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SUMMARY OF GEOTECHNICAL DESIGN AND OPERATIONAL CONSIDERATIONS FOR HIGHWALL MINING—I, J, N, AND L PITS, TRAPPER MINE

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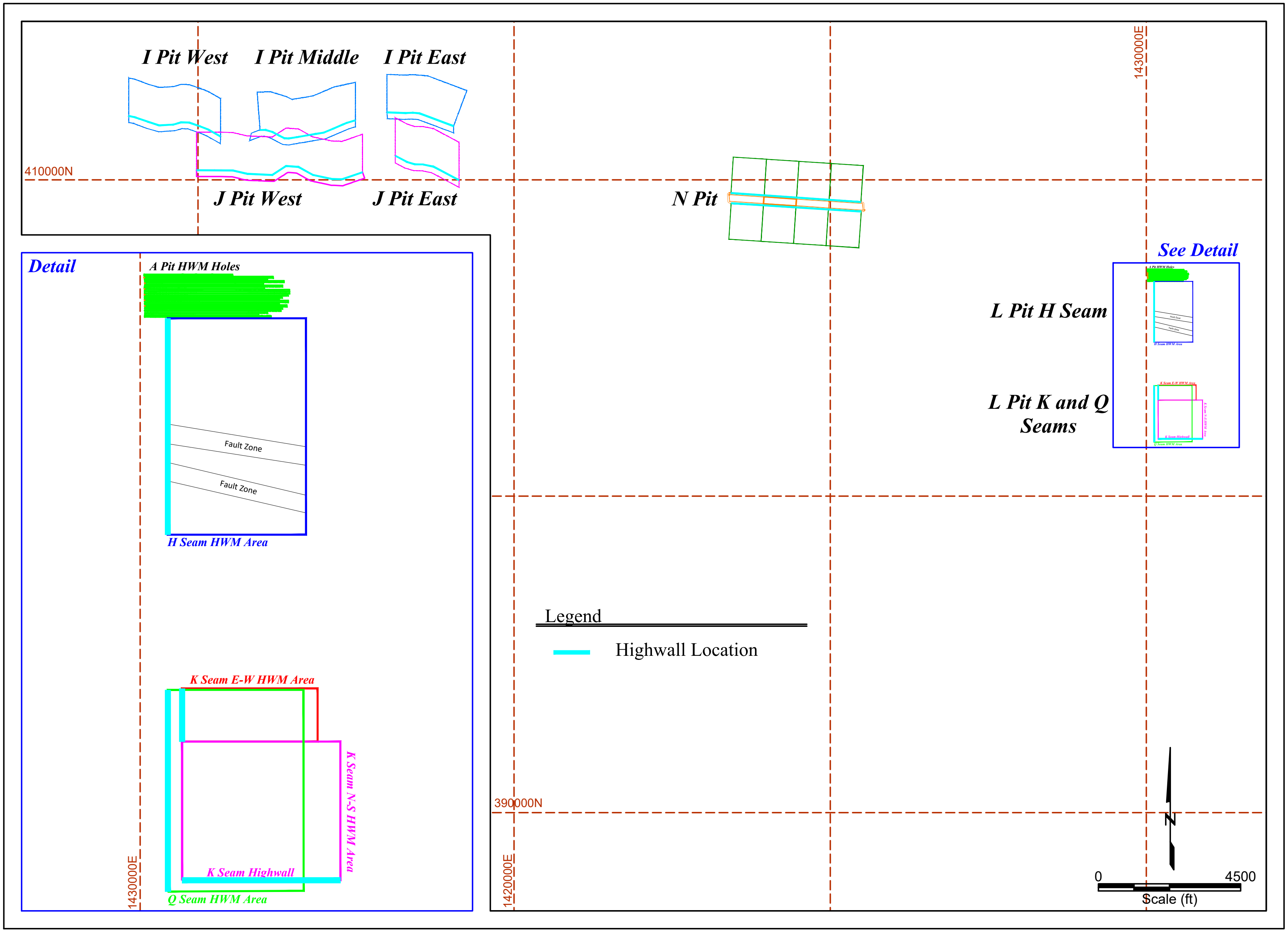
1 INTRODUCTION

Beginning in 2016, Agapito Associates, Inc. (AAI) was contracted by Trapper Mining, Inc. (Trapper) to perform evaluations of highwall mining (HWM) for several different mining areas at the Trapper Mine, Craig, Colorado. These design efforts built upon a successful trail of HWM of the H Seam in the A Pit in 2007, for which AAI had also provided design guidance. Table 1-1 summarizes the areas studied and the seams currently targeted. Note that the North Ashmore and North Colt Pits are not currently being considered for HWM.

Table 1-1. Summary of HWM Pits and Seams Mined

Study	HWM Area (Pit)	Seams Mined
I, J, North Ashmore and North Colt Pits (AAI 2018)	I Pit	F
	J Pit	G2
N Strikeline Pit (AAI 2019a)	N Pit	L, M, Q
L Pit (AAI 2019b)	L Pit	H, K, Q

Box cuts specifically for HWM are planned for the I, J, and N Pits, while L Pit HWM would be at the limit of strip operations. Figure 1-1 shows the locations of the box cuts and the proposed HWM areas from each pit. Although a specific contractor has not been chosen, for the purposes of the studies performed by AAI, it is assumed that an HWM system with similar capabilities to the ADDCAR Systems LLC (ADDCAR) HWM system will be used, with penetrations of up to 1,200 feet (ft).



534-44 Trapper [534-44 Trapper_HWM Areas_NOV2019.dwg]:tv/smvf (11-7-2019)

Figure 1-1. Location of Proposed Box Cuts and HWM Areas

2 PHYSICAL AND GEOTECHNICAL SETTING

The coal deposits at Trapper occur in Cretaceous sediments of the Upper Williams Fork Formation (Norwest 2000). These sediments consist primarily of sandstone, mudstone and coal, with less frequent occurrences of sandy shale and siltstone. For each HWM area, cores from holes drilled to support the design effort were recovered and tested to determine physical properties for input to the geotechnical design. The physical property data sets for each area are discussed in the individual reports. A summary of the physical properties for the major rock types is given in Table 2-1. The test type headings and abbreviations are defined as follows:

UCS	Unconfined compressive strength
E	Young's modulus
S	Slake durability (second cycle, percent [%])
PLCS	Axial point load compressive strength
PLT-D	Diametral point load Is(50) index
Density	Density (as tested)
Moisture	Water content (by weight)

Table 2-1. Physical Property Summary of Major Rock Types

Rock Type	UCS (psi)	E (10^6 psi)	Slake (%)	PLCS (psi)	PLT-D	Moisture (%)	Density (pcf)
Carbonaceous Mudstone	1,960	0.14	29.1	1,240	n/a	13.1%	127.2
Mudstone	2,640	0.52	66.3	1,610	44.3	7.7%	145.5
Sandstone	3,610	1.10	67.6	3,060	106.3	7.9%	143.0
Siltstone	3,910	1.49	81.4	3,180	89.8	6.2%	150.3

psi = pounds per square inch; pcf = pounds per cubic foot; n/a = not available

The data in Table 2-1 show that the properties of the coal-bounding strata are similar, though marginally weaker than those found at other surface mines of the Western United States (US).

Slake durability tests were specified to provide a quantitative measure of floor trafficability and as input to Coal Mine Roof Ratings (CMRR) (Mark, Molinda, and Barton 2002) used to quantify roof stability. Table 2-2 provides the slake durability classification (resistance to weathering) as proposed by Franklin and Chandra (1971). According to this classification criterion, the mudstone, sandstone, and siltstone have high durability, while carbonaceous mudstone, which occurs frequently in the immediate roof and floor, has low durability. In general, should floor trafficability or poor roof conditions be encountered, leaving approximately 6 inches in the roof and/or floor should improve the situation.

Historical data shows that jointing on the property is near-vertical, with two orthogonal joint sets trending northwest and northeast (AAI 2004).

Table 2-2. Slake Durability Classification

Second Cycle Slake Durability (%)	Classification
0–25	Very low
25–50	Low
50–75	Medium
75–90	High
90–95	Very high
95–100	Extremely high

Two known normal faults intersect the HWM area for the J Pit, H Seam, trending about north 80 degrees west (N80°W) (Figure 1-1). The faults have displacements of 15 and 25 ft and are located within gouge zones approximately 30 ft wide. The precise location of the faults is uncertain; therefore, the boundary of the HWM area excludes a 75-ft buffer zone on either side of the suspected fault location. Once the highwall is exposed and the fault locations are better defined, the buffer zone width may be reduced, allowing additional HWM openings to be mined. No other faults that may impact mining have been identified in the other HWM areas.

Aquifers at Trapper are associated with the coal seams and adjacent sandstones, with intervening shales and clays inhibiting vertical movement. Some groundwater inflows can be expected during HWM operations. Most highwall miner openings will be downdip, but water quantities are not expected to hamper HWM operations.

For each HWM area, seam models provided by Trapper were examined to establish the geometric characteristics and assess their minability. A summary of characteristics of the target seams in the various Pits is shown in Table 2-3.

Table 2-3. Physical Characteristics of the Target Seams

Pit	Seam	Cover Range (ft)	Thickness Range (ft)	Interburden Range to Target Seam Below (ft)
I Pit East	F	35–95	2–5	n/a
I Pit Middle	F	40–215	5–6	60–120
I Pit West	F	65–140	5–6	n/a
J Pit East	G2	45–170	4	n/a
J Pit West	G2	45–195	4–5	n/a
N Pit	L	40–230*	2–8	30–50
	M	60–270*	3–5	50–60
	Q	100–320*	7–11	n/a
L Pit	H	60–240	7–12	n/a
	K	60–210	8–11	75–100
	Q	120–300	9–11	n/a

To account for spoil, values reflect the equivalent rock depth of cover, with a rock unit weight of 162 pcf.

The depth of cover ranges shown in Table 2-3 are primary inputs to the web and barrier pillar designs discussed later. Normally, overburden rock unit weight (usually assumed to be 162 pcf) is multiplied by depth of cover to determine cover load. Because a significant portion of the overburden above the N Pit HWM area is spoil above the I2 Seam, this approach was modified to account for the lower unit weight of spoil based on the percentage of spoil and rock overlying the N Pit target seams. For example, for 150 ft of overburden, consisting of 50 ft of spoil (unit weight of 125 pcf) and 100 ft of rock (unit weight of 162 pcf), the equivalent rock depth of cover is 50 ft × 125 pcf/162 pcf + 100 ft = 138.6 ft.

The target seams dip to the north–northwest, generally in a range from about 6 to 10°, averaging about 8°, with localized dips rarely approaching 12°. The I and J Pits are generally oriented east–west (Figure 1-1), with HWM to the north; the N Pit is also oriented generally east–west, with HWM to both the north and south; and the L Pit is oriented north–south, with HWM to the east. An exception is the southern portion of the K Seam HWM area in the L Pit, where the highwall is oriented east–west, with mining to the north. Consequently, HWM for most areas will be either primarily updip or downdip, with minimal side dip, except for the L Pit, where most of the mining will have a side dip of 6° to 10°.

Since the HWM machine needs to be essentially level side to side, where a side dip exists, a reduced mining height will have to be used to avoid cutting into the roof and floor at opposite corners of the opening. Assuming that the machine is oriented perpendicular to the highwall, this reduced mining height can be calculated as:

$$H_r = \left(\frac{t}{\cos\theta}\right) - W_o \tan\theta \qquad \text{(Eqn. 2-1)}$$

where H_r = reduced mining height (ft)
t = true seam thickness (ft)
θ = apparent side dip at highwall (°)
W_o = opening width (ft)

No previous underground mining of the target seams is known to AAI. Deeper coal seams below the Twentymile Sandstone have been studied in the past, but the seams have not been mined. Longwall mining of deeper seams at the Empire Mine, immediately southwest of the Trapper property, was performed within the last 40 years, but that experience is not considered applicable to the HWM effort.

HWM of the H Seam in the A Pit was largely successful, although rolls in the seam prevented the miner from consistently achieving the targeted penetration of approximately 1,300 ft. Information supplied by Trapper shows that 20 HWM openings were mined (Figure 1-1), with an average penetration of 1,156 ft, or about 90% of the targeted penetration. Many of the target seams are comparable to or thinner than the H Seam in A Pit; thus, similar seam rolls, if encountered, would be expected to limit HWM penetration.

Spontaneous combustion is not uncommon in Trapper's surface mining operations, although it is not considered a serious problem. Should HWM web pillar failure occur, with related overburden fracturing to the surface, crushed coal and air circulation from natural ventilation would increase the chances for spontaneous combustion. Spoil berms are normally used to barricade HWM holes to unintentional access; however, these berms do not normally achieve an airtight seal. While the design curves presented in this report are intended to lower the risk of subsidence to acceptable levels, the risk cannot be entirely eliminated, and Trapper should be aware that associated spontaneous combustion is a risk as well.

3 HWM GEOMETRY

3.1 Opening Dimensions

The cutting height range of HWM systems, including the ADDCAR system, depends on the model of continuous miner used. From Table 2-3, it appears that nearly all areas could be mined using the Joy 14CM15 continuous miner with a cutting height of 3.5 to 10.5 ft and a cutting width of 11.5 ft. Other pertinent specifications for the ADDCAR system are shown in Table 3-1.

Table 3-1. Typical ADDCAR System Parameters

Parameter	Value
Leveling capacity	
Front (2) lift cylinder travel	5 ft
Rear (2) lift cylinder travel	5 ft
Distance between lift cylinders side to side	17.75 ft
Distance between lift cylinders front to back	60 ft
Maximum leveling capacity side to side	16°
Operational leveling capacity side to side	8°
Maximum leveling capacity front to back	5°
Operational leveling capacity front to back	4°
Maximum walking incline	8°
Platform steering radius	Rotates 180° within its footprint
Maximum practical downdip	20°
Maximum practical side dip	8°
Maximum angle off-perpendicular from highwall	15°

3.2 Infrastructure Protection

Should unplanned subsidence associated with HWM occur, measures may be needed to protect sensitive infrastructure. AAI is aware of a 6-inch pipeline and several power lines in the I and J Pit areas that likely will be re-routed around the proposed mining area. While AAI is not aware of specific structures that may require protection in other areas, should structures such as power lines, pipelines, or surface facilities exist, AAI recommends that a buffer (in plan view) be established between the protected structures and the closest HWM opening. As a criterion for establishing the buffer, AAI recommends a method that incorporates a fixed offset, plus an offset based on the angle of critical deformation (Peng 1992). The angle of critical deformation is defined as the angle from the excavation edge to the protected structure, measured from vertical, beyond which no subsidence damage is expected to occur. The angle of critical deformation is generally 10° less than the more commonly cited angle of draw, which defines the distance beyond which subsidence is measurable. AAI considers a 50-ft offset and an angle of critical deformation of 25° to be appropriate.

3.3 Roof Stability

Assessments of roof stability and unsupported stand-time were made using a combination of the CMRR, and the Council of Scientific & Industrial Research (CSIR) Rock Mass Rating (RMR) (Bieniawski 1989).

The CMRR was developed for coal mine roof quality assessment. AAI calculated CMRR values for specific core holes using the lithology of the immediate roof (first 6 ft), Rock Quality Designation (RQD) values from core logs and inspection of core photographs, judgements regarding weathering resistance based on the slake test data, and the appropriate physical property datasets for each HWM area. CMRR ratings were converted to RMR values based on an AAI-developed relationship derived from Western US experience:

$$RMR = 0.9\ CMRR + 23 \qquad \text{(Eqn. 3-1)}$$

The conversion to RMR is useful in that stand-times (the time between mining and eventual roof collapse) have been correlated to RMR and opening width (Bieniawski 1989) and provide insight to what the various CMRR and RMR values may mean from a practical roof stability standpoint.

Representative roof stability assessment results for each target seam are presented in Table 3-2.

Table 3-2. Roof Stability Summary

Area	Seam	CMRR	RMR	Stand Time (days)
I Pit East	F	34.0	53.6	32
I Pit Middle and West	F	28.8	48.9	10
J Pit East	G2	30.6	50.5	15
J Pit West	G2	32.2	52.0	21
N Pit	L	29.5	49.6	12
	M	31.8	51.6	19
	Q	30.6	50.5	15
L Pit	H	27.0	47.3	6
	K	31.8	51.6	19
	Q	38.5	57.6	89

Typical required stand-times are on the order of 14 hours or less, based on an assumed production rate of 350 tons per hour (tph), full penetration depth of 1,200 ft, and the average seam height for each of the seams. Thus, even for the weakest roof, the projected stand-times are significantly greater than the time required to mine each opening. Should localized roof failures occur, leaving approximately 6 inches of roof coal may improve conditions.

4 PILLAR DESIGN

Empirical methods based on the Mark-Bieniawski pillar strength formula (Mark, Chase, and Campoli 1995) were used to size web and barrier pillars for the various cover depths and mining heights anticipated. The National Institute of Safety and Health (NIOSH) has developed a similar procedure (NIOSH 2006), Analysis of Retreat Mining Pillar Stability-Highwall Mining (ARMPS-HWM), which is readily accepted by the Mine Safety and Health Administration (MSHA) as a design basis for HWM pillars. As discussed below, based on Western US HWM experience, AAI recommends a more conservative approach to coal strength input than ARMPS-HWM, and a minimum allowable pillar width-to-height ratio of 0.8.

4.1 Design Approach

Numerous pillar design equations have been developed over the years relating pillar strength to coal strength, pillar height, and pillar width. The most widely accepted of these formulas in the US today is the Mark-Bieniawski pillar design formula. A modified form of the equation that represents infinitely long (effectively) web pillars is given by:

$$S_p = S_c\,(0.64 + 0.54\,\frac{W}{H}) \qquad \text{(Eqn. 4-1)}$$

where S_p = pillar strength (psi)
S_c = in-situ coal strength (psi)
W = pillar width (ft)
H = pillar height (ft)

One of the reasons for the wide acceptance of the Mark-Bieniawski formula is that in addition to pillar width and height, the effect of pillar length is accounted for. In addition, pillar strengths calculated with the formula have been compared with over 100 case histories of actual pillar performance with high correlation. The Mark-Bieniawski formula is also the basis for pillar strength estimation in ARMPS-HWM.

Although the formula appears straightforward, determining S_c (the in-situ coal strength) can be difficult. Traditionally, this has been done by taking laboratory UCS test results and applying a size reduction factor (usually one-sixth the square root of the sample diameter, measured in inches). However, Mark and Barton (1997) concluded that laboratory test results are a poor predictor of in-situ pillar performance, and that a constant in-situ coal strength of 900 psi produces better results. As a result, the default in-situ coal strength in ARMPS-HWM is 900 psi.

An alternative approach is to apply site-specific coal strengths and normalize them to the 900-psi in-situ strength. Table 4-1 shows the target seam compressive strengths normalized to 900 psi. This was done by assuming that the average western coal UCS (2,070 psi in AAI's experience) can be represented by the 900-psi in-situ value. For example, the normalized strength of the F Seam, 540 psi, is the laboratory UCS (1,241 psi) divided by the western coal UCS (2,070 psi), multiplied by Mark-Barton's (1997) recommended 900-psi in-situ strength. AAI recommends, and applied, the normalized in-situ strengths shown in Table 4-1 to determine pillar widths, since they account for the relative strength difference between seams.

Table 4-1. Normalized Coal Strengths Used in Web and Barrier Pillar Design

Area	Seam	UCS (psi)	Normalized In Situ Strength (psi)
I Pit	F	1,241	540
J Pit	G2	1,307	568
N Pit	L	1,549	673
	M	1,762	766
	Q	1,956	850
L Pit	H	1,245	541
	K	1,848	803
	Q	2,050	891

Once pillar strength is determined, an estimate of pillar loading is required to calculate a stability factor (SF). Pillar loading is estimated using tributary area load theory as follows:

$$L_P = S_V \frac{(W+W_E)}{W} \qquad \text{(Eqn. 4-2)}$$

where L_P = average vertical load on the pillar (psi)
S_V = in-situ vertical stress (psi)
W = pillar width (ft)
W_E = entry width (ft)

The vertical stress is assumed to be equal to the average overburden density multiplied by the cover depth (or equivalent rock depth). The overburden density was assumed to be 162 pcf), the default value in ARMPS-HWM, resulting in a stress gradient of 1.125 psi/ft of depth. Finally, the SF is calculated as:

$$SF = \frac{S_P}{L_P} \qquad \text{(Eqn. 4-3)}$$

Using the Mark-Bieniawski formula and ARMPS-HWM SF criteria given in Table 4-2, minimum web pillar widths were calculated for the expected range of cutting heights and cover depths and are summarized as a set of design tables and charts. At lower cover depths and higher mining heights, the SF criterion is sometimes satisfied by web pillars with width-to-height ratios less than 0.8. Because some HWM designs have failed at low width-to-height ratios, AAI feels that pillar widths should be adjusted to maintain a minimum ratio of 0.8. Barrier pillar loading was calculated using a 21° abutment angle (the pillar supports all overburden directly above it and within a 21° angle over the adjacent web pillars, as measured from vertical).

In practice, web and barrier pillars are designed on a panel-by-panel basis. Pillar dimensions are determined using the design tables and charts. The input parameters to the tables are the maximum mining height anticipated for each panel, and the design cover depth. Designing for the maximum cover is somewhat conservative as the solid coal beyond the maximum HWM

Table 4-2. ARMPS-HWM SF Criteria

Stability Factor	Criteria
Overall SF	
2.0	Applicable to all conditions
Web Pillar SF	
1.6	When the panel width (excluding the barrier) exceeds 200 ft
1.3	When the panel width (excluding the barrier) is less than 200 ft
Barrier Pillar SF	
2.0	When the barrier width-to-height ratio is less than 4.0
1.5	When the barrier width-to-height ratio is greater than or equal to 4.0

opening penetration provides support unaccounted for by tributary area loading. Following a procedure suggested by Mark, Chase, and Campoli (1995), a less conservative approach would be to calculate the design depth based on a weighted average as follows:

$$\text{Design depth} = 0.75\ (\text{maximum depth}) + 0.25\ (\text{minimum depth}) \qquad \text{(Eqn. 4-4)}$$

In determining the minimum depth, some judgement should be exercised. AAI recommends that the minimum depth beyond the crest of the highwall be used. The design process is repeated for the design of subsequent panels as mining proceeds.

Trapper may elect to stack spoil material adjacent to some pit areas. The surcharge load from spoil should be accounted for by adding the thickness of the spoil multiplied by the ratio of the spoil to rock unit weight to the cover depth over the panel. For example, a 100-ft thick spoil having a density of 100 pcf would have an equivalent rock height of about 62 ft (100 ft × 100 pcf/162 pcf). Therefore, the cover depth underneath the spoil should be increased by 62 ft when determining the appropriate design depth for a given panel. By designing on a panel-by-panel basis, changing mining heights and cover depths can be accommodated reasonably and design performance can be continuously evaluated.

4.2 Pillar Design Tables and Charts

Required web and barrier pillar widths and associated recovery percentages for the target seams were calculated using the procedure and ARMPS-HWM criteria discussed above. Design tables and charts for the normalized in-situ coal strengths from Table 4-1 are given in the Appendices A through D for each Pit and target seam. In cases where the planned HWM panel width is less than 200 ft, and therefore the ARMPS-HWM SF criterion is reduced, separate charts are provided. These charts apply primarily to pit endwall areas. The tables and charts are used to determine pillar widths and panel recoveries for specific values of mining height and cover depth. The figures designated as “a” include a table for determining the required web pillar width given in inches, and a chart showing the width expressed both in inches and feet. The “b” figures give the required barrier pillar width expressed in feet in both the tables and charts. The charts sometimes show a flat area at low cover depths, corresponding to pillar widths being limited by the minimum 0.8 width-to-height ratio criterion (these widths are printed in italics in the design tables). Some barrier pillar charts also show an area where the curves spread apart, corresponding to the change of SF when the barrier pillar width-to-height ratio exceeds 4. The recovery tables and charts are given in the "c" figures and represent the plan-view recovery within the panel (between the barrier pillar centerlines).

The design curves provide Trapper with a rational starting point for web and barrier pillar layout. By using these design curves to determine the minimum pillar width for each panel as mining progresses, and adjusting that width as conditions warrant, maximum resource recovery can be attained.

AAI recommends that HWM production panels be comprised of no more than 20 openings. However, it is suggested that the initial panel in each seam contain only 10 openings. Assuming no problems are encountered, subsequent panels can be mined with 20 openings.

