GIS Applications for Title IV and V Mining Programs in West Virginia[1]

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Abstract. In support of its mission to protect and improve the environment, West Virginia Department of Environmental Protection (WVDEP) is implementing enterprise information systems to maximize efficiency and effectiveness. Several centralized Oracle-based enterprise databases, including GIS geo-databases, have been built into the Department's infrastructure. However, the Department faced a challenge of how to take advantage of the rapidly growing data warehouse. For instance, Title IV and V mining programs lacked a way to join GIS data with attribute information retrieved from non-spatial databases. Difficulties arose using available customized client-server applications as they did not offer spatial capabilities. In addition, the majority of employees in the two programs are not GIS or computer proficient enough to use standard state-of-the-art GIS software to run composite queries linking spatial and non-spatial information.

To address the issue, the Technical Applications and GIS (TAGIS) Unit at WVDEP initiated projects to develop GIS applications for the two programs. The principles underlying the development are economy and ease-of-use. Economy is defined as use of widely-accepted mature techniques and resources available department wide. Ease-of-use means final products should be user-friendly and require no further efforts from end-users to upgrade their computer or GIS skills.

To date, two toolbar applications are in use and were written using Microsoft Visual Basic 6.0, Oracle SQL statements, Microsoft ActiveX Data Object (ADO), and ESRI ArcObjects. The applications are integrated into ESRI's ArcMap interface running via Citrix terminal service architecture. Before end-users incorporated the two applications into their daily workflow, TAGIS provided quick start hands-on training. Positive feedback from current end-users includes improved work efficiency, improved GIS performance, user-friendly interfaces, easy-to-follow self-explanatory dialogues, and so on. The applications currently serve approximately 130 users in the two programs.

Additional Key Words: spatial, non-spatial, economy, ease-of-use, SQL, ArcObjects, end-users

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Introduction

In support of its mission to protect and improve the environment, West Virginia Department of Environmental Protection (WVDEP) is implementing an enterprise information system to maximize efficiency and effectiveness. The implementation adopted a multi-tier client-server architecture (Dickman, 1995), in which database applications are located in a user's desktop environment with database management systems on separate servers. A middle tier, mainly application servers, performs tasks such as queuing, application execution, and database staging.

Several Oracle databases were built into the Department's infrastructure for Title IV and V programs. These databases, specifically, include:

- Environmental Resource Information System (ERIS), a database designed to track information concerning all manner of environmental regulatory activity;
- Environmental Quality Information System (EQuIS), a database for all organizations involved in the sample data collection, processing, management and evaluation aspects of environmental project work;
- Reclamation Information Management System (RIMS), a database to manage data on the Title IV mining program for sites abandoned prior to the passage of the Federal Surface Mining Control and Reclamation Act of 1977;
- ArcSDE geo-database, a multiuser spatial database designed to store state-wide geographic data.

In the process of migrating to an ArcSDE geo-database, a large collection of GIS data was stored on WVDEP's internal network drive using a file-based tree structure. The majority of data are Digital Orthophoto Quadrangle (DOQ) and digital raster graphic (DRG) images from United States Geological Survey (USGS).

To facilitate legal requirements of the programs, a few database applications were developed or customized by WVDEP staff and contractors. These applications stay current with the databases and are placed on users' of desktops or the Internet to provide invaluable tools to meet the needs of end users. These applications include ERIS dialup/ERIS 32, Abandoned Mines Lands Management Information System (AMLMIS)

for RIMS, Interactive Mapper, Aerial Photography Browser, and other Internet or Intranet tools.

Since their inception, the databases have grown rapidly as more and more data were collected and recorded. However, the Title IV and V mining programs faced a challenge of taking full advantage of the databases. For instance, using maps to assist decision-making is part of the workflow for many employees in the two programs. It would be even more helpful if GIS data could be combined with relevant non-spatial data. Unfortunately, the two programs lacked ways to electronically link GIS data archives, including the above-mentioned SDE geo-database and file-based GIS data, with non-spatial databases such as ERIS and RIMS. This problem existed for a couple of reasons. On the one hand, then available customized database applications such as ERIS Dialup/ERIS 32 and AMLMIS were not developed to offer spatial capabilities. Information retrieved through such tools was not spatially visible. GIS tools such as Interactive Mapper and Aerial Photography Browser mainly focus on GIS visualization and didn't provide a live link to those non-spatial databases. On the other hand, standard state-of-the-art GIS software can be utilized to run composite queries linking spatial and non-spatial information but employees were not thoroughly GIS or computer proficient to perform such a challenging task. Without handy tools, the employees had to do the job manually, which was error-prone and time consuming. Accordingly, the Technical Applications and GIS (TAGIS) Unit at WVDEP initiated application development projects in an attempt to address this issue for the two programs.

