Development of a simplified approach of PCB loading estimation using a combination of passive sampling and sediment trapping

UMBC

B.5.c.iii. Effectiveness of restoration practices at the project scale; Pollutants of Emerging Concern; Toxics (PCBs).

- *Can a combination of passive sampling and sediment traps be used as more effective and low-cost alternative to traditional stormwater sampling to monitor PCB concentration during stormflow and baseflow?*
- *Can the simplified approach proposed be used to estimate PCB loading from stormflow and baseflow to determine PCB mass loading and identify ongoing sources?*

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Research Question and Hypotheses

1. Freely dissolved PCB concentrations during stormflow can be measured using specially deployed short-term passive samplers.

2. Suspended sediments collected in strategically placed low-cost sediment traps can provide PCB concentrations in suspended sediments that are comparable to those determined using ISCO sampling devices.

3. Accurate PCB loading estimates are possible using a combination of passive sampling and sediment trapping that also delineates dissolved vs. suspended solids loads and baseflow vs. stormflow contributions.

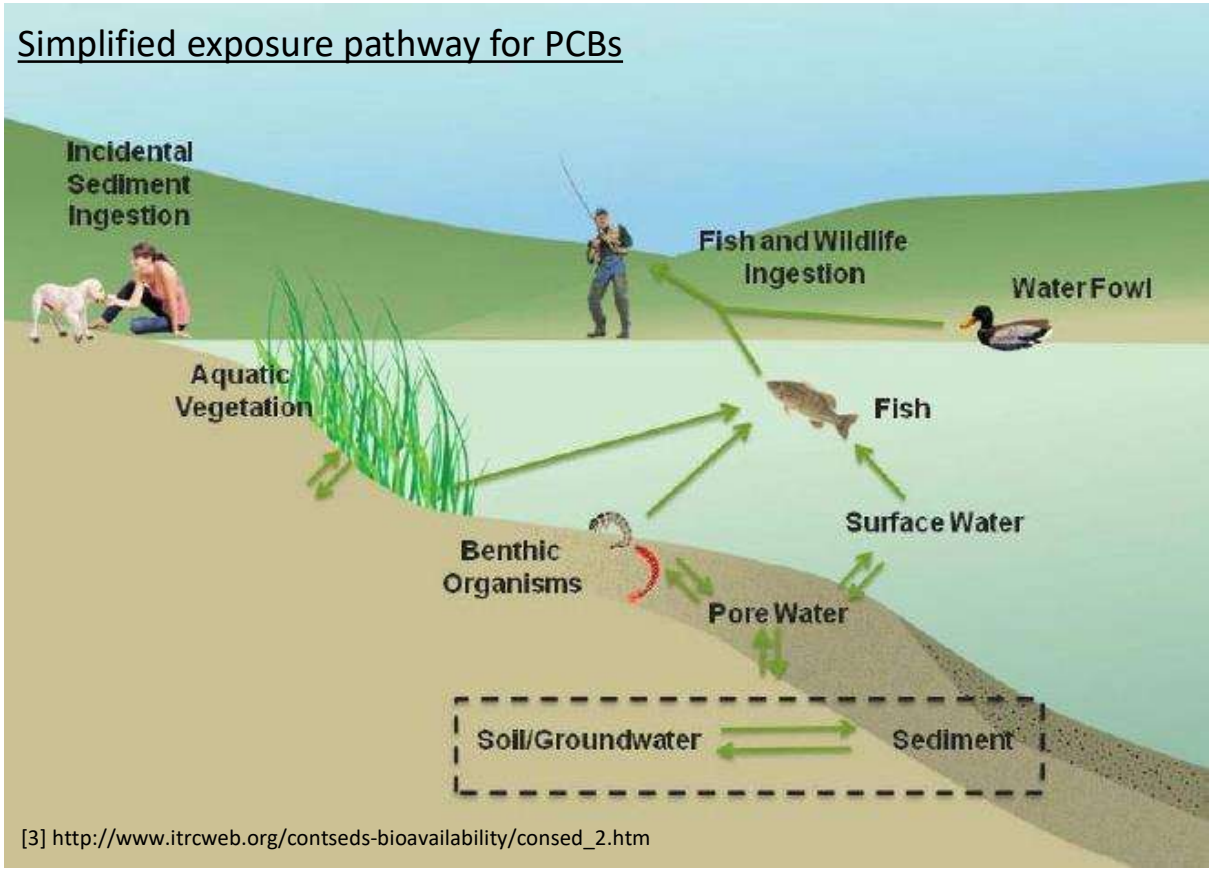
4. Accurate delineation of the PCB loadings along a stream is able to identify ongoing land sources of pollution.

5. Incorporating state of the art passive sampling into loading estimates enables an accurate and chemical activity-based assessment of PCB transport that links monitoring to the ultimate endpoint of bioaccumulation in fish.

PCB dissolved concentration are critical to monitor

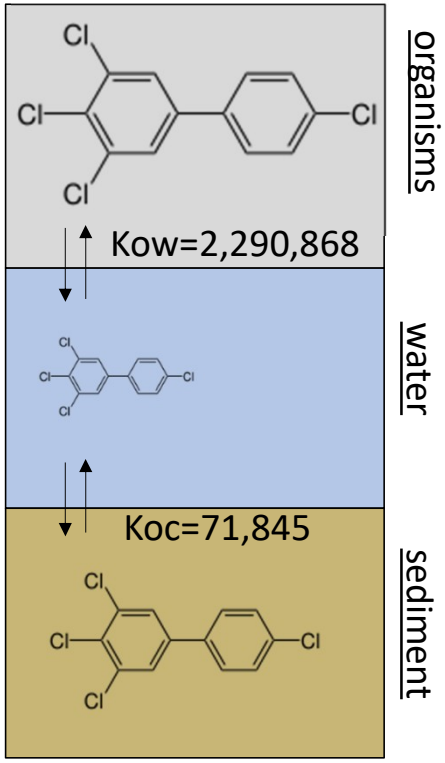
PCBs are hydrophobics: High concentration in sediment and organisms, Low concentration in water (sparingly soluble)
But **PCB concentration in water is the main driver for uptake** in organisms

