Paper UC1172: ArcGIS Tool for BFE Placement after Vertical Datum Conversion

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ABSTRACT: Base Flood Elevation (BFE) contours are drawn on Flood Insurance Rate Maps (FIRMs) to represent the 100-year flood water surface elevation. Digital Flood Insurance Rate Maps (DFIRMS) are part of the FEMA Map Modernization Program. One goal of the MMP is to convert all flood maps from a vertical datum of NGVD 29 to NAVD 88. BFEs are placed as whole-foot contour lines to represent the water surface elevation. Typically, the datum conversion value is not a whole number, which necessitates a revision of BFE contour locations. A semi-automated toolset was developed with ArcGIS Model Builder to assist in locating the datum converted BFE contour location. This toolset uses existing streamline and cross section data as inputs and produces a point shapefile. This shapefile represents the location of the datum converted whole-foot BFE locations.

INTRODUCTION

The Federal Emergency Management Agency (FEMA) Map Modernization Program (MMP) is striving to update the Flood Insurance Rate Maps (FIRMs) for the continental United States and Territories. This program is responsible for creating Digital Flood Insurance Rate Map (DFIRM) databases; a seamless database product encompassing data from Flood Insurance Rate Maps (FIRM), Flood Insurance Studies, Flood Profiles, and Floodway Data Tables (FDT). One goal of the MMP is the conversion of the vertical datum from NGVD 29 to NAVD 88. This vertical datum conversion involves applying a (vertical) conversion factor to the data in the FDT, Flood Profiles, and Base Flood Elevations (BFE). BFEs are the water-surface elevation contour for the 1% Annual Chance flood event (100-year flood).

The challenge in relocating BFEs after a vertical datum conversion is due to the FEMA guidelines governing BFE placement. These guidelines mandate that BFEs correspond to the water surface elevation as shown on the Flood Profile at whole foot intervals. A vertical datum conversion is rarely if ever a whole foot interval, which necessitates the relocation of the BFE contours along the DFRIM streamline. The countywide nature of a DFIRM database means that there can be a great number of BFE contours along each stream, and there are typically many streams in a county. Relocating a BFE at the correct location on a streamline is problematic in that the process of identifying the new location on the Flood Profile and transferring that to the DFIRM can be laborious, error prone, somewhat subjective, and thus not readily repeatable. Development of a tool or procedure was seen as a way to facilitate the relocation of these BFE contours while increasing efficiency, reducing human error, and providing for quality control of the data.

TOOL DEVELOPMENT

It was recognized that an automated or semi-automated tool or model would best address the development goals and be able to: utilize of existing spatial data; produce repeatable results; be uniformly applied to multiple streams; and be implemented by technicians with limited experience in GIS, Flood Profiles, and/or FEMA regulations. Other major considerations in the development of a tool included the need for portability between many workstations and limited development time and budget.

ArcGIS Model Builder was selected as the development environment for the tool and given the name *BFE_Tool*. This environment provided an easy to implement way to build and distribute a reusable toolset. The development of the *BFE_Tool* as an ArcMap toolbox (.tbx) file allowed the toolset to be portable and could be imported into any ArcMap session. This tool, used in combination with an intermediate numeric processing step yields the updated locations of BFEs for use in the DFIRM product. The result is a three-step process that involves running the *BFE_Tool* to extract data, numeric processing to compute new BFE station locations, and then re-running the *BFE_Tool* to create a point shapefile of the new placement locations. This hybrid solution was developed as a compromise to match the available time and budget, and the teams' skill set.

TOOL PROCESS

Several verification and pre-processing steps are necessary to prepare the data for application in the *BFE_Tool*. The cross sections must be attributed with NAVD 88 elevations. The streamline captured off of the effective FIRM panel must match the printed streamline or the Profile Baseline to ensure the best match in station values between the Flood Profile and the DFIRM. The streamline is merged to be a single arc, clipped to the bounding cross sections and the direction flipped to match that of the cross sections (from downstream to upstream). Finally, a place holding or "dummy" table is needed for the first run of the *BFE_Tool* to allow the tool to run completely. Figure 1, below, shows the operation of the *BFE_Tool*.

