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Johnson 153

Memorandum
Chief, Hydraulic Structures Branch

Denver, Colorado
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Chief, Division of General Research
Chief, Division of Design

HYDRAULICS BRANCH
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Chief, Hydraulics Branch

PAP 284

Marble Bluff Diversion Dam hydraulic model test

The subject study was made to assist in developing a satisfactory spillway structure for Marble Bluff Diversion Dam. The study's main concern was evaluation of flow conditions through the approach channel, over the free overflow spillway, and through the spillway stilling basin. The baffled apron drop was represented by a structure that had been built and developed in previous research. It closely, but not completely, modeled the prototype structure. For this reason flow conditions through the approach channel, over the free overflow spillway, and through the stilling basin were considered true while flow conditions down the baffled drop were considered only similar to the prototype. The results of these studies are generally applicable only to structures with similar geometrical configurations but may be useful in initial evaluation of similar problems. The major results are as follows:

GPO 832-606

1. Flow conditions over the free overflow spillway, through the stilling basin, and down the baffled apron drop were satisfactory for all discharges up to 17,000 cfs with or without sedimentation in the approach channel. 17,000 cfs is the 100-year flood discharge over the 150-foot-wide spillway crest.

2. The head-discharge relationships between water surface elevation in the approach channel at a point 36 feet upstream from the spillway crest and the discharge over the spillway were evaluated for model conditions representing the approach channel both with and without aggradation. For the approach channel with aggradation the discharge was also related to the reservoir water surface elevation outside the approach channel.

3. Both a dentated and a solid sill at the end of the stilling basin were evaluated. It was observed that the solid sill caused both higher spray on the baffled drop and less uniform flow along the drop. It should also be noted that experience and previous research have found the dentated sill to be most effective. For these reasons the dentated sill is recommended.

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The scale of the model was controlled by the size of the baffled apron drop. The baffled drop had been previously constructed in conjunction with a research study. The selected model scale was 14.17:1. The width of the existing baffled drop was 35 inches which represents 41.32 feet or 27.5 percent of the 150-foot total prototype width. The model included the approach channel, the free overflow spillway, the stilling basin with chute and baffle blocks, and the baffled apron drop (Figure 1). The entire model was accurately scaled except for the sill and the baffled drop. The top and upstream surfaces of the sill were correctly modeled. The height of the downstream edge of the sill and the distance to the first baffles on the baffled drop were not correctly modeled; however, in order to minimize model construction time, the actual prototype length of the baffled drop was also not correctly represented. It was accepted that the baffled apron drop design, which had been developed in previous studies, was satisfactory. Flow conditions on the baffled drop were close to actual and may be used in cursory evaluation of the structure. Flow conditions over the spillway and through the basin were correctly represented. The flow passes through critical depth as it passes over the sill and this effectively isolates upstream flow conditions from any downstream irregularities.

The first step in the investigation was the evaluation of flow conditions over the proposed structure for flows representing prototype discharges up to 17,000 cfs (Figure 2). The observed flow conditions were satisfactory at all discharges. In addition to a visual evaluation of this structure, data were obtained which yielded the water surface elevation at a point 36 feet upstream from the spillway crest versus the discharge over the spillway (Figure 3).

The model was then modified to represent the prototype structure with channel aggradation upstream from the overflow spillway (Figure 4). The bottom of the approach channel was raised from elevation 3847.5 feet to 3853.5 feet or 1 foot below the spillway crest. The model was again run at prototype discharges up to 17,000 cfs (Figure 5). At these various discharges, the flow was evaluated visually, discharge versus reservoir elevation data were obtained, and the depth of flow in the stilling basin (at a point halfway between the back of the baffle blocks and the start of the sill) was evaluated. Flow conditions over the spillway, through the stilling basin, and down the baffled drop were once again satisfactory for all discharges. Critical flows with standing waves were observed in the approach channel (Figure 5). It was felt that the high velocity of these flows will scour the channel bottom, lower the approach channel, and reduce the flow velocity. The obtained discharge calibration curves (Figure 6) relate the discharge not only to the water surface elevation in the channel at the station 36 feet upstream from the spillway crest but also to the reservoir water surface elevation. Water surface elevations in the stilling basin for the range of discharges are shown in Figure 7.

Performance of a solid sill, as compared to the previously tested dentated sill, was evaluated (Figure 8). The flow was studied at prototype discharges up to 17,000 cfs. At moderate and low discharges the solid sill did not initiate a breakup of flow as the dentated sill did. The flow that struck the first baffles of the baffled drop was consequently more uniform with the solid sill. This caused the spray from the initial row of blocks to be both higher and more dense (Figure 9), which in turn caused a less uniform flow along the baffled apron drop. For these reasons and because previous experience and research have found the dentated sill to be most effective, it is recommended that the dentated sill be used.

