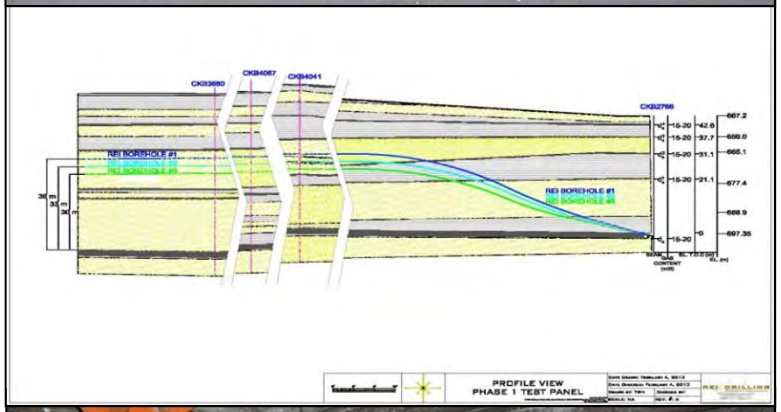
Directional Drilling for Gob Gas Drainage at the Belozerskaya Mine

Practices and Technologies:
Coal Mine Methane Recovery and Utilization In Ukraine

Victoria Hotel

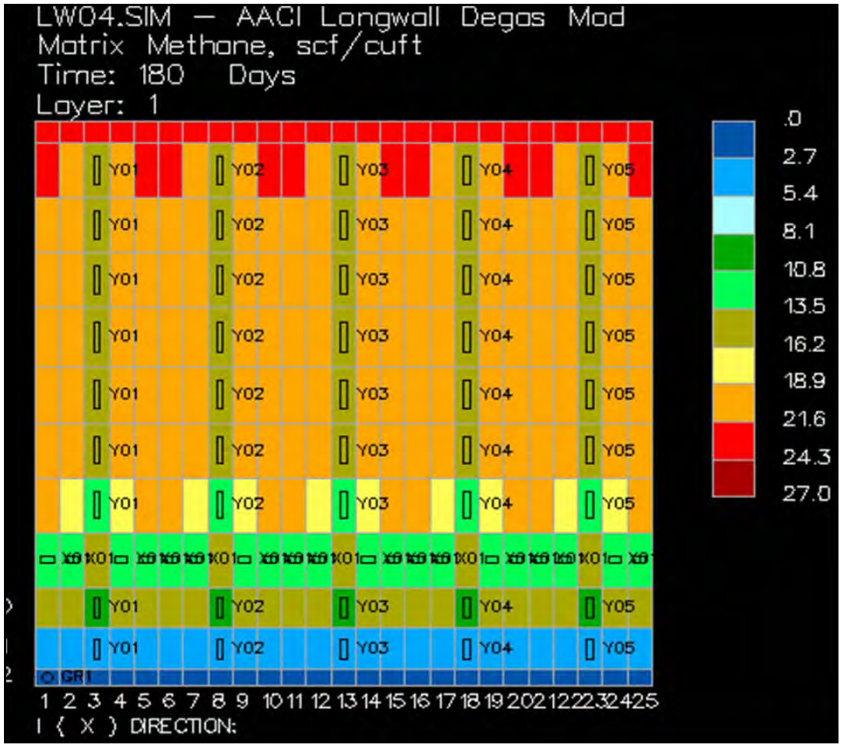
Donetsk, Ukraine

September 21-22, 2011



Methane Drainage Considerations

- **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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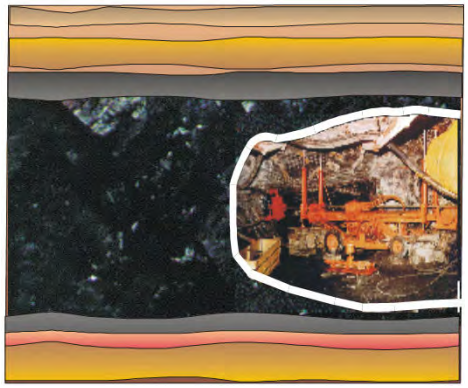
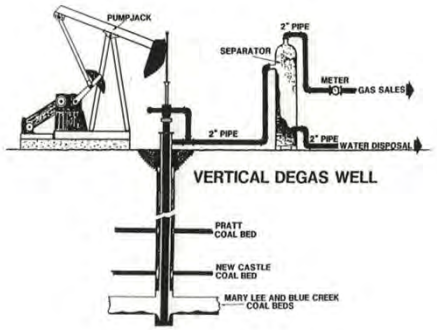
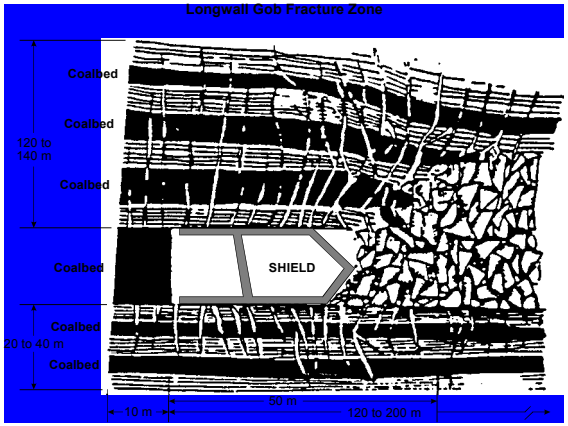
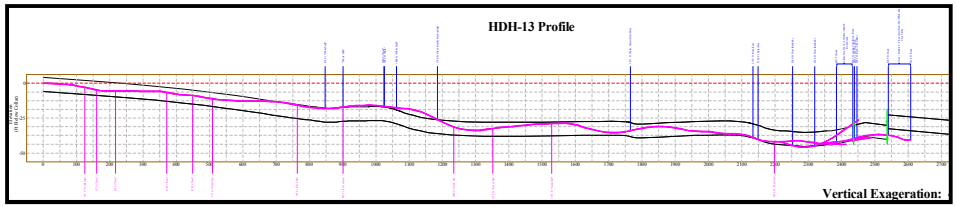
Methane Drainage Techniques

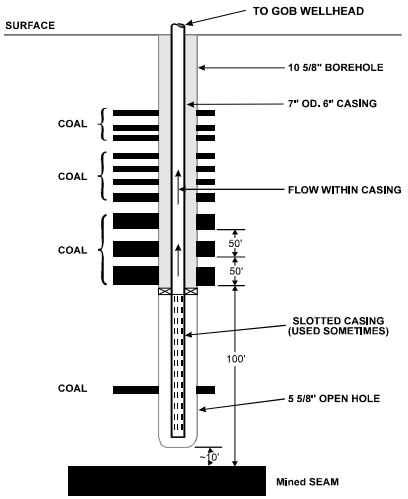
- **Pre-Mining**
- **Gob Degasification**

