

Appendix K – Review of Longwall Pillar Designs at UBB

U.S. Department of Labor

Mine Safety and Health Administration
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10BA115

December 8, 2010

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Signature

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FROM: MICHAEL GAUNA
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SUBJECT: Review of Longwall Pillar Designs at Performance Coal Company,
Upper Big Branch Mine-South, Raleigh County, West Virginia,
MSHA I. D. No. 46-08436

Background

As requested, the longwall pillar designs for Headgate 1 North and Tailgate 1 North at the Upper Big Branch Mine-South (UBB) operating in the Eagle coal seam were evaluated by the Roof Control Division (RCD). No undermining exists in the region. Overmining exists in the Powellton coal seam. In order to establish a comparative reference, the historical pillar designs for longwall panels to the south were also calculated. The historical areas evaluated were Tailgate 11 (western four-entry portion), Headgate 11 (western portion), Headgate 12 (west of overlying Black Knight belt system), Headgate 14 (west of overlying Black Knight belt system), Headgate 15 (west of overlying Black Knight belt system), and Headgate 16 (west of overlying Black Knight belt system). The NIOSH Analysis of Longwall Pillar Stability (ALPS - version 5.2.07) software was used and NIOSH Analysis of Multiple Seam Stability (AMSS - version 1.0.56) software was used. The ALPS analyses were conducted to evaluate the longwall gate pillar designs where no multiple seam interaction exists from workings in the overlying coal seam. The AMSS analyses focus on longwall gate pillar areas that are overlain by Powellton seam gob-solid boundaries. The ALPS and AMSS software are older versions, rather than the current October 2010 software, that were used to be consistent with evaluations which would have been conducted prior to October 2010.

Analysis Parameters

The pillar sizes and the longwall panel widths were taken from an AutoCAD map furnished for the mine. Depth of cover was determined by placing the electronic versions of the U.S.G.S. topographic maps for the region onto the mine AutoCAD map and calculating the depth based on the mine floor elevations and the topographic elevations.

Based on discussions with the UBB investigation team personnel, a mining height of 7 feet was used to account for the typically 5-foot coal height and the additional typical 4 feet of rock mined above the coal seam (practice is to add 50% of competent mined rock thickness to the coal seam height). A 21-foot mining width was used to account for mining widths that reportedly typically exceed 20 feet. The roof quality is considered to be moderate strength. The database for the NIOSH Coal Mine Roof Rating (CMRR) lists 7 Eagle seam CMRR values that have an average CMRR of 51. For comparative discussions, the RCD assigned the Coal Mine Roof Rating (CMRR) to have a value of 51 for UBB.

The overlying workings from the Powellton coal seam (closest overlying workings) could impact the UBB Eagle coal seam mining. Consequently, multiple seam mining conditions were evaluated with AMSS calculations. There are no underlying workings. For the AMSS calculations, the Powellton coal seam workings were scanned and overlain on the UBB AutoCAD map. The interburden between the two seams was obtained by calculating the difference between the floor elevations for the two coal seams. In the areas where AMSS calculations were conducted, the difference in floor elevations ranged from 160 to 205 feet and was assigned as the interburden. The interburden was not reduced by the Powellton mining height because the elevation surveying accuracy is unknown and reducing the interburden by the 8 to 10 feet of mining height does not significantly affect the calculations. The Powellton seam gob and barrier pillar widths were measured from the scanned image of the overlying Powellton seam workings.

ALPS Analyses

The ALPS calculates stability factors (SF) for five loading conditions: development, headgate (loading from the longwall front abutment), tailgate (loading from the longwall front abutment and abutment loading from the previously mine longwall panel), bleeder (loading along a pillar system from an adjoining extracted longwall panel) and isolated loading (loading onto a pillar system positioned between two fully extracted longwall panels). The relevant loading conditions for the UBB analyses are headgate, bleeder, and tailgate loading and are shown in the following memo tables. The ALPS offers two pillar strength calculation approaches: Bieniawski (minimum pillar width used in the strength calculation, know as Classic ALPS) and Mark-Bieniawski (pillar width and length used in the strength calculation, know as ALPS(R) output). For consistency with current calculation techniques the ALPS(R) output is most appropriate and should be used. The NIOSH offers design guidelines (suggested stability factors) only for the tailgate loading condition. The guideline is based on the mine site CMRR. For the 51 CMRR assigned to UBB, the NIOSH suggested minimum tailgate stability factor is 1.18. The ALPS analyses ignore the impact from mining in the overlying Powellton coal seam.

