

# Heli Source Ltd.

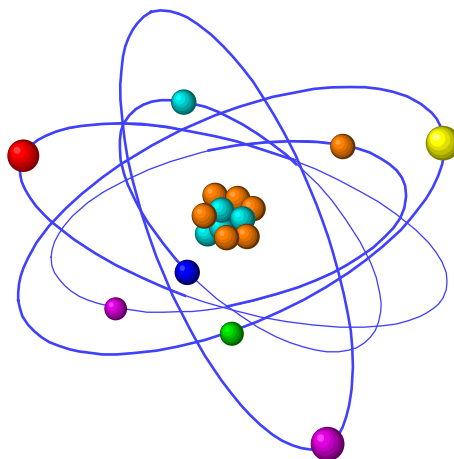
Work Order-Ref #: 22410

## Vapor Intrusion Assessment (VIA)

## Surface Casing Vent (SCV) Flow Test

**Cameron Hills L-47**

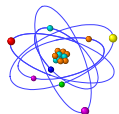
October 28, 2022



**GCHEM** Ltd.

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FORENSIC SOLUTIONS FOR ENERGY CHALLENGES

**1.0 Vapor Intrusions Assessment (VIA) Summary**

**Operating Company:** Not Provided  
**Well Name:** L-47  
**UWI:** 60-10N 117-30W

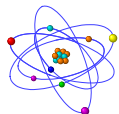
**License Number:** Not Provided  
**Test Date** October 28, 2022  
**GCHEM Project Number** 22410

**1.1 Production Casing Assessment Summary Table**

<b>Combustible Gas (CH<sub>4</sub>) (%LEL)</b>	nm		
<b>Hydrogen Sulphide (H<sub>2</sub>S) Gas (ppm v/v)</b>	nm		
<b>PC Flow Rate (m<sup>3</sup>/day)</b>	nm		
<b>P-T Date Logger Installed</b>	nm		
<b>P-T Data Logger Removed</b>	nm		
<b>P-T Data Logger Test Duration</b>	nm		
<b>MAX Pressure (kPa)</b>	nm		
<b>Gas Spl. Collection-Measurement</b>	<b>Total Collected</b>	<b>Analysis Requested*</b>	<b>Classification**</b>
<b>PC Samples (Total)</b>	0		
<b>PC Combustible Gas Class. Level-1 (Chemical)</b>		NA	NA
<b>PC Combustible Gas Class. Level-2 (δ<sup>13</sup>C)</b>		NA	NA
<b>PC Combustible Gas Class. Level-3 (δD)</b>		NA	NA
<b>PC Combustible Gas Class. Level-4 (<sup>14</sup>C)</b>		NA	NA

**1.2 Surface Casing Vent Flow (SCVF) Assessment Summary Table**

<b>SCV Ten-Minute Bubble Test Result</b>	PASS		
<b>SCV Flow Rate (m<sup>3</sup>/day)</b>	0		
<b>SCV Pressure-Temp Logger Installed</b>	NA		
<b>SCV Pressure-Temp Data Logger Removed</b>	NA		
<b>SCV Shut-In Time (hrs)</b>	NA		
<b>SCV MAX-Recorded Build Up Pressure (kPa)</b>	NA		
<b>SCV Stabilized Build-up Pressure (kPa):</b>	NA		
<b>SCV Stabilized Build-up Time (hours)</b>	NA		
<b>SCV Standpipe Max CH<sub>4</sub> Content:</b>	7.57 % vol.		
<b>SCV Standpipe Max H<sub>2</sub>S Content</b>	<1		
<b>SCV Gas Spl. Collection-Measurement</b>	<b>Total Collected</b>	<b>Analysis Requested*</b>	<b>Classification**</b>
<b>SCV Samples (Total)</b>	1		
<b>SCV Combustible Gas Class. Level-1 (Chemical)</b>		1	L.L. Combustible Gases
<b>SCV Combustible Gas Class. Level-2 (δ<sup>13</sup>C)</b>		NA	NA
<b>SCV Combustible Gas Class. Level-3 (δD)</b>		NA	NA
<b>SCV Combustible Gas Class. Level-4 (<sup>14</sup>C)</b>		NA	NA



**1.3 Soils Outside Casing (AGM) Assessment Summary Tables**

**A) Non-Intrusive CH<sub>4</sub> Surface Soil Scan (PMD) (Figure-1 and Table-1)**

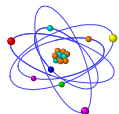
Well Casing Surface CH <sub>4</sub> Test Sites	28
MAX Surface CH <sub>4</sub> Reading	1 ppm v/v
MAX H <sub>2</sub> S Well Soil Reading (ppm v/v)	<1
Number of Background Sites	1
MAX Background CH <sub>4</sub> (ppm v/v)	1
Max H <sub>2</sub> S BKG Soil Reading (ppm v/v)	<1
<b>Surface CH<sub>4</sub>-PMD Gas Classification</b>	
NON-IMPACTED	

