MUS-93-12.84

APPLIED MINE GROUTING TECHNOLOGIES

P. PAUL PAINTER, PG
KIRK BEACH
OHIO DOT

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- The Ohio Department of Transportation (ODOT) inspects nearly 12,000 structures annually
- During the inspection of MUS-93-12.84 Bridge in 2007, a large subsidence feature was noted under the right rear abutment
- Bridge carries traffic over Interstate Route 70 in Muskingum County
- Determined that corrective actions were necessary to protect the structure and roadway

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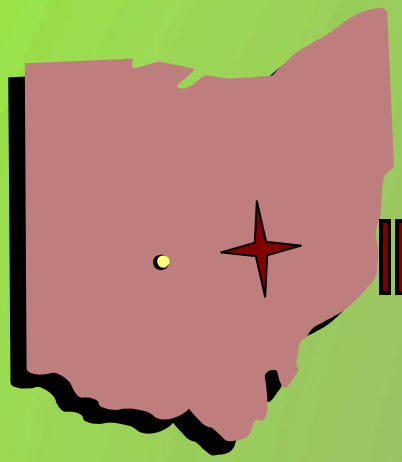
Project Location: Pleasant Grove, Ohio



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Project Aerial Location

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Subsidence Feature Noted During Bridge Inspection at Rear Abutment

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- No historical mine maps were available for the workings
- Historical archives, construction diaries, indicated that Interstate 70 was over-excavated through the mine interval, including the bridge piers, but the north and south bridge abutments and approach roadway and ramps could be underlain by mine voids
- Original construction plans indicated an abandoned mine entrance within project
- Underground utility vault, east side of rear abutment, encountered a void uuring installation.

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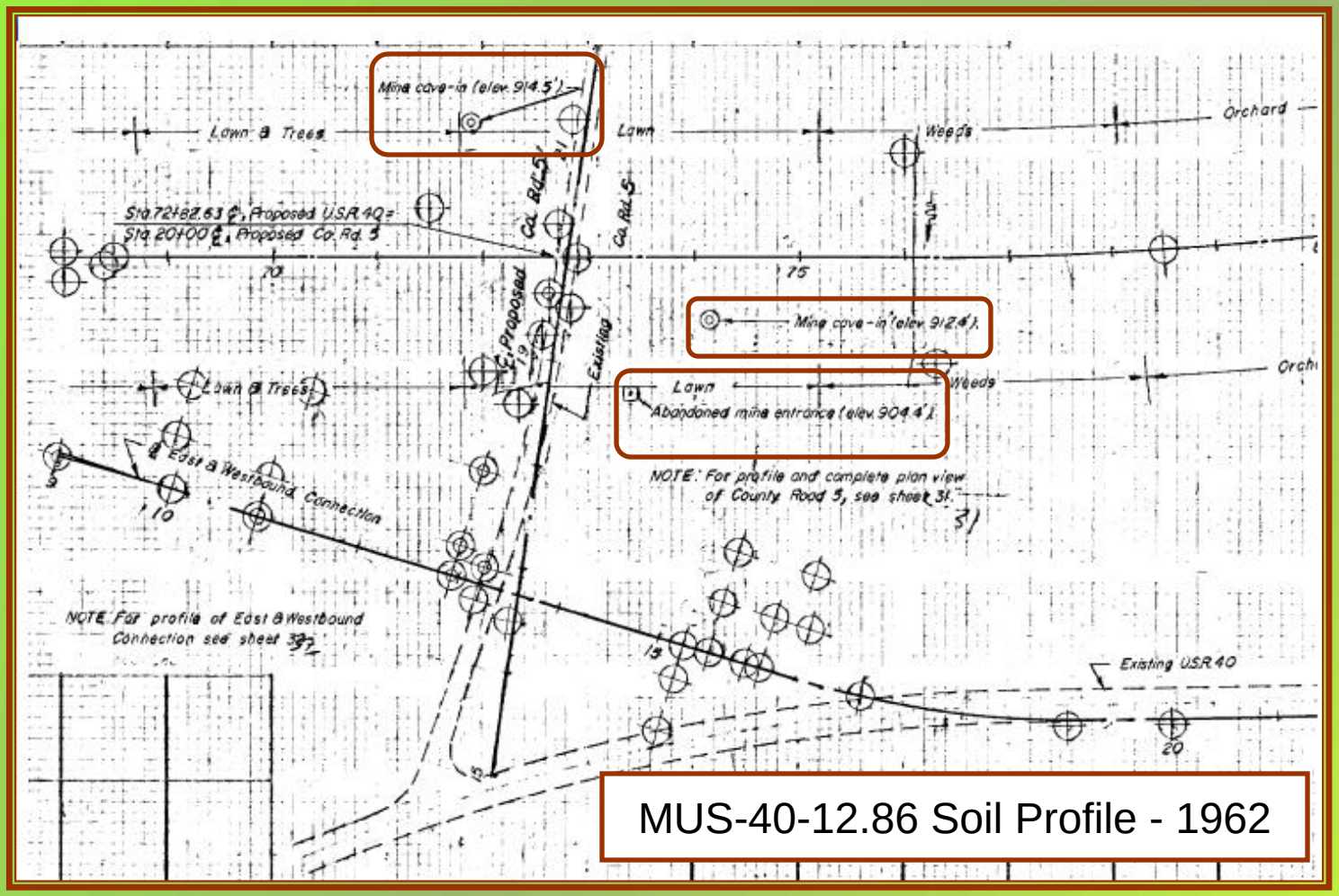

MUS-40-12.86 Soil Profile - 1962

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- Area has been noted for active subsidence:

- 1962: two subsidence features noted on original soil profile notes;

- 2000: large subsidence(s) investigated in northwest quadrant infield;

- 2007: Subsidence feature under rear abutment.