It must be emphasized that the suggested tailgate pillar stability factor must also be accompanied with supplemental support (typically roof-to-floor standing support) installed in the tailgate entry. The suggested SF criteria is derived from a case history database that had failures and success based on the tailgate functioning satisfactorily. The tailgate conditions were dependent on pillar performance plus the performance of the installed supplemental support and were also found to be dependent on the quality of the roof (mine site CMRR). Consequently, when conducting an ALPS evaluation, you could have an adequate pillar size, but, could have a tailgate failure if insufficient supplemental support is installed. The opposite could also occur, where a pillar system with an inadequate SF could function satisfactorily if a very robust and substantial support system is employed. The situation to avoid is to have a low tailgate pillar system SF and also an inadequate supplemental support system.

Table 1a summarizes the ALPS analyses for the historical mining area to the south of the 1 North longwall panel. Table 1b summarizes the ALPS analyses for the 1 North longwall panel. Tables 1a and 1b with all the calculation parameters are shown in Appendix 1. Tailgate 1 North, when functioning as a bleeder, does not meet the NIOSH tailgate SF criteria. Tailgate 11, when functioning as a bleeder, meets the NIOSH tailgate SF criteria. Tailgate 1 North has SF values that are approximately 80% of the SF values achieved with the historical Tailgate 11 design. Headgate 1 North and Headgates 11 through 16 do not meet the NIOSH tailgate SF criteria. Headgates 11 through 16 have tailgate SF values that range from 69% to 86% of the suggested NIOSH criteria. Headgate 1 North has a SF that is less than the historical cases at only 64% of the suggested NIOSH criteria.

Table 1a - ALPS Analyses; Historical LW Mining Tailgate 11 to Headgate 16									
Area	Pillar Design - centers, ft	Depth (1), ft	Type Overlying MS Boundary	ALPS(R) SF Active LW Face (HG Loading)	ALPS(R) SF Bleeder Loading	ALPS(R) SF TG Loading	Percent of NIOSH Suggested ALPS(R) TG SF=1.18 for CMRR 51	Meets Suggested ALPS(R) TG SF	NIOSH AMSS Projected Ground Condition (2)
TG 11	100x100 100x100 100x100	1020	N/A	1.74	1.39	N/A	N/A	Bleeder Exceeds TG Criteria	N/A
HG 11	90x105 115x105	1035	N/A	1.64	1.24	0.91	77.1%	No	N/A
HG 12	90x105 115x105	980	N/A	1.76	1.34	0.99	83.9%	No	N/A
HG 14	90x105 115x105	970	N/A	1.78	1.36	1.01	85.6%	No	N/A
HG 15	90x105 115x105	1020	N/A	1.67	1.27	0.93	78.8%	No	N/A
HG 16	90x105 115x105	1115	N/A	1.49	1.12	0.81	68.6%	No	N/A

Table 1b - ALPS Analyses; Tailgate 1 North & Headgate 1 North									
Area	Pillar Design - centers, ft	Depth (1), ft	Type Overlying MS Boundary	ALPS(R) SF Active LW Face (HG Loading)	ALPS(R) SF Bleeder Loading	ALPS(R) SF TG Loading	Percent of NIOSH Suggested ALPS(R) TG SF=1.18 for CMRR 51	Meets Suggested ALPS(R) TG SF	NIOSH AMSS Projected Ground Condition (2)
TG 1N east	79x100 79x100 79x100 79x100	1020	N/A	1.40	1.13	N/A	N/A	Bleeder Does Not Exceeds TG Criteria	N/A
HG 1N	100x100 100x100	1115	N/A	1.39	1.04	0.75	63.6%	No	N/A

Note: (1) = High Average Depth for gate entries (3 x Max Depth + Min Depth) / 4
(2) = Color code ground condition refers to required roof support (Local Stability requirements).
The Stability Factors (SF) refer to the required pillar design (Global Stability requirements).