**B) Non-Intrusive Surface Enclosed Soil Vapor FLUX Chamber Test**

Surface SV-FC CH <sub>4</sub> Test Sites	nm		
MAX SV-FC CH <sub>4</sub> Reading	nm		
<b>SV-FC Gas Spl. Collection-Measurement</b>	<b>Total Collected</b>	<b>Analysis Requested*</b>	<b>Test Site</b>
SV-FC Samples (Total)	0		
SV-FC & Sites Requested for Level-1 Analysis		NA	NA
Combustible Gas Classification Level-1 (Chem.)		NA	
SV-FC & Sites Requested for Level-2 Analysis		NA	NA
Combustible Gas Classification Level-2 (δ <sup>13</sup> C)		NA	
SV-FC & Sites Requested for Level-3 Analysis		NA	NA
Combustible Gas Classification Level-3 (δD)		NA	
SV-FC & Sites Requested for Level-4 Analysis		NA	NA
Combustible Gas Classification Level-4 ( <sup>14</sup> C)		NA	

**C) Intrusive Auger Test Holes with Soil Vapor Probes (Figure 2 and Table 2)**

Number Soil Vapor Probe (SVP) Test Sites	15		
MAX SVP CH <sub>4</sub> Reading (ppm v/v)	2289		
Max H <sub>2</sub> S SVP Field Reading (ppm v/v)	<1		
Number SVP BKG Test Sites	1		
MAX SVP CH <sub>4</sub> BKG Test Sites (ppm v/v)	1		
<b>SVPs Gas Spl. Collection &amp; Measurement</b>	<b>Total Collected</b>	<b>Analysis Requested*</b>	<b>Test Site</b>
Soil Vapor Probes (SVPs) AGM (Total)	4		
SVP & Sites Requested for Level-1 Analysis		4	S0.5, W0.5, W1 & W3
Combustible Gas Classification Level-1 (Chem.)		NON-IMPACTED	
SVP & Sites Requested for Level-2 Analysis		0	NA
Combustible Gas Classification Level-2 (δ <sup>13</sup> C)		NA	
SVP & Sites Requested for Level-3 Analysis		0	NA
Combustible Gas Classification Level-3 (δD)		NA	
SVP & Sites Requested for Level-4 Analysis		0	NA
Combustible Gas Classification Level-4 ( <sup>14</sup> C)		NA	



BKG Gas Spl. Collection-Measurement	Total Collected	Analysis Requested*	Test Site
<b>BKG Soil Vapor Probe (SVPs) (Total)</b>	1		
<b>BKG &amp; Sites Requested for Level-1 Analysis</b>		1	BKG NW20
<b>Combustible Gas Classification Level-1 (Chem.)</b>		BASELINE	
<b>BKG &amp; Sites Requested for Level-2 Analysis</b>		0	NA
<b>Combustible Gas Classification Level-2 (<math>\delta^{13}\text{C}</math>)</b>		NA	
<b>BKG &amp; Sites Requested for Level-3 Analysis</b>		0	NA
<b>Combustible Gas Classification Level-3 (<math>\delta\text{D}</math>)</b>		NA	
<b>BKG &amp; Sites Requested for Level-4 Analysis</b>		0	NA
<b>Combustible Gas Classification Level-4 (<math>^{14}\text{C}</math>)</b>		NA	

\* Sample selection for chemical and isotope analysis (geochemical analytical suite) selected by client/operator.

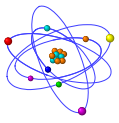
### 1.4 Interpreted Source of Migrating Gases

Sample Point	Geologic Formation	Depth Range	Source Depth
No samples submitted for stable isotope composition analysis.			

