*Collectively improving stormwater management*

Date: September, 04, 2018

To: Robert Black
SAM Nearshore Sediment Monitoring Lead
US Geological survey

CC: Dana de Leon, chair of the Stormwater Work Group
City of Tacoma

From: Keunyea Song, SAM Scientist, and
Brandi Lubliner, SAM Coordinator,
Department of Ecology Water Quality Program

**Technical Memorandum:** Additional analyses of the SAM Marine Nearshore Sediment Monitoring data

## Highlights

1. This tech memo provides a regional scale assessment of the 2016 SAM nearshore sediment chemistry results from Puget Sound Urban Growth Areas (UGAs).
2. The 49 randomized sites in this study represent 1,357 km (843 mi) of Puget Sound nearshore adjacent to UGAs. The 41 SAM spatially balanced sites alone cover 1,344 km of the nearshore length, contributing 99.1% of the length in the total study whereas the eight additional Pierce County sites represent 12.8 km, or 0.9 % of total nearshore length.
3. Regionally, Puget Sound UGA nearshore sediments had low concentrations of organic contaminants (total PCBs, total PAHs, and total PBDEs).
4. Puget Sound UGA nearshore sediments had low concentrations of metals (As, Cd, Cu, Pb, Hg and Zn), all below the marine sediment quality standards.
5. While metal concentrations were low regionally, significantly higher concentrations of copper and lead were found in incorporated cities than in unincorporated UGAs. This suggests metal accumulation in the urban nearshore.
6. Strong and complex currents in Puget Sound move sediment around and accumulate the contaminants in the areas with low or no currents. Our randomized site were placed in both high energy and low energy environments and the current movement weakened our ability to detect stormwater impacts on sediment chemical distribution in this study design (see the final report Black et al., 2018).

## Background

Stormwater Action Monitoring (SAM) staff conducted additional analyses at the regional scale using the sediment chemistry assessment results gathered in the Puget Sound Urban Growth Area (UGA) nearshore. This memo covers 1) an interpretation of the probabilistic design, 2) a status summary of sediment contamination in the Puget Sound UGA nearshore, and 3) comparison and incorporation of SAM study with additional Pierce County (Option 2) results.

We first calculated the spatial weight for each SAM (SAM was "option 1" in the permit) and Option 2 sites (Result 1, Table 1). Option 2 sites were sampled per Pierce County's chosen alternative municipal stormwater permit monitoring requirements at the smaller spatial scale in the unincorporated UGAs in the county. The spatial weights calculation for Pierce County sites followed the same process but was done separately (Result 1, Table 1).

Next, we extrapolated the site-specific contamination results to the region: the entire Puget Sound UGA nearshore. Spatial weights calculated at the first step and contamination result of sites were used to assess contaminants distribution patterns in the region. We focused on sediment chemistry of three organic contaminant types (total PAHs, PCBs, and PBDEs; Result 2) and six metals (As, Cu, Cd, Pb, Hg and Zn; Result 3) as indicators of Puget Sound urban nearshore sediment quality. Where available, we compared results to the marine sediment quality standards (WAC 173-204-320) to evaluate the status of UGA nearshore sediment quality.

Last, we compared contaminant regional distribution patterns between two subgroups. We followed the same approach as the SAM Mussel tech memo to divide subgroups, 1) SAM regional study sites vs. Option 2 sites, and 2) incorporated cities vs. unincorporated UGA.

The final sediment study report (Black et al., 2018) suggested a significant role the oceanic currents and drift cells in Puget Sound have on redistributing sediments and helps explain this projects' sediment chemistry results. The sediment movement related to oceanic currents and drift cells make it difficult to find reference (*i.e.*, least-disturbed or baseline) conditions; thus we did not compare results to any reference conditions.

## Results & Discussion

## Result 1. Spatial weight adjustment analysis

Spatial weights were calculated for SAM and Option 2 sampling sites (Table 1).

The SAM sediment study sampled 41 sites out of 2008 potential sites in the study area comprised of the marine nearshore adjacent to UGAs in Puget Sound, but excluding the unincorporated portions of UGAs in Pierce County. During site evaluation, eight SAM sites were rejected due to safety concerns and limited accessibility. The final adjusted spatial weight for each SAM site is 32.8 km (20 mi). Pierce County evaluated 20 of the total of 40 candidate sites located along the county's unincorporated UGA nearshore and sampled eight of them. Each Option 2 site represents 1.6 km (1 mi) of UGA nearshore length.

