Electronic Supplementary Information

Efficacy of Corrosion Control and Pipe Replacement in Reducing Citywide Lead Exposure during the Flint, MI Water System Recovery

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Text S1. Estimating percentage of biosolids lead that will continue to be released from indoor plumbing (16-28%) and composite 90th percentile water lead levels (or, WLL90) (5.3-7.4 µg/L) after Flint replaces all lead and galvanized service lines by late 2020.

Equation 1: *Biosolids-Pb = (% services remaining) x* $Pb_{services}$ *+* Pb_{indoor} *+* Pb_{other}

A. We use the following equation from Roy et al., 2019 that relies on composite water lead levels from first and second draws:[1]

Equation 2: *Biosolids-Pb (kg) = 0.37 x WLL90 (µg/L) + 1.41*, where

WLL90 = ½ x first draw + ½ second draw (Equation 2A)

Var.	Year	2013	2017	2018
A	**Total Biosolids-Pb (kg)**	117.7	77.6	72.9
B	**% services remaining**	100%	48%	34%
	• *Solving Equation 1 for both 2017 and 2018 against 2013 data*			
C	**$Pb_{services}$ (kg)**	--	77.1	67.9
D	**Pb_{indoor} + Pb_{other} (kg)**	--	40.6	49.8
E	**Pb_{other} (kg) for full year** = 1.41 x 12 = 16.9 kg (from Equation 2)			
F	**Pb_{indoor} (kg) = D – E**	--	23.7	32.9
G	**Percentage of Biosolids-Pb from plumbing = Pb_{indoor} / Total Biosolids-Pb or (F / A)**	--	20.1%	28.0%
	• *Assuming Flint replaces all service lines by end of 2020, % of pipes in system = 0%.* • *Therefore, Total Biosolids-Pb =* Pb_{indoor} *+* Pb_{other} *(Equation 3)* • *Dividing Equation 3 by 12 months to get Biosolids-Pb/month, substituting Equation 3 in Equation 1:* $Pb_{plumbing+other}$ *= 0.37 x WLL90 + 1.41, and solving for WLL90.*			
H	**WLL90 (µg/L)**	--	5.3	7.4
I	**Percentage WLL90 reduction against worst 3 FWC months (40.5 µg/L)**	--	86.9%	81.7%
J	**Percentage WLL90 reduction against pre-FWC year of 2013 (22.7 µg/L)**	--	76.7%	67.4%

II. We also use the following equation from Roy et al., 2019 that relies on composite water lead levels from first, second, and third draws:[1]

Equation 4: *Biosolids-Pb (kg/month) = 0.483 x WLL90 (µg/L) + 1.79*,

where *WLL90 = 1/3 x first draw + 1/3 second draw + 1/3 third draw*

(Equation 4A)

Var.	Year	2013	2017	2018
A	**Total Biosolids-Pb (kg)**	117.7	77.6	72.9
B	**% services remaining**	100%	48%	34%
	• *Solving Equation 2 for both 2017 and 2018 against 2013 data*			
C	**$Pb_{services}$ (kg)**	--	77.1	67.9
D	**Pb_{indoor} + Pb_{other} (kg)**	--	40.6	49.8
E	**Pb_{other} (kg) for full year** = 1.79 x 12 = 21.5 kg (from Equation 2)			
F	**Pb_{indoor} (kg) = D – E**	--	19.1	28.3
G	**Percentage of Biosolids-Pb from plumbing = Pb_{indoor} / Total Biosolids-Pb or (F / A)**	--	16.2%	24.1%

Text S1 References:

1. S. Roy, S., M. Tang and M. A. Edwards, Lead release to potable water during the Flint, Michigan water crisis as revealed by routine biosolids monitoring data, *Water Res.*, 2019, **160**, 475-483.

