



Bellingham Bay Regional Background

Data Workshop

December 8, 2014

Goals For Today

- Describe the regional background concept.
- Provide an overview of the data and analysis results.
- Discuss your thoughts about our data analysis approach and any identified errors or technical issues.
- Communicate next steps and our timeline for completing the Data Evaluation and Summary Report.
- Discuss remaining questions or technical issues.

Acknowledgments

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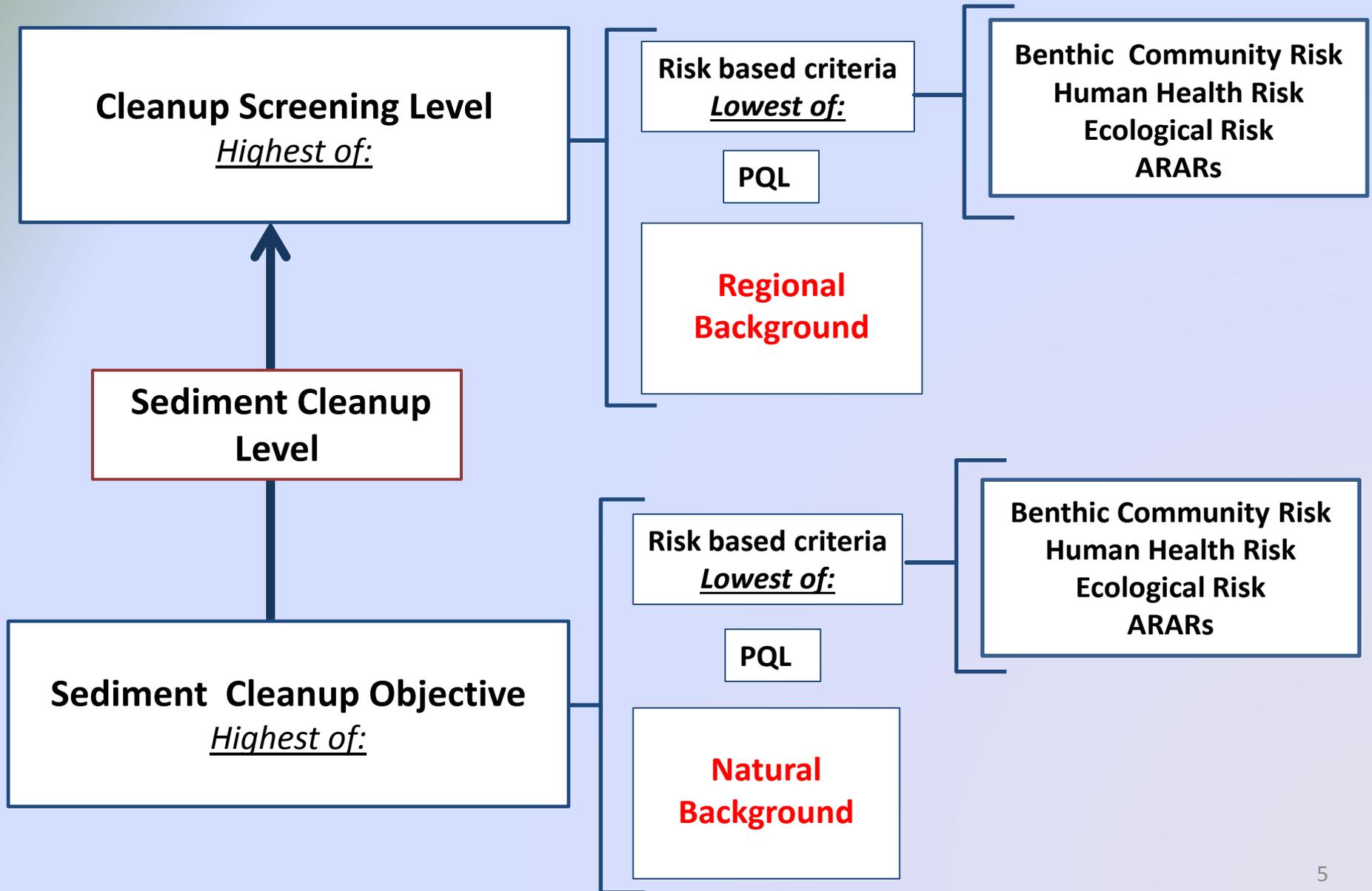
Regional Background

How can it be used under the SMS rule?

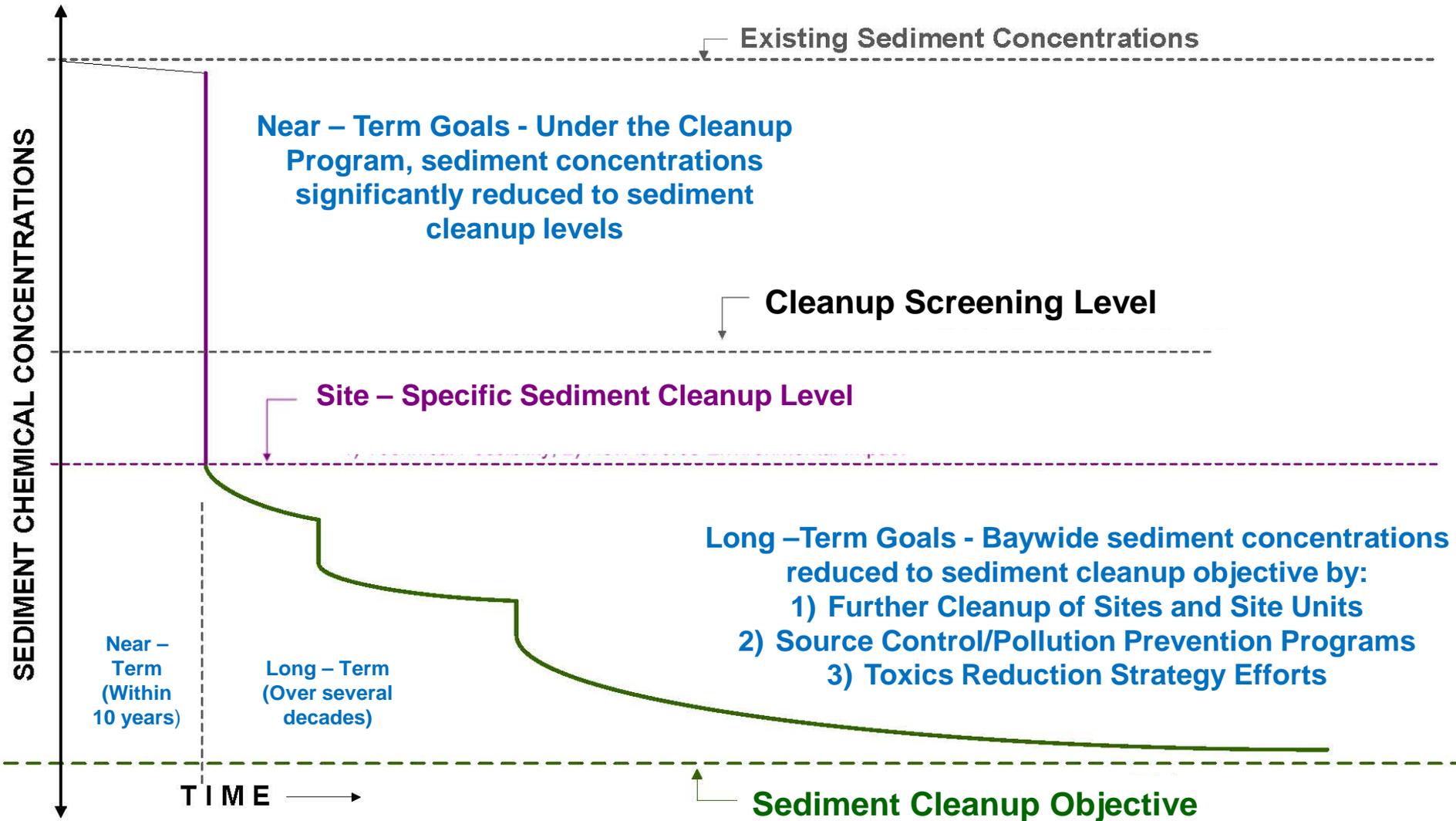
To establish the Cleanup Screening Level (CSL) which can be used:

- To identify a cleanup site
- As the upper bound for establishing a sediment cleanup level
- To identify the areas of a cleanup site requiring active cleanup
- To identify areas for interim actions

Background & SMS rule - Establishing Cleanup Levels



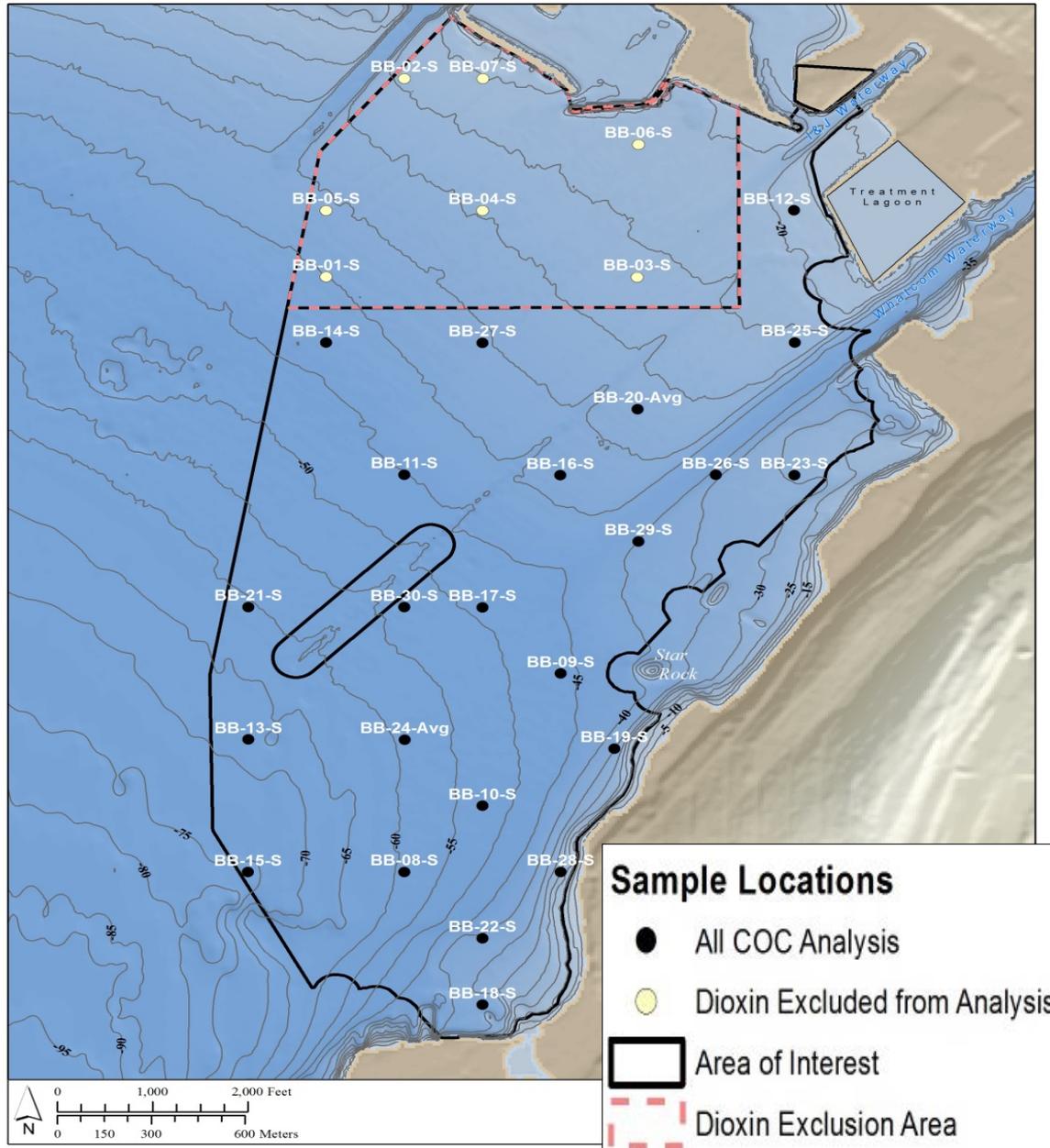
How Cleanup Fits with Long Term SMS Goals



