GPS- Useful Tool for AML Project Management

K. Scott Davies, M.A. - Geographer/Design Specialist

Advanced Integration of Geospatial Technologies in Mining and Reclamation
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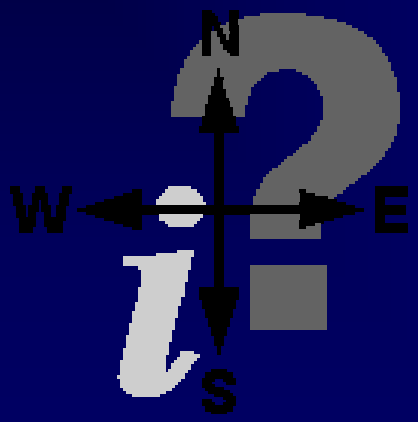
Introduction

Since I started with the Division of Mineral Resources Management in the fall of 2000, I have been incorporating geographic techniques into our engineering process to more effectively and accurately manage our AML projects. The use of GPS can serve as a valuable tool for collecting and verifying data.

Four areas that I have been using GPS at ODNR are: Delineation of project boundaries for mapping, location and verification of borrow area limits, mapping of failed vegetation, and location of mine entries and other project related features. This presentation will highlight four actual projects and what methods were used.

I purchased a personal GPS to learn the fundamentals in my spare time. I quickly learned how to use the device and used it on several of my travels. I took a night class at a local college to learn the GeoExplorer 3 that the Office of Surface mining was using. Once I was comfortable with the device, I started using it at work along with other GPS units provided to me. Later, I conducted Intro and Advanced courses in Garmin GPS units for fellow co-workers.



Treeline 12,750’

Get Familiarized

Take time to familiarize yourself with the GPS. I purchased for personal use a Garmin Etrex Legend. Starting out with a simple and low cost GPS allows you to understand the fundamentals of GPS operation which will help you use a more sophisticated GPS in the future. The Etrex series of GPS units were developed with the sportsman in mind. Whether it is used for hunting, fishing, geocaching, or hiking, an entry level GPS will be fun to use.

Summit 14,640’

My first experiment with the Etrex Legend was to collect data while climbing a volcano (Malinch) in Mexico. This experiment was to simply collect a continuous line of data recorded every 60 seconds. The GPS was strapped to my shoulder to ensure good satellite visibility. In this case I simply started recording at the cabin (above red line) and stopped once I made it to the summit (below red line). The GPS elevation was 14, 613 while the official elevation is 14,640. The chart shows latitude, longitude, altitude, time, horizontal feet traveled and feet per second. From this data it can be seen that it took 3.5 hours to ascend from the cabin (10,052’) to the top. The horizontal distance traversed was nearly 4 miles one way.

Beginning

End

Seq.No	Coordinate	Alt(f)	Local Time (UTC -06)	S	seconds	ft	ft/s
0001	N19°16'56.26" W098°02'39.44"	10052.0	02/17/2002 07:11:27	S	ACTIVE LOG		
0002	N19°16'57.11" W098°02'36.97"	10046.0	02/17/2002 07:12:28	C	61	251	4.1
0003	N19°16'55.02" W098°02'35.73"	10082.0	02/17/2002 07:13:28	C	121	494	4.0
0004	N19°16'52.32" W098°02'35.96"	10110.0	02/17/2002 07:14:28	C	181	769	4.6
0005	N19°16'50.08" W098°02'34.88"	10153.0	02/17/2002 07:15:28	C	241	1018	4.2
0006	N19°16'49.69" W098°02'32.87"	10139.0	02/17/2002 07:16:28	C	301	1214	3.3
0199	N19°13'52.10" W098°01'55.41"	14567.0	02/17/2002 10:29:11	C	11400	19162	1
0200	N19°13'51.94" W098°01'55.33"	14553.0	02/17/2002 10:30:11	C	11460	19180	0
0201	N19°13'51.79" W098°01'55.25"	14587.0	02/17/2002 10:31:11	C	11520	19197	0
0202	N19°13'51.63" W098°01'55.33"	14598.0	02/17/2002 10:32:11	C	11580	19215	0
0203	N19°13'51.63" W098°01'55.25"	14600.0	02/17/2002 10:33:11	C	11640	19222	0
0204	N19°13'51.63" W098°01'55.25"	14608.0	02/17/2002 10:34:11	C	11700	19222	0
0205	N19°13'51.71" W098°01'55.25"	14613.0	02/17/2002 10:35:11	C	11760	19230	0

Equipment Used

Trimble GeoXT

Garmin Etrex

Vista

Legend

Trimble GeoXt

Trimble GeoXT

- $5000 +
- Submeter accuracy
- WAAS enabled
- Multipath error correction
- Windows CE operating system
- Post processing capability
- Rechargeable battery
- Color touch screen
- Large memory store
- Runs multiple GPS software including ArcPad
- Allows DOQQ images to be used in background

Garmin Etrex

- Under $500 including software
- < 3 meter accuracy
- WAAS enabled
- Toggle stick
- Graphical Display
- Grey scale screen
- Compact
- 2 AA batteries
- 8 – 24 MB memory
- Ability to upload road and topomaps
- Real-time area calculations
- Free firmware updates from Garmin
- Includes data cable
- Can be used with freeware software such as GPS Utility
- Several models to choose from

Garmin Etrex

Vista

Legend

Pros and Cons

Trimble GeoXT

Pros

- Submeter accuracy
- WAAS enabled
- Multipath error correction
- Rechargeable battery
- Color touch screen
- Large memory store
- Runs multiple GPS software including ArcPad
- Allows DOQQ images to be used in background
- Good Data Collector

Cons

- Larger
- Less user friendly although much better than GeoExplorer 3
- Color Screen is hard to see in some light conditions
- Must be willing to spend more time mastering GPS unit and accompanying software
- Expensive

Garmin Etrex

Pros

- Under $500 including software
- WAAS enabled
- Toggle stick
- Compact
- 2 AA batteries
- Ability to upload road and topo maps
- Can be used with freeware software such as GPS Utility
- Simple to use

Cons

- Not meant to be a data collector (more hand written notes)
- Memory Limitations
- Small Screen

AML Project Applications

CHANEY

After I became familiarized with my personal GPS I began to use the technology to aid in the different parts of the AML process. GPS is useful at all stages of the project. The Chaney project is in early stages of development. As with most projects it is necessary to submit areas to be mapped for aerial photography and topographic mapping. GPS aided in determining these mapping boundaries.

NIBERT ROAD

At Nibert Road, it became apparent during design and again during construction that GPS would be vital in solving important issues. Late in the design it was unclear where the property lines were on the aerial photo and in relation to our work limits. During construction it became clear that the borrow area sizes were over estimated. GPS use remedied these problems by verifying the property line location and mapping borrow area limits.