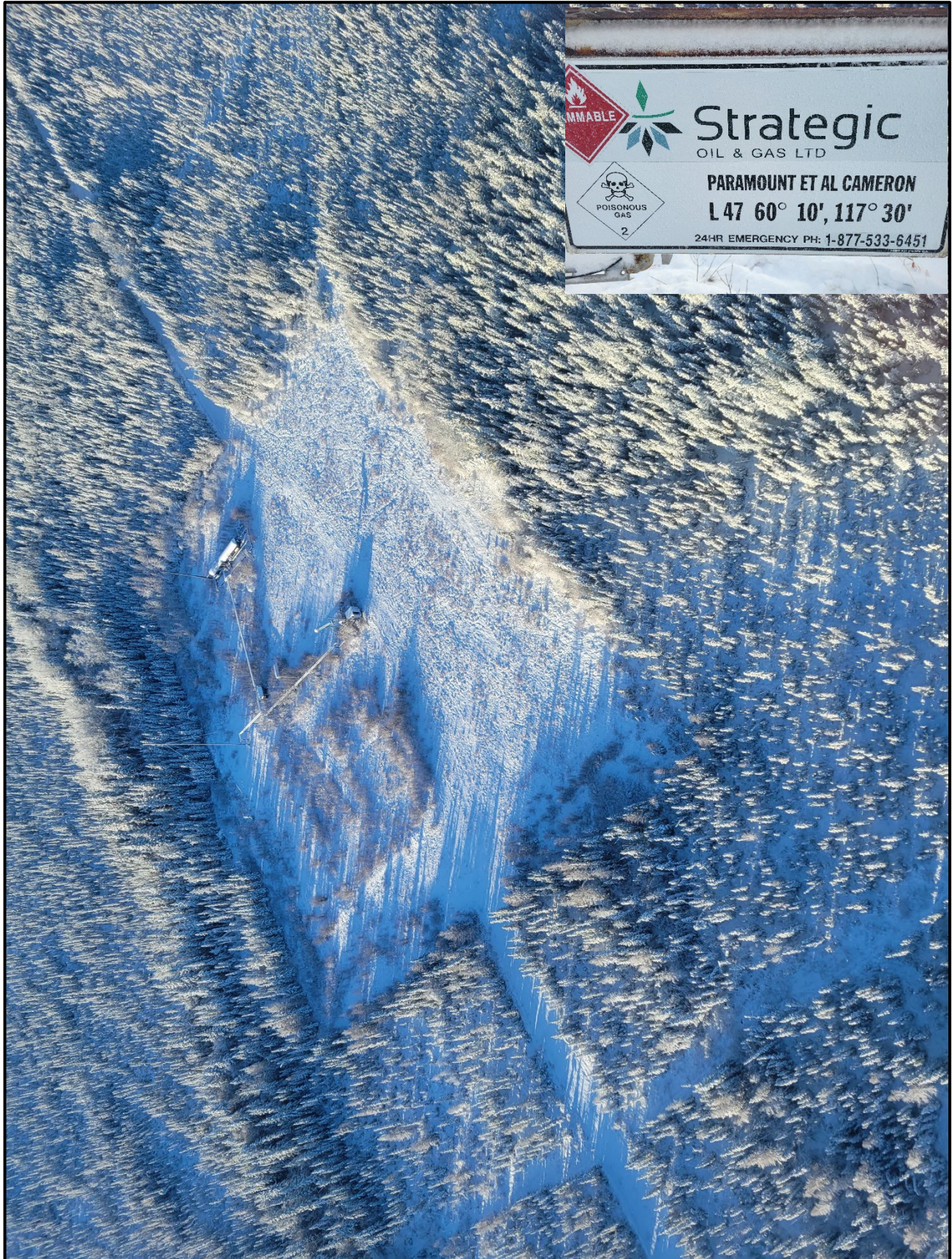
### 3.0 Vapor Intrusion and Surface Casing Vent Flow Testing and Sampling Comments

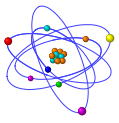
**Assessment-Collection Date: October 28, 2022**

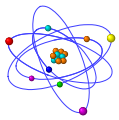
- 1) The Surface Casing Vent passed the ten-minute bubble test (7.57 % vol. methane).
- 2) Light alkane gas content of the SCV gases is elevated above baseline levels indicating the presence of thermogenic natural gases.
- 3) The SCV does not have any observable flow and the SCVF gases are comprised of predominantly atmospheric air (~95%). This indicates that gases in the surface casing are likely trapped, stagnant gas from previous drilling, production, service and abandonment operations and not active gas migration.
- 4) A surface combustible gas scan was performed near the wellbore using a Sensit Portable Methane Detector (PMD). All readings were low, (1 ppm v/v methane at N3) comparable to background (1 ppm v/v) established 20m northwest from the wellbore (Figure 1, Table 1).
- 5) An intrusive soil gas migration test was then performed by drilling test holes and inserting Soil Vapor Probes (SVPs). Combustible gas readings in the SVPs were elevated ( up to 2289 ppm v/v at W1), compared to the background probe (1 ppm v/v methane) installed approximately 20m northwest of the wellbore to establish background levels in the area and for comparison to other samples collected during this investigation (Figure 2, Table 2).
- 6) Four soil gas samples from SVPs (S0.5, W0.5, W1 & W3) and gases from background (BKG NW20) were collected, contained, and preserved for geochemical analysis and characterization, classification, geologic origin (source) and depth measured from the KB (Table 3).
- 7) C2 + light alkane gas levels in soil gases collected near the wellbore are low, comparable to background established 20m east of the wellbore (Figure 3). Elevated combustible gas readings in the soils are the result of the presence of biogenic methane (swamp gas).
- 8) C<sub>6+</sub> contents in the soil samples are low and comparable to background levels.
- 9) This well does not contain evidence of SCVF or gas migration at the time of this investigation.



