# Elliott Bay Regional Background Workshop

# Early Development of the Draft Sampling and Analysis Plan

**Sept 3, 2013**

**Chance Asher**

**Department of Ecology**

# Goals for Today

## Work collaboratively to:

- Gather information to guide our development of a draft sampling & analysis plan (SAP) to establish regional background.
- Develop a SAP Conceptual Site Model.
- Understand feasibility of proposed alternatives for the SAP considering:
    - Financial resources
    - Ecology (and stakeholder) staff resources
    - Time frames
    - Regulatory definition of regional background

# Today's Agenda

- **Morning Session – Information Sharing**:
  - Provide high level summaries of past and current studies in Elliott Bay and Duwamish River area.
  - Determine if or how this information can be used to:
    - Develop a Conceptual Site Model.
    - Complement implementing the proposed alternatives.

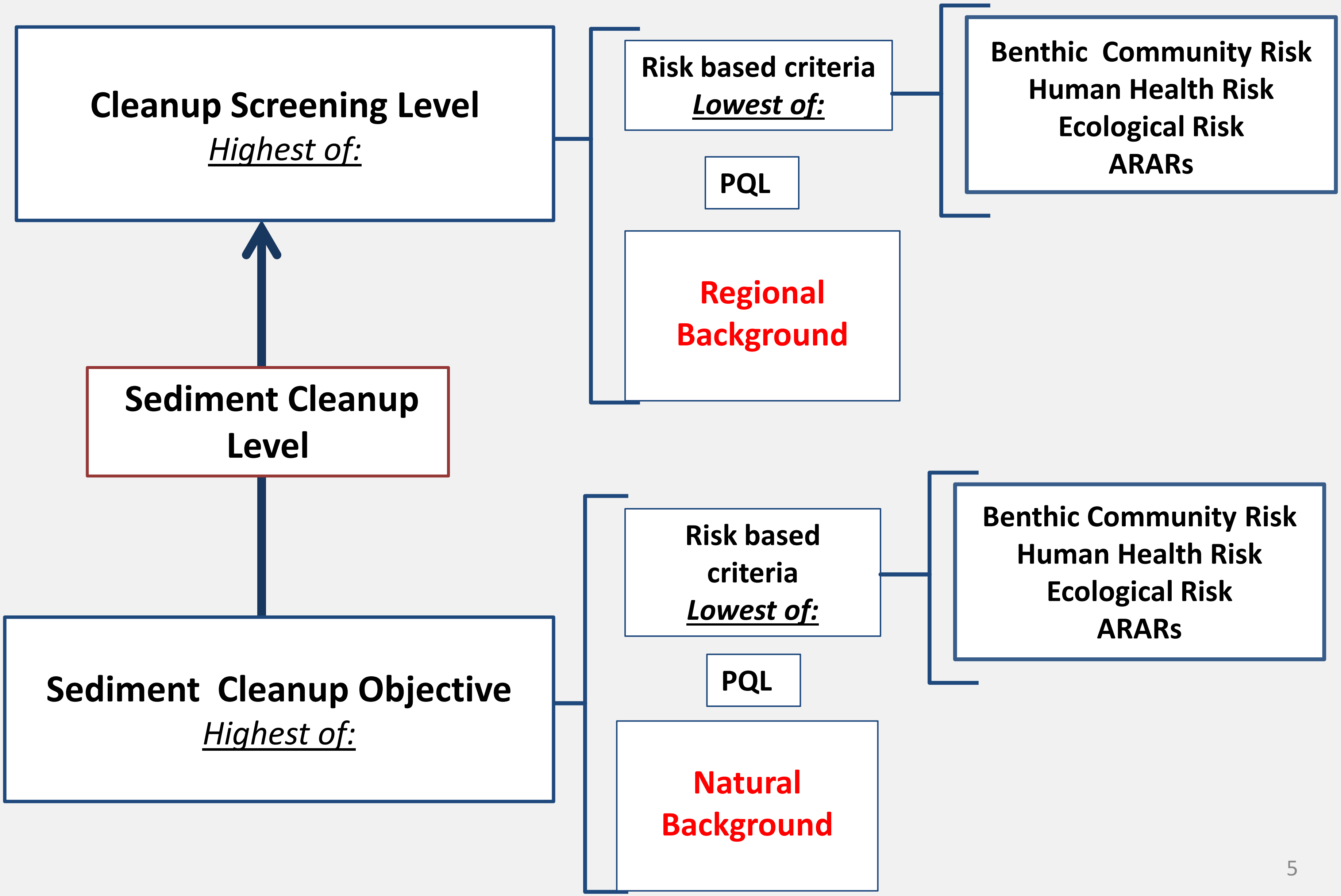
- **Lunch** – Working session to review alternatives (see handout).

- **Afternoon Session – Work Session/Discussion of Alternatives**:
  - Feasibility/technical implementability.
  - Pros and cons.
  - Consistency with SMS rule definition.

# Sediment Management Standards Context & Bit O'History

- Revised rule adopted February 22, 2013.
- Revised rule effective September 1, 2013.
- Includes concepts of background:
  - Natural background as part of the **Sediment Cleanup Objective**
  - Regional background as part of the **Cleanup Screening Level**
- The rule advisory groups consistently advised Ecology to lead the development of background.
- Elliott Bay is one of three where Ecology is currently working to establish regional background.

# How Background Fits - Establishing Cleanup Levels



# SMS Background Definitions (in a nutshell)

- **Natural Background WAC 173-204-505(11):**

  *…the concentration of a hazardous substance consistently present in the environment that has not been influenced by localized human activities.*

- **Regional Background WAC 173-204-505(16):**

  *…the concentration of a contaminant within a department defined geographic area that is primarily attributable to diffuse sources, such as atmospheric deposition or storm water, not attributable to a specific source or release.*

- **Difference:** Globally distributed contaminants from global sources versus locally distributed contaminants from diffuse sources such as storm water, atmospheric deposition, etc.

# Regional Background Definition expanded nutshell

**WAC 173-204-560(5):**

- Ecology establishes background.
- Ecology defines the geographic area. Can include an embayment, stretch of a river, watershed.
- Regional background expected to be > natural background.
- Ecology can default to natural background if regional background is not established or if regional background concentrations are not elevated above natural background.

# Intent of Regional Background

- To address the reality of ubiquitous contaminants continuously entering the environment that are:
  - Not able to be technically or physically controlled or eliminated:
    - Contaminants from vessel traffic, automobiles, septic systems, backyards.
    - Contaminants in the atmosphere from diffuse, un-definable sources.
  - Not able to be controlled or eliminated in any practicable or timely manner:
    - Contaminants in stormwater that cannot be treated with current technology (due to type of contaminant, load, volume of stormwater, inordinate cost).
    - Contaminants from orphan pilings.

# Intent of Regional Background

- Includes the concentrations that are primarily from diffuse sources.
- Can include some influence from definable sources such as piped stormwater, but not the direct influence (that is, the primary contributor).
- To provide a technically implementable structure to meet and maintain cleanup standards given the potential for recontamination from the above mentioned sources.

# Regional Background - What it is NOT

- Not primary influenced by definable sources, such as a cleanup site.
- Not defined by "recontamination potential" primarily from definable sources.
- Cannot sample within an area of elevated concentrations due to the direct impact of a definable source. For example:
  - Within the depositional zone of an outfall (akin to the SMS Sediment Impact Zone area).
  - Within an established cleanup site.
- Not natural background – if there's a statistically significant difference between regional and natural background.

# Regional Background
# How can it be used under the SMS rule?

- To establish the Cleanup Screening Level, if it is higher than risk based concentrations and the PQL.
- As the potential upper bound for establishing a sediment cleanup level.
- To identify a cleanup site – the areas where cleanup needs to be done.
- To identify the areas of a cleanup site for active cleanup.
- To identify areas for interim actions.

# Questions and Discussion

# Elliott Bay - summary of existing chemistry data

Sept 3, 2013

Laura Inouye

Department of Ecology

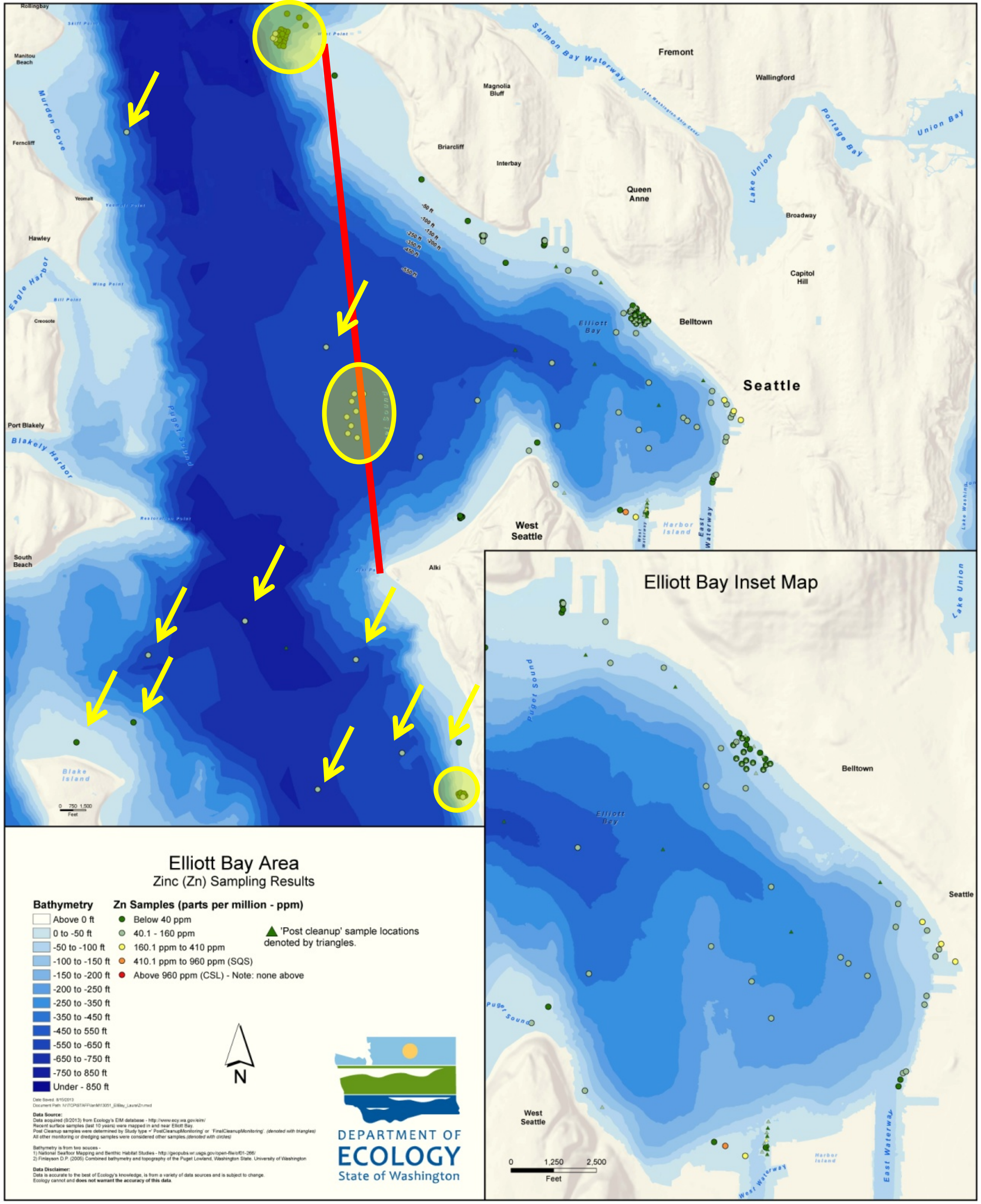
Shorelands and Environmental Assistance Program

# Overview

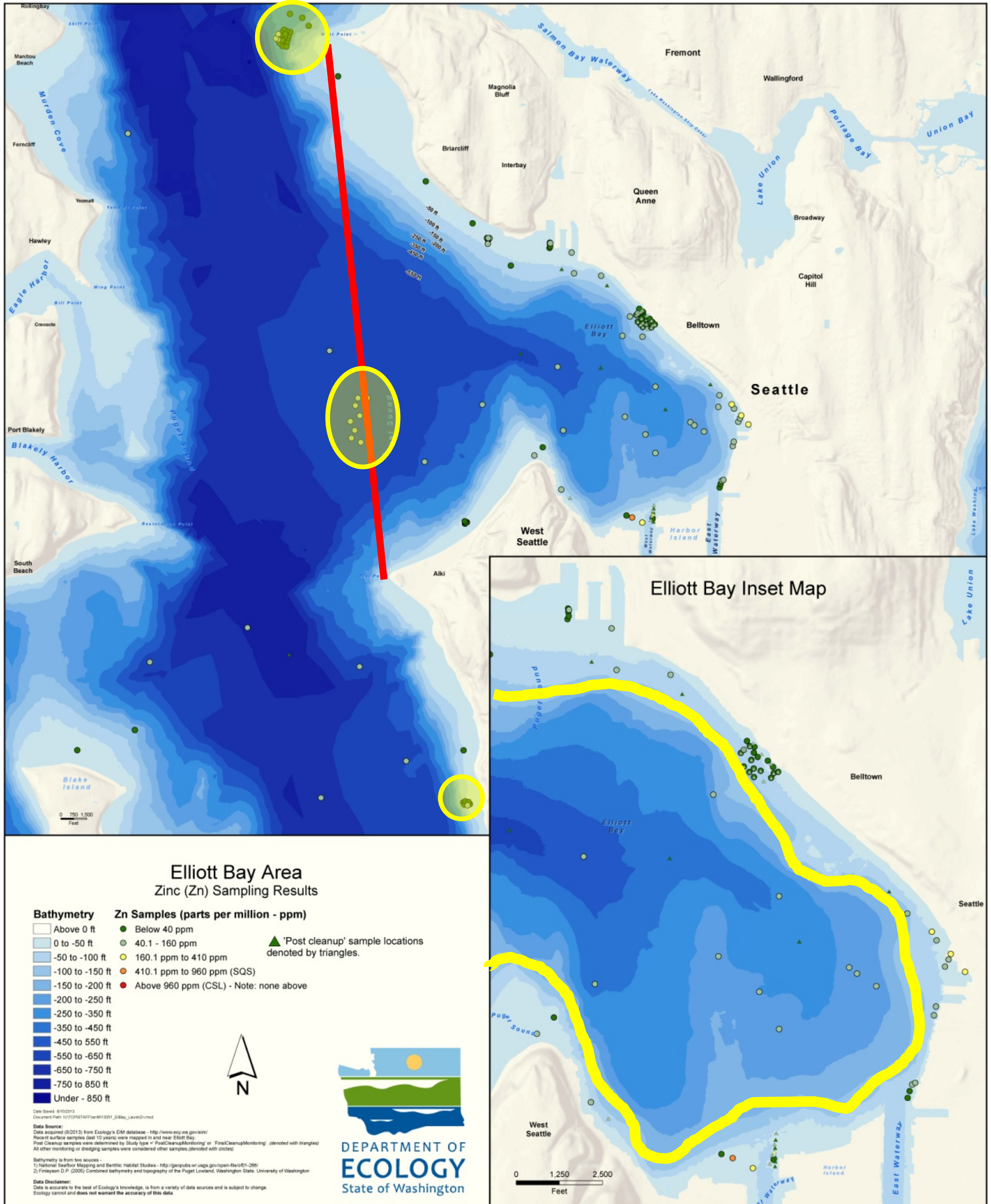
- This presentation is a summary of existing data and data trends to assist in later discussions
- It is NOT presenting data or statistics for use as regional background values
- Presentation will cover:
  - Data selection
  - Data processing
  - Preliminary evaluations
  - Box plots for selected parameters

# Data Selection

- Physical parameters: Depth, TOC, % fines
- Chemical parameters:
  - PCBs (Aroclor)- insufficient congener data
  - Dioxin- sum TEQ
  - cPAHs
  - Bis(2-ethylhexyl) phthalate (BEHP)
  - Metals (Arsenic, Copper, Mercury, Zinc)
- Includes surface but not limited to top 10 cm
- Less than 10 years old




- "Bold Plus" is data from the 2008 OSV Bold survey, and Ecology approved reference areas and other non-anthropogenically impacted areas.
- "Nearby Puget Sound" is data from west of the line from West Point to Alki Point
  - Doesn't include data collected for the two outfalls.
  - South to Blake Island State Park
  - North to Lake Washington Ship Canal




- " Basin" is data from east of the line from West Point to Alki Point, and deeper than 120 ft.
  - Includes outfall data if deeper than 120 ft
- "Near shore" is data from east of the line from West Point to Alki Point, and shallower than 120 ft
  - Includes outfall data shallower than 120 ft

# Data processing

- Data downloaded from EIM
- Since MyEIM analytical tools do not have Kaplan Meier capabilities, data analysis here is based on 0.5 DL substitution for non-detects. PCB summing follows standard Aroclor summation rules.

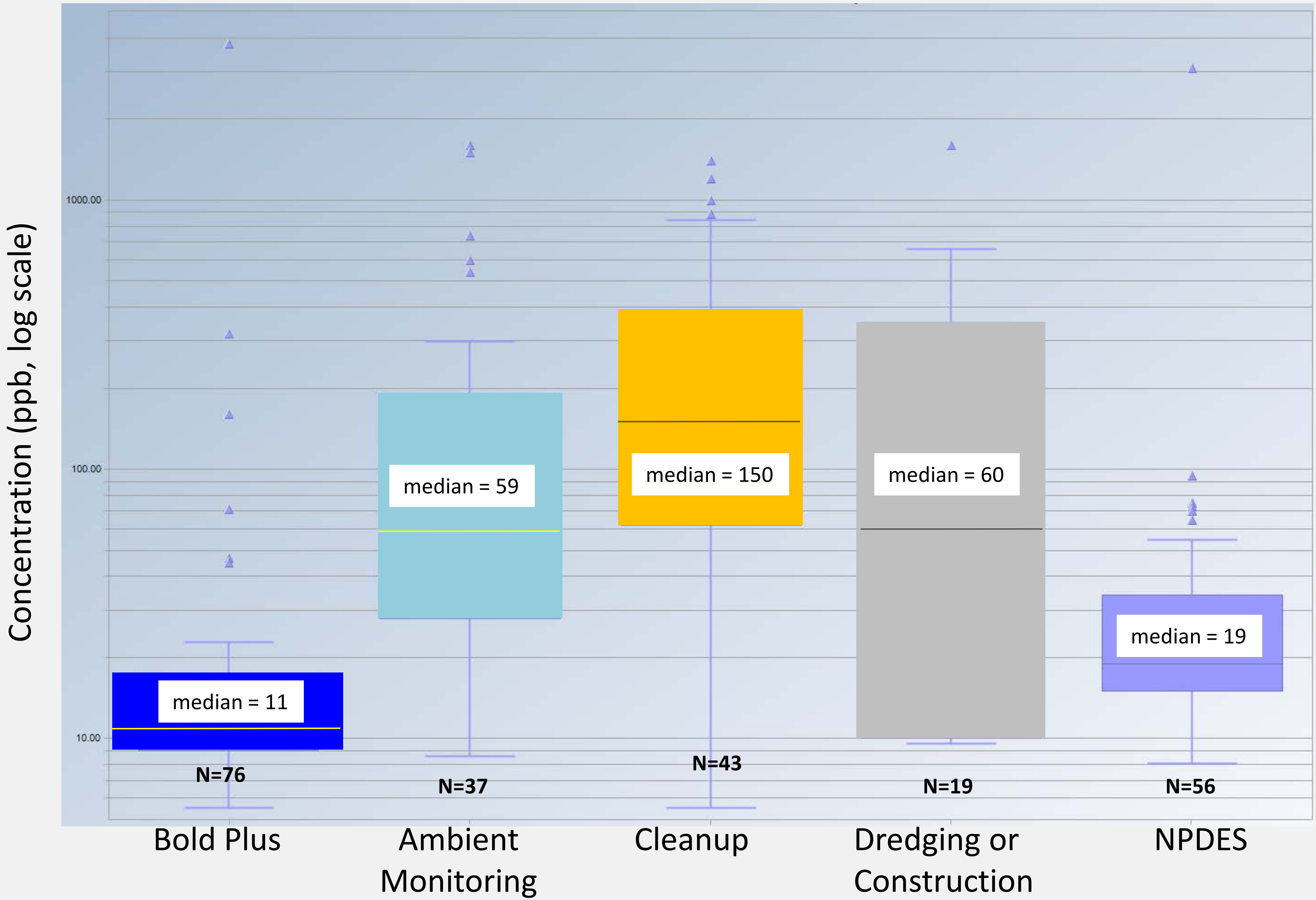
QUESTION: Since data was collected for different purposes, can they be combined?

# Preliminary Data Analysis

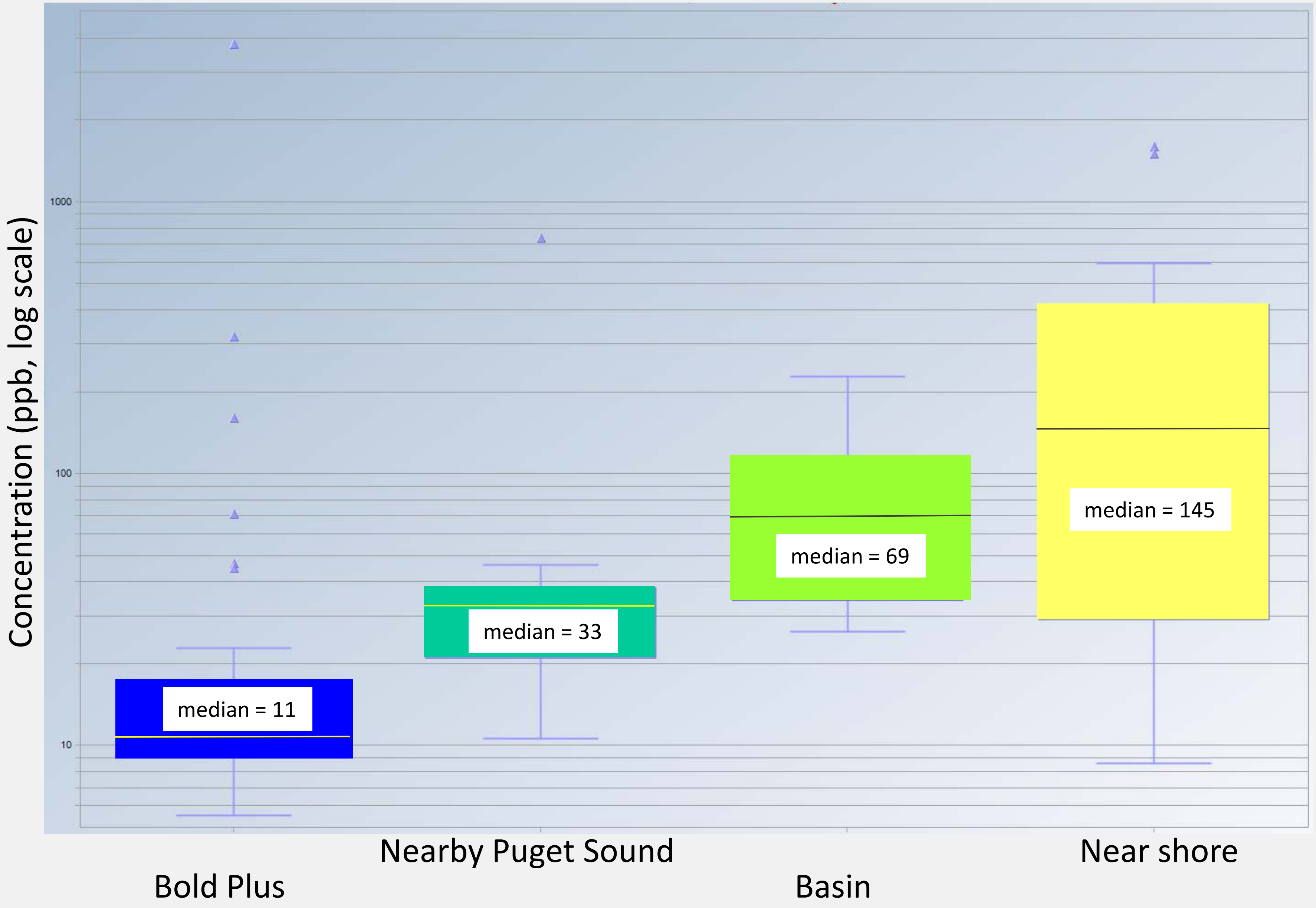
- Exploratory analyses were conducted to determine if the data from the various studies could be combined (Is there a difference in data collected for different purposes?)
  - Ambient monitoring
  - NPDES permit monitoring
  - Cleanup (post cleanup monitoring, final cleanup monitoring)
  - Dredging/construction sediment evaluations
  - Analysis conducted on all analytes plus % fines and %TOC, but is presented only for Bis(2-ethylhexyl) phthalate (BEHP) which had the most data for organic compounds
  - Calculated means, and generated box plot comparisons for each study type

- Calculated means, generated box plot comparisons for ambient monitoring. (Are there trends based on sample depth/locations?)
  - Comparison of Bold, nearby Puget Sound, Basin, and Near Shore
  - NPDES and Cleanups had basin and near shore data, Dredging only had near shore data.

# Preliminary data example results: BEHP, by study type



Preliminary data example results: BEHP, ambient monitoring data only



# Preliminary Data Analysis, Summary

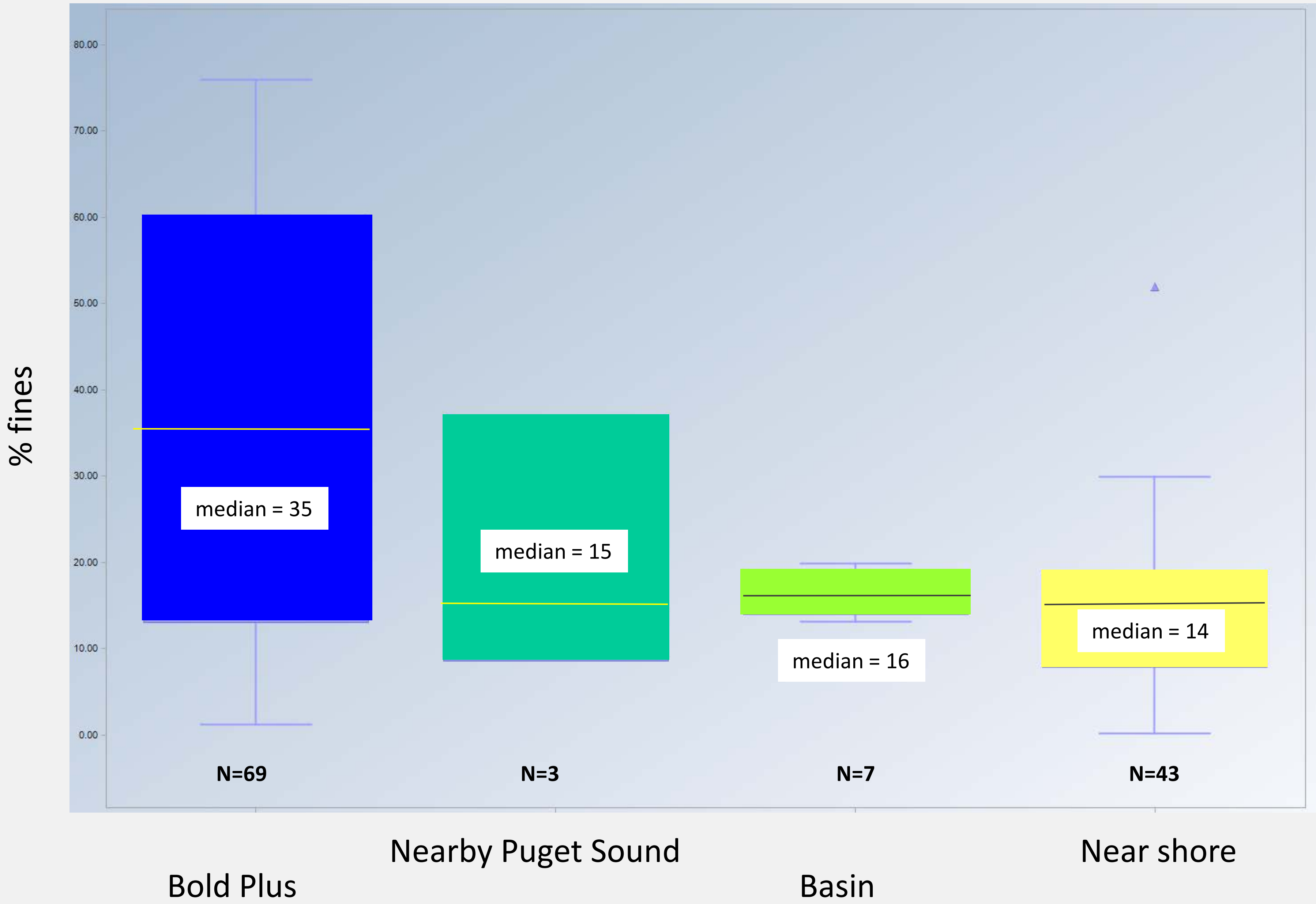
- DID STUDY TYPE IMPACT DATA?
  - In all cases where data was available, NPDES data were similar to or lower than the Bold Plus dataset.
  - Cleanup data had similar distribution as ambient monitoring and other study types
  - ALL STUDY TYPES CAN BE COMBINED FOR THIS ANALYSIS

- WERE THERE TRENDS IN THE AMBIENT MONITORING DATA WITH RESPECT TO DISTANCE FROM SHORE?
  - cPAHs, BEHP, cPAHs, dioxins, had increasing concentrations as sample location moved inshore.
  - Arsenic, copper, mercury and zinc showed no trends as sample locations moved inshore.

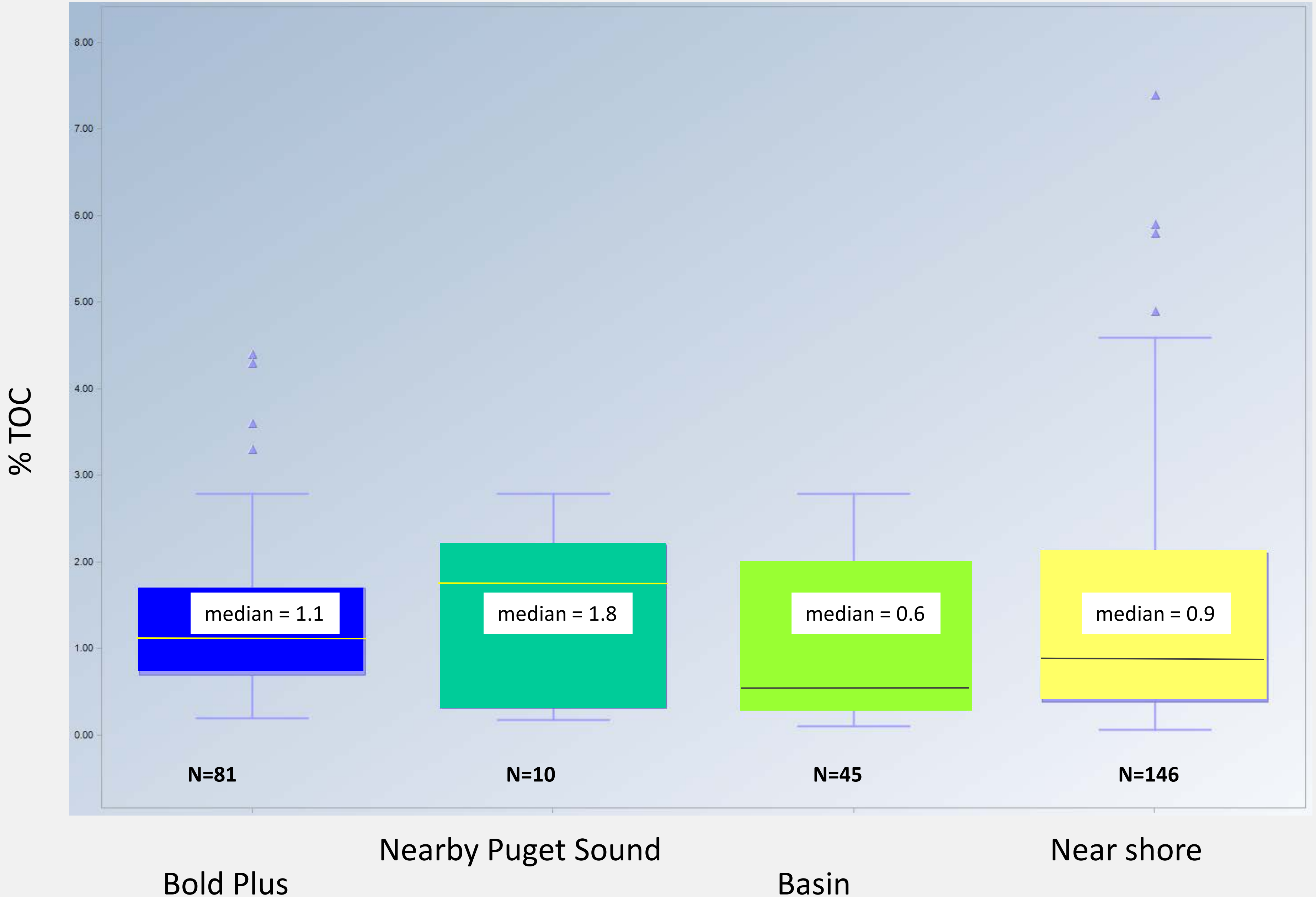
# Data Analysis- combined data

- Following slides are box plots for the selected parameters.
- Data for each parameter are presented broken into four groups, moving from off shore to inshore.
  - Bold plus
  - Nearby Puget Sound
  - Basin
  - Less than 120 ft deep (near shore)

