# Evaluation and Review of Best Management Practices for the Reduction of Polychlorinated Biphenyls to the Chesapeake Bay

Presented to the Toxic Contaminant Working Group

May 8, 2024

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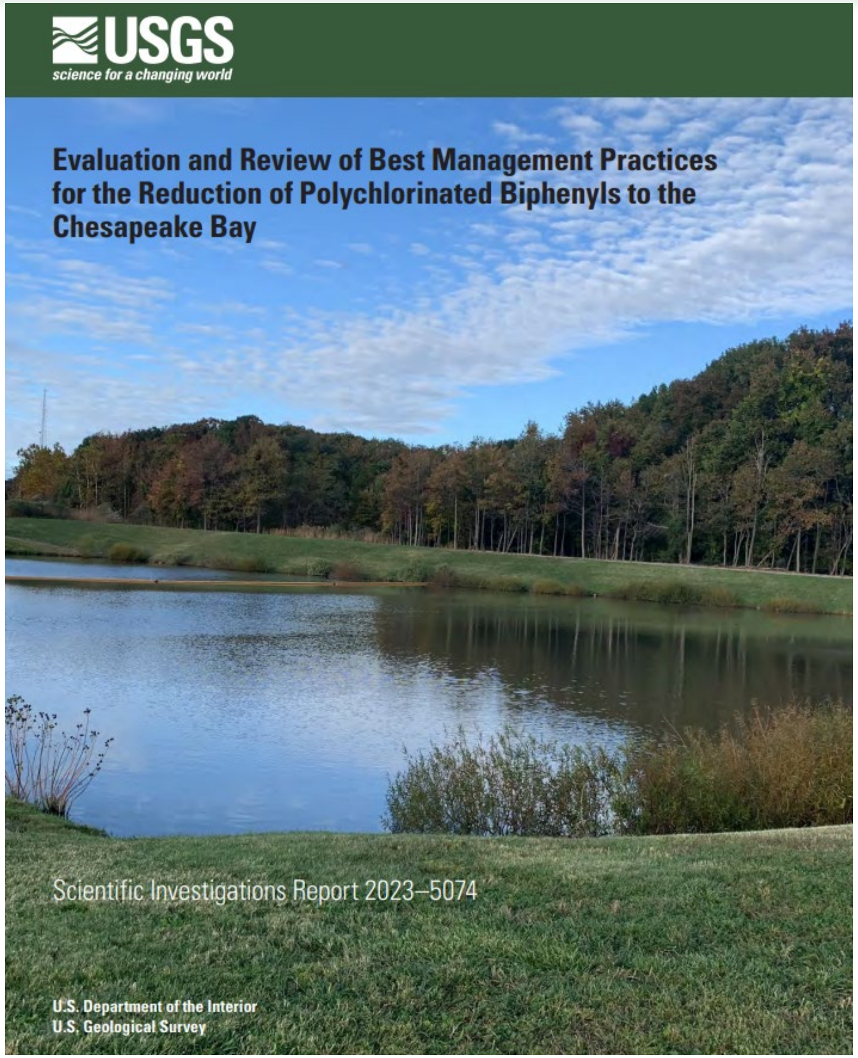
# Agenda

- Background
- Approach
- Discussion of Best Management Practices by Type
- Modeling PCB Reductions
- Opportunities for Integrating Efforts to Reduce PCBs
- Summary of Findings



