Pre-Mining Methane Drainage Drilling Applications

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Coal Mine Methane And Coalbed Methane Technical Workshop

June 4, 2015

Bogotá, Colombia

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Pre-Mining Methane Drainage Drilling Applications

- International CMM Industry
- Methane Drainage Considerations
- Surface Based Pre-Drainage Wells
- Longhole Directional Drilling
- Directional Drilling Equipment
- Drilling Capabilities
- Pre-Mining Applications
- Enhancing Gas Drainage from Lower Perm Seams
- Well Interception Technology and Applications
- Wellhead and Gas Collection
- Summary

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International CMM Industry

- Coal is the most abundant fossil fuel. IEA predicts continued reliance and consumption of coal increasing by 50% by 2030.
- Mining technology continues to evolve resulting in more rapid excavation and production techniques.
- We continue to mine deeper, gassier and more challenging coal reserves. This has resulted in a need to improve methane drainage techniques.
- Use of surface drilled methane drainage wells has been affected due to surface ownership, approvals, topography, culture, lack of equipment, etc.
- Many coal reserves develop multiple coal seams and require flexible methane drainage approach.
- Gas collection systems typically use steel pipeline and demonstrate significant erosion of gas quality from wellhead to surface.
- There is a recognized need to mitigate methane emissions and demonstrate environmental awareness.
- The international CMM industry shows tremendous growth and spread of upstream and downstream technologies.

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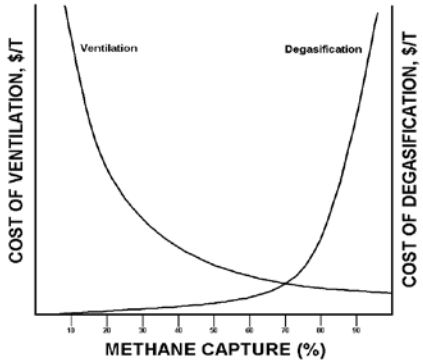
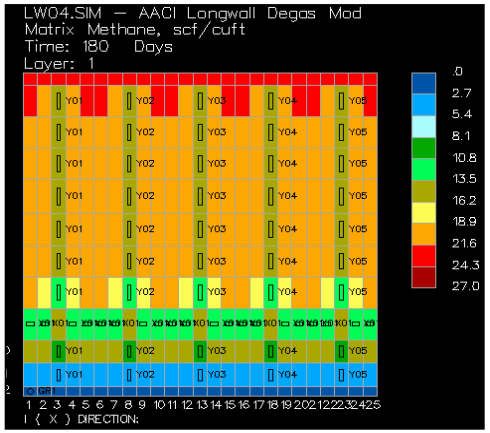
Methane Drainage Considerations

- The production and recovery of methane prior to mining CBM can greatly improve mine safety and productivity.
- Ventilation vs. Methane Drainage
  - Relative costs versus drainage efficiency
- Source of gas emissions
  - Adjacent gas bearing strata, geologic features or working seam
- Geologic characterization
  - Coal thickness, rank, stress, friability, other mechanical properties
- Reservoir characterization
  - Gas content, permeability, porosity, reservoir pressure, and desorption time constant
- Mining technique and schedule
  - Gate road development, start of LW, available drainage times, multiple seams
- Drainage approach
  - Source, feature, or shield focused
- Logistics
  - Surface and underground access
- Gas Utilization
  - Alternatives, gas quality
  - Market





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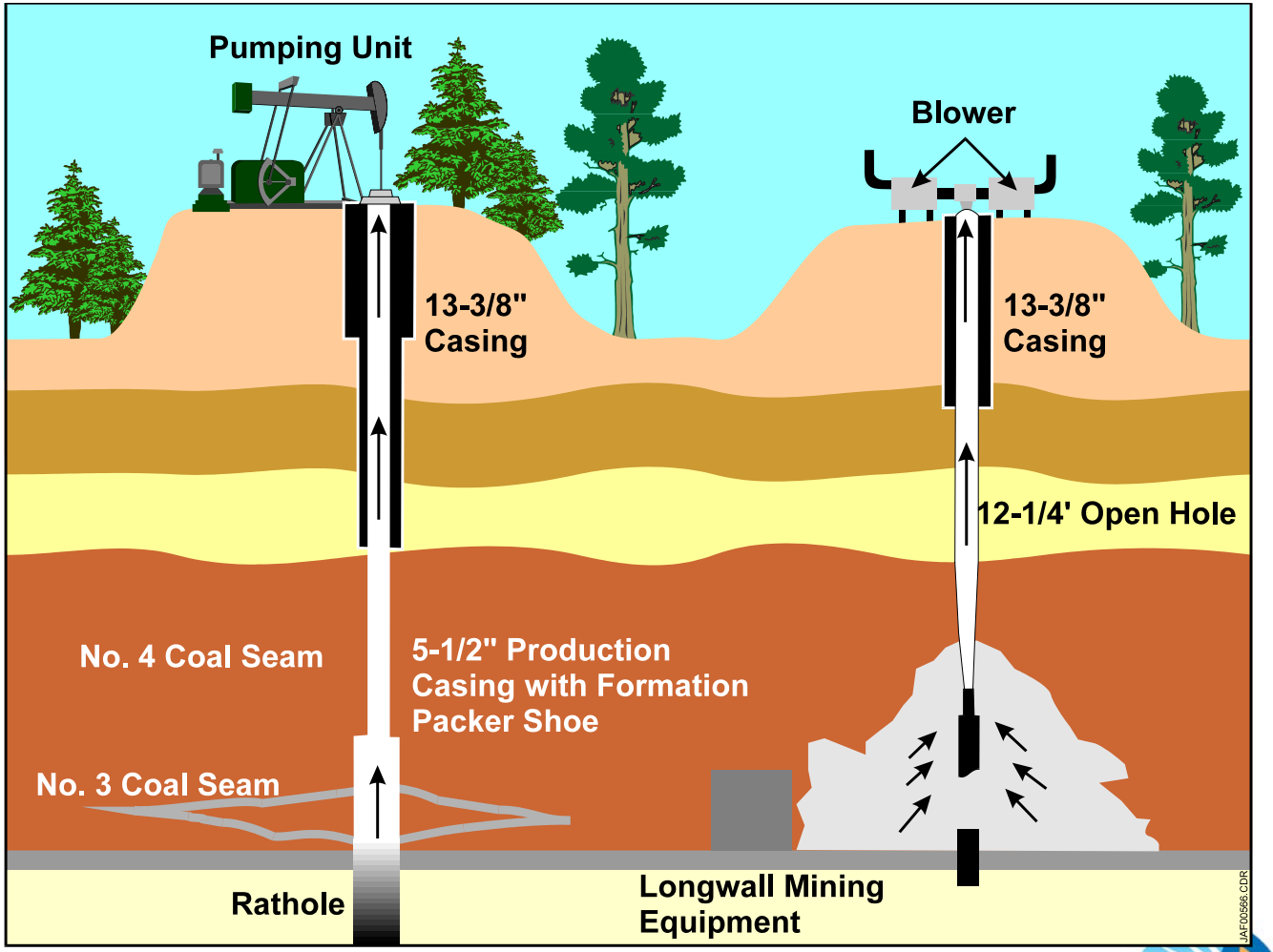
Surface-Based Degasification Methods

- **Vertical, Stimulated Wells.** Wells drilled from the surface that are generally cased, cemented, and hydraulically stimulated. Studies by the U.S. Bureau of Mines show that up to 73% of the original gas in-place can be produced via vertical wells. These type of wells are ideally suited for multiple, thin seam situations.
- **Horizontal Wells.** These types of well are gaining in popularity and can produce 70 to 80% of the gas in-place. Good application for settings where there is one or two principal seams.

Design of Vertical CBM and CMM Wells



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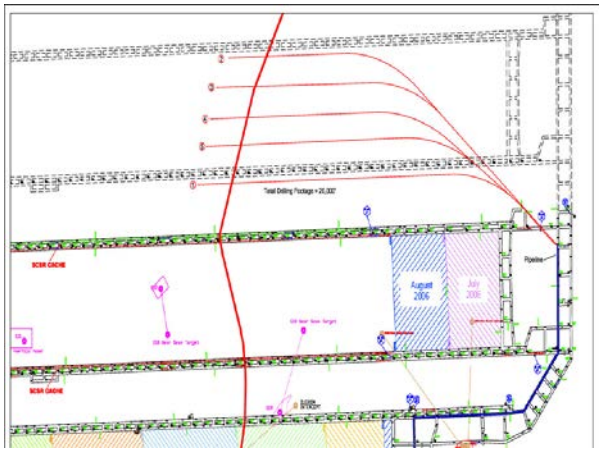
Why Consider Long Hole Directional Drilling?

