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MEMORANDUM

To:	Mark Janssen; LADCO
	Tom Velalis; OHEPA
Cc:	Tom Moore; WESTAR-WRAP
From:	John Grant, Rajashi Parikh, Amnon Bar-Ilan; Ramboll Environ
Subject:	National Oil and Gas Emissions Analysis, Task 2: Utica Basin Regional Analysis

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This memorandum describes the Utica Basin[1] oil and gas (O&G) emissions analysis developed as part of the National Oil and Gas Emissions Analysis, Task 2: Regional Analysis. The analysis includes two components:

1. Analysis of the extent of missing compressor stations in the National Emission Inventory (NEI) in the Utica Basin in Ohio.
2. Work in consultation with Ohio Environmental Protection Agency (OHEPA) staff to determine the meaning of "null" control IDs.

Gas Gathering Compressor Stations

Gas gathering compressor stations (or booster stations) are typically located downstream of well-sites and upstream of gas processing facilities. Equipment at these compressor stations typically includes spark-ignition and/or turbine compressor engines and can also include limited gas treatment (such as dehydration).

OHEPA reports emissions to the NEI for any compressor station meeting Air Emissions Reporting Requirements (AERR) Type B or synthetic minor reporting requirements. If a compressor station has emissions that do not meet AERR Type B or synthetic minor reporting requirements, emissions from these facilities would be captured in the NEI as nonpoint sources. The engines at these nonpoint source facilities would be included in the NEI as nonpoint source lateral compressor engines under the following source category classification (SCC) codes:

- 2310021251: On-Shore Gas Production, Lateral Compressors 4 Cycle Lean Burn
- 2310021351: On-Shore Gas Production, Lateral Compressors 4 Cycle Rich Burn
- 2310023251: Coal Bed Methane Natural Gas, Lateral Compressors 4 Cycle Lean Burn
- 2310023351: Coal Bed Methane Natural Gas, Lateral Compressors 4 Cycle Rich Burn

[1] For this analysis the Utica Basin is defined according to the American Association of Petroleum Geologists (AAPG) Appalachian Basin (Eastern Overthrust Area). Counties in the Appalachian Basin (Eastern Overthrust Area) which are outside of Ohio will not be considered in this analysis.

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In the 2014 NEI (version 1) nonpoint emissions of 100 tons per year (tpy) nitrogen oxides (NOx) were reported for lateral compressor engines; 88 tpy NOx were reported for SCC 2310021351 and 12 tpy NOx were reported for SCC 2310021251.

Ramboll Environ extracted emissions from point source facilities from the NEI (version 1) as described in Grant et al. (2017); Ohio O&G point sources in the Utica Basin were identified for counties located in the Utica Basin (i.e. Belmont, Carroll, Columbiana, Harrison, Jefferson, Mahoning, Monroe, and Washington). We excluded emissions from the following point source facilities because they are not considered gas gathering compressor stations:

- **Gas Processing Facilities**: Cadiz Gas Plant and Kensington Processing Plant
- **Oil Gathering Facility**: Ohio Oil Gathering II, LLC – Bells Run Terminal
- **Natural Gas Distribution Facilities**[2]: Brinker Compressor Station; East Ohio Gas - Columbiana Compressor Station; East Ohio Gas - Stock Compressor Station; and East Ohio Gas Company – Austintown; and Dominion Transmission - Carroll Station
- **Interstate Gas Pipeline Transmission Facility**: Tennessee Gas Pipeline - Station 214

Table 1. Point source gas gathering compressor station emissions (2014 NEI, version 1) in the Utica Basin (Ohio only).