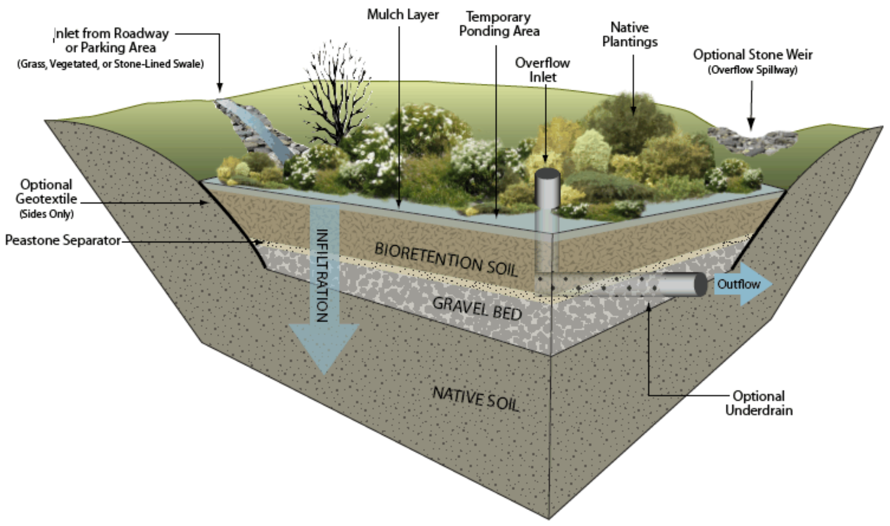

USGS SIR 2023-5074
https://pubs.usgs.gov/sir/2023/5074/sir20235074.pdf

# Best Management Practices (BMPs)

- *BMP is a specific action (or actions) taken to achieve or aid in the achievement of a management measure (EPA, 2022)*
- *BMPs are specific actions taken to achieve a management measure which includes removal and prevention of pollutants from entering receiving waters via stormwater (EPA, 1993)*
- Pollutant load reductions can be calculated when design removal criteria (or efficiencies) exist
- A co-benefit can reduce multiple pollutants through the same BMP

**Structural BMPs**

Constructed measures to include: infiltration basins, stormwater retention ponds, or green infrastructure

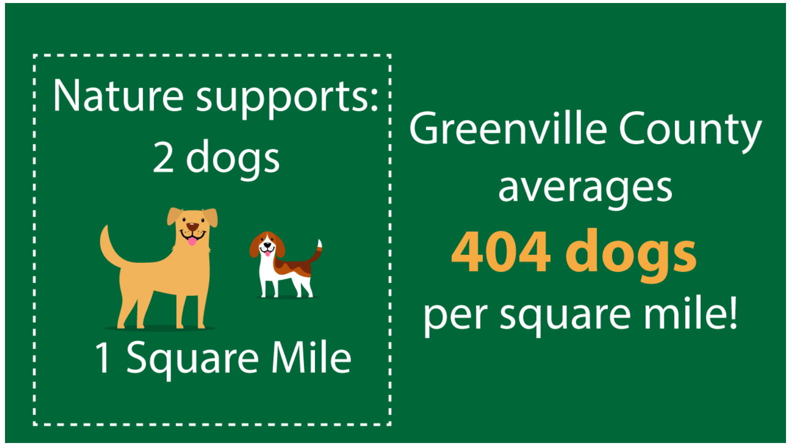



USGS NE WSC: Monitoring the Effectiveness of Bioretention Cells
https://ne.water.usgs.gov/projects/bioretention/gi.html

**Nonstructural BMPs**

Control practices and behavioral changes to include: pet waste pick-up education, watershed planning, and restoration