AML Project Applications (cont)

REHOBOTH

The Rehoboth re-construction site involves a previously reclaimed site that a large portion of the vegetation had burned out due to the incompatible chemicals in the resoil material. To assist in the design, I located all of the burned out areas using the GeoXT. These polygons were placed on the design plans and a specified amount of lime was prescribed for each area and shown on the site plan. Later the corners of the reconstruction plots were staked using the GeoXT.

UNIT PRICE ENTRIES

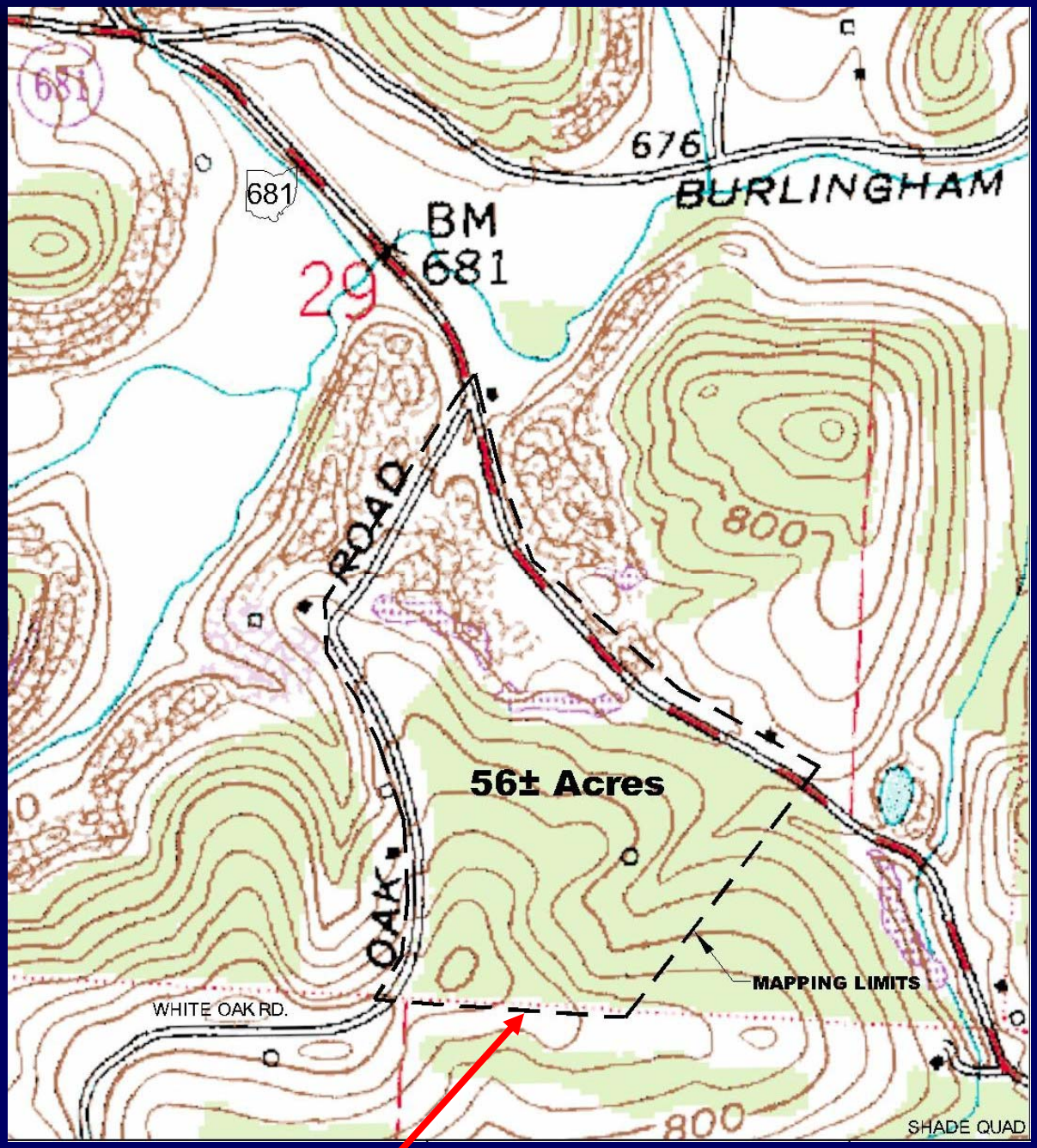
The Unit Price Entries Project consists of 11 different sites. Each site contains multiple mine entries. GPS made it easy to locate each of the 53 entries for future reference.

Chaney

The Chaney project consists of a pit impoundment and highwall. The foot print of this project is fairly easy to identify on a quad map or an air photo, however additional areas were needed to be mapped for borrow considerations. The project is bounded on two sides by two separate roads. The south line is the owner's property fence line . The fence line is visible on both the topo quad and DOQQ. I located the fence line using the Trimble GPS to verify the location.

Projects that are remote and do not have recognizable features such as roads are much easier to locate mapping limits with the use of GPS. The data can easily be captured by walking around the limits either using a line feature or using points or waypoints at corners.

Accurately delineating aerial mapping limits eliminates unnecessary costs due to over mapping.



GPS verified P/L

Nibert Road

Nibert Road is a large surface mine AML project which contains erosion, impoundments, and highwalls. In addition there are illegal activities including trespassing with ORV and 4x4 vehicles, dumping and abandonment of stolen vehicles.

The project is over a mile long and involves multiple property owners. Locating property lines was essential in preparing an aerial photo with property information.

This site contains up to 7 potential borrow areas. Accurate delineation of these borrows is crucial in determining the amount of resoil available.

