



NSW DEPARTMENT OF
PRIMARY INDUSTRIES

**Technical Reference
Mine Safety
CTR-001**

NSW DPI Technical Reference

**FOR A NOTIFICATION OF
HIGHWALL MINING AND AUGER MINING
(AS A HIGH-RISK ACTIVITY)**

Supplement to Guidance Note GNC-009 High-risk Activities

August 2008 (version 1.1)

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GENERAL - HIGHWALL MINING AND AUGER MINING

The NSW Department of Primary Industries (NSW DPI) has prepared this technical reference for use by colliery operators in collating information to submit with a notification to conduct high wall mining including auger mining.

Section 54 of the *Coal Mine Health and Safety Act 2002* (CMHS Act) requires the 'Operator' of a coal operation to notify of an intended high risk activity. Clause 49 of the *Coal Mine Health and Safety Regulation 2006* (CMHS Reg) identifies highwall mining (mining by entry into a previously formed highwall and during which no people are underground) as a high risk activity. Refer to the 'Guidance Note – 009 High Risk Activities' for further information.

This technical reference document should be used by the operator to ensure that sufficient information is provided to NSW DPI to provide an adequate understanding of the intended activity.

This document is intended to provide all parties with sufficient background material to enable proper assessment of the notification in the minimum amount of time. To achieve this objective the guidelines are divided into three distinct elements.

1. Data Collection and Design.
2. Implementation.
3. Notification.

It is the responsibility of the applicant wishing to mine the resource to properly research, investigate and plan the mining operations.

1. DECISION MAKING, DESIGN AND DATA COLLECTION

A colliery operator who is proposing to conduct highwall or auger mining in a coal seam should undertake the following actions regarding decision making, design and data collection:

- 1) Undertake a Risk Assessment (MDG 1010, AS 4360 and AS 2430t) of the proposed mining when:
 - a. a particular method is first used at the mine; or
 - b. a different coal seam from those previously experienced is to be mined; or

- c. a seam which has varying physical characteristics is to be mined.

2) In all cases, implement “best practice” design standards as outlined in annexures A and B.

Should the proponent wish to deviate from “best practice” then the proposed layout must be submitted to the Subsidence Management Plan (SMP) process. SMP approval would be required prior to the proposal being submitted under Clause 49 as a High Risk Activity.

3) In all cases, the applicant shall make an assessment which would cover and provide detailed information regarding the following areas:

a. Geology

Geological information related to an area under notification should be provided including sections and borehole illustrations. All mineable coal seams should be identified, a resource statement should be provided, and a proposed recovery statement for each seam should also be included.

Details will be provided on:

- Seam thickness
- Seam analysis
- Propensity to spontaneous combustion

b. Geotechnical Studies

These studies should address both the underground and surface mine design and stability. Such studies should identify mining methods and mining layouts which are proposed for the area, and the reasons for selecting a particular layout. In particular, it will be necessary to:

- Estimate the bulk strength of coal webs used in the layout.
- Determine the probable ‘Factors of Safety’ for these webs. Consideration of the likely impact on web strength, of variation in web width due to guidance and/or operational errors, will be required.
- Identify geological and structural factors that may adversely impact upon web stability.

- Determine the span necessary across a panel of webs to maintain strata and web stability and then locate inter-panel barriers accordingly. Consideration of the impacts of varying strata types and varying depths of cover upon panel widths and inter-panel barrier dimensions will be required.
- Determine the minimum width of inter-panel barriers taking into account their strength, probability of instability and ability to permanently segregate panels.
- Identify geological factors that may impact upon or determine spacing of inter-panel barriers.
- Estimate the impacts of seam grade and/or variation in seam grade upon stability.
- Assess the stability of the immediate highwall face taking into account its age prior to mining, its weathering capacity and batter angle.

Note: “annexure B”, is attached to assist in preparation of the geotechnical report. This information is required to be addressed within the final notification.

c. Mining Parameters

This information should address:

- Seam gas content and any ventilation arrangements for the control of gas and dust both within the excavation.
- Detailed specification of mining equipment and coal handling equipment for this mining method.
- The proposed method of sealing openings created and the associated time frame for sealing.
- The proneness of the immediate roof and floor strata to incendive sparking.
- The potential for inrush of gas, water, etc from old workings or other sources and the methods of control and prevention.
- Surface drainage plans, and location of any water emplacements over the areas proposed for mining.
- A system to ensure that the workings are not subject to spontaneous combustion.
- An estimate of the extent and effects of surface subsidence.
- The protection of persons on the surface from falling objects including from the highwall face.

- The protection of persons from a dust or gas ignition in the excavation.
- The rehabilitation of the highwall, and entries. This will need to be consistent with the accepted rehabilitation program on the Mining Operations Plan. A timeframe for these works is to be completed.
- The survey technique to determine bearing and distance of each driveage. (See 'annexure A' for guidance.)

2. IMPLEMENTATION

Prior to the commencement of highwall mining at the mine or coal seam, the Operator will have prepared a 'Highwall Mining Management Plan' as outlined below. This Plan should accompany the notification. Where relevant, the Highwall Mining Management Plan should reference 'Health and Safety Management Systems' as required by Section 20 of the Coal Mine Health and Safety Act 2002.

