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Bibliography for PCB TMDL SW-WLA Plan Guidance Development

The purpose of this bibliography is to examine some of the leading approaches to tracking sources of toxic chemicals, particularly polychlorinated biphenyls (PCBs), in the ambient environment as well as provide supporting documentation for methodologies that support these approaches. This review was done to assist MDE in the development of guidance to aid jurisdictions in identifying sources of PCBs to meet the reductions called for by Maryland's TMDL stormwater wasteload allocations (SW-WLA).

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Fish Tissue Monitoring and PCB Effects on Health

Berninger, Jason P., Tillitt, Donald E. 2019. Polychlorinated Biphenyl Tissue-Concentration Thresholds for Survival, Growth, and Reproduction in Fish. Environmental Toxicology and Chemistry. Volume 38, Number 4. pp. 712–736, 2019712. Columbia Environmental Research Center, US Geological Survey, Department of the Interior, Columbia, Missouri.

Berninger and Tillit (2019) compiled data from controlled studies on PCB-related adverse effects in fish to determine trends in mortality, growth, and reproductive (MGR) threshold responses. Their analysis led to a prediction of the likelihood that a significant MGR adverse effect will occur in a fish based on the PCB tissue concentration. For example, a 1 µg/g PCB tissue concentration would predict a 17% chance of mortality, 15% chance of adverse growth affect, and 39% chance of adverse reproductive effect.

Faroon, O. and Ruiz, P. 2016. Polychlorinated biphenyls: New evidence from the last decade. *Toxicology and Industrial Health.* 32(11), 1825-1847. https://doi.org/10.1177%2F0748233715587849

This paper compiles the results of various animal studies to describe and discuss a few of the known health risk factors associated with exposure to PCBs such as immunological, developmental, reproductive, and neurological effects.

Gallagher M.T., J.W. Snodgrass, D. Ownby, A.B Brand, R.E. Casey and S. Lev. 2011. Watershed-Scale Analysis of Pollutant Distributions in Stormwater Management Ponds. *Urban Ecosystems*. 14, 469-484. https://doi.org/10.1007/s11252-011-0162-y

Stormwater management ponds are a common Best Management Practice in urban and suburban areas and are often used by various semi-aquatic and aquatic wildlife species as habitat. Gallagher et al. (2011) sampled the sediments and waters of these ponds in the Red Run subwatershed of the Gwynns Falls watershed in Baltimore County, MD and found that toxicity thresholds for trace metals, PAHs, and Cl^- are routinely exceeded in the majority of the watershed's stormwater ponds. These pollutants, along with PCBs, could be negatively impacting the wildlife residing in or near these ponds.

King, R.S., Beaman, J.R., Whigham, D.F., Hines, A.H., Baker, M.E. and Weller, D.E. (2004). Watershed Land Use Is Strongly Linked to PCBs in White Perch in Chesapeake Bay Subestuaries. *Environmental Science & Technology*. 38(24), 6546-6552. https://doi.org/10.1021/es049059m

King et al. (2004) observed a strong positive correlation between the intensity of land development in a watershed—characterized by % impervious surface, % total developed land, % high-intensity residential + commercial land, and % commercial land—and the total amount of PCBs found in white perch sampled from subestuaries fed into by the watershed. They also found that developed land close to subesturaries had the greatest effect on the PCB concentration in the fish. This knowledge can help to identify unsampled subestuaries with a high risk of PCB contamination.

Maryland Department of the Environment (MDE). 2020. Standard Operating Procedures for Fish and Shellfish Collection, Analysis, Data Management, and QA/QC. Maryland Department of the Environment.

This manual provides detailed information on standard operating procedures (SOP) from MDE's Water and Science Administration (WSA) for the collection and analysis of fish and shellfish tissue.