Nibert P/L

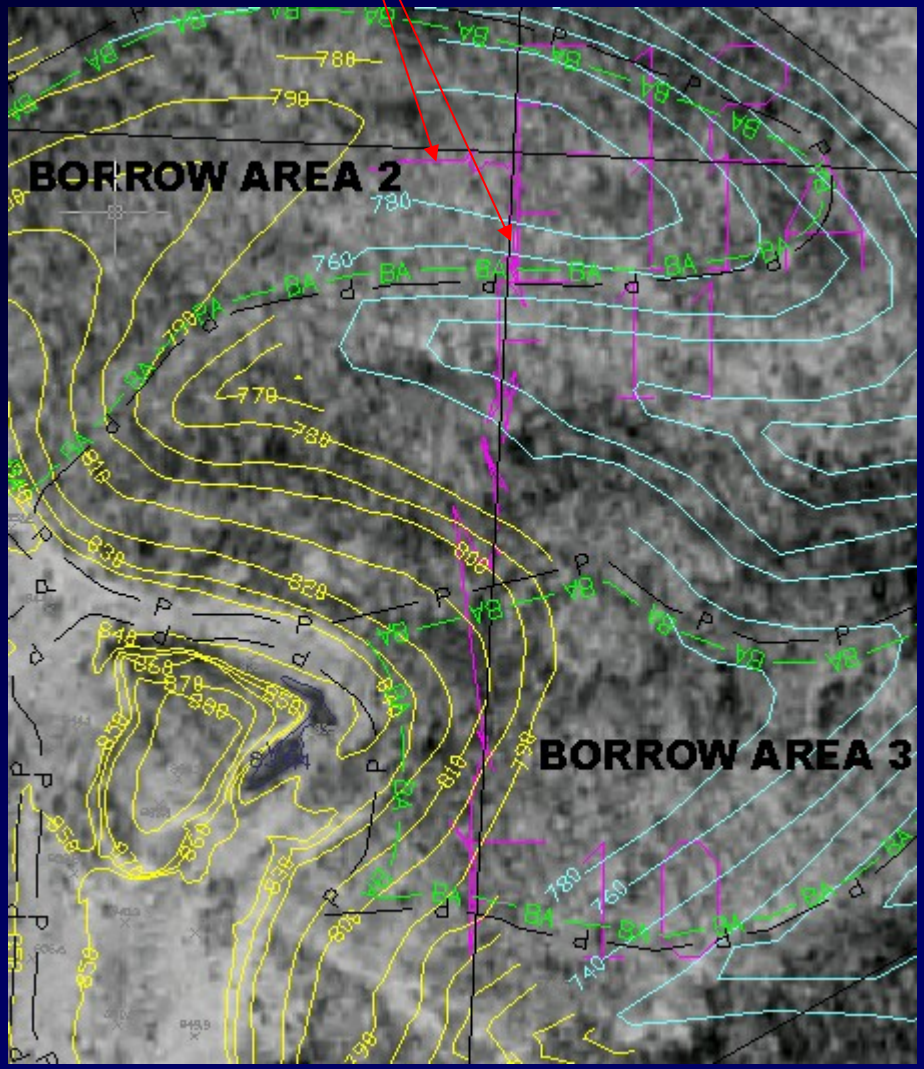
The first step in placing the property lines in their approximate location on the map was to gather tax maps for the site. Determine from the tax map and from aerial photo which lines are best to locate.

Using the Trimble GPS I located several property lines throughout the project. In addition I located visible features such as roads and intersections for reference.

In the office, the GPS points and lines were downloaded into the same file as the aerial photo. By maintaining the same coordinate system, the features fall in correct location on the air photo. After scanning and digitally tracing the tax map, the property lines were resized, rotated and shifted into the correct place using the visible reference points and fence lines located.

At the right, the pink lines represent the raw GPS lines and the black represent the adjusted tax map lines.

GPS location of P/L



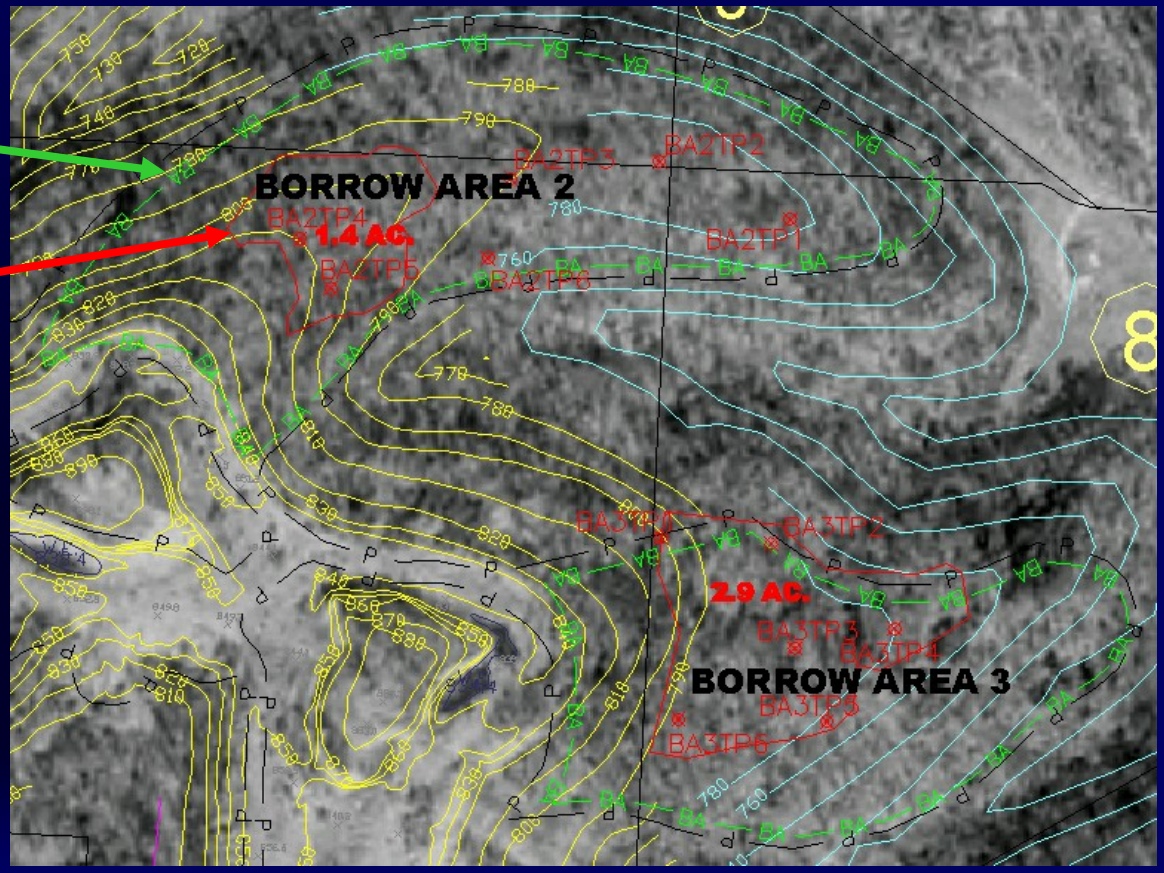
Seven borrow areas were delineated on the plans during the design stage. These areas are represented by the green lines. During construction it was found that the borrow areas were over estimated. Over estimation would lead to insufficient soil cover for the project.

During construction, the Project Officer used a Garmin Etrex GPS while walking the boundary of the actual borrow limits. As mentioned before, the Garmin is simple to use and provides an instant estimate of borrow acreage. Once the data is back in the office, it was imported into AutoCAD on the aerial photo page. The raw data was redrawn into smooth lines and it was apparent that many of the borrow areas had the same shape as the original borrow limits, but were significantly smaller.