4.3 Numerical Modeling of Pillar Design Cases

Numerical modeling, including efforts using the LAMODEL boundary-element method, the Universal Distinct Element Code (UDEC) distinct-element method, and the FLAC3D™ finite-difference method were preformed for typical web and barrier pillar designs for each of the Pits and target seams to confirm the validity of the empirical pillar designs, study seam interaction, and detect possible susceptibility to roof, floor, or rib instability. The modeling confirmed the pillar designs, and no major issues were identified. Details of the modeling are fully discussed in each individual pit report (AAI 2018, 2019a, 2019b).

5 RECOVERABLE RESOURCE ESTIMATE

The design guidelines developed for each seam were used to lay out panels in each HWM area in order to estimate the recoverable resource. Based on previous experience in the A Pit, a 0.9 factor was applied to account for the ratio between achieved HWM hole penetration versus the planned penetration. In areas where side dips were significant, a reduced mined seam height due to the side dip was accounted for. An in-place coal unit weight of 82.3 pcf was assumed; results are shown in Table 5-1.

Table 5-1. Estimated HWM Recoveries

Pit	Seam	Estimated Recovery[3] (tons)
I-Pit East	F	273,018
I-Pit Middle	F	436,330
I-Pit West	F	454,781
	Sub-Total, I Pit	1,164,129
J Pit East	G2	239,179
J-Pit West	G2	589,841
	Sub-Total, J Pit	829,020
	L	1,104,348
N Pit	M	1,042,763
	Q	2,005,030
	Sub-Total, N Pit	4,152,141
	H	149,065
L Pit	K	447,656
	Q	306,039
	Sub-Total, L Pit	902,760
	Grand Total	**7,048,050**

6 OPERATIONAL CONSIDERATIONS

The design curves presented in the Appendices A through D provide Trapper with a rational starting point for highwall web and barrier pillar layout. By using these design curves to determine the minimum pillar width for each panel as mining progresses and adjusting that width as conditions warrant, maximum resource recovery can be attained. Based on the observations and analyses discussed in this report, the following comments related to implementation of the design are made.

Roof Stability and Dilution—The calculated standup times for the roofs of all HWM areas indicate that the roofs should be sufficiently stable to allow HWM. However, using CMRR criteria, the roofs are generally classified as weak and occasional roof falls may occur. The areas with the least competent roof are predicted to be the H Seam in the L Pit, the F Seam in the Middle and West I Pit, and the L Seam in the N Pit. If roof falls in these or other areas become problematic, leaving a thin, 0.5- to 1-ft layer of top coal may improve stability. Floor conditions should also be adequate, although where carbonaceous mudstone makes up the immediate floor, occasional floor trafficability problems may occur. Again, leaving floor coal may solve the problem; however, given the relatively thin seam thicknesses in some areas, frequent implementation of roof and/or floor coal will have a relatively large impact on project recovery and economics.

Mining Sequence

I and J Pits—From an HWM standpoint, the resource areas are independent of one another. If the box cuts are mined before HWM, there is no preference regarding the sequencing of HWM. However, the three I Pits partially overlie the G2 Seam HWM reserve and blasting in the I Pits could adversely impact HWM panels in the G2 Seam. Therefore, the surface reserves of the I Pit should be mined prior to HWM the G2 Seam. Decisions regarding which areas to mine first (East, Middle, or West) should be based on operational preferences, as no known geotechnical issues are involved. Given the side dip slightly to the west, mining from west to east would allow the mining to progress away from any water accumulations in the pit.

N Pit—Stability of the southern highwall, updip from the box cut, needs to be preserved as much as possible, in light of landslides that have occurred at Trapper related to pits oriented along strike. To accomplish this, Trapper intends to subdivide the N Pit HWM into segments, to keep the open cut length to a practical minimum. AAI has performed numerical modeling of the HWM in N Pit that takes the seam dip and excavation sequence into account, and specific recommendations for mining the south (updip) and north (downdip) HWM areas have been given in the N Pit detailed report (AAI 2019a). Many tradeoffs exist, but in general, mining each segment from the pit bottom up (i.e. mining the Q Seam first) is preferred, with the sequence of developing and mining the pit segments from west to east.

Additionally, the following operational measures may be adopted to minimize the risk of global instabilities, especially in the southern highwall:

- Blasting designs with longer delays, as currently implemented to overcome ground conditions in the L Pit, should be appropriately applied to limit excessive damage of the highwall rock mass and weak shale/mudstone layers.

- The ultimate south highwall should be pre-split to limit blast-induced damage and weakening of the rock mass.
- No additional spoils should be placed on the crest of the south highwall, as its SF is close to the criterion without surcharge loading.
- Following creation of the south highwall, tension cracks parallel to the crest could develop in the L Seam and M Seam overburden benches due to the adverse gradient and dilation of the slope rock mass. If such cracks occur, they should be filled as soon as possible to restrict water ingress. In general, the upslope surface drainage of the south highwall should direct surface water runoff away from the highwall crest.

Monitoring of the south highwall and crest in active mining zones is recommended. Either time domain reflectometry (TDR) or extensometers can provide useful data and potentially identify critical movements of the south highwall. Periodic drone or conventional surveys are also recommended.

L Pit—From a water management standpoint, HWM progression updip (north to south) is preferred. The order in which the K and Q Seams are mined makes no difference, geotechnically. Top-down mining would require greater coordination with stripping operations; however, it might be simpler from an operational standpoint to open the pit to the bottom of the Q Seam, highwall mine the Q Seam, then backfill to the K Seam and mine the K Seam from the backfill bench. Should HWM pillar failure occur, miner entrapment is more of a concern with the bottom-up sequence, as subsidence of the active seam is possible. The bottom-up sequence also has the potential to sterilize HWM reserves should overlying seams subside. From a personnel safety standpoint, the top-down sequence exposes workers to possible air blasts from web failure in overlying seams and associated rock fall. Additionally, the bottom-up sequence provides confinement to HWM areas as the pit is filled. Operational preferences may take precedence, but other factors being equal, it is AAI's opinion that the bottom-up sequence is most advantageous.

N Pit Protective Buffer—The HWM openings in the south highwall of the N Pit need to be terminated a sufficient distance away from the old F Pit perimeter. The primary concern is possible inflow of water pooled in the relatively porous backfill/spoil material of the F Pit. MSHA's rules regarding mining into old workings (30 Code of Federal Regulations [CFR] Sections 75.388 and 75.389, US Department of Labor 2019) may apply to the proposed HWM plan. The rules require maintaining a buffer zone around old workings, unless the old workings are sampled by probe drilling and found to be safe. Since probe drilling is impractical in the HWM holes, it is unlikely that the buffer zones can be mined. The regulations indicate that a 50-ft buffer zone is adequate if the previous workings have been accurately surveyed and certified. If the previous areas are not accurately surveyed, a 200-ft buffer zone is required. Additionally, Trapper should develop a hazard management plan in the event of accidentally mining into the previously mined pits.

Multiple-Seam Mining—Only a small portion of the J Pit, G2 Seam HWM area underlies the I Pit, F Seam area, with 60 to 120 ft of interburden. This thickness precludes significant seam interaction. Interaction generally becomes problematic when the interburden thickness is less than about two times the thickness of the lower seam. In the N Pit, the L-M interburden thickness ranges from 30 to 50 ft, which is much greater than the 5-ft maximum thickness of the M Seam. The M-Q-Interburden thickness is 50 to 60 ft, which is also much greater than the 11-ft maximum thickness of the Q Seam. Therefore, designs for each seam are independent of one another, and the pillars in adjacent seams do not need to be columnized. The same is true for the K and Q Seams in the L Pit.

Contingency Planning—Because the web and barrier pillar designs for each seam are independent, should poor mining conditions be encountered in one seam or area of the pit, designs for the remainder of the seams or pit should not be impacted.

Highwall Stability—The design curves provided in this report are intended to provide for pillar stability during active mining operations and therefore, preserve the integrity of the highwall. If any situations not contemplated during the underlying HWM studies (AAI 2018, 2019a, 2019b) are considered by Trapper, these should be analyzed separately.

Nearby Blasting—It is common practice to limit blasting to within 1,500 ft of HWM operations. If exceptions to this procedure are necessary, HWM operations should cease until the blast is complete and the highwall, pillars, and openings have been re-examined for any damage caused by the blast.

Required Pit Width—The standard ADDCAR launch vehicle requires a minimum pit width of 150 to 200 ft. This includes a stand-off distance of 25 ft between the launch vehicle and the highwall. At the pit bottom, a spoil catch berm is also required.

Hole Closure—Leaving several holes open adjacent to the active hole is recommended to allow observation of the web pillars and possible signs of movement. AAI recommends that a maximum of eight holes be left open for this purpose. To keep the open holes at or below this number, spoil or other suitable material should be placed over the mouth of the entries to close them and prevent personnel entry, which is prohibited per 30 CFR 77.1502 (US Department of Labor 2019).

Long-Term Subsidence Potential—The pillar designs included in this report provide for an acceptable safety margin against pillar failure during active mining. Trapper should be aware that, historically, subsidence has occurred over some HWM panels and that there is a risk of subsidence associated with any form of underground mining, including HWM. Because this risk increases with time, every effort should be made to accomplish the planned HWM in a timely manner. Use of the design curves based on normalized coal strengths given in this report will reduce the likelihood of long-term subsidence but will not eliminate the possibility.

Spontaneous Combustion—Should web pillar failure occur, the risk of spontaneous combustion is increased. This is due to coal crushing and possible air circulation through the highwall miner openings to the surface, through subsidence cracks. Again, while the design curves provided in this report are intended to reduce the likelihood of pillar failure, Trapper should be aware of the consequences should failure occur.

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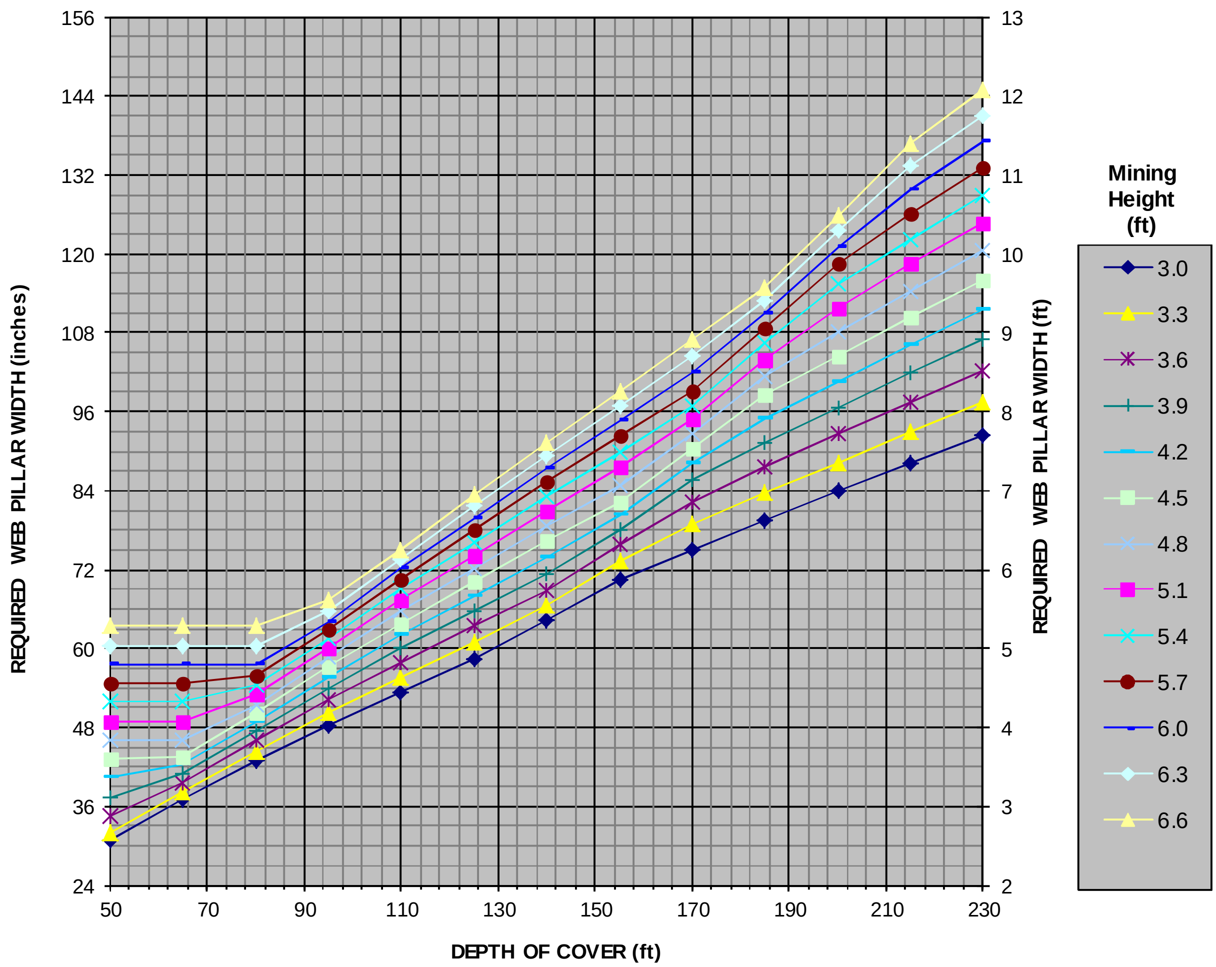
APPENDIX A

I PIT WEB AND BARRIER PILLAR DESIGN CURVES

Design Depth of Cover (ft)	Mining Height (ft)												
	3	**3.3**	**3.6**	**3.9**	**4.2**	**4.5**	**4.8**	**5.1**	**5.4**	**5.7**	**6**	**6.3**	**6.6**
50	*31*	*32*	*35*	*38*	*41*	*44*	*47*	*49*	*52*	*55*	*58*	*61*	*64*
65	*37*	*39*	*40*	*41*	*43*	*44*	*47*	*49*	*52*	*55*	*58*	*61*	*64*
80	*43*	*45*	*47*	*48*	*49*	*51*	*52*	*53*	*55*	*56*	*58*	*61*	*64*
95	49	51	53	54	56	58	59	61	62	63	65	66	*68*
110	54	56	58	60	62	64	66	68	69	71	73	74	76
125	59	61	64	66	69	71	73	75	77	79	80	82	84
140	65	67	69	72	74	77	79	81	84	86	88	90	92
155	71	74	76	79	81	83	85	88	90	93	95	98	100
170	76	79	83	86	89	91	93	95	97	100	102	105	107
185	80	84	88	92	95	99	102	104	107	109	111	113	115
200	84	89	93	97	101	105	109	112	116	119	122	124	126
215	89	93	98	102	107	111	115	119	123	127	130	134	137
230	93	98	103	107	112	117	121	125	129	134	138	142	145

Coal Strength (psi) 540 **Mining Width (ft)** 11.50 **No. Web Pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8



534-40 Trapper [534-40 Trapper_Design Charts18JUL2018.pptx]:dc/smvf (7-18-2018)

Figure A-1a. I Pit, F Seam Web Pillar Design Chart

Design Depth of Cover (ft)	Mining Height (ft) 3	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6	6.3	6.6
50	4.0	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	*4.7*	*4.9*	*5.1*	*5.3*
65	5.9	6.2	6.4	6.4	6.3	6.2	6.3	6.5	6.6	6.8	6.9	7.0	7.2
80	7.5	7.9	8.2	8.5	8.8	9.1	9.3	9.2	9.2	9.1	9.1	9.3	9.5
95	9.1	9.5	9.9	10.3	10.7	11.1	11.4	11.7	12.1	12.4	12.7	12.7	12.7
110	10.7	11.2	11.7	12.2	12.6	13.0	13.5	13.9	14.3	14.7	15.0	15.4	15.7
125	12.2	12.8	13.4	13.9	14.5	15.0	15.5	16.0	16.5	16.9	17.4	17.8	18.2
140	12.9	14.0	15.1	15.7	16.3	16.9	17.5	18.1	18.6	19.1	19.7	20.2	20.7
155	13.3	14.3	15.5	16.6	17.8	18.8	19.5	20.1	20.7	21.3	21.9	22.5	23.1
170	14.6	15.4	16.1	16.9	18.1	19.3	20.4	21.5	22.7	23.5	24.2	24.8	25.4
185	16.0	16.8	17.6	18.3	19.1	19.8	20.8	21.9	23.1	24.3	25.4	26.5	27.6
200	17.3	18.2	19.1	19.9	20.7	21.5	22.2	23.0	23.7	24.7	25.9	27.0	28.2
215	18.6	19.6	20.5	21.4	22.3	23.1	24.0	24.8	25.6	26.3	27.1	27.8	28.7
230	19.9	21.0	22.0	23.0	23.9	24.8	25.7	26.6	27.4	28.3	29.1	29.9	30.7

Coal Strength (psi) 540 **Mining Width (ft)** 11.50 **No. Web Pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8

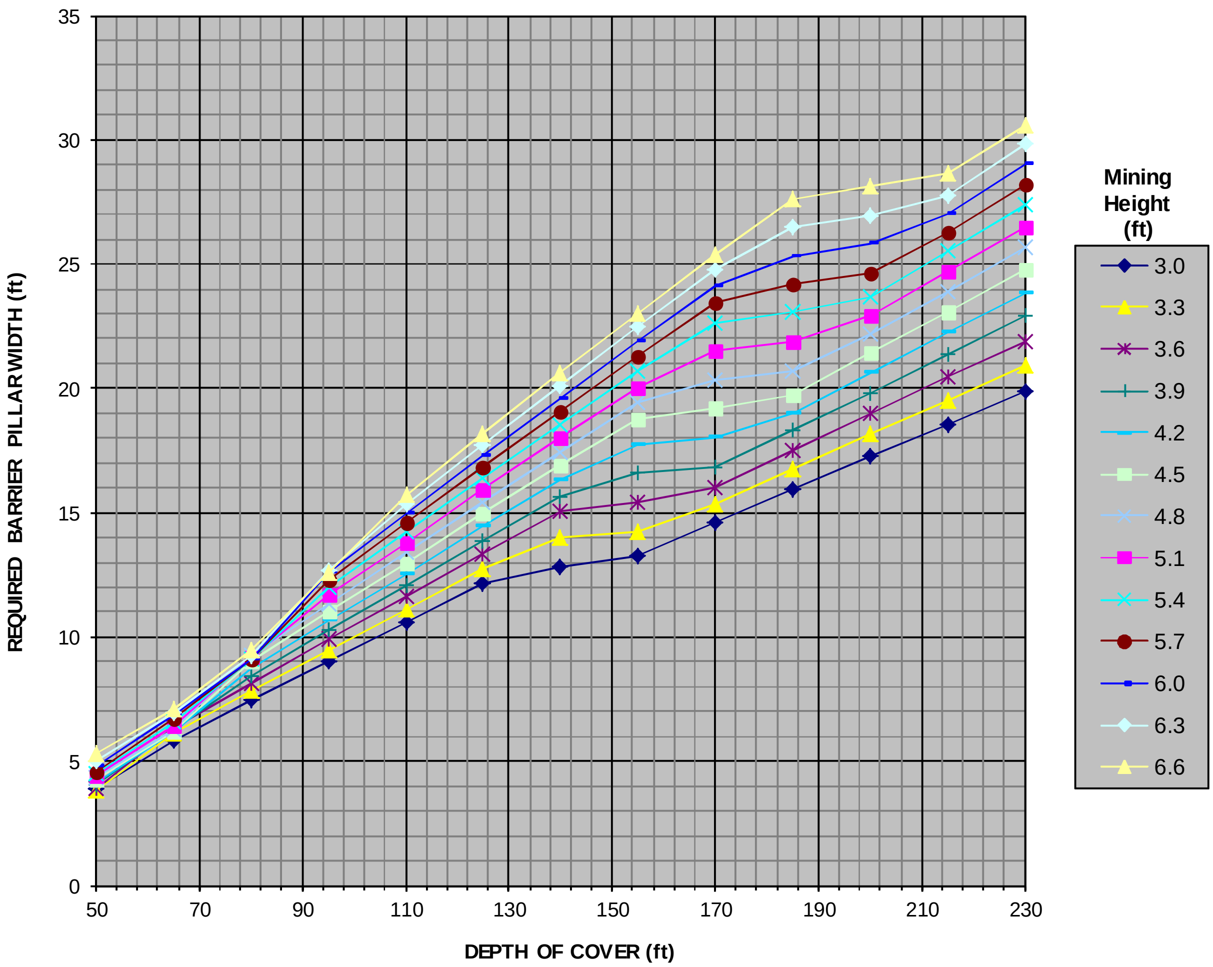


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Figure A-1b. I Pit, F Seam Barrier Pillar Design Chart

Design Depth of Cover (ft)	Mining Height (ft)												
	3	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6	6.3	6.6
50	81.2	80.8	79.5	78.2	76.9	75.7	74.5	73.7	72.6	71.5	70.4	69.3	68.3
65	78.1	77.2	76.7	76.3	75.6	75.2	74.0	73.2	72.1	71.0	70.0	68.9	67.9
80	75.3	74.4	73.6	73.1	72.7	71.9	71.5	71.2	70.5	70.2	69.5	68.5	67.5
95	72.6	71.8	71.0	70.6	69.8	69.1	68.7	68.0	67.6	67.2	66.5	66.2	65.6
110	70.5	69.7	69.0	68.2	67.5	66.8	66.1	65.4	65.1	64.4	63.8	63.4	62.8
125	68.5	67.8	66.7	66.0	65.0	64.4	63.7	63.1	62.4	61.8	61.5	60.9	60.3
140	66.5	65.7	64.9	63.9	63.3	62.4	61.7	61.1	60.3	59.7	59.1	58.6	58.0
155	64.7	63.6	62.9	61.9	61.2	60.5	59.9	59.1	58.5	57.7	57.2	56.4	55.9
170	63.0	62.1	60.9	60.0	59.1	58.5	57.8	57.2	56.6	55.8	55.3	54.6	54.1
185	61.7	60.6	59.4	58.4	57.6	56.6	55.8	55.2	54.4	53.9	53.3	52.8	52.3
200	60.5	59.1	58.0	57.0	56.0	55.1	54.1	53.4	52.6	51.9	51.2	50.7	50.3
215	59.0	58.0	56.7	55.7	54.5	53.6	52.7	51.9	51.1	50.3	49.7	48.9	48.4
230	57.9	56.6	55.4	54.4	53.3	52.3	51.4	50.6	49.8	48.9	48.2	47.4	46.9

Coal Strength (psi) 540 **Mining Width (ft)** 11.50 **No. Web Pillars** 19

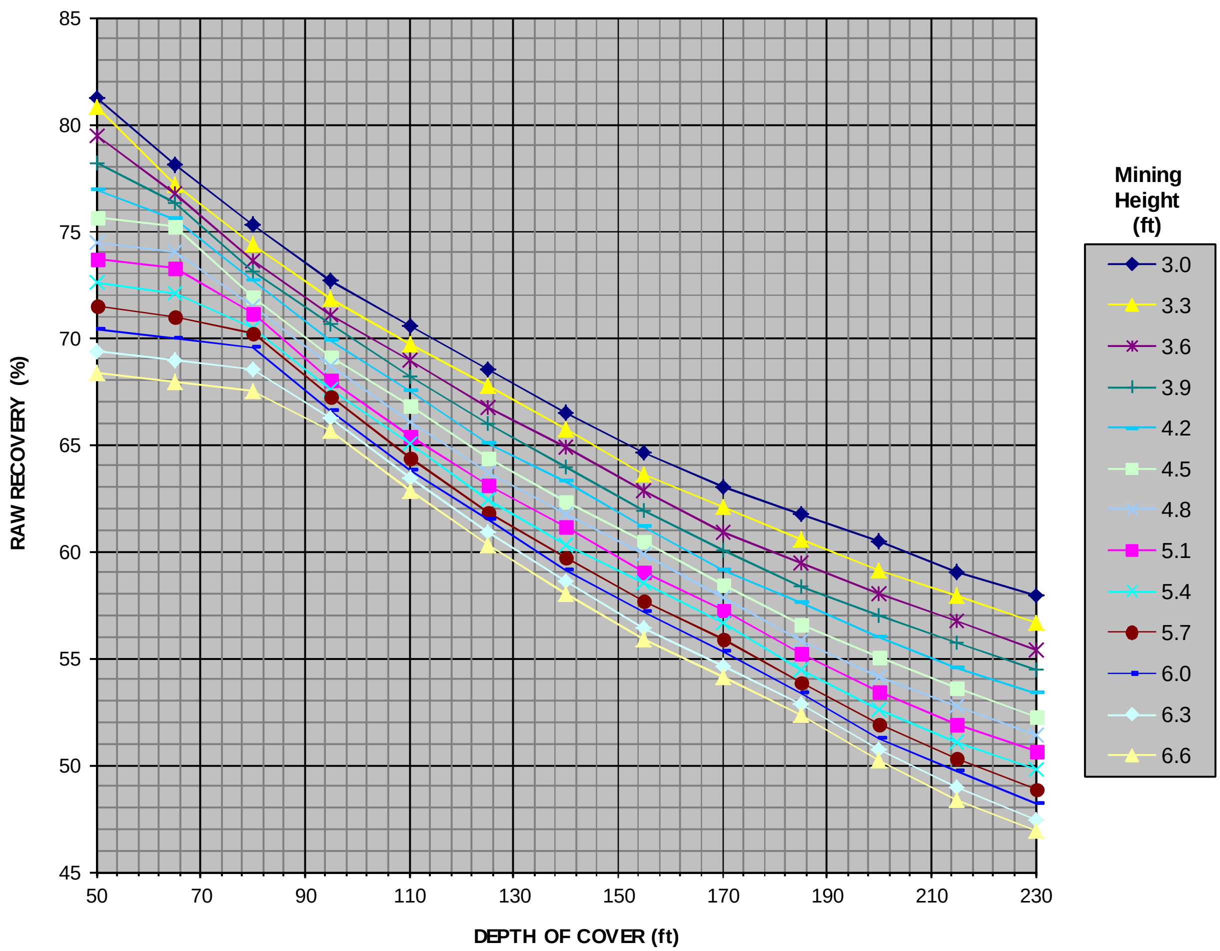

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Figure A-1c. I Pit, F Seam Recovery Chart

