

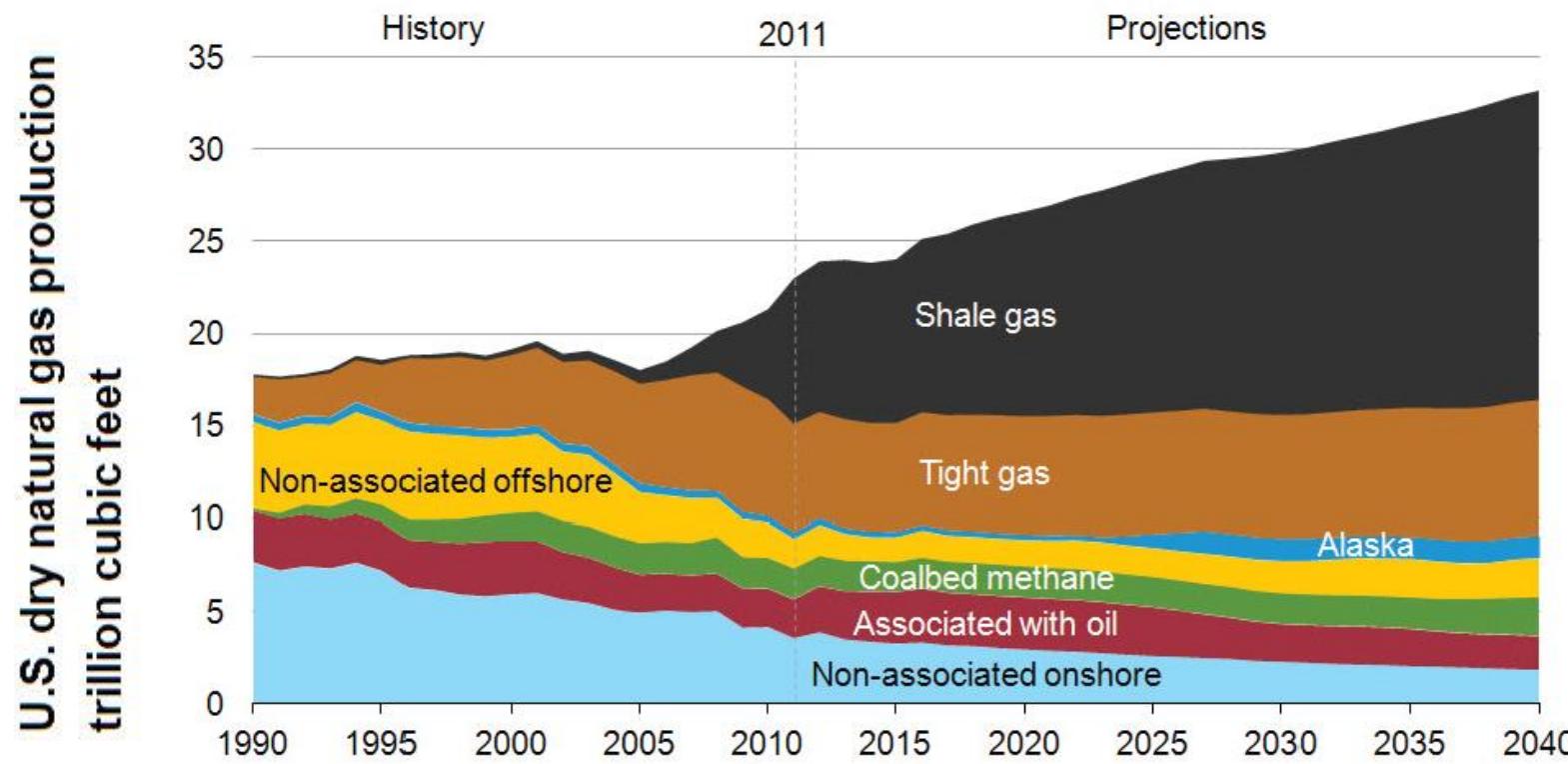
# Ambient Air Quality Near a Marcellus Shale Well Pad in Southwestern Pennsylvania

Nur H. Orak\*, Natalie Pekney, Matthew Reeder



# Overall Project Objective

- To investigate and characterize the effect of shale gas well pad production activity on local air quality.



# Outline

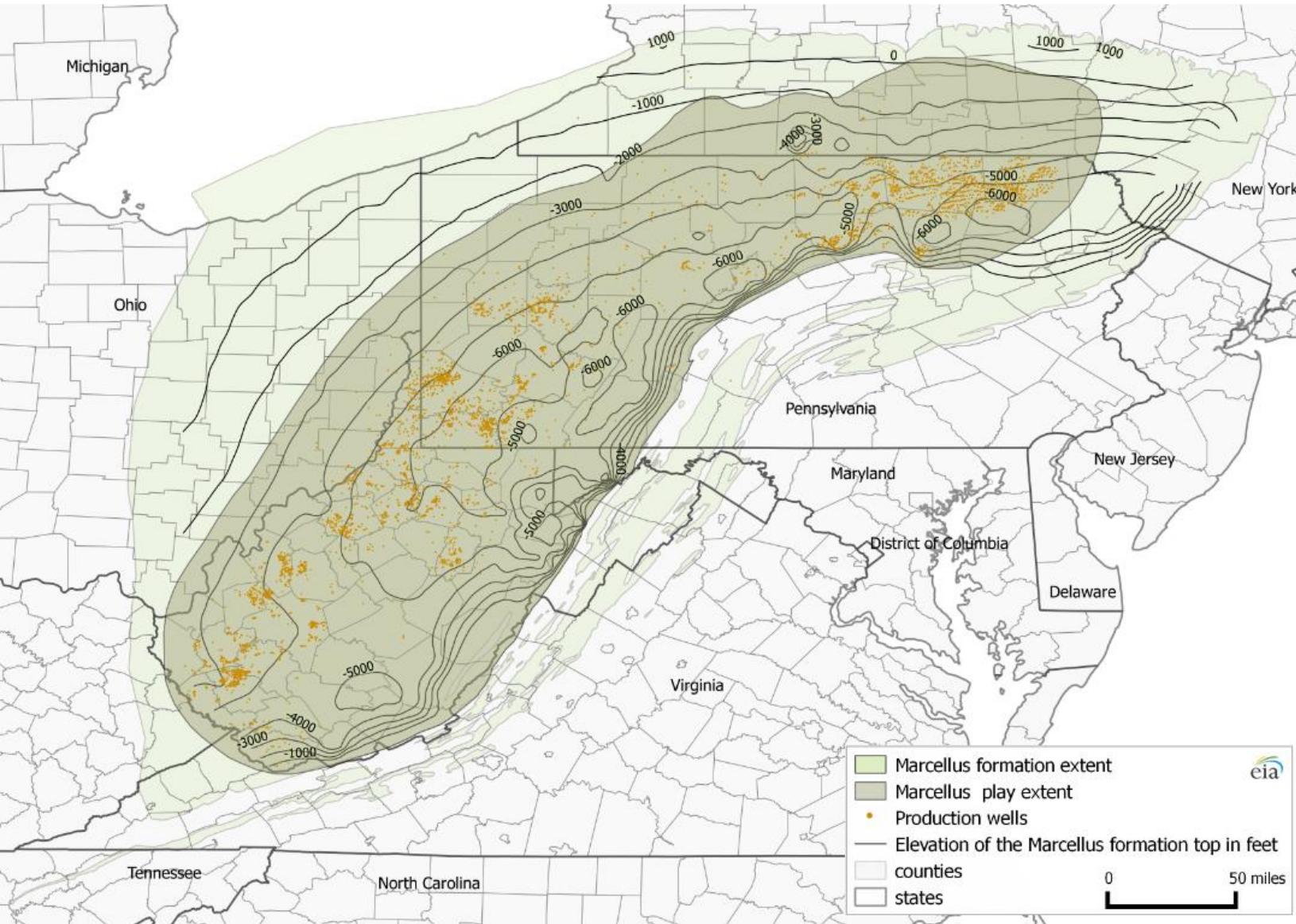
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- Marcellus Shale Information
- Case Study Background
- Methods
- Results
- Discussions

