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VENTILATION ANALYSIS OF THE REVENUE LEVEL DRIFT AT THE VIRGINIUS MINE

Prepared for

TETRA TECH, INC.

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Prepared by

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DISCLAIMER: *Agapito Associates, Inc. (AAI) has applied its professional knowledge and judgment in conducting this ventilation analysis. AAI has relied on certain data provided by others and has not independently verified that data. AAI has prepared this report in accordance with generally accepted mining engineering principles and practices used for ventilation of underground mines. Opinions are based on subjective interpretations of ventilation data; other equally valid interpretations may exist. Identification and control of hazardous conditions are the responsibilities of the Owner.*

1.0 INTRODUCTION

Agapito Associates, Inc. (AAI) was contracted by Tetra Tech, Inc. (Tetra Tech) to propose suggestions for ventilation of Star Mine Operations, LLC's (Star Mine) currently inactive Virginius Mine located near Ouray, Colorado.

2.0 MINE VISIT AND DATA COLLECTION

On November 16, 2011, Philip Patton, P.E., AAI Associate, and Martin Chenoweth, P.E., Tetra Tech Senior Mining Engineer, visited the Revenue Level of the Virginius Mine, led by John R. Trujillo, Owner/President of Trujillo Development LLC, and accompanied by John Bettridge and Jim Williams, Southwestern Production Corp. (Southwestern).

An M40 multi-gas monitor was used to measure oxygen, methane, and carbon dioxide levels throughout the mine visit. All measurements were within normal atmospheric levels.

AAI's Philip Patton measured mine airway openings and air velocities using a hot wire anemometer and smoke tube. Ten air readings were taken, five along the Revenue Level Drift, two in the Yellow Rose Drift, and three at the bottom of the Monogahela Drift. Readings were taken at sites thought to be possible air vents to the surface.

Figure 1 shows locations of air readings taken and the quantities measured. Figure 2 is a detail of the Monogahela Drift area with air reading locations and quantities listed. Table 1 lists all airway dimensions and airway velocities and calculated air volumes. No measurable air movement was detected in the Yellow Rose Drift. The incline, described by Southwestern as a possible escapeway, located inby the air lock door, had no detectable air movement to the surface. No air movement in or out of the main Revenue Level Drift was detected, except at the Revenue Portal and the Monogahela Drift area. All readings along the Revenue Main Level were within the accuracy level (10%) of the measuring instruments. Air volumes on the west end of the Revenue Level (i.e., the Monogahela Drift area) varied considerably. The Monogahela Drift has been mined out to the surface and air flows in or out of the area depending on atmospheric conditions.

3.0 VENTILATION SYSTEMS AND MODEL

3.1 Natural Ventilation

Natural ventilation in an underground mine is commonly described as the "chimney effect." In the case of the Revenue Level Drift, the chimney is the Monogahela Drift. In the winter months, the warmer air in the Monogahela Drift is lighter than the column of air outside the Revenue Portal. In the winter, the heavier colder outside air column pushes air through the Revenue Portal, the Revenue Level and up into the Monogahela Drift. In the summer, the opposite is true and the air flows down out of the Monogahela Drift, through the Revenue Level, and out the Revenue Portal. Generally, the mine temperature is 47 degrees Fahrenheit (°F). Frequently, because outside temperatures are greater than 47°F during the day and less than 47°F