APPENDIX B

J PIT WEB AND BARRIER PILLAR DESIGN CURVES

Design Depth of Cover (ft)	Mining Height (ft)												
	3.6	3.8	4	4.2	4.4	4.6	4.8	5	5.2	5.4	5.6	5.8	6
50	*35*	*37*	*39*	*41*	*43*	*45*	*47*	*48*	*50*	*52*	*54*	*56*	*58*
65	*39*	*39*	*40*	*41*	*43*	*45*	*47*	*48*	*50*	*52*	*54*	*56*	*58*
80	45	46	46	47	48	*49*	*50*	*51*	*52*	*53*	*54*	*56*	*58*
95	50	52	53	54	55	56	57	58	58	59	60	*61*	*62*
110	56	57	59	60	61	62	63	64	65	66	67	68	69
125	61	63	64	66	67	68	70	71	72	73	74	76	77
140	66	68	70	71	73	74	76	77	79	80	81	83	84
155	73	74	75	77	78	80	82	83	85	86	88	89	91
170	79	81	83	84	86	87	88	90	91	93	94	96	98
185	84	87	89	91	93	95	97	98	100	101	102	104	105
200	89	92	94	97	99	102	104	106	108	110	112	113	115
215	94	97	99	102	105	107	110	112	115	117	120	122	124
230	98	101	104	107	110	113	116	118	121	124	126	129	131

Coal Strength (psi) 568 **Mining Width (ft)** 11.50 **No. Web Pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8

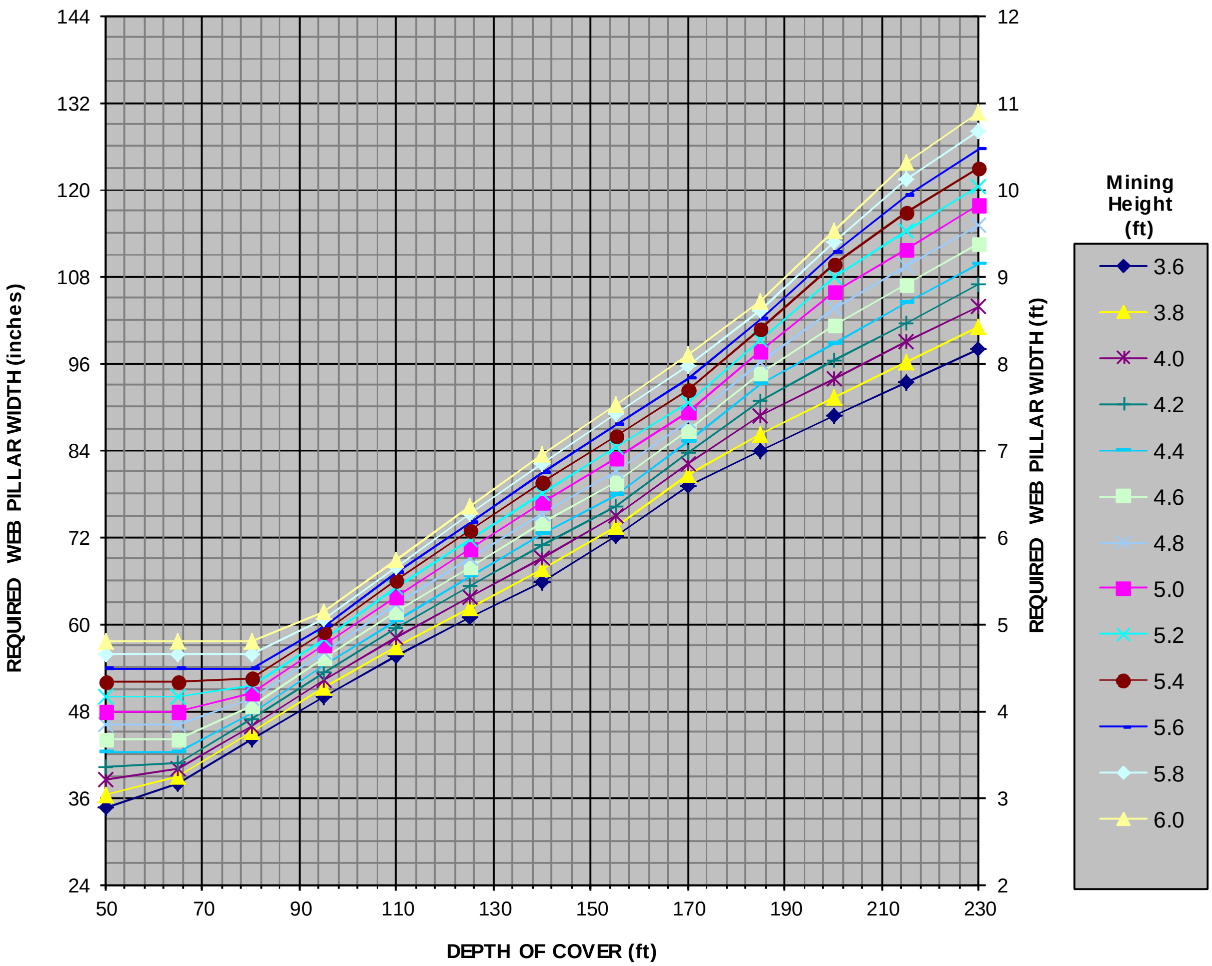

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Figure B-1a. J Pit, G2 Seam Web Pillar Design Chart

Design Depth of Cover (ft)	Mining Height (ft)												
	3.6	**3.8**	**4**	**4.2**	**4.4**	**4.6**	**4.8**	**5**	**5.2**	**5.4**	**5.6**	**5.8**	**6**
50	3.8	3.9	4.0	4.0	4.1	4.2	4.2	4.3	4.3	4.4	*4.5*	*4.7*	*4.9*
65	6.0	5.9	5.9	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.6
80	7.9	8.1	8.3	8.5	8.6	8.7	8.6	8.6	8.6	8.5	8.6	8.7	8.8
95	9.6	9.9	10.1	10.3	10.6	10.8	11.0	11.2	11.4	11.6	11.8	11.8	11.8
110	11.3	11.6	11.9	12.2	12.5	12.7	13.0	13.3	13.5	13.8	14.0	14.2	14.5
125	12.9	13.3	13.6	14.0	14.3	14.6	15.0	15.3	15.6	15.9	16.2	16.5	16.7
140	14.6	15.0	15.4	15.8	16.2	16.5	16.9	17.3	17.6	18.0	18.3	18.6	19.0
155	15.3	16.1	16.8	17.5	18.0	18.4	18.8	19.2	19.6	20.0	20.4	20.8	21.1
170	15.6	16.4	17.1	17.9	18.7	19.4	20.2	20.9	21.6	22.0	22.5	22.9	23.3
185	17.0	17.5	18.0	18.4	19.0	19.8	20.6	21.3	22.1	22.8	23.6	24.3	25.1
200	18.4	19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5	23.2	24.0	24.8	25.6
215	19.9	20.4	21.0	21.6	22.1	22.6	23.2	23.7	24.2	24.7	25.2	25.7	26.1
230	21.3	21.9	22.5	23.1	23.7	24.3	24.8	25.4	25.9	26.5	27.0	27.5	28.1

Coal Strength (psi) 568 **Mining Width (ft)** 11.50 **No. web pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8

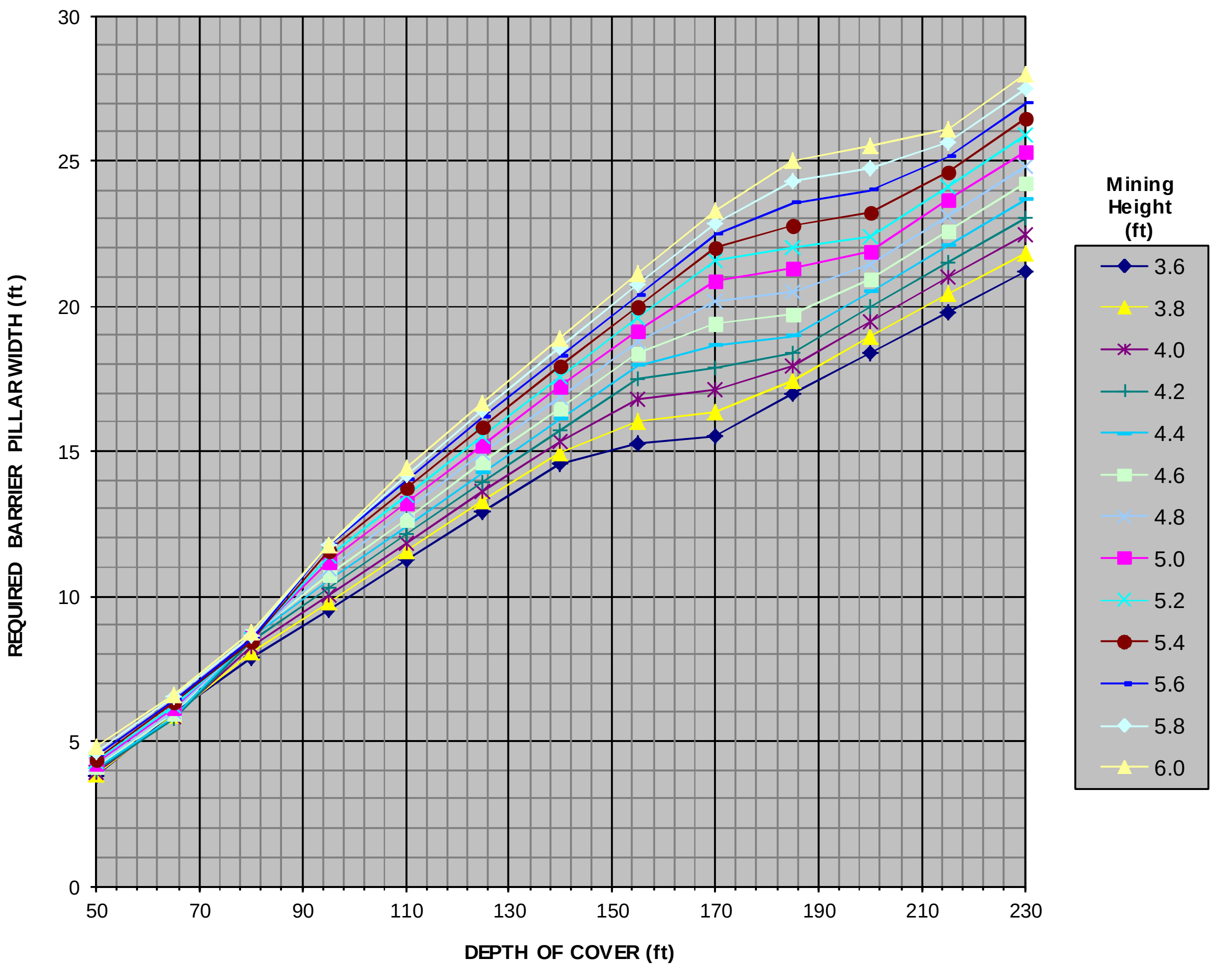

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Figure B-1b. J Pit, G2 Seam Barrier Pillar Design Chart

Design Depth of Cover (ft)	Mining Height (ft)												
	3.6	3.8	4	4.2	4.4	4.6	4.8	5	5.2	5.4	5.6	5.8	6
50	79.5	78.6	77.8	76.9	76.1	75.3	74.5	74.1	73.4	72.6	71.9	71.1	70.4
65	77.2	77.3	76.9	76.5	75.7	74.9	74.1	73.7	72.9	72.2	71.4	70.7	70.0
80	74.4	74.0	73.9	73.5	73.1	72.7	72.4	72.0	71.7	71.3	71.0	70.3	69.6
95	72.2	71.4	71.0	70.6	70.2	69.8	69.4	69.1	69.0	68.7	68.3	68.0	67.7
110	69.7	69.3	68.6	68.2	67.8	67.5	67.1	66.7	66.4	66.0	65.7	65.4	65.0
125	67.8	67.0	66.7	66.0	65.6	65.3	64.6	64.3	64.0	63.6	63.3	62.7	62.4
140	65.9	65.2	64.6	64.2	63.6	63.2	62.6	62.3	61.7	61.4	61.1	60.5	60.2
155	63.7	63.3	62.9	62.3	61.9	61.3	60.7	60.4	59.9	59.6	59.0	58.7	58.2
170	62.0	61.4	60.8	60.4	59.8	59.4	59.0	58.5	58.1	57.6	57.3	56.8	56.3
185	60.5	59.7	59.1	58.6	58.0	57.5	56.9	56.6	56.0	55.7	55.4	54.9	54.6
200	59.1	58.3	57.7	57.0	56.5	55.8	55.3	54.8	54.3	53.8	53.3	53.0	52.5
215	57.7	56.9	56.4	55.7	55.0	54.5	53.8	53.4	52.7	52.3	51.7	51.2	50.8
230	56.6	55.9	55.1	54.4	53.8	53.1	52.5	52.0	51.4	50.8	50.4	49.8	49.4

Coal Strength (psi) 568 **Mining Width (ft)** 11.50 **No. Web Pillars** 19

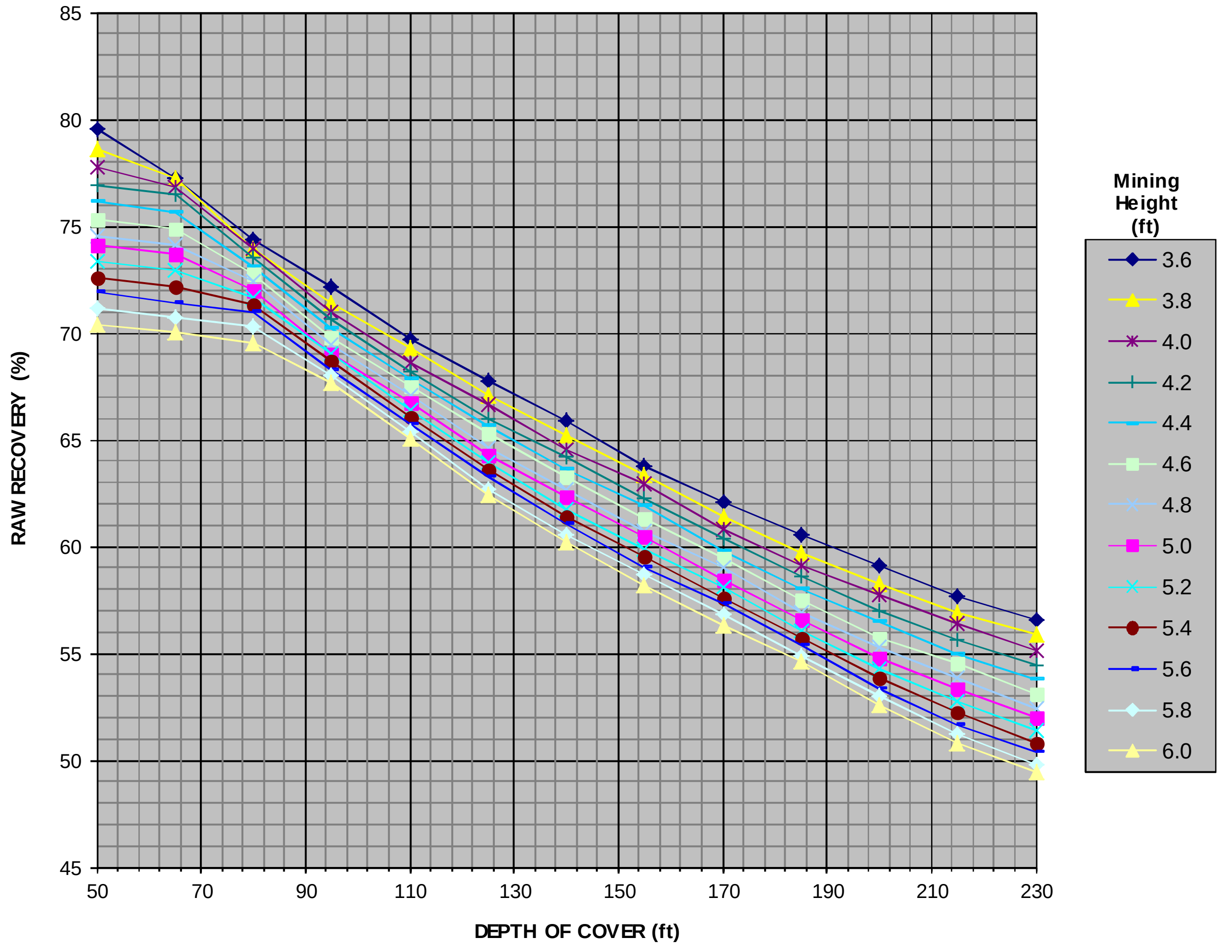

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Figure B-1c. J Pit, G2 Seam Recovery Chart

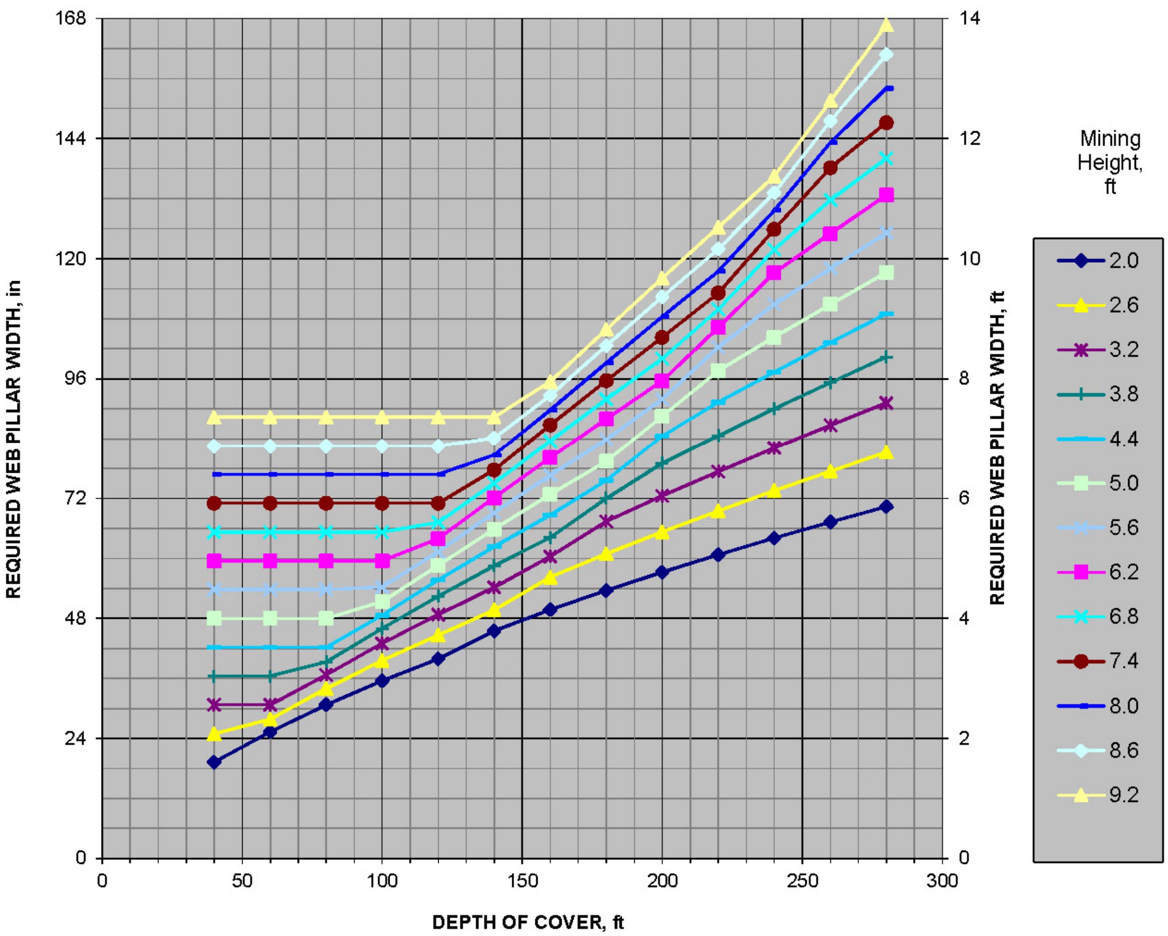
APPENDIX C

N PIT WEB AND BARRIER PILLAR DESIGN CURVES

Design Depth of Cover, ft	Mining Height, ft												
	2	2.6	3.2	3.8	4.4	5	5.6	6.2	6.8	7.4	8	8.6	9.2
40	*20*	*25*	*31*	*37*	*43*	*48*	*54*	*60*	*66*	*72*	*77*	*83*	*89*
60	26	*28*	*31*	*37*	*43*	*48*	*54*	*60*	*66*	*72*	*77*	*83*	*89*
80	31	34	37	*40*	*43*	*48*	*54*	*60*	*66*	*72*	*77*	*83*	*89*
100	36	40	44	47	49	*52*	*55*	*60*	*66*	*72*	*77*	*83*	*89*
120	40	45	49	53	56	59	62	*64*	*68*	*72*	*77*	*83*	*89*
140	46	50	55	59	63	66	70	73	76	78	*81*	*85*	*89*
160	50	57	61	65	69	73	77	81	84	87	90	93	96
180	54	61	68	73	76	80	84	88	92	96	100	103	106
200	58	66	73	80	85	89	92	96	101	105	109	113	117
220	61	70	78	85	92	98	103	107	110	114	118	122	127
240	65	74	83	91	98	105	111	118	122	126	130	134	137
260	68	78	87	96	104	111	119	126	132	139	144	148	152
280	71	82	92	101	110	118	126	133	141	148	155	161	167

Coal strength, psi 673 **Mining width, ft** 11.50 **No. web pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8



