

Measuring and Modeling Air Pollution and Noise Exposure Near Unconventional Oil and Gas Development in Colorado

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Department of Public
Health & Environment





Study objectives

- **Objective 1**: Identify exposure pathways that connect BTEX and other air pollution emissions from UOGD to nearby communities
 - Recent + new air pollutant measurements in DJ Basin
 - Focus on pre-production activities at large, multi-well pads
- **Objective 2**: Sound measurements to characterize the range of exposure to noise from UOGD operations
- **Objective 3**: Contextualize community impacts by operation phase; develop TRACER emissions model; stakeholder outreach and engagement

O&G air emissions

➤ Hydraulic fracturing

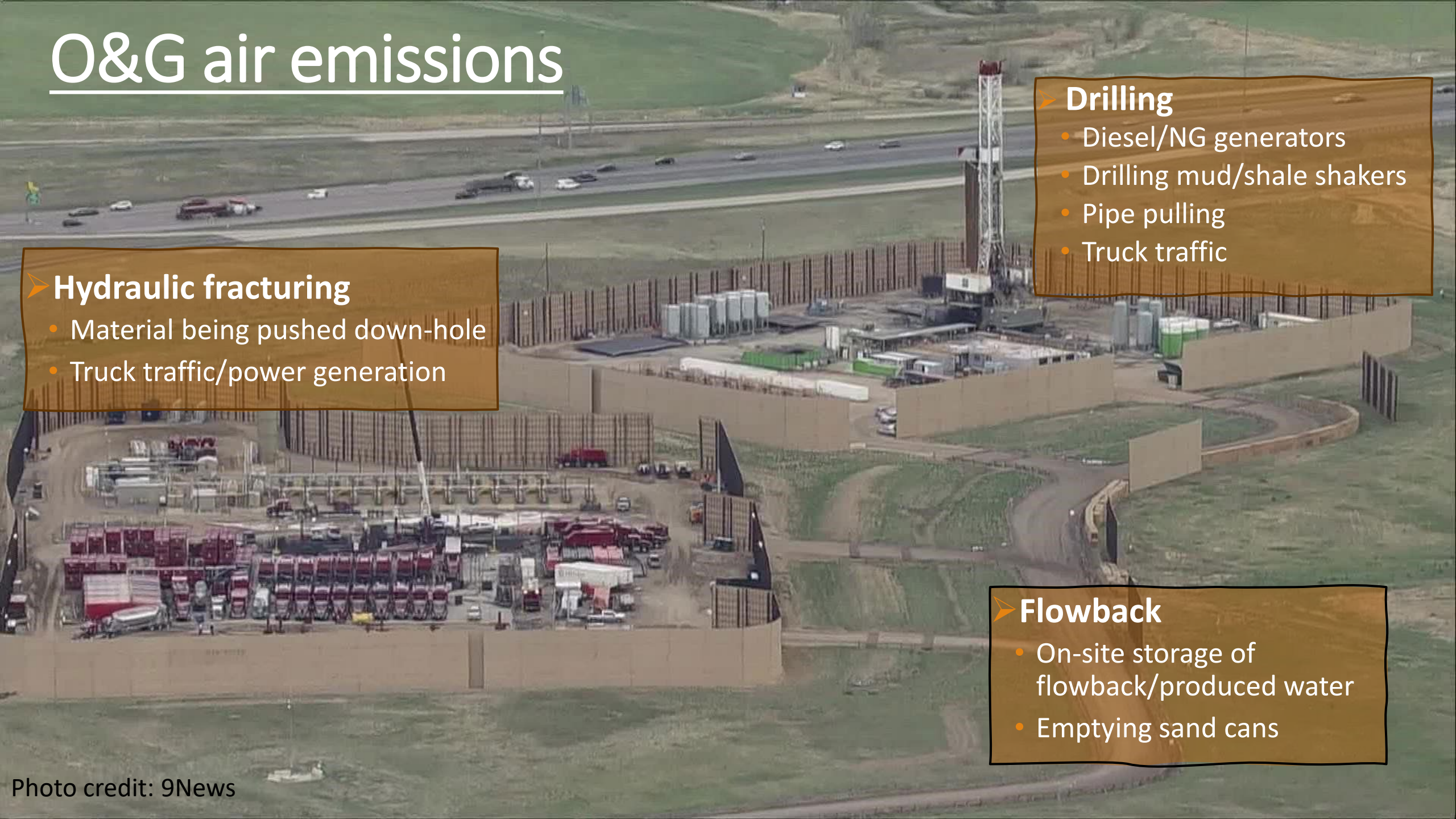
- Material being pushed down-hole
- Truck traffic/power generation

