Contributions of bromide from coal-fired power plants at Pennsylvania drinking water intakes

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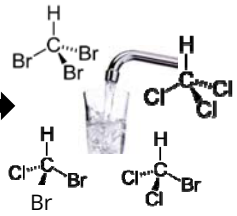
Disinfection is critical for public health…

organic matter

inorganic (Br, I, N)

chlorine | chlorine dioxide | chloramines | ozone

>600 DBPs identified



precursors + chemical disinfectant = disinfection byproducts (DBPs)

…but it has the unintended consequence of forming toxic DBPs, which have their own health risks

Cancer | Miscarriage | Low birth weight

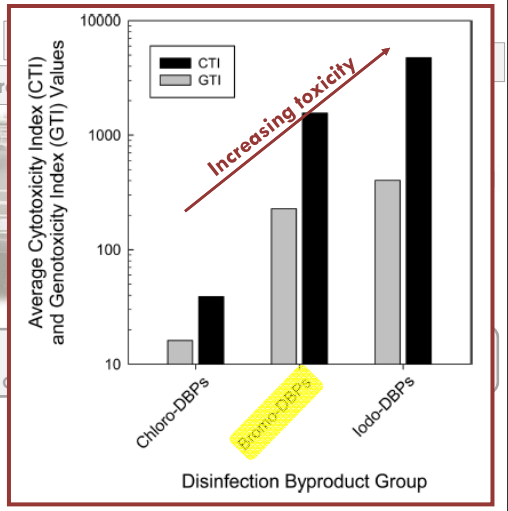
organic matter

inorganic (Br, I, N)

chlorine

chlor

Elevated bromide leads to increases in toxic brominated DBPs in finished drinking water



Yang et al (2014) "Toxic impact of bromide and iodide on drinking water disinfected with chlorine or chloramine" EST 48(20): 12362-12369.

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More to worry over

Observer-Reporter

This article has been read 424 times.

Just in case you might need something els

The Pennsylvania Department of Environn
Monongahela River, the source of most pu
University have found the chemical in high

DEP searching for source of bromide in Mon River

The Associated Press
Updated: 09/17/2010 09:55:13 AM EDT

post-gazette.com
Pittsburgh Post-Gazette

Study finds lower bromide levels in Mon, but not in Allegheny

November 13, 2012 12:15 AM

By Don Hopey Pittsburgh Post-Gazette

Salty bromide concentrations in the Monongahela River, which had risen in 2009 and 2010 due, at least in part, to discharges of Marcellus Shale gas drilling wastewater by sewage treatment plants, returned to normal levels in 2011 and this year, according to a Carnegie Mellon University river monitoring study.

Discharge from Belews Creek power plant affects water quality

POSTED 11:12 AM, APRIL 13, 2014, BY WINSTON-SALEM JOURNAL North Carolina

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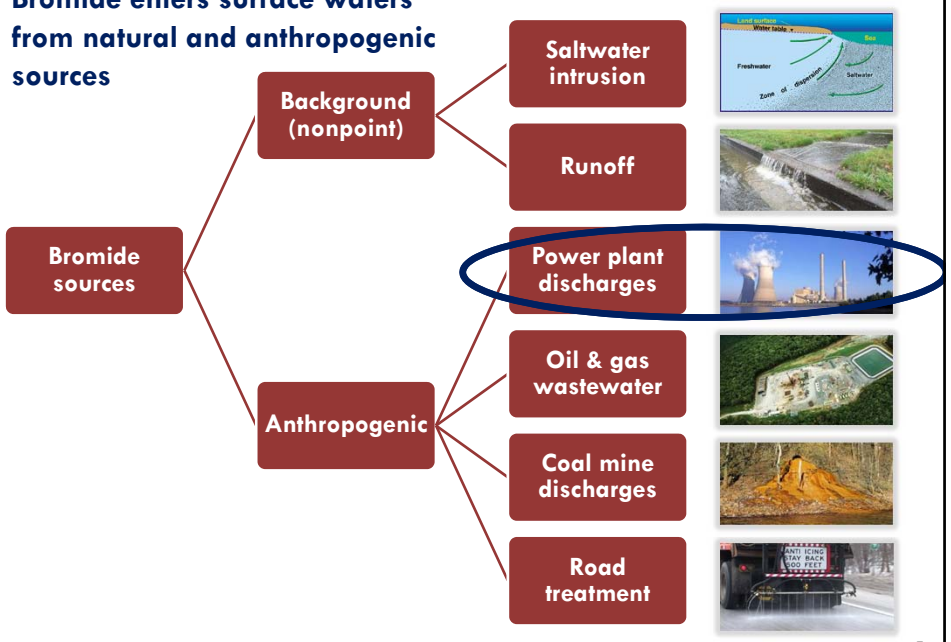
Bromide enters surface waters from natural and anthropogenic sources



