GEOSPATIAL CAPABILITIES OF HEC-RAS FOR MODEL DEVELOPMENT AND MAPPING

Cameron T. Ackerman, P.E., D.WRE, cameron.ackerman@usace.army.mil; Mark R. Jensen; and Gary W. Brunner, P.E.; Hydrologic Engineering Center, Institute for Water Resources, U.S. Army Corps of Engineers, 609 2nd St., Davis, CA 95616; (530) 756-1104

Abstract: The use of geospatial data for the development of hydraulic models and mapping of simulation results has become standard practice for floodplain evaluation. As the use for geospatial data has grown, reliance on a GIS to store, process, and visualize data has increasingly placed requirements on the hydraulic engineer to develop GIS proficiency. GIS proficiency has resulted in even more complex datasets being provided to the hydraulic engineer, requiring additional GIS expertise to manage and process data suitable for hydraulic analysis. Geospatial capabilities have been added to the Hydrologic Engineering Center's River Analysis System (HEC-RAS) to allow the hydraulic engineer to more efficiently develop hydraulic models through visualization of model results and refinement of model geometry within a consistent modeling environment.

INTRODUCTION

The use of geospatial data with the Hydrologic Engineering Center's River Analysis System, HEC-RAS, began in the mid-1990s when the geometric data was georeferenced. A spatial data format was also developed that would allow import of geospatial data developed through GIS or survey to be imported for the river network and associated floodplain geometry. At the time, gathering geometric base data for a ground surface that could be used for hydraulic modeling was often cost-prohibitive except for major studies that found multiple uses (and therefore multiple funding sources) for the terrain data. As the availability and relative affordability of geospatial data improved, GIS tools to utilize the data more efficiently for hydraulic analysis progressed, as well. HEC-GeoRAS, released in 1999 for Arc/Info, was the first interface built specifically to assist hydraulic engineers take advantage of using terrain data within a GIS (HEC, 1999). The HEC-GeoRAS interface was comprised of a simple set of macro tools that allowed hydraulic engineers, that were unfamiliar with using a GIS, to create geometric data and extract cross-sectional information from a terrain data source for a river hydraulic model. Hydraulic simulation results could then be exported back to GeoRAS to perform automated floodplain delineation within the GIS. These automated tools greatly improved the efficiency with which hydraulic models could be created and results analyzed.

As newer GIS software was developed that improved geospatial visualization and computational efficiency, newer versions of HEC-GeoRAS followed (HEC, 2002; HEC, 2005; HEC, 2009). The hydraulic engineering community had to become more experienced GIS professionals in order to keep up with changes to GIS software and fully utilize the tools and data available.

Therefore, new capabilities were added to HEC-RAS to allow modelers the benefits of automated data generation and analysis using GIS data without having to become expert GIS users.

HEC-RAS CAPABILITIES

New to HEC-RAS version 4.1 is the capability to perform floodplain delineation directly within the HEC-RAS software. These new floodplain delineation tools in HEC-RAS increase the efficiency of model analysis and refinement by allowing the use and visualization of geospatial data, along with RAS simulation results, within a single modeling environment. Therefore, hydraulic modelers can focus on hydraulic analysis without the need of additional GIS software or knowledge. The GIS tools created in HEC-RAS are available through the RAS Mapper interface.

The RAS Mapper, shown in Figure 1, is arranged based on the underlying HEC-RAS data organization. The RAS Mapper provides a Layer Window which provides a list of layers to be displayed in the Display Window. The layers list is organized in a tree node structure that distinguishes between Geometry, Results, and Terrain data.

