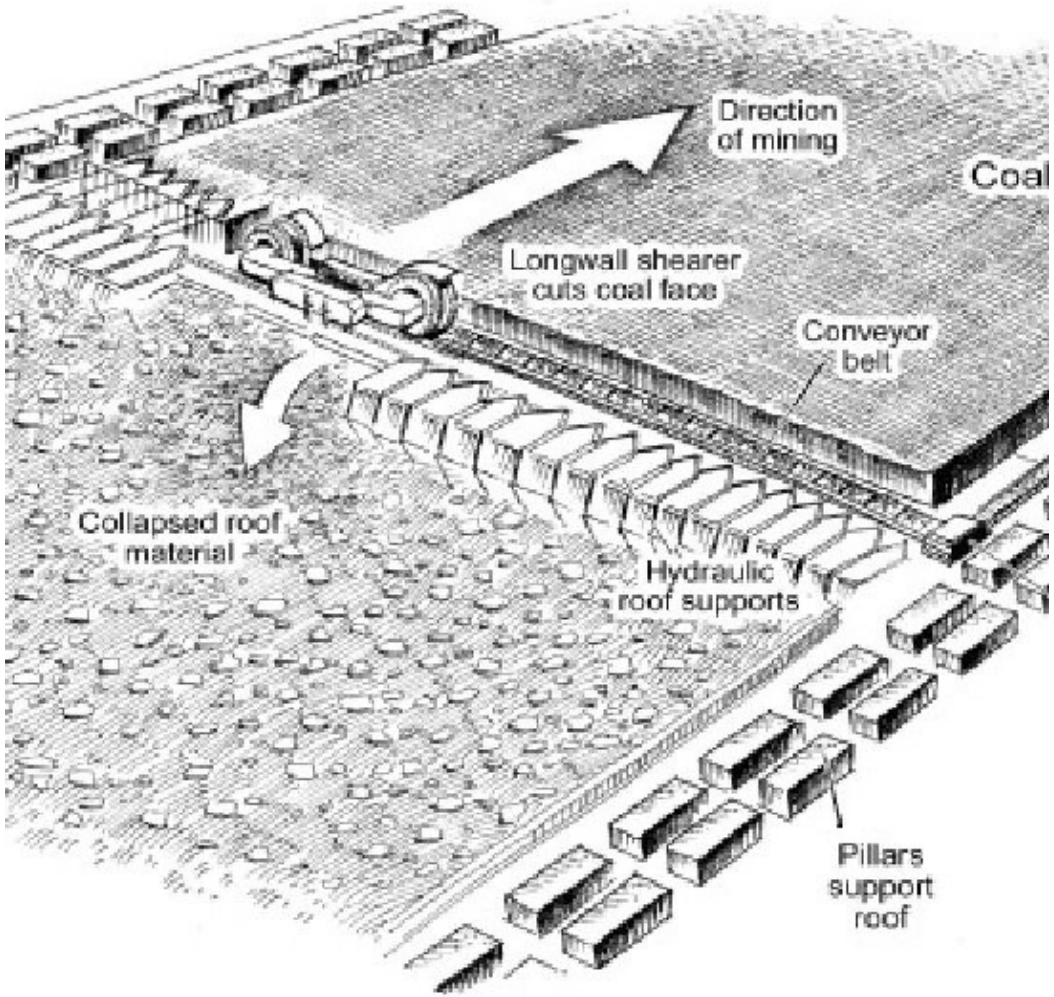
A Field Study of Longwall Mine Ventilation Using Tracer Gas in a Trona Mine



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Outline

- Introduction
- Geology
- Study Site
- Experimental methodology
- Ventilation measurements
- Discussion and results
  - Face test
  - Gob test
- Summary and conclusions

What makes longwall ventilation complex and dynamic?

Impact of face width?

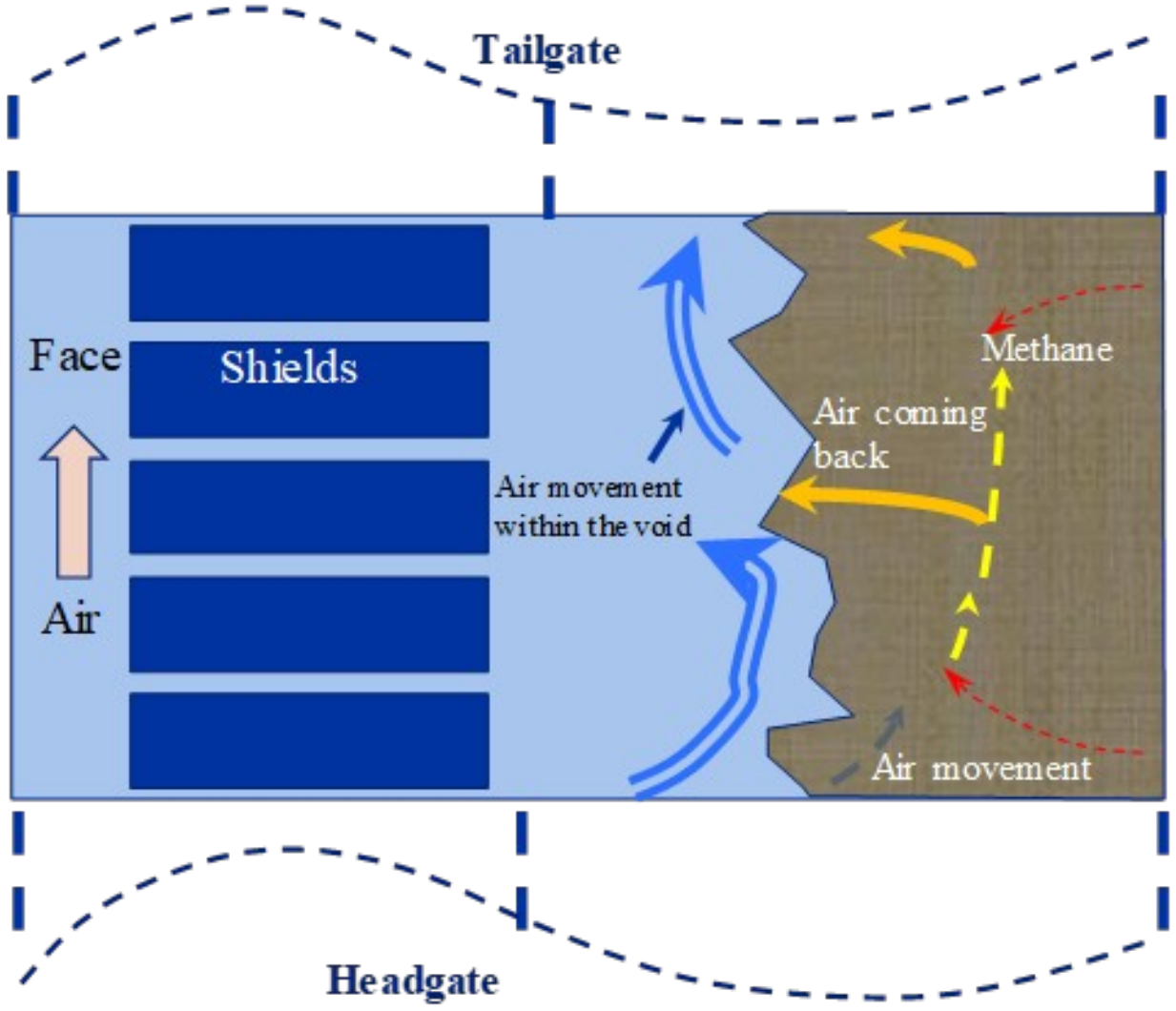
Impact of panel length?

Impact of caving?

Type of ventilation system?

Gas content of the gob?

Nitrogen injection?