# Fines- all data

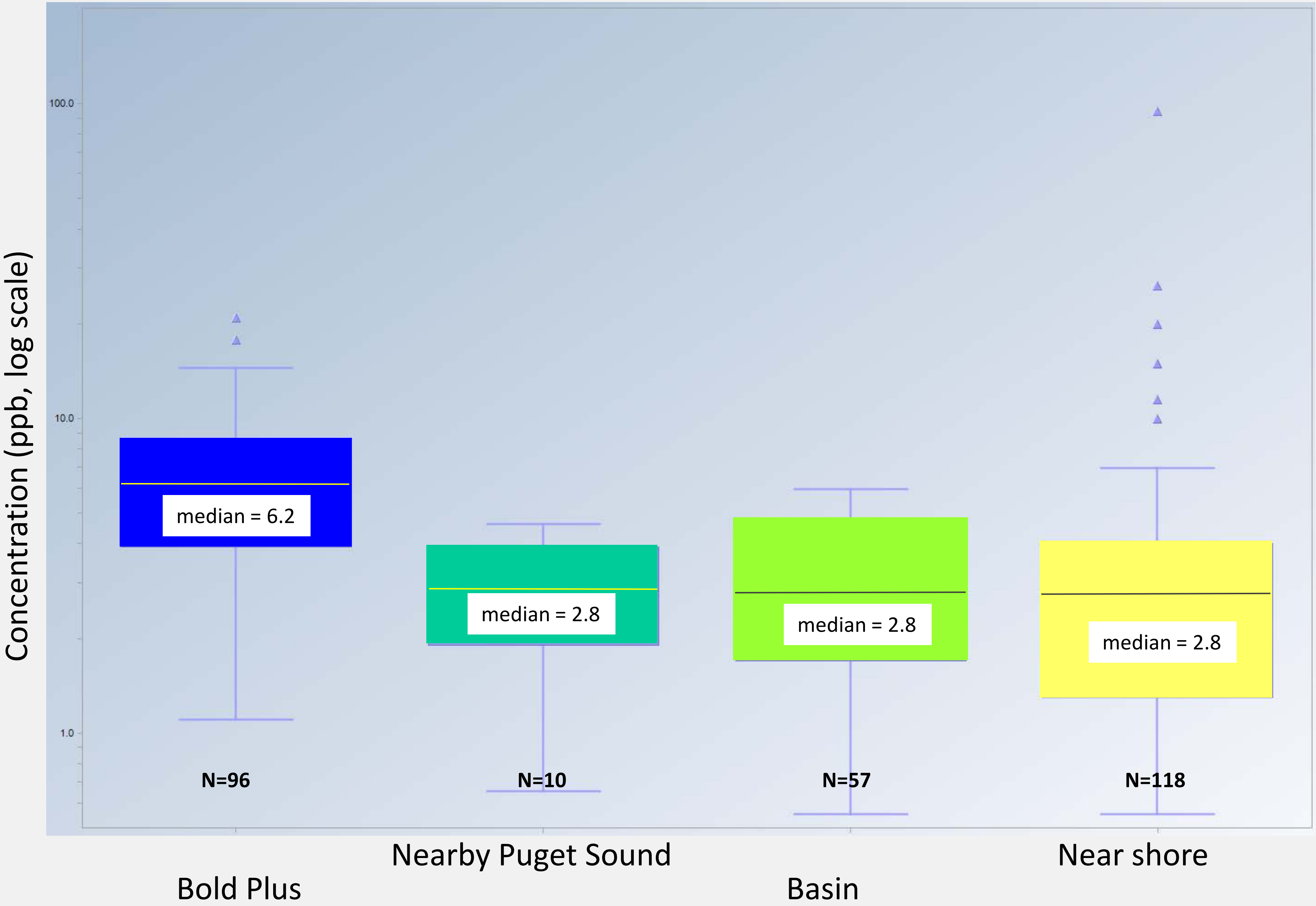


# TOC- all data

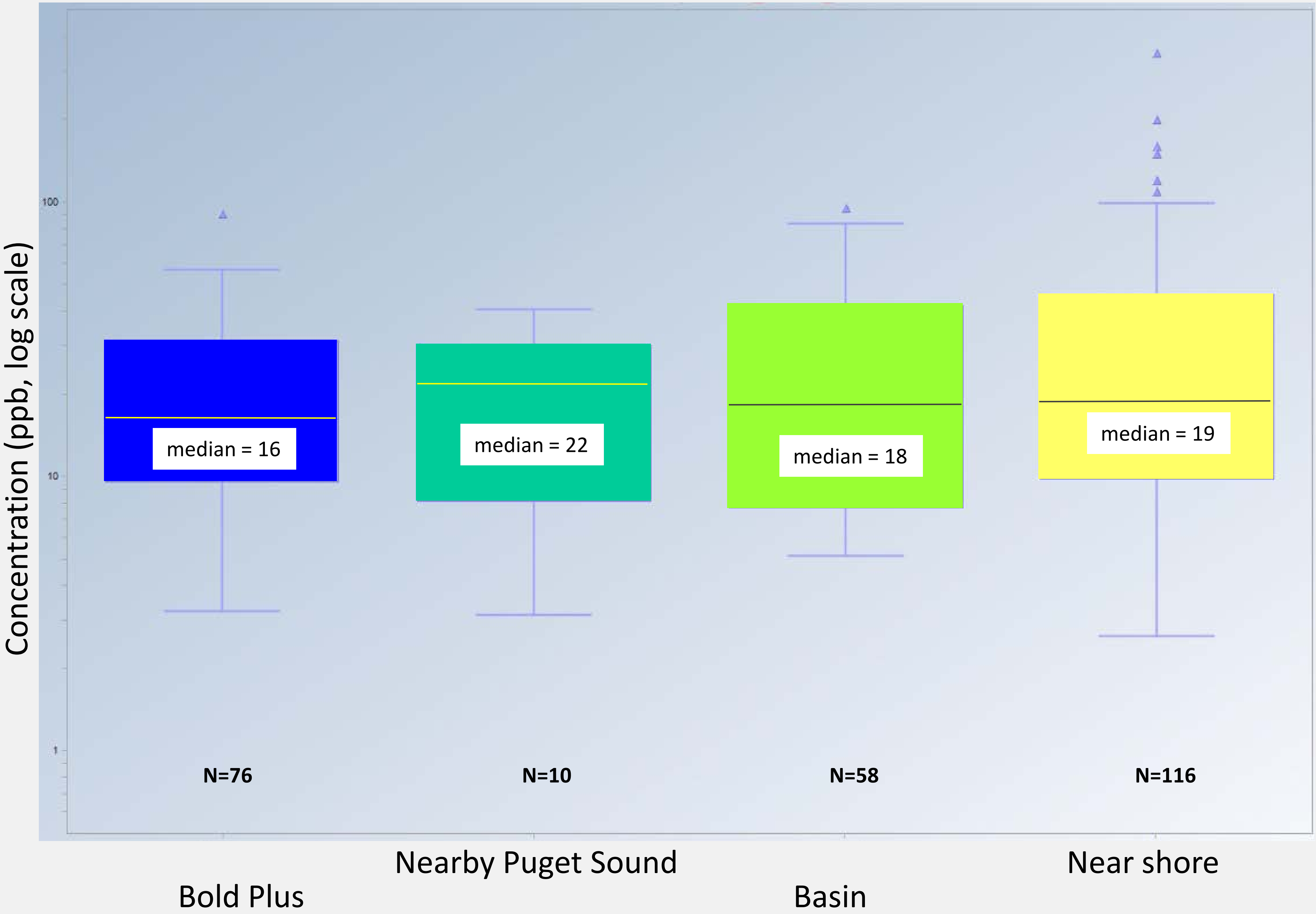


8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
% TOC
median = 1.1
median = 1.8
median = 0.6
median = 0.9
N=81
N=10
N=45
N=146
Bold Plus
Nearby Puget Sound
Basin
Near shore

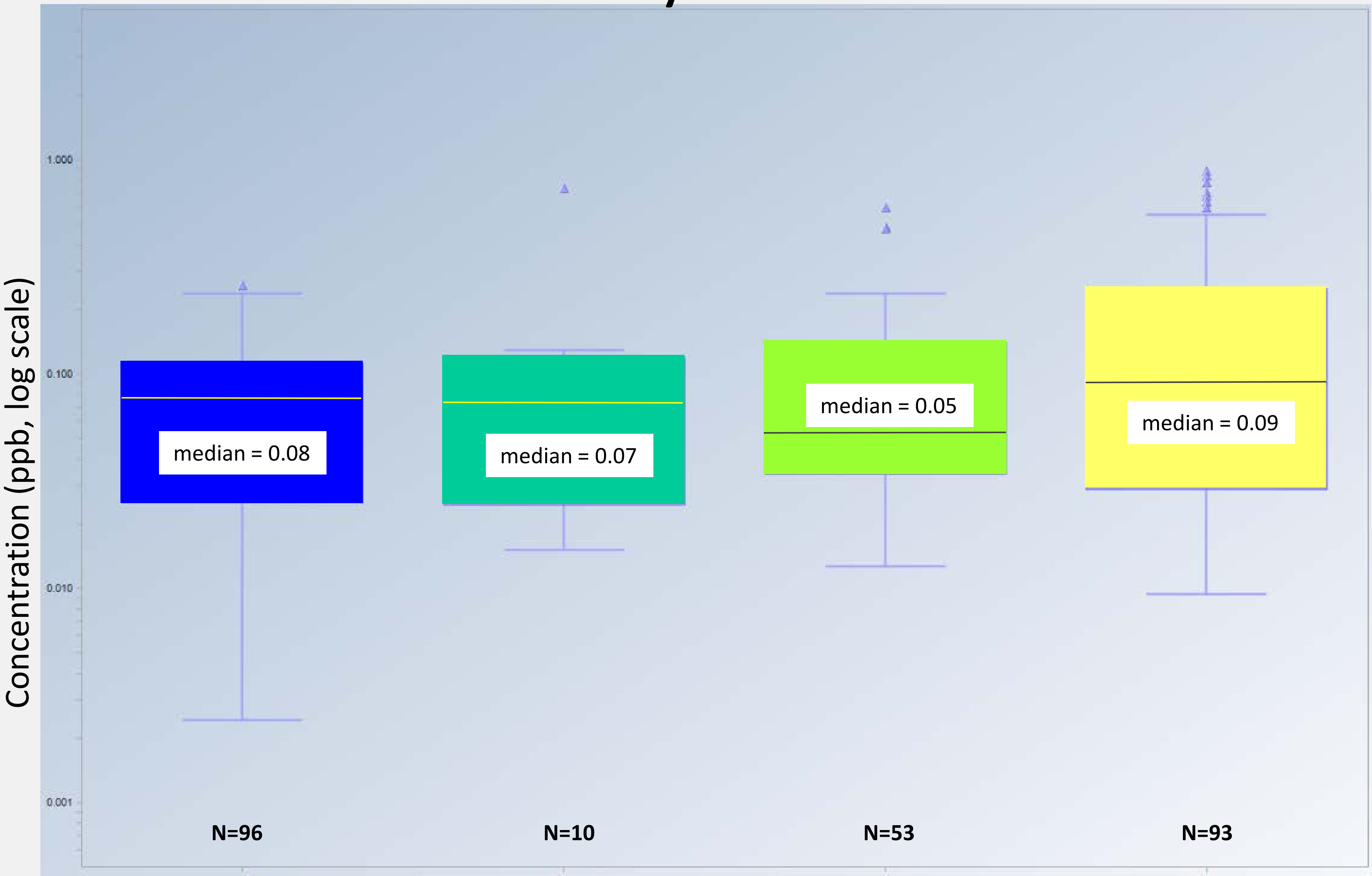
# Arsenic- all data



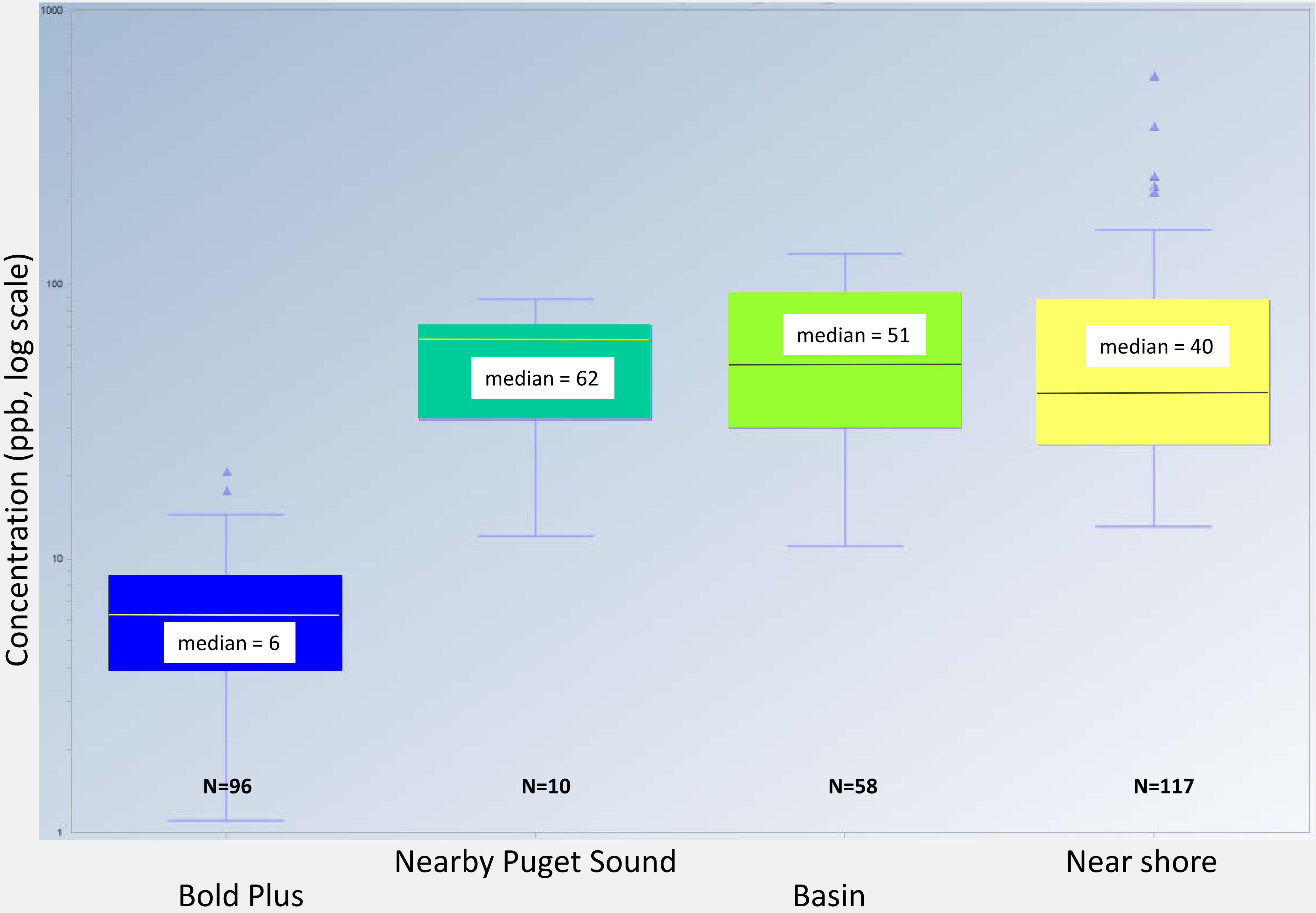
# Copper all data



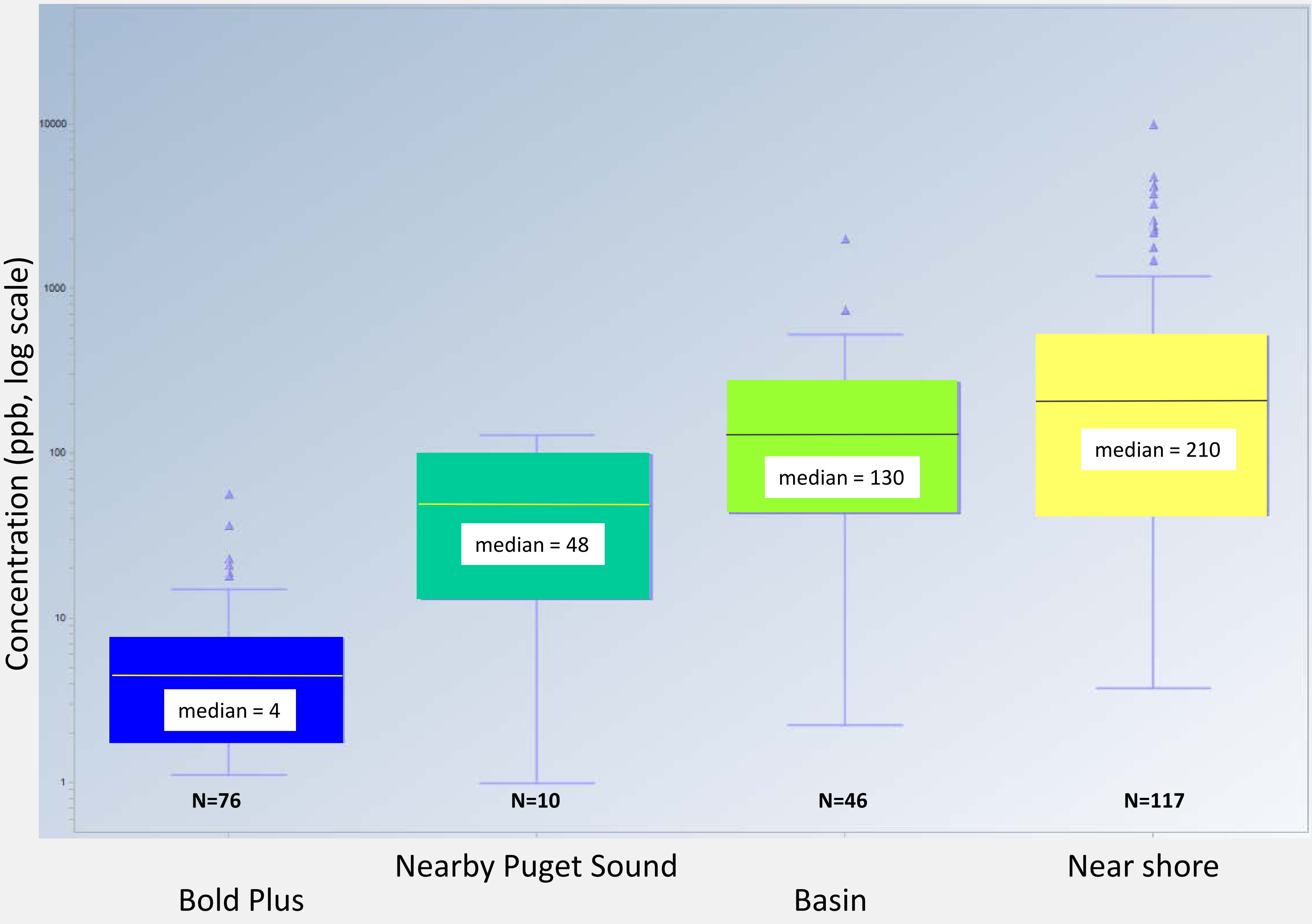
# Mercury- all data



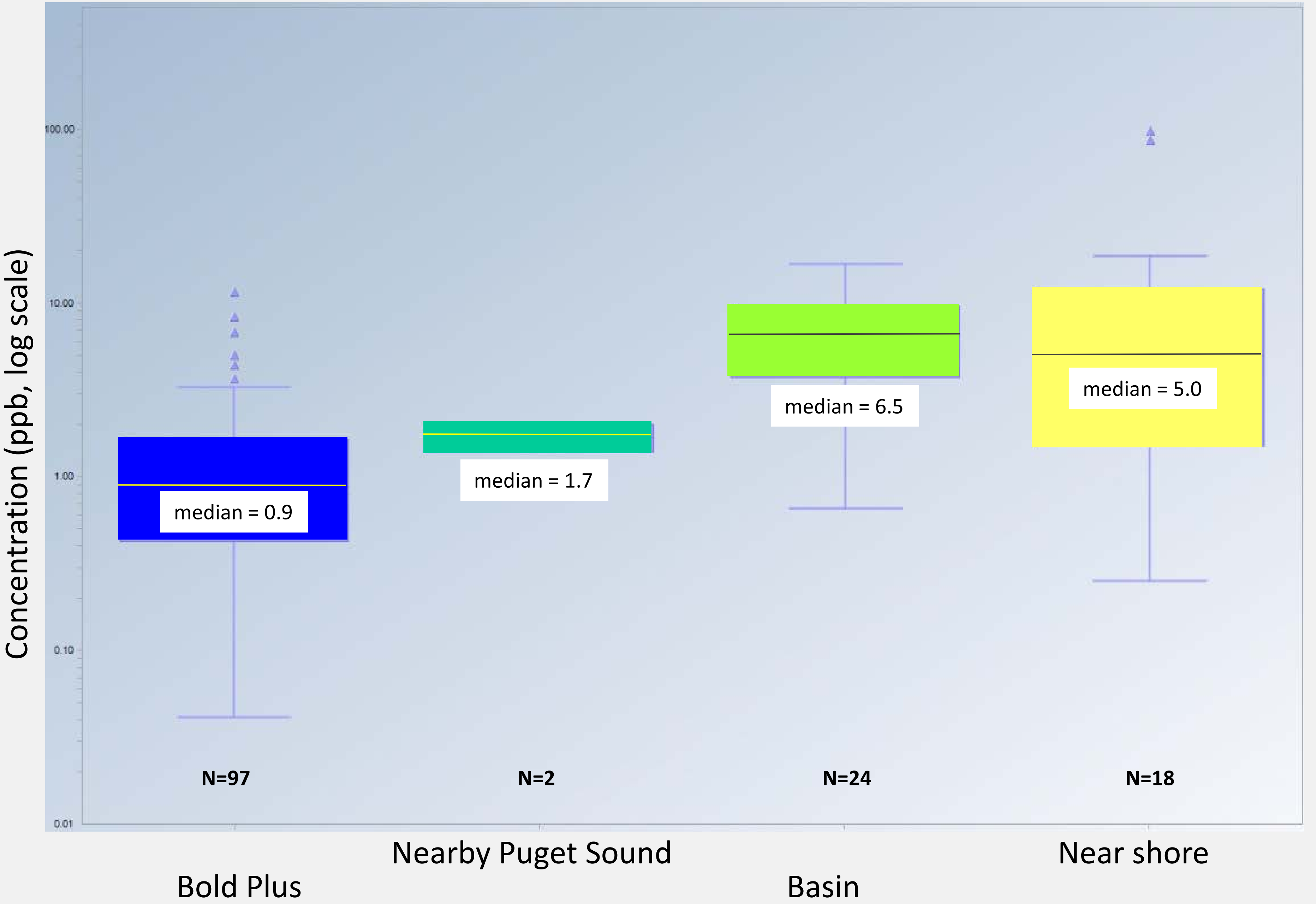
# Zinc- all data



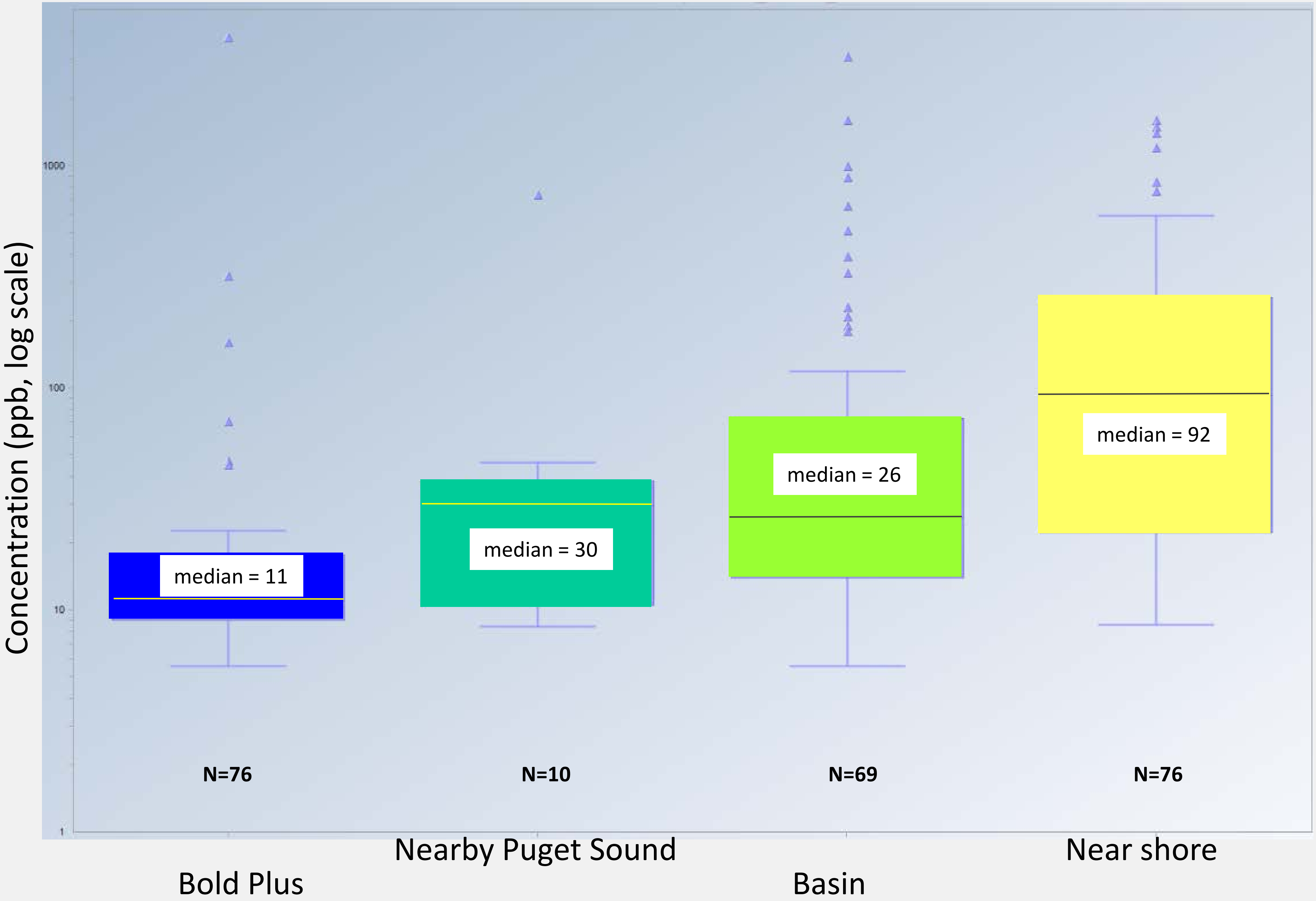
# cPAH- all data



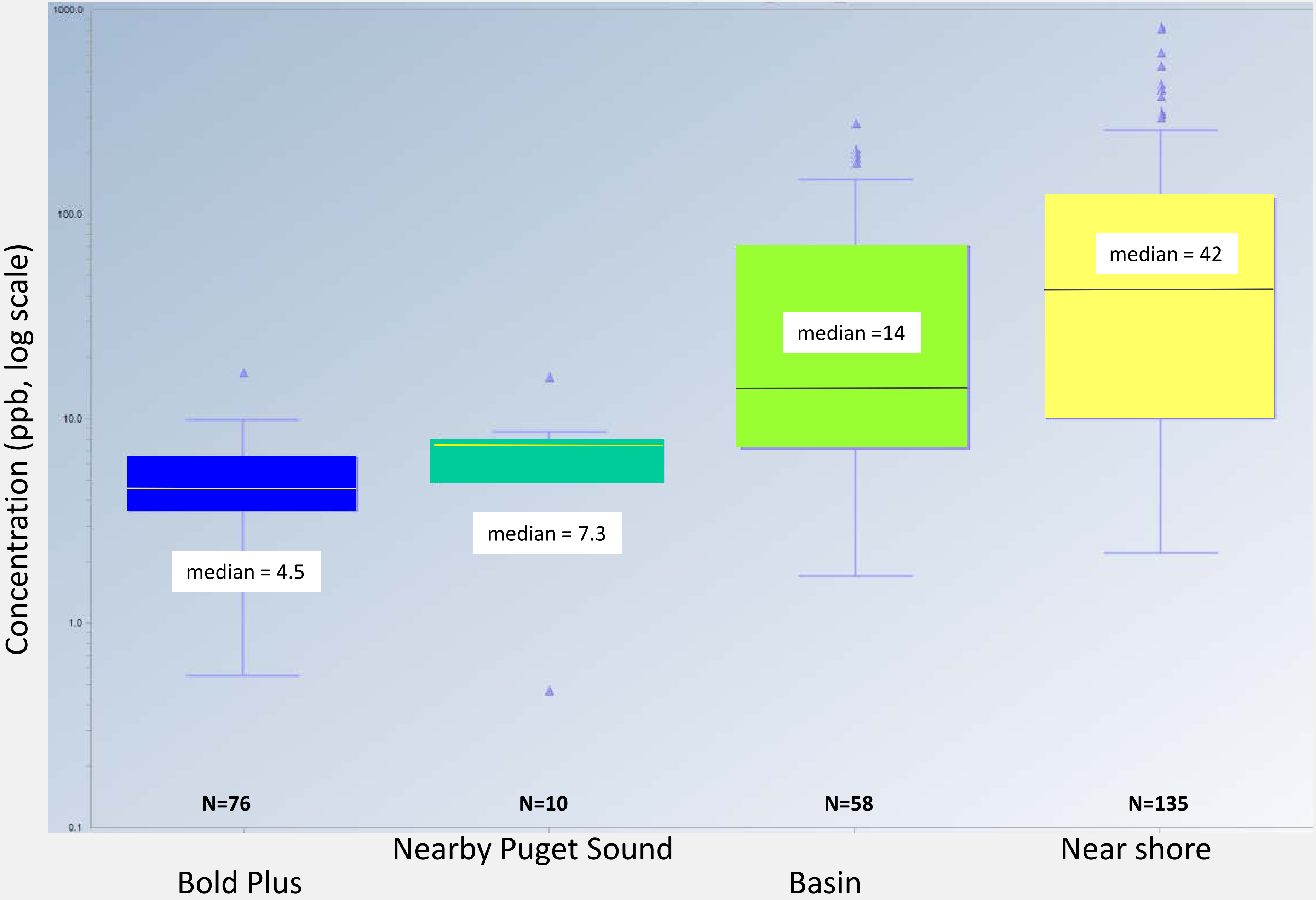
# Dioxin TEQ- all data



# BEHP-all data



# PCB (Aroclor)- all data



# Summary, combined data

- No trend:
  - % fines (Bold Plus had higher average and range than others)
  - Arsenic (Bold Plus slightly higher than other data)
  - % TOC
  - Copper
  - Mercury

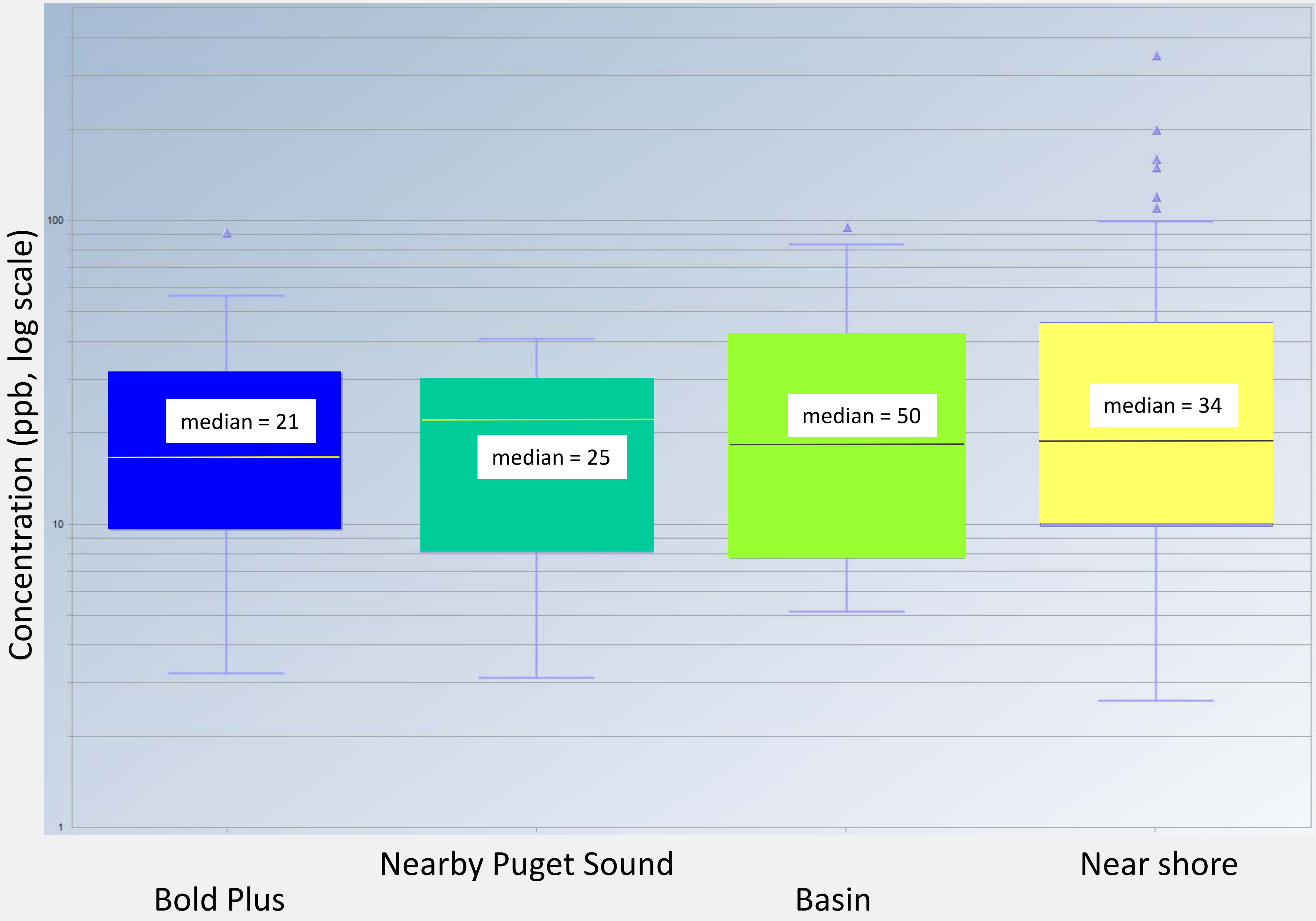
- Bold Plus < Nearby=basin=near shore:
  - Zinc (~1 order of magnitude)

- Trend of increasing concentrations moving towards the shoreline:
  - cPAH
  - Dioxin
  - BEHP
  - PCB (sum Aroclor)
  - All about 1 order of magnitude range

QUESTIONS?