- Allows longer length and more accurate placement of boreholes for improved methane drainage efficiency and longer drainage times
- Allows implementation of innovative pre-mining drainage techniques
- Ability to steer borehole to stay in-seam or hit specific targets
- Promotes a more focused, simplified gas collection system
- Less labor intensive
- Provides additional geologic information (such as coal thickness, faults, and other anomalies, etc. prior to mining



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Directional Drilling Equipment

Single Piece and Modular Units

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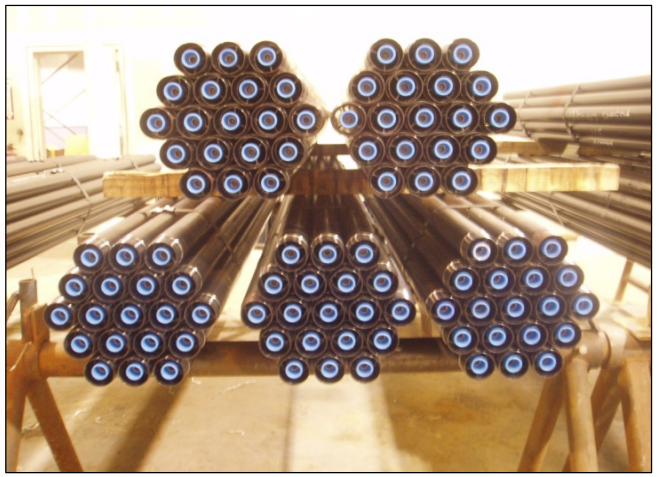
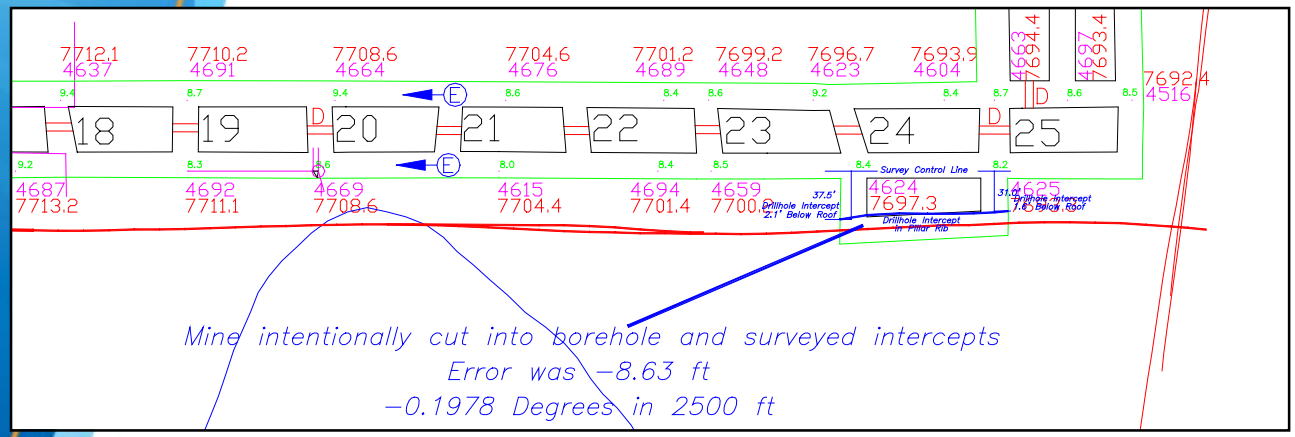
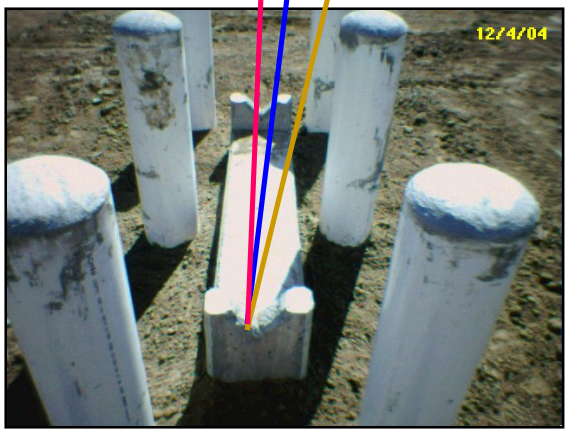
Directional Drilling Downhole Equipment