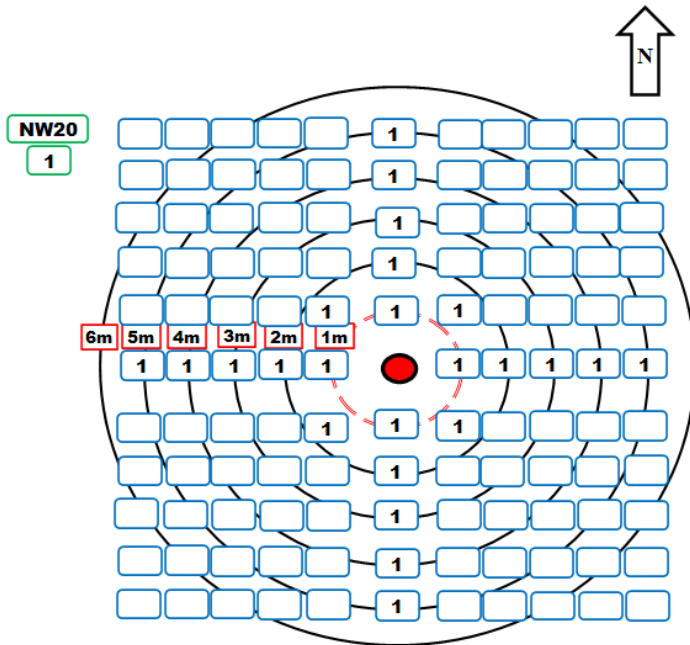
**Well Site Photographs**



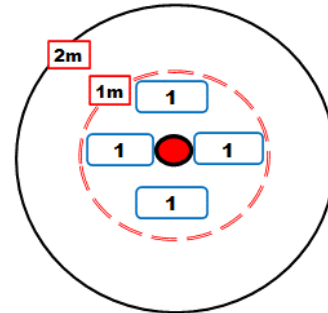




**Figure 1. AGM Non-Intrusive Surface PMD**



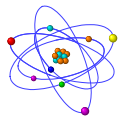
**Figure 1A. Non-Intrusive CH<sub>4</sub> Surface Well Casing Detail VIEW**



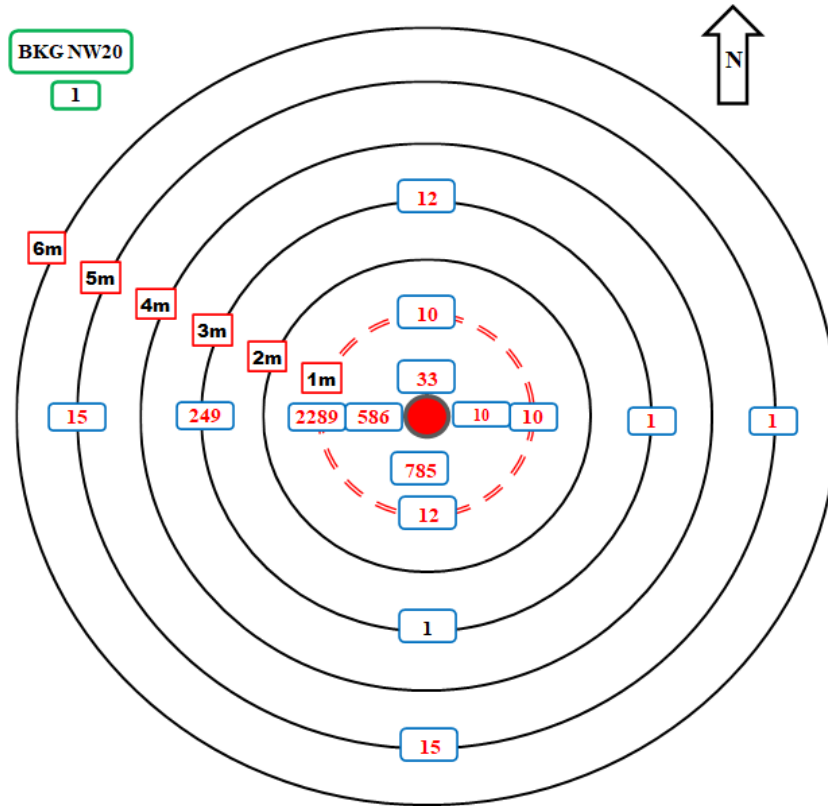
**Table 1. AGM Non-Intrusive Surface PMD**

