

COAL MINING GEOSPATIAL DATA FOR THE NATION¹

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Abstract. Digital geospatial data describing past, present, and proposed coal mining operations can provide significant benefits to government agencies, business interests, and the public when planning land use activities in coal-bearing areas of the nation. In September 2005, the Office of Surface Mining Reclamation and Enforcement (OSM) established the National Coal Mining Geospatial Committee (NCMGC) to promote the use of geospatial technology for implementing the Surface Mining Control and Reclamation Act of 1977 (SMCRA). The NCMGC is supported by OSM's Technical Innovation and Professional Services (TIPS) program and operates as a partnership between OSM and the states authorized to implement SMCRA. Committee members represent the geospatial technology interests of the states, tribes, and OSM offices. SMCRA organizations with representation in the NCMGC include the Interstate Mining Compact Commission (IMCC), National Association of Abandoned Mine Lands Programs (NAAML), and the Western Interstate Energy Board (WIEB). In June 2006, the NCMGC hosted the first National Meeting of SMCRA Geospatial Data Stewards in Denver, CO. These stewards are designated by each state/tribe regulatory and/or AML program to represent their geospatial technology interests and provide national coordination. Meeting accomplishments included identifying local needs for advancing use of geospatial data; identifying goals within organizations to obtain and use geospatial data; and identifying NCMGC activities at a national level to advance the use of geospatial technology within SMCRA organizations. The stewards approved development of the first two national coal mining data layers: coal surface mining boundaries and coal underground mining boundaries. The NCMGC formed a Coal Mining Spatial Data Standards ASTM Task Group to establish voluntary standards for these two layers. The NCMGC also created a Coal Mining Spatial Data Infrastructure Team to prototype methodology to collect selected coal mining datasets contributed by each participating state/tribe. These data will be assembled into national datasets for use in SMCRA business processes and distribution to the nation. Automation, reuse, and dissemination of coal mining geospatial data will bring multiple benefits to government, the coal mining industry, other business interests, academia, and the public. These benefits will include improved regulation of active coal mining operations, more successful reclamation of abandoned mine lands, and better public policy at local, state, and national levels.

Additional Key Words: surface coal mining, underground coal mining

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Introduction

The Office of Surface Mining Reclamation and Enforcement (OSM) and the state and tribal coal mining regulatory authorities (SRA's) implementing the Surface Mining Control and Reclamation Act of 1977 (SMCRA) regularly make decisions and perform actions in controlling the potential environmental impacts of surface coal mining operations. The majority of these actions consider the proximity of the proposed or existing coal mining operation to potentially affected adjacent areas and resources. Historically, these regulatory actions have been supported through the use of paper maps containing geographic features describing the coal mining operation and adjacent areas of interest.

Since 1988, the Technical Innovation and Professional Services (TIPS) program of OSM has promoted the use of Commercial-off-the-Shelf (COTS) computer software applications by SRA's to model the potential impacts of coal mining operations. In recent years, these computer software applications allowed the SRA to convert coal mining features shown on mining operations maps to digital format for use in computer mapping applications and also store these features in standardized geographic databases for reuse in multiple ways. For many reasons, efforts have been in progress within individual SRA's to digitally acquire and use coal mining geospatial features in many of their SMCRA business processes. In 2005, OSM initiated a national effort to promote the standardized use of geospatial technology within the entire SMCRA community.

National Coordination of Coal Mining Geospatial Activities

At the TIPS Steering Committee meeting held in St. Louis on May 3-5, 2005, the TIPS Steering Committee and OSM Director Jeff Jarrett concurred on the formation of a National Coal Mining Geospatial Committee (NCMGC). The NCMGC was established in late FY 2005 to promote the use of geospatial technology for implementing SMCRA. The NCMGC is supported by TIPS and operates as a partnership between OSM and the states authorized to implement SMCRA. Committee members represent the coal mining geospatial technology interests of the states, tribes, and OSM offices. SMCRA organizations with representation in the NCMGC include the Interstate Mining Compact Commission (IMCC), National Association of Abandoned Mine Lands Programs (NAAML), and the Western Interstate Energy Board (WIEB).