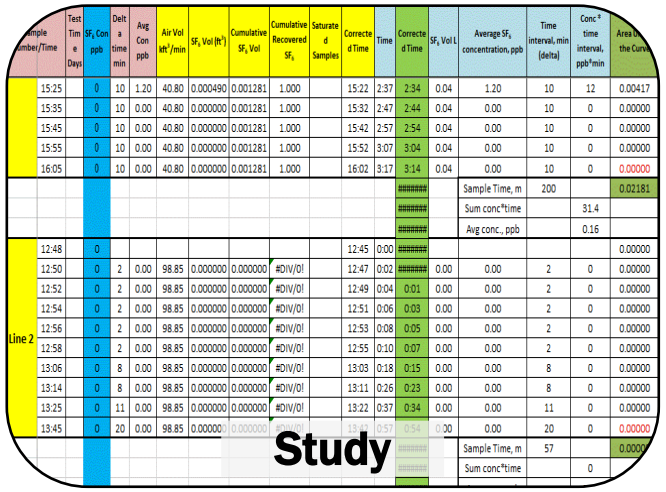


Tracer Gas Experimental Methodology

- Small volume for face test
- Large volume for gob test
- SF_6 gas used
- Released as a slug

- >3000 samples
- UG monitoring on face and gob
- Surface monitoring at GGVs and bleeder shafts

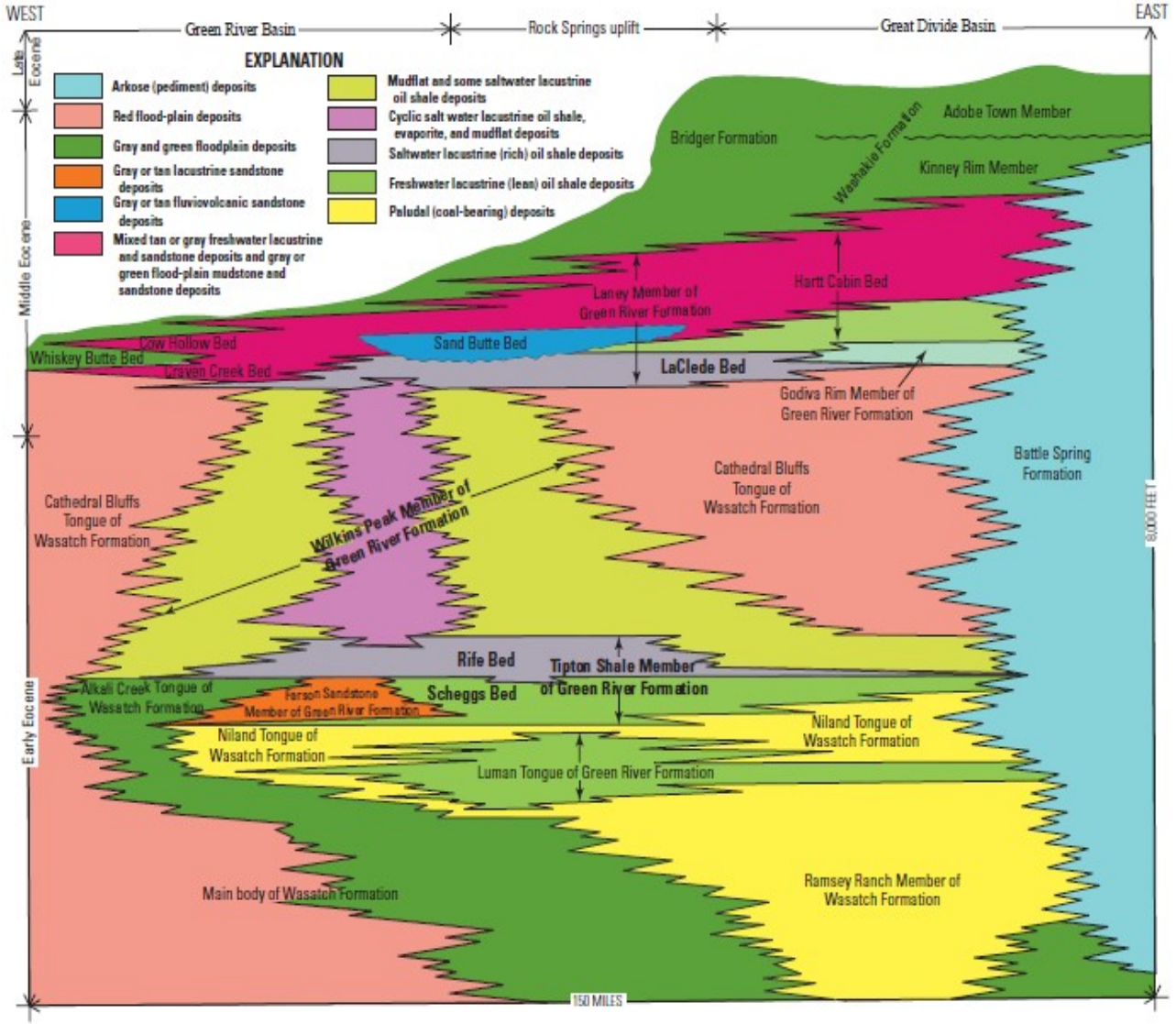
- Gas chromatography
- NIOSH method 6602
- 1 ppb measurement limit

