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Multi-Year Spatial and Temporal Surrogates for Emissions Modeling

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Overview of the Presentation

- Introduction/Background Information
- Project Goals
- Data Sources
- Project Tasks
- Notes



Introduction/Background Information

- Oil and gas exploration and production sources can vary significantly by year.
- Typically, oil and gas emissions are annual county-level estimates (some states provide point source emissions)
 - For air quality modeling, these county-level estimates need to be allocated to grid cells (defined as a gridding surrogate) that are often smaller than a county.
 - Additionally, annual emissions need to be temporally allocated to monthly profiles (based on activity).

Project Goals

- #1 Develop special year nationwide oil and gas emissions inventories
 - 2002, 2005, 2008, 2011, 2014, 2016, 2017, 2018, and 2019 for EPA's Air Quality Time Series (EQUATES) Project
 - <https://www.epa.gov/cmaq/equates>
 - 2020 through NEI cycle
 - Note - is currently finalizing the 2021 inventory a separate project

Project Goals (cont.)

- #2 Develop multi-year gridded spatial allocation factors for oil and gas sources
 - Develop 4-km shapefiles for 27 surrogates
- #3 Develop monthly temporal profiles for all years of interest.
- #4 Develop HAP Augmentation Factors for all years of interest.
- #5 Develop GSREF Flaring Factors for all years of interest.

Data Sources

- ENVERUS (formerly DI Desktop)
 - 3rd-party vendor compiling oil and gas data from state databases
 - In accordance with the EPA's licensing agreement, well-level data is proprietary, but derived products, such as aggregation at the county-level, are acceptable for public dissemination and use in the Tool.
 - Provides data in a standardized format for individual well locations, production information, drilling information, and well completion information
 - Most states were complete for years of interest

Data Sources (Cont.)

- States
 - Illinois, Kansas, Oklahoma, Pennsylvania, Texas, and West Virginia, WRAP
 - Mostly production data, some exploration data and basin factor updates
- Oil and Gas Commission Websites
 - Alabama, Arkansas, Arizona, California, Colorado, Florida, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Michigan, Mississippi, Missouri, Nebraska, Nevada, New Mexico, New York, Ohio, Oklahoma, Oregon, Pennsylvania, South Dakota, Tennessee, Utah, Virginia, Washington, and West Virginia
 - Information retrieved varied, but included well locations, production data, and/or exploration data

Data Sources

- RigData - Used by permission
 - State-level feet drilled allocated to the county-level using county proportion of spuds to the state totals of spuds
- Energy Information Agency (EIA)
 - State-level production for: Illinois and Tennessee
 - Allocated to the county-level using county proportion of active wells to state totals.

Data Attributes Compiled

Associated Gas Production

Condensate Production - Gas Wells

Spud Counts - CBM Wells*

Coalbed Methane (CBM) Production*	Feet Drilled	Spud Counts - Gas Wells
CBM Well Counts*	Natural Gas Production	Spud Counts - Oil Wells
Completions - All Wells	Natural Gas Well Counts	Total Exploratory Wells
Completions - CBM Wells*	Oil Production	Total Production Wells
Completions - Gas Wells	Oil Well Counts	Total Wells
Completions - Oil Wells	Produced Water - All Wells	Unconventional Well Completions*
Condensate Production - CBM Wells*	Spud Counts - All Wells	

* = No CBM wells or hydraulically-fractured wells in Alaska

Task 1 - Estimating Emissions

- Summed data attributes to the county-level and entered into the 2017 Oil and Gas Estimation (O&G) Tool:
 - 2017 Production and Exploration Modules modified to year of interest (e.g., 2002, 2005, 2008, etc.)

EPA Oil and Gas - Production Activities

EPA Oil and Gas Tool, 2017 NEI Version 1.2 - Production Activities Module (Used for 2002 Conditions)


Welcome to the U.S. Environmental Protection Agency (EPA) Oil and Gas Tool - Production Activities Module. This Module allows the User to generate county-level emission estimates of criteria and hazardous air pollutants (CAPs and HAPs) for oil and gas source categories related to production activities. When finished, data can be exported to Emission Inventory System (EIS) Staging tables.

To begin, first link to the EIS Staging tables in the nonpoint_bridge_tool.acddb database. When finished, please click the "BEGIN" button below to make your geographic and source category selections.

[LINK TO EIS STAGING TABLES](#)

[BEGIN \(go to DASHBOARD VIEW\)](#)

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Data Summary

- For each year of interest, approximately one million oil, gas, and CBM wells compiled into an Access[®] database.

- Coverage:

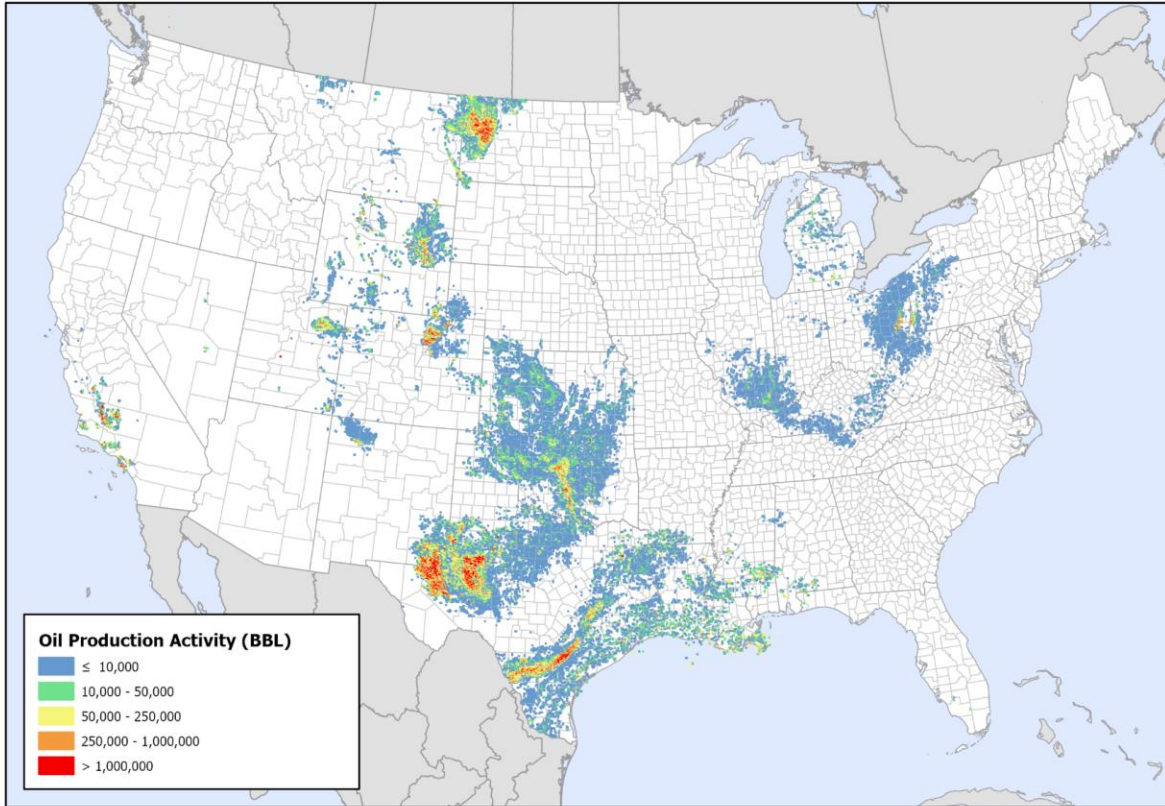
Year	# Wells	# States	# Counties
2002	852,621	34	1,140
2005	919,400	34	1,153
2008	1,023,717	34	1,185
2011	1,001,062	33	1,068
2014	1,041,404	34	1,165
2016	1,120,270	34	1,155
2017	1,078,845	34	1,177
2018	1,072,947	34	1,143
2019	1,011,197	34	1,128
2020	976,975	34	1,124
2021	945,914	34	1,122

Task 2 - Developing Spatial Surrogates

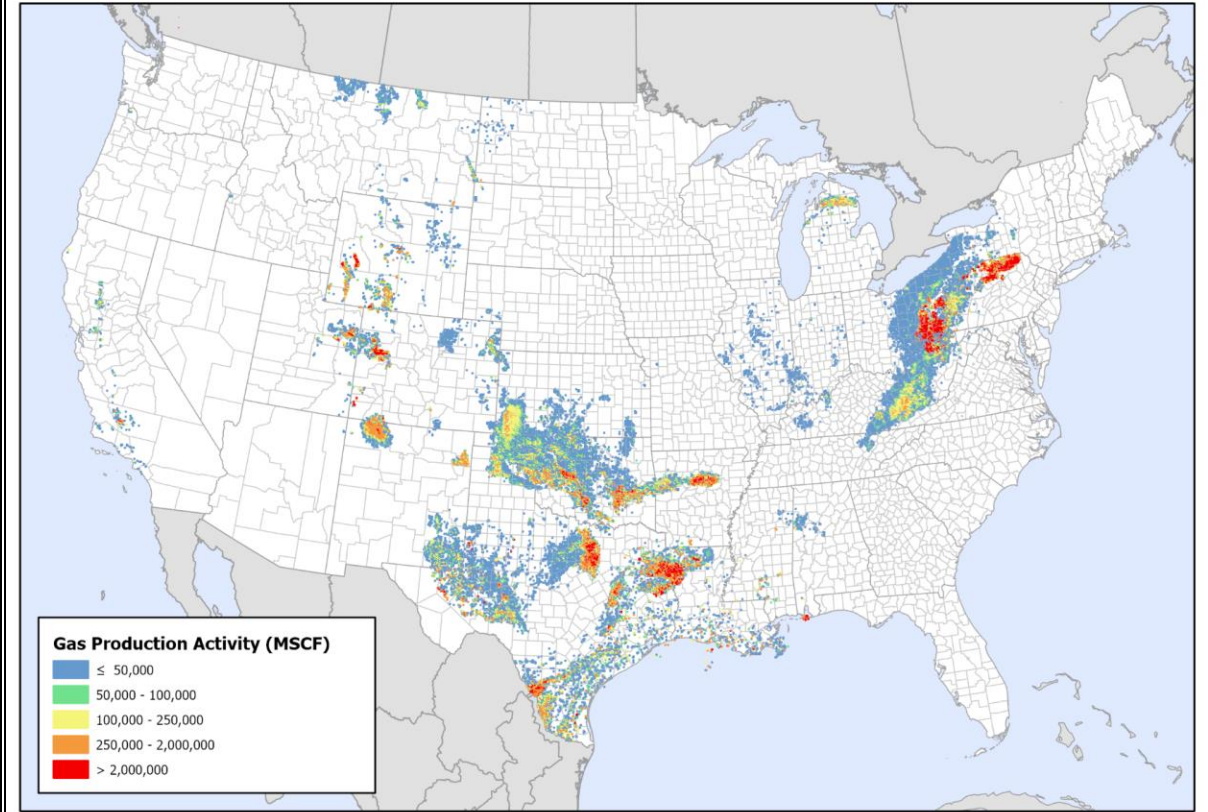
- Assigned each well and corresponding data attribute to a 4-km grid cell, including a special Alaska 4-km gridded domain
- Each well and attribute were summed to the 4-km grid cell.
- Prepared GIS shapefiles for each attribute and year.

