MODEL STUDY
OF THE
CATLIN DIVERSION DAM
CANAL INLET

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SUMMARY

As a result of the model study it is recommended that the canal be cleaned out to an extent which will lower the present water level by about two feet. It is further recommended that the face of the ice hood be modified by cutting two symmetrically located holes or notches as suggested in figures 5, 7, 9 and 11, to eliminate the oscillations within the ice hood.

INTRODUCTION

The Catlin Diversion Dam is located on the Arkansas River near Fowler, Colorado, with the canal intake structure at the right bank of the river. The inlet to the canal is submerged below reservoir pond level with a lift gate controlling the flow. The appurtenant structures to the inlet works consists of a trash guide and an ice hood at the inlet to prevent icing during winter operations. There are also two sluice gates near the inlet to permit removal of sediment deposits from the vicinity of the intake.

The intake structure was designed to flow 350 cfs with reservoir pond level at elevation 4270 and with certain canal water level conditions as will be discussed later. After construction of the facilities, it was apparent that the design discharge was not obtainable even with pond levels higher than elevation 4270. Also at certain pond levels violent oscillations occurred from side to side within the ice hood which tended to reduce discharge into the canal because of the additional head losses and flow disturbances created. Some field modifications were attempted to suppress the oscillations for it was concluded that this was a major factor in the reduced discharge from design conditions. Little success was realized from the modifications.

Engineers from Tipton and Kalmbach, Inc. made a field study of the situation, and they surveyed the canal profile downstream of the intake structure. Their study showed that the canal bed level was about four feet higher than that used for the design of the intake structure and this was thought to be the principal reason for the reduced discharge. However, there was sufficient question and concern about the variation of actual discharge and flow conditions within the ice hood from design conditions, that it was considered necessary to conduct a model study of the inlet works.

The purpose of the model study was to determine the reason for the reduced discharge and to find a remedy which would enable an increase in canal discharge from existing conditions. The minimum desirable condition was to enable a discharge of 345 cfs into the canal at pond level elevation 4270.8.

THE MODEL

The model was limited to the intake structure, the outlet conduit and the outlet transition which leads into the canal (see fig. 1). The sluice gates were not included. The model was constructed to a scale of 1:12, or one inch in the model was equal to one foot in the prototype.

MODEL RESULTS

Existing Conditions

Initial tests were made in the model with existing conditions. Verification of the model was achieved with field data. For a discharge of 285 cfs with canal level at elevation 4268.5 the pond level was elevation 4270.7. When the reservoir pond level was between elevation 4269.5 and 4271, violent oscillations occurred within the ice hood. These oscillations had a maximum amplitude of

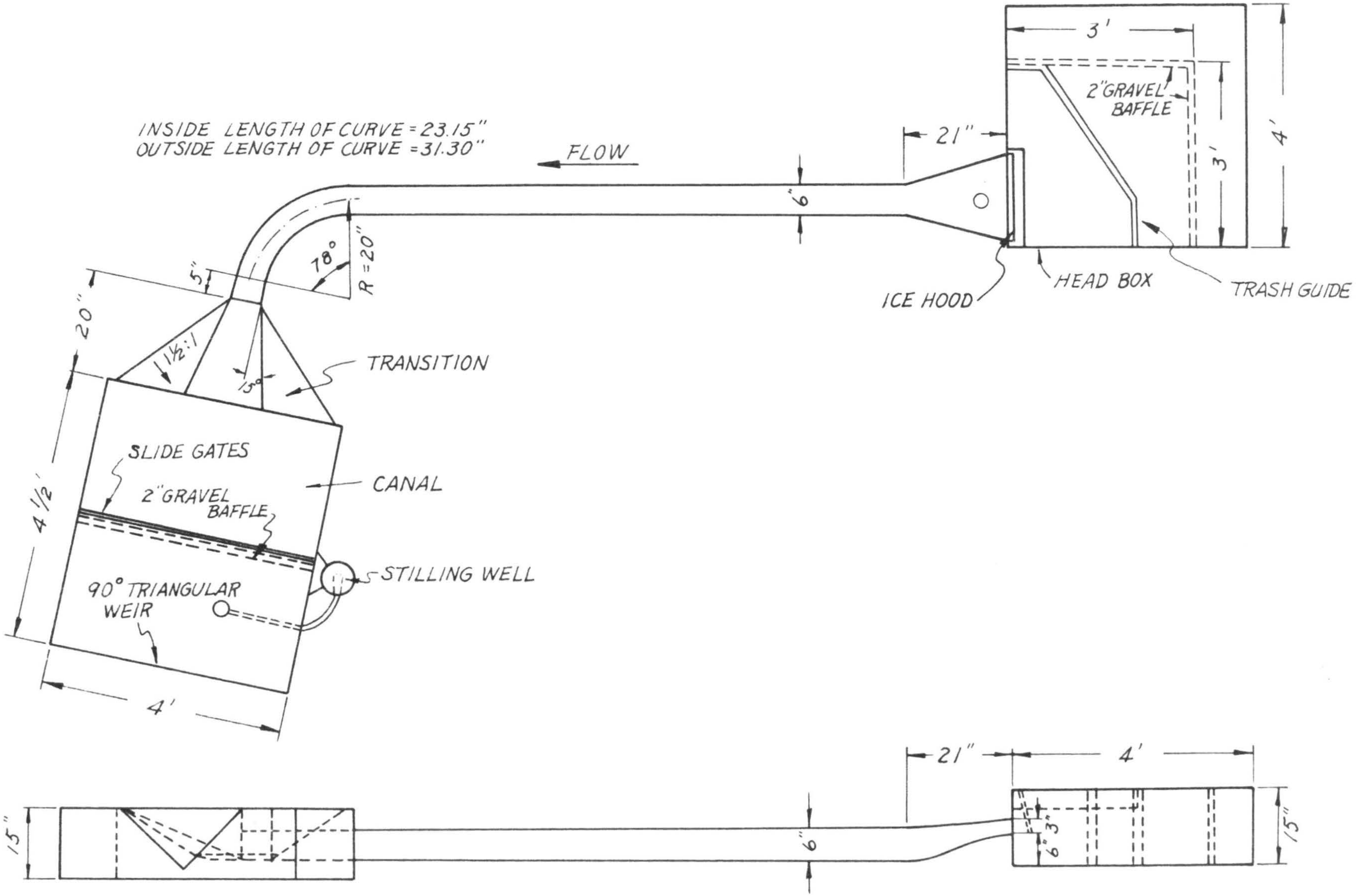


FIG. 1 MODEL OF CATLIN CANAL

approximately six feet and considerable splashing occurred. At higher pond levels the oscillations subsided. The oscillations produced periodic air intake into the outlet conduit. The magnitude of air intake was not particularly serious. The air vent pipe appeared neither to hinder nor aid the flow condition. There was alternate suction and purging of air through the vent pipe.

