SURFACE EMISSIONS MONITORING TECHNOLOGY COMPARISON AT VANCOUVER LANDFILL

SWANA Northwest Regional Solid Waste Symposium 2025

CITY OF VANCOUVER

Outline

- Site Background
- ECCC Funding Opportunity and Proposed Draft Regulations
- Trial of SEM Technologies
- Comparison of SEM Technologies
- Future Considerations

Site Background

Site Background – Vancouver Landfill

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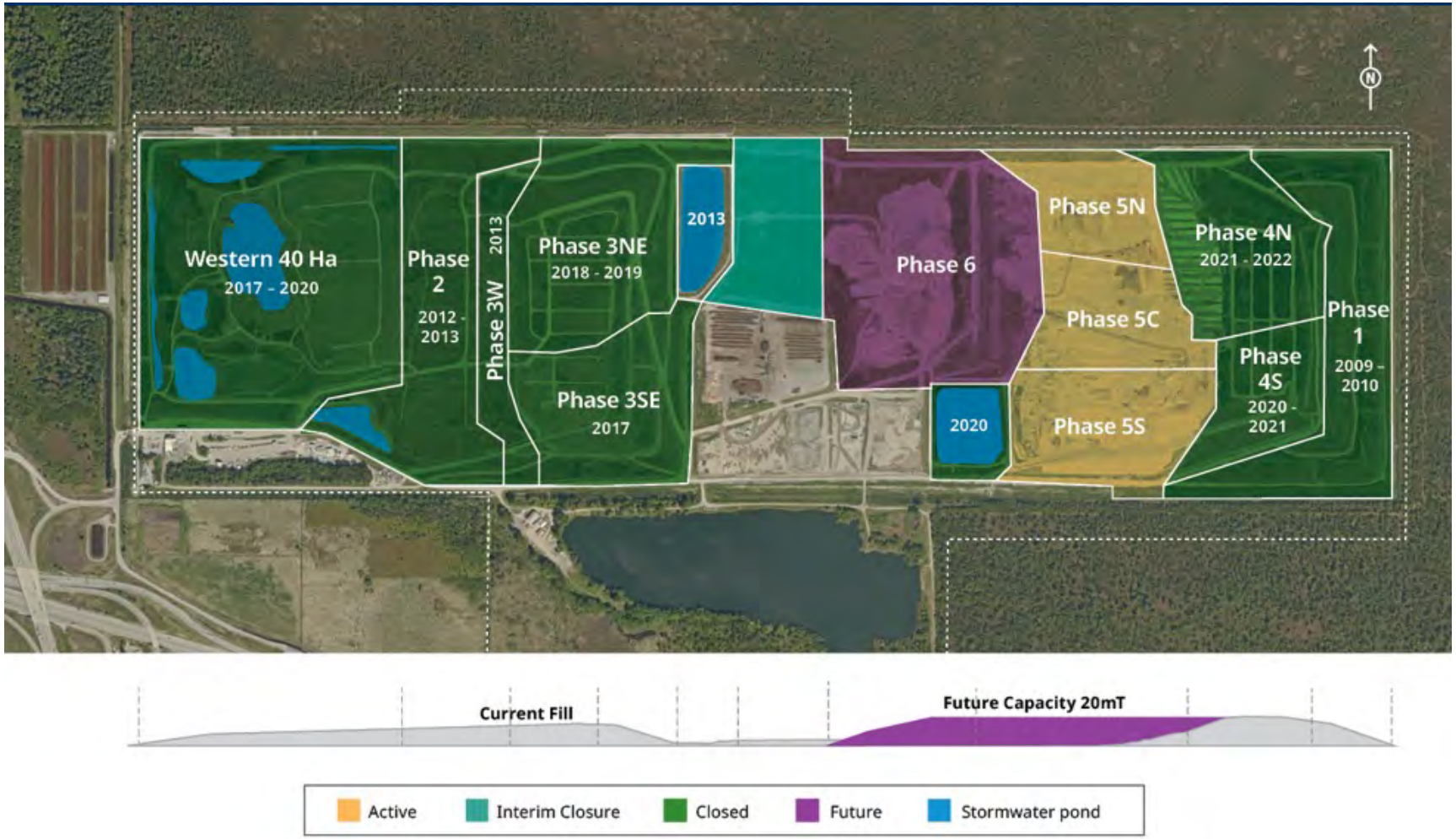


Location: Delta BC, Canada

Began operation: 1966

Total property: 320 hectares

Landfill footprint: 225 hectares

Annual operating budget: ~$40M

Annual capacity: 750,000 TPY

Number of staff: Approx. 85

Customer visits: ~140,000/year

Landfill Gas Control

- Collection since 1991
- Gas utilization for cogeneration from 2003 to 2022
- Two renewable natural gas (RNG) plants commissioned in 2023
- Provincial target of 75% LFG collection efficiency
- Conducted SEM for methane flux several times since 2015 with some follow up using FID and SEM5000

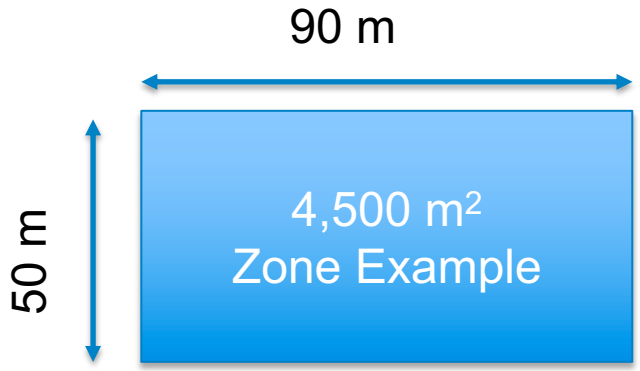
Draft ECCC Proposed Regulations

ECCC Funding

- ECCC Proposed Regulatory Framework first published **April 18, 2023**
  - Reading Path-integrated methane concentrations using drone mounted downward facing laser methane detector
  - Providing a measure of methane concentration in atmosphere between drone and landfill surface
  - Target limit of no more than 200 ppm*m by drone
    - or a follow up walking SEM required
- Funding Opportunity: Emerging Approaches for Reducing Landfill Methane Emissions 2023-2024
  - *"Above the waste: Innovating landfill gas management with aerial technology"*
  - $75,000 to investigate effectiveness of drone-mounted laser methane sensor, compared to other technologies, for quantifying methane emissions and identifying methane leaks and hotspots at the 225 ha Vancouver Landfill