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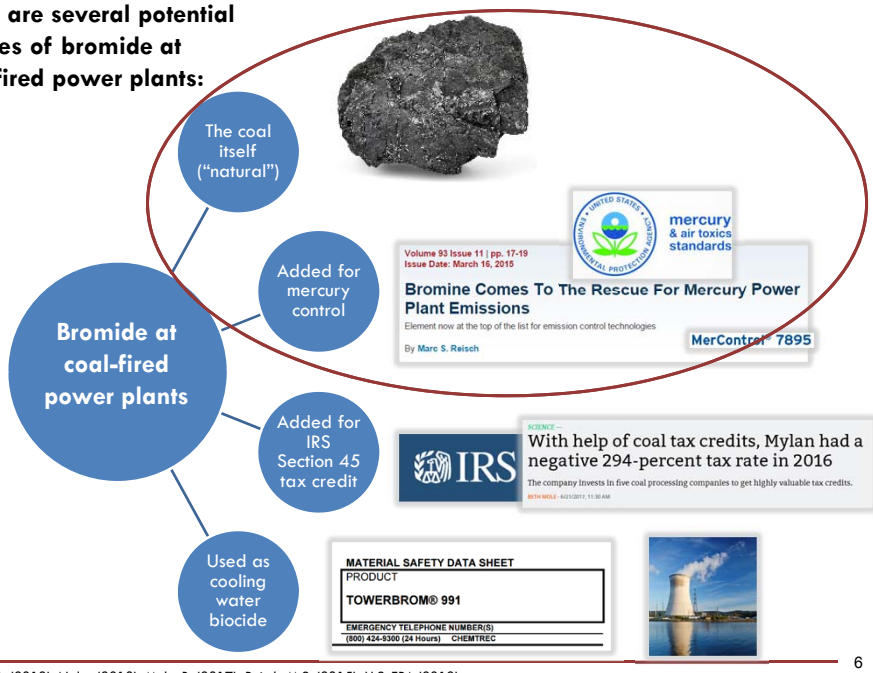
There are several potential sources of bromide at coal-fired power plants:



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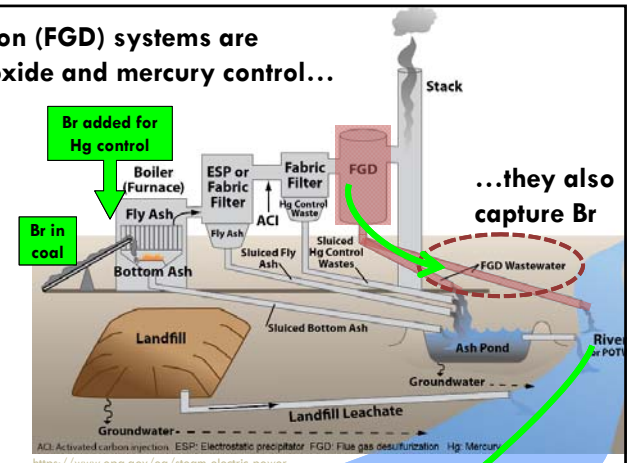
EcoLab (2018); Nalco (2010); Mole, B. (2017); Reisch, M.S. (2015); U.S. EPA (2012)

Flue gas desulfurization (FGD) systems are installed for sulfur dioxide and mercury control…



…they also capture Br

https://www.epa.gov/eg/steam-electric-power-generating-effluent-guidelines-2015-final-rule

Wet FGD wastewater discharges release bromide naturally present in coal and bromide added for mercury control

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Many coal-fired power plants utilize **wet FGD scrubbers** for sulfur dioxide control (and co-benefits for mercury removal)

[unpublished figure removed]

Over 60% of coal-fired power generating capacity in the U.S. is associated with wet FGD.

Created using data from:
U.S. Energy Information Administration. (2015). Form 860. Available at https://www.eia.gov/electricity/data/eia860/ [Accessed January 14, 2017].

