ENERGY-FORENSICS

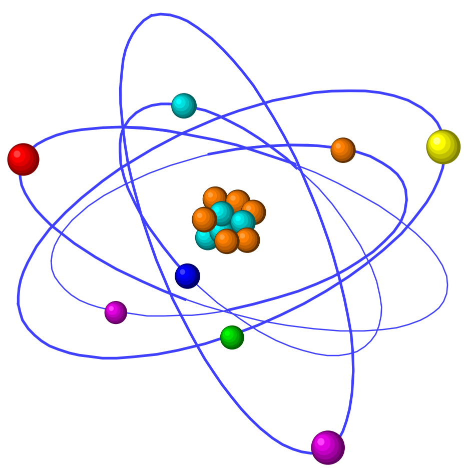
Strategic Oil & Gas Ltd.

Work Order-Ref #: 19129

Vapor Intrusion Assessment (VIA) Soils Outside Casing (AGM)

Strategic et al Cameron C-19

September 11 & 12, 2019



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FORENSIC SOLUTIONS FOR ENERGY CHALLENGES

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1.0 Executive Summary

On September 11-12, 2019, Strategic et al Cameron Hills C-19 was investigated for natural gas leakage in soils outside of casing (AGM). Total Combustible gases (%LEL) and H_2S levels were used to measure gas levels and types at soil test sites. Gas samples were collected, contained and preserved from soils outside casing (AGM) and for baseline comparison, background locations, ~30m away from the well bore were also assessed.

Soils outside casing immediately adjacent to, S and E of the well bore were water saturated however, no gas bubbling in standing water was observed. A 112 site non-intrusive surface CH_4 scan was conducted in soils outside casing and at 3-background locations (N30m, E30m, and W30m). All sites tested near the wellbore contained low CH_4 gas levels (2 ppm v/v) that were similar to the 3-BKG sites. A total of 12 soil sites outside casing were assessed for gas leakage using an intrusive methodology where 5cm soil vapor test holes were augered into soils and Soil Vapor Probes (SVPs) were inserted into each test hole. Of the 12 soil vapor test sites outside casing, no sites contained elevated, above background (E30m 1192 ppm v/v) levels of methane gas. SOG selected 1 soil site (SVP N0.5m) to measure chemical and $\delta^{13}C$ isotopic compositions to aid in classifying combustible gas contents. N0.5m contained low levels of CH_4 gas and low, similar to background levels of associated ΣC_2+ gas. These values are below the minimum thresholds required for stable carbon and/or hydrogen isotope analysis and therefore no isotope compositions were measured. Based on chemical analysis, CH_4 gas is probably the result of low temperature biological degradation of organic matter generating methane gas (swamp gas). Low ΣC_2+ gas contents in soils outside casing at N0.5m are consistent with the natural movement of light hydrocarbon gases from reservoirs at depth, upward through subsurface fractures and micro-fractures to surface. This is a naturally occurring process in all hydrocarbon sedimentary basins in the world.

With information available to date, soil vapor test site N0.5m would be classified as ‘Biogenic-Naturally Occurring CH_4-Non-Impacted’.

2.0 Vapor Intrusion Assessment Summary

Operating Company: Strategic Oil & Gas Ltd.
Well Name: Strategic et al Cameron C-19
UWI: 300C196010117300

License Number: 001767
Test Date September 11-12, 2019
GCHEM Project Number 19129

2.1 Production Casing Test Summary

Combustible Gas (CH_4) ([%LEL])	nm		
Hydrogen Sulphide (H_2S) Gas (ppm v/v)	nm		
PC Flow Rate (m^3/day)	nm		
P-T Date Logger Installed	nm		
P-T Data Logger Removed	nm		
P-T Data Logger Test Duration	nm		
MAX Pressure (kPa)	nm		
Gas Spls. Collection-Measurement	**Total Collected**	**Analysis Requested***	**Classification****
PC Samples (Total)	0		
PC Combustible Gas Class. Level-1 (Chemical)		NA	NA
PC Combustible Gas Class. Level-2 ($\delta^{13}C$)		NA	NA
PC Combustible Gas Class. Level-3 (δD)		NA	NA
PC Combustible Gas Class. Level-4 (^{14}C)		NA	NA

2.2 Surface Casing Vent Flow (SCVF) Test Summary

SCV Ten-Minute Bubble Test Result	nm		
SCV Flow Rate (m^3/day)	nm		
SCVF Pressure-Temp Logger Installed	nm		
SCV Pressure-Temp Data Logger Removed	nm		
SCV Shut-In Time (hrs)	nm		
SCV MAX-Recorded Build Up Pressure (kPa)	nm		
SCV Stabilized Build-up Pressure (kPa):	nm		
SCV Stabilized Build-up Time (hours)	nm		
SCV Standpipe Max CH_4 Content (% LEL):	nm		
SCV Standpipe Max H_2S Content	nm		
SCV Gas Spls. Collection-Measurement	**Total Collected**	**Analysis Requested***	**Classification****
SCV Samples (Total)	0		
SCV Combustible Gas Class. Level-1 (Chemical)		NA	NA
SCV Combustible Gas Class. Level-2 ($\delta^{13}C$)		NA	NA
SCV Combustible Gas Class. Level-3 (δD)		NA	NA
SCV Combustible Gas Class. Level-4 (^{14}C)		NA	NA

2.3 Soil Gas Migration Test-Vapor Intrusion Assessment: Soils Outside Casing (AGM) Summary

A) Non-Intrusive CH_4 Surface Soil Scan (PMD) (Figure 1 and Table 1)

Well Casing Surface CH_4 Test Sites	112
MAX Surface CH_4 Reading	2
MAX H_2S Well Soil Reading (ppm v/v)	<1
Number of Background Sites	3
MAX Background CH_4 (ppm v/v)	2
Max H_2S BKG Soil Reading (ppm v/v)	<1
Surface CH_4-PMD Gas Classification	

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

Surface SV-FC CH_4 Test Sites	0		
MAX SV-FC CH_4 Reading	nm		
SV-FC Gas Spls. Collection-Measurement	**Total Collected**	**Analysis Requested***	**Test Site**
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 ($\delta^{13}C$)		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 (^{14}C)		NA	

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

Number Soil Vapor Probe (SVP) Test Sites	12		
MAX SVP CH_4 Reading (%LEL)	1.4		
Max H_2S SVP Field Reading (ppm v/v)	<1		
Number SVP BKG Test Sites	3		
MAX SVP CH_4 BKG Test Sites (ppm v/v)	1192		
SVPs Gas Spl. Collection & Measurement	**Total Collected**	**Analysis Requested***	**Test Site**
Soil Vapor Probes (SVPs) AGM (Total)	4		
Soil Vapor Probes (SVPs) AGM (Total)		1	N0.5m
SVPs & Sites Requested for Level-1 Analysis		Biogenic-Non Impacted	
Combustible Gas Classification Level-1 (Chem.)		1	N0.5m
SVPs & Sites Requested for Level-2 Analysis		Biogenic-Non Impacted	
Combustible Gas Classification Level-2 ($\delta^{13}C$)		0	NA
SVPs & Sites Requested for Level-3 Analysis		NA	
Combustible Gas Classification Level-3 (δD)		0	NA
SVPs & Sites Requested for Level-4 Analysis		NA	

BKG Gas Spl. Collection-Measurement	Total Collected	Analysis Requested*	Test Site
BKG Soil Vapor Probe (SVPs) (Total)	3		
SVPs & Sites Requested for Level-1 Analysis		1	BKG E30m
Combustible Gas Classification Level-1 (Chem.)		Biogenic-Naturally Occurring-Baseline	
SVPs & Sites Requested for Level-2 Analysis		1	BKG E30m
Combustible Gas Classification Level-2 ($\delta^{13}C$)		Biogenic-Naturally Occurring-Baseline	
SVPs & Sites Requested for Level-3 Analysis		0	
Combustible Gas Classification Level-3 (δD)		NA	
SVPs & Sites Requested for Level-4 Analysis		0	
Combustible Gas Classification Level-4 (^{14}C)		NA	

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

2.4 Interpreted Source of Natural Gas Found at/near Surface: measured depth from KB of the well (Figures 3 to 6)

Sample Point	Geologic Formation	Depth Range	Source Depth
SVP N0.5m	Near Surface Soil Respiration	Biogenic CH_4, Non-Impacted, Baseline	

3.0 Background of Vapor Intrusion Assessments (VIA) at Resource Wells & Tracing Gas Contents in the Environment using Energy Forensics

Undesired natural gas leakage from depth to surface at resource wells is becoming increasingly recognized and is a significant financial burden to the resource industry. When high levels of natural gas are found in the surface casing vent it is termed surface casing vent flow (SCVF) and when found in soils outside casing it is termed active gas migration (AGM). Identifying the source of leaking gas, maintaining zonal isolation and eliminating gas leakage to surface has proven to be a challenging task. Industry success rates using conventional gas leakage identification tools (e.g. noise, temperature, cement bond-integrity, ultra-sonic imaging logs, etc.) to eliminate surface gas migration in the first attempt is approximately 15% to 20%. Since 1997, through collaboration with industry, government regulators and academic institutions, GCHEM Ltd. has developed 'Energy-Forensics' and has obtained extensive expertise in field testing, gas sampling and preservation, analytical and interpretational techniques to pinpoint the geologic source of natural gases at resource wells.