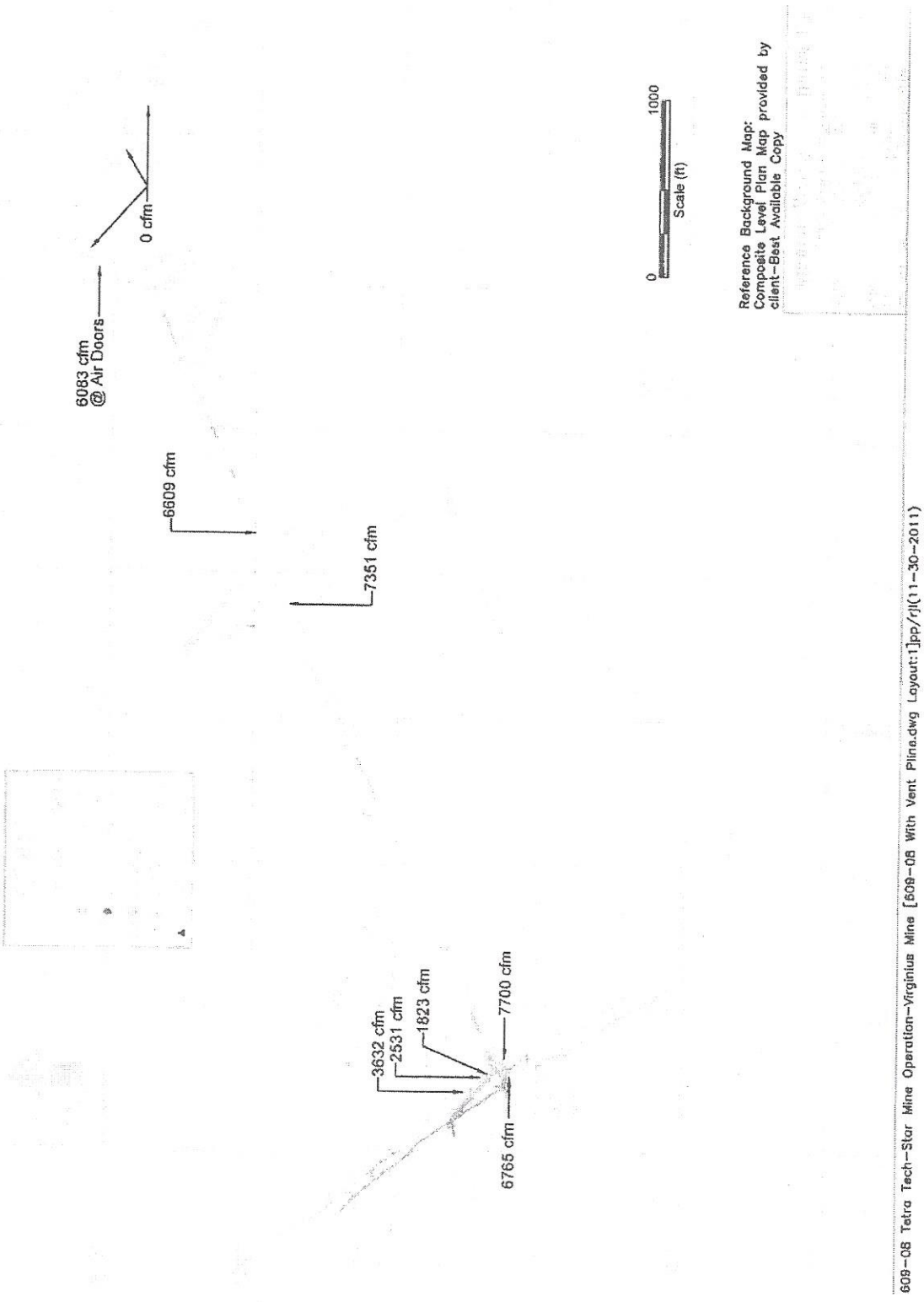


Figure 1. Revenue Level with Air Reading Locations and Quantities

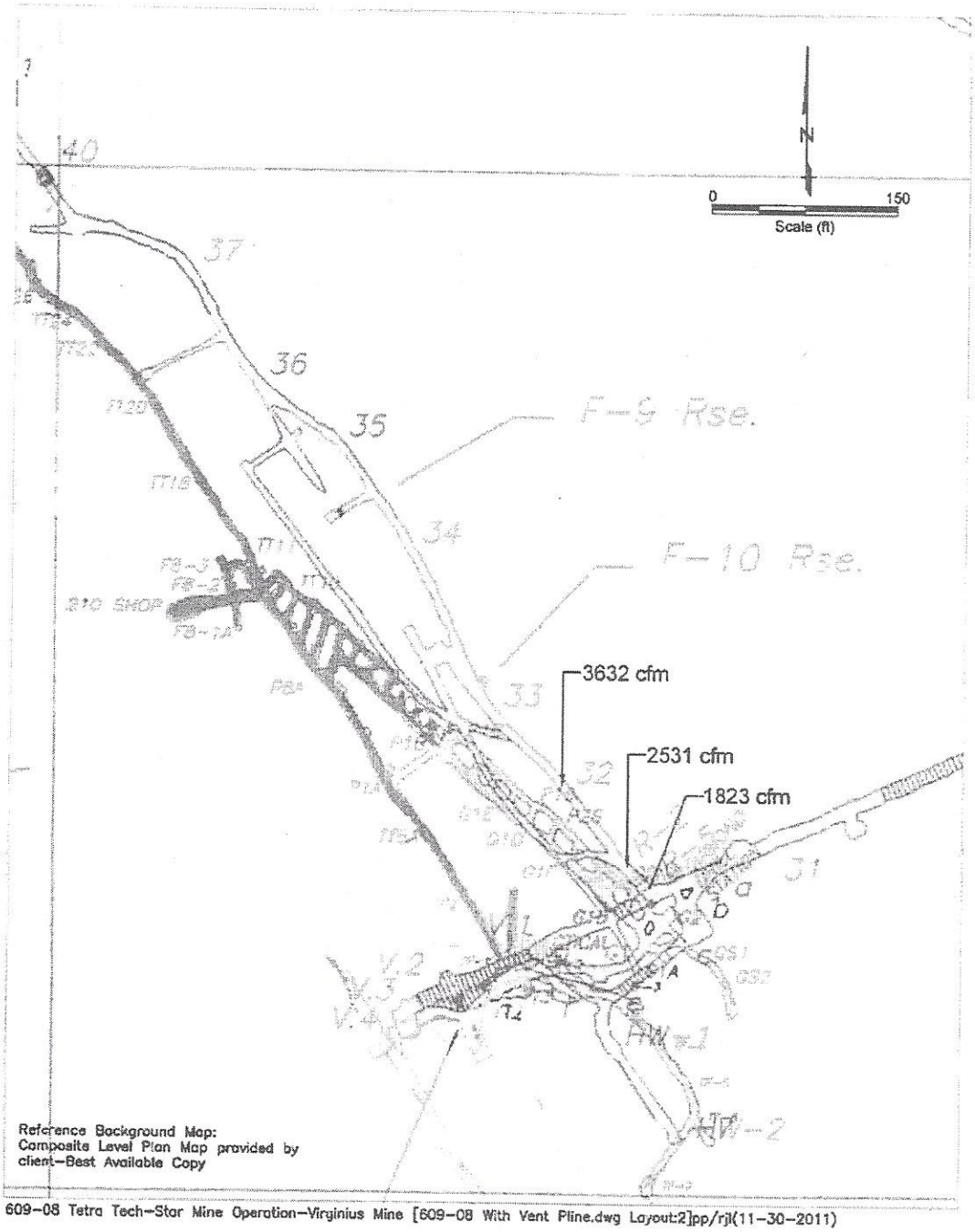


Figure 2. Detail of Monogahela Drift Area with Air Reading Locations and Quantities

Table 1. Revenue Level Ventilation Measurements and Calculations

Air Reading #	Height (ft)	Width (ft)	Area (ft^2)	Air Readings: Up Right (fpm)	Low Right (fpm)	Up Center (fpm)	Low Center (fpm)	Up Left (fpm)	Low Left (fpm)	Average (fpm)	Volume (ft^3/min)	Comments
1	9.0	9.0	81.0	45	0			45	0	23	1,823	Outby Monogahela Raise, looking inby
2	9.0	9.0	81.0	55	30			40	0	31	2,531	10-ft inby Monogahela Raise
3	8.0	8.0	64.0	45	52			65	65	57	3,632	
4	8.0	10.0	80.0	95	105			95	90	96	7,700	Toward Vica inby power supply pad
5	10.0	11.0	110.0	52	64			72	58	62	6,765	First right past rail
6	9.0	11.0	99.0	72	95			60	70	74	7,351	Inby Cumberland Drift
7	8.0	11.5	92.0	48	97	50	98	40	98	72	6,609	Inby ventilation raise
8	6.8	7.0	47.3	120	145			120	130	129	6,083	Outby ventilation raise in steel door frame outby vent
9	No velocity detected			0	0			0	0	0	0	Yellow Rose inby Wheel of Fortune
10				0	0			0	0	0	0	Yellow Rose outby Wheel of Fortune

during the night, air flow reverses on a 24-hour cycle. During this cycle, however, when surface and mine temperatures are similar, underground air flow is stagnant.

3.2 Ventilation Measurements and Calculations

Table 2 shows natural ventilation pressures and the fan pressures needed to counteract them. Table 2 lists calculations resulting from the two methods that require the least amount of data. The surface temperature variations, underground temperature and barometric pressures were estimated. Using the two methods, the highest calculated pressure was 0.7 inches water gauge (iwg). A 1.0 iwg was used in the ventilation model.