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Steam Electric Power Plant Effluent Limitation Guidelines (ELGs)

- Rule finalized on ***September 30, 2015***
- Timeline for compliance: 2018-2023 *(postponed 2 years for FGD)*
- Bromide is not included directly

"Depending on site-specific conditions and applicable state water quality standards, it **may be appropriate for permitting authorities to establish water quality-based effluent-limitations on bromide**, especially where steam electric power plants are located **upstream from drinking water intakes**."

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

- *Which DW systems are downstream?*
- *What are the wet FGD effects?*

U.S. Environmental Protection Agency. (2015) Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category; Final Rule; Vol. 80, pp 67838–67903.

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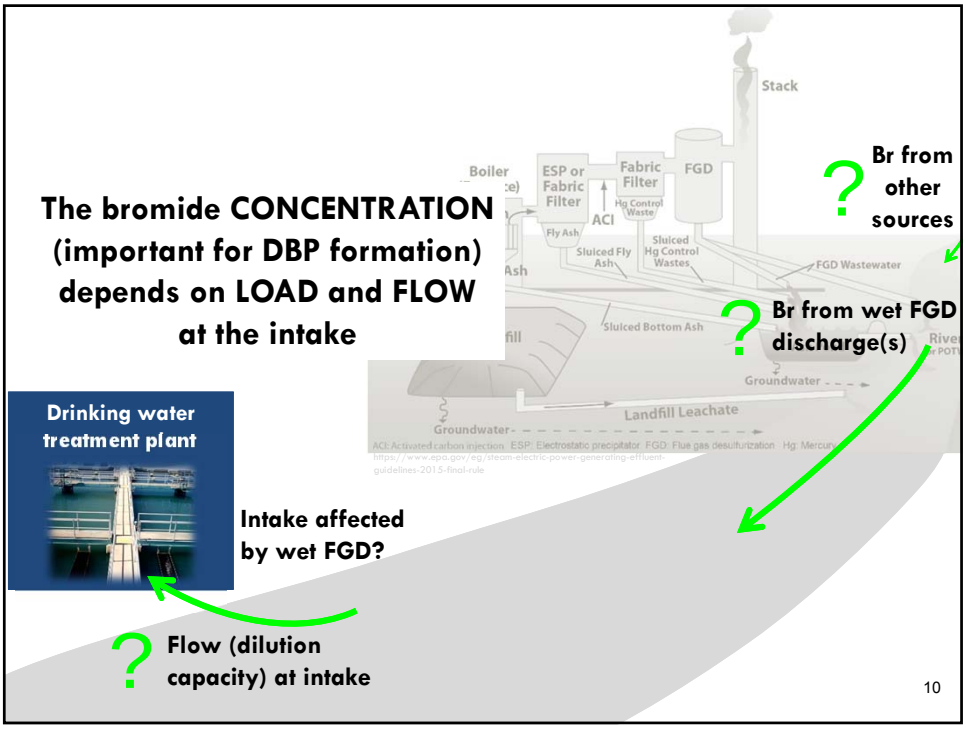
The bromide CONCENTRATION (important for DBP formation) depends on LOAD and FLOW at the intake



? Br from other sources

? Br from wet FGD discharge(s)

Drinking water treatment plant

Intake affected by wet FGD?

? Flow (dilution capacity) at intake

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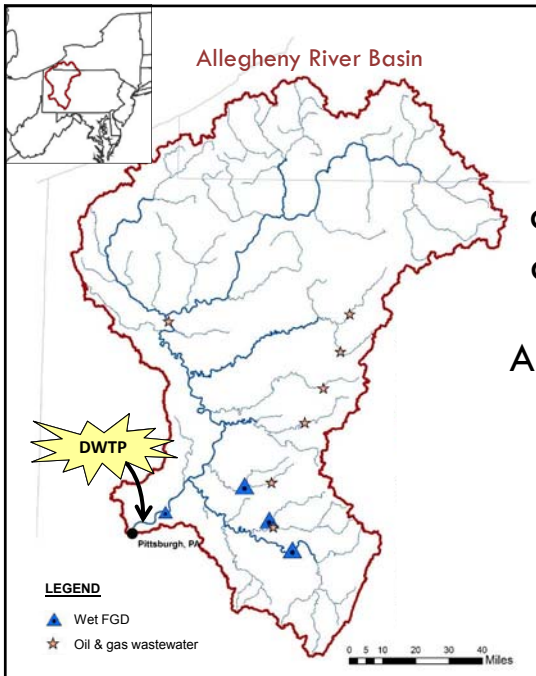

Our prior work demonstrated the effects of wet FGD discharges at a single drinking water intake:

Approximately **40 µg/L** from wet FGD in low flow (August).