Year 2020 Heat Maps

Oil Production Activity in the Continental U.S.



Gas Production Activity in the Continental U.S.



Task 3 - Monthly Temporal Profile Development

- Developed monthly temporal profiles for O&G source classification codes (SCCs) for all O&G counties.
- The majority of the well-level attribute data is at the monthly level
 - Sum attribute activity data to the monthly timeframe
 - Divide summed monthly activity data by the summed annual activity to calculate monthly temporal factors
 - Monthly profiles must sum to 1.

FIPS	SCC	J	F	M	A	M	J	J	A	S	O	N	D
48113	2310000550	0.13	0.12	0.12	0.10	0.12	0.11	0.09	0.05	0.04	0.04	0.04	0.04

Task 4 - HAP Augmentation

- Using the emissions from the O&G Tool, develop HAP augmentation factors (HAP/VOC) and (HAP/PM10-PRI) based tool emissions ratios*

Profile Name (200 Chars)	EIS Input Pollutant Code	EIS Output Pollutant Code	Multiplication Factor
ONG_TOOL_01003_2310000550	VOC	100414	0.000483217
ONG_TOOL_01003_2310000550	VOC	108883	0.000682004
ONG_TOOL_01003_2310000550	VOC	1330207	0.000538298
ONG_TOOL_01003_2310000550	VOC	71432	0.001850922
ONG_TOOL_01003_2310021010	VOC	100414	0.000608641
ONG_TOOL_01003_2310021010	VOC	108883	0.003888618
ONG_TOOL_01003_2310021010	VOC	1330207	0.002320454
ONG_TOOL_01003_2310021010	VOC	50000	0
ONG_TOOL_01003_2310021010	VOC	71432	0.003091868
ONG_TOOL_01003_2310021400	VOC	100414	0.05949311
ONG_TOOL_01003_2310021400	VOC	107028	2.82011E-05
ONG_TOOL_01003_2310021400	VOC	108883	0.3371329
ONG_TOOL_01003_2310021400	VOC	110543	0.002764812
ONG_TOOL_01003_2310021400	VOC	1330207	0.3470432
ONG_TOOL_01003_2310021400	VOC	50000	0.000115201
ONG_TOOL_01003_2310021400	VOC	71432	0.3371309
ONG_TOOL_01003_2310021400	VOC	75070	2.4911E-05
ONG_TOOL_01003_2310021400	VOC	91203	9.36964E-07
ONG_TOOL_01003_2310021603	VOC	100414	0.000583465
ONG_TOOL_01003_2310021603	VOC	108883	3.21691E-05
ONG_TOOL_01003_2310021603	VOC	1330207	0.000493859

- Ratios are source and county-specific

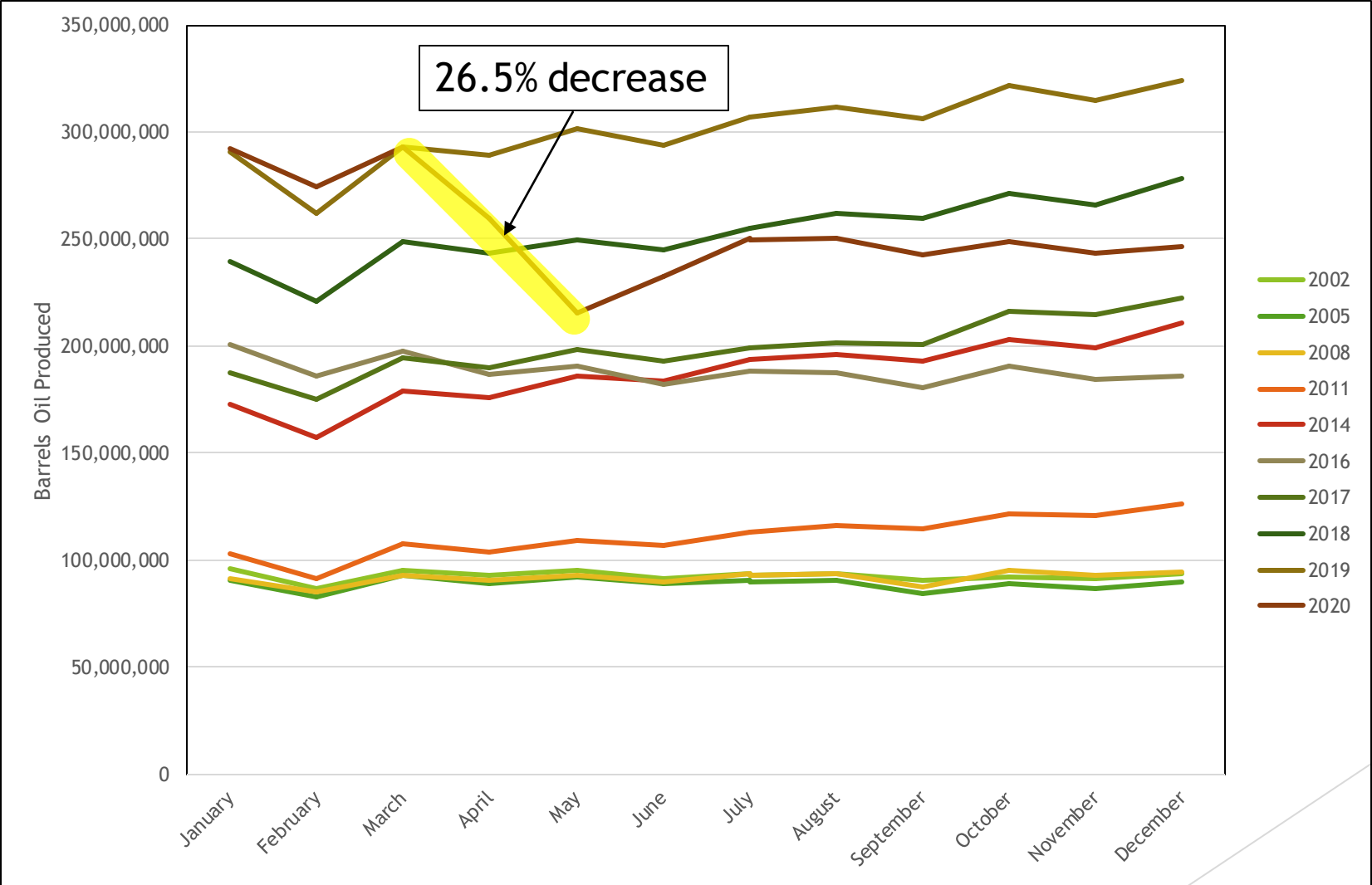
* PM10-PRI: PM10-primary (PM10, filterable + condensable)