# SUPPLEMENTARY SLIDES

# Exploratory data example results: Copper, all data



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Summary Statistics for Raw Full Data Sets

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All fines | 53 | 0.086 | 52 | 15.4 | 15 | 88.7 | 9.418 | 5.93 | 1.196 | 3.479 | 0.612 |
| Ambient (AMB) | 23 | 0.086 | 37 | 15.43 | 17 | 85.2 | 9.23 | 7.413 | 0.0876 | 0.288 | 0.598 |
| AMB-PS | 2 | 8.6 | 37 | 22.8 | 22.8 | 403.3 | 20.08 | 21.05 | N/A | N/A | 0.881 |
| AMB-NS | 21 | 0.086 | 29 | 14.73 | 17 | 67.6 | 8.222 | 5.93 | -0.545 | -0.301 | 0.558 |
| CLEANUP (CU) | 28 | 2.6 | 52 | 15.41 | 14.5 | 101.4 | 10.07 | 7.265 | 1.891 | 5.507 | 0.654 |
| CU-PS | 1 | 15 | 15 | 15 | 15 | N/A | N/A | 0 | N/A | N/A | N/A |
| CU-B | 7 | 13 | 20 | 16.43 | 16 | 6.952 | 2.637 | 2.965 | 0.112 | -1.638 | 0.16 |
| CU-NS | 20 | 2.6 | 52 | 15.07 | 11.5 | 141.4 | 11.89 | 9.414 | 1.774 | 3.825 | 0.789 |
| Dredging/construction | 2 | 15 | 15 | 15 | 15 | 0 | 0 | 0 | N/A | N/A | 0 |
| Bold plus | 69 | 1.1 | 76 | 37.14 | 35 | 644.7 | 25.39 | 35.58 | -0.00239 | -1.66 | 0.684 |
| all_PS | 3 | 8.6 | 37 | 20.2 | 15 | 221.9 | 14.9 | 9.489 | 1.379 | N/A | 0.737 |
| all_B | 7 | 13 | 20 | 16.4 | 16 | 6.952 | 2.637 | 2.965 | 0.112 | -1.638 | 0.16 |
| all_NS | 43 | 0.086 | 52 | 14.9 | 15 | 96.18 | 9.807 | 8.599 | 1.223 | 3.585 | 0.658 |

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Summary Statistics for Raw Full Data Sets

| Variable | | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All TOC | | 201 | 0.049 | 7.4 | 1.316 | 0.84 | 1.522 | 1.234 | 0.964 | 1.563 | 3.519 | 0.938 |
| Ambient (AMB) | | 61 | 0.06 | 5.8 | 1.043 | 0.66 | 0.964 | 0.982 | 0.504 | 2.204 | 7.823 | 0.942 |
| AMB-PS | | 9 | 0.16 | 2.8 | 1.63 | 1.9 | 0.769 | 0.877 | 0.445 | -0.819 | -0.122 | 0.538 |
| AMB-B | | 12 | 0.55 | 2.3 | 1.639 | 1.8 | 0.375 | 0.612 | 0.593 | -0.659 | -1.1 | 0.373 |
| AMB-NS | | 40 | 0.06 | 5.8 | 0.731 | 0.545 | 0.932 | 0.965 | 0.274 | 4.156 | 20.18 | 1.32 |
| CLEANUP (CU) | | 60 | 0.049 | 5.9 | 1.916 | 1.9 | 1.727 | 1.314 | 1.534 | 0.515 | 0.0738 | 0.686 |
| CU-PS | | 1 | 0.22 | 0.22 | 0.22 | 0.22 | N/A | N/A | 0 | N/A | N/A | N/A |
| CU-B | | 3 | 0.2 | 0.27 | 0.23 | 0.22 | 0.0013 | 0.0361 | 0.0297 | 1.152 | N/A | 0.157 |
| CU-NS | | 56 | 0.049 | 5.9 | 2.037 | 2 | 1.631 | 1.277 | 1.483 | 0.484 | 0.244 | 0.627 |
| Dredging/construction | | 29 | 0.39 | 7.4 | 1.841 | 1.6 | 2.076 | 1.441 | 0.89 | 2.406 | 7.412 | 0.783 |
| NPDES all | | 51 | 0.073 | 2.8 | 0.638 | 0.31 | 0.58 | 0.762 | 0.237 | 1.762 | 1.727 | 1.193 |
| NPDES-B | | 30 | 0.095 | 2.8 | 0.879 | 0.41 | 0.807 | 0.898 | 0.23 | 1.103 | -0.504 | 1.022 |
| NPDES-NS | | 21 | 0.073 | 1.2 | 0.295 | 0.21 | 0.0704 | 0.265 | 0.104 | 2.346 | 6.214 | 0.9 |
| Bold plus | | 81 | 0.19 | 4.4 | 1.34 | 1.1 | 0.814 | 0.902 | 0.741 | 1.276 | 1.875 | 0.673 |
| all_PS | | 10 | 0.16 | 2.8 | 1.489 | 1.75 | 0.882 | 0.939 | 0.667 | -0.478 | -1.196 | 0.631 |
| all_B | | 45 | 0.095 | 2.8 | 1.038 | 0.55 | 0.786 | 0.886 | 0.549 | 0.593 | -1.346 | 0.854 |
| all_NS | | 146 | 0.049 | 7.4 | 1.39 | 0.875 | 1.775 | 1.332 | 0.986 | 1.583 | 3.174 | 0.959 |

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Summary Statistics for Raw Full Data Sets

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All As | 185 | 0.55 | 95 | 3.803 | 2.8 | 54.92 | 7.411 | 2.076 | 10.49 | 126.4 | 1.949 |
| Ambient (AMB) | 76 | 0.55 | 95 | 4.514 | 3.175 | 114.9 | 10.72 | 2.595 | 8.227 | 70.2 | 2.375 |
| AMB-PS | 9 | 1.2 | 4.65 | 3.039 | 3.25 | 1.422 | 1.192 | 1.408 | -0.198 | -1.433 | 0.392 |
| AMB-B | 20 | 2.8 | 6 | 4.808 | 4.975 | 0.751 | 0.866 | 0.778 | -0.602 | -0.282 | 0.18 |
| AMB-NS | 47 | 0.55 | 95 | 4.671 | 1.8 | 186.3 | 13.65 | 1.408 | 6.572 | 44.3 | 2.922 |
| CLEANUP (CU) | 37 | 0.55 | 26.5 | 3.899 | 3.5 | 17.54 | 4.188 | 2.224 | 4.53 | 24.68 | 1.074 |
| CU-PS | 1 | 0.65 | 0.65 | 0.65 | 0.65 | N/A | N/A | 0 | N/A | N/A | N/A |
| CU-B | 3 | 0.55 | 0.8 | 0.65 | 0.6 | 0.0175 | 0.132 | 0.0741 | 1.458 | N/A | 0.204 |
| CU-NS | 33 | 0.85 | 26.5 | 4.292 | 3.7 | 18.25 | 4.272 | 1.779 | 4.598 | 24.31 | 0.995 |
| Dredging/construction | 17 | 3 | 20 | 6.265 | 3.5 | 28.47 | 5.336 | 0.741 | 1.715 | 1.772 | 0.852 |
| NPDES all | 55 | 0.8 | 5 | 1.995 | 1.65 | 1.431 | 1.196 | 0.445 | 1.526 | 1.042 | 0.599 |
| NPDES-B | 34 | 1.55 | 5 | 2.507 | 1.775 | 1.588 | 1.26 | 0.334 | 1.071 | -0.699 | 0.503 |
| NPDES-NS | 21 | 0.8 | 1.65 | 1.167 | 1.05 | 0.0763 | 0.276 | 0.371 | 0.227 | -1.316 | 0.237 |

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| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bold Plus As all detected | 96 | 1.1 | 21 | 6.575 | 6.15 | 11.49 | 3.39 | 3.558 | 1.381 | 3.403 | 0.516 |
| all_PS | 10 | 0.65 | 4.65 | 2.8 | 2.825 | 1.834 | 1.354 | 1.52 | -0.21 | -1.292 | 0.484 |
| all_B | 57 | 0.55 | 6 | 3.217 | 2.8 | 2.753 | 1.659 | 1.853 | 0.137 | -1.55 | 0.516 |
| all_NS | 118 | 0.55 | 95 | 4.171 | 2.75 | 84.52 | 9.193 | 2.15 | 8.573 | 83.08 | 2.204 |

From File: C:\Users\lino461\Desktop\EB regional bkg\Cu EB dataset final.wst

Summary Statistics for Raw Full Data Sets

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All Cu | 184 | 2.6 | 350 | 32.53 | 18.5 | 1566 | 39.57 | 17.94 | 3.962 | 24.27 | 1.216 |
| Ambient (AMB) | 75 | 3.1 | 350 | 36.94 | 26 | 2033 | 45.09 | 20.76 | 4.944 | 31.9 | 1.22 |
| AMB-PS | 9 | 3.1 | 41 | 22.13 | 27 | 166.3 | 12.9 | 16.31 | -0.102 | -1.268 | 0.583 |
| AMB-B | 20 | 19 | 95 | 49.55 | 44 | 402.7 | 20.07 | 18.53 | 0.771 | 0.0505 | 0.405 |
| AMB-NS | 46 | 5.7 | 350 | 34.35 | 18 | 3022 | 54.97 | 12.16 | 4.664 | 25.13 | 1.6 |
| CLEANUP (CU) | 36 | 4.9 | 110 | 36.22 | 31.5 | 692.4 | 26.31 | 27.43 | 0.951 | 0.653 | 0.727 |
| CU-PS | 1 | 4.9 | 4.9 | 4.9 | 4.9 | N/A | N/A | 0 | N/A | N/A | N/A |
| CU-B | 3 | 5.4 | 8 | 6.267 | 5.4 | 2.253 | 1.501 | 0 | 1.732 | N/A | 0.24 |
| CU-NS | 32 | 9.1 | 110 | 40.01 | 35.5 | 648.4 | 25.46 | 28.91 | 0.948 | 0.739 | 0.636 |
| Dredging/construction | 17 | 12 | 200 | 68.06 | 37 | 3726 | 61.04 | 37.06 | 0.799 | -0.583 | 0.897 |
| NPDES all | 56 | 2.6 | 44 | 13.47 | 7.95 | 155.9 | 12.49 | 4.003 | 1.648 | 1.265 | 0.927 |
| NPDES-B | 35 | 5.1 | 44 | 16.75 | 8.7 | 206.4 | 14.37 | 4.151 | 1.132 | -0.516 | 0.858 |
| NPDES-NS | 21 | 2.6 | 24 | 8.005 | 6.4 | 27.74 | 5.267 | 2.817 | 1.852 | 3.478 | 0.658 |

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bold plus | 76 | 3.2 | 91.2 | 21.47 | 16.15 | 252.4 | 15.89 | 13.64 | 1.535 | 3.772 | 0.74 |
| all_PS | 10 | 3.1 | 41 | 20.41 | 21.5 | 177.5 | 13.32 | 16.98 | 0.107 | -1.477 | 0.653 |
| all_B | 58 | 5.1 | 95 | 27.52 | 18 | 522.7 | 22.86 | 18.38 | 0.964 | 0.342 | 0.831 |
| all_NS | 116 | 2.6 | 350 | 36.08 | 18.5 | 2181 | 46.7 | 16.46 | 3.619 | 18.51 | 1.294 |

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Summary Statistics for Raw Full Data Sets

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All Hg | 156 | 0.0093 | 0.89 | 0.155 | 0.0865 | 0.0385 | 0.196 | 0.0912 | 2.029 | 3.586 | 1.267 |
| Ambient (AMB) | 144 | 0.01 | 0.85 | 0.161 | 0.105 | 0.0363 | 0.191 | 0.111 | 1.934 | 3.156 | 1.187 |
| AMB-PS | 9 | 0.015 | 0.74 | 0.146 | 0.1 | 0.0515 | 0.227 | 0.0808 | 2.783 | 8.046 | 1.55 |
| AMB-B | 12 | 0.12 | 0.6 | 0.259 | 0.17 | 0.0272 | 0.165 | 0.0593 | 1.308 | 0.164 | 0.636 |
| AMB-NS | 18 | 0.031 | 0.85 | 0.228 | 0.14 | 0.0543 | 0.233 | 0.128 | 1.702 | 2.169 | 1.02 |
| CLEANUP (CU) | 50 | 0.01 | 1.9 | 0.313 | 0.135 | 0.183 | 0.428 | 0.159 | 2.245 | 5.001 | 1.366 |
| CU-PS | 1 | 0.018 | 0.018 | 0.018 | 0.018 | N/A | N/A | 0 | N/A | N/A | N/A |
| CU-B | 6 | 0.03 | 0.2 | 0.0848 | 0.0535 | 0.00483 | 0.0695 | 0.0334 | 1.174 | -0.117 | 0.819 |
| CU-NS | 43 | 0.01 | 1.9 | 0.352 | 0.18 | 0.202 | 0.45 | 0.222 | 2.035 | 3.948 | 1.277 |
| Dredging/construction | 17 | 0.01 | 2.2 | 0.394 | 0.23 | 0.316 | 0.562 | 0.304 | 2.387 | 6.421 | 1.425 |
| NPDES all | 56 | 0.0093 | 0.14 | 0.047 | 0.035 | 0.0018 | 0.0424 | 0.0289 | 1.277 | 0.111 | 0.903 |
| NPDES-B | 35 | 0.0125 | 0.14 | 0.0619 | 0.043 | 0.00221 | 0.047 | 0.0423 | 0.677 | -1.329 | 0.76 |
| NPDES-NS | 21 | 0.0093 | 0.047 | 0.0223 | 0.016 | 1.68E-04 | 0.013 | 0.00741 | 0.808 | -0.94 | 0.582 |

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bold plus | 96 | 0.0024 | 0.26 | 0.079 | 0.077 | 0.00359 | 0.0599 | 0.0741 | 0.888 | 0.409 | 0.758 |
| all_PS | 10 | 0.015 | 0.74 | 0.134 | 0.073 | 0.0474 | 0.218 | 0.0708 | 2.914 | 8.849 | 1.63 |
| all_B | 53 | 0.0125 | 0.6 | 0.109 | 0.052 | 0.0144 | 0.12 | 0.0578 | 2.494 | 7.149 | 1.101 |
| all_NS | 93 | 0.0093 | 0.89 | 0.183 | 0.090 | 0.05 | 0.224 | 0.11 | 1.644 | 1.868 | 1.221 |

From File: C:\Users\lino461\Desktop\EB regional bkg\Zn EB dataset final.wst

Summary Statistics for Raw Full Data Sets

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All Zn | 185 | 11 | 580 | 64.74 | 43 | 3964 | 62.96 | 29.65 | 4.155 | 27.08 | 0.973 |
| Ambient (AMB) | 76 | 13 | 580 | 72.59 | 54 | 5213 | 72.2 | 42.25 | 4.917 | 32.75 | 0.995 |
| AMB-PS | 9 | 17 | 89 | 59.11 | 69 | 617.4 | 24.85 | 28.17 | -0.481 | -0.825 | 0.42 |
| AMB-B | 20 | 54 | 130 | 95.6 | 95 | 570.6 | 23.89 | 22.24 | -0.262 | -1.052 | 0.25 |
| AMB-NS | 47 | 13 | 580 | 65.38 | 37 | 7838 | 88.53 | 20.76 | 4.656 | 25.6 | 1.354 |
| CLEANUP (CU) | 36 | 11 | 380 | 70.42 | 58.5 | 4305 | 65.62 | 52.63 | 3.104 | 13.81 | 0.932 |
| CU-PS | 1 | 12 | 12 | 12 | 12 | N/A | N/A | 0 | N/A | N/A | N/A |
| CU-B | 3 | 11 | 15 | 12.33 | 11 | 5.333 | 2.309 | 0 | 1.732 | N/A | 0.187 |
| CU-NS | 32 | 19 | 380 | 77.69 | 66.5 | 4369 | 66.1 | 49.67 | 3.194 | 14.05 | 0.851 |
| Dredging/construction | 17 | 23 | 230 | 100.6 | 87 | 5896 | 76.79 | 87.47 | 0.604 | -1.086 | 0.763 |
| NPDES all | 56 | 15 | 95 | 39.54 | 30.5 | 546.6 | 23.38 | 8.154 | 1.683 | 1.45 | 0.591 |
| NPDES-B | 35 | 20 | 95 | 45.77 | 32 | 721.2 | 26.86 | 7.413 | 1.185 | -0.409 | 0.587 |
| NPDES-NS | 21 | 15 | 56 | 29.14 | 27 | 95.53 | 9.774 | 8.895 | 1.191 | 1.53 | 0.335 |
| | | | | | | | | | | | |
| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
| Bold plus | 96 | 1.1 | 21 | 6.575 | 6.15 | 11.49 | 3.39 | 3.558 | 1.381 | 3.403 | 0.516 |
| all_PS | 10 | 12 | 89 | 54.4 | 62 | 770.7 | 27.76 | 34.84 | -0.333 | -1.267 | 0.51 |
| all_B | 58 | 11 | 130 | 61.22 | 50.5 | 1308 | 36.16 | 38.55 | 0.379 | -1.35 | 0.591 |
| all_NS | 117 | 13 | 580 | 67.36 | 40 | 5563 | 74.59 | 25.2 | 3.884 | 21.03 | 1.107 |

From File: C:\Users\lino461\Desktop\EB regional bkg\cPAH EB dataset final.wst

Summary Statistics for Raw Full Data Sets

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All cPAH | 164 | 0.98 | 10000 | 502.6 | 150 | 1264704 | 1125 | 201.6 | 4.99 | 33.35 | 2.237 |
| Ambient (AMB) | 46 | 0.98 | 2600 | 326.9 | 160 | 277773 | 527 | 204.6 | 3.2 | 10.93 | 1.612 |
| AMB-PS | 9 | 0.98 | 130 | 62.22 | 76 | 2427 | 49.27 | 80.06 | -0.0161 | -2.007 | 0.792 |
| AMB-B | 12 | 130 | 740 | 290 | 255 | 32545 | 180.4 | 111.2 | 1.702 | 2.851 | 0.622 |
| AMB-NS | 25 | 4.6 | 2600 | 439.8 | 190 | 464867 | 681.8 | 249.1 | 2.355 | 5.149 | 1.55 |
| CLEANUP (CU) | 52 | 4.5 | 4800 | 772.3 | 335 | 1331713 | 1154 | 464.8 | 2.105 | 3.769 | 1.494 |
| CU-PS | 1 | 5.5 | 5.5 | 5.5 | 5.5 | N/A | N/A | 0 | N/A | N/A | N/A |
| CU-B | 6 | 5.1 | 2000 | 462.8 | 146.5 | 601920 | 775.8 | 207.2 | 2.153 | 4.781 | 1.677 |
| CU-NS | 45 | 4.5 | 4800 | 830.6 | 390 | 1445270 | 1202 | 449.2 | 2.02 | 3.266 | 1.447 |
| Dredging/construction | 18 | 3.7 | 10000 | 1258 | 330 | 5980208 | 2445 | 469.2 | 3.08 | 10.32 | 1.944 |
| NPDES all | 48 | 2.2 | 530 | 95.7 | 53.5 | 13652 | 116.8 | 35.58 | 2.268 | 5.31 | 1.221 |
| NPDES-B | 28 | 2.2 | 530 | 127.9 | 54 | 20215 | 142.2 | 60.19 | 1.575 | 1.98 | 1.112 |
| NPDES-NS | 20 | 4.4 | 160 | 50.6 | 44 | 1374 | 37.06 | 31.88 | 1.283 | 2.795 | 0.733 |

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bold plus | 76 | 1.1 | 57 | 6.805 | 4.3 | 71.9 | 8.479 | 3.855 | 3.652 | 17.46 | 1.246 |
| all_PS | 10 | 0.98 | 130 | 56.55 | 47.5 | 2479 | 49.79 | 65.62 | 0.21 | -1.972 | 0.881 |
| all_B | 46 | 2.2 | 2000 | 213.9 | 130 | 101367 | 318.4 | 153.4 | 4.193 | 22.26 | 1.489 |
| all_NS | 117 | 3.7 | 10000 | 635.8 | 210 | 1675298 | 1294 | 281.7 | 4.307 | 24.59 | 2.036 |

From File: WorkSheet.wst

Summary Statistics for Raw Full Data Sets

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| dioxin all | 44 | 0.25 | 98 | 10.21 | 6.3 | 352.3 | 18.77 | 5.263 | 4.126 | 17.09 | 1.838 |
| dioxin, ambient | 36 | 0.66 | 98 | 11.28 | 6.4 | 419.8 | 20.49 | 4.893 | 3.782 | 13.96 | 1.816 |
| AMB-PS | 2 | 1.4 | 2 | 1.7 | 1.7 | 0.18 | 0.424 | 0.445 | N/A | N/A | 0.25 |
| AMB-B | 18 | 1.5 | 14 | 7.311 | 7.1 | 11.3 | 3.361 | 2.965 | 0.0608 | -0.292 | 0.46 |
| AMB_NS | 16 | 0.66 | 98 | 16.95 | 5.45 | 901.2 | 30.02 | 6.004 | 2.387 | 4.59 | 1.771 |
| dredging | 2 | 0.25 | 5.4 | 2.825 | 2.825 | 13.26 | 3.642 | 3.818 | N/A | N/A | 1.289 |
| disposal site | 6 | 0.65 | 17 | 6.242 | 4.4 | 39.48 | 6.283 | 5.078 | 1.135 | 0.626 | 1.007 |

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bold plus | 97 | 0.041 | 11.59 | 1.4 | 0.877 | 2.996 | 1.731 | 0.893 | 3.35 | 14.75 | 1.236 |
| all_PS | 2 | 1.4 | 2 | 1.7 | 1.7 | 0.18 | 0.424 | 0.445 | N/A | N/A | 0.25 |
| all_B | 24 | 0.65 | 17 | 7.044 | 6.5 | 17.16 | 4.142 | 4.448 | 0.434 | 0.0636 | 0.588 |
| All_NS | 18 | 0.25 | 98 | 15.38 | 4.95 | 816.8 | 28.58 | 5.263 | 2.571 | 5.588 | 1.858 |

From File: C:\Users\lino461\Desktop\EB regional bkg\BEHP EB dataset final.wst

Summary Statistics for Raw Full Data Sets

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All BEHP | 155 | 5.5 | 3100 | 186.6 | 38 | 148201 | 385 | 41.51 | 4.268 | 23.85 | 2.063 |
| Ambient (AMB) | 37 | 8.5 | 1600 | 200.6 | 59 | 135712 | 368.4 | 71.91 | 2.986 | 8.899 | 1.836 |
| AMB-PS | 9 | 10.5 | 740 | 106.4 | 32.5 | 56589 | 237.9 | 17.05 | 2.985 | 8.935 | 2.235 |
| AMB-B | 12 | 26 | 230 | 85.92 | 69 | 4434 | 66.59 | 57.45 | 1.237 | 0.738 | 0.775 |
| AMB-NS | 16 | 8.5 | 1600 | 339.7 | 145 | 255811 | 505.8 | 197.6 | 1.977 | 3.01 | 1.489 |
| CLEANUP (CU) | 43 | 5.5 | 1400 | 288.7 | 150 | 112855 | 335.9 | 163.1 | 1.822 | 2.856 | 1.163 |
| CU-PS | 1 | 8.3 | 8.3 | 8.3 | 8.3 | N/A | N/A | 0 | N/A | N/A | N/A |
| CU-B | 9 | 5.5 | 1000 | 356.2 | 210 | 142386 | 377.3 | 301.9 | 0.861 | -0.624 | 1.059 |
| CU-NS | 33 | 18 | 1400 | 278.8 | 150 | 108687 | 329.7 | 131.9 | 2.2 | 4.671 | 1.182 |
| Dredging/construction | 19 | 9.5 | 1600 | 238.7 | 60 | 153886 | 392.3 | 74.13 | 2.61 | 7.922 | 1.643 |
| NPDES all | 56 | 8 | 3100 | 81.25 | 19 | 169061 | 411.2 | 7.784 | 7.459 | 55.75 | 5.06 |
| NPDES-B | 35 | 8 | 3100 | 112.4 | 18 | 270491 | 520.1 | 11.86 | 5.907 | 34.93 | 4.626 |
| NPDES-NS | 21 | 13.5 | 95 | 29.29 | 19.5 | 545.3 | 23.35 | 5.189 | 1.891 | 2.528 | 0.797 |

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bold plus | 76 | 5.5 | 3800 | 69.83 | 11 | 189584 | 435.4 | 3.706 | 8.611 | 74.68 | 6.235 |
| all_PS | 10 | 8.3 | 740 | 96.63 | 29.5 | 51264 | 226.4 | 18.9 | 3.144 | 9.913 | 2.343 |
| all_B | 69 | 5.5 | 3100 | 159 | 26 | 197458 | 444.4 | 23.72 | 5.086 | 29.83 | 2.795 |
| all_NS | 76 | 8.5 | 1600 | 223.6 | 92 | 115958 | 340.5 | 110.5 | 2.624 | 7 | 1.523 |

From File: C:\Users\lino461\Desktop\EB regional bkg\PCB EB dataset final.wst

Summary Statistics for Raw Full Data Sets

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All cPAH | 203 | 0.47 | 840 | 80.31 | 33 | 15999 | 126.5 | 40.62 | 3.209 | 13.26 | 1.575 |
| Ambient (AMB) | 77 | 3.5 | 320 | 84.05 | 54 | 6012 | 77.54 | 66.12 | 0.979 | 0.101 | 0.922 |
| AMB-PS | 9 | 4.9 | 16 | 7.889 | 7.3 | 10.91 | 3.303 | 1.334 | 2.128 | 5.543 | 0.419 |
| AMB-B | 20 | 14 | 280 | 114.3 | 101.5 | 5552 | 74.51 | 78.58 | 0.521 | -0.612 | 0.652 |
| AMB-NS | 48 | 3.5 | 320 | 85.75 | 53.5 | 5973 | 77.28 | 64.49 | 1.084 | 0.478 | 0.901 |
| CLEANUP (CU) | 53 | 0.47 | 810 | 132.8 | 52 | 31420 | 177.3 | 48.93 | 2.008 | 3.943 | 1.335 |
| CU-PS | 1 | 0.47 | 0.47 | 0.47 | 0.47 | N/A | N/A | 0 | N/A | N/A | N/A |
| CU-B | 3 | 3 | 14 | 6.833 | 3.5 | 38.58 | 6.212 | 0.741 | 1.719 | N/A | 0.909 |
| CU-NS | 49 | 2.2 | 810 | 143.2 | 58 | 32569 | 180.5 | 57.82 | 1.918 | 3.527 | 1.26 |
| Dredging/construction | 17 | 3.9 | 840 | 111.9 | 34 | 42932 | 207.2 | 44.63 | 3.088 | 10.37 | 1.851 |
| NPDES all | 56 | 1.7 | 190 | 15.87 | 6.9 | 1043 | 32.3 | 4.818 | 4.423 | 20.29 | 2.035 |
| NPDES-B | 35 | 1.7 | 190 | 21.09 | 8.4 | 1587 | 39.84 | 6.82 | 3.489 | 12.08 | 1.889 |
| NPDES-NS | 21 | 2.4 | 34 | 7.167 | 5.4 | 43.65 | 6.607 | 0.741 | 3.682 | 14.97 | 0.922 |

| Variable | NumObs | Minimum | Maximum | Mean | Median | Variance | SD | MAD/0.675 | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bold plus | 76 | 0.55 | 17 | 5.124 | 4.475 | 5.457 | 2.336 | 1.668 | 1.826 | 7.704 | 0.456 |
| all_PS | 10 | 0.47 | 16 | 7.147 | 7.3 | 15.2 | 3.899 | 1.705 | 0.884 | 3.395 | 0.546 |
| all_B | 58 | 1.7 | 280 | 52.48 | 14 | 4852 | 69.66 | 16.01 | 1.536 | 1.346 | 1.327 |
| all_NS | 135 | 2.2 | 840 | 97.69 | 42 | 21014 | 145 | 51.74 | 2.863 | 9.82 | 1.484 |

# *Elliott Bay Waterfront Recontamination Study*

***Teresa Michelsen***
***Avocet Consulting***

***September 2013***

# Study Goals

- Determine rates of sedimentation, recontamination, and/or natural recovery
- Identify and quantify the components of recontamination
- Model recontamination processes and their effects on sediment cleanup
- Identify source control and resuspension measures to minimize recontamination
- Provide recommendations on whether cleanup along the Seattle waterfront was feasible

# *Acknowledgments (partial)*


Dale Norton & Jim Cubbage, Ecology

Mike Francisco, NOAA

Chuck Boatman, Aura Nova

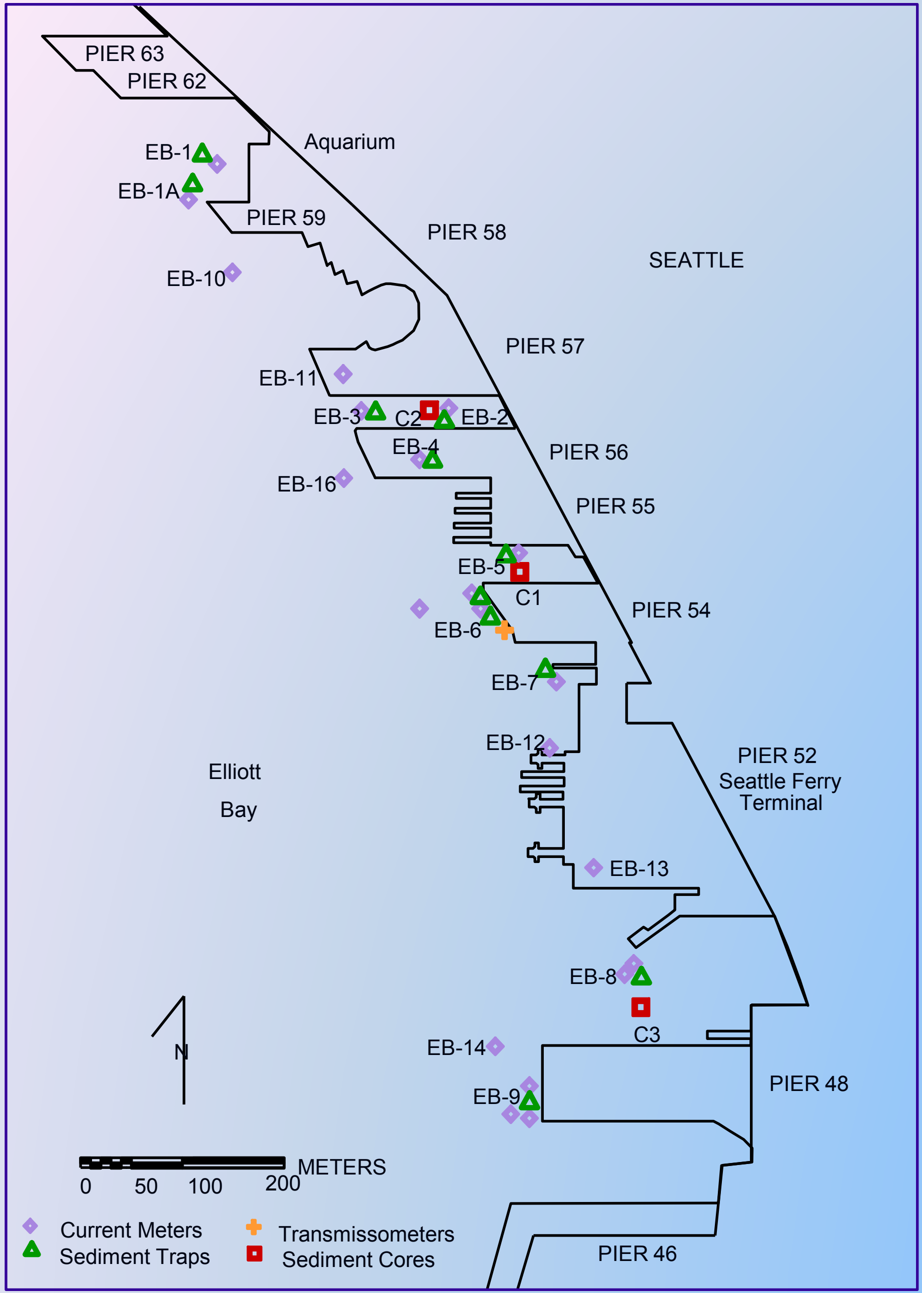
Eric Crecelius, Evans-Hamilton

Teri Floyd, Floyd|Snider

Beth Schmoyer, Herrera

Vladimir Shepsis, Hartman Assts.

*Funded by the Elliott Bay/Duwamish Restoration Panel, Port of Seattle, Ecology, and DNR (1991-1993)*




Sampling Locations and Instrumentation

## Field Instrumentation

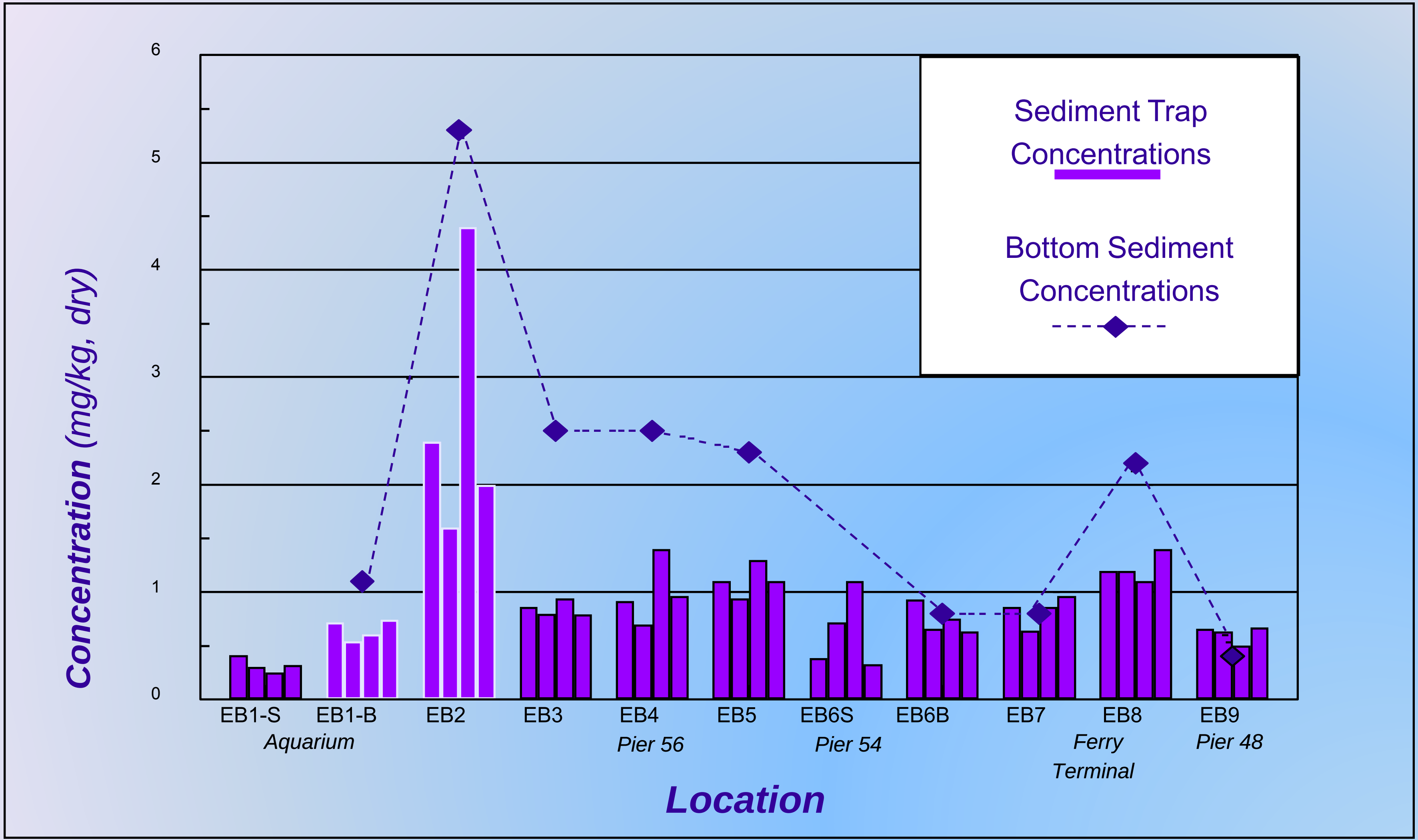
- 3 Core samples for radiometric dating, chemistry
- 69 Surface sediment samples for grain size
- Sediment traps – 9 bottom, 2 surface
- Quarterly analysis for conventionals, metals, SVOCs, PCBs, $^{210}Pb$
- Current meters, surface and bottom, ~21 stations
- 2 Transmissometers
- Bathymetric survey

## Data Evaluation & Modeling

- Point and nonpoint source evaluation and modeling, including Duwamish River
- Resuspension, deposition, and net sedimentation rates
- Current circulation and sediment transport patterns
- Vessel specifications and movements
- Prop wash resuspension modeling
- Wind wave/wake modeling
- Recommendations for cleanup

# *Conclusions – Sources/Contaminants*

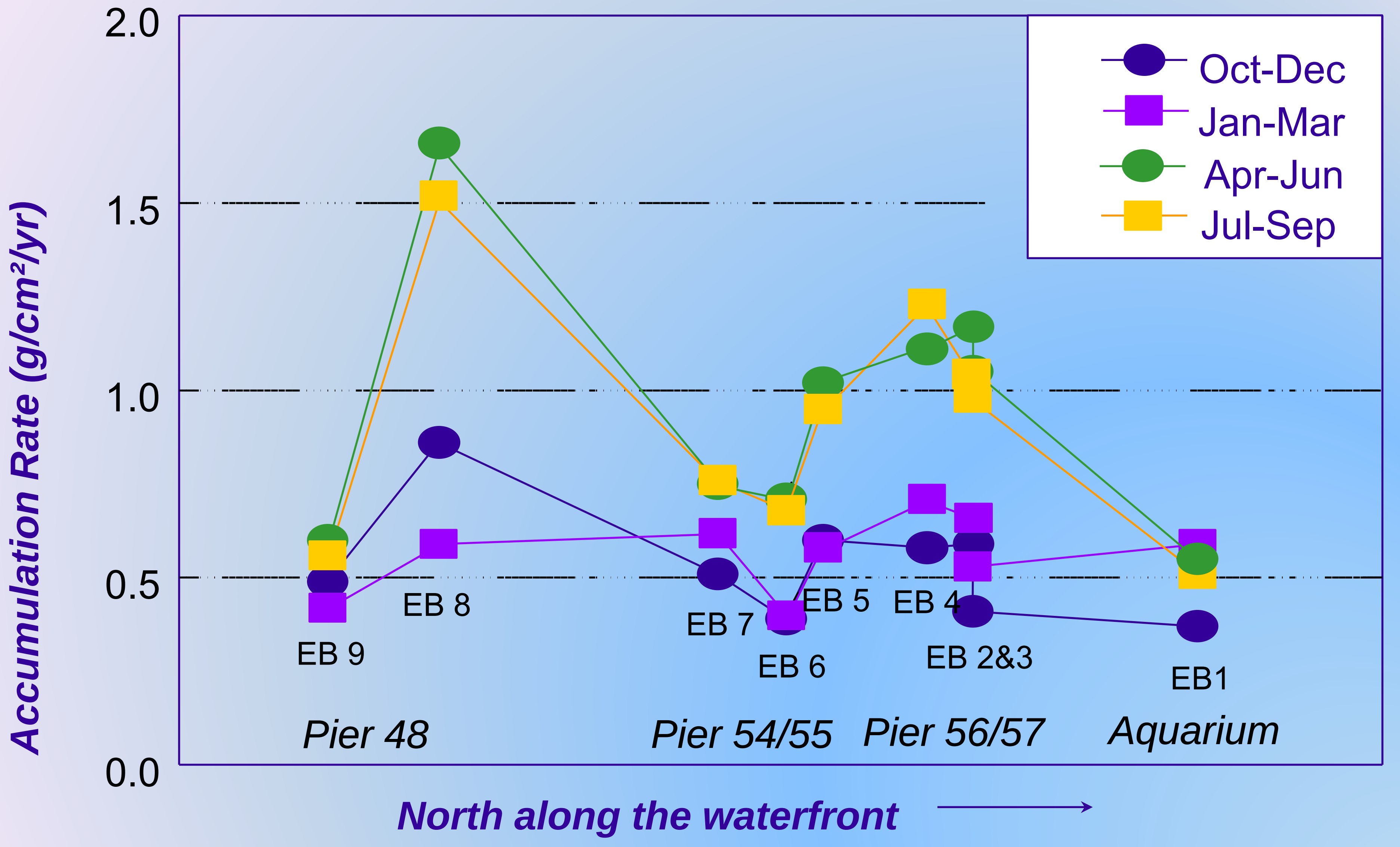
- Contaminants are present on particles in the water column above CSLs
- Duwamish River surface plume does not contribute substantially to this area
- King St. and Denny Way CSOs were potential ongoing sources to limited areas
- Surface sources of LPAHs were found but not expected to substantially impact sediments
- Vast majority of contaminants on particulates were from legacy sediment contamination



