ENERGY-FORENSICS

# Heli Source

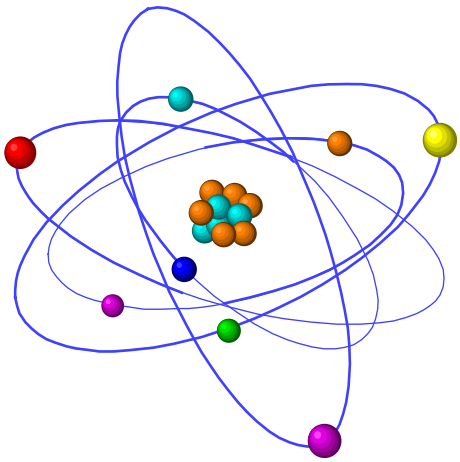
**Work Order-Ref #: 21272**

# Vapor Intrusion Assessment (VIA)

# Surface Casing Vent (SCV) Flow Test

## Cameron Hills J-37

**October 31, 2021**

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**FORENSIC SOLUTIONS FOR ENERGY CHALLENGES**

## 1.0 Vapor Intrusions Assessment (VIA) Summary

**Operating Company:** Strategic Oil and Gas Ltd.
**Well Name:** Paramount et al Cameron Hills J-37
**UWI:** J-37 60-10N 117-30W

**License Number:** 1751
**Test Date** October 31, 2021
**GCHEM Project Number** 21272

### 1.1 Production Casing Assessment Summary Table

| | | | |
|---|---|---|---|
| **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 ($\delta D$)** | | NA | NA |
| **PC Combustible Gas Class. Level-4 ($^{14}C$)** | | NA | NA |

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

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

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

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

| | |
|---|---|
| **Well Casing Surface $CH_4$ Test Sites** | 28 |
| **MAX Surface $CH_4$ Reading** | 1 ppm v/v |
| **MAX $H_2S$ Well Soil Reading (ppm v/v)** | <1 |
| **Number of Background Sites** | 1 |
| **MAX Background $CH_4$ (ppm v/v)** | 1 |
| **Max $H_2S$ BKG Soil Reading (ppm v/v)** | <1 |
| | |
| **Surface $CH_4$-PMD Gas Classification** | NON-IMPACTED |

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

| | | | |
|---|---|---|---|
| **Surface SV-FC $CH_4$ Test Sites** | nm | | |
| **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 ($\delta D$)** | | 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** | 16 | | |
| **MAX SVP $CH_4$ Reading (ppm v/v)** | 1 | | |
| **Max $H_2S$ SVP Field Reading (ppm v/v)** | <1 | | |
| **Number SVP BKG Test Sites** | 1 | | |
| **MAX SVP $CH_4$ BKG Test Sites (ppm v/v)** | 1 | | |
| | | | |
| **SVPs Gas Spl. Collection & Measurement** | **Total Collected** | **Analysis Requested*** | **Test Site** |
| **Soil Vapor Probes (SVPs) AGM (Total)** | 4 | | |
| **SVP &Sites Requested for Level-1 Analysis** | | 4 | N0.3, E0.3, S0.3 & W2 |
| **Combustible Gas Classification Level-1 (Chem.)** | | NON-IMPACTED | |
| **SVP &Sites Requested for Level-2 Analysis** | | 0 | NA |
| **Combustible Gas Classification Level-2 ($\delta^{13}C$)** | | NA | |
| **SVP &Sites Requested for Level-3 Analysis** | | 0 | NA |
| **Combustible Gas Classification Level-3 ($\delta D$)** | | NA | |
| **SVP &Sites Requested for Level-4 Analysis** | | 0 | NA |
| **Combustible Gas Classification Level-4 ($^{14}C$)** | | NA | |

| BKG Gas Spl. Collection-Measurement | Total Collected | Analysis Requested* | Test Site |
|---|---|---|---|
| BKG Soil Vapor Probe (SVPs) (Total) | 1 | | |
| BKG &Sites Requested for Level-1 Analysis | | 1 | BKG SW15 |
| Combustible Gas Classification Level-1 (Chem.) | | BASELINE | |
| BKG &Sites Requested for Level-2 Analysis | | 0 | NA |
| Combustible Gas Classification Level-2 ($\delta^{13}C$) | | NA | |
| BKG &Sites Requested for Level-3 Analysis | | 0 | NA |
| Combustible Gas Classification Level-3 ($\delta D$) | | NA | |
| BKG &Sites Requested for Level-4 Analysis | | 0 | NA |
| Combustible Gas Classification Level-4 ($^{14}C$) | | 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 31, 2021**

