Conducting CMM Project Pre-Feasibility Studies

Training by the U.S. EPA in Support of the Global Methane Initiative (GMI)

Global Methane Initiative

Welcome

The United States Environmental Protection Agency (EPA) developed this course in support of the GMI and in conjunction with the United Nations Economic Commission for Europe (UNECE). What is the GMI?

EPA United States Environmental Protection Agency

UNECE

This course introduces principles for assessing the potential of developing projects to capture and/or use Coal Mine Methane (CMM). The introduced general approach should be underpinned by mine-specific data and analyses, allowing the principles to be tailored to the unique conditions at each mine. Ideally, such an assessment will lead to project development and implementation.

What Is the Global Methane Initiative?

Global Methane Initiative

The Global Methane Initiative (GMI) is a voluntary, multilateral partnership that aims to reduce methane emissions and to advance the abatement, recovery, and use of methane as a clean energy source.

GMI Partner Countries

GMI Partner Countries account for nearly 70% of total global manmade methane emissions, which is equivalent to approximately 5,000 $MMTCO_2e$.

Conducting CMM Project Pre-Feasibility Studies: Course Modules

Module 1: Introduction and Objectives

Module 2: Mine Background Information and Evaluation

Module 3: Resource Assessment

Module 4: Forecasting Methane Production from Gas Drainage Systems

Module 5: Improvements to Gas Drainage

Module 6: Quantifying the Benefits of Improvements to Methane Drainage Systems

Module 7: Market, Risk, and Financial Analyses

Module 8: Case Study – Liulong Mine, China

Module 2

Mine Background Information and Evaluation

What You Will Learn

In this module, you will learn about:

- A two-stage approach to data gathering and analysis for CMM project prospects.

  Stage 1: Initial Data Request

  Stage 2: Detailed Mine Evaluation

- How to identify the data requirements for each stage.
- How and why the data are collected and their relevance to a pre-feasibility study.

Time needed to complete this module:

Approximately 45 minutes

Two Stages of Mine Evaluation

Mine evaluations for CMM projects are conducted through a two-stage approach:

- **Stage 1:** Initial data are requested from a mine owner/operator to obtain general mine background information.
- **Stage 2:** Initial analysis is conducted, which might include: clarifying data, visiting a mine site and initiating a more detailed analysis.

Stage 1: Initial Data Request

The initial data request is a simplified request to obtain general but informative data at the beginning of a pre-feasibility study. Such a request is typically brief and in an easily understood format to ensure a quick response from the mine owner/operator.

It can also rely on publicly available information, such as corporate annual reports, regulatory filings and other similar sources.

Additional follow-up with the owner/operator may be required.

Initial Data Request Questions

The initial data request should answer the following questions:

- Who is the mine owner/operator and what is their interest, technical capacity and financial capability to support the project?
- Where would the project be located?
- Is there reasonable access to the site?
- Does the owner/operator have experience hosting and/or developing other CMM or VAM projects?
- Is the gas resource potential sufficient to supply a CMM or VAM project over time?
- Is the type of mining (longwall vs room-and-pillar) and the rate of coal production likely to release reliable, consistent and predictable quantities of gas?
- Is the mine gas of a quantity and quality that is capable of supplying an end use?

Benefits of the Initial Data Request

Benefits of conducting the initial data request include:

- ✓ Requires responses from mine owner/operator without significant level of effort.
- ✓ Offers an opportunity for cost-effective data collection, since data can be transferred quickly and site visits are not required.
- ✓ Provides a basis for substantive engagement with the mine owner/operator.
- ✓ Allows for early-stage evaluation of CMM or VAM project potential before commitment of significant financial and labor resources for the pre-feasibility study.
- ✓ Highlights some notable issues that could impact a project and project structure.
- ✓ Flags items for more in-depth review and analysis.

View an example of a simplified data request that is used by GMI and EPA.
Note that the data request can be tailored to the specific circumstances at a mine based on prior knowledge.

Sample Elements of an Initial Data Request.

GMI/EPA Example Initial Data Request	
1	Name of coal mine
2	Physical address (with map and/or satellite photo if possible)
3	Parent company overview
4	Name of mine contact/position/telephone and email
5	Date coal mine opened
6	Coal and gas resources and reserves if known
7	Remaining life of mine (years)
8	Coal production capacity (tonnes per year)
9	Historical coal production – last 5 years (tonnes per year)
10	Depth of mining below surface

Other Sources of Data

Relevant data may also be available from other public sources, including:

- Corporate information
- Mine plans, including ventilation and degasification
- Geologic data
- National, regional, and mine-specific coal and gas production and sales
- National, regional, and mine-specific coal and gas reserves
- CMM project type (power generation, flaring, etc.) and emission reductions
- Natural gas infrastructure
- Potential markets for CMM, energy pricing and pricing for environmental attributes (e.g., carbon pricing, feed-in-tariffs, etc.)
- Mine safety records
- Topographic, geographic and meteorological information

Where to Find Other Data

Data can be found on the Internet, often with very limited effort, or through direct approaches to regulatory agencies.

Sources may include:

- Corporate annual reports, especially for publicly held companies
- Websites for mine owner/operators
- Other stakeholders such as GMI, USEPA, UNECE, CSIRO, CCII, and the International Centres of Excellence on CMM and other organizations
- Regulatory filings with regulatory agencies and design institutes
- Tax records showing gas and electricity production