It is important to note that detection of elevated combustible gases at surface does not always mean the well is impacted with deep sourced natural gas (thermogenic). Accurate gas characterization at well sites is critical as elevated CH_4 (%LEL) contents measured at or near surface may not indicate it is leaking or impacted (false-positive) but rather the combustible gases present are the result of biogenic activity or hydrocarbon contamination (or a combination of).

Thermogenic hydrocarbon gases have unique chemical and isotopic signatures based on many variables including the starting organic material they are produced from, the chemical processes from organic origin to current form, interaction with surrounding formation rock and fluids, and effects from migrating from origin to current trap. For example, molecular and isotopic composition ($\delta^{13}C$ and $\delta^{2}H$) of a low temperature, shallow sourced natural gas is significantly different with respect to those of a high temperature deep sourced natural gas. This principle allows the geologic source of leaking natural gas at a wellbore to be determined.

3.1 Biogenically Derived Methane Gas

As a normal part of soil respiration, methane may be generated via two biotic pathways (depending on substrate availability):

CO_2 reduction reaction	$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$
Fermentation Process	$CH_3COOH \rightarrow CH_4 + CO_2$

Biogenic methane gas may be further oxidized by bacteria. Oxidizing bacteria in soils preferentially consume ^{12}C over ^{13}C resulting the residual gas enriched in ^{13}C (i.e. $\delta^{13}C$ values become less negative) with respect to the biogenic gas (isotope enriching effect). Therefore, biogenic oxidization may provide the false signature of a 'mixture of biogenic and thermogenic methane' or 'thermogenic' gas (GCHEM in prep). Biogenic CH_4 is generally prevalent in landfill or swamp gas.

3.2 Thermogenic Methane Gas

Methane gas can be generated by abiotic processes such as the thermo-degradation of organic matter at high pressure and temperature (thermogenesis). During thermogenic CH_4 generation, pending organic matter content, pressure and temperature, associated C_2+ gases may also be formed. Thermogenic CH_4 and C_2+ gases contain enriched $\delta^{13}C$ and δD values pending gas maturity, mixing and alteration and torturous pathway from source to trap.

3.3 Classification, Characterization and Geological Origins of Combustible Gases in the Environment.

Combustible gases in soils outside casing maybe classified and characterized (biogenic, thermogenic or mixed) using chemical, carbon and hydrogen and isotopic measurements and ^{14}C concentrations. Leaking thermogenic natural gas in soils outside casing is easier to scientifically prove than biogenic methane sources. Elevated %LEL measured in AGM (on location) maybe the result of naturally occurring biogenic processes, anthropogenic leaking thermogenic natural gases and mixtures of both. A systematic 4-level approach can be used to determine the origins (biogenic-thermogenic or mixed) combustible gas contents and include:

1)	**Level-1 Characterization**	**High Resolution Compositional-Chemical Measurements.** Permanent, inert and CH_4 to n-C_5H_{12} & C_6+. See NGGC-1 CH_4 vs ΣC_2+ (Szatkowski et al 2000 & 2001). See NGGC-2 C_2H_6 vs. c_6+ (Szatkowski et al 2000 & 2001).
2)	**Level-2 Characterization**	**Stable Carbon Isotope Measurements ($\delta^{13}C$).** $\delta^{13}C$ CH_4 to n-C_5H_{12} & CO_2 (pending concentrations-gas levels). See NGGC-3 $CH_4/\Sigma C_2$+ vs. $\delta^{13}C$ CH_4 (Bernard 1978). See NGGC-4 $\delta^{13}C$ CO_2 vs. $\delta^{13}C$ CH_4 (Whiticar 1993).
3)	**Level-3 Characterization**	**Hydrogen in Methane (δD).** δD CH_4 to δD C_4H_{12} (pending concentrations-gas levels). See NGGC-5 $\delta^{13}C$ CH_4 vs δD CH_4 (Coleman 1993).
4)	**Level-4 Characterization**	**^{14}C pMC concentrations (radioactive ½ life of 5750 yr).** Pending concentrations-gas levels. ^{14}C reveals the age of the organic matter source from which CH_4 was generated but not the time of methanogenesis.

To determine the geological origins of leaking thermogenic natural gas contents, a series of plots developed by GCHEM Ltd are used and include.

1)	**Chemical & Isotopic Gas Field Diagram**	$C_2H_6/\Sigma C_3$+ vs $\delta^{13}C$ C_2H_6 (Szatkowski et al 2000, 2001).
2)	**Isotopic Gas Field Diagram**	$\delta^{13}C$ C_2H_6 vs. $\delta^{13}C$ C_3H_8 (Szatkowski et al 2000, 2001).
3)	**Modified Chung Plot**	$\delta^{13}C$ vs 1/n (carbon & hydrogen number) (Chung 1988, and GCHEM Ltd. Unpublished).

Additional chemical and stable carbon and hydrogen isotopic plots have been developed to aid in determining the geological origins of natural gas found in the environment however, GCHEM has not published these novel and new correlations and relationships and they will not be shown or discussed in detail at this time (GCHEM Unpublished Internal Research).

4.0 Methods and Results

4.1 Field Assessment Methods and Results

4.1.1 Non-Intrusive Vapor Intrusion Assessment

On September 11, 2019, GCHEM conducted a surface soil methane scan using a Sensit PMD (Figure 1). CH_4 readings were measured at 112 locations-test sites on a grid pattern (1m x 1m) covering approximately an 10m x 10m square area around the wellbore. Soils outside casing were wet (standing water in some areas) however, no gas bubbling in standing water was observed while conducting and the VIA in soils outside casing.

To establish baseline surface soil CH_4 gas levels, three background locations were assessed 30m from the well bore (N30m, E30m and W30m). To enhance results of the surface methane scan and reduce potential effects from industrial contamination, at each test site, an atmospheric CH_4 gas level was recorded, the PMD gas sampling wand was coupled to surface soils and the CH_4 level was recorded for that specific test site. Atmospheric CH_4 level was subtracted from the CH_4 level measured after ground coupling to derive a surface soil CH_4 level at that point of the grid.

All sites tested near the wellbore contained low levels of CH_4 gas (2 ppm v/v) that were similar to the BKG sites.

Figure 1. AGM Non-Intrusive Surface PMD

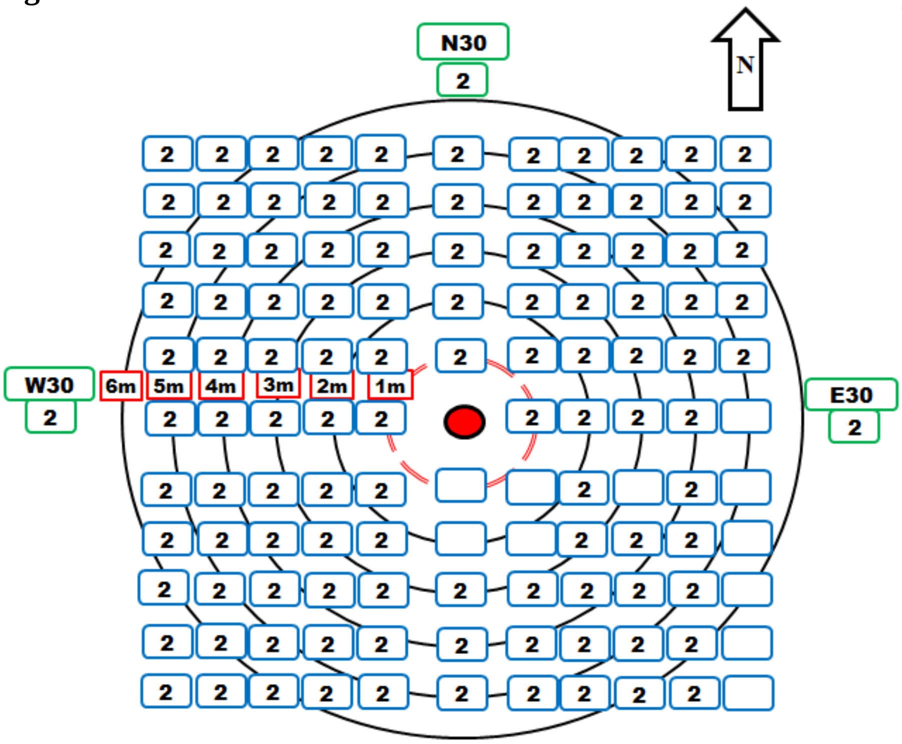
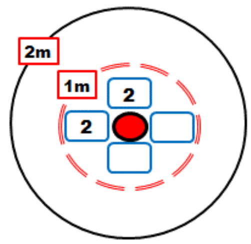


