GIS Mine Post

ESRI • Spring 2009 GIS for Mining

Using GIS to Remedy Coal Mining's Aftermath

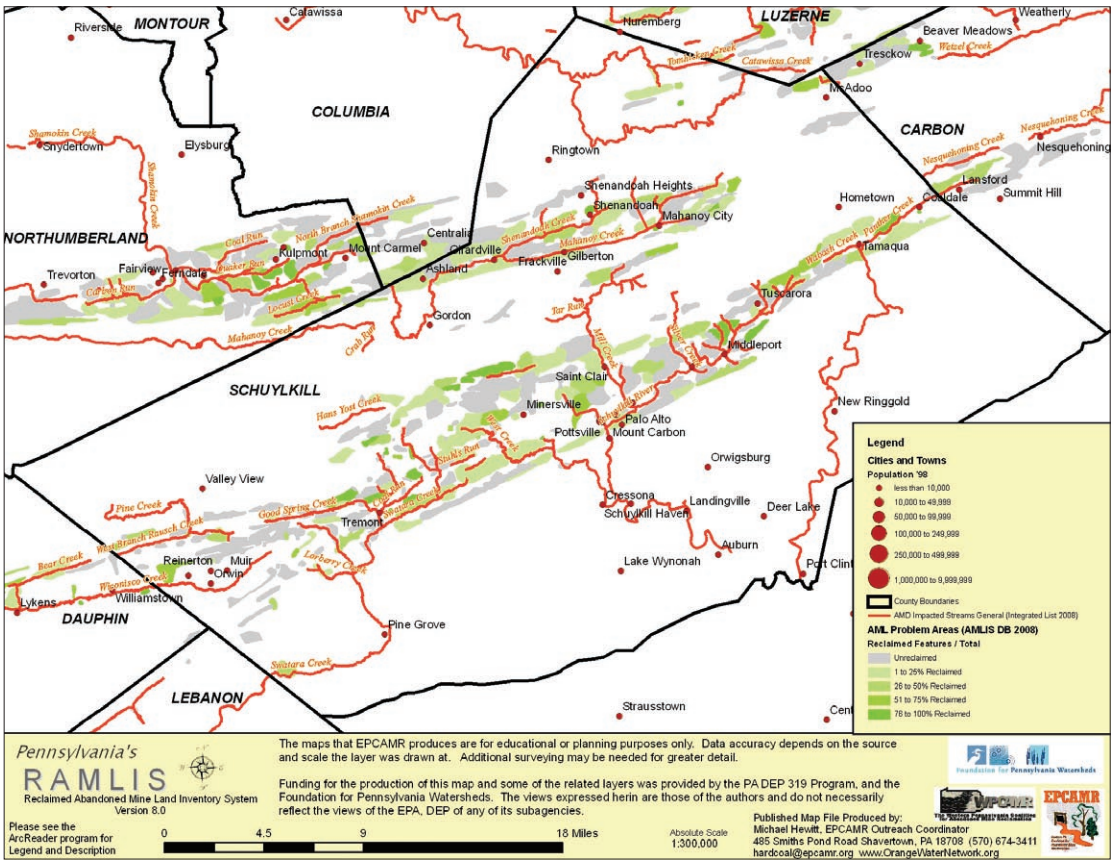
Pennsylvania Coalition Designs Mapping Application to Target Areas Most in Need of Reclamation

By Matthew DeMeritt, ESRI Writer

Abandoned coal mines cover hundreds of thousands of acres throughout the eastern United States. As such, having accurate maps of the mines is important to keep those involved in their cleanup spatially informed. In Pennsylvania, a regional nonprofit abandoned mine reclamation group is promoting the use of a state-of-the-art geographic information system (GIS) mapping tool to assist in the reclamation of mined-out land. The tool, created by the Eastern Pennsylvania Coalition for Abandoned Mine Reclamation (EPCAMR), has proved successful in maximizing the limited funds available for restoring this blighted land to its approximate premined state.

As recently as 30 years ago, coal mining companies weren't required to clean up and restore the land they excavated. Streams ran orange, green, and white with heavy metals leached from nearby mines. Strip pits with sheer cliffs were a hazard, causing many people to fall to their deaths. Pennsylvania was left with more than 200,000 acres of mine-scarred land and 5,000 miles of polluted streams. The impact of surface mining became evident in the mid-1970s, and Congress passed the Surface Mining Control and Reclamation Act (SMCRA) in 1977. SMCRA attached a per-ton fee to all extracted coal to create an interest-accruing federal reclamation fund. The fund is maintained by the United States Department of the Interior Office of Surface Mining (OSM) and is dispersed to states and Native American tribes that still face problems caused by coal mines abandoned before 1977.