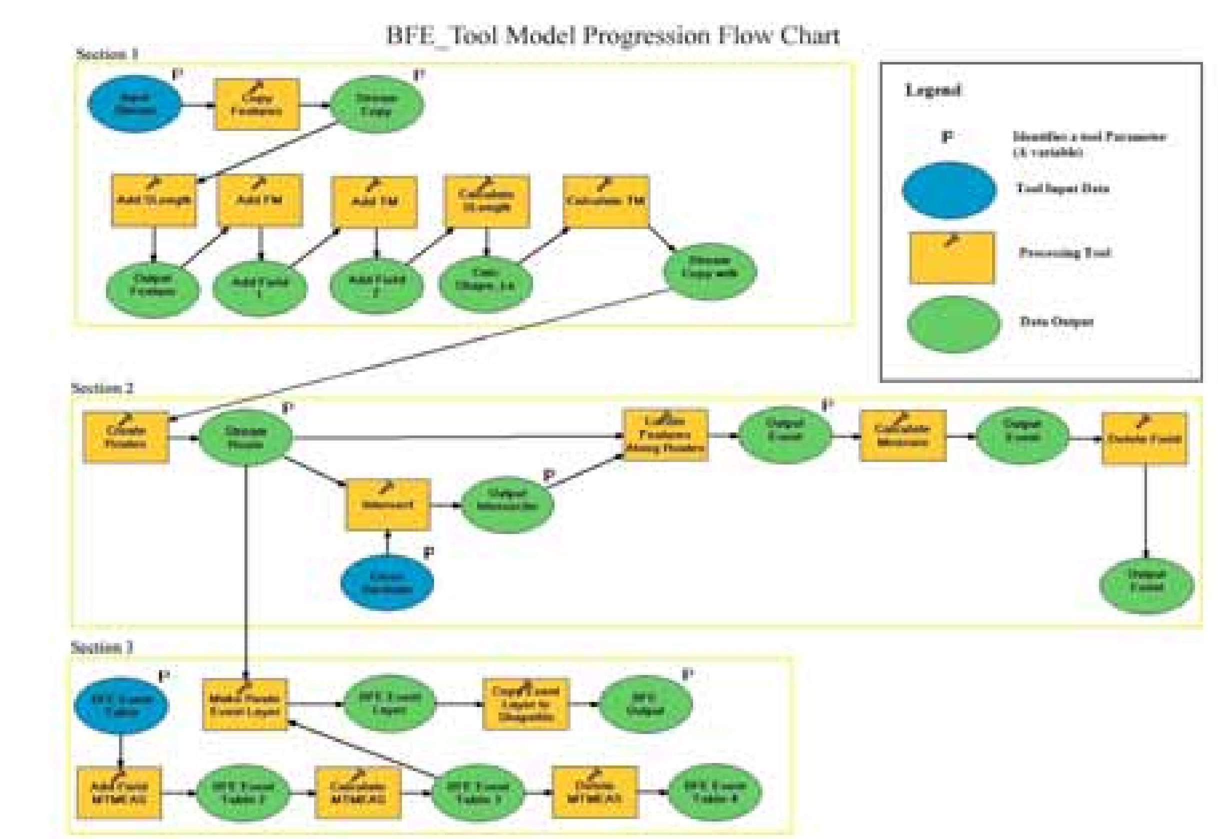

Figure 1

In operation, the *BFE_Tool* provides the user a parameters window to designate the input features, the output features, and the path to the data location, see Figure 2 below. To start, the *BFE_Tool* makes a copy of the input stream centerline feature class to not risk changing the original.

The attributes for length (SLength), from measure (FM), to measure (TM) are added automatically to the feature class by the *BFE_Tool* as shown in Section 1 of Figure 1. These values are automatically populated by BFE Tool and used in the creation of a route feature class using the “Create Routes” tool from the Arc Toolbox. The route system (or route feature class) provides a means for identifying locations along a line separate from the actual geospatial X and Y coordinates. This is important as these values generated by the route feature class can be compared with the station values present in the Flood Profile and FDTs.