Task 5 - Update Flaring Speciation Cross Reference

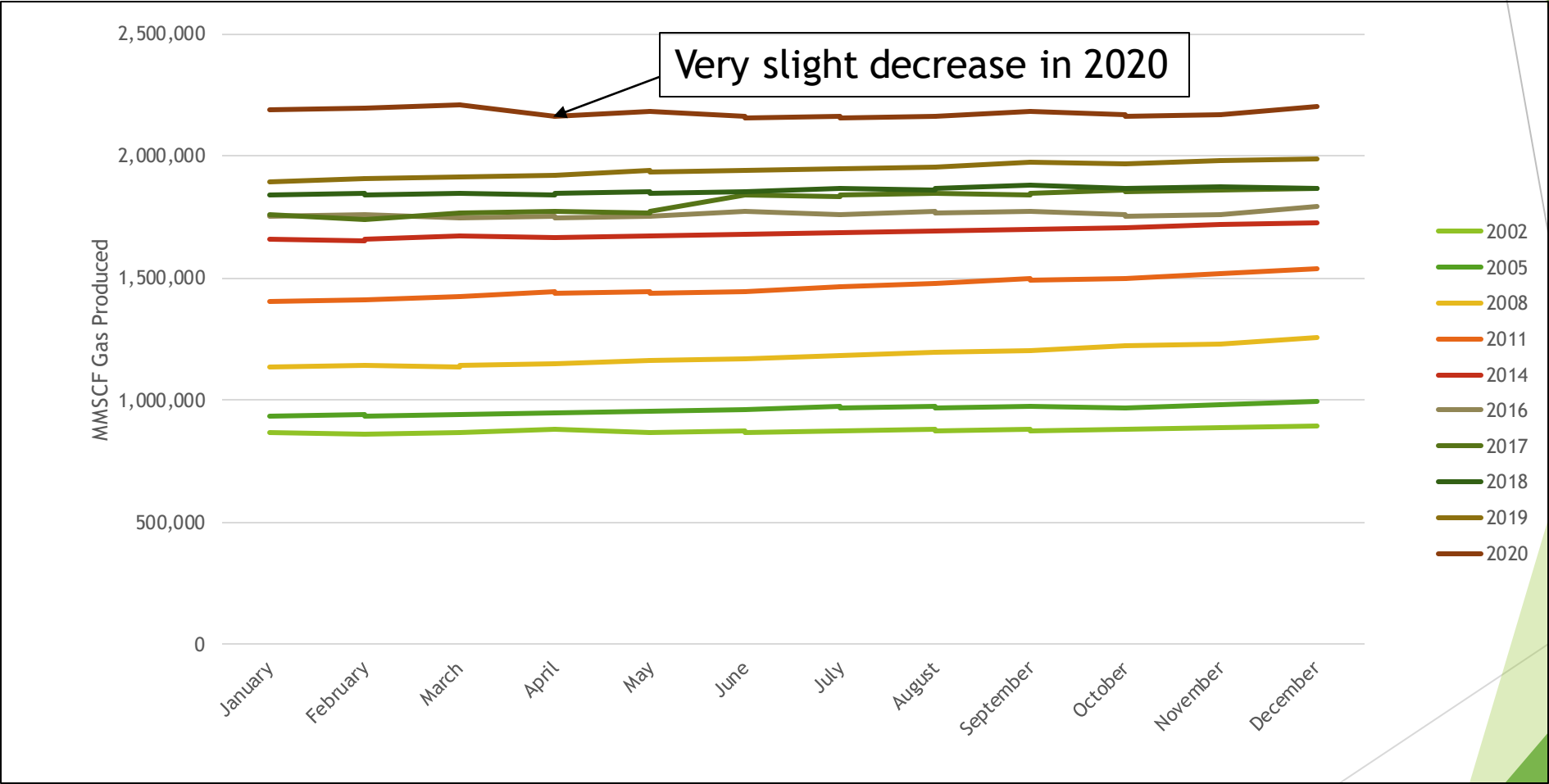
- Oil and gas SCCs don't distinguish flared portion of process. For example, SCC 2310021400 (gas well dehydrators) consists of process, reboiler, and/or flaring emissions
- O&G Tool generates information on how much VOC is from process, flare and reboiler, by basin.
- From that output, compute weight fractions by county and SCC profile for speciation assignment file