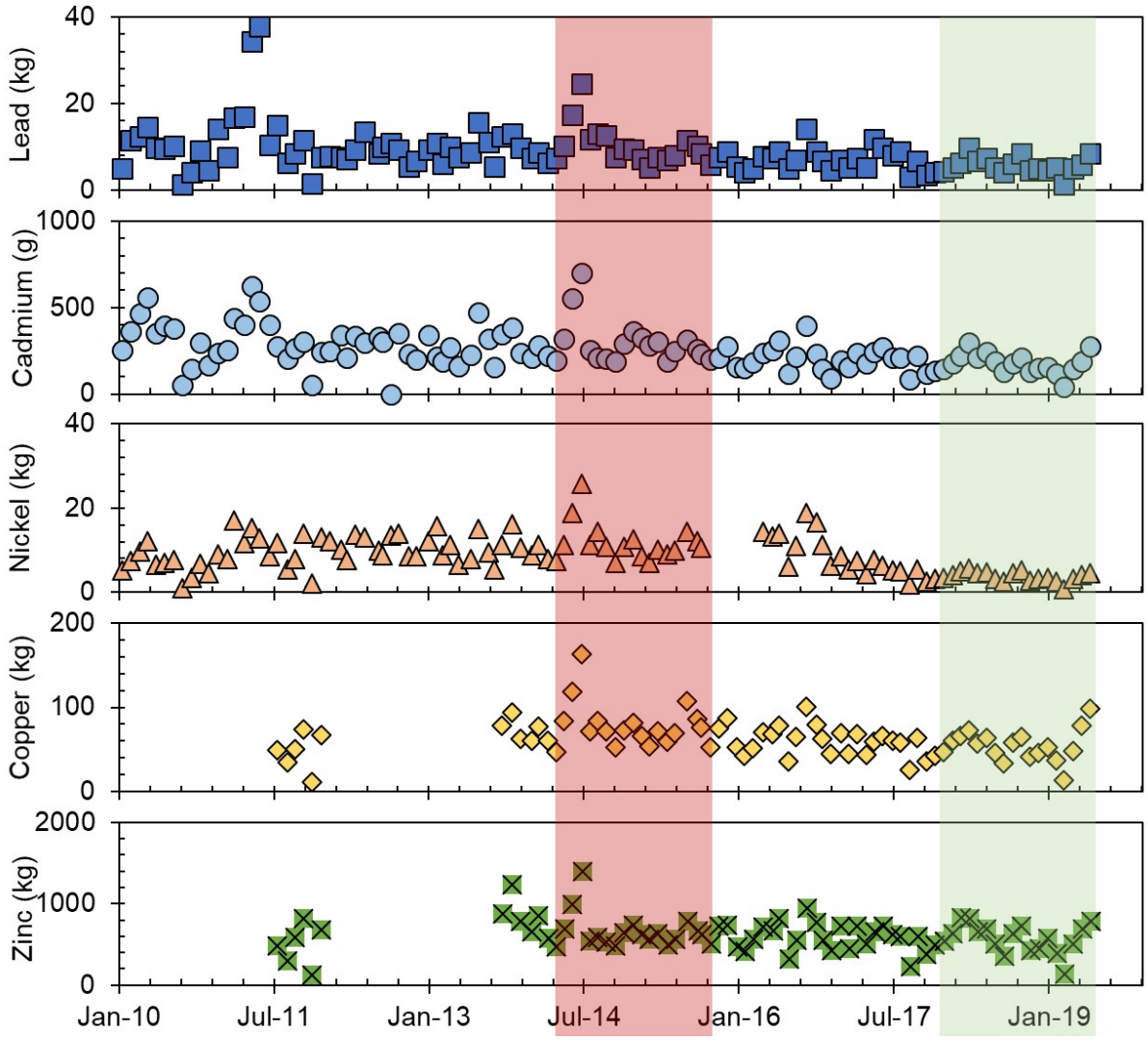


Figure S1. Monthly cumulative lead, cadmium, nickel, copper and zinc mass in biosolids (kg) during Jan 2010-Jun 2019. The red and green highlighted areas denotes biosolids metal levels during the 18 months of the Flint Water Crisis (April 2014-October 2015) and the most recent 18 month time period for which data is available (January 2018-June 2019).

