Comprehensive Pressure Quantity Survey for Investigating the Effects of Booster Fans in a Trona Mine

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Outline:

1. Introduction
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4. Ventilation Model (Heat Simulation)
5. Present Ventilation Model Improvements (15 scenarios)
6. Future Model (2013, 2018)
7. Conclusion
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Introduction

- The ventilation survey was conducted in an underground longwall Trona mine. The mine is relatively shallow and categorized as a gassy mine.
- Annual Production 4.5 MT.
- Three surface based axial fans ventilate the mine.
- Two Development panels (Bore Miner 4.8m by 2.4m) and a Longwall (LW).

Problem statement

Minimum Air requirement:

1. Two active development (25 m^3/s* 2); 50 m^3/s
2. LW; 50 m^3/s

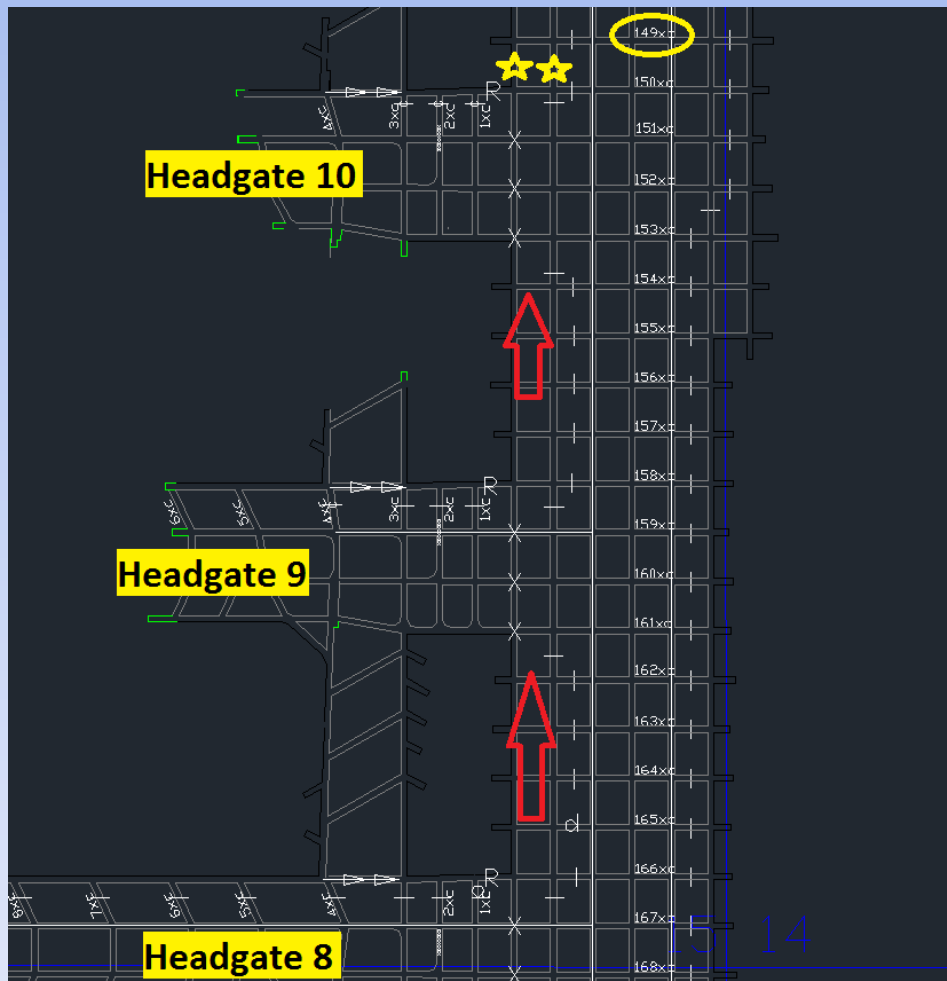
Total Air : 100 m^3/s

- PQ results show that was also determined that the 6 shaft is exhausting at maximum capacity (Stoppings 65 xc).

Problem Statement Cont'

Optimal solution: Cheapest way to increase/create the differential pressure upstream of bore miner sections

- The air total pressure (TP) drops by the time it reaches to the development panels.
- At this point, the air gets drawn towards 9 shaft due to less resistance and distance comparing to 6 shaft.
- Regulating the 9 shaft might NOT be an option since it reduces the total airflow



Ventilation Survey

- 85 ventilation Stations.
- Survey included:

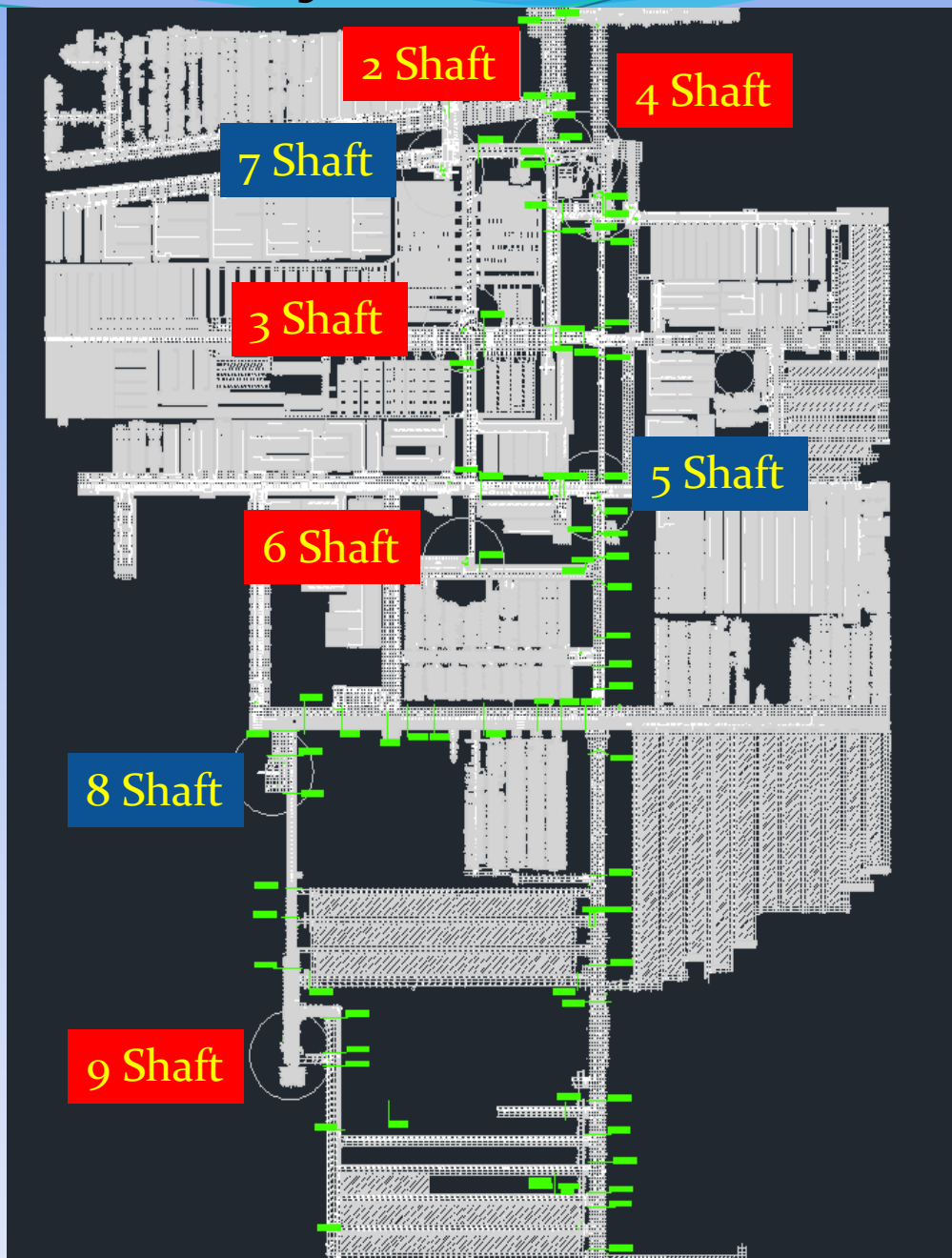
i. Absolute Pressure

ii. Temperature

iii. Velocity Readings

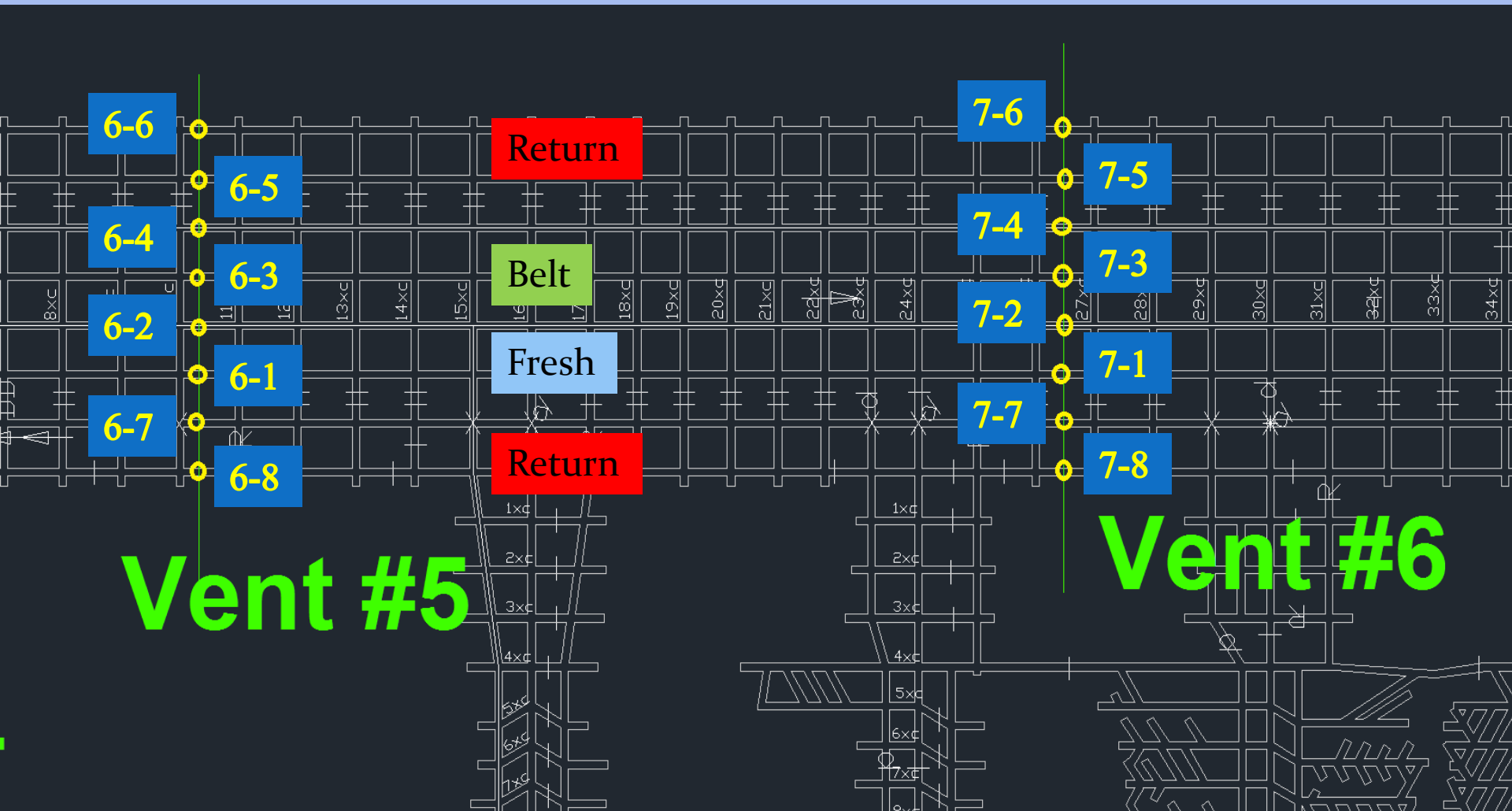
iv. Area (dimensions)

v. Other characteristics



Ventilation Survey Cont'

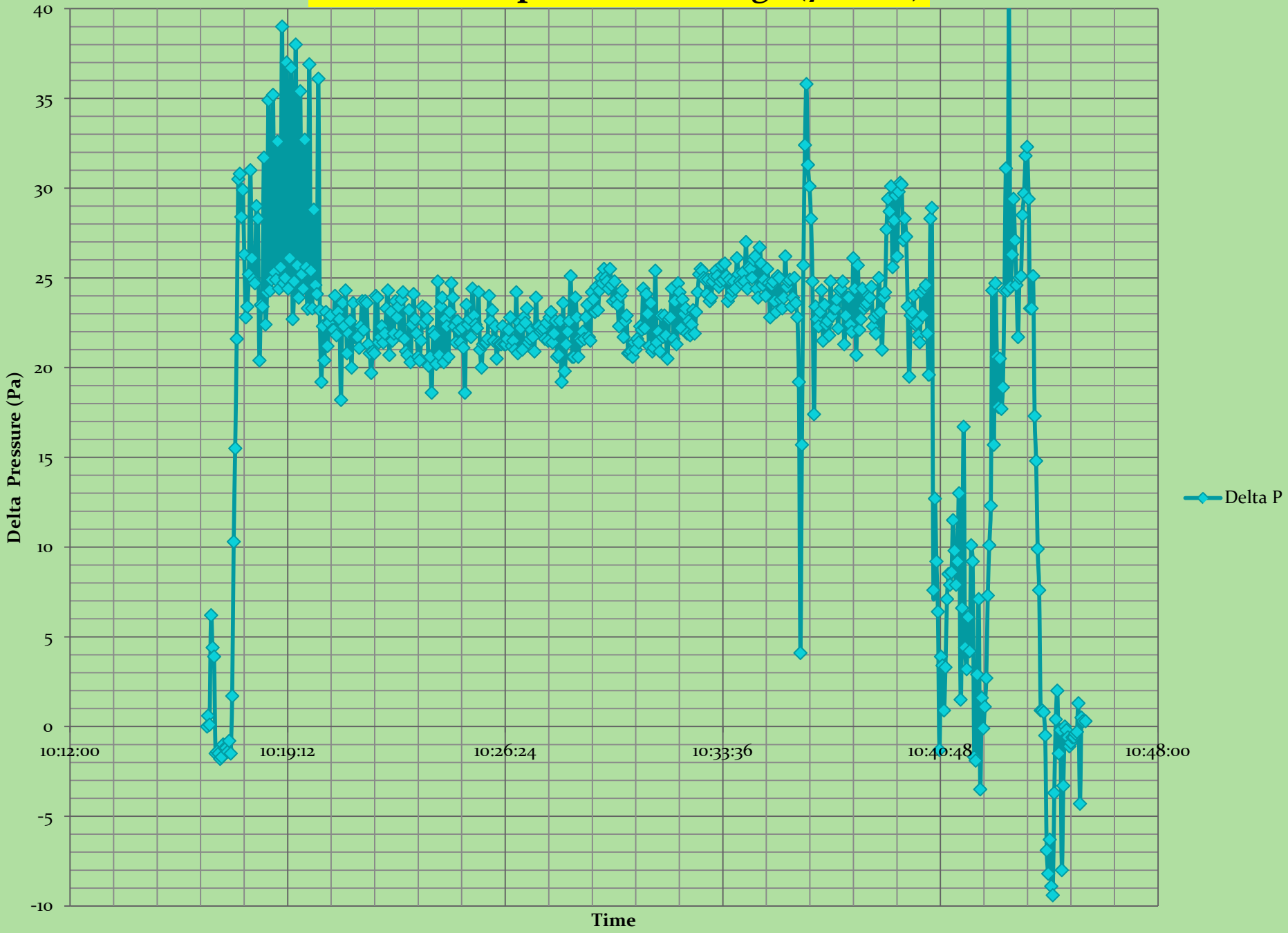
Leapfrogging method: Both instruments are taken underground and read simultaneously at adjacent stations with the aid of synchronized watches.