➤ Drilling

- Diesel/NG generators
- Drilling mud/shale shakers
- Pipe pulling
- Truck traffic

➤ Flowback

- On-site storage of flowback/produced water
- Emptying sand cans

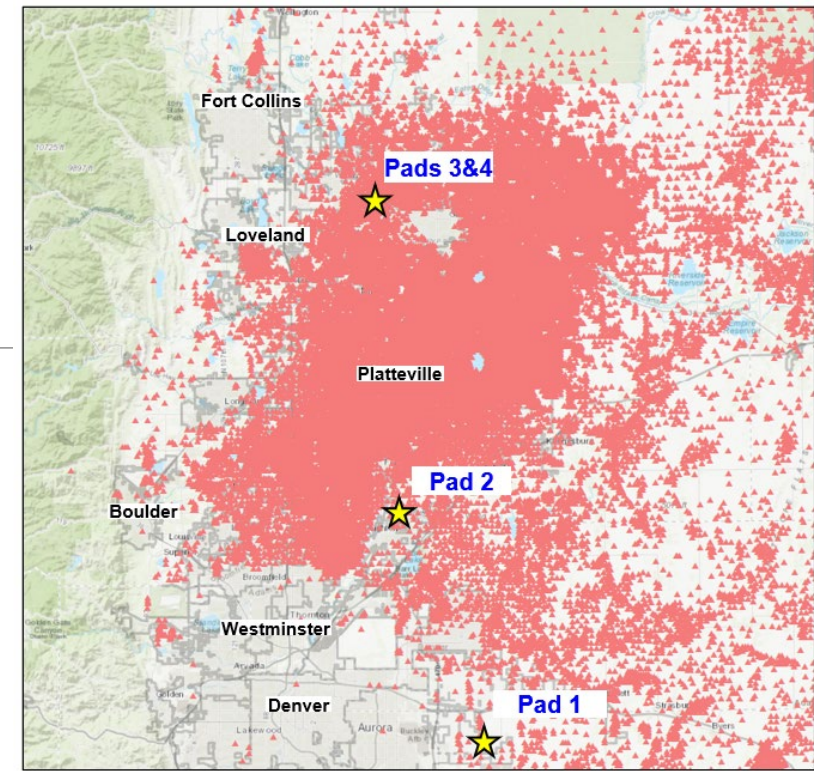
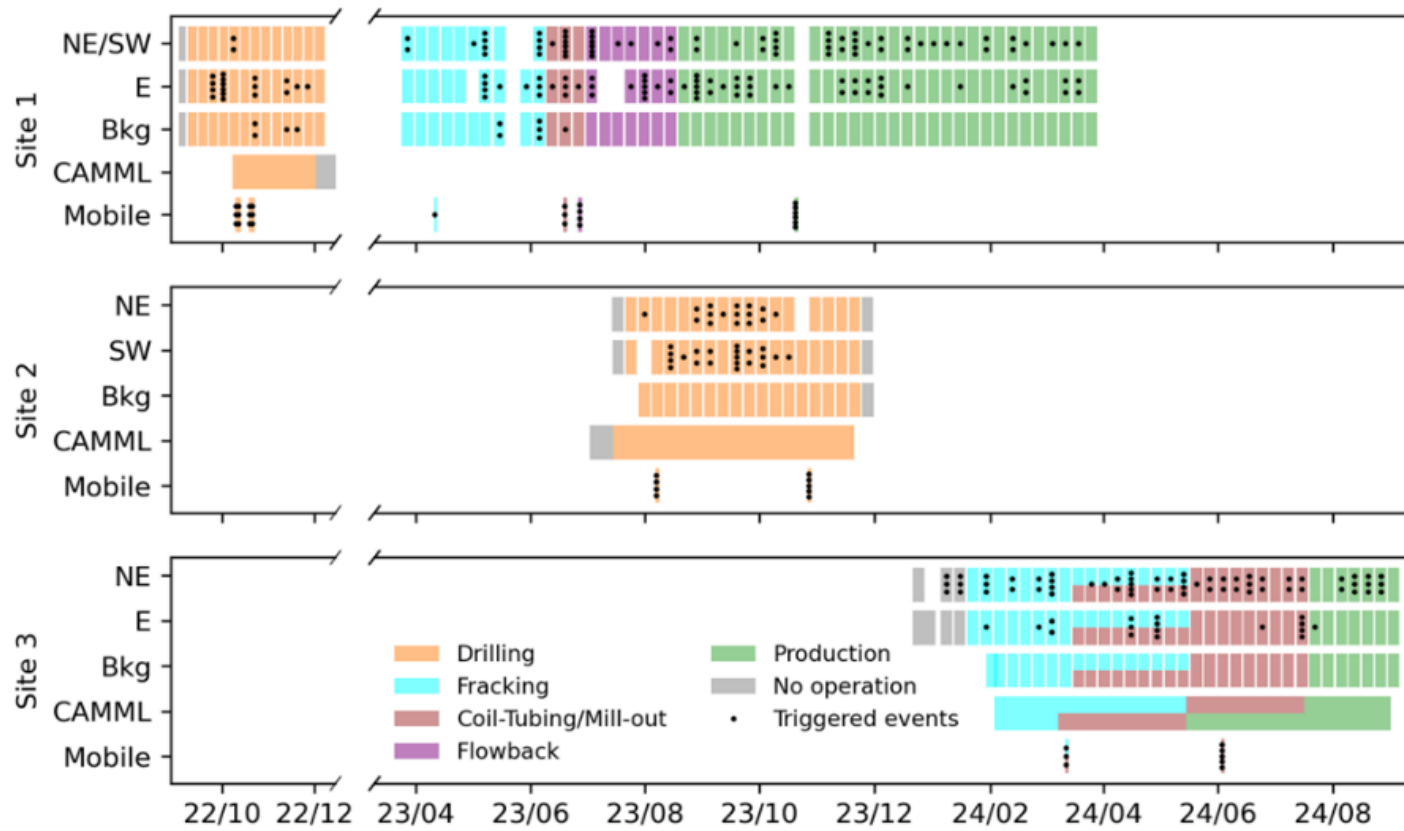