Because Pennsylvania leads most states in the amount of reclamation that needs to be done, in 2006 Congress authorized an increase in Pennsylvania's reclamation allotment to $1.4 billion over the next 15 years. With so many abandoned mines still awaiting



Map showing streams impacted by pollutant run-off from abandoned mine in Shuylkill County, Pennsylvania

continued on page 7

In This Issue

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ESRI News

2008 ESRI User Conference Connects Attendees and Ushers in ArcGIS 9.3

GIS Users Experience Geography in Action

From petroleum to K–12 education, from back East to the Far East, more than 14,000 ESRI GIS users from 114 countries attended the 2008 ESRI International User Conference (ESRI UC) August 4–8 at the San Diego Convention Center in California. With a more comprehensive agenda than ever before, this year's conference offered visitors a broad range of technical workshops, GIS concept sessions, user presentations, special interest group (SIG) meetings, and regional user group (RUG) meetings as well as speakers, demonstrations, and resources that dived into the hottest topics and technologies. The GIS user community could connect and collaborate as well as explore the newest release of ArcGIS software, 9.3.

Save the Date

Mark your calendar to attend the 2009 ESRI UC to be held July 13–17 at the San Diego Convention Center. Watch for event updates and ways you can be part of the conference at www.esri.com/uc.

"We wanted users to not only enjoy the forum the conference provides but also hear firsthand about ArcGIS 9.3 and start digging into it," said Jack Dangermond, ESRI president. "This event is about finding what you need—be it a session, an answer to a question, or an inspiring presentation. The ESRI UC brings all the best resources together in one place so each person has access to all the information they need."

Keynote speaker Dr. Peter H. Raven, a biodiversity expert and president of the Missouri Botanical Garden, took the stage at the end of the Plenary Session. Raven illustrated the problems resulting from growing populations, altered landscapes, overconsumption, and climate change. "Technological tools, such as GIS, bring to bear a proper understanding of these problems and a proper solution," said Raven. "It helps us in our endeavors to develop love and concern for other people. These tools equip us to turn from passivity toward active engagement in developing much-needed solutions."

The Office of Surface Mining Celebrates GIS Day

GIS Day achieved an important milestone last year. November 19, 2008, marked the 10th anniversary of this global grassroots event. GIS Day celebrates the many ways GIS software users analyze and solve problems and recognizes the importance of GIS and geography in our everyday lives.

The program's ongoing success can be attributed to the thousands of GIS users who organize events inside and outside their organizations. Open houses, school presentations, and map gallery displays—the forms of celebrating are endless, but the message is the same. GIS is making a difference in our world.

The mission of the Office of Surface Mining (OSM) implements regulations for coal mining operations according to the Surface Mining Control and Reclamation Act (SMCRA). Across OSM's three regions, promoting GIS awareness is important because the technology is advancing into everyday use in the office to support SMCRA activities.

GIS Day is one of OSM's many outreach efforts to promote the use of GIS and other software tools for SMCRA support and decision making throughout OSM, states, and tribes. The internal event was a success and included demonstrations of GIS software, geodatabases OSM has developed, videos, and games.

"The feedback received was very positive; people didn't realize how GIS is affecting so many aspects of everyday life," said Karyn Evans, OSM's Technical Innovation and Professional Services (TIPS) Training Program team leader.

Join OSM in sharing the powerful role GIS is playing in the mining industry. To learn more about GIS Day and download free materials for your event, visit the GIS Day Web site at www.gisday.com.

New ArcGIS API for Flex Makes Creating Web Mapping Applications Faster and Easier

Web GIS Tool Gives Developers Direct Access to ArcGIS Server 9.3

Web GIS technology takes a leap forward with ArcGIS API for Flex, new from ESRI.

Using the Flex API, available for free from the ArcGIS API for Flex Resource Center, developers can combine GIS-based Web services from ArcGIS Server with other Web content, which can be displayed in simple, dynamic mapping applications over the Web or on the desktop. The API exploits the powerful geospatial capabilities of ArcGIS services. Users can transform their local data into a visually rich interactive map, query and display GIS data features and attributes, locate addresses, identify features, and perform complex spatial analytics.

Integrated with Adobe Flex Builder 3, Flex is a client-side technology that is rendered by Flash Player 9 or Adobe Integrated Runtime (AIR). Developers can even program with ArcGIS API for Flex remotely, as long as they have access to ArcGIS Server via a URL. Since the API is built on the Adobe Flex framework, developers can put all Flex components, such as list boxes, data grids, landscapes, and text controls, into custom applications.

"ArcGIS API for Flex is a powerful framework for building rich Internet applications on top of ArcGIS Server that look good, run fast, and are fun to use," said Antony Jayaprakash, a product engineer at ESRI. "ArcGIS API for Flex enables combining the best of desktop and the best of Web technologies."

Developers can download the API library at the ArcGIS API for Flex Resource Center, which makes available source code samples that display tiled maps, turn layers off and on, and switch between different kinds of maps and imagery. The samples demonstrate how to incorporate symbology, create a map layer, geocode, analyze data, add drawing tools, and much more.

