Drilling and Design Considerations for Methane Drainage

Mongolia Coal Mine Methane Project Development Workshop

Ulaanbaatar Hotel
Ulaanbaatar, Mongolia

August 30-31, 2010

U.S. EPA Coalbed Methane Outreach Program

Methane to Markets

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Presentation Outline

Introduction

Observations

Methane Drainage Design

Fundamentals of Directional Drilling

- Equipment
- Techniques

Gas Collection

Methane Drainage Techniques

Summary

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REI DRILLING, INC.

- Operate 8 long hole directional drills and 2 core drills on a contract basis across North America
- Became affiliated with Valley Longwall International in 2008
- Jointly operate >25 long hole drills worldwide on a contract basis
- Turnkey package of directional drilling units for sale and training for coal mining
- Methane drainage consulting and directional drilling training
- Design and implement methane recovery and sale projects
- Managed and participated in numerous international directional drilling projects
- Expanded uses for directional drilling, e.g. exploration and dewatering
- >25 years experience

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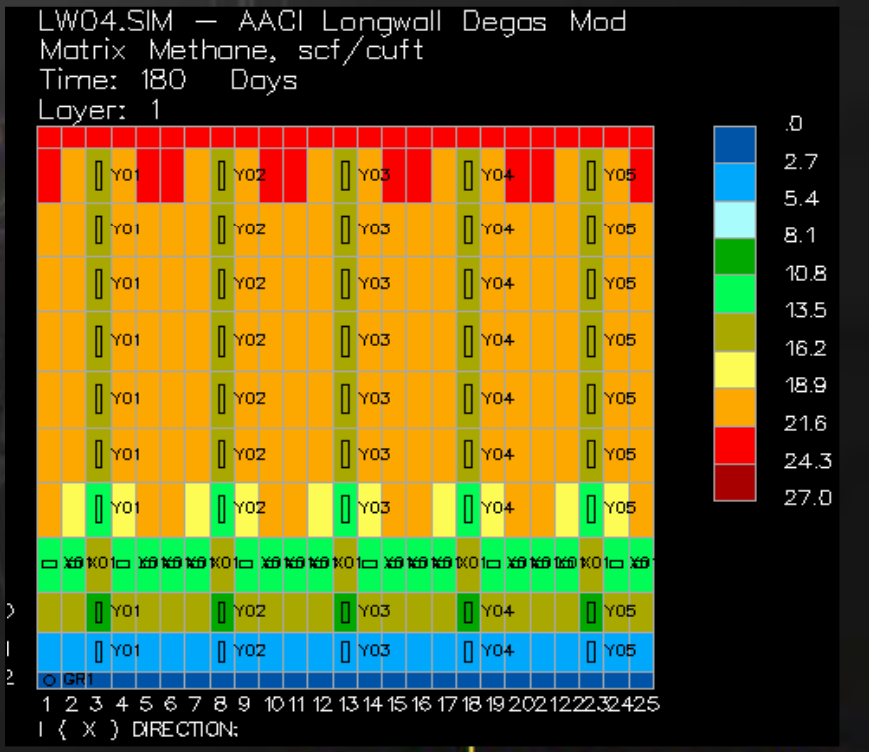
International CMM Industry

- Coal is the most abundant fossil fuel. IEO 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.

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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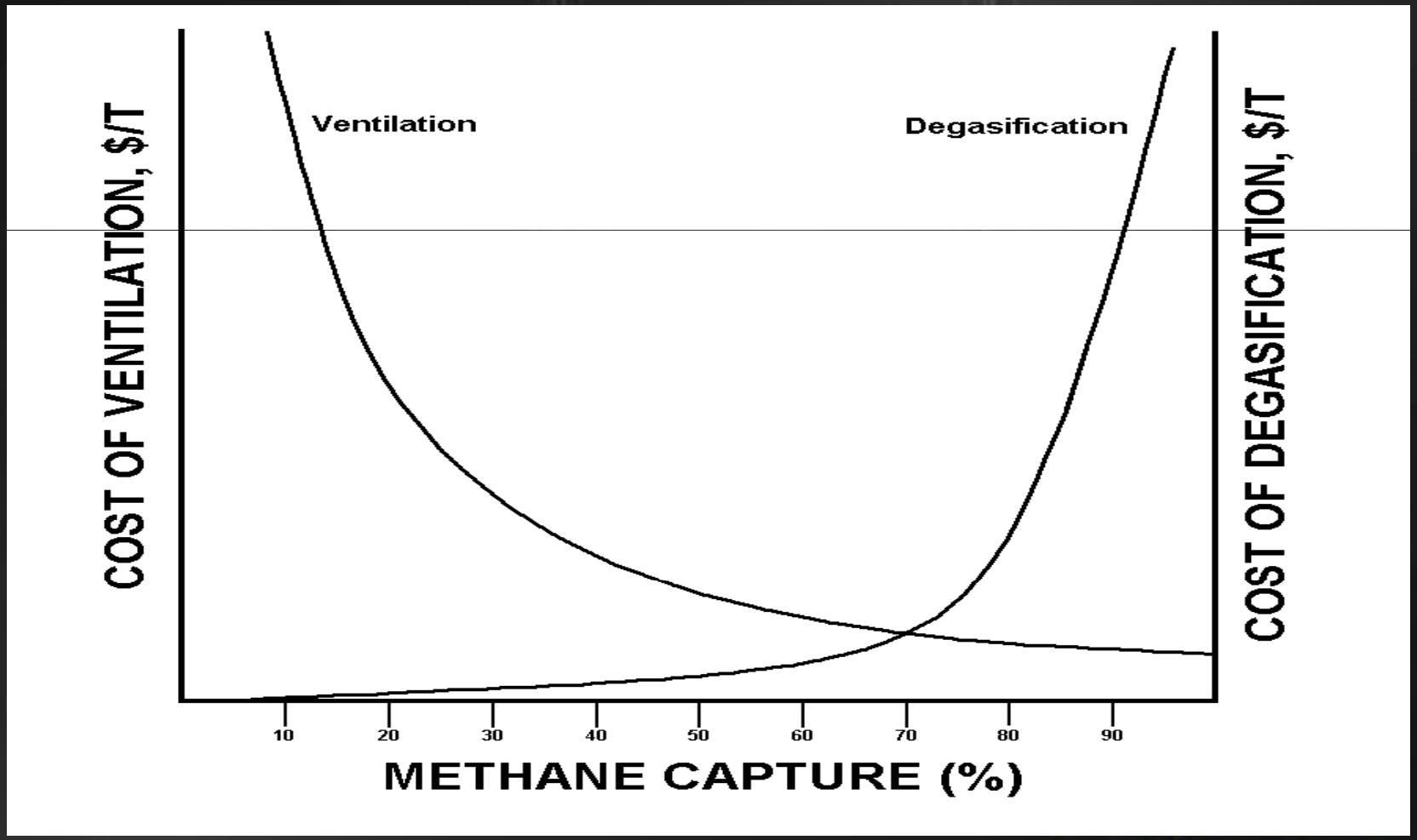
OPTIMIZE VENTILATION AND METHANE DRAINAGE



Geologic and Reservoir Characteristics

- Gas content of the coal seam and shale is commonly determined through the “direct method.”
- Core or cuttings are placed in canisters.
- Simulate reservoir conditions.
- Monitor gas production from core/cuttings.

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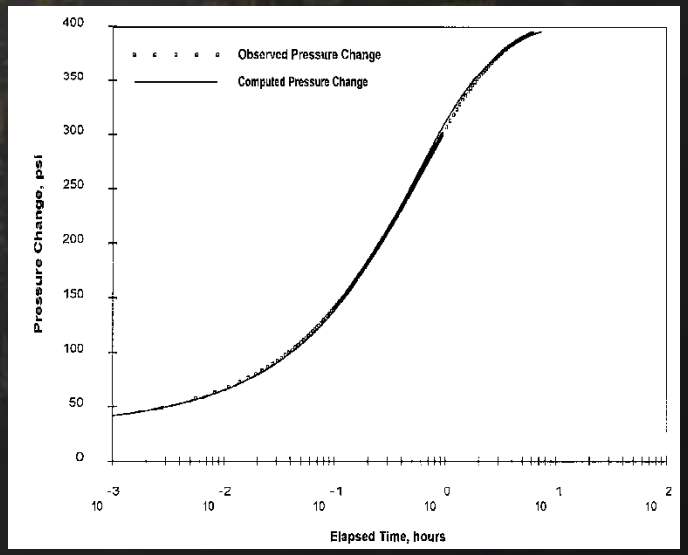
Geologic and Reservoir Characteristics

- Matrix permeability is the characteristic that affects the ability of gas (water) to flow through a material.
- Gas flow is also affected by cleat (face and butt) presence, spacing, and jointing.



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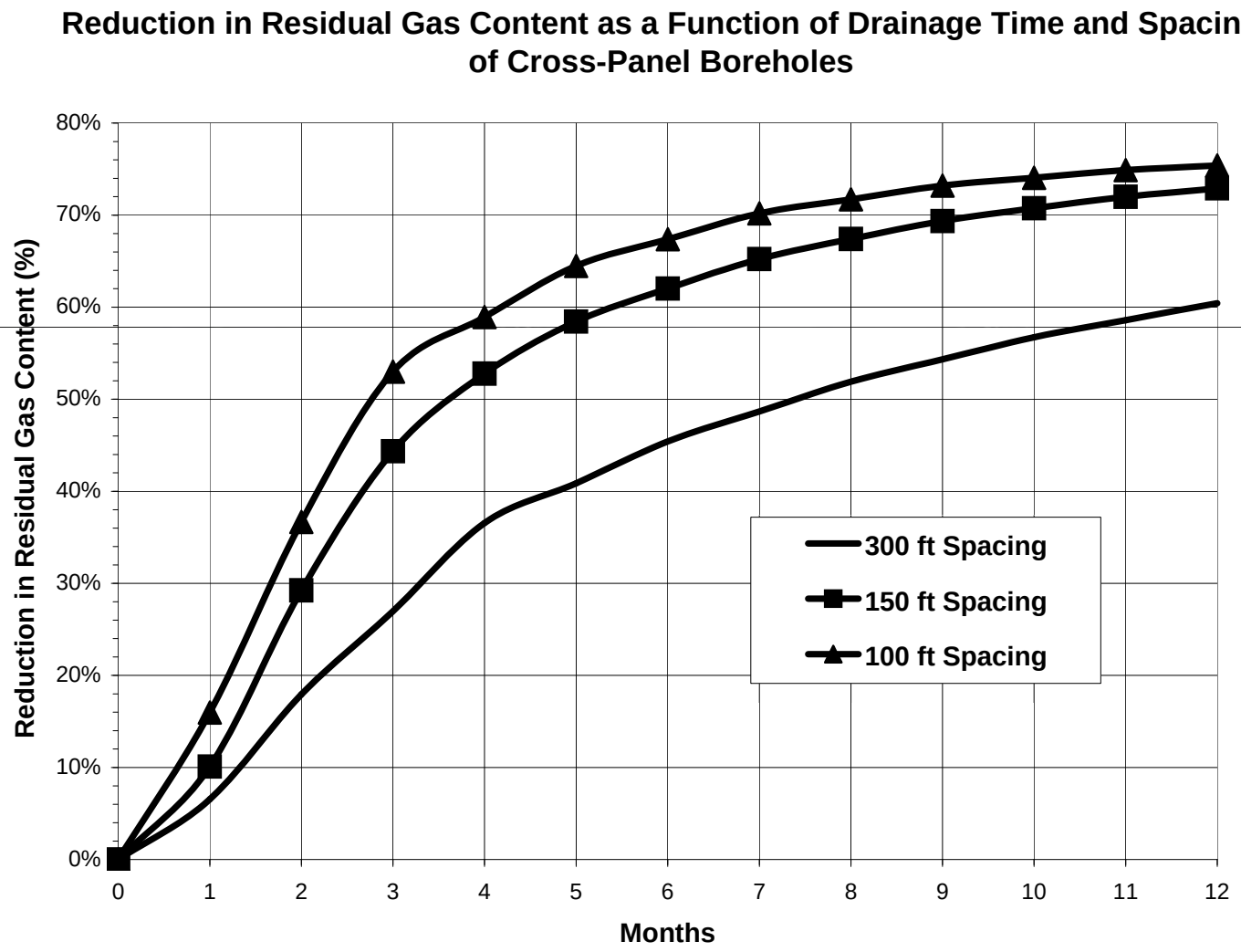
Borehole Planning and Design



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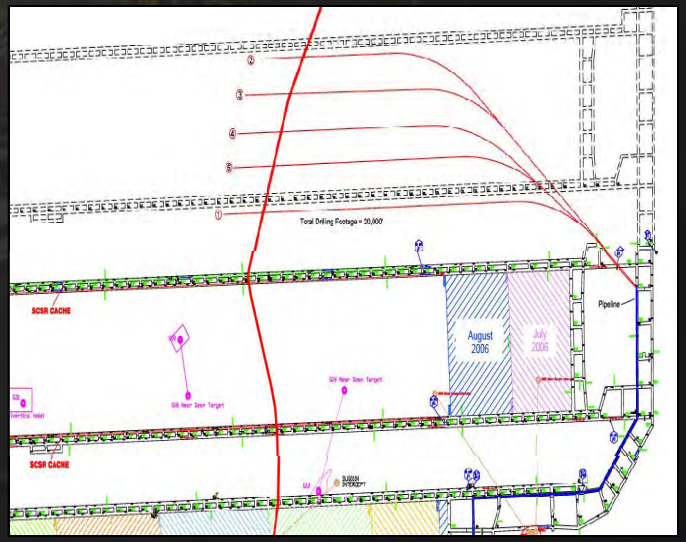
Why Consider Long Hole Directional Drilling?

