technical Report HL-89-16, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Director of ERDC during preparation and publication of this report was Dr. James R. Houston, and Commander and Executive Director was COL John W. Morris III, EN.

1 Introduction

Location and Description of Prototype

The Red River flows easterly from the northwest portion of Texas along the border between Texas and Oklahoma, through southwestern Arkansas into northwestern Louisiana, then southeasterly to join the Old River and form the Atchafalaya River (Figure 1). Flow in the upper part of the Red River is controlled by releases from Denison Dam, which is located on the Texas-Oklahoma state line. Flow from the Mississippi River has considerable backwater effect on upstream stages including the Lower Red River. A 23-by 366-m (75- by 1,200-ft) lock at the mouth of Old River provides navigation between the Mississippi, Red, and Atchafalaya Rivers.

Prior to construction of the locks and dams, the Red River had large fluctuations in stage, a shifting bed, caving banks, and unpredictable shoaling. The controlling depths of natural conditions in the Red River had averaged about 1.8 m (6 ft) from the mouth to Alexandria, LA, and about 1.5 m (5 ft) from Alexandria to Shreveport, LA, from January to July and generally less the remainder of the year. The controlling depths during some periods were as low as 0.305 to 0.6 m (1 to 2 ft) in the Alexandria to Shreveport reach. The movement of cargo by barges in the Red River was limited as a result long periods of low flows, narrow bends of short radii, and a heavy sediment load.

Present Development Plan

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

The second in a series of five locks and dams (John H. Overton) was constructed in a cutoff canal approximately 119 km (74 miles) above the Mississippi River and about 50 km (31 river miles) above Lindy C. Boggs Lock and Dam (formerly Lock and Dam No. 1). This series of five locks and dams is designed to furnish the required maximum lift of 43 km (141 ft) to provide

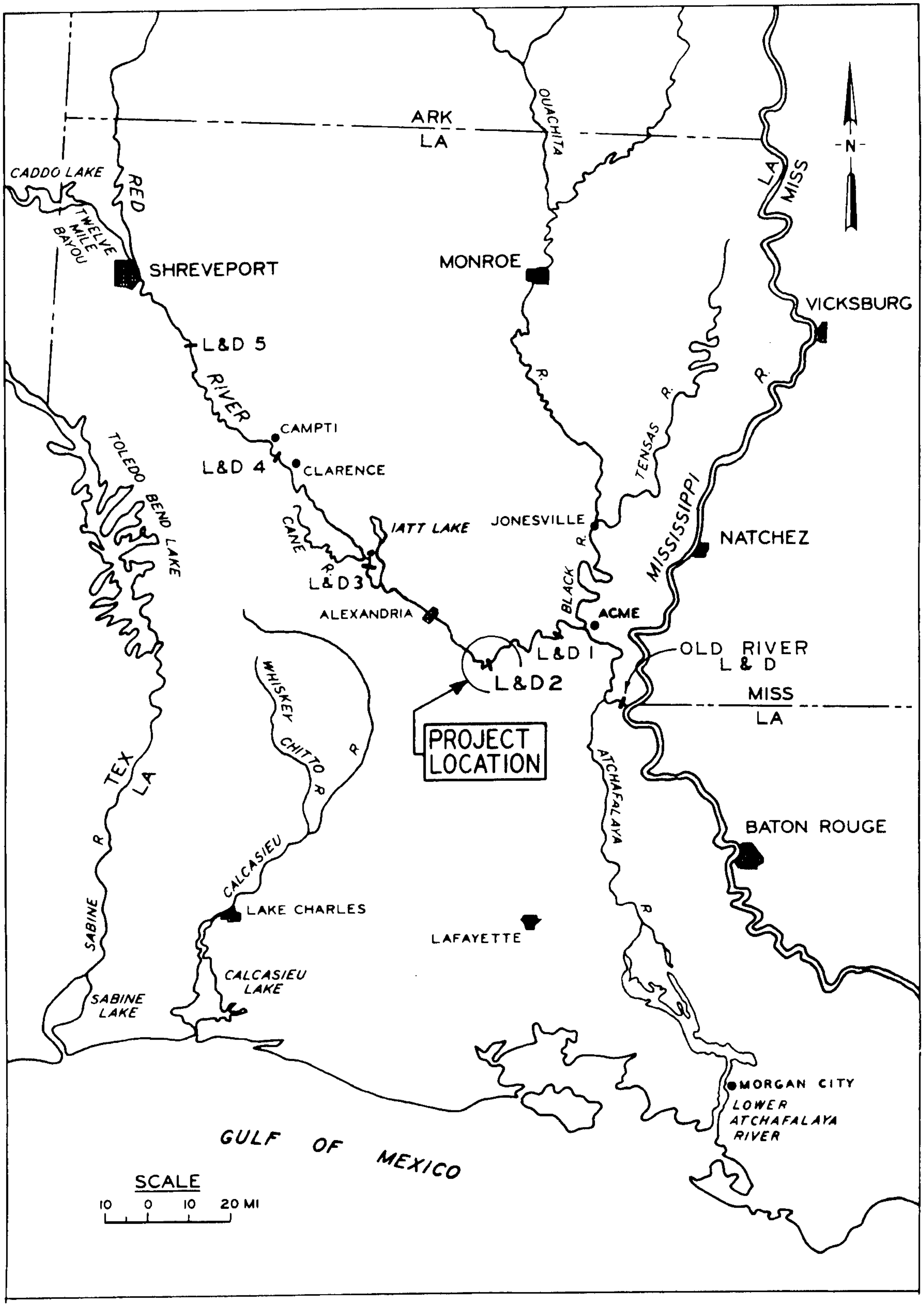

Figure 1. Location map

year-round navigation on the Old and Red Rivers Waterway from the Mississippi River to Shreveport, a distance of 380 km (236 miles). The general design of John H. Overton Lock and Dam consists of a 26-by 209-m (84- by 685-ft) navigation lock with an adjacent spillway containing five 18-m (60-ft)-wide gate bays and a 71-m (233-ft) overflow weir. The structures will provide a normal upper pool elevation (el) of 64.0 with a normal lift of 7 m (24 ft) in the lock chamber from Lindy C. Boggs Lock and Dam pool at el 40.0.[1] The lock will be located on the left side of the cutoff canal with the gated spillway to the right adjacent to the lock, and an overflow weir with top elevation of 66.0 connecting the spillway to the right bank of the cutoff canal. The John H. Overton Lock and Dam began holding an interim pool in Nov. 1987 and began holding normal pool in Feb. 1989.

Purpose of Model Study

The general design of John H. Overton 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. Since John H. Overton Lock and Dam was to be located in an excavated channel bypassing the natural river channel, it was important that the alignment of the channel and the arrangement of the lock and dam be satisfactory for navigation. Therefore, a comprehensive navigation model study using a 1:100-scale fixed-bed model and remote controlled vessel was considered necessary to investigate conditions that could be expected with the proposed design and to develop modifications required to ensure satisfactory navigation conditions. The specific purposes of the model study were to:

a. Determine optimum channel alignment, channel-training structures required, and location and arrangement of auxiliary lock walls.

b. Develop modifications required providing satisfactory navigation conditions and minimizing construction.

c. Provide data for use in a movable-bed study to determine the effects of the changes on the movement of sediment and its effects on channel width and depth.

d. Evaluate navigation conditions with future bed configurations as predicted by the movable-bed study and to develop any modifications required maintaining acceptable navigation conditions.

e. Demonstrate to navigation interests the conditions resulting from the proposed design and satisfy these interests of the design's acceptability from a navigation standpoint.

[1] All elevations cited herein are in feet referenced to the National Geodetic Vertical Datum (NGVD) of 1929.

f. Investigate the effects of a hydropower plant at the site on navigation using the lock.

g. Evaluate navigation conditions with the "AS-BUILT PROJECT" and the bed form indicated by hydrographic surveys made in 1989 and 1990.

2 The Model

Description

The model (Figure 2) is a scale reproduction of approximately 6 km (3.7 miles) of the Red River channel as realigned and adjacent overbank areas (between miles 90.1 and 85.6) extending approximately 2,835 m (9,300 ft) upstream of the lock and dam and 3,124 m (10,250 ft) downstream. The model was of the semifixed-bed type, located in a flume 17 m (55 ft wide) and 61 m (200 ft) long, with the channel and overbank areas molded in pea gravel to sheet metal templates to permit modifications as required. The lock, dam crest, piers, guard walls, and overflow weir were fabricated of sheet metal. The dam gates were simulated schematically with simple sheet metal slide-type gates.

The model was molded to a combination of the hydrographic survey made in 1967-1968, the Whittington Revetment Survey made in September 1976, and the Hog Lake Revetment Survey made in April 1975.

Scale Relations

The model was built to an undistorted linear scale of 1:100, model to prototype, to effect accurate reproduction of velocities, crosscurrents, and eddies affecting navigation. Other scale ratios resulting from the linear scale ratio are as follows:

Characteristic	Units of Length	Model: Prototype
Area	$A = Lr^2$	1:10,000
Velocity	$V = Lr^{1/2}$	1:10
Time	$T = Lr^{1/2}$	1:10
Discharge	$D = Lr^{5/2}$	1:100,000
Roughness (Manning's n)	Manning's $n = Lr^{1/6}$	1:2.15

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

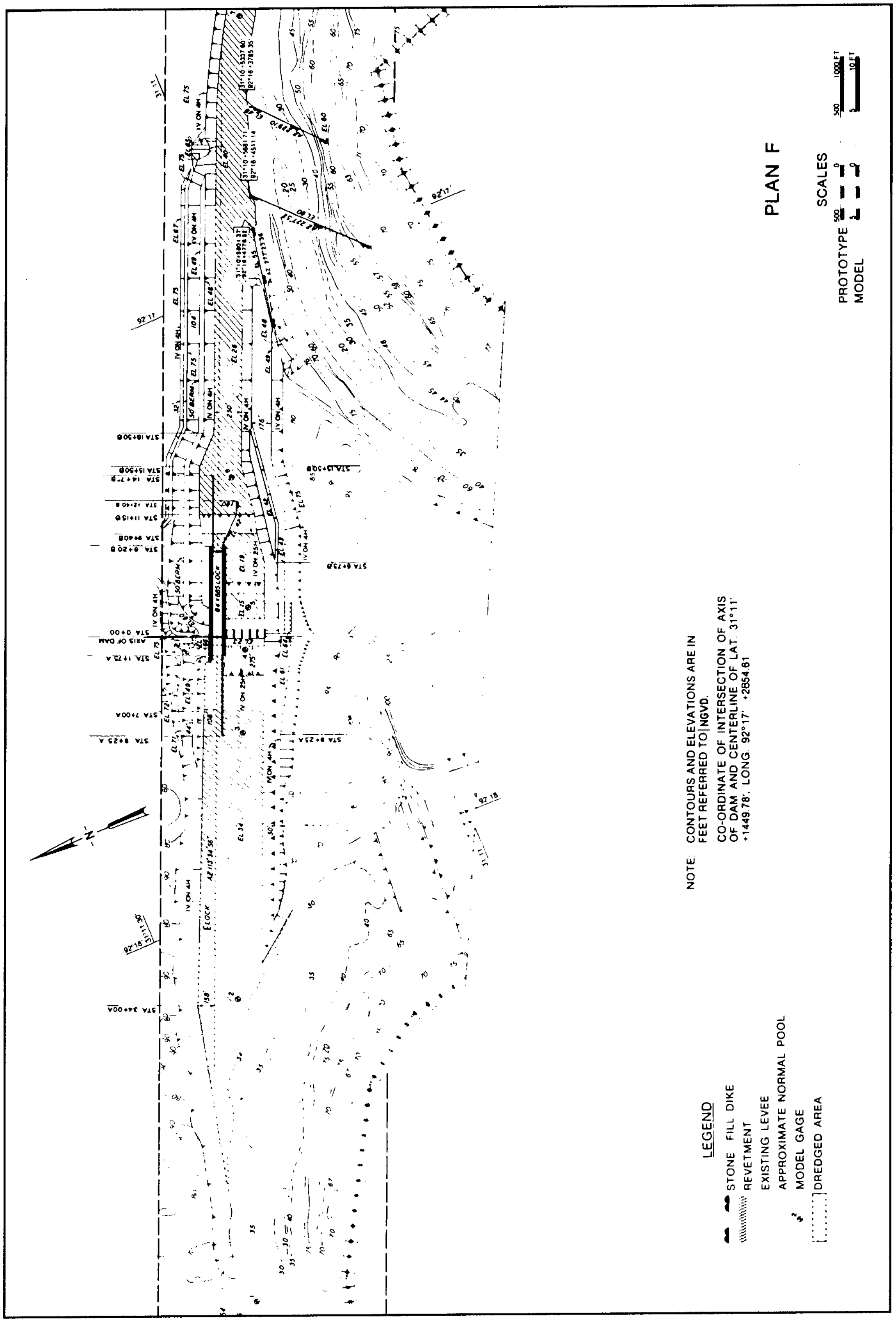

Figure 2. Model layout

Appurtenances

Water was supplied to the model by means of a 0.3-cu m/sec (10-cu ft/sec) pump operating in a circulating system. The discharge was controlled and measured at the upper end of the model by means of valves and venturi meters. Water-surface elevations were measured by means of piezometer gages located in the model channel and connected to a centrally located gage pit (Figure 2). A slide-type tailgate was provided at the lower end of the model to control the tailwater elevation downstream of the dam, and the upper pool elevation was controlled by operation of the dam gates during controlled riverflows.

Velocities and current directions were determined by plotting the paths of cylindrical wooden floats weighted on one end to simulate the maximum permissible draft for loaded barge (3-m (9-ft) prototype). Surface currents were also shown by time exposure photographs recording the movement of paper confetti on the water surface. A remote controlled model tow, consisting of a towboat and six barges, was used to determine and demonstrate the effects of currents on tows approaching and leaving the lock and moving through the river channel upstream and downstream of the lock. The model towboat and barges represented a six-barge flotilla, three barges wide and three barges long. Each barge was 11 m (35 ft) wide by 59 m (195 ft) long, and the model towboat was 30 m (100 ft) long, making the total length of the flotilla 209 m (685 ft). The model towboat was equipped with twin screws, Kort nozzles, and forward and reverse rudders, and it was powered by a small electric motor operating from batteries in the tow. The towboat could be operated in forward and reverse, at various speeds, and with variable rudder settings. It was calibrated to the speed of a comparable size prototype towboat moving in slack water and operated at 1.6 km\hr to 3.2 km/hr (1 to 2 miles\hour) above the speed of the currents to maintain rudder control but not overpower the currents. Multiple-exposure photographs recorded the path of the tow with the various conditions. A miniature current meter measured spot velocities.

Model Adjustment

Inclusion of the proposed lock and dam plans in the initial model construction precluded adjustment of the model to the existing 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 pea gravel and brushed-cement mortar mix to provide a roughness (Manning's n) of about 0.016, which corresponds to a prototype channel roughness of about 0.035. Based on experience with other models of this type, brushed-cement mortar gives a close approximation of the roughness required to reproduce prototype conditions.

3 Experiments and Results

Experiment Procedures

The primary concerns of the experiments were the study of flow patterns, measurement of velocities and water-surface elevations, and effects of currents on the movement of the model tow approaching and leaving the lock. Most of the modifications were developed during preliminary experiments. Data obtained during these experiments were sufficient to assist in the development of the plan that appeared to provide satisfactory results. Results of the preliminary experiments are not included in this report.

The riverflows were reproduced by introducing the proper discharge and manipulating the tailgate until the required tailwater elevation was obtained. During controlled pool flow conditions, the upper pool was maintained by adjusting the gates of the dam, maintaining a uniform opening for all gates. During open riverflows, all of the dam gates were removed. During the experiments, the upper pool elevation was controlled at Gage 3 to settings supplied by the U.S. Army Engineer District, Vicksburg (USAED), and the lower pool elevation was controlled at Gage 7 (Figure 2).

A selection of representative flows was used for evaluation based on information furnished by the USAED, Vicksburg, as follows:

a. Controlled riverflows of 170 (6,000); 340 (12,000); 680 (24,000); 877 (31,000); 1,982 (70,000); and 2,406 cu m/sec (85,000 cu ft/sec) with normal upper pool el 64.0.

b. An intermediate uncontrolled riverflow of 3,113 cu m/sec (110,000 cu ft/sec).

c. The maximum navigable riverflow of 4,104 cu m/sec (145,000 cu ft/sec).

The 170-cu m/sec (6,000-cu ft/sec) riverflow represents the maximum flow for one hydropower-generating unit, and the 680-cu m/sec (24,000-cu ft/sec) riverflow represents the maximum total flow through the powerhouse. The powerhouse was operated with total riverflows up to and including 1,982 cu m/sec (70,000 cu ft/sec). The 2,406-cu m/sec (85,000-cu ft/sec) riverflow is the maximum flow at which the normal upper pool elevation can be maintained.

Velocities were measured by timing the travel of floats over a measured distance; current directions were determined by plotting the paths of the floats with respect to ranges and grids established for that purpose; general surface-current directions were determined by time-exposure photographs recording the movement of paper confetti on the water surface. During tests with the model tow, the effects of currents on the movement of the towboat, drifting or powered, were observed and in some cases recorded by means of multiexposure photographs.

Experiments with Plan F (Base Conditions)

Description

Plan F was the plan proposed for the reformulated project and included a normal upper pool elevation raised 1.8 m (6 ft) to el 64.0 and the number of gate bays reduced from seven to five. Many features of Plan F were the same as Plan E, reported in T R HL-79-3.[1] The principal features reproduced or simulated in the model (shown in Figures 2 and 3) included the following:

a. A nonnavigable gated spillway, an overflow weir, and a lock located in the cutoff cannel. The lock located along the left bank of the bypass channel had useable chamber dimensions of 25.6 m (84 ft) wide by 208.8 m (685 ft) long. The spillway contained five 18.2-m (60-ft)-wide gate bays and six 2.7-m (9-ft)-wide piers with the gate sills at el 28.0.

b. A 71-m (233-ft)-long overflow weir extended from the gated spillway to the right bank with a crest at el 66.0. A closure dike extended from the right abutment of the overflow weir across the right overbank and upper reach of the existing bendway channel.

c. A 228.6-m (750-ft)-long ported buttress-type upper guard wall with top at el 74.5. The top of ports was at el 47.0, and there were thirteen 3.7-m (12-ft)-wide buttresses, separating thirteen 11.6-m (38-ft)-wide ports and one 2.7-m (9-ft)-wide port adjacent to the lock.

d. A 198-m (650-ft)-long unported lower guide wall with a top at el 74.5.

e. A 105-m (345-ft)-long wing dike with a crest at el 42.0 extended from the riverward lock wall. The upstream 67 m (220 ft) was angled 24 deg riverward of the lock wall, and the downstream 38.1 m (125 ft) extended from the end of the angled section parallel to the lock. This dike was developed on the movable-bed model to reduce sediment deposition in the lower lock approach.

f. The excavated channel bottom adjacent to the gated spillway was at el 34.0 on the upstream side and at el 15.0 on the downstream side. The channel bottom adjacent to the overflow weir was at el 61.0 on the upstream side and at el 49.0 on the downstream side.

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[1] Lewis J. Showes and John J. Franco. (1979). "Navigation conditions at John H. Overton Lock and Dam, Red River," Technical Report HL-79-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

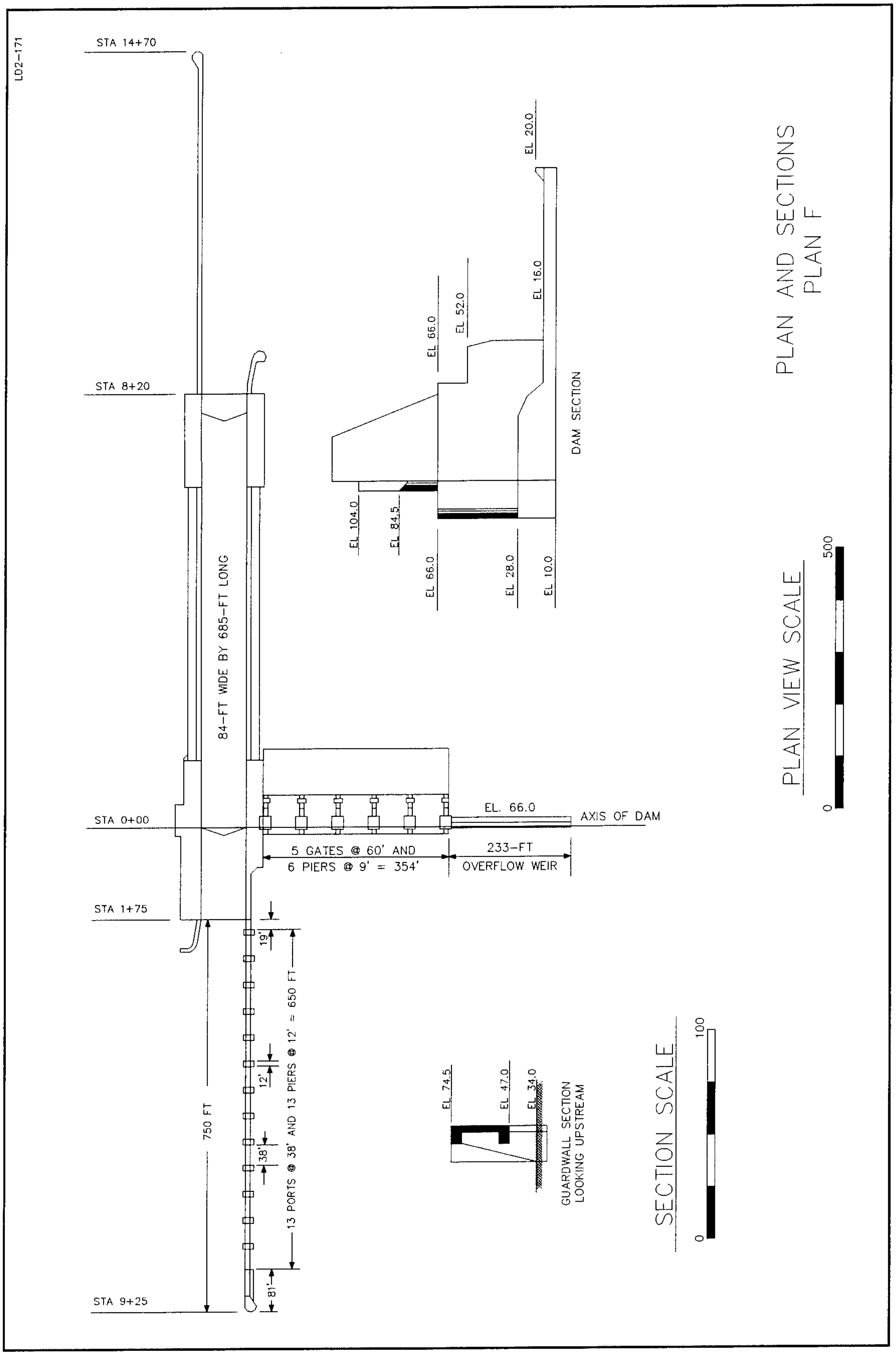


Figure 3. Plan and sections, Plan F structures

g. The excavated channel bottom approaching the lock was at el 34.0 with a berm along the descending left bank at el 49.0.

Results

Water-surface elevations. Water-surface elevations shown in Table 1 indicate that with open riverflow conditions, the slope in water-surface elevations varied from about 0.5 to 1.0 m/km (0.3 to 0.6 ft/mile) upstream of the structures (Gages 1 through 3) and about 1.0 to 2.1 m/km (0.6 to 1.3 ft/mile) downstream of the structures (Gages 6 and 7). The swellhead through the gated dam (Gages 4 and 5) varied from about 0.06 to 0.12 m (0.2 to 0.4 ft), and the total drop through all structures (Gages 3 through 6) varied from about 0.3 to 0.5 m (1.0 to 1.8 ft) for the 2,406-(85,000-) and 4,104-cu m/sec (145,000-cu ft/sec) riverflows, respectively.

Current directions and velocities. Current directions and velocities obtained during Plan F experiments are shown in Plates 1 through 4. With all riverflows evaluated, the alignment of the currents in the approaches to the lock was generally straight and parallel to the left descending bank with reasonably good distribution of flow in the channel (Photos 1 through 4 and Plates 1 through 4). The maximum velocity in the approaches to the lock varied from about 0.5 to 2.2 mps (1.8 to 7.3 fps) in the upstream approach to about 2.1 to 3.0 mps (6.8 and 9.7 fps) in the downstream approach.

Navigation conditions. Navigation conditions in the lock approaches were satisfactory with all riverflows evaluated assuming towboats have sufficient power to overcome the current during open riverflows (Plates 1 through 4). In the upstream lock approach a surface eddy would tend to form landward of the guard wall as indicated by surface current patterns shown in Photographs 1 and 2. However, this did not adversely affect tows entering or leaving the lock (Photos 5 through 8). No navigation problems were noted in the downstream lock approach except for the high velocity with open riverflow conditions. Tows with sufficient power to overcome the effects of the high-velocity currents should experience no difficulties in approaching or leaving the lock (Photos 9 through 12). There were no problems for navigation in either lock approach with the lower flows.

Experiments with Plan G

Description

Plan G was the same as Plan F except for the following modifications developed in the movable-bed model study (Figure 4):

a. The bed configuration upstream of the dam was modified to reproduce the deposition that occurred in the movable-bed model.

b. Two dikes were located along the right bank just upstream of the entrance to the approach channel with crests at el 75.0.

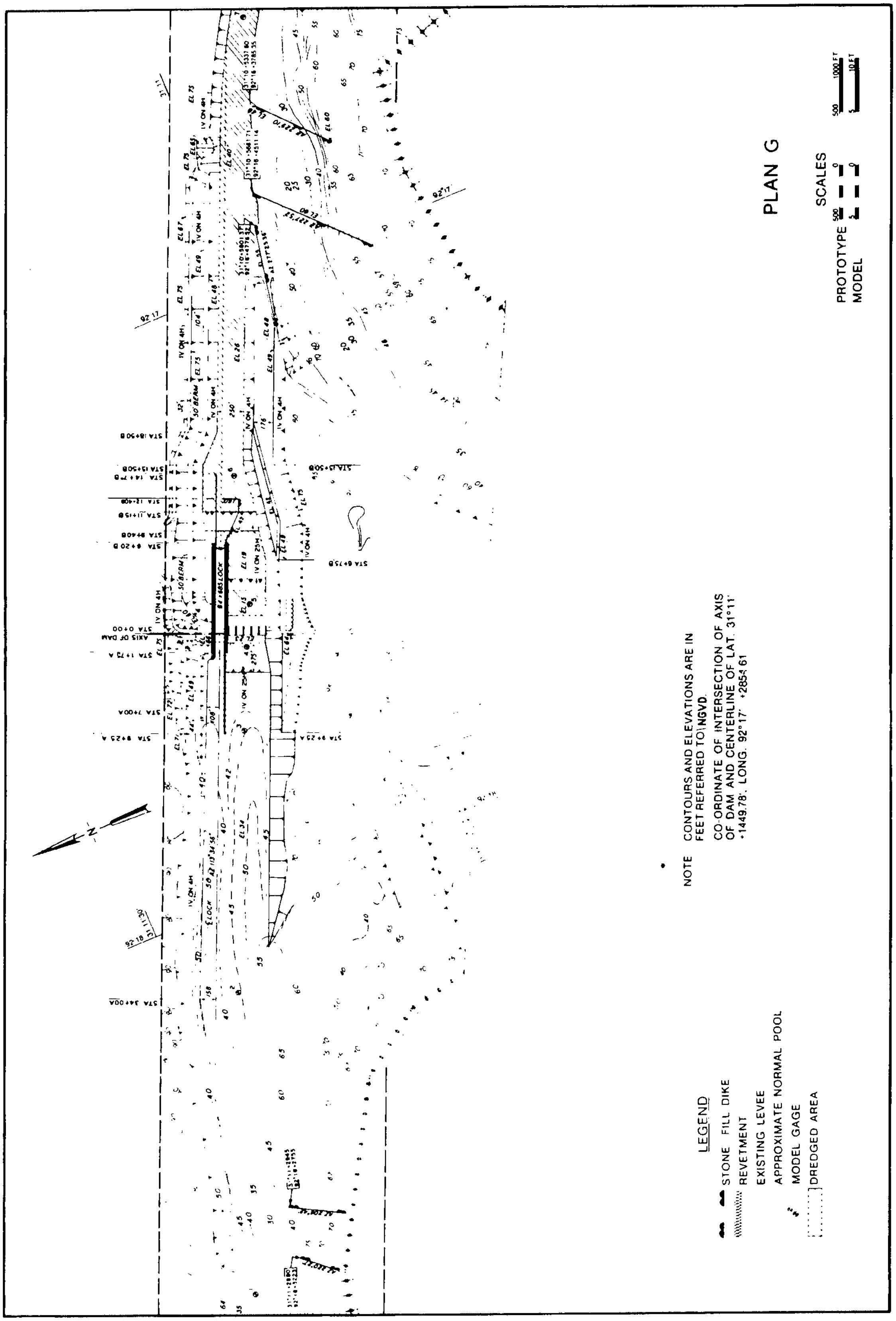


Figure 4. Plan G

c. The 15.2-m (50-ft)-wide berm along the right bank upstream of Sta. 9+25A was removed with a resulting increase of 15.2 m (50 ft) in the spillway approach channel width.

Results

Water-surface elevations. A comparison of Plan F (Table 1) and Plan G (Table 2) water-surface elevations with open riverflow conditions shows the deposition indicated by the movable-bed model would increase water-surface elevations near the upper end of the model from 0.39 to 0.48 m (1.3 to 1.6 ft) with a slight decrease near the upstream end of the upper guard wall. This resulted in water-surface slopes from 3.1 to 3.4 m/km (1.9 to 2.1 ft/mile) (Gages 1 through 3) and about 0.97 to 0.18 m/km (0.6 to 1.1 ft/mile) downstream of the structures (Gages 6 and 7). The change in elevation through the gated dam (Gages 4 and 5) varied from about 0.09 to 0.12 m (0.3 to 0.4 ft) with a total change through all structures (Gages 3 through 6) varying from about 0.37 to 0.49 m (1.2 to 1.6 ft) with the 2,406- (85,000-) and 4,104-cu m/sec (145,000-cu ft/sec) riverflows, respectively (Table 2). Discharge through each spillway bay was determined by measuring velocity through the bay with a miniature velocity meter. Discharge measurements through the gated section of the dam with a total river discharge of 2,406 cu m/sec (85,000 cu ft/sec) indicated flow was concentrated in the three gate bays near the right end of the dam as follows:

Gate Bay No.	Percent of Flow
1	15.6
2	18.8
3	22.8
4	22.4
5	20.4

Gate bays were numbered from the lock and discharge measurements are in percent of total riverflow.

Current directions and velocities. Current directions and velocities obtained with Plan G are shown in Plates 5 through 8. There were no significant changes in the current alignment in the upstream or downstream lock approaches or current velocities in the downstream approach to the lock. However, the current velocities in the upstream approach to the lock were increased considerably. Maximum velocities varied from about 1.0 mps (3.3 fps) with the 877-cu m/sec (31,000-cu ft/sec) riverflow to greater than 2.7 mps (9.0 fps) with open riverflows (Plates 5 through 8).

Navigation conditions. The alignment of the currents was satisfactory for tows entering and leaving the upper lock approach. However, because of the high-velocity currents, a towboat with marginal power for its tow could experience difficulty entering and leaving the upper lock approach. Tows with sufficient power to overcome the effects of the high-velocity currents should have no major difficulties entering or leaving the lock. There were no measurable changes in navigation conditions in the lower approach to the lock compared to results obtained with Plan F.

Experiments with Plan H

Description

Plan H was the same as Plan G except for the following modification (Figure 5):

a. A 70.4-m (231-ft)-long nonoverflow hydropower generating plant was located parallel to the dam axis, beginning 61 m (200 ft) from the right abutment pier and terminating near the right end of the fixed crest weir (Figure 5). The power plant contained four generating units with a maximum discharge of 170 cu m/sec (6,000 cu ft/sec) per unit.

b. The wing dike at the downstream end of the lock wall was straight and shortened to 103.6 m (340 ft) in length, angled 16 deg riverward of the lock wall, with the crest sloping from el 42.0 at the lock wall to el 35.0 at the downstream end of the dike.

Results

Water-surface elevations. Table 3 shows the water-surface elevations obtained with Plan H. These elevations indicate the water-surface elevations upstream of the dam increased from 0.03 to 0.12 m (0.1 to 0.4 ft) with open riverflows. There were no significant changes in elevations or water-surface slopes downstream of the dam. The swellhead through the dam (Gages 4 and 5) varied from about 0.09 to 0.15 m (0.3 to 0.5 ft) with the total change through all the structures (Gages 3 through 6) varied from about 0.4 to 0.52 m (1.3 to 1.7 ft) with open riverflows (Table 3). There was no significant change with the controlled riverflows.

Current directions and velocities. Current direction and velocity data indicate the flow through the powerhouse had only a local effect on current directions and velocities. Current velocities were very slow in the upper lock approach with the one unit discharging 170 cu m/sec (6,000 cu ft/sec), and there were no adverse effects on navigation entering or leaving the lock (Plate 9). Maximum velocities in the upper approach to the lock varied from about 0.30 mps (1.0 fps) with two generating units operating 340 cu m/sec (12,000 cu ft/sec) to 2.3 mps (7.5 fps) with the maximum flow for powerhouse operations 1,982 cu m/sec (70,000 cu ft/sec). With the maximum flow for the powerhouse operations, 680 cu m/sec (24,000 cu ft/sec) passed through the four generating units and 1,302 cu m/sec (46,000 cu ft/sec) passed through the gated dam (Plates 10 through 12). Maximum velocities in the lower approach to the lock varied from about 0.64 to 2.6 mps (2.1 to 8.5 fps) with the 170- to 1,982-cu m/sec (6,000- to 70,000-cu ft/sec) flows, respectively (Plates 9 through 12).

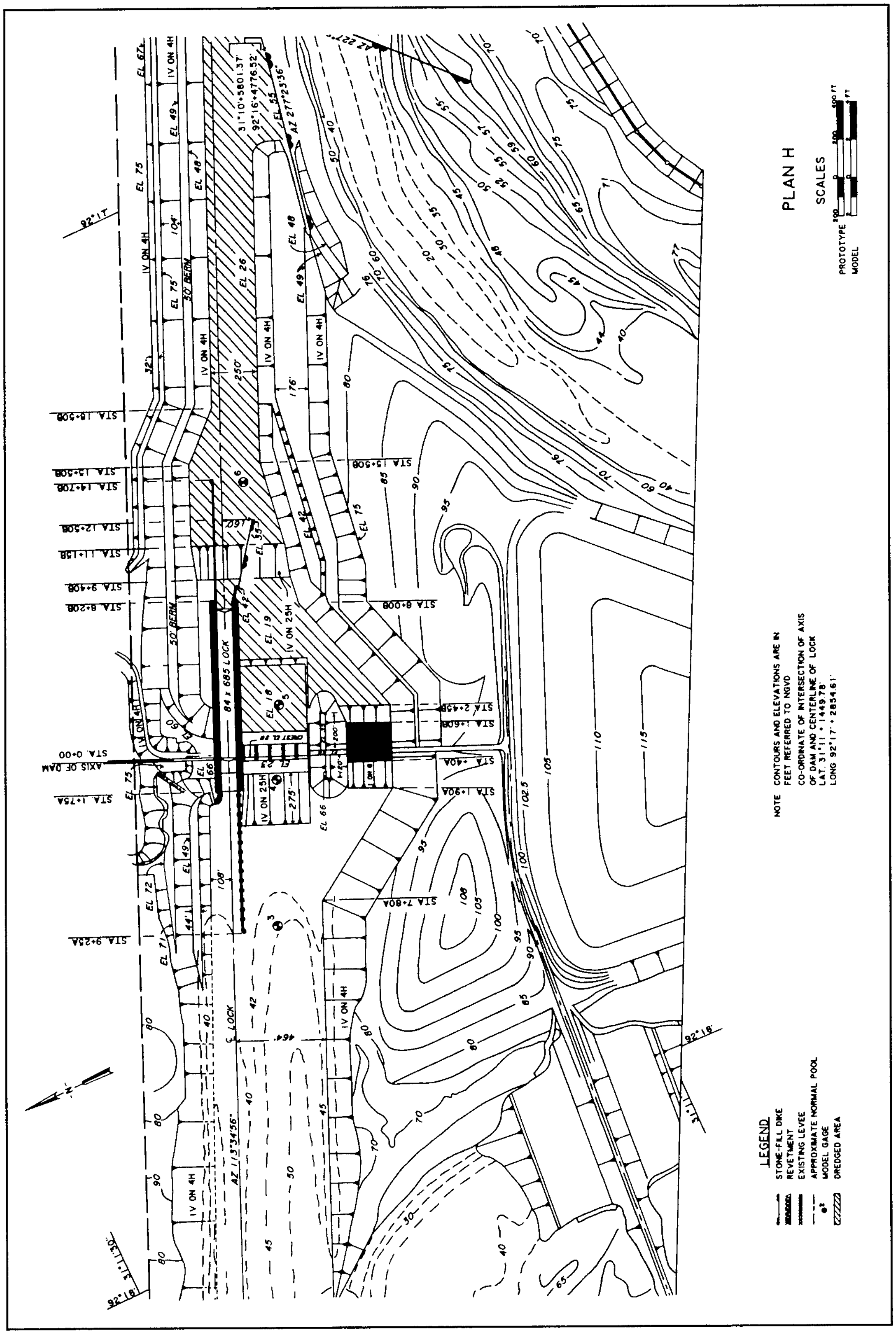


Figure 5. Plan H

There were no significant changes in maximum velocities or alignment of current in the lock approaches with the 1,982-cu m/sec (70,000-cu ft/sec) riverflow with or without the powerhouse operating (Plates 12 and 13). Maximum velocities in the upper approach to the lock with open riverflows were about the same as with Plan G (without the powerhouse in place) and varied from about 2.53 to 2.9 mps (8.3 to 9.5 fps) with the 2,406- to 4,104-cu m/sec (85,000- to 145,000-cu ft/sec) riverflows, respectively. Lowering the crest elevations of the wing dikes at the end of the lock wall would tend to increase velocities to about 2.56 to 2.77 mps (8.4 to 9.1 fps) in the lower approach to the lock with the 2,406- to 3,113-cu m/sec (85,000- and 110,000-cu ft/sec) riverflows, respectively (Plates 14 and 15). There were no major changes in current velocities with the 4,104-cu m/sec (145,000-cu ft/sec) riverflow (Plate 16).

Navigation conditions. There were no major changes in navigation conditions in either lock approach as a result of the powerhouse configuration or the flow from the powerhouse. As indicated by surface-current patterns, a large eddy would tend to develop in the upper lock approach and in the upper and lower approach to the powerhouse with the 1,982-cu m/sec (70,000-cu ft/sec) riverflow (Photos 13 and 14) and just downstream of the gated section of the dam when all the 680-cu m/sec (24,000-cu ft/sec) flow was through the powerhouse (Photo 15). Navigation conditions in the approaches to the lock were about the same as those obtained in Plan G. Tows could enter or leave the lock in either direction with all flows tested without difficulty provided the tow had sufficient power to overcome the high-velocity currents (Photos 16 through 21).

Based on results obtained with a total riverflow of 2,406 cu m/sec (85,000 cu ft/sec), the powerhouse had no significant effects on flow distribution through the gated section of the dam. The results were as follows:

Gate Bay No.	Percent of Flow
1	15.6
2	18.6
3	22.4
4	22.4
5	22.1

Gate bays were numbered from the lock and discharge measurements are in percent of total riverflow.

Experiments with Plan I

Discussion and purpose of experiment

Preliminary experiments were conducted with various modifications to Plan I. These modifications were developed in the movable-bed model to control sediment deposits and channel depths and then placed in the navigation model for evaluation. The purpose of these experiments was to select a plan that had a reasonable expectation of providing both satisfactory navigation conditions and sediment control. The preliminary results were presented to district personnel at the time of the experiments and were used to select a plan for complete evaluation. The results of these preliminary experiments are not presented in this report.

Experiments with Plan J

Discussion and purpose of experiment

The movable-bed model of the project without hydropower-generation indicated a satisfactory navigation channel could not be maintained downstream of the lock without control structures. A series of dikes was developed in the movable-bed model to maintain channel width and depth downstream of the lock. The series of dikes was then installed in the navigation model for evaluation of navigation conditions for tows entering and leaving the lock. The channel bed installed in the navigation model represented the "as designed channel" prior to any deposit of sediments.

The model was controlled using a revised tailwater rating curve received from the USAED, Vicksburg, titled "Lock and Dam No. 2, Rating Curve, Preproject Mile 86.29, Postproject Mile 72.79" dated 11 July 1986. The revised tailwater rating curve for the project resulted in lower water-surface elevations at the downstream end of the model. During all subsequent experiments, the upper pool elevation was controlled at Gage 3 to settings supplied by the USAED, Vicksburg, and the lower pool elevation was controlled at Gage 7 (Figure 6).

Description

Plan J (Figure 7) was the same as Plan F except as follows:

a. The left bank near the lower guide wall was modified and three dikes were added immediately downstream of the lower guide wall. The dikes were perpendicular to the left bank and spaced about 61 m (200 ft) apart with top at el 70.0.

b. The area immediately downstream of the dam gates was changed from el 15.0 to el 18.0.

c. The right bank opposite the downstream end of the lock was moved landward about 30 m (100 ft) creating an expansion in the channel beginning at about sta 6+75 to sta 20+15 (Figure 7).

d. Three dikes were added along the right bank immediately downstream of the dam. The dikes were spaced about 91 m (300 ft) apart, angled upstream with the riverward ends at top el 41.0 and the landward ends at top elevation of 48.0.

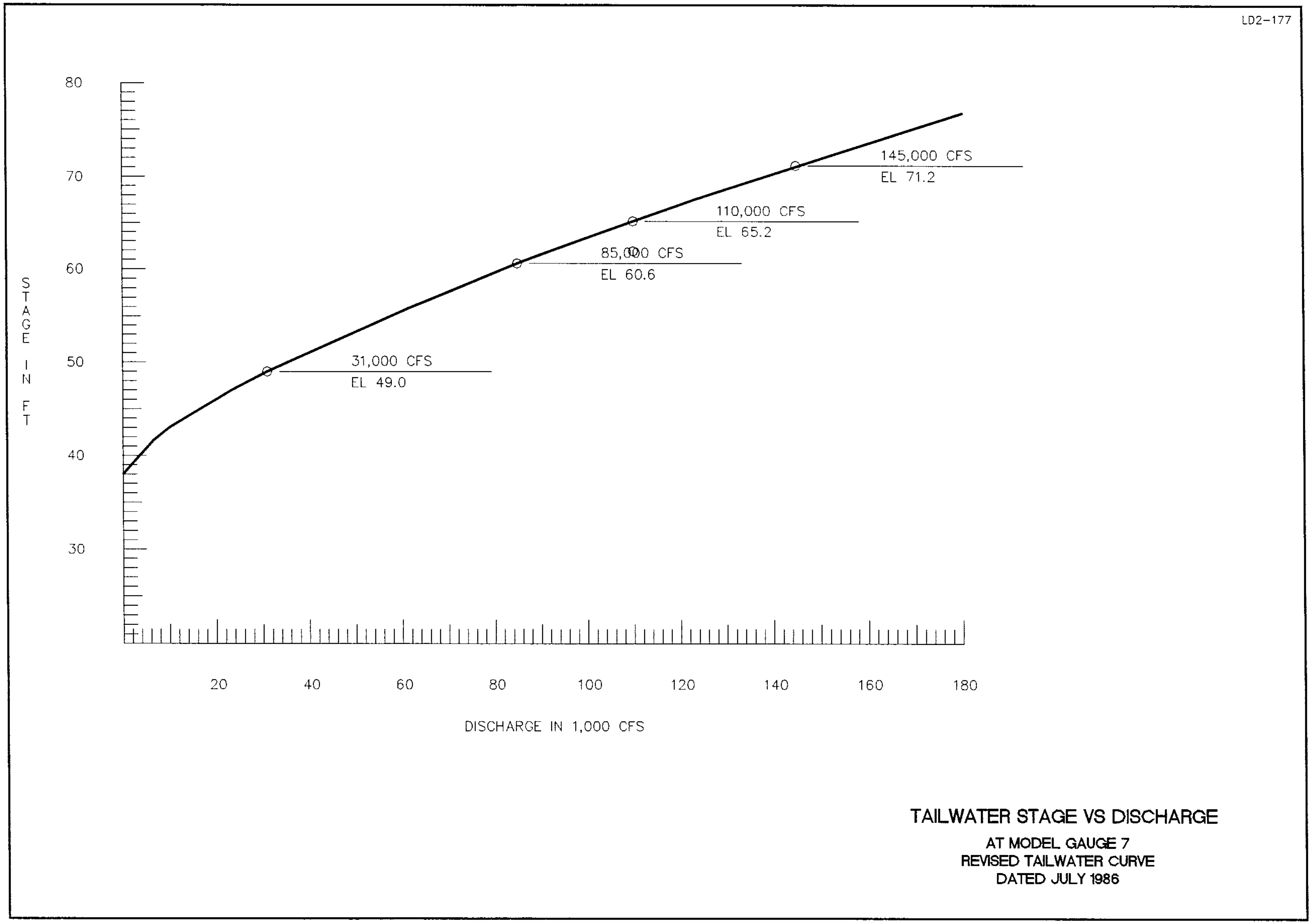


Figure 6. Tailwater stage vs discharge, July 1986

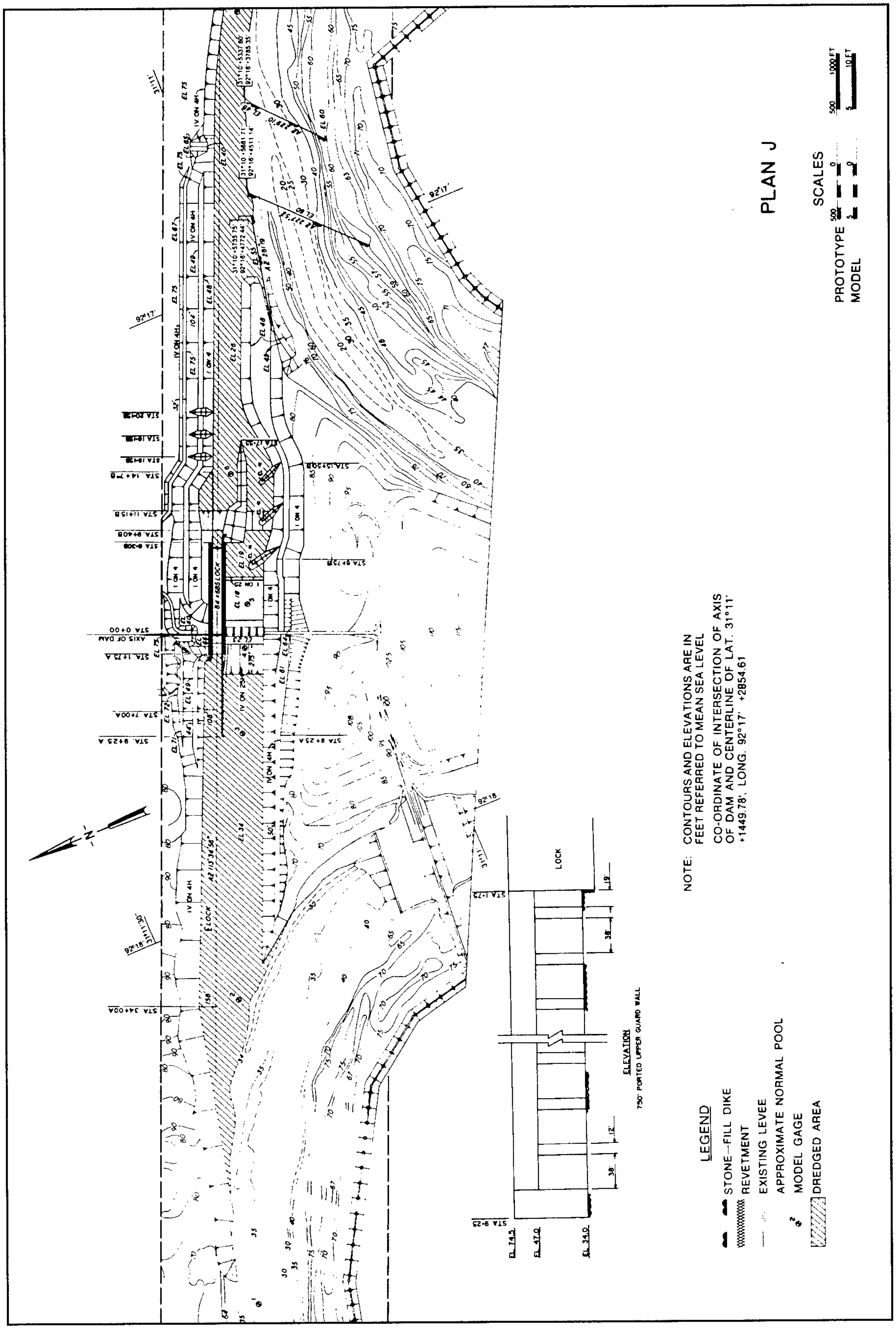


Figure 7. Plan J

e. The wing dike at the riverward lock wall has a total crown length of 219.8 m (721 ft). The nonovertopping portion is 88.7 m (291 ft) in length; the overtopping portion is 121.9 m (400 ft) in length with a transition length of 9.4 m (31 ft) between the two portions. The dike slopes from elevation 50.0 to el 26.0 for a length of 61 m (200 ft.)

f. The upstream guard wall was modified by adding a port at the upstream end of the guard wall. The revised guard wall was a 228.6-m (750-ft)-long ported buttress-type upper guard wall with top at el 74.5. The top of ports was at el 47.0, and there were fourteen 3.7-m (12-ft)-wide buttresses, separating fourteen 11.6-m (38-ft)-wide ports and one 5.8-m (19-ft)-wide port adjacent to the lock.

Results

Water-surface elevations. Water-surface elevations indicate that with controlled riverflows the slope in water-surface elevations through the upper pool of the model (Gages 1 through 3) varied from about 0.16 to 0.32 m/km (0.1 to 0.2 ft/mile) and downstream of the dam (Gages 6 and 7) the slope varied from about 0.80 to 1.77 m/km (0.5 to 1.1 ft/mile) (Table 4). With open riverflows, the average slope in the model upstream of the dam ranged from about 0.16 to 0.32 m/km (0.1 to 0.2 ft/mile), while the slope downstream of the dam ranged from about 0.80 to 0.97 m/km (0.5 to 0.6 ft/mile). The drop through the gated section of the dam ranged from about 0.06 to 0.12 m (0.2 to 0.4 ft) (Gages 4 and 5), and the total change through all the structures (Gages 3 through 6) varied from about 0.79 to 0.85 m (2.6 to 2.8 ft) with open riverflows of 4,104 and 3,113 cu m/sec (145,000 and 110,000 cu ft/sec), respectively.

Current directions and velocities. With all riverflows evaluated, the alignment of the currents in the upper approach to the lock were generally straight and parallel to the left descending bank with reasonably good distribution of flow in the channel (Plates 17 through 20). The maximum velocity in the upper approach to the lock varied from about 0.58 to 2.01 mps(1.9 to 6.6 fps) with the 877- and 4,104-cu m/sec (31,000- and 145,000-cu ft/sec) riverflows, respectively.

Downstream of the dam the currents are generally parallel to the right bank from the dam to the downstream end of the trail dike, then the currents turn sharply toward the left bank. The currents move across the downstream end of the lower approach to the lock and then move into the left banks about 457 m (1,500 ft)downstream of the lock. A large counterclockwise eddy forms in the lower lock approach with all riverflows. As the riverflow increases, the eddy increases in strength. The maximum velocities of the currents in the approach to the lock varied from about 2.1 to 3.1 mps (6.9 to 10.3 fps) with the 877- and 4,104-cu m/sec (31,000- and 145,000-cu ft/sec) riverflows, respectively.

Navigation conditions. Navigation conditions for tows entering and leaving the upper lock approach were the same as with Plan F. Tows could enter and leave the upper lock approach without any major difficulties. Navigation conditions for tows entering and leaving the lower lock approach were difficult to hazardous. With the higher riverflows, there was a tendency for the tow to be pushed into the left bank dikes immediately downstream of the lock. Navigation conditions were most difficult with the 2,406-cu m/sec (85,000-cu ft/sec) riverflow. Tows entering and leaving the lower lock approach would encounter extremely high current velocities.

Experiments with Plan J-Modified (J-1)

Discussion and purpose of experiment

Lock and Dam 2 structures were to be constructed in an excavation east of the natural river channel. The material upstream and downstream of the excavation was left in place and protected to provide a cofferdam for construction of the project. The river continued to flow through the natural river channel during construction. Upon completion of construction a channel was excavated to the lock and dam and an overflow structure was built across the existing river channel to divert the river to the new dam. As part of the excavation plan, a portion of the cofferdam upstream of the new lock would be left in place, creating a berm in the upper approach to the new lock. The purposes of the experiments were to determine the effects of the berm on tows entering and leaving the upper approach to the lock, distribution of flow through the guard wall ports and water-surface elevations.

Description

Plan J-1 (Figure 8) was the same as Plan J except a 213-m (700-ft)-long berm with top el 49.0 was added in the upper approach to the lock. The most downstream toe of the berm was 30 m (100 ft) upstream of the guard wall and the upstream toe of the berm was 262 m (860 ft) upstream of the guard wall and angled upstream to tie into the left bank.

Results

Water-surface elevations. Water-surface elevations indicate that with controlled riverflows the slope in water-surface elevations through the upper pool of the model (Gages 1 through 3) varied from about 0.32 to 0.97 m/km (0.2 to 0.6 ft/mile), and downstream of the dam (Gages 6 and 7) the slope varied from about 0.48 to 1.6 m/km (0.3 to 1.0 ft/mile) (Table 5). With open riverflows, the average slope in the model upstream of the dam ranged from about 0.32 to 0.80 m/km (0.2 to 0.5 ft/mile), while the slope downstream of the dam ranged from about 0.64 to 0.97 m/km (0.4 to 0.6 ft/mile). The drop through the gated section of the dam ranged from about 0.03 to 0.06 m (0.1 to 0.2 ft) (Gages 4 and 5), and the total change through all the structures (Gages 3 through 6) varied from about 0.79 to 0.82 m (2.6 to 2.7 ft) with open riverflows.

Current directions and velocities. With all riverflows evaluated, the alignment of the currents in the upper approach to the lock were generally straight and parallel to the left descending bank with reasonably good distribution of flow in the channel (Plates 21 and 22). The maximum velocity in the upper approach to the lock varied from about 0.67 to 2.16 mps (2.2 to 7.1 fps) with the 877- and 4,104-cu m/sec (31,000- and 145,000-cu ft/sec) riverflows, respectively. A large counterclockwise eddy formed in the upper lock approach. The upstream velocity of the currents varied from less than 0.15 mps (0.5 fps) to about 0.46 mps (1.5 fps) with the 877- and 4,104-cu m/sec (31,000- and 145,000-cu ft/sec) riverflows, respectively.

Navigation conditions. Navigation conditions were satisfactory with all riverflows evaluated. Downbound tows could align with the upper lock approach approximately two tow lengths upstream of the guard wall, start reducing speed, and approach the guard wall at a safe speed. Upbound tows could break free of the guard wall and move upstream along the left descending bank without any major difficulties

Experiments with Plan J-2

Discussion and purpose of experiment

Based on experiments conducted in the moveable-bed model and results from preliminary experiments in the navigation model, the Vicksburg District selected a plan that combined modifications from both studies as the "FINAL DESIGN" for construction of the project. The purpose of the experiment was to evaluate navigation conditions with these modifications in place.

During construction of Lock and Dam 3, the upper pool of John H. Overton Lock and Dam was to be controlled at an interim pool to reduce the backwater effect at the Lock and Dam 3 site. Additional experiments were conducted to determine the effects of the interim pool on tows entering and leaving the upper approach of John H. Overton Lock and Dam.

Description

Plan J-2 (Figure 9) was the same as Plan J-Modified except the three left bank dikes immediately downstream of the lock were removed and the two right bank dikes upstream of the lock were installed in the model. This plan represents the "FINAL DESIGN" or "TIME ZERO" conditions immediately after construction of the project and prior to any deposit of sediments in the channel.

Results

Water-surface elevations. Water-surface measurements indicate there was a slight increase in water-surface elevations upstream of the right bank dikes and a slight decrease in water-surface elevation immediately downstream of the dam (Table 6). With the controlled riverflows, the slope in water-surface elevations through the upper pool of the model (Gages 1 through 3) varied from about

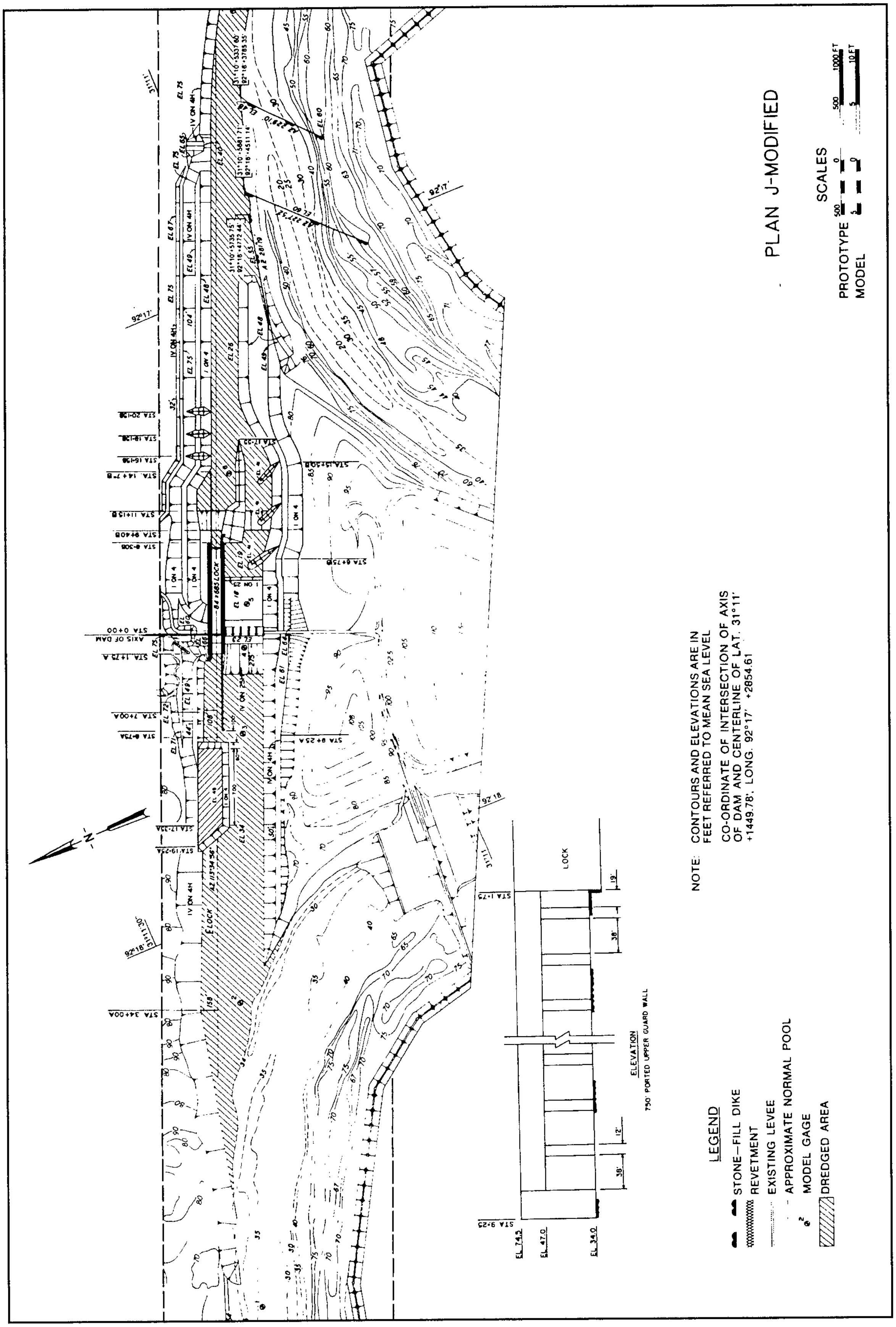


Figure 8. Plan J - Modified (J-1)

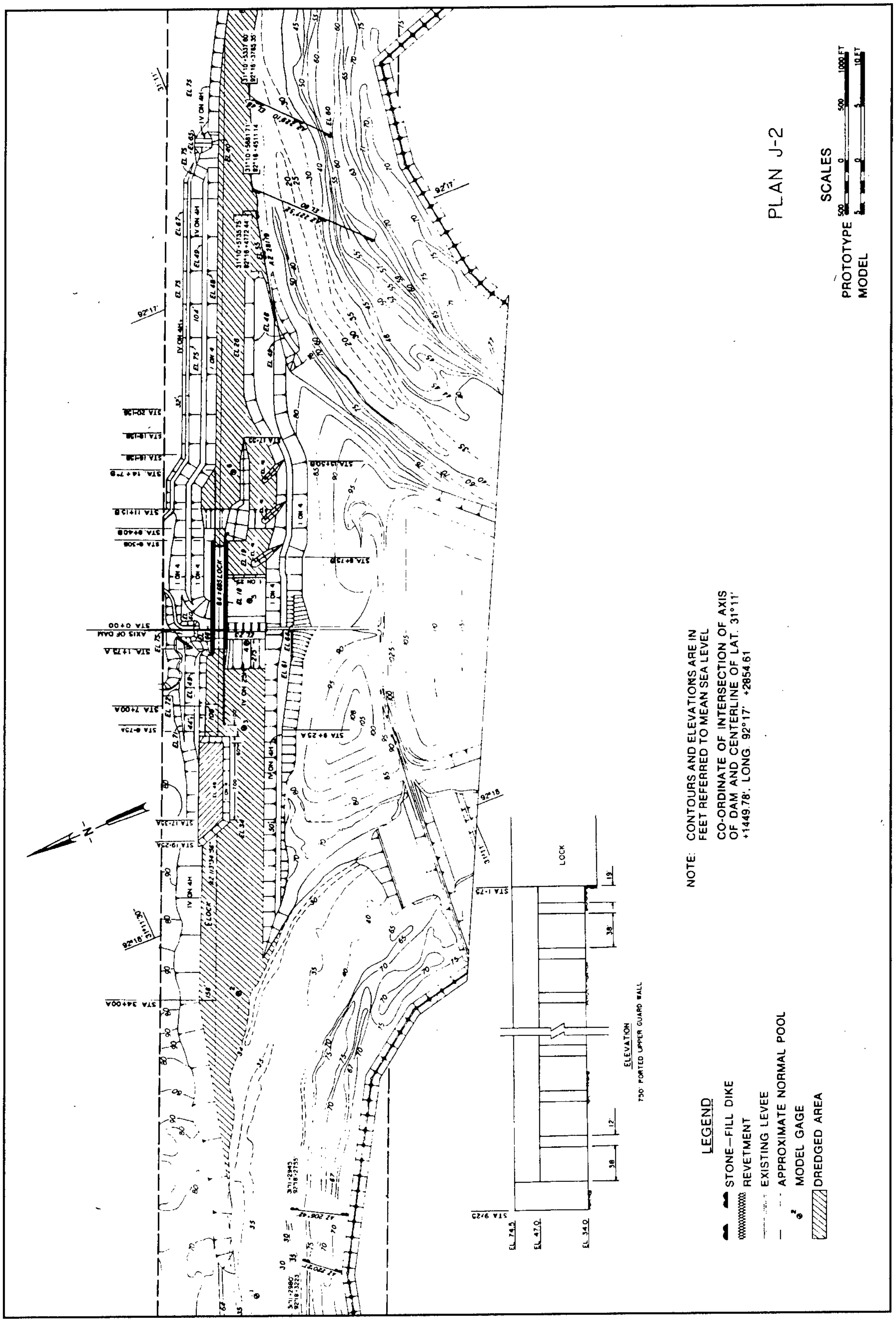


Figure 9. Plan J-2

0.16 to 0.80 m/km (0.1 to 0.5 ft/mile), and downstream of the dam (Gages 6 and 7), the slope varied from about 0.80 to 1.77 m/km (0.5 to 1.1 ft/mile). With open riverflows, the average slope in the model upstream of the dam was about 0.80 m/km (0.5 ft/mile), while the slope downstream of the dam ranged from about 0.80 to 1.77 m/km (0.5 ft/mile to 1.1 ft/mile). The drop through the gated section of the dam ranged from about 0.30 to. 0.18 m (0.1 to 0.6 ft) (Gages 4 and 5) and the total change through all the structures (Gages 3 through 6) was about 0.76 m (2.5 ft) with open riverflows.