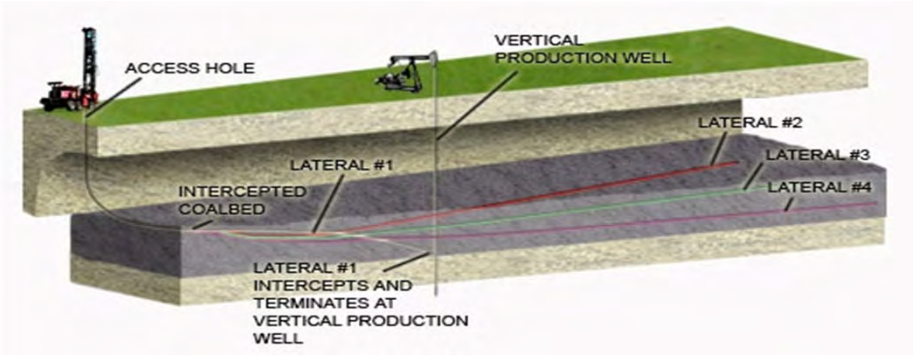












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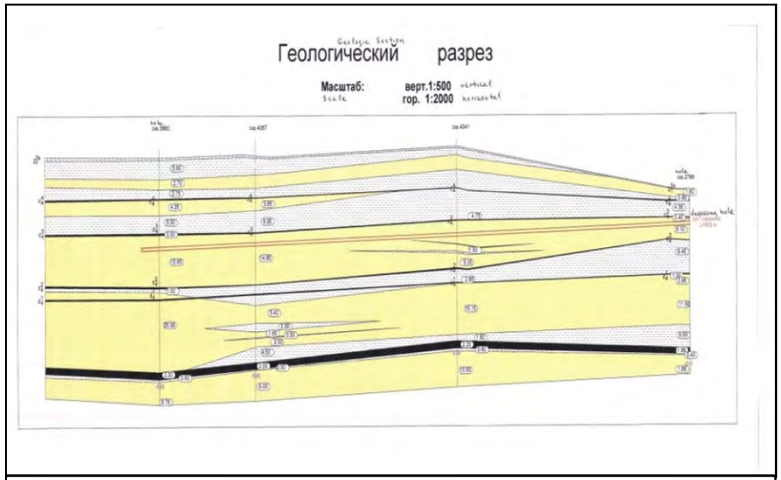
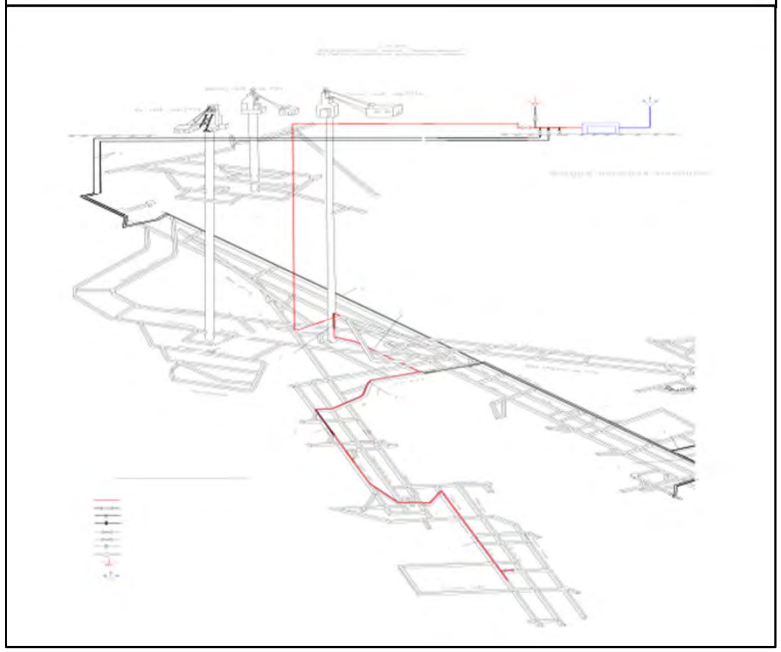
Drainage Considerations in Ukraine

- Many coal reserves develop multiple coal seams and require flexible methane drainage approach.
- Working seam is very low permeability and little success has occurred with in-seam gas drainage techniques.
- Overlying and underlying strata typically contains numerous other coal seams, sandstone and shale measures that release gas following undermining.
- Typically, cross-measure borehole drainage techniques are used to drain gas after strata has been relaxed as a result of mining.
- Use of surface drilled methane drainage wells has been affected due to multiple seam mining, expense, depth, surface ownership, approvals, topography, culture, lack of equipment, etc.
- Gas collection systems typically use steel pipeline and demonstrate significant erosion of gas quality from wellhead to surface.





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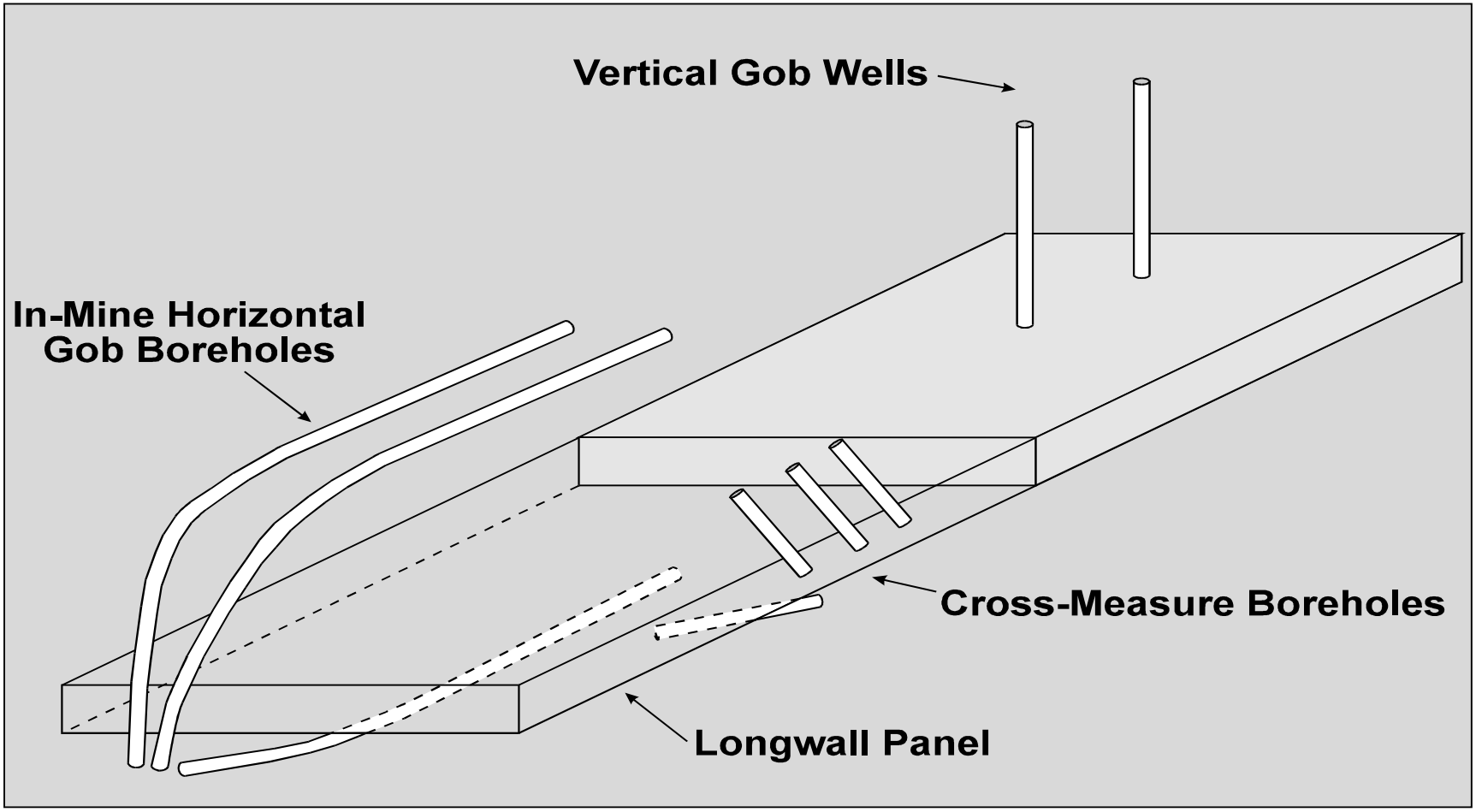
Gob Gas Drainage Techniques



