Considerations in Evaluation of Potential Exposures to Emissions from Unconventional Oil and Gas Exploration

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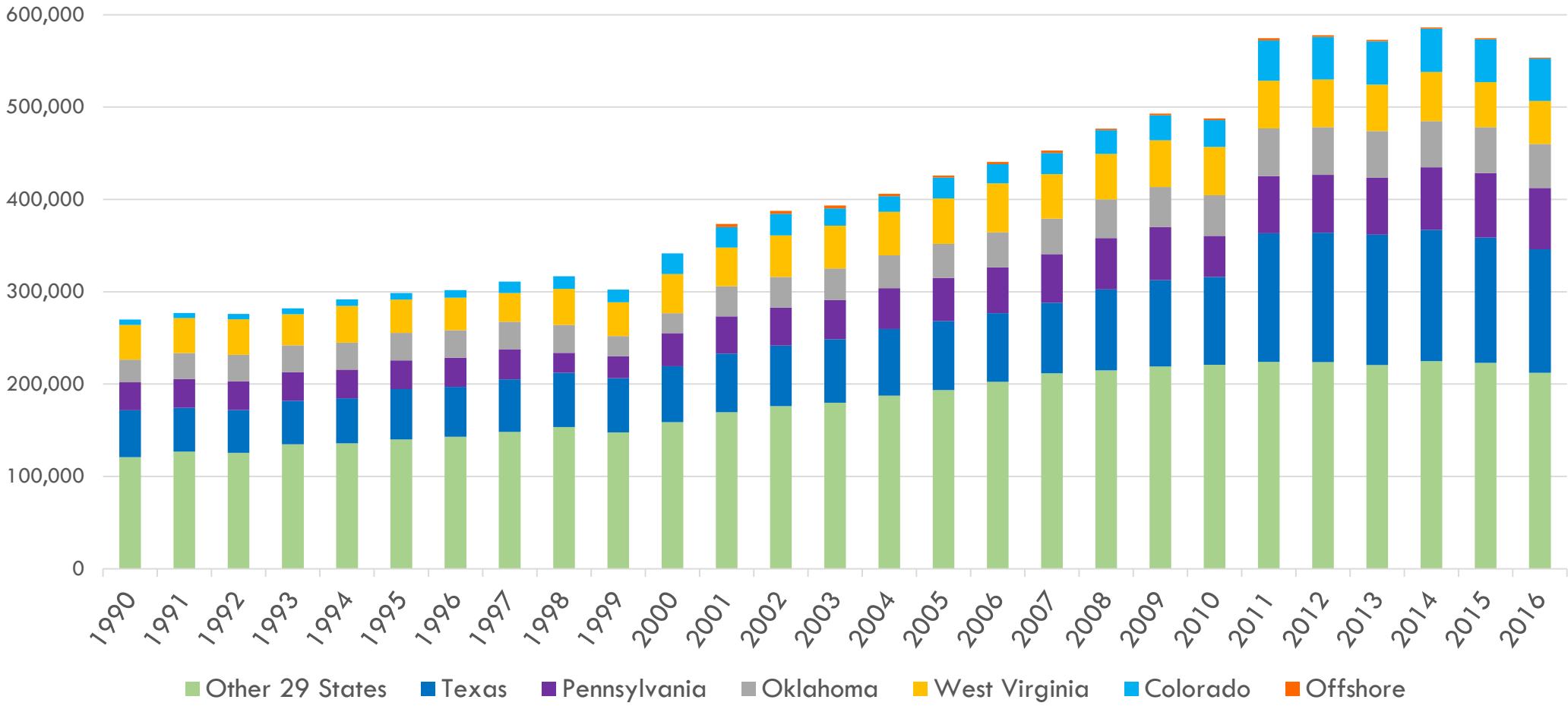
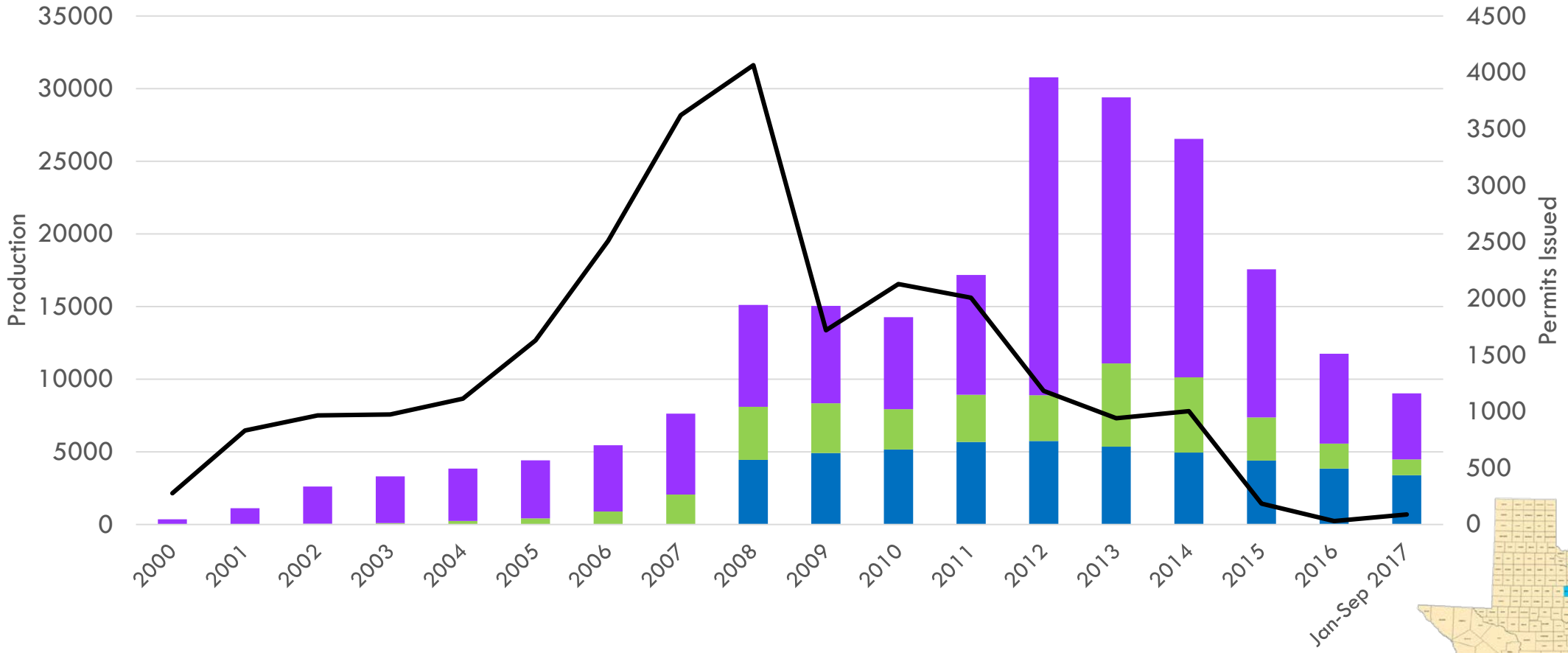
Number of Producing Gas and Gas Condensate Wells, 1990-2016



Source: US Energy Information Administration, 2017

Production in the Barnett Shale Area, 2000-2017



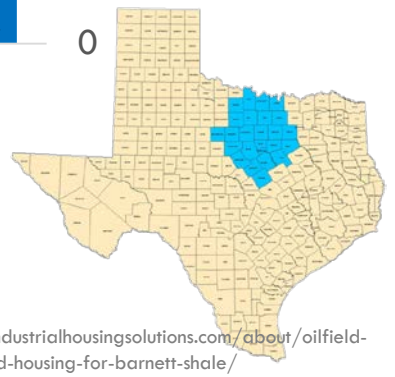


Image: http://industrialhousingsolutions.com/about/oilfield-locations/oilfield-housing-for-barnett-shale/