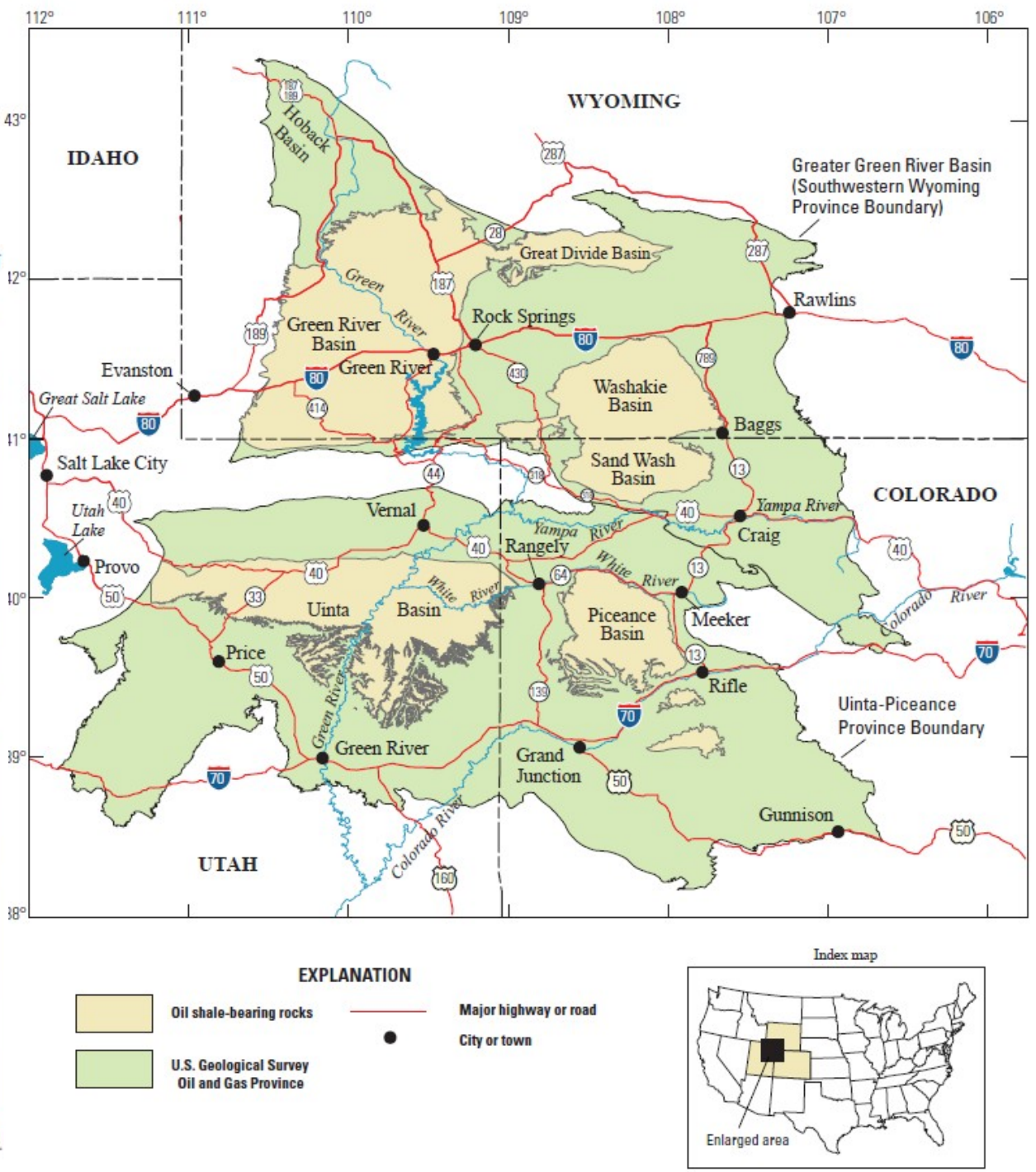


Sample Number/Time	Test Time Days	SF_6 Conc ppb	Delta time min	Avg Conc ppb	Air Vol kft^3/min	SF_6 Vol (ft^3)	Cumulative SF_6 Vol	Cumulative Recovered SF_6	Saturated Samples	Corrected Time	Time	Corrected Time	SF_6 Vol L	Average SF_6 concentration, ppb	Time interval, min (delta)	Conc * time interval, ppb*min	Area Under the Curve
	15:25	0	10	1.20	40.80	0.000490	0.001281	1.000		15:22	2:37	2:34	0.04	1.20	10	12	0.00417
	15:35	0	10	0.00	40.80	0.000000	0.001281	1.000		15:32	2:47	2:44	0.04	0.00	10	0	0.00000
	15:45	0	10	0.00	40.80	0.000000	0.001281	1.000		15:42	2:57	2:54	0.04	0.00	10	0	0.00000
	15:55	0	10	0.00	40.80	0.000000	0.001281	1.000		15:52	3:07	3:04	0.04	0.00	10	0	0.00000
	16:05	0	10	0.00	40.80	0.000000	0.001281	1.000		16:02	3:17	3:14	0.04	0.00	10	0	0.00000
												#######		Sample Time, m	200		0.02181
												#######		Sum conc*time		31.4	
												#######		Avg conc., ppb		0.16	
	12:48	0								12:45	0:00	#######					0.00000
	12:50	0	2	0.00	98.85	0.000000	0.000000	#DIV/0!		12:47	0:02	#######	0.00	0.00	2	0	0.00000
	12:52	0	2	0.00	98.85	0.000000	0.000000	#DIV/0!		12:49	0:04	0:01	0.00	0.00	2	0	0.00000
	12:54	0	2	0.00	98.85	0.000000	0.000000	#DIV/0!		12:51	0:06	0:03	0.00	0.00	2	0	0.00000
	12:56	0	2	0.00	98.85	0.000000	0.000000	#DIV/0!		12:53	0:08	0:05	0.00	0.00	2	0	0.00000
Line 2	12:58	0	2	0.00	98.85	0.000000	0.000000	#DIV/0!		12:55	0:10	0:07	0.00	0.00	2	0	0.00000
	13:06	0	8	0.00	98.85	0.000000	0.000000	#DIV/0!		13:03	0:18	0:15	0.00	0.00	8	0	0.00000
	13:14	0	8	0.00	98.85	0.000000	0.000000	#DIV/0!		13:11	0:26	0:23	0.00	0.00	8	0	0.00000
	13:25	0	11	0.00	98.85	0.000000	0.000000	#DIV/0!		13:22	0:37	0:34	0.00	0.00	11	0	0.00000
	13:45	0	20	0.00	98.85	0.000000	0.000000	#DIV/0!		13:42	0:57	0:54	0.00	0.00	20	0	0.00000
												#######		Sample Time, m	57		0.00000
												#######		Sum conc*time		0	

- Pump rate, temperature and elevation corrections
- Arrival time and cumulative gas retrieval

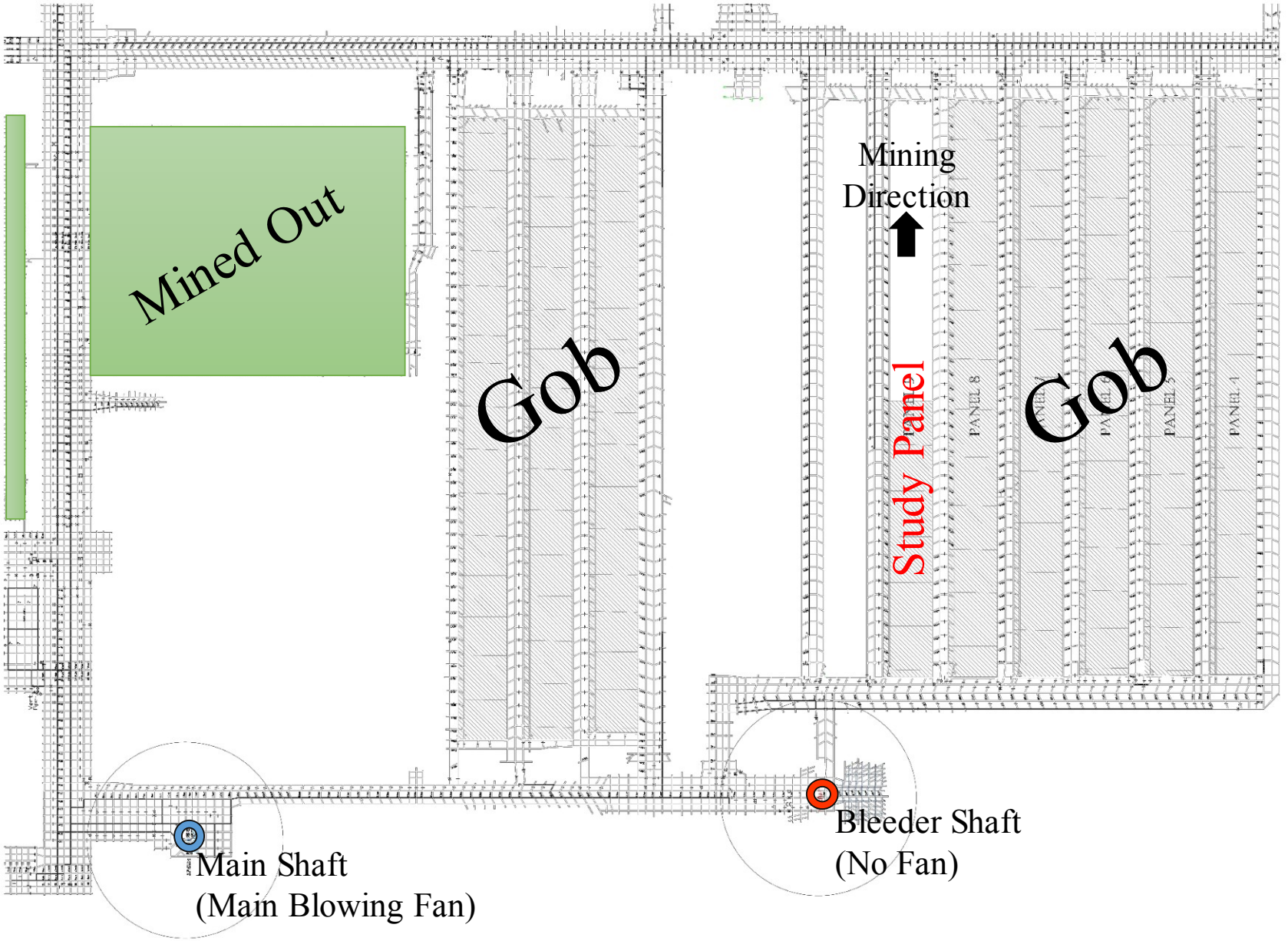
Geology of the Green River Basin





Site A: Trona Mine

- Longwall mining
- Bleeder ventilation
- Blowing main fan
- 750 ft face length
- 10,000 ft panels
- 1600 ft overburden
- ~10 ft mining height
- 2 entry intake (unique zero entry)
- 2 entry return
- Caving up to the shields

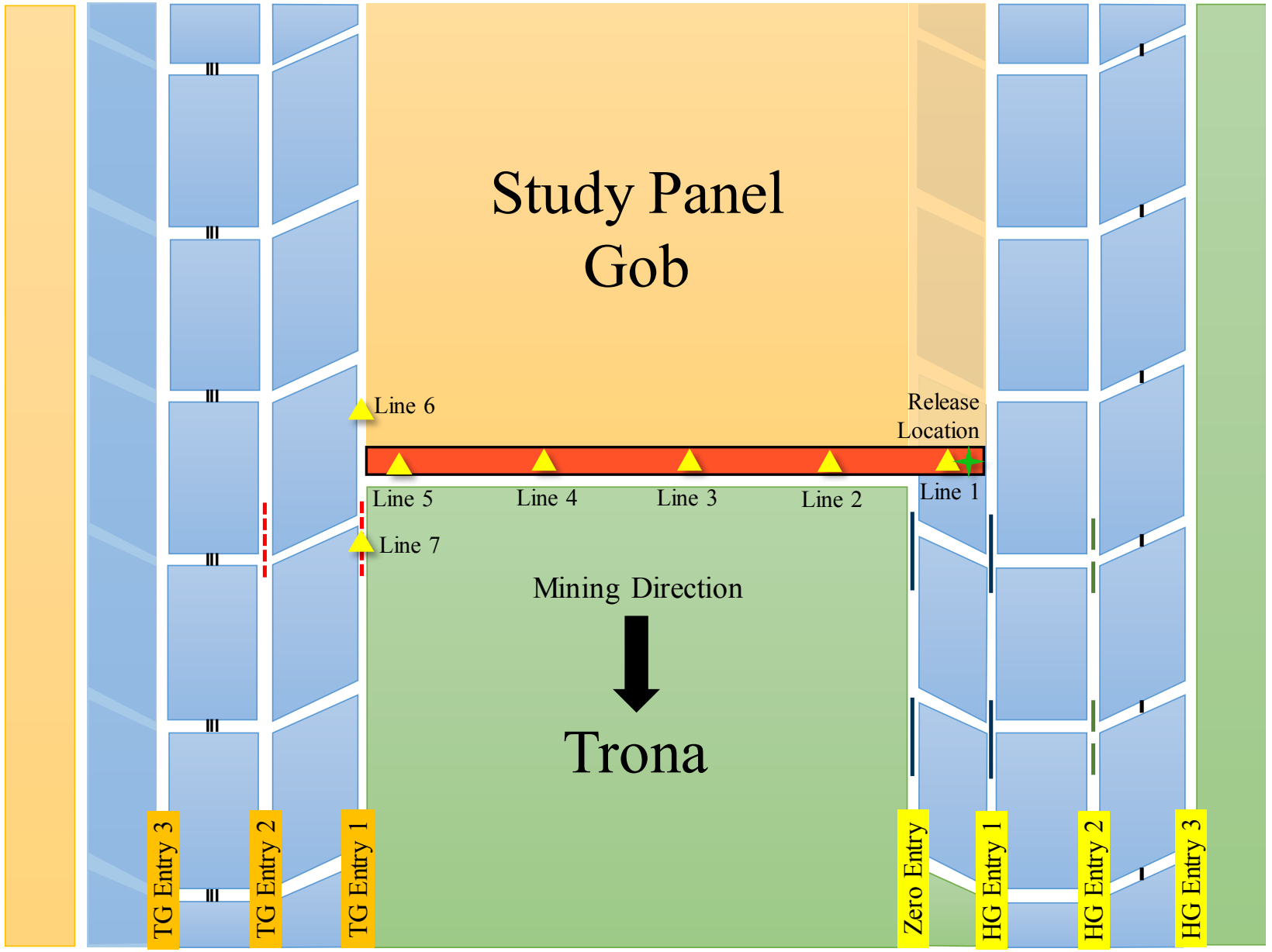


Face Test

- The face test was conducted during a daylight non-production shift on the first day of the field study
- During the entire duration of this test, the shearer was positioned at the zero entry
- The tracer gas (SF_6) was released for about 2 seconds near the leg of the first shield on headgate side
- Monitoring was initiated at the time of the release from all face monitoring locations
- The released volume of SF_6 was 0.35 L (0.012 ft^3), determined by the released mass and corrected for underground temperature and pressure conditions