Finally, a single scour test was performed at the base of the baffled drop. The bed material elevation and the tailwater elevation were arbitrarily set with no consideration of prototype conditions. This test was therefore significant only in that it evaluated the scour for the particular arbitrary conditions. The test does, however, establish an understanding of possible scour potential. The bed material was leveled at an elevation of 3782.9 feet. The tailwater was set at an elevation of 3798.2 feet. The model was run at the 50-year flood discharge of approximately 12,000 cfs for 2 hours. A scour hole with a bottom elevation of 3775.2 feet was created at a location between 20 and 30 feet downstream from the 3782.9 feet elevation position of the apron face. Laterally, the hole was located below the right half of the modeled drop.

W. E. Wagner

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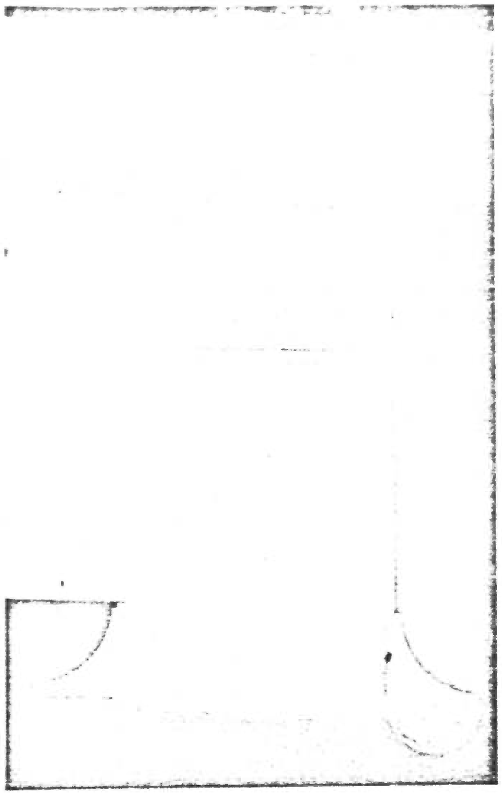
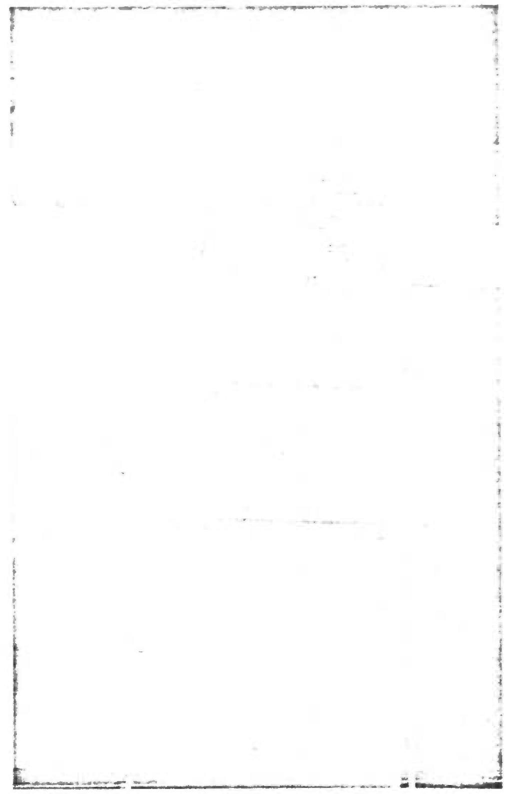