Study Design

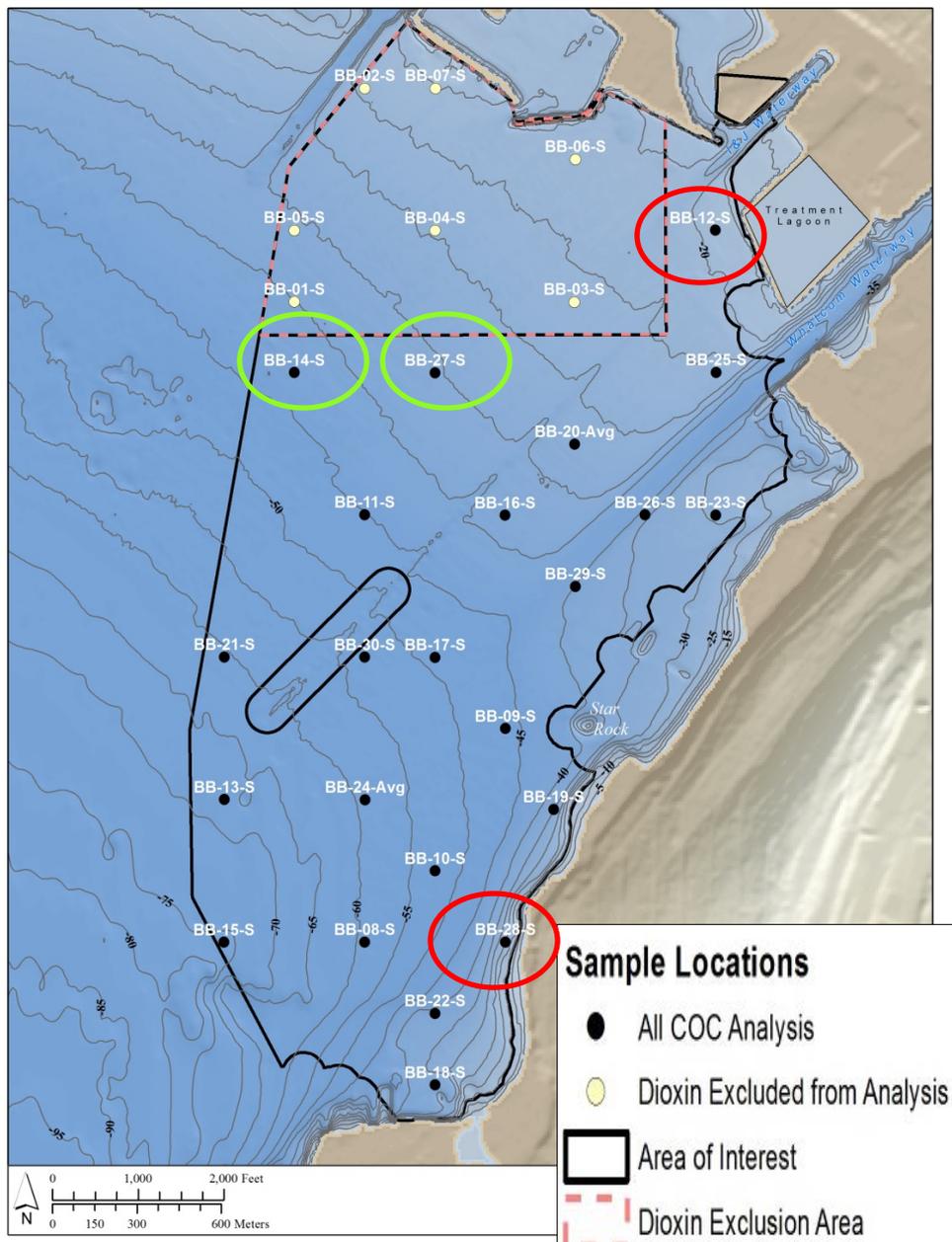
- Rationale and Conceptual Bay Model
 - Used existing data and trends to determine analytes and the sampling area of interest (AOI).
- Determining Areas of Primary Influence
 - Used bay-specific information, including completed Remedial Investigations, to define the shoreward AOI boundary.
 - Allowed for sampling closer to site boundaries and the shoreline.
- Differentiating from Natural Background
 - Existing data were compared to natural background to define the western AOI boundary.
- Differing Areas of Interest for Different CoCs
 - Concentrations above natural background in different areas of the bay, resulting in chemical-specific AOIs.

Study Design



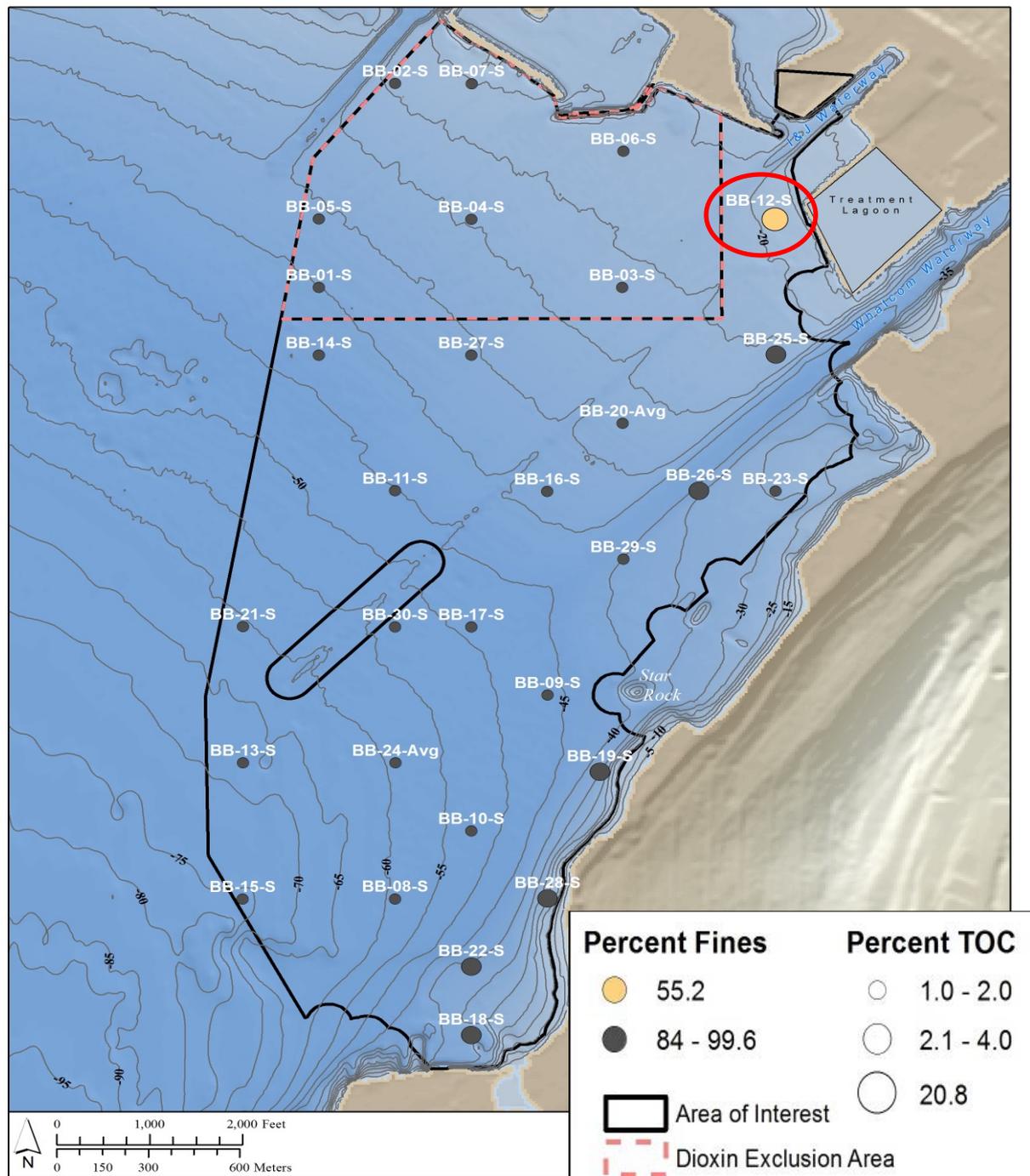
- The AOIs differed based on comparisons of existing dioxin and cPAH data to natural background.
- Existing As and Cd data did not exceed natural background and were not analyzed. Hg was not analyzed because the bay is impacted from an identifiable source.
- Lead was added to the CoC list in response to stakeholder comments.
- Sampling included:
 - 23 samples for all CoCs
 - 7 additional samples for PCB congeners, cPAHs, and lead

Chemistry Data Observations



- Lowest concentrations were observed in the northwestern area – likely due to the influence of cleaner sediment from the Nooksack River.
- Higher concentrations were generally distributed in the southern and proximal shoreline portions of the AOI.
- Remaining areas appear to be without strong trends or direct source/site influences, when certain stations are excluded from the AOIs:
 - BB-14 & 27 due to Nooksack River influence
 - BB-12 & 28 due to source/site influences
- Chemical concentrations were generally correlated with TOC (except dioxins/furans).