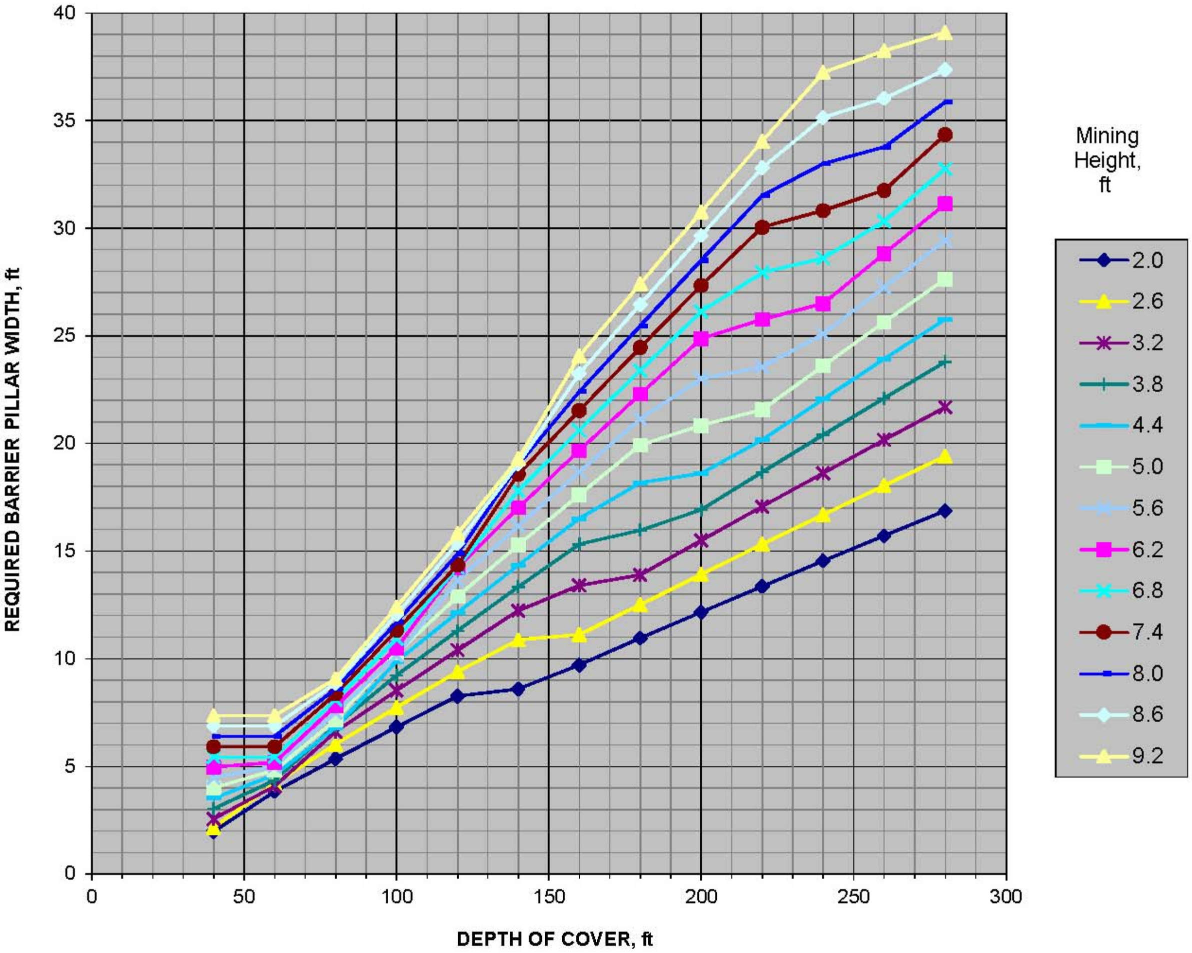
534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-1a. N Pit, L Seam Web Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	2	**2.6**	**3.2**	**3.8**	**4.4**	**5**	**5.6**	**6.2**	**6.8**	**7.4**	**8**	**8.6**	**9.2**
40	2.0	2.2	*2.6*	*3.1*	*3.6*	*4.0*	*4.5*	*5.0*	*5.5*	*6.0*	*6.5*	*6.9*	*7.4*
60	3.9	4.3	4.1	4.4	4.7	4.9	5.1	5.2	*5.5*	*6.0*	*6.5*	*6.9*	*7.4*
80	5.4	6.1	6.7	7.0	6.9	7.2	7.5	7.9	8.1	8.4	8.7	8.9	9.1
100	6.9	7.8	8.6	9.3	9.9	10.3	10.2	10.6	11.0	11.4	11.8	12.1	12.5
120	8.3	9.5	10.5	11.4	12.2	13.0	13.7	14.3	14.3	14.4	14.9	15.4	15.9
140	8.6	10.9	12.3	13.4	14.4	15.3	16.2	17.1	17.9	18.6	19.0	19.1	19.3
160	9.8	11.2	13.5	15.4	16.6	17.7	18.7	19.7	20.7	21.6	22.5	23.3	24.1
180	11.0	12.6	13.9	16.0	18.2	20.0	21.2	22.3	23.4	24.5	25.5	26.5	27.5
200	12.2	14.0	15.5	17.0	18.7	20.9	23.1	24.9	26.2	27.4	28.6	29.7	30.8
220	13.4	15.4	17.1	18.7	20.2	21.6	23.6	25.8	28.0	30.1	31.6	32.9	34.1
240	14.6	16.7	18.7	20.4	22.1	23.7	25.1	26.6	28.7	30.9	33.1	35.2	37.3
260	15.8	18.1	20.2	22.2	24.0	25.7	27.3	28.9	30.4	31.8	33.8	36.1	38.3
280	16.9	19.5	21.7	23.8	25.8	27.7	29.5	31.2	32.8	34.4	35.9	37.4	39.2

Coal strength, psi 673 **Mining width, ft** 11.50 **No. web pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8

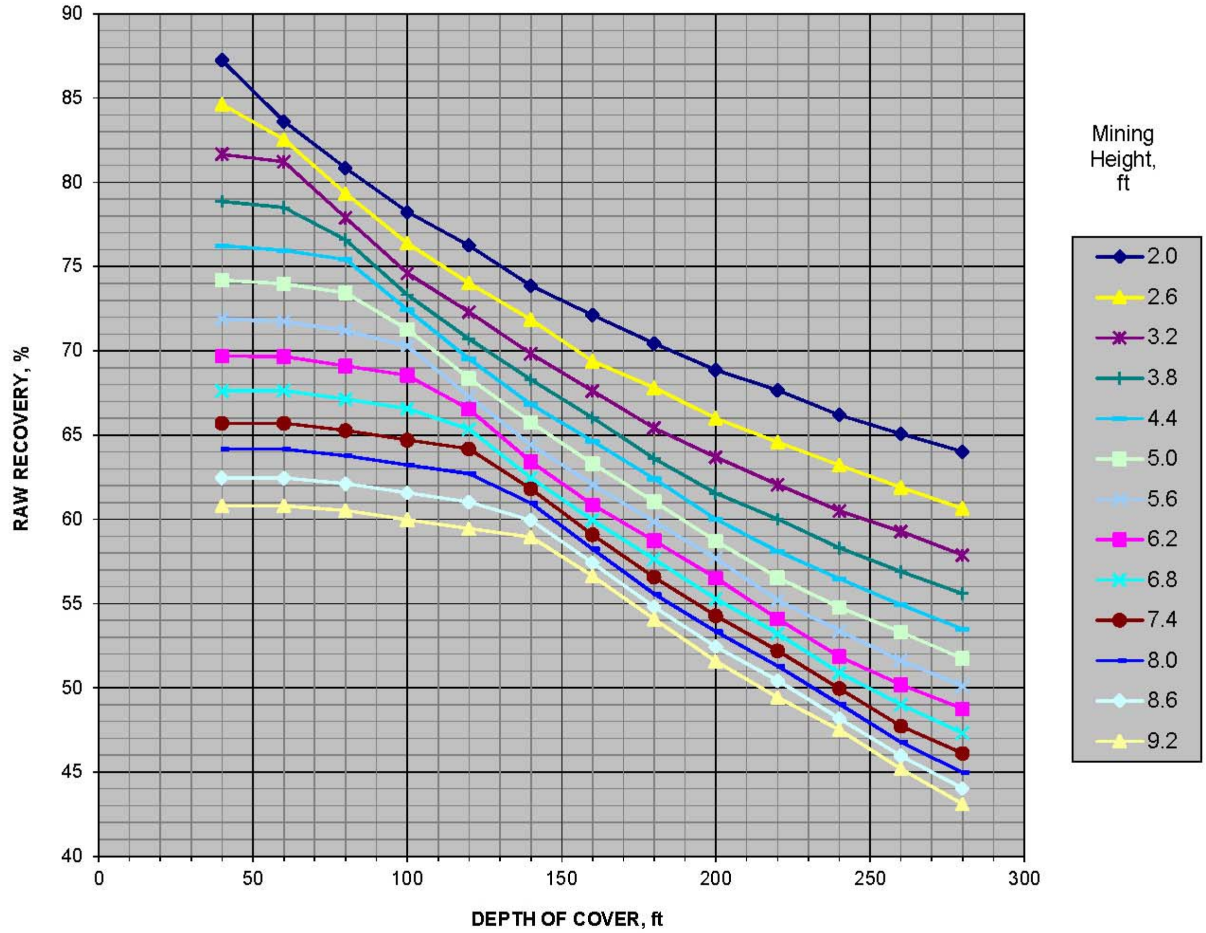


534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-1b. N Pit, L Seam Barrier Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	2	2.6	3.2	3.8	4.4	5	5.6	6.2	6.8	7.4	8	8.6	9.2
40	87.2	84.6	81.7	78.9	76.2	74.2	71.9	69.7	67.6	65.7	64.2	62.4	60.8
60	83.6	82.5	81.2	78.5	76.0	74.0	71.7	69.7	67.6	65.7	64.2	62.4	60.8
80	80.8	79.3	77.9	76.6	75.4	73.4	71.2	69.1	67.1	65.3	63.8	62.1	60.5
100	78.3	76.4	74.6	73.3	72.4	71.3	70.3	68.5	66.6	64.7	63.2	61.6	60.0
120	76.3	74.0	72.3	70.7	69.5	68.4	67.3	66.5	65.3	64.2	62.7	61.0	59.5
140	73.9	71.9	69.8	68.3	66.8	65.8	64.4	63.4	62.5	61.8	61.0	59.9	58.9
160	72.1	69.4	67.6	66.0	64.6	63.3	62.1	60.9	59.9	59.1	58.2	57.4	56.6
180	70.4	67.8	65.4	63.6	62.4	61.1	59.9	58.7	57.6	56.6	55.6	54.8	54.1
200	68.9	66.0	63.7	61.6	60.0	58.7	57.7	56.5	55.3	54.3	53.3	52.4	51.6
220	67.7	64.6	62.1	60.0	58.1	56.5	55.2	54.1	53.2	52.2	51.3	50.4	49.4
240	66.2	63.2	60.5	58.3	56.5	54.8	53.4	51.9	50.9	50.0	49.0	48.2	47.5
260	65.1	61.9	59.3	56.9	54.9	53.3	51.6	50.2	49.0	47.7	46.8	46.0	45.2
280	64.0	60.6	57.9	55.6	53.5	51.7	50.1	48.8	47.3	46.1	45.0	44.0	43.1

Coal strength, psi 673 Mining width, ft 11.50 No. web pillars 19



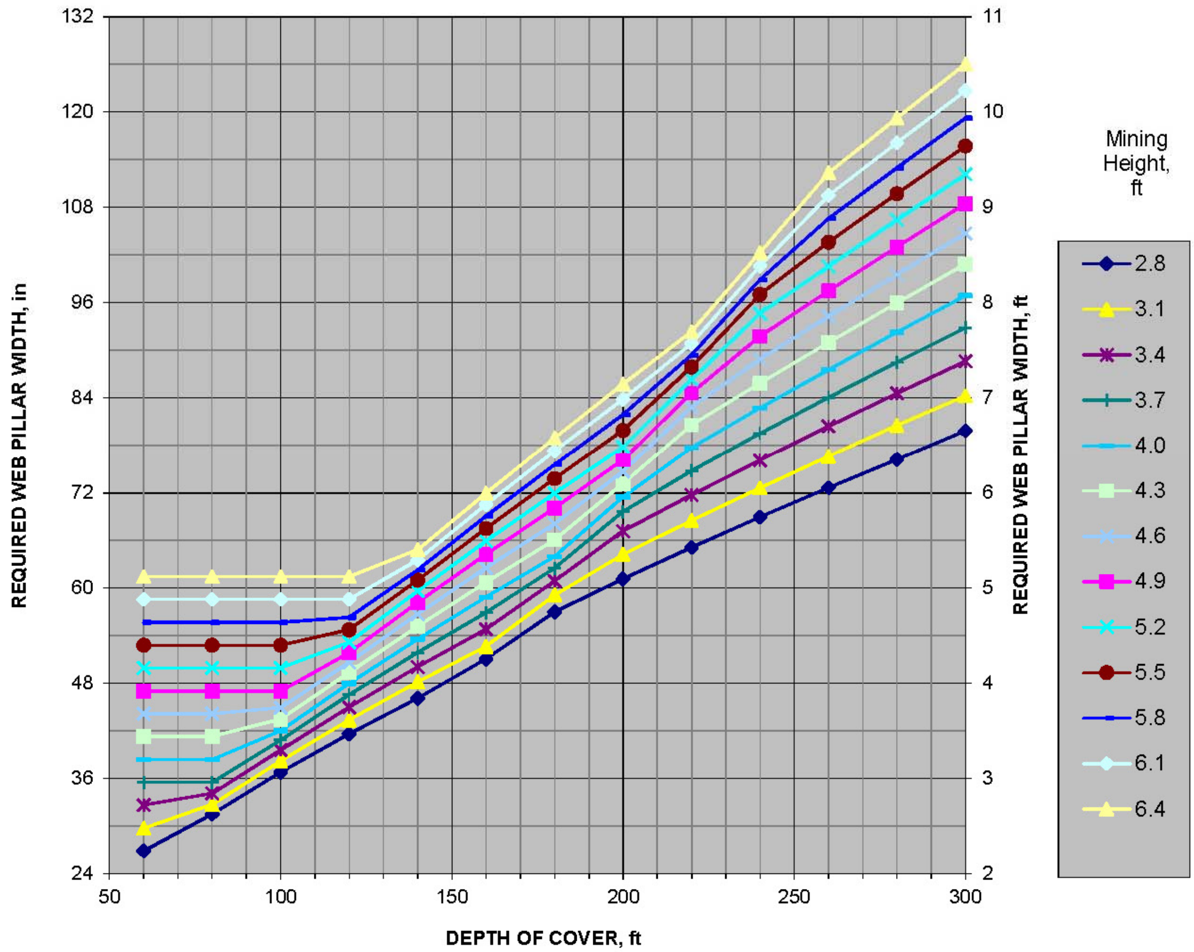
534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-1c. N Pit L-Seam Recovery Chart

Design Depth of Cover, ft	Mining Height, ft												
	2.8	3.1	3.4	3.7	4	4.3	4.6	4.9	5.2	5.5	5.8	6.1	6.4
60	*27*	*30*	*33*	*36*	*39*	*42*	*45*	*48*	*50*	*53*	*56*	*59*	*62*
80	32	*33*	*35*	*36*	*39*	*42*	*45*	*48*	*50*	*53*	*56*	*59*	*62*
100	37	39	40	41	43	*44*	*45*	*48*	*50*	*53*	*56*	*59*	*62*
120	42	44	46	47	48	50	51	52	*54*	*55*	*57*	*59*	*62*
140	47	49	51	52	54	56	57	59	60	61	63	64	*65*
160	52	53	55	57	59	61	63	65	66	68	70	71	72
180	57	60	61	63	64	67	69	71	72	74	76	78	79
200	62	65	68	70	72	74	75	77	78	80	82	84	86
220	66	69	72	75	78	81	83	85	87	88	90	91	93
240	69	73	77	80	83	86	89	92	95	98	99	101	103
260	73	77	81	85	88	91	95	98	101	104	107	110	113
280	77	81	85	89	93	96	100	104	107	110	113	117	120
300	80	85	89	93	97	101	105	109	113	116	120	123	127

Coal strength, psi 766 Mining width, ft 11.50 No. web pillars 19

Pillar widths in italics have width-to-height ratios of 0.8



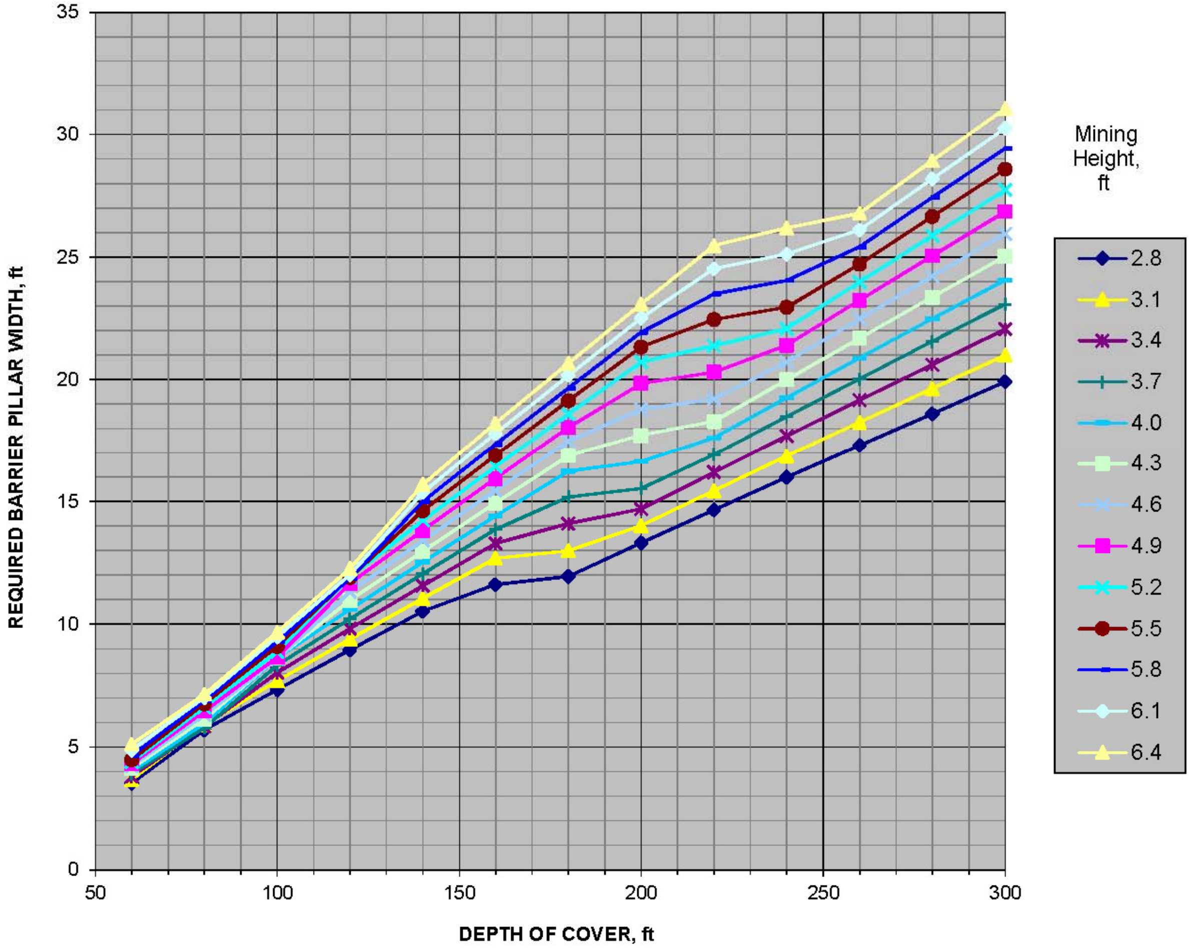
534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-2a. N Pit, M Seam Web Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	2.8	3.1	3.4	3.7	4	4.3	4.6	4.9	5.2	5.5	5.8	6.1	6.4
60	3.6	3.7	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.5	*4.7*	*4.9*	*5.2*
80	5.7	6.0	5.9	5.8	6.0	6.2	6.4	6.5	6.7	6.8	6.9	7.1	7.2
100	7.4	7.7	8.1	8.4	8.7	8.7	8.6	8.7	8.9	9.1	9.4	9.5	9.7
120	9.0	9.5	9.9	10.3	10.7	11.0	11.4	11.7	12.0	12.0	11.9	12.1	12.3
140	10.6	11.1	11.6	12.1	12.6	13.0	13.5	13.9	14.3	14.7	15.1	15.4	15.7
160	11.7	12.7	13.3	13.9	14.5	15.0	15.5	16.0	16.5	16.9	17.4	17.8	18.3
180	12.0	13.1	14.2	15.2	16.3	16.9	17.5	18.1	18.6	19.2	19.7	20.2	20.7
200	13.4	14.1	14.7	15.6	16.7	17.8	18.8	19.9	20.8	21.4	22.0	22.6	23.1
220	14.7	15.5	16.3	17.0	17.7	18.3	19.3	20.4	21.4	22.5	23.5	24.6	25.5
240	16.0	16.9	17.7	18.5	19.3	20.0	20.8	21.5	22.1	23.0	24.1	25.2	26.2
260	17.4	18.3	19.2	20.1	20.9	21.7	22.5	23.3	24.0	24.8	25.5	26.2	26.8
280	18.7	19.7	20.7	21.6	22.5	23.4	24.3	25.1	25.9	26.7	27.5	28.2	29.0
300	20.0	21.0	22.1	23.1	24.1	25.1	26.0	26.9	27.8	28.7	29.5	30.3	31.1

Coal strength, psi 766 Mining width, ft 11.50 No. web pillars 19

Pillar widths in italics have width-to-height ratios of 0.8

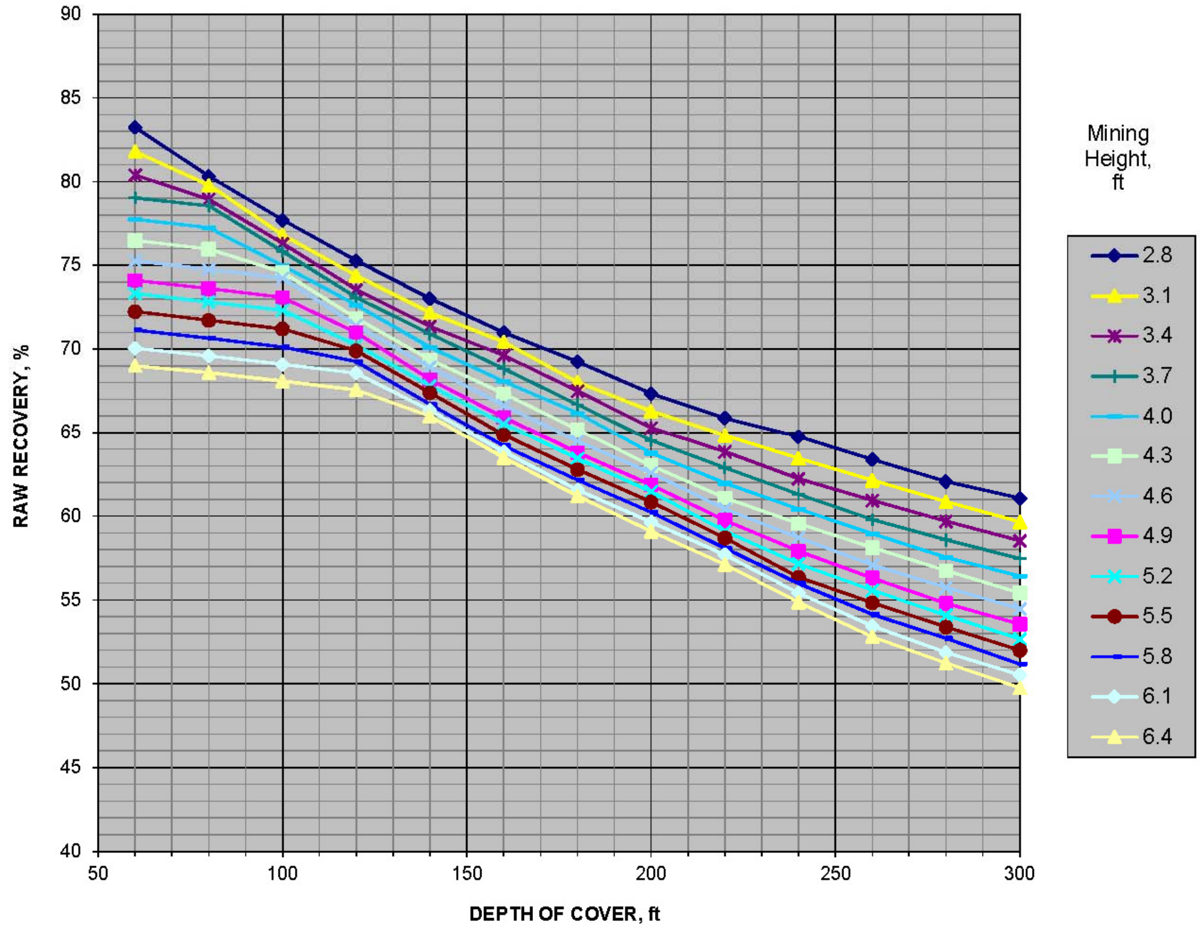


534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-2b. N Pit, M Seam Barrier Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	2.8	3.1	3.4	3.7	4	4.3	4.6	4.9	5.2	5.5	5.8	6.1	6.4
60	83.2	81.8	80.4	79.0	77.7	76.5	75.3	74.1	73.3	72.2	71.1	70.1	69.0
80	80.3	79.8	79.0	78.6	77.2	76.0	74.8	73.6	72.8	71.7	70.6	69.6	68.6
100	77.7	76.8	76.3	75.8	75.0	74.6	74.2	73.1	72.3	71.2	70.1	69.1	68.1
120	75.3	74.4	73.5	73.1	72.6	71.8	71.4	71.0	70.2	69.9	69.2	68.6	67.6
140	73.0	72.2	71.4	70.9	70.1	69.3	68.9	68.2	67.8	67.4	66.7	66.3	66.0
160	71.0	70.4	69.6	68.8	68.1	67.3	66.6	65.9	65.5	64.9	64.2	63.9	63.5
180	69.2	68.0	67.5	66.7	66.2	65.2	64.5	63.8	63.4	62.8	62.2	61.5	61.2
200	67.3	66.3	65.3	64.5	63.8	63.0	62.6	61.9	61.4	60.8	60.2	59.6	59.1
220	65.9	64.8	63.8	62.9	62.0	61.1	60.4	59.7	59.1	58.7	58.1	57.7	57.1
240	64.7	63.5	62.2	61.3	60.4	59.6	58.7	57.9	57.1	56.3	56.0	55.4	54.9
260	63.4	62.1	60.9	59.8	58.9	58.1	57.1	56.3	55.6	54.8	54.1	53.4	52.8
280	62.1	60.9	59.7	58.6	57.5	56.7	55.7	54.8	54.1	53.4	52.7	51.9	51.2
300	61.1	59.6	58.5	57.4	56.4	55.4	54.5	53.6	52.7	52.0	51.2	50.5	49.8