The 'Highwall Mining Management Plan' should identify:

- Barriers that are to be in place to control hazards identified in the Risk Assessment study. (AS 2430 may assist).
- Operational work procedures for major tasks associated with the work.
- Standards to be achieved in monitoring and controlling the operation.
- Measures for the covering or sealing of entries in order to prevent spontaneous combustion, provide protection from windblast debris and to prevent inadvertent entry.
- The emergency management system, which should reference the mine site emergency management system as required by clause 45 of the Coal Mine Health and Safety Regulation 2006.
- Recovery procedures for trapped augers or cutting machines.
- Procedures to be implemented for the auditing of management systems and control documents to assure their effectiveness and conformance to set standards.
- Circumstances where persons may enter an underground excavation.

It should be noted that any electrical apparatus within the underground excavation or directly connected thereto is to be constructed installed and maintained in accordance with the legislative requirements for underground coal mining operations.

3. NOTIFICATION

Format

The notification shall contain as a minimum:

- 1) Notification Form (GNC-009f High-Risk Activities – Highwall Mining form).
- 2) A comprehensive report dealing with the technical matters including design criteria, highwall mining risk assessments, management plans, control and review documents.
- 3) The Operator will include information on “Resource Utilisation” for the proposed mining. The Operator shall justify why highwall / auger mining is a superior option over underground or open cut mining.
- 4) Provide details on site security, and actions to be instigated to prevent unauthorised access.
- 5) Contractors and Employees:

Details on induction, training, and safe operating procedures will be prepared, and submitted to the Inspector of Coal Mines.
- 6) A plan hereafter referred to as the “Highwall Mining Plan” (HWM Plan)
- 7) A Statutory Declaration identifying “Confirmation of *right to mine* and to carry out mining purposes” is to accompany the notification.

Two (2) complete copies of above reports and three copies of the High Wall Mining Plan should be submitted.

See below for further detail on methods of notification.

Notification Form

- Complete the form from Guidance Note High-risk Activities GNC-009f available from www.dpi.nsw.gov.au/minerals/safety/legislation .

Reports

Reports can be bound in a single document or may be supplied separately. The notification should include reports covering the following aspects:

- Geology;
- Geotechnical Studies;
- Mining Parameters (Including an equipment listing);
- Risk Assessment;
- A copy of SMP approval, if necessary (see decision making, design and data collection section (2))
- Management Plan; and
- Control and Review.

Plans

Plans supplied will follow the requirements of "Survey and Drafting Directions for Mine Surveyors"

Plan of Existing Environment

This plan will be provided at a scale of 1 in 25,000. With respect to the highwall operation the plan shall show:

- the colliery holding boundary;
- mining lease boundaries;
- the boundary of any sublease affected by the notification;
- cadastral information; and
- the location and extent of all extraction areas: open-cut, underground, trenching, box-cut, highwall mining and dredging methods including "catch" bench locations.

Highwall Mining Plan (HWM Plan)

This plan will be provided at a scale of 1 in 4000.

The HWM Plan will indicate all existing workings and proposed mining within the seam, length of extraction, date of application, and any voids to be created by the mining proposed in the notification. The plan will include:

- All future workings proposed for the mining systems;
- Design on plan and section showing dimensions of abutment pillars adjacent to extracted voids;
- All highwall / auger areas previously extracted within the area of the plan;
- Surface features, drainage and water storages; and
- A cross section through a typical zone of the highwall. Identification of the floor, seams to be mined, penetration limit, "catch" benches and top of any highwall will be shown.

The HWM Plan will show details of the following:

- Mining titles;
- Land ownership;
- Lease conditions / restrictions;
- Seam name(s);
- Colliery holding boundary;
- Record tracing reference number; and
- Proposed length of (auger / highwall mining) entries to be mined.

The HWM Plan will be certified as correct by the Mine Surveyor.

The area(s) identified within a HMP will be added to the Mining Operation Plan(s) for the mine at their next review.

Survey Procedures

The Department requires the applicant to demonstrate methods to be implemented for auger setout, design and monitoring. "annexure A", is provided as a guide for these requirements.

'ANNEXURE A'

HIGHWALL MINING / AUGER MINING

GUIDANCE NOTES

Auger Setout

1.Design.

Prior to mining taking place, a detailed design of the auger layout is to be carried out, determining hole direction, distance, grade and spacing as well as the auger pattern and extraction sequence.

1.1 Direction

The direction of auger mining is usually perpendicular to the wall being augered, although this may vary. For example in steeply dipping areas holes may be drilled on an angle to the wall to reduce the apparent grade.

1.2 Distance

Wherever possible the auger mining is to proceed as far as possible to maximise resource utilisation but at times physical restraints, such as previous auger mining, lease boundaries or geological anomalies may shorten the length of penetration.

1.3 Grade

The proposed grade of auger mining is to be estimated using both survey and borehole information. The auger will have a grade scale in the cabin, which reads in inches. A conversion chart from degrees to the scale is also to be located on the auger. The first few holes are to be monitored and the grade altered if necessary to maximise penetration distance.

1.4 Hole spacing and pattern layout.

A Geotechnical investigation is to be carried out prior to auger mining taking place. This investigation will result in both hole spacing and pattern layout being determined for any particular area.