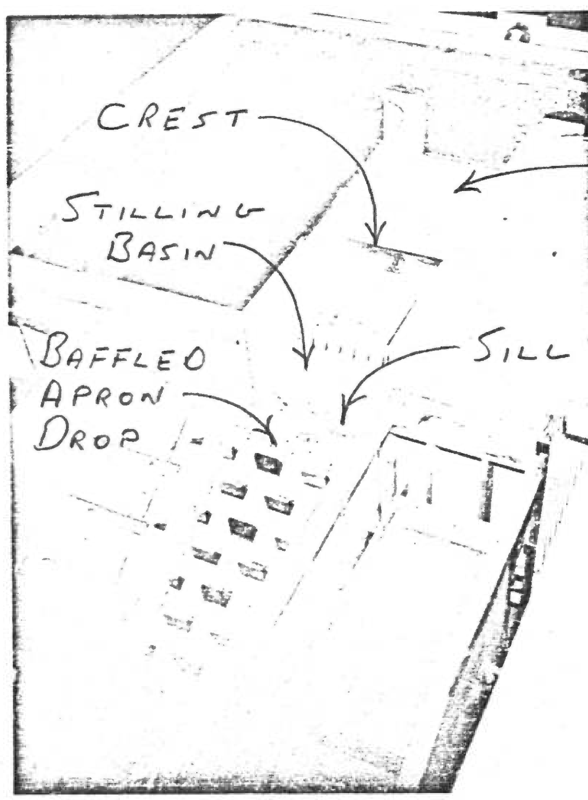
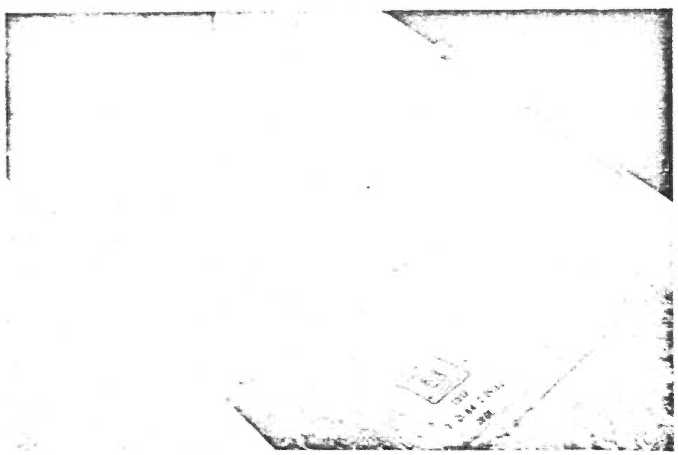


FIGURE 1 INITIAL MODEL OF ~~aggradatio~~ approach channel STRUCTURE WITH~~OUT~~ ~~SEDIMENTATION~~ at Elev. ——.

