DEM PROCESSING TO MAP SINKHOLE CATCHMENTS

Sinkhole location maps have been, or are being, prepared by various State agencies in the regional study area; however, different sinkhole identification and mapping criteria are being used and the catchment areas of the sinkholes are usually not delineated. In karst terranes, delineation of sinkhole catchment areas is equally if not more important to hydrologic or water-quality studies and assessments as delineation of surface-stream watersheds. For this regional study, individual sinkhole catchment areas define useful "subbasins" within the 10-digit HUs. Therefore, a method of GIS processing of DEM data sets was developed to standardize and partly automate the mapping of sinkhole catchment areas. Topographic depressions in the DEMs are identified and artificially filled using GIS-processing tools, and a grid of the difference between the filled and unfilled depressions is developed. "Throats," or locations within the depressions that are internally drained, are identified using a GIS "SINK" tool. Grid cells associated with these throats are grouped together by assigning them unique numeric values that lump throats together into clusters and tie the clusters to an associated topographic depression. Grouped topographic depressions and throats are then used as input data to define sinkhole catchment areas using a GIS "WATERSHED" delineation tool (fig. 4A). The grouping process helps eliminate over-tessellation (subdivision) of catchment areas for depressions identified in the raster grid (fig. 4B) and helps to produce more physically realistic delineations of sinkhole catchments, complex sinkholes, and the watersheds of sinking streams that terminate in a sinkhole depression. Additional processing techniques, such as setting filters on depression size (area) and buffers near surface streams and performing cross-checks with sinkholes identified on available State maps, are needed to eliminate depressions in the raster grid that are not likely to be actual dissolution-generated sinkhole features.

RELIC STREAM VALLEYS

One unique component of the GIS processing being done for the regional study is the delineation of relic stream valleys, which are also called paleovalleys (Thrailkill, 1985). Relic stream valleys are karst geomorphic features identifiable as alignments or "trains" of sinkholes sometimes co-located within shallow topographic valleys and often appear to be the downstream extensions of sinking or losing stream reaches. Relic stream valleys represent former surface-stream channels in which flow was abandoned as a result of subsurface conduit piracy. In this study, relic stream valleys are being delineated using a GIS approach similar to that described by Glennon and Groves (2002) in which the DEMs are processed so that traces of the former surface-flow routes develop as sinkhole depressions are artificially filled to their spillover points (figs. 5A and 5B).

The identification and mapping of relic stream valleys using GIS is a potentially important outcome of this regional study because these features are often associated with the locations of major karst conduits and karst drainage basins (Thrailkill, 1985). The trends and geomorphic characteristics of the relic stream valleys also provide clues that are helpful in conceptualizing the pre-karst drainage history and in understanding the development of conduit networks and the directions of subsurface flow revealed by dye-tracer tests (fig. 6). In addition, identification and mapping of relic stream valleys may help to identify potential flood hazard areas in the region's karst terranes. Flooding of relic stream valleys—as with sinking or losing streams—occurs when the drainage capacity of sinkholes, swallets, or karst conduits cannot accommodate the volume of stormwater runoff generated within the surface catchment area (Ray, 2001). This mechanism has been identified in at least one location in the regional study area where flooding of a relic stream valley has resulted in substantial property damage (Bayless and others, 1994), and it may be an important, but poorly recognized, potential karst hazard elsewhere.

