

The Importance of Horizontal Roughness Delineation in HecRas

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Background

Over the past few years the NRCS HecRas Support Team has trained over 600 students in the use of the river analysis program HecRas (from <http://www.hec.usace.army.mil/>, the US Army Corps of Engineers). Instructors have noticed a number of common user mistakes that are worth publicizing. Beginning users often assume that default program settings and “typical” values will suffice for their projects, not evaluating unique site characteristics that make this practice hazardous for obtaining reliable or correct results.

Water surface profile calculations are very sensitive to choice of roughness coefficient, which is a function of many physical characteristics, including vegetation and channel sediment size. The program default is to delineate a single channel roughness and one for each overbank. These are easily modified from cross-section to cross-section, that is, longitudinally along the river profile. But across the width of a single cross-section (horizontally) natural roughness variation can often call for more than one roughness coefficient. Modelers who do not account for this variation can significantly skew their results.

Example and Explanation

Of course, a key skill that river modelers must acquire is the ability to see the real world from the HecRas point of view. Almost everything about the landscape is given to Ras with cross-sections. Whatever landscape features happen to exist between cross-sections will be “unseen” by RAS. But program results are based on the concept that the landscape between two cross-sections is adequately modeled as a blend of the two—in effect, an interpolation between them. If this is not so, the modeler must add more cross-sections.

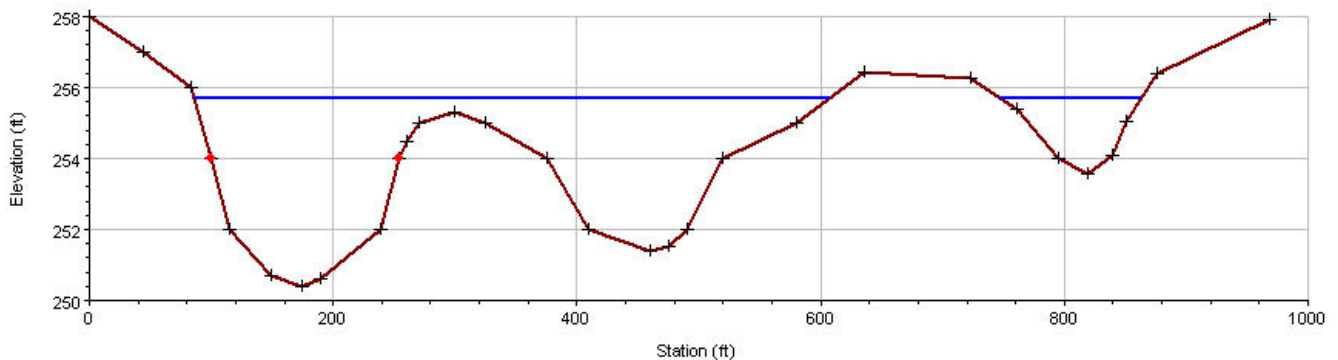
The discharge through a cross-section is highly dependent on roughness. Slight adjustments in roughness coefficients can result in significant differences in discharge. Therefore, in specifying roughness coefficients the modeler must not only determine magnitude but also extent. The modeler must decide whether to provide a composite value for roughness that varies over a wetted perimeter, or whether to provide the program more detail and let it do the compositing.

Since Ras can compute composite roughness on-the-fly the modeler’s best practice is to delineate more roughness values rather than fewer. This is especially true if several discharges are being analyzed, since the particular proportions of wetted perimeters of different roughnesses will generally change from one discharge to another.

One of the most obvious examples requiring more than the default number of roughness values (three) is when there is more than one flow channel in the section. Shown below is an aerial photo of a meandering river in which a mid-channel bar has split the flow for a short section. The longer term channel migration tendency here is toward a bend of tighter and tighter radius. Thus, the current cross-section actually has three channels, with different roughnesses in the areas between them.