5,600 CFS

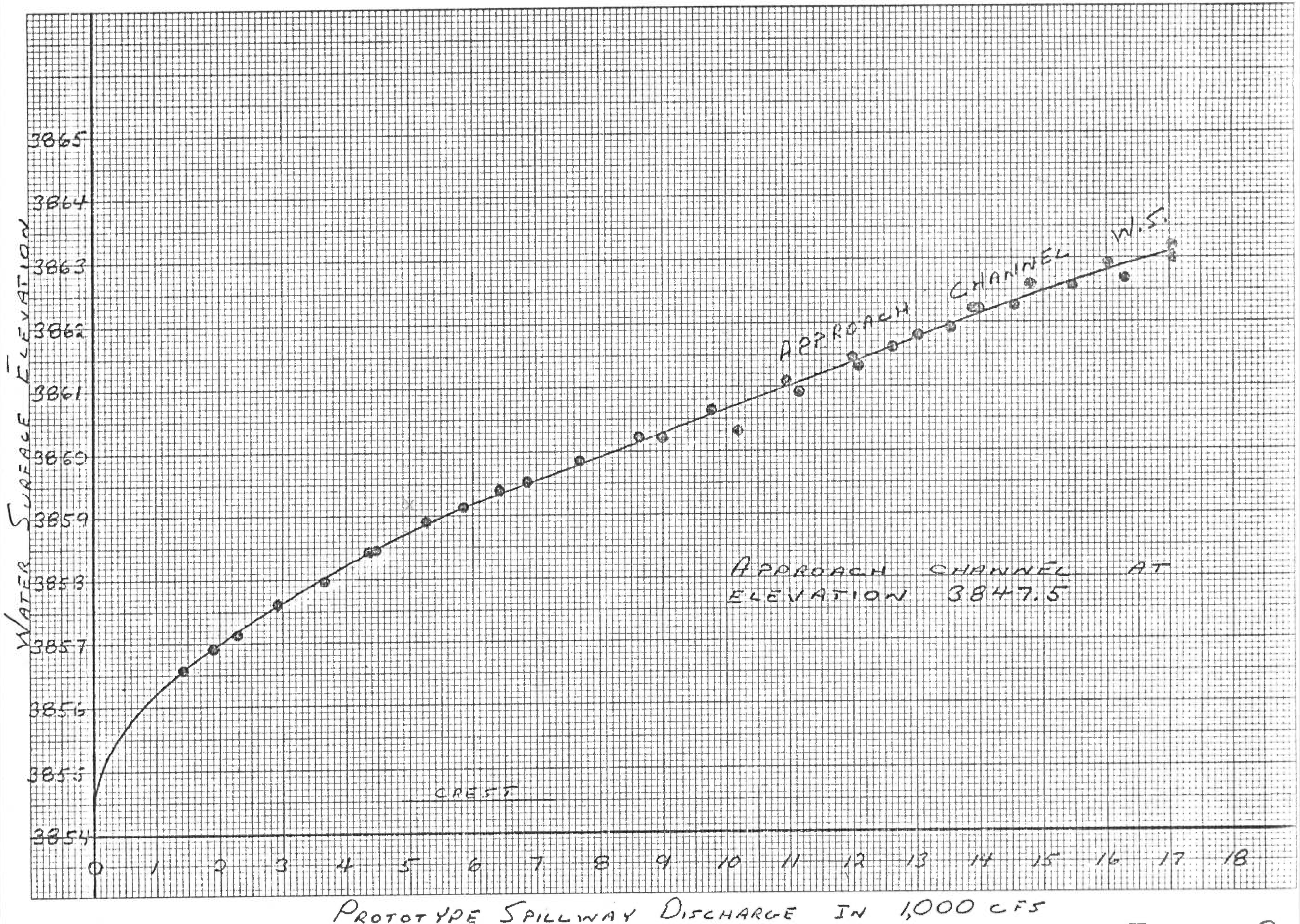


12,100 CFS

17,000 CFS

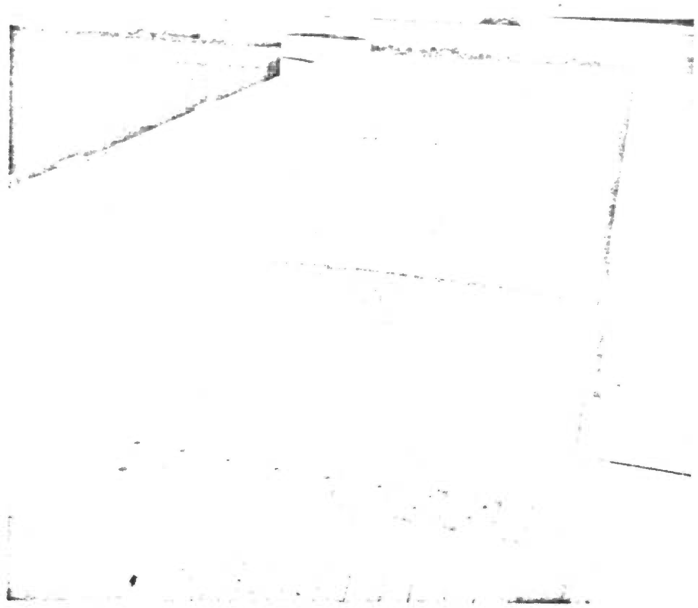
FIGURE 2 MODEL OPERATION WITHOUT SEDIMENTATI

app ch at El. —



WATER SURFACE ELEVATION
3865
3864
3863
3862
3861
3860
3859
3858
3857
3856
3855
3854
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
APPROACH CHANNEL W.S.
APPROACH CHANNEL AT
ELEVATION 3847.5
CREST
PROTOTYPE SPILLWAY DISCHARGE IN 1,000 CFS