The 49 SAM and Option 2 sites together represent 1,357 km of Puget Sound UGA shoreline length. The 41 SAM sites cover 99.1 % of the length whereas the eight Option 2 sites represent 0.1 % of the total study length. The total sampled nearshore length (1,357 km) became shorter than the original study frame length (1,638 km) due to rejected sites of both studies.

**Table 1.** Results of spatial weights calculations for SAM Option 2 mussel monitoring sites.

| Nearshore Sediment Survey | | SAM | Option 2 | Total |
|---|---|---|---|---|
| **Initial Design** | # of candidate sites | 2008 | 40 | 2048 |
| | Initial study length (km) | 1,606 | 32 | 1,638 |
| **Site information** | # of sampled sites | 41 | 8 | 49 |
| | # of rejected sites | 8 | 12 | 20 |
| **Adjusted length of nearshore in Puget Sound UGAs** | Adjusted length (km) per site | 32.8 | 1.6 | - |
| | Total sampled length (km) | 1,344 | 12.8 | 1,357 |
| **Contribution** | Contribution to total sampled length (%) | 99.1 | 0.9 | 100 |
| | Lost contribution by rejected sites to each option length (%) | 16.3 | 60.0 | - |

## Result 2. Cumulative distribution of organic contaminants in urban Puget Sound nearshore sediments

Regional distribution patterns of organic contaminants (total PCBs, total PAHs, and total PBDEs) are presented in cumulative distribution function (CDF) plots (Figure 1). The Y axis indicates the cumulative percentage of UGA nearshore length and the X axis is the range of contamination.

CDF plots of all organic contaminants show the majority of the area has low concentrations with limited area having higher concentrations (the sharp right turn in the graphs at low concentrations; Figures 1, A-C). Comparison of the contamination patterns shows that Option 2 and SAM nearshore sediment were in similar ranges for the three organics (Figures 1, D-F). Unincorporated UGA nearshore sediment had slightly lower organic chemical contaminants than in incorporated UGAs, but no significant differences were found (Figures 1, G-I).