The NCMGC develops national strategies for implementing and promoting the use of geospatial technology within the SMCRA community; seeks solutions to problems affecting implementation of enterprise Geographic Information Systems (GIS) among SMCRA organizations; and identifies geospatial activities, policies, standards, and products that will increase the effectiveness and efficiencies of organizations working on SMCRA-related projects on a national scale. The committee assesses the need for geospatial resources to support all regulatory aspects of coal mining and reclamation activities and the availability of coal mining geospatial data, systems, and expertise. The committee evaluates the gap between requirements and available resources; identifies critical coal mining geospatial needs for federal, state, and tribal managers and staff; facilitates improved sharing of coal mining geospatial resources; and

helps to coordinate federal coal mining geospatial resources and initiatives relevant to national requirements.

In the future, the committee will examine SMCRA business processes for application of geospatial technology, and facilitate sharing of geospatial technologies to support implementation of SMCRA. The committee will recommend guidance in reengineering business processes across the SMCRA community to gain efficiency and benefit from today's geospatial automation technology. The committee will help ensure that scientifically sound coal mining geospatial data, spatial information products, technology applications, and services are provided in an efficient and cost effective manner to the SMCRA user community for use in minimizing risk and improving regulatory decision-making relevant to surface coal mining and reclamation operations.

NCMGC Accomplishments in FY 2006

The FY 2006 accomplishments of the NCMGC include holding a meeting to plan work activities; determining geospatial technology development status among all SMCRA organizations; establishing a Geospatial Data Steward within each SMCRA organization; conducting the first National Meeting of SMCRA Geospatial Data Stewards; identifying geospatial technology development needs of SMCRA organizations for FY 2007; establishing a Coal Mining Spatial Data Standards ASTM Task Group from Geospatial Data Stewards offering to help develop voluntary standards for exchanging coal mining spatial data; conducting the first meeting of this task group at ASTM headquarters; formation of a Coal Mining Spatial Data Infrastructure Team; and successful first steps in a "proof of concept" effort to develop a geospatial infrastructure to exchange selected coal mining spatial datasets between two networked servers inside OSM's Wide Area Network (WAN). These activities of the NCMGC support the goals of the President's Management Agenda in the expansion of e-Government to reduce redundancy; facilitate horizontal (cross-federal) and vertical (federal, state and local) information sharing; establish a direct relationship between IT and mission/program performance to support citizen-centered, customer-focused government; and maximize IT investments to better achieve mission outcomes.

NCMGC Activities in FY 2007

In FY 2007, the NCMGC continued efforts to promote the use of geospatial technology to meet the business needs of SMCRA organizations. Activities in FY 2007 include a planning meeting to review and implement recommendations from the first National Meeting of SMCRA Geospatial Data Stewards; briefings to OSM management and SMCRA organizations on the accomplishments and progress of the NCMGC in its activities; holding three meetings of the Coal Mining Spatial Data Standards ASTM Task Group to develop voluntary spatial data standards for the first two coal mining spatial data sets of national interest: coal surface mining boundaries and coal underground mining boundaries; sending qualified Geospatial Data Stewards to attend 18 vendor software training courses in managing coal mining geospatial data in an enterprise environment; continuing development work by the Coal Mining Spatial Data Infrastructure Team on a geospatial infrastructure to exchange selected coal mining spatial datasets among networked servers outside OSM's WAN; recruiting state regulatory programs to participate in this geospatial infrastructure; conducting an outreach program by giving presentations about NCMGC activities at national meetings of SMCRA organizations; exploring participation with the Mine Safety and Health Administration (MSHA); and establishing a

planning team to begin preparations for an FY 08 National Meeting of SMCRA Geospatial Data Stewards with a proposed theme of “Integrating Geospatial Technology into SMCRA Business Processes”.