Research Question

- Are ambient air concentrations of pollutants at levels that could negatively impact public health or the environment in areas of high oil and natural gas activity?
  - Not included in this question
    - Traffic, noise, light (local jurisdictions)
    - Indoor air quality or personal exposure
    - Water (considered separately)
    - Indirect impacts

Potential Pollutants

- Volatile Organic Compounds (VOCs)
  - Modified TO-15 suite of 84 VOCs (grab, 30-minute, or 24-hour discrete canister samples)
  - Suite of 46 VOCs (1-hour continuous sampling using autoGCs)
- Carbonyls (aldehydes)
  - TO-11 suite of 18 carbonyls (1-hour or 24-hour discrete cartridge samples)

Exposure Considerations

- Constituents and concentrations
- Distance to receptor
  - Emission source is sometimes very close to residences
- Length of exposure

Typical Timelines

Site selection, pad site preparation

4-6 weeks

Drilling

2-4 weeks

Fracturing

3-5 days

Production

Decades

Investigative Strategy

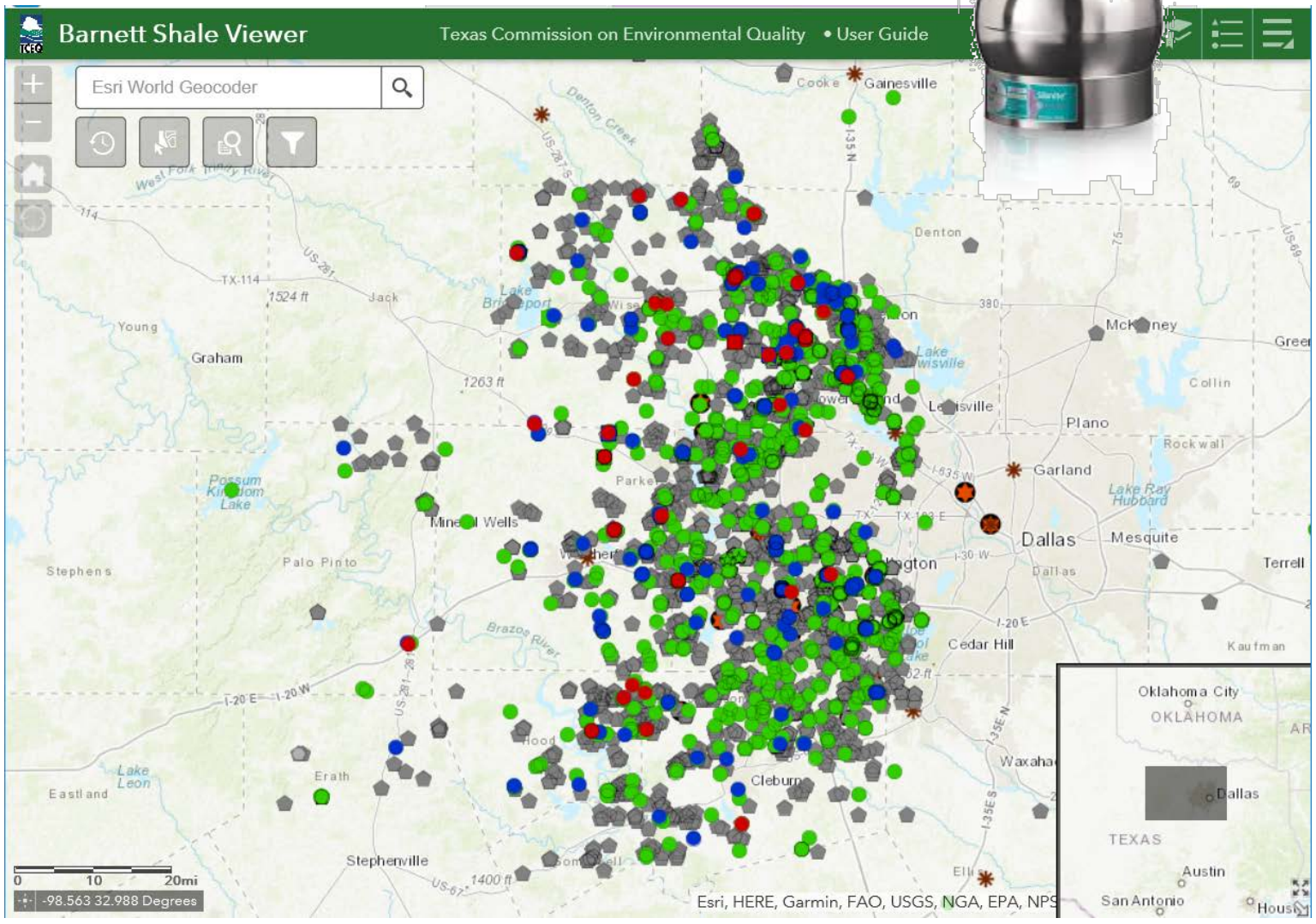
- Qualitative Sampling and Surveys
  - Pro: Highly mobile, provides data closer to both sources and residents
  - Con: Unspeciated data not useful for health effect evaluations
- Quantitative Sampling
  - Pro: Provides insight into pollutant concentrations and variability over time
  - Con: Not easily movable, expensive
- Special Emission Inventory
  - Pro: Provides insight into likely sources
  - Con: Data collection takes time and relies on calculations

Qualitative Data Collection

- Handheld instruments
  - Over 4000 surveys on the ground
    - Almost all used a survey VOC monitor
    - Over 90 investigations used a handheld H_2S monitor
- Infrared Imaging
  - Over 3000 investigations used a handheld IR camera
  - Thousands of images collected during flyovers in 2005 and 2007

Quantitative Data Collection

- Field Sampling
  - Over 1700 individual canister samples
  - 52 carbonyl samples
  - Collected distance and source information



http://www.tceq.texas.gov/airquality/barnettshale

Quantitative Data Collection

- Mobile Monitoring
  - Eight multi-day trips in 2009 and 2010
  - Discrete and real-time sampling for VOCs, NOx, sulfur compounds, carbonyls

Quantitative Data Collection

- Fixed-site monitors
  - 2009 – 6 monitoring sites
    - 2 autoGCs
    - 6 canister samplers (2 collocated with autoGCs)
    - 2 carbonyl samplers
  - 2017 – 26 monitoring sites
    - 15 autoGCs
    - 13 canister samplers (2 collocated with autoGCs)
    - 2 carbonyl samplers