GIS Application Development

After thorough research, TAGIS planned to develop GIS applications that could bridge the gap between the GIS data archive and non-spatial databases. This development encountered such questions as follows:

- Who would be the end-users of the GIS applications?
- What functionality should the GIS applications contain?
- What principles should the application development follow?

To answer the above questions, TAGIS performed repetitive surveys; determining that end-users of the GIS applications would be employees in the Title IV and V programs. They may also include agency staff interested in Title IV and V data but not necessarily employed within the two programs. TAGIS also realized that the majority of the end-users were not GIS and computer proficient. Therefore, the GIS applications should simplify the whole process of conducting a composite query for end-users. The GIS applications should also simplify complex GIS analysis procedures that end-users conducted frequently in their daily work. In addition, the applications should not replace available database applications with rich functions due to cost considerations and staff usage. Last but not least, the GIS applications should provide end-users easy and quick access to the GIS data archives; addressing the slow performance issues caused by ESRI ArcGIS, the main GIS software package used by the two programs. The principles underlying the development are economy and ease-of-use. In the context of this work, economy means the development that relies on widely-accepted mature techniques and resources available department wide in light of the tight departmental IT budget. Ease-of-use means final products are user-friendly and require little end-user effort to significantly upgrade their computer or GIS skills.

After two years' development work, the final products were released as two toolbars integrated into the ESRI ArcGIS desktop component using the ArcMap platform. The toolbars were written using Microsoft Visual Basic 6.0, Oracle SQL statements, Microsoft ActiveX Data Object (ADO), Microsoft OLE DB provider, and ESRI ArcOjbects library based on Microsoft Component Object Module (COM) technology.

Introduction to the GIS Applications

3.1 Setting up the Applications

The applications were deployed via a Citrix Metaframe terminal services architecture, in which ArcGIS desktop runs on a central Citrix server for remote access by multiple users. The central server is on the internal network in WVDEP and transfers only the user interface, keystrokes, and mouse movements between itself and the remote clients. The

remote client is an Internet browser or a Citrix client. Administration and upgrades of the GIS applications occur only on the central server (see Lowe, 2004).

3.2 Launching and Closing the Applications

There are two simple ways to launch the applications in an ArcMap environment. A user can right click anywhere on the top of the ArcMap interface (the gray area) to get a pull down list or click the View menu on the main menu bar and then pick Tools. From the pull down list, the user can check out "WVDEP DMR GIS-ERIS Information Navigator (Version 3.1)", the DMR toolbar for Title V mining program and "WVDEP AML&R GIS-RIMS Information Navigator (Version 3.1)", the AML&R toolbar for Title IV program. Following these operations, two toolbars are visible in the ArcMap interface (see Fig. 1). To close the applications, a user unchecks the pull down list or simply clicks the close sign ("X") on the upper right corner of the toolbars. Figure 1 shows the two toolbars.

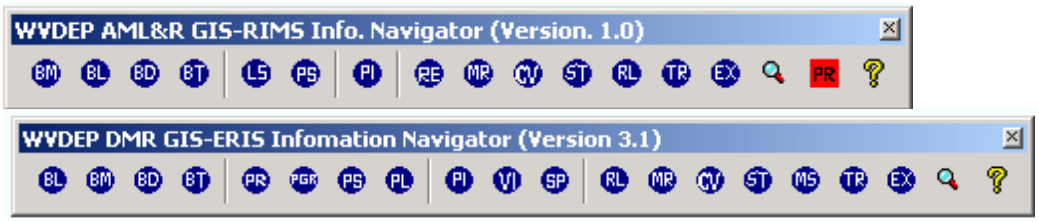

Figure 1. AML toolbar and DMR toolbar

3.3 Decomposing the Applications

Like other pre-built buttons in ArcMap, the two toolbars are dockable. A user can drag them around; placing them anywhere in the ArcMap interface. The toolbars are composed of individual buttons and when the cursor is placed on an individual button, a tooltip is displayed.

As shown in Figure 1, the two toolbars share the same structure; separated into four functional areas along the bar. The first four buttons constitute Group 1, providing easy access to the GIS data archive; the second series of buttons, combined into Group 2, enables users to search spatial features using different approaches; Group 3 provides

users with a live link to non-spatial databases; and Group 4 is composed of goodies that were developed to facilitate GIS users' work.