Table 2. Natural Ventilation Calculations

Elevation at Monogahila Drift at Surface (ft)	Elevation at Revenue Portal (ft)	Revenue Portal Temp (°F)	Monogahila Drift Surface Temp (°F)	Estimate of Barometer Pressure (inches mercury)	Distance at Monogahila Drift to Surface (ft)	Monogahila Drift Bottom Temp (°F)	Revenue Portal Temp (°F)	Method 4* Natural Ventilation Pressure (inches water)	Method 5* Natural Ventilation Pressure (inches water)	Direction of Airflow
11,900	10,500	-30	-34	19.575	1,400	47	-30	-1.3	-1.6	Into portal
11,900	10,500	-10	-11	19.575	1,400	47	-10	-0.9	-1.2	Into portal
11,900	10,500	0	-1	19.575	1,400	47	0	-0.7	-1.0	Into portal
11,900	10,500	10	9	19.575	1,400	47	10	-0.6	-0.8	Into portal
11,900	10,500	30	26	19.575	1,400	47	30	-0.2	-0.4	Into portal
11,900	10,500	47	41	19.575	1,400	47	47	0.0	0.0	
11,900	10,500	60	53	19.575	1,400	47	60	0.2	0.3	Out of portal
11,900	10,500	80	71	19.575	1,400	47	80	0.4	0.7	Out of portal

*This is based on Hartman (1997), p. 298. These methods do not take into account the moisture in the air

There are four fans currently at the Revenue Level of the Virginius Mine, manufactured by the Spendrup Fan Company (Spendrup) of Grand Junction, Colorado. Figure 3 is a fan curve graph for the fans currently installed at Revenue Level, supplied by Spendrup. Table 3 shows the same information with calculations made for the elevation at the Revenue Level.

