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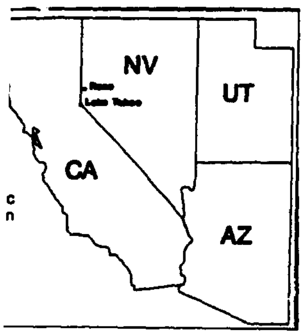

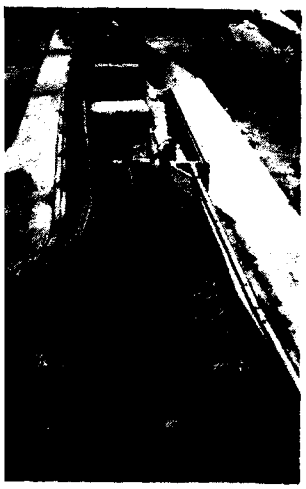

HYDRAULICS LABORATORY

TECHNICAL REPORT HL-92-10

TRUCKEE RIVER FLOOD-CONTROL PROJECT TRUCKEE MEADOWS (RENO-SPARKS METROPOLITAN AREA), NEVADA

Hydraulic Model Investigation

by

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13. ABSTRACT *(Maximum 200 words)*

Tests were conducted on a 1:30-scale model of the Truckee River, Nevada, to determine the adequacy of channel improvements proposed by the sponsor. The model reproduced approximately 3,200 ft of the Truckee River running through downtown Reno, NV.

Tests conducted with the proposed design channel with the design flow (100-year frequency event, 18,500 cfs) indicated areas within the modeled reach that needed modifications to improve flow conditions. These modifications to the sponsor-proposed improvements included replacing the paved slopes at the north abutment of the North Arlington Street Bridge with a vertical wall extending down to the channel invert, increasing the floodwall heights in the vicinity of the South Arlington Street Bridge, moving the channel invert chute upstream approximately 44 ft, and using two bridge piers at the Sierra Street crossing rather than one. The recommended design resulted in acceptable flow conditions throughout the modeled reach with the design discharge.

14. SUBJECT TERMS

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PREFACE

The model investigation reported herein was authorized by the Headquarters, US Army Corps of Engineers (HQUSACE), on 3 January 1990 at the request of the US Army Engineer District, Sacramento (SPK). The studies were conducted by personnel of the Hydraulics Laboratory (HL), US Army Engineer Waterways Experiment Station (WES), during the period June 1990 to August 1990. All studies were conducted under the direction of Messrs. Frank A. Herrmann, Jr., Director, HL; Richard A. Sager, Assistant Director, HL; and Glenn A. Pickering, Chief, Hydraulic Structures Division (HSD), HL. Tests were conducted by Messrs. Van E. Stewart, Sr., and Richard L. Stockstill, Locks and Conduits Branch, HSD, under the supervision of Mr. John F. George, Chief of the Locks and Conduits Branch. This report was prepared by Mr. Stockstill and edited by Mrs. Marsha C. Gay, Information Technology Laboratory, WES.

The model was constructed by Messrs. Edward A. Case, Joseph M. Lyons, Mitchell A. Simmons, and Lawrence B. Storey of the Model Shop, Engineering and Construction Services Division (E&CSD), WES, under the supervision of Mr. Sidney J. Leist, Chief of the Model Shop; and Messrs. Dan Barnes, Jr., Dennis J. Beausoliel, Charles L. Brown, Herman R. Brown, James Carpenter, Avery L. Harris, and Willie C. Thomas under the supervision of Mr. Clarence Drayton, Jr., Model Construction Section, E&CSD.

Messrs. Ed Sing, on a developmental assignment to and representing HQUSACE, and Dan Pridal of SPK visited WES during the course of the model study to observe model operation and correlate results with concurrent design works.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander and Deputy Director was COL Leonard G. Hassell, EN.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
feet	0.3048	meters
pounds (mass)	0.4535924	kilograms

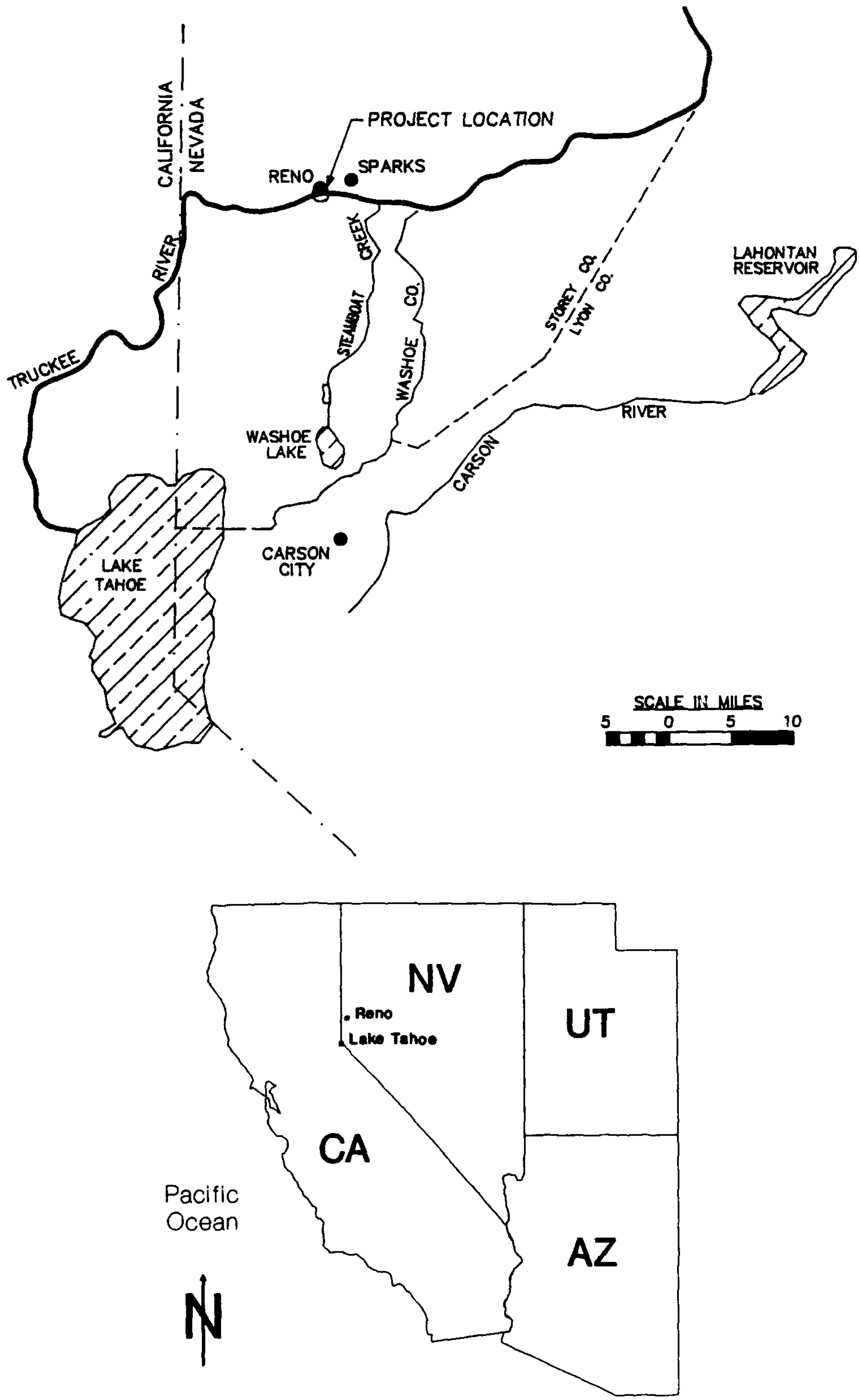

Figure 1. Location and vicinity maps

TRUCKEE RIVER FLOOD-CONTROL PROJECT
TRUCKEE MEADOWS (RENO-SPARKS METROPOLITAN AREA), NEVADA

Hydraulic Model Investigation

PART I: INTRODUCTION

The Prototype

1. The Truckee Meadows (Reno-Sparks Metropolitan Area), Nevada, project (Figure 1) extends along the Truckee River from Booth Street Bridge (River Mile 53) in Reno, downstream to Vista Gage (River Mile 43) in Sparks. The project will provide complete protection against the 100-year-frequency flood event on the Truckee River within the Reno-Sparks-Truckee Meadows area and will reduce flood stages for floods greater than the 100-year-frequency event. The model study was concerned with the reach of the Truckee River running through downtown Reno where the channel floodwalls are concrete and the channel bed is alluvial gravel.

Purpose and Scope of the Model Investigation

2. The model study was concerned with the proposed channel improvements to the existing river channel to accommodate the 100-year flood event. The purpose of the model study was to investigate hydraulic aspects of this improved channel and to develop desirable modifications. A physical model study was needed because of the complex division and combination of flow around and over Wingfield Park island and Wingfield Park. Documentation of local velocities was important for subsequent channel stability analysis. Also, the physical model was used to optimize head losses through the downstream reach to save two historical bridges (Virginia and Center Streets).

PART II: THE MODEL

Description

3. The model, constructed to a scale of 1:30, shown in Figure 2, reproduced approximately 3,200 ft* of the Truckee River; the South Arlington Street, Virginia Street, and Center Street Bridges; the North Arlington Street, Sierra Street, and Lake Street Bridge piers; and Wingfield Park. The model also reproduced the Fountain Walk Park under construction at the time of the model investigation. A plan view of the project's alignment is shown in Plate 1. The baseline, north channel center line, and south channel center line were established at the US Army Engineer Waterways Experiment Station (WES) to facilitate the presentation of model data. Preliminary hydraulic analysis of the Truckee River by the US Army Engineer District, Sacramento, determined that the North Arlington Street, Sierra Street, and Lake Street Bridges would require replacement due to excessive head losses through the bridges and/or because of low bridge soffits at these crossings. Modeling of the bridge decks of these crossings was not necessary because the new decks will be placed above the water-surface elevation measured in the model with adequate freeboard. Therefore, only the bridge piers for each of these crossings were reproduced in the model. Each of these bridge piers consisted of a 5-ft-wide solid pier having a semicircular nose and tail. Table 1 provides pertinent data on the South Arlington Street, Virginia Street, and Center Street Bridges. The two existing pedestrian footbridges accessing Wingfield Park island were not modeled.

4. The channel's floodwalls were fabricated of plastic-coated plywood. The invert was molded in rounded gravel scaled from prototype gradations (Plate 2). The gravel was lightly sprinkled with cement such that the bed of the model was essentially fixed. The gradation representing the existing channel bed was used for the entire modeled reach with the exception of the area where the north and south channels merge. The original design consisted of chute structures having steep slopes on both the north and south channels just upstream of the Sierra Street crossing. These chute structures would

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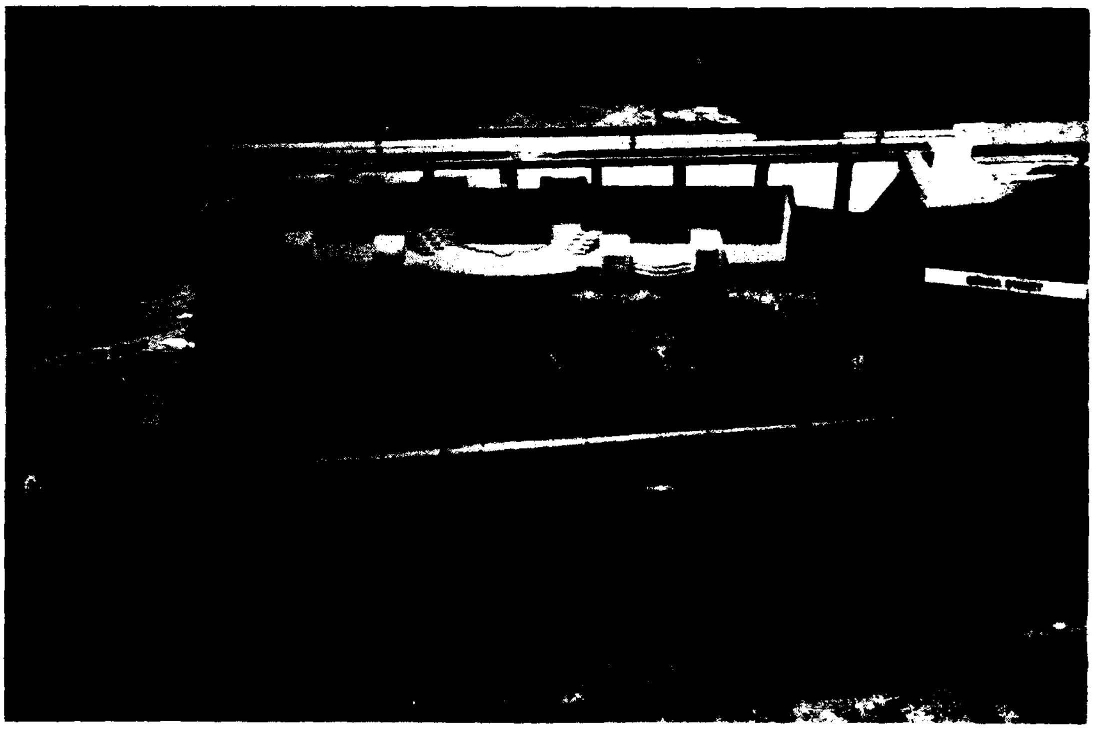
* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

a. General view



b. Fountain Walk Park

Figure 2. The 1:30-scale model

result in flow accelerations and require a stone size larger than the existing bed material to avoid erosion. This larger stone size, which consisted of the gradation shown in Plate 3, was designated type A stone gradation and was placed in the model between sta 24+50 and 29+00. Stones 4 to 6 ft in diameter were spaced at random intervals (approximately 30 ft) on the inverts of the north and south channels between sta 27+00 and 29+00 to increase channel roughness and to provide resting places for fish.

Model Appurtenances

5. Water used in the operation of the model was supplied by a circulating system. Discharges were measured with flowmeters installed in the flow lines and were baffled before entering the model. Velocities were measured with a pitot tube that was mounted to permit measurement of flow from any direction and at any depth. Water-surface elevations were measured with point gages. Different designs and various flow conditions were recorded photographically.

Scale Relations

6. The accepted equations of hydraulic similitude, based on Froudian relations, were used to express mathematical relations between the dimensions and hydraulic quantities of the model and prototype. General relations for transference of model data to prototype equivalent are presented in the following tabulation:

Characteristic	Dimension*	Scale Relation Model:Prototype
Length	$L_r = L$	1:30
Area	$A_r = L_r^2$	1:900
Velocity	$V_r = L_r^{1/2}$	1:5.48
Discharge	$Q_r = L_r^{5/2}$	1:4,929.5
Time	$T_r = L_r^{1/2}$	1:5.48
Roughness coefficient	$N_r = L_r^{1/6}$	1:1.76
Weight	$W_r = L_r^3$	1:27,000

* Dimensions are in terms of length.

Model measurements of discharge, water-surface elevations, and velocities can be transferred quantitatively to prototype equivalents by means of the preceding scale relations.

PART III: TESTS AND RESULTS

7. Areas of particular concern within the modeled reach were in the vicinity of the North Arlington Street Bridge where paved slopes at the north bridge abutment caused asymmetric flow through the bridge area, in the vicinity of the South Arlington Street Bridge where flow overtopped the floodwall, and near the Sierra Street crossing where local velocities were significantly higher than the average velocity.

Boundary Roughness

8. Preliminary test results indicated that the water-surface elevations downstream of Sierra Street to the end of the modeled reach resulting from the design discharge were lower than those computed by the Sacramento District. There was concern that the physical model's invert was not representing a rough enough prototype channel.

9. Tests were conducted to determine the composite roughness of the model from Sierra Street to the downstream end of the modeled reach. The testing procedure was as follows:

a. The Sierra Street and Lake Street Bridge piers and the Virginia Street and Center Street Bridges were removed.

b. Channel control was established by complete lowering of the model's tailgate.

c. The discharges and water-surface elevations at various cross sections were recorded.

d. The friction slope between sta 21+00 and 11+00 was calculated.

e. The Manning's n value was calculated from parameters measured in the model.

Two discharges were tested. First the design discharge (18,500 cfs) was tested, and then the discharge was increased until the water-surface elevation at baseline sta 10+00 coincided with that resulting from the losses in the prototype channel downstream of the modeled reach as determined by the Sacramento District. The larger discharge (28,600 cfs) was tested to determine if the n value was sensitive to changes in flow geometry or model Reynolds numbers near design flow conditions. The results of both tests indicated that the model's composite n value was 0.022 (prototype).

Representatives of the Sacramento District stated that a composite n of 0.030 had been used during analysis.

10. The model invert was remolded such that the gravel (same size as original test) was not compacted as densely as in the original test. Sprinkling of the gravel with cement was necessary because the velocities generated with no tailgate control would scour the bed. However, very little cement was used; about one-half of the grain diameter protruded above the bed.

11. The boundary loss tests were conducted again with the remolded invert. The results indicated that the composite n value of the remolded channel was 0.030 (prototype). Based on these roughness tests, it was concluded that boundary losses on the invert are not only a function of the particle size, but also a function of the density of the particles. In other words, for a given particle size, the relative roughness is dependent upon the amount of the particle protruding above the bed and the spacing of each of these protrusions. The exact size and density of the bed particles in the prototype after excavation of the invert are unknown. However, the Sacramento District's estimated composite n value of 0.030 appears reasonable.

12. Test results indicated that the flow control through the lower end of the modeled reach was at the Virginia Street and Center Street Bridges. The form losses through the channel reach downstream of the Sierra Street crossing were so significant that the water-surface elevation was not very sensitive to differences in the boundary roughness.

Type 1 (Original) Design Channel

13. The type 1 design channel is presented in Photos 1 and 2. Water-surface elevations recorded for the design flow (100-year-frequency event, 18,500 cfs, water-surface elevation of 4483.9* at baseline sta 10+00) with the type 1 design channel are presented in Plates 4-6 and Table 2. The drop structure on the north channel resulted in a hydraulic jump being formed just upstream of the North Arlington Street crossing (Photo 2a, Plate 5). The flow conditions with the design discharge included flow over the South Arlington Street Bridge. A bulking of the water surface occurred as the jet through the

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

bridge expanded just downstream of the South Arlington Street Bridge (Plate 5).