[Pet Waste – Greenville County Soil and Water Conservation District (greenvillesoilandwater.com)]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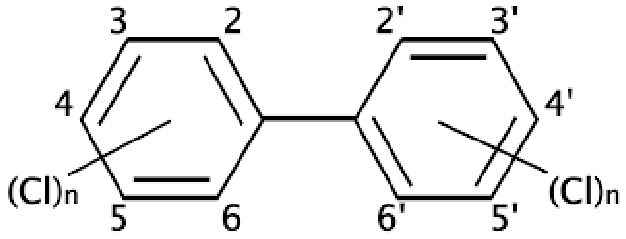
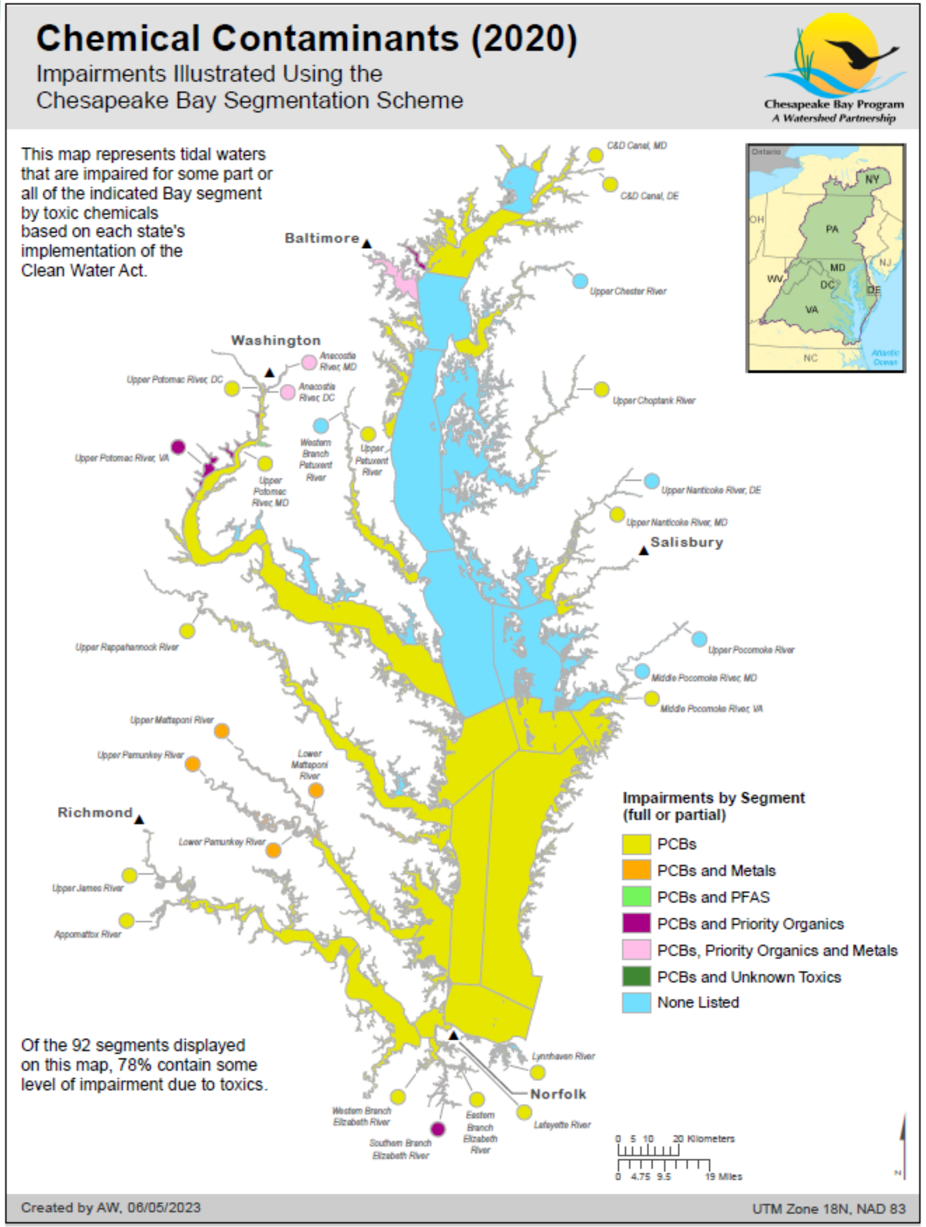
# Polychlorinated Biphenyls (PCBs)

- Primary toxic contaminant impairing the Chesapeake Bay Watershed
- Originally manufactured as flame retardants in 1929 and new production was banned in 1979.
- Commercial name “Aroclor” consisting of a blend of PCB congeners.
- Used in a variety of applications to include: electrical transformer coolant oil, hydraulic oils, insulation, and paints.