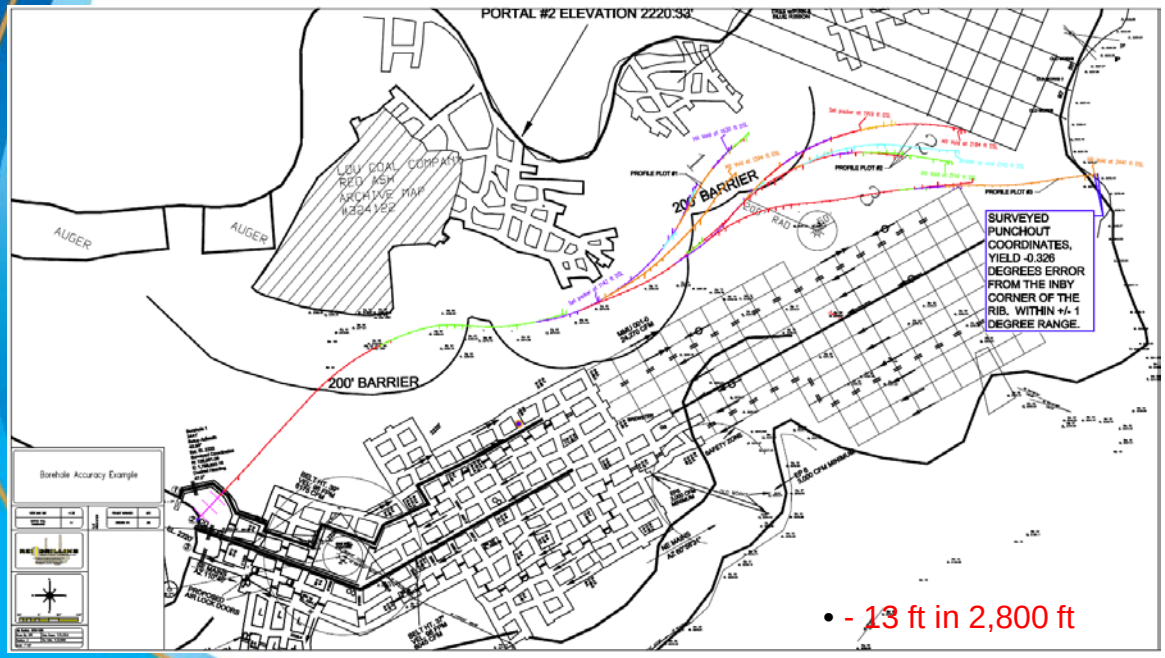


Drilling Capabilities



Placement Accuracy





- - 13 ft in 2,800 ft

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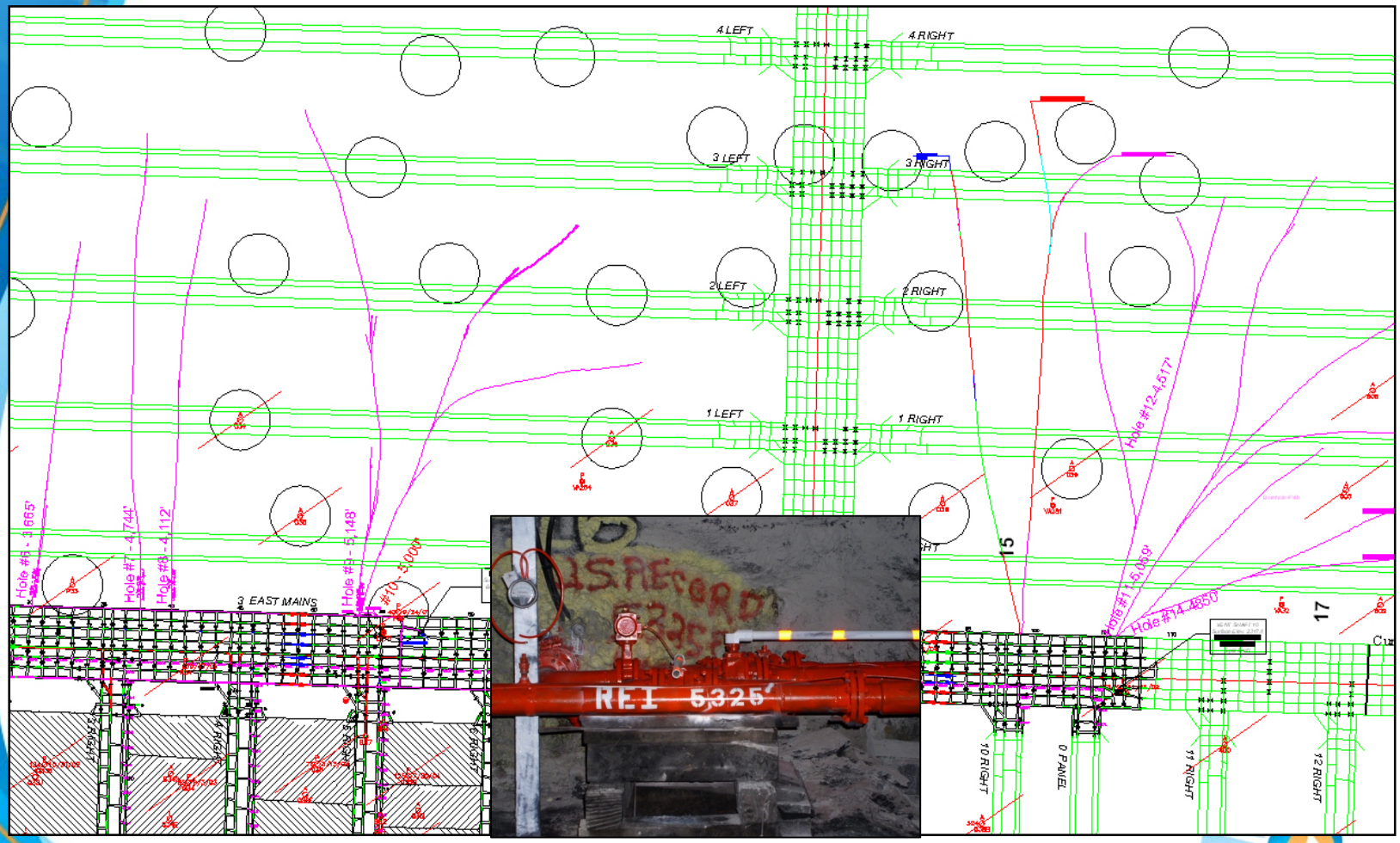
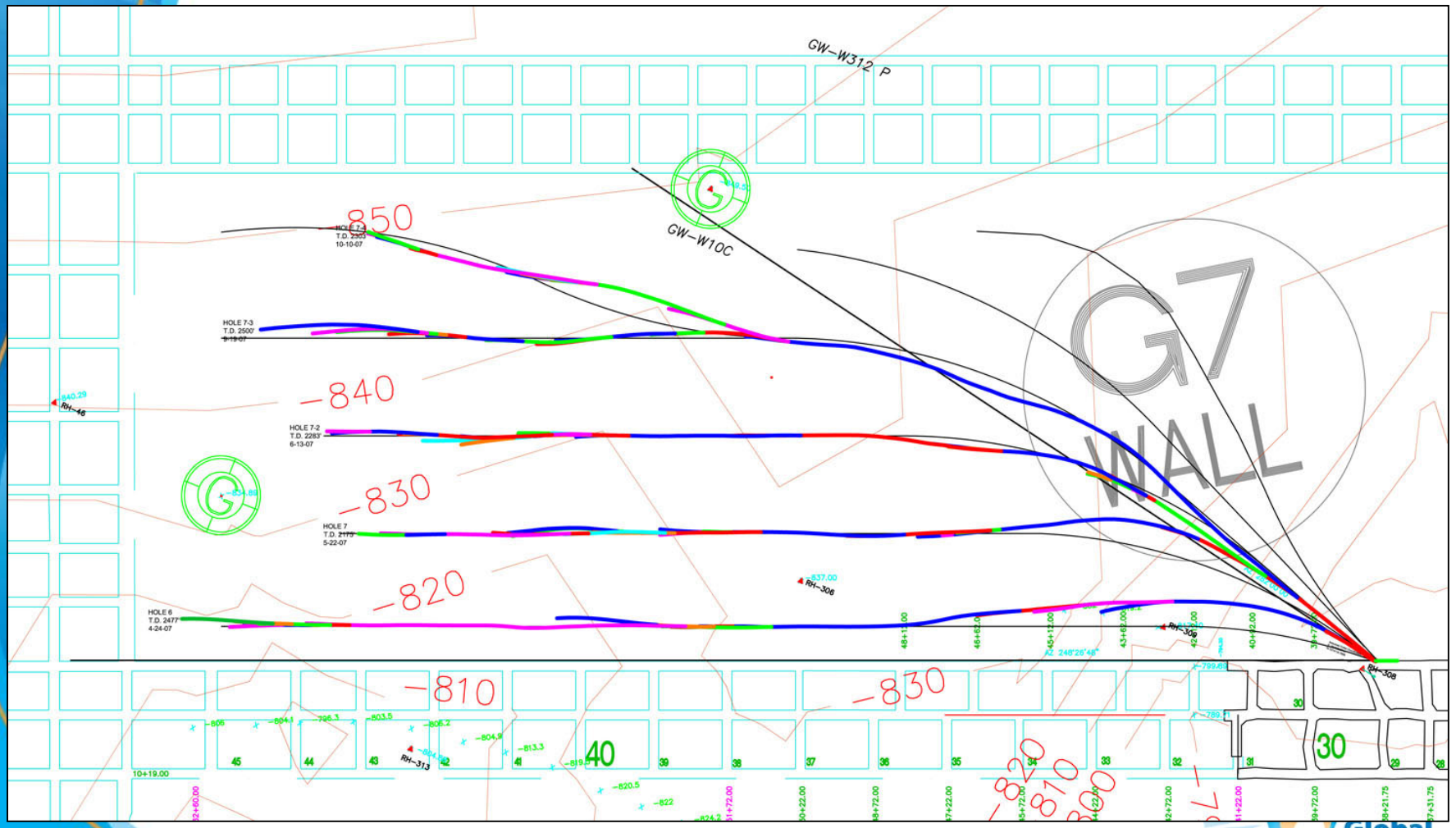
Drilling Capabilities