Sparks, Daniel W., Fish, Polychlorinated Biphenyls (PCBs) and Natural Resource Injury. (2017). Graduate Theses, Dissertations, and Problem Reports. 6696. https://researchrepository.wvu.edu/etd/6696

Creek chubs at several PCB-contaminated locations were studied. Their liver health, oxidative stress enzymes, reproductive condition, age and growth were examined. The researchers observed reduced survivorship in females at PCB sites as well as the alteration of certain reproductive aspects such as reduced vitellogenin, altered sex steroid ratios, reduced fertility, delayed/impaired spawning of ova, and reduced/impaired testes maturation. They also noticed that general growth and survival were an issue in PCB-contaminated streams.

Examples of Local, State, and Federal Programs for PCB Source Trackdowns

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Belton, T., Botts, J., Lippincott, L., & Stevenson, E. (2008). PCB TMDLs, Pollution Minimization Plans and Source Trackdown in Camden City (United States, New Jersey Department of Environmental Protection, Division of Science, Research and Technology). Trenton, NJ: New Jersey Department of Environmental Protection

Belton et al. (2008) executed a PCB source trackdown study in the sewer collection system of a NJ county using the EPA PCB analytical Method 1668a, quantification of PCB congeners, a passive *in-situ* continuous extraction sampler (PISCES), and GIS. They found that 24-hour composite sampling allowed the most confidence in analytical results, grab sampling effectively identified PCBs in wastewater, and the use of PISCES offered the advantage of long-term media integration. GIS analysis indicated that potential sources were located in more industrialized areas. Source categories—listed in decreasing order of nearby street soil PCB concentrations—were determined to be (1) known HazMat contaminated sites, (2) metal reclamation sites, (3) gas pipelines, (4) transportation, (5) drum cleaning, (6) manufacturing, (7) paper-pulping, (8) waste management, (9) electrical transmission, (10) concrete aggregate processing, and (11) landfills.

Benoit, N., Dove, A., Burniston, D. and Boyd, D. (2016) Tracking PCB Contamination in Ontario Great Lakes Tributaries: Development of Methodologies and Lessons Learned for Watershed Based Investigations. Journal of Environmental Protection, 7, 390-409. http://dx.doi.org/10.4236/jep.2016.73035

Benoit et al. (2016) examined PCB concentrations in sediment, soil, water, passive samplers, benthic invertebrates, young-of-the-year fish, and mussels to evaluate bioavailability and identify potential PCB sources for Great Lakes tributaries. Their methods also included fingerprinting PCB congener profiles, using chemometric techniques, and studying anecdotal information such as land use history and alterations to tributaries. They concluded that comparing homologs or congener patterns for similarities is the best method for fingerprinting between sites, statistical mining and data reduction techniques such as principal component analysis (PCA) are useful for comparing PCB patterns not evident by congener patterns, and that young-of-the-year forage fish are the best suited for source trackdown because they have enough tissue to integrate PCBs over their lifetime and because of their lower vulnerability to substrate differences.

Delaware DNREC. (2014). Policy for Polychlorinated Biphenyl (PCB) Analysis Method (United States, Delaware Department of Natural Resources and Environmental Control, Division of Waste and Hazardous Substances). Dover, DE: Delaware Department of Natural Resources and Environmental Control.

This policy memo lists standards for three PCB analysis methods. (1) EPA Method 8082 detects the presence of PCB aroclors via the screening of soil samples and sending one or more samples to HSCA-approved labs for confirmatory analysis. Although cost effective (≈ $85/sample), if PCBs are present in non-aroclor form, or the aroclor is too weathered, results can be incorrectly reported as not detected. This method is most effective when a release of PCBs has occurred within the last 6 months. (2) EPA Method 680 detects PCB homologs—the 10 "families" of congeners containing 1-10 Cl atoms. It can detect PCBs not in aroclor form as well as weathered aroclors, allowing it to provide the PCB concentration used for site-specific human health and ecological risk assessments, however, it is much more expensive than Method 8082 (≈$475/sample). (3) EPA Method 1668 uses a gas chromatography/mass spectrometry procedure to identify the presence and concentration of each of the 209 PCB congeners. It can be used to quantify dioxin-like PCBs and track unique signatures to compare with specific source areas. It can detect much lower concentrations than Methods 8082 and 680, but is the most expensive of the three (≈$750-$1000/sample).

