J7.5 # FLDVIEW: THE NWS FLOOD FORECAST MAPPING APPLICATION

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1. INTRODUCTION

The National Weather Service (NWS) is responsible for providing river forecasts of our Nation's streams. After it has been determined that a flood event is eminent, a piece of useful information flood forecasters can provide is the expected aerial extent of flooding. This type of information helps emergency managers and the general public focus attention on the most appropriate areas. Currently, information about the areas expected to flood is part of a flood forecast, but the information on the extent of flooding is often coarse (i.e. county or regional-scale), and it may be given in a text format. With the proliferation of computers, the general public has been tuned to expect and better understand visual images. The need has arrived for river forecasters to produce graphical information showing the areas that may flood.

The NWS flood forecast mapping application (FLDVIEW) is developed to produce maps of the expected aerial extent of flooding in an operational setting where timeliness is as important as accuracy. FLDVIEW has been developed using ESRI's ArcView 3.1 software along with the Spatial Analyst and 3-D Analyst extensions. It uses custom scripts written in Avenue, ArcView's scripting language, to produce a map of the inundated area in both raster and vector formats. This paper describes the capabilities of FLDVIEW and its application on the Juniata River in the vicinity of Lewistown, PA.

2. OVERVIEW OF FLDVIEW

The flood raster is a hydraulic representation of the water surface in a specified area. It represents the extent of flooding due to unsteady flow, backwater from tributaries or man-made structures (e.g., dams, bridges, levees) and levee overtopping/ failure. FLDVIEW, a geographic information system (GIS) application, takes advantage of the increased availability in digital-spatial data and the relative ease in using current, off-the-shelf GIS software. The development of the flood raster in FLDVIEW involves three activities: (1) processing the GIS data to obtain a ground grid; (2) processing the hydraulic data to obtain a water surface grid; and (3) generating the flood raster from the ground and water surface grids. The processes have been automated so the user is not required to have extensive knowledge of GIS or ArcView and so that the raster may be generated in a timely manner. The flood raster display within FLDVIEW makes the development of the flood raster more user-friendly. After the ground grid has been created, multiple flood rasters may be generated as often as a forecast is made.

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2.1 Ground Grid

To create a flood raster, a ground surface must first be generated in grid format using digital terrain models (DTM). Although FLDVIEW is not dependent on the type of DTM data used, the quality of the flood raster generated by FLDVIEW is directly related to the quality (resolution) of the DTM. For example, high resolution DEM from LIDAR (Light Detection and Radar) data will provide a more accurate ground grid than one using 7.5' DEM. If infrastructure data is available in the DTM, it may be extracted and made part of the ground grid. The river centerline and river bottom are also necessary to complete the ground grid. This data allows FLDVIEW to map below the lowest measured water surface. The latitude/ longitude of the starting and ending points of the routing reach are needed to determine the extent of the map. To prevent mapping beyond the extent of DTM, a base map is generated. After processing the land surface, structure and river bottom data, their results are combined to produce the ground grid. The ground grid is created once.

The current version of FLDVIEW can import an existing USGS DEM and convert it to a grid, or create a grid from contour lines in AutoCAD's DXF or ArcView's shapefile file formats. Although FLDVIEW will automatically process this data, other data types must be processed manually. The USGS DEMs are available for free on the Internet as part of the National Elevation Dataset (NED), but currently the finest resolution available nationally is 30 meters (NED 2001). As will be shown later, this resolution is not sufficient for producing flood forecast maps in most areas. In contrast, the AutoCAD DXFs or ArcView shapefiles are likely to produce more accurate maps, but are not freely available and must be acquired before using FLDVIEW. River centerline data is also available for free on the Internet through the National Hydrography Dataset (NHD) website. The NHD covers most of the country and is the result of an effort by the EPA and the USGS to merge EPA Reach File Version 3 (RF3) and the hydrologic features on the USGS topographic maps. FLDVIEW is currently automated to use this type of data, but it also allows for other ways of specifying a river centerline (e.g., importing it from another source or manually drawing it).

