

Benzene and Other Air Toxics Near Oil and Gas Well Pads During Well Drilling, Completions, and Early Production

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Introduction

- Colorado ranks 4th among U.S. states for oil production and 8th for natural gas production. Increased unconventional oil and gas development (UOGD) near residences, schools, and parks has increased concerns about air quality impacts.
- We measured VOCs surrounding oil and gas well pads in the Denver-Julesburg (DJ) Basin. The study focuses on air quality impacts of emissions of air toxics and other VOCs during development of new well pads.

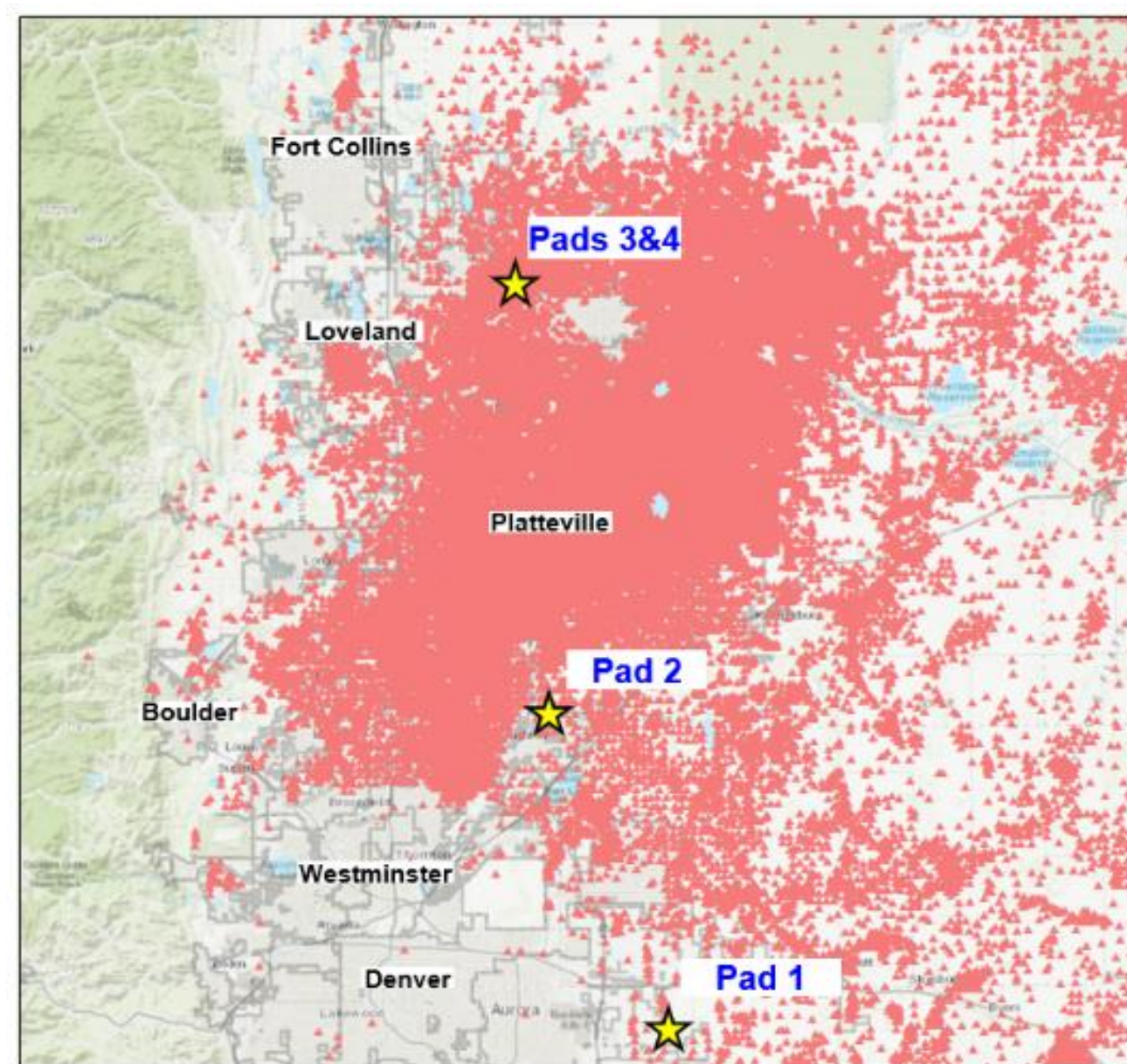


Figure 1. Map of the DJ Basin study region and monitoring locations: Site 1 (Pad 1), Site 2 (Pad 2) and Site 3 (Pads 3 & 4). Pink dots represent well locations.

