SOLUTION BRIEF · LANDFILL METHANE QUANTIFICATION

Quantifying Landfill Methane, Source by Source and Site-Wide

Point-Source and Whole-Site Emission Rates From Laser OGI Drone Surveys

This document describes how Xplorobot Laser OGI quantifies methane on a landfill at two scales: the emission rate of each individual source, and the total emission rate of the site.



Figure 1. Xplorobot Laser OGI on a drone surveying a landfill cover.

0.04 g/hr
handheld detection limit, confirmed by GTI Energy (formerly the Gas Technology Institute)[1]

0.16 kg/hr
drone 90% probability of detection at the Methane Emissions Technology Evaluation Center (METEC)[2]

±30 cm
source localization from the drone

1.45×
handheld rate uncertainty factor, 1σ

Introduction

Landfill methane is more often estimated than measured. Inventories are typically built from gas generation models and assumed collection efficiencies, while surface emissions monitoring (SEM) relies on a technician walking a grid across the cover with a pump-driven sensor, i.e. a sniffer, to find locations above a concentration threshold. Neither approach produces a measured emission rate for an individual source or for the landfill as a whole.

Operators need both. A source-level rate shows which emissions are consequential and where to send the repair crew first (e.g. a leaking wellhead versus a crack in the cover). A site-level rate shows how much methane the landfill emits in total and provides an independent check on the inventory. Comparing the sum of the quantified sources with the measured site total shows how much of the emission has been found. Xplorobot Laser OGI provides both from the same instrument and the same top-down drone flights (Table 1).

TABLE 1	SOURCE LEVEL	SITE LEVEL
Question	Which sources emit, and how much?	How much does the site emit in total?
Measurement	Concentration around each source, with wind	Top-down column readings, with wind
Output	Emission tag with image, location and g/hr	Site rate in kg/hr and a 2D methane map

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Point-Source Quantification

Xplorobot Laser OGI measures methane from a distance, from the drone or in the hand. Every reading is tied to an image, a GPS position, the wind and the temperature, so each source found is recorded with where it is, what it looks like and the conditions at the time of the survey.

Finding Sources From the Air

The inspector plans the flight in Xplorobot software to cover the area of interest and loads it into the drone, which then flies the pattern automatically (Figure 2). During the flight, the app creates a digital emission tag wherever the column-integrated concentration exceeds the configured threshold. A methane map of the surveyed area is ready on landing; the inspector checks it for full coverage, reviews each tag, rejects those below the reporting threshold and attributes the rest to a location or component.

Flight plan **Methane map after the flight**

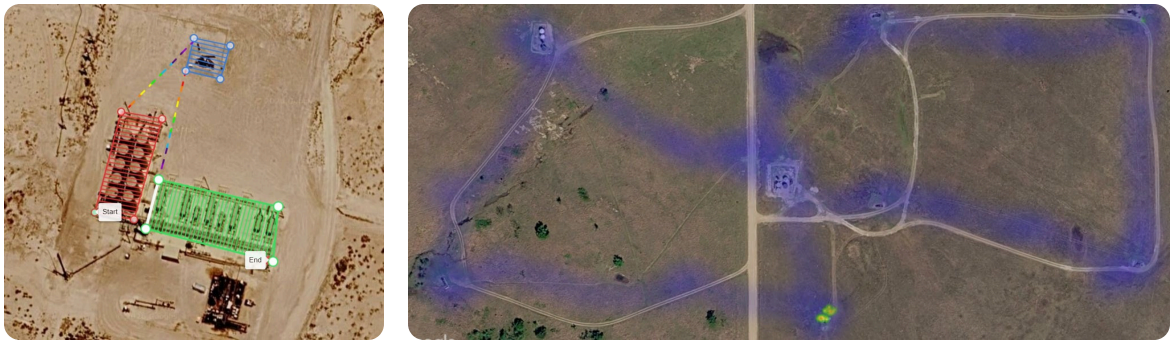


Figure 2. Flight planning software (left) and the methane map of a multi-pad flight (right).

