Overview of Surface-Based Methods for Methane Drainage

International Workshop on
Optimum Utilization of CMM/CBM in India
24th – 25th April 2019
Ranchi (Jharkhand) India

Daniel J. Brunner
President, Resource Enterprises
REI Drilling Inc., DPI Inc., DPI-IPG LLC.
Salt Lake City, UT, USA
Jonathan R. Kelafant
Sr. Vice President
Advanced Resources International, Inc.
Arlington, VA USA

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Overview

Surface-based boreholes can be used to drain gas either prior to mining or for recovering gob gas from mined-out areas:

1. Pre-drainage techniques include:
   - Vertical wells (various simulation techniques);
   - Surface to in-seam wells drilled directionally from the surface.
2. Post-mining surface techniques include:
   - Vertical gob wells;
   - Surface drilled horizontal gob lateral wells.

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Pre-Drainage Techniques

- Vertical fracture stimulated wells
- Vertical open-hole/under-reamed wells
- Surface to in-seam wells

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Vertical Stimulated Wells

- Hydraulically fractured wells have been shown to drain up to 73% of the original gas in-place based on studies by the U.S. Bureau of Mines;
- Wells are typically cased, cemented and then stimulated by hydraulic fracturing.

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Open-Hole/Under-Reamed Wells

- In open-hole/under-reamed wells, no casing is set across the targeted coals seams;
- Formation damage induced by drilling is mitigated by either mechanically under-reaming or by pressuring up the well and then quickly flowing it back to allow the coal to spall into the wellbore;
- Generally less expensive than vertical stimulation wells.

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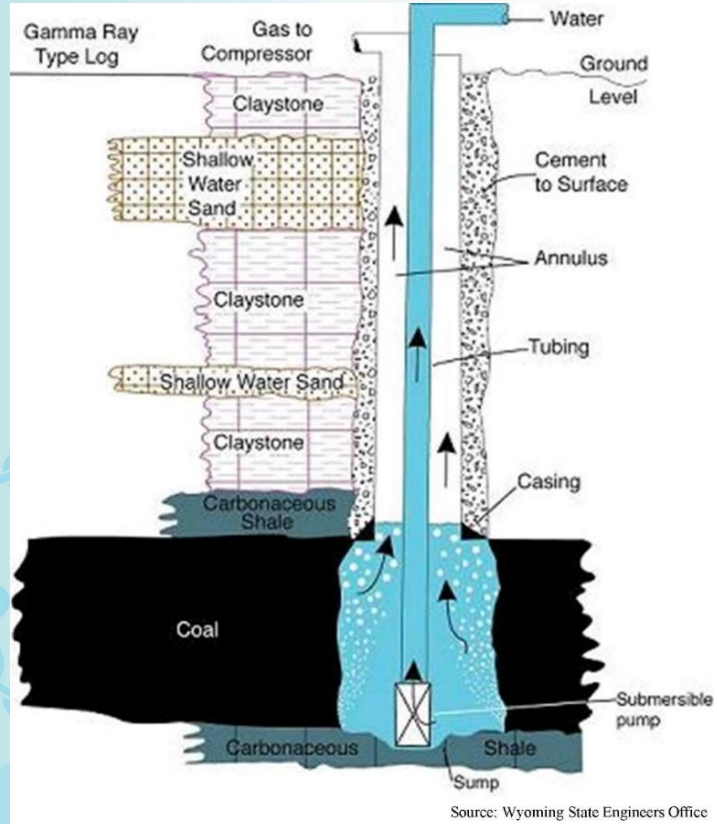
Open-Hole/Under-Reamed Completion

Advantages

- Eliminates the need for hydraulic fracturing (operations and costs)
- No casing across the coal seam