Figure-1A. NON-Intrusive CH_4 Surface Scan Well Casing Detail VIEW



Seeded grass surrounding the well casing is of similar stand-growth to surrounding lease vegetation. No stressed dead spots or discoloration was observed.

Table 1. AGM Non-Intrusive Surface PMD

WELL CASING (AGM) Non-Intrusive Surface PMD (CH_4) Soil Scan

Test Site (m)	PMD CH_4 (ppm v/v)	(% Vol)	Test Site (m)	PMD CH_4 (ppm v/v)	(% Vol)	Test Site (m)	PMD CH_4 (ppm v/v)	(% Vol)	Test Site (m)	PMD CH_4 (ppm v/v)	(% Vol)
N.5	2		E.5			S.5			W.5	2	
N1	2		E1	2		S1			W1	2	
N2	2		E2	2		S2			W2	2	
N3	2		E3	2		S3	2		W3	2	
N4	2		E4	2		S4	2		W4	2	
N5	2		E5			S5	2		W5	2	
N5-E1	2		E5-S1			S5-W1	2		W5-N1	2	
N4-E1	2		E5-S2			S4-W1	2		W5-N2	2	
N3-E1	2		E5-S3			S3-W1	2		W5-N3	2	
N2-E1	2		E5-S4			S2-W1	2		W5-N4	2	
N1-E1	2		E5-S5			S1-W1	2		W5-N5	2	
N1-E2	2		E4-S5	2		S1-W2	2		W4-N5	2	
N2-E2	2		E4-S4	2		S2-W2	2		W4-N4	2	
N3-E2	2		E4-S3	2		S3-W2	2		W4-N3	2	
N4-E2	2		E4-S2	2		S4-W2	2		W4-N2	2	
N5-E2	2		E4-S1	2		S5-W2	2		W4-N1	2	
N5-E3	2		E3-S1	2		S5-W3	2		W3-N1	2	
N4-E3	2		E3-S2	2		S4-W3	2		W3-N2	2	
N3-E3	2		E3-S3	2		S3-W3	2		W3-N3	2	
N2-E3	2		E3-S4	2		S2-W3	2		W3-N4	2	
N1-E3	2		E3-S5	2		S1-W3	2		W3-N5	2	
N1-E4	2		E2-S5	2		S1-W4	2		W2-N5	2	
N2-E4	2		E2-S4	2		S2-W4	2		W2-N4	2	
N3-E4	2		E2-S3	2		S3-W4	2		W2-N3	2	
N4-E4	2		E2-S2	2		S4-W4	2		W2-N2	2	
N5-E4	2		E2-S1	2		S5-W4	2		W2-N1	2	
N5-E5	2		E1-S1			S5-W5	2		W1-N1	2	
N4-E5	2		E1-S2			S4-W5	2		W1-N2	2	
N3-E5	2		E1-S3	2		S3-W5	2		W1-N3	2	
N2-E5	2		E1-S4	2		S2-W5	2		W1-N4	2	
N1-E5	2		E1-S5	2		S1-W5	2		W1-N5	2	

BACKGROUND Non-Intrusive Surface PMD (CH_4) Soil Scan

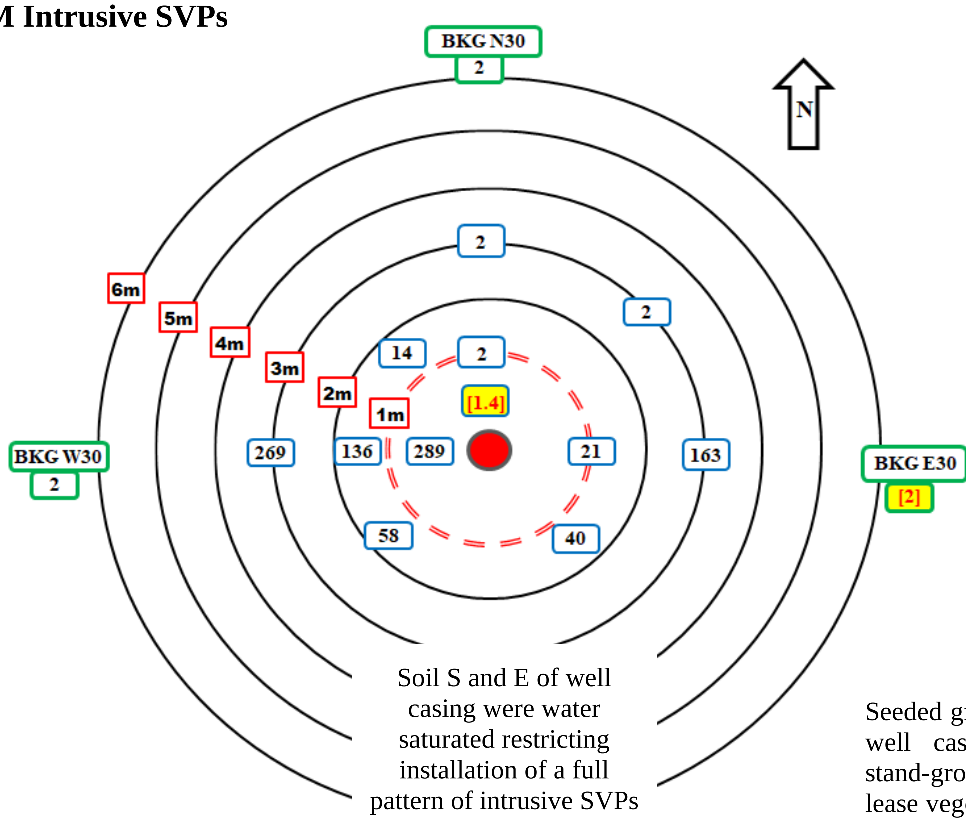
Test Site (m)	PMD CH_4 (ppm v/v)	(%)	Test Site (m)	PMD CH_4 (ppm v/v)	(%)	Test Site (m)	PMD CH_4 (ppm v/v)	(%)	Test Site (m)	PMD CH_4 (ppm v/v)	(%)
N30	2		E30	2					W30	2	

4.1.2 Intrusive Vapor Intrusion Assessment

A total of 12 soil sites outside casing were assessed for gas leakage using an intrusive methodology where a series of 5cm soil vapor test holes were augered into soils and Soil Vapor Probes (SVPs) were inserted into each test hole. The SVPs were allowed to stabilize for approximately 30-minutes prior to combustible gas content measurement with the PMD (Figure 2). Soils were water saturated primarily south of the well bore at depths below 1.5m thus a full intrusive 16-aurger hole test pattern could not be conducted.

Background SVP E30m contained 1192 ppm v/v CH_4. Of the 12 SVP soil vapor test sites assessed outside casing, no sites contained higher CH_4 levels when compared to BKG SVP E30m.

Figure 2. AGM Intrusive SVPs



Seeded grass surrounding the well casing is of similar stand-growth to surrounding lease vegetation. No stressed dead spots or discoloration was observed.