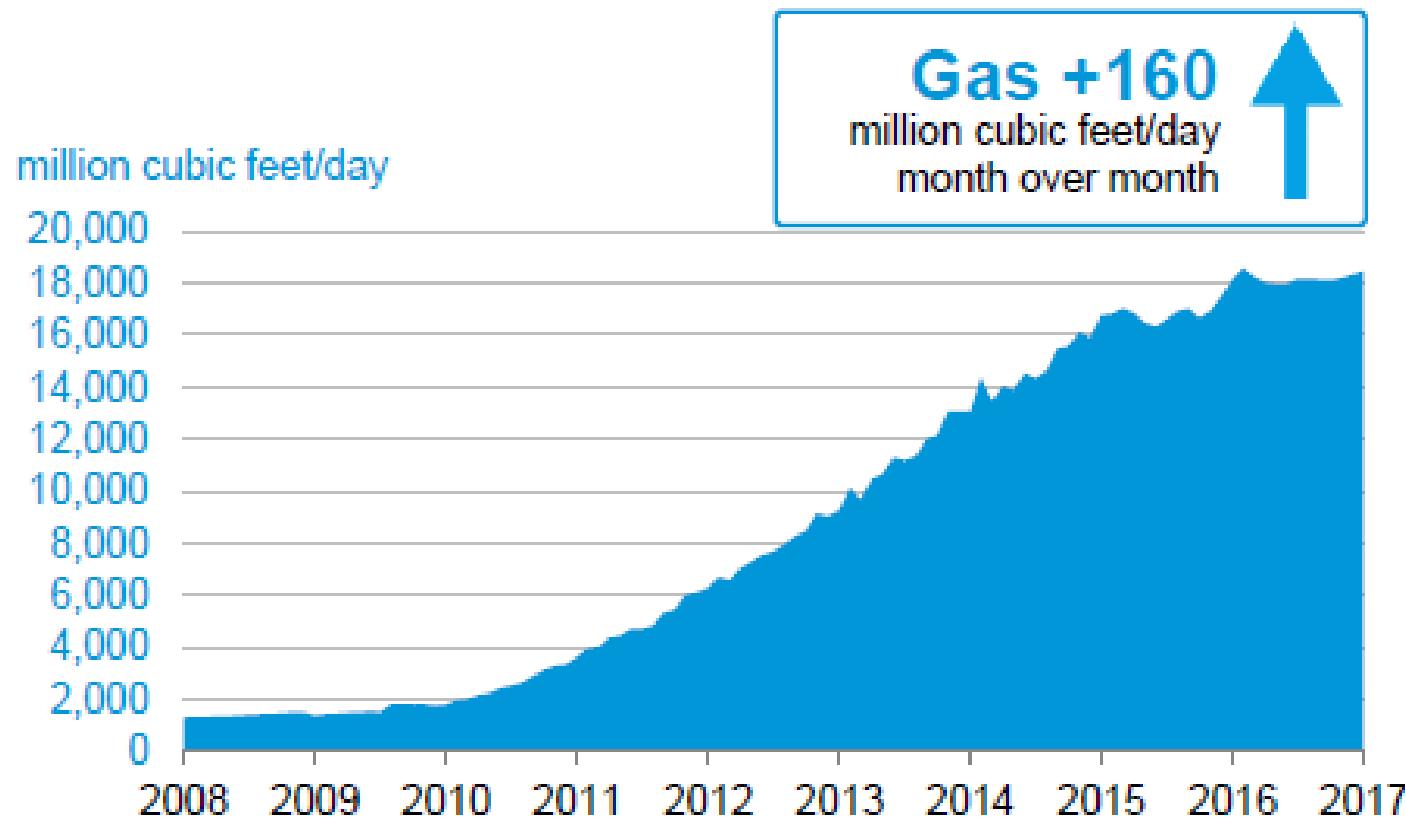
# Marcellus Shale

Structure map of the Marcellus formation



- Focuses on 5 states
- Provides more than 35% of shale gas production in the U.S.
- The Marcellus is about 1 mile below the surface