*Empirical experience has seen most layouts evolve around the practice of driving 9 holes in sequence, separated by coal webs 0.5 x hole diameter wide and barriers being formed by the deletion of every tenth hole. **This type of layout is not considered best practice because it fails to address the specific conditions that apply at any given location and does not consider relevant geotechnical criteria necessary for stability. See annexure B for best practice layout design.***

2. Supplying of information.

Auger operators are to be supplied with a plan, approval conditions and record sheets prior to mining commencing.

2.1 Plan

The plan should show proposed auger mining, noting any special conditions, such as hole lengths, grade of the seam in areas to be mined and hole sequence.

2.2 Approval conditions.

The approval conditions are supplied to the auger operators and the Open Cut Examiner to ensure they are aware of special conditions required for auger mining in the area.

2.3 Record sheets.

Auger operators are to fill in auger record sheets daily, noting hole number, hole length, grade and any remarks in relation to the hole, **especially the possibility of hole deviation or connection with an existing hole**. Surveyors are to periodically check these sheets and collect them at the completion of auger mining for archival purposes. ***Hole deviations or connections with exist holes are to be forwarded immediately to the Manager of Mining Engineering and the mine Operator.***

3. Survey Control

Each auger hole drilled or highwall entry mined shall be fully surveyed for length and direction. ***Operational imperatives are not to prevent this survey from being undertaken.***

3.1 Safety

Surveyors are to notify both the Open Cut Examiner and the Auger operators of their presence in the auger area.

Prior to marking the face, an inspection of the wall above is to be carried out to ensure the wall is safe to work under.

The face marks are to be ideally placed when the auger is not operating, in order to eliminate working under the wall during active mining and to minimise interaction with machinery.

Normal P.P.E is to be worn.

3.2 Fieldwork

Holes are to be set-out in advance of auger mining taking place.

The following method is used to ensure that the desired hole spacing is maintained for each hole.

- The desired bearing of the auger holes is determined.
- This is then altered to be cardinal, eg 0 degrees.
- The right hand edge of each hole is to be marked on the face by a vertical line and appropriate point number.
- Holes are marked out by adding the hole spacing onto the Easting of the previous hole.
- Both the Easting and Northing for each hole are recorded for plotting of the auger hole.
- Line pegs are placed approximately 30 – 40m from the face, by setting out the corresponding Easting for each hole.
- Both the Easting and Northing of line pegs are recorded for archival purposes.
- It is common practice to have a windrow constructed for easy positioning and protection of line pegs.
- Line pegs should, wherever possible placed in a straight line, to allow for replacement of pegs by measuring between adjacent remaining pegs.
- Line pegs are to be numbered to correspond to the appropriate mark on the face.
- In the case of the Brydet Auger a vertical plate is to be set towards the rear of the auger and which is in line with the right hand edge of the hole. The Auger operator is to use this plate and the line peg to position the auger. Note: the plate referred to will be highlighted by paint.

4. Data collection

4.1 Survey Information.

A record of the survey is to be written on the standard form and filed for archival purposes. The face points are to be recorded on the job and downloaded under the relevant seam name.

4.2 Auger Records.

Auger record sheets are to be collected and the data entered into the appropriate spreadsheet and the spreadsheet filename recorded. Tonnages are to be correlated against coal haul tonnages and any major differences investigated.

4.3 Drafting of Auger mining

Auger information is to be transferred from the relevant source into a drafting package, usually by DXF format. The auger holes are to be drawn in the drawing (filename and path) on the appropriate layer, depending on which seam is mined. This information is then referenced to the Mine Working Plan.

‘ANNEXURE B’

HIGHWALL MINING / AUGER MINING

GEOTECHNICAL STUDIES

Definitions

Auger mining – Extraction is conducted by circular auger scrolls.

Coal webs – Coal separating miner or auger entries.

Factor of Safety – Coal web strength divided by load acting on coal web.

Highwall mining – Extraction is conducted by remotely controlled continuous miners.

Septum – Vertical separation between auger holes in a double auger layout.

Symbols

w – Coal web width (m). Refer to Figures 1, 2, 3 and 4.

h – Mining height (m):- For miner operations this is the cutting height. For single row auger holes this is the auger diameter. For double row auger operations this is twice the auger diameter. Refer to Figures 1, 2, 3 and 4.

ϕ – Auger hole diameter (m).

W – Panel width between barriers (m).

H – Maximum depth of cover over a panel of coal webs (m).

Geotechnical studies should address both underground and surface mine design and stability.

Such studies should identify mining methods and mining layouts which are proposed for an area, and the reasons for selecting a layout. In particular, it will be necessary to:-

1. Estimate the Strength and Dimensions of Coal Webs Employed in the Layout

Research by the CSIRO¹ has indicated that web strength needs to be determined on a case by case basis, with the nature of roof and floor contacts being vital. It is essential to have a good understanding of mass “in situ” coal strength. The influence of structure zones, joint swarms, cleat frequency and stone bands within the coal are relevant factors in estimating mass “in situ” coal strength.

The following values of coal web strength are recommended for use in design.

This is accepted as best practice.

Table 1 – Estimates of Coal Web Strength

SITUATION	COAL WEB STRENGTH (MPa)
Strong coal, strong contacts	6.0
Strong coal, weak contacts	5.1
Weak coal, strong contacts	3.6
Weak coal, weak contacts	3.1

Research conducted in South Africa² on the use of pillar design equations for small pillars at shallow depths (such as those that apply for highwall and auger operations), supports the CSIRO findings that mass “in situ” coal strength should be used for web strength. The South African work recommends that **pillar design equations not be employed** when determining strengths of small pillars having width/height ratios (w/h) of 2 or less.