Study Panel Layout

- Lines 1 to 5 are located at 5%, 25%, 50%, 75% and 95% of the face length, respectively
- Line 6 is located one break inby the face
- Line 7 is located one break outby the face
- Gas samples were initially collected every 30 seconds at these locations

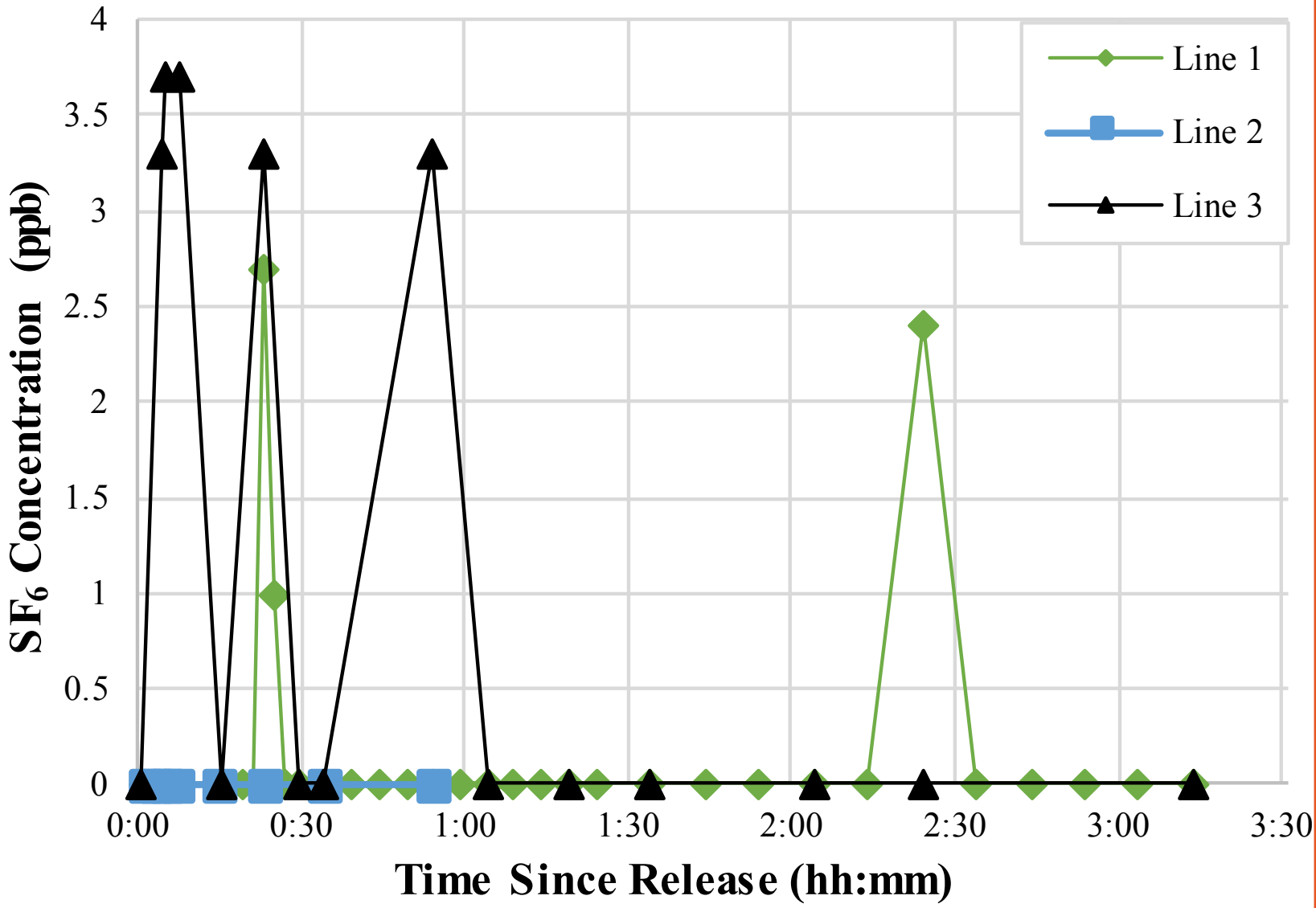


Ventilation Measurements

Location	Velocity (m/s)	Area (m^2)	Flowrate (m^3/s)	Flowrate (kcfm)
Line 1, Shield 7	1.29	15.0	19.3	40.8
Zero Entry	2.73	12.3	33.5	71.0
Line 2, Shield 33	2.97	15.7	46.7	98.8
Line 3, Shield 65	3.30	13.9	45.9	97.3
Line 4, Shield 98	4.31	13.1	56.4	119.5
Line 5. Shield 124	3.41	17.8	60.7	128.7

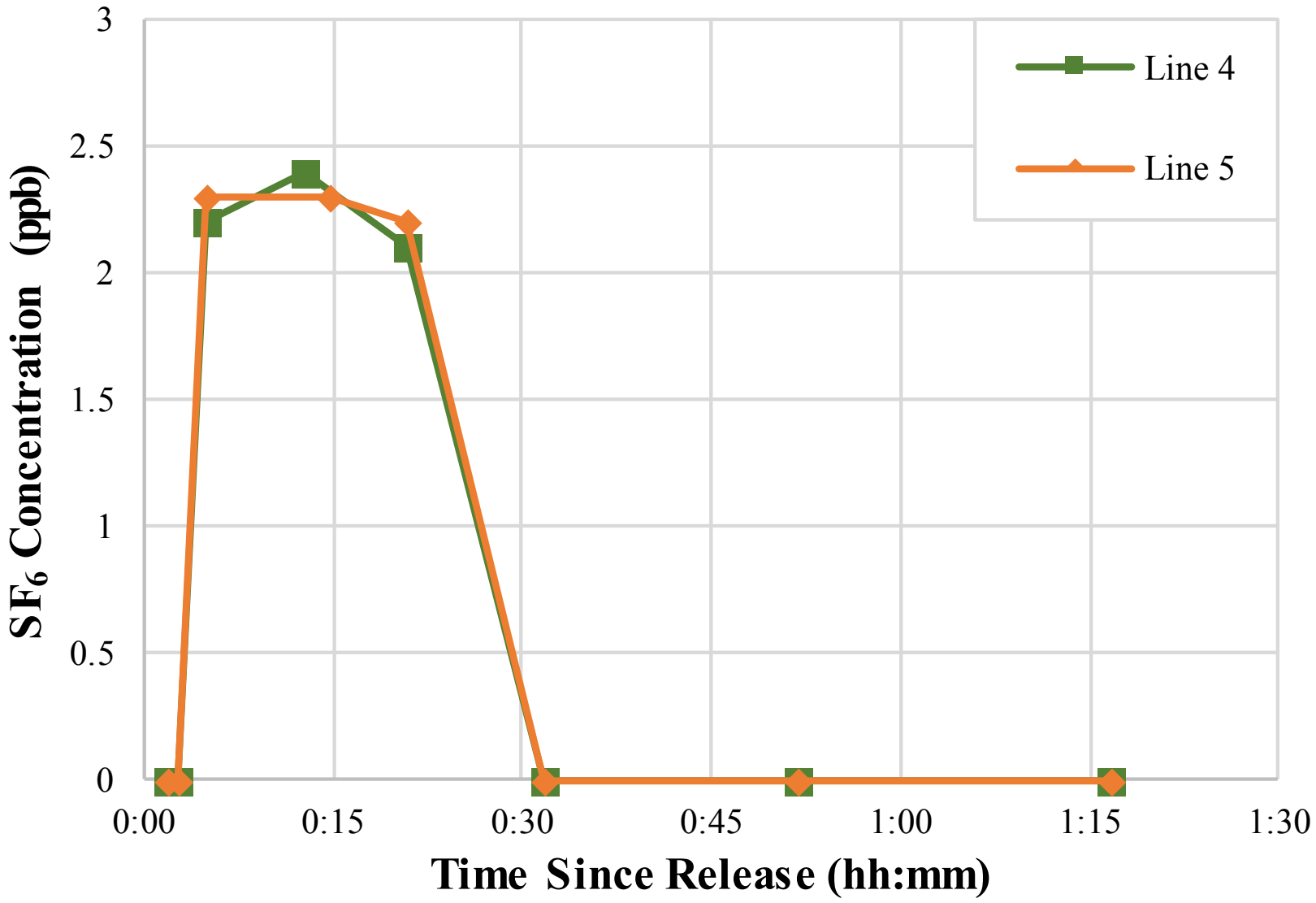
Face Test (Lines 1–3)