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REGIONAL GEOLOGY & MINING

- *Area located in the non-glaciated Marietta-Pittsburgh Plateau which is characterized by its moderately high to high relief*
- Pennsylvanian aged bedrock rock consists of siltstone, shale, sandstone, coal, and claystone
- Locally: No. 7 coal typically mined through drift entries
- Drift entries advanced into the coal seam from the head of tributary valleys
- Shallow soil cover typically ranging form 5 to 20 feet
- No Site Specific Mine Map for the project

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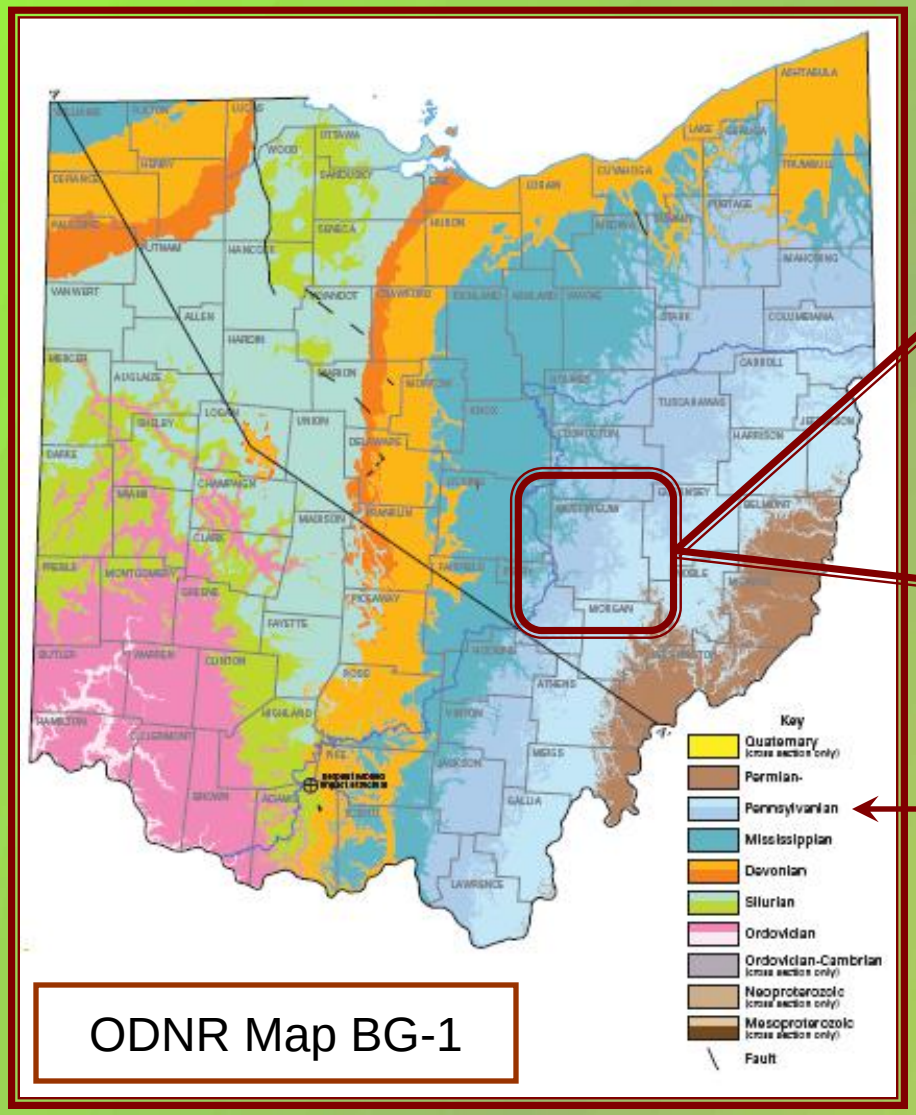

ODNR Map BG-1

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REGIONAL GEOLOGY & MINING

- Typically: All of the local mines were abandoned prior to mechanization, circa 1930's.
- Most exhibit pre-mechanization mining features, i.e.,
  - Long, Narrow Rooms & Pillars (5-6 foot widths),
  - ± 50% Extraction,
  - Rooms Driven on the Face Cleat,
  - No retreat or second mining.