ECCC Current Draft Regulations

- **<u>Draft June 29, 2024</u>**
- Requirements
  - Three monitoring events per year separated by 90 days with at least 72 hours since rainfall
  - Corrective action required within 30 days
- Methane Concentration Action Threshold
  - Zone-average methane concentration of 25 ppm
  - Single location concentration of 500 ppm
- Methodologies
  - Handheld SEM
  - Sniffer drone with probe (10 cm from ground surface)
  - **Drone mounted path-integrated laser methane sensing no longer included**



Method 21

Other Test Method 51

Trial of SEM Technologies

SEM Technologies Trialed

- Handheld SEM

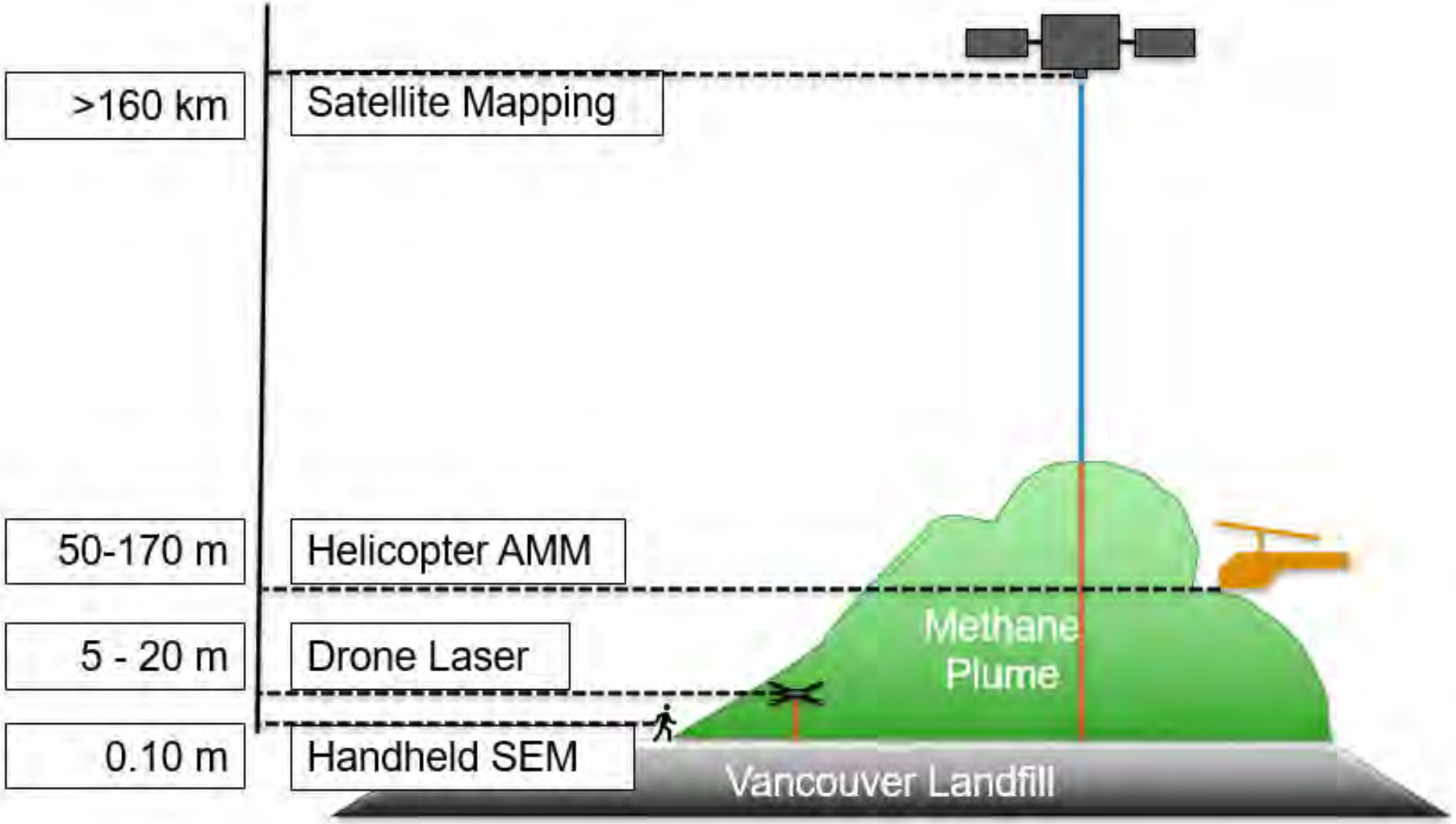
- Satellite Mapping

- Helicopter Airborne Matter Mapping (AMM)

- Autonomous Drone (Laser)
- Manually Operated Drone SEM (Laser)

