Map Set 4: Impact on Air Emissions

This series of maps displays information related to the potential environmental impacts of *additional* gas development in *Pennsylvania* if all remaining technically recoverable resources in the Interior Marcellus shale were developed using high volume hydraulic fracturing and horizontal drilling with eight wells per well pad.

This map set includes projections of air emissions of Nitrogen oxides (NO_x), volatile organic compounds (VOCs), and methane (CH_4) associated with activities associated with pre-production, production, and compression and transport during the gas development process. (The activities only include those that support the well drilling, fracturing, production, and compression processes up to when produced gas is delivered through the gathering line to the larger gas transmission network. Emissions associated with transmission pipelines and delivery of gas to customers are not included.) These estimates are presented as the highest annual average emissions in tons per year for the combination of these activities (i.e. when ongoing emissions from producing wells peak), assuming a constant development rate over 30 years. The emissions estimates are aggregated by county and compared to 2014 natural gas sector emissions reported to the PA Department of Environmental Protection.

Note: These maps contain *projections* of natural gas development and associated impacts under a particular set of circumstances and assumptions. Changes to the assumptions could change the results. They are not *predictions* of development or impacts, and should not be used for commercial purposes, to guide investment decisions, or for short-range planning decisions. Furthermore, the maps should not be used to inform planning or decision making for geographic units smaller than the primary units of analysis (counties or HUC-10 watersheds).

Air Emissions Maps

This map set includes projections of the following air emissions impacts:

4.1 NOx emissions from projected development

4.2 VOC emissions from projected development

4.3 Methane emissions from projected development

For additional documentation and methodology used to create these maps, as well as discussion of results, please download the research report at: www.cna.org/PA-Marcellus

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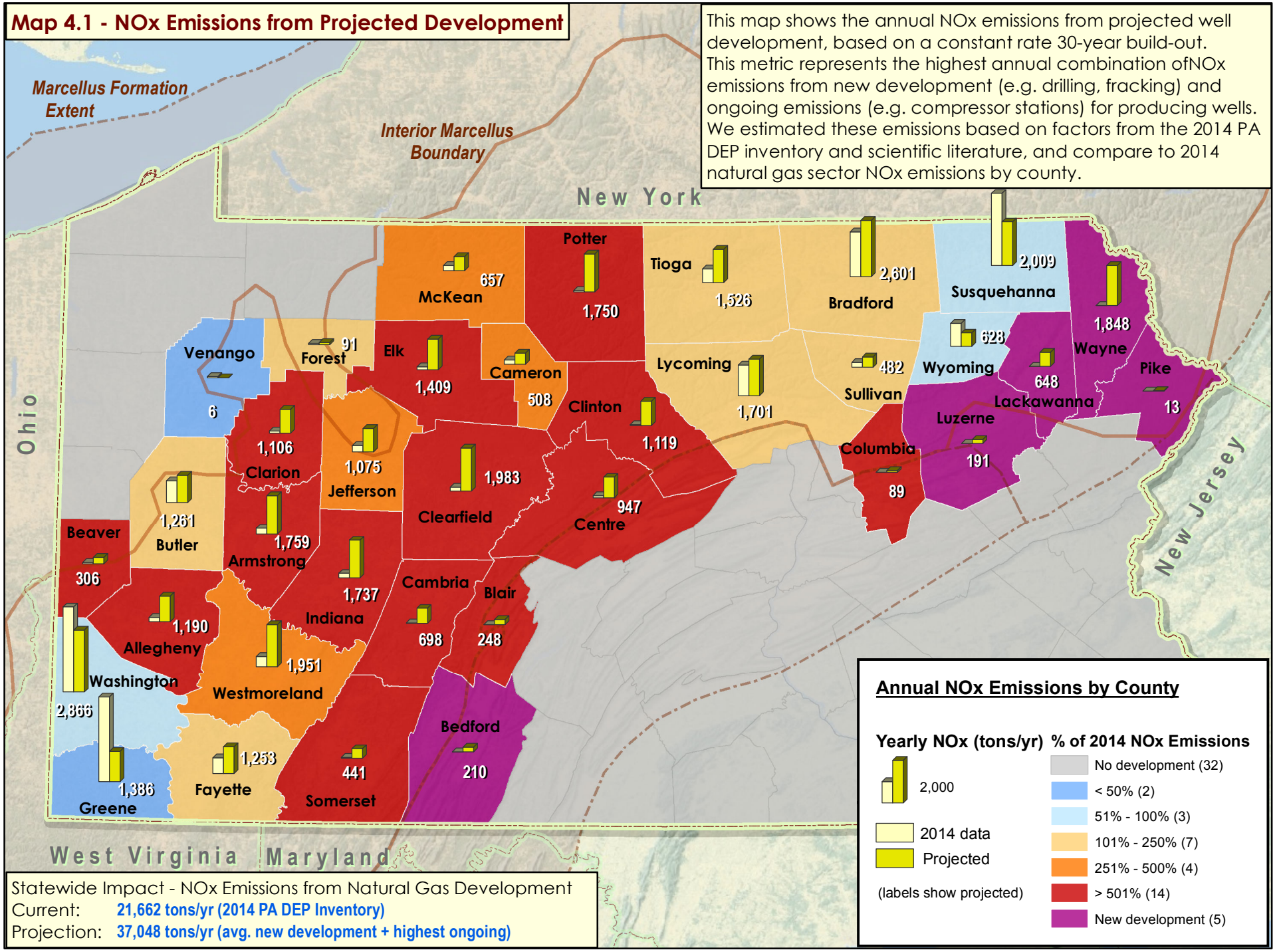
Map 4.1 - NOx Emissions from Projected Development

