



# Integrating Mine and Mine Map Databases with Georeferenced Maps to Provide a Mine Safety GIS for Southwestern Virginia

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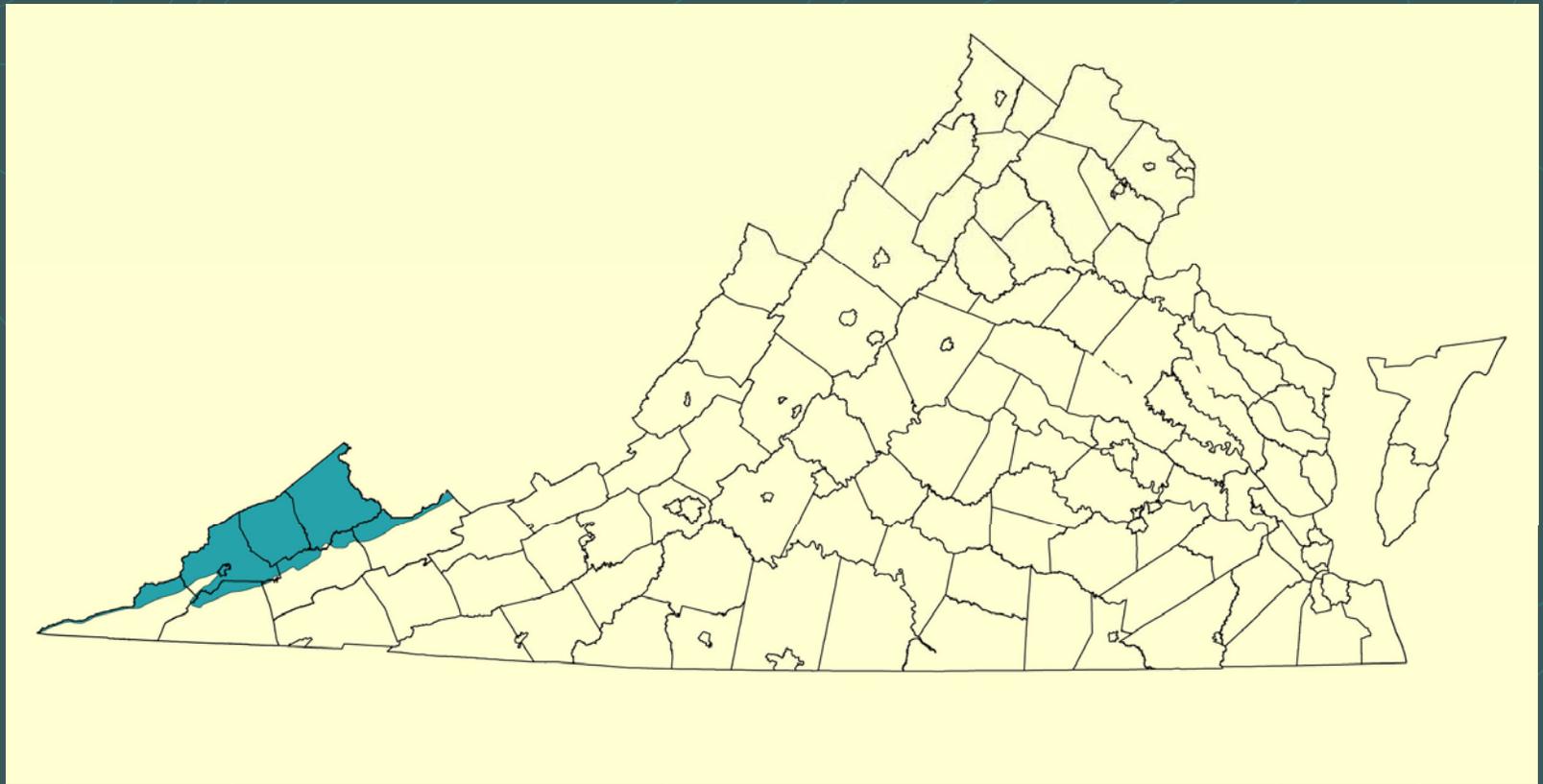


# Introduction



Digital rendering of underground coal mine maps is a critical component of Virginia's commitment to enhance mine safety.

# Southwest Virginia Coalfield





# Driving Forces

- ❖ The Department of Mines, Minerals and Energy (DMME) has been collecting mine maps since the late 1950s.
- ❖ DMME has identified over 20,000 available mine maps.
- ❖ Safety personnel, inspectors, and regulators all need quick and easy access to these maps to perform their jobs.