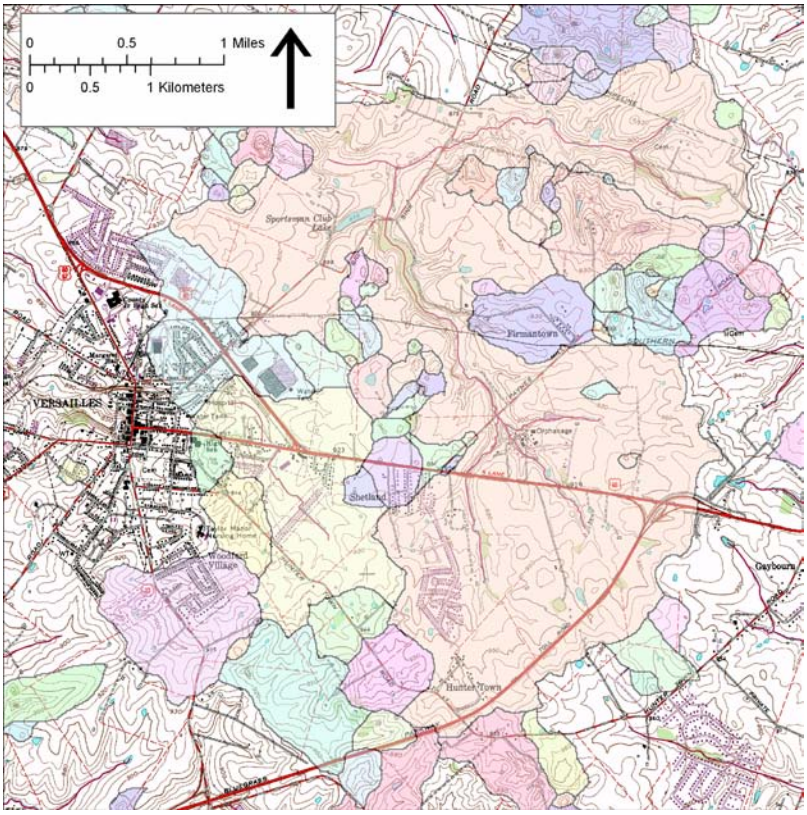

Figure 4A. Delineation of sinkhole catchments (shaded or colored polygons) near Versailles, Kentucky, (Inner Bluegrass karst terrane) using GIS-processed DEM data. The image shows the more realistic delineation of sinkhole catchments achieved by grouping "throats" (grid cells with internal drainage) within topographic depressions prior to applying the "WATERSHED" delineation tool.

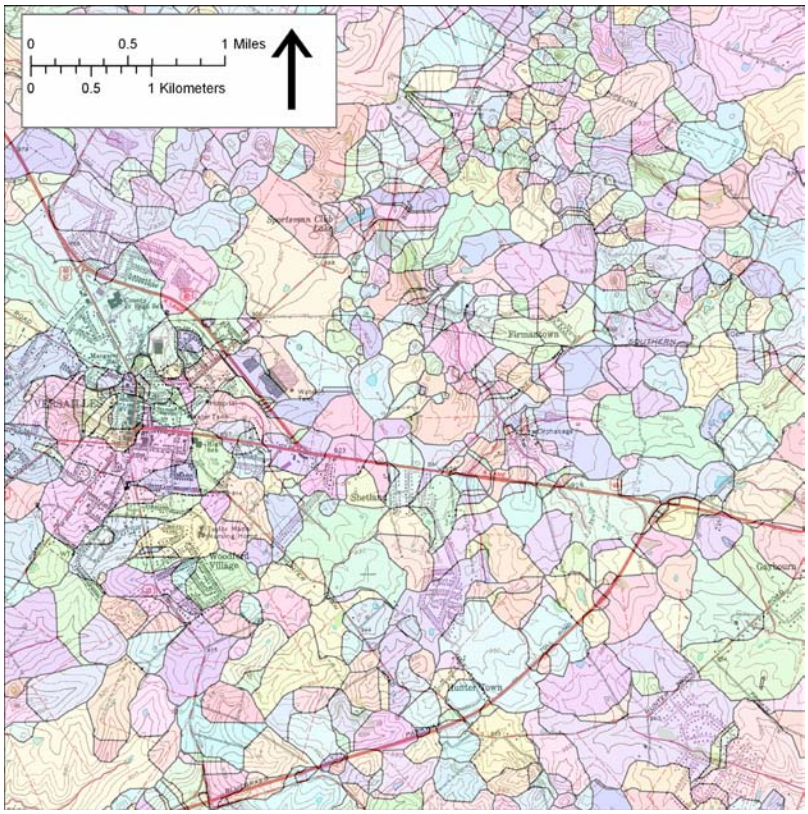

Figure 4B. Delineation of sinkhole catchments in the same area as that shown in figure 4A, illustrating the over-tessellation obtained by applying the "WATERSHED" delineation tool without grouping "throats."