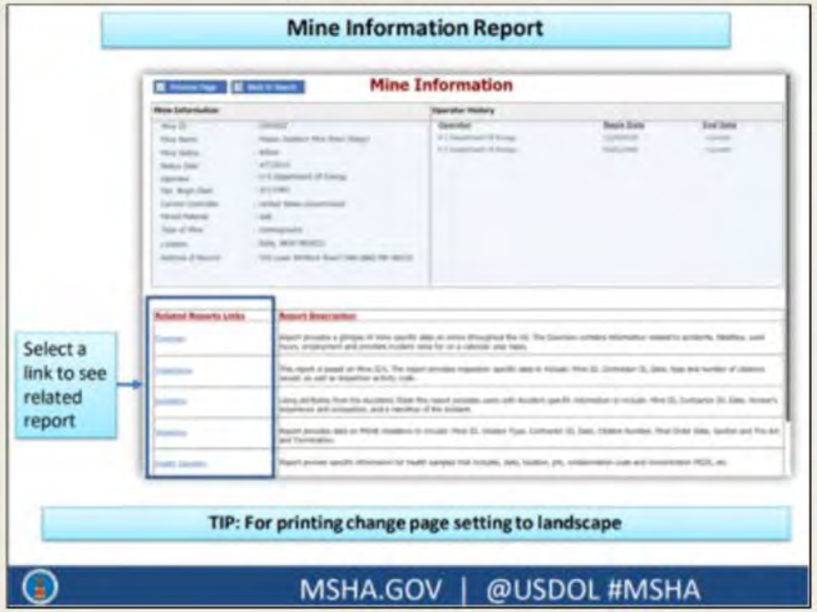
Other Options to Locate Data

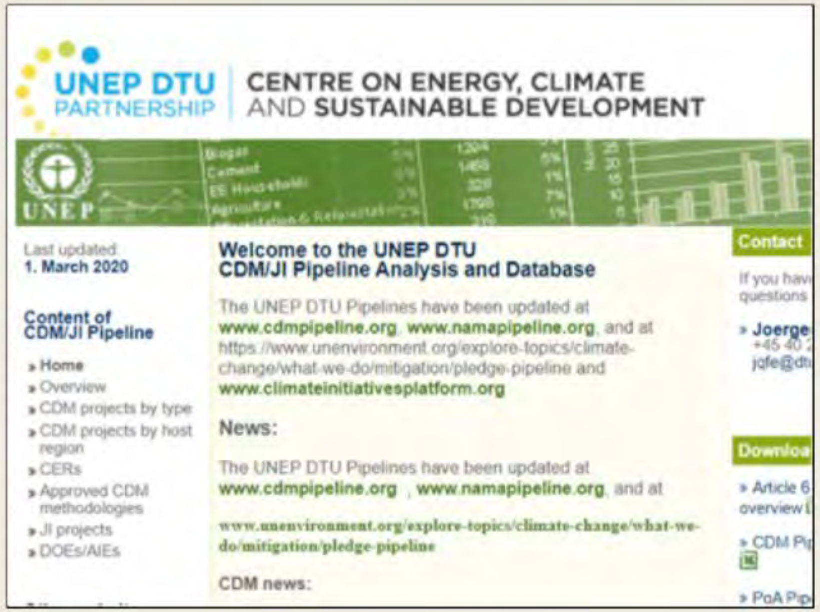
Data may also be found by reviewing conference and workshop presentations, papers and feasibility/pre-feasibility studies that are available to the public, as well as by checking:

- Documentation and websites for mine safety, energy, environmental and bilateral trade ministries.
- Carbon registries and carbon trading programs such as the UNEP CDM pipeline and the California Cap-and-Trade Program.

Examples of Publicly Available Data

Examples of public websites that provide mine information are presented below.





[Mine Safety and Health Administration]

[Coalbed Methane Outreach Program]

[Centre on Energy, Climate and Sustainable Development]

Stage 2: Preparing for the Detailed Mine Evaluation

Data obtained in response to the initial data request can be used to determine whether to continue with a pre-feasibility study.

If this initial analysis shows promising results, continuing the study will require:

- Additional clarification of responses to the initial data request.
- A detailed mine evaluation based on a more detailed data request.
- Site visit to review additional data at the mine, engage with the mine staff, and tour the surface and underground workings.

Objectives of the Detailed Mine Evaluation

- Provide additional insight into the **mine company management and operations**.
- Confirm **location of mine facilities** and planned CMM project site and site access.
- Obtain detailed **geologic data** to confirm gas and coal resources necessary for accurate gas production forecasts.
- Obtain more detailed **time-series data** on coal production, drained gas production, and VAM emissions including variations in CH_4 concentrations and flow rates.
- Gather **mine maps** showing longwall panels, mains, gate roads, ventilation circuits, boreholes and shafts.
- Obtain **surface maps**, cross sections, stratigraphic columns and geologic history.
- Confirm **borehole designs** for surface and in-mine pre-drainage and gob wells.
- Review **gas drainage systems** and the efficiency of those systems.
- Evaluate **mine ventilation systems**.

Benefits of a Detailed Mine Evaluation

- ✓ Developing comprehensive knowledge of the mine operations and mine workings
- ✓ Engaging directly with mine staff through site visits and visually inspecting surface installations and potentially underground workings

The more accurate the data are that you are able to obtain, the more accurate the pre-feasibility study report will be.

Steps for a Detailed Mine Evaluation

Overview and Characteristics | Ventilation | Gas Drainage | **Detailed Mine Evaluation**

The detailed mine evaluation typically requires additional data that may be obtained through numerous iterations.

Such data are relevant to the mine overview and characteristics, ventilation, and gas drainage.

Steps for a Detailed Mine Evaluation

Overview and Characteristics → Ventilation → Gas Drainage → Detailed Mine Evaluation

1. Mine Background – History and Culture
2. Mine Overview
3. Characteristics – Coal Production
4. Characteristics – Mining Hazards
5. Characteristics – Methane Emissions

Steps for a Detailed Mine Evaluation

Overview and Characteristics | **Ventilation** | Gas Drainage | Detailed Mine Evaluation

6. Ventilation – Requirements
7. Ventilation – Mains
8. Ventilation – Practices
9. Ventilation – Methane Flow Distribution
10. Ventilation – Source of Emissions

Steps for a Detailed Mine Evaluation

Overview and Characteristics → Ventilation → **Gas Drainage** → Detailed Mine Evaluation

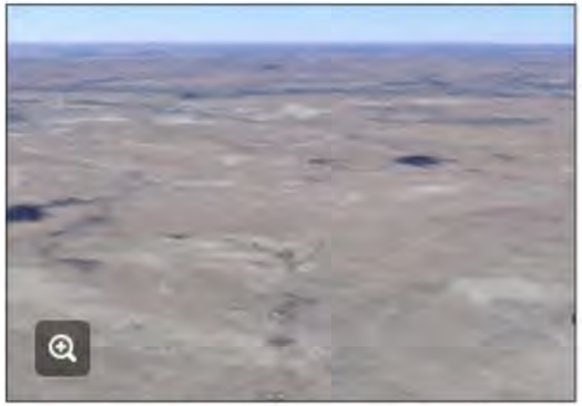
11. Gas Drainage – Current Practices
12. Gas Drainage – In-seam Analysis
13. Gas Drainage – Gob Gas Analysis
14. Gas Drainage – Capture Efficiency

Mine Background - History and Culture

A better understanding of the target mine and the local coal industry and mining practices is obtained by researching:

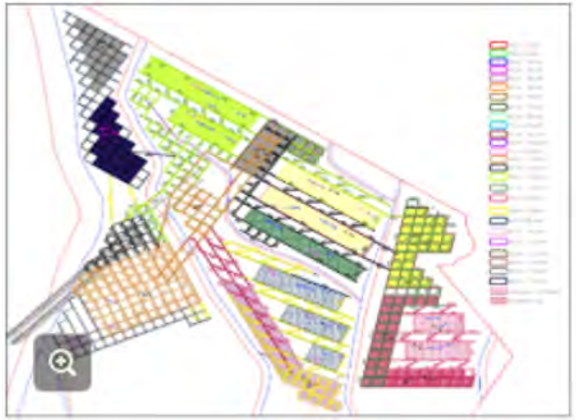
- Regional history and adjacent mining
- Method of coal handling and transport
- Detailed topography
- Surface access to all mine operations including gas pumping stations and ventilation shafts
- Surface rights and infrastructure
- Local industry

Poland



Kazakhstan

Mine Overview



Obtain detailed mine maps that show the mine layout and production plan.