FIGURE 3



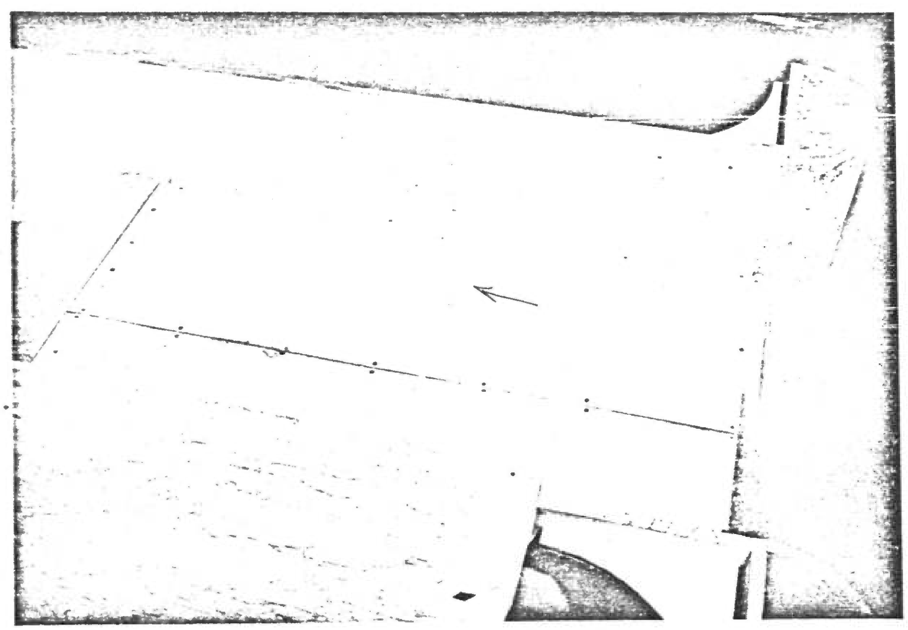
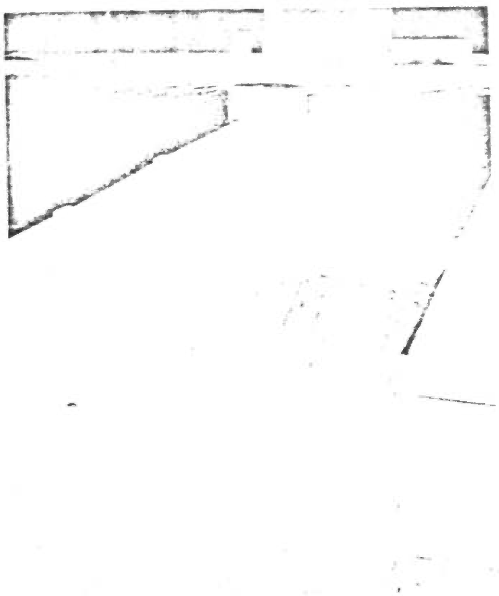
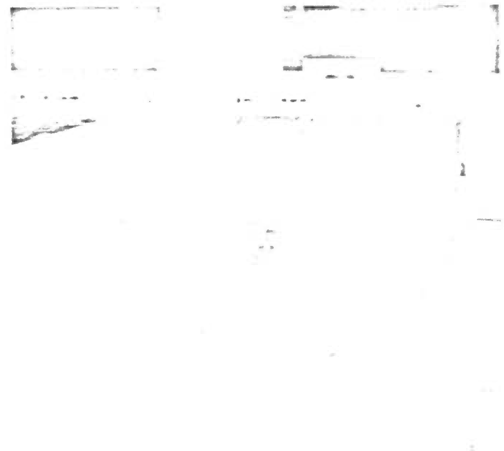


FIGURE 4 APPROACH CHANNEL ~~WITH~~ ~~SEDIMENTATION~~ at Elevation ____

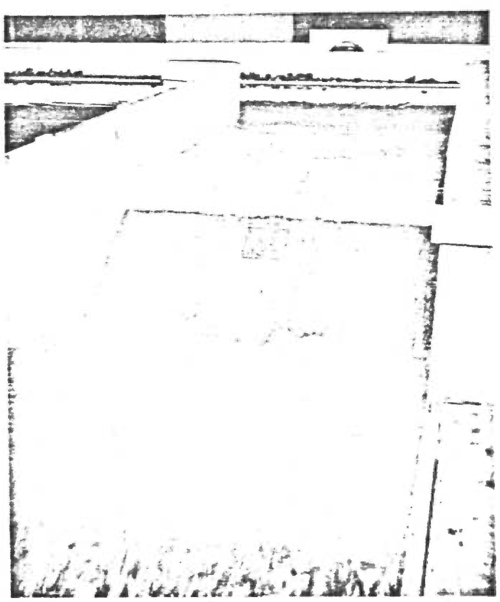
Q ?