From the Air to the Ground

The methane readings from the drone form a heat map of the surveyed area. The app places a tag automatically at the highest reading of each hotspot, grouping adjacent hotspots that belong to the same plume into one tag, and attaches the drone image taken at that location (Figure 3).

Emission sources are localized to approximately 30 cm from the drone, and vision-based localization delivers approximately 40 cm accuracy from an altitude of 50 m. This shortens the walk to each source for follow-up with the same device on the ground, where the technician confirms the emission, records a ground tag that is added to the same tag record (Figure 3, inset), and later verifies the repair.

Aerial tag image, from the drone **Methane map with automatic tags**

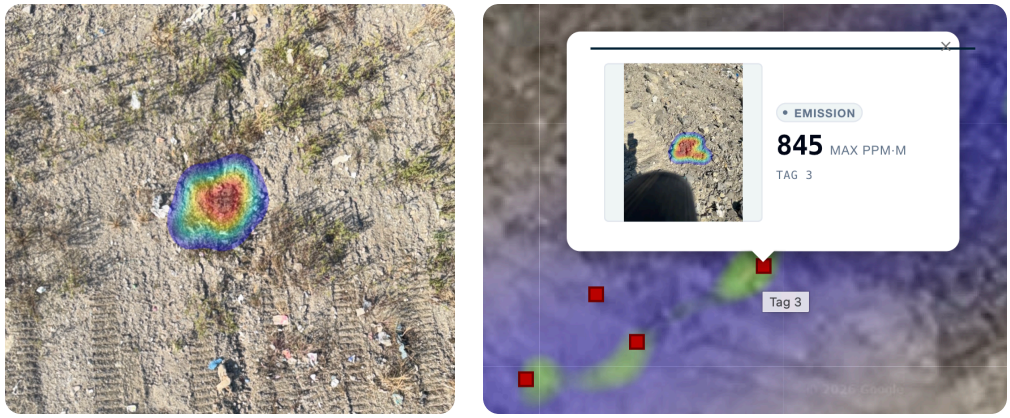


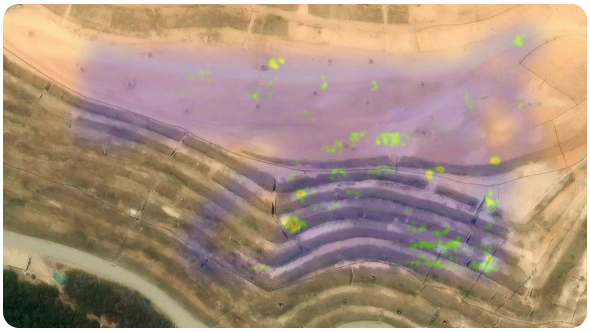
Figure 3. Air to ground: the aerial tag image (left), and automatic tags on the methane map with the ground tag inset (right).

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Mapping a Landfill

On a landfill, the same workflow produces a site-wide methane map showing how emissions are distributed across the cover, the side slopes and the gas collection system, and a digital emission tag for each source with its image, peak concentration, emission rate, wind speed and temperature (Figure 4).

Site-wide methane map



Ground tag on a gas collection duct

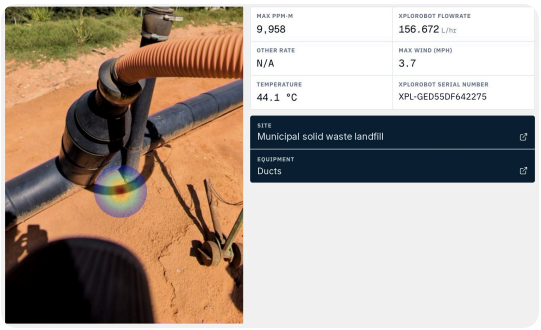


Figure 4. Site-wide methane map from an aerial landfill survey (left) and a ground tag at a gas collection duct (right).