Current directions and velocities. Current directions and velocities data obtained with Plan J-2 indicate the alignment of the currents in the upper approach to the lock were generally straight and parallel to the left descending bank with reasonably good distribution of flow in the channel (Plates 23 through 27). The maximum velocity in the upper approach to the lock varied from about 0.64 to 2.35 mps (2.1 to 7.7 fps) with the 877- and 4,104-cu m/sec (31,000- and 145,000-cu ft/sec) riverflows, respectively. A large counterclockwise eddy formed in the upper lock approach. The velocity of the upstream currents varied from less than 0.18 mps (0.6 fps) to about 0.37 mps (1.2 fps) with the 877- and 3,113-cu m/sec (31,000- and 110,000-cu ft/sec) riverflows, respectively. With the 4,104-cu m/sec (145,000-cu ft/sec) riverflow, there is some indication of a slight outdraft near the upstream end of the guard wall.

Downstream of the dam, the currents are generally parallel to the right bank from the dam to the lower end of the trail dike extending downstream from the riverward lock wall, then the currents turn toward the left bank. The currents move across the downstream end of the lower approach to the lock and move into the left bank about 457 m (1,500 ft) downstream of the lock. A large counter-clockwise eddy formed in the lower lock approach with all riverflows. As the riverflow increased the eddy increased in strength. The maximum velocities of the currents in the approach to the lock varied from about 2.4 to 3.29 mps (8.0 to 10.8 fps) with the 850- and 4,104-cu m/sec (30,000- and 145,000-cu ft/sec) riverflows, respectively.

Navigation conditions. Navigation conditions for tows entering and leaving the upper lock approach were generally the same as with Plan J-1. Tows could enter and leave the upper lock approach with no major difficulties. Navigation conditions for tows entering and leaving the lower lock approach were difficult. However, removing the left bank dikes allowed upbound tows to move closer along the left bank and therefore enter the lock with more control. With the higher riverflows there was a tendency for a downbound tow to be pushed into the left bank about 610 m (2,000 ft) downstream of the lock. Tows entering and leaving the lower lock approach would encounter extremely high current velocities.

Drawdown experiments

During construction of Lock and Dam 3, the upper pool of Lock and Dam 2 was to be controlled at an interim pool to reduce the backwater effect at the Lock and Dam 3 site. Additional experiments were conducted to determine the effects of the interim pool on tows entering and leaving the upper approach of Lock and Dam 2.

During these experiments the upper pool was controlled at Gage 3 to interim pool el 58.0 and the lower pool was controlled at Gage 7.

Water-surface elevations. Water-surface elevations measured with drawdown conditions indicate a slight increase in the water-surface slope upstream of the dam (Table 7). The water-surface elevations downstream of the dam were generally the same as with normal pool conditions. The slope in water-surface elevations through the upper pool of the model (Gages 1 through 3) varied from about 0.32 to 0.80 m/km (0.2 to 0.5 ft/mile) and downstream of the dam (Gages 6 and 7) the slope varied from about 0.64 to 0.97 m/km (0.4 to 0.6 ft/mile) with the 877- and 1,698-cu m/sec (31,000- and 60,000-cu ft/sec) riverflows, respectively

Current directions and velocities. Current directions and velocities data obtained with drawdown conditions are shown on Plate 28. These data indicate the alignment of the currents were generally the same as with normal pool conditions, but the velocities of the currents increased slightly. The maximum velocity in the upper approach to the lock varied from about 0.64 to 1.2 mps (2.1 to 4.1 fps) with the 877- and 1,698-cu m/sec (31,000- and 60,000-cu ft/sec) riverflows, respectively. The large counterclockwise eddy that was present in the upper lock approach with normal pool conditions was reduced in size and intensity. There was also some indication that the outdraft near the upstream end of the guard wall was reduced somewhat.

Navigation conditions. Navigation conditions for tows entering and leaving the upper lock approach were satisfactory. However, downbound tows could experience stronger forces moving the tow toward the guard wall, and upbound tows could experience some difficulties breaking free of the guard wall as a result of the stronger forces.

Experiments with Plan J-2 Modified through J-6

Discussion and purpose of experiments

After construction of the project, towboat pilots navigating the Red River reported that excessive flow through the ports near the downstream end of the guard wall was causing navigation problems in the upstream lock approach to John H. Overton Lock and Dam. Review of the "AS BUILT DRAWINGS" showed some discrepancies between the upper guard wall of the lock constructed in the prototype and the guard wall studied in the model. The major differences were: the length of the guard wall was shortened from 228.6 to 213.3 m (750 to 700 ft) and the port size was changed from 11.6 to 12.8 m (38 to 42 ft) wide. To facilitate a quick response to the needs of the district, it was decided to modify the guard wall by removing one port and pier which would shorten the wall to the required 213.3 m (700 ft) and would provide approximately the correct port opening but not the correct number of ports and piers. Several experiments were conducted to investigate modifications to the upper approach of the lock that would reduce the flow entering the approach or improve navigation conditions for tows entering and leaving the lock. These modifications were Plans J-4 through J-6.

Operational procedure

Experiments were conducted to determine the effects of the various changes on navigation conditions, distribution of flow across the channel, distribution of flow through the guard wall ports, and the speed at which a static tow would be moved toward the guard wall. Data sufficient for preliminary evaluation were collected on the various plans but compete sets of data were not collected on all plans. Current directions and velocities measured with a float submerged to the draft of a loaded barge (2.7 m (9 ft)) and meter velocities were used to determine the distribution of flow. Head differentials across the guard wall were measured at various locations along the wall to determine the potential forces on the wall. A model tow was placed in the upper lock approach, released and tracked with the Video-Based Tracking System (VIS) to measure the speed and angle of impact when the tow struck the guard wall. The movement of the tow in the upper lock approach was also recorded with multiple-exposure photographs.

Description Plan J-2 Modified

The model was rehabilitated to simulate Plan J-2 conditions with some minor modification and designated Plan J-2 Modified (Figure 10). Plan J-2 Modified was the same as Plan J-2 except the upper guard wall was modified to simulate "AS BUILT DRAWINGS" by shortening the wall from 228.6 to 213.3 m (750 to 700 ft). The revised guard wall was a 213.3-m (700-ft)-long ported buttress-type upper guard wall with the top at el 74.5. The top of ports was at el 47.0, and there were thirteen 3.7-m (12-ft)-wide buttresses, separating thirteen 11.6-m (38-ft)-wide ports and one 5.8-m (19-ft)-wide port adjacent to the lock (Figure 11). The elevation of the berm upstream of the lock was changed from el 49.0 to el 47.0 (Figure 10).

Base data compared

Because of minor changes that could occur during reconstruction of the model, base data in the form of current directions and velocities, meter velocities, and water-surface profiles were collected for comparison with field measurement made in April 1988 and with later modifications to the model.

Results

Water-surface elevations. Water-surface elevations with normal pool conditions, Table 8, show the water-surface elevations were generally the same as with Plan J-2, which indicates the model was reproducing Plan J-2 conditions prior to reconstruction of the model. The slope in water-surface elevations

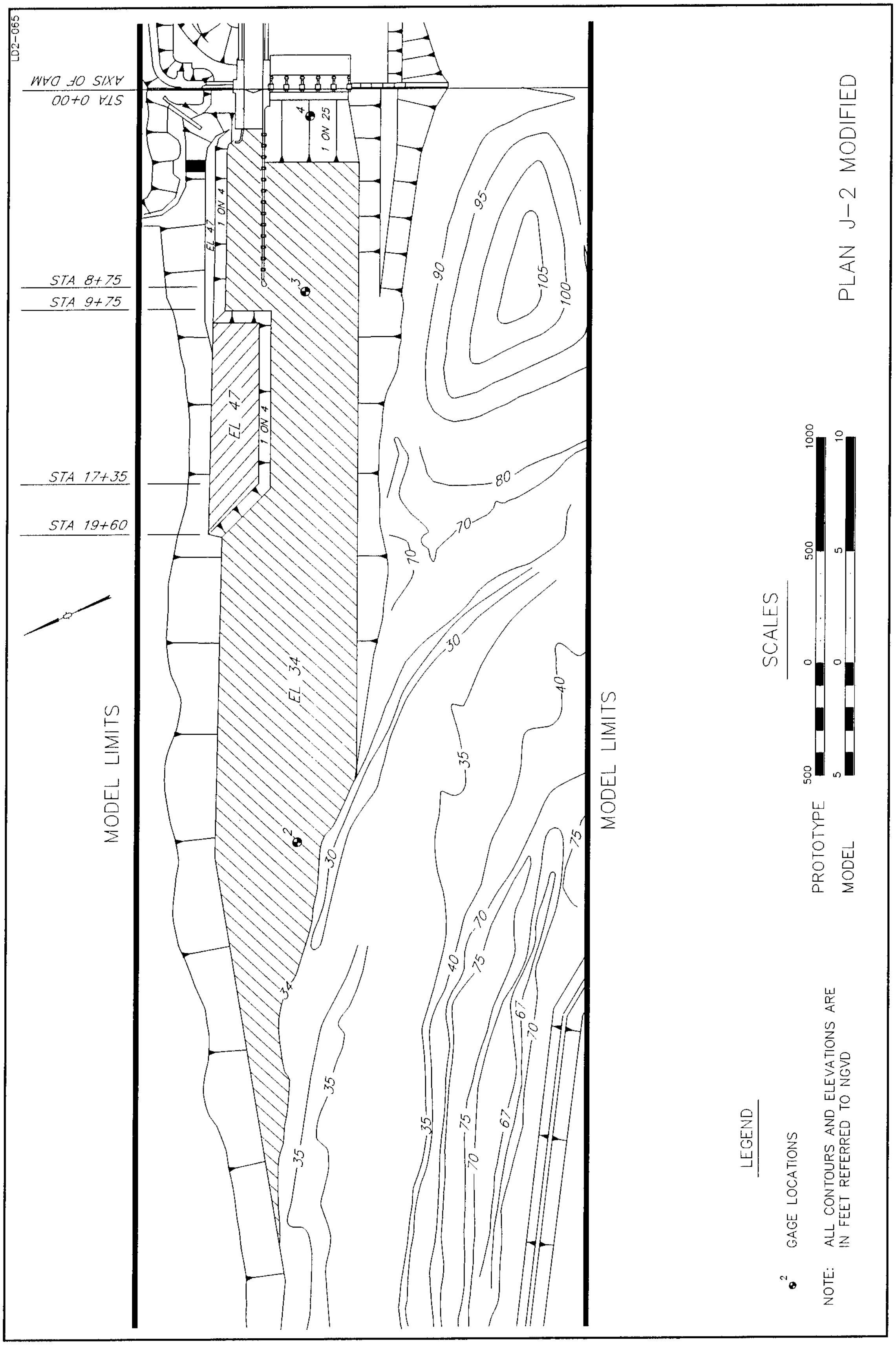


Figure 10. Plan J-2 Modified

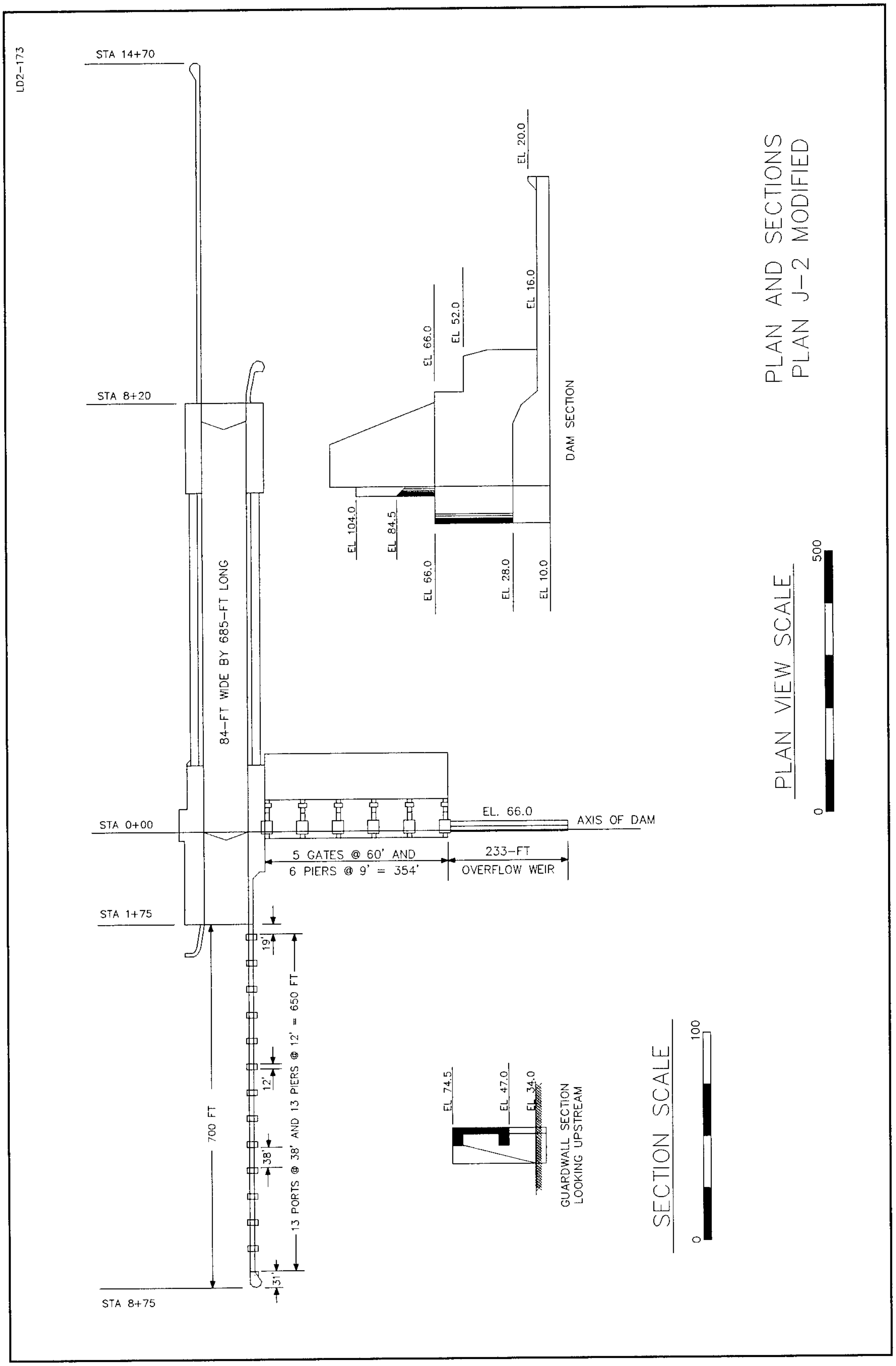


Figure 11. Plan and Sections, Plan J-2 modified structures

through the upper pool of the model (Gages 1 through 3) varied from about 0.16 to 0.64 m/km (0.1 to 0.4 ft/mile), and downstream of the dam (Gages 6 and 7) the slope varied from about 0.80 to 1.77 m/km (0.5 to 1.1 ft/mile) with the 877- and 2,406-cu m/sec (31,000- and 85,000-cu ft/sec) riverflows, respectively. Water-surface elevations measured with drawdown conditions (upper pool controlled to interim pool el 58.0) are shown in Table 9. These data show the slope in water-surface elevations through the upper pool of the model (Gages 1 through 3) varied from about 0.16 to 0.48 m/km (0.1 to 0.3 ft/mile) and downstream of the dam (Gages 6 and 7) the slope varied from about 0.80 to 1.44 m/km (0.5 to 0.9 ft/mile) with the 877- and 1,698-cu m/sec (31,000- and 60,000-cu ft/sec) riverflows, respectively

Current directions and velocities. Current directions and velocities data are shown in Plates 29 through 33. These data indicate the current alignment and velocities were generally the same as with Plan J-2. With normal pool conditions, the maximum velocity in the upper approach to the lock varied from about 0.70 to 1.58 mps (2.3 to 5.2 fps) with the 877- and 2,406-cu m/sec (31,000- and 85,000-cu ft/sec) riverflow, respectively (Plates 29 - 31). With an interim pool elevation of 58.0, the maximum velocity in the upper approach to the lock varied from about 0.73 to 1.4 mps (2.4 to 4.6 fps) with the 877- and 1,698-cu m/sec (31,000- and 60,000-cu ft/sec) riverflow, respectively (Plates 32 and 33).

Flow distribution. Field measurements were made with a velocity meter during a riverflow that ranged from about 793.0 to 1,132 cu m/sec (28,000 to 40,000 cu ft/sec). Measurements were made at 0.6 of the total depth and at four ranges upstream of the dam. The lateral velocity profiles and flow distributions are shown on Plate 34. These data show the velocities of the currents are generally uniform across the channel at station 11+00. However, as the flow approaches the dam, the higher velocities tend to move toward the center of the channel. These data also show the percent of flow landward of a straight line extended upstream from the guard wall ranged from about 25.5 to 11.6 percent at station 11+00 and 3+64. Lateral velocity profiles and flow distributions taken with Plan J-2 Modified are shown on Plates 35 through 39 and summarized in Table 10. These data show a close correlation between the field data and model data taken with an interim pool el 58.0 and 877-cu m/sec (31,000-cu ft/sec) riverflow (Plate 35). The difference in distribution across the channel varied from less than 1 percent near station 6+75 to about 8 percent near station 14+25. Both the field data and the model data indicate a fairly uniform distribution of flow along the upstream two-thirds of the guard wall, with the percent of flow landward of the guard wall being slightly higher with field data. These data also show a large percentage of the flow was concentrated near the most downstream 91 m (300 ft) of the guard wall.

Model data taken with normal pool conditions (el 64.0) are shown in Plates 36 through 38. These data show the percent of flow landward of a line extended upstream from the guard wall varied from 15.7 to11.0 at station 4+25, 18.6 to 16.2 at station 6+75, 24.6 to 20.4 at station 9+25, and 22.0 to 22.4 at station 14+25 with the 877- and 2,406-cu m/sec (31,000- and 85,000-cu ft/sec) riverflows, respectively. Lowering the pool from 64.0 to 58.0 reduced the percentage of flow entering the upper approach of the lock with the 877-cu m/sec (31,000-cu ft/sec) riverflow (Plates 35 and 36) but had little effect with the 1,698-cu m/sec (60,000-cu ft/sec) riverflow (Plates 37 and 39).

Static tow experiments. Static tow experiments were conducted by placing a tow in the upper lock approach at various locations parallel to the guard wall, releasing the tow, and recording the path of the tow with time-lapse photographic and multiple flashes (Figure 12).

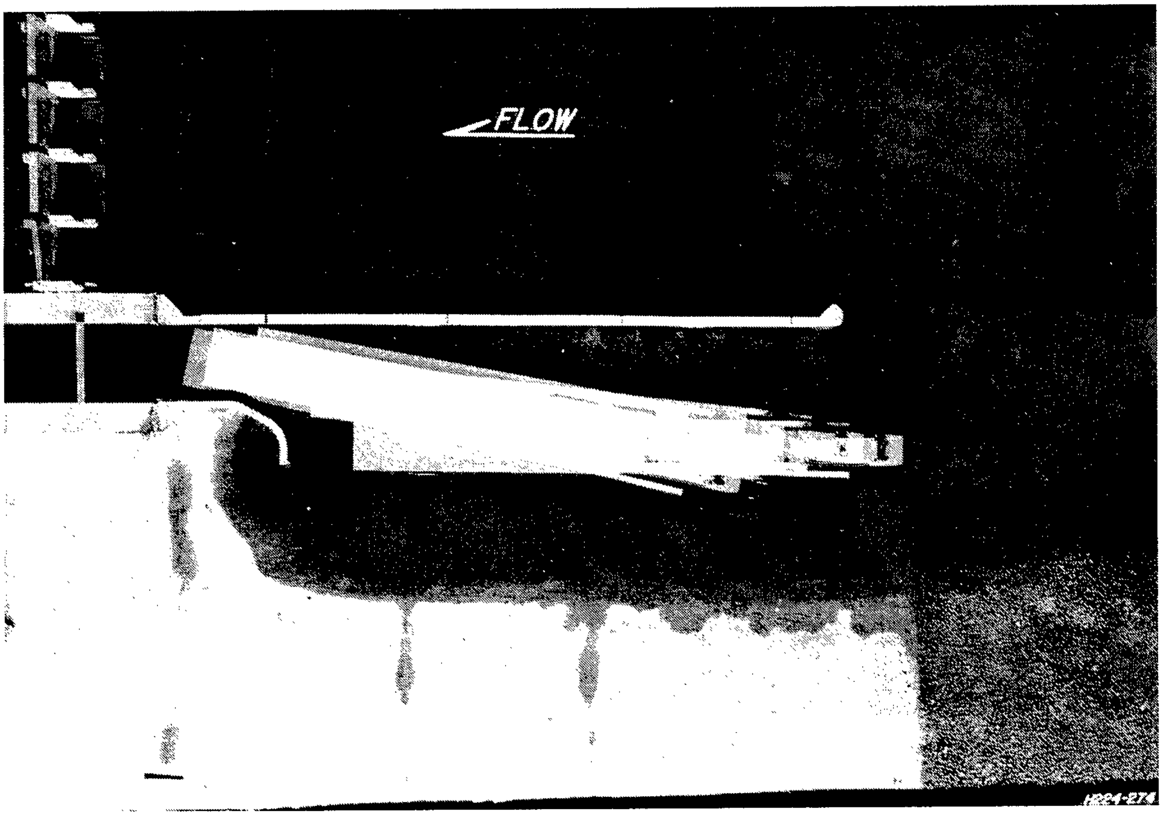


Figure 12. Multiple flashes at 10-sec intervals, showing path of released tow

The results of these experiments are summarized in Table 11. These data indicate the tow moves into the guard wall at a higher speed and greater angle of impact with the interim pool el 58.0 than with the design pool el 64.0. These data also indicate navigation conditions for tows entering and leaving the upper approach to the lock would be somewhat better with the normal pool el 64.0.

Description Plan J-3

Plan J-3 was the same as Plan J-2 Modified except for modifications to the berm along the left bank immediately upstream of the lock and the right bank at the entrance to the lock canal. These modifications were made so the model would represent "AS SURVEYED CONDITIONS" as shown by a recent survey provided by the USAED, Vicksburg.

Base data compared

The field survey was completed after Plan J-2 Modified was documented with the various types of data. Therefore, additional data were collected for comparison with Plan J-2 Modified and any later modifications to the model.

Results

Water-surface elevations. Water-surface elevations, shown in Tables 12 and 13 indicate the slope in water-surface elevations was generally the same as with Plan J-2 Modified. The slope in water-surface elevations through the upper pool of the model (Gages 1 through 3) with normal pool operation varied from about 0.16 to 0.64 cu m/km (0.1 to 0.4 ft/mile) and downstream of the dam (Gages 6 and 7) the slope varied from about 0.80 to 1.77 m/km (0.5 to 1.1 ft/mile) with the 877- and 2,406-cu m/sec (31,000- and 85,000-cu ft/sec) riverflows, respectively. Water-surface elevations measured with drawdown conditions (upper pool controlled to interim pool el 58.0) are shown in Table 13. These data show the slope in water-surface elevations through the upper pool of the model (Gages 1 through 3) varied from about 0.16 to 0.48 cu m/km (0.1 to 0.3 ft/mile) and downstream of the dam (Gages 6 and 7) the slope varied from about 0.80 to 1.44 cu m/km (0.5 to 0.9 ft/mile) with the 877- and 1,698-cu m/sec (31,000- and 60,000-cu ft/sec) riverflows, respectively.

Current directions and velocities. Current directions and velocities data are shown on Plates 40 through 43. These data indicate the current alignment and velocities were generally the same as with Plan J-2 Modified. With normal pool conditions, the maximum velocity in the upper approach to the lock varied from about 0.67 to 1.77 mps (2.2 to 5.8 fps) with the 1,019- and 2,406-cu m/sec (36,000- and 85,000-cu ft/sec) riverflow, respectively (Plates 40 through 42). With an interim pool elevation of 58.0 and a riverflow of 1,019 cu m/sec (36,000 cu ft/sec), the maximum velocity in the upper approach to the lock was about 0.88 mps (2.9 fps). This showed an increase of about 0.21 mps (0.7 fps) compared to normal pool conditions (Plates 40 and 43).

Meter velocities. Measurements made near the center of the guard wall ports with Plan J-3 and 1,698- and 2,406-cu m/sec (60,000- and 85,000-cu ft/sec) riverflows are shown in Plate 44. These data show the velocities of the currents moving along the landward face or the guard wall near the center of the ports varied from about 0.60 to 0.91 mps (1.9 to 3.0 fps) with the 1,699-cu m/sec (60,000-cu ft/sec) riverflow and from 0.60 to 1.40 mps (1.9 to 4.6 fps) with the 2,406-cu m/sec (85,000-cu ft/sec) riverflow. The higher velocities tend to occur near the midsection of the guard wall.

Flow distribution. Model data taken with normal pool conditions (el 64.0) are shown in Plates 45 through 47 and summarized in Table 14. These data indicate a slight increase in the percent of total flow moving along the left descending bank except at the most downstream station where there is a slight decrease in percent of total flow. These data show that the percent of flow landward of a line extended upstream from the guard wall varied from 10.3 to 13.3 at station 4+25, 17.2 to 20.2 at station 6+75, 21.7 to 25.5 at station 9+25, and 20.6 to 22.3 at station 14+25 with the 1,019- and 2,406-cu m/sec (36,000- and 85,000-cu ft/sec) riverflows, respectively. Lowering the pool from el 64.0 to 58.0 increased the percentage of flow entering the upper approach of the lock with the 1,019-cu m/sec (36,000-cu ft/sec) riverflow (Plates 45 and 48) but had little effect with the 1,698-cu m/sec (60,000-cu ft/sec) riverflow (Plates 46 and 49).

Static tow experiments. The results of the static tow experiments are summarized in Table 11. These data indicate some differences when compared to data collected with Plan J-2 Modified. However, the trend is generally the same. The tow tends to move into the guard wall at a higher speed and greater angle of impact with the interim pool el 58.0 than with the design pool el 64.0.

Preliminary Experiments of Plans J-4 through J-6

Discussion and purpose of experiments

After reviewing data taken with Plans J-2 Modified and J-3, it was felt the best approach for improving navigation conditions for tows entering the upper lock approach and reducing the forces moving the tow toward the guard wall was to reduce the amount of flow entering the lock approach.

Modifications suggested

Three modifications were suggested for improving flow distribution across the channel and along the guard wall. Flow distribution measurements were made at the same four stations upstream of the dam as with Plans J-2 Modified and J-3. These data were analyzed to select the plan that would provide the best distribution of flow across the channel.

Descriptions of Plans J-4 through J-6

Comparison of plans

Plan J-4 was the same as J-3 except the berm in the upper approach to the lock was removed by excavating the area to the same elevation as the adjacent channel (el 34.0).

Plan J-5 was the same as Plan J-4 except three submerged dikes with top el of 14 m (47.0 ft) were added upstream of the upper lock approach. The dikes were spaced about 91 m (300 ft) apart with the most downstream dike being about 30.5 m (100 ft) upstream of the upper guard wall. The riverward ends of the dikes were in line with the upper guard wall of the lock and the landward ends tied into the left bank.

Plan J-6 was the same as Plan J-3 except the upstream end of the berm was modified so it was perpendicular to the left bank and two dikes with top el 47.0 were added upstream of the berm (Figure 13). The top 50 percent of the four

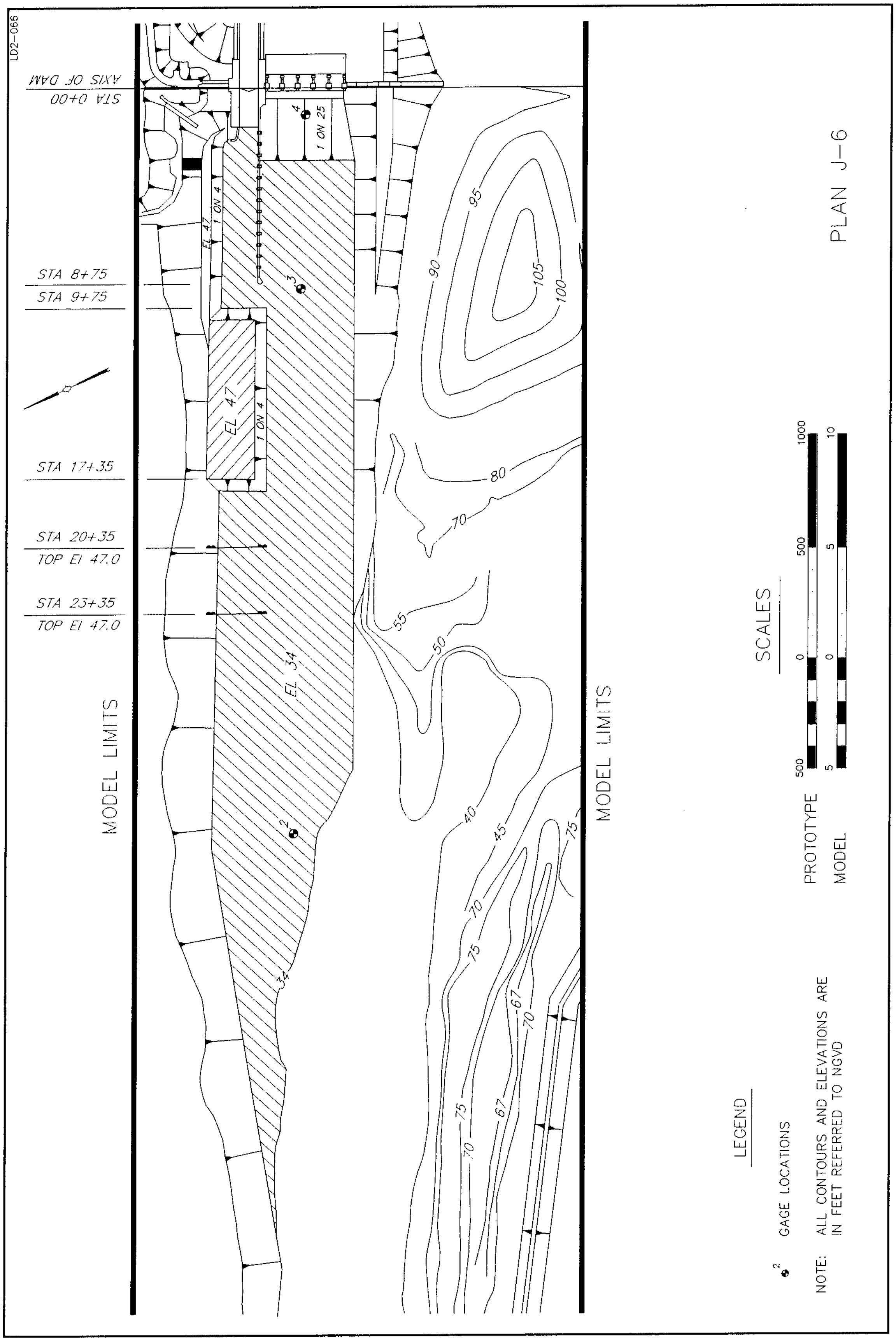


Figure 13. Plan J-6

alternate most downstream guard wall ports were closed to restrict flow through the ports.

Results

Current directions and velocities. Current directions and velocities taken with Plan J-6 are shown in Plates 50 through 52. These data indicate the alignment of the currents were generally the same as with Plan J-3. With normal pool conditions the maximum velocity in the upper approach to the lock varied from about 1.07 to 2.1 mps (3.5 to 6.9 fps) with the 1,698-and 4,104-cu m/sec (60,000-and 145,000-cu ft/sec) riverflow, respectively (Plates 50 through 52). A large counterclockwise eddy formed in the lock forebay. The upstream velocities in the eddy increased as the riverflow increased. The maximum upstream velocity in the eddy varied from about 0.33 to 0.58 mps (1.1 to 1.9 fps) with the 1,698- and 4,104-cu m/sec (60,000-and 145,000-cu ft/sec) riverflow, respectively.

Meter velocities. Measurements made near the center of the guard wall ports with Plan J-6 and 1,698-and 2,406-cu m/sec (60,000-and 85,000-cu ft/sec) riverflows are shown in Plate 53. These data indicate a slight decrease in velocities through the guard wall ports as compared to Plan J-3. The velocities of the currents moving along the landward face or the guard wall near the center of the ports varied from about 0.30 to 0.79 mps (1.0 to 2.6 fps) with the 1,698-cu m/sec (60,000-cu ft/sec) riverflow and from 0.70 to 1.1 mps (2.3 to 3.7 fps) with the 2,406-cu m/sec (85,000-cu ft/sec) riverflow. The higher velocities tend to occur near the midsection of the guard wall.

Navigation conditions. With Plan J-6, navigation conditions were improved in comparison to Plan J-3. Navigation conditions for downbound tows were satisfactory provided the tow aligned with the left bank upstream of the submerged dike at station 23+00 and navigated landward of the river end of the dike. The tow could reduce speed and enter the forebay of the lock without severe effects from the outdraft near the upstream end of the guard wall. With riverflows above 2,406 cu m/sec (85,000 cu ft/sec), the forces moving the tow toward the guard wall appeared to increase somewhat. With riverflows of 2,406 cu m/sec (85,000 cu ft/sec) and less, upbound tows could break free of the guard wall and move upstream out of the lock forebay with no difficulties. There was a tendency for the upbound tow to be moved toward midchannel as it moved over the submerged dikes upstream of the berm. With riverflows above 2,406 cu m/sec (85,000 cu ft/sec) an upbound tow had some difficulties breaking free of the guard wall.

Flow distribution. Model data taken with Plans J-4 through J-6 are shown on Plates 54 through 60. Flow distribution data taken in the prototype and the model with Plans J-2 Modified through J-6 are summarized in Table 15. These data indicate:

a. Removing the berm (Plan J-4) increased the percentage of flow entering the lock forebay.

b. Placing three submerged dikes with top el of 14.3 m (47.0 ft) upstream of the upper lock approach (Plan J-5) reduced the percentage of flow entering the forebay as compared to Plan J-4 and reestablished a flow distributions similar to Plan J-3 except with the 1,698-cu m/sec (60,000-cu ft/sec) riverflow and a normal pool of el 64.0, which was considerably less than with Plan J-3.

c. Realigning the upstream end of the berm and adding two dikes upstream of the berm (Plan J-6) reduced the percentage of flow entering the forebay slightly.

Experiments with Plans K through K-2

Discussion and purpose of experiments

The USAED, Vicksburg, conducted a hydrographic survey of the upper pool at Lock and Dam No. 2 in February 1989. Comparing the new survey with previous surveys indicated the bed geometry had changed significantly. The prototype survey data showed the bed had aggraded up to 2.4 m (8 ft) in some areas since the upper pool was raised to el 64.0, NGVD. These changes in the bed geometry could affect navigation conditions for tows entering and leaving the lock and influence the distribution of flow across the channel. Therefore, it was decided to document the changes in bed geometry with monthly hydrographic surveys to determine the best bed geometry for additional experiments.

Prototype data

The USAED, Vicksburg, made hydrographic surveys in the upper pool of John H. Overton Lock and Dam about once a month from February to July 1989. The results of these surveys are shown in Plates 61 and 62. These data show deposits up to 2.4 m (8 ft) in some areas with the major deposits along the right descending bank. These deposits could be causing a higher concentration of flow along the left descending bank and more flow to enter the lock approach. During a meeting between the USAED, Vicksburg, and personnel from the U.S Army Engineer Research and Development Center (ERDC), it was decided to remold the upper pool of the model to a new hydrographic survey taken in January 1990. It was also decided to modify the upper guard wall of the lock to conform to the as-built wall in the prototype. The USAED, Vicksburg, also provided a revised tailwater rating curve for the project based on data observed after completion of the project. Additional experiments were conducted to evaluate navigation conditions for tows entering and leaving the upper lock approach.

Experiments with Plan K

Description

Plan K was the same as Plan J-3 except the upper ported guard wall was modified to accurately match as-built drawings (Figure 14) and the model bed

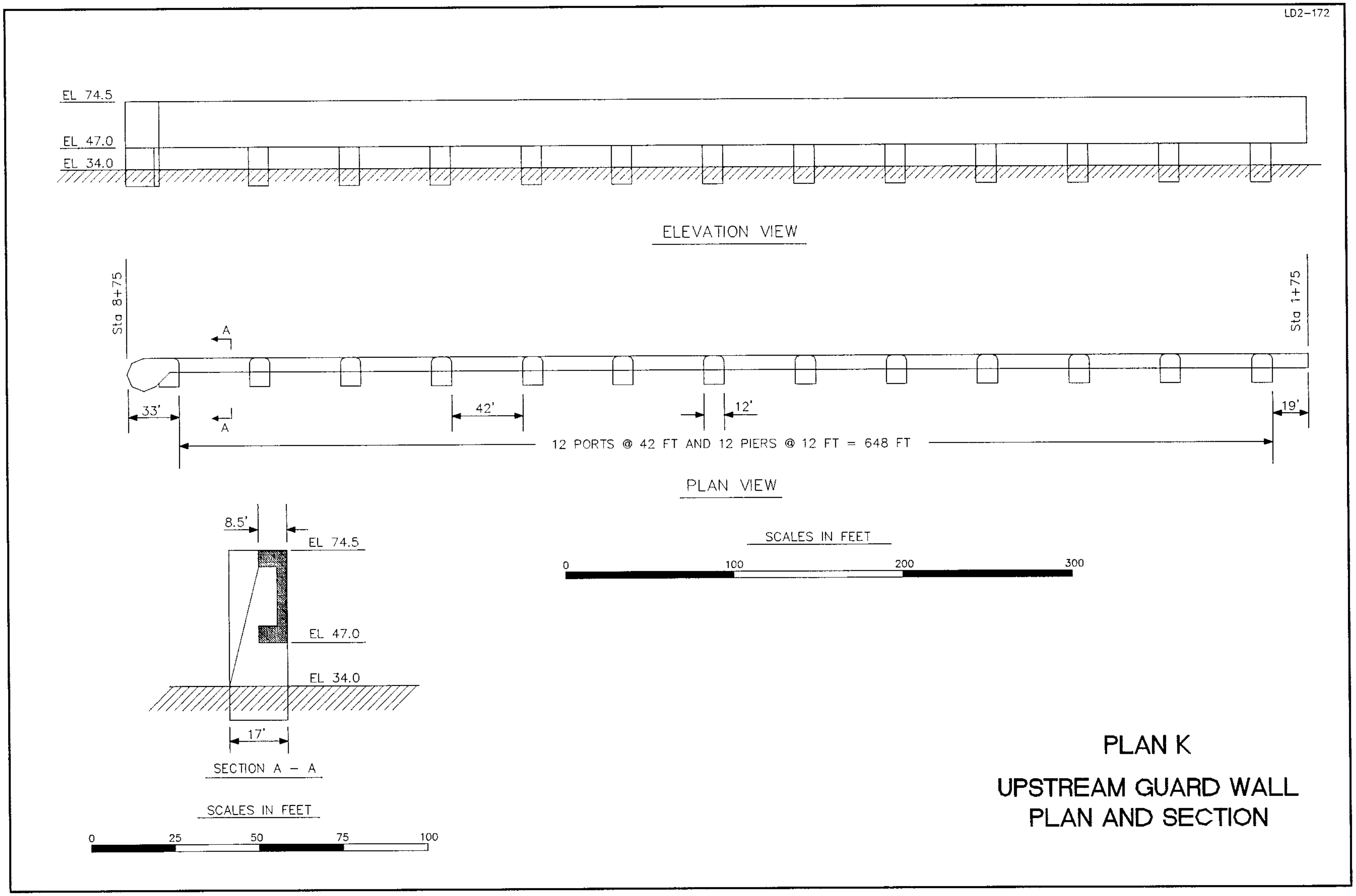


Figure 14. Plan and section, Plan K upstream guard wall

upstream of the dam was remolded to the January 1990 hydrographic survey provided by the USAED, Vicksburg, which was similar to the June and July 1989 cross sections (Plates 61 and 62). The revised guard wall was a 213-m (700-ft)-long ported buttress-type upper guard wall with top at el 74.5. The top of ports was at el 47.0, and there were twelve 3.7-m (12-ft)-wide buttresses, separating twelve 12.8-m (42-ft)-wide ports and one 5.8-m (19-ft)-wide port adjacent to the lock.

Results

Water-surface elevations. With controlled riverflows the upper pool was controlled at Gage 3 to normal pool el 64.0. With all riverflows, the lower pool was controlled at Gage 6 to elevations provided by the USAED, Vicksburg. These revised tailwater elevations were based on field data collected by the district after completion of the project. These tailwater elevations were considerably lower than the projected tailwater water elevations used with Plan J-3 (Figure 15). Therefore, the slope in water surface elevations downstream of the dam increased considerably. Water-surface elevations measured with Plan K are shown in Table 16. These data show the slope in water-surface elevations upstream of the dam were considerably higher than with Plan J-3 because of the higher bed elevations and smaller cross section area of this plan. The slope in water-surface elevations through the upper pool of the model (Gages 1 through 3) varied from about 0.32 to 2.1 m/km (0.2 to 1.3 ft/mile) with the 877- and 4,104-cu m/sec (31,000- and 145,000-cu ft/sec) riverflows, respectively. Downstream of the dam (Gages 6 and 7) the slope varied from about 1.6 to 4.2 m/km (1.0 to 2.6 ft/mile) with the 877- and 3,113- cu m/sec (31,000- and 110,000-cu ft/sec) riverflows, respectively. The slope in water-surface elevations downstream of the dam can be misleading because of scour and fill that was present in the prototype was not reproduced in the model.

Current directions and velocities. Current directions and velocities data are shown on Plates 63 through 67. These data indicate the currents were generally parallel to the left descending bank from the upstream end of the model to the upstream lock wall. A large counterclockwise eddy formed in the lock approach that increased in intensity as the riverflow increased. The maximum velocity of the currents in the navigation channel approaching the lock varied from about 0.70 to 2.68 mps (2.3 to 8.8 fps) near the upstream end of the guard wall, 0.73 to 2.5 mps (2.4 to 8.3 fps) about 609.6 m (2,000 ft) upstream of the guard wall and 0.79 to 2.99 mps (2.6 to 9.8 fps) about 1,219 m (4,000 ft) upstream of the guard wall with the 877- and 4,104-cu ft/sec (31,000- and 145,000-cu ft/sec) riverflows, respectively.

Navigation conditions. Navigation conditions were documented using an overhead VTS and tow tracks are shown on Plates 68 through 70. Navigation conditions were satisfactory for tows entering and leaving the upper lock approach with riverflows up to 1,698 cu m/sec (60,000 cu ft/sec) (Plate 68). As the riverflow increased above 1,698 cu m/sec (60,000 cu ft/sec), navigation conditions became difficult for tows entering and leaving the upper lock approach. An upbound tow would have some difficulty breaking free of the guard wall and

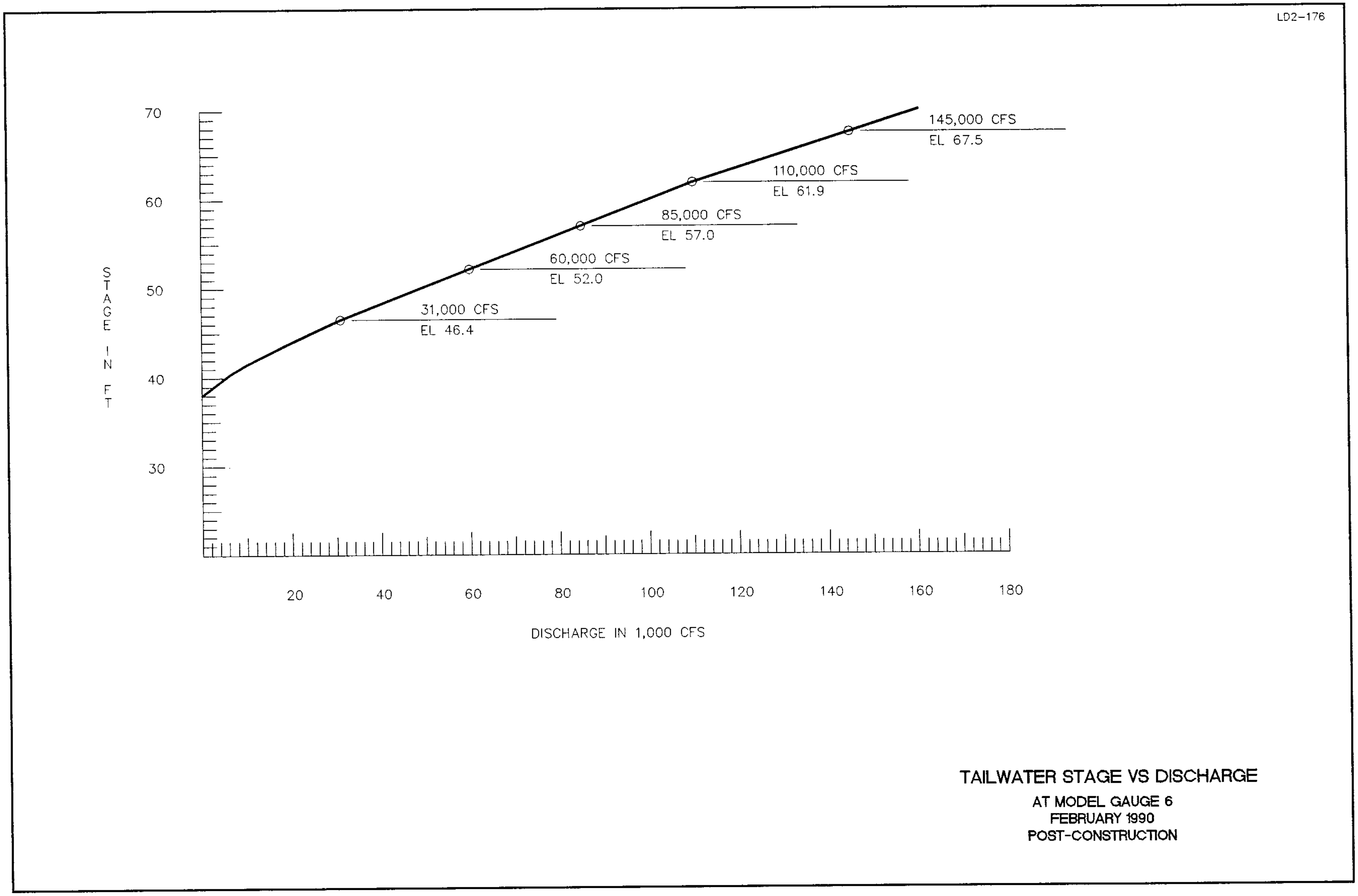


Figure 15. Tailwater stage VS discharge, February 1990

moving upstream along the left descending bank. Downbound tows could align with the guard wall two tow lengths upstream of the guard wall but would have some difficulty reducing speed in the lock forebay and approaching the guard wall at a slow speed (Plates 69 and 70). There was some indication of an outdraft near the upstream end of the guard wall that could adversely affect the tow as it entered the lock forebay and approached the guard wall.

Static tow experiments. Static tow drift experiments were conducted by placing a tow in the upper lock approach 15 and 30 m (50 and 100 ft) landward of and parallel to the guard wall with the head of the tow at stations 3+00, 4+00, and 6+00, releasing the tow and recording the speed and angle of impact with a VTS. The results of these experiments are shown in Table 17. These data indicate:

a. With any given riverflow, tows released 30m (100 ft) landward of the guard wall and upstream of station 3+00 tend to strike the guard wall with higher velocities of impact than those released 15m (50 ft) landward of the guard wall or at station 3+00.

b. As the riverflow increases the velocity of impact of the released tow increases.

c. The velocity of impact ranged from about 0.18 to 1.04 mps (0.6 to 3.4 fps) with the 1,698- and 4,104-cu m/sec (60,000- and 145,000-cu ft/sec) riverflows, respectively.

d. The angle of impact varied from a negative 4.3 deg (stern or side of tow strikes the guard wall) to about 2.2 deg.

e. With the 1,698- and 2,406-cu m/sec (60,000- and 85,000-cu ft/sec) riverflows, the head of the tow tended to strike the guard wall, while with the 4,104-cu m/sec (145,000-cu ft/sec) riverflow, the stern of the tow tended to strike the guard wall. This indicates with the higher riverflow there was some outdraft near the upstream end of the guard wall acting on the stern of the tow.

Experiments with Plan K-1

Description

Plan K-1 was the same as Plan K except two submerged dikes with top elevations of 14.3 m (47.0 ft) NGVD were placed in the model at Stations 20+00 and 23+00 on top of the existing bed. The riverward ends of the dikes were in line with the upper guard wall of the lock and the landward ends tied into the left bank.

Results

Water-surface elevations. Water-surface elevations measured with Plan K 1 are shown in Table 18. These data show the water-surface elevations upstream of the dam were generally the same as with Plan K, except with a riverflow of 2,406 cu m/sec (85,000 cu ft/sec). Adding the two submerged dikes upstream of the left bank berm increased water-surface elevations 0.55 and 0.21 m (1.8 and 0.7 ft) at Gages 1 and 2, respectively. Water-surface levels downstream of the dikes remained about the same as with Plan K. The slope in water-surface elevations through the upper pool of the model (Gages 1 through 3) varied from about 0.16 to 4.35 m/km (0.1 to 2.7 ft/mile) with the 877- and 2,406-cu m/sec (31,000- and 85,000-cu ft/sec) riverflows, respectively. Downstream of the dam (Gages 6 and 7) the slope varied from about 1.6 to 4.02 m/km (1.0 to 2.5 ft/mile) with the 877- and 3,113-cu m/sec (31,000- and 110,000-cu ft/sec) riverflows, respectively.

Current directions and velocities. Current directions and velocities measured with Plan K-1 are shown in Plates 71 through 75. These data show the alignment of the current was generally the same as with Plan K. The currents were generally parallel to the left descending bank from upstream of the submerged dikes to the upstream end of the guard wall. A large counterclockwise eddy formed in the lock approach that increased in intensity as the riverflow increased. With the 2,265-cu m/sec (80,000-cu ft/sec) riverflow, the currents downstream of the dike at Station 20+00 were split with some currents moving toward the left bank and some moving toward midchannel. With all riverflows the dikes reduced the velocity of the currents downstream of the dikes and in the vicinity of the guard wall as compared to Plan K. The maximum velocity of the currents in the navigation channel approaching the lock varied from about 0.61 to 2.44 mps (2.0 to 8.0 fps) near the upstream end of the guard wall and 0.70 to 2.53 mps (2.3 to 8.3 fps) about 609.6 m (2,000 ft) upstream of the guard wall with the 877- and 4,104-cu m/sec (31,000- and 145,000-cu ft/sec) riverflows, respectively.

Navigation conditions. Navigation conditions were generally the same as with Plan K. With the 1,698-cu m/sec (60,000-cu ft/sec) riverflow, a downbound tow could align with the guard wall about two tow lengths upstream of the guard wall, start reducing speed, and enter the lock forebay at a safe speed (Plate 76). As the riverflow increased above 1,698 cu m/sec (60,000 cu ft/sec), a downbound tow could align with the guard wall about two tow lengths upstream of the wall but had difficulties reducing speed and entering the forebay at a safe speed (Plates 77 and 78). To maintain control a downbound tow was driving about 2.44 mps (8.0 fps) with the 2,406-cu m/sec (85,000- cu ft/sec) riverflow and about 3.35 mps (11.0 fps) with the 44,196 mps (145,000 fps) in the vicinity of two tow lengths upstream of the guard wall. The speed of the tow varied from about 1.49 to 2.07 mps (4.9 to 6.8 fps) when the head of the tow was opposite the upstream end of the guard wall with the 1,698- and 2,406-cu m/sec (60,000- and 85,000-cu ft/sec) riverflows, respectively. The speed of the tow was 1.890 mps (6.2 fps) when the head of the tow was opposite the upstream end of the guard wall with the 4,104-cu m/sec (145,000-cu ft/sec) riverflow. The speed of the tow was less than with the 2,406-cu m/sec (85,000-cu ft/sec) flow at this point because of the approach taken by the model tow pilot. Because of the high velocities with the 4,104-cu m/sec (145,000-cu ft/sec) flow, the pilot stayed very close to the left descending bank and cautiously maneuvered the tow down the bank to the lock approach. An upbound tow would have some difficulty breaking free of the guard wall and moving upstream along the left descending bank.

Static tow experiments. Static tow drift experiments were conducted by placing a tow in the upper lock approach 15 and 30 m (50 and 100 ft) landward of and parallel to the guard wall with the head of the tow at stations 3+00, 4+00, and 6+00, releasing the tow and recording the speed and angle of impact with a VTS. The results of these experiments are shown in Table 19. These data indicate the angles and the velocities of impact were generally the same as with Plan K.

Experiments with Plan K-2

Description

Plan K-2 was the same as Plan K-1 except the areas in the immediate vicinity of the submerged dikes were dredged to elevation 10.4 m (34.0 ft).

Results

Water-surface elevations. Water-surface elevations measured with Plan K-2 are shown in Table 20. These data show the water-surface elevations upstream of the dam were generally the same as with Plan K. Dredging in the vicinity of the submerged dikes reduced the water-surface elevations at Gages 1 and 2 with the 2,406-cu m/sec (85,000-cu ft/sec) riverflow to about the levels measured with Plan K. Water-surface levels downstream of the dikes remained about the same as with Plans K and K-1. The slope in water-surface elevations through the upper pool of the model (Gages 1 through 3) varied from about 0.16 to 2.6 m/km (0.1 to 1.6 ft/mile) with the 877- and 2,406-cu m/sec (31,000- and 85,000-cu ft/sec) riverflows, respectively. Downstream of the dam (Gages 6 and 7) the slope varied from about 1.6 to 4.0 m/km (1.0 to 2.5 ft/mile) with the 877- and 3,113-cu m/sec (31,000- and 110,000-cu ft/sec) riverflows, respectively.

Current directions and velocities. Current directions and velocities measurement made with Plan K-2 conditions are shown in Plates 79 through 81. These data show from upstream of the submerged dikes to the upstream end of the guard wall the currents were generally parallel to the left descending bank with the 1,698-cu m/sec (60,000-cu ft/sec) riverflow. As the riverflow increased to 2,406 cu m/sec (85,000 cu ft/sec) and above, the currents downstream of the submerged dikes tended to move away from the lock approach and toward the main river channel. With the 4,104 cu m/sec (145,000 cu ft/sec), the alignment of the currents suggest a strong outdraft near the upstream end of the guard wall. With all riverflows evaluated, a large counterclockwise eddy formed in the lock approach. As the riverflow increased, the size and intensity of the eddy increased. The maximum velocity of the upstream currents varied from about 0.3

to 0.5 mps (1.1 to 1.8 fps) with the 1,698- and 4,104-cu m/sec (60,000- and 145,000-cu ft/ sec) riverflows, respectively. The maximum velocity of the currents in the navigation channel approaching the lock varied from about 1.1 to 2.5 mps (3.7 to 8.3 fps) near the upstream end of the guard wall and 1.3 to 2.6 mps (4.3 to 8.6 fps) about 609.6 m (2,000 ft) upstream of the guard wall with the 1,698- and 4,104-cu m/sec (60,000- and 145,000-cu ft/sec) riverflows, respectively.

Navigation conditions. Navigation conditions were generally the same as with Plan K.

Static tow experiments. Static tow drift experiments were conducted by placing a tow in the upper lock approach 15.2 and 30.4 m (50 and 100 ft) landward of and parallel to the guard wall with the head of the tow at stations 3+00, 4+00, and 6+00, releasing the tow and recording the speed and angle of impact with a video tracking system. The results of these experiments are shown in Table 21. These data indicate:

a. The velocity of impact with the 1,698- and 2,406-cu m/sec (60,000- and 85,000-cu ft/sec) riverflows were generally the same as with Plan K.

b. With the 4,104-cu m/sec (145,000-cu ft/sec) riverflow, the velocity of impact was somewhat less than with Plan K.

c. The angles of impact were generally the same as with Plan K with all riverflows.

4 Discussion of Results and Conclusions

Limitations of Model Results

Analysis of the results of this investigation is based on a study of: (a) the effects of various plans and modifications on water-surface elevations and current directions and velocities, and (b) the effects of the resulting currents on model towboat and tow behavior. In evaluating the results, it should be taken into consideration that small changes in current directions and velocities are not necessarily changes produced by a modification in the plan, since several floats introduced at the same point may follow a different path and move at somewhat different velocities because of pulsating currents and eddies. Current directions and velocities shown in the plates were obtained with floats submerged to the depth of a loaded barge (9-ft prototype) and are more indicative of currents affecting the behavior of tows than those indicated by photographs. The photographs indicate the movement of confetti on the water surface and could be affected by surface tension.

The small scale of the model made it difficult to reproduce accurately the hydraulic characteristics of the prototype structures or to measure water-surface elevation with accuracy greater than about ±0.1-ft prototype. Also, current directions and velocities were based on steady riverflows and would be somewhat different with varying riverflows. The model was a fixed-bed type and not designed to reproduce overall sediment movement that might occur in the prototype with the various plans. Therefore, changes in channel configuration resulting from scouring and deposition and any resulting changes in current directions and velocities were not evaluated.

Summary of Results and Conclusions

The following results and conclusions were developed during the investigation:

a. Plan F (Base Conditions) provides satisfactory navigation conditions in the lock approaches with all riverflows evaluated assuming towboats have sufficient power to overcome the current during open riverflows.

b. Modifying the bed upstream of the dam to reproduce the deposition that occurred in the movable-bed model increased the water-surface elevation near the upstream end of the model 0.40 to 0.49 m (1.3 to 1.6 ft) (Plan G). The modified bed also increased the velocities of the currents upstream of the dam and produced navigation conditions that were difficult for tows entering and leaving the upper lock approach.

c. There were no major changes in navigation conditions in either lock approach as a result of the powerhouse configuration or the flow from the powerhouse (Plan H).

d. Plans J provided satisfactory navigation conditions for tow entering and leaving the upper lock approach.

e. With Plan J, navigation conditions for tows entering and leaving the lower lock approach were difficult to hazardous. With the higher riverflows, there was a tendency of the tow to be pushed into the left bank dikes immediately downstream of the lock by the high-velocity currents.

f. Leaving a portion of the cofferdam as a berm in the upper approach to the lock did not adversely affect navigation conditions for tows entering and leaving the lock (Plan J-1).

g. Removing the three left bank dikes immediately downstream of the lock improved navigation conditions for tows entering and leaving the lock (Plan J-2). However, navigation conditions were still difficult as a result of the alignment and velocity of the currents.

h. Plan J-2 drawdown through remaining modifications only looked at improvements to upstream approach. No attempt was made to modify lower approach.

i. Lowering the upper pool from el 64.0 to 58.0 with controlled riverflows increased the slope in water-surface elevations upstream of the dam, increased the velocity of the currents slightly, and increased the forces moving a tow toward the guard wall (Plan J-2 Drawdown).

j. Shortening the guard wall from 228.6 to 213.4 m (750 to 700 ft) did not adversely affect navigation conditions for tows entering and leaving the upper lock approach (Plan J-2).

k. Plan J-6 provided improved navigation conditions for tows entering and leaving the upper lock approach compared to Plan J-3.

l. Plan K provided satisfactory conditions for tows entering and leaving the upper lock approach with riverflows up to 1,698 cu m/sec (60,000 cu ft/sec). However, as the riverflow increased above 1,698 cu m/sec (60,000 cu ft/sec), navigation conditions became difficult for tows entering and leaving the upper lock approach. An upbound tow would have some difficulty breaking free of the guard wall and moving upstream along the left descending bank. Downbound were operating at relatively high speeds.

m. The slope in water-surface elevations upstream of the dam were considerably higher with Plans K, K-1, and K-2 compared to Plan J-3 because of the higher bed elevations and smaller cross section area of these plans.

Table 1
Water-Surface Elevations, Plan F

Gage No.	Water-Surface Elevations, ft NGVD, cu ft/sec			
	31,000	**85,000**	**110,000**	**145,000**
1	64.1	64.6	69.0	73.6
2	64.0	64.3	68.9	73.3
3	64.0[1]	64.0[1]	68.6	73.3
4	63.9	63.7	67.9	72.5
Axis of Dam				
5	51.2	63.5	67.6	72.1
6	51.0	63.0	67.1	71.5
7	50.6[1]	62.0[1]	66.3[1]	71.0[1]
Head/Dam (G4 – G5)	12.7	0.2	0.3	0.4
Slope 1-3 (ft/ mi)	0.1	0.6	0.4	0.3
Drop G3-G6	N/A	1.0	1.5	1.8
Slope 6-7 (ft/ mi)	0.5	1.3	1.0	0.6

[1] Controlled elevation.

Table 2
Water-Surface Elevations, Plan G

Gage No.	Water-Surface Elevations, ft NGVD, cu ft/sec			
	31,000	**85,000**	**110,000**	**145,000**
1	64.1	66.2	70.3	75.0
2	64.1	65.1	69.6	74.4
3	64.0[1]	64.1	68.3	73.1
4	63.9	63.7	67.9	72.6
Axis of Dam				
5	51.2	63.4	67.6	72.2
6	51.0	62.9	66.9	71.5
7	50.6[1]	62.0[1]	66.3[1]	71.0[1]
Head/Dam (G4 – G5)	12.7	0.3	0.3	0.4
Slope 1-3 (ft/mi)	0.1	2.1	2.0	1.9
Drop G3-G6	N/A	1.2	1.4	1.6
Slope 6-7 (ft/mi)	0.5	1.1	0.8	0.6

[1] Controlled elevation.

Table 3
Water-Surface Elevations, Plan H

Gage No.	Water-Surface Elevations, ft NGVD, cu ft/sec							
	6,000	12,000	24,000	70,000	70,000[1]	85,000[1]	110,000[1]	145,0005[1]
1	64.0	64.0	64.2	65.5	65.5	66.4	70.6	75.1
2	64.0	64.0	64.1	64.7	64.7	65.4	69.7	74.4
3	64.0[2]	64.0[2]	64.0[2]	64.0[2]	64.0[2]	64.3	68.7	73.2
4	64.0	64.0	64.0	63.8	63.8	63.8	68.1	72.6
Axis of Dam								
5	42.2	44.6	49.0	59.8	59.8	63.5	67.6	72.2
6	42.1	44.5	48.9	59.2	59.2	63.0	67.0	71.5
7	42.1[2]	44.4[2]	48.5[2]	58.2[2]	58.2[2]	62.0[2]	66.3[2]	71.0[2]
Head/Dam (G4 – G5)	21.8	19.4	15.0	4.0	4.0	0.3	0.5	0.4
Slope 1-3 (ft/mi)	< 0.1	< 0.1	0.2	1.5	1.5	2.1	1.9	1.9
Drop G3-G6	N/A	N/A	N/A	N/A	N/A	1.3	1.7	1.7
Slope 6-7 (ft/mi)	0.1	0.2	0.5	1.6	1.6	1.5	1.3	1.2

[1] Powerhouse closed.
[2] Controlled elevation.