Table 1. AML Toolbar and Its Components

Button Icon and Tool tip	Function
Group 1: Assessing GIS Data	
Add background geo-features	Assess GIS data related to WV
Add DMR geo-features	Assess GIS data related to DMR
Add a DOQ background	Display a DOQ raster background
Add a DRG (topo) background	Display a DRG raster background
Group 2: Searching Spatial Features	
Search AML sites by location	Search by a spatial query
Search AML sites by PAD number(s)	Search by PAD number(s)
Group 3: Querying RIMS Information	
Query problem area information	Retrieve PAD info. from RIMS
Group 4: Facilitating AML Work	
Search result summary	Toggle a dockable window
Merge two layers	Merge layers with same structure
Clear the active data view	Remove one or more layers
Calculate statistical results	Summarize a layer attribute
Render a layer	Create a thematic layer
Set a transparent layer	Change the transparency of a layer
Create a layout	Make a map ready for print
Open a magnifier window	Create a magnifier window
Set up your preference	Set preferences for a data frame
Show the quick start tutorial	Access the reference book

Table 2. DMR Toolbar and Its Components

Button Icon and Tooltip	Function
Group 1: Assessing GIS Data	
Add DMR geo-features	Assess GIS data related to DMR
Add background geo-features	Assess GIS data related to WV
Add a DOQ background	Display a DOQ raster background
Add a DRG (topo) background	Display a DRG raster background
Group 2: Searching Spatial Features	
Search spatial features by a pre-defined request	Pick from a list of requests
Search spatial features by a general request	Search by a conditional request
Search spatial features by permit ID(s)	Search by permit ID(s)
Search spatial features by location	Search by a selected area
Group 3: Querying ERIS Information	
Query permit information	Retrieve permit info. from ERIS
Query violation information	Retrieve violation info. from ERIS
Group 4: Facilitating DMR Work	
Render a layer	Create a thematic layer
Merge two layers	Merge two layers of same schema
Clear the active data view	Remove one or more layers
Get statistical results	Summarize a layer attribute
Show digital photo(s)	Display related digital picture(s)
Show coal mine statuses	Display current mine statuses
Set a transparent layer	Change the transparency of a layer
Create a layout	Make a map ready for print
Open a magnifier window	Create a magnifier window
Show the quick start tutorial	Access the reference book

A few buttons on the two toolbars share the same icons, but were created for different purposes. Tables 1 and 2 list more details about the two toolbars and their components.

3.4. Demonstrating the Applications

Two examples are given below to demonstrate some functions of the two toolbars.

Example 1: Querying Problem Area Description (PAD) information

This example displays the location of the AML&R site tagged with PAD ID "WV0004" and retrieves relevant information stored in RIMS and/or Office of Surface Mining (OSM)'s AMLIS databases using the AML toolbar.

- Display the location of the AML&R site

In the ArcMap environment, start a new map document. Launch the AML toolbar. Click the button "Add background geo-features ", which gives quick access to a GIS data archive. On the next window "Background Geo-datasets" (see Fig. 2), check "county" and then "Add". A polygon feature layer showing state counties is added to the display area as a reference layer.

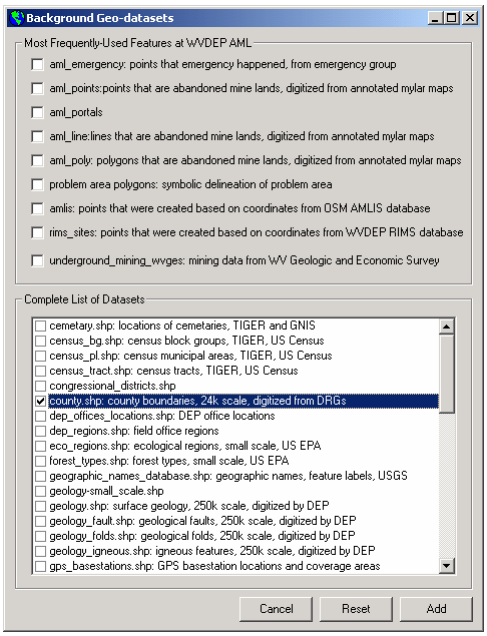

Figure 2. "Background Geo-datasets" window

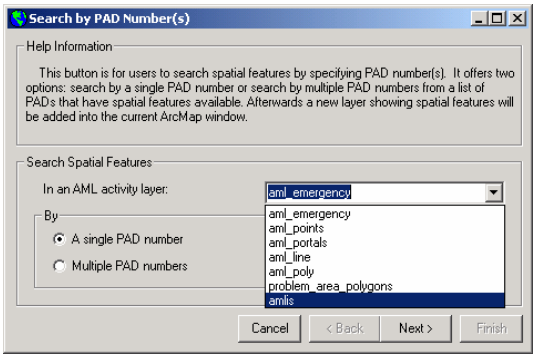

Figure 3. "Search by PAD number(s)" window

Click the button “Search AML sites by PAD number(s) ”. A new window “Search by PAD number(s)” (see Fig. 3) is invoked. This window gives users the option to search by a single PAD number or more than one PAD number at a time. Pick “amlis” from the “In an AML activity layer” dropdown list. Choose “A single PAD number”. Click “Next >”. An input dialog box “AML&R Operations!” (see Fig. 4) appears. Type in “WV0004” and click the “OK” button. A point feature for the AML&R site “WV0004” is added to the map display area.