# Driving Forces

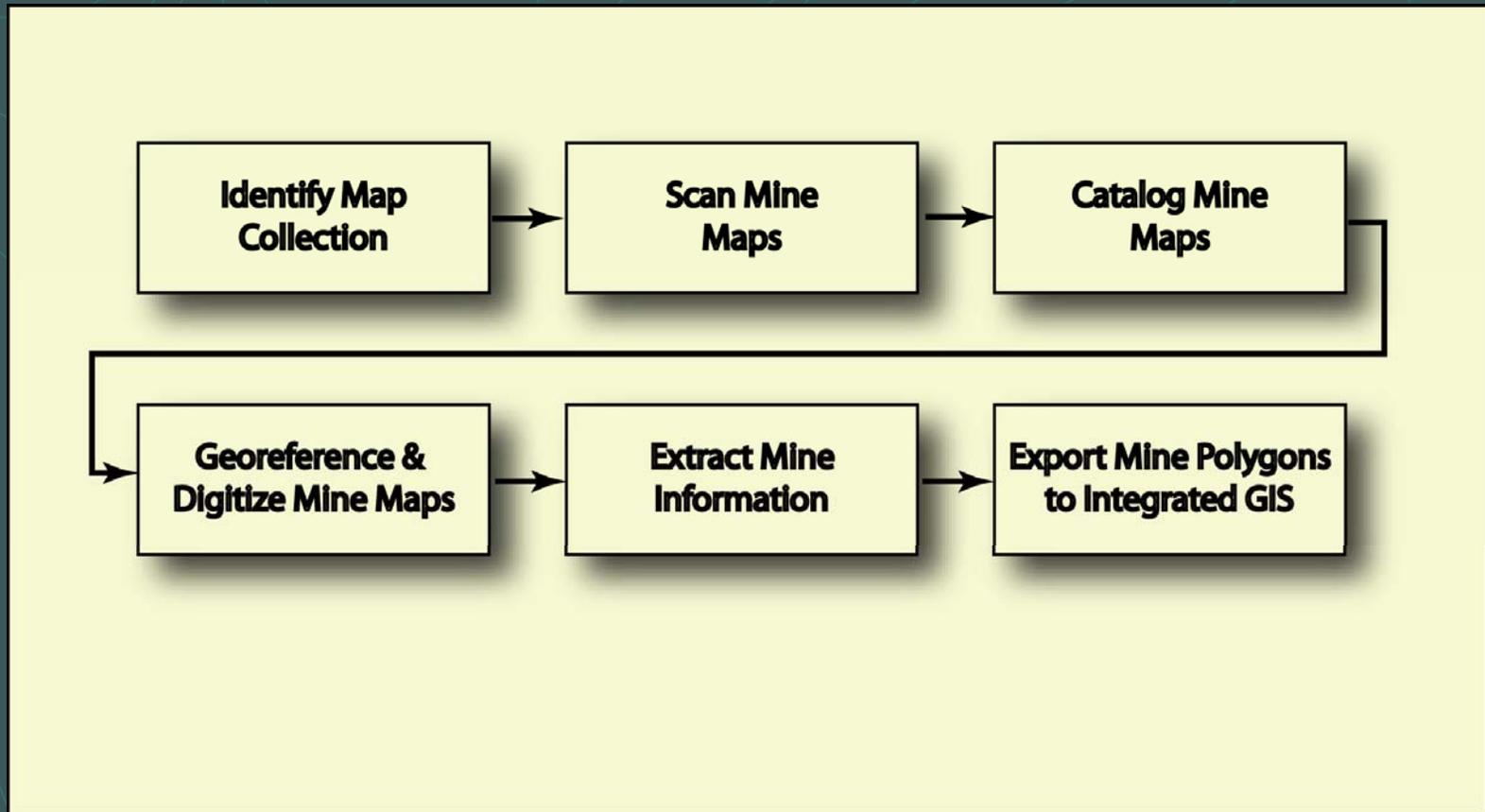
- ❖ DMME needed an efficient way to get the right data to the right people.
- ❖ DMME needed a way to store and view 20,000 plus maps.
- ❖ DMME needed to know what information was on which maps.

Solution:

Develop an integrated web-based  
inventory system with GIS  
capabilities!



# Process Flowchart





# Identify Mine Maps

- ❖ DMME Internal Collections
- ❖ Federal Collections
- ❖ Mine Company Collections
- ❖ Library Collections
- ❖ Personal Collections

# Sources of Underground Mine Maps

<b>Source</b>	<b>Estimated # of Maps</b>	<b>Type of Maps</b>	<b>Estimated Age Range</b>
State Library of Virginia	1866	Microfilms of closure maps	1958 to 2002
DMME Client Assistance Center	4848	Diazo duplicates of State Library microfilm	1907 to 2003
OSM National Mine Map Archive	3533	Microfilms	1910 to 1999
DMME Active Mines	461	Paper maps	1996 to 2004
DMME Division of Mineral Resources Archive	2515	Paper maps	1960 to 2002
DMME Previously Donated Map Collection	2277	Paper maps	Various
DMME Scanned Map Archives	821	Paper maps	1938 to 2003
Map Archives of Collaborating Mining and Land Companies	4221	Paper maps	Various



# Scan Mine Maps

- ❖ Paper maps were scanned using a large format scanner at 200 to 300 dpi.
- ❖ Microfilm Images were out-sourced to be converted to digital images.