- Comparison and Analysis

Depiction of SEM Monitoring



Ten SEM Monitoring Events

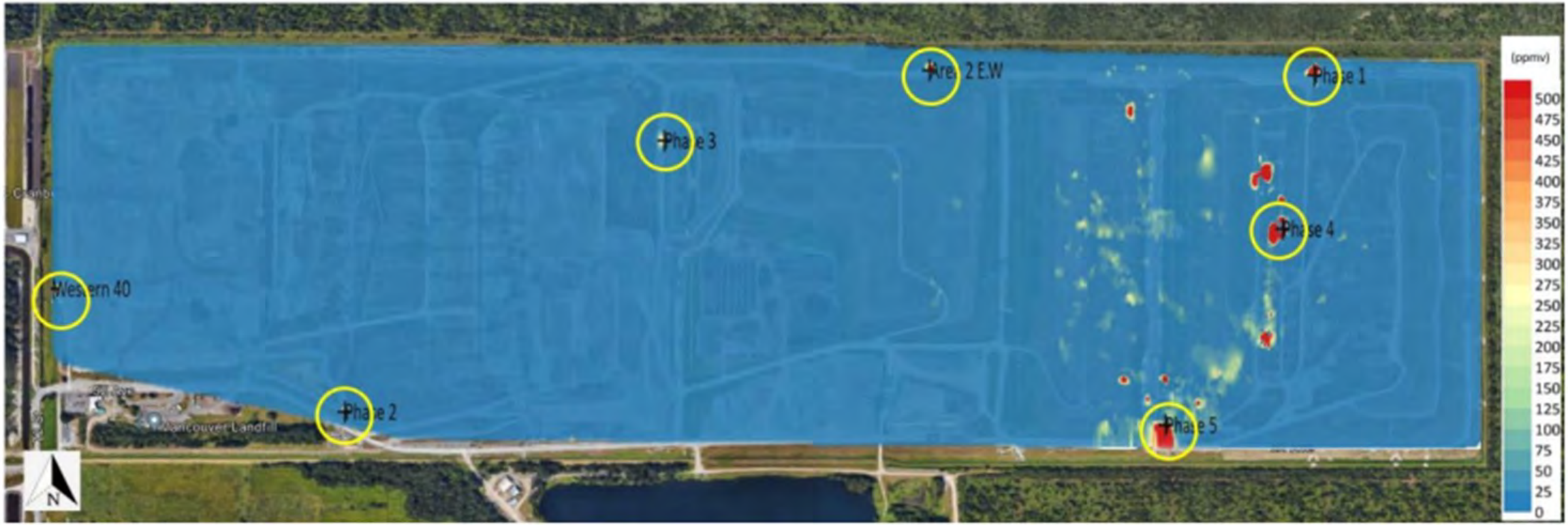
Methodology	Q3 2023	Q4 2023	Q1 2024	Q2 2024	Q3 2024
Handheld SEM	Sept. 2-5				
Helicopter (AMM)	Aug. 22				
Autonomous Drone SEM	Sept. 3-4				
Manually Operated Drone SEM		Dec. 11-13	Mar. 5-8	Jun. 13-16	Sept. 10-13
Satellite Mapping		Jan. 13	Apr. 10	Jul. 7	

Handheld SEM Overview

- Thermo Scientific TVA 2020 FID (flame ionization detector) and three SEM5000 used at ground surface
- 2-5 Sept 2023 week, walking path 15 m spacing (as per 2023 proposed framework) at 10 cm height, readings every 3 seconds, in 0.5-2.0 hectare grid
- Results adjusted using barometric pressure data

Handheld SEM Results

- Methane concentrations greater than 500 ppm methane shown below
- 4,500 m^2 zone methane averages were not assessed