# Marcellus Region Natural Gas Production

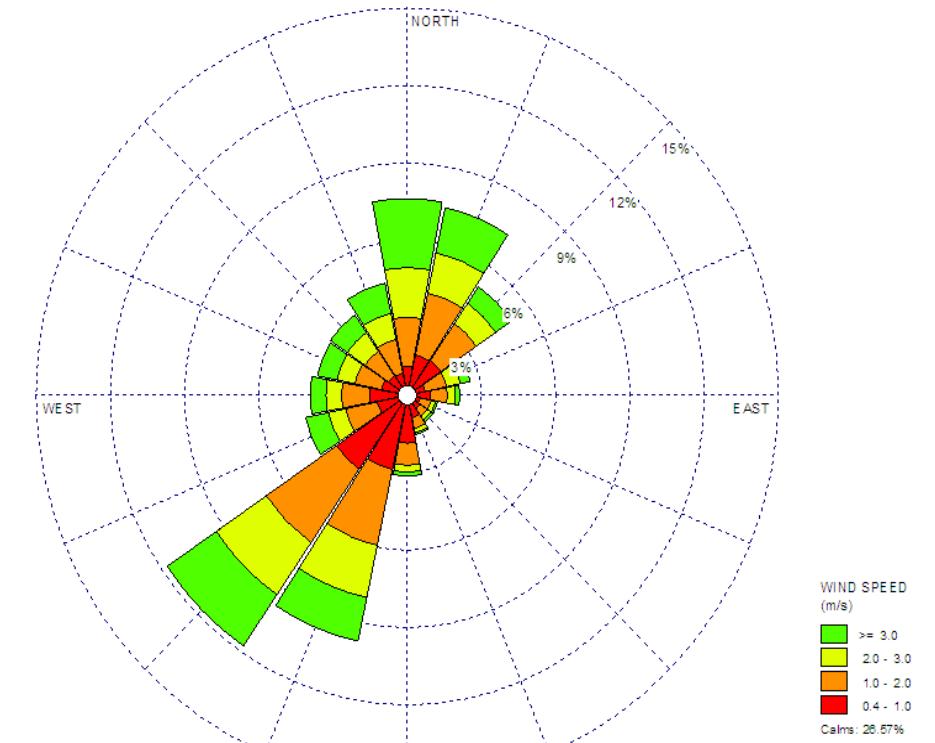
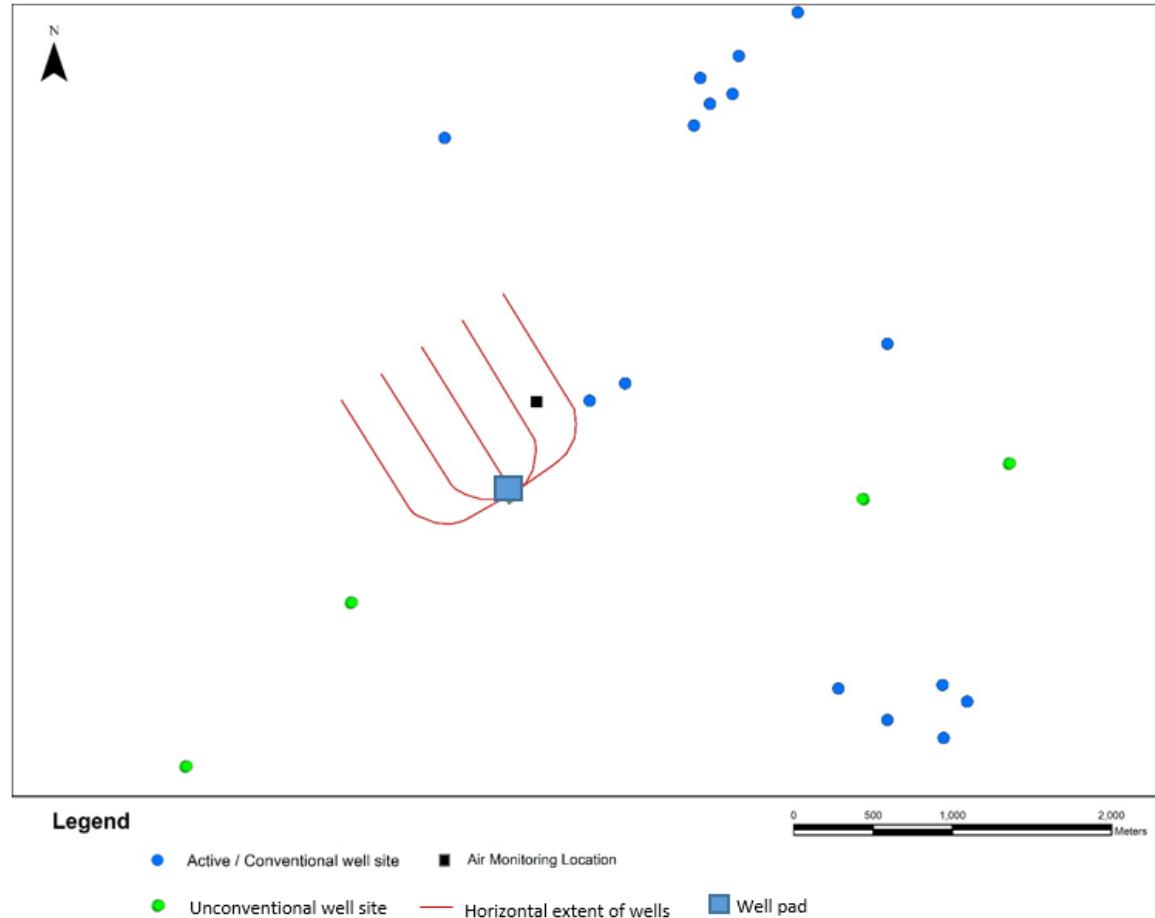