Simplified exposure pathway for PCBs



[3] http://www.itrcweb.org/contseds-bioavailability/consed_2.htm

PCB partitioning between phases
Example of PCB#81



Need for low-cost and integrative measurement of PCB in stormwater

Collection of dissolved and particulate fractions

https://www.usgs.gov/media/images/grab-sampling

- ☻ Inexpensive
- ☻ Do not require highly qualified personnel

- ☹ Unsafe during storm events
- ☹ Snapshot measurement of the storm event

https://www.teledyneisco.com/

- ☻ No personnel on site during storm collection
- ☻ Programmed to sample varying size of samples
- ☻ Integrative measurement possible

- ☹ Expensive, limited number of sites monitored
- ☹ Require qualified personnel for setup and maintenance
- ☹ Require batteries, electricity

Proposed passive sampling tools for water and suspended sediments

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Dissolved PCBs in water

Feasibility of Short-Term and Flow-Weighted Long-Term Measurements Using Equilibrium Passive Sampling

Oindrila Ghosh, Louis Cheung, Nathalie Lombard, and Upal Ghosh*

Cite This: https://doi.org/10.1021/acsestwater.5c00686 Read Online

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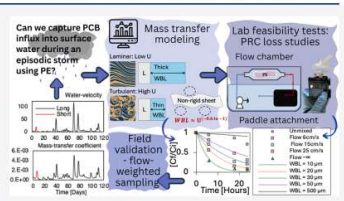
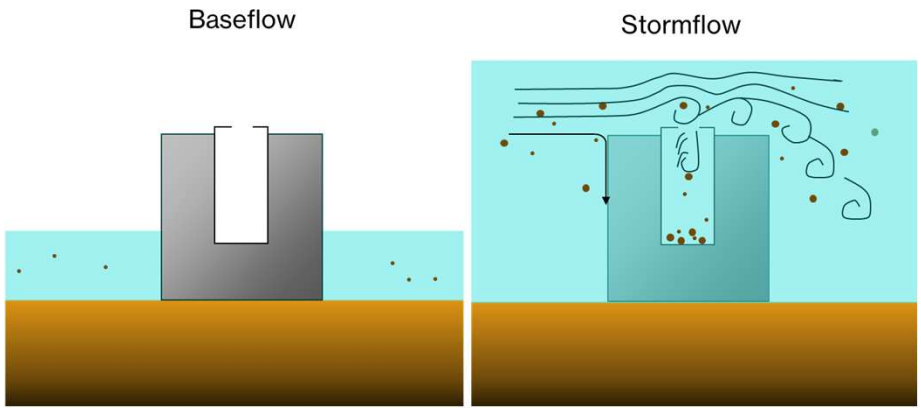
ABSTRACT: Short-term surface water measurements are often critical in assessing pollutant inputs from episodic events, while long-term flow-weighted measurements are needed for loading calculations. For either application involving hydrophobic pollutants, equilibrium passive sampling is currently less explored. In this paper, we first evaluate the feasibility of short-term sampling of polychlorinated biphenyls in polyethylene and polydimethylsiloxane samplers using a combination of mathematical modeling, laboratory-scale experiments, and field demonstration. Laboratory-scale experiments under a range of flow conditions revealed that short-term measurements of dissolved polychlorinated biphenyls using an 18 μm thick polyethylene sheet are possible with 24 h of exposure in high-flow conditions. The optimized samplers deployed at Anacostia River, Washington, DC, were able to measure the water concentration during a storm event and showed that the concentrations were not diluted by the high flow and that the loading during the storm event was substantial. Laboratory experiments revealed that with increasing flow velocity, the diffusive boundary layer thickness decreased and the resulting mass transfer rate increased for the sampler. The positive correlation between flow and exchange rate enables a passive approach for flow-weighted water quality sampling across changing flow conditions in a river.



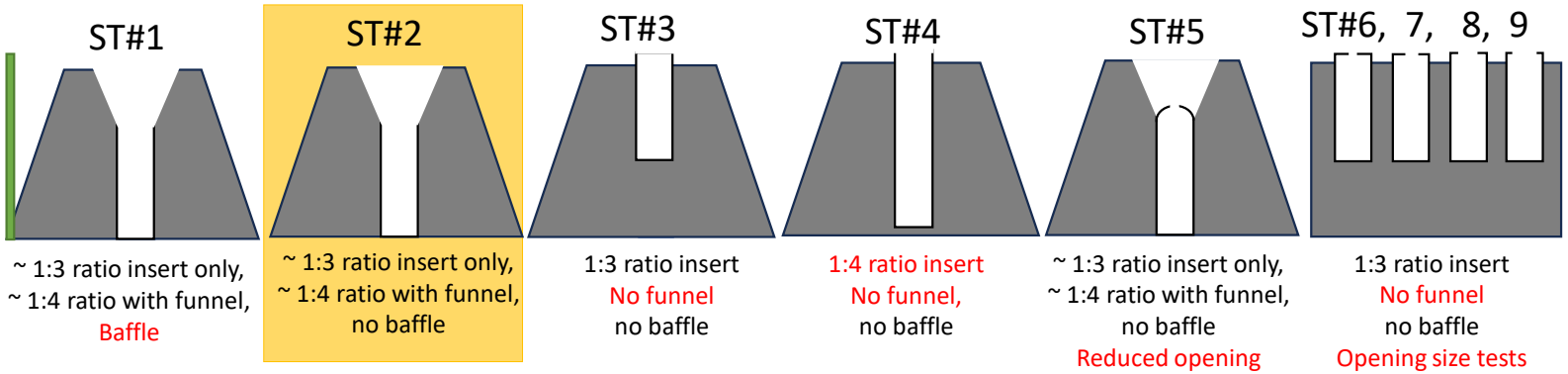
KEYWORDS: *passive sampling, freely dissolved concentrations, polyethylene (PE), short-term sampling flow-weighted sampling*