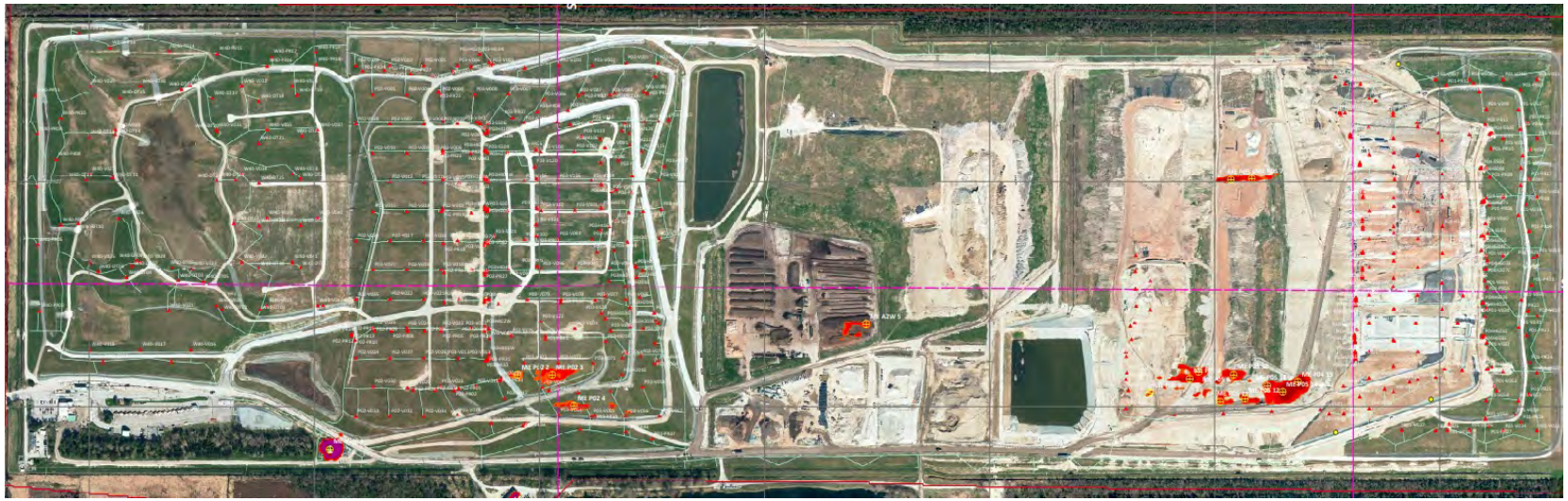


Satellite Mapping Overview

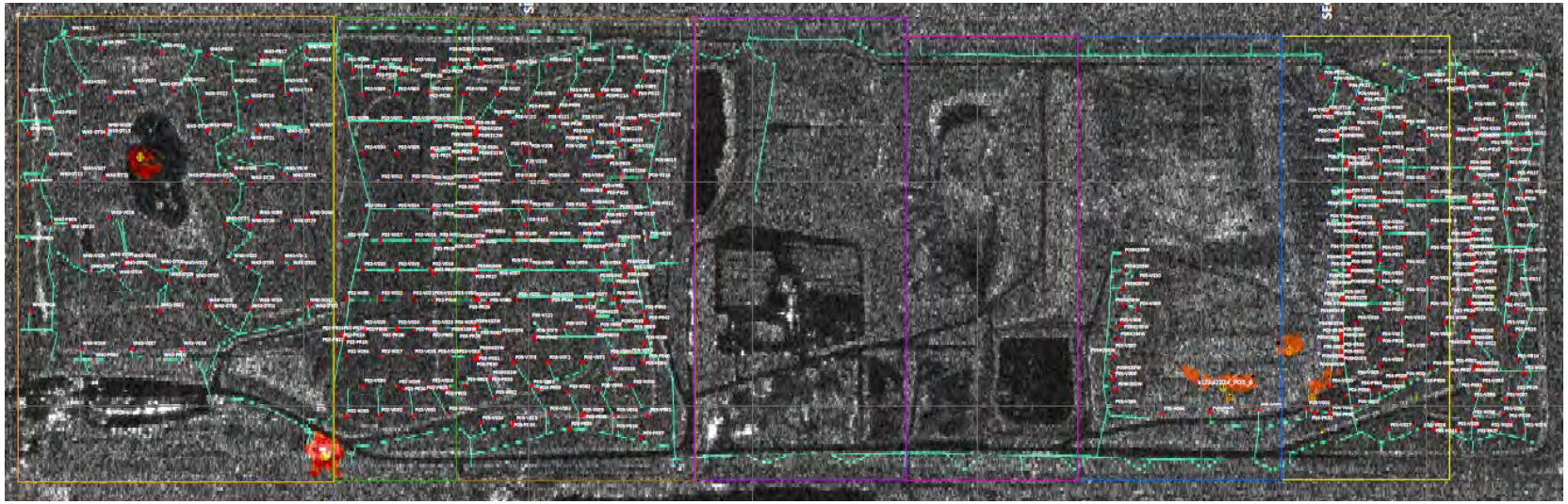
- Shortwave Infrared (SWIR) satellite data
- MUD® (Mapped Underworld Dimension)
- Methane plume detection

Satellite Mapping Results

Q1
2024