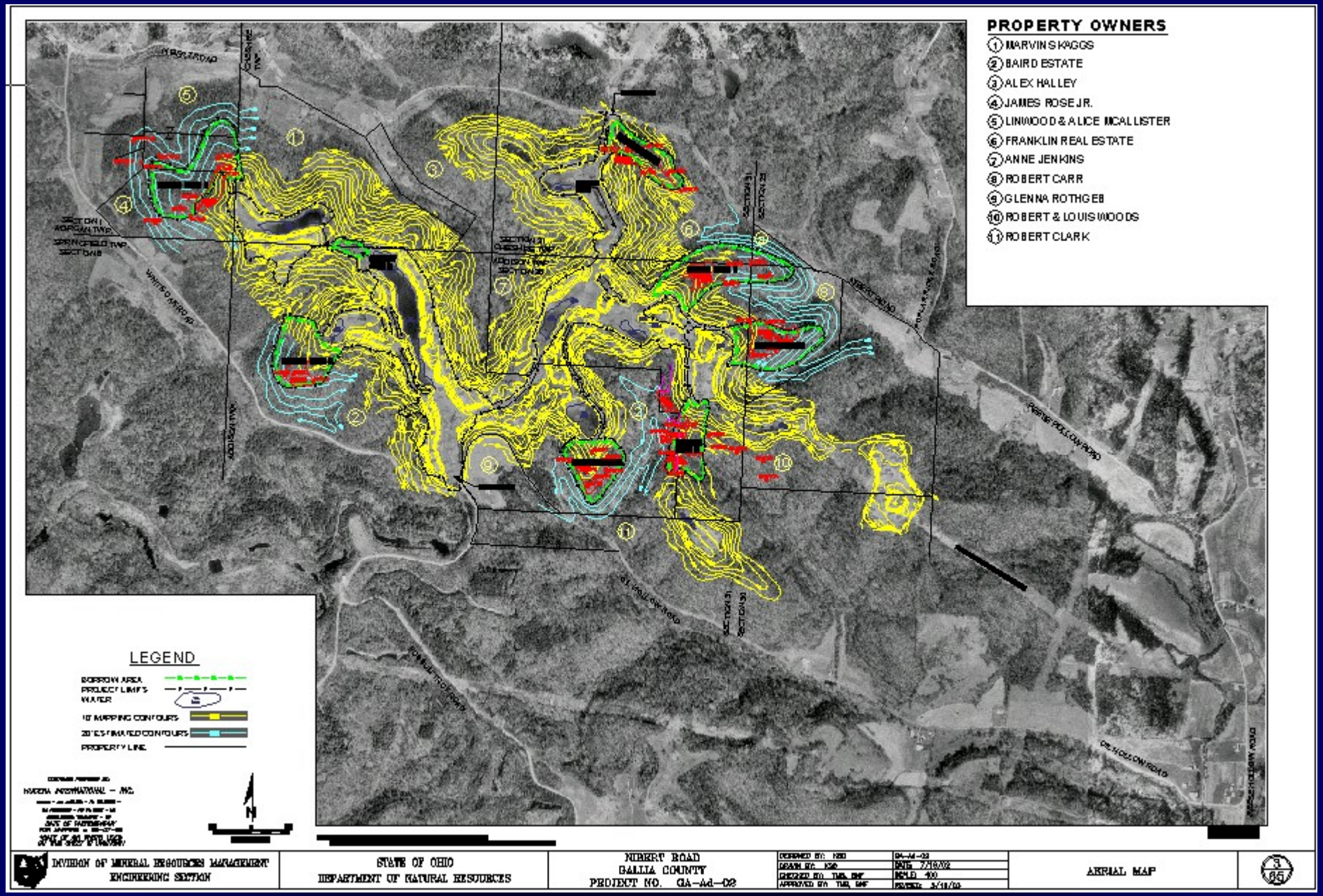
The red lines represent the actual borrow limits and the red text represents soil test locations.

Original Borrow Estimate

Actual GPS Limits



Nibert Borrow


PROPERTY OWNERS
1 MARVIN SKAGGS
2 BAIRD ESTATE
3 ALEX HALLEY
4 JAMES ROSE JR.
5 LINWOOD & ALICE MCALLISTER
6 FRANKLIN REAL ESTATE
7 ANNE JENKINS
8 ROBERT CARR
9 GLENNA ROTHGEB
10 ROBERT & LOUIS WOODS
11 ROBERT CLARK
LEGEND
BORROW AREA
PROJECT LIMITS
WATER
10' MAPPING CONTOURS
20' ESTIMATED CONTOURS
PROPERTY LINE
N
DIVISION OF MINERAL RESOURCES MANAGEMENT
ENGINEERING SECTION
STATE OF OHIO
DEPARTMENT OF NATURAL RESOURCES
NIBERT ROAD
GALLIA COUNTY
PROJECT NO. GA-Ad-02
AERIAL MAP