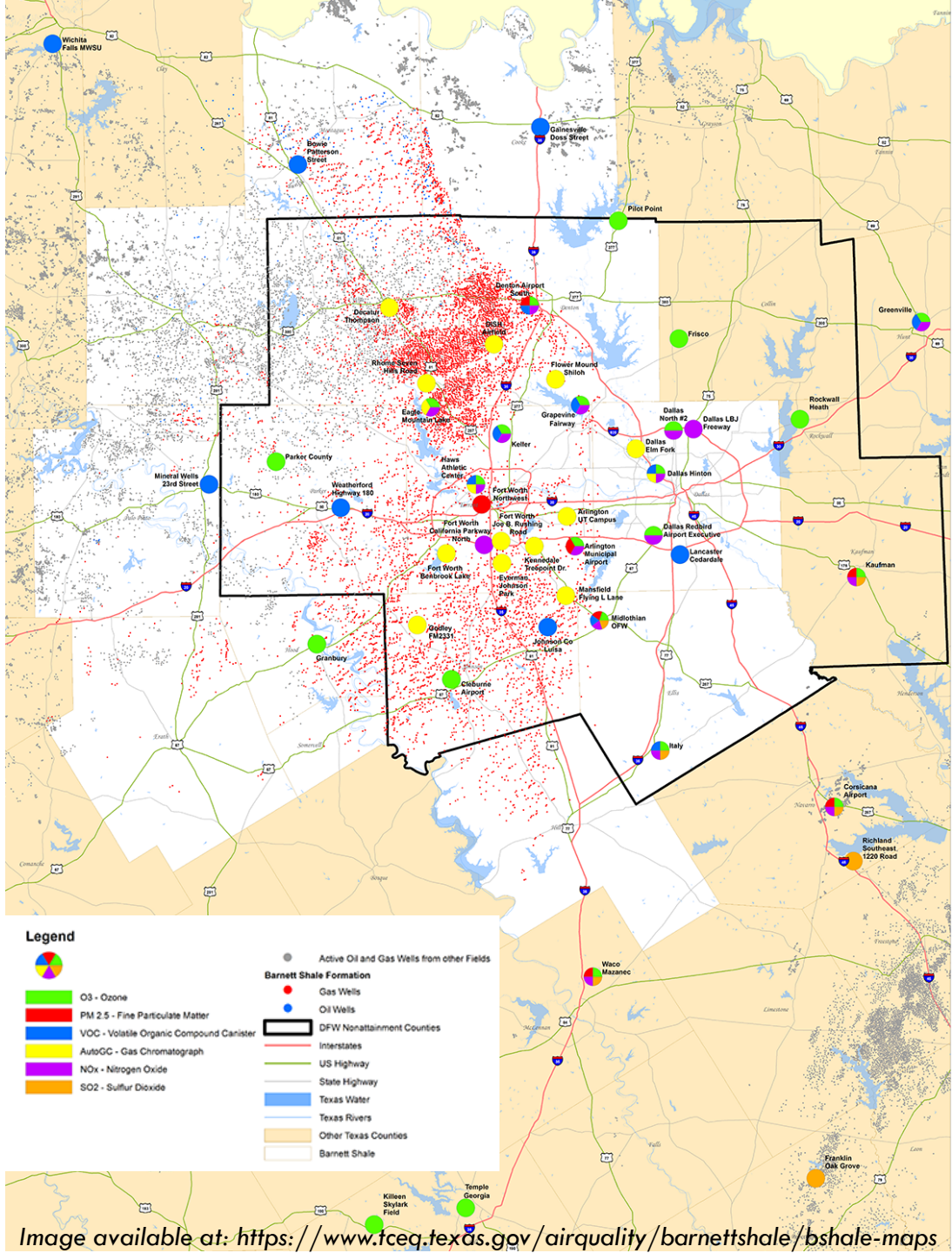
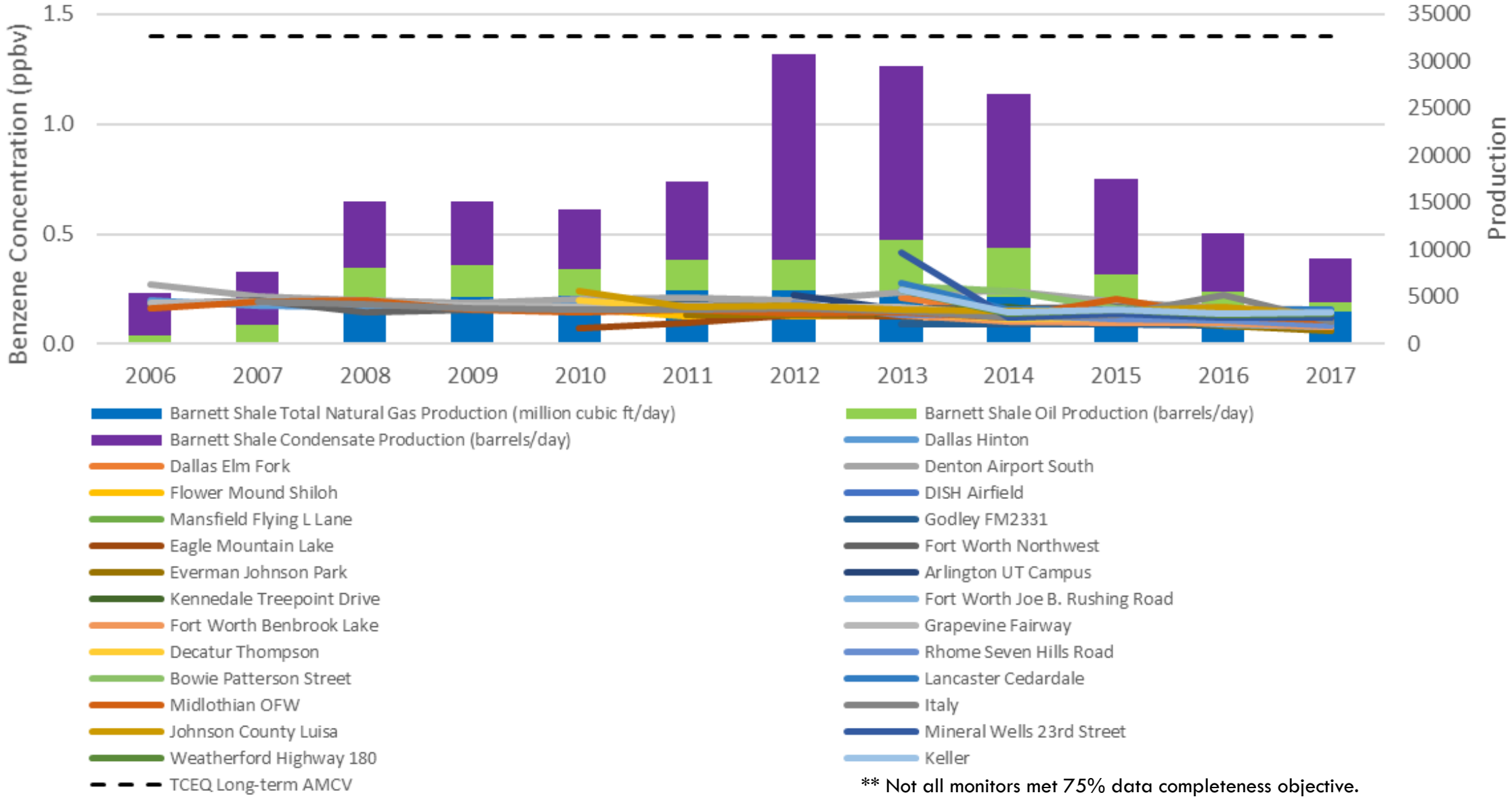


Image available at: https://www.tceq.texas.gov/airquality/barnettshale/bshale-maps

Results to Date

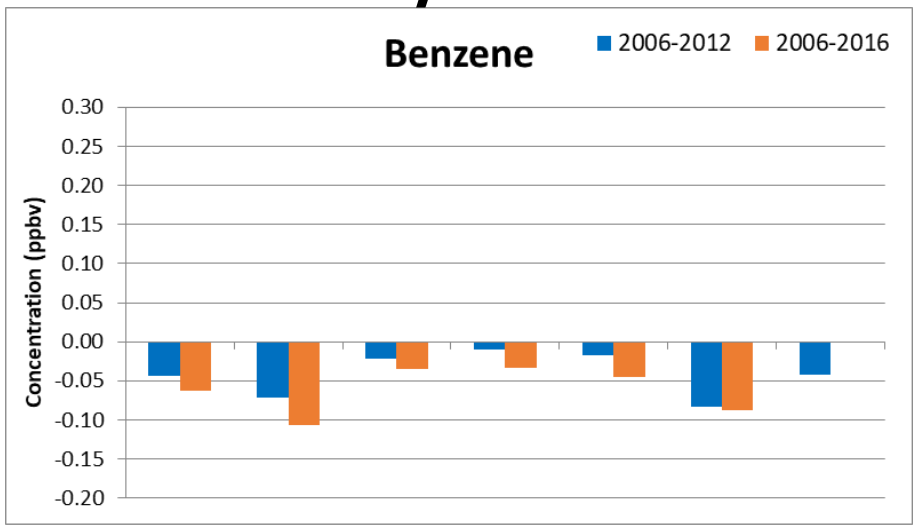
- Nearly all of the issues documented arose from human or mechanical failures.
- These items were quickly remedied and could have been avoided through increased diligence on the part of the operator.
- Corrective actions amounted to little more than replacing worn gaskets, closing open hatches, and repairing stuck valves.