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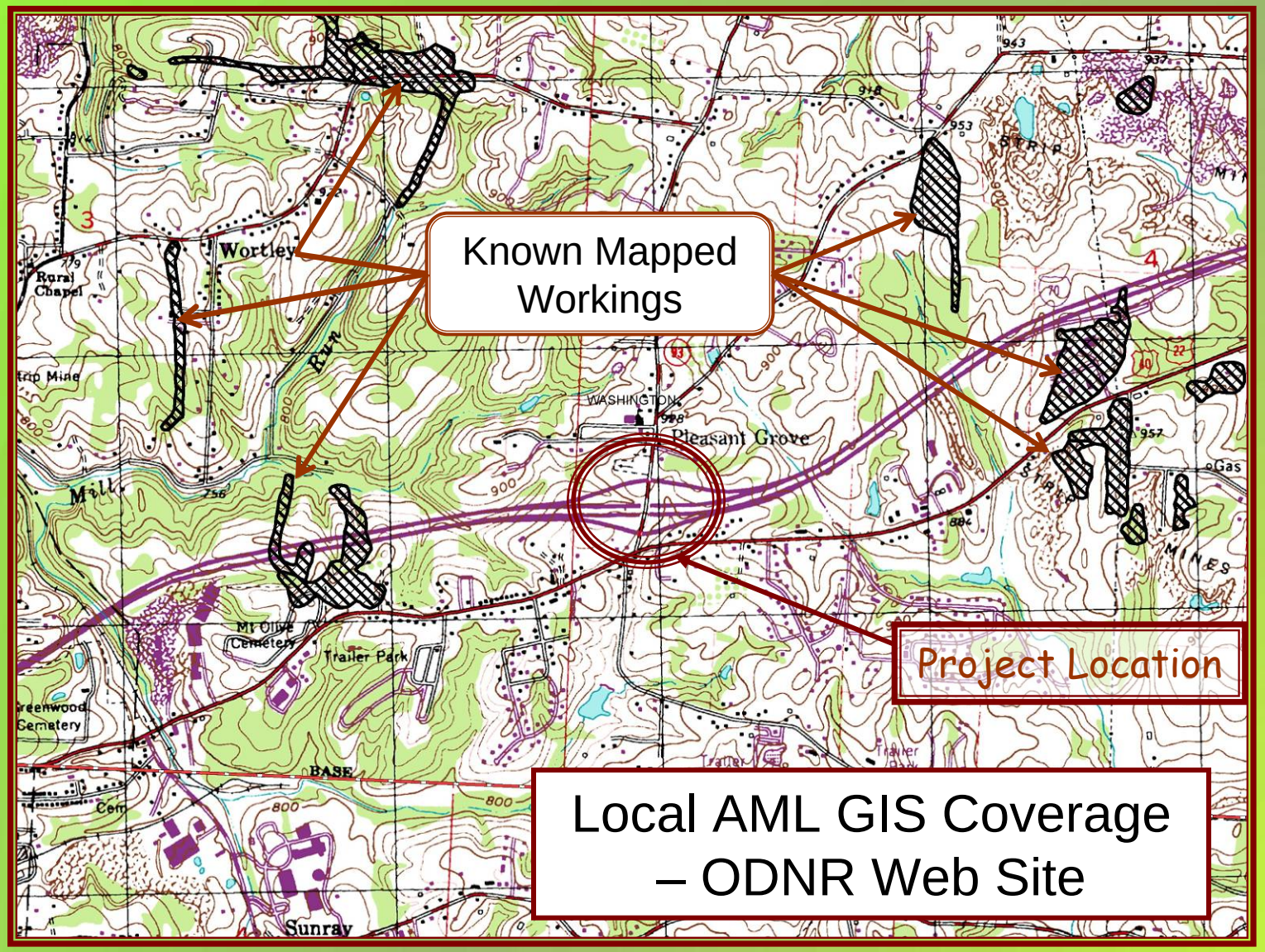

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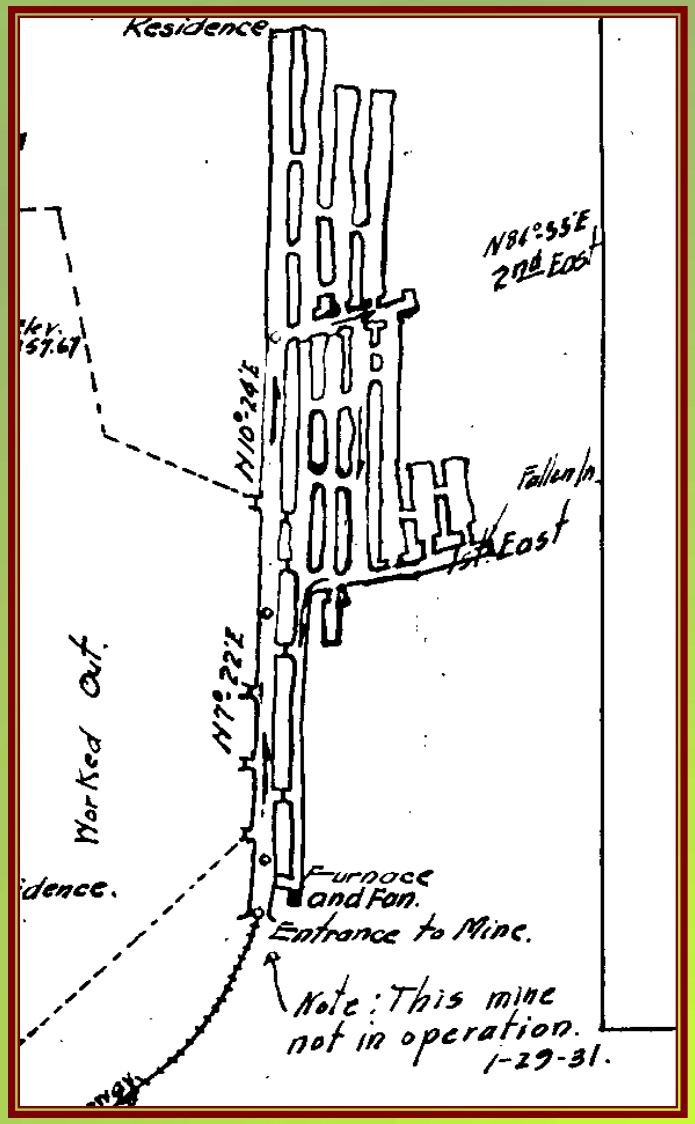
Typical Mine Map From Area
(Local 1 mi. east of project)