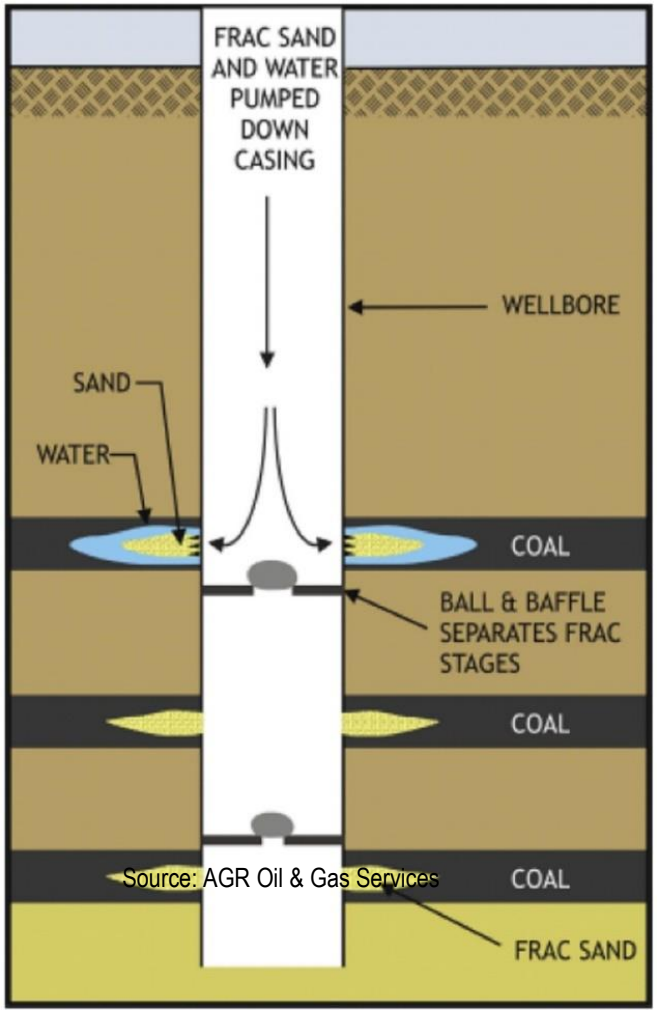
Disadvantages

- Not good for multiple seam settings



Source: Wyoming State Engineers Office

Hydraulically Fractured Well



Source: AGR Oil & Gas Services

Advantages

- Proven to increase production from low permeability coal seams
- Provides good wellbore control
- Ideal for multiple seams

Disadvantages

- Leaves casing across the coal seam; can mill out, or use fiberglass casing
- Higher cost than open/under-reamed

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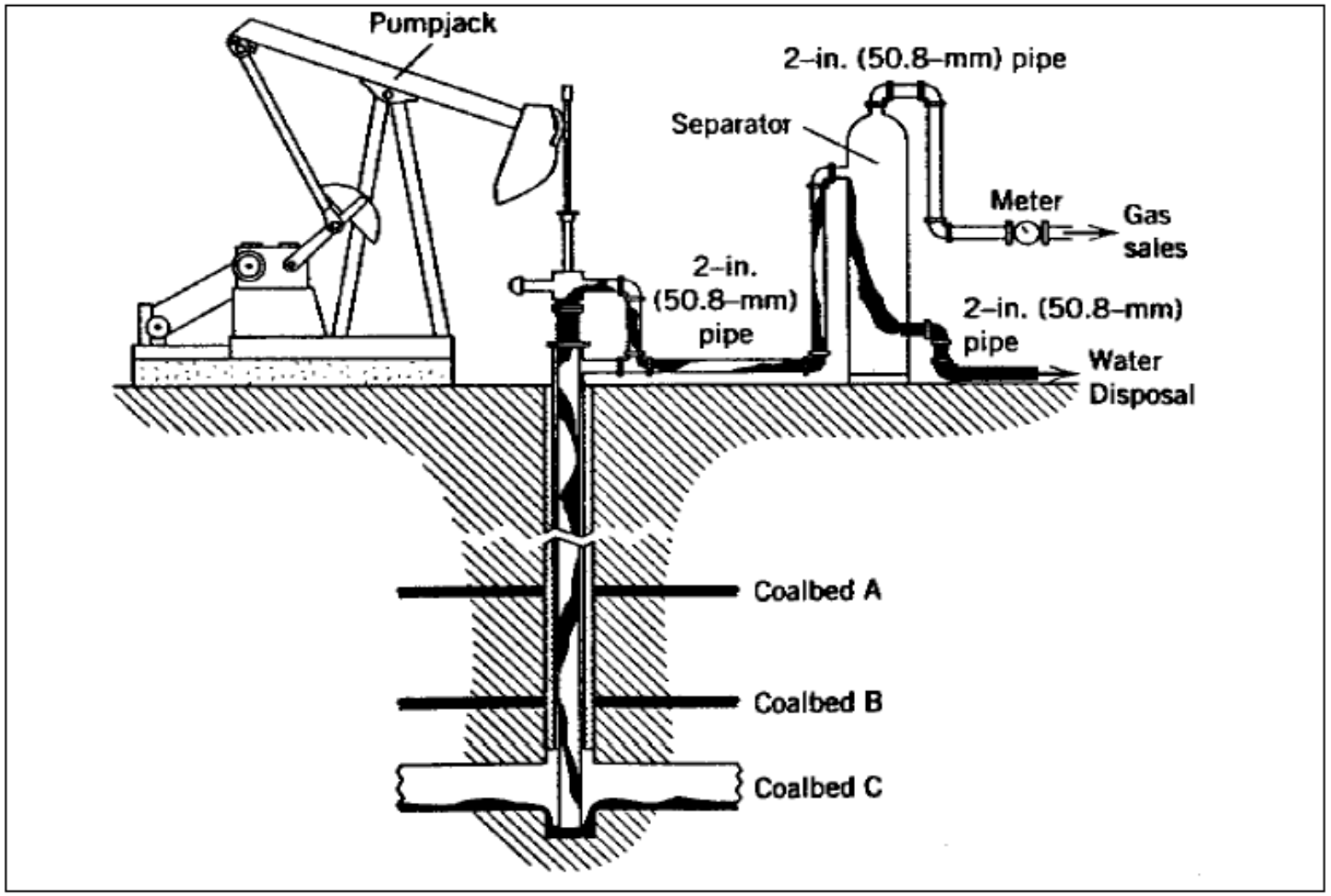
Typical Vertical Well Setup After Completion (Both Hydraulically Fractured Wells and Open-Hole Well)



