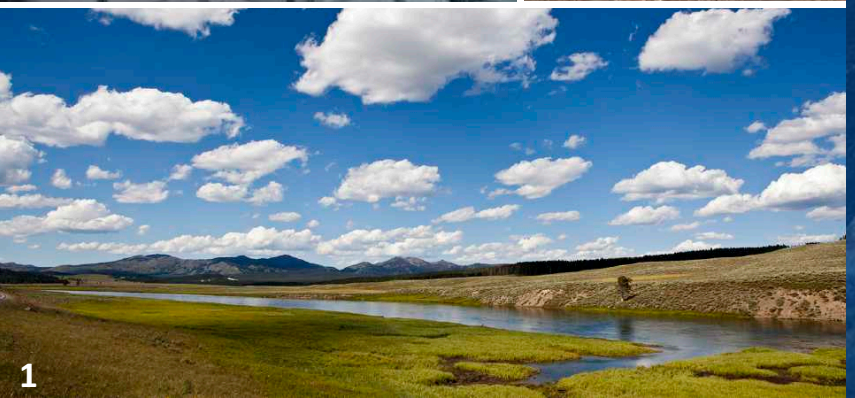
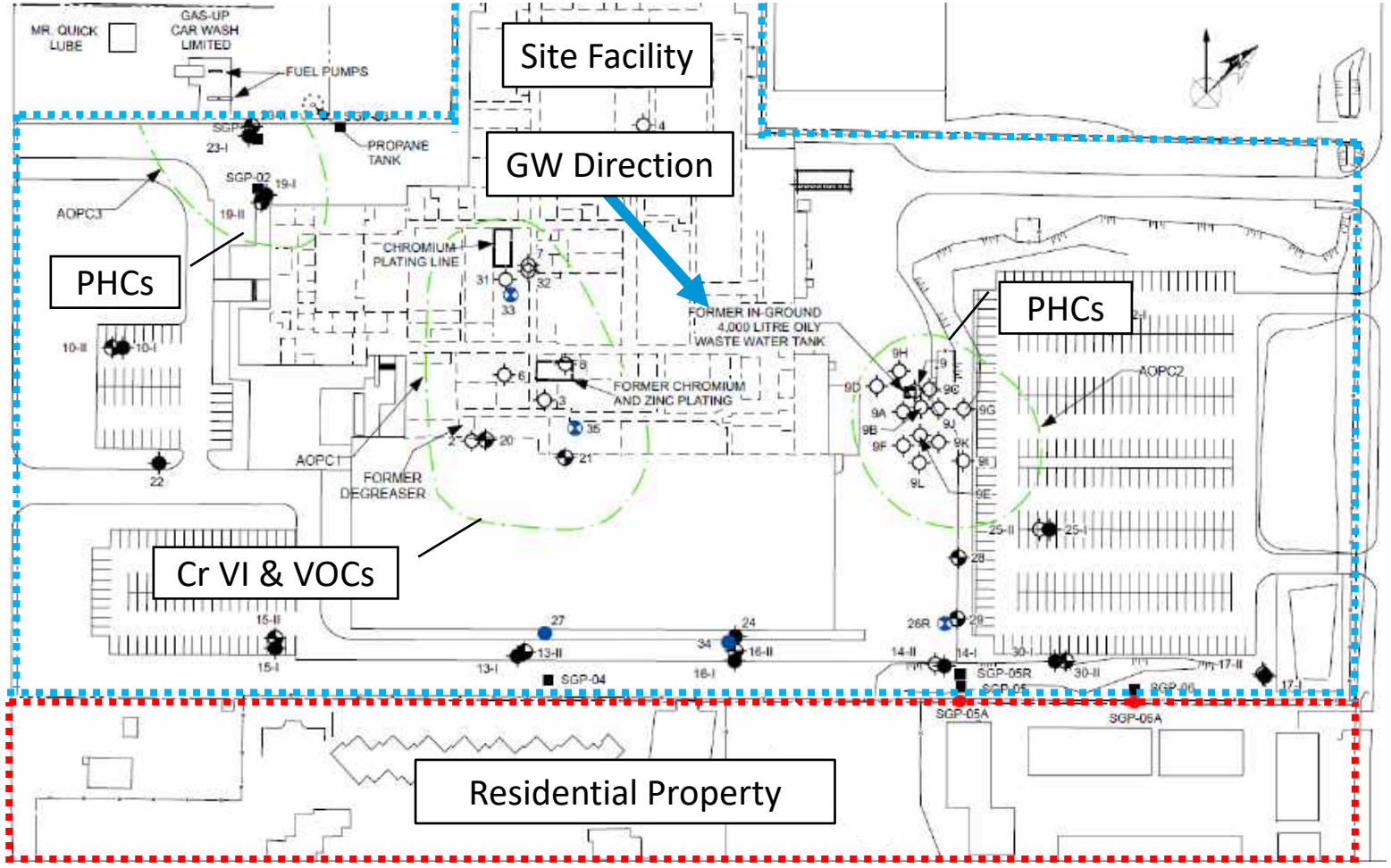


Geosyntec consultants

A Case Study – Forensic Analysis to Characterize an Unknown Source of Methane in Soil Vapour