Table 4
Water-Surface Elevations, Plan J

Gage No.	Water-Surface Elevations, ft NGVD, cu ft/sec			
	31,000	85,000	110,000	145,000
1	64.1	64.2	68.7	74.3
2	64.0	64.1	68.6	74.3
3	64.0[1]	64.0[1]	68.5	74.2
4	63.9	63.4	67.7	73.5
Axis of Dam				
5	50.7	63.0	67.3	73.3
6	49.4	61.5	65.7	71.6
7	49.0[1]	60.6[1]	65.2[1]	71.2[1]
Head/Dam (G4 – G5)	13.9	0.4	0.4	0.2
Slope 1-3 (ft/mi)	0.1	0.2	0.2	0.1
Drop G3-G6	N/A	3.5	2.8	2.6
Slope 6-7 (ft/mi)	0.5	1.1	0.6	0.5

[1] Controlled elevation.

Table 5
Water-Surface Elevations, Plan J-Modified (Plan J-1)

Gage No.	Water-Surface Elevations, ft NGVD, cu ft/sec			
	31,000	85,000	110,000	145,000
1	64.2	64.3	68.8	74.4
2	64.0	64.2	68.6	74.3
3	64.0[1]	64.0[1]	68.3	74.2
4	63.9	63.5	67.6	73.4
Axis of Dam				
5	49.6	63.0	67.4	73.3
6	49.2	61.4	65.7	71.5
7	49.0[1]	60.6[1]	65.2[1]	71.2[1]
Head/Dam (G4 – G5)	14.3	0.5	0.2	0.1
Slope 1-3 (ft/mi)	0.2	0.6	0.5	0.2
Drop G3-G6	N/A	2.6	2.6	2.7
Slope 6-7 (ft/mi)	0.3	1.0	0.6	0.4

[1] Controlled elevation.

Table 6
Water-Surface Elevations, Plan J-2

Gage No.	Water-Surface Elevations, ft NGVD, cu ft/sec				
	31,000	60,000	85,000	110,000	145,000
1	64.1	64.3	64.5	68.8	74.6
2	64.1	64.2	64.3	68.6	74.4
3	64.0[1]	64.0[1]	64.0[1]	68.3	74.1
4	63.9	63.8	63.5	67.5	73.3
Axis of Dam					
5	50.9	57.5	62.9	67.3	73.2
6	49.4	56.1	61.5	65.8	71.6
7	49.0[1]	55.5[1]	60.6[1]	65.2[1]	71.2[1]
Head/Dam (G4 – G5)	13.0	6.3	0.6	0.2	0.1
Slope 1-3 (ft/mi)	0.1	0.3	0.5	0.5	0.5
Drop G3-G6	N/A	N/A	2.5	2.5	2.5
Slope 6-7 (ft/mi)	0.5	0.8	1.1	0.8	0.5

[1] Controlled elevation.

Table 7
Water-Surface Elevations, Plan J-2, Drawdown

Gage No.	Water-Surface Elevations, ft NGVD, cu ft/sec 31,000	60,000
1	58.2	58.5
2	58.1	58.4
3	58.0[1]	58.0
4	57.9	57.9
Axis of Dam		
5	51.0	57.6
6	49.3	56.0
7	49.0[1]	55.5[1]
Head/Dam (G4 – G5)	6.9	0.3
Slope 1-3 (ft/mi)	0.2	0.5
Drop G3-G6	N/A	N/A
Slope 6-7 (ft/mi)	0.4	0.6

[1] Controlled elevation.

Table 8
Water-Surface Elevations, Plan J-2 Modified

Gage No.	Water-Surface Elevations, ft NGVD, cu ft/sec			
	31,000	36,000	60,000	85,000
1	64.1	64.1	64.2	64.4
2	64.1	64.1	64.1	64.3
3	64.0[1]	64.0[1]	64.0[1]	64.0[1]
4	64.0	63.9	63.8	63.6
Axis of Dam				
5	51.0	51.8	57.6	63.0
6	49.4	50.1	56.1	61.5
7	49.0[1]	49.6[1]	55.5[1]	60.6[1]
Head/Dam (G4 – G5)	13.0	12.1	6.2	0.6
Slope 1-3 (ft/mi)	0.1	0.1	0.2	0.4
Drop G3-G6	N/A	N/A	N/A	N/A
Slope 6-7 (ft/mi)	0.5	0.6	0.6	1.1

[1] Controlled elevation.

Table 9
Water-Surface Elevations, Plan J-2 Modified, Drawdown Pool

Gage No.	Water-Surface Elevations, ft NGVD, cu ft/sec 31,000	36,000	60,000
1	58.1	58.2	58.6
2	58.0	58.1	58.5
3	58.0[1]	58.0[1]	58.3[2]
4	57.9	57.9	58.0
Axis of Dam			
5	51.0	52.0	57.8
6	49.4	50.1	56.2
7	49.0[1]	49.6[1]	55.5[1]
Head/Dam (G4 – G5)	6.9	5.9	0.2
Slope 1-3 (ft/mi)	0.1	0.2	0.3
Drop G3-G6	N/A	N/A	2.1
Slope 6-7 (ft/mi)	0.5	0.6	0.9

[1] Controlled elevation.
[2] All dam gates open.

Table 10
Plan J-2 Modified, Percent of Total Flow Landward of Guard Wall

Discharge cu ft/sec	Pool El	Distance Upstream of Dam, ft Sta 4+25	Sta 6+75	Sta 9+25	Sta 14+25
31,000	58.0	12.9	15.6	17.9	17.5
31,000	64.0	15.7	18.6	24.6	22.0
36,000	58.0	15.7	17.4	21.1	17.9
36,000	64.0	13.2	21.3	20.8	21.0
60,000	58.0	13.2	16.0	19.8	17.7
60,000	64.0	12.2	16.4	19.8	22.1
85,000	64.0	11.0	16.2	20.4	22.4

Table 11
Static Tow Releases in the Upper Approach

Discharge, cfs	Release Sta/Dist	Impact Station	Angle of Impact	Seconds to Impact
Plan J-2 Mod 60,000 cfs Pool el 58.0	3+00 / 50	2+30	1.0	10
	3+00 / 100	1+90	10.5	20
	3+00 / 140	Guide Wall[1]	-13.5	30
	4+00 / 50	1+50	< 1.0	30
	4+00 / 100	1+40	1.0	30
	4+00 / 140	1+70	0.0	30
	6+00 / 50	5+00	4.0	10
	6+00 / 100	3+75	5.0	20
	6+00 / 140	3+65	7.5	20
Plan J-2 Mod 60,000 cfs Pool el 64.0	3+00 / 50	8+00	-1.0	10
	3+00 / 100	Guide Wall[1]	-9.0	30
	3+00 / 140	Left bank[2]	-13.0	40
	4+00 / 50	No Hit[3]	0.0	50
	4+00 / 100	Guide Wall[1]	-9.0	35
	4+00 / 140	Guide Wall[1]	-7.0	40
	6+00 / 50	2+30	<1. 0	40
	6+00 / 100	No hit[3]	0.0	60
	6+00 / 140	1+70	8.0	40
Plan J-3 60,000 cfs Pool el 58.0	3+00 / 100	Guide Wall[1]	-7.0.	40
	4+00 / 100	2+20	5.0	20
	6+00 / 50	3+40	5.5	20
	6+00 / 100	3+25	6.0	20
	6+00 / 140	2+20	6.0	30
Plan J-3 60,000 cfs Pool el 64.0	3+00 / 100	Guide Wall[1]	-14.5	30
	4+00 / 100	No hit[3]	0.0	50
	6+00 / 50	4+00	2.0	30
	6+00 / 100	2+90	1.5	40
	6+00 / 140	No hit[3]	0.0	60

[1] Head of tow hit guide wall prior to hitting guard wall.
[2] Head of tow hit left bank prior to hitting guard wall.
[3] Tow entered lock without striking guard wall.

Table 12
Water-Surface Elevations, Plan J-3

Gage No.	Water-Surface Elevations, ft NGVD, cu ft/sec			
	31,000	36,000	60,000	85,000
1	64.1	64.1	64.2	64.4
2	64.1	64.1	64.1	64.3
3	64.0[1]	64.0[1]	64.0[1]	64.0[1]
4	64.0	63.9	63.8	63.6
Axis of Dam				
5	51.0	51.8	57.6	63.0
6	49.4	50.1	56.1	61.5
7	49.0[1]	49.6[1]	55.5[1]	60.6[1]
Head/Dam (G4 – G5)	13.0	12.1	6.2	0.6
Slope 1-3 (ft/mi)	0.1	0.1	0.2	0.4
Drop G3-G6	N/A	N/A	N/A	N/A
Slope 6-7 (ft/mi)	0.5	0.6	0.6	1.1

[1] Controlled elevation.

Table 13
Water-Surface Elevations, Plan J-3, Drawdown Pool

Gage No.	Water-Surface Elevations, ft NGVD, cu ft/sec		
	31,000	36,000	60,000
1	58.1	58.2	58.6
2	58.0	58.1	58.4
3	58.0[1]	58.0[1]	58.0[1]
4	57.9	57.9	57.9
Axis of Dam			
5	51.0	52.0	57.7
6	49.4	50.1	56.2
7	49.0[1]	49.6[1]	55.5[1]
Head/Dam (G4 – G5)	6.9	5.9	0.2
Slope 1-3 (ft/mi)	0.1	0.2	0.3
Drop G3-G6	N/A	N/A	2.1
Slope 6-7 (ft/mi)	0.5	0.6	0.9

[1] Controlled elevation.
[2] All dam gates open.

Table 14
Plan J-3, Percent of Total Flow Landward of Guard Wall

Discharge cu ft/sec	Pool El	Distance Upstream of Dam, ft			
		Sta 4+25	Sta 6+75	Sta 9+25	Sta 14+25
36,000	58.0	13.7	17.1	17.6	17.2
36,000	64.0	10.3	17.2	21.7	20.6
60,000	58.0	13.9	19.1	21.1	18.7
60,000	64.0	13.6	18.9	25.8	23.8
85,000	64.0	13.3	20.2	25.5	22.3

Table 15
Flow Distribution

Plan	Discharge cu ft/sec	Pool Elev	Percentage of Flow Left of Guard Wall, ft			
			Sta 4+25	Sta 6+75	Sta 9+25	Sta 14+25
Prototype	36,000		11.6[1]	15.6[2]	21.0[3]	25.5[4]
Prototype	83,690		16.9	24.2	28.0	29.1
Prototype	124,555		12.0	17.7	38.4	35.0
J-2 Mod	31,000	64.0	15.7	18.6	24.6	22.0
J-2 Mod	31,000	58.0	12.9	15.6	17.9	17.5
J-2 Mod	36,000	64.0	13.2	21.3	20.8	21.0
J-2 Mod	36,000	58.0	15.7	17.4	21.1	17.9
J-2 Mod	60,000	64.0	12.2	16.4	19.8	22.1
J-2 Mod	60,000	58.0	13.2	16.0	19.8	17.7
J-2 Mod	85,000	64.0	11.0	16.2	20.4	22.4
J-3	36,000	64.0	10.3	17.2	21.7	20.8
J-3	36,000	58.0	13.7	17.1	17.6	17.2
J-3	60,000	64.0	13.6	18.9	25.8	23.8
J-3	60,000	58.0	13.9	19.1	21.1	18.7
J-3	85,000	64.0	13.3	20.2	25.5	22.3
J-4	60,000	64.0	16.8	24.4	27.7	29.8
J-4	60,000	58.0	20.9	26.7	29.0	29.6
J-4	85,000	64.0	19.5	25.0	28.8	31.1
J-5	60,000	64.0	4.6	14.1	16.5	30.9
J-5	60,000	58.0	13.1	17.8	16.3	29.0
J-5	85,000	64.0	15.8	20.5	20.2	31.1
J-6	60,000	64.0	12.2	14.5	18.4	17.2

[1] Station 3+64.
[2] Station 5+80.
[3] Station 8+00.
[4] Station 11+00.

Table 16
Water-Surface Elevations, Plan K

Gage No.	Water-Surface Elevations, ft NGVD, cu ft/sec				
	31,000	**60,000**	**85,000**	**110,000**	**145,000**
1	64.2	64.5	64.9	66.7	72.2
2	64.1	64.4	64.6	66.3	71.6
3	64.0[1]	64.0[1]	64.0[1]	65.4	70.9
4	64.0	63.8	63.7	64.8	70.3
Axis of Dam					
5	49.1	55.4	59.9	64.4	69.9
6	46.4[1]	52.0	57.0[1]	61.9	67.5
7	45.6	50.5[1]	55.3	59.8	66.2[1]
Head/Dam (G4 – G5)	14.9	8.4	3.8	0.4	0.4
Slope 1-3 (ft/mi)	0.2	0.5	0.9	1.3	1.3
Drop G3-G6	N/A	N/A	N/A	3.5	3.4
Slope 6-7 (ft/mi)	1.0	1.9	2.1	2.6	1.6

[1] Controlled elevation.

Table 17
Static Tow Releases in the Upper Approach, Plan K

Discharge cu ft/sec	Release Sta / Dist	Impact Station	Angle of Impact	Velocity of Impact
60,000	3+00 / 50	2+36	1.1	0.9
		2+35	3.6	0.9
		2+51	1.6	0.6
	4+00 / 50	3+66	1.5	0.9
		3+17	0.3	1.2
		3+58	2.3	1.0
	4+00 / 100	3+33	-3.8[1]	1.2
		2+60	0.2	1.2
		2+77	0.4	1.2
	6+00 / 100	4+32	2.3	1.2
		4+18	1.5	1.3
85,000	3+00 / 50	2+71	1.7	1.2
		2+46	0.6	1.3
		2+50	1.6	1.1
	4+00 / 50	3+45	2.2	1.7
		3+54	1.7	1.4
		3+22	1.2	1.8
	4+00 / 100	2+32	0.3	1.3
		2+15	0.3	1.6
		2+57	0.8	2.0
	6+00 / 100			
145,000	3+00 / 50	2+13	-2.8[1]	1.8
		1+59	0.2	1.2
		2+21	-2.8[1]	1.9
	4+00 / 50	3+31	1.3	2.1
		3+26	1.7	1.7
		3+15	1.3	2.1
	4+00 / 100	2+65	-4.3[1]	2.3
		2+44	-4.3[1]	2.6
		2+44	-4.3[1]	2.7
	6+00 / 100	3+76	-3.2[1]	3.4
		3+84	-0.5[1]	3.1

[1] Negative angle shows stern or side of tow strikes guard wall before head of tow.

Table 18
Water-Surface Elevations, Plan K-1

	Water-Surface Elevations, ft NGVD, cu ft/sec				
Gage No.	**31,000**	**60,000**	**85,000**	**110,000**	**145,000**
1	64.1	64.5	66.7	66.6	72.1
2	64.1	64.4	65.3	66.2	71.6
3	64.0[1]	64.0[1]	64.0[1]	65.3	71.0
4	64.0	63.9	63.8	64.6	70.3
Axis of Dam					
5	49.0	55.4	59.9	64.3	69.9
6	46.4	52.1	57.0	61.8	67.5
7	45.6[1]	50.5[1]	55.3[1]	59.8[1]	66.2[1]
Head/Dam (G4 – G5)	15.0	8.5	3.9	0.3	0.4
Slope 1-3 (ft/mi)	0.1	0.5	2.7	1.2	1.1
Drop G3-G6	N/A	N/A	N/A	3.5	3.5
Slope 6-7 (ft/mi)	1.0	2.0	2.1	2.5	1.6

[1] Controlled elevation.

Table 19
Static Tow Releases in the Upper Approach, Plan K-1

Discharge cu ft/sec	Release Sta / Dist	Impact Station	Angle of Impact	Velocity of Impact
60,000	3+00 / 50	0+0	-1.4[1]	0.4
		0+0	1.3	0.9
	4+00 / 50	3+80	3.9	0.7
		3+60	1.7	0.9
		3+08	0.3	1.0
	4+00 / 100	2+20	0.7	1.2
		2+93	2.1	0.8
	6+00 / 100	4+23	-5.1[1]	1.0
		3+73	1.8	1.1
		3+99	3.7	1.4
85,000	3+00 / 50	2+69	2.1	0.9
		2+49	3.1	1.0
		2+68	2.2	1.2
	4+00 / 50	3+96	4.7	0.9
		3+50	2.7	1.4
		3+76	3.9	1.2
	4+00 / 100	2+80	2.3	1.5
		2+55	0.7	1.6
		3+03	4.6	1.5
	6+00 / 100	3+12	-1.9[1]	2.1
		3+50	2.2	2.0
		4+18	5.1	1.8
145,000	3+00 / 50	2+18	-1.8[1]	1.7
		2+30	0.5	1.5
		2+64	2.4	1.3
	4+00 / 50	3+13	1.3	1.8
		2+88	0.2	2.1
		3+48	3.4	1.8
	4+00 / 100	2+90	-4.3[1]	2.6
		2+95	-2.9[1]	2.4
		3+00	-2.7[1]	2.2
	6+00 / 100	4+07	0.8	3.1
		3+89	0.4	2.5

[1] Negative angle shows stern or side of tow strikes guard wall before head of tow.

Table 20
Water-Surface Elevations, Plan K-2

Gage No.	Water-Surface Elevations, ft NGVD, cu ft/sec				
	31,000	**60,000**	**85,000**	**110,000**	**145,000**
1	64.1	64.5	65.0	66.6	72.2
2	64.1	64.3	64.8	66.1	71.7
3	64.0[1]	64.0[1]	64.0[1]	65.0	70.9
4	64.0	63.9	63.8	64.4	70.4
Axis of Dam					
5	49.0	55.3	59.9	64.0	70.0
6	46.4	52.1	57.1	61.8	67.5
7	45.6[1]	50.5[1]	55.3[1]	59.8[1]	66.2[1]
Head/Dam (G4 – G5)	15.0	8.6	3.9	0.4	0.4
Slope 1-3 (ft/mi)	0.1	0.5	1.0	1.6	1.3
Drop G3-G6	N/A	N/A	N/A	3.2	3.4
Slope 6-7 (ft/mi)	1.0	2.0	2.2	2.5	1.3

[1] Controlled elevation.

Table 21
Static Tow Releases in the Upper Approach, Plan K-2

Discharge cu ft/sec	Release Sta / Dist	Impact Station	Angle of Impact	Velocity of Impact
60,000	3+00 / 50	2+48	1.5	0.8
		2+37	0.1	0.9
		2+70	0.1	0.8
	4+00 / 50	3+93	2.8	0.7
		3+65	2.3	0.9
		3+80	1.9	0.9
	4+00 / 100	3+00	4.8	1.1
		3+37	0.4	1.2
		2+85	4.9	1.1
	6+00 / 100	3+80	4.0	1.3
		3+74	1.8	1.5
		5+50	8.0	1.2
85,000	3+00 / 50	2+85	0.4	1.0
		2+77	1.1	1.0
		2+85	0.8	1.1
	4+00 / 50	3+45	0.8	1.6
		3+75	1.4	1.4
		3+75	0.2	1.4
	4+00 / 100	3+25	5.0	1.6
		3+15	5.5	1.3
		3+10	7.0	1.2
	6+00 / 100	4+70	4.3	1.9
		4+63	4.5	1.8
		4+25	5.5	1.9
145,000	3+00 / 50	2+08	0.2	0.6
		2+08	-0.1[1]	0.9
		2+66	-2.9[1]	1.5
	4+00 / 50	3+46	-0.1[1]	1.9
		3+58	-0.2[1]	1.8
		3+87	-0.3[1]	1.7
	4+00 / 100	2+28	0.0	1.0
		2+83	-2.1[1]	1.7
		2+30	-0.1[1]	1.1
	6+00 / 100	4+11	-4.5[1]	2.7
		2+41	-0.1[1]	1.3
		4+87	4.4	2.6

[1] Negative angle shows stern or side of tow strikes guard wall before head of tow.

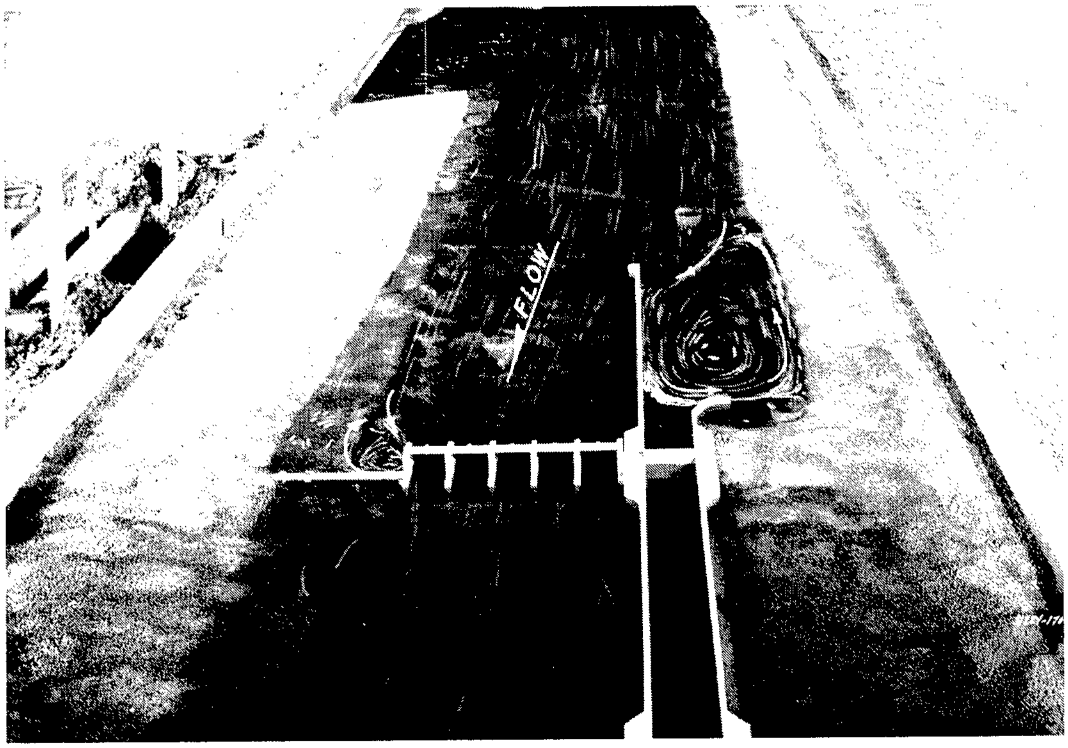


Photo 1. Plan F, looking upstream, discharge 2,406 cu m/sec (85,000 cu ft/sec), confetti showing surface current pattern, note eddy in lock approach

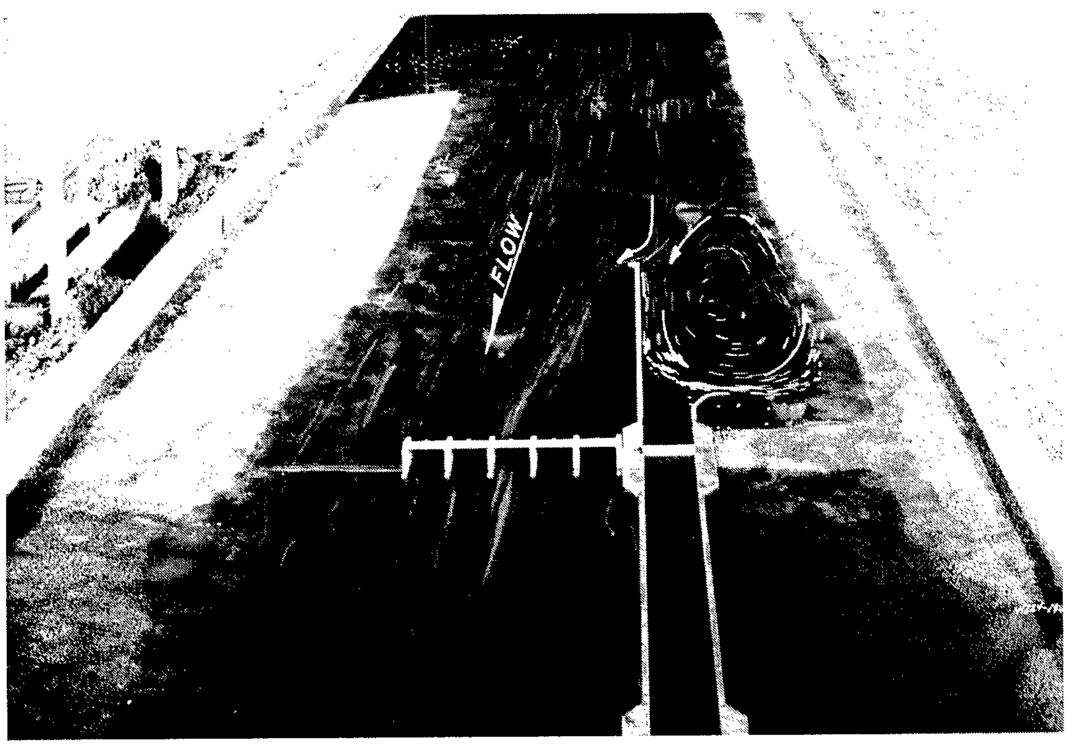


Photo 2. Plan F, looking upstream, discharge 4,104 cu m/sec (145,000 cu ft/sec), confetti showing surface current pattern, note eddy in lock approach

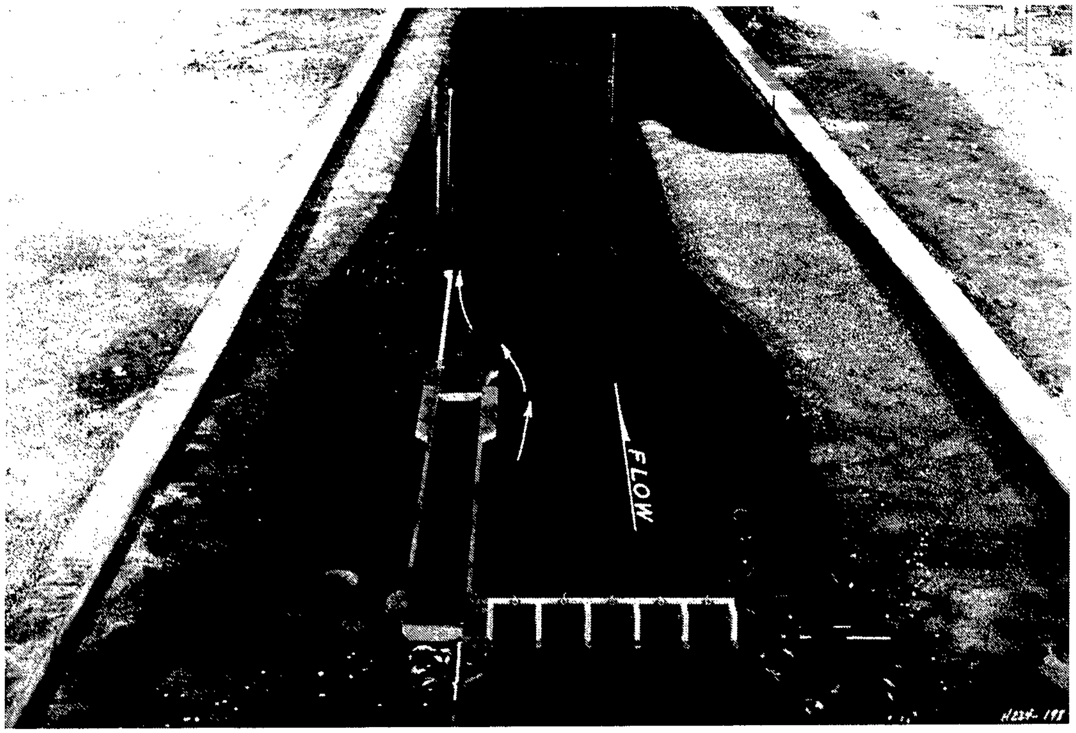


Photo 3. Plan F, looking downstream, discharge 2,406 cu m/sec (85,000cu ft/sec), confetti showing surface current pattern

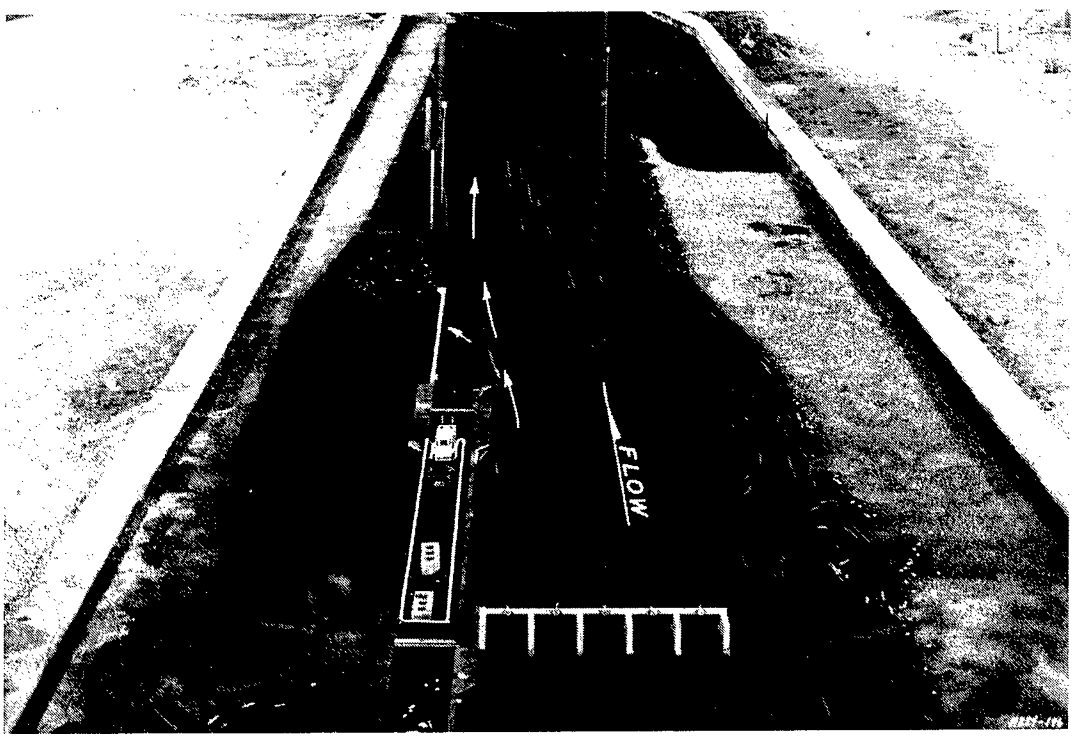


Photo 4. Plan F, looking downstream, discharge 4,104 cu m/sec (145,000 cu ft/sec), confetti showing surface current pattern

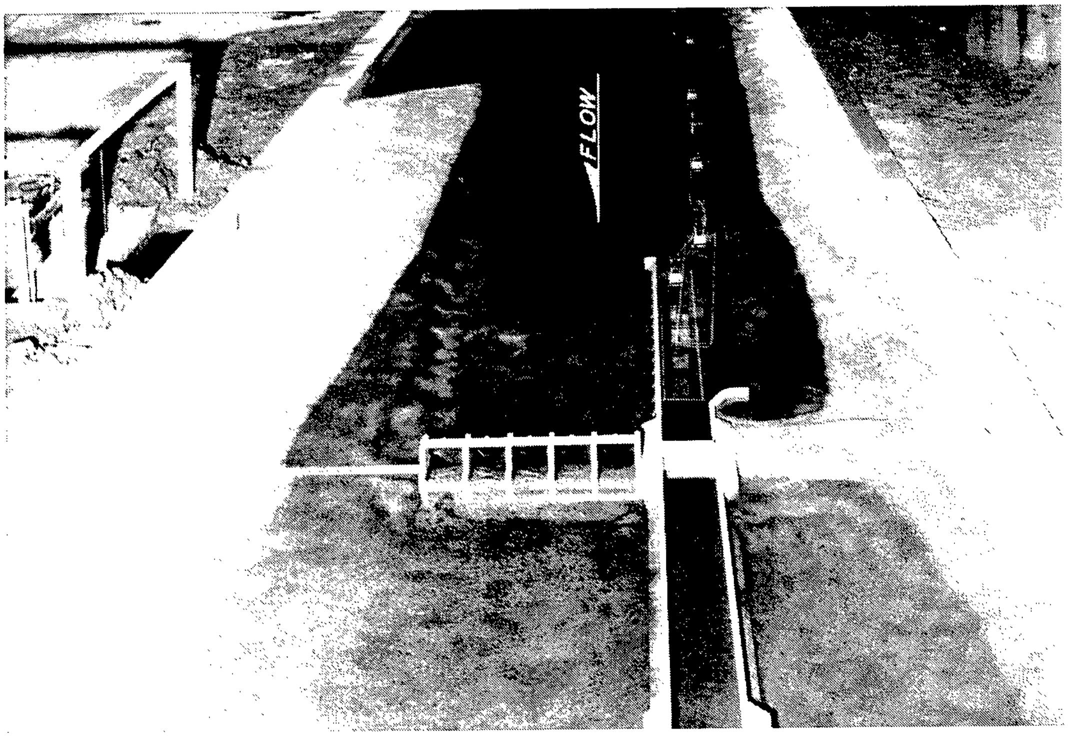


Photo 5. Plan F, looking upstream, discharge 2,406 cu m/sec (85,000 cu ft/sec), showing path of downbound tow

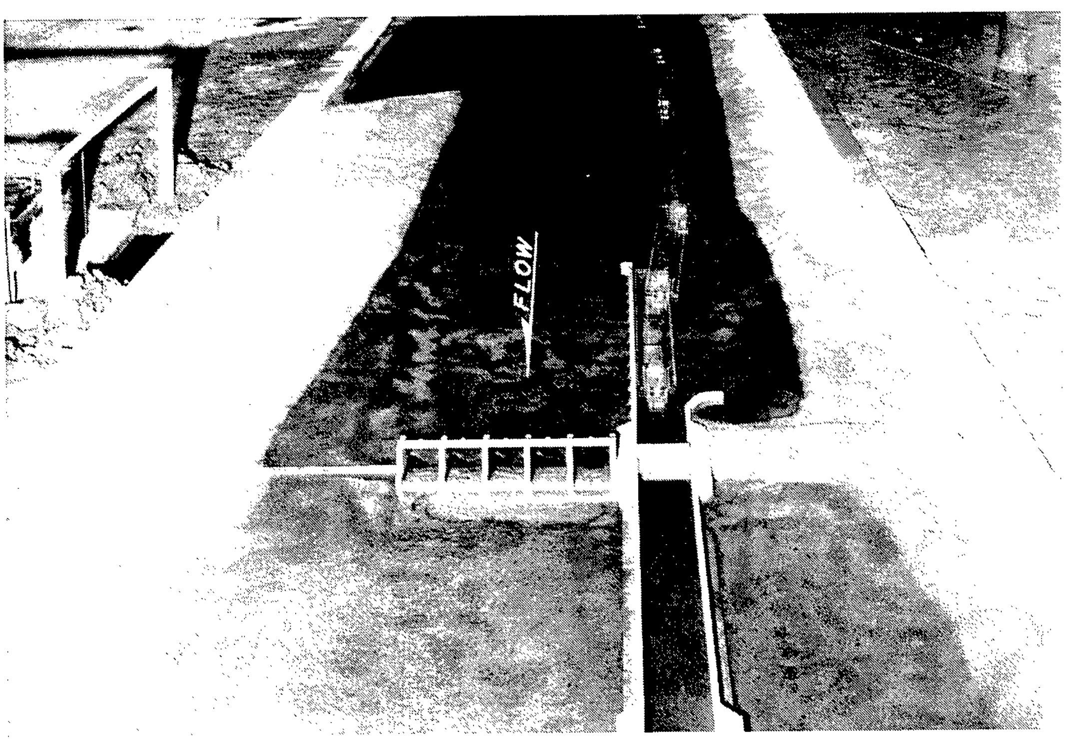


Photo 6. Plan F, looking upstream, discharge 2,406 cu m/sec (85,000 cu ft/sec), showing path of upbound tow

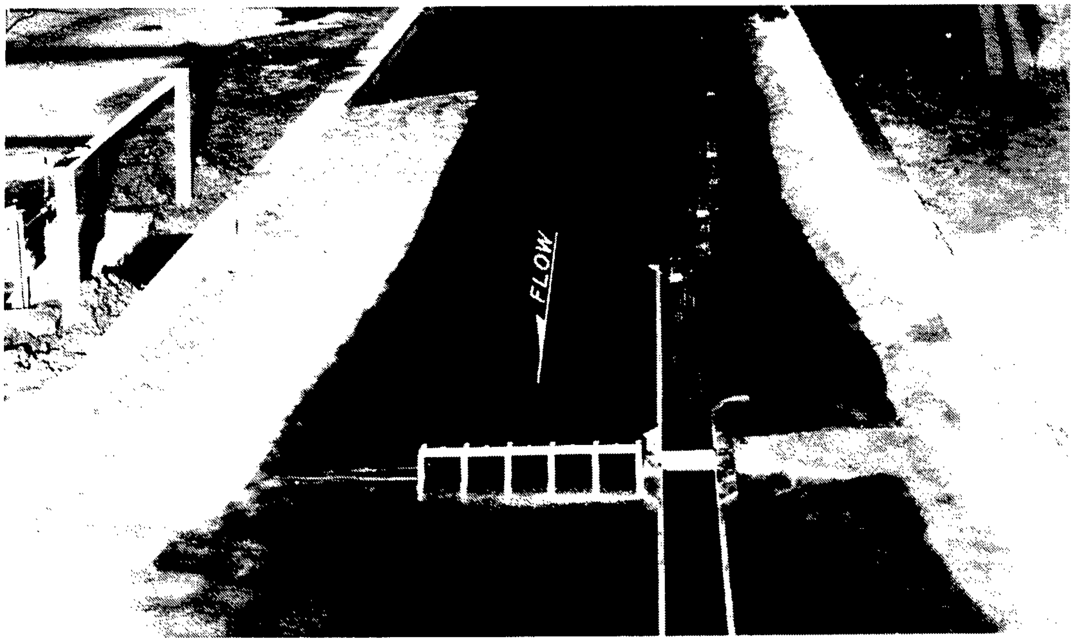


Photo 7. Plan F, looking upstream, discharge 4,104 cu m/sec (145,000 cu ft/sec), showing path of downbound tow

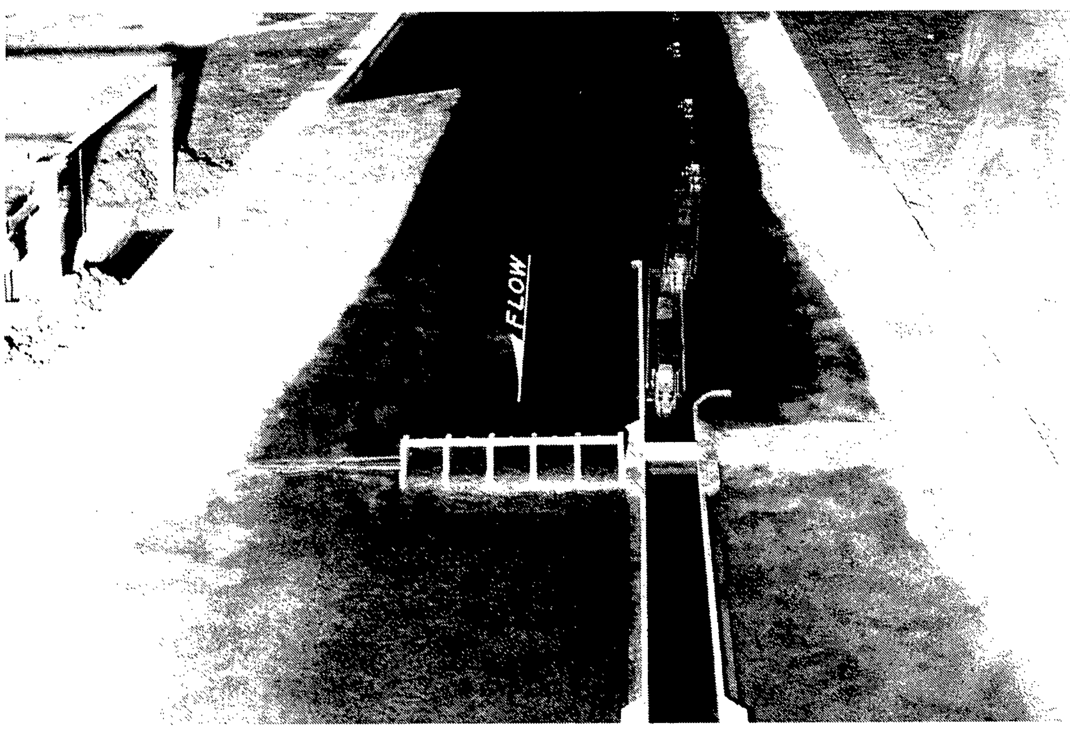


Photo 8. Plan F, looking upstream, discharge 4,104 cu m/sec (145,000 cu ft/sec), showing path of upbound tow

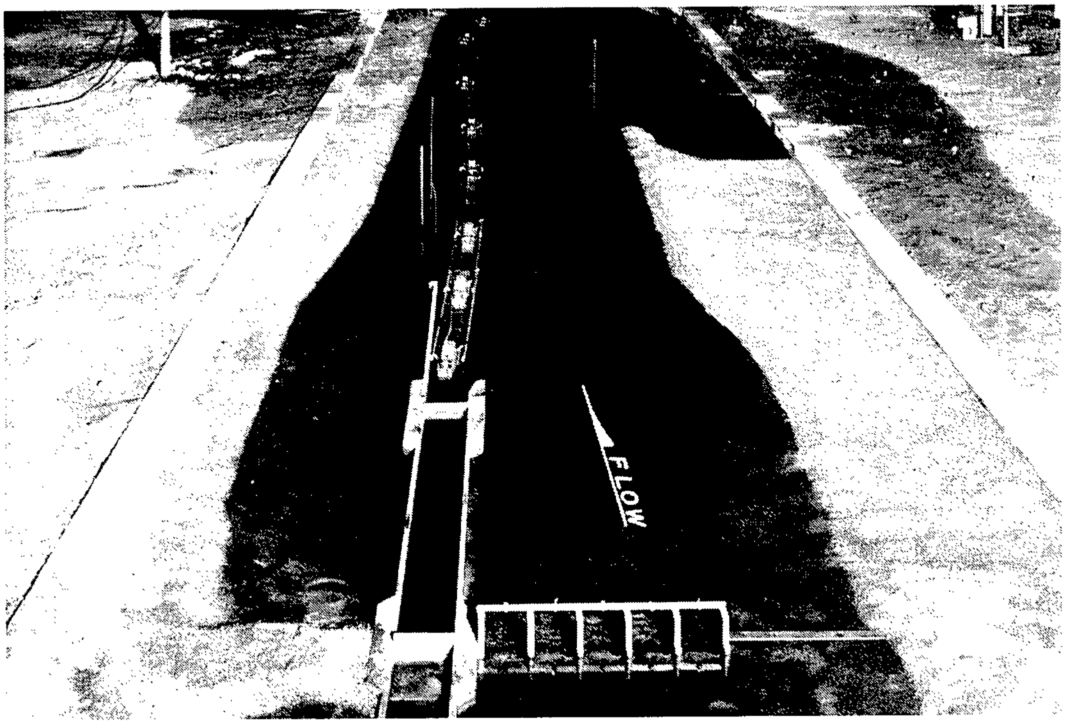


Photo 9. Plan F, looking downstream, discharge 2,406 cu m/sec (85,000 cu ft/sec), showing path of downbound tow

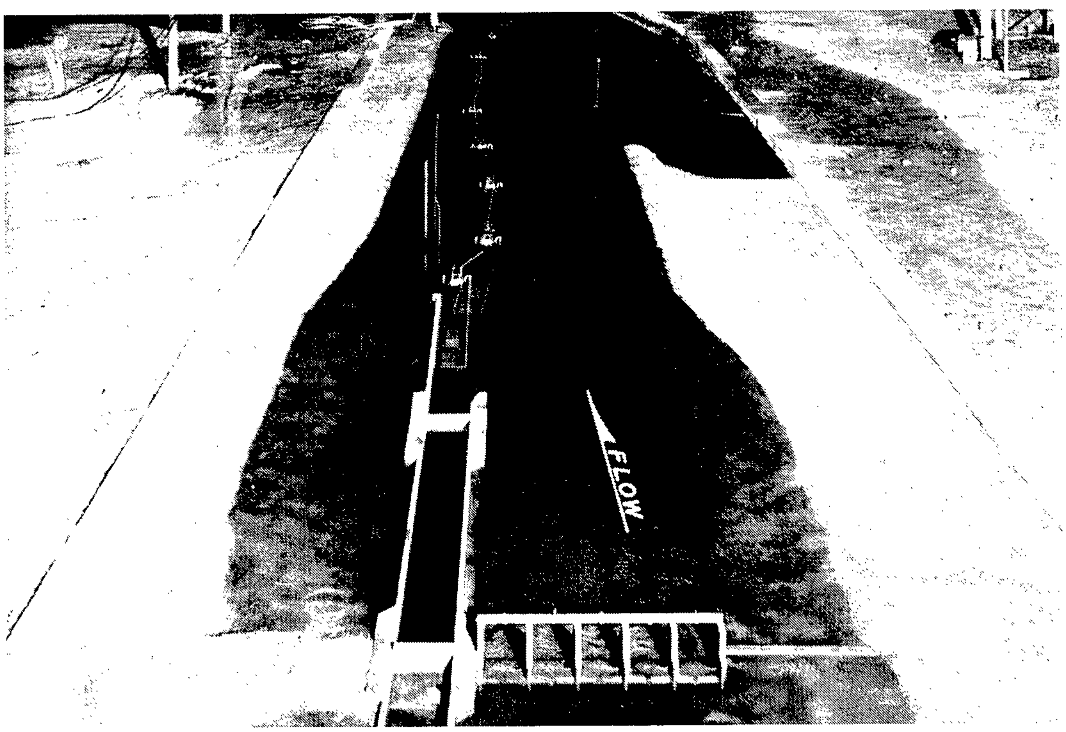


Photo 10. Plan F, looking downstream, discharge 2,406 cu m/sec (85,000 cu ft/sec), showing path of upbound tow

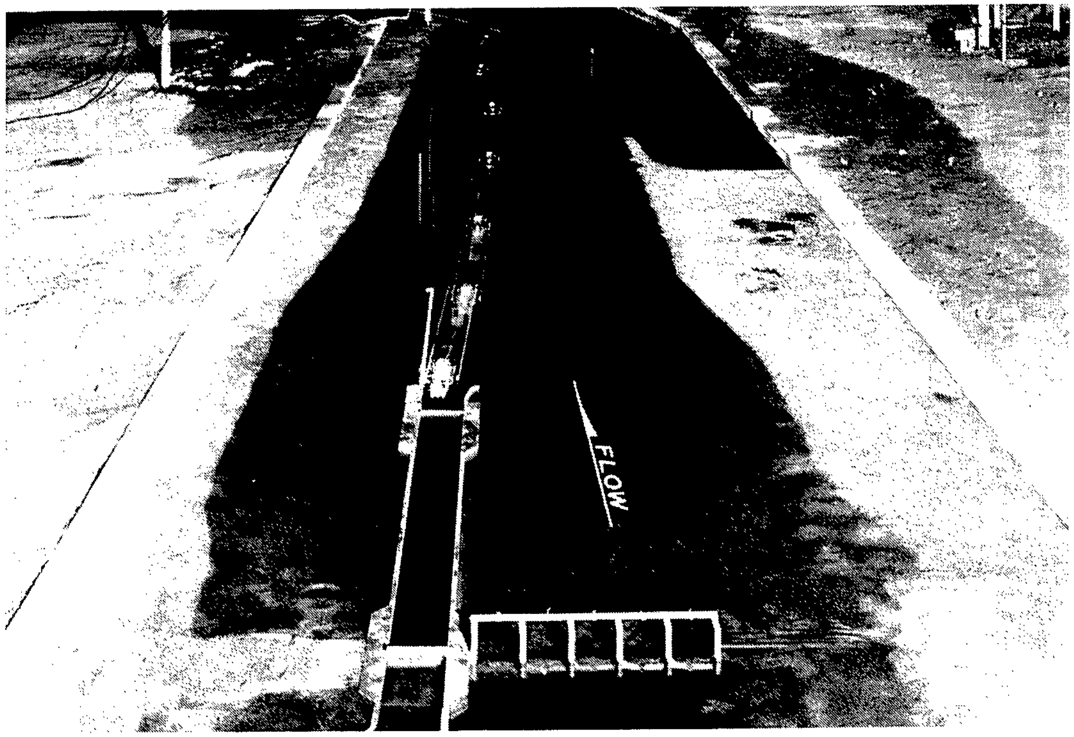


Photo 11. Plan F, looking downstream, discharge 4,104 cu m/sec (145,000 cu ft/sec), showing path of downbound tow

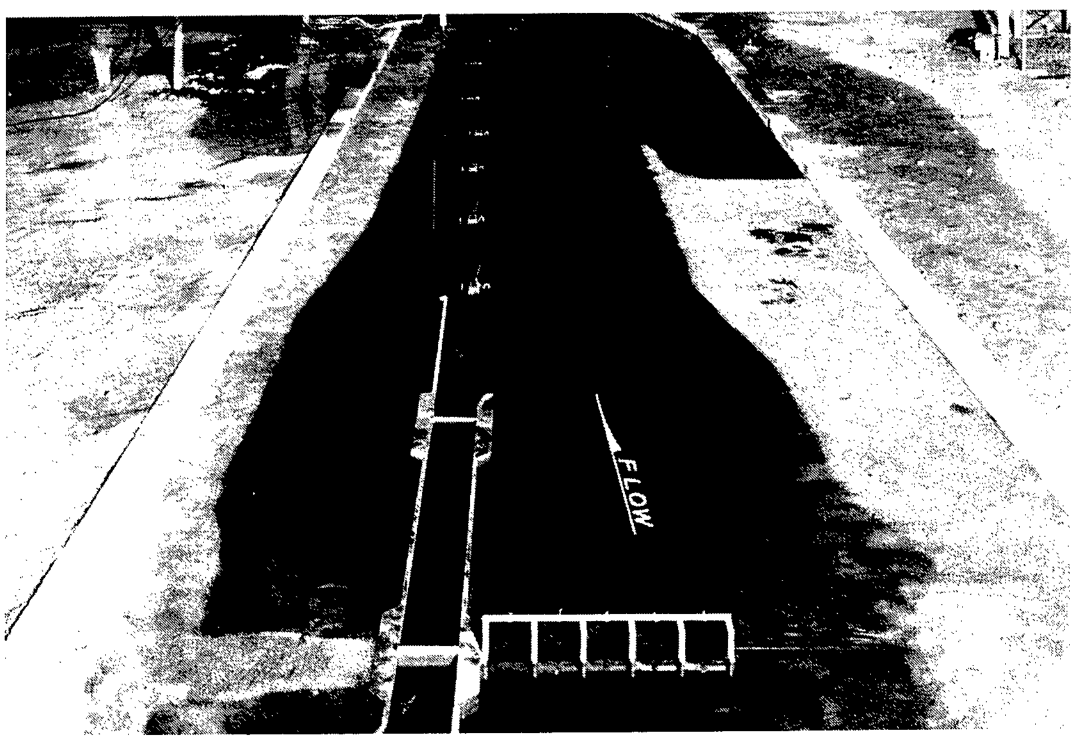


Photo 12. Plan F, looking downstream, discharge 4,104 cu m/sec (145,000 cu ft/sec), showing path of upbound tow

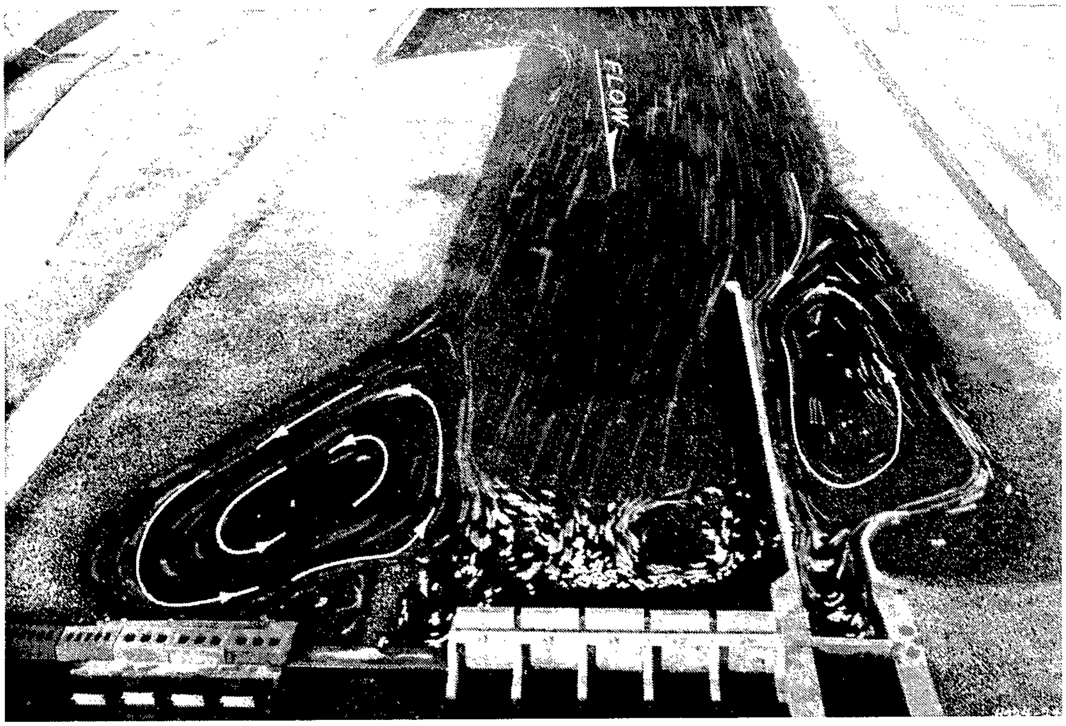


Photo 13. Plan H, looking upstream, discharge 1,982 cu m/sec (70,000 cu ft/sec) (680 cu m/sec (24,000 cu ft/sec) through powerhouse), confetti showing surface current pattern

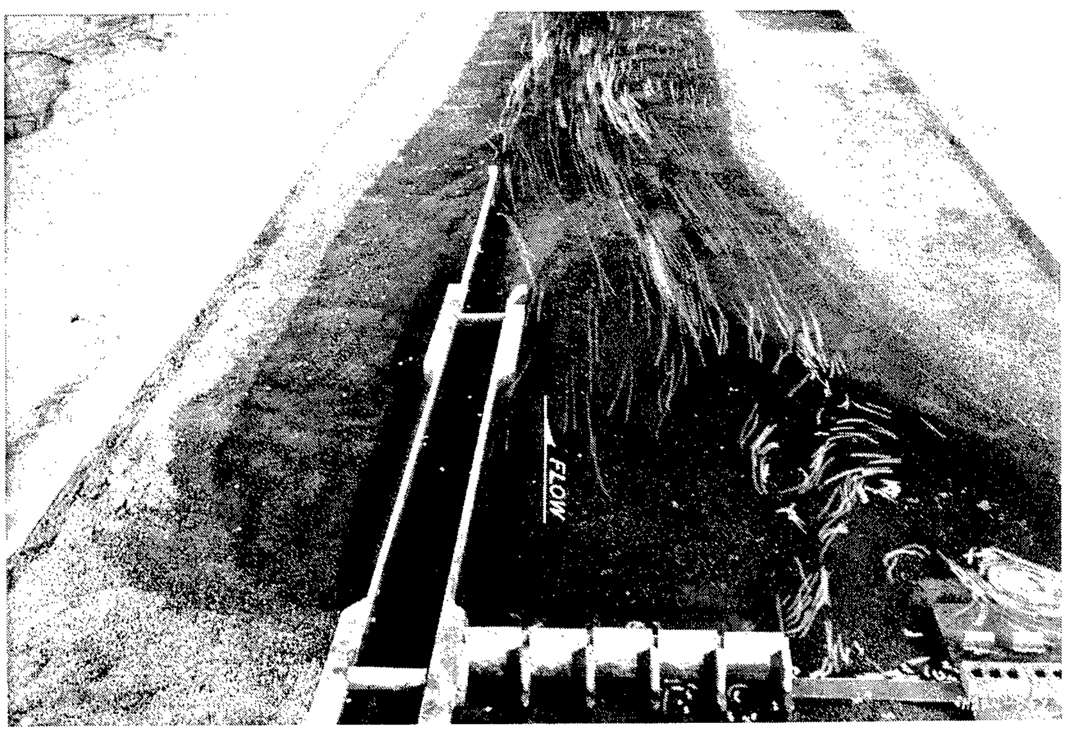


Photo 14. Plan H, looking downstream, discharge 1,982 cu m/sec (70,000 cu ft/sec) (680 cu m/sec (24,000 cu ft/sec) through powerhouse), confetti showing surface current pattern

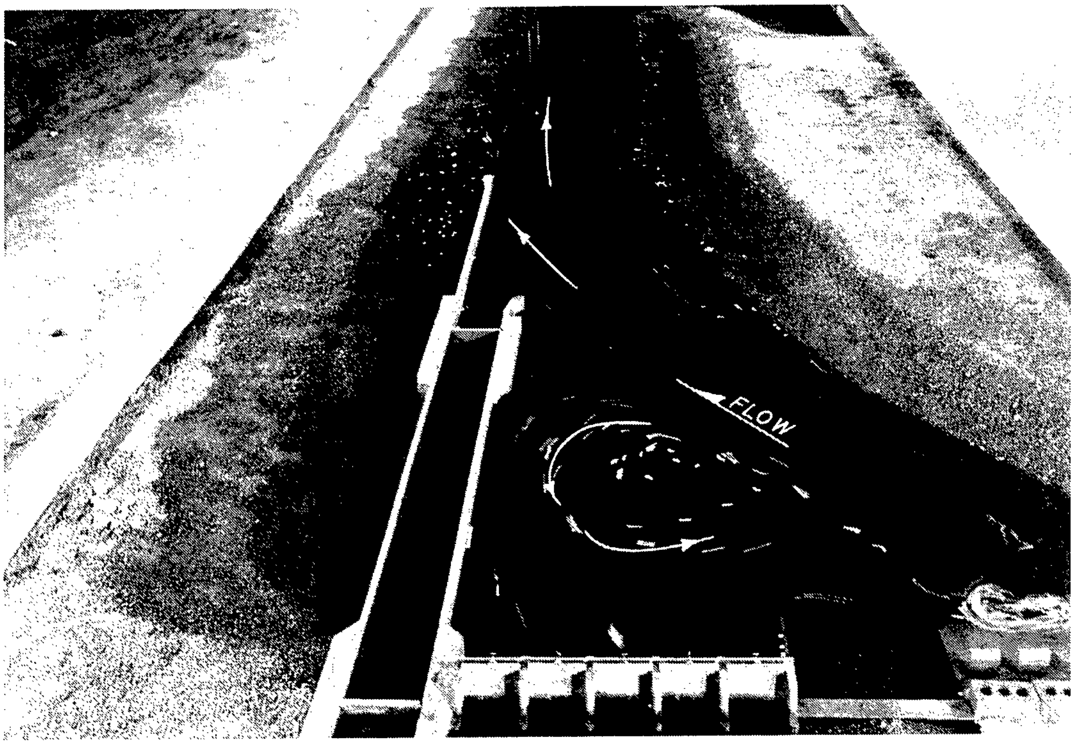


Photo 15. Plan H, looking downstream, discharge 680 cu m/sec (24,000 cu ft/sec) (no flow through gated dam), confetti showing surface current pattern

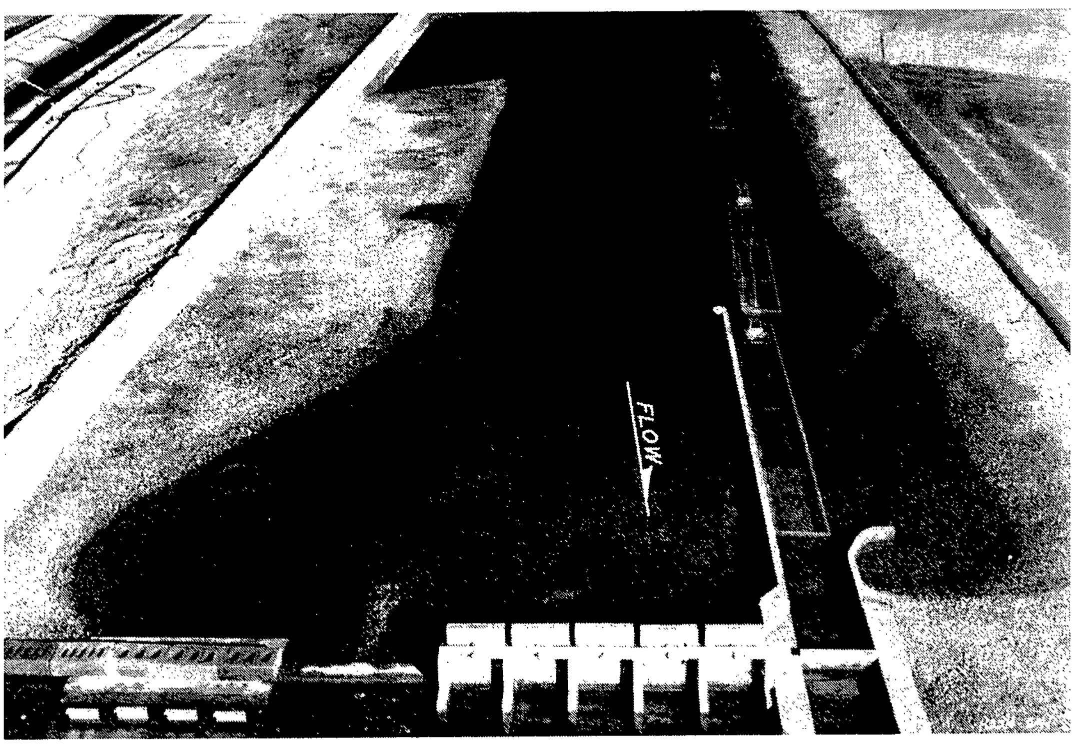


Photo 16. Plan H, looking upstream, discharge 1,982 cu m/sec (70,000 cu ft/sec) (680 cu m/sec (24,000 cu ft/sec) through powerhouse), showing path of downbound tow

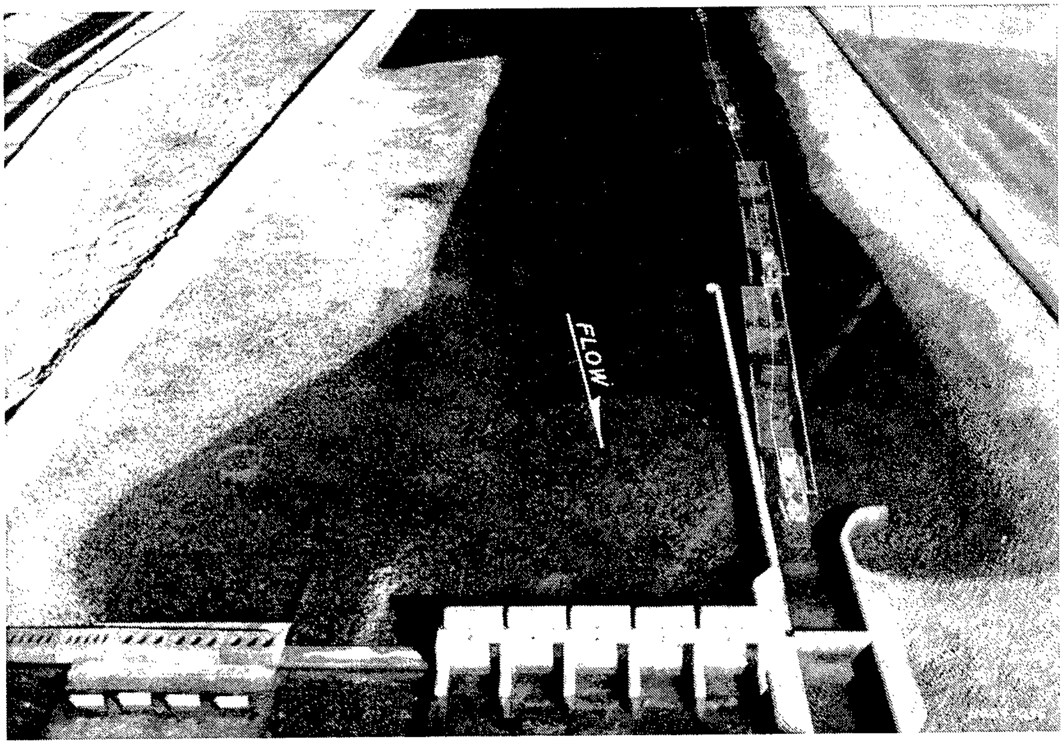


Photo 17. Plan H, looking upstream, discharge 1,982 cu m/sec (70,000 cu ft/sec) (680 cu m/sec (24,000 cu ft/sec) through powerhouse), showing path of upbound tow