Table 2. AGM Intrusive SVPs

Intrusive AGM - Hand Auger-Test Hole-Install Soil Vapor Probes (SVPs) ATM-Isolated

Test Site (m)	Soil Vapor Probes IR-CH_4 (ppm v/v)	IR-CH_4 (%LEL)	H_2S (ppm v/v)	Soil Parameters Type	Moist. (1-5)	HC-CONT (Y-N)	Gas Sample (Y-N)	Site Assessment Comments
N.5	**705**	**[1.4]**	<1.0		5	no	Yes	
N1	**2**		<1.0		5	no		
N3	**2**		<1.0		5	no		
NE1.5	**2**		<1.0		5	no		
E.5								Surface Water
E1	**21**		<1.0		5	no		
E3	**163**		<1.0		5	no	Yes	
E5								Surface Water
SE1.5	**40**		<1.0		5	no		Final SVP-Watered Out
SW1.5	**58**		<1.0		5	no		Final SVP-Watered Out
S3								Surface Water
S5								Surface Water
W.5	**289**		<1.0		5	no	Yes	
W1.5	**136**		<1.0		5	no		
W3	**269**		<1.0		5	no	Yes	
NW1.5	**14**		<1.0		5	no		

Test Site (m)	Soil Vapor Probes IR-CH_4 (ppm v/v)	IR-CH_4 (% LEL)	$H2_S$ (ppm v/v)	Soil Parameters Type	Moist. (1-5)	HC-CONT (Y-N)	Gas Sample (Y-N)	Site Assessment Comments
BKG N30	**2**		<1.0		5	No	Yes	
BKG E30	**1192**	**[2]**	<1.0		5	No	Yes	
BKG W30	**2**		<1.0		5	No	Yes	

4.2 Analytical Methods

a. High Resolution Compositional Analysis (HRCA).
   i. He, H_2, O_2, N_2, CO_2, CH_4 to n-C_5H_{12} & C_6+
b. Stable Carbon ($\delta^{13}C$) and Hydrogen (δD) Isotopic Analysis.
   i. $\delta^{13}C$ CH_4 to n-C_5H_{12} and CO_2, and δD CH_4 to n-C_5H_{12}

Compositional (molecular) analyses were conducted at GCHEM's Analytical Laboratory using Hewlett Packard 5890 and Agilent 7890 Gas Chromatographs (GCs) configured for low (ppb v/v to ppm v/v) too high (vol. %) level detection of light alkane/alkene gases and atmospheric gas components. Chemical analysis of gases measured, and analytical error are shown in Table-1.

Stable carbon ($\delta^{13}C$) isotope ratios of light hydrocarbon gases (LHG) and carbon dioxide and hydrogen isotope ratios (δD) of LHG were also measured at GCHEM's Analytical Laboratory on a Thermo-Scientific MAT-253 Gas Chromatograph-Combustion-Continuous Flow-Isotope Ratio Mass Spectrometer (GC-C-CF-IRMS). Carbon isotope ratios are reported in delta (δ) notation and per mil (‰, parts per thousand) with respect to VPDB (Vienna Pee Dee Belemnite). Hydrogen isotope ratios are reported in delta (δ) notation and per mil (‰) with respect to VSMOW (Vienna Standard Mean Ocean Water).

Gas Component (ppmv)	Molecular Formula	Analytical Error (%)	Stable Carbon Isotopic Composition ($\delta^{13}C$)	Analytical Error (‰ VPDB)	Hydrogen Isotopic Composition (δD)	Analytical Error (‰ VSMOW)
Hydrogen	H_2	±7%	-	-	δD H_2	±10
Helium	He	±7%	-	-	-	-
Nitrogen	N_2	±7%	-	-	-	-
Oxygen	O_2	±7%	-	-	-	-
Carbon Dioxide	CO_2	±7%	$\delta^{13}C$ CO_2	±0.2	-	-
Hydrogen Sulphide	H_2S	±7%	-	-	-	-
Methyl Mercaptan	CH_4S	±7%	-	-	-	-
Ethyl Mercaptan	C_2H_6S	±7%	-	-	-	-
Thiophene	C_4H_4S	±7%	-	-	-	-
Dimethyl Disulfide	$C_2H_6S_2$	±7%	-	-	-	-
Methane	CH_4	±7%	$\delta^{13}C$ CH_4	±0.1	δD CH_4	±10
Ethane	C_2H_6	±7%	$\delta^{13}C$ C_2H_6	±0.2	δD C_2H_6	±10
Ethene	C_2H_4	±7%	$\delta^{13}C$ C_2H_4	±0.2	δD C_2H_4	±10
Propane	C_3H_8	±7%	$\delta^{13}C$ C_3H_8	±0.2	δD C_3H_8	±10
Propene	C_3H_6	±7%	$\delta^{13}C$ C_3H_6	±0.2	δD C_3H_6	±10
iso-Butane	i-C_4H_{10}	±7%	$\delta^{13}C$ i-C_4H_{10}	±0.2	δD i-C_4H_{10}	±10
normal-Butane	n-C_4H_{10}	±7%	$\delta^{13}C$ n-C_4H_{10}	±0.2	δD n-C_4H_{10}	±10
iso-Pentane	i-C_5H_{12}	±7%	$\delta^{13}C$ i-C_5H_{12}	±0.2	δD i-C_5H_{12}	±10
normal-Pentane	n-C_5H_{12}	±7%	$\delta^{13}C$ n-C_5H_{12}	±0.2	δD n-C_5H_{12}	±10
Hexane and higher	C_6+	±7%	-	-	-	-

Table 3. Gas components, isotopic compositions measured and the analytical error of the measurements at GCHEM's Analytical Laboratory.

5.0 Geochemical Measurements-Laboratory Results.

As part of this VIA (AGM), a total of 4 gas samples were collected, contained and preserved from the following locations or sample points: SVPs-soils outside casing (N0.5m, E3m, W0.5m and W3m) and 3-BKG locations (N30m, E30m and W30m).

At the request of the Strategic Oil and Gas, chemical and $\delta^{13}C$ isotopic compositions were measured for gases obtained from one site SVP N0.5m that contained elevated, above background, levels of combustible gases and for one BKG SVP E30m. High Resolution chemical and isotope compositions compositions were measured at GCHEM's Forensic Lab and are provided in Table 4.

5.1 Gases Obtained from Soil Vapor Probes (SVPs).

Gases measured in one SVP in soils near the well bore (N0.5m) contain above atmospheric levels of CO_2 (1553 ppm v/v). Methane gas was low (8.06 ppm v/v) and was lower than background levels measured at site BKG E30m (813.8 ppm v/v) (Table 4 and Figure 3). C_2+ gas levels in SVP N0.5m were low (<0.01) and were similar to background levels (<0.01 ppm v/v). Low methane and low associated C_2+ thermogenic gas contents suggests a biogenic or biotic source via CO_2 reduction or fermentation reactions for methane gas (Figure 3). C_{6+} gas contents at SVP site N0.5m were low (0.06 ppm v/v) and suggest hydrocarbon contamination was not present at the SVP test site (Figure 4).

Sufficient levels of CH_4, CO_2, and C_{2+} light alkanes were not available at N0.5m. C_2+ gas levels at SVP site N0.5m and were too low to measure $\delta^{13}C$ isotopic compositions to further characterize light hydrocarbon gas contents.

Table 4. High resolution molecular and stable carbon isotopic compositions of gas samples collected as part of the VIA at Strategic et al Cameron C-19. Hydrogen isotopic compositions were not measured at the request of SOG.