- Production increased to approximately **18.0 Bcf/d** in **2016**

U.S. Energy Information Administration, 2016

# Case Study Background

## Air Monitoring at Washington County Well Pad



# Case Study Background

## NETL's Mobile Air Monitoring Laboratory



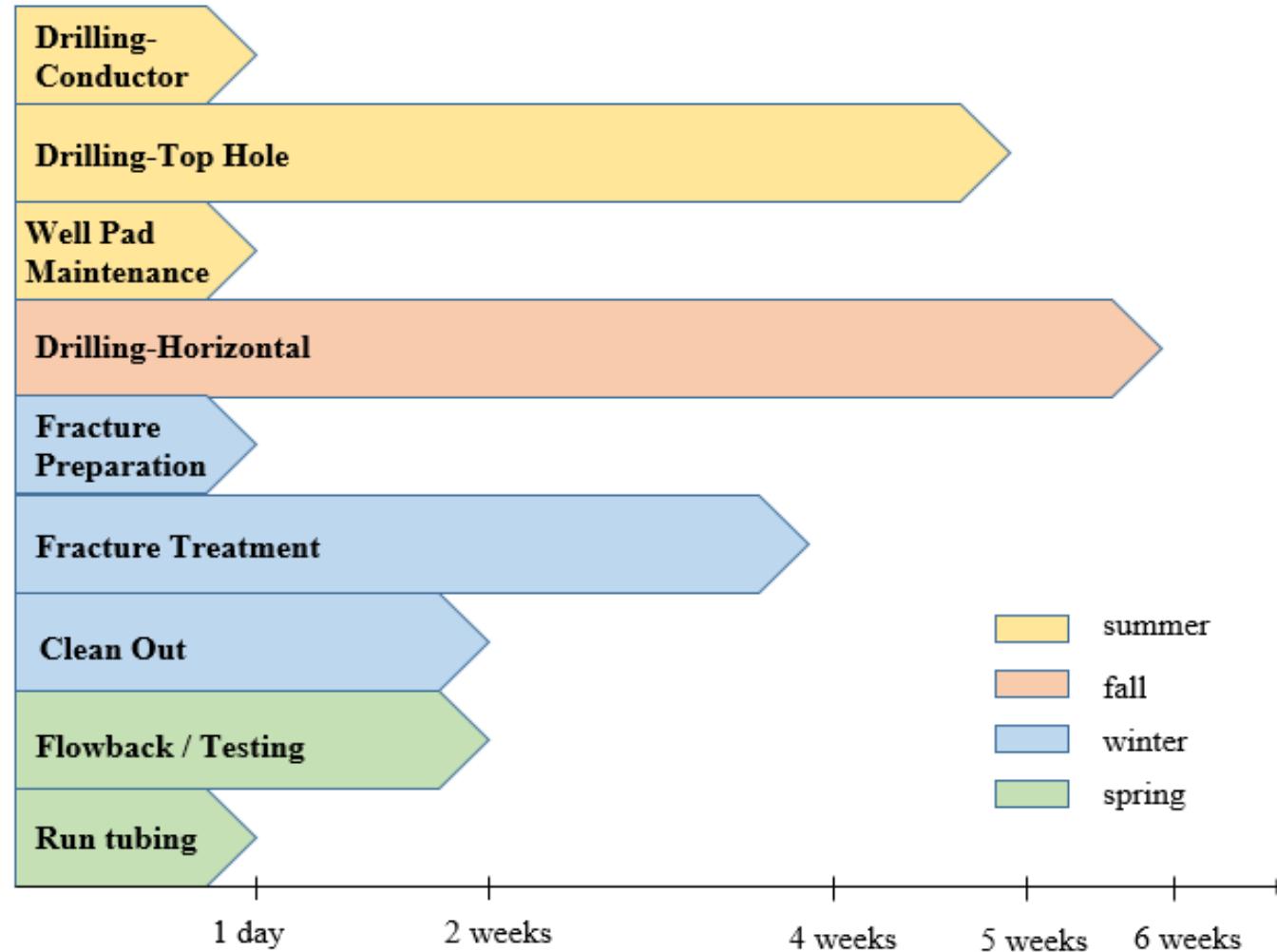
Continuously measures ambient concentrations of methane, VOCs, NOx, Ozone, Particulate Matter, as well as meteorological parameters



- Satellite Link for Remote, Unattended Operation
- Requires Electric Power (line or generator)