Purpose

- Improve understanding of mine operations
- Identify future mining districts including reserve additions
- Identify ventilation circuits and existing boreholes
- Necessary to ultimately decide on placement and scheduling of boreholes for improved gas drainage

Data Required

- All mining levels
- Men and materials egress routes
- Coal production/belt routes
- Sealed areas
- Developments
- Longwalls
- Timing map

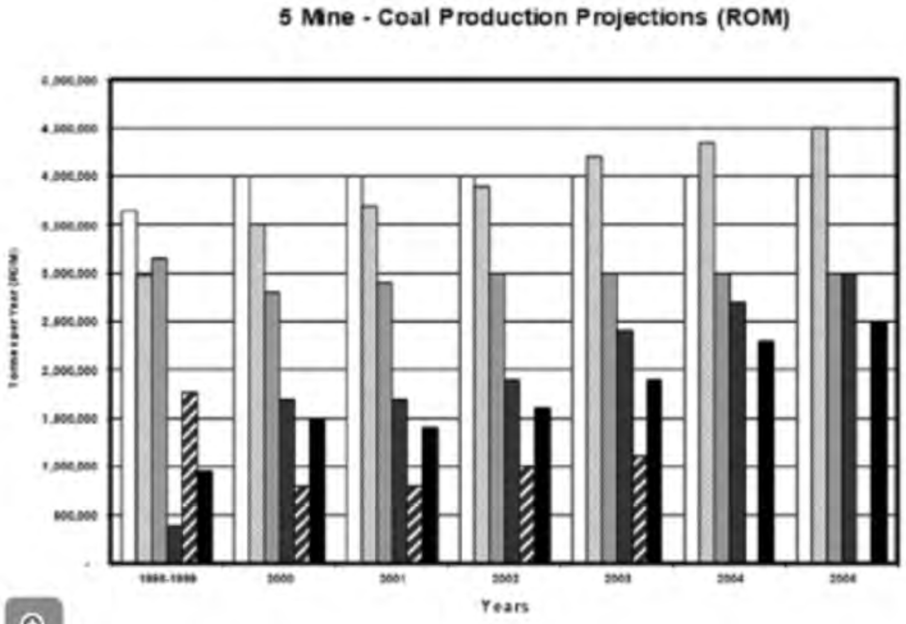
Coal Production

Obtain historical coal production data and the mine's production forecast, including:

- Run of Mine "ROM" production
- Clean or saleable production

These data are used to understand:

- Mine operational history
- Production capacity
- Future production plans that can impact a CMM project and mine gas production
- Possibly correlate trends in gas production to coal production



Mining Hazards

Identify mining hazards that can impact coal production, gas emissions and general mine safety, which may include the following:

Coal Production

- Methane related delays
- Methane ignitions
- Gas outbursts
- Spontaneous combustion

Structural Concerns

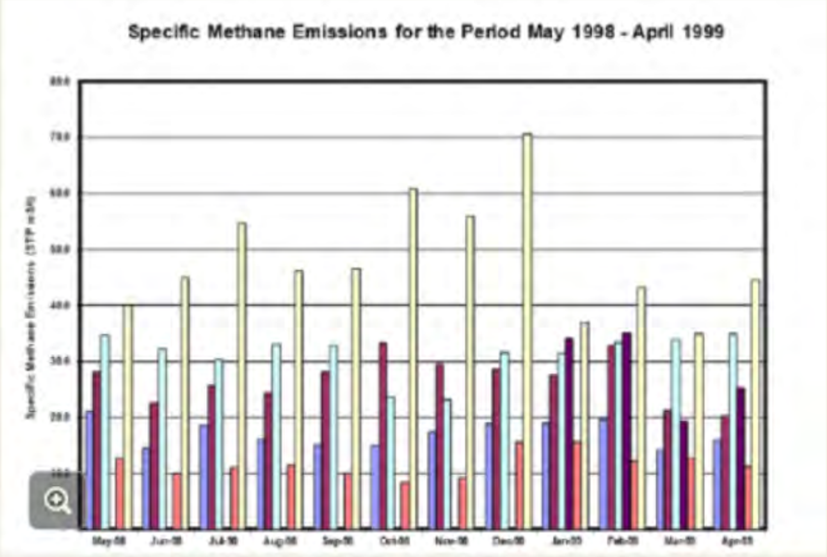
- Vertical stresses
- Horizontal stresses
- Potential for air pockets and water reservoirs (especially in karst formations)
- Igneous intrusions

Historical Information

- Methane-related explosions
- Mine fires

Methane Emissions

Obtain more detailed time-series methane emissions data. This provides a clear picture of historical methane production and the relationship between ventilation and gas drainage.



Important data include:

- Methane vented and methane drained
- Historical emissions
- Specific emissions (m^3 CH_4/t coal mined)
- Gas composition
- Percent methane vented and percent methane drained

Ventilation Requirements

Mine ventilation systems are essential to the underground workings and are required by regulation. They introduce fresh air and remove dust and gases, including methane.

Ventilation systems are the first step in removing methane from the mine. Mines will attempt to balance methane capture through ventilation and gas drainage systems to minimize costs while maximizing capture.

