DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
MISSISSIPPI RIVER COMMISSION

SLUICES AND DIVERSION SCHEME FOR ALLATOONA DAM, ETOWAH RIVER GEORGIA

MODEL INVESTIGATION

TECHNICAL MEMORANDUM NO. 214-2

WATERWAYS EXPERIMENT STATION
VICKSBURG, MISSISSIPPI

MRC-WES-125-11-48

NOVEMBER 1948

CONTENTS

SYNOPSIS

A model study of the sluices for Allatoona Dam, Etowah River, Georgia, was conducted to check their over-all performance and to determine the adequacy of the stilling basin, developed from consideration of spillway flow, with respect to dissipation of energy of sluice flow. A series of tests also was conducted to determine the capacity of several schemes proposed for a low monolith through which flow will be diverted during a certain stage in the construction of the dam.

Performance of the sluice of basic design was adequate. It was necessary to lower the secondary end sill of the stilling basin (developed from the previous series of model tests) by 5 ft to eliminate spray action when only one or two of the sluices were discharging. However, the spray action produced with only one or two sluices discharging did not cause severe conditions in the exit area.

Of the diversion schemes tested, scheme H with a crest control at elevation 713 passed the required discharge and, from the standpoint of ease of initial construction and ultimate closure, was the most desirable.

SLUICES AND DIVERSION SCHEME
FOR ALLATOONA DAM, ETOWAH RIVER, GEORGIA
Model Investigation

PART I: INTRODUCTION

The Problems

1. A description of the Allatoona Dam is contained in Part II of Technical Memorandum No. 214-1, "Model Study of Spillway, Allatoona Dam, Etowah River, Georgia," dated 23 October 1944, which reports the results of tests made on the spillway and stilling basin. At the time of those tests no permanent flood-control outlets were contemplated. Subsequently, however, four rectangular sluices, each 5.67 ft wide by 10.0 ft high, through the spillway section were incorporated in the design. Available data were not sufficient to predict accurately the performance of the stilling basin, developed from consideration of spillway flow, with respect to dissipation of energy of sluice flow. The general purpose of the sluice model study then was to check the over-all performance of the sluices and to provide means for correcting any unfavorable conditions found to exist, avoiding the addition of any feature which would interfere with stilling of spillway discharge.

2. Also, during one stage of the construction of the dam one 50-ft-wide monolith is to be left at an elevation lower than the rest and river flow is to be diverted through this monolith and two of the sluices. It was difficult to determine by analytical methods a design

for this low monolith which would be desirable from a structural standpoint and which would pass the required diversion flow. The purpose of the diversion study was to develop the best design for the low monolith from a structural standpoint which also would pass the required flow.

3. Authority to conduct the studies was granted by the Office, Chief of Engineers, in a letter dated 13 December 1946.

The Models

Sluice model

4. A 1:20-scale model reproduced two complete sluices, including the bellmouth intakes, sluice gates and exit portals, that portion of the spillway face below elevation 720, one-half of the stilling basin, and 130 ft of exit channel. The reservoir was represented by a steel pressure tank to which the bellmouth intakes were attached. The sluices, including intakes, gates, and exit portals were fabricated of transparent plastic. The spillway face, stilling basin, and end sill were molded in cement mortar. The exit channel was molded flat in sand for scour tests and was rendered immovable by a thin coating of cement mortar for velocity tests.

Diversion model

5. The diversion model was constructed to a linear scale ratio of 1:25 in an existing flume and reproduced one-half of the dam and stilling basin, including the low monolith, the cofferdam inclosing the other half of the dam, and sufficient portions of the approach and exit channels to allow representative flow conditions therein.

Personnel

6. Personnel of the Waterways Experiment Station directly concerned with the studies were Messrs. E. P. Fortson, Jr., F. R. Brown, T. E. Murphy, and C. Kestenbaum, engineers, and Messrs. H. S. Hansen and C. M. Wright, engineering aides. The following engineers visited the Experiment Station in an advisory capacity during the testing program: Mr. J. C. Harrold, Office, Chief of Engineers; Messrs. L. G. Leach and R. W. Pierce, South Atlantic Division; and Messrs. George Gaines and C. E. Bentzel, Mobile District, CE.

PART II: DESCRIPTION OF TESTS

Sluice Model

7. Details of the sluice, together with the locations of piezometers installed in the model, are shown on plate 1. Figure 1 is a view of the model sluice. There were investigated in the sluice model the basic design and one modification to the stilling basin.

8. Discharge through the model sluice closely matched the computed discharge. Model and computed rating curves are shown on plate 2. Pressure conditions were entirely satisfactory, being positive throughout the sluice. Pressures are recorded in table 1. Investigation of pressures in the sluice intake was not made since this intake design had been thoroughly investigated in a series of general tests and found to provide satisfactory pressure conditions.

Type A stilling basin

9. The type A stilling basin (figure 2) consisted of a horizontal apron 144 ft long at elevation 690, terminated at a 15-ft-high end sill. A small secondary end sill with its crest at elevation 695 was designed to deflect the flow passing over the main end sill away from the floor of the exit channel. Stilling-basin tests were conducted with the pool at elevations 800, 840, and 860 (top of gates). Tailwater was set according to the curve shown on plate 3, representing expected conditions with the tailrace excavated.

10. With one sluice operating an eddy formed in the stilling basin and the jet from the sluice was forced against the side wall. The jet

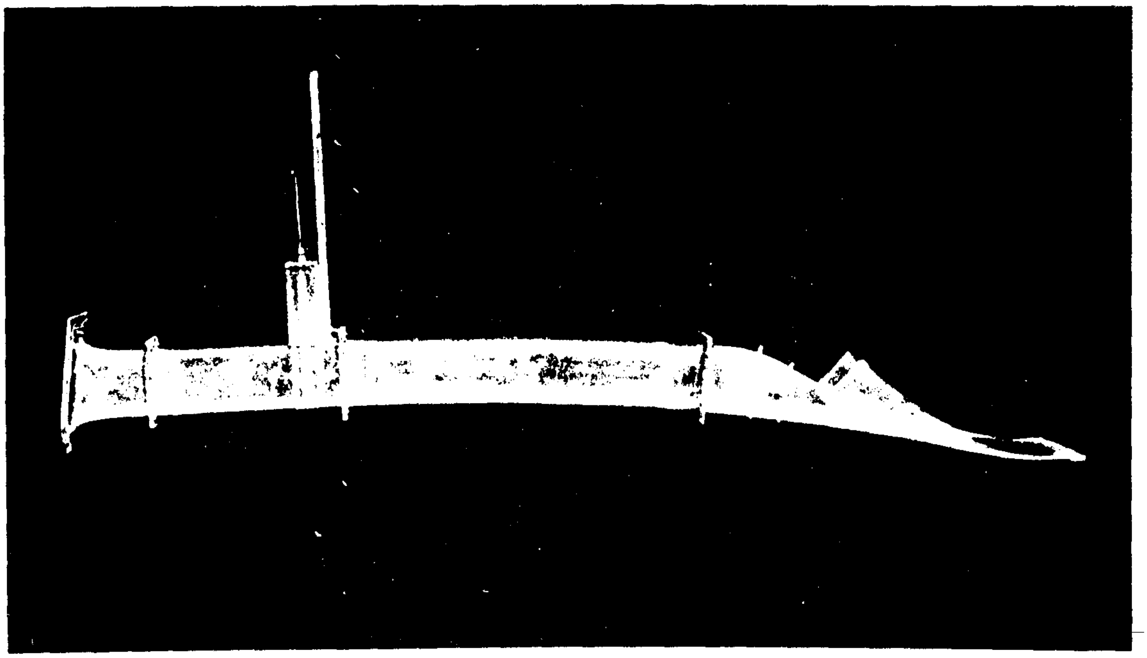

Fig. 1. Model sluice

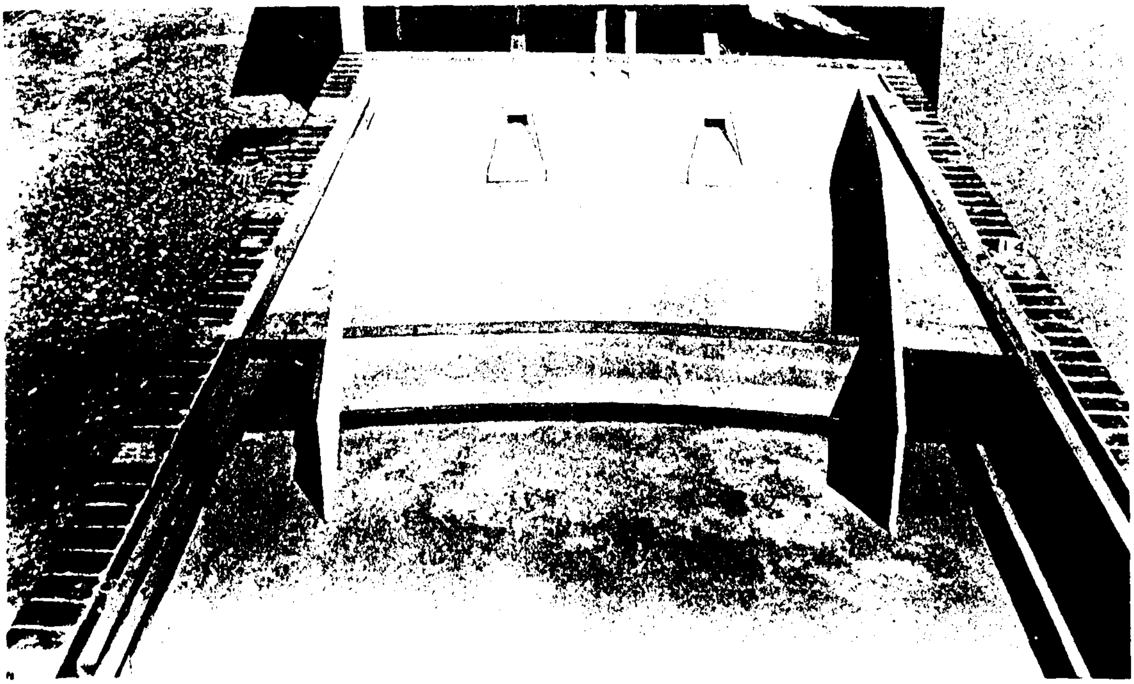

Fig. 2. Type A stilling basin

did not diffuse from the exit portal and remained concentrated until dispersed by the end sill. With the pool at elevation 800 and tailwater representing discharge from only one sluice, the tailwater over the secondary end sill was not sufficient to cause roller action and the jet of water falling from the main sill was deflected downstream in a spray (figure 3). These conditions produced maximum bottom velocities in the exit channel of 10 ft per sec (plate 4) and a test of one-hour duration eroded the sand bed a maximum of 10 ft in depth (plate 5). Spray action off the secondary end sill was not eliminated by raising the tailwater to represent flow from two sluices (figure 4), but was eliminated by raising tailwater to represent flow from three sluices (figure 5).

11. With the pool at elevation 840 and the tailwater representing flow from only one sluice, flow from one sluice caused spray action off the secondary end sill (figure 6), produced maximum bottom velocities in the exit channel of 11 ft per sec (plate 6), and a test of one-hour duration eroded the sand bed a maximum of 14 ft in depth (plate 7). Spray action was eliminated by raising the tailwater to represent flow from two and three sluices (figures 7 and 8).

12. Since it was not considered probable that only one sluice would be in operation with the pool at elevation 860 (top of spillway gates) no velocity or scour data were taken for this condition, but observation of flow revealed a violent boil over the primary end sill with flow splashing onto the secondary end sill (figure 9).

13. Flow from two sluices produced considerable turbulence and numerous small eddies and whirls in the stilling basin, and flow over the primary end sill was characterized by surges but in general was well

Fig. 3. Pool elev, 800 dischg, 3170 cfs; TW elev, 692.7

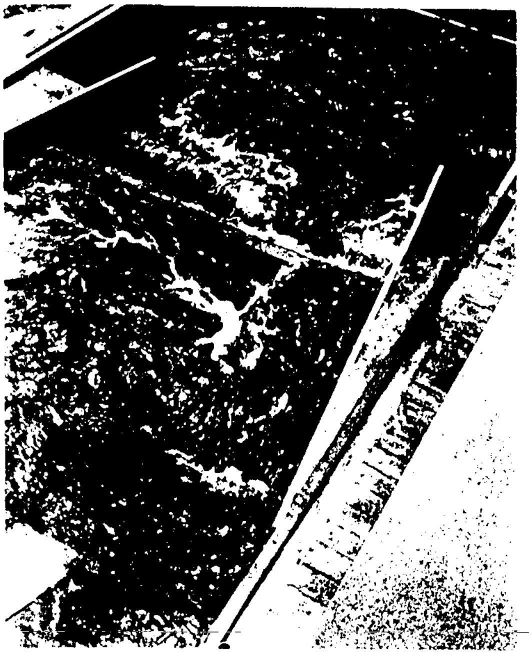

Fig. 4. Pool elev, 800 dischg, 3170 cfs; TW elev, 694.6

Fig. 5. Pool elev, 800 dischg, 3170 cfs; TW elev, 696.5

Fig. 6. Pool elev, 840 dischg, 3750 cfs; TW elev, 693.1

Type A stilling basin, one outside sluice operating under various tailwater conditions

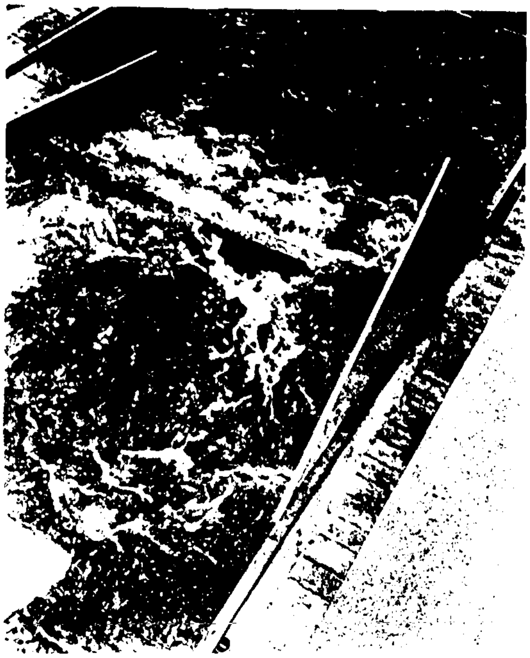

Fig. 7. Pool elev, 840
dischg, 3790 cfs; TW elev, 695.4

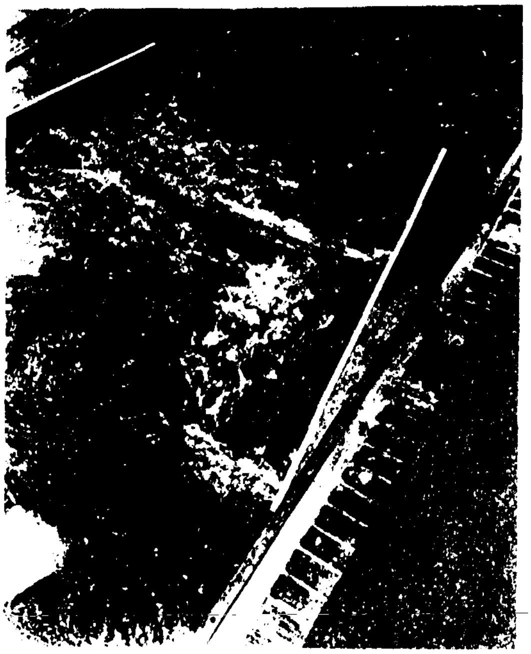

Fig. 8. Pool elev, 840
dischg, 3790 cfs; TW elev, 697.7

Fig. 9. Pool elev, 860
dischg, 4070 cfs; TW elev, 693.3

Fig. 10. Pool elev, 800
dischg, 6340 cfs; TW elev 694.6

Type A stilling basin, one outside sluice operating in Fig. 7-9,
two in Fig. 10

Fig. 11. Pool elev, [illegible]
dischg, [illegible] cfs; TW elev, [illegible]