# Case Study Background

## Unconventional Natural Gas Production Process Activity Diagram

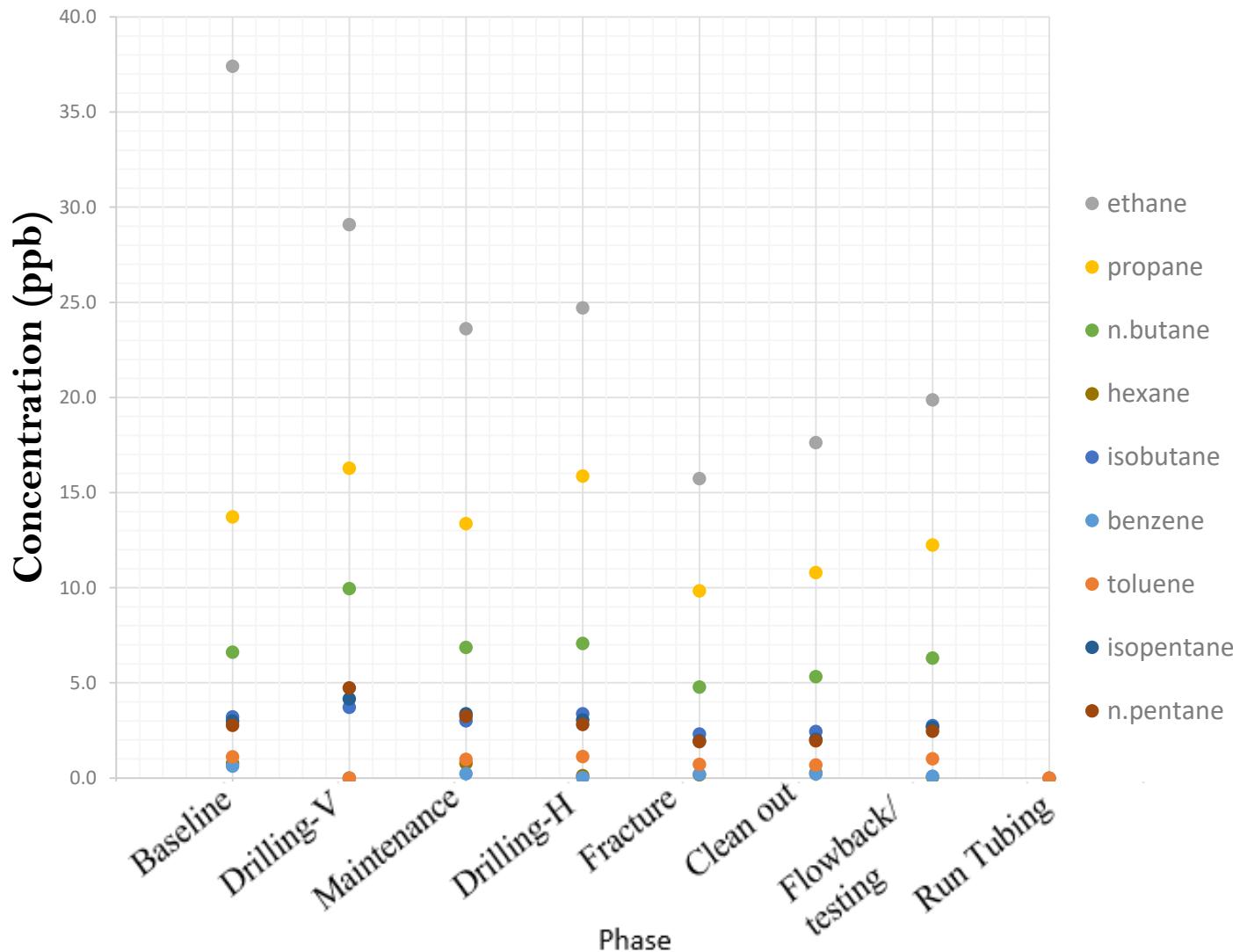


# Methods: Data Collection



Measurement	Unit	Time resolution	Instrument	Measurement technique
VOCs (52 compounds, U.S. EPA PAMS Spectra VOC calibration standard, Linde Specialty Gases, Stewartsville, NJ)	ppb	1 hr	Perkin Elmer Ozone Precursor Analyzer	GC-FID with thermal desorption
Ozone, NO <sub>x</sub> , SO <sub>2</sub>	ppb	1 min	Teledyne-API Gas Analyzers	UV absorption, Chemiluminescence, UV fluorescence
Methane* and Carbon Isotopes** in Methane, CO <sub>2</sub> * and Carbon Isotopes** in CO <sub>2</sub>	* ppm ** per mil	1 sec	Picarro G2201-i	Cavity ring-down spectrometry
PM <sub>10</sub> and PM <sub>2.5</sub>	µg/m <sup>3</sup>	1 hr	Thermo Fisher TEOM 1405DF	Microbalance
Meteorological Parameters: wind speed and direction, temperature, relative humidity, barometric pressure, rainfall, and solar intensity	various	1 min	Davis Instruments Vantage Pro2 Plus	Various

# Methods: Data Collection

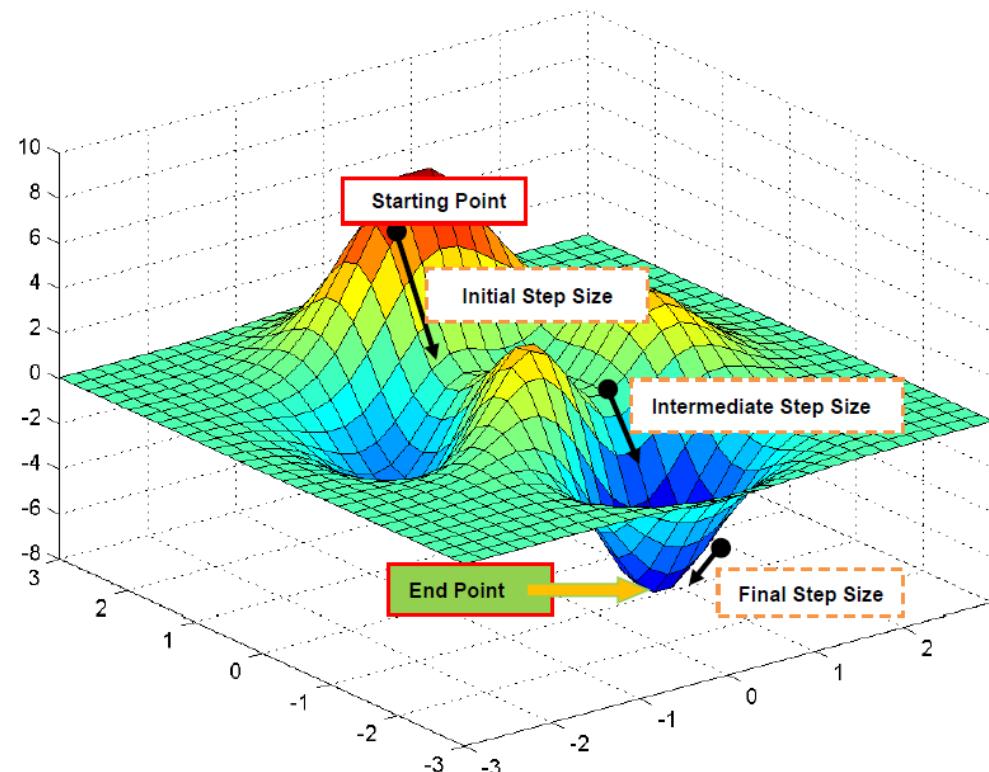
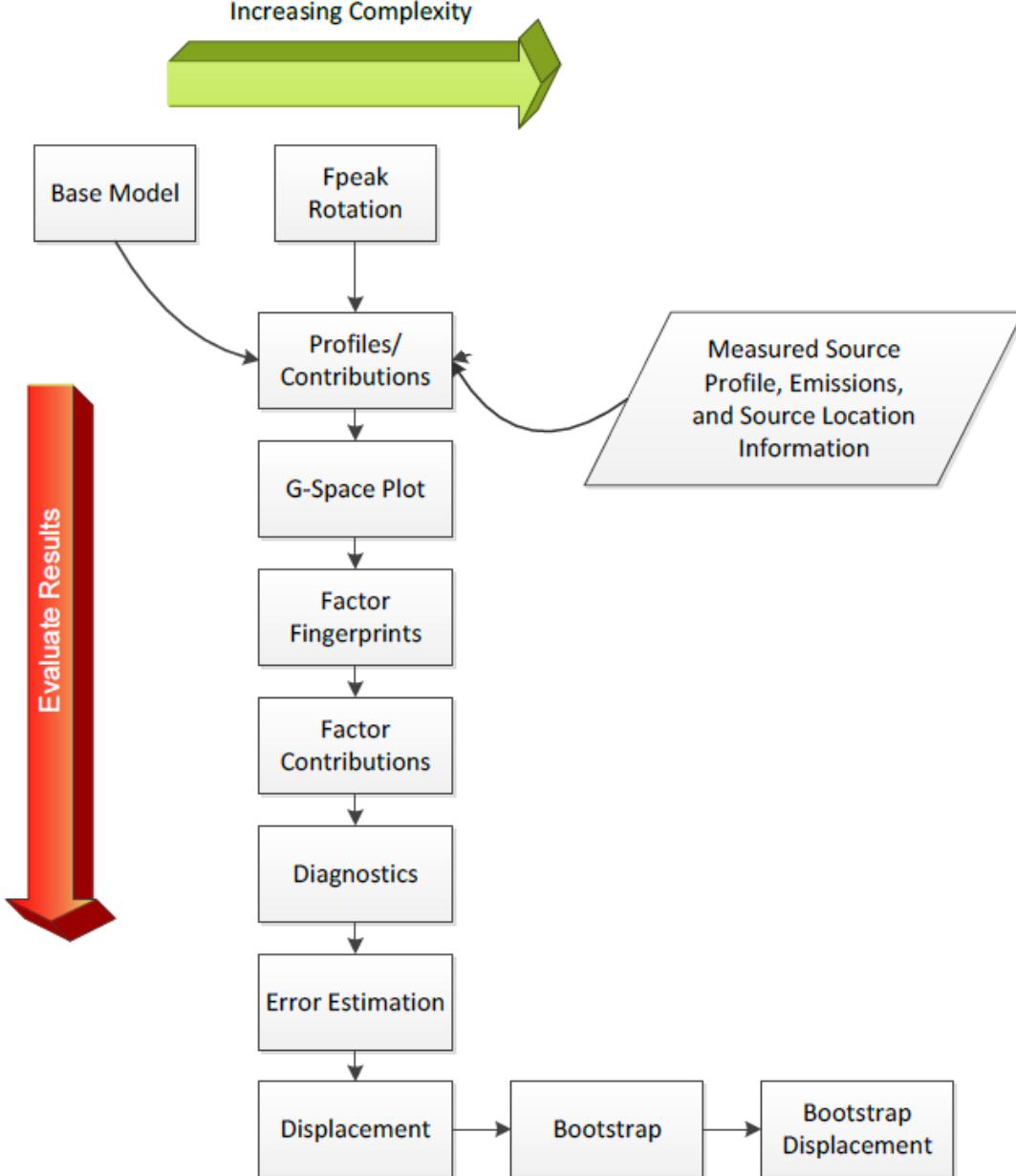


