CHAPTER 9

Floodplain Encroachment Calculations

The evaluation of the impact of floodplain encroachments on water surface profiles can be of substantial interest to planners, land developers, and engineers. It is also a significant aspect of flood insurance studies. HEC-RAS contains five optional methods for specifying floodplain encroachments within a steady flow analysis. This chapter describes the computational details of each of the five encroachment methods, as well as special considerations for encroachments at bridges, culverts, and multiple openings. Discussions are also provided on a general modeling approach for performing an encroachment analysis.

For information on how to enter encroachment data, how to perform the encroachment calculations, and viewing encroachment results, see Chapter 9 of the HEC-RAS user's manual.

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Introduction

The HEC-RAS floodway procedure for steady flow analyses is based on calculating a natural profile (existing conditions geometry) as the first profile in a multiple profile run. Other profiles in a run are calculated using various encroachment options, as desired. Before performing an encroachment analysis, the user should have developed a model of the existing river system. This model should be calibrated to the fullest extent that is possible. Verification that the model is adequately modeling the river system is an extremely important step before attempting to perform an encroachment analysis.

Encroachment Methods

HEC-RAS contains five optional methods for specifying floodplain encroachments. Each method is illustrated in the following paragraphs.

Encroachment Method 1

With encroachment method 1 the user specifies the exact locations of the encroachment stations for each individual cross section. The encroachment stations can also be specified differently for each profile. An example of encroachment method 1 is shown in Figure 9.1.

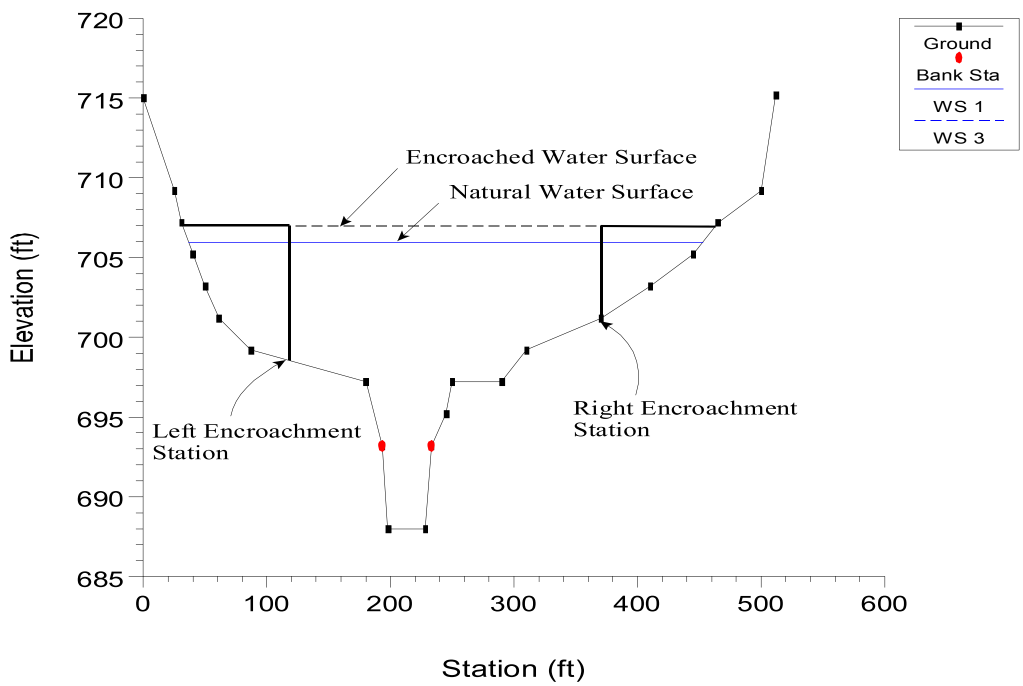

Figure 9.1 Example of Encroachment Method 1

Encroachment Method 2

Method 2 utilizes a fixed top width. The top width can be specified separately for each cross section. The left and right encroachment stations are made equal distance from the centerline of the channel, which is halfway between the left and right bank stations. If the user specified top width would end up with an encroachment inside the channel, the program sets that encroachment (left and/or right) to the channel bank station. An example of encroachment method 2 is shown in Figure 9.2.

HEC-RAS also allows the user to establish a left and right offset. The left and right offset is used to establish a buffer zone around the main channel for further limiting the amount of the encroachments. For example, if a user established a right offset of 5 feet and a left offset of 10 feet, the model will limit all encroachments to 5 feet from the right bank station and 10 feet from the left bank station. If a user entered top width would end up inside of an offset, the program will set the encroachment at the offset stationing.