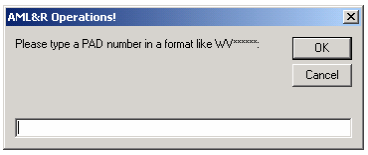

Figure 4. “AML&R Operations!” dialog box

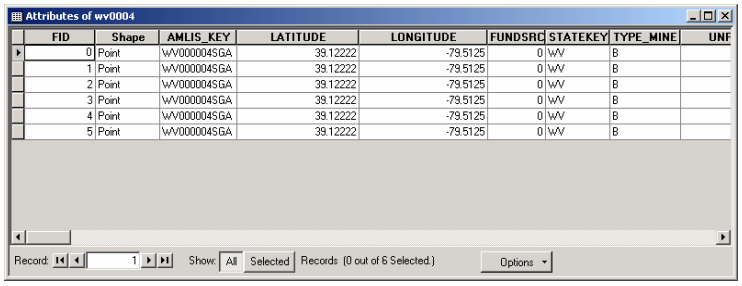

Figure 5. The point layer’s attribute table

- Check AMLS information

Double click the point layer’s name to open the layer’s attribute table (see Fig. 5). The table has six rows; however, in the display area there is only one point because all rows share the same coordinate (x, y) values. The information in the attribute table is downloaded from the AMLIS database on a regular basis[3]. Close the attribute table.

- Check RIMS information

Click the button “Query problem area information ” on the Navigator toolbar. A new window titled “Problem Area Number: 0004” is available (see Fig. 6). The window has eight tabs. The first seven tabs provide real-time access to the RIMS database. The last tab is a multimedia link to access digital field photos or scanned technical drawings associated with the site.

[3] In the not too distant future TAGIS hopes to be able to automate the refresh of the information in this table regularly by nightly downloading the contents of OSM’s amlis database. Up to this point TAGIS has not been able to accomplish this because of the “Indian Trust” law suit.