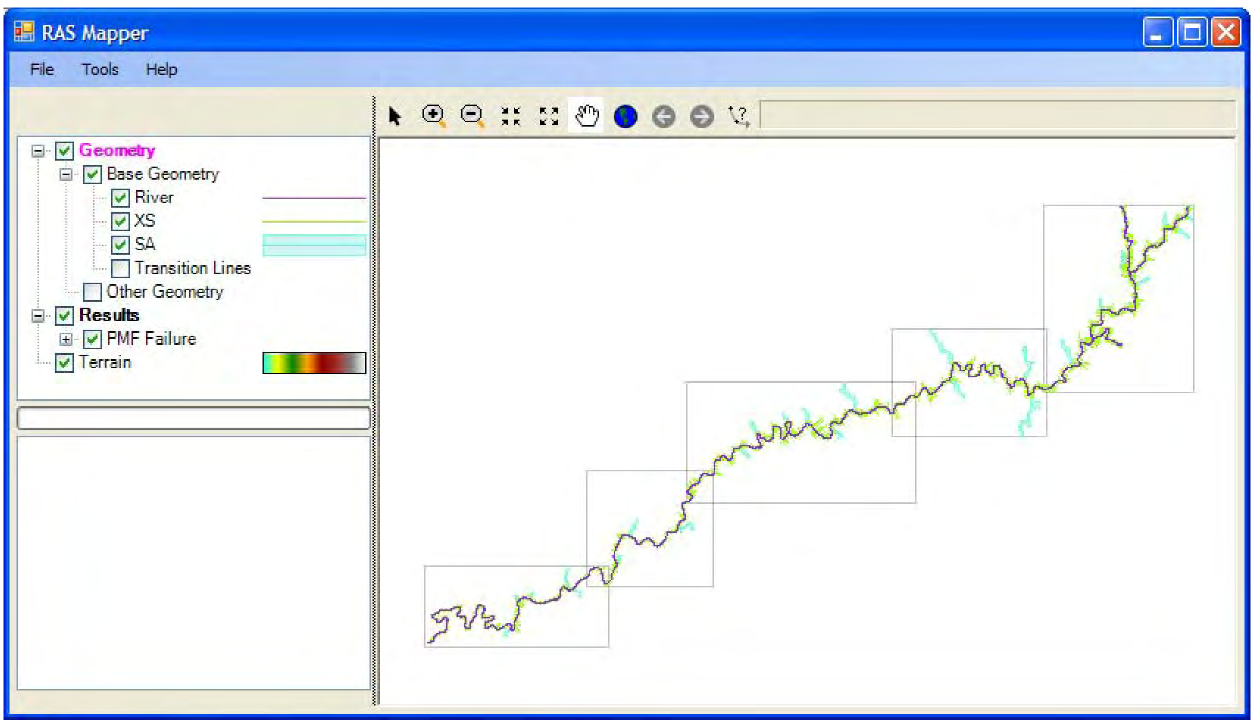

Figure 1 The HEC-RAS Mapper provides geospatial processing and visualization of data.

TERRAIN

The underlying premise of using geospatial data for hydraulic modeling is that a terrain model exists for the floodplain of study. The RAS Mapper has been built to utilize the binary raster floating-point value format. The “float” (or FLT) format is a non-proprietary format that consists of two files: the binary floating-point file (.flt) stores the grid values and the supporting header file (.hdr) that describes the gridded data. The FLT format is a convenient format to use because many software packages support the import and export of this format and the files can be compressed for data storage and dissemination.

HEC-RAS supports either a single terrain model or multiple terrain tiles that cover the area of interest. The handling of the gridded data has been implemented so that there is no software limitation on the number or size of terrain files. Further, it is encouraged that users store terrain data using a tiling scheme of multiple (smaller) terrain tiles to reduce the number of empty grid cells (i.e. NoData or Null data cells) where the terrain is not used for analysis. This is further encouraged by how RAS manages the terrain data - one layer is used for organizing, accessing, and displaying multiple terrain data sources.

GEOMETRY

HEC-RAS geometry in the RAS Mapper is synced with the geometry in the RAS Geometric Editor. Layers are created in the RAS Mapper for river centerline, cross sections, and storage areas for each geometry file. These layers are then available for interpolation and mapping of simulation results. Version 4.1 introduced the inundation mapping capabilities. Future versions of HEC-RAS will provide tools for creation, editing, and extraction of geometric data.