Source: Hartman et al., 1997. Copyright 1997, John Wiley & Sons, Inc. Reprinted with permission of John Wiley & Sons, Inc.

Surface to In-Seam Techniques

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Surface-drilled directional oil & gas well types defined by radius size

Radius Type	Radius (m/ft)	Achievable Lateral Length (m/ft)	Drilling Method
Zero	0	3 / 10	Telescopic probe with hydraulic jet
Ultra-short	0.3-0.6 / 1-2	60 / 200	Coiled tubing with hydraulic jet
Short	1-12 / 3-40	460 / 1,500	Curved drilling guide with flexible drill pipe; entire drill string rotated from the surface
Medium	60-300 / 200-1000	460-1,525+ / 1,500-5,000+	Steerable mud motor used with compressive drill pipe; conventional drilling technology can also be used
Long	300-850+ / 1000-2,500+	600+ / 2,000+ (Record is over 12,000 m/ 40,000 ft)	Conventional directional drilling equipment used; very long curve length of 850-1,350 m (2,800-4,400 ft) needed to be drilled before achieving horizontal

Source: USDOE, 1993

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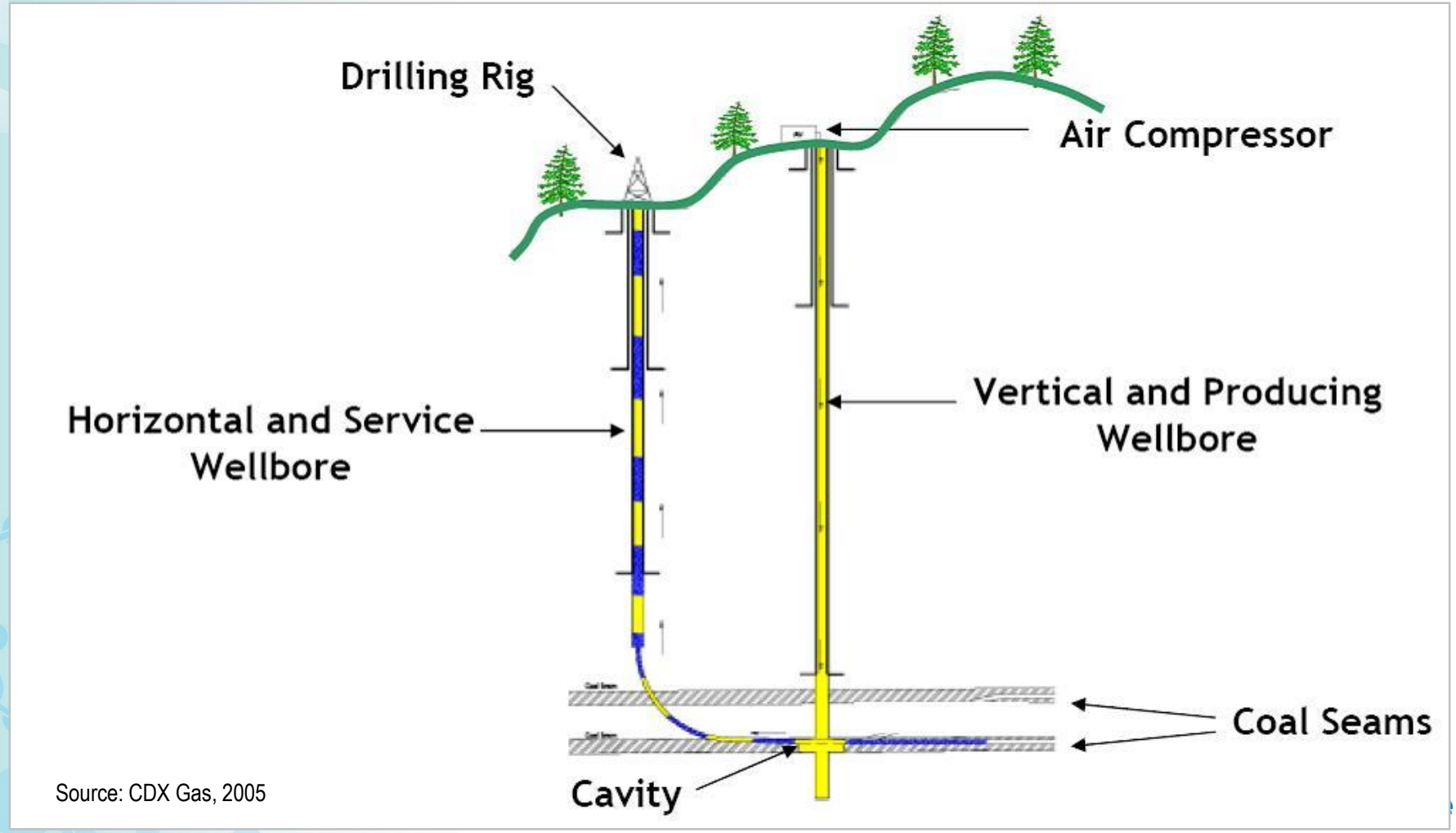
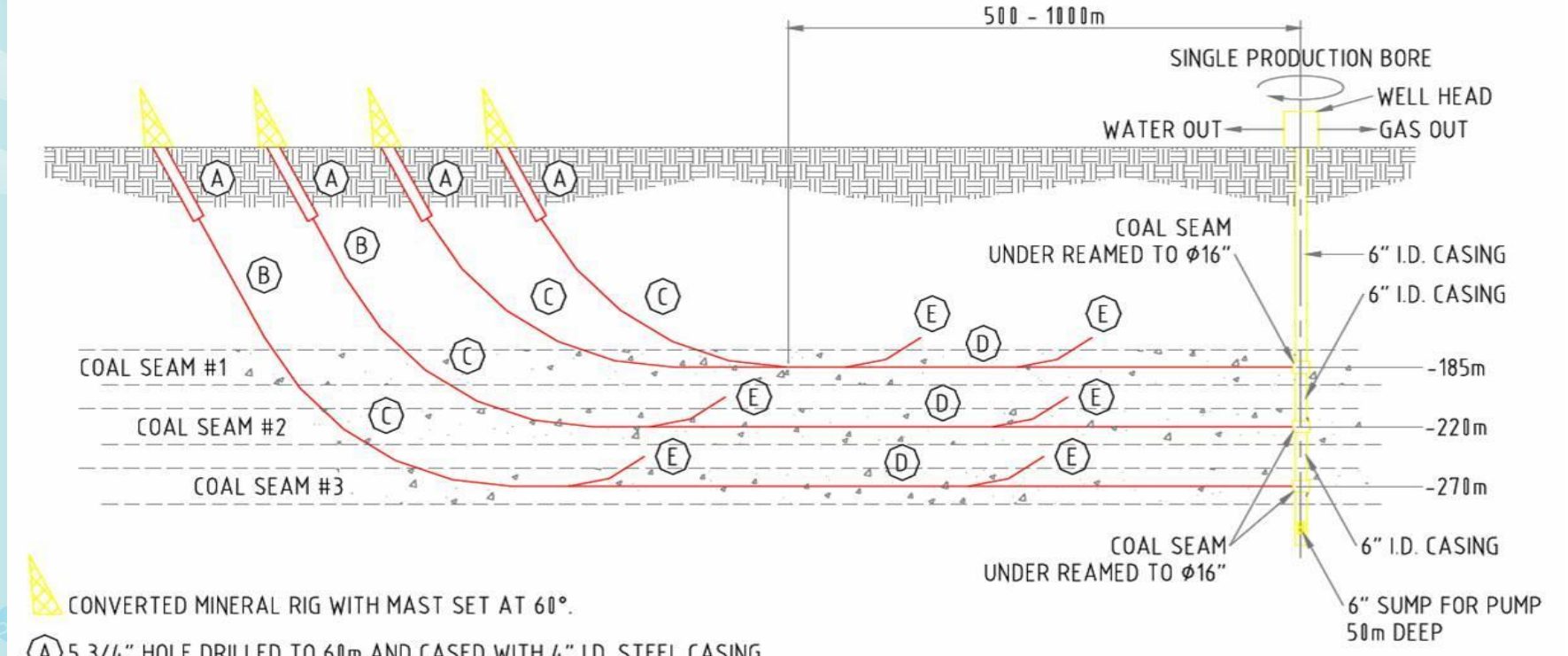
Surface to In-Seam Techniques Rely on Multiple Wells to Produce Gas

Dual Well System



Source: CDX Gas, 2005

Schematic of multiple horizontal wells drilled to a single vertical well



CONVERTED MINERAL RIG WITH MAST SET AT 60°.

(A) 5 3/4" HOLE DRILLED TO 60m AND CASED WITH 4" I.D. STEEL CASING.

(B) ø96mm HOLE DRILLED STRAIGHT TO WITHIN 125m OF THE TARGET COAL SEAM.