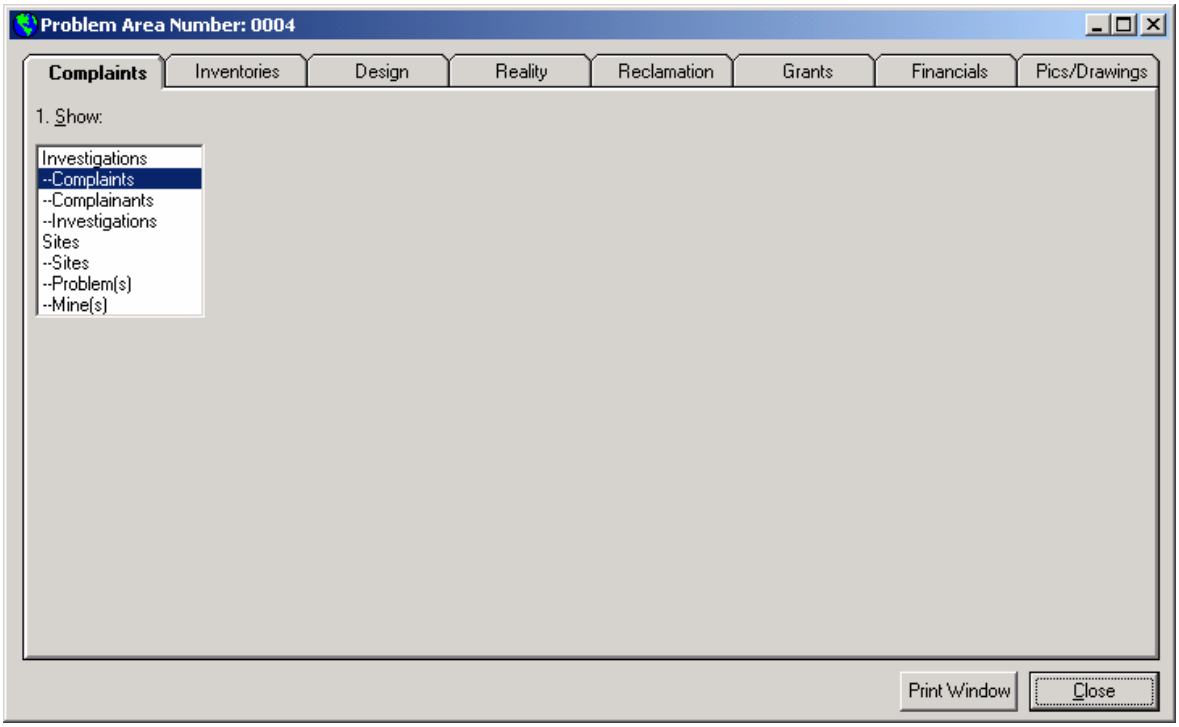

Figure 6. “Problem Area Number: 0004” window with default setting

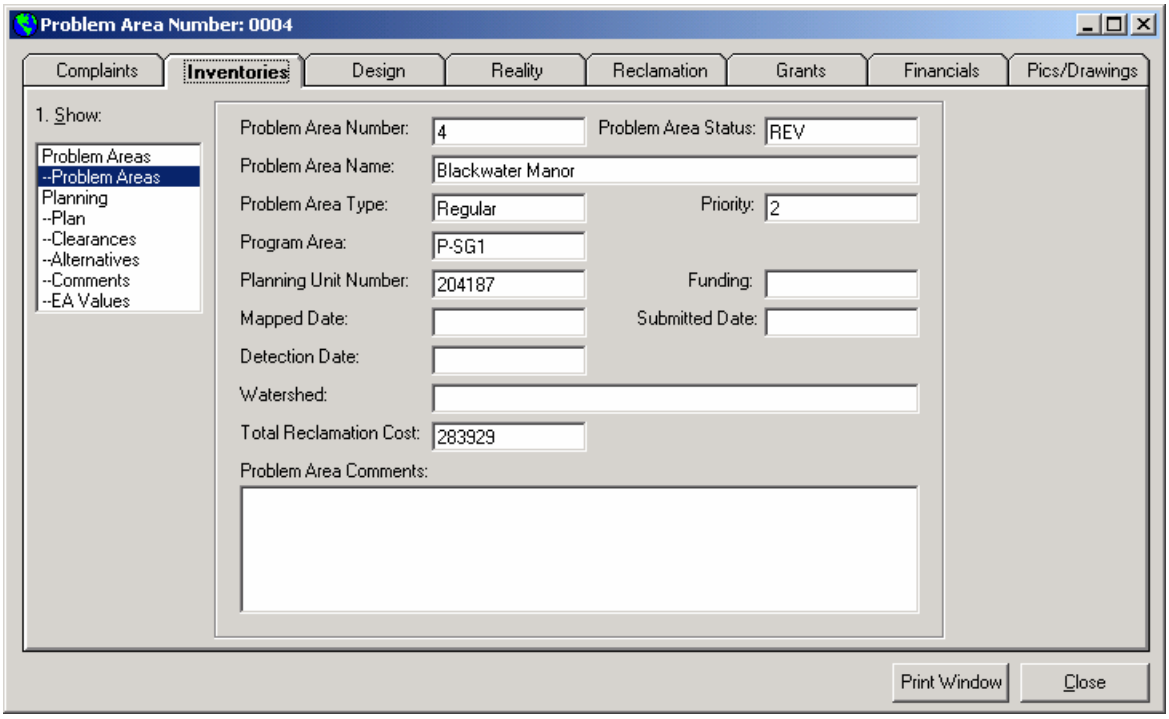

Figure 7. “Problem Area Number: 0004” window after “Inventories” is clicked

For example, click the tab “Inventories”. As shown in Figure 7, on the left side of the window, there is a listbox under “Show”. The second item “Problem Areas” is the default pick in the listbox. Results of these selections are retrieved from the RIMS database and displayed on the right side of the window as shown below. Contents of the window will be printed if the user clicks “Print Window”.

- Check digital pictures and technical drawings

Click the tab “Pics/Drawings”. The window “Problem Area Number: 0004” is updated. As shown below in Figure 8, the default option in the listbox below “Show” is “Digital Pics”; the second listbox below “Pick from the list below” lists two digital picture file names. On the right of the window, thumbnail previews with the title are visible. If the user clicks the title above a picture preview, a new property window will appear displaying information such as the date the picture was taken and which project it is related to. If the picture preview is double-clicked, a third party tool “Imaging for Windows”, embedded in Windows operating system, will be launched to display the full resolution of the picture.