Establishing Geospatial Data Stewards

The NCMGC hosted the first National Meeting of SMCRA Geospatial Data Stewards at the Warwick Hotel in Denver, CO on June 27-28, 2006. Benny R. Wampler, Deputy Director of the Virginia Department of Mines, Minerals, and Energy, delivered the keynote address on “Coal Mining Datasets of National Significance”.

During this two-day meeting attended by 44 participants, Geospatial Data Stewards from 18 approved state regulatory programs and 7 OSM offices worked through issues affecting the coal mining spatial data interests of their respective organizations. Topics discussed during the meeting included promoting the use of geospatial data in coal mining, results of a recent geospatial technology development questionnaire distributed among SMCRA programs, establishing voluntary standards for coal mining geospatial data, working with the coal mining industry to exchange coal mining spatial data, activities and accomplishments of the NCMGC in FY 06, establishing an electronic infrastructure to share coal mining geospatial data, and vendor software training for qualified Geospatial Data Stewards and other SRA staff.

The Geospatial Data Stewards participated in a live panel discussion on the first day of the meeting and a business networking session on the second day. During the business networking session, Geospatial Data Stewards first identified needs, goals, and expectations and then established priorities. Working with the Geospatial Data Stewards were representatives from the MSHA, Peabody Western Coal Company, Environmental Systems Research Institute (ESRI), and the American Society of Testing Materials (ASTM) International. More information about the meeting can be found at http://www.tips.osmre.gov/NCMGC/NCMGC_Meeting_2006.asp.

Developing Coal Mining Spatial Data Standards

At the National Meeting of SMCRA Geospatial Data Stewards, the NCMGC announced plans and requested volunteers to help develop voluntary standards for the exchange of coal mining spatial data among the states, tribes, OSM offices, coal mining industry, and the public. Developing these standards will help advance the use of geospatial technology for implementing SMCRA.

On August 2, 2006 initial selections among the volunteers were made to establish the Coal Mining Spatial Data Standards ASTM Task Group. Currently, the task group consists of representatives from the SRA's, OSM offices, the Mine Safety and Health Administration (MSHA), the coal mining industry, and the general public. A qualified professional facilitator knowledgeable and experienced in development of voluntary standards under American Society of Testing Materials (ASTM) guidelines provides technical support. In addition, a representative from the Federal Geographic Data Committee (FGDC) provides coordination as the task group works on establishing an ASTM standard.

The first task group meeting was held September 20-21, 2006 at ASTM International Headquarters near Philadelphia, PA. At this meeting, group members learned how the ASTM methodology works for developing voluntary national standards for geospatial data. The task group began the process to develop standards for the first two national coal mining spatial data sets – coal surface mining boundaries and coal underground mining boundaries – which will be assembled and periodically updated from existing data sets already in use within each of the various regulatory programs in differing formats. The task group also began to identify and work on many issues to define the content, scope, geometry, accuracy, attributes, and other characteristics of these first two national coal mining spatial data sets.

When voluntary standards have been drafted for these first two coal mining spatial data sets, review and comment will be requested from all interested parties. As requirements are met for establishing ASTM standards for these two spatial data sets, requirements to establish FGDC standards will also be accomplished.

In FY 07, three additional team meetings were planned for various locations in the U.S to continue work on this task. A meeting was held in Costa Mesa, CA on January 30. Future meetings are planned for Norfolk, VA on June 26, and possibly Salt Lake City, UT in September. In future years, development of additional national layers of coal mining spatial data will be considered. These additional layers may include geologic sampling locations and their chemical attributes, surface- and ground water sampling locations and their associated water quality attributes, bond increment areas, abandoned mined land areas, or other data layers determined by the task group to be of national interest.

