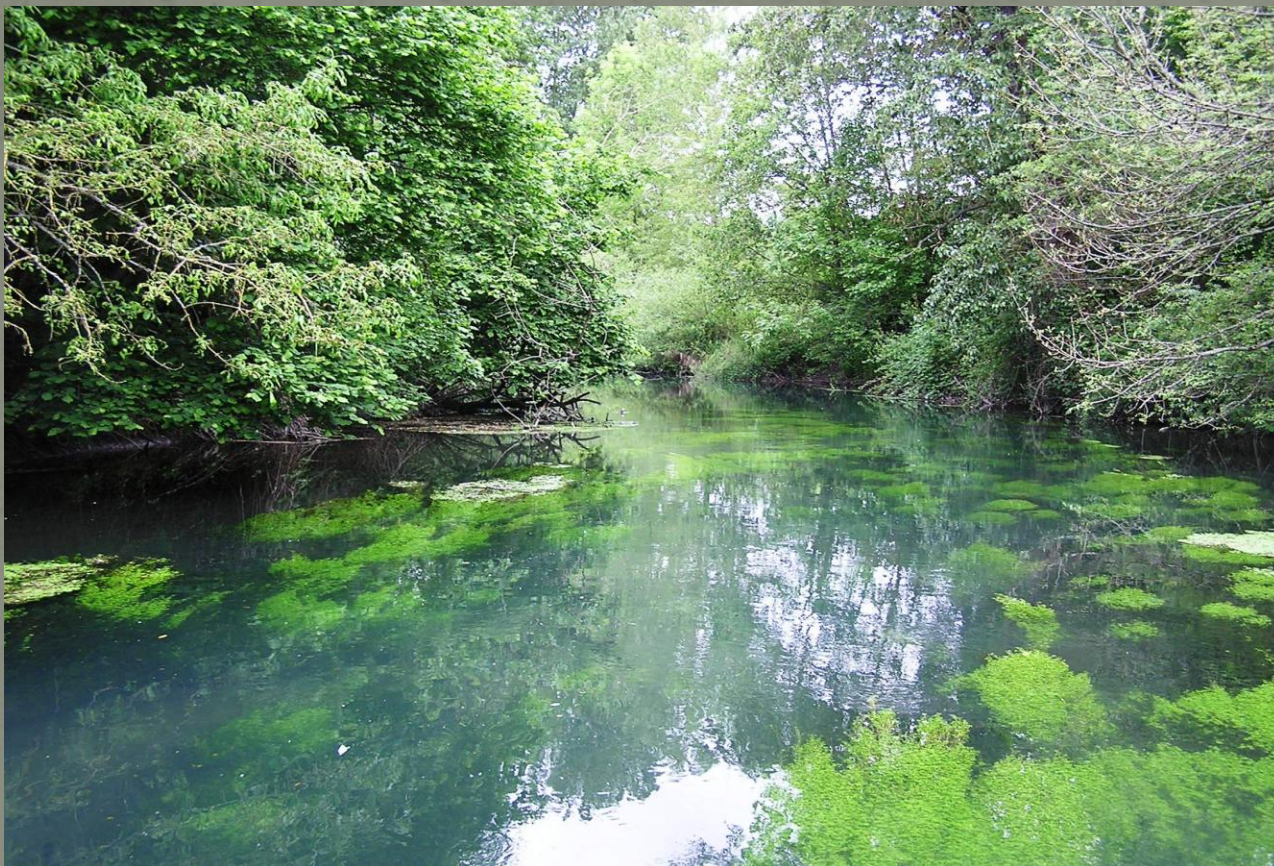




Columbia Slough Sediment Study



DEQ Cleanup Program- Northwest Region
Paul Seidel; Annette Dietz; Jennifer Sutter; Bob Williams; Sarah Miller;
Ken Cameron
Funded by EPA Grant #EM-96054601-0

Columbia Slough- Previous information

- Previous investigations provide baseline of data which was used and supplemented.
- Previous Portland BES sediment data provides understanding of sediment contamination- 1994, 2005
- USGS deployed semipermeable membrane devices (SPMDs) in the water column 2004, 2005.
- Portland BES fish (carp) sampling in 2005

Columbia Slough Sediment Study

- Objectives of Study

- Determine average concentrations of contaminants in slough sediment and developing new, updated estimates of baseline concentrations in the sampled segments
- Development of predictive relationships between sediment and fish tissue: DEQ's 2009 work found good correlations between sediment and fish tissue.
- Validate DEQ's bioaccumulation guidance using data specific to the Columbia Slough.
- Perform exploratory multivariate analyses and PCB source attribution.

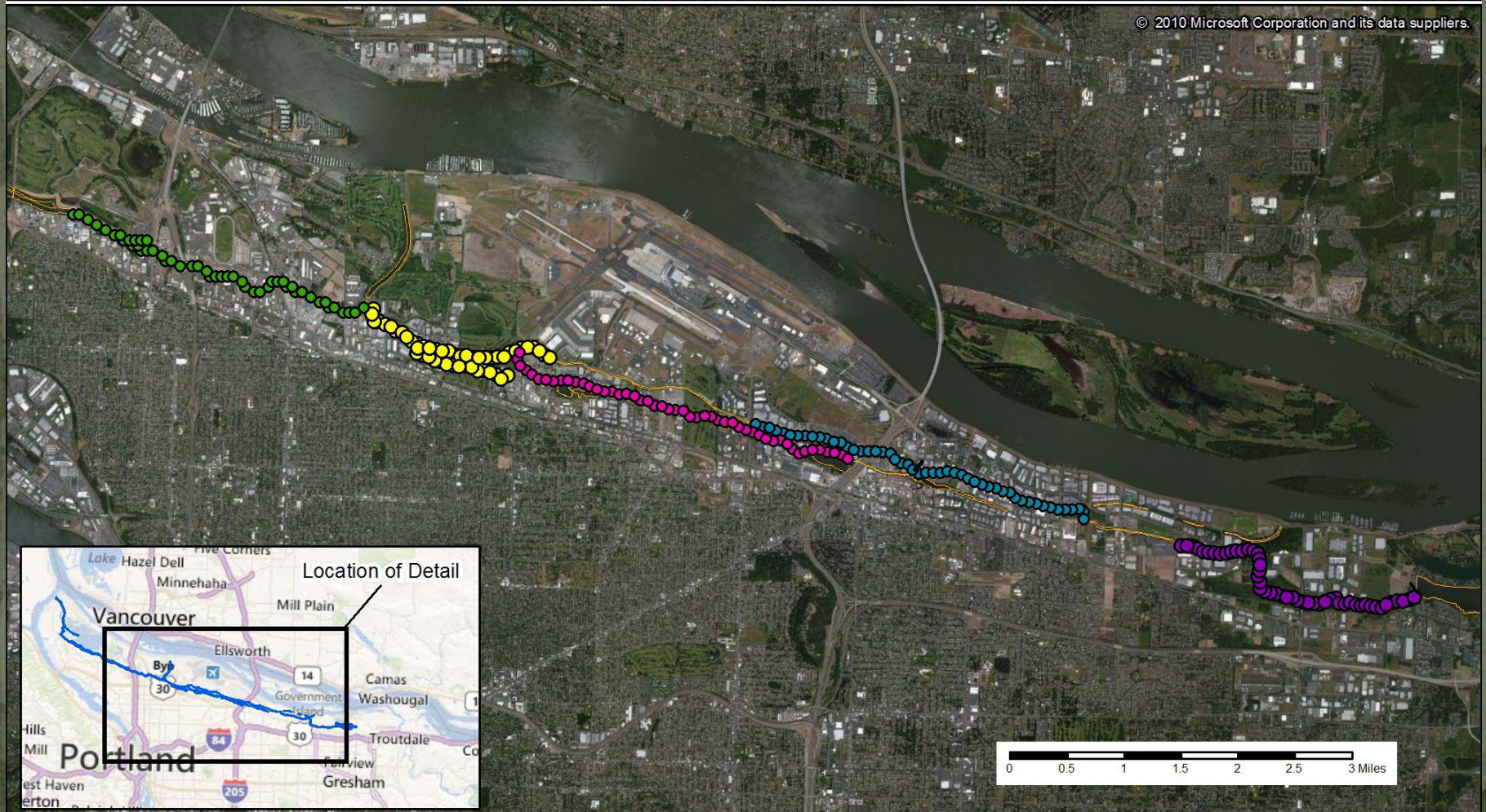
Sampling Design

- **Incremental Sample**-Three 2-mile reaches of the Columbia Slough surrounding prior fish tissue collection areas. 50 incremental locations were evenly spaced and placed into three replicates to produce a statistically valid average.
- **Targeted Sites**-Four sites with 5-8 locations in each composite sample near possible elevated sediment concentrations.
- **Bioaccumulation**- Sediments collected at targeted sites to determine worm tissue uptake from Slough sediments in a controlled laboratory

COLUMBIA SLOUGH INCREMENTAL SAMPLE SCHEME



- Lower Slough 2009 IS sample
- Whitaker 2011 IS sample
- Upper Upper IS sites
- Upper Middle IS sites
- Lower Middle IS sites
- Slough Waterway