Site Layout



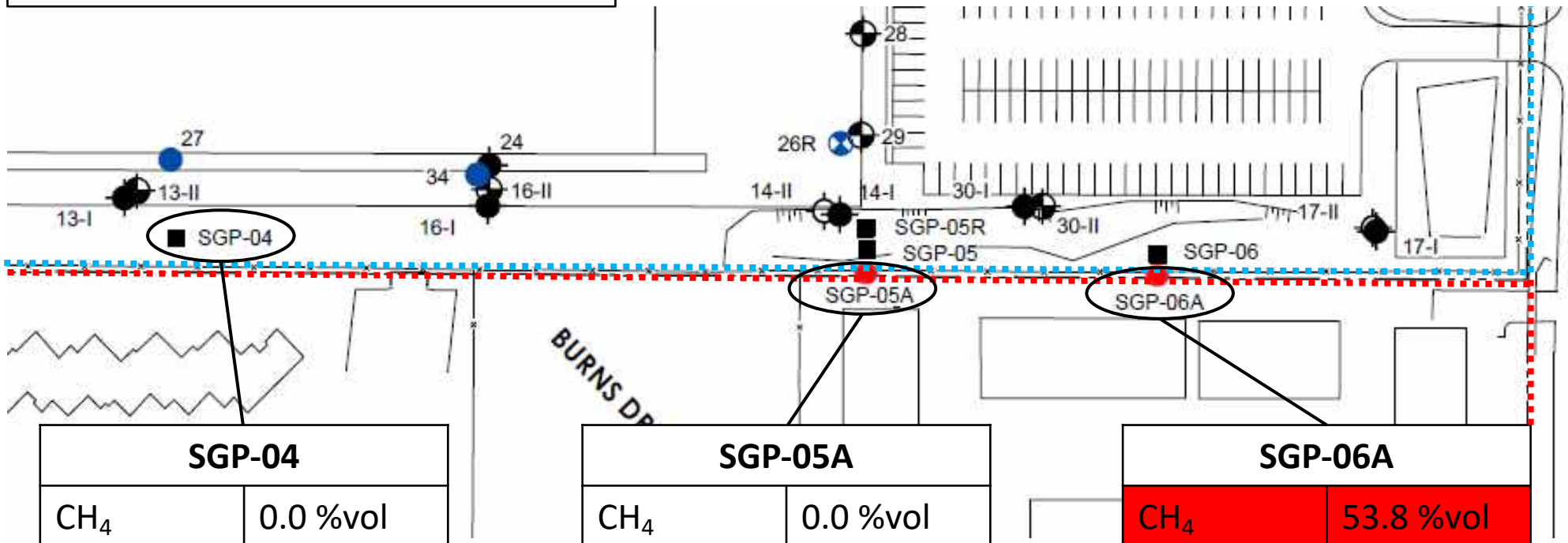


- Industrial facility located in southern Ontario (operational since 1964)
- Groundwater PHC, Cr VI, and VOCs impacts
- Groundwater flow direction (east)
- Eastern property boundary (residential)
- Active groundwater extraction system
- Quarterly groundwater monitoring

Field Screening Results



December 2020 Screening Results of Soil Vapour Probes



SGP-04	
CH_4	0.0 %vol
O_2	21.5 %vol
CO_2	1.0 %vol

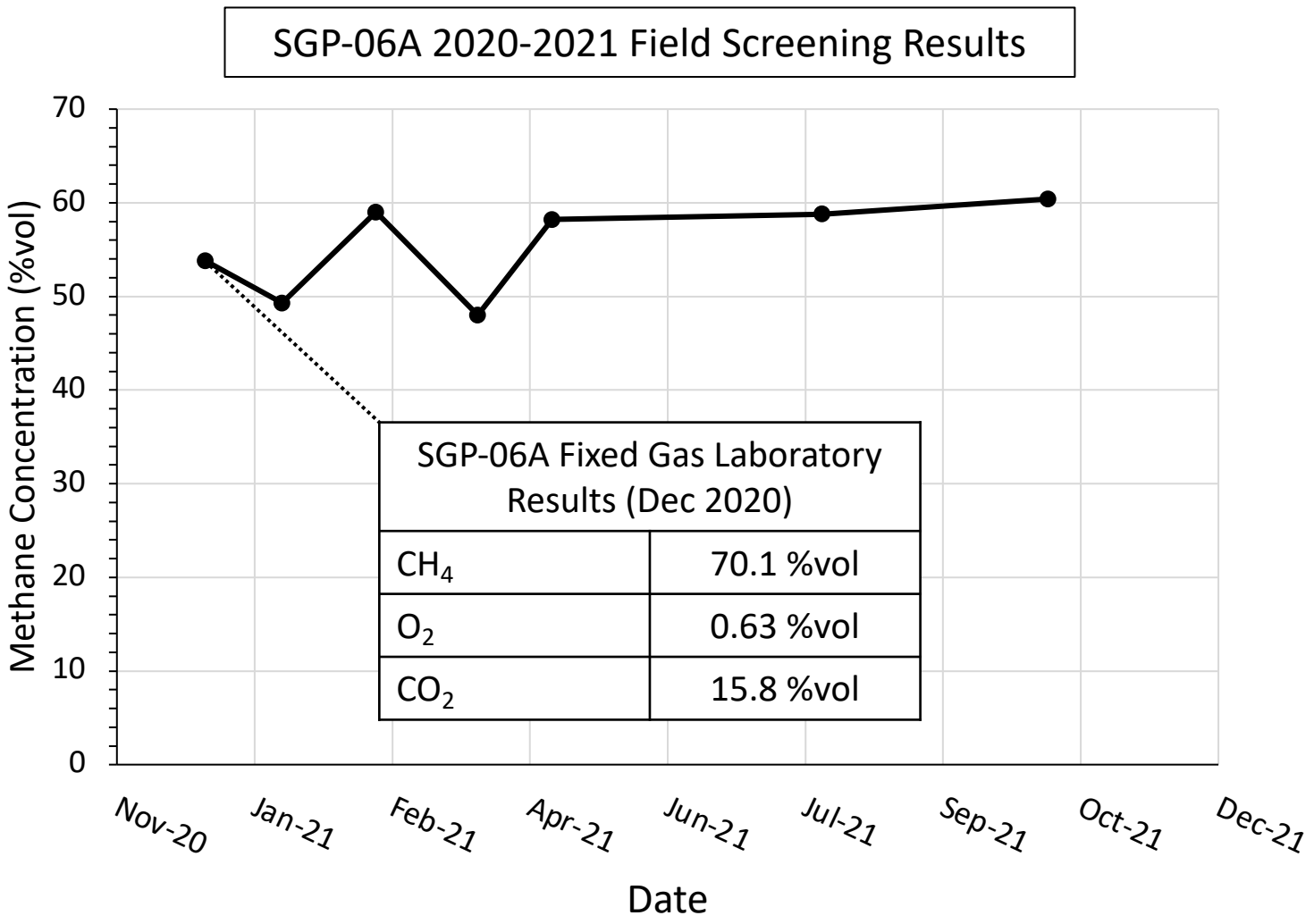
SGP-05A	
CH_4	0.0 %vol
O_2	15.2 %vol
CO_2	2.6 %vol

