# Lake Washington Area Regional Background

Draft Data Report Workshop
October 20, 2016

Photo source: Wikimapia.org

# Goals For Today

1. Explain the concept of Regional Background.
2. Present the Lake Washington Area study design.
3. Discuss technical issues and your ideas for resolving them.
4. Next steps.



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# Acknowledgments

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Thea Levkovitz
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TerraStat Consulting Group
Lorraine Read

# Goal No. 1:

Explain the concept of Regional Background.

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# What is "Regional Background"?

Concentrations of bioaccumulative chemicals in sediment that vary depending on levels of urbanization.

- Common chemicals found almost everywhere
- Diffuse sources such as stormwater and air
- Can include metals, PCBs & carcinogenic PAHs (for example)
- Concentrate up the food chain

WAC 173-204-505(16)
Report Section 1.1



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# Under the SMS rule, **Regional Background can…**

…establish the Cleanup Screening Level (CSL)

which can then be used to:

- Identify a cleanup site
- Serve as the upper bound for establishing a sediment cleanup level
- Identify areas of a cleanup site requiring active cleanup
- Identify site boundaries
- Identify areas for interim actions



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# Regional Background Helps Establish Cleanup Levels

**Cleanup Screening Level**
*Highest of:*

- **Risk based criteria** *Lowest of:*
  - **Benthic Risk**
  - **Human Health Risk**
  - **Ecological Risk**
  - **ARARs**
- **PQL**
- **Regional Background**

**Sediment Cleanup Level**

**Sediment Cleanup Objective**
*Highest of:*

- **Risk based criteria** *Lowest of:*
  - **Benthic Risk**
  - **Human Health Risk**
  - **Ecological Risk**
  - **ARARs**
- **PQL**
- **Natural Background**



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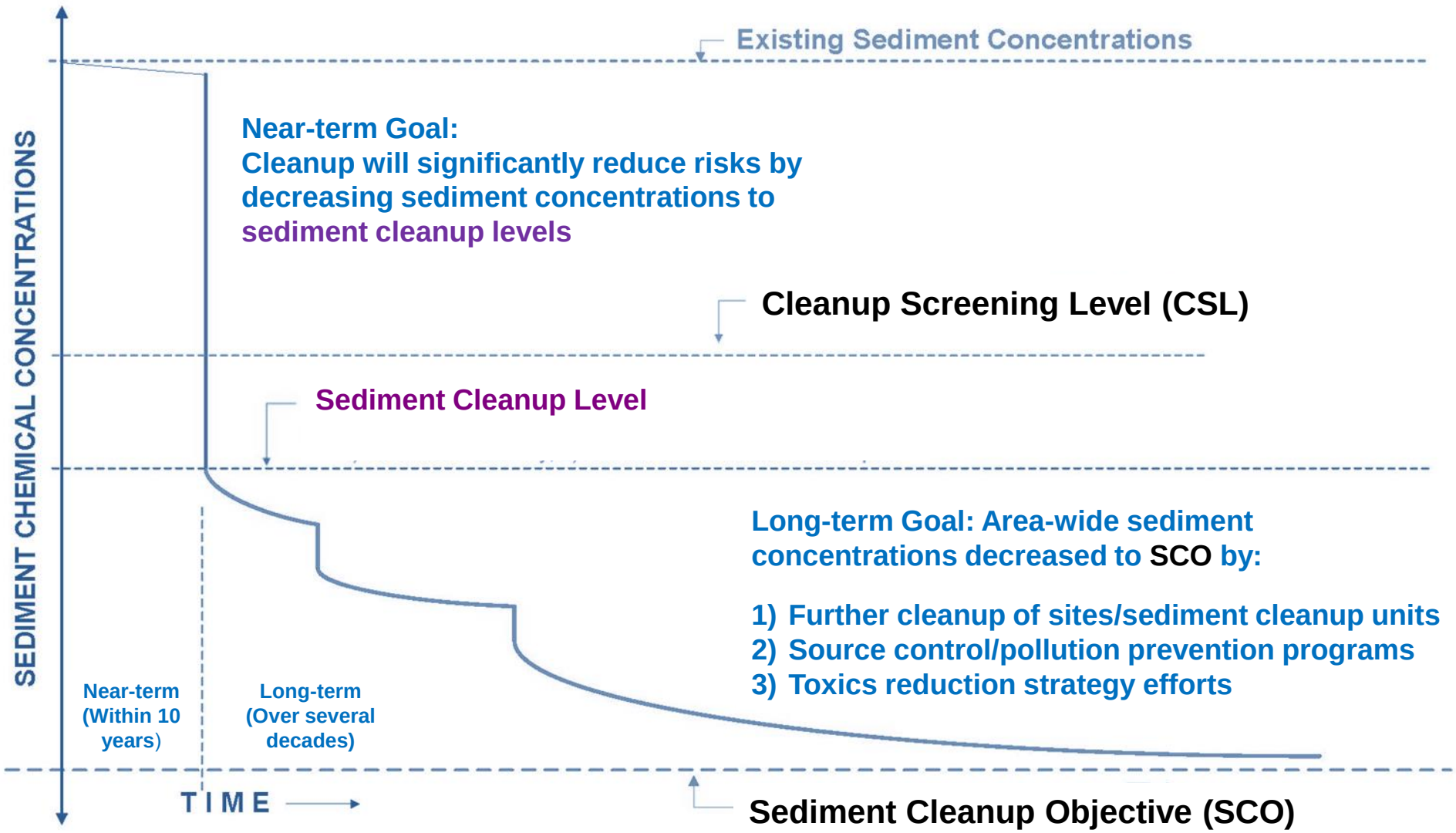
# How Cleanup Fits with Long-Term Environmental Goals



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# Why Establish Regional Background?

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# Why Establish Regional Background?

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# Establishing Regional Background: **A Bit o' History**

- ✓ Established regional background using new data for:
  - Port Gardner
  - Bellingham Bay
  - North Olympic Peninsula
- ✓ Established regional background using new and some existing data for:
  - cPAHs applicable to Port Angeles
- ✓ Working on establishing regional background using existing data from Lake Washington Area.



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# Establishing Regional Background Using Existing Data

Advantages:

- ✓ Quicker
- ✓ Cost effective

Disadvantages:

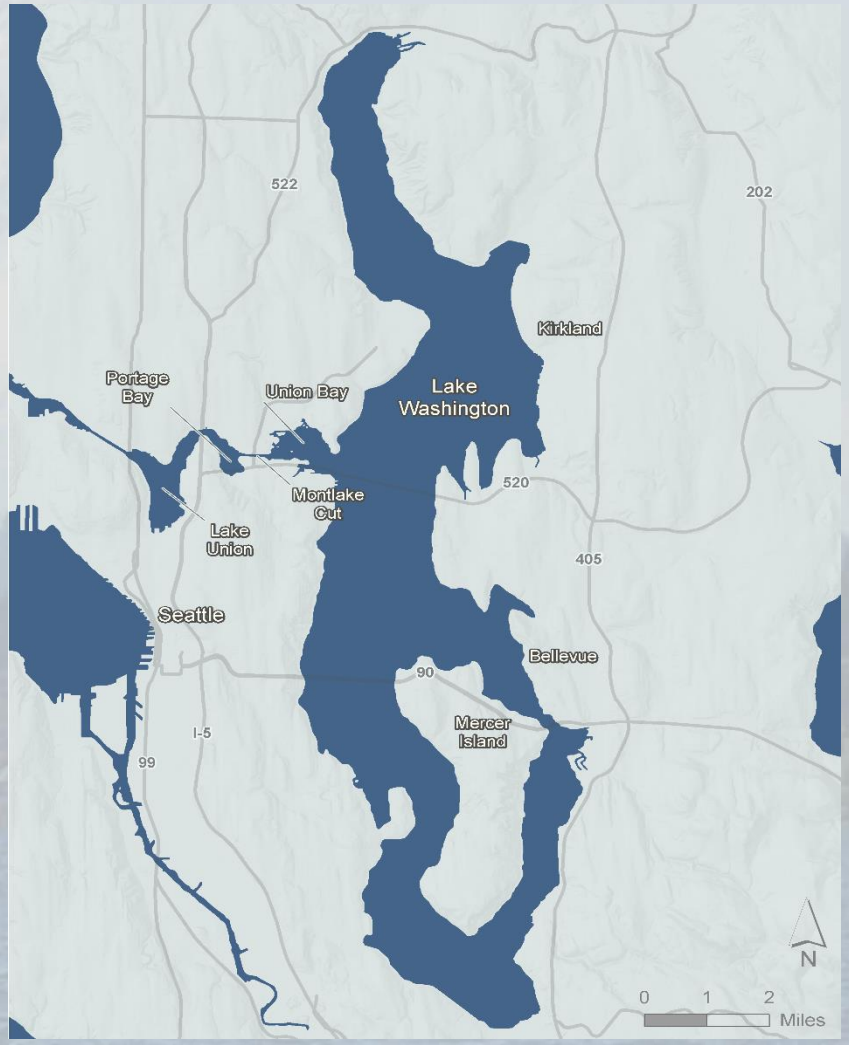
- ✓ Different study designs
- ✓ Useable data
- ✓ Identifying a representative distribution

# Lake Washington Area Surrogate for WRIA 8 Urban Lakes

**SMS allows use of data from a different area than cleanup sites.**

Lake Washington Area (Lake Washington, Union Bay, Montlake Cut, Portage Bay) meets requirements:

- ✓ Same watershed and geologic units
- ✓ Connected to Ship Canal, Lake Union, Salmon Bay
- ✓ Less impacted than proximal urban areas
- ✓ Receives input from diffuse, mixed urban sources




WAC 173-204-560(5)(f)
Report Section 2.0

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# Goal No. 2:

Present the study design.



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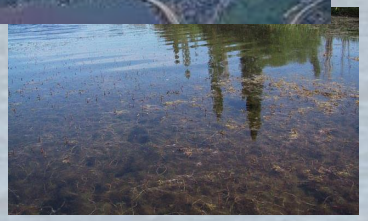
# Study Design

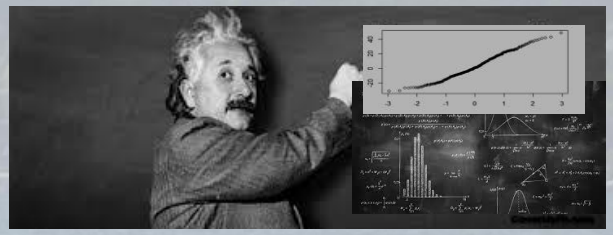
## Maintain Consistency with Past Studies

### Conceptual Model
- Determine area of interest
- Compile data
- Data quality criteria
- Identify areas and characteristics unrepresentative of water body

### Identify Direct Influences
- Current and historical sources
- Cleanup sites
- Elevated values
- Data :
  - o Within cleanup sites
  - o Directly influenced by sources

### Statistical Analyses
- Data Independence
- Outlier analysis
- Representative distribution
- Review elevated values to determine if directly influenced by sources
- Calculate 90/90 UTL





Report Sections 2 & 3



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# Process for Screening Data

**First Screen**

**Data Quality**

- Age
- QA/QC
- Depth
- Replicates

Enough data remaining for Hg, As, cPAHs

**Second Screen**

**Sources**

- Sites w/CoCs
- Sources with direct impacts
- High TOC

**Third Screen**

**Statistics**

- Independence
- Populations
- Outliers

Enough data remaining for cPAHs



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# Conceptual Model: Lake Washington Area

- Area of Interest: Lake Washington, Union Bay, Montlake Cut, Portage Bay.
- Receives input from typical mixed urban sources
- Historical uses: Shipyards, sawmill, coal loading, wood treating
- Connected to Lake Union, Ship Canal, and Salmon Bay before discharging into Puget Sound.
- Water levels controlled by locks: Mean residence time 2.4 years
- Thermally stratified in summer, isothermal conditions in winter

Report Sections 2.0 – 2.3

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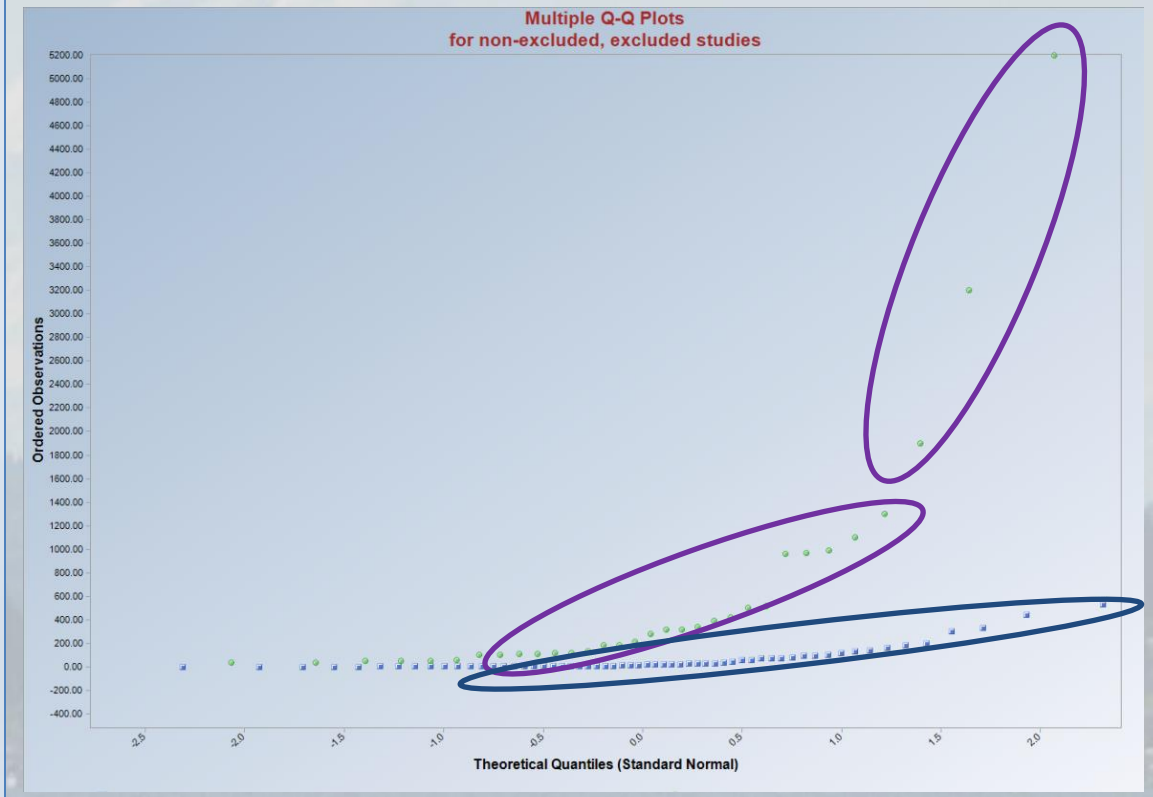
# First Screen: Data Quality – Age of Data

2005 +

- Smoother distribution
- Less high-end outliers.