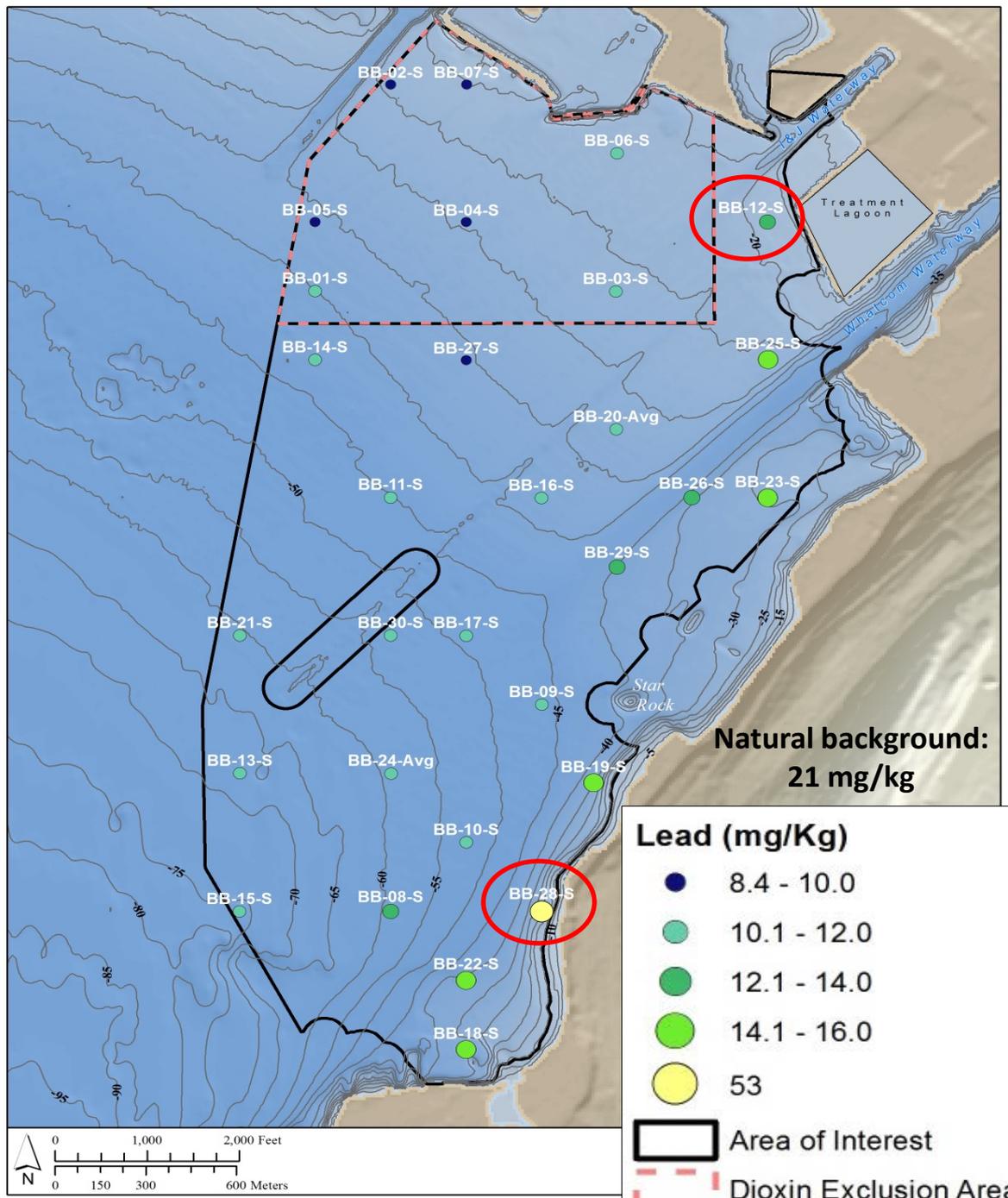
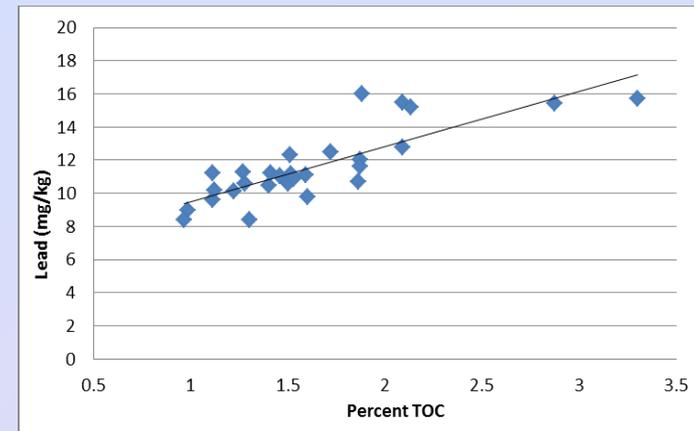
Percent Fines/TOC



- BB-12 had 20.8% TOC and 55% fines.
- In the remaining samples:
 - TOC ranged from 0.97 to 3.68%.
 - Fines ranged from 84 to 99%.
 - Higher TOC along shoreline.
- Correlation between fines and TOC was weak and slightly negative.

