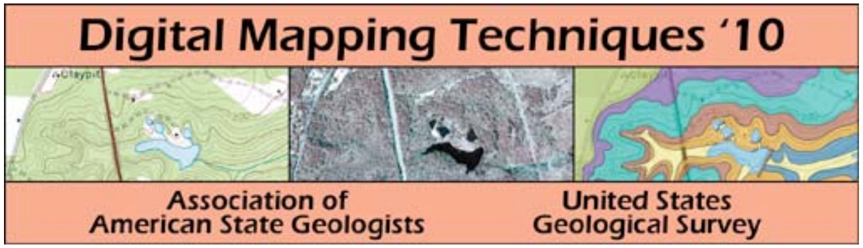

The following was presented at DMT'10
(May 16-19, 2010).

The contents are provisional and will be
superseded by a paper in the
DMT'10 Proceedings.

See also earlier Proceedings (1997-2009)
http://ngmdb.usgs.gov/info/dmt/

Evaluating Mine Subsidence Using a GIS Software Application

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INTRODUCTION

Underground mining for coal in Ohio was first reported in 1800 (Crowell, 1995). The majority of underground mining takes place in coal- and clay-mining areas of eastern and southern Ohio (fig. 1). Other commodities have been mined underground within Ohio, such as salt, gypsum, limestone, shale, and even peat. Geologists have estimated that over 8,000 mines have been in operation over the last 200 years (DeLong, 1988). Such a large number of mines occurring over a long period of time increases probability that mines will collapse and subside as they age and deteriorate and as development occurs across the Ohio landscape.

Mine subsidence has been recognized as a problem in Ohio only in the last 40 years. In 1977, a mine shaft collapsed underneath a garage in Youngstown, Ohio (fig. 2). A car located in the garage fell 110 feet down a 230-feet shaft. Because of this incident, the Ohio Department of Natural Resources (ODNR), Division of Geological Survey began mapping the detailed locations of abandoned underground mines (DeLong, 1988). Other prominent incidents have occurred, such as the collapse of Interstate 70 near Cambridge, Ohio, in 1995 (fig. 3; Crowell, 1995) and the recent subsidence underneath a house in Sugarcreek, Ohio (fig. 4). Costs associated with the remediation of abandoned mines are high. The repair of the collapse of I-70 near Cambridge cost approximately $3.8 million (Crowell, 1995). As of 2005, the Ohio Department of Transportation had spent approximately $14.3 million to repair highway damage caused by mine subsidence. In 2008, the ODNR Division of Mineral Resources Management invested more than $1.3 million to complete 32 projects related to abandoned underground mines (Gordon, 2009). As abandoned underground mines age and deteriorate, remediation costs likely will increase.

Most homeowner insurance policies do not cover damages from mine subsidence. In Ohio, the Mine Subsidence Insurance Fund gives property owners the opportunity to purchase mine subsidence insurance. To assist the evaluation of insurance claims, the ODNR Division of Geological Survey has entered into an agreement with the Ohio Mine Subsidence Insurance Underwriting Association (OMSIUA) to provide geologic information and preliminary evaluation of the validity of mine subsidence claims. When OMSIUA officials receive a claim from a property owner, geologists at the ODNR Division of Geological Survey are given the claim for further evaluation. The geologists gather all digital geologic maps and documents for the claim location, using a GIS software application; evaluate the potential of an underground mine to underlie the property, and then write a claim report. The claim report is submitted to a consulting engineering company for further evaluation and potential remediation. The GIS software application provides easy access to digital geologic information for insurance claim processing and potential property remediation.