2005 –

- Elevated values.
- More high-end outliers.




Report Sections 3.0 – 3.1; Figure 9



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# First Screen: Data Quality

## Detection Limits

- Retained samples detected above practical quantitation limit.

## Depth

- Retained samples up to 2 feet deep.

## Replicates

- Retained newest samples

Report Sections 3.0 – 3.1; Figure 4

# Second Screen: Unrepresentative Areas

High Total Organic Carbon

- Wetlands
- Decomposition

Sand Beaches

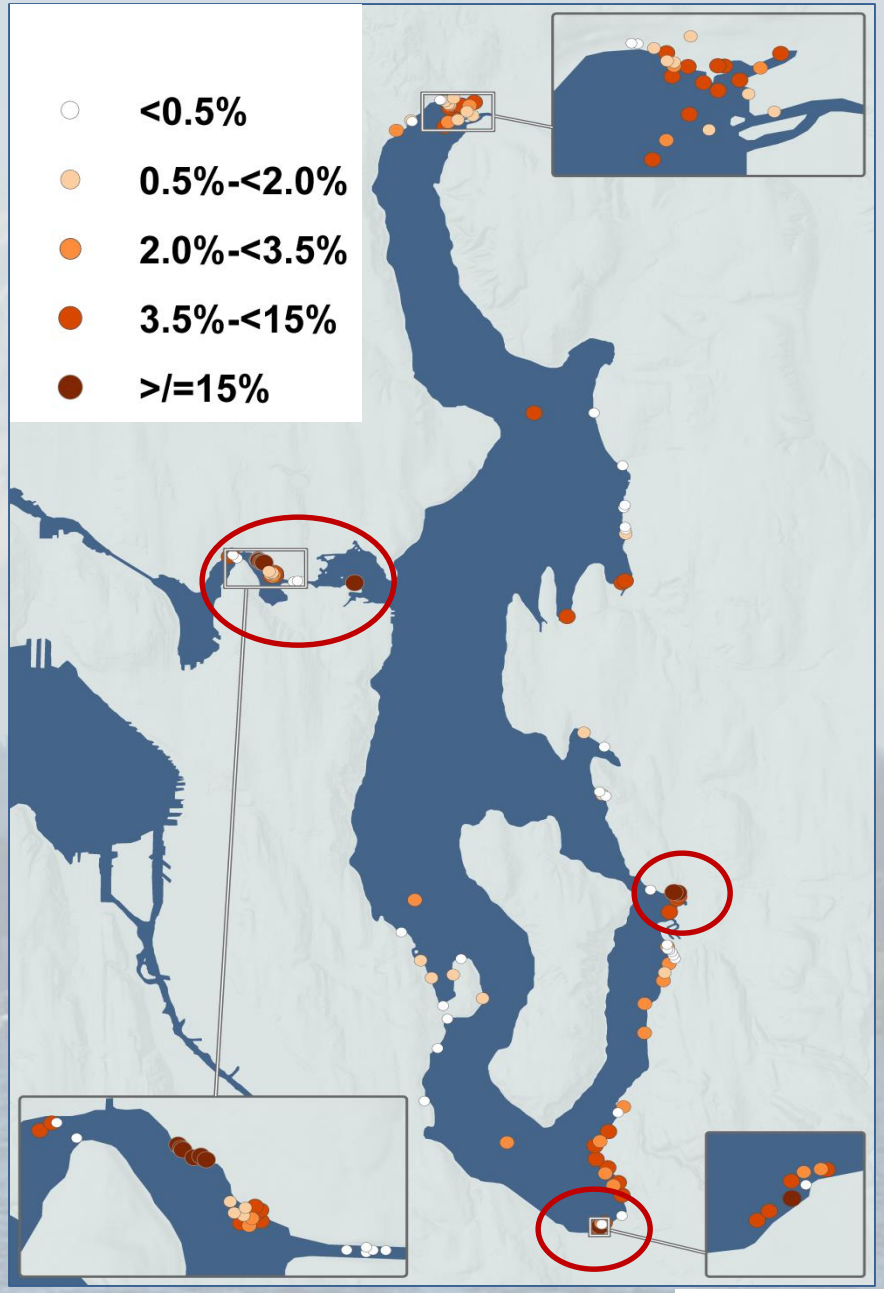
- Imported clean sand
- Concentrations < natural background

Unusual percent fines

Report Sections 3.0 & 3.2; Figures 2 & 3

# Total Organic Carbon

- TOC for cPAHs: 0.05% to 48.4%.
- Nine samples ≥ 15 %.
- 3rd screen TOC: 0.05 to 7.4%.
- Weak correlation between TOC, fines, and chemistry.




Report Sections 3.0 & 3.2; Figures 2 & 4

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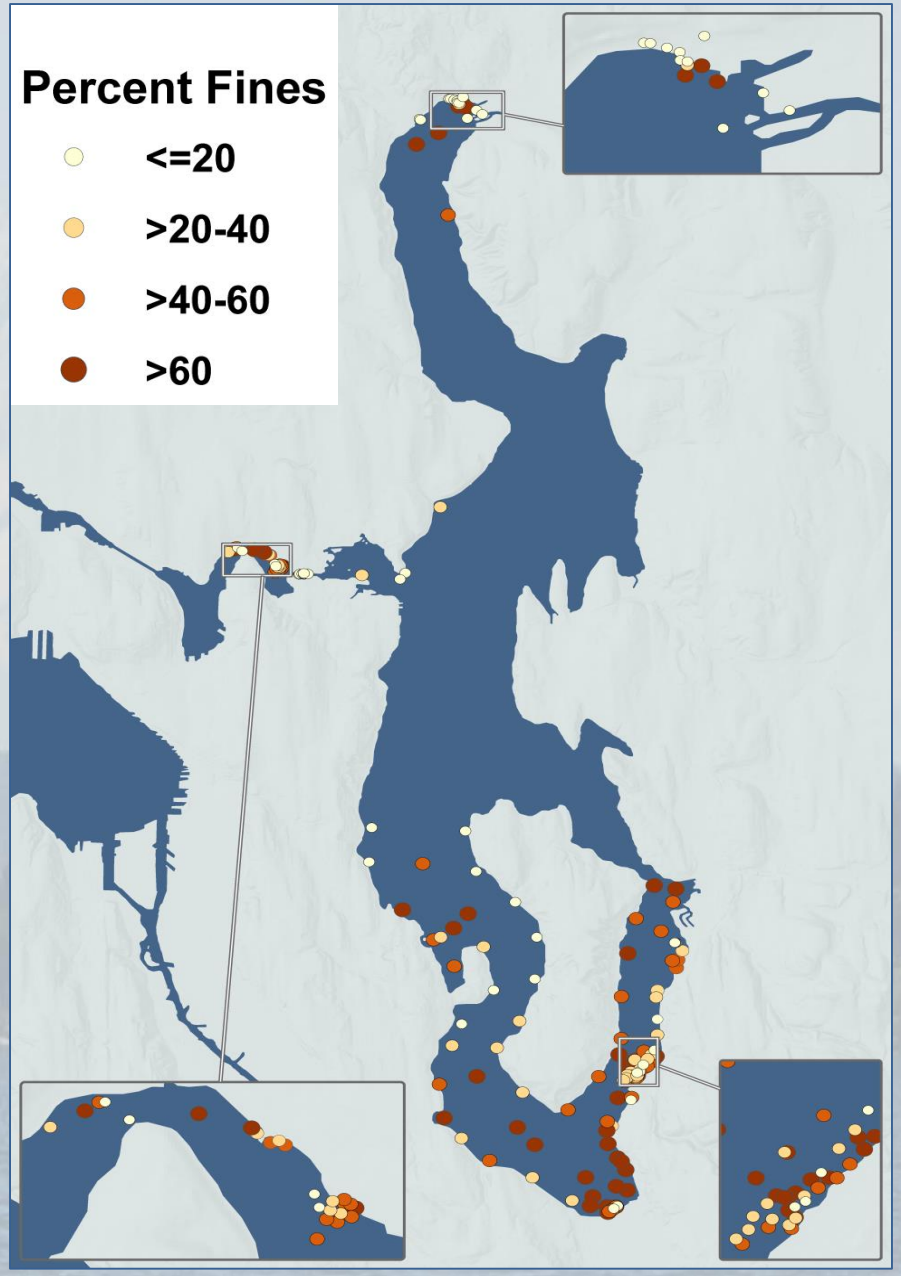
# Percent Fines

- Typically fine silt or mud.
- Coarser nearshore, river mouths.
- Finer in middle of lake.
- cPAHs: 16.1% - 91.7%.
- No samples screened out.
- Weak correlation: TOC, fines, chemistry.




Report Sections 3.0 & 3.2; Figure 3



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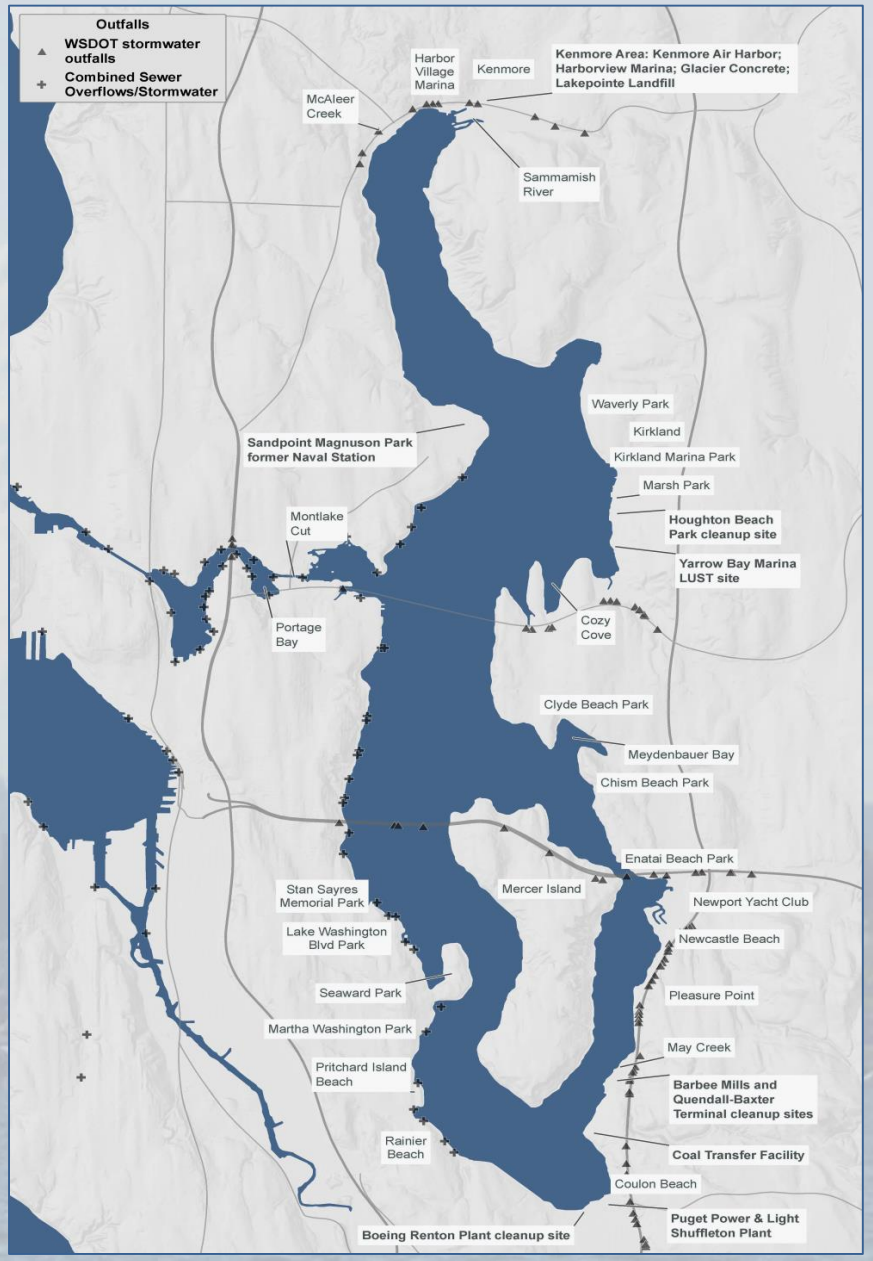
# Second Screen: Sources w/Direct Impacts

- Current and historic sites.
- Combined Sewer Overflows.
- Stormwater outfalls with elevated values and gradient from sources.
- Highway and bridge runoff.
- Current and historical industrial activities.