COLUMBIA SLOUGH INCREMENTAL SAMPLE SCHEME

Lower Middle Buffalo Slough



Incremental Sample Location



Increment Sample A



Increment Sample B



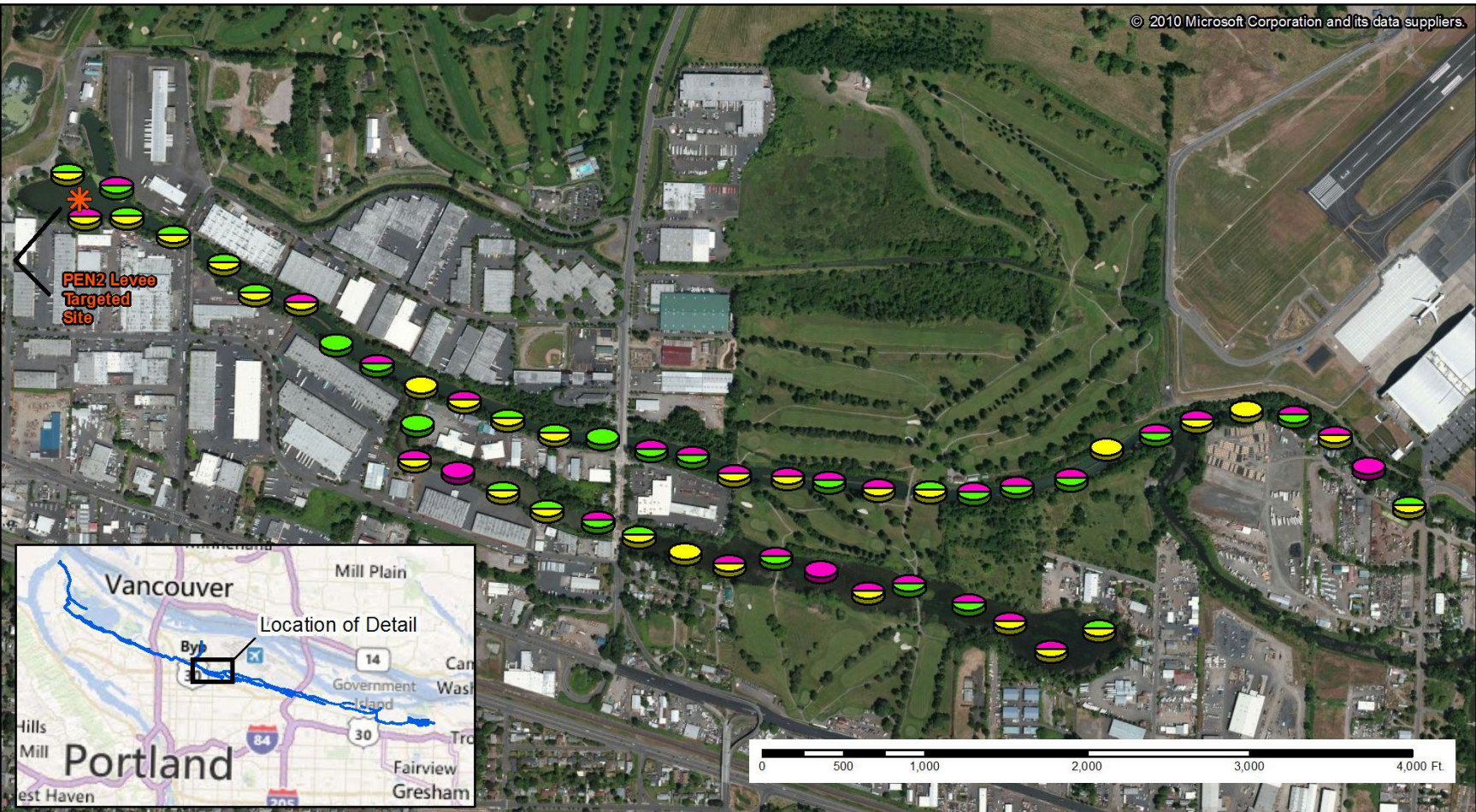
Increment Sample C



Targeted Sites





© 2010 Microsoft Corporation and its data suppliers.






COLUMBIA SLOUGH INCREMENTAL SAMPLE SCHEME

Upper Middle Slough



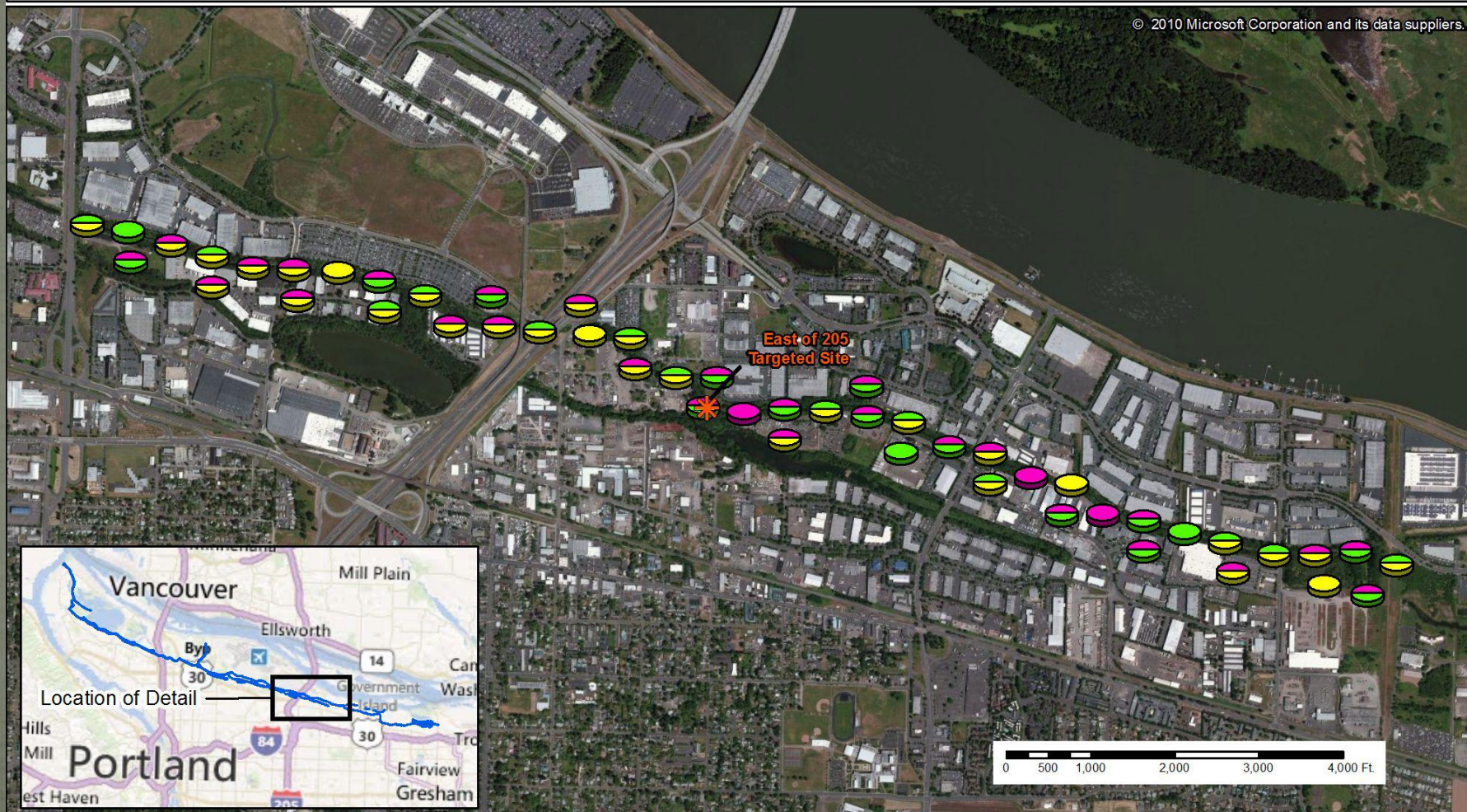
-  Incremental Sample Location
-  Increment Sample A

-  Increment Sample B
-  Increment Sample C

-  Targeted Sites





© 2010 Microsoft Corporation and its data suppliers.





COLUMBIA SLOUGH INCREMENTAL SAMPLE SCHEME

Upper Upper Slough



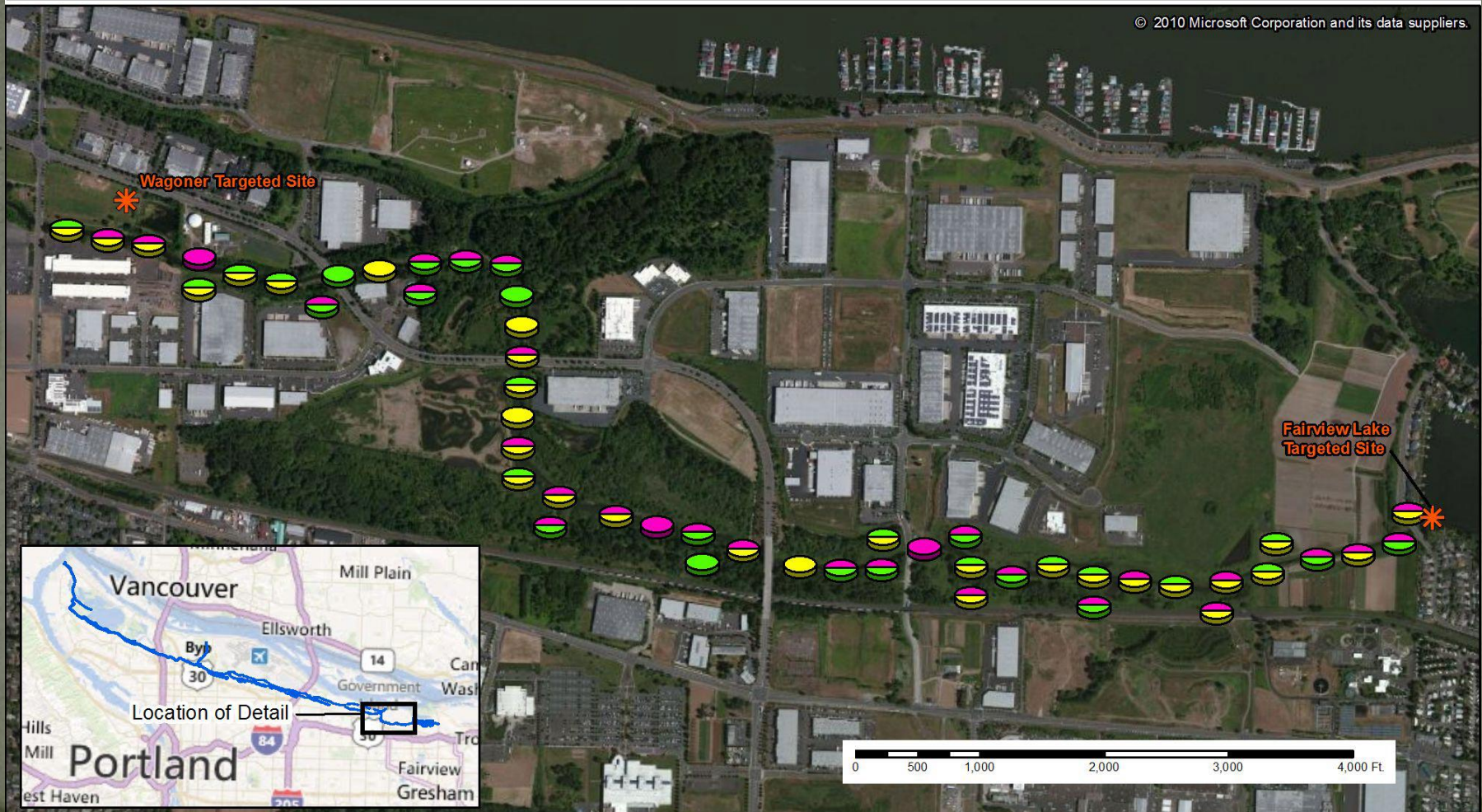
-  Incremental Sample Location
-  Increment Sample A

-  Increment Sample B
-  Increment Sample C

-  Targeted Sites



© 2010 Microsoft Corporation and its data suppliers.



