Update on ACARP coal burst project C25004

Ismet Canbulat

ACARP Project: 25004 Review of Australian and International Coal Burst Experience and Control Technologies – OBJECTIVES

- Scoping of ACARP's coal burst research
  - Develop a strategy and scope for ACARP's proposed coal burst project in a structured, step-by-step process using the experienced gained around the world over a century.
  - Divide the scope into different research projects and/or tasks.
  - Recommendations regarding an ACARP Coal Burst Project Review Board.
- Stage 1: Review of Australian and international coal burst experience and control technologies

The outcome of this project will be preliminary coal burst risk identification and control guidelines for Australian coal mines.

- Understanding of coal burst phenomenon and international experience
- Understanding of extent of Australian experience
- Establish the preliminary coal burst risk identification and control guidelines that are (i) in line with the Australian regulations, mine design and operational practices, and (ii) will be used to classify the coal burst proneness of the mines as well as management and control strategies.
- Develop a training package that will demonstrate the causes of coal burst, failure mechanisms and other contributing factors.

Key Personnel

- Ismet Canbulat (UNSW Australia)
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- Anthony Iannacchione (University of Pittsburgh)
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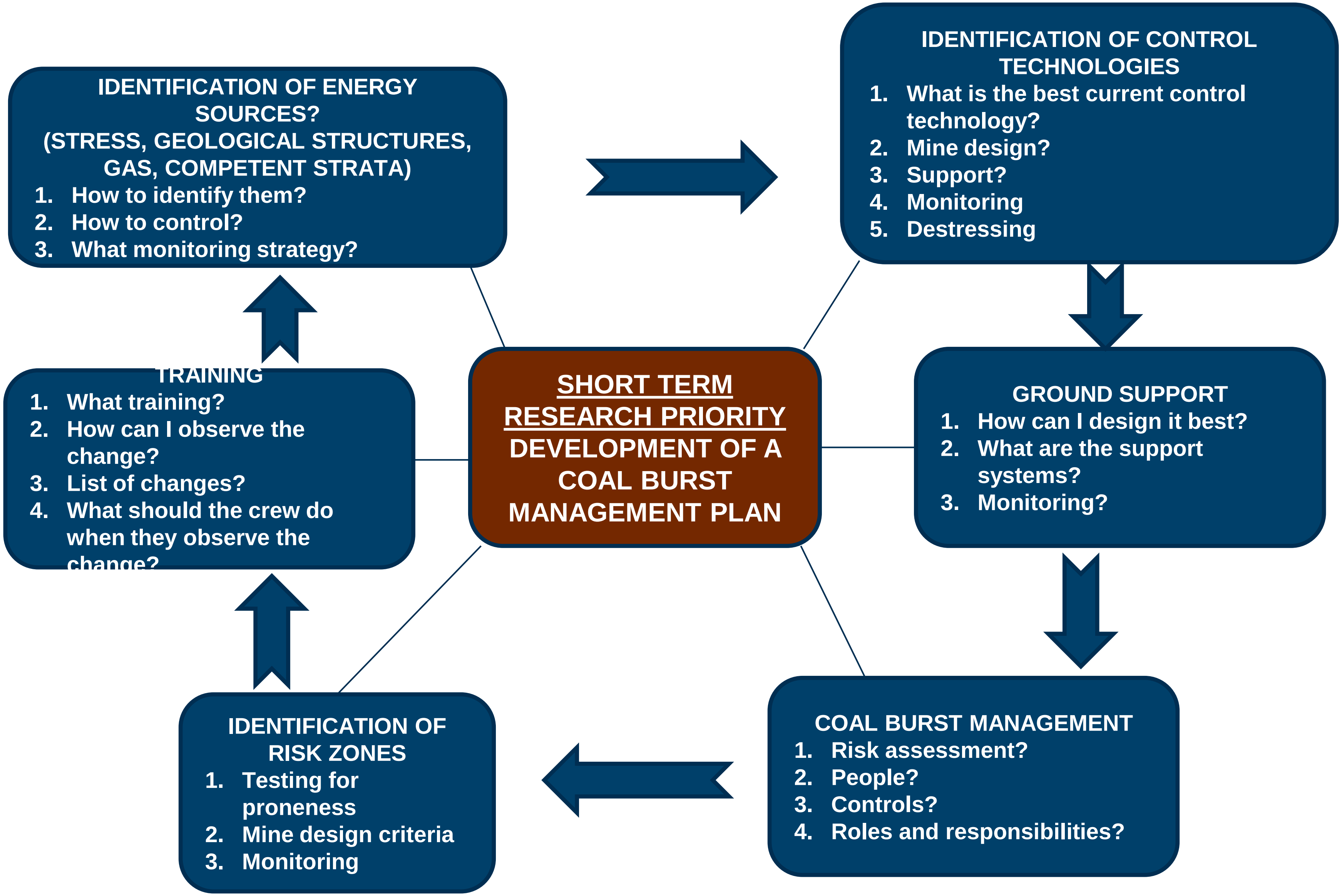
Progress

- An extensive literature review has been conducted
- 4 internal and 1 international workshops have been held
- At the internal workshops approximately 30 projects have been identified and prioritised
- An extensive numerical modelling study has been conducted to understand the energies within rock masses
- Evaluation of the seismicity in NSW coal mines has been conducted
- Analytical models have been developed to understand the strain energy and the gas expansion energy
- A coal burst proneness model has been developed
- A framework for coal burst management plans has been suggested
- A risk assessment has been conducted

Short-term Research Themes



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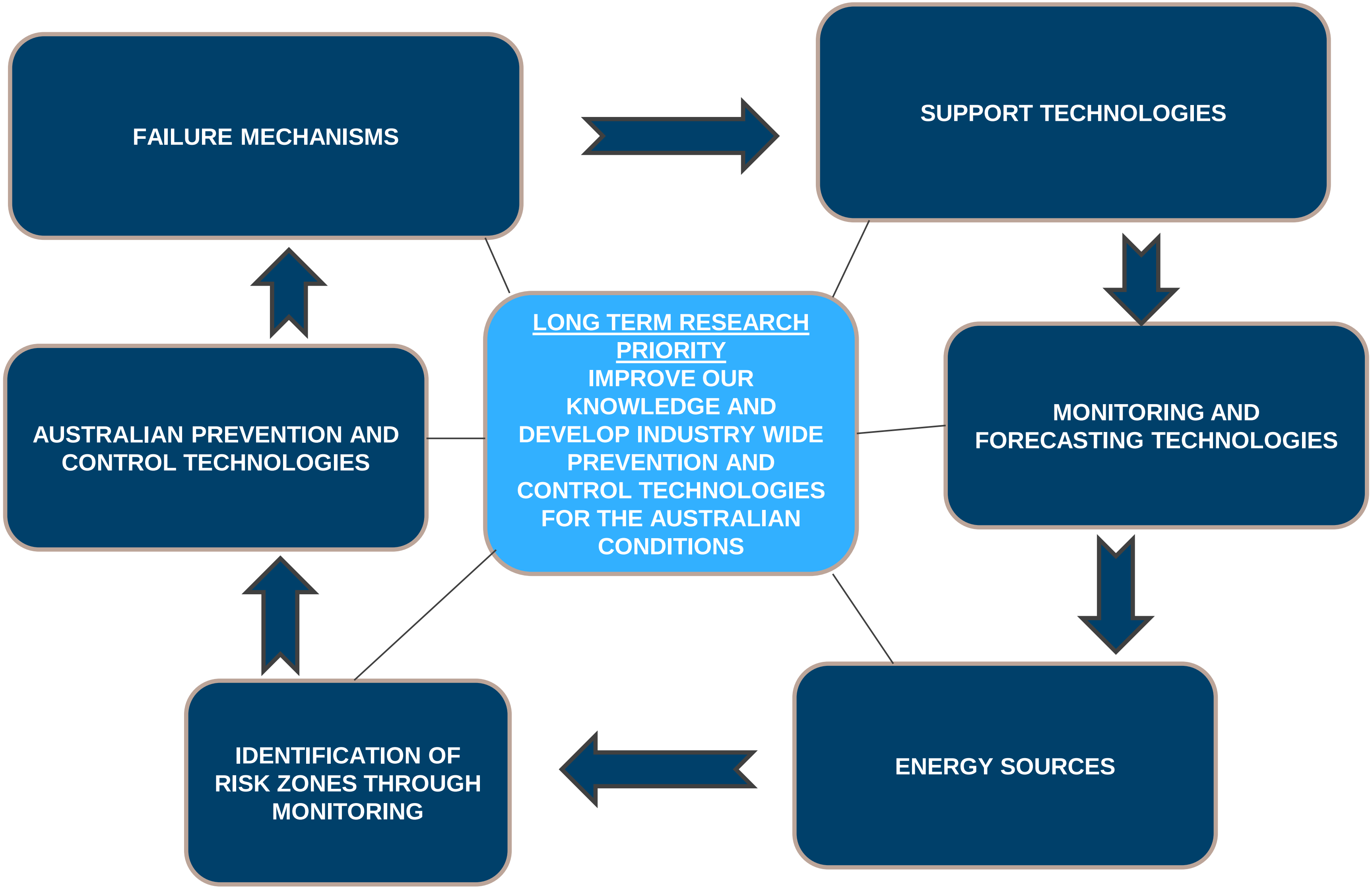
Long-term Research Themes



Coal burst proneness

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Purpose

Coal bursts can neither be predicted nor prevented with current knowledge and technology, but they may be controlled if the operation is prepared for their occurrence. Therefore, the purpose of this part of the project is to classify the coal burst **proneness** of the mines as well as management and control strategies.

