

**Date:** February 26, 2015

**To:** Urban Stormwater Work Group  
Agricultural Work Group  
Wastewater Work Group

**From:** Tom Schueler, Chesapeake Stormwater Network

**Re:** Soliciting Feedback on Draft Project Work Plan:  
*Summarizing Potential Benefits of Nutrient and Sediment Practices  
to Reduce Toxic Contaminants in the Chesapeake Bay watershed*

**Request:** CSN is soliciting feedback from the sector workgroups on the technical approach for this project and to identify any specific research or monitoring studies that could support the project. Comments and resources are requested to be sent to me [watershedguy@hotmail.com](mailto:watershedguy@hotmail.com) **no later than Friday, March 13.**

## **Background and Purpose of Project**

One of the key outcomes under the Toxic Contaminant Goal established in the 2014 Chesapeake Bay Watershed Agreement is to "identify which best management practices (BMPs) might provide multiple benefits of reducing nutrient and sediment pollution as well as toxic contaminants in waterways". Such multiple benefits could provide significant cost savings to the Chesapeake Bay Partnership to simultaneously meet the Bay TMDL and to reduce toxic contaminants in the environment.

The broad purpose of this one year study is to:

- (1) Investigate the potential toxic contaminant reduction benefits that could be associated with the implementation of BMPs for sediment and nutrient reduction under the Bay TMDL.
- (2) Provide water resource managers with better BMP data to develop more effective local TMDLs and action strategies to control toxic pollutants in the watershed.

To support this outcome, the Chesapeake Bay Trust issued an RFP on the behalf of the Chesapeake Bay Partnership, and selected the Chesapeake Stormwater Network (CSN) to perform the technical analyses on January 28, 2015. In its proposal, CSN indicated the need to get broad feedback from the many CBP workgroups involved in this issue, and solicit important research citations, resources and monitoring data from the sector work groups.

The work groups will need to make several important choices to ensure this highly interdisciplinary project will ultimately be successful. These choices are broadly outlined

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in the subsequent project work plan which presents proposals on how to organize the work to accomplish several tasks:

- Select priority toxins with highest environmental risk to the Bay
- Link toxic sources and pathways to BMP treatment, and
- Develop protocols to estimate potential toxic reduction by various BMPs.

## Technical Approach for the Project

To complete the project, CSN will perform four major technical tasks, as follows:

### Task 1: Screening to Prioritize Toxins and BMPs For Intensive Analysis

Under the first task, CSN will develop a technical approach to prioritize which toxic contaminants and BMPs should be targeted for further analysis, based on three screening tiers, as outlined below:

#### Tier 1 Screening: Identifying Toxic Contaminants with Greatest Environmental Risk.

The first tier involves prioritizing the universe of toxic contaminants based on their potential environmental risk in the Bay watershed. The degree of environmental risk is broadly defined based on three primary criteria, as previously established by CBP (2012).

(a) Relative extent of the individual toxic contaminant in the Bay watershed based on prior monitoring data that indicate it has been detected in water, sediment, and/or tissue samples, as summarized in CBP (2012).

(b) Relative severity of the human health and/or fish and wildlife impacts caused by the toxin in localized hotspots or across the entire Bay watershed.

(c) Toxins that Bay states have directly linked to water quality impairments and/or fish consumption advisories in specific receiving waters within the Bay watershed.

Based on this first tier of screening analysis, a priority list of nearly 45 toxic contaminants is proposed for review (Table 1). It should be noted that some emerging toxic contaminants were included on the list even though data on their prevalence and risk were less certain.

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**Table 1: Priority Contaminants to Investigate Based on Environmental Risk<sup>1</sup>**