SGP-06A	
CH_4	53.8 %vol
O_2	4.9 %vol
CO_2	12.1 %vol

VOCs not detected at SGP-04, SGP-05A, and SGP-06A

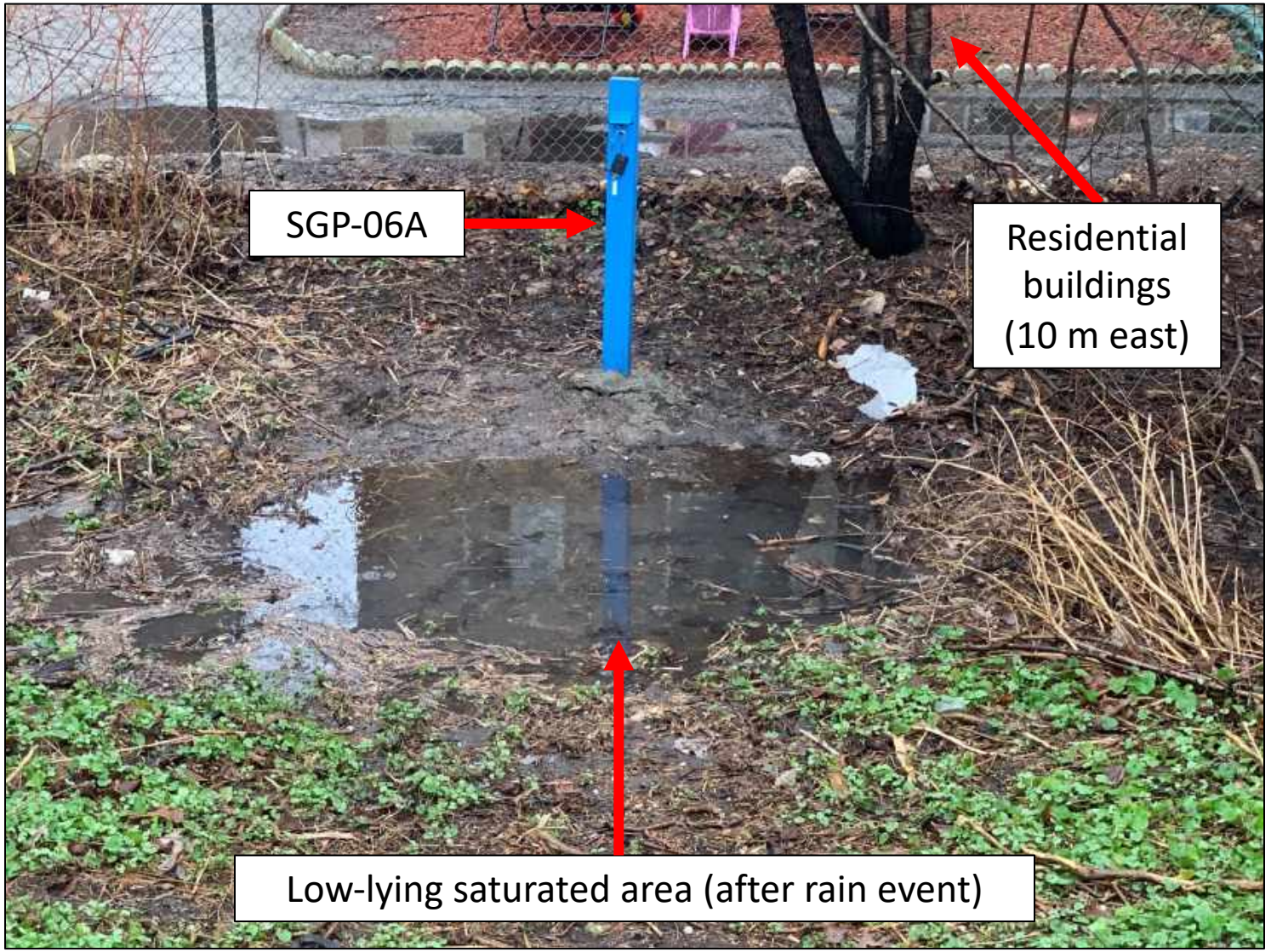
Field Screening Results





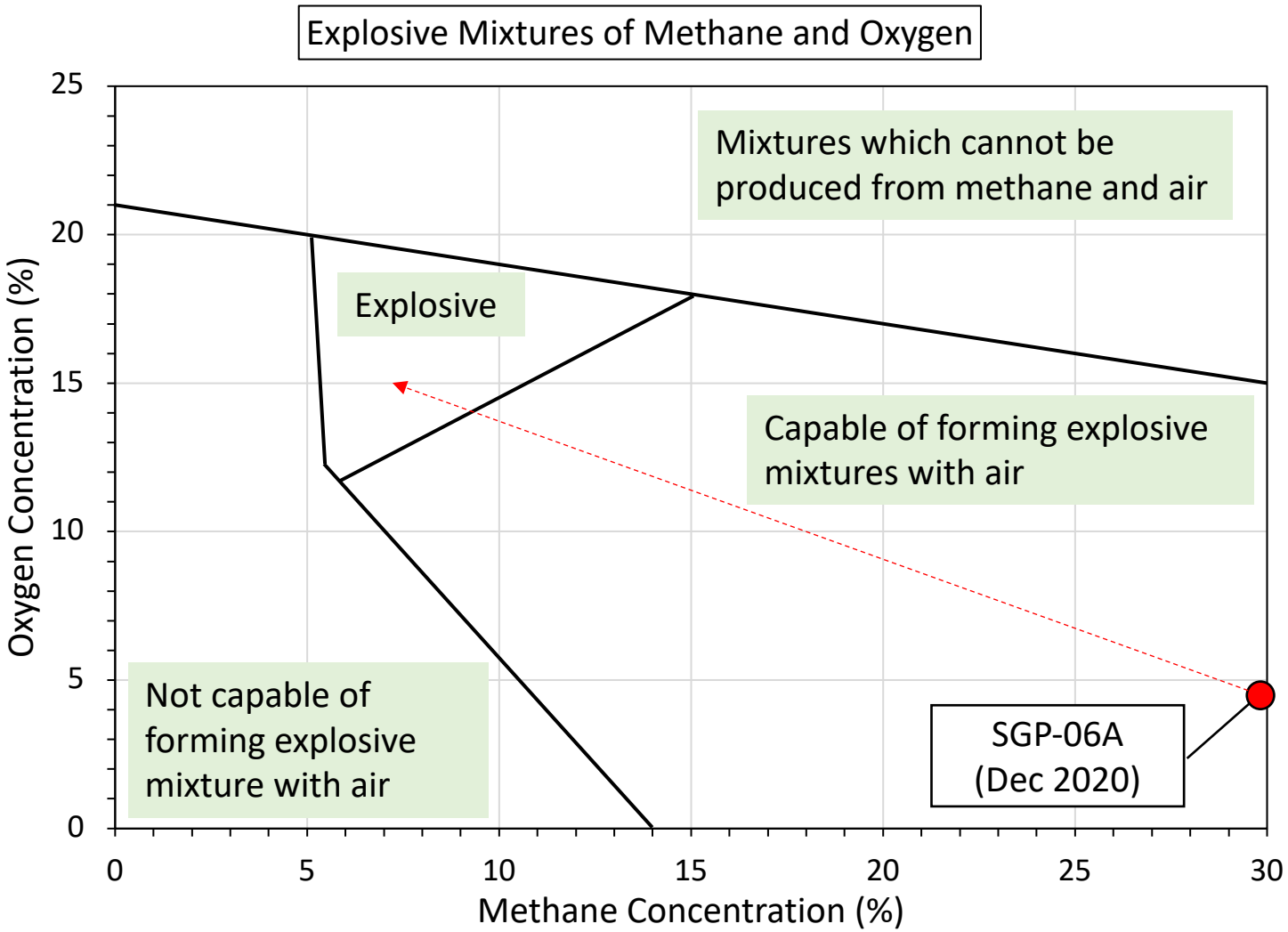
- Laboratory sample collected for fixed gases support December 2020 screening results
- Continuous monitoring of SGP-06A in 2021 and pump test indicate a persistent source
- Methane not historically detected at SGP-06A (2005, 2013, and 2014)

Soil Vapour Probe SGP-06A



Methane Hazard





Kissell, 2006

- Acute hazard (fire/explosion)
- Off-site residential property owner notified
- At atmospheric conditions
  - lower explosive limit 5 %vol and
  - upper explosive limit 15 %vol