King County (2016). A Review of Select PCB Source Tracing Programs. Prepared by J. Colton, R. Jack, C. Greyell, and C. Magan, Water and Land Resources Division. Seattle, Washington.

This report summarizes PCB source tracing programs in Washington State, Oregon, the San Francisco Bay Area, and the Delaware River Basin. In the Lower Duwamish Waterway of King County (KC), Washington, a framework identifying source control issues and implementing controls was outlined. This included synthesis of chemistry data for stormwater (SW), SW solids, baseflow, and oil water separator and treatment solids collected in the watershed as well as surveys of construction materials, guano and product testing.

A source tracking study was conducted by the Washington Dept. of Ecology at North Boeing Field—a sediment site ranked as requiring early remediation. Soil samplings and storm line cleanings were done in catch basins, manholes and the KC pump station, but high PCB sediment concentrations were still detected after several cleanings which indicated an ongoing PCB source. PCBs in caulk material were also found after visual inspection, material analysis, and sampling. After removal of contaminated caulking, sediment traps were deployed upstream and downstream from suspected source areas for 4-6 months to collect SW runoff samples. Comparing samples allowed for the identification of the greatest PCB contributor to the station.

In Seattle, a PCB source identification and control plan was implemented for the city's storm drain system. This included sampling from the city's drainage system, private properties and business inspections, starting at the downstream end of SW basins or at key junctions and moving upstream. Samples were also taken at catch basins during business inspection. Sediment samples were preferred to water due to PCBs' insolubility and their tendency to adsorb to particles. Inline sediment traps/grab samples, catch basin solids, and soil/street dust samples were used to identify potential sources. Pilot tests in 2016 were conducted to see if trained dogs can locate PCB sources at industrial sites.

In Tacoma, WA's Commencement Bay Superfund Site, after sediment cleanup activities, fate and transport modeling determined that PCB and other contaminant concentrations would continue to rise under current conditions. The City's strategy included source control actions, sediment monitoring in waterways downstream from the bay, SW and suspended sediment monitoring, and computer modeling to predict sediment concentrations in waterways. Program activities were integrated with those required by the Phase I Municipal Stormwater NPDES permit. Water samples were collected as composites by autosamples, and inline sediment traps were collected in non-tidal SW outfall drainages for a year. Samples were analyzed using EPA Method 8270. SW sediment trap data was analyzed using ANOVA and post-hoc testing by Dunn test. Although no significant spatial differences were found from the analysis (in part due to intermittent detections), they were able to reduce the area of interest.

In Portland's Lower Willamette River Superfund Site, the City and the Oregon Dept. of Environmental Quality (ODEQ) created a source control program where ODEQ addressed high priority sites and the City addressed lower priority ones. Drainage basin and conveyance maps, land usage and zoning maps, outfall sediment concentrations, databases of state and federal cleanup programs, and city records of properties within the basins were used in the investigation. The City used catch basins, manhole and in-pipe grabs, sediment traps and a unique inline sediment trap (Patent No. US8857280 B2) to collect samples. After identifying outfalls with high sediment PCB concentrations, the City conducted SW solids sampling at areas representative of the drainage like outfall basins or at key branches. After evaluation, inline solids/SW sampling was added to refine source locations. Once sources were identified, the information was compiled and referred to ODEQ for remediation.

. In the San Francisco Bay area, sediment studies were completed to identify areas contributing the most sediment and associated pollutants. It was found that industrial, commercial and residential urban sites contributed the most to the PCB load, and stormwater was the leading PCB pathway to the Bay. The Ettie St. Pump Station in Oakland was identified as having one of the highest PCB sediment concentrations in the region. Phase I sampling was conducted during the dry season to maximize the retention of fine sediments in the system. Samples were collected from drainage lines leading to the pump stations, although two were eliminated due to short length and lack of deposition. Weirs were determined to be the best sampling locations. Since the PCB load was associated with fine sediment, concentrations were examined as total PCBs normalized to percent of fines. Phase II composite samples were taken from inlets in industrial areas. Congener profiles were studied to make correlations between locations and highlight differences between sources. A multiple linear regression analysis indicated that areas with the highest PCB concentrations were not the most significant contributors to PCB loading, and that other nearby locations should be prioritized. The Clean Watersheds for a Clean Bay project (CW4CB) identified high priority watersheds by conducting a records review, windshield survey, site inspections, and sediment/soil sampling.