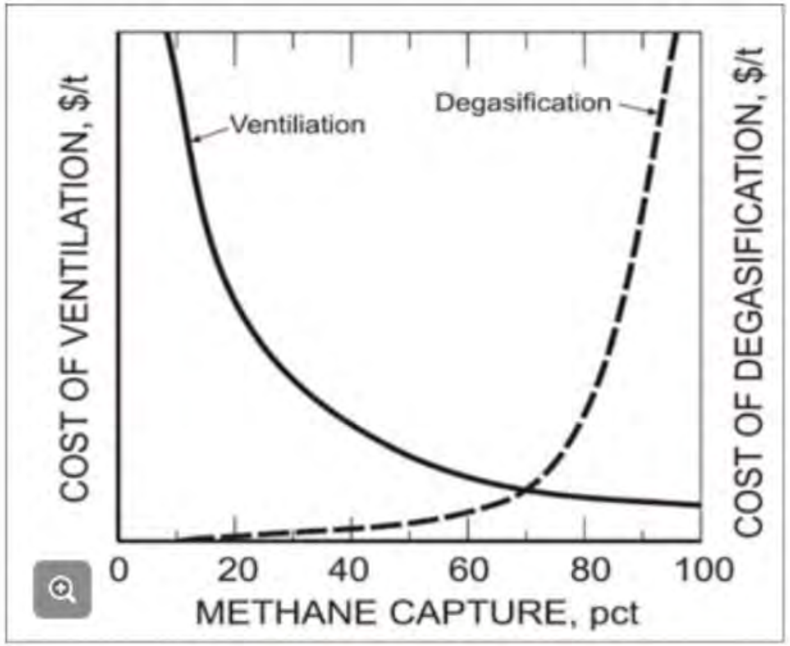
Data that are Necessary to Assess the Ventilation System

- Minimum airflow and maximum velocity
- Maximum methane concentration
- Beltways
- Gob ventilation (bleeder shafts)
- Sealed airways
- Booster fans and main fans

Ventilation Main

The ventilation main is the primary ventilation circuit to introduce fresh air into the mine working areas. It is important to understand the type of ventilation system and the capacity of the system. Data to collect include:

- The ventilation system
  - ➢ "Exhaust" system pulling air through the mine from the intake shafts
  - ➢ "Forcing" system pushing air through the mine to uptake exhaust shafts
- Main fan performance
- Main fan capacity



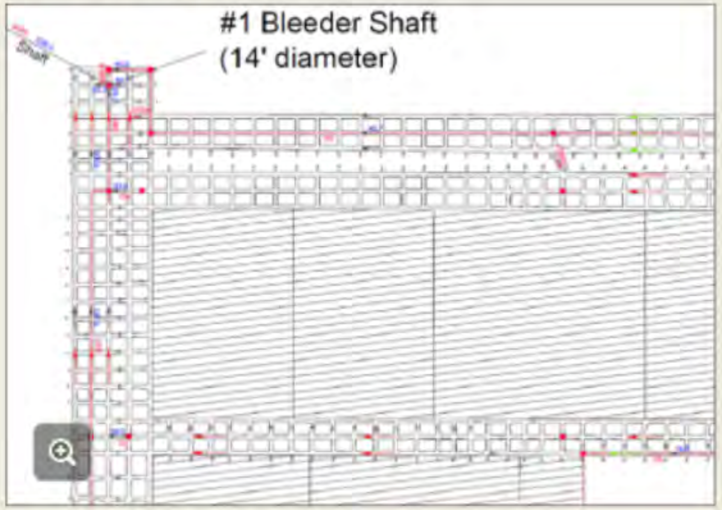
Ventilation Practices

Depending on the purpose of the pre-feasibility study, additional data on ventilation practices may benefit the study.

- Necessary for a VAM project pre-feasibility study
- May benefit a gas drainage-based CMM project pre-feasibility study if ventilation practices could impact the volumes and CH_4 concentrations in gas drainage

Ventilation Practice Data to Collect

- Ventilation surveys and network modeling
- Ventilation practice used for developments
- Ventilation practice used for longwall panels and longwall districts
- Ventilation measurement locations and methodology



Overview and Characteristics | Ventilation | Gas Drainage | Detailed Mine Evaluation

Methane Flow Distribution

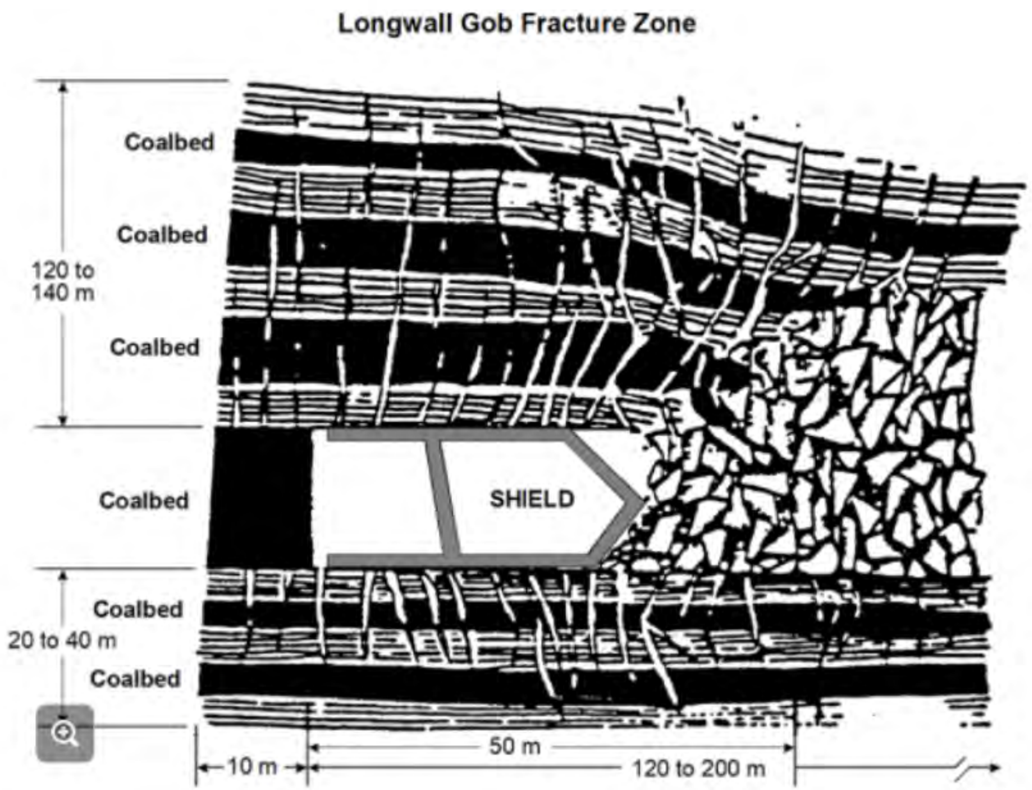
Methane flow distribution data contribute to understanding the gas balance of the mine. Methane flow distribution data:

- Support design of the gas drainage plan
- Provide the basis for potential improvements to the ventilation plan

Methane Flow Distribution Data to Collect

- Gas Flow/Concentration
  - ➢ Development section
  - ➢ Longwall districts, panels and faces
- Mine Wide
  - ➢ Gas flow distribution
  - ➢ Concentration distribution

Ventilation Sources of Emissions



It is very important to understand the source of emissions into the mine ventilation systems.