WELL CASING (AGM) Non-Intrusive Surface PMD (CH <sub>4</sub> ) Soil Scan											
Test	PMD CH <sub>4</sub>		Test	PMD CH <sub>4</sub>		Test	PMD CH <sub>4</sub>		Test	PMD CH <sub>4</sub>	
Site (m)	(ppm v/v)	(% Vol)	Site (m)	(ppm v/v)	(% Vol)	Site (m)	(ppm v/v)	(% Vol)	Site (m)	(ppm v/v)	(% Vol)
N.5	1		E.5	1		S.5	1		W.5	1	
N1	1		E1	1		S1	1		W1	1	
N2	1		E2	1		S2	1		W2	1	
N3	1		E3	1		S3	1		W3	1	
N4	1		E4	1		S4	1		W4	1	
N5	1		E5	1		S5	1		W5	1	
N5-E1			E5-S1			S5-W1			W5-N1		
N4-E1			E5-S2			S4-W1			W5-N2		
N3-E1			E5-S3			S3-W1			W5-N3		
N2-E1			E5-S4			S2-W1			W5-N4		
N1-E1	1		E5-S5			S1-W1	1		W5-N5		
N1-E2			E4-S5			S1-W2			W4-N5		
N2-E2			E4-S4			S2-W2			W4-N4		
N3-E2			E4-S3			S3-W2			W4-N3		
N4-E2			E4-S2			S4-W2			W4-N2		
N5-E2			E4-S1			S5-W2			W4-N1		
N5-E3			E3-S1			S5-W3			W3-N1		
N4-E3			E3-S2			S4-W3			W3-N2		
N3-E3			E3-S3			S3-W3			W3-N3		
N2-E3			E3-S4			S2-W3			W3-N4		
N1-E3			E3-S5			S1-W3			W3-N5		
N1-E4			E2-S5			S1-W4			W2-N5		
N2-E4			E2-S4			S2-W4			W2-N4		
N3-E4			E2-S3			S3-W4			W2-N3		
N4-E4			E2-S2			S4-W4			W2-N2		
N5-E4			E2-S1			S5-W4			W2-N1		
N5-E5			E1-S1	1		S5-W5			W1-N1	1	
N4-E5			E1-S2			S4-W5			W1-N2		
N3-E5			E1-S3			S3-W5			W1-N3		
N2-E5			E1-S4			S2-W5			W1-N4		
N1-E5			E1-S5			S1-W5			W1-N5		

BACKGROUND Non-Intrusive Surface PMD (CH <sub>4</sub> ) Soil Scan											
Test	PMD CH <sub>4</sub>		Test	PMD CH <sub>4</sub>		Test	PMD CH <sub>4</sub>		Test	PMD CH <sub>4</sub>	
Site (m)	(ppm v/v)	(%)	Site (m)	(ppm v/v)	(%)	Site (m)	(ppm v/v)	(%)	Site (m)	(ppm v/v)	(%)
NW20	1										



**Figure 2. AGM Intrusive SVPs-**

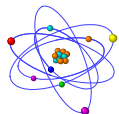


**Table 2. AGM Intrusive SVPs**

Test Site (m)	Intrusive AGM -Test Hole-Install Soil Vapor Probes (SVPs) ATM-Isolated			Soil Parameters			Gas Sample (Y-N)
	Soil Vapor Probes		H <sub>2</sub> S (ppm v/v)	Type	Moist. (1-5)	HC-CONT (Y-N)	
	IR-CH <sub>4</sub> (ppm v/v)	(%LEL)					
N0.5	33		<1.0	Silt / Clay	3	Yes	No
N1	10		<1.0	Silt / Clay	3	No	No
N3	12		<1.0	Silt / Clay	3	No	No
E0.5	10		<1.0	Silt / Clay	3	No	No
E1	10		<1.0	Silt / Clay	3	No	No
E3	1		<1.0	Silt / Clay	3	No	No
E3	1		<1.0	Silt / Clay	3	No	No
S0.5	785		<1.0	Silt / Clay	3	No	Yes
S1	12		<1.0	Silt / Clay	3	No	No
S3	1		<1.0	Silt / Clay	3	No	No
S5	15		<1.0	Silt / Clay	3	No	No
W0.5	586		<1.0	Silt / Clay	3	Yes	Yes
W1	2289		<1.0	Silt / Clay	3	No	Yes
W3	249		<1.0	Silt / Clay	3	No	Yes
W5	15		<1.0	Silt / Clay	3	No	No