Sample Point / Date Collected / Gas Component	N.5 Sept. 11-19 (ppm v/v)	BKG E Sept. 11-19 (ppm v/v)
Hydrogen	4.02	4.54
Helium	3.05	2.86
Nitrogen	777601	774430
Oxygen	220831	217322
Carbon Dioxide	1553	7427
Methane	8.06	813.8
Ethane	<0.01	<0.01
Ethene	<0.01	<0.01
Propane	<0.01	<0.01
Propene	<0.01	<0.01
iso-Butane	<0.01	<0.01
n-Butane	<0.01	0.34
iso-Pentane	<0.01	0.13
n-Pentane	<0.01	<0.01
C_6+	0.06	0.08
C1 Index (C1/ΣC2+)	N/A	2425
C2 Index (C2/ΣC3+)	N/A	N/A
C3 Index (C3/ΣC4+)	N/A	N/A
C4 Index (C4/C5)	N/A	N/A
ΣC2+	N/A	0.34
ATM Ratio (N2/O2)	3.52	3.56
Vol % CO2 of TG	0.16	0.74
Vol % Lt. Alk. of TG	0.00	0.08
Vol % Lt. Alk. CH4	100.0	99.94
Vol % Lt. Alk. C2+	0.00	0.06
Vol % C2+ of TG	0.00	0.00
Stable Carbon Isotope Compositions (‰ VPDB)		
δ13C CH4	nm	nm
δ13C C2H6	nm	nm
δ13C C2H4	nm	nm
δ13C C3H8	nm	nm
δ13C C3H6	nm	nm
δ13C i-C4H10	nm	nm
δ13C n-C4H10	nm	nm
δ13C i-C5H12	nm	nm
δ13C n-C5H12	nm	nm
δ13C CO2	nm	nm
Stable Hydrogen Isotopic Compositions (‰ VSMOW)		
δD H2	nm	nm
δD CH4	nm	nm
δD C2H6	nm	nm
δD C3H8	nm	nm
δD i-C4H10	nm	nm
δD n-C4H10	nm	nm
14C Concentration (pMC)	nm	nm

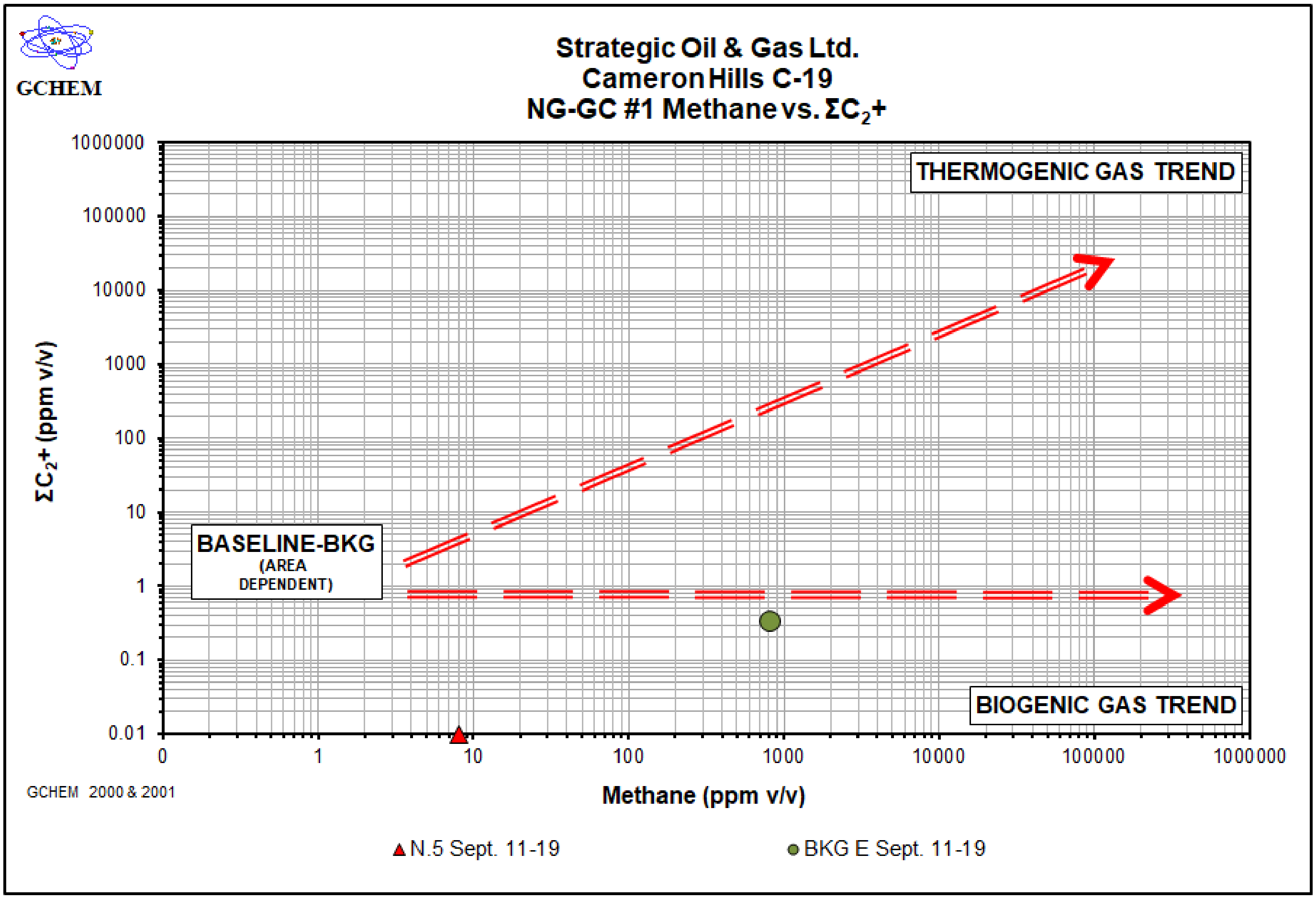


Figure-3. ΣC_2+ vs Methane. Combustible gases detected in soils and SCVs at a wellhead may result from several origins. Natural gases indicative of SCVF or AGM are thermogenic in origin (natural gas in deep reservoirs), contain high methane and C_2+ contents and plot in the Upper RH Quadrant. Low natural 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.

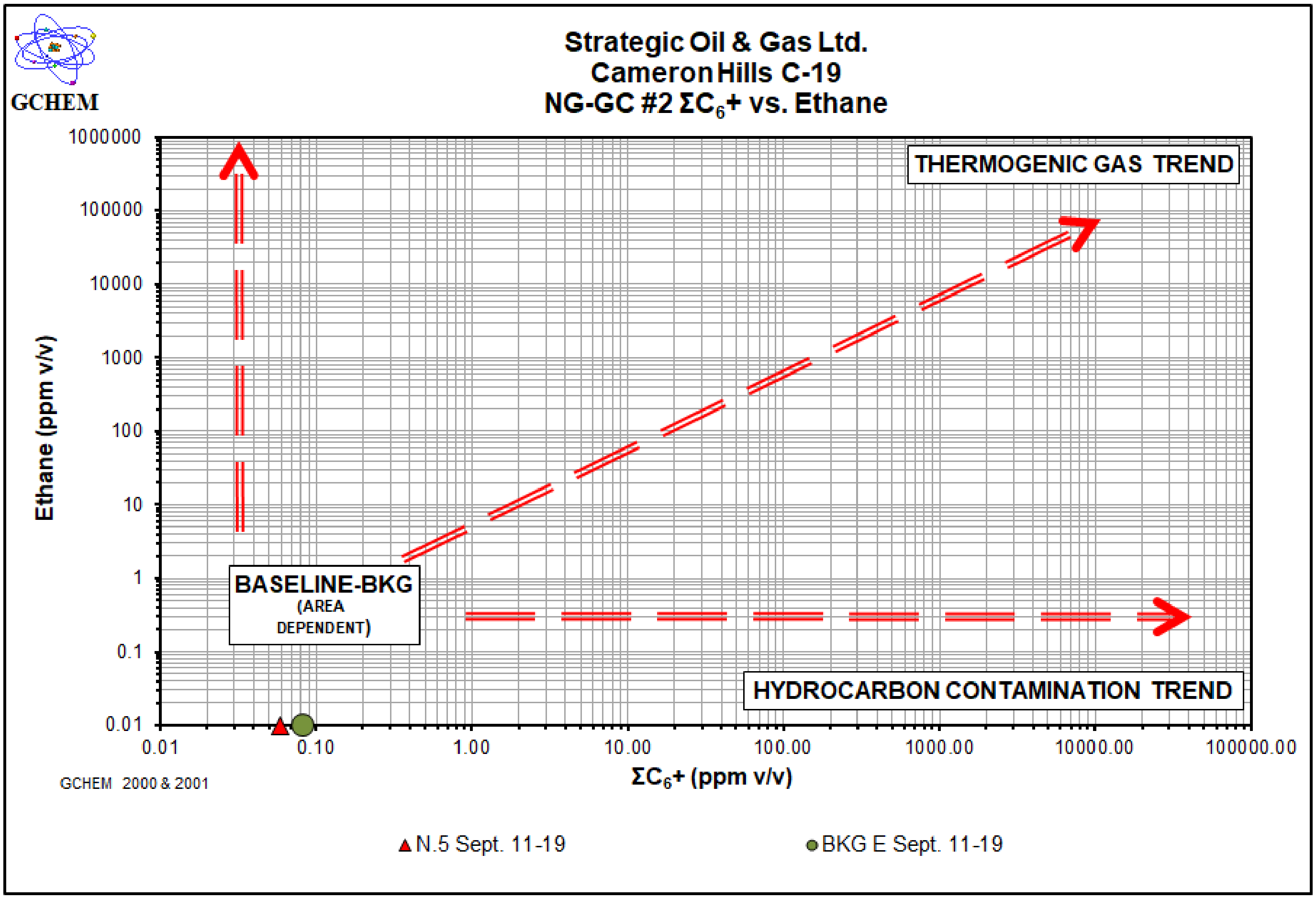


Figure 4. ΣC_6+ vs Ethane. C_6+ gases are relatively large molecules that do not readily or easily migrate in large quantities from depth upwards through subsurface fractures or micro-fractures to surface. Contamination by oil spills, fuels, and solvents is indicated by soil vapor samples that have high 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.