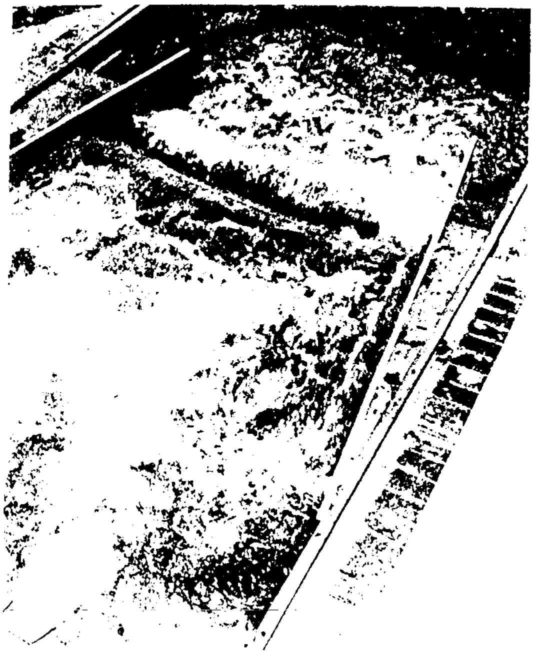

Fig. 12. Pool elev, [illegible]
dischg, [illegible] cfs; TW elev, 6[illegible]9.4

Fig. 13. Pool elev, 840
dischg, 7580 cfs; TW elev, 699.9

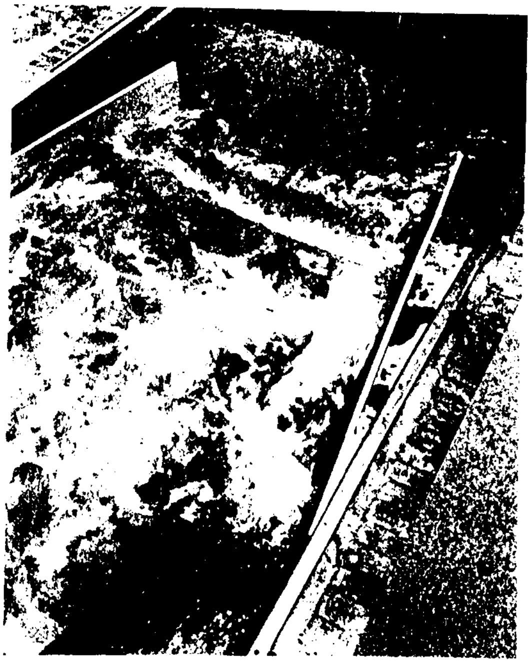

Fig. 14. Pool elev, 860
dischg, 8140 cfs; TW elev, 700.7

Type A stilling basin, two sluices operating distributed. With the pool at elevation 800 and the tailwater representing flow from two sluices, spray action occurred off the secondary end sill (figure 10). With the tailwater representing flow from four sluices, roller action obtained over the secondary end sill (figure 11). Bottom velocities in the exit channel produced by flow from two sluices, with the pool at elevation 800 and tailwater representing flow from four sluices, did not exceed 10 ft per sec (plate 8); and the maximum scour hole in the sand bed produced by a test of one-hour duration was 8 ft deep (plate 9).

14. With the pool at elevation 840 and tailwater representing flow from two sluices, flow from two sluices produced spray action over the secondary end sill (figure 12). With the tailwater representing flow from four sluices, roller action obtained over the secondary end sill (figure 13), maximum bottom velocities in the exit area were 13 ft per sec (plate 10), and at the end of a test of one-hour duration a scour hole 12 ft deep (plate 11) was found.

15. Flow from two sluices with the pool at elevation 860 produced violent surges over the primary end sill, but with the tailwater representing flow from four sluices roller action occurred over the secondary end sill (figure 14).

Type A-1 stilling basin

16. The type A-1 stilling basin (figure 15) was the same as the type A except that the secondary end sill was lowered 5 ft. This alteration was made to eliminate spray action off the secondary end sill.

17. With one sluice operating, the pool at elevations 800 and 840,

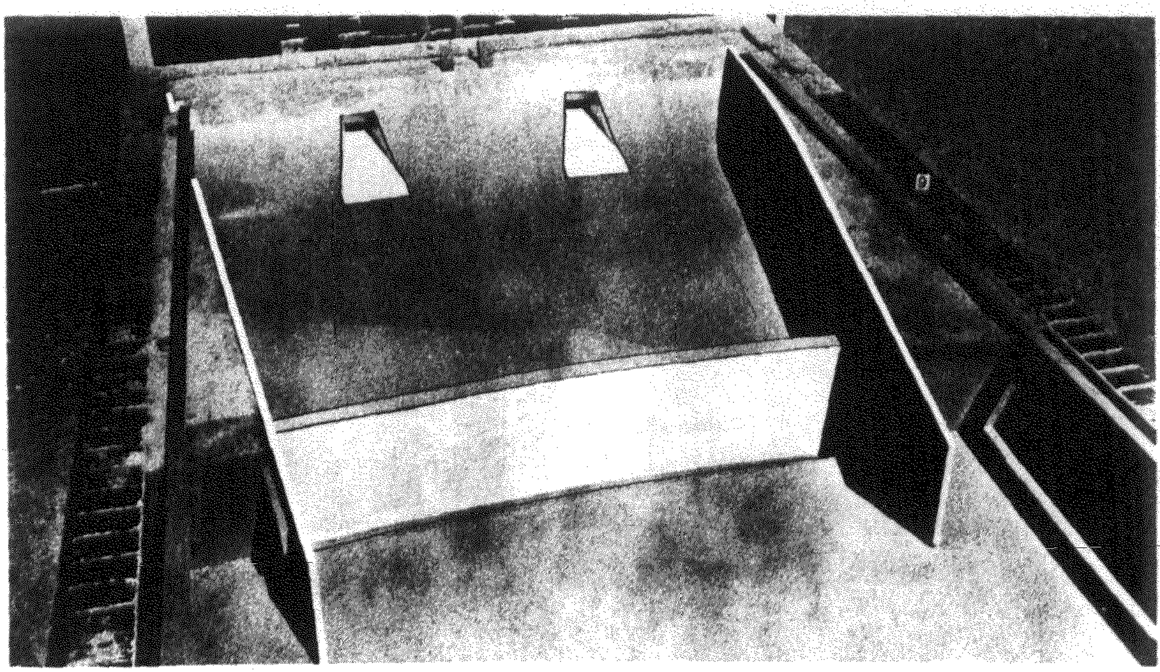

Fig. 15. Type A-1 stilling basin

and minimum tailwater, roller action obtained over the secondary end sill (figures 16 and 17). With one sluice operating, bottom velocities in the exit area downstream from the type A-1 stilling basin were slightly greater than those below the type A stilling basin (compare plates 12 and 14 with plates 4 and 6). However, scour tendencies were less (compare plates 13 and 15 with plates 5 and 7).

18. With two sluices operating, the pool at elevations 800 and 840, and tailwater representing flow from four sluices, more water was held in the bucket of the type A-1 stilling basin than was held in the bucket of the type A stilling basin for like conditions (compare figures 18 and 19 with figures 11 and 13). Also bottom velocities and erosion tendencies in the exit area downstream from the type A-1 stilling basin were less severe than those downstream from the type A stilling basin (compare plates 16-19 with plates 8-11).

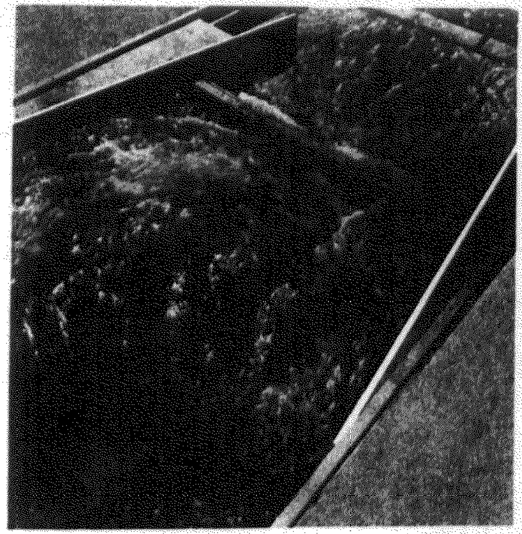

Fig. 16. Pool elev, 800
dischg, 3170 cfs; TW elev, 692.7

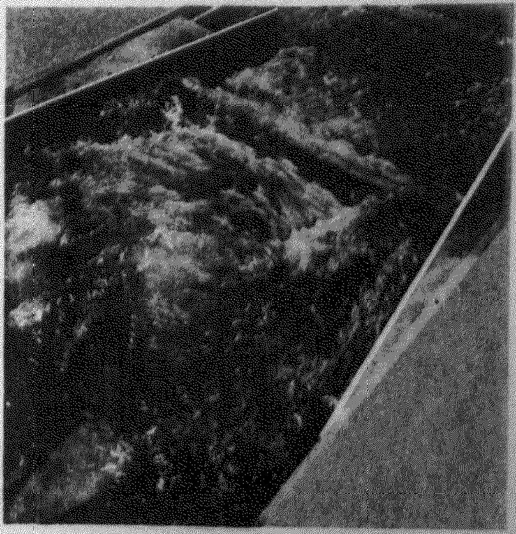

Fig. 17. Pool elev, 840
dischg, 3790 cfs; TW elev, 693.1

Type A-1 stilling basin, one sluice operating

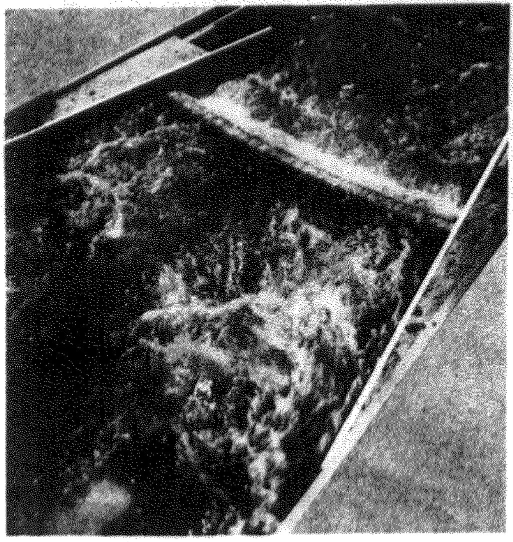

Fig. 18. Pool elev, 800
dischg, 6340 cfs; TW elev, 698.4

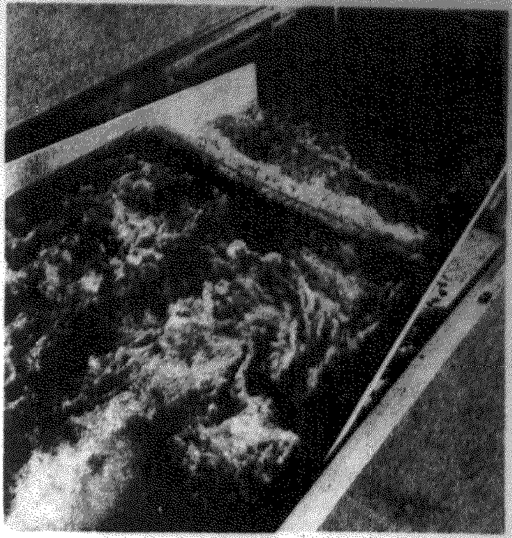

Fig. 19. Pool elev, 840
dischg, 7580 cfs; TW elev, 699.9

Type A-1 stilling basin, two sluices operating

End sill pressures

19. Since the jet from one sluice appeared to remain concentrated until it impinged on the end sill, it was feared that the end sill was

being subjected to considerable impact pressures. Consequently two pressure cells were installed in the vertical upstream face of the primary end sill at the section where impact appeared to be the greatest. Pressure fluctuations and impact pressures measured by these cells were negligible (see plate 20).

Diversion Model

20. The criterion established for diversion was that the combined discharge through the two sluices and the low monolith must equal 25,000 cfs with the pool at elevation 738. Computations indicated that about 3,500 cfs could be passed through the two sluices, thus it was necessary to design the low monolith to pass 21,500 cfs with the pool at elevation 738. It also was desirable to construct the diversion monolith as high as possible to facilitate its completion at a later date.

21. Details of eight schemes tested, together with discharge passed at a pool elevation of 738, are shown on plates 21 and 22. Scheme A considered the use of a broad crest at elevation 712. It was found however that to pass the required discharge such a crest would have to be lowered to elevation 709.2, scheme C. An ogee weir with its crest at elevation 715 constituted scheme B. While a greater discharge was passed by the ogee weir with its crest at elevation 715 than was passed by the broad-crested weir with its crest at elevation 712, consideration of the use of a true ogee weir was abandoned because of the construction difficulties involved. A simplified ogee-type crest appeared to offer the most favorable solution. Tests on schemes D, E, F, and G led to the development of scheme H, which passed the required discharge with

Fig. 20. Diversion scheme A
pool elev, 738; dischg, 18,900 cfs

Fig. 21. Diversion scheme H
pool elev, 738; dischg, 21,500 cfs

a crest elevation of 713 and with the downstream part of the monolith raised as high as possible without materially reducing the discharge. Figures 20 and 21 show flow through schemes A and H, respectively. The streaks caused by confetti on the water give an indication of the contraction effect caused by the sides of the opening. This contraction was evident in all schemes tested and, no doubt, played a major role in reducing the efficiency of all schemes tested.

PART III: CONCLUDING REMARKS

22. Decision to include sluices in the Allatoona project was not made until actual construction of the dam had been undertaken and thus a limited time interval was available for development of a sluice design. While the sluice design adopted is adequate, it is felt that additional investigation would have been worthwhile had more time been available. The high positive pressures which obtained in the sluice proper are an indication that the constriction in the sluice outlet could have been reduced and thus the capacity of the sluice increased. Also, a deflector type sluice outlet similar to that proposed for Bluestone Dam* might have proved favorable for conditions at Allatoona Dam.

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* Waterways Experiment Station T.M. No. 2-227, "Model Study of Sluice Outlet for Bluestone Dam, New River, West Virginia."