Figure 2 shows the water level variations at the pond for different discharges through the inlet. The tail water curve, or canal water level at the outlet transition, was calculated by Tipton and Kalmbach Engineers and used for this study. It signifies existing conditions. As the figure shows, under existing conditions, it would be necessary to increase the pond level to about 4273.5 or greater in order to obtain 350 cfs.

Tests were also conducted to determine to what extent the ice hood was responsible for the reduced discharge. As figure 2 shows, with the ice hood removed, there generally was an increase of about 25 cfs for the same pond level, but even under this condition, the pond level needed to be at about elevation 4272 for 350 cfs to flow into the canal or alternatively, the canal water level should be lowered by about two feet to maintain pond level at elevation 4270.8.

With the ice hood removed, the oscillations subsided. One and sometimes two isolated vortices were created, but the reduction in discharge because of these vortices was not significant.

Design Conditions

Tests were made to determine whether the inlet structure would have been adequate for the design conditions. It was found that with the design canal water level, a discharge of 350 cfs could be obtained with an upstream pond level of 4269.9 as shown in figure 3. It should be noted that the design canal tail water is approximately four feet lower than the existing conditions. The data were taken with the ice hood in place.

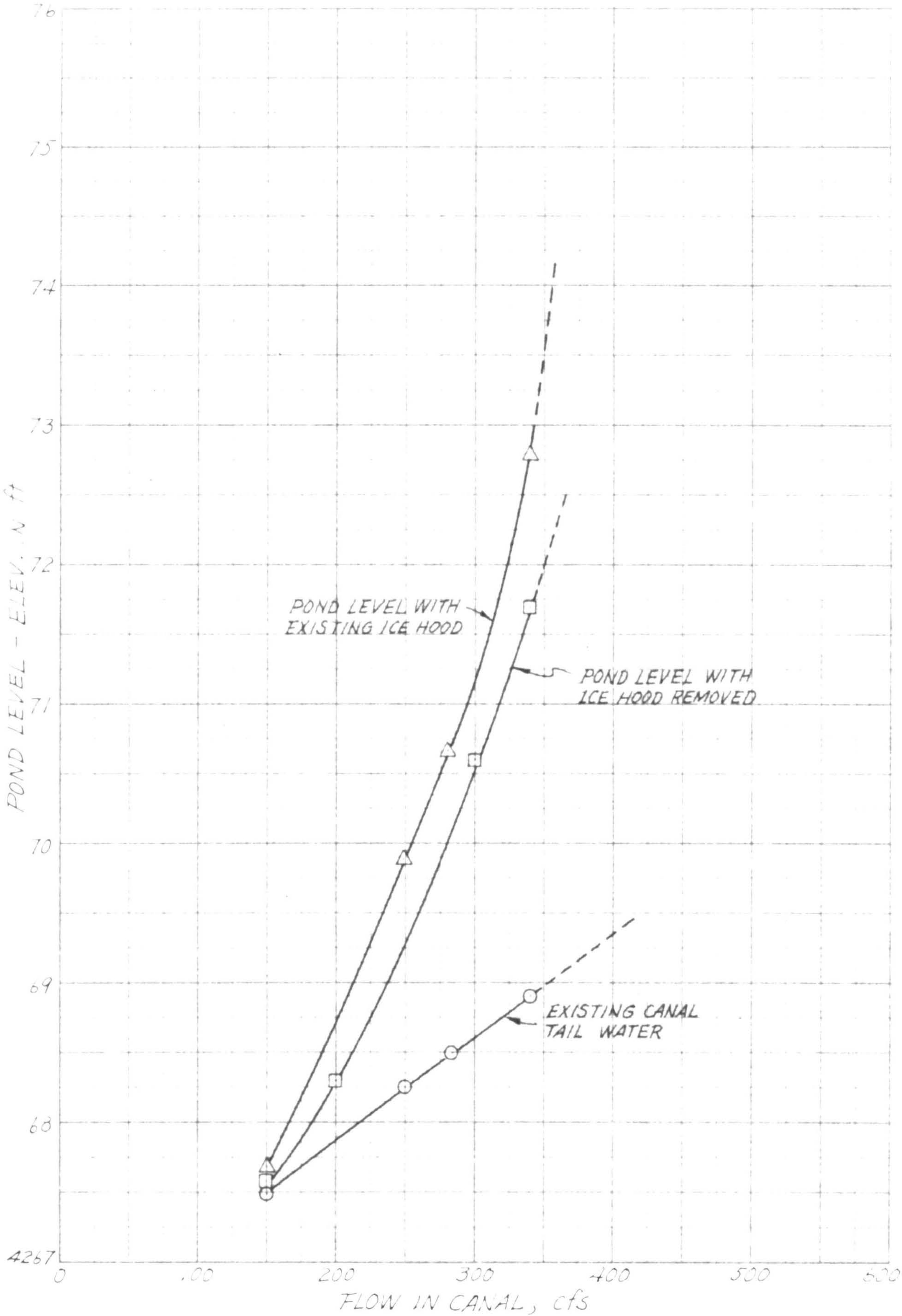


FIG. 2 EXISTING CONDITIONS

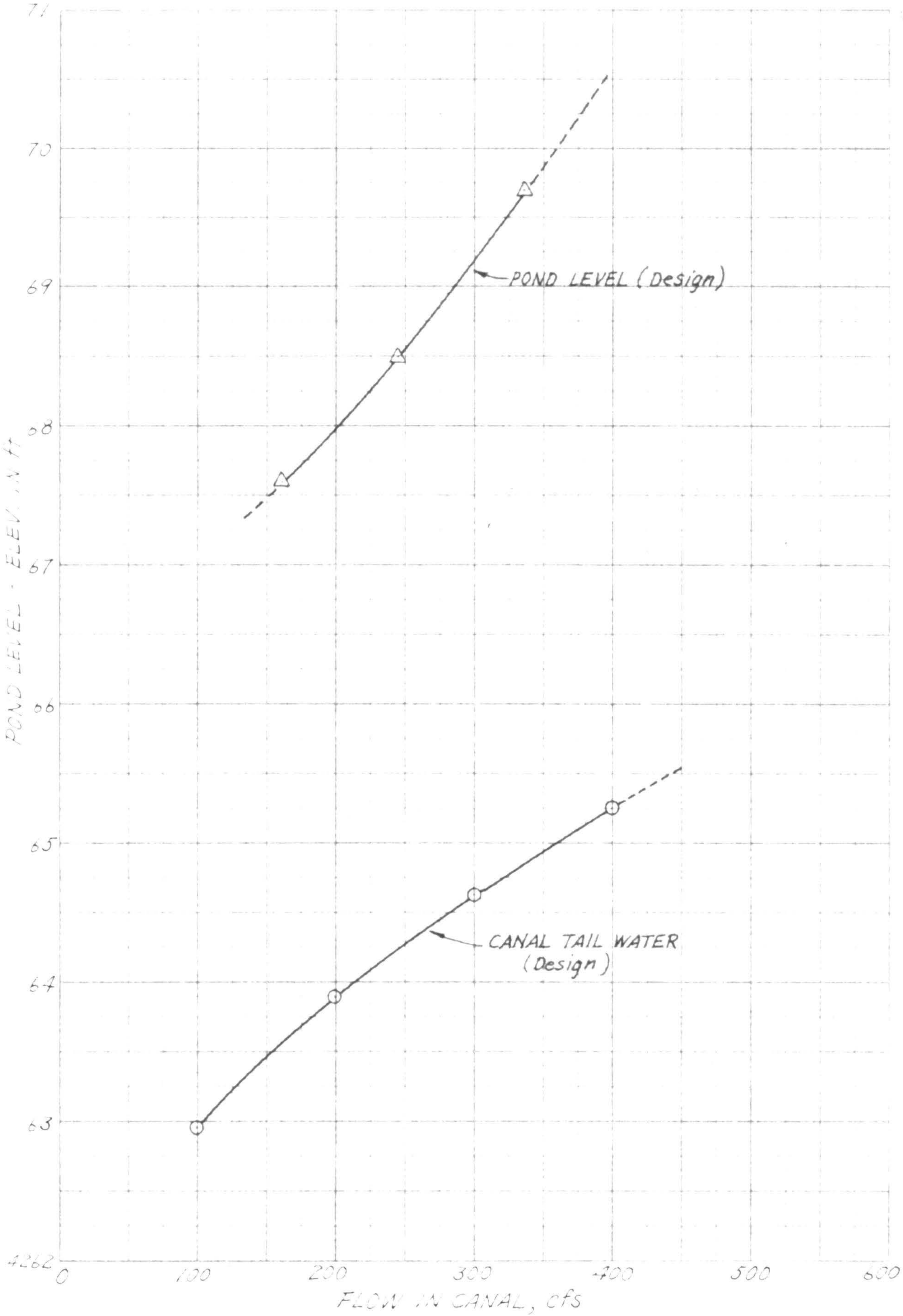


FIG. 3 DESIGN CONDITIONS

Elimination of Oscillations