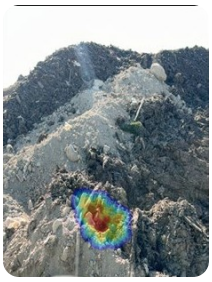
Underground and Buried Sources

Much of the methane on a landfill reaches the surface through cover soil or escapes from buried collection piping, with little or no thermal contrast between the gas and its surroundings. Infrared OGI cameras rely on that contrast; the Laser OGI measures methane absorption directly, so underground and buried sources are detected from the drone and confirmed on the ground (Figure 5).

Underground source, from the drone



Same source, on the ground



Buried pipe route, drone

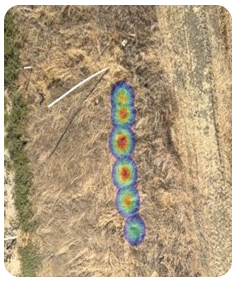


Figure 5. An underground source detected from the drone and on the ground, and a buried pipe detected from the drone.

Emission Rate of Each Source

Each tag carries an emission rate in grams per hour, calculated from the methane readings and the wind measured during the survey. Adjacent detections that belong to the same plume are grouped, so each source is counted once. Ranking the sources by rate shows which emissions are consequential and where to send the repair crew first.

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Quantification Accuracy on the Ground

On the ground, the technician scans the source with the handheld from close range and from several positions. In controlled release testing by GTI Energy, the handheld demonstrated a minimum detection limit of 0.04 g/hr and an emission rate uncertainty of a factor of 1.45 at 1σ, i.e. 68% of measurements fell within a factor of 1.45 of the true rate, and 39 of 42 measurements (93%) fell within a factor of two (Figure 6).

Because the handheld and the drone use the same sensor, a rate measured on the ground can be compared directly with the tag recorded from the air. The handheld is also used to verify each repair, so the record for a source runs from the aerial tag through the repair verification.

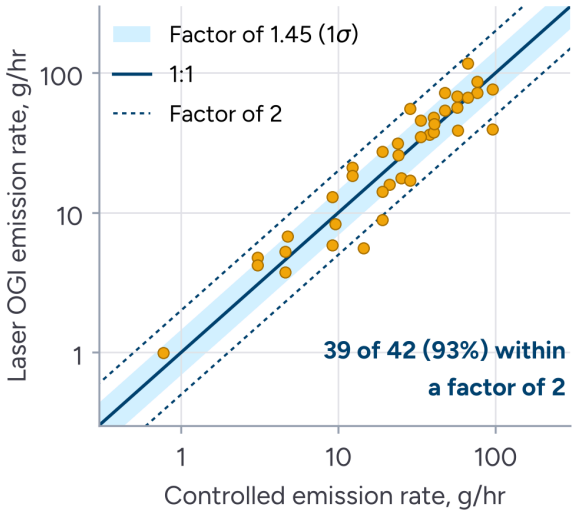


Figure 6. Handheld versus controlled emission rate (GTI Energy data).

Detection From the Drone

Detection from the drone depends on flight altitude, speed and site conditions. In single-blind testing at METEC in July 2026, the drone flew 30 to 45 ft above the equipment at 1 to 2 m/s over 93 controlled releases between 0.01 and 4.8 kg/hr. Scored at both the pad and the equipment level, it reached a 90% probability of detection on par with the handheld, and every release above 0.2 kg/hr was detected (Table 2).