Trends Review

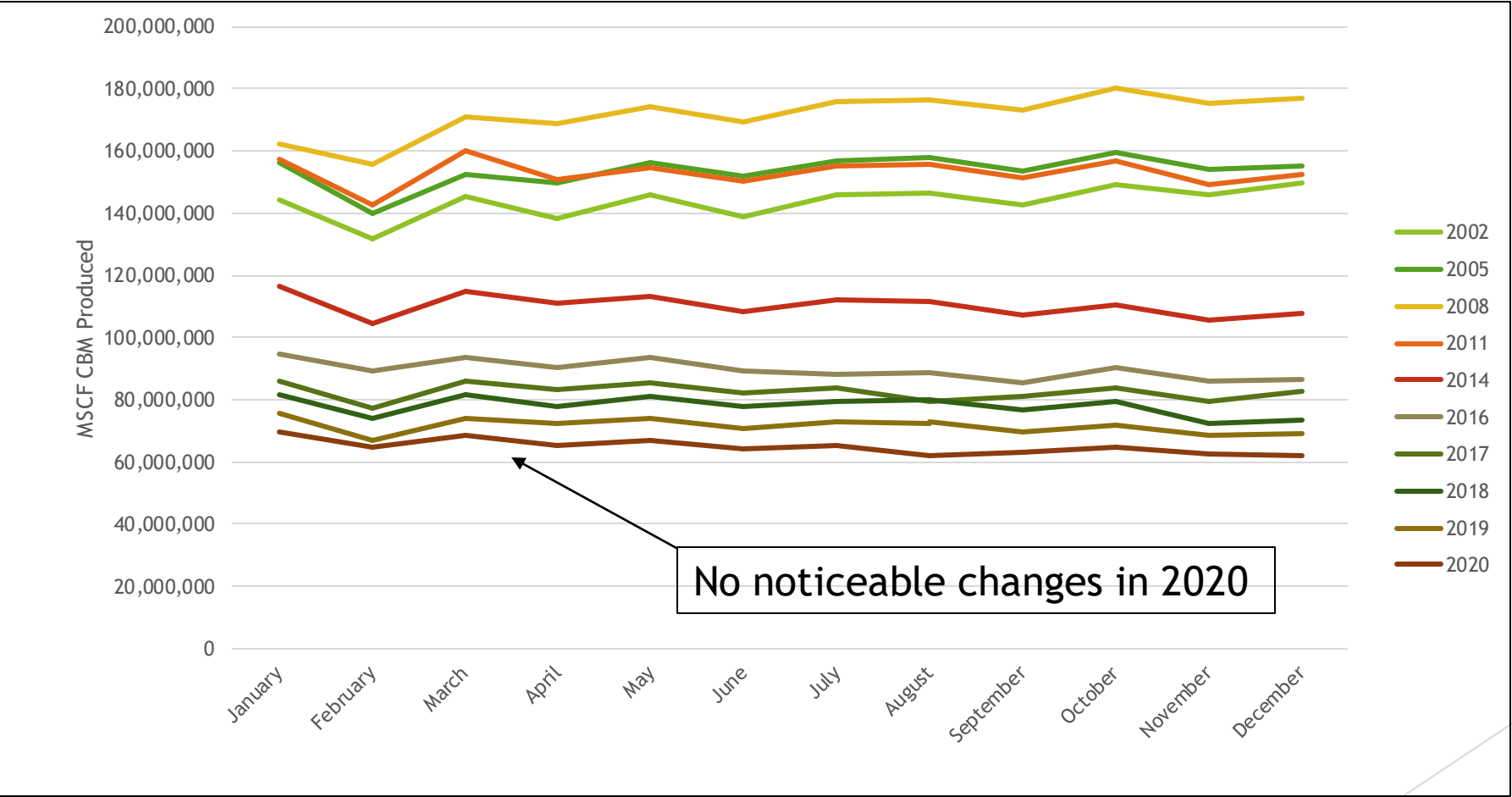
Nationwide Oil Production Monthly Trends