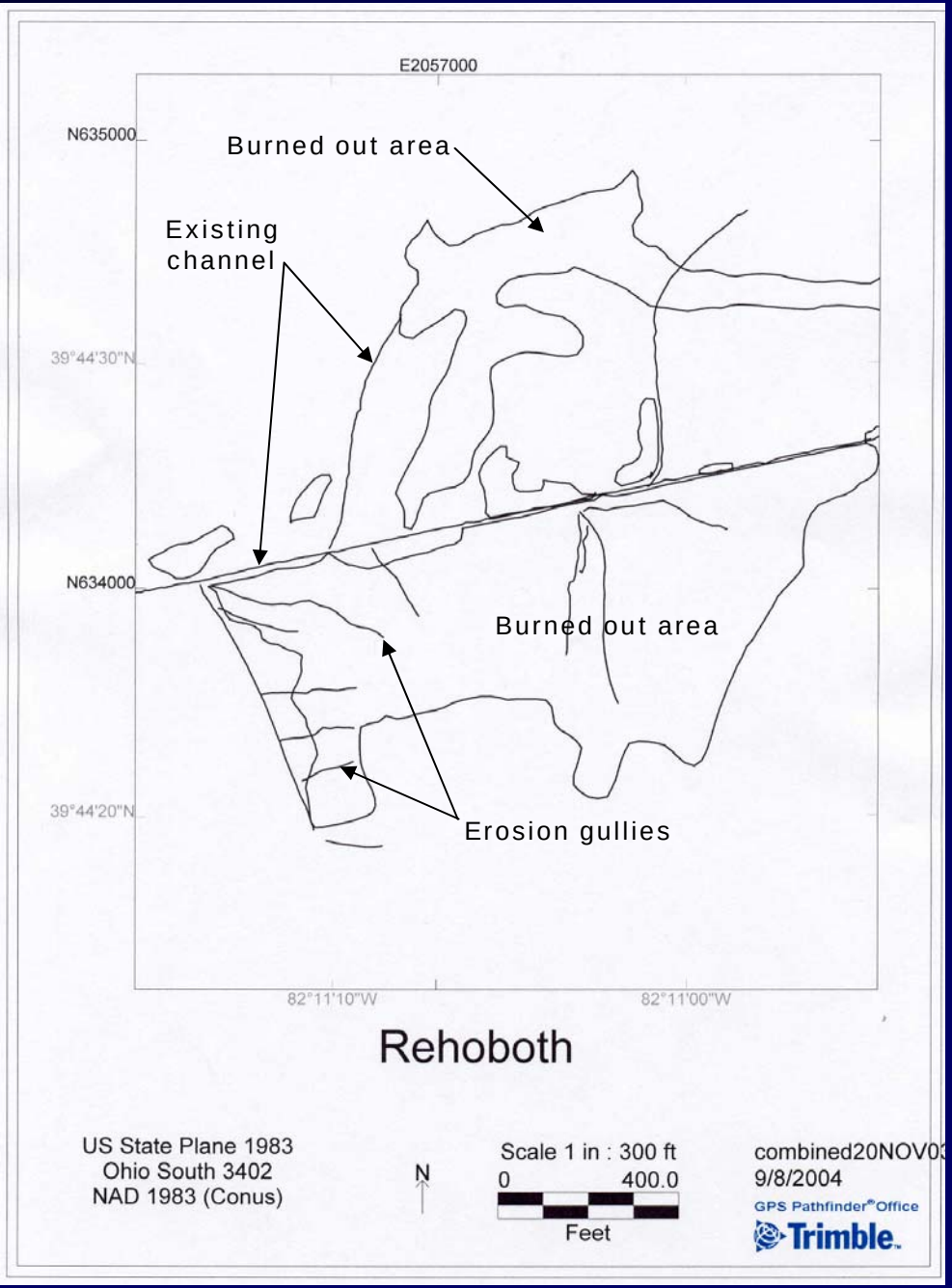
Final Map

Rehoboth

The Rehoboth re-construction site involves a previously reclaimed site that a large portion of the vegetation had burned out due to the incompatible chemicals in the resoil material.

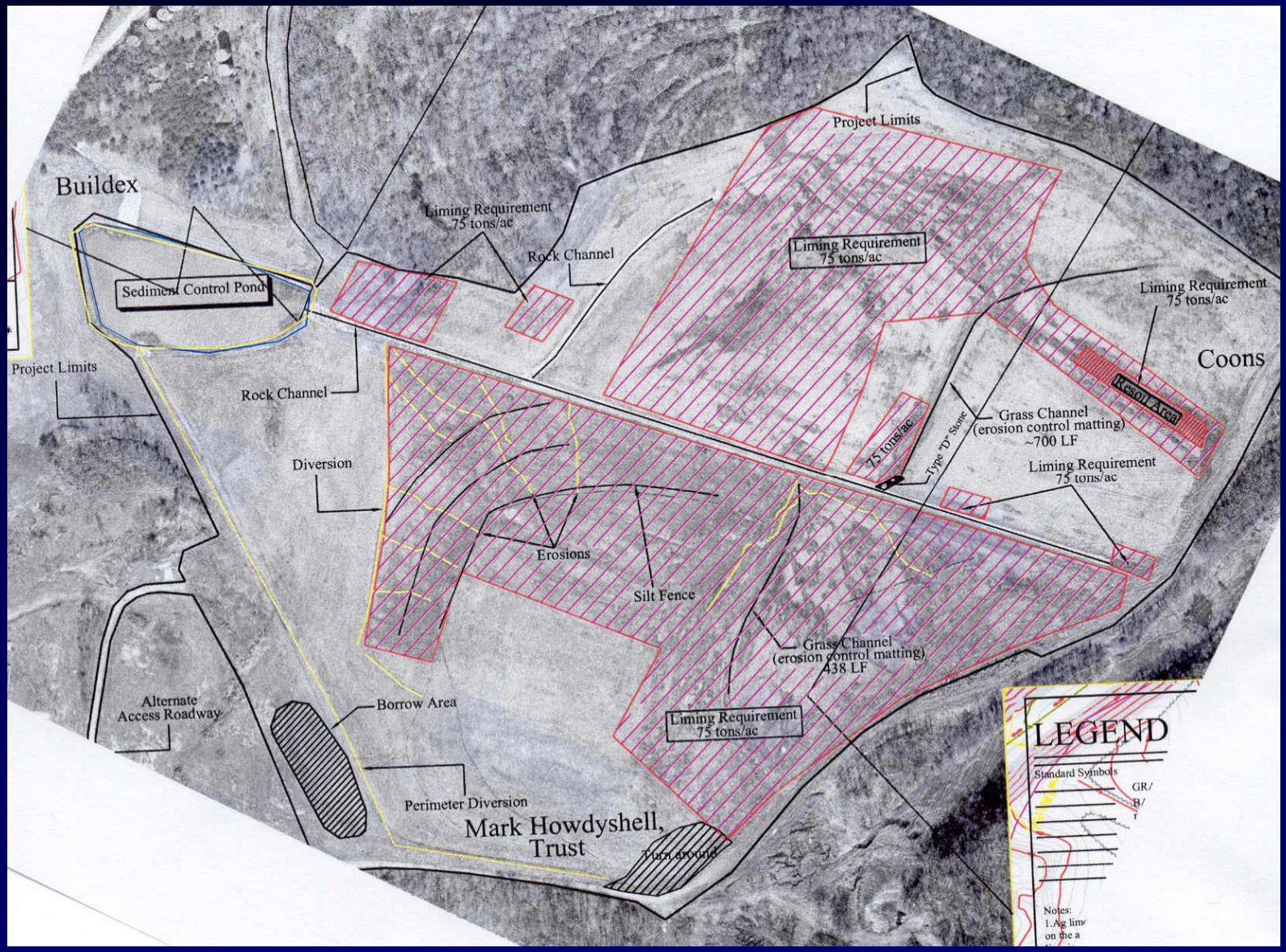
Before the design began, I located all burned out areas, erosion gullies and existing features. This information was laid over an air photo and the design was completed by a colleague.

The figure on the right shows the raw data collected from the GeoXT before it was exported to AutoCAD as a .dxf file.



Rehoboth

Liming areas are shown on the site plan with the prescribed tonnage. The corners of the areas to be limed and disked were staked using the GeoXT. Stake out of projects like this are made easy with the GeoXT and the use of a surveyor and total station is not needed for this level of precision.