It is emphasised that this methodology has been developed to identify if the mines are prone to coal burst NOT to manage coal burst risks as in Europe and China, where application of these methods have shown mixed results.

Why Need for a Risk Based Coal Burst Classification Method?

- to enable the operations to assess their coal burst proneness
- to assist the mines to develop coal burst management plan
- to assist in the management of risks to health and safety associated with mining induced seismic activity at the mine (NSW WH&S Reg 2014 - Division 4A – Section 44B Mining induced seismic activity)

Proposed Model

- A semi-quantitative risk model for coal burst proneness based on geological and geotechnical conditions
- Qualitative factors have been assigned preliminary values in order to establish **relativity**
- The numbers are combined using a formula to determine the likelihood of occurrence and severity of occurrence
- It produces a **relative** risk ranking for the given conditions

Initial Parameters

1. Depth of Cover
2. Mountainous Region
3. Competent Strata (Roof and/or Floor)
4. Roof-coal-floor UCS
5. Roof-coal-floor RQD
6. Sandstone Channels
7. Proximity to Faults, Dykes, Folds
8. Cleating and Jointing
9. % Hard Rock Content in the Overburden
10. Coal stiffness (i.e., cleating #8)
11. Past Seismic Activity
12. Periodic Weighting
13. Pillar Geometry, W/H, FoS
14. Gate Pillar Geometry
15. Mining (Development, Longwall, Pillar Extraction)
16. Multi-seam Interaction
17. Past Mining Activity
18. Expansion of Mined Area
19. Stress Notching
20. Roof/pillar contact
21. Rate of retreat/advancement

International experience - USA

For pillar recovery

Risk Factor	Level of Factor		
	Low	Moderate	High
Depth of cover	<360 m	360 m – 450 m	>450 m
Pillar design	Meets NIOSH[1] or other criteria, including barrier pillars		Does not meet NIOSH or other criteria
Multiple seam interaction	Stress shadow or AMSS[2] condition = "Green"	AMSS Condition = "Yellow"	Inadequate maps or remnant surrounded by goaf (AMSS Condition ="Red")
Roof condition	Weak shale or similar, no massive strata within 15 m	Typical Western US or Central Appalachian stratigraphy	Strong, thick, and massive strata near the seam
Floor condition	Claystone or similar, no massive strata within 15 m	Typical Western US or Central Appalachian stratigraphy	Strong, thick, and massive strata near the seam
Other geologic factors			Sandstone channels, faults or fracture zones, seam dips, rapid topographic changes
Pillar recovery method	Development only, or partial pillar recovery	Typical Christmas tree or outside lift pillar recovery	Closing in center (continuous haulage), barrier pillar extraction, split-and-fender pillar recovery
Panel width	<100 m	100-150 m	>150 m
Past history of bursts	No burst history in the seam	Burst history in the seam	Burst history in the mine

International Experience - USA

For longwall mining

Risk Factor	Level of Factor		
	Low	Moderate	High
Depth of cover	<360 m	360 m – 600 m	>600 m
Pillar design	Development only, meets NIOSH or other criteria	Longwall mines should use yield, abutment-yield, or interpanel barrier pillars as appropriate for depth and geology	
Multiple seam interaction	AMSS Condition = "Green"	AMSS Condition = "Yellow"	Inadequate maps or remnant surrounded by goaf (AMSS Condition ="Red")
Roof condition	Weak shale or similar, no massive strata within 15 m	Typical Western US or Central Appalachian stratigraphy	Strong, thick, and massive strata near the seam
Floor condition	Claystone or similar, no massive strata within 15 m	Typical Western US or Central Appalachian stratigraphy	Strong, thick, and massive strata near the seam
Other geologic factors			Sandstone channels, faults or fracture zones, seam dips, rapid topographic changes
Past history of bursts	No burst history in the seam	Burst history in the seam	Burst history in the mine

International Experience - China

Geological factors

No.	Risk factor	Risk factor definition	Risk index
W_1	Previous coal burst occurrences	No	-2
		Yes	0
		Extensively occurred within coal seam and pillars using the same mining method	3
W_2	Mining depth (m)	<500	0
		500-700	1
		>700	2
W_3	Distance between seam and competent strata (≥60 MPa) (m)	>100	0
		100-50	1
		<50	3
W_4	Tectonic stress concentration	>10%	1
		>20%	2
		>30%	3
W_5	Thickness of the roof strata (L_{st}/m)	<50	0
		≥50	2
W_6	Uniaxial compressive strength of coal (MPa)	$Rc \leq 16$	0
		$Rc > 16$	2
W_7	Energy Index of coal (W_{et})	$W_{et} < 2$	0
		$2 \leq W_{et} < 5$	2
		$W_{et} \geq 5$	4

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International Experience – China

Mining factors

No.	Risk factor	Risk factor definition	Risk index
W_1	Distance between the face to the finish line	>60	0
		60-30	2
		<30	3
W_2	Un-destressed thick coal seam	Thickness of unmined top coal or floor coal > 1 m	3
W_3	Coal seam thickness (m) (not applied to longwall top coal caving method)	<3.0	0
		3.0-4.0	1
		>4.0	3
W_4	Length of isolated longwall (m)	>300	0
		300-150	2
		<150	4
W_5	Roadway extracted along the goaf	No pillars or the width of pillars is less than 3 m	0
		Width of pillars is 3-10 m	2
		Width of pillars is 10-15 m	4
W_6	Distance to goaf is less than 50 m	Development heading	2
		Longwall face	3
	Distance to pillar is less than 50 m	Development heading	1
		Longwall face	3
W_7	Distance between development heading and previously-mined gate road is less than 50 m	Backfilled gate road	1
		Unfilled gate road	2
	Distance between face and previously-mined gate road is less than 30 m	Backfilled gate road	1
		Unfilled gate road	2
	Distance between face and intersections is less than 50 m	Development heading or longwall face	3
W_8	Distance between the face and fault (fault throw> 3 m) is less than 50 m	Adjacent to hanging wall	1
		Adjacent to footwall	2
W_9	Distance between the face and folds with vastly-changing dipping is less than 50 m	>15º	2
W_{10}	Face is adjacent to erosive coal seams or composite layers	Development heading or working face	2
W_{11}	The degree of stress relief, by mining top or bottom stress-relieving coal seam	Weak	-2
		Medium	-4
		Strong	-8
W_{12}	Goaf treatment	Backfilled	2
		Normal caved	0

International Experience – Poland

No.	Factor influencing the hazard state	Definition of factor	Points
1	Depth of the mining operation	400 ÷ 600 m	2
		601 ÷ 900 m	6
		> 900 m	10
2	Presence in the roof of rock burst-prone rocks at the distance to the seam:	20 ÷ 30 m	5
		30 ÷ 50 m	3
		< 20 and > 50 m	2
3	Thickness of the rock burst-prone rocks at the distance up to 50 m to the seam:	10 ÷ 30 m	5
		≥ 30 m	2
4	Presence of a fault in the distance up to 60 m with throw *h*:	1.5 m < *h* ≤ 3.5 m	1
		h > 3.5 m	5
5	Conducing of working face in the proximity of fault (in distance up to 60 m) with throw ≥ 1.5 m	approaching to the fault	5
		along the fault, parallel to it	3
		moving away	2
6	Presence, in the roof or floor, of the remainder or edge in the horizontal distance *z* during mining operations in depth *H*≤ 600;	z ≤ 30 m	6
	if 600 < H ≤ 800 m – multiply points by 1.5	30 < z ≤ 50 m	4
	if H > 800 m multiply points by 2	50 < z ≤ 200 m	2
7	Summing up of influences of at least two remainders or/and edges at the distance in the horizontal direction between them lower than 50 m and distance of the nearest remainder or edge to the seam:	< 30 m	10
		31 ÷ 50 m	8
		51 ÷ 100 m	6
8	Mining activities in coal seam with rock burst-prone coal	30 MPa ≥ *UCS* ≥ 16 MPa	4
		16 MPa > *UCS* > 30 MPa	1
9	Predicted or observed seismic tremors during mining activity at depth *H* with maximal seismic energy *E*	$E < 10^5$J when $H \le 600$ m	4
		$E < 10^5$J when $600 < H \le 900$ m	6
		$E < 10^5$J when $H > 900$ m	8
		$E \ge 10^5$J when H > 400 m	10
10	Height of exploitation work *w*	3.5 m ≥ *w* ≥ 2.0 m	4
		2.0 m > *w* > 3.5 m	2
11	Floor structure of the mining work (gallery or exploitation work)	in floor of working presence of coal layer with thickness ≥ 1.0 m or presence of coal seam with similar thickness in distance ≤ 10 m	6
12	Approaching of face of mining working to pillars, goaf or place of excessive seam development in distance ≤ 50 m when mining activities depth *H*	≤ 600 m	4
		601 ÷ 900 m	6
		> 900 m	10
13	Exploitation conducted in two-sided goaf surroundings when mining activities depth *H*	≤ 600 m	4
		601 ÷ 900 m	6
		> 900 m	10
14	Exploitation conducted in destressed seam	effective destressing	-6
		low effective destressing	-4
15	Active rock burst prevention in not destressed coal seam	prevention in source of danger	-5
		prevention aside from source of danger	-3
16	Results of analytical rock burst risk state prediction	compatible with factors 1 ÷ 15	12
		incompatible with factors 1 ÷ 15	-8

