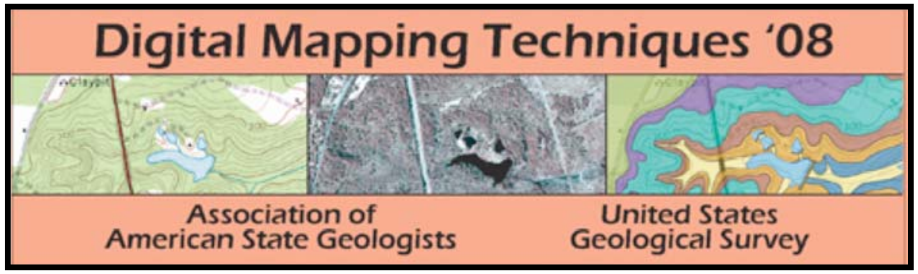

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The contents are provisional and will be
superseded by a paper in the
DMT'08 Proceedings.

See also earlier Proceedings (1997-2007)
http://ngmdb.usgs.gov/info/dmt/

Creating Geologic Maps for the Appalachian Plateau in a GIS Environment

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Abstract

Using GIS analysis in combination with traditional fieldwork, we have developed a system to produce geologic maps utilizing coal resource data, oil and gas information, and field data. Field mapping is being conducted at scale of 1:24,000, but compilation of mapping at other scales is highly desirable. The availability of other datasets, such as high resolution digital elevation models and much improved U.S. Census Bureau Tiger files are being considered by the West Virginia Geological and Economic Survey (WVGES) for use in developing new digital base maps potentially ranging in scale from 1:4,800 to 1:250,000 or smaller.

West Virginia has a wealth of geologic and mineral resources information. Petroleum resources extraction began in 1859, and development of a digital oil and gas database at WVGES began in the late 1960s. Large-scale coal mining in West Virginia, which began immediately after the Civil War, has generated vast amounts of coal resource and mining information. In 1995, the WVGES Coal Bed Mapping Program (CBMP) began developing a GIS-based mineral inventory. This inventory includes several GIS layers including structure grids, thickness grids, mining, and outcrops for each economically mineable coal bed.

Introduction

WVGES has been collecting, archiving, and, more recently, developing digital databases of geologic and mineral resource data in West Virginia for many years. The extraction of petroleum resources in West Virginia began in 1859, and development of a digital oil and gas database at WVGES was initiated in the 1960s. Large-scale coal mining began in West Virginia immediately following the Civil War, and it has generated a wealth of coal resources and mining information. The Coal Bed Mapping Program (CBMP) and its predecessor the Coal Resources and Pollution Potential Study are sources of much pre-interpreted mineral resource information that have provided a starting point for our mapping. The structure of the probable mineable extent of the Pittsburgh coal, shown in Figure 1, is an example of the large amount of coal resource information available at WVGES. Coal resource maps and GIS coverages have been created for 42 mineable or potentially mineable coal beds in West Virginia to date. The WVGES Oil and Gas digital database, which contains information about more than 140,000 oil and gas wells, is another useful source of data. Locations of wells included in this digital database are shown in Figure 2. This leverage has enabled us to complete two or three quadrangles per year in data dense areas. Even without this pre-processed information, given reasonable data density, the procedures described below represent a reasonable strategy to develop geologic maps in a GIS environment.

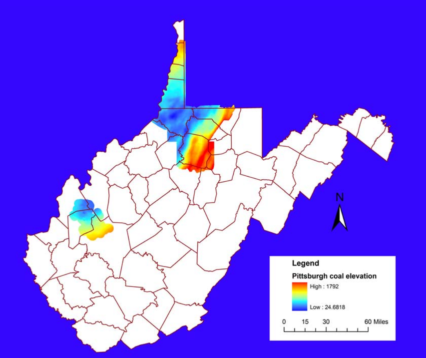

Figure 1. This representation of the structure of the probable mineable extent of the Pittsburgh coal, which forms the base of the Upper Pennsylvanian Monongahela Group, is an example of the large amount of resources information available at the West Virginia Geological and Economic Survey. The colors represent elevation of the base of the coal. Elevations range from a little less than 24 feet above sea level in the center of the basin (represented by the deepest blue) to 1792 feet above sea level (represented by the brightest red). The presence of thin coal that is not economically mineable is responsible for the apparent gap in data in western West Virginia. The southern area is connected to the northern area through Ohio.