- 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
- 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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Long Hole Directional Drills

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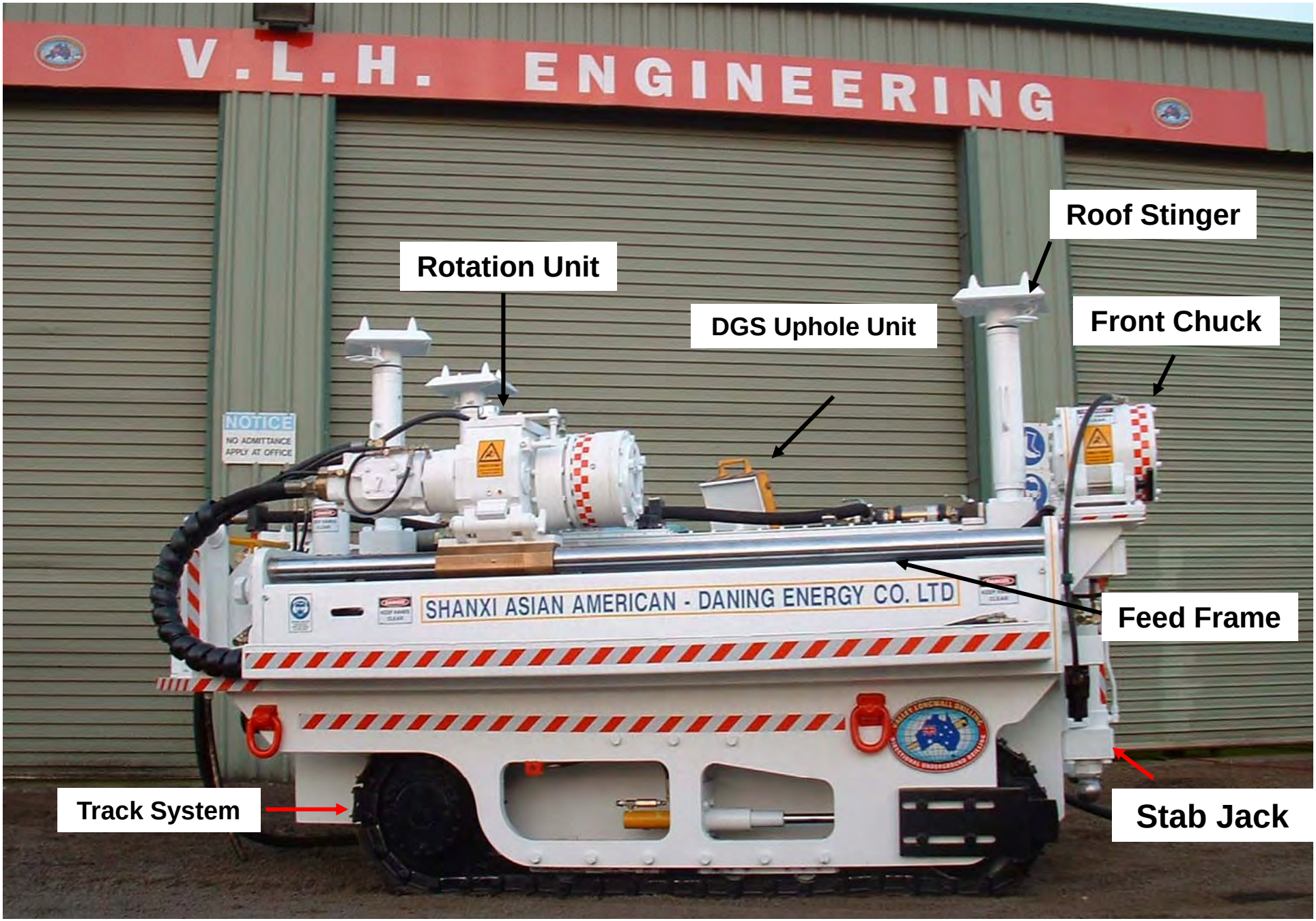
VLD Series 1000 Track Mounted Directional Drill System



VLD SERIES 1000 MODULAR DIRECTIONAL DRILL RIG

Modular system follows the same design principles as the track mounted system but is broken down into three main components - power pack, feed frame, and operator's console - to be used in areas where access is difficult, or there is limited access from the surface.

Feed Frame

Power Pack

Operator's Console

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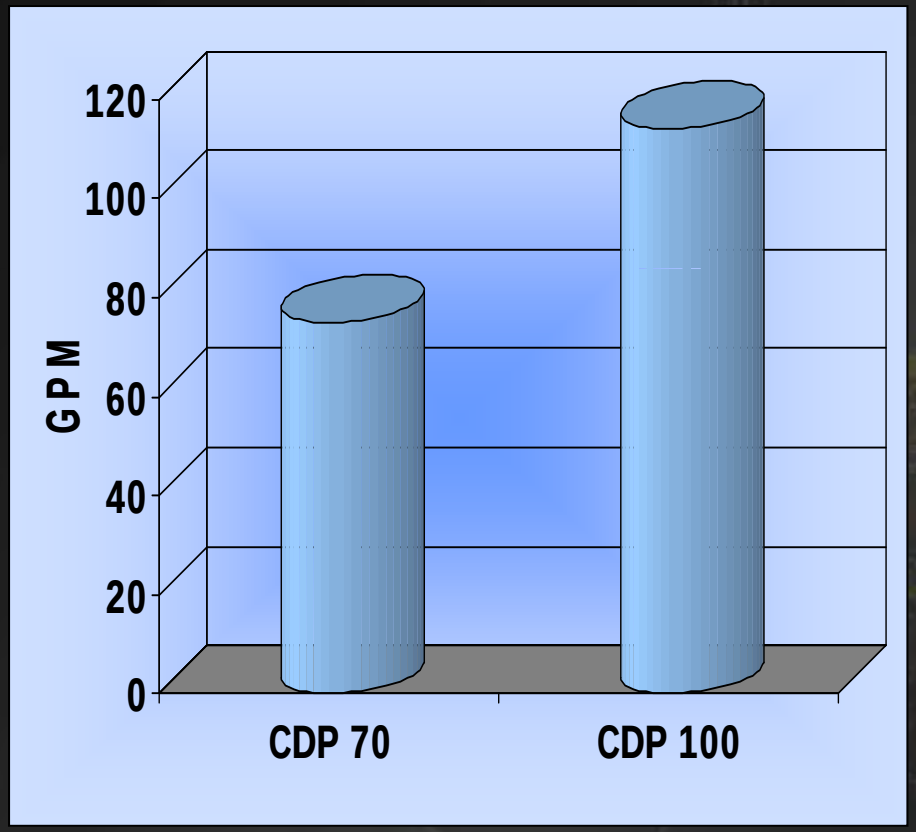
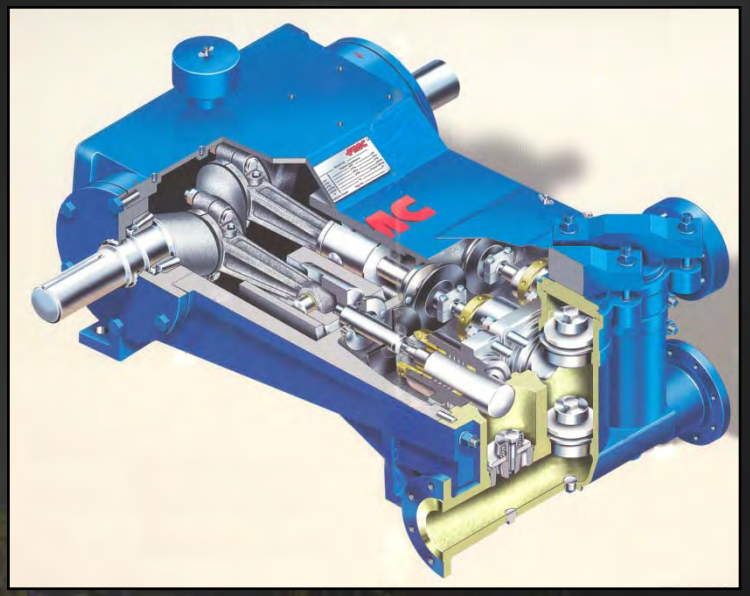
Water Power





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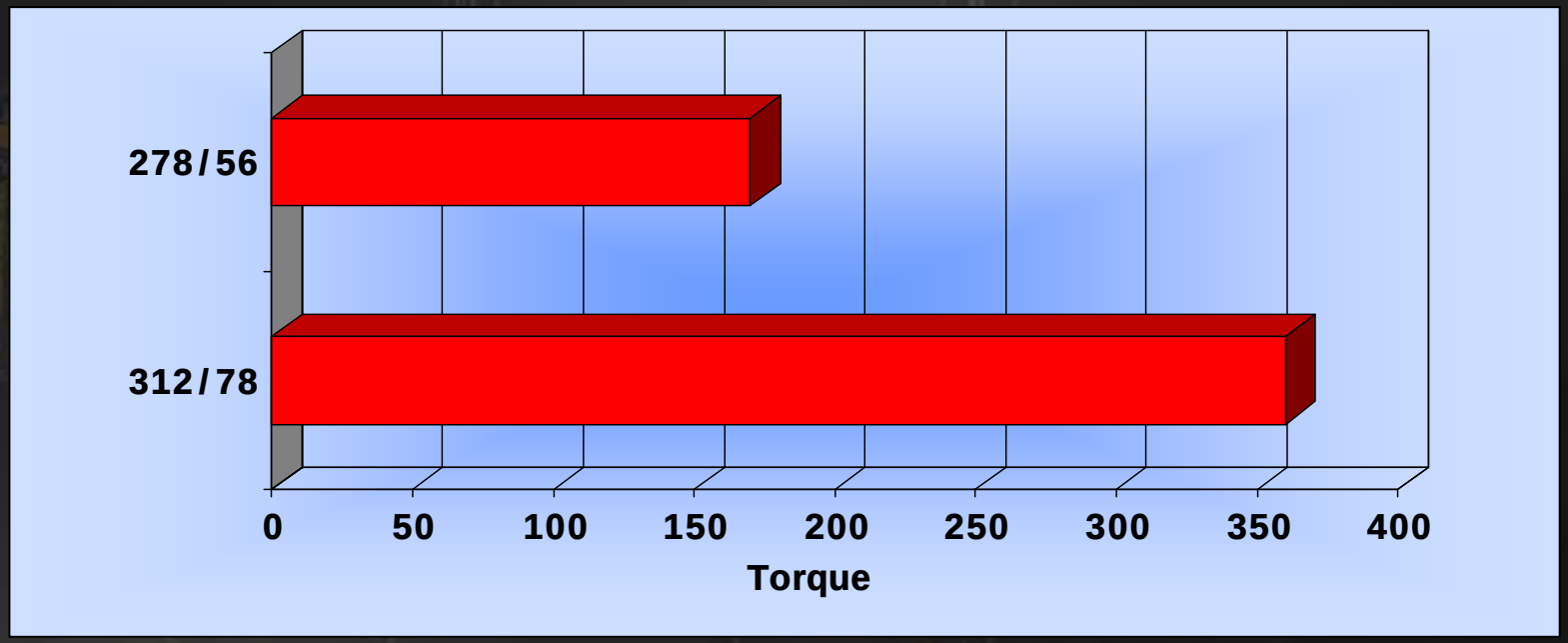
Down Hole Motors



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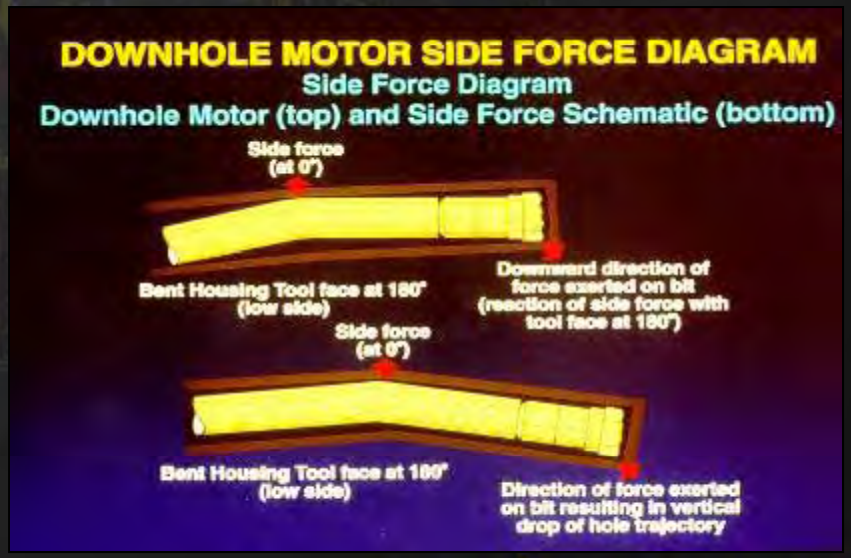
Directional Drilling Technology

- REI uses down hole motor directional drilling technology to accurately steer long holes in coal seams. A down hole motor, operating on the Moyno pump principle, converts hydraulic (water) energy to mechanical torque (bit) without rotation of the drill rods.
- Drillers control direction by orienting a bent housing behind the bit through rotation of the rods. The axial force exerted by the drill on the rods is distributed to the bit by the bent housing according to its orientation.