- Rooms driven on Face Cleat; N6ºW
- Long, Narrow Pillars
- No Secondary (retreat) mining
- Coal Elev. 858.0±; 30 ft. below MUS-93 site (El. 890.0)
- Drift entry from valley outcrop



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Remediation Selection

- Monitoring of the structure and roadway:

  High traffic resulted in in unacceptable risk due to potential catostraphic failure

- Excavation and replacement:

  High costs and long closure time

  Impractical at the abutments

- Drill and grout options:

  Expensive and small risk for subsidence

Drill and Grout Selected due to time constraints!

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Project Concerns

1) Limiting Road Closure Due To Heavy Truck Volumes From Industrial Park

2) Limiting Access To Emergency Vehicles

3) Settlement of Structure During Grouting

4) Blowout of the Cut Slope Above IR 70

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1) Limiting Road Closure Due To Heavy Truck Volumes From Industrial Park:

- Selection Of Drill and Grout To Limit The Time Required For The Road Closure
- Do Not Implement Road Closure Until Drilling Of The Roadway Production Holes

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2) Limiting Access To Emergency Vehicles:

- Only Work In One Traffic Lane At A Time, Even During Closure Period, To Allow Access To Emergency Vehicles

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3) Settlement of Structure During Grouting:

- Required Structure Monitoring 24/7 For The Duration Of The Construction.

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4) Blowout of the Cut Slope Above IR 70:

- Contractor Must Have Contingency For Immediate Interstate Closure If Blow Out Occurs With Cleanup Plan;
- Monitoring Of The Slope Required During Grouting Operations.

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STRUCTURE MONITORING

- Leica RCRP 1200+ robotic system was manned 24 hours a day, 7 days a week during the project
- Reflective glass targets were mounted on each concrete abutment and concrete pier.
- Vertical Surface Monitoring Points were surveyed once daily during the project.

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Reflective glass targets

Leica RCRP 1200+

(Photos Courtesy Gannet Flemming, Inc.)

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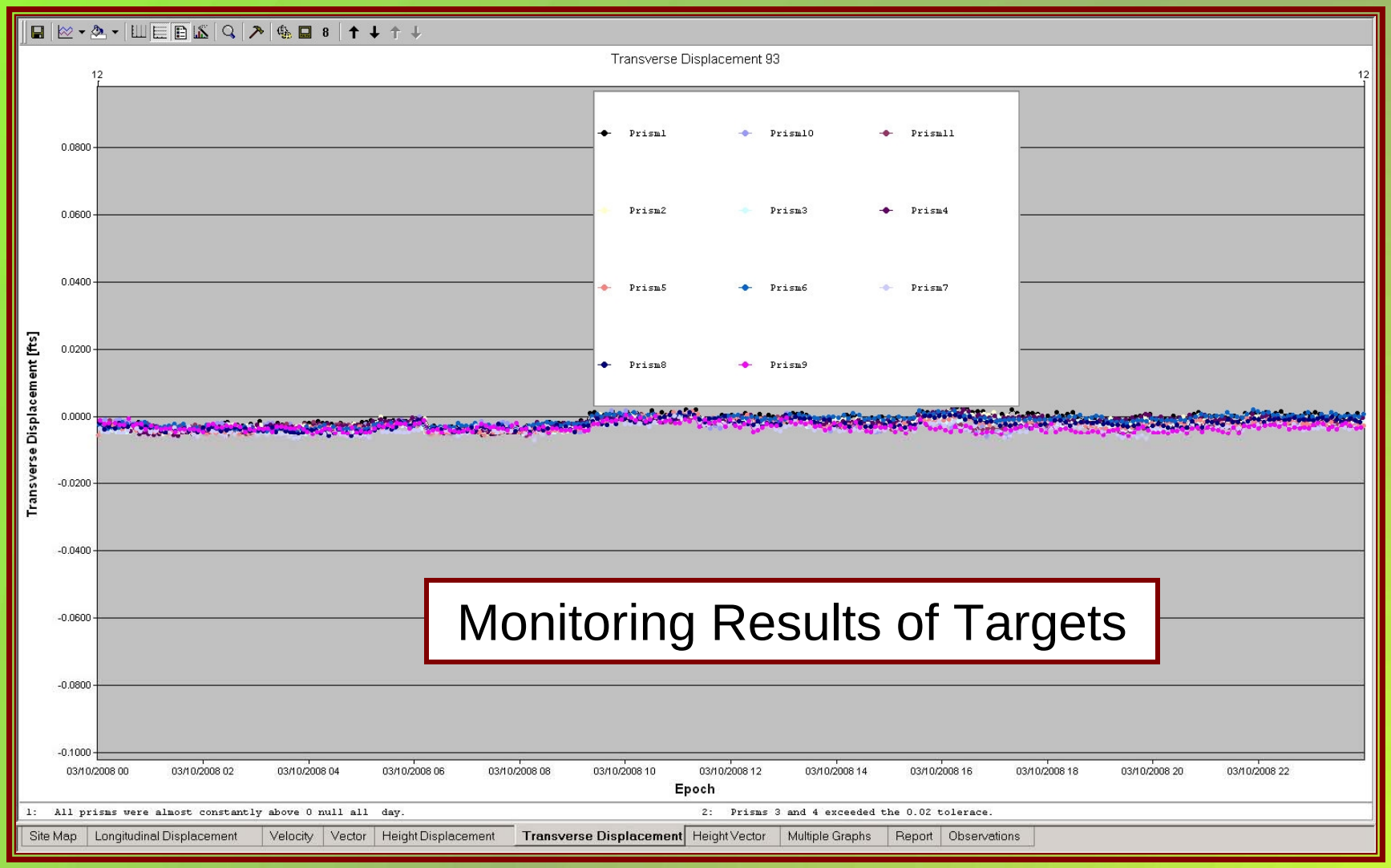