Reach



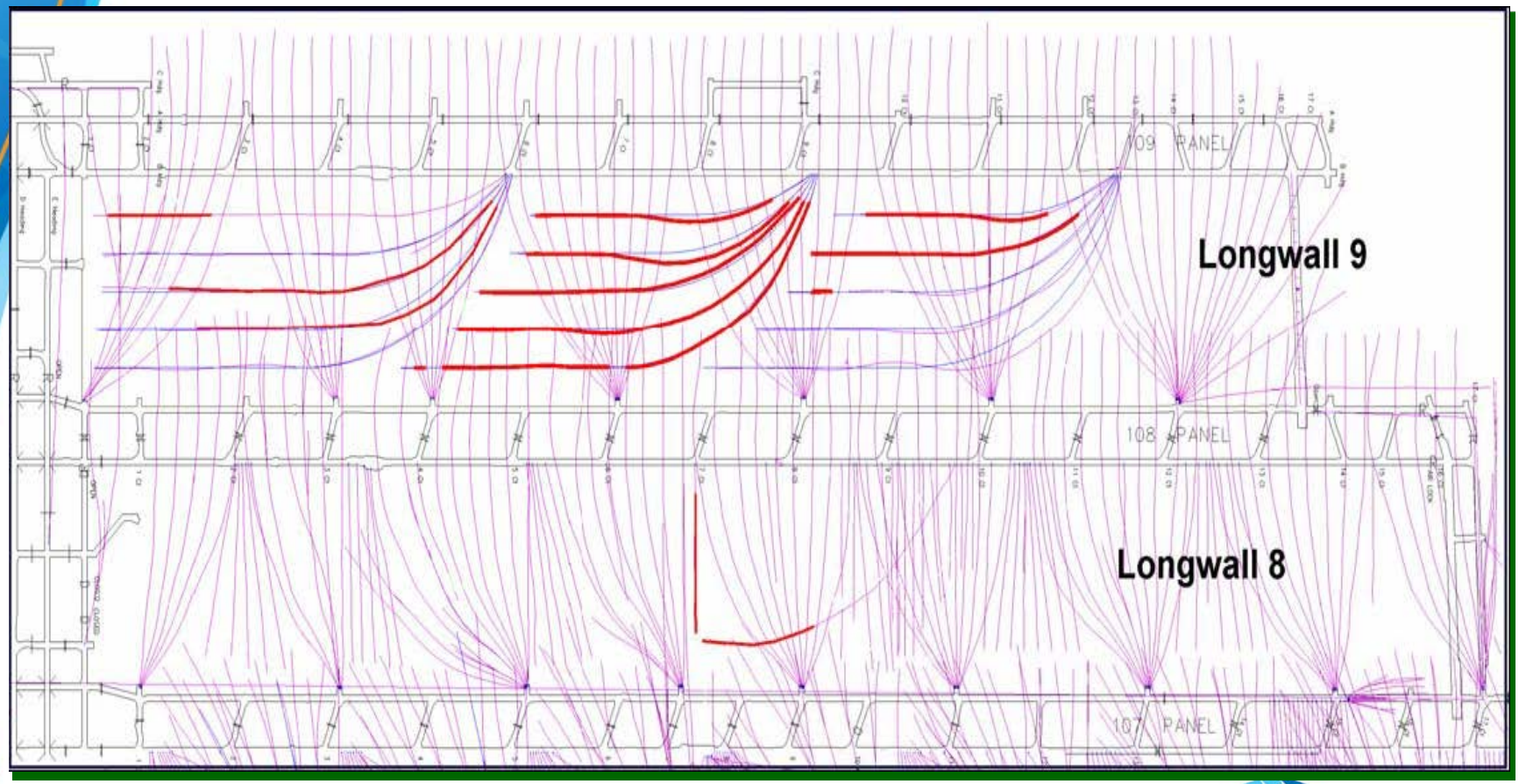
Reducing GC in Longwall Panels

High Permeability



Reducing GC in Longwall Panels

Low Permeability with Outburst Conditions



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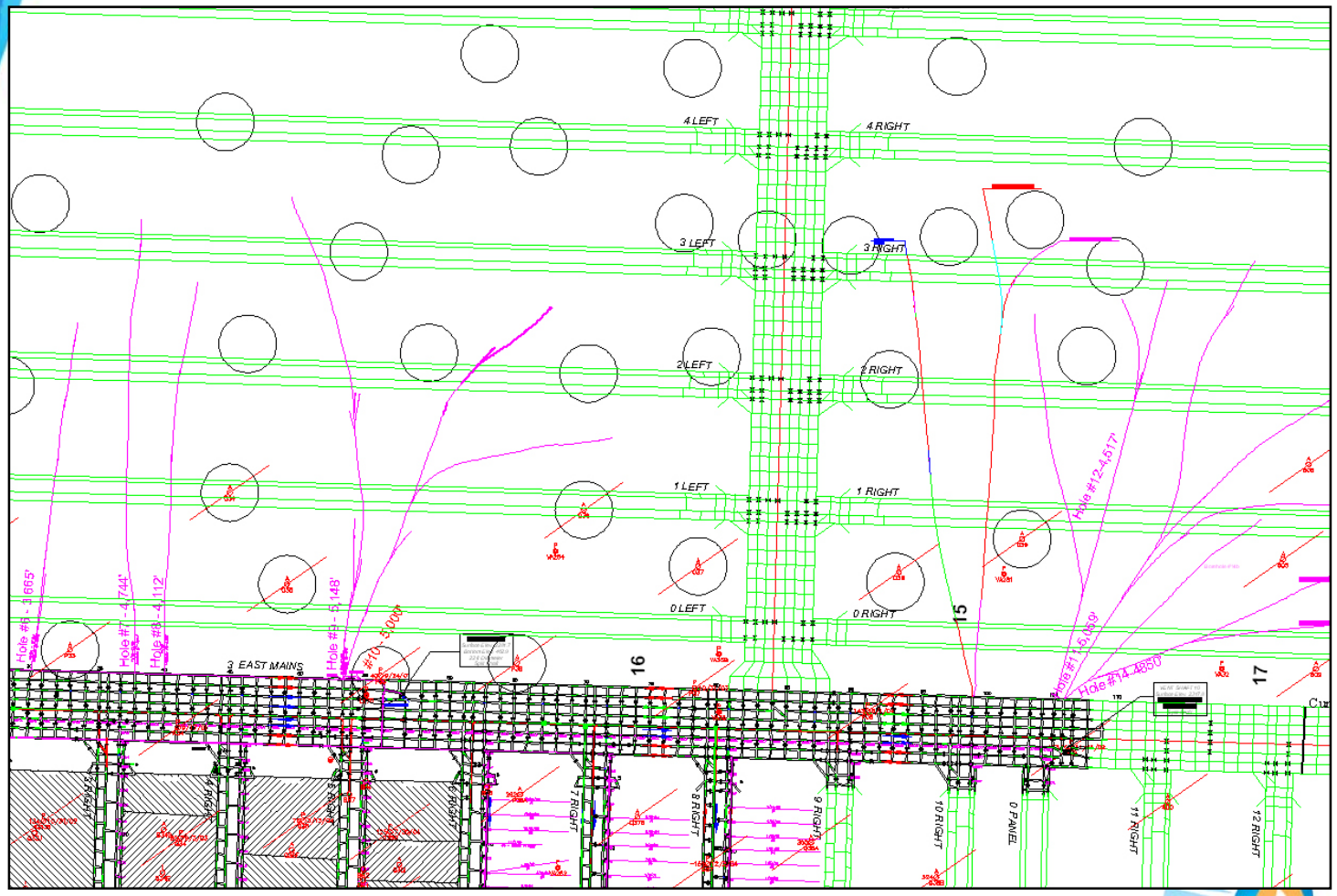
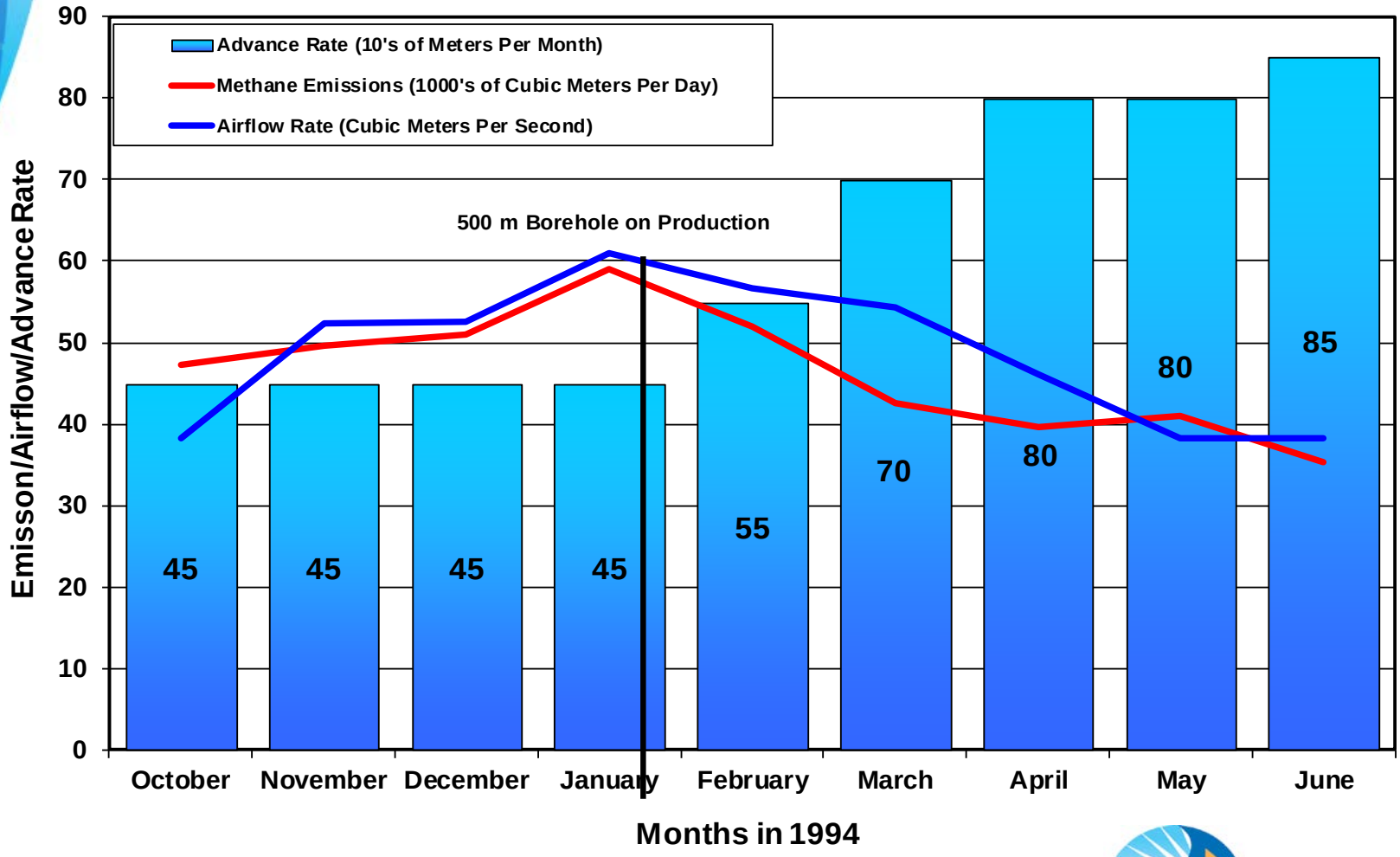
Reducing GC Significantly in Advance of Mining