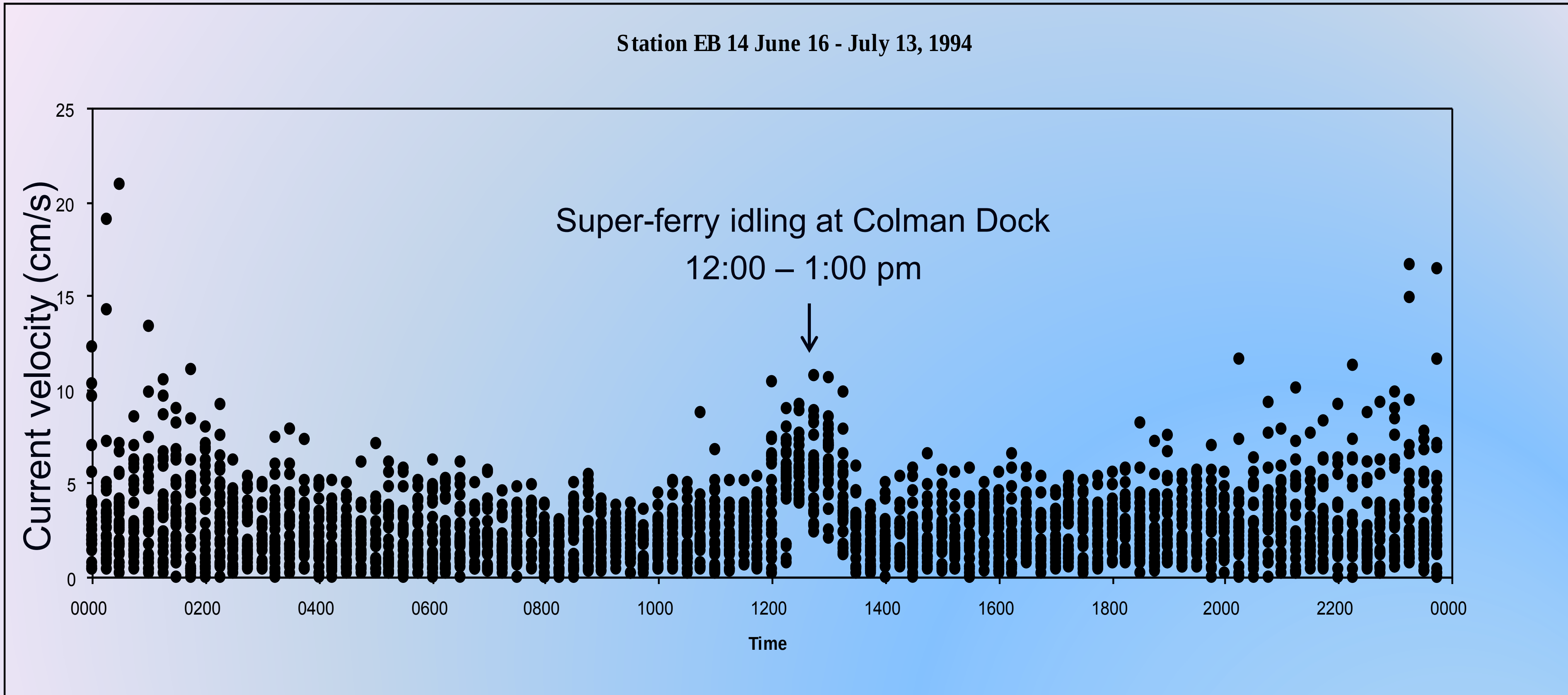

**Example: Mercury Concentrations in Bottom Sediments and Sediment Traps**

# Conclusions – Resuspension

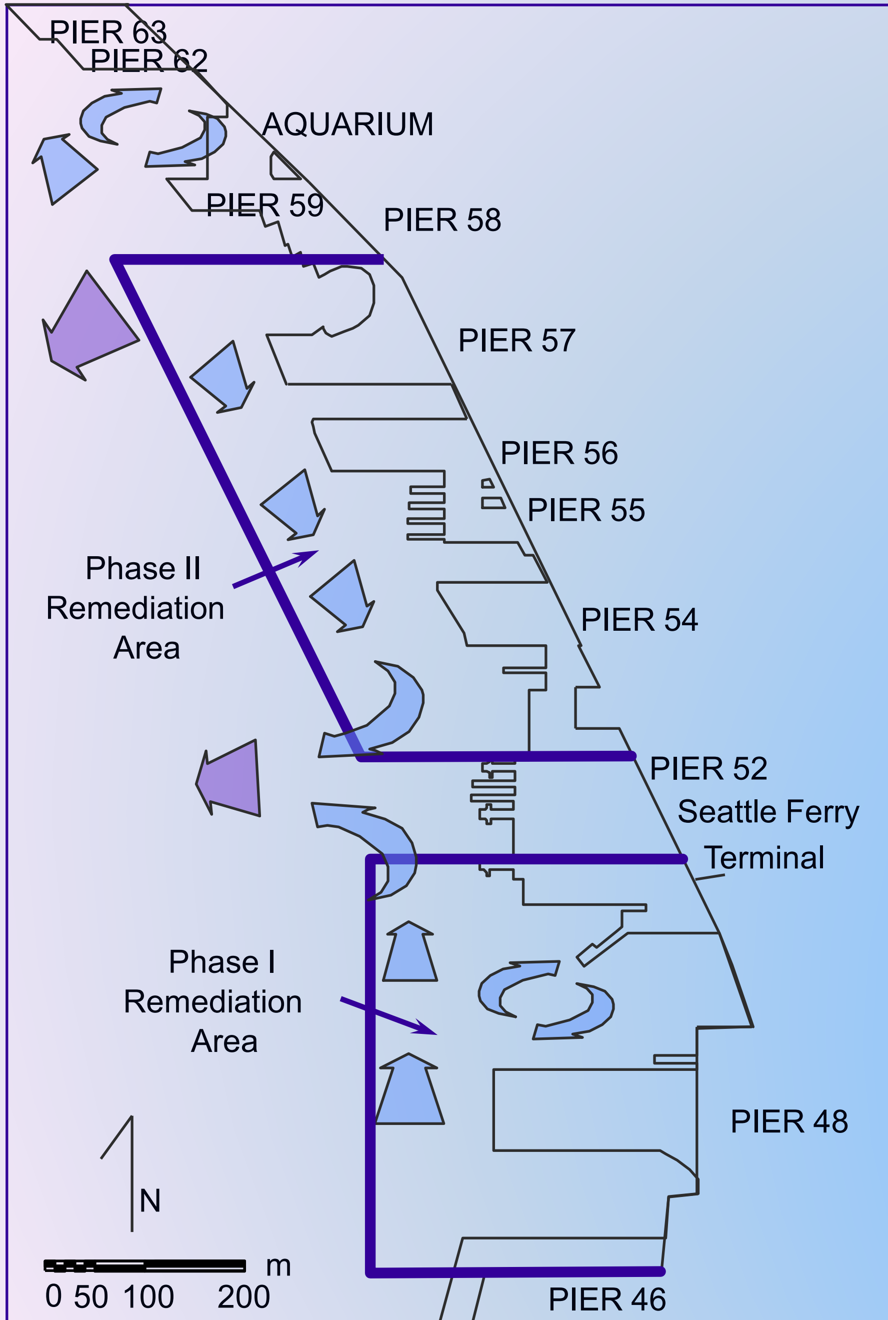
- Minor resuspension from wind waves/wakes near the seawall (fall/winter)
- Vessel traffic is responsible for most resuspension of contaminated sediments
- Resuspension higher in summer months due to increased vessel traffic
- Current spikes correlated to vessel movements
- Super-ferries, passenger ferries, tour boats, fire boats, tug boats can all cause resuspension
- Resuspension incidents associated with construction (large or small projects) can also be significant




Quarterly Accumulation Rates in Sediment Traps




*Correlation of Current Meter Records with Vessel Traffic*




Seattle Waterfront Currents and Remediation Areas

## *Conclusions – Currents and Sediment Transport*

- Legacy contaminants are resuspended into the water column by vessel traffic
- Natural bottom currents are weak and variable
- Bottom currents are overwhelmed by super-ferries, which induce large net gyres along the waterfront
- Gyres result in mixing and redeposition of historic contaminated sediments throughout large areas of the waterfront
- Ferries move a lot of water (3x Duwamish River flow) offshore and may also distribute nearshore contaminants offshore

# *Conclusions – Cleanup*

- Waterfront dynamics must be understood prior to attempting cleanup, or the risk of recontamination from legacy contamination is high
- Cleanup must be designed to accommodate the working waterfront by addressing vessel traffic patterns and coordinating with planned construction activities

*Considerations for regional background sampling and application?*

# *References*


Ecology 1995. Elliott Bay Waterfront Recontamination Study. Volume I: Field Investigation Report. Pub. #95-335. Prepared for the Elliott Bay/Duwamish Restoration Council. https://fortress.wa.gov/ecy/publications/summarypages/95335.html

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# References


Michelsen et al. 1999. Resuspension and transport of contaminated sediments along the Seattle waterfront. Part 1: Field investigations and conceptual site model. J Marine Env Eng 5:35-65.

Francisco et al. 1999. Resuspension and transport of contaminated sediments along the Seattle waterfront. Part 2: Resuspension and transport mechanisms. J Marine Env Eng 5:67-84.

Michelsen et al. 1998. Transport of contaminants along the Seattle waterfront: effects of vessel traffic and waterfront construction activities. Wat Sci Tech 37(6-7):5-15.

# Near-field Modeling: Depositional Patterns at Outfalls

Presented at

Elliott Bay Regional Background Workshop

September 3, 2013

Jeff Stern, Bruce Nairn, Kevin Schock

King County Wastewater Treatment Division

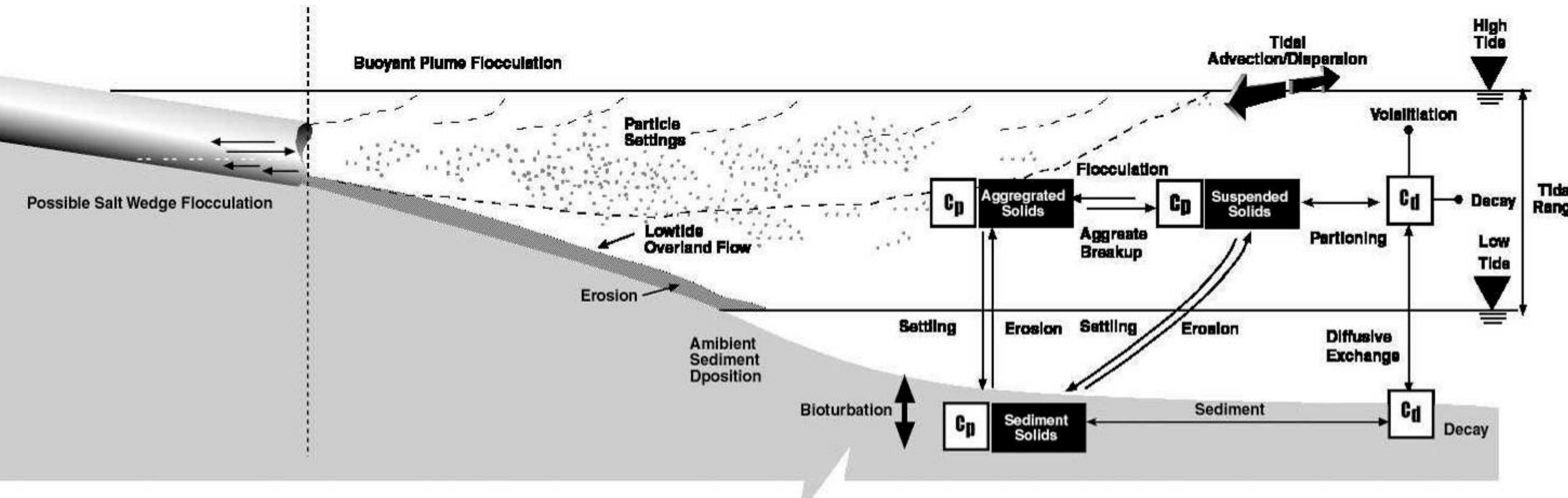
King County

Department of Natural Resources and Parks

**Wastewater Treatment Division**

# Background

- Objective to predict the spatial distribution of constituents of concern close to a CSO outfall
- Conceptual Model of sediment deposition from CSOs created with Foster Wheeler, Ecology, EPA (~2002)




Consultant and modeling team to develop model

Walter Frick, U.S. EPA; Robert Donneker, Oregon Graduate Institute; Nigel Blakley, Ecology
Tarang Khangaonkar, Chegwan Lee, Steve Breithaup, Battelle
Bruce Nairn, Kevin Schock, Jeff Stern, King County

# Near-field Modeling Approach

- EFDC selected as model / approach, covered most conceptual processes
  - Particle settling
  - Buoyant plumes / stratified flows
  - Tidal advection / dispersion
  - Chemical partitioning to solids
  - Sediment transport
  - spatially refined cells around discharge point
- Conducted sensitivity analyses and refined modeling approach
- EFDC modeling compared to sediment data at Brandon
- EFDC simulations (surface discharge) in simple channel to evaluate sensitivity
- **3-D hydrodynamic model can be predictive if receiving body cells at the scale of discharge**
  - **Cell size ~ pipe diameter near outfall**

# Predicted Sediment Concentration

Battelle work showed particles with settling velocities less than 0.025 cm/s ($2.5 \times 10^{-4}$ m/s) didn't have significant deposition, so 0.1 cm/s is above this threshold.

Fate & Transport Model (EFDC)

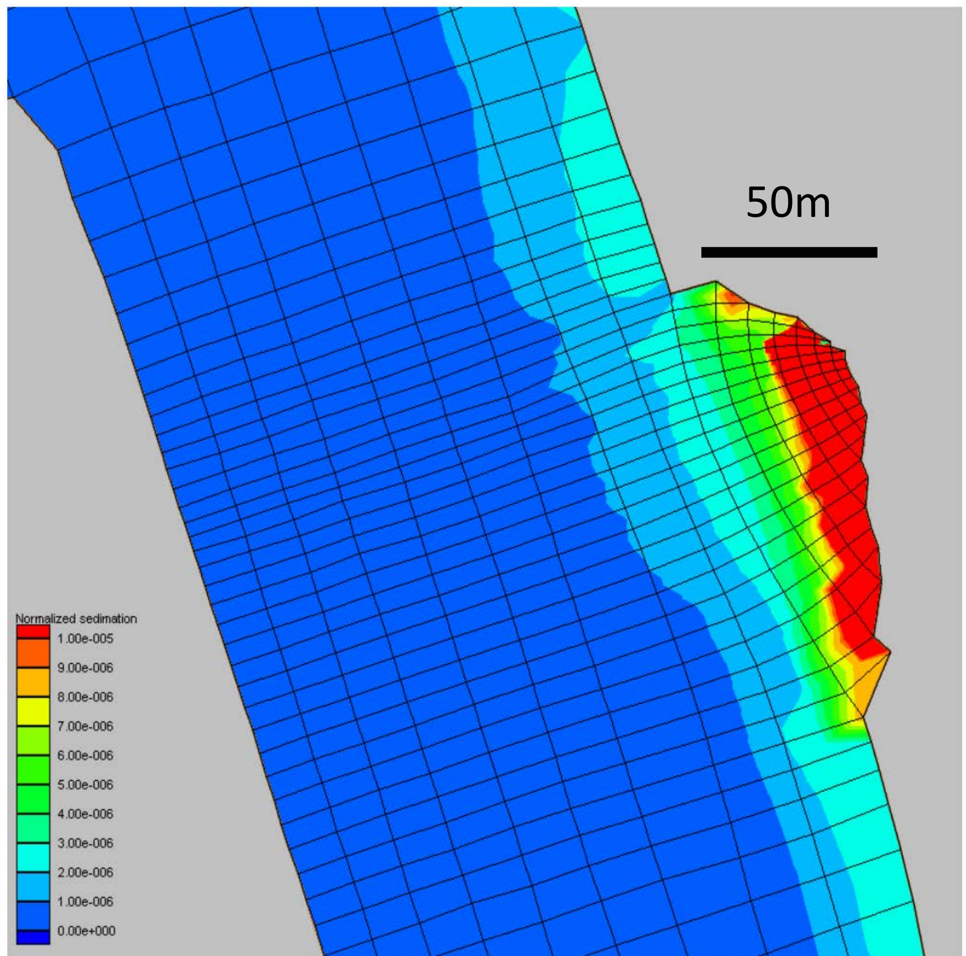
↓

Sediment Mixing Model

↓

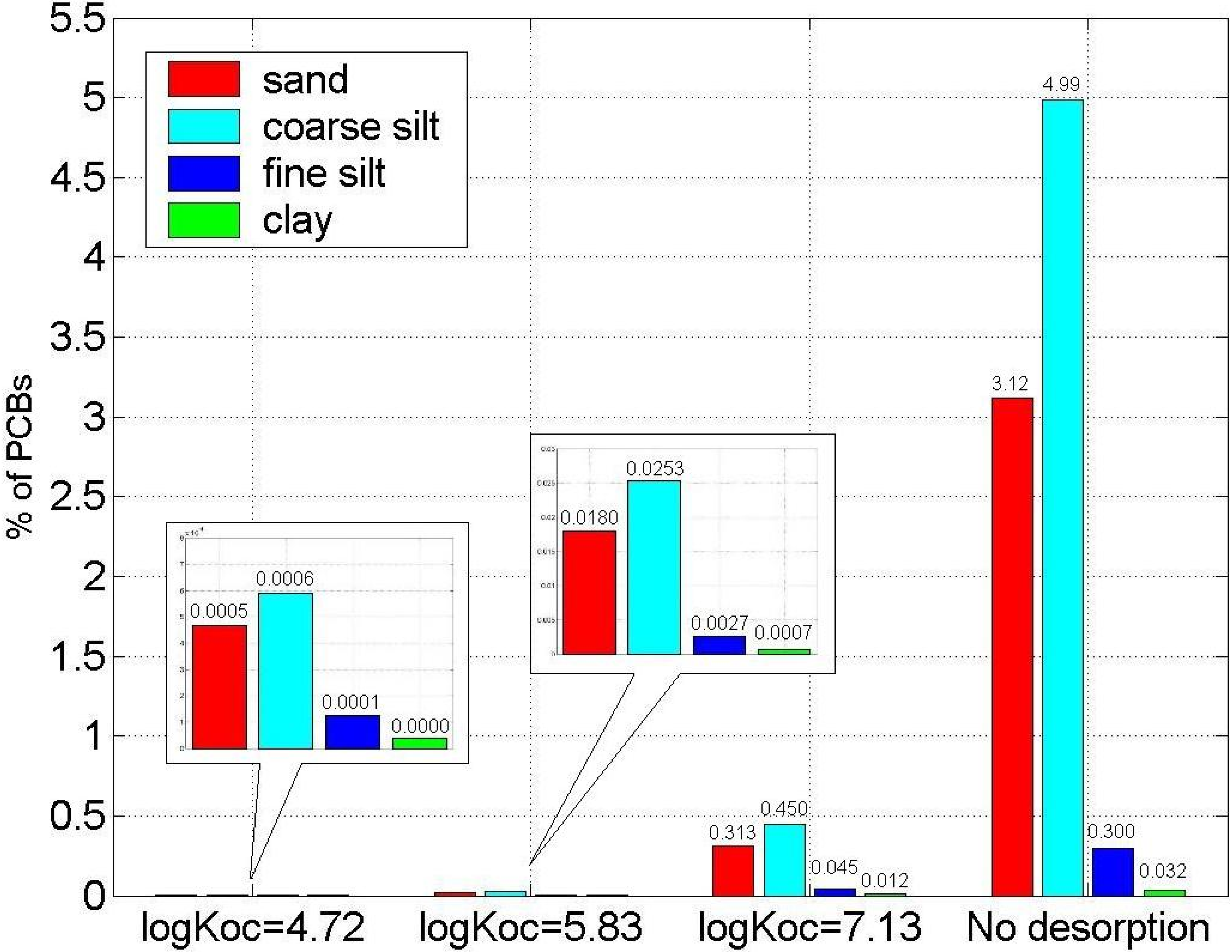
Predicted Sediment Concentrations

Normalized Concentration




Simulation with settling velocities of 0.01 cm/s and 0.003 cm/s

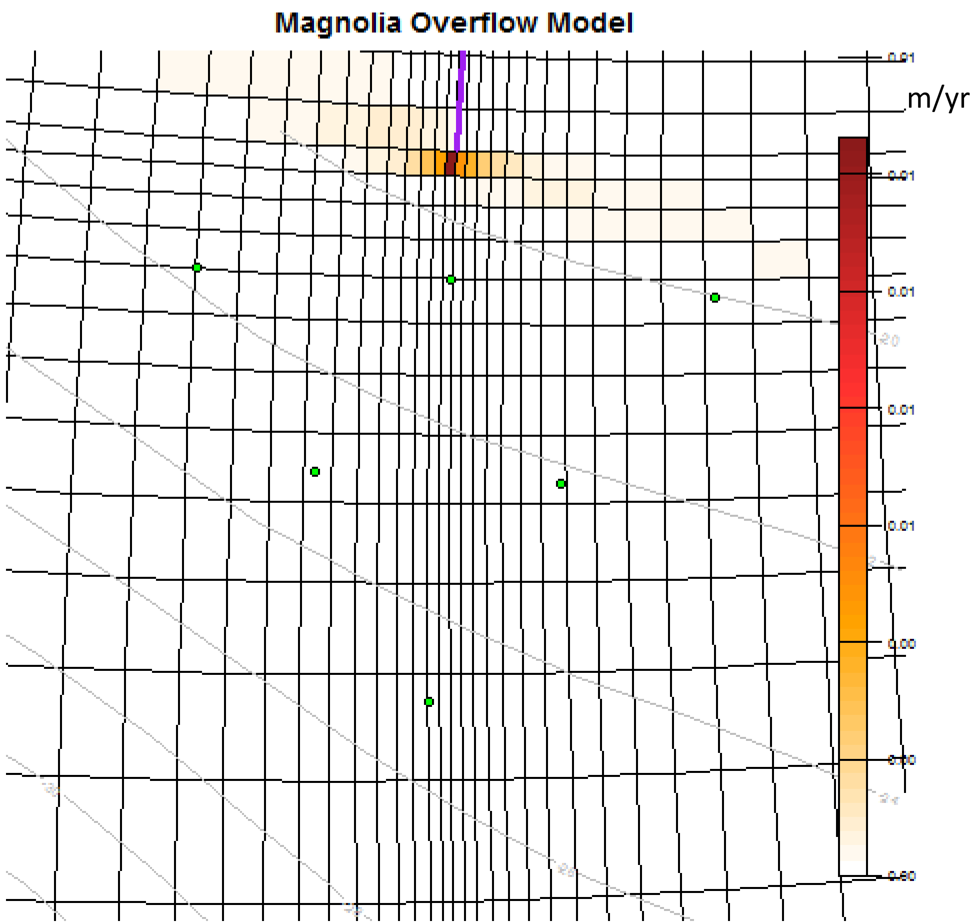
# Model Sensitivity: Effect of Partition Coefficent

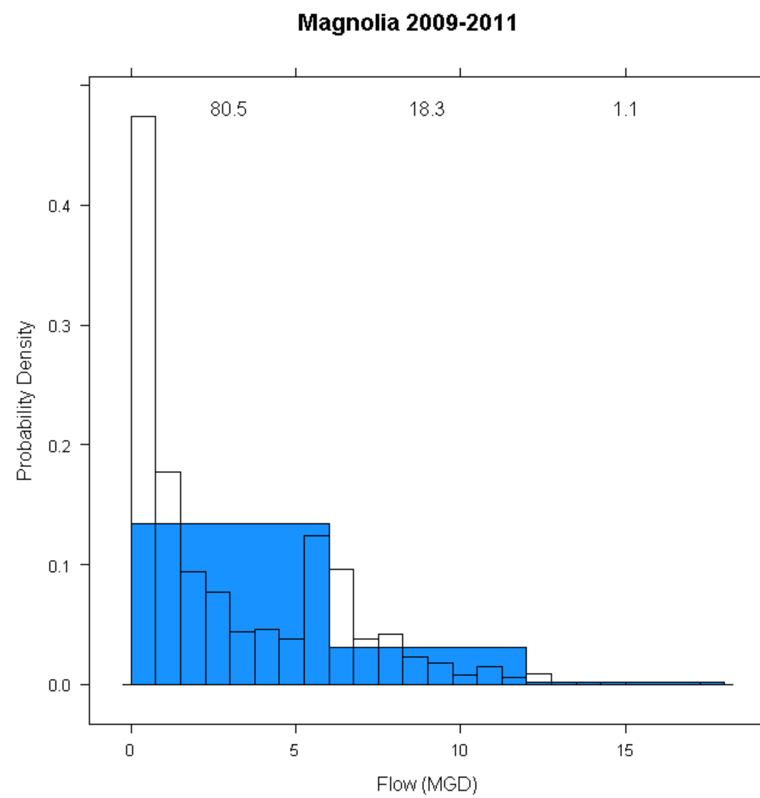


# Model Configuration

- 3-D hydrodynamic model (EFDC) to predict sediment accumulation
  - Locally enhance grid resolution near discharge points
  - 10 vertical layers
  - Several actual CSO discharge locations
  - 6 sediment size (settling velocity) classes
    - settling velocity from CSO samples at Denny, Henderson/MLK, and Norfolk
  - Assume no desorption of chemicals during release and sedimentation

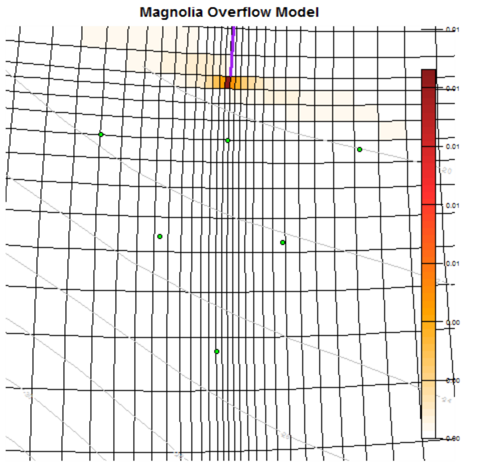
# Magnolia

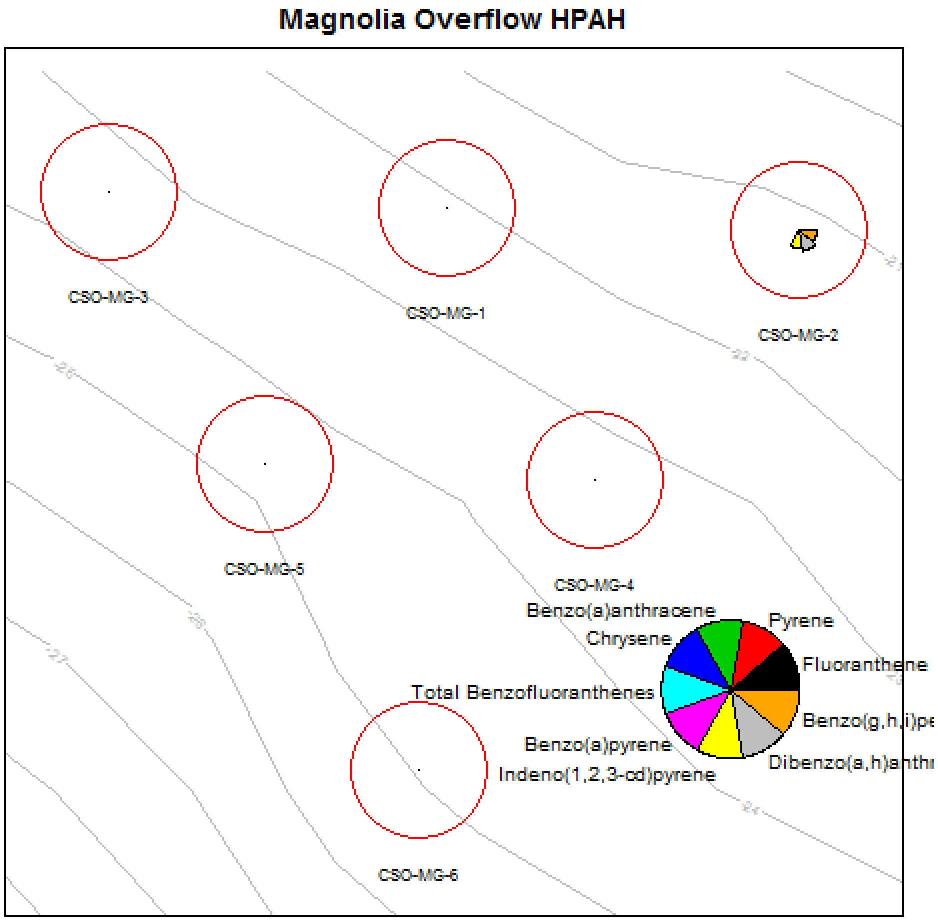


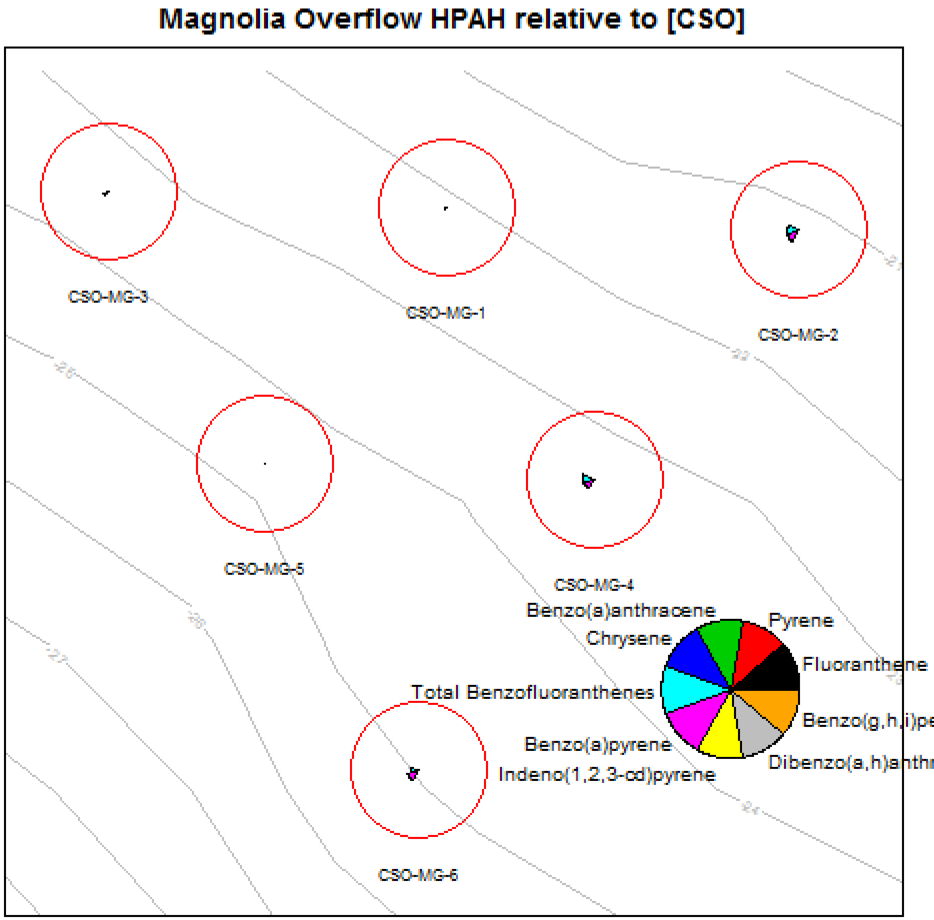




Ave. Volume 12MG/yr
Deposition represents ~3 years release

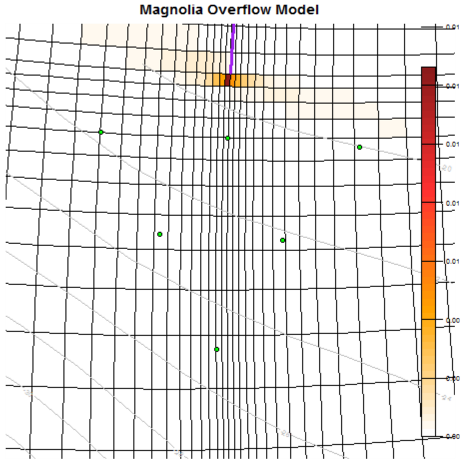
# Magnolia

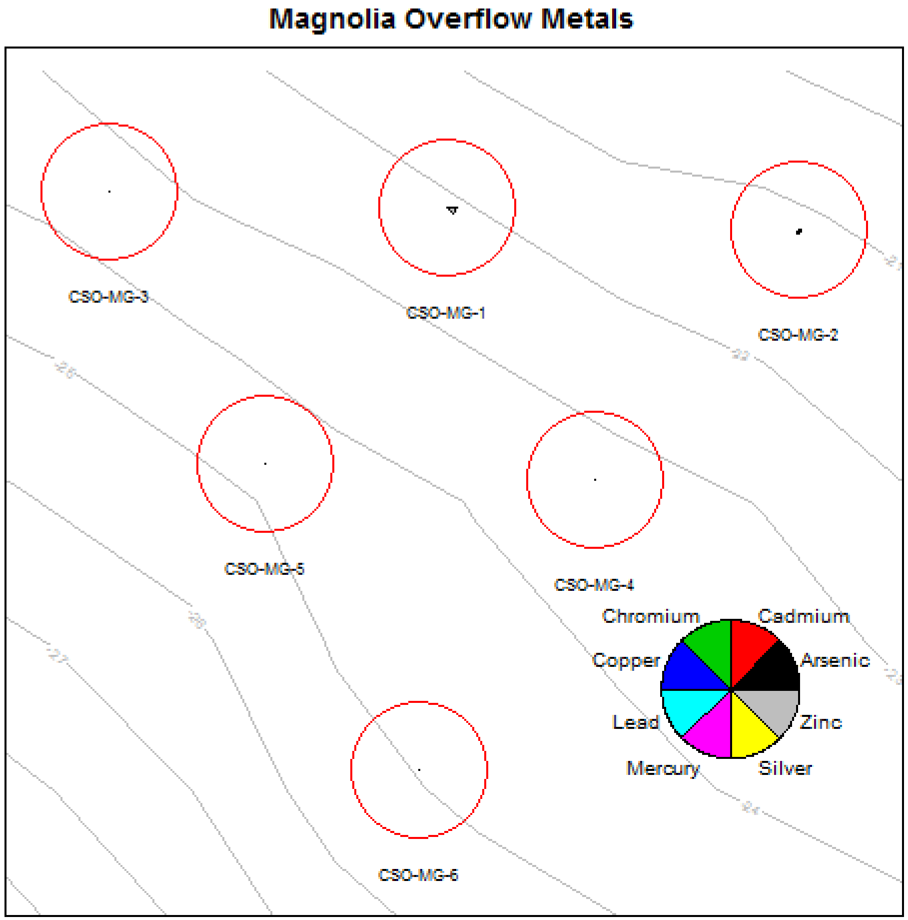

Magnolia Overflow Model

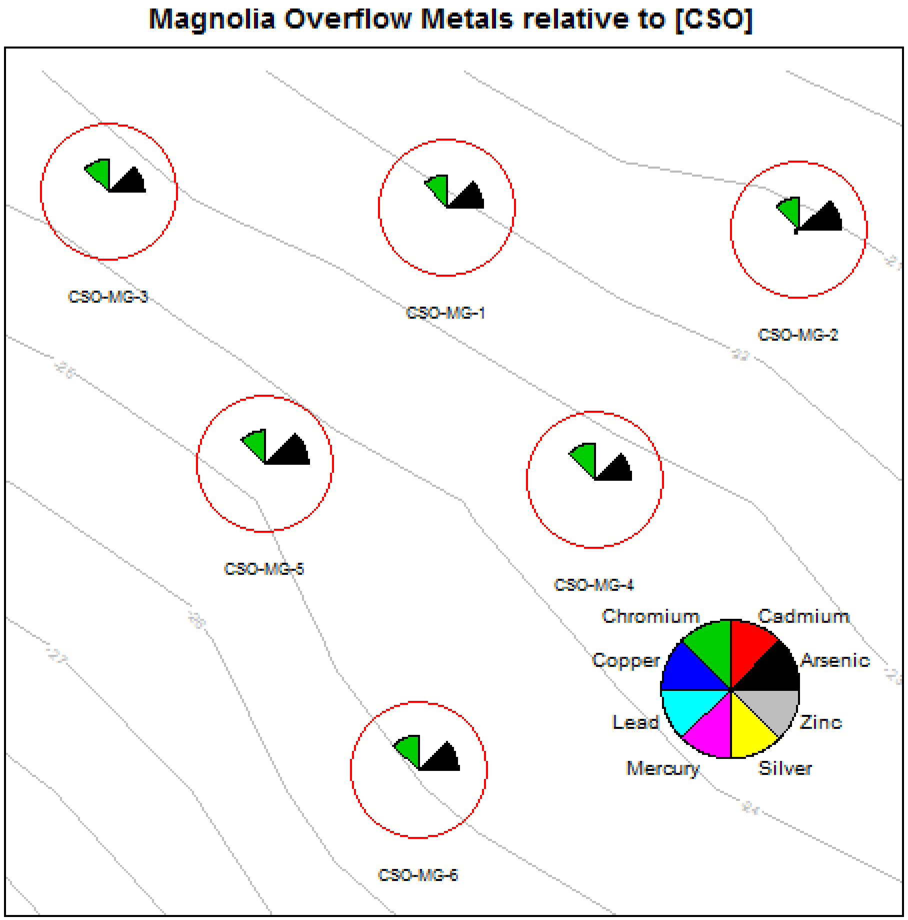

Magnolia Overflow HPAH
CSO-MG-3
CSO-MG-1
CSO-MG-2
CSO-MG-5
CSO-MG-4
CSO-MG-6
Benzo(a)anthracene
Chrysene
Pyrene
Fluoranthene
Total Benzofluoranthenes
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenzo(a,h)anth


Magnolia Overflow HPAH relative to [CSO]
CSO-MG-3
CSO-MG-1
CSO-MG-2
CSO-MG-5
CSO-MG-4
CSO-MG-6
Benzo(a)anthracene
Chrysene
Pyrene
Fluoranthene
Total Benzofluoranthenes
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenzo(a,h)anth