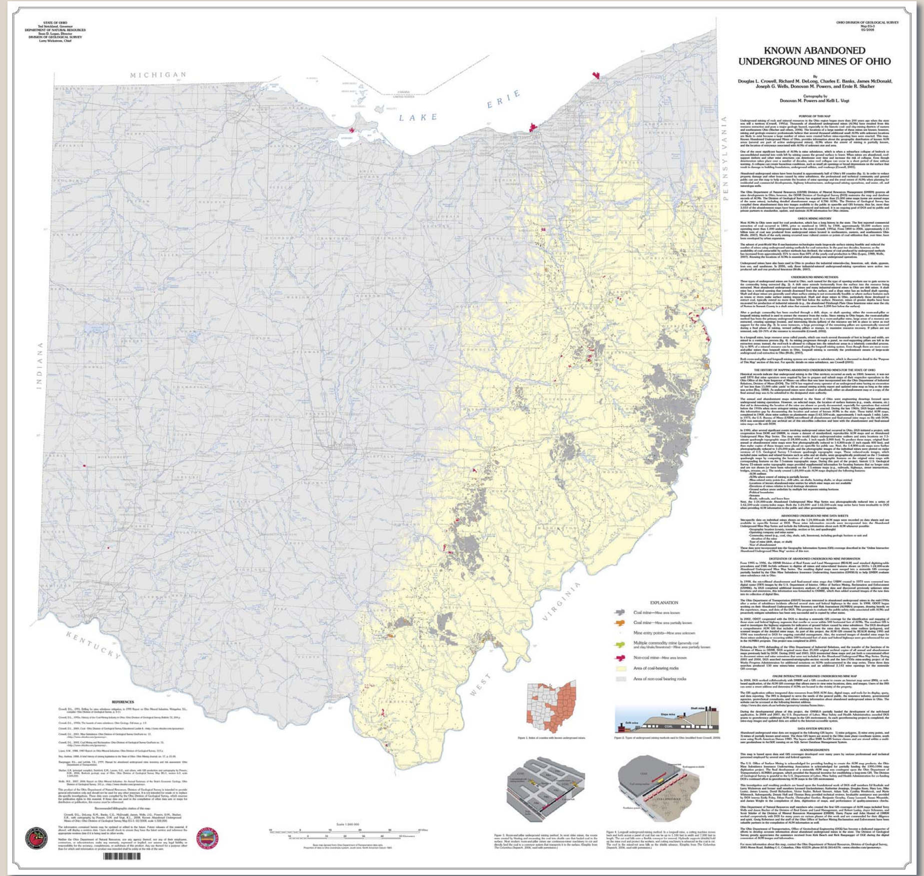

FIGURE 1.—Map EG-3: *Known Abandoned Underground Mines of Ohio* (Crowell and others, 2008). The majority of abandoned underground mines are associated with coal and clay mining in eastern Ohio.

FIGURE 2.—Aerial photograph showing location of mine subsidence occurrence. A garage collapsed and a car fell into a shaft at 523 W. Hylda Avenue, Youngstown, Mahoning County, Ohio (DeLong, 1988; Crowell, 1980). The property at 537 W. Hylda Avenue was inventoried by Fuller and Sturgeon (1941) as containing an abandoned mine shaft of the Foster #1 mine; the authors noted that the Foster #1 was abandoned in 1884 and was the most productive mine on the south side of Youngstown. Fuller and Sturgeon also noted that in 1876 a block measuring 4' x 4' x 7' was taken out of the shaft and exhibited at the Centennial Exposition in Philadelphia. It won a gold medal for the best block on exhibition.

FIGURE 3.—Collapse of Interstate 70, near Cambridge, Ohio, caused by mine subsidence (Crowell, 1995).

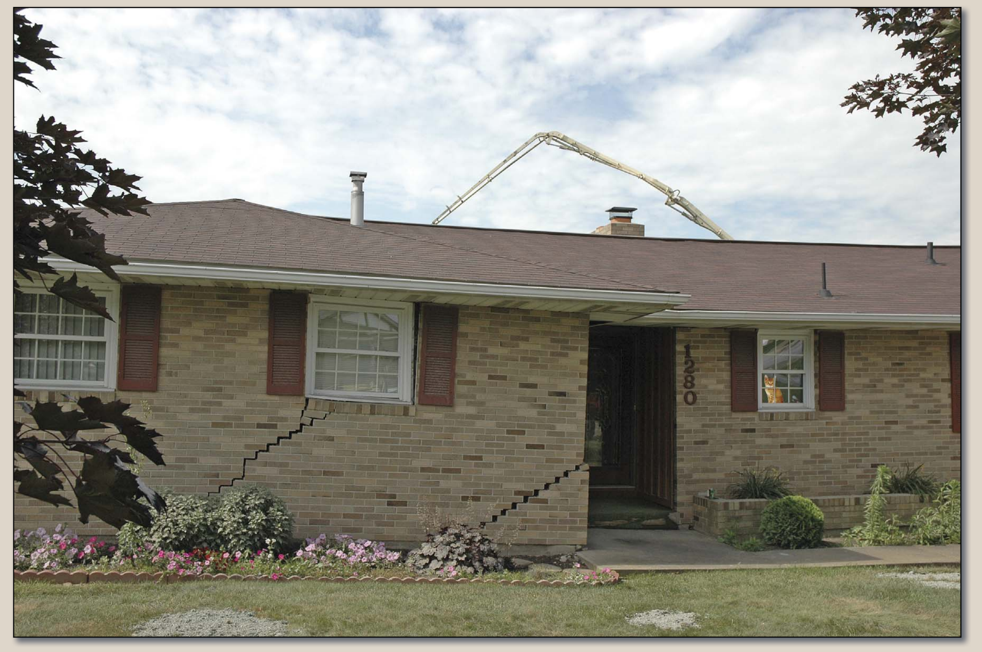

FIGURE 4.—A house damaged by mine subsidence. Sugarcreek Township, Tuscarawas County, Ohio.