Jan 13



Q3
2024
July 4



Satellite Mapping Results

- Maximum point source found was less than 1 ppm CH4

Figure3: Methane Emission Rate Zone 1 and Landfill Phase W40 (in ppm)

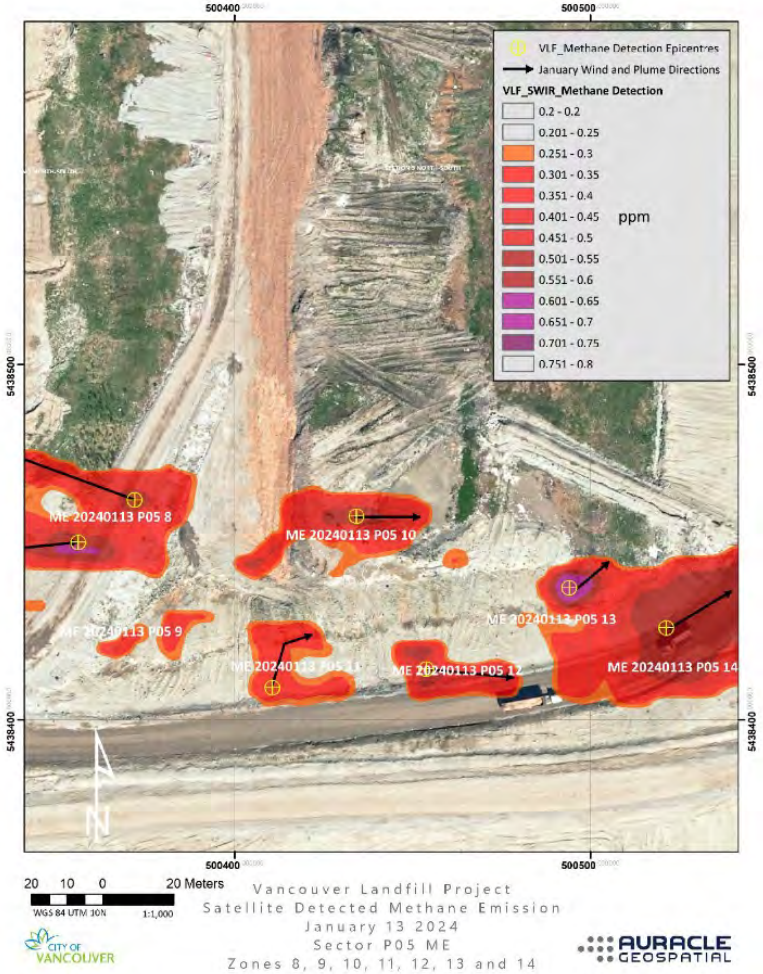
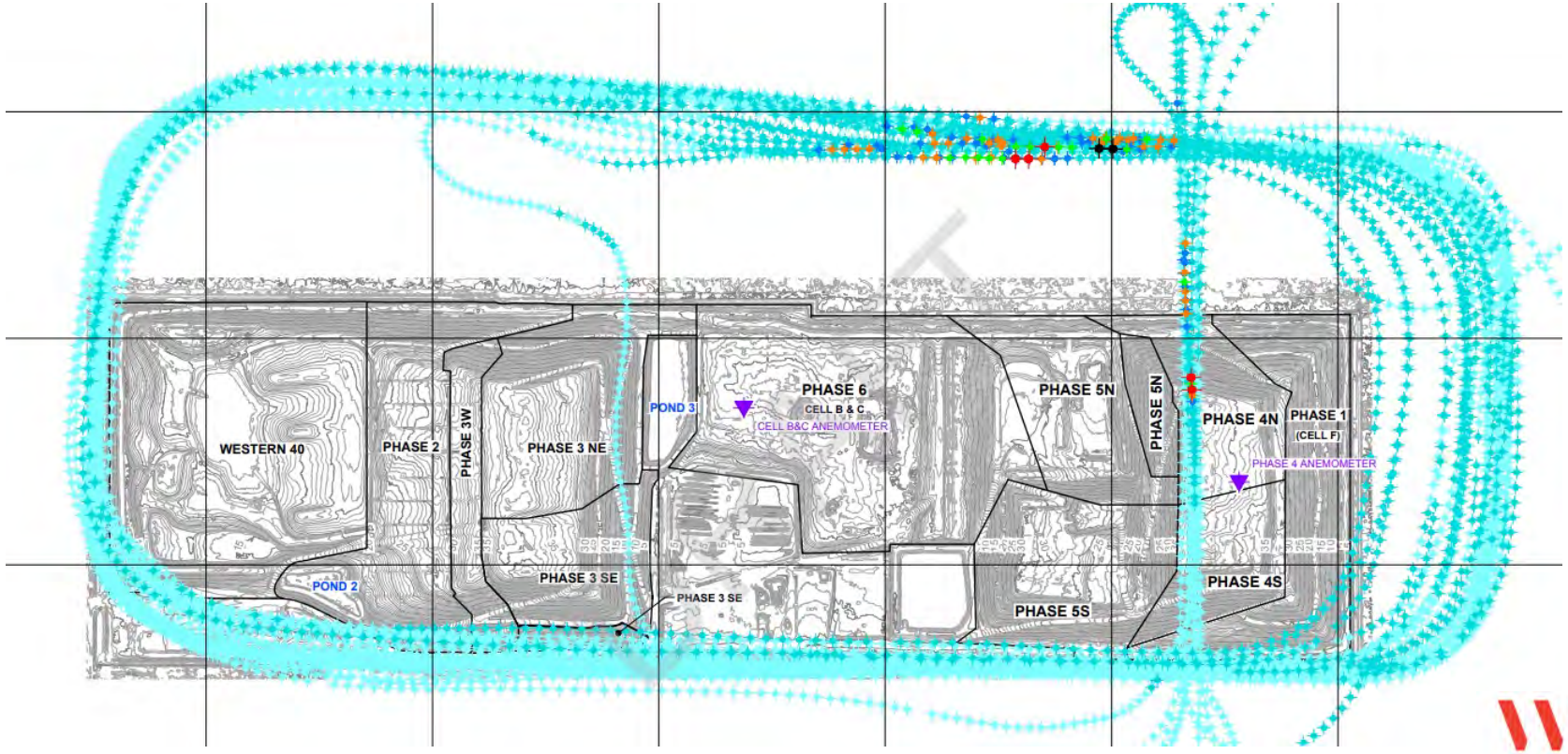


