HYDRAULIC MODEL STUDY OF THE CLAY CREEK DAM NEAR LAMAR, COLORADO

Prepared for

State of Colorado
Game, Fish, and Parks Commission
6060 North Broadway
Denver, Colorado

Civil Engineering Department
Engineering Research Center
Colorado State University
Fort Collins, Colorado

December 1967

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by

Morris M. Skinner

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PREFACE

As a result of the June 1965 flood in the Clay Creek drainage near Lamar, Colorado, claims were initiated by certain landowners and private organizations against the State of Colorado Game, Fish and Parks Commission contending that the Clay Creek Dam, constructed under the authority of the Commission, had induced additional flood damages. In a sincere, conscientious effort to review the flow conditions that existed during the flood period, the Commission entered into a contract with Colorado State University to construct a hydraulic model of the Clay Creek Dam and terrain in the immediate vicinity. In addition to re-establishing the flow conditions that existed at the site during the flood period, modifications of the model were included to evaluate what flow conditions would have existed if a dike had been placed across a certain topographic saddle area and what flow conditions would have existed in the area if no dam had been constructed. The results of the model tests were to be documented with a report and a 16 mm color movie.

For operational planning and/or technical assistance, thanks are extended to Mr. John F. Haley and Mr. Elmo G. Peterson of Nelson, Haley, Patterson and Quirk Engineering Consultants, Greeley, Colorado; Mr. Gordon L. Allott, Jr., of the law offices of Winner, Berge, Martin and Camfield, Denver, Colorado; and Mr. Clyde Smith and Mr. George W. Wischmeyer, Chief Engineer and legal council, respectively, for the Colorado Game, Fish and Parks Commission.

A great deal of appreciation is due the shop supervisors, Mr. Ralph V. Asmus and Mr. Ewald Patzer and their crew members for their persistent efficiency and required innovations throughout the entire construction and maintenance phases of the model. For technical assistance in asphalt application, thanks are extended to Mr. William T. Lauer, Engineer and Mr. Robert W. Gardner, Estimator from Sterling Sand and Gravel Co., Fort Collins, Colorado.

Thanks are expressed to Mr. James F. Ruff, now at the Massachusetts Institute of Technology working towards a Ph.D. in Civil Engineering, for his contributions in the early phases of the project.

Grateful acknowledgment is made to Dr. D. B. Simons, Professor of Civil Engineering and Associate Dean for Research, College of Engineering, for his technical guidance throughout the entire program and for reviewing the report.

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SUMMARY

An undistorted, 1:36 scale hydraulic model of the Clay Creek Dam vicinity near Lamar, Colorado was constructed and evaluated for four basic model configurations: (1) a model of the dam, spillway and adjacent topography that existed at the time of the completion of the actual dam; (2) the model described in (1), but with a dike added across a topographic saddle region; (3) the model described in (1), but with an inflow having a more rapidly rising hydrograph and/ or various approach patterns; and (4), a model of the topography that existed in the same area prior to the construction of the Clay Creek Dam.

A 16 mm color movie was produced to illustrate the construction and operation of the model and the flow patterns for each of the four model configurations.

The results of the model tests are summarized as follows:

(1) With the Clay Creek Model Dam entirely intact, a flood with a peak prototype discharge of 158,000 cfs produced a peak discharge of 105,000 cfs across the saddle area. For various inflow distributions at the upper end of the model and/or for two different time base inflow hydrographs, a peak prototype inflow discharge ranging from 158,000 cfs to 160,000 cfs produced a peak discharge across the saddle area ranging from 102,000 cfs to 105,000 cfs.

(2) A dike, placed across the saddle region to the same elevation as the crest of the dam, reduced the peak prototype discharge across the saddle area by about 40,000 cfs or approximately 38%. Conversely, the dike increased the peak discharge downstream from the dam by about 75%.

(3) Regardless of the inflow distributions into the model, in the case for Configuration-4, a flood in the Clay Creek Model with a peak prototype discharge of 158,000 cfs produced no flow across the saddle area. The various inflow patterns in the model produced a peak water surface level in the saddle area equivalent to 3661 feet in the prototype.

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*Figures 1 and 2 are found in the packet on the back page of this report.

HYDRAULIC MODEL STUDY OF THE CLAY CREEK DAM NEAR LAMAR, COLORADO

by

Morris M. Skinner[1]

Purpose:

A model study was performed to re-establish as accurately as possible the flow conditions that existed at the Clay Creek Dam and vicinity during the flood of June 1965. In addition, accurate representations were desired for the flow conditions that would have existed if a dike had been placed across the saddle region and for the flow conditions that would have existed with the same flood if no dam had been constructed.

Results:

A hydraulic model (scale: 1-36 horizontal, 1-36 vertical) of the Clay Creek Dam area was constructed and tested at the Outdoor Modeling facility of the Engineering Research Center at Colorado State University. Four basic model configurations were investigated:

Configuration-1: a model of the dam, spillway and adjacent topography that existed at the time of completion of the Dam.

Configuration-2: configuration-1 with a dike placed across the saddle region.

Configuration-3: configuration-1 with a rapidly rising hydrograph in three approach patterns.

Configuration-4: a model of the topography that existed in the same area prior to construction of the Clay Creek Dam.

In addition to this report, a 16 mm movie film was produced to illustrate the construction, arrangement, performance and flow patterns for each of the four basic model configurations. Construction details were also recorded on black and white photographs and 35 mm color slides.

A summary of the results for each of the four basic model configurations is presented in the following section:

Configuration-1: For a relatively steady, prototype inflow of 158,000 cfs, the flow across the saddle area was 105,000 cfs resulting in a calculated[2] flow below the dam of 53,000 cfs. The prototype water surface elevation at the steady inflow of 158,000 cfs, of the pool in front of the dam, was 3672 feet.

Configuration-2: For a relatively steady, prototype inflow of 158,000 cfs, the flow across the saddle area was 65,000 cfs resulting in a calculated flow below the dam of 93,000 cfs. The prototype water surface elevation at the steady inflow of 158,000 cfs, of the pool in front of the dam, was 3674 feet.

Configuration-3: This configuration consisted of a series of six runs intended to evaluate the possible effect, if any, caused by an extreme flash flood situation and/or various inflow patterns on the flow distribution across the saddle.

Run No. 1: A one-hour hydrograph with a peak prototype discharge of 159,000 produced a peak discharge across the saddle area of 103,000 cfs.

Run No. 2: With no distribution blocks for directing the inflow, a one-hour hydrograph with a peak prototype discharge of 159,000 cfs produced a peak discharge across the saddle area of 105,000 cfs.

Run No. 3: An approximate duplication of inflow conditions and hydrograph that occurred in Run No. 2 produced a peak discharge across the saddle area of 102,000 cfs.

Run No. 4: With the inflow distribution intentionally directed to the left, a one-hour hydrograph with a peak prototype discharge of 160,000 cfs produced a peak discharge across the saddle area of 102,000 cfs.