Sediment Analyses Performed

- Focus on Bioaccumulative Analyses-
- Pesticide EPA 1699- *high resolution pg/g*
- PCB-Aroclor EPA 8082
- PCB Congener EPA 1668A- *high resolution ng/kg*
- grain size/TOC/solids
- Bio-accumulation **test** with *Lumbriculus* worms*
 - Worm tissue analyzed for PCB Congeners and Pesticides

* Targeted sediment sites only.

Let the Sampling Begin!



Incremental Sampling Equipment



Aquatic Plants were constant companions!



I asked for Mud
Pie, not Salad
Greens!!

Bioaccumulation Sample-how many gallons of sediment do you need to grow 100g of worm tissue?

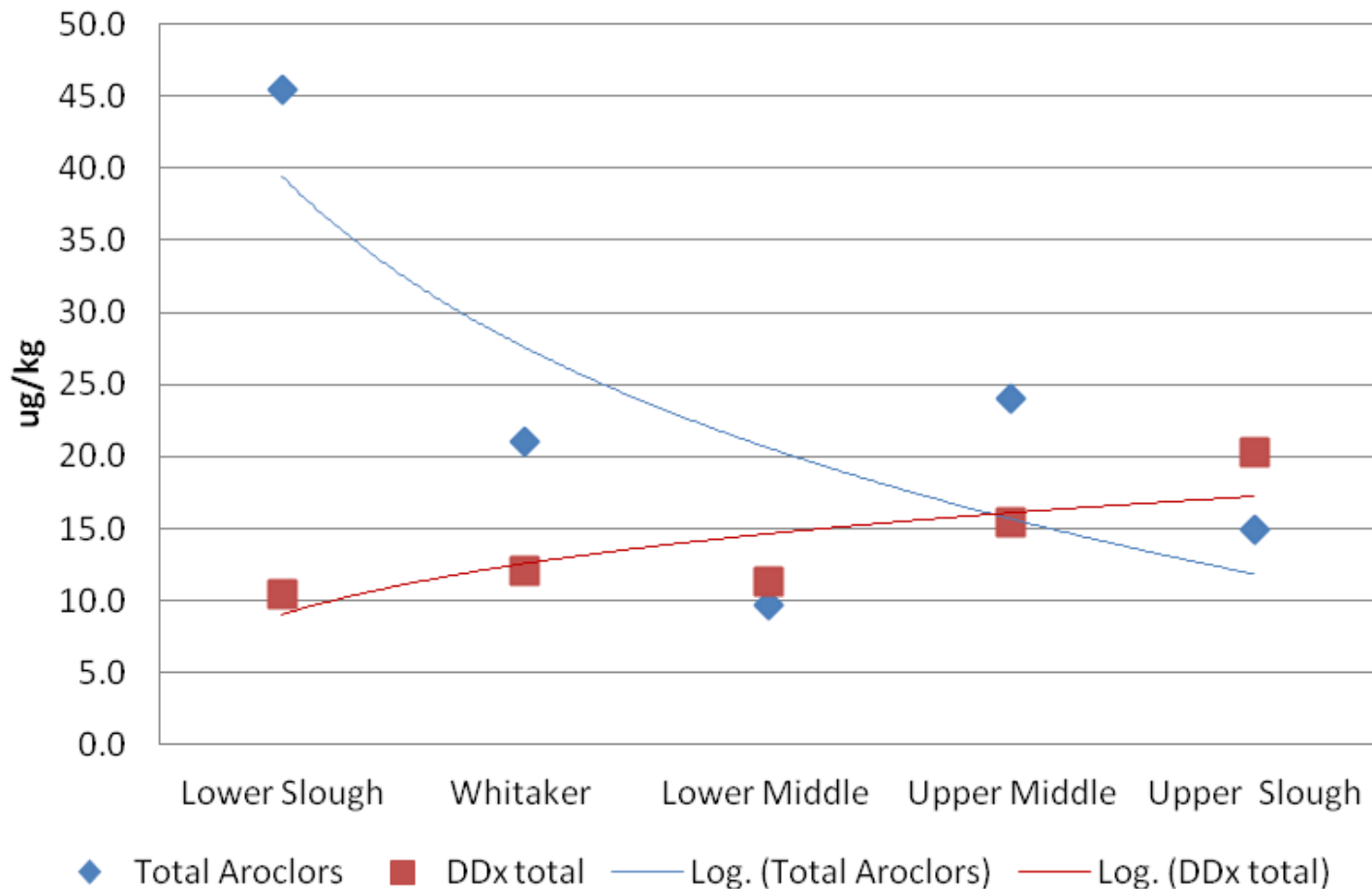


Triplicate Sediment Sample-QA review. Were samples less than 30% Relative Standard Deviation (RSD)?

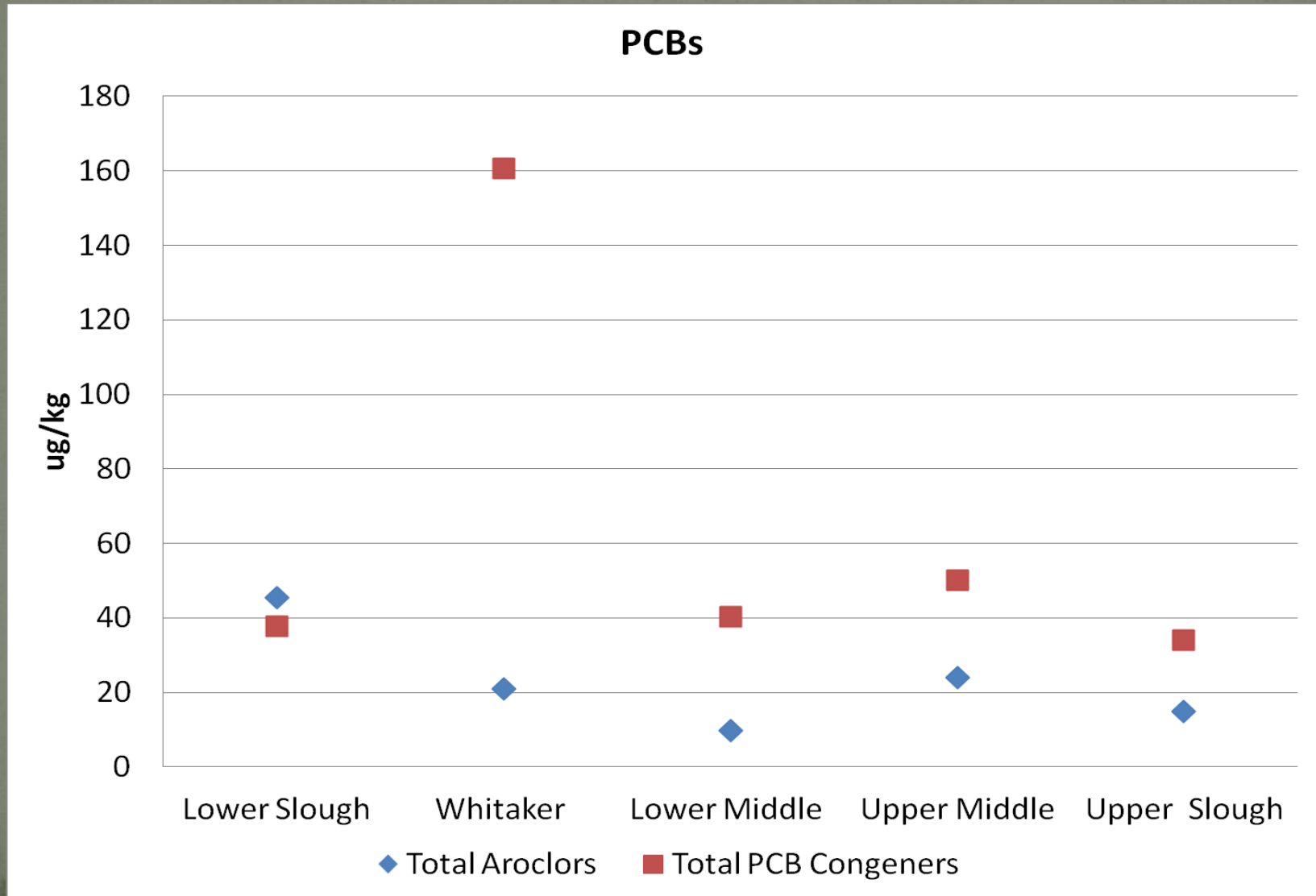
Location	Parameter	Relative Percent Difference	Pass QA?
Lower Middle Columbia Slough	PCB Congeners Average of RSDs	32%	Just barely
Lower Middle Columbia Slough	Pesticide Average of RSDs	29 %	Yes
Upper Middle Columbia Slough	PCB Congeners Average of RSDs	26%	Yes
Upper Middle Columbia Slough	Pesticide Average of RSDs	24%	Yes
Upper Columbia Slough	PCB Congener Average RSDs	5%	Yes
Upper Columbia Slough	Pesticide Average of RSDs	17%	Yes