PCBs in suspended sediments



Sediment trap optimisation

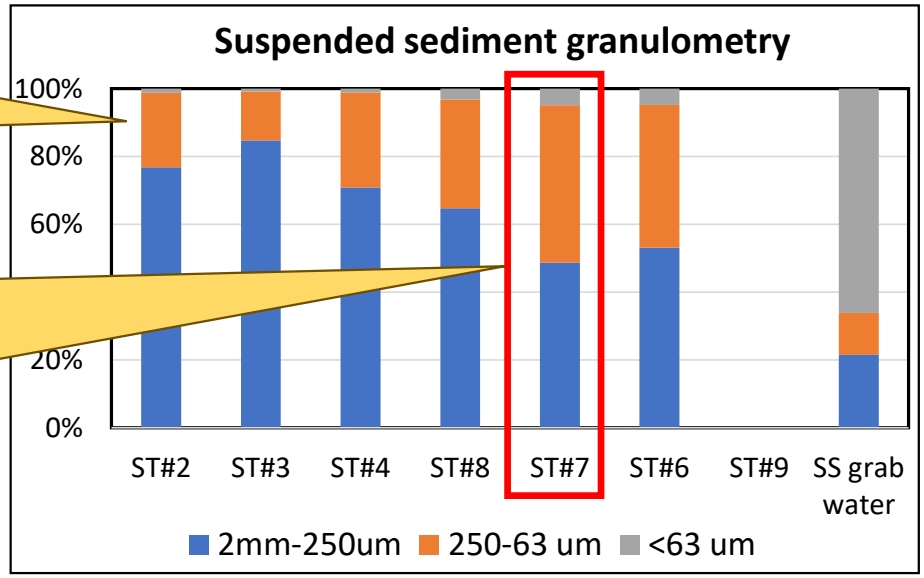
Several sediment trap iterations tested over 4 storms events at LBC1

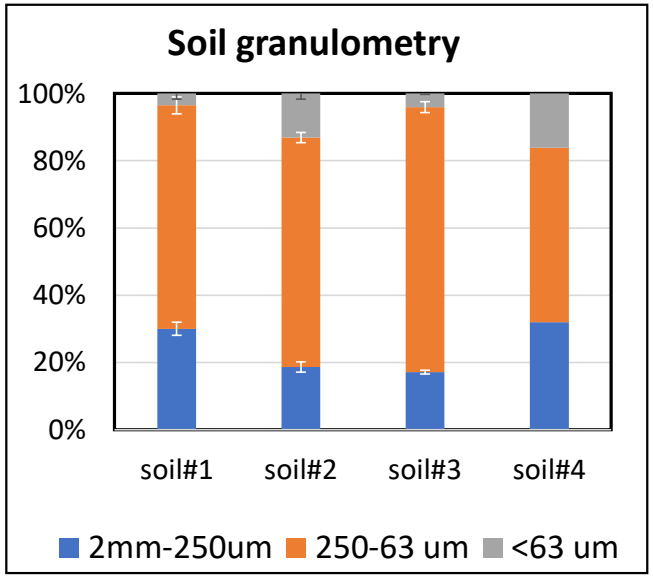


ST#1	ST#2	ST#3	ST#4	ST#5	ST#6, 7, 8, 9
~ 1:3 ratio insert only, ~ 1:4 ratio with funnel, Baffle	~ 1:3 ratio insert only, ~ 1:4 ratio with funnel, no baffle	1:3 ratio insert No funnel no baffle	1:4 ratio insert No funnel, no baffle	~ 1:3 ratio insert only, ~ 1:4 ratio with funnel, no baffle Reduced opening	1:3 ratio insert No funnel no baffle Opening size tests