OMSIUA GIS APPLICATION

The OMSIUA GIS application consists of a toolbar featuring a mixture of native ArcGIS tools and several custom-designed tools using VBA for ArcObjects (fig. 5).

To locate mine subsidence claims, two tools are used to zoom into the claim location and load all geologic maps and documents. The toolbar contains the native ArcGIS Find Tool (fig. 6), which is used to locate insurance claims using the Address Locator function. The second tool, the Selection Location Tool (fig. 7), will load all known digital geologic maps and GIS data for a mine subsidence location into the ArcMap document for that location. Some of the GIS datasets include abandoned underground mines; permitted surface mines; 1:24,000-scale bedrock geology; and the one-foot resolution, digital orthophotography. One of the most important sets of historical records is the collection of 15-minute thematic geologic maps. These maps have been scanned and indexed. The Select Location Tool will identify all scanned maps within a one-mile radius and load them into ArcMap (fig. 8).

Once the information is loaded, the geologist can conduct a preliminary mine subsidence analysis. The Underground Mine Information Form (fig. 9A) will present the attribute information on abandoned underground mines. Using the form, georeferenced abandoned mine maps can be loaded into ArcMap (fig. 9B). Documents can be accessed using the native ArcGIS Hyperlink Tool (fig. 10). Some of the documents that can be accessed are measured stratigraphic sections, core descriptions, and oil-and-gas well completion cards—all of which can have a description of a coal bed within them and possibly the notation that an underground mine is nearby.

After the analysis is completed, portions of the preliminary mine subsidence report can be automated. A tool will export thematic, page-sized, PDF maps (fig. 11A). The page-sized maps are generated with the correct titles (fig. 11B). The PDF maps, along with all the geologic documents within one mile of the site will be exported to a temporary directory (fig. 11C). The geologist can then ZIP the files together and send them to the consulting engineering company for further analysis.

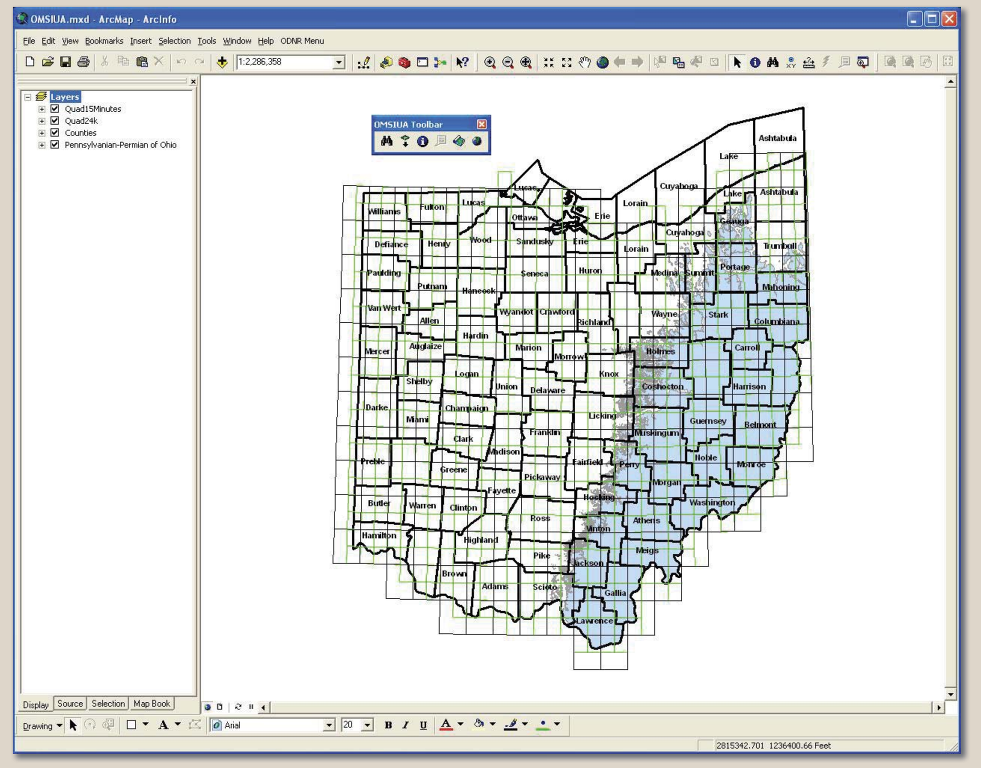

FIGURE 5.—OMSIUA Toolbar.