(C) ø96mm RADIUS BEND DRILLED TO LAND HORIZONTAL AND INTO THE COAL SEAM. BEND RATIO IS 7° PER 30m.

(D) ø96mm HOLE STEERED TO STAY WITHIN THE TARGET SEAM AND TO INTERSECT THE VERTICAL PRODUCTION WELL. - DRILLED DOWN DIP.

E LIMITED "ROOF TOUCH" BRANCHES TO ACCURATELY POSITION THE INSEAM HOLE IN THE SEAM AND TO CONFIRM SEAM DIP ANGLES.

Source: Mitchell Drilling, 2005

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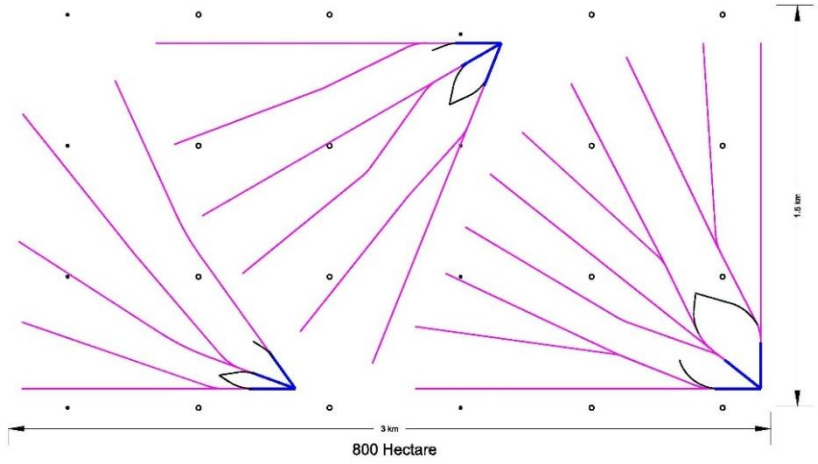
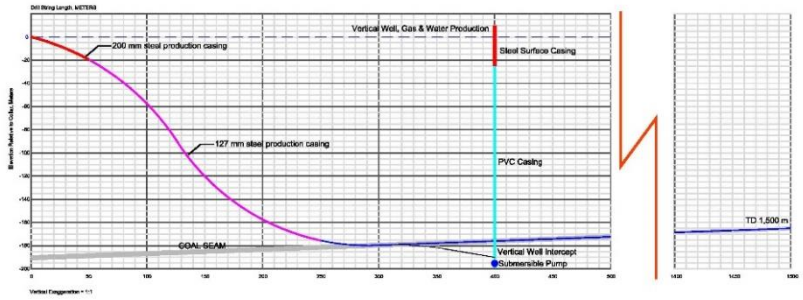
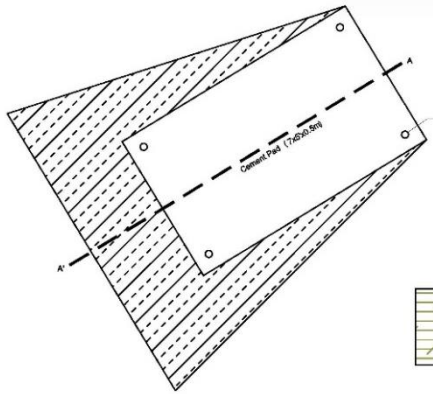
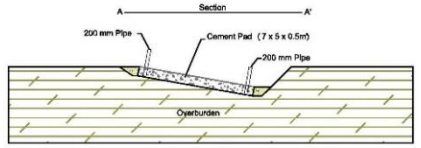
Example of a Surface to In-Seam for a Coal Mine in Mexico