#	Toxic Category	Individual Contaminants
1	PCBs	Total PCBs
2	Dioxins	Dioxins
3	PAH's	Total PAH, benzo(a)pyrene, naphthalene <sup>2</sup>
4	Petroleum HC	TPH, oil and grease, benzene <sup>3</sup>
5a	Legacy Pesticides <sup>4</sup>	DDT/DDE, chlordane, dieldrin, diazinon <sup>5</sup> , chlorpyrifos <sup>5</sup>
5b	Current Pesticides <sup>6</sup>	atrazine, acetochlor, glyphosate, fipronil, simazine, metolachlor, prometon, carbaryl, malathion, 2,4-D, dichlorvos
6	Pharmaceuticals <sup>7</sup>	caffeine, acetaminophen, carbamazepine, tetracycline
7	HPCPs <sup>7</sup>	phthalates, triclosan, triclocarban, surfactants
8	Flame Retardants <sup>8</sup>	PBDE
9	Biogenic Hormones <sup>7</sup>	Estradiol, estrone, testosterone
10	Trace Metals <sup>9</sup>	As, Cu, Cd, Cr, Hg, Pb, Zn, Chloride <sup>10</sup>
<b>Codes:</b> PCB's = Polychlorinated Biphenyls, PAH= Polycyclic Aromatic Hydrocarbons, HPCP= Household and Personal Care Products, PBDE = Polybrominated Diphenyl Ether, TPH: Total Petroleum Hydrocarbons. <b>Notes:</b> <sup>1</sup> As defined by the extent and prevalence of the contaminant in the Bay watershed, as well as actual impairments or fish advisories, as defined in CBP (2012). <sup>2</sup> The team may also categorize PAH's by molecular weight (high/low), and/or whether they are pyrogenic or not <sup>3</sup> There are at least 14 additional hydrocarbons that could be listed, but these have the greatest potency <sup>4</sup> Legacy BMPs refer to insecticides that have been banned or phased out, but have such long half lives that they are still detected in the environment; this list is based on a national assessment of pesticide prevalence in streams and groundwater by Gilliom et al (2006). <sup>5</sup> While not banned like other legacy BMPs, their use has been seriously restricted since 2001 <sup>6</sup> The list of pesticides currently being applied changes constantly, this list was compiled based on recent data from a national assessment of pesticide prevalence in streams and groundwater (Stone et al, 2014) <sup>7</sup> Research for these categories will be primarily restricted to wastewater operations <sup>8</sup> Depending on the availability and quality of monitoring data for this emerging toxicant, this category may be omitted from the literature search <sup>9</sup> While there are also impairments for Mn and Fe in the watershed, they tend to be associated with discharges from abandoned mines, and are not subject to treatment by conventional BMPs. <sup>10</sup> While chloride is not a metal, it has been classified as a toxin by Environment Canada.		

## Tier 2 Screening: Matching Toxic Sources and Pathways to BMPs in the Watershed.

The second tier of screening involves targeting where toxics are being generated in the watershed, and which pathways they tend to move through. This tier is important since it influences which land use sectors and BMPs could most effectively capture or treat individual toxins in the Bay watershed.

The screening analysis will evaluate four key factors, as shown in Table 2 and described below.

1. **Primary Sector:** Most toxics tend to be associated with a specific land use sector (e.g., urban or agricultural), whereas others are dispersed across many watershed sectors (e.g., mixed). In addition, some emerging toxics of concern are generated from "point" sources, such as wastewater, feedlot or septic effluents. A good understanding of the primary sector is needed to identify the most

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appropriate BMP or treatment process that could be applied to each individual toxic compound.

*2. Key Watershed Sources:* Given the diversity of toxics found in the watershed, it is not surprising that there are many different sources, including atmospheric deposition, spills, applications and a variety of wastewater discharges. Some of these sources can be managed by a BMP, whereas other may not.

*3. Hydrologic Pathways.* Some toxics are primarily transported via surface water or stormwater runoff, whereas others move through groundwater. Lastly, others are discharged from different kinds of wastewater discharges. Most of the traditional BMPs are primarily designed to treat pollutants transported in agricultural and/or urban stormwater, while a smaller number are capable of reducing pollutants transported in groundwater or wastewater effluent.

*4. Landscape Position:* The relative landscape position where the toxic is discharged can have a strong influence on BMP treatability. For the screening analysis, toxics could potentially be discharged from either upland areas, the stream corridor, or into a river basin segment (e.g., wastewater effluent). With a few exceptions, most BMPs are located in upland areas. Consequently, toxics that are located further downstream are less likely to be treated by a BMP and more likely to be delivered to the main stem of the Bay

The ten toxic contaminant categories will be screened according to these four factors. Initial results from the screening can be found in Table 2.