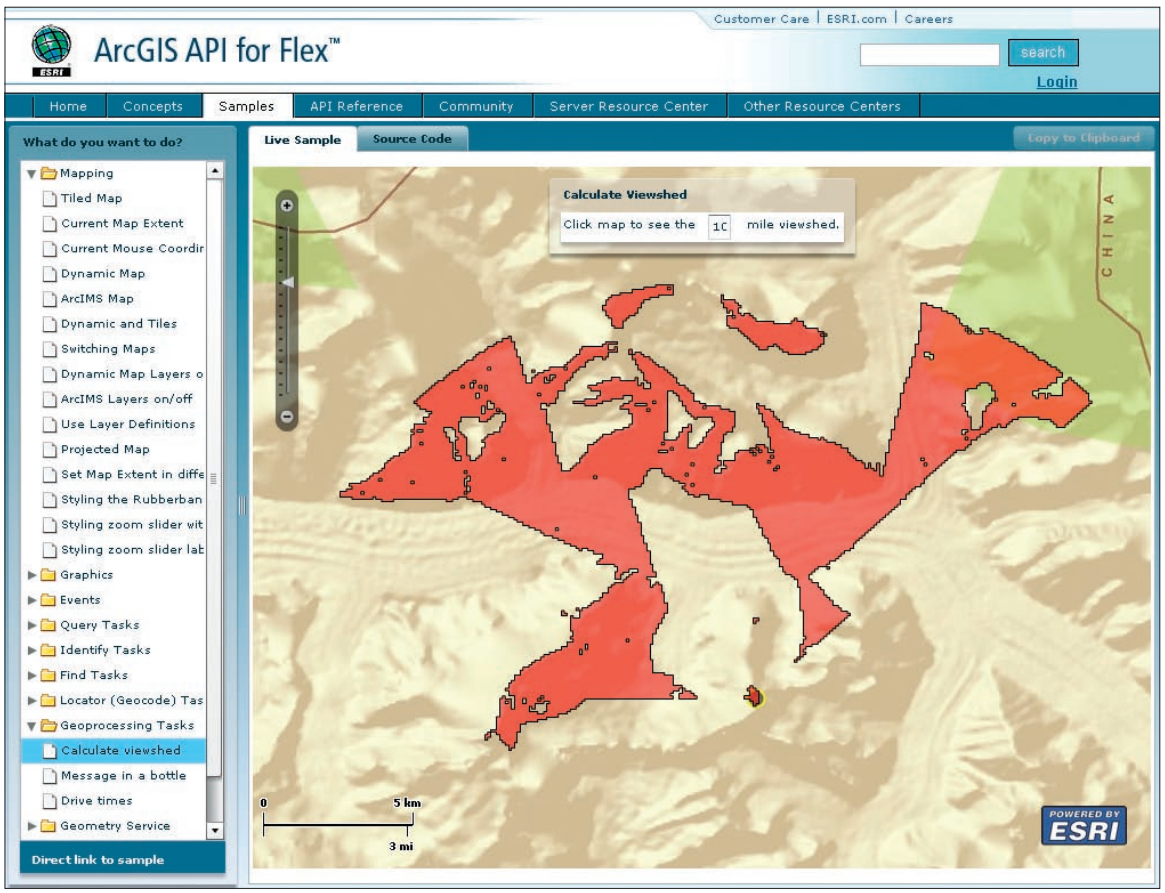
The resource center contains specific documentation about using the API and also includes a code gallery with sample applications, so developers can share their work.

Mansour Raad, a senior software architect at ESRI, also talks about the new ArcGIS API for Flex in a recent podcast. He discusses MXML, ActionScript, REST, and AIR.

The City of Boston, Massachusetts, was an early adopter of ArcGIS API for Flex and ArcGIS Server. The city recently deployed the Solar Boston application, a public-facing Web mapping application designed to showcase active renewable energy installations. The application, with a fast and visually dynamic user interface, allows users to calculate the solar power that can potentially be obtained via rooftops.

"We chose ArcGIS API for Flex because it allowed us to leverage the power of ArcGIS Server while delivering a rich, interactive experience to our users," explained Greg Knight, senior GIS applications developer, Boston Redevelopment Authority. "Development was both fast and enjoyable, and we are pleased with the functionality and performance of the application."

To learn more about ArcGIS API for Flex and ArcGIS Server, visit www.esri.com/flex or call 1-800-447-9778.



The ArcGIS API for Flex Resource Center includes live samples and the source code for adding mapping, graphics, events, and many different tasks such as this geoprocessing task for calculating viewshed from a point on the map.