Coal strength, psi 766 Mining width, ft 11.50 No. web pillars 19



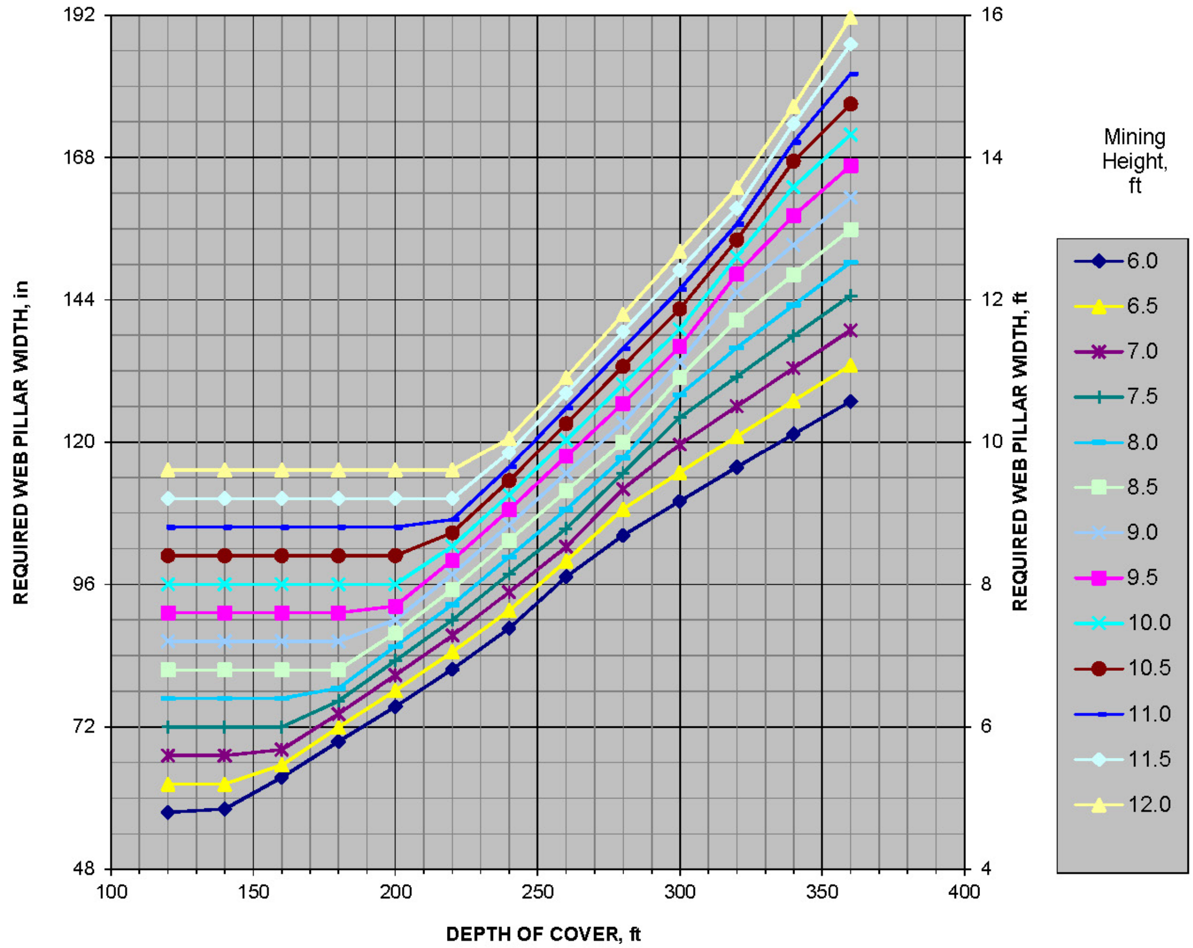
534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-2c. N Pit, M Seam Recovery Chart

Design Depth of Cover, ft	Mining Height, ft												
	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
120	*58*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
140	*59*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
160	64	66	*69*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
180	70	72	75	77	*79*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
200	76	79	81	84	86	88	91	*93*	*96*	*101*	*106*	*111*	*116*
220	82	85	88	91	93	96	98	101	103	105	107	*111*	*116*
240	89	92	95	98	101	104	107	109	112	114	116	119	121
260	98	100	103	106	109	112	115	118	121	124	126	129	131
280	105	109	113	115	118	120	124	127	130	133	136	139	142
300	110	115	120	125	128	131	134	137	140	143	146	150	153
320	116	121	127	132	136	141	146	149	152	155	157	160	163
340	122	127	133	138	144	149	154	159	164	168	171	174	177
360	127	133	139	145	151	156	162	167	172	177	183	188	192

Coal strength, psi 850 **Mining width, ft** 11.50 **No. web pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8



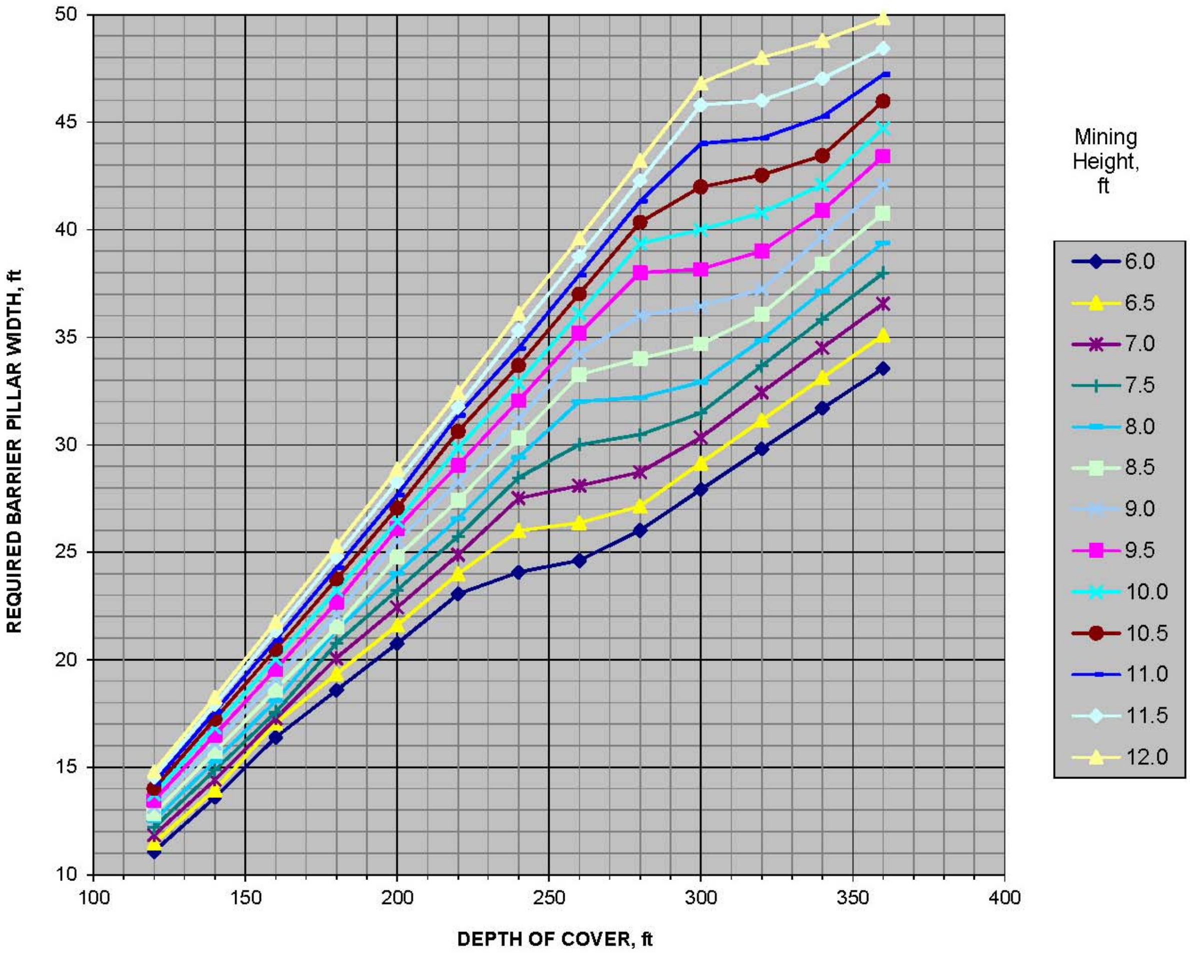
534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-3a. N Pit, Q Seam Web Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
120	11.1	11.5	11.9	12.2	12.6	12.9	13.2	13.5	13.8	14.1	14.3	14.6	14.9
140	13.6	14.0	14.5	14.9	15.3	15.8	16.2	16.5	16.9	17.3	17.6	18.0	18.3
160	16.4	17.1	17.3	17.6	18.1	18.7	19.1	19.6	20.1	20.5	21.0	21.4	21.8
180	18.6	19.4	20.1	20.8	21.4	21.6	22.2	22.7	23.3	23.8	24.3	24.8	25.3
200	20.8	21.7	22.5	23.3	24.1	24.8	25.6	26.2	26.5	27.1	27.7	28.3	28.9
220	23.1	24.0	24.9	25.8	26.6	27.5	28.3	29.1	29.9	30.7	31.4	31.8	32.5
240	24.1	26.0	27.6	28.5	29.5	30.4	31.2	32.1	32.9	33.7	34.5	35.4	36.2
260	24.7	26.4	28.1	30.0	32.0	33.3	34.3	35.2	36.2	37.1	37.9	38.8	39.7
280	26.1	27.2	28.8	30.5	32.3	34.0	36.0	38.0	39.4	40.4	41.4	42.3	43.3
300	28.0	29.2	30.4	31.5	33.0	34.7	36.5	38.2	40.0	42.0	44.0	45.9	46.9
320	29.9	31.2	32.5	33.7	34.9	36.1	37.3	39.1	40.8	42.6	44.3	46.0	48.0
340	31.7	33.2	34.6	35.9	37.2	38.5	39.7	40.9	42.1	43.5	45.3	47.1	48.9
360	33.6	35.1	36.6	38.0	39.4	40.8	42.2	43.5	44.8	46.0	47.3	48.5	49.9

Coal strength, psi 850 **Mining width, ft** 11.50 **No. web pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8

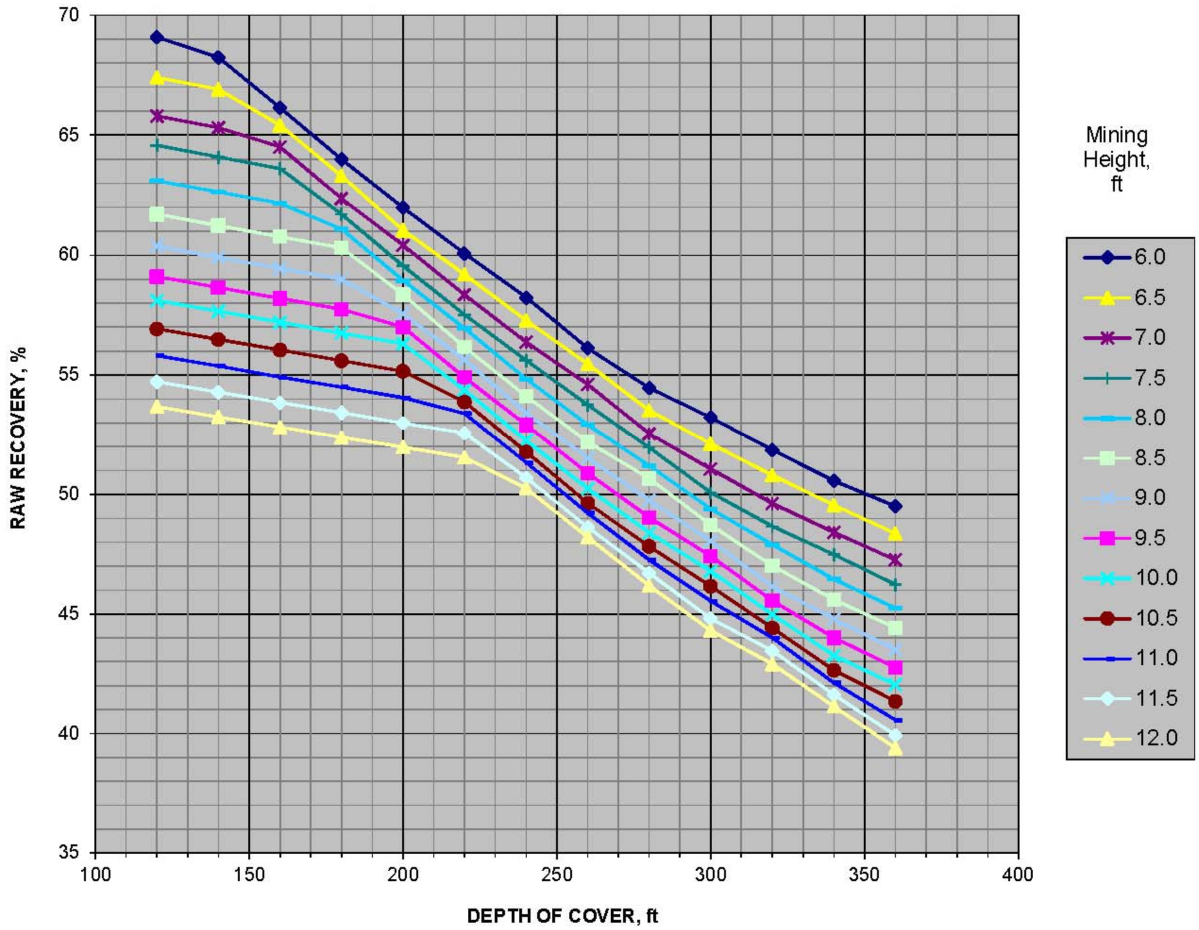


534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-3b. N Pit, Q Seam Barrier Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
120	69.1	67.4	65.8	64.6	63.1	61.7	60.4	59.1	58.1	56.9	55.8	54.7	53.7
140	68.2	66.9	65.3	64.1	62.6	61.2	59.9	58.6	57.7	56.5	55.4	54.3	53.2
160	66.1	65.4	64.5	63.6	62.2	60.8	59.5	58.2	57.2	56.0	54.9	53.8	52.8
180	64.0	63.3	62.4	61.7	61.1	60.3	59.0	57.7	56.7	55.6	54.5	53.4	52.4
200	62.0	61.0	60.4	59.5	58.9	58.4	57.5	57.0	56.3	55.2	54.0	53.0	52.0
220	60.1	59.2	58.3	57.5	57.0	56.2	55.6	54.9	54.4	53.9	53.4	52.6	51.6
240	58.2	57.3	56.4	55.6	54.8	54.1	53.4	52.9	52.2	51.8	51.3	50.7	50.2
260	56.1	55.5	54.6	53.8	52.9	52.2	51.5	50.9	50.2	49.6	49.2	48.6	48.2
280	54.5	53.5	52.5	52.0	51.2	50.7	49.7	49.0	48.4	47.8	47.3	46.7	46.2
300	53.2	52.1	51.1	50.1	49.4	48.7	48.1	47.4	46.8	46.1	45.5	44.8	44.3
320	51.9	50.8	49.6	48.7	47.9	47.0	46.1	45.5	45.0	44.4	44.0	43.5	42.9
340	50.6	49.5	48.4	47.5	46.4	45.6	44.8	44.0	43.3	42.6	42.1	41.6	41.1
360	49.5	48.4	47.3	46.2	45.2	44.4	43.5	42.8	42.0	41.3	40.6	39.9	39.4

Coal strength, psi 850 Mining width, ft 11.50 No. web pillars 19



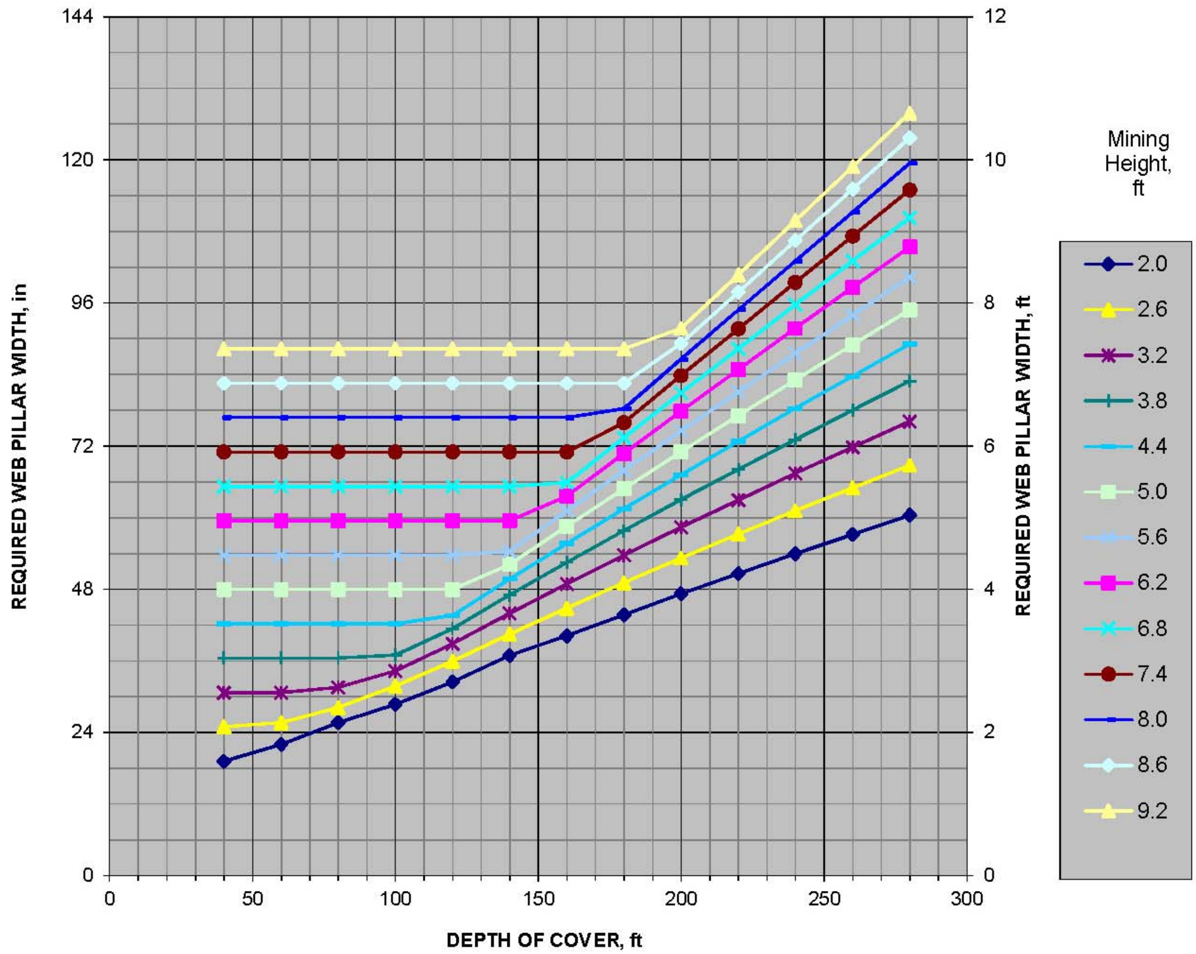
534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-3c. N Pit, Q Seam Recovery Chart

Design Depth of Cover, ft	Mining Height, ft												
	2	2.6	3.2	3.8	4.4	5	5.6	6.2	6.8	7.4	8	8.6	9.2
40	*20*	*25*	*31*	*37*	*43*	*48*	*54*	*60*	*66*	*72*	*77*	*83*	*89*
60	*23*	*26*	*31*	*37*	*43*	*48*	*54*	*60*	*66*	*72*	*77*	*83*	*89*
80	26	29	*32*	*37*	*43*	*48*	*54*	*60*	*66*	*72*	*77*	*83*	*89*
100	29	32	35	*37*	*43*	*48*	*54*	*60*	*66*	*72*	*77*	*83*	*89*
120	33	36	39	42	44	*48*	*54*	*60*	*66*	*72*	*77*	*83*	*89*
140	37	41	44	48	50	53	55	*60*	*66*	*72*	*77*	*83*	*89*
160	41	45	49	53	56	59	62	64	66	*72*	*77*	*83*	*89*
180	44	50	54	58	62	65	68	71	74	76	79	*83*	*89*
200	48	54	59	64	68	72	75	78	81	84	87	90	92
220	51	58	63	69	73	78	82	85	89	92	95	98	101
240	54	62	68	74	79	84	88	92	96	100	104	107	110
260	58	66	72	79	84	90	94	99	104	108	112	116	119
280	61	69	77	83	90	95	101	106	111	115	120	124	128