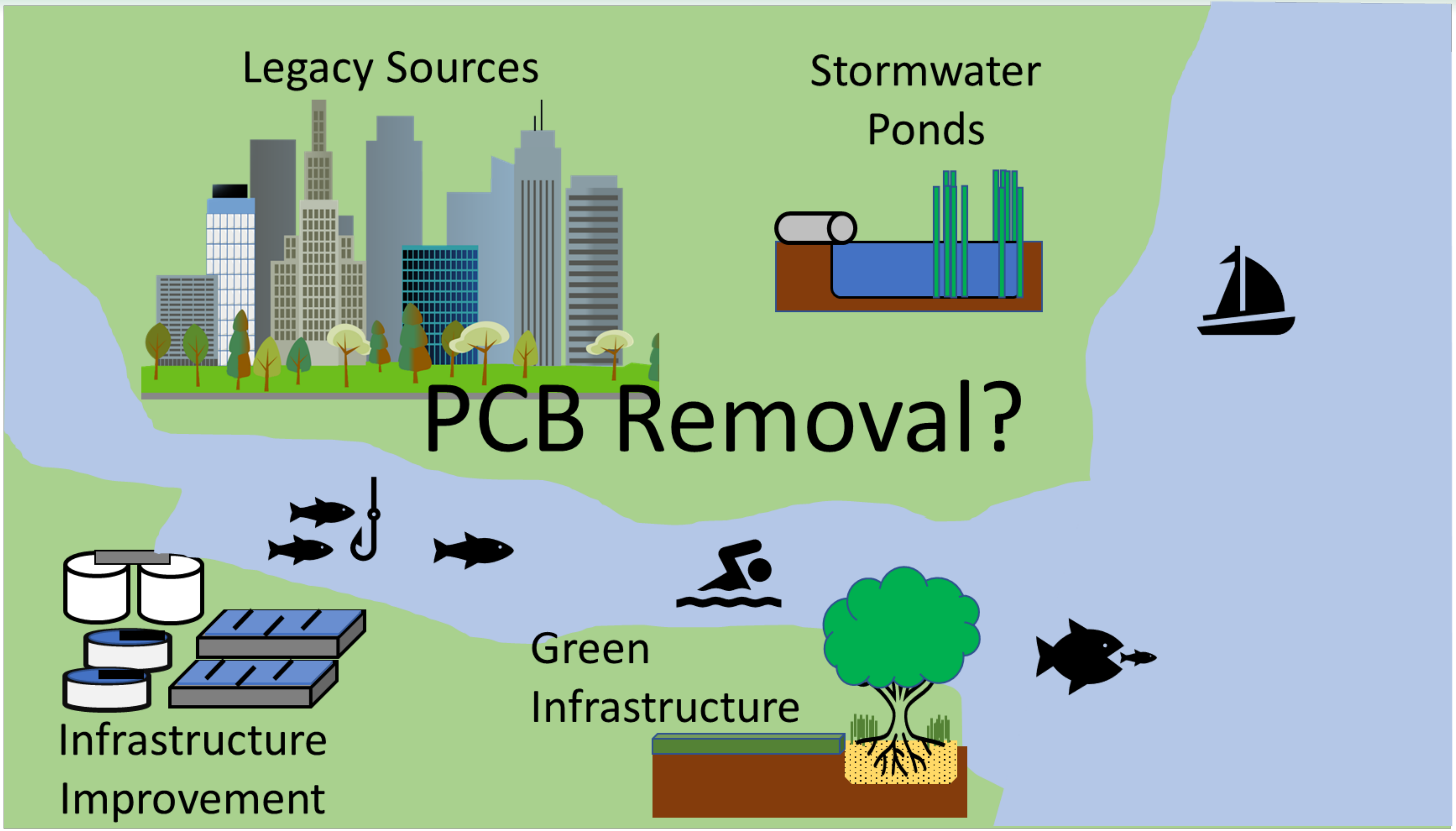



*Generalized chemical structure representing the 209 different PCB congeners*


https://en.wikipedia.org/wiki/Transformer



# Motivation for the study



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# Approach

- Conducted a scientific literature review of PCB reduction practices of PCBs in stormwater BMPs
- 19 studies were identified and summarized in Table 1 of the USGS SIR 2023-5074.

**Table 1.** Literature review of polychlorinated biphenyl reductions associated with best management practices (BMPs).

[PCB, polychlorinated biphenyl; WWTP, wastewater treatment plant; —, no data; Calif., California; Hg, mercury; PAH, polyaromatic hydrocarbon; TOC, total organic carbon; %, percent; <, less than; min, minute; Tex., Texas; OCDD, octachlorodibenzodioxin ; Cd, cadmium; Pb, lead; Ni, nickel; Zn, zinc; Cu, copper; MethHg, methylmercury; SSC, suspended sediment concentration; Wash., Washington; Va., Virginia; Mass., Massachusetts; Del., Delaware.]

| Authors | Location | Types of BMPs | Contaminant types measured | Method of evaluation | PCB reductions | Other reductions |
|---|---|---|---|---|---|---|
| Rossi and others, 2004 | Switzerland | Stormwater sewer system and WWTP | PCB | Calculated load | — | — |
| McKee and others, 2006 | San Francisco Bay Area, Calif. | Multiple | PCB and Hg | Qualitative | — | — |
| Jartun and others, 2008 | Bergen, Norway | Stormwater sediment traps | PCB, metals, PAH, and TOC | Sampled and measured | — | — |
| Mangarella and others, 2010, | San Francisco Bay Area, Calif. | Multiple | PCB and Hg | Qualitative | — | — |
| SFEI, 2010 | San Francisco Bay Area, Calif. | Multiple | PCB and Hg | Qualitative | — | — |
| Yee and McKee 2010 | San Francisco Bay Area, Calif. | Stormwater sediment capture | PCB and Hg | Load reduction | PCB (31–53% reduction) based on <2 min and <20 min settling time | Hg (7–12% average) |

# Stormwater Ponds and Wetlands

Consist of permanent pools or shallow marsh areas to treat urban stormwater.