Exploration and GIS: Closing the Productivity Gap

ESRI and Geosoft Work to Solve Exploration Challenges

By Carmela Burns, Geosoft

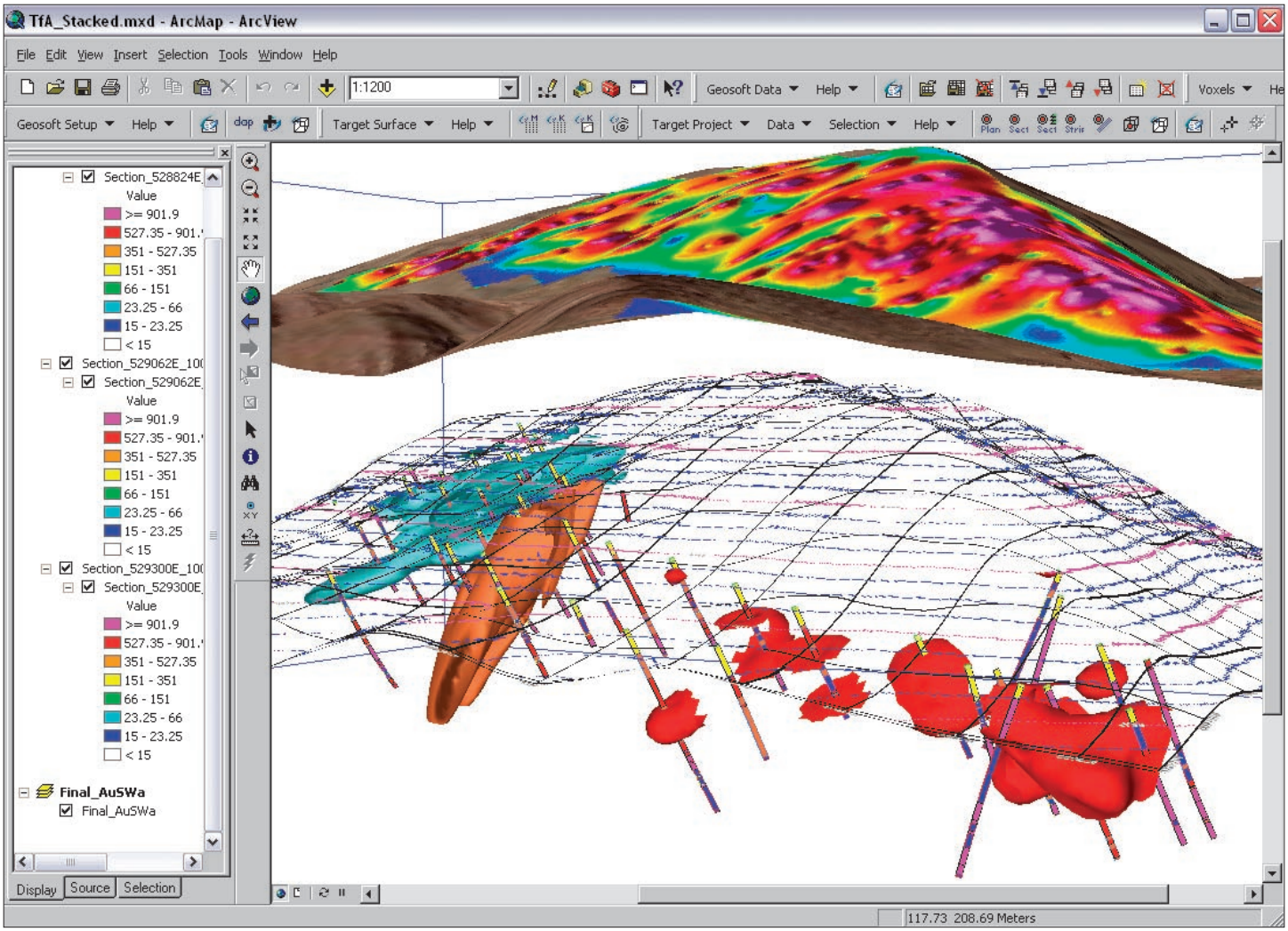
Exploration software and GIS are essential for geologists searching for petroleum and mineral deposits. With discoveries harder to find, geoscientists are collecting more data than ever and examining their findings with greater scrutiny. The key to keeping the whole process efficient and focused is technology.

Earth mapping software has come a long way in the past 10 years, providing more advanced three-dimensional tools to visualize and create sophisticated models of the subsurface. Exploration software developers like Canada-based Geosoft have focused on fine-tuning workflows and algorithms for handling large geological, geophysical, and geochemical earth data. Geoscientists working within the mining and petroleum industries rely on these powerful algorithms to piece together their understanding of the subsurface and develop their exploration projects. But until recently, the inability to work and share data between earth mapping platforms such as Geosoft and ESRI's ArcGIS environments had left a gap for explorers. As software developers on both sides of the gap begin to collaborate, technology and solutions are now evolving to allow geoscientists to share data between their mapping and GIS environments.

GIS software has been used for 2D mapping for decades. However, the limited ability of GIS to visualize below the earth's surface meant exploration companies have had to resort to workarounds. As a result, geoscientists tend to store their geological, geophysical, and geochemical information in one database and their surface geospatial data in another, with no efficient way of merging the two.