# Methods: Receptor Modeling

## Positive Matrix Factorization (PMF)



- Mathematical approaches for quantifying the contribution of sources to samples based on the composition or fingerprints of the sources.
- Goal: Determining the contribution of each identified stage source to ambient air polluters' concentrations
  - EPA PMF 5.0



# Methods: Receptor Modeling

Decision parameters:



- Factor solution fingerprints
- Factor profile contributions
- Error estimation results
- Hourly peak concentrations of pollutants

## MODEL 1

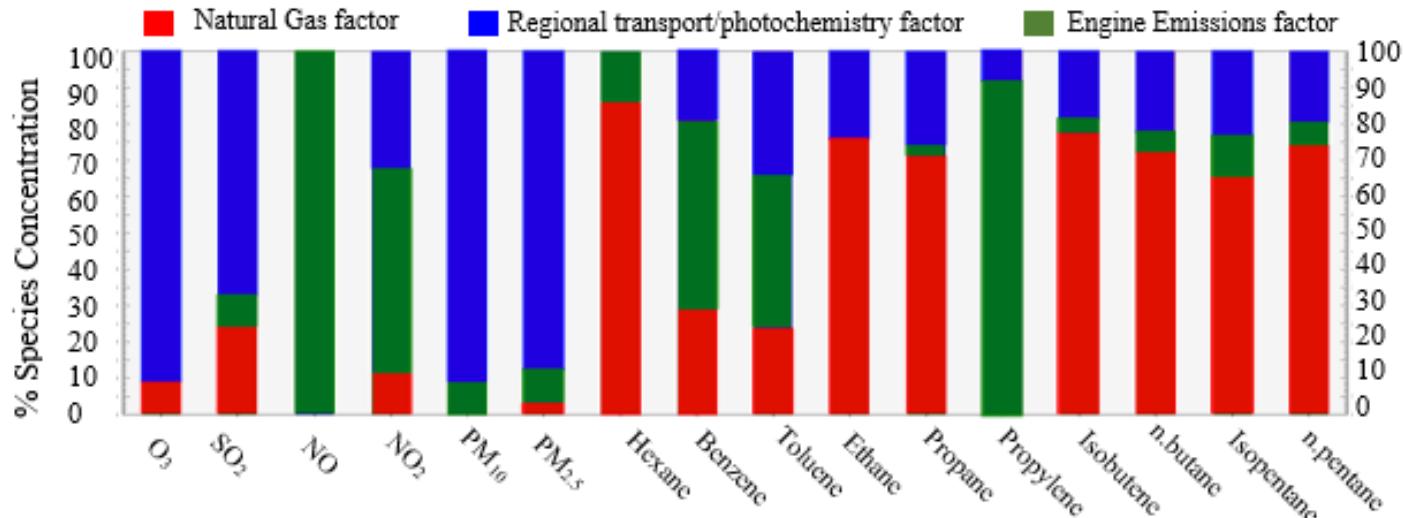