Run No. 5: With the inflow distribution intentionally directed to the left, and for a relatively steady, prototype inflow of 158,000 cfs, the flow across the saddle area was 105,000 cfs resulting in a calculated flow below the dam of 53,000 cfs. The prototype water surface elevation, at the steady inflow of 158,000 cfs, of the pool in front of the dam, was 3672 feet.

Run No. 6: With no distribution blocks for directing the inflow and for a relatively steady, prototype inflow of 158,000 cfs, the flow across the saddle area was 105,000 cfs resulting in a calculated flow below the dam of 53,000 cfs. The prototype water surface elevation, at the steady inflow of 158,000 cfs, of the pool in front of the dam, was 3673 feet.

Configuration-4: This configuration consisted of a series of two runs intended to evaluate the effect of inflow distribution, if any, on the flow distribution across the saddle.

Run No. 1: With the inflow distribution intentionally directed to the right, and for a relatively steady inflow of 158,000 cfs, no flow crossed the saddle area. At the steady inflow of 158,000 cfs, the water surface elevation in the saddle area was 3661 feet.

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[1] Assistant Professor, Civil Engineering Department, Colorado State University

[2] A calculated value for flow below the dam was used due to the excessive velocity of approach in the 3' weir at the higher discharges.

Run No. 2: With the inflow distribution intentionally directed to the left, and for a relatively steady inflow of 158,000 cfs, no flow crossed the saddle area. At the steady inflow of 158,000 cfs, the water surface elevation in the saddle area was 3661 feet.

Model Construction

In the planning stages for the proposed model study of the Clay Creek Dam, three model alternates were considered: (1) a distorted model, scale: 1:100 horizontal, 1:50 vertical; (2) an undistorted model, scale 1:36 horizontal, 1:36 vertical; and (3) a distorted model, scale 1:500 horizontal, 1:50 vertical.

Generally, distorted models (i.e., a model with a horizontal scale different than the vertical scale) are required where the horizontal dimensions of the model site are limited, and/or the modeling of sediment transport phenomena are of paramount interest. Distortion, however, results in a departure from strict dynamic similarity and for this reason was deemed undesirable for this particular model study.

The selected 1:36 scale undistorted model required a relatively large area and specialized construction techniques. In this particular type of model construction, however, the larger scale allowed for a more accurate representation of the actual field situation.

For an undistorted model based on the "Froude" criteria with a length ratio of 1:36, the scale ratios for the following characteristics exist:[3]

Time ratio = $[\text{length ratio}]^{1/2}$ = 1:6
Velocity ratio = $[\text{length ratio}]^{1/2}$ = 1:6
Discharge ratio = $[\text{length ratio}]^{5/2}$ = 1:7776
Roughness ratio[4] = $[\text{length ratio}]^{1/6}$ = 1:1.82

In order to model the prototype area involving the dam, saddle, and a portion of the streambed downstream from the dam, approximately 60,000 square feet of model space was required. The overall area of the model, including the water inflow control area and downstream collection and measurement areas involved about 2.6 acres.

Topographic maps (scale 1 inch = 200 feet, contour interval = 2 feet) for the Clay Creek area were prepared by the firm of Underwood and Parker, Inc., Greeley, Colorado, from aerial photography flown on May 20, 1966. These maps were used to obtain the topographic features of the model.

A base line was established on the 1:2400 scale maps at the left side of the area to be modeled and cross sections were laid out to represent 100-inch intervals on the model. Cross-section notes for the model construction were obtained by measuring from the base line out along a given cross section to each contour and cultural feature. In areas of particular interest, additional cross sections were established. Map distances were recorded to the nearest one hundredth of an inch (0.01 inch) and converted to a model distance by the appropriate factor (200/36). Elevations were reduced to the model scale by dividing by 36. Approximately 3650 point locations and elevations were obtained from the maps and converted to the model scale. A schematic drawing illustrating the orientation of the base line and the majority of the cross sections are illustrated in Fig. 1.[5] The modeled area and appurtenant features are illustrated in Fig. 2.[5]

Some enlargement of the existing model platform was necessary prior to the construction of the model. A considerable amount of a suitable fill material had to be obtained, transported, and compacted at the existing model platform in order to accommodate such a large model. Concurrently with the filling and compaction process, the base line for horizontal control in the model was laid out, cross sections located and bench marks established for the vertical control in the model. Cut and fill stakes were located on the cross sections at about ten foot intervals and the approximate topography progressively constructed with a cat and dozer, a motorized grader and finally with a small tractor-mounted backhoe (Fig. 3). During this process, additional compaction was achieved with a rubber tired roller.

At this point in the construction phase, a sizeable portion of the model topography was nearly to grade and the remaining areas of the model were generally within one half of a foot of grade except in the immediate vicinity of the dam. The ability to achieve this degree of topography refinement in the early stages of the model construction phase was attributed to three important factors: (1) the small amount of relief in the prototype, (2) the large model scale, and (3) the extreme care and capabilities of the heavy equipment operators.

The final topography was constructed by restaking the entire model area and progressively cutting or filling, by hand labor, to the proper elevations (Figs. 4 and 5). Constant compacting operations followed immediately behind any terrain modification (Fig. 6). A special steel roller was constructed by the laboratory shop to facilitate compaction of the 100-inch wide cross sections (Fig. 7). Additional moisture content for compaction operations was obtained by frequent sprinkling (Fig. 8). Final compaction in certain areas required rolling with another laboratory shop innovation shown in Fig. 9.

The final topography was stabilized by applying a total of about one gallon per square yard of prime coat asphalt in two applications (Fig. 10). Following each application, the prime coat was lightly dusted with fine, dry sand and rolled with a rubber tired roller or the steel roller shown in Fig. 9.

A head box was installed, fitted with valves and connected to the twenty-four inch supply line from College Lake (Figs. 11, 12, and 2). A twelve-inch orifice was installed in the supply line a short distance from the head box and appropriate pressure taps located for the manometer (Figs. 13 and 2). To accurately measure the complete flow range, both a water and mercury manometer were utilized. Two trapezoidal weirs were located at the downstream end of the model to record the flow in either the stream channel or across the saddle region (Figs. 14 and 2). Provisions

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[3]"Hydraulic Models", A.S.C.E. Manuals of Engineering Practice No. 25, American Society of Civil Engineers, 1942.

[4]The boundary roughness for the actual site was estimated to be 0.035; the boundary roughness for the model was estimated to be 0.018 or about equal to the calculated model roughness of 0.035 ÷ 1.82 = 0.019.

[5]Figures 1 and 2 are found in the packet on the back page of this report.