- ***Line 1***, first measured 23 minutes after release. Representative of tracer gas residing in the gob for a period of time before being detected on the face
- ***Line 2***, SF_6 was not measured at this location. Result of the influx of air from zero entry
- ***Line 3***, first arrival on the face in 4 minutes. A portion of air from the release location thought to have traveled in a region behind the shield line and reached the mid-face region first



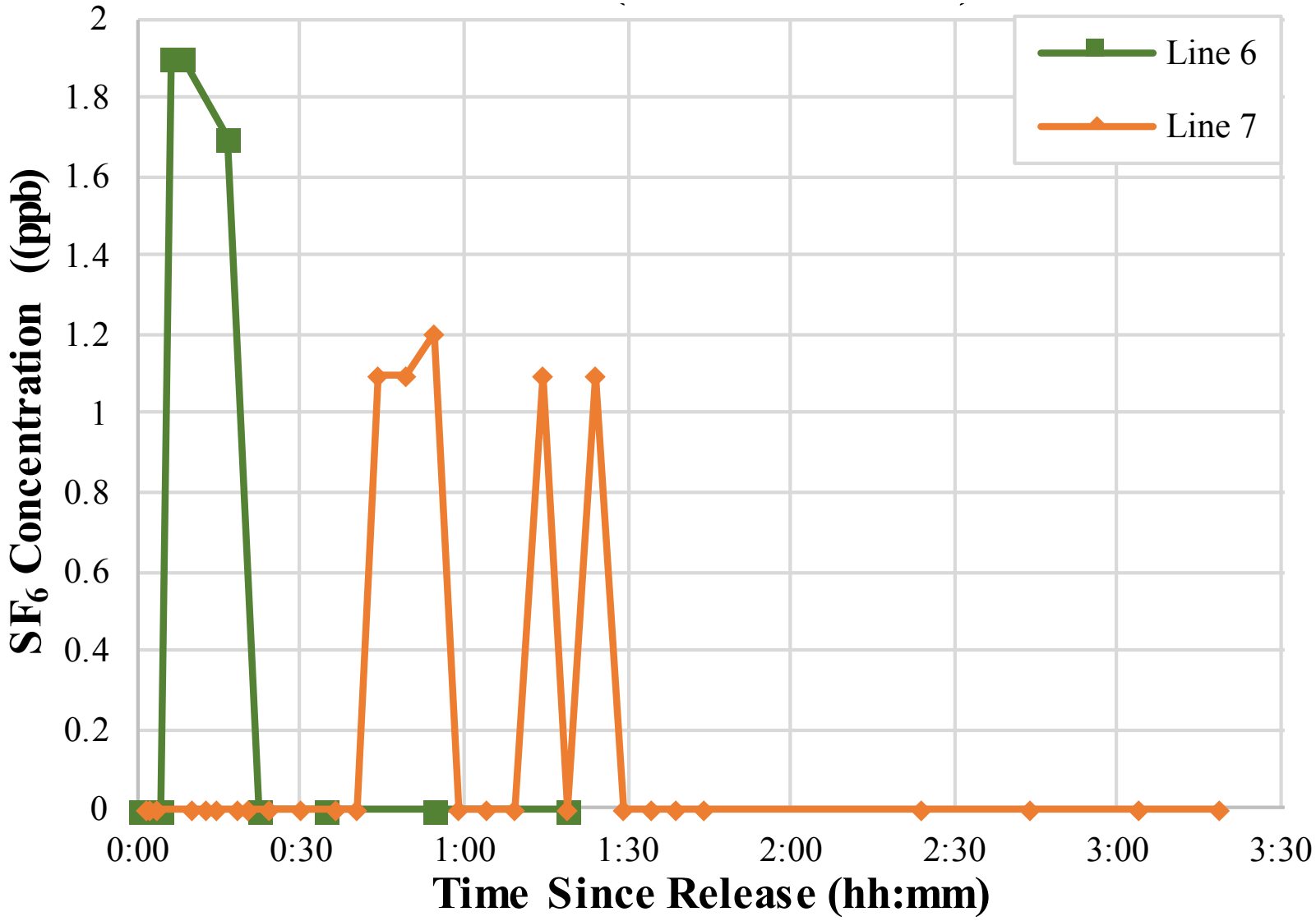
Face Test (Lines 4–5)

- The tracer gas arrived at lines 4 and 5 at approximately the same time, 4 minutes after the release
- The last occurrence of SF_6 was measured 20 minutes after release for both the locations
- Such behavior of gas indicates transport from the release point to the tailgate end of the face through an undefined pathway



Face Test (Lines 6–7)

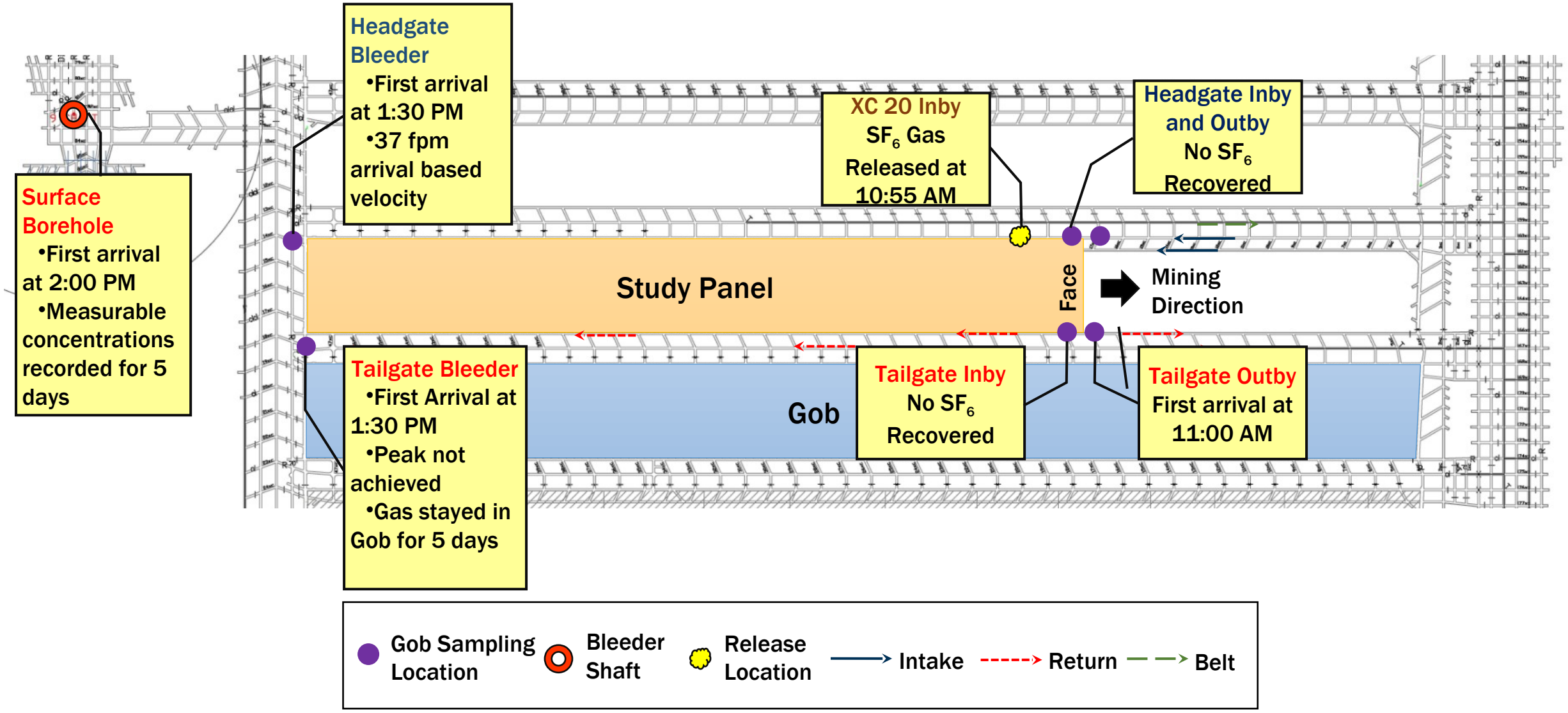
- ***Line 6, TG Inby,*** the tracer gas arrived at line 6 prior to arriving at line 7. Peak was recorded 6 minutes after release
- ***Line 7, TG Outby,*** tracer gas arrived after 44 minutes and peak was recorded 54 minutes after release. Tracer was measured for 1.5 hours
- Such behavior demonstrates rapid movement of tracer to the inby monitoring location and a long duration of tracer on the face, indicating the residence time of gas in the gob