# 20,000 MAPS, NOW WHAT?



# Catalog Mine Maps

With 20,000 mine maps, a queryable database needed to be established.



*The Coal Mine and Mine Map Inventory System*



# Catalog Mine Maps

- ❖ A list of key data was developed.
- ❖ A platform that was robust and could serve individuals working in multiple locations was needed – Microsoft SQL Server.
- ❖ Dual monitor work stations – allows for quicker data entry.

# Dual Monitor Workstation



# Data Cataloged From Mine Maps

- 
- ❖ Unique DMME ID number
  - ❖ Date of Mine Map
  - ❖ Map Scale
  - ❖ Company Name
  - ❖ Thickness and Elevation Data
  - ❖ Surface Mines and Auger Mines
  - ❖ Adjacent Mines
  - ❖ Gas Wells Present
  - ❖ Roof Falls
  - ❖ Water
  - ❖ Crop Line
  - ❖ Company Coal Bed
  - ❖ Scan Information
  - ❖ Mines Shown on Map
  - ❖ Standard Coal Bed
  - ❖ Coordinates
  - ❖ Location Information (County, Quad, Drainage)
  - ❖ Georeference

# Screen Shot of Mine Map Entry Form



## Coal Mine and Mine Map Inventory System

[Back](#) [Map Scans](#) [Mines Shown\(Georeferenced\)](#) [Geographical Info](#) [Coalbeds](#) [Adjacent Mines](#) [New Map Entry](#) [Home](#)

### Basic Map Information

Collection Name:	DM Current
Collection ID:	462
DMME ID:	DMC462
Map ID:	62914
Date of Mine Map:	09/12/1976 OR <input type="checkbox"/> No Date
Date Type:	OTHER
Map Scale:	100
Company Name:	GRASSHOPPER ENTERPRISE
Mine Name:	K 1 MINE
Certified Engineer:	
Map Type:	HAND-DRAFTED
Map Quality:	GOOD
Vault Location:	
Entry Date:	10/18/2004
Entry Initials:	RJK

- |  |  |
|--|--|
| <input checked="" type="checkbox"/> Thickness Data | <input type="checkbox"/> Water                 |
| <input checked="" type="checkbox"/> Elevation Data | <input checked="" type="checkbox"/> Roof Falls |
| <input type="checkbox"/> Surface Mines             | <input type="checkbox"/> Final Map             |
| <input type="checkbox"/> Adjacent Mines            | <input type="checkbox"/> Drains                |
| <input type="checkbox"/> Auger Mines               | <input checked="" type="checkbox"/> Crop Line  |
| <input type="checkbox"/> Coreholes Present         | <input type="checkbox"/> Other Portals         |
| <input type="checkbox"/> Gas Wells Present         | <input type="checkbox"/> VVHs                  |

How do all of these maps relate to each other in the real world?