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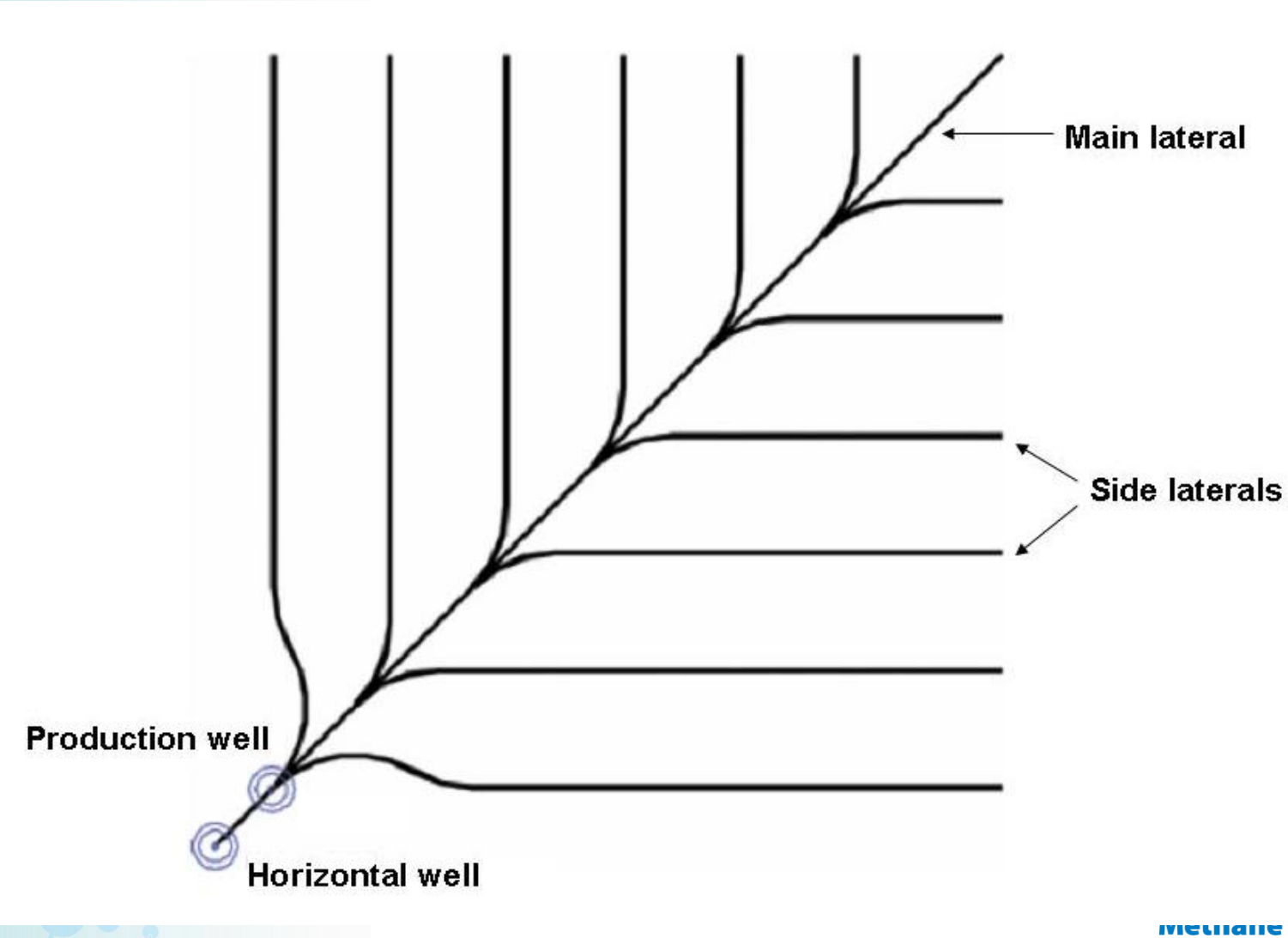
Top view of pinnate drainage pattern