2.2 Water Surface Grid

The water surface grid is generated using the water surface and corresponding channel top width at specified locations along the routing reach and the river centerline. 2-Dimensional cross-sections are placed perpendicular to the centerline and extend into the flood plain to a distance equal to the water surface top width on both sides of the centerline. Usually, additional points are needed in the water surface profile to improve the accuracy of the water surface grid. The water elevation and top widths for these extra locations are linearly interpolated from the known cross sections. Depending on the sinuosity of the river, the cross-sections may overlap. To prevent this, the cross-section widths are reduced (clipped) by giving upstream ones precedence, but only for a limited distance downstream. Once the cross-sections have been clipped, a bounding polygon is automatically created by tracing a continuous line through all the cross-section endpoints and then is converted to a grid. The water surface elevations are extended perpendicularly away from the river until they intersect the ground; the intersections are connected to form inundation polygons and then converted to a grid. The final water surface grid the is intersection of the two grids.

Although the water surface profile may come from any source (e.g. hydrologic/hydraulic models, high water marks, empirical methods), the quality of the water surface grid is highly dependent upon the quality of the water surface profile. Although simpler methods may be adequate for many situations, many river systems require an unsteady-flow hydraulic model to account for the dynamic effects in the river system. When doing river forecasts, the NWS can generate a deterministic forecast (water surface profile of the peak condition during the forecast period) or a probabilistic forecast (several water surface profiles with each containing a different probability associated with the forecast points). Currently the NWS FLDWAV (Fread, 1998) dynamic routing model is used to generate either the deterministic or probabilistic water surface profiles and export all of the data necessary to run FLDVIEW. This file spatially identifies the user-defined upstream, downstream and intermediate cross-section locations along with their associated water surface elevations and top widths. In the event of levee overtopping, additional sets of water surface elevations and top widths are exported to represent the conditions on the town-side of the levee.

2.3 Flood Forecast Map

The flood forecast map is generated by subtracting the ground grid from the water surface grid. The resultant grid represents the extent of flooding. Once the ground grid has been generated, multiple flood forecast maps can be generated automatically as often as flood forecasts are made. These maps are in shapefile format and can be overlaid with other layers (e.g. orthophoto images, tiger maps, etc.).

3.0 CASE STUDY

FLDVIEW is applied to the Juniata River in Lewistown, Pennsylvania as part of a project done for the Susquehanna River Basin Commission. LIDAR data in AutoCAD's DXF format was obtained from SEDA-COG (SEDA Council of Governments) through the Susquehanna River Basin Commission (SRBC). This data contains contour elevations with 15 cm RMSE (Root Mean Squared Error) vertical and 1 m RMSE horizontal) as well as information about the structures (bridges) in the area. In addition, orthophoto images at the same resolution were supplied along with four high water marks for February 15, 1984.

The NWS FLDWAV model has been calibrated for the Juniata River from Lewistown, PA to Newport, PA using data from the January 11-20, 1996 flood event. Inflows from the 1984 flood event have been generated using the NWS River Forecast System (NWSRFS) and is used as input to FLDWAV. A deterministic water surface profile for February 15th is generated and mapped using FLDVIEW. Figure 1 shows the flood map generated by FLDVIEW overlaid by the orthophoto image and the high water marks. It can be seen that FLDVIEW does a reasonable job of matching the highwater marks.

To determine the sensitivity to the ground grid's cell resolution, the flood map using the AutoCAD data is compared to the flood map generated using the USGS 7.5' DEM with an accuracy of 30 m x 30 m horizontal and 7-15 m vertical. The 30 m resolution grid is derived from a 30 m DEM of the Lewistown, PA area downloaded from the USGS website. Figure 2 shows that the flood map generated using the USGS data is significantly less accurate than the flood map generated using the AutoCAD data. It is also noted that the flood map could not adequately move up the tributary. The error is due primarily to the large contour interval (~6 m vs. ~0.6 m). The peak water surface profile 1996 flood event is also mapped and similar results are shown in Figure 3.