14. Velocities measured in the vicinity of the Sierra Street crossing where the flows from the north and south channels merge are shown in Plates 7 and 8. The water-surface elevation at the downstream limit of the model (baseline sta 10+00) was set in the model for each test. These elevations were provided by the Sacramento District and represented the water-surface elevations resulting from channel losses downstream of the modeled reach. Two different water-surface elevations were set at baseline sta 10+00 depending on the type of test being conducted (Plate 9). A maximum value, el 4483.9, resulting from maximum computed losses downstream of baseline sta 10+00 was used when water-surface profiles were obtained, and a minimum value, el 4482.5, resulting from minimum losses downstream of baseline sta 10+00 was used when velocities were measured.

Type 2 Design Channel

15. The type 1 (original) design channel produced a nonuniform flow distribution through the North Arlington Street Bridge. Paved slopes at the north bridge abutment (left channel wall) caused asymmetric flow through the bridge area with the flow being concentrated near the bridge pier. The type 2 design channel (Plate 10) consisted of removing the paved slopes and extending the vertical wall down to the channel invert. The type 2 design channel resulted in uniform flow through the bridge. Photo 3 shows flow conditions with the type 2 design channel near the North Arlington Street Bridge.

Type 3 Design Channel

16. The type 1 design resulted in flow overtopping the floodwall in the vicinity of the South Arlington Street Bridge (Photo 2b). The floodwaters were contained in the channel by increasing the floodwall heights of the type 2 design channel above the maximum water-surface elevation in the vicinity of the bridge (type 3 design channel). The type 3 design channel near the South Arlington Street Bridge is shown in Photo 4.

Type 4 Design Channel

17. Modifications of the type 3 design channel were made in the vicinity of the Sierra Street Bridge in an attempt to reduce local velocities that might scour the bed material (Plate 8). The type 4 design channel consisted of streamlining the south (right) channel wall by providing a straight wall between sta 25+65 and 24+55 (Plate 11 and Photo 5a). The type 4 design channel reduced local velocities but did produce a nonuniform flow distribution through the bridge as shown in Plates 12 and 13. The flow along the curve on the north (left) channel wall separated from the wall thus reducing the effective flow area at the bridge. Water-surface profiles with the type 4 design channel are presented in Plates 14 and 15 and Table 3. Flow conditions for the type 4 design channel are shown in Photo 5b. Velocities in the south channel downstream of South Arlington Street Bridge are shown in Plate 16.

Type 5 Design Channel

18. In an attempt to reduce channel velocities in the vicinity of the Sierra Street crossing and in the south channel downstream of the South Arlington Street Bridge, the channel invert chute of the type 4 design channel was moved upstream approximately 44 ft from immediately upstream of the Sierra Street crossing to sta 25+71 to 26+71 and the bottom width of the south channel was reduced from 30 ft to 15 ft at sta 28+70 (type 5 design channel). The type 5 design channel is shown in Photo 6. Water-surface profiles and channel velocities with the type 5 design are presented in Plates 17-21 and Table 4. The type 5 design channel resulted in a slight reduction in main channel velocities with the exception of sta 25+00 (Sierra Street Bridge pier location, Plate 20). The velocities in the south channel were not reduced. The south channel downstream of South Arlington Street Bridge may require riprap to prevent bed scour.

19. Velocities produced with the type 5 design channel were measured at the downstream edge of the South Arlington Street Bridge (Plate 21). Using these velocities, the discharge through the South Arlington Street Bridge was computed to be about 40 percent of the total discharge. The remaining 60 percent of the design flow was through the north channel, over the Wingfield Park island, and over the South Arlington Street Bridge.

Type 6 Design Channel

20. Tests were conducted at the Sierra Street crossing to evaluate the flow conditions resulting from two bridge piers at Sierra Street rather than only one as was previously tested. This was designated the type 6 design channel, which consisted of the type 5 design channel with two bridge piers at Sierra Street rather than one. Two piers could result in project construction cost savings since the bridge span lengths would be reduced. Also, it was felt that two piers may produce a more uniform flow distribution through the bridge. Both of the bridge piers were 3 ft wide with a semicircular nose and tail. The type 6 design channel at the Sierra Street Bridge piers is shown in Photo 7. Water-surface elevations in the vicinity of Sierra Street (between sta 18+00 and 27+00) resulting from the type 6 design are presented in Plate 22 and Table 5. The water surface upstream of sta 18+00 and downstream of sta 27+00 was identical to the type 5 design (Plates 17 and 18). Channel velocities with the type 6 design channel are presented in Plates 23 and 24. Water-surface elevations with the type 6 design were no higher than with the type 5 design. However, the flow was more uniformly distributed at sta 25+00, and therefore the velocities at this station were lower than those resulting from a single pier (Plate 20).

Debris Blockage Tests

21. At this point in the testing program, representatives of the Sacramento District requested that tests be conducted to document the results of debris blockage at the Virginia Street Bridge. The blockage tests were conducted by blocking the upper portion of the Virginia Street Bridge in the type 6 design channel with a solid cover set at various elevations. The results of these tests are presented in Table 6. The cemented model bed material began to scour when the blockage soffit was set at el 4481. Blockage caused by debris will not only increase the water surface upstream but will also increase velocities at the bridge, which may result in excessive scour of the bed material.

PART IV: SUMMARY AND CONCLUSIONS

22. Physical model tests to determine the adequacy of channel improvements for the Truckee River reach through downtown Reno, NV, indicated that the original design with certain modifications would effectively contain design flow conditions.

23. Tests conducted to determine the composite roughness of the channel concluded that boundary losses on the invert are not only a function of the particle size, but also a function of the density of the particles. Bed roughness depends on bed material size and density. The exact size and density of the bed particles in the prototype after excavation of the invert is unknown. However, the Sacramento District's estimated composite n value of 0.030 appears reasonable. Therefore, the model was molded to produce a composite n of 0.030.

24. Tests conducted with the type 1 (original) design channel with the design flow (100-year frequency event, 18,500 cfs) indicated areas within the modeled reach that needed modifications to improve flow conditions. Areas of particular concern were in the vicinity of the North Arlington Street Bridge where paved slopes at the north bridge abutment caused asymmetric flow through the bridge area, in the vicinity of the South Arlington Street Bridge where the flow was overtopping the floodwall, and near the Sierra Street crossing where local velocities were significantly higher than the average velocity.

25. The recommended design (type 6 design channel) consisted of the original design with modifications. These modifications included replacing the paved slopes at the north abutment of the North Arlington Street Bridge with a vertical wall extending down to the channel invert, increasing the floodwall heights in the vicinity of the South Arlington Street Bridge, straightening the south channel wall between sta 25+65 and 24+55, moving the channel invert chute upstream approximately 44 ft, and using two bridge piers at the Sierra Street crossing rather than one. The recommended design resulted in acceptable flow conditions throughout the modeled reach with the design flow.

Table 1

Details of Existing Bridges

Bridge	Span Type	Soffit Elevation*	Top of Road Elevation*
South Arlington Street	Single arch	4492.2	4494.7
Virginia Street	Solid face Double arch	4490.1 left arch 4490.0 right arch	4496.0 left bank 4493.6 right bank
Center Street	Open face Double arch	4488.6 left arch 4488.6 right arch	4491.2 left bank 4492.0 right bank

* Given in feet referred to the National Geodetic Vertical Datum (NGVD).

Table 2

Water-Surface Elevations, Type 1 (Original) Design

Discharge 18,500 cfs, Water-Surface Elevation at

Sta 10+00 = 4483.9

Station	Elevation Left Side	Elevation Center	Elevation Right Side
	Sta 42+00 to Sta 37+00		
42+00	4497.2	4497.2	4497.2
41+50	4497.1	4496.9	4497.2
41+00	4496.5	4496.5	4497.4
40+50	4496.6	4496.6	4497.1
40+00	4496.9	4496.8	4496.8
39+50	4497.2	4496.8	4496.6
39+00	4497.0	4496.8	4496.5
38+50	4496.8	4496.7	4496.6
38+00	4496.9	4497.0	4496.7
37+50	4496.8	4496.9	4496.8
37+00	4496.7	4497.3	4496.6
	North Channel		
11+36	4496.8	4496.9	4497.0
10+69	4496.6	4496.6	4497.0
10+11	4496.4	4495.8	4493.7
9+58	4496.3	4496.4	4496.1
9+05	4495.4	4495.9	4496.0
8+52	4496.3	4495.2	4493.8
8+01	4494.2	4492.9	4492.2
7+90	4488.1	4488.1	4489.0
7+69	4493.9	4493.9	4492.6
7+01	4492.2	4491.1	4492.7
6+51	4492.6	4492.3	4492.4
6+00	4493.1	4492.6	4492.2
5+50	4492.4	4492.2	4492.3
4+99	4492.0	4491.9	4492.1
4+48	4492.0	4491.7	4492.0
3+97	4491.7	4491.6	4491.5
3+46	4490.8	4490.9	4490.6
2+95	4491.3	4490.6	4489.3
2+44	4489.7	4488.7	4489.7
1+93	4489.7	4489.4	4489.7
1+42	4489.1	4489.6	4489.5
0+91	4488.8	4489.1	4489.2
0+41	4487.1	4488.5	4488.9

(Continued)

Note: Sides of channel are referenced to downstream direction.

Table 2 (Continued)

Station	Elevation Left Side	Elevation Center	Elevation Right Side
	North Channel (Continued)		
0+00	4486.8	4487.6	4488.1
	South Channel		
11+77	4497.0	4496.9	4496.6
11+23	4497.2	4496.9	4496.4
10+68	4497.8	4497.1	4496.5
10+14	4497.3	4496.8	4496.4
9+78	4496.4	4496.6	4496.6
9+23	4496.6	4496.7	4496.8
8+69	4496.6	4496.6	4496.7
8+15	4496.6	4496.7	4496.6
7+43	4496.5	4496.3	4496.3
6+89	4495.6	4495.8	4495.8
6+46	4493.6	--	--
6+37	--	4495.9	4496.0
5+87	4495.6	4495.8	4495.9
5+68	4495.3	4495.6	4495.5
5+60	4491.5	4491.0	4491.0
5+35	4491.5	4494.9	4491.0
4+83	4491.4	4491.0	4493.0
4+31	4491.5	4491.6	4491.4
3+79	4491.4	4491.3	4492.5
3+26	4490.0	4490.4	4491.1
2+72	4489.6	4489.9	4489.0
2+19	4489.4	4489.7	4490.6
1+66	4489.0	4489.2	4489.4
1+12	4489.1	4489.0	4488.8
0+59	4488.6	4488.5	4489.1
0+00	4488.7	4488.8	4488.8
	Sta 27+00 to Sta 10+00		
27+00	4487.1	4488.3	4489.0
26+50	4486.5	4488.6	4488.6
26+00	4486.8	4487.8	4488.6
25+50	4486.8	4487.6	4489.1
25+00	4486.7	4486.6	4486.0
24+50	4486.7	4487.1	4486.2
24+00	4487.0	4487.0	4486.9
23+50	4487.1	4486.4	4486.9
23+00	4487.2	4487.1	4487.1
22+50	4487.3	4487.4	4487.3
22+00	4487.3	4488.0	4487.9

(Continued)

Table 2 (Concluded)

Station	Elevation Left Side	Elevation Center	Elevation Right Side
	Sta 27+00 to Sta 10+00 (Continued)		
21+00	4485.8	4485.3	4485.2
20+50	4486.1	4486.0	4485.7
20+00	4486.3	4486.2	4486.1
19+50	4486.4	4486.3	4486.1
19+00	4486.4	4486.4	4486.3
18+50	4486.6	4486.5	4486.4
18+00	4486.6	4486.7	4486.7
17+00	4485.8	4485.6	4486.1
16+50	4485.9	4486.0	4485.8
16+00	4485.9	4485.9	4485.7
15+50	4485.8	4485.8	4485.8
15+00	4485.6	4485.6	4485.7
14+50	4485.7	4485.8	4485.8
14+00	4485.7	4485.7	4485.6
13+50	4485.7	4484.5	4485.9
13+00	4485.4	4485.5	4486.2
12+50	4485.6	4485.6	4485.9
12+00	4485.3	4485.2	4485.8
11+50	4485.2	4484.9	4484.3
11+00	4484.9	4484.7	4484.5
10+50	4484.6	4484.6	4484.5
10+00	4483.9	4483.9	4483.9

(Sheet 3 of 3)

Table 3

Water-Surface Elevations, Type 4 Design Channel

Discharge 18,500 cfs, Water-Surface Elevation

at Sta 10+00 = 4483.9

Station	Elevation Left Side	Elevation Center	Elevation Right Side
	Sta 27+00 to Sta 10+00		
27+00	4487.2	4488.0	4488.6
26+50	4486.2	4488.0	4488.1
26+00	4486.7	4487.2	4487.5
25+50	4486.7	4487.5	4488.1
25+00	4486.8	4487.3	4487.6
24+50	4487.0	4487.4	4487.0
24+00	4487.1	4486.8	4486.1
23+50	4487.1	4487.0	4486.8
23+00	4487.3	4487.2	4487.0
22+50	4487.2	4487.2	4487.2
22+00	4487.3	4487.8	4487.3
21+00	4485.6	4485.1	4484.9
20+50	4486.2	4485.9	4485.8
20+00	4486.3	4486.2	4486.0
19+50	4486.4	4486.3	4486.2
19+00	4486.5	4486.5	4486.4
18+50	4486.6	4486.6	4486.5
18+00	4486.7	4486.7	4486.7
17+00	4485.8	4485.9	4486.3
16+50	4485.9	4486.1	4485.8
16+00	4485.9	4485.8	4485.8
15+50	4485.8	4485.8	4485.8
15+00	4485.4	4485.7	4486.1
14+50	4485.7	4485.8	4486.0
14+00	4485.7	4485.8	4485.6
13+50	4485.5	4484.2	4485.8
13+00	4485.4	4485.3	4486.0
12+50	4485.3	4485.4	4485.7
12+00	4485.1	4485.0	4485.7
11+50	4485.3	4484.8	4484.0
11+00	4484.3	4484.5	4484.3
10+50	4484.3	4484.3	4484.2
10+00	4483.9	4483.9	4483.9

(Continued)

Note: Sides of channel are referenced to downstream direction.

Table 3 (Continued)

Station	Elevation Left Side	Elevation Center	Elevation Right Side
	North Channel		
11+36	4496.8	4496.9	4497.0
10+69	4496.6	4496.6	4497.0
10+11	4496.4	4495.8	4493.7
9+58	4496.3	4496.4	4496.1
9+05	4495.4	4495.9	4496.0
8+52	4496.3	4495.2	4493.8
8+01	4484.2	4492.9	4492.2
7+90	4489.0	4488.4	4489.1
7+69	4494.0	4493.9	4491.9
7+01	4493.8	4492.7	4492.7
6+51	4493.5	4492.8	4492.7
6+00	4493.4	4492.8	4492.6
5+50	4492.5	4492.2	4492.3
4+99	4491.4	4491.9	4492.1
4+48	4491.9	4491.9	4491.9
3+97	4491.6	4491.7	4490.8
3+46	4491.1	4490.7	4490.4
2+95	4490.1	4490.5	4491.0
2+44	4489.2	4488.2	4489.1
1+93	4489.1	4489.0	4489.6
1+42	4488.5	4489.0	4489.2
0+91	4488.4	4488.4	4488.8
0+41	4487.1	4488.0	4488.8
0+00	4485.7	4488.2	4488.0
	South Channel		
11+77	4497.0	4496.9	4496.6
11+23	4497.2	4496.9	4496.4
10+68	4497.8	4497.1	4496.5
10+14	4497.3	4496.8	4496.4
9+78	4496.4	4496.6	4496.6
9+23	4496.6	4496.7	4496.8
8+69	4496.6	4496.6	4496.7
8+15	4496.6	4496.7	4496.6
7+43	4496.5	4496.3	4496.3
6+89	4495.6	4495.8	4495.8
6+46	4495.6	--	--
6+37	--	4495.9	4496.0
5+87	4495.6	4495.0	4495.9
5+68	4495.3	4495.6	4495.5
5+60	4491.2	4490.1	4492.2
5+35	4491.5	4492.2	4492.3

(Continued)

Table 3 (Concluded)

Station	Elevation Left Side	Elevation Center	Elevation Right Side
	South Channel (Continued)		
4+83	4491.4	4491.0	4492.9
4+31	4491.7	4491.7	4491.3
3+79	4491.2	4491.5	4492.6
3+26	4489.9	4490.4	4490.9
2+72	4489.5	4489.6	4489.7
2+19	4489.2	4489.9	4490.4
1+66	4488.8	4489.0	4489.3
1+12	4488.6	4488.4	4487.9
0+59	4487.1	4488.0	4488.8
0+00	4485.7	4488.2	4488.0

Table 4

Water-Surface Elevations, Type 5 Design Channel

Discharge 18,500 cfs, Water-Surface Elevation

at Sta 10+00 = 4483.9

Station	Elevation Left Side	Elevation Center	Elevation Right Side
	Sta 27+00 to Sta 10+00		
27+00	4488.3	4488.0	4488.6
26+50	4486.6	4487.9	4488.5
26+00	4487.4	4487.7	4488.7
25+50	4487.4	4487.7	4488.9
25+00	4487.5	4489.8	4488.5
24+50	4487.6	4488.5	4487.6
24+00	4487.5	4487.2	4487.2
23+50	4487.4	4487.2	4487.2
23+00	4487.6	4487.6	4487.7
22+50	4487.6	4487.7	4487.7
22+00	4487.6	4488.5	4487.9
21+00	4485.9	4485.2	4485.2
20+50	4486.3	4486.3	4485.7
20+00	4486.5	4486.5	4486.3
19+50	4486.7	4486.6	4486.6
19+00	4486.8	4486.8	4486.7
18+50	4486.7	4486.7	4486.8
18+00	4486.8	4487.1	4486.8
17+00	4485.8	4486.1	4486.4
16+50	4485.8	4486.2	4485.9
16+00	4486.1	4486.1	4485.9
15+50	4486.0	4486.0	4485.9
15+00	4486.1	4486.0	4485.9
14+50	4485.9	4486.0	4485.9
14+00	4485.6	4485.9	4486.1
13+50	4485.6	4484.6	4485.5
13+00	4485.4	4485.5	4486.1
12+50	4485.5	4485.6	4485.9
12+00	4485.2	4485.3	4485.8
11+50	4485.4	4484.9	4484.2
11+00	4484.7	4484.6	4484.3
10+50	4484.6	4484.5	4484.3
10+00	4483.9	4483.9	4483.9

(Continued)

Note: Sides of channel are referenced to downstream direction.