It has been mentioned previously that oscillations occurred within the ice hood. Under existing conditions these oscillations were very violent. Even during the tests with the design conditions, these oscillations occurred when the pond level rose to about elevation 4269.5. The oscillations therefore seemed to be a function of pond level, and relatively independent of discharge. The oscillations were reduced however if the gate at the inlet was partially closed. The peculiarity of the inlet size and ice hood geometry appeared to be the cause of the oscillations. It was thought that the vortices created downstream of the gate shafts might be the origin of the oscillations, but when they were removed in the model, the oscillations persisted.

Several different schemes were tested to determine if the oscillations could be eliminated. One idea attempted a number of nine inch diameter holes punched through the face of the ice hood and this successfully eliminated the oscillations, and by so doing, discharge was increased by about 10 cfs for the same pond level. However, this solution seemed impractical for the prototype. Instead of holes in the ice hood, six vertical slots one foot wide and 4 feet high were made through the ice shield. The oscillations were damped but the size of the slots would have structurally weakened the face of the ice hood and again it seemed to be an impractical solution. By trial and error testing, it was found that all six slots were not required. By properly locating two slots, one foot by four feet near both ends of the hood, the oscillations were satisfactorily damped. When the oscillations were damped the discharge increased by about 10 cfs as shown in the graph of figure 4. The canal tail water in figure 4 is for existing canal conditions, and for comparison purposes, the existing pond level, or pond level resulting with the ice hood undisturbed, is also shown.

Further alterations and tests resulted in three other possible ways to arrange the holes in the ice shield to damp the oscillations. As it has been previously mentioned, the damping of the oscillations