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Drill Bits

- Polycrystalline Diamond Cutter (PDC)

- Impregnated Diamond

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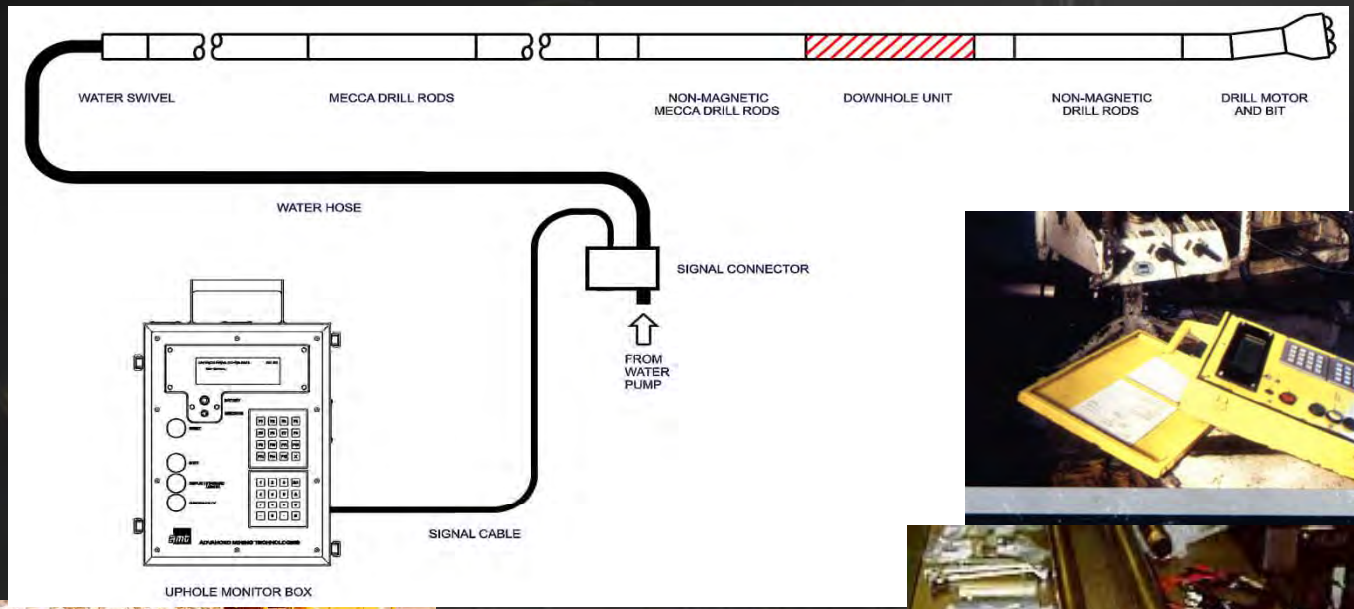
Borehole Surveying Instruments

- Real Time Surveying – DMM MECCA Instrument



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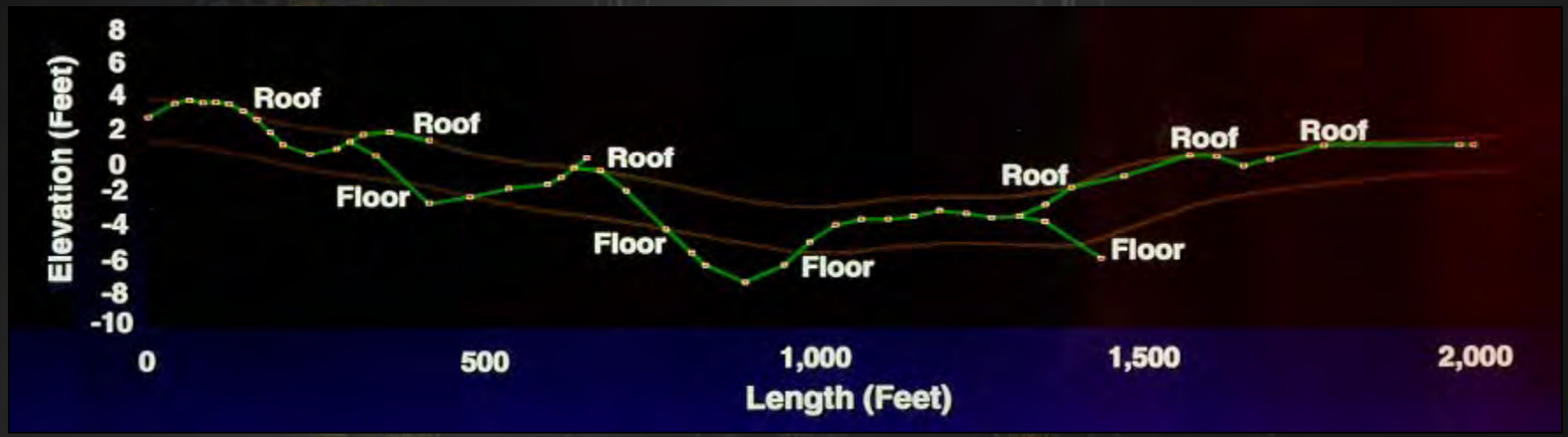
Directional Drilling Technology

- Drillers maintain boreholes in-seam by monitoring down hole motor pressure, axial thrust, cuttings, and survey information.
- Using this system, drillers can develop tangential boreholes (side-tracks) to help maintain the borehole in-seam, correct trajectory, or develop multiple boreholes from one main branch.



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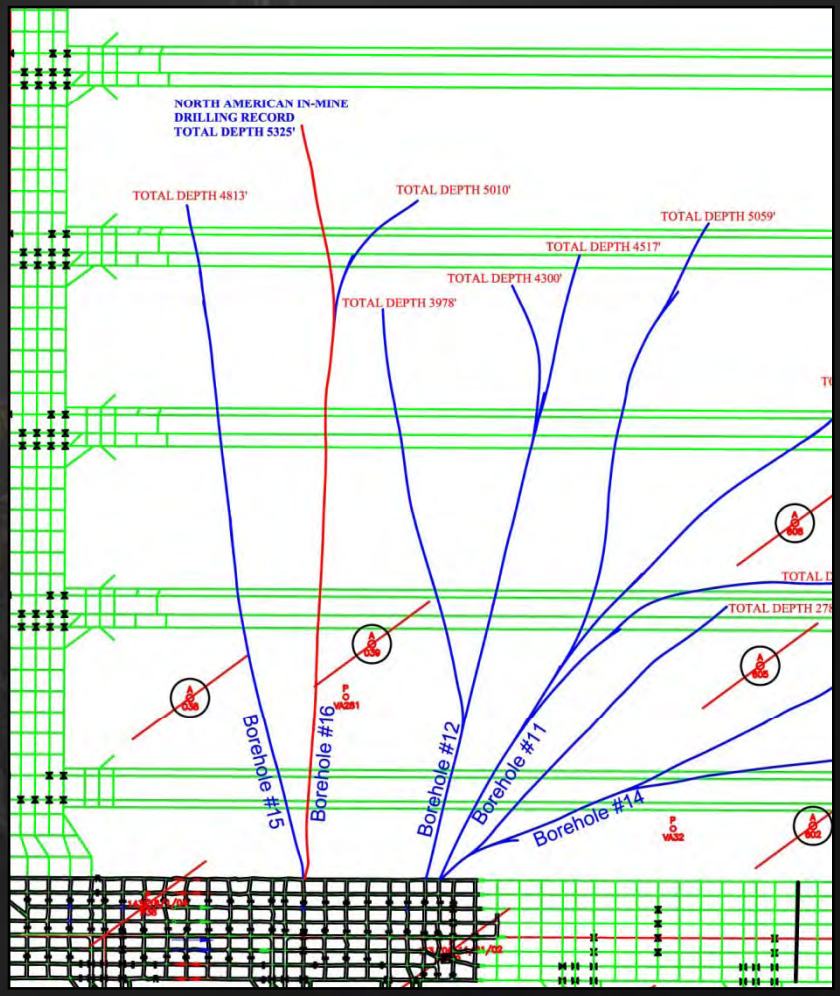
NORTH AMERICAN RECORD

- October 6, 2006
- 1623 meters



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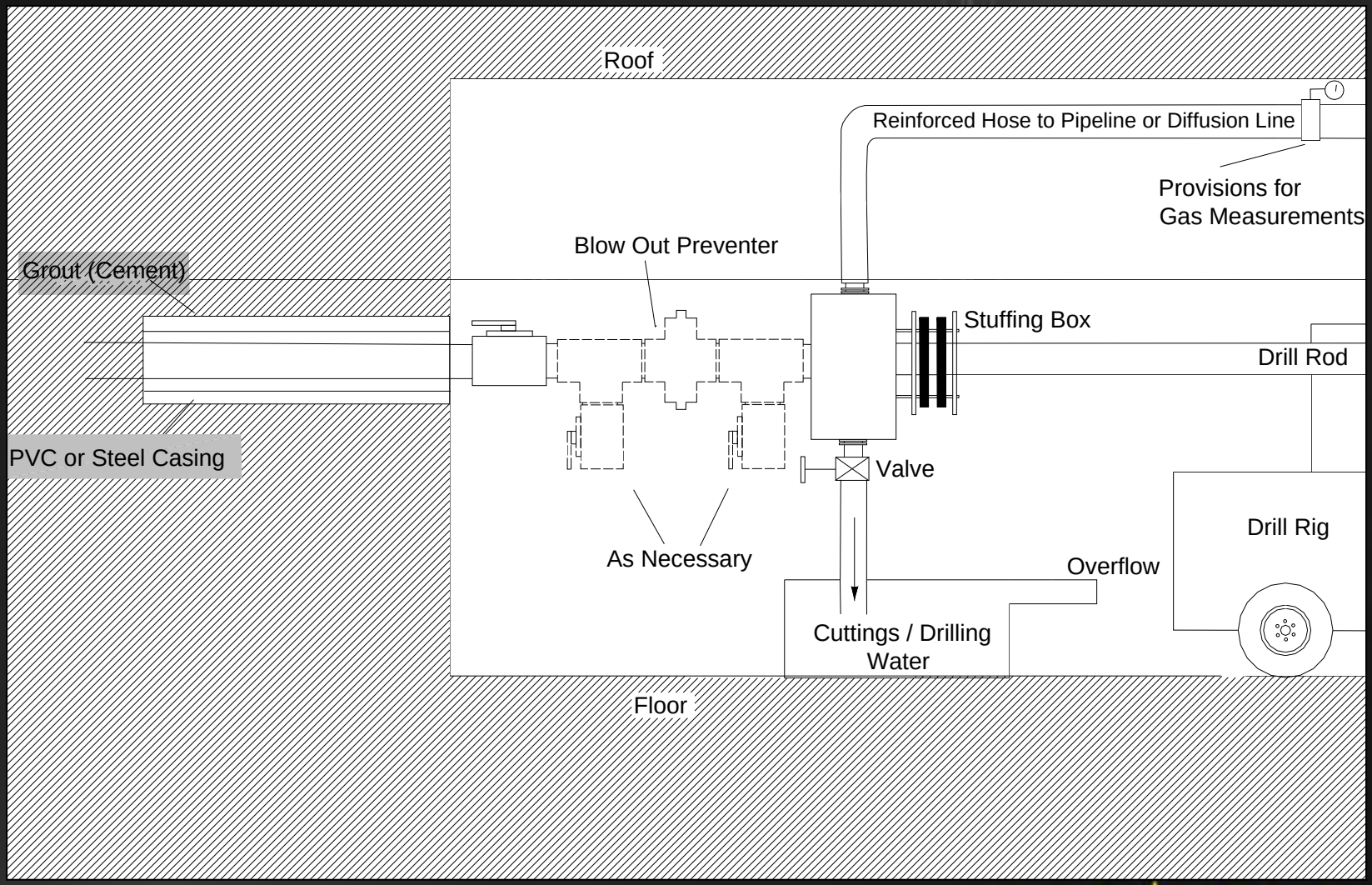
Drilling Configuration