Gob Test

- The gob test was conducted for a duration of five days. The operator was mining on the evening 8-hr shift and NIOSH staff were monitoring during the daylight shift
- 92.1 L (3.25 ft^3) SF_6 was released 2 crosscuts inby the face on the headgate side, at crosscut 20
- Following the tracer release, 265 L (9.34 ft^3) of compressed CO_2 was injected to clear the sampling port and sample line of SF_6 and mix the tracer in the gob
- Following the release, sampling commenced at all monitoring locations

Gob Test

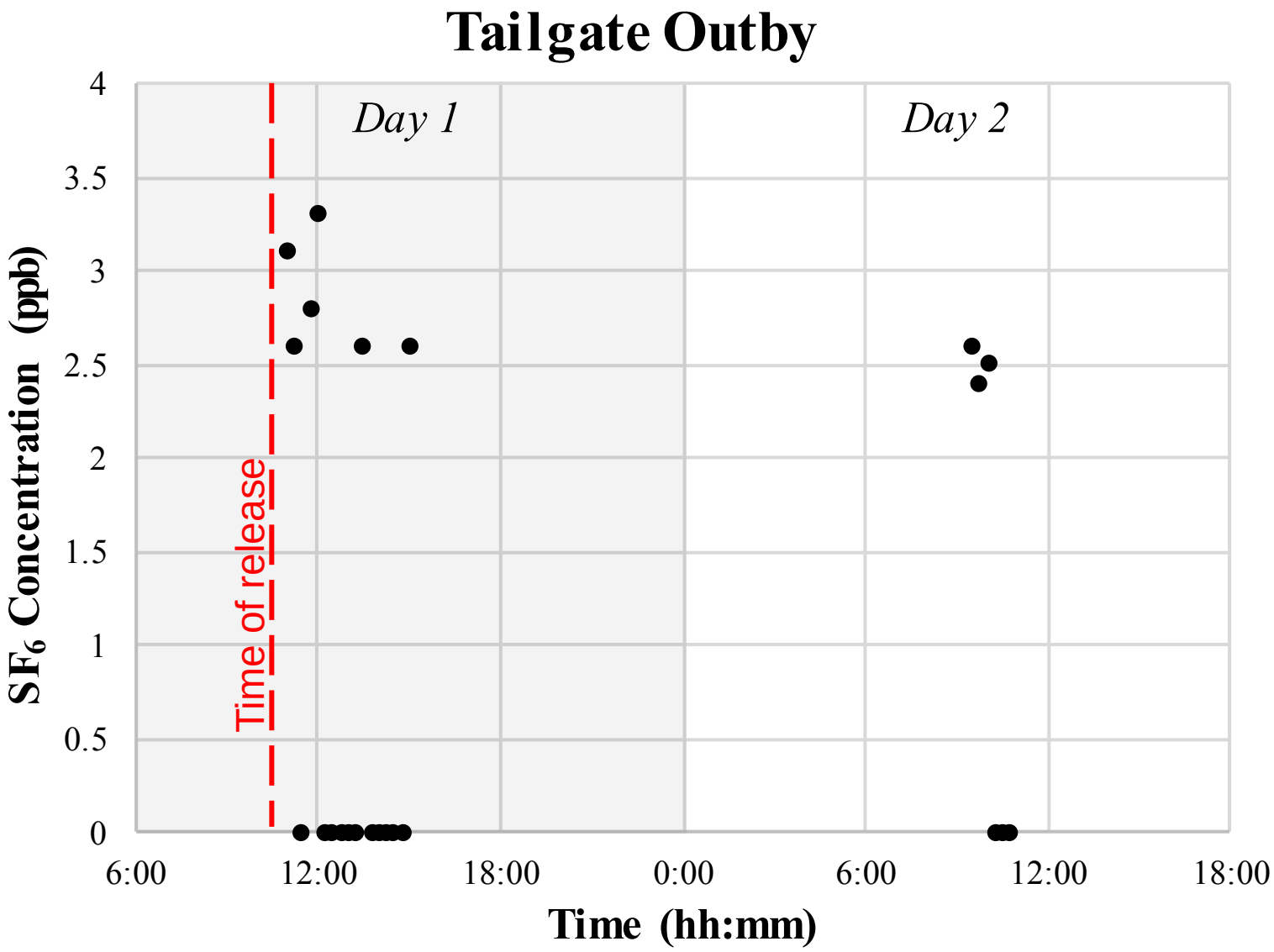

Surface Borehole
•First arrival at 2:00 PM
•Measurable concentrations recorded for 5 days
Headgate Bleeder
•First arrival at 1:30 PM
•37 fpm arrival based velocity
XC 20 Inby
SF_6 Gas Released at 10:55 AM
Headgate Inby and Outby
No SF_6 Recovered
Study Panel
Face
Mining Direction
Tailgate Bleeder
•First Arrival at 1:30 PM
•Peak not achieved
•Gas stayed in Gob for 5 days
Gob
Tailgate Inby
No SF_6 Recovered
Tailgate Outby
First arrival at 11:00 AM
Gob Sampling Location
Bleeder Shaft
Release Location
Intake
Return
Belt

Gob Test (Tailgate)

Tailgate Outby, tracer gas arrived at this location quickly after the release.

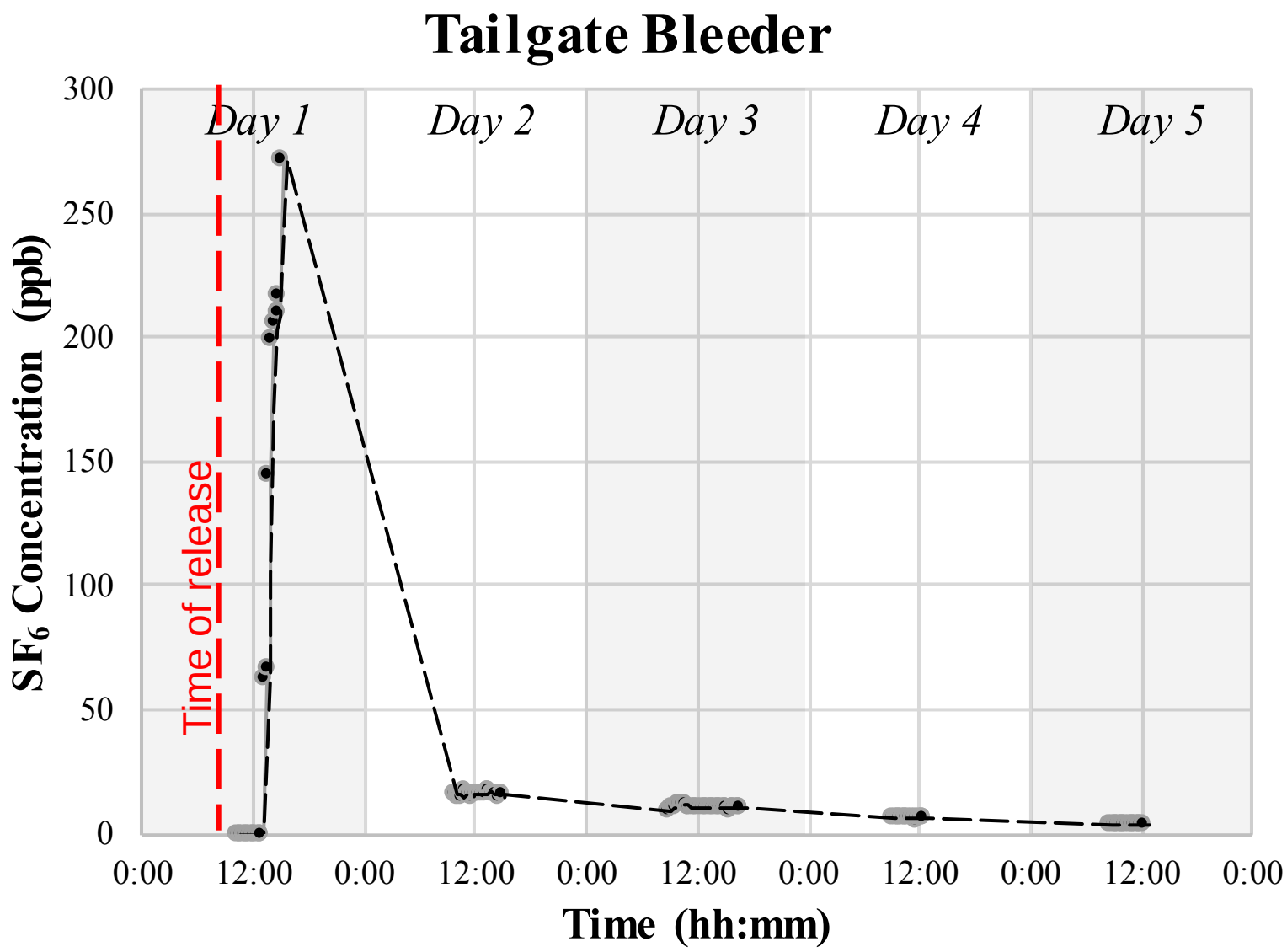
Gas may have moved outby from the release location towards the face and eventually mixed with face air flowing towards the tailgate