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Good, K.D. & VanBriesen, J.M. 2016. *Environmental Science & Technology, 50 (17), pp 9078–9088.*

The EPA evaluated the proximity of power plant discharges to drinking water resources using a 5-mile radius

[unpublished figure removed]

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Good, K.D. & VanBriesen, J.M. (2017). *ES&T*, 51(20), 11829–11838.
Good, K.D. & VanBriesen, J.M. (2016). *ES&T*, 50 (17), 9078–9088.

In Pennsylvania…

Which drinking water intakes are downstream of wet FGD?

How many people are served by those systems?

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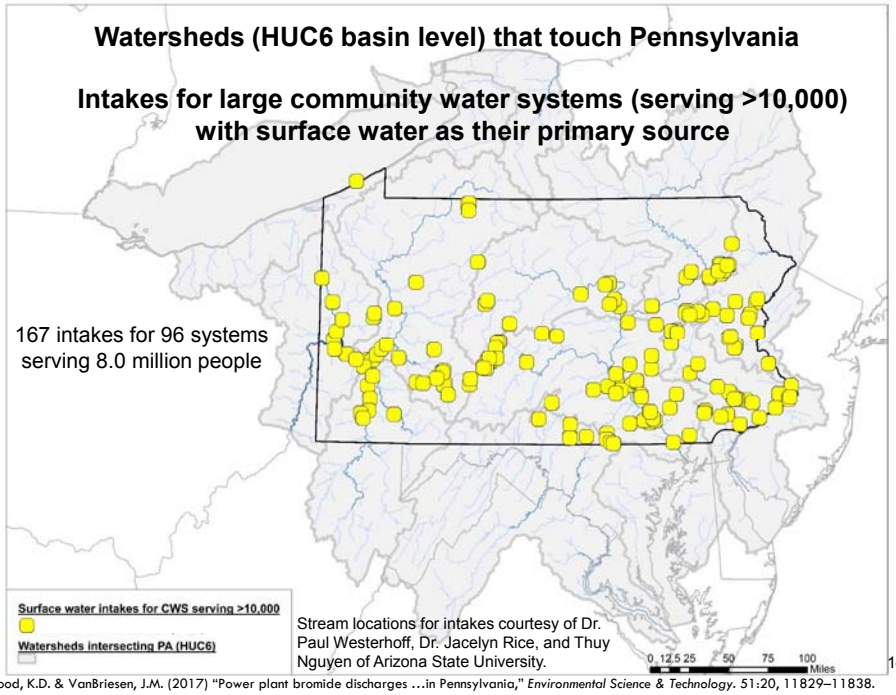

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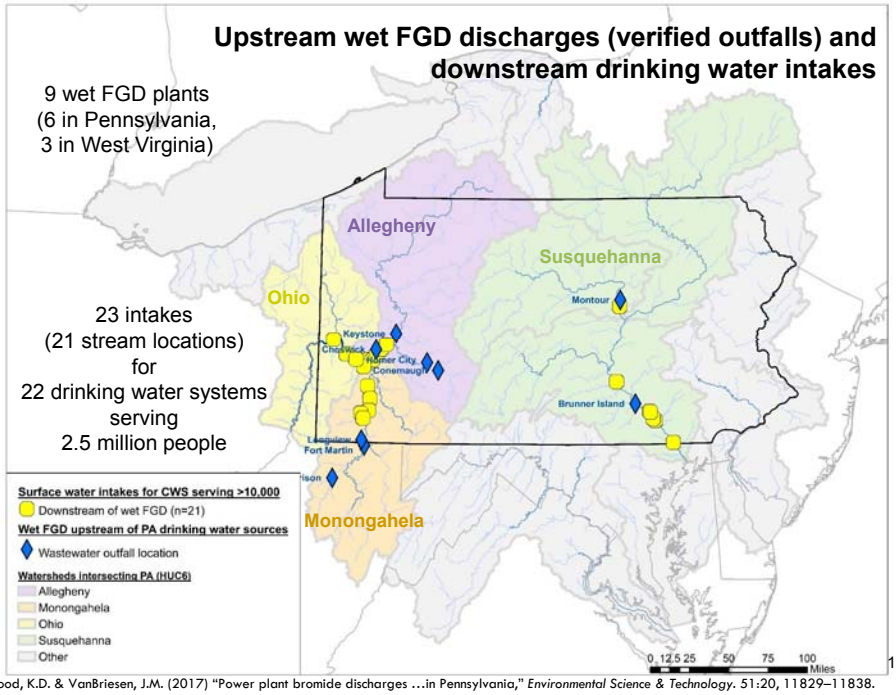

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In Pennsylvania…

Which drinking water intakes are downstream of wet FGD?