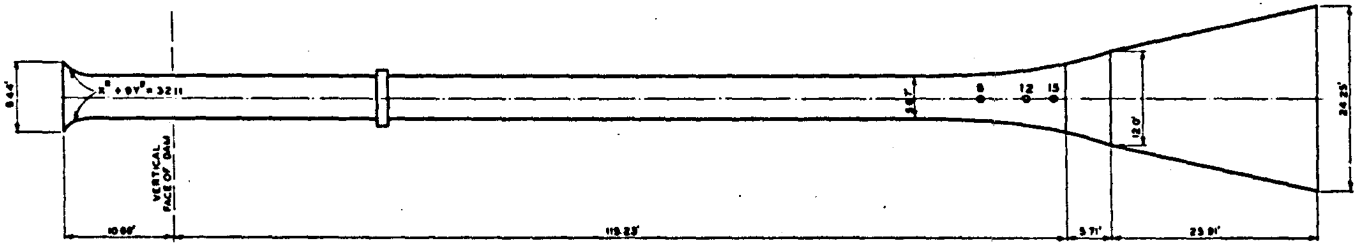
TABLE 1

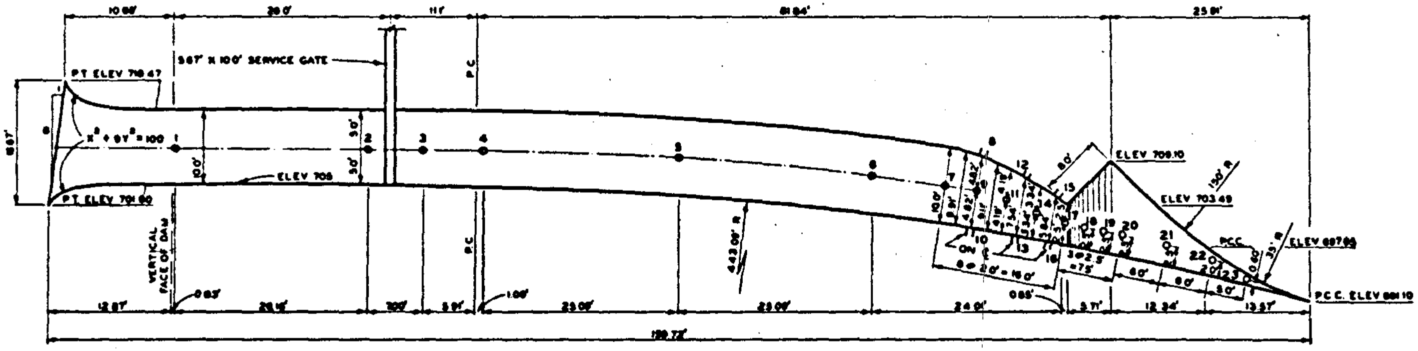
Pressures Throughout Sluice

(Pressures recorded in prototype feet of water)

Piez. No.	Dischg, 3170 Pool Elev, 800	Dischg, 3790 Pool Elev, 840	Dischg, 4070 Pool Elev, 860
1	44	63	73
2	40	56	65
3	36	52	61
4	36	52	61
5	38	55	66
6	34	48	57
7	33	46	54
8	44	62	73
9	32	45	52
10	34	45	51
11	29	40	45
12	35	49	58
13	31	41	46
14	25	31	36
15	19	27	31
16	23	30	34
17	14	17	20
18	10	12	13
19	9	10	11
20	8	10	9
21	7	6	6
22	10	9	9
23	12	11	11

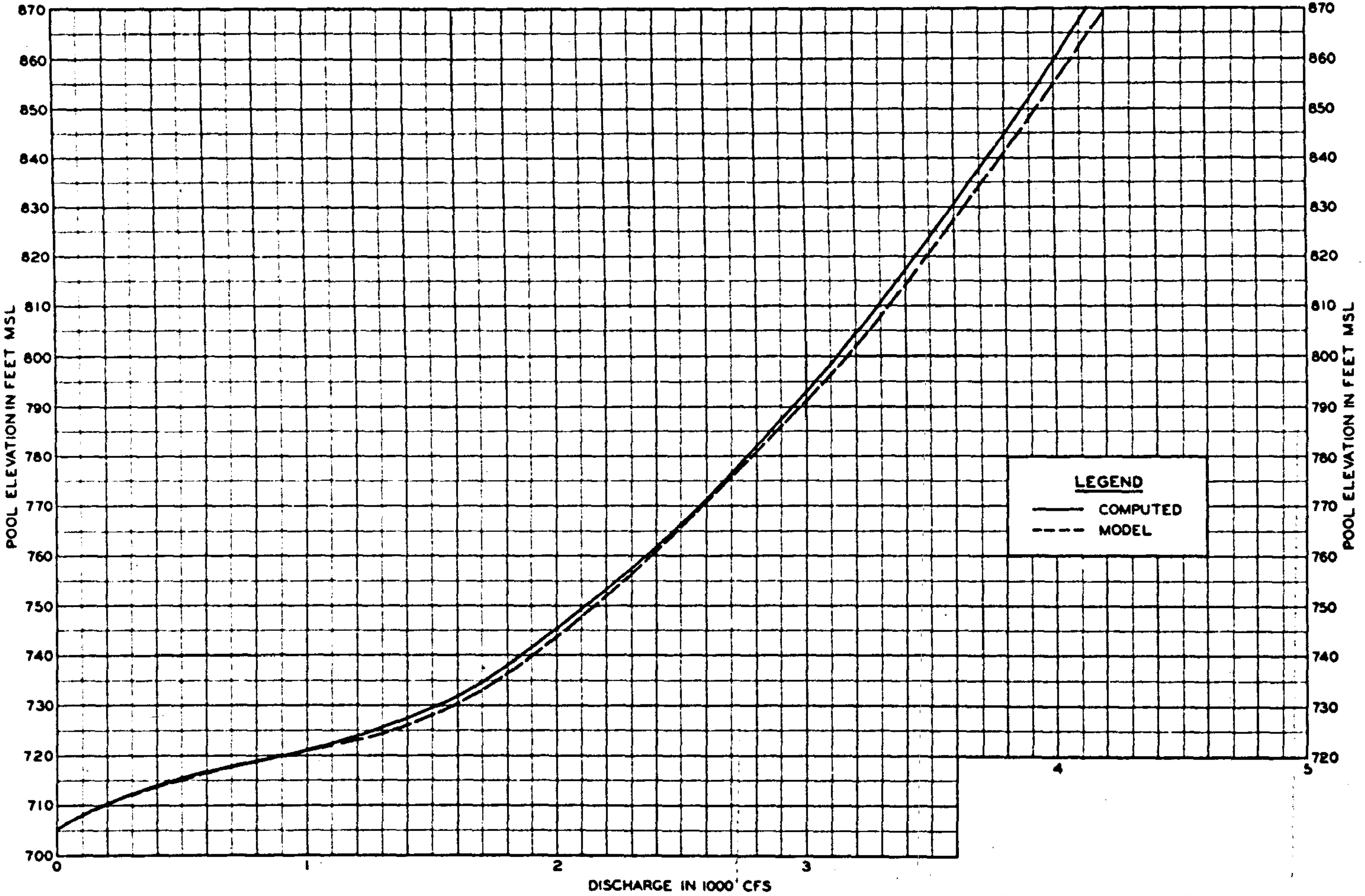
Locations of piezometers are shown on plate 1.