Creating a Coal Mining Spatial Data Infrastructure

Following the National Meeting of SMCRA Geospatial Data Stewards in 2006, OSM began internal discussions to determine how to develop a prototype coal mining geospatial infrastructure to collect, store, manage, use, and distribute selected coal mining spatial data from among all participating SMCRA organizations. At the SRA level, two elements are critical to implementation. First, SMCRA Geospatial Data Stewards must adopt the data standards developed by the Coal Mining Spatial Data Standards ASTM Task Group and apply them to applicable coal mining spatial data used within their respective SMCRA organizations. Second, the SMCRA Geospatial Data Stewards must adopt an enterprise geospatial data model. This model uses a Relational Database Management System (RDBMS) such as Microsoft SQL Server or Oracle for data storage and a spatial data management system such as ESRI's ArcSDE.

Through read-only access to selected coal mining spatial data in the SMCRA organization's enterprise geodatabase, an automated process from a centralized server within OSM's WAN will periodically download the selected spatial data, re-project the data from a state coordinate system to a national coordinate system, perform other data adjustments as may be required, and aggregate it with data from other SMCRA organizations into a single national dataset for each selected theme. By using an automated process, no resource requirements will be imposed by OSM on participating SMCRA organizations to manually collect, process, or upload "stale" coal mining spatial data to OSM, and resource requirements on OSM also will be minimized. Coal mining spatial data uploaded through this automated process will be the highest quality, most reliable, and latest available data from the Authoritative Data Source (ADS), the SMCRA

organization creating and managing the data on a daily basis for their respective area. In this manner, selected coal mining spatial data from all participating SMCRA organizations will be combined to form national datasets appropriate for internal use by OSM and for distribution to the public via Internet map server applications and/or data services to Geospatial One Stop (GOS), the National Map, and other means as appropriate without additional human resource commitments by the participating SMCRA organizations.

Many problems will need to be overcome during development of a national coal mining spatial data infrastructure. Potential problems include but are not limited to inability of small SRA programs to adequately participate due to resource issues; possible resistance to participation by SRA's; state and federal mandated Information Technology (IT) requirements adversely affecting infrastructure development; IT security issues; unanticipated difficulties within OSM in collecting, managing, and developing applications for national datasets; spatial data metadata documentation; ADS stewardship issues; data liability and confidentiality concerns; and funding for infrastructure development. All of these problems appear to have manageable solutions.

An initial meeting of the Coal Mining Spatial Data Infrastructure team on June 29, 2006 and subsequent teleconferences of September 5 and November 7 provided opportunities for team members to identify issues, discuss possible solutions, and develop plans to prototype a "proof-of-concept" spatial data infrastructure. An implementation plan consisting of two phases was selected. In Phase 1, a pilot project to exchange coal mining spatial data between at least two ArcSDE servers at remote locations within OSM's WAN would be attempted. In Phase 2, a similar effort would be made to exchange selected coal mining spatial data between a server inside OSM's WAN and one or more enterprise geospatial data servers located outside the OSM WAN at a SRA.

The Phase 1 attempt was successfully conducted on August 3, 2006. Prior to this attempt, a user account with read-only permission was established on an ArcSDE server located at an OSM office in Knoxville, TN to allow access through the Internet from a workstation located at an OSM office in Denver, CO. In this test, a GIS specialist in Denver manually executed a script written in ArcGIS ModelBuilder to automate the entire process of logging onto the ArcSDE server in Knoxville and a similar ArcSDE server in Denver from the workstation, downloading selected data from both servers, closing connections, re-projecting four datasets from different coordinate systems to a single national coordinate system, and merging them into a single dataset. In this test, 891 surface coal mining polygon boundaries and attributes of Tennessee were combined with 8 surface coal mining polygon boundaries and attributes representing 4 surface coal mining operations located on Indian tribal lands in Arizona and New Mexico. This entire process required less than a minute for completion.