Instrumetns:

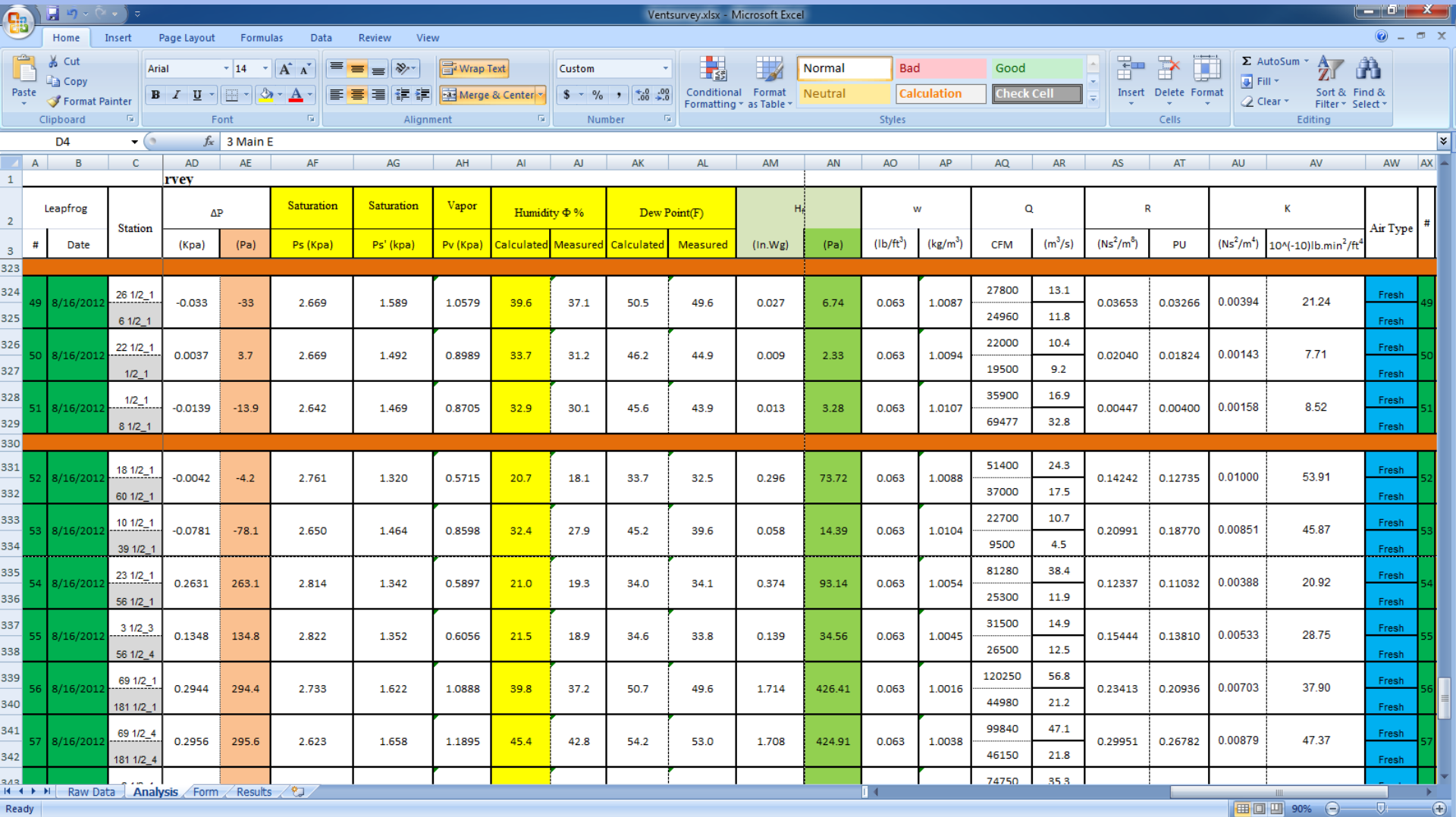
Unit	Model	Specification
Pressure Transducer	Paroscientific 765-16B	Resolution ..... 0.0001% (<1 microbar) Accuracy ..... ±0.08 hPa or better Stability .....0.1 hPa /year or better Range ..... 500-1100 hPa (14.7-32.5 in Hg)
Digital Psychrometer	SAM 9900DW	Temperature Range: -4 to +122°F (-20 to +50°C)
		Temperature Accuracy: ±1.8°F (±1°C)
		RH Range: 0 to 100% RH
		RH Accuracy: ±3% RH at +77°F within 10 to 90% RH ±4% RH at all other ranges
		Resolution: +1°F/C, 1% RH
		Response Time: Approximately 60 seconds

Pressure Drop Across the Cage (7 Shaft)



P-Q Survey Analysis Results

	K Value (10^(-10)lb.min^2/ft^4)	K Value (Ns^2/m^4)
Airways	65	0.01221



Ventsim Visual Model

- The model has been built based on the mine existed AutoCAD model.

- The model consists of 26,725 airways with the total length of 586 miles.

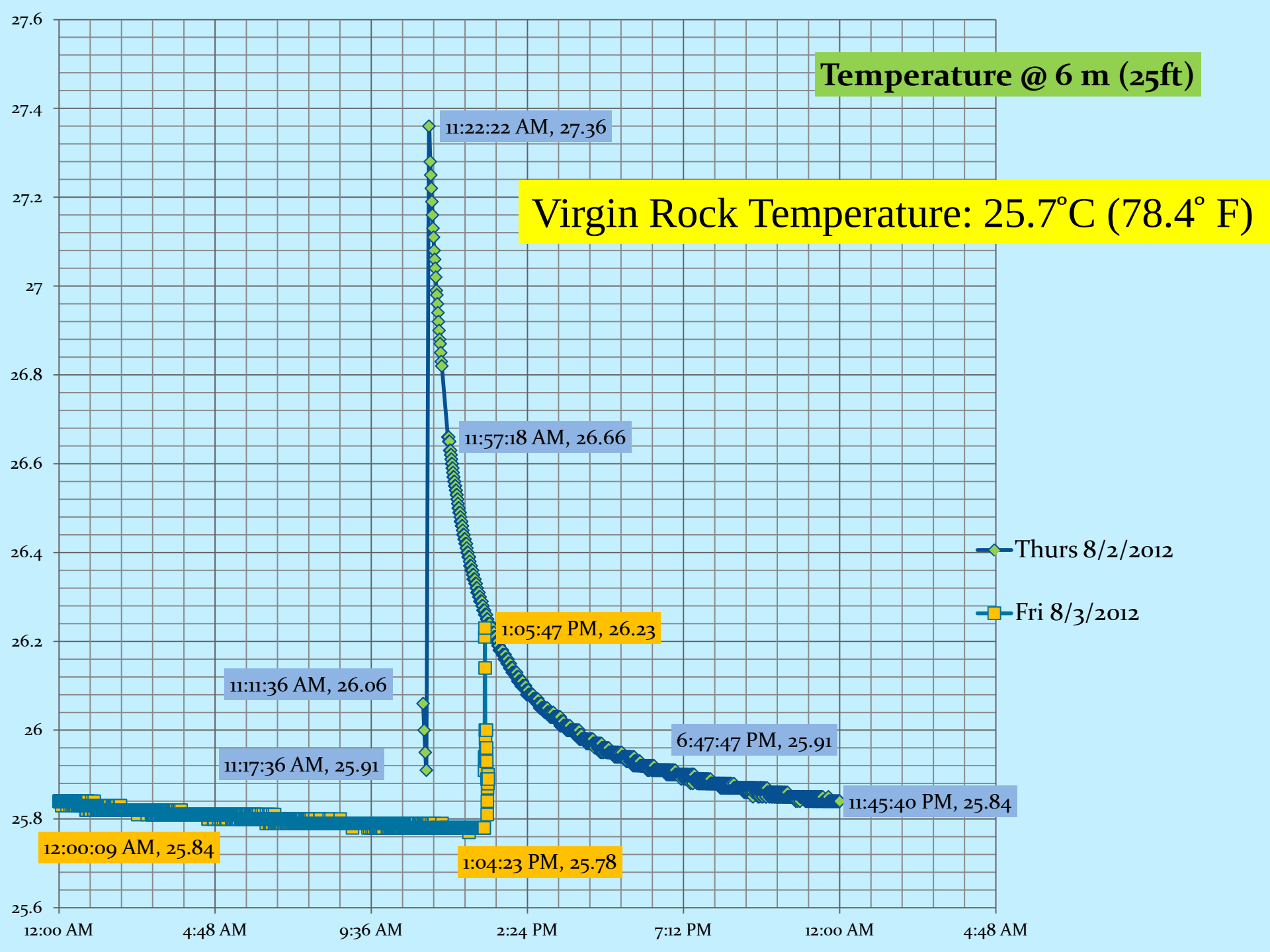
- The Ventsim results were in 8% accuracy of the weekly air readings.