- Dilution presents the potential to form an explosive mixture
- SGP-06A identified to be under constant positive pressure

Potential Sources



Biogenic


Landfill Gas


Sewer Gas


Buried Vegetation


Degradation of Petroleum

Thermogenic


Natural Gas Leak

Methane Forensic Analysis



- **Forensic methods applied to identify the source of methane:**
  - Mercaptans
  - Light hydrocarbon fraction (C_2-C_{6+})
  - Isotopic composition
    - Radiocarbon dating (^{14}C [pmc])
- **Supporting lines of evidence:**
  - Utility locates
  - Historical property use

Mercaptan Analysis



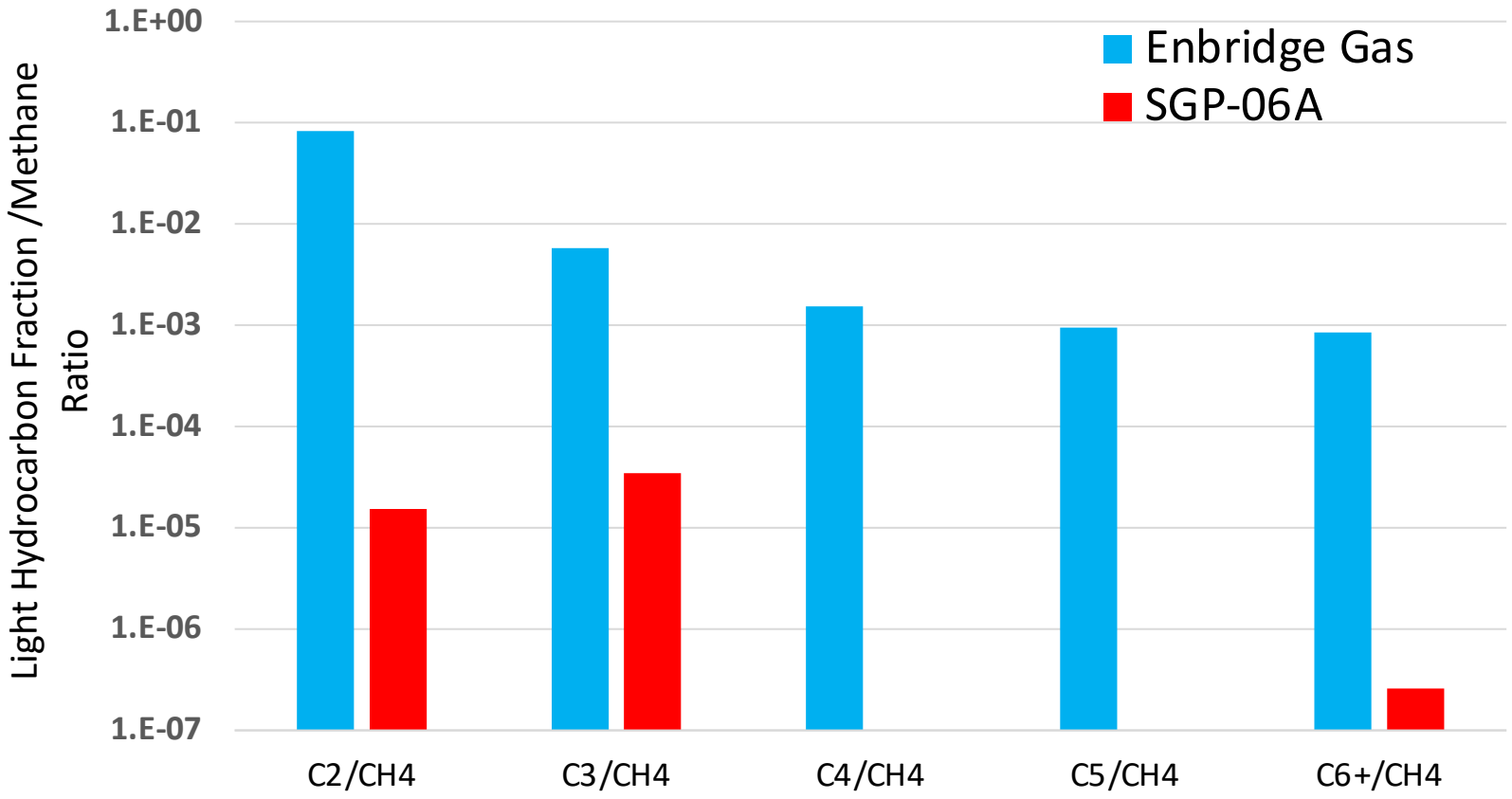
Analyte	Enbridge Gas (mg/m^3)	SGP-06A (mg/m^3)
Total Mercaptans	3-5	0.0255