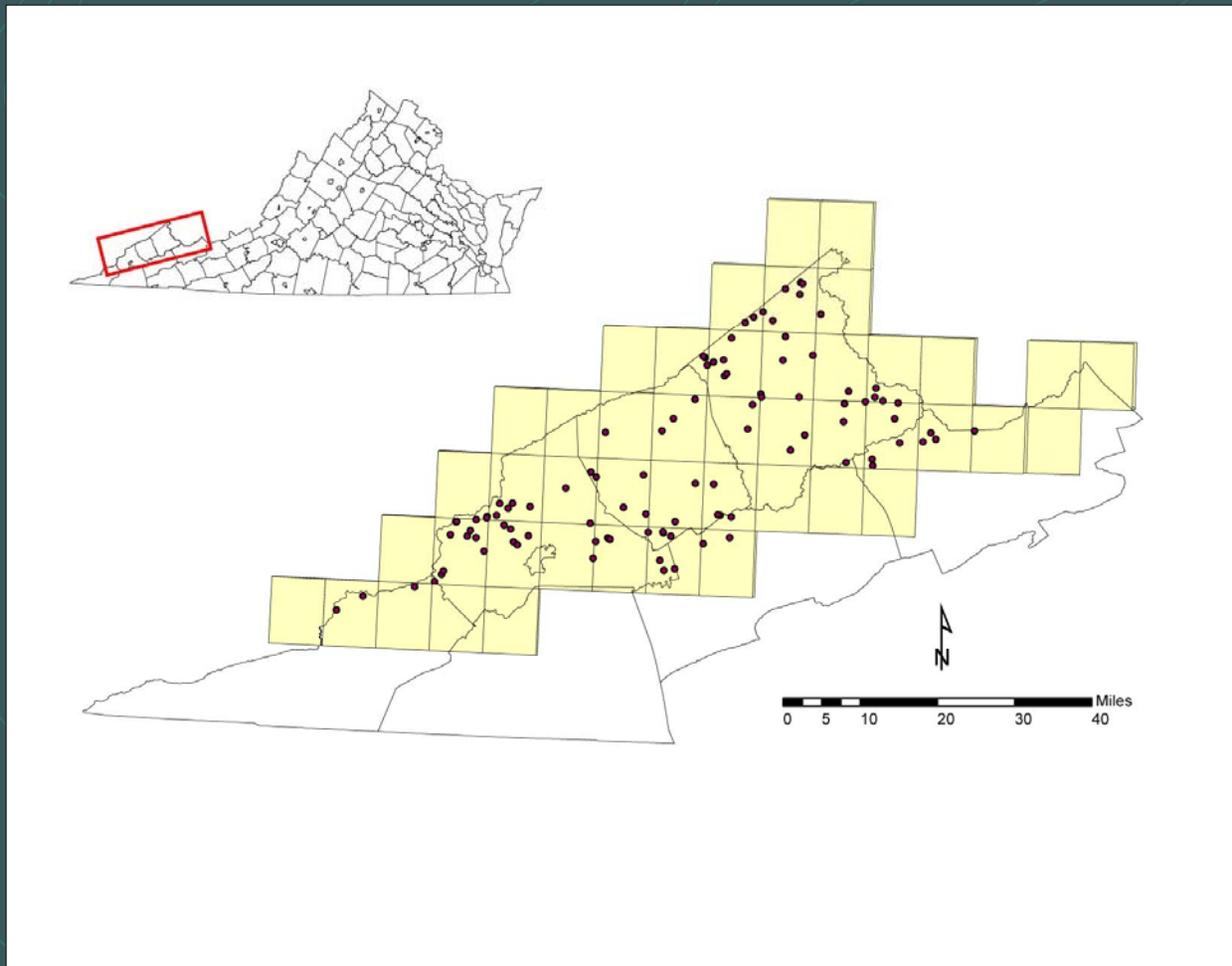




# Georeferencing Mine Maps

- ❖ Georeferencing is the groundwork for integrating the database and spatial information (a GIS).
- ❖ A GIS improves the quality, searchability, distribution and manipulation of data.
- ❖ Maps were located in the X, Y and Z dimensions.
- ❖ Areas of active mining were prioritized.

# Locations of Active Mining in Southwest Virginia



# The Z Dimension



Coal bed naming and assignment  
(Stratigraphy)



# Stratigraphy

- ❖ Coal bed names have varied due to local and regional naming, proximity to one another, temporal name changes, and deliberate name switching.
- ❖ Up to 250 variations in local and regional coal bed names have been identified.
- ❖ Stratigraphic nomenclature has been standardized and normalized to 75 reference coal beds.



# Assigning Stratigraphy

- ❖ The first step in assigning a coal bed is to use the coal bed the mining company has assigned.
- ❖ Then the elevations and coal outcrop on the mine map are compared to information published on geologic quadrangles.

# Stratigraphy

## Local Naming Variations of the Imboden Coal Bed in Virginia

Blue Gem	
Burnwell	
Campbell Creek	
Freeburn	
Lower Bolling	
Lower Campbell Creek	
Lower Elkhorn	
Lower Marrobone	
Mason No. 2	
Mason No. 3	
No. 1	
No. 2	
No. 3	
No. 2 Gas	
Path Fork	
Pond Creek	
Upper Bolling	
Upper St. Charles	
Upper War Eagle	
Warfield	

Imboden coal bed

Twenty local names have been identified for the Imboden Coal bed at this time.



# Cataloging Mine Data

- ❖ Mine footprints are digitized and vectorized in AutoCAD.
- ❖ Coal thickness and elevation data are also captured in AutoCAD.
- ❖ A mine record is generated in the *Coal Mine and Mine Map Inventory System*.