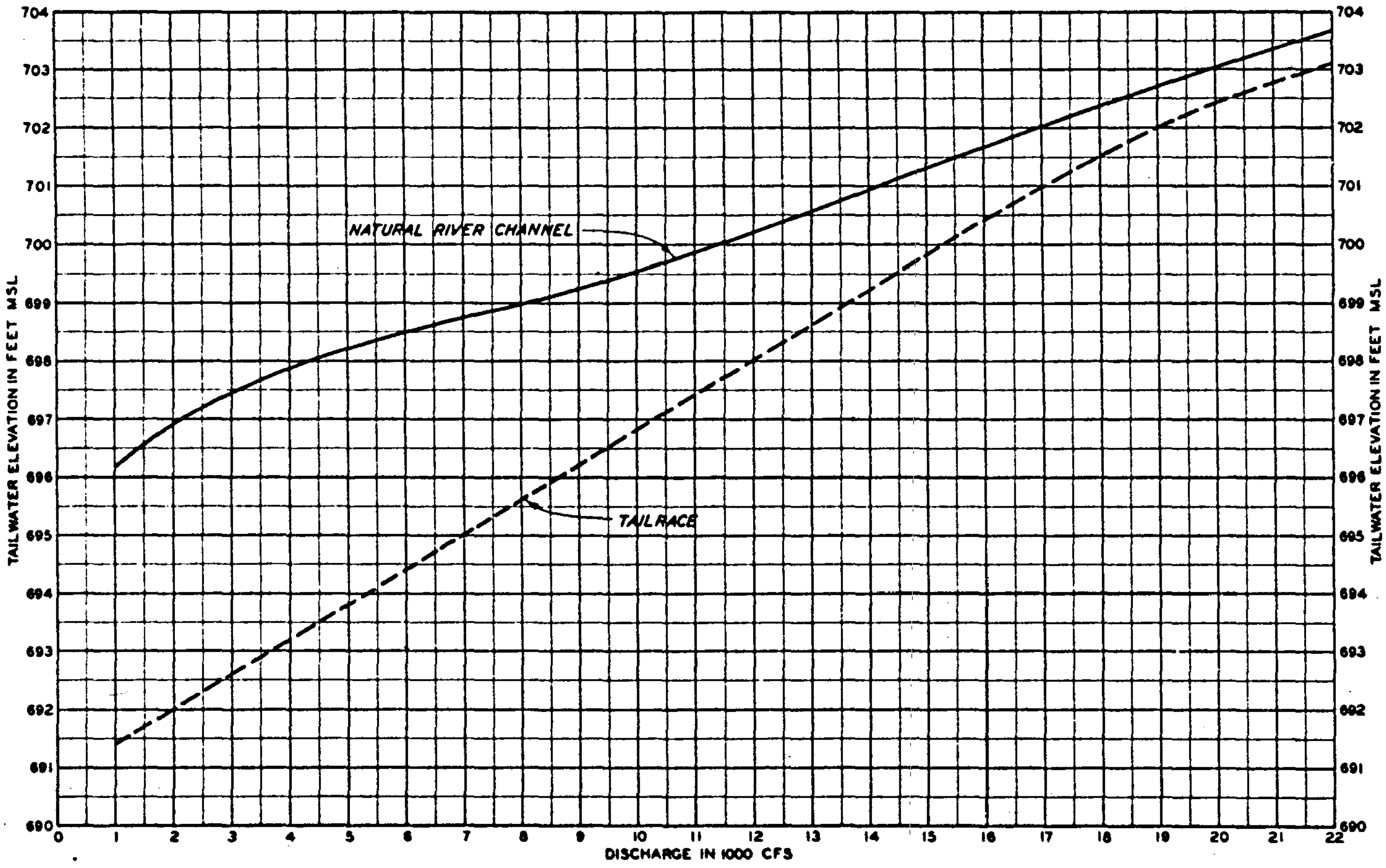


SLUICE DESIGN

PLATE I



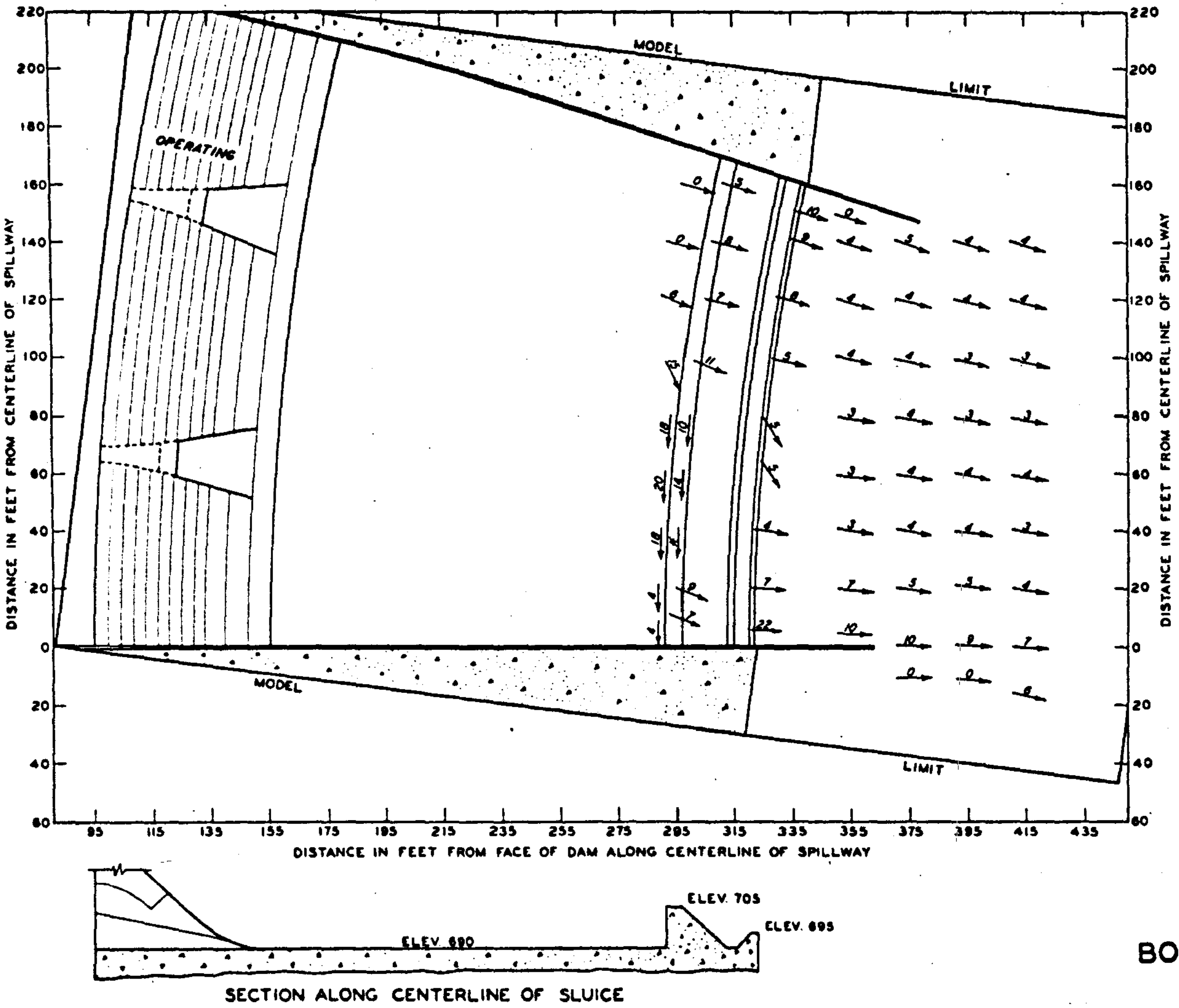
SLUICE RATING CURVES



TAILWATER RATING CURVES

PLATE 3

PLATE 4



SECTION ALONG CENTERLINE OF SLUICE

TEST CONDITIONS

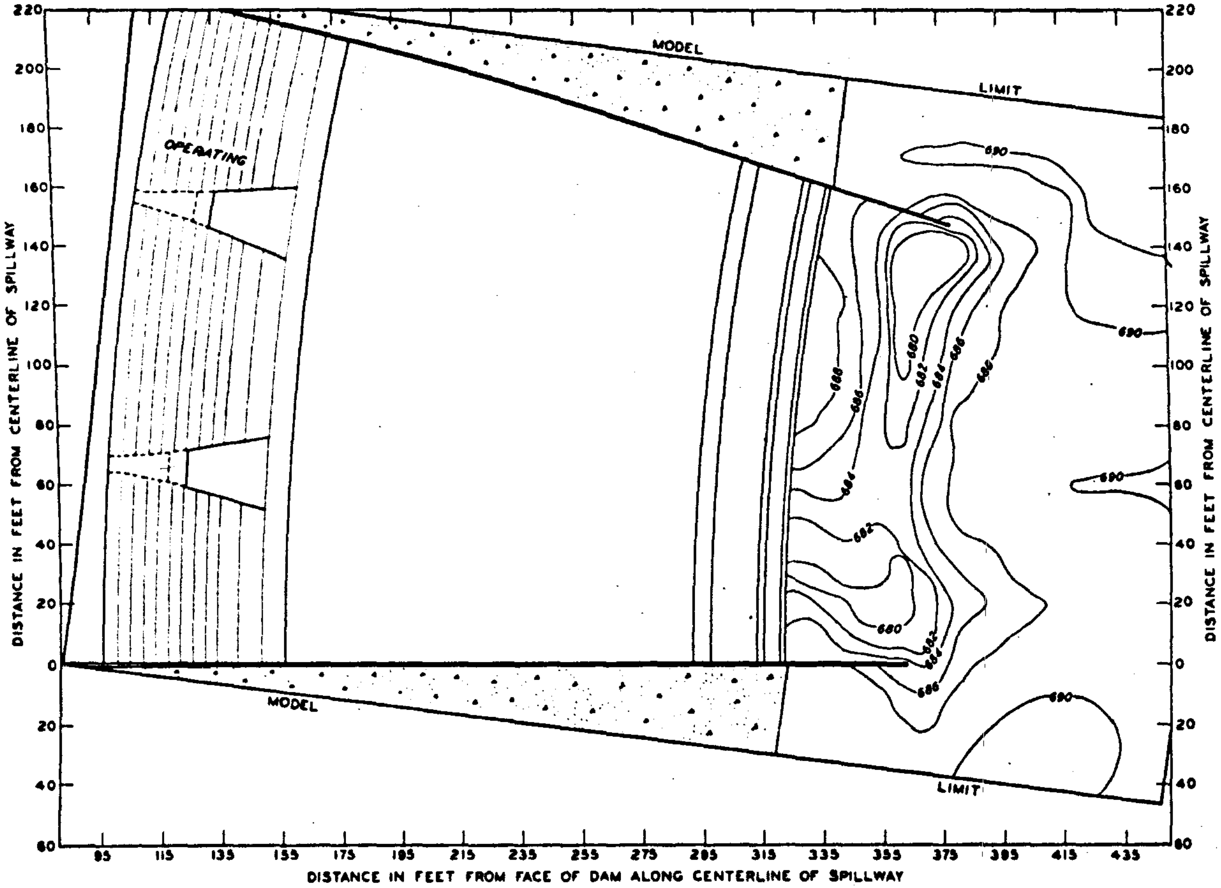
DISCHARGE	3,170	C.F.S.
POOL ELEV.	800	
TAILWATER ELEV.	692.7	
TYPE A BASIN		

NOTE: BED OF EXIT CHANNEL FIXED IN CEMENT MORTAR AT ELEV. 690.

VELOCITIES ARE PROTOTYPE F.T. PER SEC.

* WATER TOO SHALLOW TO MEASURE VELOCITY.

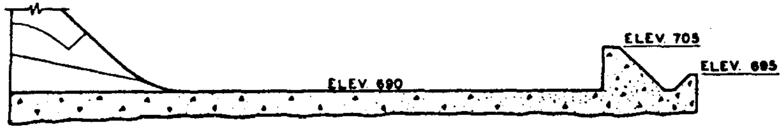
BOTTOM VELOCITIES



TEST CONDITIONS

DISCHARGE	3,170 CFS
POOL ELEV.	800
TAILWATER ELEV.	692.7
TYPE A BASIN	

NOTE: BED OF EXIT CHANNEL MOLDED FLAT TO ELEV. 690.

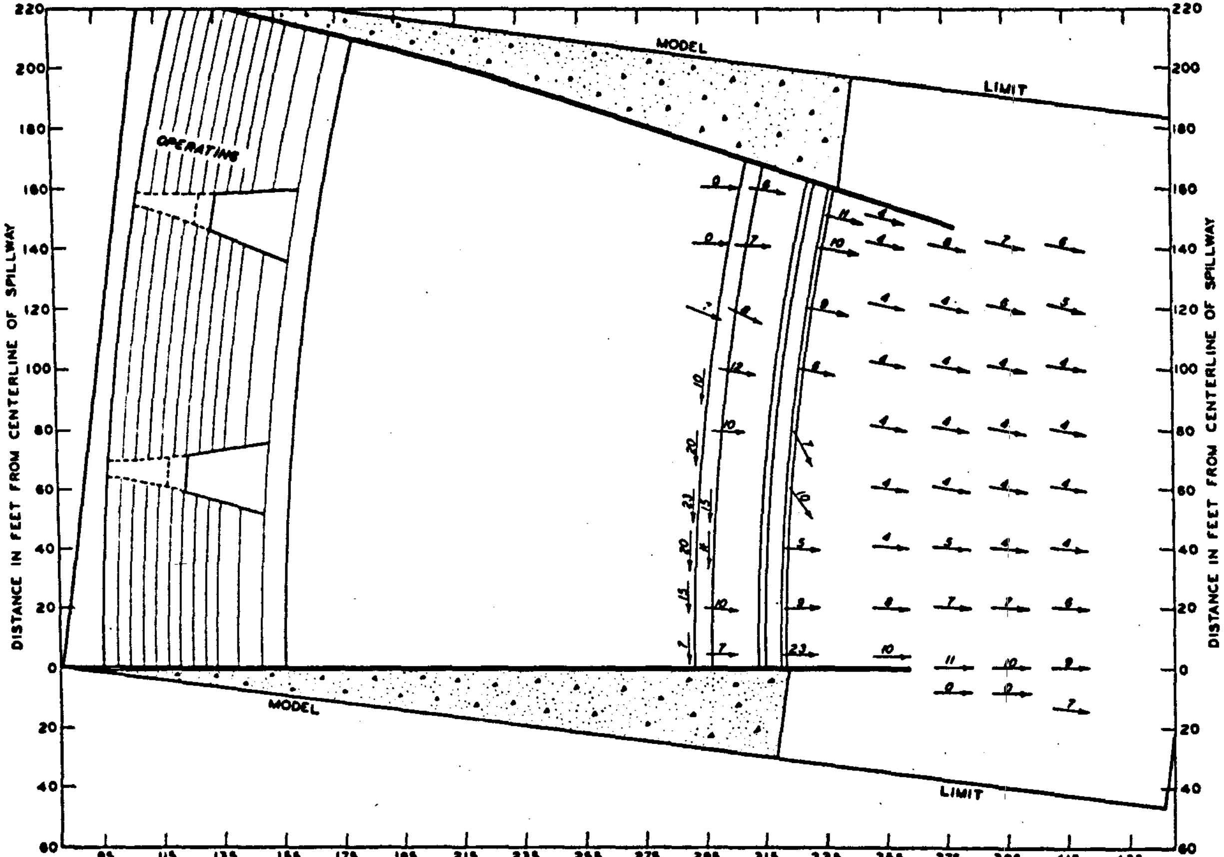


SECTION ALONG CENTERLINE OF SLUICE

SCOUR PATTERN

PLATE 5

PLATE 6



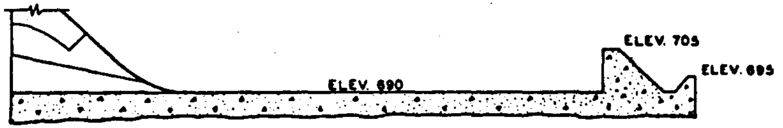
TEST CONDITIONS

DISCHARGE	3,790	CFS
POOL ELEV.	840	
TAILWATER ELEV.	693.1	
TYPE A BASIN		

NOTE: BED OF EXIT CHANNEL FIXED IN CEMENT MORTAR AT ELEV. 690.

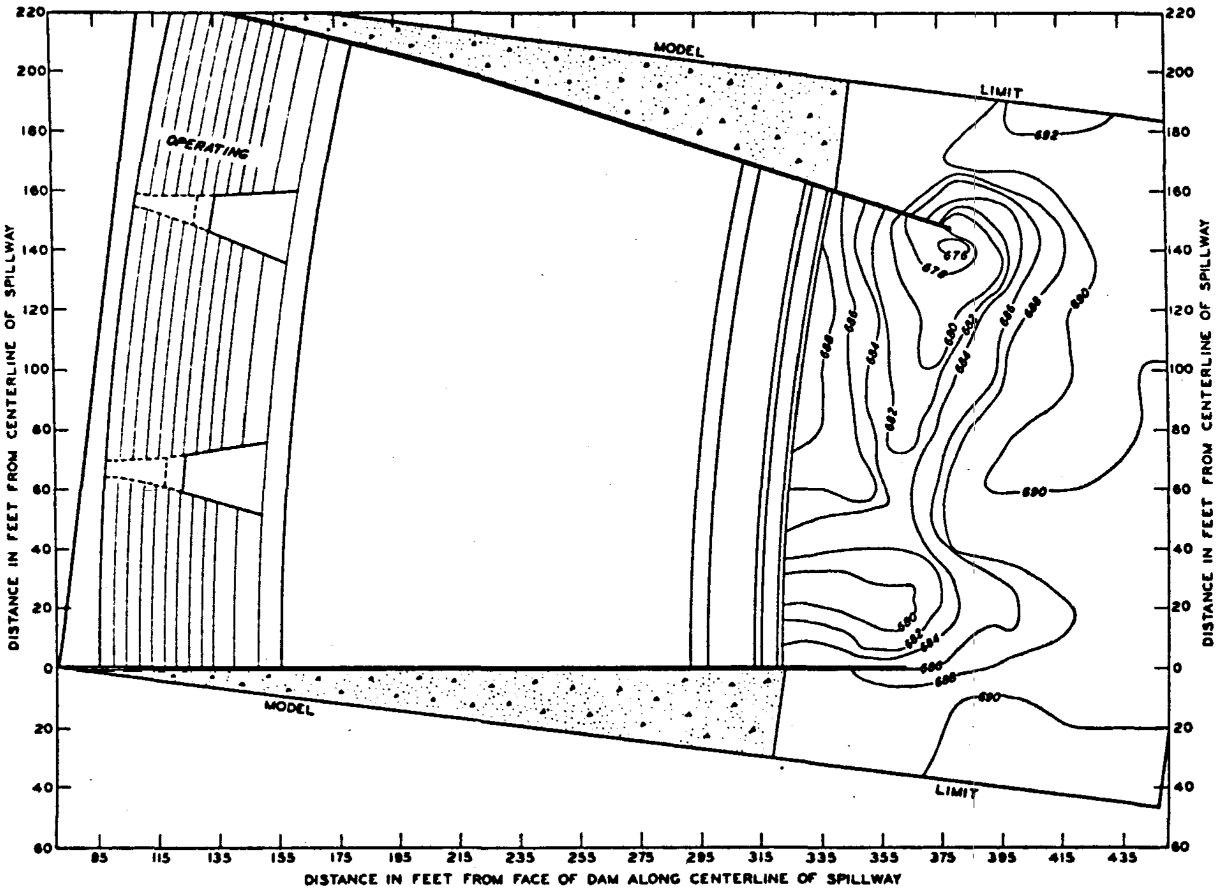
VELOCITIES ARE PROTOTYPE FT PER SEC.

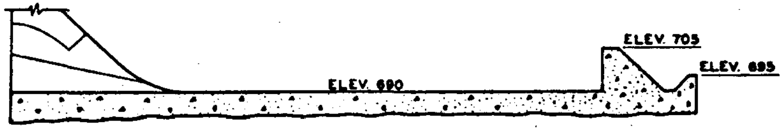
* WATER TOO SHALLOW TO MEASURE VELOCITY.



SECTION ALONG CENTERLINE OF SLUICE

BOTTOM VELOCITIES





SECTION ALONG CENTERLINE OF SLUICE

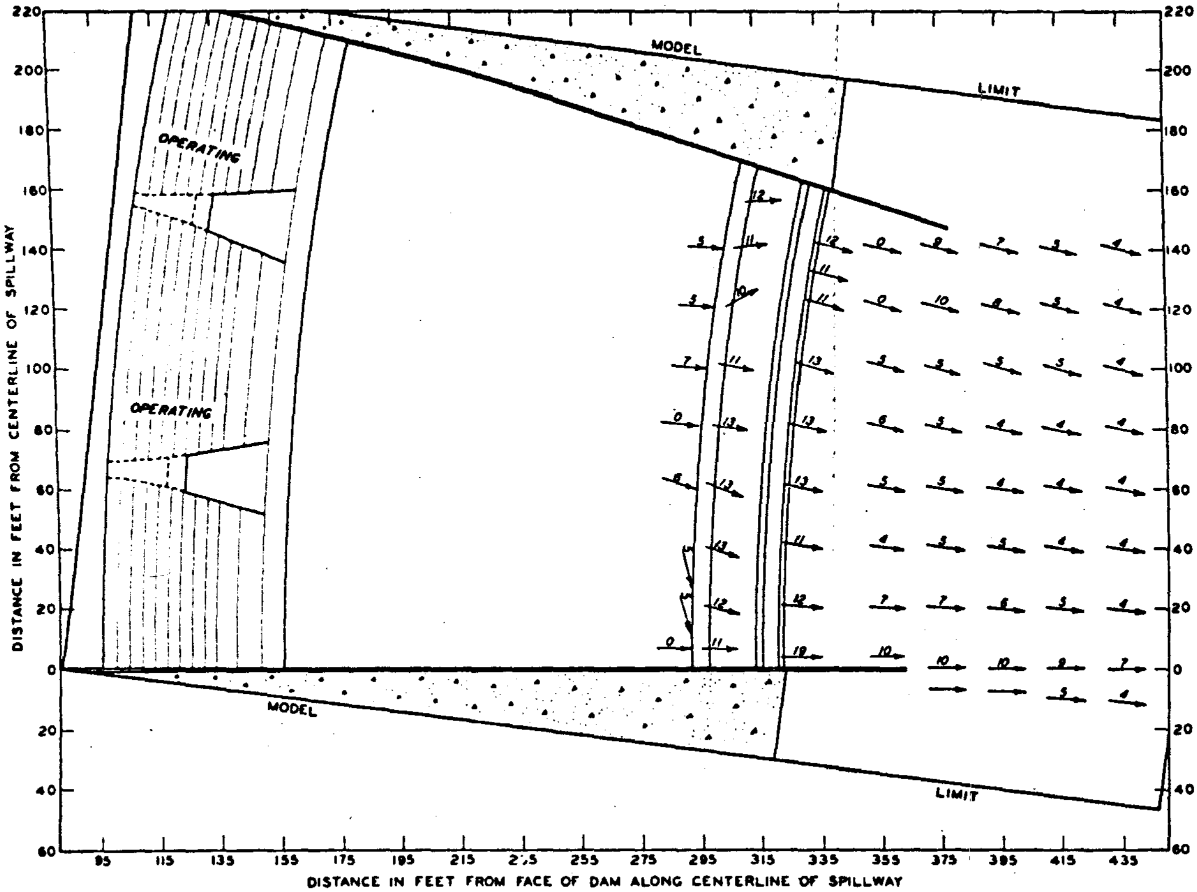
TEST CONDITIONS

DISCHARGE	3,790 CFS
POOL ELEV.	840
TAILWATER ELEV.	693.1
TYPE A BASIN	

NOTE: BED OF EXIT CHANNEL MOLDED FLAT TO ELEV. 690.