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Valve and Blow Out Control

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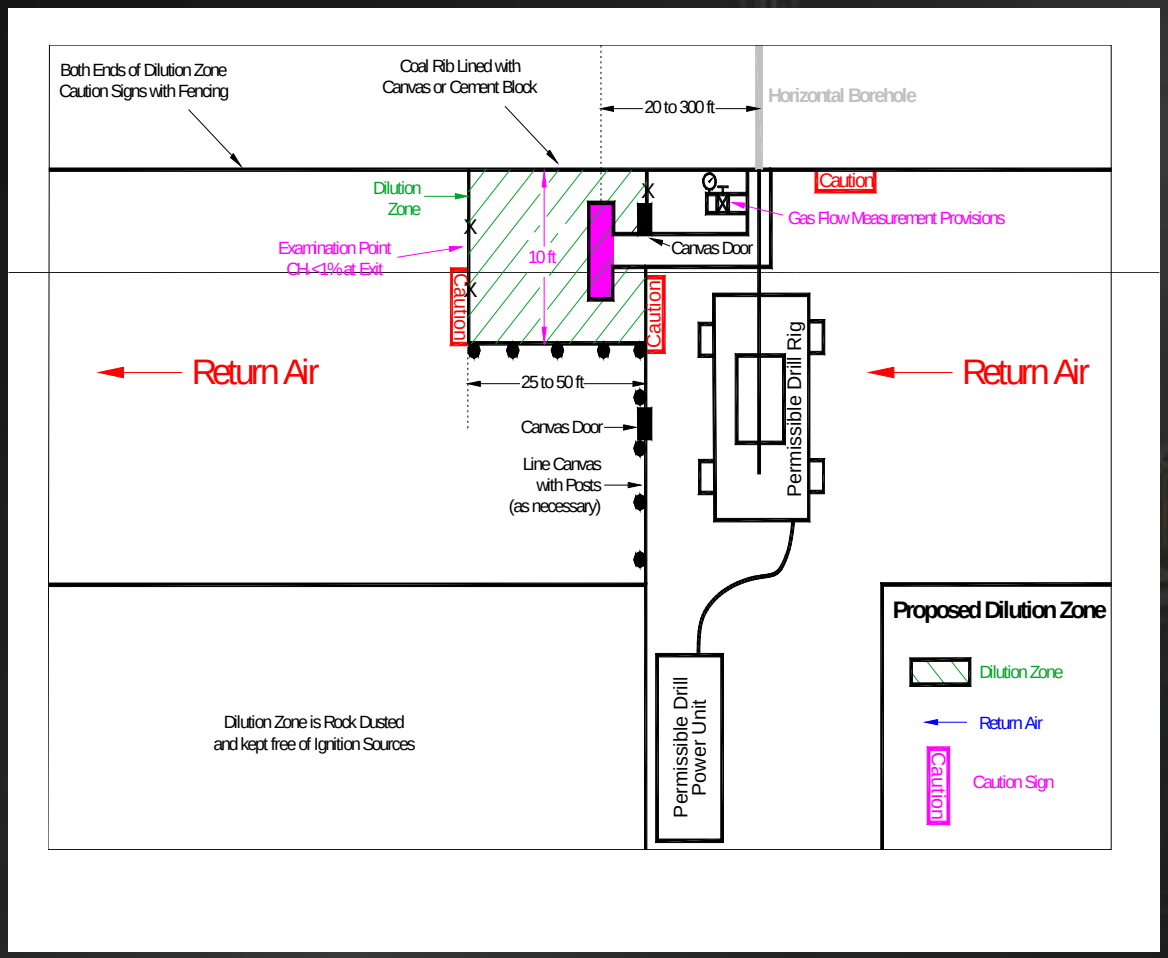
Gas Handling and Collection

Drilling and Post Drilling



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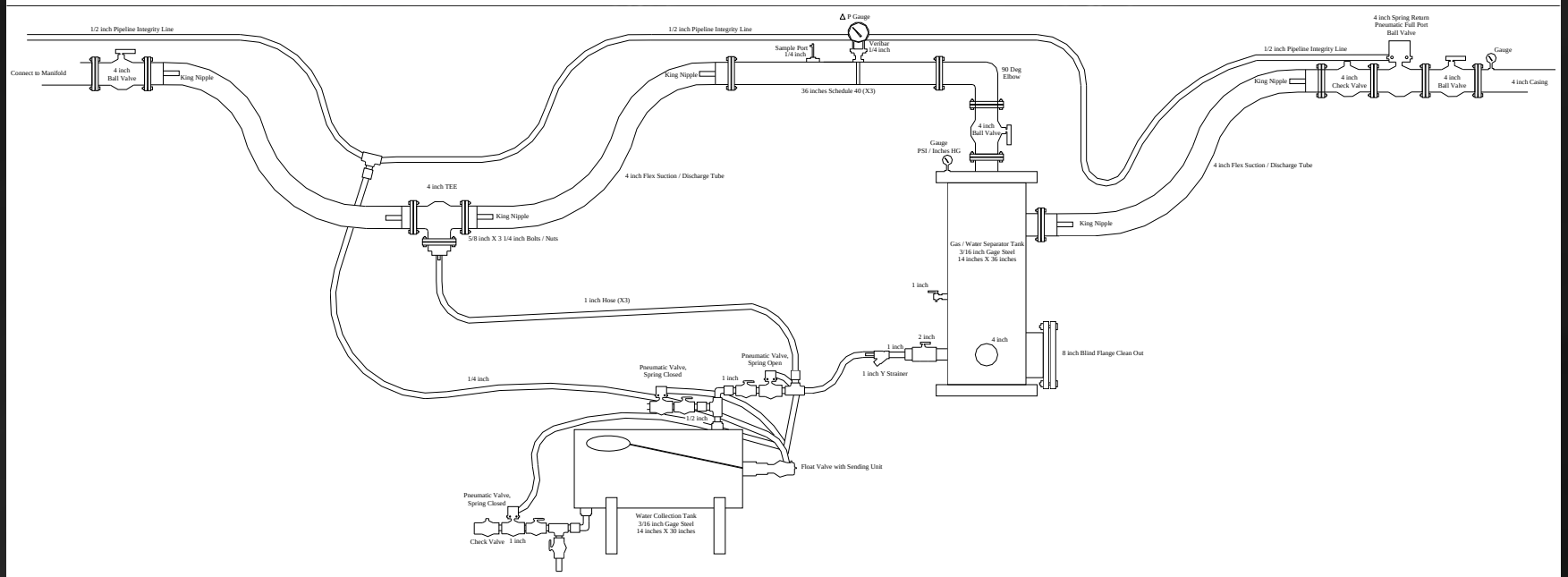
Gas Collection

Well head design:



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Gas Collection

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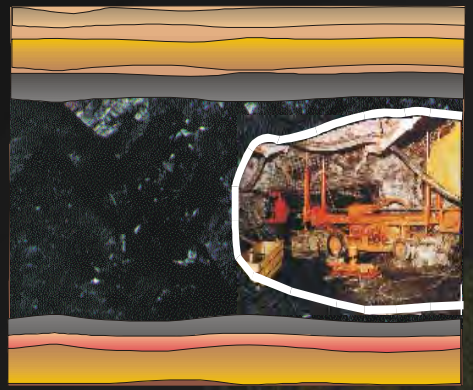
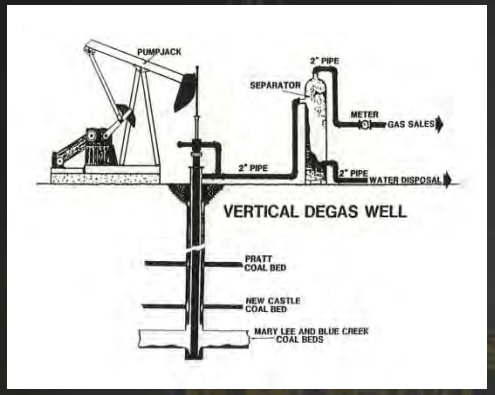
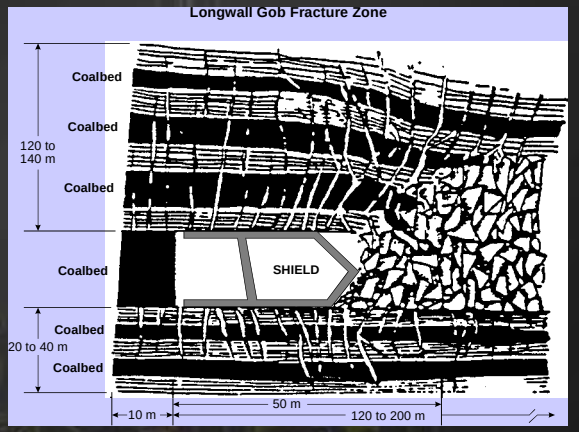
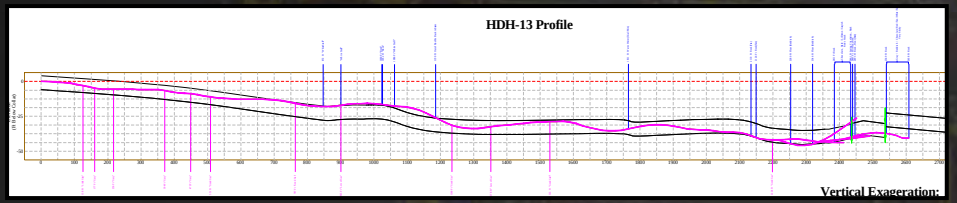
Methane Drainage Techniques

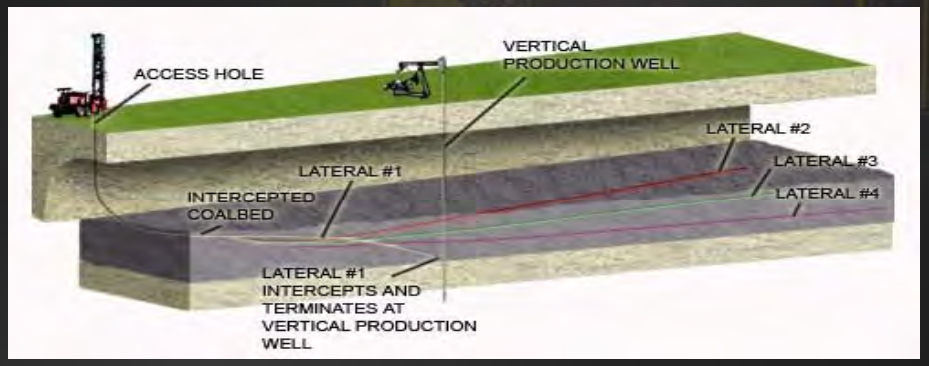
- Pre-Mining
- Gob Degasification

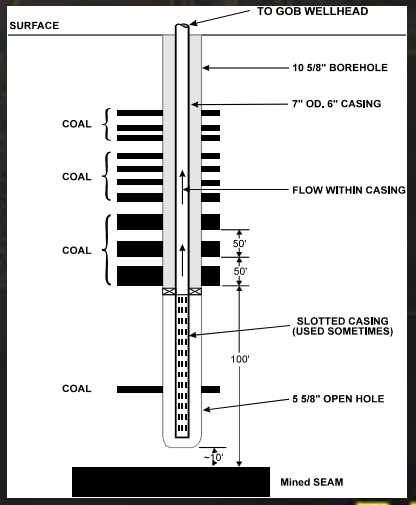












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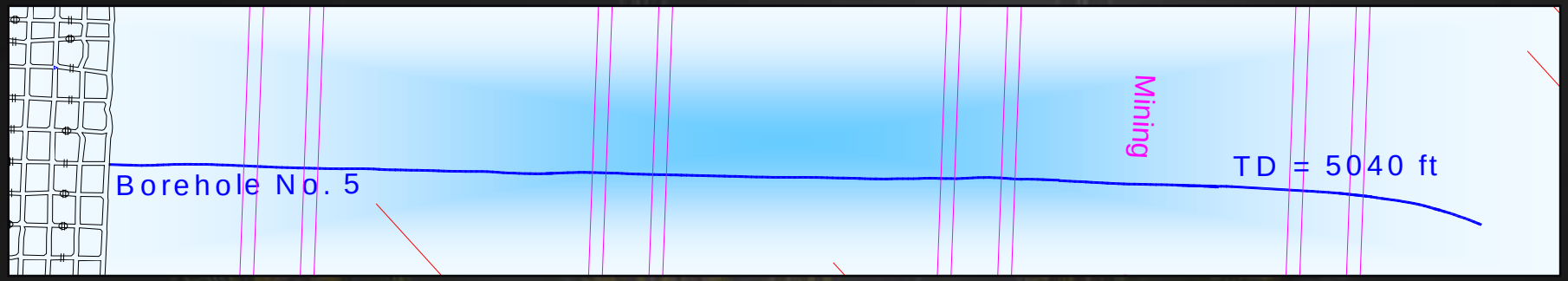
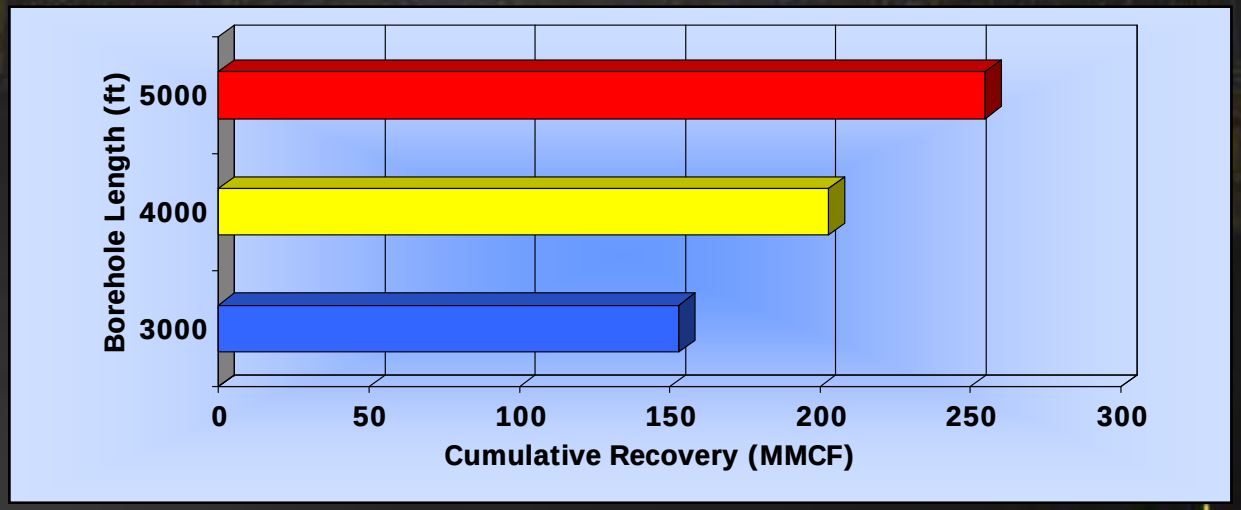
Ultra Long Boreholes