Air monitoring approach

- CDPHE CAMML
 - Hourly speciated VOCs, CH_4 , NO_x , $\text{PM}_{2.5}$
- Weekly integrated VOC canisters
 - 51 speciated VOCs + CH_4
 - 2 near-pad locations + background reference site
- Continuous PID VOC monitors with event-triggered canister samples
 - 2 near-pad locations
- Mobile measurements
 - CH_4 and VOCs

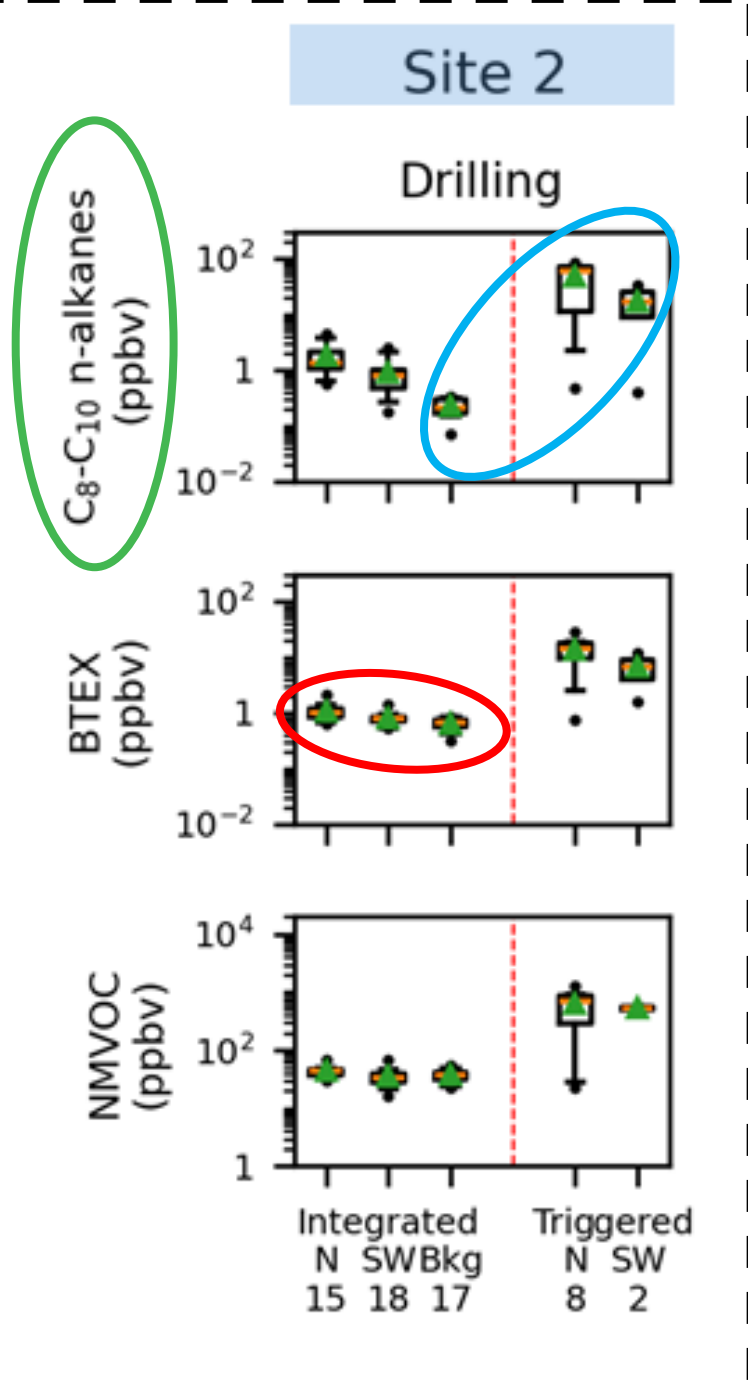
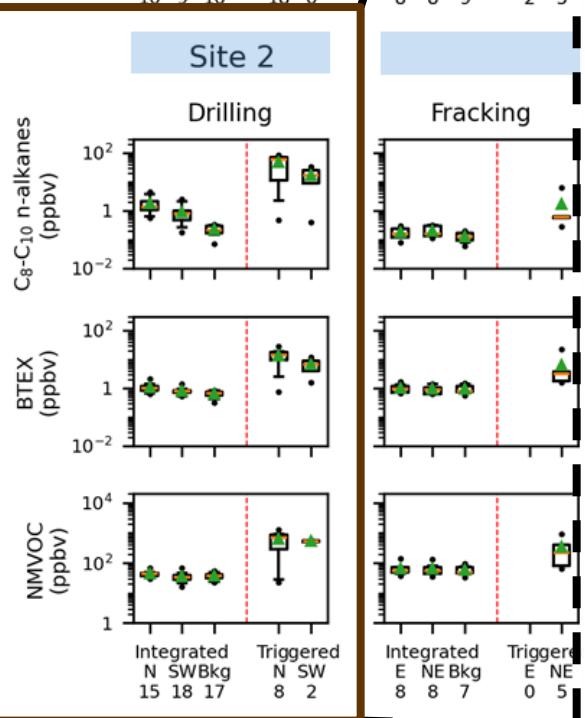
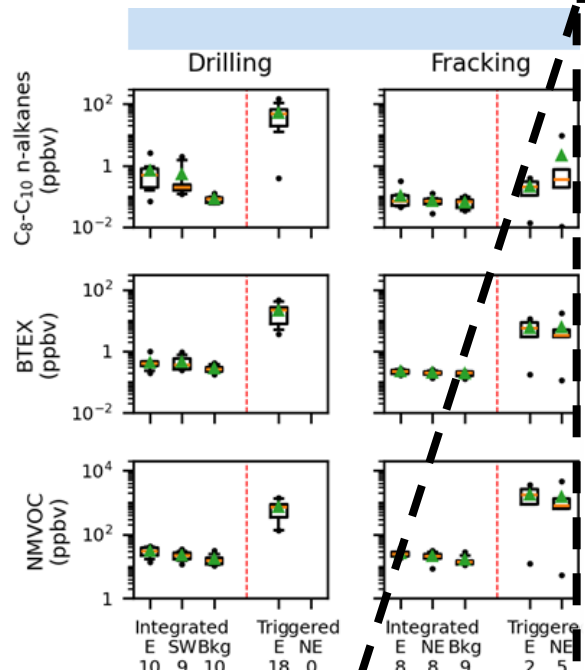


Air monitoring summary



- 3 locations (4 well pads)
 - near Aurora, Brighton, and Windsor
- 3 DJ Basin O&G Operators
- >50 air toxics and other VOCs