AMSS Analyses

The AMSS evaluates the potential impact from overlying or underlying older workings onto the pillar design being evaluated. The AMSS offers two modes of analysis: a modified ALPS analysis for multiple seam mining conditions and a modified pillar recovery analysis (ARMPS-Analysis of Retreat Mining Pillar Stability) that is adjusted for multiple seam conditions. The multiple seam mining stresses are estimated and added onto the pillar design being studied. In the case for UBB, AMSS adjusts the ALPS analyses to account for these multiple seam stresses from the gob boundaries in the overlying Powellton coal seam and furnishes an evaluation of the Eagle coal seam pillar design. The pillar design assessment is referred to as a global stability assessment. The AMSS also furnishes an estimate of the impact on mine roof and rib conditions

to ascertain if additional roof and/or rib support may be needed. The roof/rib support assessment is referred to as a local stability assessment. The AMSS local stability outputs are coded as green, yellow, and red. The green and yellow codes generated for the UBB analyses are defined in the following memo tables. The AMSS analyses are conducted for specific localized areas where stress concentrations from the other seam will affect a particular area of the mine. In the case for UBB, it will be Powellton gob boundaries impacting the UBB longwall gate pillars. The areas where the AMSS analyses were conducted are outline in Appendix 2 which is a map of the UBB workings.

Table 2a summarizes the AMSS analyses for the historical mining area to the south of the 1 North longwall panel. Table 2b summarizes the AMSS analyses for the 1 North longwall panel. Tables 2a and 2b with all the calculation parameters are shown in Appendix 3. Tailgate 1 North (except the AMSS evaluation at crosscut 94) and the historical Tailgate 11, when functioning as a bleeder, meet the NIOSH tailgate SF criteria. Tailgate 11 has SF values that range from 2.00 to 2.76 for the regions where AMSS was calculated. Tailgate 1 North has SF values that are lower and range from 1.12 to 1.51. The one calculation site on Headgate 1 North and seven of the ten calculation sites for Headgates 11 through 16 do not meet the NIOSH tailgate SF criteria. The sites that do not meet criteria for Headgates 11 through 16 have tailgate SF values that range from 63% to 93% of the suggested NIOSH criteria. The Headgate 1 North AMSS site has a SF that is 65% of the suggested NIOSH criteria.

The RCD cannot comment on the actual ground conditions encountered with the longwall extraction for the sites evaluated. The AMSS local stability prediction for Tailgate 1 North and Headgate 1 North is a "Green" condition which suggests that a major interaction is unlikely. AMSS local stability predictions for the Headgates 11 through 16 sites are a combination of "Green" and "Yellow" conditions. A "Yellow" condition suggests that a major interaction is considered likely unless a pattern of supplemental support is installed. Rib instability is also likely.

Area	Pillar Design - centers, ft	Depth (1), ft	Type Overlying MS Boundary	ALPS(R) SF Active LW Face (HG Loading)	ALPS(R) SF Bleeder Loading	ALPS(R) SF TG Loading	Percent of NIOSH Suggested ALPS(R) TG SF=1.18 for CMRR 51	Meets Suggested ALPS(R) TG SF	NIOSH AMSS Projected Ground Condition (2)
TG 11 Xcut spad10593	100x100 100x100 100x100	550	Gob Solid	3.11	2.76	N/A	N/A	Bleeder Exceeds TG Criteria	Green
TG 11 Xcut spad10819	100x100 100x100 100x100	555	Gob Solid	2.85	2.55	N/A	N/A	Bleeder Exceeds TG Criteria	Green
TG 11 Xcut spad 10899	100x100 100x100 100x100	685	Gob Solid	2.30	2.00	N/A	N/A	Bleeder Exceeds TG Criteria	Green
HG 11 Xcut 125	90x105 115x105	930	Gob Solid	1.62	1.29	0.99	83.9%	No	Green
HG 11 Xcut 136	90x105 115x105	935	Remnant	1.41	1.15	0.91	77.1%	No	Yellow
HG 11 Xcut 146	90x105 115x105	745	Gob Solid	2.07	1.71	1.36	115.3%	Yes	Green
HG 12 Xcut 82	90x105 115x105	690	Remnant	1.89	1.62	1.34	113.6%	Yes	Yellow - Almost Green
HG 12 Xcut 138	90x105 115x105	1125	Gob Solid	1.30	1.00	0.74	62.7%	No	Yellow - Almost Green
HG 14 Xcut 51	90x105 115x105	860	Gob Solid	1.74	1.41	1.10	93.2%	No	Green
HG 14 Xcut 62	90x105 115x105	670	Gob Solid	2.37	1.97	1.60	135.6%	Yes	Green
HG 14 Xcut 134	90x105 115x105	960	Gob Solid	1.57	1.24	0.95	80.5%	No	Green
HG 15 Xcut 63	90x105 115x105	1065	Remnant	1.24	0.99	0.75	63.6%	No	Yellow
HG 16 Xcut 16	90x105 115x105	1070	Gob Solid	1.37	1.07	0.80	67.8%	No	Green