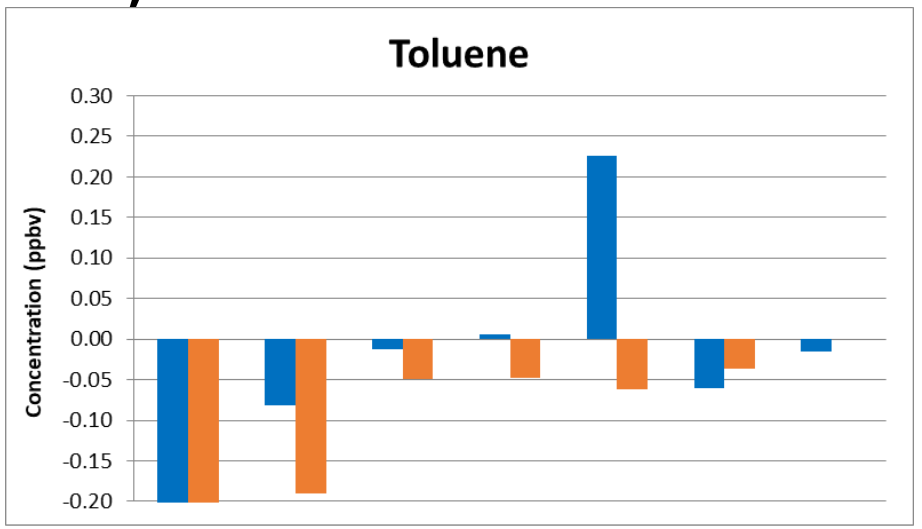
Annual Average Benzene Concentrations and Production in the Barnett Shale Area, 2006-2017

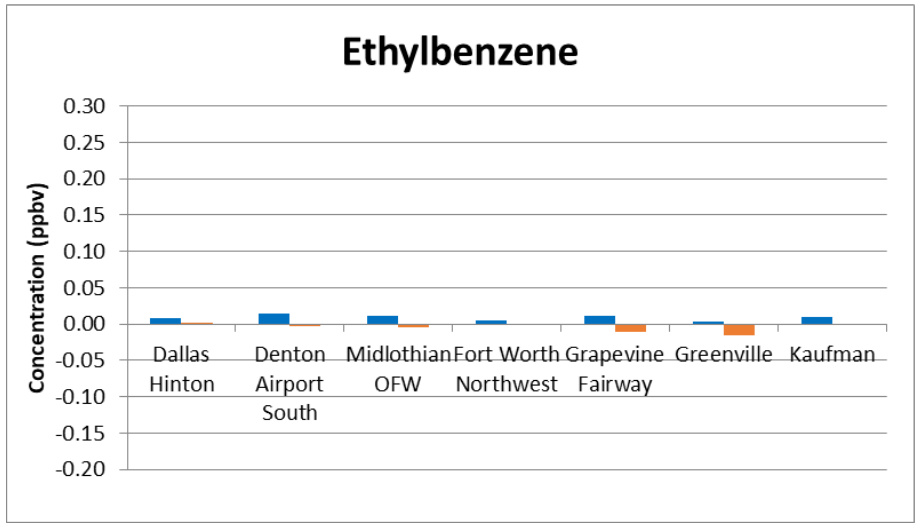


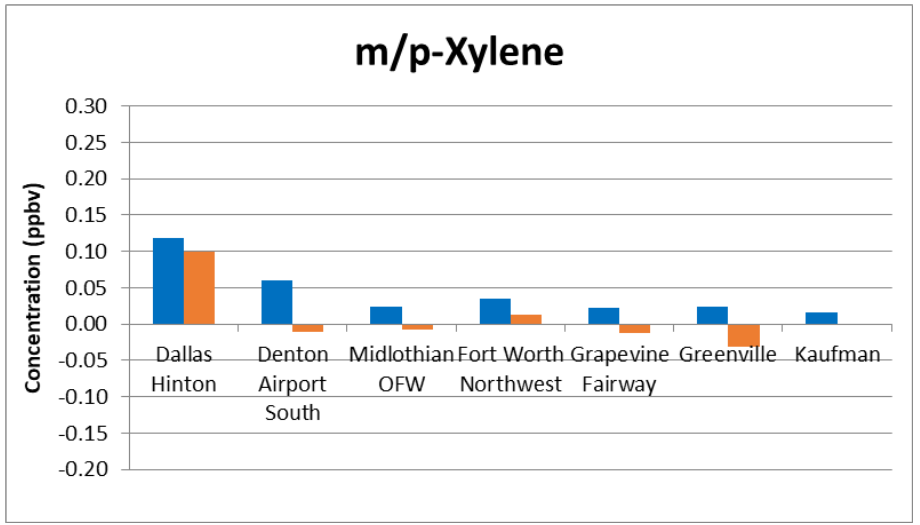
** Not all monitors met 75% data completeness objective.

Changes in Annual Average BTEX Concentrations at Stationary Canister Sites, 2006-2016