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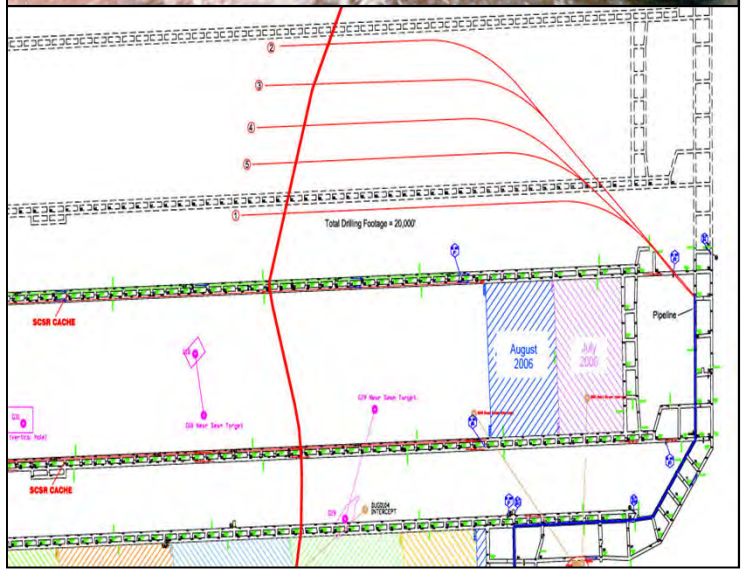
Why Consider Long Hole Directional Drilling?

- Allows longer length and more accurate placement of boreholes for improved methane drainage efficiency and longer drainage times
- Allows implementation of innovative gob gas drainage techniques to develop boreholes remotely and away from working face.
- Ability to steer borehole to stay in-seam or hit specific gas bearing 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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PEER Project Objectives

- Primarily funded by US Department of Labor. This project initiated in 2005.
- Demonstrate the application of long hole directional drilling technology
- Evaluate the application of long in-mine horizontal gob boreholes
- Demonstrate a cost effective gob degasification alternative
- Provide training and improve mine safety

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Ukraine Directional Drilling Program Overview

- **Project Management**
  - PEER
- **Project Design and Training**
  - REI
- **Objective**
  - Design, implement, and evaluation of the use of long, directionally drilled boreholes in a coal mine in the Donbass region.
- **Approach**
  - REI provided equipment design, selection, and procurement. Project provides training of directional drilling techniques to Ukrainian counterparts and implementation at a local Mine.
- **Candidate Mines**
  - Initially Krasnolimanskaya, demonstrated at Belozyorskaya Mine. Current discussions with other Ukraine mine operators.

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Long Hole Drill (LHD)
Design Considerations

- Compact, skid mounted, high thrust LHD equipped with hydraulic controls typically used in directional drilling.

- Will be constructed in components. Each piece will be taken down shaft and assembled underground.

- Dimensions – L x W x H less than
  3.8 x 1.3 x 1.3 meters
- Weight – less than 6.8 tonnes

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Long Hole Drill (LHD)
Design Considerations

- Electrical System – 660 volts, 50 Hz
- Permissibility – will meet US Mine Safety and Health Administration permissibility standards.
- Thrust – 40,000 lbs.
- Orientation – Boom capable of ± 15 degrees
- Water pump, wire line hoist, methane detection.
- Training, spare parts

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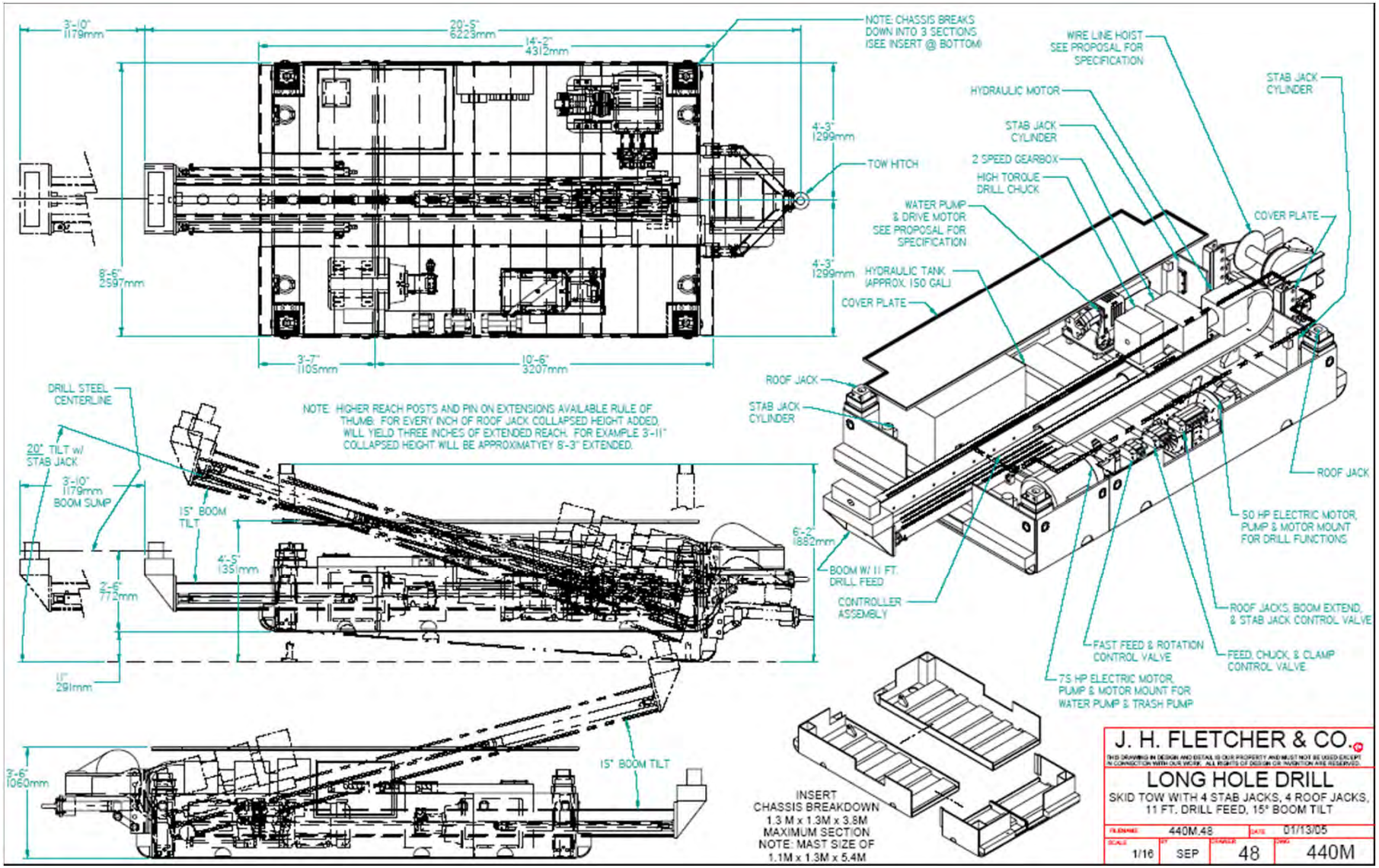
Ukraine Long Hole Drill