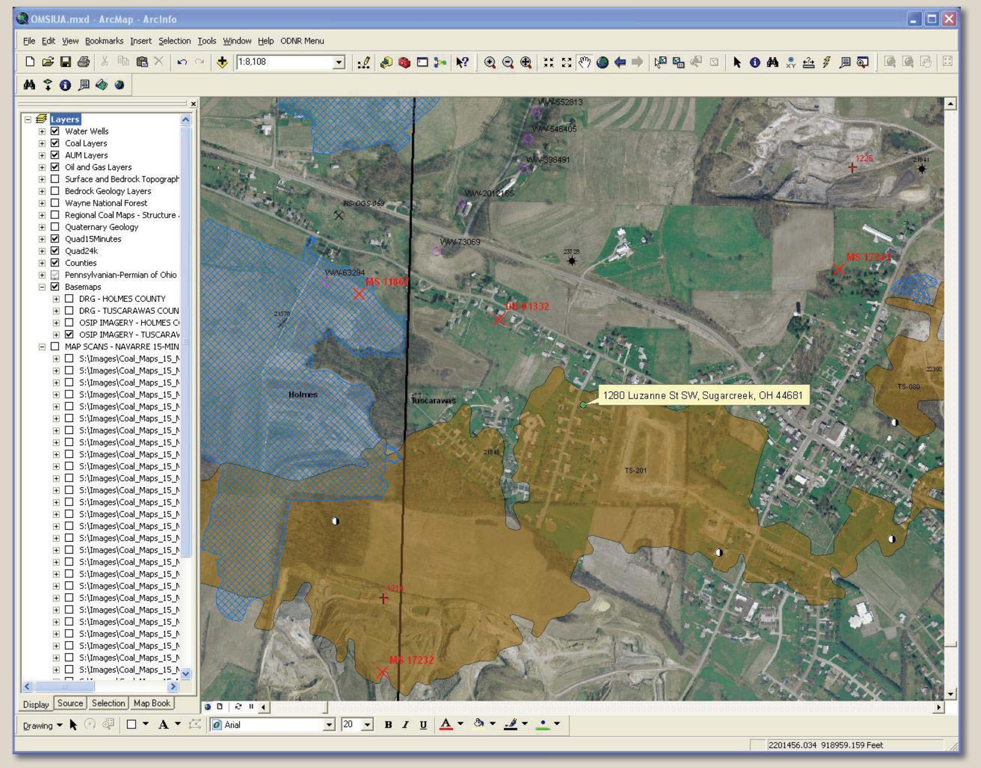

FIGURE 7.—Select Location Tool. All geologic information is loaded into the ArcMap for the complaint location.

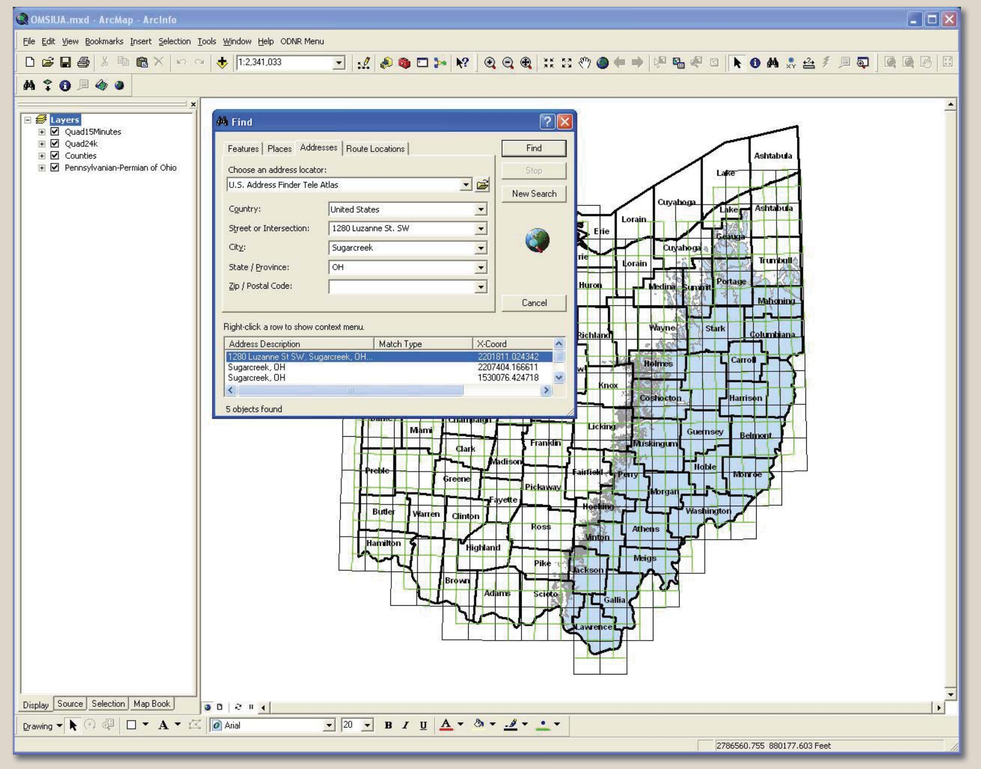

FIGURE 6.—Find Tool on the OMSIUA Toolbar. The Find Tool and the ESRI Address Locator are used to locate insutrance claims based upon the claim address.

