

Addendum to Phase 2 subtask 2F: Evaluation of the recalculated loading rates with the box model of PCBs in Puget Sound

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February 2010

The following 5-page technical memo is an addendum to this
Washington State Department of Ecology publication:

Control of Toxic Chemicals in Puget Sound: Phase 2, Development of simple numerical models: The long-term fate and bioaccumulation of polychlorinated biphenyls in Puget Sound

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DEPARTMENT OF ECOLOGY

Technical Memorandum

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cc: Jim Maroncelli, Water Quality Program
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Date: February 4, 2010

Subject: **Implications of the revised loading estimates of PCBs by Herrera (2010) on the Puget Sound box model of PCBs**

The purpose of this memo is to update key graphics and findings from the previously published Puget Sound box model of polychlorinated biphenyls (PCBs) (Pelletier and Mohamedali, 2009). Herrera (2010) recalculated loads of PCBs to Puget Sound. The box model was revisited to consider the revised loading estimates.

Three reports present estimates of the loading of total PCBs and other toxic contaminants to Puget Sound: Hart Crowser et al. (2007), Envirovision et al. (2008), and Herrera (2010). Table 1 presents a comparison of the interquartile range (75% and 25% exceedance) and median (50% exceedance) estimates of the load of total PCBs to the watersheds of the Puget Sound box model.¹ There is approximately a factor of 3 difference between the highest and lowest reported loading estimates, although total loads from all three of the studies are not significantly different from each other. The estimates reported by Herrera (2010) are considered to be the most accurate of the three because of the correction of an error that was discovered in the flow calculation method in the prior two studies.

Table 1. Summary of published estimates of the interquartile range and median loads of total PCBs to the Puget Sound box model watersheds¹ at various phases of the collaborative effort to provide scientific information about toxic chemicals in Puget Sound. All units are kg/year.

| | 75 % exceedance | Median (50% exceedance) | 25% exceedance |
|--|--------------------|----------------------------|-------------------|
| Phase 2: Hart Crowser et al. (2007) | 27 | 116 | 512 |
| Phase 2: Envirovision et al. (2008) | 72 | 285 | 1100 |
| Phase 2: Recalculation: Herrera (2010) | 23 | 98 | 436 |

¹ The watersheds for the Puget Sound box model include only the following 11 of the 14 sub-basins summarized by Hart Crowser et al. (2007), Envirovision et al. (2008), and Herrera (2010): Main Basin, Port Gardner, Elliott Bay, Commencement Bay, South Sound (east), South Sound (west), Hood Canal (south), Hood Canal (north), Sinclair/Dyes Inlet, Admiralty Inlet, and Whidbey Basin.

The reported watershed loading of total PCBs from Hart Crowser et al. (2007), Envirovision et al. (2008) and Herrera (2010) is presented in more detail in Table 2 for each basin of the Puget Sound box model¹. Figure 1 shows the loading and concentration from each land cover category into each of the box model basins. Figure 2 shows the fraction of total PCB loading to Puget Sound that originates from each land cover category that was summarized by Hart Crowser et al. (2007) and Envirovision et al. (2008). In general, estimates of loading from residential land covers by Envirovision et al. (2008) were much higher than Hart Crowser et al. (2007) and Herrera (2010) due to the different assumptions about flows from each land cover in each basin.

Pelletier and Mohamedali (2009) predicted a plausible range of total PCB loading of about 20 to 200 kg/year based on the Puget Sound box model. The revised loading estimate of Herrera (2010) is similar in magnitude to the plausible range of total loads to Puget Sound.

Pelletier and Mohamedali (2009) also predicted fate and transport of PCBs in Puget Sound for the median and interquartile ranges of loading reported by Hart Crowser et al. (2007) and Envirovision et al. (2008). The Puget Sound box model developed by Pelletier and Mohamedali (2009) was re-run using the revised loads estimated by Herrera (2010) (Figure 3). The total mass of PCBs in the water column and upper 10 cm of sediment of Puget Sound predicted under a scenario of median loading reported by Herrera (2010) changes by less than about 10 percent compared with the median loading scenario based on Hart Crowser et al. (2007).

In conclusion, the revised loads reported by Herrera (2010) slightly reduce the magnitude and uncertainty in the predicted mass of PCBs in Puget Sound compared with the loads reported by Hart Crowser et al. (2007). The conclusions of Pelletier and Mohamedali (2009) are not significantly affected by the updated PCB loading estimates.