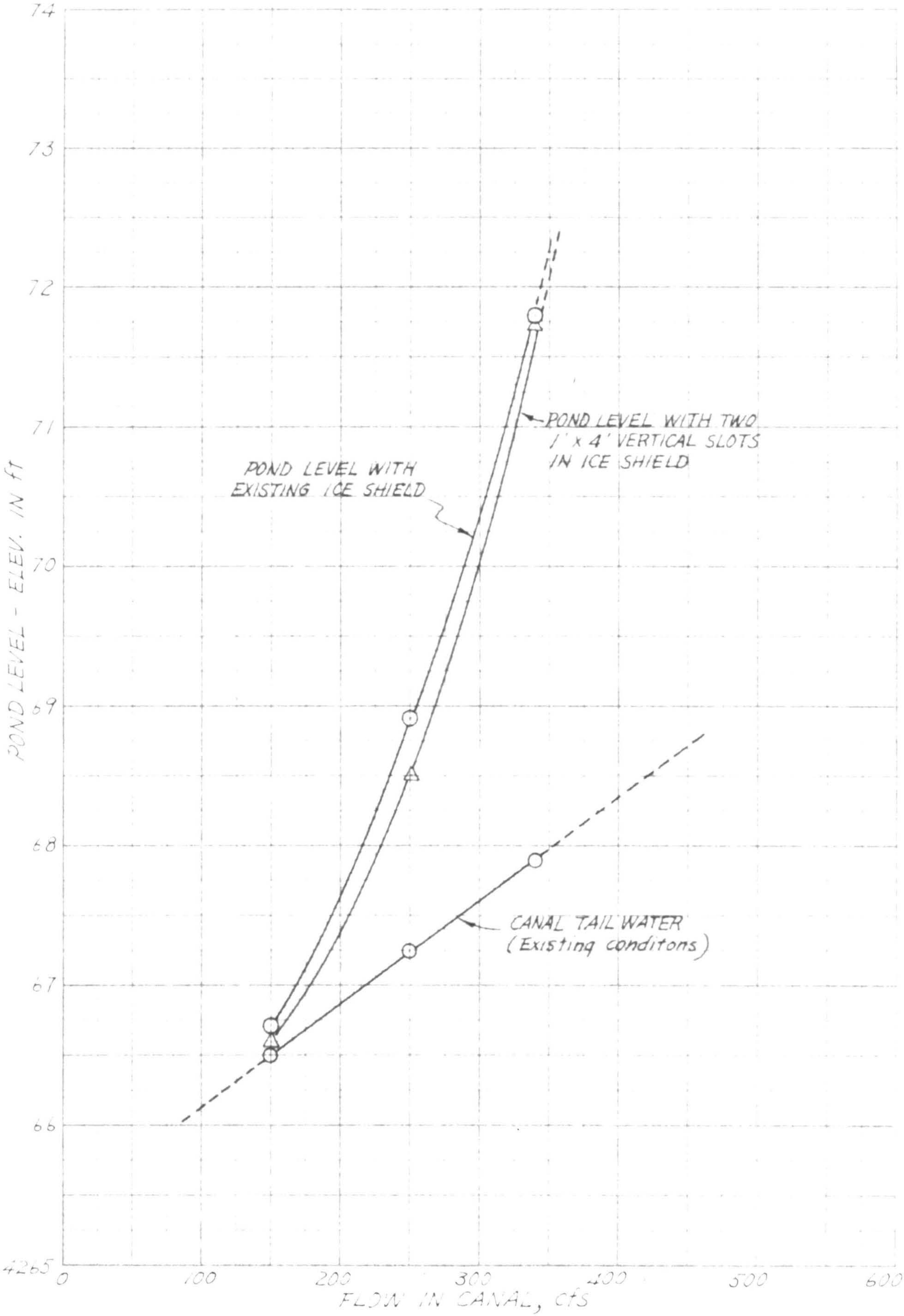


FIG. 4 MODIFICATION OF THE ICE HOOD WITH EXISTING CANAL TAIL WATER

alone did not increase the discharge sufficiently to meet the water requirements in the canal. Observation of the flow through the structure with satisfactory ice hood modifications indicated that in order to obtain the required discharge at the specified pond level of elevation 4270.8, it would be necessary to lower the tail water level in the canal. The only way to achieve this is to clean out approximately two feet of sediment from the canal bottom for a sufficiently long distance downstream of the outlet to cause a lower canal level. The alternative solutions to ice hood modifications are described subsequently.

Recommended Ice Hood Modifications

Solution A

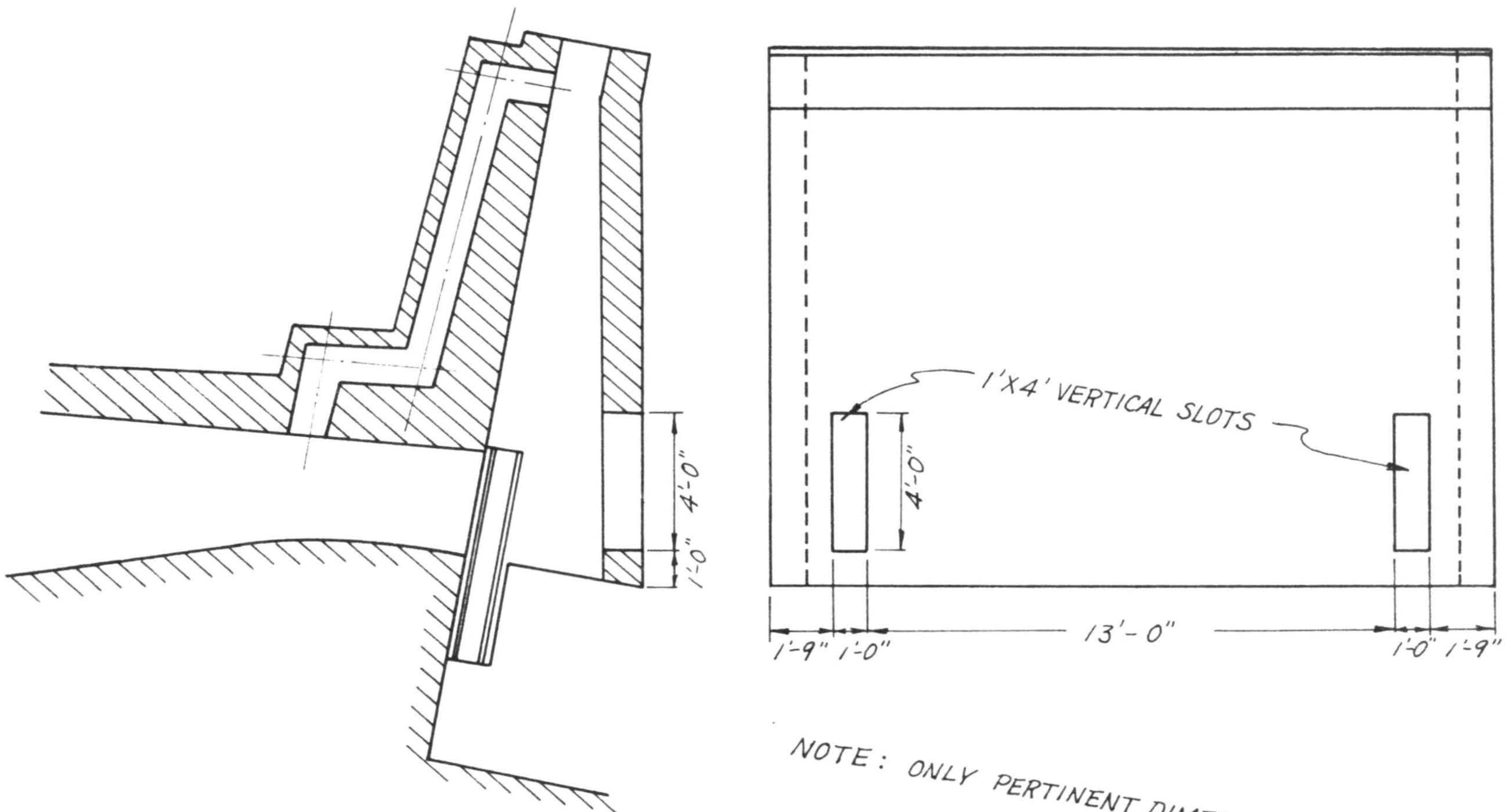
The required modification to the ice shield is shown in figure 5. It consists of two holes in the face of the ice hood at the designated location. Each hole should be one foot wide and four feet high. This places the top elevation of the holes at approximately elevation 4270. Should this be undesirable from the icing standpoint, other suggested solutions should be considered. The resulting pond level with lowered canal tail water level is shown in figure 6.

Solution B

This modification consists of cutting one foot off the bottom face of the ice hood and cutting two holes one foot wide by two feet high as shown in figure 7. The holes should be located as shown. The resulting pond level and discharge for the lowered tail water in the canal is given in figure 8.

Solution C

This modification requires cutting two feet off the bottom face of the ice hood and two holes at the location shown in figure 9. The holes should be two feet wide and one foot high. The resulting pond level conditions with lowered canal tail water is shown in figure 10. A variation of scheme C consists of cutting notches out of the face of the hood instead of holes. Either would perform satisfactorily. The choice depends upon structural feasibility. The modification is shown in figure 11 and the resulting pond level is shown in figure 12.