Monitoring Results of Targets

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UNDERGROUND MAPPING

- Due To Lack Of Mine Map, In-situ Underground Mapping Was Completed to Determine Working Layout and Condition
- Workhorse Technologies, Pittsburgh PA, Were Retained To Perform Mapping Using Sonar “Wet Ferret” and/or LiDAR “Dry Ferret”

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- South and North Side “Dry” at Completion of Production Hole Drilling – To Be Mapped Using “Dry Ferret” – LiDAR Scanning
- At Time of Mapping:
  - South Side had “Squeezed” Closed with only a 6-inch opening below roof rock
  - North Side “flooded”
- South Side Not Mapped
- North Side Mapped Using “Wet Ferret” - Sonar

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WET FERRET

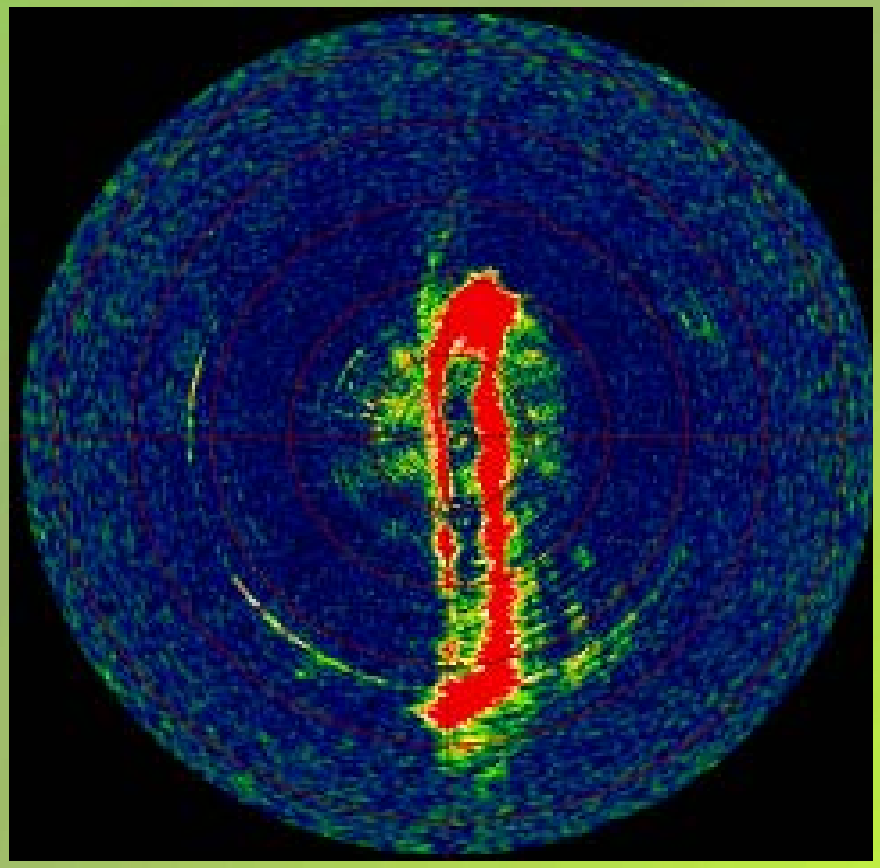
- Used in Flooded Conditions
- Requires Minimum 3-foot "Clear" (low Turbidity) Water
- Single Planar Scan Six-inch Thick on a 360º Horizontal Profile
- Resolution: 0.4-inches from 6 inch to 300 feet; up to a depth of 3280 feet

(Photo Courtesy Workhorse Technologies, LLC.)

MUS-93-12.84: MINE GROUTING

MUS-93-12.84: MINE GROUTING

Raw Data Point Collection by “Wet Ferret”



(Courtesy Workhorse Technologies, LLC.)