Figure 7: Methane Emission Rate Zones 8, 9, 10, 11, 12, 13 and 14 and Landfill Phase PO5 (in ppm)

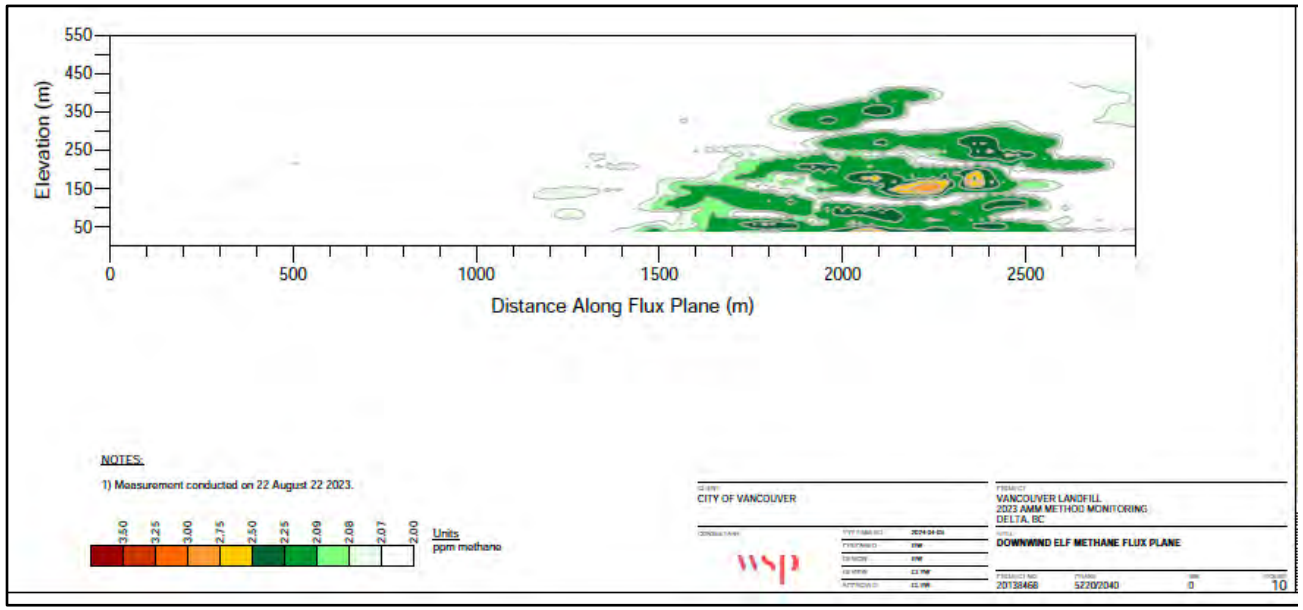
Helicopter (AMM) Overview

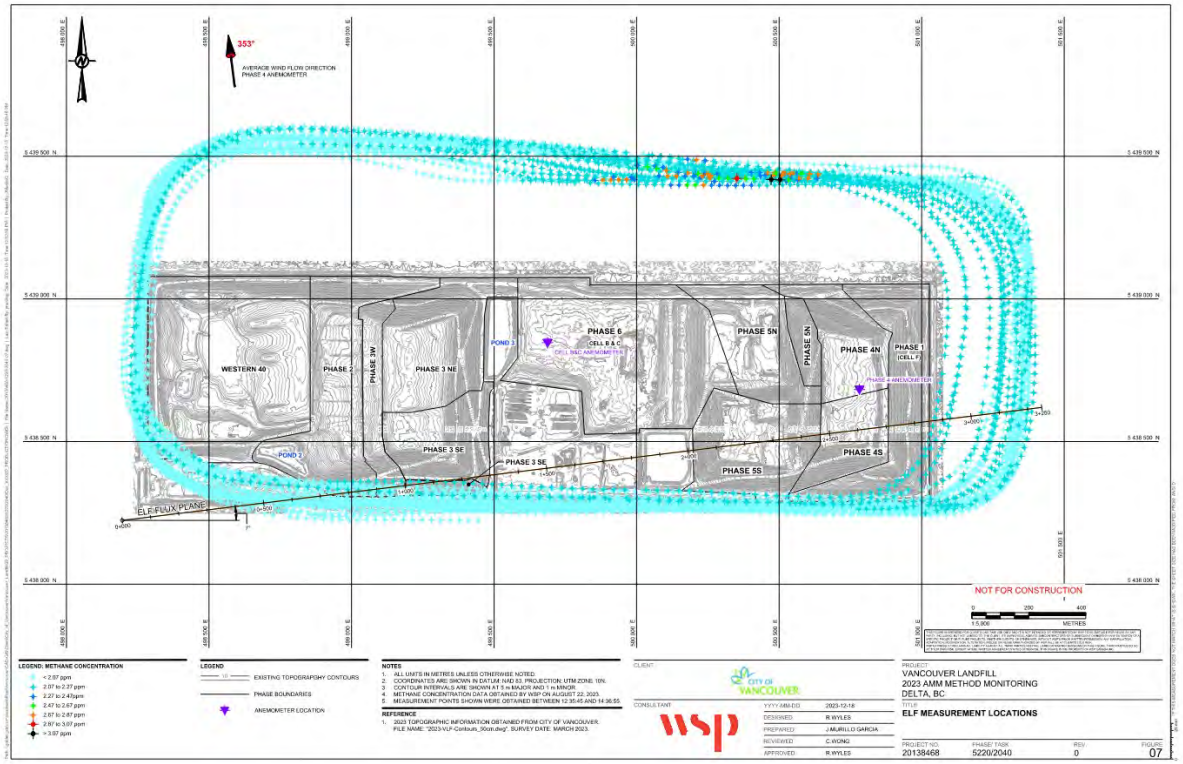
- Los Gatos Gast Greenhouse Gas Analyzer (FGGA) and Aeris Technologies MIRA Ultra Gas Analyzer used in a helicopter over multiple runs at 51 - 167 m
- Concentrations were collected in the plume



Helicopter (AMM) Overview

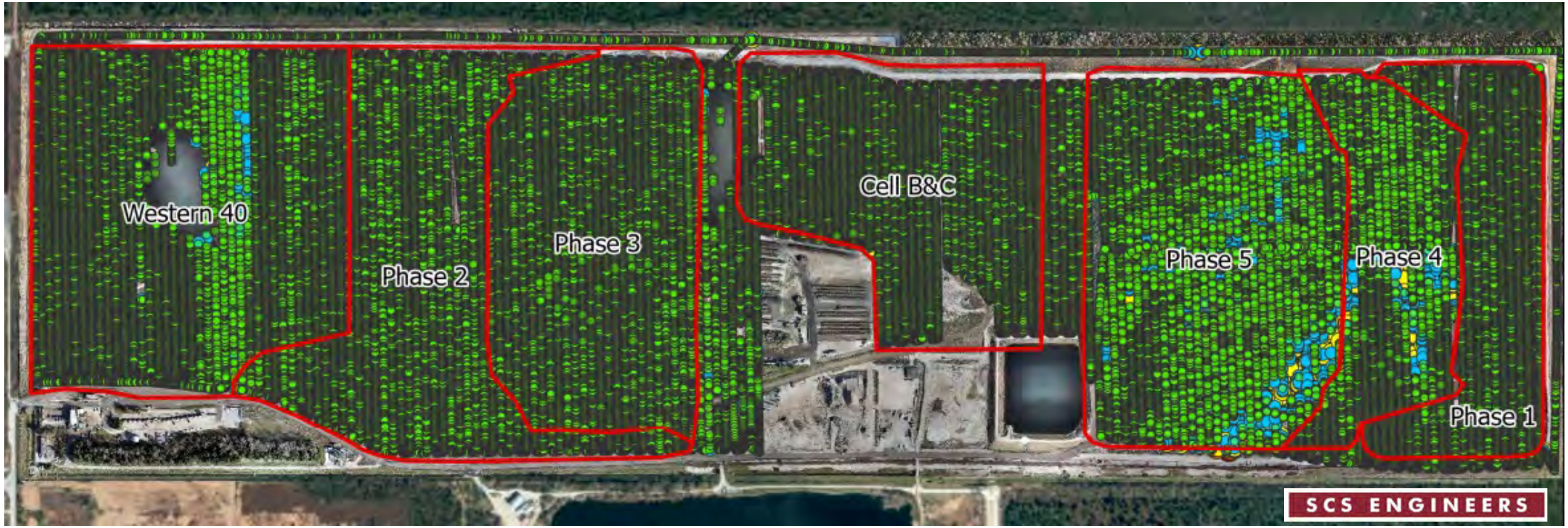
- Purpose AMM: quantify methane emission, concentration and flux rate, using mass balance rather than identify leaks
- In the past used to confirm the main emission source is the active face





Autonomous Drone SEM Overview

- Using laser spectrometry technology, 14.5km/hour, 13 m spacing, 20 m height maintained by radar altimeter
- Remotely operated drone, pre-programmed flight path
- Blue dots are 101-200 ppm*m, yellow dots 201-500 ppm*m CH4 (as per 2023 proposed framework)