# Mine Information Cataloged

- ❖ Unique label
- ❖ Mine name
- ❖ License numbers
- ❖ Coal company and/or operator
- ❖ Coal bed
- ❖ Roof falls
- ❖ Flooding
- ❖ County and Quadrangle

# Screen Shot of Mine Entry Form

**DM** Virginia  
**ME** Department of  
Mines Minerals  
and Energy

## Coal Mine and Mine Map Inventory System

[Back](#) [Vector Amendments](#) [Geographical Info](#) [New Mine Entry](#) [Home](#)

### Basic Mine Information

Mine ID:	<input type="text" value="RJK001"/>	<input checked="" type="checkbox"/> Unknown
License #:	<input type="text"/>	<input checked="" type="checkbox"/> License Possible
MSHA ID:	<input type="text"/>	
Previous ID:	<input type="text"/>	
Mine Name:	<input type="text" value="GRASSHOPPER MINE #1"/>	
Company:	<input type="text" value="GRASSHOPPER ENTERPRISE"/>	
Operator:	<input type="text" value="John Doe"/>	
Lessor:	<input type="text"/>	

### Coalbed Information

Standard Coalbed	<input type="text" value="RAVEN"/>
Company Coalbed	<input type="text" value="R NO. 2"/>

### Other Information

Mining Method	<input type="text" value="ROOM AND PILLAR (OLD)"/>
Mine Size	<input type="text" value="MEDIUM"/>

Roof falls     Mine Drains     Water in Mine

How do we get the data to people  
who need it?



AutoDesk MapGuide



# Data Delivery

- ❖ A topology is created to establish the relationship of spatial elements to each other.
- ❖ Data are added to MapGuide as layers.
- ❖ Mine Polygons in MapGuide are linked to the *Coal Mine and Mine Map Inventory System* and scanned map images can be imported.