Columbia Slough Sediment: Average Total Aroclor PCB and DDX Concentrations

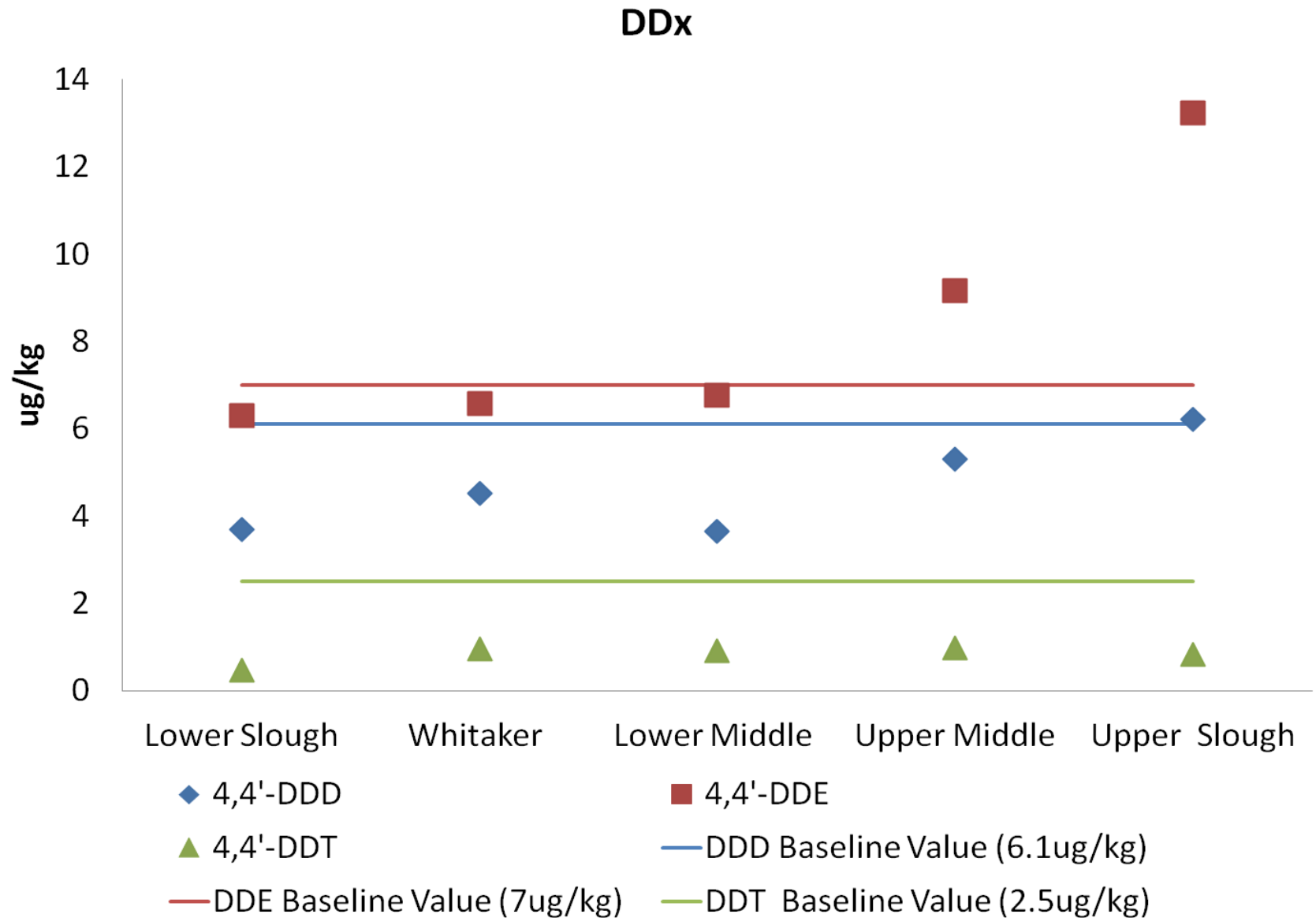
Total Aroclor PCBs and DDX Total



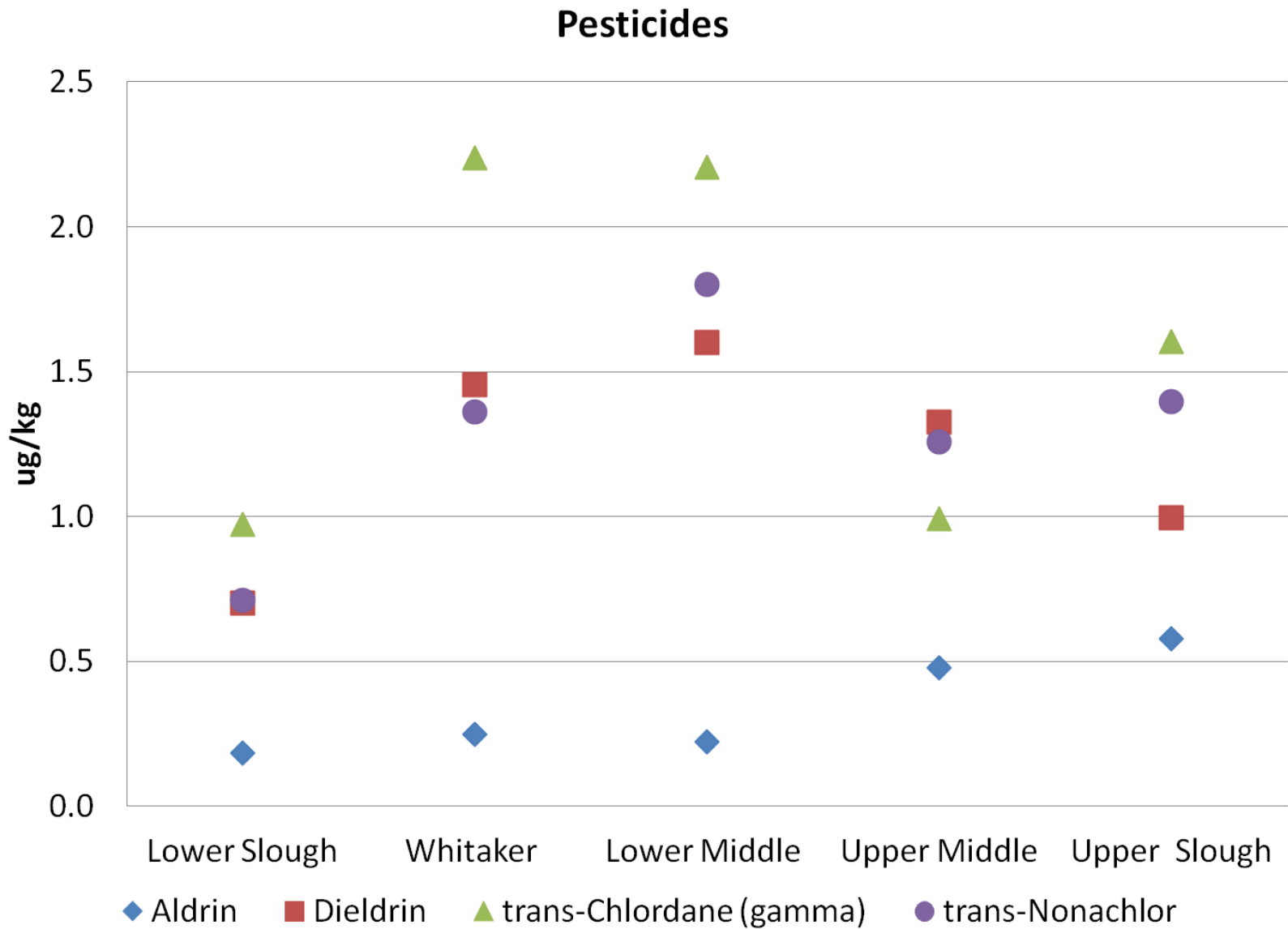
Columbia Slough Sediment PCB Average Concentrations



Columbia Slough Average DDx Concentrations



Columbia Slough Average Pesticide Concentrations



Targeted Site Sediment Results

Analyte- ug/kg	Pen 2 Levee	East of I-205	Wagner Mining	Fairview Lake
Total PCB Aroclors	7.7	15	29	3u
Total PCB Congeners	39	39	114	3
Total DDx	9.6	50	36	9.4

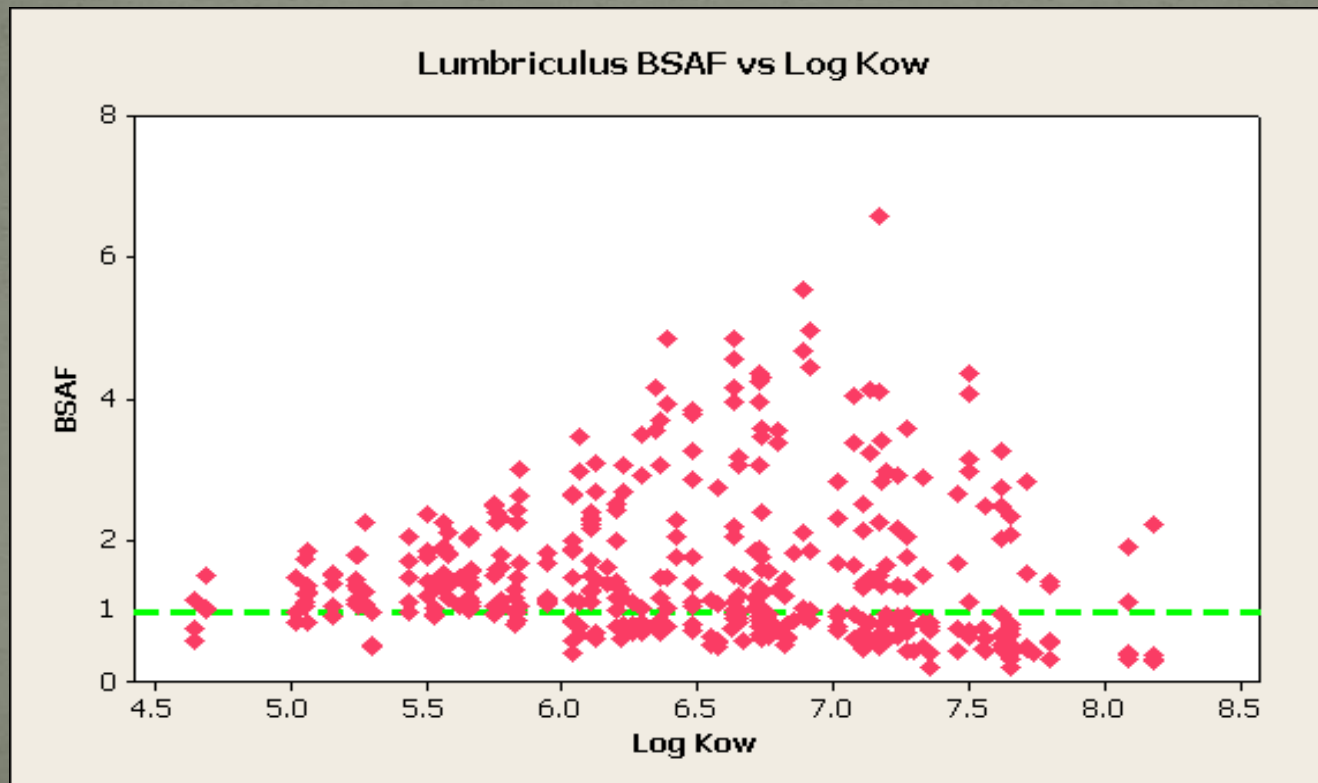


Replicate Sample Results- PCBs (ug/kg)