**Controlling factors:**

- Stormwater retention time
- Settling of mobilized sediments within the catchment
- Total organic carbon (TOC) associated with higher capture efficiency
- PCBs sources need to be in the stormwater drainage

**Results:**

- Multiple studies exist investigating detections of PCBs in wet pond sediments
- Presence of PCBs across landscapes were not consistent or ubiquitous (Bishop and others, 2000; Flanagan and others, 2021; Bishop and others, 2000, DiBlasi and others, 2009; Van Metre and Mahler, 2010).

https://www.pondlakemanagement.com/stormwater-retention-ponds/

# Green Infrastructure

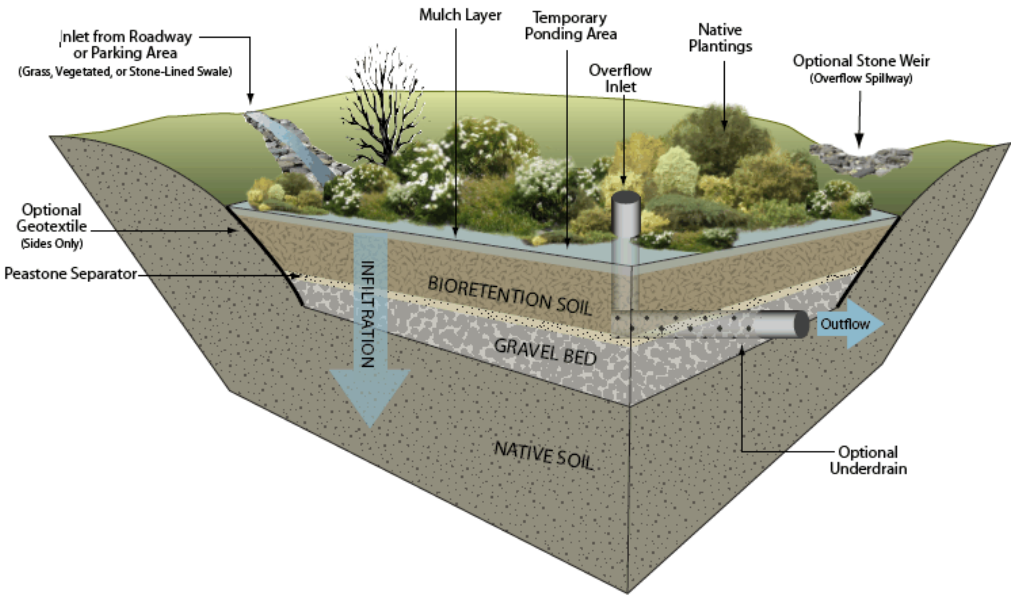
Green infrastructure (GI) is defined as, “the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspire stormwater and reduce flows to sewer systems or to surface waters” (EPA, 2020).

**Controlling Factors:**

- PCB capture in GI is primarily through contaminated sediment capture in stormwater or sorption to natural media.
- PCBs sources need to be in the stormwater drainage

**Results:**

- Bioretention BMPs report removal efficiencies of 82-96% (David and others, 2014; Schueler and Youngk, 2015; Wu and others, 2018; Gilbreath and others, 2019)
- Vegetation did not significantly affect removal
- Efficiency determined largely by sediment capture efficiency




USGS NE WSC: Monitoring the Effectiveness of Bioretention Cells
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# Stormwater and Municipal Wastewater Sewer System Associated BMPs

- Stormwater and municipal wastewater sewer systems are known conveyance for PCBs and other pollutants
- Enter the Chesapeake Bay either through combined sewer outfalls (CSOs) or through treated effluent discharge
- Track down studies within municipal wastewater sewer system has been effective in identifying areas of high concentration to focus maintenance and replacement of legacy infrastructure with quantifiable reductions

Effective implementation within the Chesapeake Bay Watershed:

- Baltimore City, MD (Needham and Ghosh, 2019; Majcher and others 2022)
- City of Camden, NJ (Belton and others, 2008)
- Philadelphia, Pa. (Delaware River Basin Commission, 1998, Rodenburg and others, 2010)
- Wilmington, Del. (New Castle County, 2014)
- Middle River, Md. (Lockheed Martin Corporation, 2017)

# Source Removal

- Physical removal of PCB materials from the landscape

- The widespread use of these materials in many older urban landscapes creates the appearance of a general elevated background level but has specific sources that can be targeted (like caulks and paint).