Report Sections 3.0 & 3.2; Figures 5 - 7

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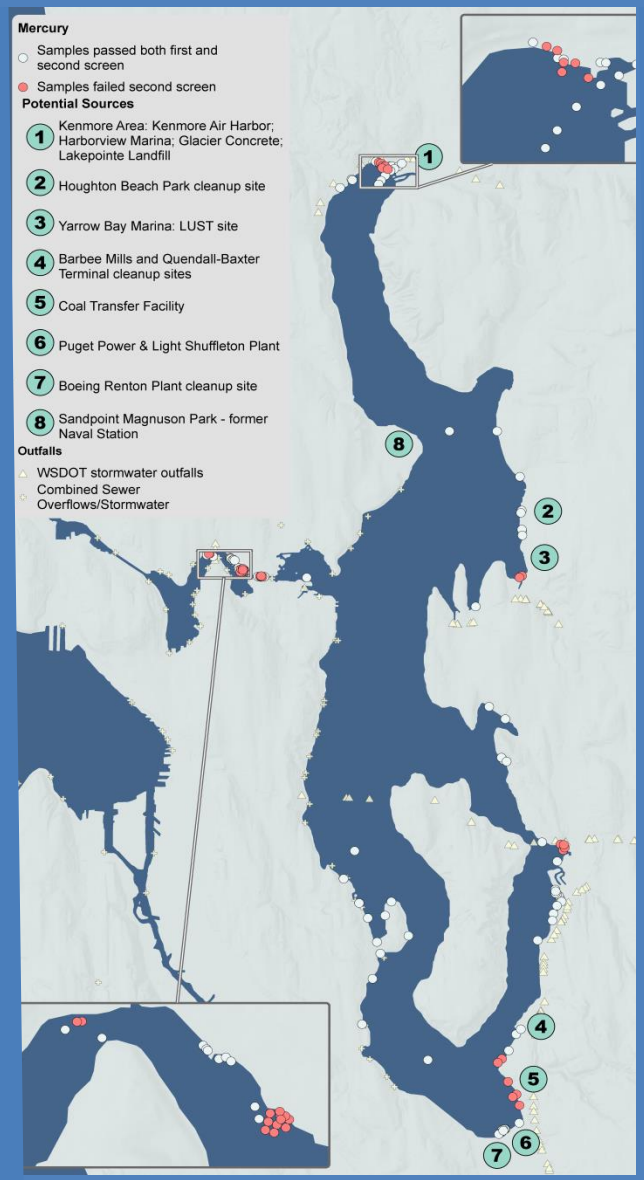
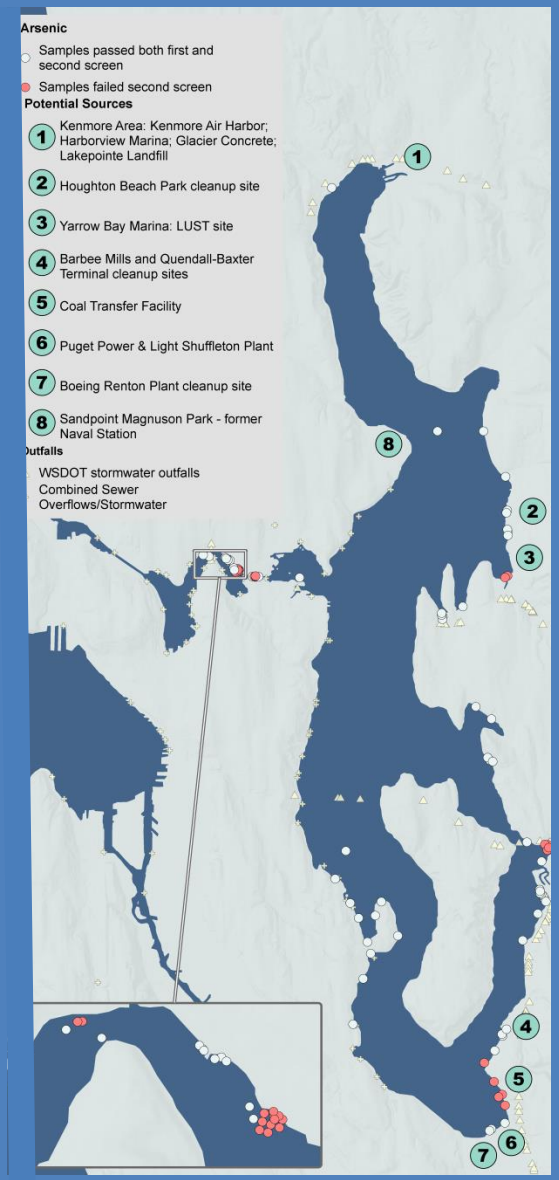
# Second Screen: Remaining Samples for Statistical Analysis






Report Figures 5 - 7

# Third Screen: Statistical and Policy Decisions

- Outlier analysis
- Sample independence
- Population separation
- Identify final population
- Re-examine elevated values verified for source influence
- 90/90 UTL

Report Section 3.3; Appendix B; Figure 8



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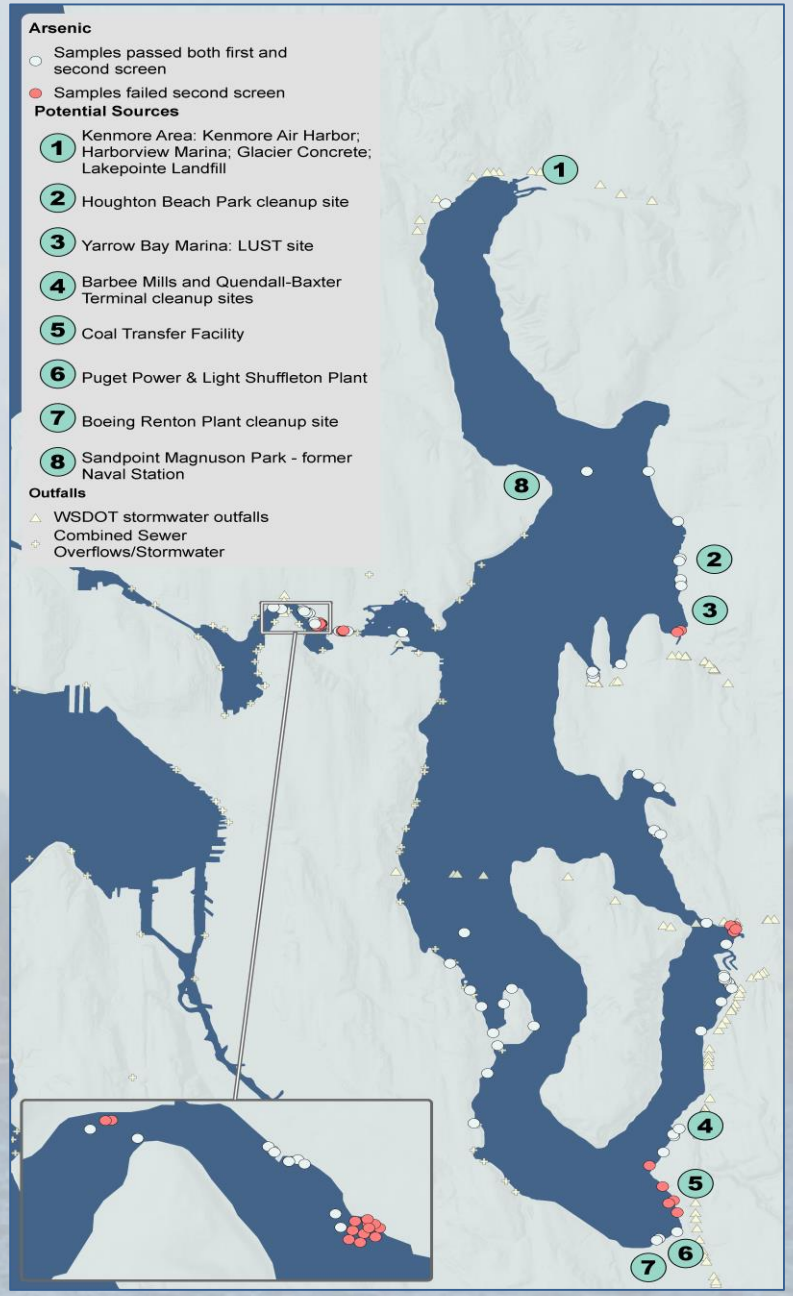
# Chemistry Data Summary Arsenic

- Concentrations reduced over time.
- Most data in nearshore.
- Higher values offshore?
- 44 independent values - statistics.
- Three outliers or influenced by unknown sources.
- Remaining data insufficient for regional background.






Report Section 4.0; Appendix B

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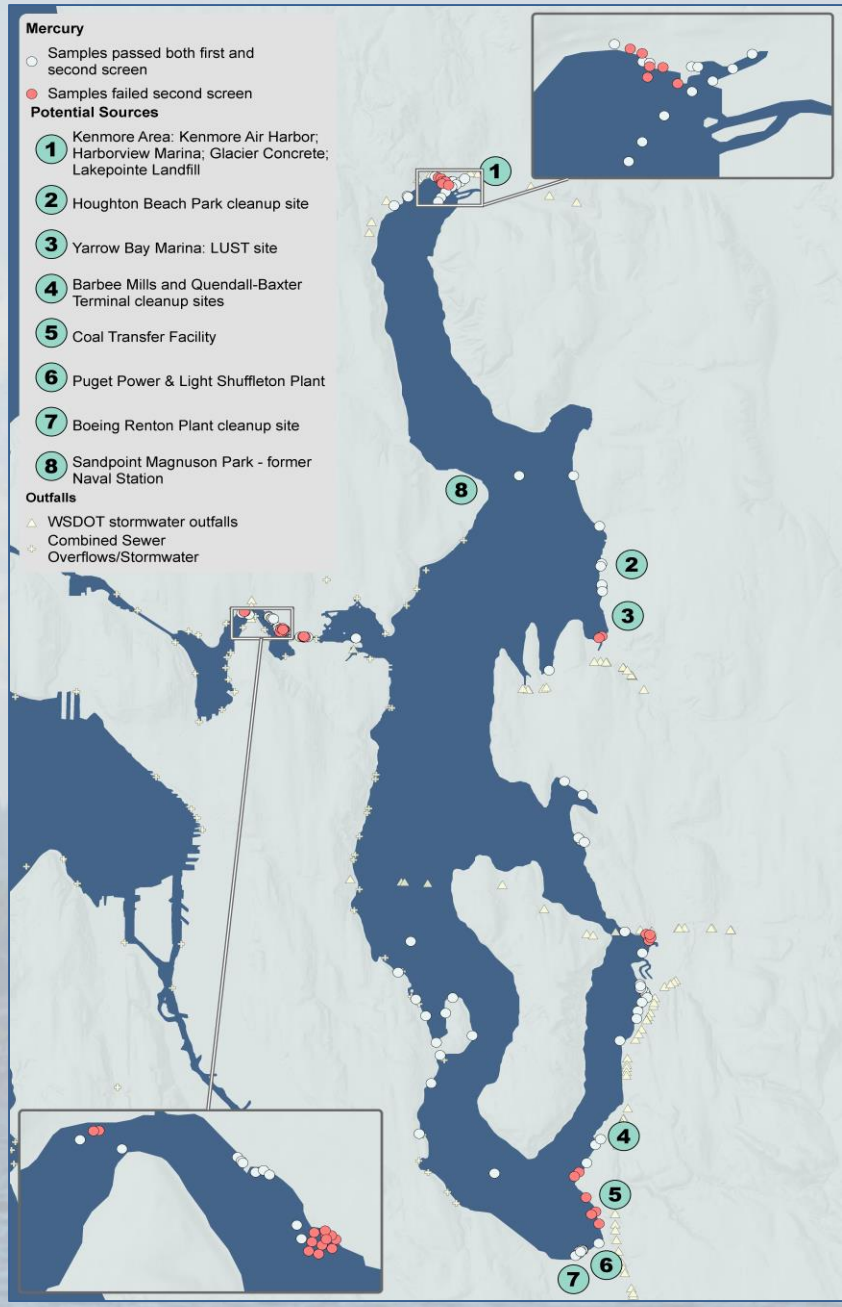
# Chemistry Data Summary Mercury

- Concentrations reduced over time.
- Most data in nearshore.
- Higher values offshore (?).
- 64 independent values for statistics.
- Three outliers or influenced by unknown sources.
- Remaining data insufficient for regional background.