As coal webs employed in New South Wales have never exceeded a width/height ratio (w/h) of 2, web strength must be estimated from Table 1.

The Influence of Underlying workings on Coal Web Strength

Coal web strength, as selected from Table 1, will be adversely affected by **prior** extraction in a lower seam(s). Subsidence from lower seam workings will create zones of tension and shear in overlying, and as yet unmined seams, necessitating a conservative application of the CSIRO strengths contained in Table 1.

In a recent case, a series of longwall panels extracted over a decade earlier and some 200m below the seam to be highwall mined, reduced web strength from an expected 5.1 MPa (obtained from Table 1) to an actual field value of less than 3.0 MPa.

Minimum Coal Web Width/Height ratio (w/h)

Experience in the United States^{3,4} has shown that width/height ratios (w/h) for individual webs of **above unity** are desirable for more effective web integrity.

In New South Wales the recommended minimum coal web width/height ratio (w/h) is 1.0. *This is accepted as best practice.*

This value for width/height ratio (w/h) applies irrespective of estimated web strength. Controls on the cutting height of highwall miners will be required to ensure that the design value of web height (h) is not exceeded.

Reference to Figures 1, 2, 3 and 4 is required when determining dimensions that apply for any individual w/h configuration.

2. Determine the Probable Factors of Safety for Coal Webs

This calculation requires an estimate of strata load acting upon coal webs. Unless reliable load measurements have been established at the site, then tributary area load estimation must be used. Load should be determined at the maximum depth for the proposed layout.

Where an area to be highwall or auger mined is overlain by pre-existing workings then the potential for load concentration on coal webs, above tributary values, exists. Load concentration is most likely when pillar extraction has occurred because stooks and sub-pillar remnants can concentrate vertical load. The quantum of any such load increase must be estimated in a conservative manner and the result employed in design calculations for load.

Experience in Australia¹ and the United States³ suggests that **where a reliable guidance system is employed on the miner or auger**, a Factor of Safety (FoS) of 1.3 as a minimum should be used. *This is accepted as best practice.*

A minimum Factor of Safety (FoS) of 1.6 is recommended **for new highwall/auger operations and/or where no guidance system is employed on the miner or auger.** *This is accepted as best practice.*

Double Augering

Where seam height permits some auger operations employ two rows of holes located directly over each other as shown in the attached Figure 3. Unless the integrity of septums can be guaranteed, by the use of accurate guidance systems, then auger holes may intersect causing the vertical dimension of coal webs to vary greatly.

To cater for this uncertainty in determining coal web width/height ratios (w/h) it is recommended that a value of twice the auger diameter (2 x ϕ) be used for web

height (h). Thus, holes will also need to be separated by the distance $2 \times \phi$ as a minimum. (Refer to coal web minimum w/h in Section 1).

This is accepted as best practice.

3. Determine Span Stability for the Entry Between Each Web

An assessment of the unsupported span between coal webs must be made. This assessment will need to consider time related impacts as well as the consequences on web stability should falls occur in the unsupported span.

4. Determine the Maximum Permissible Panel Span Between Barrier Pillars

Limiting panel spans improves stability for the panel – web – barrier system. Australian experience¹ has found that panel spans greater than critical width are vulnerable to catastrophic collapse. This vulnerability exists because panel spans at or above critical width are much less likely to “bridge” across the panel should a localised web failure occur.

Catastrophic web failures are much less likely when panel span, between panel barriers, is kept to sub-critical widths.

One catastrophic highwall collapse, at a NSW mine, released sufficient energy to register as a magnitude 4 earthquake (recorded at the Australia Centre for Geoscience, Canberra) and propelled rock and coal horizontally from web entries for over 90m, embedding them in a neighbouring highwall. Catastrophic web collapses are a multiple fatality hazard and must be prevented.

Assessment of critical widths may be aided by studying subsidence panel width/cover depth ratio (W/H) data for the coalfield in which the mine is situated. A conservative approach of selecting the shallowest depth of cover (H), when computing panel span, is recommended.

It is recommended that the maximum W/H value for a panel of coal webs not exceed 1. This is accepted as best practice.

5. Determine the Minimum Width for Barrier Pillars

Barriers are essential to maximising panel – web – barrier system stability. Barriers stiffen the system and provide the basis for regional stability through compartmentalisation of the workings. Barriers should be designed to be permanently stable and sufficiently wide to ensure that web collapse in one panel will not propagate or cascade into adjacent panels.

During barrier design, strata load on coal webs is to be ignored (that is, to assume all coal webs have failed) and that all super-incumbent strata load within a panel has been transferred to the barrier.

For sound geotechnical reasons **barriers must have a minimum width/height ratio (w/h) of 4.** (Refer to the Definitions section for h values). *This is accepted as best practice.*

Therefore, as barriers have w/h ratios greater than 2, their strength may be estimated by pillar design equations that are capable of assigning probabilities of instability related to any calculated factor of safety.

Barriers must have a minimum probability of instability of 1×10^{-6} . *This is accepted as best practice.*

6. Use of Numerical Models

Proponents of highwall/auger operations often present the results of numerical (computer) modelling as proof of the geotechnical stability of their proposal.