Test Site (m)	Soil Vapor Probes			Soil Parameters			Gas Sample (Y-N)
	IR-CH <sub>4</sub>		H <sub>2</sub> S (ppm v/v)	Type	Moist. (1-5)	HC-CONT (Y-N)	
	(ppm v/v)	(% Vol)					
BKG NW20	1		<1.0	Silt / Clay	3	No	Yes



**Table 3: High resolution molecular compositions of gas samples collected as part of the VIA Heli Source L-47.**

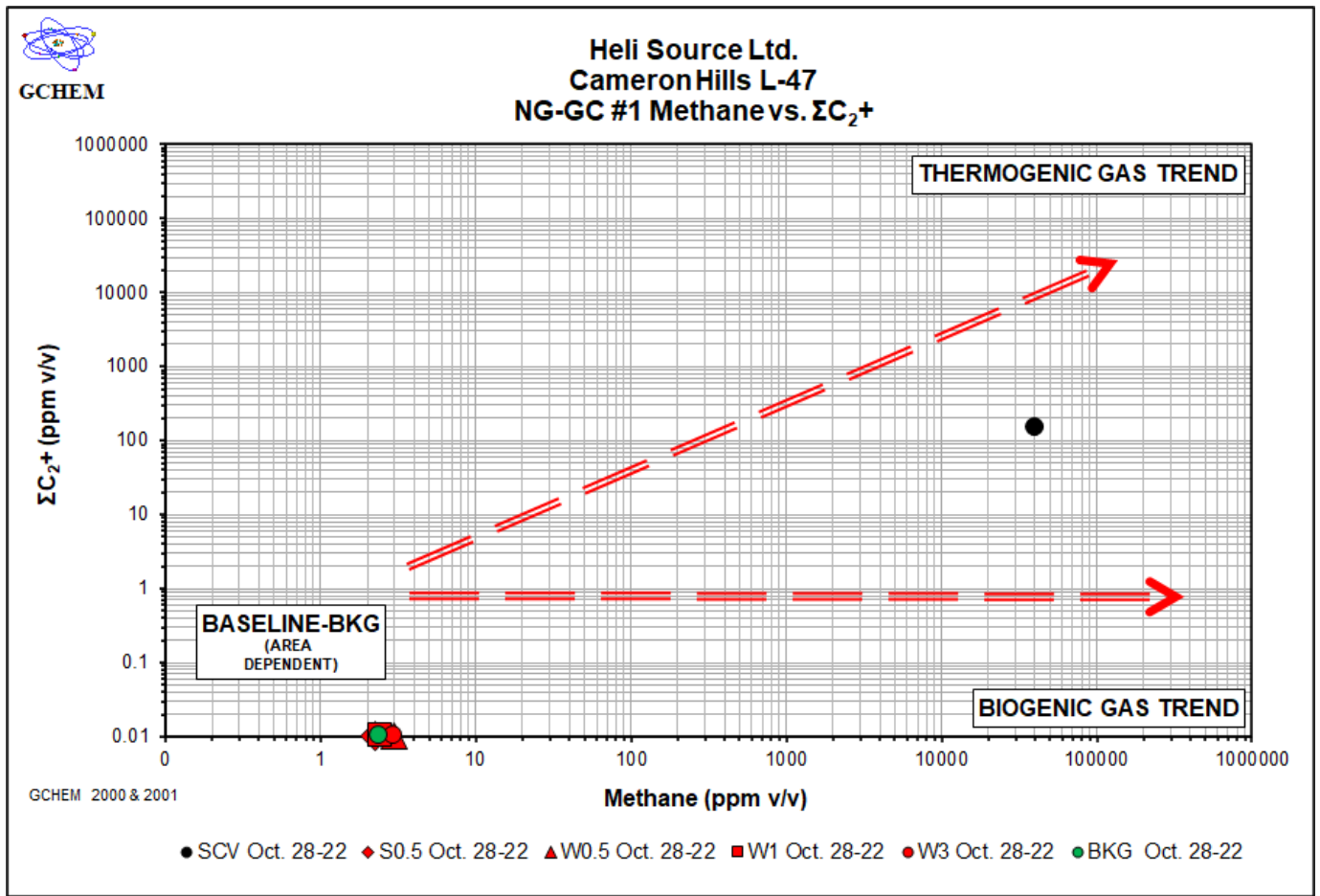
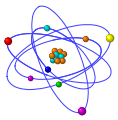
Gas Component	Sample Point	SCV	S0.5	W0.5	W1	W3	BKG
	Date Collected	Oct. 28-22	Oct. 28-22	Oct. 28-22	Oct. 28-22	Oct. 28-22	Oct. 28-22
		ppm v/v	ppm v/v	ppm v/v	ppm v/v	ppm v/v	ppm v/v
Neon		16.86	18.19	17.87	17.12	17.46	17.55
Hydrogen		15.55	160.9	22.13	11.80	11.80	202.8
Helium		79.55	4.01	4.06	3.88	8.41	3.96
Nitrogen		749607	776677	780076	776652	777276	774565
Oxygen		209333	222199	219666	222784	222231	224307
Carbon Dioxide		489.9	938.9	206.4	528.7	452.6	901.3
Methane		40303	2.26	3.00	2.45	2.98	2.41
Ethane		130.4	<0.01	<0.01	<0.01	<0.01	<0.01
Ethene		0.00	<0.01	<0.01	<0.01	<0.01	<0.01
Propane		16.95	<0.01	<0.01	<0.01	<0.01	<0.01
Propene		0.00	<0.01	<0.01	<0.01	<0.01	<0.01
iso-Butane		2.67	<0.01	<0.01	<0.01	<0.01	<0.01
n-Butane		2.36	<0.01	<0.01	<0.01	<0.01	<0.01
iso-Pentane		1.34	<0.01	<0.01	<0.01	<0.01	<0.01
n-Pentane		1.58	<0.01	<0.01	<0.01	<0.01	<0.01
C6+		0.62	0.23	3.73	0.25	0.25	0.53