Although geoscientific data can be moved into and out of a GIS environment, doing so is time-consuming and can result in lost, changed, or corrupted data. For consulting geophysicists like Michal Ruder, whose livelihood depends on delivering accurate, up-to-date maps to clients in the oil and gas sector, recent advances in integrated GIS exploration tools mean smoother workflow and higher productivity in both 2D and 3D environments.

"Most of the time, I work with gridded data, and I can manipulate it using Geosoft exploration software," said Ruder, who is principal of Denver-based Wintermoon Geotechnologies. "That's not the whole solution, though, because after I've processed the gridded data, I need to integrate it with vector data. That means putting my magnetic and gravity data into the geographic context of my exploration problem."



Geologists can create and share 3D models across earth mapping platforms such as Geosoft and ESRI's ArcGIS environments.

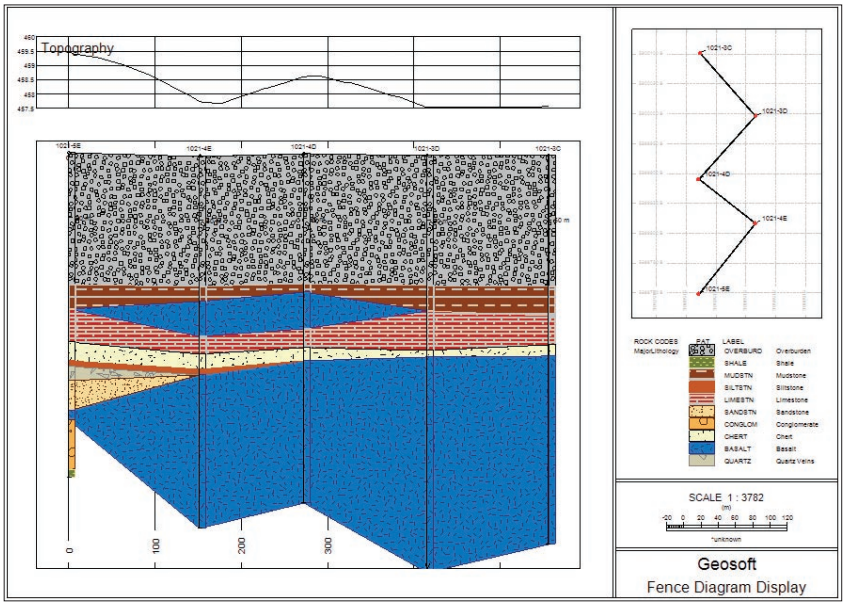
After moving the data into ESRI's ArcGIS, Ruder uses Geosoft extension software, Target for ArcGIS, to see geographic and other associations. She then searches for patterns in the Geosoft grids and ArcGIS vector data. Geosoft is working to close the exploration GIS gap entirely with its recent introduction of earth mapping software that has ArcGIS Engine technologies built in. The new generation of Geosoft mapping software allows geoscientists to work seamlessly between their Geosoft and ESRI environments, using ESRI technology to display Arc.mxd and .lyr files without leaving the Geosoft environment.

The breakthrough is expected to boost productivity and result in smoother workflows for geoscientists in both the private and public sectors. It will also prevent data from being changed or lost. "With this software, geoscientists have greater flexibility and control in achieving the results they need," said Louis Racic, director of product management for Geosoft Inc.

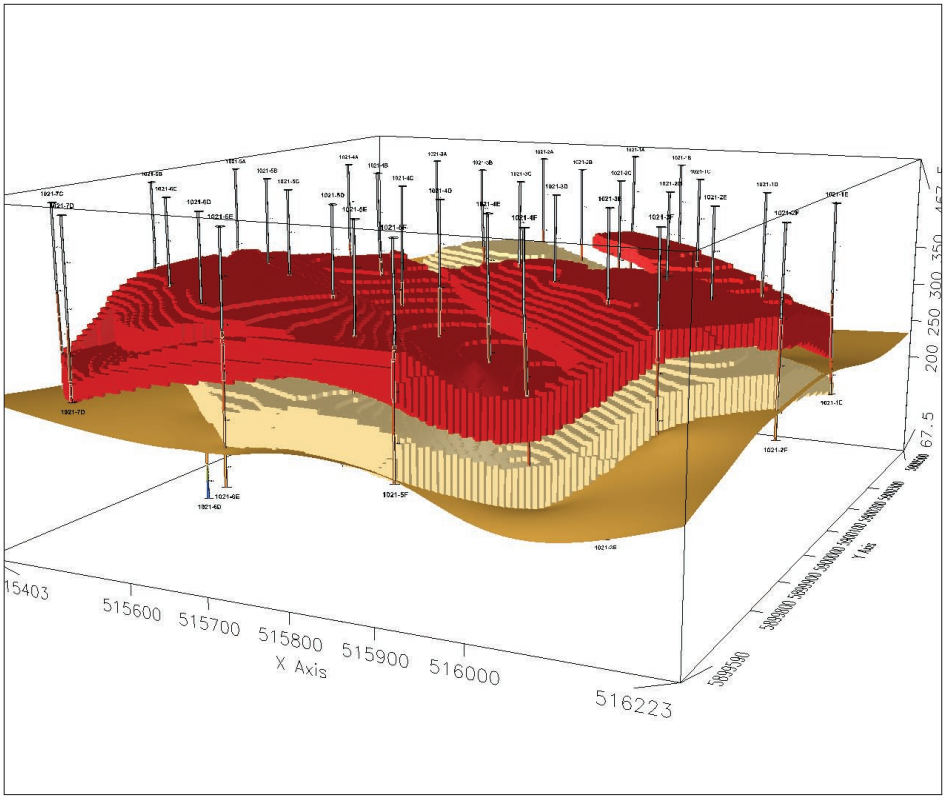
Closing the gap between GIS and geoscience also benefits large companies with multiple users and datasets. The more integrated their exploration software is, the less likelihood of costly mistakes or missed opportunities for discovery. Ana Maria Gonçalves is information manager for the exploration and project development division of Brazil-based Companhia Vale do Rio Doce (Vale), one of the largest mining companies in the world with 14 regional exploration offices. "As we become more global, being able to share information and expertise with other regions is increasingly important," said Gonçalves. "In the past, our exploration applications didn't connect with our GIS. We had to make all sorts of conversions, and with datasets such as geophysical grids, you can lose important information when you try to convert the data to other formats."