TABLE 2 · DETECTION	RESULT
Drone at METEC, 90% probability of detection (true positive rate 88.6–89.2%)	0.16 kg/hr
Drone at METEC, minimum detection limit demonstrated	50 g/hr
Handheld, 90% probability of detection	0.155 kg/hr
Landfill, low and slow flight mode (30–45 ft altitude), 90% probability of detection	160 g/hr
Landfill, fast and high flight mode (80–100 ft altitude), 90% probability of detection	1.35 kg/hr

Whole-Site Quantification

Summing sources gives a bottom-up total, but a landfill also emits through diffuse areas (e.g. the active face and cover soils), and some sources fall below the detection threshold. The whole-site emission rate is therefore measured directly from the same top-down drone flights that locate the individual sources (Figure 7). The result is a site emission rate in kg/hr and a 2D methane map of the site. The difference between the site total and the sum of the tagged sources indicates how much of the emission is diffuse or below the detection threshold of the flight.

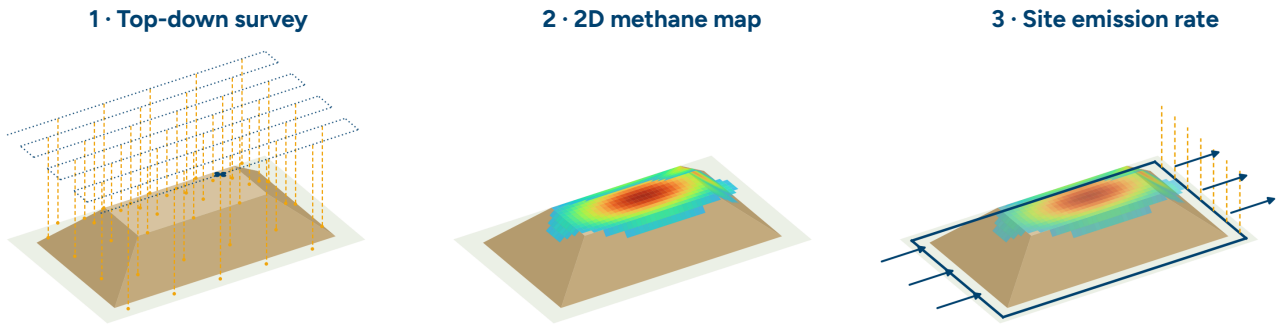


Figure 7. Whole-site quantification illustrated on a landfill cell.

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Records, Quality Control and Reporting Threshold

All raw data and every digital emission tag go to the cloud-based Xplorobot Compliance Database, which notifies the people responsible for repair and tracks each source through repair verification. Quality checks include a daily calibration check against a methane vial, a coverage check of each flight against the site map, and a match between tags recorded from the air and on the ground.

A column reading cannot match a point reading exactly, since it also depends on how methane is spread along the laser path. In controlled releases of 0.4 to 787 g/hr, verified with a Hi Flow device, every source at or above 500 ppm by Method 21 read above 500 ppm·m with the Laser OGI, which is why 500 ppm·m is used as the drone reporting threshold.

Limitations and Operating Envelope

- Surveys run in sustained winds below 20 mph and from −12 °F to 108 °F, with enough light for the camera. Light rain and snow have not affected detection; heavy rain or snow are avoided for flight safety.
- The detection threshold depends on drone altitude, speed and site conditions, so the flight mode is chosen for the threshold required (Table 2).
- Whole-site results depend on full survey coverage of the site and its boundary.

Summary

Xplorobot Laser OGI quantifies landfill methane at both scales from the same instrument and the same top-down flights. Individual sources, including underground and buried ones, are tagged from the air, localized to within approximately 30 cm and quantified in g/hr, with ground follow-up by the handheld. The whole-site rate is measured from the same flights. Comparing the two shows how much of the emission has been found.

References

1. Colorado State University METEC. Xplorobot drone-based Laser OGI controlled release test report. August 2026.
2. GTI Energy. Controlled release testing of the Xplorobot Laser OGI handheld: detection limit and emission rate quantification.
3. Xplorobot. Laser OGI on a drone: Description of Technology and Formal Alternative Test Method.

[1] GTI Energy is an independent, non-profit research and training organization serving the natural gas industry.

[2] METEC is an outdoor test facility at Colorado State University where methane is released at known rates from real oil and gas equipment to evaluate detection and quantification technologies.

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