Report Section 4.0; Appendix B

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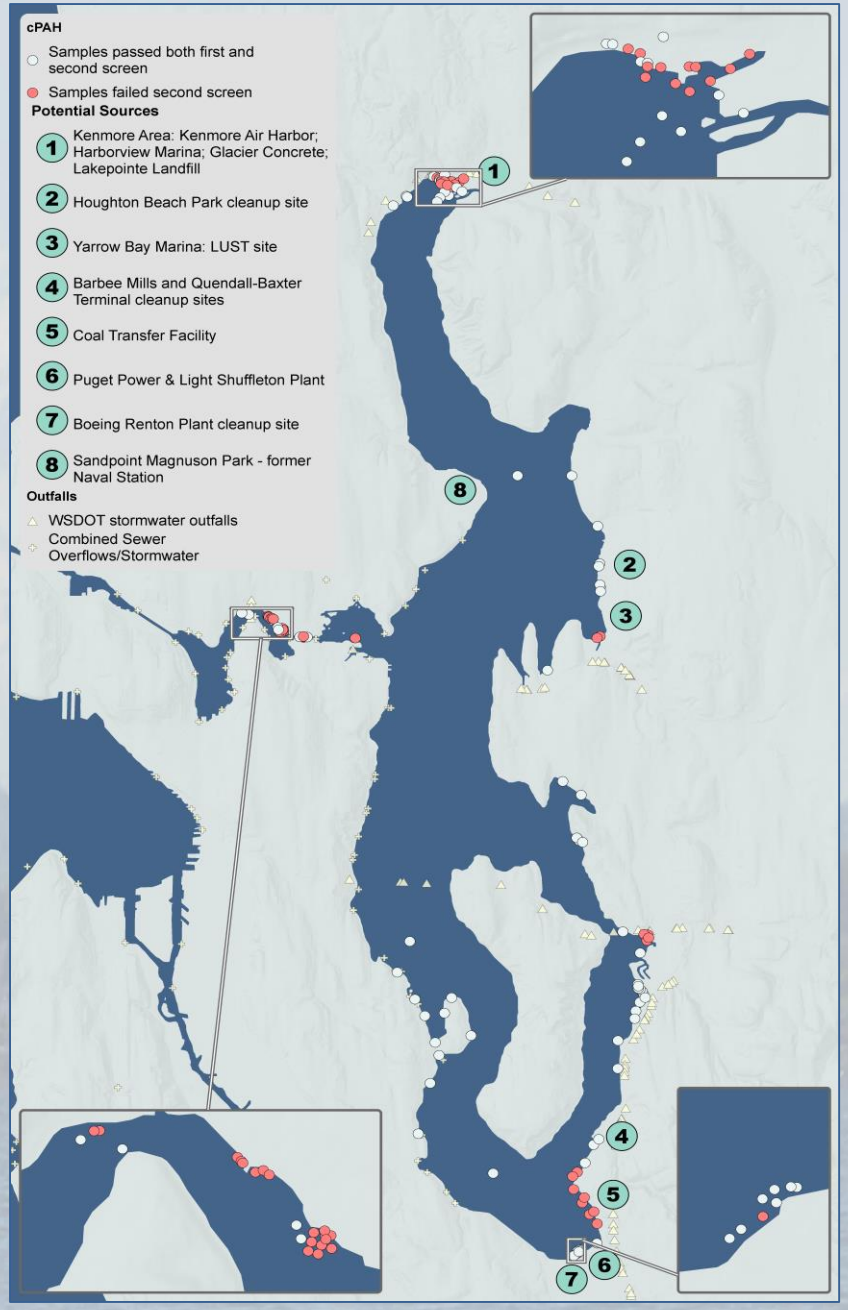
# Chemistry Data Summary cPAHs

- Most data in nearshore.
- Offshore reflect long-term influences?
- Remaining areas appear to be without strong trends or direct source/site influences when these stations are excluded:
  - 370 ppb - Chism, near a low value
  - 330 ppb - Quendall, Coal transfer
  - 220 ppb - Boeing runoff (?)






Report Section 4.0; Appendix B

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# Third Screen
# Statistical Analysis of Existing Data

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# Statistical Analysis of Existing Lake Washington Area Data Sets

- The ideal data set:
  A random, stratified, spatially balanced independent sample from the area of interest (n > 30-50?).

- What we have to work with:
  A compilation of multiple data sets, each with differing objectives, spatial sampling frames, and sampling densities.

- Our objective:
  To filter out the samples that are correlated or unrepresentative of Regional Background.



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# Statistical Analysis – Five Step Process

Identify Autocorrelation Distance

+

Identify Subpopulations to Clarify Clusters

→

Assign Clusters to Subpopulations

↓

Identify Final Subpopulations

+

Calculate Precision and 90/90 UTL

=

Regional Background Value



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# Step 1:
# Identify Autocorrelation Distance

Problem:

- Many samples were clustered (adjacent samples as close as 15 meters).
- Treating all samples as independent would bias results towards areas with higher sampling density.

Solution:

- Calculate the minimum distance required to consider samples independent.



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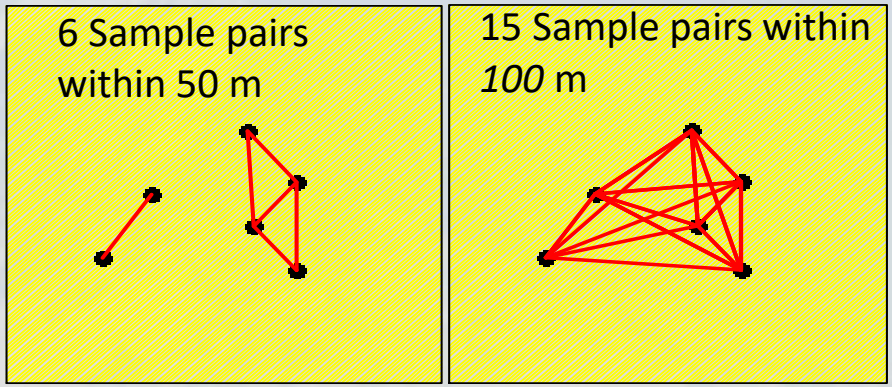
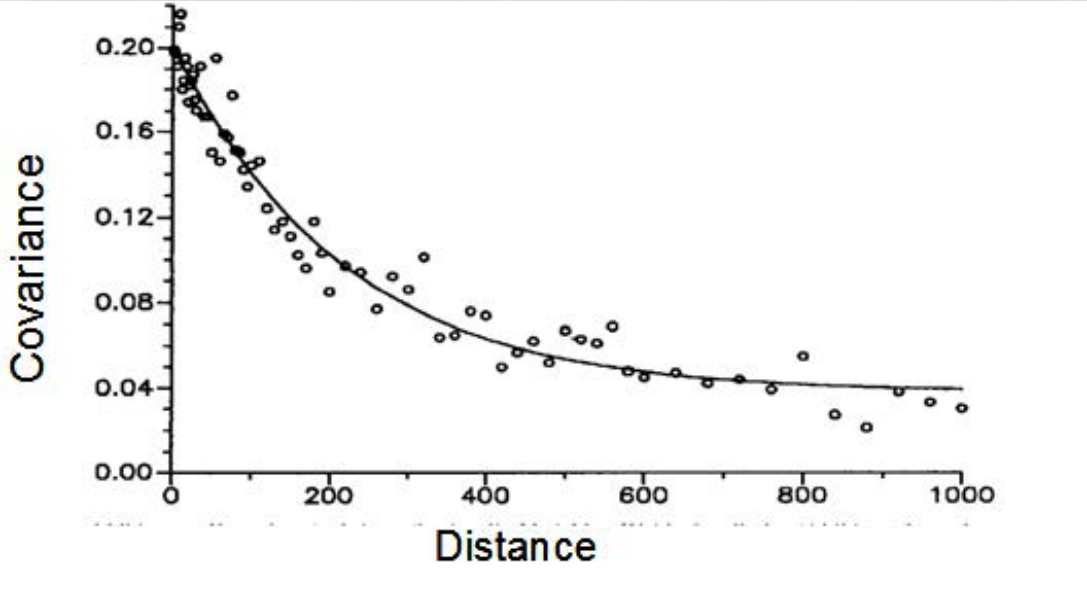
# Step 1: Identify Autocorrelation Distance - Methods

- Exclude swim beach samples and chemical/spatial outliers.
- Estimate trend/generate residuals.
- Bin spatially adjacent observations.
- Calculate Pearson's correlation between residuals for pairs within each distance bin.



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# Step 1: Identify Autocorrelation Distance - Results

| Analyte | Total Number of Samples | Concentration Range of the Data | Minimum Autocorrelation Distance |
|---|---|---|---|
| cPAH TEQ | 59 | <2.4 to 370 ppb | 250 m |
| Arsenic | 39 | 1.2 to 13 ppm | 100 m |
| Mercury | 57 | 0.0061 to 0.24 ppm | 50 m |



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# Step 2: Identify Subpopulations to Clarify Clusters

Problem:

- Some autocorrelated samples ("clustered samples") had concentrations ranging over an order of magnitude or more.
- This pattern suggests different sources, despite geographic proximity.
- Need a method to deal with all sample clusters.

Solution:

- Use an iterative statistical procedure, along with BPJ to estimate prediction limits for individual subpopulations.
- Apply limits to allocate clustered samples to respective subpopulations.



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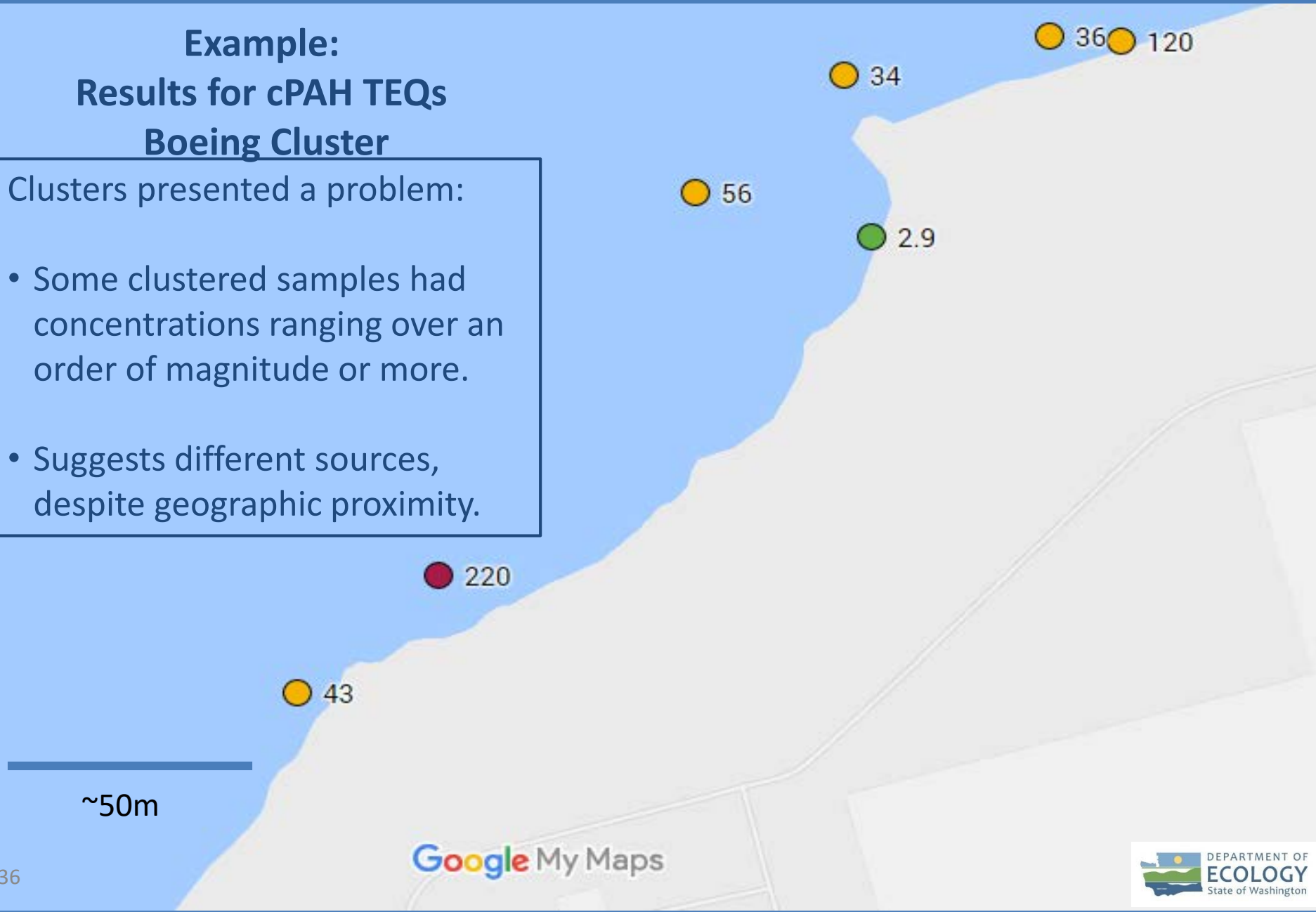
# Step 2: Identify Subpopulations to Clarify Clusters

**Example:**
**Results for cPAH TEQs**
**Boeing Cluster**

Clusters presented a problem:

- Some clustered samples had concentrations ranging over an order of magnitude or more.
- Suggests different sources, despite geographic proximity.