The majority of catastrophic failures of highwall/auger operations have had numerical modelling that concluded the proposed layouts were completely stable!!

Most numerical models supplied in support of applications have been based upon:-

- assumed (rather than measured) strata property values,
- the assumption that the modelled configuration will never be altered or varied during the operation (which is rarely the case),
- the assumption that excavation will be conducted in an orderly sequence (eg. in one case, in a series of six panels the design formation sequence was to be 1,2,3,4,5 then 6 whereas in the field the actual sequence was 1,2,3,6,5, then 4. This led to unexpected loading conditions),
- the assumption that strata property values are uniformly consistent across the applied site.

Modelling that is patently parametric has been presented as a calibrated design. Sensitivity analyses from parametric modelling is either rarely undertaken or not reported upon in the application.

Unless modelling is fully calibrated and verifiable, numerical model predictions are at best only indicative of actual field outcomes.

Parametric studies will not be accepted as best practice for design purposes.

7. **Multi - Seam Mining**

Where a multi-seam layout is proposed extreme caution is needed in design to ensure stability. The number of complicating variables that could interfere with overall stability is high and much thought and care in design will be required.

Some examples of matters that may complicate design are the use of varying auger diameters in separate seams, the use of single, double and even triple augering in different seams and varying interburden thicknesses.

The base case for design is shown in Figure 4. In this general circumstance the following principles apply:-

- **The dimension of barrier pillars and coal webs is to be determined from the greatest depth (H_3).**
- **The dimension of panel spans is to be determined from the shallowest depth (H_1).**
- **All workings are to be superimposed.**

This is accepted as best practice.

Where a mining proposal varies from the above listed principles it will be necessary to conduct a site specific geotechnical risk assessment with credible geotechnical input.

The proposed geotechnical design will also need to have been independently “peer reviewed”. Any such review will need to extend beyond the overall design methodology and must consider the correctness of formulae used, calculations performed and of all conclusions and recommendations made.

This is accepted as best practice.

8. Identify Geological and/or Structural Factors that may Impact upon System Design

The presence of faults, dykes, seam rolls, stone intrusions, seam grades etc may adversely impact upon panel – web – barrier stability. These adverse influences will need to be addressed in the design of web, panel and barrier dimensions.

9. Assess the Stability of the Immediate Highwall Face Taking into Account its Age Prior to Mining, its Weathering Capacity and Batter Angle

Loose material falling from the highwall face presents a hazard to mineworkers. Loose material may be dislodged by natural processes or by the influence of strata response to highwall or auger mining. One particular hazard relates to persistence joints running parallel (or close to parallel) to the highwall face. Slope failures are possible in this circumstance. Suitable prevention and protection measures are required to stabilize highwall slopes.

A common and very effective safety precaution employed to minimise the impact of rock falls from a highwall face is to create “catch” benches along the face, above the operation. *This is accepted as best practice.*

Installation of “catch” benches is recommended for all new highwall/auger operations where the highwall face exceeds 25 metres in height.

In existing operations mining without “catch” benches may be considered provided alternate safety measures have been implemented **and** a conservative design approach for the panel – web – barrier system has been adopted.

10. Establish Monitoring and Reporting Systems to Enable Variations in Mining Conditions to be Geotechnically Assessed

Geological conditions encountered on a day by day basis may vary from those predicted by the mines geological model. As well, variations in operational procedures are likely to occur, for example excessive cutting height or stopping a driveage short of full distance.

All such variations are likely to have geotechnical impacts and need to be thoroughly assessed in a timely manner. Procedures to monitor the performance of the operation

and the geological environment will need to be developed and appropriate analysis undertaken (based on this monitoring), to maintain system safety and strata stability.

It needs to be remembered that a conservative design of the panel – web – barrier system may negate many of the adverse impacts arising from geological variations.

Figures

Figure 1 - Nomenclature for Guidelines – Highwall Mining.

Figure 2 - Nomenclature for Guidelines – Single Pass Auger Mining.