The shape of the river centerline, cross section locations, and bank station locations are used to create transition lines from cross section to cross section. These transition lines connect the cross sections along the river centerline, at the bank stations, and at the end of the cross sections and are stored in the shapefile format to allow users to edit the lines outside of RAS. The transition lines and cross section lines are then merged and triangulated to create an interpolation surface. The interpolation surface will determine how the output results from RAS simulations will be spatially distributed.

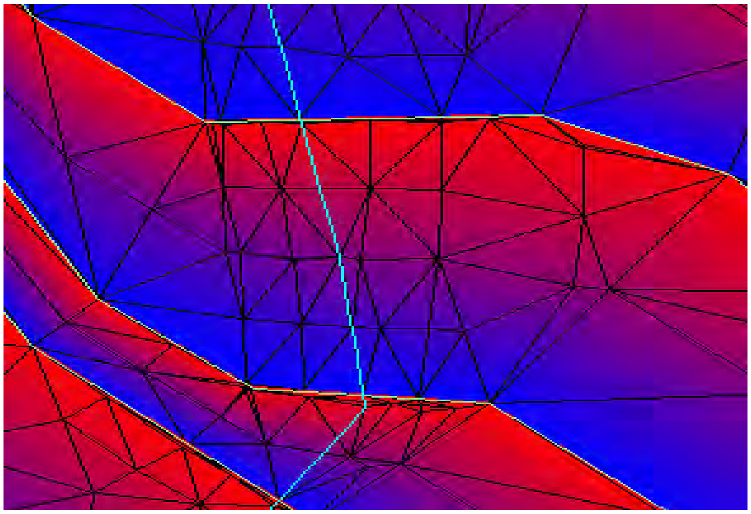

Figure 2 Example interpolation surface between cross sections.

RESULTS

The interpolation surface determines how simulation results will be distributed spatially between cross sections. Output variables that can be processed include the floodplain boundary and inundation depth. Provided that the floodplain boundary was previously computed, additional variables that can be mapped include velocity, shear stress, stream power, and ice thickness. The floodplain mapping dialog shown in Figure 3, provides access to the water surface profiles and variables available for mapping.