Lead

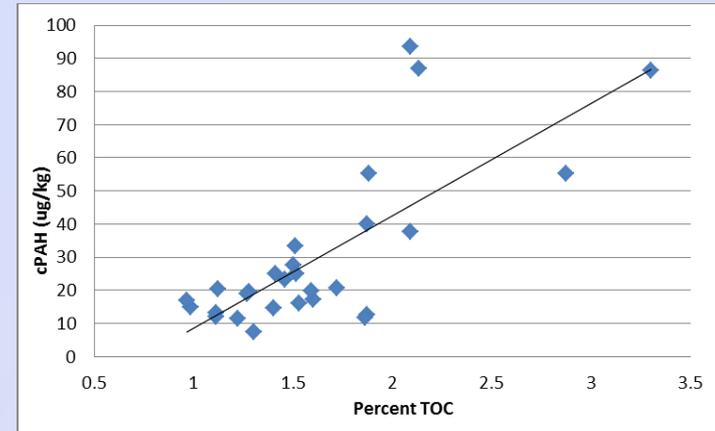
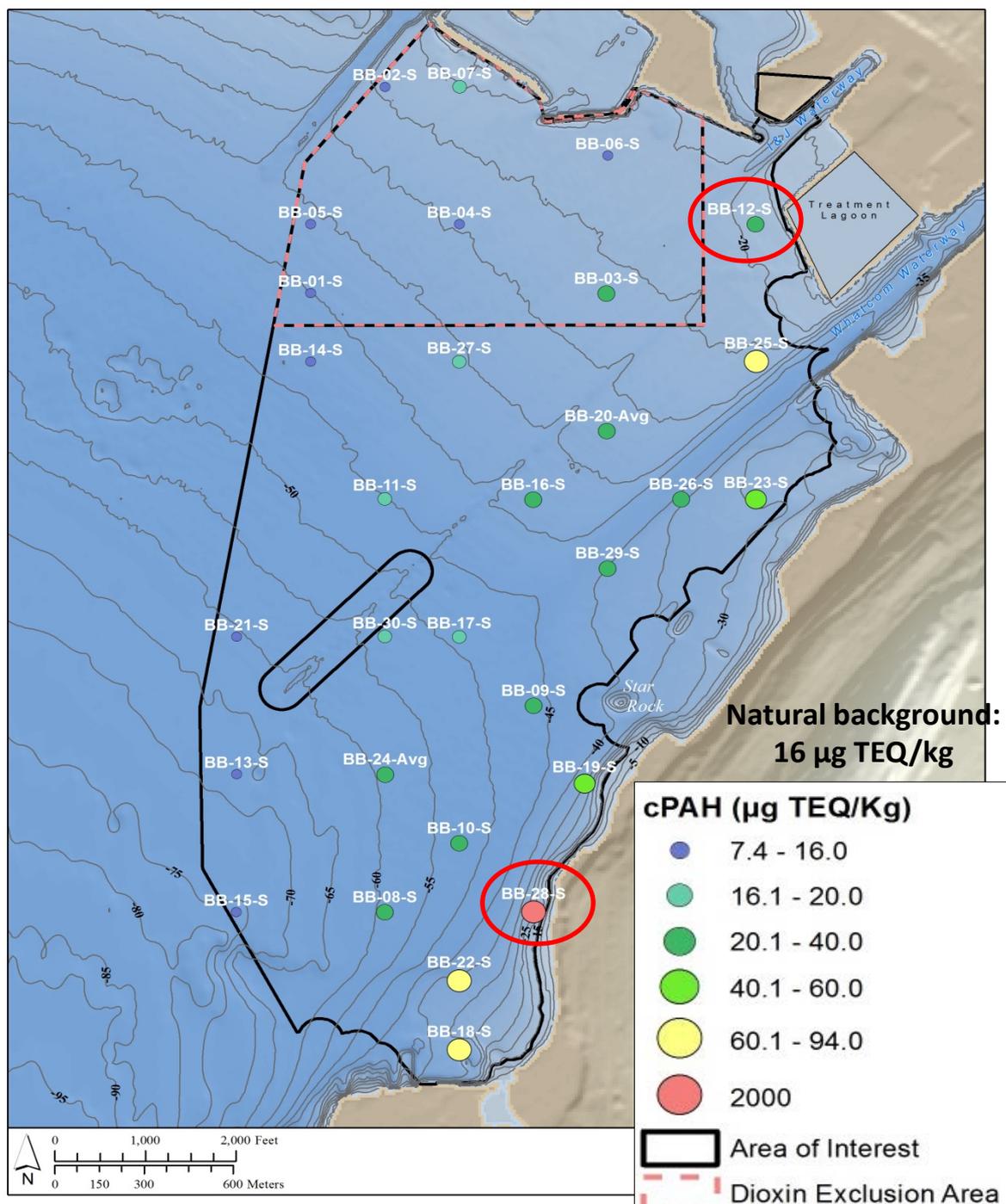
- Correlation coefficient w/TOC
 - r - value = 0.818
- Excludes:
 - BB-12 (TOC = 20.8%)
 - BB-28 (Pb = 53 mg/kg)



mg/kg, DW	
Summary Statistics	
Sample Size	28
Minimum	8.4
Average	12
Median	11
Maximum	16

Carcinogenic PAHs TEQ

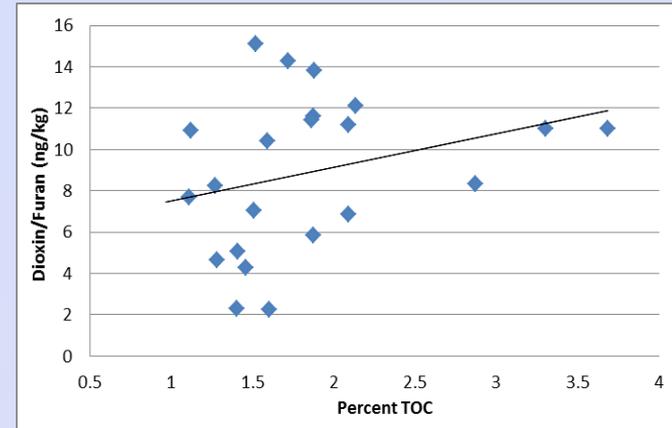
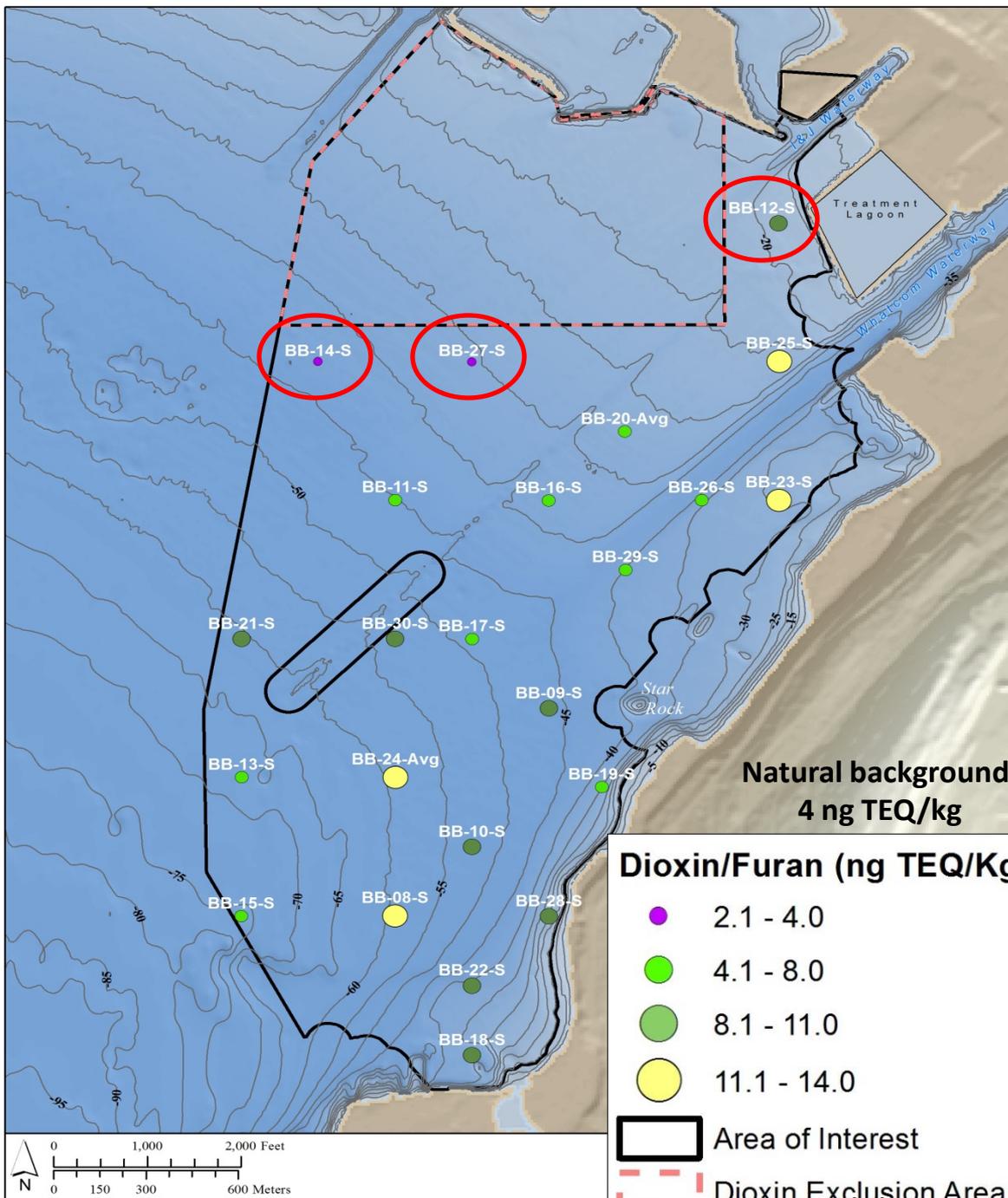
- Correlation coefficient w/ TOC
 - r – value = 0.751
- Excludes:
 - BB-12 (TOC = 20.8%)
 - BB-28 (cPAH = 2000 $\mu\text{g TEQ/kg}$)