VOC concentration gradients around well pads

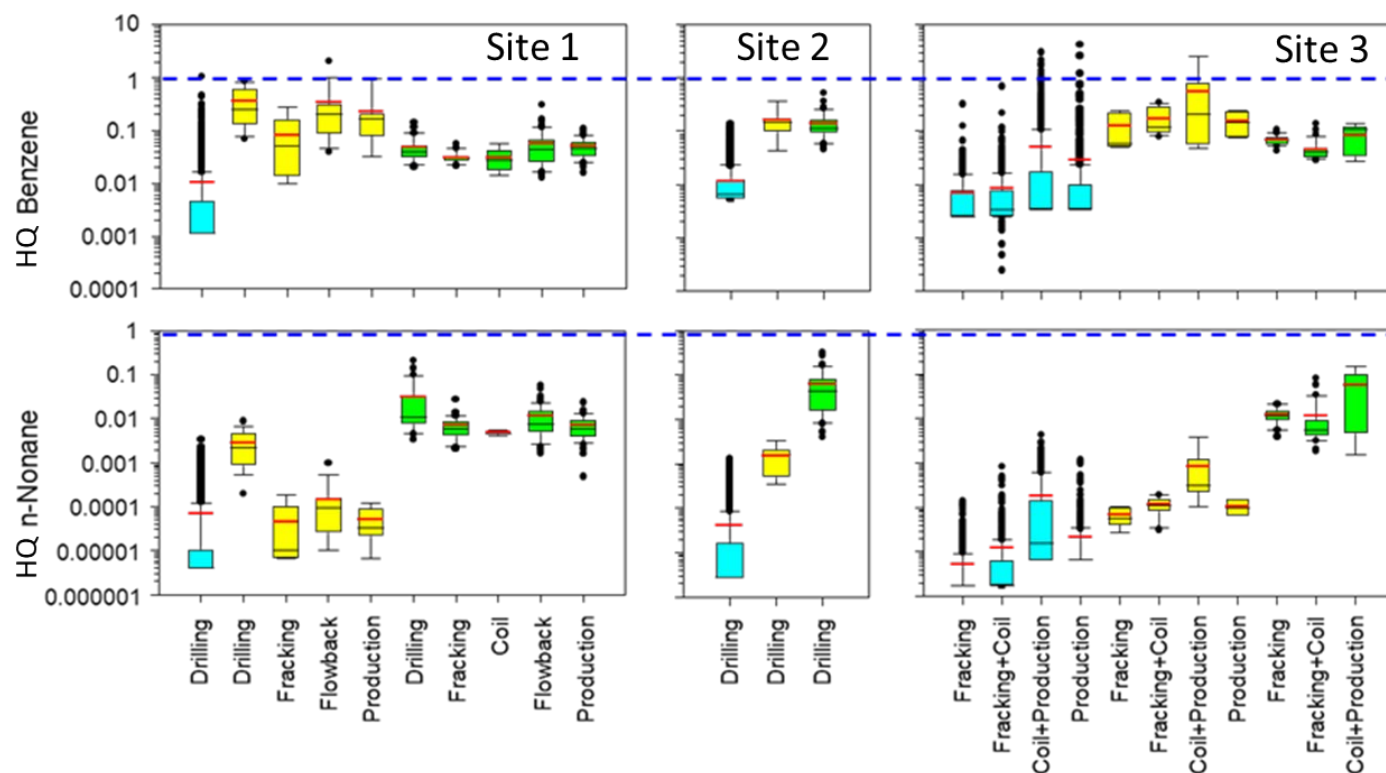


- Typically modest increases in **weekly average concentrations** near pad
- **Concentrations in transient plumes** much higher than weekly averages
 - Plume durations at sensor typically 10s of minutes
- Strong local enhancements of **C₈-C₁₀ alkanes** (from synthetic Neoflo drilling mud volatilization) during drilling and millout
 - Nonane is an air toxic
 - Potential effects on O₃ formation