- To Drain Gas Significantly in Advance of Mining:





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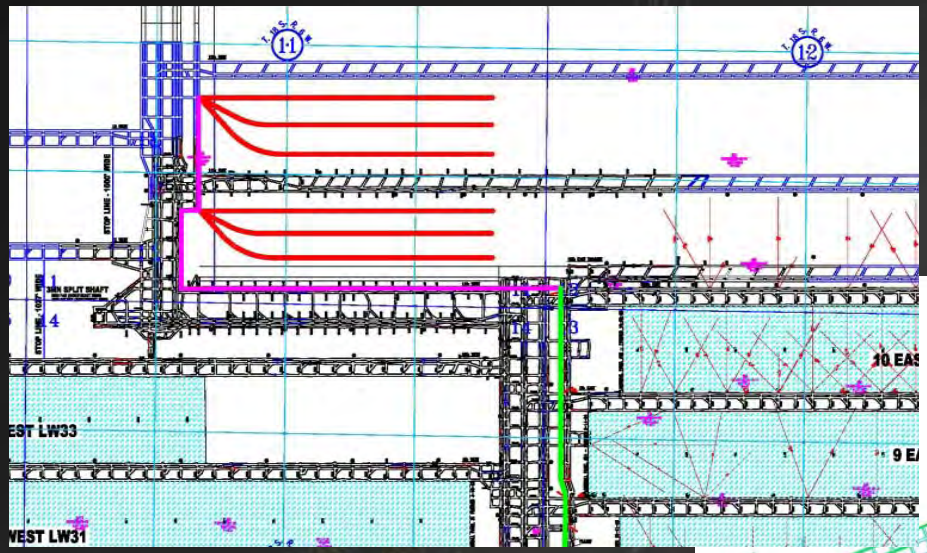
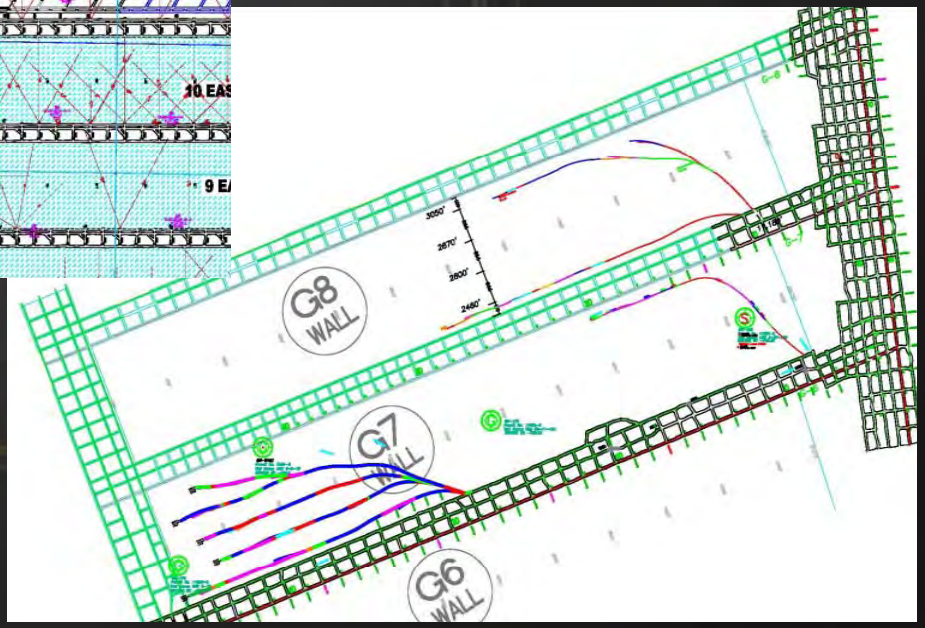
Methane Drainage

- Warrior Basin - Alabama





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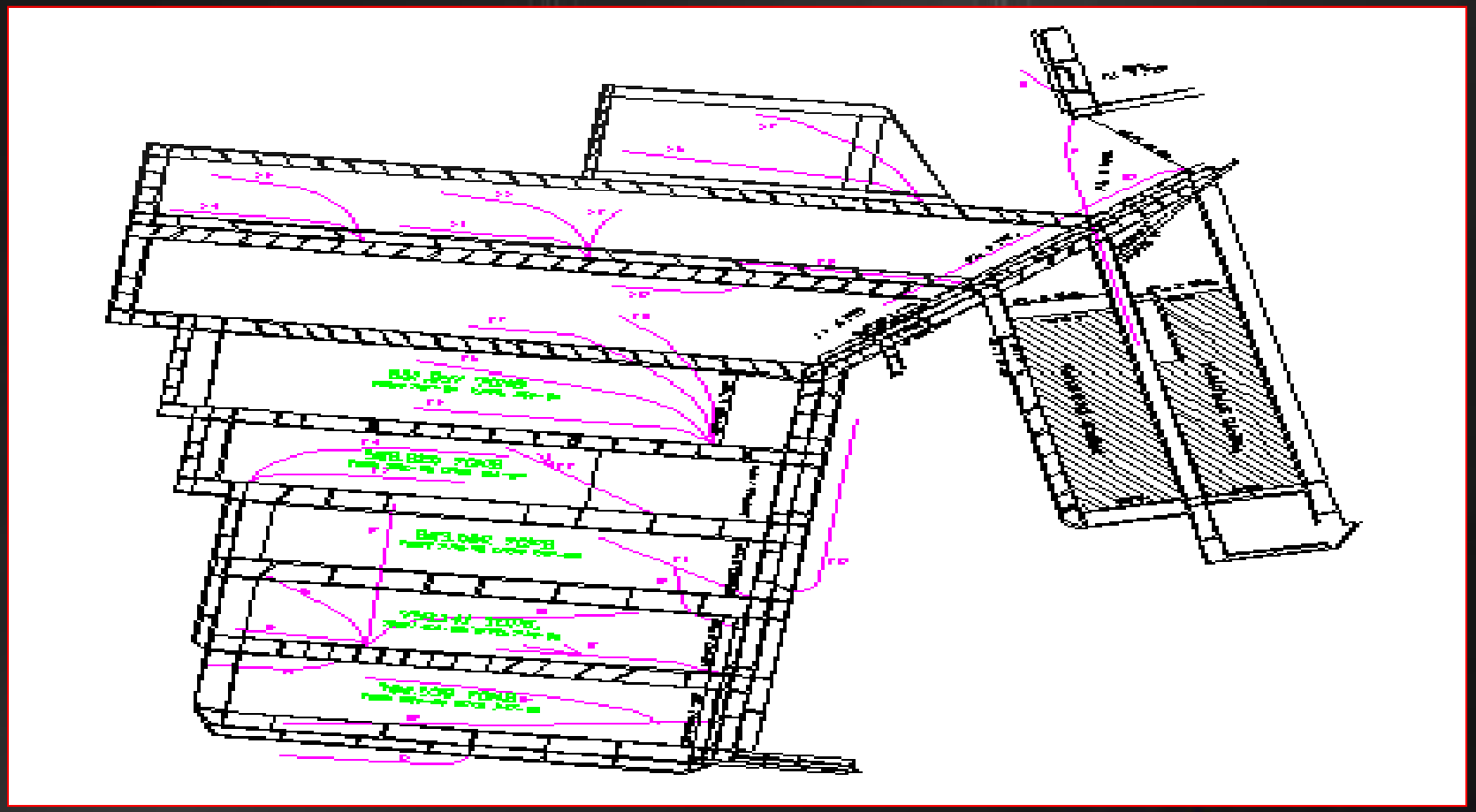
Methane Drainage

- **Mexico – Case Study**
- Pre-Mining - Long, In-Seam Directionally Drilled Boreholes:



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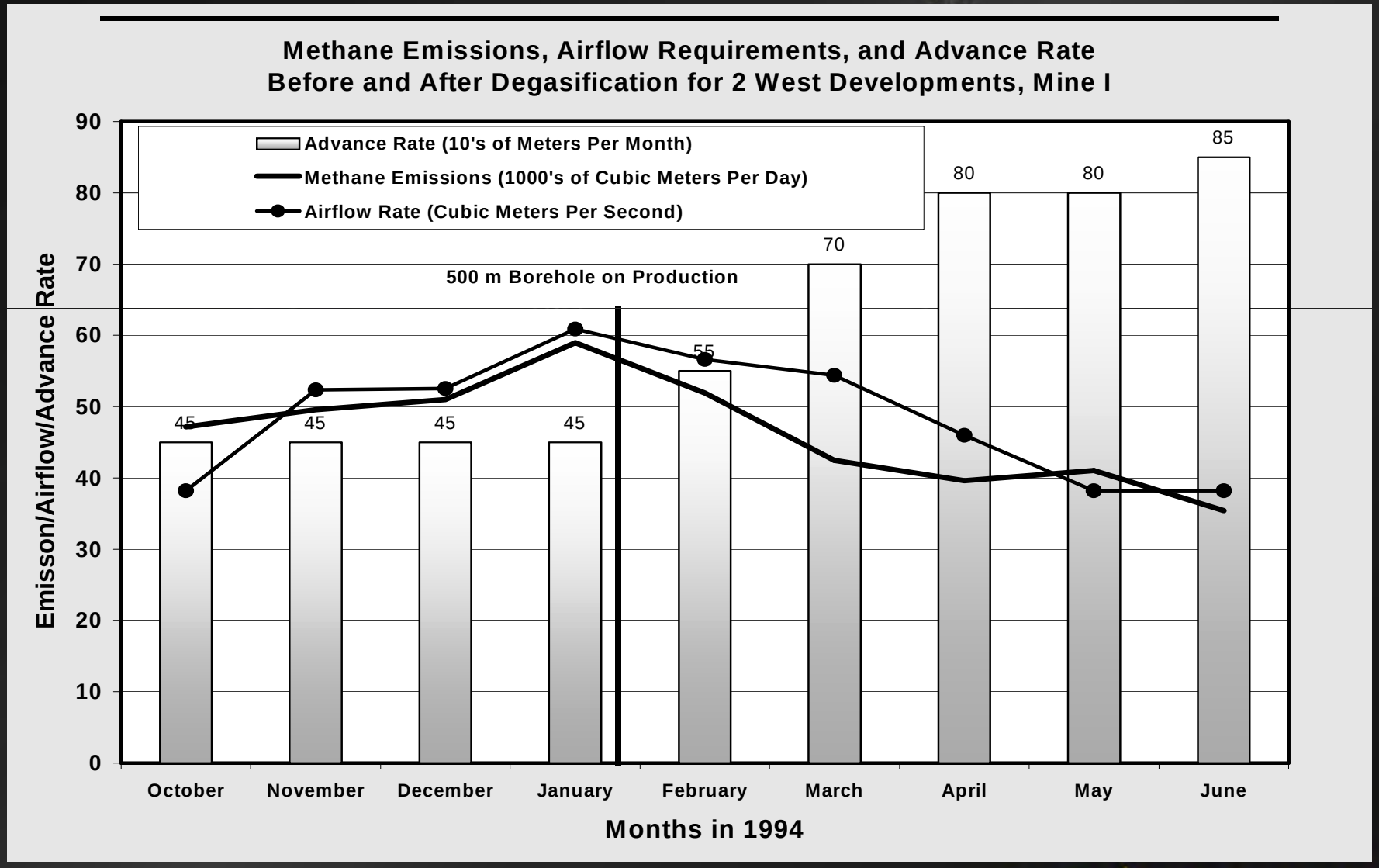
Effect on Gate Road Development