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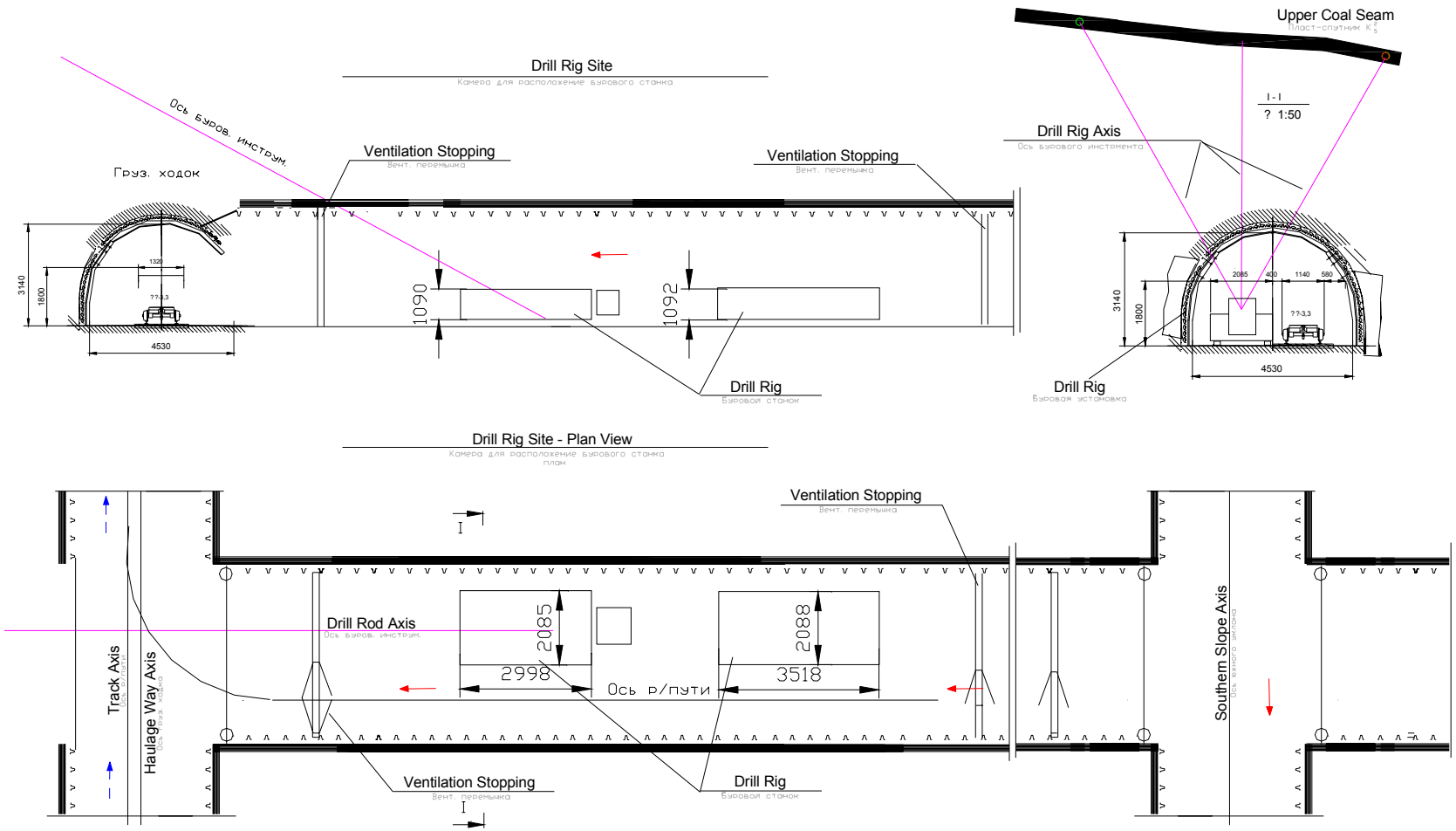
Design of Drilling Room