References

Envirovision Corp., Herrera Environmental Consultants, Inc., and Washington State Department of Ecology, 2008. Control of Toxic Chemicals in Puget Sound – Phase 2: Improved Estimates of Loadings from Surface Runoff and Roadways. Washington State Department of Ecology, Olympia, WA. Publication No. 08-10-084. www.ecy.wa.gov/biblio/0810084.html.

Hart Crowser, Inc. et al., 2007. Control of Toxic Chemicals in Puget Sound – Phase 1: Initial Estimate of Toxic Chemical Loadings to Puget Sound. October 2007. Prepared for Washington State Department of Ecology; U.S. Environmental Protection Agency; and Puget Sound Partnership. Olympia, WA. Ecology Publication No. 07-10-079. www.ecy.wa.gov/biblio/0710079.html.

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Pelletier, G.J. and T. Mohamedali, 2009. Control of Toxic Chemicals in Puget Sound: Phase 2, Development of simple numerical models: The long-term fate and bioaccumulation of polychlorinated biphenyls in Puget Sound. Washington State Department of Ecology, Olympia, WA. Publication No. 09-03-015. www.ecy.wa.gov/biblio/0903015.html.

Table 2. Summary of total PCB loading estimates for the watersheds of the Puget Sound box model derived by Hart Crowser et al. (2007), Envirovision et al. (2008), and Herrera (2010). Note that the box model watershed includes 11 of the 14 sub-basins reported in those studies. All loads are kg/year.