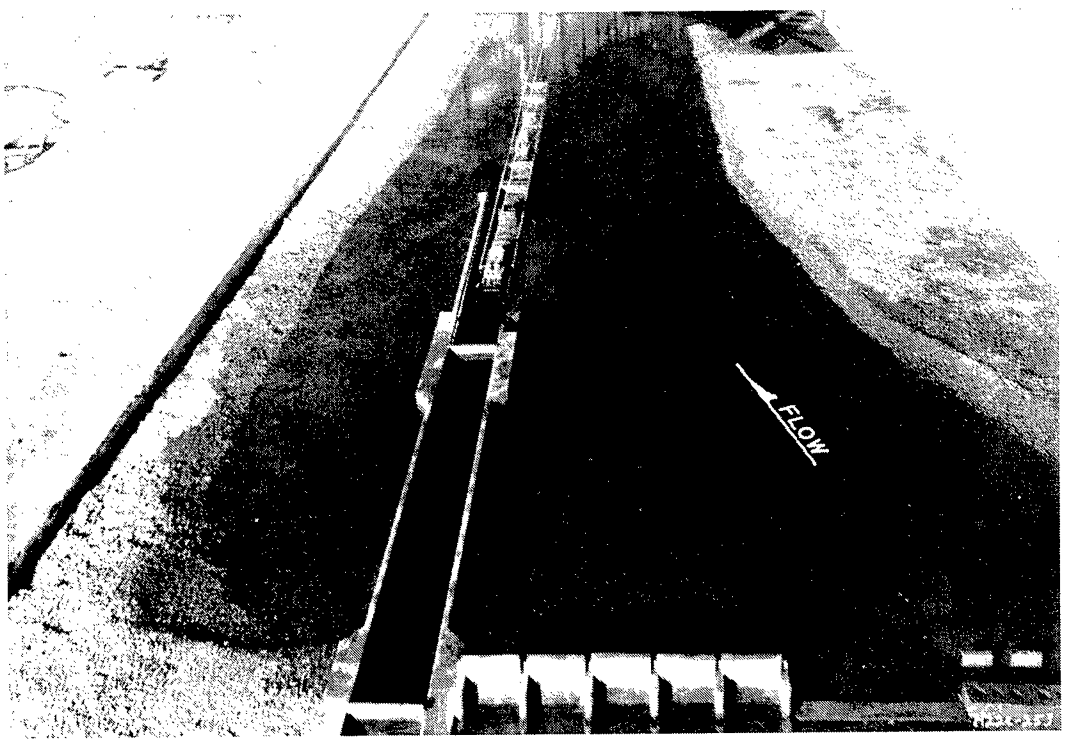


Photo 18. Plan H, looking downstream, discharge 1,982 cu m/sec (70,000 cu ft/sec) (680 cu m/sec (24,000 cu ft/sec) through powerhouse), showing path of downbound tow

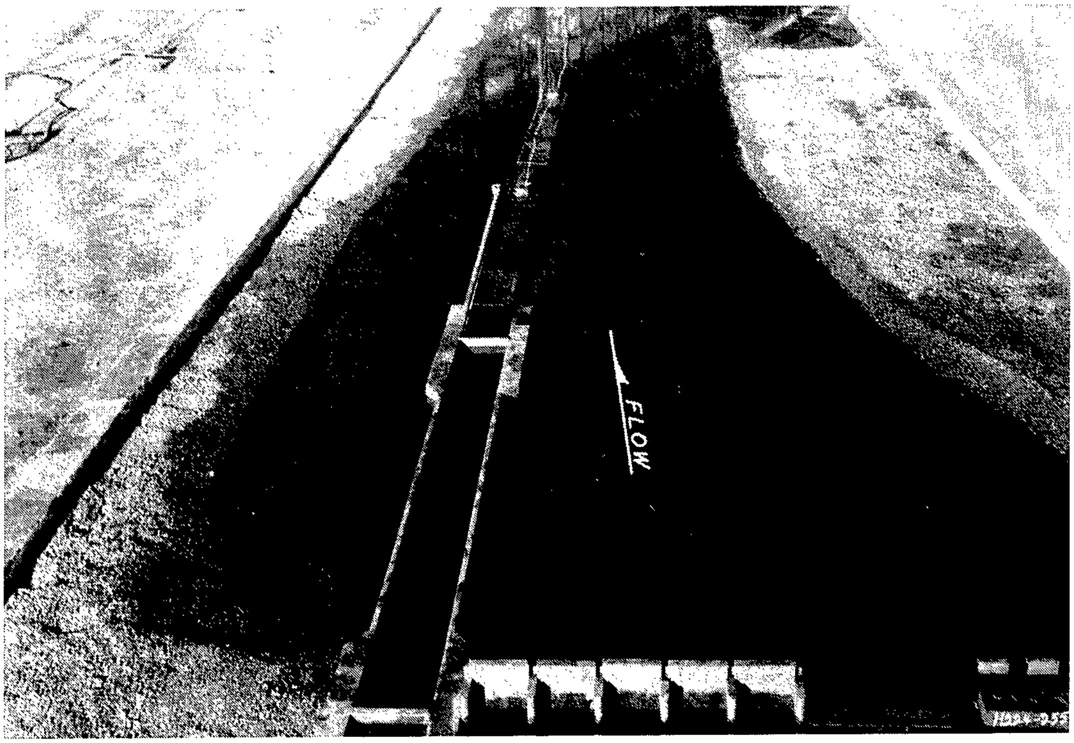


Photo 19. Plan H, looking downstream, discharge 1,982 cu m/sec (70,000 cu ft/sec) (680 cu m/sec (24,000 cu ft/sec) through powerhouse), showing path of upbound tow

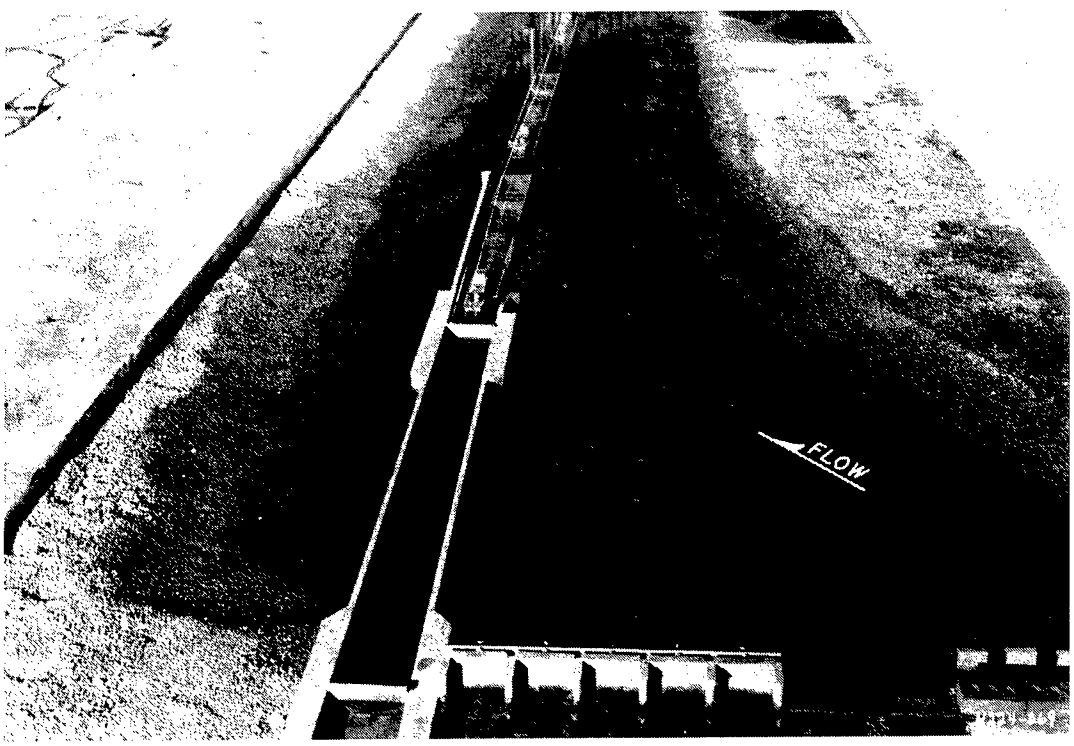


Photo 20. Plan H, looking downstream, discharge 680 cu m/sec (24,000 cu ft/sec) (no flow through powerhouse), showing path of downbound tow

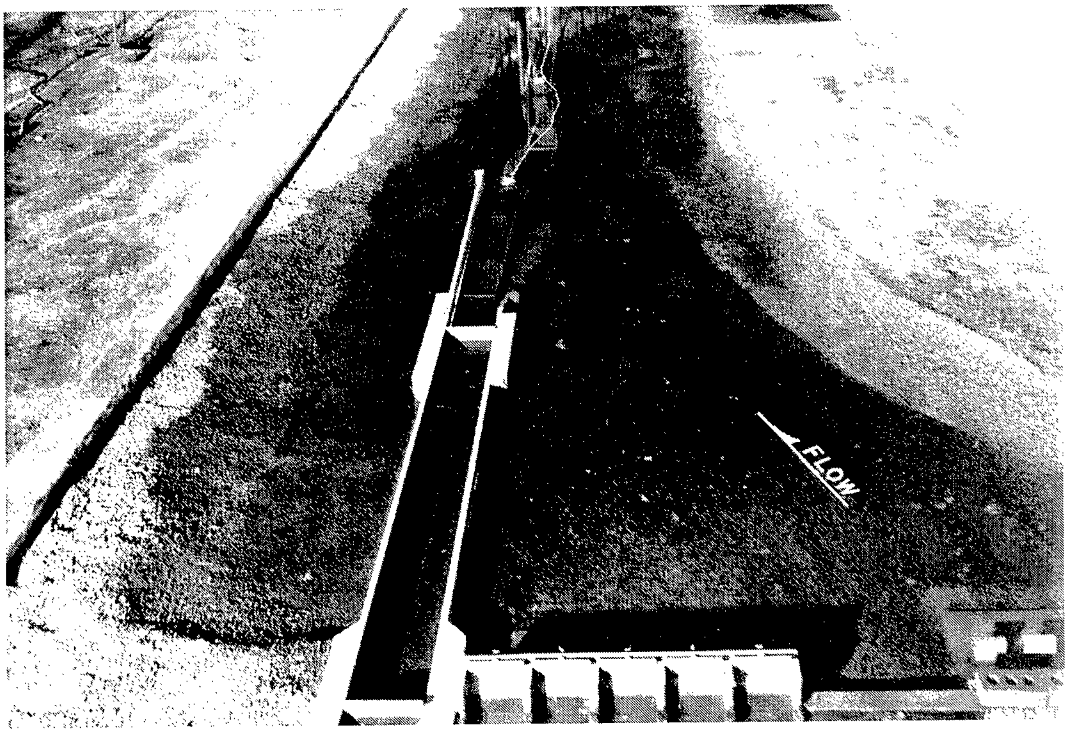
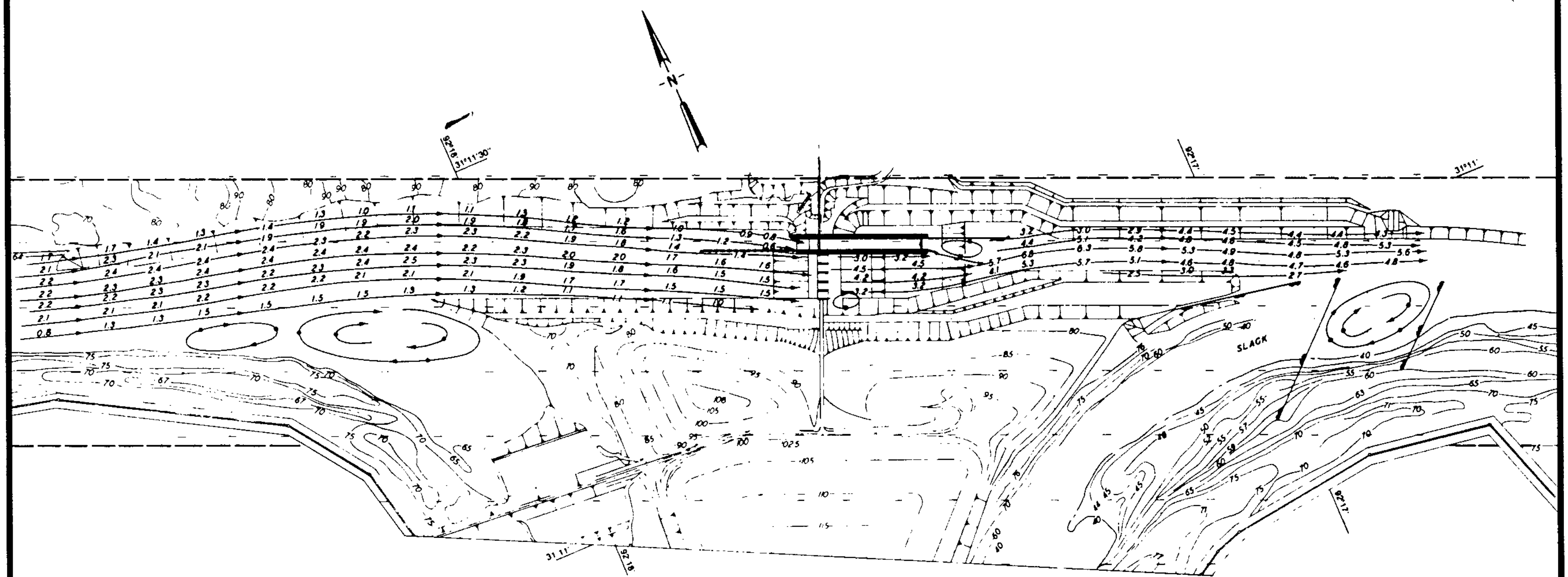


Photo 21. Plan H, looking downstream, discharge 680 cu m/sec (24,000 cu ft/sec) (no flow through powerhouse), showing path of upbound tow



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE–FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

VELOCITIES AND CURRENT DIRECTIONS

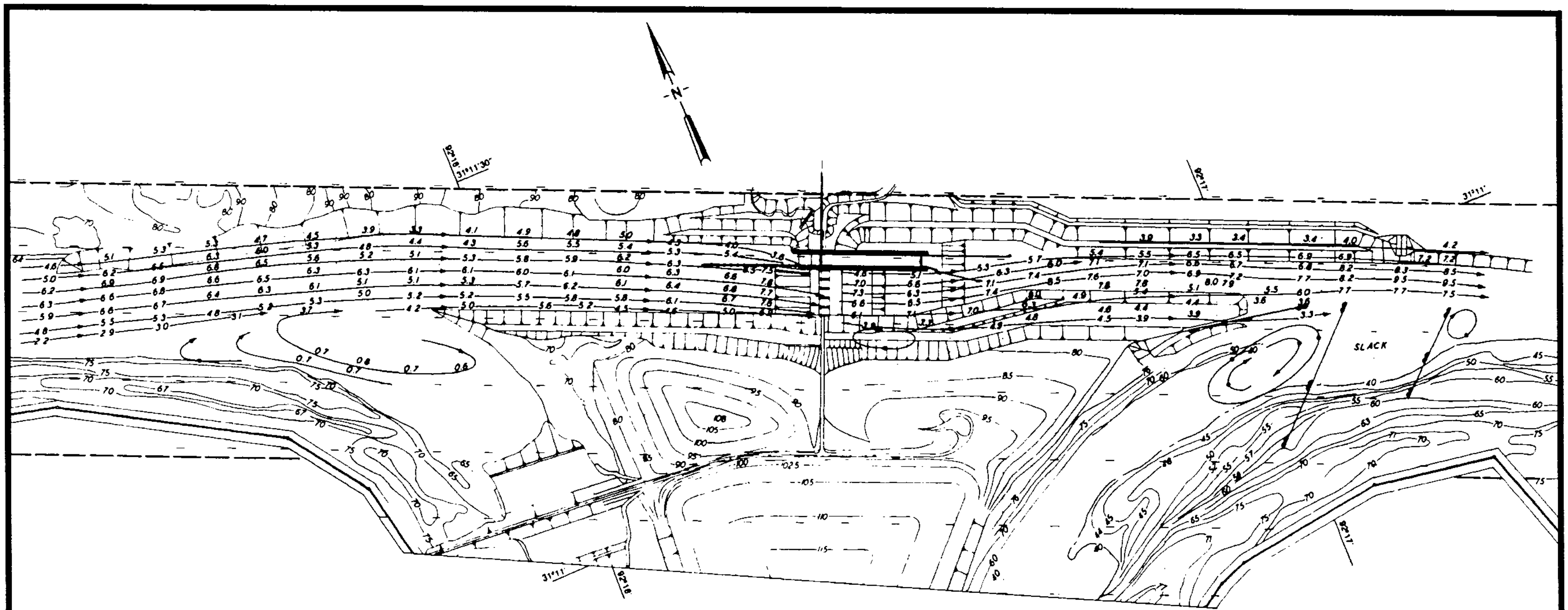
PLAN F

DISCHARGE: 31,000 CFS
TAILWATER EL: 50.6 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

PLATE 1



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE–FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

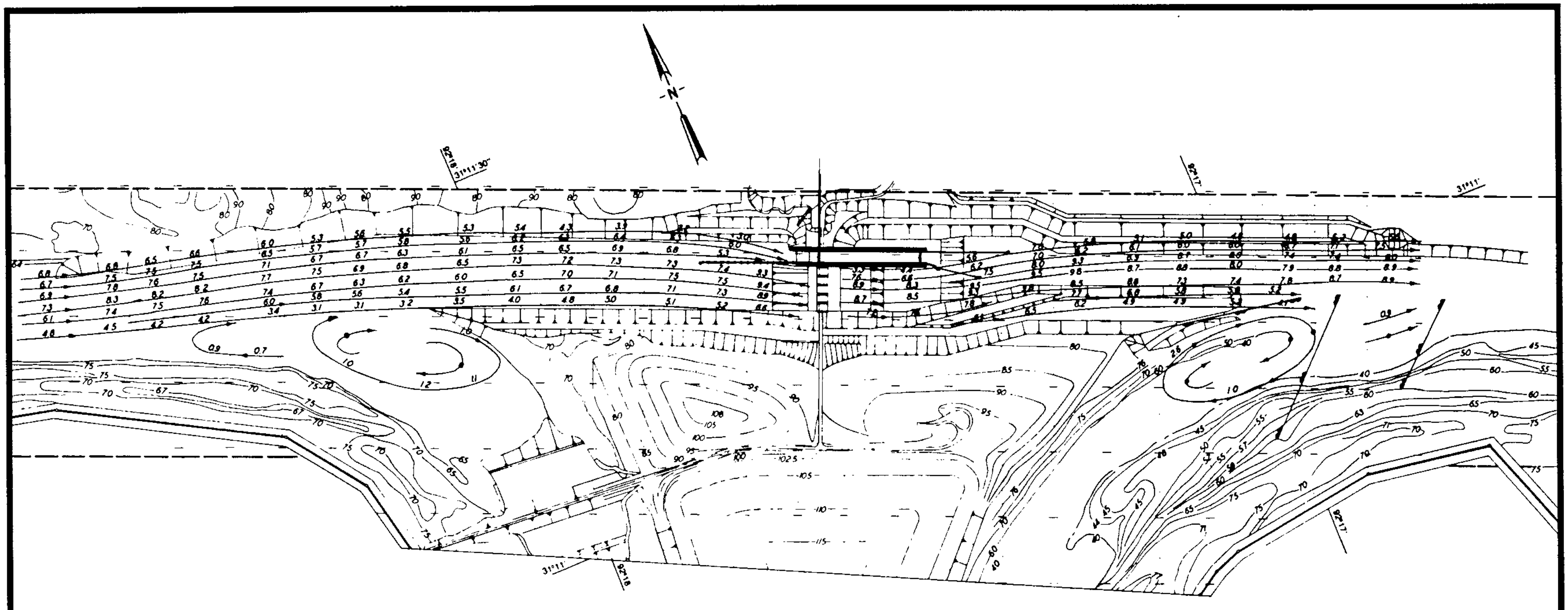
VELOCITIES AND CURRENT DIRECTIONS

PLAN F

DISCHARGE: 85,000 CFS
TAILWATER EL: 62.0 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE—FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

VELOCITIES AND CURRENT DIRECTIONS

PLAN F

DISCHARGE: 110,000 CFS
TAILWATER EL: 66.3 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

PLATE 3

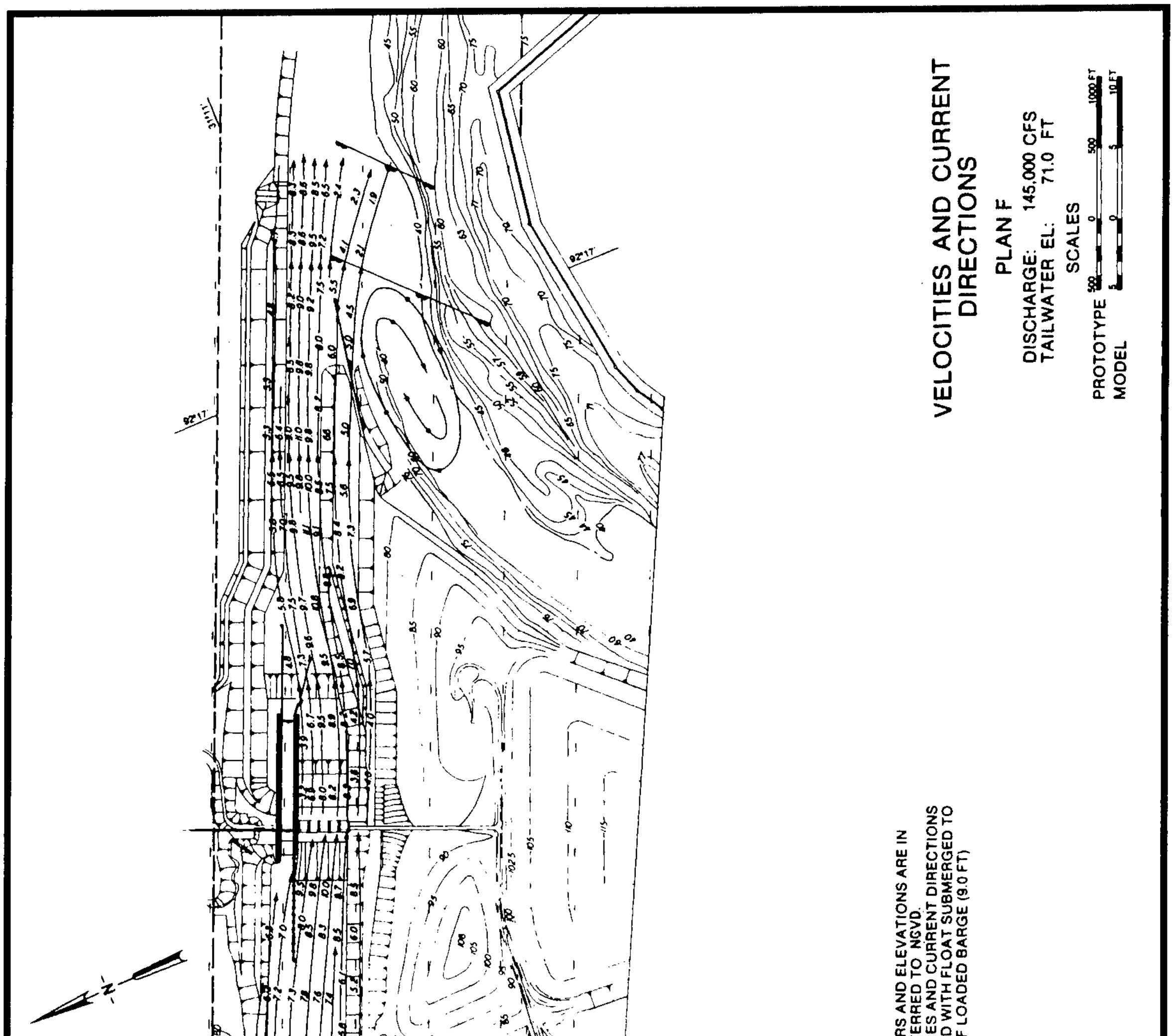
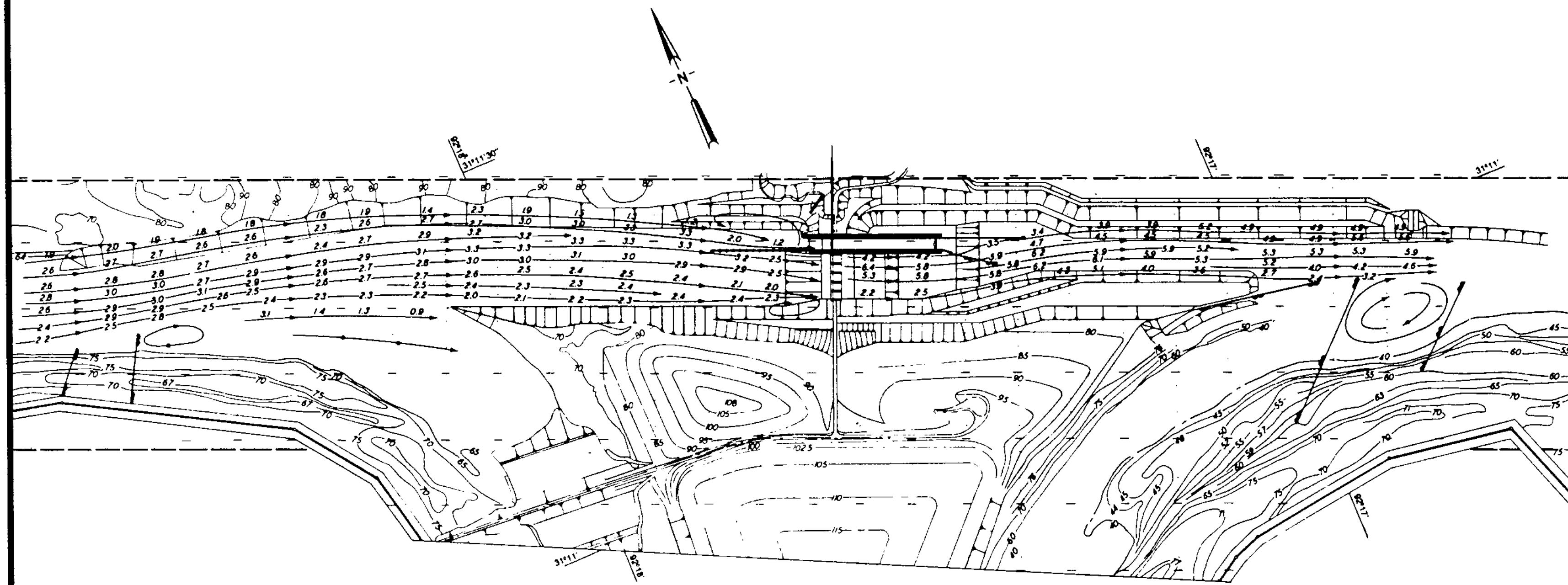

VELOCITIES AND CURRENT DIRECTIONS
PLAN F
DISCHARGE: 145,000 CFS
TAILWATER EL: 71.0 FT
SCALES
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
STONE—FILL DIKE
REVETMENT
EXISTING LEVEE
APPROXIMATE NORMAL POOL
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD.
VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
N
92°18'
92°17'
31°11'
31°11'30"

PLATE 4



LEGEND

VELOCITY IN FEET PER SECOND

VELOCITY LESS THAN 0.5 FEET PER SECOND

STONE—FILL DIKE

REVETMENT

EXISTING LEVEE

APPROXIMATE NORMAL POOL

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

VELOCITIES AND CURRENT DIRECTIONS

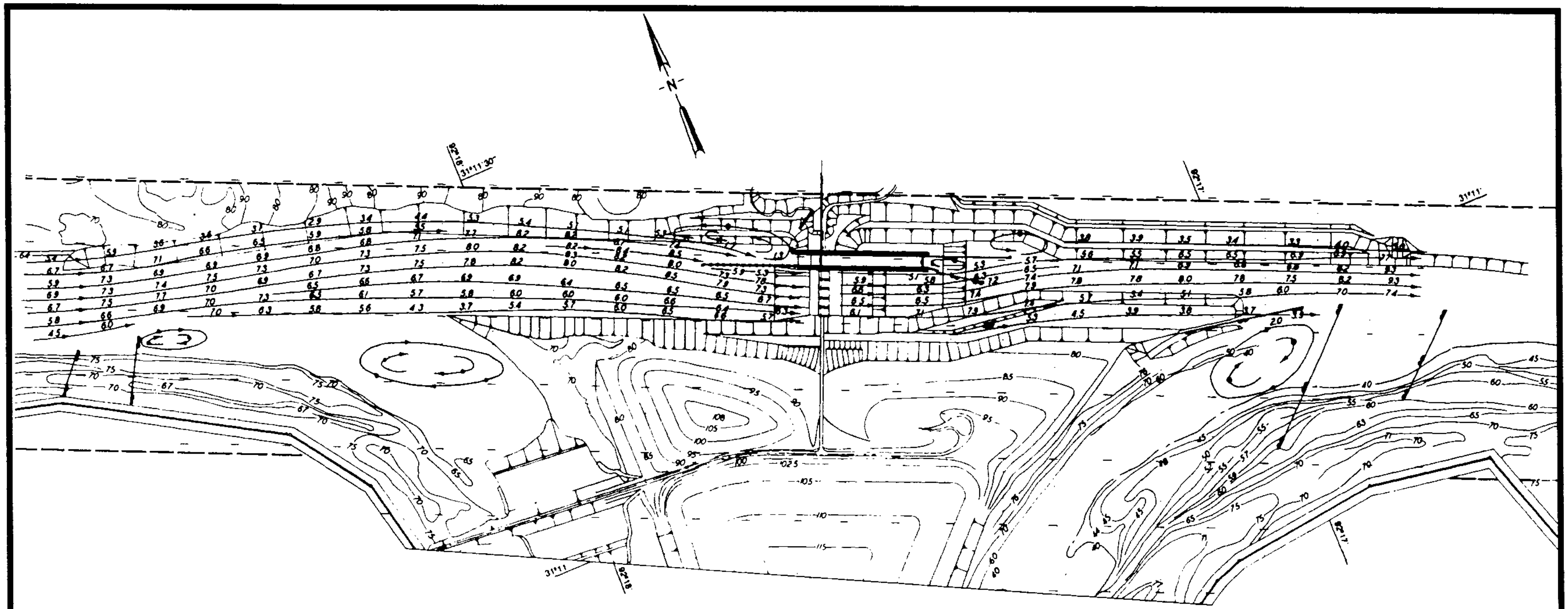
PLAN G

DISCHARGE: 31,000 CFS
TAILWATER EL: 50.6 FT

SCALES

PROTOTYPE 500 0 500 1000 FT

MODEL 5 0 5 10 FT



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE—FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

VELOCITIES AND CURRENT DIRECTIONS

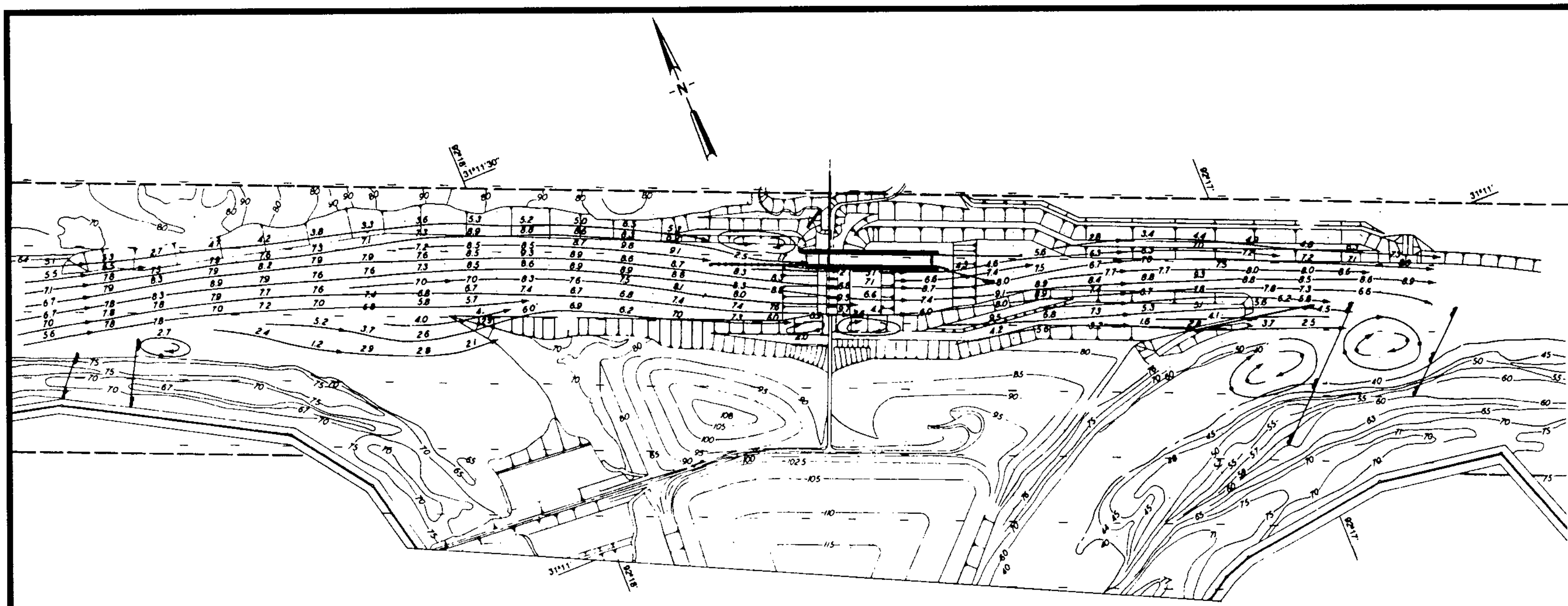
PLAN G

DISCHARGE: 85,000 CFS
TAILWATER EL: 62.0 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

PLATE 6



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE—FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

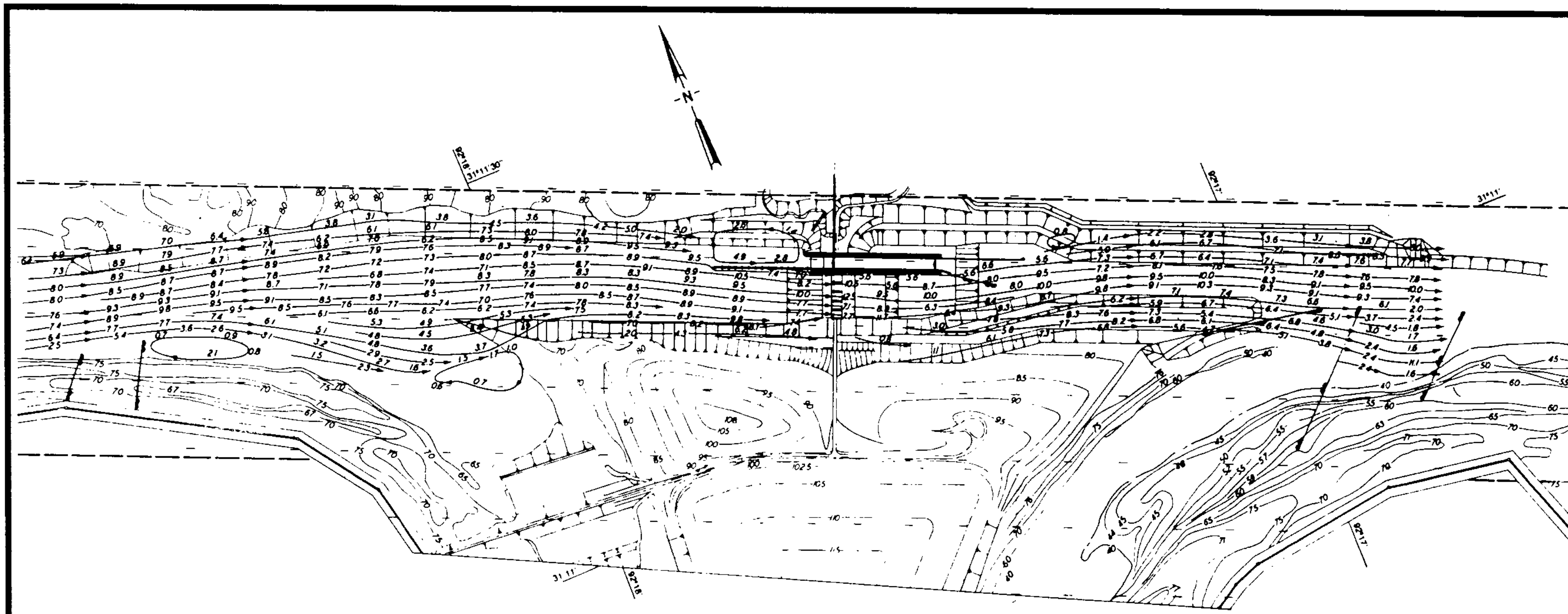
VELOCITIES AND CURRENT DIRECTIONS

PLAN G

DISCHARGE: 110,000 CFS
TAILWATER EL: 66.3 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT



VELOCITIES AND CURRENT DIRECTIONS

PLAN G

DISCHARGE: 145,000 CFS
TAILWATER EL: 71.0 FT

SCALES

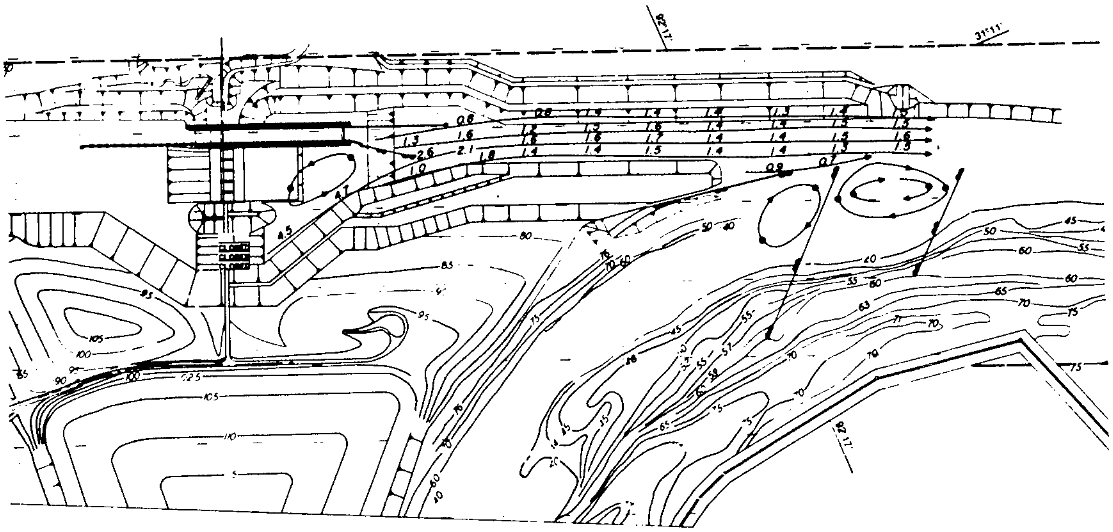
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

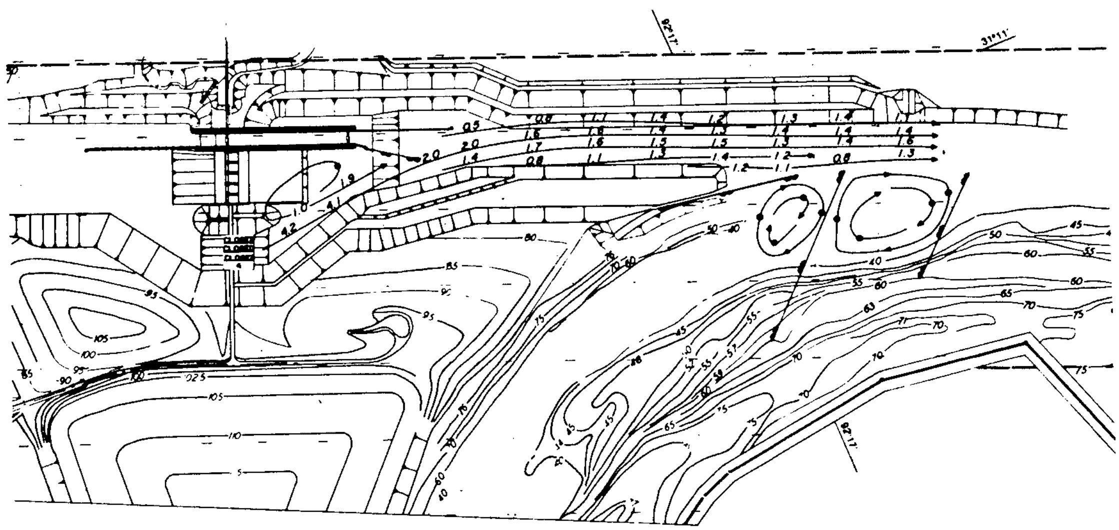
LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE—FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

PLATE 8





LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE—FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

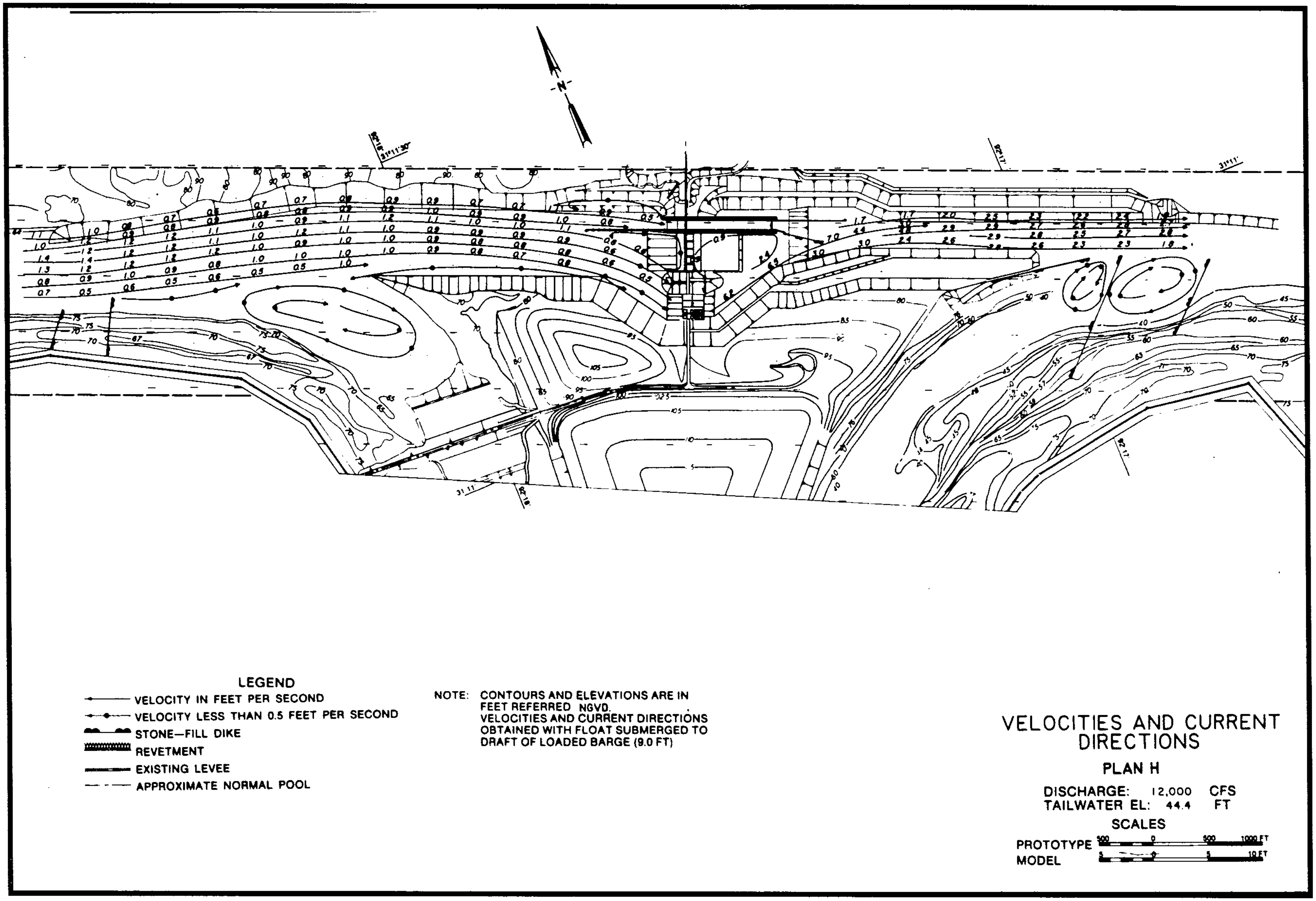
VELOCITIES AND CURRENT DIRECTIONS

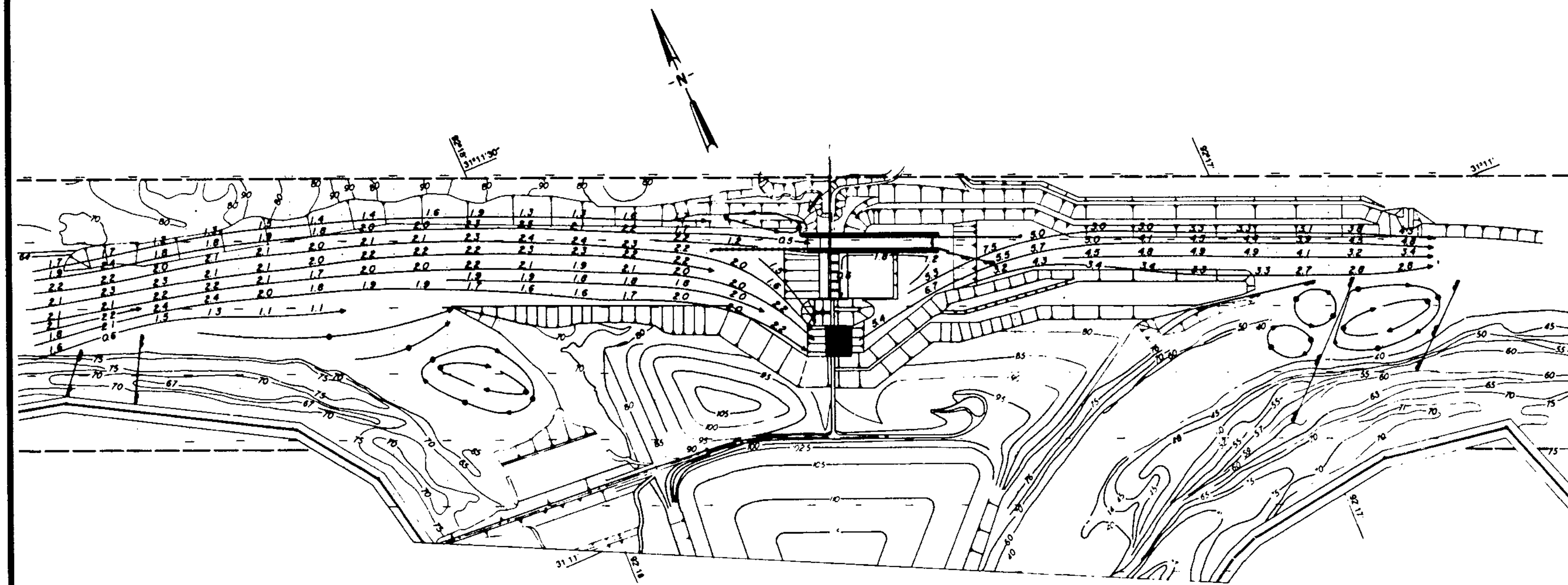
PLAN H

DISCHARGE: 6,000 CFS
TAILWATER EL: 42.1 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT


LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
STONE–FILL DIKE
REVETMENT
EXISTING LEVEE
APPROXIMATE NORMAL POOL
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED NGVD.
VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
VELOCITIES AND CURRENT DIRECTIONS
PLAN H
DISCHARGE: 12,000 CFS
TAILWATER EL: 44.4 FT
SCALES
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT



LEGEND

VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
STONE–FILL DIKE
REVETMENT
EXISTING LEVEE
APPROXIMATE NORMAL POOL

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

VELOCITIES AND CURRENT DIRECTIONS

PLAN H

DISCHARGE: 24,000 CFS
TAILWATER EL: 48.5 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

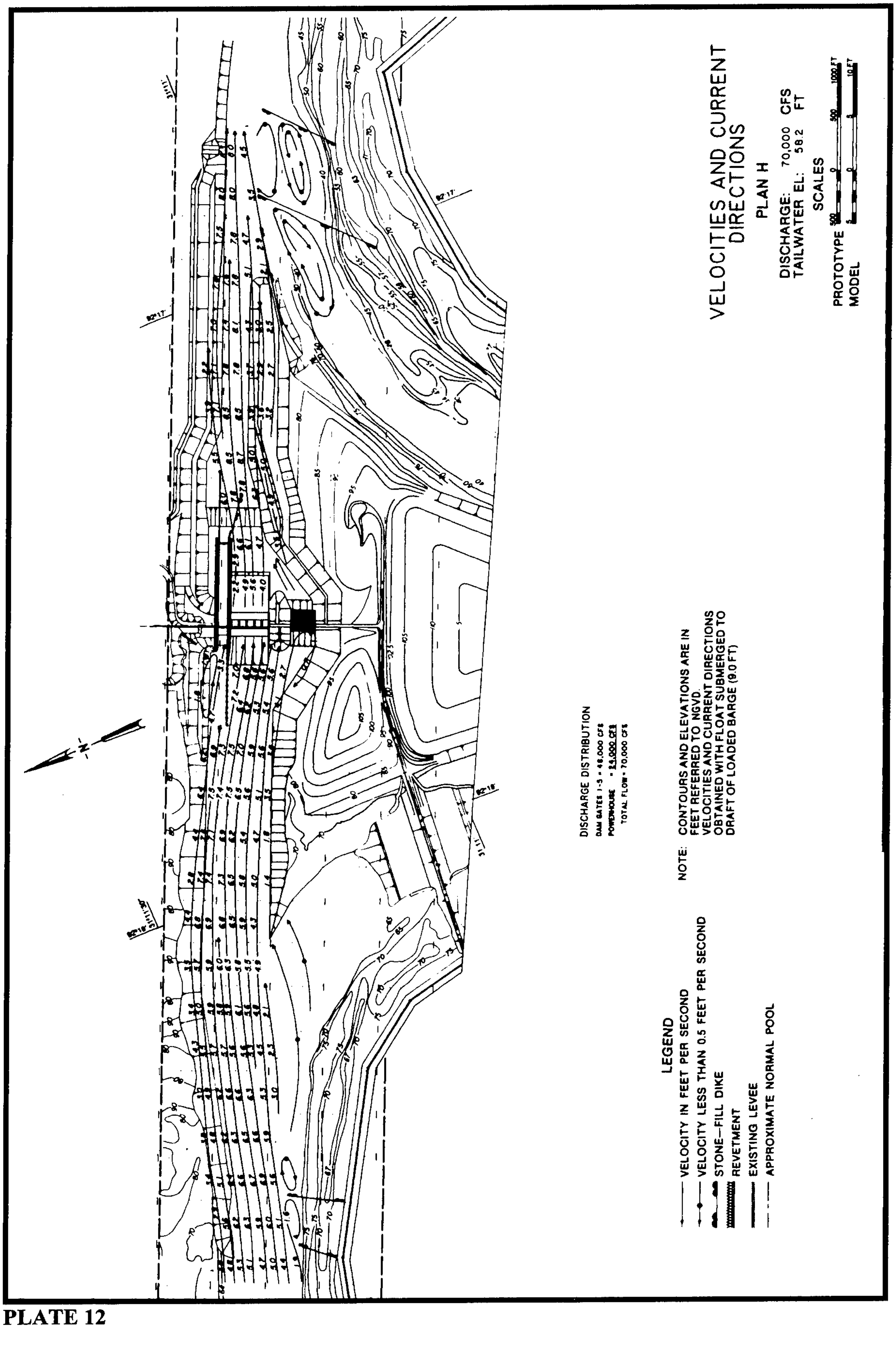

VELOCITIES AND CURRENT DIRECTIONS
PLAN H
DISCHARGE: 70,000 CFS
TAILWATER EL: 58.2 FT
SCALES
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT
DISCHARGE DISTRIBUTION
DAM GATES 1-5 = 46,000 CFS
POWERHOUSE = 24,000 CFS
TOTAL FLOW = 70,000 CFS
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD. VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
STONE–FILL DIKE
REVETMENT
EXISTING LEVEE
APPROXIMATE NORMAL POOL

PLATE 12

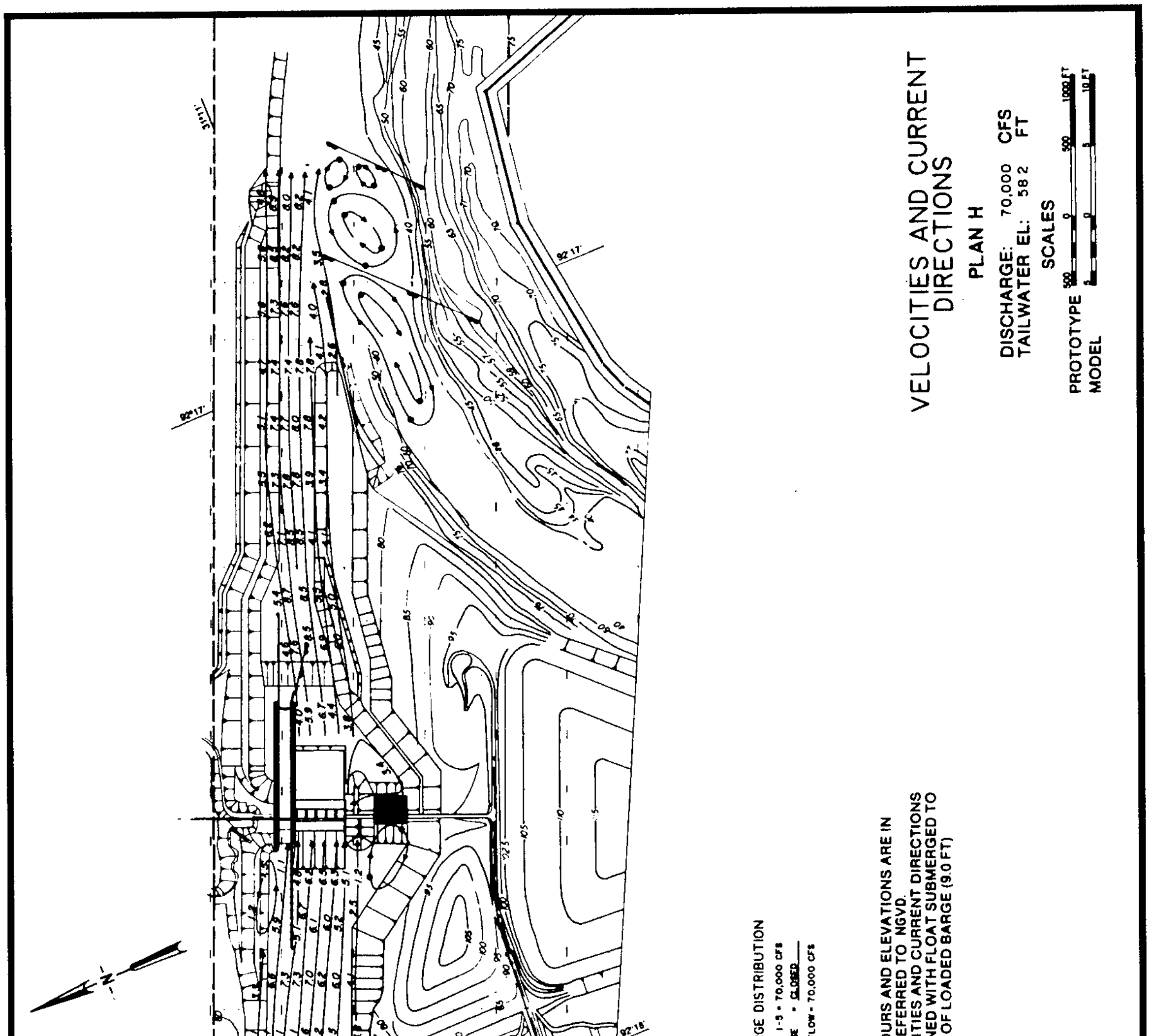
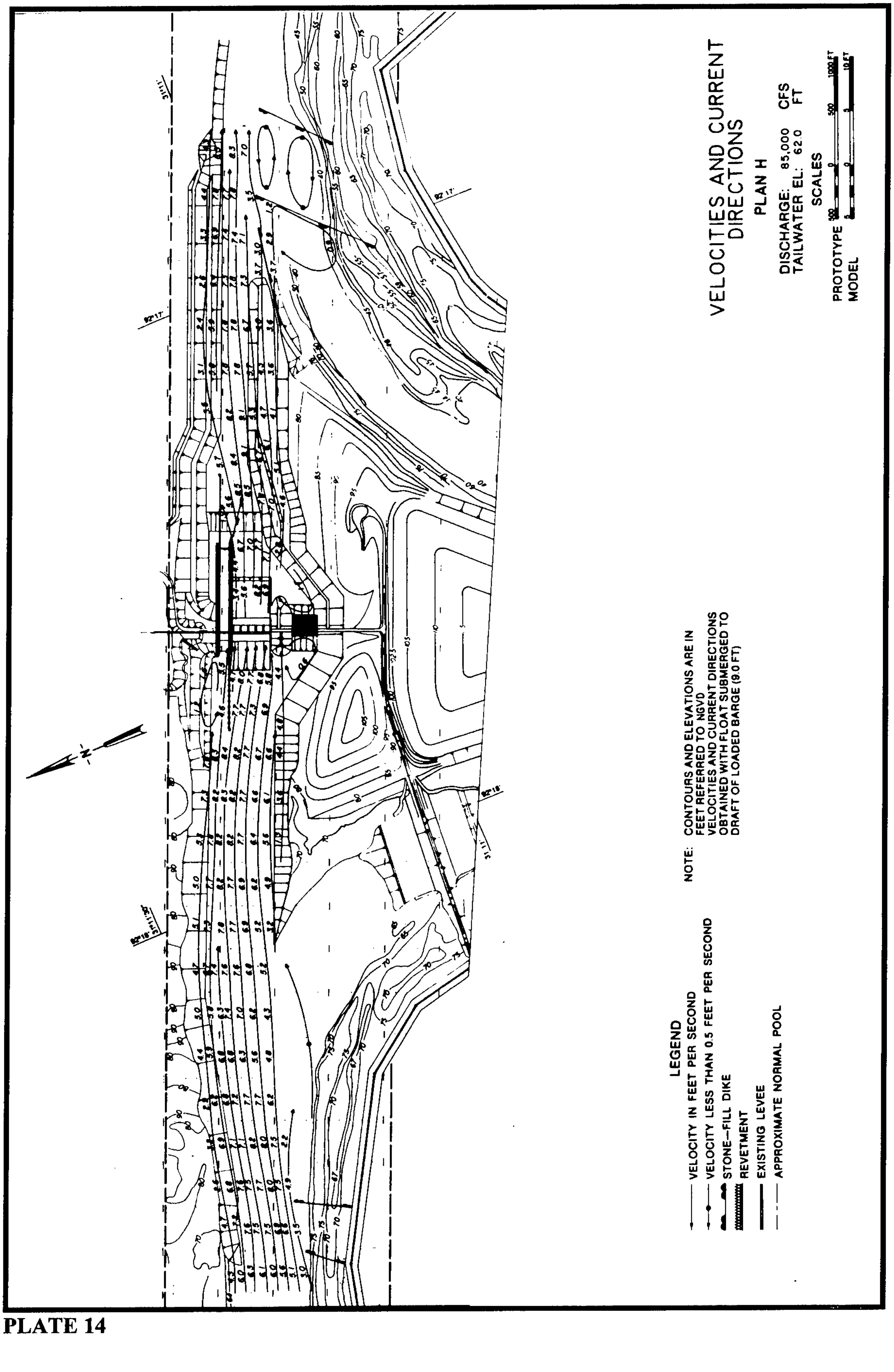
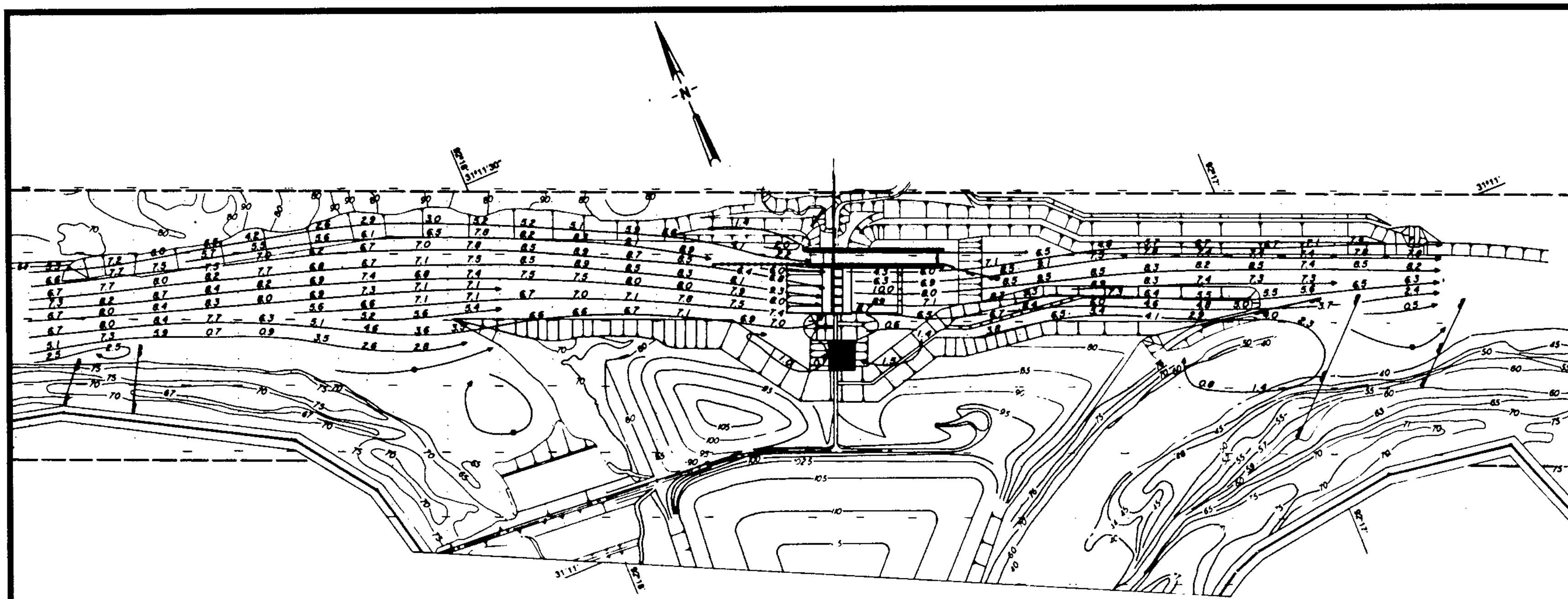

VELOCITIES AND CURRENT DIRECTIONS
PLAN H
DISCHARGE: 70,000 CFS
TAILWATER EL: 58.2 FT
SCALES
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
STONE-FILL DIKE
REVETMENT
EXISTING LEVEE
APPROXIMATE NORMAL POOL
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD. VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
DISCHARGE DISTRIBUTION
DAM GATES 1-5 = 70,000 CFS
POWERHOUSE = CLOSED
TOTAL FLOW = 70,000 CFS