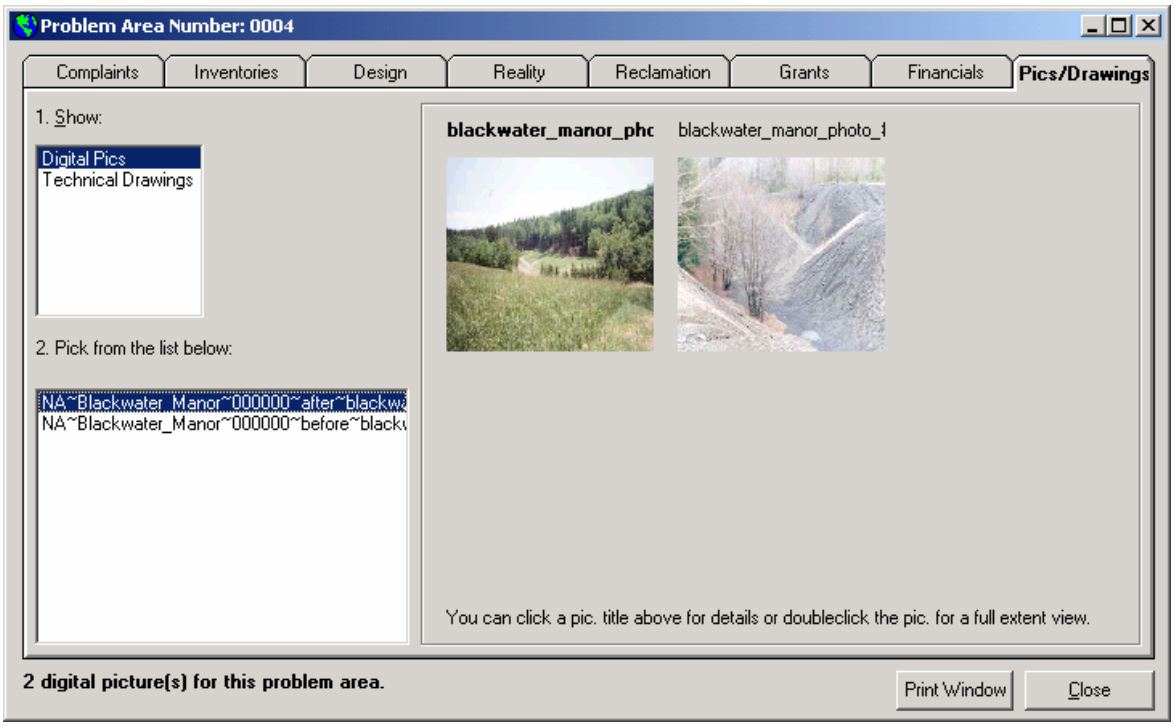

Figure 8. “Problem Area Number: 0004” window after “Pics/Drawings” is clicked.

Click the second option “Technical Drawings” in the listbox under “Show”. As shown in Figure 9, a long list appears in the listbox under “Pick from the list below”. As reported on the bottom left of the window 93 drawings exist for this site. The first six drawings are previewed on the right side of the window. Likewise, these previews can be loaded into “Imaging for Windows”. Close the “Problem Area Number:004” window.

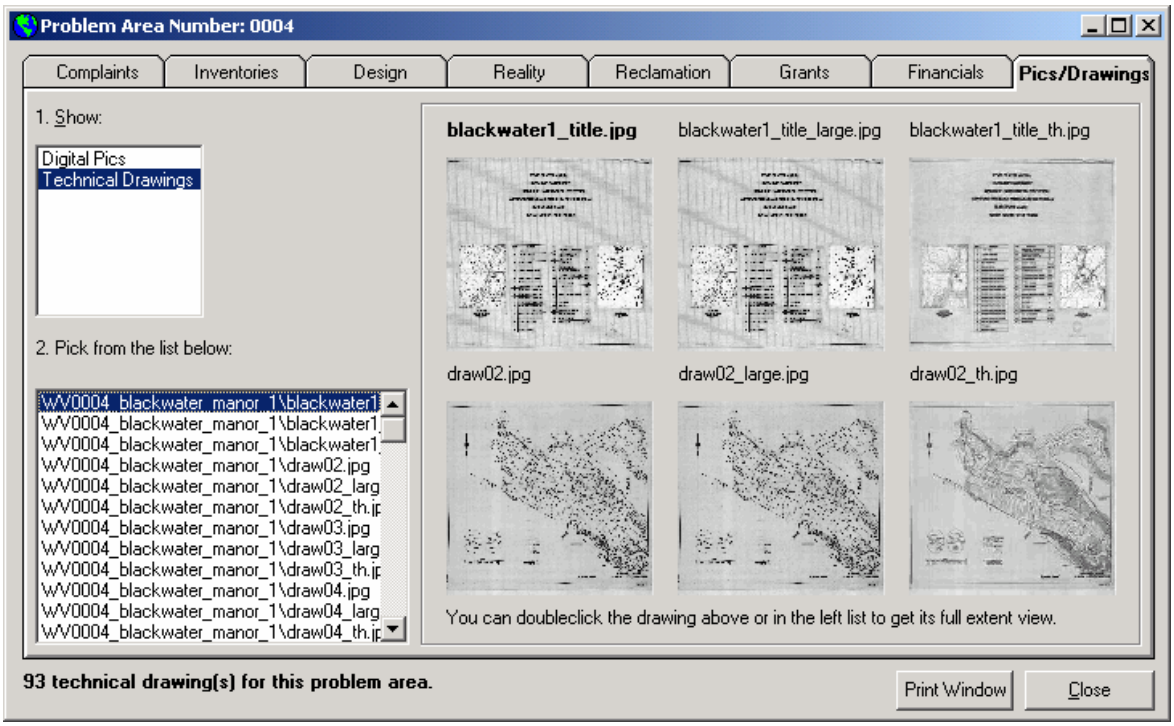

Figure 9. “Problem Area Number: 0004” window after “Technical Drawings” is clicked.

3.4.2 Example 2: Searching violations caused by Elk Run Coal Company, Inc.

In this example, a map is created to display all violations caused by Elk Run Coal Company, Inc., a coal mine company currently doing business in West Virginia.