| | South Sound | Main basin | North Hood Canal | South Hood Canal | Whidbey | Elliott Bay | Sinclair/Dyes Inlet | Commence-ment Bay | Admiralty Inlet | Total |
|--|-------------|------------|------------------|------------------|---------|-------------|---------------------|-------------------|-----------------|-------|
| Phase 1: Hart Crowser (2007) (Kg/year): | | | | | | | | | | |
| TOTAL SURFACE RUNOFF (Kg/year) | | | | | | | | | | |
| 95% exceedance | 0.49 | 0.59 | 0.02 | 0.1 | 1.5 | 0.31 | 0.088 | 0.38 | 0.056 | 3.534 |
| 75% | 3.7 | 4.2 | 0.15 | 1 | 12 | 2.3 | 0.64 | 2.8 | 0.41 | 27.2 |
| 50% | 15 | 16 | 0.66 | 5.1 | 54 | 9 | 2.6 | 12 | 1.7 | 116 |
| 25% | 64 | 65 | 2.9 | 26 | 250 | 37 | 11 | 49 | 7.1 | 512 |
| 5% | 520 | 480 | 26 | 280 | 2300 | 280 | 86 | 410 | 59 | 4441 |
| 50% EXCEEDANCE LOADS BY LAND COVER (Kg/year) | | | | | | | | | | |
| Commercial/Industrial | 3.30 | 4.36 | 0.203 | 0 | 6.50 | 4.00 | 0.740 | 4.30 | 0.250 | 23.7 |
| Residential | 6.60 | 10.6 | 0.210 | 0.780 | 10.1 | 2.98 | 1.34 | 3.58 | 0.650 | 36.9 |
| Agriculture | 1.68 | 0.245 | 0.0111 | 0.230 | 11.5 | 0.990 | 0.0810 | 1.17 | 0.431 | 16.3 |
| Forest | 3.44 | 1.11 | 0.229 | 4.1 | 26.6 | 1.07 | 0.454 | 2.72 | 0.380 | 40.1 |
| Total | 15.0 | 16.3 | 0.653 | 5.11 | 54.7 | 9.04 | 2.615 | 11.8 | 1.71 | 117 |
| Phase 2: Envirovision et al. (2008) (Kg/year): | | | | | | | | | | |
| TOTAL SURFACE RUNOFF (Kg/year) | | | | | | | | | | |
| 95% exceedance | 1.47 | 1.07 | 0.07 | 0.44 | 4.74 | 0.71 | 0.30 | 1.04 | 0.16 | 10.0 |
| 75% | 10.4 | 7.49 | 0.51 | 3.35 | 34.6 | 4.97 | 2.07 | 7.35 | 1.11 | 71.8 |
| 50% | 40.6 | 29.0 | 2.00 | 14.0 | 139 | 19.3 | 8.02 | 28.8 | 4.34 | 285 |
| 25% | 160 | 112 | 7.97 | 59.4 | 570 | 75.2 | 31.2 | 114 | 17.1 | 1147 |
| 5% | 1162 | 792 | 59.2 | 499 | 4471 | 536 | 221 | 834 | 124 | 8700 |
| 50% EXCEEDANCE LOADS BY LAND COVER (Kg/year) | | | | | | | | | | |
| Commercial/Industrial | 2.93 | 3.56 | 0.0309 | 0.117 | 6.01 | 4.44 | 0.66 | 3.29 | 0.145 | 21.2 |
| Residential | 33.8 | 24.9 | 1.81 | 10.1 | 98.3 | 13.7 | 7.17 | 22.7 | 3.58 | 216 |
| Agriculture | 1.84 | 0.150 | 0.00807 | 0.150 | 13.6 | 0.604 | 0.0323 | 1.07 | 0.376 | 17.9 |
| Forest | 2.08 | 0.424 | 0.159 | 3.63 | 21.4 | 0.546 | 0.161 | 1.77 | 0.235 | 30.4 |
| Total | 40.6 | 29.0 | 2.00 | 14.0 | 139 | 19.3 | 8.02 | 28.8 | 4.34 | 285 |
| Phase 2 re-calculation: Herrera (2010) (Kg/year): | | | | | | | | | | |
| TOTAL SURFACE RUNOFF (Kg/year) | | | | | | | | | | |
| 95% exceedance | 0.493 | 0.506 | 0.0208 | 0.152 | 1.13 | 0.228 | 0.0803 | 0.269 | 0.00951 | 2.88 |
| 75% | 3.65 | 3.61 | 0.155 | 1.33 | 9.63 | 1.67 | 0.569 | 2.06 | 0.0699 | 22.7 |
| 50% | 14.9 | 14.2 | 0.638 | 6.19 | 44.3 | 6.75 | 2.23 | 8.70 | 0.284 | 98.2 |
| 25% | 62.2 | 56.6 | 2.67 | 29.7 | 210 | 27.8 | 8.83 | 37.6 | 1.18 | 436 |
| 5% | 504 | 420 | 21.9 | 296 | 2055 | 220 | 64.9 | 323 | 9.4 | 3914 |
| 50% EXCEEDANCE LOADS BY LAND COVER (Kg/year) | | | | | | | | | | |
| Commercial/Industrial (Urban and Non-urban area) | 0.707 | 1.27 | 0.00827 | 0.0146 | 0.47 | 0.978 | 0.158 | 0.545 | 0.00465 | 4.16 |
| Residential | 10.3 | 11.7 | 0.485 | 2.33 | 16.1 | 4.30 | 1.92 | 5.13 | 0.19 | 52.4 |
| Agriculture | 0.88 | 0.144 | 0.00422 | 0.0563 | 2.60 | 0.334 | 0.0138 | 0.404 | 0.038 | 4.47 |
| Forest | 3.04 | 1.13 | 0.14 | 3.79 | 25.2 | 1.14 | 0.144 | 2.61 | 0.0518 | 37.2 |
| Total | 14.9 | 14.2 | 0.64 | 6.19 | 44.3 | 6.75 | 2.2 | 8.7 | 0.284 | 98 |