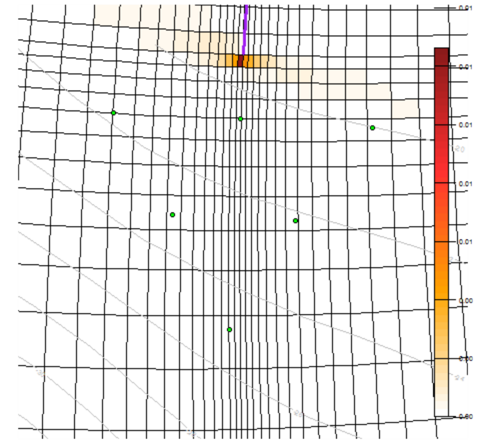
# Magnolia


Magnolia Overflow Model

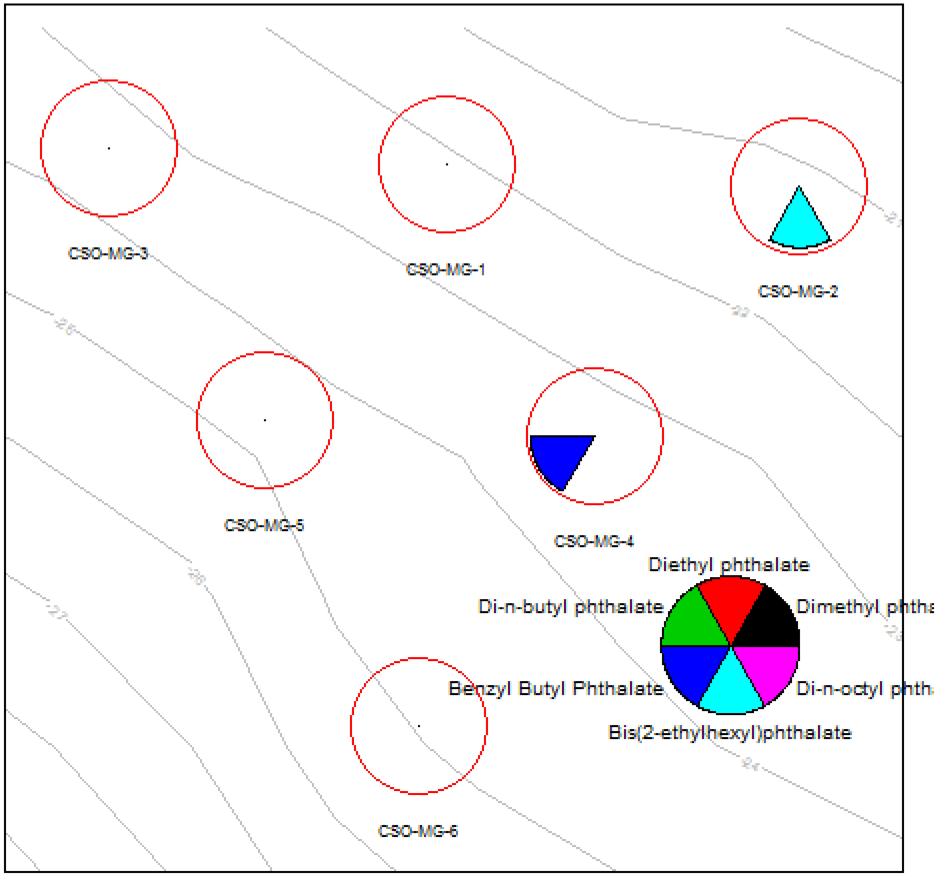

Magnolia Overflow Metals
CSO-MG-3
CSO-MG-1
CSO-MG-2
CSO-MG-5
CSO-MG-4
CSO-MG-6
Chromium
Cadmium
Copper
Arsenic
Lead
Zinc
Mercury
Silver


Magnolia Overflow Metals relative to [CSO]
CSO-MG-3
CSO-MG-1
CSO-MG-2
CSO-MG-5
CSO-MG-4
CSO-MG-6
Chromium
Cadmium
Copper
Arsenic
Lead
Zinc
Mercury
Silver

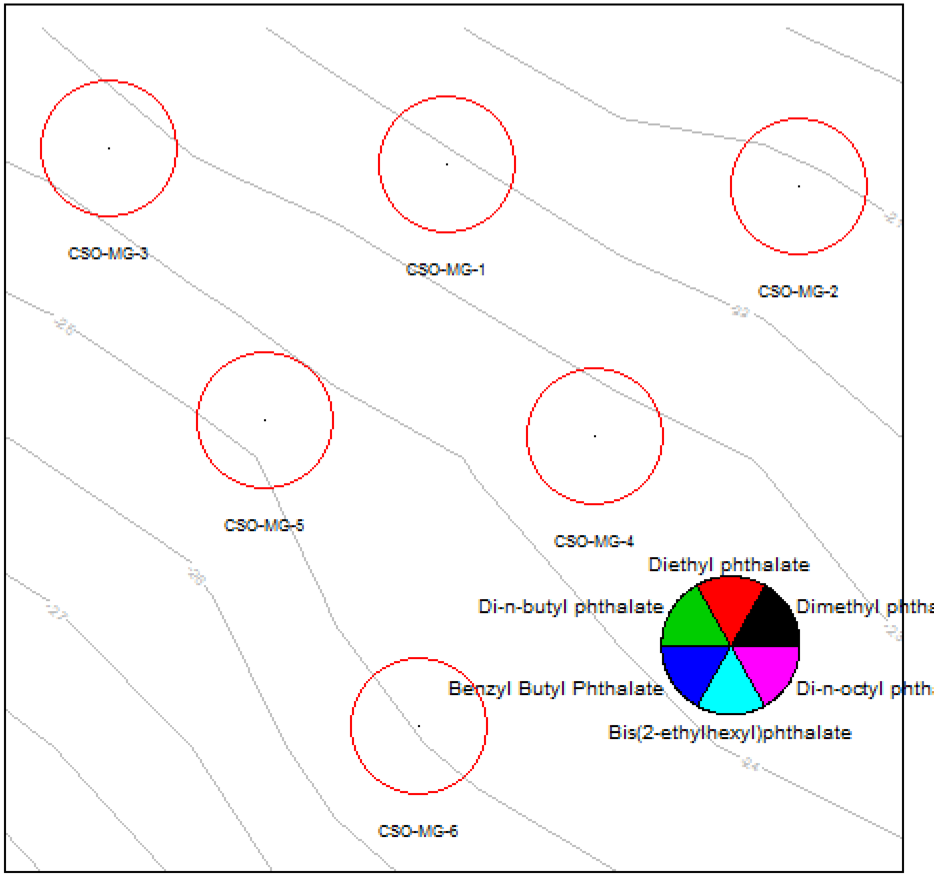
# Magnolia



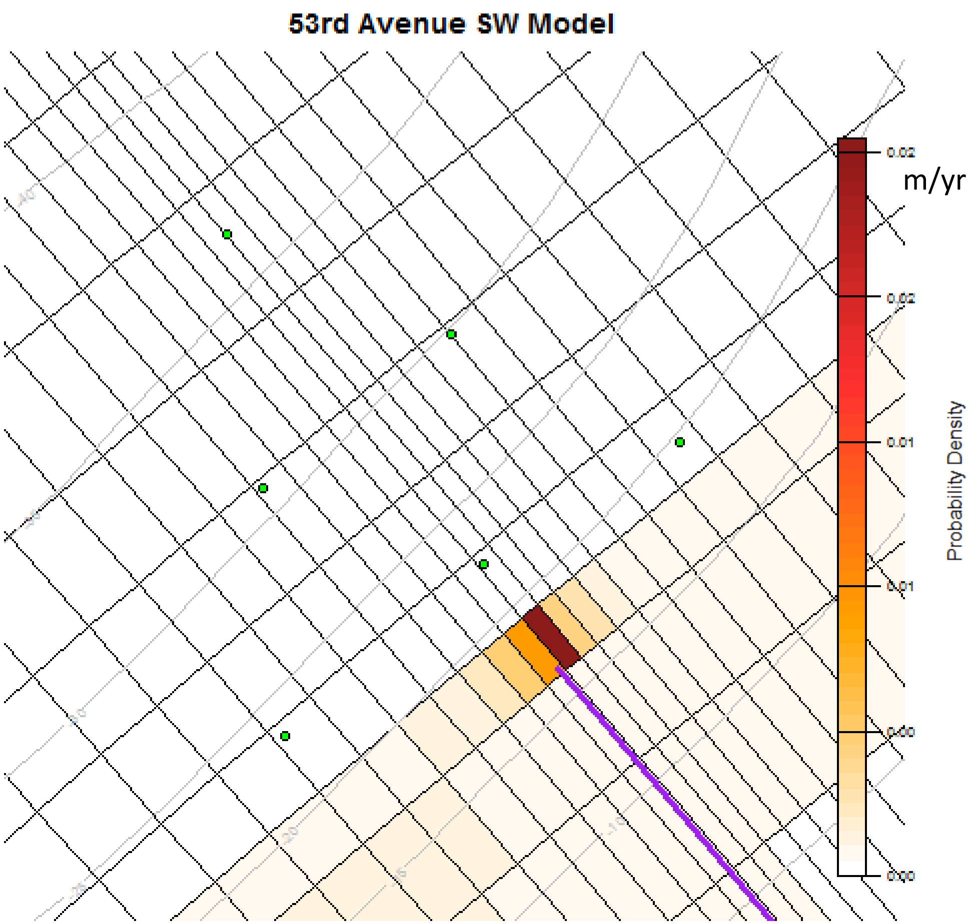

Magnolia Overflow Phthalates

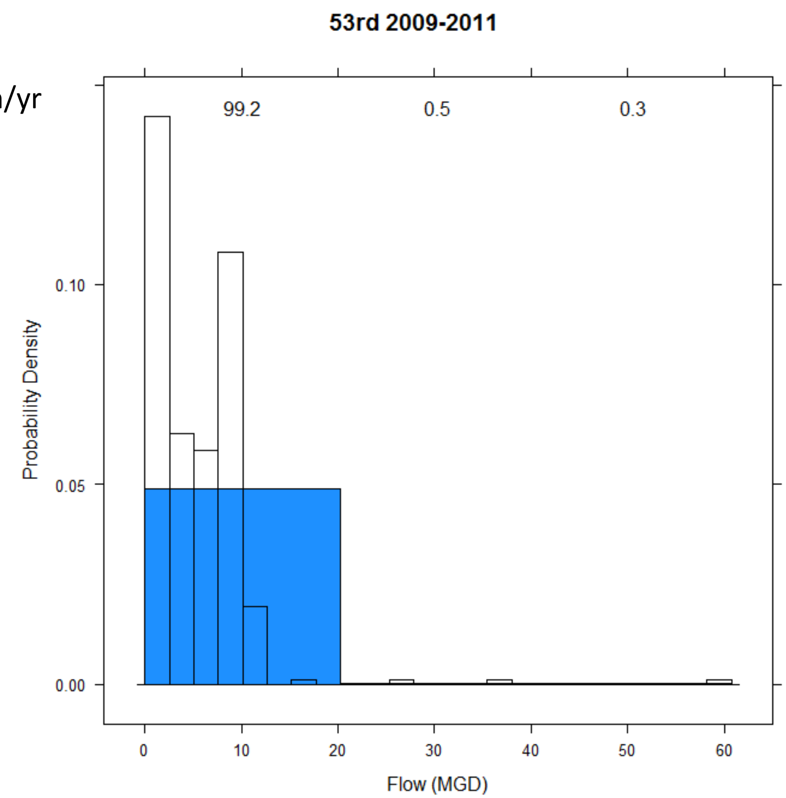



Magnolia Overflow Phthalates relative to [CSO]



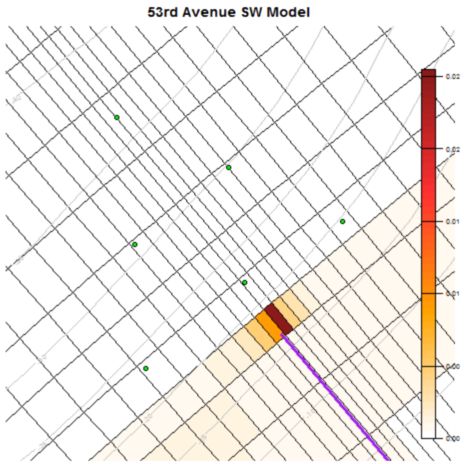
# 53rd Ave SW

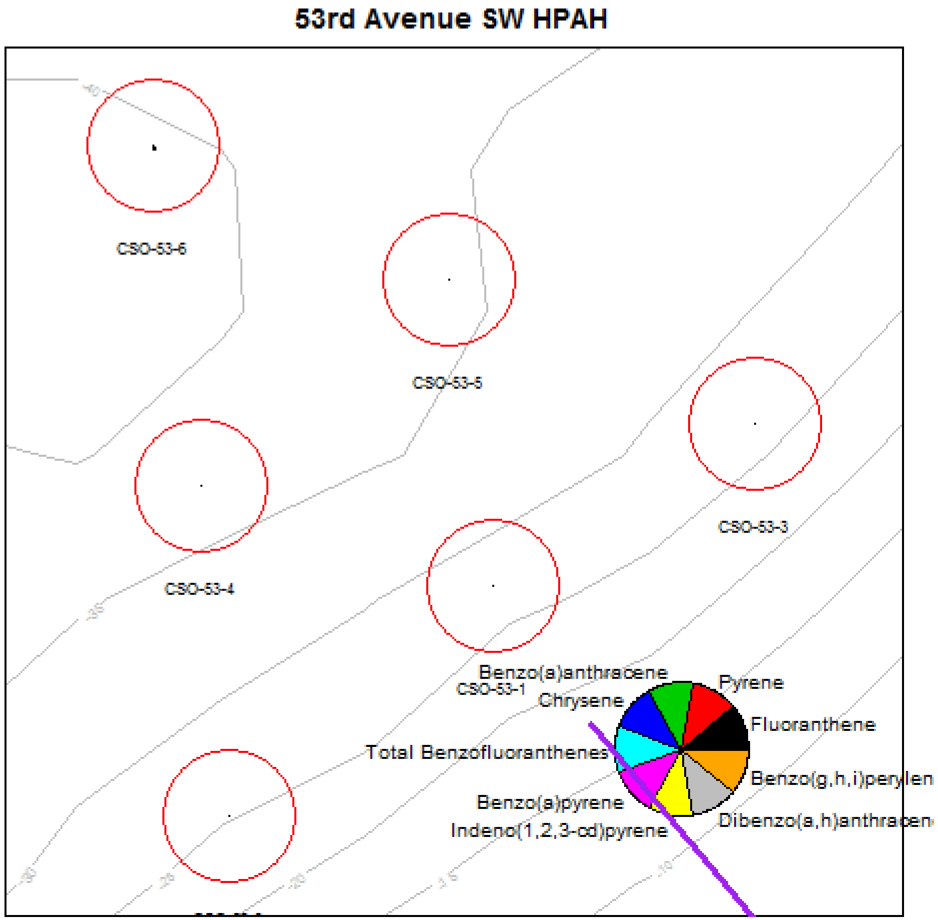


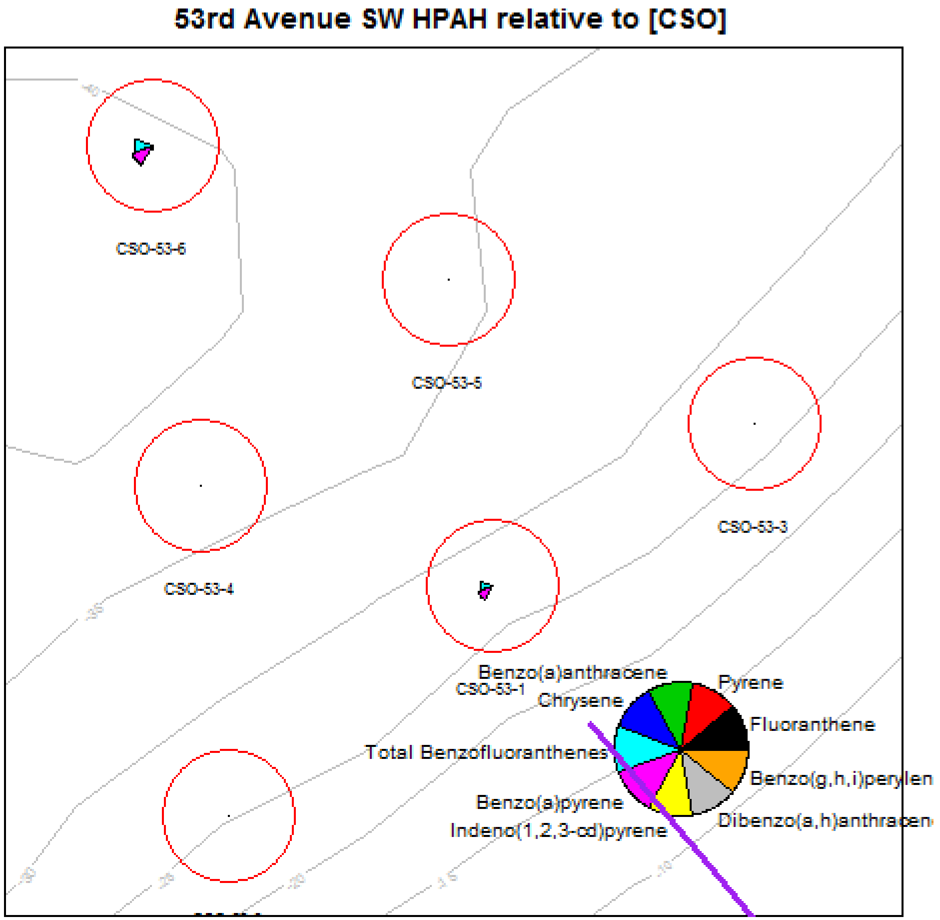




Ave. Volume 0.5MG/yr
Deposition represents ~25 years release

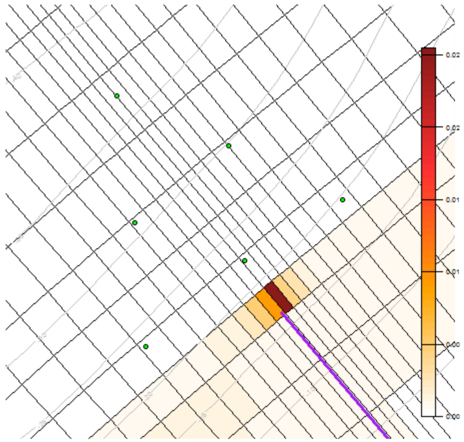
# 53rd Ave SW


53rd Avenue SW Model

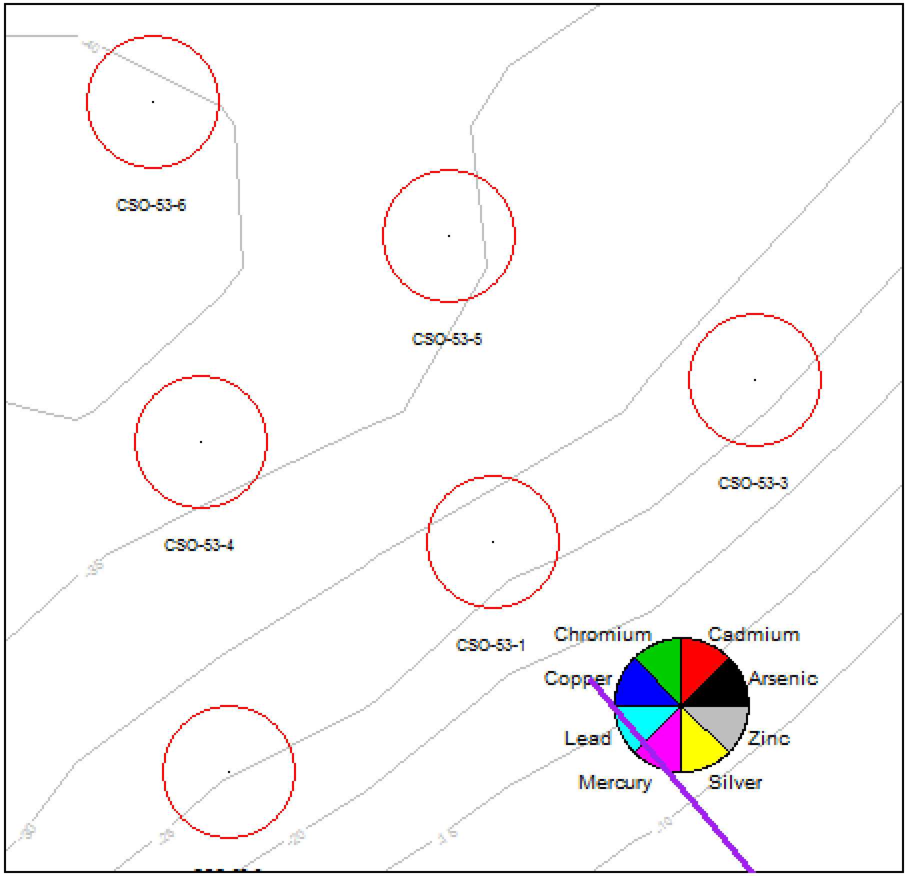

53rd Avenue SW HPAH
CSO-53-6
CSO-53-5
CSO-53-4
CSO-53-3
CSO-53-1
Benzo(a)anthracene
Chrysene
Pyrene
Fluoranthene
Total Benzofluoranthenes
Benzo(g,h,i)perylen
Benzo(a)pyrene
Dibenzo(a,h)anthracen
Indeno(1,2,3-cd)pyrene


53rd Avenue SW HPAH relative to [CSO]
CSO-53-6
CSO-53-5
CSO-53-4
CSO-53-3
CSO-53-1
Benzo(a)anthracene
Chrysene
Pyrene
Fluoranthene
Total Benzofluoranthenes
Benzo(g,h,i)perylen
Benzo(a)pyrene
Dibenzo(a,h)anthracen
Indeno(1,2,3-cd)pyrene

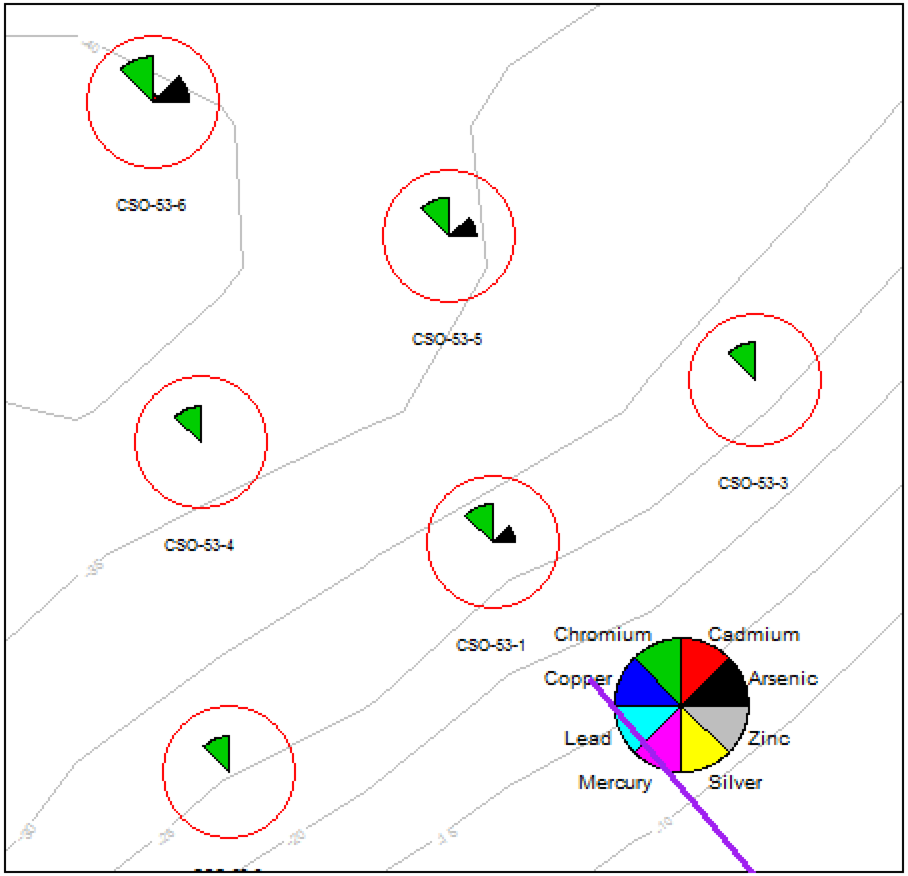
# 53rd Ave SW



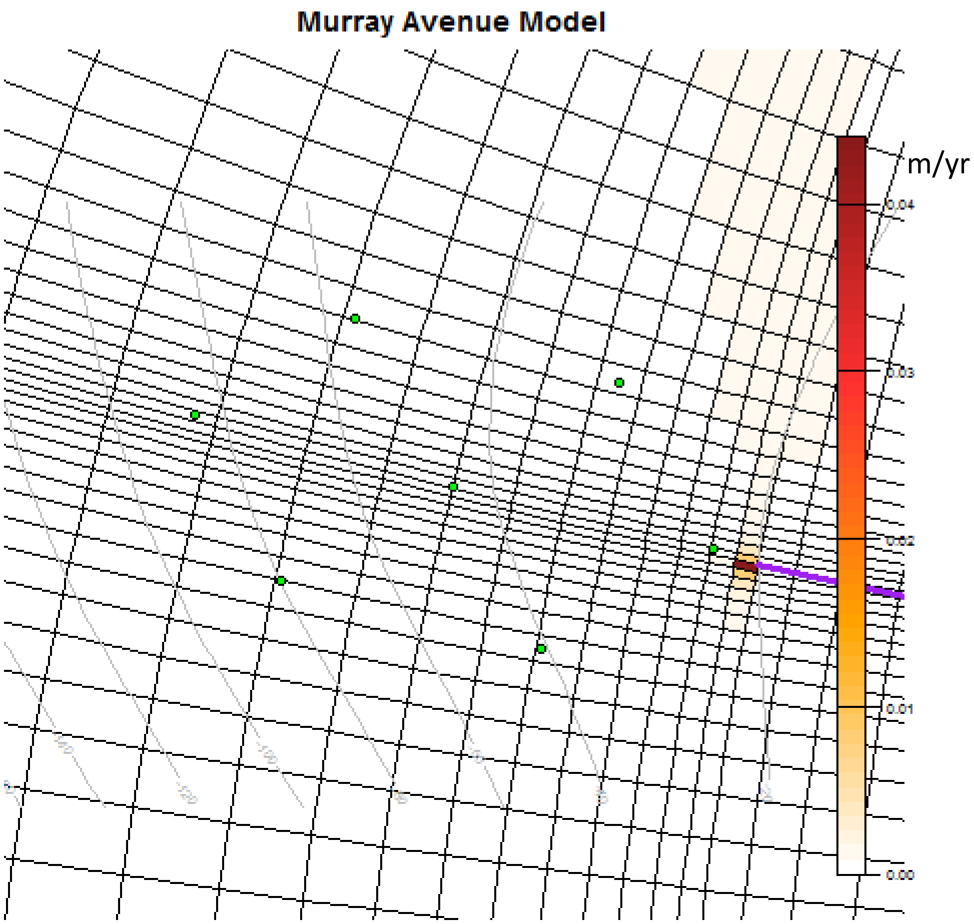

53rd Avenue SW Metals

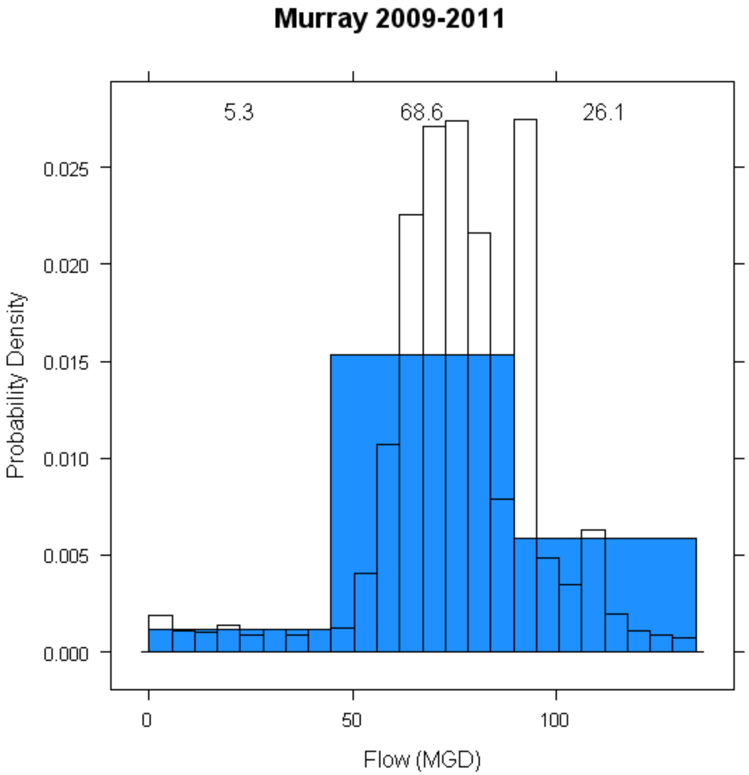



53rd Avenue SW Metals relative to [CSO]



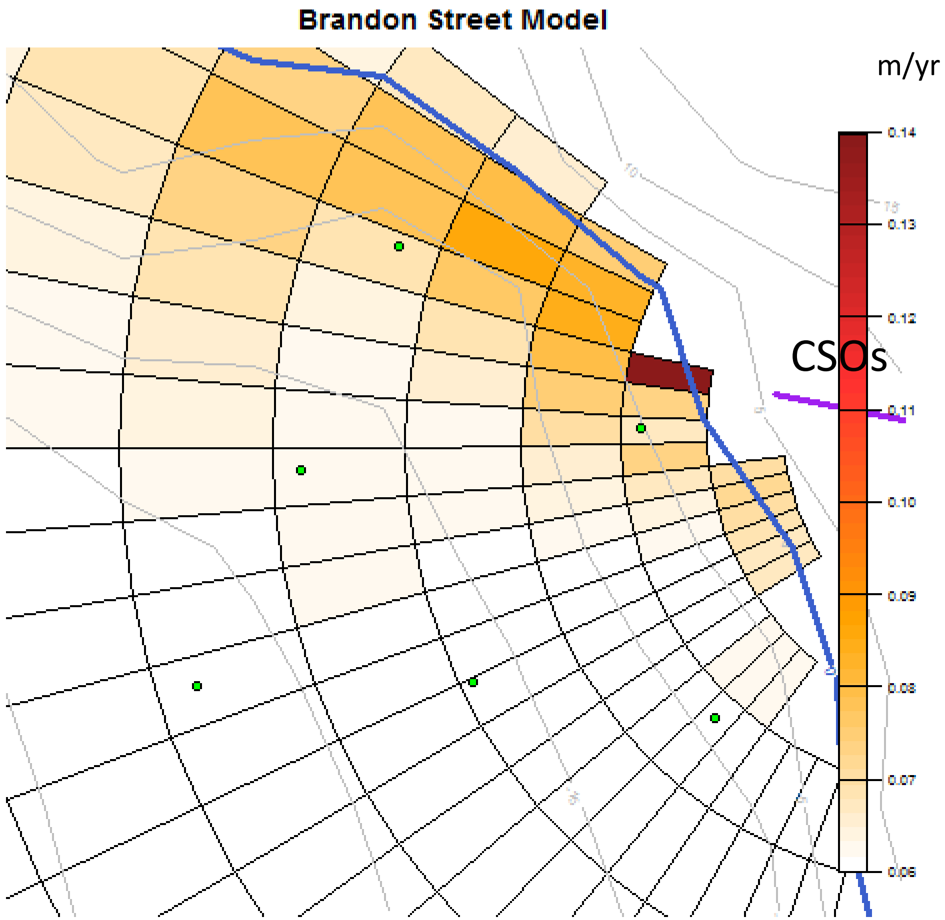
# Murray

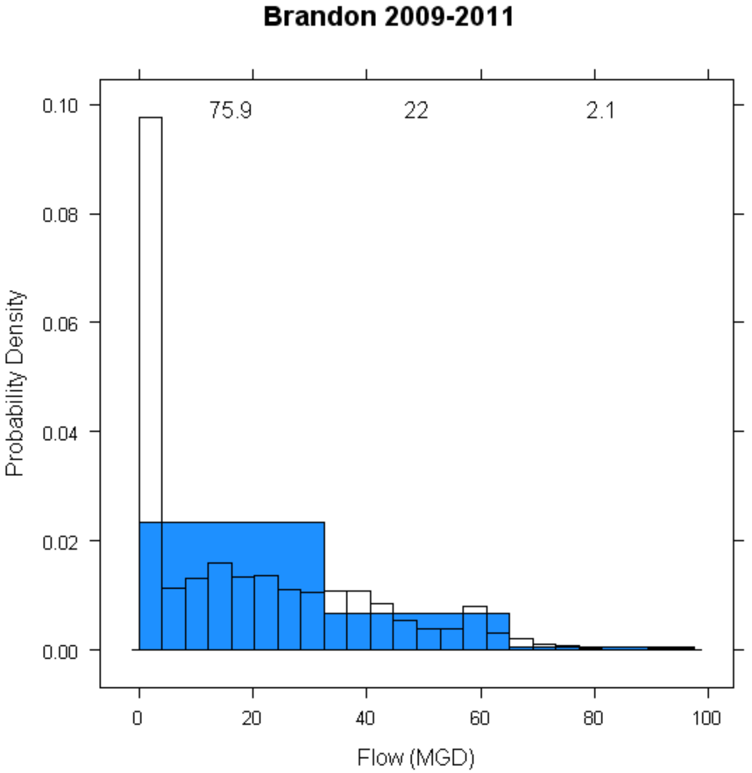



Ave. Volume 25MG/yr
Deposition represents ~28 years release

# Brandon



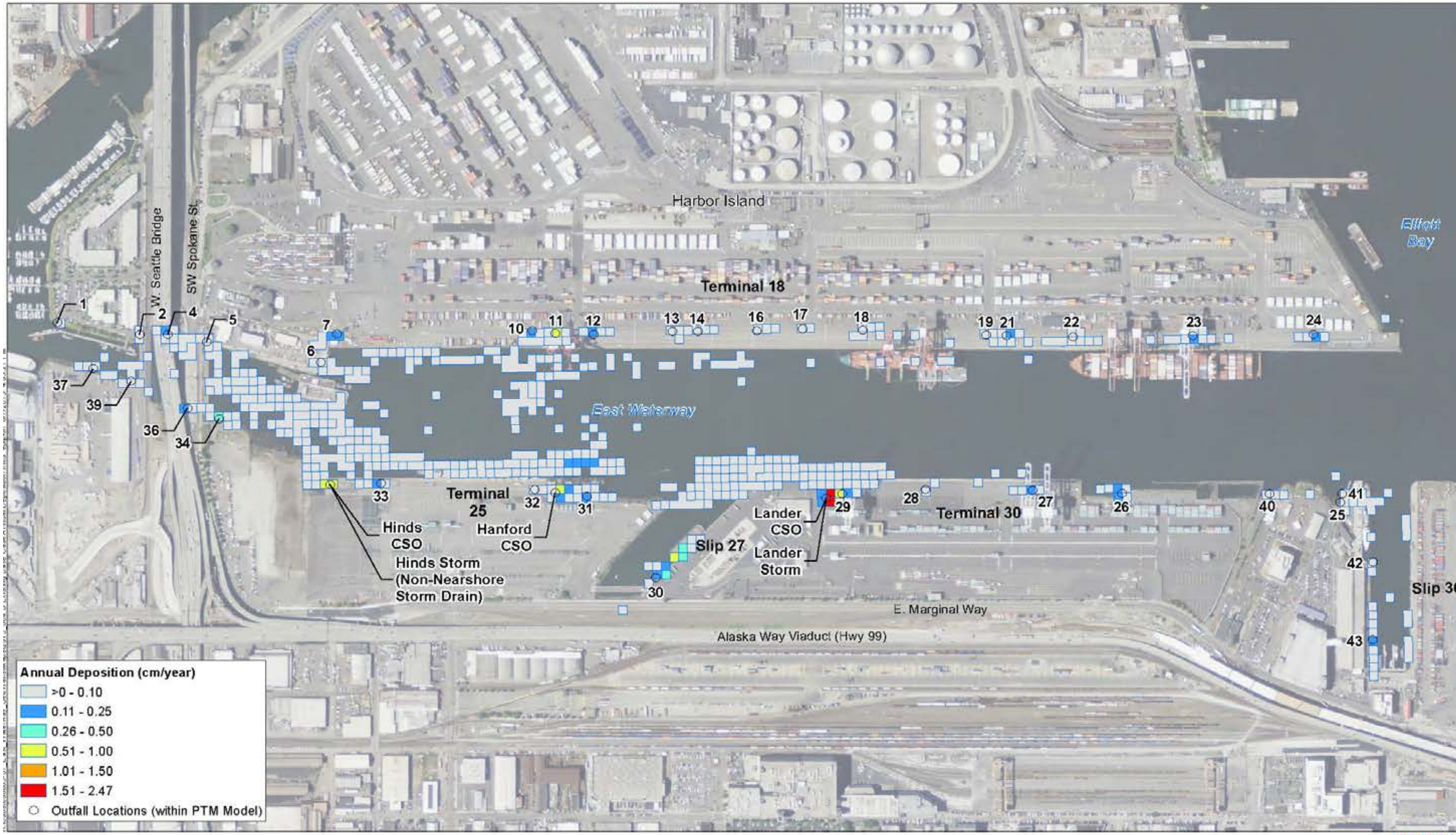




Ave. Volume 30MG/yr
Deposition represents ~8 years release

# Results from Another Modeling Effort used to Compare Stormwater Depositional Patterns

- Particle Tracking Model (USACE) used for East Waterway Discharges
- Lower Duwamish EFDC model used for hydrodynamics
  - Modified to have finer grid resolution in East Waterway
- Tracked initial deposition of 4 particle sizes
  - PSD Data from LDW stormwater and container terminal studies
  - TSS varied by land use
  - No resuspension (hydrodynamics suggest threshold velocities not exceeded)

# PTM Results for East Waterway Outfalls




NOTES:
1. Horizontal Datum: WA State Plane North, NAD83, Meters.
2. Raster cell size is 50' x 50'.
3. Aerial photo is NAIP, 2011.