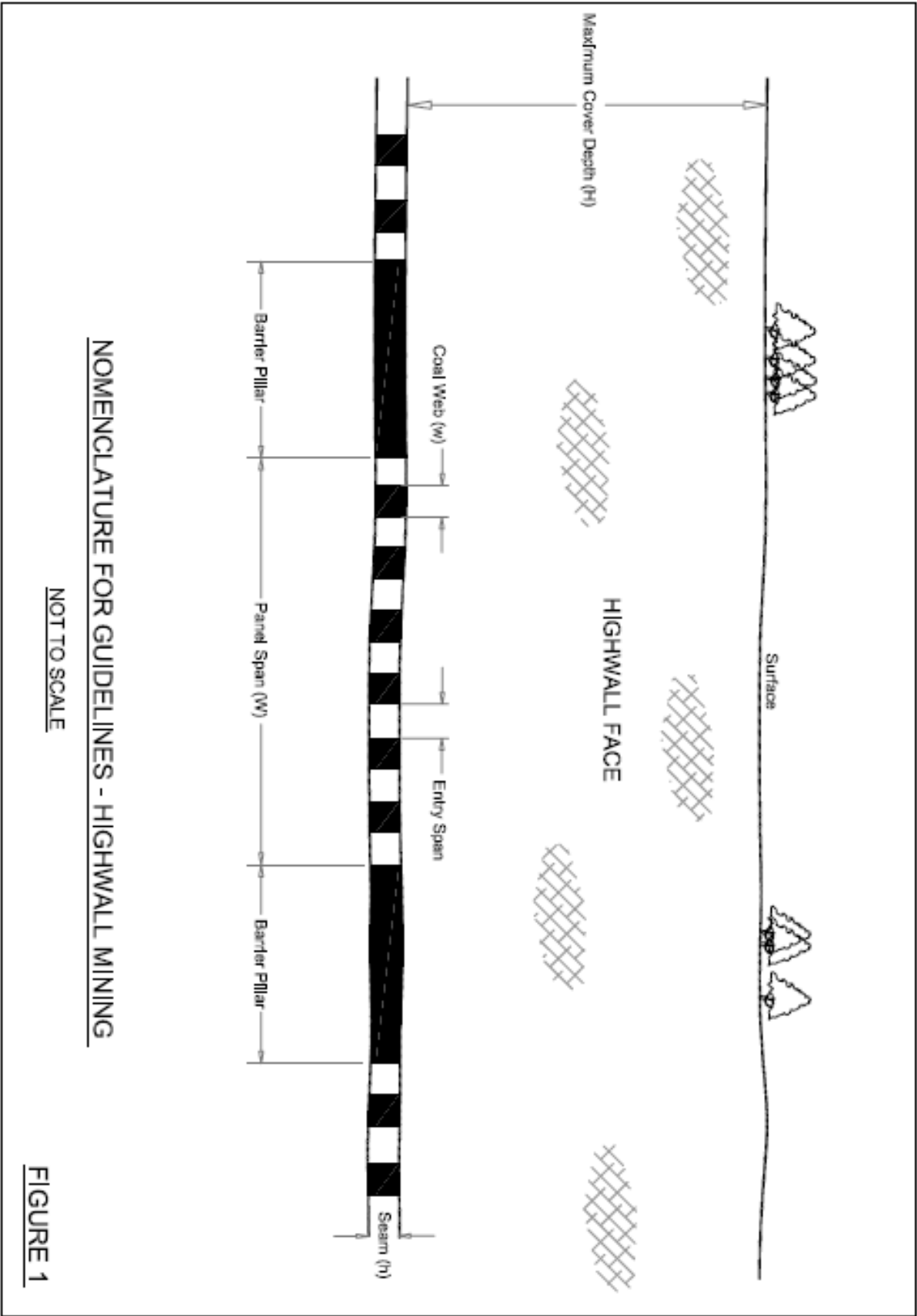
Figure 3 - Nomenclature for Guidelines – Double Pass Auger Mining.

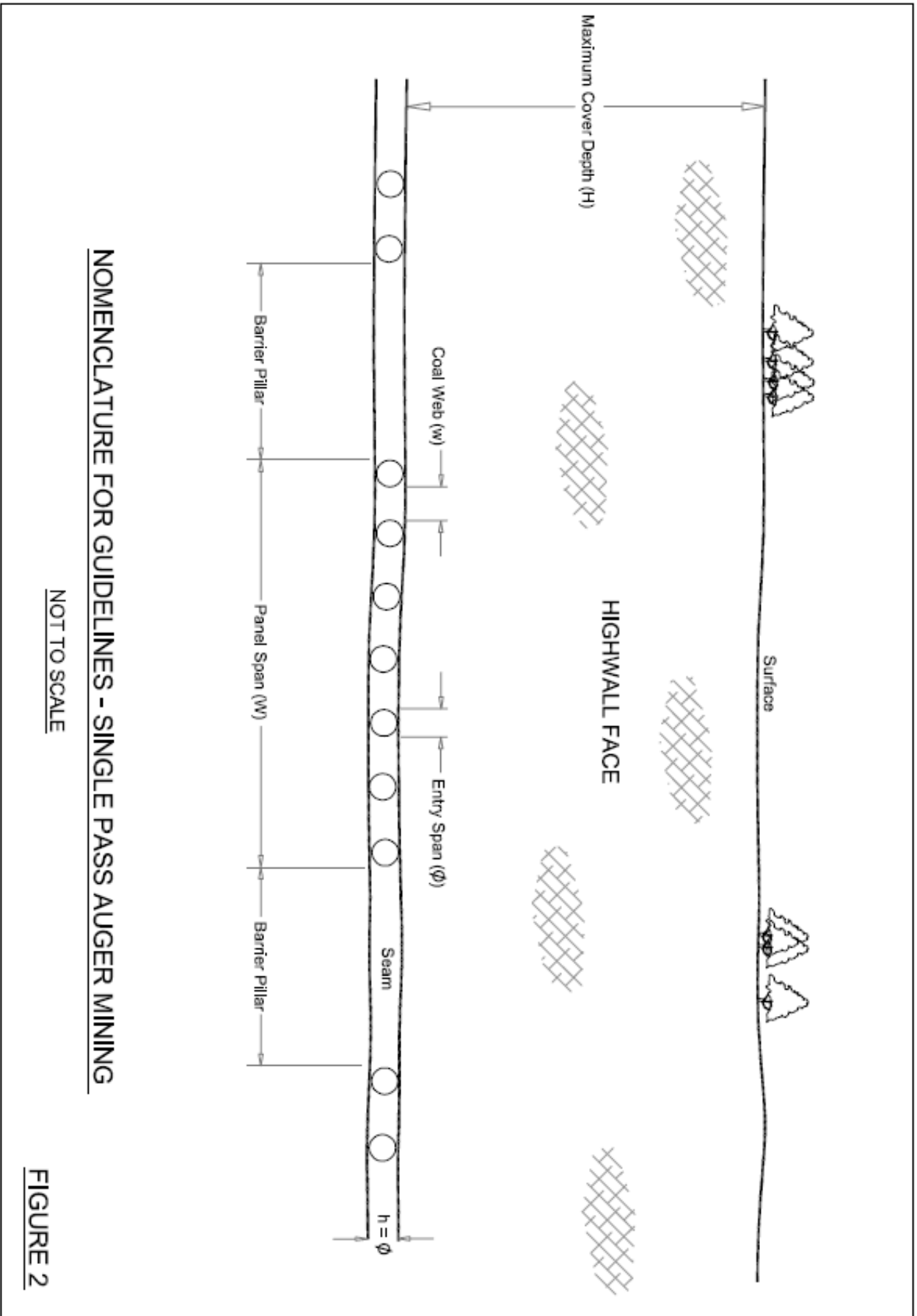
Figure 4 - Nomenclature for Guidelines – Multi Seam Augering (Single Pass).