PLATE 13



VELOCITIES AND CURRENT DIRECTIONS
PLAN H
DISCHARGE: 85,000 CFS
TAILWATER EL: 62.0 FT
SCALES
PROTOTYPE
MODEL
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
STONE—FILL DIKE
REVETMENT
EXISTING LEVEE
APPROXIMATE NORMAL POOL
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)

PLATE 14



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE–FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

VELOCITIES AND CURRENT DIRECTIONS

PLAN H

DISCHARGE: 110,000 CFS
TAILWATER EL: 66.3 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

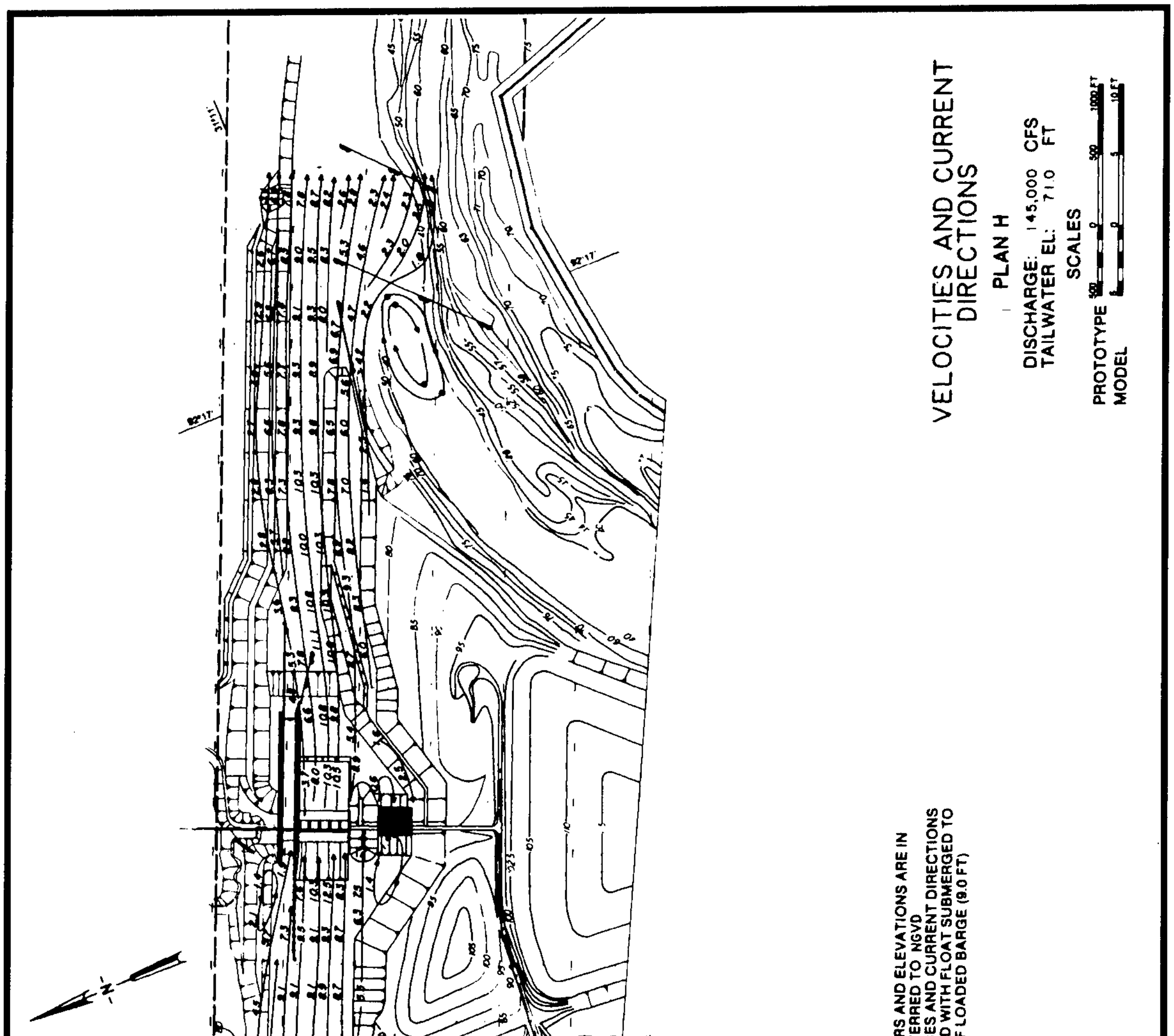
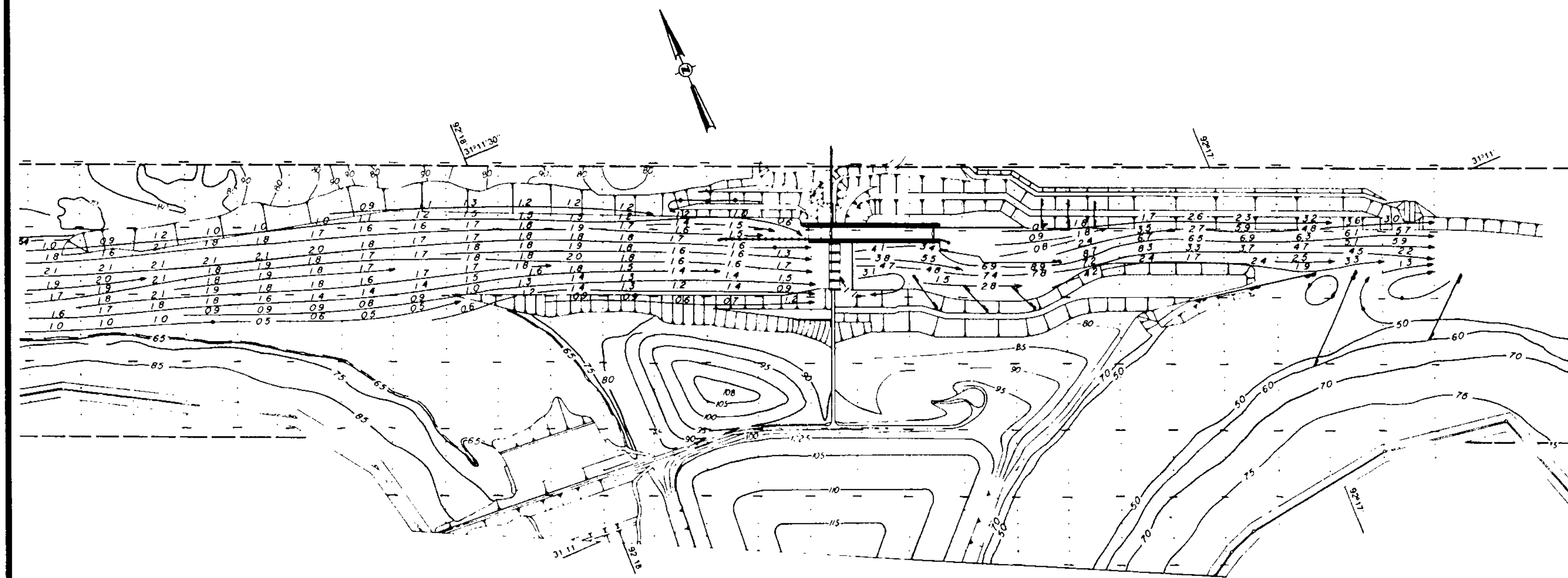

VELOCITIES AND CURRENT DIRECTIONS
PLAN H
DISCHARGE: 145,000 CFS
TAILWATER EL: 71.0 FT
SCALES
PROTOTYPE
MODEL
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
STONE—FILL DIKE
REVETMENT
EXISTING LEVEE
APPROXIMATE NORMAL POOL

PLATE 16



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE–FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

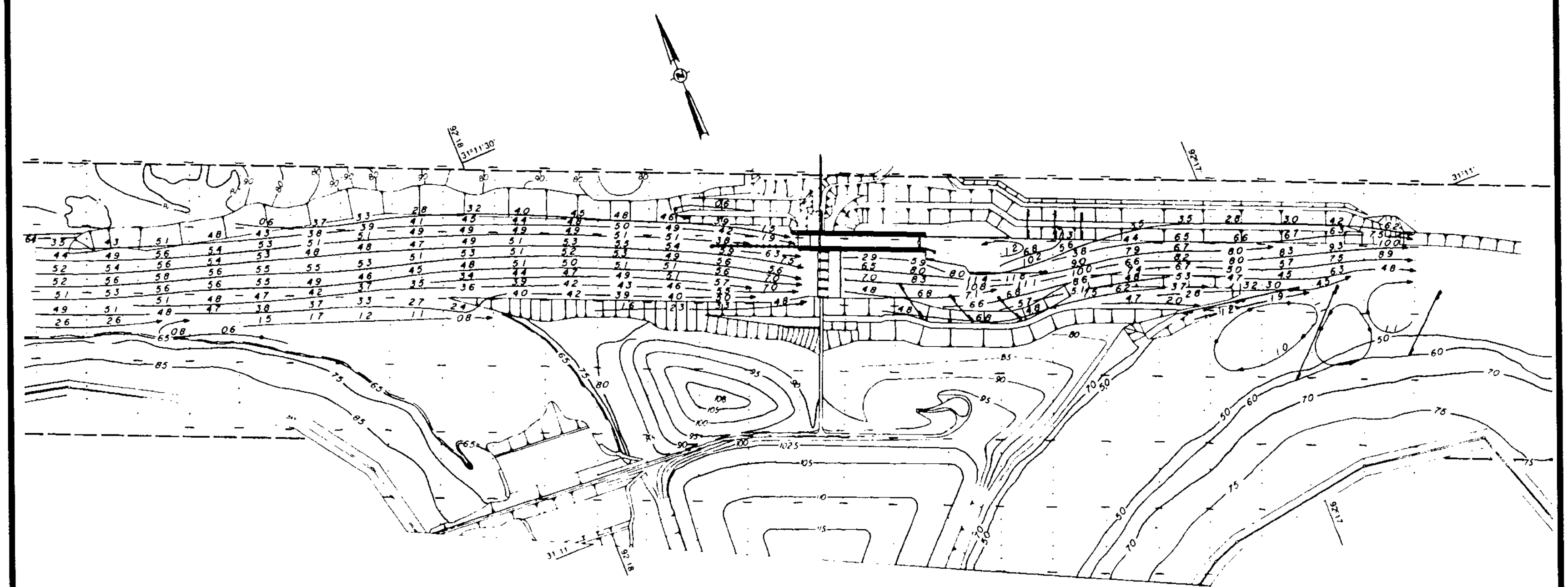
VELOCITIES AND CURRENT DIRECTIONS

PLAN J

DISCHARGE: 31,000 CFS
TAILWATER EL: 49.0 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE—FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

VELOCITIES AND CURRENT DIRECTIONS

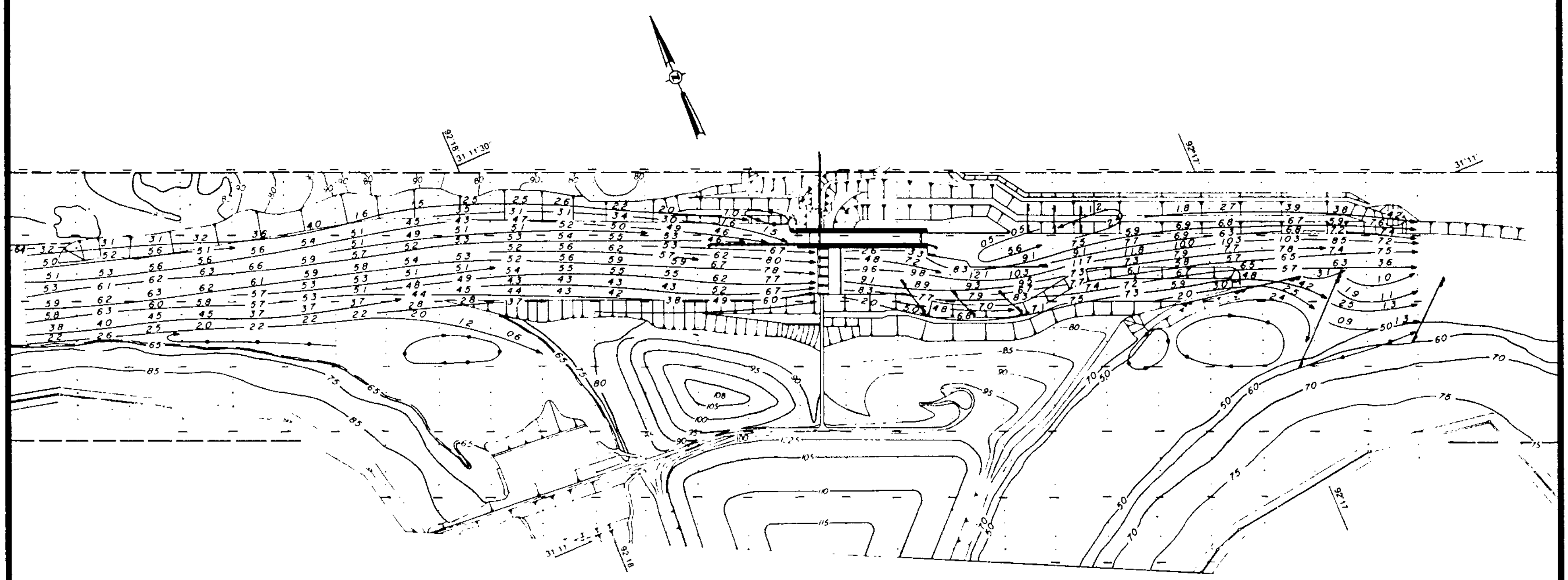
PLAN J

DISCHARGE: 85,000 CFS
TAILWATER EL: 60.6 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

PLATE 18



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE—FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

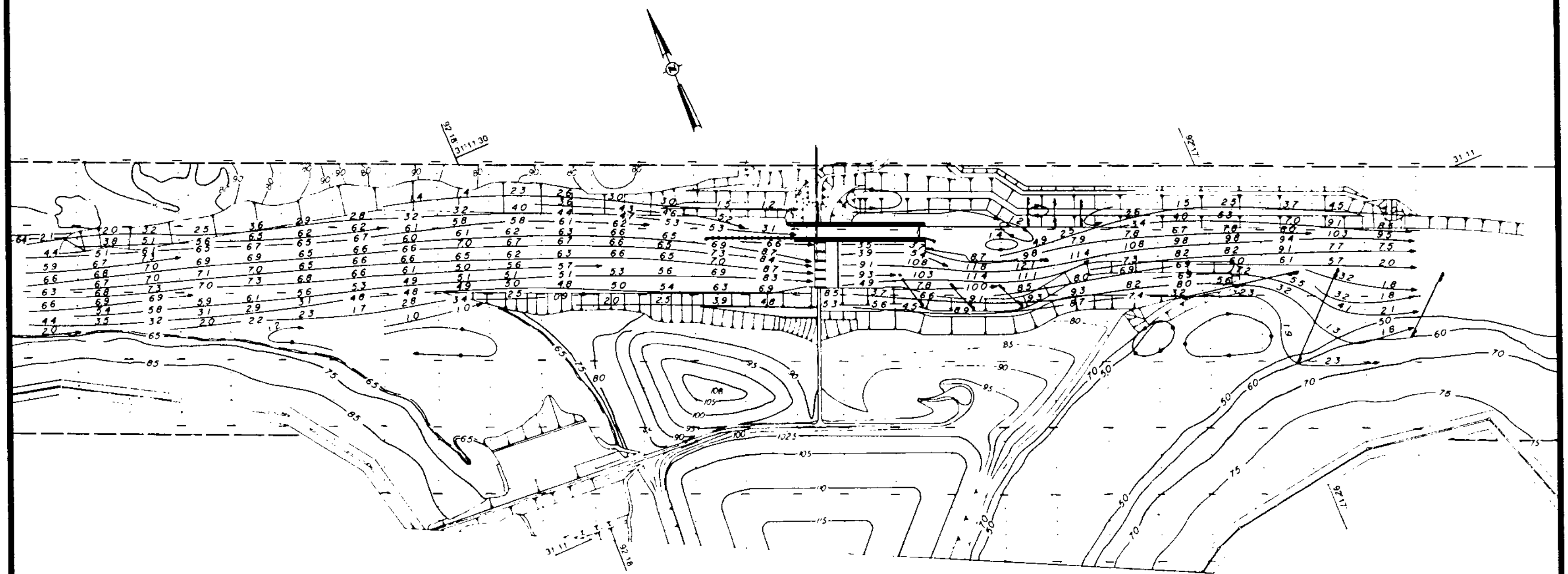
VELOCITIES AND CURRENT DIRECTIONS

PLAN J

DISCHARGE: 110,000 CFS
TAILWATER EL: 65.2 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE–FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

NOTE. CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)

VELOCITIES AND CURRENT DIRECTIONS

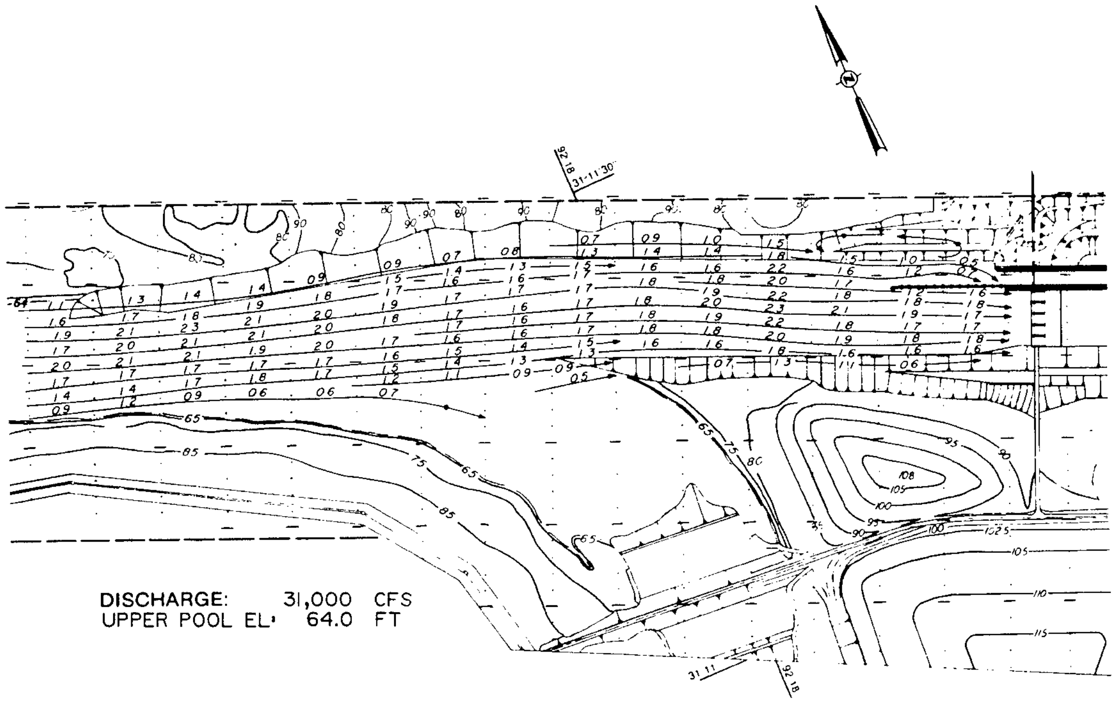
PLAN J

DISCHARGE: 145,000 CFS
TAILWATER EL: 71.2 FT

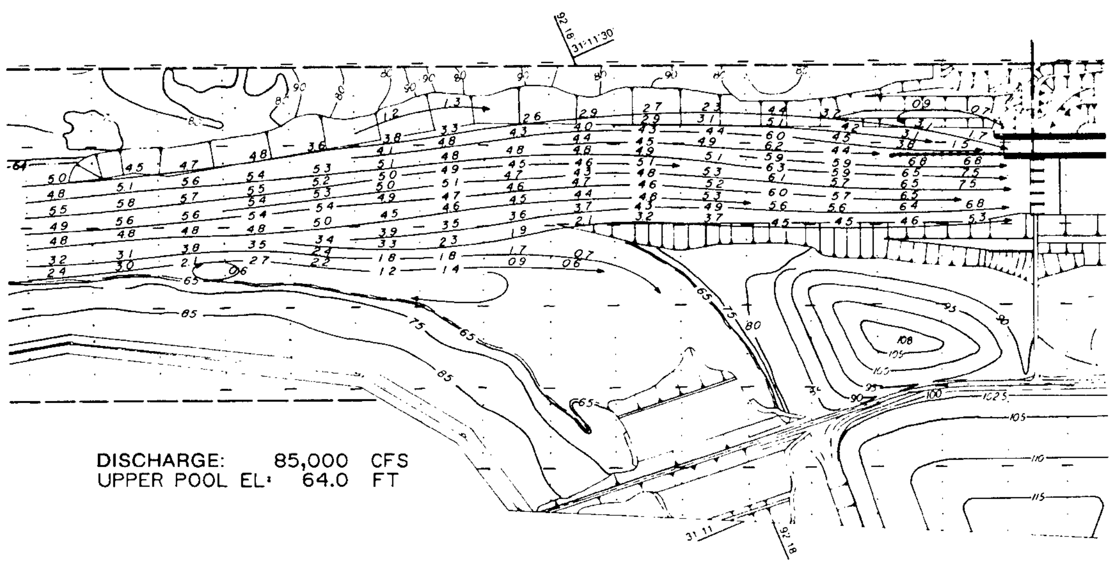
SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

PLATE 20



DISCHARGE: 31,000 CFS
UPPER POOL EL: 64.0 FT



DISCHARGE: 85,000 CFS
UPPER POOL EL: 64.0 FT

LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE—FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

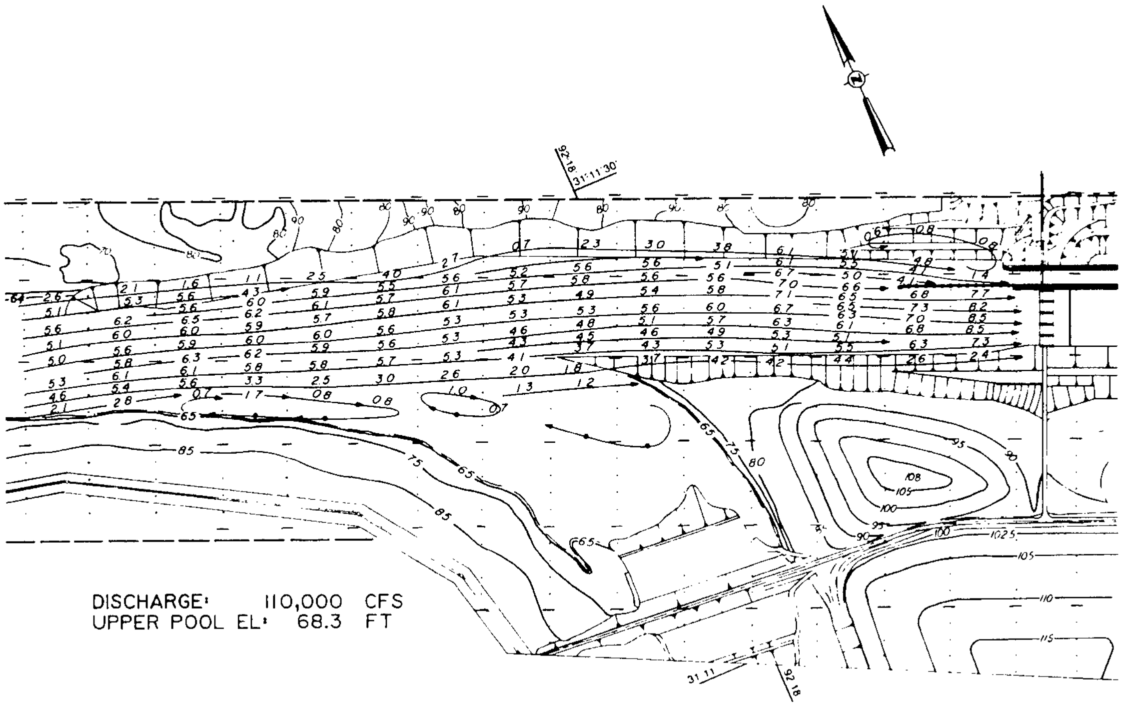
VELOCITIES AND CURRENT DIRECTIONS

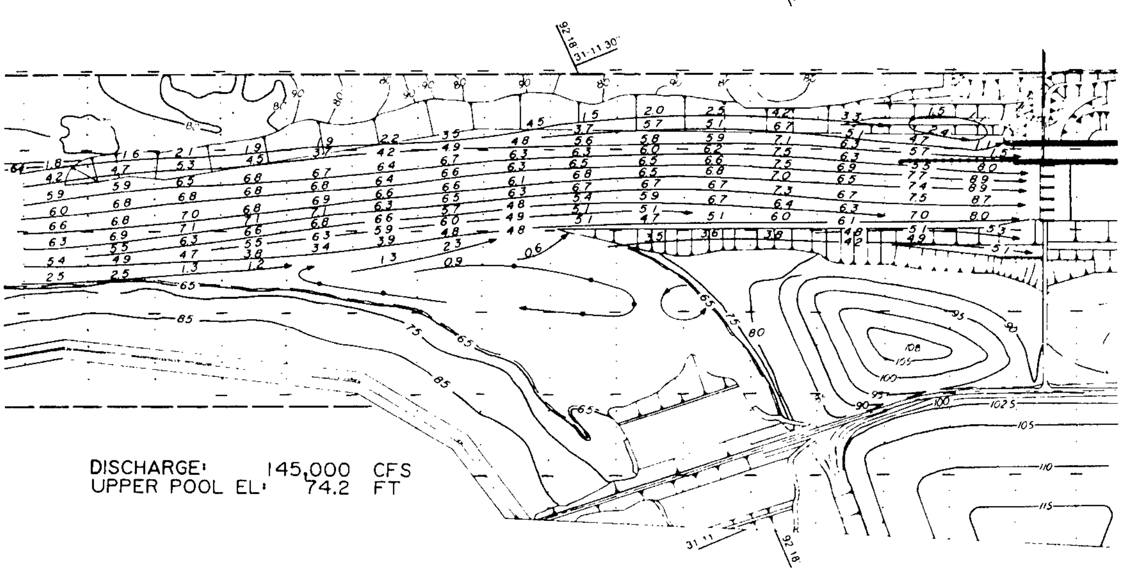
PLAN J-MODIFIED

SCALES

PROTOTYPE 500 0 500 1000 FT

MODEL 5 0 5 10 FT





LEGEND

VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
STONE—FILL DIKE
REVETMENT
EXISTING LEVEE
APPROXIMATE NORMAL POOL

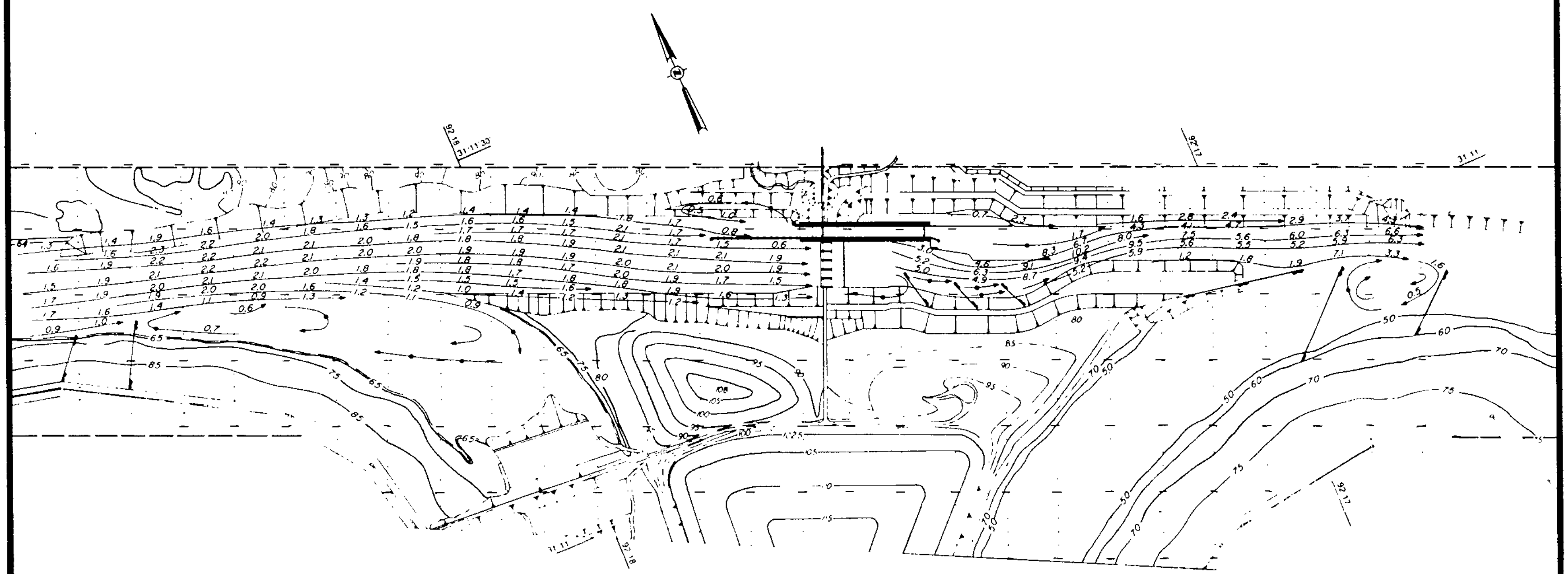
NOTE: CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)

VELOCITIES AND CURRENT DIRECTIONS

PLAN J-MODIFIED

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

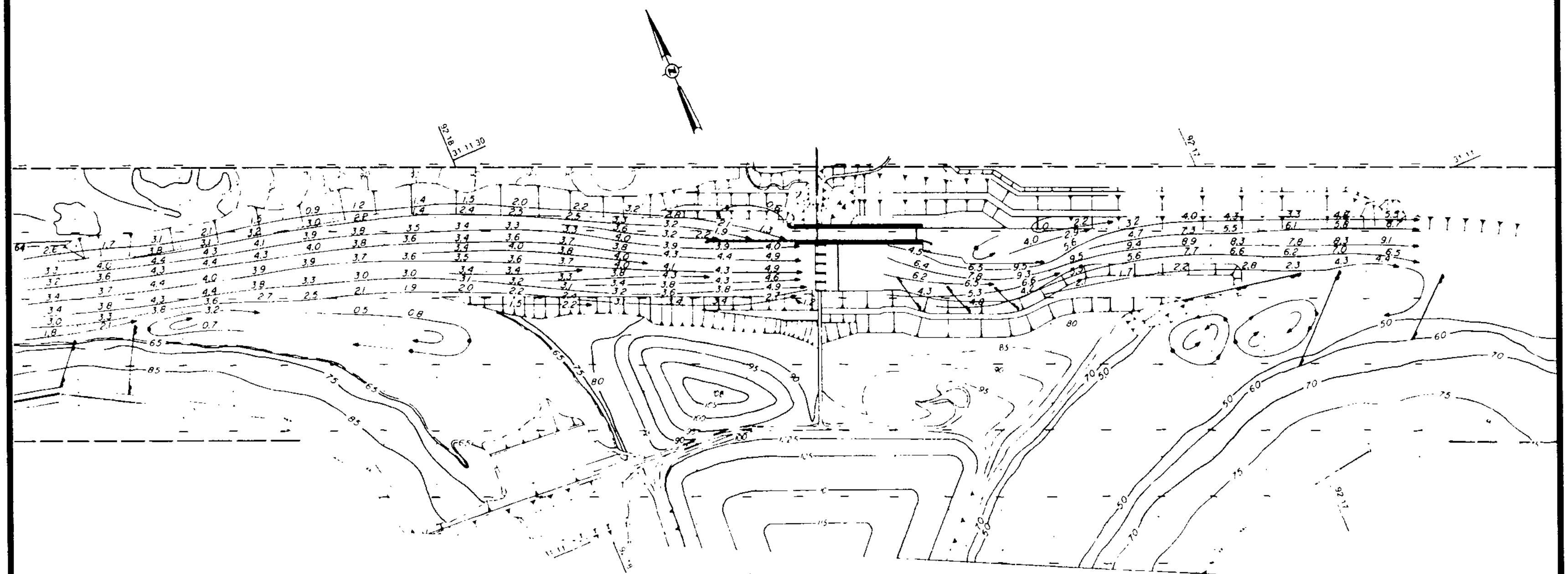
VELOCITIES AND CURRENT DIRECTIONS

PLAN J-2

DISCHARGE: 31,000 CFS
TAILWATER EL: 49,0 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT



LEGEND

VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
STONE FILL DIKE
REVETMENT
EXISTING LEVEE
APPROXIMATE NORMAL POOL

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

VELOCITIES AND CURRENT DIRECTIONS

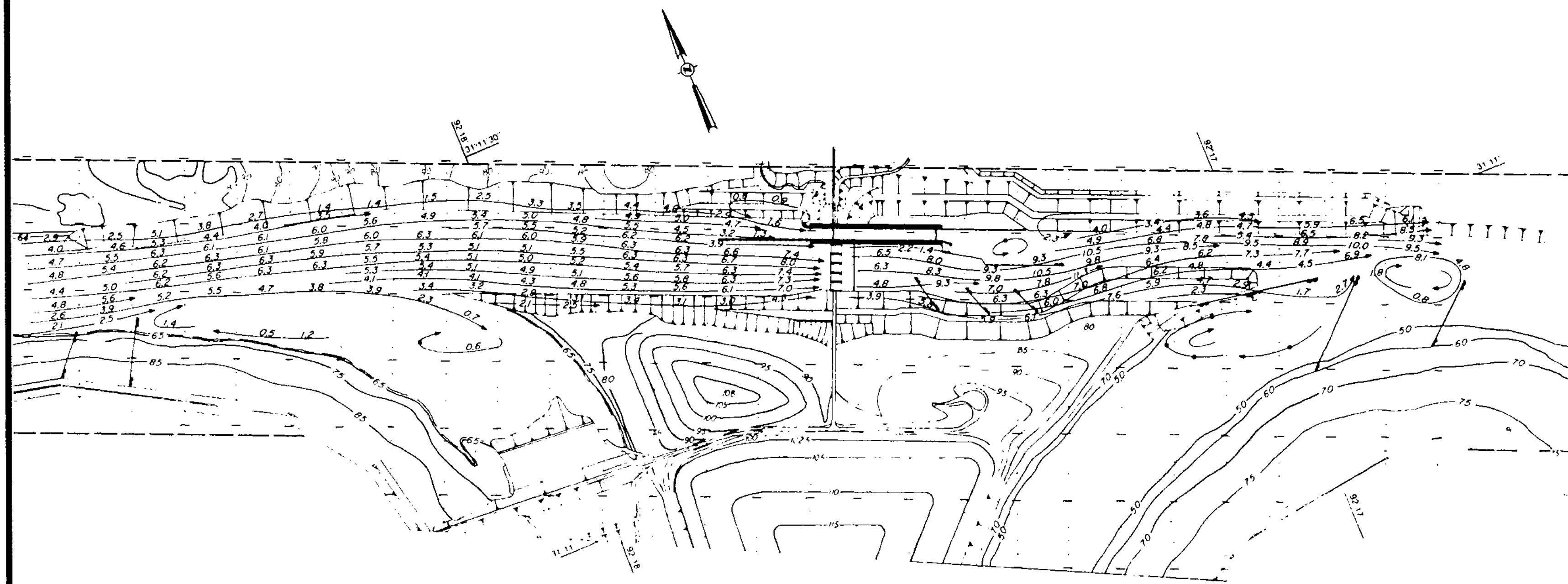
PLAN J-2

DISCHARGE: 60,000 CFS
TAILWATER EL: 55.5 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

PLATE 24



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE–FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

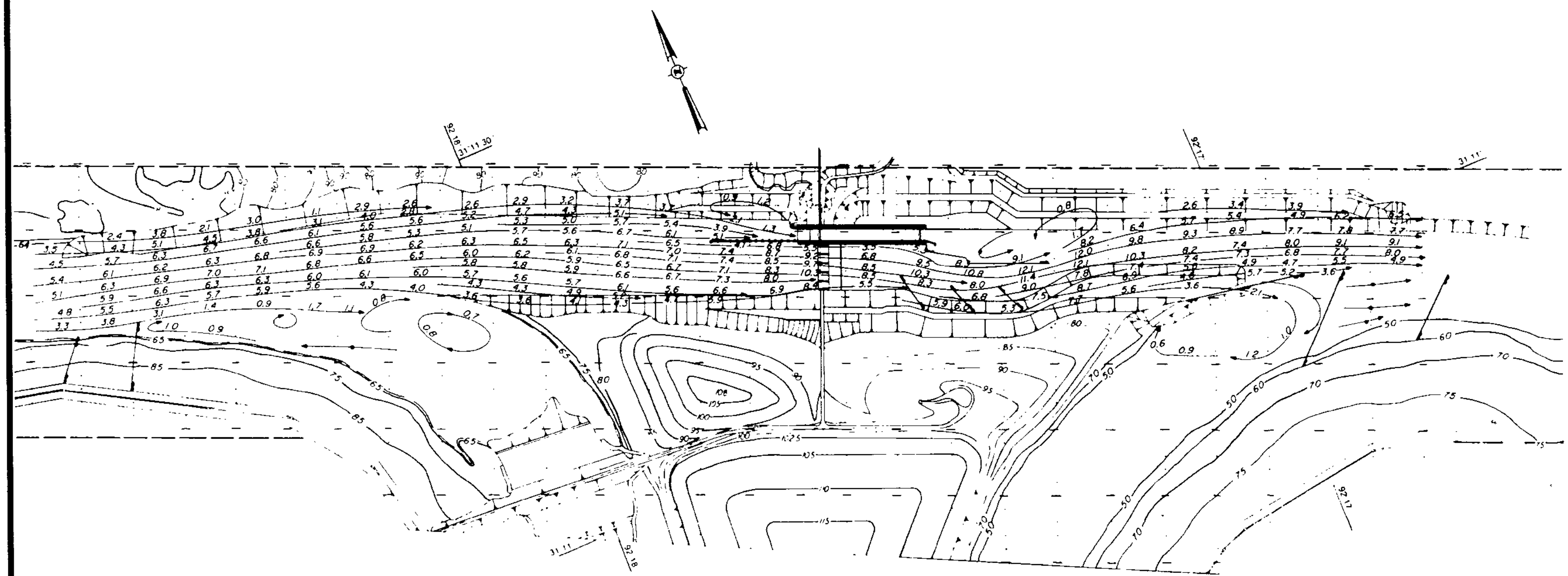
VELOCITIES AND CURRENT DIRECTIONS

PLAN J-2

DISCHARGE: 85,000 CFS
TAILWATER EL: 60.6 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE–FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

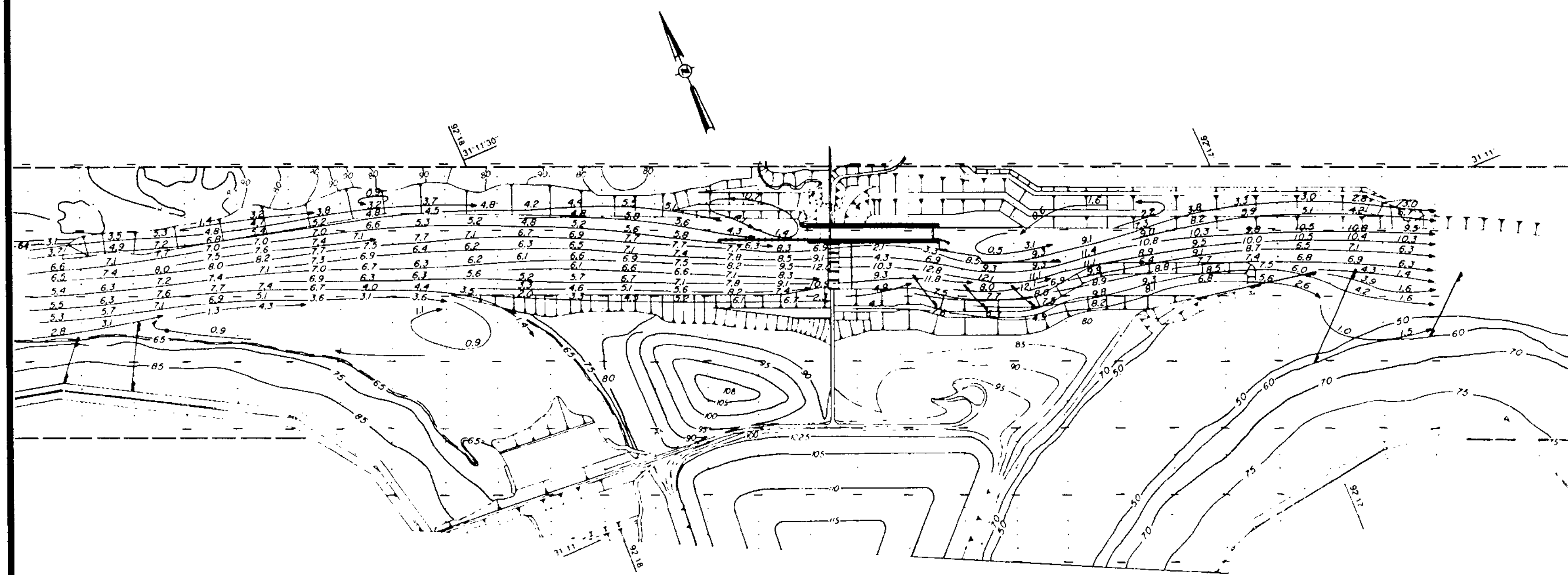
VELOCITIES AND CURRENT DIRECTIONS

PLAN J-2

DISCHARGE: 110,000 CFS
TAILWATER EL: 65.2 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT



LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE–FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

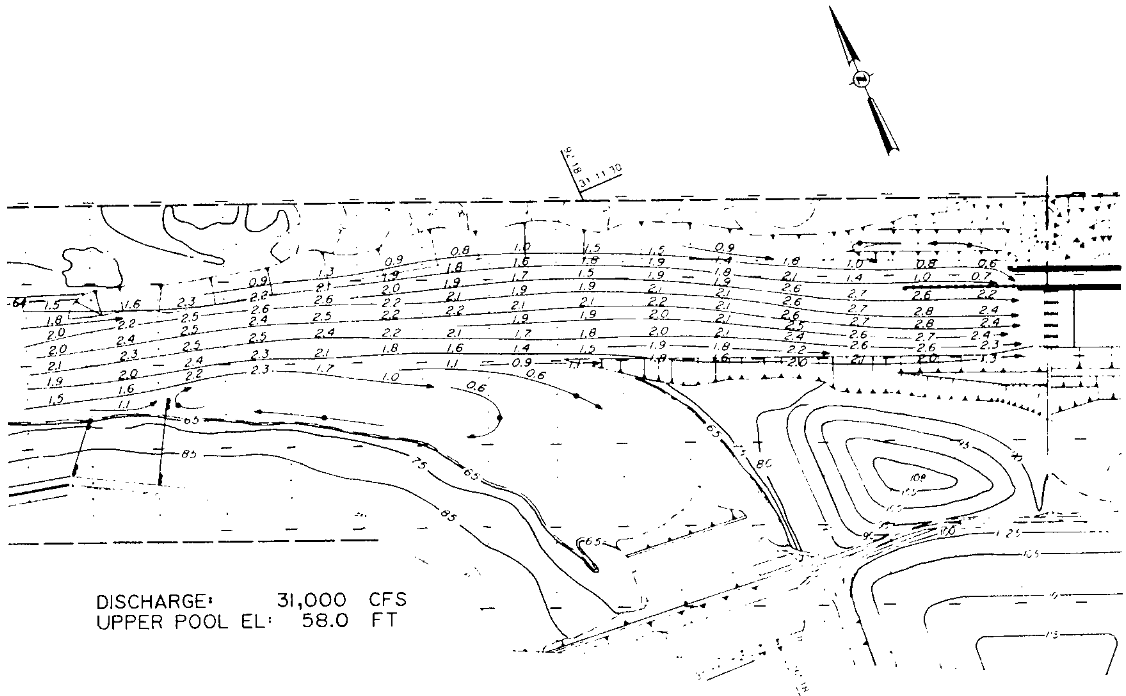
VELOCITIES AND CURRENT DIRECTIONS

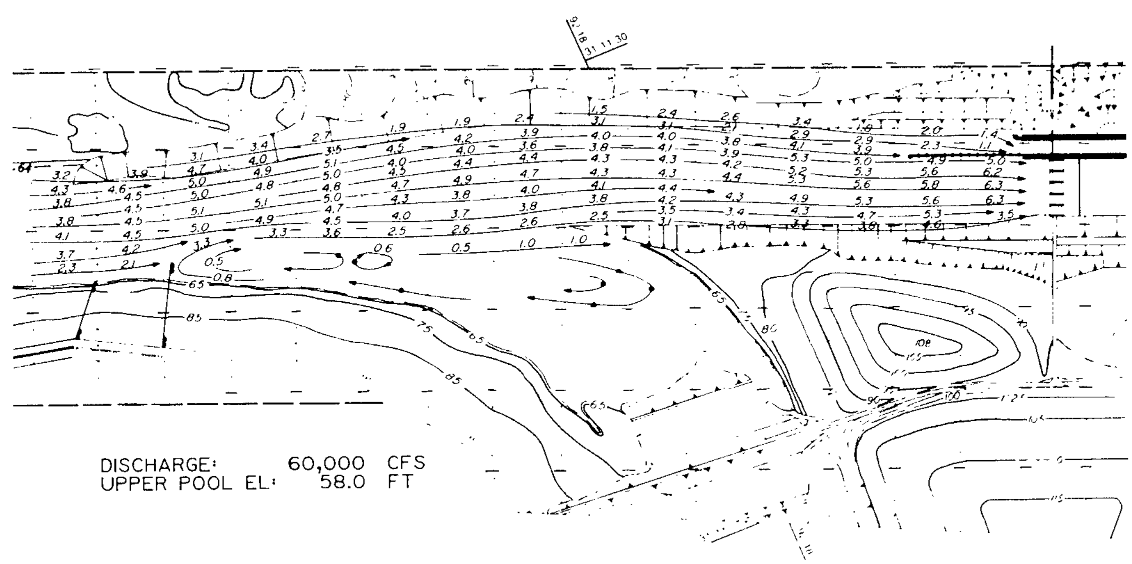
PLAN J-2

DISCHARGE: 145,000CFS
TAILWATER EL: 71.2 FT

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT





LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE—FILL DIKE
- REVETMENT
- EXISTING LEVEE
- APPROXIMATE NORMAL POOL

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

VELOCITIES AND CURRENT DIRECTIONS

PLAN J-2
DRAWDOWN

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

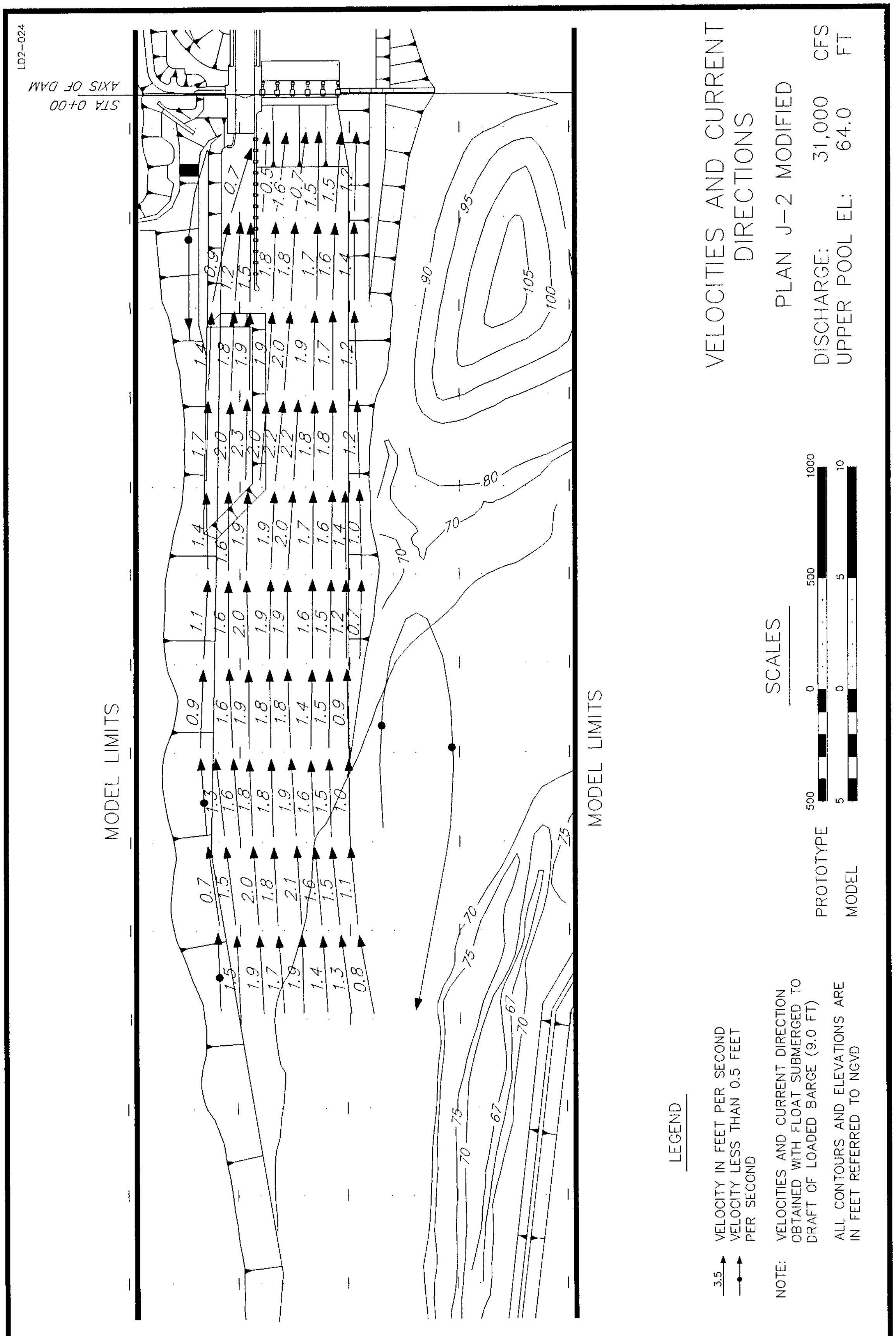

VELOCITIES AND CURRENT DIRECTIONS
PLAN J-2 MODIFIED
DISCHARGE: 31,000 CFS
UPPER POOL EL: 64.0 FT
SCALES
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10
LEGEND
3.5 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
MODEL LIMITS
MODEL LIMITS
STA 0+00
AXIS OF DAM
LD2-024

PLATE 29

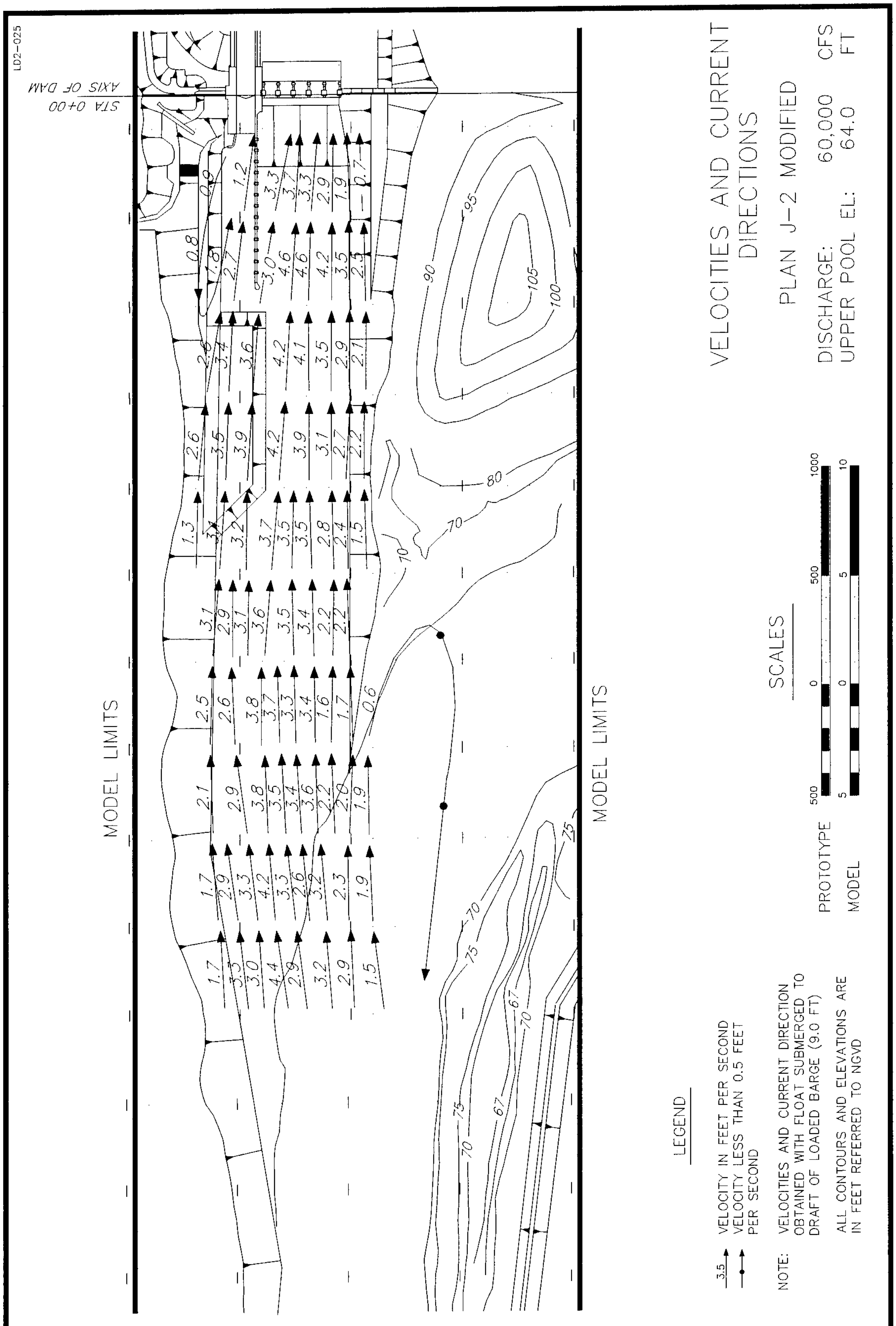
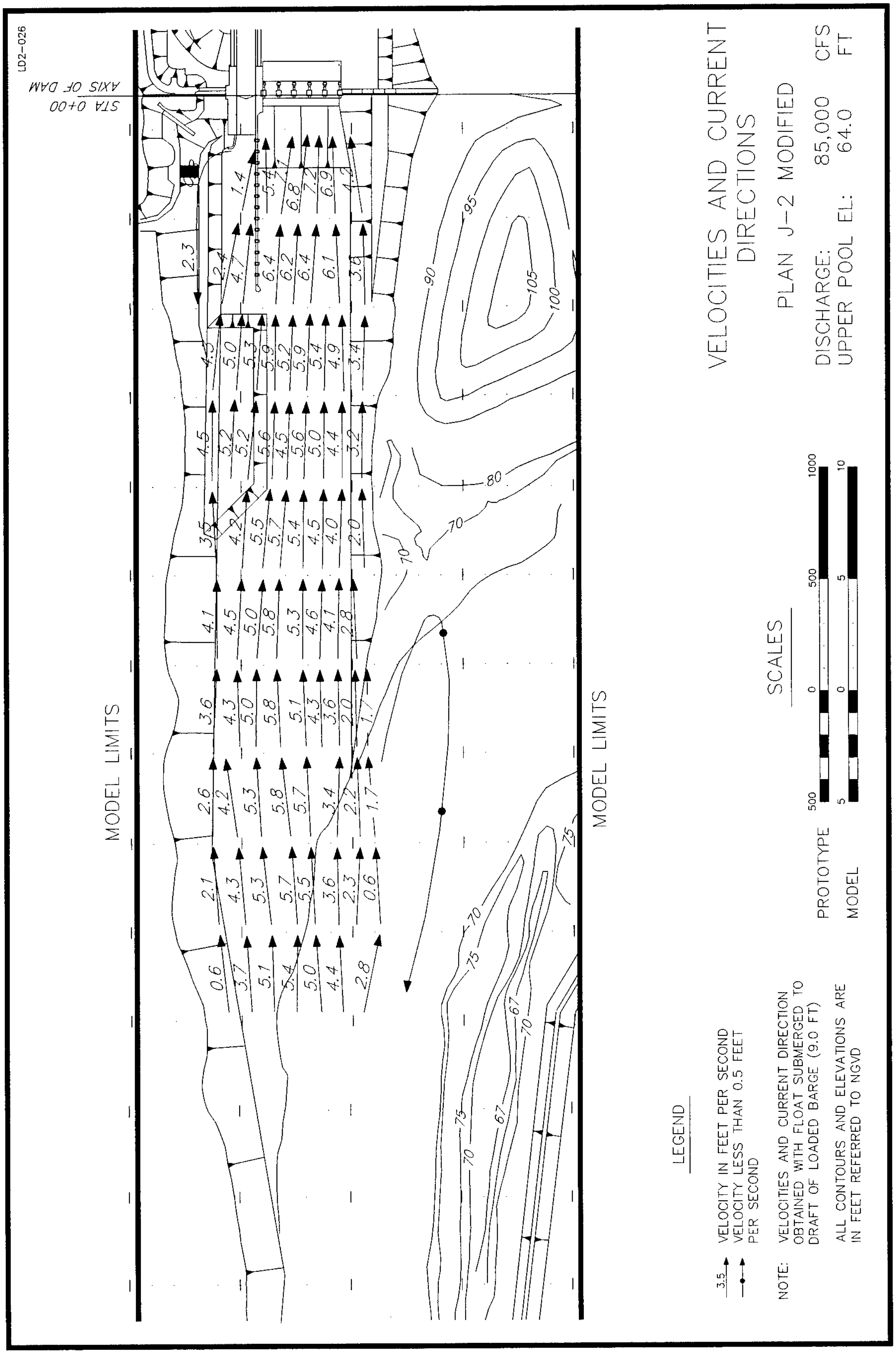

LD2-025
AXIS OF DAM
STA 0+00
MODEL LIMITS
MODEL LIMITS
VELOCITIES AND CURRENT DIRECTIONS
PLAN J-2 MODIFIED
DISCHARGE: 60,000 CFS
UPPER POOL EL: 64.0 FT
SCALES
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10
LEGEND
3.5 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

PLATE 30



LD2-026
AXIS OF DAM
STA 0+00
MODEL LIMITS
MODEL LIMITS
VELOCITIES AND CURRENT DIRECTIONS
PLAN J-2 MODIFIED
DISCHARGE: 85,000 CFS
UPPER POOL EL: 64.0 FT
SCALES
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10
LEGEND
3.5 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

PLATE 31

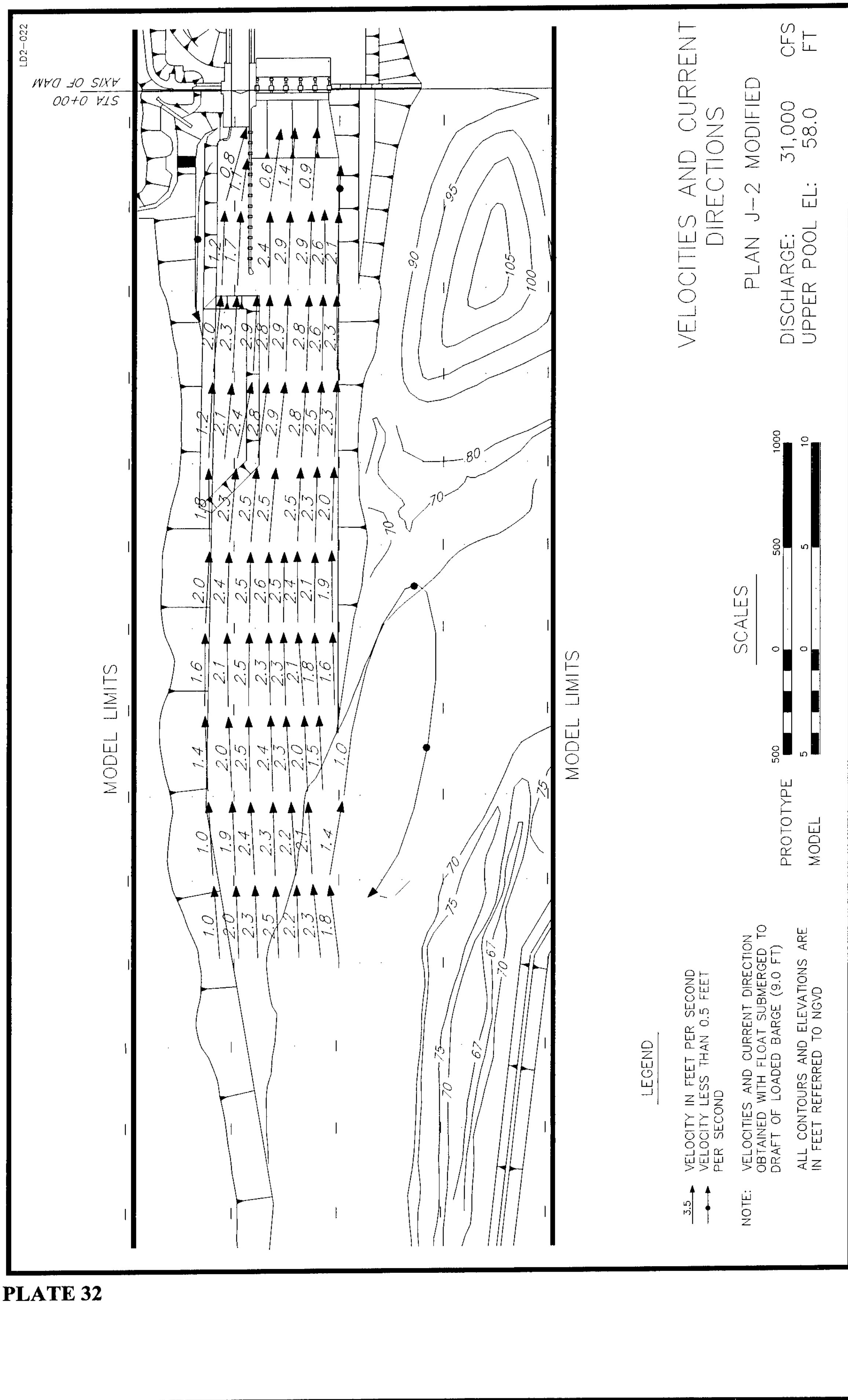
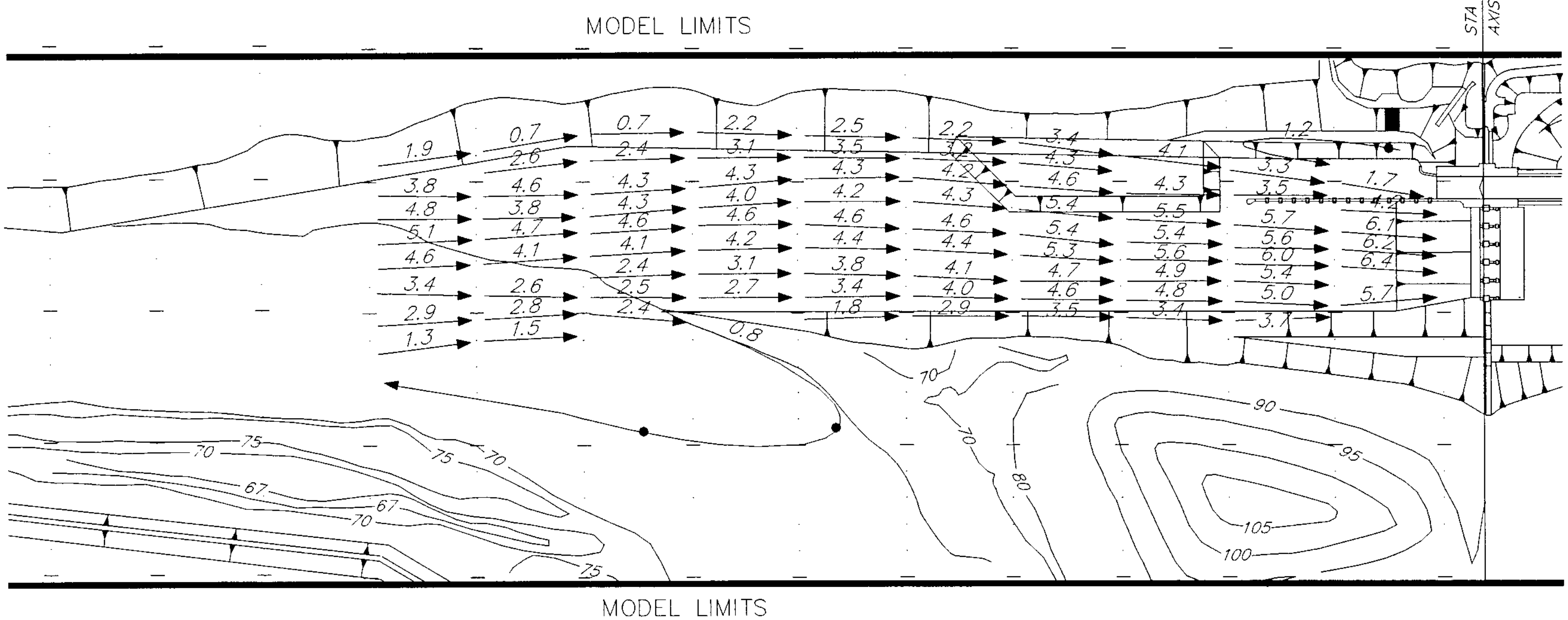

