

The Issue

Permeable pavement systems are one type of green infrastructure increasingly applied for urban stormwater management. In most cases, infiltrate water from permeable pavement systems, which may carry significant metals loads from urban roadways, directly drains to surrounding soil. The infiltrate could reach and affect subsurface ecology and drinking water supplies.



Permeable parking lot, Edison, NJ

Long-term research on metal concentrations in infiltrate from permeable pavement will help determine the potential effect on groundwater.

Objectives

1. Compare infiltrate metal concentrations with existing standards (¹GELs and ²MCLs).
2. Clarify whether winter deicing chemicals applied affect the infiltrate metal concentrations
3. Identify the long-term pattern of infiltrate metal concentrations from permeable pavement

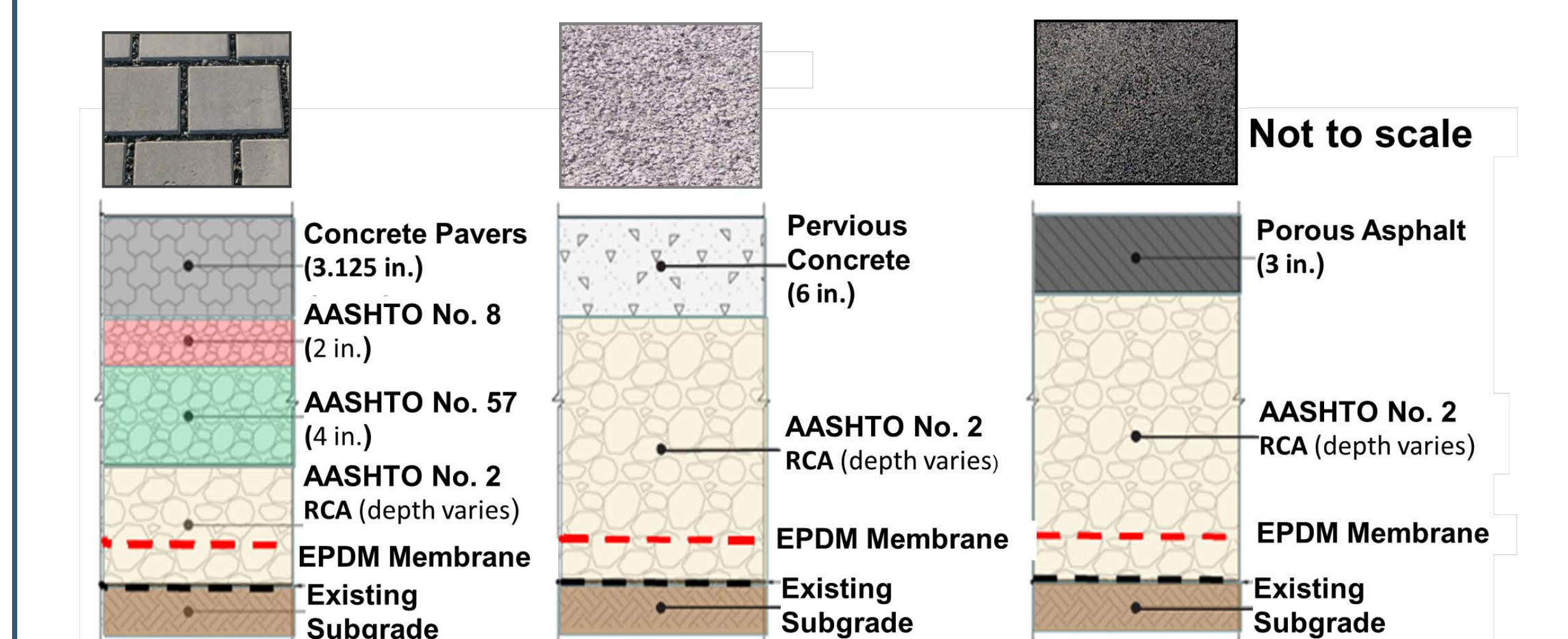
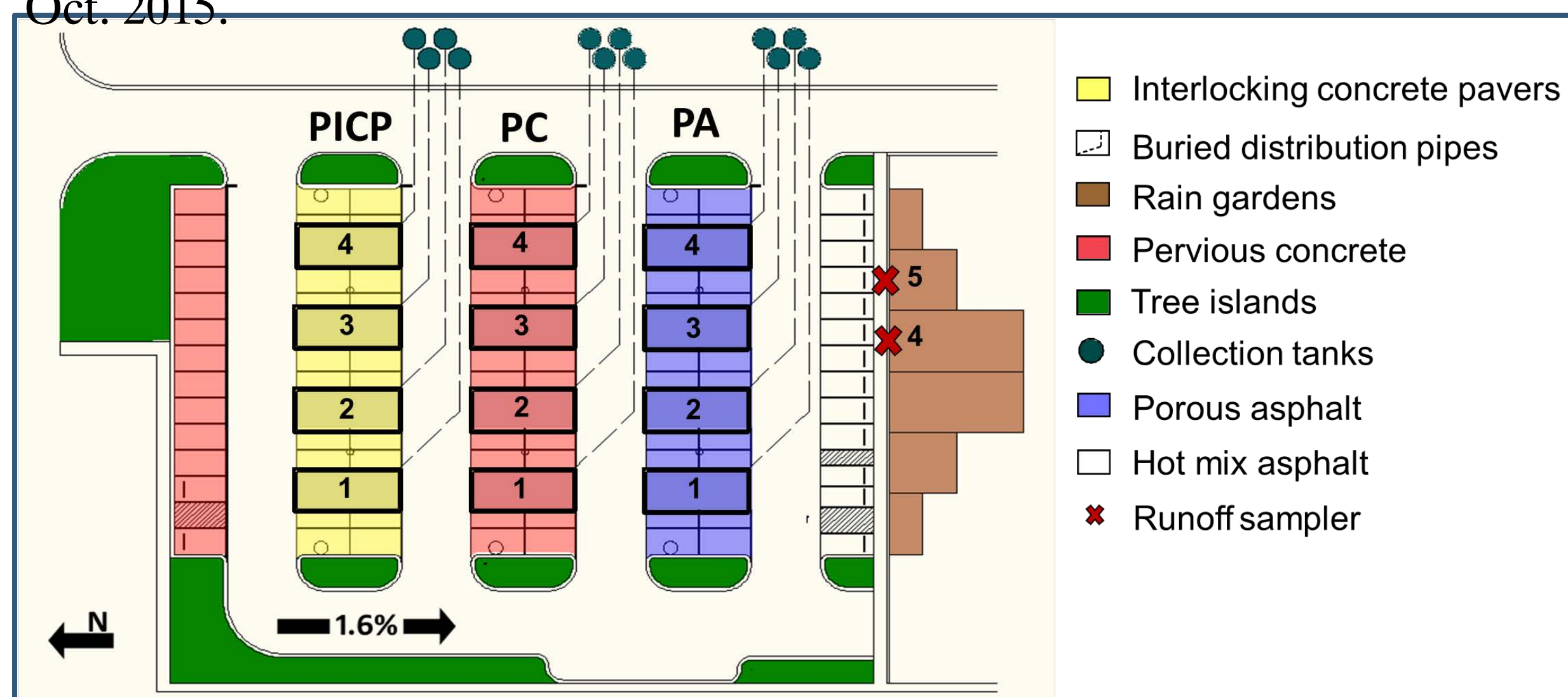
Reference:

¹GELs : groundwater effluent limitations, DEC NYS, 2014. Part 703.6

²MCLs: maximum contaminant levels in national primary drinking water regulations, USEPA, 2009

Background

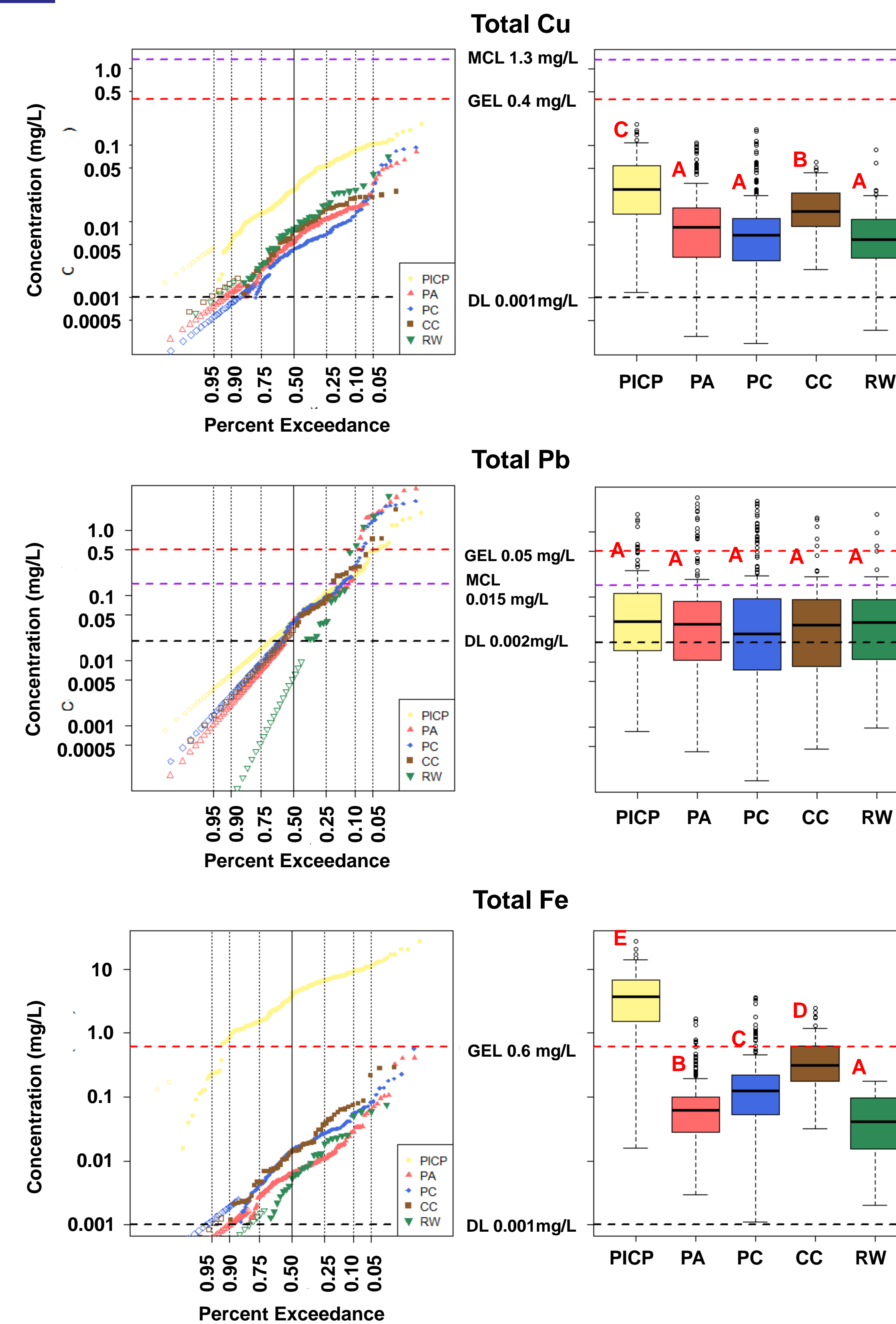
The U.S. Environmental Protection Agency constructed a 4,000-m² parking lot in Edison, New Jersey in 2009. The parking lot is surfaced with three permeable pavements [permeable interlocking concrete pavers (PICP), pervious concrete (PC), and porous asphalt (PA)]. Infiltrate samples from each permeable pavement, surface runoff (CC) and rainwater (RW) were analyzed for 22 metals (total and dissolved) for 6 years from Jan. 2010 to Oct. 2015.



Comparing with existing standards

Twelve metals have an associated GEL, MCL, or both.

	More than 99% of metal concentrations less than both GEL and MCL	At least 1% of metal concentrations larger than GEL, or MCL, or both
No significant difference found among permeable pavements		As, Cd, Pb, Sb
Significant difference found among permeable pavements	Ba, Cr, Cu, Mn, Ni, Zn	Al, Fe



Notes: "A, B, C, ..." indicates statistical groups. A < B < C ...

Snow effects on infiltrate concentration

	Snow > No-snow	Snow = No-snow	Snow < No-snow
PICP	Ba, Ca, Cr, K, Li, Mg, Na, Sn, Sr	As, Cd, Mn, Pb, Sb, Zn	Al, Cu, Fe, Si, V
PA	As, Ca, Mg, Mn, Na, Sb, Sn	Ba, Cd, Cr, Cu, Fe, K, Li, Ni, Pb, Sr	Al, Si, V, Zn
PC	Ba, Ca, K, Li, Mg, Mn, Na, Sn, Sr	As, Cd, Cr, Cu, Fe, Ni, Pb, Sb, Zn	Al, Si, V

Notes: Red color indicates metal concentrations are different during snow/no-snow season in all permeable pavement infiltrates.