µg TEQ/kg	
Summary Statistics	
Sample Size	28
Minimum	7.4
Average	30
Median	21
Maximum	94

Dioxins/Furans TEQ

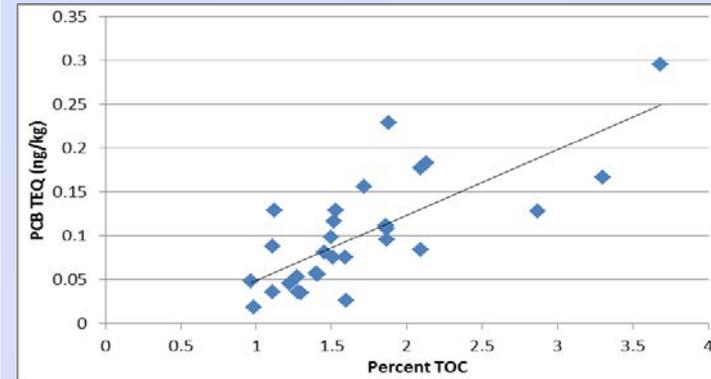
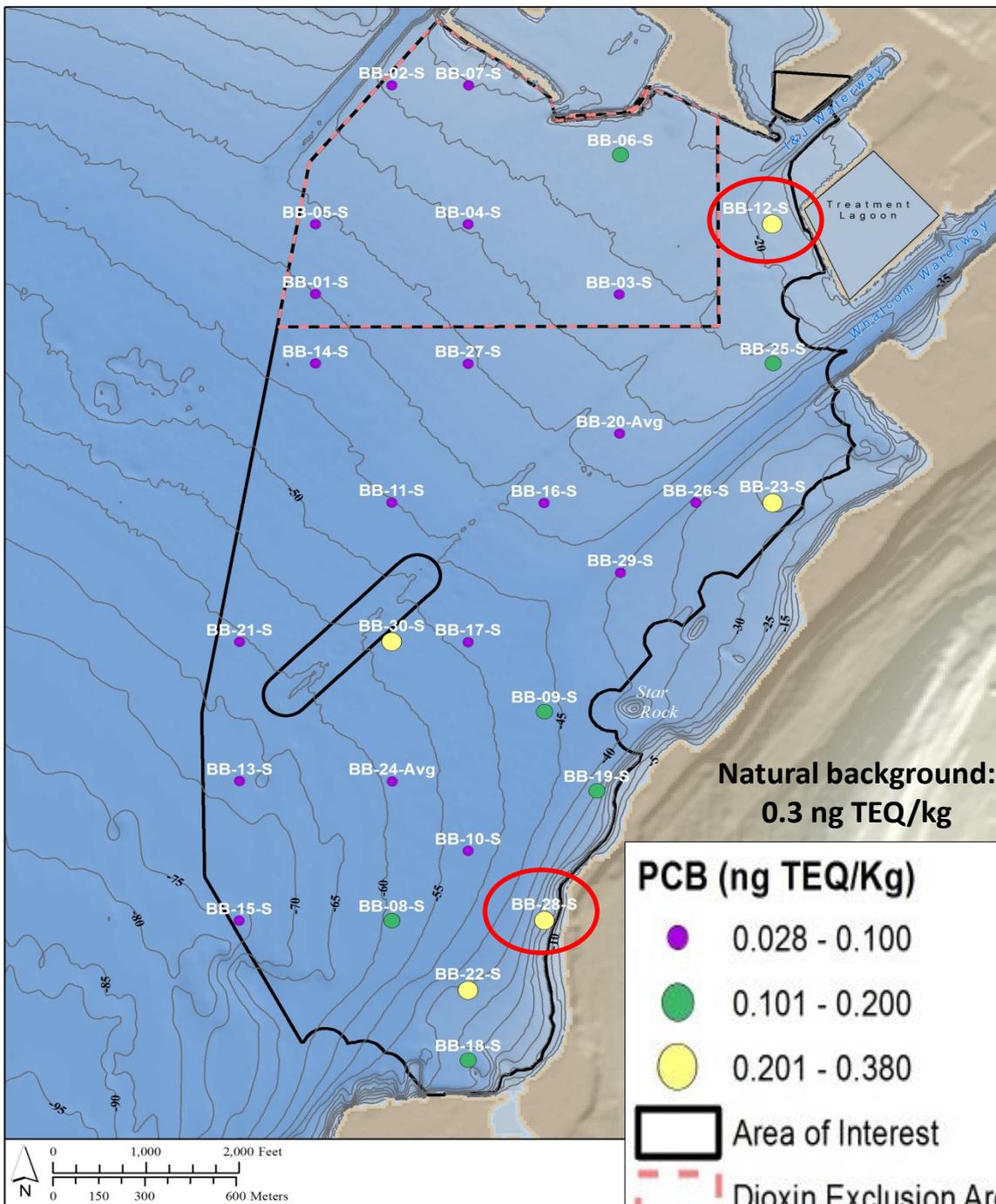
- Correlation coefficient w/ TOC
 - r – value = 0.300
- Excludes:
 - BB-12 (TOC = 20.8%)
 - BB-14 & 27 (\leq NB)



ng TEQ/kg	
Summary Statistics	
Sample Size	20
Minimum	4.2
Average	9.3
Median	10
Maximum	14