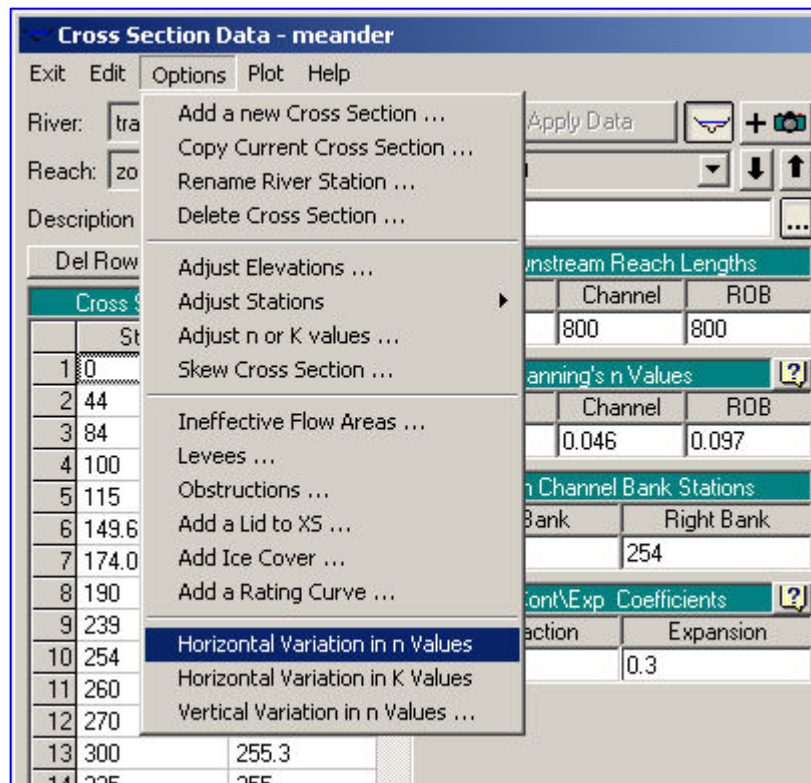
With downstream to the left, in Ras this cross-section might be plotted as follows:



Note that the plotted water surface is higher than that in the photo. The red dots indicate the assumed bank stations and the three default roughness values would apply left of the first bank station, in the leftmost channel, and right of the right bank station. Assume that the channel roughnesses are well represented by a Manning’s n -value of 0.032 and the forested left bank by 0.085. Suppose the user assumed a right overbank roughness of, say, 0.05. That might be close for the sparsely vegetated mid-channel bar, but too high for both of the right-most channels. It would probably be too low for the rightmost, heavily vegetated bar and the overbank on the far right.

Specifying More than the Default Three Roughness Values in Ras

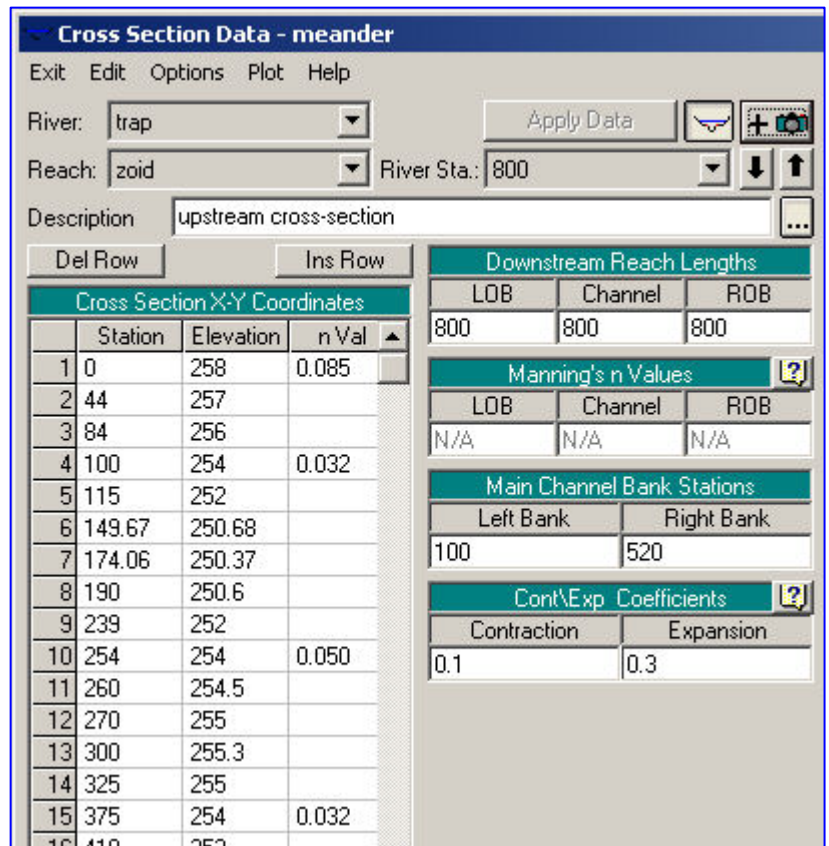
Cross-sections are entered via the Geometric Data Editor in HecRas by specification of horizontal stations and vertical elevations. The Cross-Section Data Editor provides three spaces for the standard Manning’s n -values, Left OverBank, Channel, and Right OverBank. To specify more horizontal roughness values, one must go to the Options pull-down menu, as shown below:



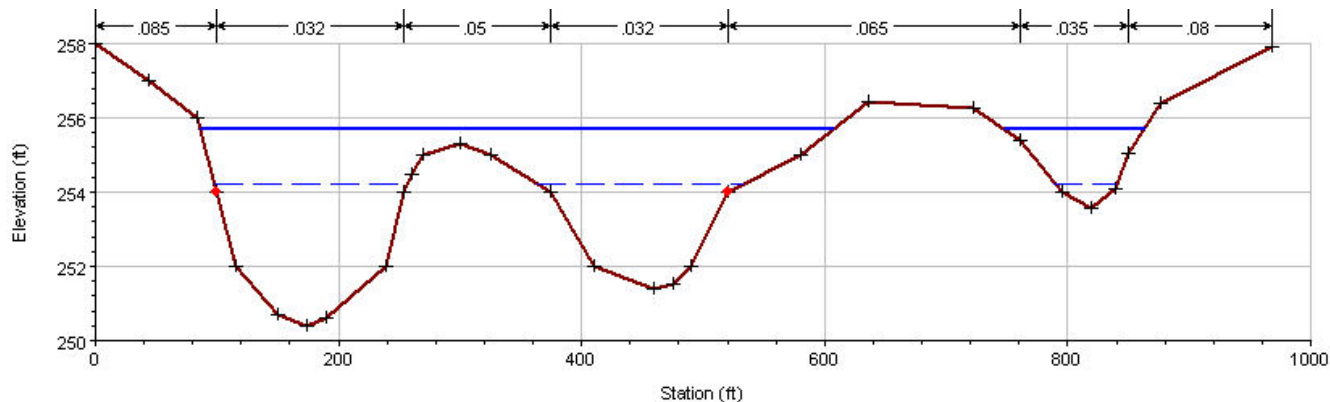
“Horizontal Variation in n Values” is one of the options toward the bottom of the list. When selected, the station / elevation table is given a third column, as shown at right, for specifying additional roughness values which are given between any two cross-section points. More appropriate roughnesses have been entered into the table.

Note that when this option is selected the slots for default roughness locations show “N/A”.

It is no surprise that in this case, the difference in water surface elevation between the choice of three roughness coefficients versus further horizontal delineation is significant. As shown on the next page, the water surface with horizontal delineation is much lower (plotted with a dashed blue line).



Notice that the Manning’s *n*-values chosen in the horizontal delineation are shown across the top of the plot.



The three flow channels, with a Manning’s n -value of near 0.032 are much more efficient at passing discharge than was assumed by the modeler who allowed everything right of the first channel to be represented by a 0.05 roughness value.

Summary

Although HecRas steady flow models can almost always be made to run without program errors, the accuracy of the output, of course, depends heavily on the quality of the input. The onus is on the modeler to be well-trained, fully understand how HecRas works, and not rely on default values. Determination of Manning’s roughness coefficient for any particular land surface is itself not elementary, and existing guidance provides a number of empirical steps. But failure to recognize the impact of inadequate horizontal delineation of roughness in a cross-section is an all too common mistake.