Autonomous Drone SEM Results

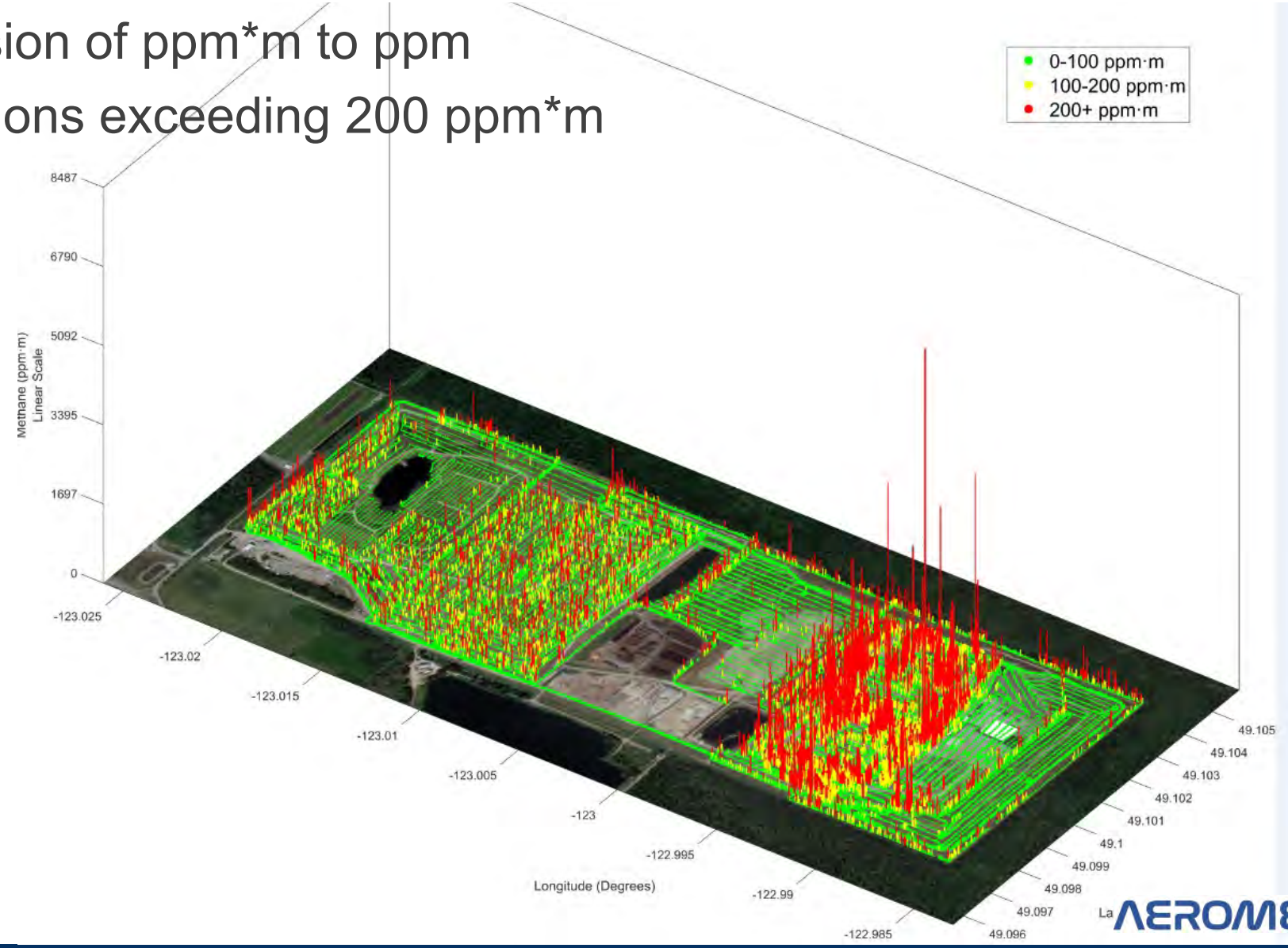
- Convert from ppm*m to ppm CH4 using “Landfill B”
- Found no methane concentrations exceeding 500 ppm
- Highest concentrations found in active landfilling area

Manually Operated Drone SEM Overview

- Aerometrix LaserScan© RPAS, Aerometrix GasMap©
- Drone path 15 m spacing and 5 m height, red dots are greater than 200 ppm*m CH_4 (as per 2023 proposed framework)

Manually Operated Drone SEM Results

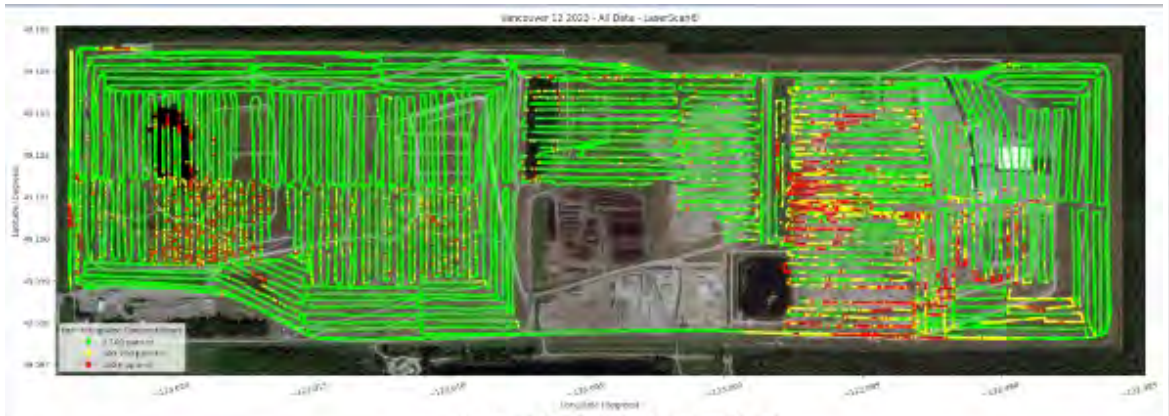
- No conversion of ppm*m to ppm
- Many locations exceeding 200 ppm*m



Manually Operated Drone SEM Results

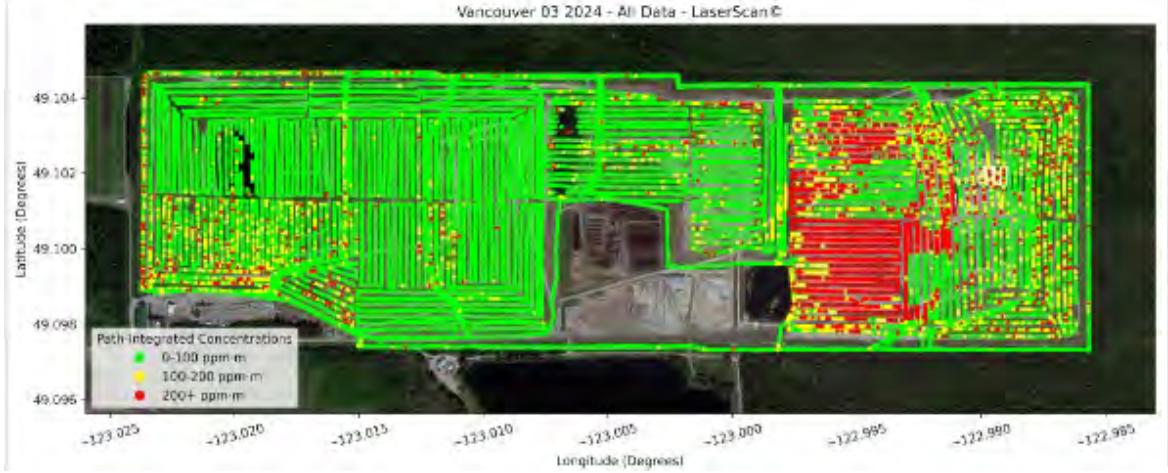
- Seasonal variation apparent
- Weather Conditions:
  - Q4 2023 Rainy
  - Q1 2024 Rainy and Windy
  - Q2 2024 Mixed (Sun and Rain)
  - Q3 Mixed (Cloud and Light Rain)

