DRAFT -- To be published in DMT'07 Proceedings
(see http://ngmdb.usgs.gov/Info/dmt/)

Mapping Potential Geologic Hazards for Proposed Highway Construction Projects in Pennsylvania: Route 15 in Lycoming County

By Stuart O. Reese, P.G.

Pennsylvania Geological Survey
3240 Schoolhouse Road
Middletown, PA 17057
Telephone: (717) 702-2028
Fax: (717) 702-2065
email: streese@state.pa.us

INTRODUCTION

Recently, the Pennsylvania Geological Survey has worked on behalf of the Pennsylvania Department of Transportation (PennDOT) to develop maps for specific highway construction projects. The purpose of these maps is to identify potential geologic hazards such as landslides, sinkholes, mineralization, historic deep mines, acid drainage, and groundwater conditions. Map layers have included aerial imagery, digital elevation model (DEM) datasets, digital raster graphics (DRGs), bedrock units and their contacts, surficial and structural geology features, mapped landslides, glacial boundaries, and water well locations. Possible issues are described in the accompanying poster for the proposed construction zones (Figure 1). The current example is a proposed Interstate 99 upgrade of existing U. S. Route 15 in Lycoming County, Pennsylvania.

BACKGROUND

At PennDOT's request, the Pennsylvania Geological Survey has provided overviews of potential geologic hazards for proposed construction projects. Prior to this, PennDOT had encountered numerous unexpected geologic complexities that cost hundreds of millions of dollars in additional construction and environmental mitigation costs. Examples include major sinkholes that plagued bridge repair and adjacent new bridge construction over Bushkill Creek in Northampton County; a large sulfide deposit (known to the geologic community) that created lengthy delays and expensive remediation measures for Interstate 99 in Centre County; and, in Mifflin County, acidic drainage from uncovered Marcellus Shale (a black shale with approximately 3 percent sulfur) that had to be mitigated.

The current project is situated in north-central Pennsylvania in the Deep Valleys section of the Appalachian Plateaus physiographic province in Lycoming County, Pennsylvania. Section C41 of U.S. Route 15 is located from north of Trout Run to the Village of Buttonwood in the "Steam Valley" area of Cogan House and Lewis Townships. The improved highway corridor will become part of Interstate 99, the Appalachian Thruway. This requires an upgrade of the 4 1/2 mile Steam Valley section (C41) to a four-lane limited access highway that meets current design standards comparable to adjacent sections of U.S. 15. Construction is estimated to begin in fall 2007 (pending the availability of funds). At the time this paper was written, right-of-way appraisals were completed and acquisitions and negotiations nearly finished.

MAP USAGE AND PREPARATION

The map represents information that we recommend to be considered during the construction of the highway. It also represents the Pennsylvania Geological Survey's collective knowledge of the location's geology and its potential hazards. The process of gathering this knowledge for a report begins with a geologic literature search.

The starting point for the map was a digitized version of the proposed highway realignment. The geologic map portrays the underlying bedrock and surficial geology of the region. Mapped landslide locations, glacial boundaries, and groundwater points of information were included. Text descriptions of potential hazards were added to the map. A base map using PAMAP imagery was tried but not used because it was more detailed than the presentation scale selected for this geologic hazard map (1:24,000). Ultimately a transparent hillshade layer derived from the 10-meter DEM data was used over a seamless DRG layer as the base. To generate the map, ArcInfo ver. 9.2 software was used.

CONSIDERATIONS AND RECOMMENDATIONS

The following is a summary of geologic issues that were identified on the map. Regarding the bedrock geology, the C41 section is almost entirely underlain by Upper Devonian Catskill Formation. These rocks are dominated by interbedded and alternating red and gray sandstones, siltstones, shales, and mudstones. The rocks are arranged in fining-upward cycles from gray sandstones through red mudstones. The Catskill Formation is overlain by the Huntley Mountain Formation. For the most part, the C41 section occurs within the Catskill Formation, though a portion of the highway at the north end intersects the Huntley Mountain Formation.

The major issue for this area is terrain stability, with shallow groundwater as an additional, related consideration. Minor issues include potential mineralization in channel lag deposits in the Catskill rocks, and a possible contribution to instability by Wisconsinan glacial deposits. Delano and Wilshusen (1999) classified the area as a "high-susceptibility" zone of landslide occurrence. Moist and saturated shales and mudstones sequences on steep slopes may form landslides. Instability and landsliding in the colluvium also may occur. Steep valley slopes with high vertical relief have the potential to form rock falls where interbedded sandstones create ledges, in contrast to undercutting into the underlying mudstones and shales. Jointing perpendicular to bedding can enhance this potential. Previous landslides typically occurred on north-facing slopes. Mapped landslides are included on the geologic map along with a note that other, unmapped landslides may be present.