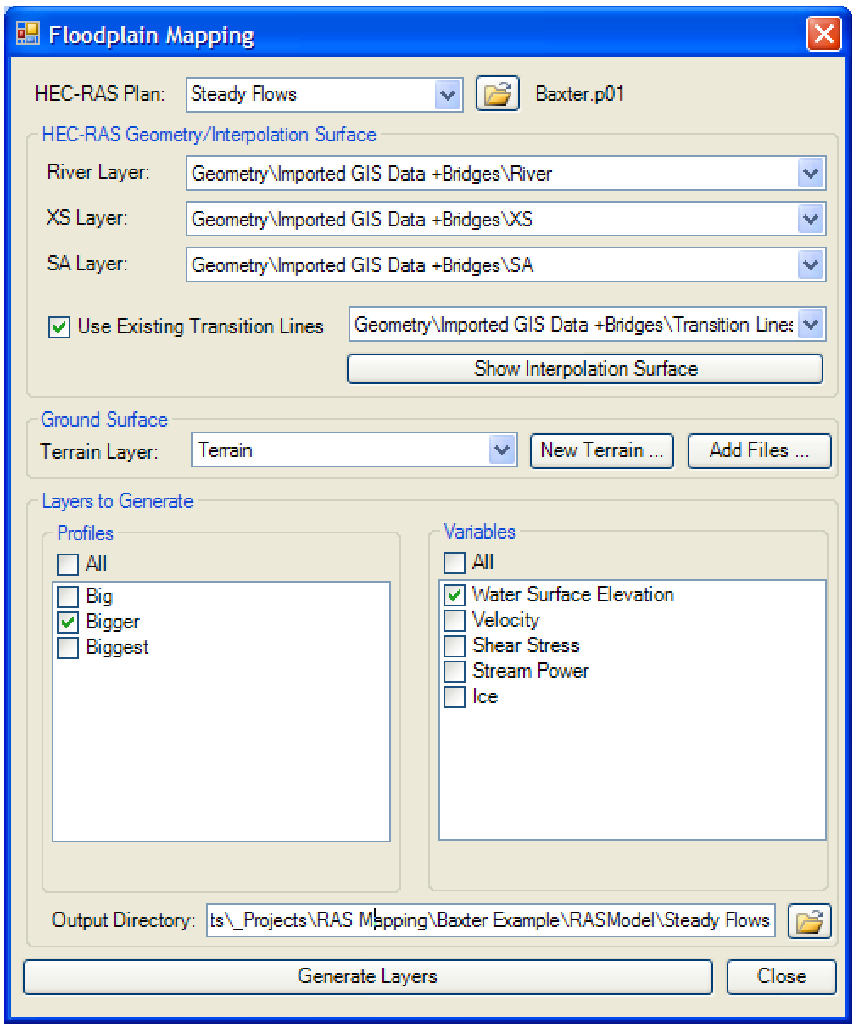

Figure 3 Profiles and variables for processing are selected in the Floodplain Mapping dialog.

<u>Floodplain Delineation:</u> Floodplain delineation results are achieved by applying the water surface elevations computed by RAS to the interpolation surface. The water surface elevation surface is converted to a grid and differenced with the ground surface to create a continuous depth surface (positive depths are considered wet, negative depths are considered dry). If levees are present, the levee elevations are added to the terrain. At this point, the final inundation depth grid is evaluated as those areas that have a positive depth and that are connected (so areas separated by a levee are removed). If storage areas are present, the water surface elevations for each storage area are evaluated and the depths are added to inundation depth grid. The inundation depth grid is stored in the binary float format based on the properties of the underlying terrain dataset.

The floodplain boundary polygon, however, is computed contouring the continuous depth surface (that has positive and negative depths) at zero depth. This creates a smoother, more accurate transition from one grid cell to the next and allows for only a portion of a grid cell to be included in the floodplain delineation. The floodplain boundary polygon is stored in the Shapefile format (ESRI, 1998).

Visualization: While the RAS Mapper results are being written to formats that can be easily viewed in other GIS packages, the benefit of this analysis to RAS users is that the data can be readily viewed alongside the base geometric data that was used in creating the river hydraulics model. Further, multiple parameters can be processed and examined together to quickly identify model deficiencies requiring correction.