<b>Table 2: Matching Toxic Sources and Pathways to BMPs in the Watershed</b>					
<i>Toxic Category <sup>1</sup></i>		<i>Dominant Sector(s)</i>	<i>Key Watershed Sources</i>	<i>Hydrologic Pathway</i>	<i>Landscape Position</i>
1	PCBs	Urban	CS/Leaks/AD	SW	U
2	Dioxins/Furans	Mixed	CS/Combustion	SW	SC
3	PAH's	Urban	CS/AD/Combustion	SW	U, SC
4	Petroleum HC	Urban	CS/AD, Spills	SW	U
5	Pesticides	Ag, Urban	Legacy, Applications	SW & GW	U
6	Pharmaceuticals	Point	Wastewater, Septic	WW, GW	SC,RS
7	HPCPs	Point	Wastewater, Septic	WW,GW	SC,RS
8	Flame Retardants	?	?	?	?
9	Biogenic Hormones	Ag, Point	Manure, AFOs, Wastewater, Septic	SW,WW,GW	U, SC
10	Metals	Urban, Ag	AD	SW & GW	U
<b>Codes:</b> PCB's = Polychlorinated Biphenyls, PAH= Polycyclic Aromatic Hydrocarbons, HPCP= Household and Personal Care Products, PBDE = Polybrominated Diphenyl Ether, AD = Atmospheric Deposition, CS = Contaminated sediments or sites SW = Stormwater GW= Groundwater, WW = Wastewater Effluent, AFO = Animal Feeding Operation, ? = Unknown, U = Upland, SC =Stream Corridor, RS = River Segment. <sup>1</sup> as defined in CBP (2012).					

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## Tier 3 Screening. Identifying BMPs with Significant Potential to Achieve Toxic Reduction.

While more than 200 BMPs have been approved by the Chesapeake Bay Partnership, many of them are similar and can be grouped together. CSN proposes that 20 major CBP-approved BMPs shown in Table 3 be targeted to determine their toxic reduction potential. CSN will consult with the TCWG, sector coordinators and workgroup chairs to review and modify the priority BMP list, as needed.

<b>Table 3. Priority List of CBP-Approved BMPs for Analysis</b> <sup>1</sup>		
<i>Urban</i> <sup>1, 2</sup>	<i>Agricultural</i> <sup>1, 2</sup>	<i>Wastewater and Forestry</i>
Stormwater Retrofits	Manure Treatment Technology	Onsite Septic Systems
New State Stormwater Stds <sup>3</sup>	Animal Waste Storage Systems	Septic Attenuation
Urban Nutrient Management	Manure Injection/Incorporation	Stream Buffer
Street Cleaning	Cropland Irrigation Mgmt	WWTP Technologies <sup>4</sup>
ND from Grey Infrastructure	Poultry Litter	
Stream Restoration	Conservation Crops	
Stormwater Ponds/Wetlands	Conservation Tillage	
Stormwater Filtering Practices		
<sup>1</sup> Not all of the expert panels listed below have come to consensus, in these cases, CSN will directly contact the expert panel chair or facilitator to at least review any toxics data uncovered during the literature review phase. <sup>2</sup> CSN will work with the workgroup chairs/coordinators to prioritize which past and current expert panels would likely have the most relevance to the management of toxic contaminants, so not every expert panel will need to be fully analyzed (e.g. shoreline management, floating treatment wetlands, etc.). <sup>3</sup> Where data permits, CSN will provide removal rates for individual stormwater practices within this category (i.e., bioretention, permeable pavement, etc.). <sup>4</sup> Wastewater processes and technologies are not a BMP per se, but CSN will work with WWWG to obtain data on their capability to remove toxicants from wastewater influent.		

## **Task 2: Literature Search for Actual BMP Removal Data**

CSN will conduct a national literature review to identify key research on the potential toxic contaminant reductions associated with current approved BMPs for the urban, agricultural, forestry and wastewater sectors.

## **Task 3: Develop and Apply Protocol to Estimate or Infer Toxic Removal Rates for BMPs.**

It is anticipated that there will be little or no actual monitoring data on BMP removal for many toxic contaminants, and consequently, removal rates will need to be estimated based on similarities in the chemical properties of the toxicant, in relation to either sediment, phosphorus or nitrogen removal rates. These three pollutants span a continuum of potential removal potential.

For example, sediment tends to have the highest removal rates because its particles are relatively easy to settle out or filter through a medium, under most conditions. Total phosphorus, on the other hand, has an intermediate removal rate, since it is commonly found in roughly equal particulate and soluble fractions. While the particulate fraction is subject to settling or filtering, removal of the soluble fraction requires further biological uptake and/or adsorption to solids/carbon. Lastly, total nitrogen usually has the lowest

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removal rates, as the various nitrogen species often require specific environmental conditions for microbial communities to be transformed into N gas.

Therefore, under this task, CSN will conduct a review to define the basic characteristics and/or behavior of each toxic contaminant to determine if they can be directly linked to similar properties for sediment, phosphorus and nitrogen, and therefore be assumed to have comparable removal potential.