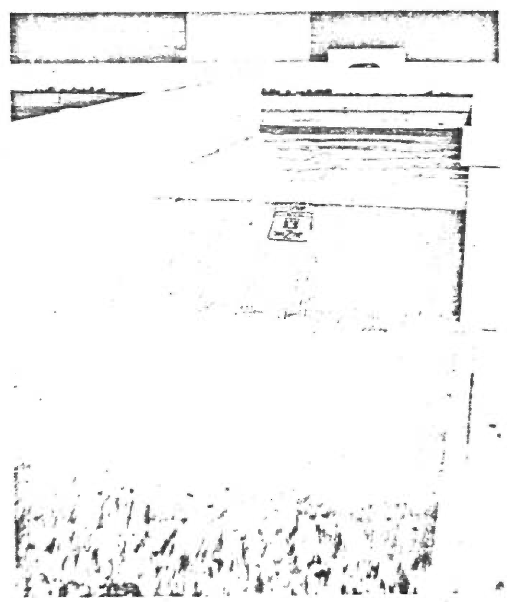
17,000 CFS



12,000 CFS

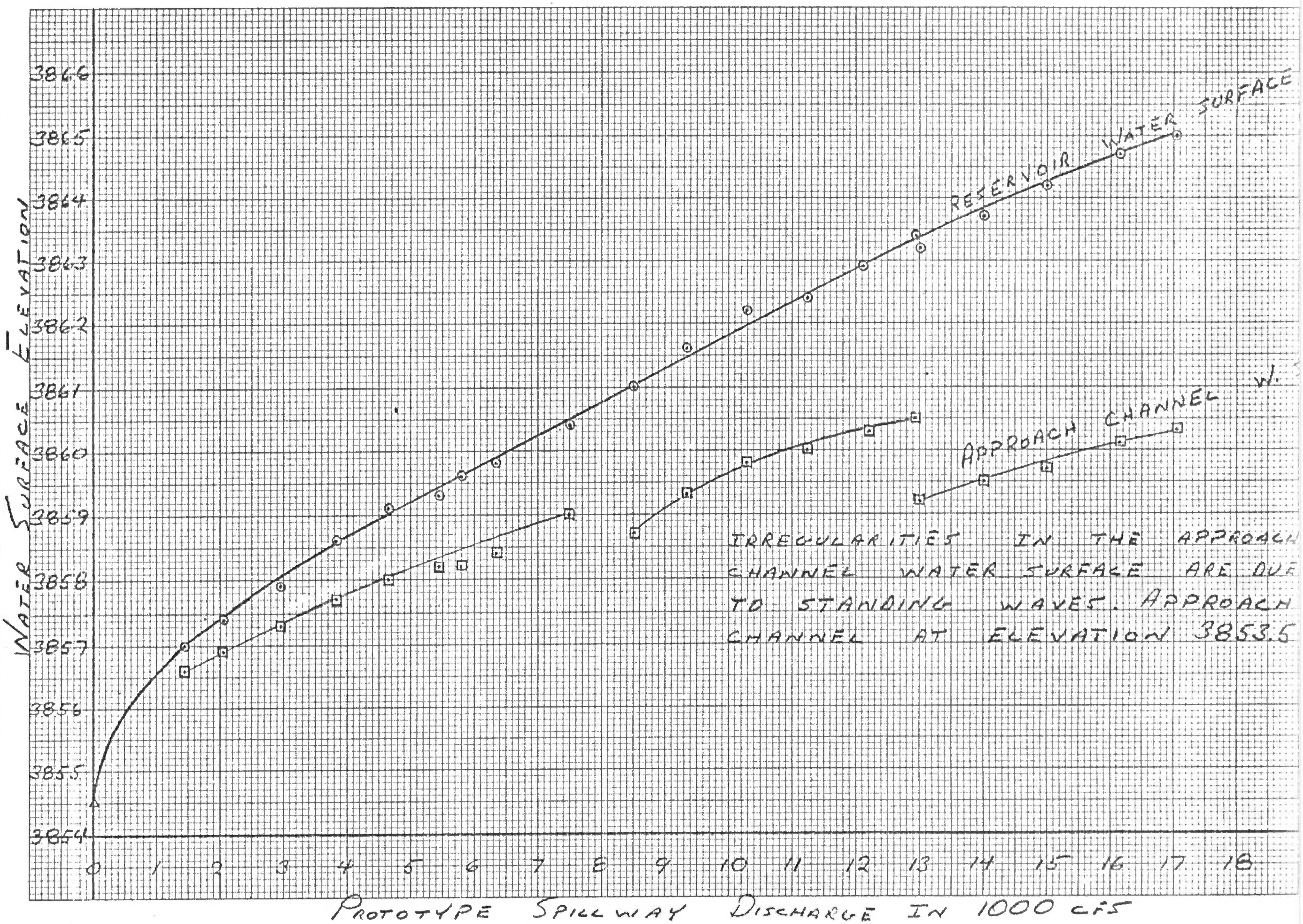


10,000 CFS



5,000 CFS

FIGURE 5 MODEL OPERATION FOR APPROACH CHANNEL WITH SEDIMENTATION



WATER SURFACE ELEVATION
3854
3855
3856
3857
3858
3859
3860
3861
3862
3863
3864
3865
3866
0
1
2
3
4
5
6
7
8
9
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11