NOTE: ONLY PERTINENT DIMENSIONS SHOWN

FIG. 5 ICE HOOD MODIFICATION SOLUTION A

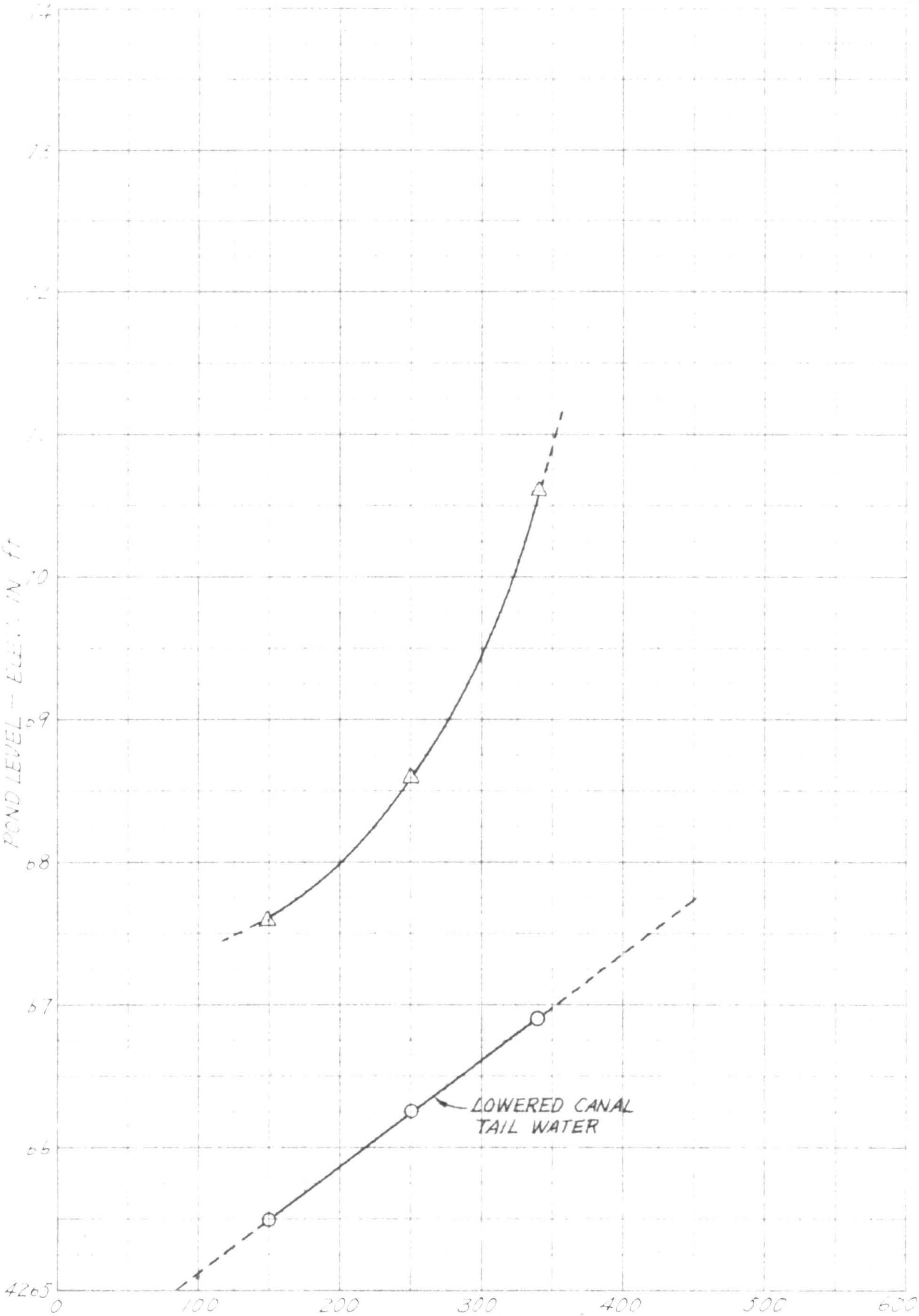


FIG. 6 SOLUTION A WITH LOWERED CANAL TAIL WATER

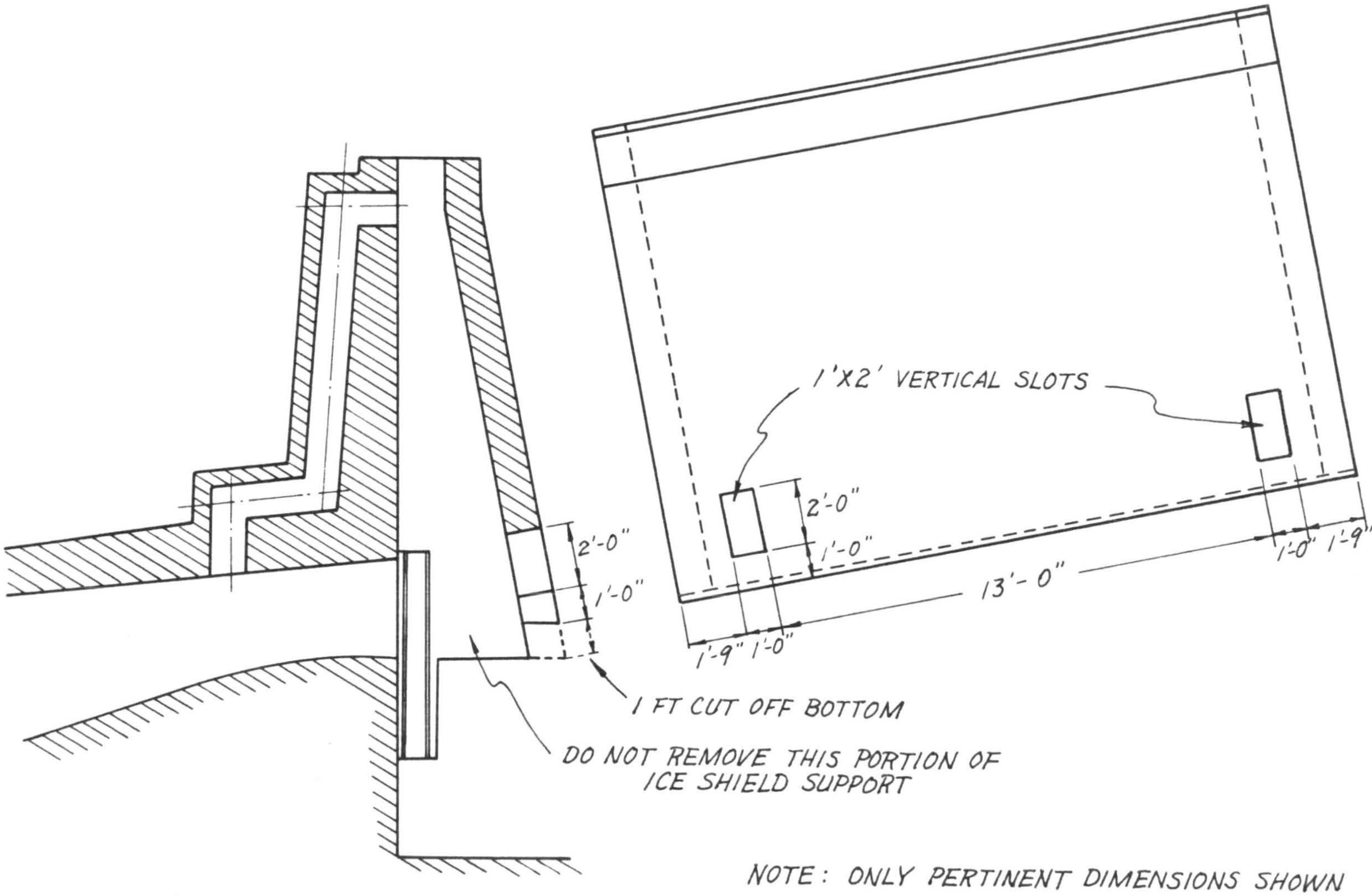


FIG. 7 ICE HOOD MODIFICATION SOLUTION B

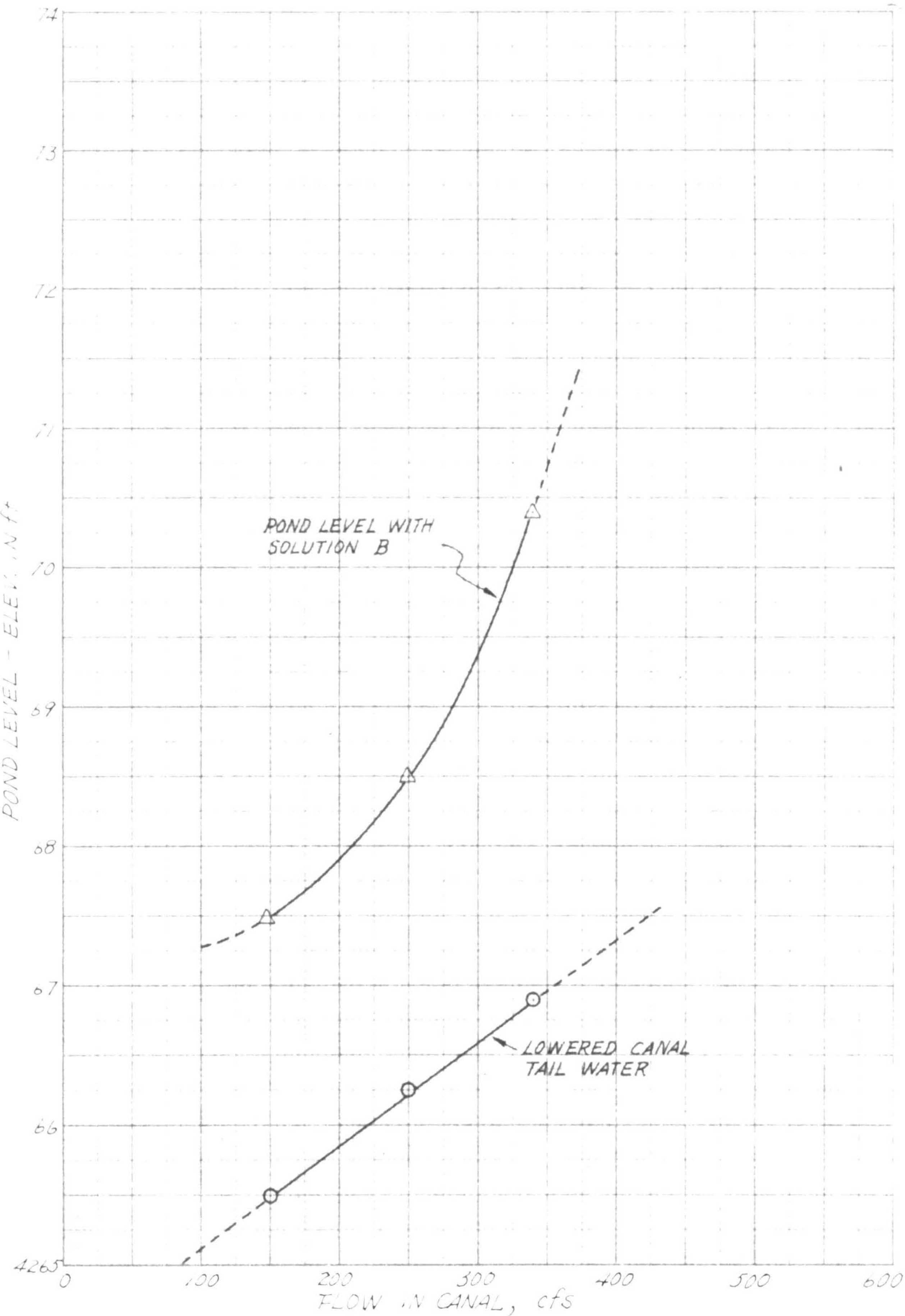


FIG. 8 SOLUTION B WITH LOWERED CANAL TAIL WATER