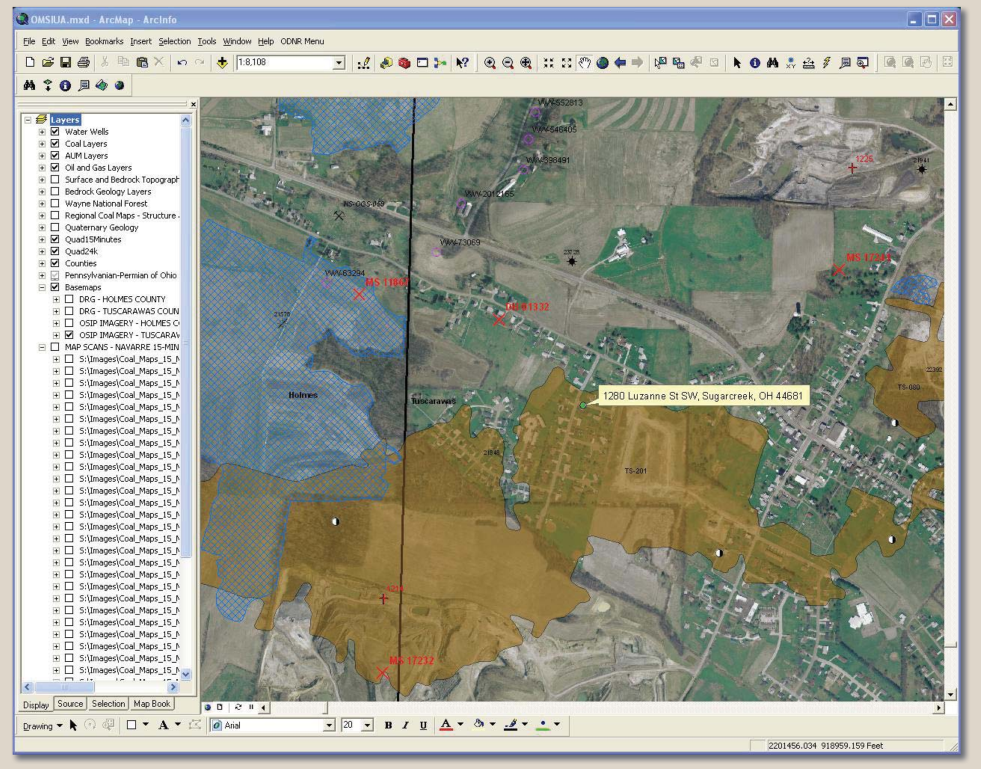

FIGURE 8.—Historic thematic 15-minute topographic map as a basemap. Map shows coal sample locations.

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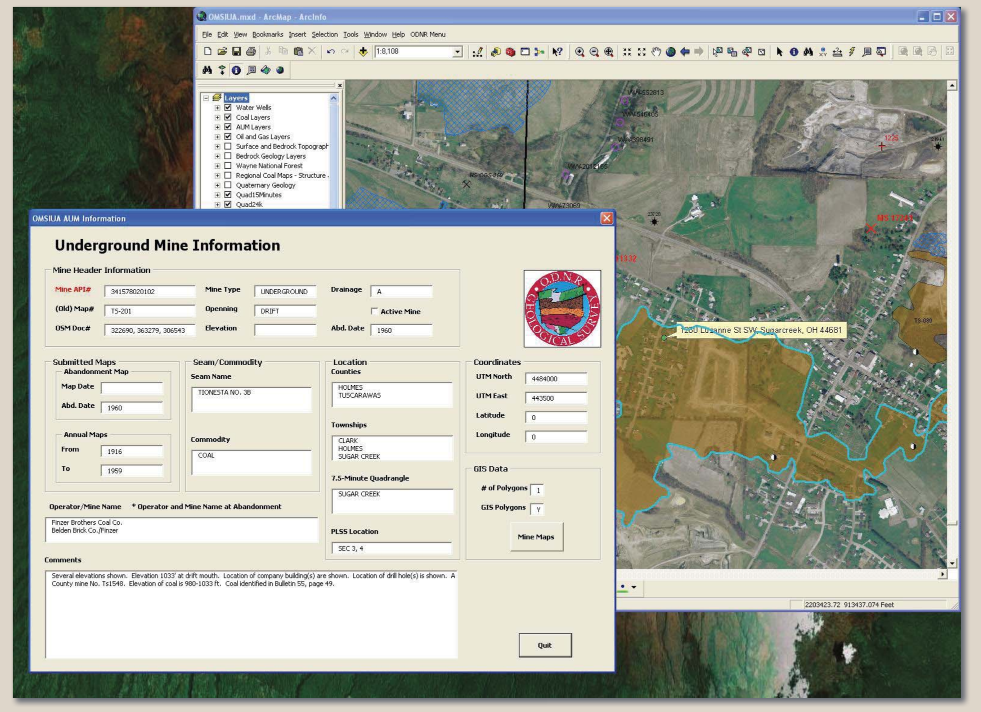