HQ = Concentration/Health Guideline Value



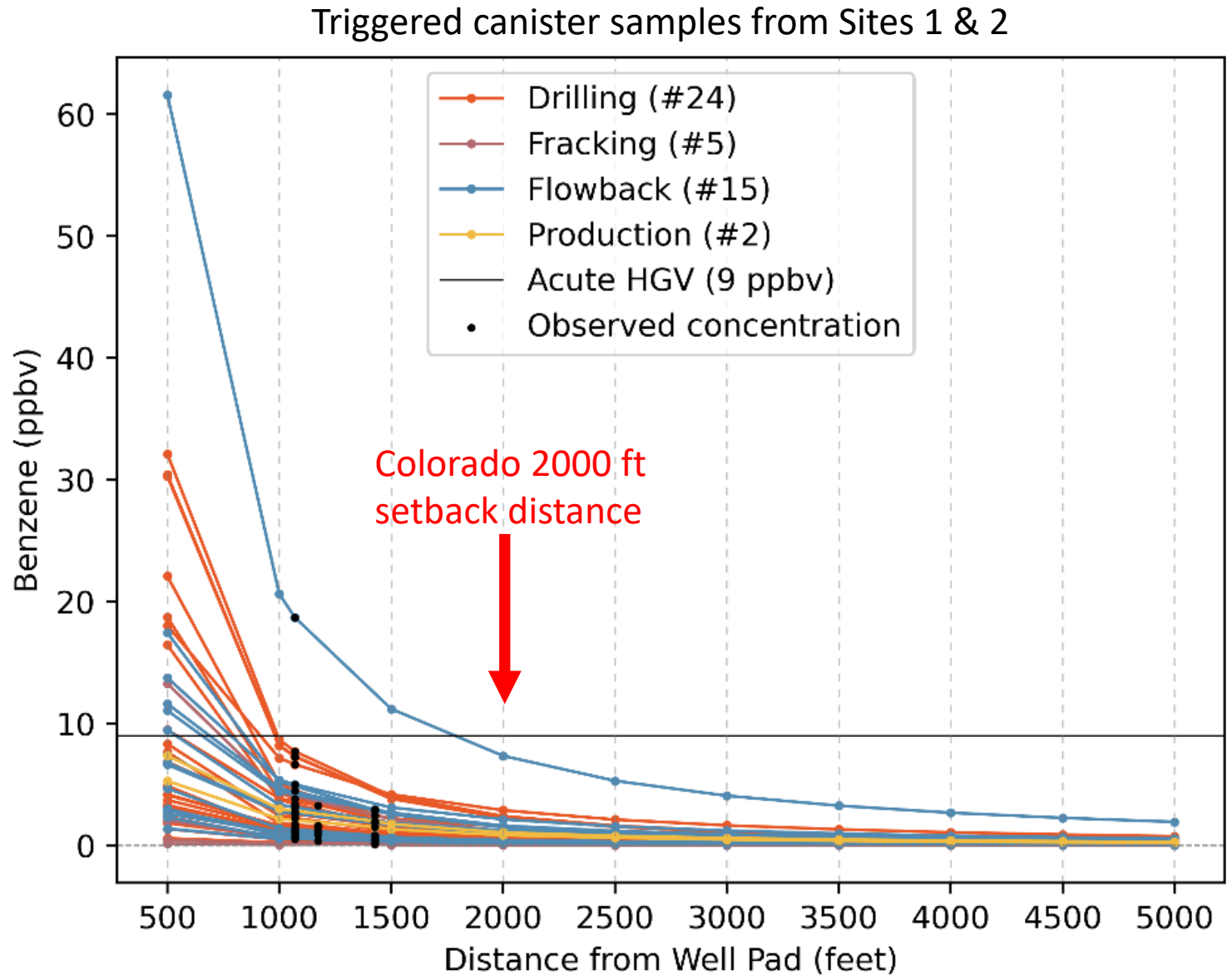
Acute and chronic exposure risk



- Chronic exposure Health Guideline Values (HGVs) not exceeded
 - Benzene and n-nonane important contributors
- Benzene levels occasionally exceeded acute exposure HGVs across UOGD operation types
- Consistent with predictions from Holder et al. (2019) Health Risk Analysis sponsored by CDPHE

Exposure vs. distance

- Observationally-constrained AERMOD dispersion simulations used to examine concentration vs. distance
- Colorado's 2,000-foot presumptive setback distance helps reduce exposure levels