C1 Index (C1/ΣC2+)	266.4	N/A	N/A	N/A	N/A	N/A
C2 Index (C2/ΣC3+)	6.24	N/A	N/A	N/A	N/A	N/A
C3 Index (C3/ΣC4+)	4.30	N/A	N/A	N/A	N/A	N/A
C4 Index (C4/C5)	1.49	N/A	N/A	N/A	N/A	N/A
ΣC2+	151.3	N/A	N/A	N/A	N/A	N/A
ATM Ratio (N2/O2)	3.58	3.50	3.55	3.49	3.50	3.45
Vol % CO2 of TG	0.05	0.09	0.02	0.05	0.05	0.09
Vol % Lt. Alk. of TG	4.05	0.00	0.00	0.00	0.00	0.00
Vol % Lt. Alk. CH4	99.62	100.0	100.0	100.0	100.0	100.0
Vol % Lt. Alk. C2+	0.38	0.00	0.00	0.00	0.00	0.00
Vol % C2+ of TG	0.02	0.00	0.00	0.00	0.00	0.00

Stable Carbon Isotope Compositions (‰ VPDB)							
d13C CH4	nm	nm	nm	nm	nm	nm	
d13C C2H6	nm	nm	nm	nm	nm	nm	
d13C C2H4	nm	nm	nm	nm	nm	nm	
d13C C3H8	nm	nm	nm	nm	nm	nm	
d13C C3H6	nm	nm	nm	nm	nm	nm	
d13C i-C4H10	nm	nm	nm	nm	nm	nm	
d13C n-C4H10	nm	nm	nm	nm	nm	nm	
d13C i-C5H12	nm	nm	nm	nm	nm	nm	
d13C n-C5H12	nm	nm	nm	nm	nm	nm	
d13C CO2	nm	nm	nm	nm	nm	nm	

Stable Hydrogen Isotopic Compositions (‰ VSMOW)							
dD H2	nm	nm	nm	nm	nm	nm	
dD CH4	nm	nm	nm	nm	nm	nm	
dD C2H6	nm	nm	nm	nm	nm	nm	
dD C3H8	nm	nm	nm	nm	nm	nm	
dD i-C4H10	nm	nm	nm	nm	nm	nm	
dD n-C4H10	nm	nm	nm	nm	nm	nm	