Fig. 3. A tractor mounted backhoe completed the rough topography layout

Fig. 4. After the rough topography was completed, the model was restaked for final hand grading

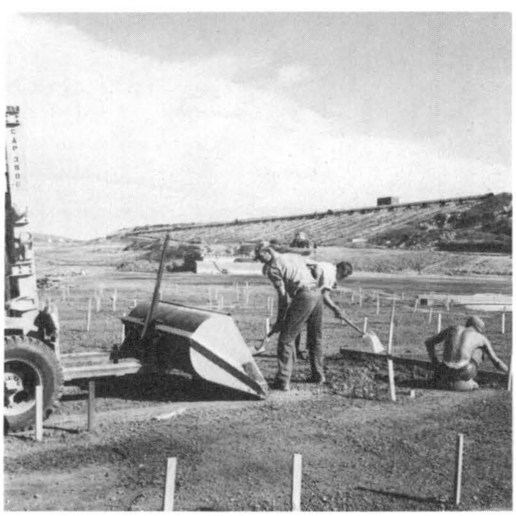


Fig. 5. The final topography was established by hand labor

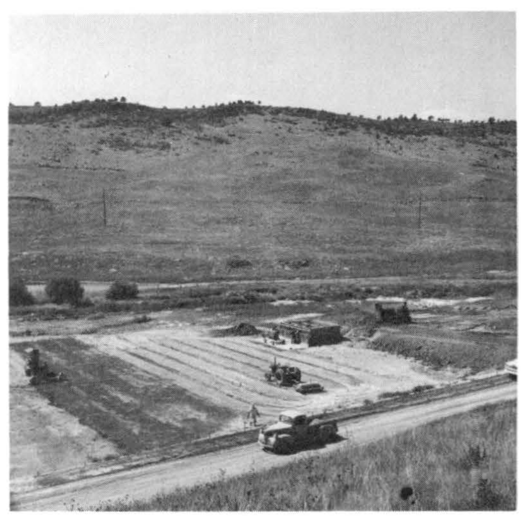


Fig. 6. The area between cross sections was compacted after filling or cutting operations

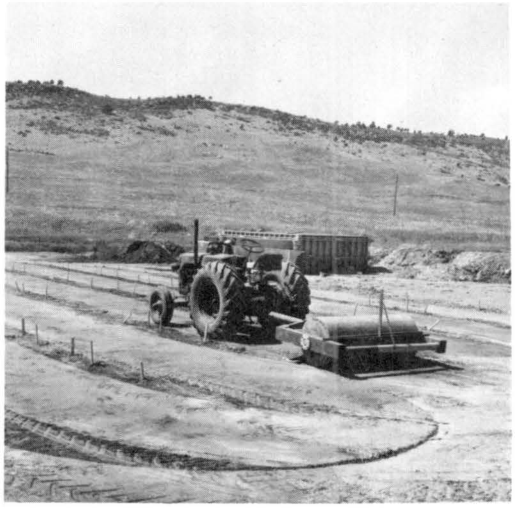


Fig. 7. A special steel roller was constructed for compaction between the 100" cross sections

Fig. 8. Sprinkling maintained the proper soil moisture for good compaction.

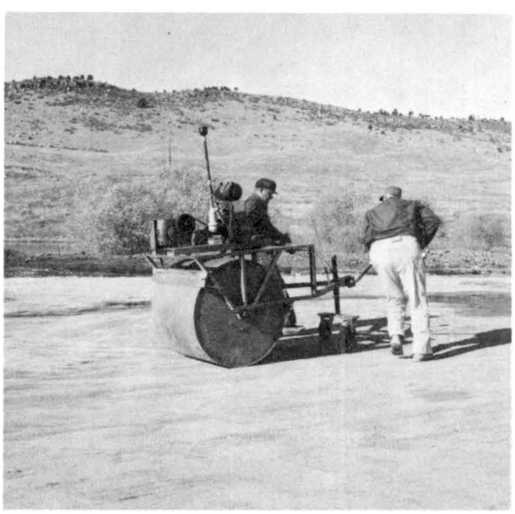


Fig. 9. A self-propelled steel roller was used in certain areas for final compaction

Fig. 10. Prime coat asphalt was used to stabilize the terrain

Fig. 11. A heavy sheet metal splashway connected the headbox to the concrete apron

Fig. 12. Installation of the 24-inch line between the main supply line and headbox required a considerable amount of excavation in very resistant material

Fig. 13. Inflow was measured with a 12-inch orifice in the 24-inch line

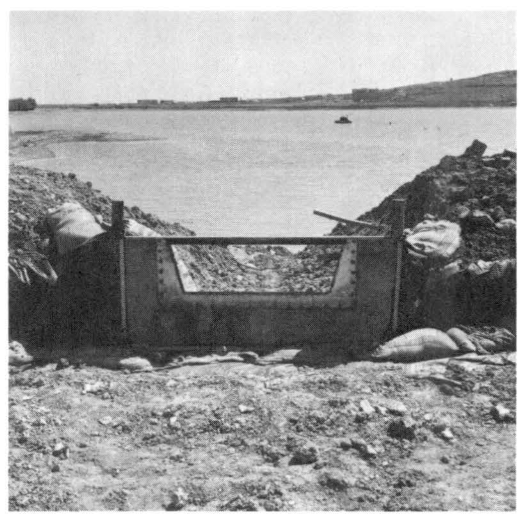


Fig. 14. Trapezoidal weirs were located downstream from the saddle area and the dam

were made for draining the model with a valved, eight-inch line; the drain intake was constructed flush with the bottom of the model at the appropriate location (Fig. 15).

The Clay Creek Dam was simulated with a small concrete structure, carefully formed and poured to correspond to the alignment of the prototype. The area immediately downstream from the model dam was stabilized with concrete carefully finished to simulate the actual topography (Figs. 16, 17 and 18). Particular care was taken in constructing the top of the dam at the proper elevation. The concrete had to be "stoned" down in some areas to remove slight irregularities (Fig. 19). Obviously, the top of the dam became part of the hydraulic control at certain discharges (Fig. 20).

The dike for configuration-2 was simulated by installing a treated 2" x 12" plank to the same elevation as the top of the dam (Fig. 21).

From a distance, the modeled topography appeared to be "practically flat," but when water was introduced, the similarity became quite apparent (Fig. 22).

Testing Procedure

The initial series of runs in the model were expressly for model verification. With the terrain, and cultural features constructed as precisely as possible (generally to within ± 0.01 foot in both the horizontal and vertical directions for areas of hydraulic control such as the top of the dam, spillway, and saddle region) high water marks were reproduced and staked in the model and the peak model discharge (158,000 cubic feet per second in the prototype represented by 20.3 cubic feet per second in the model) was established. Distribution blocks on the apron of the headbox were adjusted to give a uniform inflow pattern into the approach section of the model and in addition to allow for the water surface at peak discharge, to correspond with the selected high water marks. The high water marks, reproduced from actual field locations, checked out very closely in the model (Fig. 23).

With the verification accomplished and after gaining adequate familarity with the operation of the model, the next step was to proceed to the actual testing. Configurations 1 through 4 were tested in that order with a concentrated effort to accomplish the required modification between various configurations with a minimum of delay. A continuing program of model checking, repair and maintenance was pursued with the utmost diligence throughout the entire program (Figs. 24 and 25).