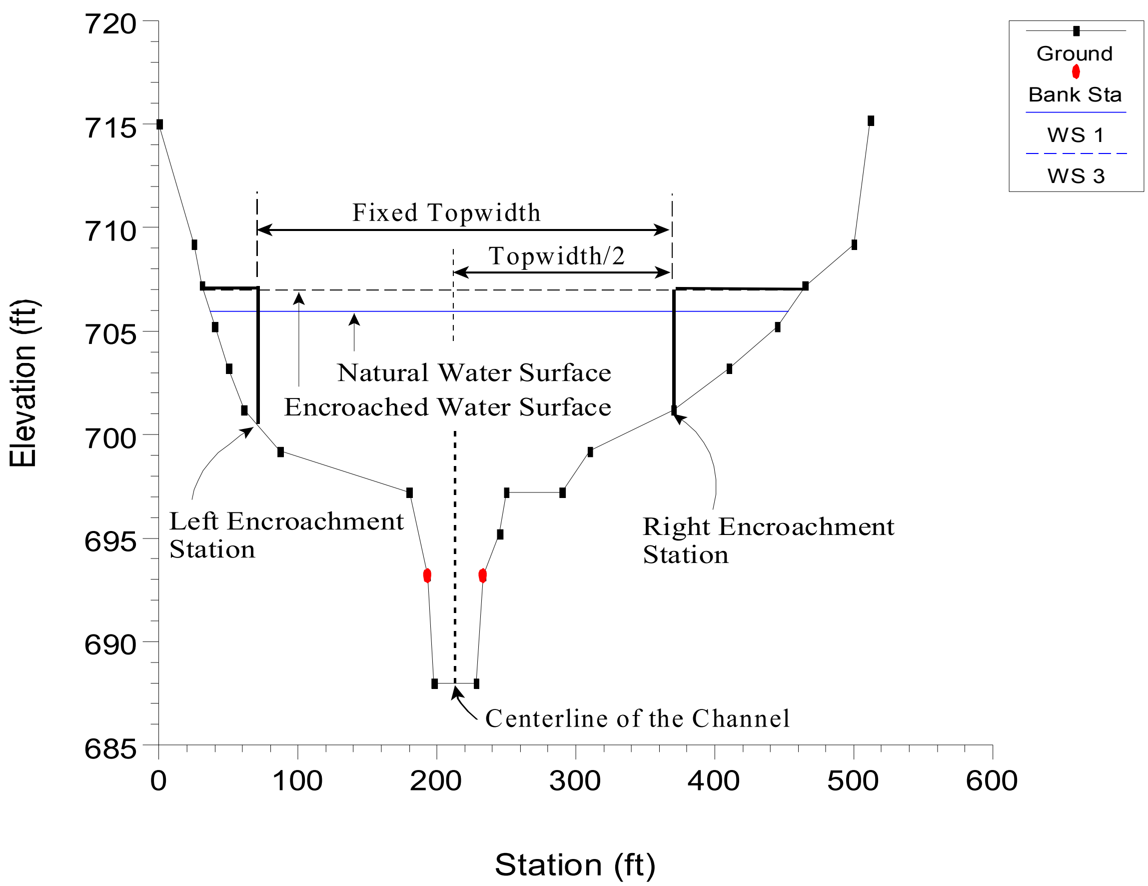

Figure 9.2 Example of Encroachment Method 2

Encroachment Method 3

Method 3 calculates encroachment stations for a specified percent reduction in the conveyance (%K Reduction) of the natural profile for each cross section. One-half of the conveyance is eliminated on each side of the cross section (if possible). The computed encroachments cannot infringe on the main channel or any user specified encroachment offsets. If one-half of the conveyance exceeds either overbank conveyance, the program will attempt to make up the difference on the other side. If the percent reduction in cross section conveyance cannot be accommodated by both overbank areas combined, the encroachment stations are made equal to the stations of left and right channel banks (or the offset stations, if specified). An example of encroachment method 3 is shown in Figure 9.3.

