Applying GIS to Hydraulic Analysis

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Abstract

HEC-RAS is one of the popular programs that are made for hydraulic analysis. This is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. In spite of many benefits of this program, some problems are found while running HEC-RAS. The most significant problem is the geometric input data. This procedure requires lots of manual work and gives engineers a burden of manipulating. Geographic Information System (GIS) could be an excellent assistant to aid this time-consuming work. GIS provides a powerful tool for spatially distributed data and makes the input procedure easier. HEC-GeoRAS allows engineers to develop geometric data for import in HEC-RAS and view exported water surface profile result data. As a result, the engineer could concentrate on hydraulic principles, rather than time-consuming work, during model analysis.

Introduction:

This project deals with Linking GIS to Hydraulic Analysis using HEC-GeoRAS and HEC-RAS. HEC-GeoRAS provides a graphical user interface (GUI) that enables the hydraulic engineer to create a HEC-RAS import file containing geometric attribute data from an existing digital terrain model (DTM), process water surface profile data exported from HEC-RAS, and perform floodplain mapping. Without supporting HEC-GeoRAS, lots of manual works are required during hydraulic analysis. During running HEC-RAS, data preparation and model interpretation consume a lot of time. But hydraulic modeling of river systems may be facilitated and could evaluate more accurate results with GIS. This is why GIS is recommended in...
hydraulic modeling.

**Literature Review**

To perform this project, several articles and books are reviewed. The two main programs that are used in this project are HEC-GeoRAS and HEC-RAS. Therefore ‘HEC-RAS: River Analysis System User’s manual’, ‘HEC-RAS: River Analysis System Application Guide’, and ‘HEC-GeoRAS An Extension for support of HEC-RAS using ArcView’ are indispensable to practice both programs. To Link HEC-RAS to HEC-GeoRAS, understanding of geometric input system at HEC-RAS is needed, so ‘HEC-RAS River Analysis System Hydraulic Reference Manual’ is used to understand the theory and data requirements for the hydraulic calculations performed by HEC-RAS. ‘Floodplain Determination Using ArcView GIS and HEC-RAS’ introduced Linking ArcView and HEC-RAS to increase efficiency and accuracy. Meanwhile, ‘HEC-GeoRAS: Linking GIS to Hydraulic Analysis Using ARC/INFO and HEC-RAS’ represent linking ARC/INFO and HEC-GeoRAS to provide a simple, logical user environment. Because ArcView is easier to handle than ARC/INFO, I determined to find and execute the way to link ArcView and HEC-GeoRAS.

**Methodology**

Most of all, HEC-RAS and HEC-GeoRAS are indispensable at this project. Both program could be obtained from Hydrologic Engineering Center of the U.S. Army Corps of Engineers. These are free softwares but the important fact is that HEC-GeoRAS is a extension which is scripted with AVENUE, so ArcView 3.X version program with 3D analysis is needed to use HEC-GeoRAS. When all of above programs are obtained, project is ready to start. First, triangulated irregular network (TIN) data of the river channel and surrounding floodplain must be required to prepare geometric data. There are two way to get TIN data, The first way is to find TIN data directly from available source and another way is converting digital elevation model (DEM) into TIN using ArcGIS. In this project, TIN data of Jennings creek at central Colorado are used.
After loading the Terrain TIN using the ArcView, create contours from the Terrain TIN.
Stream centerline and Bank themes are used to establish the river reach network. Using Draw Line tool and River Reach ID tool, define the stream centerline and banks.

The flow path centerlines theme is used to determine downstream reach lengths between cross sections in the channel and overbanks areas. Cross section cut lines are used to identify location at which cross sectional data will be extracted from Terrain TIN and for bank station, downstream reach length, and land use computation. Therefore flow path centerlines have to be drawn within cross section.
Picture 6 Create Flow Path Centerlines and Cross Sections

The two themes which have data appended to their tables are the stream centerline and cross section cut lines themes. Using input data, two intermediate data, which are Stream Centerline (3D) and XS Surface Line (3D), would be created. Once two data are created, create the complete import file that has information of stream network and cross section information.

Picture 7 Theme setup
Now, new geometric data could be imported from HEC-GeoRAS. If there are artificial hydraulic structures such as bridges and culverts, these data will need to be completed with HEC-RAS. Once completing the flow data and boundary condition, run the HEC-RAS to obtain water profiles. Then simulation results are obtained.

To use HEC-RAS simulation results, export the results to the RAS GIS Export File with RAS Post-Processor.

**Picture 8 HEC-RAS**

**Picture 9 Simulation Results from HEC-RAS**
Once the data has been read in from the RAS GIS Export File, water surface and velocity data sets could be created with post-processing.

Application, results and discussion

My study area is the Jennings Creek at Central Colorado. I obtained the TIN data from Dr. R. Srinivasan’s web page. The results of this project are water surface polygon, depth grid, and velocity grid.
Picture 9 represents the simulation result from HEC-RAS. Although that HEC-RAS provides graphical user interface, inexperienced engineers might need some time to be familiar with interface. But anyone who did not familiar with hydraulic analysis could find the simulation results easily at HEC-GeoRAS. Even if research area is huge, the engineer could concentrate on hydraulic analysis and results from simulation.

**Conclusion**

This project focused on linking GIS tools to Hydraulic analysis. The notable acquirement from this project is that engineers could reduce time to prepare geometric data. Before using GIS, geometric data preparation is time-consuming and painful work. But GIS allows the engineer to concentrate on hydraulic principles rather than data preparations. If detailed TIN data were given, more accurate results would be produced. Results from hydraulic analysis are displayed in the GIS. It is easy to confirm results (Floodplain extent, flood depth, velocity). Meanwhile, there is a one thing that might be improved at next version of HEC-GeoRAS. Because of the geometric interpolation routines in HEC-RAS, inaccurate results could be calculated if number of cross sections is not enough. Thus, lots of cross sections are
needed by manual work. In order to avoid this, I hope that the function, which can produce cross sections automatically, should be added at next version.

References