Area	Pillar Design - centers, ft	Depth (1), ft	Type Overlying MS Boundary	ALPS(R) SF Active LW Face (HG Loading)	ALPS(R) SF Bleeder Loading	ALPS(R) SF TG Loading	Percent of NIOSH Suggested ALPS(R) TG SF=1.18 for CMRR 51	Meets Suggested ALPS(R) TG SF	NIOSH AMSS Projected Ground Condition (2)
TG 1N Xcut 75	79x100 79x100 79x100 79x100	725	Gob Solid	1.73	1.51	N/A	N/A	Bleeder Exceeds TG Criteria	Green
TG 1N Xcut 94	84x100 78x100 78x100 78x100	935	Gob Solid	1.33	1.12	N/A	N/A	Bleeder Does Not Meets TG Criteria	Green
TG 1N Xcut 100	84x100 78x100 78x100 78x100	800	Gob Solid	1.58	1.36	N/A	N/A	Bleeder Exceeds TG Criteria	Green
HG 1N Xcut 71	100x100 100x100	1050	Gob Solid	1.33	1.03	0.77	65.3%	No	Green

Note: (1) = Average depth in vicinity of overlying gob/remnant boundary

(2) = Color code ground condition refers to required roof support (Local Stability requirements).

The Stability Factors (SF) refer to the required pillar design (Global Stability requirements).

Green: A major interaction is unlikely.

Yellow: A major interaction should be considered likely unless a pattern of supplemental roof support (cable bolts or equivalent) is installed. Rib instability is also likely.

The information presented in this memorandum is based on the information submitted from various sources without an underground assessment and should be considered in that context. If the RCD can be of further assistance, or if you have any questions regarding this memorandum, please contact Mike Gauna at 304-547-2311.

Appendix 1
UBB ALPS Evaluation including Calculation Parameters

Table 1a - ALPS Analyses: Historical LW Mining Tailgate 11 to Headgate 16

Pillar Design Area	Depth (1) ft.	Type Overlying MS Boundary	ALPS(R) SF Active LW Face (HG Loading)	ALPS(R) SF Bleeder Loading	ALPS(R) SF TG Loading	Percent of NIOSH Suggested ALPS(R) SF=1.18 for CMRR 51	Meets Suggested ALPS(R) TG SF Exceeds TG Criteria	NIOSH AMSS Projected Ground Condition (2)
TG 11	100x100	N/A	1.74	1.39	N/A	N/A	No	N/A
HG 11	80x105	N/A	1.64	1.24	0.91	77.1%	No	N/A
HG 12	90x105	N/A	1.76	1.34	0.99	85.9%	No	N/A
HG 14	115x105	N/A	1.78	1.36	1.01	86.6%	No	N/A
HG 15	115x105	N/A	1.67	1.27	0.93	76.8%	No	N/A
HG 16	115x105	N/A	1.49	1.12	0.81	66.6%	No	N/A