This map shows the annual NOx emissions from projected well development, based on a constant rate 30-year build-out. This metric represents the highest annual combination ofNOx emissions from new development (e.g. drilling, fracking) and ongoing emissions (e.g. compressor stations) for producing wells. We estimated these emissions based on factors from the 2014 PA DEP inventory and scientific literature, and compare to 2014 natural gas sector NOx emissions by county.



Annual NOx Emissions by County

Yearly NOx (tons/yr) | **% of 2014 NOx Emissions**

2,000

2014 data

Projected

(labels show projected)

- No development (32)
- < 50% (2)
- 51% - 100% (3)
- 101% - 250% (7)
- 251% - 500% (4)
- > 501% (14)
- New development (5)

Statewide Impact - NOx Emissions from Natural Gas Development

Current: 21,662 tons/yr (2014 PA DEP Inventory)

Projection: 37,048 tons/yr (avg. new development + highest ongoing)

Miles

0 20 40 80

NOx = Nitrogen oxides

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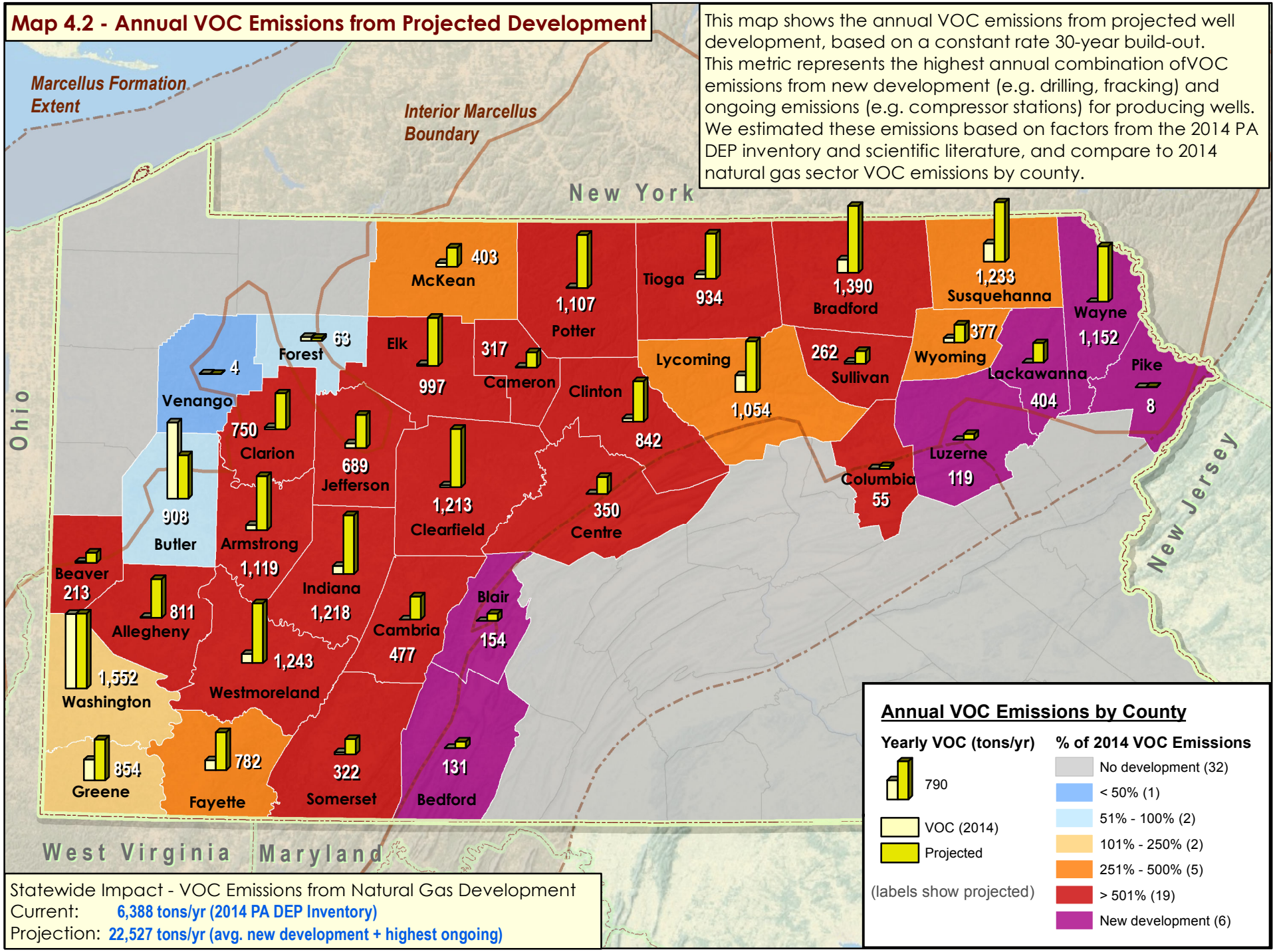
Map 4.2 - Annual VOC Emissions from Projected Development

This map shows the annual VOC emissions from projected well development, based on a constant rate 30-year build-out. This metric represents the highest annual combination ofVOC emissions from new development (e.g. drilling, fracking) and ongoing emissions (e.g. compressor stations) for producing wells. We estimated these emissions based on factors from the 2014 PA DEP inventory and scientific literature, and compare to 2014 natural gas sector VOC emissions by county.



Statewide Impact - VOC Emissions from Natural Gas Development
Current: 6,388 tons/yr (2014 PA DEP Inventory)
Projection: 22,527 tons/yr (avg. new development + highest ongoing)