(Sheet 1 of 3)

Table 4 (Continued)

Station	Elevation Left Side	Elevation Center	Elevation Right Side
	North Channel		
11+36	4496.8	4496.9	4497.0
10+69	4496.6	4496.6	4497.0
10+11	4496.4	4495.8	4493.7
9+58	4496.3	4496.4	4496.1
9+05	4495.4	4495.9	4496.0
8+52	4496.3	4495.2	4493.8
7+84	4492.4	4491.6	4492.5
7+72	4493.9	4494.0	4492.4
7+51	4493.2	4492.7	4492.7
7+01	4493.6	4492.3	4492.7
6+51	4493.5	4493.0	4492.7
6+00	4493.1	4492.4	4492.5
5+50	4492.4	4492.2	4492.4
4+99	4491.5	4492.1	4492.2
4+48	4492.3	4492.4	4492.7
3+97	4491.6	4492.4	4492.0
3+46	4491.4	4491.0	4490.9
2+95	4491.5	4491.0	4490.5
2+44	4489.6	4489.5	4490.4
1+93	4490.3	4490.1	4490.4
1+42	4489.7	4490.0	4490.0
0+91	4488.9	4488.7	4489.3
0+41	4487.1	4487.8	4487.8
0+00	4486.6	4487.9	4488.0
	South Channel		
11+77	4497.0	4496.9	4496.6
11+23	4497.2	4496.9	4496.4
10+68	4497.8	4497.1	4496.5
10+14	4497.3	4496.8	4496.4
9+78	4496.4	4496.6	4496.6
9+23	4496.6	4496.7	4496.8
8+69	4496.6	4496.6	4496.7
8+15	4496.6	4496.7	4496.6
7+43	4496.5	4496.3	4496.3
6+89	4495.6	4495.8	4495.8
6+46	4495.6	--	--
6+37	--	4495.9	4496.0
5+87	4495.6	4495.0	4495.9
5+68	4495.3	4495.6	4495.5
5+60	4490.7	4489.9	4490.9

(Continued)

Table 4 (Concluded)

Station	Elevation Left Side	Center	Right Side
	South Channel (Continued)		
5+35	4491.8	4493.9	4492.1
4+83	4492.1	4491.7	4492.6
4+31	4492.6	4492.5	4491.7
3+79	4492.2	4492.4	4492.7
3+26	4491.1	4491.4	4491.7
2+72	4491.5	4491.7	4491.5
2+19	4488.7	4489.1	4490.2
1+66	4489.2	4489.4	4489.2
1+12	4488.7	4489.0	4488.7
0+59	4488.3	4488.0	4488.6
0+00	4487.9	4488.0	4488.5

(Sheet 3 of 3)

Table 5

Water-Surface Elevations, Type 6 Design Channel

Sta 27+00 to Sta 18+00, Discharge 18,500 cfs,

Water-Surface Elevation at Sta 10+00 = 4483.9

	Elevation		
Station	Left Side	Center	Right Side
27+00	4487.2	4487.7	4488.4
26+50	4486.5	4487.9	4488.6
26+00	4487.3	4488.2	4488.7
25+50	4487.3	4488.2	4489.1
25+00	4487.6	4487.3	4488.4
24+50	4487.6	4487.8	4487.4
24+00	4487.6	4487.1	4486.6
23+50	4487.5	4487.8	4487.0
23+00	4487.5	4487.4	4487.3
22+50	4487.4	4487.6	4487.6
22+00	4487.5	4488.5	4487.8
21+00	4485.9	4485.6	4485.2
20+50	4486.2	4486.3	4485.9
20+00	4486.4	4486.4	4486.4
19+50	4486.6	4486.6	4486.4
19+00	4486.7	4486.6	4486.6
18+50	4486.7	4486.6	4486.5
18+00	4486.7	4487.0	4486.9

Note: Sides of channel are referenced to downstream direction.

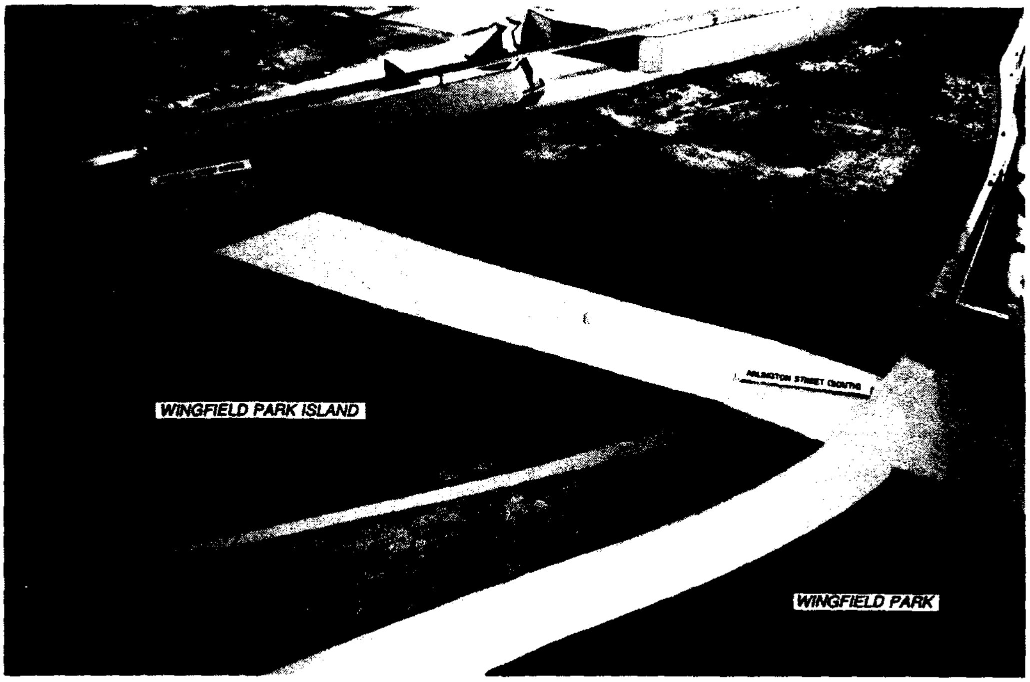
Table 6

Virginia Street Blockage Test Results

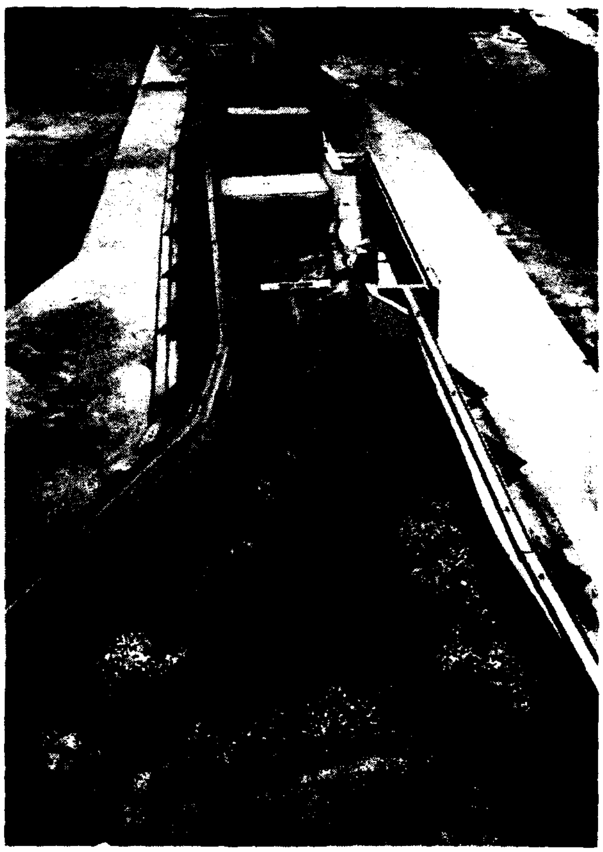
Type 6 Design Channel, Discharge 18,500 cfs

Water-Surface Elevation at Sta 10+00 = 4483.9

Blockage Soffit Elevation	Station	Center-Line Water-Surface Elevation	Blockage Soffit Elevation	Station	Center-Line Water-Surface Elevation
4489	22+00	4488.5	4485	22+00	4489.1
4489	22+50	4487.3	4485	22+50	4488.4
4489	23+00	4487.2	4485	23+00	4488.2
4489	23+50	4487.8	4485	23+50	4487.9
4489	24+00	4487.2	4485	24+00	4488.2
4489	24+50	4487.3	4485	24+50	4488.1
4488	22+00	4488.7	4484	22+00	4489.7
4488	22+50	4487.3	4484	22+50	4488.7
4488	23+00	4487.2	4484	23+00	4488.6
4488	23+50	4487.8	4484	23+50	4488.6
4488	24+00	4487.3	4484	24+00	4488.8
4488	24+50	4487.5	4484	24+50	4488.6
4487	22+00	4488.8	4483	22+00	4490.6
4487	22+50	4487.4	4483	22+50	4489.9
4487	23+00	4487.3	4483	23+00	4489.8
4487	23+50	4487.5	4483	23+50	4489.6
4487	24+00	4487.4	4483	24+00	4489.8
4487	24+50	4487.5	4483	24+50	4489.8
4486	22+00	4488.9	4482	22+00	4492.4
4486	22+50	4487.8	4482	22+50	4491.6
4486	23+00	4487.4	4482	23+00	4491.6
4486	23+50	4488.0	4482	23+50	4491.7
4486	24+00	4487.7	4482	24+00	4491.6
4486	24+50	4488.0	4482	24+50	4491.8

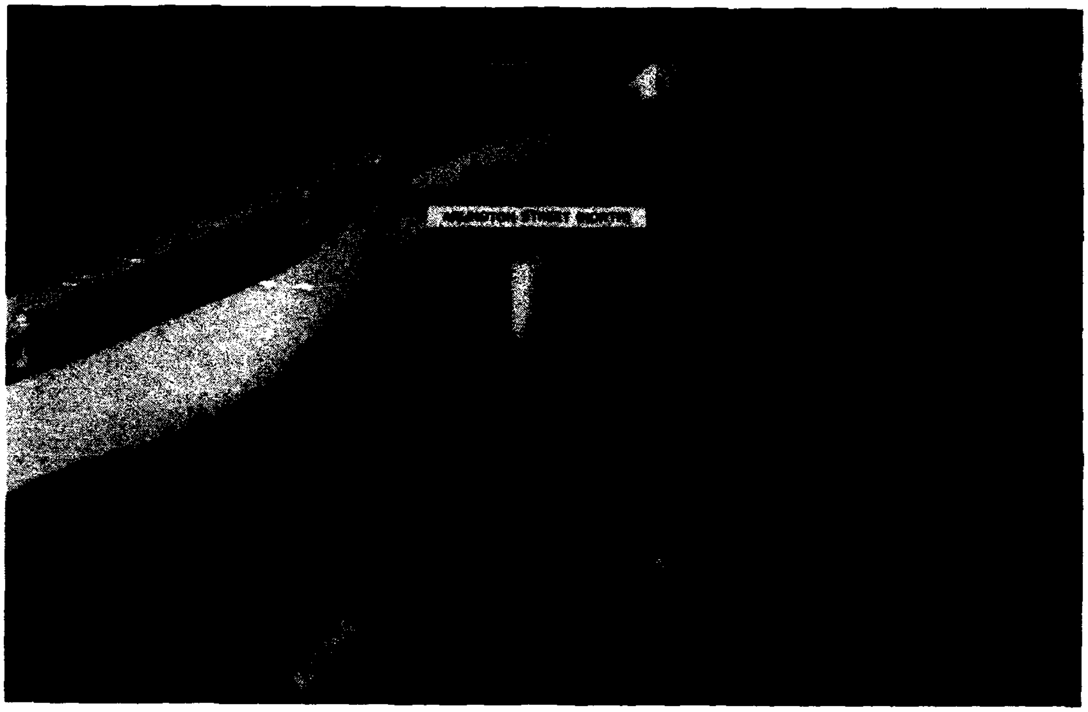


a. Wingfield Park and North and South Arlington Street crossings

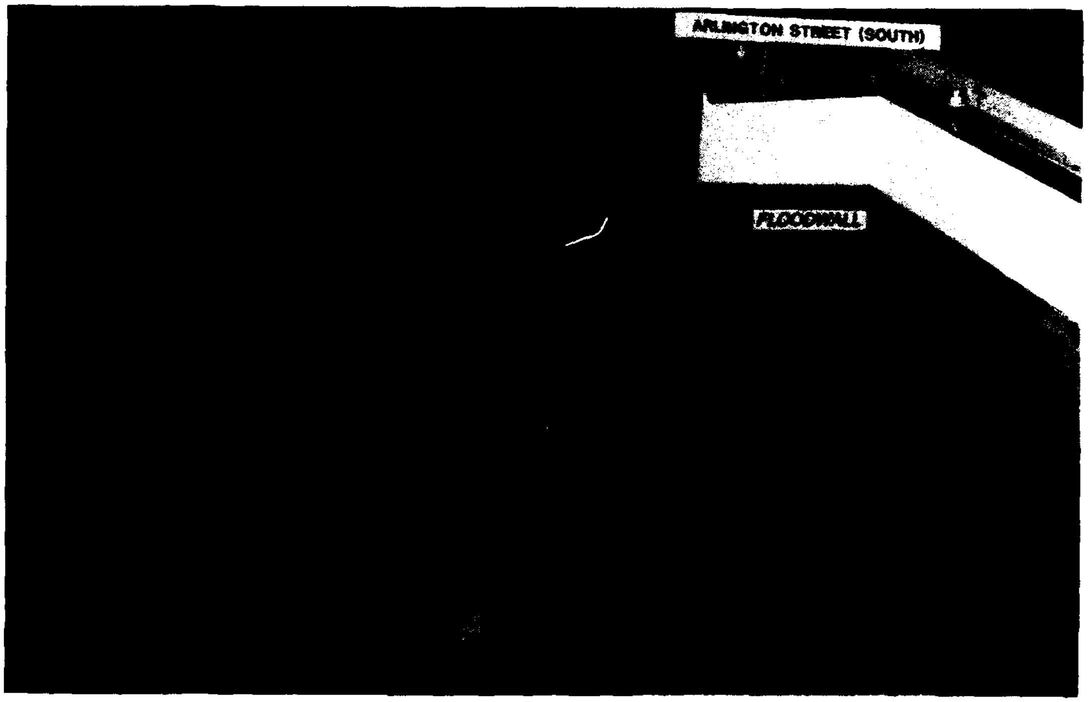


b. Lower reach of model

Photo 1. Dry bed view of type 1 (original) design channel looking downstream



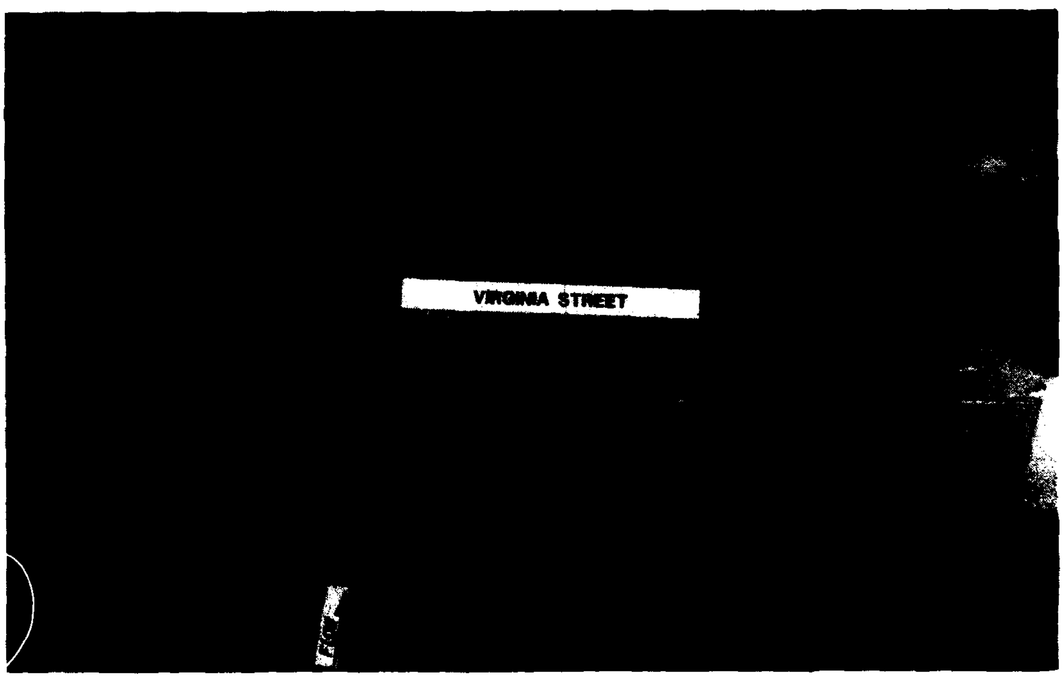
a. North Arlington Street crossing



b. South Arlington Street Bridge

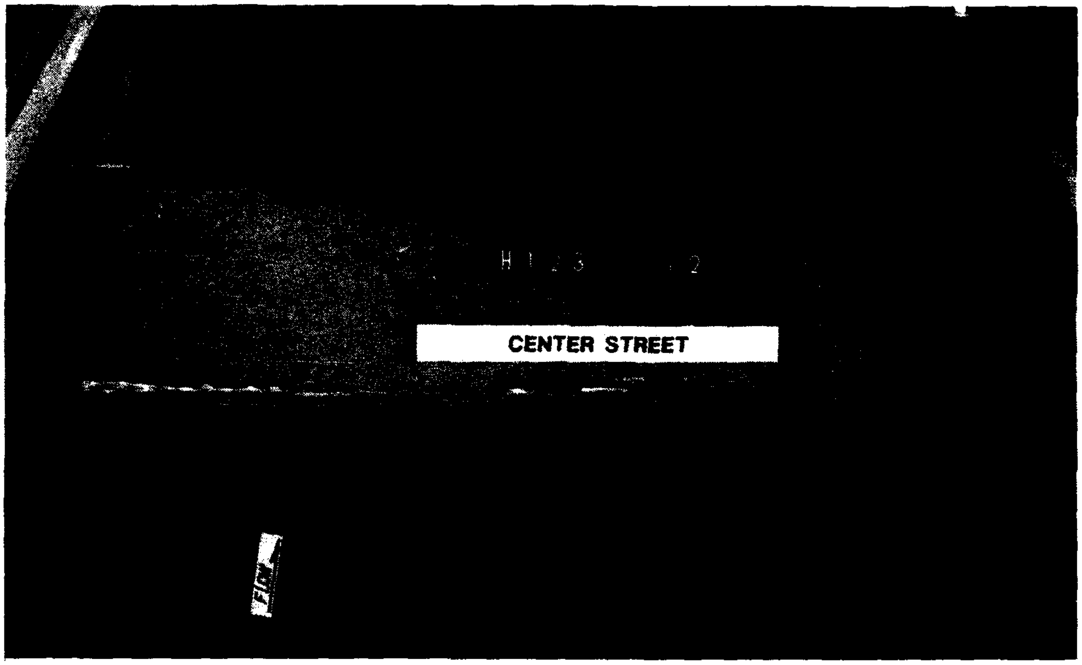
Photo 2. Flow conditions with the type 1 (original) design channel looking downstream, discharge 18,500 cfs (Sheet 1 of 3)

c. Sierra Street crossing



d. Virginia Street Bridge

Photo 2. (Sheet 2 of 3)