Table 1b - ALPS Analyses: Tailgate 1 North & Headgate 1 North

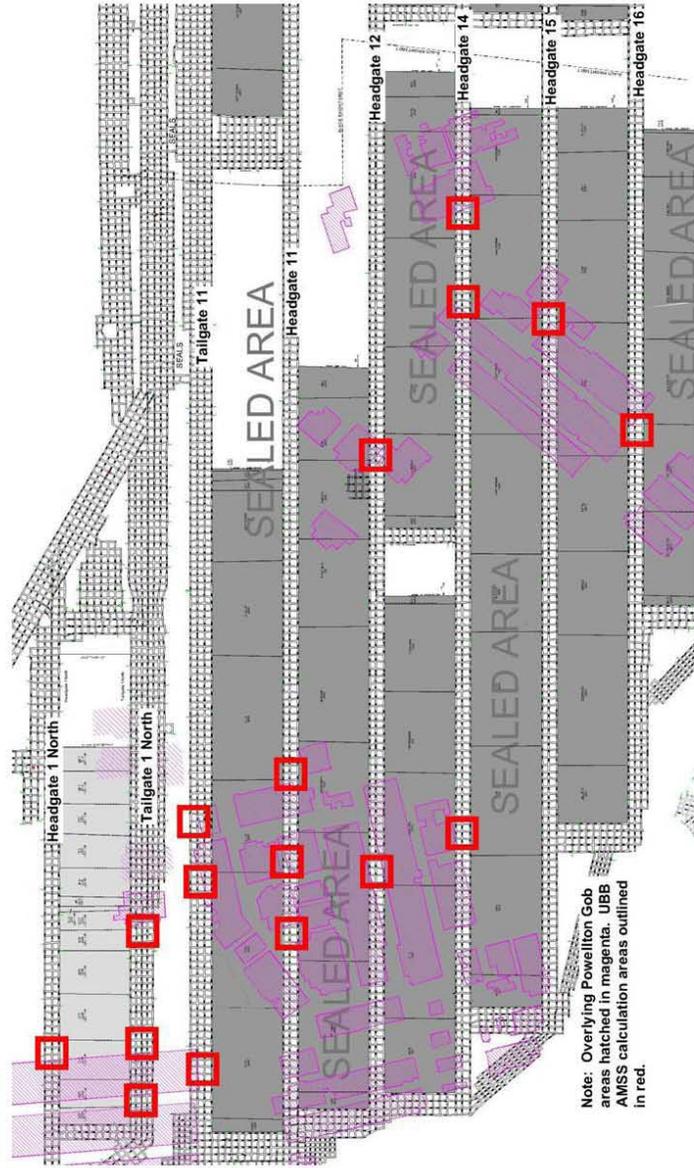
Pillar Design Area	Depth (1) ft.	Type Overlying MS Boundary	ALPS(R) SF Active LW Face (HG Loading)	ALPS(R) SF Bleeder Loading	ALPS(R) SF TG Loading	Percent of NIOSH Suggested ALPS(R) SF=1.18 for CMRR 51	Meets Suggested ALPS(R) TG SF Exceeds TG Criteria	NIOSH AMSS Projected Ground Condition (2)
TG 1N east	79x100	N/A	1.40	1.13	N/A	N/A	No	N/A
HG 1N	100x100	N/A	1.39	1.04	0.75	63.6%	No	N/A

Note: (1) = High Average Depth for gate entries (3 x Max. Depth + Min Depth) / 4
 (2) = Color code ground condition refers to required roof support (Local Stability requirements).
 The Stability Factors (SF) refer to the required pillar design (Global Stability requirements).

Eagle Seam Mining Height, ft.	Eagle Seam Mining Width, ft.	Eagle Seam Panel Center Width, ft.	Interburden, ft.	Powellton Seam Gob 1 Width, ft.	Powellton Seam Remnant Width, ft.	Powellton Seam Gob 2 Width, ft.	Powellton Seam Mining Height, ft.
7	21	1020	N/A	N/A	N/A	N/A	N/A
7	21	1020	N/A	N/A	N/A	N/A	N/A
7	21	1020	N/A	N/A	N/A	N/A	N/A
7	21	1020	N/A	N/A	N/A	N/A	N/A
7	21	1020	N/A	N/A	N/A	N/A	N/A
7	21	1020	N/A	N/A	N/A	N/A	N/A

Eagle Seam Mining Height, ft.	Eagle Seam Mining Width, ft.	Eagle Seam Panel Center Width, ft.	Interburden, ft.	Powellton Seam Gob 1 Width, ft.	Powellton Seam Remnant Width, ft.	Powellton Seam Gob 2 Width, ft.	Powellton Seam Mining Height, ft.
7	21	1024	N/A	N/A	N/A	N/A	N/A
7	21	1024	N/A	N/A	N/A	N/A	N/A