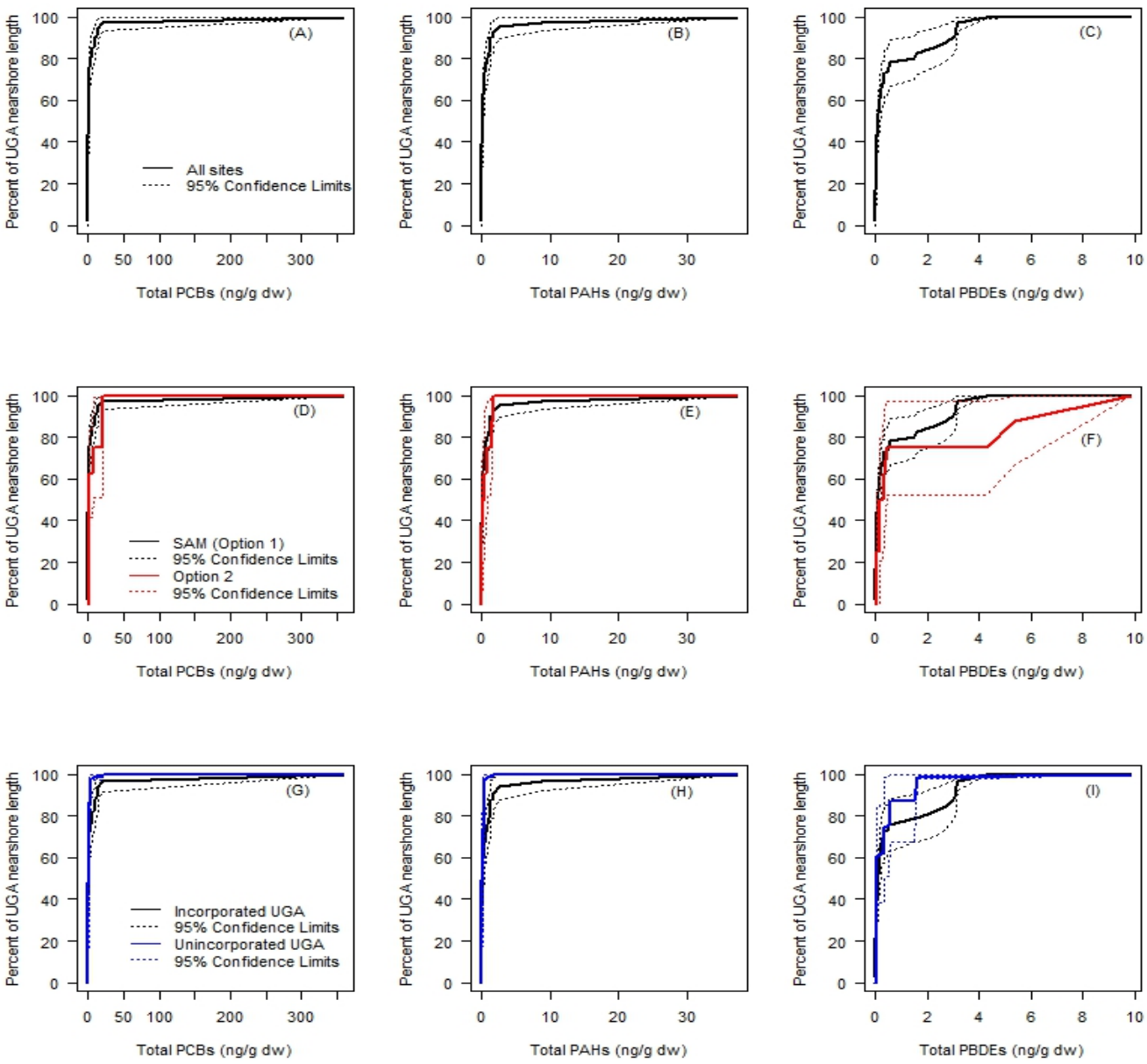


**Figure 1.** Cumulative distribution of organic contaminants in Puget Sound UGA nearshore sediment. A-C are CDFs from all study sites including SAM and Option 2. Total nearshore length 100% represents 1,357 km. D-F are CDFs from two subgroups: SAM sites, in black, representing 1,344 km (100% on Y axis) and Option 2, in red, representing 12.8 km (100% on Y axis). G-I are comparisons of CDFs between two subgroups: incorporated cities, in black, versus unincorporated UGAs, in blue. Total PCBs, PAHs and PBDEs were calculated as group sums of detected concentrations of compounds.

## Result 3. Cumulative distribution of metal concentrations in sediment along the Puget Sound nearshore UGA

The concentrations of metals were more dispersed than organic chemicals in the Puget Sound nearshore sediment (Figure 2, A-C). All of the Puget Sound UGA nearshore samples had metal concentrations below the marine sediment quality standards.

The metal distributions for SAM and Option 2 sites overlapped considerably (Figure 2D-F, and Figure 3F), except for lead and mercury, indicating similar metal contamination levels throughout Puget Sound UGAs.

Despite the low concentrations regionally, copper and lead were significantly higher in the incorporated UGA nearshore sediment than unincorporated UGAs (Figure 2I and Figure 3D).