Notes:
Result collected from SGP-06A, January 2021
mg/m^3 – milligrams per cubic meter

- Mercaptans (organo sulfur compounds) are added to natural gas supplies to provide an odor for detection purposes
- Mercaptans detected at SGP-06A but ~100x less than the natural gas supply

Light Hydrocarbon Fraction Analysis





- Natural gas composition:
  - Methane (~95 mol%)
  - Light hydrocarbons (C_2-C_{6+}) (~4 %mol)
  - Fixed gases (~1 %mol)
- Natural gas has a specific ratio of C_2-C_{6+} /CH_4
- SGP-06A does not indicate a natural gas leak

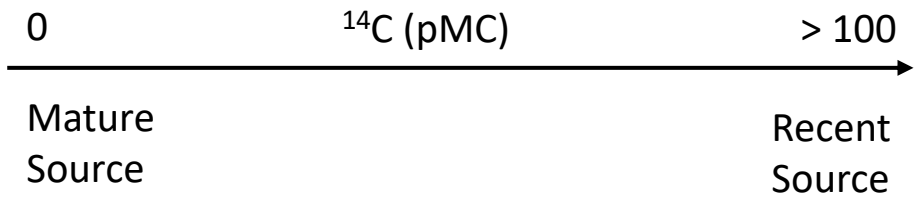
Notes:
Results collected from SGP-06A, January 2021
Hydrocarbon fractions C_4 and C_5 were below the laboratory detection limit
C_2-C_9 – ethane/ethene (C_2), propane (C_3), propene (C_3), butane (C_4), pentane (C_5), hexane (C_6+), heptane (C_6+), octane (C_6+), and nonane (C_6+)
CH_4 – methane

Radiocarbon Dating



Source	Scientific Literature (pMC)	SGP-06A (pMC)
Landfill Gas	≥ 100	96
Sewer Gas	≥ 100	
Buried Vegetation	≥ 100	
Degradation of Petroleum	~0	
Natural Gas Leak	~0	

Note:
Result collected from SGP-06A, February 2021
pMC – percent modern carbon



- Living organisms absorb ^{14}C in equilibrium with the atmosphere
- ^{14}C is no longer absorbed after death and gradually decays ($t_{1/2}$= 5,730 years)
- ^{14}C analyzed from methane collected at SGP-06A indicates a recent source