Coal strength, psi 673 **Mining width, ft** 11.50 **No. web pillars** vary

Pillar widths in italics have width-to-height ratios of 0.8

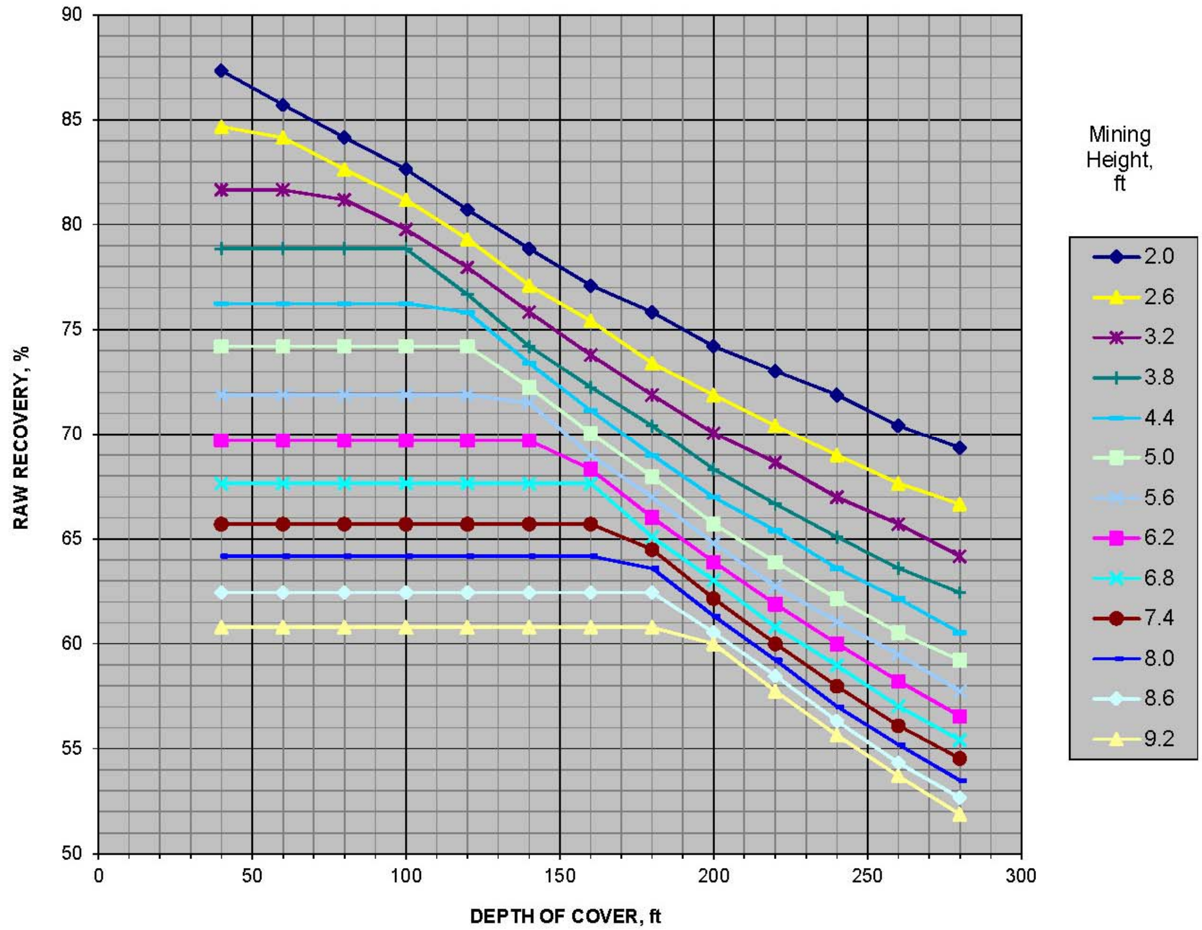


534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-4a. N Pit, L Seam Endwall Web Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	2	2.6	3.2	3.8	4.4	5	5.6	6.2	6.8	7.4	8	8.6	9.2
40	87.3	84.7	81.7	78.9	76.2	74.2	71.9	69.7	67.6	65.7	64.2	62.4	60.8
60	85.7	84.1	81.7	78.9	76.2	74.2	71.9	69.7	67.6	65.7	64.2	62.4	60.8
80	84.1	82.6	81.2	78.9	76.2	74.2	71.9	69.7	67.6	65.7	64.2	62.4	60.8
100	82.6	81.2	79.8	78.9	76.2	74.2	71.9	69.7	67.6	65.7	64.2	62.4	60.8
120	80.7	79.3	78.0	76.7	75.8	74.2	71.9	69.7	67.6	65.7	64.2	62.4	60.8
140	78.9	77.1	75.8	74.2	73.4	72.3	71.5	69.7	67.6	65.7	64.2	62.4	60.8
160	77.1	75.4	73.8	72.3	71.1	70.1	69.0	68.3	67.6	65.7	64.2	62.4	60.8
180	75.8	73.4	71.9	70.4	69.0	68.0	67.0	66.0	65.1	64.5	63.6	62.4	60.8
200	74.2	71.9	70.1	68.3	67.0	65.7	64.8	63.9	63.0	62.2	61.3	60.5	60.0
220	73.0	70.4	68.7	66.7	65.4	63.9	62.7	61.9	60.8	60.0	59.2	58.5	57.7
240	71.9	69.0	67.0	65.1	63.6	62.2	61.1	60.0	59.0	58.0	57.0	56.3	55.6
260	70.4	67.6	65.7	63.6	62.2	60.5	59.5	58.2	57.0	56.1	55.2	54.3	53.7
280	69.3	66.7	64.2	62.4	60.5	59.2	57.7	56.6	55.4	54.5	53.5	52.7	51.9

Coal strength, psi 673 Mining width, ft 11.50 No. web pillars vary



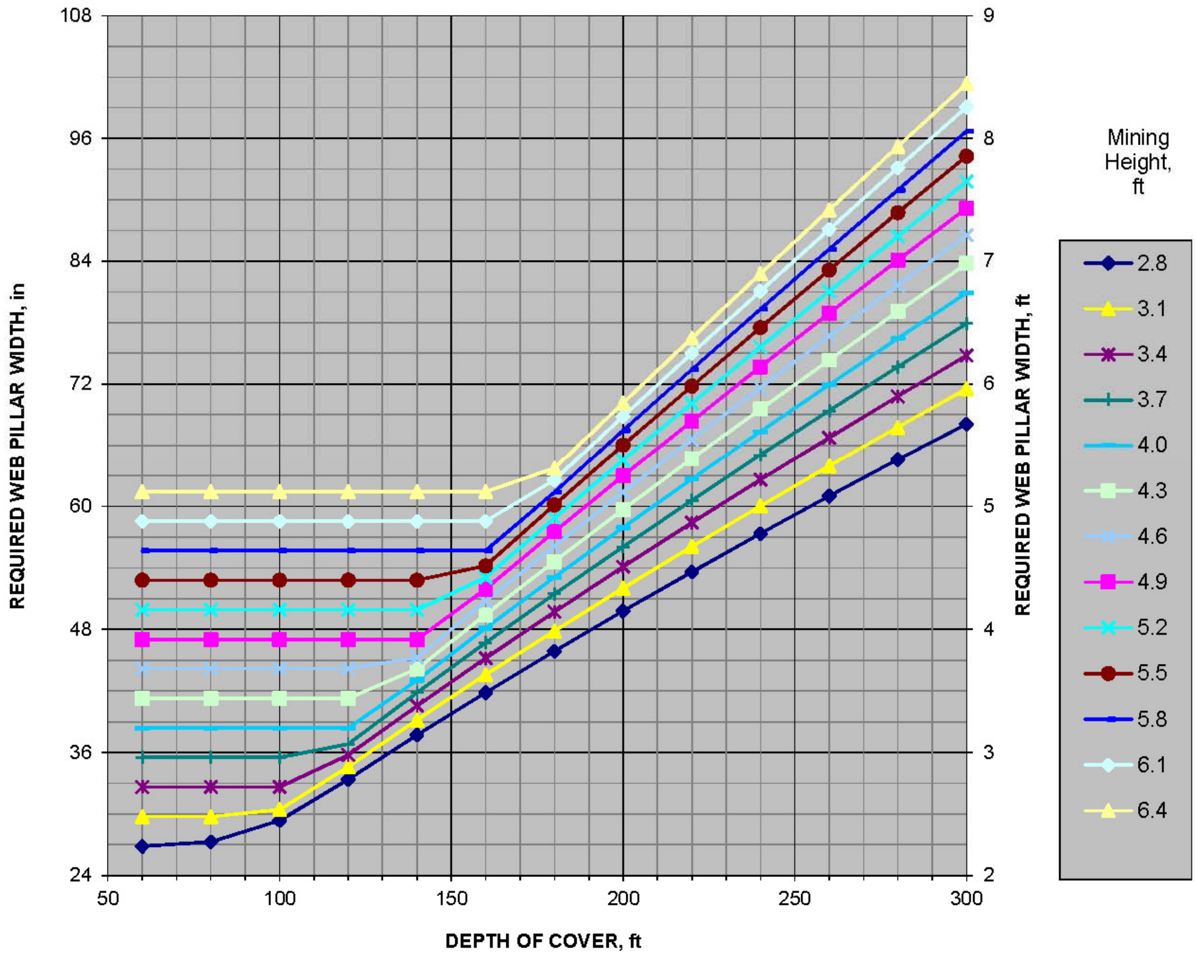
534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-4b. N Pit, L Seam Endwall Recovery Chart

Design Depth of Cover, ft	Mining Height, ft												
	2.8	3.1	3.4	3.7	4	4.3	4.6	4.9	5.2	5.5	5.8	6.1	6.4
60	*27*	*30*	*33*	*36*	*39*	*42*	*45*	*48*	*50*	*53*	*56*	*59*	*62*
80	*28*	*30*	*33*	*36*	*39*	*42*	*45*	*48*	*50*	*53*	*56*	*59*	*62*
100	30	31	*33*	*36*	*39*	*42*	*45*	*48*	*50*	*53*	*56*	*59*	*62*
120	34	35	36	37	*39*	*42*	*45*	*48*	*50*	*53*	*56*	*59*	*62*
140	38	40	41	42	44	45	46	*48*	*50*	*53*	*56*	*59*	*62*
160	42	44	46	47	49	50	51	52	54	55	*56*	*59*	*62*
180	46	48	50	52	54	55	57	58	59	61	62	63	64
200	50	53	55	57	58	60	62	63	65	67	68	69	71
220	54	57	59	61	63	65	67	69	71	72	74	75	77
240	58	61	63	66	68	70	72	74	76	78	80	82	83
260	61	64	67	70	72	75	77	79	82	84	86	88	90
280	65	68	71	74	77	80	82	85	87	89	91	94	96
300	69	72	75	78	81	84	87	90	92	95	97	100	102

Coal strength, psi 766 **Mining width, ft** 11.50 **No. web pillars** vary

Pillar widths in italics have width-to-height ratios of 0.8

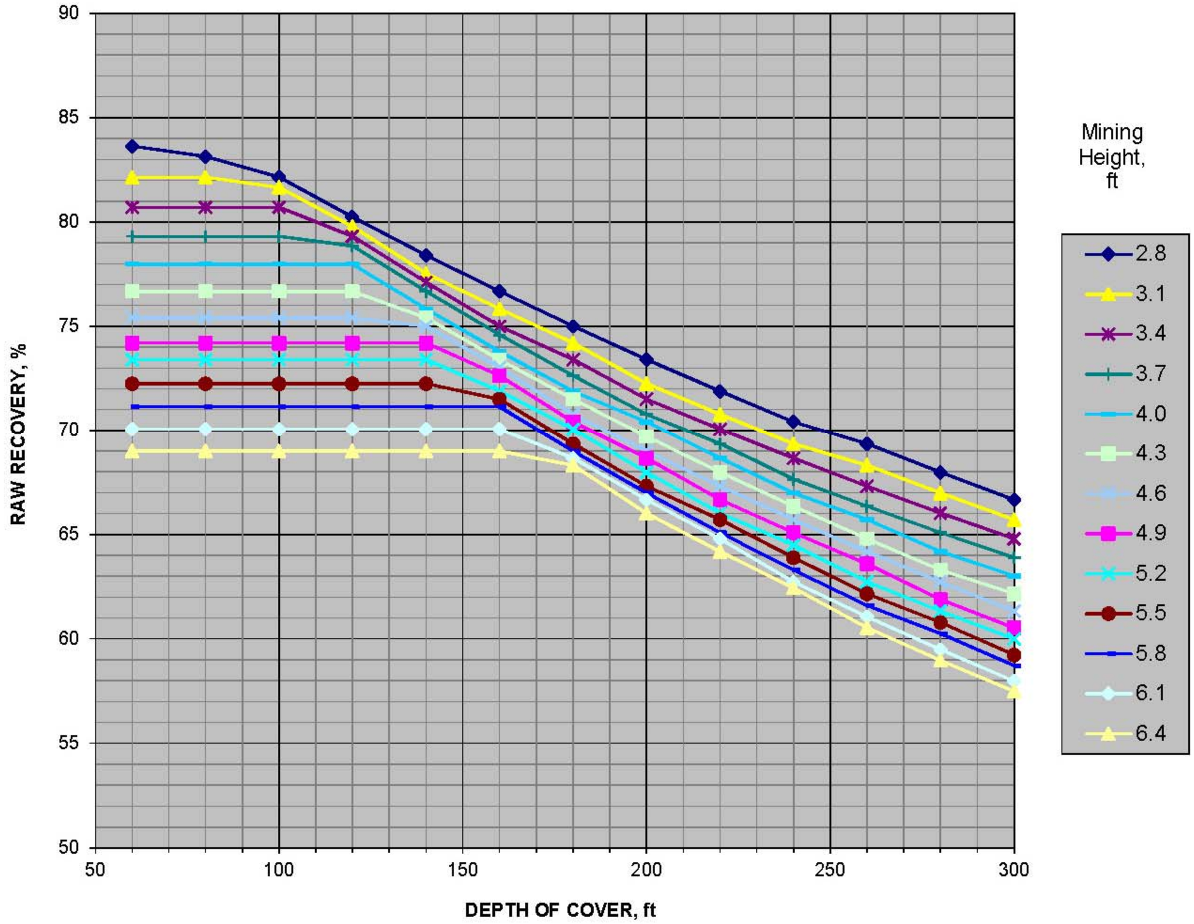


534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-5a. N Pit, M Seam Endwall Web Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	2.8	3.1	3.4	3.7	4	4.3	4.6	4.9	5.2	5.5	5.8	6.1	6.4
60	83.6	82.1	80.7	79.3	78.0	76.7	75.4	74.2	73.4	72.3	71.1	70.1	69.0
80	83.1	82.1	80.7	79.3	78.0	76.7	75.4	74.2	73.4	72.3	71.1	70.1	69.0
100	82.1	81.7	80.7	79.3	78.0	76.7	75.4	74.2	73.4	72.3	71.1	70.1	69.0
120	80.2	79.8	79.3	78.9	78.0	76.7	75.4	74.2	73.4	72.3	71.1	70.1	69.0
140	78.4	77.5	77.1	76.7	75.8	75.4	75.0	74.2	73.4	72.3	71.1	70.1	69.0
160	76.7	75.8	75.0	74.6	73.8	73.4	73.0	72.6	71.9	71.5	71.1	70.1	69.0
180	75.0	74.2	73.4	72.6	71.9	71.5	70.8	70.4	70.1	69.3	69.0	68.7	68.3
200	73.4	72.3	71.5	70.8	70.4	69.7	69.0	68.7	68.0	67.3	67.0	66.7	66.0
220	71.9	70.8	70.1	69.3	68.7	68.0	67.3	66.7	66.0	65.7	65.1	64.8	64.2
240	70.4	69.3	68.7	67.6	67.0	66.3	65.7	65.1	64.5	63.9	63.3	62.7	62.4
260	69.3	68.3	67.3	66.3	65.7	64.8	64.2	63.6	62.7	62.2	61.6	61.1	60.5
280	68.0	67.0	66.0	65.1	64.2	63.3	62.7	61.9	61.3	60.8	60.3	59.5	59.0
300	66.7	65.7	64.8	63.9	63.0	62.2	61.3	60.5	60.0	59.2	58.7	58.0	57.5

Coal strength, psi 766 Mining width, ft 11.50 No. web pillars vary



534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-5b. N Pit, M Seam Endwall Recovery Chart

Design Depth of Cover, ft	Mining Height, ft												
	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
120	*58*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
140	*58*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
160	*58*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
180	*58*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
200	63	65	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
220	68	71	73	75	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
240	74	76	79	81	83	85	*87*	*92*	*96*	*101*	*106*	*111*	*116*
260	79	82	85	87	90	92	94	96	98	*101*	*106*	*111*	*116*
280	85	88	91	93	96	99	101	103	106	108	110	112	*116*
300	90	93	97	100	103	105	108	111	113	116	118	121	123
320	95	99	102	106	109	112	115	118	121	124	126	129	131
340	101	105	108	112	116	119	122	125	128	131	134	137	140
360	106	110	114	118	122	126	129	133	136	139	143	146	149

Coal strength, psi 850 **Mining width, ft** 11.50 **No. web pillars** vary

Pillar widths in italics have width-to-height ratios of 0.8

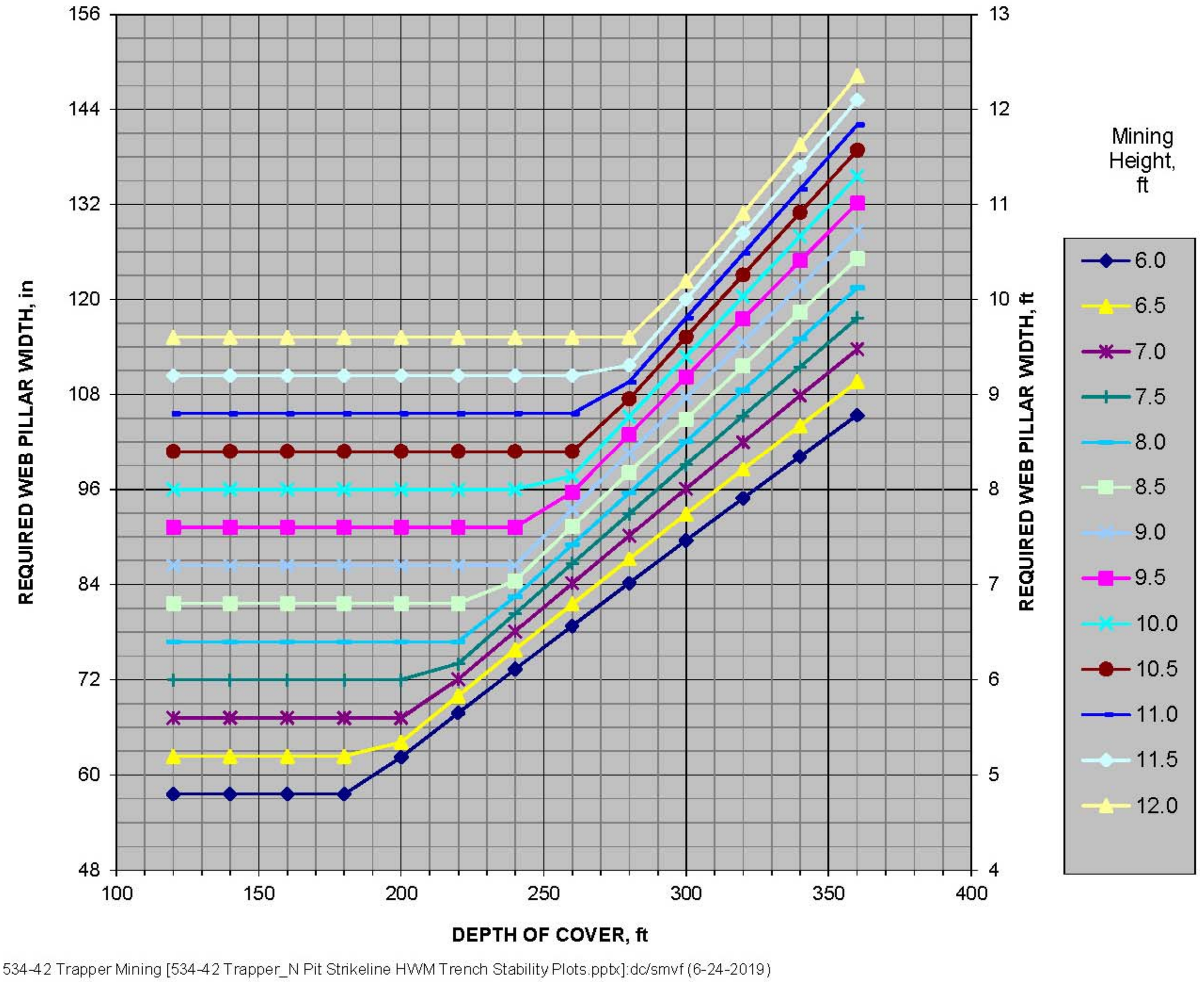
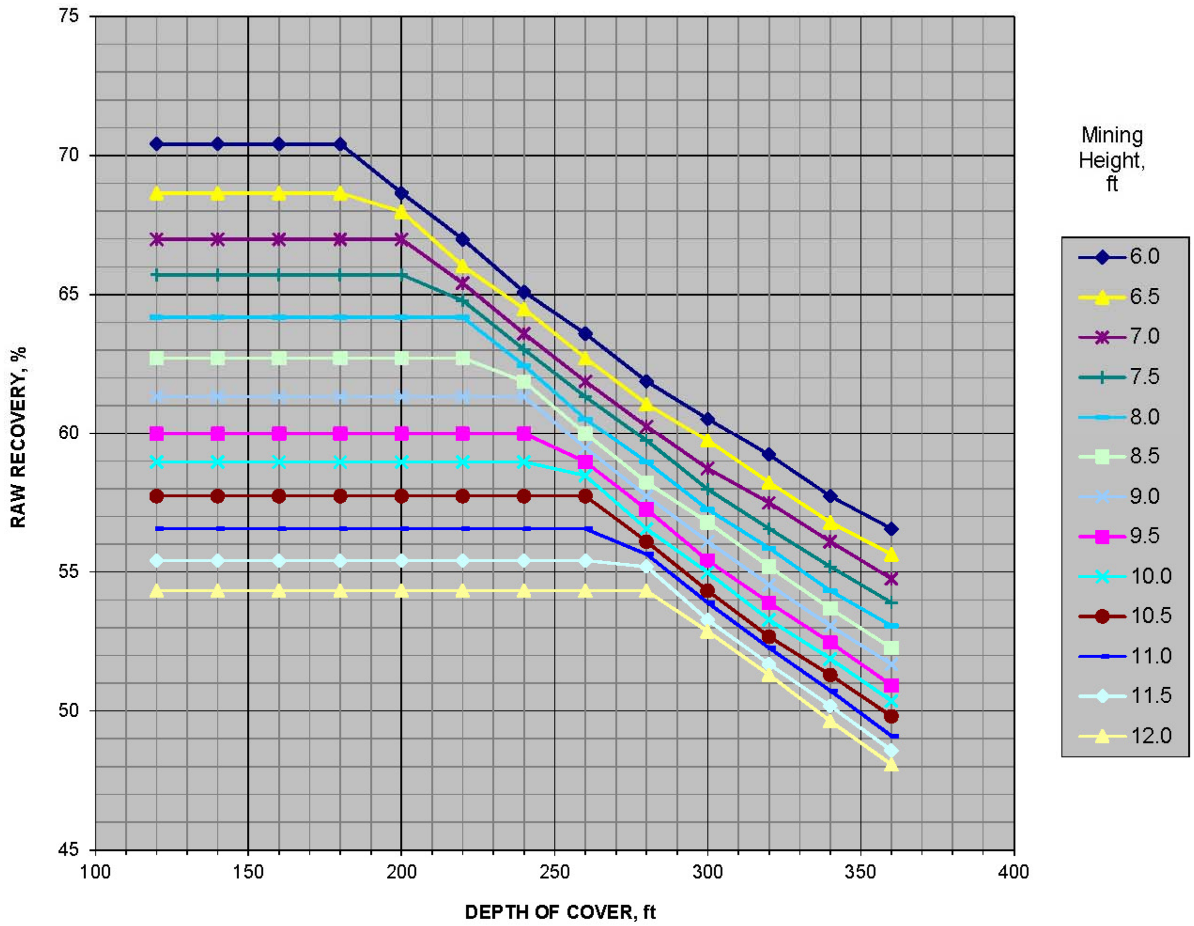


Figure C-6a. N Pit, Q Seam Endwall Web Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
120	70.4	68.7	67.0	65.7	64.2	62.7	61.3	60.0	59.0	57.7	56.6	55.4	54.3
140	70.4	68.7	67.0	65.7	64.2	62.7	61.3	60.0	59.0	57.7	56.6	55.4	54.3
160	70.4	68.7	67.0	65.7	64.2	62.7	61.3	60.0	59.0	57.7	56.6	55.4	54.3
180	70.4	68.7	67.0	65.7	64.2	62.7	61.3	60.0	59.0	57.7	56.6	55.4	54.3
200	68.7	68.0	67.0	65.7	64.2	62.7	61.3	60.0	59.0	57.7	56.6	55.4	54.3
220	67.0	66.0	65.4	64.8	64.2	62.7	61.3	60.0	59.0	57.7	56.6	55.4	54.3
240	65.1	64.5	63.6	63.0	62.4	61.9	61.3	60.0	59.0	57.7	56.6	55.4	54.3
260	63.6	62.7	61.9	61.3	60.5	60.0	59.5	59.0	58.5	57.7	56.6	55.4	54.3
280	61.9	61.1	60.3	59.7	59.0	58.2	57.7	57.3	56.6	56.1	55.6	55.2	54.3
300	60.5	59.7	58.7	58.0	57.3	56.8	56.1	55.4	55.0	54.3	53.9	53.3	52.9
320	59.2	58.2	57.5	56.6	55.9	55.2	54.5	53.9	53.3	52.7	52.3	51.7	51.3
340	57.7	56.8	56.1	55.2	54.3	53.7	53.1	52.5	51.9	51.3	50.7	50.2	49.6
360	56.6	55.6	54.8	53.9	53.1	52.3	51.7	50.9	50.4	49.8	49.1	48.6	48.1