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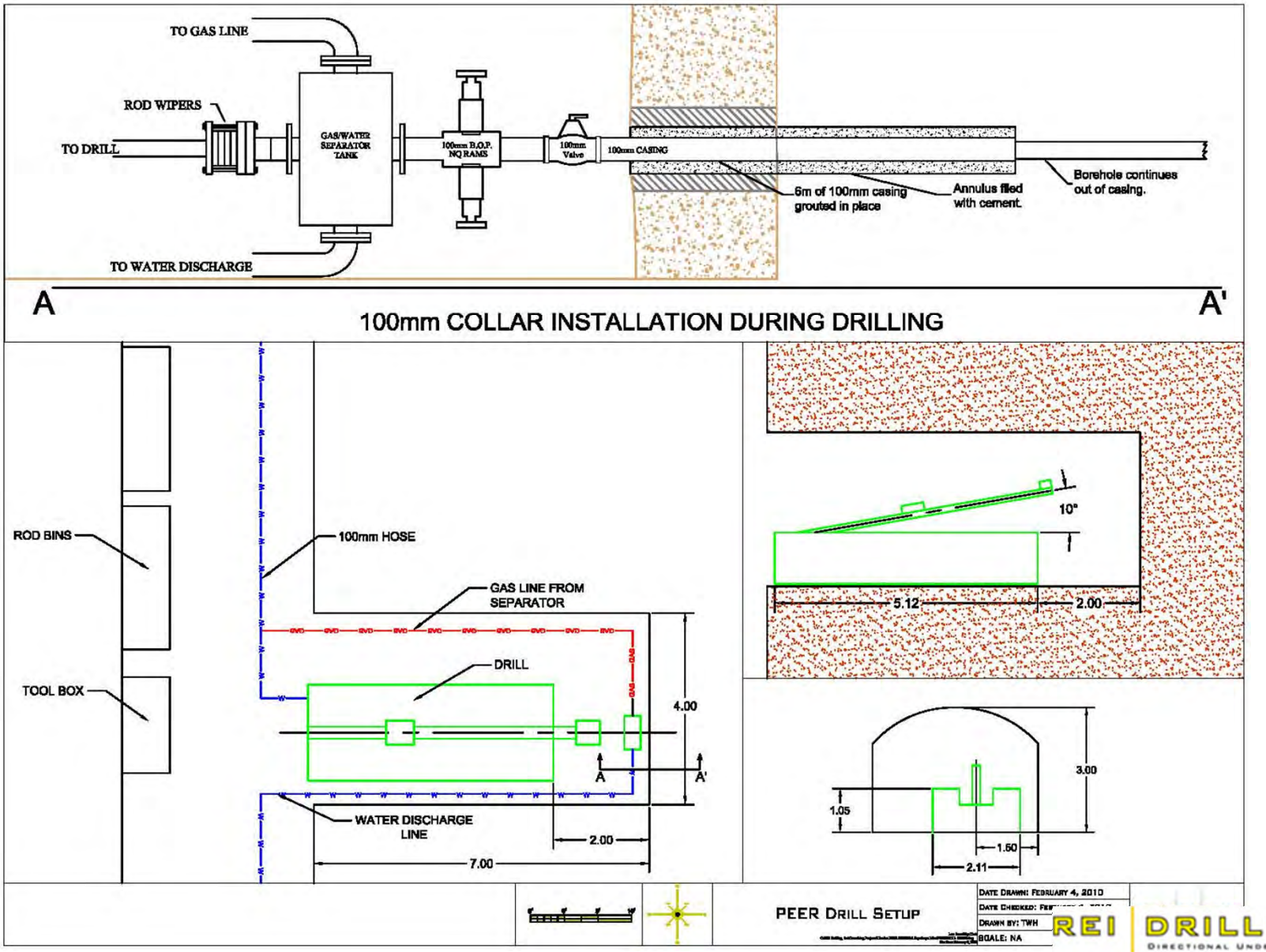
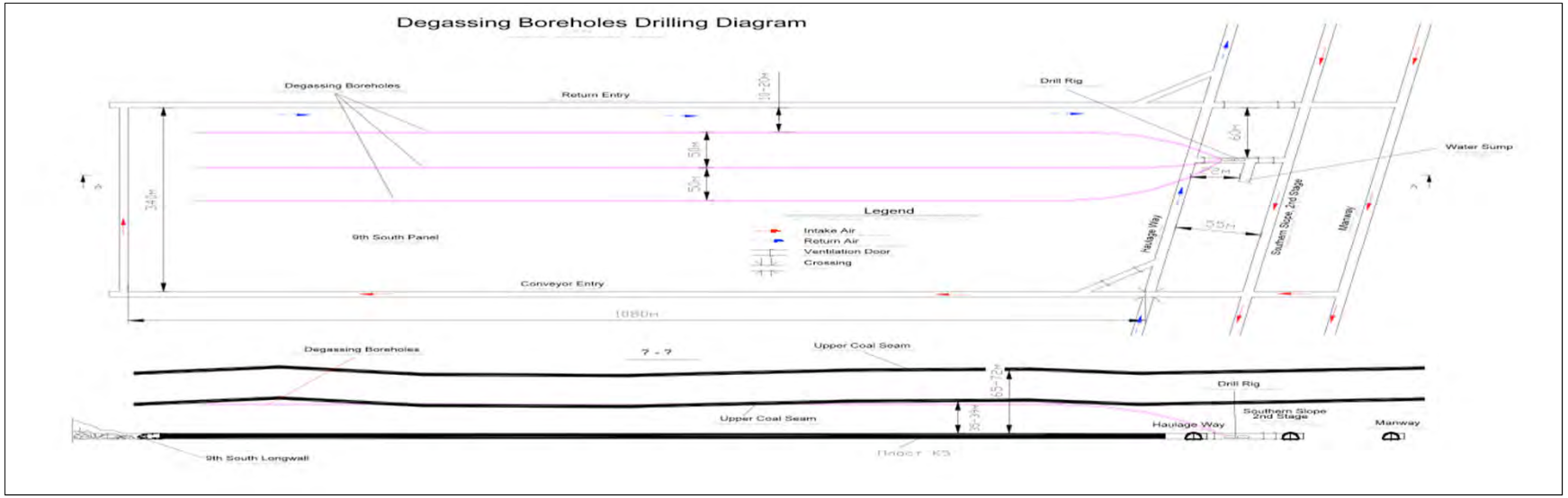


Horizontal Gob Borehole Design Considerations

- Place boreholes near edges of the longwall panel where strata will be in tension
- Place boreholes along ventilation return (tailgate)
- Place boreholes along high elevation side of the gob
- Place above rubble zone (> 5 times mining height) to remain intact during undermining
- Typical placement 20 to 30 m above top of coal



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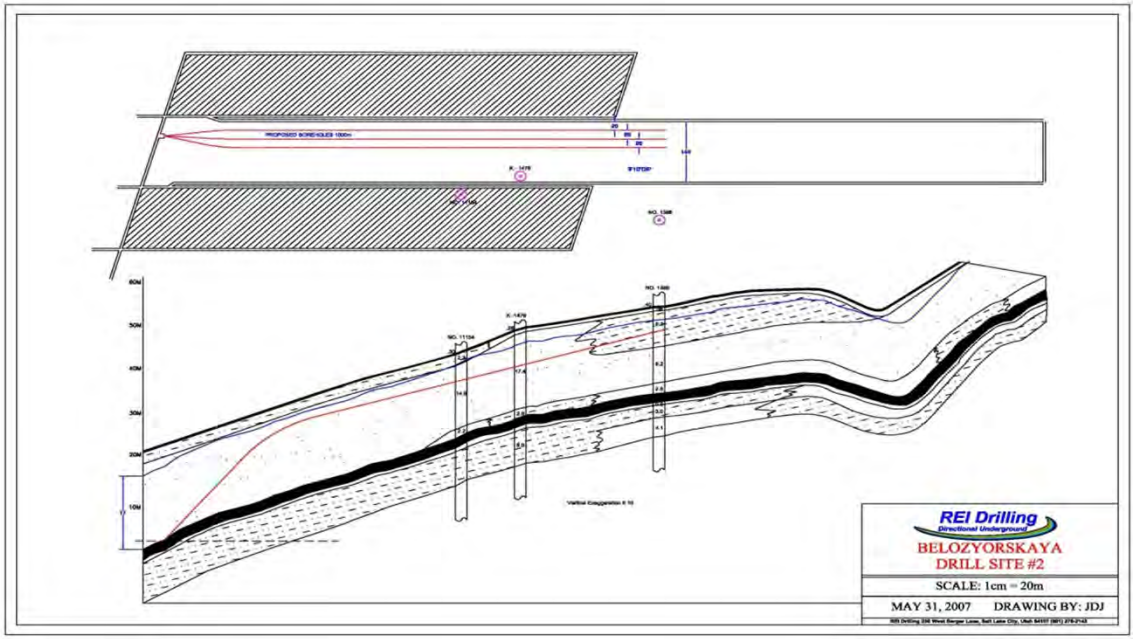
Belozyorskaya – Design and Approach