1) The Surface Casing Vent passed the ten-minute bubble test (1 ppm v/v methane).
2) 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) comparable to background (1 ppm v/v) established 15m southwest from the wellbore (Figure 1, Table 1).
3) 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 low (1 ppm v/v), comparable to the background probe (1 ppm v/v methane) installed approximately 15m southwest of the wellbore to establish background levels in the area and for comparison to other samples collected during this investigation (Figure 2, Table 2).
4) Four soil gas samples from SVPs (N0.3, E0.3, S0.3 & W2) and gases from background (BKG SW15) were collected, contained, and preserved for geochemical analysis and characterization, classification, geologic origin (source) and depth measured from the KB (Table 3).
5) Methane and C2 + light alkane gas levels in soil gases collected near the wellbore (except fro are low, comparable to background established 15m southwest of the wellbore (Figure 3).
6) $C_{6+}$ contents in the soil samples are low and comparable to background levels (Figure 4).
7) This well does not contain evidence of SCVF or gas migration at the time of this investigation.

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

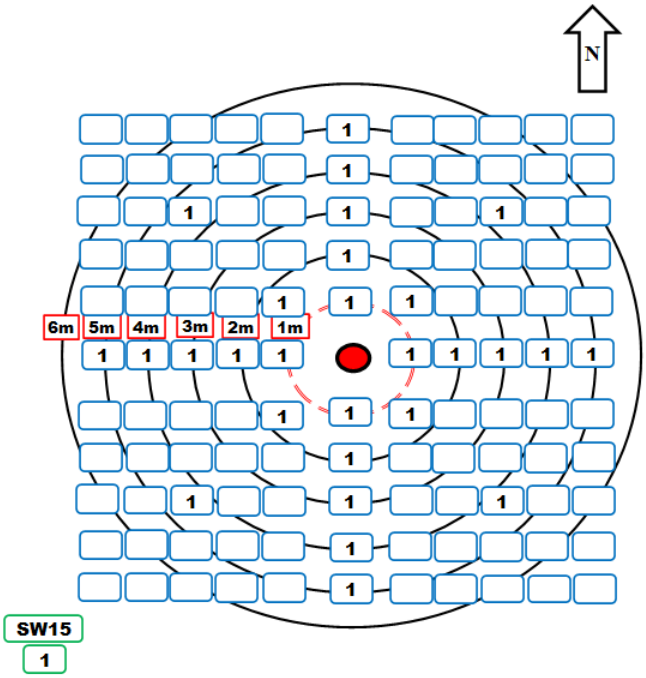



**Figure 1A. Non-Intrusive $CH_4$ Surface Well Casing Detail VIEW**

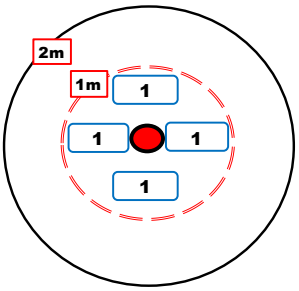



**Table 1. AGM Non-Intrusive Surface PMD**

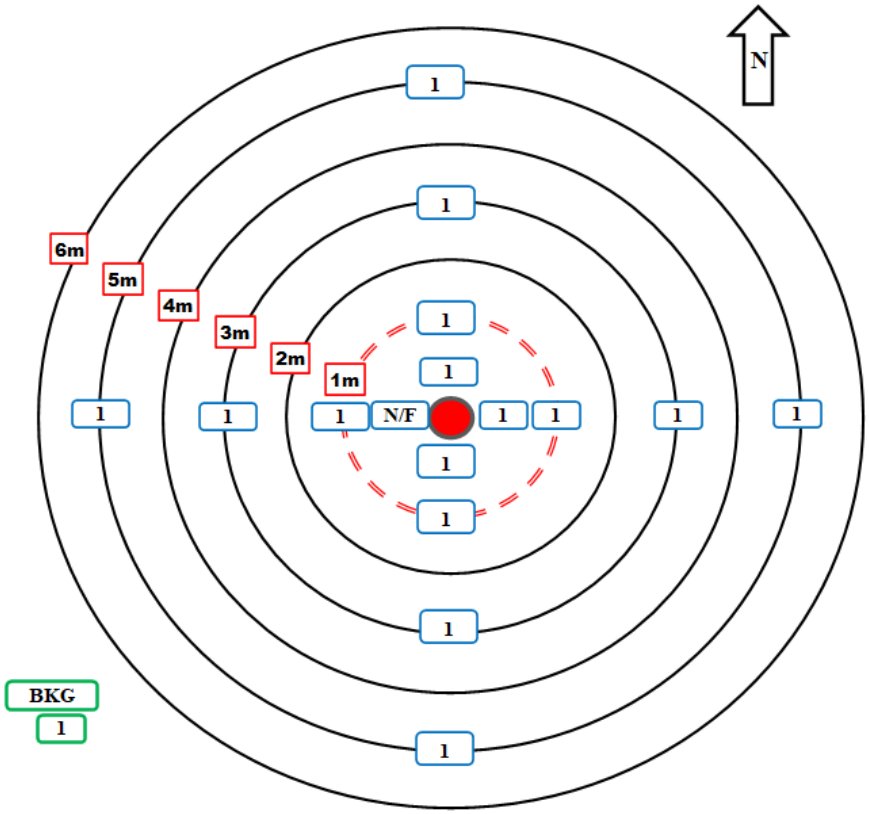