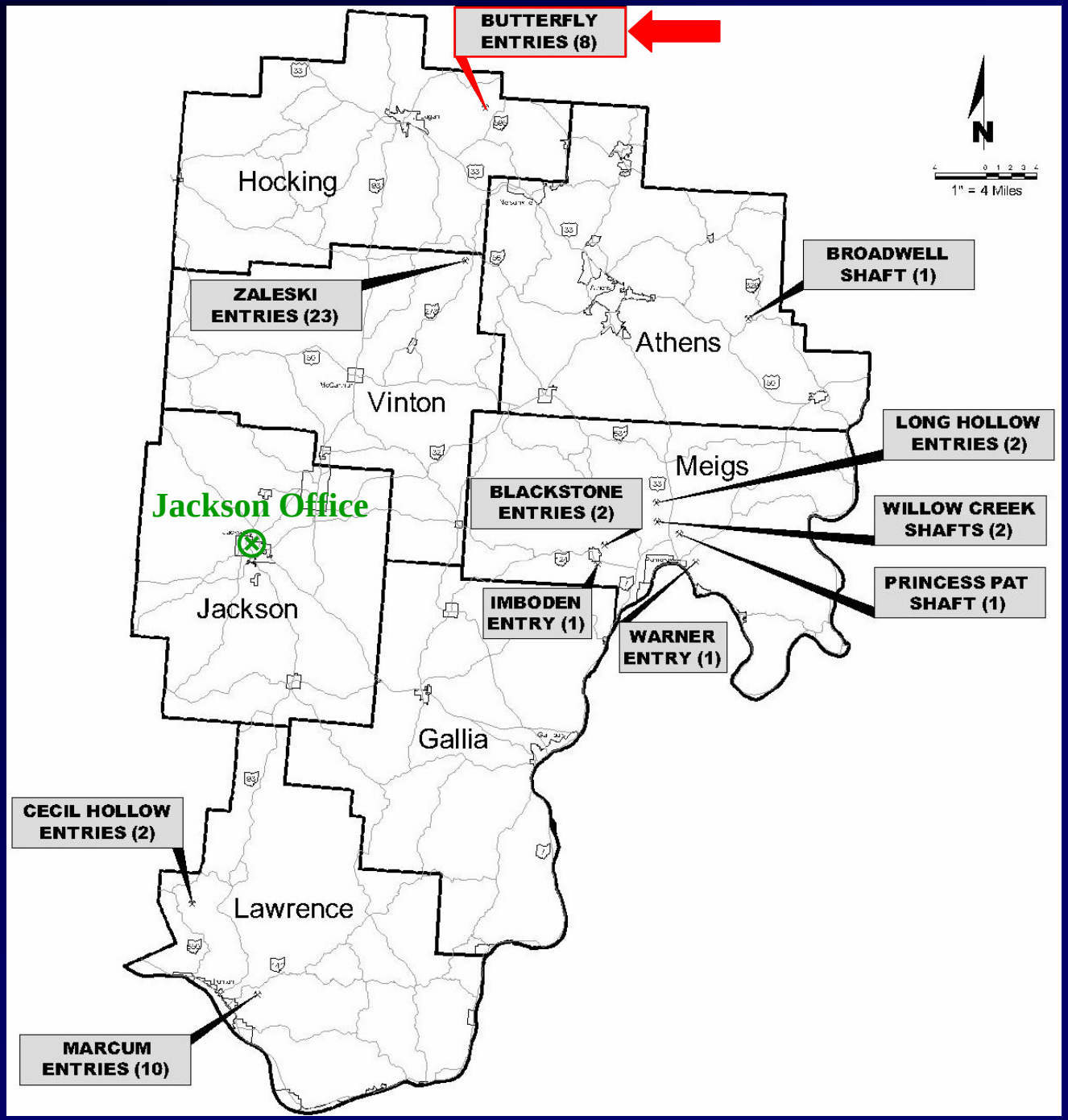


Unit Price Entries

The Unit Price Entries project consists of 11 sites. Most sites contain more than one entry that needs closed. A total of 53 separate entries are located in 5 counties.

Using a combination of Trimble and Garmin GPS units, all 53 entries were located. Each entry has now been recorded on a USGS quad and filed with the project. This method provides a valuable historic record of mine features.

The map to the right shows all 11 sites in the region that are currently under construction. This map serves as a general locater for each site but is also referenced by the GPS data. Each site has its own quad map that more specifically locates the entry.