Complementary Approach with Frac Wells



Immediate Impact on Mining



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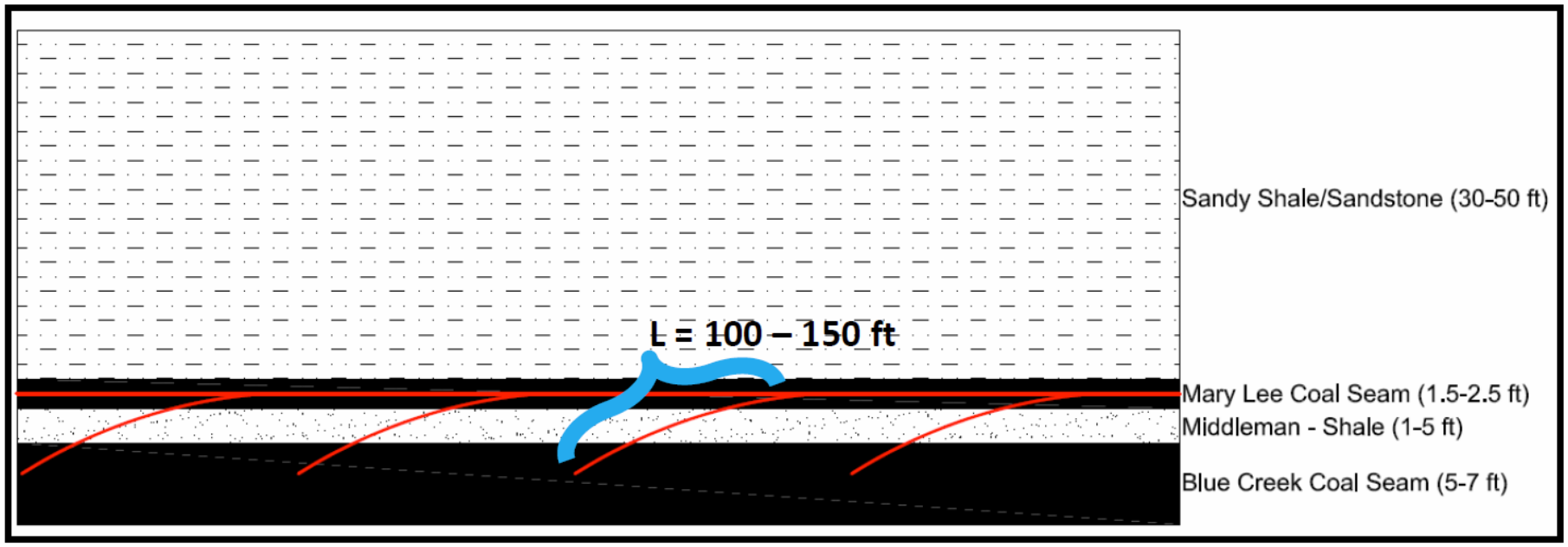
Reducing GC from Adjacent Seams