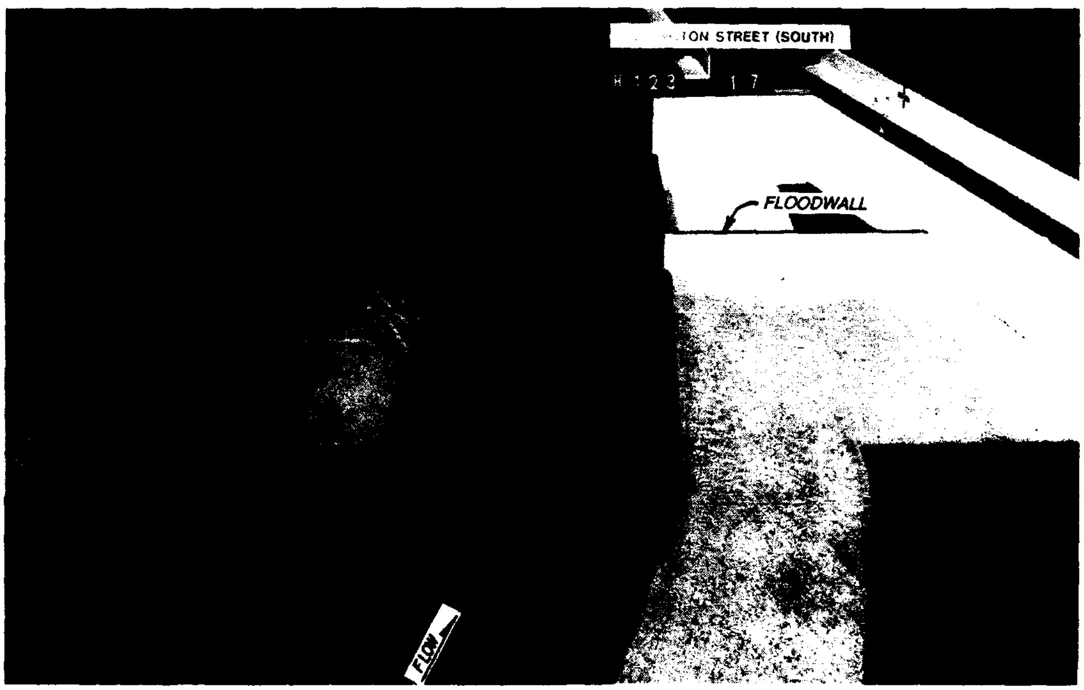
e. Center Street Bridge

f. Lake Street crossing

Photo 2. (Sheet 3 of 3)

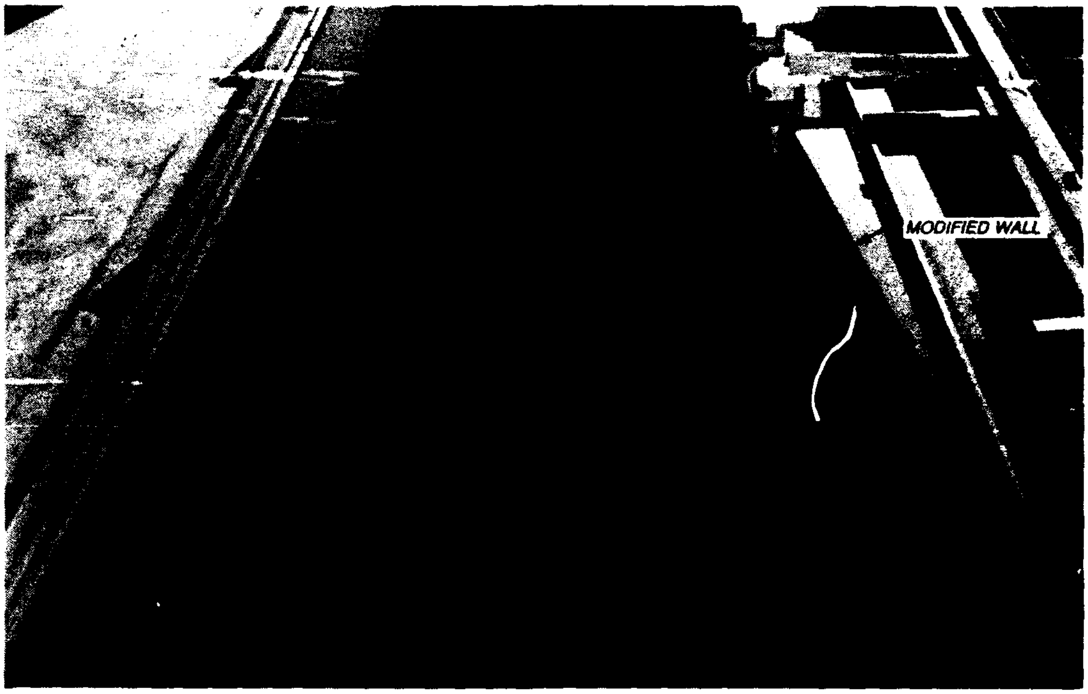
Photo 3. Flow conditions near the North Arlington Street crossing with the type 2 design channel, looking downstream, discharge 18,500 cfs

a. Dry bed

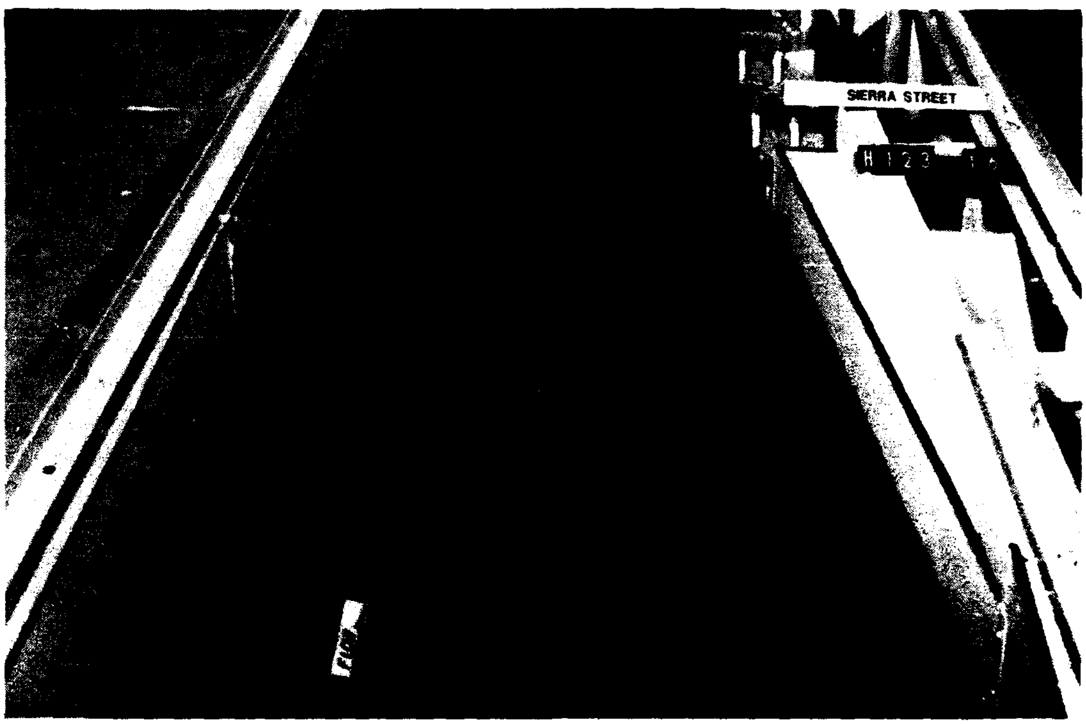


b. Discharge 18,500 cfs

Photo 4. Type 3 design channel near the South Arlington Street Bridge, looking downstream



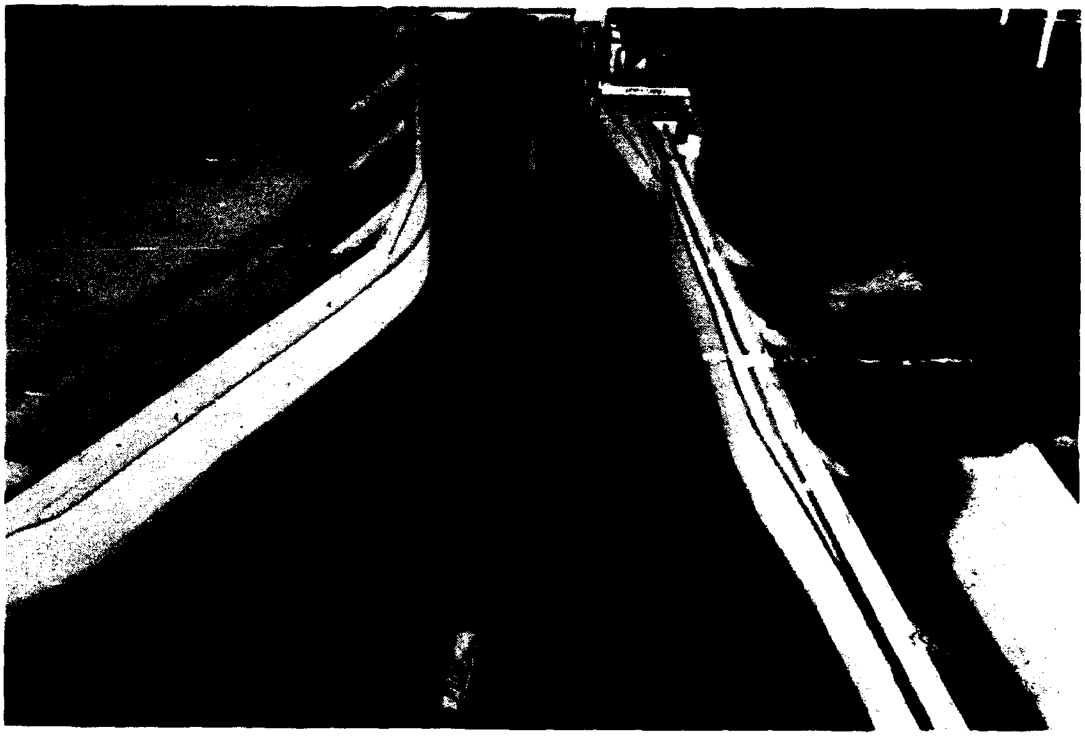
a. Dry bed



b. Discharge 18,500 cfs

Photo 5. Type 4 design channel near the Sierra Street crossing, looking downstream

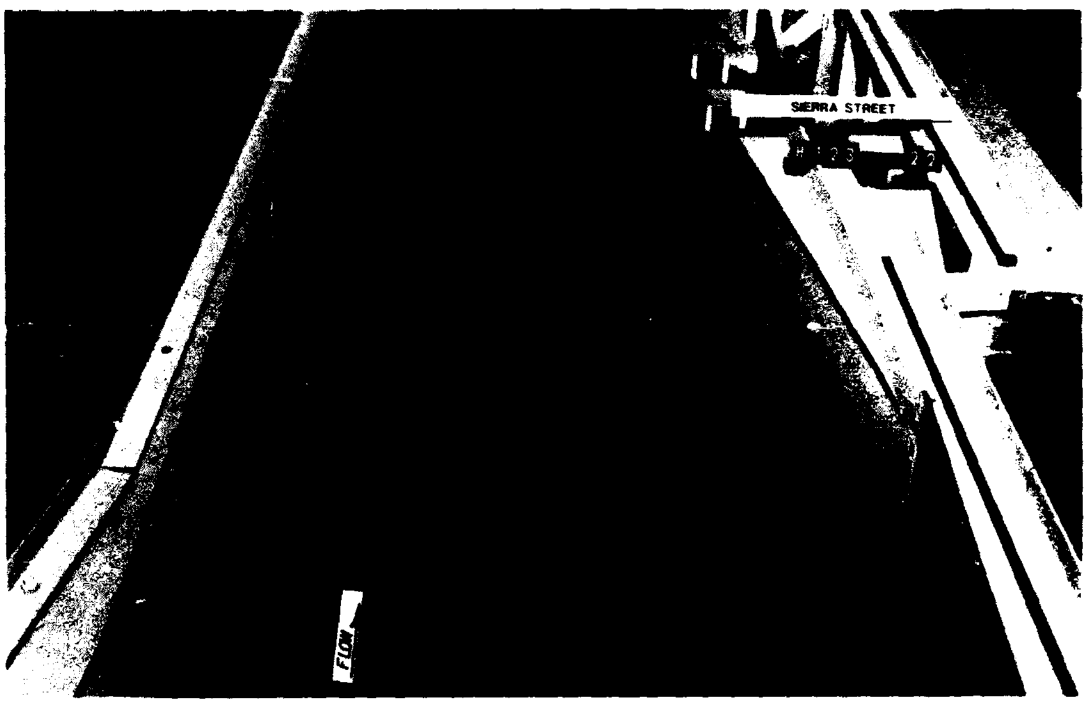
a. Dry bed



b. Discharge 18,500 cfs

Photo 6. Type 5 design channel near the Sierra Street crossing, looking downstream

a. Dry bed



b. Discharge 18,500 cfs

Photo 7. Type 6 design channel near the Sierra Street crossing, looking downstream

ALIGNMENT DATA

BASELINE (℄) DATA

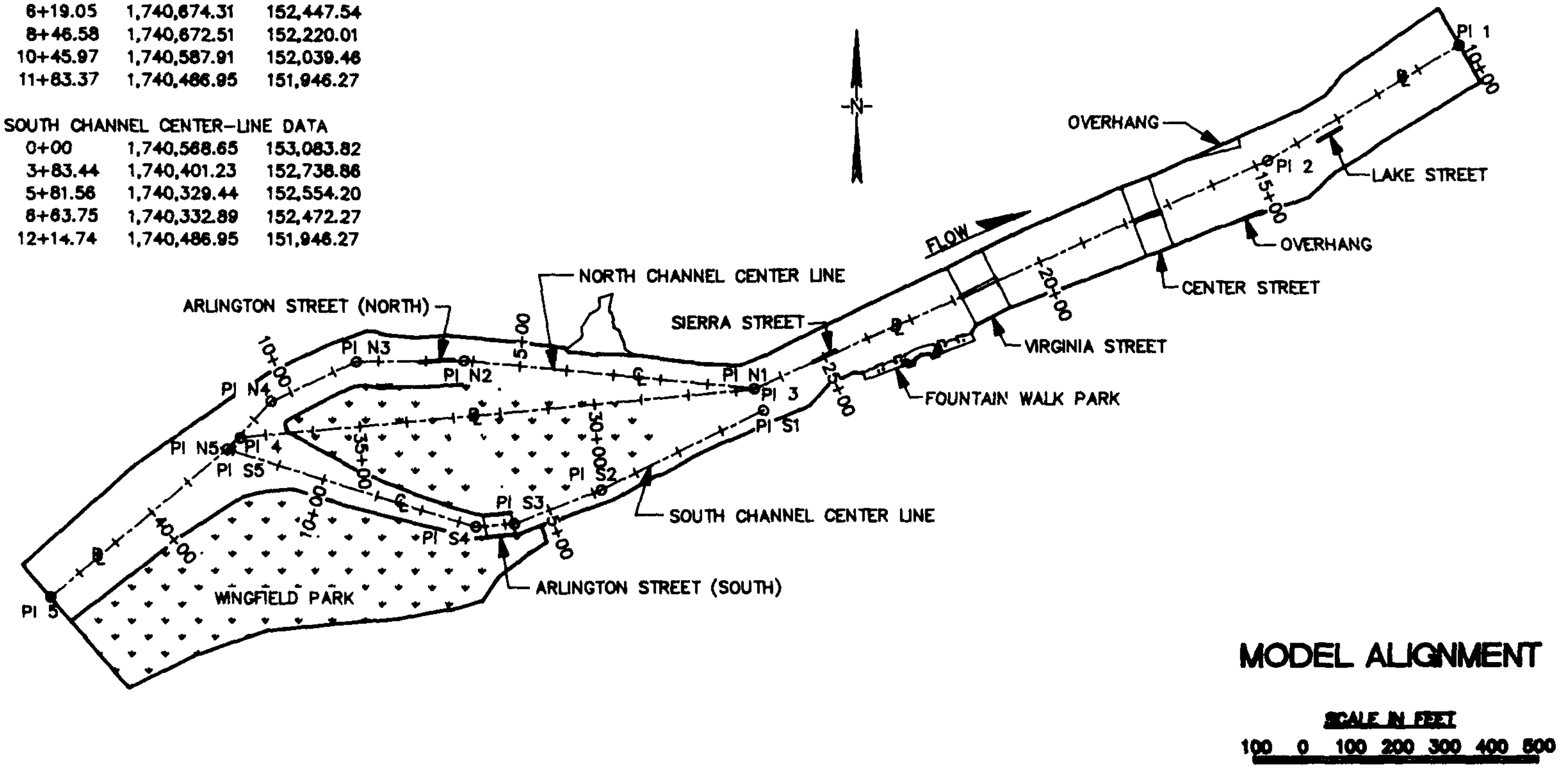
PI	STATION	NORTH	EAST
1	10+00	1,741,337.57	154,555.68
2	14+71.48	1,741,095.10	154,151.33
3	26+60.61	1,740,614.42	153,063.68
4	37+54.77	1,740,510.63	151,974.45
5	42+80.09	1,740,172.64	151,572.30