LD2-022
STA 0+00
AXIS OF DAM
MODEL LIMITS
MODEL LIMITS
VELOCITIES AND CURRENT DIRECTIONS
PLAN J-2 MODIFIED
DISCHARGE: 31,000 CFS
UPPER POOL EL: 58.0 FT
SCALES
PROTOTYPE
MODEL
LEGEND
3.5 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

PLATE 32



LEGEND

3.5 → VELOCITY IN FEET PER SECOND
→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

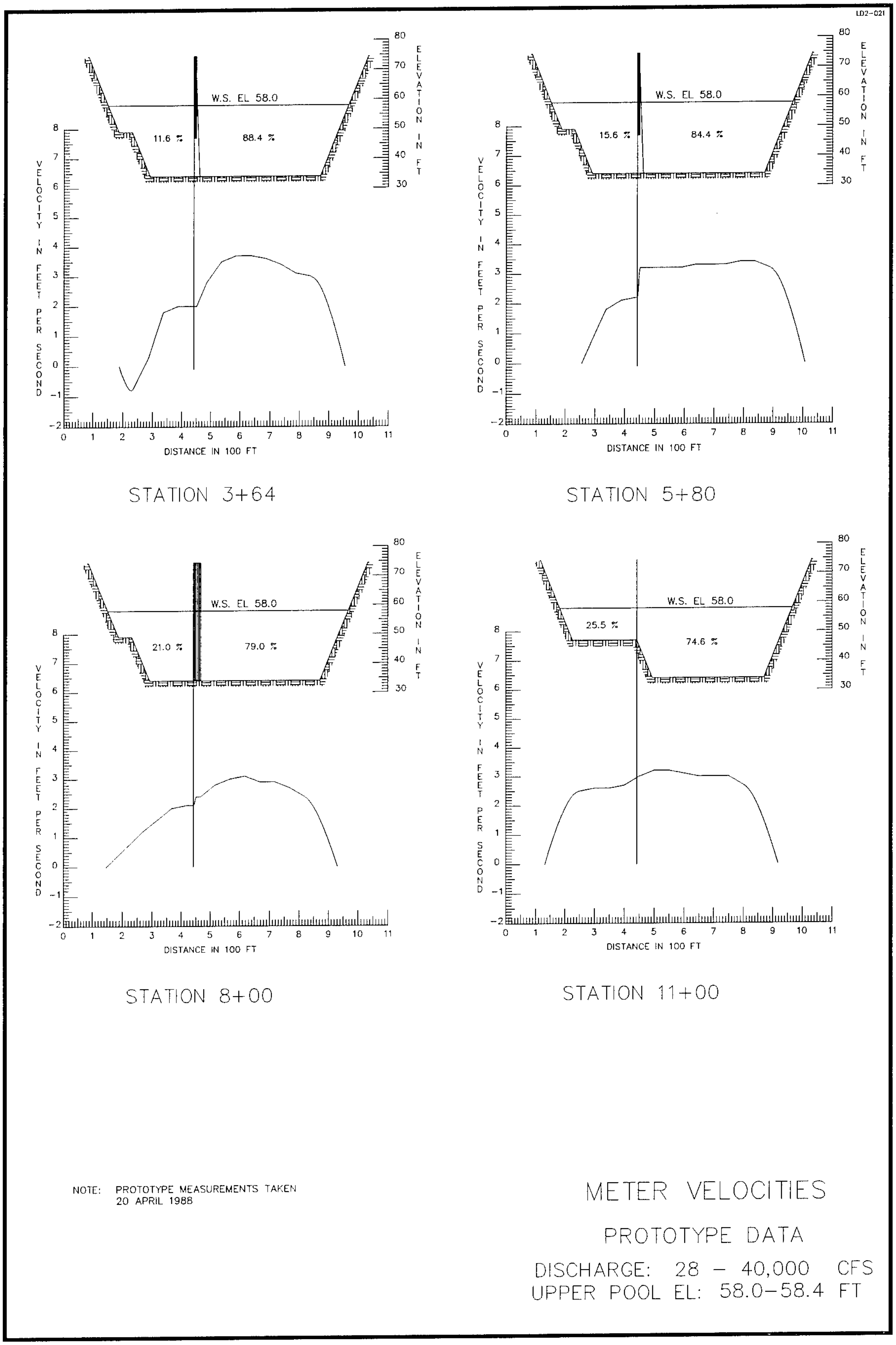
SCALES

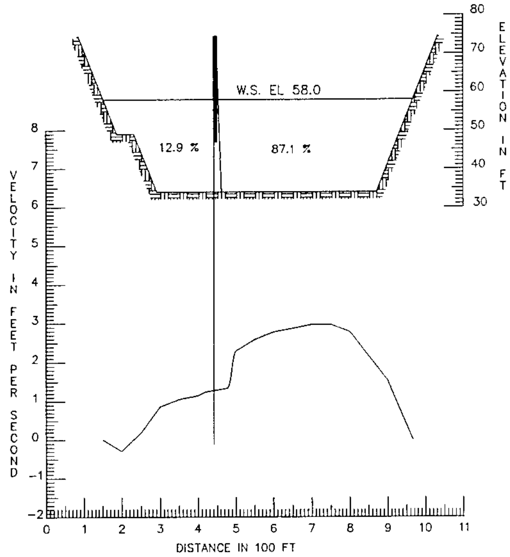
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

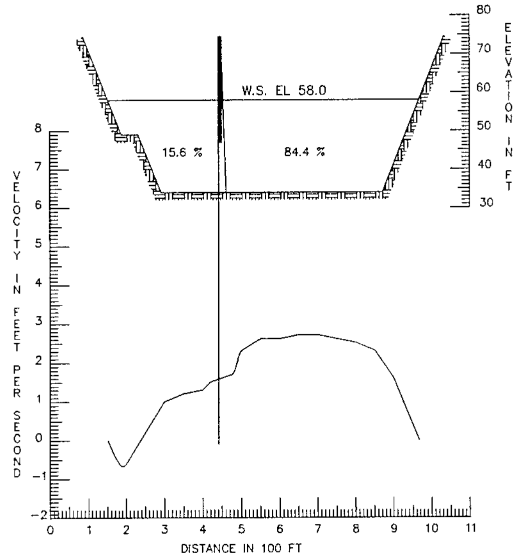
PLAN J-2 MODIFIED

DISCHARGE:	60,000	CFS
UPPER POOL EL:	58.0	FT

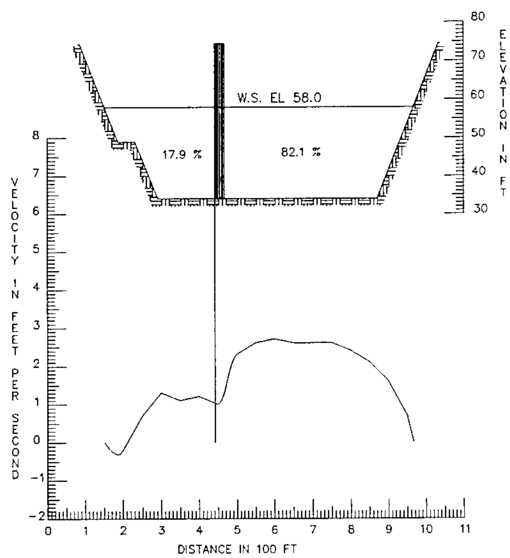

LD2-021
W.S. EL 58.0
11.6 %
88.4 %
VELOCITY IN FEET PER SECOND
ELEVATION IN FT
DISTANCE IN 100 FT
STATION 3+64
W.S. EL 58.0
15.6 %
84.4 %
STATION 5+80
W.S. EL 58.0
21.0 %
79.0 %
STATION 8+00
W.S. EL 58.0
25.5 %
74.6 %
STATION 11+00
NOTE: PROTOTYPE MEASUREMENTS TAKEN 20 APRIL 1988
METER VELOCITIES
PROTOTYPE DATA
DISCHARGE: 28 – 40,000 CFS
UPPER POOL EL: 58.0–58.4 FT



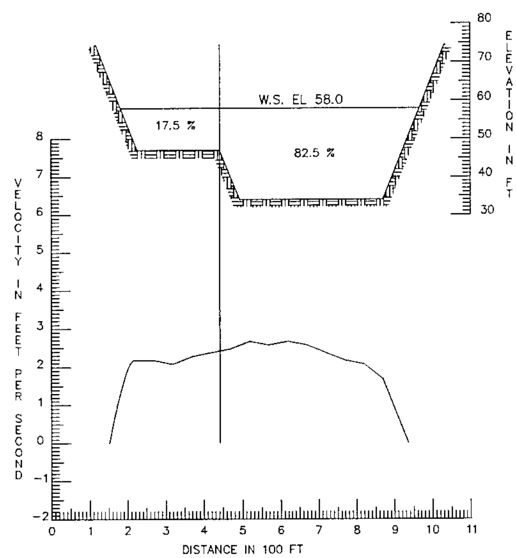
STATION 4+25



STATION 6+75



STATION 9+25



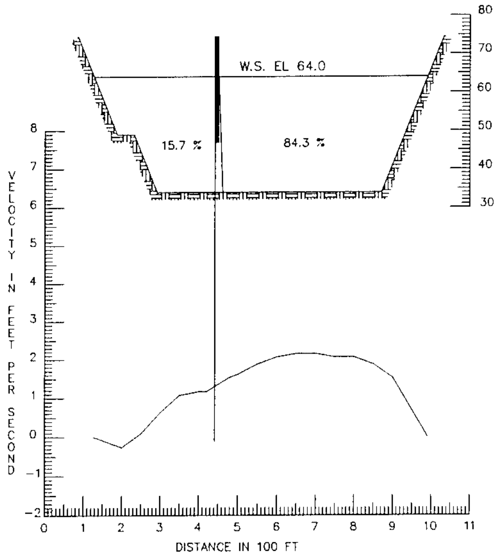
STATION 14+25

NOTE: VELOCITIES TAKEN AT MID-DEPTH WITH MINIATURE MAGNETIC METER

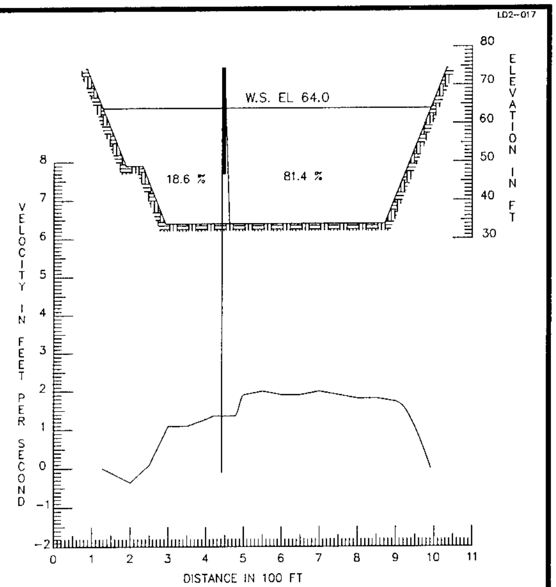
METER VELOCITIES

PLAN J-2 MODIFIED

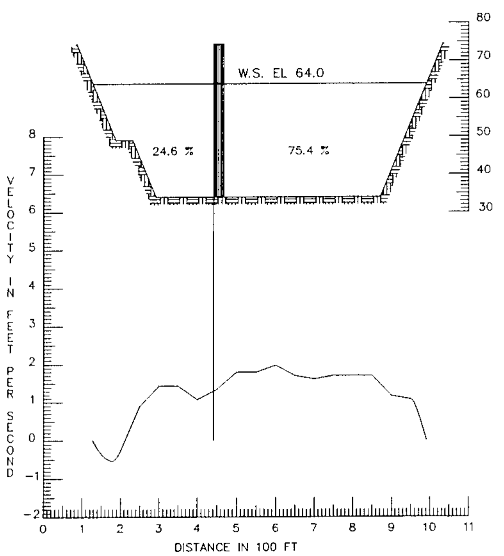
DISCHARGE: 31,000 CFS
UPPER POOL EL: 58.0 FT



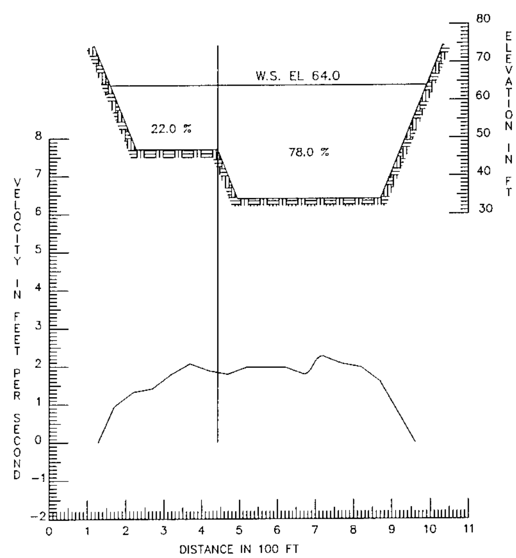
STATION 4+25



STATION 6+75



STATION 9+25



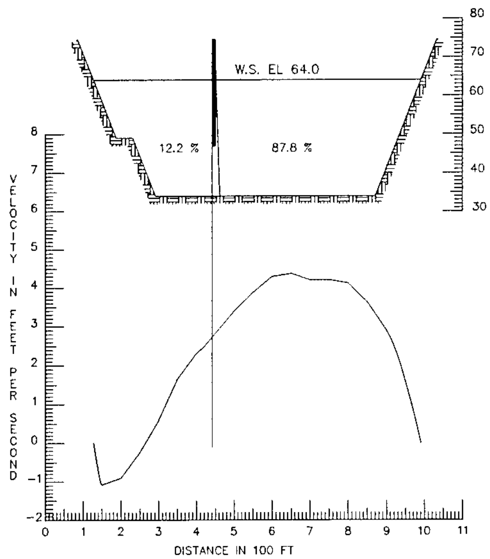
STATION 14+25

NOTE: VELOCITIES TAKEN AT MID-DEPTH WITH MINIATURE MAGNETIC METER

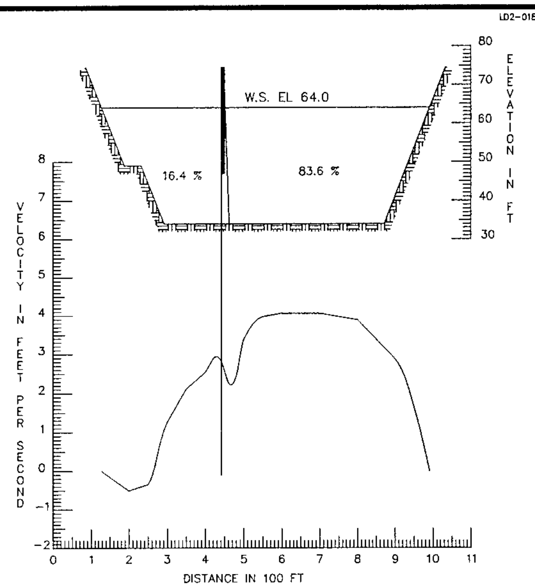
METER VELOCITIES

PLAN J-2 MODIFIED

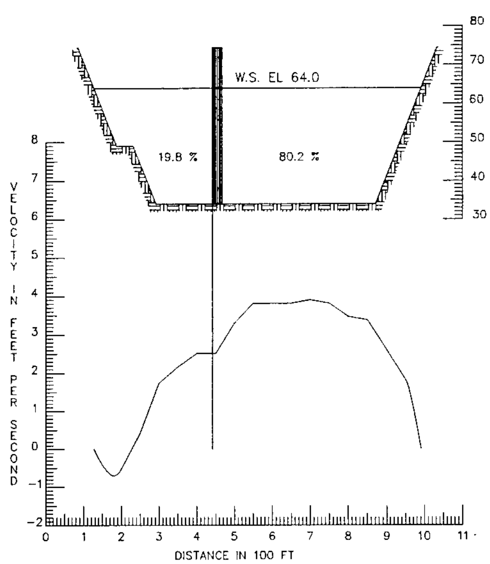
DISCHARGE: 31,000 CFS
UPPER POOL EL: 64.0 FT



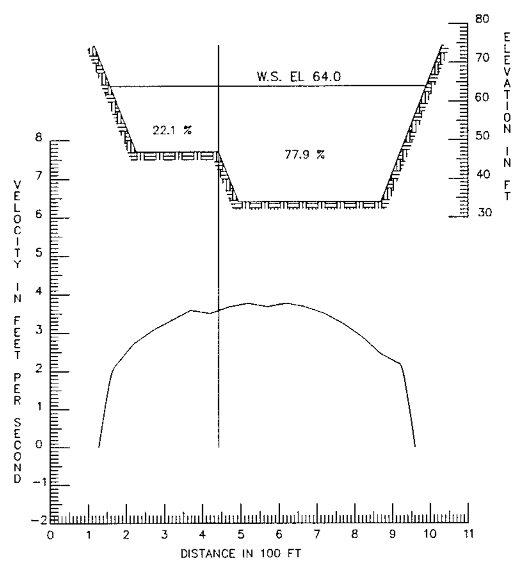
STATION 4+25



STATION 6+75



STATION 9+25



STATION 14+25

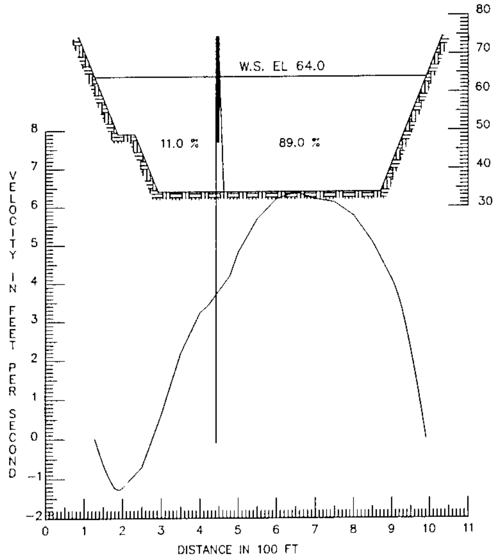
NOTE: VELOCITIES TAKEN AT MID-DEPTH WITH MINIATURE MAGNETIC METER

METER VELOCITIES

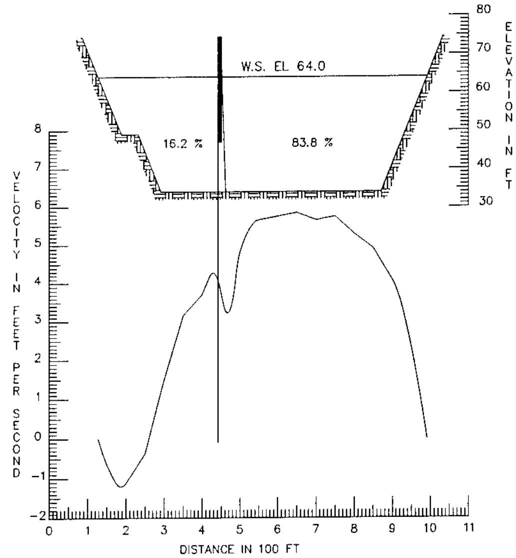
PLAN J-2 MODIFIED

DISCHARGE: 60,000 CFS
UPPER POOL EL: 64.0 FT

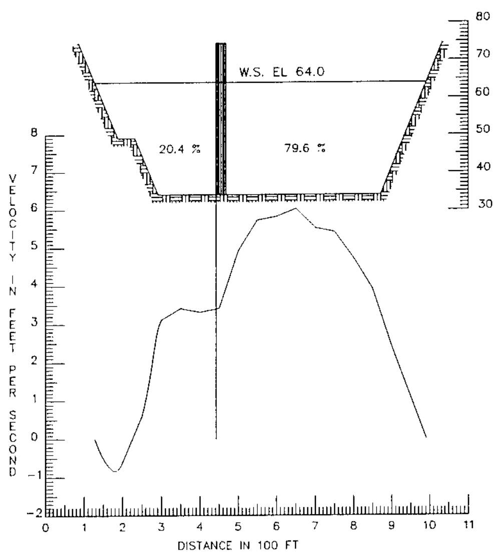
LD2-019



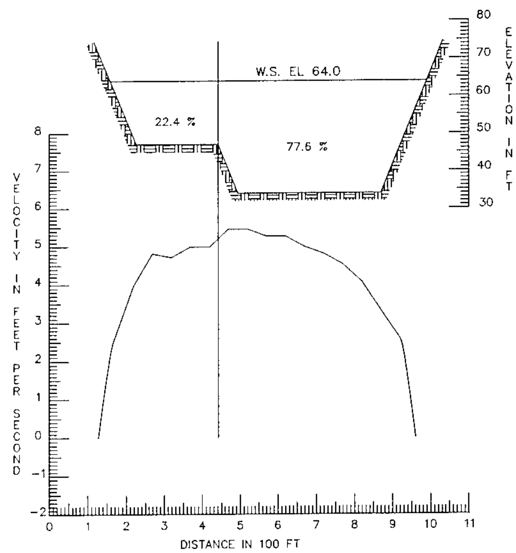
STATION 4+25



STATION 6+75



STATION 9+25



STATION 14+25

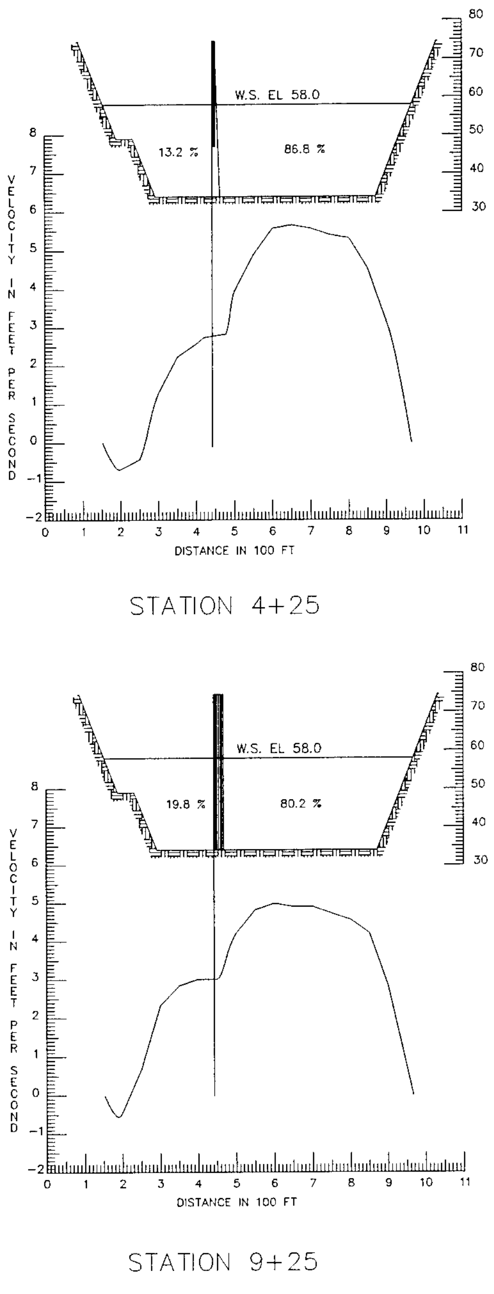
NOTE: VELOCITIES TAKEN AT MID-DEPTH WITH MINIATURE MAGNETIC METER

METER VELOCITIES

PLAN J-2 MODIFIED

DISCHARGE: 85,000 CFS
UPPER POOL EL: 64.0 FT

PLATE 38



NOTE: VELOCITIES TAKEN AT MID-DEPTH WITH MINIATURE MAGNETIC METER

METER VELOCITIES

PLAN J-2 MODIFIED

DISCHARGE: 60,000 CFS
UPPER POOL EL: 58.0 FT

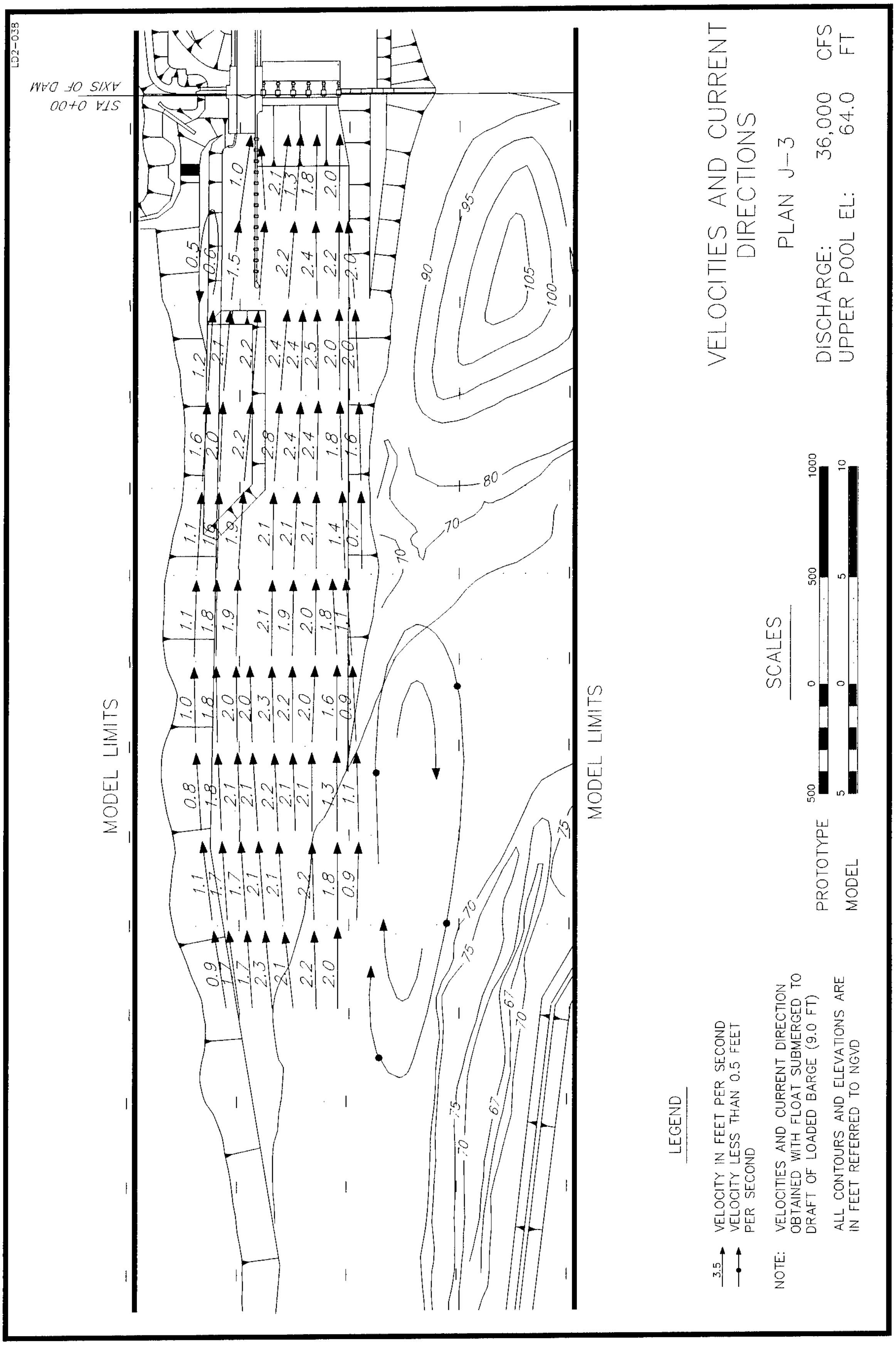
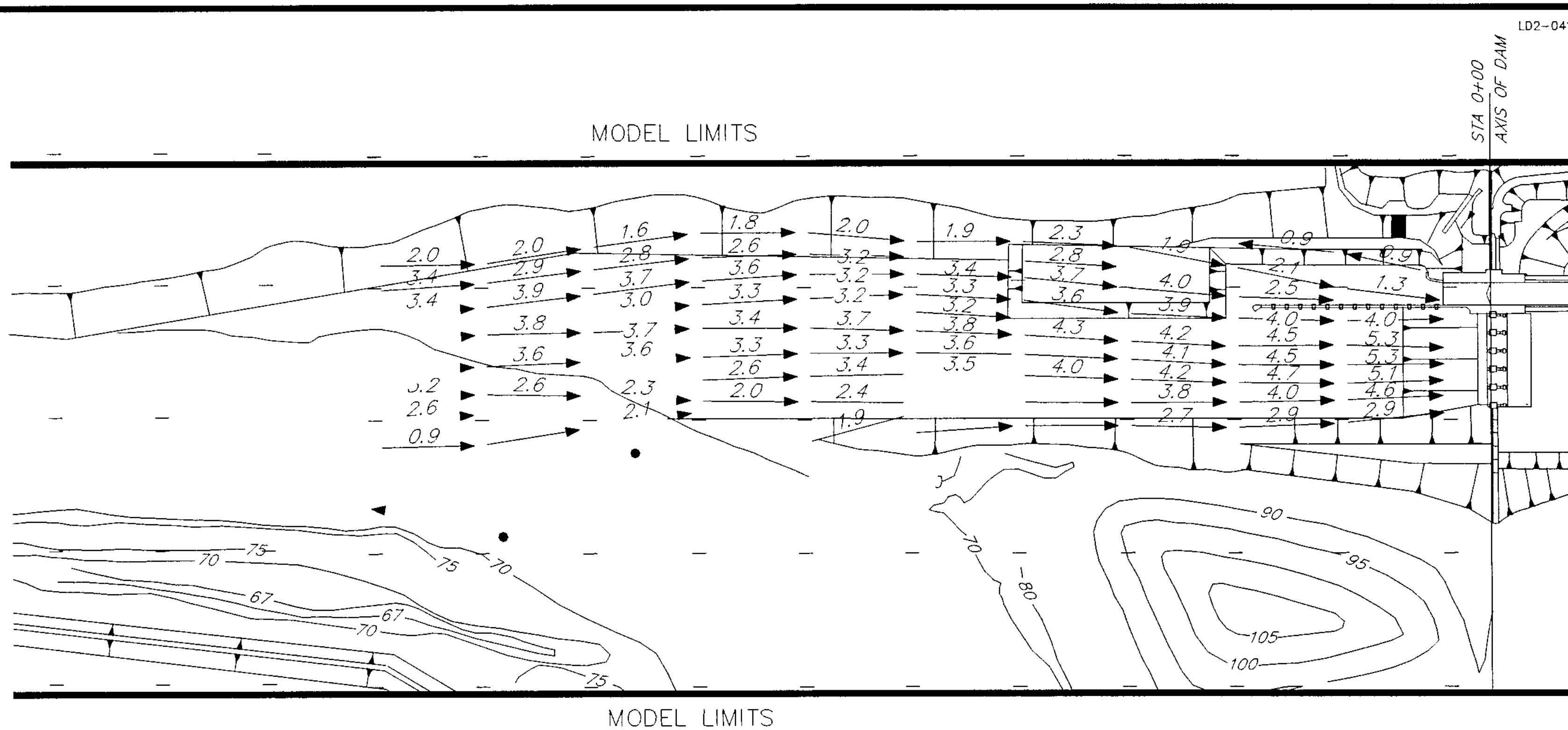

VELOCITIES AND CURRENT DIRECTIONS
PLAN J-3
DISCHARGE: 36,000 CFS
UPPER POOL EL: 64.0 FT
SCALES
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10
LEGEND
3.5 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
MODEL LIMITS
MODEL LIMITS
AXIS OF DAM
STA 0+00
LD2-038

PLATE 40



LEGEND

3.5 → VELOCITY IN FEET PER SECOND
→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

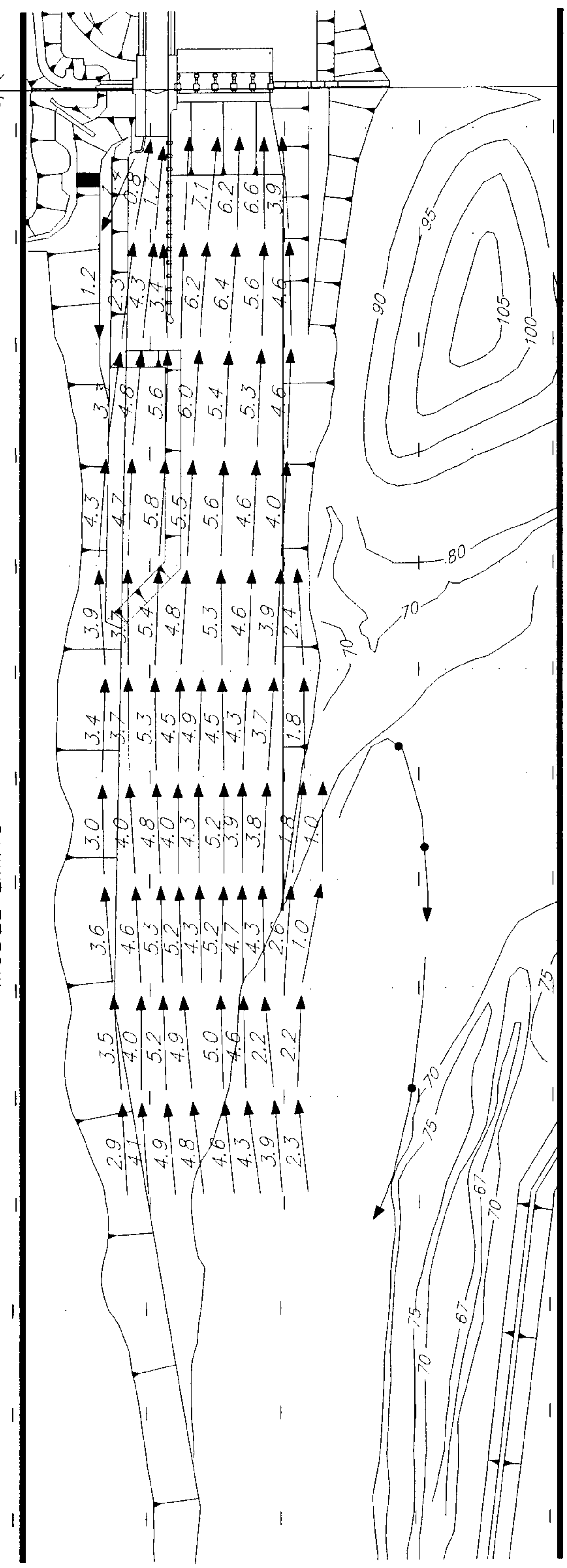
SCALES

PROTOTYPE	500	0	500	1000
MODEL	5	0	5	10

VELOCITIES AND CURRENT DIRECTIONS

PLAN J–3

DISCHARGE: 60,000 CFS
UPPER POOL EL: 64.0 FT



VELOCITIES AND CURRENT DIRECTIONS

PLAN J-3

DISCHARGE: 85,000 CFS
UPPER POOL EL: 64.0 FT

SCALES

PROTOTYPE 500 0 500 1000

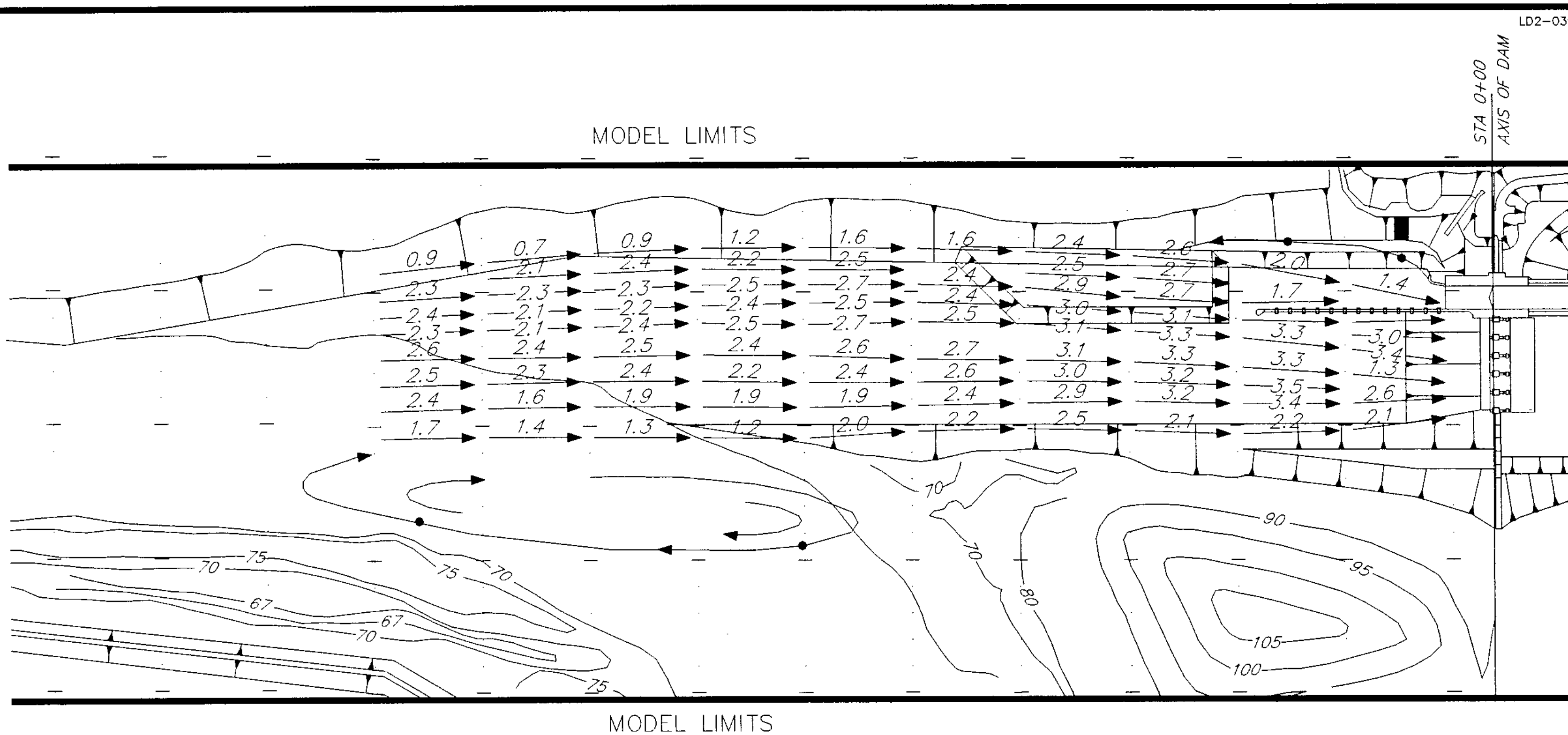
MODEL 5 0 5 10

LEGEND

3.5 → VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD



LEGEND

3.5 → VELOCITY IN FEET PER SECOND
—•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

SCALES

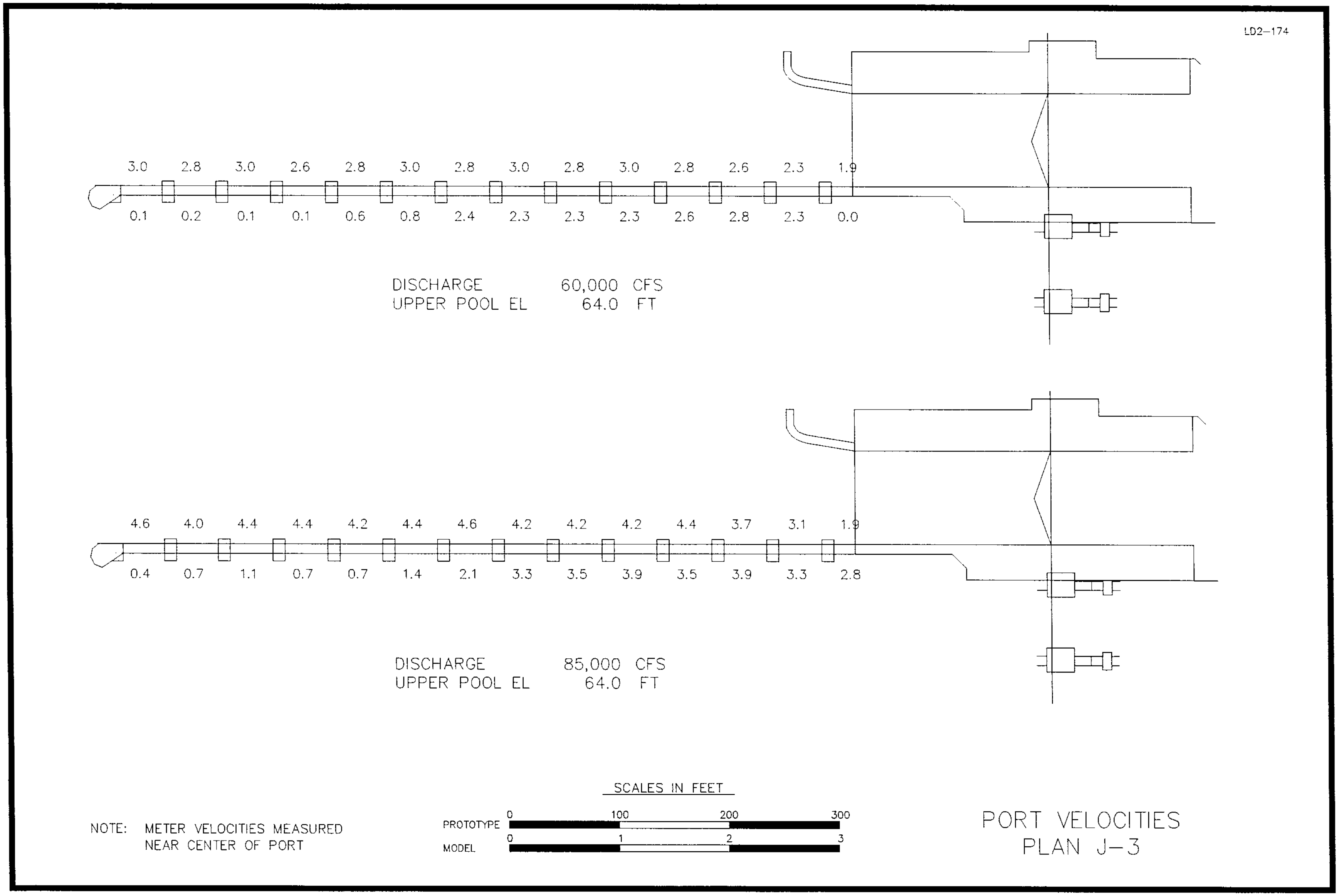
PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

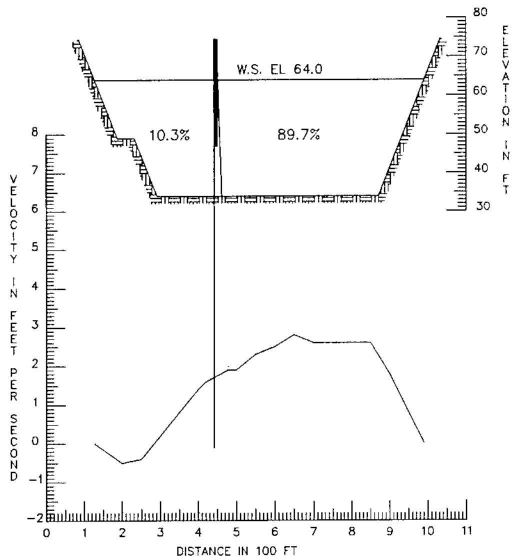
PLAN J–3

DISCHARGE: 36,000 CFS
UPPER POOL EL: 58.0 FT

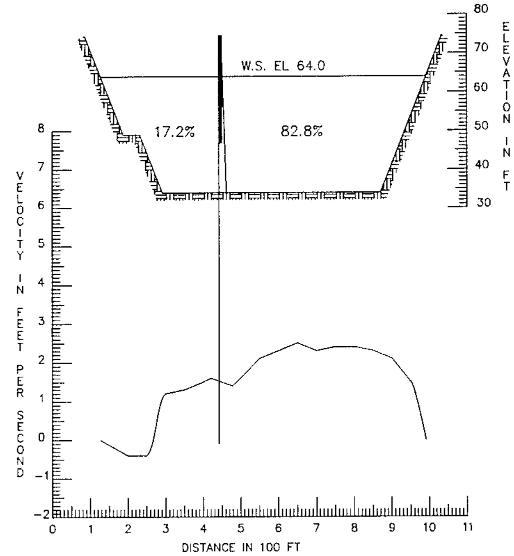


PORT VELOCITIES
PLAN J-3

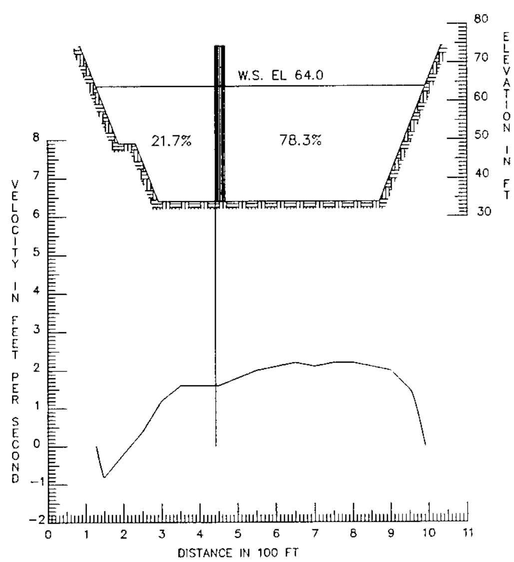
LD2-043



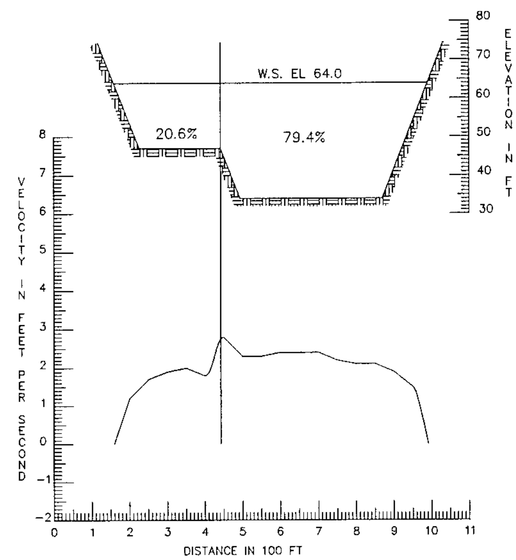
STATION 4+25



STATION 6+75



STATION 9+25



STATION 14+25

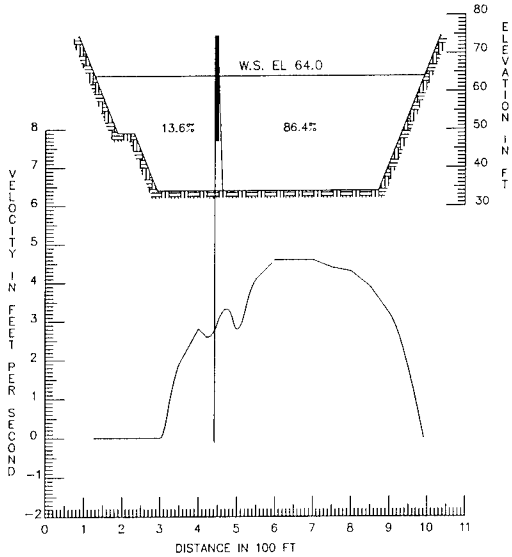
NOTE: VELOCITIES TAKEN AT SIX-TENTHS DEPTH WITH MINIATURE MAGNETIC METER

METER VELOCITIES

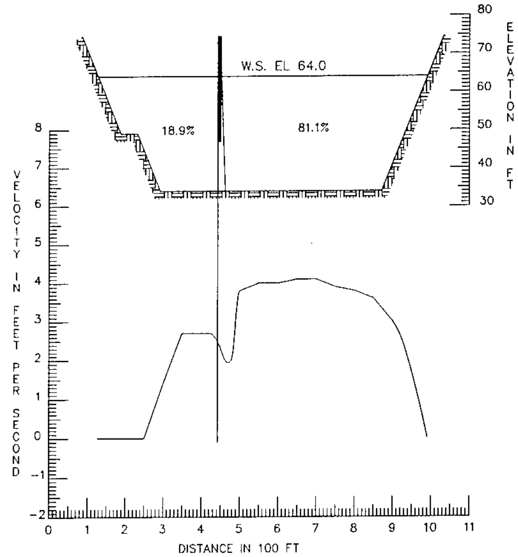
PLAN J-3

DISCHARGE: 36,000 CFS
UPPER POOL EL: 64.0 FT

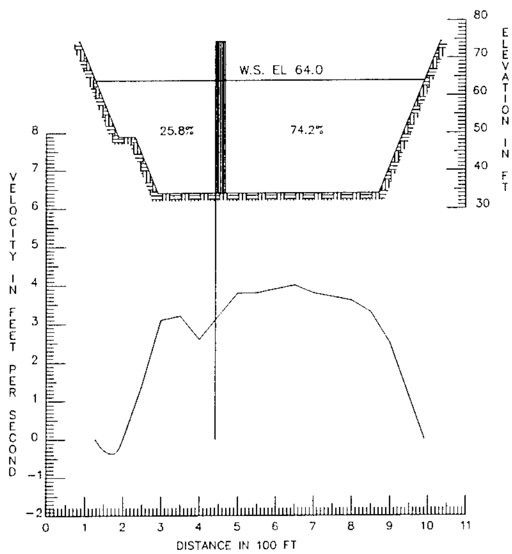
LD2-045



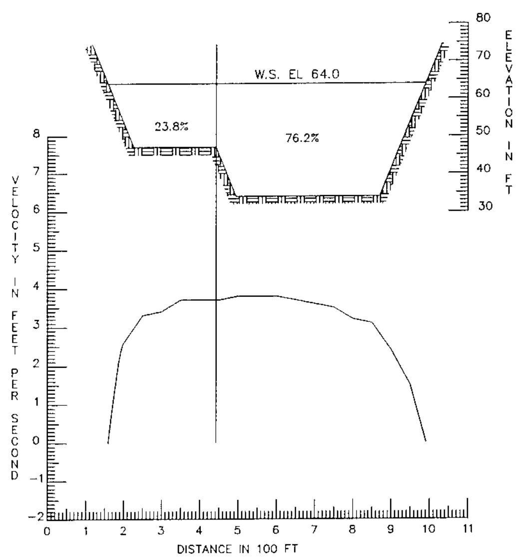
STATION 4+25



STATION 6+75



STATION 9+25



STATION 14+25

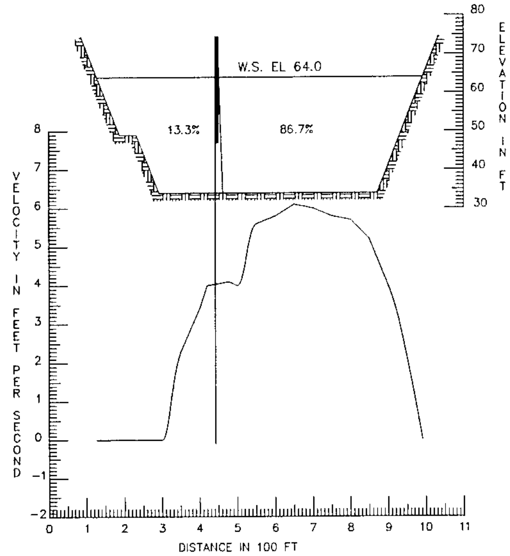
NOTE: VELOCITIES TAKEN AT SIX-TENTHS DEPTH WITH MINIATURE VELOCITY METER

METER VELOCITIES

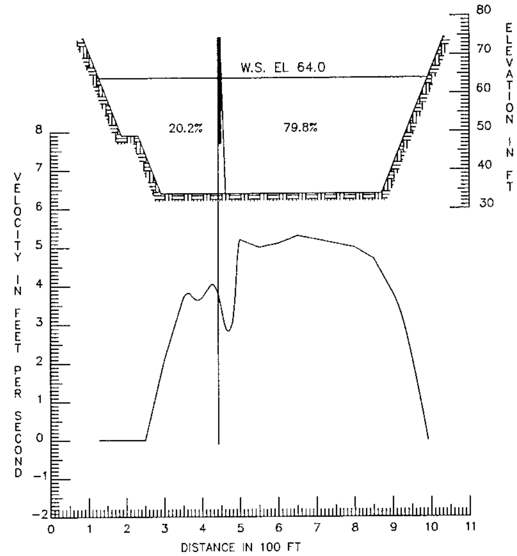
PLAN J-3

DISCHARGE: 60,000 CFS
UPPER POOL EL: 64.0 FT

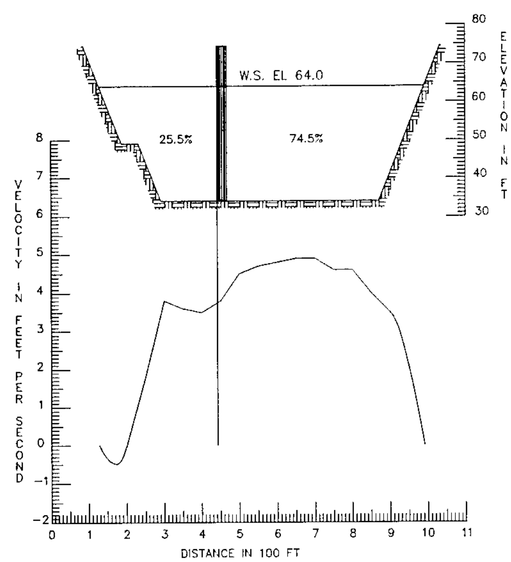
LD2-046



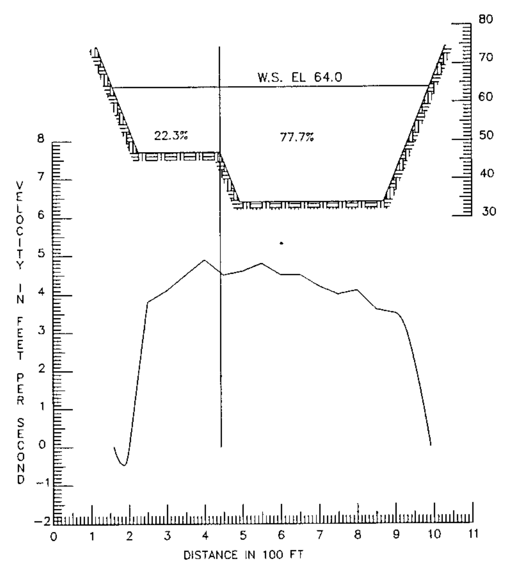
STATION 4+25



STATION 6+75



STATION 9+25



STATION 14+25

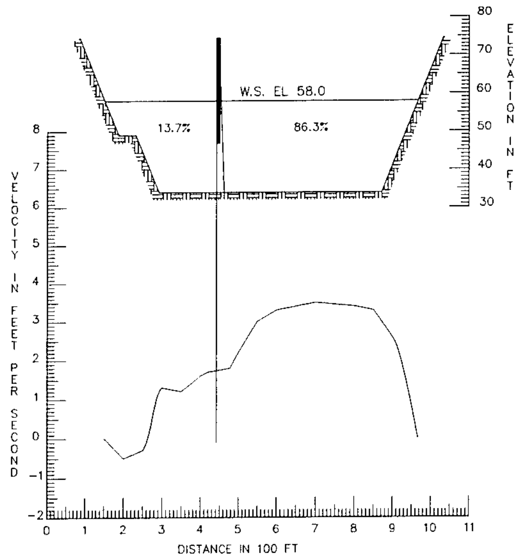
NOTE: VELOCITIES TAKEN AT SIX-TENTHS DEPTH WITH MINIATURE VELOCITY METER

METER VELOCITIES

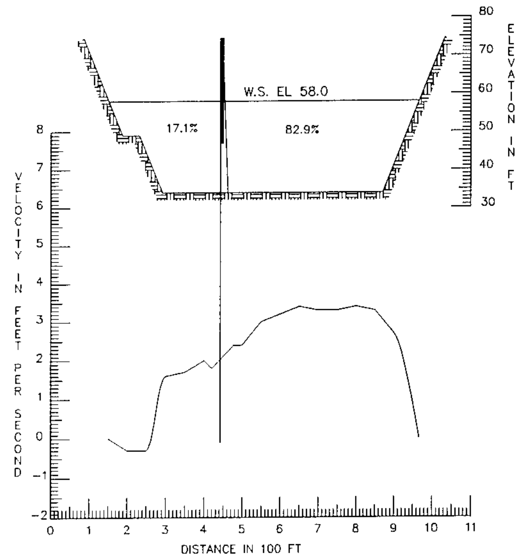
PLAN J-3

DISCHARGE: 85,000 CFS
UPPER POOL EL: 64.0 FT

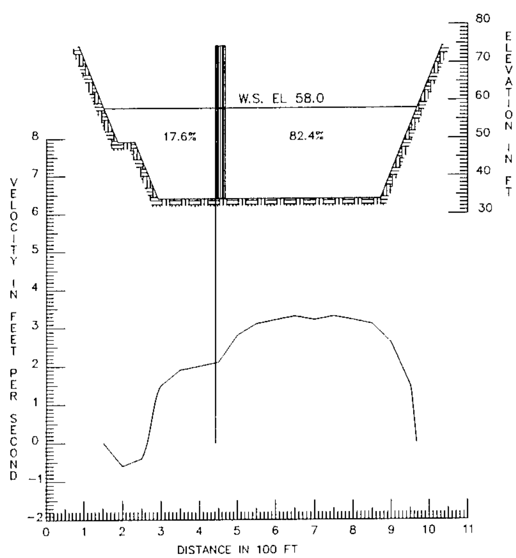
LD2-042



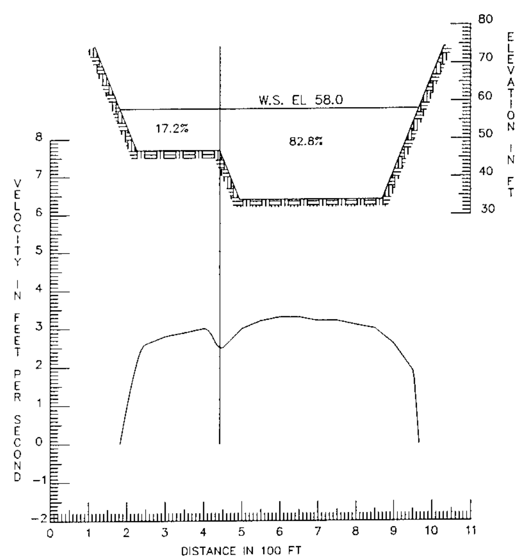
STATION 4+25



STATION 6+75



STATION 9+25



STATION 14+25

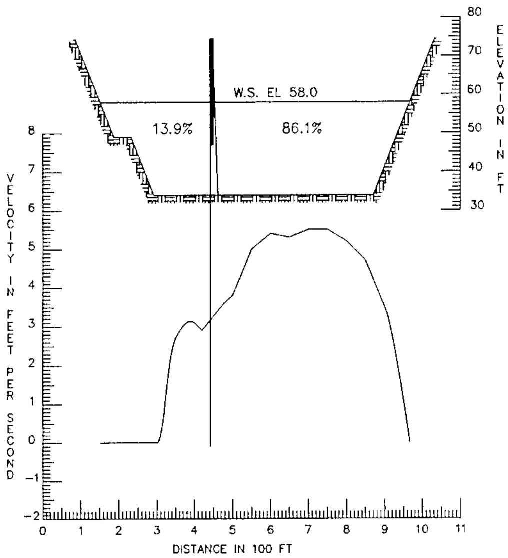
NOTE: VELOCITIES TAKEN AT SIX-TENTHS DEPTH WITH MINIATURE VELOCITY METER

METER VELOCITIES

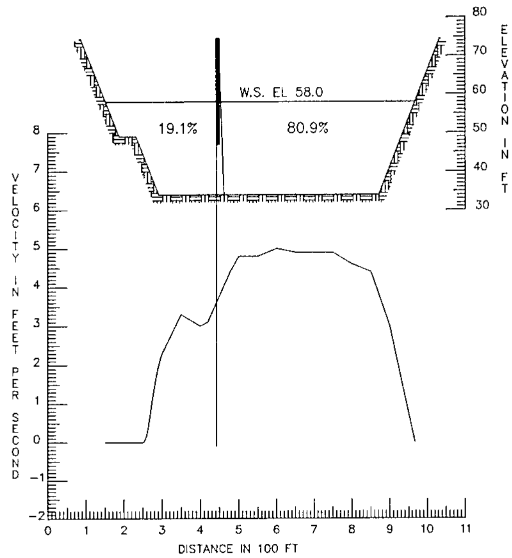
PLAN J-3

DISCHARGE: 36,000 CFS
UPPER POOL EL: 58.0 FT

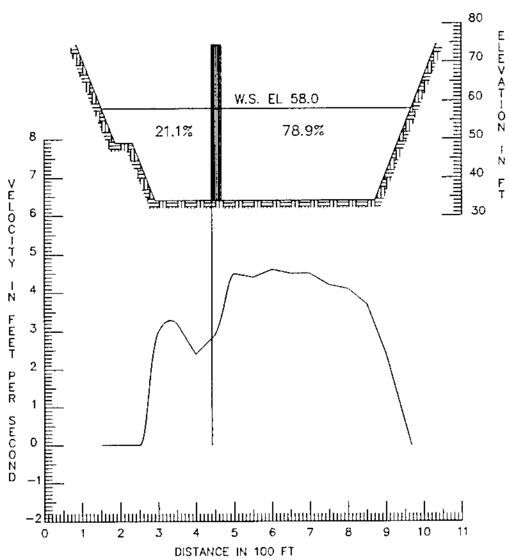
LD2-044



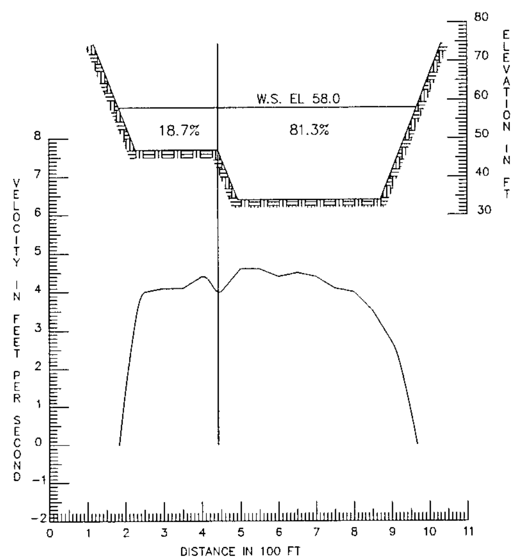
STATION 4+25



STATION 6+75



STATION 9+25



STATION 14+25

NOTE: VELOCITIES TAKEN AT SIX-TENTHS DEPTH WITH MINIATURE VELOCITY METER

METER VELOCITIES

PLAN J-3

DISCHARGE: 60,000 CFS
UPPER POOL EL: 58.0 FT

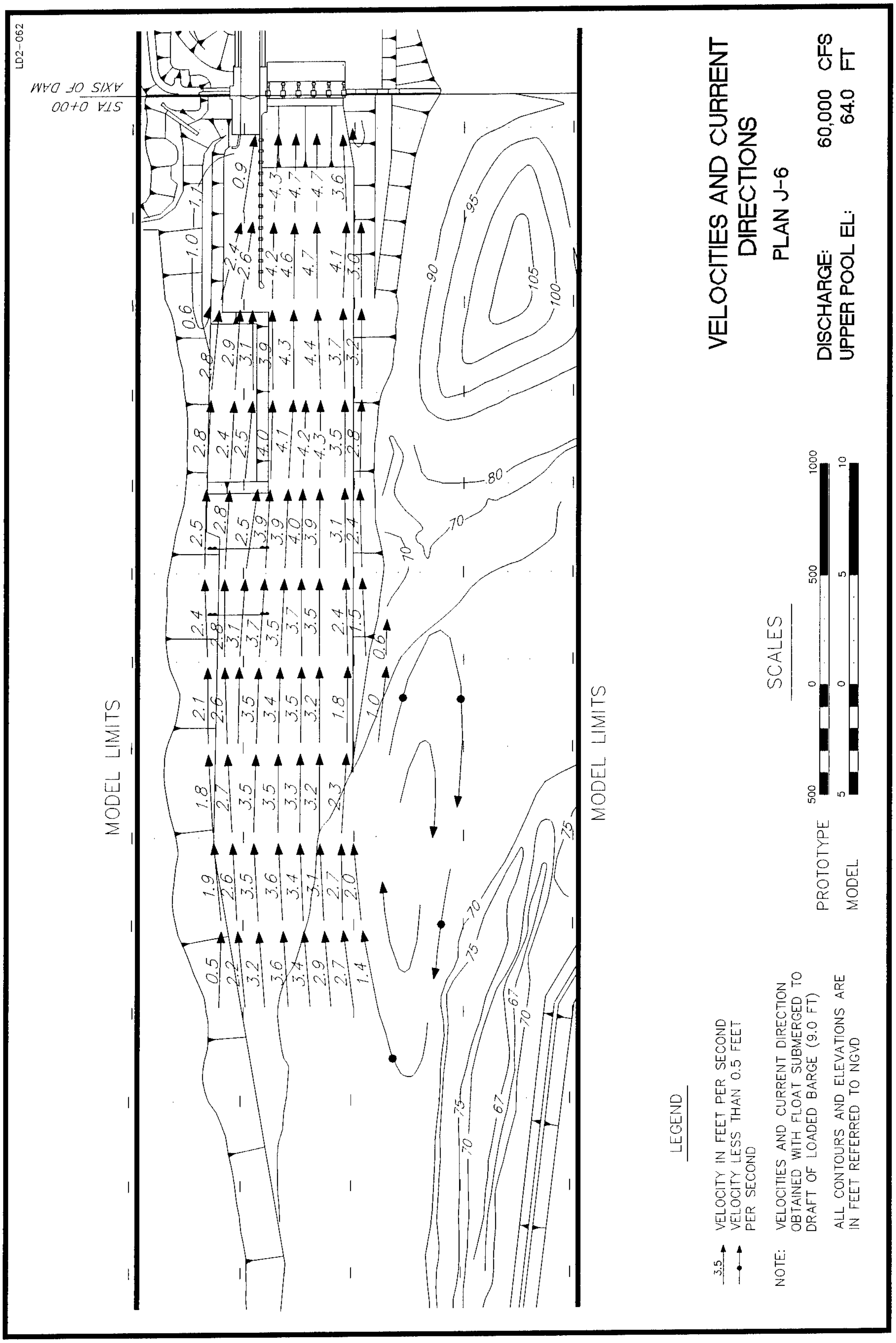
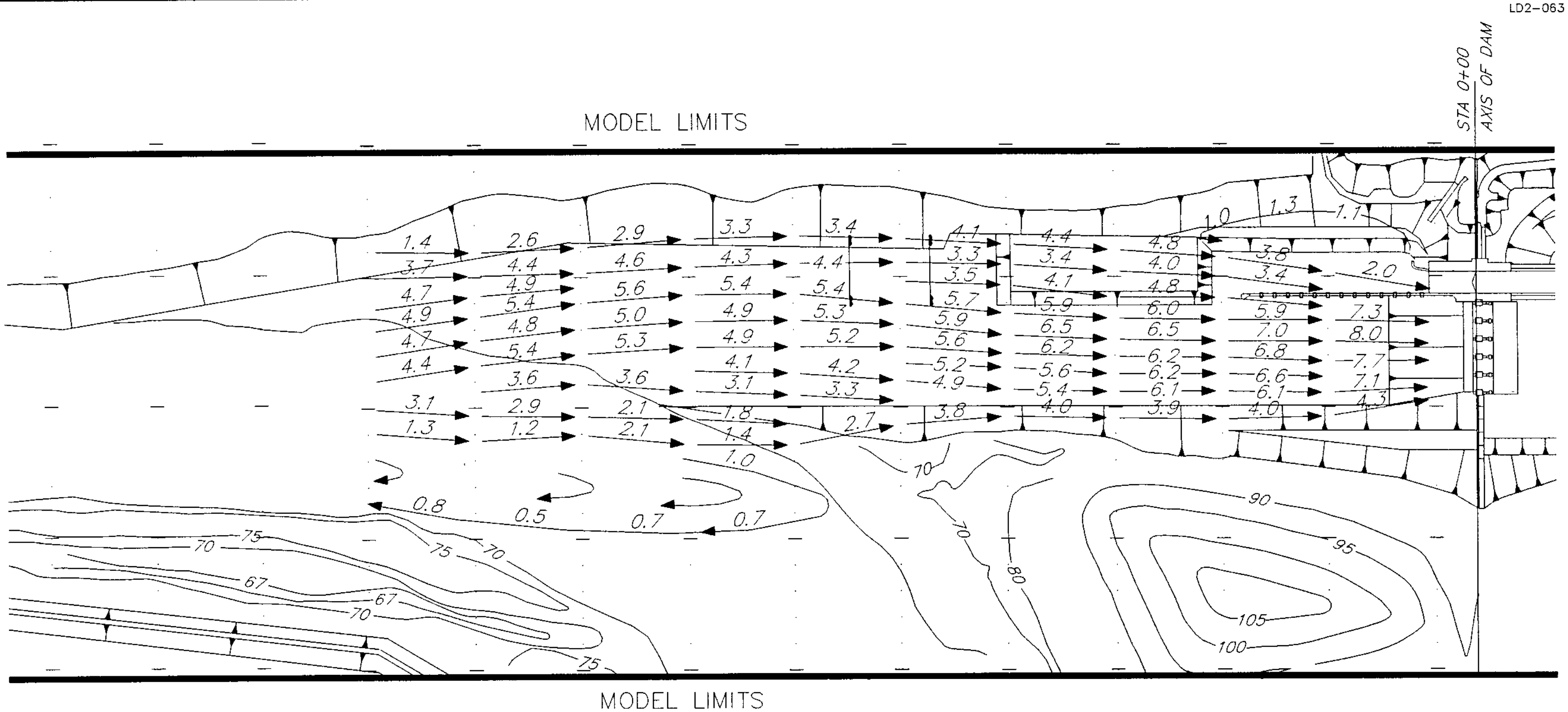