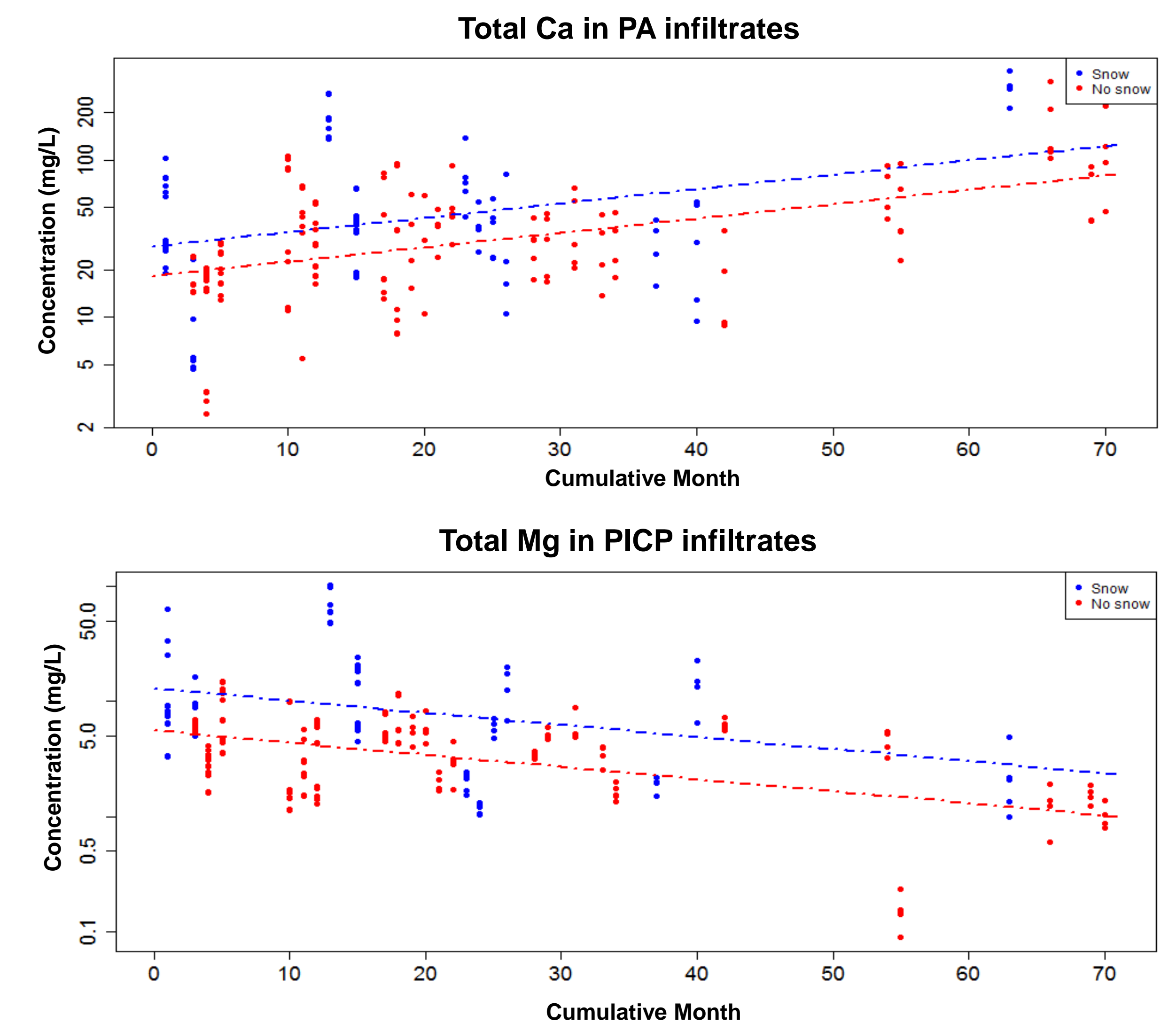
Long-term trends

Regression model:

$$\text{Log(Concentration)} = \text{slope1} * \text{Cumulative Month} + \text{slope2} * \text{Snow season} + \text{intercept}$$

	Slope1 > 0	Slope1 = 0	Slope1 < 0
PICP		Al, Ba, Ca, Cd, Cr, Cu, Ni, Pb, Si, V, Zn	As, Fe, K, Li, Mg, Mn, Sb, Sn, Na, Sr
PA	Al, Ba, Ca, Cr, Li, Sr,	Cd, Cu, Na, Ni, Pb, V,	As, Fe, K, Mg, Mn, Sb, Si, Sn, Zn
PC	Ca	Al, Ba, Cr, Cu, Mn, Ni, Pb, Sr	As, Cd, Fe, K, Li, Mg, Na, Sb, Si, Sn, V, Zn

Notes: Color coding follows the table of comparison with existing standards.



Conclusions

1. Ba, Cr, Cu, Mn, Ni and Zn concentrations in permeable pavement infiltrates are consistently less than GELs and MCLs. As, Cd, Pb and Sb concentrations exceeded the GELs and MCLs by 1% to 40% with no measurable difference among permeable pavements. More than 90% of Al and Fe samples in PA and PC infiltrates are less than GELs, however, concentrations in 50% of Al and 93% of Fe samples in PICP infiltrate samples exceeded the GELs.
2. Winter deicing salts application increased Ca, Mg, Na, Sn concentrations in permeable pavement infiltrates during snow season, whereas, Al, Si, V concentrations are found statistically smaller during no-snow season.
3. During the 70-month monitoring period, infiltrate concentrations only increased for Ca in PC infiltrate, and Al, Ba, Ca, Cr, Li, Sr in PA infiltrate. All other metals either decrease or have no obvious trend.

Acknowledgement

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