FIGURE 9A.—Underground Mine Information Form.

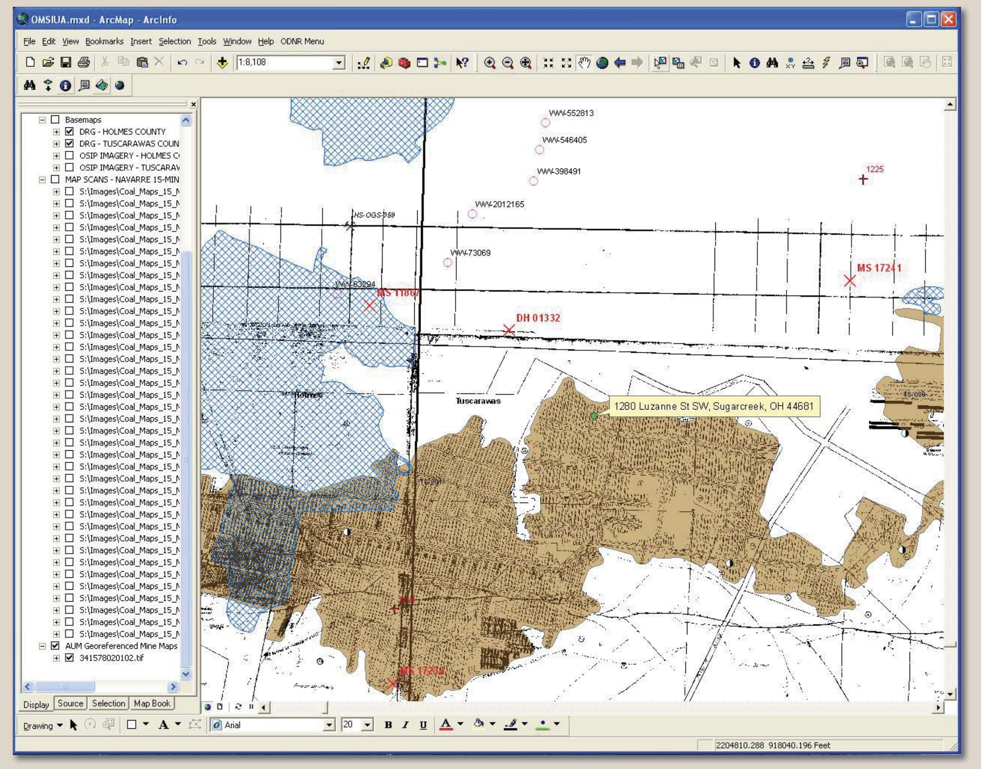

FIGURE 9B.—A georeferenced mine map can be loaded from the Underground Mine Information Form.