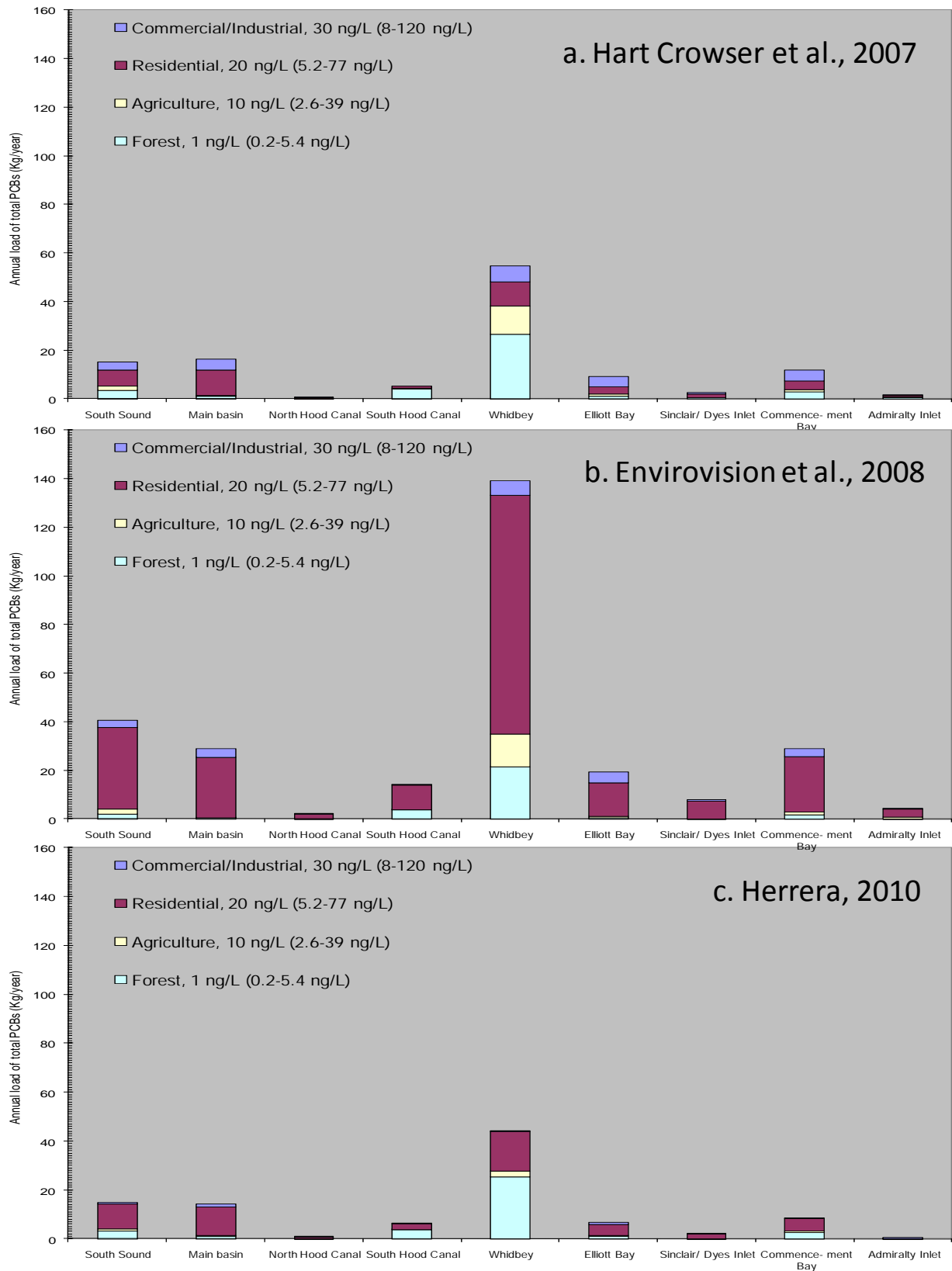


Figure 1. Summary of watershed total PCB loads and concentrations by land cover category for each box model basin. Concentration ranges shown are inter-quartile ranges.

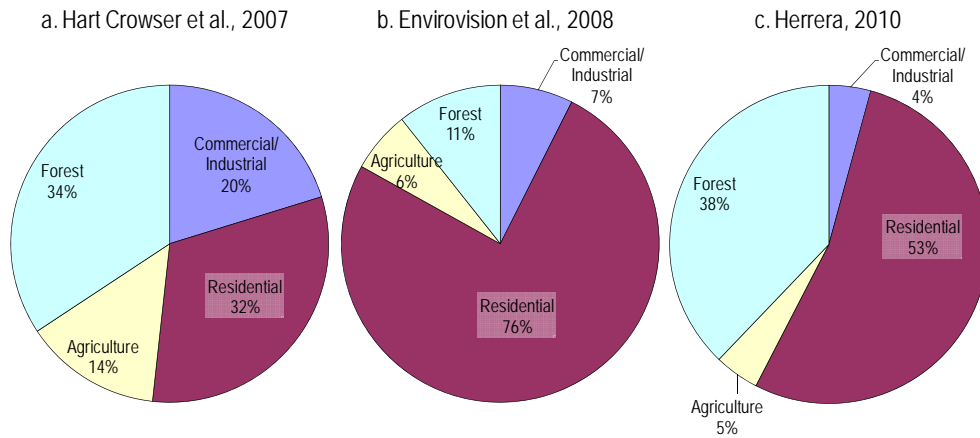


Figure 2. Fraction of the total PCB load to Puget Sound that originates from each land cover category.