Multi-step TMDLs for PCBs in the states of PA, DE, and NJ were developed by the DE River Basin Commission (DRBC). EPA Method 1668A monitoring and individual Pollution Minimization Plans (PMPs) were required instead of PCB limits for each point source discharger. The PMPs consisted of listing known/potential PCB sources on the site, biannual end-of-pipe monitoring, source tracing, reduction strategies, source prioritization, and remediation when necessary. Effluent PCBs were monitored from a range of one every two years to several wet and dry season samples per year if the discharger has continuous flow. Samples were collected as 24-hour-time-weighted samples or as grab samples. Results were added to a database accessible to all permittees.

The report acknowledges that no tool or combination of tools were consistently effective due to the unique characteristics, history and regulatory situation of each watershed. However, the most common method was by sampling solids via trap/catch basin grabs to characterize basins and trace upstream sources. PCB sources are often industrial or construction materials. Stormwater is often the major pathway of PCBs to water bodies. PCB congener data allows for advanced analysis and distinguishability of PCB types and pathways. It is particularly important that source tracing communities share information for more effective/efficient PCB tracing.

Source Identification, Assessment, and Tracking

Baker, J. E., D. Burdige, T. M. Church, G. Cutter, R. M. Dickhut, D. L. Leister, J. M. Ondov, and J. R. Scudlark. 1994. Chesapeake Bay Atmospheric Deposition Study Phase II Final Report: July 1990-December 1991. U. S. Environmental Protection Agency, Chesapeake Bay Program, Annapolis, MD.

Baker et al. (1994) conducted an 18-month field study to determine atmospheric loadings of PCBs, PAHs, and other trace elements at three field stations around the Chesapeake Bay. These elements were measured in the ambient atmosphere and in precipitation. The mean ambient concentration of PCBs was 0.21 ng/m^3 at the mid-bay station and 0.30 ng/m^3 at the southern bay station.

Bressy, A., Gromaire, M., Lorgeoux, C., Saad, M., Leroy, F., & Chebbo, G. (2012). Towards the determination of an optimal scale for STORMWATER Quality management: Micropollutants in a small residential catchment. Water Research, 46(20), 6799-6810. doi:10.1016/j.watres.2011.12.017

Stormwater and atmospheric deposits in a small residential catchment near Paris were collected to determine micropollutant levels, including PCBs. Pollutants in runoff water were identified and quantified over three rain events. Fluxes were quantified over the course of a year and PCBs/other pollutants were separated using silica columns. Quantitative results were only received from PCB molecules with the lowest weights and substitution rates. Atmospheric fallout appeared to be the only means of introducing PCBs to runoff in the area. PCB concentrations were significantly lower at the upstream catchment than those reported in literature downstream of separate, larger systems.

Cao S, Capozzi SL, Kjellerup BV, Davis AP. Polychlorinated biphenyls in stormwater sediments: Relationships with land use and particle characteristics. Water Res. 2019 Oct 15;163:114865. doi: 10.1016/j.watres.2019.114865. Epub 2019 Jul 16. PMID: 31351351.

Cao et al. (2019) provide guidance for PCB TMDL implementation, evaluate PCB affiliation with particulates, and examine the fate of PCBs in bioretention systems. They gathered samples from the Baltimore-Washington area and utilized fractionation, microwave-assisted extraction, alumina cleanup, and gas chromatography in their analysis. Smaller stormwater particles had a higher tendency to adsorb PCBs, but the greatest mass was in larger particles. Higher PCB concentrations were found in dense urban areas while lower concentrations were found in green spaces.