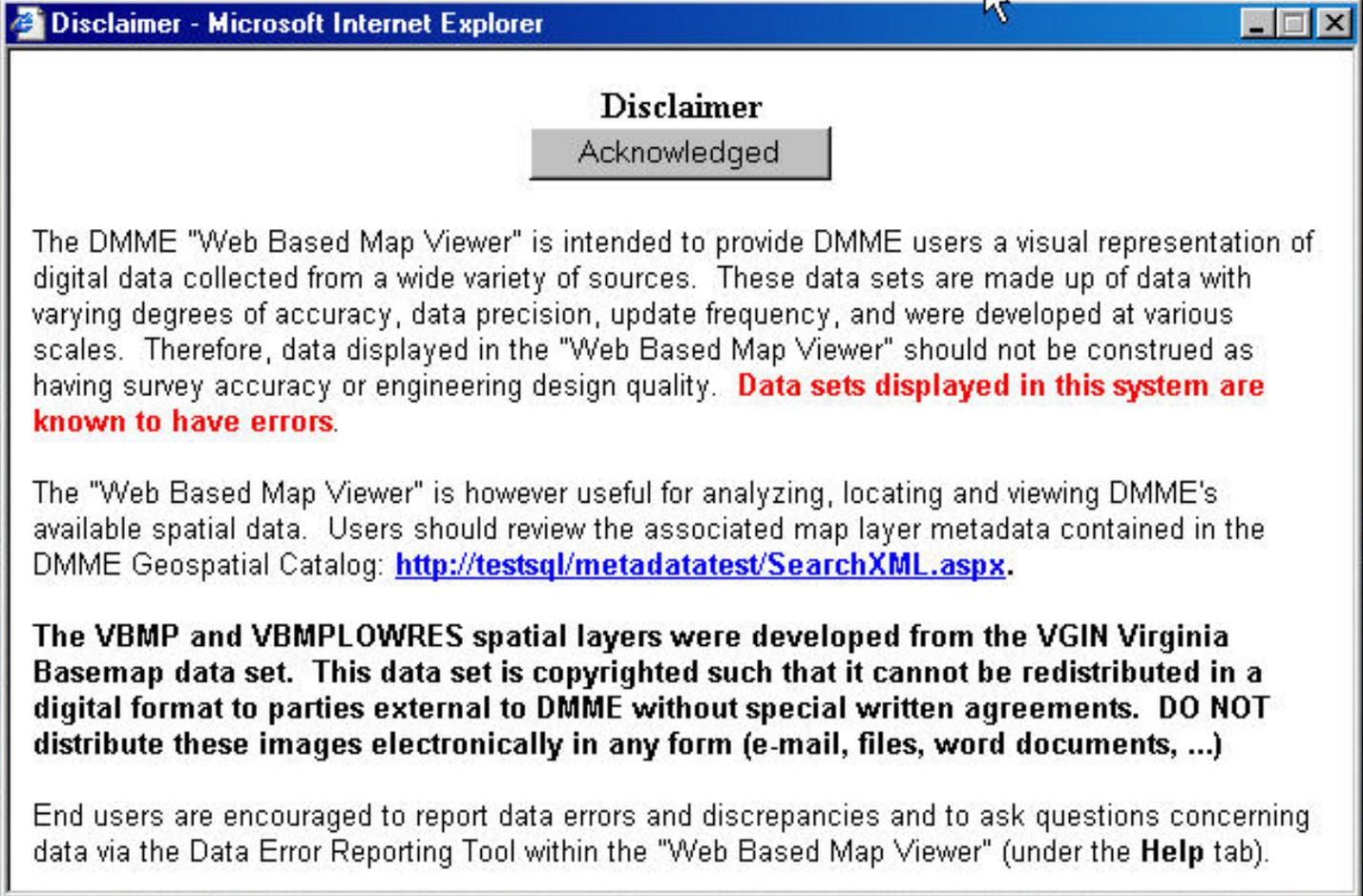
# Layer Elements

- ❖ Coal crop outlines
- ❖ Underground mine polygons
- ❖ Adjacent mines
- ❖ Active mines
- ❖ Surface mines
- ❖ Natural and cultural features

# DMME's Web Based Map Viewer



# Disclaimer



**Disclaimer**

Acknowledged

The DMME "Web Based Map Viewer" is intended to provide DMME users a visual representation of digital data collected from a wide variety of sources. These data sets are made up of data with varying degrees of accuracy, data precision, update frequency, and were developed at various scales. Therefore, data displayed in the "Web Based Map Viewer" should not be construed as having survey accuracy or engineering design quality. **Data sets displayed in this system are known to have errors.**

The "Web Based Map Viewer" is however useful for analyzing, locating and viewing DMME's available spatial data. Users should review the associated map layer metadata contained in the DMME Geospatial Catalog: <http://testsql/metadatatest/SearchXML.aspx>.

**The VBMP and VBMPLOWRES spatial layers were developed from the VGIN Virginia Basemap data set. This data set is copyrighted such that it cannot be redistributed in a digital format to parties external to DMME without special written agreements. DO NOT distribute these images electronically in any form (e-mail, files, word documents, ...)**

End users are encouraged to report data errors and discrepancies and to ask questions concerning data via the Data Error Reporting Tool within the "Web Based Map Viewer" (under the **Help** tab).

# MapGuide

DMME Web Based Map Viewer - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Media Print Copy Paste

Address <http://mapbsg/SWVA/> Go Links SnagIt

**DM Virginia**  
**ME Department of**  
**Mines Minerals**  
**and Energy**

MAIN Print... Zoom... Info/Maps... Redline... Query... Help/Install...

Map Title: DMME SWVA MAP NAD27 US Foot (test version) METADATA Reset

autodesk

- ImbodenMarker (2002)
- Addington (2002)
- Clintwood (2002)
- Blair (2002)
- Lyons (2002)
- Dorchester (2002)
- Norton (2002)
- Hagy (2004)
- Hagy (2002)
- Splashdam (2004)
- Splashdam (2002)
- Upper Banner (2002)
- Lower Banner (2002)
- Kennedy (2002)
- Aily (2002)
- Raven (2002)
- Jawbone (2004)
- Jawbone (2002)
- Tiller (2002)
- Upper Seaboard (2002)
- GreasyCreek (2002)
- MiddleSeaboard (2002)
- Lower Seaboard (2002)
- Upper Horsepen (2002)
- Middle Horsepen (2002)
- Lower Horsepen (2002)
- War Creek (2002)
- Cove Creek (2001)
- Pocahontas No. 4
- Pocahontas No. 3
- COAL CROPLINES
- No 13 crop
- High Splint crop
- Morris crop
- Pardee crop
- Wax crop
- ...

USGS\_StatesBoundaries\_1\_2000k : West Virginia

1 : 301,885 54.4 x 31.4 (mi)

# Reporting

DMME Web Based Map Viewer - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Media Print Copy Paste

Address http://mapbsg/SWVA/

DM Virginia Department of Mines Minerals and Energy

MAIN Print... Zoom... Info/Maps... Redline... Query... Help/Install...

Map Title: DMME SWVA MAP NAD27 US Foot (test version) METADATA Reset

autodesk

Low Splint cr  
34 Inch crop  
Taggart crop  
Taggart Mark  
Wilson crop  
Upper St. Ch  
Kelly crop  
Imboden crop  
ImbodenMark  
Addington cro  
Clintwood cro  
Blair crop  
Lyons crop  
Dorchester cr  
Norton crop  
Hagy crop  
 Splashdam cr

Upper Banne  
Lower Banne  
Big Fork crop  
Kennedy crop  
Ailly crop  
Raven crop  
 Jawbone crop

Tiller crop  
Castle crop  
Upper Seabo  
Greasy Creek  
Middle Seabc  
Lower Seabo  
Bandy crop  
Upper Horsep  
Middle Horsep  
War Creek cr  
Fire Creek cr  
Lower Horsep  
Little Fire Cr