This approach is best exemplified by toxic contaminants that have "sediment-like characteristics" and would tend to utilize the same sediment removal mechanisms that operate in a particular BMP. Sediment-like characteristics may include one or more of the following:

- A high affinity to bind or adsorb to sediment or organic carbon particles
- Found in a particulate form and associated with a larger particle size diameter.
- A low Henry's Law constant ( $K_H$ )
- A high soil organic carbon-water partition coefficient ( $K_{oc}$ ) (i.e., hydrophobic)
- Low solubility in water
- Long half-life for transformation

In general, data on partition coefficients and other characteristics are readily available for most toxic compounds from chemical databases (e.g., [www.pesticideinfo.org](http://www.pesticideinfo.org)) or literature reviews (e.g., Appendix 2 of Gilliom et al, 2006). Based on this data, CSN will then determine if the toxic contaminant acts in the same general manner as a sediment particle, and therefore should be expected to have the same sediment reduction potential associated with the BMP.

The other end of the removal spectrum involves toxic contaminants with "nitrogen-like" characteristics that require unique removal mechanisms and environmental conditions to achieve high removal levels. A toxic contaminant that acts in "nitrogen-like" manner may include one or more of the following characteristics:

- A low affinity to bind, adsorb or otherwise attach to sediment or organic carbon particles
- Primarily found in soluble forms and/or low molecular weight
- A high Henry's Law constant ( $K_H$ )
- A low soil organic carbon-water partition coefficient ( $K_{oc}$ ) (i.e., hydrophilic)
- Highly soluble in water
- Moderate to short half-life for transformation, often requiring soil- or phyto-bioremediation.

A toxic contaminant with many of the above characteristics can be considered to act in a similar fashion to nitrogen, and have a correspondingly lower BMP removal rate. Toxic contaminants with intermediate characteristics would be presumed to act in the same general manner as total phosphorus.

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Based on this analysis, CSN will make an initial estimate of the potential BMP reduction that could be achieved for each priority toxic contaminant. If actual values cannot be computed, a semi-quantitative estimate will be derived for the contaminant (e.g., high, moderate, low, uncertain, or negative). Where technically supported, these rankings may include with quantitative threshold values for the removal rate removal rate (e.g., greater than 50%. etc).

Along with the potential BMP reduction for each toxin, CSN will also evaluate the treatability of the toxin and the long-term reliability of BMP removal. The treatability variable reflects whether the toxin can actually be captured within a BMP, based on its source, landscape position or hydrologic pathway.

The long-term reliability factor looks at the potential risk that toxics trapped in BMP sediments, media or vegetation could be re-suspended or re-mobilized into the environment. This risk is particularly acute for toxicants with long half lives. CSN will also briefly examine the potential for bioaccumulation of toxins within fish and wildlife that may inhabit the certain BMPs, and outline any issues related to BMP sediment monitoring or testing to ensure safe disposal during maintenance activities.

### **Task 4. Final Project Report**

The BMP toxic reduction estimates will be presented in graphical and tabular form, and a draft final report will be prepared that synthesizes the key findings, identifies the most promising BMPs for toxic reduction, and recommends the most important management actions to reduce sediment, nutrient and toxics to the Bay.

Where possible, the report will assess whether it is feasible to effectively use BMPs to get below toxic action levels or benchmarks for water, sediment and tissue, using the current best estimates of the toxic loading and BMP removal rates. The draft report will also discuss additional BMPs that may need to be investigated (beyond those that are currently approved in the Bay TMDL) in order to better manage toxic contaminants in the watershed, such as soil bioremediation and industrial pollution prevention.

### **References Cited**

Chesapeake Bay Program (CBP). 2012. Technical Report: Toxic contaminants in the Chesapeake Bay and its watershed: extent and severity of occurrence and potential biological effects. U.S. EPA, USGS and U.S. FWS. Annapolis, MD.

Gilliom, R., et al. 2006. The quality of our nation's waters: pesticides in the nation's streams and groundwater, 1992-2001. National Water Quality Assessment Program. U.S. Geological Survey Circular 1291.

Stone, W., R. Gilliom and K. Ryberg. 2014. Pesticides in U.S. streams and rivers: occurrence and trends during 1992-2011. Environmental Science and Technology. 48:11025-11030.

Water Quality Goal Implementation Team (WQGIT). 2014. Protocol for the development, review and approval of loading and effectiveness estimates for nutrient and sediment controls in the Chesapeake Bay Watershed Model. U.S. EPA Chesapeake Bay Program. Annapolis, MD.

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