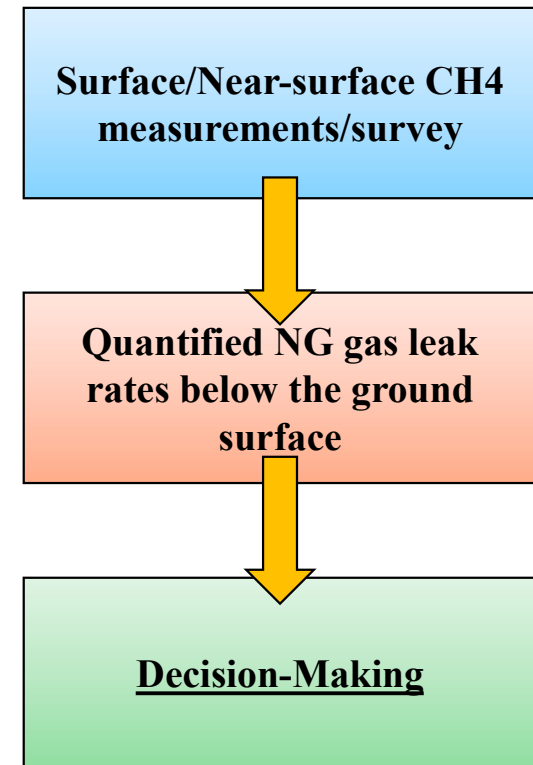


Innovative Sensor Network for Subsurface Emissions (InSENSE)

Background & Objective

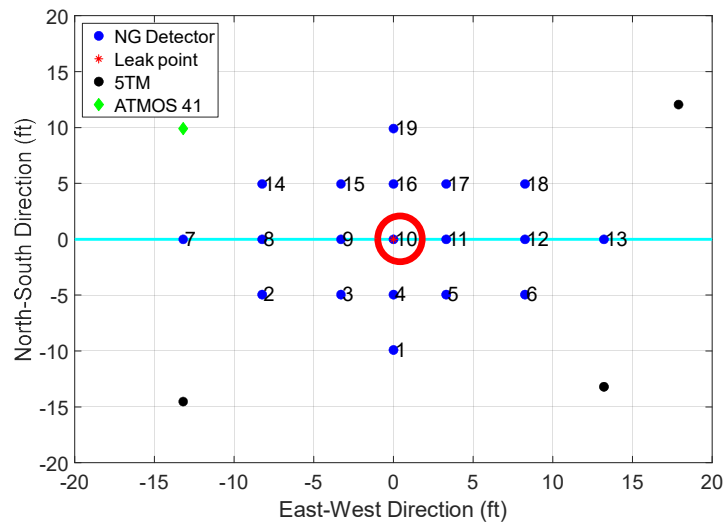
- Although natural gas detectors are commonly used to monitor and evaluate underground gas leakages and repairs, there is a **need for integrating knowledge of natural gas migration and gas leakage detection and quantification**.
- We utilized the **near real-time methane detector network** to connect the methane monitoring system and the improved gas migration model to **quantify the non-steady natural gas leakage from the pipeline** by surface measurements and environmental conditions.



Controlled NG Release Experiment

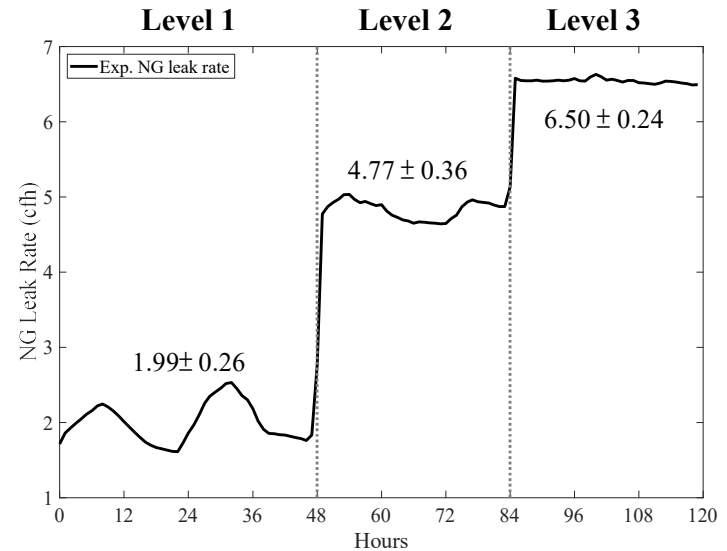
- **Near-real time sensor network**

- Nineteen CH₄ detectors (Blue point) to detect surface & belowground near-surface (BNS, depth is 0.47 inch/1.2 cm) CH₄ concentration.
- Soil moisture and soil temperature (Black point)
- Weather conditions (Green star) above ground surface.