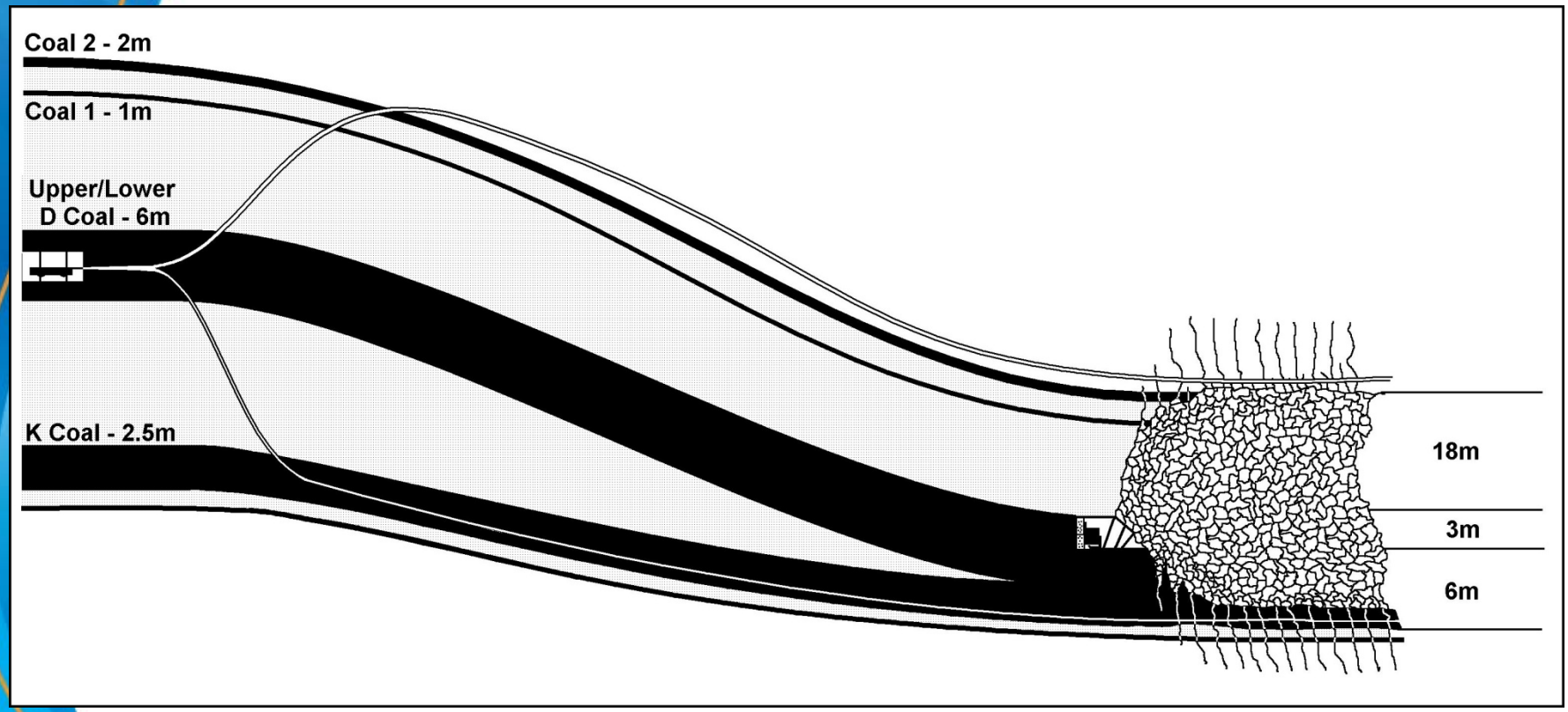
Profile

- Addressing Stability Issues
- Dual Purpose Boreholes

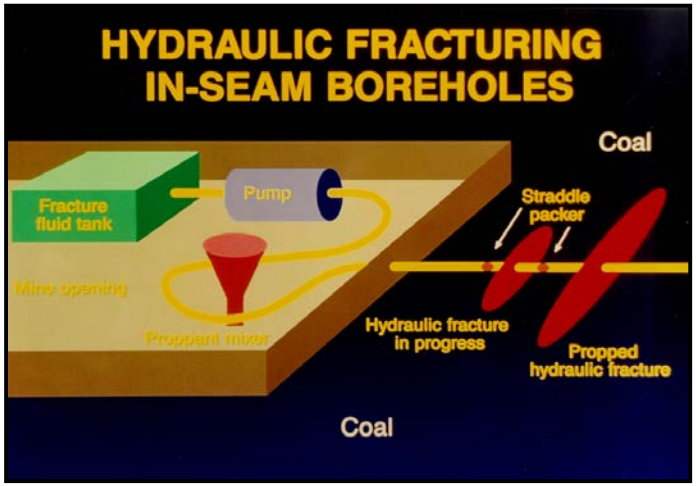


Reducing GC of Adjacent Seams

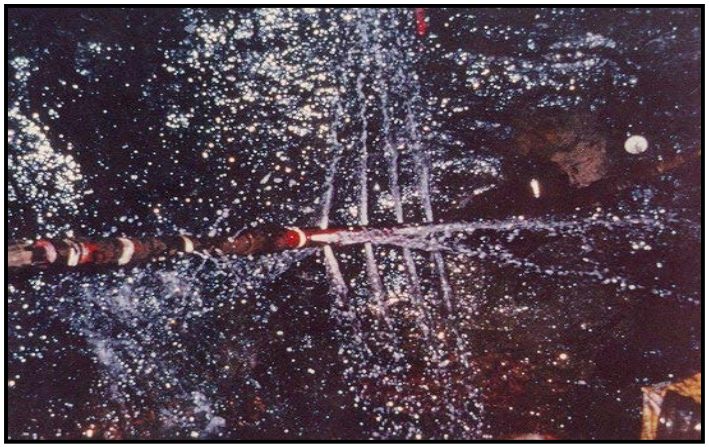
Profile - Dual Purpose Boreholes



Enhancing Drainage from Lower Permeability Coals



- Propped fracture treatments along length of 2,500 foot boreholes
- Gas production increased by nearly 50% over a month
- Other enhanced methane drainage techniques



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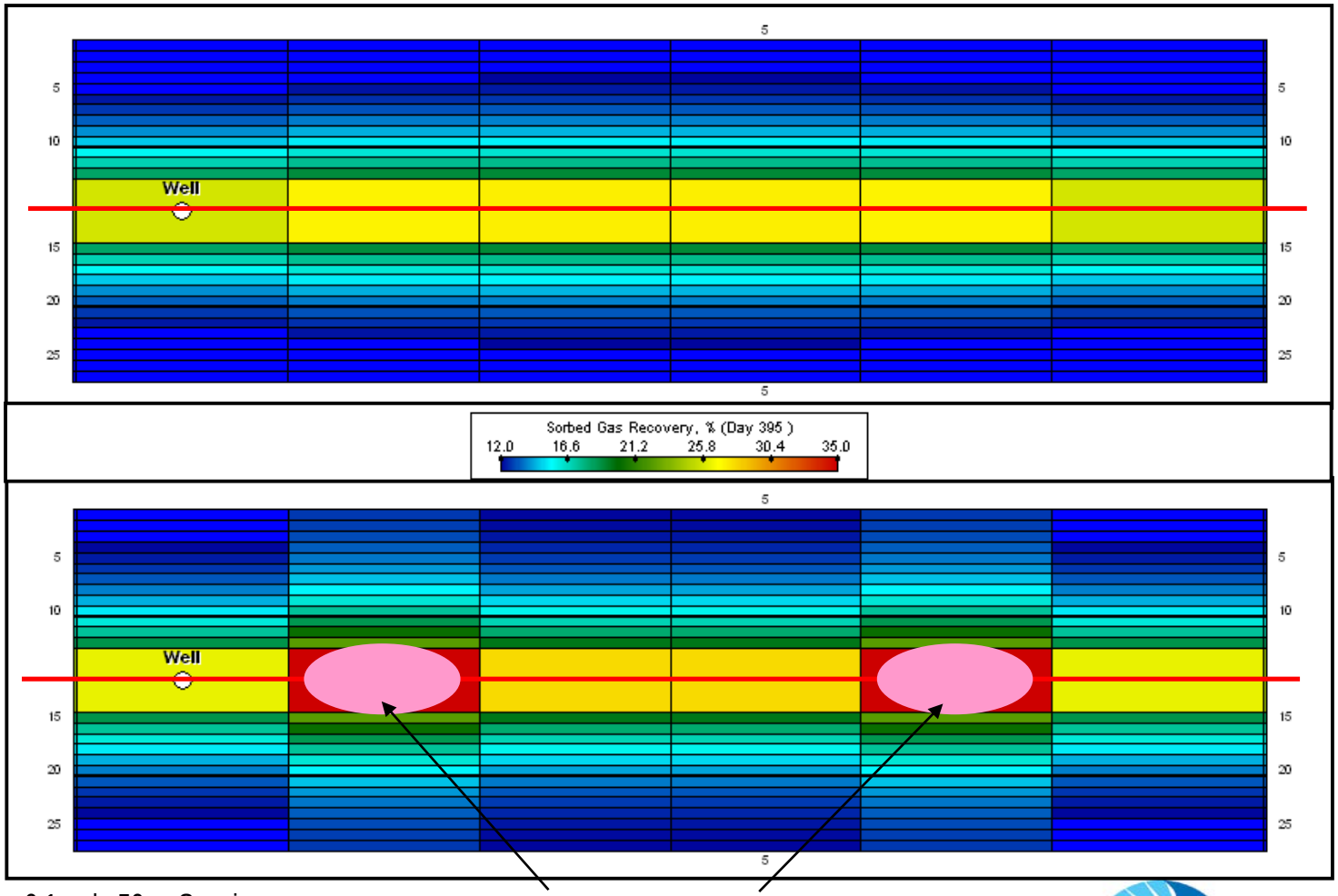
Reservoir Modeling to Assess Benefit of Hydraulic Simulation of In-Seam Boreholes



0.1 md , 50 m Spacing

Fracture Locations

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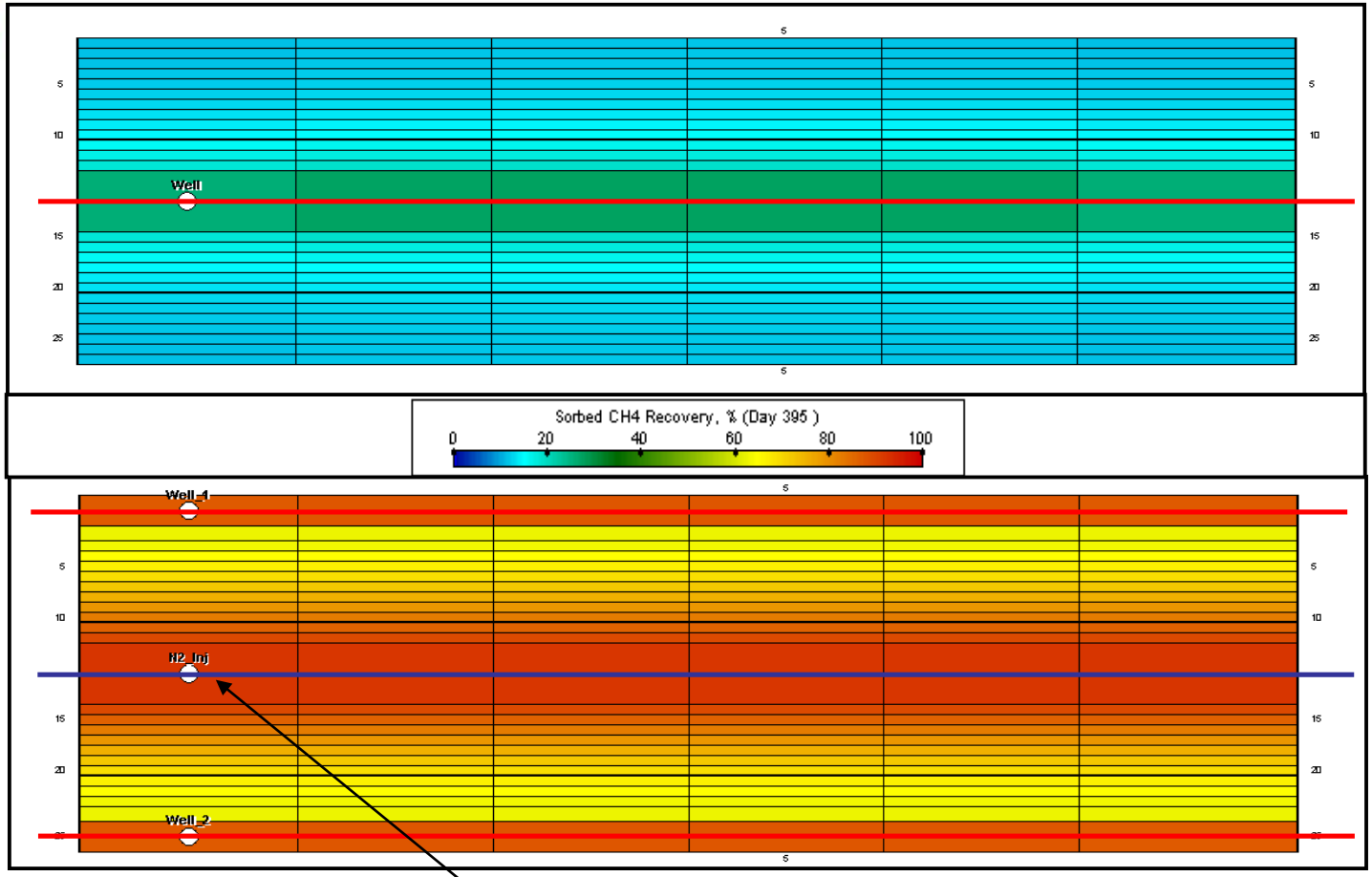
Reservoir Modeling to Assess Benefit of Nitrogen Injection