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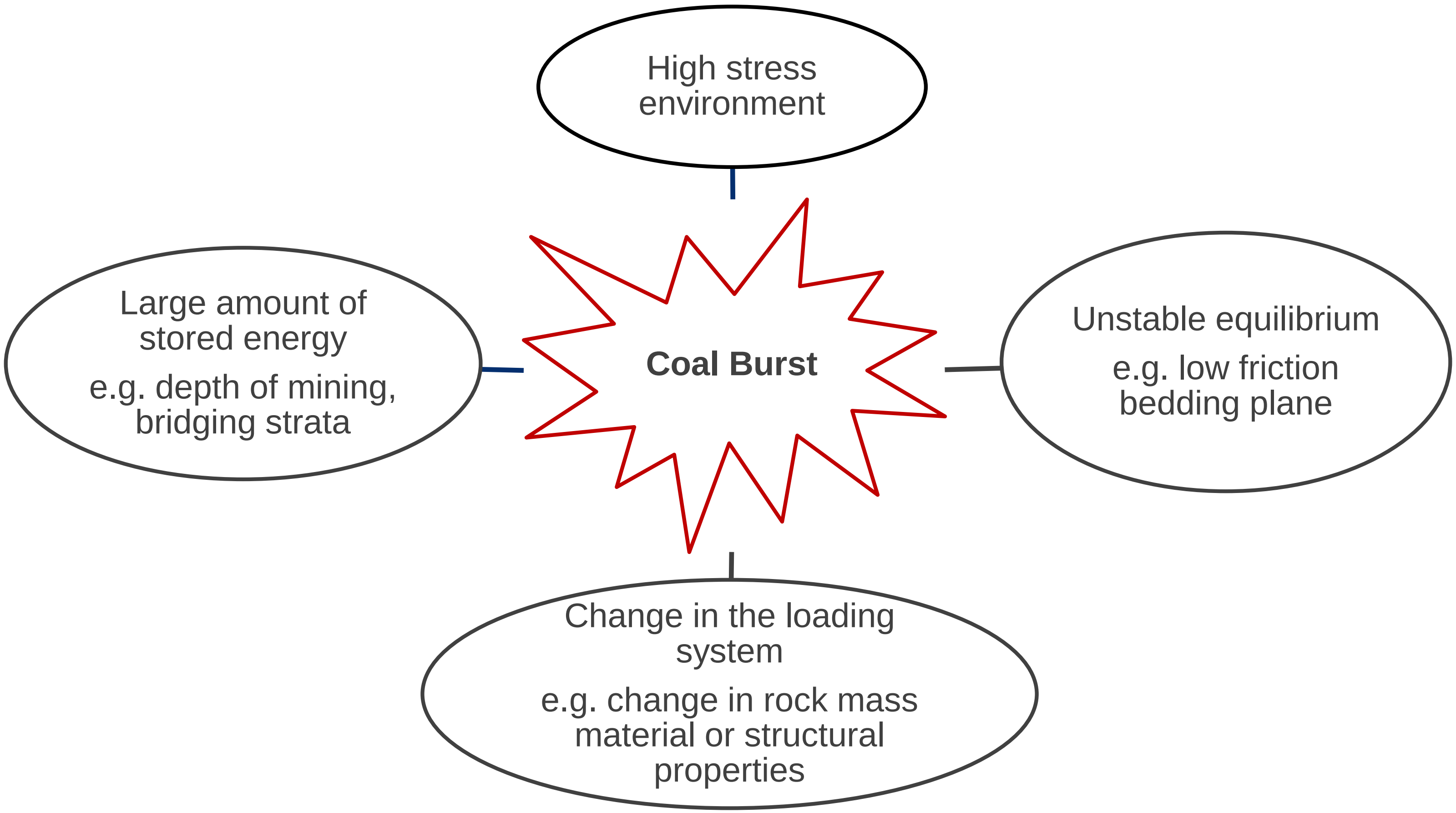
Four Coal Burst Conditions



After (Galvin, 2015)

BurstRisk

Longwall

Table II. BurstRisk – Longwall risk classification table

Weighting	Risk Factors	Rating
30	**Depth of cover**	
	<350 m	1
	351 m – 500 m	5
	>500 m	20
1	**Topography**	
	Flat	1
	Average	3
	Steep (Mountainous)	5
15	**Thick competent unit in the roof strata (within the first 50 m)**	
	None	1
	<5 m in thickness	3
	5 to 10 m in thickness	5
	>10 m in thickness	10
15	**Major geological structures**	
	No major geological structures	1
	>20 m proximity to the excavation	3
	<20 m proximity to the excavation	10
30	**Past seismic activity**	
	No recorded seismic activity	1
	Isolated minor seismic events in the mine or in neighbouring mines	5
	Persistent seismic activities in the mine or in the coalfield	20
5	**Coal cleating or jointing**	
	High density (Spalling)	1
	Low density (No spalling)	5
15	**Abutment stresses**	
	Longwall maingate	1
	Longwall face	3
	Longwall tailgate	5
5	**Multi-seam mining**	
	No mining below or above	0
	Seams >100 m apart	3
	Seams 50 m to 100 m apart	5
	Seams <50 m apart	10
1	**Gas content**	
	<3 m^3/t	1
	3-8 m^3/t	5
	>8 m^3/t (Also an outburst risk)	10

Development

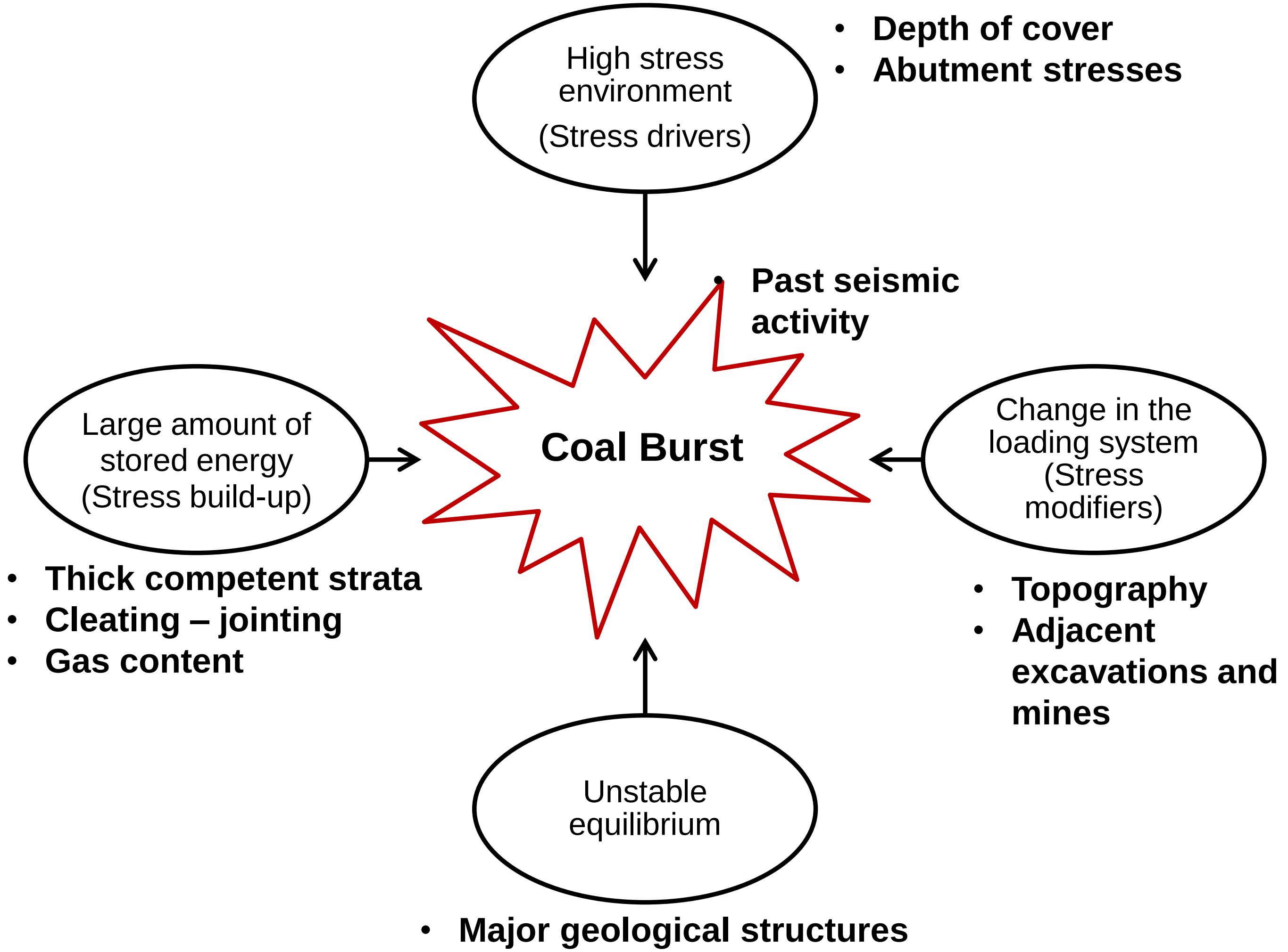
Table III. BurstRisk – Development risk classification table

Weighting	Risk Factors	Rating
30	**Depth of cover**	
	<350 m	1
	351 m – 500 m	5
	>500 m	20
5	**Topography**	
	Flat	1
	Average	3
	Steep (Mountainous)	5
30	**Major geological structures**	
	No major geological structures	1
	>20 m proximity to the excavation	3
	<20 m proximity to the excavation	10
30	**Past seismic activity**	
	NOT in the mine	1
	Isolated minor seismic events in the mine or neighbouring mines	5
	Persistent seismic activities in the mine or the coalfield	20
5	**Coal characteristics in terms of cleating or jointing**	
	High density (Spalling)	1
	Low density (No spalling)	5
20	**Abutment stresses**	
	No abutment (>500 m away)	1
	Approximate (150 to 500 m) to abutment	5
	Approximate (<150 m) to abutment	10
5	**Multi-seam mining**	
	No mining below or above	0
	Seams >100 m apart	3
	Seams 50 m to 100 m apart	5
	Seams <50 m apart	10
1	**Gas content**	
	<3 m^3/t	1
	3-8 m^3/t	5
	>8 m^3/t (Also an outburst risk)	10