4.0 SUMMARY

The NWS flood forecast mapping application (FLDVIEW) has been developed to show the extent of flooding. Given appropriate DEM, a water surface profile, and the river centerline, FLDVIEW will generate a flood forecast raster in shapefile format which can be overlaid with other information (e.g., orthophoto images, tiger maps, etc.). FLDVIEW can generate either a deterministic (instantaneous or peak condition) or probabilistic flood map. Although the ground grid is created once, multiple flood forecast maps may be generated as often as a river forecast is made. When applied to data for the Lewistown, PA area, the flood map generated by FLDVIEW compared well with the high water marks taken on February 15, 1984 when using the high resolution data. It has also be shown that the quality of USGS 30 m DEM is not adequate to generate a reasonable flood map for either the 1984 or 1996 event.

5.0 ACKNOWLEDGMENT

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5.0 REFERENCES

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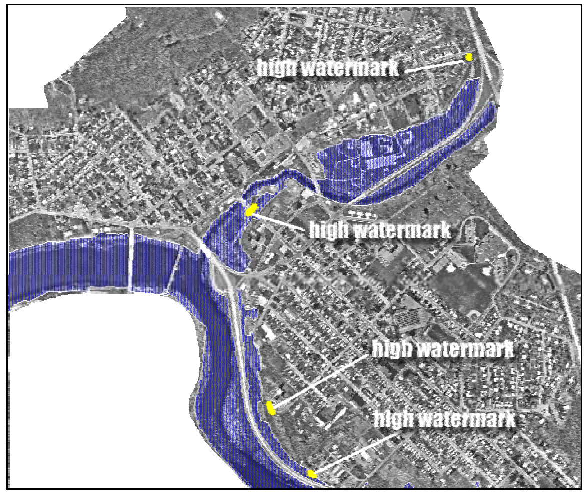

Figure 1 - 1984 Flood with known high water marks.

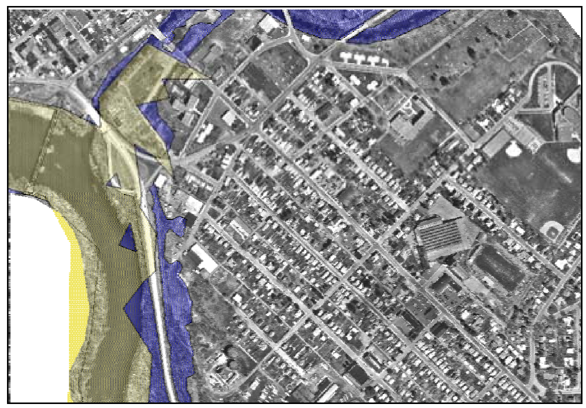
Figure 2 - Flood map comparing USGS data and AutoCAD data (1984 Flood)

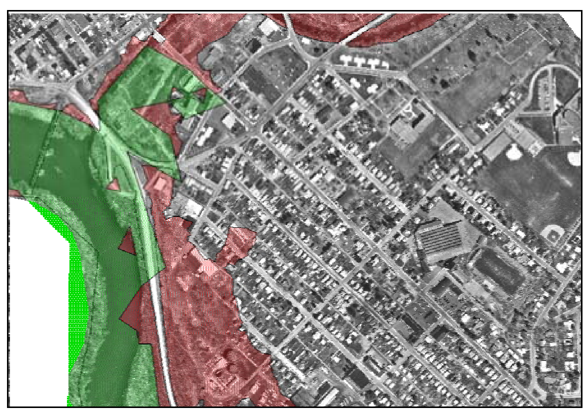
Figure 3 - Flood map comparing USGS data and AutoCAD data (1996 Flood)