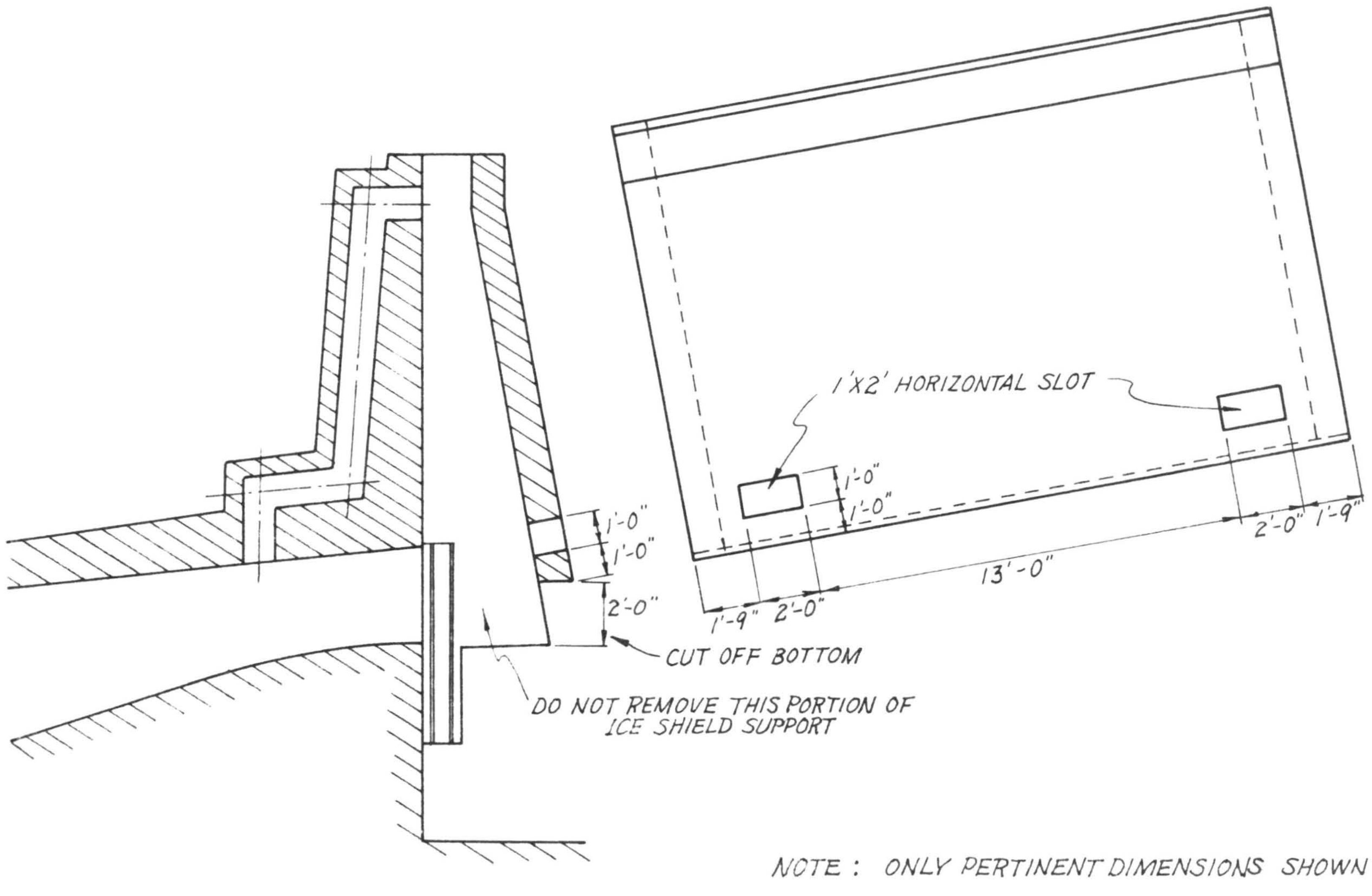


FIG. 9 ICE HOOD MODIFICATION SOLUTION C

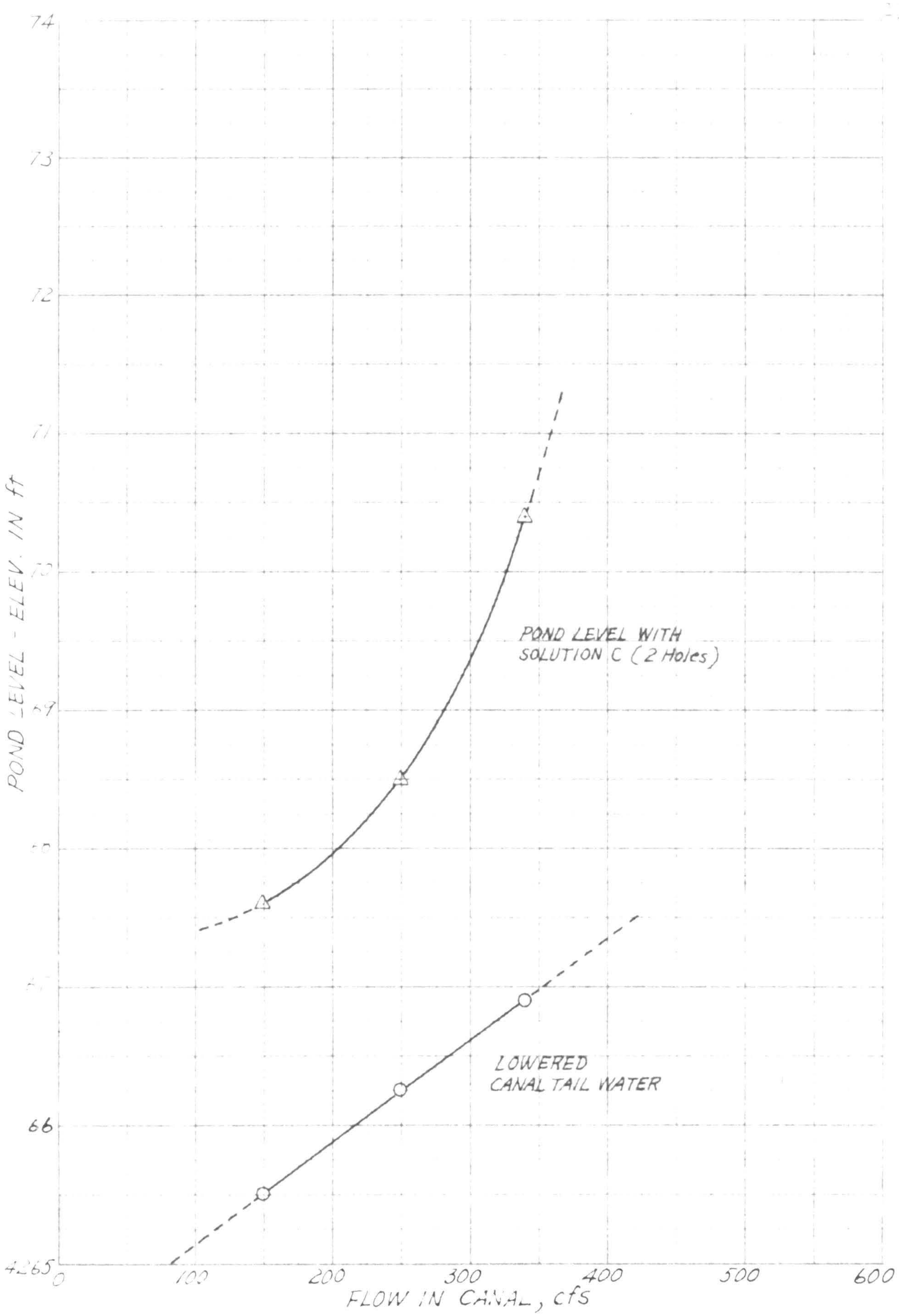


FIG. 10 SOLUTION C (Holes) WITH LOWERED CANAL TAIL WATER LEVEL

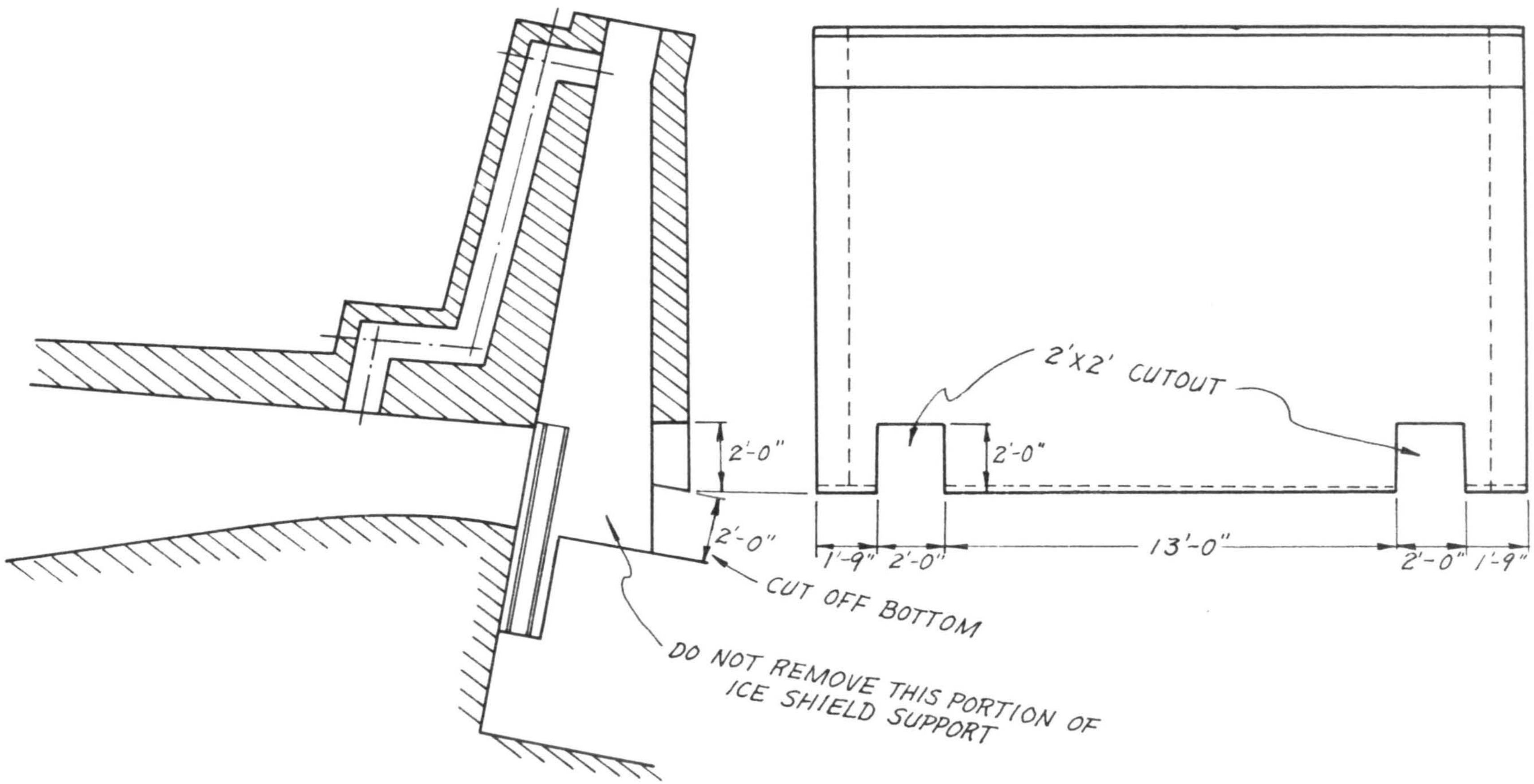


FIG. 11 ICE HOOD MODIFICATION SOLUTION C (Variation)

NOTE: ONLY PERTINENT DIMENSIONS SHOWN