MIMOSA #1 Mine



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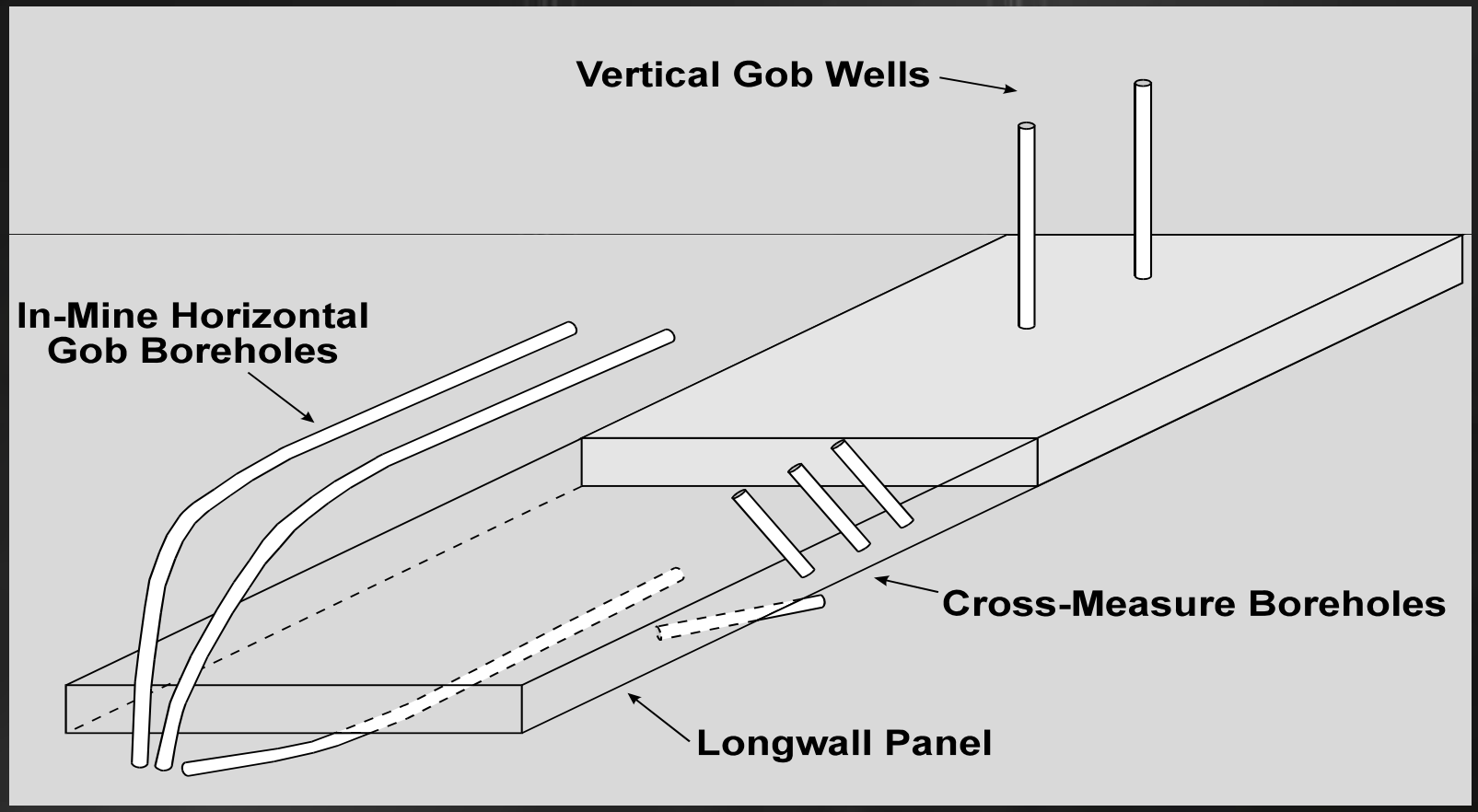
Gob Gas Drainage Techniques



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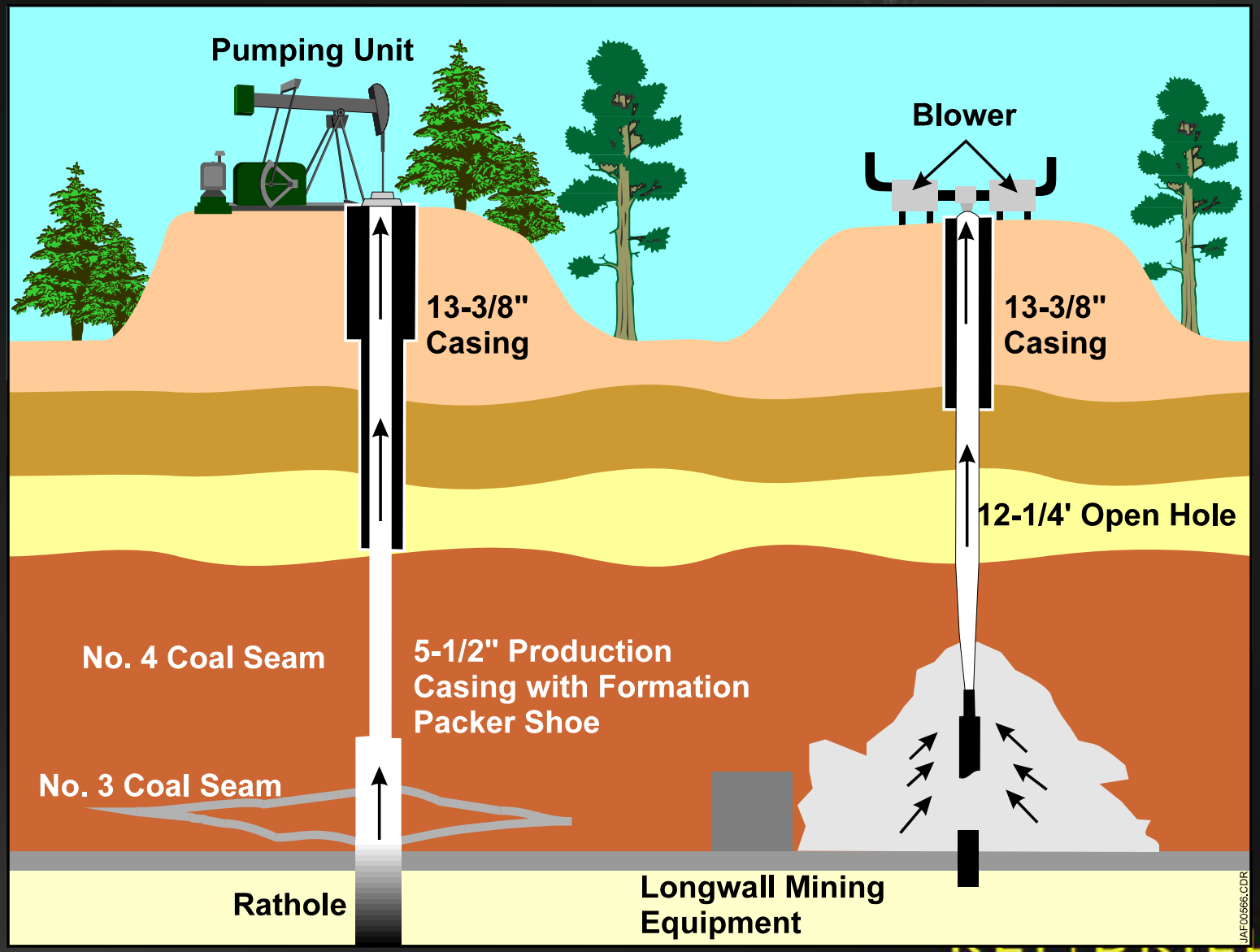
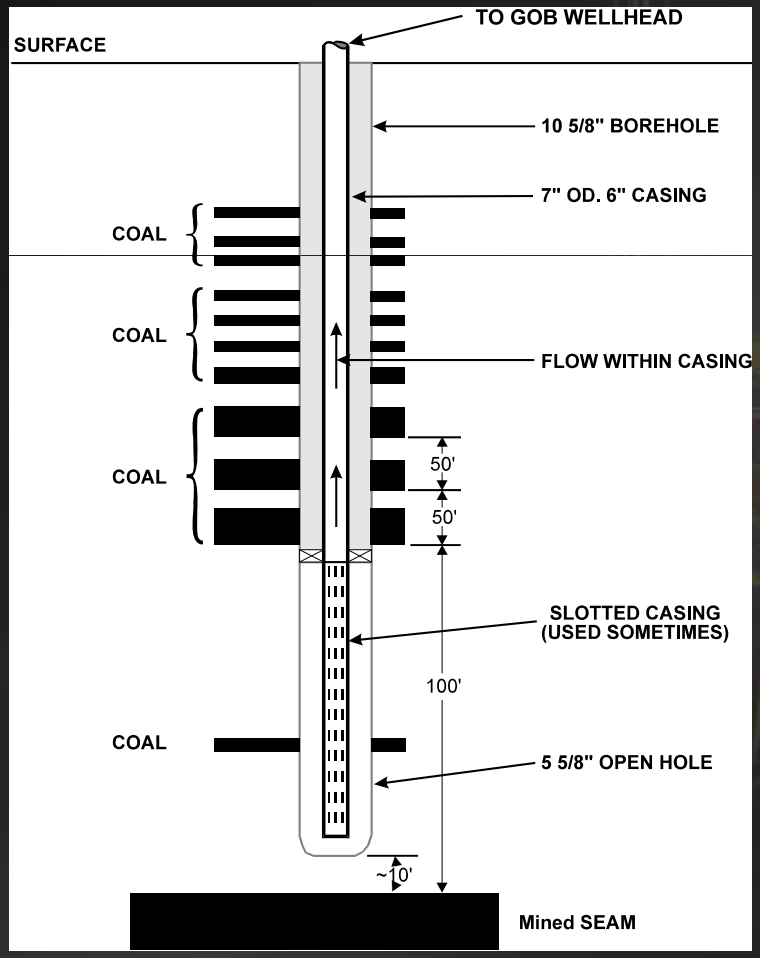
Design of Vertical CBM and CMM Wells



Methane Drainage

- Gob Gas – Vertical Gob Wells



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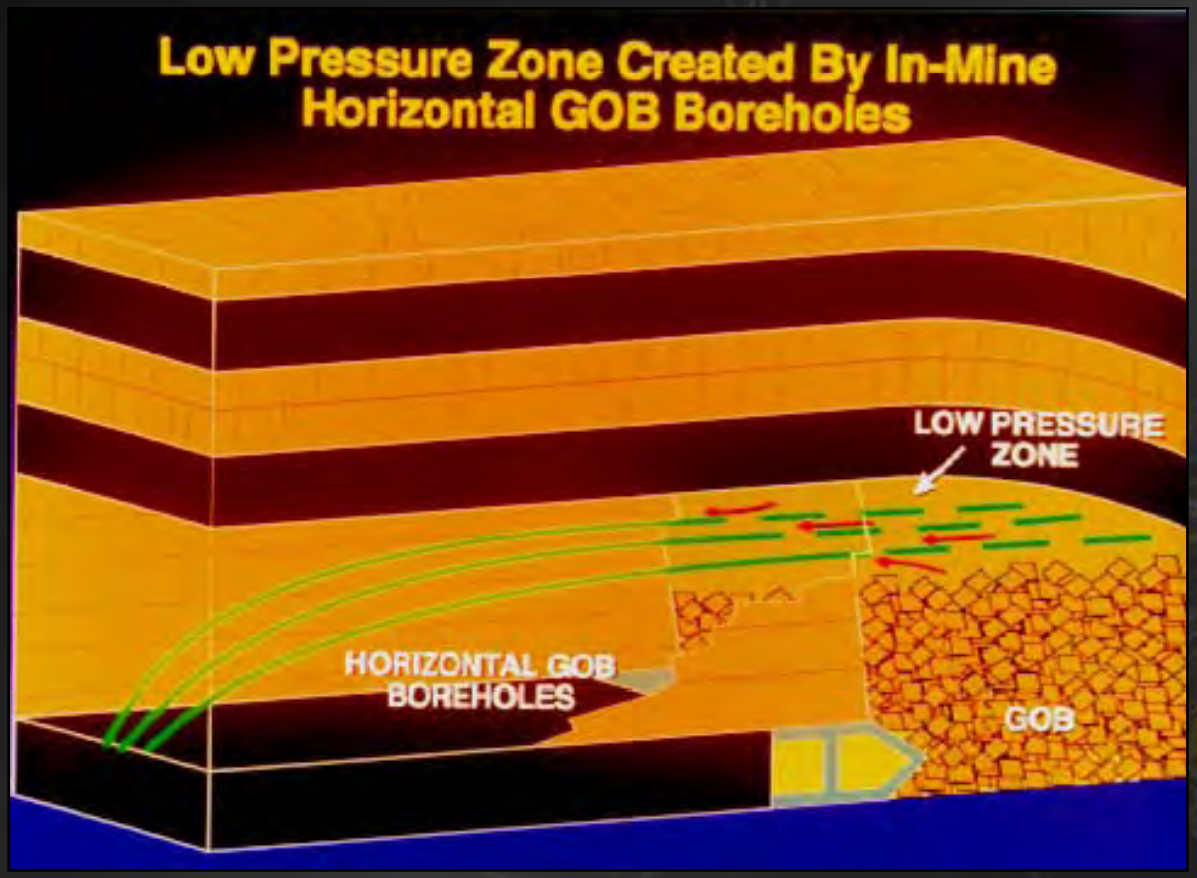
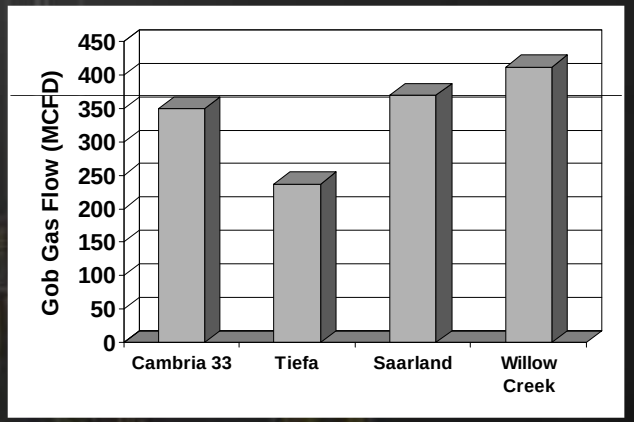
High Capacity Horizontal Gob Boreholes