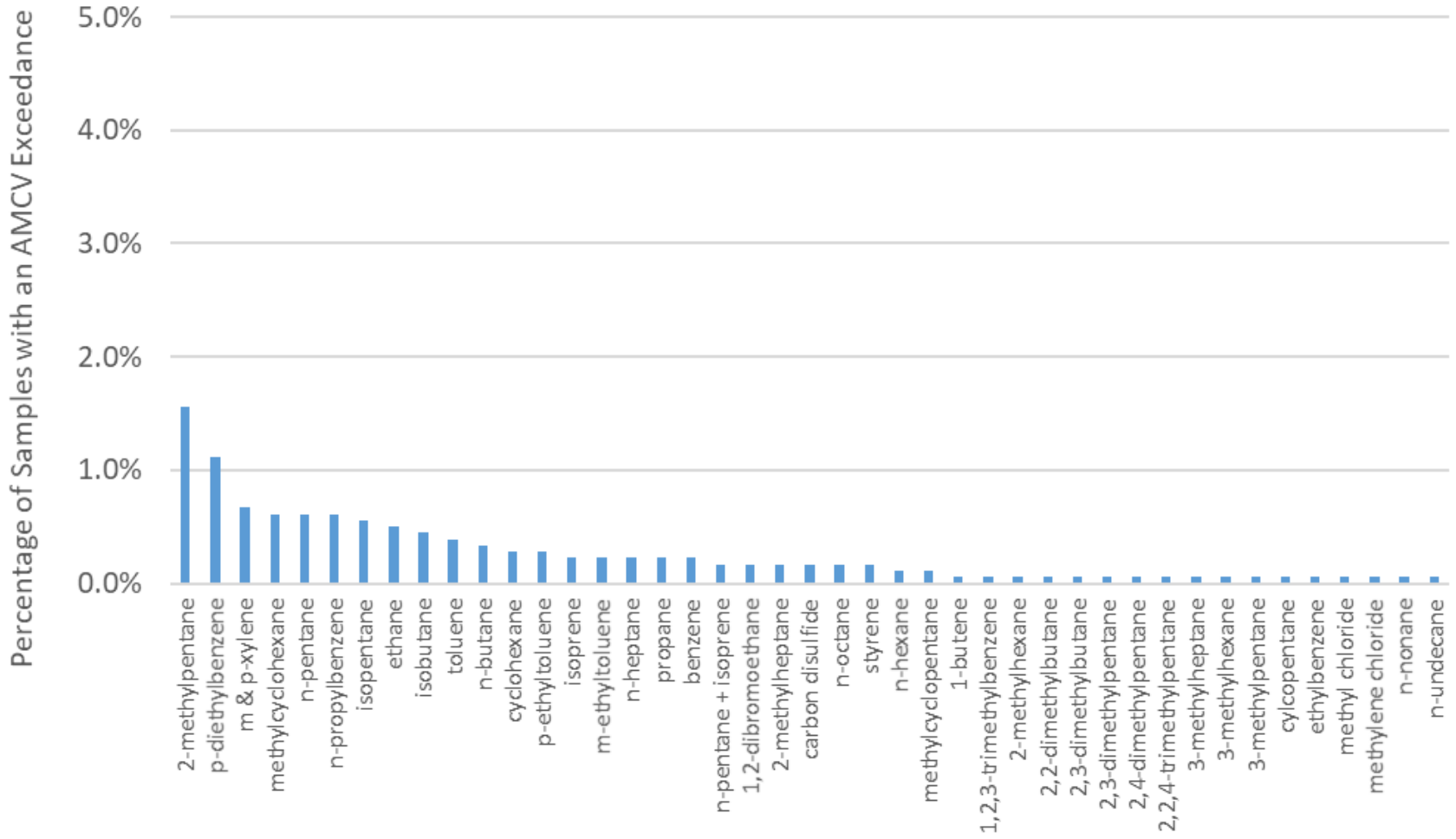




Single Canisters

- Over 1700 samples collected since 2009
- <4% of collected canisters had exceedances of short-term health or odor comparison values
- Repeat investigations showed concentrations below short-term comparison values