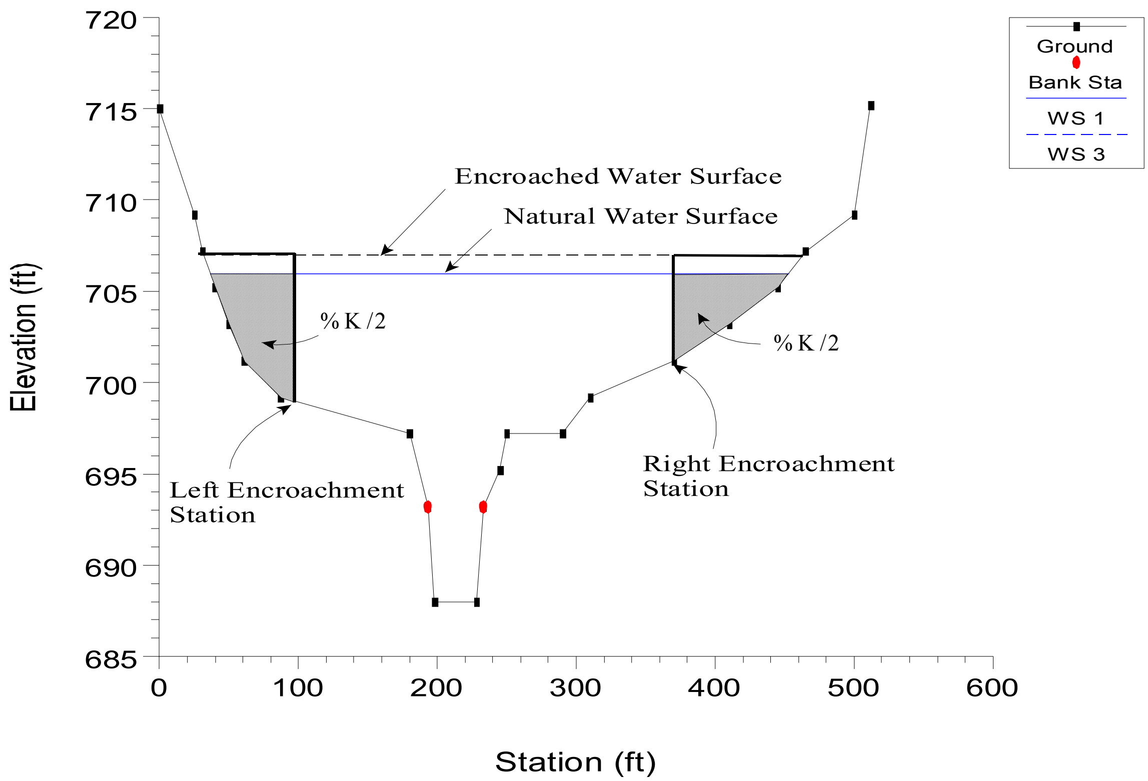

Figure 9.3 Example of Encroachment Method 3

Encroachment Method 3 requires that the first profile (of a multiple profile run) must be a natural (un-encroached) profile. Subsequent profiles (profiles 2-15) of a multiple profile run may be utilized for Method 3 encroachments. The percentage of reduction in conveyance can be changed for any cross section. A value of 10 percent for the second profile would indicate that 10 percent of the conveyance based on the natural profile (first profile) will be eliminated - 5 percent from each overbank. Equal conveyance reduction is the default.

An alternate scheme to **equal** conveyance reduction is conveyance reduction in **proportion** to the distribution of natural overbank conveyance. For instance, if the natural cross section had twice as much conveyance in the left overbank as in the right overbank, a 10 percent conveyance reduction value would reduce 6.7 percent from the left overbank and 3.3 percent from the right overbank.

Encroachment Method 4

Method 4 computes encroachment stations so that conveyance within the encroached cross section (at some higher elevation) is equal to the conveyance of the natural cross section at the natural water level. This higher elevation is specified as a fixed amount (target increase) above the natural (e.g., 100 year) profile. The encroachment stations are determined so that an equal loss of conveyance (at the higher elevation) occurs on each overbank, if possible. If half of the loss cannot be obtained in one overbank, the difference will be made up, if possible, in the other overbank, except that encroachments will not be allowed to fall within the main channel.

A target increase of 1.0 indicates that a 1 foot rise will be used to determine the encroachments based on equal conveyance. An alternate scheme to **equal** conveyance reduction is to reduce conveyance in **proportion** to the distribution of natural overbank conveyance. See Method 3 for an explanation of this. A key difference between Method 4 and Method 3 is that the reduction in conveyance is based on the higher water surface (target water surface) for Method 4, while Method 3 uses the lower water surface (natural water surface). An example of a Method 4 encroachment is shown in Figure 9.4.