VGIN\_BaseMapCounty: Tazewell

1 'Jawbone [2004]' selected 1 : 223,121 41.1 x 23.2 (mi)

http://mapbsg/swva/dmmine.aspx - Microsoft Internet Explorer

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Back Forward Stop Home Search Favorites Media Print Copy Paste

Address http://mapbsg/swva/dmmine.aspx

Mine Map Report - Requested ID Numbers 07133

Mine Maps

Map Date	GEOREF (T/F)	Mine Index #	DMME MAP ID #	Network Path to Scanned Image	Preview
07/01/1987	True	07133	CBM939	<a href="#">\\MAPBSGMINE_MAP_ARCHCVILLECBM\cbm939.TIF</a>	<a href="#">Preview</a>
02/01/1988	False	07133	LOV4332	<a href="#">\\MAPBSGMINE_MAP_ARCHLOVLOV4332.JPG</a>	<a href="#">Preview</a>
01/31/1989	True	07133	OSM510	<a href="#">\\MAPBSGMINE_MAP_ARCHOSMOSM510_1.TIF</a>	<a href="#">Preview</a>
01/31/1989	True	07133	OSM510	<a href="#">\\MAPBSGMINE_MAP_ARCHOSMOSM510_2.TIF</a>	<a href="#">Preview</a>
11/15/1985	False	07133	OSM7289	<a href="#">\\MAPBSGMINE_MAP_ARCHOSMOSM7289_1.TIF</a>	<a href="#">Preview</a>
11/15/1985	False	07133	OSM7289	<a href="#">\\MAPBSGMINE_MAP_ARCHOSMOSM7289_2.TIF</a>	<a href="#">Preview</a>
	False	07133	PCM546	<a href="#">\\CVILLESRV1\MINE_MAP_ARCHPCMPCM546.TIF</a>	<a href="#">Preview</a>

Adjacent Mine Maps

Map Date	GEOREF (T/F)	Mine Index #	DMME MAP ID #	Network Path to Scanned Image	Preview
	False			<a href="#">\\CVILLESRV1\MINE_MAP_ARCHPCMPCM546.TIF</a>	<a href="#">Preview</a>
01/31/1989	True			<a href="#">\\MAPBSGMINE_MAP_ARCHOSMOSM510_1.TIF</a>	<a href="#">Preview</a>

Tazewell

# Georeferenced Image

DMME Web Based Map Viewer - Microsoft Internet Explorer

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Address <http://mapbsg/SWVA/> Go Links SnagIt

**DM Virginia Department of Mines Minerals and Energy**

MAIN Print... Zoom... Info/Maps... Redline... Query... Help/Install...

Measure Show Info Lat/Long State Plane Get Area Get Length LOAD DEM Hide Layers Undo Hide Selectability VIEW SCANS

autodesk

TEMPORARY US ScannedMapRes 1 \MAPBSG

- SCAN2
- SCAN3
- SCAN4
- SCAN5
- SCAN6
- UNDERGROUND
  - High Splint (2)
  - Morris (2004)
  - Morris (2002)
  - Pardee (2004)
  - Pardee (2002)
  - Wax (2002)
  - Phillips (2002)
  - LowSplint (20)
  - LowSplint (20)
  - Taggart (2004)
  - Taggart (2002)
  - TaggartMark
  - TaggartMark
  - Wilson (2004)
  - Wilson (2002)
  - Kelly (2004)
  - Kelly (2002)
  - Imboden (2002)
  - Imboden (2002)
  - ImbodenMark
  - Addington (20)
  - Clintonwood (20)
  - Blair (2002)
  - Lyons (2002)
  - Dorchester (2002)
  - Norton (2002)
  - Hagy (2004)
  - Hagy (2002)
  - Selectability

7133

1 : 27,736

5.11 x 2.88 (mi)