Adopting Geosoft Target for ArcGIS has done away with the need for data conversion, said Gonçalves. "Using Target for ArcGIS, our geoscientists can work with their geophysical, geochemical, and geological data within the ArcGIS environment much more quickly and effectively."

On a broader scale, trends in mineral exploration show there's a need for better integration of GIS and geosciences. Most ore deposits with a surface expression have already been found, so 3D information from the subsurface—particularly geophysical data—is becoming the main pathfinder to discoveries.



Fence diagram generated using Geosoft Target for ArcGIS extension software

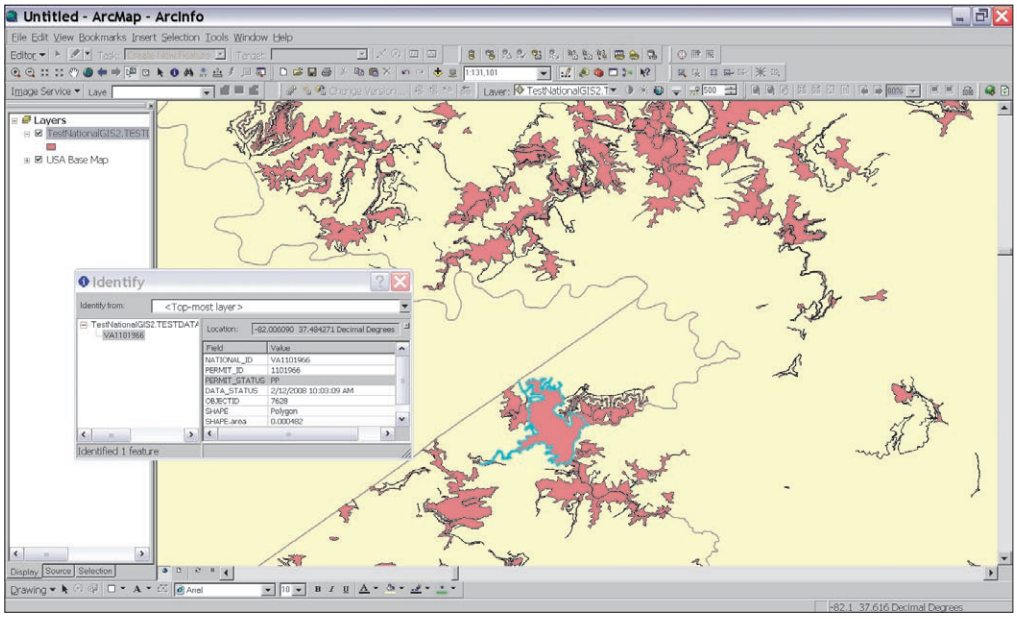


Exploration geologists can create and display their subsurface geology as 3D geology voxels and 3D geological surfaces in ArcGIS. This 3D isosurface was created with Geosoft Target for ArcGIS extension software.

Office of Surface Mining Wins 2008 Special Achievement in GIS Award for Data Migration Project

ArcGIS Data Interoperability Sets Precedent for Nationwide Standardization of Coal Mine Data

By Matthew DeMeritt, ESRI Writer



This map depicts the boundaries of a coal mine that crosses the Virginia/West Virginia state line. It is important that each state knows the boundaries of all bordering coal mines to ensure proper regulation. Data centralization is key to increasing that spatial awareness.