Tailgate Inby, tracer gas was not measured at this location. It might be due to the low concentration of tracer in the airflow



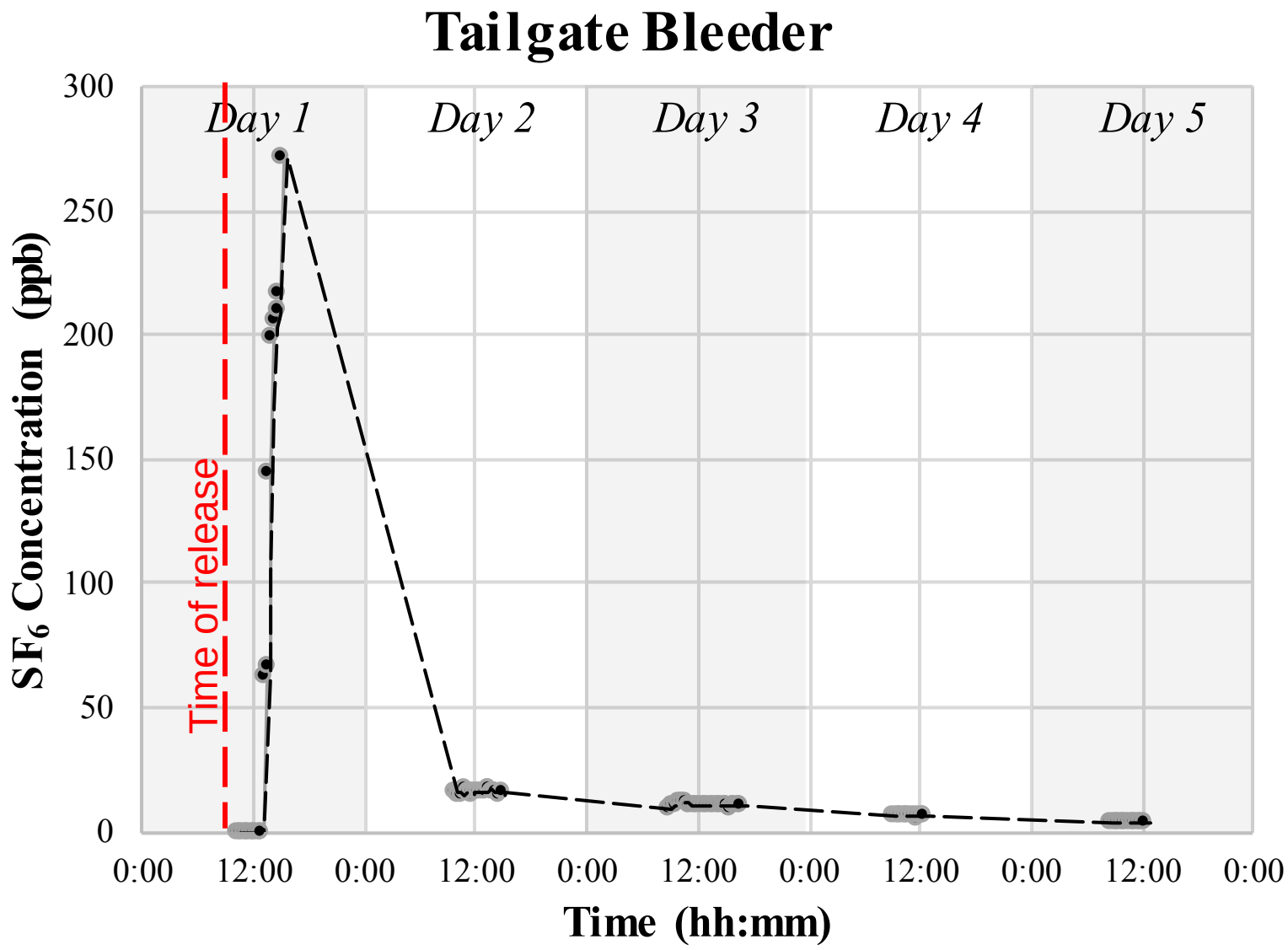
Gob Test (Tailgate Bleeder)

- Sampling was done at the intersection of the back bleeder entries and the tailgate entry number 2
- The first arrival of tracer gas was recorded after approximately 2 ½ hours of release time
- Samples were collected at this location every 30 minutes during day shift for the entire testing duration of 5 days
- Tracer gas concentrations on day 1 of the test were an order of magnitude higher compared to later in the test



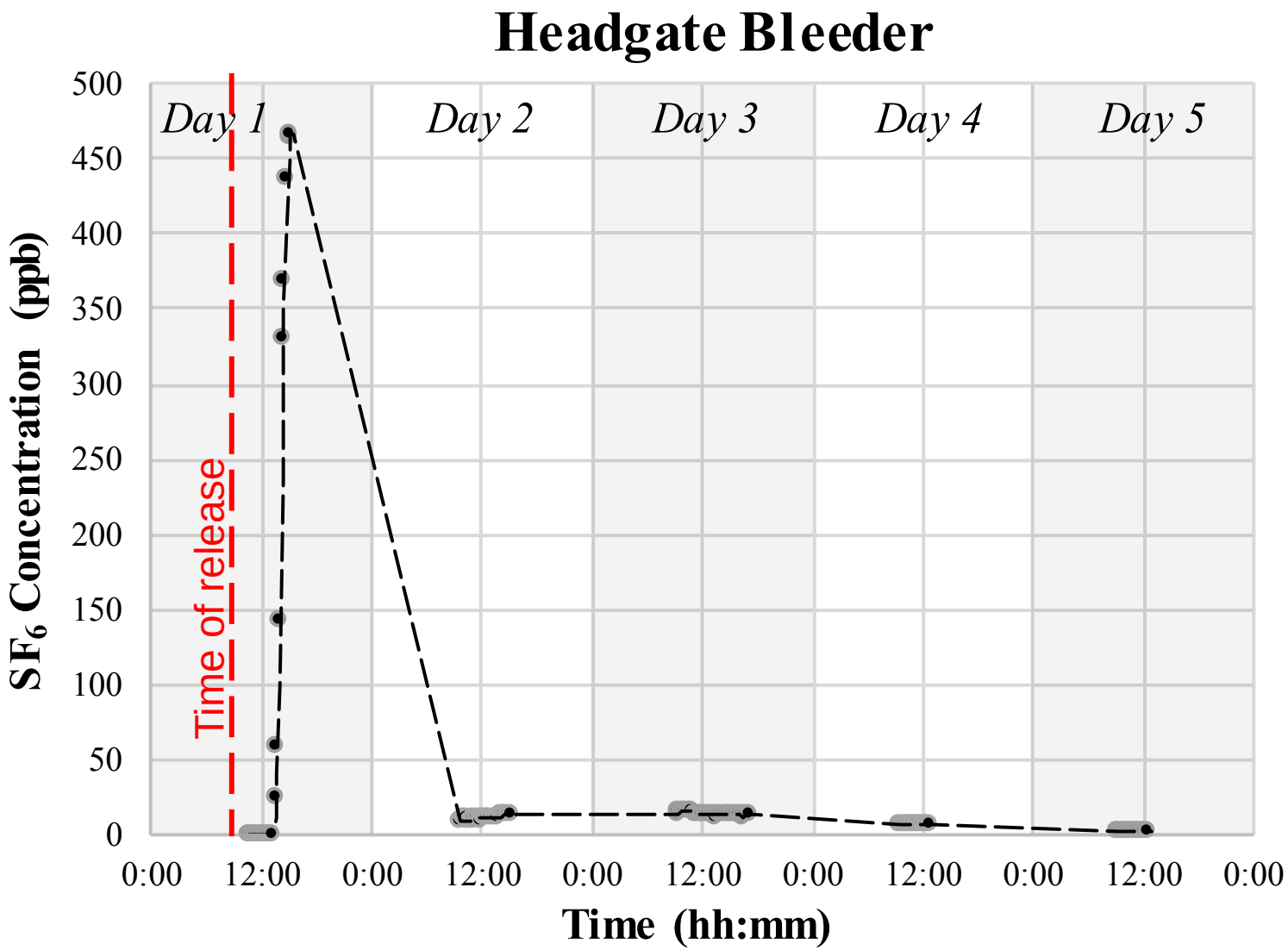
Gob Test (Tailgate Bleeder)

- Rising concentrations recorded on day 1 followed by lower tracer gas concentrations on day 2 indicate the peak concentration was not measured
- Except for the first day, measureable concentrations on the order of 2 ppb were recorded for four days of sampling
- This indicates that a portion of the gas stayed within the gob, though moving at a slow rate