Source Identification

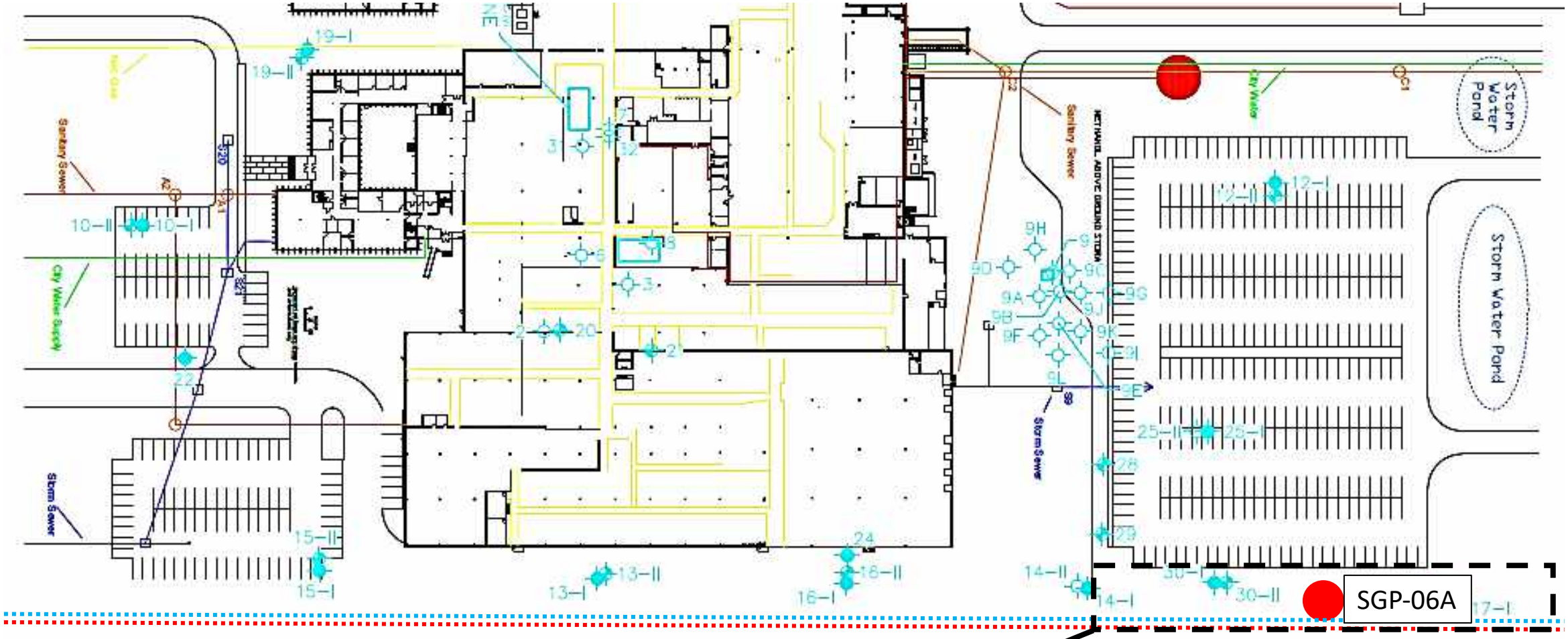


Potential Source	Lines of Evidence				
	Mercaptans	C_2-C_{6+}/CH_4	^{14}C	Site Utilities	Historical Property Use
Result	0.0255 (mg/m^3)	-	96 pMC		
Landfill Gas	√	√	√		
Sewer Gas	√	√	√		
Buried Vegetation	√	√	√		
*Degradation of Petroleum	√	√	x		
Natural Gas	x	x	x		

Notes:
*PHCs not detected in surrounding groundwater monitoring wells of SGP-06A
√ - line of evidence consistent with the source
x – line of evidence not consistent with the source
? – line of evidence is inconclusive
mg/m^3 – milligrams per cubic meter
pMC – Percent Modern Carbon

Site Utilities



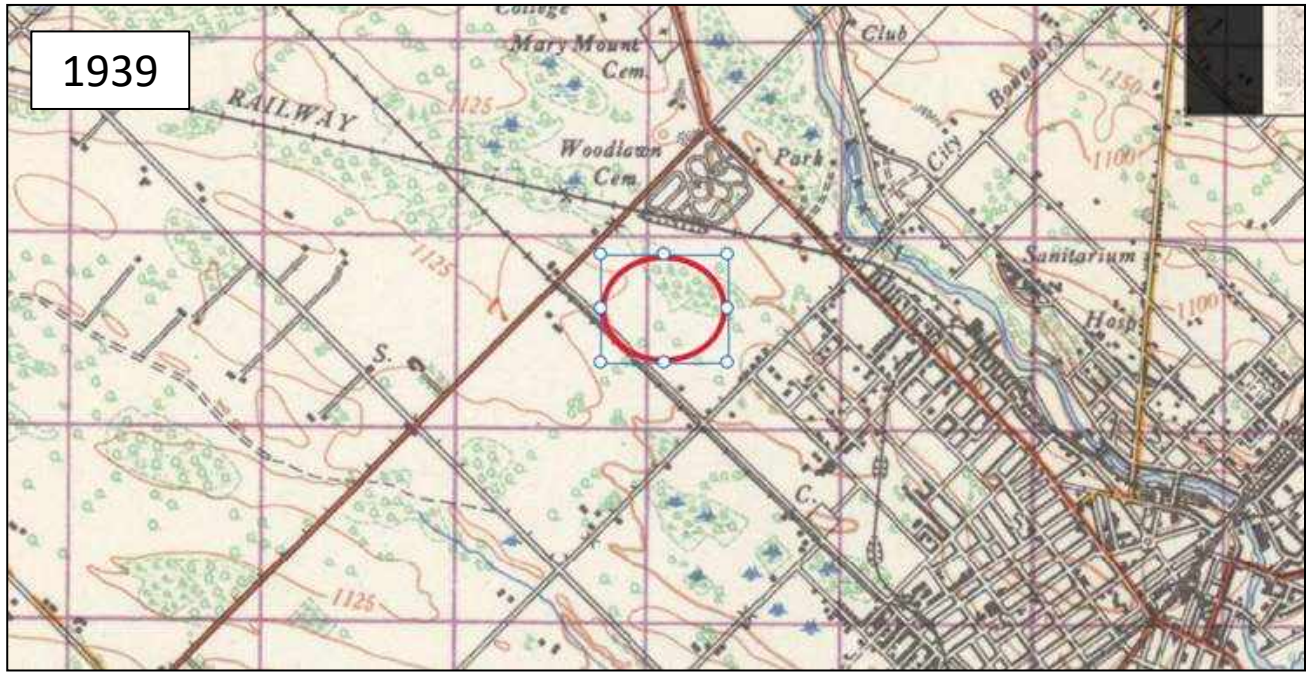


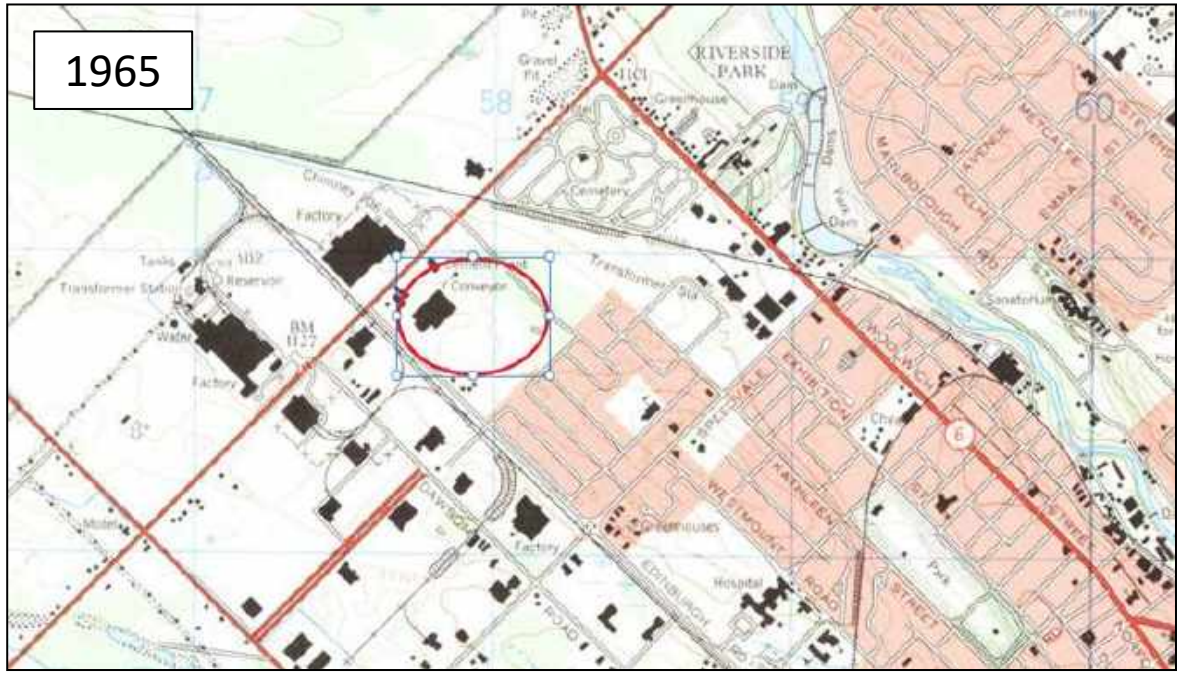
Natural Gas
Hydro
Sanitary
Water
Storm
Site Boundary