- The San Francisco Estuary Institute assessed reducing PCB loads from sources to be one of the most effective means of reducing PCB conveyance in stormwater (San Francisco Estuary Institute, 2010).

- Desktop evaluations by municipalities to identify buildings and areas where these materials may exist can assist in focusing reduction efforts.

http://www.caulkyourhome.com/diycenter/projects/weatherizeyourhome

# Water Quality Models Evaluated

- AQUATOX (Park and Clough, 2014)
- water quality and hydrodynamic model in 2D (CEQUAL-W2; Cole and Buchak, 1995)
- the Environmental Fluid Dynamics Code (EFDC; Tetra Tech, Inc., 2007)
- EPA stream water quality models (QUALs; Brown and Barnwell, 1987)
- The Soil and Water Assessment Tool (SWAT; Neitsch and others, 2001)
- the Spatially Referenced Regressions on Watershed attributes (SPARROW; Schwarz and others, 2006)
- the Water Quality Analysis Simulation Program (WASP; DiToro and others, 2004)
- Stormwater Treatment unit Model for Micropollutants (STUMP)
- Chesapeake Assessment and Scenario Tool (CAST)
- Regional Watershed Spreadsheet Model (**RWSM**) (San Francisco Estuary Institute, 2010)
- **VELMA 2.0** model (EPA, 2021b)
- **WinSLAMM** (PV & Associates, LLC, 2019)
- EPA Storm Water Management Model (**SWMM**)

# Modeling PCB Reduction

**Modeling Assumptions:**

- PCBs are hydrophobic and bond to sediment
- BMPs that capture sediment will capture sediment contaminated with PCBs
- PCBs are homogeneously distributed by land-use or drainage area
- PCBs mobilize consistently with stormwater

**Limitations:**

- Quantitative removal efficiencies for BMPs are not available to calculate load reductions
- Multiple studies have demonstrated localized distributions of PCBs within a land-use
- Will not account for event driven releases to a watershed

**Summary:**

- Regional Watershed Spreadsheet Model (RWSM) only regional scale model
- Empirically developed model of the watershed loading and does not function as a predictive tool for changes in the watershed
- ***Necessary information and data is currently not available to implement a regional scale model for the Chesapeake Bay Watershed***

# Opportunities for Integrating Efforts to Reduce PCBs

Three areas identified:

- Gray Infrastructure Improvements
- Disconnect between Contaminated Sites and Stormwater
- Total Mass Reduction versus Bioavailability

# Gray Infrastructure Improvements

- Some source track down and identification is needed
- Significant reductions in PCB loads can be achieved through regular O&M costs to municipalities
- Load reductions were observed by Majcher and others (2022) in the Back River, Md. WWTP between 2015 and 2019.
- Concentration of PCBs in both influent and effluent were reduced by 40 and 70 percent following enhanced nutrient removal (ENR) upgrades and capital improvements to the sewer system (Baltimore City Department of Public Works, 2021).


http://www.avenuenews.com/news/article_43c66fc6-c917-11e2-8274-0019bb2963f4.html
https://www.google.com/maps/@39.2944069,-76.4921966,1198m/data=!3m1!1e3?hl=en&authuser=0



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# Disconnect between Contaminated Sites and Stormwater

- Regulatory limits under the Toxic Substances Control Act for new PCB spills in soil only requires remedial actions to be taken for concentrations of 50 mg/kg (ppm) total PCB concentration by dry weight or greater and is required to be cleaned to 25 mg/kg (ppm) (40 CFR §761.125).
- By comparison, the TMDL target criteria for sediments is typically less than 0.5 mg/kg (ppm) total PCB dry weight (EPA, 2011; Maryland Department of the Environment, 2011).
- Legacy and "remediated" PCB sites can continue to be a source of PCBs to stormwater
- A wider approach can be effective such as the Watershed Approach to Toxic Assessment and Restoration (WATAR) implemented in Delaware.