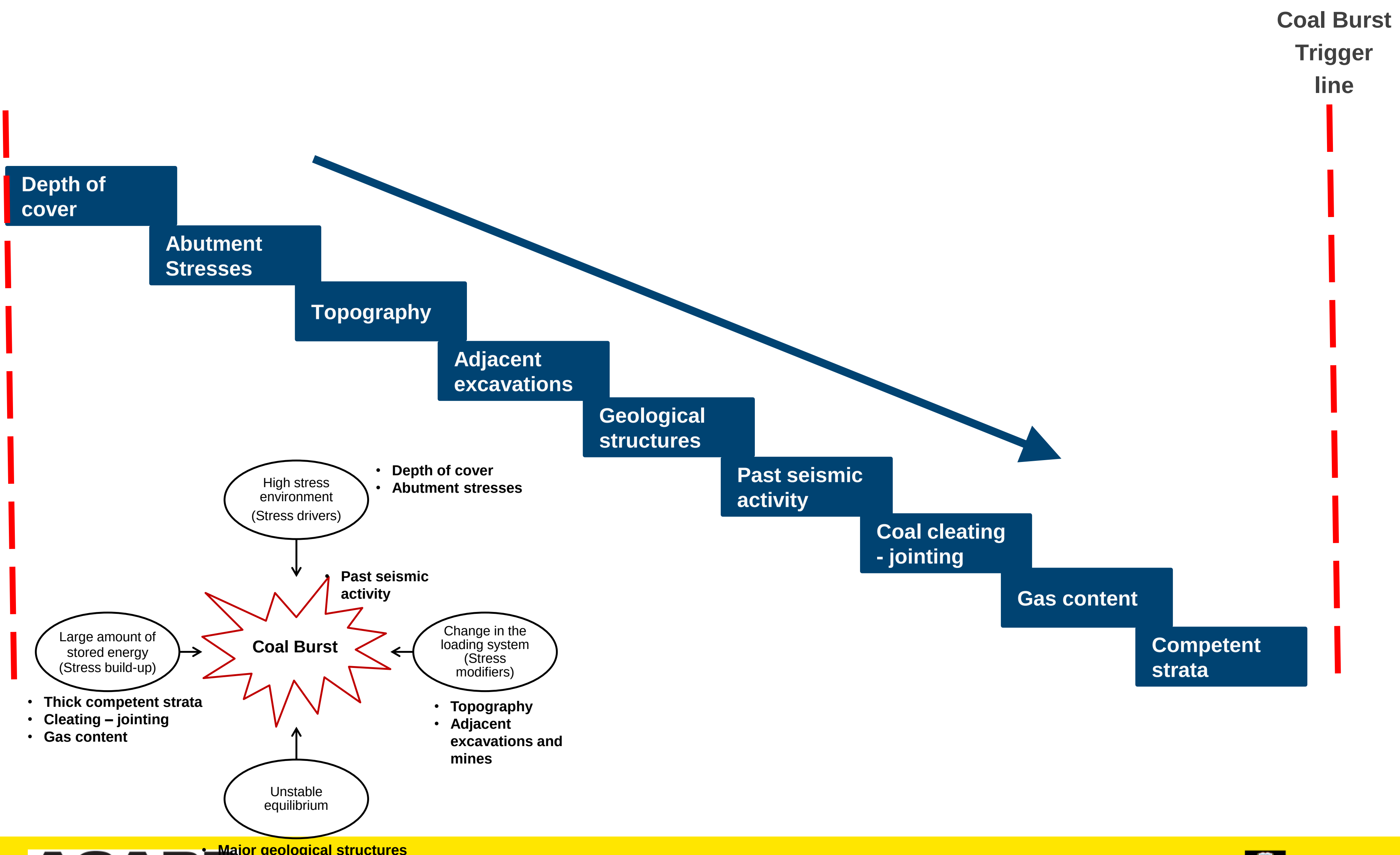
BurstRisk Generic

Weighting	Risk Factors	Rating
30	**Mining method**	
	Bord and pillar	5
	Longwall	10
	Pillar extraction	10
30	**Depth of cover**	
	<350 m	1
	351-450	5
	450 m - 700 m	15
	>700 m	20
1	**Topography**	
	Flat	1
	Average	3
	Steep (Mountainous)	5
15	**Thick competent unit in the roof strata (within the first 50 m)**	
	None	1
	<5m in thickness	3
	5 to 10m in thickness	5
	>10m in thickness	10
15	**Major geological structures**	
	No major geological structures	1
	>20 m proximity to the excavation	3
	<20 m proximity to the excavation	10
30	**Past seismic activity (i.e., bump, burst, shakedown)**	
	No recorded seismic activity	1
	Isolated minor seismic events in the mine or in the neighbouring mines	5
	Semi-regular seismic events of varying magnitudes	10
	Persistent seismic activities in the mine	20
1	**Coal cleating - jointing**	
	High density (Spalling)	1
	Low density (No spalling)	5
5	**Multi-seam mining**	
	No mining below or above	0
	Seams >100m apart	3
	Seams 50m to 100m apart	5
	Seams <50m apart	10
5	**Gas content**	
	<3 m^3/t	1
	3-8 m^3/t	5
	>8 m^3/t (Also an outburst risk)	10