How many people are served by those systems?

What are the bromide concentration contributions from wet FGD at the intakes?

How do the concentration contributions change if the power plants add bromide for mercury control?

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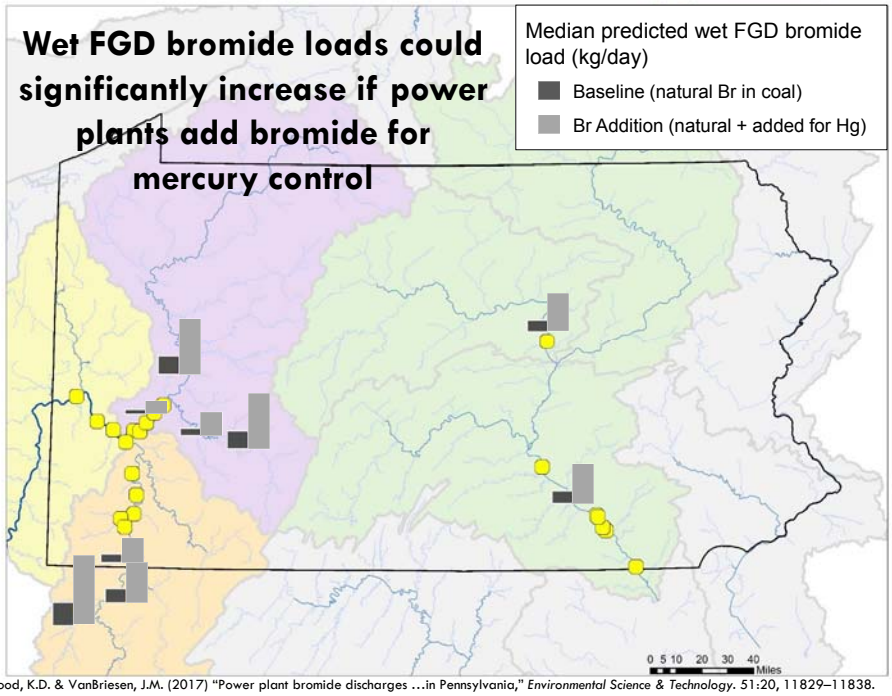

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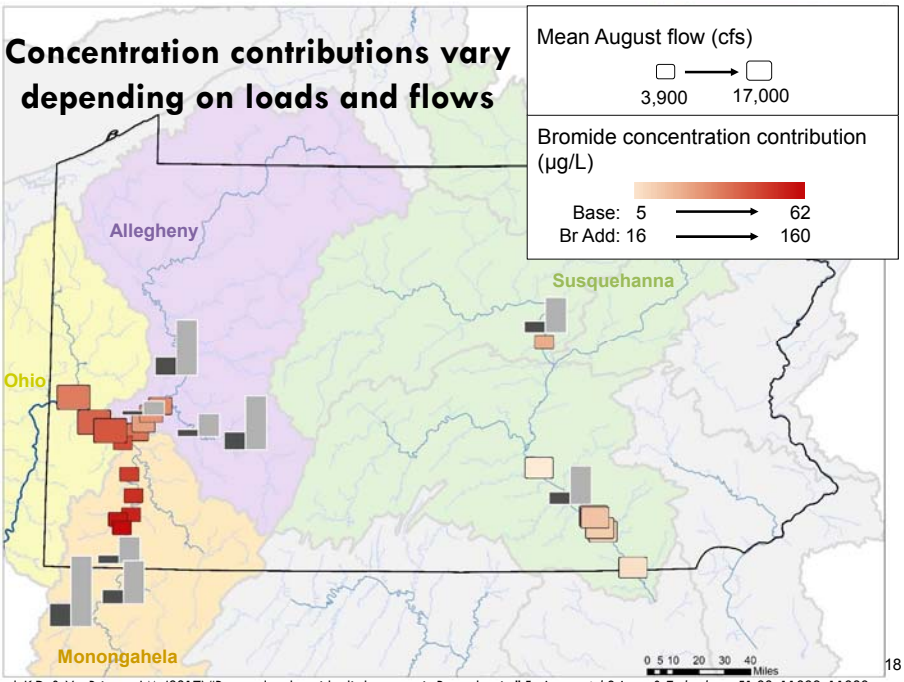