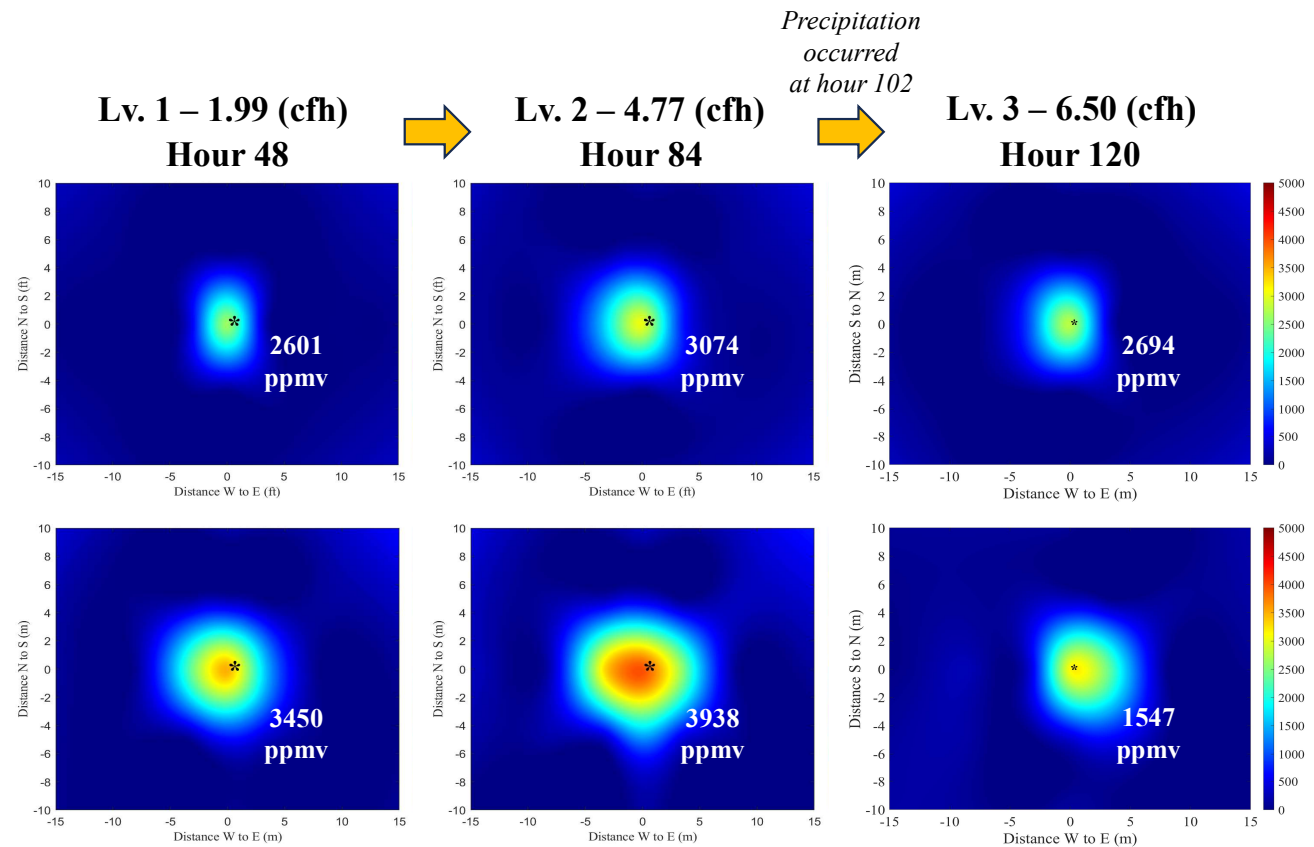
- **Controlled gas leak rates**

- The depth of a leak point was **3 ft (0.91 m)** directly below Detector 10.
- 1) Level 1: 1.99 ± 0.26 (cfh) / 37 ± 4.8 (g/h) for 2 days.
 - 2) Level 2: 4.77 ± 0.36 (cfh) / 89 ± 6.8 (g/h) for 1.5 days.
 - 3) Level 3: 6.50 ± 0.24 (cfh) / 121 ± 4.4 (g/h) for 1.5 days.



Surface and BNS CH₄ Plume Areas

- The plume area of the belowground near-surface BNS CH₄ extended approximately **two times** farther than that of the surface CH₄ as the gas leak rate increased from 1.99 to 6.50 (cfh) (37 to 84 g/h).
- **The BNS CH₄ concentration is an important factor in leak rate estimates as the surface expression does not necessarily define the belowground plume location/behavior.**



Modeled NG Leak Rates by Modified ESCAPE

- The modified ESCAPE model used **the meteorological data, soil moisture/temperature, and surface/BNS CH₄ concentrations** to estimate the non-steady NG leak rate.
- Estimated NG leak rates agrees well with the experimental NG leak rates (**$m=0.99$ and $R^2=0.77$**)
- This demonstrates that **including soil characteristics and BNS CH₄ measurements can advance estimations of non-steady NG leak rates for both low and moderate NG leak rate scenarios** (leaks from 1.99 to 4.77 cfh / 37 to 84 g/h).