The testing procedure for each of the four basic configurations was similar to allow for direct comparison in the final analysis. A peak discharge of 158,000 cubic feet per second was modeled in each configuration. A simple, six-hour hydrograph was used in all configurations. A simple, one-hour hydrograph was also used in configuration-3 in an attempt to evaluate the effect of a more rapidly rising hydrography for the case of an extreme flash flood situation. The six-hour hydrograph and the one-hour hydrograph are depicted in Figs. 27 and 28, respectively. In each case, (except for configuration-4) after the peak discharge had been reached a photographic record was obtained of the flow patterns in the model. The flow patterns, accentuated with paper confetti, were recorded on movie film.

In all cases, except obviously for configuration-4, the inflow hydrograph was initiated after the model had been filled to the "full pool" level (water level standing in the model at the spillway elevation). Inflow was controlled at the headbox by the four twelve-inch valves and/or by direct telephone contact with the pump operator. A three hundred horsepower, variable speed pump was housed in the pump station shown in Fig. 26. The pump installation had a potential of providing a controlled, variable discharge up to about 30 cubic feet per second delivered at the model site. Distribution of flow quantities in the model was recorded at the two weir stations prior to direct discharge back to College Lake (Fig. 2).

Data pertaining to the performance of each of the four basic configurations is given in the Appendix of this report.

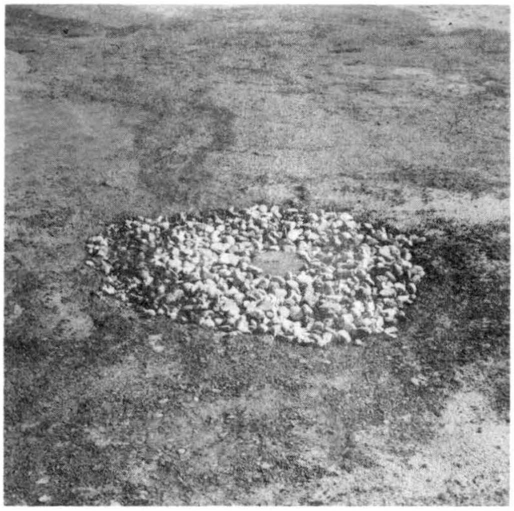


Fig. 15. The intake to the model drain was installed flush with the terrain and rip-rapped with coarse gravel

Fig. 16. Topography downstream from the model dam was laid out and compacted by hand

Fig. 17. Wire netting was used as reinforcing for the first coat of concrete

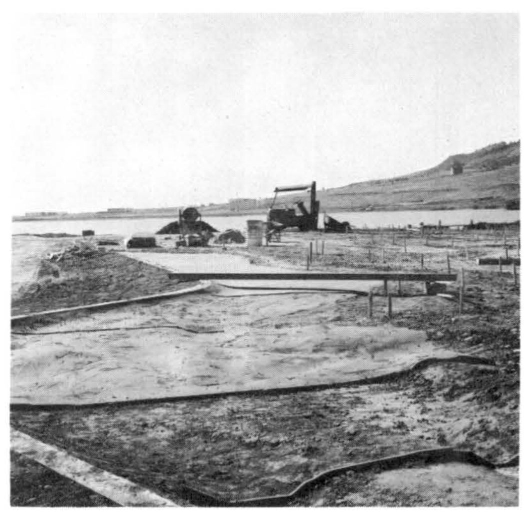


Fig. 18. A final coat of concrete was applied and finished to the proper grade

Fig. 19. The top of the dam was finished to the proper elevation with a "masons stone"

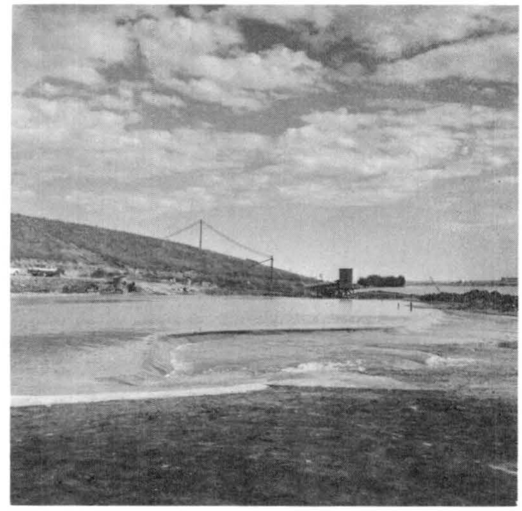


Fig. 20. The crest of the dam became a control at the higher discharges

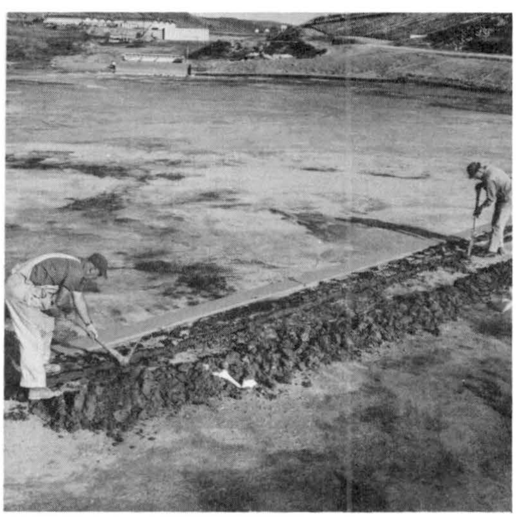


Fig. 21. A 2" x 12" treated plank was installed in the saddle region to represent a dike

Fig. 22. The topographic features of the model were hardly noticeable until flow was turned in

Fig. 23. High water marks corresponded quite well with the field-targeted high water marks

Fig. 24. "Patching" procedures were initiated immediately after each run

Fig. 25. Repairs were completed by hand rolling

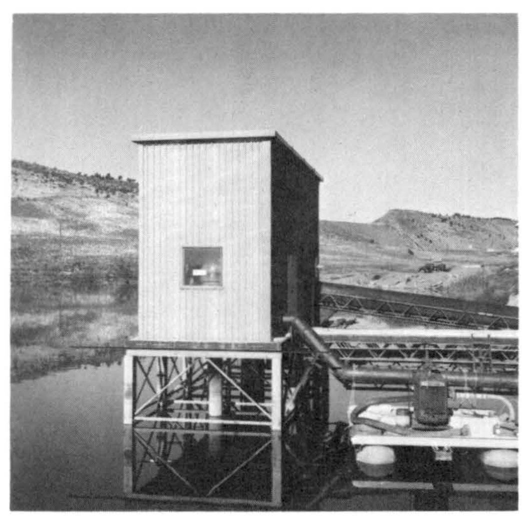


Fig. 26. The College Lake pumping station provided a controlled, variable range of discharges