VGIN\_BaseMapCounty : Buchanan

1 'Jawbone (2004)' selected



# Challenges

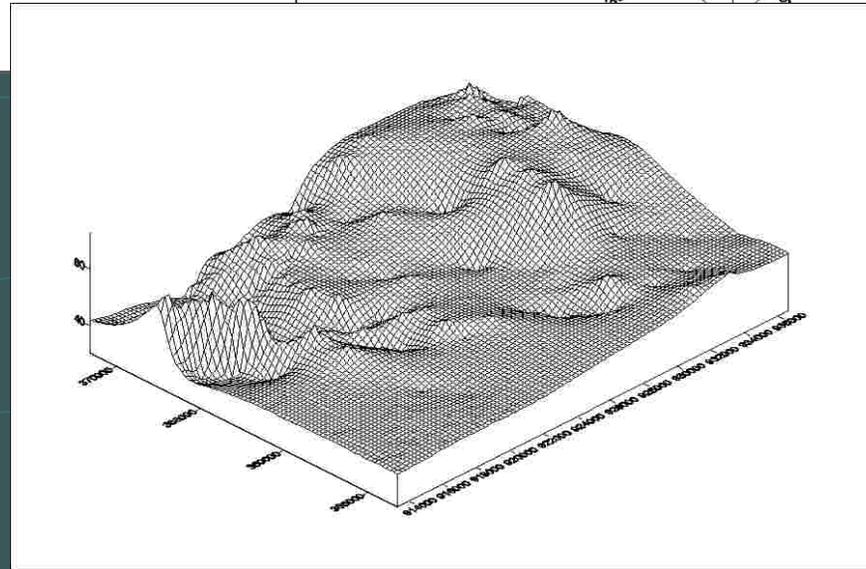
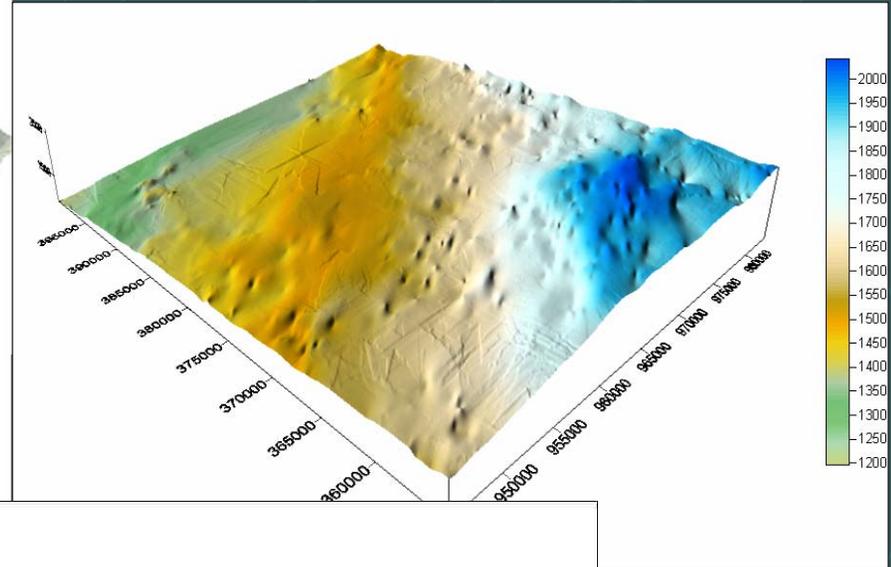
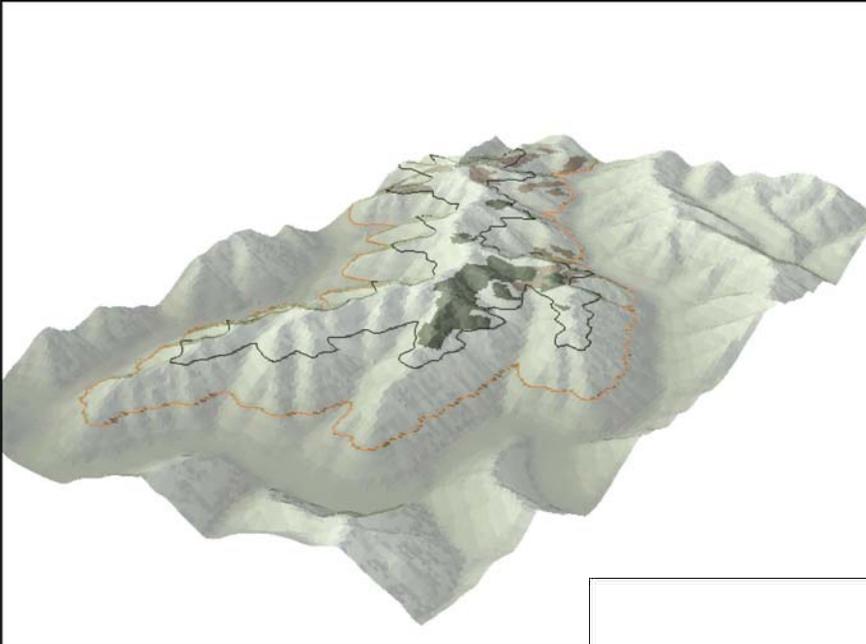
- ❖ Different media
- ❖ Uneven data distribution
- ❖ Scale (mine maps 1" = 400' → base maps 1" = 2000')
- ❖ Accuracy
- ❖ Interpretation



# The Future

- ❖ Identify new collections
- ❖ Scan and catalog these collections
- ❖ Georeference mine maps
- ❖ Generate three-dimensional models of the coalfield
- ❖ Search for better methods and innovations
- ❖ Roll out to external customers

# Three-Dimensional Models



# Questions



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