NORTH CHANNEL CENTER-LINE DATA

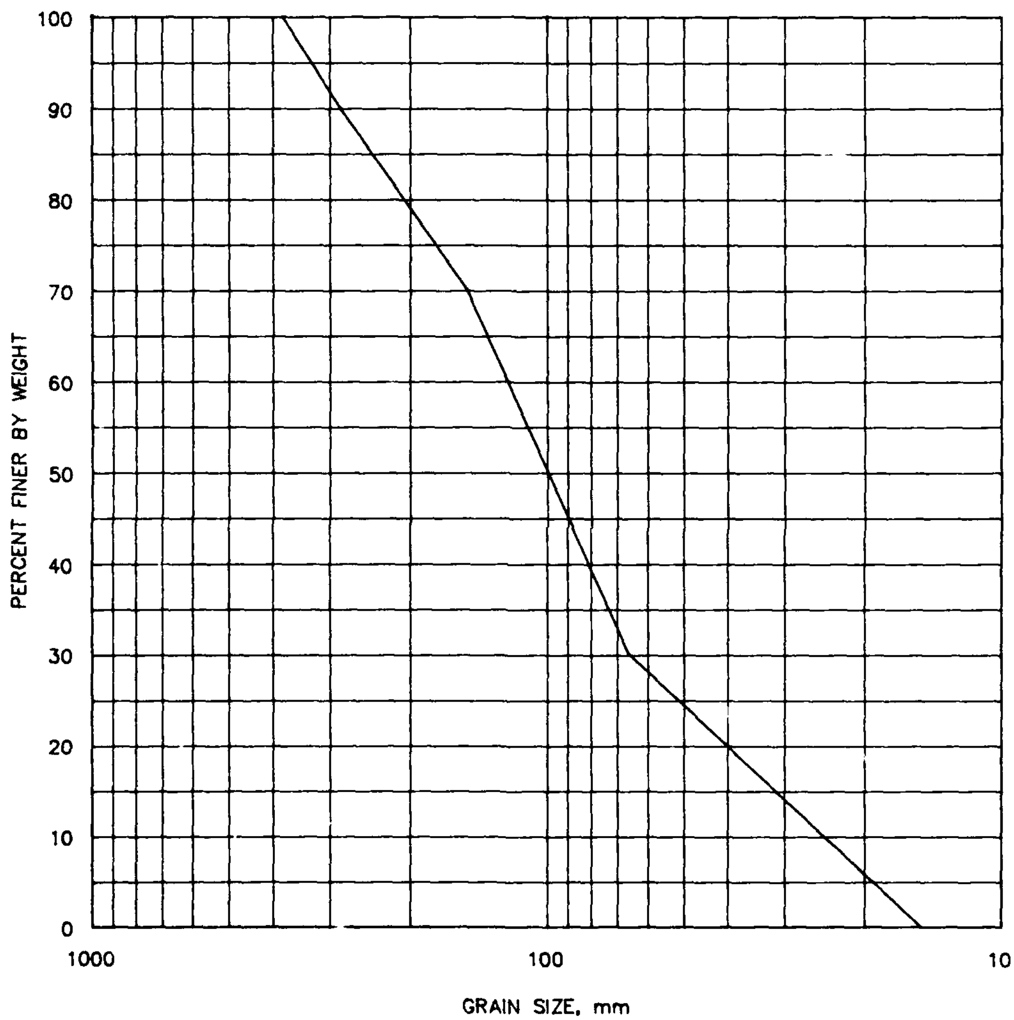
N1	0+00	1,740,614.42	153,063.68
N2	6+19.05	1,740,674.31	152,447.54
N3	8+46.58	1,740,672.51	152,220.01
N4	10+45.97	1,740,587.91	152,039.46
N5	11+83.37	1,740,486.95	151,946.27

SOUTH CHANNEL CENTER-LINE DATA

S1	0+00	1,740,568.65	153,083.82
S2	3+83.44	1,740,401.23	152,738.86
S3	5+81.56	1,740,329.44	152,554.20
S4	8+63.75	1,740,332.89	152,472.27
S5	12+14.74	1,740,486.95	151,946.27

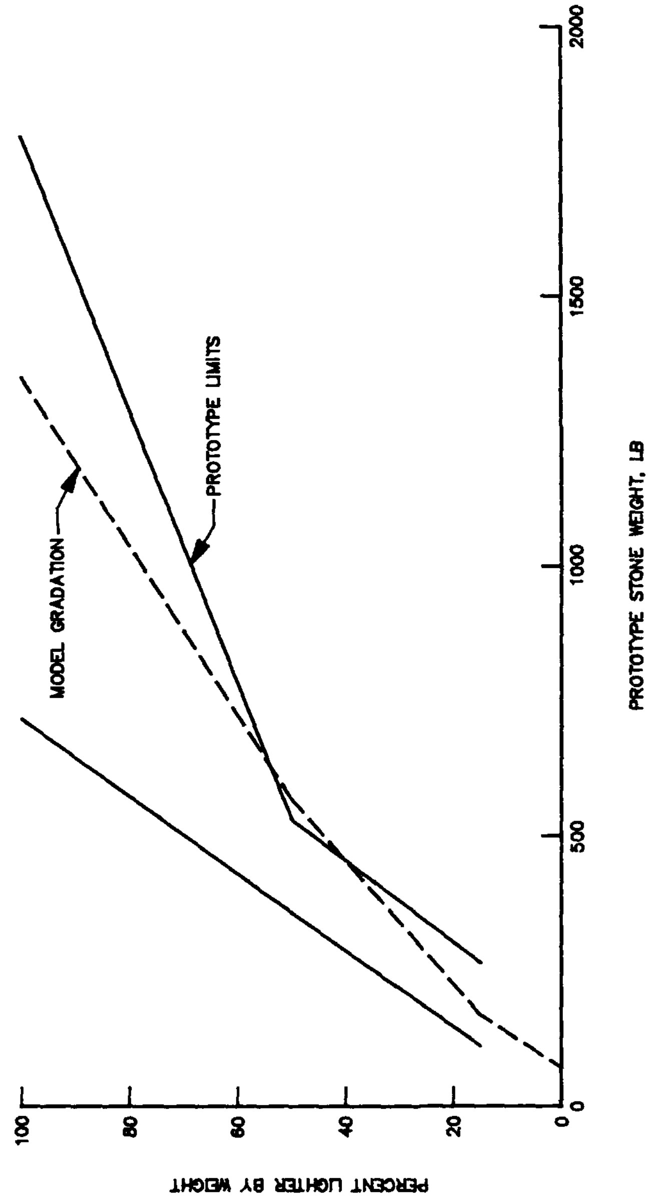


MODEL ALIGNMENT

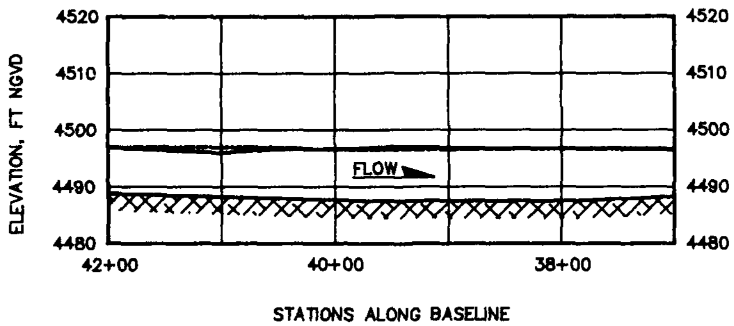


CHANNEL BED GRADATION

PLATE 2



TYPE A STONE GRADATION



LEGEND

—— LEFT SIDE OF CHANNEL

—— RIGHT SIDE OF CHANNEL

(REFERENCED TO LOOKING DOWNSTREAM)

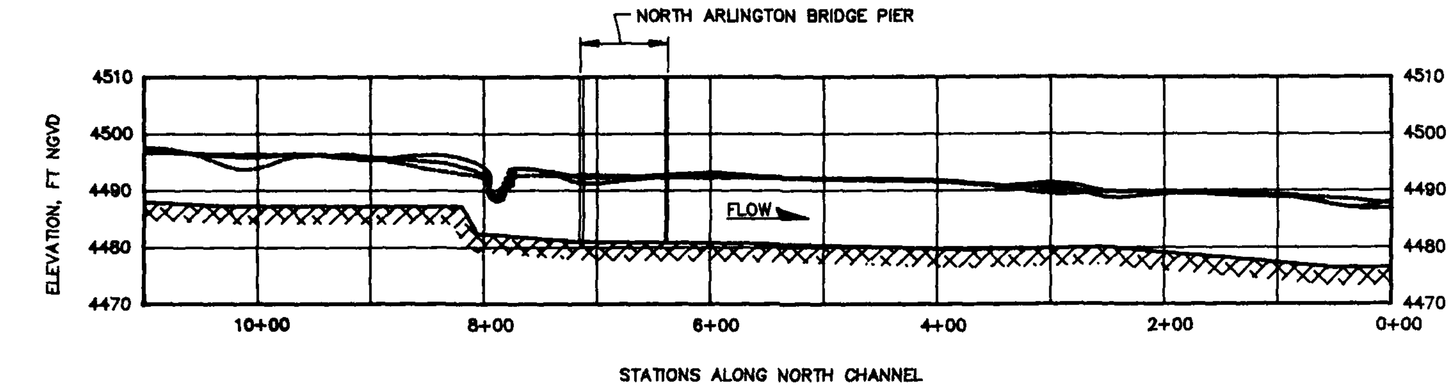
WATER-SURFACE PROFILES

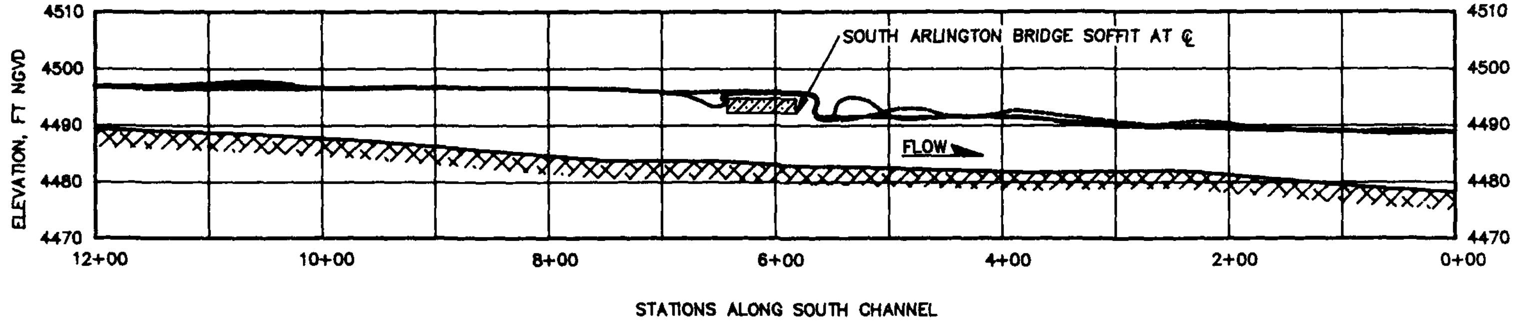
STA 37+00 TO STA 42+00

TYPE 1 (ORIGINAL) DESIGN

DISCHARGE 18,500 CFS

WATER-SURFACE ELEVATION AT STA 10+00 = 4483.9



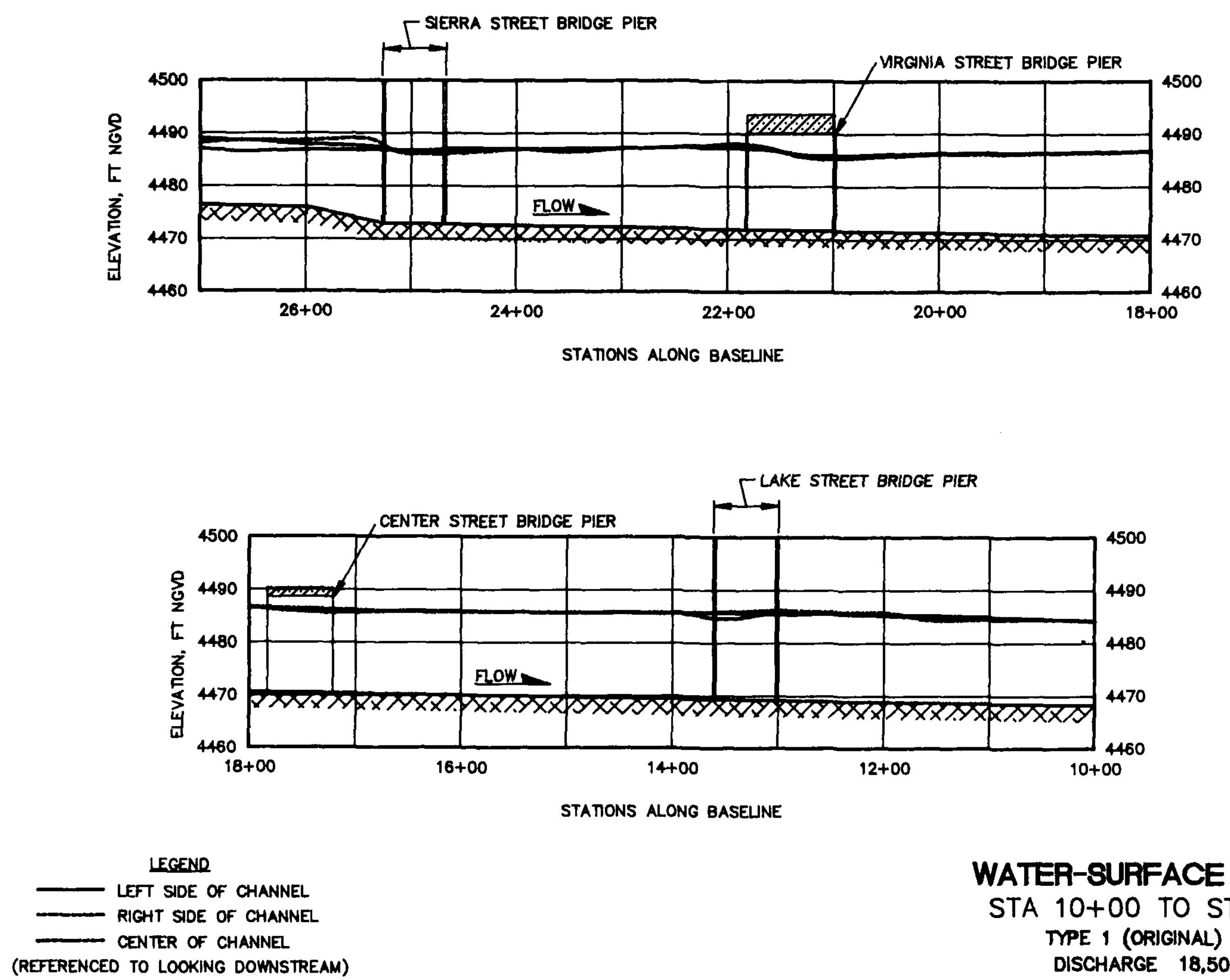


LEGEND

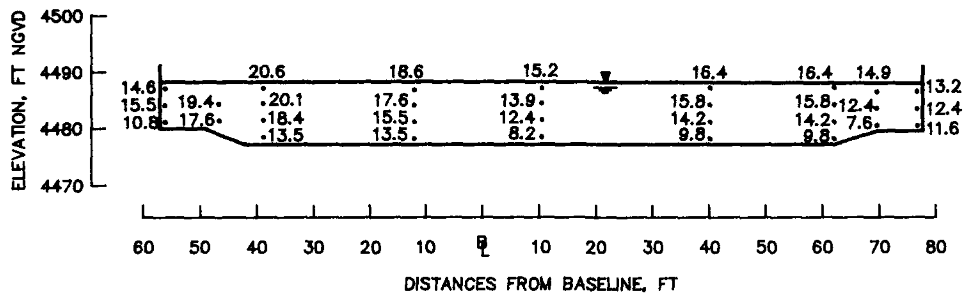
- LEFT SIDE OF CHANNEL
- RIGHT SIDE OF CHANNEL
- CENTER OF CHANNEL

(REFERENCED TO LOOKING DOWNSTREAM)