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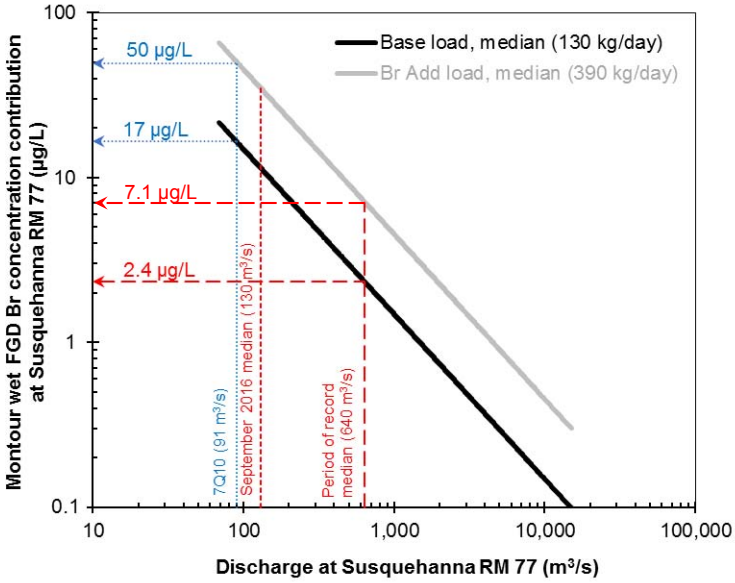

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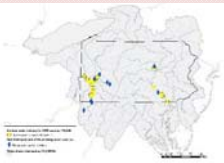
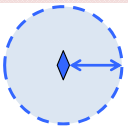
Good, K.D. & VanBriesen, J.M. (2017) "Power plant bromide discharges …in Pennsylvania," *Environmental Science & Technology*. 51:20, 11829–11838.

This Analysis	EPA Analysis
• Watershed approach (no distance limit) • 22 drinking water systems	• Geographic buffer approach (5 mi, 8 km) • 10 drinking water systems





2.5 million DW consumers

150,000 DW consumers

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Good, K.D. & VanBriesen, J.M. (2017) "Power plant bromide discharges …in Pennsylvania," *Environmental Science & Technology*. 51:20, 11829–11838.

Nationally, there are many wet FGD discharges that could impact downstream drinking water intakes

[unpublished figure removed]

Created using data from U.S. Energy Information Administration. (2016). Form 860. Available at https://www.eia.gov/electricity/data/eia860/ [Accessed March 14, 2018].

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Good, K.D. and VanBriesen, J.M. (2018). Wet flue gas desulfurization discharges across U.S. watersheds and their potential drinking water impacts. *In prep.*

Changes in load or flow (or both) can dramatically affect concentrations

Monitoring data are needed to understand these changes

[unpublished figure removed]

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Bromide concentrations from PADEP Water Quality Network available at https://www.waterqualitydata.us/portal/ [Accessed July 13, 2017]
River discharge from USGS available at https://waterdata.usgs.gov/nwis/uv?01576000 [Accessed July 13, 2017]

Conclusions

- Power plants with wet FGD (and oil and gas produced water treatment facilities with surface discharges) contribute to bromide concentrations in surface waters
- Spatiotemporal context matters. The load from the discharge and the dilution capacity at the intake – not the geographic proximity – dictate the bromide concentration contribution at the intake
- Dilution may be insufficient to protect downstream drinking water plants if bromide loads increase, especially under low-flow conditions
- In Pennsylvania, at least 2.5 million people are served by large public drinking water systems that are downstream of at least one wet FGD wastewater discharge

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Acknowledgements

- VanBriesen Research Group
- Dr. Paul Westerhoff, Dr. Jacelyn Rice, Thuy Nguyen, Arizona State University
- Three Rivers QUEST (3RQ), West Virginia Water Research Institute

Carnegie Mellon University Scott Institute for Energy Innovation

NSF

NEEP

Colcom Foundation

WaterQUEST

PWSA The Pittsburgh Water & Sewer Authority Quality Water Quality Service

Pennsylvania American Water

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