Facility	2014 NOx Emissions (tpy)
Archer Compressor Facility (0634005040)	57
Augusta Compressor Facility- Utica Gas Services, L.L.C. (0210012004)	115
Churchtown Compressor Station (Cobra Pipeline Co. LTD) (0684020025)	54
Kilgore Compressor Station-Utica Gas Services, LLC (0210002039)	89
Scio Compressor Station (0634005056)	59
Texas Eastern Transmission LP - Berne (0656000032) [A]	1
Utica Gas Services, LLC-Carrollton Compressor Facility (0210012002)	83
Totals	**459**

[A] Information was not readily available to determine whether Texas Eastern Transmission LP - Berne (0656000032) was a gas gathering, transmission, or distribution compressor station; given the small emissions from this station, the effect on this analysis will be small.

OHEPA provided 2014 gas throughput estimates for several compressor stations in the Utica Basin[3]. Based on the 2014 gas throughput provided and the 2014 NEI NOx emissions, NOx emissions per unit of gas throughput was estimated for each facility (see Table 2).

[2] The owner of each these facilities was determined to be a natural gas distribution company.
[3] Email from Tom Velalis (OHEPA), March 21, 2017.

Table 2. Point source gas gathering compressor station emissions per unit throughput in the Utica Basin (Ohio only).

Facility Name	2014 NOx Emissions (tpy)	2014 Gas Throughput (MMCF/yr)[A]	NOx Emissions Per Unit Gas Throughput (grams/MMCF)[B]
Archer Compressor Facility (0634005040)	57.3	27,940	1,860
Augusta Compressor Facility- Utica Gas Services, L.L.C. (0210012004)	114.9	48,975	2,129
Kilgore Compressor Station-Utica Gas Services, LLC (0210002039)	89.0	45,200	1,787
Scio Compressor Station (0634005056)	58.5	23,145	2,295
Utica Gas Services, LLC-Carrollton Compressor Facility (0210012002)	83.5	46,147	1,641
Totals	**403.3**	**191,407**	**1,911**

[A] million cubic-feet per year
[B] grams per million cubic-feet

Based on the emission per unit throughput estimates (Table 2), emissions from all Utica Basin (Ohio) gas gathering compressor stations (Table 1), and total gas gathering throughput, we estimated missing compressor station emissions according to the Equations 1 to 5 below.

$$EF_{NOx} = \frac{E_s \times C}{Q_s} \quad (1)$$

where:

EF_{NOx} = Gas gathering compressor station emissions per unit of gas throughput (grams/MMCF)

E_s = Total Utica Basin (Ohio only) gas gathering compressor station emissions for compressor stations for which 2014 throughput estimates are available (tpy; reported in Table 2)

Q_s = Total Utica Basin (Ohio only) gas gathering compressor station natural gas throughput for compressor stations for which 2014 throughput estimates were available (MMCF/yr; reported in Table 2)

C = conversion factor (907,185 grams per ton)

$$Q_{PtGG} = \frac{E_{NOx,PtGG} \times C}{EF_{NOx}} \quad (2)$$

where:

Q_{PtGG} = Total Utica Basin (Ohio only) point source gas gathering compressor station natural gas throughput (MMCF/yr)

$E_{NOx,PtGG}$ = Total Utica Basin (Ohio only) point source gas gathering compressor station NOx emissions (tpy; reported in Table 1)

$$Q_{NotInPt} = [Q_{Utica} \times (1 - F)] - Q_{PtGG} \quad (3)$$

where:

$Q_{NotInPt}$ = Utica Basin (Ohio only) natural gas throughput not accounted for in point source gas gathering compressor station emissions (MMCF/yr)

Q_{Utica} = Total Utica Basin (Ohio only) gas production (MMCF/yr; reported in Table 1)

F = Fraction of natural gas which does not require compression[4] (unitless)

$$E_{NotInPt} = EF_{NOx} \times C \times Q_{NotInPt} \quad (4)$$

where:

$E_{NotInPt}$ = Utica Basin (Ohio only) gas gathering emissions not accounted for in point source gas gathering compressor station emissions (tpy)

$$E_{NotInNEI} = E_{NotInPt} - E_{Nonpoint} \quad (5)$$

where:

$E_{NotInNEI}$ = Utica Basin (Ohio only) gas gathering emissions not accounted for in the 2014 NEI point or nonpoint emission inventory (tpy)

$E_{Nonpoint}$ = Utica Basin (Ohio only) gas gathering emissions from nonpoint source lateral compressor engines (tpy)

Results are shown in Table 3. We estimate 213 tpy NOx from gas gathering compressor stations are missing from the 2014 NEI (range of 119-308 tpy NOx based 95% confidence interval).