Prior to well pad constructions

## MODEL 2

drilling, hydraulic fracturing, flowback, and production activity

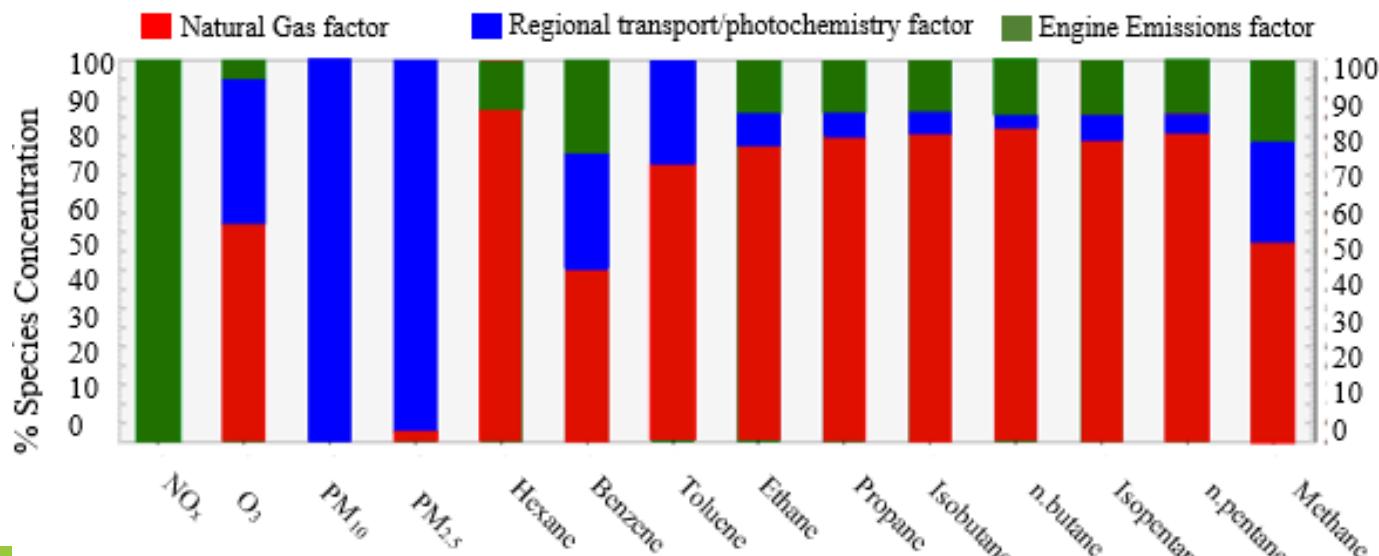
# Results

## 3-Factor Solutions



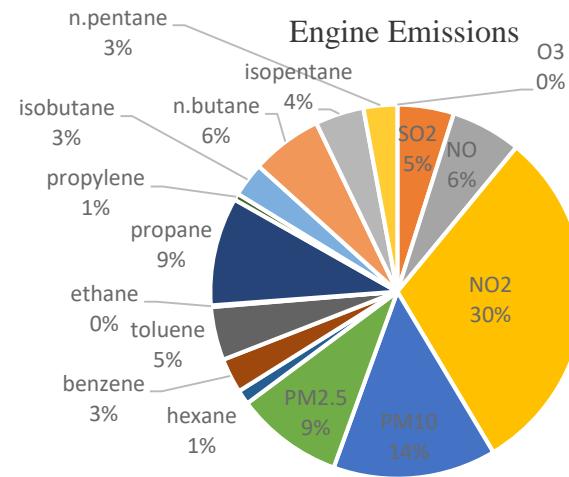
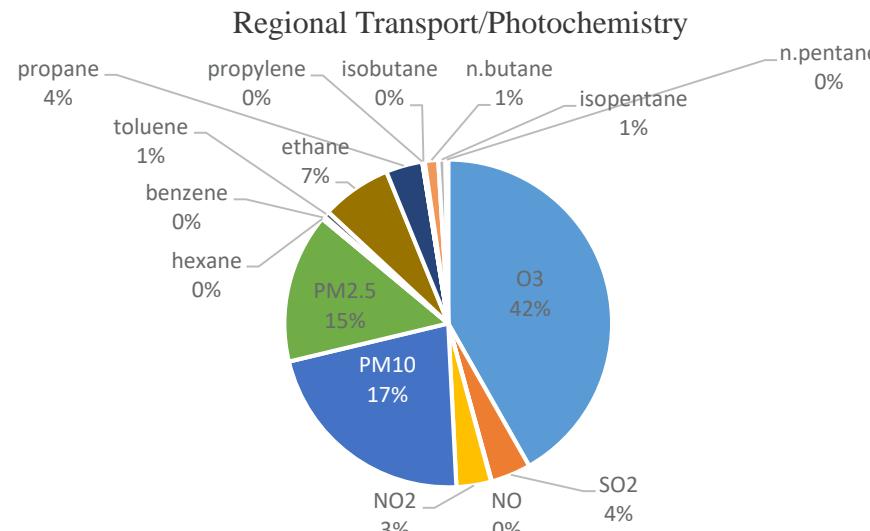
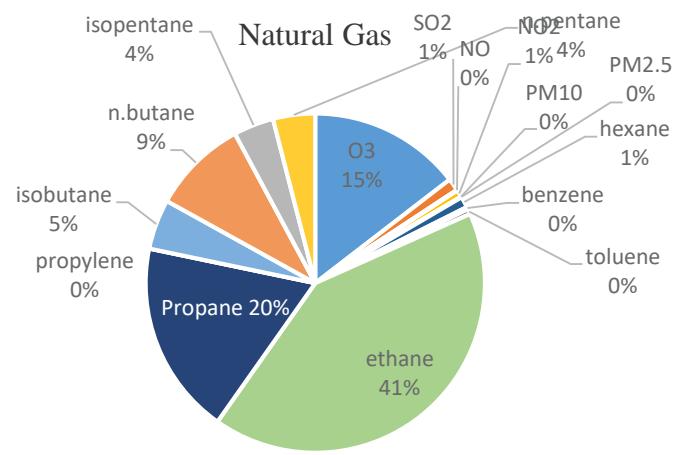
← For Baseline Monitoring Period,  $F_{peak}=1$

For Drilling through Production Monitoring Period,  $F_{peak}=1 \rightarrow$

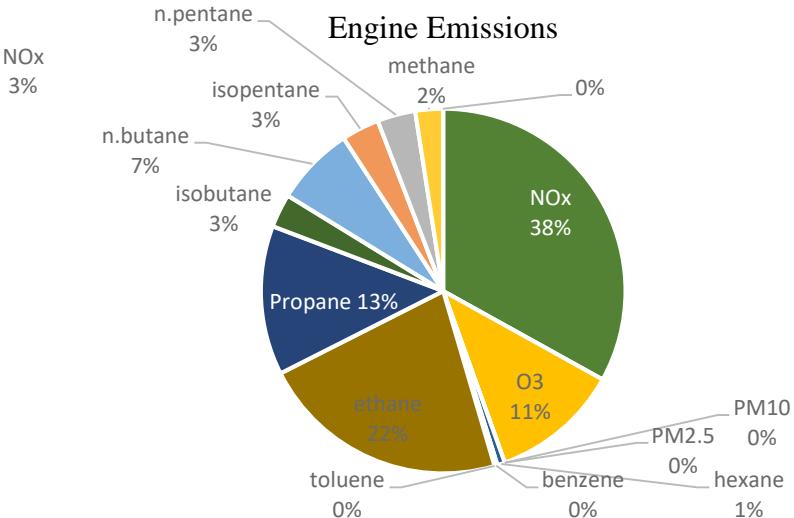
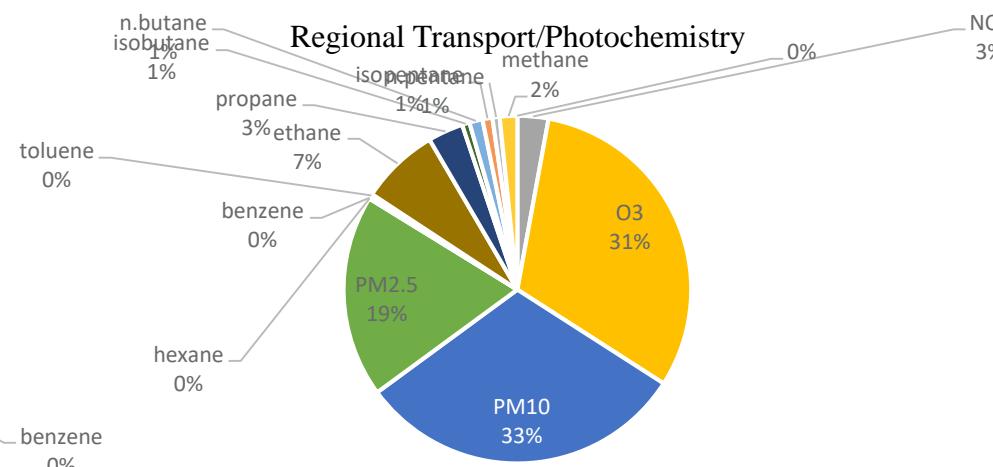
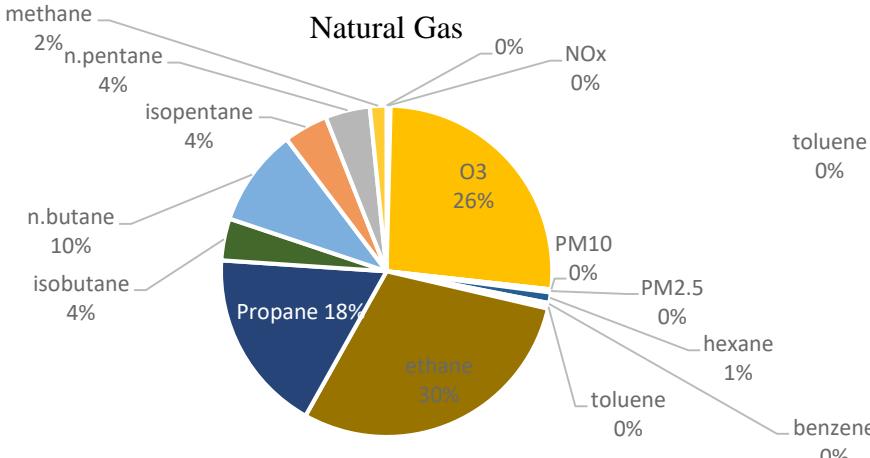