Location	Total Congeners	RSD	Total Aroclors	RSD
Lower Slough	37.8	11.7%	40.5	34.2%
	33.5		29.9	
	42.4		59.1	
Lower Middle	56.6	40.8%	14.8	53.6%
	23.8		4.7	
	40.3		8.9	
Upper Slough	36.6	4.8%	15.6	8.9%
	33.9		13.4	
	33.6		15.8	
Upper Middle	67.6	36.1%	16.3	69.2%
	51.7		43	
	31.4		12.6	

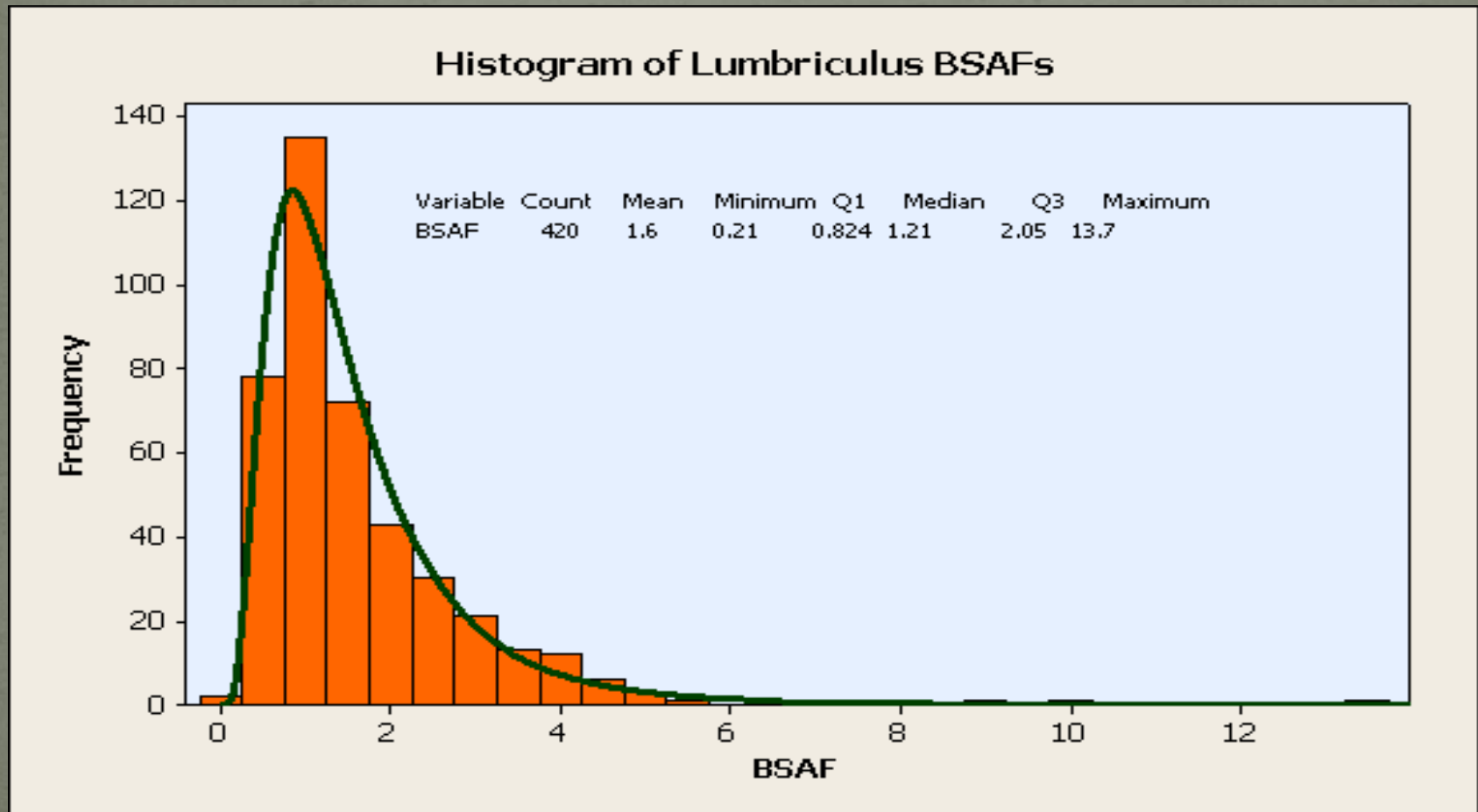
Invertebrate Biota-Sediment Factors

- BSAFs are “standardized” ratios of tissue to sediment: used as a measure of bioaccumulation potential.
- Calculated for each PCB congener detected in both sediment and *Lumbriculus* (worm) tissue .



Invertebrate Biota-Sediment Factors

For all PCB Congeners combined most BSAFs < 2

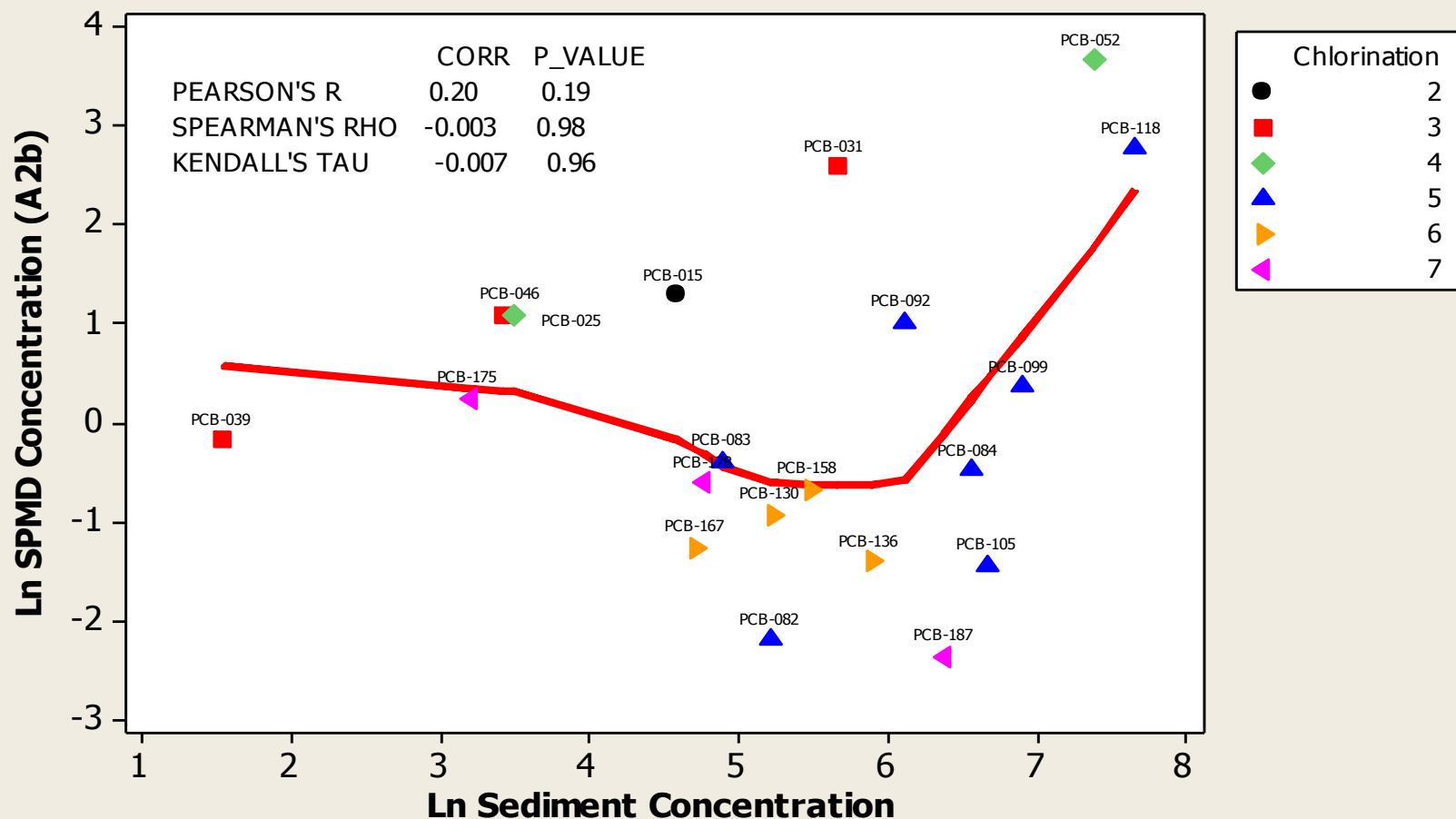


Total PCB BSAFs by Method

Location	Parameter	Sediment (oc norm)	Invert Tissue (lipid norm)	BSAF
LMCS-Pen-2	Total Aroclor	356,481	1,554,278	4.36
	Total PCB (Congener Sum)	2,133,987	1,554,278	0.73
UMCS-I-205	Total Aroclor	407,557	1,654,018	4.06
	Total PCB (Congener Sum)	1,470,715	1,654,018	1.12
US-WgnrM	Total Aroclor	856,716	2,697,833	3.15
	Total PCB (Congener Sum)	4,211,406	2,697,833	0.64