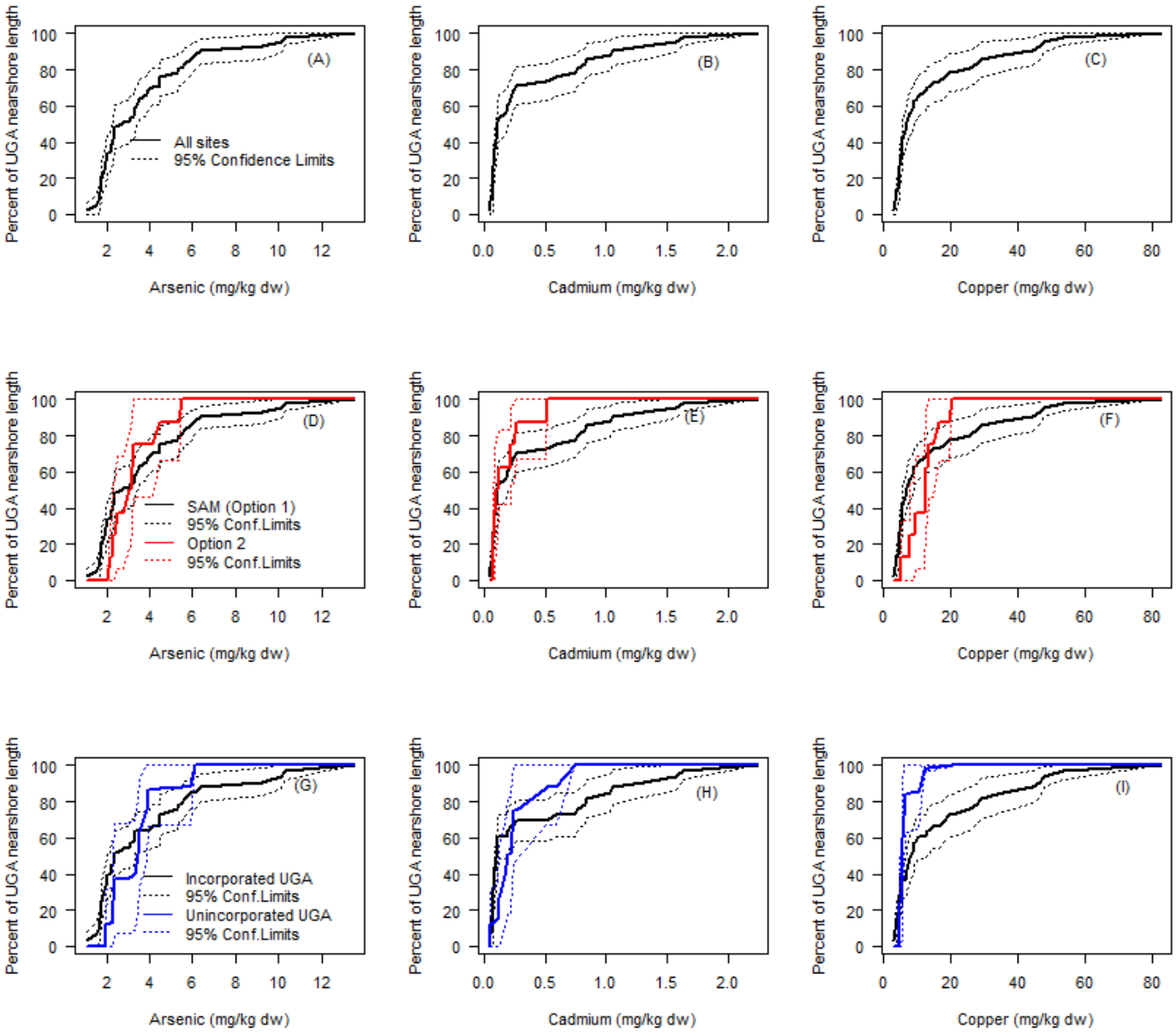


**Figure 2.** Cumulative distribution of arsenic, cadmium and copper in Puget Sound UGA nearshore sediment. A-C are CDFs from all study sites including SAM and Option 2. Total nearshore length 100% represents 1,357 km. D-F are CDFs from two subgroups: SAM sites, representing 1,344 km (100% on Y axis) and Option 2, representing 12.8 km (100% on Y axis) in red. G-I are comparison of CDFs between two subgroups: incorporated cities, in black versus unincorporated UGAs, in blue.