Appendix 2
Location of UBB AMSS Evaluations



Appendix 3
UBB AMSS Evaluation including Calculation Parameters

Table 2a - AMSS Analyses: Historical Longwall Mining Tailgate 1 to Headgate 16														
Area	Pillar Design - Depth (1), centers, ft	Type Overlying MS Boundary	ALPS(R) SF Active (HG Bleeder Loading)	ALPS(R) SF (ALPS(R) TG Suggested SF)	Percent of NIOSH Support SF ALPS(R) SF TG SF=1.18 for ALPS(R) TG SF	NIOSH Proposed Ground Condition (2)	Eagle Seam Mining Height, ft	Eagle Seam Mining Width, ft	Eagle Seam LV Panel Center Width, ft	Interburden (3), ft	Powellton Seam Gob Remnant Width, ft	Powellton Seam Gob Mining Height, ft		
TG 11 Xcut 100x100	100x100	Gob Solid	3.11	2.76	N/A	Bleeder Exceeds TG Criteria	7	21	1020	180	270	N/A	6	
TG 11 Xcut 100x100	100x100	Gob Solid	2.85	2.55	N/A	Bleeder Exceeds TG Criteria	7	21	1020	180	450	N/A	6	
TG 11 Xcut 100x100	100x100	Gob Solid	2.39	2.00	N/A	Bleeder Exceeds TG Criteria	7	21	1020	190	600	N/A	6	
TG 11 Xcut 100x100	100x100	Gob Solid	1.82	1.28	83.9%	No	7	21	1020	185	450	N/A	6	
TG 11 Xcut 100x100	100x100	Remnant	1.41	1.15	81%	No	7	21	1020	185	475	110	380	6
TG 11 Xcut 100x100	100x100	Gob Solid	2.07	1.71	135.3%	Yes	7	21	1020	180	560	N/A	6	
TG 12 Xcut 90x105	90x105	Remnant	1.89	1.62	113.8%	Yes	7	21	1020	160	490	80	500	6
TG 12 Xcut 90x105	90x105	Gob Solid	1.39	1.00	72.7%	No	7	21	1020	185	490	N/A	6	
TG 14 Xcut 90x105	90x105	Gob Solid	1.74	1.41	81.2%	No	7	21	1020	160	550	N/A	6	
TG 14 Xcut 90x105	90x105	Gob Solid	2.37	1.87	135.6%	Yes	7	21	1020	175	330	N/A	6	
TG 14 Xcut 90x105	90x105	Gob Solid	1.57	1.24	88.5%	No	7	21	1020	190	450	N/A	6	
TG 15 Xcut 90x105	90x105	Remnant	1.24	0.89	71.8%	No	7	21	1020	170	400	150	420	6
TG 16 Xcut 100x100	100x100	Gob Solid	1.37	1.07	77.4%	No	7	21	1020	173	430	N/A	6	

Table 2b - AMSS Analyses: Tailgate 1 North & Headgate 1 North													
Area	Pillar Design - Depth (1), ft	Type Overlying MS Boundary	ALPS(R) SF Active (HG Bleeder Loading)	ALPS(R) SF (ALPS(R) TG Suggested SF)	Percent of NIOSH Support SF ALPS(R) SF TG SF=1.18 for ALPS(R) TG SF	NIOSH Proposed Ground Condition (2)	Eagle Seam Mining Height, ft	Eagle Seam Mining Width, ft	Eagle Seam LV Panel Center Width, ft	Interburden (3), ft	Powellton Seam Gob Remnant Width, ft	Powellton Seam Gob Mining Height, ft	
TG 11 Xcut 78x100	78x100	Gob Solid	1.73	1.51	N/A	Bleeder Exceeds TG Criteria	7	21	1024	180	390	N/A	6
TG 11 Xcut 78x100	78x100	Gob Solid	1.33	1.12	N/A	Does Not Meet TG Criteria	7	21	1024	186	585	N/A	6
TG 11 Xcut 78x100	78x100	Gob Solid	1.58	1.36	N/A	Bleeder Exceeds TG Criteria	7	21	1024	194	585	N/A	6
TG 11 Xcut 100x100	100x100	Gob Solid	1.33	1.03	77.4%	No	7	21	1024	205	585	N/A	6

Note: (1) = Average depth in vicinity of overlying gob/bleeder boundary
(2) = Color code ground condition refers to required roof support (Local Stability requirements).
The color code refers to the required pillar design (Global Stability requirements).
Green: A major interaction is unlikely.
Yellow: A major interaction should be considered likely unless a pattern of supplemental roof support (cable bolts or equivalent) is installed. Rib instability is also likely.
Also, in the AMSS output, the calculated multiple seam ALPS SF is compared to the suggested Bleiweisk - Classic ALPS SF value rather than the ALPS(R) suggested SF value shown in this table.