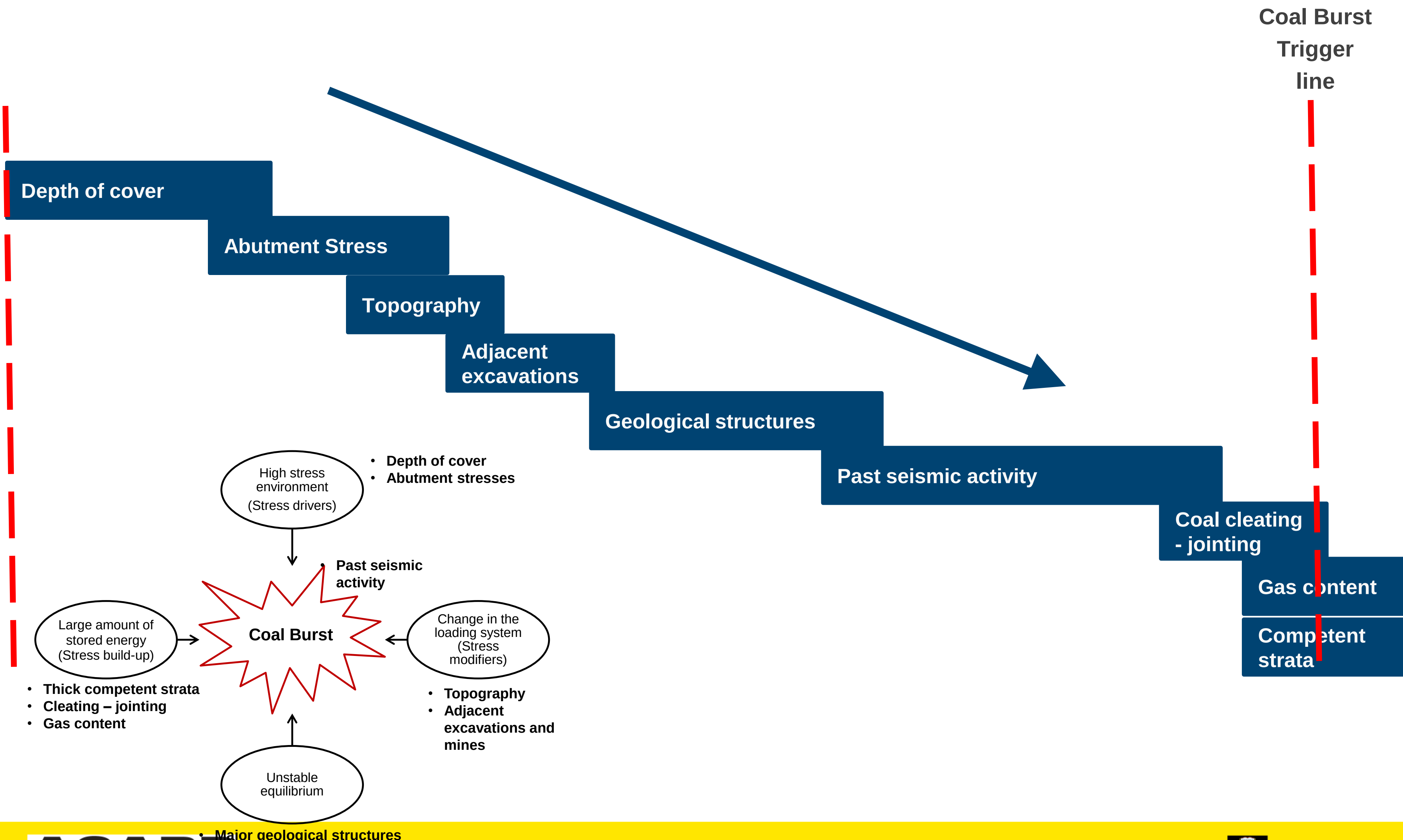
Identified Burst Prone Conditions



Identified Burst Prone Conditions

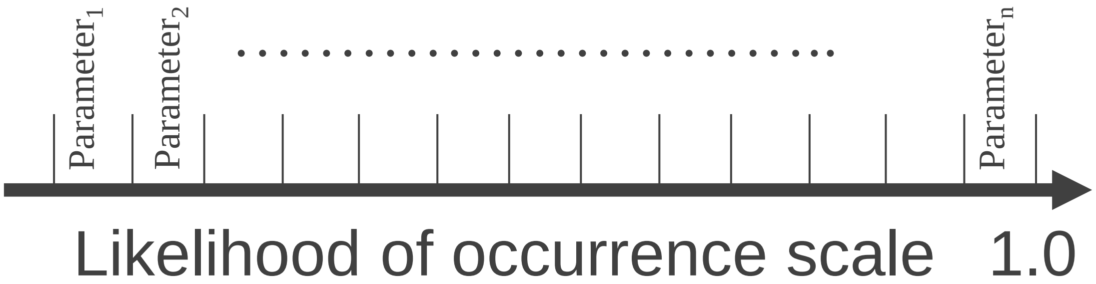


Identified Burst Prone Conditions



Likelihood of occurrence

1.0 represents that a coal burst occurrence is imminent



Propensity based on critical factors

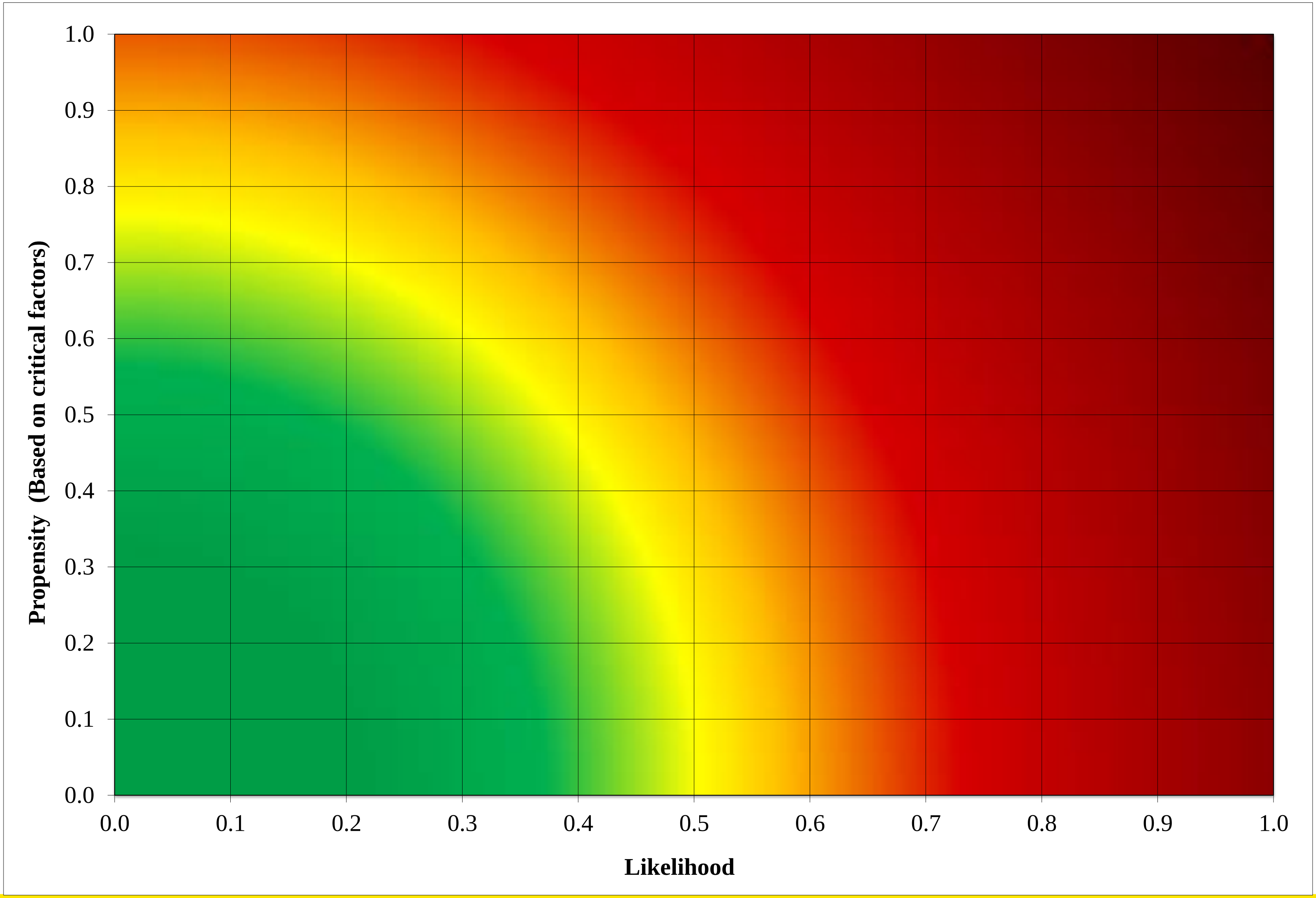
Calculations

$$LoF = \frac{\sum_{i=1}^{n} SPF_i}{\sum_{i=1}^{n} MPF_i}$$

$$Sev = \frac{\sum_{i=1}^{n} SPF_i \times W_i}{\sum_{i=1}^{n} MPF_i \times W_i}$$

Where, SPF_i = Selected probability factor for each parameter;
MPF_i = Maximum of probability factor of each parameter;
W_i = Weighting of each parameter.