6.0 Conclusions

Soils outside casing at SOG Cameron Hills C-19 are wet and such conditions provides challenges for AGM vapor intrusion assessments. One BKG test site (E30m) contained elevated CH_4 gas contents that were higher than any of the 12-well bore SVP tests sites. H_2S was not detected (< 1.0 ppm v/v) at any of the soil test hole sites. SOG selected site N0.5m (705 ppm v/v or 1.4%LEL SVP field CH_4 measurement) for high resolution chemical and stable carbon isotope measurements to classify combustible gas contents. Light hydrocarbon gases were dominated by methane gas while associated C_2+ gases were low and similar to background levels measured at test site BKG E30. Sufficient levels of methane gas were not available for $\delta^{13}C$ compositional analysis at test site N0.5m.

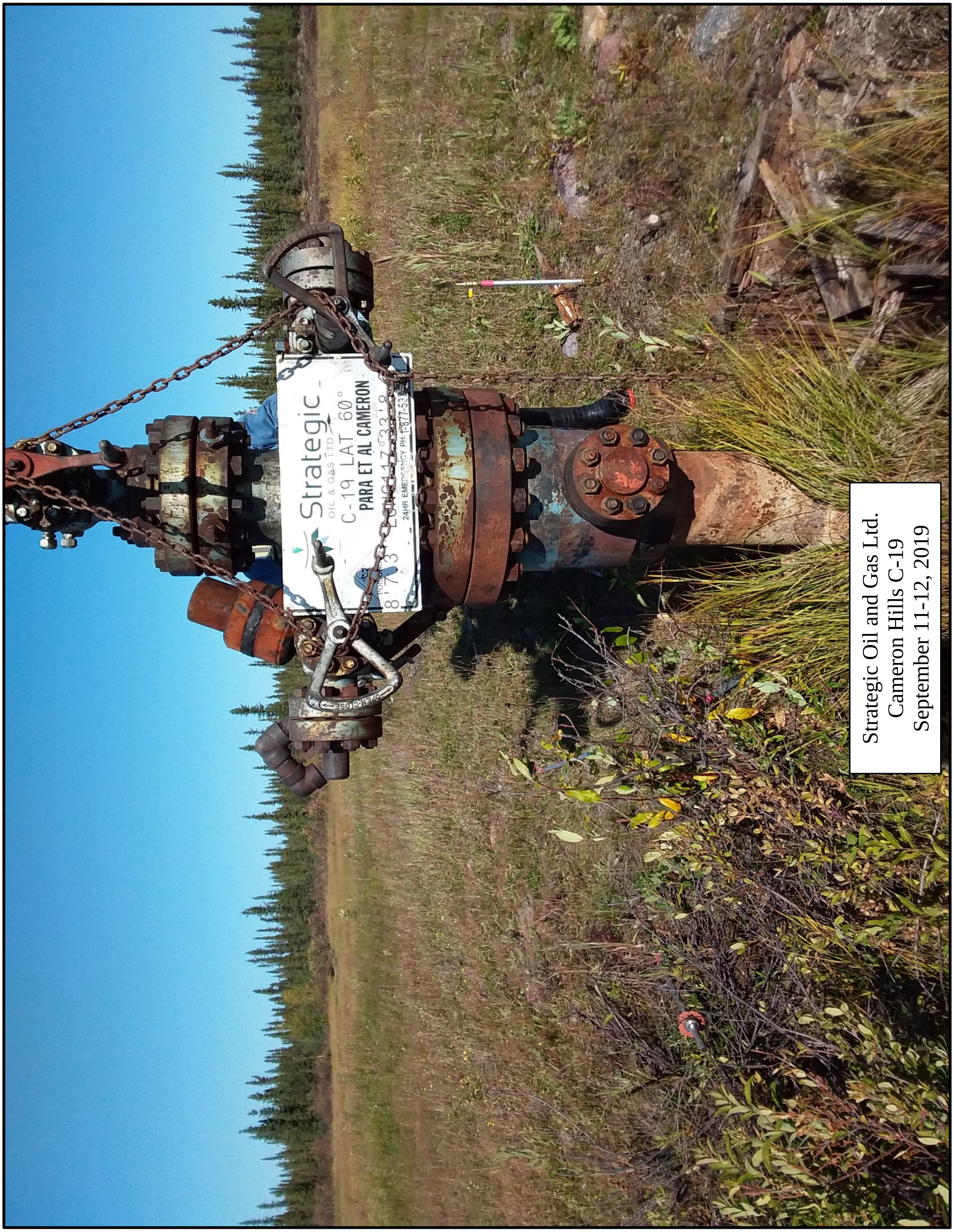
With information available to date, SVP soil test site N0.5m would be classified as 'biogenic-baseline' where CH_4 gas is the result of natural soil respirations processes via CO_2 reduction or fermentation processes generating biogenic CH_4. C_2+ gases in soils near the well are low, similar to background levels and the result of natural movement of thermogenic natural gas, from reservoirs at depth, upward through fractures and micro-fractures to surface. This is a naturally occurring process prevalent in every hydrocarbon sedimentary basin in the world.

Attachment-1

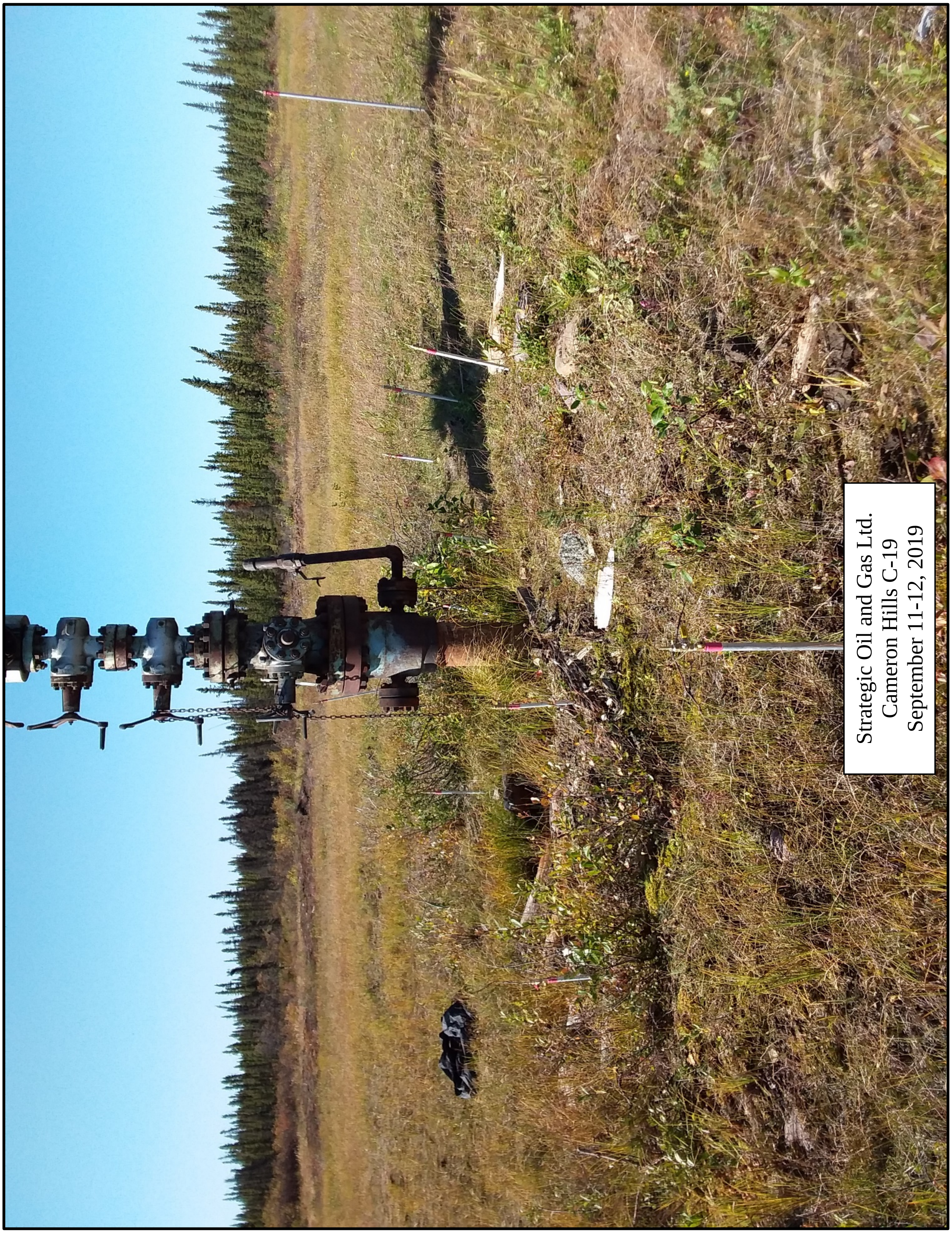
Strategic Oil & Gas Ltd.