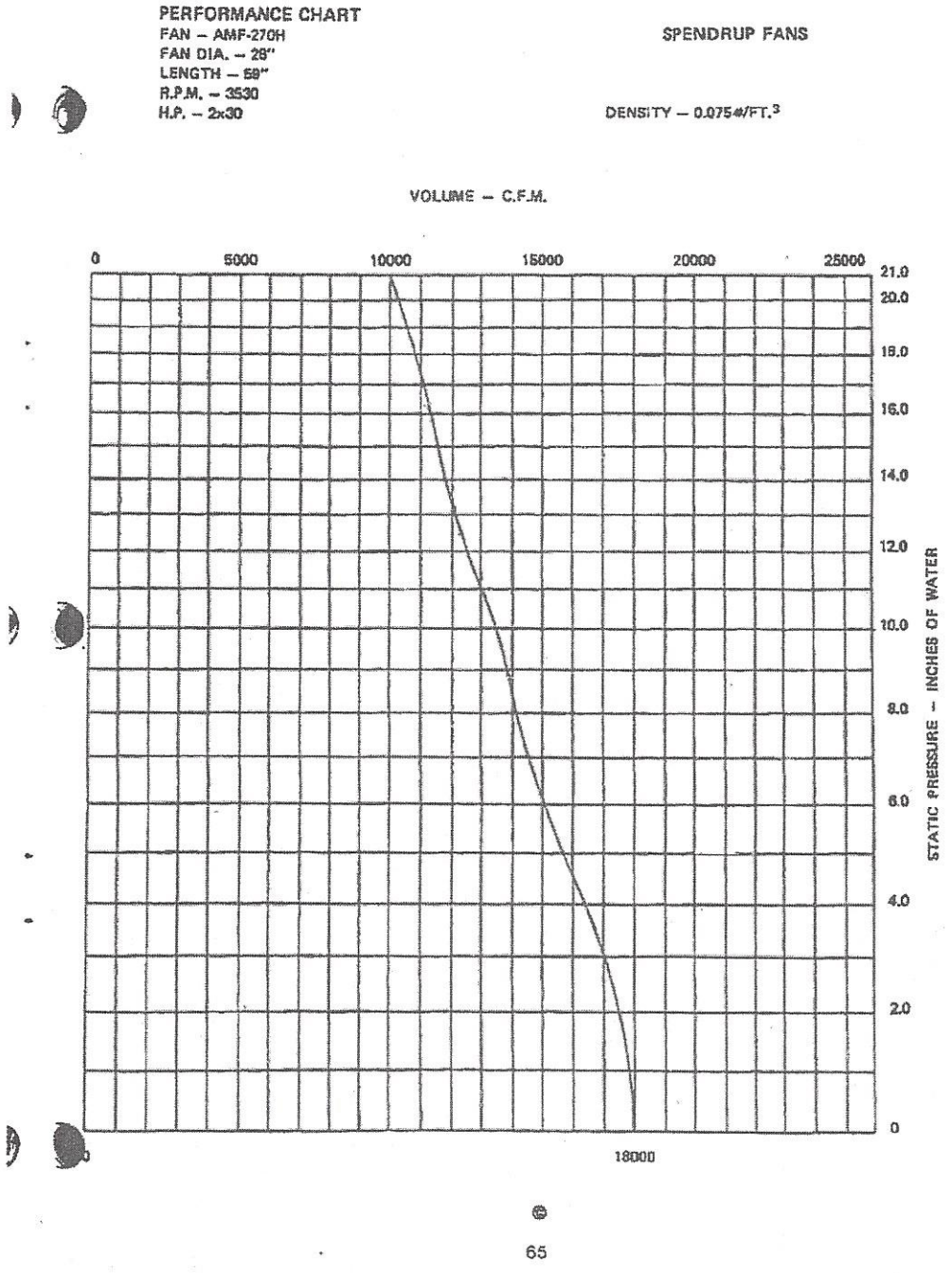


Figure 3. Revenue Level Spendrup Fan Performance Curve (provided by Spendrup)

Table 3. Performance Chart for Existing Fans at Revenue Level

0.075 lb/ft^3 Air Density at MSL		0.055 lb/ft^3 Air Density at 10,500-ft Elevation	
(cfm)	(iwg)	(cfm)	(iwg)
10,000	21.0	10,000	15.4
11,500	15.0	11,500	11.0
13,000	11.0	13,000	8.1
13,500	10.0	13,500	7.3
14,000	9.5	14,000	7.0
15,000	6.1	15,000	4.5
16,000	4.5	16,000	3.3
17,000	3.0	17,000	2.2
17,500	2.0	17,500	1.5
17,900	1.0	17,900	0.7
18,000	0.0	18,000	0.0

*Estimates for mean sea level performance provided by Spendrup Fan Company.

3.3 Ventilation Model

VentSim was used to model the existing and proposed ventilation systems of the Revenue Level and the Yellow Rose Drift.