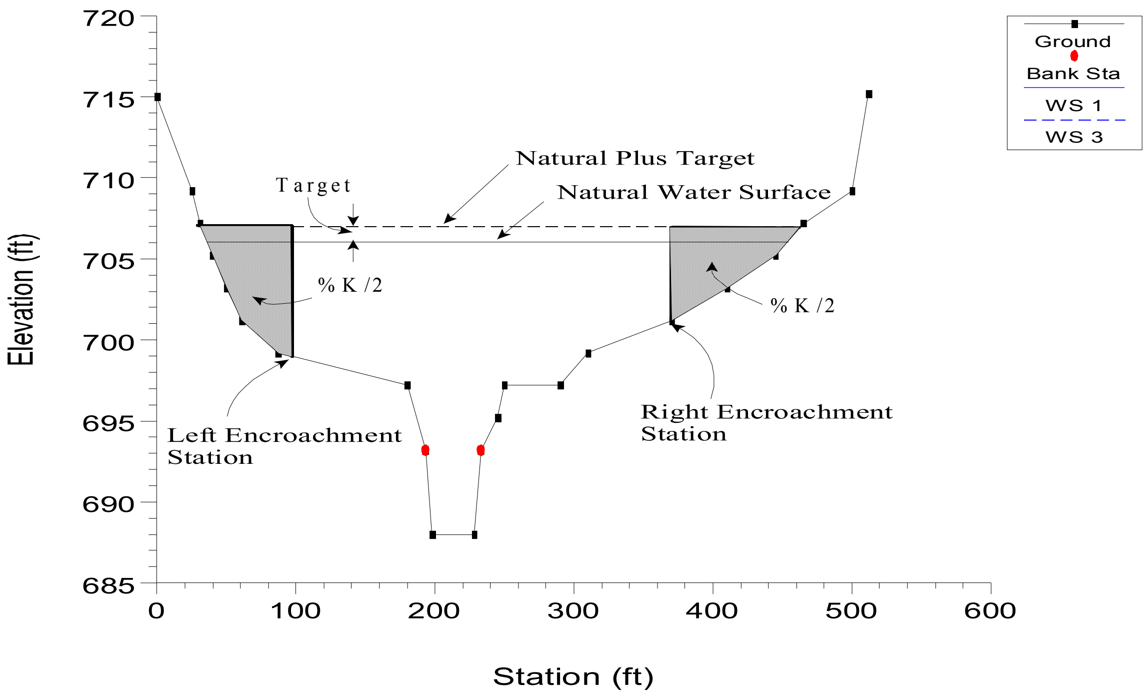

Figure 9.4 Example of Encroachment Method 4

Encroachment Method 5

Method 5 operates much like Method 4 except that an optimization scheme is used to obtain the target difference in water surface elevation between natural and encroached conditions. A maximum of 20 trials is allowed in attempting a solution. Equal conveyance reduction is attempted in each overbank, unless this is not possible (i.e., the encroachment goes all the way into the bank station before the target is met). The input data for method 5 consists of a target water surface increase and a target energy increase. The program objective is to match the target water surface without exceeding the target energy. If this is not possible, the program will then try to find the encroachments that match the target energy. If no target energy is entered, the program will keep encroaching until the water surface target is met. If only a target energy is entered, the program will keep encroaching until the target energy is met. If neither of the criteria is met after 20 trials, the program will take the best answer from all the trials and use it as the final result. The target water surface and energy can be changed at any cross section, like Methods 1 through 4. An example of method 5 is shown in Figure 9.5.