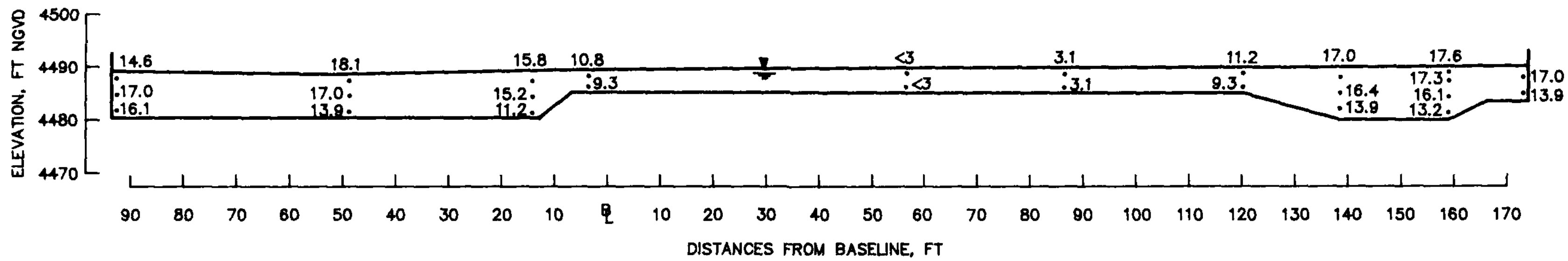
WATER-SURFACE PROFILES
NORTH AND SOUTH CHANNELS
TYPE 1 (ORIGINAL) DESIGN
DISCHARGE 18,500 CFS
WATER-SURFACE ELEVATION AT STA 10+00 = 4483.9



WATER-SURFACE PROFILES
STA 10+00 TO STA 27+00
TYPE 1 (ORIGINAL) DESIGN
DISCHARGE 18,500 CFS
WATER-SURFACE ELEVATION AT STA 10+00 = 4483.9



STA 26+60



STA 29+00

NOTE: DISTANCES FROM BASELINE ARE REFERENCED TO LOOKING DOWNSTREAM. VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

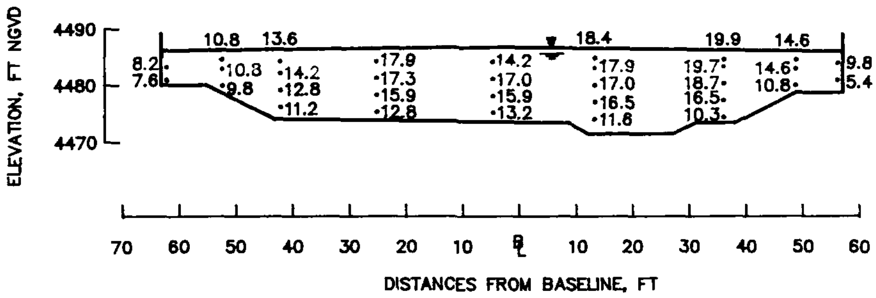
CHANNEL VELOCITIES

STA 26+60 AND 29+00

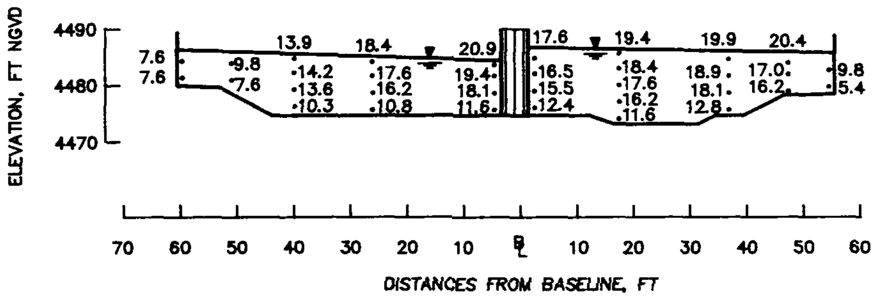
TYPE 1 (ORIGINAL) DESIGN

DISCHARGE 18,500 CFS

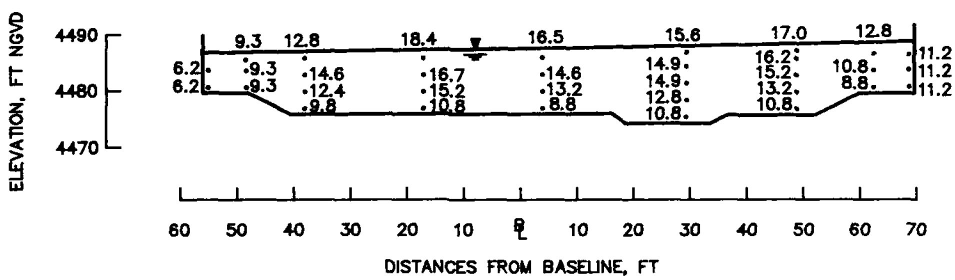
WATER-SURFACE ELEVATION AT STA 10+00 = 4482.5



STA 24+50



STA 25+00



STA 25+42

NOTE: DISTANCES FROM BASELINE ARE REFERENCED TO LOOKING DOWNSTREAM. VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

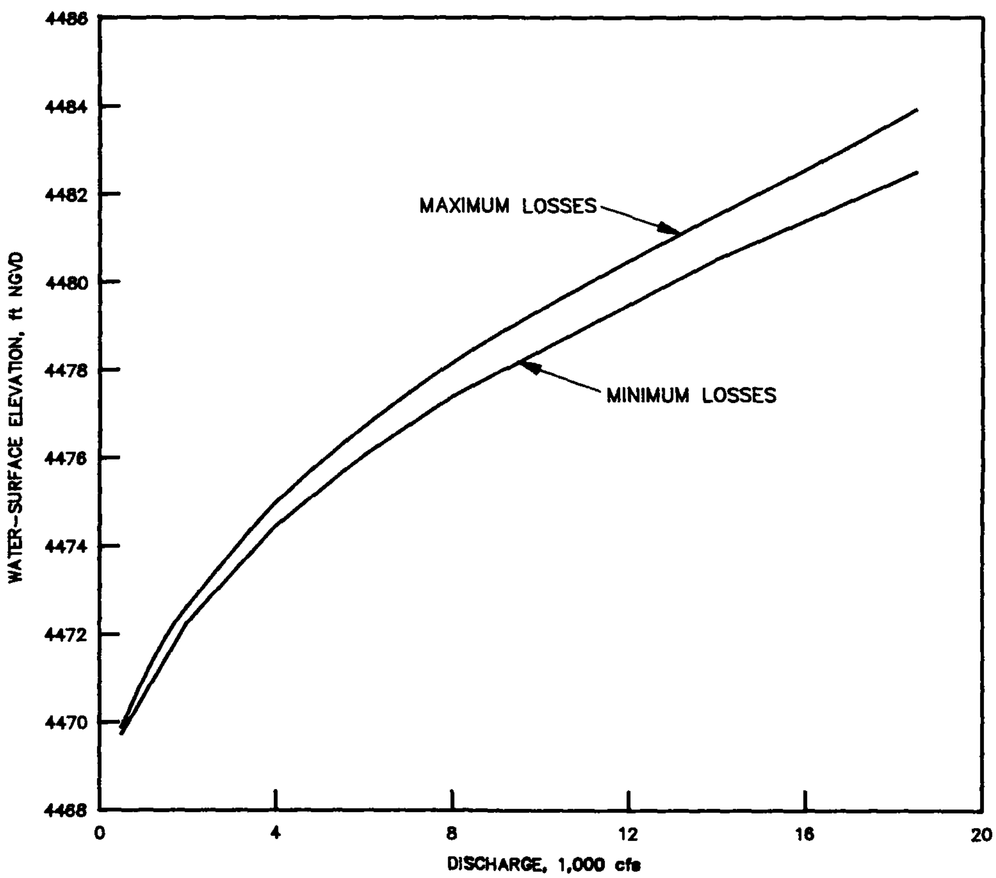
CHANNEL VELOCITIES

STA 24+50, 25+00, AND 25+42

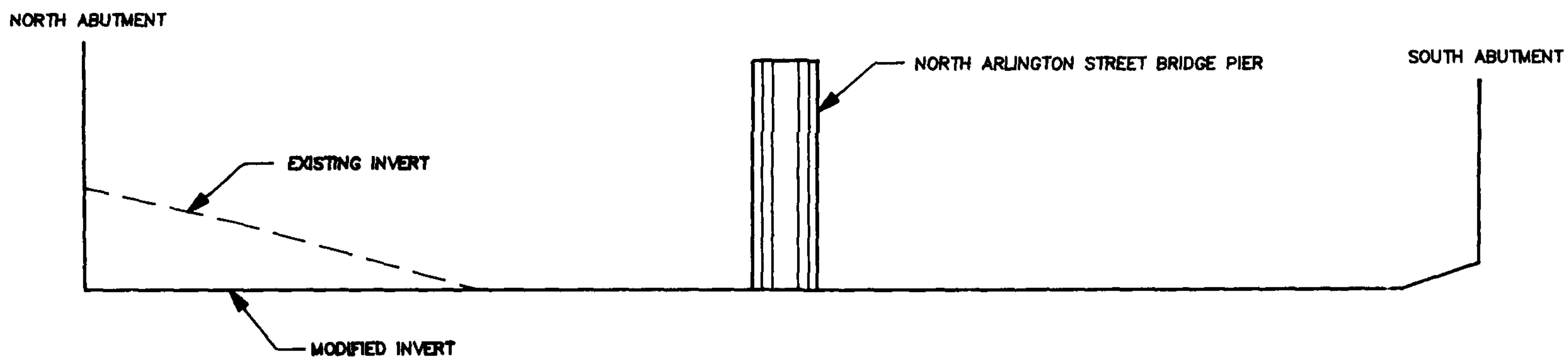
TYPE 1 (ORIGINAL) DESIGN

DISCHARGE 18,500 CFS

WATER-SURFACE ELEVATION AT STA 10+00 = 4482.5



RATING CURVE FOR STA 10+00



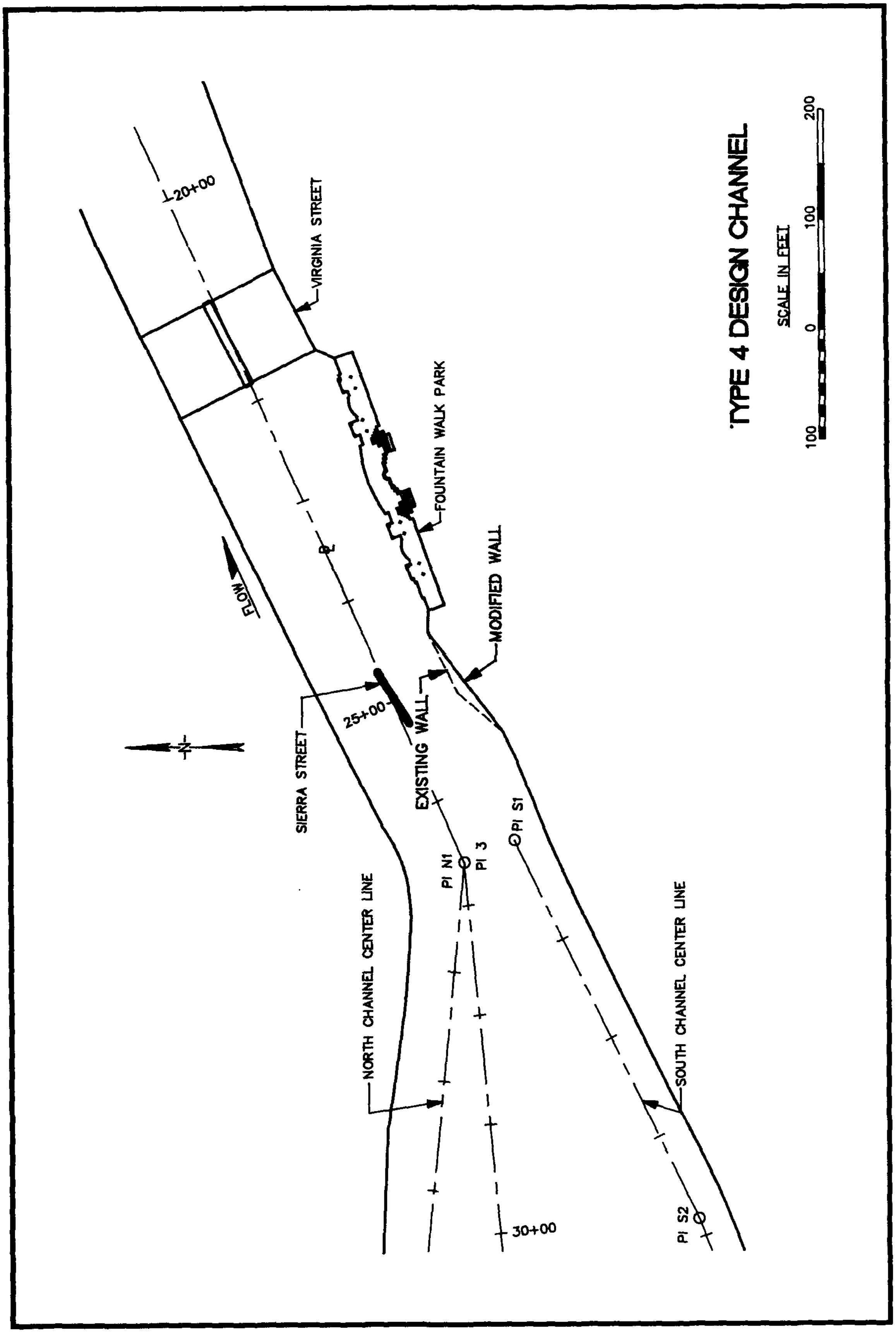
CROSS SECTION AT NORTH ARLINGTON STREET CROSSING

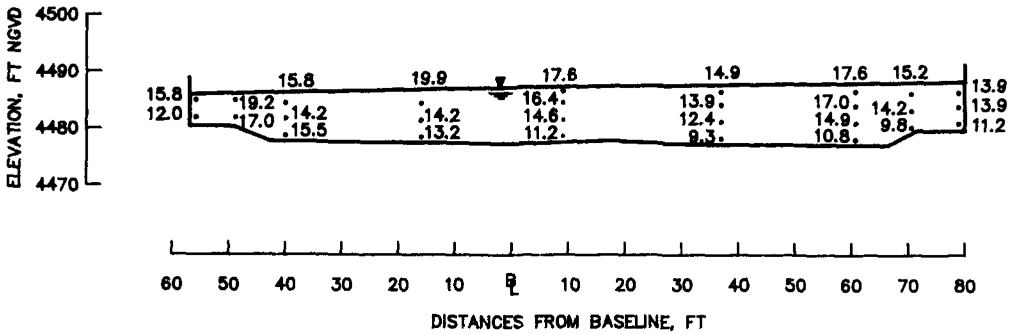
TYPE 2 DESIGN CHANNEL
LOOKING DOWNSTREAM

SCALE IN FEET

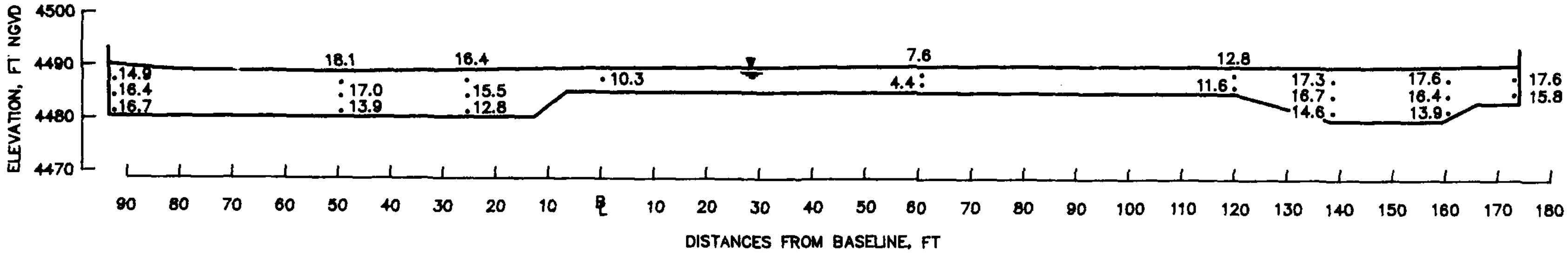
20 0 20

PLATE 10


TYPE 4 DESIGN CHANNEL
SCALE IN FEET
100
0
100
200
VIRGINIA STREET
20+00
FOUNTAIN WALK PARK
MODIFIED WALL
EXISTING WALL
FLOW
SIERRA STREET
25+00
N
PI N1
PI 3
PI S1
NORTH CHANNEL CENTER LINE
SOUTH CHANNEL CENTER LINE
PI S2
30+00



STA 26+60



STA 29+00

NOTE: DISTANCES FROM BASELINE ARE REFERENCED TO LOOKING DOWNSTREAM. VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

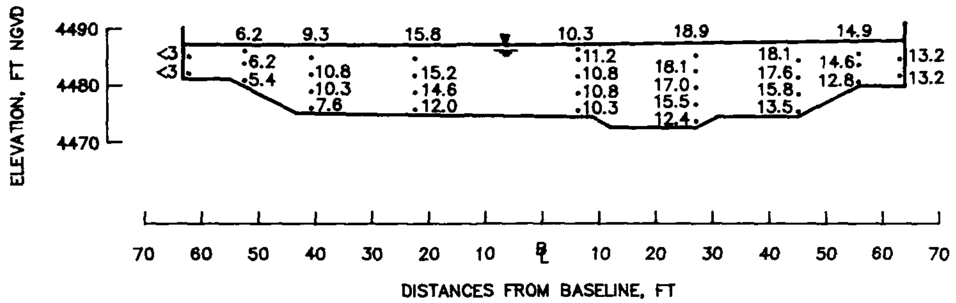
CHANNEL VELOCITIES

STA 26+60 AND 29+00

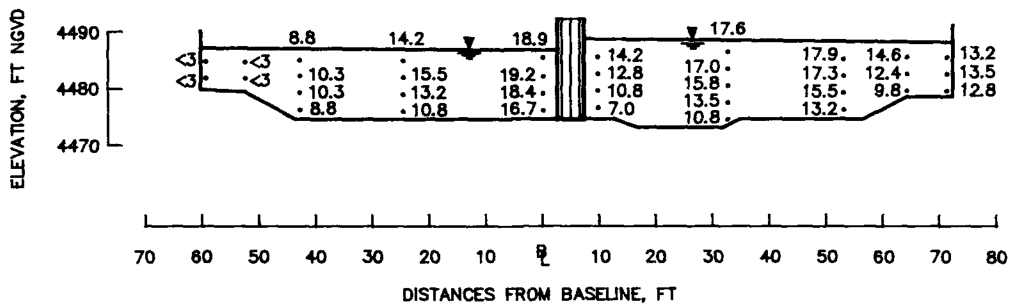
TYPE 4 DESIGN CHANNEL

DISCHARGE 18,500 CFS

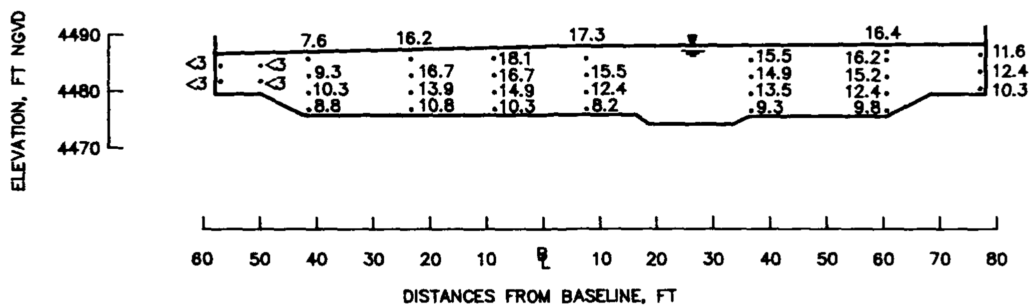
WATER–SURFACE ELEVATION AT STA 10+00 = 4482.5