**WELL CASING (AGM) Non-Intrusive Surface PMD ($CH_4$) Soil Scan**

| 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 | 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 | 1 | | E3-S3 | 1 | | S3-W3 | 1 | | W3-N3 | 1 | |
| 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 ($CH_4$) 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) | (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SW15 | 1 | | | | | | | | | | |

**Figure 2. AGM Intrusive SVPs-**




## 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) | (%LEL) | $H_2S$ (ppm v/v) | Soil Parameters Type | Moist. (1-5) | HC-CONT (Y-N) | Gas Sample (Y-N) | Site Assessment Comments |
|---|---|---|---|---|---|---|---|---|
| N0.3 | 1 | | <1.0 | Silt | 5 | No | Yes | |
| N2 | 1 | | <1.0 | Silt | 5 | No | No | |
| N4 | 1 | | <1.0 | Silt | 5 | No | No | |
| N6 | 1 | | <1.0 | Silt | 5 | No | No | |
| E0.3 | 1 | | <1.0 | Silt | 5 | No | Yes | |
| E2 | 1 | | <1.0 | Silt | 5 | No | No | |
| E4 | 1 | | <1.0 | Silt | 5 | No | No | |
| E6 | 1 | | <1.0 | Silt | 5 | No | No | |
| S0.3 | 1 | | <1.0 | Silt | 5 | No | Yes | |
| S2 | 1 | | <1.0 | Silt | 5 | No | No | |
| S4 | 1 | | <1.0 | Silt | 5 | No | No | |
| S6 | 1 | | <1.0 | Silt | 5 | No | No | |
| W0.3 | N/F | | <1.0 | Silt | 5 | No | No | No Flow |
| W2 | 1 | | <1.0 | Silt | 5 | No | Yes | |
| W4 | 1 | | <1.0 | Silt | 5 | No | No | |
| W6 | 1 | | <1.0 | Silt | 5 | No | No | |

| Test Site (m) | Soil Vapor Probes IR-$CH_4$ (ppm v/v) | (% Vol) | $H_2S$ (ppm v/v) | Soil Parameters Type | Moist. (1-5) | HC-CONT (Y-N) | Gas Sample (Y-N) | Site Assessment Comments |
|---|---|---|---|---|---|---|---|---|
| BKG SW15 | 1 | | <1.0 | Silt | 5 | No | Yes | |