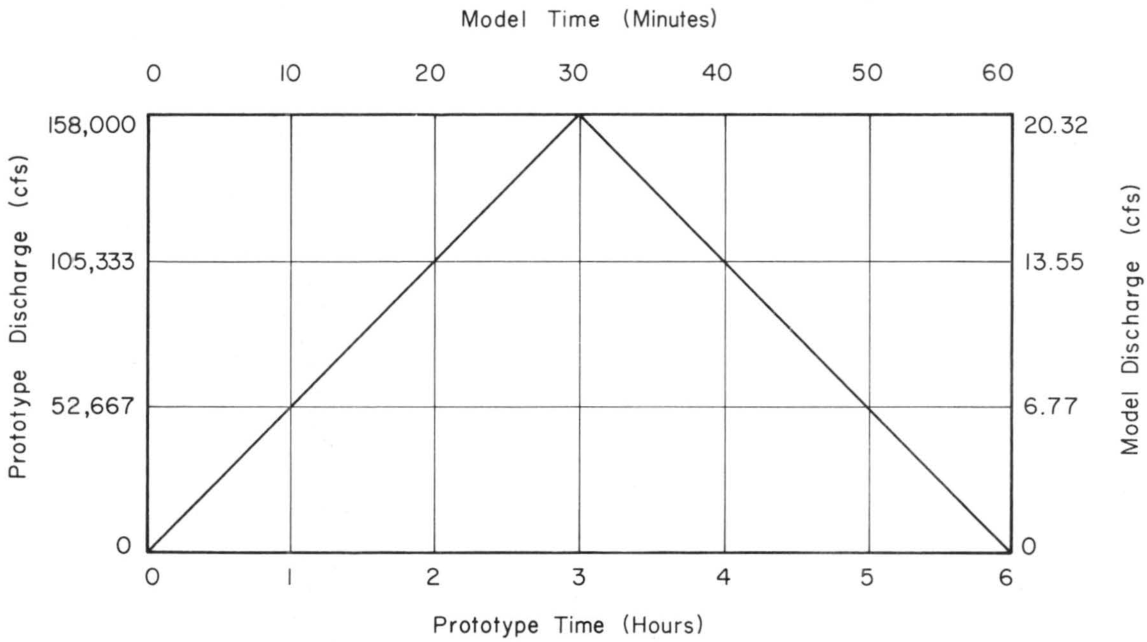


Fig. 27 Six Hour Hydrograph Used in Model Tests

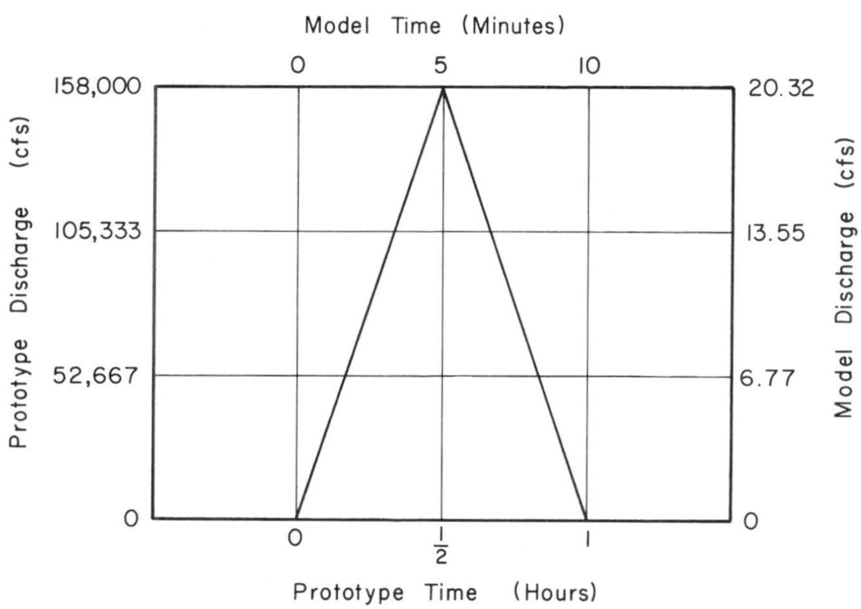


Fig. 28 One Hour Hydrograph Used in Model Tests

APPENDIX

Configuration - 1 (Dam Complete - No Dike - Six-Hour Hydrograph)

Date of Test - September 29, 1967

Model				Prototype			
Clock Time	Discharge (cfs) Inflow*	3'Weir**	4'Weir	Elapsed Time (Hours)	Discharge (cfs) Inflow	Dam	Saddle
2:00 PM	0	0	0	0	0	0	0
2:05	3.31	0	0	0.5	25,700	0	0
2:10	6.76	0	0	1.0	52,600	0	0
2:15	8.63	0.6	0.3	1.5	67,100	5,000	2,000
2:20	13.2	1.4	5.8	2.0	103,000	11,000	45,000
2:25	17.2	2.9	10.7	2.5	134,000	23,000	83,200
2:30	19.7	5.3	13.1	3.0	153,000	41,000	102,000

FLOW DISTRIBUTION PHOTOGRAPHY - PROTOTYPE DISCHARGE = 158,000 cfs

Prototype Water Surface Elevations, Recorded 1.25 Feet (45 feet in the Prototype) Back From the Centerline of the Crest of the Model Dam, were 3672 Feet (Except in the Drawdown Area Near the Spillway Section)

3:50	20.3	6.0	13.5	0	158,000	47,000	105,000
3:55	17.0	5.5	12.9	0.5	132,000	43,000	100,000
4:00	13.2	4.2	11.1	1.0	103,000	33,000	86,300
4:05	10.0	3.0	9.6	1.5	77,800	23,000	75,000
4:10	6.74	2.1	7.6	2.0	52,400	16,000	59,000
4:15	4.09	1.6	5.6	2.5	31,800	12,000	44,000
4:20	0	1.4	3.9	3.0	0	11,000	30,000
4:25	0	1.2	1.8	3.5	0	9,300	14,000
4:30	0	0.9	0.9	4.0	0	7,000	7,000
4:35	0	0.7	0.4	4.5	0	5,000	3,000

* Inflow Measured with 12"-Orifice in 24"-Line, $Q = 0.63A\sqrt{2gh}$, Reference; "Fluid Meters, Their Theory and Application, American Society of Mechanical Engineers," Fifth Edition, 1959.

** At the Higher Discharges, There Was Noticeable Velocity of Approach at the 3'Weir

Configuration - 2 (Dam Complete - Dike in Place - Six-Hour Hydrograph)

Date of Test - October 2, 1967

	Model			Prototype			
Clock Time	Discharge (cfs) Inflow	3'Weir	4'Weir	Elapsed Time (Hours)	Discharge (cfs) Inflow	Dam	Saddle
2:30	0	0	0	0	0	0	0
2:35	3.35	0	0	0.5	26,100	0	0
2:40	6.74	0	0	1.0	52,400	0	0
2:45	10.1	0	0	1.5	78,500	0	0
2:50	12.6	2.6	0	2.0	98,000	20,000	0
2:55	17.2	8.1	4.6	2.5	134,000	63,000	36,000
3:00	20.3	10.0	7.7	3.0	158,000	77,800	60,000

FLOW DISTRIBUTION PHOTOGRAPHY - PROTOTYPE DISCHARGE = 158,000 cfs

Prototype Water Surface Elevations, Recorded 1.25 Feet (45 Feet in the Prototype) Back from the Centerline of the Crest of the Model Dam, were 3674 Feet (Except in the Drawdown Area Near the Spillway Section).