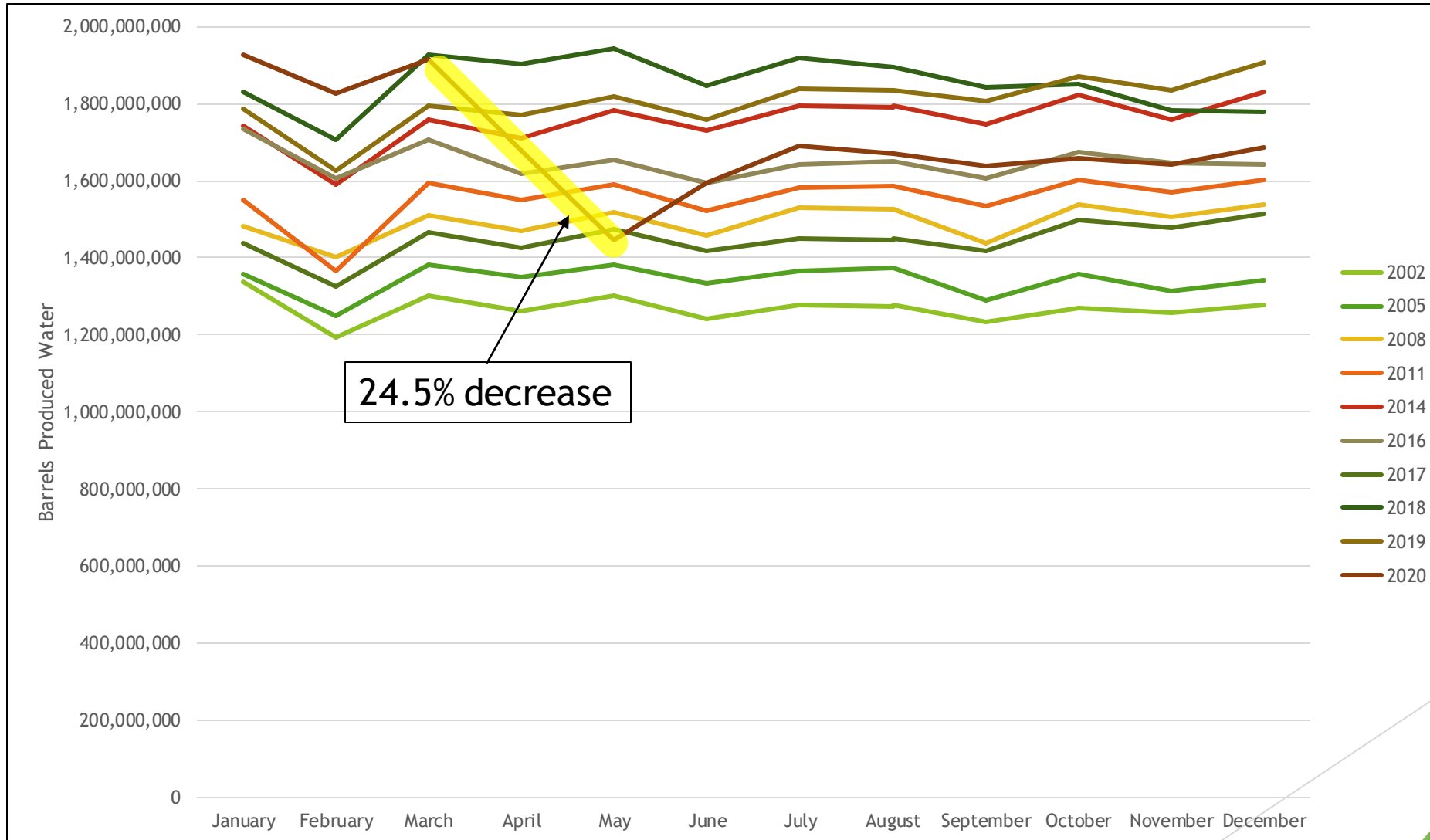
Nationwide Gas Production Monthly Trends



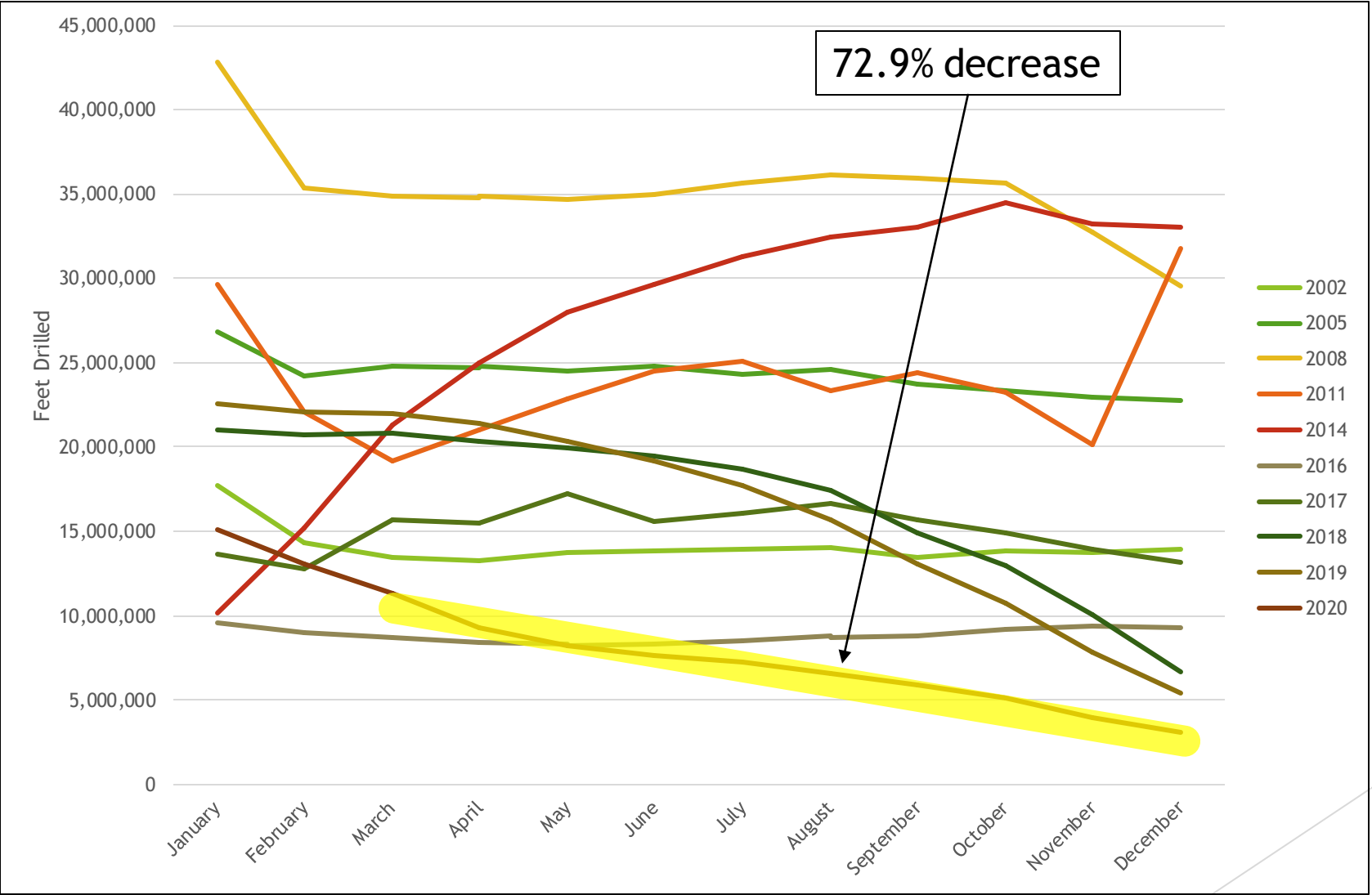
Nationwide CBM Production Monthly Trends