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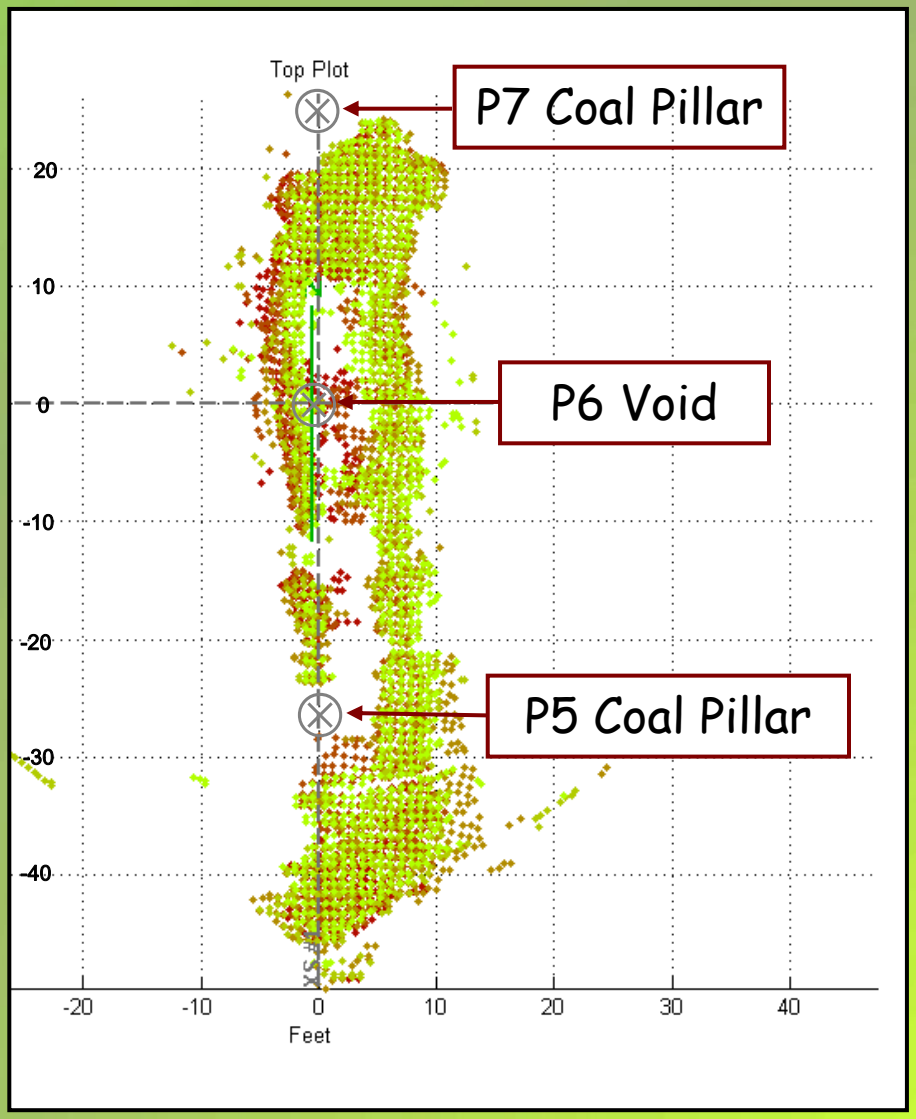
Post Processed Data
Point Collection by
"Wet Ferret"
(at a single scan point)

(Courtesy Workhorse Technologies, LLC.)



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- Scan in P6 revealed a void:
  - 2.5 ft. high.
  - 15 ft. wide.
  - 70 ft. long.
  - Est. volume 97 cy.
- Excellent correlation with borehole camera.
- P6 took 90 cy grout!

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DRY FERRET

- Used in Dry Air Filled Void Conditions;
- LiDAR scanning sequence collecting thousands of measurements;
- Scanning sequence is processed into a 3-D model of the void;
- Accuracy: 1-inch up to 160 feet from scanner; up to a depth of 2500 feet.

(Courtesy of Workhorse Technologies, LLC. Web Site: http://www.workhorsetech.com/etomite0613/)