**Table 1. High resolution molecular compositions of gas samples collected as part of the VIA Heli Source J-37.**

| Sample Point / Date Collected / Gas Component | SCV Oct. 31-21 ppm v/v | N0.3 Oct. 31-21 ppm v/v | E0.3 Oct. 31-21 ppm v/v | S0.3 Oct. 31-21 ppm v/v | W2 Oct. 31-21 ppm v/v | BKG Oct. 30-21 ppm v/v |
|---|---|---|---|---|---|---|
| Neon | 23.40 | 24.52 | 23.21 | 25.53 | 24.62 | 23.22 |
| Hydrogen | 202.9 | 175.0 | 197.8 | 231.0 | 146.0 | 154.5 |
| Helium | 0.86 | 1.12 | 0.78 | 2.40 | 0.90 | 0.83 |
| Nitrogen | 778223 | 775474 | 774664 | 774796 | 775273 | 775300 |
| Oxygen | 220985 | 222395 | 222335 | 222970 | 223158 | 223046 |
| Carbon Dioxide | 548.6 | 1951 | 2787 | 1994 | 1412 | 1494 |
| Methane | 8.25 | 2.97 | 11.87 | 4.41 | 8.28 | 3.65 |
| Ethane | 1.77 | <0.01 | 0.32 | <0.01 | <0.01 | 0.43 |
| Ethene | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Propane | 9.23 | 0.71 | 0.95 | <0.01 | 0.23 | ,0.01 |
| Propene | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| iso-Butane | 3.06 | <0.01 | 1.10 | <0.01 | 0.35 | 0.21 |
| n-Butane | 8.07 | 0.27 | 0.51 | 0.15 | 0.21 | 0.18 |
| iso-Pentane | 3.76 | 0.17 | 0.50 | 0.15 | 0.27 | <0.01 |
| n-Pentane | 3.47 | <0.01 | 0.23 | 0.12 | <0.01 | <0.01 |
| C6+ | 1.58 | 0.18 | 0.18 | 0.94 | 0.40 | 0.06 |
| | | | | | | |
| C1 Index (C1/ΣC2+) | 0.37 | 3.03 | 5.92 | 16.35 | 19.04 | 5.98 |
| C2 Index (C2/ΣC3+) | 0.08 | N/A | 0.19 | N/A | N/A | 2.47 |
| C3 Index (C3/ΣC4+) | 0.80 | 2.66 | 1.29 | N/A | 1.09 | N/A |
| C4 Index (C4/C5) | 2.33 | N/A | 2.20 | 1.22 | N/A | N/A |
| ΣC2+ | 22.53 | 0.98 | 2.01 | 0.27 | 0.43 | 0.61 |
| ATM Ratio (N2/O2) | 3.52 | 3.49 | 3.48 | 3.47 | 3.47 | 3.48 |
| Vol % CO2 of TG | 0.05 | 0.20 | 0.28 | 0.20 | 0.14 | 0.15 |
| Vol % Lt. Alk. of TG | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Vol % Lt. Alk. CH4 | 21.95 | 72.07 | 76.69 | 91.29 | 88.71 | 81.65 |
| Vol % Lt. Alk. C2+ | 78.05 | 27.93 | 23.31 | 8.71 | 11.29 | 18.35 |
| Vol % C2+ of TG | 0.00 | 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 |