Source: CDX Gas, 2005

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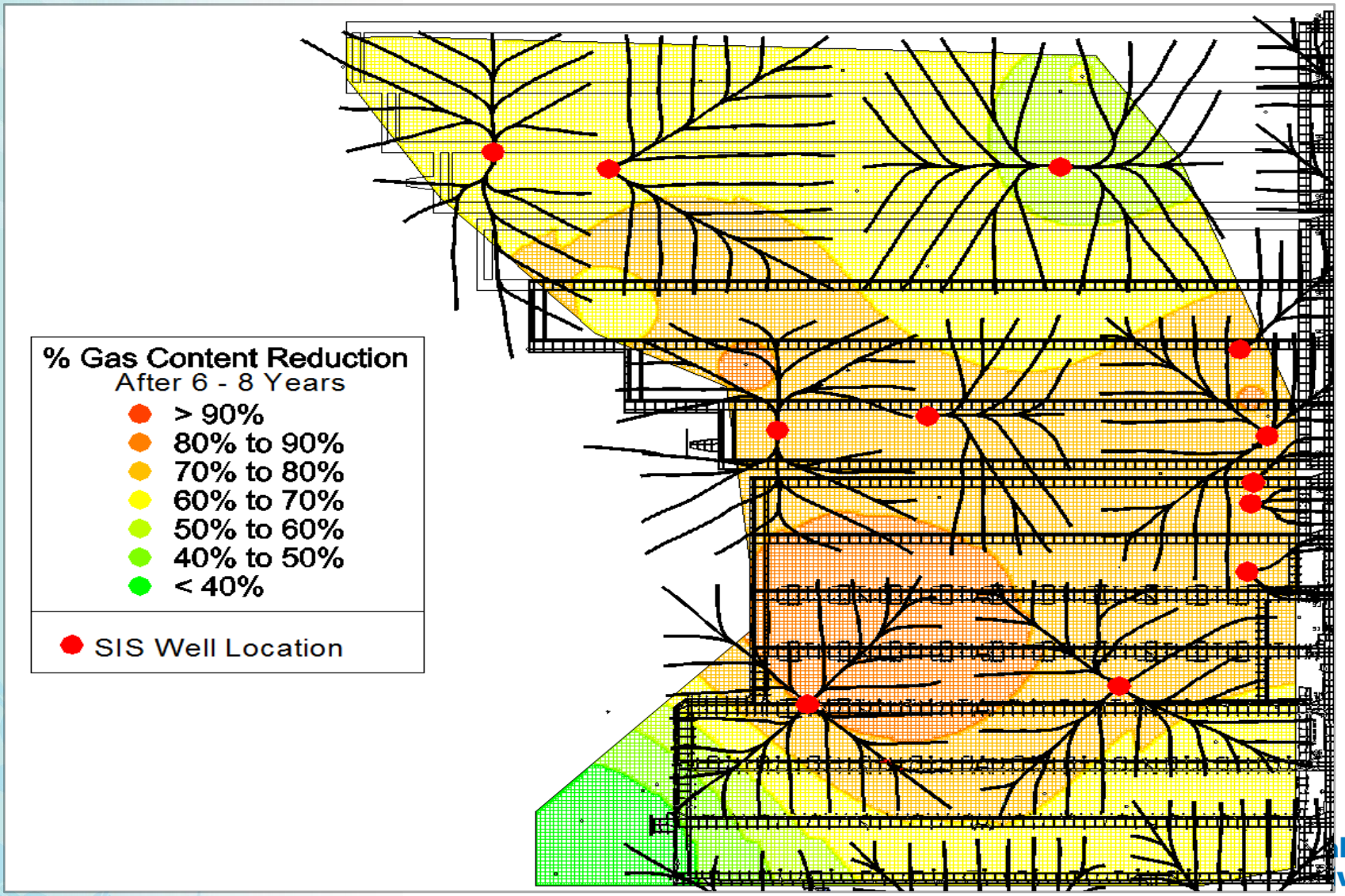
Effectiveness of SIS drainage



Post-Mining Techniques

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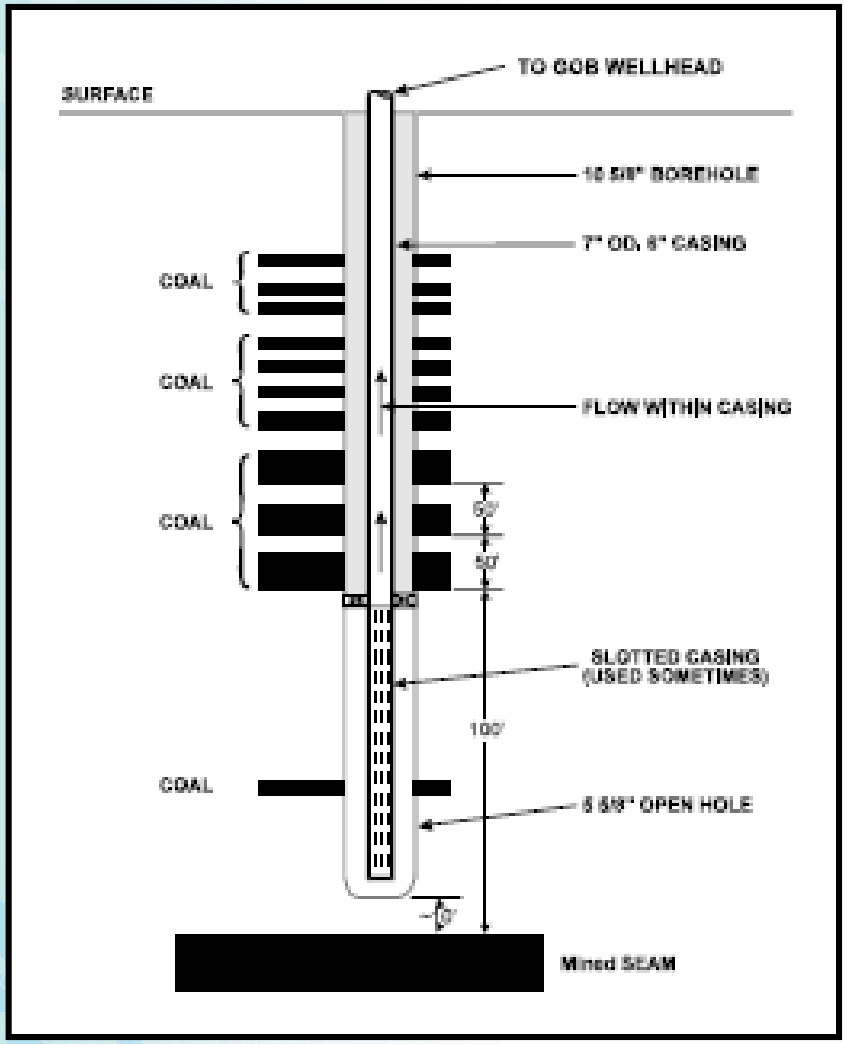
Vertical Gob Gas Drainage