In the Catskill Formation of north-central Pennsylvania, localized enrichments of copper and uranium in paleochannel lag deposits may exist. Such lag deposits also may contain elevated concentrations of trace elements of arsenic, lead, and silver, and may contain pyrite nodules (Smith and Hoff, 1984). Wisconsinan glaciation penetrated the valleys of both the southern and northern portions of the section including the Lycoming Creek valley past the village of Trout Run, and north of the village of Steam Valley.

The glacial deposits consist of discontinuous Quaternary Olean ground moraine, which is composed of a wide range of unsorted sediment types from clay and sand, to cobbles and boulders (collectively referred to as “till”). Till deposits have been mapped in these areas by Crowl and Sevon (1980); these deposits, if excavated, could be unstable, especially in areas where relatively high groundwater levels might be encountered. The median value of static water levels for all types of “valley” wells in the Catskill Formation of the Deep Valleys physiographic section was 20 feet (n = 116 wells; Fleeger, McElroy, and Moore, 2004). For 25 percent of these wells, the static water level was less than 11 feet below surface. Records for three water wells near the village of Trout Run show static water levels less than 20 feet. In areas with such high water tables, slope stability is impaired where the geologic materials are excavated.

On the map delivered to PennDOT, it was noted that “This map is not a substitute for site-specific subsurface tests and investigations.” The map included Pennsylvania bedrock geology units with geologic unit contacts that were widened to reflect the coarser precision at 1:24,000. Geologic structure axes (e.g., folds) and measurements of their strike and dip were added to the map, based on internal data from an unpublished dataset of the Pennsylvania Geological Survey. For this area, folds are broad and dips rarely exceed 15 degrees. Most jointing is steeply dipping (70 degrees or more) and parallel or perpendicular to bedding. The Late Wisconsinan glacial border was also portrayed. A shaded relief layer was used as derived from 10-meter DEM data for the Cogan Station, Salladasburg, Trout Run, and White Pine 7.5-minute quadrangles. DRGs for these quadrangles were used as the base layer for the map. Data showing the alignment of the highway centerlines were provided by a PennDOT consulting firm.

Digital and paper copies of the map were mailed to the Central and District offices of PennDOT. In a cover letter, we noted that our main concern was that new road construction might encounter some severe rockfall and landslide problems, based on the steepness and north-facing aspect of the slopes, the Catskill Formation’s propensity for jointing in the sandstone, its variable lithology and subsequent differential weathering properties, known historical landslides, the presence of colluvium, and the probable shallow water table along the slopes. We also noted the expectation of a new surficial geologic map for part of the area in late spring, and that within the next year, as part of the PAMAP program, we are expecting the delivery of LiDAR data for Lycoming County. This new data will provide for a DEM and 2-foot contour data sets, and may help to identify historical stability issues with other slopes in the area.

We are hopeful that such mapping products will alert the engineers and geotechnical participants to the potential hazards that might be encountered, and that such information will benefit not only the engineering participants but the entire Commonwealth of Pennsylvania.

ACKNOWLEDGEMENTS

The author thanks Michael Moore (Pennsylvania Geological Survey) for his helpful comments on the original manuscript.

REFERENCES

ArcInfo, ArcGIS - Environmental Systems Research Institute, Inc., 380 New York St., Redlands, CA 92373-8100 USA, (909) 793-2853, http://www.esri.com/.

Crowl, G.H., and Sevon, W.D., 1980, Glacial border deposits of the late Wisconsinan age in northeastern Pennsylvania: Pennsylvania Geological Survey, 4th Ser., General Geology Report 71, 68 p.

Delano, H.L., and Wilshusen, J.P., 1999, Landslide susceptibility in the Williamsport 1- by 2-degree quadrangle, Pennsylvania: Pennsylvania Geological Survey, 4th Ser., Environmental Geology Report 9, 192 p.

Fleeger, G. M., McElroy, T. A., and Moore, M. E., 2004, Hydrogeologic and well-construction characteristics of the rocks of Pennsylvania: Pennsylvania Geological Survey, 4th Ser., Water Resources Report 69, Database (Microsoft Access 97 and 2000).