0.1 md

N2 Injection Borehole
(between 160 ft spaced horizontal boreholes)

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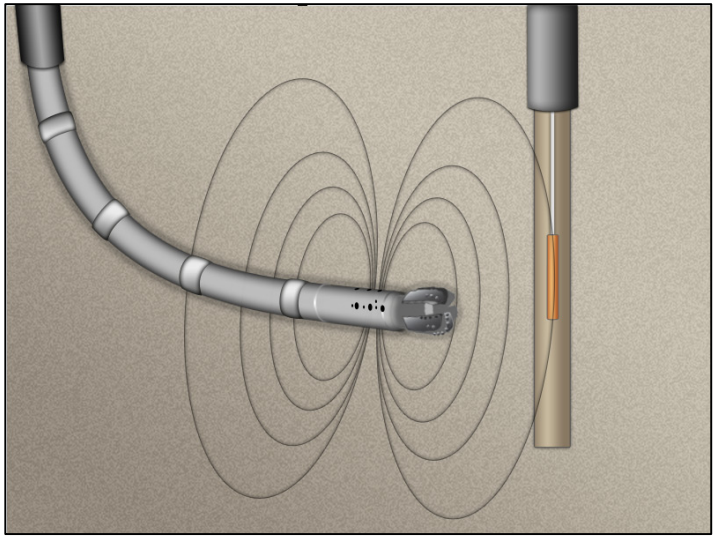
Well Interception Using Magnetic Ranging Technology

Concept

- Magnetic sub installed immediately behind the bit on the downhole motor
- Rotating magnet generates a time varying AC magnetic field
- Proximity sonde (tri-axial accelerometer and multi-frequency magnetometer) is lowered in to a surveyed target well/location. This measures the magnetic field magnitude and orientation.
- The drill bit's position relative to the proximity sonde is triangulated based on the AC magnetic vectors.
- Magnetic ranging software analyzes the data and determines a corrected borehole path for the drill operator to steer to after each data collection phase.
- *Ability to intercept a 5 inch target on any range of borehole lengths*



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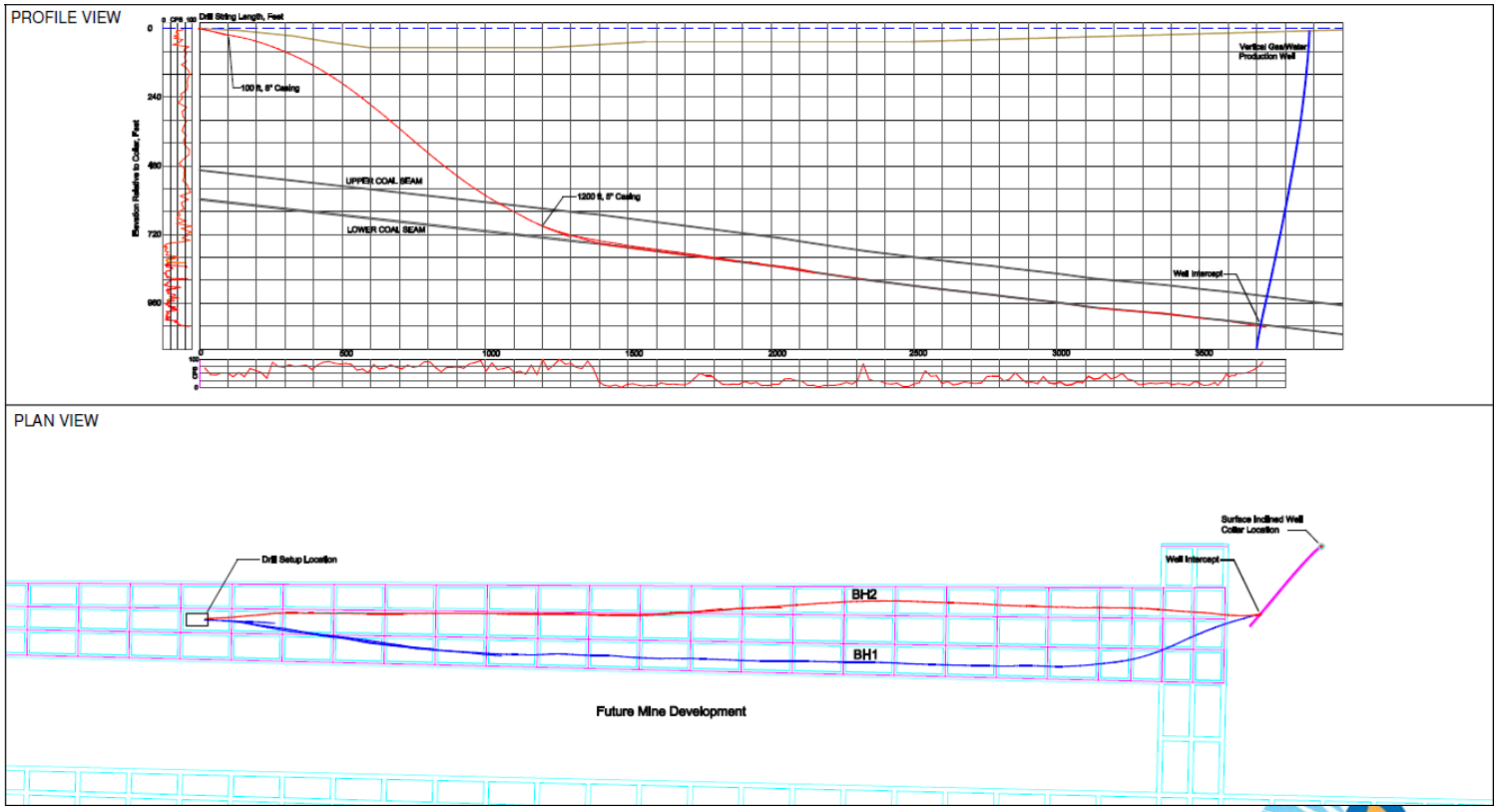
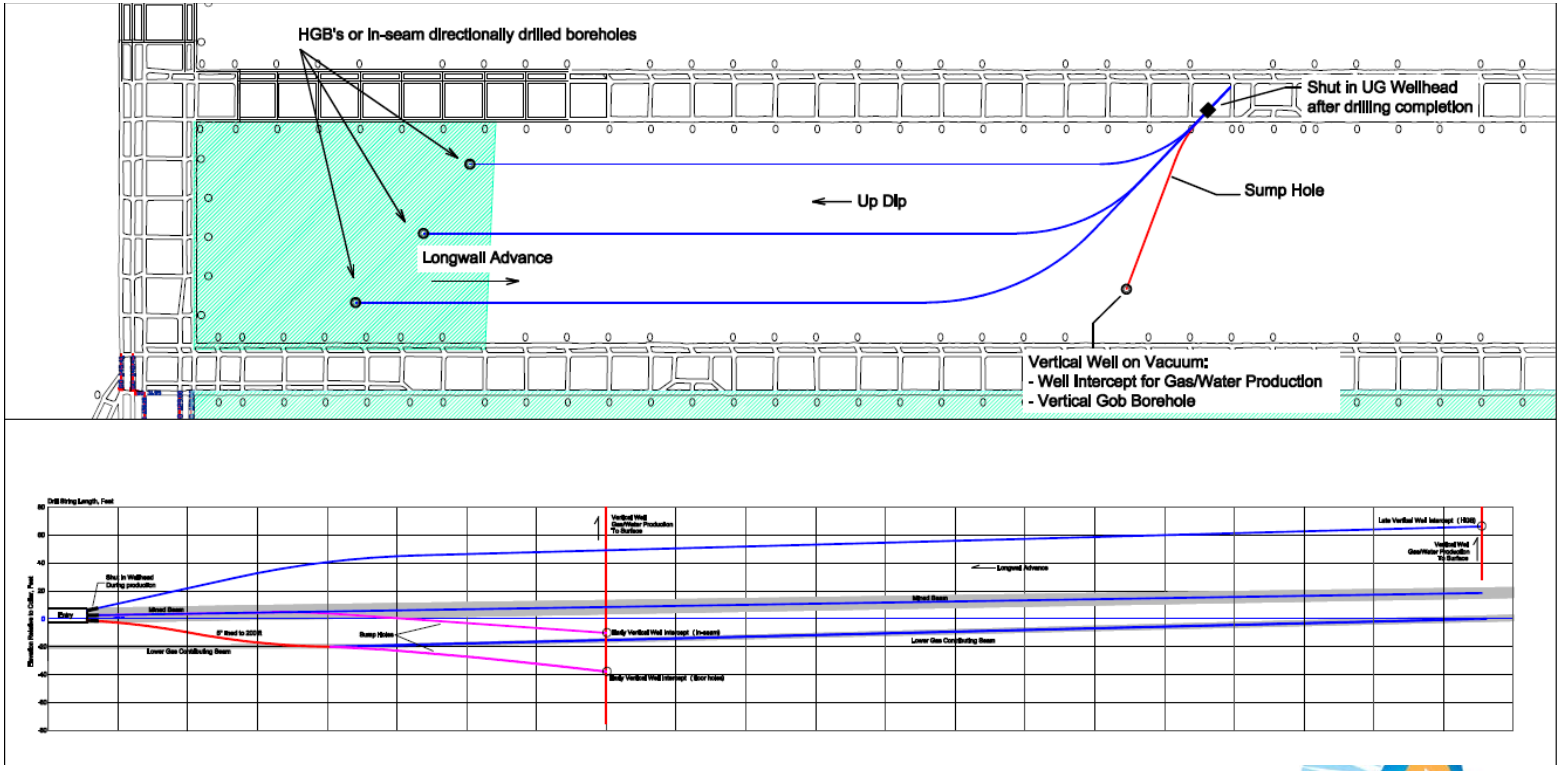
Applications of Magnetic Ranging Technology