PCB Congeners TEQ

- Correlation coefficient w/ TOC
 - $r = 0.750$
- Excludes:
 - BB-12 (TOC = 20.8%)
 - BB-28 (0.28 ng TEQ/kg)



ng TEQ/kg	
Summary Statistics	
Sample Size	28
Minimum	0.03
Average	0.10
Median	0.09
Maximum	0.25



Statistical Analysis of Results

Lorraine Read

TerraStat Consulting Group

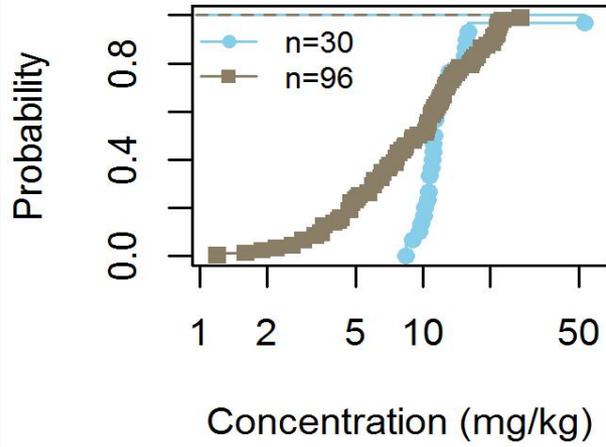
Analysis of Results from Baseline Locations

- Initial results were evaluated using empirical cumulative distribution functions (ECDF) plots and box plots.
- Some Notes on Interpreting ECDF Plots:
 - The concentration is shown on the x-axis.
 - The cumulative probability is shown on the y-axis.
 - The shape of the curve describes the distribution of the data:
 - Curves shifted to the right indicate higher concentrations.
 - Steeper curves have less variance (i.e., many samples within a small concentration range).
 - Flatter or skewed curves have larger variance (i.e., fewer samples across a large concentration range).
- Bellingham Bay preliminary results were compared to the Bold Plus natural background data set using ECDF plots and box plots.

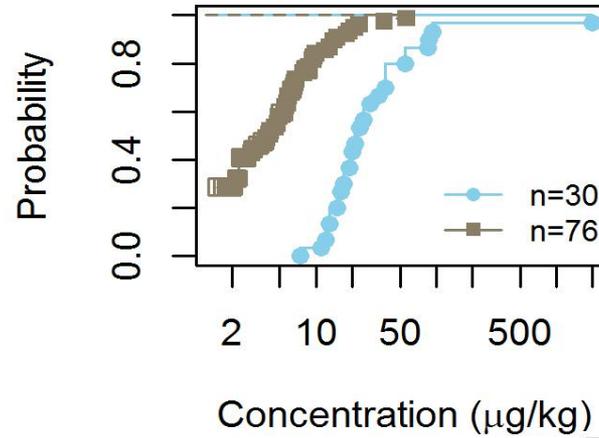
ECDF Plots for CoCs

Dry Weight Concentrations

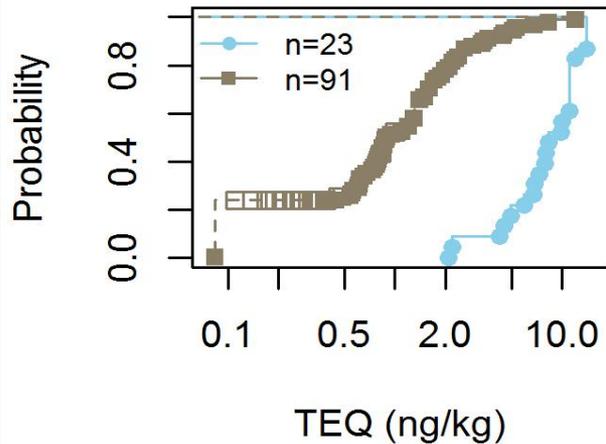
Lead



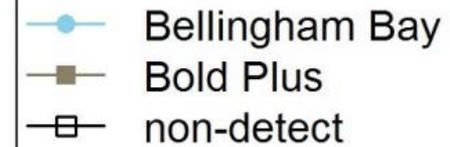
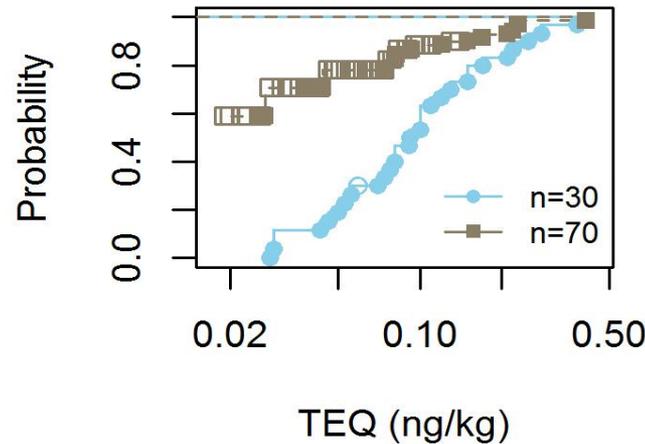
cPAH TEQ