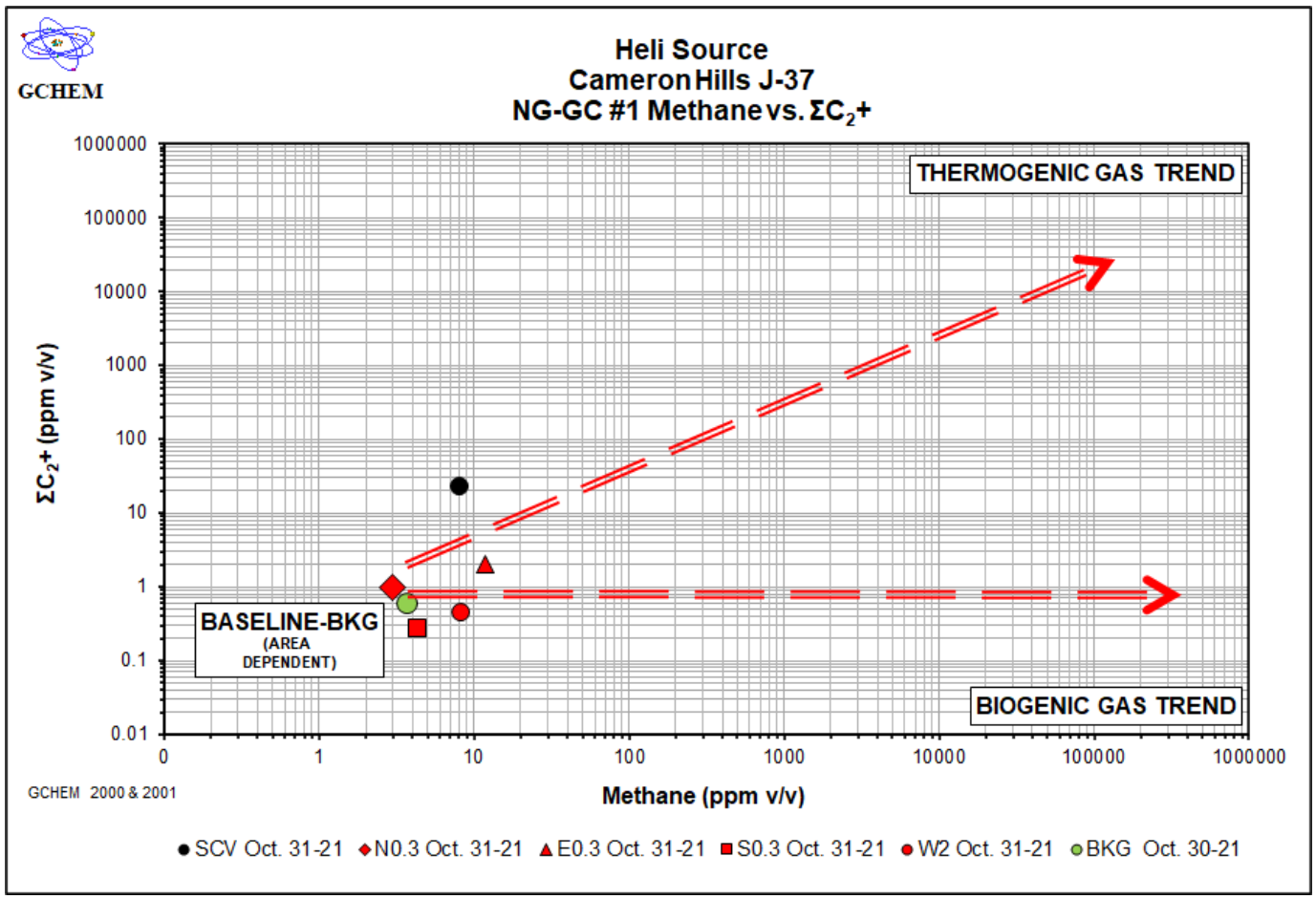



**Figure 3: ΣC2+ vs Methane.**Combustible gases detected in soils and SCVs at a wellhead may result from several origins. Natural gases indicative of SCVF or AGM are thermogenic in origin (natural gas in deep reservoirs), contain high methane and $C_2$+ contents and plot in the Upper RH Quadrant. Low 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 and soils near the wellbore contain low levels of C2+ gases indicating that this well is not impacted with leaking thermogenic natural gases.