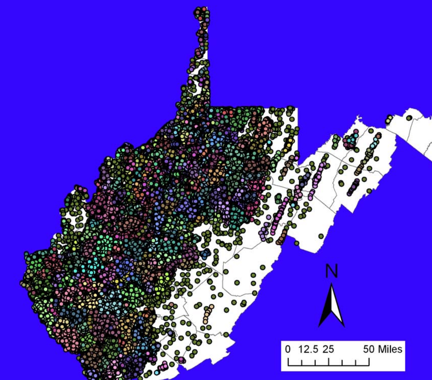

Figure 2. The locations of the more than 140,000 oil and gas wells contained in the WVGES Oil and Gas database.

Methodology

Geologic mapping in relatively flat lying rocks of the Appalachian Plateau involves tracing important marker beds that are coals, sandstones, or other geographically extensive units. Pennsylvanian unit boundaries are frequently associated with coal beds, e.g., the base of the Upper Pennsylvanian Monongahela Group is the base of the Pittsburgh coal bed (Figure 2) and the boundary between the Washington and Greene Formations of the transitional Upper Pennsylvanian-Lower Permian Dunkard Group is the base of the Jollytown coal bed (Figure 3).

The first priority during a mapping project is to do a triage of coal resources information produced by the CBMP for the proposed mapping area and to identify gaps in data coverage where the important marker beds do not represent economically important resources. Oil and gas data, other data from Survey files, and collection of additional field data are used to eliminate these gaps. Oil and gas data also provides subsurface information for completing cross sections.

Croplines of important beds are automatically generated by intersecting the grids representing structure of each bed with the grid representing the topography. This process is accomplished by subtracting the two grid surfaces and generating a zero contour line that denotes the cropline (Figure 3).

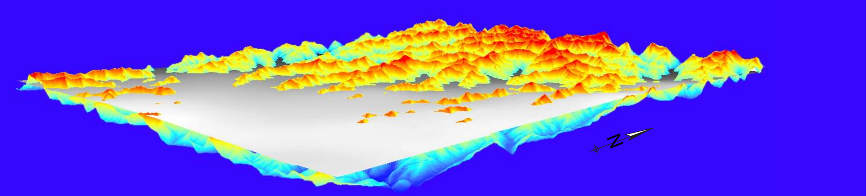

Figure 3. The Jollytown coal bed is the horizon that divides the Washington and Greene Formations of the transitional Upper Pennsylvanian-Permian Dunkard Group. The Jollytown coal bed structure on the Mannington 7.5-Minute Quadrangle is represented in gray shades. This horizon was extrapolated by adding a fixed interval to the elevation grid for the underlying Washington coal bed, although sophisticated statistics can be utilized to estimate the interval between markers where a variable interval is appropriate. The more colorful grid is the 1/9 arc second resolution digital elevation model where warm colors represent higher elevations and cooler colors represent lower elevations (vertical exaggeration 3x). By definition, the cropline is the intersection of these two surfaces.

Preliminary field maps include the croplines of all critical horizons, as shown in Figure 4, a representation of part of the field map for the Mannington 7.5-Minute Quadrangle. In creating the preliminary field map, to an extent, three-dimensional geologic data has become reduced to two dimensions. After field maps are generated, the GIS-generated croplines are field checked, which frequently involves digging out ditches along country roads to verify contacts. During the field check, additional field data is collected for our use and entered into field volumes and databases for future use.

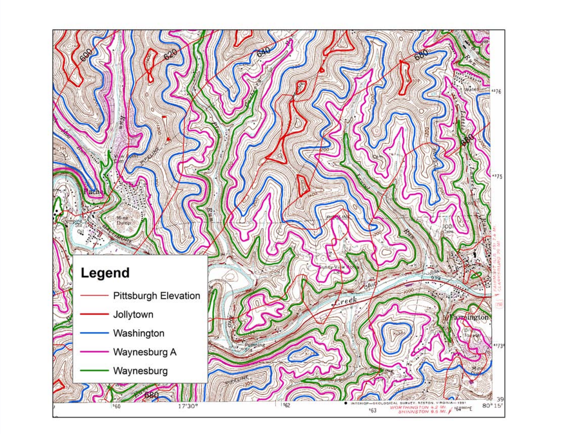

Figure 4. Part of the preliminary field map of the Mannington 7.5-Minute Quadrangle, showing croplines of critical horizons.