VOC = Volatile Organic Compounds

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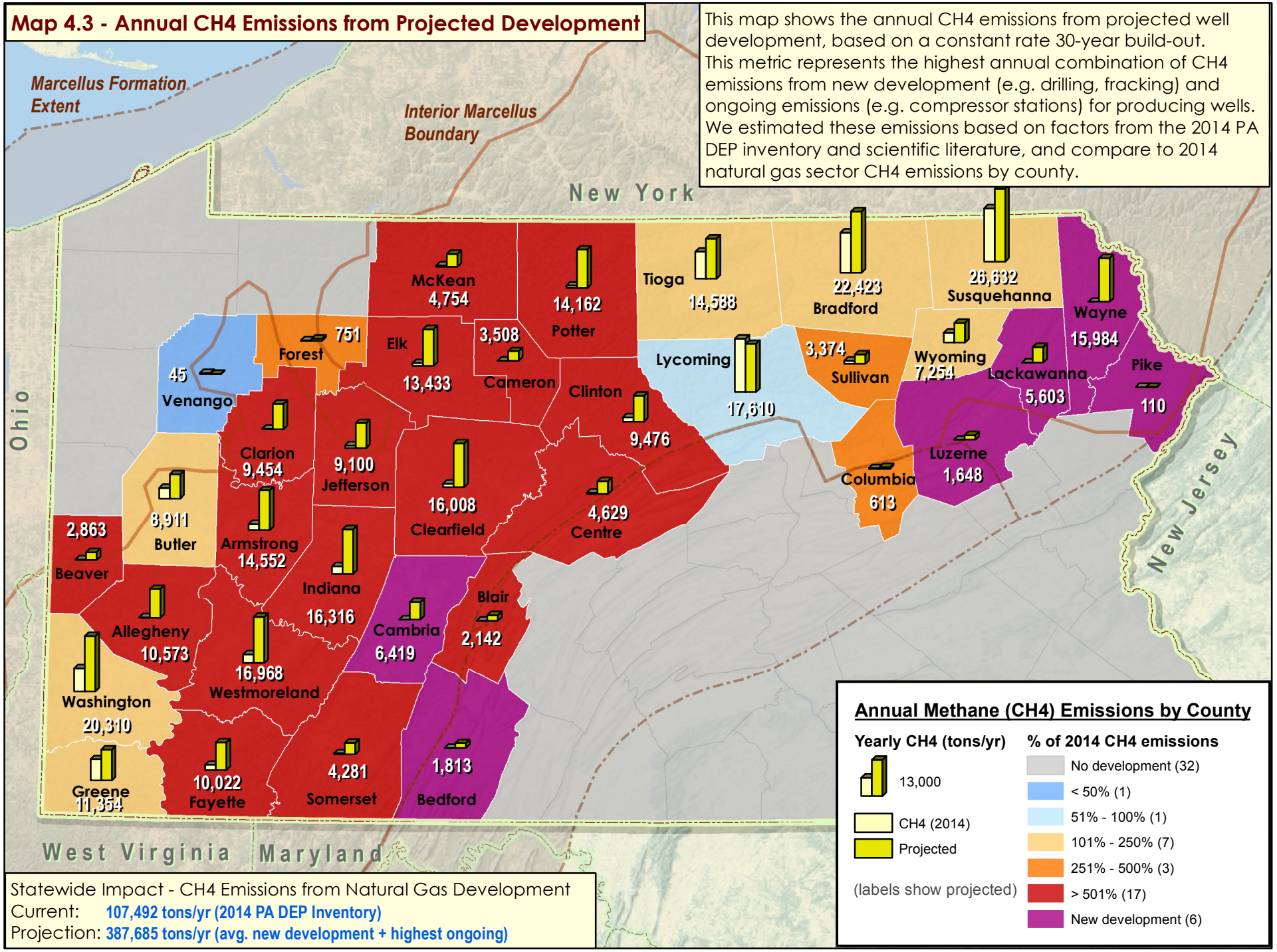
Map 4.3 - Annual CH4 Emissions from Projected Development

This map shows the annual CH4 emissions from projected well development, based on a constant rate 30-year build-out. This metric represents the highest annual combination of CH4 emissions from new development (e.g. drilling, fracking) and ongoing emissions (e.g. compressor stations) for producing wells. We estimated these emissions based on factors from the 2014 PA DEP inventory and scientific literature, and compare to 2014 natural gas sector CH4 emissions by county.



Annual Methane (CH4) Emissions by County

Yearly CH4 (tons/yr)

13,000

CH4 (2014)

Projected

(labels show projected)

% of 2014 CH4 emissions

- No development (32)
- < 50% (1)
- 51% - 100% (1)
- 101% - 250% (7)
- 251% - 500% (3)
- > 501% (17)
- New development (6)

Statewide Impact - CH4 Emissions from Natural Gas Development
Current: 107,492 tons/yr (2014 PA DEP Inventory)
Projection: 387,685 tons/yr (avg. new development + highest ongoing)

Miles
0 20 40 80