The full list of emission sources may not exist in every case, but effort should be made to identify the most significant contributing sources and the entry points of emissions into ventilation.

Potential Ventilation Sources of Emissions

In addition to distribution of emissions, a study should assess emission characteristics, location and source (see table to the right).

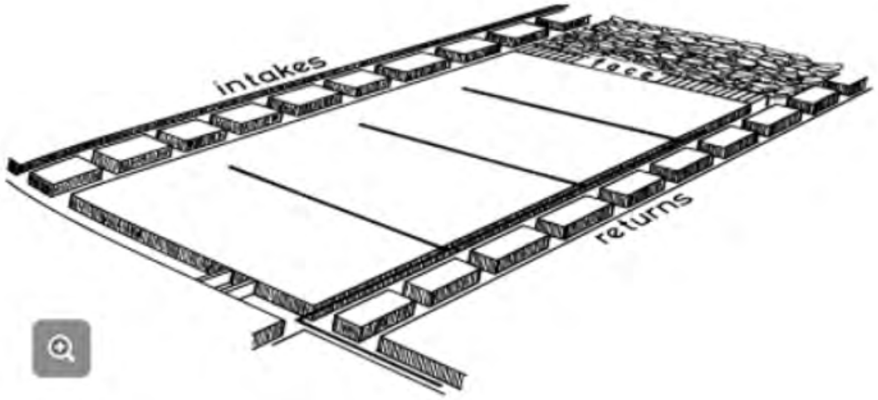
Ventilation Emissions Considerations		
Characteristics	**Location**	**Source**
• Operating coal faces • Start of longwall panels • Gas bearing underlying strata • Charged deep underlying gas sources	• Roof fractures • Floor fractures • Working seam • Behind shields • Gob, bleeders, belt, transported coal	• Mining seam • Gas bearing overlying strata • Gas bearing underlying strata • Charged deep underlying gas sources

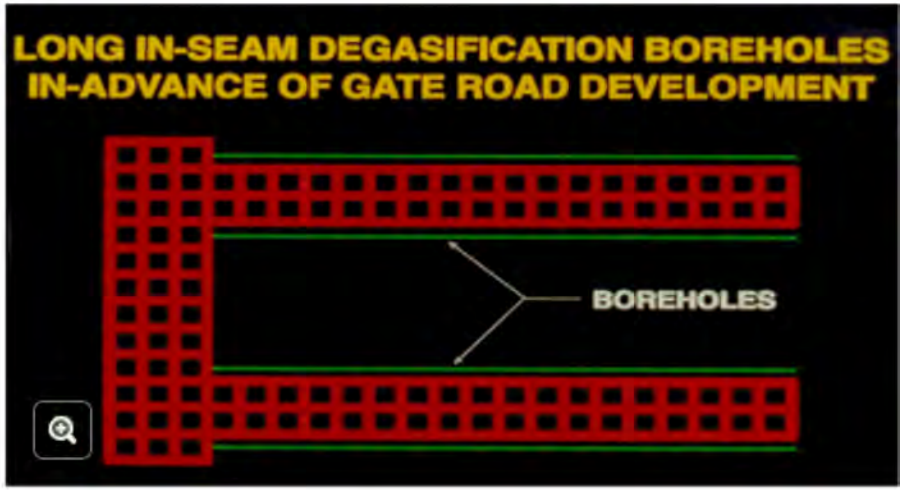
Gas Drainage Practices

Gas drainage is the removal of CMM through a system of pre-mine or post-mine boreholes or drainage galleries, and the collection and movement of that gas through a pipeline network to the surface.

Understanding the existing drainage system is critical for a pre-feasibility study for the following reasons:

- Impacts mine gas balance
- Provides data on gas availability and drainage efficiency
- Provides basis for proposing improvements to gas drainage

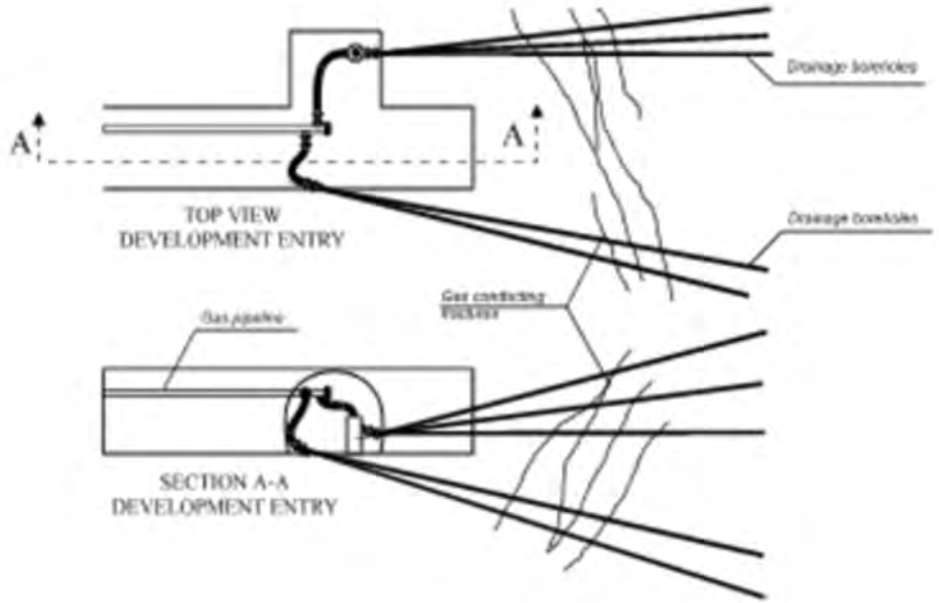




Gas Drainage Current Practices: Boreholes

Various pre-drainage techniques exist and are dependent on mining operations, gas properties, typical practice and availability. The following lists common techniques employed by mines worldwide:

- Surface vertical pre-drainage boreholes
- Horizontal surface in-seam or in-mine gob boreholes
- Surface gob wells
- In-mine horizontal gob wells
- In-mine cross-measure boreholes
- Overlying or underlying drainage galleries