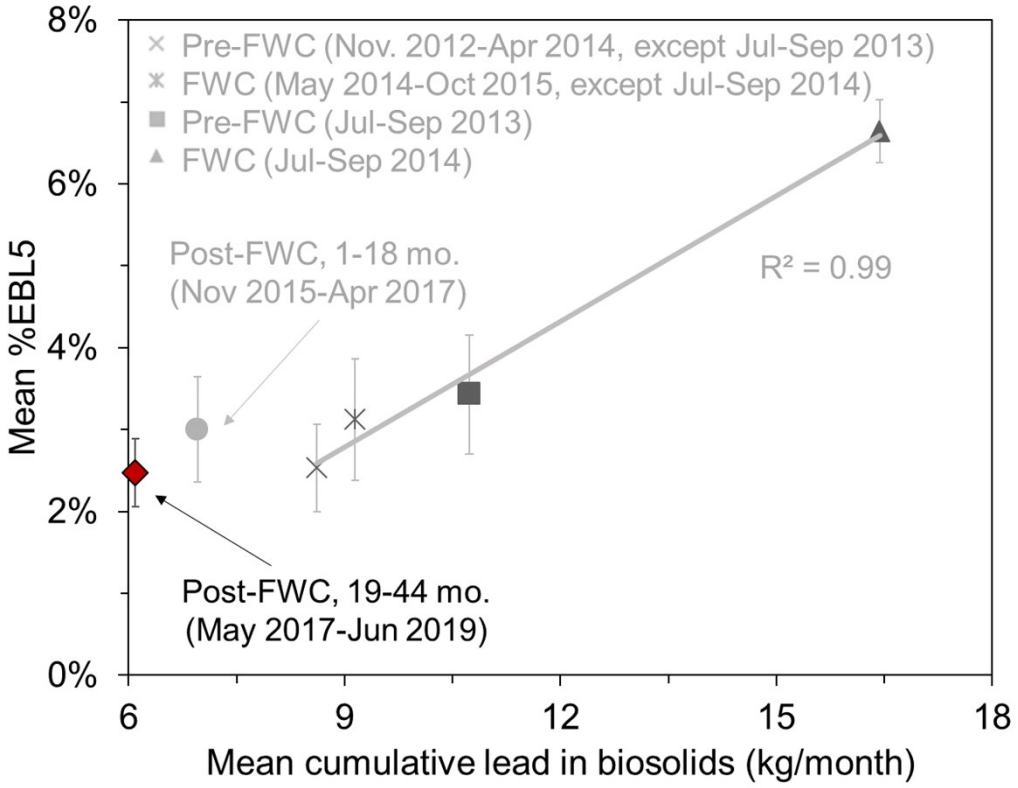
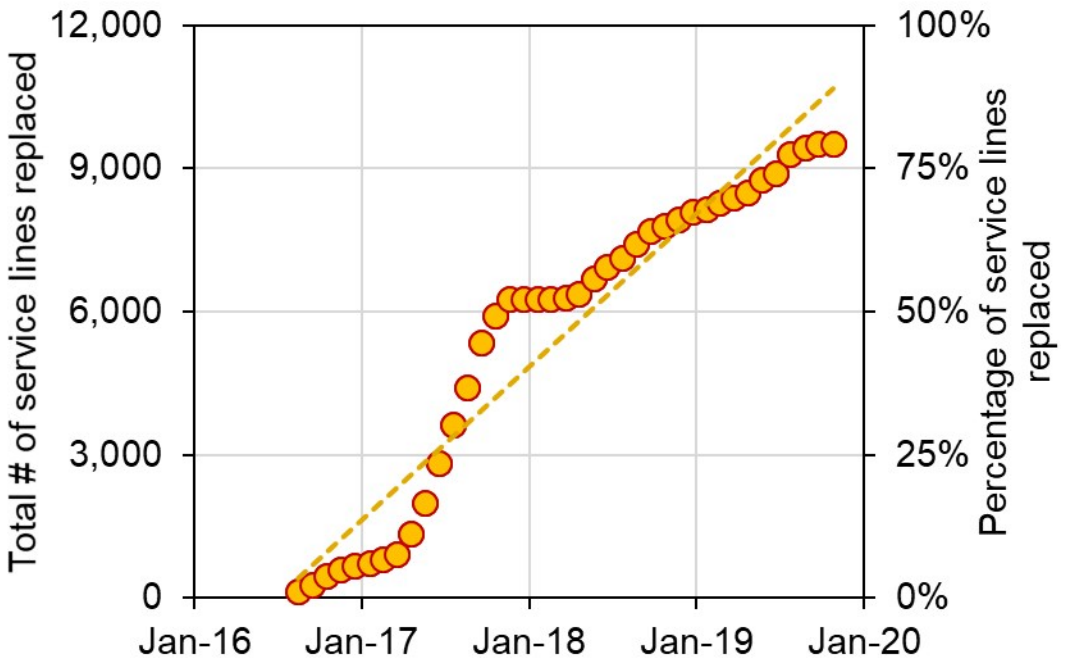


Figure S2. The latest post-FWC results of mean cumulative lead mass in biosolids (kg/month) and mean %EBL5 for May 2017-Jun 2019 (highlighted) are overlaid on the grayscale graph from Roy et al. 2019 described thus: Mean cumulative lead mass in biosolids (kg/month) correlated with mean %EBL5 for four time intervals pre- and during FWC ($R^2 = 0.99$, $p < 0.05$). Error bars indicate 95% confidence intervals for %EBL5. Due to water protective measures and a dramatic increase in EBL testing frequency by Federal Emergency Management Agency (FEMA), the post-FWC result is excluded from the regression.



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49 **Figure S3.** Total number and percentage of lead and galvanized iron service lines

50 replaced in the City of Flint, 2016-19 (Data courtesy: Eric Schwartz [University of

51 Michigan, Ann Arbor] and Jared Webb [BlueConduit]).

Table S1. Coefficient of determination (R^2) between plumbing-related metals mass measured in biosolids for January 2018-June 2019.

Metals	R^2	p-value
Pb vs. Cu	0.01957	0.5798
Pb vs. Zn	0.007	0.7348
Cu vs. Zn	0.3033	0.0178

Table S2. Reductions in mean WLLs between the July 2016 and August 2017 water sampling rounds in Flint homes (n=138) with enhanced corrosion control when approximately 30% (3,624) of lead and galvanized iron pipes had been replaced.

Sample \ Test Round	**July 2016**	**August 2017**	**% WLL reduction**
First Draw	9.6	9	5.8%
Second Draw	3.0	2.1	30.1%
Third Draw	2.4	1.8	23.7%
Composite WLL = ½ x first draw + ½ x second draw	6.3	5.6	12.0%

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