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# Step 2: Identify Subpopulations to Clarify Clusters - Methods

**Data Set**

- Independent samples, swim beaches, chemical & spatial outliers

**Quantile – Quantile Plots**

- To identify population breaks

**Robust Prediction Limits**

- Defines statistical boundaries of subpopulations

After Singh et al. 1994



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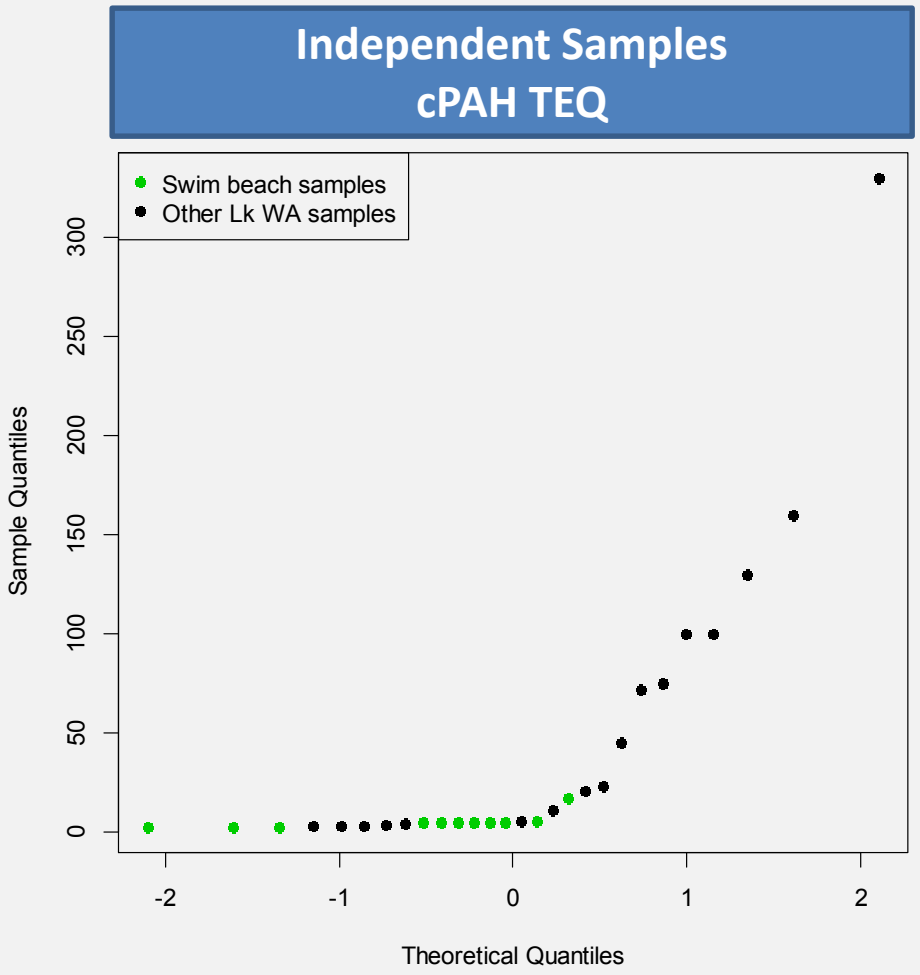
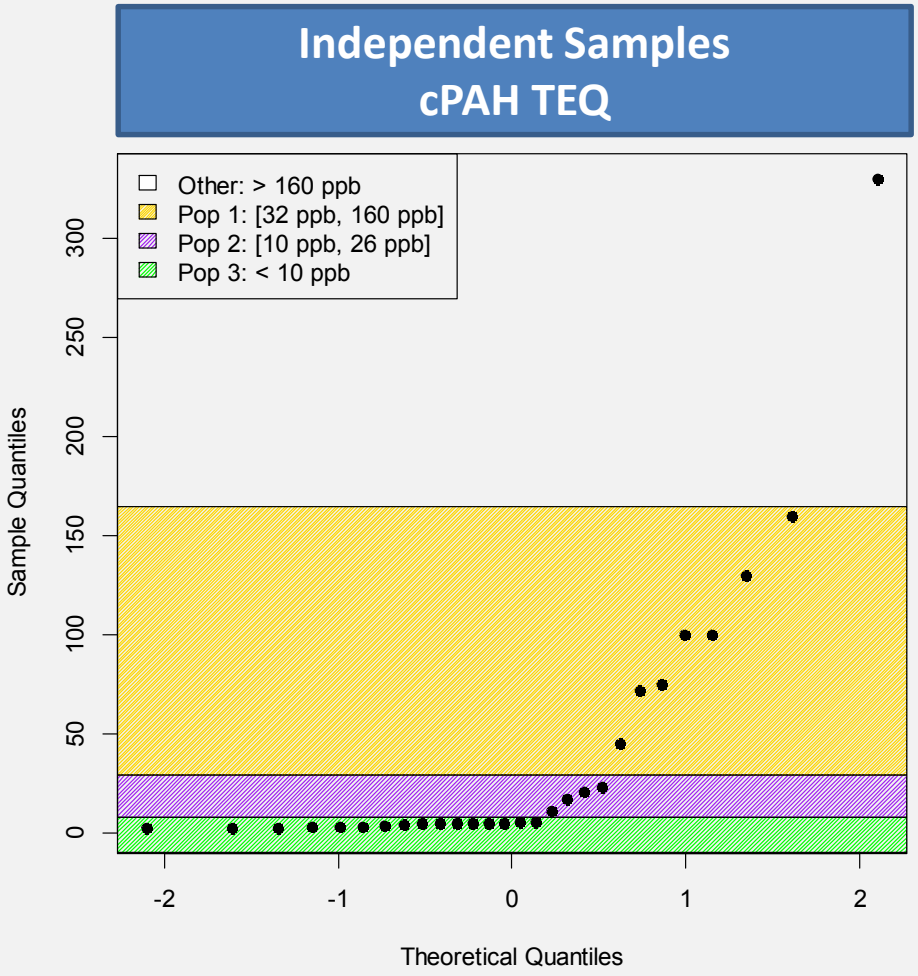
# Step 2: Identify Subpopulations to Clarify Clusters - Results



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# Step 3: Assign Clustered Samples to Appropriate Subpopulations

Problem:

- Some autocorrelated samples ("clustered samples") had concentrations ranging over an order of magnitude or more.
- This pattern suggests different sources, despite geographic proximity.

Solution:

- Apply prediction limits from Step 2 to samples within clusters.



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# Step 3: Assign Clustered Samples to Relevant Subpopulation

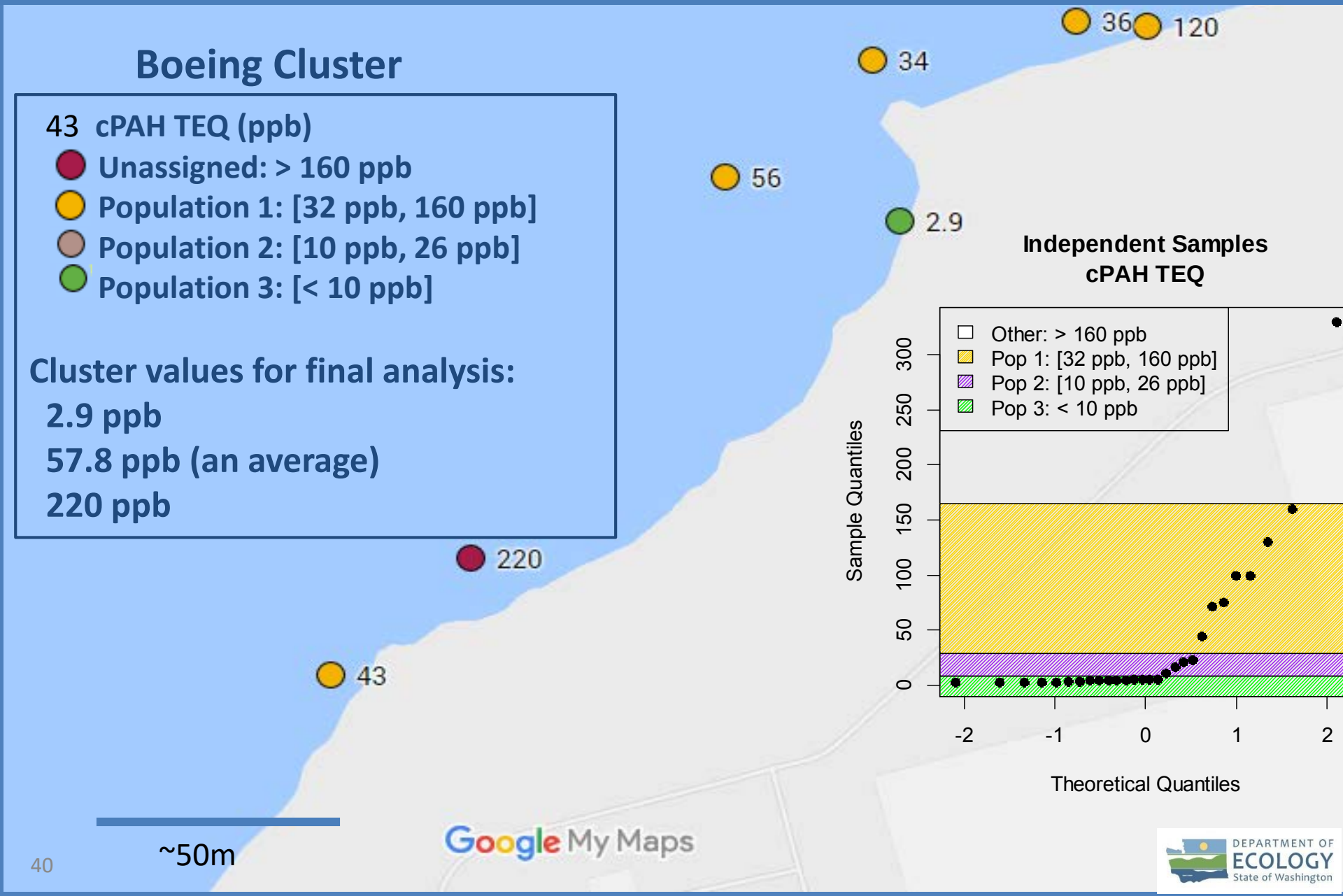
## Boeing Cluster

43 cPAH TEQ (ppb)

- Unassigned: > 160 ppb
- Population 1: [32 ppb, 160 ppb]
- Population 2: [10 ppb, 26 ppb]
- Population 3: [< 10 ppb]

**Cluster values for final analysis:**

2.9 ppb
57.8 ppb (an average)
220 ppb



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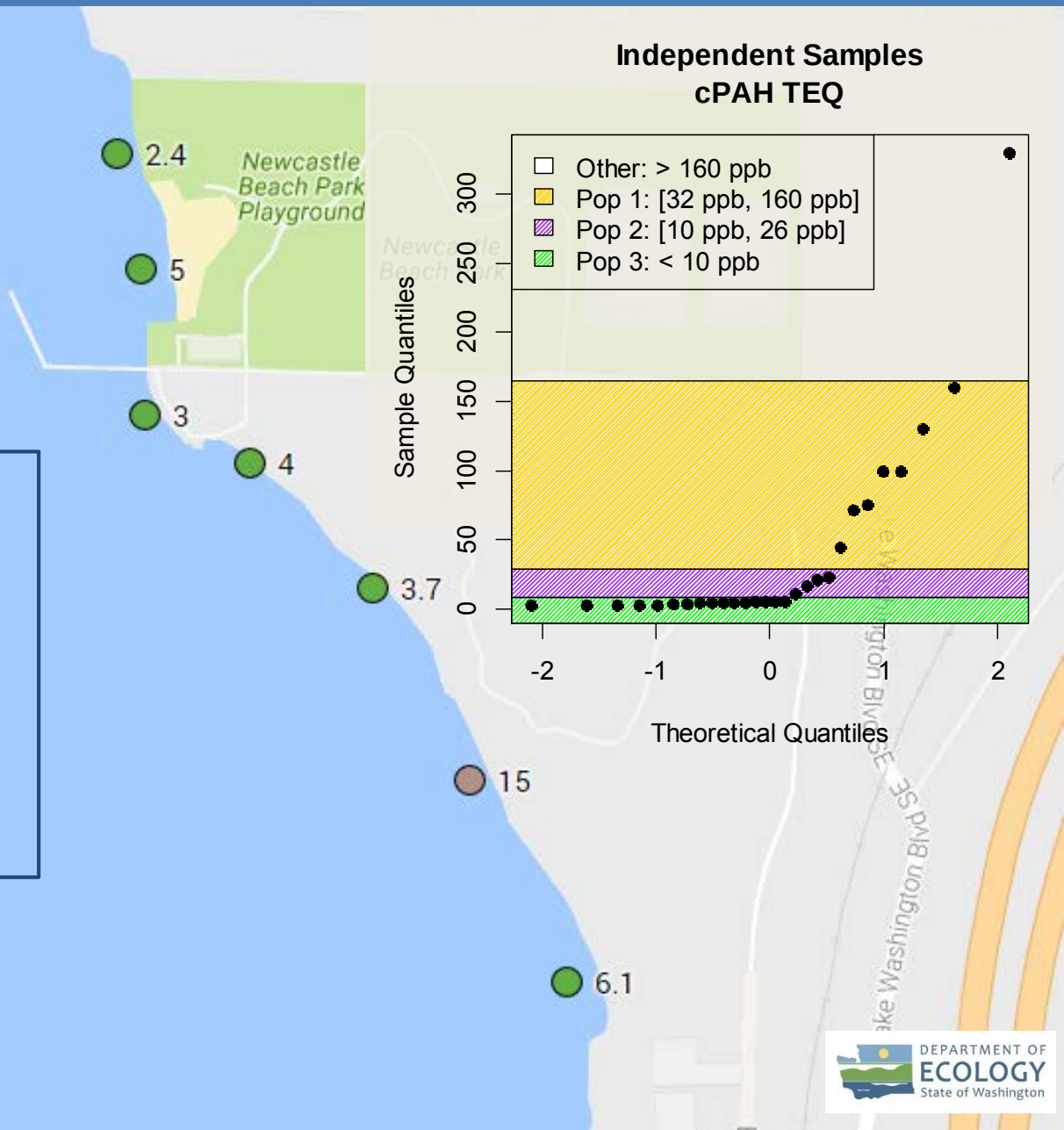
# Step 3: Assign Clustered Samples to Relevant Subpopulation

## Newcastle Beach Cluster

**2.4** cPAH TEQ (ppb)
- Population 2 [10, 26 ppb
- Population 3: < 10 ppb)

Cluster values for final analysis:
3.8 ppb (an average)
15 ppb




~50m

# Step 4: Identify Final Subpopulations

Problem:

- Multiple concentration populations present, from natural background to highly elevated values.
- Concentrations ranged over 1 to 2+ orders of magnitude within the 3 COC datasets.