3:45	20.3	11.7	8.4	0	158,000	91,000	65,000
3:50	17.5	10.8	7.6	0.5	136,000	84,000	59,000
3:55	13.2	9.2	6.4	1.0	103,000	72,000	50,000
4:00	11.3	7.9	5.2	1.5	87,900	61,000	40,000
4:05	6.74	6.2	4.1	2.0	52,400	48,000	32,000
4:10	3.45	4.6	2.3	2.5	26,800	36,000	18,000
4:15	0	3.2	1.3	3.0	0	25,000	10,000
4:20	0	2.1	0.6	3.5	0	16,000	5,000
4:25	0	1.5	0.2	4.0	0	12,000	1,600
4:30	0	1.4	0.2	4.5	0	11,000	1,600
4:35	0	1.3	0.1	5.0	0	10,000	800

Configuration - 3 (Dam Complete - No Dike - One-Hour Hydrograph)

Date of Test - October 5, 1967 (Run #1 - Normal Inflow Distribution)

Model				Prototype			
Elapsed Time (Minutes)	Discharge (cfs) Inflow	3'Weir	4'Weir	Elapsed Time (Hours)	Discharge (cfs) Inflow	Dam	Saddle
0	0	0	0	0	0	0	0
1	4.01	0	0	0.1	31,200	0	0
2	8.63	0	0	0.2	67,100	0	0
3	10.9	0	0	0.3	84,800	0	0
4	15.9	0	0	0.4	124,000	0	0
5	19.1	0	0	0.5	149,000	0	0
6	20.1	0	0	0.6	156,000	0	0
7	20.3	0	0	0.7	158,000	0	0
8	20.3	0	1.6	0.8	158,000	0	12,000
9	20.3	0.6	3.9	0.9	158,000	5,000	30,000
10	20.4	1.7	7.9	1.0	159,000	13,000	61,000
11	20.3	3.4	10.6	1.1	158,000	26,000	82,400
12	20.3	4.7	12.5	1.2	158,000	37,000	97,200
13	20.1	5.3	12.9	1.3	156,000	41,000	100,000
14	16.5	5.5	13.3	1.4	128,000	43,000	103,000
15	11.0	5.7	13.1	1.5	85,500	44,000	102,000
16	8.02	5.1	12.3	1.6	62,400	40,000	95,700
17	5.82	4.2	11.3	1.7	45,300	33,000	87,900
18	0	3.4	10.0	1.8	0	26,000	77,800
19	0	2.7	8.6	1.9	0	21,000	67,000
20	0	2.1	7.1	2.0	0	16,000	55,000

Configuration - 3 (Dam Complete - No Dike - One-Hour Hydrograph)

Date of Test - October 5, 1967 (Run #2 - Inflow Distribution Blocks Removed)

Model				Prototype			
Elapsed Time (Minutes)	Discharge (cfs) Inflow	3'Weir	4'Weir	Elapsed Time (Hours)	Discharge (cfs) Inflow	Dam	Saddle
0	0	0	0	0	0	0	0
1	3.91	0	0	0.1	30,400	0	0
2	8.22	0	0	0.2	63,900	0	0
3	9.35	0	0	0.3	72,700	0	0
4	15.4	0	0	0.4	120,000	0	0
5	19.9	0	0	0.5	155,000	0	0
6	20.4	0	0	0.6	159,000	0	0
7	20.3	0.1	0	0.7	158,000	800	0
8	20.3		2.1	0.8	158,000		16,000
9	20.2	0.9		0.9	157,000	7,000	
10	20.3		9.1	1.0	158,000		71,000
11	20.2	3.0		1.1	157,000	23,000	
12	20.2		12.3	1.2	157,000		95,600
13	20.0	4.9		1.3	156,000	38,000	
14	17.5		13.5	1.4	136,000		105,000
15	11.6	5.5		1.5	90,200	43,000	
16	7.90		12.7	1.6	61,400		98 ,800
17	5.80	4.4		1.7	45,100	34,000	
18	0		9.8	1.8	0		76,000
19	0	2.7		1.9	0	21,000	
20	0		6.7	2.0	0		52,000
21	0	1.8		2.1	0	14,000	

Configuration - 3 (Dam Complete - No Dike - One-Hour Hydrograph)
Date of Test - October 5, 1967 (Run #3 - Inflow Distribution Blocks Removed)

Model				Prototype			
Elapsed Time (Minutes)	Discharge (cfs) Inflow	3'Weir	4'Weir	Elapsed Time (Hours)	Discharge (cfs) Inflow	Dam	Saddle
0	0	0	0	0	0	0	0
1	3.91	0	0	0.1	30,400	0	0
2	8.43	0	0	0.2	65,600	0	0
3	9.19	0	0	0.3	71,500	0	0
4	14.4	0	0	0.4	112,000	0	0
5	18.8	0	0	0.5	146,000	0	0
6	20.3	0	0	0.6	158,000	0	0
7	20.4	0	0	0.7	159,000	0	0
8	20.1	0	1.2	0.8	156,000	0	9,300
9	20.2	0.7		0.9	157,000	5,000	
10	20.4		7.9	1.0	159,000		61,000
11	20.3	2.5		1.1	158,000	19,000	
12	20.3		11.5	1.2	158,000		89,400
13	20.0	4.7		1.3	156,000	37,000	
14	19.2		13.1	1.4	149,000		102,000
15	10.7	5.4		1.5	83,200	42,000	
16	8.22		12.7	1.6	64,000		98,800
17	7.46	4.5		1.7	58,000	35,000	
18	0		9.8	1.8	0		76,000
19	0	2.8		1.9	0	22,000	
20	0		7.4	2.0	0		58,000
21	0	1.9		2.1	0	15,000	

Configuration - 3 (Dam Complete - No Dike - One-Hour Hydrograph)
Date of Test - October 5, 1967 (Run #4 - Inflow Distribution to the Left)

Model				Prototype			
Elapsed Time	Discharge (cfs)			Elapsed Time	Discharge (cfs)		
(Minutes)	Inflow	3'Weir	4'Weir	(Hours)	Inflow	Dam	Saddle
0	0	0	0	0	0	0	0
1	3.91	0	0	0.1	30,400	0	0
2	8.22	0	0	0.2	63,900	0	0
3	10.8	0	0	0.3	84,000	0	0
4	15.5	0	0	0.4	121,000	0	0
5	19.2	0	0	0.5	149,000	0	0
6	20.6	0	0	0.6	160,000	0	0
7	20.4	0.1		0.7	159,000	800	0
8	20.2		2.2	0.8	157,000		17,000
9	20.2	1.0		0.9	157,000	8,000	
10	20.6		9.1	1.0	160,000		71,000
11	20.4	3.8		1.1	159,000	30,000	
12	20.3		12.5	1.2	158,000		97,200
13	20.1	5.4		1.3	156,000	42,000	
14	17.2		13.1	1.4	134,000		102,000
15	11.3	5.8		1.5	87,900	45,000	
16	8.14		12.7	1.6	63,300		98,800
17	4.86	4.4		1.7	37,800	34,000	
18	0		9.6	1.8	0		75,000
19	0	2.7		1.9	0	21,000	
20	0		6.7	2.0	0		52,000
21	0	1.7		2.1	0	13,000	