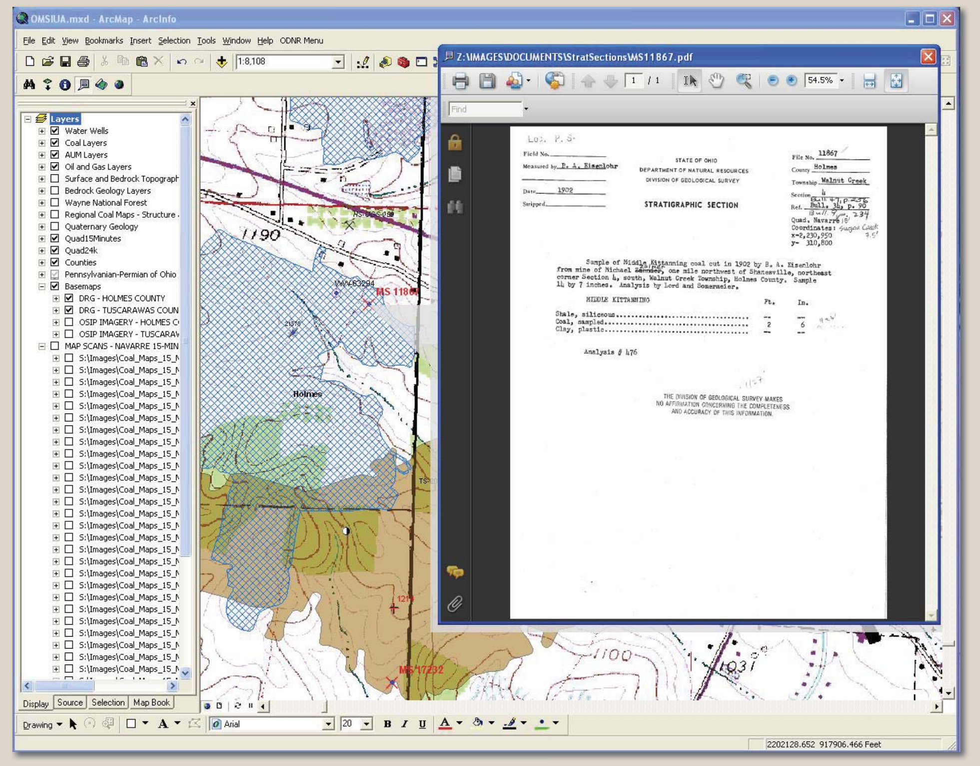

FIGURE 10.—Hyperlink to a Measured Section document.

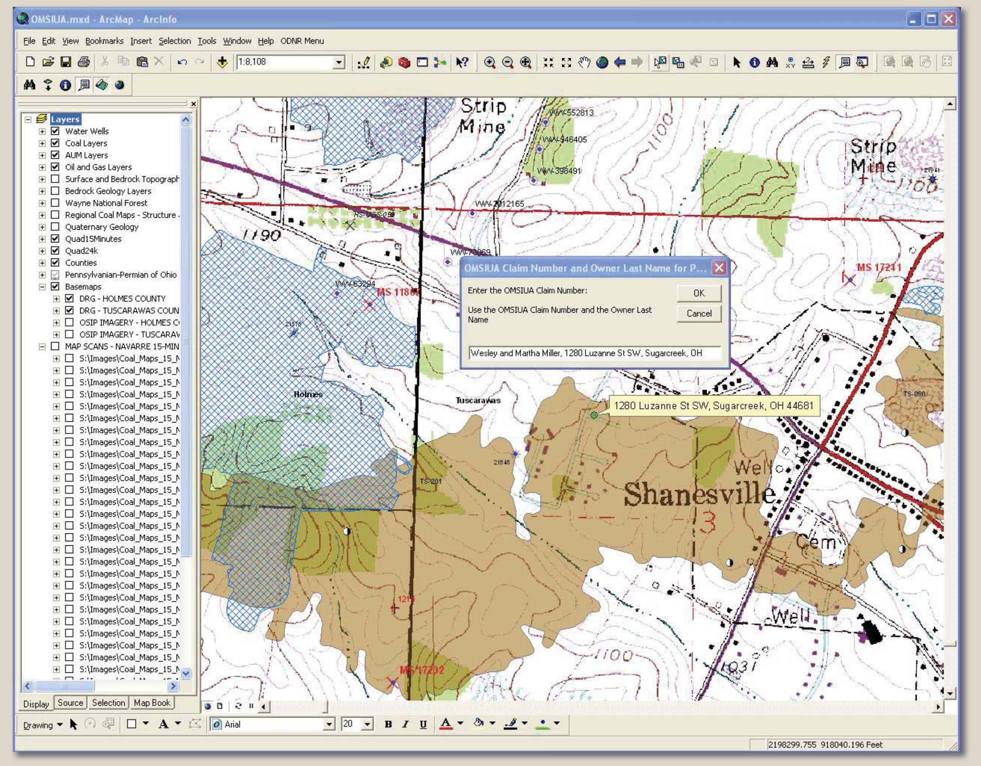

FIGURE 11A.—Automating the export of PDF maps.