SCOUR PATTERN

PLATE 7

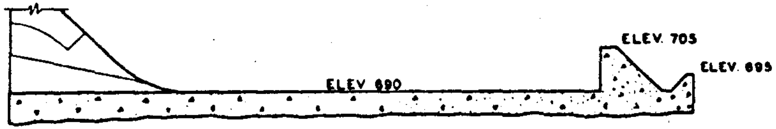


TEST CONDITIONS

DISCHARGE	6,340	CFS
POOL ELEV.	800	
TAILWATER ELEV.	698.4	
TYPE A BASIN		

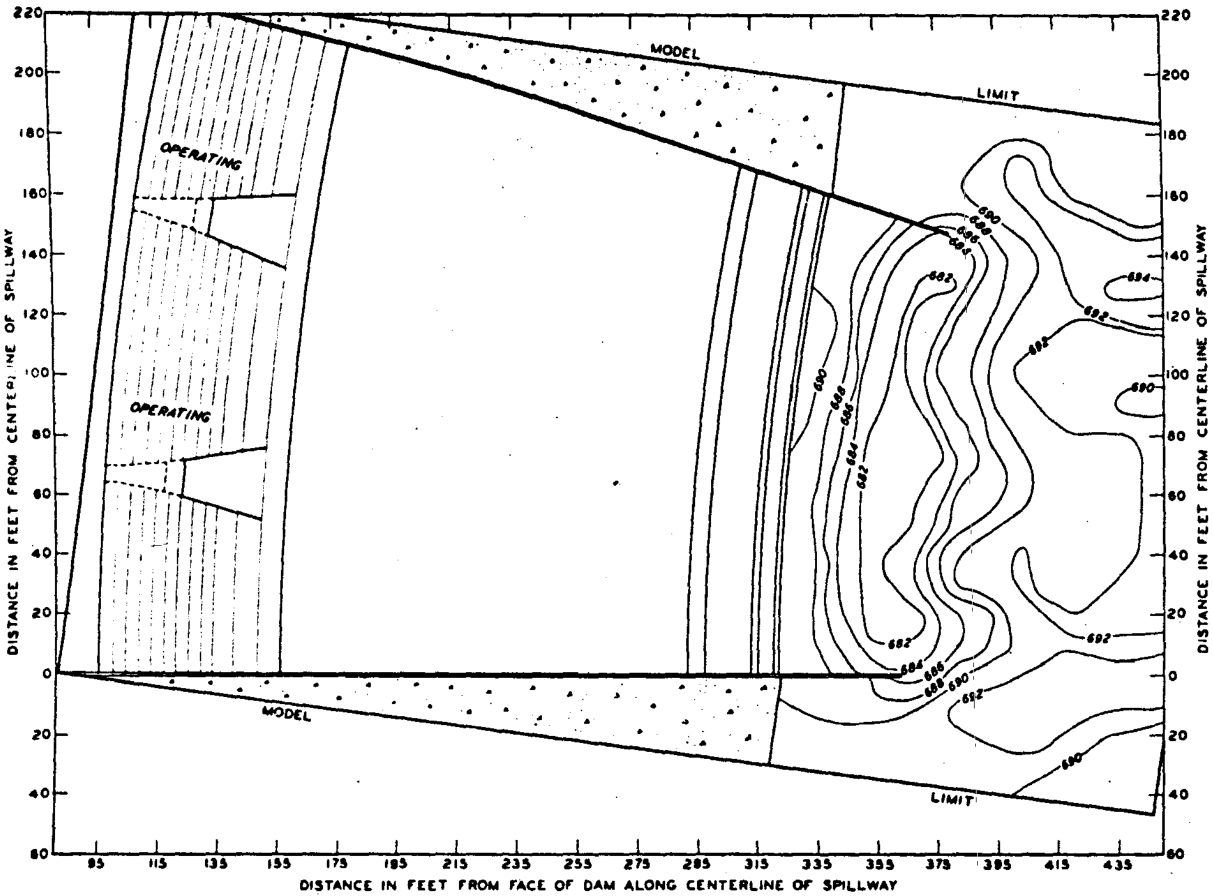
NOTE: BED OF EXIT CHANNEL FIXED IN CEMENT MORTAR AT ELEV. 690.

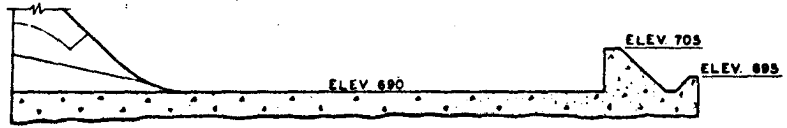
VELOCITIES ARE PROTOTYPE FT PER SEC.



SECTION ALONG CENTERLINE OF SLUICE

BOTTOM VELOCITIES





SECTION ALONG CENTERLINE OF SLUICE

TEST CONDITIONS

DISCHARGE	6,340 CFS
POOL ELEV.	800
TAILWATER ELEV.	698.4
TYPE A BASIN	

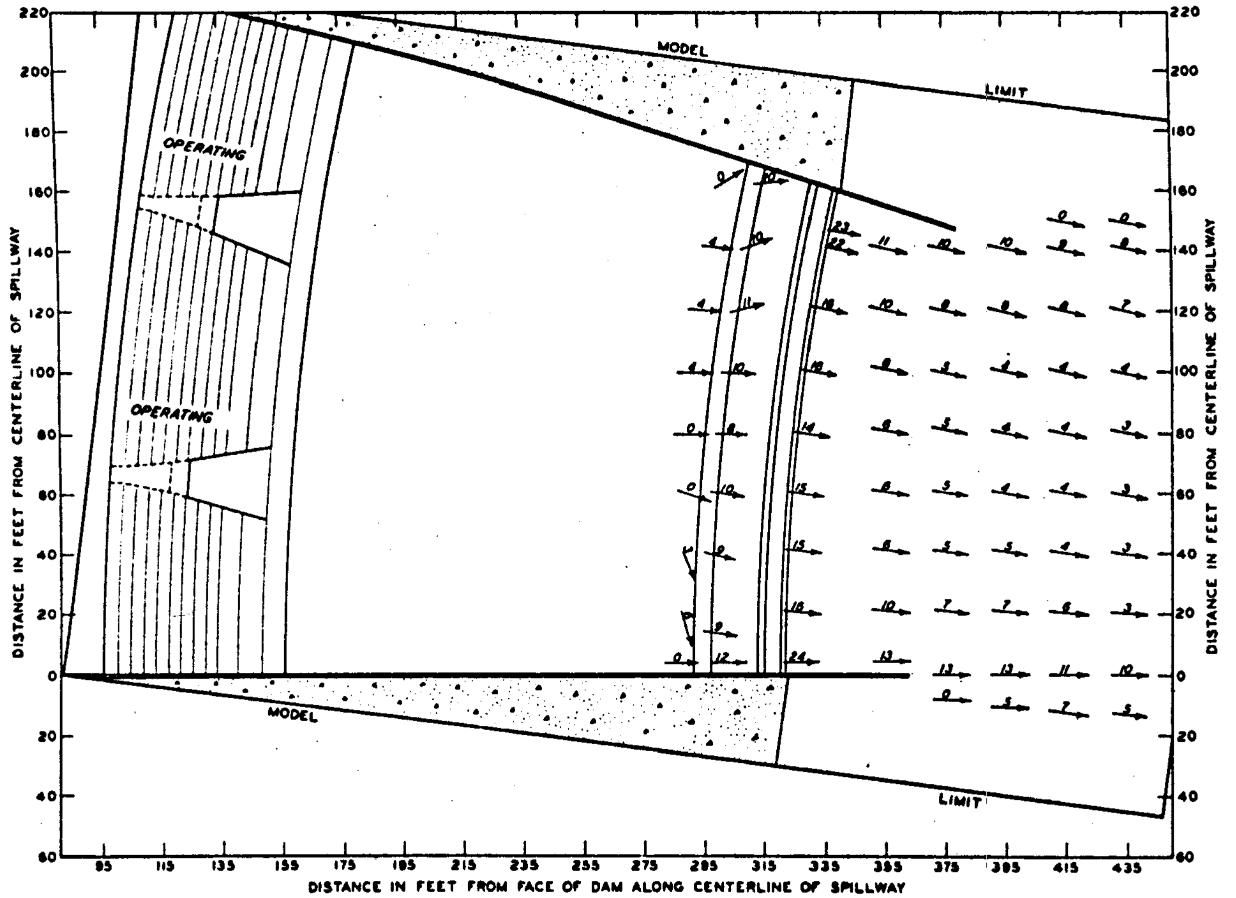
NOTE: BED OF EXIT CHANNEL MOLDED FLAT TO ELEV. 690.

SCOUR PATTERN

PLATE 9

31839

PLATE 10

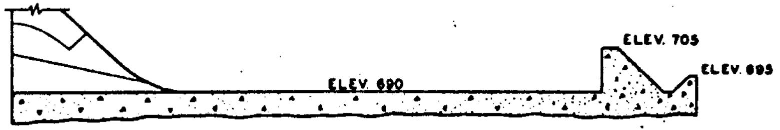


TEST CONDITIONS

DISCHARGE	7,580	CFS
POOL ELEV.	840	
TAILWATER ELEV.	699.9	
TYPE A BASIN		

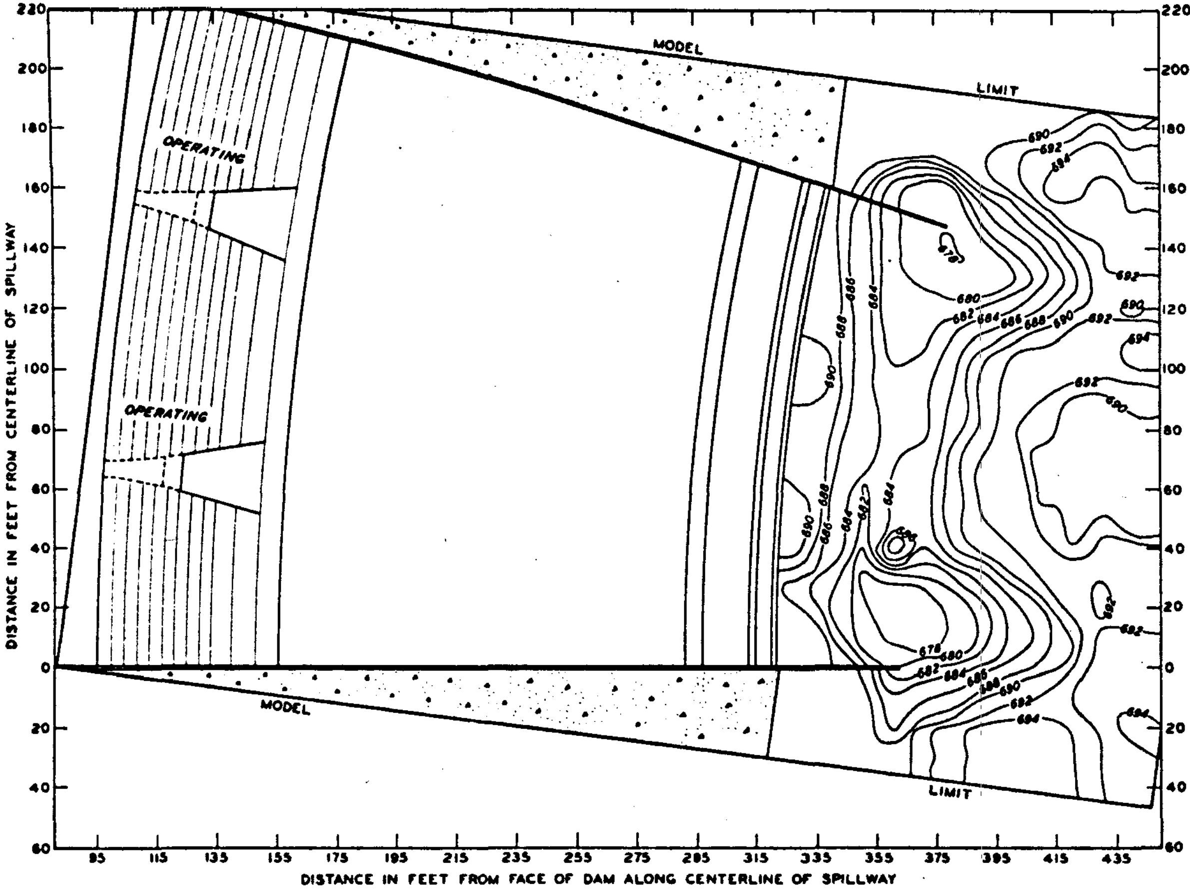
NOTE: BED OF EXIT CHANNEL FIXED IN CEMENT MORTAR AT ELEV. 690.

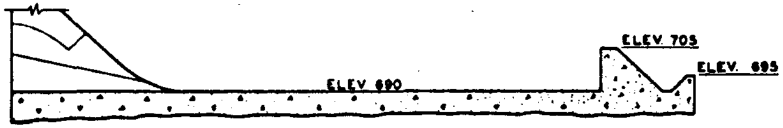
VELOCITIES ARE PROTOTYPE FT PER SEC.