- Medium radius surface to in-seam drilling for pre-mining degasification of gate roads
- Provides for significant gas content reduction in advance of mining
- 150 mm diameter vertical well intercepted by 2 x 1130 m laterals



Applications of Magnetic Ranging Technology

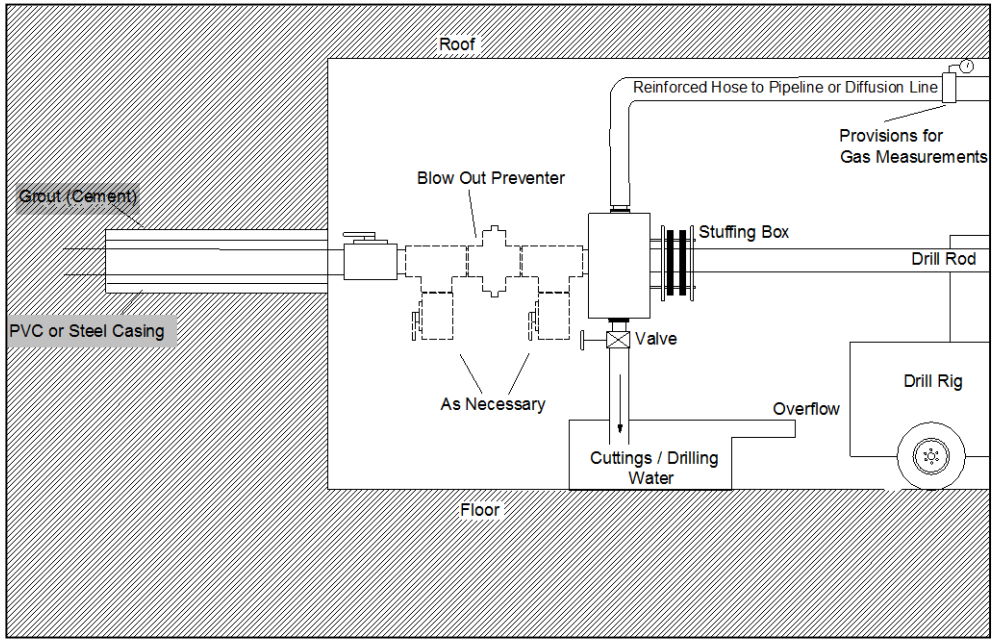
- Underground in-seam boreholes and horizontal gob boreholes drilled in advance of longwall mining intercept vertical wells to eliminate underground gas collection systems.
- Intercepted vertical wells can serve as gob wells post-longwall mining



Wellhead and Gas Handling

Gas/Water Separator During Drilling

Drilling Configuration



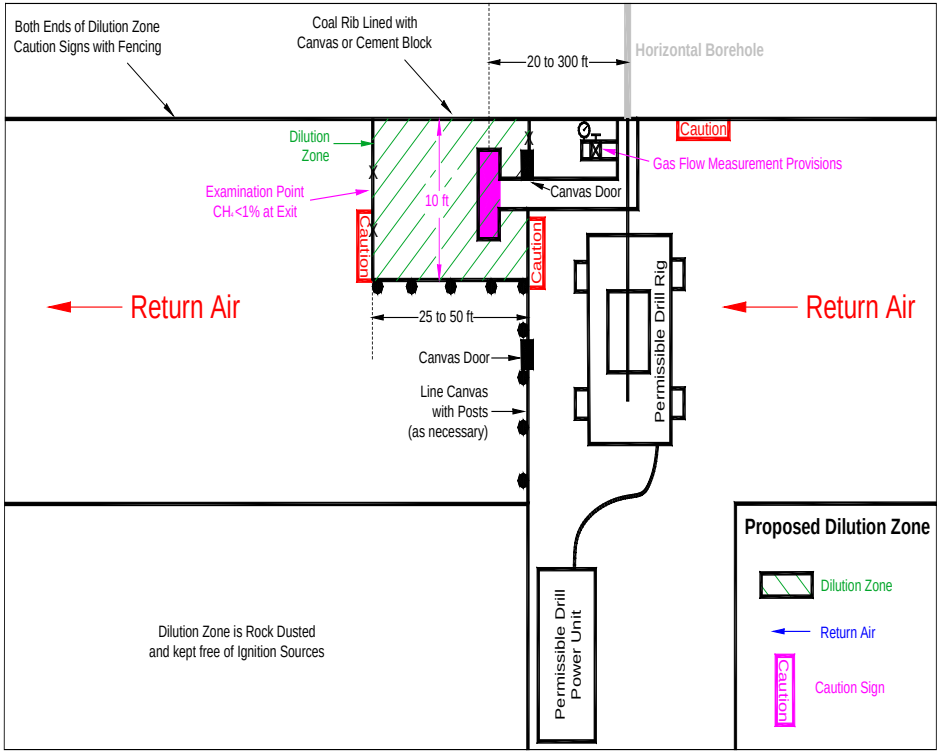
Valve and Blow Out Preventer

Gas Handling and Collection

Post Drilling Gas/ Water Separator

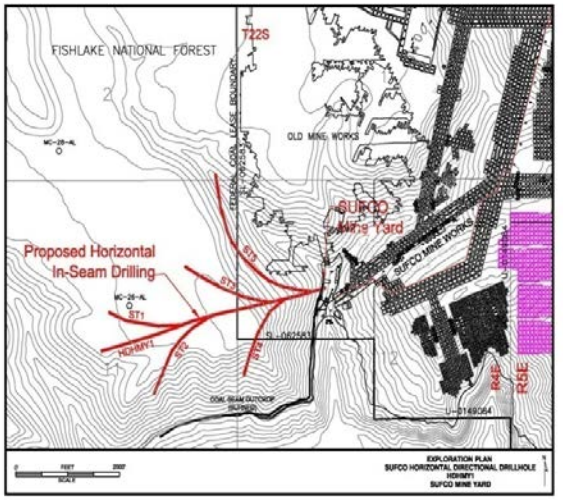
Underground Gas Pipeline with Integrity System

Gas Dilution During Drilling



Summary - Benefits of Directional Drilling

- Allows longer length and more accurate placement of boreholes for improved methane drainage efficiency and longer drainage times.
- Also allows implementation of innovative gob gas drainage techniques.
- Ability to steer borehole to stay in-seam or hit specific targets.
- Provides additional geologic information (such as coal thickness/thinning, identification of faults, intrusions, and other anomalies, etc. prior to mining.
- Mapping and survey information.



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