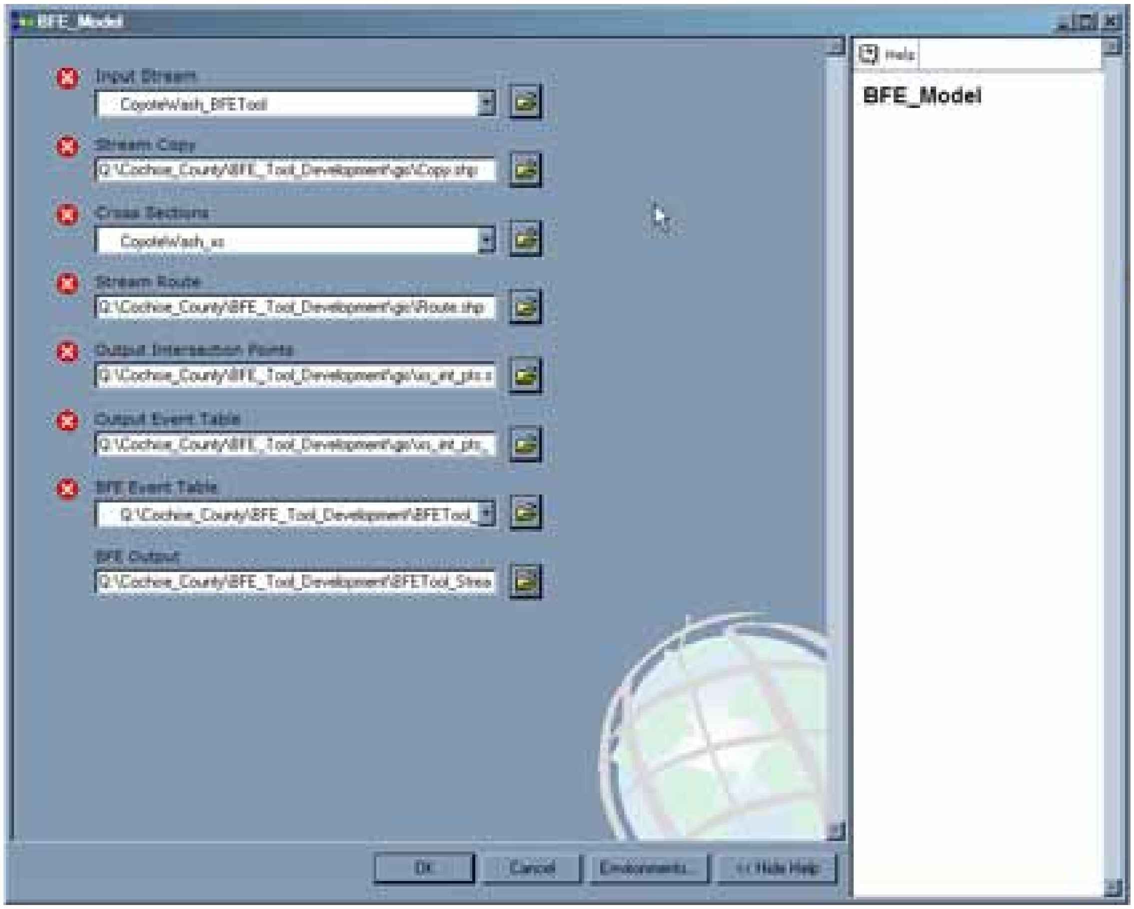

Figure 2

Next, the *BFE_Tool* was programmed to use the “Intersect” tool to find the intersection of the route system and the cross-sections to create a point feature class. This point feature class contains the attributes of both the measure along the route system as well as the attributes of the cross-section. At this point, the measure values are converted from the native DFIRM data format – meters – into English units – feet – to match the information as published in the Flood Profiles and FDT. The *BFE_Tool* then outputs these data into a dbase file. These steps are shown in Section 2 of Figure 1. It is at this point that the placeholder or “dummy” file is utilized for the remainder of the tool.

The output from the above steps is used as an input for the numerical processing, which is completed in Excel. The objective of the numeric processing is to compute the whole-foot station or route measure values for the BFEs. To achieve this the working assumption is that the rate of change of the water-surface elevation is linear between cross-sections. Calculation of the slope of the line between cross sections allows us to compute or back-calculate the new station values for the BFE contours. These values are the new whole-foot water surface elevation contour locations along the streamline. These data are exported from Excel as a dbase file, which is the input for the second run of *BFE_Tool*.