Measurements

- The study measured methane and VOCs around 4 large, multi-well pads. VOCs were collected in weekly canister samples and in canister samples triggered by photoionization detector plume detection. CDPHE measured VOCs by online gas chromatography (GC).
- Measurements were conducted during well drilling, hydraulic fracturing, coil tubing/millout, flowback, and early production operations at 3 locations near Aurora, Brighton, and Windsor, Colorado.
- We worked with 3 major DJ Basin oil and gas operators who facilitated site access and provided operations information to aid interpretation of study findings.

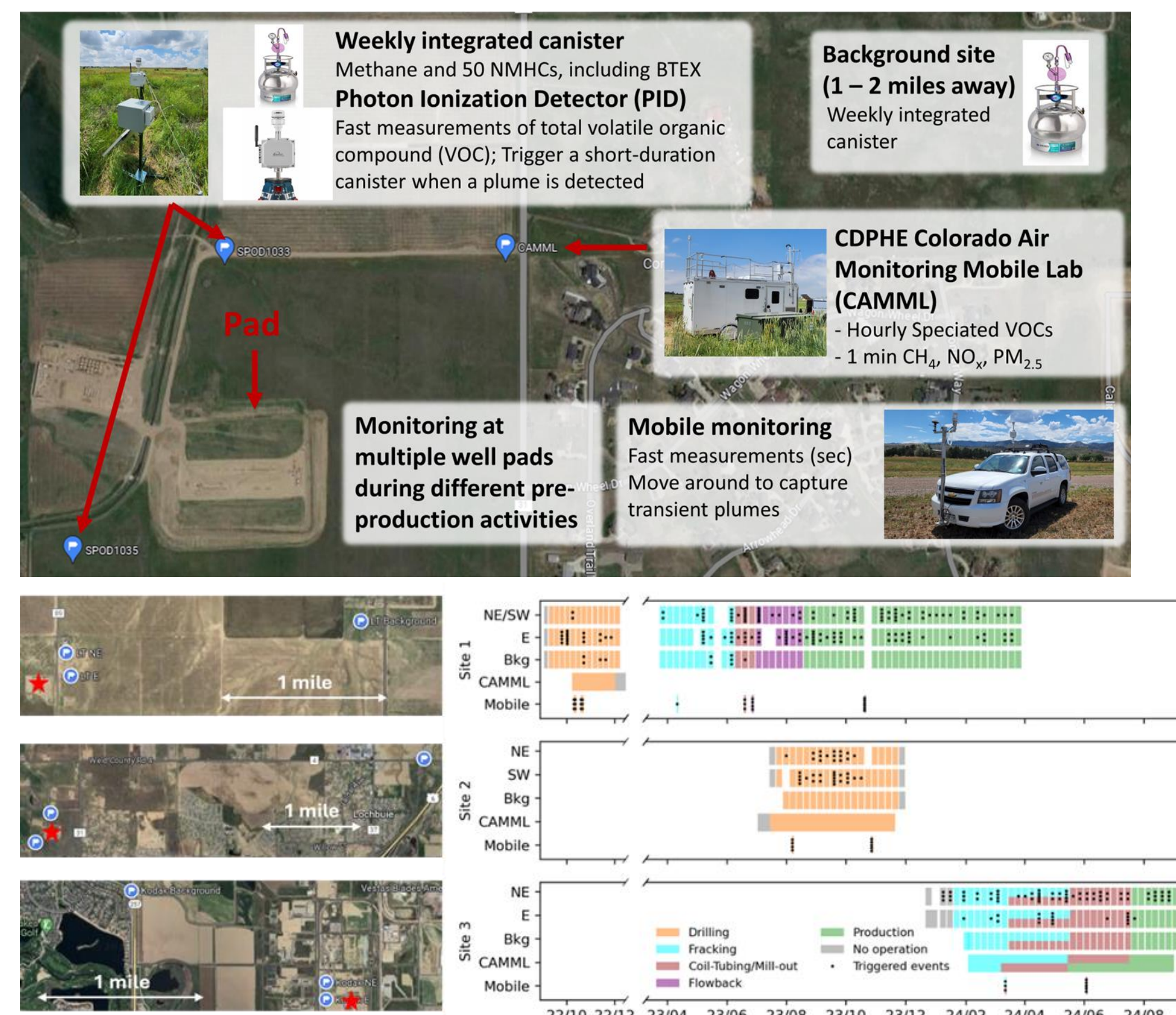


Figure 2. Typical setup (left) showing air monitoring around a well pad. Air monitoring summary (below) for 3 study locations.