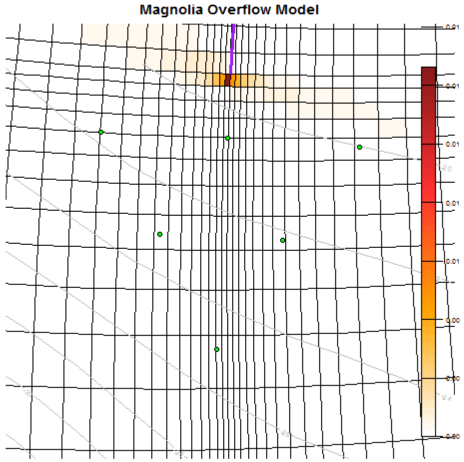
0 250 500 750 1,000
Scale in Feet

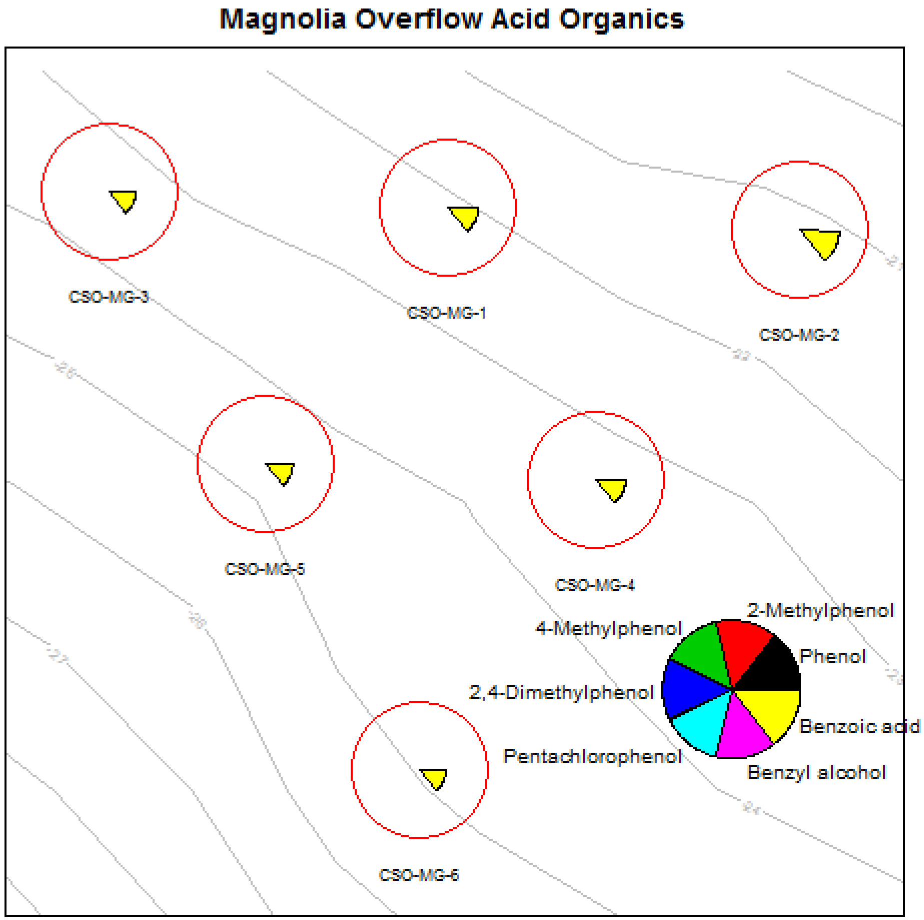
# Summary of Results

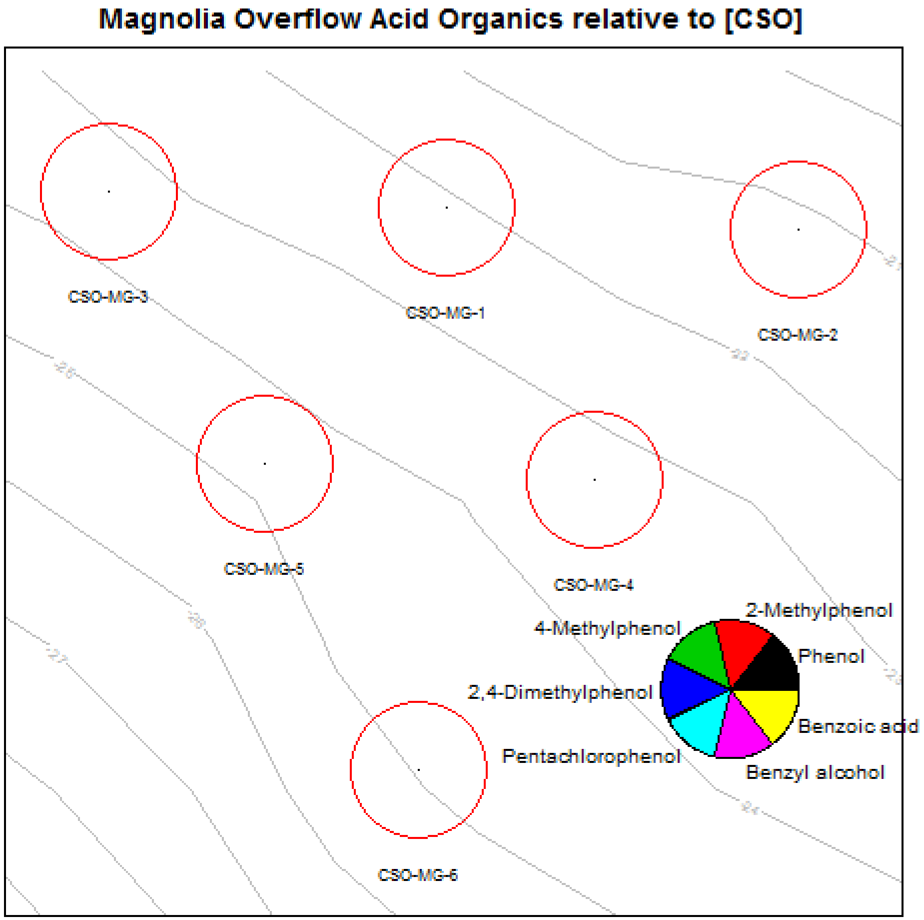
- CSOs
  - Measurable deposition directly in front of pipe
  - Deposition rates fall off by an order of magnitude within 10's of feet
  - Chemistry is noticeable only at stations within 35 -100 feet
  - Depth to bed decreases near-field accumulations
- Stormwater
  - Similar patterns seen although the slightly larger-skewed particle size distribution

# Remainder of Chemistry Results

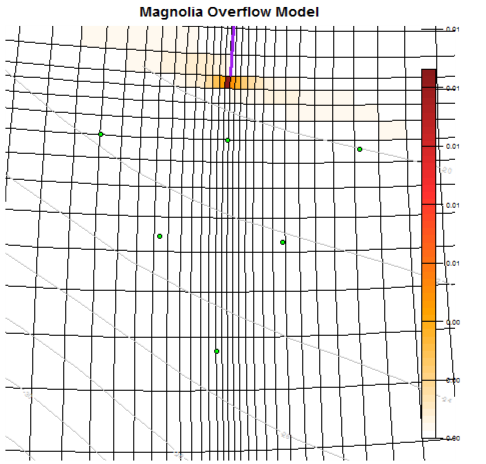
# Magnolia


Magnolia Overflow Model

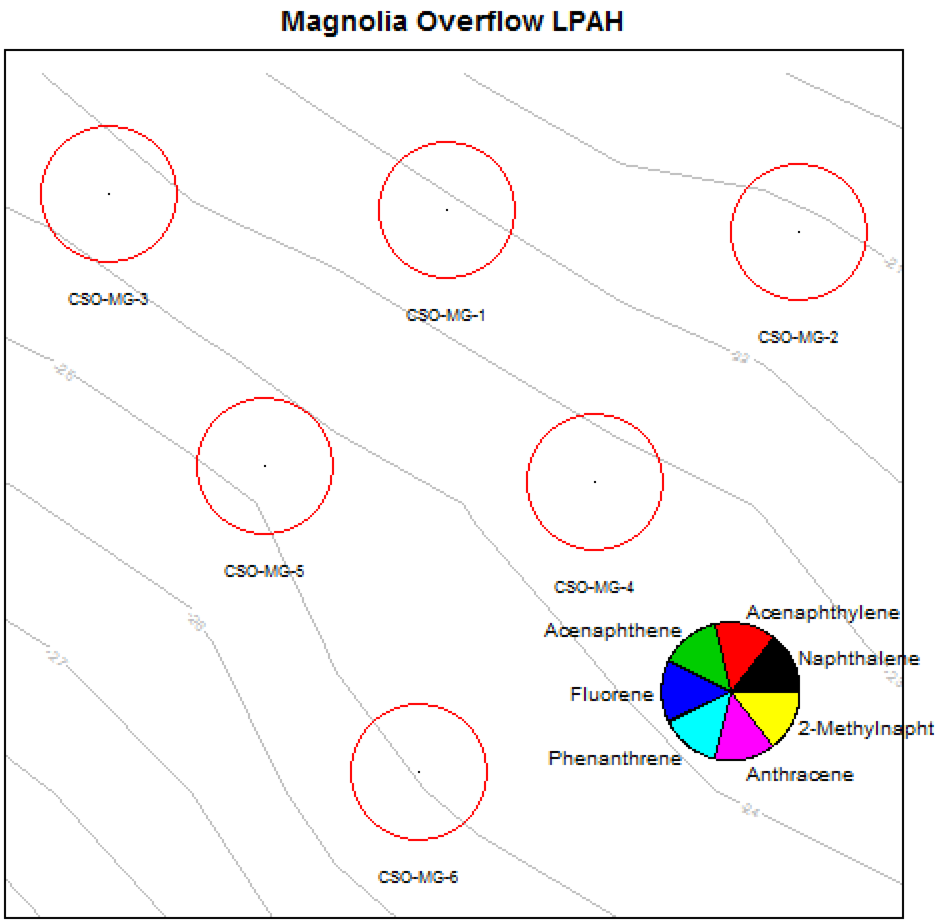

Magnolia Overflow Acid Organics
CSO-MG-3
CSO-MG-1
CSO-MG-2
CSO-MG-5
CSO-MG-4
CSO-MG-6
2-Methylphenol
4-Methylphenol
Phenol
2,4-Dimethylphenol
Benzoic acid
Pentachlorophenol
Benzyl alcohol


Magnolia Overflow Acid Organics relative to [CSO]
CSO-MG-3
CSO-MG-1
CSO-MG-2
CSO-MG-5
CSO-MG-4
CSO-MG-6
2-Methylphenol
4-Methylphenol
Phenol
2,4-Dimethylphenol
Benzoic acid
Pentachlorophenol
Benzyl alcohol

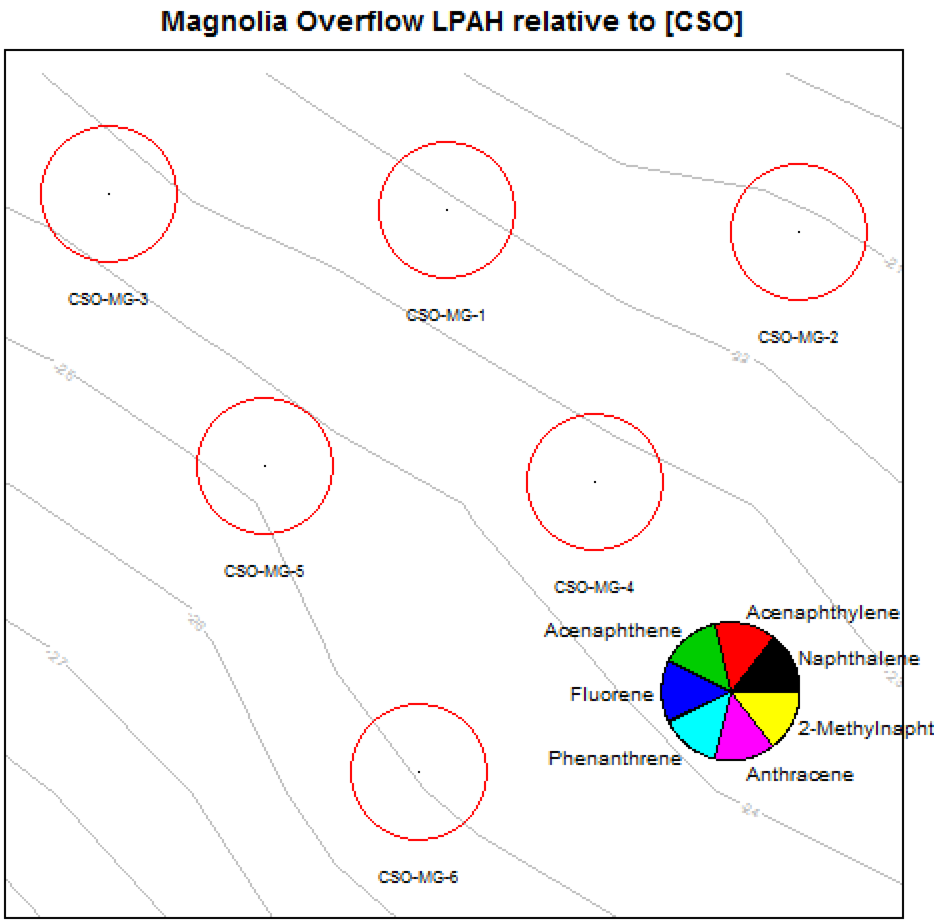
# Magnolia



Magnolia Overflow Model

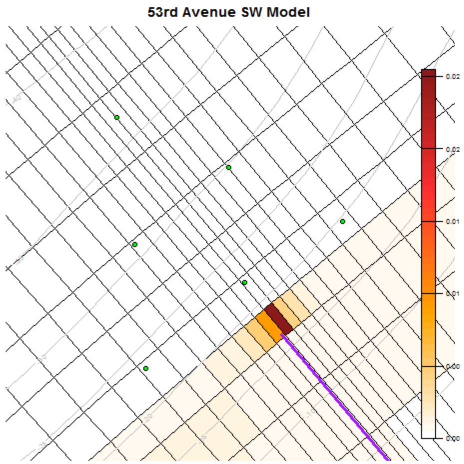



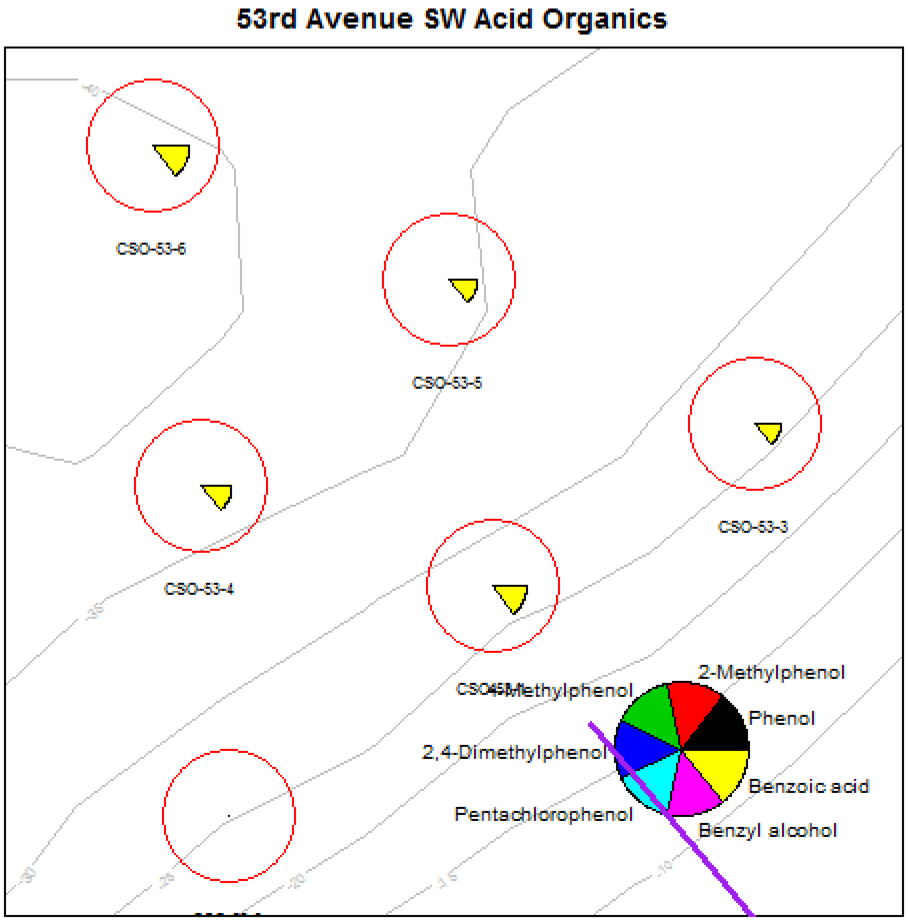
Magnolia Overflow LPAH
CSO-MG-3
CSO-MG-1
CSO-MG-2
CSO-MG-5
CSO-MG-4
CSO-MG-6
Acenaphthylene
Acenaphthene
Naphthalene
Fluorene
2-Methylnapht
Phenanthrene
Anthracene

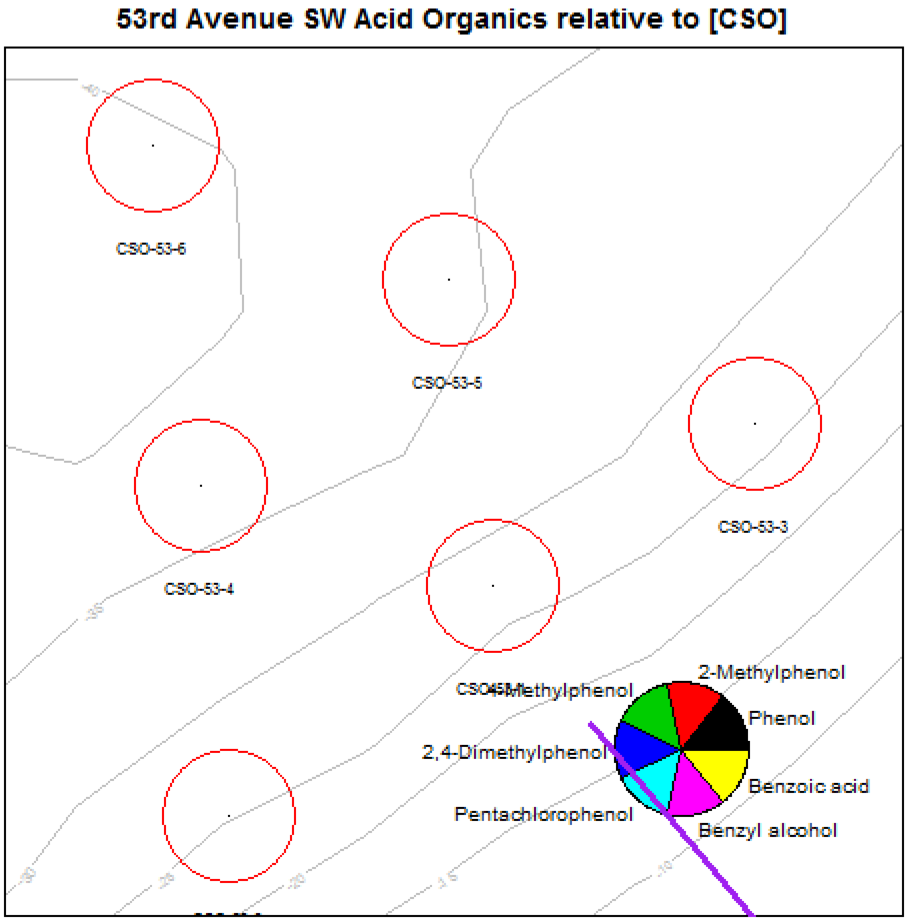



Magnolia Overflow LPAH relative to [CSO]
CSO-MG-3
CSO-MG-1
CSO-MG-2
CSO-MG-5
CSO-MG-4
CSO-MG-6
Acenaphthylene
Acenaphthene
Naphthalene
Fluorene
2-Methylnapht
Phenanthrene
Anthracene

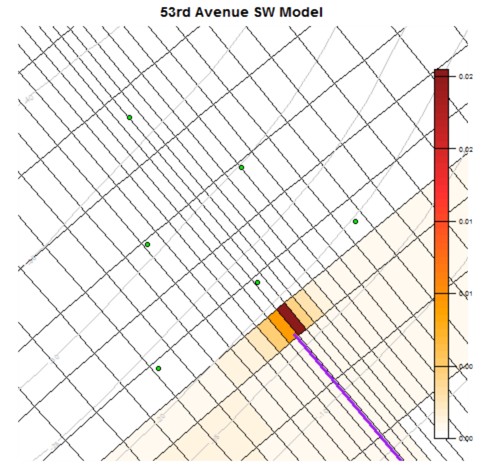
# $53^{rd}$ Ave SW


53rd Avenue SW Model

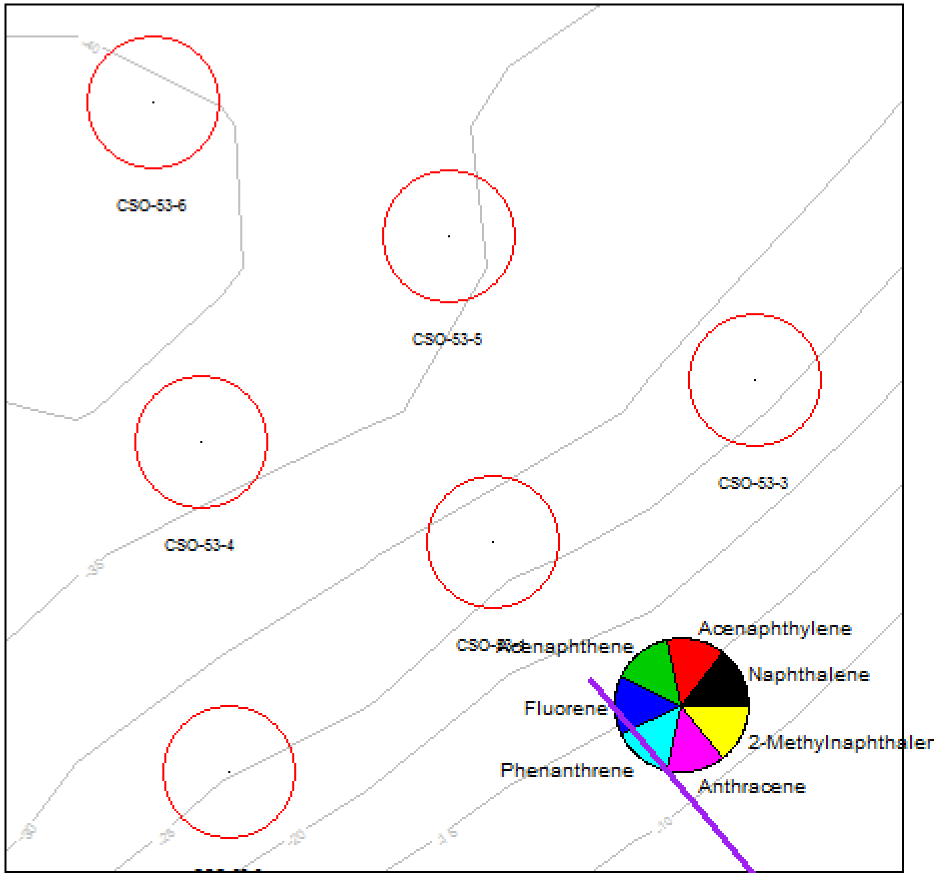

53rd Avenue SW Acid Organics
CSO-53-6
CSO-53-5
CSO-53-3
CSO-53-4
2-Methylphenol
4-Methylphenol
Phenol
2,4-Dimethylphenol
Benzoic acid
Pentachlorophenol
Benzyl alcohol


53rd Avenue SW Acid Organics relative to [CSO]
CSO-53-6
CSO-53-5
CSO-53-3
CSO-53-4
2-Methylphenol
4-Methylphenol
Phenol
2,4-Dimethylphenol
Benzoic acid
Pentachlorophenol
Benzyl alcohol

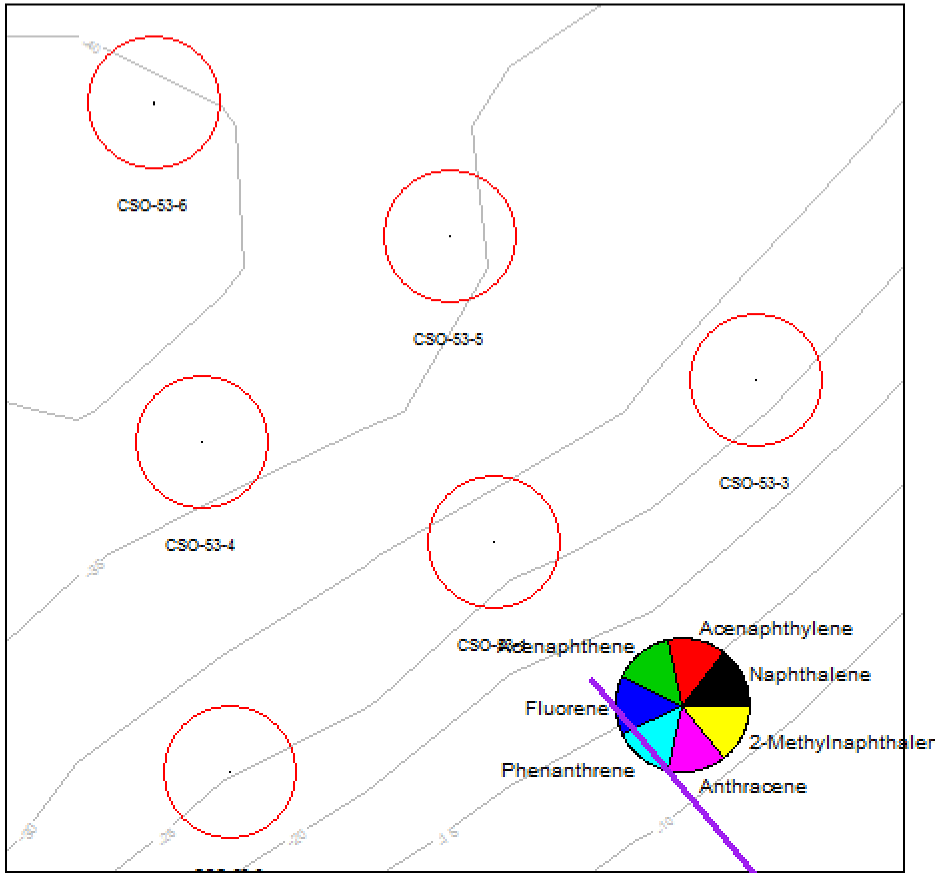
# 53$^{rd}$ Ave SW



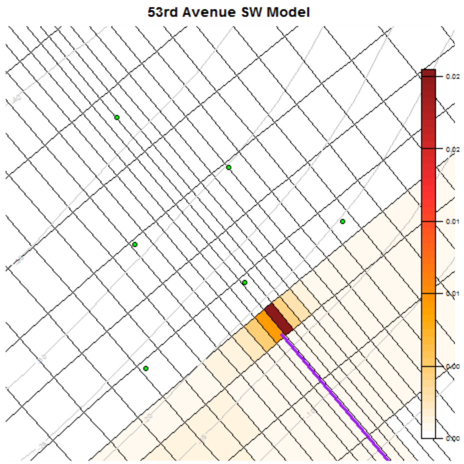

53rd Avenue SW LPAH

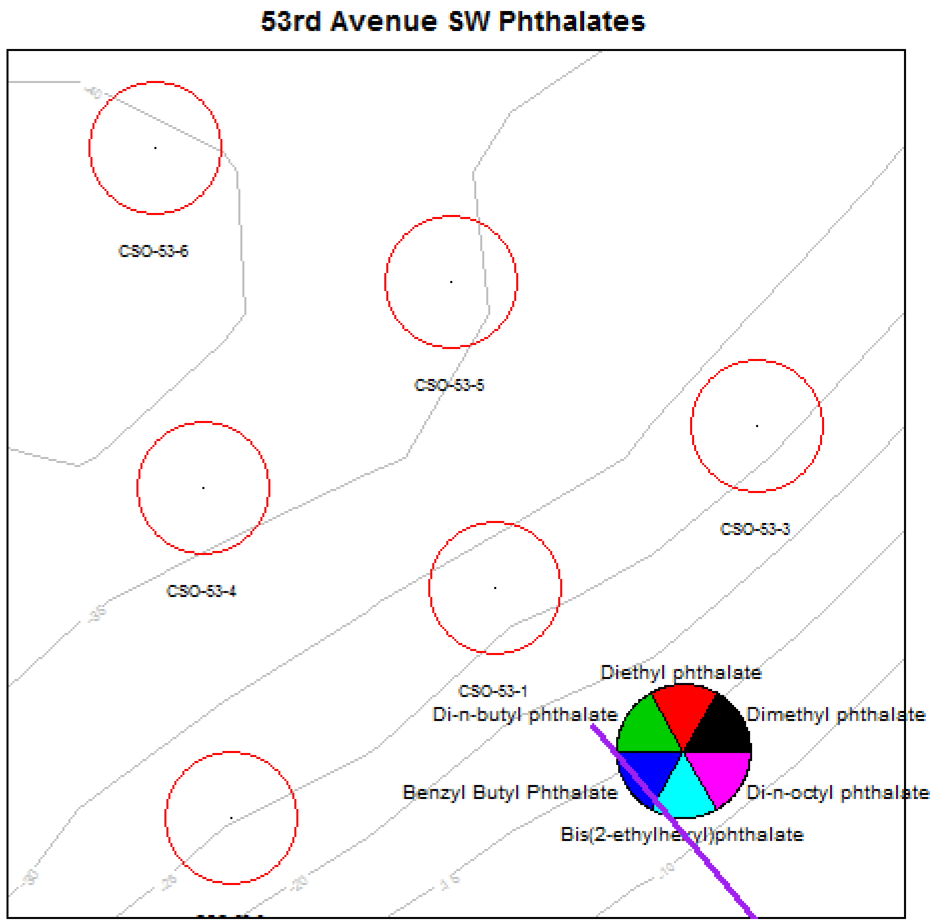


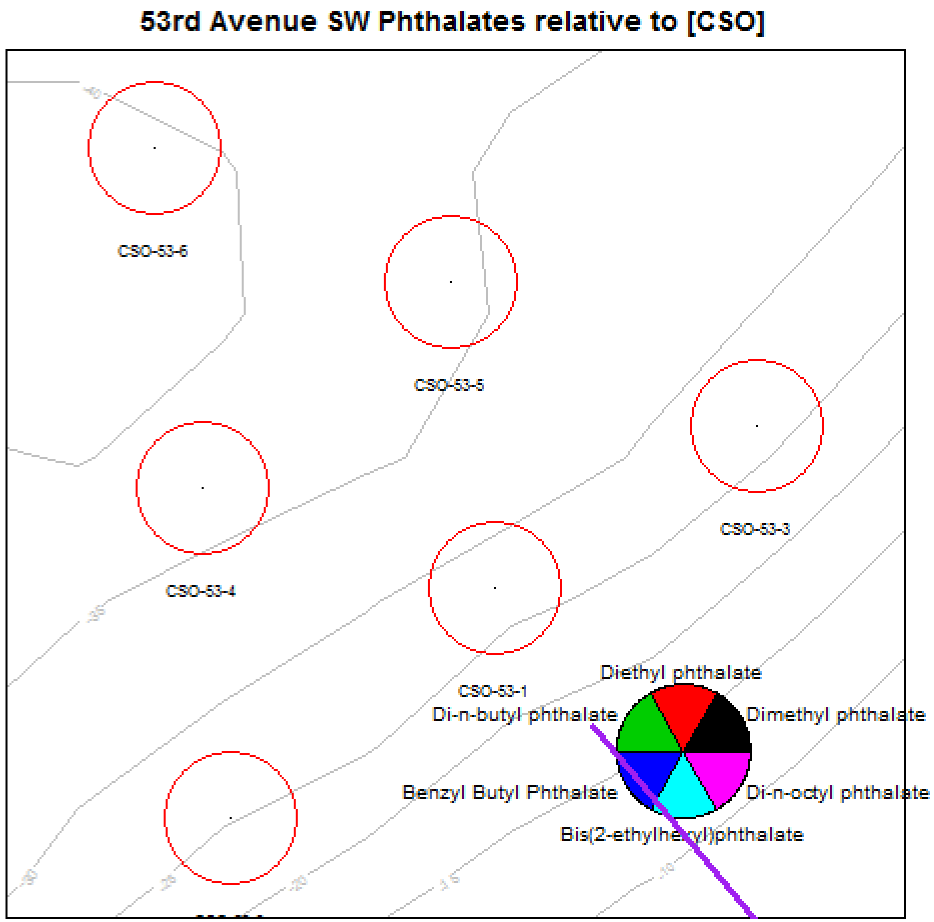

53rd Avenue SW LPAH relative to [CSO]



# 53rd Ave SW


53rd Avenue SW Model


53rd Avenue SW Phthalates
CSO-53-6
CSO-53-5
CSO-53-3
CSO-53-4
CSO-53-1
Diethyl phthalate
Di-n-butyl phthalate
Dimethyl phthalate
Benzyl Butyl Phthalate
Di-n-octyl phthalate
Bis(2-ethylhexyl)phthalate


53rd Avenue SW Phthalates relative to [CSO]
CSO-53-6
CSO-53-5
CSO-53-3
CSO-53-4
CSO-53-1
Diethyl phthalate
Di-n-butyl phthalate
Dimethyl phthalate
Benzyl Butyl Phthalate
Di-n-octyl phthalate
Bis(2-ethylhexyl)phthalate

# Details of Modeling Runs

# Modeling Simulation Design

- Separate EFDC grid for each discharge
- Model discharged particulate fate
    - particle size distribution / settling velocity from CSO samples
    - discharge geometry specific to each CSO
- Apply contaminant concentrations to accumulated sediment
    - no dissolution
    - no resuspension / dispersion after initial deposition
    - concentrations from inline “CSO-like” samples, primarily Hanford, Michigan, Brandon
- Mix with ambient sedimentation (assume rate; use chemistry from reference sampling stations)

# EFDC model grids

- Model grid width = diameter of discharge pipe
  - model grid width increases away from discharge point
- Model grid typically 3:1 aspect ratio
  - grid length = 3x discharge pipe diameter
  - grid expands away from discharge point
- Model grid typically extends ~ 1 km from discharge point
- Model grid is semi-circular for most discharges; rectangular for ship canal locations

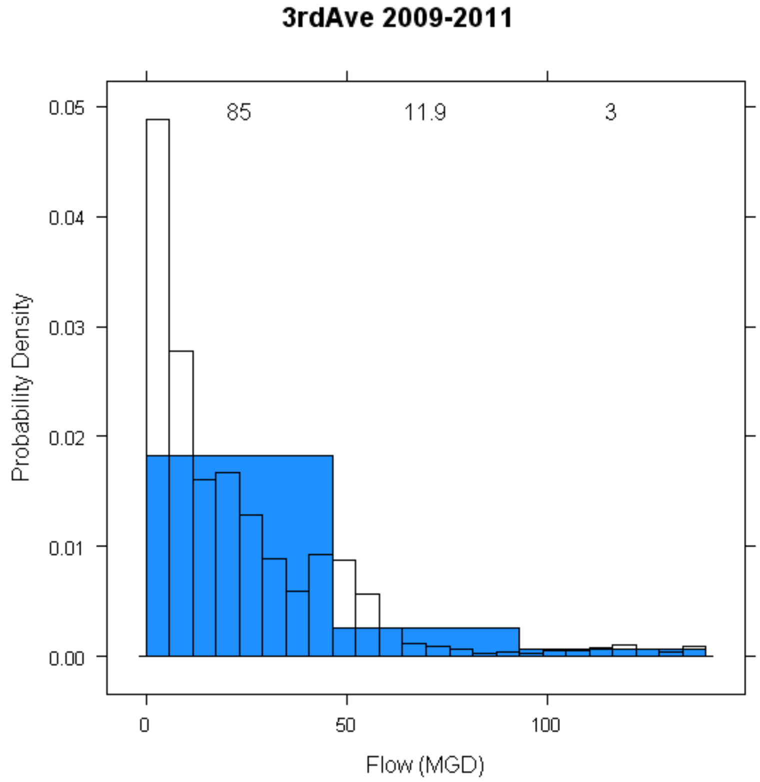
# Model Boundary Conditions

- Puget Sound discharges:
  - Simplified tide (M2, K1) applied at boundary
  - Minimal stratification (November density profiles)
- Ship Canal discharges:
  - constant elevation difference specified between boundaries
- Duwamish discharges:
  - Simplified tide (M2, K1) plus constant elevation difference between boundaries
  - Minimal stratification (November density profiles)

# Discharge Rates

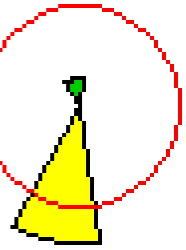
- Simulated 3 discharge rates; determined from histograms of previous 2 – 3 years
- 10 days total simulated discharge – represents ~1+ to 20+ years of discharge depending on location

Example Discharge Histogram



# Sampling Results

- Sediment Quality is shown as a pie-chart for each location
- colour denotes compound (see key)
- length of pie slice denotes concentration
  - Concentration plotted as log scale: $\log([x]/[x_{scale}])+1$
  - values less than 10% of reference scale are not shown
- Red circle denotes the scale, either:
  - SQS standards (dry or OC normalized, as appropriate)
  - CSO discharge concentration, average of:
    - Hanford Sed traps
    - Michigan and Brandon in-line samples



Example:

- Red circle is SQS concentration
- two compounds detected (at > 10% of SQS)
- Green compound is less than SQS (15% of SQS)
- Yellow compound exceeds SQS (215% of SQS)
  - note LOG scale

# Elliott Bay and Duwamish Conceptual Site Model, Modeling Efforts, and Data Inputs



Presentation for
Elliott Bay Regional Background Workshop Meeting
September 3, 2013 (hosted by Ecology)

by *Anne Fitzpatrick (AECOM)* and Bruce Nairn (King County)*

** representing Port of Seattle / City of Seattle / King County / The Boeing Company*

# Overview

1. Modeling Options and Work Completed To Date
2. Duwamish Models/Conceptual Site Model
3. Empirical Data Compiled for Input to Duwamish Model
4. Comparisons to Background Data

# Objectives of Presentation

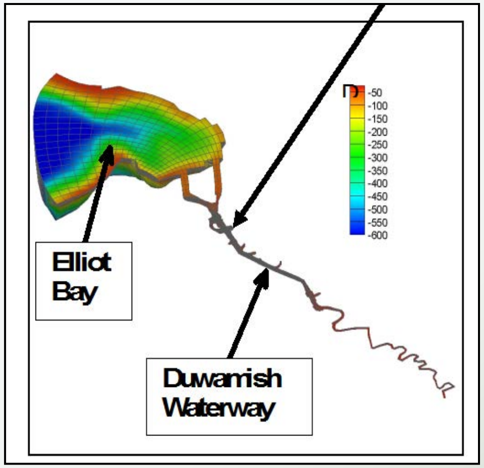
1. Understand what tools and data already exist that could be used to help develop regional background.
2. Review empirical data used for model inputs.
3. Review our understanding of the conceptual site model.
4. Compare results to other background studies.