VELOCITIES AND CURRENT DIRECTIONS
PLAN J-6
DISCHARGE: 60,000 CFS
UPPER POOL EL: 64.0 FT
LD2-062
STA 0+00
AXIS OF DAM
MODEL LIMITS
MODEL LIMITS
SCALES
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10
LEGEND
3.5 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

PLATE 50



LEGEND

3.5 → VELOCITY IN FEET PER SECOND
—•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

SCALES

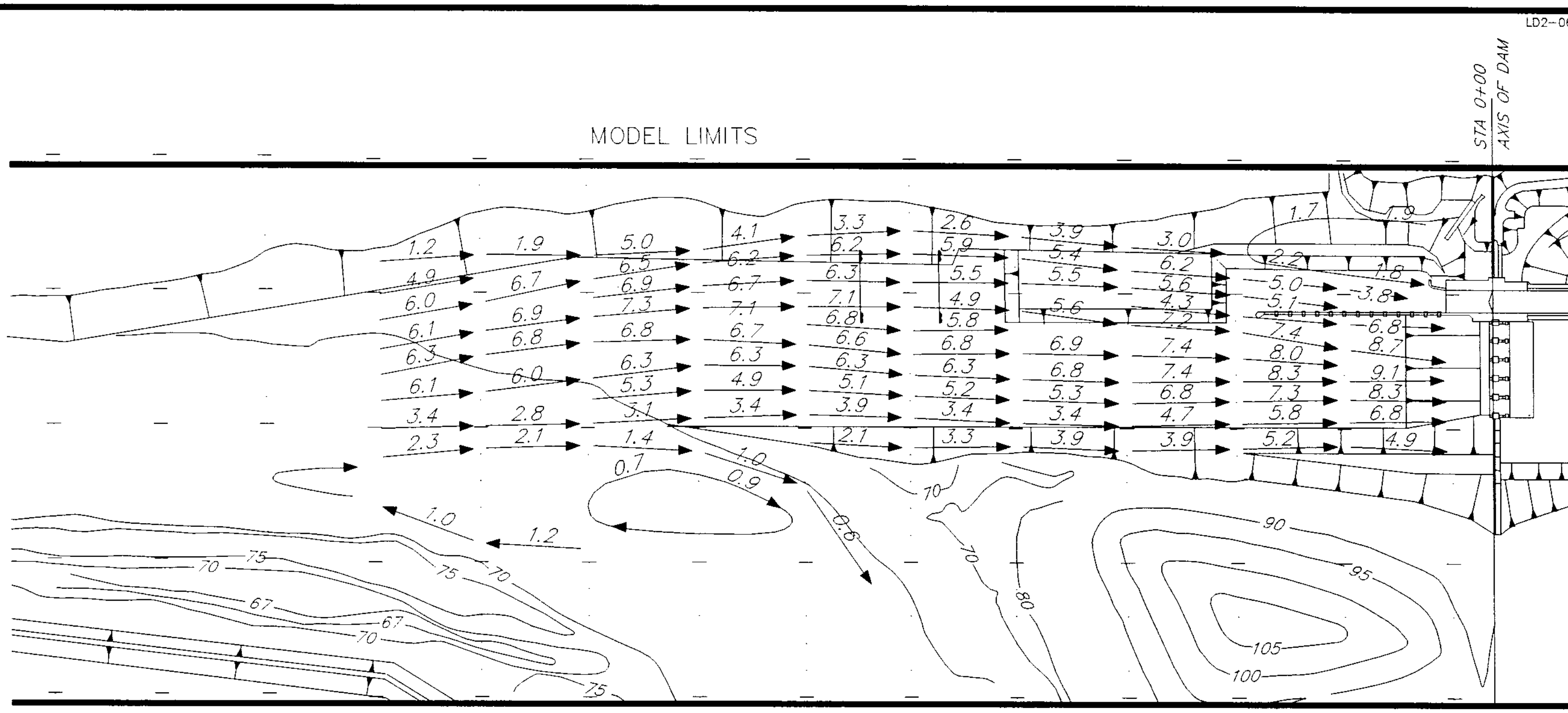
PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

PLAN J-6

DISCHARGE: 85,000 CFS
UPPER POOL EL: 64.0 FT



LEGEND

3.5 → VELOCITY IN FEET PER SECOND

→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

SCALES

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

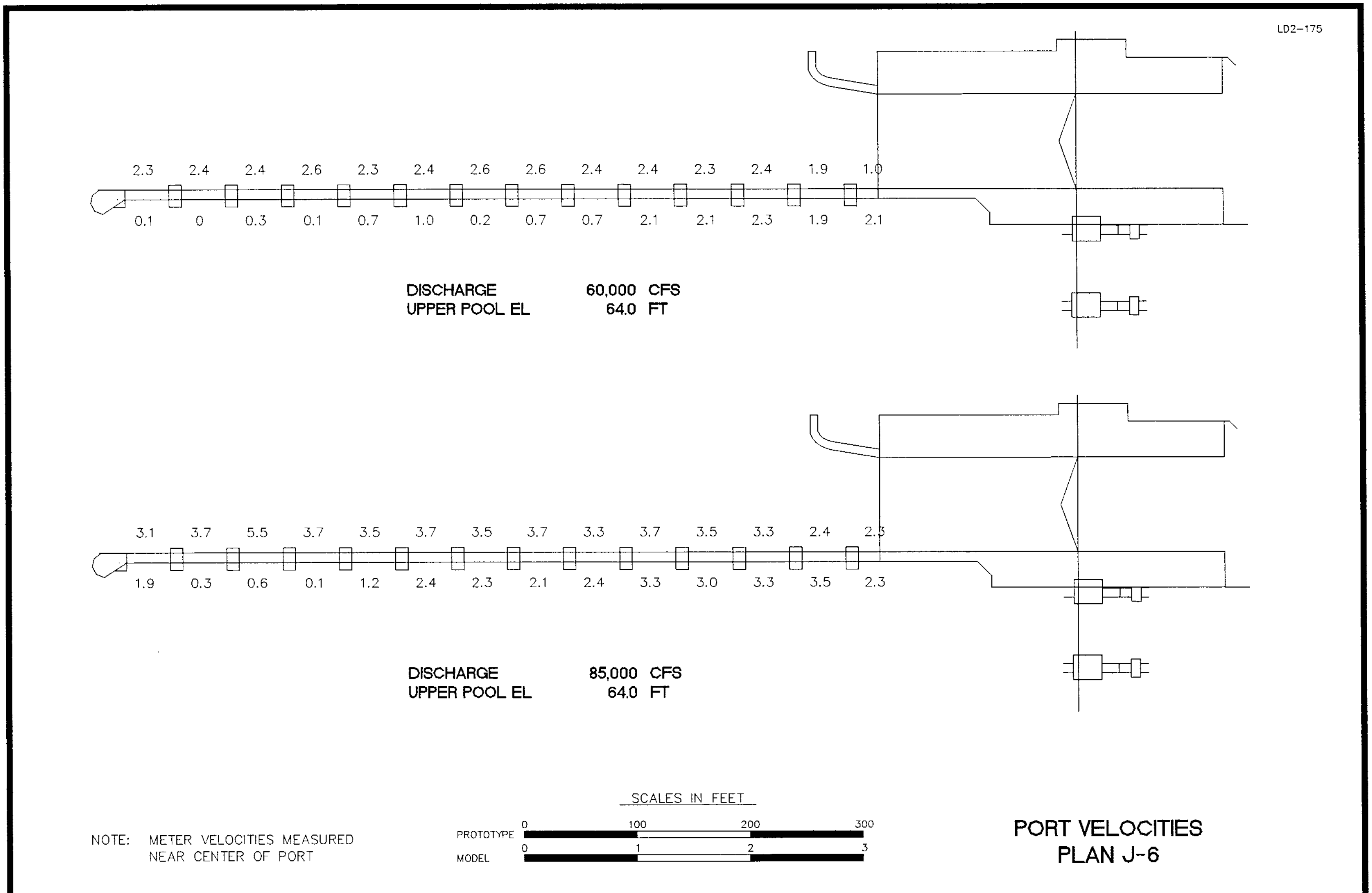
VELOCITIES AND CURRENT DIRECTIONS

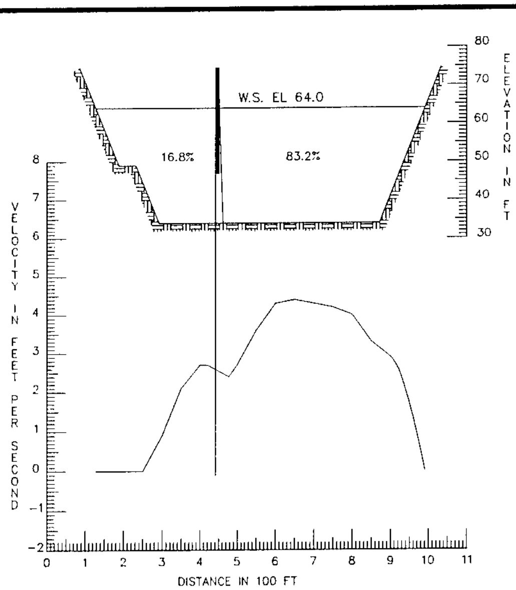
PLAN J-6

DISCHARGE: 145,000 CFS

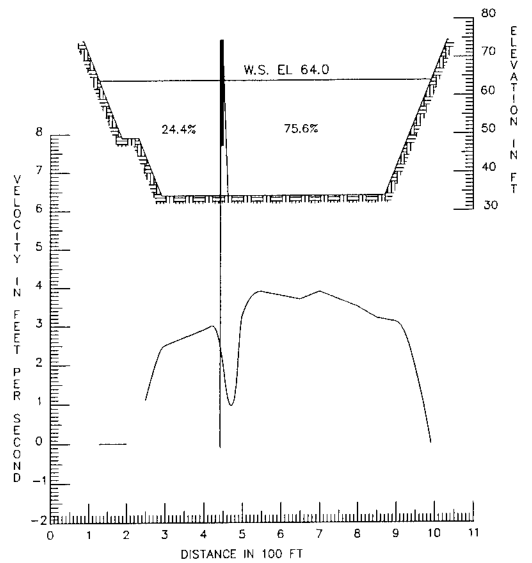
UPPER POOL EL: 74.1 FT

PLATE 52

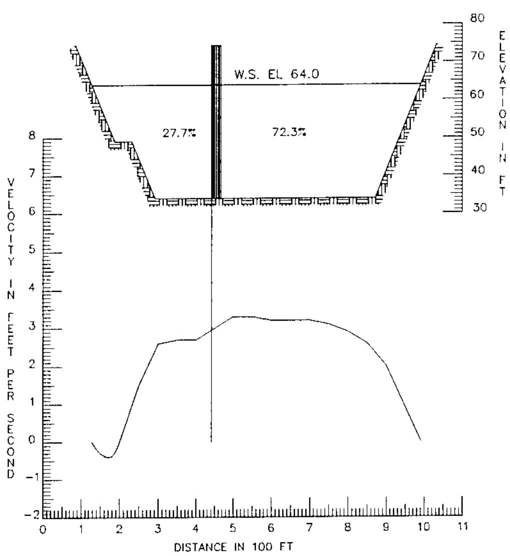

LD2-175
2.3 2.4 2.4 2.6 2.3 2.4 2.6 2.6 2.4 2.4 2.3 2.4 1.9 1.0
0.1 0 0.3 0.1 0.7 1.0 0.2 0.7 0.7 2.1 2.1 2.3 1.9 2.1
DISCHARGE 60,000 CFS
UPPER POOL EL 64.0 FT
3.1 3.7 5.5 3.7 3.5 3.7 3.5 3.7 3.3 3.7 3.5 3.3 2.4 2.3
1.9 0.3 0.6 0.1 1.2 2.4 2.3 2.1 2.4 3.3 3.0 3.3 3.5 2.3
DISCHARGE 85,000 CFS
UPPER POOL EL 64.0 FT
NOTE: METER VELOCITIES MEASURED
NEAR CENTER OF PORT
SCALES IN FEET
PROTOTYPE 0 100 200 300
MODEL 0 1 2 3
PORT VELOCITIES
PLAN J-6



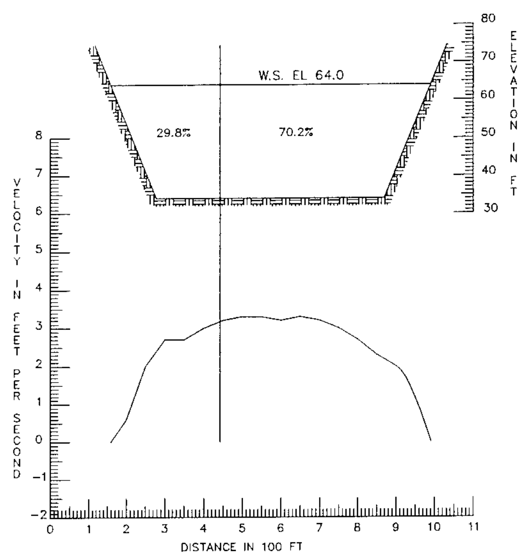
STATION 4+25



STATION 6+75



STATION 9+25



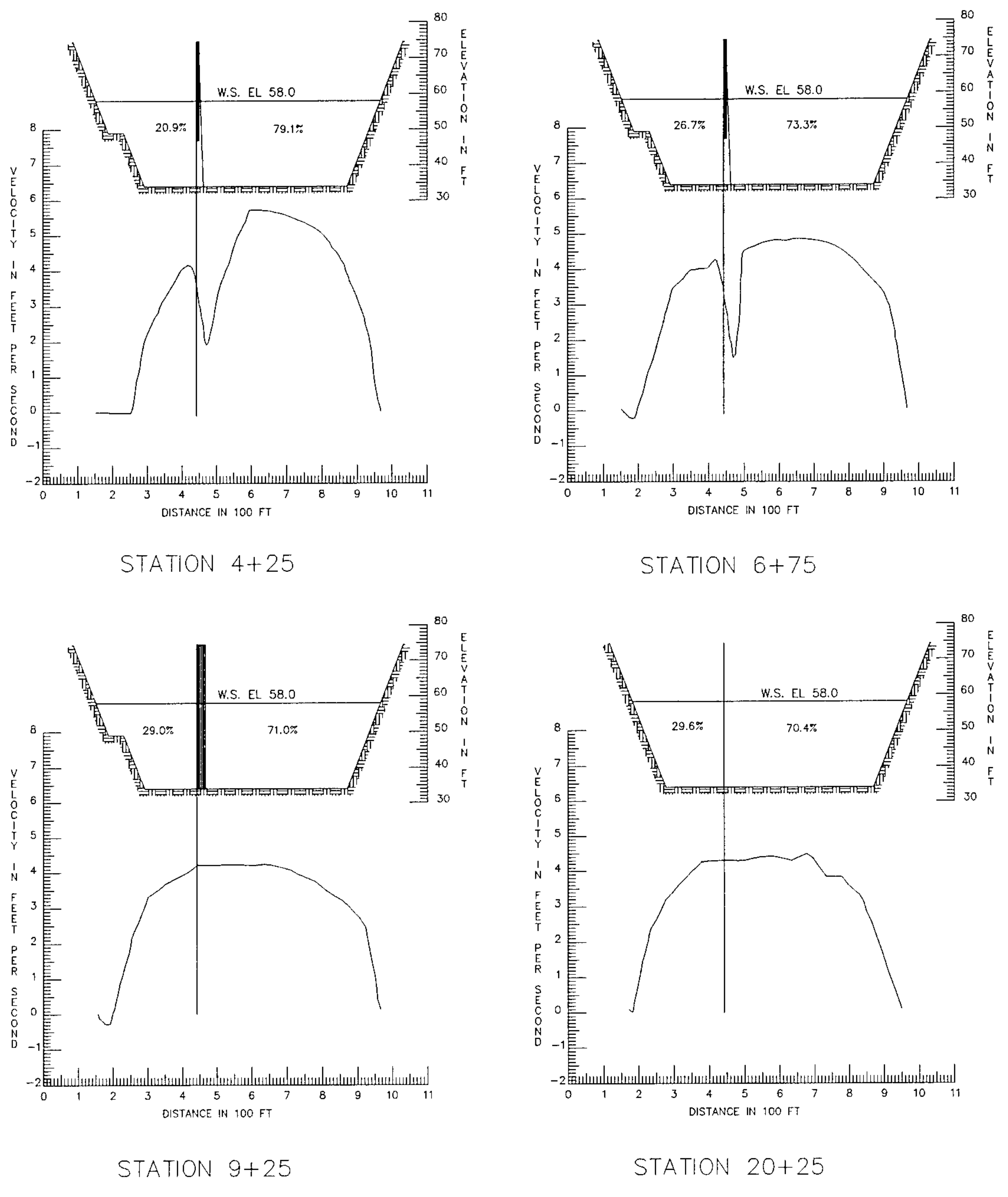
STATION 14+25

NOTE: VELOCITIES TAKEN AT SIX-TENTH DEPTH WITH MINIATURE VELOCITY METER

METER VELOCITIES

PLAN J-4

DISCHARGE: 60,000 CFS
UPPER POOL EL: 64.0 FT

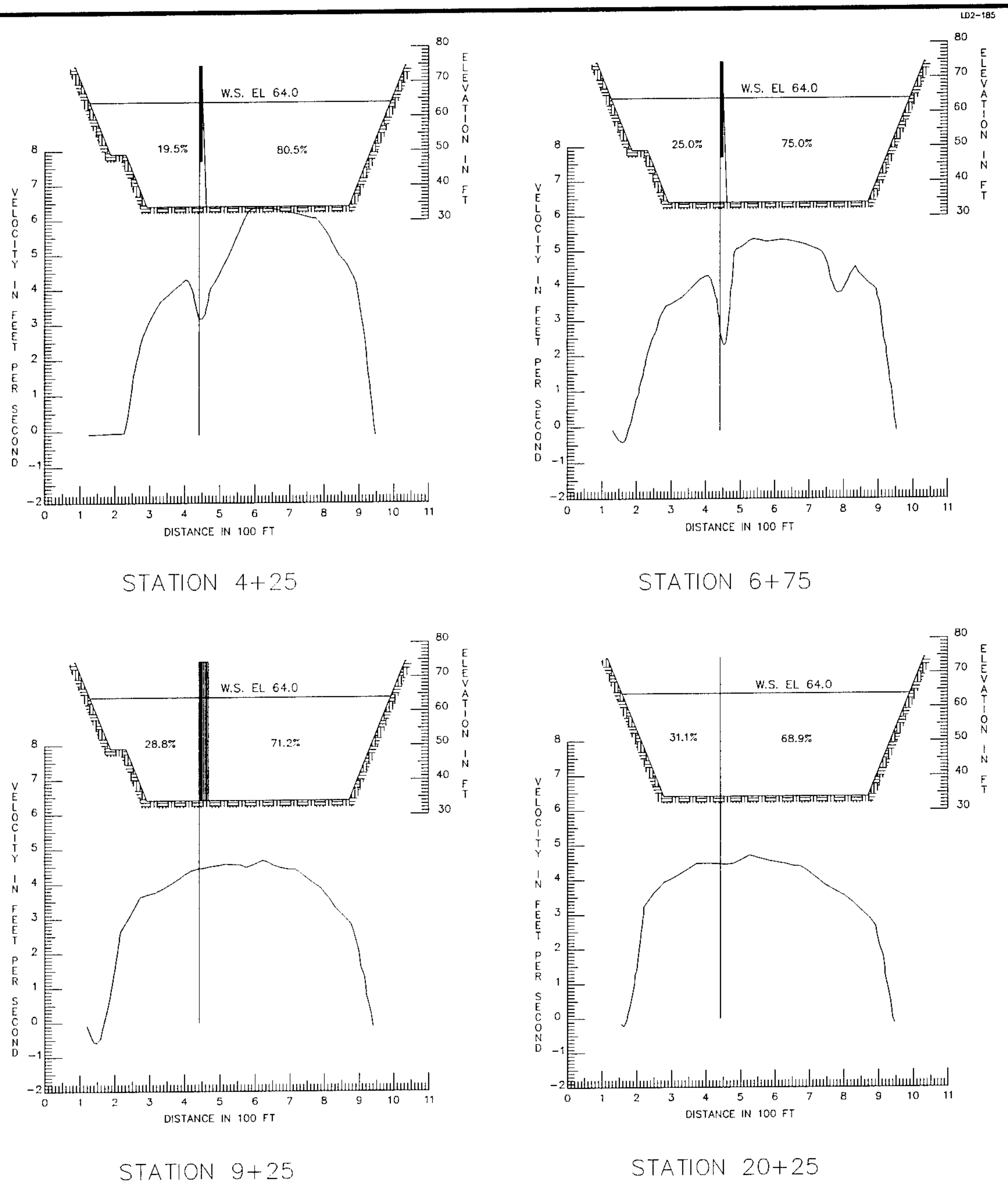


NOTE: VELOCITIES TAKEN AT SIX-TENTHS DEPTH WITH MINIATURE VELOCITY METER

METER VELOCITIES

PLAN J-4

DISCHARGE: 60,000 CFS
UPPER POOL EL: 58.0 FT

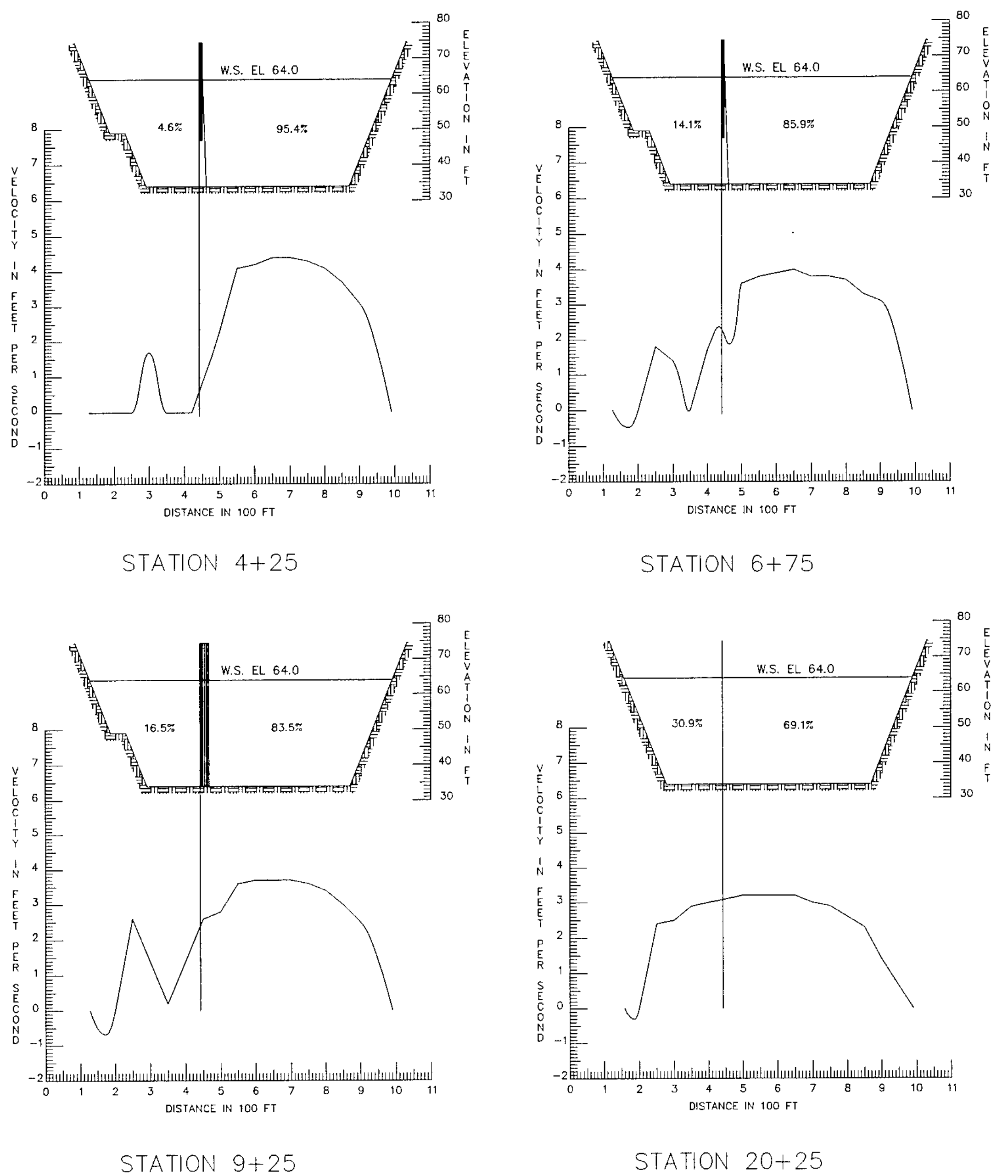


NOTE: VELOCITIES TAKEN AT SIX-TENTHS DEPTH WITH MINIATURE VELOCITY METER

METER VELOCITIES

PLAN J-4

DISCHARGE: 85,000 CFS
UPPER POOL EL: 64.0 FT

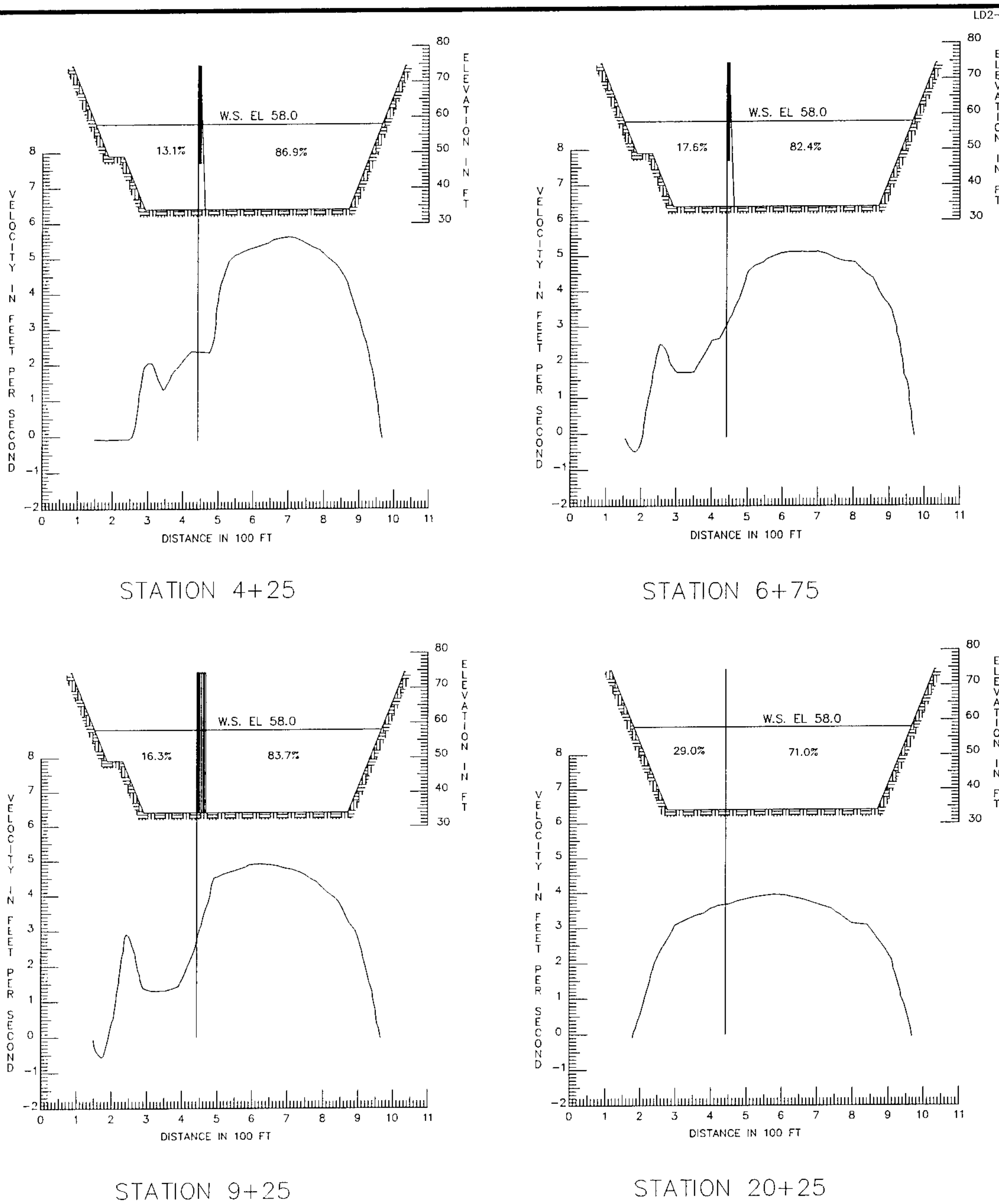


NOTE: VELOCITIES TAKEN AT SIX-TENTHS DEPTH WITH MINIATURE VELOCITY METER

METER VELOCITIES

PLAN J-5

DISCHARGE: 60,000 CFS
UPPER POOL EL: 64.0 FT



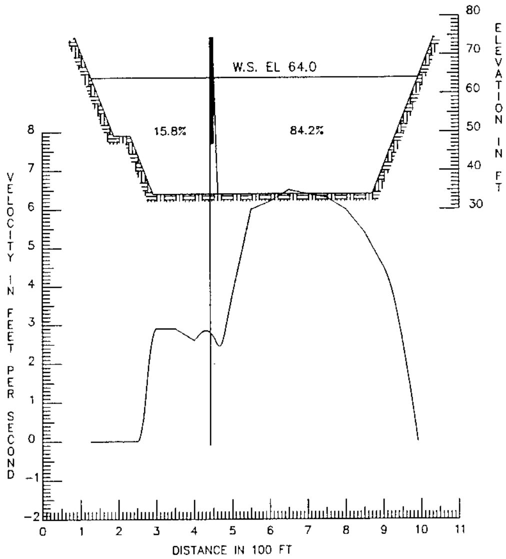
NOTE: VELOCITIES TAKEN AT SIX-TENTHS DEPTH WITH MINIATURE VELOCITY METER

METER VELOCITIES

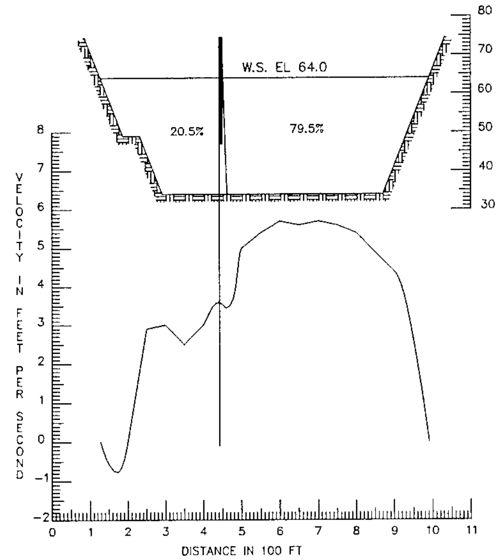
PLAN J-5

DISCHARGE: 60,000 CFS
UPPER POOL EL: 58.0 FT

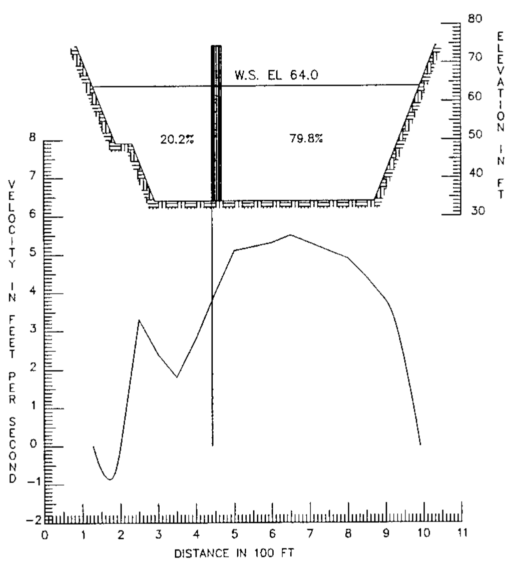
LD2-057



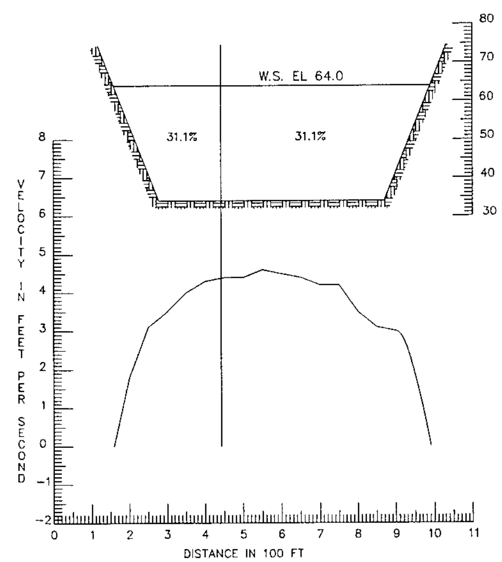
STATION 4+25



STATION 6+75



STATION 9+25



STATION 20+25

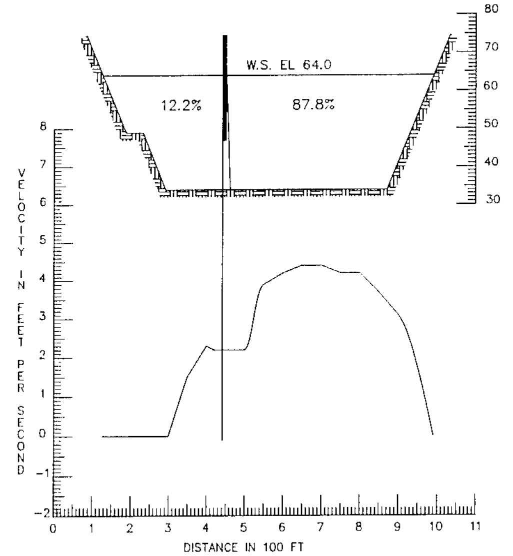
NOTE: VELOCITIES TAKEN AT SIX-TENTHS DEPTH WITH MINIATURE VELOCITY METER

METER VELOCITIES

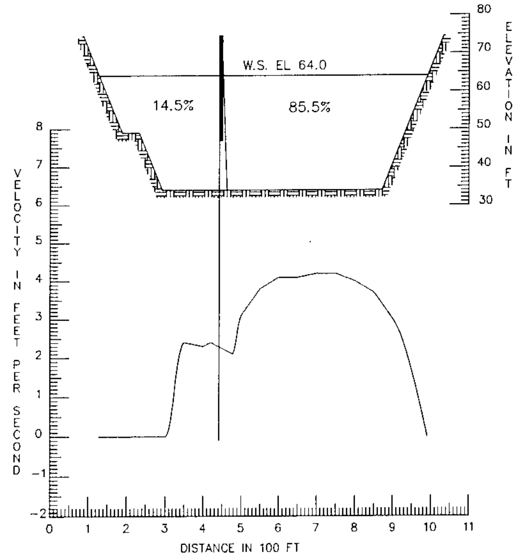
PLAN J-5

DISCHARGE: 85,000 CFS
UPPER POOL EL: 64.0 FT

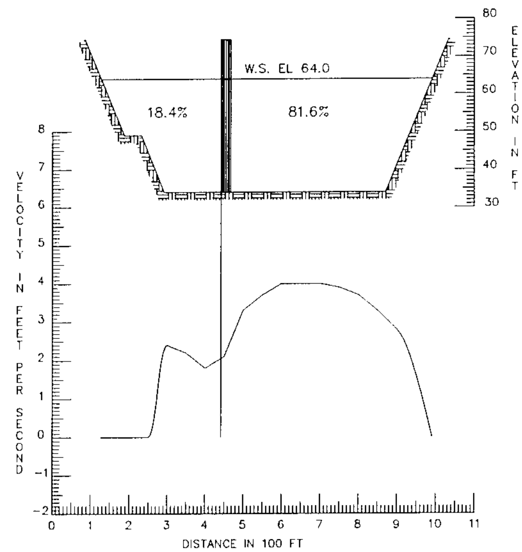
ld2-068



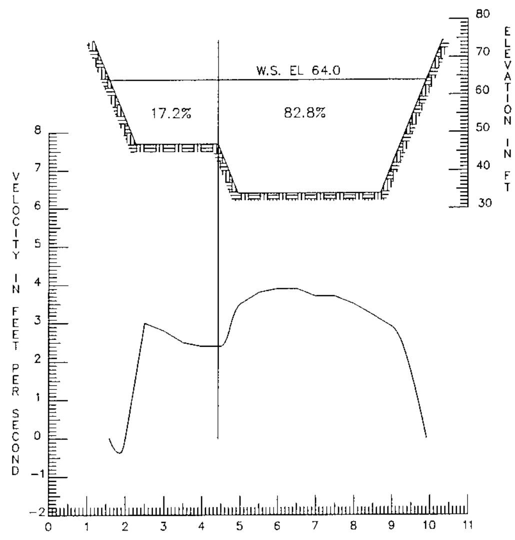
STATION 4+25



STATION 6+75



STATION 9+25



STATION 14+25

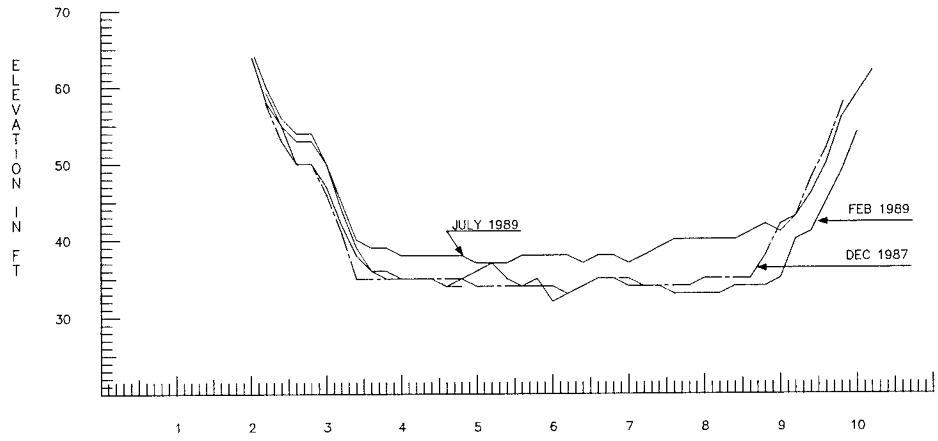
NOTE: VELOCITIES TAKEN AT SIX-TENTHS DEPTH WITH MINIATURE VELOCITY METER

METER VELOCITIES

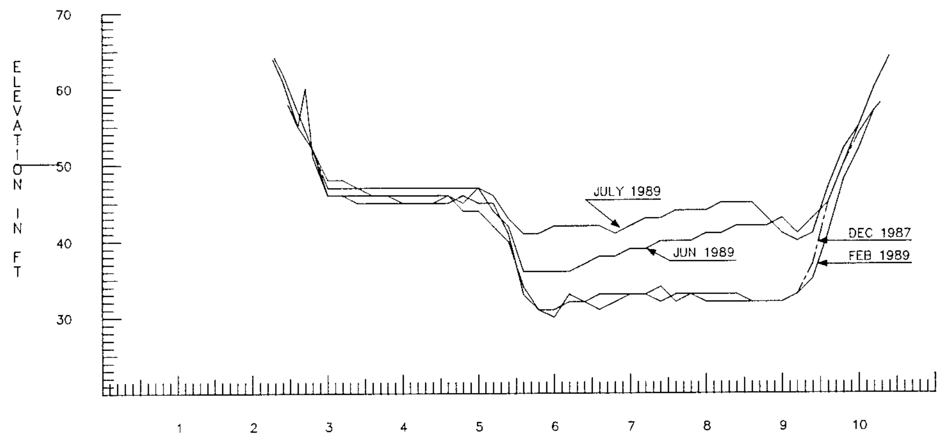
PLAN J-6

DISCHARGE: 60,000 CFS
UPPER POOL EL: 64.0 FT

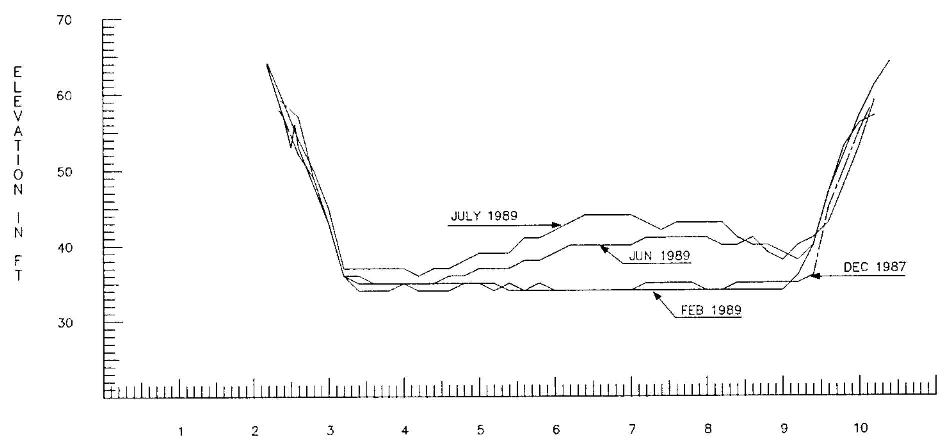
LD2-075A



STATION 9+00 LOOKING DOWNSTREAM



STATION 15+00 LOOKING DOWNSTREAM

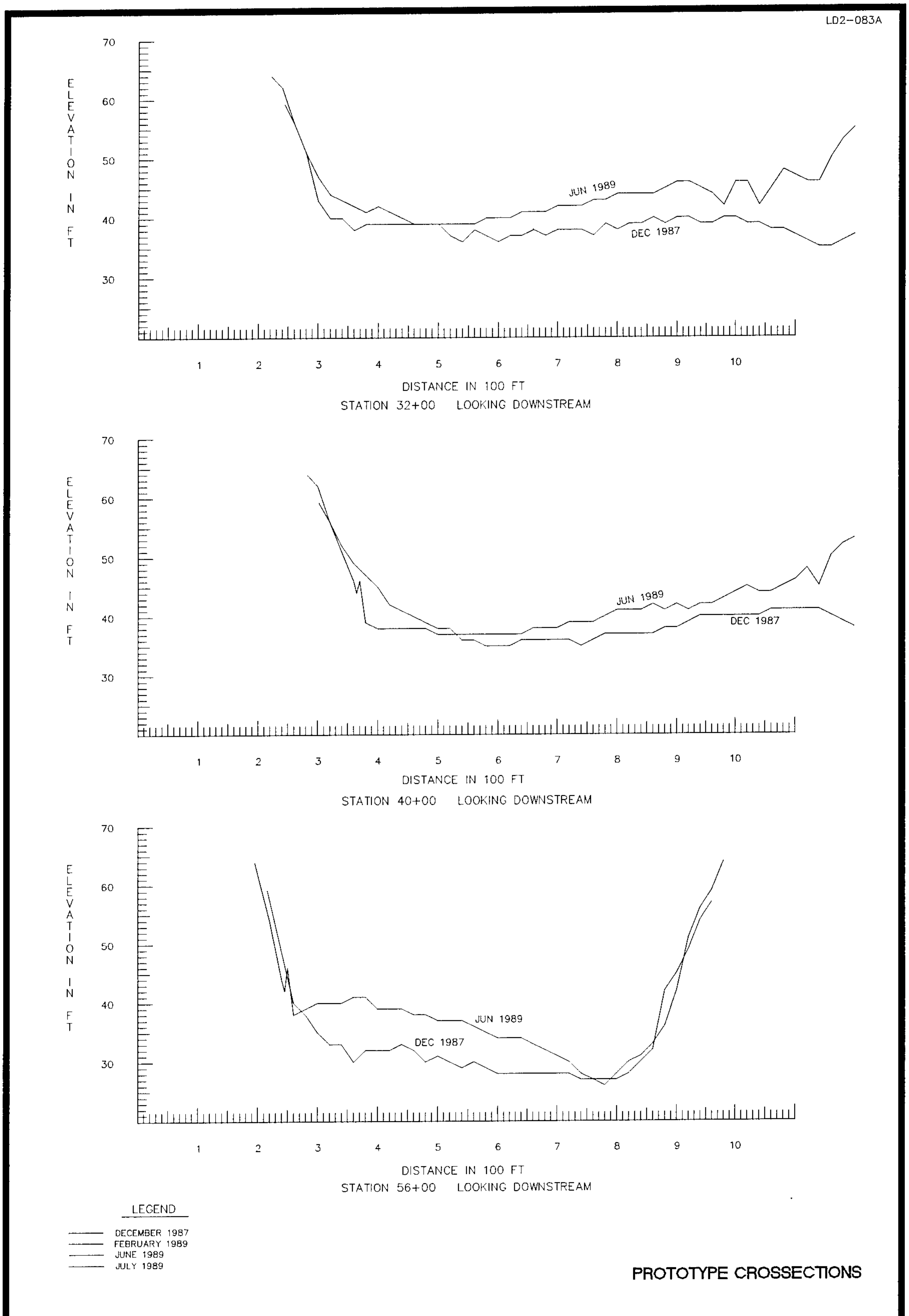


STATION 20+00 LOOKING DOWNSTREAM

LEGEND

- DECEMBER 1987
- FEBRUARY 1989
- JUNE 1989
- JULY 1989

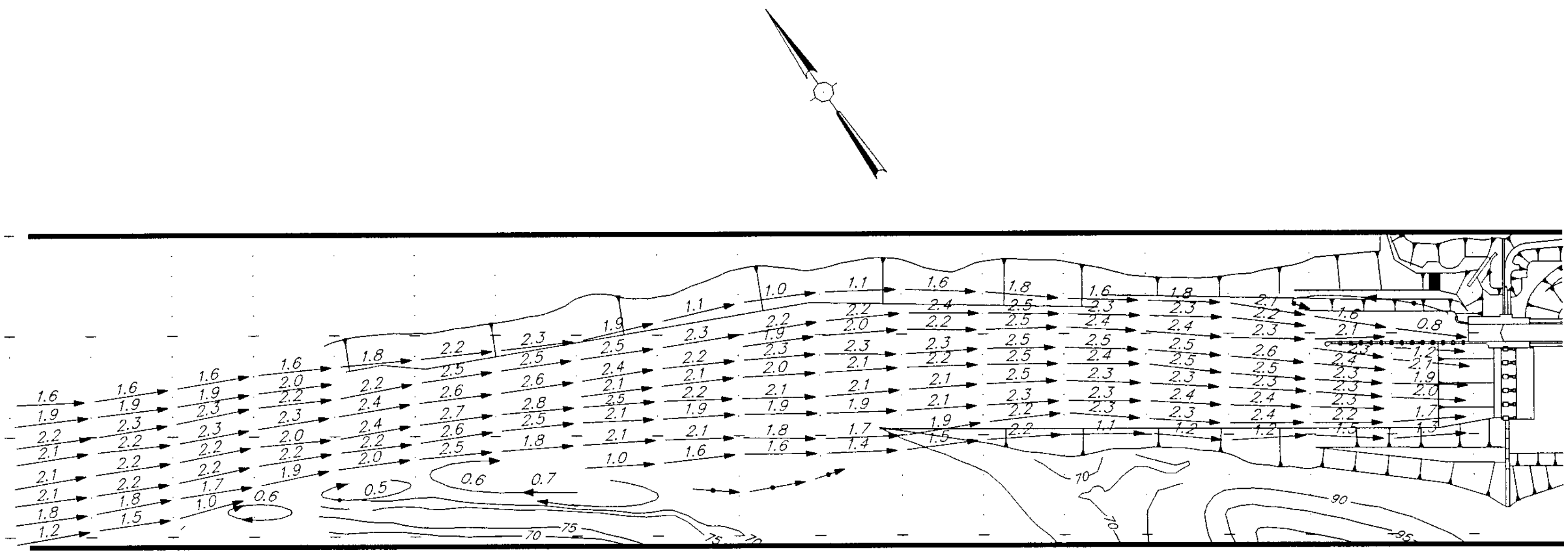
PROTOTYPE CROSSECTIONS



PROTOTYPE CROSSECTIONS

PLATE 62

LD2-178



LEGEND

3.5 → VELOCITY IN FEET PER SECOND
—•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

SCALES

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

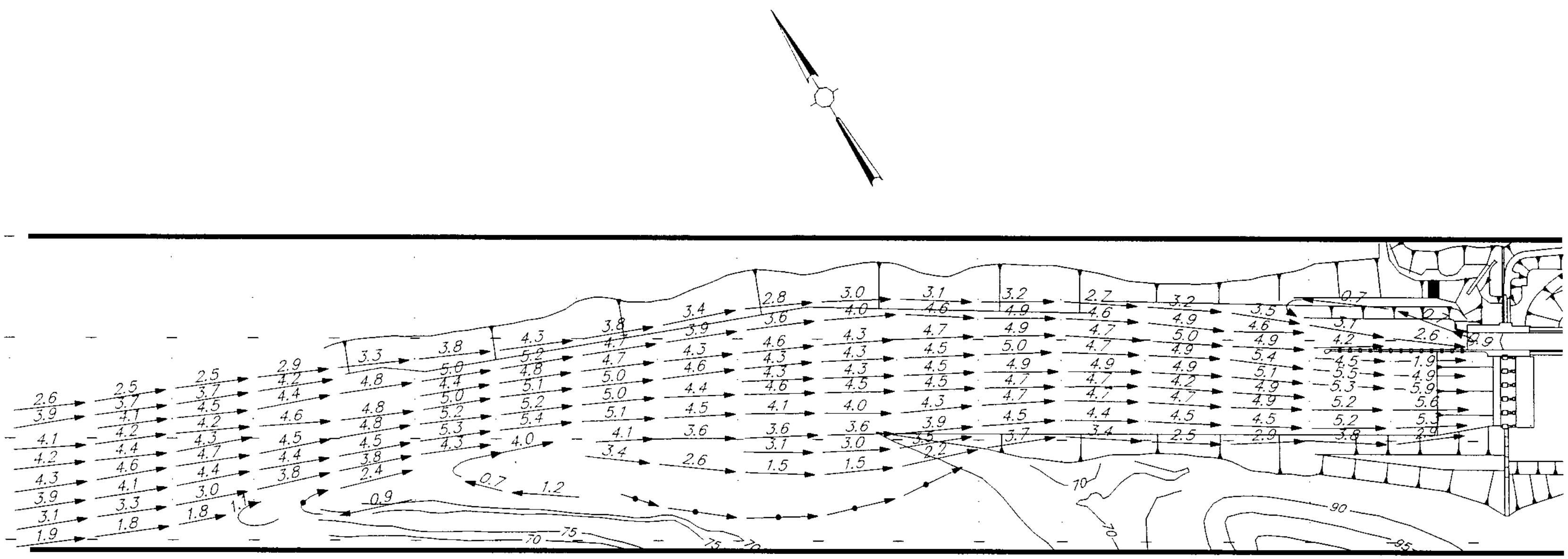
VELOCITIES AND CURRENT DIRECTIONS

PLAN K

DISCHARGE: 31,000 CFS

UPPER POOL EL: 64.0 FT

LD2-179



LEGEND

3.5 → VELOCITY IN FEET PER SECOND

—•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

SCALES

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

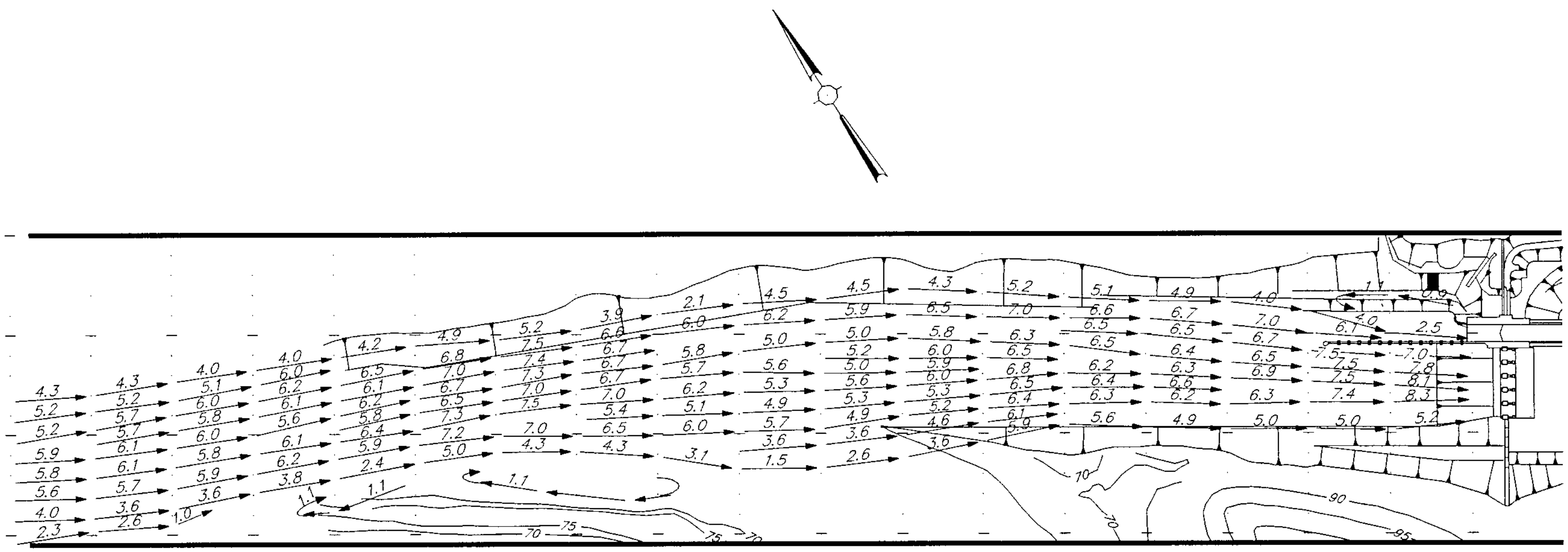
VELOCITIES AND CURRENT DIRECTIONS

PLAN K

DISCHARGE: 60,000 CFS

UPPER POOL EL: 64.0 FT

LD2-180



LEGEND

3.5 → VELOCITY IN FEET PER SECOND

—•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

SCALES

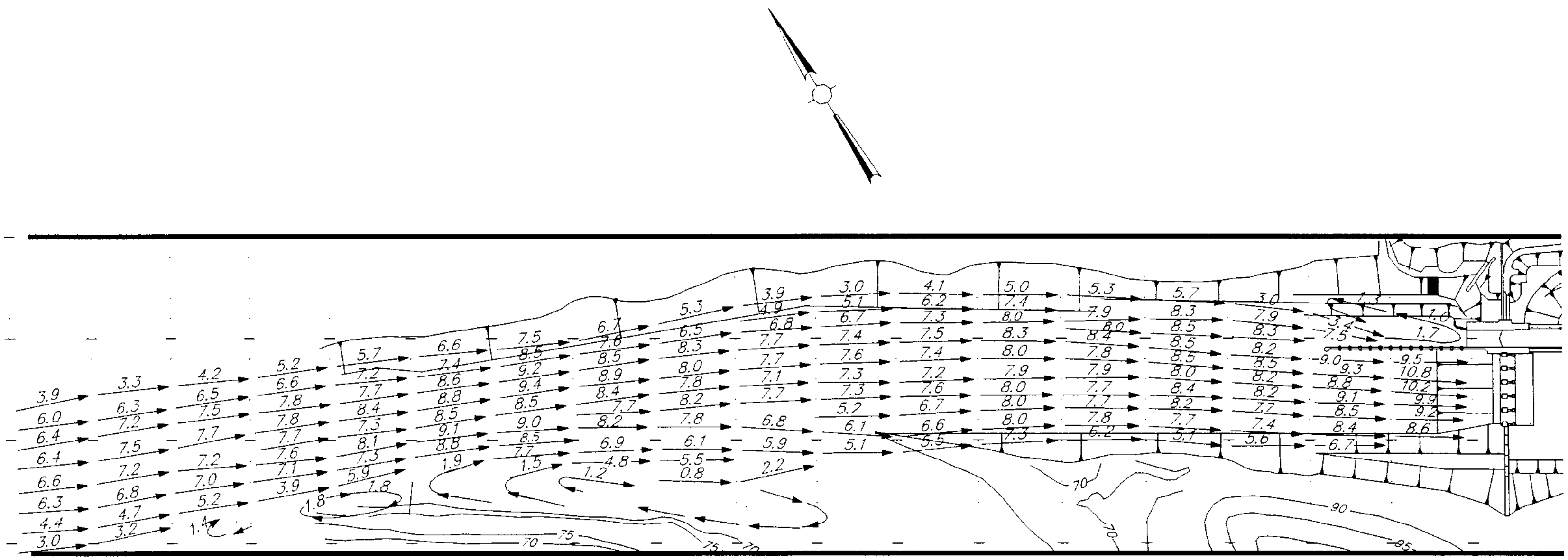
PROTOTYPE	500	0	500	1000
MODEL	5	0	5	10

VELOCITIES AND CURRENT DIRECTIONS

PLAN K

DISCHARGE:	85,000	CFS
UPPER POOL EL:	64.0	FT

LD2-181



LEGEND

3.5 → VELOCITY IN FEET PER SECOND
→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