14C Concentration (pMC)	nm	nm	nm	nm	nm	nm
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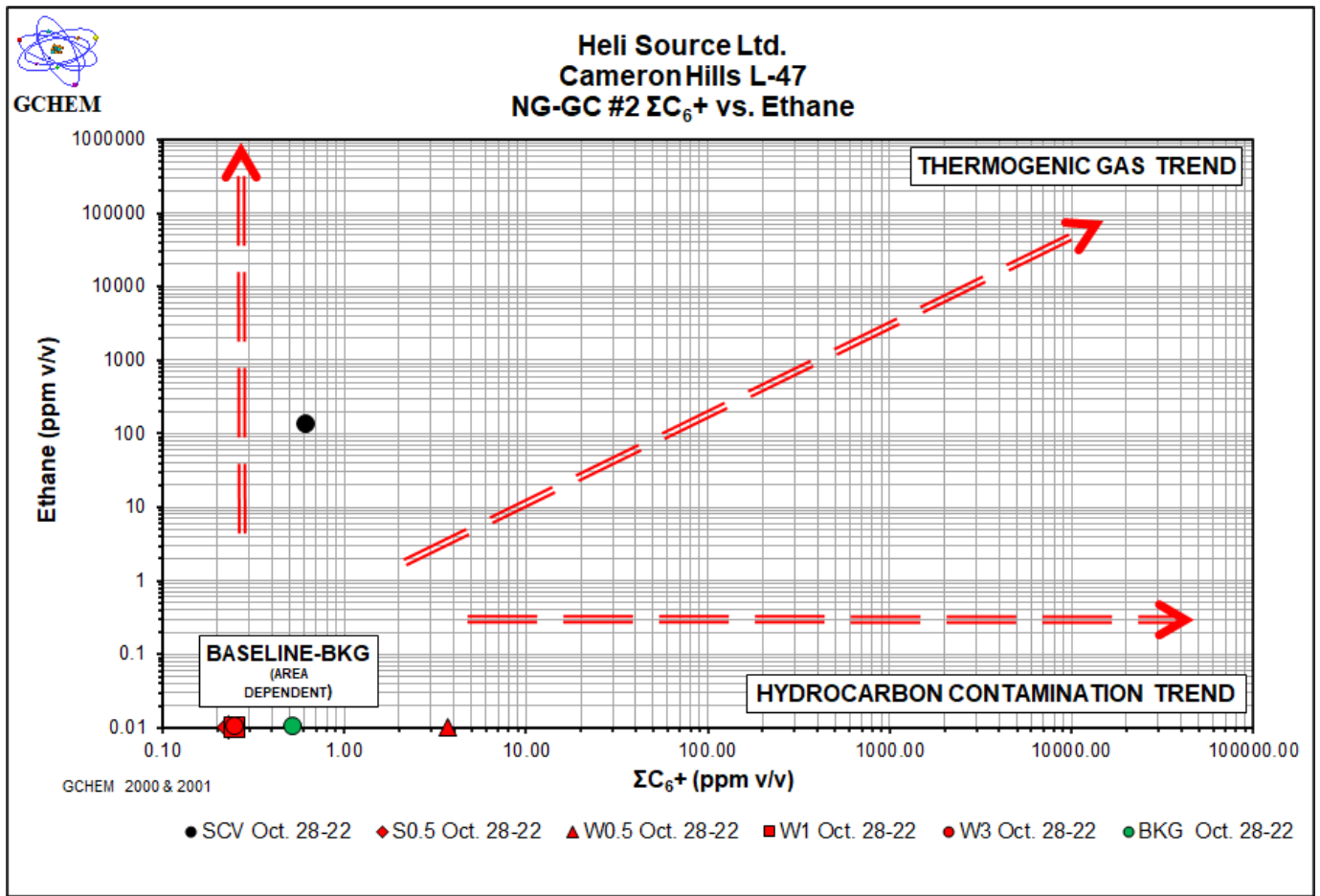
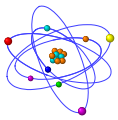


**Figure 3:  $\Sigma C_2+$  vs Methane.** Combustible gases detected in soils and SCVs at a wellhead may result from several origins. Natural gases indicative of SCVF or AGM are thermogenic in origin (natural gas in deep reservoirs), contain high methane and  $C_2+$  contents and plot in the Upper RH Quadrant. Low natural gas levels in background, off lease areas are naturally present in soils, vary from region to region and plot in the Lower LH Quadrant. Biogenic gases (swamp-gas) are produced by bacteria, are comprised of predominantly methane and plot in Lower RH Quadrant. Samples plotting in the Lower LH and RH do not contain SCVF or AGM and would not require down-hole remediation

NG-GC-1 Comments

**NG-GC-1 Comments**

- 1) Natural gases in the SCV contains elevated levels of  $C_2+$  gases.
- 2) The soils near the wellbore contain baseline levels of light alkane gases.



**Figure 4:  $\Sigma C_6+$  vs Ethane.**  $C_6+$  gases are relatively large molecules that do not readily or easily migrate in large quantities from depth upwards through subsurface fractures or micro-fractures to surface. Contamination by oil spills, fuels, and solvents is indicated by soil vapor samples that have high contents of  $C_6+$  compounds and plot in the Lower RH Quadrant. Samples plotting in the Lower LH and RH Quadrants do not contain evidence of either SCVF or AGM and would not require downhole repair operations.

**NG-GC-2 Comments**

- 1)  $C_6+$  contents of the SCV and soil gas samples are low and are similar to expected baseline readings. Measured combustible gas levels are not the result of near surface hydrocarbon or chemical contamination.