- Three boreholes were drilled along the up-dip side of the panel near the tailgate entry
- Borehole 1 was drilled approximately 20 m from the tailgate entry
- Boreholes 2 and 3 were maintained generally 40 m and 60 m from the tailgate entry, respectively
- Boreholes 2 and 3 were connected to the same collar
- A fault limited the lengths of the boreholes
- Boreholes maintained 14 to 16 m above the top of the coal
- Boreholes could not be drilled in higher elevation formation due to borehole stability problems



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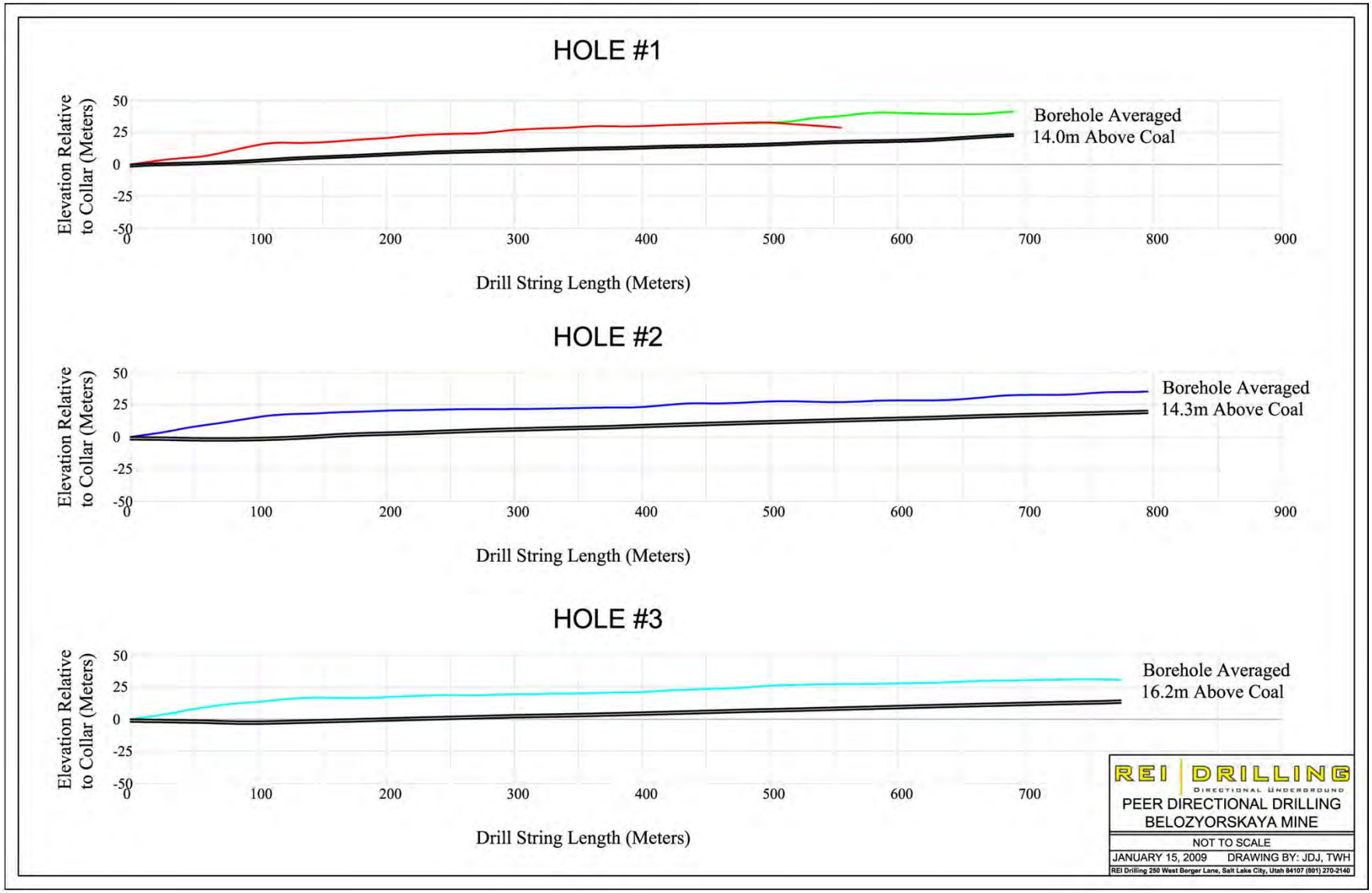
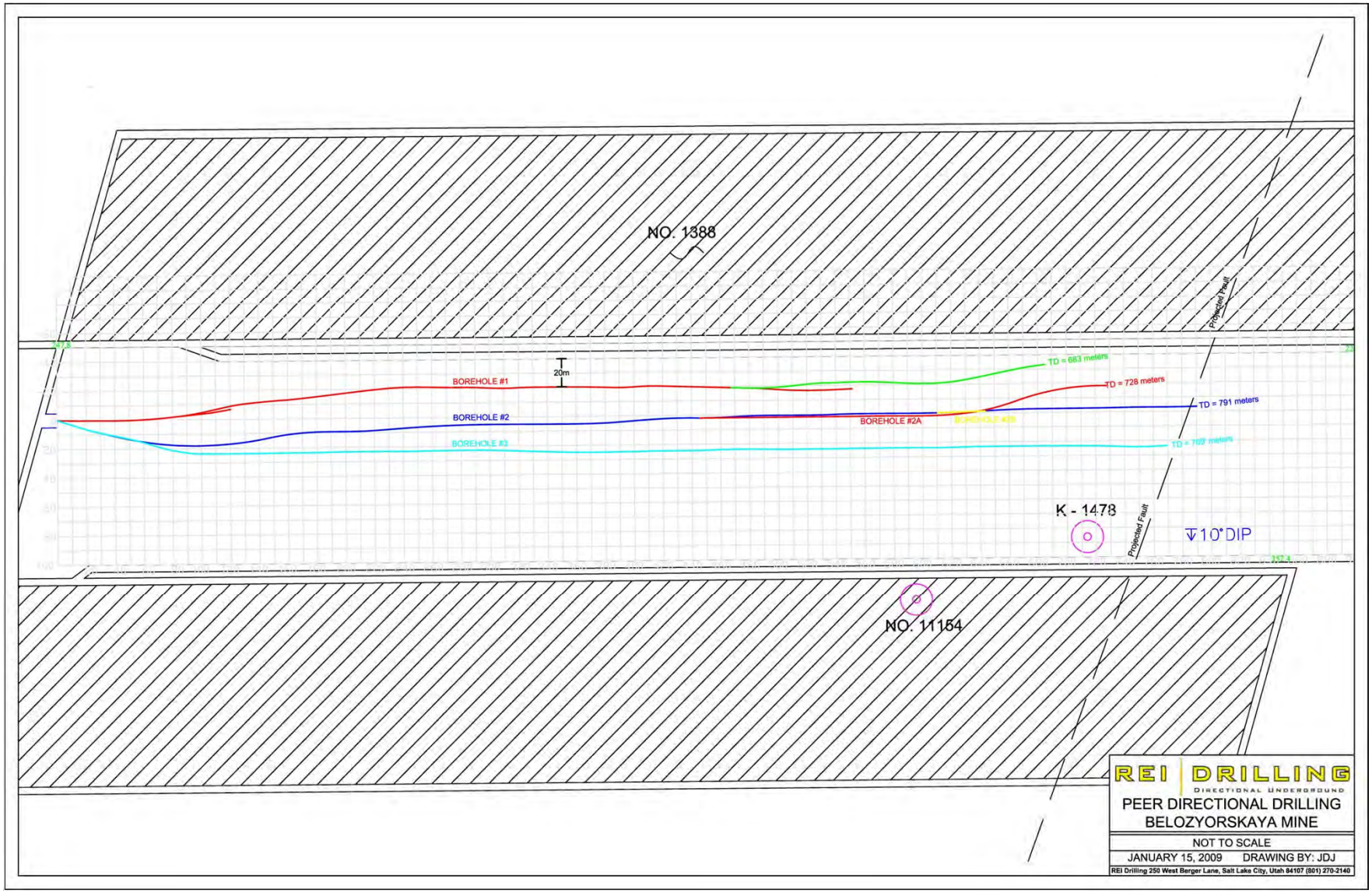
Belozyorskaya Mine – Profile View