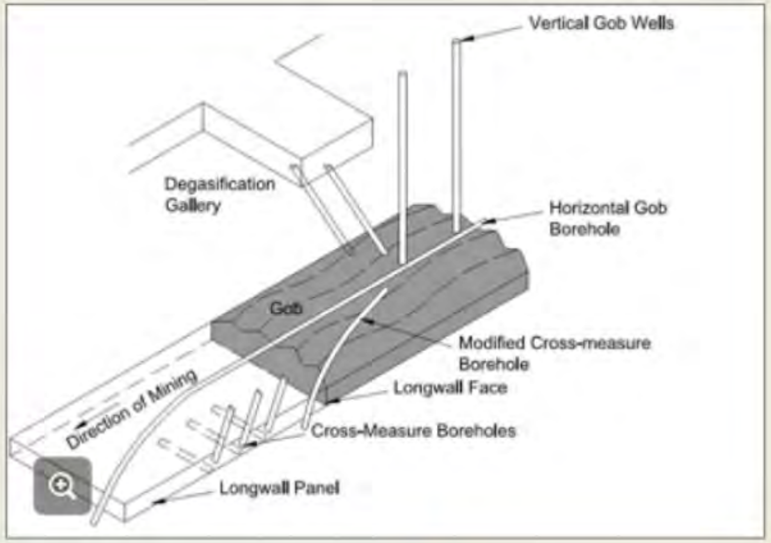
Borehole Data

For all existing boreholes, effort should be made to collect data on:

- The approach
- Borehole/well patterns
- Overall gas production
- Overall gas concentration
- Recovery duration

If available, review time series gas production and methane concentration data rather than single measurements.

For example, continuously monitored, hourly or daily measurements will be more accurate and provide greater confidence in the data.



Gas Drainage Current Practices: Gas Collection

A gas collection system is a network of pipeline and vacuum pumps that move produced CMM from boreholes to the surface to be used or vented. The system often includes dewatering and dust removal equipment.

Air ingress into the gas collection system can compromise mine safety, reduce efficiency of gas drainage and impact the operation of a CMM utilization project.

Data on Gas Collection

Gas collection data to obtain include:

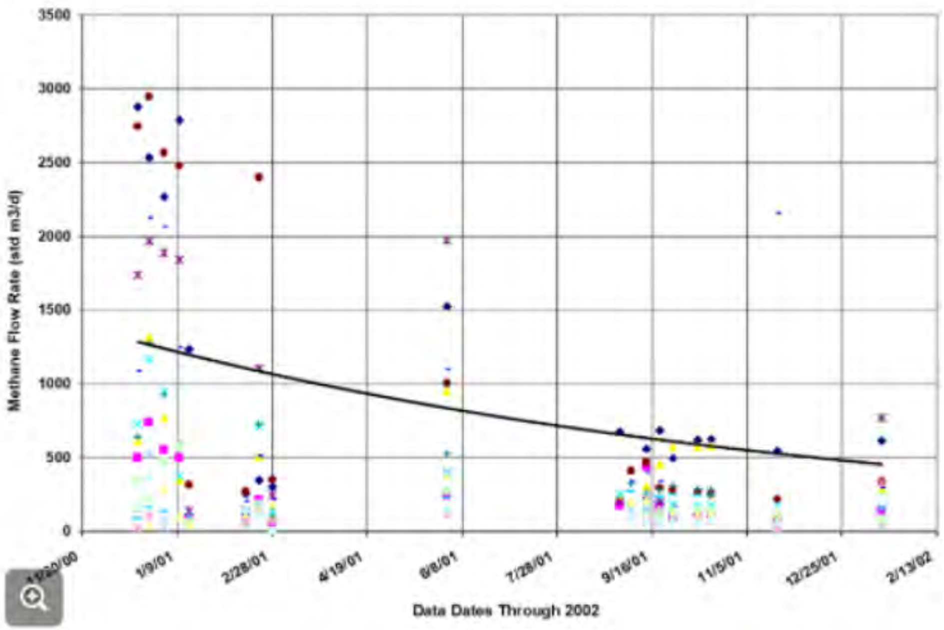
- Approach
- Pipeline routes
- Pipeline characteristics
- Integrity monitoring
- Performance monitoring
- Overall production
- Overall performance
- Capacity

In-seam Analysis: Individual Borehole Performance

Individual borehole performance should be reviewed and assessed. Borehole-specific data derived from a consistent and regular monitoring program should be available for review.

Information regarding the following are required to assess in-seam drainage:

- Gas production rates
- Rate vs. time
- Residual gas content
- Effectiveness
- Costs



Drilling Techniques and Production Casing

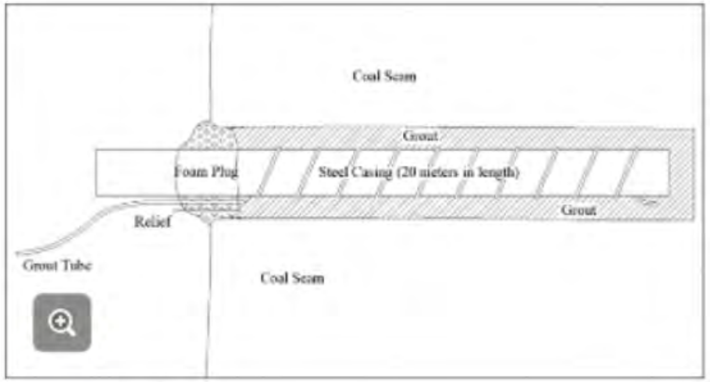
Additional data on the drilling techniques and production casing will provide a more complete picture of the effectiveness of current drainage practices. Relevant data include:

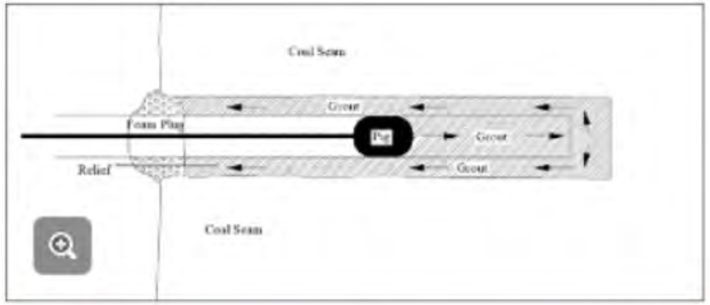
Standpipe

- Specifications
- Grouting procedures
- Pressure testing

Drilling

- Technique
- Equipment
- Geomechanical properties of coal seam
- Friability/solubility of the coal