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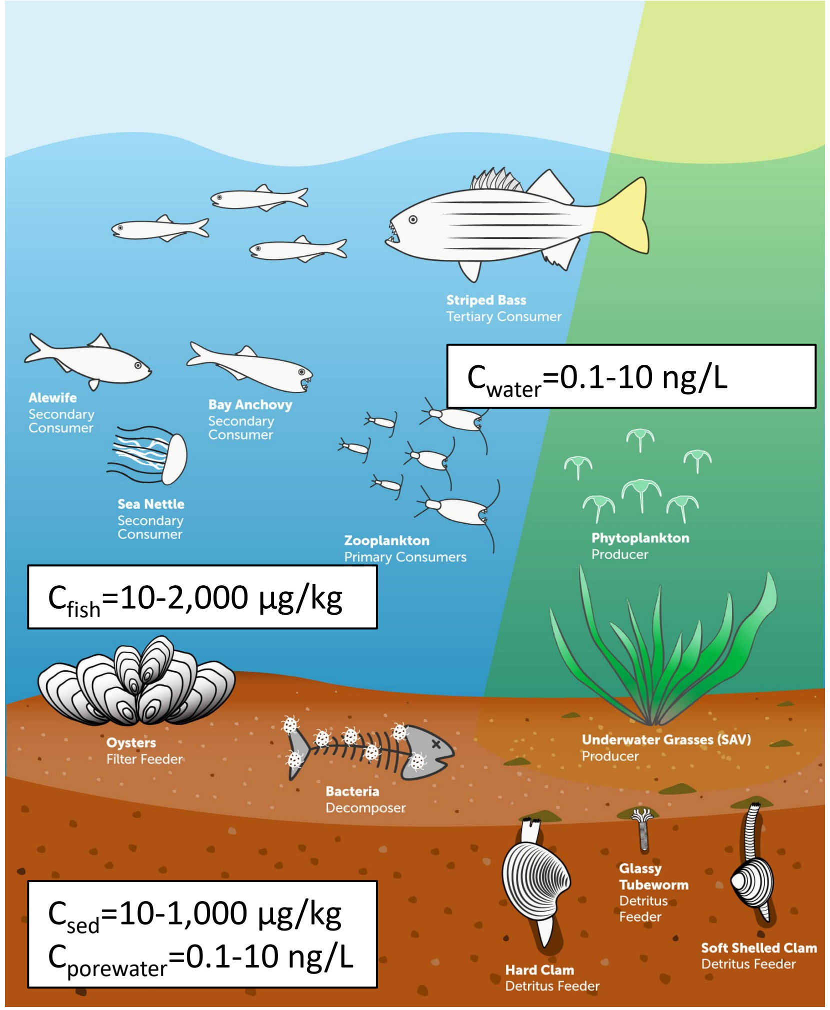
# Total Mass Reduction versus Bioavailability




https://www.chesapeakebay.net/discover/ecosystem/food_web#:~:text=The%20food%20chain%20starts%20with,as%20bluefish%20and%20striped%20bass.

- Current regulation focuses on total maximum daily load (TMDL)
- The bioavailability of the PCBs drives uptake into the aquatic food chain, not total mass present
- New remediation strategies that focus on bioavailability have can reduce PCB risk without removal
- Additional information and case study will be presented by Dr. Kevin Sowers

# Summary

- Literature review identified limited studies that quantified PCB reductions through BMPs
- BMPs designed for nutrient and sediment reductions *may* have co-benefits for PCB reduction when PCBs are present in the associated drainage area
- Modeling PCB fate and transport at a watershed-scale is difficult and would require assumptions that are not supported by the current state of the science
  - Assumptions include uniform PCB distribution by land type and reliable mobilization by stormwater events
- Opportunities exist to reduce PCB loads through gray infrastructure improvement, source track down studies, integrated watershed management, and a shift towards PCB bioavailability

# Questions?

**Trevor Needham**

tneedham@usgs.gov

**USGS SIR:**

Needham, T.P., Majcher, E., Foss, E., and Devereux, O.H., 2024, Evaluation and review of best management practices for the reduction of polychlorinated biphenyls to the Chesapeake Bay: U.S. Geological Survey Scientific Investigations Report 2023–5074, 18 p., https://doi.org/10.3133/sir20235074.

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