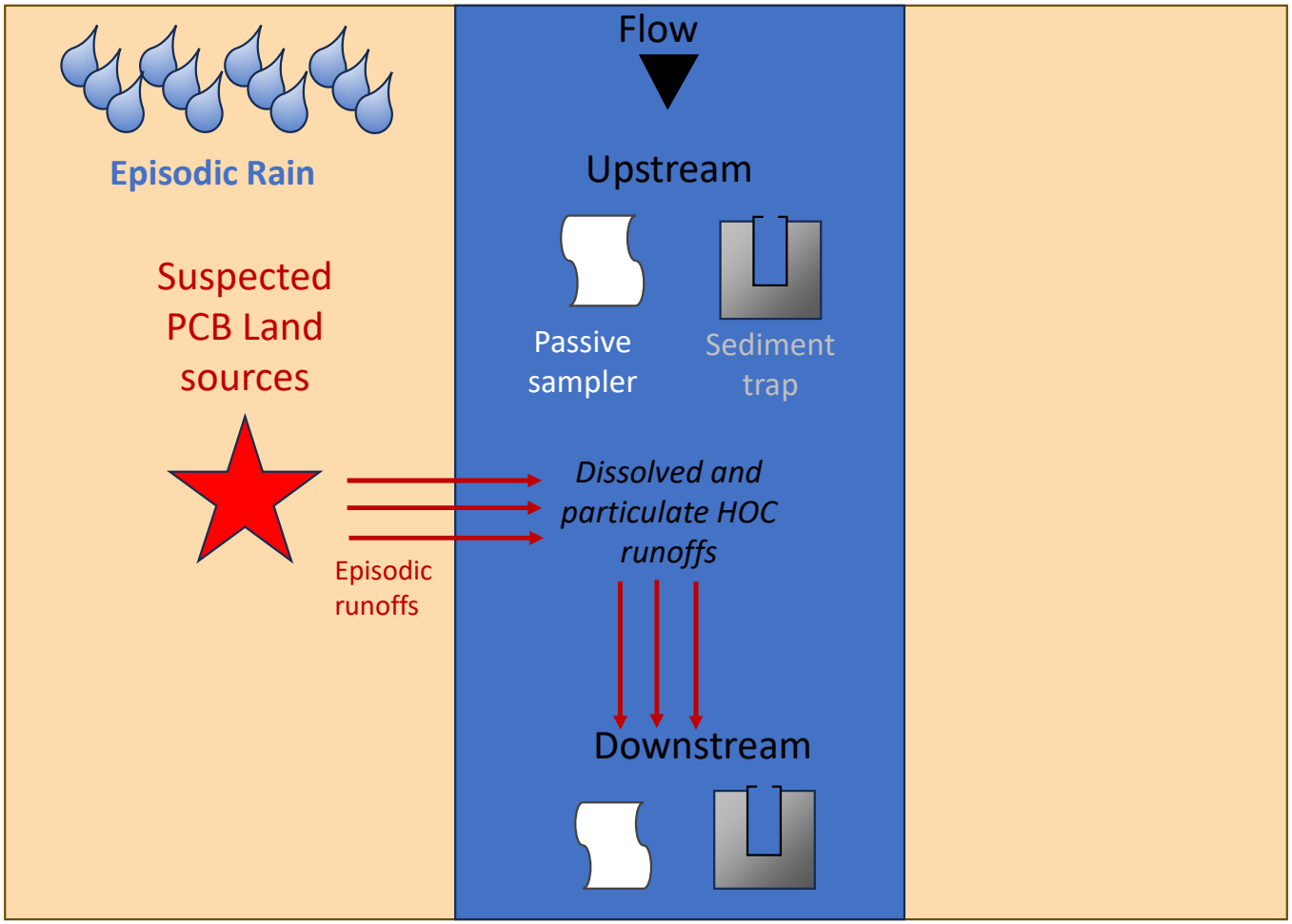
Configuration tends to overfill with SS

Best compromise for finer SS and sufficient amount collected for PCB and TOC analysis





The approach



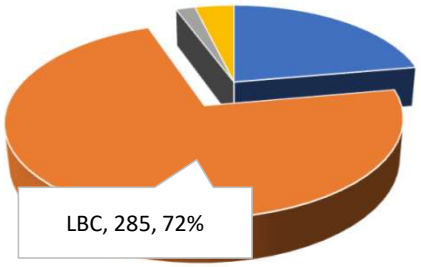
<u>Comparison upstream vs downstream:</u>
Increase of PCB concentration downstream vs upstream confirms presence of a PCB source

<u>Comparison baseflow vs stormflow:</u>
PCB concentration dilution during storms indicates a baseflow source

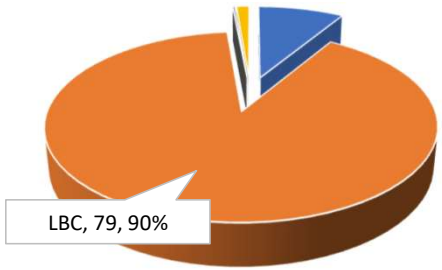
<u>PCB loads calculation:</u>
Delineate baseflow vs stormflow contribution to the impairment

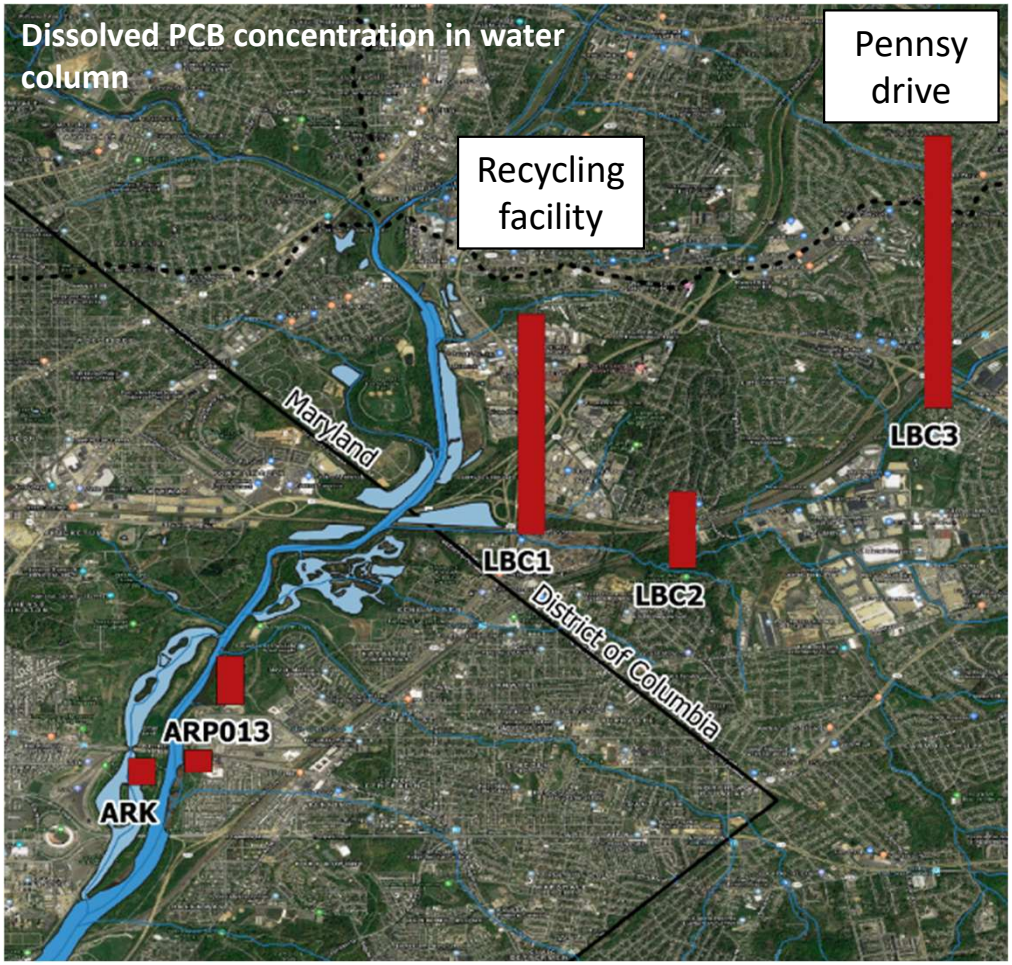
Study site

Total PCB loads from Tributaries (g/year)