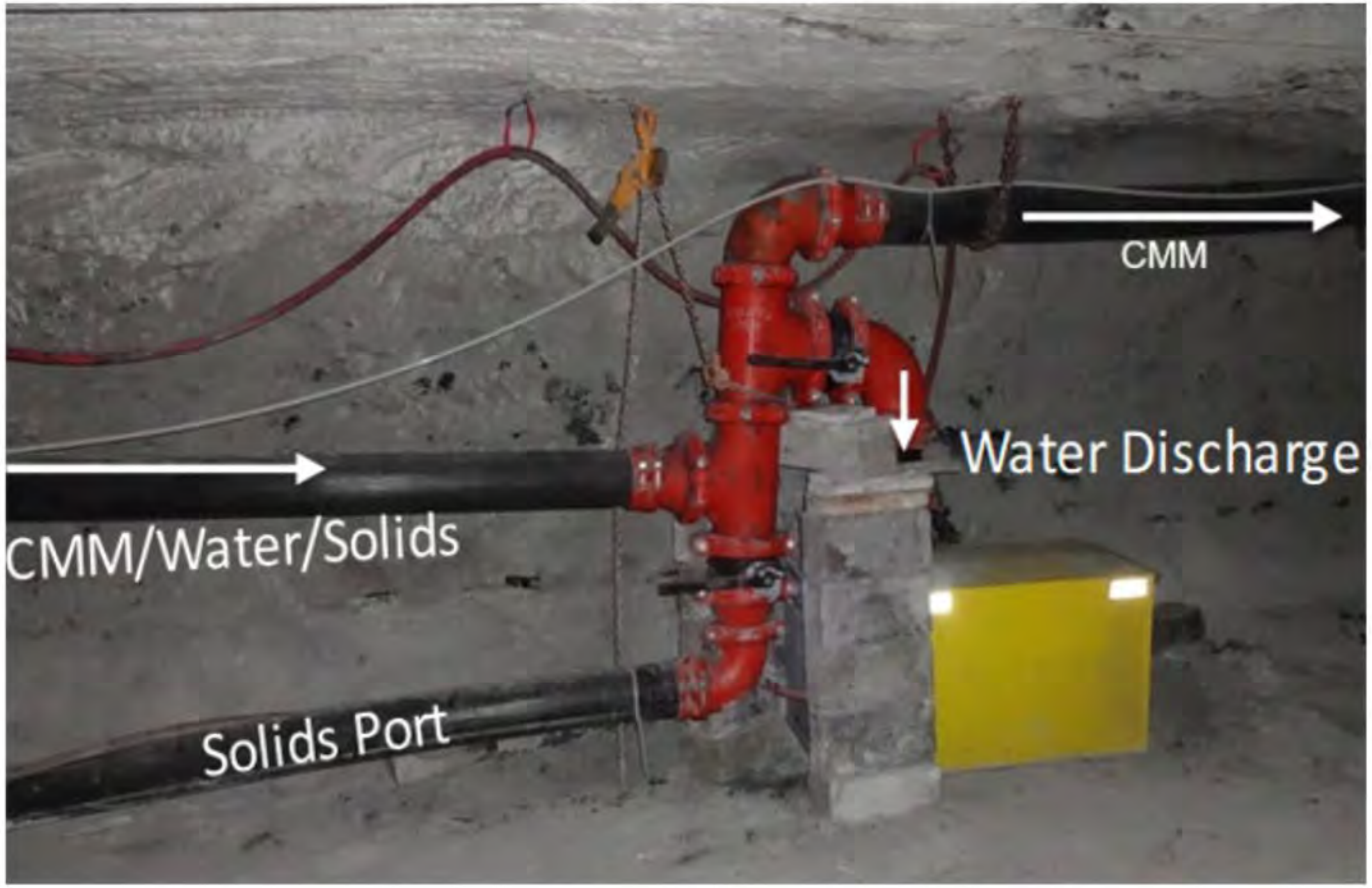


Production Wellhead and Gas Pipeline

Monitoring provisions should be in place to regularly check the gas flow at the wellhead and to ensure any leaks or emissions are addressed.

Improvements to wellhead performance and the pipeline network can increase gas availability for use.

Data on Production Wellheads and Gas Pipelines



Production wellhead data to collect:

- Gas/water separation
- Performance monitoring provisions
- Safety systems

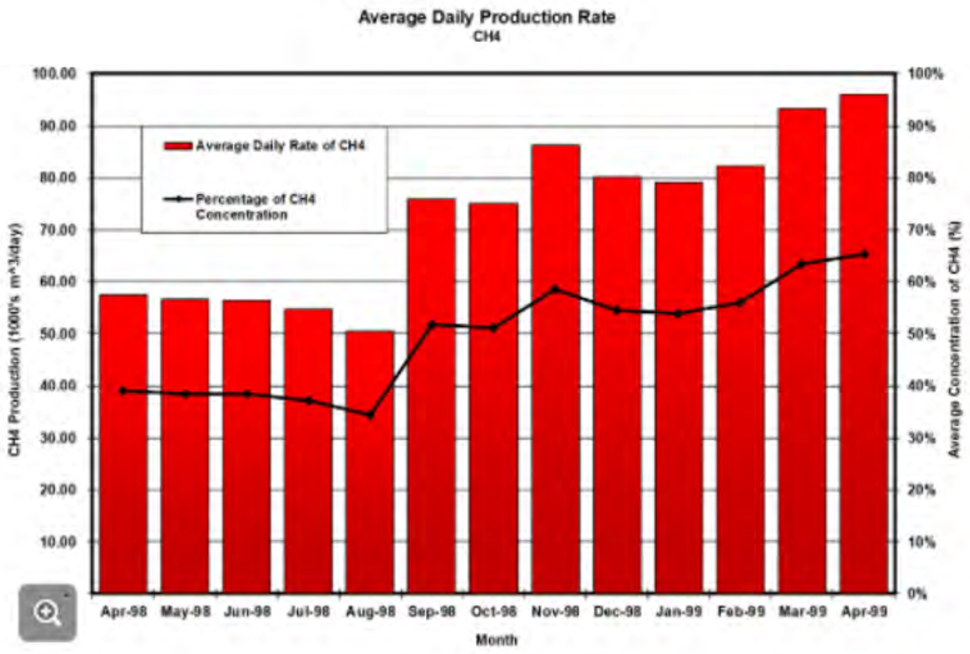
Pipeline data to collect:

- Gas/water separation
- Performance monitoring provisions
- Gas flow distribution
- Concentration distribution
- Pressure distribution

Analysis of Gob Data

Collect and review data for each gob borehole or gallery, preferably continuously monitored data, average daily data, or data collected at the same locations and times each day, such as:

- Gas production rate (m3/min)
- Methane concentration
- Methane production rate in relation to:
    - Coal production rate
    - Location of the longwall face
- Effectiveness of the gob wells, including if gobs/galleries are:
    - Delivering methane flows at safe and useable concentrations (≥30% methane)
    - Maintaining safe methane concentrations in the mine ventilation air



Gob Gas Analysis: Individual Borehole Performance

Significant volumes of methane can be released into the goaf (gob) area as the longwall panel is mined through.