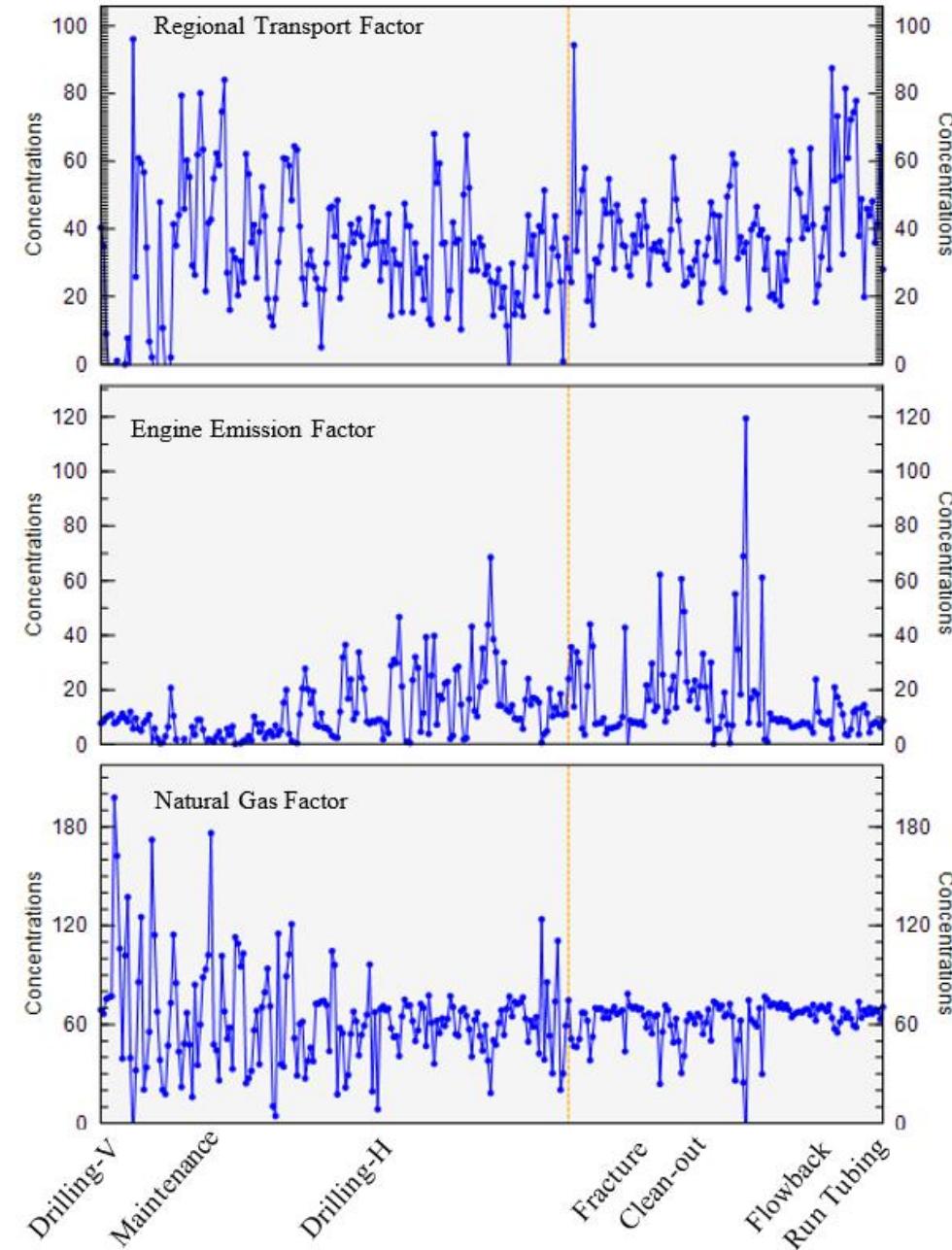
# Results: Factor Contributions

## Baseline PMF



## Drilling through Production PMF





# Conclusion

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- Vertical drilling and maintenance stages → the *natural gas* factor
  - horizontal drilling phase → *natural gas* factor
- An increasing contribution over time → the *engine emission* factor
  - The peak concentration → clean-out stage
- Vertical drilling, horizontal drilling and flowback → the *regional transport/photochemistry* factor
  - High variability

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# QUESTIONS?

[Nur.Orak@netl.doe.gov](mailto:Nur.Orak@netl.doe.gov)