In the second run, the user uses the parameters window to specify the necessary inputs being sure to select the dbase file created in the numeric processing step instead of the placeholder table used in the first run. The steps described above are repeated albeit with the data calculated from the numerical processing. The tool imports the updated station values from the numeric processing and matches them to the route measure of the feature class. The stream route system and the BFE event table are used to create a route events feature class. The event feature class is then converted to a point shapefile. This point shapefile represents the location along the streamline of the NAVD 88 BFE elevations. Labeling of these BFE points with the elevation facilitates drawing and subsequent attribution. The new BFE features can now be drawn in the DFIRM database by the GIS technician. Figure 3 outlines the operations of *BFE_Tool*.

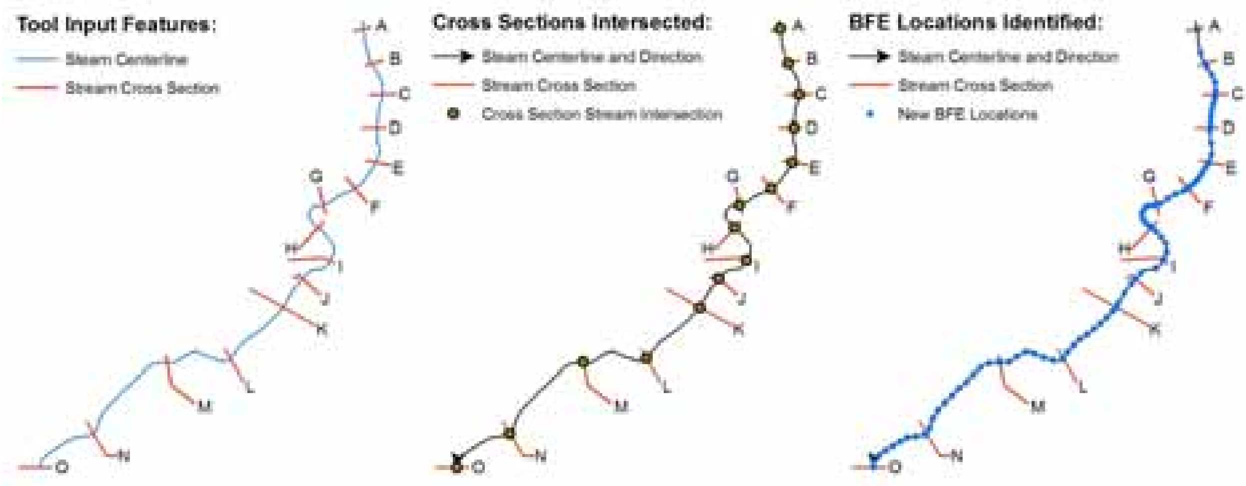

Figure 3 Streamline Processing Steps of the *BFE_Tool*

CONSIDERATIONS

The *BFE_Tool* was first used in production on 2005 DFIRM conversions of Cochise and Yavapai Counties, Arizona. The BFEs, as an output of the tool, were reviewed both internally and externally as part of the DFIRM QA/QC process. Comments from these reviews were favorable. The tool succeeded in locating BFEs that correctly matched the NAVD 88 Flood Profile where the slope was linear or nearly so between the cross-sections. The tool failed to correctly locate the BFEs where one or more breaks exist in the Flood Profile between cross-sections. This observation of the weakness of *BFE_Tool* and data reduction procedure was anticipated because of the assumption of a linear relation of the Flood Profile between the cross-sections.

Critique of the tool and procedure indicate that relying solely on the cross-sections for elevation input and control diminishes the reliability of output. Additional control points identified from the Flood Profiles, such as roads or stream confluences, could be easily added as inputs along with the cross-sections. Additionally, each profile should be evaluated to identify significant breaks in the slope of the line between the cross-section and other elevation control points. Where these breaks are identified additional elevation (control) data should be added as input.

CONCLUSION

ArcGIS Model Builder and the custom *BFE_Tool* created in it provided a robust tool to streamline the process of vertical datum conversion of BFEs in a DFIRM project. This tool assisted in the generation of BFE contour locations that were consistent, uniform, repeatable, and accurate in most cases.

ACKNOWLEDGMENTS

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