References

1. CSIRO Exploration and Mining Report 616F “Review of Highwall Mining Experience in Australia and Case Studies” – B Shen and M E Duncan Fama, May 1999.
Produced as part of ACARP Project C5007.
2. “Long Term Stability of Bord and Pillar Workings” – BJ Madden and DR Hardman, Chamber of Mines Research Organization, South Africa 1992.
3. “Analysis of Practical Ground Control Issues in Highwall Mining” – R Zipf and S Bhatt, NIOSH, 23rd International Conference on Ground Control in Mining 2004 pp 210 – 219.
4. “Analysis of Highwall Mining Stability – The Effect of Multiple Seams and Prior Auger Mining on Design” – R Zipf and D Newman, NIOSH, 24th International Conference on Ground Control in Mining 2005 pp 208 – 217.

FIGURES





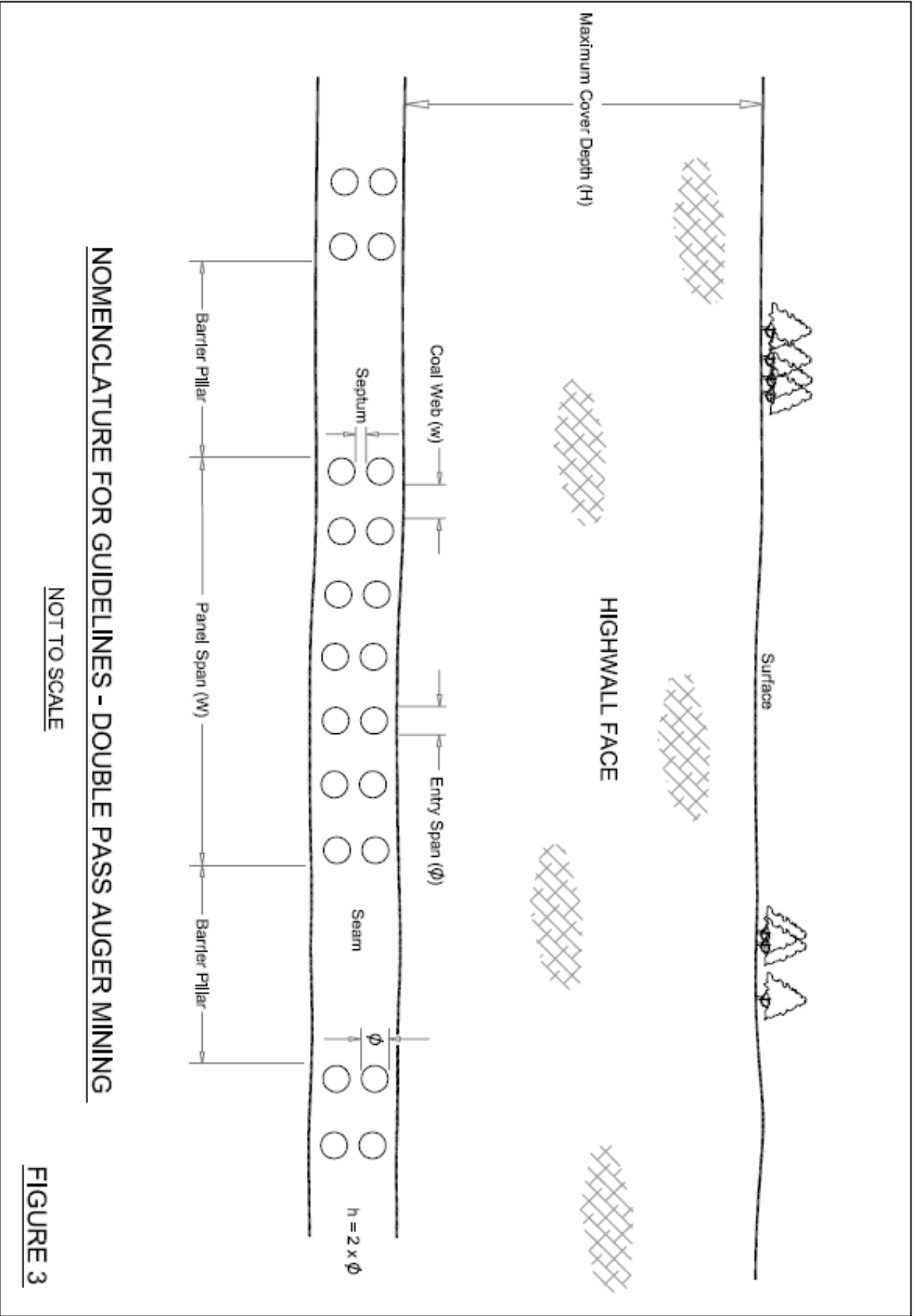