Duffield Associates Inc. 2016. Pollutant Minimization Plan (PMP) for Polychlorinated Biphenyls (PCBs). Duffield Associates, Inc. Wilmington, DE.

This Pollutant Minimization Plan (PMP) for PCBs was prepared as required by NPDES Permit Number DE 0051071. The plan proposes to gather information leading to a better understanding of the overland transport of PCBs into the municipal separate storm sewer system (MS4) located in New Castle County, DE, which in turn will be used to propose a path forward to further assess or otherwise address identified sources.

Environmental Standards, Inc. 2016. Sampling and Analysis Plan - Christina Basin and Shellpot Creek Watersheds - Pollutant Minimization Plan (PMP) for Polychlorinated Biphenyls (PCBs). Environmental Standards, Inc. Valley Forge, PA.

This sampling and analysis plan (SAP) is part of the pollutant minimization plan (PMP) addressing the potential conveyance of PCBs in the Delaware River watershed from the municipal separate storm sewer system (MS4) located in New Castle County, Delaware. The plan describes the sampling and analytical approach to obtain high-quality PCB data at various stormwater discharge locations (outfalls) from the MS4 into the Christina Basin and Shellpot Creek.

Environmental Standards, Inc. 2018. Sampling and Analysis Plan - Red Lion Creek and Chesapeake & Delaware (C&D) Canal Watersheds - Pollutant Minimization Plan (PMP) for Polychlorinated Biphenyls (PCBs). Environmental Standards, Inc. Valley Forge, PA.

This sampling and analysis plan (SAP) is part of the pollutant minimization plan (PMP) addressing the potential conveyance of PCBs in the Delaware River watershed from the municipal separate storm sewer system (MS4) located in New Castle County, Delaware. The plan describes the sampling and analytical approach to obtain high-quality PCB data at various stormwater discharge locations (outfalls) from the MS4 into the Red Lion Creek and Chesapeake and Delaware (C&D) Canal watersheds.

EPA. (2021, April 30). Learn about polychlorinated biphenyls (PCBs). Retrieved May 06, 2021, from https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls-pcbs

On this website, the EPA provides information on PCBs, including a description of what PCBs are, the definition of inadvertent PCBs, commercial uses, examples of PCB releases, definitions of congeners and homologs, trade names and mixtures, health effects, and laws and regulations related to PCBs. Links are also provided for cleanup procedures for PCBs, disposal and storage of PCBs, PCBs in building materials, and contact information for regional PCB programs.

Eriksson, E., Baun, A., Scholes, L., Ledin, A., Ahlman, S., Revitt, M., ... Mikkelsen, P. (2007). Selected stormwater priority Pollutants — a European perspective. Science of The Total Environment, 383(1-3), 41-51. doi:10.1016/j.scitotenv.2007.05.028

Eriksson et al. (2007) propose a list of stormwater priority pollutants for evaluation of chemical risks. PCB-28 was chosen as the PCB to prioritize because it was the most water-soluble PCB confirmed to be present in storm runoff, and so it is most likely to be mobilized.

Strachan, W M.J. Polychlorinated biphenyls (PCBs) - fate and effects in the Canadian environment. Canada: N. p., 1988. Web.

Assessment of the hazards posed by PCBs in Canada suggests the atmosphere to be a major medium for PCB transport in the biosphere, and the distribution of PCBs was shown to be potentially global. It was also speculated that foods are a major vector, although concentrations at the time of the study were not enough to be acutely harmful.

Yagecic, J.R. 2014. Identification and Assessment of Polychlorinated Biphenyls (PCBs) in Storm Water in the Delaware Estuary. Delaware River Basin Commission. West Trenton, NJ.

This report summarizes a project completed by the Delaware River Basin Commission (DRBC) with the objective of identifying and assessing non-point sources of PCBs to the Delaware Estuary. The main task associated with the project involves collection of storm water runoff samples from selected sub-basins and analysis of these samples for PCB congeners. The report describes sampling and analytical methodologies as well as the lessons learned and recommendations for future work.