Prior to attempting Phase 2, additional requirements must be met. In Phase 2, GIS personnel within selected SRA's will be enlisted to allow access to selected coal mining spatial data on enterprise servers within state organizations operating outside OSM's WAN. The use of ArcGIS Server 9.2 by the SRA to create an ArcGIS Internet service on their server will be encouraged. Otherwise, OSM may be required to establish interconnection agreements with the SMCRA organizations for direct access, provide business plan documentation to OSM's Chief Information Officer (CIO), and address potential issues relative to security. An automation

procedure similar to that used in Phase 1 will be employed. New technologies, such as ESRI's Data Interoperability Kit, Feature Manipulation Engine, and replicated geodatabases maintained by ArcGIS Server 9.2 will be evaluated. Phase 2 is planned for May, 2007.

Using Coal Mining Geospatial Data

Within SMCRA organizations, managers have struggled with demands to modernize business processes, improve efficiency, and produce higher quality work products in a budget-constrained environment with limited resources. A key factor affecting these demands is the high but hidden cost of managing paper information products such as narrative reports, tables of environmental data, and maps. Historically, SMCRA organizations have required that mining companies provide a considerable amount of data with every permit action in order to conduct analyses supporting regulatory decisions affecting surface coal mining operations. This data involves the use of considerable quantities of paper. Extracting features shown on coal mining operation maps with their associated attributes for storage and management in a Geographic Information System (GIS) allows access, analysis, and reuse of this data by modern software applications. This is a significant technological advancement in processing data contained in the information product most resistant to conversion to "intelligent data" – paper maps. With this development, opportunities now exist for re-engineering SMCRA business processes to employ automation to improve efficiency and use scientific software mapping applications to conduct better analyses resulting in higher quality work products.

In the modern SRA working environment, a spatial data infrastructure which uses data storage structures in a client-server architecture will promote acquisition of new spatial data from the mining industry in a digital format; aid in conversion of existing paper-based maps to digital format through scanning and/or digitizing; support the business processes of the organization through the use of scientific software to display, query, and map coal mining spatial data at desktop workstations; provide spatial data for use in the field by mobile computing devices equipped with Global Positioning System (GPS) technology at coal mining operations; support Electronic Permitting (EP) initiatives; and set a foundation for On-Line Analytical Processing (OLAP). OLAP allows users to query summarized, multidimensional data; apply relevant business logic; retrieve information; and produce fast, consistent, and accurate information products that support decision-making in applications without manual data manipulation. For more about OLAP geospatial data, see <http://www.esri.com/news/arcuser/0206/olap1of2.html>.

For many reasons, SMCRA organizations will require coal mining spatial data infrastructures which support the present operational needs of their organizations and provide an adequate foundation to meet future challenges. At the SRA, these systems will support the management of day-to-day activities related to technical reviews of coal mining permit applications and inspections of coal mining operations. At OSM, coal mining spatial data collected from SRA enterprise systems and aggregated into national datasets will be used to help implement the nation's coal mining laws and regulations, promote better understanding of the potential impacts of surface coal mining operations, detect and identify problems, and provide new opportunities in the assignment of resources to resolve potential environmental issues.

These national datasets may consist of coal mining features such as surface coal mining boundaries, underground coal mining boundaries, coal haul roads, critical earth fill structures, sediment basins, geologic drill holes, surface- and groundwater monitoring locations, and other coal mining features determined to be of national interest. Sharing these datasets provides access to valuable natural resource information otherwise stored in paper files within the various SRA program offices and subject to future loss. OSM intends to make these national coal mining spatial datasets available to the public through Internet mapping services, registration with Geospatial One Stop (GOS), publication on the National Map, and other media as appropriate.

Benefits to the Nation

Digital geospatial data describing past, present, and proposed coal mining operations can provide significant benefits to government agencies, business interests, and the public when planning land use activities in coal-bearing areas of the nation. These benefits will include improved regulation of coal mining operations, more successful reclamation of abandoned mine lands, and better informed public participation.