- Display violations caused by Elk Run Coal Company, Inc.

In the ArcMap environment, start a new map document. Launch the DMR toolbar. Click the button “Search spatial features by a general request” on the DMR toolbar. In the subsequent window “Search by General Request(s)” (see Fig. 10), select “Elk Run Coal Company, Inc” from the drop down list “Permitee”. Do not change any other values in the window, and then click “Finish”. This combination selects options displayed as spatial features (coal mine boundaries) having violation activities caused by Elk Run Coal Company, Inc from 01/01/1900 through 12/31/2004 based on all existing

environmental enforcement standards. A new thematic polygon layer is added to the display area of ArcMap.

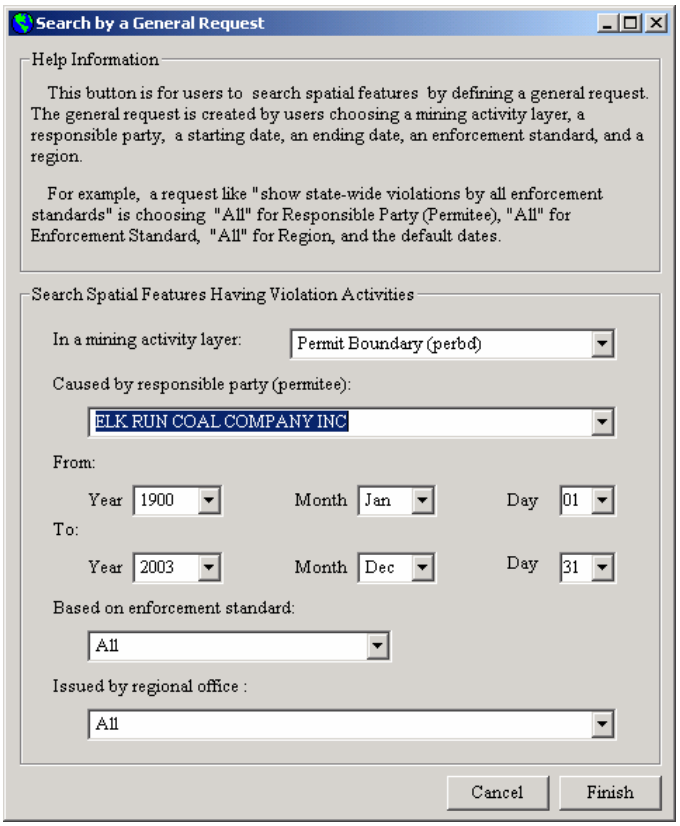

Figure 10. "Search by General Request(s)" window

As described in Example 1, use the button "Add background geo-features" on the DMR toolbar to add a layer of "County" as the reference background. Label each county with its name. Now the ArcMap interface has two layers (see Fig. 11). The first layer displays polygons with number of total violations characterized by color. The second layer shows which county the polygons are located in.

- Create a map layout

Click the button "Create a layout " on the DMR toolbar. In the following dialog box "Create a Layout" choose the default paper size "ANSI A – 8 ½ * 11 in.", which is the standard paper size of most desktop printers. Click "Next >". A further message box follows to remind users the printer and the paper size that are chosen. Then, as shown in