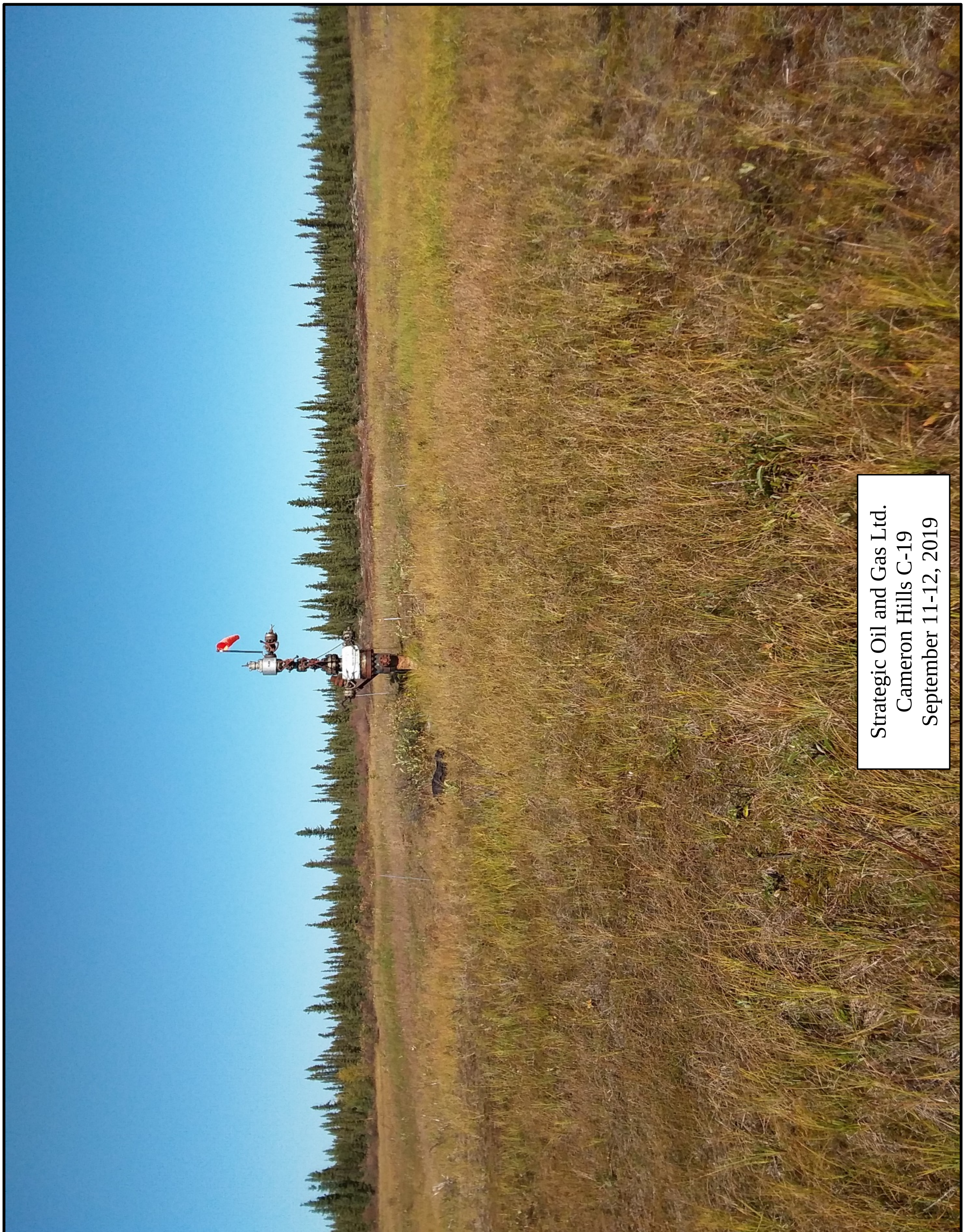
Strategic Cameron C-19

Well Site Photographs



Strategic Oil and Gas Ltd.
Cameron Hills C-19
September 11-12, 2019


Strategic Oil and Gas Ltd.
Cameron Hills C-19
September 11-12, 2019


Strategic Oil and Gas Ltd.
Cameron Hills C-19
September 11-12, 2019

Attachment-2

Strategic Oil & Gas Ltd.

Strategic Cameron C-19

Chain of Custody (COC)

GCHEM LTD.
Bay#1, 4810-62nd Ave, Lloydminster, Alberta T9V 2E9
E:info@gchem.ca
Tel:(780) 871-4668
Fax:(780) 808-8881

CHAIN OF CUSTODY

ENERGY FORENSICS

Sample Submission Form

GCHEM Ltd. Project#_______

Client Information

Company Strategic
Address
City,Prov.
Postal Code
Client Contact
Phone #
Fax #
E-Mail

Billing/Report Information

Company
Address
City,Prov.
Postal Code
Client Contact
Phone #
Fax #
E-mail

Services Needed (TAT)

*Standard 5-7 Days ✓
**Rush 48hrs.____
**Priority Rush 24hrs.____

(*) Working Days
(**) Call for Pricing and Advance Notice

Sampled By Walker, Brian

AFE/PO #

No.	Location	Sample Identifier	Sample Time	Date Sampled	Pressure Received	Actual Pressure	Container Type	Qty.	Sample Volume	Media Type	High Resolution Compositional Analysis	IRMS δ^2H (δD) Analysis	IRMS $\delta^{13}C$ Analysis	Produced Water Forensic Suite	High Resolution Compositional H_2S Analysis
1	C19	SoilGas - initial		Sep 11/19			glass	5							
2		BackGround - Initial		Sep 11/19			glass	7							
3		Soil Gas - final		Sep 12/19			glass	4							
4		Background - final		Sep 12/19			glass	1							
5															
6															
7															
8															
9															
10															

Comments

Relinquished By: [signature] Date/Time: Sep 17, 2019 Relinquished To: Date/Time:
Relinquished By: Date/Time: Relinquished To: Date/Time:

Attachment-3

Strategic Oil & Gas Ltd.

Strategic Cameron C-19

Gas Sample Containers

Photographs

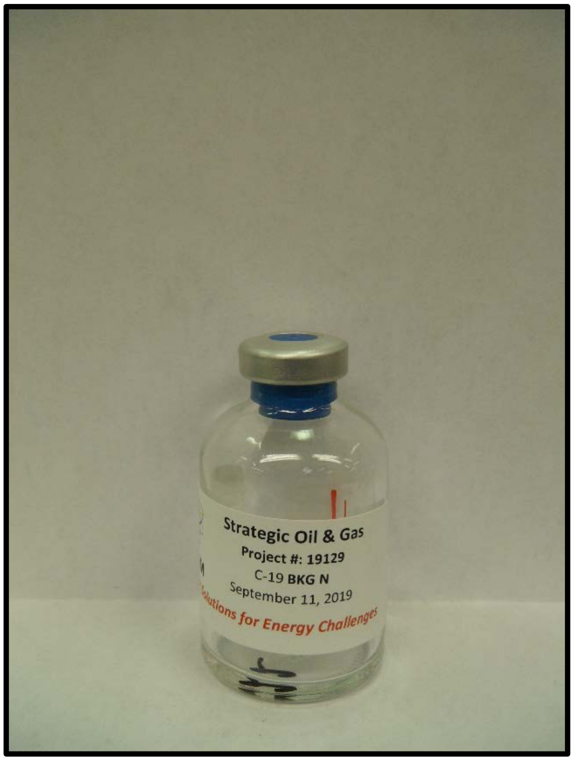
(red boxed pictures are samples measured for chemical and/or isotopic compositions)

N0.5m
September 11, 2019

E3m
September 11, 2019

W0.5m
September 11, 2019

W3m
September 11, 2019



BKG N30m
September 11, 2019

BKG E30m
September 11, 2019

BKG W30m
September 11, 2019

N0.5m
September 12, 2019

W0.5m
September 12, 2019

BKG E30m
September 12, 2019

Attachment-4

Strategic Oil & Gas Ltd.