Gob Gas – Vertical Gob Wells

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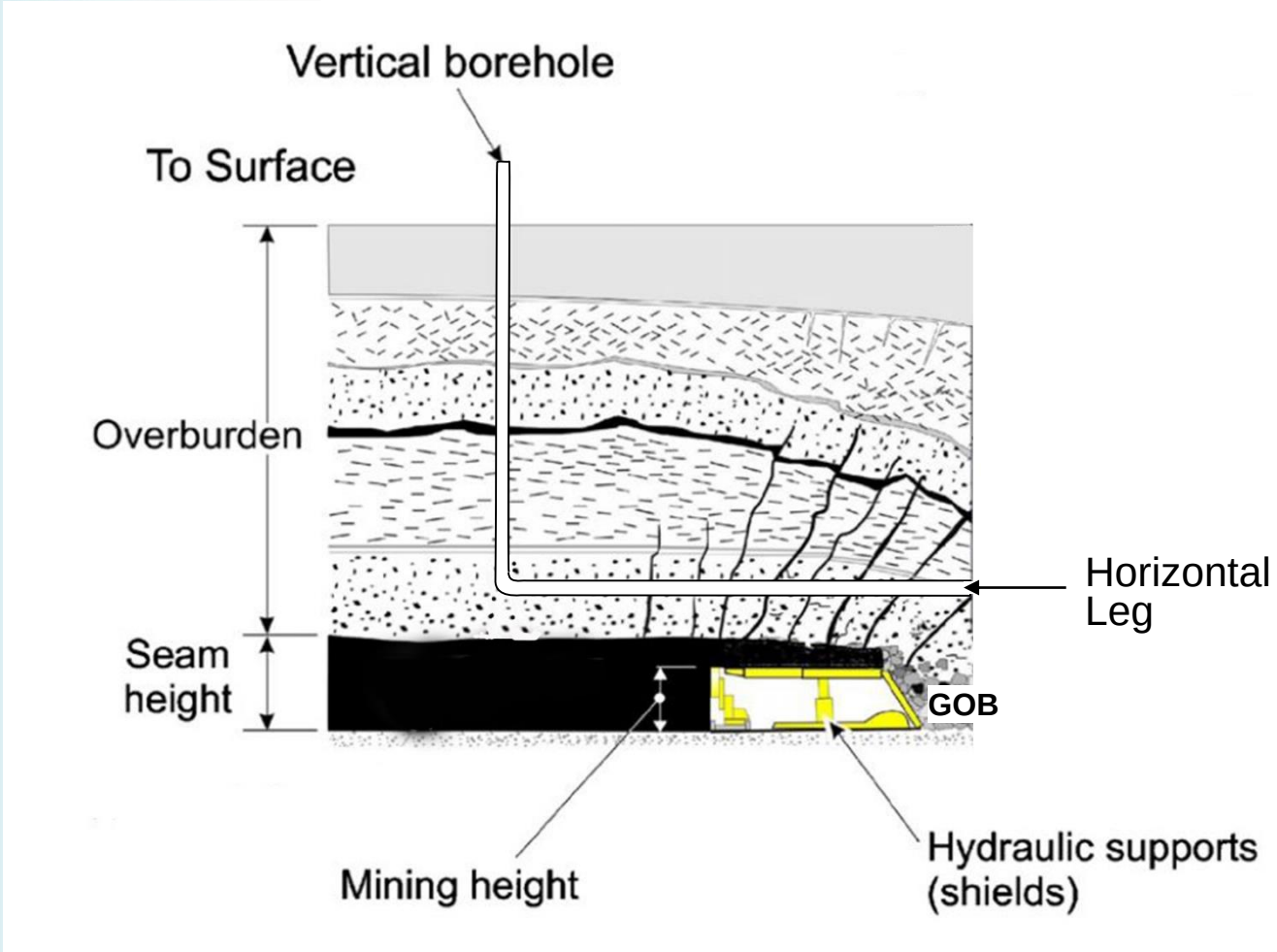
Schematic representation of longwall mining environment and surface drilled horizontal gob well



Source: Modified from C. Ozgen Karacan.

Thank You!

Jonathan R. Kelafant
jkelafant@adv-res.com
Sr. Vice President
Advanced Resources International

Monica Shimamura
Shimamura.Monica@epa.gov
Manager
GMI Administrative Support Group
U.S. Environmental Protection Agency

Valerie Askinazi
Askinazi.Valerie@epa.gov
Non-CO2 Programs Branch
Office of Atmospheric Programs
U.S. Environmental Protection Agency