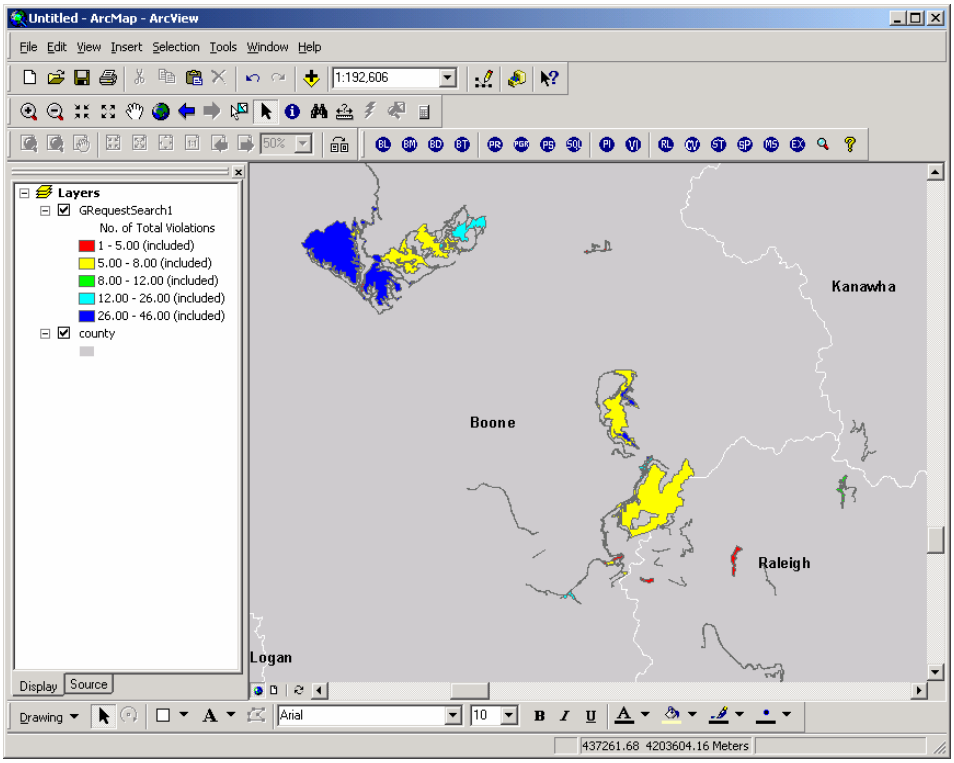

Figure 11. The ArcMap interface with a thematic layer and a county layer

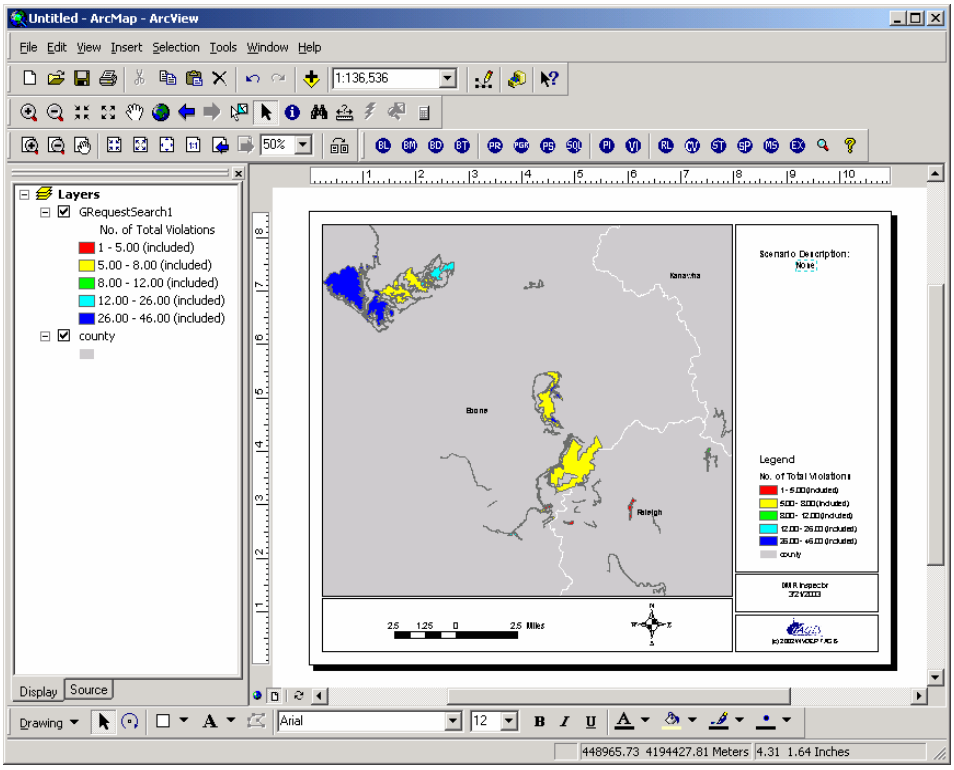

Figure 12. A customized map layout for search results

Figure 12, the ArcMap display area becomes the layout view containing elements such as legend, title, north arrow, and scale bar. Replace default texts in the map layout with meaningful ones. The layout is ready to be printed or exported to a JPEG image.

Conclusions

This paper examines the two GIS applications developed for Title IV and V programs in WVDEP and how they fit into WVDEP's enterprise information system using the two examples to show the functionality of the applications.

Before end-users incorporated the two applications into their daily workflow, TAGIS provided quick start hands-on training. Positive feedback from current end-users includes improved work efficiency, greater GIS use, user-friendly interfaces, easy-to-follow self-explanatory dialogues, and so on. The applications currently serve approximately 130 users in the Title IV and V programs.

However, further improvements are needed for the two applications. For example, the two applications provide print form function only. In the foreseeable future, the function needs to be improved to generate reports. The upcoming deployment of ArcGIS 9.0 by OSM will pose a challenge to the applications and their Citrix environment due to the changes and added functionality in AcrGIS 9.0(Wilson and Culpepper, 2004).

Literature Cited

1. Dickman, A., 1995, Two-Tier Versus Three-Tier Apps, Informationweek 553 (November 13, 1995), pp. 74-80.
2. Jonathan W. L., 2004, GIS Through the Looking Glass – Terminal Services and Thin-Client GIS, Geospatial Solutions (March 2004), pp. 41-44.
3. Wilson J. and ___. Culpepper, 2004, ArcGIS 9.0: A User's Guide to Changes and Added Functionality, GeoWorld (August 2004), pp 38-41.