12
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14
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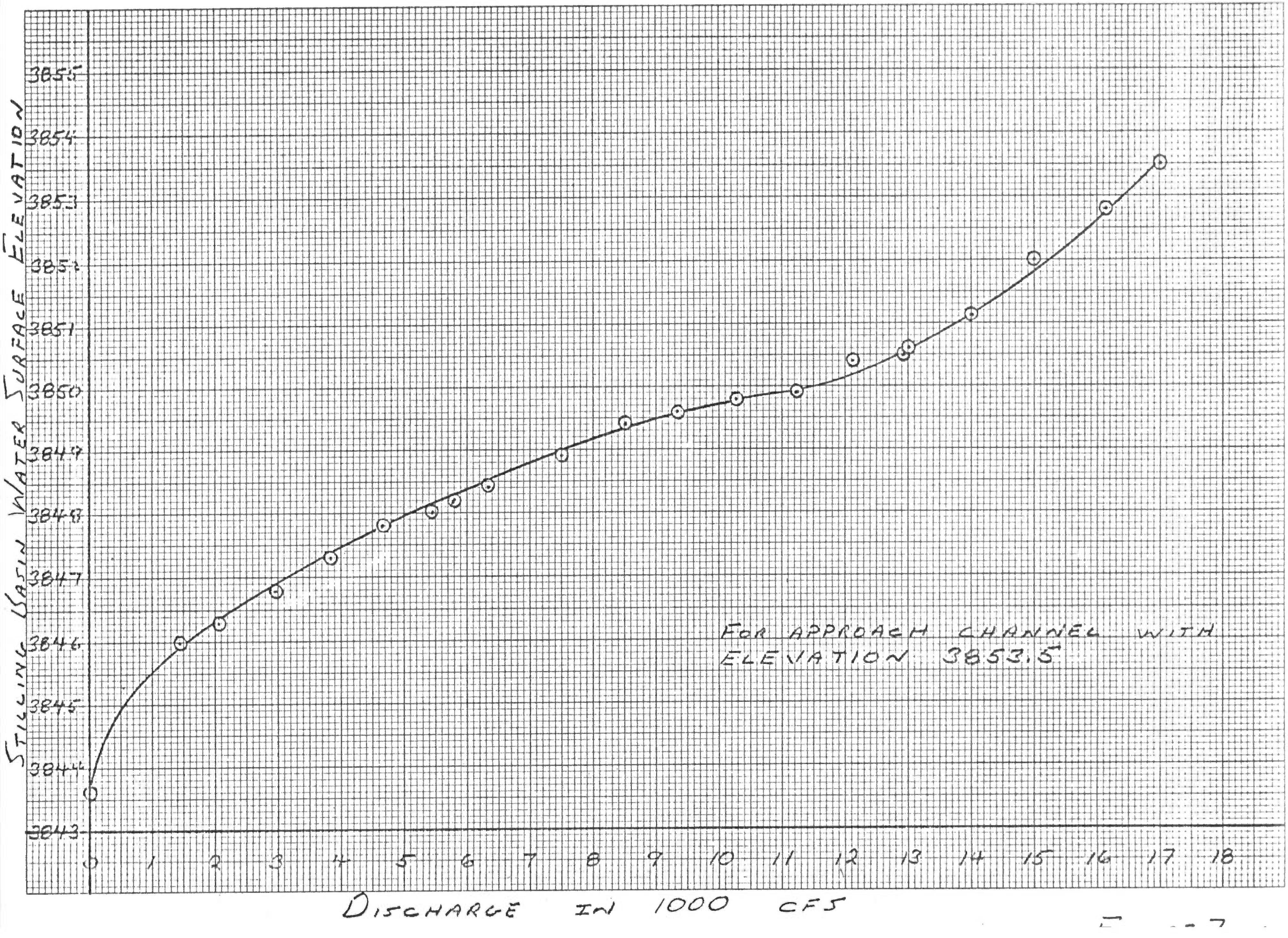
16
17
18
PROTOTYPE SPILLWAY DISCHARGE IN 1000 CFS
RESERVOIR WATER SURFACE
APPROACH CHANNEL W.S.
IRREGULARITIES IN THE APPROACH CHANNEL WATER SURFACE ARE DUE TO STANDING WAVES. APPROACH CHANNEL AT ELEVATION 3853.5