Krauss M. and Wilcke, W. 2003. Polychlorinated naphthalenes in urban soils: analysis, concentrations, and relation to other persistent organic pollutants. *Environmental Pollution*. 122, 75-89. https://doi.org/10.1016/S0269-7491(02)00285-3

This paper describes the sampling of urban and rural topsoils and testing for organic pollutants such as PCBs, PCNs, and PAHs. Pollutant concentrations were highest at industrial sites and house gardens. Rural soils receive these organic pollutants through atmospheric deposition while urban soils often receive them through site-specific sources. Lower chlorinated PCBs were more prevalent in rural areas because they are more volatile and subject to increased atmospheric transport.

TMDL Model Creation

Delaware River Basin Commission. (2006). (tech.). Total Maximum Daily Load for Polychlorinated Biphenyls (PCBs) for Zone 6 of the Delaware River. Trenton, NJ.

A TMDL for PCBs was developed for Zone 6 of the Delaware River by the Delaware River Basin Commission (DRBC). Pentachlorobiphenyls, the penta-PCB homolog group, were used as a surrogate for total PCBs with a 1:4 penta-PCB to total PCB ratio. EPA Method 1668A was used to ID and quantify all congeners in water, sediment, soil and fish tissue. Yearly ambient water surveys using this method are utilized to track TMDL achievement progress. The DRBC required NPDES permittees to continuously monitor for PCB congeners. They also worked with a university to monitor air emissions at two urban sites for PCBs. Using a one year hydrologic condition, they created a one-dimensional model for penta-PCBs to calculate external loads, boundary loads, exchanges between river zones, gas phase exchanges, net sediment-water diffusion, and net settling and resuspension of particulate PCBs. Decadal and centennial scale model simulations were also conducted to consider seasonal variations in certain model input parameters.

Interstate Commission on the Potomac River Basin. (2007). (rep.). Total Maximum Daily Loads of Polychlorinated Biphenyls (PCBs) for Tidal Portions of the Potomac and Anacostia Rivers in the District of Columbia, Maryland, and Virginia. Rockville, MD.

The Interstate Commission on the Potomac River Basin (ICPRB) listed 28 segments of the tidal waters of the Potomac and Anacostia Rivers as impaired by PCBs, and TMDLs were created to ensure that the designated use of “fish consumption” is protected. To inform the TMDL’s creation, several hundred water, sediment, and fish tissue samples were used to create a model for the Potomac, simulating the transport and fate of PCB homologs 3-10 over the course of a hydrologic design year. PCB concentrations in semipermeable membrane devices (SPMDs) revealed patterns by reach and region. PCB levels in the water column and sediment were related to fish tissue concentrations using a method based on bioaccumulation factors (BAFs). BAFs for non-migratory fish species were calculated to select a target species based on the highest BAF and data availability. Daily flows and loads from direct drainage and several lower basin tributaries were estimated using the Chesapeake Bay Watershed Model (WM5). Loadest Program regression model 9 was used to estimate PCB and carbon loads from the non-tidal Potomac River. Daily PCB and carbon loads from WWTPs were estimated from facility PCB and biochemical oxygen demand (BOD) concentrations and monthly/daily average flows. Daily atmospheric loads were estimated from literature, and contaminated site loads were estimated by the Revised Universal Soil Loss Equation (RUSLE2).

LimnoTech. (2013). (rep.). Statewide Michigan PCB Total Maximum Daily Load (TMDL). Ann Arbor, MI.