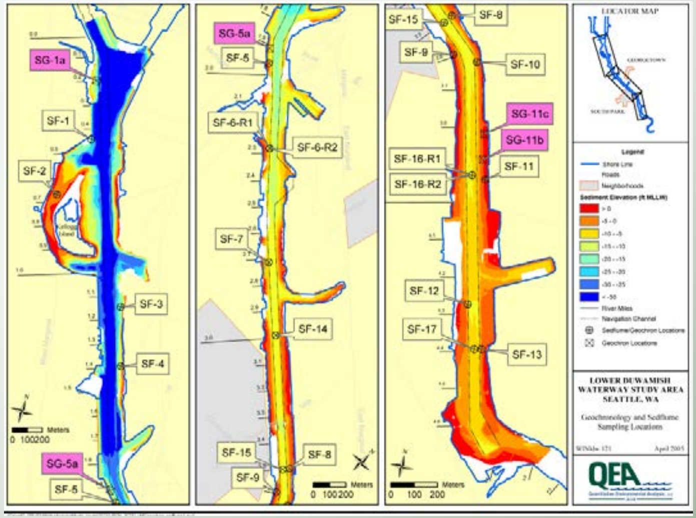
# King County Modeling Efforts

Part 1

# General Classes of Models

- Hydrodynamics – Movement of Water
- Sediment Transport – Movement of Solids
- COC Fate
  - Simple Sediment Mixing
  - Box Models
  - EFDC Fate and Transport
  - Empirical / Multiple Linear Regression



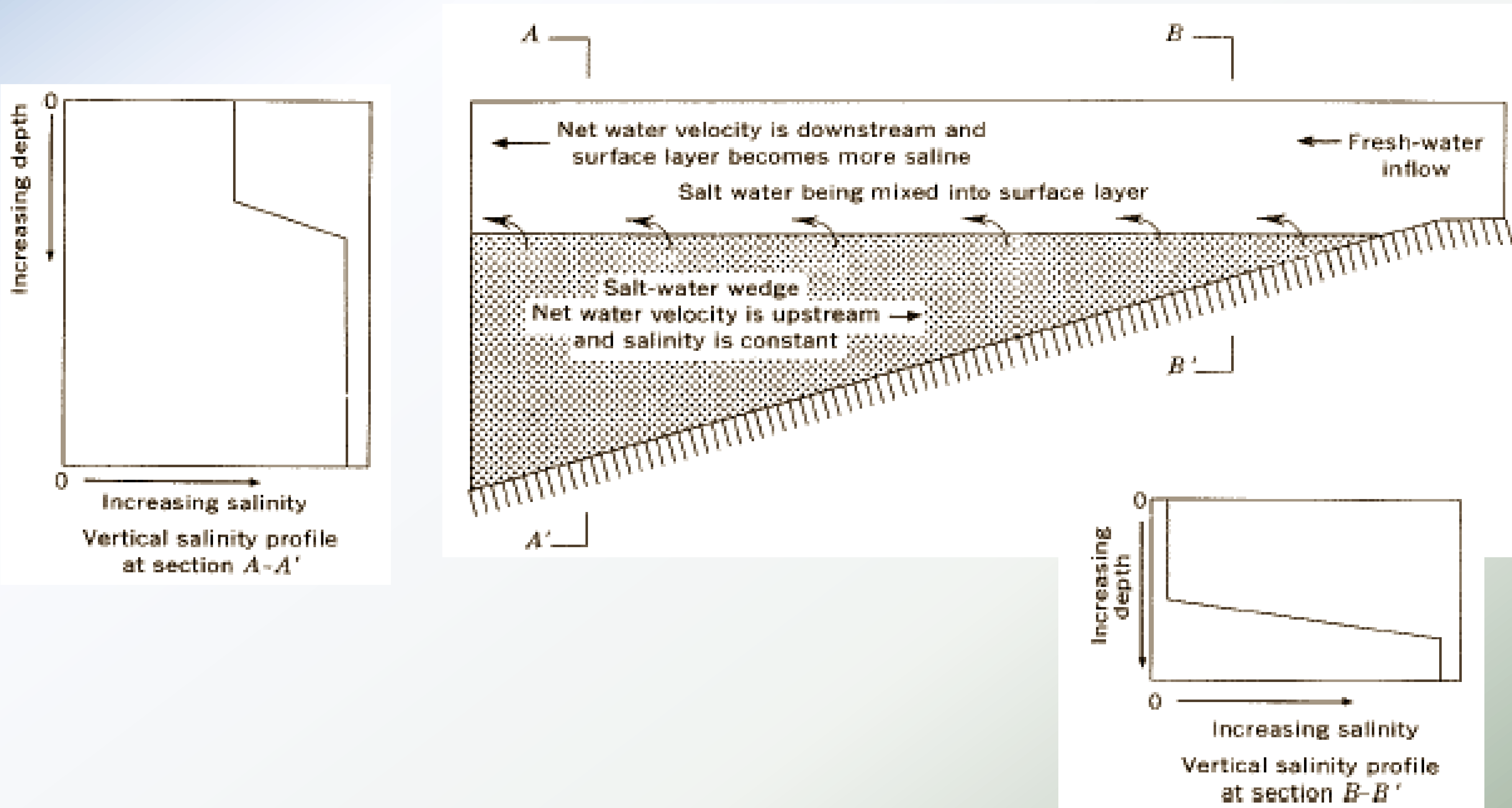
# King County
# CSO Water Quality Assessment (WQA) 1999

- Formal Model Selection Process
- Selected EFDC (Environmental Fluid Dynamics Code) as highest ranked model (circa 1996):
  - Three-Dimensional Hydrodynamics with Coupled Salinity and Temperature Transport
  - Directly Coupled Water Quality-Eutrophication Model
  - Directly Coupled Sediment and Toxic Contaminated Transport and Fate Model
  - Previous applications to estuaries
  - Source code available / non-proprietary

# EFDC CAPABILITIES

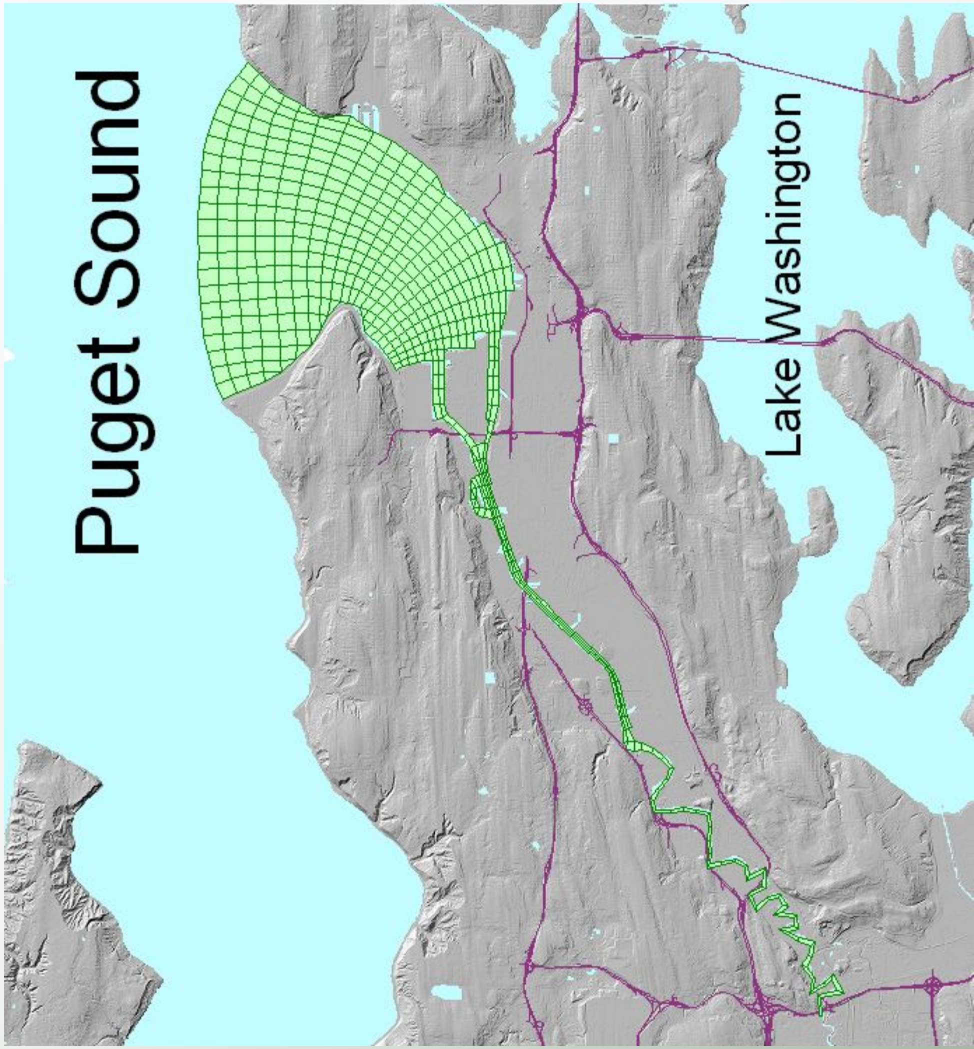
- Three-Dimensional Hydrodynamics with Coupled Salinity and Temperature Transport
- Directly Coupled Water Quality-Eutrophication Model
- Directly Coupled Sediment and Toxic Contaminated Transport and Fate Model
- Integrated Near-field Mixing Zone Model
- Preprocessing Software for Grid Generation and Input File Creation
- Postprocessing Software for Analysis, Graphic and Visualization
- Track Record for Surface Water Applications

# Conceptual Models: Salt-Wedge Estuary

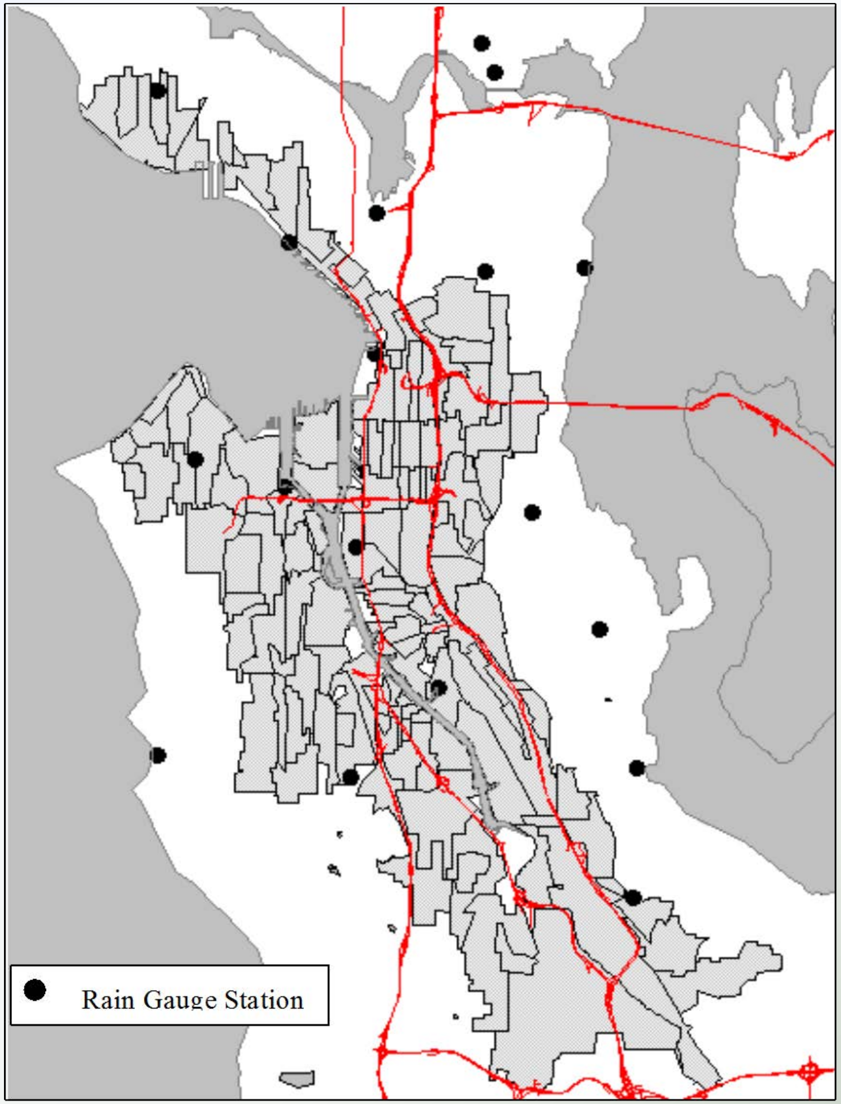


# Elliott Bay – Duwamish River Water Quality Assessment (1999)

- Evaluation of CSO impacts
- EFDC (Environmental Fluid Dynamics Computer Code)
- Simulated:
  - Sediments
  - Metals
  - Organics
  - Bacteria (Fecals)



# Watershed inputs



# Model Inputs

- Geophysical
  - Initial water depth
  - Initial water velocity
  - Bottom elevation (bathymetry)
  - Initial suspended solid concentration
  - Initial sediment depth (mass)
  - Suspended solids settling velocity (usually spatially constant)
  - Critical sediment resuspension and deposition shear stresses (usually spatially constant)
  - Water elevations or flows over time (boundary condition)
  - Wind speeds over time (boundary condition)
  - Suspended solid concentrations over time (boundary condition)
- Geochemical
  - Initial chemical concentration in water and sediments
  - Chemical partitioning in water and sediment columns (usually spatially constant)
  - Chemical decay in water and sediment columns (usually spatially constant)
  - Initial salinity
  - Chemical and salinity concentrations over time (boundary condition)

# WQA Selected Chemicals

- Metals
  - arsenic
  - cadmium
  - copper
  - lead
  - nickel
  - zinc
  - mercury
  - tributyltin
- Fecal coliform bacteria
- Organics
  - 1,4 dichlorobenzene
  - 4 methylphenol
  - bis(2ethylhexyl)phthalate
  - fluoranthene
  - phenanthrene
  - total PCB
  - pyrene
  - benzo(k)fluoranthene
  - chrysene
  - benzo(b)fluoranthene

# WQA Output

- Results were incorporated into a risk assessment, presented as risk

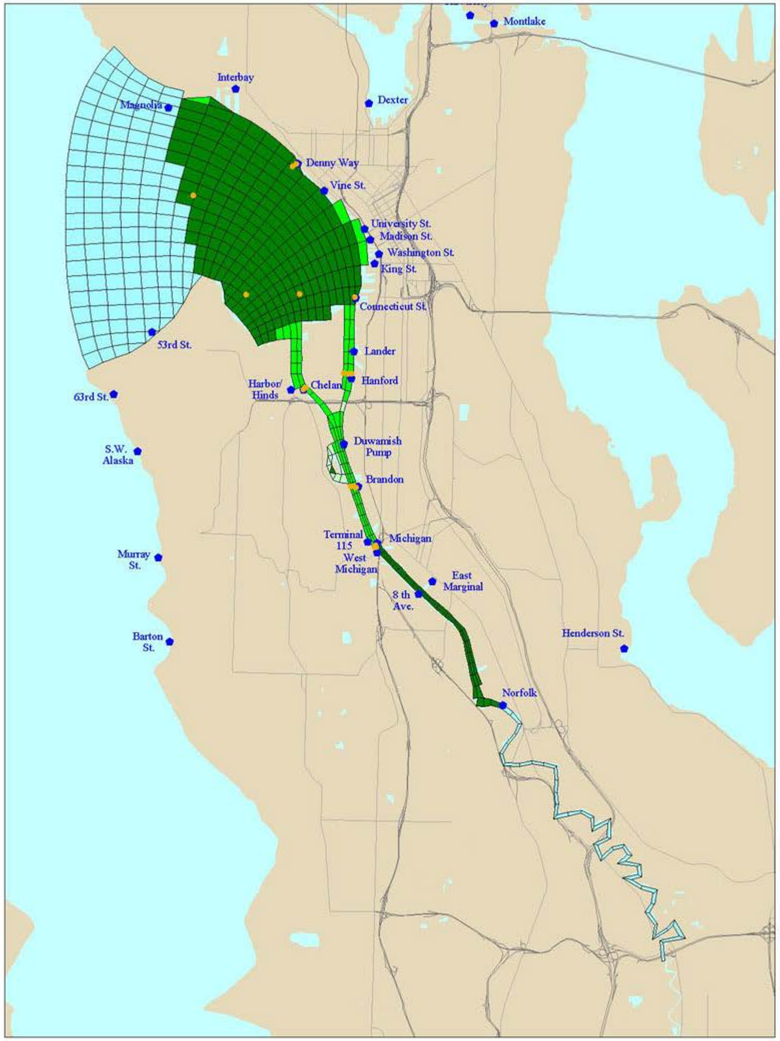


Figure 4-4. Chronic Risks from Water Column Copper Concentrations to Aquatic Life

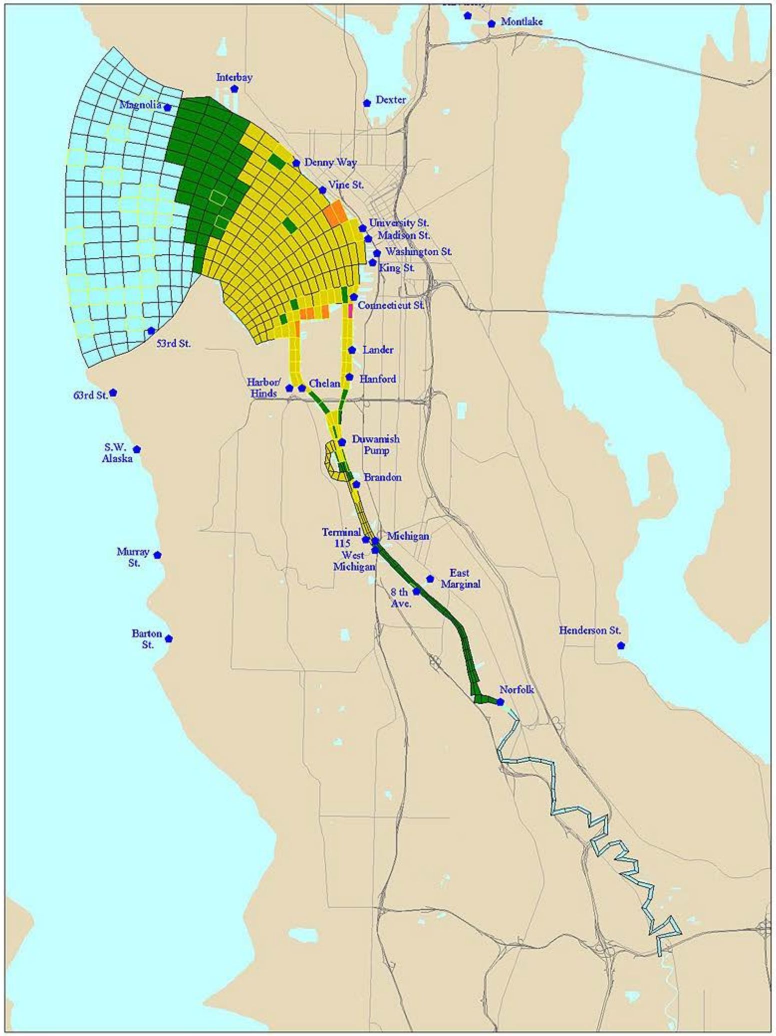


Figure 4-9. Chronic Risks from Sediment PAH Concentrations to Aquatic Life

# Summary Points

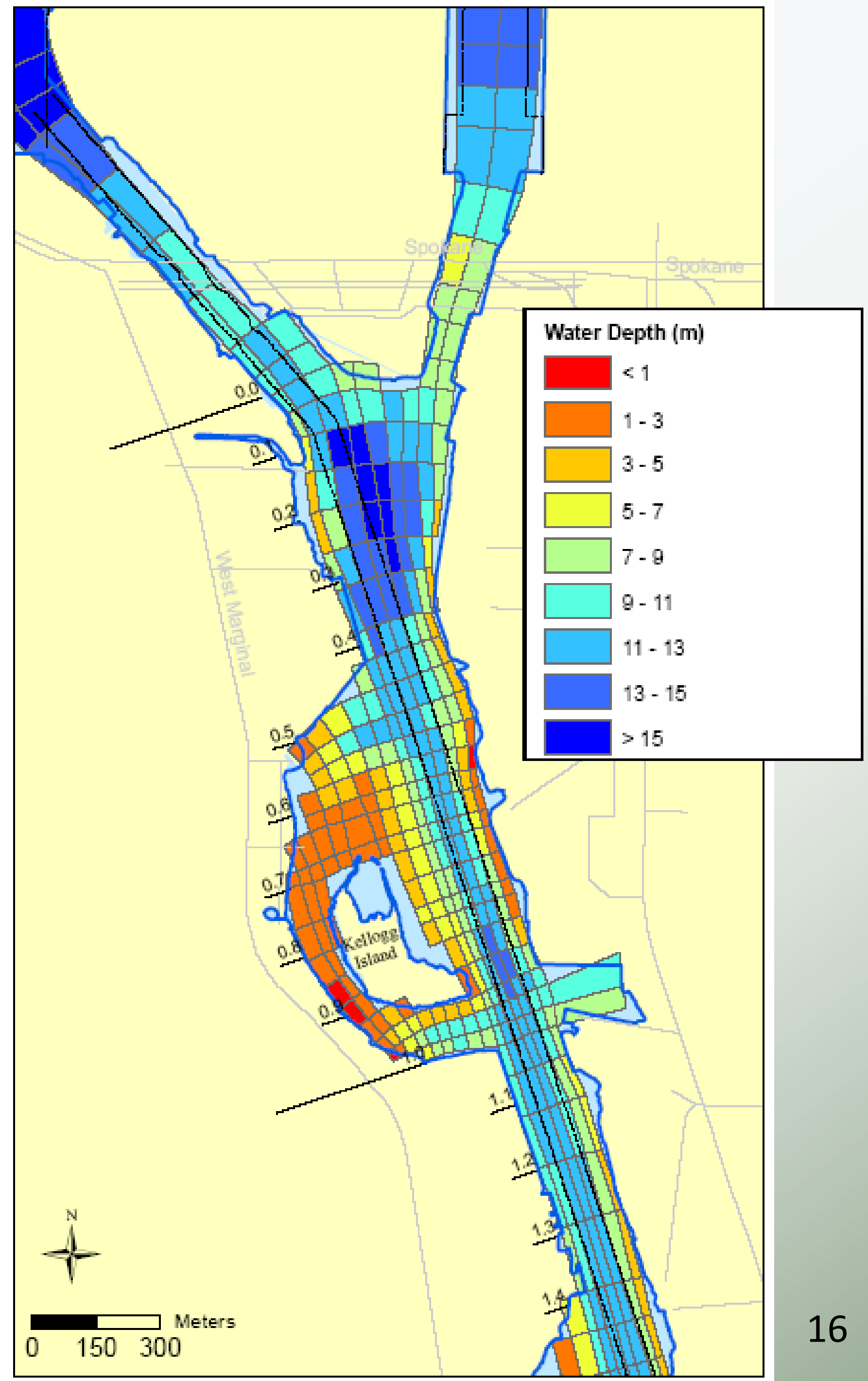
- The EFDC model used by King County incorporates Duwamish, East/West Waterways, and Elliott Bay areas
  - Focuses on chemical fate and transport in the water column (not sediment disturbance)
  - Can track sources of sediment deposited
- Model could be used to estimate future water quality and sediment quality concentrations in Elliott Bay
- Not all sediment erosion processes are incorporated into the model

# LDW Modeling Efforts and Conceptual Site Model

Part 2

# EFDC Water Quality Model Adapted for Duwamish

- Modifications made by EPA and QEA
  - Sediment scour/deposition added
  - 7 cells wide (from 3 cells)
  - 10 vertical layers
  - 1000 cells total (from 512)
  - Allocated lateral loads
- 21-year calibration period, which included a major storm event
- Consensus reached for model calibration and peer-reviewed by modeling work group

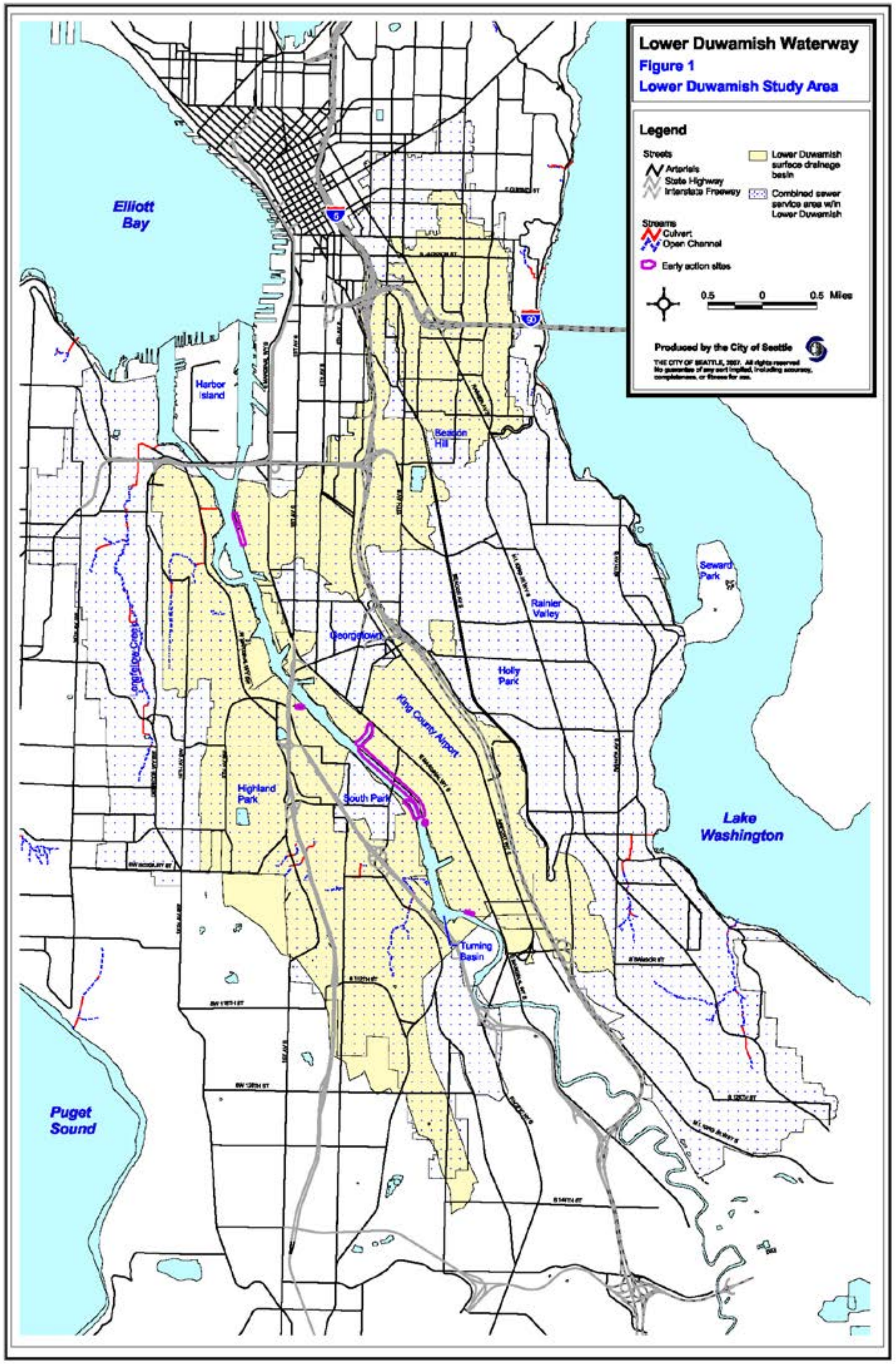


# LDW Study Area

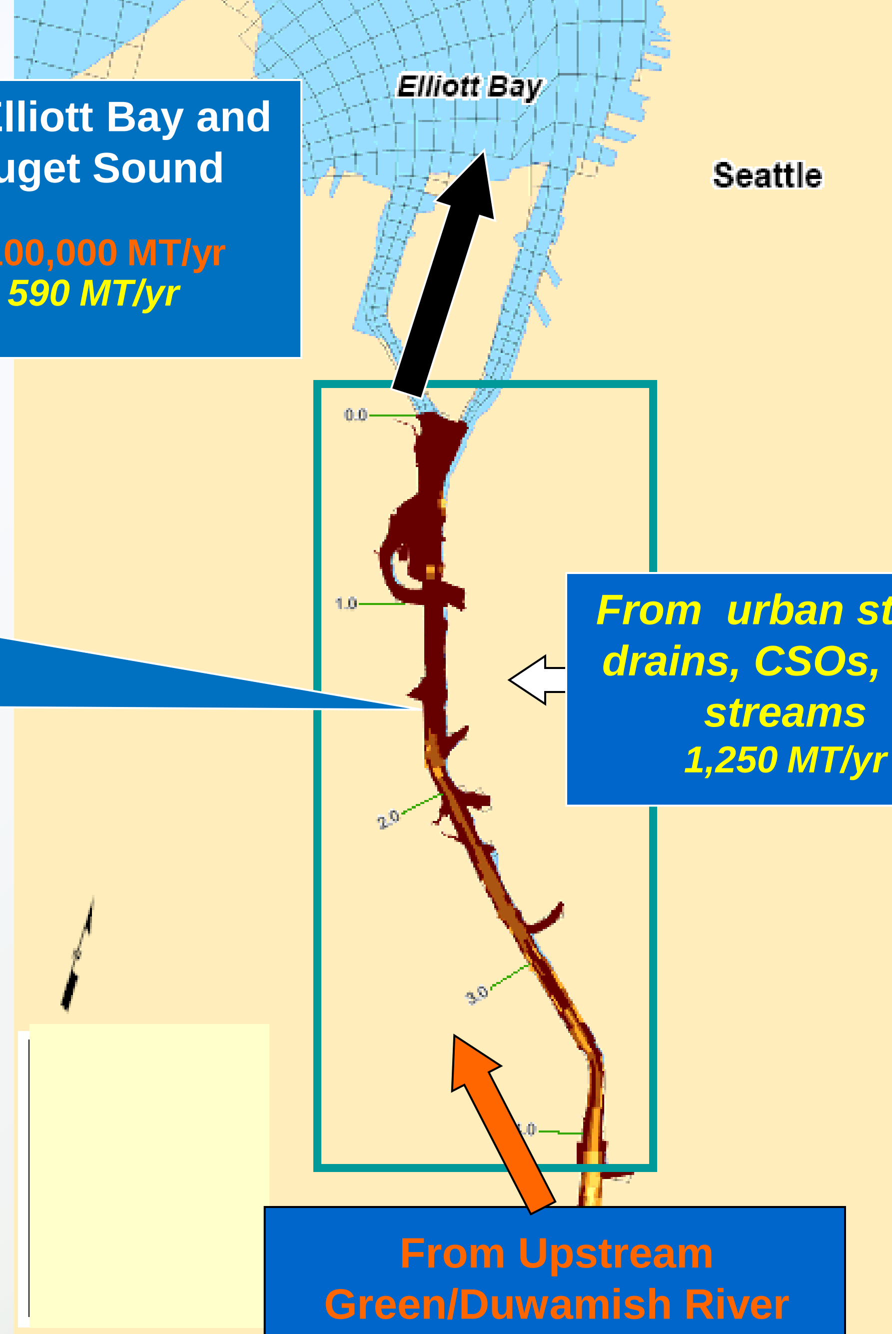
Combined sewer service area:
20,000 Ac

Storm drain basin:
9,350 Ac

Outfalls:
9 CSOs
5 EOFs
44 Municipal SDs
149 Other outfalls



# Simplified Sediment Transport and Deposition in the LDW




**To Elliott Bay and Puget Sound**

**~100,000 MT/yr**
***590 MT/yr***

**~100,000 MT/yr**
***660 MT/yr***

**Net deposition in the LDW**
is about 100,000 metric tons of sediment from upstream per year

***From urban storm drains, CSOs, and streams***
***1,250 MT/yr***

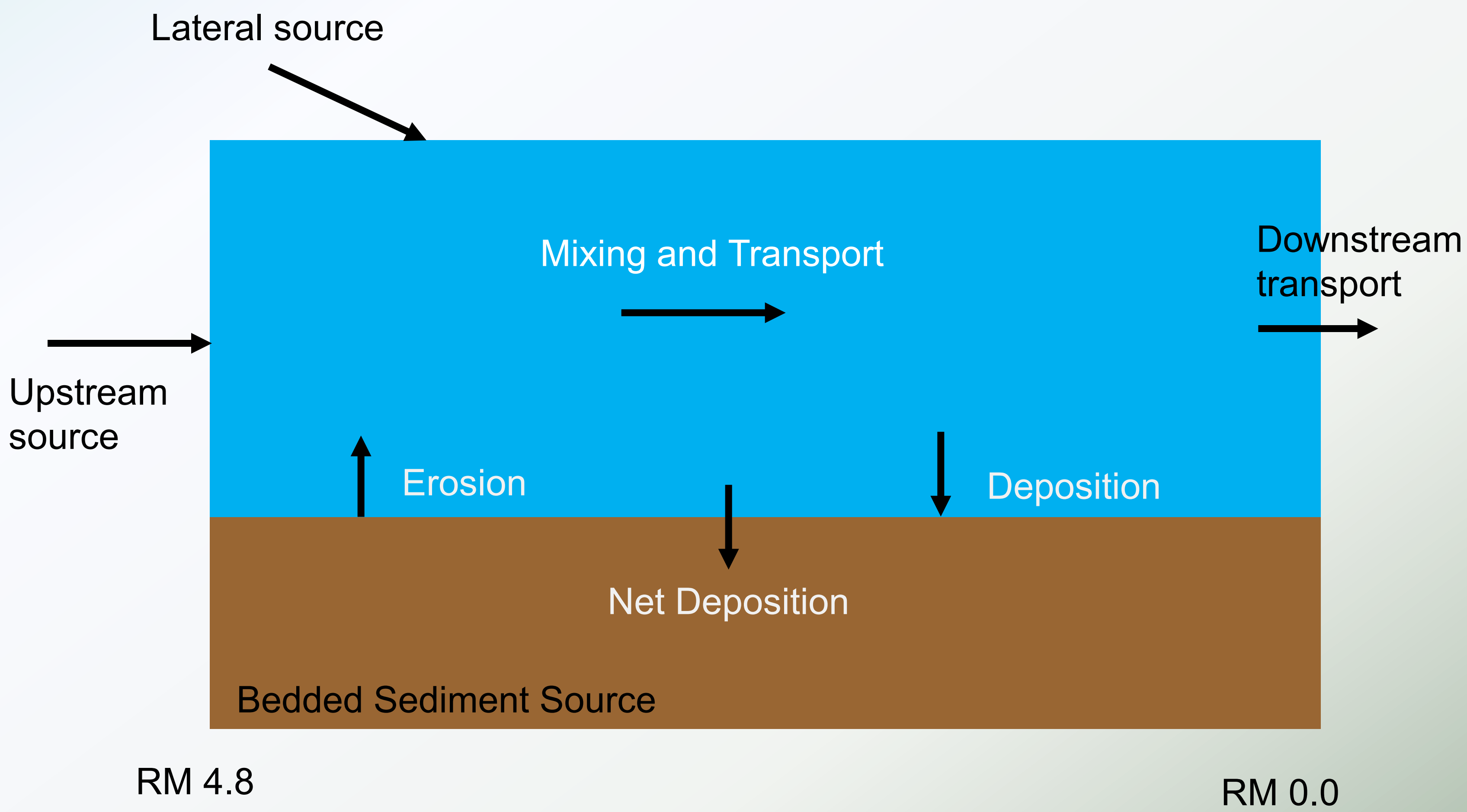
**From Upstream Green/Duwamish River**
**~200,000 MT/yr**