FIGURE 6



Stilling Basin Water Surface Elevation
3855
3854
3853
3852
3851
3850
3849
3848
3847
3846
3845
3844
3843
0
1
2
3
4
5
6
7
8
9
10
11
12
13
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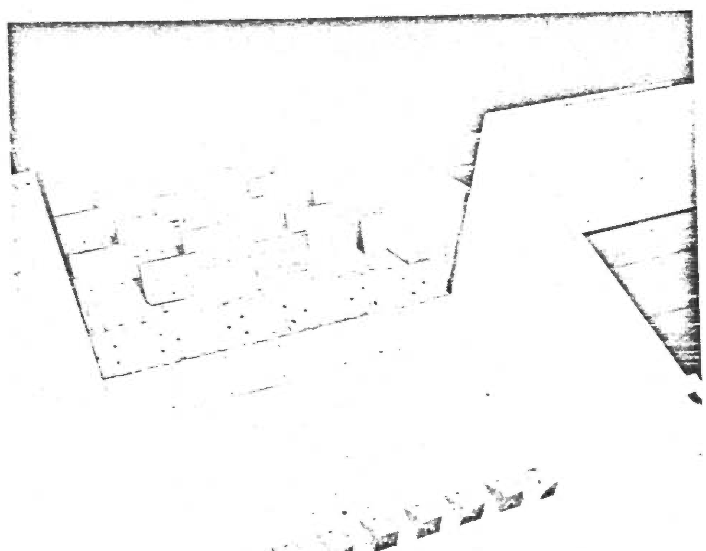
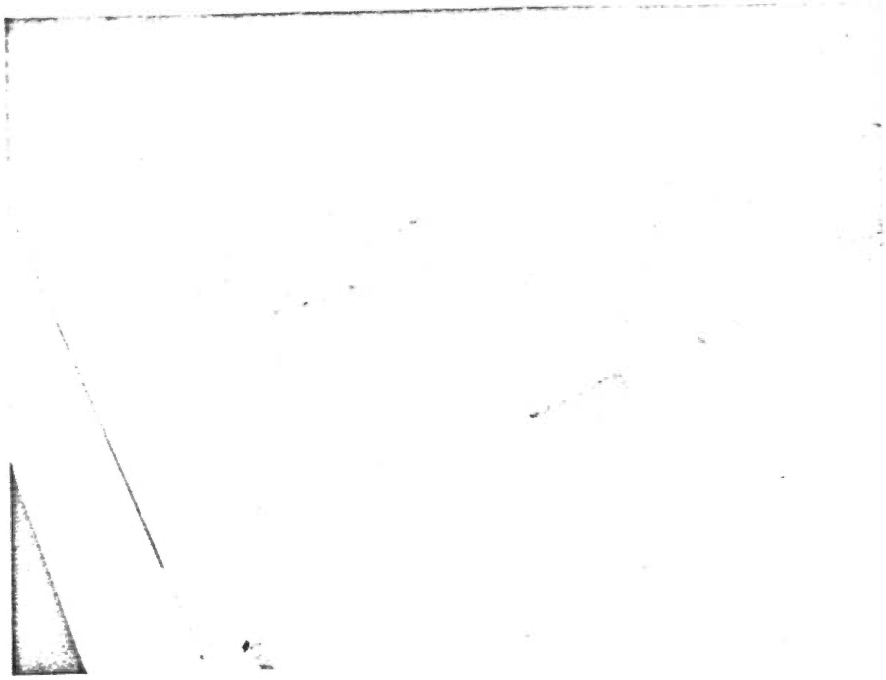
17
18
For approach channel with elevation 3853.5
Discharge in 1000 CFS

DENTATED SILL

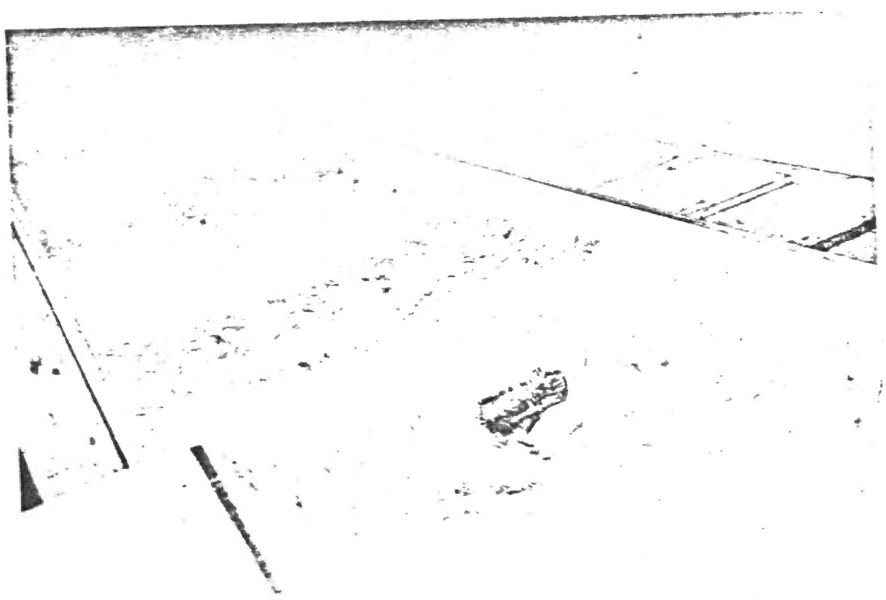


SOLID SILL

FIGURE 8 SILLS



SOLID SILL



DENTATED SILL

FIGURE 9 DENTATED & SOLID SILL OPERATION