Configuration - 3 (Dam Complete - No Dike - Six-Hour Hydrograph)

Date of Test - October 6, 1967 (Run #5 - Inflow Distribution to the Left)

	Model			Prototype			
Clock	Discharge (cfs)			Elapsed Time	Discharge (cfs)		
Time	Inflow	3'Weir	4'Weir	(Hours)	Inflow	Dam	Saddle
10:30	0	0	0	0	0	0	0
10:35	3.41	0	0	0.5	26,500	0	0
10:40	6.78	0	0	1.0	52,700	0	0
10:45	10.2	0.6	0.9	1.5	79,300	5,000	7,000
10:50	13.6	1.5	7.4	2.0	106,000	12,000	58,000
10:55	16.2	3.1	10.6	2.5	126,000	24,000	82,400
11:00	20.4	4.8	12.7	3.0	159,000	37,000	98,800

FLOW DISTRIBUTION PHOTOGRAPHY - PROTOTYPE DISCHARGE = 158,000 cfs

Prototype Water Surface Elevations, Recorded 1.25 Feet (45 Feet in the Prototype) Back from the Centerline of the Crest of the Model Dam, were 3672 Feet (Except in the Drawdown Area Near the Spillway Section.)

11:30	20.3	6.0	13.5	0	158,000	47,000	105,000
11:35	16.9	6.0	12.9	0.5	131,000	47,000	100,000
11:40	13.8	4.4	11.1	1.0	107,000	34,000	86,300
11:45	10.2	3.4	9.5	1.5	79,300	26,000	74,000
11:50	6.78	2.1	7.4	2.0	52,700	16,000	58,000
11:55	3.45	1.6	5.5	2.5	26,800	12,000	43,000
12:00	0	1.3	3.8	3.0	0	10,000	30,000

Configuration - 3 (Dam Complete - No Dike - Six-Hour Hydrograph)

Date of Test - October 9, 1967 (Run #6 - Inflow Distribution Blocks Removed)

	Model			Prototype			
Clock Time	Discharge (cfs) Inflow	3'Weir	4'Weir	Elapsed Time (Hours)	Discharge (cfs) Inflow	Dam	Saddle
9:50	0	0	0	0	0	0	0
9:55	3.41	0	0	0.5	26,500	0	0
10:00	6.78	0	0	1.0	52,700	0	0
10:05	10.3	0	0	1.5	80,100	0	0
10:10	13.0	1.4	6.7	2.0	101,000	11,000	52,000
10:15	17.3	2.6	10.7	2.5	135,000	20,000	83,200
10:20	20.4	4.8	12.9	3.0	159,000	37,000	100,000

FLOW DISTRIBUTION PHOTOGRAPHY - PROTOTYPE DISCHARGE = 158,000 cfs

Prototype Water Surface Elevations, Recorded 1.25 Feet (45 Feet in the Prototype) Back From the Centerline of the Crest of the Model Dam, were 3763 Feet (Except in the Drawdown Area Near the Spillway Section).

10:50	20.3	5.9	13.5	0	158,000	46,000	105,000
10:55	16.7	5.4	12.9	0.5	130,000	42,000	100,000
11:00	13.3	4.2	10.9	1.0	103,000	33,000	84,800
11:05	10.1	3.1	9.6	1.5	78,500	24,000	75,000
11:10	6.78	2.0	7.1	2.0	52,700	16,000	55,000
11:15	3.37	1.6	5.2	2.5	26,200	12,000	40,000
11:20	0	1.3	3.4	3.0	0	10,000	26,000

Configuration - 4 (No Dam - No Dike - Six-Hour Hydrograph)

Date of Test - November 9, 1967 (Run #1 - Inflow Distribution to the Right)

Model				Prototype			
Clock Time	Discharge (cfs) Inflow	3'Weir	4'Weir	Elapsed Time (Hours)	Discharge (cfs) Inflow	Creek	Saddle
11:45	0	0	0	0	0	0	0
11:50	3.45	0	0	0.5	26,800	0	0
11:55	6.90	3.3	0	1.0	53,700	26,000	0
12:00	10.1	6.4	0	1.5	78,500	50,000	0
12:05	13.4	9.7	0	2.0	104,000	75,000	0
12:10	17.3	14.0	0	2.5	135,000	109,000	0
12:15	20.0	17.4	0	3.0	156,000	135,000	0

At Q = 158,000 cfs, Prototype Water Surface Elevations Measured in the Saddle Area of the Model, were 3661 Feet.

12:16	20.3	17.8	0	3.1	158,000	138,000	0
12:20	20.4	18.9	0	3.5	159,000	147,000	0
12:23	20.3	19.1	0	3.8	158,000	149,000	0
12:28	0	16.4	0	4.3	0	128,000	0

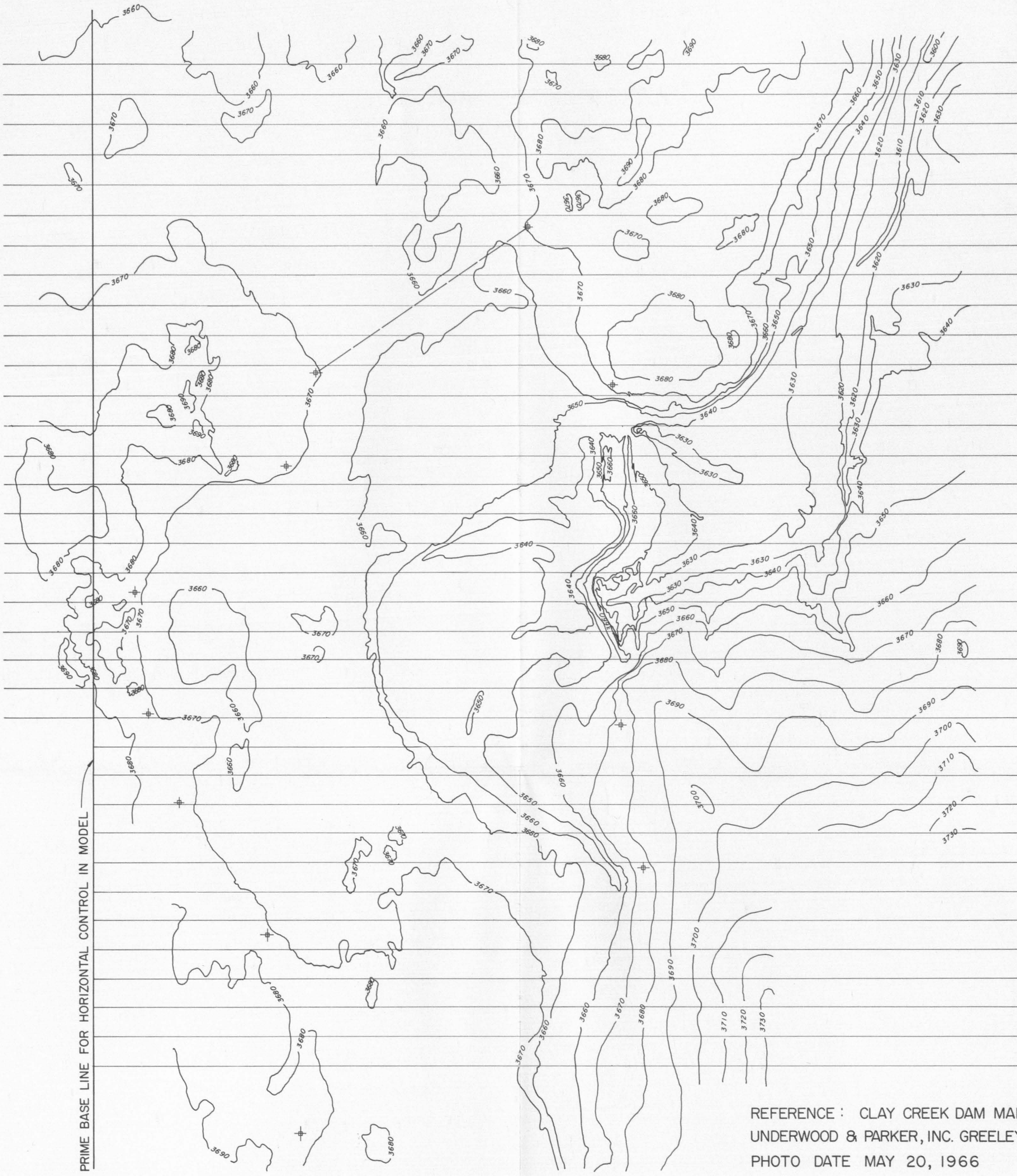
Configuration - 4 (No Dam - No Dike - Six-Hour Hydrograph)