Dioxin/Furan TEQ



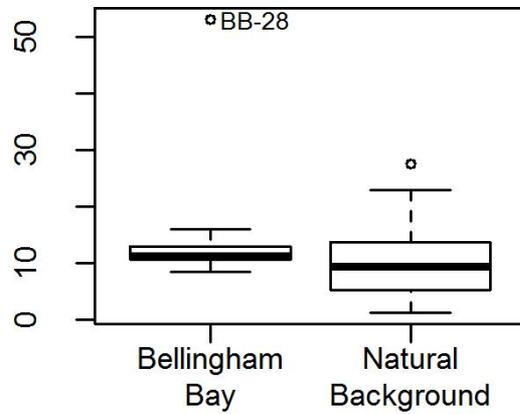
PCBs TEQ



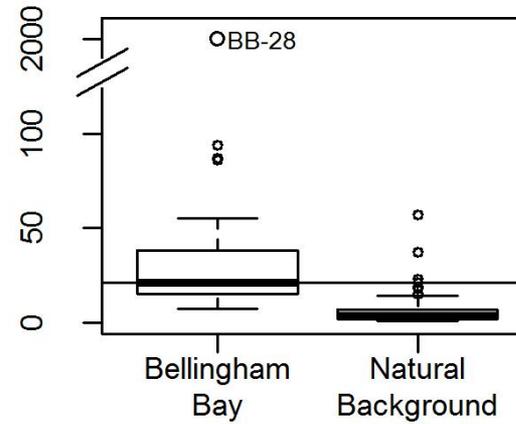
Boxplots for CoCs

Dry Weight Concentrations

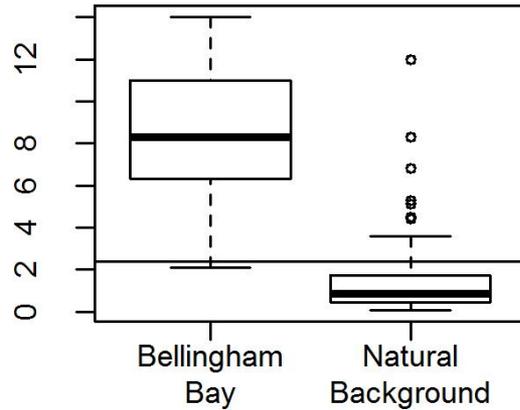
Lead (mg/kg)



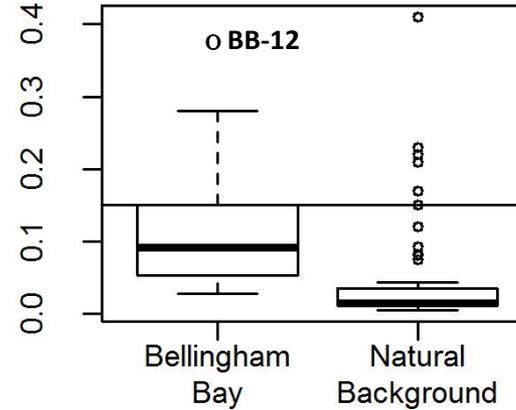
cPAH TEQ ($\mu\text{g/kg}$)



D/F TEQ (ng/kg)



PCB TEQ (ng/kg)



Weight of Evidence Approach for Outlier Analysis

- AOI and Bold Plus natural background distributions compared:
 - Visually for entire distribution and using 90/90 UTLs
 - If AOI distribution is within natural background distribution, no further evaluation
 - If AOI distribution exceeds natural background, potential outliers further evaluated
- Statistical analysis is conducted to identify potential outliers:
 - Q-Q plots
 - Box plots
 - Univariate outlier tests appropriate to the distribution
 - Bivariate and multivariate exploratory analyses

Weight of Evidence Approach for Outlier Analysis

- Determine if an elevated station is directly impacted by a site or source. If so, the affected analytes may be removed from the data set.
- If not directly impacted by a source, conduct further evaluation:
 - Gradients or patterns
 - Correlations with natural geologic factors
 - Sediment transport processes
- Calculate 90/90 UTLs with and without any elevated values and/or statistically identified outliers. May retain analytes in the data set if results are within the range of analytical variability or not significantly different.

Summary: Stations Removed from Data Set

- **Station BB-12:**
 - Had >20% TOC; ~4X the natural maximum in Puget Sound.
 - Had 5X TOC than other stations and was a statistical outlier for TOC.
 - Direct anthropogenic influence (wood waste observed during sampling).
 - For these reasons, we removed all analytes from the data set.
- **Station BB-28:**
 - Identified as a statistical outlier for cPAHs and lead.
 - Had much higher concentrations of lead and cPAHs than other stations.
 - May be due to a former refueling station source of lead, cPAHs, PCBs.
 - For these reasons, we removed lead, cPAHs, and PCBs from the data set.
- **Stations BB-14 & 27:**
 - These stations are near the boundary of the dioxin AOI and within the natural background footprint for dioxins/furans.
 - For this reason, we removed dioxins/furans from the data set .

Bellingham Bay Data Set and BOLD Plus Natural Background

Analyte	Units	Bellingham Bay 90/90 UTL	BOLD Plus 90/90/UTL
cPAH TEQ	ppb	86	16
Dioxins/Furans TEQ	ppt	15	4
Lead	ppm	16	21
PCB TEQ	ppt	0.2	0.2

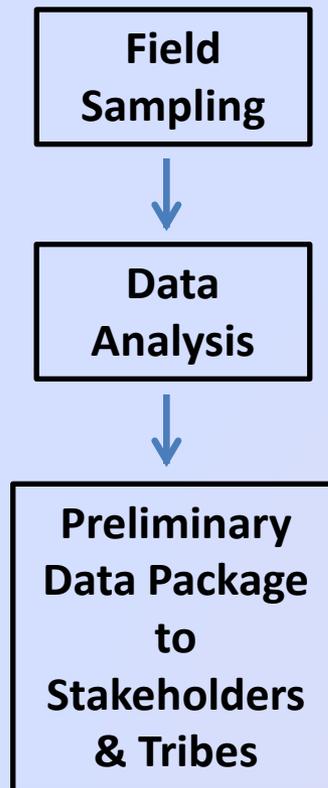
- cPAH and dioxin/furan TEQs are higher than natural background.
- Lead and PCB TEQ are within natural background.

Bellingham Bay Regional Background Timeline & Next Steps

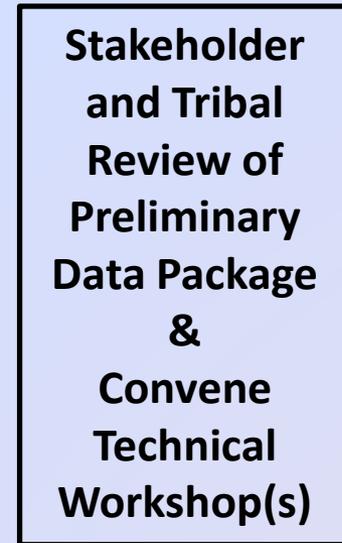
July - August 2014



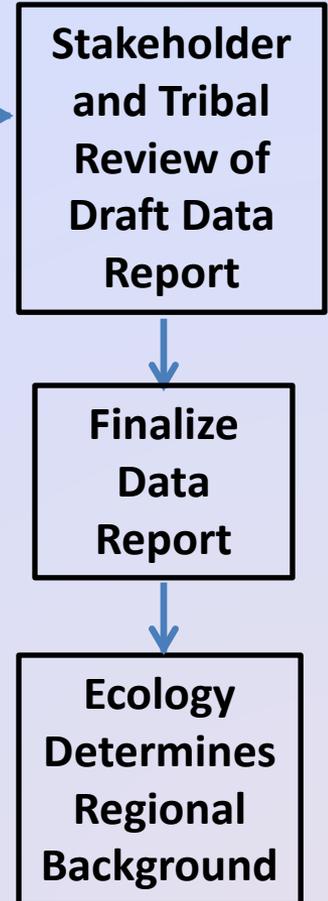
Fall 2014



Fall/Winter 2014



Early 2015





Questions and Discussion Session