STA 24+50



STA 25+00



STA 25+42

NOTE: DISTANCES FROM BASELINE ARE REFERENCED TO LOOKING DOWNSTREAM. VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

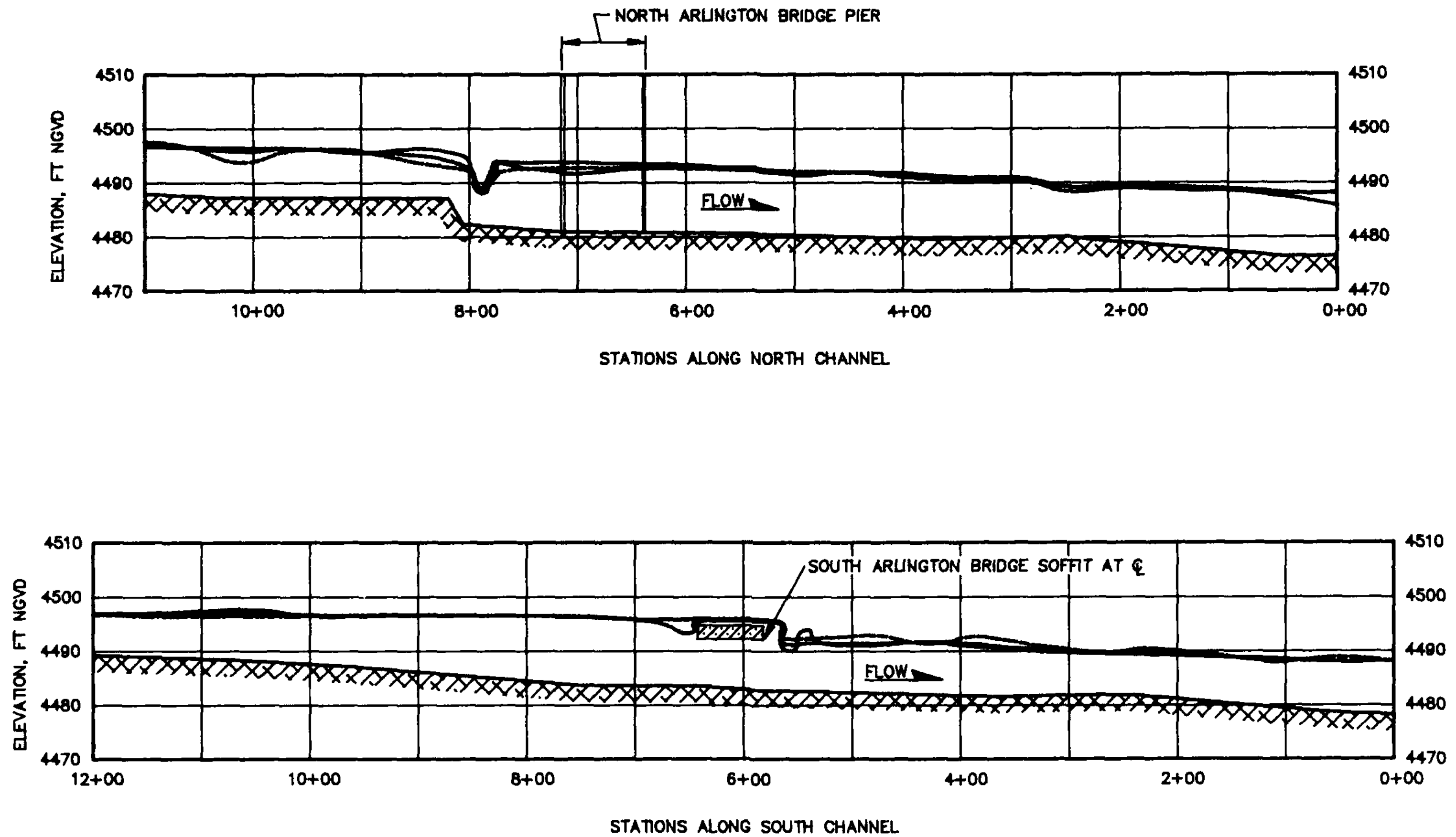
CHANNEL VELOCITIES

STA 24+50, 25+00, AND 25+42

TYPE 4 DESIGN CHANNEL

DISCHARGE 18,500 CFS

WATER-SURFACE ELEVATION AT STA 10+00 = 4482.5

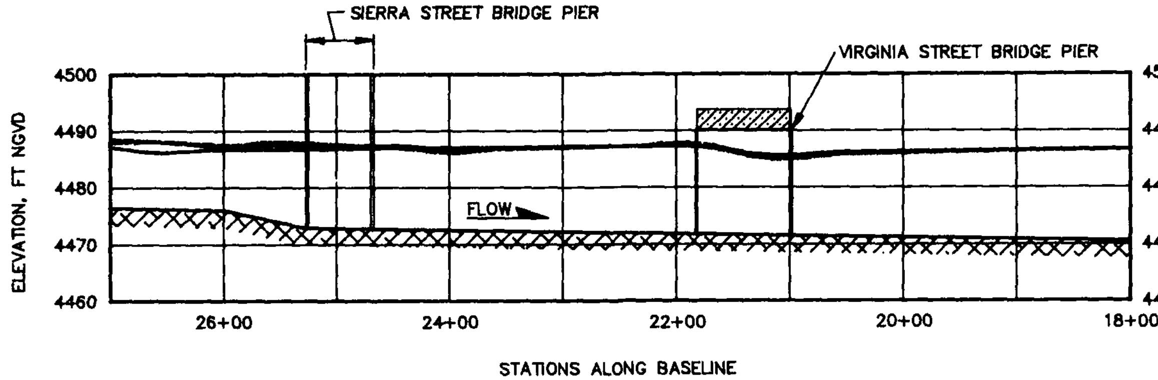


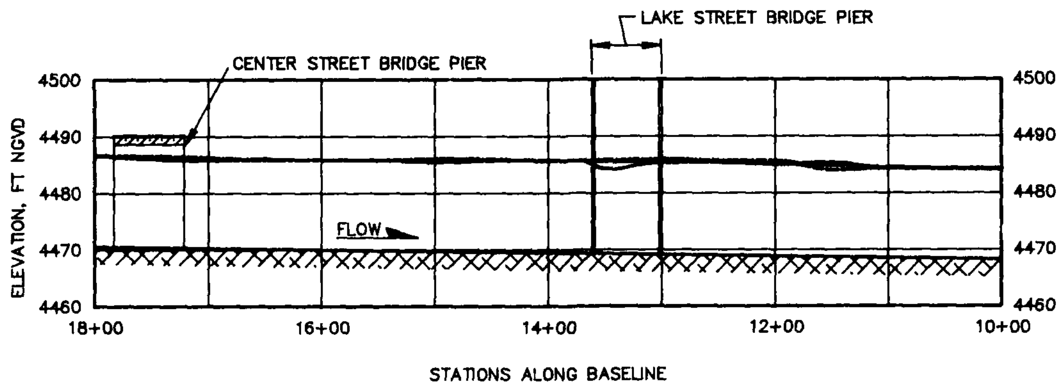
LEGEND

- LEFT SIDE OF CHANNEL
- RIGHT SIDE OF CHANNEL
- CENTER OF CHANNEL

(REFERENCED TO LOOKING DOWNSTREAM)

WATER-SURFACE PROFILES
NORTH AND SOUTH CHANNELS
TYPE 4 DESIGN CHANNEL
DISCHARGE 18,500 CFS
WATER-SURFACE ELEVATION AT STA 10+00 = 4483.9

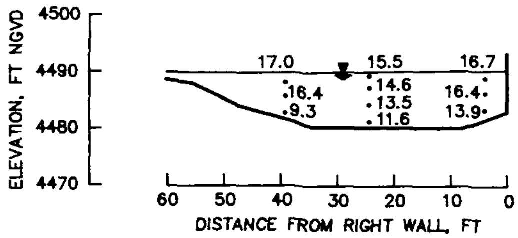




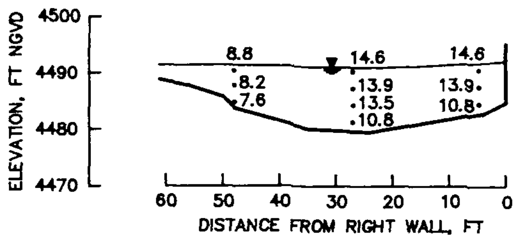
LEGEND
- LEFT SIDE OF CHANNEL
- RIGHT SIDE OF CHANNEL
- CENTER OF CHANNEL

(REFERENCED TO LOOKING DOWNSTREAM)

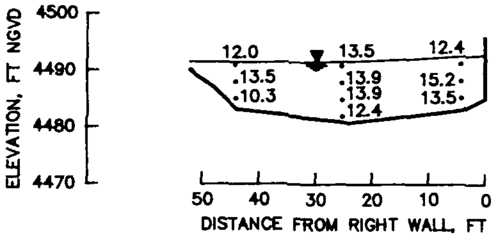
WATER-SURFACE PROFILES
STA 10+00 TO STA 27+00
TYPE 4 DESIGN CHANNEL
DISCHARGE 18,500 CFS
WATER-SURFACE ELEVATION AT STA 10+00 = 4483.9



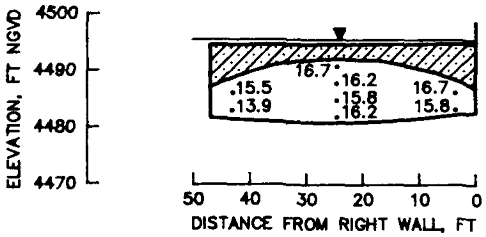
3+00



4+00



5+00



DOWNSTREAM EDGE OF SOUTH ARLINGTON ST. BRIDGE

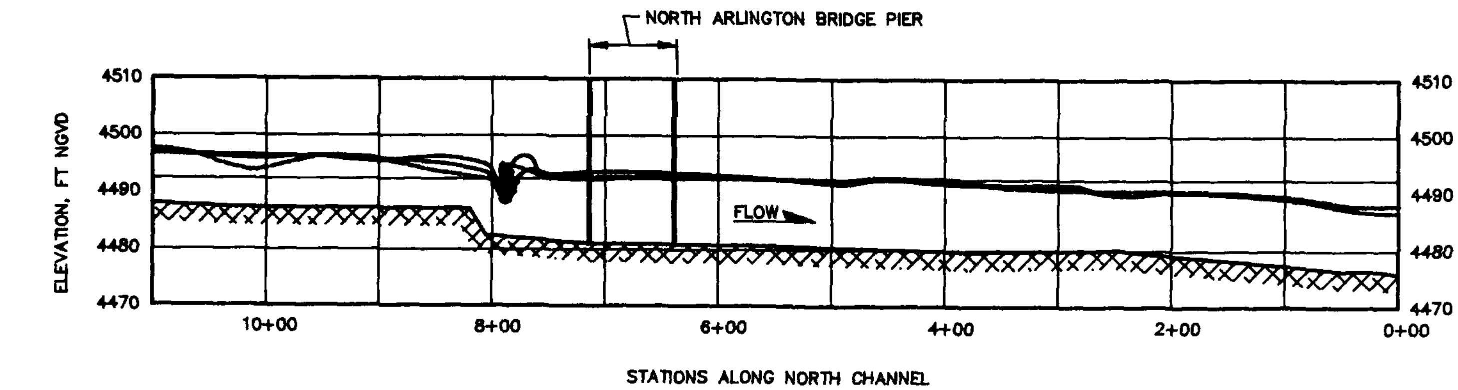
NOTE: DISTANCES FROM WALLS ARE REFERENCED TO LOOKING DOWNSTREAM. VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

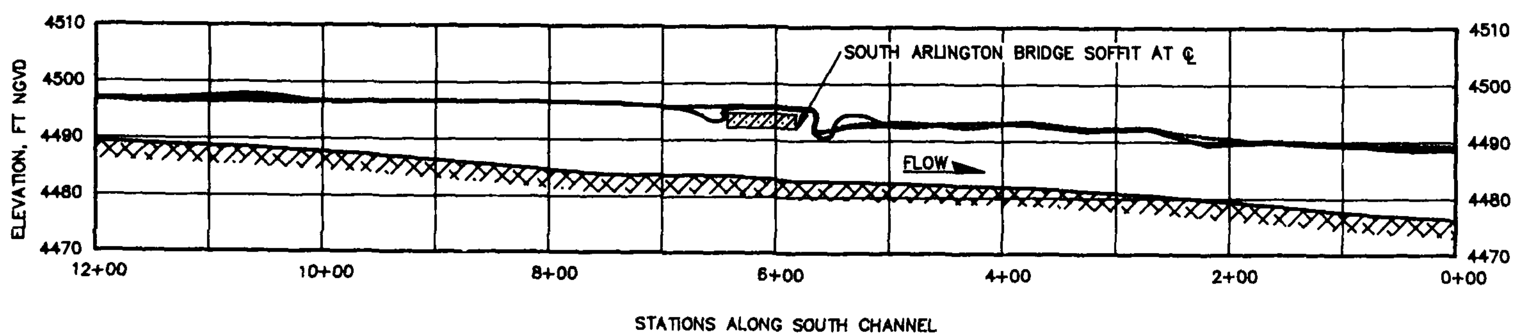
VELOCITIES IN SOUTH CHANNEL

TYPE 4 DESIGN CHANNEL

DISCHARGE 18,500 CFS

WATER-SURFACE ELEVATION AT STA 10+00 = 4482.5



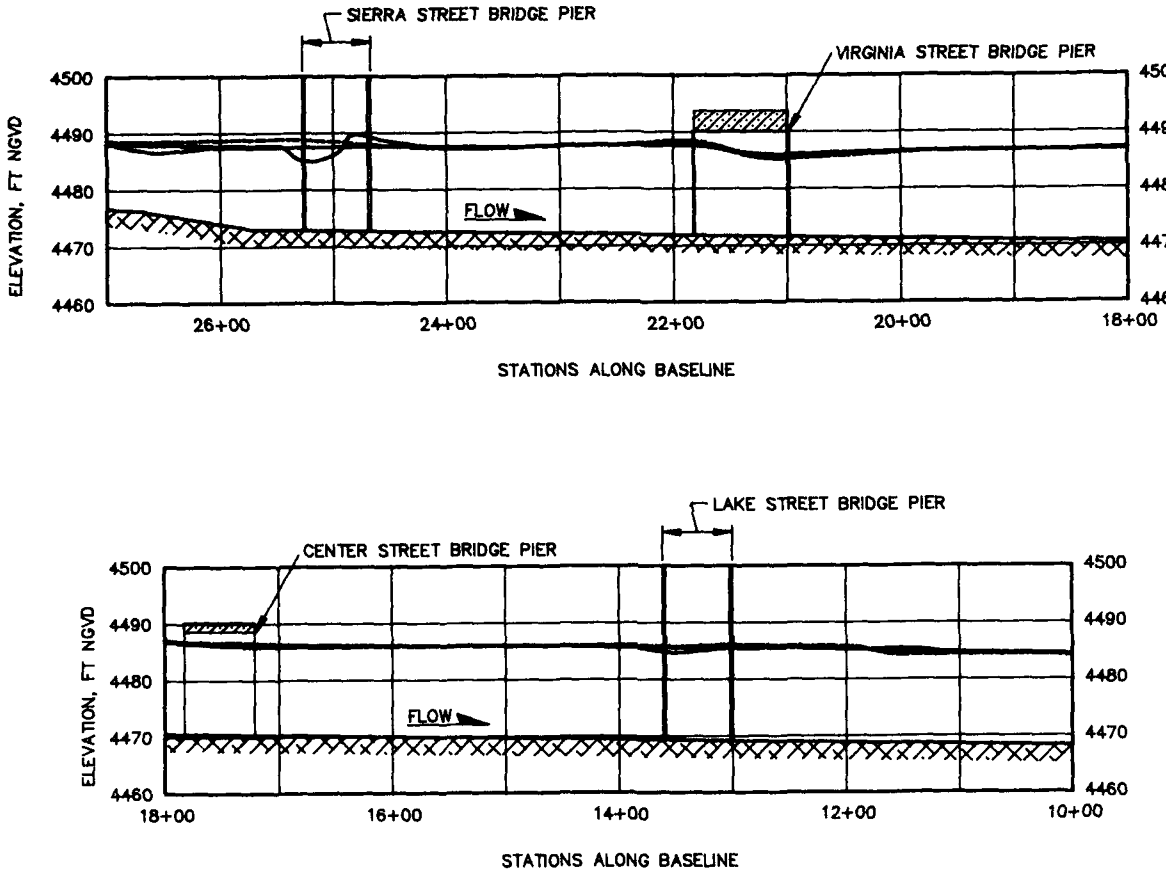


LEGEND

- LEFT SIDE OF CHANNEL
- RIGHT SIDE OF CHANNEL
- CENTER OF CHANNEL

(REFERENCED TO LOOKING DOWNSTREAM)