Improved Regulation of Coal Mining Operations

Aggregation of selected SRA coal mining spatial data into a collection of national datasets provides an opportunity for OSM to use these new data sources to better understand and more efficiently work with individual SRA's on issues of local importance. For the first time, OSM will have near real-time access to coal mining spatial data accurately describing location, boundaries, spatial extent, and important attributes of significant coal mining features of coal mining operations in the United States. These data can be used to enhance OSM's administrative capabilities by being able to locate, identify, and conduct reviews of permitted coal mining operations. Information products derived from this data can be used to help determine and verify on a state, regional, or national basis acres under permit and acres reclaimed in various phases of bond release; support or replace current methods of obtaining information for OSM's Annual Report; and help answer other "state of the land regarding SMCRA" questions in near real-time.

Creation and use of national coal mining spatial datasets by OSM will support better cooperative efforts. Government organizations will be able to work in new ways to reduce the environmental impacts of coal mining such as regional hydrologic studies of subterranean water flow among interconnected underground coal mine workings, determinations of potential mine blowout locations, acid mine drainage prediction and remediation efforts, and underground subsidence planning and investigation. Use of these data to support traditional "oversight inspections" conducted by OSM of SRA activities may result in reallocation of human resources by OSM from random inspections to focus on geographically-defined "problem areas" to help SRA's better implement SMCRA.

More Successful Reclamation of Abandoned Mine Lands

SMCRA organizations manage the reclamation of lands mined for coal and abandoned prior to passage of the Act through funding provided by OSM. When reclaimed, these lands support higher and better land uses. However, certain types of reclaimed coal mine features present

limitations to future land uses. These include former coal refuse piles, mine spoil areas, slurry impoundments, and underground coal mines with a high potential for subsidence.

Reclaimed coal refuse piles, mine spoil areas, and slurry impoundments should not be built upon for many years unless special construction methods are used. During reclamation, these materials may be covered by only two to four feet of earth to provide adequate depth for plant growth. Reclaimed coal mining areas may be difficult for the public to recognize without prior training or experience. These coal mining areas will continue consolidating over time and may be structurally unstable without earth compaction methods.

In home and building construction, excavations for basements and foundations may also expose toxic and acidic coal mine wastes resulting in loss of reclamation and construction damage. Structures built in these areas may also be susceptible to accumulation of CO₂ and other coal mine gases. If basements and crawl spaces are excavated into recently mined and reclaimed mine spoil, CO₂ may fill the completed structure to concentrations which can cause injury or death to the occupants if not properly ventilated. Abandoned underground coal mines near the surface may be susceptible to subsidence, causing very serious structural damage as room-and-pillar mining areas collapse many years after abandonment. The OSM AML inventory only identifies areas where abandoned mines have already subsided, causing damage to existing structures. The AML inventory does not identify those locations in which abandoned coal mines may yet subside in the future. Prior public knowledge of the location of former coal mining areas is required to adequately plan for construction in these areas and address potential problems.

Better Informed Public Participation

Dissemination of coal mining spatial data to the nation provides opportunities for others outside the SMCRA community to benefit from state and federal coal mining spatial data resources. In the future, these data may help inform the public about the extent and potential impacts of proposed and existing surface and underground coal mining operations, reduce the amount of new construction on abandoned mine sites, help reduce the growth of the AML inventory by public awareness of the location of abandoned coal mines, support MSHA responses to underground coal mine emergencies, assist the USGS in their efforts to estimate remaining coal reserves (Tewalt et al., 2001), help update surface land use and geologic information for improved environmental impact assessments, and enhance the utility and relevance of the approximately 134,000 underground mine map images contained in the National Mine Map Repository managed by OSM by providing a “geographic footprint” which can be used as a spatial index to the location of the map image.

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