Solution and Methods:

- Same as Step 2, this time including clustered sample results (from Step 3).



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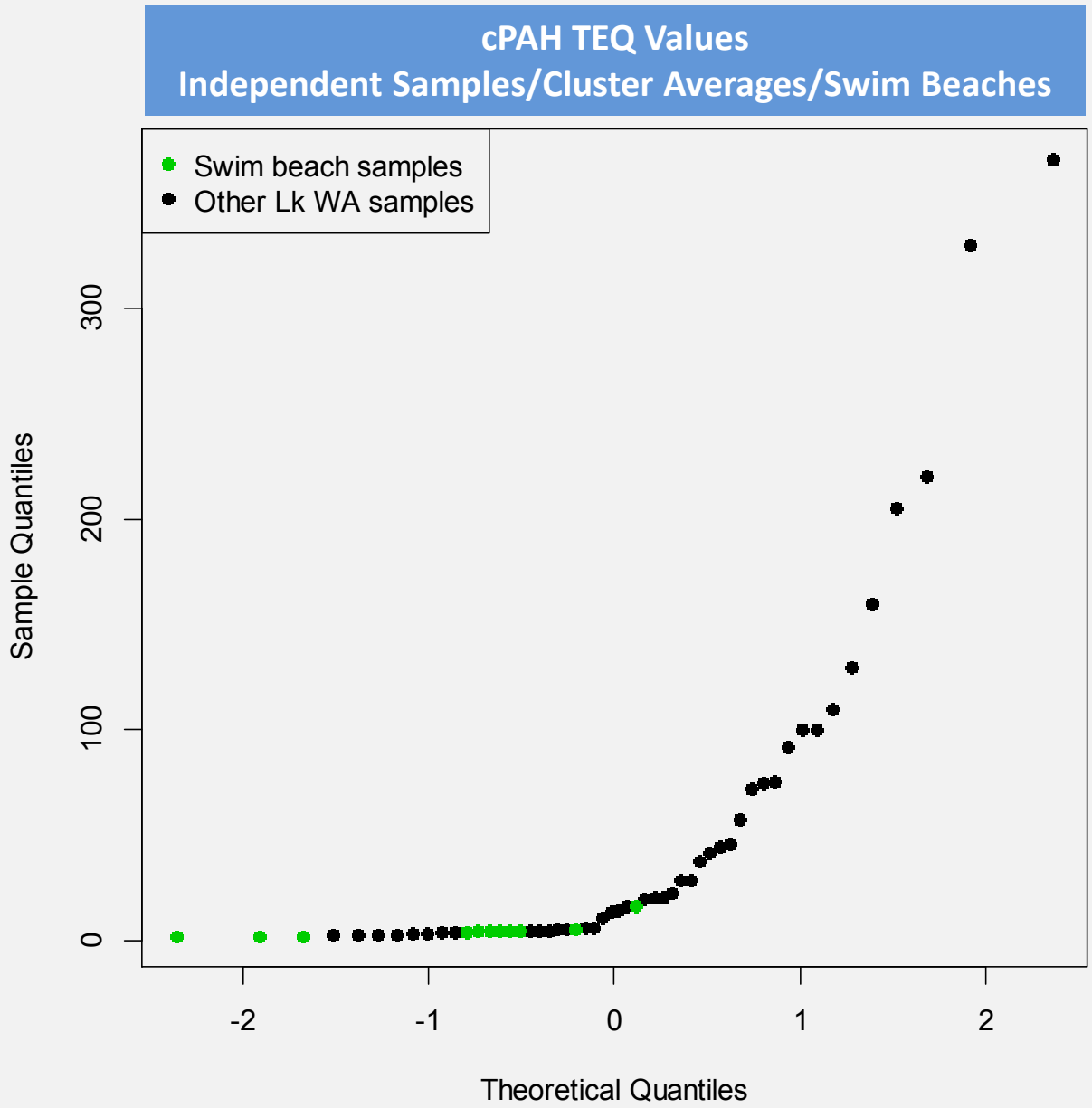
# Step 4: Identify Regional Background Population



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# Step 4: Identify Regional Background Population Methods

Data Set

- Independent samples, cluster results, swim beaches, chemical & spatial outliers

Quantile – Quantile Plots

- To identify population breaks

Robust Prediction Limits

- Defines statistical boundaries of subpopulations

After Singh et al. 1994



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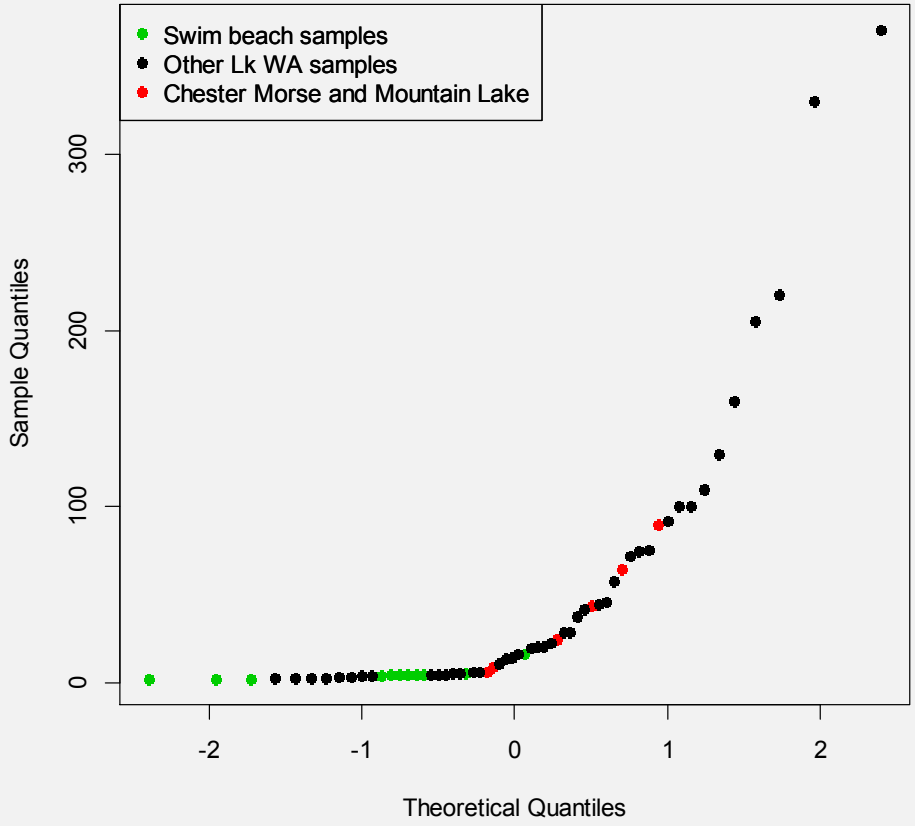
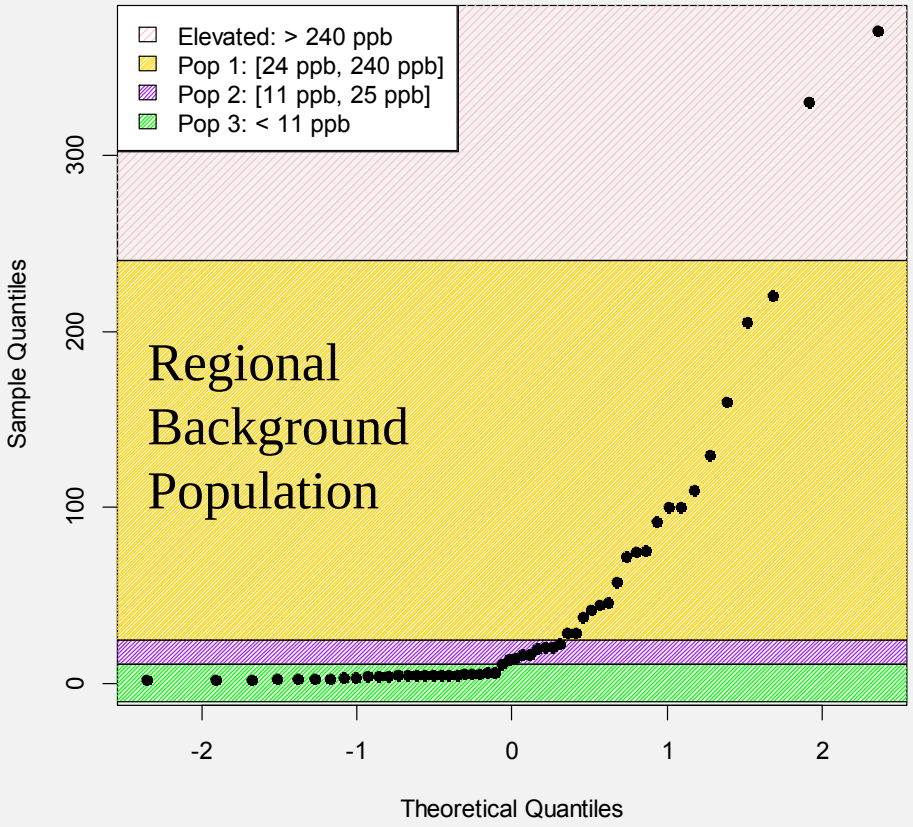
# cPAH TEQ

**Independent Samples/Cluster Averages/Swim Beaches + Reference Lakes**




**Independent Samples/Cluster Averages/Swim Beaches**




**Note: Chester Morse and Mountain Lake samples shown only for reference; they were not included in population analysis.**



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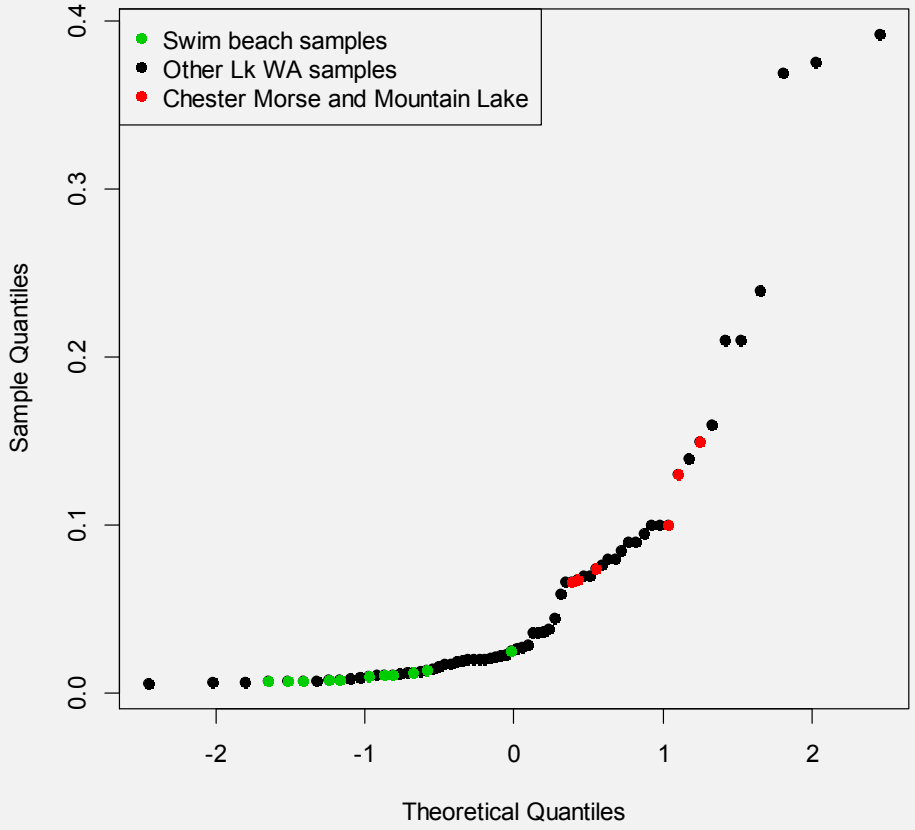
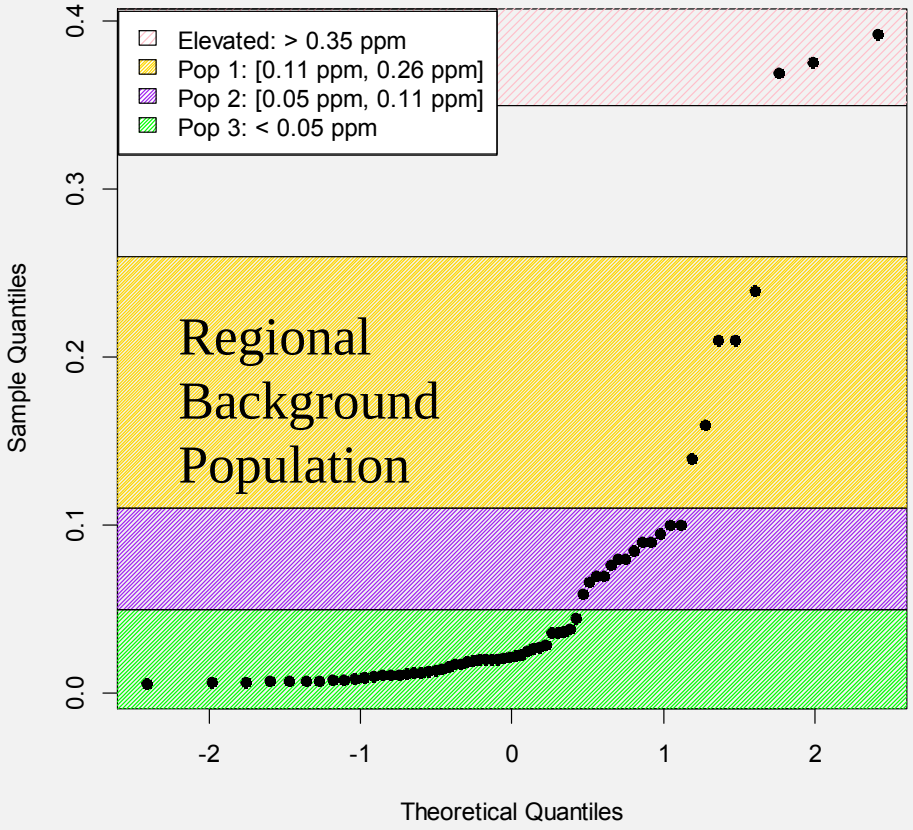
# Mercury