Two Dimensional Presentation

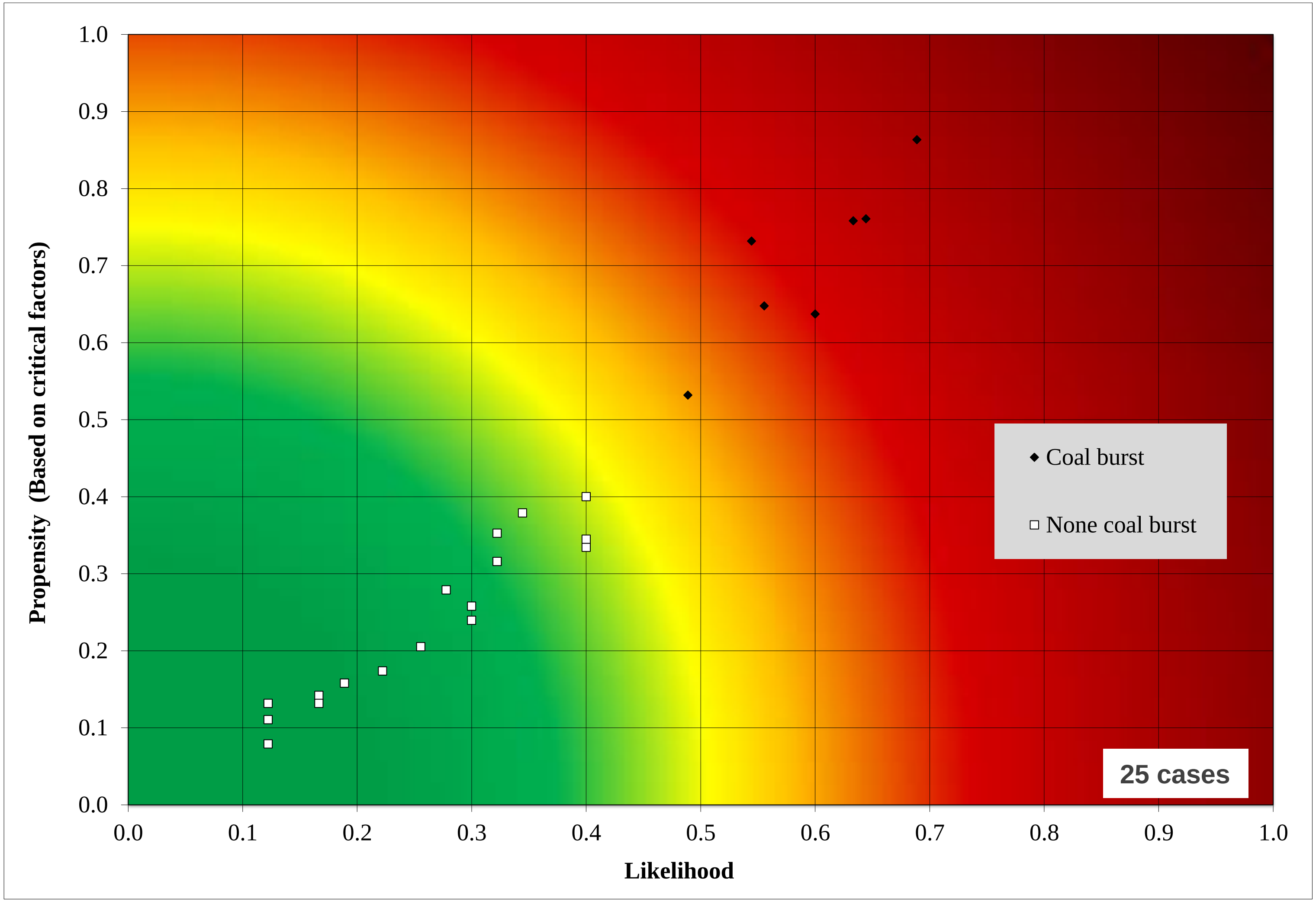


Back analysis

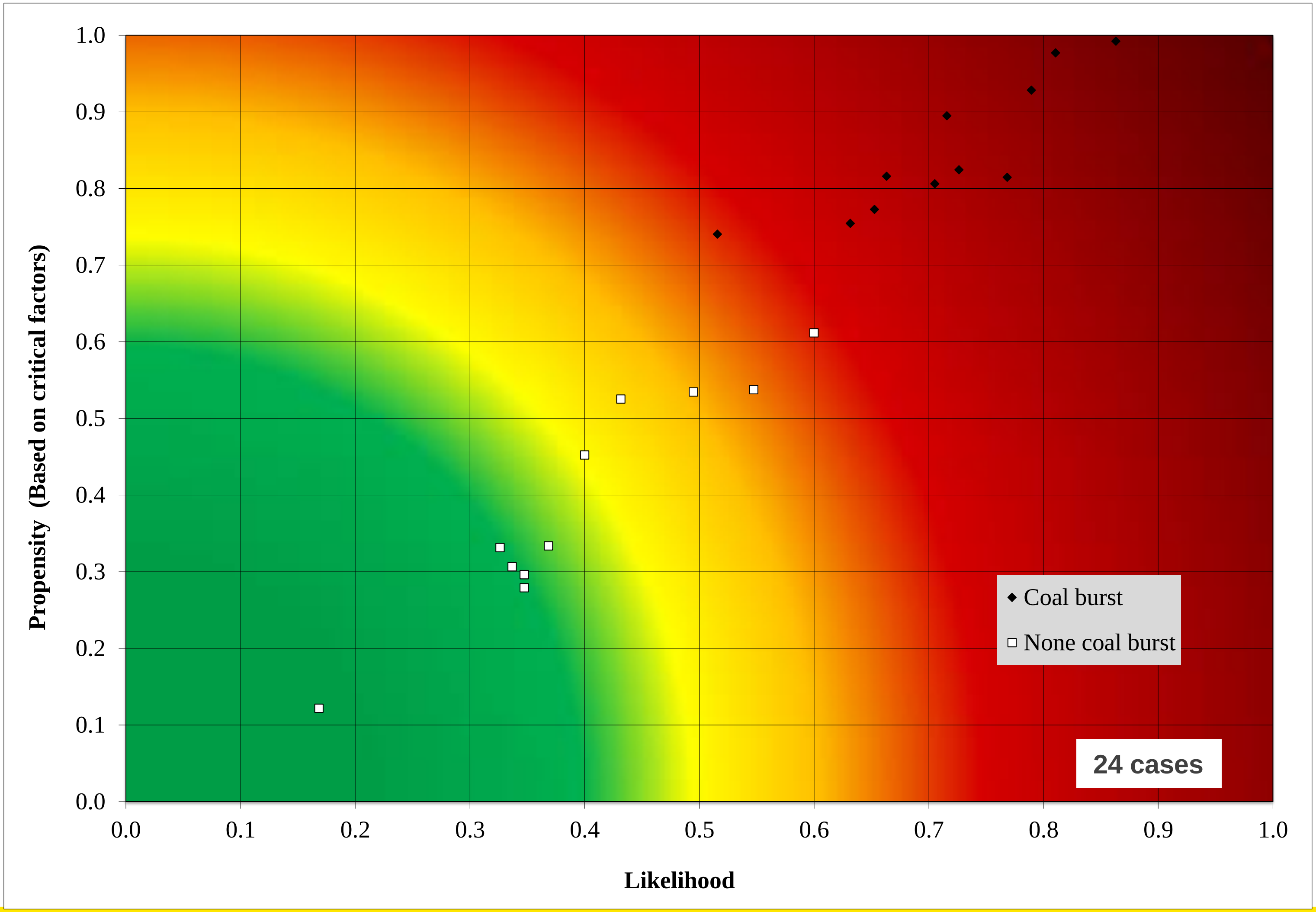
Cases from 27 mines from Australia, China, USA

- Generic assessment 50 cases
- Development assessment 25 cases
- Longwall assessment 24 cases
- Bord & pillar assessment 7 cases

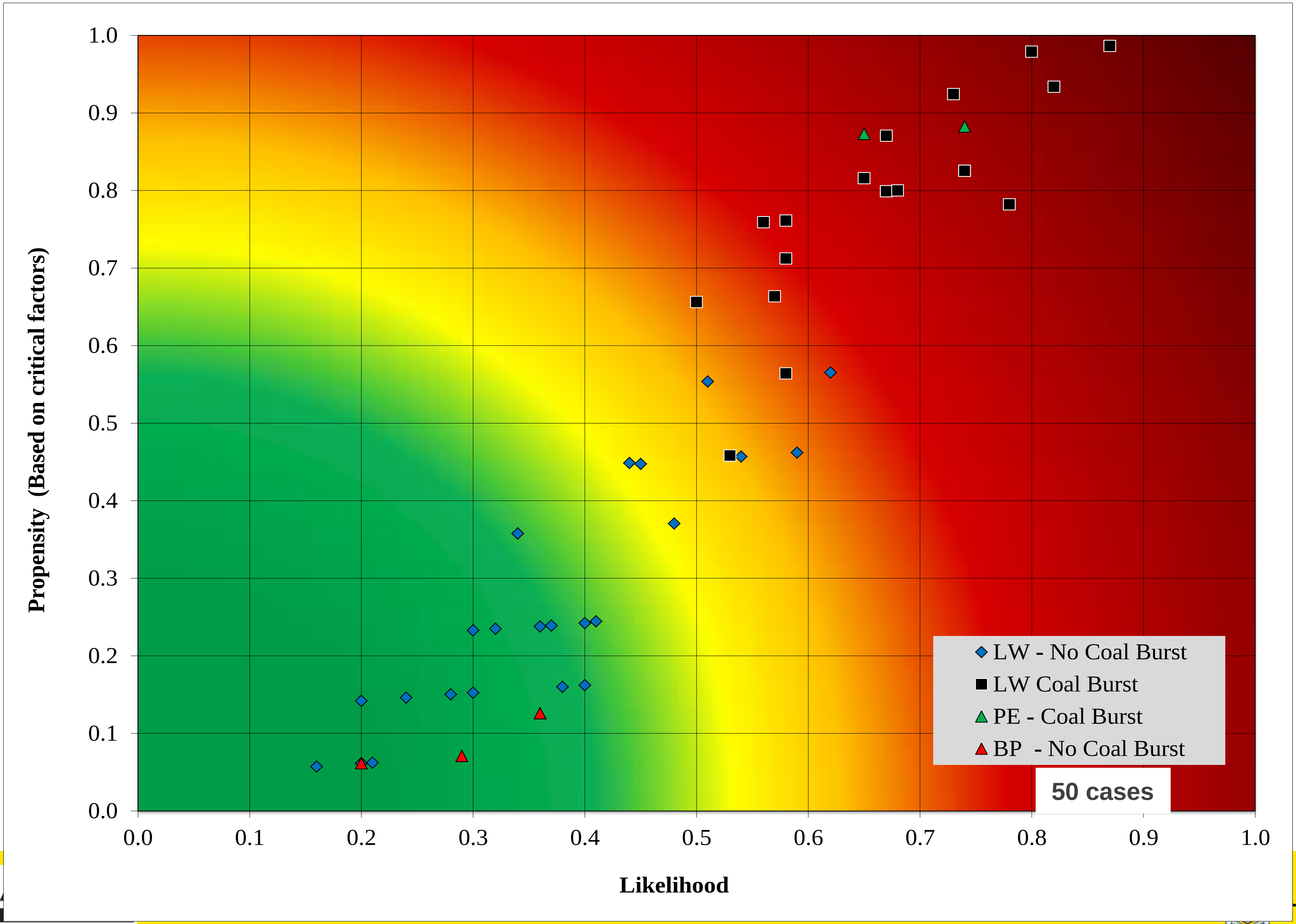
Preliminary Coal Burst Classification - Development



Preliminary Coal Burst Classification - Longwall



Preliminary Coal Burst Classification - Generic



Preliminary Coal Burst Classification – All

Development	Ranking
Mine (No Coal Burst)	11
Mine (No Coal Burst)	11
Mine (No Coal Burst)	11
Mine (No Coal Burst)	15
Mine (No Coal Burst)	15
Mine (No Coal Burst)	17
Mine (No Coal Burst)	20
Mine (No Coal Burst)	23
Mine (No Coal Burst)	25
Mine (No Coal Burst)	27
Mine (No Coal Burst)	27
Mine (No Coal Burst)	29
Mine (No Coal Burst)	29
Mine (No Coal Burst)	29
Mine (No Coal Burst)	31
Mine (No Coal Burst)	36
Mine (No Coal Burst)	36
Mine (No Coal Burst)	36
Mine (Coal Burst)	44
Mine (Coal Burst)	49
Mine (Coal Burst)	50
Mine (No Coal Burst)	54
Mine (Coal Burst)	57
Mine (Coal Burst)	58
Mine (Coal Burst)	62

Longwall	Ranking
Mine (No Coal Burst)	16
Mine (No Coal Burst)	31
Mine (No Coal Burst)	32
Mine (No Coal Burst)	33
Mine (No Coal Burst)	33
Mine (No Coal Burst)	33
Mine (No Coal Burst)	35
Mine (No Coal Burst)	38
Mine (No Coal Burst)	41
Mine (No Coal Burst)	47
Mine (Coal Burst)	49
Mine (Coal Burst)	52
Mine (Coal Burst)	57
Mine (Coal Burst)	58
Mine (Coal Burst)	60
Mine (Coal Burst)	62
Mine (Coal Burst)	63
Mine (Coal Burst)	67
Mine (Coal Burst)	68
Mine (Coal Burst)	69
Mine (Coal Burst)	73
Mine (Coal Burst)	75
Mine (Coal Burst)	77
Mine (Coal Burst)	82