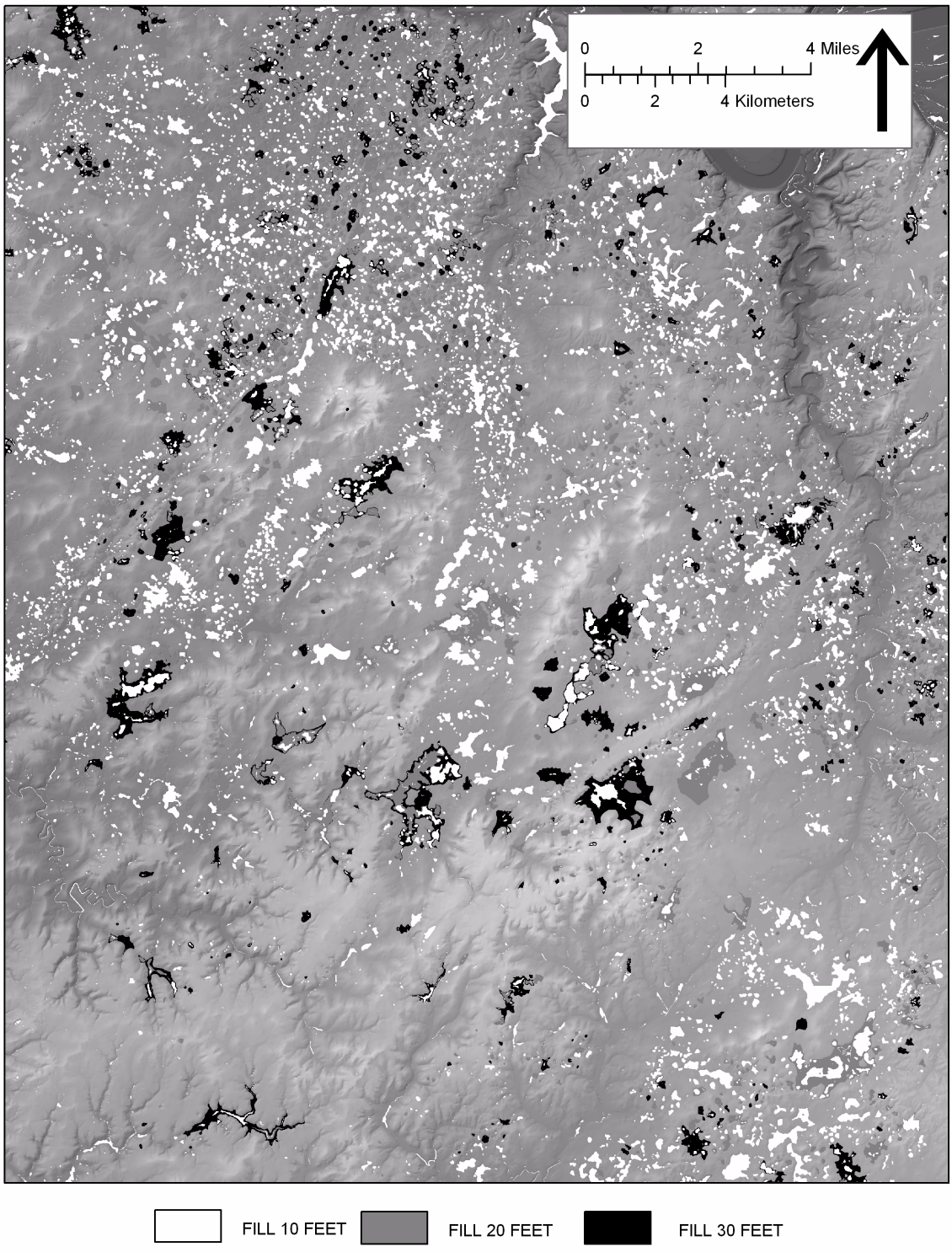

Figure 5A. Example of DEM processing used to delineate relic stream valleys in part of the Central Kentucky karst terrane. The image shows the geomorphologic patterns obtained by artificially filling identified sinkhole depressions to three different depths (indicated by shading).