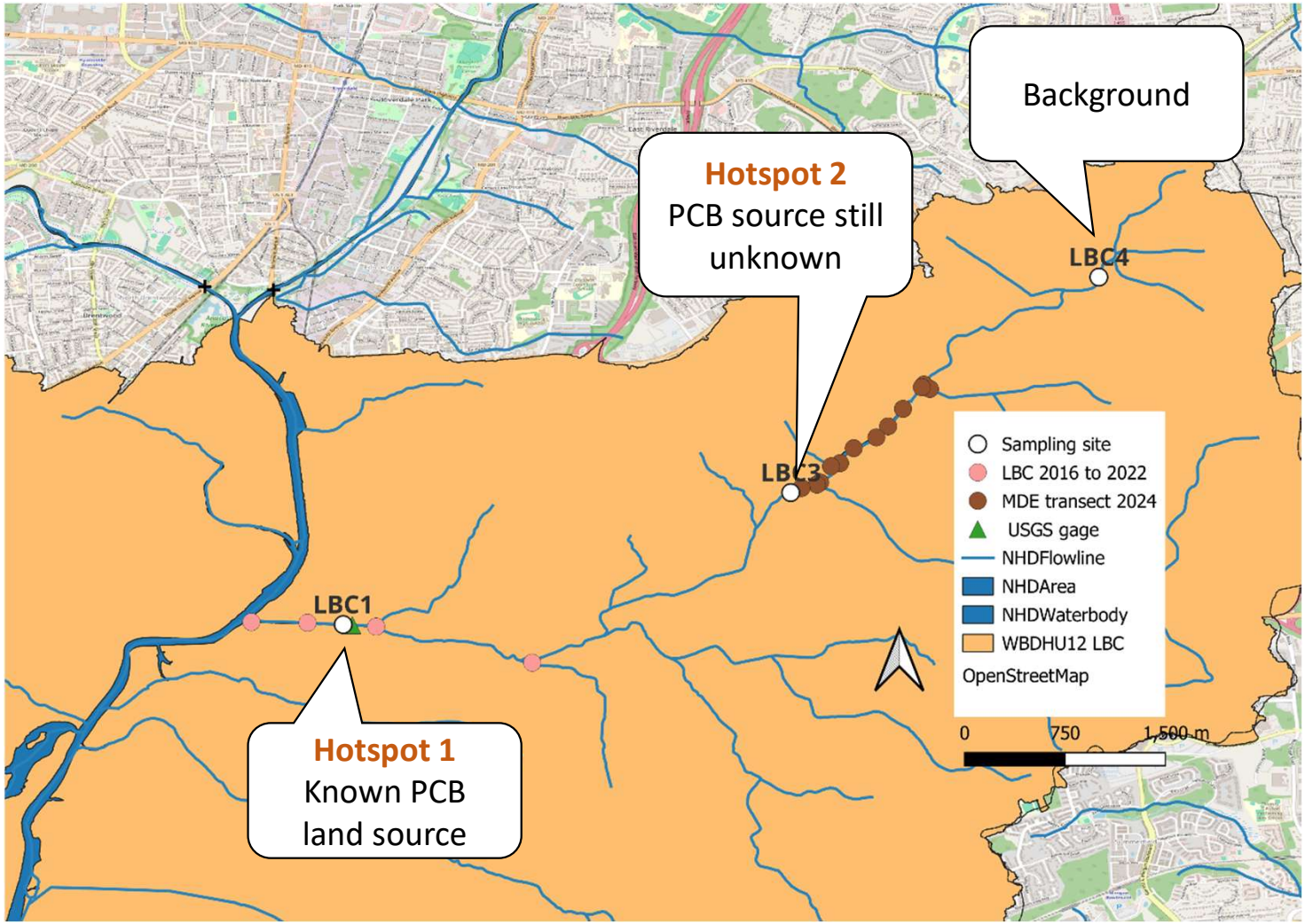
Dissolved PCB loads from Tributaries (g/year)