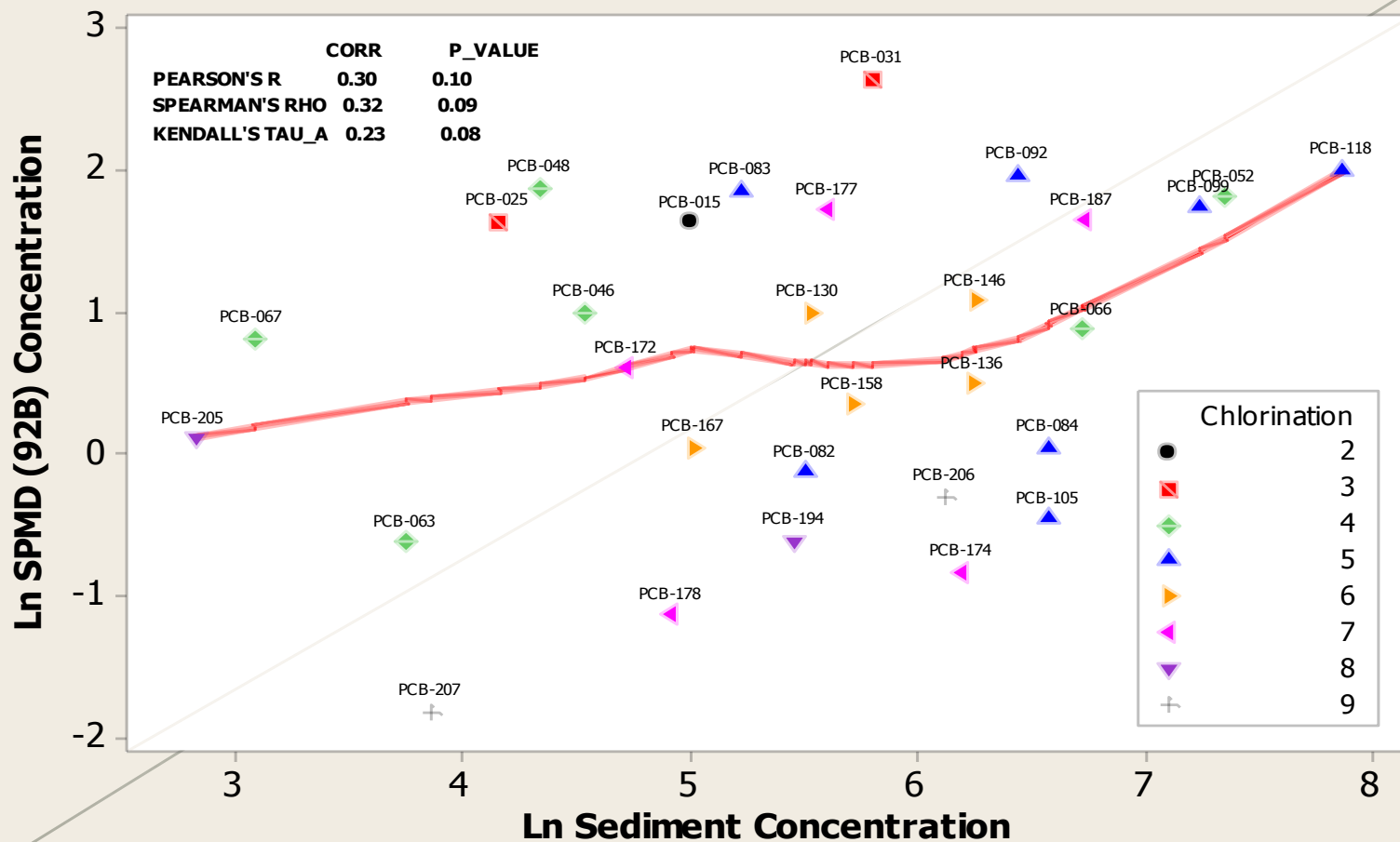
Sediment v. Water (SPMD)

Buffalo Slough-Deep



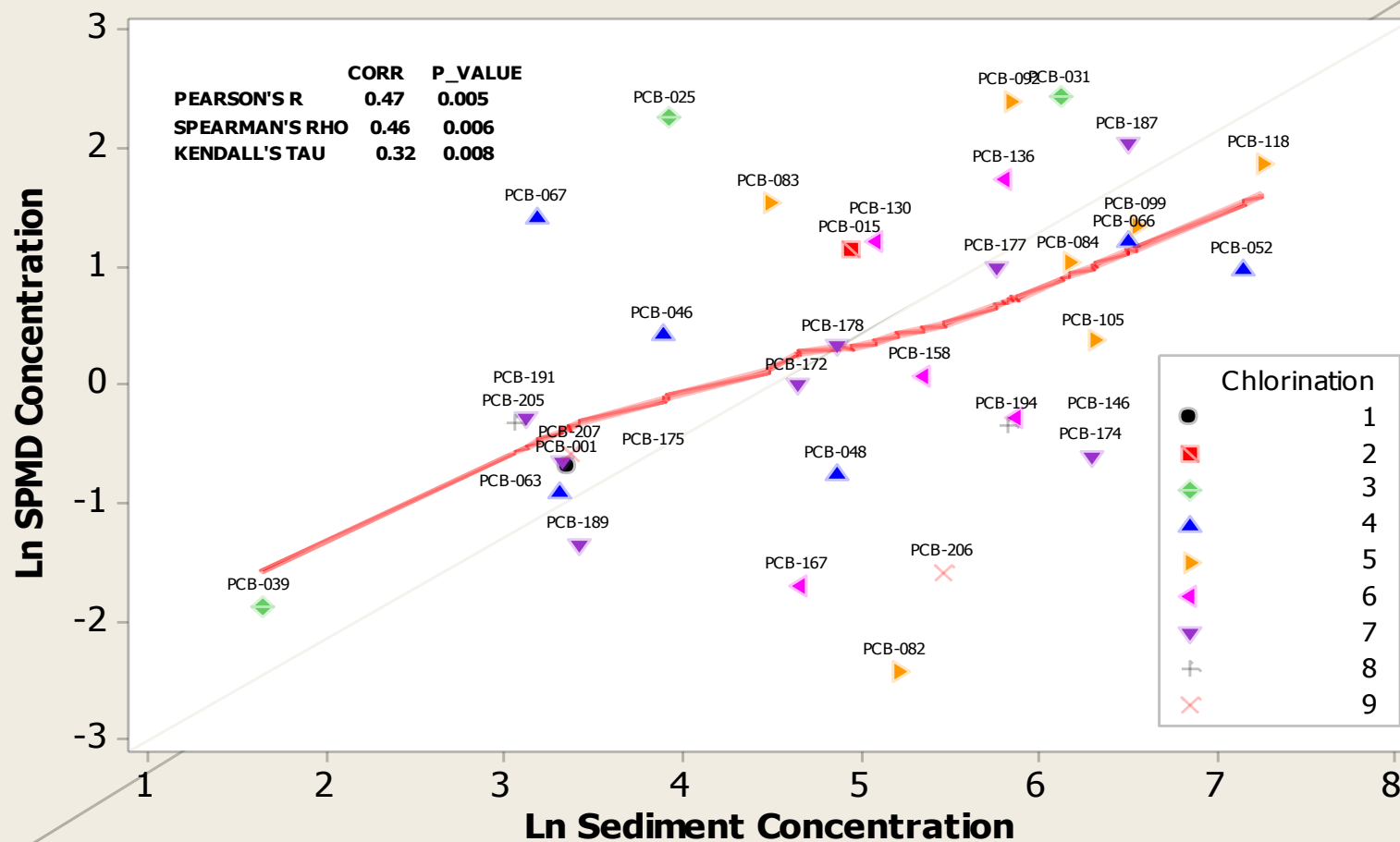
Sediment v. Water (SPMD)

Upper Middle



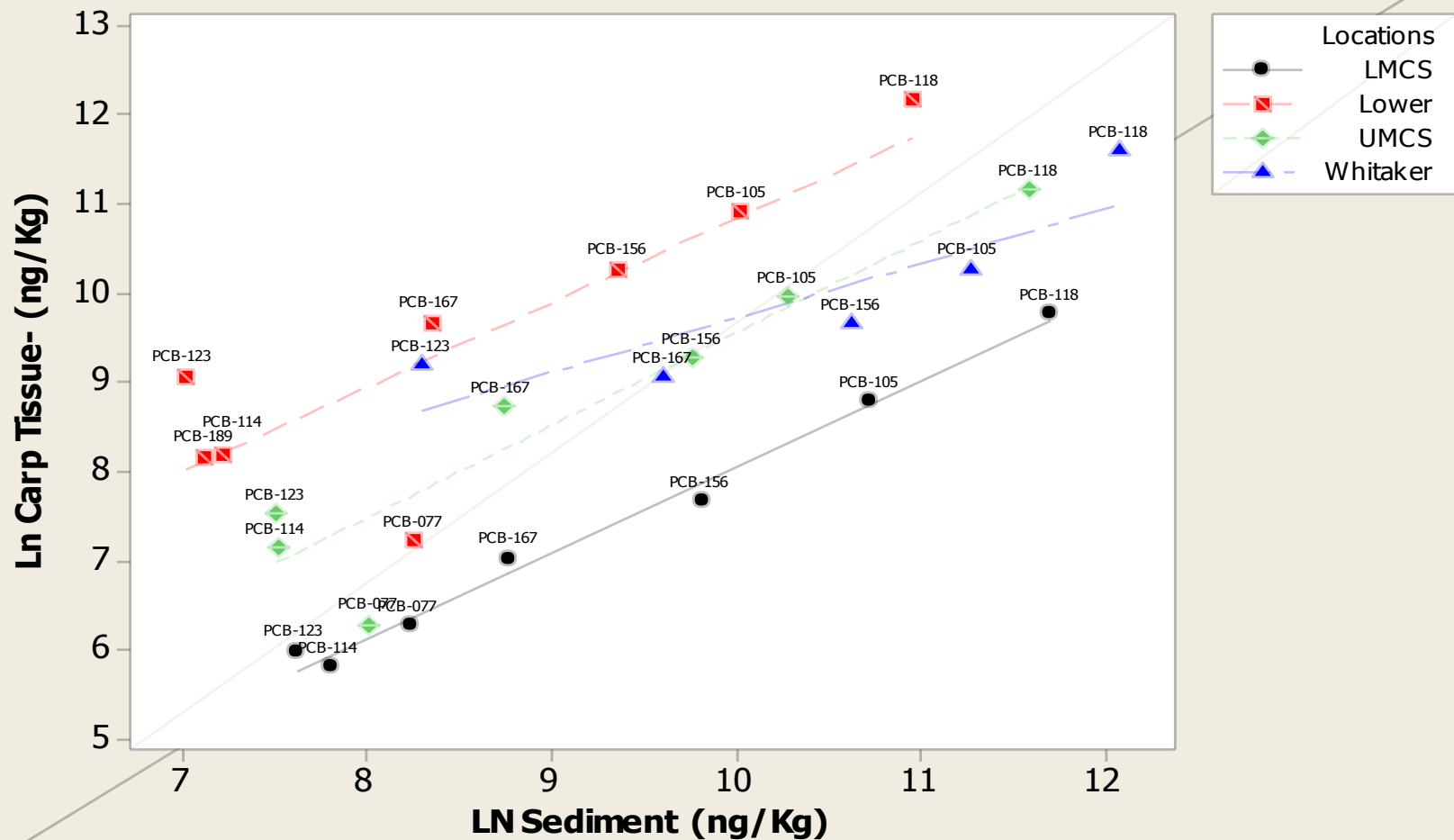
Sediment v. Water (SPMD)