Heat Sources

#	Pump Station	Power (hp)	Heat (Btu/min)	Kilocalories/hr	Kilojoules/hr
1	5 Shaft	1200	53,569	769,423	3,219,266
2	578	100	4,464	64,118	268,270
3	349	700	31,248	448,830	1,877,905
4	Bypass	350	15,624	224,415	938,952
5	3 NE	350	15,624	224,415	938,952
6	2 NW	150	6,696	96,177	402,405
7	7 S				0,678
8	3 S				73,087
9	3				5,339
10	8 Shaft	100	4,464	64,118	268,270
11	473	100	4,464	64,118	268,270
12	LW 4 Panel	40	1,786	25,647	107,307
13	LW pump	100	4,464	64,118	268,270
14	Fresh Water 3 ME	100	4,464	64,118	268,270
15	1 NE	30	1,339	19,235	80,479
	Total	4095	182,811	2,625,658	10,985,753

5 Shaft :

Warm up 767,870 Liters (202,859 gal) of water by 1° C (1.5°F).


Temperature @ 6 m (25ft)
Virgin Rock Temperature: 25.7°C (78.4° F)
11:22:22 AM, 27.36
11:57:18 AM, 26.66
1:05:47 PM, 26.23
11:11:36 AM, 26.06
6:47:47 PM, 25.91
11:17:36 AM, 25.91
11:45:40 PM, 25.84
12:00:09 AM, 25.84
1:04:23 PM, 25.78
Thurs 8/2/2012
Fri 8/3/2012
27.6
27.4
27.2
27
26.8
26.6
26.4
26.2
26
25.8
25.6
12:00 AM
4:48 AM
9:36 AM
2:24 PM
7:12 PM
12:00 AM
4:48 AM

Natural Ventilation Pressure

All Fans Off

Input Surface temp: 5.5ºC (42˚ F)

Shaft	Ventsim Visual Simulation Results		Experimental Results
	Air Direction	Quantity (kcfm)	
1 Shaft	Down cast	4	Down cast
2 Shaft	Down cast	11.8	Down cast
3 Shaft	Down cast	12.3	Down cast
4 Shaft	Down cast	45	Down cast
5 Shaft	Up cast	42	Up cast
6 Shaft	Down cast	32.8	Down cast
7 Shaft	Up cast	38.7	Up cast
8 Shaft	Up cast	45.5	Up cast
9 Shaft	Down cast	8	Down cast

Scenario 1, 5 Shaft Fan Off

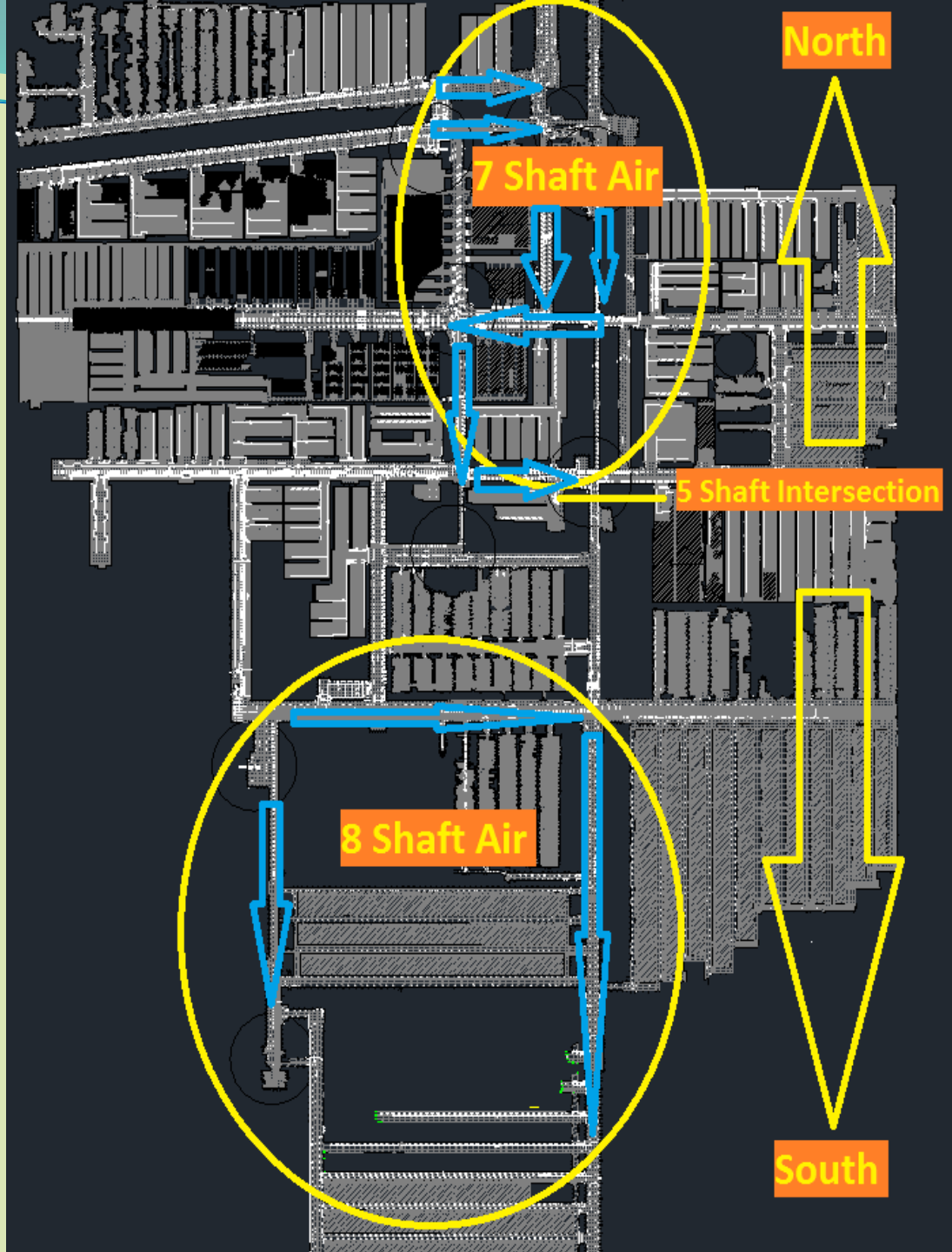
- Ventilate the entire mine using 7 and 8 shaft surface fans.

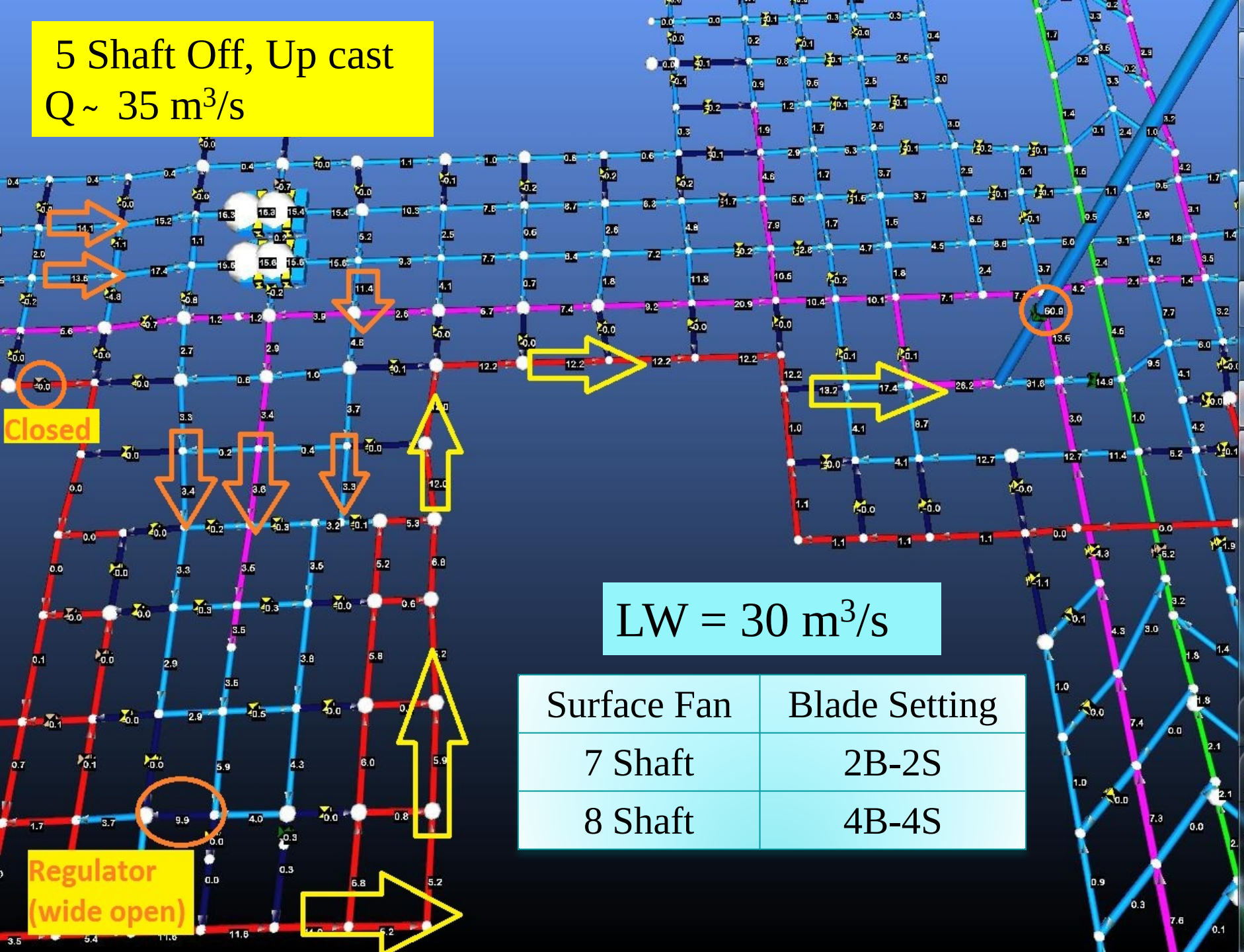
- The mine has been divided in two regions:

1. 7 shaft will ventilate all pump station north of 2 Main East (including 3 Shaft, 5 shaft and By Pass pump stations).
2. 8 shaft will be used to ventilate the south (LW and Panels).

Ventilation Changes:

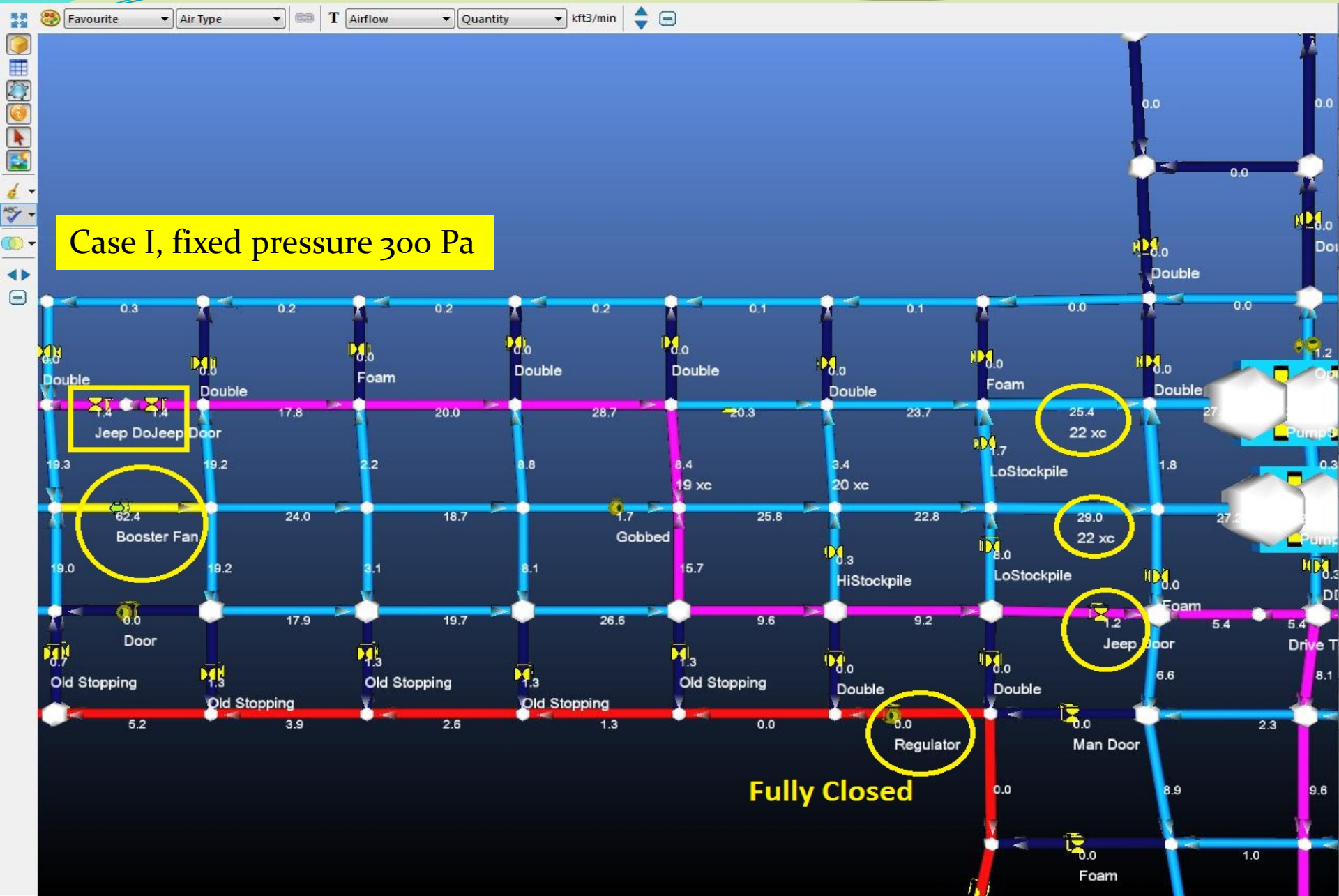
1. Install one set of airlock doors south of 5 shaft.
2. Close the regulator at 3 Shaft pump station regulator.
3. *Jeep door may be installed prior to the 5 shaft pump station.*
4. *5 Shaft will act as an exhaust shaft.*