This PCB TMDL was developed for inland water bodies in Michigan primarily impacted by atmospheric deposition. Fish consumption is the most significant route of human exposure, so a fish tissue residue value was recommended as the TMDL’s target. A trend analysis was conducted on datasets for fish collected every two to five years. Concentrations in fish tissue were analyzed as total congeners. Lake trout were selected as a representative species because they have the second highest tissue PCB concentration, are a native species, a trophic level 4 fish, and are a preferred sport fish species. The gas phase was the largest source of PCBs to surface waters, and air PCB concentrations were measured from 1992 to 2002 with a general decrease during that time. Water column samples were taken, but only met the water quality standard (WQS) on one occasion in a ten year period. These samples are no longer collected due to their high cost and the knowledge that almost all samples exceed the WQS

PCB Remediation and Best Management Practices (BMPs)

Cao, Siqi. (2020). "Occurrence and Removal of Polychlorinated Biphenyls (PCBs) in Urban Stormwater." PhD diss. University of Maryland, College Park.

Cao (2020) found that smaller stormwater particles have an increased tendency to adsorb PCBs than larger particles, but greater PCB mass is in larger particles. They concluded that buildings appear to contribute more PCBs to stormwater than roads, that sediment capture may be a viable treatment for stormwater PCBs, and that PCB concentration decreases as the bioretention media depth increases and with distance from stormwater entrance.

David, N., Leatherbarrow, J.E., Yee, D. and McKee, L.J. (2015). Removal Efficiencies of a Bioretention System for Trace Metals, PCBs, PAHs, and Dioxins in a Semiarid Environment. *Journal of Environmental Engineering*. 141(6), 04014092. https://doi.org/10.1061/(ASCE)EE.1943-7870.0000921

David et al. (2015) set up a bioretention system composed of four rain gardens and one bioswale in Daly City, CA and analyzed its effectiveness. They compared PCB concentrations in stormwater before and after the system was installed and observed a 44% decrease in mean stormwater PCB concentration with the bioretention system as well as a 82% reduction in the loading rate. Higher chlorinated PCBs showed the greatest decrease, which could be explained by the bioretention system more effectively removing PCB congeners that are more strongly associated with particles.

Geosyntec. 2010. Desktop Evaluation of Controls for Polychlorinated Biphenyls and Mercury Load Reduction. Geosyntec Consultants. San Francisco Estuary Institute. Oakland, CA.

This report builds off the findings of a White Paper that analyzed mercury and PCB usage in the San Francisco Bay Area and identified and quantified the various sources. The authors completed a Desktop Evaluation consisting of two parts: (1) the characterization of sources by land use—done by using spreadsheets to calculate the annual loads of mercury and PCB to the Bay from different land use categories—and (2) the evaluation of BMP scenarios through the use of BMP scenario spreadsheets incorporating local, regional and national data to calculate the mercury and PCB load reduction estimate for the BMP scenarios.

Gilbreath A., L. McKee, I. Shimabuku, D. Lin, L.M. Werbowski, X. Zhu, J. Grbic, and C. Rochman. 2019. Multi-year water quality performance and mass accumulation of PCBs,

mercury, methylmercury, copper and microplastics in a bioretention rain garden. SFEI Contribution #872. San Francisco Estuary Institute, Richmond, CA.

Gilbreath et al. (2019) set up a bioretention cell located near a roadway with heavy traffic in the San Francisco Bay Area and planted it with native drought-tolerant species. They found that stormwater PCB and suspended sediment concentrations were reduced by over 90% after passing through the cell while other pollutants such as heavy metals were also moderately captured. The study also provides useful data for supporting decisions about bioretention cell media replacement and overall maintenance schedules.

Glass, J.S. and Kelly, T.M. 2010. Polychlorinated Biphenyls in Stormwater Sediments at Bernalillo County, New Mexico. US EPA Urban Waters Partnership Presentation. https://www.epa.gov/urbanwaterspartners/polychlorinated-biphenyls-stormwater-and-sediments-middle-rio-grande

This study, completed by the Bernalillo County Public Works Division in conjunction with the US Geological Survey, assesses historical discharges of PCBs from county stormwater facilities by examining sediment-bound PCBs and it evaluates the efficacy of a stormwater BMP treatment facility for reducing PCB concentrations. They established that passive sediment removal followed by treatment in a constructed wetlands effectively reduces PCB concentrations in stormwater.