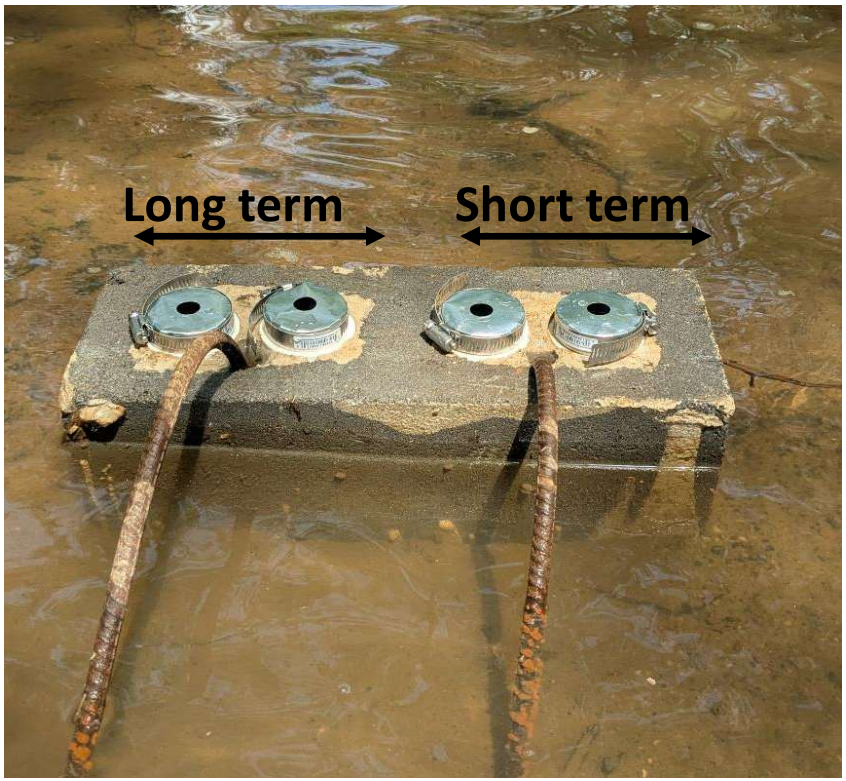


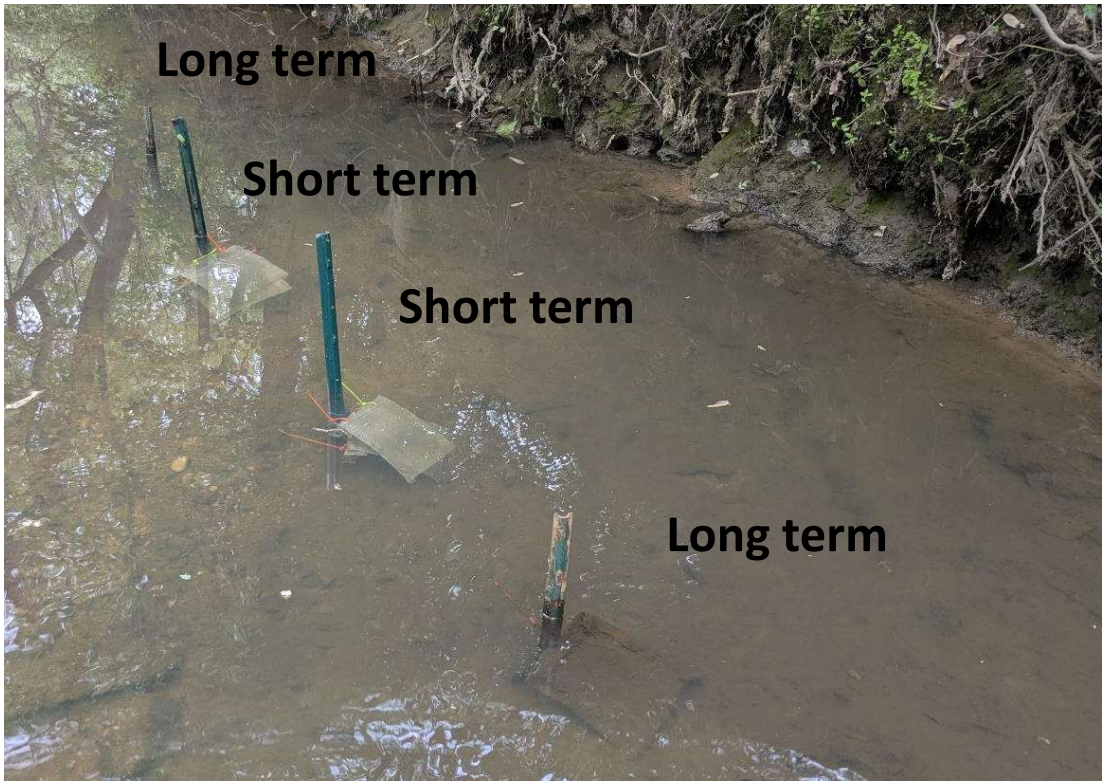
- ❑ PCB in water and SS data collected in 2017
- ❑ LBC is a major source of PCB to the Anacostia River
- ❑ Two hot spots of PCB contamination confirmed by multiple studies
- ❑ Source identification ongoing at LBC3/Pennsy drive

Sampling location

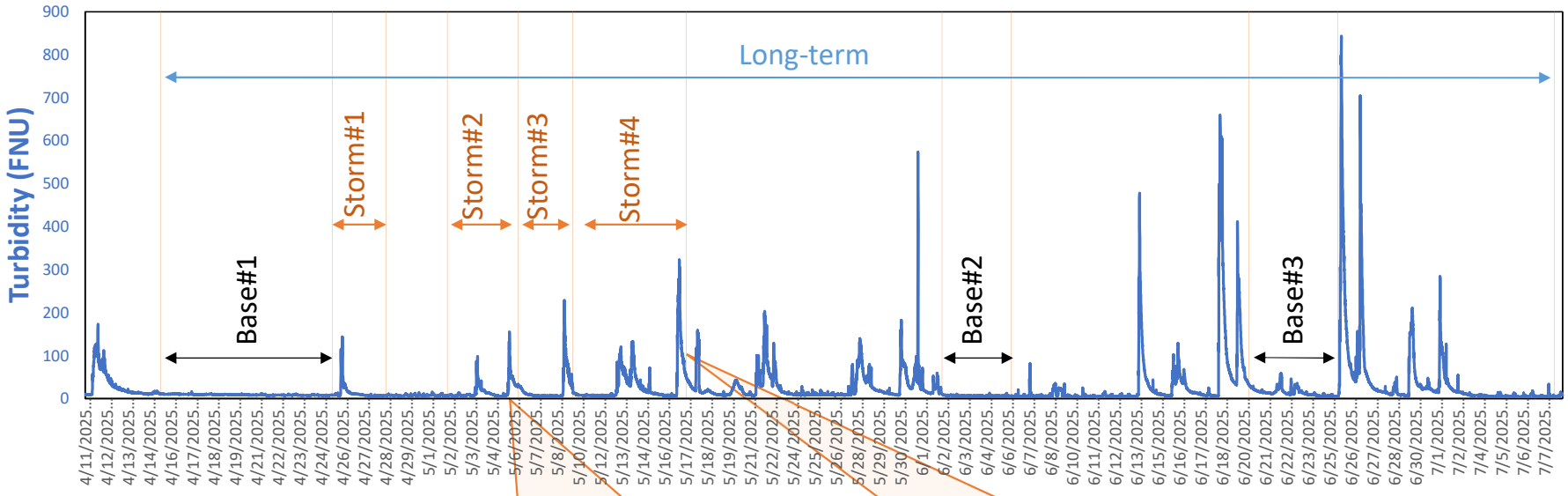


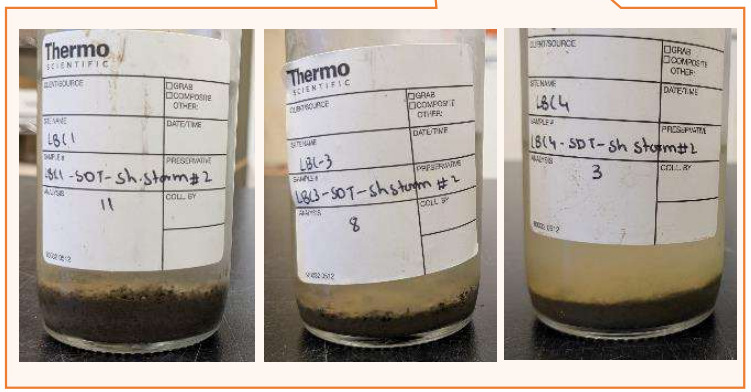
Sediment trap and passive sampler deployment