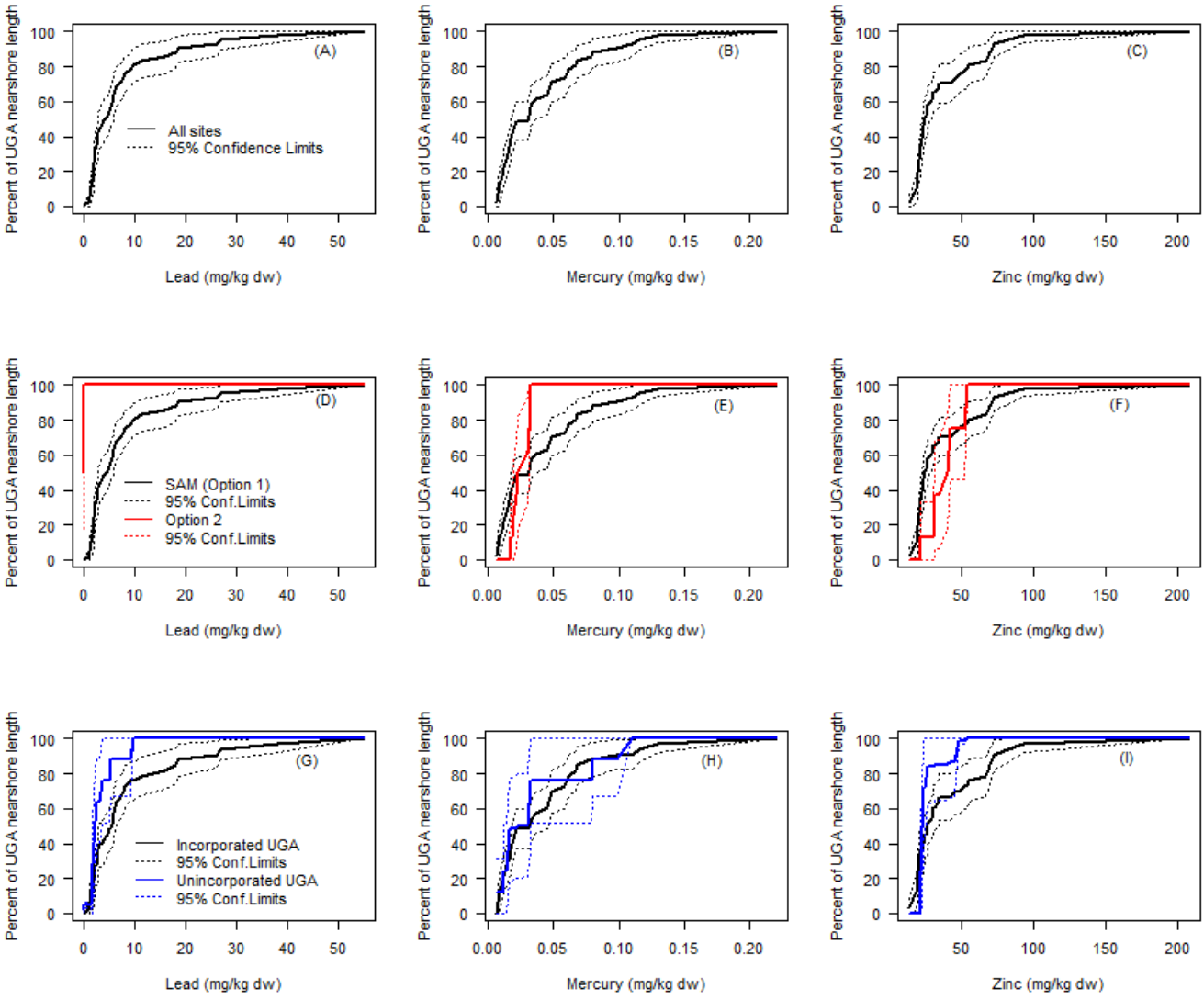


**Figure 3.** Cumulative distribution of lead, mercury and zinc in Puget Sound UGA nearshore sediment. A-C are CDFs from all study sites including SAM and Option 2. Total nearshore length 100% represent 1,357 km. D-F are CDFs from two subgroups: SAM sites, in black, representing 1,344 km (100% on Y axis) and Option2, in red, representing 12.8 km (100% in Y axis). G-I are comparison of CDFs between two subgroups: incorporated cities, in black, versus unincorporated UGAs, in blue.

## List of abbreviations

As = arsenic
Cd = cadmium
Cu = copper
dw = dry weight
g = gram
Hg = mercury
kg = kilogram
km = kilometer
ng = nanogram
PAHs = polycyclic aromatic hydrocarbons
Pb = lead
PCBs = polychlorinated biphenyls
PBDEs = polybrominated diphenyl ethers
SAM = Stormwater Action Monitoring
UGAs = Urban Growth Areas
Zn = zinc

## References

Black, R.W., A. Barnes, C. Elliot, and J. Lanksbury. 2018. Nearshore sediment monitoring for the Stormwater Action Monitoring (SAM) Program, Puget Sound, western Washington. Prepared in cooperation with the Washington State Department of Ecology, Stormwater Action Monitoring (SAM) Program. U.S. Department of Interior. U.S. Geological Survey. Tacoma, WA. Scientific Investigations Report 2018-5076.