The zone of influence for gas-bearing coal and rock strata is 160-200m above and 40-70m below the mined seam.

Gob gas may be removed from the mine by use of vertical surface boreholes, surface directionally drilled boreholes, in-mine directionally drilled boreholes, cross-measure boreholes and drainage galleries.

In-mine Drilling Techniques & Production Casing

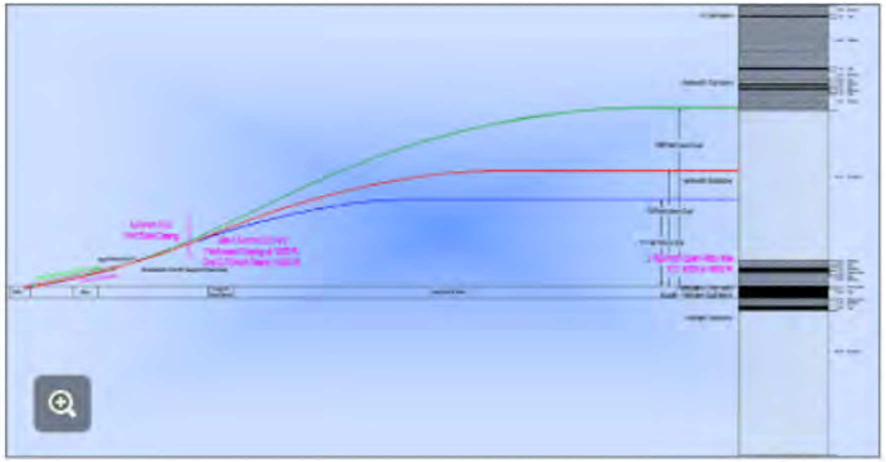
Similar to in-seam drainage boreholes, in-mine drilling techniques used for gob gas boreholes (directionally drilled, cross-measure, overlying/underlying drainage galleries) and production casing should be reviewed for the pre-feasibility study.

Development

- Installation technique
- Geomechanical properties
- Friability/solubility
- Costs

Standpipe/Connection

- Specifications
- Procedures
- Pressure testing



Surface Wellhead & Production Casing

Use of vertical gob wells produce CMM at the surface where it is sent through a pipeline gathering system to an end-use.

A vacuum is eventually placed on the wellhead to create sufficient pressure to produce the gas.

Data on Surface Wellhead & Production Casing

Where surface gob wells are used, the following information should be analyzed.

Production Wellhead

- Mover (i.e., fan)
- Vacuum pressure
- Performance monitoring

Pipeline

- Wellhead vacuum
- Control provision
- Gas/water separation
- Gas flow distribution
- Concentration distribution
- Pressure distribution

Capture Efficiency of Gas Drainage System

"Capture Efficiency" of the drainage system is the share of drained gas as a percentage of total methane emissions produced. See the table below for an example chart that displays capture efficiency by month at a mine.

Capture Efficiency = *CH_4 from drainage / (CH_4 from gas drainage + CH_4 from mine ventilation)*

	Jul	Aug	Sep	Oct	Nov	Dec
Average Ventilation (m^3/min of CH_4)	23.7	21.9	24.5	21.6	17.9	20.7
Average Captured (m^3/min of CH_4)	78.4	102.2	91.2	94.1	99.6	105.7
Total (m^3/min of CH_4)	102.1	124.1	115.7	115.7	117.5	126.4
Capture Efficiency (%)	76.8	82.3	78.8	81.4	84.8	83.6

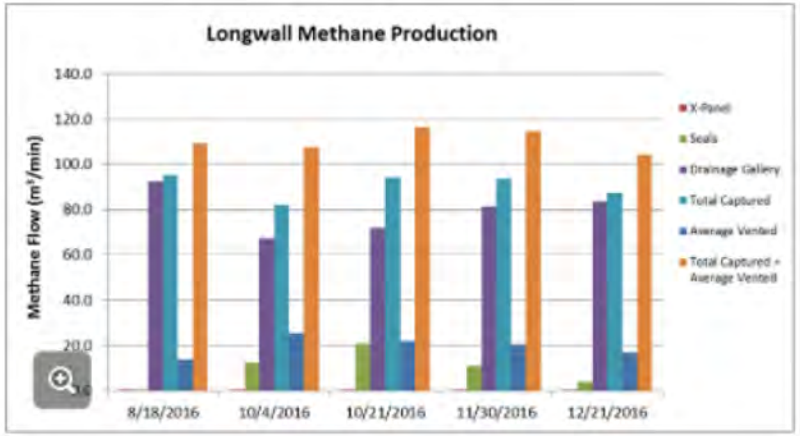
Capture Efficiency Considerations

Greater efficiency can indicate better designed boreholes and a more effectively operated gas collection system.

- **Lower efficiency** – potential for improvements to gas drainage that could increase gas quantity and quality.
- **Higher efficiency** – there may be limited improvements that can be made to gas drainage and it may not be cost-effective to do so.

Efficiency should also be considered with CH_4 concentrations in mine ventilation and gas drainage. High efficiency but very low methane concentrations may indicate an over-reliance on gas drainage.

Capture Efficiency Data



To accurately assess capture efficiency, obtain and review the following data.

System Efficiency

- In-seam drainage/panel/district
- Gob gas drainage/panel/district
- Overall methane drainage efficiency

Observations

- Overall effectiveness
- Contributions
- Concentrations
- Impact on mining

Module 2 Summary

In this module, you learned about the two stages of data collection that provide the person who prepares the pre-feasibility study report with an understanding of mine operations and methane management. This allows for early-stage evaluation of CMM or VAM project potential before commitment of significant financial and labor resources for the pre-feasibility study.

- While it is ideal to obtain all of the data identified in this module, it is rarely feasible to do so.
- It is imperative to recognize, understand and account for the potential uncertainties of the data throughout the development of the pre-feasibility study.
- The analysis and outcomes of a pre-feasibility study are only as good as the data that underpin the study.

Looking Ahead

The initial data request and detailed mine evaluation provide the basis for a thorough understanding of the sources and management of CMM at a mine. This will be supported through acquisition and evaluation of additional geologic data to define the gas resource available for CMM recovery and use as outlined in Module 3 - Resource Assessment.

Thank you!

You have completed Module 2.