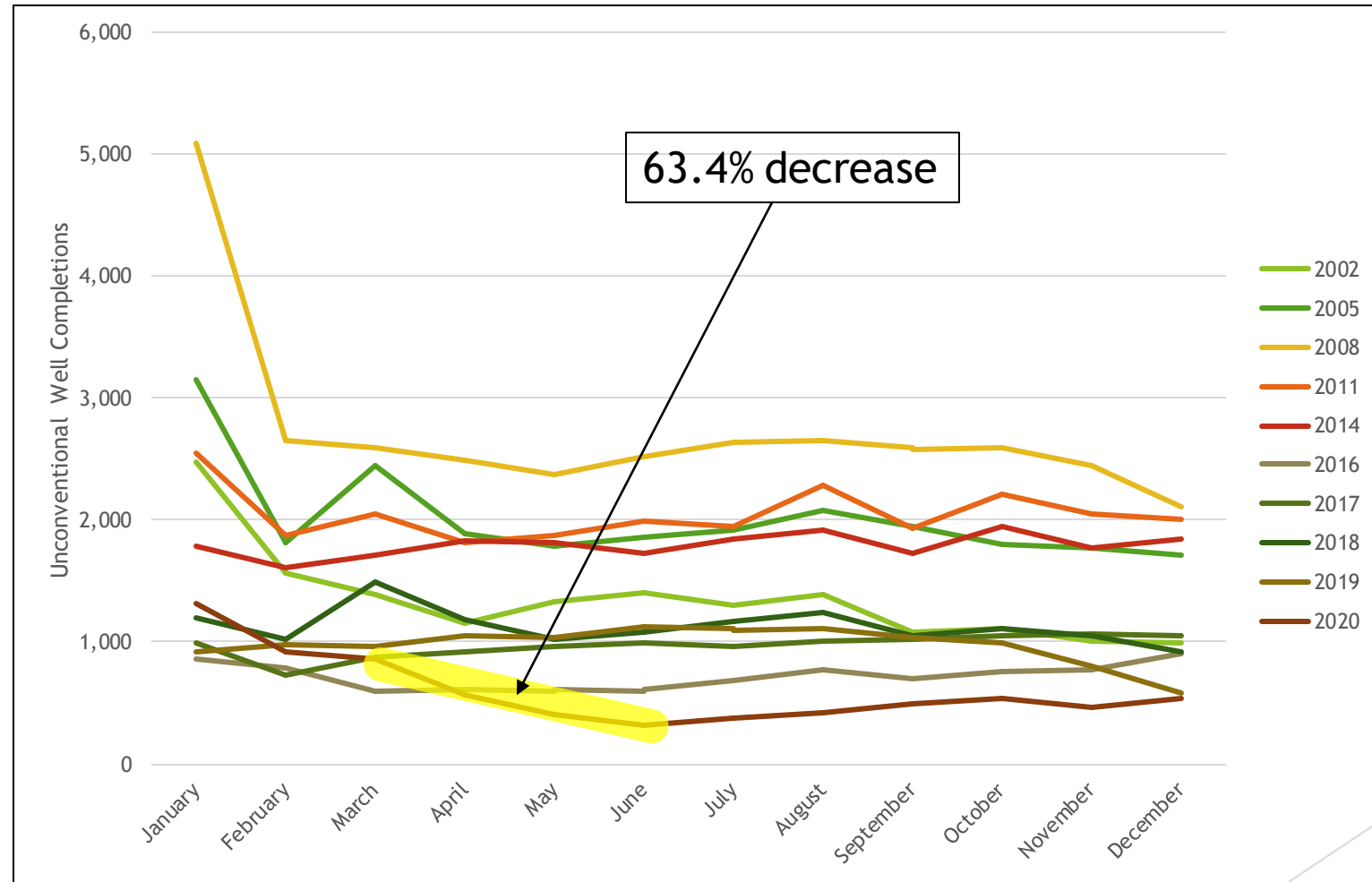
Nationwide Produced Water Monthly Trends