Investigation Canisters with an Exceedance of a Health or Odor Value, 2009-2017



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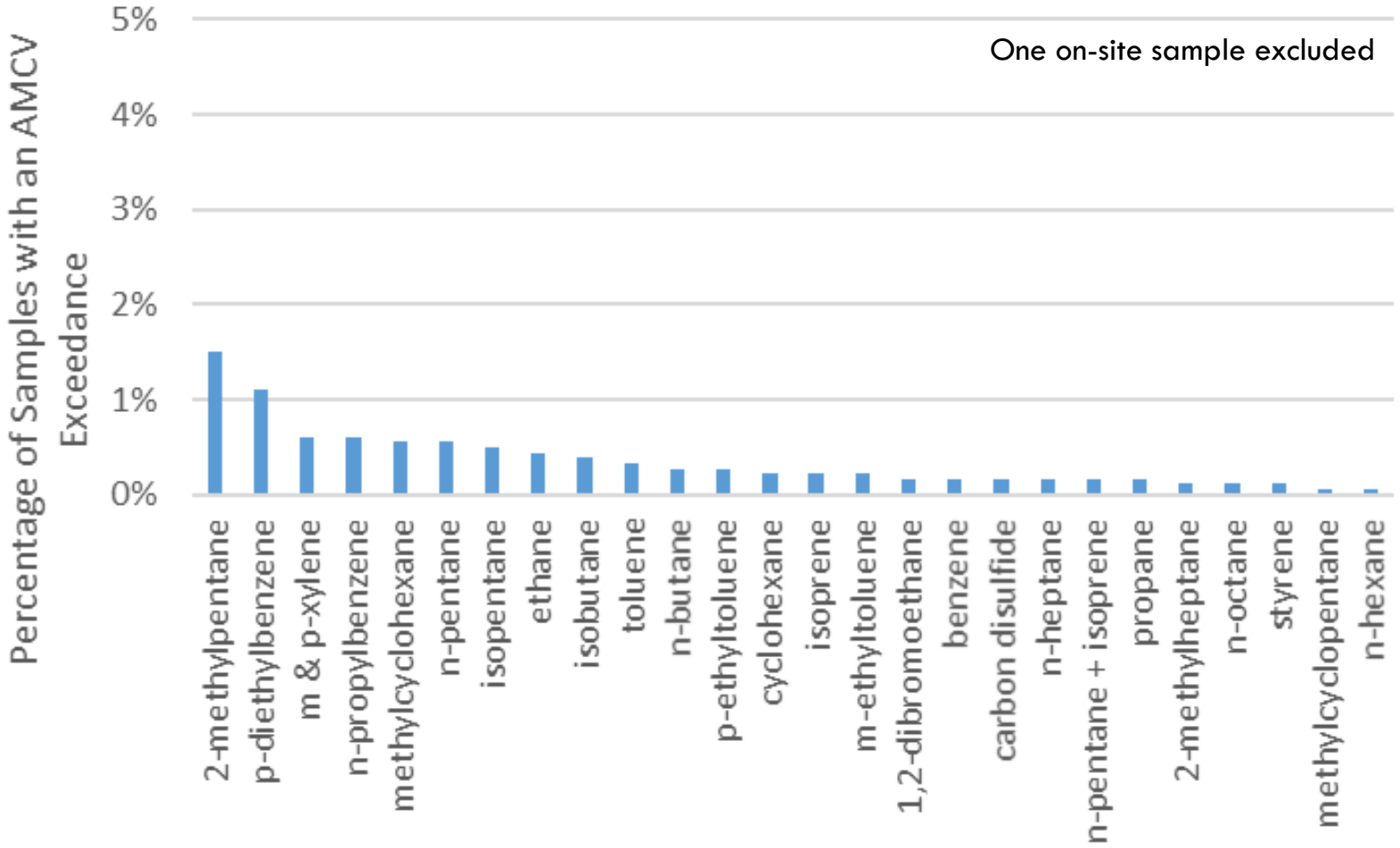
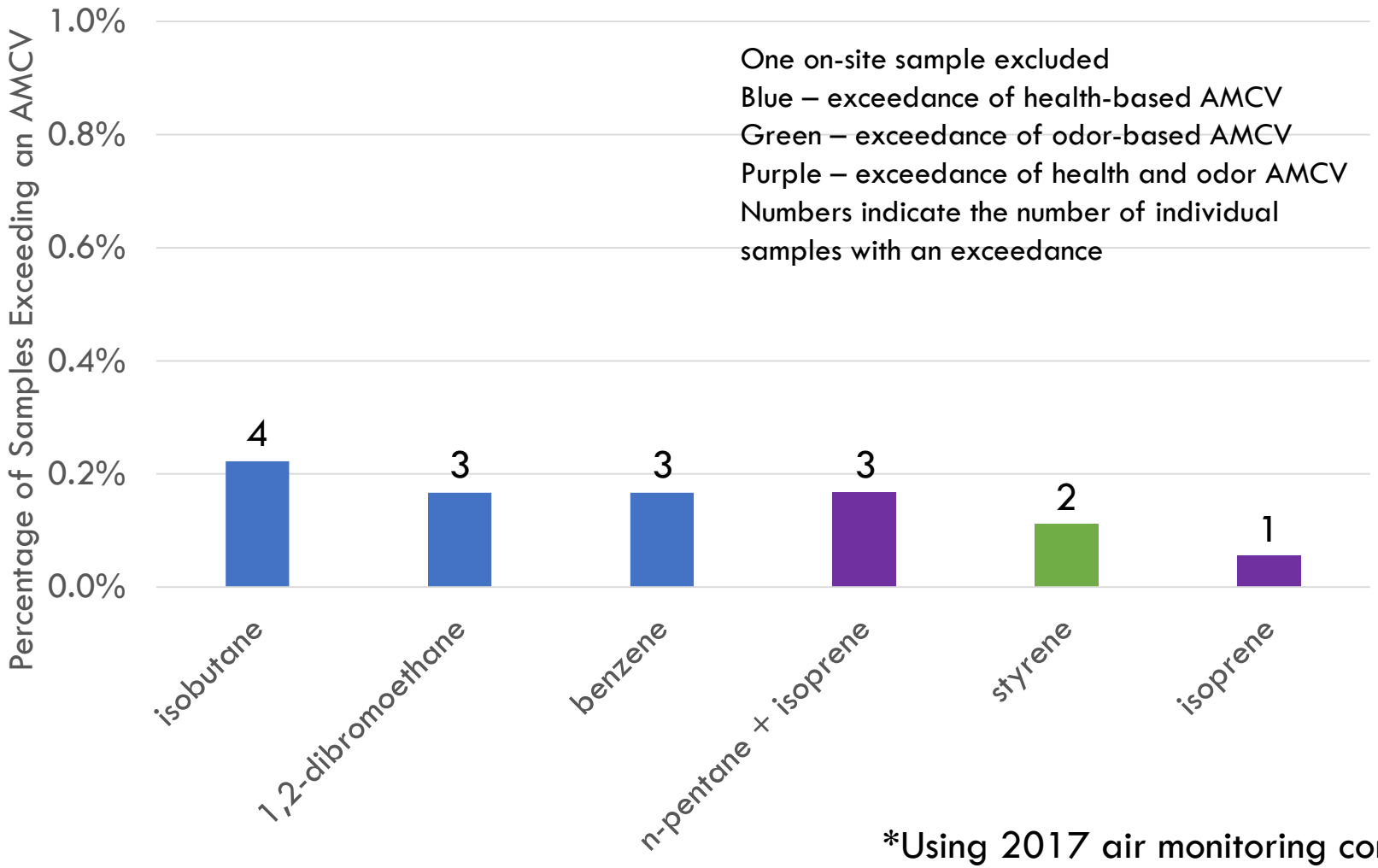
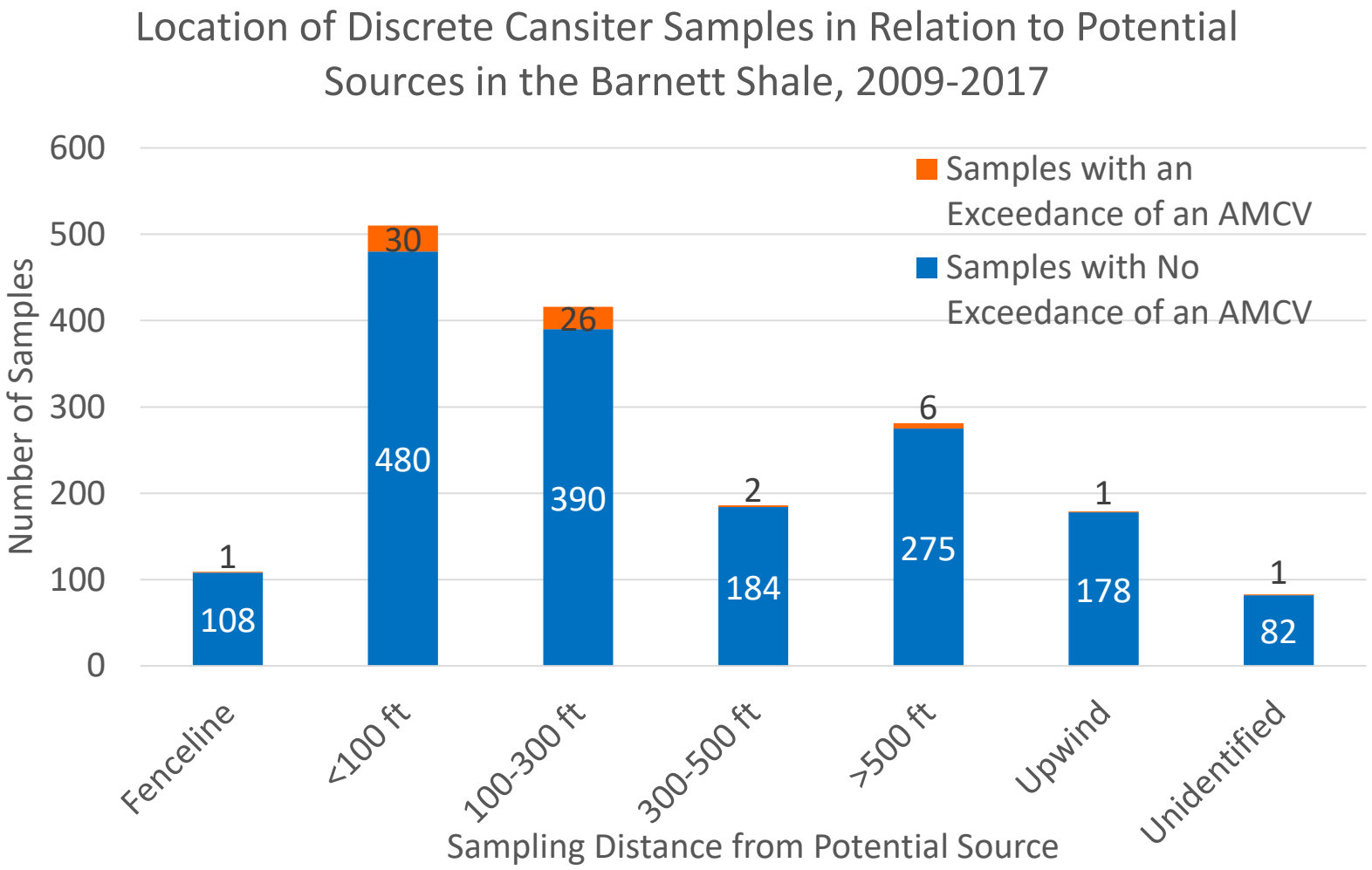


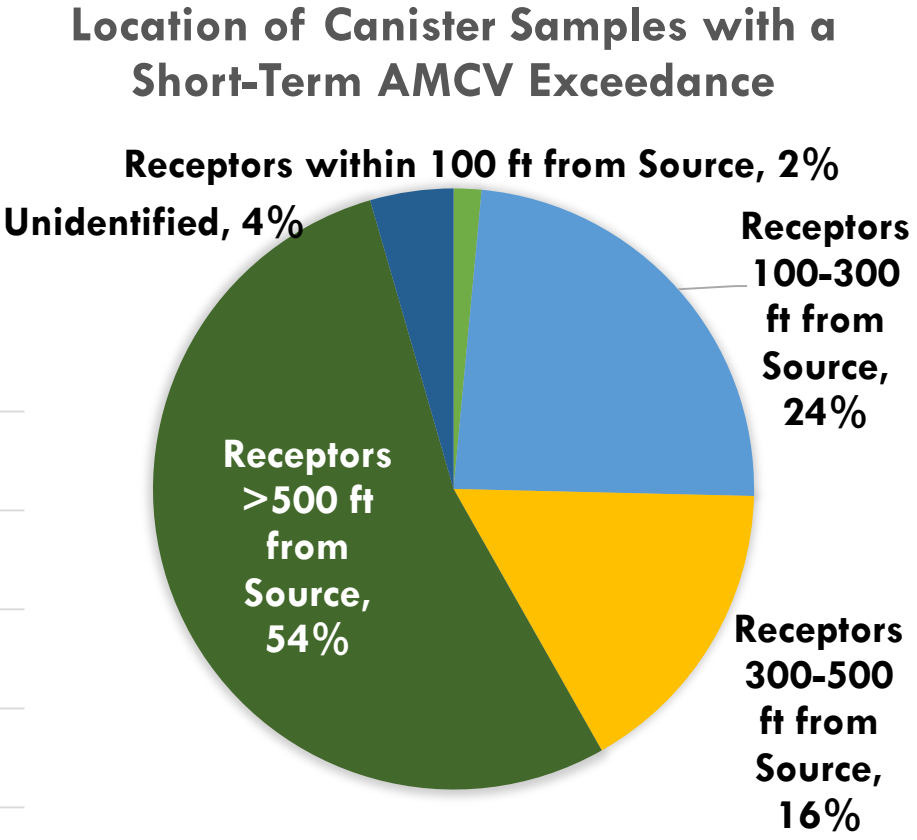
Investigation Canisters with an Exceedance of a Health or Odor Value, 2009-2017