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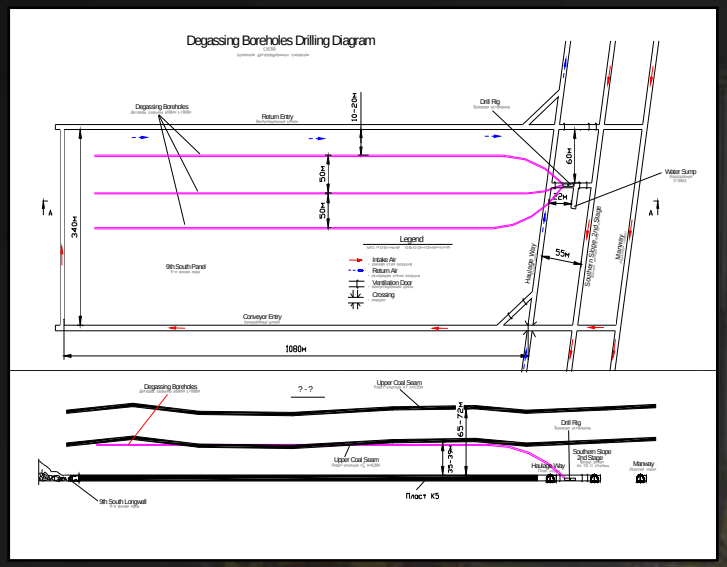
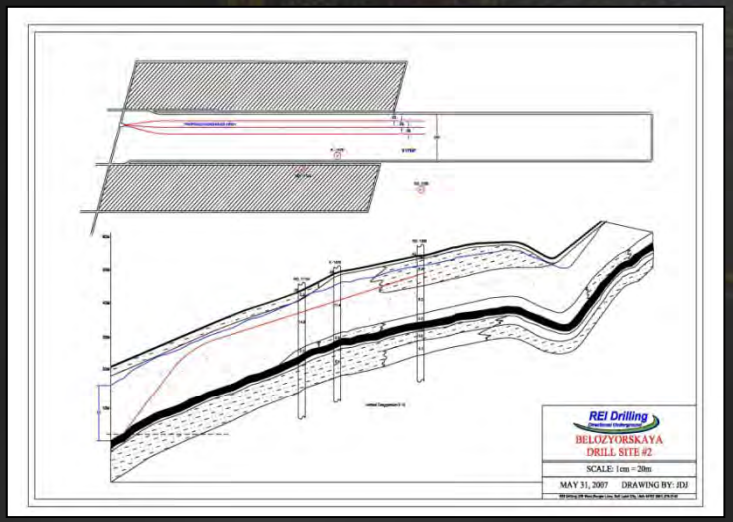
Ukraine - Methane Drainage Approach





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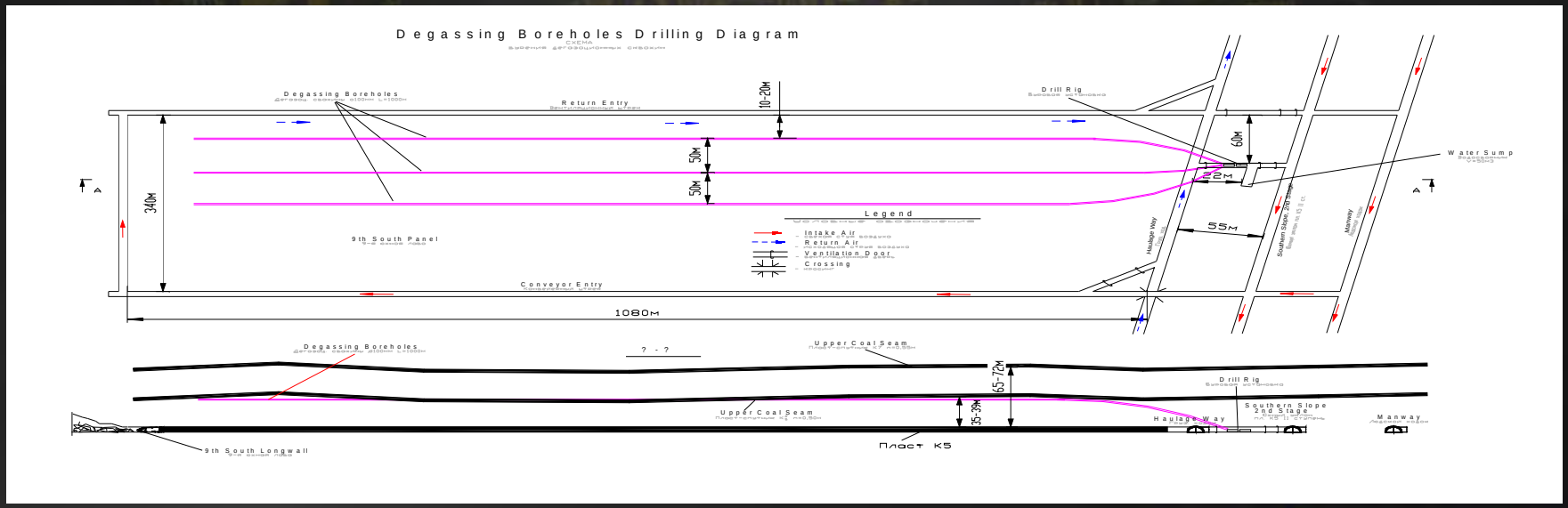
Horizontal Gob Borehole Design Considerations

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



Krasnolimanskaya Mine

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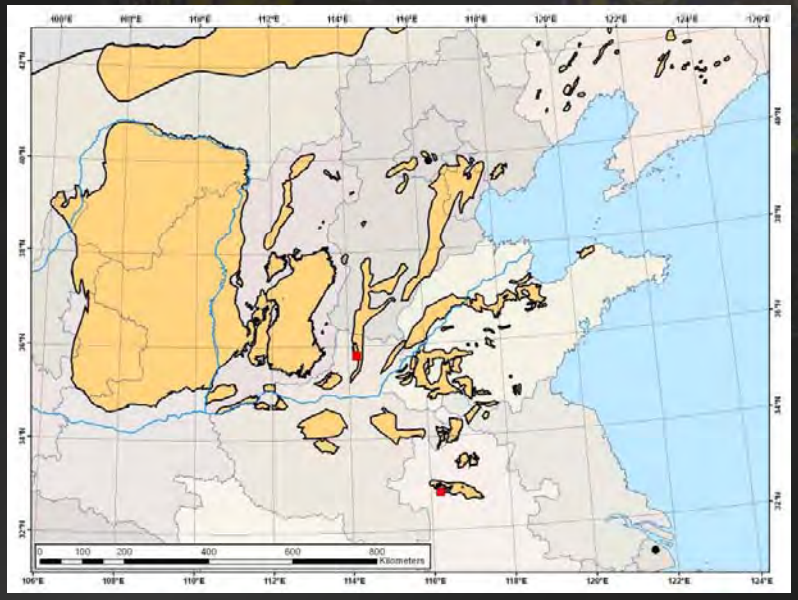
Case Study
Recommendations for the Liuzhuang Mine



Liuzhuang is located in East China Coal Region. Faulting and fragile coals with low permeability makes in-seam drilling less effective.

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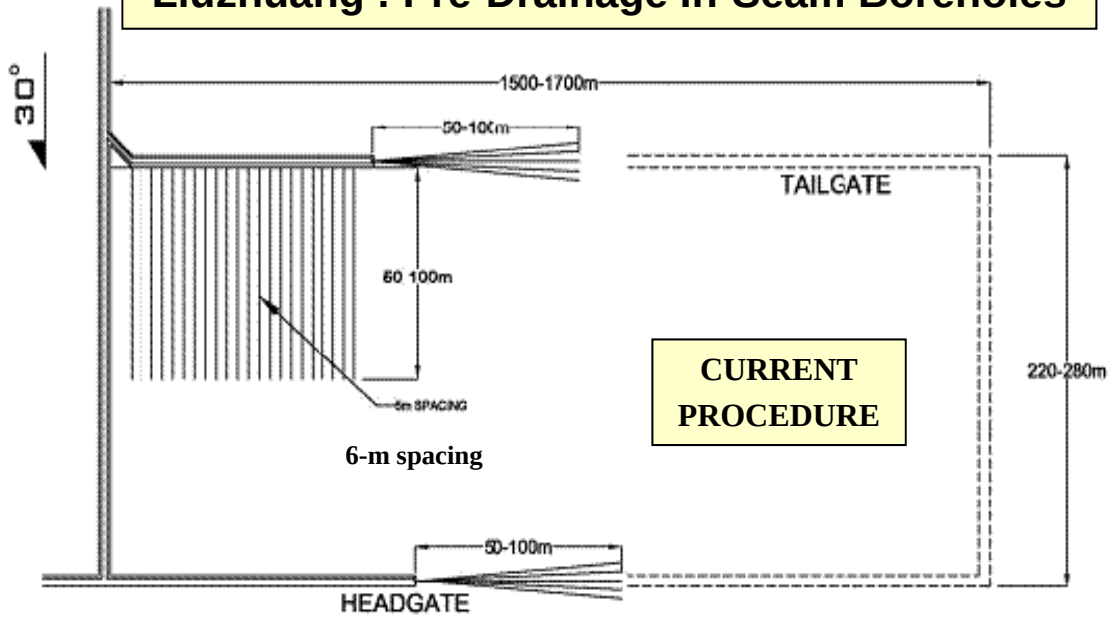
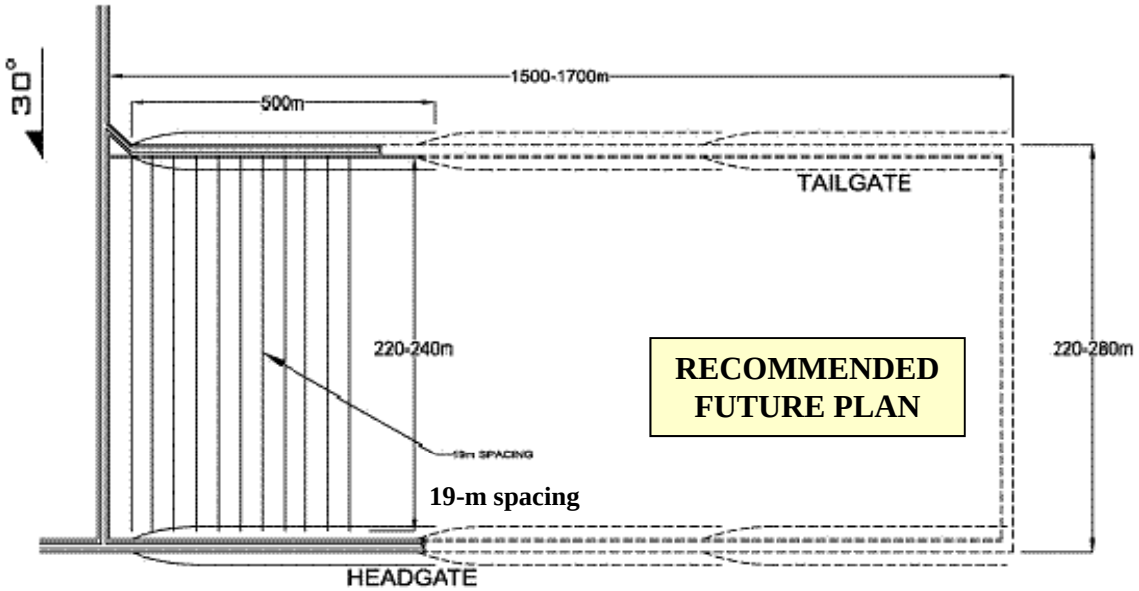
Liuzhuang : Pre-Drainage In-Seam Boreholes





Current vs Recommended

- **Top:** Retreat longwall mine employing 220-280 m x 1500-1700 meter panels
- Currently, cross-panel in-seam boreholes are drilled from the tailgate 80-110 m long on 6-m spacing .
- Boreholes probably stay in the lower half of the 4.5-m thick seam 13-1.

- **Bottom:** Recommended changes to in-seam borehole drilling strategy
- Directional drilling equipment
- 19-m borehole spacing
- 225-m long in-seam boreholes should be feasible.
- Top and bottom of seam drained
- Similar residual gas content reduction with > CH_4 quantity/concentration.