Air monitoring is set up around each pad and at a background location. Monitoring at site 1 included the full well development cycle from drilling through early production. Drilling was monitored at site 2 and well completions and early production were monitored at two well pads at site 3.

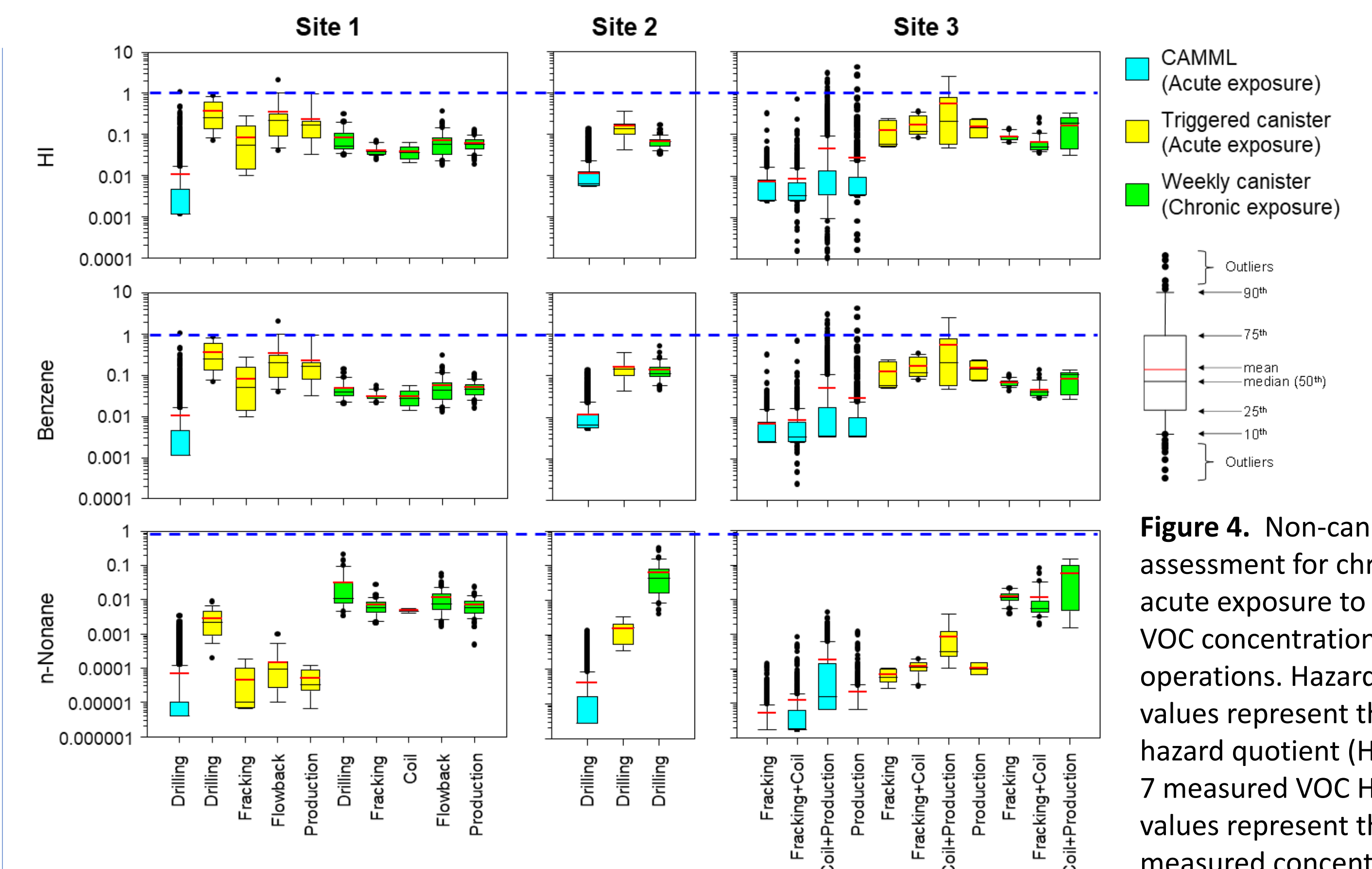
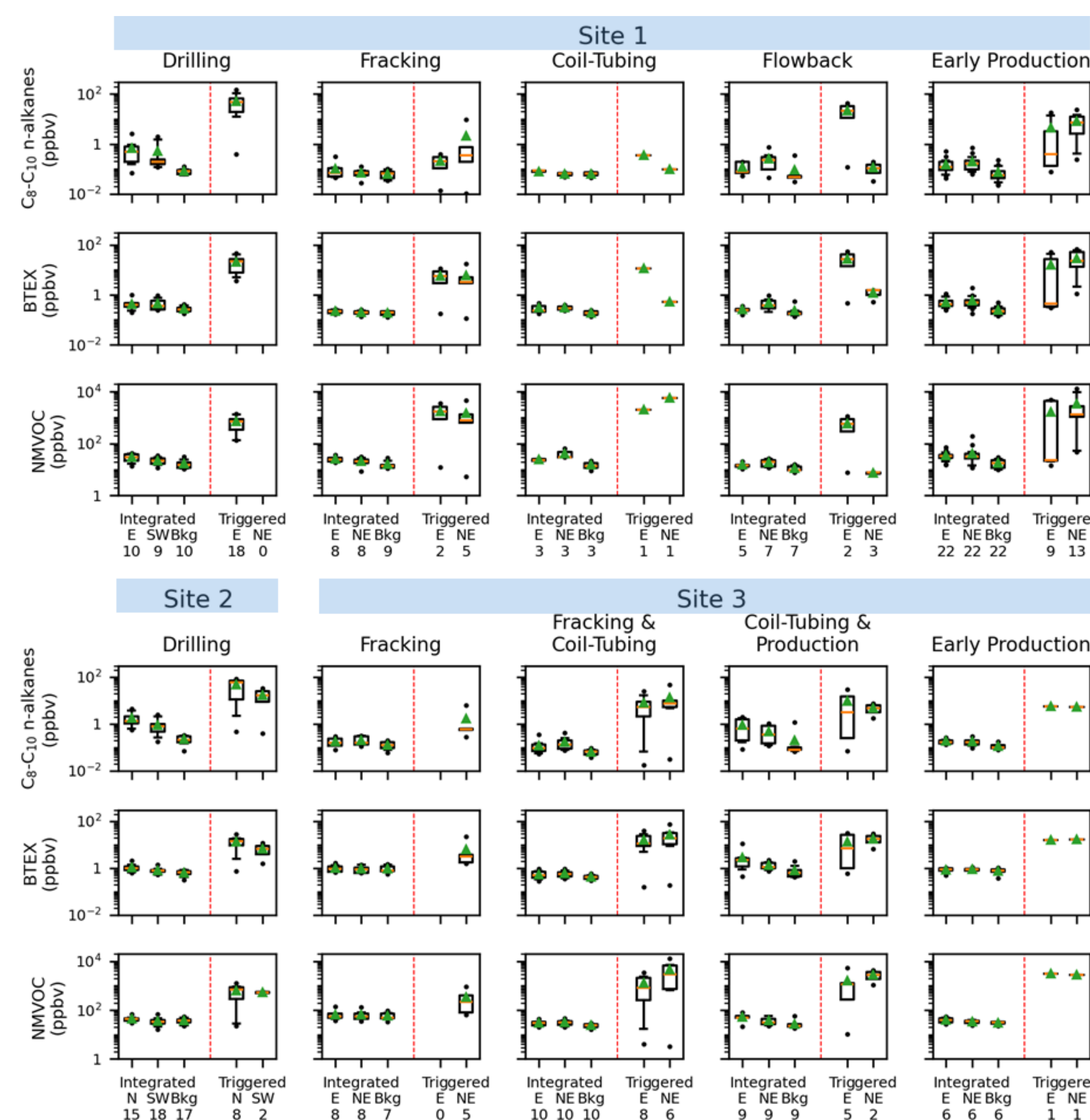


