UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON, D.C. 20242

August 14, 1972

4351 4016

SURFACE WATER BRANCH TECHNICAL MEMORANDUM NO. 73.01

Subject: COMPUTATION--Indirect Determinations of Discharge

There has been a growing need to disseminate quickly through the field offices items of interest to those personnel who are engaged in surface-water activities. Such items include:

(a) Errata sheets, or changes in procedures, for publications in the Techniques of Water-Resources Investigations series.

(b) Changes in job control cards or in available options in existing computer programs, and explanations of various types of errors or questions of interpretation of output in computer programs.

(c) Helpful hints and computation aids for the various techniques of measuring discharge by indirect methods.

These small technical notes will be distributed by Surface Water Branch Technical Memorandums, with the hope that each employee working in surface-water activities receives a copy.

The process of rewriting and publication of new instruction manuals plus the appropriation of old instructions by those who have transferred or otherwise departed from our offices have brought about an attrition in copies of existing instructions. The novice at computing flow over embankments, for example, may not readily find an approved method of computation. The accompanying instructions for computation of discharge over highway and railroad embankments were written by Howard Matthai, Regional Surface Water Specialist, WR.

Walter Hofmann

Walter Hofmann
Chief, Surface Water Branch

Attachment

WRD Distribution: All professional & technical personnel

COMPUTATION OF DISCHARGE
OVER EMBANKMENTS--HIGHWAY AND RAILROAD

The following instructions for the approved method of computing flow over embankments are not new--just a compilation of previous instructions. Appropriate coefficients for highway and railroad embankments are indicated.

Whether flow is over a road or over a railroad, the data required and the general sequence of steps in the computation are the same. The use of a form similar to the form 9-230 at the end is helpful.

Column 1.--Station is distance, in feet, along the highway and railroad. Except for end points which may be interpolated or selected from a plot of the profile along the embankment, stationing is usually the same as points surveyed in field.

The length of the flow section is determined at an elevation equal to the minimum embankment elevation plus five-sixths of the maximum value of h. If the velocity of approach exceeds 4 feet per second, use five-sixths of the value of H.

Column 2.--Distances, b, are differences between adjacent stationing. Sum of b's should equal difference in stationing between first and last station.

Column 3.--Water-surface elevation is elevation at the approach section. The approach section should be at least 3 or 4 times the static head, h, upstream from the embankment. Interpolate water-surface elevations across channel if there is a difference between elevations on left and right banks.

Column 4.--Road elevation. Elevations correspond to stationing in column 1. For highway embankments, always use elevations along the highest part of the embankments (these are often along the crown or centerline). Elevations for railroad embankments are along top of the highest rail.

Column 5.--Static head, h, is difference between water-surface and road or rail elevations.

Column 6.--The velocity head, h_{v_1}, at the approach section is computed as $\alpha_1 V_1^2/2g$. The entire approach section is used even if part of the flow goes through a bridge or over another section of road. The discharge, Q, must be estimated. For ponded approach conditions, the small velocity head is virtually offset by the friction loss; therefore, h = H.

Column 7.--The friction loss, $h_{f_{1.2}}$, is the loss between the approach section and the embankment. It is computed as $L_w Q^2/K_1^2$. L_w is the distance between the approach section and the embankment, and K_1 is the conveyance for the entire approach section.

Column 8.--The total head, H, equals the static head, h, plus the velocity head, and minus the friction loss.

Column 9.--Average head. Averages are for successive pairs of heads in either column 5 or column 8. Whether average h or average H is used depends upon which head is used to determine the discharge coefficient.

Column 10.--The ratio h/L is computed for highway embankments because the discharge coefficient is a function of this ratio when it exceeds 0.15. See TWRI Book 3, Chapter A5, page 27.

Column 11.--The discharge coefficient, C, for highway embankments is obtained from curves in TWRI Book 3, Chapter A5, pages 26, 27.

For railroad embankments the discharge coefficient for all values of H is 3.25 for a single track embankment with both rails in place, and 3.00 for a double track embankment with four rails in place.

The coefficients thus obtained are for freefall over the embankment. If the depth of water over the crest on the downstream side of the embankment exceeds 0.7 of the head, h, then the discharge coefficient must be adjusted for the degree of submergence.

For highway embankments, obtain the correction factor, k_t, from TWRI Book 3, Chapter A5, figure 24. For railroad embankments, interpolate between values in the following table or plot this curve in figure 24 and select values from the curve.

d/h	0.70	0.75	0.80	0.85	0.90	0.95
k_t	0.96	0.93	0.90	0.84	0.74	0.58

Column 12.--H or h to the three-halves power. Use values in column 9. Table of three-halves power in King's Handbook of Hydraulics.

Column 13.--The discharge for each subsection is computed as $CLh^{3/2}$ or $CLH^{3/2}$. Sum subsection discharges to obtain total flow over embankment.

If the total head, H, has been used, add total flow over embankment to flow through any structures. Recompute velocity head and friction loss, columns 6 and 7. If H is changed more than 3 percent, recompute discharges until change is less than 3 percent.

Reference.--Yarnell, D. L., and Nagler, F. A., 1930, Flow of flood water over railway and highway embankments: Public Roads, v. 11, no. 2, p. 30-34.

****

9-230
(Rev. 9-67)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

File No. ....

Computation of flow over highway or railroad embankment

Sta.	Dist. b	W.S. Elev.	Road Elev.	h	h_{v_1}	$h_{f_{1,2}}$	H	Avg. h or H	$\frac{h}{L}$	C	$h^{3/2}$ $H^{3/2}$	Q
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)

Comp. by: .... date: ....

$Q = CbH^{3/2}$ or $Q = Cbh^{3/2}$ Ck. by: .... date: ....

INT: 1028-72

2.13