SECTION ALONG CENTERLINE OF SLUICE

BOTTOM VELOCITIES





SECTION ALONG CENTERLINE OF SLUICE

TEST CONDITIONS

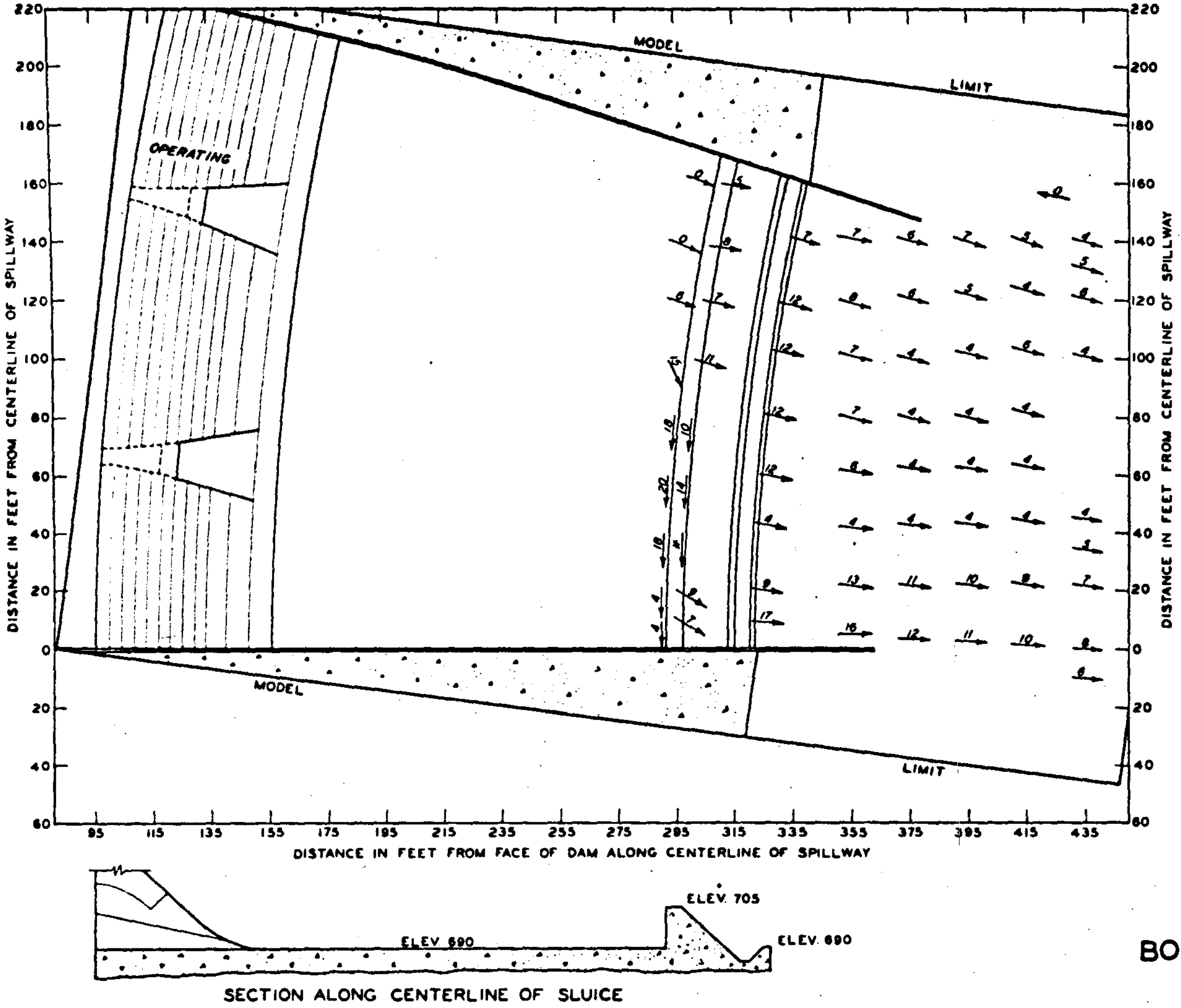
DISCHARGE	7,580 CFS
POOL ELEV.	840
TAILWATER ELEV.	698.9
TYPE A BASIN	

NOTE: BED OF EXIT CHANNEL MOLDED FLAT TO ELEV. 690.

SCOUR PATTERN

PLATE 11

PLATE 12



TEST CONDITIONS

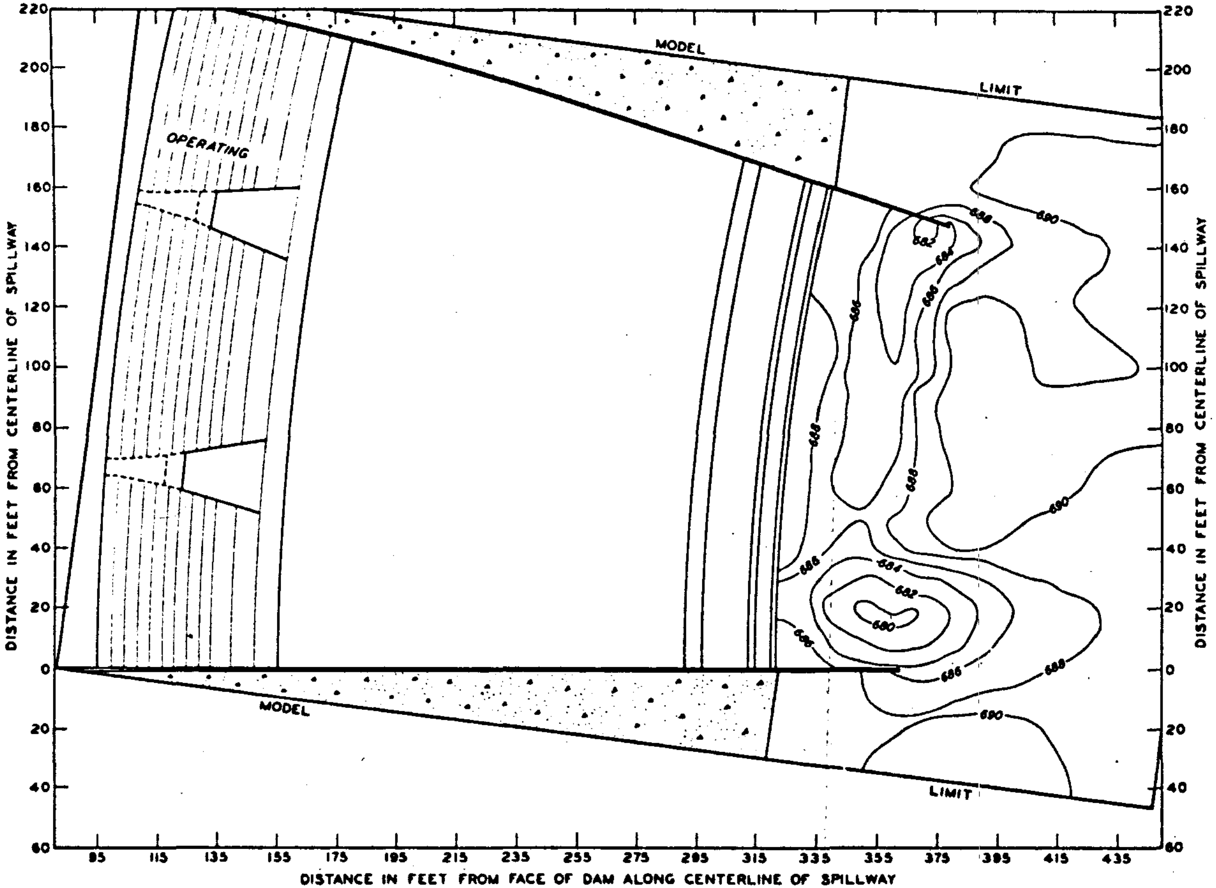
DISCHARGE	3,170	CFS
POOL ELEV	800	
TAILWATER ELEV.	692.7	
TYPE A-1 BASIN		

NOTE: BED OF EXIT CHANNEL FIXED IN CEMENT MORTAR AT ELEV 690

VELOCITIES ARE PROTOTYPE FT PER SEC.

* WATER TOO SHALLOW TO MEASURE VELOCITY.

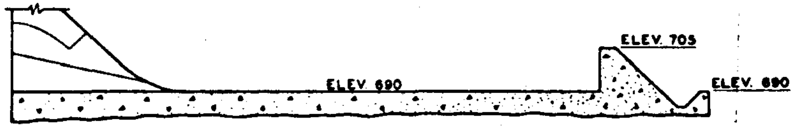
BOTTOM VELOCITIES



TEST CONDITIONS

DISCHARGE	3,170 CFS
POOL ELEV.	800
TAILWATER ELEV.	692.7
TYPE A-1 BASIN	

NOTE: BED OF EXIT CHANNEL
MOLDED FLAT TO ELEV. 690.

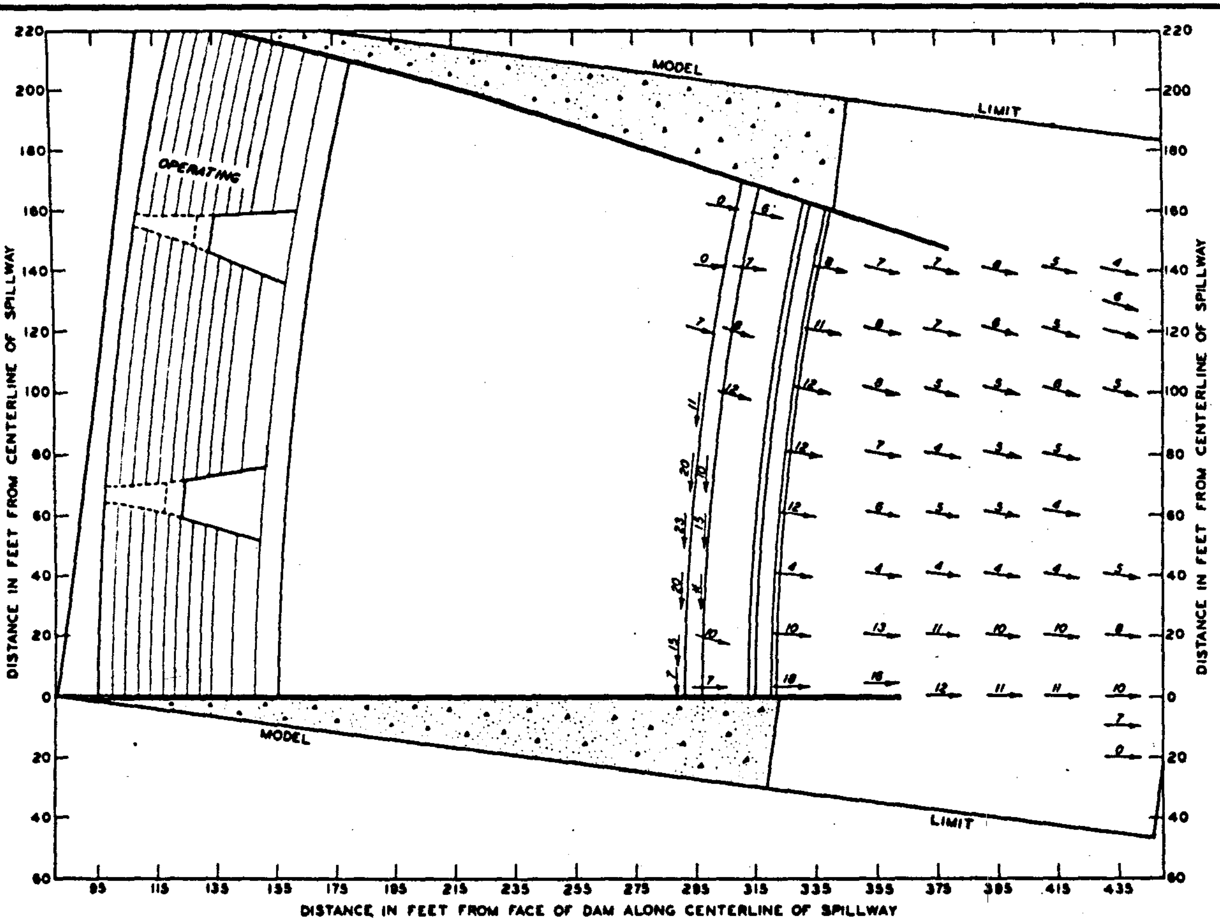


SECTION ALONG CENTERLINE OF SLUICE

SCOUR PATTERN

PLATE 13

PLATE 14



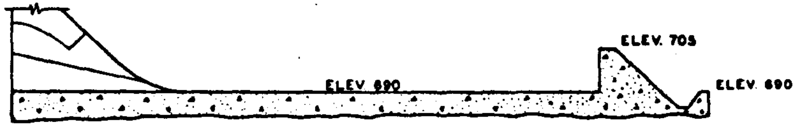
TEST CONDITIONS

DISCHARGE	3,790	CFS
POOL ELEV.	840	
TAILWATER ELEV.	693.1	
TYPE A-1 BASIN		

NOTE: BED OF EXIT CHANNEL FIXED IN CEMENT MORTAR AT ELEV. 690.

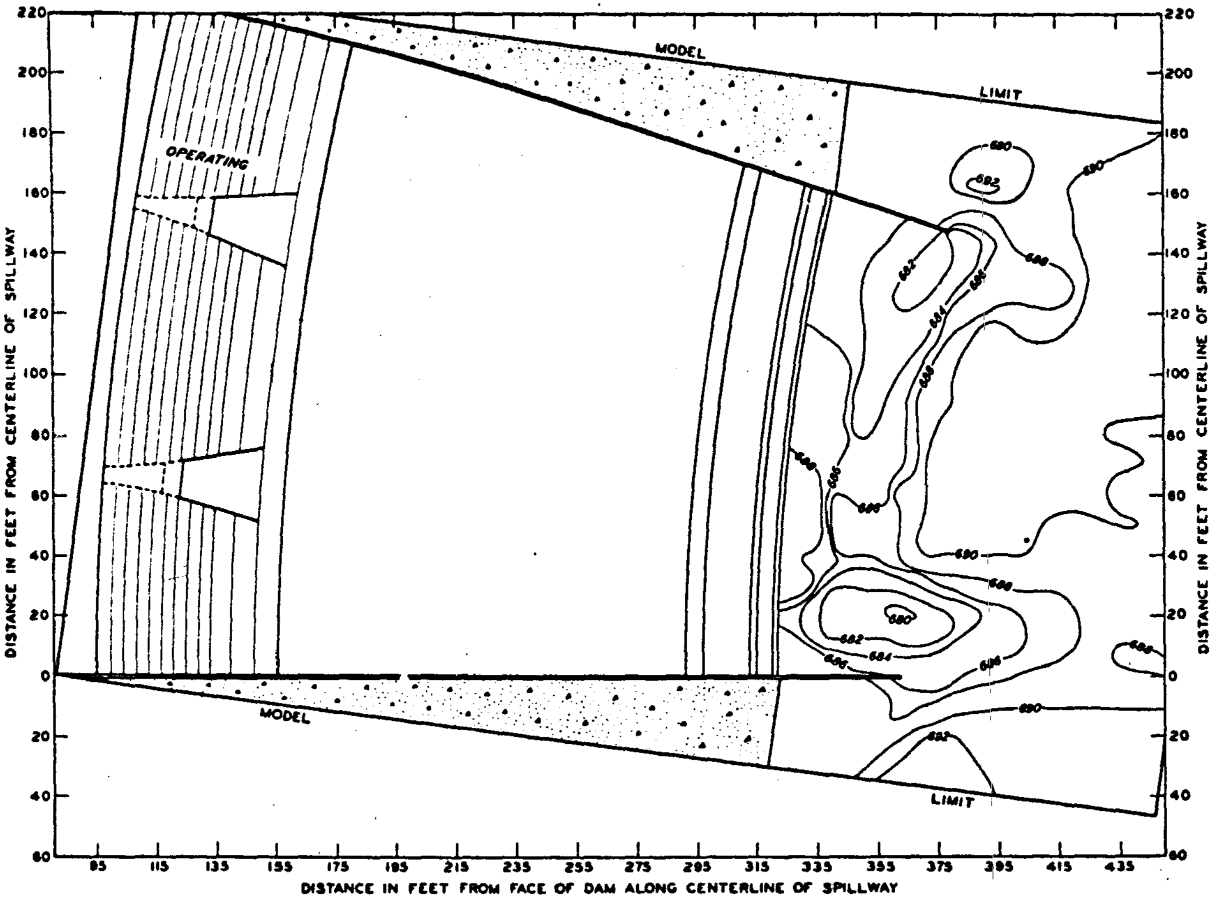
VELOCITIES ARE PROTOTYPE FT PER SEC.