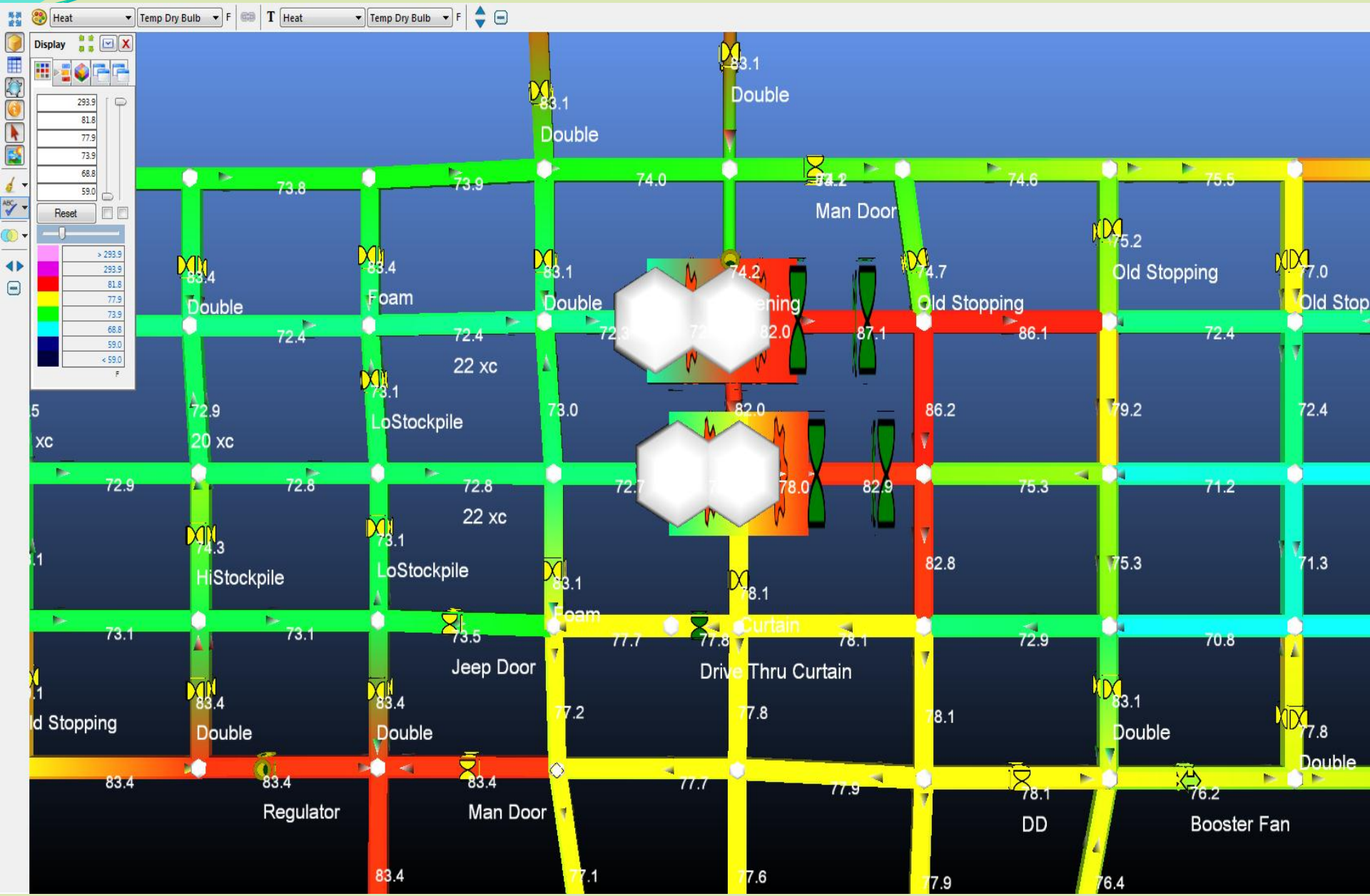


Surface Fan	Blade Setting
7 Shaft	2B-2S
8 Shaft	4B-4S

Scenario 1, 5 Shaft Fan Off, Booster



Scenario 1, 5 Shaft Fan Off, Booster



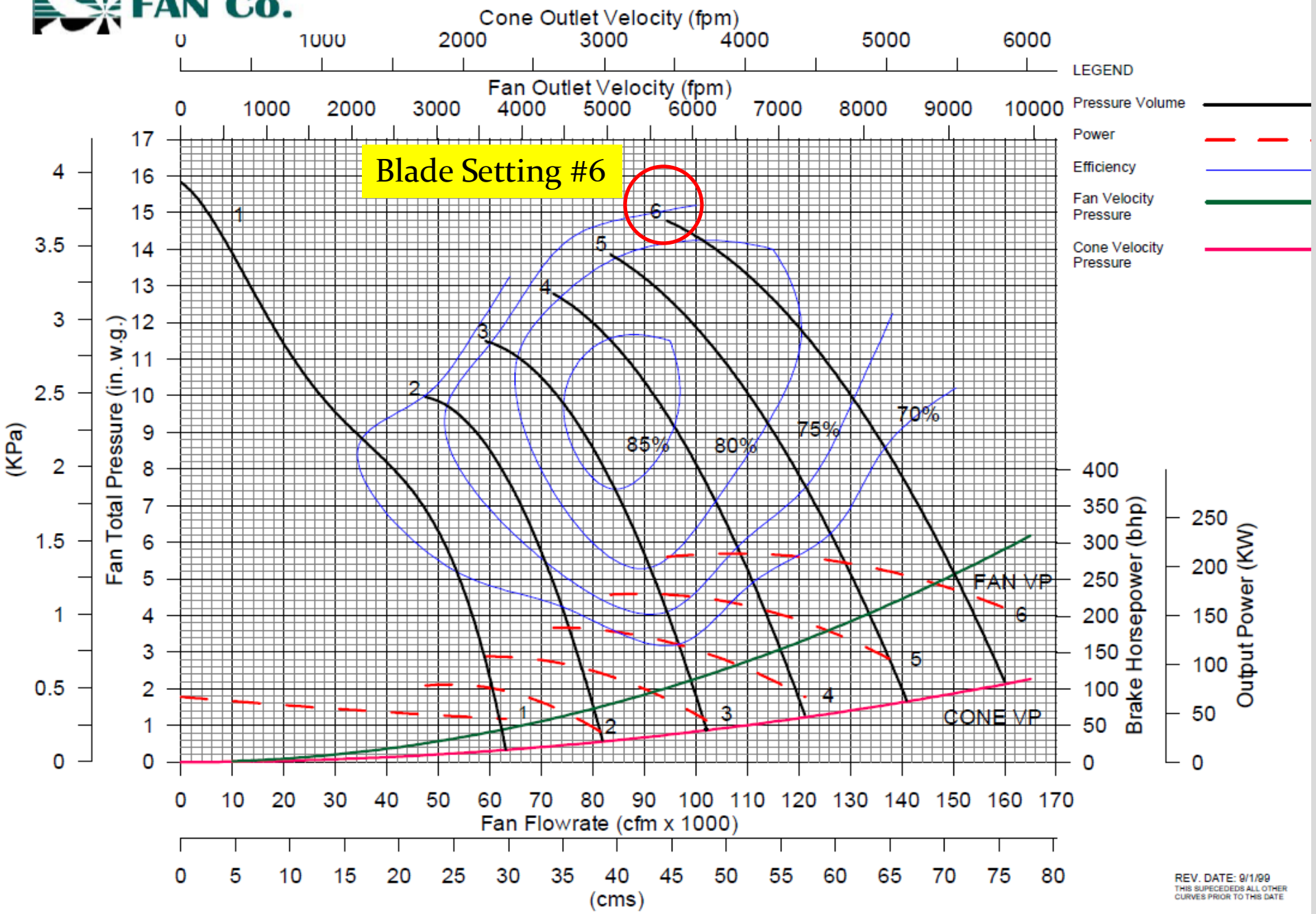
Scenario 2, Use Main Shop Air

Location	Present Model Q (m^3/s)	Scenario 2 Q (m^3/s)
Fresh Air, 592 S, 133 xc	96.7	101.7
10 HG	6.5	7.1
9 HG	2.4	2.8
8 HG	11.0	13.7
Set-up Room (Regulator)	9.9	9.6
LW	42.1	41.5
9 Shaft	94.6	98.1

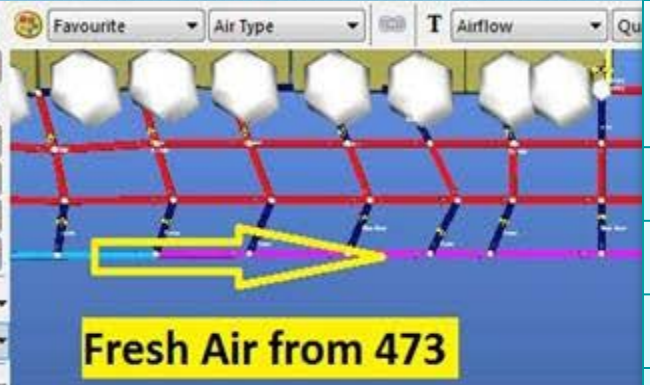
SPENDRUP FAN Co.

Series 140-80-1760

Fan Diameter 55.125 inches
Air Density 0.075 lbs./cu. ft.