Kjellerup B.V. and A.P. Davis. 2019. Treatment Media for Control of Persistent Organic Pollutants and Metals in Stormwater. PCB TMDL Technical Workshop. University of Maryland at College Park, MD.

Geomedia for stormwater treatment should be selected based on six criteria: (1) adsorption capacity, (2) adsorption kinetics, (3) hydraulic conductivity, (4) no leaching of contaminants of concern (COC), (5) ease of production and handling, and (6) COC biodegradation potential.

Kjellerup B.V. 2019. Removal of the toxic contaminants PCBs and PAHs by urban BMPs. STAC Workshop Contaminants of Concern in Ag/Urban Settings. University of Maryland at College Park, MD.

Kjellerup (2019) summarizes several studies in this presentation. PCB 11 can be a marker of non-legacy PCB contamination. PCB concentration and toxicity decreases with depth in a bioretention cell and distance from the entrance. Soil biofilms enhance the PCB dechlorination rate because they contain PCB-dechlorinating bacteria. Biofilms on granulated activated carbon (GAC) were the most effective for PCB degradation.

Leigh, M.B., Prouzova, P., Mackova, M., Macek, T., Nagle, D.P. and Fletcher, J.S. 2006. Polychlorinated Biphenyl (PCB)-Degrading Bacteria Associated with Trees in a PCB-Contaminated Site. *Applied and Environmental Microbiology*. 72(4), 2331-2342. https://doi.org/10.1128/AEM.72.4.2331-2342.2006

Leigh et al. (2006) worked to identify plants that enhance the microbial PCB degradation potential in soil. They noticed significantly higher numbers of PCB degraders in the root zones of Austrian pine (*Pinus nigra*) and goat willow (*Salix caprea*) than in the root ones of other plants or non-root-containing soil in certain seasons and at certain soil depths. The majority of

PCB-degrading bacteria belonged to the genus *Rhodococcus*. Other PCB-degrading bacteria were members of the genera *Luteibacter* and *Williamsia*.

MacGillivray R. 2019. Lessons Learned from other watersheds: Delaware River Basin Contaminants of Emerging Concern Surveys & PCB TMDL. STAC workshop. Delaware River Basin Commission. West Trenton, NJ.

The Delaware Estuary was severely impaired by PCBs which led to the establishment of PCB TMDLs for the Estuary and Bay in 2003 and 2006. Point dischargers were required to adopt pollutant minimization plans (PMPs) which included the removal of known PCB sources, the tracking back of potential sources and removal, and monitoring of discharge using EPA Method 1668A. State agencies were in charge of PCB cleanup and cutting off PCB pathways of contaminated sites. Through these methods, there was a 76% reduction in PCB loadings from the top 10 point source dischargers from 2005 to 2016. The implementation of these TMDLs illustrated the importance and effectiveness of a basin and interstate approach through organizations like the Delaware River Basin Commission and Chesapeake Bay Program.

National Research Council. A Risk-Management Strategy for PCB-Contaminated Sediments. Washington, D.C.: National Academy Press, 2001.

In this report, the National Research Council’s Committee on the Remediation of PCB-Contaminated Sediments propose a framework and guidance for assessing the risks of managing PCB-contaminated sediment. Based on the assessment of selected unique contaminated sites, they present general conclusions and make recommendations for further scientific and engineering research. They also provide a general assessment of the human health and ecological impacts associated with management approaches that may be used at contaminated sites.

Tetra Tech. 2019. Assessing Benefits of Wastewater Treatment Plant Nutrient Control Upgrades on Toxic Contaminants. Tetra Tech, Inc. Owing Mills, MD.

Upgrading wastewater treatment plants (WWTPs) for enhanced biological nutrient reduction (ENR) is highly likely to aid in the reduction of effluent toxic compounds like PCB. Because PCBs are strongly hydrophobic, processes that reduce suspended solids in WWTP effluents, such as advanced filtration for low level total phosphorus treatment, will reduce PCB concentrations in the effluent as well.