Coal strength, psi 850 Mining width, ft 11.50 No. web pillars vary



534-42 Trapper Mining [534-42 Trapper_N Pit Strikeline HWM Trench Stability Plots.pptx]:dc/smvf (6-24-2019)

Figure C-6b. N Pit, Q Seam Endwall Recovery Chart

APPENDIX D

L PIT WEB AND BARRIER PILLAR DESIGN CURVES

Design Depth of Cover, ft	Mining Height, ft												
	4	**4.75**	**5.5**	**6.25**	**7**	**7.75**	**8.5**	**9.25**	**10**	**10.75**	**11.5**	**12.25**	**13**
60	*40*	*46*	*53*	*60*	*68*	*75*	*82*	*89*	*96*	*104*	*111*	*118*	*125*
75	46	*50*	*53*	*60*	*68*	*75*	*82*	*89*	*96*	*104*	*111*	*118*	*125*
90	53	56	60	*64*	*68*	*75*	*82*	*89*	*96*	*104*	*111*	*118*	*125*
105	59	63	67	71	*74*	*79*	*82*	*89*	*96*	*104*	*111*	*118*	*125*
120	65	70	75	79	83	87	90	*95*	*99*	*104*	*111*	*118*	*125*
135	71	77	82	87	91	96	100	104	107	*112*	*116*	*121*	*125*
150	77	83	89	94	100	105	109	114	118	122	126	130	*135*
165	84	90	96	102	108	113	119	124	129	134	138	143	147
180	91	99	104	109	116	122	128	134	139	145	150	155	160
195	97	106	114	120	125	131	137	144	150	156	162	168	173
210	102	112	122	130	137	143	148	154	161	167	174	180	187
225	107	118	128	138	147	155	161	168	173	179	186	193	200
240	112	124	135	146	156	166	175	182	189	195	201	207	213

Coal strength, psi 541 **Mining width, ft** 11.50 **No. web pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8

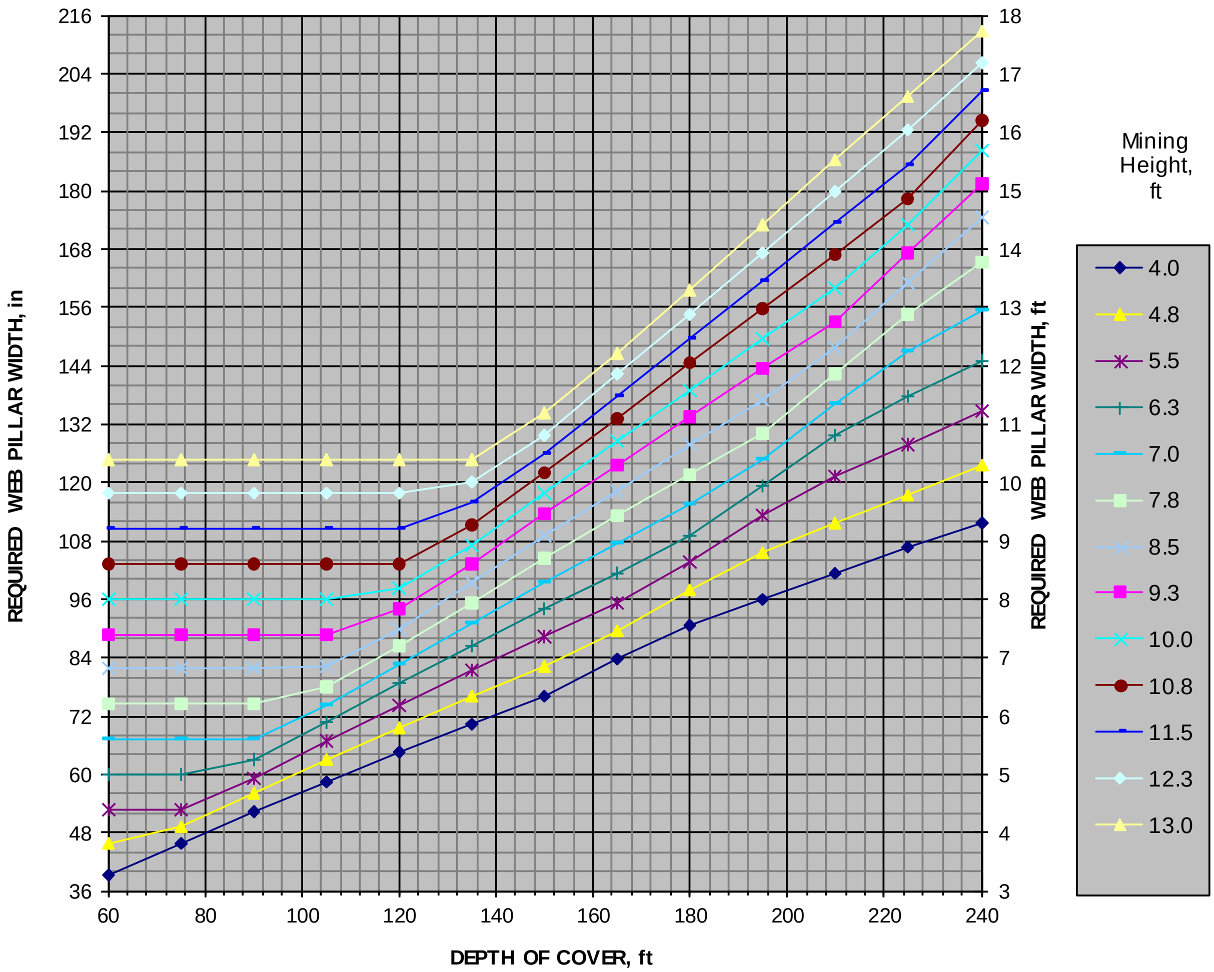


Figure D-1a. L Pit, H Seam Web Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	4	**4.75**	**5.5**	**6.25**	**7**	**7.75**	**8.5**	**9.25**	**10**	**10.75**	**11.5**	**12.25**	**13**
60	5.4	5.6	6.0	6.3	6.5	6.8	7.0	*7.5*	*8.0*	*8.7*	*9.2*	*9.9*	*10.4*
75	7.9	8.2	8.1	8.5	8.9	9.3	9.6	10.0	10.3	10.5	10.8	11.1	11.3
90	9.8	10.6	11.4	11.4	11.4	11.9	12.4	12.8	13.3	13.7	14.1	14.4	14.8
105	11.7	12.7	13.6	14.5	15.3	15.3	15.2	15.8	16.3	16.9	17.4	17.9	18.3
120	13.5	14.7	15.8	16.9	17.9	18.8	19.7	19.8	19.9	20.1	20.7	21.3	21.9
135	15.3	16.7	18.0	19.3	20.4	21.5	22.6	23.6	24.6	25.1	25.3	25.4	25.6
150	16.9	18.7	20.2	21.6	22.9	24.2	25.4	26.6	27.7	28.8	29.9	30.9	31.4
165	17.2	20.1	22.3	23.9	25.4	26.8	28.2	29.6	30.9	32.1	33.3	34.5	35.6
180	18.0	20.5	23.3	26.1	27.9	29.5	31.0	32.5	34.0	35.4	36.7	38.1	39.4
195	19.6	21.5	23.8	26.7	29.5	32.1	33.8	35.5	37.1	38.6	40.2	41.6	43.1
210	21.2	23.2	25.1	27.1	30.1	32.9	35.8	38.4	40.1	41.9	43.5	45.2	46.8
225	22.7	24.9	27.0	29.0	30.9	33.5	36.5	39.3	42.2	45.0	46.9	48.7	50.5
240	24.3	26.7	28.9	31.1	33.1	35.0	37.1	40.1	43.0	45.9	48.8	51.6	54.1

Coal strength, psi 541 **Mining width, ft** 11.50 **No. web pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8

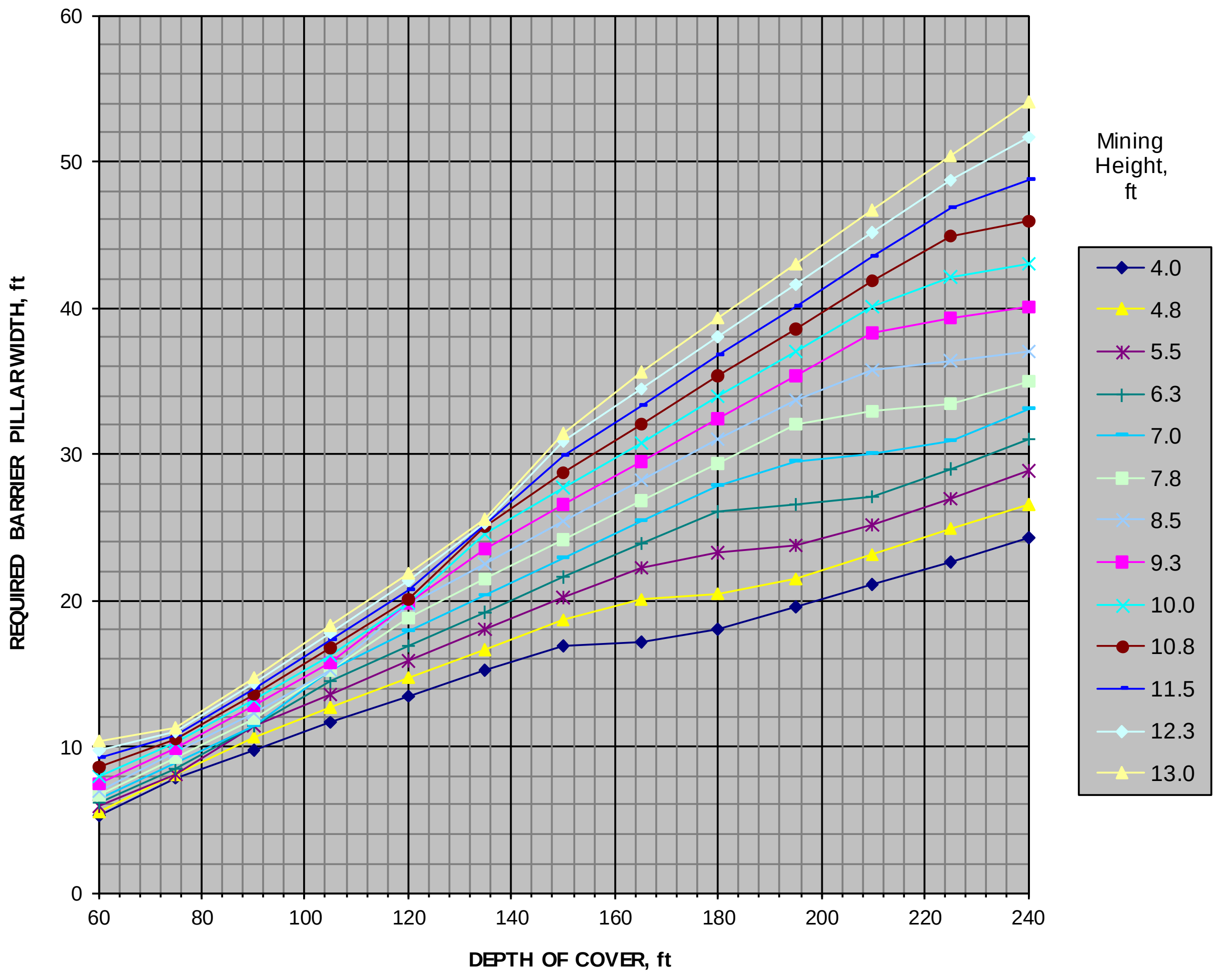


Figure D-1b. L Pit, H Seam Barrier Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	4	4.75	5.5	6.25	7	7.75	8.5	9.25	10	10.75	11.5	12.25	13
60	77.0	74.6	71.9	69.4	66.8	64.7	62.7	60.8	59.0	57.0	55.4	53.9	52.5
75	74.0	72.5	71.4	69.0	66.4	64.2	62.3	60.4	58.6	56.8	55.2	53.7	52.4
90	71.0	69.9	68.4	67.1	65.9	63.8	61.8	59.9	58.2	56.3	54.8	53.3	52.0
105	68.6	67.2	65.8	64.4	63.5	62.1	61.3	59.5	57.7	55.9	54.4	52.9	51.5
120	66.4	64.7	63.1	61.8	60.6	59.5	58.6	57.5	56.6	55.5	53.9	52.5	51.1
135	64.3	62.4	60.9	59.4	58.3	57.0	56.0	55.0	54.2	53.2	52.4	51.5	50.7
150	62.4	60.5	58.8	57.4	55.9	54.7	53.7	52.6	51.7	50.9	50.1	49.3	48.4
165	60.5	58.6	56.9	55.4	53.9	52.8	51.5	50.4	49.4	48.5	47.7	46.9	46.2
180	58.7	56.5	55.0	53.7	52.1	50.8	49.6	48.5	47.5	46.5	45.6	44.8	44.0
195	57.0	54.8	53.0	51.5	50.3	49.0	47.8	46.6	45.6	44.6	43.7	42.8	42.0
210	55.7	53.4	51.3	49.7	48.2	47.0	46.0	44.9	43.8	42.9	41.9	41.1	40.1
225	54.5	52.1	50.0	48.2	46.6	45.2	44.1	43.0	42.1	41.2	40.3	39.4	38.5
240	53.3	50.8	48.7	46.7	45.1	43.6	42.3	41.2	40.2	39.3	38.5	37.7	37.0

Coal strength, psi 541 **Mining width, ft** 11.50 **No. web pillars** 19

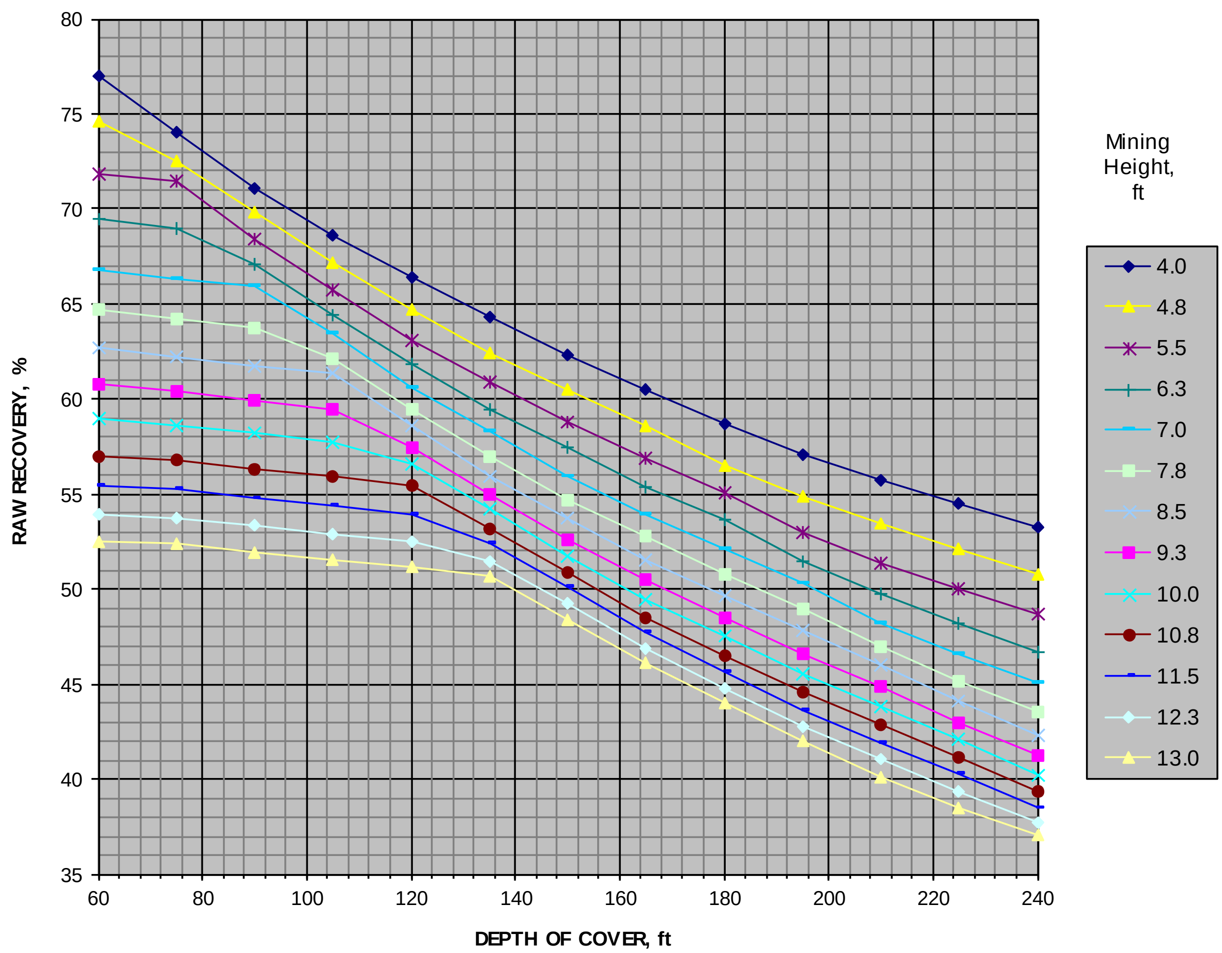


Figure D-1c. L Pit, H Seam Recovery Chart

Design Depth of Cover, ft	Mining Height, ft												
	6	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**
60	*58*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
75	*58*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
90	*58*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
105	*58*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
120	*58*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
135	*60*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
150	64	66	69	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
165	69	71	74	76	*79*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
180	74	76	79	81	84	86	*88*	*92*	*96*	*101*	*106*	*111*	*116*
195	79	81	84	87	89	92	94	96	*99*	*102*	*106*	*111*	*116*
210	83	86	89	92	95	98	100	103	105	107	110	*112*	*116*
225	88	91	95	98	100	103	106	109	112	114	117	119	122
240	95	98	100	104	107	110	113	115	118	121	124	127	129

Coal strength, psi 803 **Mining width, ft** 11.50 **No. web pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8

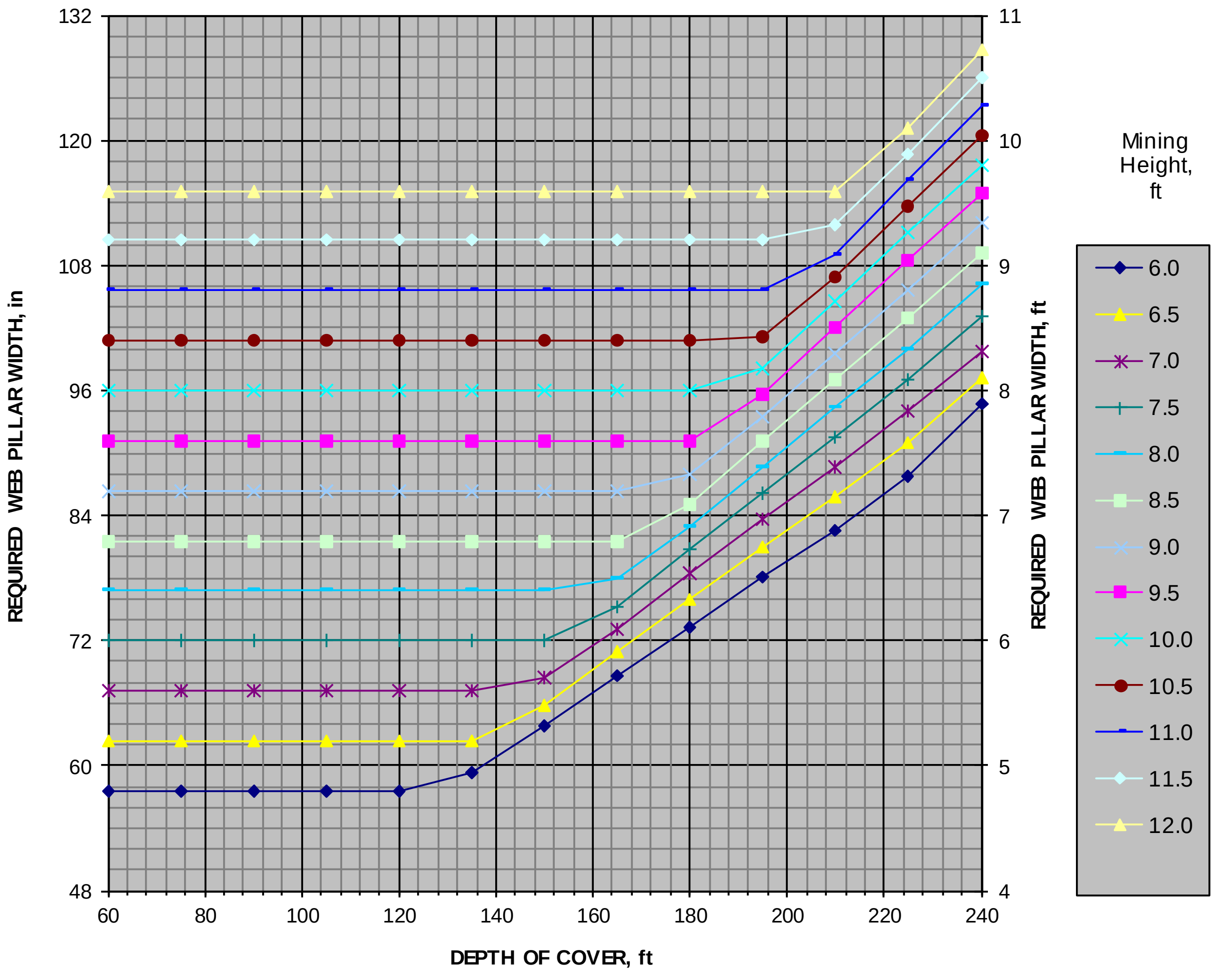


Figure D-2a. L Pit, K Seam Web Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	6	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**
60	*4.9*	*5.2*	*5.6*	*6.0*	*6.5*	*6.9*	*7.2*	*7.6*	*8.0*	*8.4*	*8.9*	*9.2*	*9.7*
75	6.2	6.4	6.5	6.7	6.9	7.0	*7.2*	*7.6*	*8.0*	*8.4*	*8.9*	*9.2*	*9.7*
90	8.0	8.2	8.5	8.7	8.9	9.1	9.3	9.5	9.7	9.8	10.0	10.2	10.3
105	9.8	10.1	10.4	10.7	11.0	11.3	11.5	11.8	12.0	12.2	12.5	12.7	12.9
120	11.6	12.0	12.4	12.8	13.1	13.5	13.8	14.1	14.4	14.7	15.0	15.3	15.5
135	13.8	13.9	14.4	14.8	15.3	15.7	16.1	16.5	16.8	17.2	17.5	17.9	18.2
150	16.0	16.6	16.7	16.9	17.4	17.9	18.4	18.8	19.3	19.7	20.1	20.5	20.9
165	17.7	18.4	19.1	19.7	19.9	20.2	20.7	21.2	21.7	22.2	22.7	23.2	23.7
180	19.4	20.2	21.0	21.7	22.4	23.1	23.4	23.6	24.2	24.8	25.3	25.9	26.4
195	21.1	22.0	22.8	23.6	24.4	25.2	26.0	26.7	27.3	27.5	28.0	28.6	29.2
210	22.8	23.7	24.7	25.6	26.4	27.3	28.1	28.9	29.7	30.5	31.2	31.7	31.9
225	24.1	25.6	26.6	27.5	28.4	29.3	30.2	31.1	32.0	32.8	33.7	34.5	35.2
240	24.5	26.2	28.0	29.6	30.6	31.5	32.5	33.3	34.2	35.2	36.1	36.9	37.8

Coal strength, psi 803 **Mining width, ft** 11.50 **No. web pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8