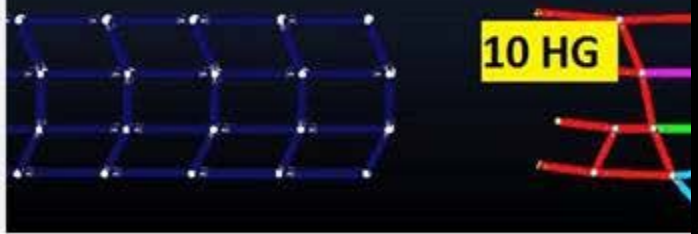


REV. DATE: 9/1/99
THIS SUPECEDEDS ALL OTHER CURVES PRIOR TO THIS DATE

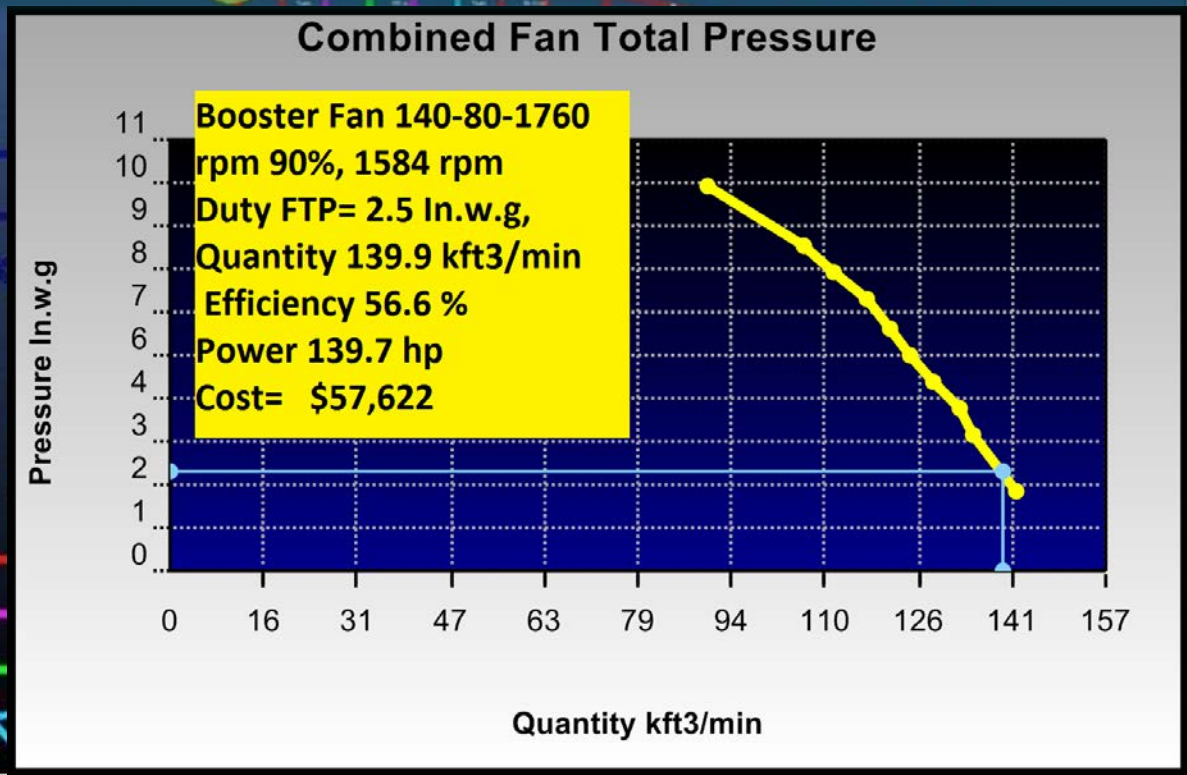


Bores to 4 & 6 Shaft
LW to 9 Shaft

5 Shaft lower blade
Saving: $30,000



Location	Present Model Q (m^3/s)	Scenario Q (m^3/s)
Fresh Air, 592 S, 133 xc	96.7	119.4
10 HG	6.5	↑ 26.5
9 HG	2.4	↑ 8.5
8 HG	11.0	↑ 24.0
Set-up Room (Regulator)	9.9	↑ 9.0
LW	42.1	↑ 40
9 Shaft	94.6	93.8



Scenario 4, Changing Blade Setting or RPM

- Currently 8 and 5 fans are on 4B-4S and 7 fan on 2B-2S blade setting. All the fans are operating at 100% rpm (710 rpm).

Fan	Blade Setting	Static Pressure(kPa)	Quantity (m^3/s)
8 Shaft	4B – 4S	1.7	206.2
5 Shaft	4B – 4S	1.7	210.8
7 Shaft	2B – 2S	1.8	166.0
Total			583.0

Scenario 4, All fans Set to 85% rpm

- The PQ results show that 5 and 8 shaft fans are fighting to overcome the pressure.

Followings are the advantages of installing VFD on surface fans.

i. Adjusting the frequency to reduce the operating cost (lowering down the speed in off shift/maintenance).
ii. Increases the safety by being more flexible in case of emergency. For example increase the 8 shaft speed to ventilate the 5 shaft pump station in case of losing 5 shaft fan.
iii. Capable of over speeding the motors.
iv. Set the blades on high setting and slow it down to reduce the operating cost. In this case the fan is capable of pushing more air by increasing the frequency at any time.

Scenario 4, All fans Set to 85% rpm

Fan	rpm		Static Pressure (kPa)		Quantity (m^3/s)	
	Present	rpm	Present	Predicted	Present	Predicted
8 Shaft	710	600	1.7	1.2	206.2	186.0
5 Shaft	710	600	1.7	1.3	210.8	177.7
7 Shaft	710	600	1.8	1.4	166.0	139.6
Total					583.0	502

40% Operating Cost Reduction

Location	Present Model Q (m^3/s)	Scenario 4 Q (m^3/s)
Fresh Air, 592 S, 133 xc	109	96
10 HG	10	8
9 HG	9	7
8 HG	15	13
Set-up Room (Regulator)	20	17
LW	41	35
9 Shaft	92	76

Scenario 6, Sinking a Vent Raise

- The vent raise has been sunk in southern part of the mine (helps 4&6 Shafts).

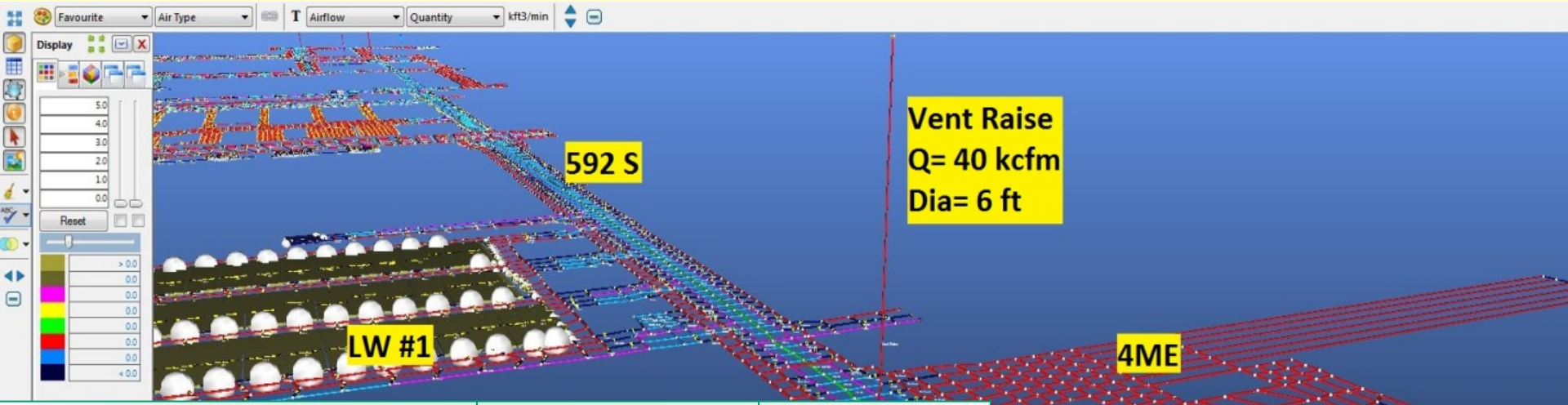
- Current Blade settings.