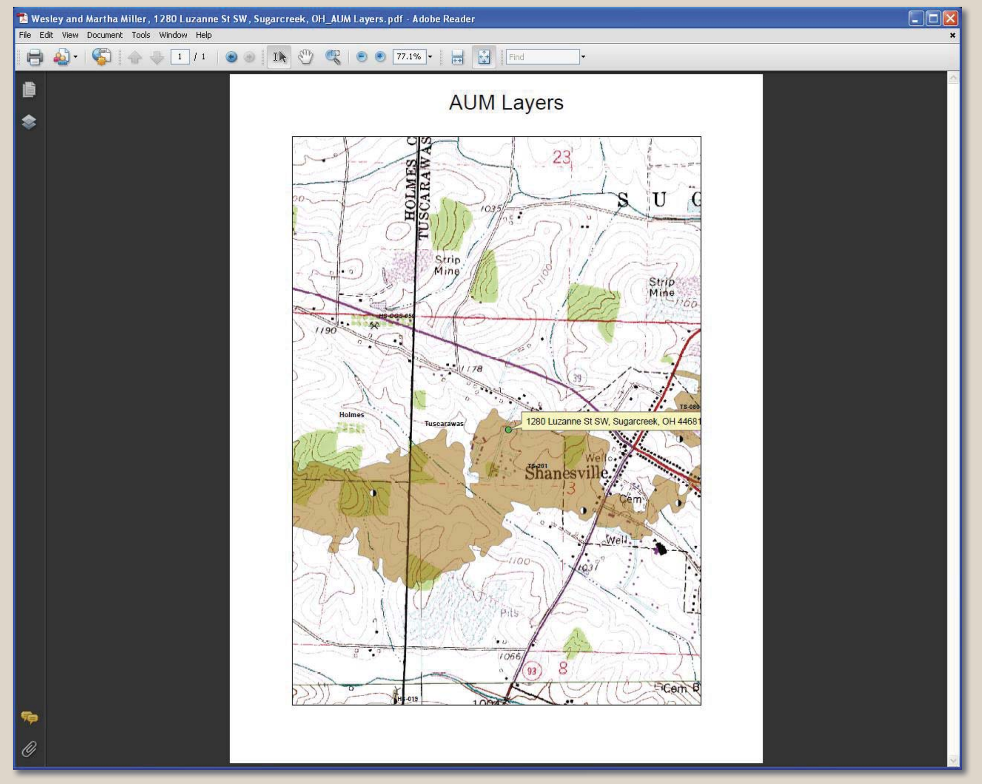

FIGURE 11B.—All automated PDF figures are generated with the correct titles.

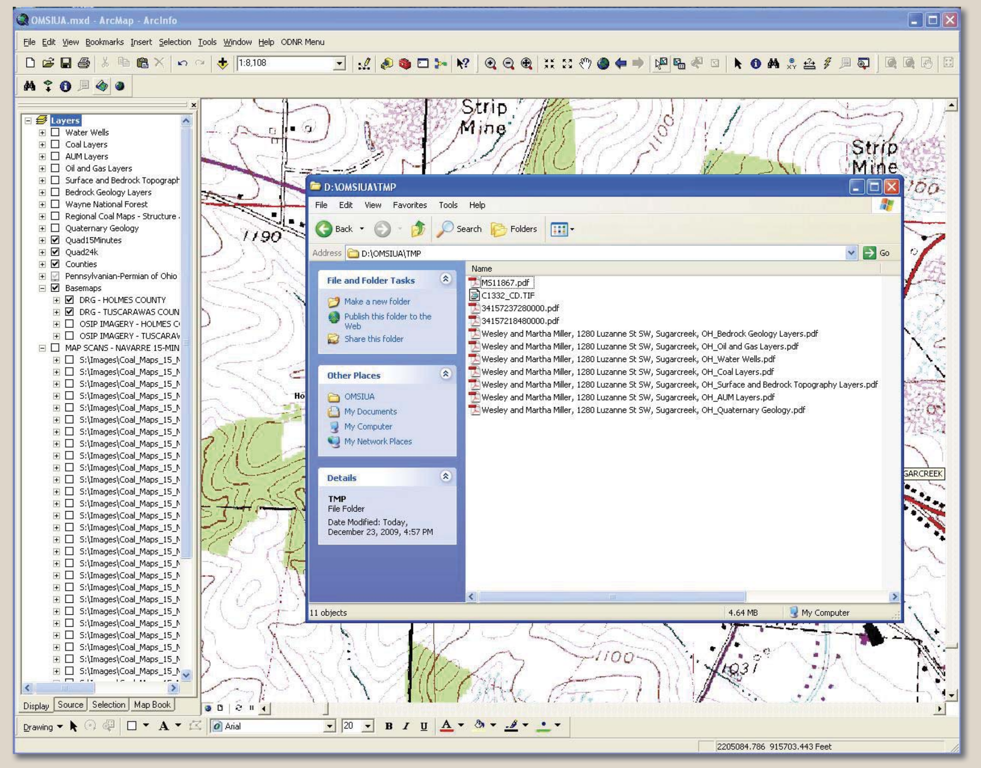

FIGURE 11C.—All documents within a half-mile radius and the PDF figures are copied to a temporary directory.