Belozyorskaya Mine – Plan View



Long Hole Directional Drilling
Belozyorskaya Mine - Ukraine

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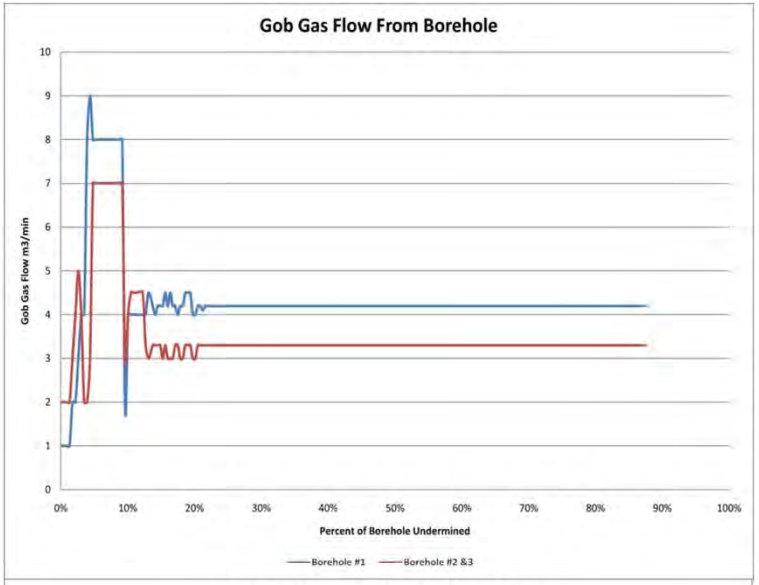
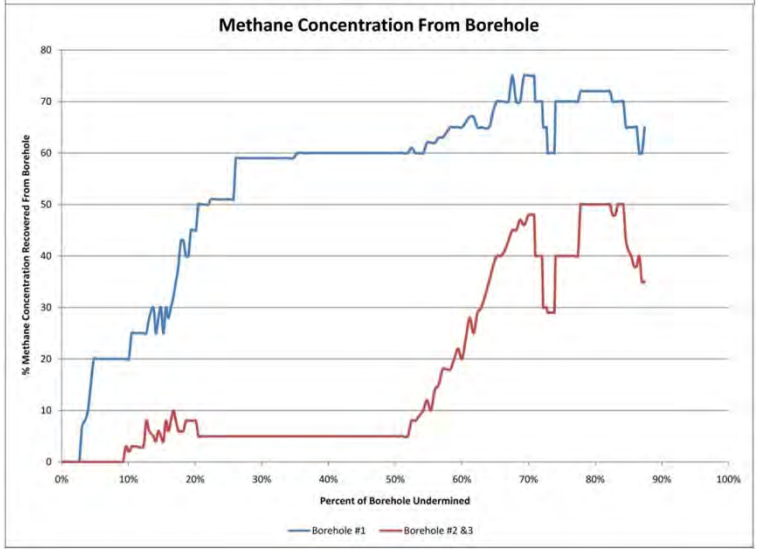
Belozyorskaya Mine

Gob Borehole Performance

- Following undermining the boreholes produced significant volumes of gob gas
- Placement of the first half of Boreholes 2 and 3 was apparently too low above the top of the coal and produced mostly ventilation air
- The outby half of boreholes 2 and 3 was higher above the top the coal and resulted in the production of higher quality gob gas
- Borehole 1 produced higher quantity and quality gob gas than Boreholes 2 and 3 combined.
- The gas flow rates for Boreholes 2 and 3 combined should have been higher than that of the Borehole 1. This may have resulted from:
    1) Borehole collapse when undermined (drawing in ventilation air from the longwall face and not the gob gas reservoir).
    2) One or both of the boreholes may have collapsed after drilling or blocked by cuttings





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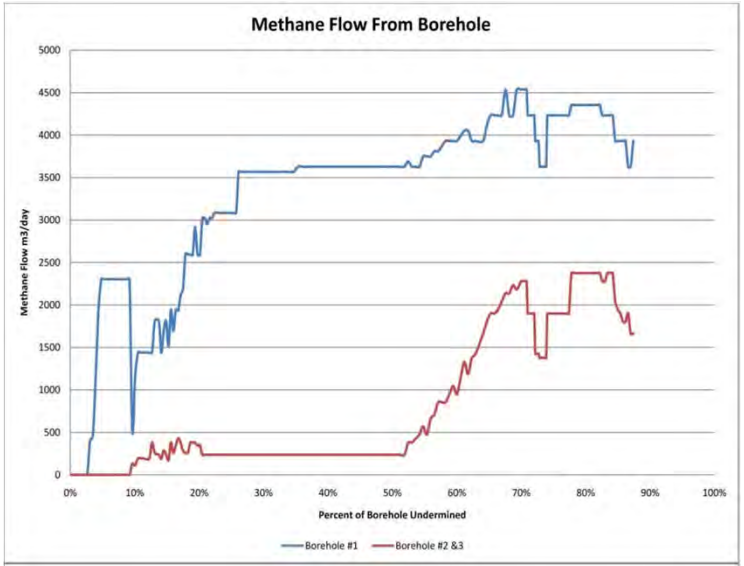
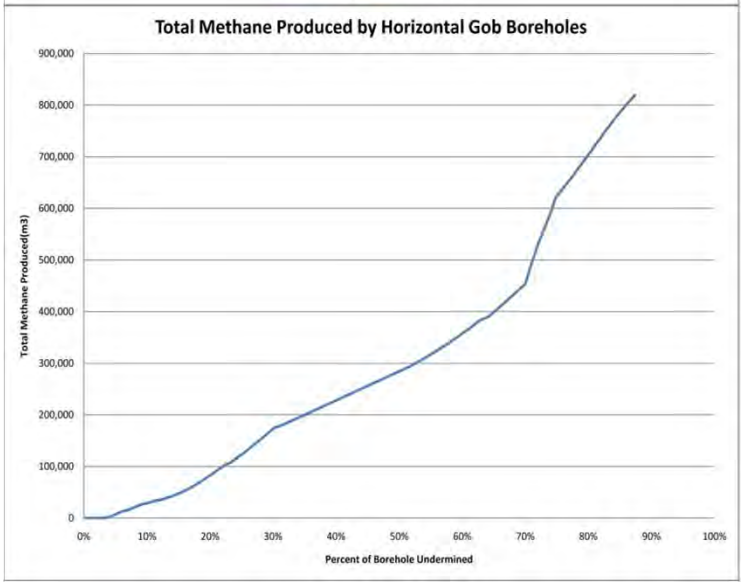
Belozyorskaya Mine