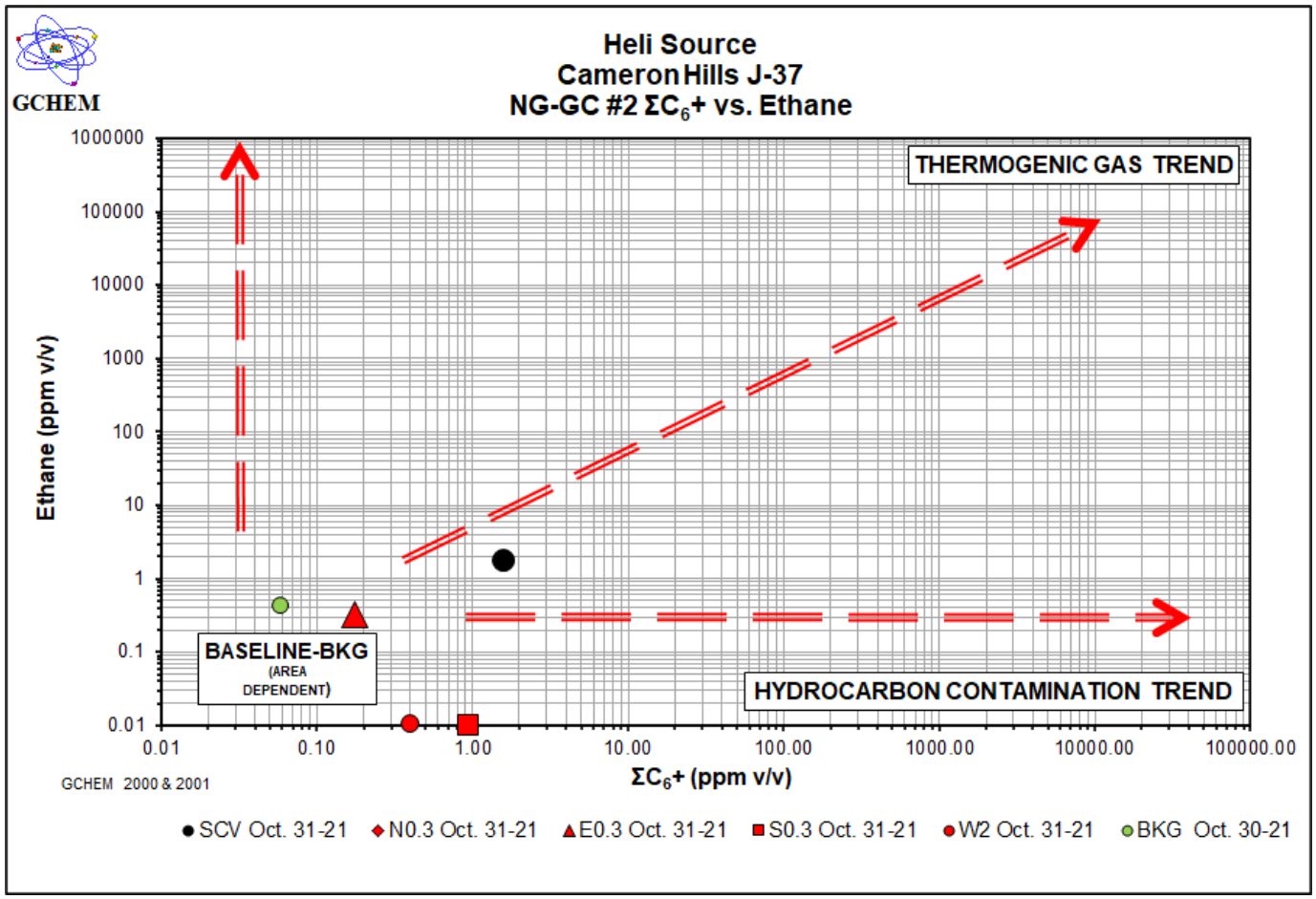



**Figure 4: $\Sigma C_6+$ vs Ethane.** $C_6+$ gases are relatively large molecules that do not readily or easily migrate in large quantities from depth upwards through subsurface fractures or micro-fractures to surface. Contamination by oil spills, fuels, and solvents is indicated by soil vapor samples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