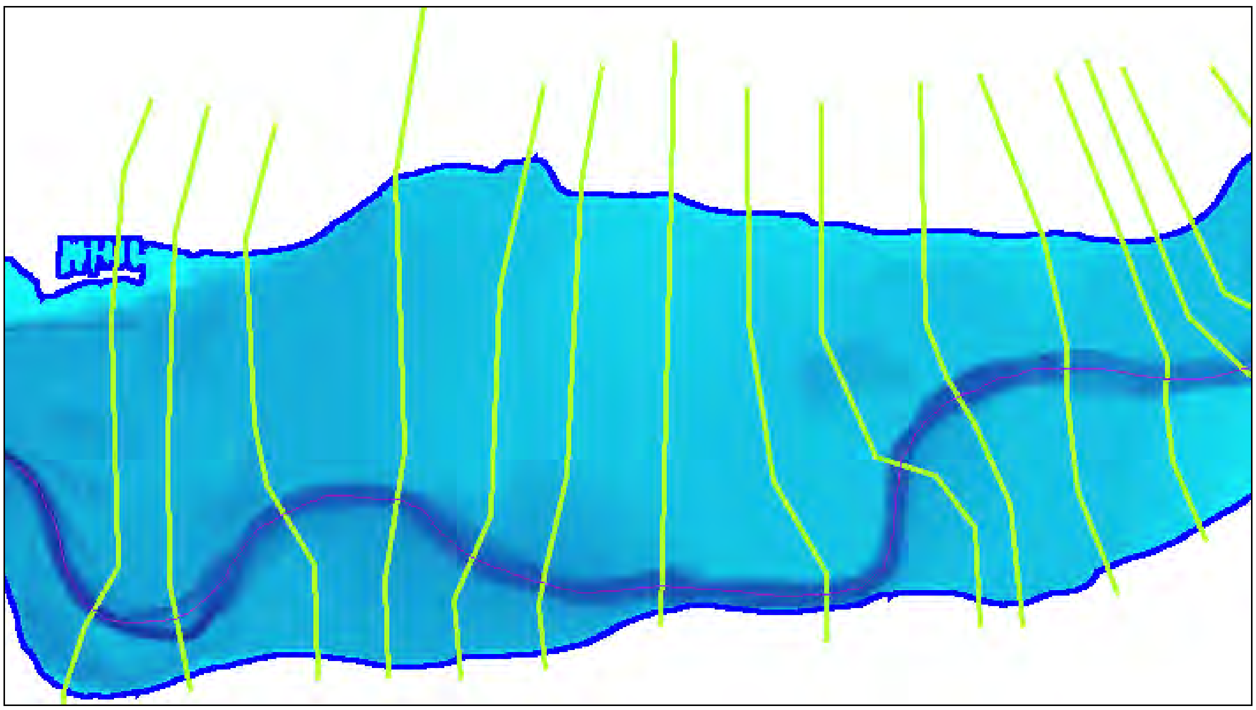

Figure 4 Example depth grid overlain with cross section locations in the RAS Mapper.

SUMMARY

The addition of geospatial capabilities to HEC-RAS 4.1 through the RAS Mapper allows the user to process and visualize the spatial distribution of simulation results. These improvements will allow hydraulic modelers the opportunity to more efficiently build, refine, and analyze hydraulic models because they will not be required to obtain and learn an additional piece of software to perform mapping of output. The technology added to the HEC-RAS software utilizes standardized file formats for output data and emphasizes the need to handle very large terrain datasets that may be stored in multiple terrain files. Further, the floodplain delineation method introduced has marked improvement over current automated techniques. In future versions of HEC-RAS, users can expect to see continued improvement in the floodplain delineation methods, increased support for background data, and tools for creating geometry data.

REFERENCES

ESRI (1998). *ESRI Shapefile Technical Description, An ESRI White Paper*. Environmental Systems Research Institute, Inc., Redlands, CA. (http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf)

HEC (1999). *HEC-GeoRAS – An extension for support of HEC-RAS using ArcInfo*, CPD-75, March 1999. Hydrologic Engineering Center, Institute for Water Resources, U.S. Corps of Engineers, Davis, CA.

HEC (2002). *HEC-GeoRAS – An extension for support of HEC-RAS using ArcView*, CPD-76, October 2002. Hydrologic Engineering Center, Institute for Water Resources, U.S. Corps of Engineers, Davis, CA.

HEC (2005). *HEC-GeoRAS – An extension for support of HEC-RAS using ArcGIS (v8.3/9.1)*, CPD-83, September 2005. Hydrologic Engineering Center, Institute for Water Resources, U.S. Corps of Engineers, Davis, CA.

HEC (2009). *HEC-GeoRAS – An extension for support of HEC-RAS using ArcGIS (v9.2/9.3)*, CPD-83, September 2009. Hydrologic Engineering Center, Institute for Water Resources, U.S. Corps of Engineers, Davis, CA.

HEC (2010). *HEC-RAS River Analysis System, User’s Manual, Version 4.1*, CPD-68, January 2010. Hydrologic Engineering Center, Institute for Water Resources, U.S. Corps of Engineers, Davis, CA