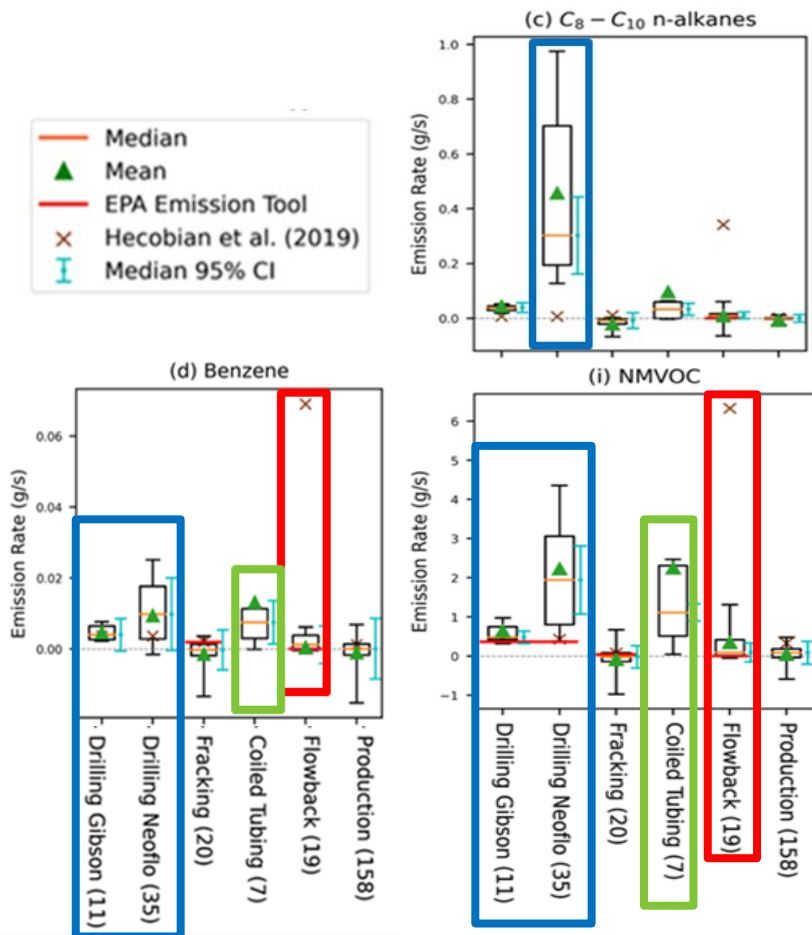




BROOMFIELD
Colorado



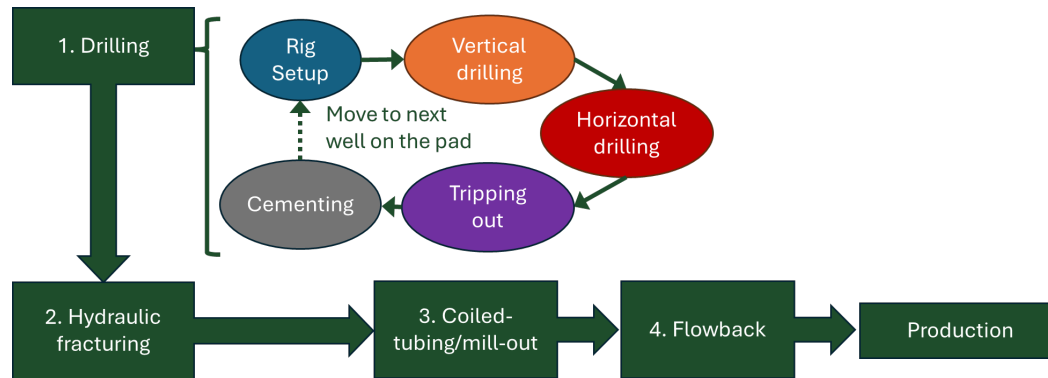
UOGD VOC emission rates



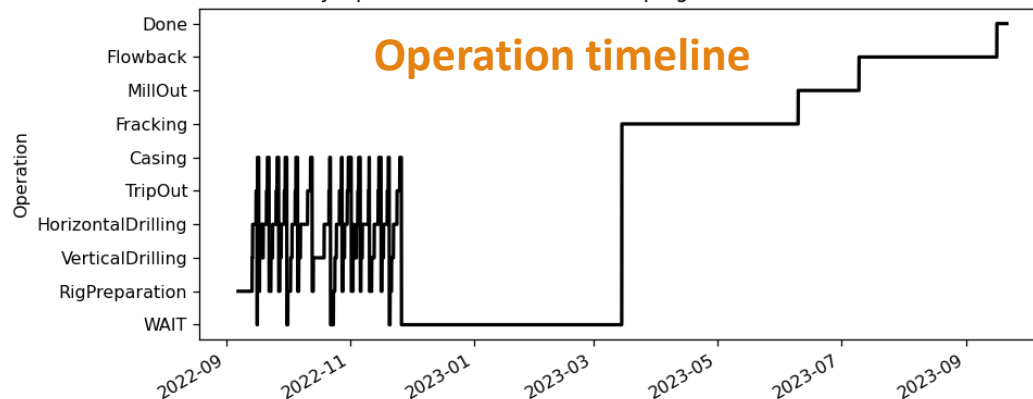
- Utilized extensive VOC observations during development of 6 well pads in Broomfield, Colorado
- Largest average benzene and VOC emissions during drilling and coil tubing/millout operations
- Modern estimates for drilling mud volatilization, including synthetic Neoflo
- First VOC emission estimates for coil tubing/millout operations
- >95% reduction in average VOC and benzene emissions from flowback using closed loop, tankless systems vs. other green completions