Generic	Ranking
Mine (No Coal Burst)	16
Mine (No Coal Burst)	20
Mine (No Coal Burst)	20
Mine (No Coal Burst)	20
Mine (No Coal Burst)	20
Mine (No Coal Burst)	21
Mine (No Coal Burst)	24
Mine (No Coal Burst)	28
Mine (No Coal Burst)	29
Mine (No Coal Burst)	29
Mine (No Coal Burst)	30
Mine (No Coal Burst)	30
Mine (No Coal Burst)	32
Mine (No Coal Burst)	34
Mine (No Coal Burst)	36
Mine (No Coal Burst)	36
Mine (No Coal Burst)	36
Mine (No Coal Burst)	37
Mine (No Coal Burst)	38
Mine (No Coal Burst)	40
Mine (No Coal Burst)	40
Mine (No Coal Burst)	41
Mine (No Coal Burst)	44
Mine (No Coal Burst)	45
Mine (No Coal Burst)	48

Generic	Ranking
Mine (Coal Burst)	50
Mine (Coal Burst)	51
Mine (Coal Burst)	53
Mine (Coal Burst)	54
Mine (Coal Burst)	56
Mine (Coal Burst)	57
Mine (Coal Burst)	58
Mine (Coal Burst)	58
Mine (Coal Burst)	58
Mine (Coal Burst)	59
Mine (Coal Burst)	62
Mine (Coal Burst)	65
Mine (Coal Burst)	65
Mine (Coal Burst)	67
Mine (Coal Burst)	67
Mine (Coal Burst)	67
Mine (Coal Burst)	68
Mine (Coal Burst)	73
Mine (Coal Burst)	74
Mine (Coal Burst)	74
Mine (Coal Burst)	74
Mine (Coal Burst)	78
Mine (Coal Burst)	80
Mine (Coal Burst)	82
Mine (Coal Burst)	87

A Frame work Coal Burst Management Plan

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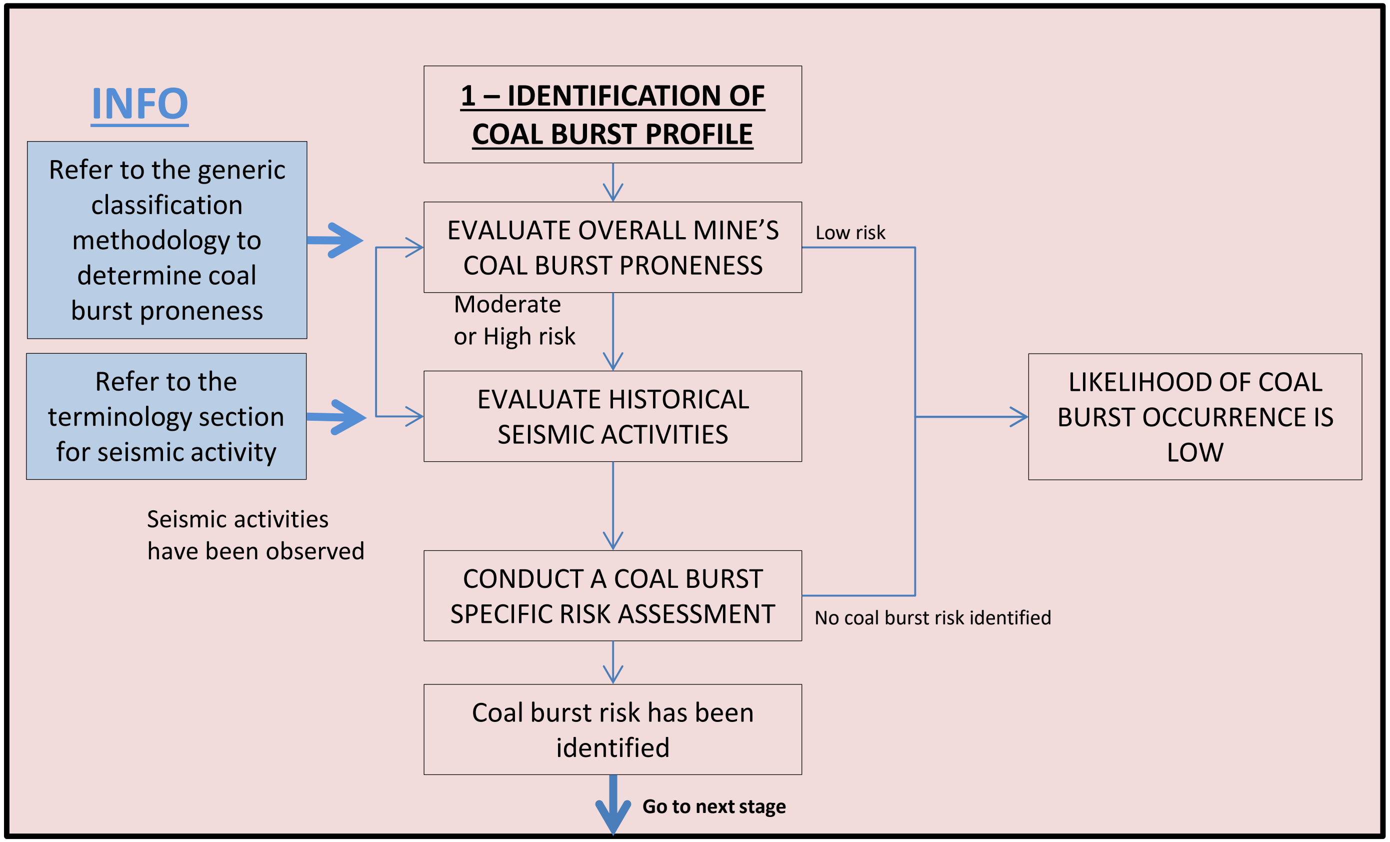
A Framework For A Coal Burst Management Plan

- Coal bursts can neither be predicted nor prevented with current knowledge and technology, but they may be controlled if the operation is prepared for their occurrence.
- Coal burst management is highly complex and there is no one approach that is applicable to all operations.
- Therefore, the purpose of this framework is to emphasise the critical considerations in a coal burst management plan for site specific applications; it is not to develop a generic management plan.
- The critical considerations have been identified through a detailed review of the international practices; hence all may not be applicable to Australian conditions.
- A risk-based evaluation of these considerations by all operations is recommended.