After fieldwork is completed, the linework used to construct field maps is modified, as needed, attributed, and built into final GIS datasets that are used to produce geologic maps (Figure 5). Cartalinx, an application produced by Clark Labs in Worchester, MA, was used for editing, although other GIS editors could also be used. The complete set of structure grids and the topography grid enables the sampling of grids along profiles, and the sampled profiles are used to generate cross sections (Figure 6). Open file report maps are produced utilizing Adobe Illustrator with the MaPublisher plug-in (Figure 7).

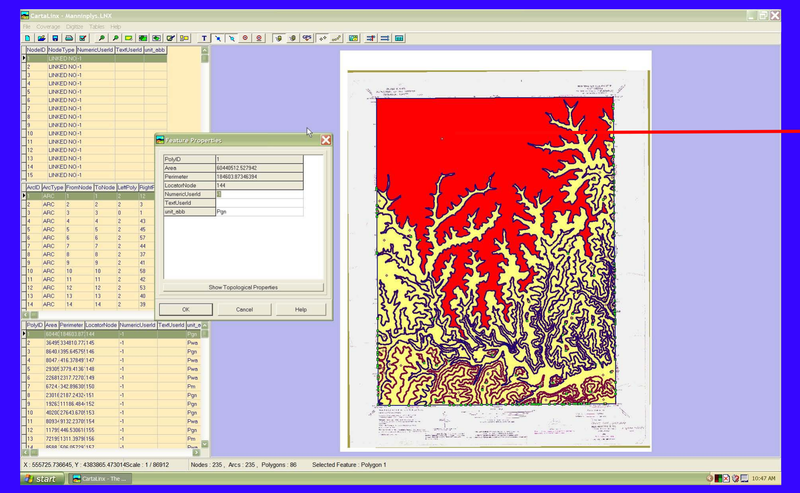

Figure 5. Cartalinx display of outcrop polygons on the Mannington 7.5-Minute Quadrangle.

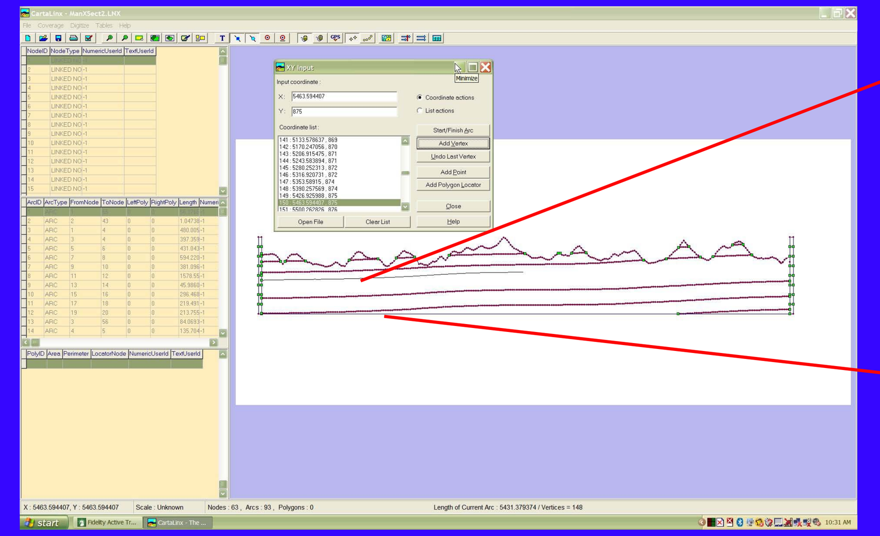

Figure 6. The cross section accompanying the preliminary geologic map of the Mannington 7.5-Minute Quadrangle is generated by sampling structure grids of critical horizons and the topographic grid along a profile. The incomplete line is in the process of being plotted. The coordinates of the line being plotted can be seen in the window above the cross section in the illustration.