After Wyoming, the Virginias host the largest concentration of coal deposits in the United States. Because of the prevalence of coal mines in these states, the Office of Surface Mining (OSM) recently centralized the two states' coal mine data repositories in a pilot project. The goal of the project was to prove that centralization of coal mine data can be done on a national scale with enterprise GIS. Meeting this objective earned OSM the Special Achievement in GIS (SAG) Award at the 2008 ESRI User Conference.

Thirty years ago, mines that were depleted of all coal were simply abandoned with no remediation required. The environmental hazards of such practices became evident in the mid-1970s, and Congress passed the Surface Mine Reclamation Control Act in 1977. The legislation applied per-ton fees to all extracted coal and placed the money in an abandoned mine land fund. Money from the fund is distributed to assist reclamation efforts throughout the United States.

OSM oversees mine regulation in 26 states by reviewing reclamation plans and ensuring companies are in compliance. The process of reclamation is comprehensive, involving the restoration of mined-out land to the way it was before the operation started. In strip coal mines, topsoil is returned, surface and groundwater disturbances are mitigated, and vegetation is restored. Because coal mining has such a significant impact on the environment, it is the most regulated mining process in the United States.

The Virginia and West Virginia data migration project (which also included data from Tennessee and Indian reservations in the western states) is part of OSM's overall goal to standardize coal mine data in the United States. In 2006, the office established a task group to develop standards for exchanging geospatial data about coal mines. By standardizing the way coal mining geospatial data is exchanged, OSM will be able to better enforce mining laws and respond faster to mining-related emergencies. Standards developed by the task group can ultimately guide the efforts of rescue workers trying to reach miners trapped in an underground mine. Such a mishap can be the result of two neighboring states not knowing that their coal mines cross each others' borders. For example, if a mining company in Virginia starts a mine that is extended beyond the state line into West Virginia, Virginia might keep regulating that coal mine without informing West Virginia. Then a public works project could potentially drill into a flooded void that wasn't in its data because the mine was begun in another state. This exemplifies the need for a federated database of U.S. coal mine data.

To centralize the states' data stores, OSM needed a tool to simplify the data migration process and automate time-consuming manual tasks. For this, OSM used the ArcGIS Data Interoperability extension. This extension includes the FME Workbench application, which provides the graphic user interface for building spatial data flows to extract, transform, and load (ETL) data. For OSM's prototype project, this involved mapping the state-maintained geodatabase to the standardized OSM SDE geodatabase.

In FME Workbench, OSM's GIS team used geoprocessing tools, transformers, to automatically rename or recalculate field names and field values to ensure the resulting datasets accurately matched the new database schema. Transformers were also used to reproject the data into a common coordinate system.

"We took whatever format the states had their data in, replicated that on our central server, then connected the Data Interoperability service on our end," says Greg Morlock, OSM GIS team member. "From there, we simply entered the new data into a central database. By converting all the data into a single format, we were able to generate boundary and permit information faster than anyone expected. In five minutes, we created 9,000 permit boundaries."

By successfully combining data from two large coal mining states, OSM proved that a single tool can quickly and automatically convert a state's source data into the centralized destination dataset. Extending this technology to the rest of the country would improve the environment and protect the public from the potential complications of incomplete data.

More Information

For more information on OSM's use of the Data Interoperability extension, contact Greg Morlock by phone at 303-293-5075 or e-mail gmorlock@osmre.gov. To find out more about centralizing GIS data using the Data Interoperability extension, contact Jaylene Crick (jaylene.crick@safe.com).

continued from page 1

Using GIS to Remedy Coal Mining's Aftermath

reclamation in Pennsylvania, EPCAMR sought a way to more efficiently pinpoint the areas in need of remediation. Although the new allotment will significantly increase the work that can be done, $1.4 billion still needs to go a long way.

With a grant from the Foundation for Pennsylvania Watersheds and an agreement with the OSM Technical Innovation and Professional Services (TIPS) Program, EPCAMR used ArcGIS Desktop software and the ArcGIS Publisher extension to create a tool to keep track of abandoned mines. Called the Reclaimed Abandoned Mine Land Information System (RAMLIS), the application creates highly detailed maps at different scales with layers of information that help identify the areas most in need of remediation. RAMLIS also combines state, federal, and local data in maps that reveal all the components of mines such as mine discharge points, backfilled strip pits, and reclaimed mine shafts. To work safely and effectively, reclamation crews must know the location of these features. Knowing the location of flooded voids, for example, can potentially save enormous expense—even lives.

The dynamic, interactive maps assist reclamation efforts because they allow the public and local municipalities to understand what features are contained within a mine site and which features can be fixed using SMCRA funding. Map layers show a multitude of problems caused by leaving mines unattended. For example, the quality of water running off these sites is identified in a stream layer from the Pennsylvania Department of Environmental Protection (DEP) called the Integrated List of Waters. This layer shows streams that do not meet their intended use because pollution from the seepage of mining by-products drains into the stream. By turning on this layer, users can see certain sections of a stream that are impacted by mine drainage of heavy metals, such as iron or aluminum, into the stream. Toxic discharge from this runoff also decreases the pH to uninhabitable levels for fish and other aquatic organisms.