*Using 2017 air monitoring comparison values (AMCVs)

Sampling Distances

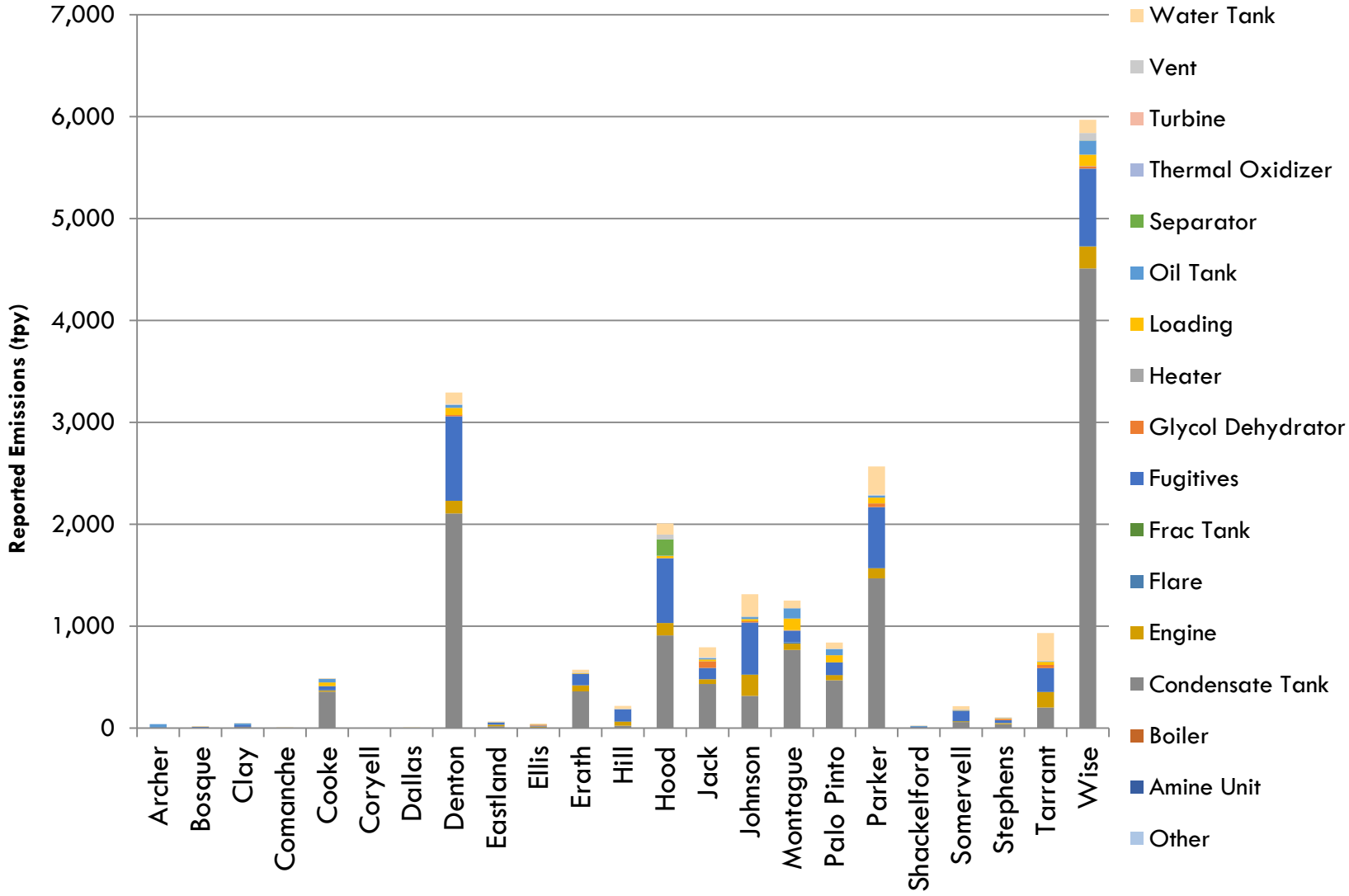




Carbonyl Concentrations

- None of the 52 sample concentrations was above a level of health concern
- Relatively consistent concentration independent of sampling location
- Formaldehyde, acetaldehyde, and acetone were the most abundant carbonyls detected
- Formaldehyde concentrations were typical for populated areas

Barnett Shale Special Emissions Inventory-VOCs , 2009



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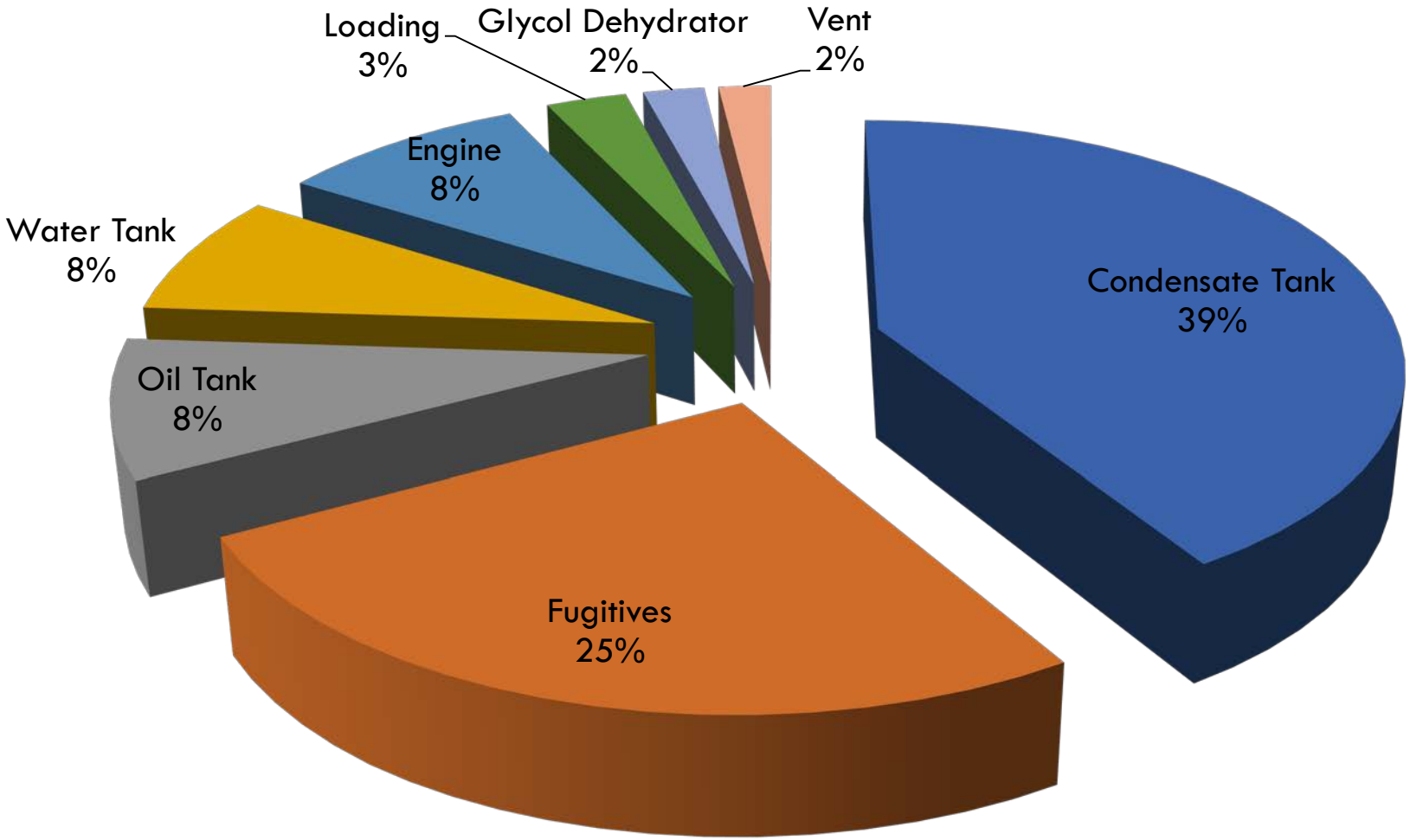