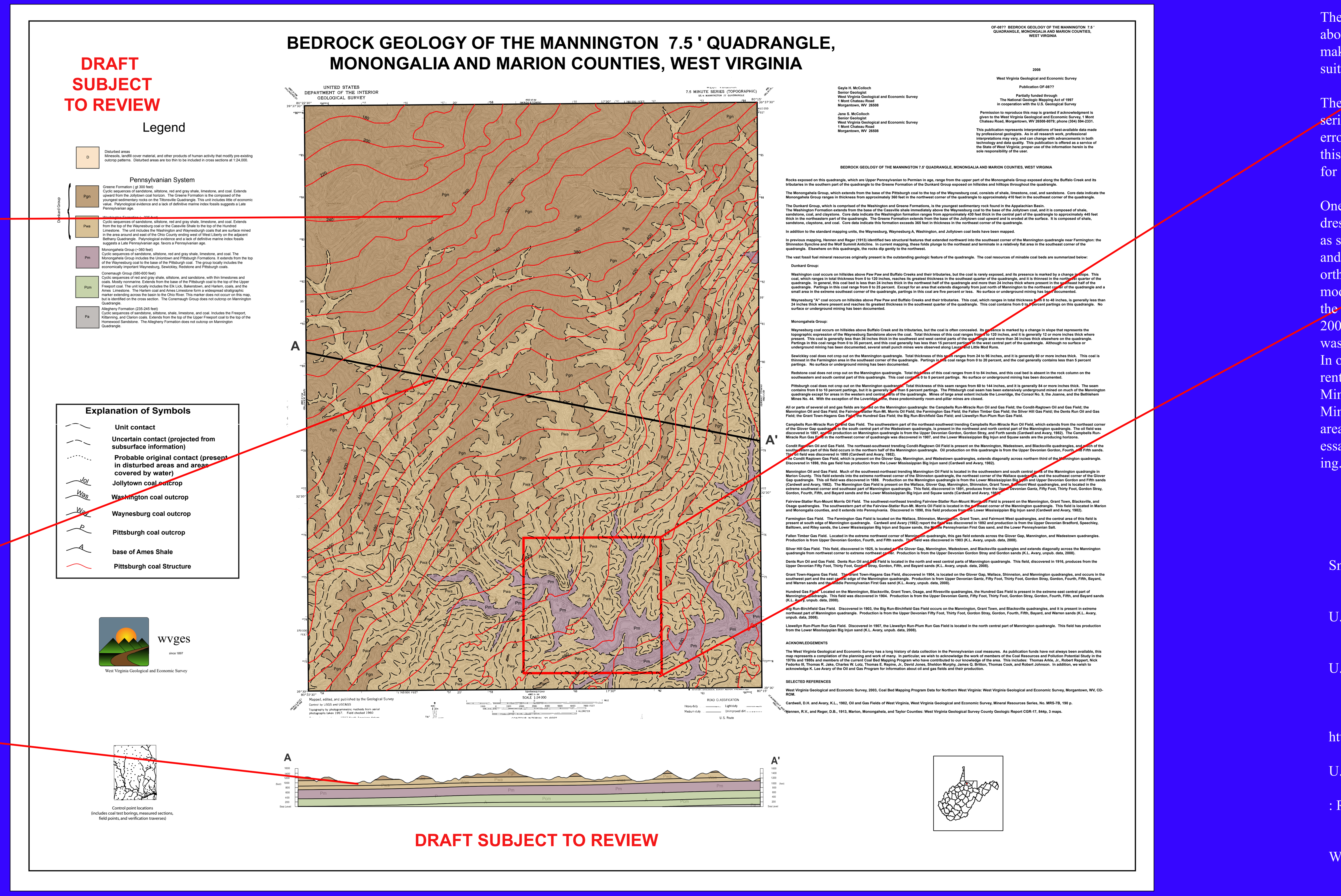

Figure 7. A reduced version of the open file Mannington 7.5-Minute Geologic Quadrangle Map produced utilizing Adobe Illustrator with the MaPublisher plug-in.

New Base Map Issues

A recent decision to produce a new West Virginia State Geologic Map to replace the last version compiled in 1968 with minor updates in 1986 has generated discussion of several issues including modern base maps for use in preparing new geologic maps of all scales.

The planned State Geologic Map is to be a living document representing the current state of knowledge about West Virginia geology. A robust data model and an accurate scalable base map are two tools that will make this possible. The North American Geologic Map Data Model Steering Committee has provided a suitable data model.