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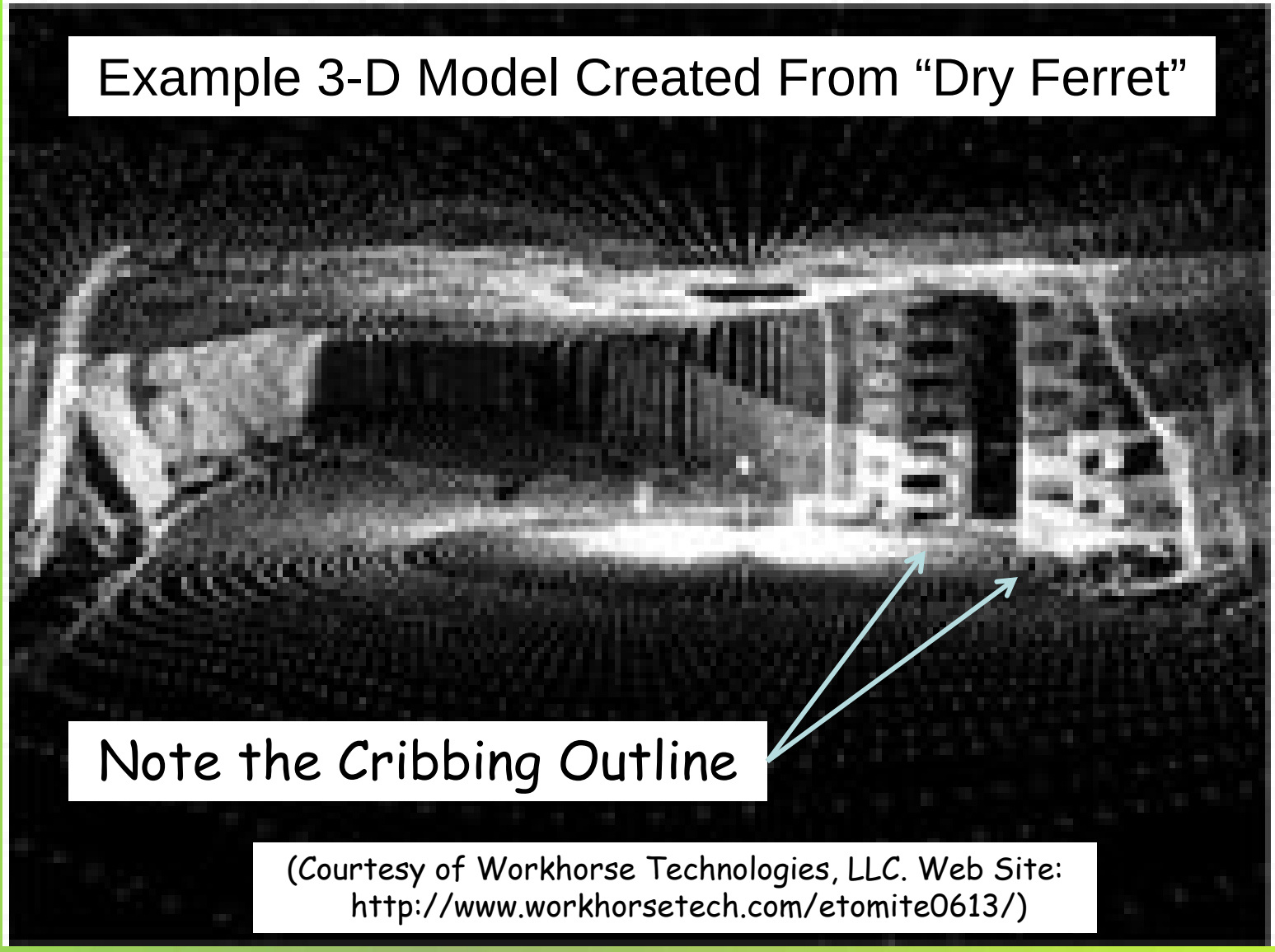

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Project Stats:

- Drilled 2,000 liner feet of injection holes.
- Placed about 2,000CY of Barrier Grout.
- Placed about 250 CY of Production grout (virtually all on the north side).
- Began project Feb 14th, completed Mar 4th.

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Interesting Facts & Pondering Points

- North side IR70 lots of open voids, South side mostly coal.
- Proximity to crop line and shallow cover contribute to poor roof stability.
- Proximity to entrance, more coal left insitu.

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Interesting Facts & Pondering Points

- Mine workings on the north side were “flooded”, south side workings were “dry”.
- Originally presumed a regional NW-SE geologic dip; drilling revealed a N-S dip.
- Construction fill on IR70 Cut slopes acted to dam water on North side.
- Greater aerial extent of mine workings to north
- South side drained to local drainages along US40.

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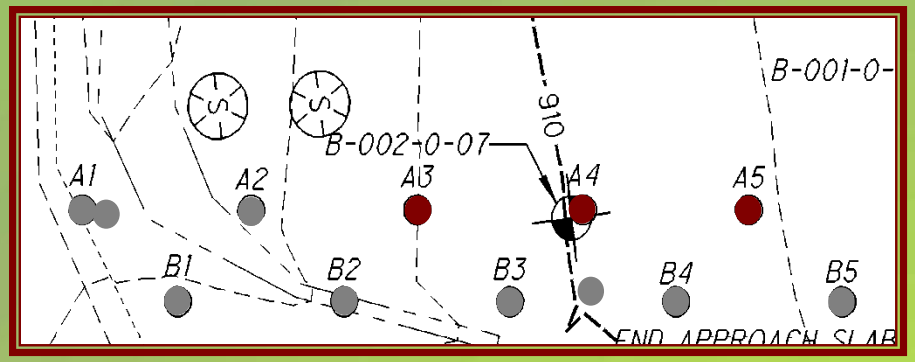
Interesting Facts & Pondering Points

- A3 & A4 both encountered voids at 898.0 and 900.7, respectively. A3 was open 5 feet and full of water; A4 was open 5 feet and dry;
- Put light source in A3 could not see from A4;
- Borehole camera could see towards A3;
- A3 took 18 CY grout; A4 took 58 CY grout;
- Possible collapse, but drilled like insitu material;



•Miners could have used soil or “mine gob” to block rooms for ventilation control since this section of the mine was near the crop line.