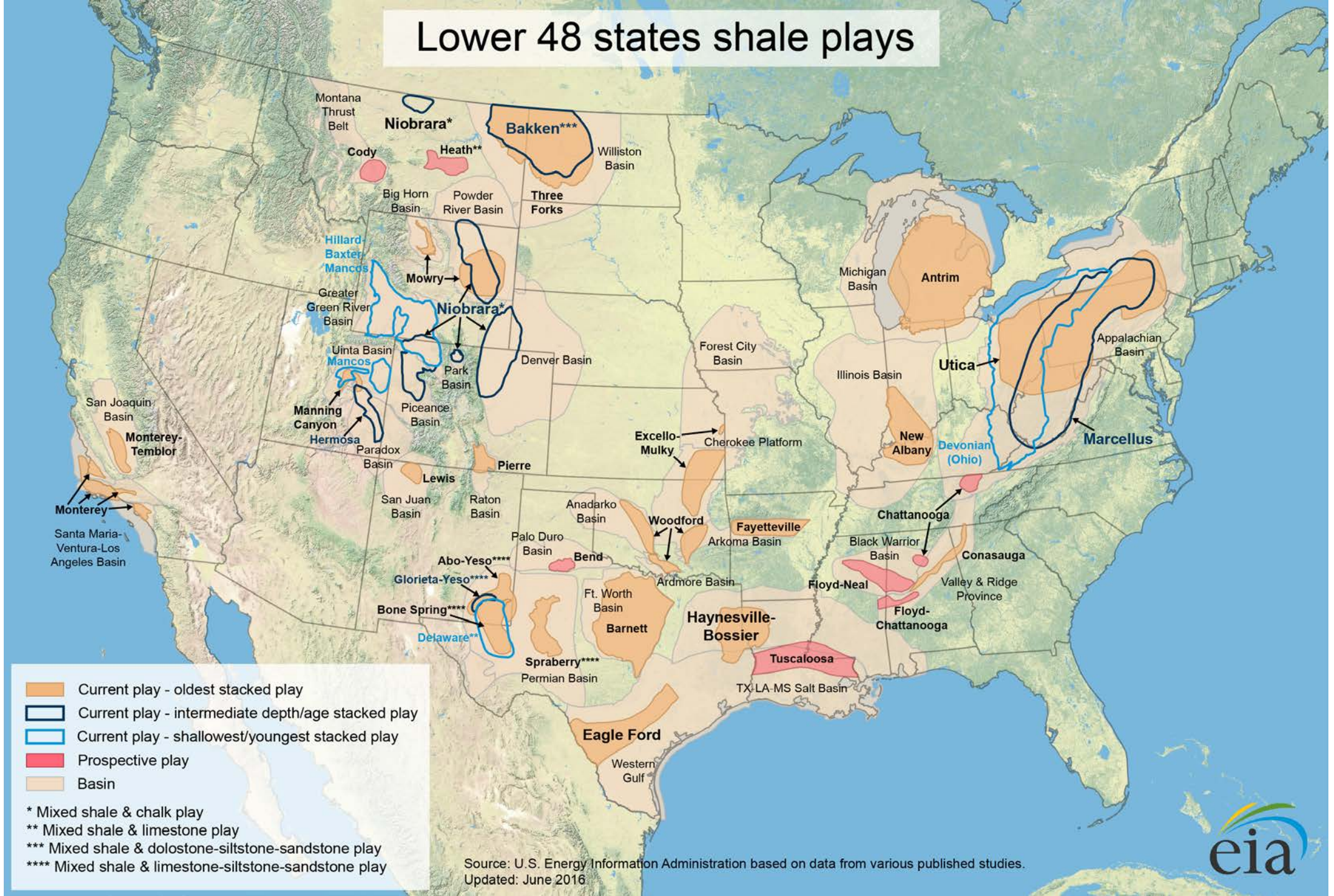
Conclusions

- Monitored ambient VOC, carbonyl, and H_2S concentrations remain below a level of health concern
- Using a multi-pronged approach to evaluating potential for exposure leads to a more complete picture of potential risk and helps to focus investigative efforts

Moving Forward

- Ensure transparency of our efforts through abundant and timely communication with all interested parties
- Evaluate data from the existing ambient air quality monitoring network and samples collected during investigations
- Maintain a frequent, routine investigative presence while also providing timely complaint response
- Adjust as necessary

Extras


Lower 48 states shale plays
Montana Thrust Belt
Niobrara*
Bakken***
Cody
Heath**
Williston Basin
Big Horn Basin
Powder River Basin
Three Forks
Hillard
Baxter
Mancos
Mowry
Greater Green River Basin
Niobrara*
Uinta Basin
Mancos
Park Basin
Denver Basin
Piceance Basin
Manning Canyon
Hermosa
Paradox Basin
San Joaquin Basin
Monterey-Temblor
Pierre
Lewis
San Juan Basin
Raton Basin
Monterey
Santa Maria-Ventura-Los Angeles Basin
Anadarko Basin
Palo Duro Basin
Bend
Abo-Yeso****
Glorieta-Yeso****
Bone Spring****
Delaware**
Spraberry****
Permian Basin
Ft. Worth Basin
Barnett
Ardmore Basin
Eagle Ford
Western Gulf
Forest City Basin
Excello-Mulky
Cherokee Platform
Woodford
Fayetteville
Arkoma Basin
Haynesville-Bossier
Tuscaloosa
TX-LA-MS Salt Basin
Michigan Basin
Antrim
Illinois Basin
Utica
Appalachian Basin
New Albany
Devonian (Ohio)
Marcellus
Chattanooga
Black Warrior Basin
Conasauga
Floyd-Neal
Valley & Ridge Province
Floyd-Chattanooga
Current play - oldest stacked play
Current play - intermediate depth/age stacked play
Current play - shallowest/youngest stacked play
Prospective play
Basin
* Mixed shale & chalk play
** Mixed shale & limestone play
*** Mixed shale & dolostone-siltstone-sandstone play
**** Mixed shale & limestone-siltstone-sandstone play
Source: U.S. Energy Information Administration based on data from various published studies.
Updated: June 2016
eia

Wells and Ambient Air Quality Monitors