* WATER TOO SHALLOW TO MEASURE VELOCITY.



SECTION ALONG CENTERLINE OF SLUICE

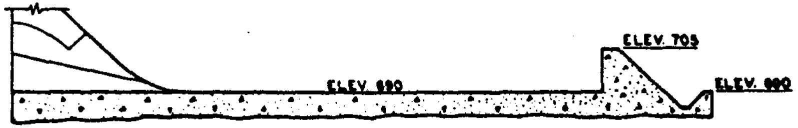
BOTTOM VELOCITIES



TEST CONDITIONS

DISCHARGE	3,790 CFS
POOL ELEV.	840
TAILWATER ELEV.	693.1
TYPE A-1 BASIN	

NOTE: BED OF EXIT CHANNEL MOLDED FLAT TO ELEV. 690.

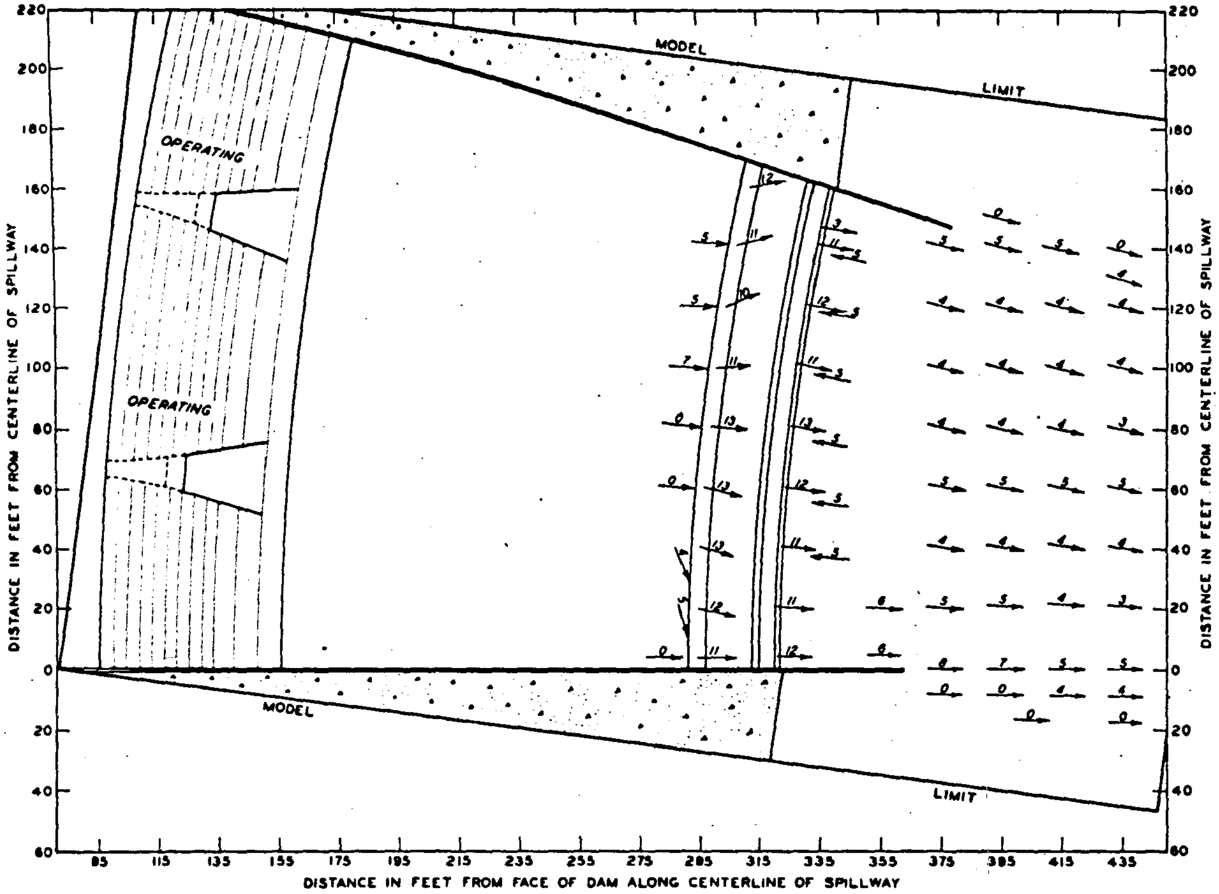


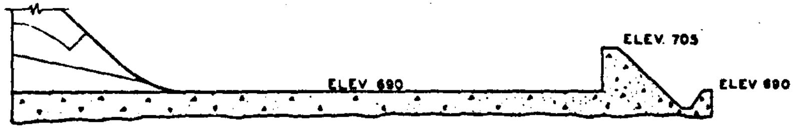
SECTION ALONG CENTERLINE OF SLUICE

SCOUR PATTERN

PLATE 15

PLATE 16





SECTION ALONG CENTERLINE OF SLUICE

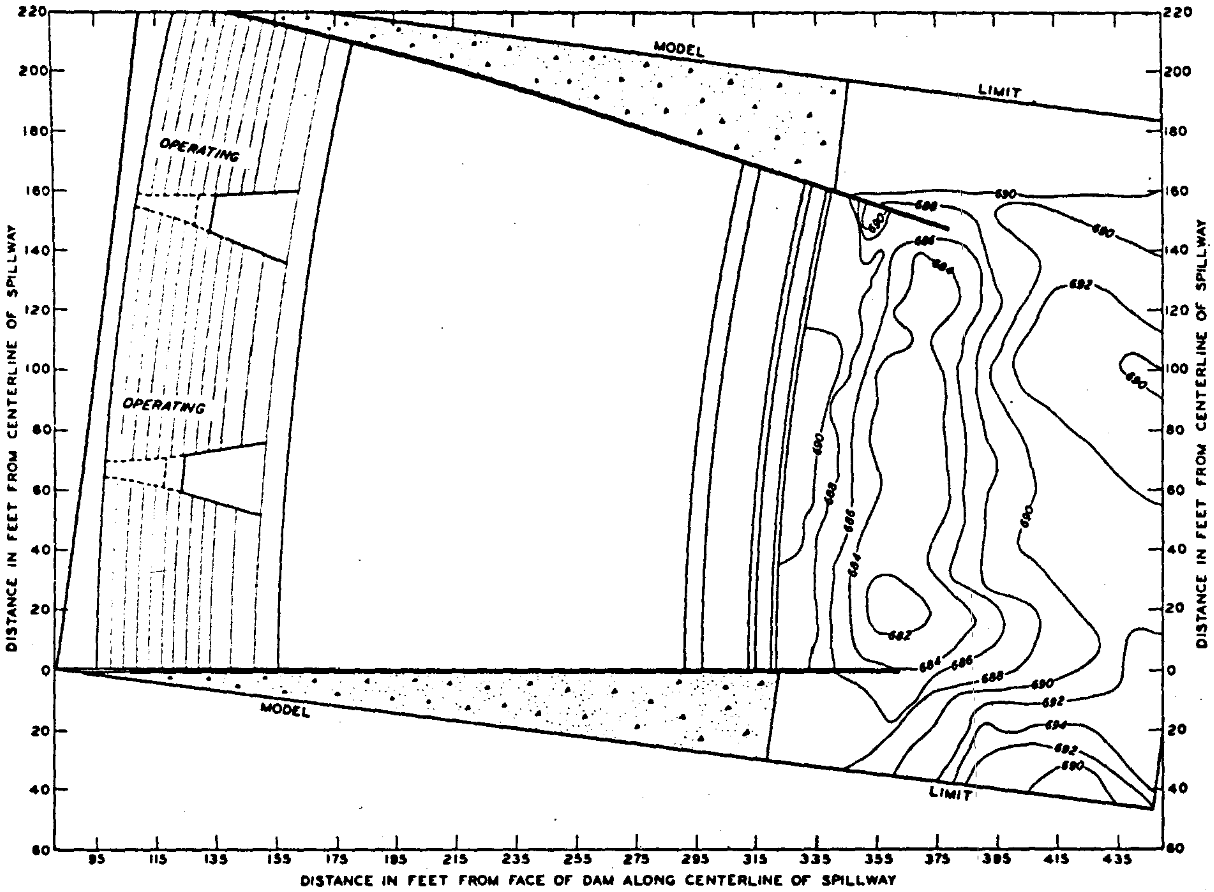
TEST CONDITIONS

DISCHARGE	6,340	CFS
POOL ELEV.	800	
TAILWATER ELEV.	698.4	
TYPE A-1 BASIN		

NOTE: BED OF EXIT CHANNEL FIXED IN CEMENT MORTAR AT ELEV. 690.

VELOCITIES ARE PROTOTYPE FT PER SEC.

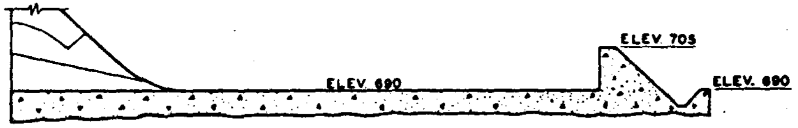
BOTTOM VELOCITIES



TEST CONDITIONS

DISCHARGE	6,340 CFS
POOL ELEV.	800
TAILWATER ELEV.	698.4
TYPE A-1 BASIN	

NOTE: BED OF EXIT CHANNEL
MOLDED FLAT TO ELEV. 690.