Lower Slough

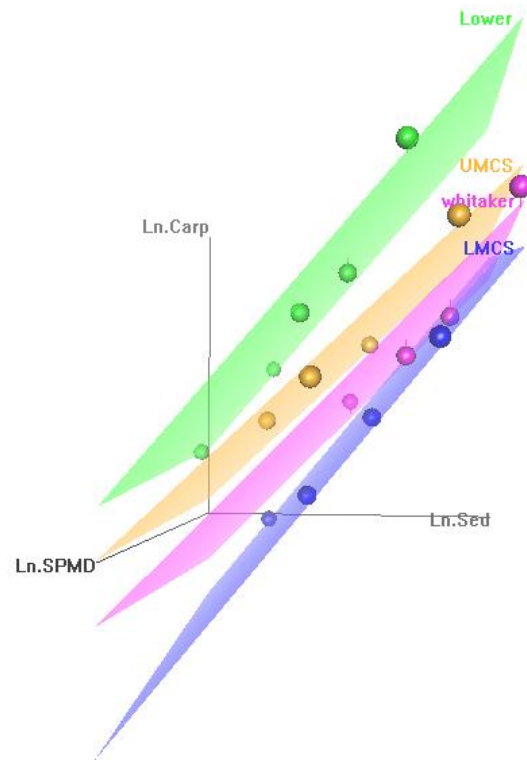


Sediment vs. Carp

All Reaches Select PCB Congeners



SPMD, Sediment, Carp Interactions



Predictive Modeling

- How to relate correlation between sediment (or SPMDs) to acceptable levels in Carp tissue?
- Since relationships between sediment and Carp tissue appear nearly linear, regression approach selected.
- Using reach-specific models, and assuming the Carp concentration at DEQ risk-based levels (for Aroclor 4.7 ug/kg-wet); predict corresponding sediment concentration.

Predictive Modeling-Results

PCB Congener	Regression Predicted Sediment Concentration (ug/kg-dry weight)		
	Lower Slough	Upper Middle Slough	Lower Middle Slough
PCB-77	0.037	0.66	1.0
PCB-81	0.012	0.17	0.33
PCB-105	0.13	3.0	3.7
PCB-114	0.13	3.0	3.7
PCB-118	0.13	3.0	3.7
PCB-123	0.13	3.0	3.7
PCB-126	0.000026	0.00012	0.00077
PCB-156	0.13	3.01	3.7
PCB-157	0.13	3.01	3.7
PCB-167	0.13	3.01	3.7
PCB-169	0.000093	0.00053	0.0027
PCB-189	0.13	3.0	3.7
Total PCB TEQ	0.00002	0.0001	0.0006
Total PCB as Aroclor	0.034	0.59	0.94

Total PCB guidance default = 0.39 ug/kg

Predictive Modeling- Interpretation

- Predicted Sediment Concentrations for Total PCB (as Aroclor) in lower and middle upper slough are similar to existing DEQ PCB sediment screening levels for human health.
- Predicted risk-based sediment levels for lower slough 10x lower than existing DEQ sediment criteria, inconsistent with carp tissue /ATLs. Lower Slough Carp PCBs ~ 200 ug/kg.
- Both Sediment and SPMDs appear to be related to tissue concentrations, limited tissue data prevents further consideration of whether water or sediment is more important for tissue loadings

Predictive Modeling- Interpretation

- Sediment levels for congeners exceeding on the order of 10x. However, excluding the lower slough Aroclor exceeds by approximately a factor of 100x.
- Concentration reduction of 10x (i.e., 90%) could reduce dioxin like risks to acceptable levels, but:
- If Aroclor based criteria are the relevant then 100x (99%) reduction would be required to reach risk-based levels.

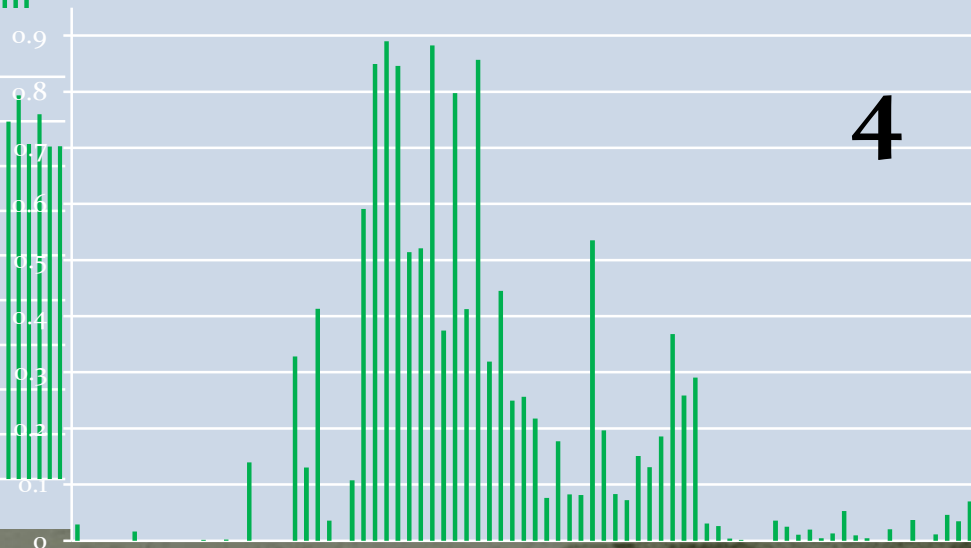
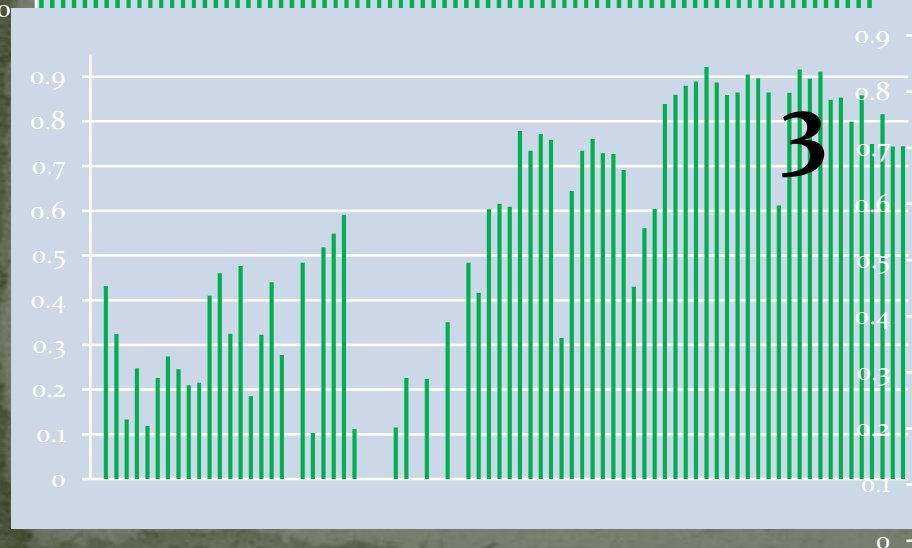
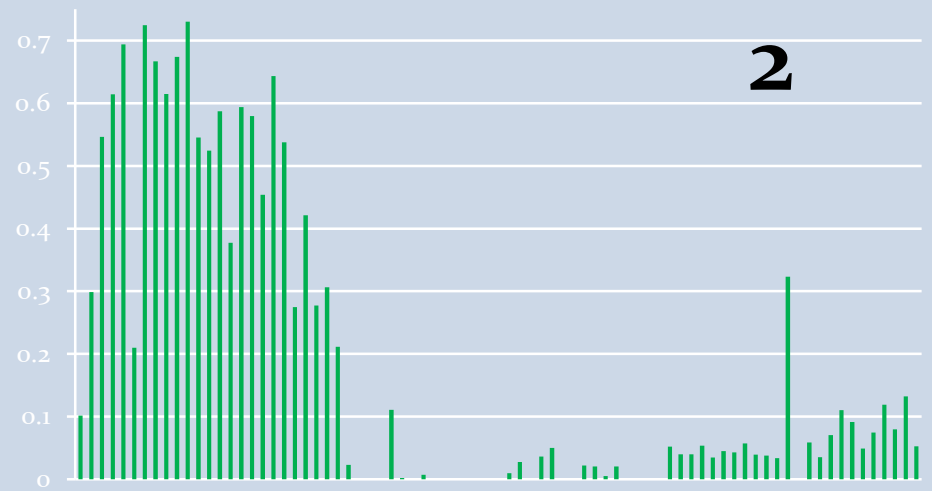
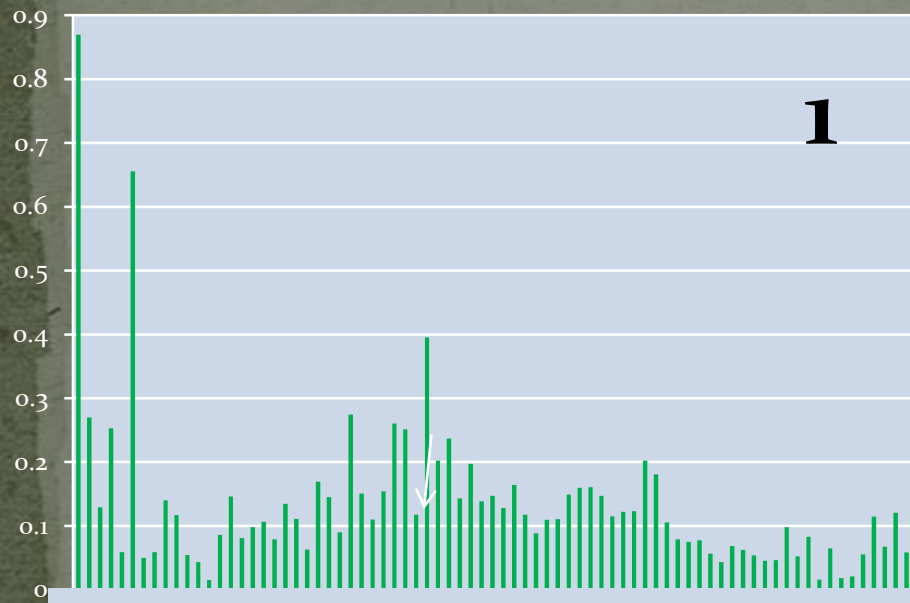
Source Attribution

- Since PCB levels in sediment and tissue appear stable and not declining, what are the sources?; and can they be controlled?
- Approach: Use mathematical “unmixing” algorithm.
- Method also termed receptor modeling has been used in air pollution monitoring.