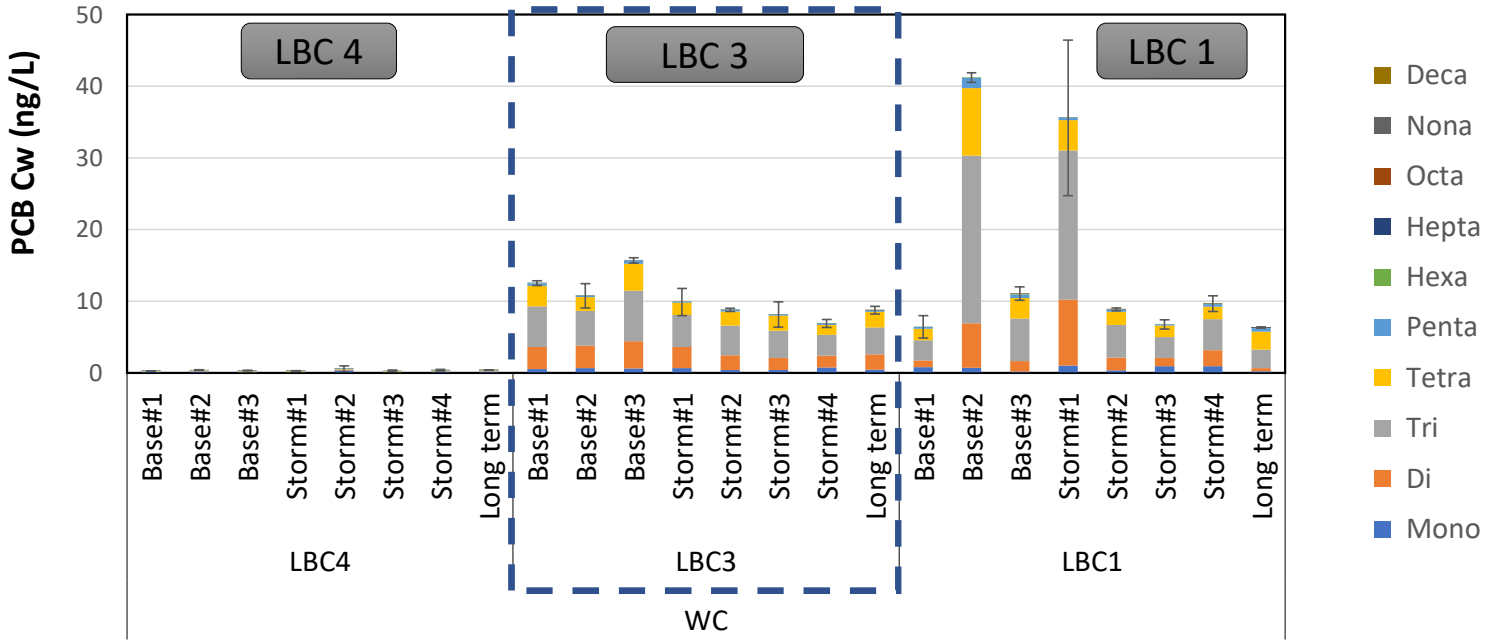


Sampling timeline



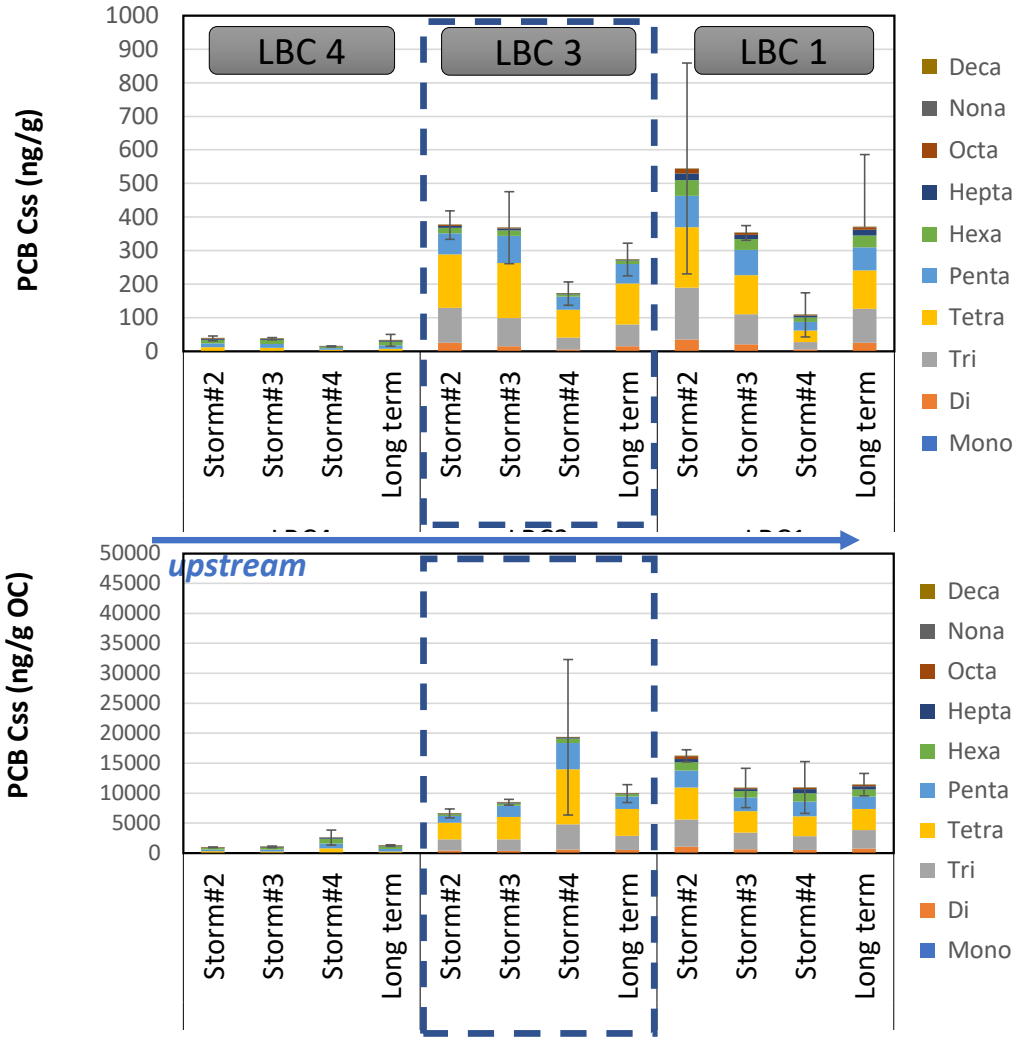


Dissolved PCB concentration can be measured during short-term



- Short-term measurements show higher PCBs concentration in water at LBC3 and LBC1
- Low intra variability between replicates (median RSD of 10%)
- Measurements comparable to that of 2017 and 2022
- Similar PCB levels between baseflow and stormflow (no dilution effect),
- Episodic high-concentration events at LBC1 (Base#2 and Storm#1)

Long term sediment trap provide representative PCB concentration in SS



- Higher PCB concentration in SS at LBC3 and LBC1 vs LBC4
- PCB concentration at LBC1 in 2025 is higher than that measured with ISCO sampler from 2017 (range of 5.4 - 140 ng/g)
- Variability of PCB concentration between storms

- Similar PCB concentration across storms per site **after OC normalization**
- Average PCBs from 3 storms similar to the long-term measurements per site
- Higher MW congeners at LBC1 versus LBC3 suggesting **different sources**

Conclusions

Our low-cost technology alternative can identify PCB land sources mobilized in particulate or dissolved form during rain event

- ❑ Low variability of PCB concentration in SS after OC normalization.
- ❑ Higher variability can be observed in dissolved forms across storms and baseflow depending on the site complexity.
- ❑ Transect monitoring recommended to track multiple potential sources such as outfalls or tributaries.
- ❑ Although tested in this project for PCBs, the methods have wide applications for other legacy and emerging pollutants

Next steps:

- ❑ PCB loading calculations to evaluate relative contribution of storm versus baseflow and identify the major inputs impacting downstream waterbody
- ❑ Test the approach in a second watershed

Funding & Acknowledgments

This research was funded through the Pooled Monitoring Initiative (PMI), Restoration Research Program.

Award #23847| UMBC| 2025-2027

The Pooled Monitoring Initiative funds applied science to advance restoration research for cumulative impacts, comparative effectiveness of stormwater practices, pollutants of emerging concern, and trade-offs with new research questions added annually.

WEBSITE: https://cbtrust.org/grants/restoration-research/

Translation Slides

Chris Clark, Engineer IV, Water Quality Coordinator
Prince George's County Department of the Environment
Stormwater Management Division

What does this mean for me?

Low-cost monitoring tools can significantly expand PCB source investigations

Passive samplers and sediment traps provide a scalable alternative to traditional ISCO storm sampling.

Lower equipment and staffing requirements allow more locations to be monitored simultaneously.

Increased spatial coverage improves the ability to isolate active PCB source areas.

BE CAREFUL WHERE YOU PLACE YOUR SAMPLERS!

What does this mean for me?