Q4 Dec 2023

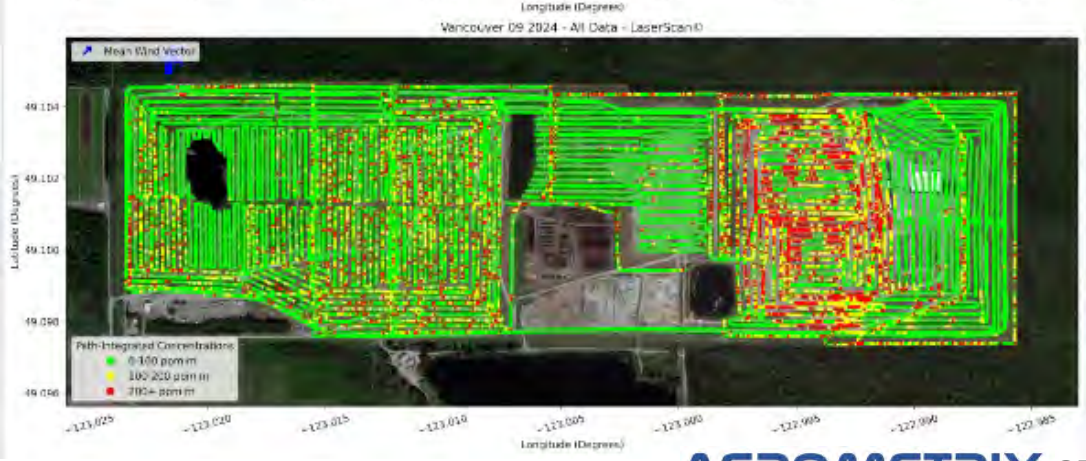


Q2 Jun 2024

Q1 Mar 2024



Q3 Sep 2024



Comparison of SEM Technologies

SEM Results Comparison

Parameter	Handheld SEM	Helicopter (AMM)	Autonomous Drone SEM	Manually Operated Drone SEM	Satellite Mapping
Maximum CH_4	**10,724 ppm**	~3 ppm	~36 ppm	>200 ppm*m	~0.8 ppm
ECCC Threshold Exceedance Locations	All Phases	-	None	-	None

Handheld SEM locations >500 ppm.
Autonomous drone SEM >501 ppm*m or approximately 75 ppm.
Manually operated drone SEM >200 ppm*m (no ppm values reported).
Helicopter (AMM) approximately 3 ppm.
Satellite mapping approximately 0.8 ppm.

Flux Results Comparison

- Not part of GHD comparison
- Not part of current ECCC Draft Regulations

Methane Emissions Rate/Flux

	Handheld SEM	Helicopter AMM	Satellite	Autonomous Drone	Manual Drone			
					Q4	Q1	Q2	Q3
CH4 (g/s)	231	177	1.4	116.40	146	52	321	244

Future Considerations

- Revisit laser drone (autonomous and/or manually operated) vs. handheld SEM
  - Zone-average concentrations with same geometry
  - Vancouver Landfill model for converting ppm*m to ppm

- Use remote monitoring technologies with handheld SEM on the same day. Focus the comparison on areas where leaks were observed previously by the handheld SEM

- Complete three events using the remote monitoring technologies of interest and record weather in parallel with the reported values. Compare and contrast the three events for effects of weather conditions.

Questions?

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2024 Annual Report for the Vancouver Landfill:

2024 Annual Report for the Vancouver Landfill

References

Abedini, A. (2024, May 3). Vancouver Landfill Methane Emissions Quantification. Sperling Hansen Associates.

Asad, O. (2024, February 27). Aerial Methane Survey Q1. Aerometrix.

Asad, O. (2024, June 25). Aerial Methane Survey Q3. Aerometrix.

Asad, O. (2024, March 22). Aerial Methane Survey Q2. Aerometrix.

Asad, O. (2024, October 11). Aerial Methane Survey Q4 2023. Aerometrix.

Massart, T. (2024, March 6). Methane Surface Emissions Flux Rate Estimates using Reverse Air Dispersion Modeling Q3 2023. SCS Engineers.

McLelland, D. (2024, April 10). Technical Report Vancouver Landfill Remote Sensing Q1 2024 Program. Auracle.

McLelland, D. (2024, January 13). Technical Report Vancouver Landfill Remote Sensing Q4 2023 Program. Auracle.

McLelland, D. (2024, July 4). Technical Report Vancouver Landfill Remote Sensing Q2 2024 Program. Auracle.

Ramkellawan, J., & Wong, C. (2013). Calibration of a Fugitive Emission Rate Measurement of an Area Source. Journal of the Air & Waste Management Association, 63(11), 1324 - 1334.

Wong, C., & Wyles, R. (2012). Mapping Concentrations of Airborne Matter to Quantify the Fugitive Emissions. Greenhouse Gas Measurement and Management, 2(1), 50-60.

Wyles, R., & Wong, C. L. (2024). 2023 Surface Emissions Monitoring. WSP.

Government of Canada. (2024). Reducing Canada's landfill methane emissions: Proposed regulatory framework. Retrieved from https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/publications/reducing-landfill-methane-emissions.html