Figure 4. Non-cancer risk assessment for chronic and acute exposure to measured VOC concentrations near UOGD operations. Hazard index (HI) values represent the sum of hazard quotient (HQ) values for 7 measured VOC HAPs. HQ values represent the ratio of measured concentrations to health guideline values.

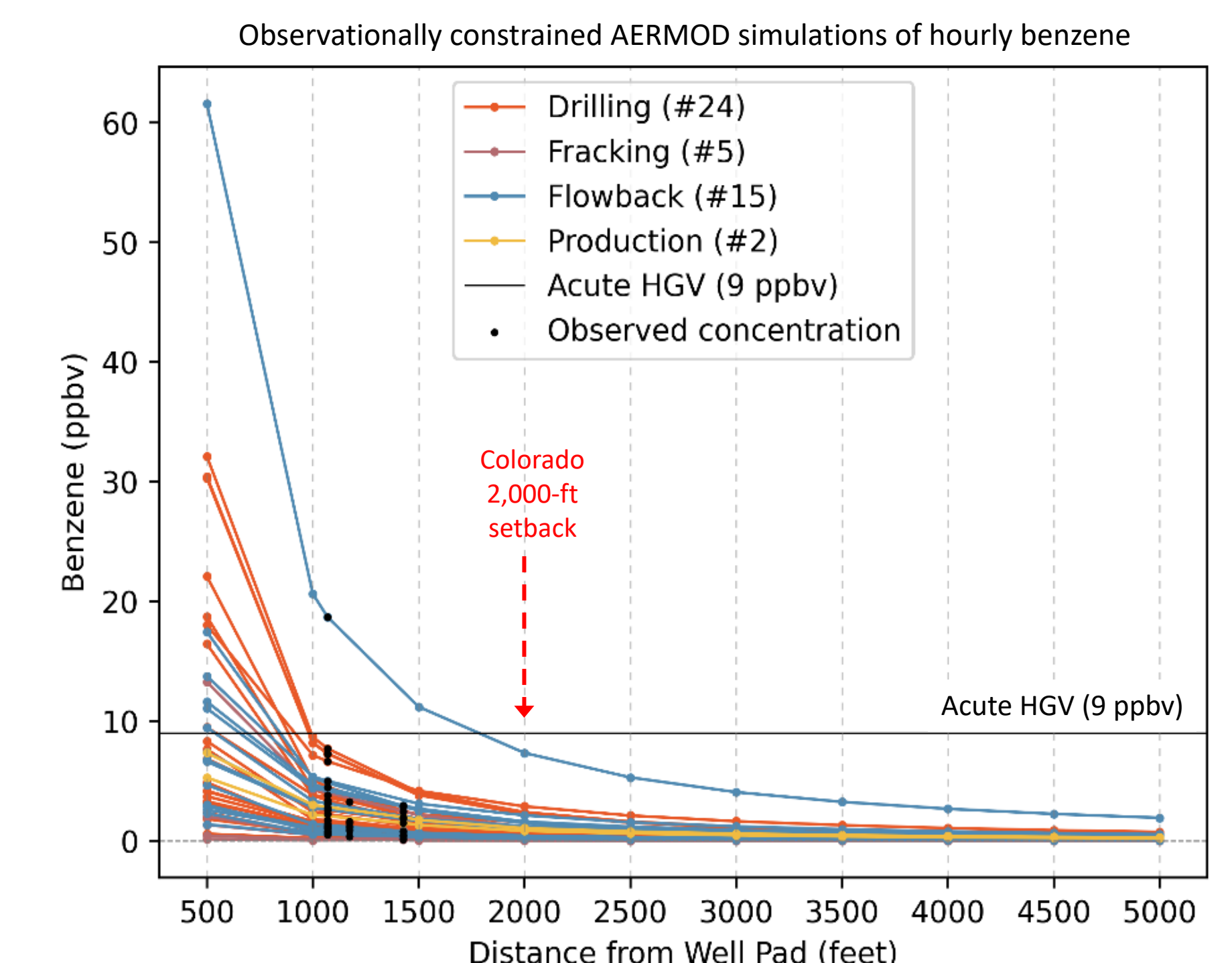
Non-cancer risk associated with chronic exposure near study well pads remained below chronic health guideline values (HGVs) for all UOGD operation types. Exceedances of benzene HGVs for acute exposure (9 ppbv) are seen in 1-hr values across multiple UOGD operations. Acute HGV exceedances are predicted to be less common at Colorado's 2,000-ft setback distance.

Figure 3. Summary of weekly and triggered canister VOC concentration distributions by operation at 3 study locations.



The largest VOC concentration increases are observed in transient plumes. Large emissions of C₈-C₁₀ n-alkanes are associated with outgassing from synthetic Neoflo-based drilling muds increasingly used to reduce odor complaints.

Figure 5. Predicted hourly benzene concentrations as a function of distance for periods when plume-triggered canisters were collected at sites 1 and 2. Concentrations are simulated using AERMOD at 500-foot intervals along the plume centerline, with benzene emission rates constrained so that simulated and observed (black dots) concentrations match.



Summary

- Average concentration increases of most VOCs are modest at near-pad monitoring locations, partly reflecting implementation of best management practices, including electrified, grid-powered drill rigs and closed-loop flowback systems.
- Transient plumes often contain significant VOC concentrations, with hourly benzene levels found to occasionally exceed the 9 ppbv acute HGV during well drilling, completions, and early production operations.
- Colorado's presumptive setback distance of 2000 feet is an important factor helping reduce exposure to air toxics.

Acknowledgments

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