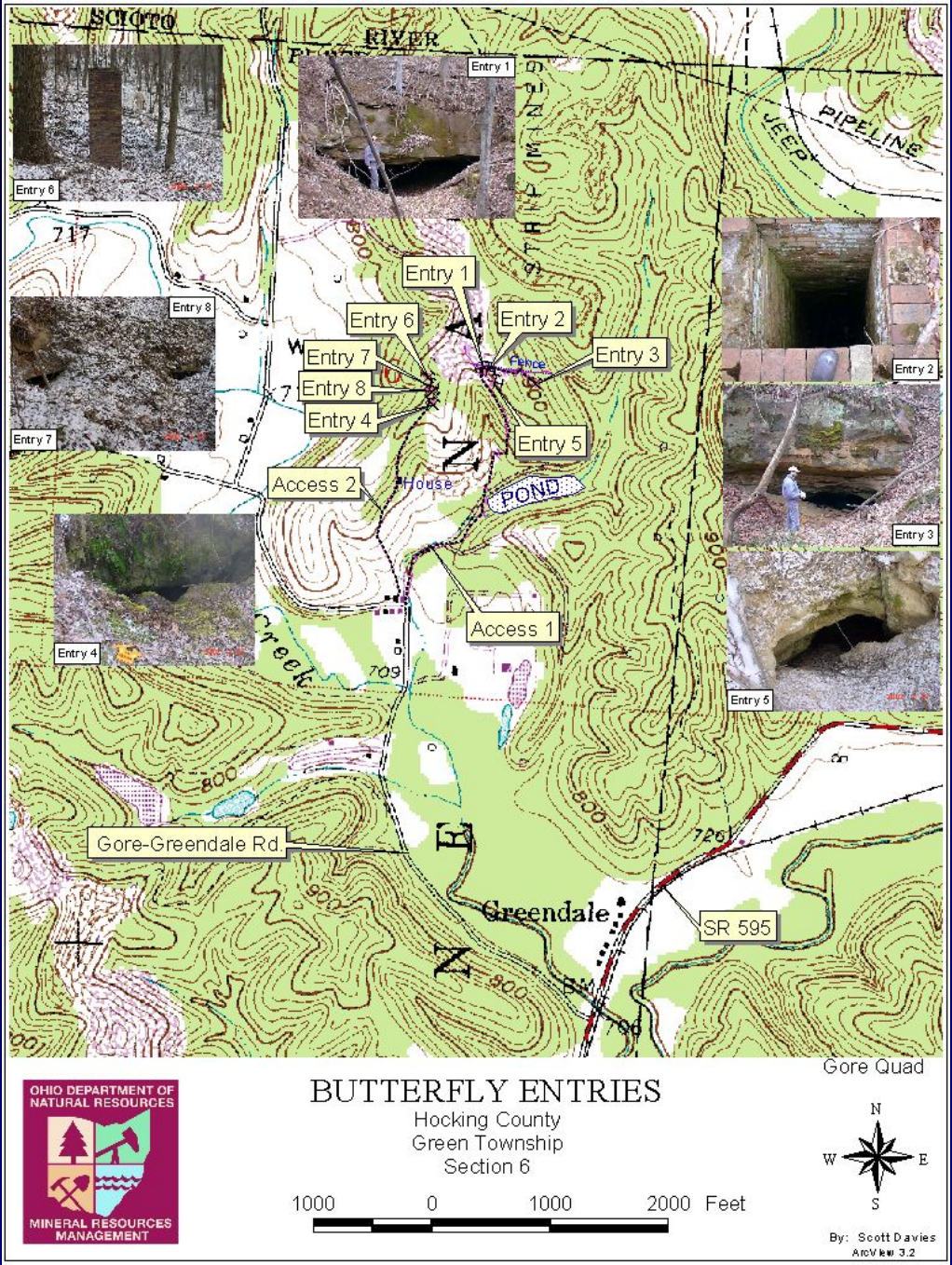


Butterfly

The Butterfly site in the Unit Price Contract is a good example of GPS use for locating features. At Butterfly 8 mine entries are located in a close proximity. Being a wooded property, finding these entries without a previous visitation may be difficult. The Trimble GPS gathered a data point at each entry while assigning it a number. The GPS point number can be matched to the corresponding engineering sketch of each entry.

Locating access roads 1 and 2 was as simple as walking the desired route. A large pond is located near access road 1 and was referenced by the GPS. The pond was not shown on the topo quad.

ArcView GIS is used to display all features in the correct coordinate system on the Gore topo quad.



Butterfly Entry 4

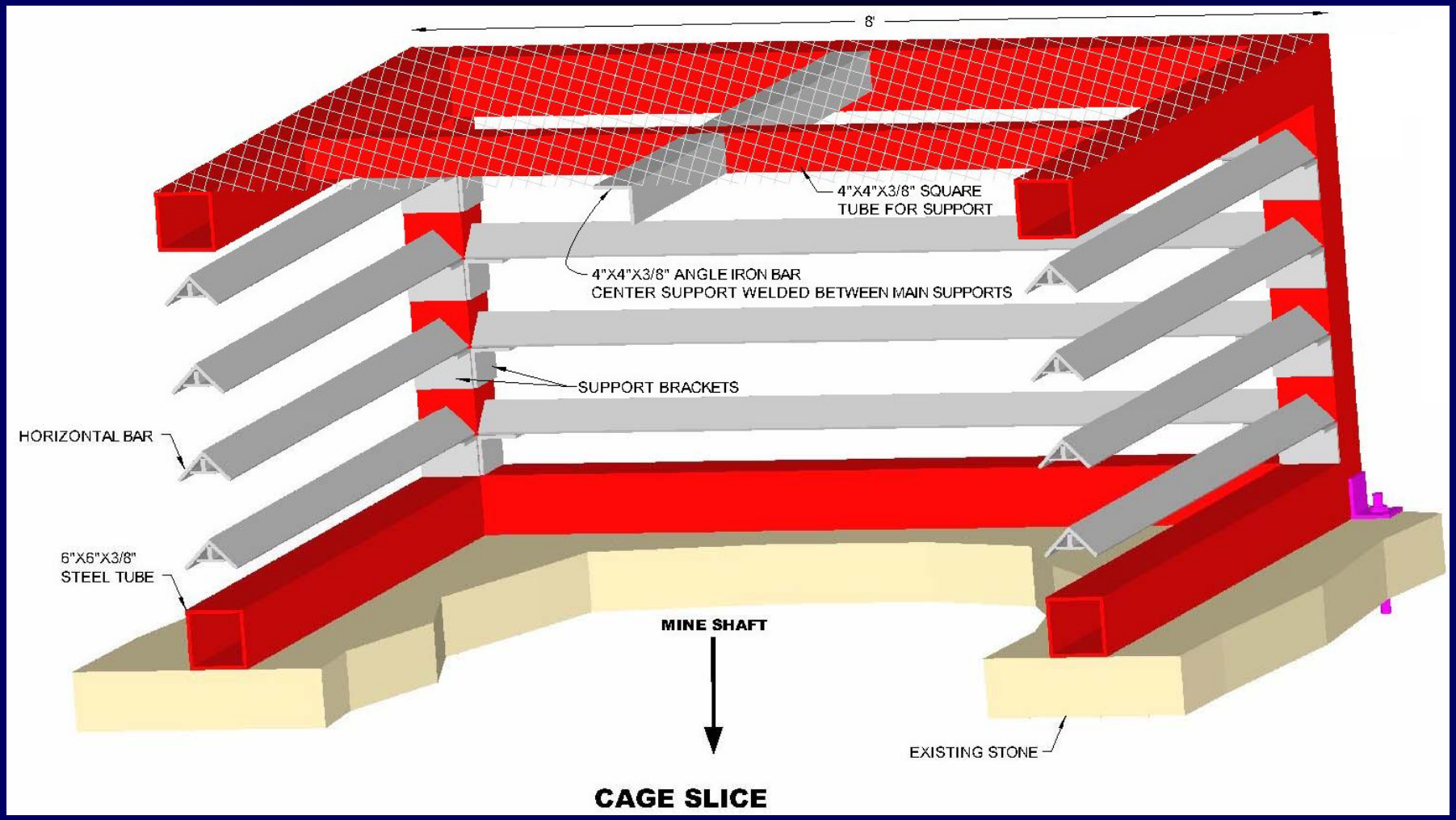
Keeping a large number of entries organized starts with the field visit and GPS data collection. By assigning an entry number from day one with the GPS, the same number can be carried through the whole project.

For example, at the Butterfly site, entry 4 can easily be spatially oriented on the map and a photo visibly identifies the entry. From this information the contractor can find the entry number on the Table of Estimated Quantities and determine the size and closure method of the entry. The corresponding entry detail can be found in the drawings.

Butterfly	Closure Method	Drawing Detail Number	Est. Const. Length	Est. Const. Width	Est. Const. Depth	Sq. Feet of Gate Heavy Duty
Entry 1	Bat Gate- Heavy	1	20	6.5		130
Entry 2	Precast Concrete and Steel Closure	9	2.7	2.7	16.4	
Entry 3	Bat Gate- Heavy	1	17	7		119
Entry 4	Vertical Shaft Bat Cage	10				
Entry 5	Bat Gate- Heavy	1	7	6		42
Entry 6	Precast Concrete and Steel Closure	9	2.7	2.7		
Entry 7	Culvert vent	2	2	2	10	
Entry 8	Culvert vent	2	4	1	5	
TOTALS						291

Detail 10

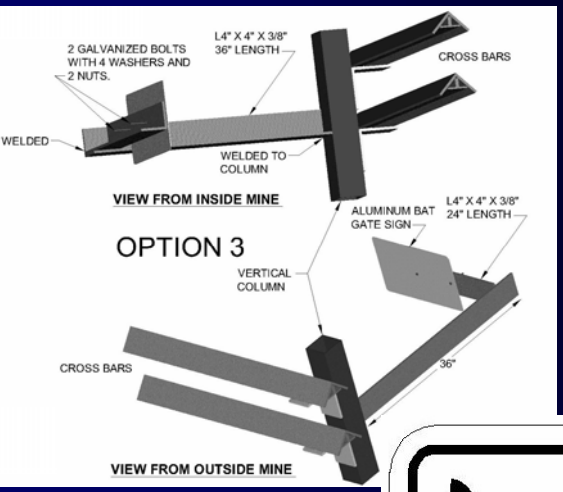
Detail 10



From detail 10 the contractor can construct a vertical bat gate. In addition, a bat gate sign is needed and he can acquire the specifics from detail 7.