TRACER pre-production model

User-friendly model to
examine local air quality
impacts from well pad
development and evaluate
potential benefits of BMPs



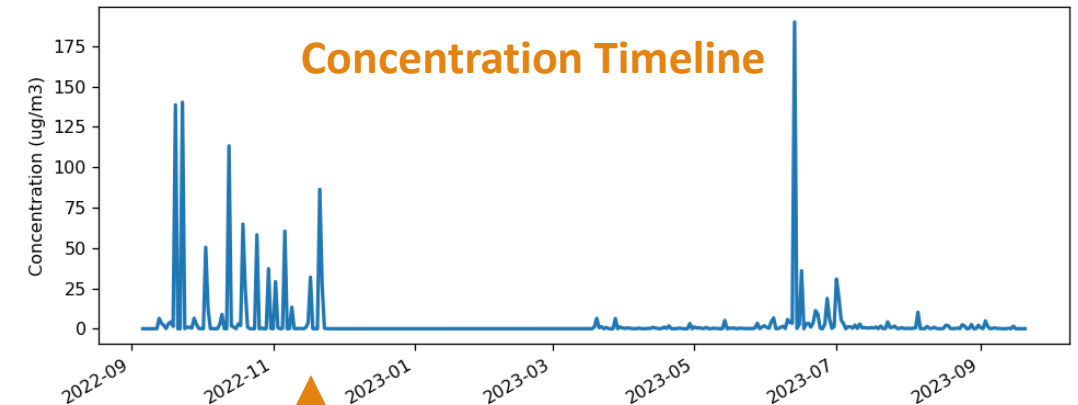
Hourly Operation Timeline of Developing 14 wells from 1 simulations



Select
Emission
Factor

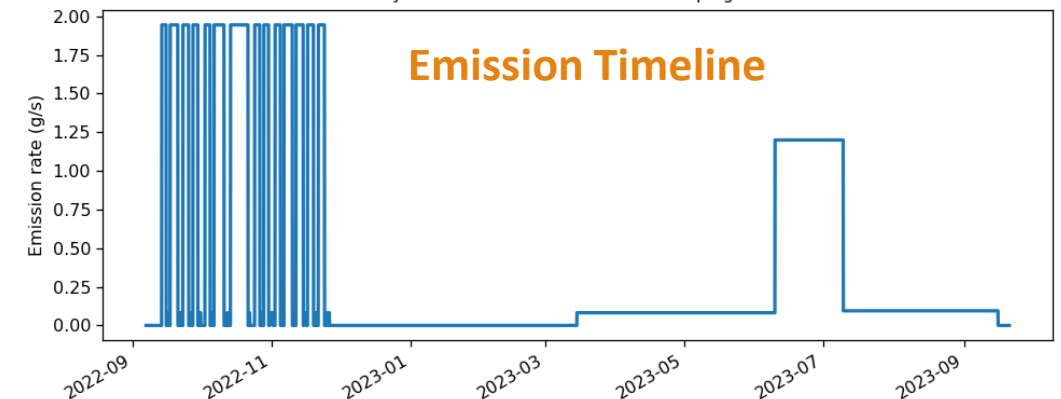


Daily Concentration Timeline of Developing 14 wells, AERMOD Model



Couple with dispersion model

Hourly Emission Rate Timeline of Developing 14 wells



Key findings – air pollution

- Transient plumes much more concentrated than weekly samples
 - Dominate non-cancer exposure risk
 - Need high time resolution monitoring (~minutes) to capture periods of elevated exposure
 - Colorado's 2000-foot setback distance helps limit exposure levels
- Largest average benzene & VOC emissions during drilling and coil tubing/millout
 - Grid-powered electrified drill rigs reduce emissions but outgassing from drilling mud remains major VOC source
 - Closed-loop, tankless flowback systems reduce average flowback benzene & VOC emissions >95% but we still see large, transient emission plumes during emptying of sand cans
- TRACER pre-production allows users to predict downwind exposures and evaluate benefits associated with implementation of best management practices