Date of Test - November 9, 1967 (Run #2 - Inflow Distribution to the Left)

Model				Prototype			
Clock Time	Discharge (cfs) Inflow	3'Weir	4'Weir	Elapsed Time (Hours)	Discharge (cfs) Inflow	Creek	Saddle
12:50	0	0	0	0	0	0	0
12:55	3.45	0	0	0.5	26,800	0	0
1:00	6.78	2.4	0	1.0	52,700	19,000	0
1:05	10.4	5.9	0	1.5	80,900	46,000	0
1:10	14.0	9.7	0	2.0	109,000	75,000	0
1:15	17.0	14.1	0	2.5	132,000	110,000	0
1:20	20.3	17.4	0	3.0	158,000	135,000	0

At Q = 158,000 cfs, Prototype Water Surface Elevations Measured in the Saddle Area of the Model, were 3661 Feet.

1:23	20.4	18.7	0	3.3	159,000	145,000	0
1:30	20.3	18.9	0	4.0	158,000	147,000	0

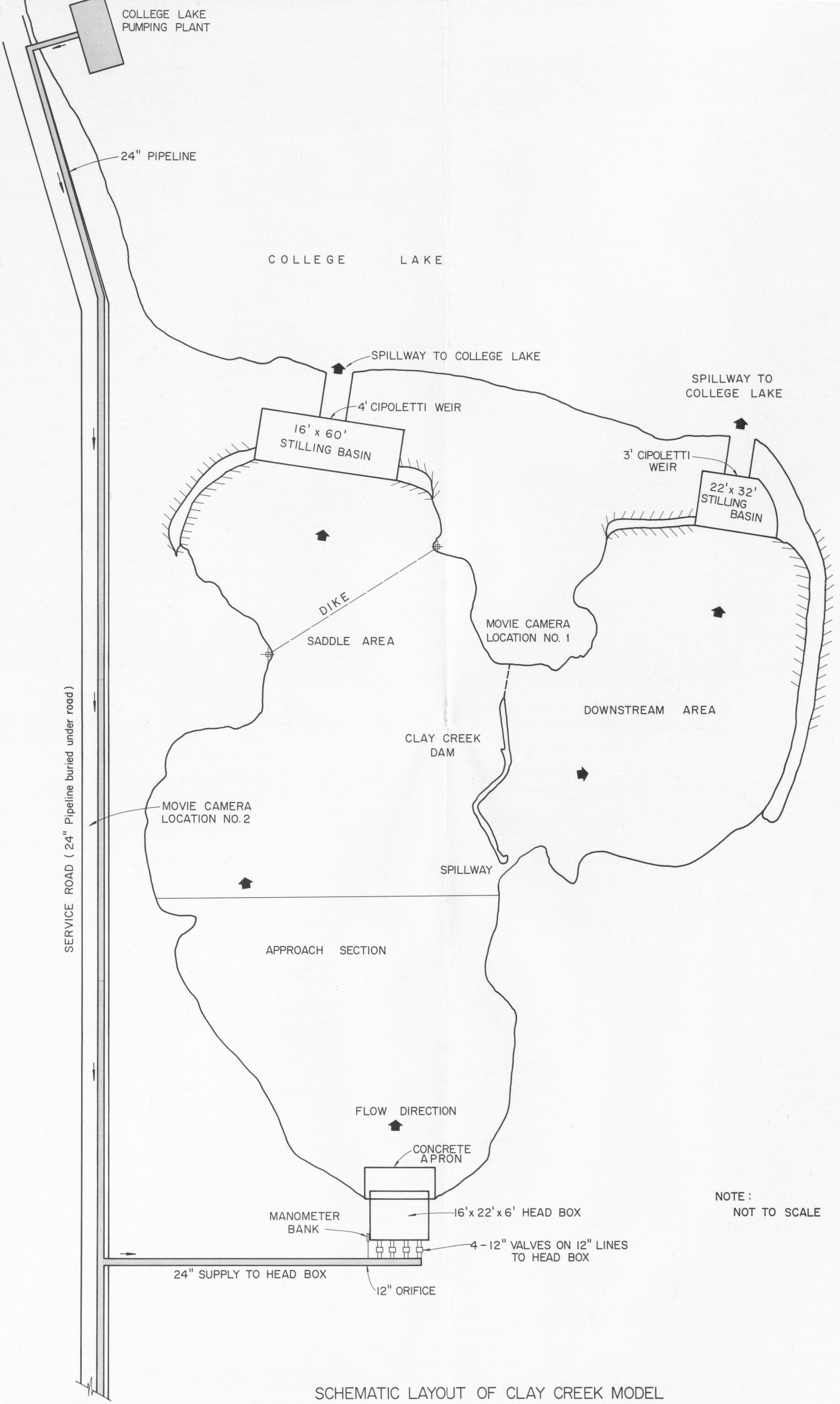


REFERENCE: CLAY CREEK DAM MAPS,
UNDERWOOD & PARKER, INC. GREELEY, COLO.
PHOTO DATE MAY 20, 1966

NOTE: NOT TO SCALE

SCHEMATIC LAYOUT OF BASE LINE AND CROSS SECTION LOCATION
FOR CLAY CREEK MODEL

FIGURE – 1



SCHEMATIC LAYOUT OF CLAY CREEK MODEL

FIGURE — 2