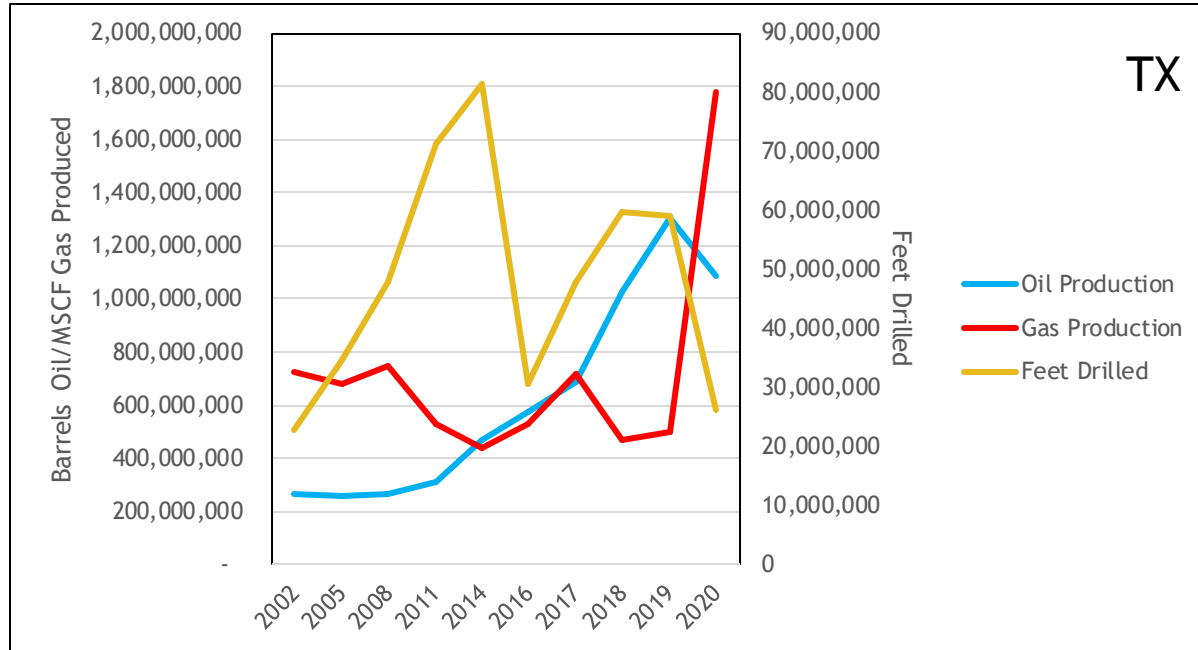
Nationwide Feet Drilled Monthly Trends



Nationwide Unconventional Well Completions Monthly Trends

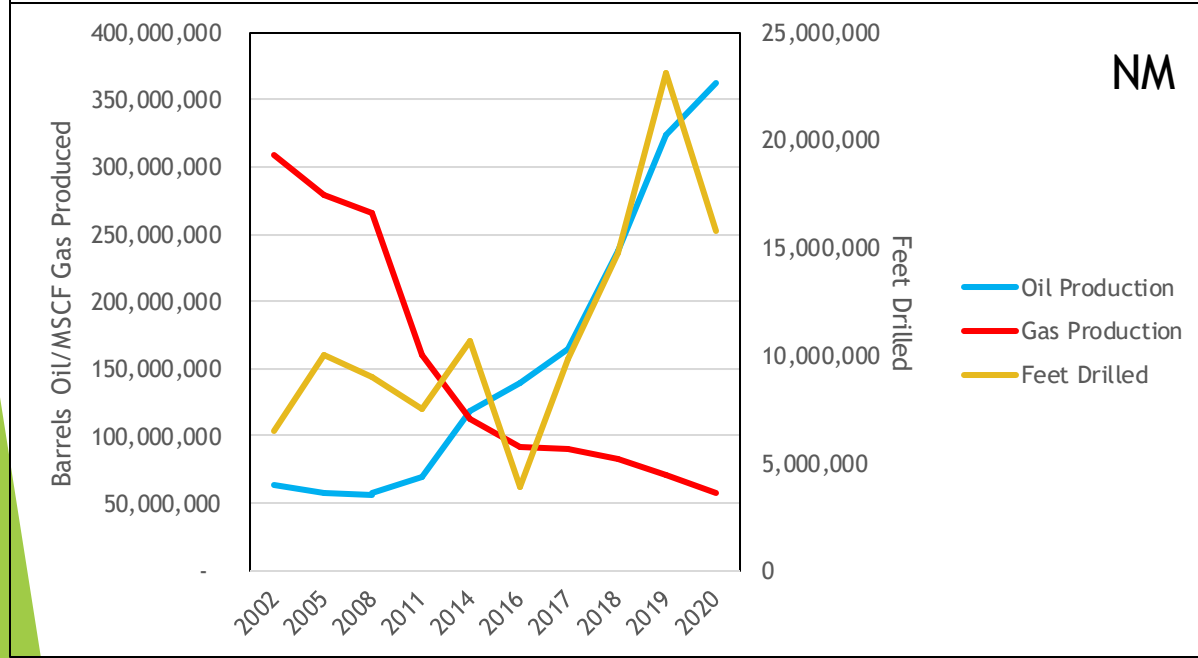


Permian Basin Trends



Permian Basin (TX) Production

- 255% increase in gas production from 2019 to 2020 (255%)
- 133% increase in oil production from 2014 to 2020
- Large increase in drilling from 2002 to 2014 (258%)



Permian Basin (NM) Production

- 78% decrease in gas production from 2008 to 2020
- 427% increase in oil production from 2011 to 2020
- Large increase in drilling from 2006 to 2019 (493%)

Notes:

- Through EQUATES and the 2020 NEI, EPA has 11 years of comprehensive emissions and modeling information for oil and gas sources.
 - EPA is working on a 2021 special year emissions inventory, plans to conduct a 2022 special year emissions inventory, and will complete a 2023 NEI for oil and gas
- The data can be used to investigate relationships in exploration activities to production activities at a local level.
- 4-km spatial surrogates allow for more refined analysis of emissions data and observed ambient monitoring concentrations

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