The ventilation model was built using the mine map shown in Figure 1. The model was calibrated with the air readings measured on the November 16th mine visit. Assumptions were added to the model to simulate the proposed ventilation system. The assumptions were:

- Air direction would be in the same direction year round (this would eliminate the possibility of poor quality air flowing out to the surface at times of air reversal out of the Monogahela Drift)
- Air direction would be into the mine from the Revenue Level Portal and up the Monogahela Drift
- Existing fans at the Revenue Level would be used and the fans would function according to the specifications on Spendrup's performance fan curve (Figure 3)
- As measured on the November 16th mine visit, there are no airflow openings other than than the Revenue Portal and Monogahela Drift
- Monogahela Drift would be open all year with the same air flow potential (no snow or rock blockages) as existed on the November 16th mine visit
- Airways would be cleaned up
- Two-feet (ft) diameter ducting will be used in Yellow Rose
- Three-ft diameter ducting will be used between the air lock doors in the Revenue Level Drift

- Ducting will be run to the end of the Yellow Rose with no leakage (the location of proposed activities was not known and this was assumed as a worst case scenario)
- One iwg was added in a direction down the Monogahela Drift to simulate the assumed worst case the fans would encounter (outside temperatures of approximately 80°F)
- Air quantities would be sufficient for fifteen to twenty personnel working in Yellow Rose using electric or air-powered equipment (200 cubic feet per minute [cfm] per person)
- Air velocities (25 feet per minute [fpm]) would be sufficient to clear Yellow Rose faces of blasting fumes
- Air quantities in the Revenue Level Drift inby the Yellow Rose Drift would be sufficient for ten personnel bolting with electric or air equipment and cleaning up (200 cubic feet per minute [cfm] per person)

Figure 4 is a view of the model after the assumptions have been added.

4.0 CONCLUSIONS AND RECOMMENDATIONS

- The model indicates the existing fans will supply the currently planned air quantities and velocities needed by the mine.
- The fans should be inspected by qualified personnel from Spendrup or another appropriate company.
- Southwestern should provide the location of work areas so they can be added to the ventilation model. The model has assumed the worst case but adding multiple work points would more closely approximate the projected situation.
- One existing fan should be used to supply air to the Yellow Rose work areas using 24-inch ducting. The inlet to the fan should be 30-ft or more outby the intersection of the Yellow Rose and the Revenue Level.
- Two existing fans should be installed at the air lock doors of the Revenue Level, pushing air inby, using one 36-inch ducting or equivalent. The ducting is to be installed through the length of the airlock only.
- The air lock doors should be placed in service and checked for leaks. The doors should be as tight as possible. A procedure should be in-place and personnel trained to operate the doors correctly.
- Tight seals at tubing joints are important and should be emphasized in personnel training. Tubing holes should be repaired or tubing should be changed out when damaged. Mine personnel could be trained in proper installation procedures by the tubing manufacturer.
- The fourth fan not in use in this scenario should also be inspected and repaired, if necessary, and added to the mine inventory.
- Any fan maintenance suggested by the fan's manufacturer should be followed. The fan in inventory should also be inspected and maintained as suggested by the manufacturer.