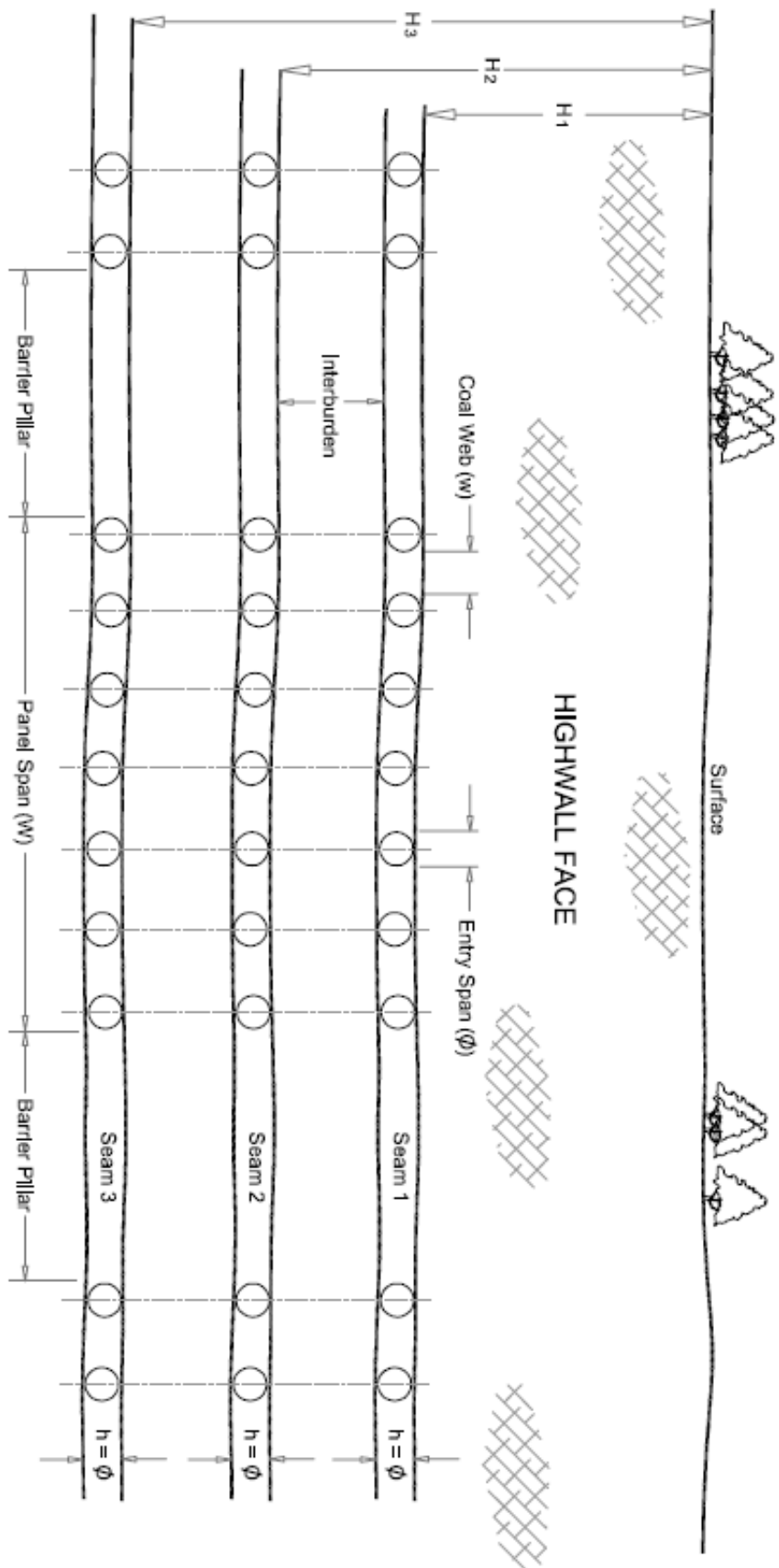


FIGURE 3



NOMENCLATURE FOR GUIDELINES - MULTI SEAM AUGER MINING (SINGLE PASS)

NOT TO SCALE

FIGURE 4

Feedback Form

Your comments will be very helpful in reviewing and improving this document.

Please copy and complete the Feedback Form and return it to:

Area Manager North East

Mine Safety Operations

NSW Department of Primary Industries

PO Box 344

MAITLAND NSW 2310

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How did you use, or intend to use, this Technical Reference?

What do you find most useful about this Technical Reference?

What do you find least useful?

Do you have any suggested changes to this Technical Reference?

Thank you for completing and returning this Feedback Form.

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