[4] Assumed that 10% of gas production is vented, flared, fugitive loss, or combusted upstream of gas gathering stations.

Table 3. Utica Basin (Ohio only) gas gathering compressor station emissions analysis results.

Parameter	Estimate			Units
NEI 2014 Point Source NOx Emissions from Gas Gathering Compressor Stations	458			**(tpy)**
NEI 2014 Nonpoint Source NOx Emissions from Lateral Compressor Engines	100			**(tpy)**
IHS Enerdeq [A] Production	408,663			**(MMCF/yr)**
Estimated Gas Gathering Throughput [B]	367,797			**(MMCF/yr)**
	Average	**Lower 95% Confidence**	**Upper 95% Confidence**	
NOx Emissions per unit Gas Throughput from Gas Gathering Compressor Stations	1,911	1,679	2,144	**(grams/MMCF)**
Estimated Gas Throughput for Gas Gathering Compressor Stations in 2014 NEI Point Source Inventory	217,602	247,678	194,040	**(MMCF/yr)**
	59%	67%	53%	**(%)**
Estimated Gas Throughput for Gas Gathering Compressor Stations NOT in 2014 NEI Point Source Inventory	150,194	120,119	173,757	**(MMCF/yr)**
	41%	33%	47%	**(%)**
NOx Emissions Estimate for Gas Gathering Compressor Stations NOT Included in NEI 2014 Point Source Inventory	316	222	411	**(tpy)**
NOx Emissions Missing Estimate from the Nonpoint Source Emission Inventory for Gas Gathering Compressor Stations NOx Emissions	213	119	308	**(tpy)**

[A] Data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2017) all rights reserved.

[B] Assumed that 10% of gas production is vented, flared, fugitive loss, or combusted upstream of gas gathering stations.

We note the following analysis limitations:

- We assume that 90% of gas production in the Utica Basin in Ohio would be subject to compression in the same area. 10% of gas production is assumed to be vented, flared, fugitive loss, or combusted upstream of gas gathering stations. Gas produced outside of the area is assumed not be compressed in the area. Information on (1) the amount of gas loss upstream of gas gathering compressor stations and (2) the extent to which produced gas in the area does not require compression and the ingress of produced gas from neighboring areas into compressor stations in the area were not readily available.
- Gas throughput estimates were available for five of seven gas gathering compressor stations in the NEI in the Utica Basin (corresponding to 88% of Utica Basin gas gathering compressor station emissions in the NEI).
- Facility-level annual gas throughput provided by OHEPA were based on analysis of data reported by companies for 2014. Ideally, facility throughput would be confirmed with facility operators.

Ahmadov, R., et al. (2015) showed overestimation of oil and gas production NOx emissions in the bottom-up emission inventory for the Uinta Basin in Utah. While overestimation of NOx emissions is a concern, the reason why NOx emissions were overestimated has not been confirmed nor is information available to determine whether oil and gas production NOx emissions are overestimated in the Utica Basin in Ohio. The systematic analysis presented above to improve Utica Basin NOx emissions can be viewed as an incremental improvement in the Utica Basin emission inventory as will any emission inventory improvement that can be developed from follow-on studies to Ahmadov, R., et al. (2015).

Comparison to Select Pennsylvania Counties

For comparison, we conducted a limited analysis of compressor station emissions from two western Pennsylvania Counties, Greene and Washington County. As reported in Grant et al. (2017), Pennsylvania attempts to capture emissions from all point sources in their permitting requirements. For Mercer and Washington County, we extracted gas gathering compressor station NOx emissions from the 2014 NEI point source emission inventory, lateral compressor engine NOx emissions from the 2014 NEI nonpoint source emission inventory, and gas production from IHS Enerdeq. Total 2014 gas production from Greene County (388,048 MMSCF/yr) and Washington County (455,169 MMSCF/yr) account for 20% of statewide gas production in 2014. 2014 NEI point and nonpoint source emissions are shown below.