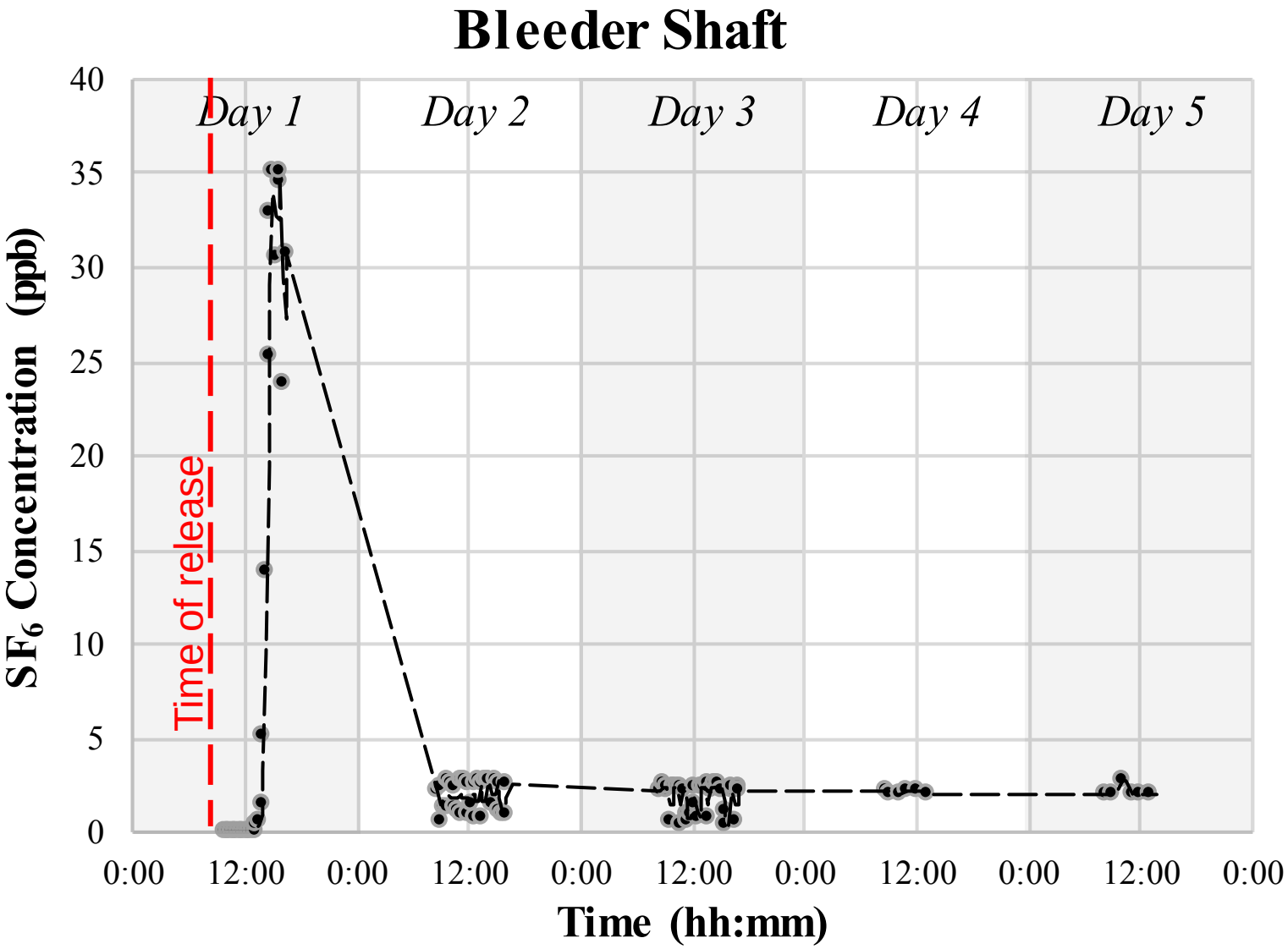
Gob Test (Headgate Bleeder)

- SF_6 arrived at the inby bleeder location on the day of the release
- A definitive peak couldn't be identified for this location although the rate of concentration increase was slowing down on day 1
- For study days 2 and 3, the concentrations were mostly the same order of magnitude, around 10-15 ppb
- For study days 4 and 5, the concentrations decreased to 3-7 ppb range, but did not reach zero



Gob Test (Bleeder Shaft)

- The tubing inlet was approximately 10 ft. below the shaft collar
- The gas arrived approximately 4 hours after the release and the peak concentration was observed approximately 7 hours after the release of SF_6
- Decreasing concentrations were measured from this site for days 2, 3, 4, and 5 with an average concentration of ~2 ppb
- The measurements at this location and the bleeder locations confirm a portion of the tracer gas stayed within the gob



Summary and Conclusions

- The face test indicates multiple possible pathways of ventilation air movement
- Face test also indicated a residence time of gas in the gob which was later detected at monitoring locations
- The primary path of tracer gas movement from gob test was towards the back of the panel at a velocity of about 0.19 m/s (37 fpm)
- From the release point in the headgate No. 1 entry, inby the active face, a portion of the released tracer gas moved towards the face and to the outby monitoring location at the tailgate
- Transport of tracer gas through the gob was rapid to the headgate and tailgate bleeders and the bleeder shaft near the back of the study panel
- The presence of multiple pathways of face air movement and the range of pathways of gas transport and rates of movement were demonstrated
- Related NIOSH field studies have also shown a degree of interaction between the gas at the front of the active panel gob and the face air

Thank you for your attention!

Questions?

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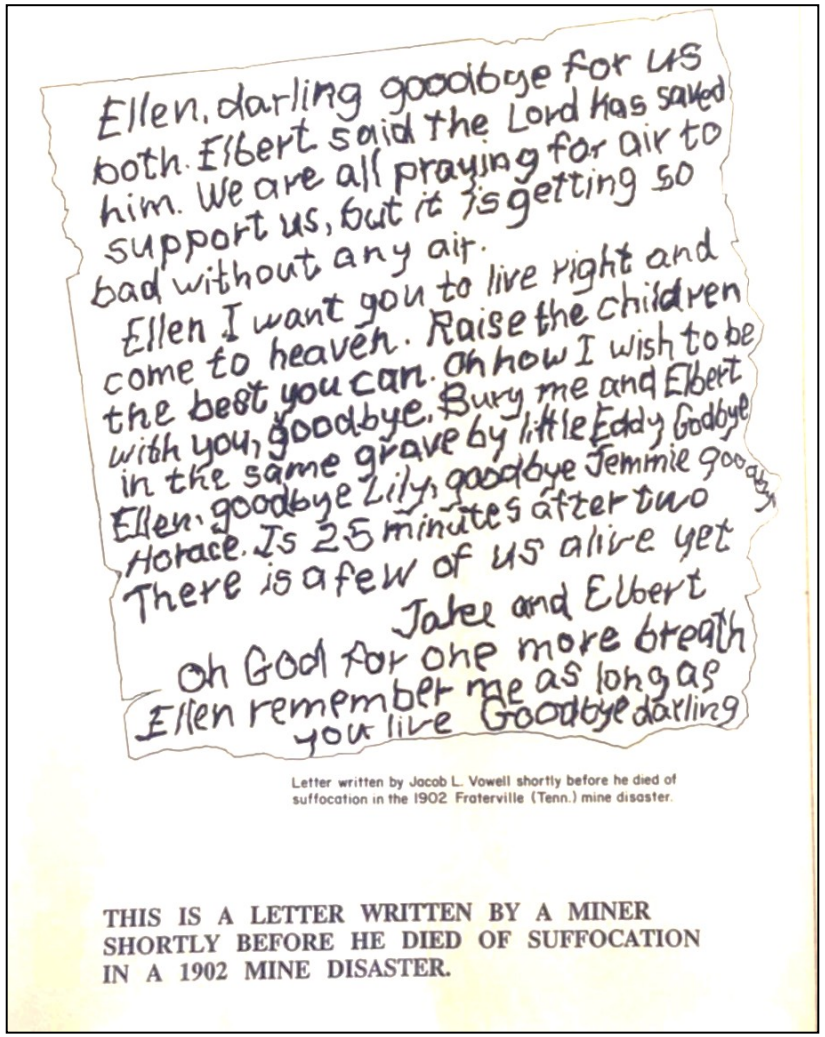

Ellen, darling goodbye for us both. Elbert said the Lord has saved him. We are all praying for air to support us, but it is getting so bad without any air.

Ellen I want you to live right and come to heaven. Raise the children the best you can. Oh how I wish to be with you, goodbye. Bury me and Elbert in the same grave by little Eddy Godbye Ellen, goodbye Lily, goodbye Jemmie goodbye Horace. Is 25 minutes after two There is a few of us alive yet

Jake and Elbert

Oh God for one more breath Ellen remember me as long as you live Goodbye darling

Letter written by Jacob L. Vowell shortly before he died of suffocation in the 1902 Fraterville (Tenn.) mine disaster.

THIS IS A LETTER WRITTEN BY A MINER SHORTLY BEFORE HE DIED OF SUFFOCATION IN A 1902 MINE DISASTER.