SCALES

PROTOTYPE 500 0 500 1000

MODEL 5 0 5 10

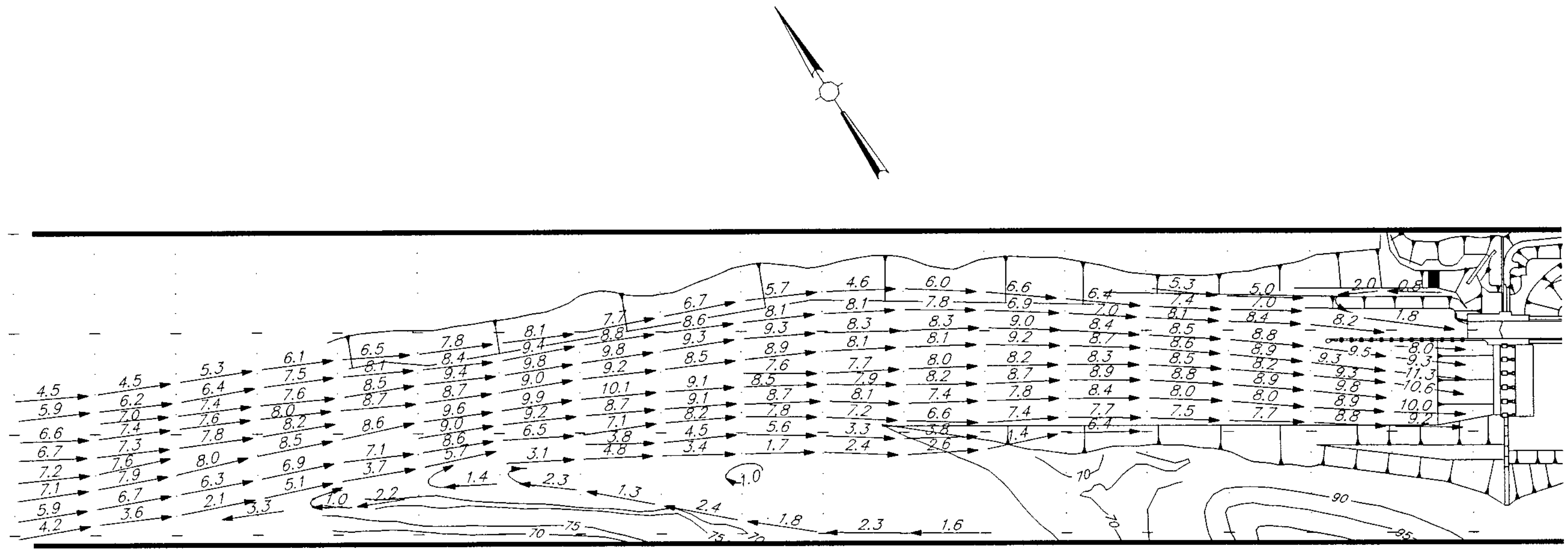
VELOCITIES AND CURRENT DIRECTIONS

PLAN K

DISCHARGE: 110,000 CFS

UPPER POOL EL: 65.4 FT

LD2-182



LEGEND

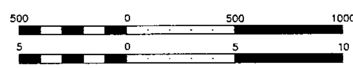
3.5 → VELOCITY IN FEET PER SECOND

—•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

SCALES



VELOCITIES AND CURRENT DIRECTIONS

PLAN K

DISCHARGE:	145,000	CFS
UPPER POOL EL:	70.9	FT

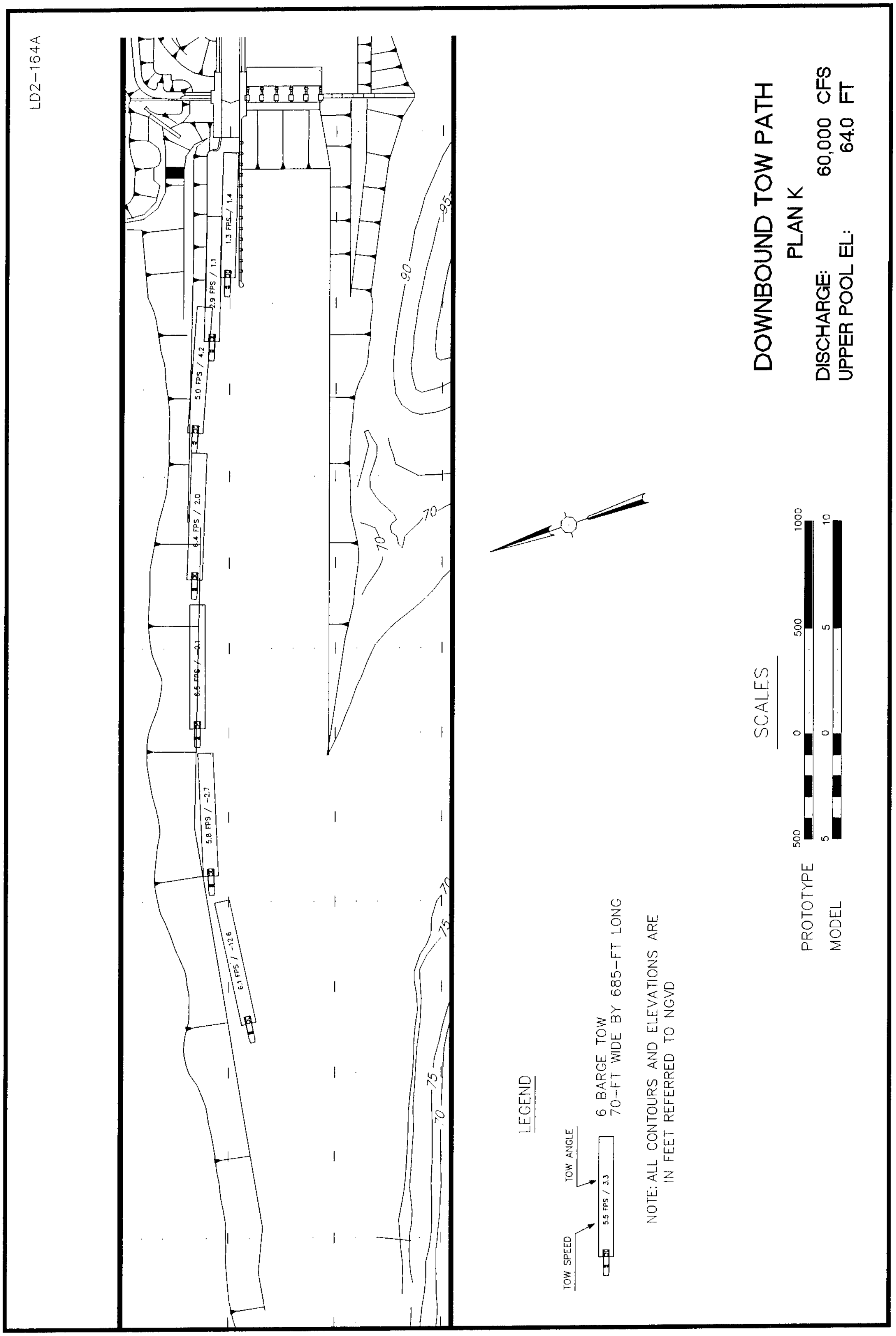
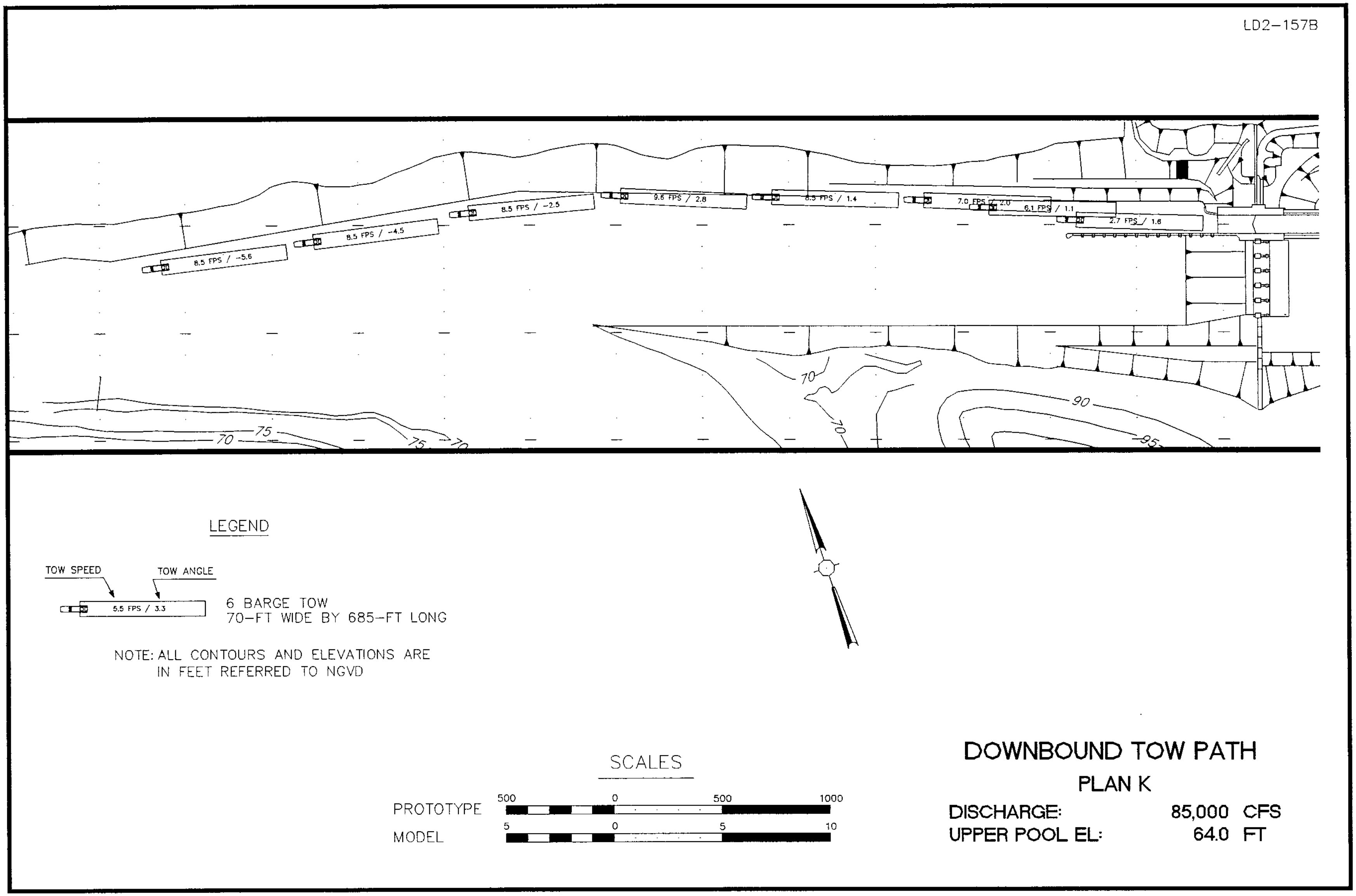

LD2-164A
1.3 FPS / 1.4
2.9 FPS / 1.1
5.0 FPS / 4.2
6.4 FPS / 2.0
6.5 FPS / -0.1
5.8 FPS / -2.7
6.1 FPS / -12.6
LEGEND
TOW SPEED
TOW ANGLE
5.5 FPS / 3.3
6 BARGE TOW
70-FT WIDE BY 685-FT LONG
NOTE: ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO NGVD
SCALES
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10
DOWNBOUND TOW PATH
PLAN K
DISCHARGE: 60,000 CFS
UPPER POOL EL: 64.0 FT

PLATE 68


LD2-157B
8.5 FPS / -5.6
8.5 FPS / -4.5
8.5 FPS / -2.5
9.6 FPS / 2.8
6.5 FPS / 1.4
7.0 FPS / 2.0
6.1 FPS / 1.1
2.7 FPS / 1.6
70
75
90
95
LEGEND
TOW SPEED
TOW ANGLE
5.5 FPS / 3.3
6 BARGE TOW
70-FT WIDE BY 685-FT LONG
NOTE: ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO NGVD
SCALES
PROTOTYPE
500 0 500 1000
MODEL
5 0 5 10
DOWNBOUND TOW PATH
PLAN K
DISCHARGE: 85,000 CFS
UPPER POOL EL: 64.0 FT

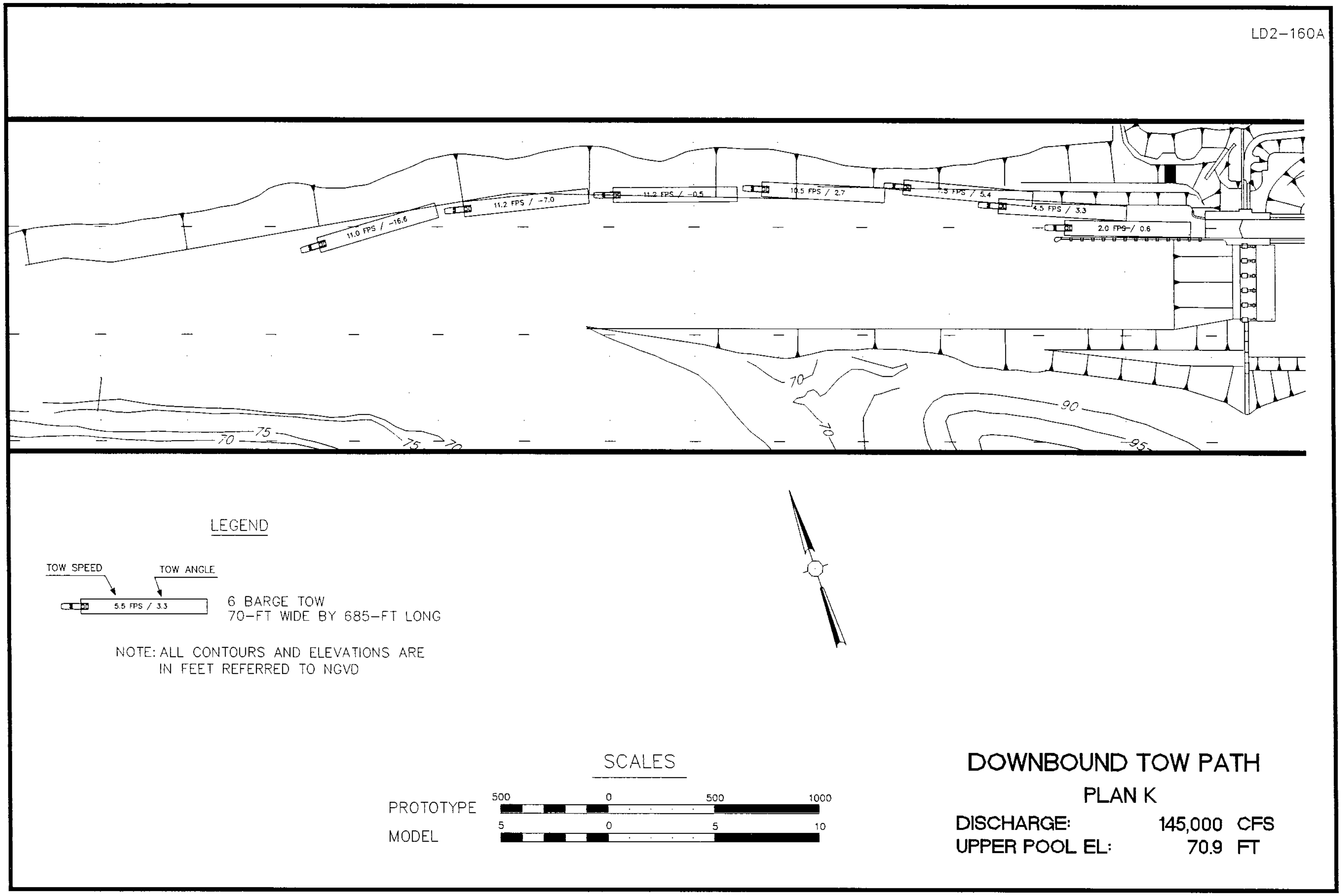
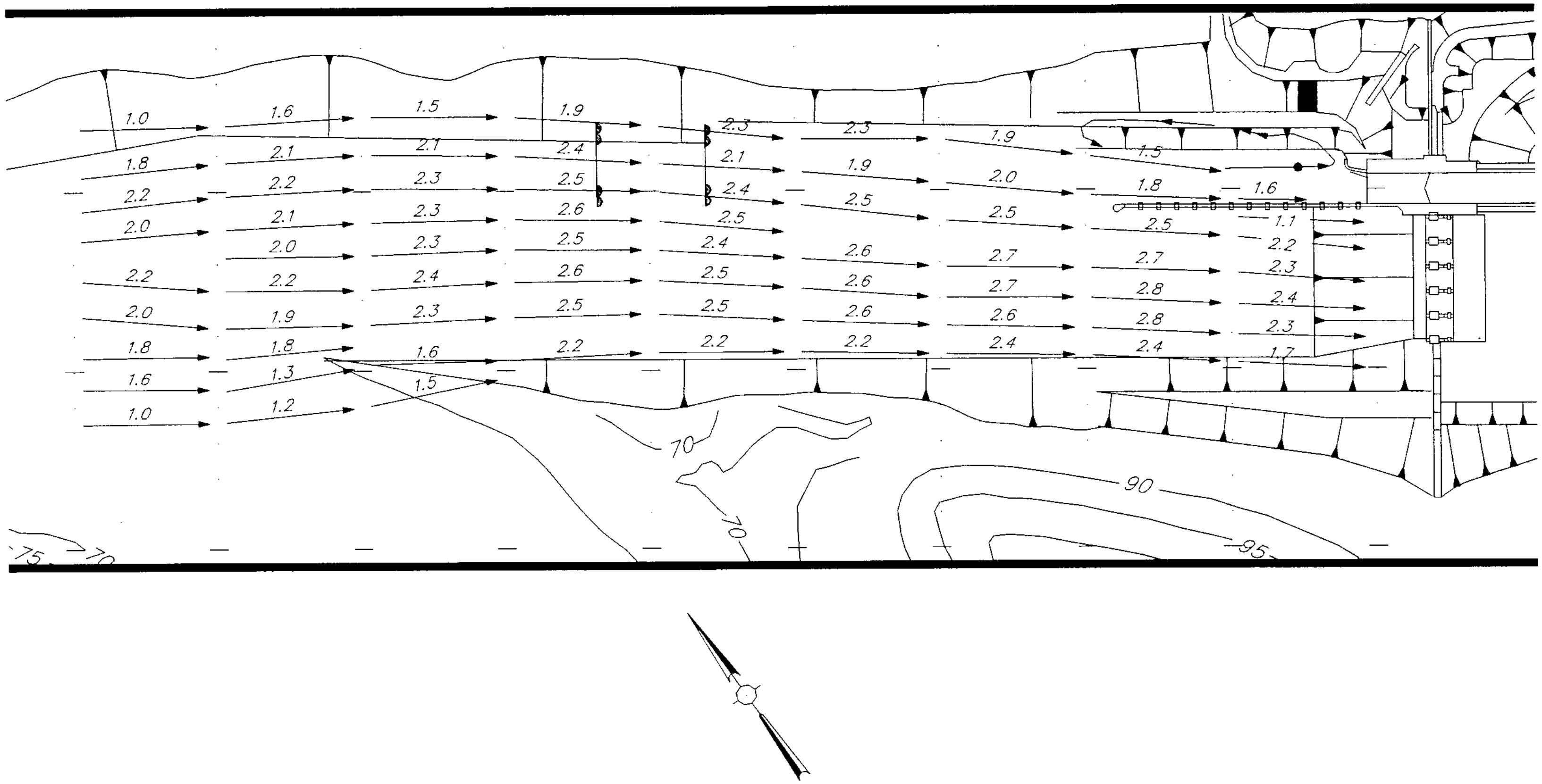

LD2-160A
11.0 FPS / -16.6
11.2 FPS / -7.0
11.2 FPS / -0.5
10.5 FPS / 2.7
4.5 FPS / 3.3
2.0 FPS / 0.6
70
75
90
95
LEGEND
TOW SPEED
TOW ANGLE
5.5 FPS / 3.3
6 BARGE TOW
70-FT WIDE BY 685-FT LONG
NOTE: ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO NGVD
SCALES
PROTOTYPE
500
0
500
1000
MODEL
5
0
5
10
DOWNBOUND TOW PATH
PLAN K
DISCHARGE: 145,000 CFS
UPPER POOL EL: 70.9 FT

PLATE 70

LD2-106A



LEGEND

3.5 → VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

SCALES IN FEET

PROTOTYPE 0 500 800
MODEL 0 5 8

VELOCITIES AND CURRENT DIRECTIONS

PLAN K-1

DISCHARGE: 31,000 CFS
UPPER POOL EL: 64.0 FT

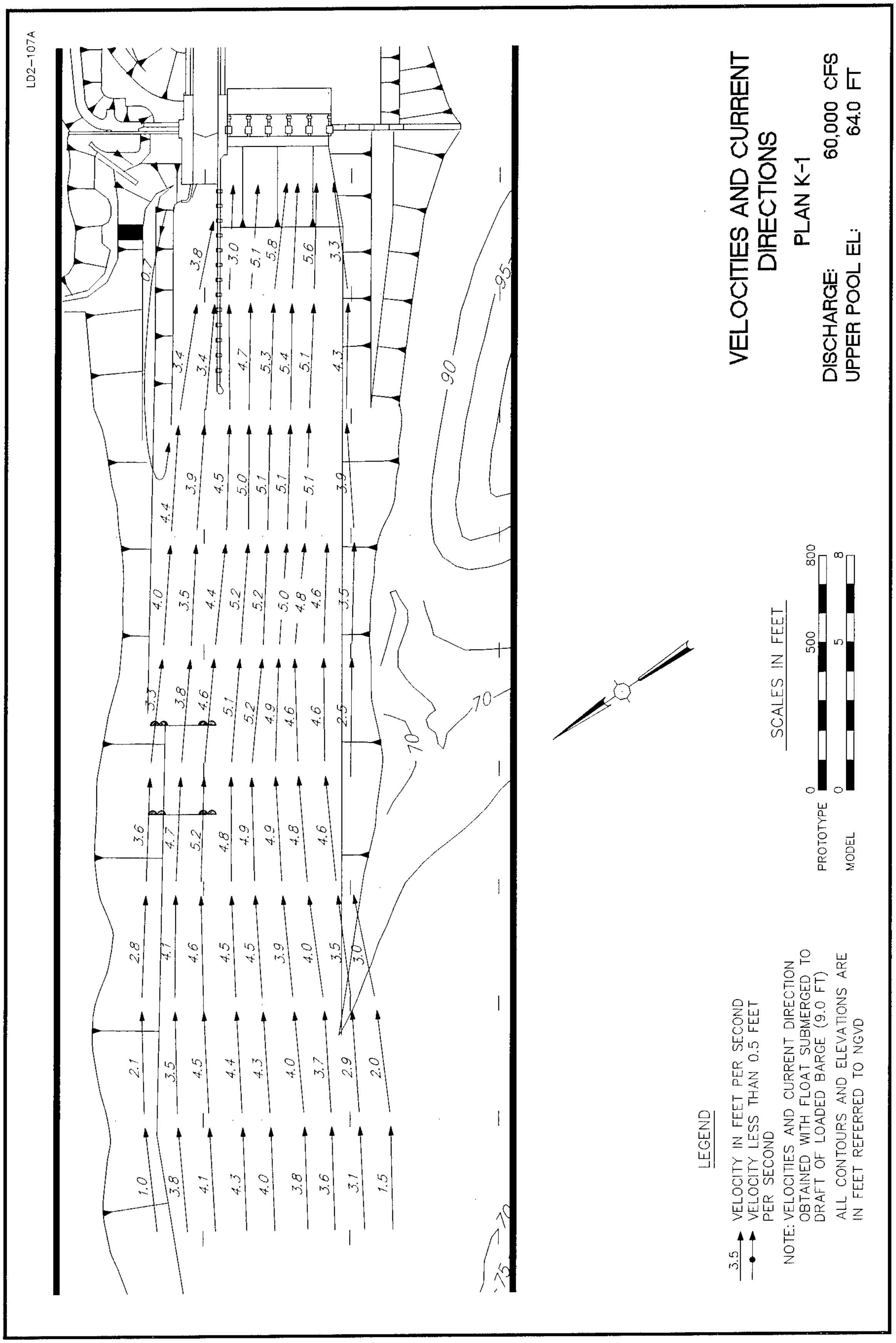

LD2-107A
VELOCITIES AND CURRENT DIRECTIONS
PLAN K-1
DISCHARGE: 60,000 CFS
UPPER POOL EL: 64.0 FT
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
3.5 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

PLATE 72

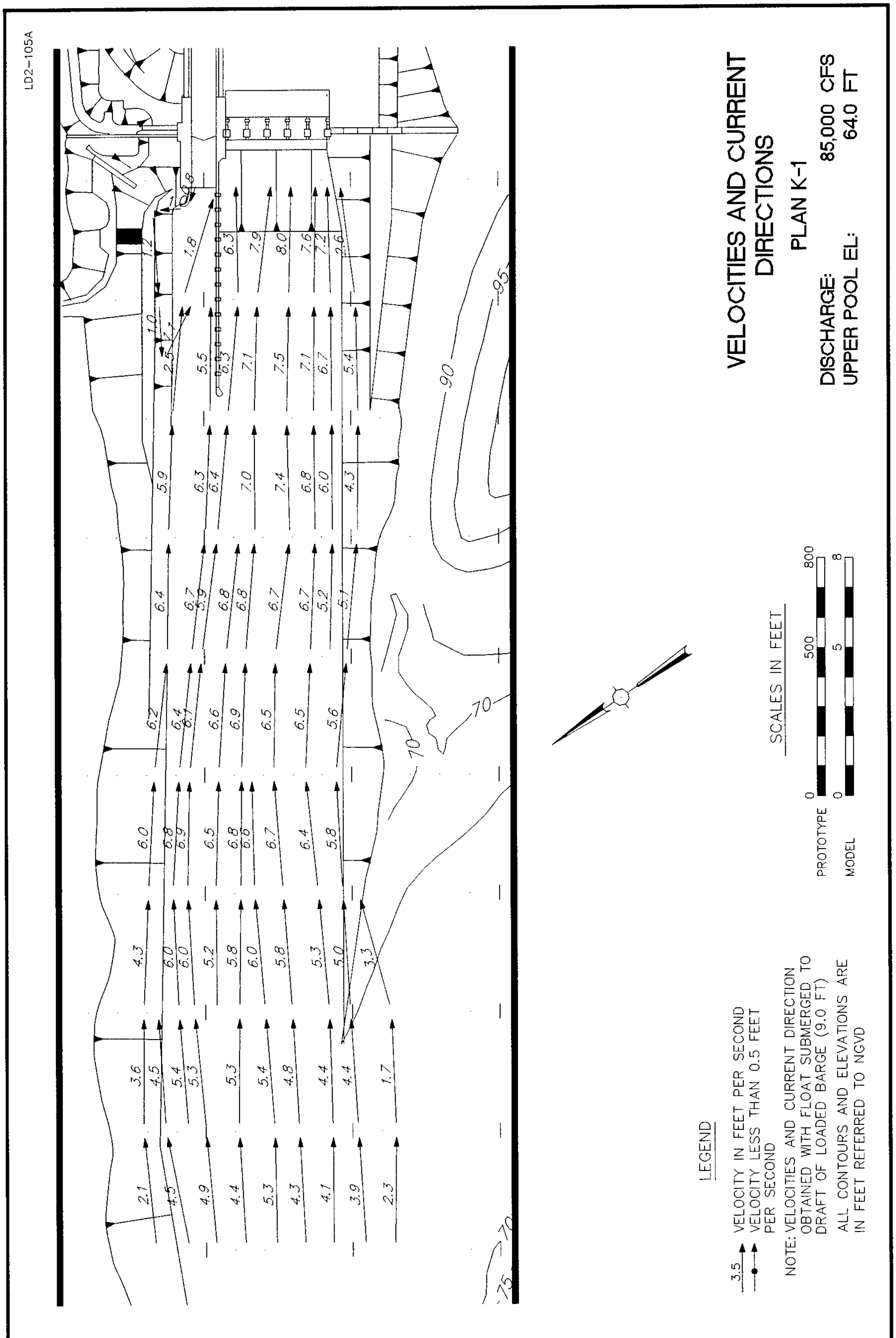
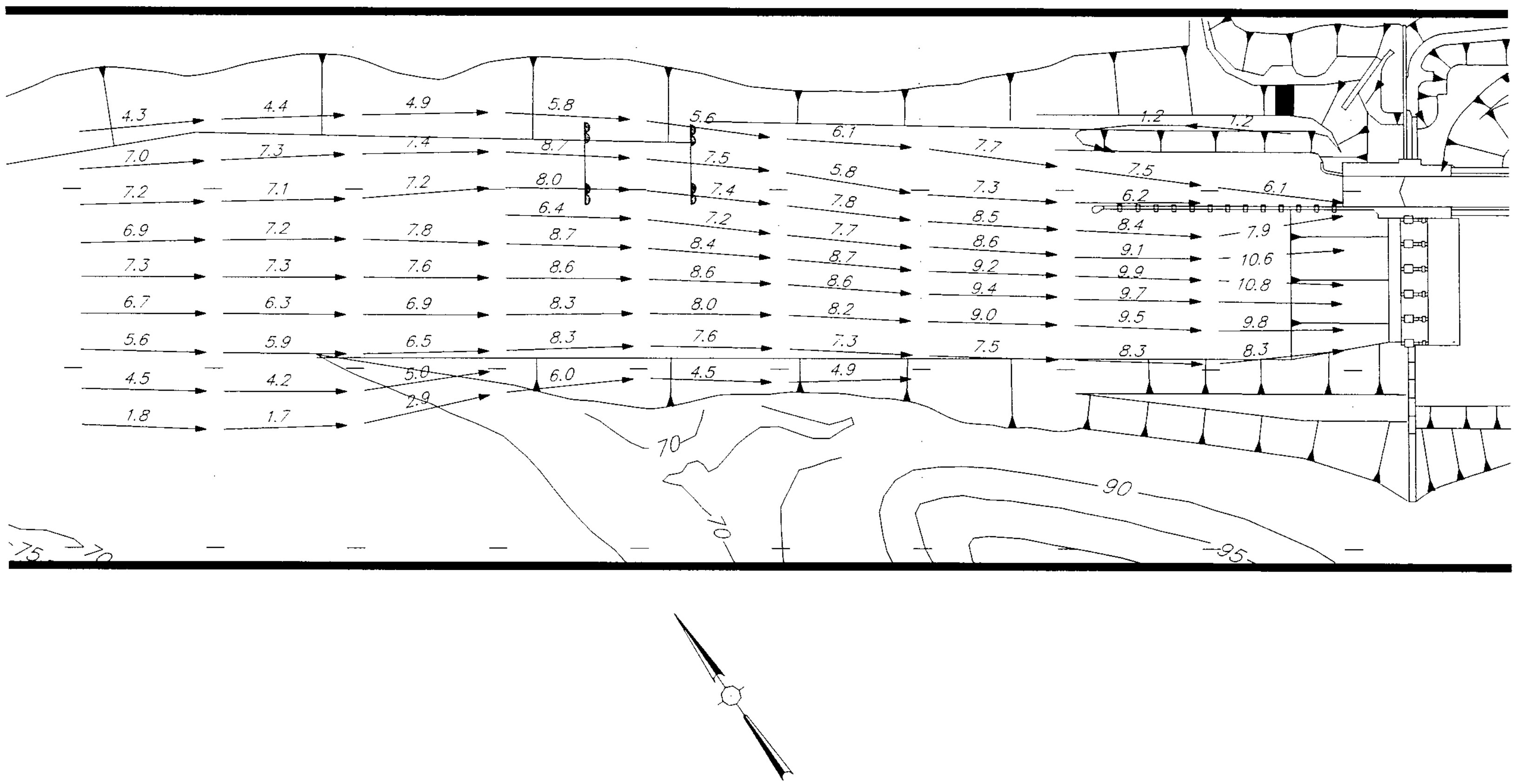

LD2-105A
VELOCITIES AND CURRENT DIRECTIONS
PLAN K-1
DISCHARGE: 85,000 CFS
UPPER POOL EL: 64.0 FT
LEGEND
3.5 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
SCALES IN FEET
PROTOTYPE 0 500 800
MODEL 0 5 8

PLATE 73

LD2-108A



LEGEND

3.5 → VELOCITY IN FEET PER SECOND
→•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

SCALES IN FEET

PROTOTYPE 0 500 800

MODEL 0 5 8

VELOCITIES AND CURRENT DIRECTIONS

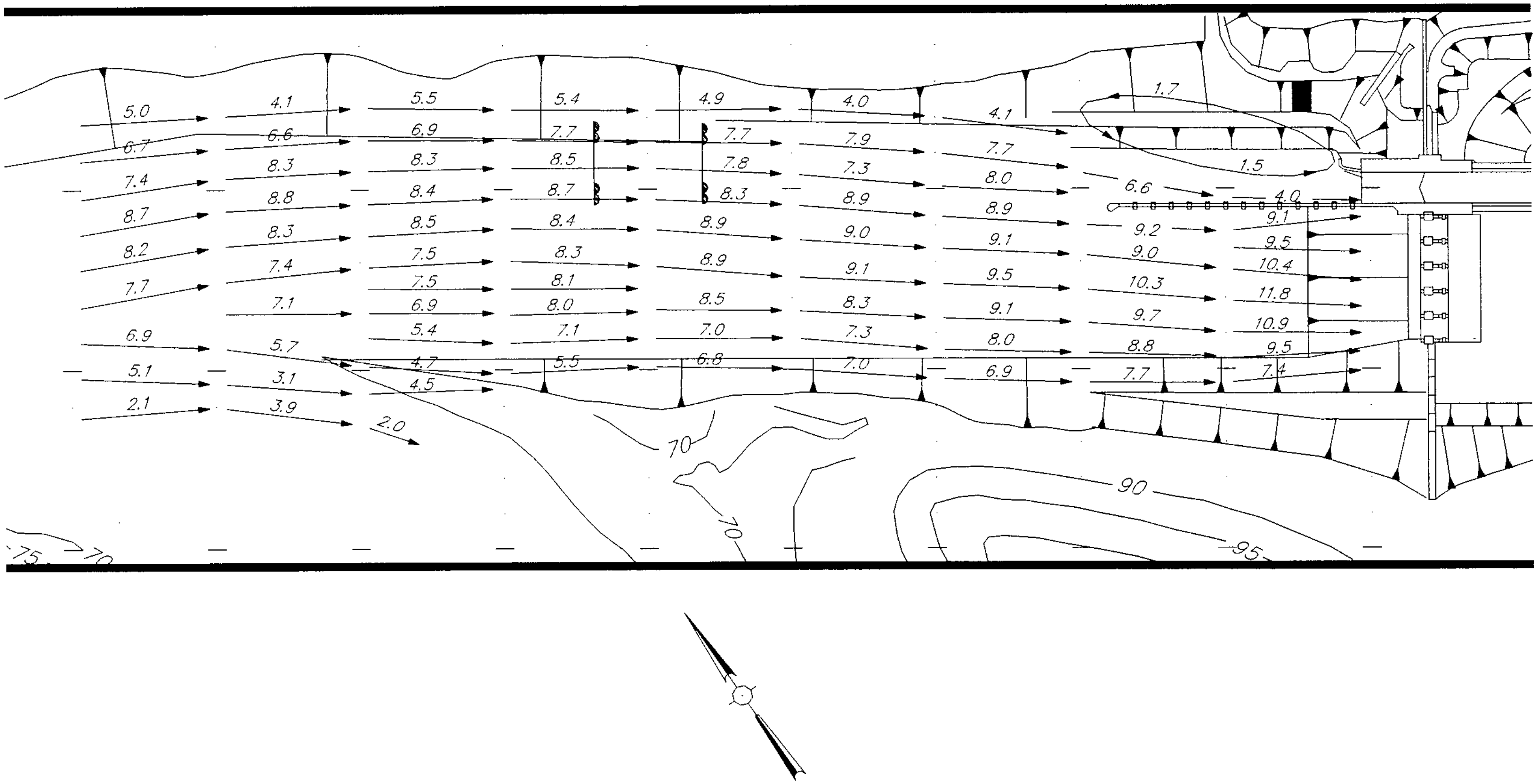
PLAN K-1

DISCHARGE: 110,000 CFS

UPPER POOL EL: 65.3 FT

PLATE 74

LD2-109A



LEGEND

3.5 → VELOCITY IN FEET PER SECOND

→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

SCALES IN FEET

PROTOTYPE 0 500 800

MODEL 0 5 8

VELOCITIES AND CURRENT DIRECTIONS

PLAN K-1

DISCHARGE: 145,000 CFS

UPPER POOL EL: 71.0 FT

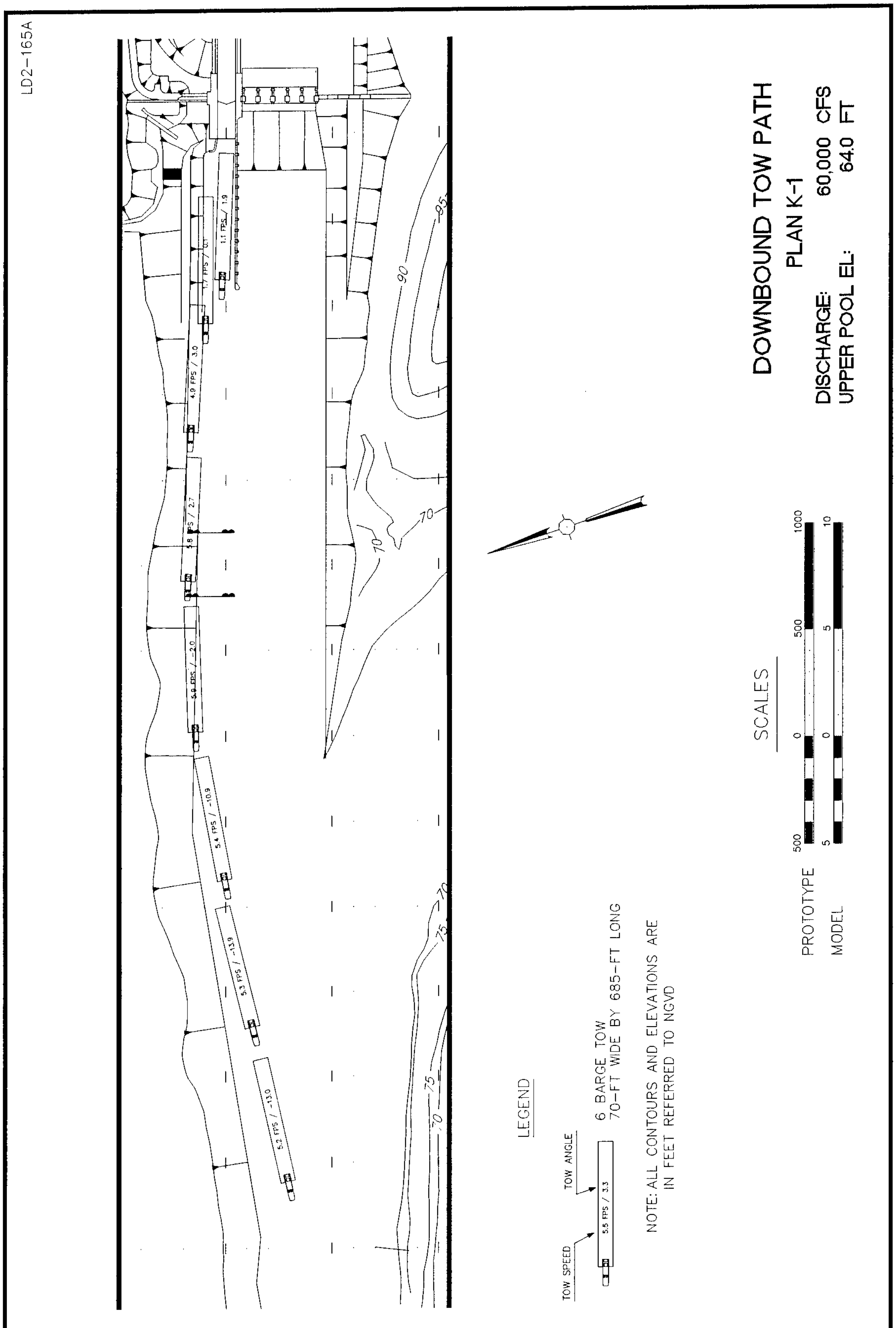
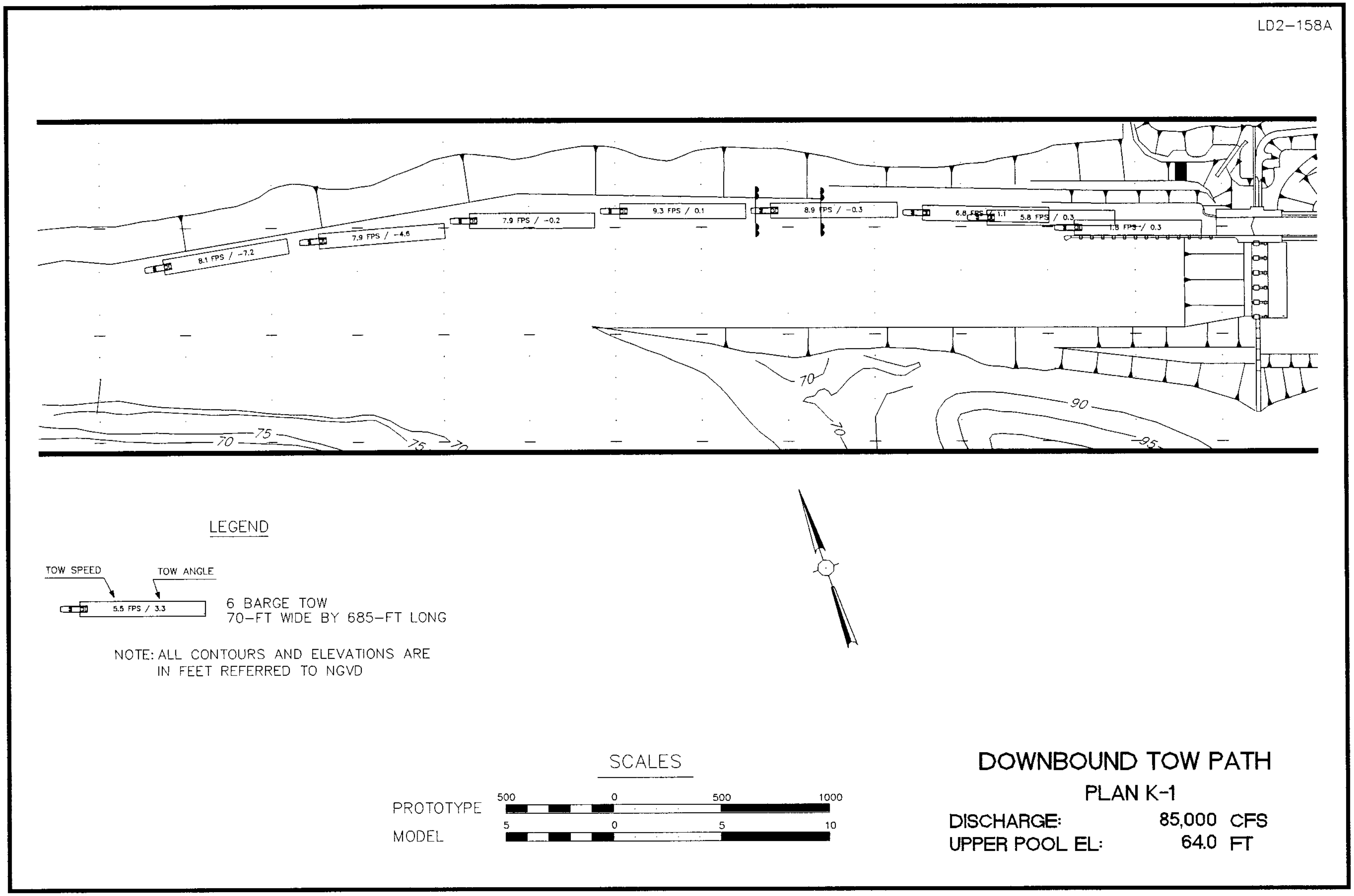

LD2-165A
DOWNBOUND TOW PATH
PLAN K-1
DISCHARGE: 60,000 CFS
UPPER POOL EL: 64.0 FT
SCALES
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10
LEGEND
TOW SPEED
TOW ANGLE
5.5 FPS / 3.3
6 BARGE TOW
70-FT WIDE BY 685-FT LONG
NOTE: ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO NGVD
1.1 FPS / 1.9
1.7 FPS / 0.1
4.9 FPS / 3.0
5.8 FPS / 2.7
5.9 FPS / -2.0
5.4 FPS / -10.9
5.3 FPS / -13.9
5.2 FPS / -13.0
85
90
70
75

PLATE 76



LD2-158A
8.1 FPS / -7.2
7.9 FPS / -4.6
7.9 FPS / -0.2
9.3 FPS / 0.1
8.9 FPS / -0.3
6.8 FPS / 1.1
5.8 FPS / 0.3
1.8 FPS / 0.3
70
75
90
95
LEGEND
TOW SPEED
TOW ANGLE
5.5 FPS / 3.3
6 BARGE TOW
70-FT WIDE BY 685-FT LONG
NOTE: ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO NGVD
SCALES
PROTOTYPE
500 0 500 1000
MODEL
5 0 5 10
DOWNBOUND TOW PATH
PLAN K-1
DISCHARGE: 85,000 CFS
UPPER POOL EL: 64.0 FT

PLATE 77

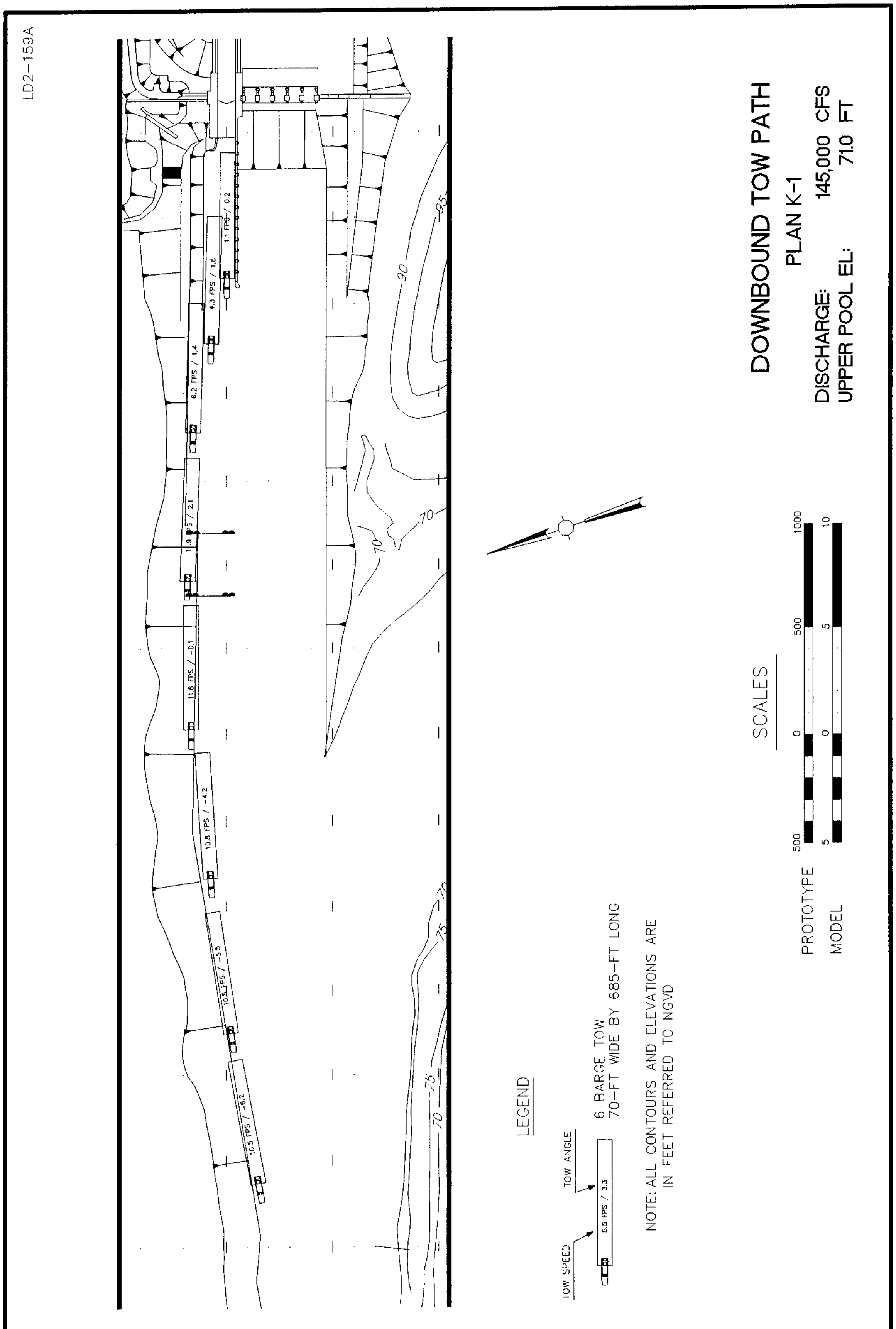
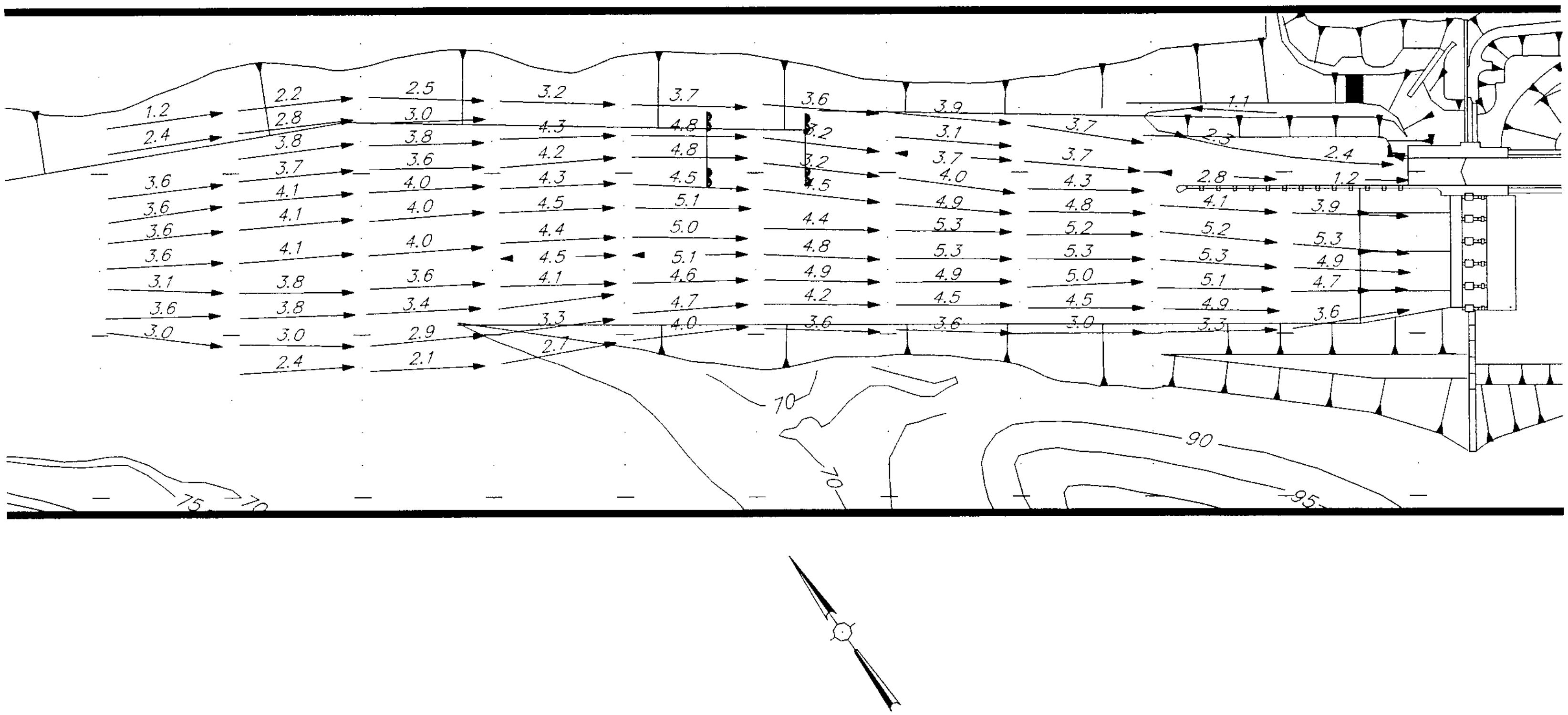

LD2-159A
DOWNBOUND TOW PATH
PLAN K-1
DISCHARGE: 145,000 CFS
UPPER POOL EL: 71.0 FT
SCALES
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10
LEGEND
TOW SPEED
TOW ANGLE
5.5 FPS / 3.3
6 BARGE TOW
70-FT WIDE BY 685-FT LONG
NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
10.5 FPS / -6.2
10.5 FPS / -5.5
10.8 FPS / -4.2
11.6 FPS / -0.1
1.9 FPS / 2.1
6.2 FPS / 1.4
4.3 FPS / 1.6
1.1 FPS / 0.2
70
75
85
90

PLATE 78

LD2-168



LEGEND

3.5 → VELOCITY IN FEET PER SECOND

→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

SCALES IN FEET

PROTOTYPE 0 500 800

MODEL 0 5 8

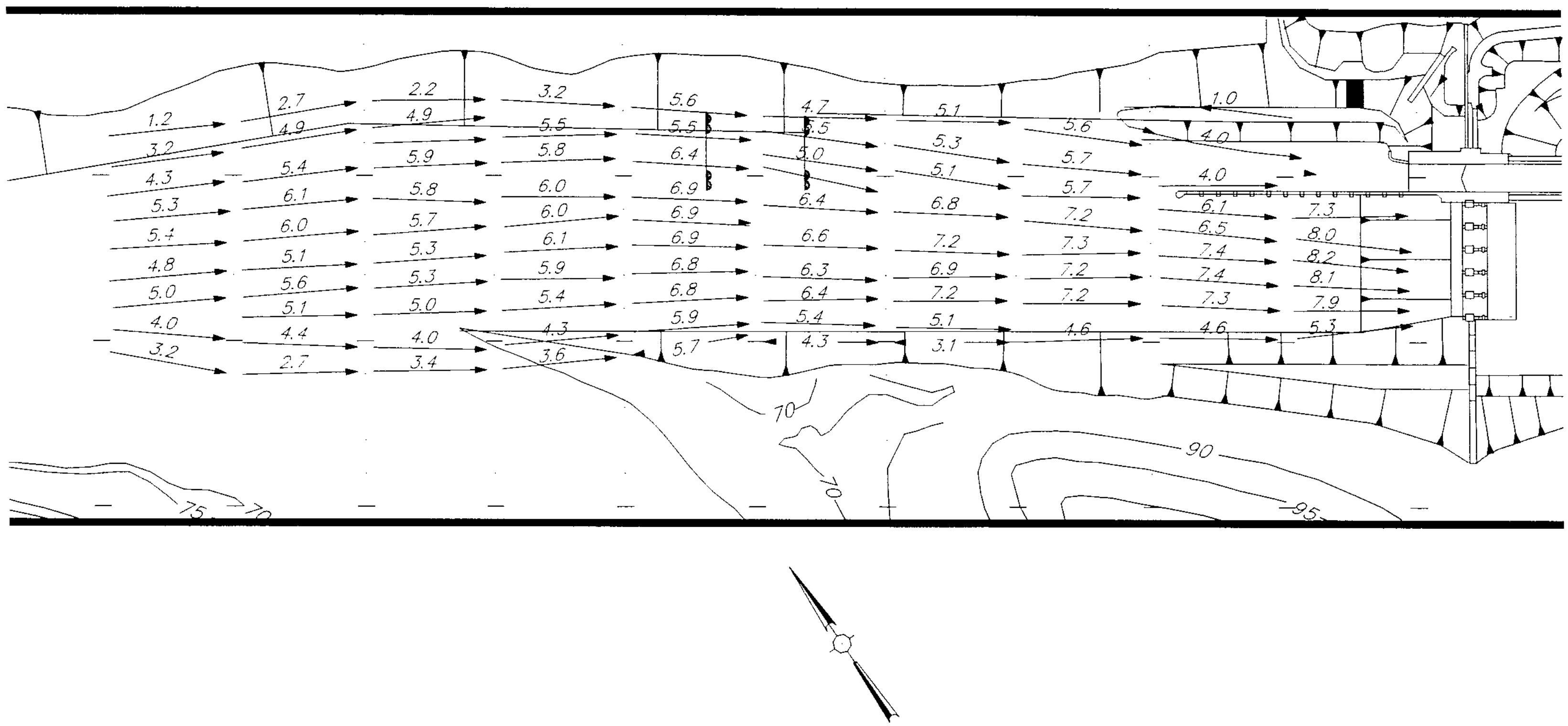
VELOCITIES AND CURRENT DIRECTIONS

PLAN K-2

DISCHARGE: 60,000 CFS

UPPER POOL EL: 64.0 FT

LD2-169A



LEGEND

3.5 → VELOCITY IN FEET PER SECOND

→•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

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

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

SCALES IN FEET

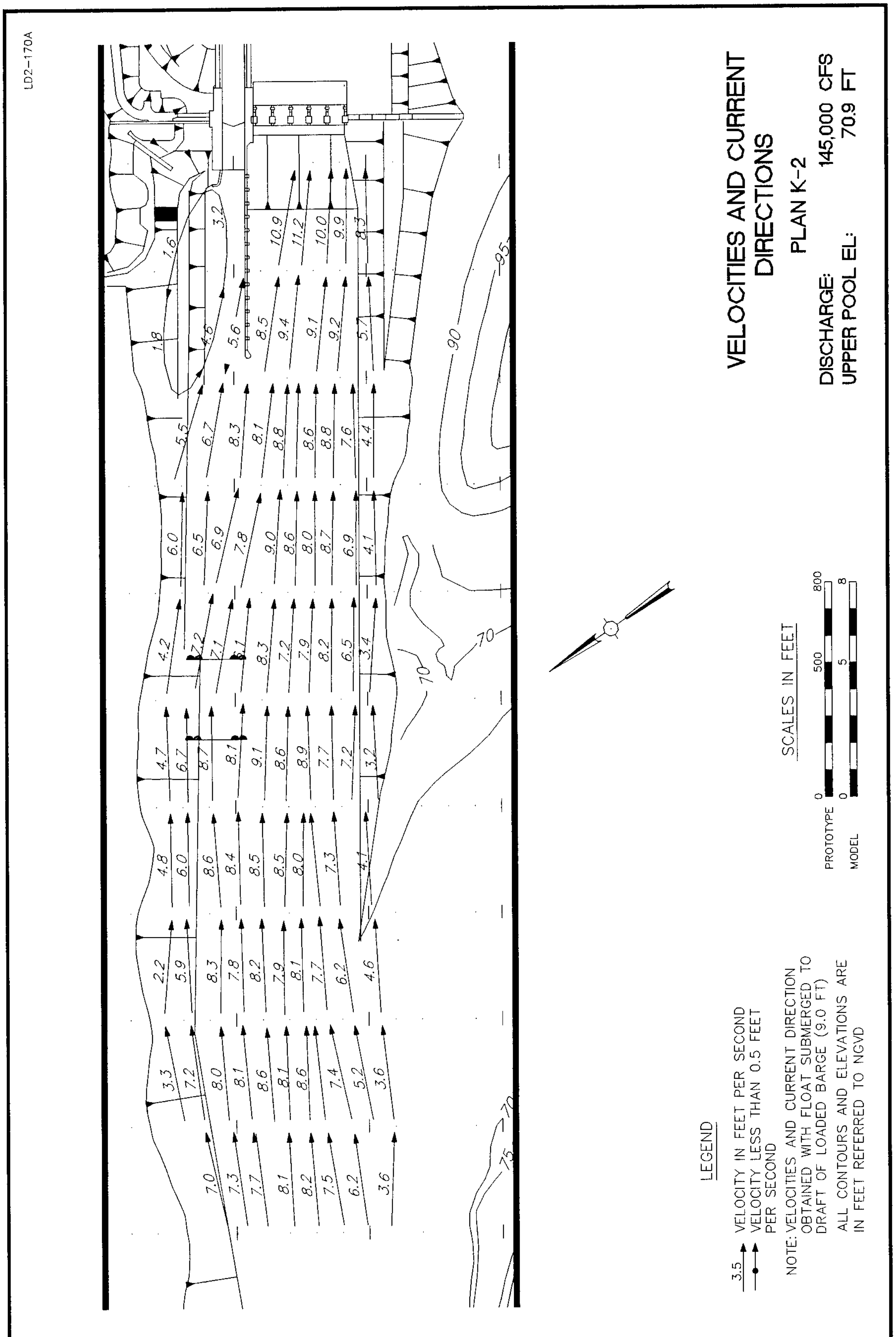
PROTOTYPE	0	500	800
MODEL	0	5	8

VELOCITIES AND CURRENT DIRECTIONS

PLAN K-2

DISCHARGE: 31,000 CFS

UPPER POOL EL: 64.0 FT


LD2-170A
VELOCITIES AND CURRENT DIRECTIONS
PLAN K-2
DISCHARGE: 145,000 CFS
UPPER POOL EL: 70.9 FT
LEGEND
3.5 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTION OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
SCALES IN FEET
PROTOTYPE 0 500 800
MODEL 0 5 8

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14. ABSTRACT

The Red River flows easterly from the northwest portion of Texas along the border between Texas and Oklahoma through southwestern Arkansas into northwestern Louisiana, then southeasterly to join the Old River and form the Atchafalaya River.

John H. Overton Lock and Dam is located in a cutoff canal approximately 74 miles above the Mississippi River and about 31 channel miles above Lindy C. Boggs Lock and Dam (formerly Lock and Dam No. 1). John H. Overton Lock and Dam is the second in a series of five locks and dams designed to furnish the required maximum lift of 43 m (141 ft) to provide year-round navigation on the Old and Red Rivers Waterway from the Mississippi River to Shreveport, a distance of 238 miles. The general design of John H. Overton Lock and Dam consists of a 26- by 209-m (84- by 685-ft) navigation lock with an adjacent spillway containing five 18-m (60-ft)-wide gate bays and a 71-m (233-ft) overflow wier. A fixed-bed model reproduced about 3.7 miles of the Red River and adjacent overbank from about 2,835 m (9,300 ft) upstream to about 3,124 m (10,250 ft) downstream of the dam to an undistorted scale of 1:100.

Since John H. Overton Lock and Dam was to be constructed in an excavated channel bypassing the natural river channel, it was important that the alignment of the channel and the arrangement of the lock and dam be satisfactory for navigation. The model investigation was concerned with evaluation of navigation conditions for proposed lock designs and development of modifications required to ensure satisfactory navigation conditions. The study identified any needed modifications to navigation channel alignment, guard wall lengths, or remedial structures. Results of the investigation revealed that a system of structures was required to eliminate adverse current patterns and establish satisfactory navigation conditions for tows entering and leaving the upper and lower lock approaches.

15. SUBJECT TERMS

Fixed-bed models	Locks (Waterways)
Hydraulic models	Navigation conditions
John H. Overton Lock and Dam	Red River

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