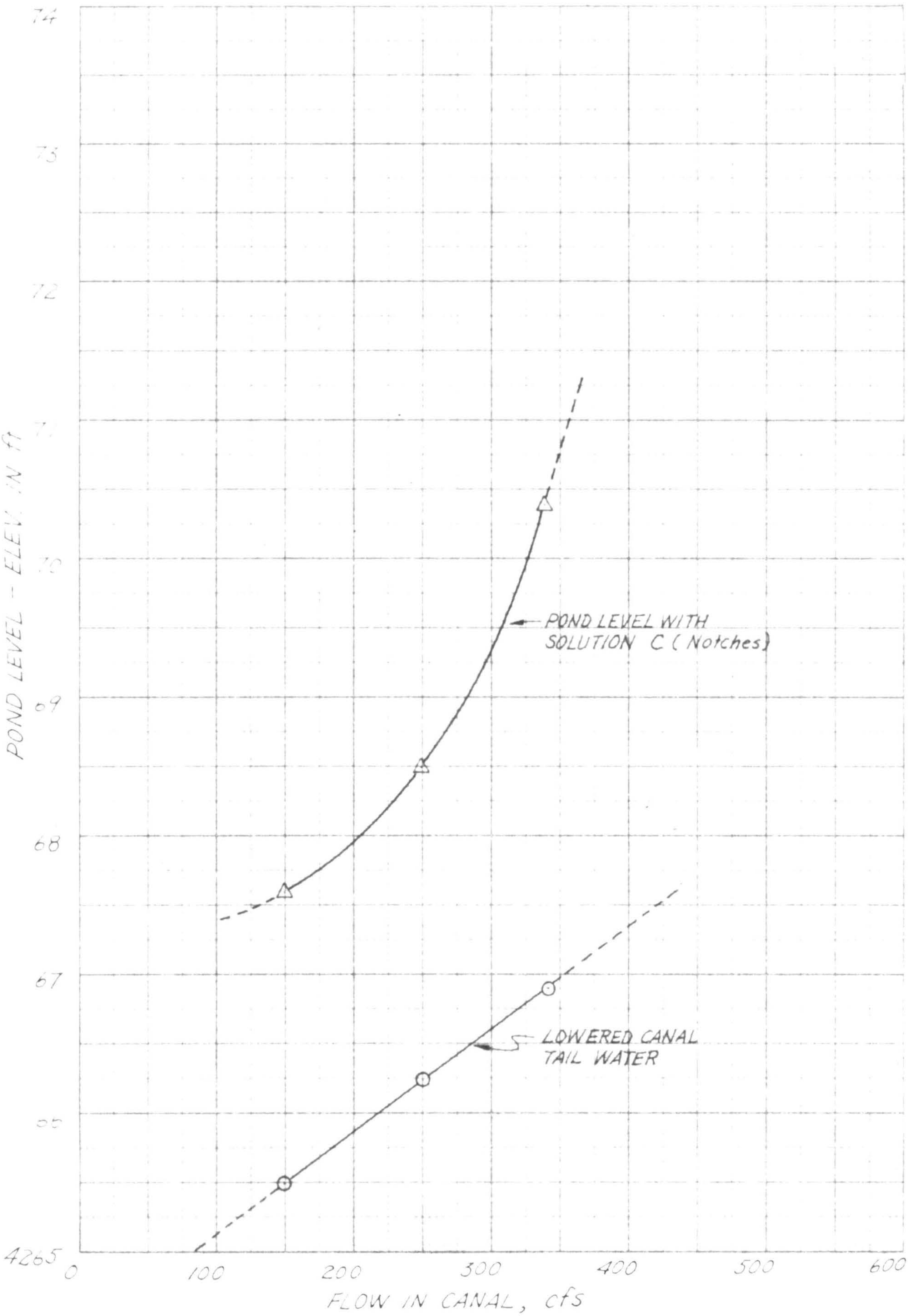


FIG. 12 SOLUTION C (Notches) WITH LOWERED CANAL TAIL WATER

CONCLUSIONS

The required discharge of 350 cfs cannot be obtained with the present canal tail water and available pond level regardless of the suggested modifications to the ice hood. Therefore, it is necessary to lower the canal tail water by about two feet from its present level. Modifications must be made to the ice hood to eliminate the violent oscillations. With any of the suggested modifications, the canal intake structure will discharge at least 345 cfs with pond level at 4270.8 provided the canal water level is lowered by about two feet.