Detail 7

Detail 7



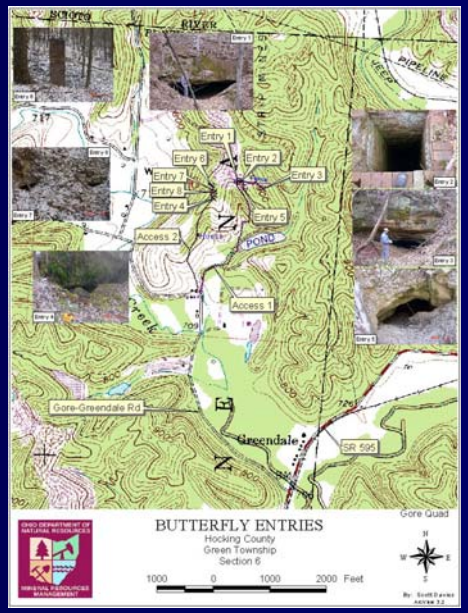
METHOD OF MOUNTING SIGN SHALL BE APPROVED BY THE CHIEF FOR EACH ENTRY. NOT EVERY ENTRY THAT REQUIRES A BAT GATE REQUIRES A SIGN, THE CHIEF WILL DESIGNATE GATES TO BE SIGNED. UNUSED SIGNS SHALL BE TURNED OVER TO THE CHIEF. ALL SIGN SUPPORTS OR BRACKETS SHALL BE PAINTED WITH THE SAME PAINT AS THE BAT GATE.

Future Improvements

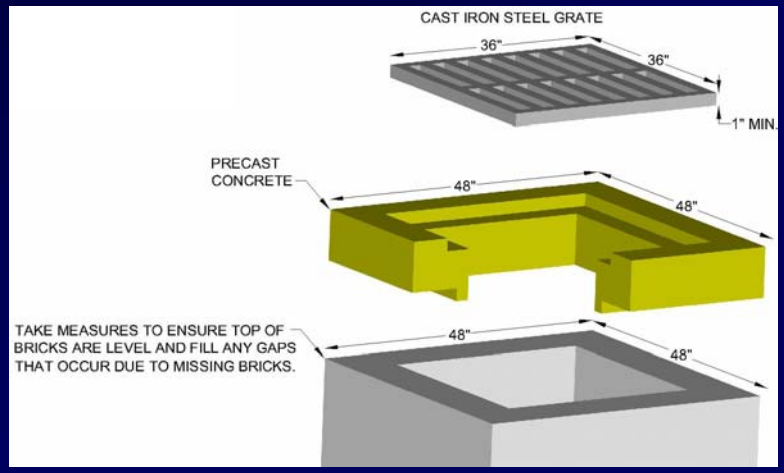
On the Unit Price Entries project the GPS serves as the geographical locator of each entry and the source of the entry naming convention. GIS serves a limited role in this project and primarily is used for displaying maps. AutoCAD was the source for engineering drawings, Excel for keeping track of quantities and hand written notes for entry sizes.

Before

After

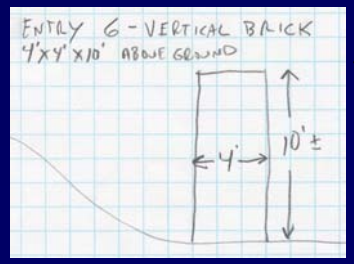


In the future, I believe that by integrating the GIS portion into the projects on a larger scale, we can organize data better. For instance, by tying all information about entry 6 to a GIS database, we can gather data more quickly and efficiently about the entry, not just location. Centrally locating this information in a GIS can eliminate numerous files in different applications and hand written notes. In addition, photos of the entries and details of methods of closure could be attached. This will also serve as a historic database for each project.



Blackstone	Closure Metho
Entry 1	Type "A" Dry M
Entry 2	Encapsulated
TOTALS	
Warner	Closure Metho
Slope Entry	Type "A" Dry M
TOTALS	
Cecil Hollow	Closure Metho
Entry 1	Bat Gate- Hea
Entry 2	Bat Gate- Hea
TOTALS	
Butterfly	Closure Metho
Entry 1	Bat Gate- Hea
Entry 2	Precast Concr
Entry 3	Bat Gate- Hea
Entry 4	Vertical Shaft
Entry 5	Bat Gate- Hea
Entry 6	Precast Concr
Entry 7	Culvert vent
Entry 8	Culvert vent
TOTALS	

On a larger scale, information could be gathered from all previous projects and could be analyzed for entry locations, types, number per county, rural, urban, etc.



N 39 33' 17.4"
W 82 16'53.0"

GIS

Summary of Uses of GPS in Ohio AML Projects

MEASURE

- Length
- Elevation
- Area

VERIFY

- Property lines
- Borrow limits

LOCATE

- Test pits
- Limits of grading
- Project limits
- New features not on topo
- Access routes
- Shafts and subsidence
- Benchmarks

STAKE OUT

ORGANIZATION

- Electronic
- Field to design
- GIS
- Project planning

When simple mapping is needed I use the GPS and do not need to acquire the services of a surveyor. This flexibility allows me to gather data when I need it and I get what I need.

GPS is a rapidly growing technology and is becoming more cost effective and accurate. Utilization of this spatial technology will become more valuable to our organization in planning, design and control of AML projects.

Links/Contact Info

Useful links for GPS information and software:

www.garmin.com

www.trimble.com

www.geocaching.com/mark/

www.gpsu.co.uk/

www.gpsworld.com/

Ohio Geodata:

www.state.oh.us/das/dcs/gis/data.htm

Contact:

OHIO DEPARTMENT OF NATURAL RESOURCES

K. Scott Davies, M.A.

Geographer/Design Specialist

DIVISION OF MINERAL RESOURCES MANAGEMENT

34 Portsmouth Street
Jackson, OH 45640

Phone: (740) 286-6411 ext. 13
Fax: (740) 286-1868
Email: scott.davies@dnr.state.oh.us