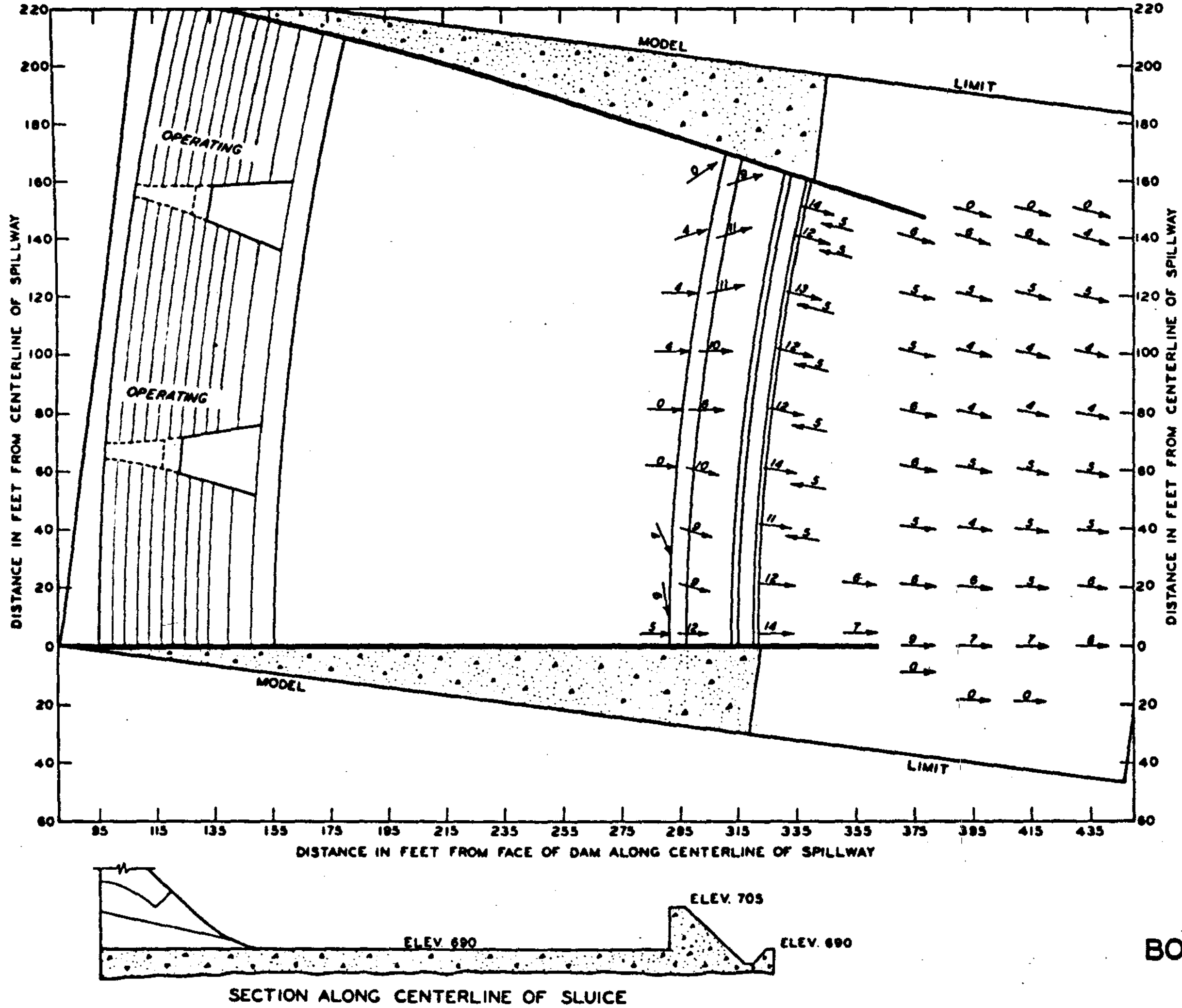


SECTION ALONG CENTERLINE OF SLUICE

SCOUR PATTERN

PLATE 17

PLATE 18



SECTION ALONG CENTERLINE OF SLUICE

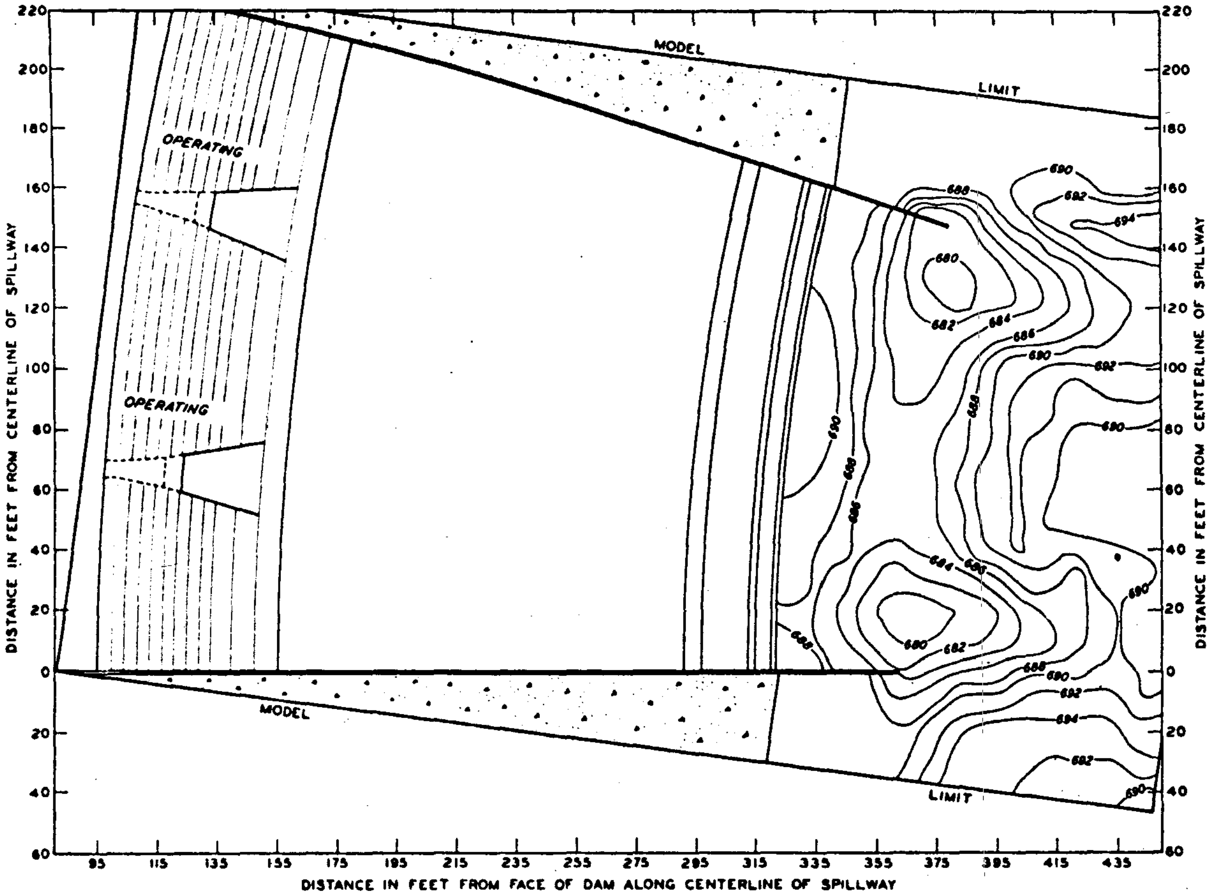
TEST CONDITIONS

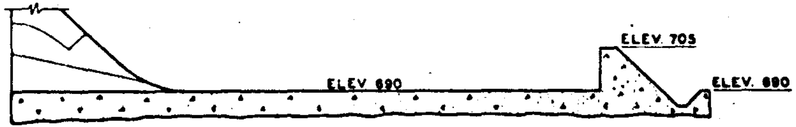
DISCHARGE	7,560	CFS
POOL ELEV.	840	
TAILWATER ELEV.	699.9	
TYPE A-1 BASIN		

NOTE: BED OF EXIT CHANNEL FIXED IN CEMENT MORTAR AT ELEV 690.

VELOCITIES ARE PROTOTYPE FT PER SEC.

BOTTOM VELOCITIES





SECTION ALONG CENTERLINE OF SLUICE

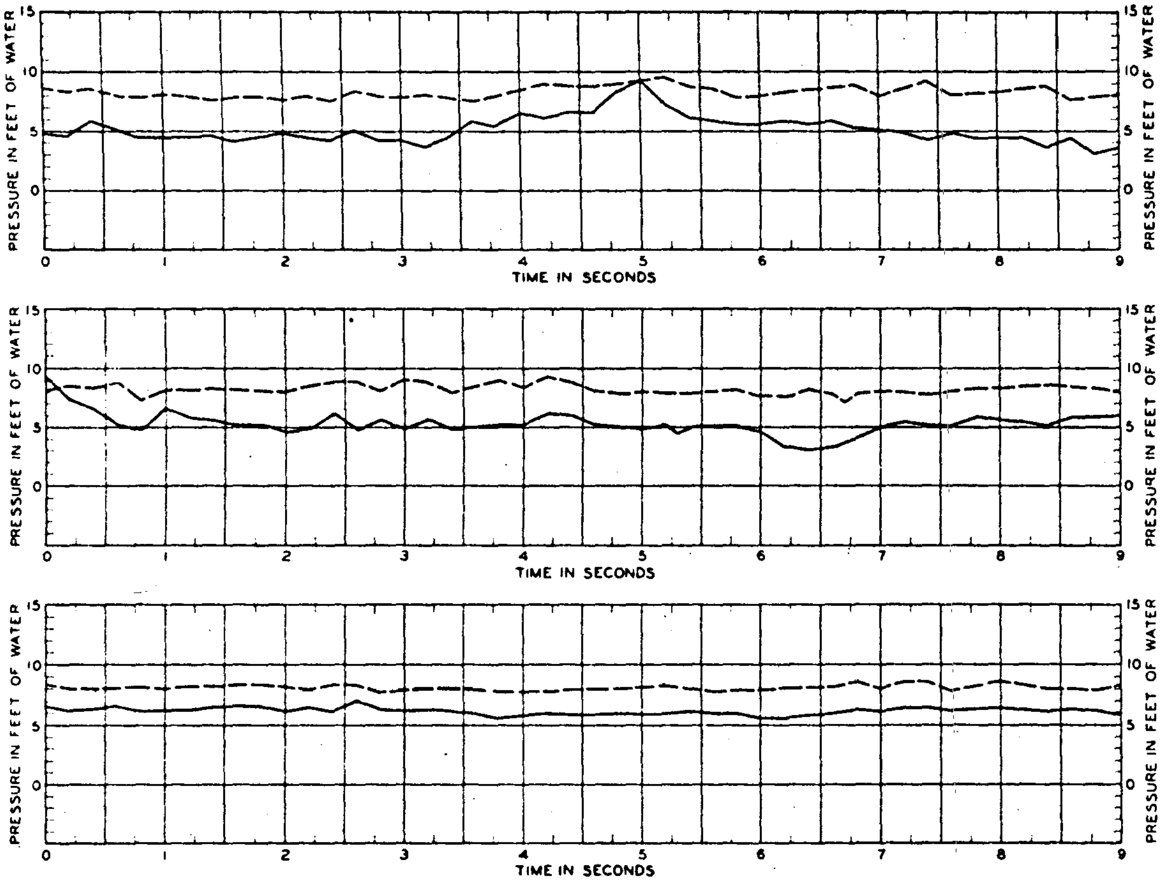
TEST CONDITIONS

DISCHARGE	7,560	CFS
POOL ELEV.	840	
TAILWATER ELEV.	699.9	
TYPE A-1 BASIN		

NOTE: BED OF EXIT CHANNEL MOLDED FLAT TO ELEV. 690.

SCOUR PATTERN

PLATE 19



TEST CONDITIONS

DISCHARGE 4070 CFS
POOL ELEV 860
ONE SLUICE OPERATING

TEST CONDITIONS

DISCHARGE 3780 CFS
POOL ELEV 840
ONE SLUICE OPERATING

TEST CONDITIONS

DISCHARGE 3160 CFS
POOL ELEV 800
ONE SLUICE OPERATING

LEGEND

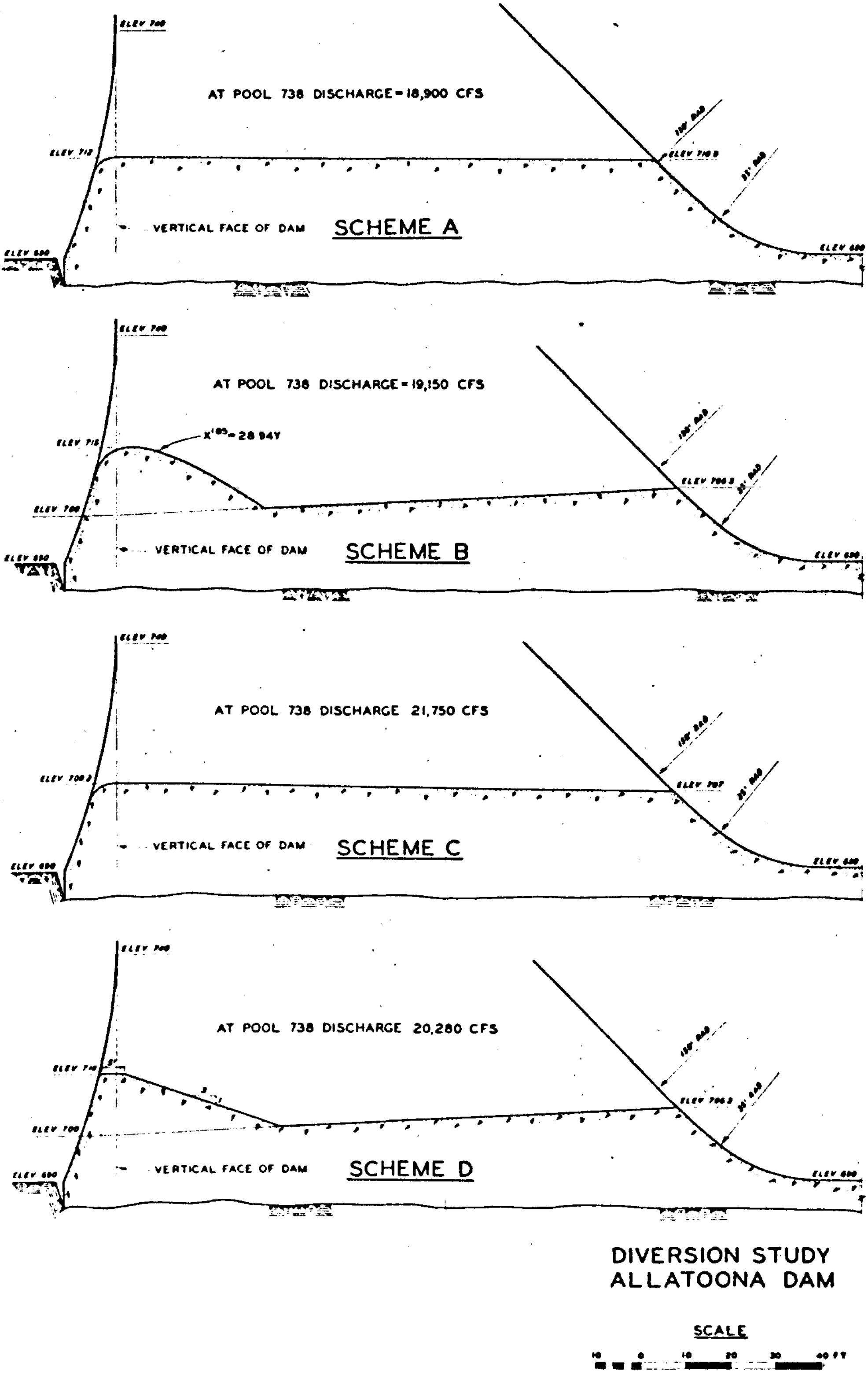
— — - — — TOP CELL
——— BOTTOM CELL

NOTES PRESSURES WERE OBTAINED THROUGH PRESSURE CELLS, IN THE UPSTREAM FACE OF THE PRIMARY END SILL, AND RECORDED BY MEANS OF AN OSCILLOGRAPH

THE TOP CELL WAS AT ELEVATION 700

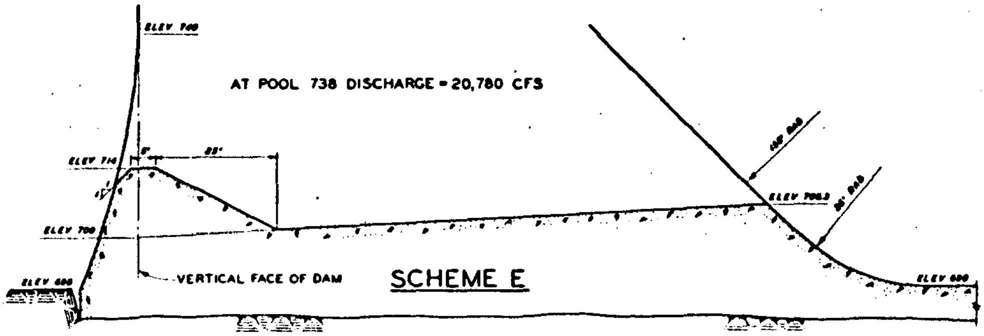
THE BOTTOM CELL WAS AT ELEVATION 695

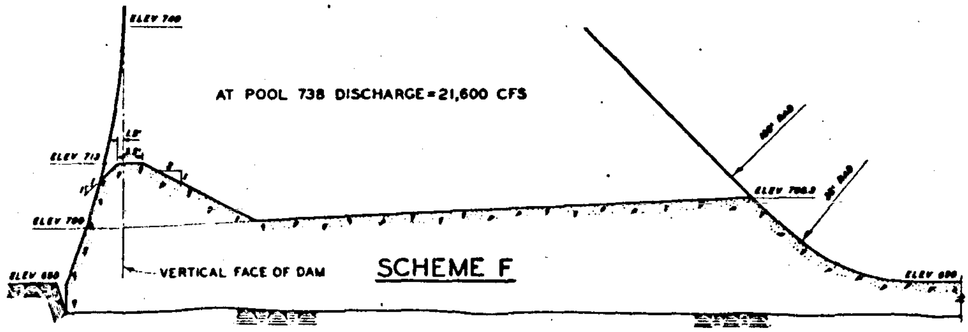
PRESSURE FLUCTUATIONS ON END SILL

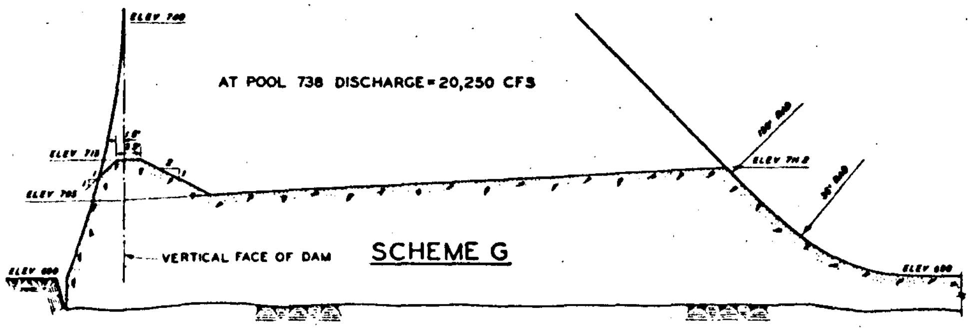


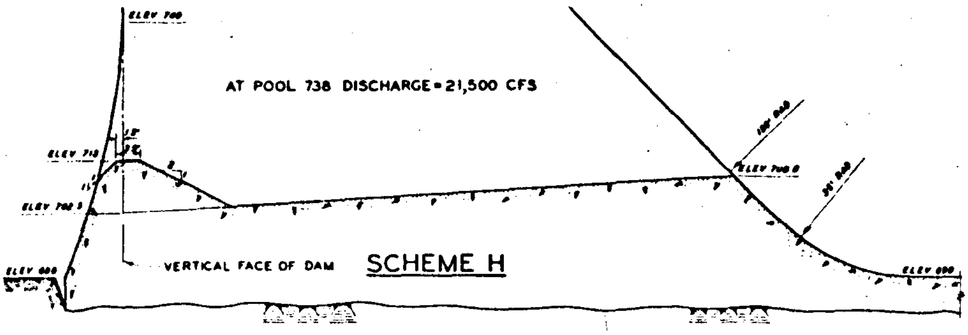
DIVERSION STUDY
ALLATOONA DAM

PLATE 21









DIVERSION STUDY
ALLATOONA DAM

SCALE
10 0 10 20 30 40 FT

PLATE 22