RAMLIS is also useful for civic management/land development. Elected officials can add their layers to this system for further analysis of a problem (e.g., input a tax parcel layer to examine neighborhoods for economic impacts because of local mine hazards). Local and county planning commissions use the program as a tool for land-use planning, storm water and floodplain management, and a host of other development-related issues. The tool contains road centerlines; municipal, county, and watershed boundaries; full-color aerial photos; and land-use datasets as background data.

Recently, EPCAMR took the application on the road to demonstrate its benefits to municipal officials throughout northeastern Pennsylvania. The goal of the workshops was to show how ArcGIS not only maximizes the value of reclamation budgets but also increases public awareness of mine hazards. In a flagging economy, and following a string of harrowing coal mine accidents in the past few years, EPCAMR's message couldn't have been more timely.

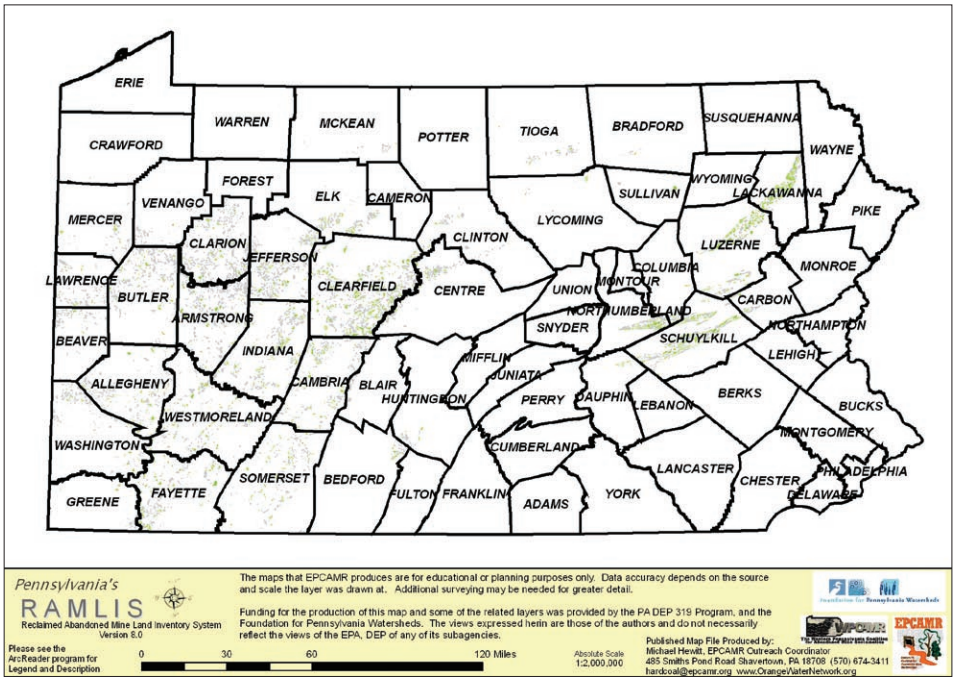
To show municipal planners and public officials what GIS was capable of, EPCAMR offered to produce up to three free maps for municipalities containing abandoned mines. One map was required to depict mined-out land, while the content of the other two was left up to elected officials based on available data. In a survey conducted after the tour, many of these municipalities responded that the new maps were helpful, since the old maps used for planning and maintenance were an average of 15 years old. Several municipalities were also interested in obtaining their own GIS software and technicians.

"If we can convince public officials who are in charge of making sound land-use planning decisions for their communities, it might turn the light bulb on for them," says Robert Hughes, regional coordinator for EPCAMR. "We're trying to say, 'Let us show you how GIS can be used to effectively allocate a limited amount of funding and resources over time.'" ArcGIS helps municipalities as well as state and federal officials by providing concrete evidence of potential health and safety hazards such as subsidence-prone areas. "Pollution from residual coal mine chemicals, illegal dumping, and land cave-ins is a real concern to some of these communities," says Hughes. "GIS gives us the best solution to identify and respond to these problems on a local level."

To date, approximately 22,500 acres of mine lands in Pennsylvania have been cleaned up and more than 280 mine drainage treatment systems are in place to treat polluted water. EPCAMR hopes the workshops in Pennsylvania continue to spread the GIS message to other organizations.

More Information

For questions regarding the use of GIS for mine reclamation, contact Robert Hughes, executive director, or Michael Hewitt, watershed outreach coordinator, EPCAMR (e-mail: hardcoal@epcamr.org; tel.: 570-674-7993). To learn more about Pennsylvania's mine reclamation work, visit www.orangewaternetwork.org.



With the Status & Priority layer turned on, public officials can see the areas in their districts that require reclamation, labeled by degree of priority. The Problem Type layer shows the specific hazards that are common in abandoned mines such as burning refuse piles and vertical mine shafts.

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