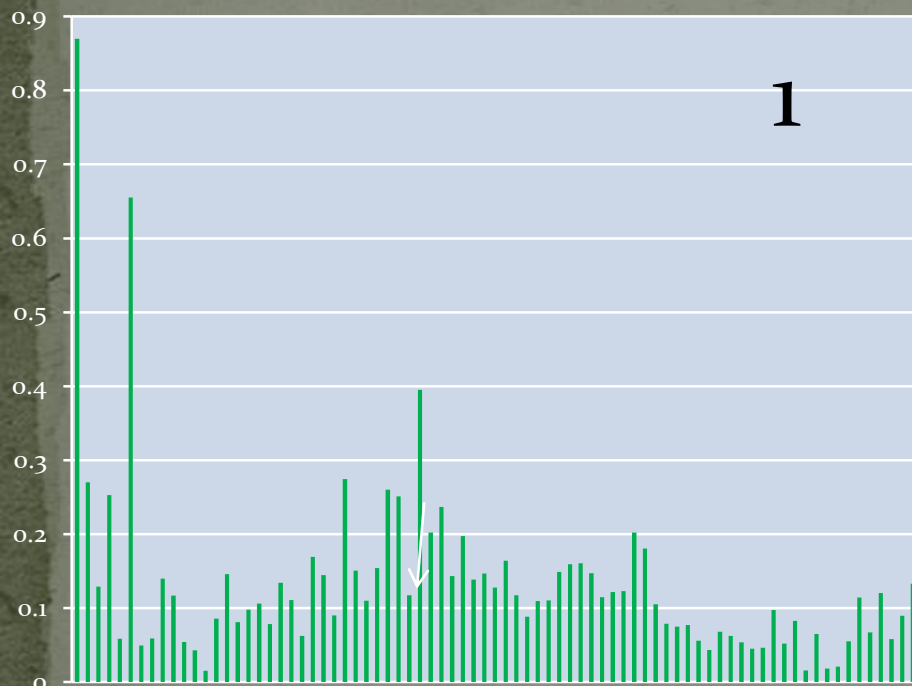
Source Attribution

- PCB Congener Data from multiple regional sources compiled in a single database, including Columbia River, Puget Sound, Lower Willamette River and the Columbia Slough.
- Data processed to create a single consistent database of approximately 85 congeners. Non-detections replaced with model estimated values
- Data analyzed using commercial software with unmixing algorithm

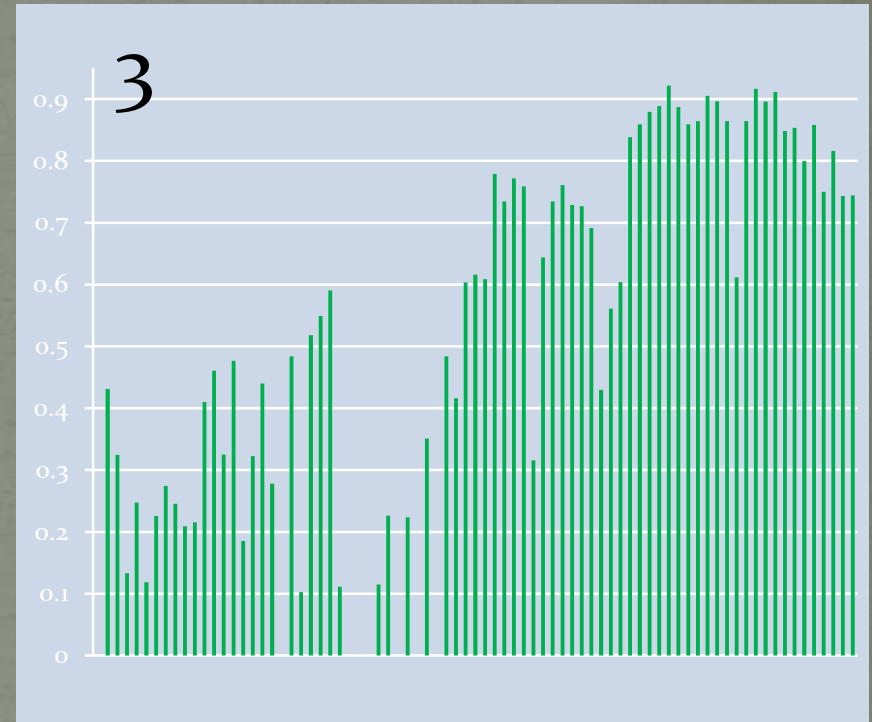
Source Attribution- Four Profiles



Source Attribution-Interpretation



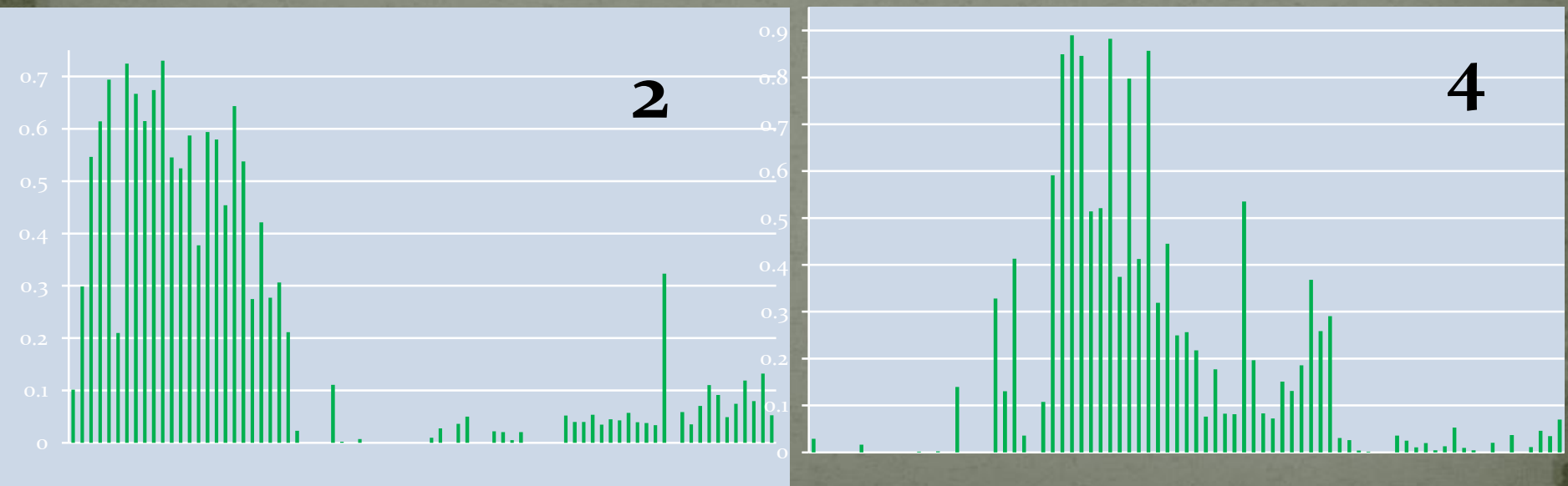
First pattern appear consistent with Atmospheric Transport, associated with low concentration (<3 ug/kg) and remote locations.



Third pattern consistent with weathered recalcitrant residual material.

Source Attribution-Interpretation

- Second and fourth patterns consistent with Aroclor 1248/42 and 1254 as original sources. Approximately equal mix and consistent with other literature.



Source Attribution- Unaddressed Questions

- Which congeners/homologues are most significant in terms of differentiating between Lower Willamette and Columbia Rivers?
- Of the Aroclor patterns identified, where are /did they come from? (stormwater, point sources)? Can they be controlled?
- What is loading fish tissue? Is weathered component in sediment significant? Complete congener data in tissue needed to assess.

Did we meet our Objectives?

- Objectives of Study

- Determine average concentrations of contaminants in slough sediment and developing new, updated estimates of baseline concentrations in the sampled segments -
 - Yes- Updated five(5) Slough segments with individual estimates of baseline concentrations in sediments for PCBs and Pesticides
- Development of predictive relationships between sediment and fish tissue: DEQ's 2009 work found good correlations between sediment and fish tissue.
 - Yes- three of four sediment vs tissue slopes were similar. Likely another unknown factor influencing tissue concentrations-possibly stormwater?

Did we meet our Objectives?

- Validate DEQ's bioaccumulation guidance using data specific to the Columbia Slough.
 - Yes-Two of Three segments within 'ball park' of DEQ guidance for PCBs. Pesticides not calculated.
- Perform exploratory multivariate analyses and PCB source attribution.
 - Yes-Found four(4) distinct types of PCB signatures –
 - Air deposition/background
 - Weathered and recalcitrant PCBs
 - Two types consistent with Aroclor 1248/42 and Aroclor 1254 as original sources



Overall Summary

- ISM sampling effective in determining average concentrations in sediment. ISM data appears useful to assess bioaccumulation, at least in some cases.
- Model predicted sediment concentrations appear to validate default screening levels for PCBs of <1 ppb.
- High quality congener data useful for assessing sources. Needed in all matrices including tissue to address most effective control strategies, assess sources to tissue.



State of Oregon
Department of
Environmental
Quality

Any Questions?

Paul Seidel- 503-693-5781

Sarah Miller-503-299-5040

<http://www.deq.state.or.us/lq/cu/nwr/columbiaslough>