- Mining Cost: $600/m, fully reinforced concrete. Total: $3,000,000

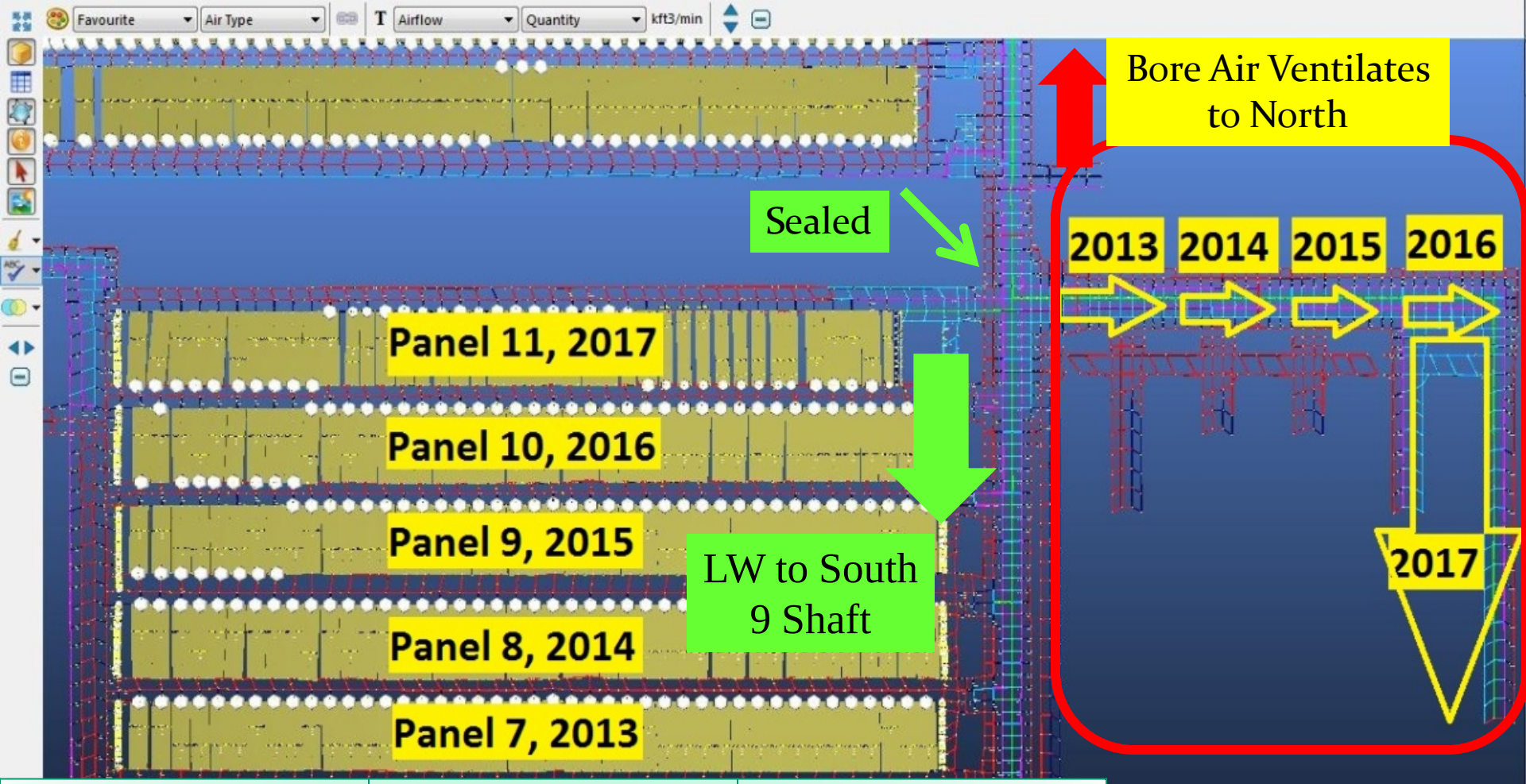
- Optimized Size: 2m in dia, Δp=600 Pa, Q= 30 m^3/s

Scenario 6, Sinking a Vent Raise

The 5 Shaft blades setting can be lower to 2B – 2S to reduce the operating cost.



Location	Present Model Q (m^3/s)	Scenario 6 Q (m^3/s)
Fresh Air, 592 S, 133 xc	108.9	118.0
10 HG	3.5	✓ 3.7
9 HG	3.3	✓ 20.8
8 HG	23.5	✓ 20.9
Set-up Room	11.3	11.8
LW	43.9	✓ 42.1
Total Panel Return (149 xc)	30.7	47.7
Vent Raise	-----	17.9



Location	Present Model Q (kcfm)	Future Plan 2017
Fresh Air, 592 S, 133 xc	108.9	108.6
Active Bore Miner #1	7.6	20.4
Active Bore Miner #2	23.5	21.8
Set-up Room	11.3	-----
LW	43.9	49.7
Total Panel Return to North	30.7	44.7

Conclusion and Recommendations

Quick Changes:

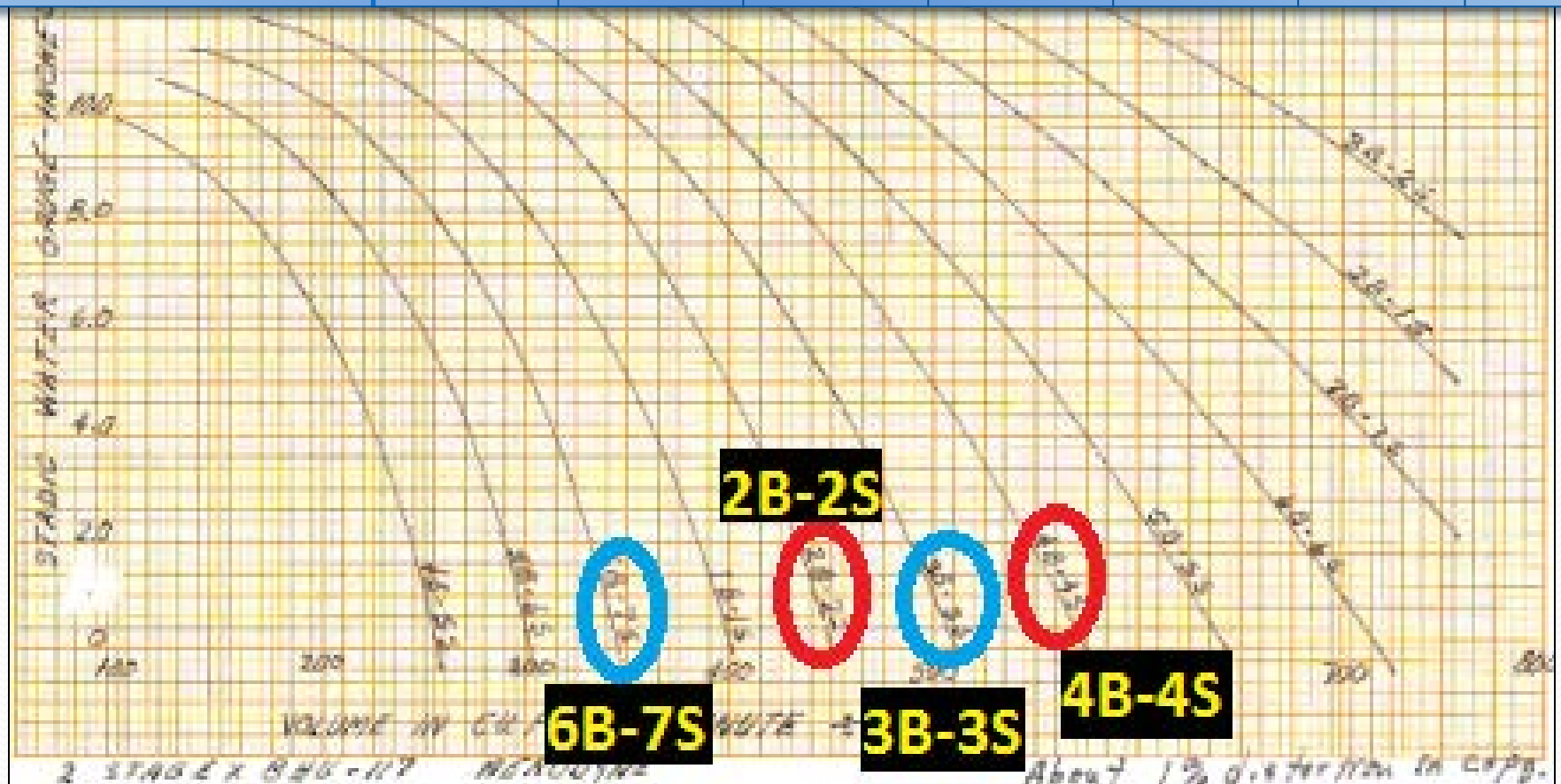
- Lower 8 and 7 Shafts Blade Setting. Savings: $60,000/yr, similar Q.
- Shop Air, 10 more m^3/s.

Long Term:

- VFDs (more studies).
- Booster Fan in the Return (Needs Approval).

• Lower 8 and 7 Shafts Blade Setting

SH	Blade Setting		Airflow(m^3/s)		Vibration(m/s)		Pressure (kPa)		Amp
	Previous	Current	Previous	Current	Previous	Current	Previous	Current	
8	4B-4S	3B-3S	209	184	0.06	0.04	1.7	1.5	12
5	4B-4S	4B-4S	202	204	0.06	0.06	1.7	1.7	3
7	2B-2S	6B-7S	160	125	0.08	0.05	1.6	1.3	24
Total			571	513					39



Future Work

- Rerouting SHOP air back to the fresh air.
- VFDs (Long Term)

Acknowledgments:

- FMC Engineering Department, Rich Kramer
- Stewart Gillies
- NIOSH