**CSOs = combined sewer overflows**

**Unit in metric tons/yr, averaged over 10-yr period**

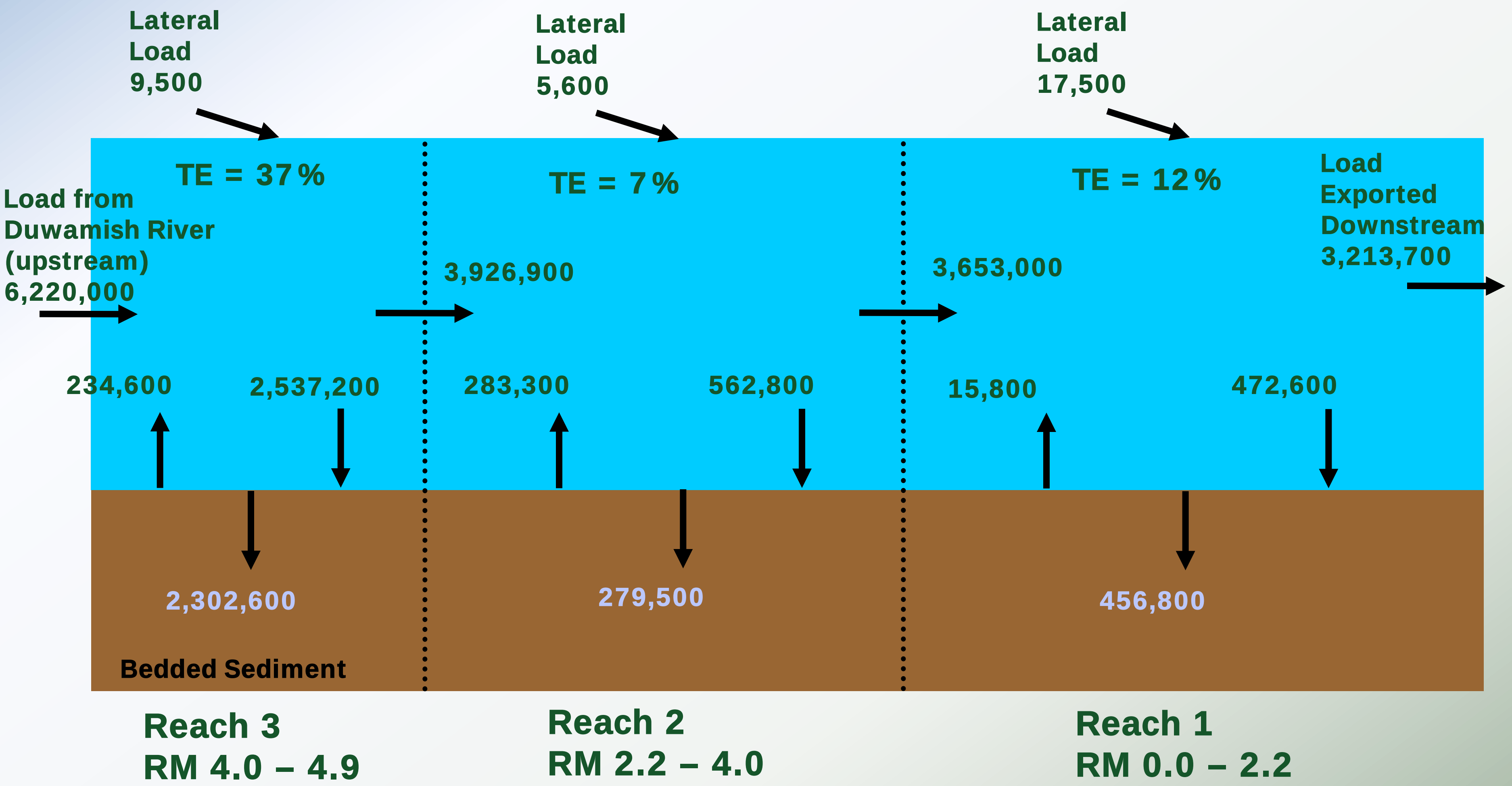
# Erosion/Transport Processes Modeled

## Creates solids mass balance for entire LDW



# Duwamish Waterway Divided into Three Reaches

Over 99.5% of downstream sediment loads originate upstream of the LDW




- Units are in metric tons. Loads presented are totals over a 30-year period.
- TE= trapping efficiency.

# BCM Model Input Concentrations include high and low sensitivity runs

| Chemical | Upstream Inputs | | | Lateral Inputs | | |
|---|---|---|---|---|---|---|
| | Best Estimate | Sensitivity Range | | Best Estimate | Sensitivity Range | |
| | | Low | High | | Low | High |
| PCBs µg/kg dw | 35 | 5 | 80 | 300 | 100 | 1000 |
| cPAHs µg TEQ/kg dw | 70 | 40 | 270 | 1400 | 500 | 3400 |
| Arsenic mg/kg dw | 9 | 7 | 10 | 12 | 9 | 30 |
| Dioxins/Furans µg TEQ/kg dw | 4 | 2 | 8 | 20 | 10 | 40 |

- High = current source control efforts
- Low = 30-40 years with significant increase in resources; goals may not be achievable everywhere

# BCM Output may have up to 27 Combinations for each time period modeled

| Lateral Inflow | Upstream Inflow | Bed Sediments |
|---|---|---|
| low | low | low |
| | | medium |
| | | high |
| | medium | low |
| | | medium |
| | | high |
| | high | low |
| | | medium |
| | | high |
| medium | low | low |
| | | medium |
| | | high |
| | medium | low |
| | | medium |
| | | high |
| | high | low |
| | | medium |
| | | high |
| high | low | low |
| | | medium |
| | | high |
| | medium | low |
| | | medium |
| | | high |
| | high | low |
| | | medium |
| | | high |

27 outcomes
per time period, per chemical

# Summary Points

- Conceptual Site Model includes three reaches

- The Duwamish sediment transport model and recovery (BCM) model incorporates several years of data and processes:
  - 200,000 metric tons solids enter LDW each year and ~ 50% settles in LDW
  - Localized areas may have recontamination near outfalls
  - Incorporated several recontamination processes
  - Chemistry dials for upstream and lateral inputs can be "turned"

- Model Tool can be used to estimate:
  - Effectiveness of future source control efforts
  - Future sediment concentrations in the Duwamish
  - Sediment quality being exported

# Sources of Chemical Data used in FS Models (Lateral and Upstream)

Part 3

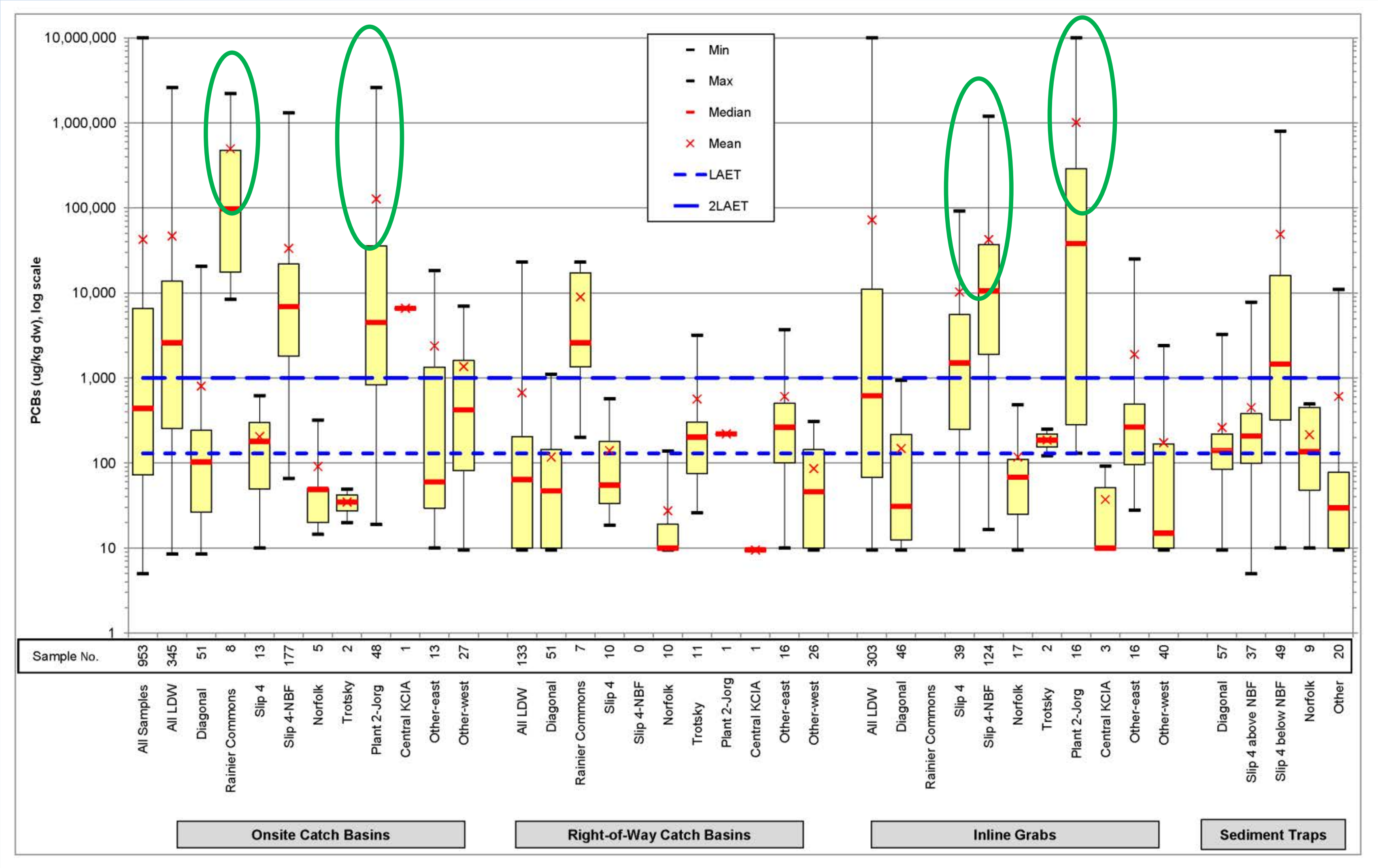
# Types of Field Data for Consideration as Model Inputs

| Data Type | Parameter Sampled | Existing LDW Study, Locations Date / Sampling Frequency |
|---|---|---|
| Sediment Grab and Core Trends* | Chemistry, Pb210, Cs-137 | > 50 cores |
| Bathymetry | Bed elevation changes | USACE various surveys; 2003 LDWG (incorporated into STM) |
| Sediment Traps | Settling particulate matter (amount and COC concentrations) | Harbor Island Suppl. RI, 5 locations, 1995, three months |
| Whole Water Green River* Samples | TSS, salinity, temp, TOC, DOC PCBs | KC Water Quality Assessment, 21 locations, Oct 1996 – June 1997, weekly, 4 storm events |
| | TSS, TSS 0.45um, TDS, TOC, DOC, salinity, temp, PCB congeners | KC Congener Survey, 4 locations, Aug 05 – July 06, monthly |
| CSO Samples* | TSS, TOC, PCBs (whole water TSS – normalized) | KC, Mar 96 – May 97, number of sampling events varied among locations, 20 samples |
| Storm Drain Samples* | Flow-weighted solids samples from on-site catch basins, in-line sediment grabs, right-of-way catch basins, and in-line sediment traps | City of Seattle and King County on-going study, data compiled from 2004-2009, 755 samples, several locations |

# Lateral Data: compiled from several storm drain and CSO sampling events, and used for Model Input (see handout)

| Study/Source | Total PCBs (µg/kg dw) | | | | Arsenic (mg/kg dw) | | | | cPAHs (µg TEQ/kg dw), | | | | Dioxins/Furans (ng TEQ/kg dw) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Lateral Inflow* | Data Screened? | N | Avg | 90th %ile | Data Screened? | N | Avg | 90th %ile | Data Screened? | N | Avg | 90th %ile | Data Screened? | N | Avg | 90th %ile |
| City of Seattle Storm Drain Data | Minus samples >2,000 | *625* | 223 | 534 | Minus samples >57 | *553* | 12 | 29 | -- | -- | -- | -- | -- | -- | -- | -- |
| | Minus samples >5,000 | *692* | 315 | 718 | Minus samples >93 | *563* | 13 | 30 | -- | -- | -- | -- | -- | -- | -- | -- |
| | Minus samples >10,000 | *755* | 638 | 1,009 | -- | -- | -- | -- | Minus samples >25,000 | 533 | 1,370 | 3,366 | -- | -- | -- | -- |
| King County CSO Water Quality Data | TSS-normalized | *28* | 580 | 920 | TSS-normalized | *21* | 9 | 13 | TSS-normalized | 26 | 1,051 | 2,728 | -- | -- | -- | -- |
| Greater Seattle Sediment and SPU Catch Basin Solids | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 187 outlier excluded | *23* | 22 | 48 |
| Best-estimate Value Used in BCM Model (low-high range); FS Table 5-1b | 300 (100 to 1,000) | | | | 13 (9 to 30) | | | | 1,400 (500 to 3,400) | | | | 20 (10 to 40) | | | |

# Lateral sources have wide range of PCB concentrations

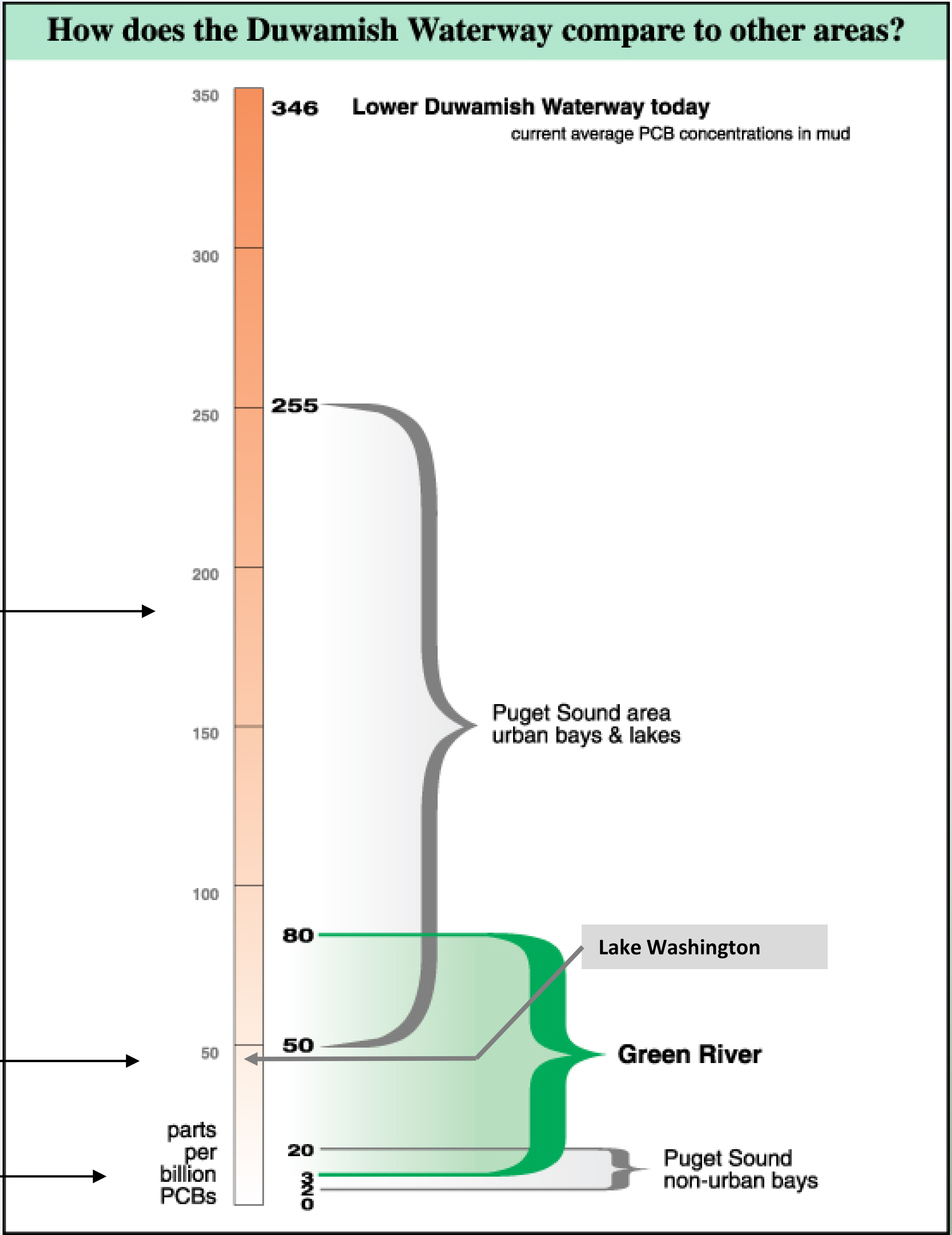



**4 Major sources of PCBs identified:** 1 has final cleanup pending under CERCLA, 2 have state/RCRA cleanups underway, 1 TSCA cleanup underway

# Upstream Data: compiled from four Lines of Evidence used for Model Input (see handout)

| Study/Source | | | Total PCBs (µg/kg dw) | | | | Arsenic (mg/kg dw) | | | | cPAHs (µg TEQ/kg dw), | | | | Dioxins/Furans (ng TEQ/kg dw) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Green/Duwamish River Inflow from Upstream* | | | Data Screened? | N | Avg | 90th percentile | Data Screened? | N | Avg | 90th percentile | Data Screened? | N | Avg | 90th percentile | Data Screened? | N | Avg | 90th percentile |
| Green River Water Quality | King County Whole-Water | | TSS-normalized | *22* | 50 | 107 | TSS-normalized | *100* | 37 | 73 | TSS-normalized | 18 | 151 | 354 | -- | -- | -- | -- |
| | Ecology Centrifuged Solids | | No | *7* | 14 | 54 | No | *7* | 17 | 24 | No | 7 | 138 | 400 | No | 6 | 6 | |
| | King County and Ecology Data Combined | | No | *29* | 42 | 120 | No | -- | -- | -- | No | 25 | 135 | 330 | -- | -- | -- | -- |
| Upstream Surface Sediment (Above RM 5.0) | LDW RI Data | | No | *37* | 23 | 40 | No | *24* | 7 | 11 | No | 16 | 55 | 135 | No | 4 | 1.7 (median) | 13 |
| | Ecology | Fines >30% | Yes | *30* | 5 | 13 | Yes | *31* | 9 | 11 | 230 outlier not excluded | 31 | 37 | 77 | Yes | 31 | 2 | 3 |
| | | Fines >50% | Yes | -- | -- | -- | Yes | -- | --- | -- | | 18 | 50 | 91 | Yes | 18 | 2 | 3 |
| | | All | Yes | *73* | 3 | 6 | Yes | *74* | 7 | 10 | | 74 | 18 | 57 | Yes | 74 | 1 | 3 |
| | LDW RI and Ecology Data Combined | | 770 (outlier excluded) | *110* | 8 | 23 | No | *98* | 7 | 10 | No | 90 | 25 | 73 | No | -- | -- | -- |
| USACE Upper Turning Basin Cores | RM. 4.5 – 4.75 (1991-2009) | | No | *10* | 23 | 38 | No | *8* | 5 | 7 | 1052 outlier excluded | 9 | 37 | 63 | -- | -- | -- | -- |
| | RM. 4.3 – 4.75 (1991-2009) | | No | *20* | 36 | 56 | No | *18* | 7 | 12 | 1052 outlier excluded | 19 | 73 | 180 | No | 2 | 2 and 2.8 | |
| Best-estimate Value Used in BCM Model (low-high range) | | | 35 (5 to 80) | | | | 9 (7 to 10) | | | | 70 (40 to 270) | | | | 6 (2 to 10) | | | |

# Comparison




**Sediment Goals**

Early actions predicted to get waterway to this level

All alternatives in Feasibility Study predicted to get waterway to this level over time

(BCM output low/high range ~10 to 100)

EPA's proposed goal is 2 ppb total PCBs

# Summary Points

- Lateral data compiled by City of Seattle includes ~800 samples over a several year period for suite of chemicals
  - Data screening already incorporate best estimate expectations regarding effectiveness of future source control efforts
  - High = what is currently being done; Mid= expectations for source control in next 10 to 15 years, Low = 30 to 40 year estimate but significant investments would need to be made, along with new technology developments, and they may not be achievable everywhere
- Upstream datasets each have some bias, best used collectively
- BCM input values and model predictions are similar to other urban areas of Puget Sound and observed nationally

# Toxic Chemicals Transported by the Green River, WA:

## Suspended Sediment, Bed Sediment, and Whole Water Analysis


Kathy Conn, Hydrologist
Bob Black, Supervisory Hydrologist
USGS Washington Water Science Center
Tacoma, WA



**Elliott Bay Regional Background Workshop**
**EPA Headquarters, Seattle, WA**
**September 3, 2013**

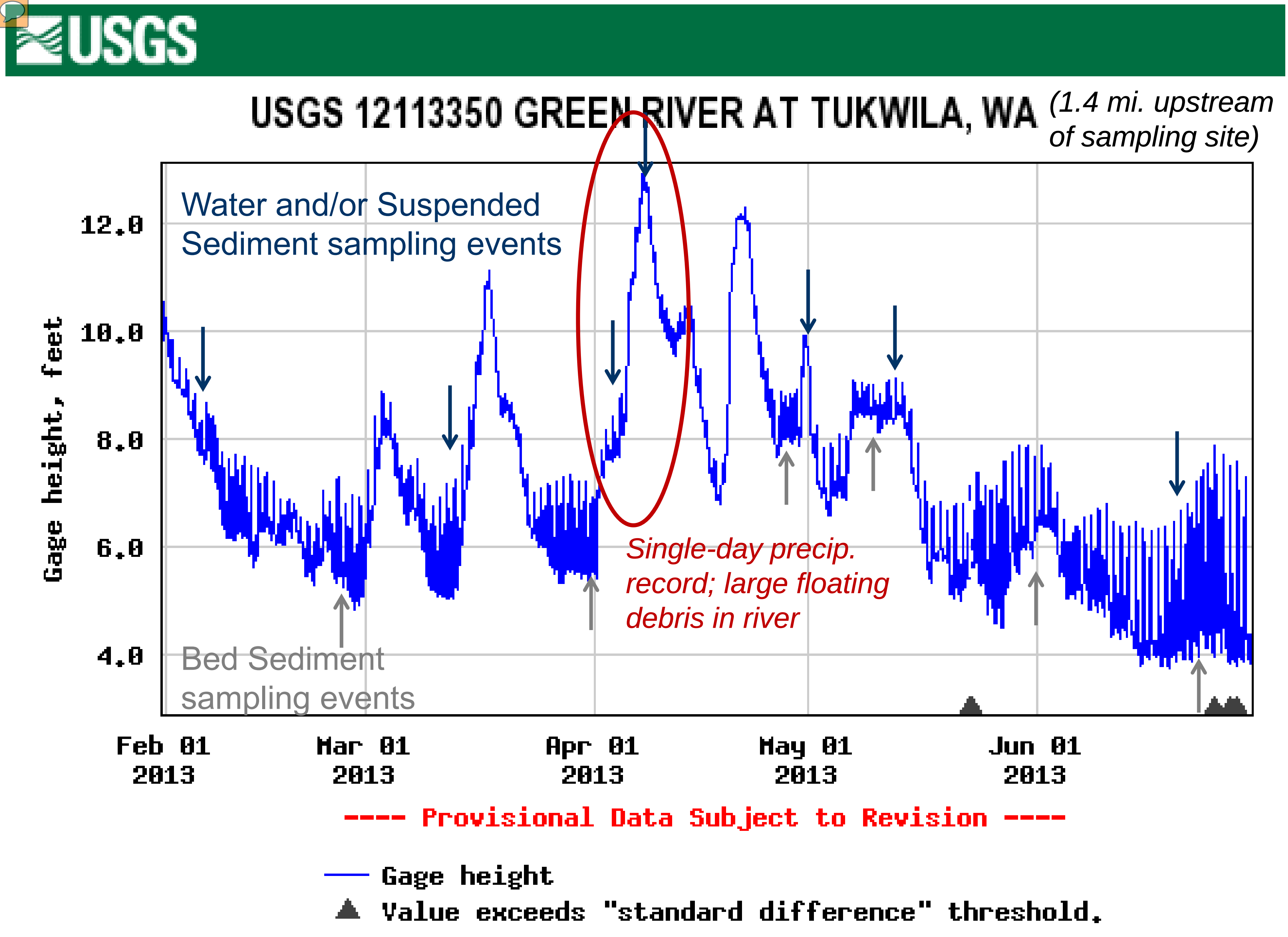
# USGS Study

*Duwamish River, Tukwila, WA (RM 10.8)*

Objective – Quantify concentrations and instantaneous loadings of toxic chemicals from the Green River, WA

Monitoring Approach (see QAPP) –

- Collect representative samples of whole water, suspended sediment, and bed sediment
- Concurrently measure discharge and suspended sediment concentration (SSC)
- Sample during a range of flow and turbidity conditions
- Analyze samples for suite of analytes, including metals, PAHs, PCBs, and Dioxins/Furans



USGS
USGS 12113350 GREEN RIVER AT TUKWILA, WA
(1.4 mi. upstream of sampling site)
Water and/or Suspended Sediment sampling events
Single-day precip. record; large floating debris in river
Bed Sediment sampling events
Gage height, feet
12.0
10.0
8.0
6.0
4.0
Feb 01 2013
Mar 01 2013
Apr 01 2013
May 01 2013
Jun 01 2013
---- Provisional Data Subject to Revision ----
Gage height
Value exceeds "standard difference" threshold.

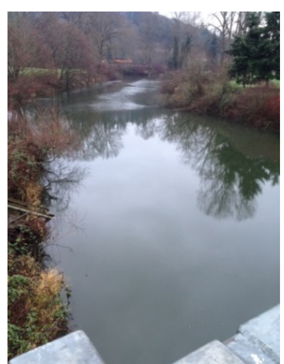
# Detections

- Compounds detected in water, suspended sediment, and bed sediment:
  - Metals
  - PCBs
  - Dioxins/Furans
  - PAHs (suspended sediment and bed sediment only)
- Not Detected / Rarely Detected (water and bed sediment); Insufficient Sample (suspended sediment):
  - Volatile organic compounds (few detections in bed sediment)
  - Semivolatile compounds (few detections in bed sediment)
  - Pesticides
  - Tributyl tin species
  - Hexavalent chromium

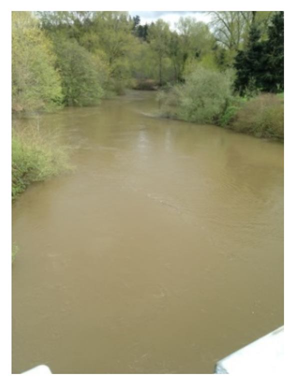
*Preliminary, subject to revision*

# Concentrations

- Water:
  - Number of detected compounds was higher during rising limb and storm peak than low precip. events
    - More metals, D/F congeners, and PCB congeners detected
  - Concentrations up to 3.5X higher during peak (PCBs)
- Suspended Sediment:
  - High number of detected compounds during all events
    - ~85% of metals, PAHs, D/Fs, and PCBs
  - Concentrations up to 2.5X higher during peak (D/F and PCBs)



*Low Precip.*



*Storm peak*

*Preliminary, subject to revision*

# Concentrations

- Suspended sediment and Fine bed sediment (<63 um) higher than Bulk bed sediment (<2 mm)
  - Average concentrations (range shown in parentheses):

| Analyte | Unit | Suspended Sediment | Fine Bed Sediment <63 um | Bulk Bed Sediment <2 mm | Ecy 2008 |
|---|---|---|---|---|---|
| | | # Samples =2-4 | # Samples = 3 | # Samples = 6 | #=70 |
| TOC | % | 4.77 (3.60-6.38) | 2.06 (1.28-2.56) | 1.78 (1.28-2.27) | - |
| Arsenic | mg/kg | 12.8 (10.7-15.7) | 9.40 (7.40-10.6) | 5.57 (4.70-6.50) | 7 |
| Chromium | mg/kg | 123 (75.0-170) | 27.3 (24.0-31.0) | 18.1 (15.9-20.0) | - |
| Copper | mg/kg | 58.3 (32.0-86.0) | 34.7 (32.0-39.0) | 19.9 (18.2-21.9) | - |
| cPAHs (TEQ) | ug/kg | 51.3 (47.6-54.9) | 18.2 (14.8-22.0) | 11.1 (5.9-17.6) | 43 |
| Total PCBs | ug/kg | 3.98 (2.43-5.36) | 6.08 (3.28-8.68) | 2.39 (1.39-3.71) | 3 |
| Total D/Fs (TEQ) | ng/kg | 2.85 (1.29-4.24) | 3.11 (1.86-4.44) | 0.683 (0.514-0.834) | 2 |
| % Fines | % | 61 (44-78) | 98 (97->99) | 21 (15-25) | - |

*Notes:*
*-- Suspended sediment samples collected on different days (high flow) than bed sediment samples (low flow)*
*-- Bed sediment sampling targeted fine material deposits*

*Preliminary, subject to revision*

# Chemical Loads - Water

- Instantaneous whole water chemical loads (g/hr)

$$Chemical\ Load\ \left(\frac{g}{hr}\right) = C_S\ \left(\frac{g}{L}\right) \times Q\ \left(\frac{L}{hr}\right)$$

$C_s$ = Chemical concentration in whole water (g/L)
Q = Instantaneous river discharge (L/hr)

| Analyte | Low Precip. Events | Rising limb | Storm peak |
|---|---|---|---|
| | Precip ≤1 cm | Precip = 2.3 cm | Precip = 5.1 cm |
| | # Samples = 5 | # Samples = 1 | # Samples = 1 |
| TOC | 309,000 | 0 | 1,404,000 |
| Arsenic | 120 | 178 | 606 |
| Chromium | 0 | 0 | 758 |
| Copper | 291 | 355 | 1,515 |
| Total D/Fs (TEQ) | 1.75E-04 | 2.04E-04 | 4.30E-04 |
| Total PCBs | 0.016 | 0.063 | 0.126 |

*Notes:*
*-- Non-detects assigned "0" value*
*-- Values for Low Flow Events represent average of 5 events*

# Chemical Loads – Suspended Sediment

*Preliminary, subject to revision*

- Instantaneous suspended sediment chemical loads (g/hr)

$$\text{Chemical Load}\left(\frac{g}{hr}\right) = C_S\left(\frac{g}{kg}\times\frac{kg}{10^6\,mg}\right)\times SSC\left(\frac{mg}{L}\right)\times Q\left(\frac{L}{hr}\right)$$

$C_s$ = Chemical concentration on suspended sediment (g/kg)
SSC = Suspended sediment concentration (mg/L)
Q = Instantaneous river discharge (L/hr)

| Analyte | Low Precip. Events | Rising limb | Storm peak |
|---|---|---|---|
| | Precip ≤1 cm | Precip = 2.3 cm | Precip = 5.1 cm |
| | # Samples = 1 | # Samples = 1 | # Samples = 1 |
| TOC | 554,000 | 155,000 | 1,768,000 |
| Arsenic | 104 | 46 | 642 |
| Chromium | 0 | 324 | 6,955 |
| Copper | 747 | 138 | 2,332 |
| cPAHs (TEQ) | - | 0.240 | 1.95 |
| Total D/Fs (TEQ) | 3.46E-06 | 1.33E-05 | 1.74E-04 |
| Total PCBs | 0.0049 | 0.018 | 0.219 |

*Notes: Non-detects assigned "0" value*

*Preliminary, subject to revision*

# Preliminary Conclusions

- Metals, PCBs, and D/Fs (not PAHs) detected in water
  - More compounds detected during storm
  - Storm concentrations up to 3.5X higher (PCBs) than Low Precip.
- Metals, PAHs, PCBs, and D/Fs always detected on suspended sediment and bed sediment
  - Concentrations: Suspended sediment and Fine bed sediment (<63 um) higher than Bulk bed sediment (<2 mm)
- Instantaneous Loadings
  - Peak storm > Rising limb and Low Precip. Events
- Future Research
  - Capture fall/early winter storms, multi-year sampling ideal
  - Relate discrete samples to continuous records (discharge, turbidity) to estimate annual chemical loading
  - Compare to other Puget Sound rivers (i.e. Puyallup)

# Thank you

**USGS Field Personnel:** Curtis Chabot, James Foreman, Andy Gendaszek, Raegan Huffman, Greg Justin, Cameron Marshall, Fred Reed, Rich Sheibley, Stephen Sissel, Andrew Spanjer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Bellevue, WA 98008-5452


**Project Website:** http://wa.water.usgs.gov/projects/riverloads/summary.htm
**USGS Publications Website**: http://pubs.er.usgs.gov/

# *Elliott Bay and Duwamish River Regional Background Alternatives*

***Teresa Michelsen***
***Avocet Consulting***

***September 2013***

# Goals for the afternoon

Evaluate and discuss regional background alternatives for Elliott Bay and the Duwamish River in terms of:

- Consistency with rule definition of regional background
- Technical implementability (can it be done, if so where, how, other details)
- Practical implementability (staff resources, time, money)
- Are the results stand-alone or would approaches need to be combined (e.g., particulate data + modeling)

# *EB-1 Bedded sediment sampling*

- Ideas for where to sample
- Representativeness and data sufficiency
- Stratification of zones?
- Defining site and depositional zone boundaries
- Outfall modeling?
- Historical cap monitoring – useful?

# EB-2 Other forms of sampling

- Are Green/Duwamish particulate concentrations useful or relevant?
- How could particulate and/or sediment trap sampling be used?
- What other creative types of sampling are possible? What data are already available?
- Can these data be used alone or only as inputs to models?
- What are the resource requirements?

# *EB-3 Modeling*

- What types of modeling have already been done?
- Which models could be useful in Elliott Bay and for what purposes?
- What inputs are needed and are they available?
- What time, staff resources, and funding would be needed to extend models to Elliott Bay?

# *DR-1 Bedded sediment sampling*

- Ideas for where to sample
- Representativeness and data sufficiency
- Green River data – applicable or not?
- Historical dredged material monitoring – useful?

# *DR-2 Other forms of sampling*

- Green River particulate concentrations?
- What other creative types of sampling are possible? What data are already available?
- Can these data be used alone or only as inputs to models?
- What are the resource requirements? How long before we have enough data?

# DR-3 Modeling

- What type of modeling has already been done?
- Are the scenarios used representative of regional background? Can they be modified?
- Which models would be most appropriate?
- What inputs are needed and are they available?
- What time, staff resources, and funding would be needed?