Strategic Cameron C-19

Gas Analysis Data Sheets (GADS)

GCHEM LTD.

HIGH RESOLUTION GAS ANALYSIS
CARBON ISOTOPE ANALYSIS
HYDROGEN ISOTOPE ANALYSIS

Sampling Company	GCHEM Ltd.	**Lab Sample No.**	19129-07
Date Tested	September 11, 2019	**Test Type**	Soil gas
Operator Name	Strategic Oil & Gas	**Sample Container Type**	Glass Botlte
Unique Well Identifier	C-19	**Sampling Point**	N.5
Well Name	not provided	**Test Intervals or Perfs mKB**	N/A
Field or Area	not provided	**Date Received**	September 17, 2019
Pool or Zone	not provided	**Date Reported**	October 2, 2019
Well License	not provided	**Entered By**	Xiaolong Wang
H2S Level (Observed at Site)	not provided	**Reviewed By**	Brad Johnston

Sample Handling Conditions

	Source/Sampled	Received
Pressure (kPa)	N/A	52
Temperature (°C)	N/A	20

Other Information:

Laboratory Analysis

Component	HRGC Analysis As Received Mol Frac.	Air Free As received Mol Frac.	Air Free / Acid Free As Received Mol Frac.	Carbon Isotope Analysis ‰ VPDB	Hydrogen Isotope Analysis ‰ VSMOW	HRGC Analysis As Received ppm v/v
Neon	0.000014	0.009210	0.009210			14.44
Hydrogen	0.000004	0.002560	0.002560			4.02
Helium	0.000003	0.001945	0.001945			3.05
Nitrogen	0.777601	0.000000	0.000000			777601
Oxygen	0.220831	0.000008	0.000008			220831
Carbon Dioxide	0.001553	0.990311	0.990311			1553
Carbonyl Sulphide	nm	nm	nm			nm
Hydrogen Sulphide	nm	nm	nm			nm
Methyl Mercaptan	nm	nm	nm			nm
Ethyl Mercaptan	nm	nm	nm			nm
Thiophene	nm	nm	nm			nm
Dimethyl Disulphide	nm	nm	nm			nm
Methane	0.000008	0.005137	0.005137			8.06
Ethane	0.000000	0.000000	0.000000			<0.01
Ethene	0.000000	0.000000	0.000000			<0.01
Propane	0.000000	0.000000	0.000000			<0.01
Propene	0.000000	0.000000	0.000000			<0.01
iso-Butane	0.000000	0.000000	0.000000			<0.01
n-Butane	0.000000	0.000000	0.000000			<0.01
iso-Pentane	0.000000	0.000000	0.000000			<0.01
n-Pentane	0.000000	0.000000	0.000000			<0.01
C_6+	0.000000	0.000038	0.000038			0.06
TOTAL	**1.000000**	**1.000000**	**1.000000**			1000000

Properties

Compositional Indicies	
Vol % Hydrocarbons	0.00
Vol % CH_4	100.00
Vol % C_2+	0.00
CH_4 / $\sum C_2$+	N/A
C_2 / $\sum C_3$+	N/A
C_3 / $\sum$n-C_{4+}	N/A

Real Gross Heating Value (mj/m3) @15°C and 101.35 kPa	
Air Free as received	Moisture and Acid Gas Free
0.00	0.23

Relative Density	
Calc. Mol. Mass Ratio	Calc. Relative Density
0.9985	0.9985

Pseudo Critical Properties	As Received	Acid Gas Free
pPc (kPa)	3761	7338
pTc (°K)	133	302

Geological Origin of Natural Gas

Geological Formation	Depth Range (MD from KB of Well)	Probable Depth (MD from KB of Well)

Comments

Forensic Solutions for Oilfield Challenges

GCHEM Ltd. Bay #1, 4810-62 Avenue Lloydminster, AB T9V 2E9 Tel: (780) 871-4668 Fax: (780) 808-8883 e-mail: info@gchem.ca www.gchem.ca
GPA 2145-09. Revision 1.3, August 1, 2016

GCHEM LTD.

HIGH RESOLUTION GAS ANALYSIS
CARBON ISOTOPE ANALYSIS
HYDROGEN ISOTOPE ANALYSIS

Sampling Company	GCHEM Ltd.	Lab Sample No.	19129-03
Date Tested	September 11, 2019	Test Type	Soil gas
Operator Name	Strategic Oil & Gas	Sample Container Type	Glass Botlte
Unique Well Identifier	C-19	Sampling Point	BKG E
Well Name	not provided	Test Intervals or Perfs mKB	N/A
Field or Area	not provided	Date Received	September 17, 2019
Pool or Zone	not provided	Date Reported	October 2, 2019
Well License	not provided	Entered By	Xiaolong Wang
H2S Level (Observed at Site)	not provided	Reviewed By	Brad Johnston

Sample Handling Conditions

	Source/Sampled	Received
Pressure (kPa)	N/A	60
Temperature (°C)	N/A	20

Other Information:

Laboratory Analysis

Component	HRGC Analysis As Received Mol Frac.	Air Free As received Mol Frac.	Air Free / Acid Free As Received Mol Frac.	Carbon Isotope Analysis ‰ VPDB	Hydrogen Isotope Analysis ‰ VSMOW	HRGC Analysis As Received ppm v/v
Neon	0.000014	0.001668	0.001668			13.76
Hydrogen	0.000005	0.000551	0.000551			4.54
Helium	0.000003	0.000346	0.000346			2.86
Nitrogen	0.774430	0.000000	0.000000			774430
Oxygen	0.217322	0.000001	0.000001			217322
Carbon Dioxide	0.007427	0.900373	0.900373			7427
Carbonyl Sulphide	nm	nm	nm			nm
Hydrogen Sulphide	nm	nm	nm			nm
Methyl Mercaptan	nm	nm	nm			nm
Ethyl Mercaptan	nm	nm	nm			nm
Thiophene	nm	nm	nm			nm
Dimethyl Disulphide	nm	nm	nm			nm
Methane	0.000814	0.098662	0.098662			813.8
Ethane	0.000000	0.000000	0.000000			<0.01
Ethene	0.000000	0.000000	0.000000			<0.01
Propane	0.000000	0.000000	0.000000			<0.01
Propene	0.000000	0.000000	0.000000			<0.01
iso-Butane	0.000000	0.000000	0.000000			<0.01
n-Butane	0.000000	0.000041	0.000041			0.34
iso-Pentane	0.000000	0.000015	0.000015			0.13
n-Pentane	0.000000	0.000000	0.000000			<0.01
C_6+	0.000000	0.000010	0.000010			0.08
TOTAL	**1.000000**	**1.000000**	**1.000000**			1000000

Properties

Compositional Indicies	
Vol % Hydrocarbons	0.08
Vol % CH_4	99.94
Vol % C_2+	0.00
$CH_4 / \sum C_2$+	2425
$C_2 / \sum C_3$+	N/A
$C_3 / \sum n\text{-}C_{4+}$	N/A

Real Gross Heating Value (mj/m3) @15°C and 101.35 kPa	
Air Free as received	Moisture and Acid Gas Free
0.03	3.76

Relative Density	
Calc. Mol. Mass Ratio	Calc. Relative Density
1.0009	1.0009

Pseudo Critical Properties	As Received	Acid Gas Free
pPc (kPa)	3780	7101
pTc (°K)	134	293

Geological Origin of Natural Gas

Geological Formation	Depth Range (MD from KB of Well)	Probable Depth (MD from KB of Well)

Comments

Forensic Solutions for Oilfield Challenges

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GPA 2145-09. Revision 1.3, August 1, 2016