## Independent Samples/Cluster Averages/Swim Beaches + Reference Lakes




## Independent Samples/Cluster Averages/Swim Beaches

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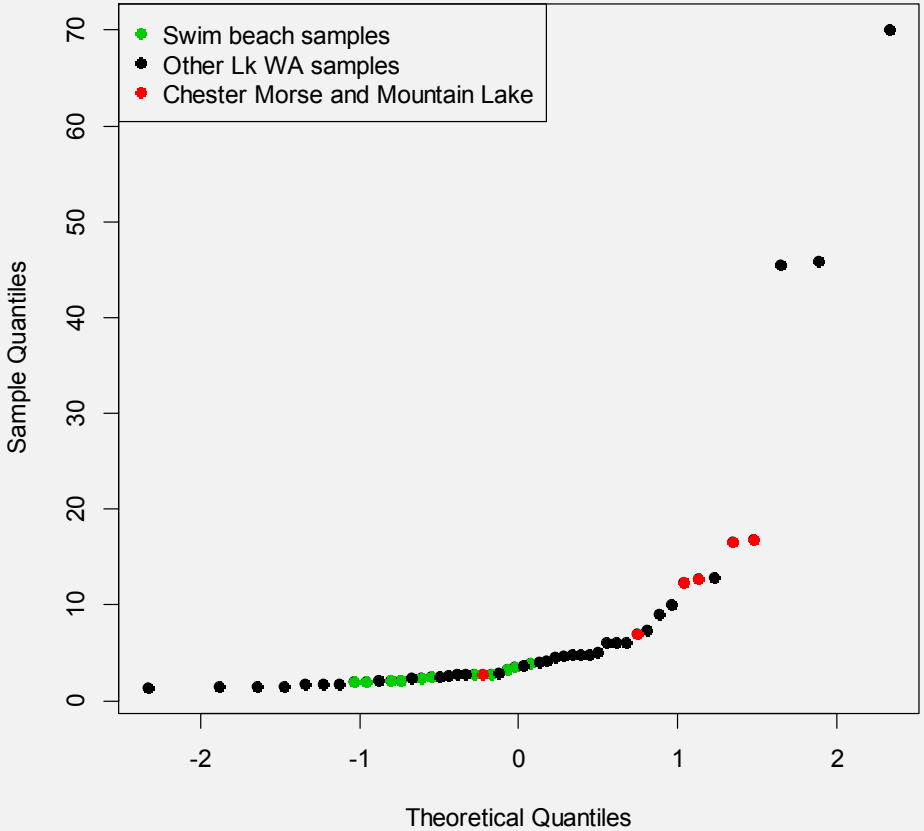
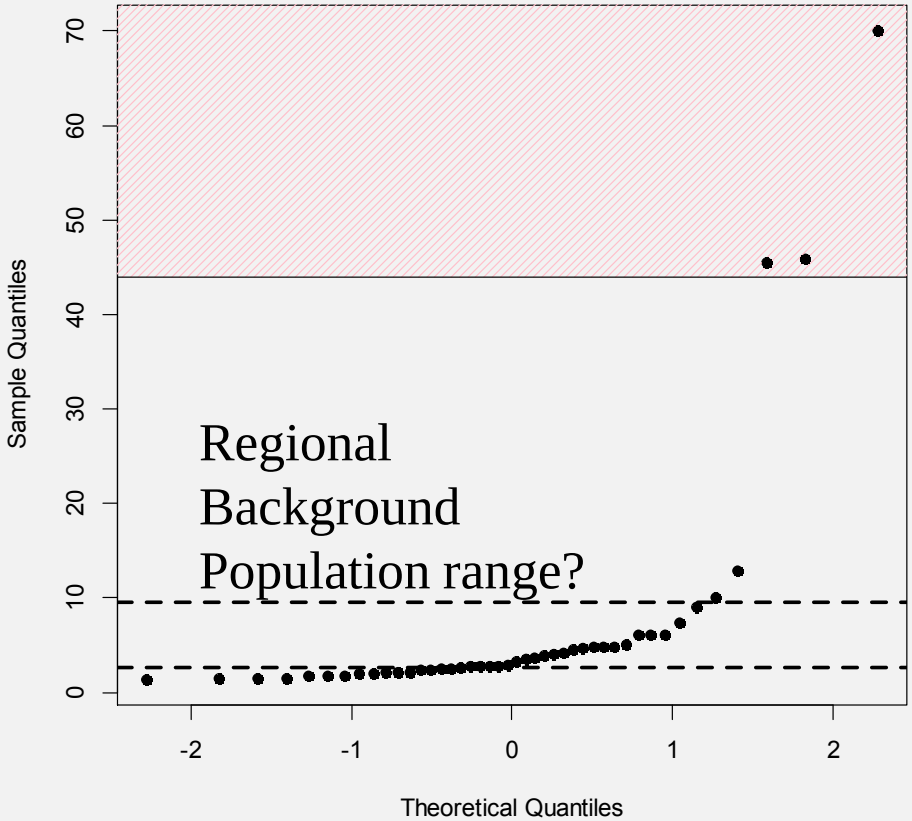
# Arsenic

**Independent Samples/Cluster Averages/Swim Beaches + Reference Lakes**




**Independent Samples/Cluster Averages/Swim Beaches**




**Note: Chester Morse and Mountain Lake samples shown only for reference; they were not included in population analysis.**



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# Step 5: Calculate Regional Background Values

Problem:

- With the full data set filtered down to the likely Regional Background population, evaluate the sample data to establish the Regional Background value (90/90 UTL).

Solution:

- Use same methods applied to all Regional Background data sets.



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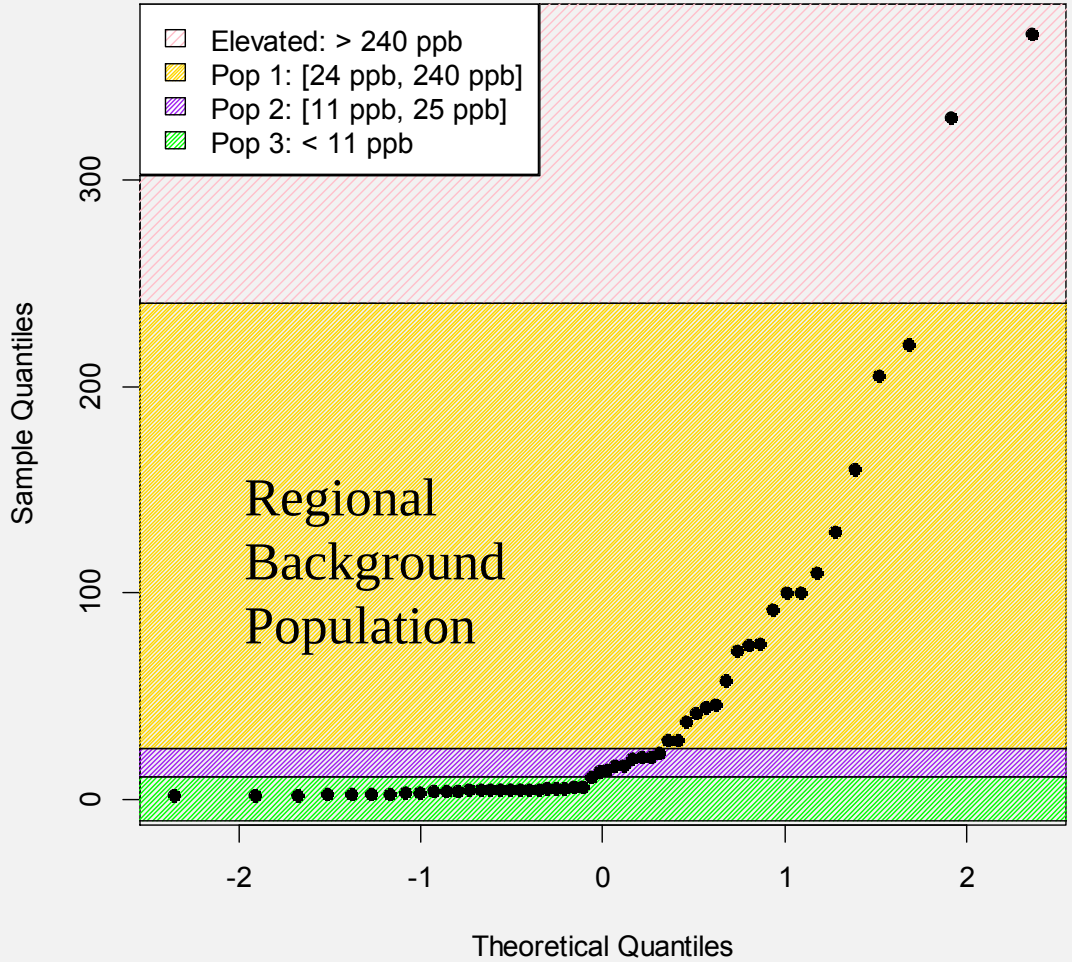
# Step 5: Calculate Regional Background Value – cPAH

**Independent Samples/Cluster Averages/ Beaches** **Swim**



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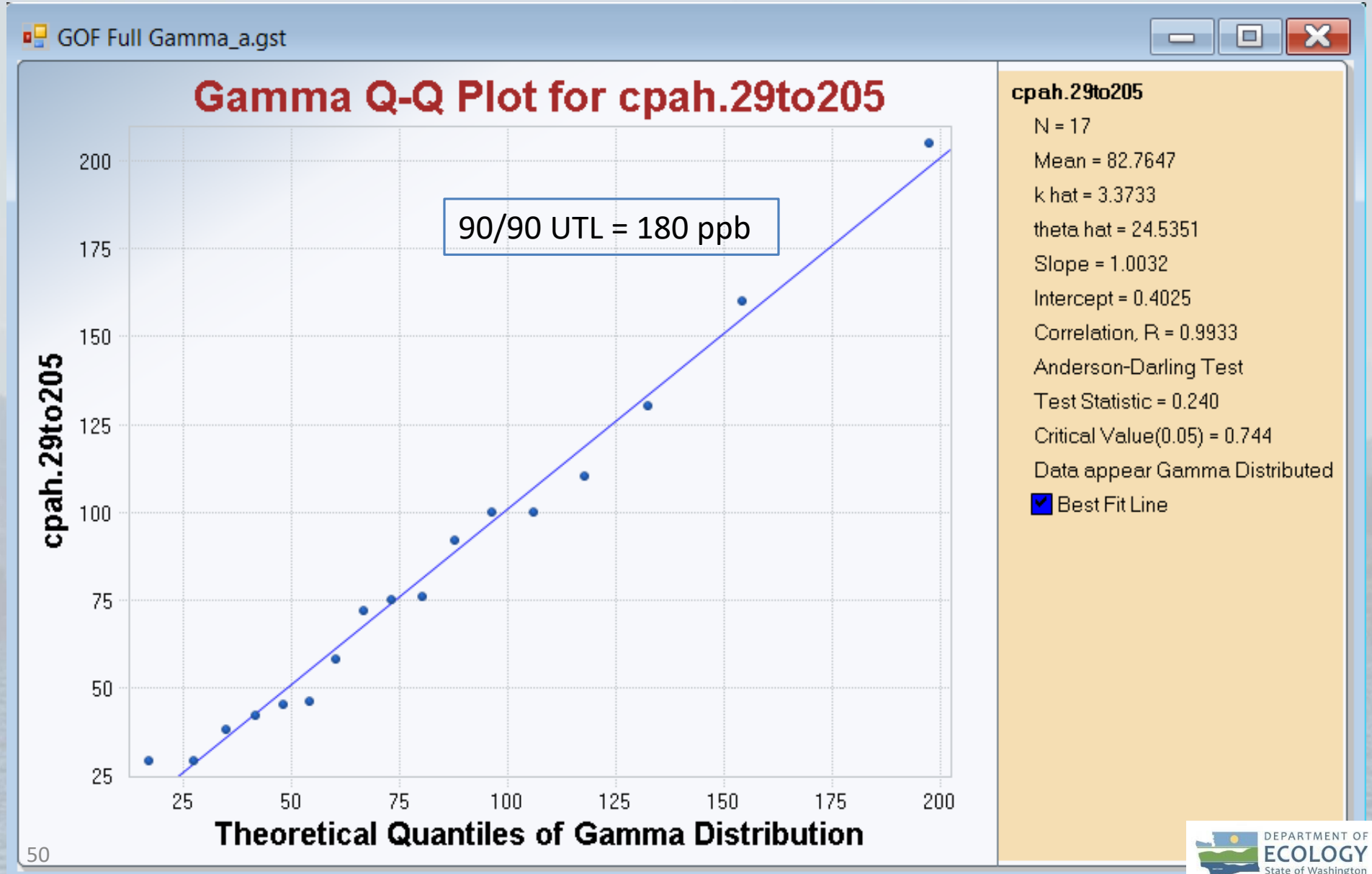
# Step 5: Calculate Regional Background Value – cPAH



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# Goal No. 3:

Discuss your issues and ideas for resolving them.