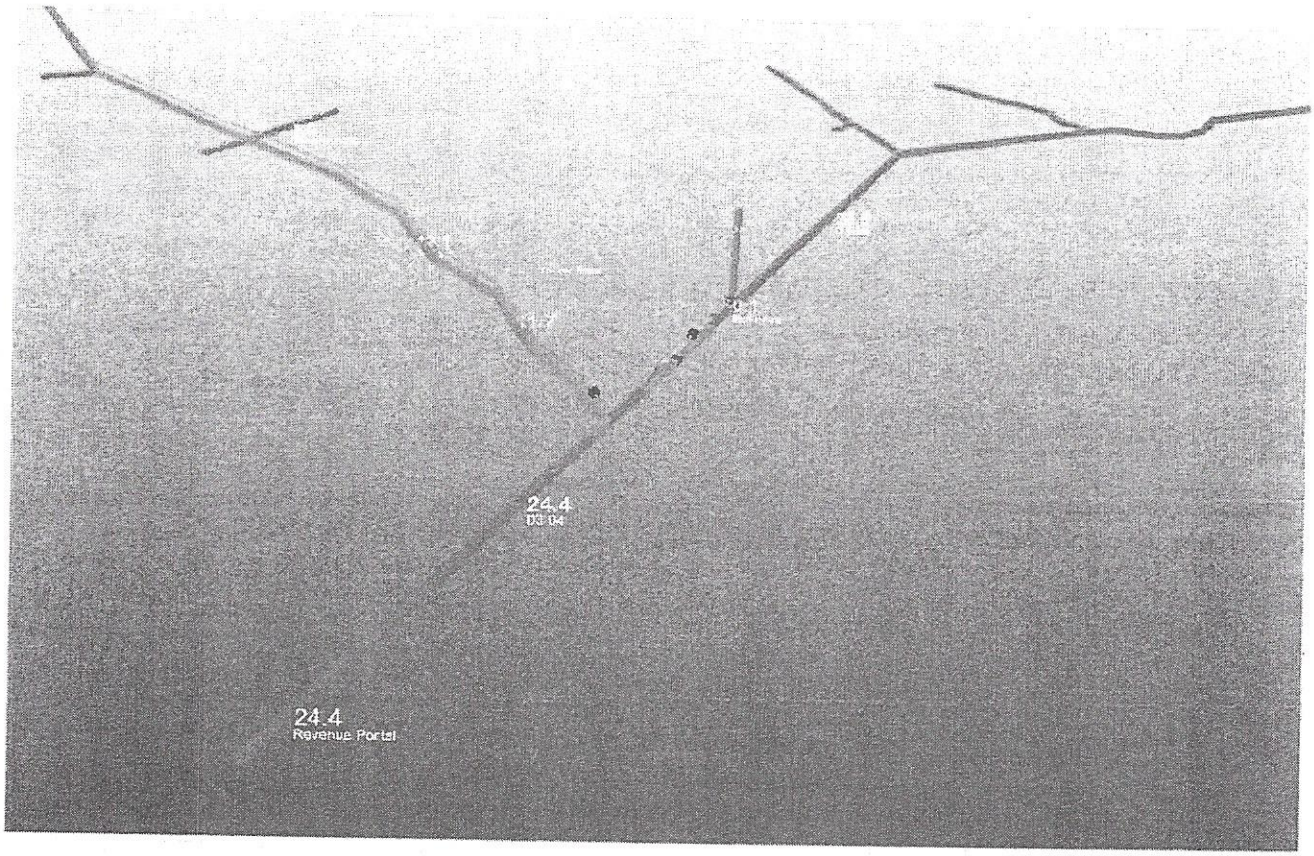
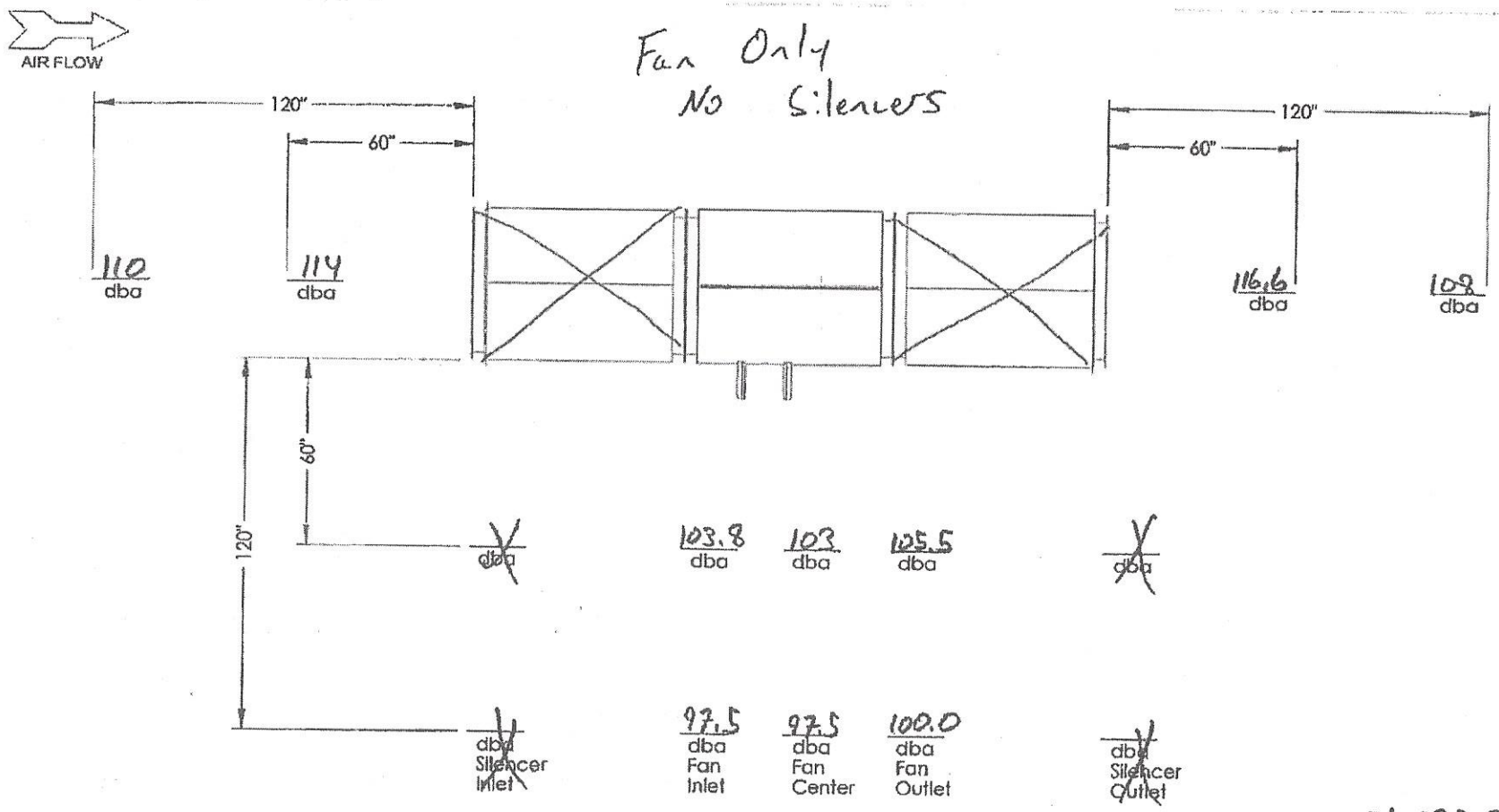


Figure 4. Proposed Ventilation Model

- There have been discussions of opening another incline to the surface for an escapeway—if this option is pursued, the air quantity leaving the incline should be limited.