No Site utilities located in proximity to SGP-06A

Historical Property Use







Historical property use search revealed no prior use/development before the site began operations in 1965

Source Identification

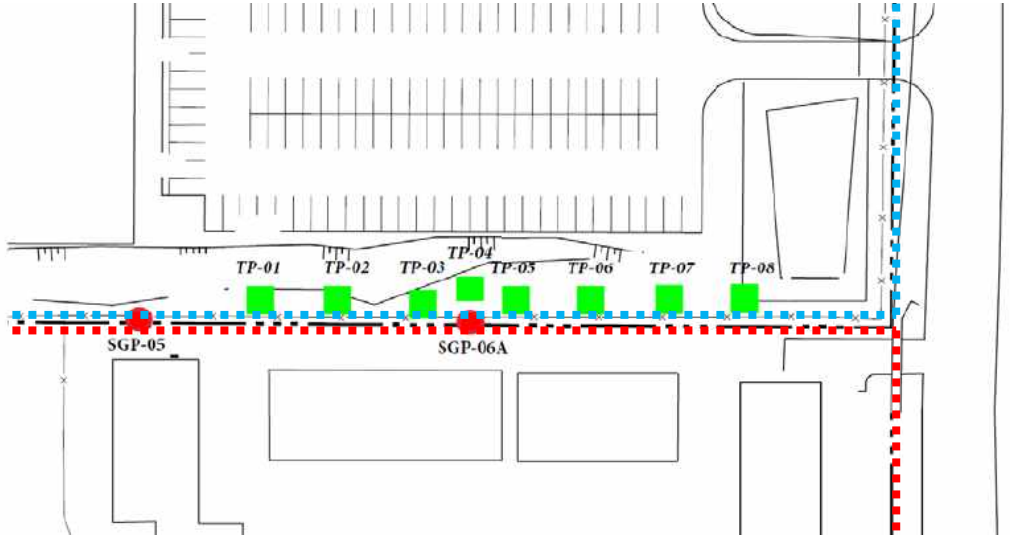


Potential Source	Lines of Evidence				
	Mercaptans	C_2-C_{6+}/CH_4	^{14}C	Site Utilities	Historical Property Use
Result	0.0255 (mg/m^3)	-	96 pMC	Unidentified	Undeveloped
Landfill Gas	√	√	√	?	x
Sewer Gas	√	√	√	x	?
Buried Vegetation	√	√	√	√	√
*Degradation of Petroleum	√	√	x	?	√
Natural Gas	x	x	x	x	x

Notes:
*PHCs not detected in surrounding groundwater monitoring wells of SGP-06A
√ - line of evidence consistent with the source
x – line of evidence not consistent with the source
? – line of evidence is inconclusive
mg/m^3 – milligrams per cubic meter
pMC – Percent Modern Carbon

Next Steps – Methane Delineation and Venting

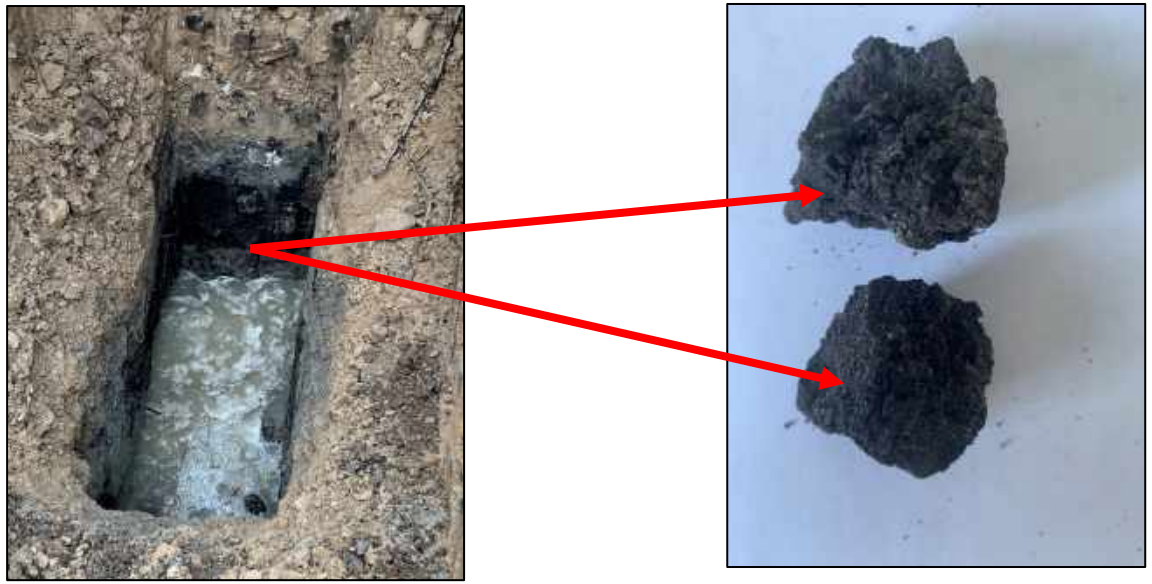




Test pit locations

- A total of eight test pits excavated along the eastern property boundary:
  - 2.5 m length x 1 m width x 2 m bgs depth
  - Temporary soil vapour probes installed at ~1.2 m bgs
  - Backfilled with gravel, geotextile, and native soil material