Gob Borehole Performance

- Borehole 1 produced between 3,500 and 4,500 m^3/day of methane on a consistent basis
- The horizontal gob boreholes produced 800,000 m^3 of methane
- The performance of the horizontal gob boreholes at Belozyorskaya compare with the performance of horizontal gob boreholes applied at other underground mines
  - Gob gas flow rates and methane concentration ranges compare with applications operating at similar vacuum pressures
  - Similar performing projects compared horizontal gob boreholes with cross-measure boreholes. These projects demonstrated that:
    - horizontal gob boreholes are 1.5 to 2 times more efficient than a system of cross-measure boreholes
    - horizontal gob boreholes are cost effective compared to cross-measure boreholes





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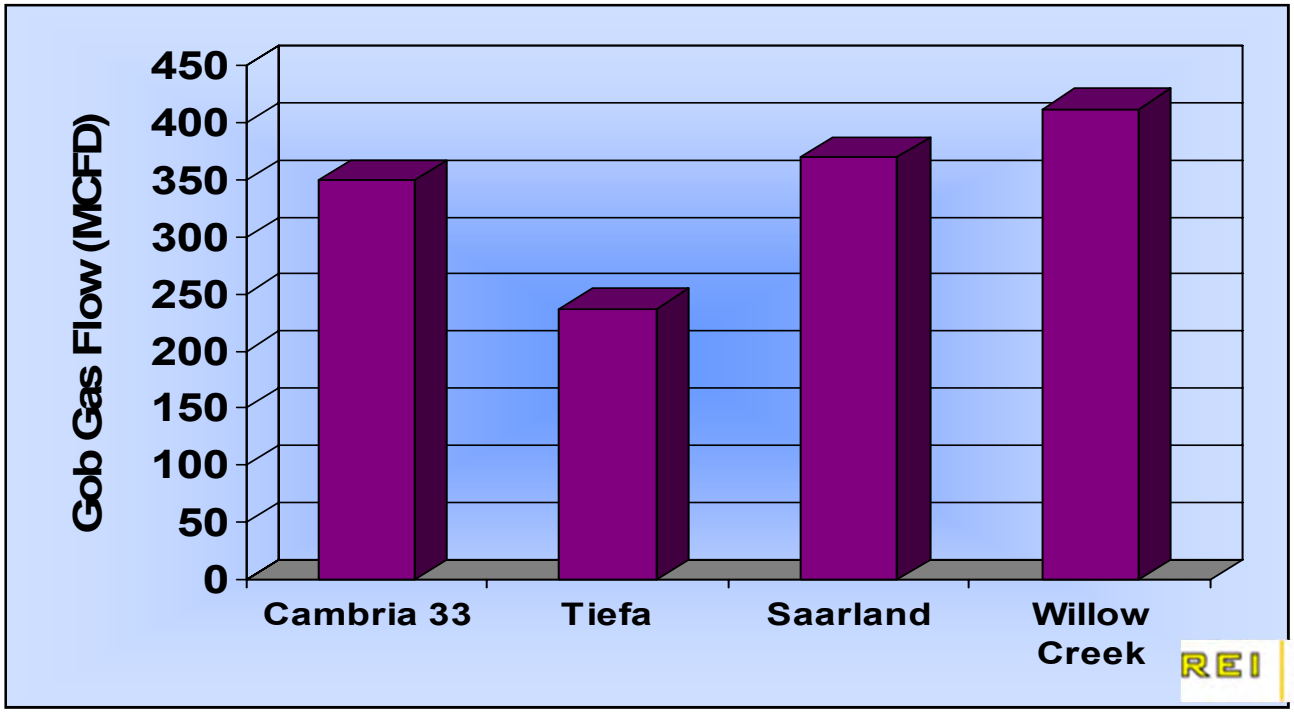
Gob Borehole Performance

at other Projects

Project Location	Country	Diameter of Boreholes (mm)	Length of Boreholes (m)	Elevation above Seam (m)	Wellhead Vacuum (mm Hg)	Gob Gas Flow (m^3/day)	Gas Quality (% CH_4)	Comments
Taiheiyo Mine	Japan	125 - 75	700					Methane drainage efficiency twice that of cross-measures system of gob degasification
Cambria 33 Mine	Pennsylvania, USA	88	400 - 700	20 - 30	150	10,000	40 - 90	5 times more effective than cross-measure holes applied to same panel
Daxing Mine	Tiefa Mining, China	90	150 - 300	35 - 45	100	8,300	35 - 90	Methane drainage efficeincy 1.5 to 2 times relative to cross-measure system of gob degasification
Warndt/Luisenthal Mine	Germany	170	500	20 - 30	N/A	13,000	70 - 80	One horizontal gob borehole as effective as 30 cross-measure boreholes
Willow Creek Mine	Utah, USA	100	600 - 800	18 - 46	180	18,000	50 - 60	High CO_2 concentrations in gob gas, gas quality dependent on face activity
Belozyorskaya	Donetsk, Ukraine	96	700 - 800	14 - 16	100	5,000 - 6,000	30 - 75	Results comprable to other applications



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Lessons Learned

Horizontal Gob Borehole Recommendations

- Optimize performance of long in-mine horizontal gob boreholes at another project site and demonstrate improvements.
- Drilling each horizontal gob borehole with its own dedicated collar/wellhead to enable individual borehole monitoring and vacuum control
- Increasing the elevation above the top of the coal seam and drill each borehole at a different elevation to optimize vertical placement
- Reducing borehole spacing and place all horizontal gob boreholes in the third part of the panel nearest the tailgate entry
- Increasing wellhead vacuum and install provisions to control vacuum for each horizontal gob borehole and provide monitoring of flow and quality
- Reaming the horizontal gob boreholes to a larger diameter as far as possible and installing perforated steel liner to ensure borehole stability irrespective of vertical placement

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Lessons Learned

Horizontal Gob Borehole Conclusions

- **The Belozyorskaya Project Demonstrated:**
  - Project results are favorable and results compare with similar projects
  - In-mine horizontal gob boreholes are an effective means of gob degasification
  - In-mine horizontal gob boreholes can be directionally drilled in Donetsk Basin mines
  - Directional drilling can be an effective methane drainage tool
  - Directional drilling can improve mine safety
  - Directional drilling technology can be applied by Ukrainian crews
- **Another Project Site is Necessary to:**
  - Train additional Ukrainian drilling crews to directionally drill
  - Further demonstrate the benefits of directional drilling to Donetsk mines
  - Expand the use of directional drilling in the Ukraine to increase mine safety

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Спасибо

Global Methane Initiative

U.S. EPA Coalbed Methane Outreach Program