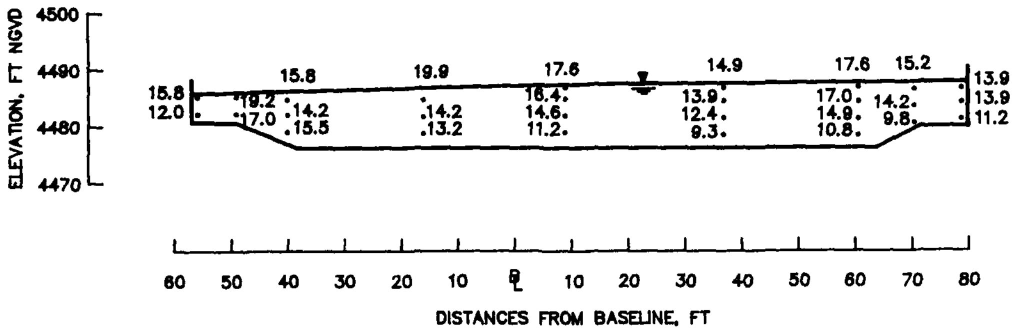
WATER-SURFACE PROFILES
NORTH AND SOUTH CHANNELS
TYPE 5 DESIGN
DISCHARGE 18,500 CFS
WATER-SURFACE ELEVATION AT STA 10+00 = 4483.9



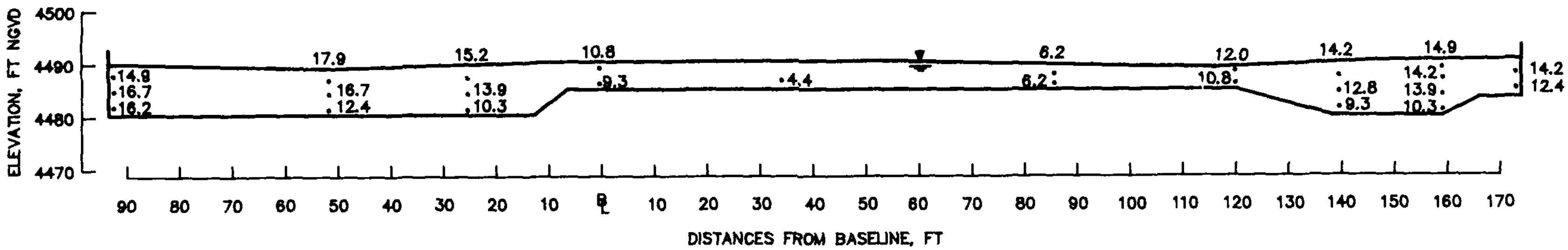
LEGEND
- LEFT SIDE OF CHANNEL
- RIGHT SIDE OF CHANNEL
- CENTER OF CHANNEL

(REFERENCED TO LOOKING DOWNSTREAM)

WATER-SURFACE PROFILES
STA 10+00 TO STA 27+00
TYPE 5 DESIGN
DISCHARGE 18,500 CFS
WATER-SURFACE ELEVATION AT STA 10+00 = 4483.9



STA 26+60



STA 29+00

NOTE: DISTANCES FROM BASELINE ARE REFERENCED TO LOOKING DOWNSTREAM. VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

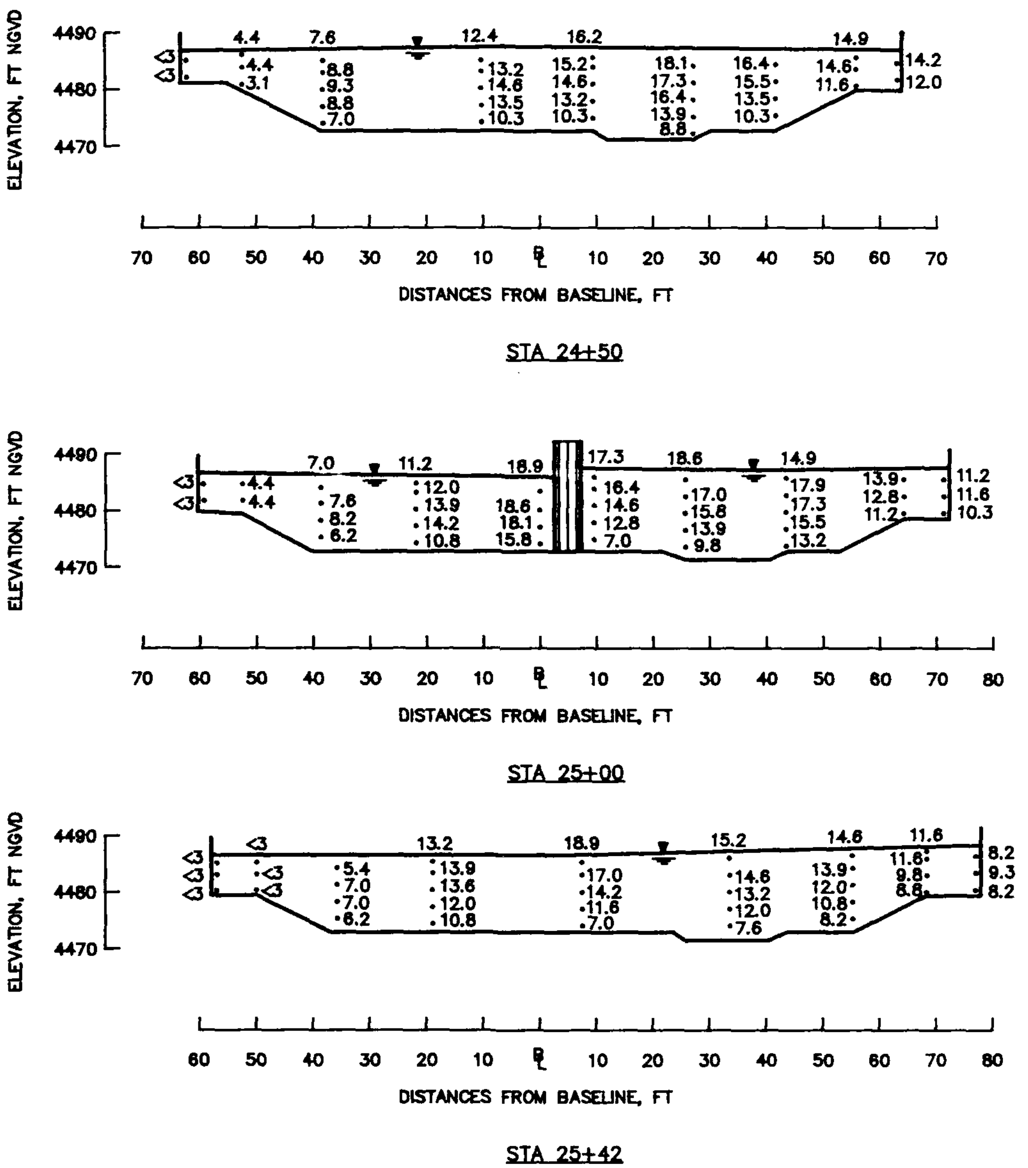
CHANNEL VELOCITIES

STA 26+60 AND 29+00

TYPE 5 DESIGN CHANNEL

DISCHARGE 18,500 CFS

WATER–SURFACE ELEVATION AT STA 10+00 = 4482.5



NOTE: DISTANCES FROM BASELINE ARE REFERENCED TO LOOKING DOWNSTREAM. VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

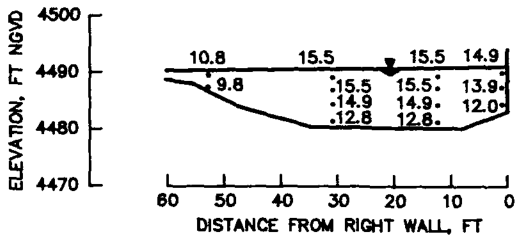
CHANNEL VELOCITIES

STA 24+50, 25+00, AND 25+42

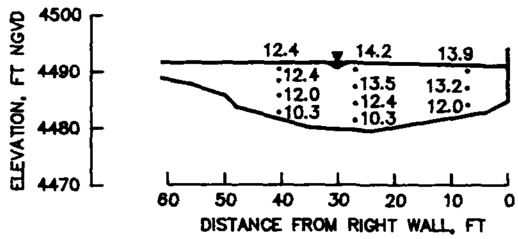
TYPE 5 DESIGN CHANNEL

DISCHARGE 18,500 CFS

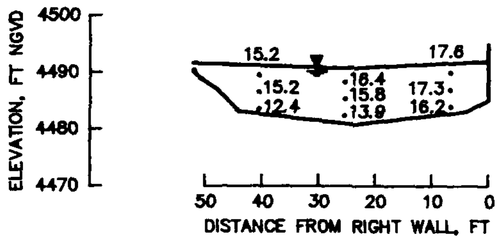
WATER-SURFACE ELEVATION AT STA 10+00 = 4482.5



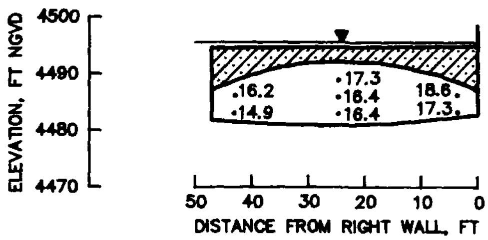
3+00



4+00



5+00

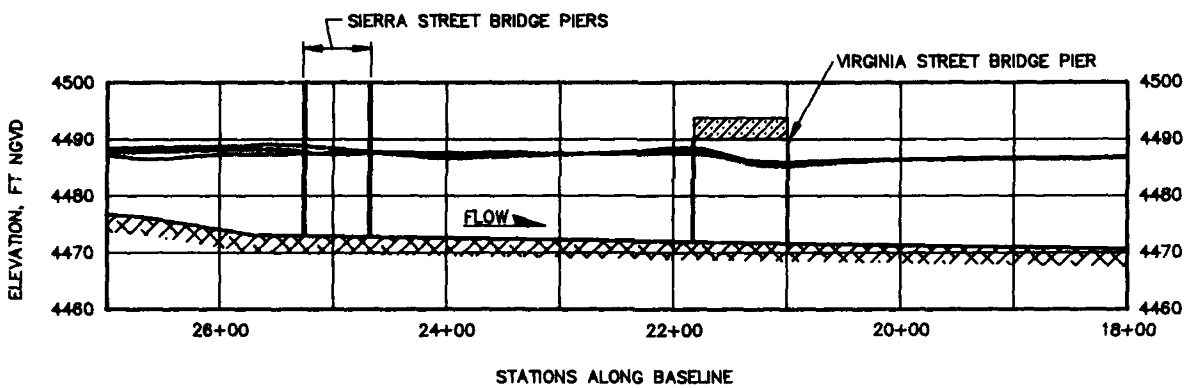


DOWNSTREAM EDGE OF SOUTH ARLINGTON ST. BRIDGE

NOTE: DISTANCES FROM WALLS ARE REFERENCED TO LOOKING DOWNSTREAM. VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

VELOCITIES IN SOUTH CHANNEL

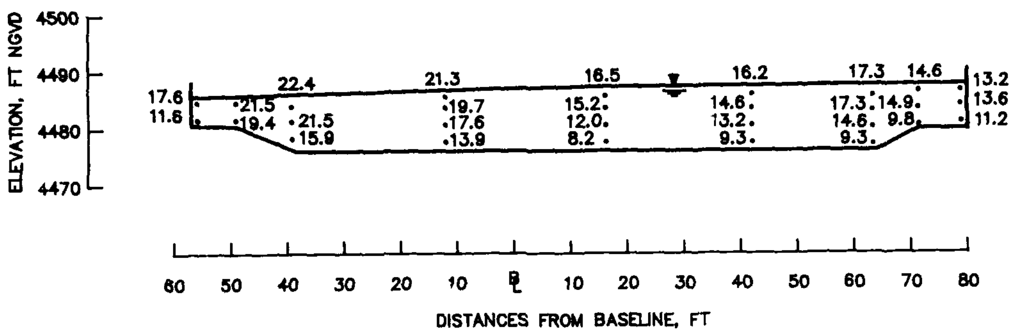
TYPE 5 DESIGN CHANNEL
DISCHARGE 18,500 CFS
WATER-SURFACE ELEVATION AT STA 10+00 = 4482.5



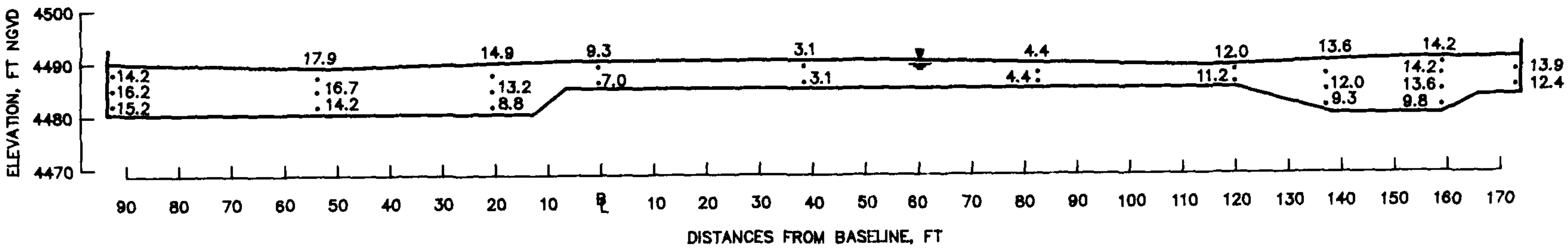
LEGEND
- LEFT SIDE OF CHANNEL
- RIGHT SIDE OF CHANNEL
- CENTER OF CHANNEL

(REFERENCED TO LOOKING DOWNSTREAM)

WATER-SURFACE PROFILES
STA 18+00 TO STA 27+00
TYPE 6 DESIGN
DISCHARGE 18,500 CFS
WATER-SURFACE ELEVATION AT STA 10+00 = 4483.9



STA 26+60



STA 29+00

NOTE: DISTANCES FROM BASELINE ARE REFERENCED TO LOOKING DOWNSTREAM. VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

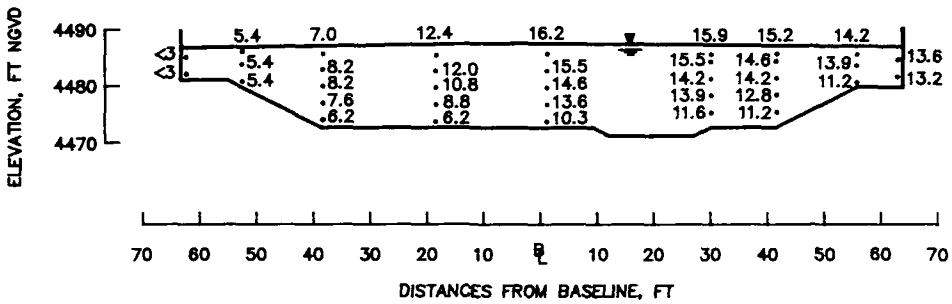
CHANNEL VELOCITIES

STA 26+60 AND 29+00

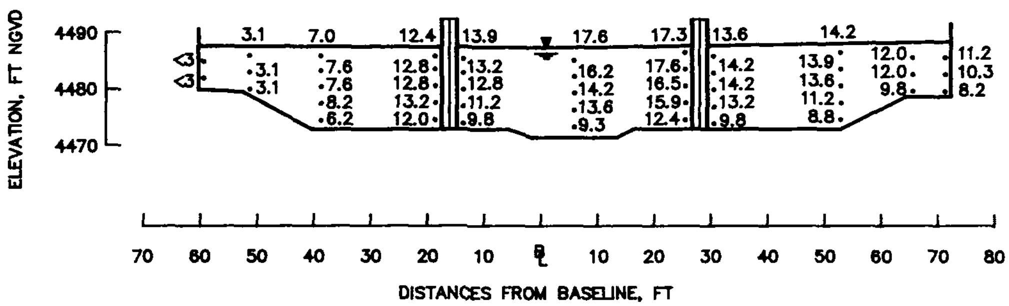
TYPE 6 DESIGN CHANNEL

DISCHARGE 18,500 CFS

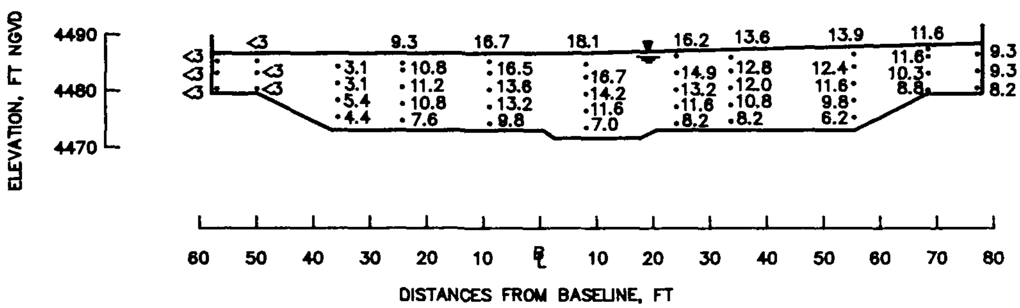
WATER-SURFACE ELEVATION AT STA 10+00 = 4482.5



STA 24+50



STA 25+00



STA 25+42

NOTE: DISTANCES FROM BASELINE ARE REFERENCED TO LOOKING DOWNSTREAM. VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

CHANNEL VELOCITIES

STA 24+50, 25+00, AND 25+42

TYPE 6 DESIGN CHANNEL

DISCHARGE 18,500 CFS

WATER-SURFACE ELEVATION AT STA 10+00 = 4482.5

Waterways Experiment Station Cataloging-in-Publication Data

Stockstill, Richard L.

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62 p. : ill. ; 28 cm. — (Technical report ; HL-92-10)

1. Flood control — Nevada — Reno Metropolitan Area — Evaluation. 2. Truckee River (Calif. and Nev.) 3. Channels (Hydraulic engineering) — Nevada — Sparks Metropolitan Area — Models. 4. Hydraulic models. I. United States. Army. Corps of Engineers. Sacramento District. II. U.S. Army Engineer Waterways Experiment Station. III. Title. IV.Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; HL-92-10.

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