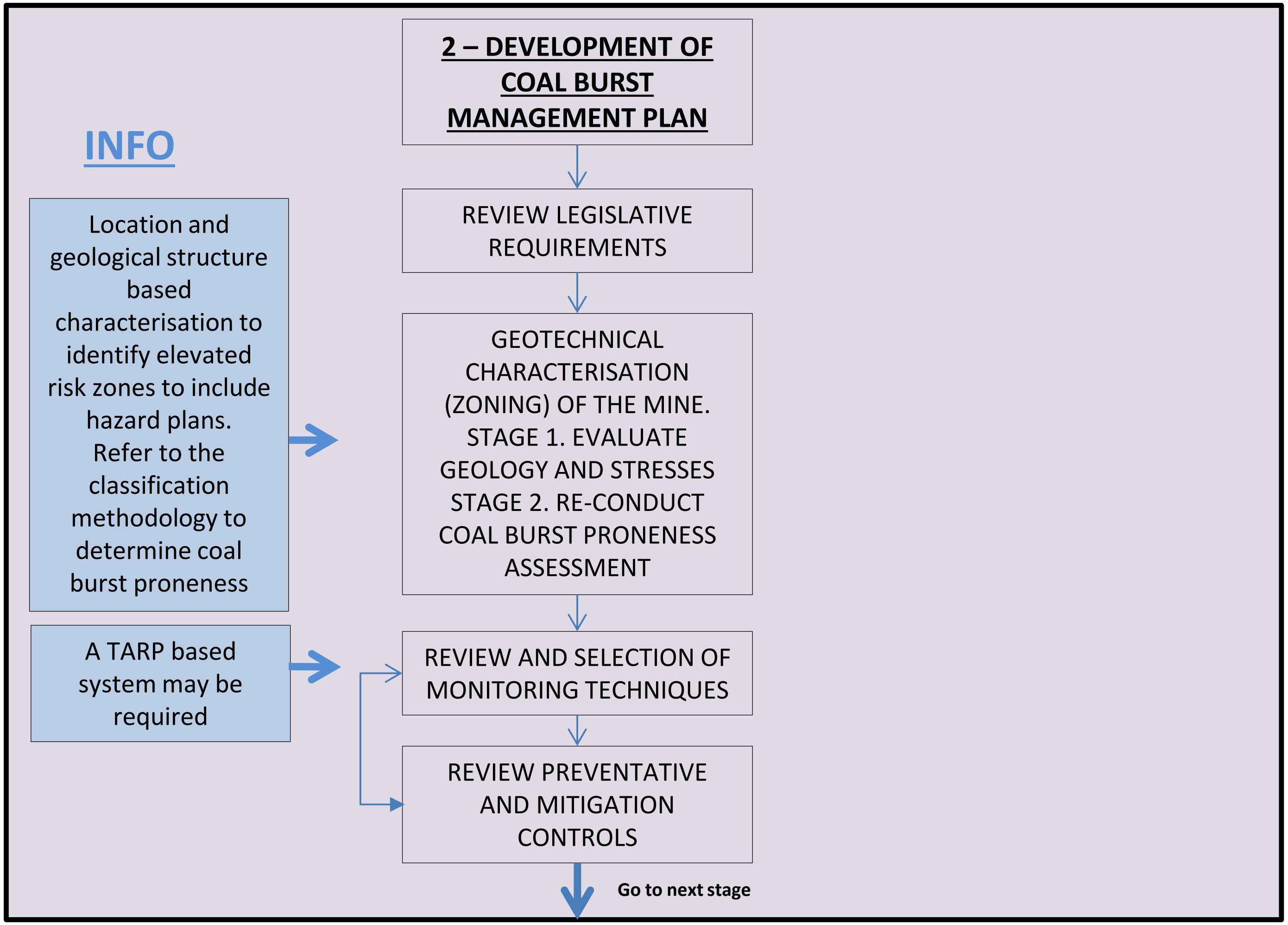
Three Stages in the Framework

1. Identification of coal burst
2. Development of coal burst management plan, and
3. Management of coal burst

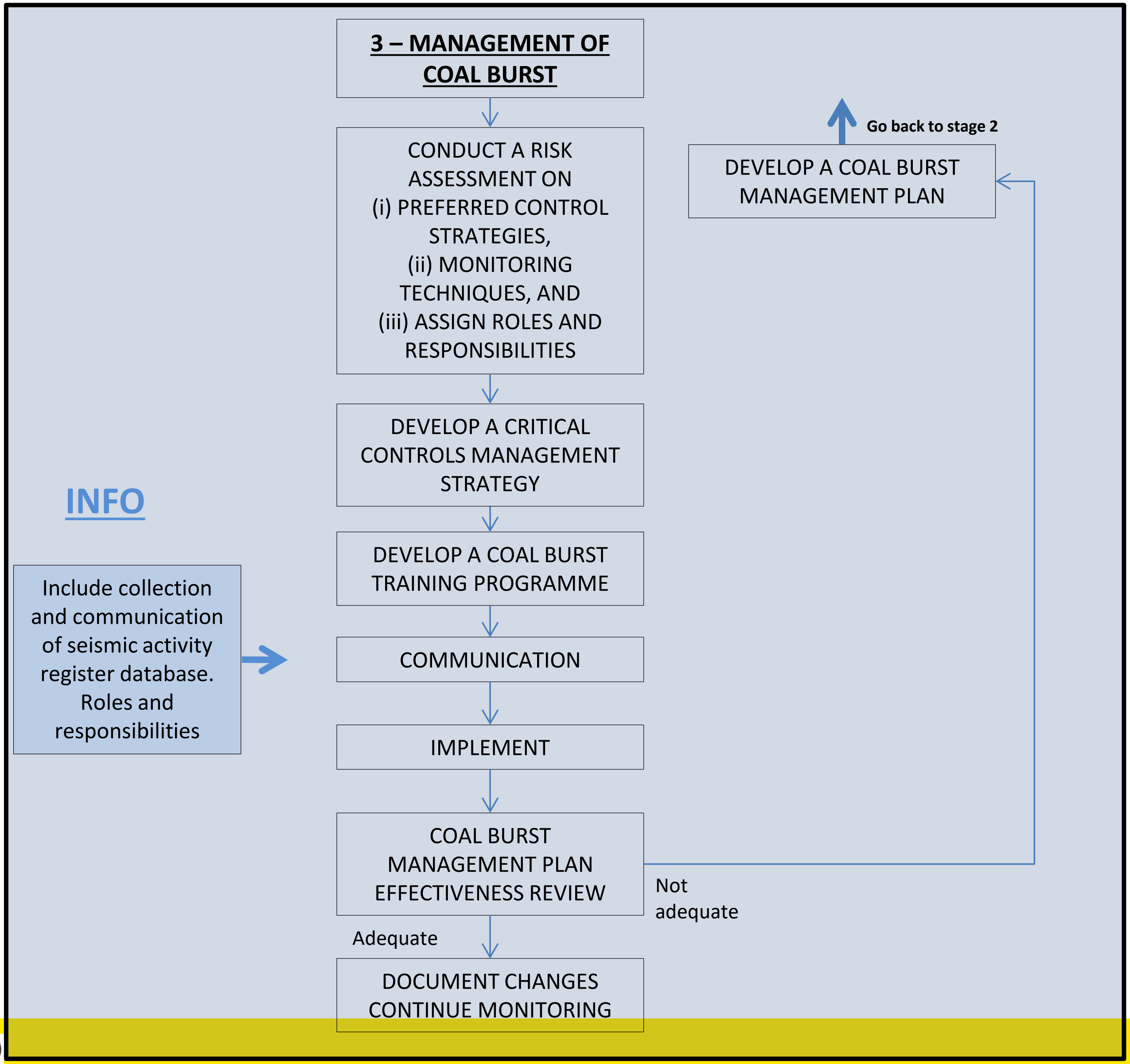
Stage 1- Identification of Coal Burst Profile



Stage 2- Development of Coal Burst MP



Stage 3 – Management of Coal Burst



An example section

5.2. Stage 2 – Development of coal burst management plan, and

DEVELOP A COAL BURST MANAGEMENT PLAN

- Using the steps summarised in this document, develop a coal burst management plan.
- The following considerations should also be included in the management plan:
  - a review strategy
  - audit schedule (internal, external, scheduled, unscheduled)

Note:

- As this management plan will be site specific, risk assessment can also identify additional steps that need to be considered in the management plan.

REVIEW AND DOCUMENT LEGISLATIVE REQUIREMENTS

- This review should include the requirements of principal hazard management plans and all associated considerations. Division 4A, Section 44B (Mining induced seismic activity 38) of Work Health and Safety (Mines and Petroleum Sites) Regulation 2014 (NSW) should also be considered.

GEOTECHNICAL CHARACTERISATION (ZONING) OF THE MINE

- Geotechnical characterisation includes two steps:
  - Step 1: Geotechnical characterisation based on different geotechnical domains in relation to variability of geological structures and units (see notes below); stress environment (including multi-seam interactions) and geotechnical properties
  - Step 2: Geotechnical characterisation based on evaluation of coal burst proneness using BurstRisk to identify coal burst risk domains.
- Identify medium and high risk zones should be included in the hazard plans.
- Identify appropriate controls and monitoring techniques to be implemented in different risk zones (e.g., development, longwall retreat, near seam massive units etc).

Note:

- Usually geotechnical characterisation can be based on:
  - locations (e.g., longwall, development, tailgate, maingate and/or multi-seam areas)
  - specific geological structures
  - near seam massive units
  - specific cover depth range
  - under certain geological feature
  - specific topography

Monitoring Technologies

		Techniques used in technical information gathering	Techniques used in operational monitoring and possible for forecasting
Localised monitoring	**In-place monitoring**	• Borehole drilling • Electromagnetic radiation technology • Visual observations • Roof deformation measurements	• Borehole drilling • Electromagnetic radiation technology
	Remote monitoring	• Seismic monitoring • Stress measurements • Acoustic monitoring • Seismic wave tomography	• Seismic monitoring • Stress measurements • Acoustic monitoring • Seismic wave tomography • A combination of the above
Regional monitoring	**Remote monitoring**	• Seismic monitoring	• Seismic monitoring

Control Technologies

		Development	Longwall Face
Mitigating Controls	**Administrative controls**	• Allow only the minimum number of persons in the areas where coal is being mined • Position remote control equipment operators as far from the active mining as practical. • Remote mining • Delayed re-entry • Training	• Allow only the minimum number of persons into the areas where coal is being mined • Position remote-control equipment operators as far from the active mining as practical • Automation • Delayed re-entry • Training
	Operational controls	• Use yielding roof/rib support system in critical areas according to the energy absorption rate • Reduce development rate • Use physical barriers and personal protective equipment • Directional hydraulic fracturing • Water infusion • Deep-hole relieve blasting (preconditioning) • Large borehole drilling • PPE	• Reduce the shear speed. • Reduce the web depth. • Cut uni-directional • Avoid double cuts at the gate ends. • Use physical barriers (including belts secured on to the shields) • Large borehole drilling • Hydraulic fracturing • Water infusion • PPE
Preventative Controls	**Prevention controls**	• Pillar design (i.e., intact or yield) • Mine layout design • Pillarless mining • Mining sequence • Protection seams in multiple seam mining	• Pillar design • Mine layout design • Mining sequence • Gate road system design • Pillar-less mining • Protection seams in multiple seam mining

Recording System

Event Category	Sub-Category	Comments
Pressure Burst	• Rock or coal burst • Pillar Burst	• Any form of burst that has led to intact rock/coal failure leading to expulsion of such failed material into a mined excavation
Pressure Bump	• Coal bump • Pillar bump	• A lower level event that may still lead to expulsion of pre-existing failed/spalling or fractured coal/rock into the roadway
Shake down		• (this, by terminology definition, is likely to be a consequence of a bump event)
Seismic Event		• Any other seismic activity or audible seismic signal that has not already been captured by one of the above burst or bump events. • This should also capture any significant evidence of face spitting.

Recording System

For each event listed above that occurs in a mine, the following records should be made:

- Classify the event according to category and sub-category
- Date and time
- Status of adjacent or nearby mining at the time
- Any evidence of anomalous or major geological structure in close proximity
- Location where event has occurred (both damage location) and any indication of source or triggering location (at least in terms of direction or horizon, if possible). This may enable classification as either direct or indirect event.
- Relative magnitude of the event in terms of audible signal/noise level (on a scale of 1-5)
- Assessment of damage, in terms of:
  - Type
  - Location within excavation (eg left hand upper rib, 3-5m back from face)
  - Magnitude of damage (a scale of 1-3, or 1-5)
  - Depth of any evident failure or damage.
  - Supplement with sketch where appropriate.

Questions?