Dissolved-phase PCB monitoring provides critical insight

Dissolved PCB concentrations are directly linked to bioavailability and fish tissue uptake.

Traditional total-water sampling alone may overlook important transport mechanisms.

Separating dissolved and particulate loads improves understanding of remediation priorities.

What does this mean for me?

Stormflow and baseflow comparisons help identify source types

Elevated baseflow concentrations may indicate groundwater or legacy infrastructure sources.

Elevated stormflow concentrations may indicate surface runoff or sediment mobilization.

Comparative monitoring improves targeting of source-trackdown investigations.

What does this mean for me?

Sediment traps can support watershed screening efforts

Sediment traps provide time-integrated particulate sampling during storm events.

Trap optimization is important to ensure representative fine sediment capture.

The approach may be particularly useful in highly urbanized MS4 systems.

Key Takeaways for Regulators

Improved monitoring efficiency can support MS4 permit implementation

Simplified monitoring approaches may allow jurisdictions to evaluate more outfalls and tributaries within existing budgets.

Expanded monitoring coverage can accelerate PCB source identification efforts required under TMDL implementation programs.

Cost-effective approaches may improve long-term watershed trend monitoring.

Key Takeaways for Regulators

Monitoring methods support risk-based watershed management

Dissolved PCB measurements provide insight into bioavailable contaminant fractions.

Loading estimates help prioritize subwatersheds and potential source areas.

Data can improve targeting of enforcement, remediation, and restoration activities.

Key Takeaways for Regulators

Approach supports adaptive management frameworks

Results can inform iterative monitoring and source-trackdown strategies.

Monitoring can be refined over time as hotspot areas are confirmed or eliminated.

The methodology supports phased investigations rather than relying solely on large-scale intensive sampling campaigns.

There is the potential to use this methodology to also evaluate the effects on the status and mobilization of PFAS and other COC's, including pesticides, PAH's, etc.

Wrap Up

Prince George's County Perspective

Urban watersheds contain complex mixtures of legacy industrial contamination, stormwater transport pathways, and remobilized sediments.

Cost-effective screening tools are essential for identifying priority areas within large regulated MS4 systems.

Integrated monitoring approaches improve the County's ability to support PCB TMDL compliance and long-term restoration planning.

Expanded monitoring flexibility can help jurisdictions respond more effectively to emerging regulatory requirements and evolving contaminant investigations.

WE'VE COME A LONG WAY.

THANK YOU!