Smith, R.C., II, and Hoff, D.T., 1984, Geology and mineralogy of copper-uranium occurrences in the Picture Rocks and Sonestown quadrangles, Lycoming and Sullivan Counties, Pennsylvania: Pennsylvania Geological Survey, 4th Ser., Mineral Resource Report 80, 271 p.

DRAFT -- To be published in DMT'07 Proceedings
(see http://ngmdb.usgs.gov/Info/dmt/)

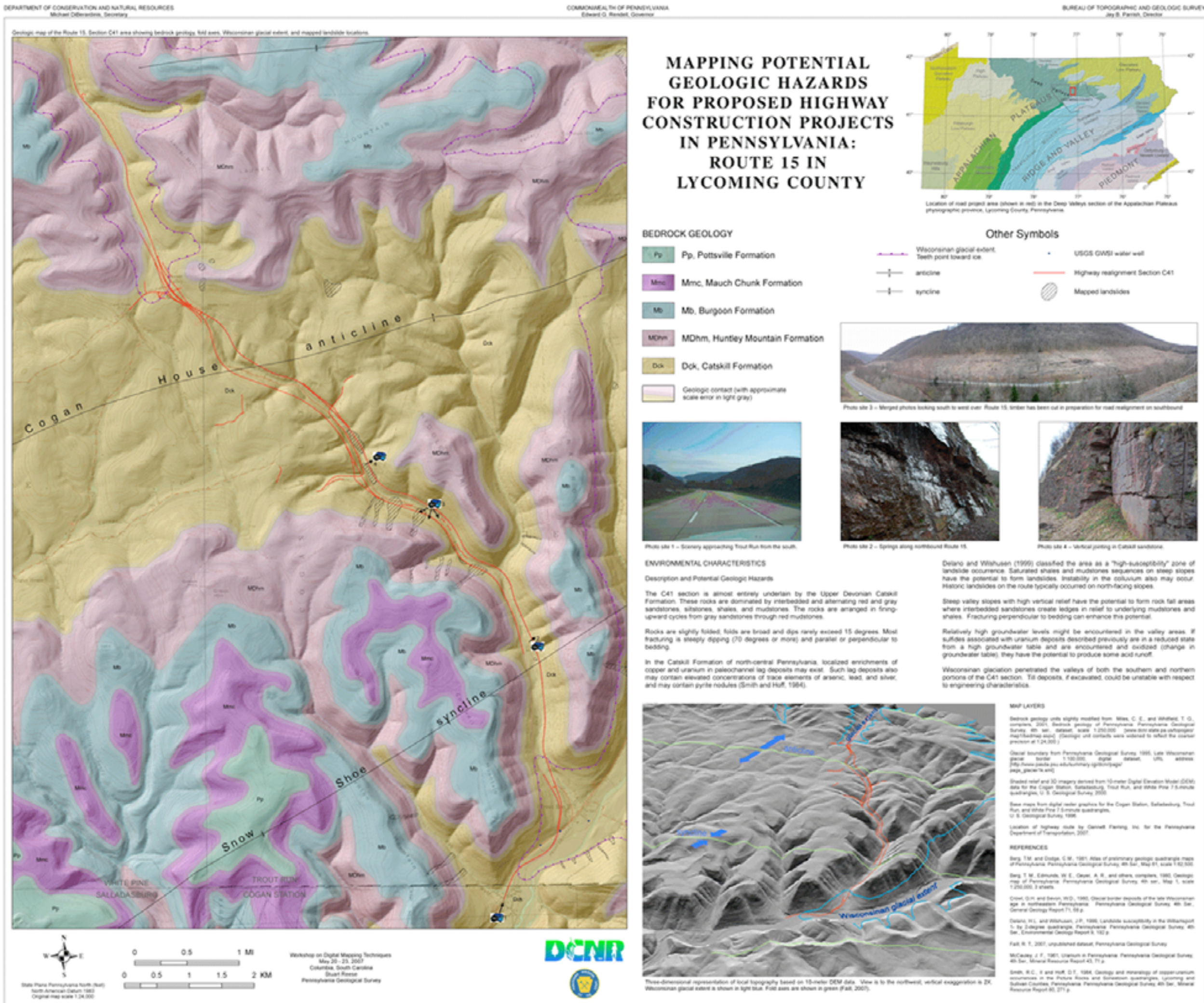

Figure 1. Mapping potential geologic hazards for proposed highway construction projects in Pennsylvania: Route 15 in Lycoming County (presented as a poster; see full-resolution image at http://ngmdb.usgs.gov/Info/dmt/docs/reese07.pdf).