Fan Model #: 071-035-3600-B-1-D
Serial Number: 5553-5554
Conditions:

Amp Draw:
L1: 45
L2: 44
L3: 43

Ambient dba: 45

Blade Setting:
Volume:
Pressure:
Number of Blades: 10
Rotating Speed: 3620 RPM

SO #:

QTY:

DATE: 3 / 6 / 2012

SPENDRUP FAN Co.

2768 C 1/2 ROAD
P.O. BOX 4308
GRAND JCT. CO
81502
TEL: (970)243-3429
FAX: (970)242-6724

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/32
ANGULAR: ± 1°
TWO PLACE DECIMAL ±.015
THREE PLACE DECIMAL ±.005
MATERIAL
FINISH
P/N QTY

DRAWN
MODELED
ENG APPR.

NAME | DATE

PART NAME: Fan Sound Test

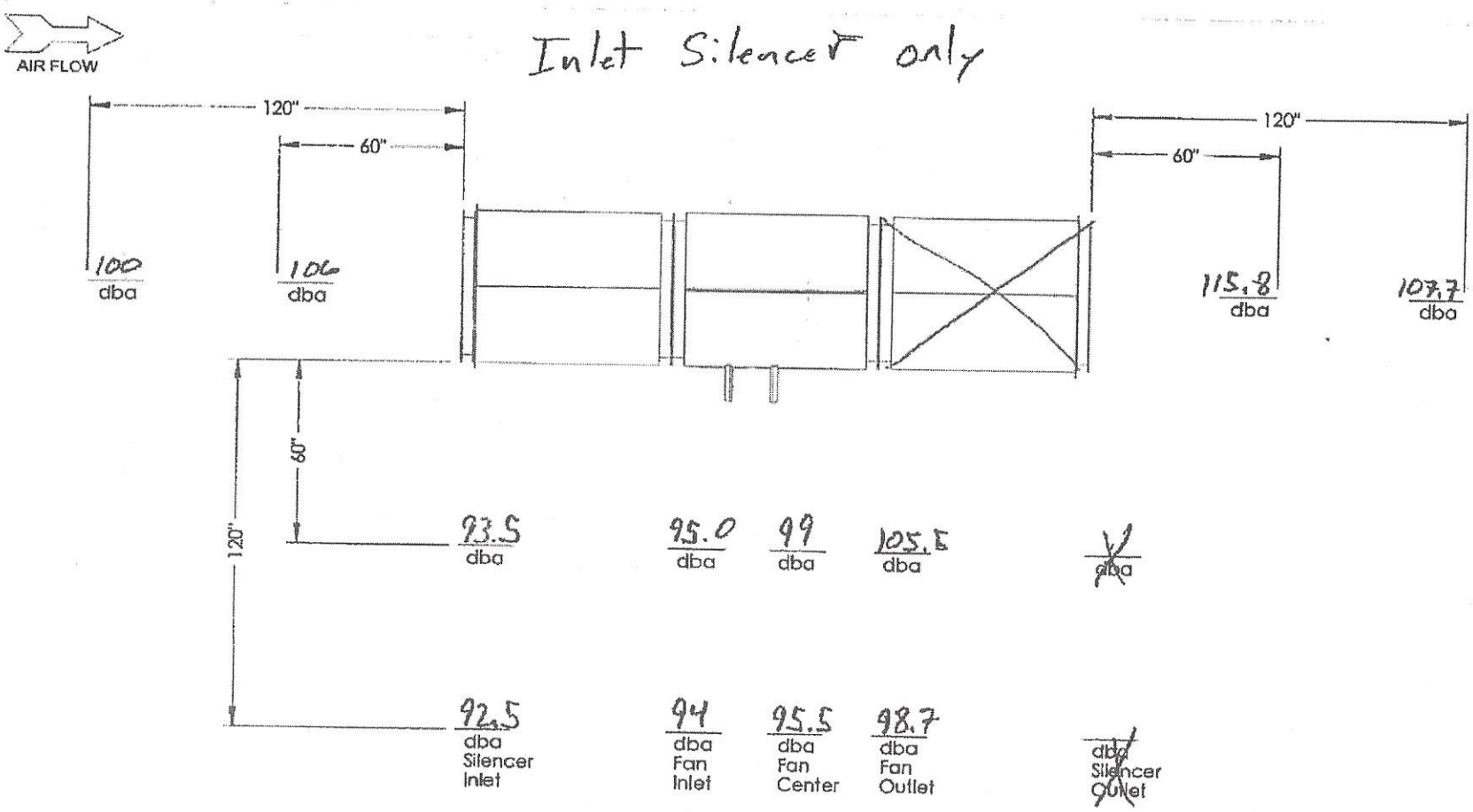
JOB ORDER

SIZE A | DWG. NO | REV. D

SCALE: 1:48 | WEIGHT: 2000.00 LBS | SHEET 1 OF 1

Refer to Detail Drawings

Inlet Silencer only



Fan Model #: 071-035-3600-D-0-1
Serial Number: 5553-5554
Conditions:

Blade Setting:
Volume:
Pressure:
Number of Blades: 10
Rotating Speed: 3600

Amp Draw:
L1: 47
L2: 48
L3: 50

Ambient dba: 48

SO #:

QTY:

DATE: ___/___/___

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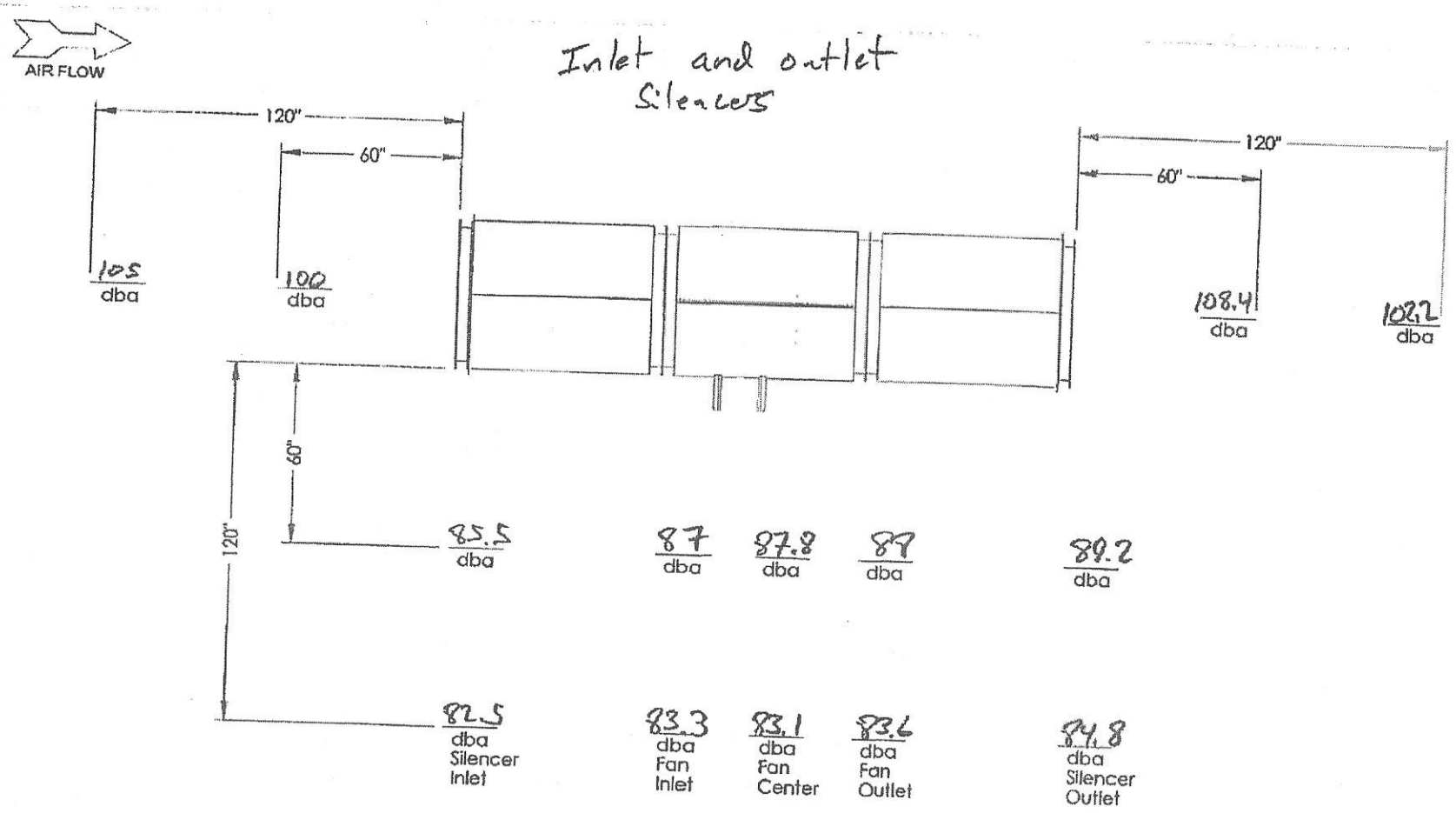
P/N QTY

	NAME	DATE
DRAWN		
MODELED		
ENG APPR.		

PART NAME
Fan Sound Test
JOB ORDER
SIZE DWG. NO. A
REV D
SCALE 1:48 WEIGHT SHEET 1 OF 1



Fan Model #: 071-035-3600-B-01
Serial Number: 8853 - 8854
Conditions:

Amp Draw:
L1: 51
L2: 52
L3: 53

Ambient dba: 54

Blade Setting:
Volume:
Pressure:
Number of Blades: 10
Rotating Speed: 3600 RPM

SO #:

QTY:

DATE: 3 / 6 / 2012

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MATERIAL
Refer to Detail Drawings
FINISH
P/N QTY

DRAWN
MODELED
ENG APPR.

NAME | DATE

PART NAME
Fan Sound Test

JOB ORDER

SIZE A | DWG. NO | REV. D

SCALE: 1=48 | WEIGHT: POUNDS LBS | SHEET 1 OF 1