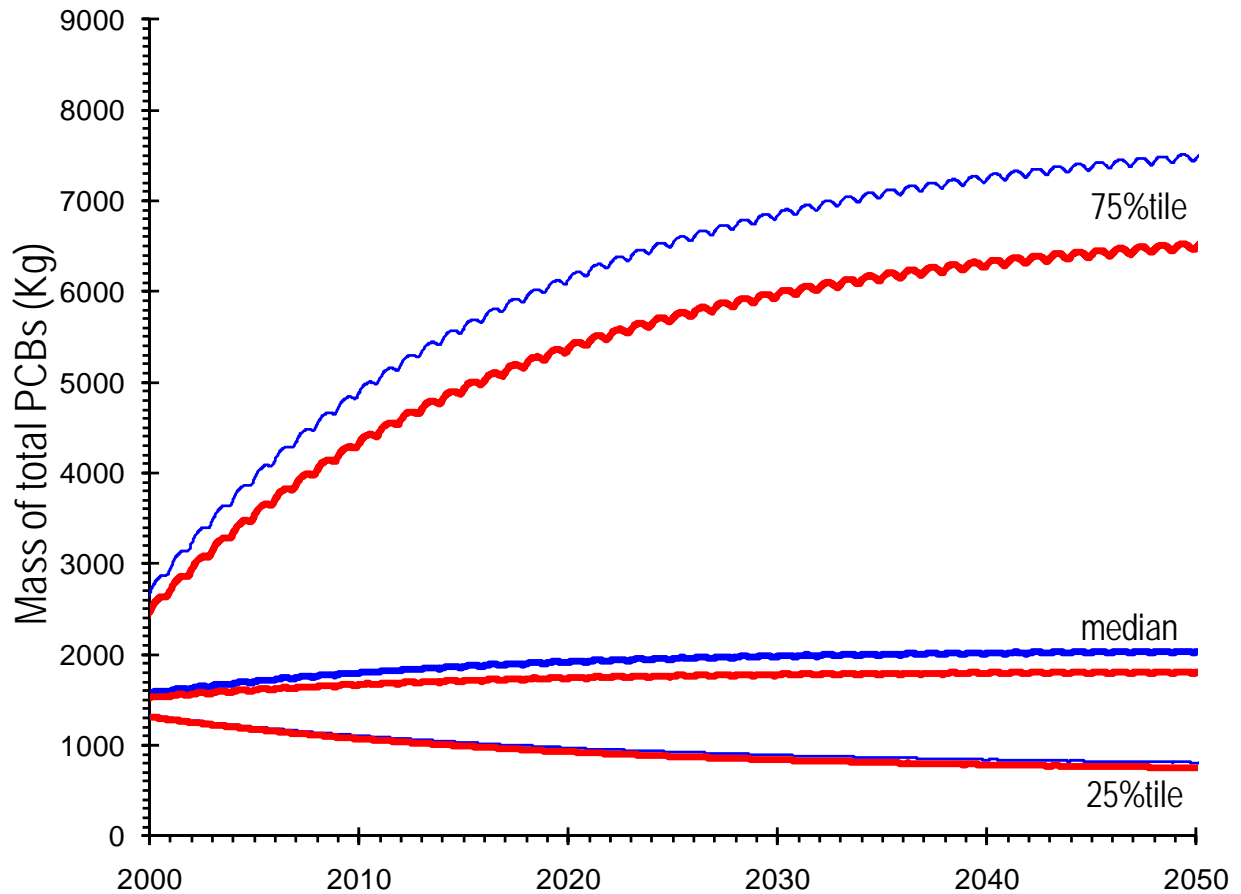


Figure 3. The predicted mass of total PCBs in the water column and upper 10 cm of sediment of Puget Sound from year 2000 to year 2050 for the median and interquartile ranges of external loading estimates reported by Hart Crowser et al. (2007) (blue) and Herrera (2010) (red).