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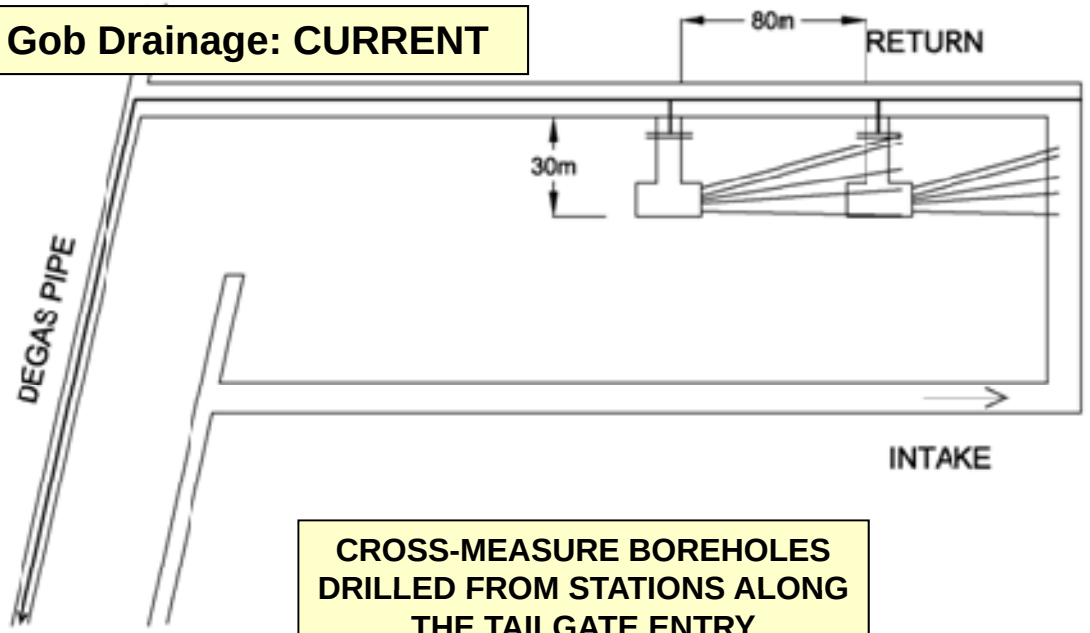
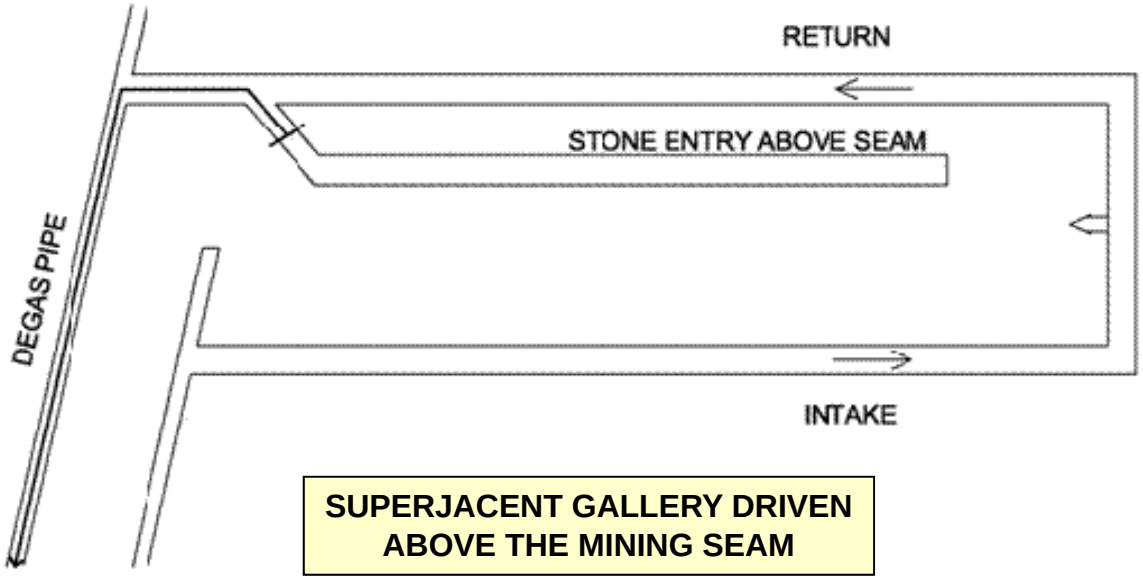
Gob Drainage: CURRENT



CROSS-MEASURE BOREHOLES DRILLED FROM STATIONS ALONG THE TAILGATE ENTRY



SUPERJACENT GALLERY DRIVEN ABOVE THE MINING SEAM

- **Top:** Cross-measure boreholes are drilled toward the retreating longwall face.
- Drill stations are spaced ~80 m along tailgate entry, ramped up 10 m into overlying strata.
- Boreholes up to 110 m long and 50-90 mm diameter are angled up 15-30° into the overlying rock strata.
- Stations are sealed and connected to vacuum.
- CMM is produced as panel is mined through and gob created. It later is isolated to limit ventilation air contamination.

- **Bottom:** Drilling gallery is developed in rock about 18-25 m above seam.
- Gallery is located along tailgate side of panel.
- Gallery is sealed to limit air influx.
- Gallery is connected to vacuum system.

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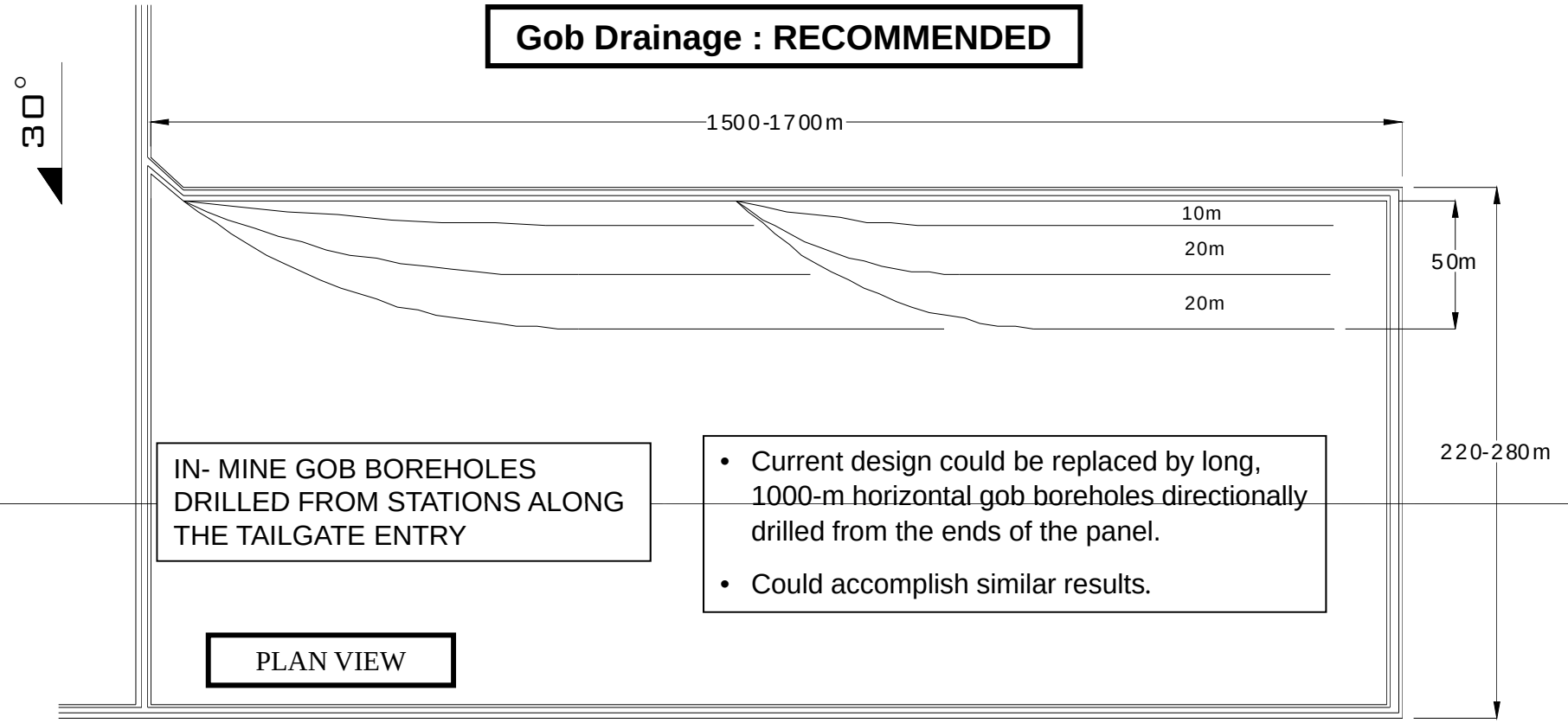
Gob Drainage : RECOMMENDED

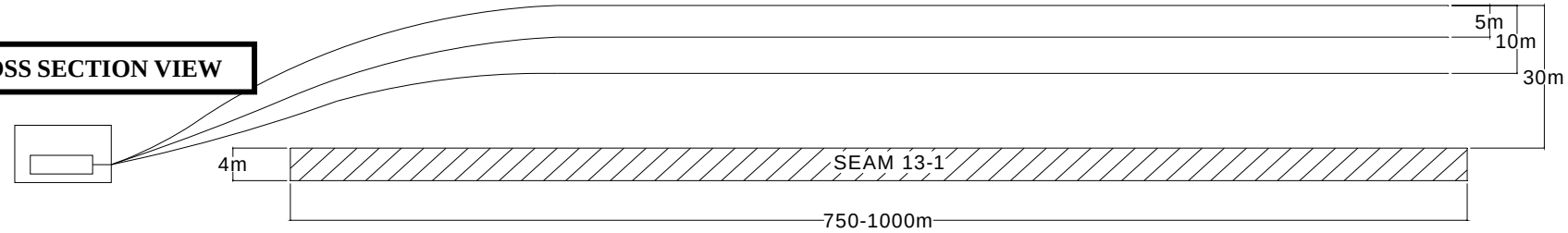


IN- MINE GOB BOREHOLES DRILLED FROM STATIONS ALONG THE TAILGATE ENTRY

- Current design could be replaced by long, 1000-m horizontal gob boreholes directionally drilled from the ends of the panel.
- Could accomplish similar results.

PLAN VIEW

CROSS SECTION VIEW



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Benefits of Recommended Cross-Seam and Gob Borehole Improvements

- 75% fewer boreholes drilled (counting the tangential boreholes individually)
- 88% fewer drill setups, borehole collars, standpipes, and wellheads
- Same volume of methane recovered
- Fewer wellheads minimizes potential for air intrusion into gathering system, thus improving recovered gas quality
- Fewer boreholes reduces methane drainage costs
- Potential for reduction in drainage time by reducing borehole spacing
- Fewer boreholes provides for reduced time required for drilling
- Reduced residual gas contents improves mine safety
- Reduced residual gas contents enables increased coal production

	Average Recovered Gas Quality (% CH4)
Current	5 -15
Recommended	40 - 70

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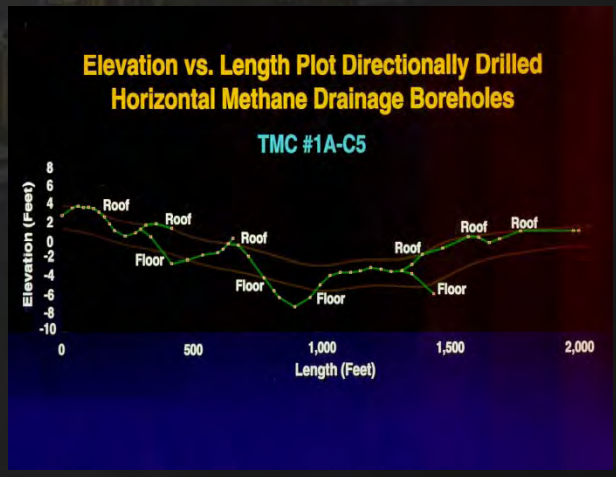
Summary

- Acquisition of geologic and reservoir properties allows mine operator to optimize methane drainage technique rather than use “trial and error.”
- Evaluate alternatives from drill bit to burner tip (e.g. drainage techniques, equipment, well heads, pipeline, safety systems, surface facilities, and gas use options).
- Directional drilling will allow application of modern methane drainage techniques tailored to site specific conditions.
- Provides geologic information such as coal thickness/thinning, identification of faults, intrusions, other anomalies, old workings, etc., prior to mining.



REI | DRILLING

High methane emissions are enough to upset anyone's stomach—as well as potentially proving disastrous for mining operations. That's why so many mine operators call on REI for downhole directional drilling before mining operations advance. Because we are able to accurately steer and place boreholes in excess of 5,000 ft in length (depending on conditions) we can explore, discover and reduce the gas content of the mining or adjacent seams. Which creates greater productivity and safer mining conditions.

REI's expertise and fleet of seven state-of-the-art directional drills allow us to accurately steer and place boreholes even through unpredictable coal seams. In many cases, the gas from these in-seam boreholes can be collected and sold in commercial markets. And that can prove significant given the rising value of and projected future demand for natural gas.

Put REI's proven world-wide expertise to work for you today, and have peace of mind about your next mining plans. REI can also assist you with exploration for old workings, geologic exploration, and de-watering, from surface or underground.

So if the thought of high methane emissions gives you a sick feeling, call REI today. After all, we're the company that can relieve your gas pains on contact.

REI Western Region
45 East 4600 South, Suite 300
Salt Lake City, UT USA 84107
Tel (801) 270-2141
Fax (801) 281-2880

REI Eastern Region
2619 White Hall Road
Crozet, VA USA 22932
Tel (434) 823-2065
Fax (434) 823-2067

REI Drilling
The source for your directional drilling needs
toll-free (877) 838-0534 www.reidrilling.com

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