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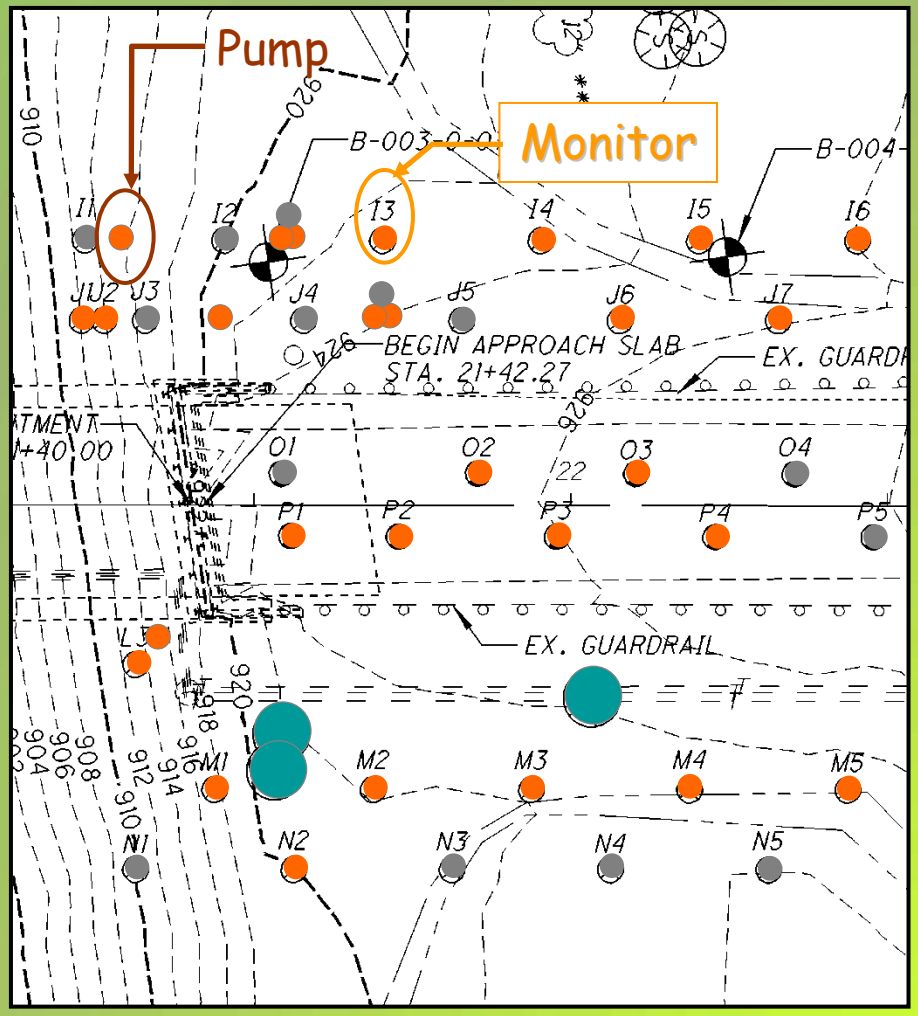
- Pump Test in I1A, monitored in I3. 4-inch Godwin, CD100M operating at 1900 rpm (710 gpm);
- Pumped for 88 minutes. Obtained a drawdown of 0.3 ft (30 min/0.1 ft);
- Wanted to drawdown pool ±2 ft. (10 hrs.) so grout injection wouldn't overpressure the mine pool;
- 12 hours later the pump was sucking air.



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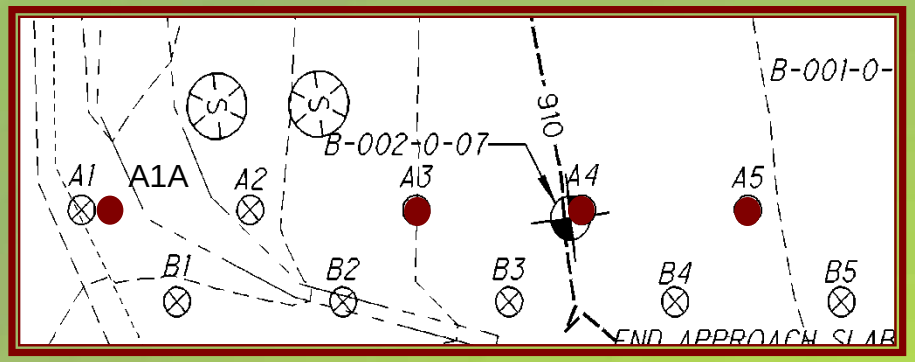
Interesting Facts & Pondering Points

- A1 hit a coal pillar. A1A encountered a void. As soon as drill tools removed hole, hole would squeeze in with a highly plastic soil material. A1A was drilled out 3 times, same result;
- 9 feet of rock was drilled before encountering the void;



- Backfilled soil/gob has become saturated enough to be at/near the liquid limit so as to act as a pseudo-liquid?;
- Grout could not displace the “mud”, virtually no take.

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CONCLUSIONS

- In-situ mapping can aid in mine grouting project;
- Sonar has limited applications due to poor performance in muddy water;
- LiDAR good in dry situations;
- Should be used prior to drilling of production holes to move hole locations to avoid pillars;
- Help refine the production volumes to reduce waste;
- Structure monitoring may be expensive, but worth piece of mine for “critical structures”;
- Structure monitoring should be automated to reduce labor costs associated with 24/7 monitoring.

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THANK YOU!

QUESTIONS??