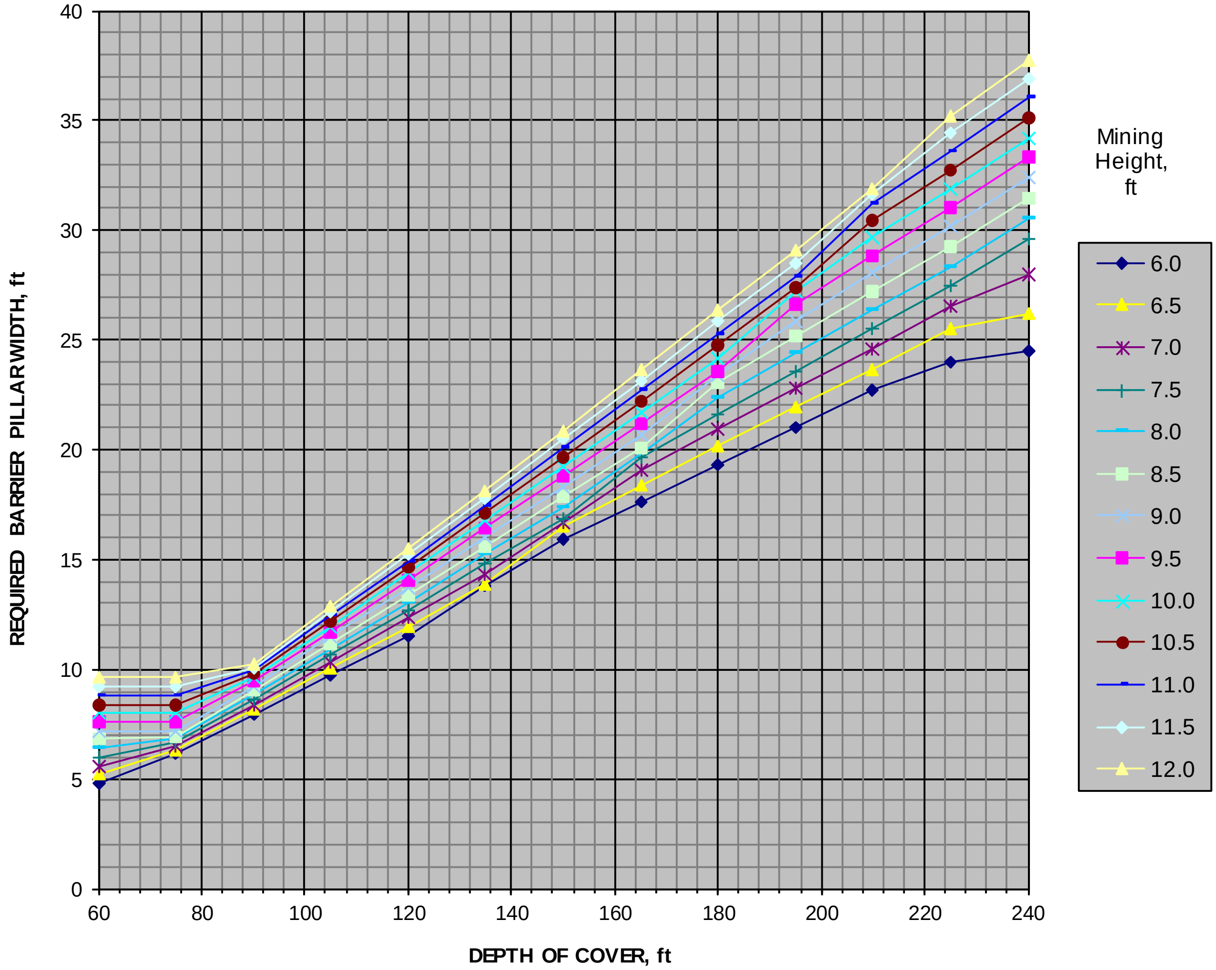


Figure D-2b. L Pit, K Seam Barrier Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	6	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**
60	70.4	68.7	67.0	65.7	64.2	62.7	61.3	60.0	59.0	57.7	56.5	55.4	54.3
75	70.1	68.4	66.8	65.6	64.1	62.7	61.3	60.0	59.0	57.7	56.5	55.4	54.3
90	69.7	68.1	66.4	65.2	63.7	62.3	61.0	59.7	58.7	57.5	56.4	55.3	54.2
105	69.4	67.7	66.1	64.8	63.4	62.0	60.6	59.4	58.4	57.2	56.1	55.0	53.9
120	69.0	67.3	65.7	64.5	63.0	61.6	60.3	59.0	58.0	56.8	55.7	54.6	53.6
135	67.9	66.9	65.3	64.1	62.6	61.2	59.9	58.6	57.7	56.5	55.4	54.3	53.3
150	66.2	65.5	64.6	63.7	62.3	60.9	59.6	58.3	57.3	56.2	55.0	54.0	52.9
165	64.4	63.7	62.8	62.2	61.3	60.5	59.2	58.0	57.0	55.8	54.7	53.6	52.6
180	62.7	62.1	61.2	60.5	59.7	59.1	58.6	57.6	56.6	55.5	54.4	53.3	52.3
195	61.1	60.5	59.6	58.8	58.2	57.4	56.8	56.3	55.5	54.9	54.0	53.0	51.9
210	59.9	59.0	58.1	57.3	56.5	55.8	55.2	54.5	54.0	53.5	52.8	52.4	51.6
225	58.5	57.5	56.5	55.7	55.2	54.5	53.7	53.0	52.4	51.9	51.2	50.8	50.2
240	56.8	55.9	55.2	54.2	53.5	52.8	52.1	51.6	51.0	50.4	49.7	49.1	48.7

Coal strength, psi 803 **Mining width, ft** 11.50 **No. web pillars** 19

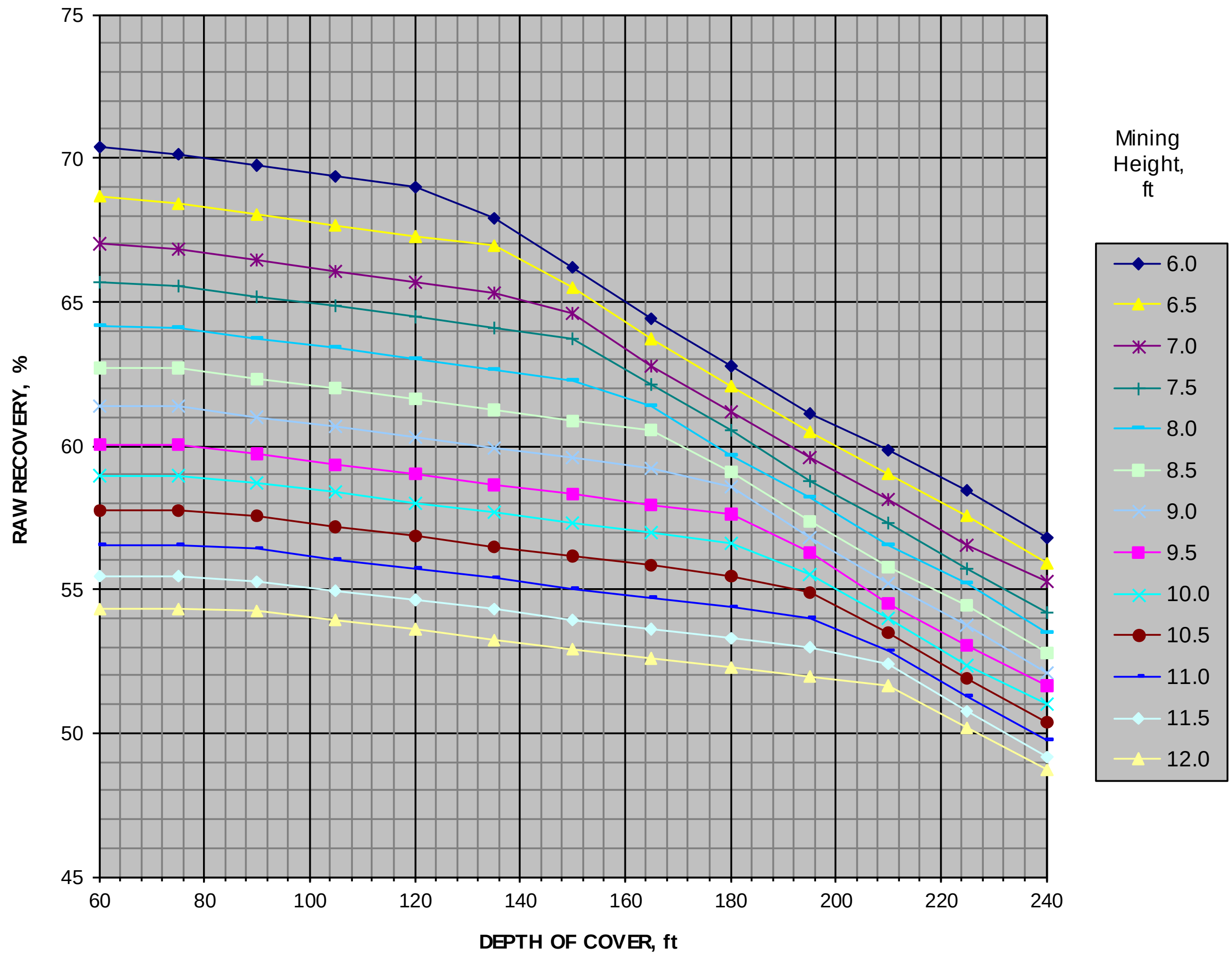


Figure D-2c. L Pit, K Seam Recovery Chart

Design Depth of Cover, ft	Mining Height, ft												
	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
120	*58*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
135	*58*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
150	*59*	*63*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
165	63	*65*	*68*	*72*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
180	67	69	71	*74*	*77*	*82*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
195	71	74	76	78	80	*83*	*87*	*92*	*96*	*101*	*106*	*111*	*116*
210	76	78	81	83	85	88	90	*92*	*96*	*101*	*106*	*111*	*116*
225	80	83	86	88	91	93	96	98	100	102	*106*	*111*	*116*
240	85	88	91	94	97	99	102	104	106	109	111	113	*116*
255	91	93	96	99	102	105	108	111	113	116	118	120	123
270	97	99	102	105	108	111	114	117	120	122	125	128	130
285	102	106	109	111	114	117	120	123	126	129	132	135	138
300	106	110	115	118	121	124	127	130	133	136	139	142	145

Coal strength, psi 891 **Mining width, ft** 11.50 **No. web pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8

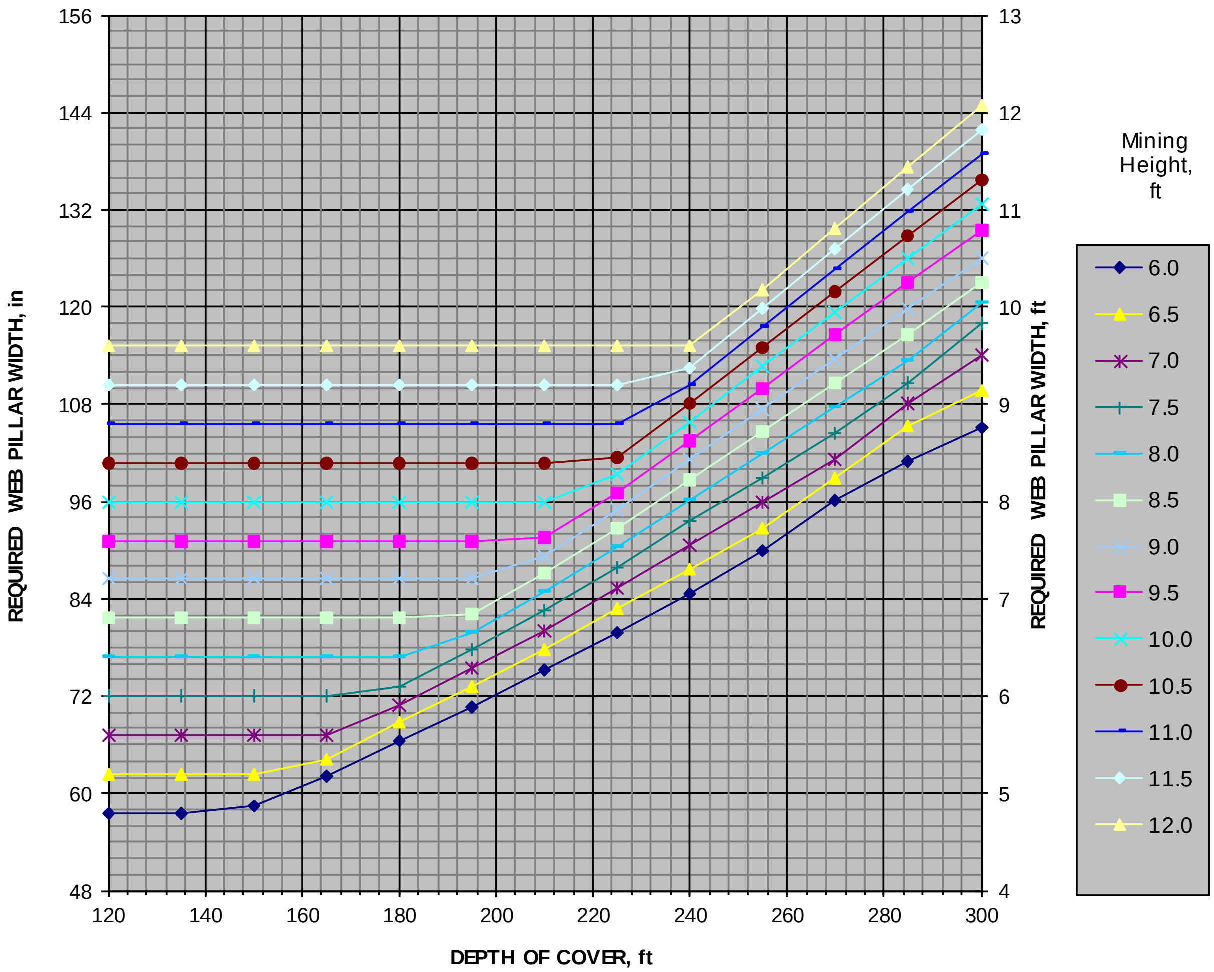


Figure D-3a. L Pit, Q Seam Web Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
120	10.8	11.1	11.5	11.8	12.1	12.5	12.8	13.0	13.3	13.6	13.8	14.1	14.3
135	12.5	12.9	13.4	13.8	14.2	14.5	14.9	15.2	15.6	15.9	16.2	16.5	16.8
150	14.4	14.8	15.3	15.7	16.2	16.6	17.1	17.5	17.9	18.3	18.6	19.0	19.4
165	16.4	17.1	17.2	17.7	18.2	18.7	19.2	19.7	20.2	20.6	21.1	21.5	21.9
180	18.0	18.8	19.5	20.0	20.3	20.9	21.4	22.0	22.5	23.0	23.5	24.0	24.5
195	19.6	20.4	21.2	21.9	22.6	23.2	23.6	24.2	24.8	25.4	26.0	26.5	27.1
210	21.2	22.1	22.9	23.7	24.5	25.3	26.0	26.6	27.2	27.8	28.5	29.1	29.7
225	23.0	23.9	24.8	25.7	26.5	27.3	28.1	28.8	29.6	30.3	30.9	31.6	32.3
240	24.0	25.8	26.7	27.7	28.6	29.4	30.3	31.1	31.9	32.7	33.4	34.2	34.9
255	24.2	26.0	28.0	29.7	30.6	31.6	32.5	33.4	34.3	35.1	35.9	36.7	37.5
270	24.6	26.4	28.1	30.0	32.0	33.7	34.7	35.7	36.6	37.5	38.4	39.3	40.1
285	25.7	26.8	28.5	30.2	32.0	34.0	36.0	38.0	39.0	40.0	40.9	41.9	42.8
300	27.1	28.3	29.4	30.7	32.5	34.2	36.0	38.0	40.0	42.0	43.4	44.4	45.4

Coal strength, psi 891 **Mining width, ft** 11.50 **No. web pillars** 19

Pillar widths in italics have width-to-height ratios of 0.8

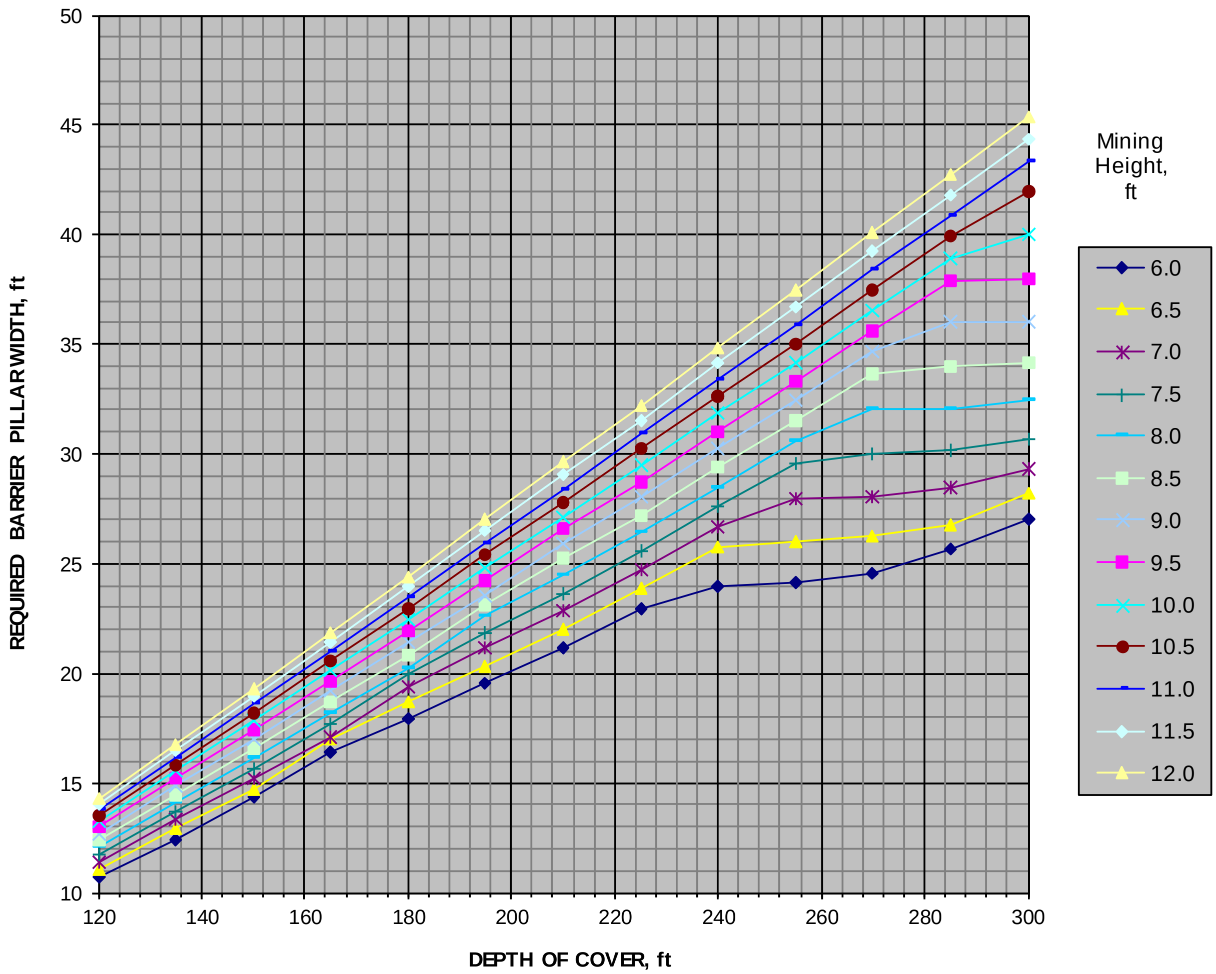


Figure D-3b. L Pit, Q Seam Barrier Pillar Design Chart

Design Depth of Cover, ft	Mining Height, ft												
	6	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**
120	69.1	67.5	65.9	64.6	63.2	61.8	60.4	59.2	58.2	57.0	55.9	54.8	53.7
135	68.8	67.1	65.5	64.3	62.8	61.4	60.1	58.8	57.8	56.7	55.6	54.5	53.4
150	68.1	66.8	65.2	63.9	62.5	61.1	59.8	58.5	57.5	56.3	55.2	54.1	53.1
165	66.4	65.7	64.8	63.6	62.1	60.8	59.4	58.2	57.2	56.0	54.9	53.8	52.8
180	65.0	64.2	63.6	62.6	61.8	60.4	59.1	57.8	56.9	55.7	54.6	53.5	52.5
195	63.5	62.6	61.9	61.3	60.6	59.8	58.8	57.5	56.5	55.4	54.3	53.2	52.2
210	61.9	61.2	60.3	59.7	59.1	58.3	57.7	57.2	56.2	55.1	53.9	52.9	51.9
225	60.6	59.7	58.8	58.2	57.4	56.9	56.1	55.6	55.0	54.5	53.6	52.6	51.6
240	59.2	58.2	57.4	56.6	55.8	55.3	54.5	54.0	53.5	52.8	52.4	51.9	51.3
255	57.7	57.0	56.1	55.2	54.5	53.8	53.1	52.4	51.9	51.3	50.8	50.4	49.8
270	56.3	55.7	54.8	54.0	53.1	52.3	51.7	51.0	50.4	49.9	49.3	48.7	48.3
285	55.1	54.2	53.4	52.8	52.0	51.2	50.4	49.7	49.1	48.5	47.9	47.4	46.8
300	54.1	53.2	52.1	51.4	50.7	49.9	49.2	48.5	47.9	47.2	46.6	46.1	45.5

Coal strength, psi 891 **Mining width, ft** 11.50 **No. web pillars** 19

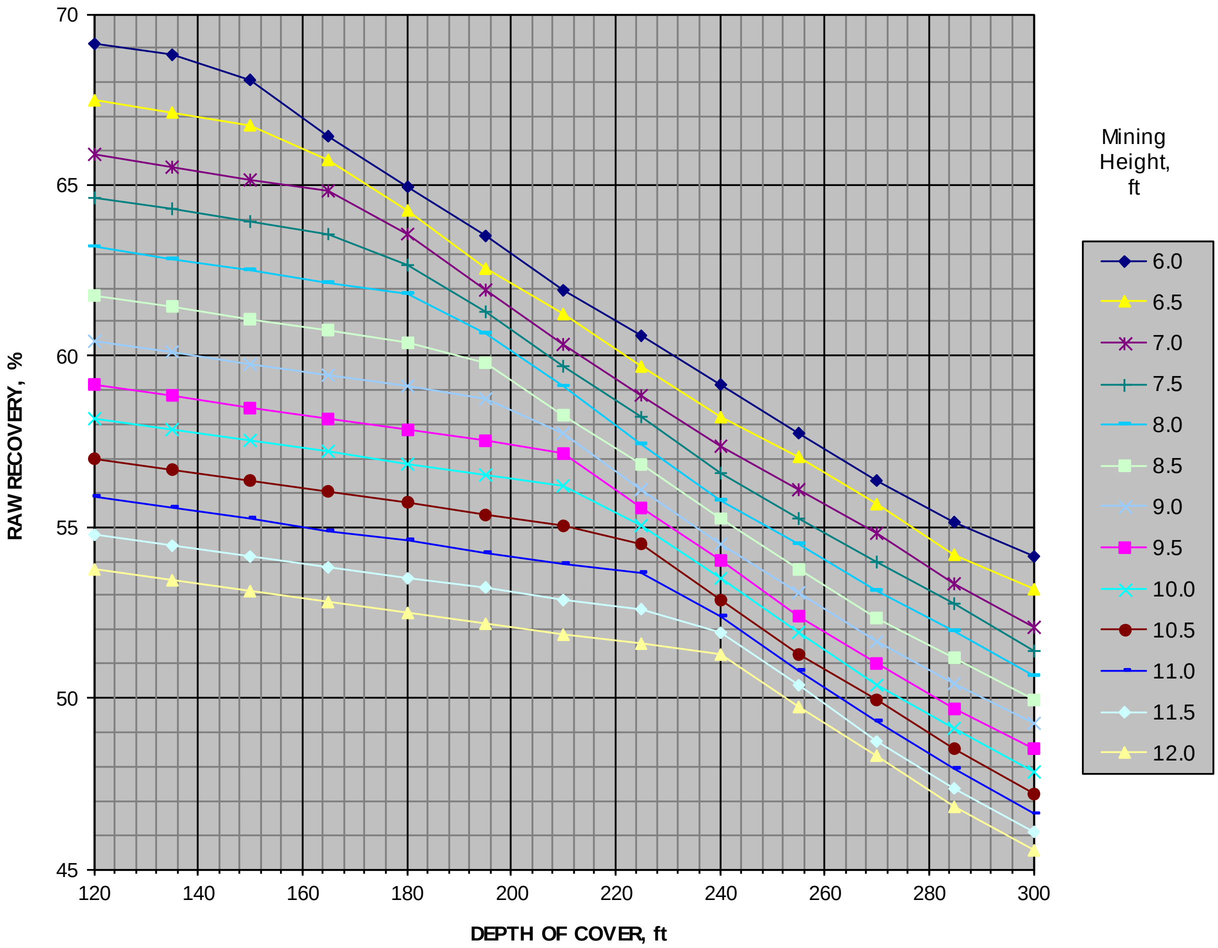


Figure D-3c. L Pit, Q Seam Recovery Chart