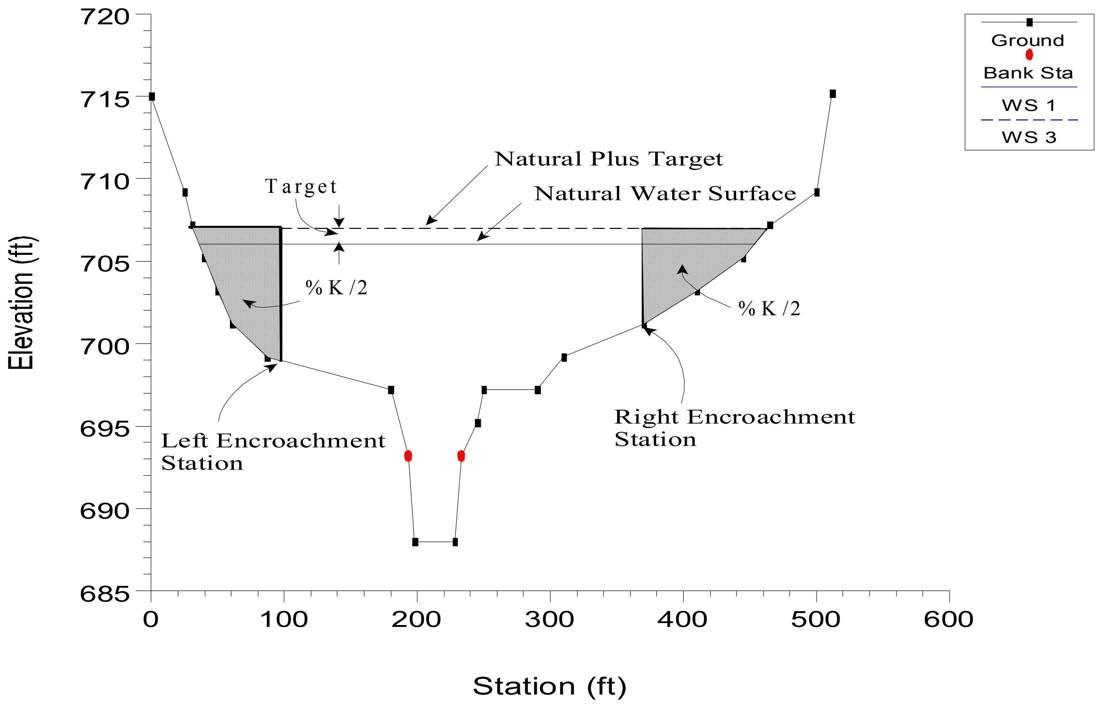

Figure 9.5 Example of Encroachment Method 5

Bridge, Culvert, and Multiple Opening Encroachments

In general, the default methodology for encroachments at bridges, culverts, and multiple openings, is to use the downstream computed encroachments through the structure, and at the cross section just upstream of the structure (the program does this automatically). There are a few exceptions to this rule.

First, when using Method 1, the user can enter separate encroachment stations downstream of the structure, inside the structure, and upstream of the structure. Only one set of encroachments can be entered for inside of the structure.

Second, for encroachment methods 2 through 5, the program will allow for separate encroachment calculations at a bridge, when using the energy based bridge computation method. For all other bridge computation methods (Momentum, Yarnell, WSPRO, Pressure Flow, Pressure and Weir Flow, and Low Flow and Weir Flow) the program will use the computed downstream encroachments through the bridge and at the cross section just upstream.

At a culvert crossing or a multiple opening, when using encroachment methods 2 through 5, the program will always use the computed downstream encroachments through the structure and just upstream of the structure. The only way to override this is to use Method 1 encroachments.

Also, encroachments can be turned off at any bridge, culvert, or multiple opening.

General Modeling Guidelines

The HEC-RAS floodway procedure is based on calculating a natural profile (no encroachments) as the first profile of a multiple profile run. Subsequent profiles are calculated with the various encroachment options available in the program.

In general, when performing a floodway analysis, encroachment methods 4 and 5 are normally used to get a first cut at the encroachment stations. Recognizing that the initial floodway computations may provide changes in water surface elevations greater, or less, than the “target” increase, initial computer runs are usually made with several “target” values. The initial computer results should then be analyzed for increases in water surface elevations, changes in velocities, changes in top width, and other parameters. Also, plotting the results with the X-Y-Z perspective plot, or onto a topographic map, is recommended. From these initial results, new estimates can be made and tried.

The increase in water surface elevation will frequently exceed the “target” used to compute the conveyance reduction and encroachment stations for the section. That is why several target increase values are generally used in the initial floodway computations.

After a few initial runs, the encroachment stations should become more defined. Because portions of several computed profiles may be used, additional runs with method 4 or 5 should be made with varying targets along the stream. The final computer runs are usually made with encroachment Method 1 defining the specific encroachment stations at each cross section. Additional runs are often made with Method 1, allowing the user to adjust encroachment stations at specific cross sections to further define the floodway.

While the floodway analysis generally focuses on the change in water surface elevation, it is important to remember that the floodway must be consistent with local development plans and provide reasonable hydraulic transitions through the study reach. Sometimes the computed floodway solution, which provides computed water surfaces at or near the target maximum, may be unreasonable when transferred to the map of the actual study reach. If this occurs, the user may need to change some of the encroachment stations, based on the visual inspection of the topographic map. The floodway computations should be re-run with the new encroachment stations to ensure that the target maximum is not exceeded.