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# Goal No. 4:

Next steps.



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# Thank you for your input today!

## For more information:

**Visit Ecology's website**

www.ecology.wa.gov

**Visit Ecology's Lake Washington Area**

Regional Background website

www.ecy.wa.gov/programs/tcp/smu/lakeWa/reg-bg-study.html

Contact Chance Asher, Department of Ecology

chance.asher@ecy.wa.gov 360-407-6914



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# Supplemental Slides

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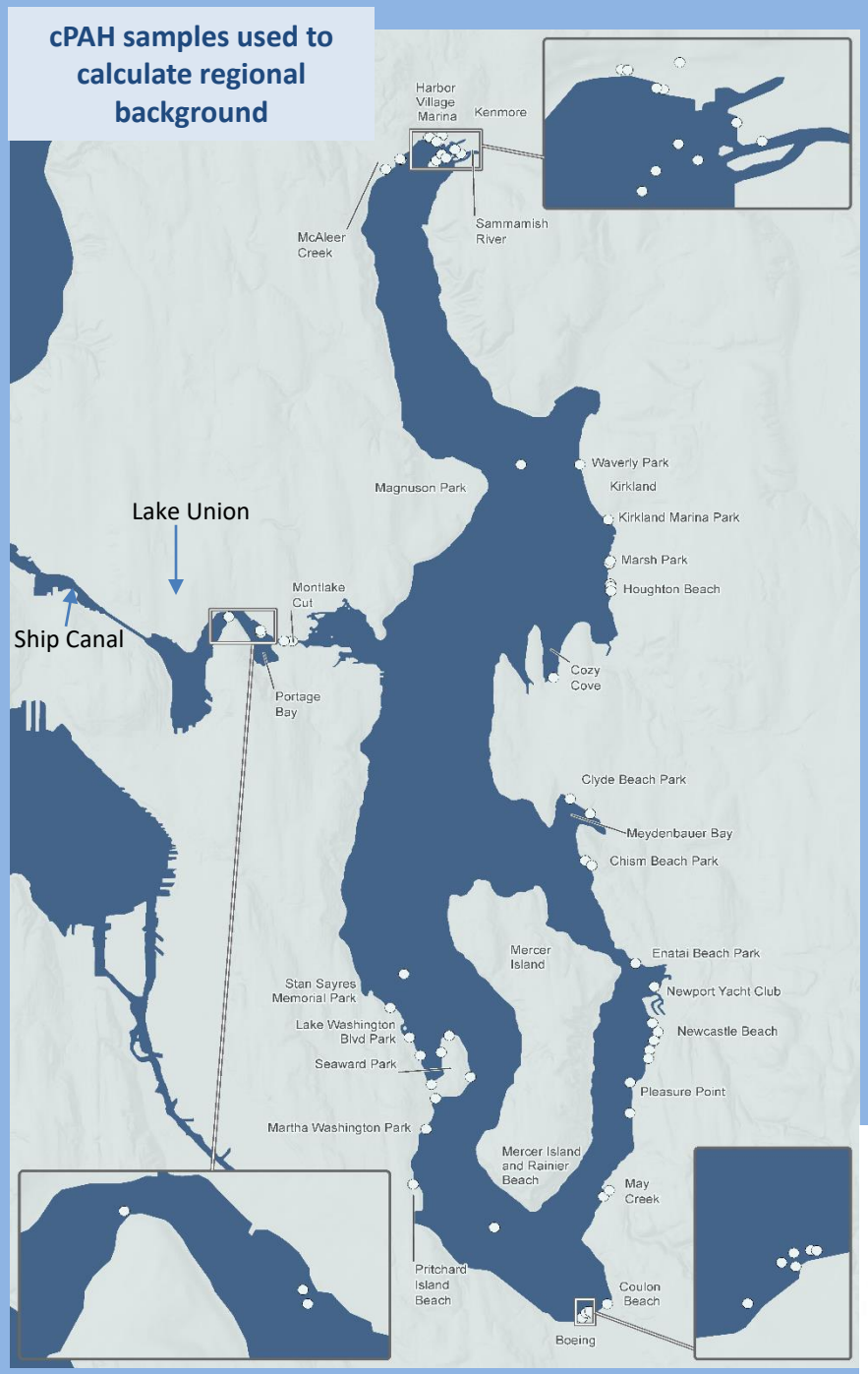
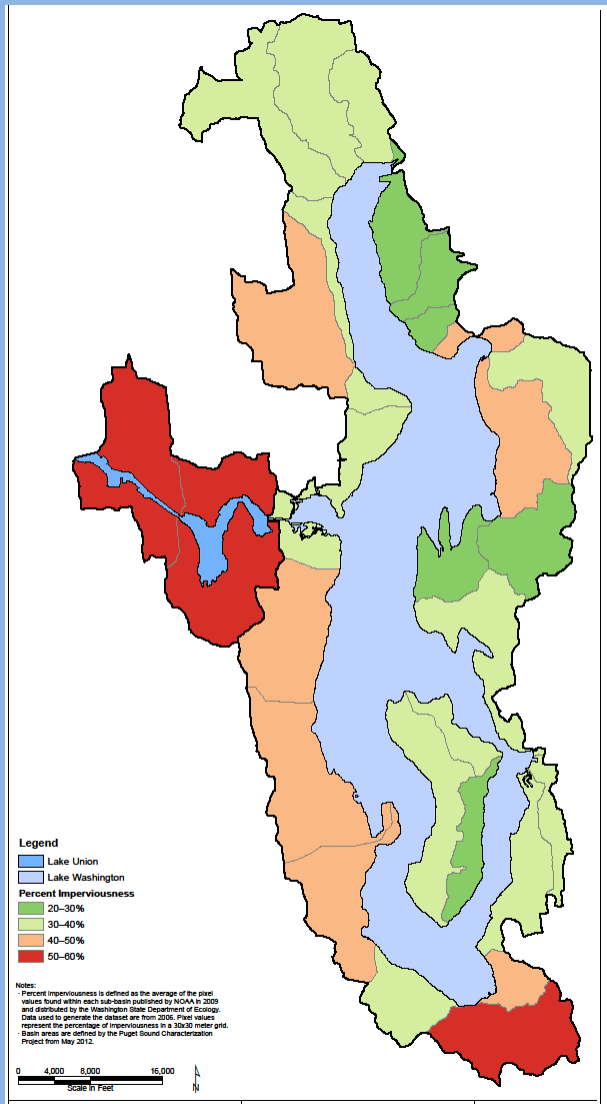
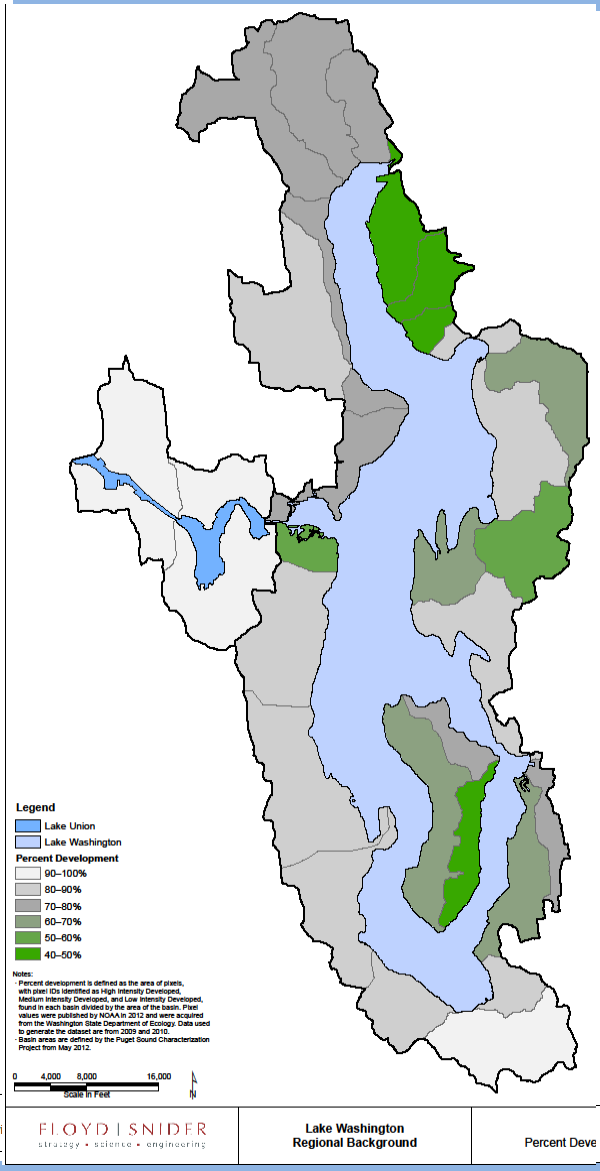
cPAH samples
Passed 1st & 2nd Screen
Failed 2nd Screen
Potential Sources
1 Kenmore Area: Kenmore Air Harbor; Harborview Marina; Glacier Concrete; Lakepointe Landfill
2 Houghton Beach Park cleanup site
3 Yarrow Bay Marina: LUST site
4 Barbee Mills and Quendall-Baxter Terminal cleanup sites
5 Coal Transfer Facility
6 Puget Power & Light Shuffleton Plant
7 Boeing Renton Plant cleanup site
8 Sandpoint Magnuson Park - former Naval Station
Outfalls
WSDOT stormwater outfalls
Combined Sewer Overflows/Stormwater
1
2
3
4
5
6
7
8


cPAH samples used to calculate regional background
Harbor Village Marina
Kenmore
McAleer Creek
Sammamish River
Waverly Park
Kirkland
Magnuson Park
Kirkland Marina Park
Lake Union
Marsh Park
Houghton Beach
Montlake Cut
Ship Canal
Cozy Cove
Portage Bay
Clyde Beach Park
Meydenbauer Bay
Chism Beach Park
Mercer Island
Enatai Beach Park
Newport Yacht Club
Stan Sayres Memorial Park
Lake Washington Blvd Park
Newcastle Beach
Seaward Park
Pleasure Point
Martha Washington Park
Mercer Island and Rainier Beach
May Creek
Pritchard Island Beach
Coulon Beach
Boeing

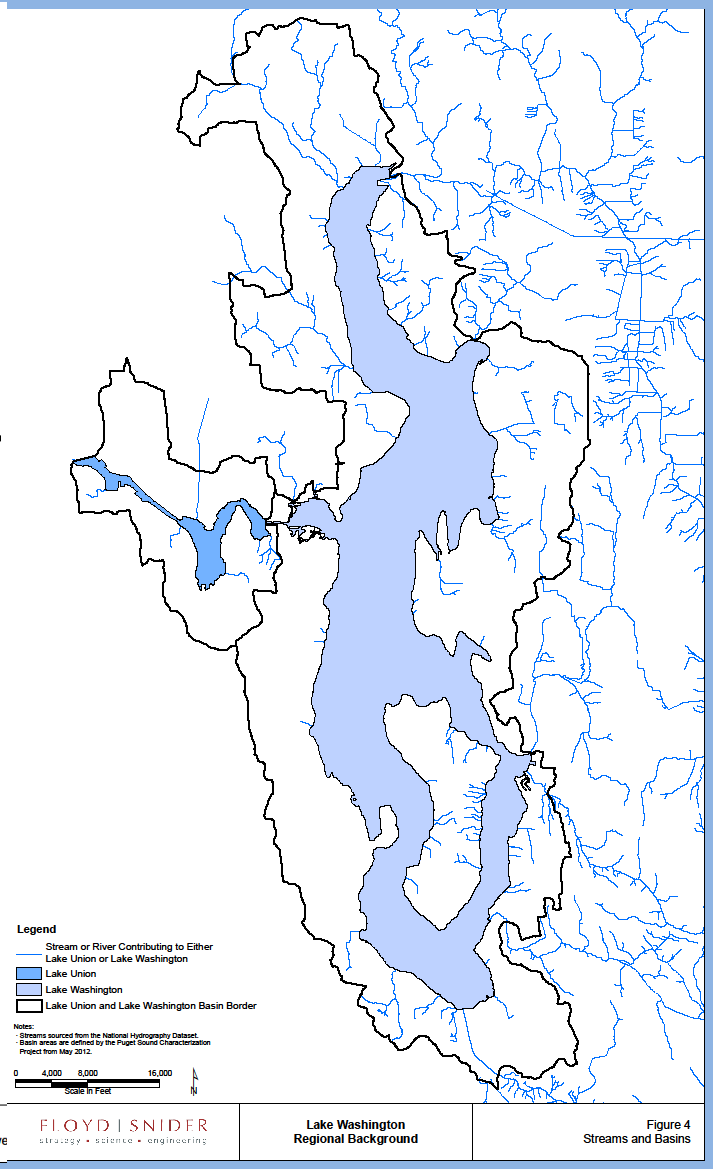
# Impervious Surface By Basin




# % Development by Basin




# Streams & Basins




DEPARTMENT OF ECOLOGY State of Washington