The 1968 West Virginia State Geologic Map is based on the 1:250,000 scale Army Map Service 2 degree series. Another base map is being explored because this series has a well-documented minor projection error (Snider, 1987), the series is becoming dated, and nothing else is being produced at 1:250,000 to replace this series. Also, it would be very useful to have a flexible statewide digital vector base that would be usable for scales ranging from 1:4800 to 1:250,000.

One possible alternative results from a data collection effort begun in 2003 when the West Virginia State Addressing and Mapping Board (SAMB) flew digital imagery of the state and subsequently made it available as state plane coordinate tiles (WVSAMB, 2004). In 2005, cooperative projects between the USGS, SAMB, and the West Virginia GIS Technical Center reformatted this imagery from state plane coordinates to digital orthophotoquads (DOQQs) (Figure 8) (USGS et al, 2005a), produced 1/9 arc second digital elevation models (DEMs) (Figure 9) (USGS et al, 2005b). In 2006, the West Virginia GIS Technical Center contoured the DEMs to produce a uniform statewide set of attributed shape files of 20-foot contours (WVSAMB, 2006). Figure 10 shows an unannotated base map of part of the Mannington 7.5-Minute Quadrangle that was produced using these contours and the new 2006 Census Bureau Tiger files (US Census Bureau, 2007). In order to support the new West Virginia State Geologic Map it will be necessary to first test whether current geologic mapping will fit the new base at 1:24,000. Figure 11 shows part of the Mannington 7.5-Minute Geologic Quadrangle map that has a backdrop of scanned separates from the Mannington 7.5-Minute Topographic Quadrangle produced in 1960 and photorevised in 1976. Figure 12 shows the same area using the linework from Figure 10 as a base map for comparison. Much additional testing will be necessary before a decision about this approach to a new base map is made, but this preliminary test is promising.

Figure 8. 1/9 arc second Digital Elevation Model. The red box on Figure 7 delineates the area covered.

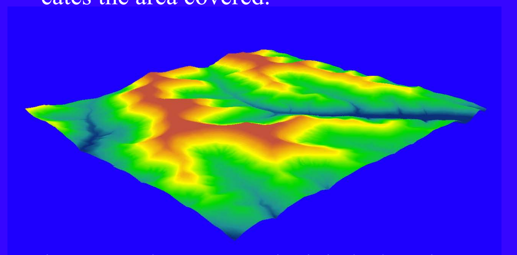

Figure 9. 1/9 arc second Digital Elevation Model.

Figure 10. Twenty foot contours and 2006 second edition Census Bureau Tiger Files used for a simple unannotated base map.

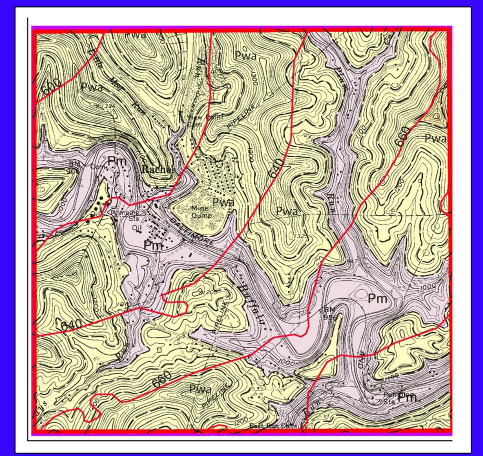

Figure 11. Mannington quadrangle geology at 1:24,000 as plotted on the draft open file report using original quadrangle separates.

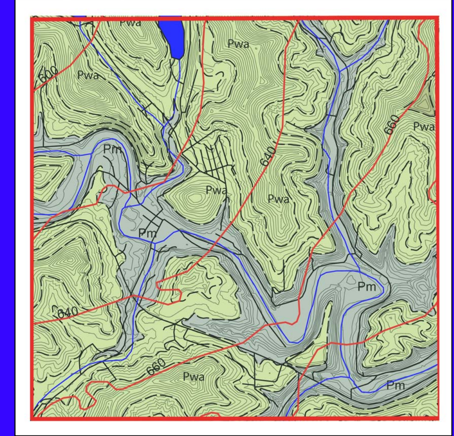

Figure 12. Mannington quadrangle geology at 1:24,000 as plotted on the draft open file report using simple base map from Figure 10.

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