- Point source gas gathering facility NOx emissions
    - Greene County: 155 tpy, 403 grams/MMSCF[5]
    - Washington County: 41.2 tpy, 91 grams /MMSCF

[5] Assumed that 10% of gas production is vented, flared, fugitive loss, or combusted prior to compression at a gas gathering station.

- Nonpoint source lateral compressor engine NOx emissions
    - Greene County: 0 tpy
    - Washington County: 0 tpy

These two Pennsylvania counties indicated much smaller NOx emissions from gas gathering compressor stations compared to estimates above for the Utica Basin in Ohio. Based on readily available data, we are unable to determine why NOx emissions per unit throughput from gas gathering compressor stations in these two counties were so much lower than estimates for the Utica Basin in Ohio.

We note that Subpart W reporting data for Washington County indicated at least three gas gathering compressor stations which reported greenhouse gas emissions in 2014 as part of Subpart W, but were not included in the 2014 NEI (Welling Compressor Station, Three Brothers Compressor Station, and Smith Compressor Station). Subpart W reporting data for Greene County indicated at least four gas gathering compressor stations which reported greenhouse gas emissions in 2014 as part of Subpart W, but were not included in the 2014 NEI (Callisto Compressor Station, Cantaral Compressor Station, Jefferson Compressor Station, and Jupiter Compressor Station).

Differences in emissions per unit of gas production from gas gathering compressor stations for Utica Basin (Ohio only) versus Greene and Washington counties in Pennsylvania may also result from differences in field pressure, differences in emission control requirements, and/or differences in gas gathering infrastructure configuration.

Null Control IDs

Ramboll Environ extracted nonpoint source emissions ancillary information from the 2014 NEI (version 1)[6] for the Utica Basin (Ohio only) and provided the emissions and ancillary data to OHEPA for review. OHEPA[3] provided additional information from their permitting records on emission control status by point source unit. Summary results (Table 4) show that 43% of NOx emissions and 33% of VOC emissions with a null entry for control ID in the SMOKE input file are subject to control.

[6] Point source emissions file: SmokeFlatFile_POINT_20160716.csv, downloaded from EIS Gateway August 18, 2016

Table 4. Summary of O&G point source controls for the Utica Basin (Ohio only).

Control Type	Count of Emission Units	Emissions (tpy)	
		NOx	VOC
No Control ID			
catalytic converter	37	247	85
flaring control	17	16	29
oxidation catalyst	20	194	53
other control	1	0	7
no control	58	609	356
Subtotals	*133*	*1065*	*530*
Has Control ID			
Flaring	1	0	1
Subtotals	*1*	*0*	*1*
Grand Totals	**134**	**1065**	**531**

EPA modeling platform emission inventory forecasts rely on estimates of base and future year control. Currently, controls information in 2014 NEI point source files for the Utica Basin in Ohio is not sufficient to provide input on the level of emission control by unit in 2014. Ideally, more complete information on 2014 NEI controls would allow for more detailed and/or area specific accounting of emission changes resulting from future controls.

Recommendations

Before adding missing NOx emissions from gas gathering compressor stations to the oil and gas emission inventory for the Utica Basin (Ohio only), two items should be addressed:

1. Further exploration of the reasons for differences in gas gathering compressor station NOx emissions per unit of gas throughput between Utica Basin (Ohio only) and Greene and Washington counties in Pennsylvania should be explored.
2. Gas producers and/or gas gathering companies should be contacted to confirm 2014 gas production throughput estimates.

Once the above items have been addressed, missing NOx emissions from gas gathering compressor stations should be added to the nonpoint source emission inventory as lateral compressor engines.

To the extent feasible, more complete information on unit-level controls should be incorporated into future NEIs.

References

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