- Soil profile of test pits:
  - 0-0.2 m bgs – topsoil
  - 0.2-1.1 m bgs - brown clay till
  - 1.1 - 1.3 m bgs – gray clay
  - **1.3-1.6 m bgs – black organic-rich layer**
  - 1.6 - 2 m bgs – gray clay
- Water table - ~2 m bgs



1.3-1.6 m bgs Organic-Rich Layer

Next Steps – Methane Delineation and Venting

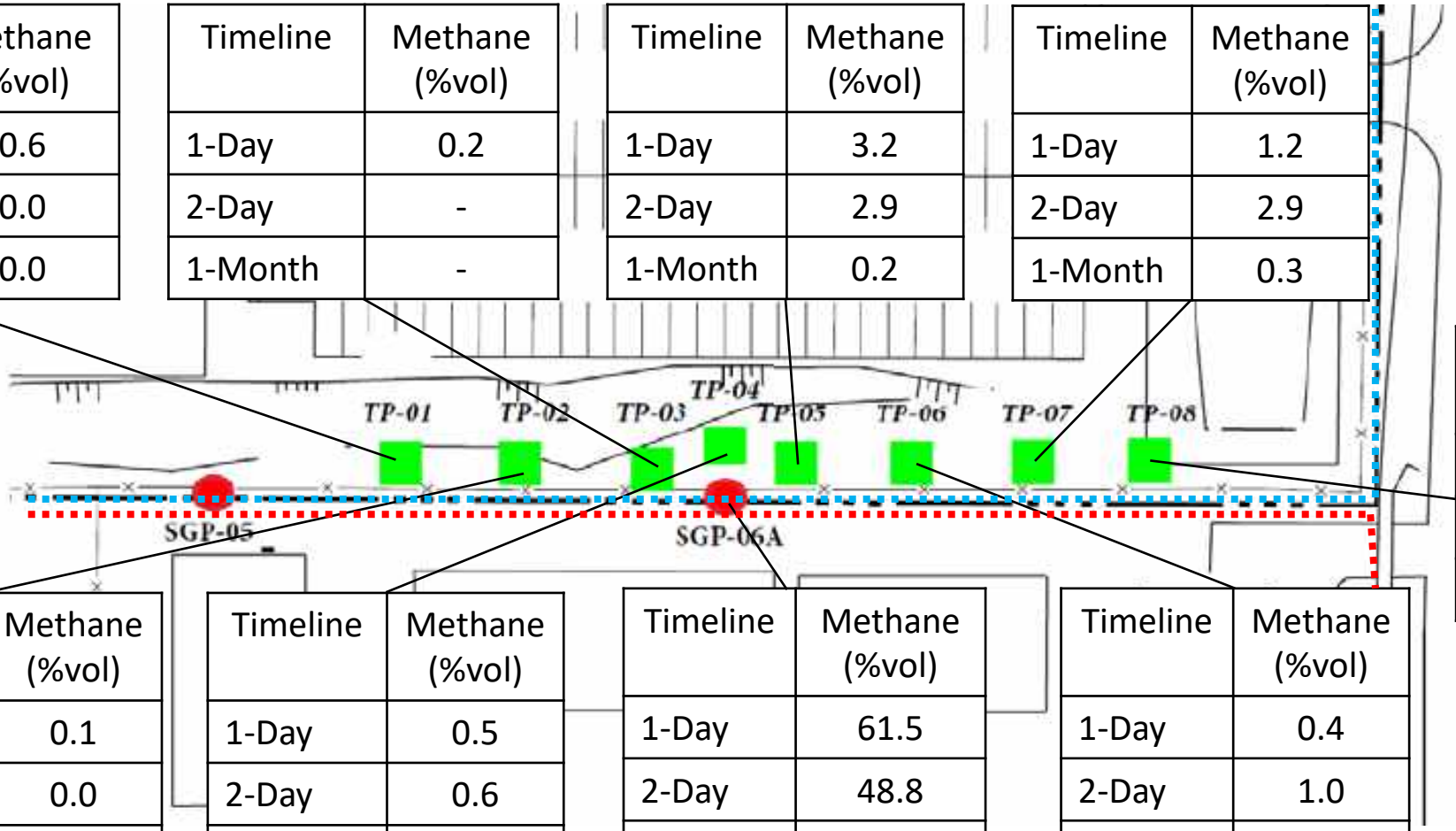


Timeline	Methane (%vol)
1-Day	0.6
2-Day	0.0
1-Month	0.0

Timeline	Methane (%vol)
1-Day	0.2
2-Day	-
1-Month	-

Timeline	Methane (%vol)
1-Day	3.2
2-Day	2.9
1-Month	0.2

Timeline	Methane (%vol)
1-Day	1.2
2-Day	2.9
1-Month	0.3



Timeline	Methane (%vol)
1-Day	0.3
2-Day	0.3
1-Month	0.0

Timeline	Methane (%vol)
1-Day	0.1
2-Day	0.0
1-Month	0.0

Timeline	Methane (%vol)
1-Day	0.5
2-Day	0.6
1-Month	0.0

Timeline	Methane (%vol)
1-Day	61.5
2-Day	48.8
1-Month	36.3

Timeline	Methane (%vol)
1-Day	0.4
2-Day	1.0
1-Month	0.0

*Timeline referenced to completion of test pits, 5 January 2022

- No measurement available

Summary



- The likely source of methane along the eastern property boundary was of an unusual small organic-rich layer of soil bound between two layers of low-permeability clay layers
- High methane detections were limited to a low-lying saturated area in proximity to SGP-06A
- Test pits demonstrated some venting and aerobic oxidation of methane
- Risk and liability to client mitigated with the source of methane identified – off-site residential property owner notified

Questions?



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