Commencement Bay PCB, PBDE, & Dioxin/Furan Monitoring Symposium

UNIVERSITY of WASHINGTON

Photo courtesy of Eyes Over Puget Sound

AGENDA

Time	Topic	Presenter
9:00 AM	Welcome	UW (Joel Baker)
9:05 AM	Setting the Stage	UW (Andy James) Port of Tacoma (Rob Healy)
9:15 AM	Commencement Bay Nearshore/Tideflats Site Remediation	Port of Tacoma (Rob Healy)
9:30 AM	Commencement Bay Remedy Effectiveness Monitoring	Anchor QEA (Clay Patmont)
10:00 AM	Q&A	
10:15 AM	Break	
10:30 AM	Commencement Bay Biota Monitoring	WDFW (Andrea Carey & Mariko Langness)
11:00 AM	Commencement Bay Water Monitoring	Ecology (Alex Gipe)
11:30 AM	Q&A	
11:45 AM	Lunch	
12:30 PM	Thea Foss Watershed Source Controls	City of Tacoma (Dana de Leon)
1:00 PM	Q&A	Port of Tacoma (Rob Healy)
1:15 PM	Break	
1:30 PM	Commencement Bay Source Tracking Programs	UW (Joel Baker & Andy James) Port of Tacoma (Rob Healy)
3:20 PM	Next Steps	UW (Marielle Kanojia)
3:30 PM	Conclusion	

WHY WE'RE HERE

Suspect ongoing sources

- Despite ongoing management efforts, there continues to be elevated levels of PCBs and PBDEs in water, fish, and mussels in the Hylebos, Blair, and Sitcum Waterways

- Dioxin furans have been detected above screening levels at certain locations within the Blair Waterway

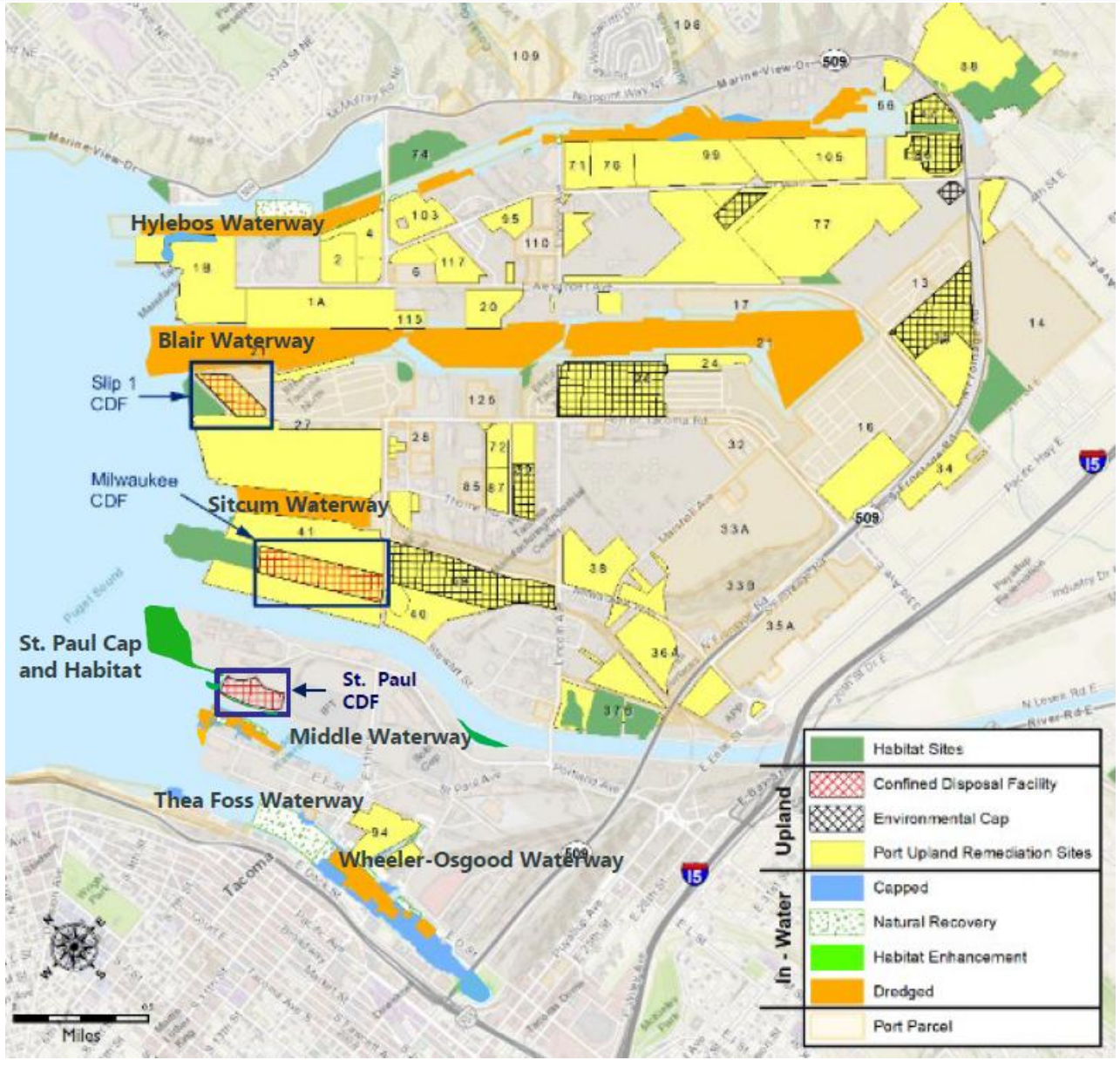
WHY WE'RE HERE

Opportunity to implement/augment source identification programs

- Recent award of two National Estuary Program grants to advance source tracking and characterize mass loadings through different pathways.
- Plan to coordinate closely between these two projects, and ongoing monitoring work.
- Work will be guided by new and existing monitoring information.
- Primary goals of this symposium is to share existing information to develop a common understanding on condition, potential sources, and information gaps.

Setting the Stage

- Significant Port investments to cleanup and restore Commencement Bay
- The latest monitoring indicates a continued source of bioaccumulative compounds from unknown and likely disperse sources.
- The plan is to develop a source tracing and monitoring system throughout the Sitcum, Blair, and Hylebos watershed.
- The purpose is to identify contaminant sources, allowing for appropriate and efficient regulatory responses to eliminate those sources of contamination.



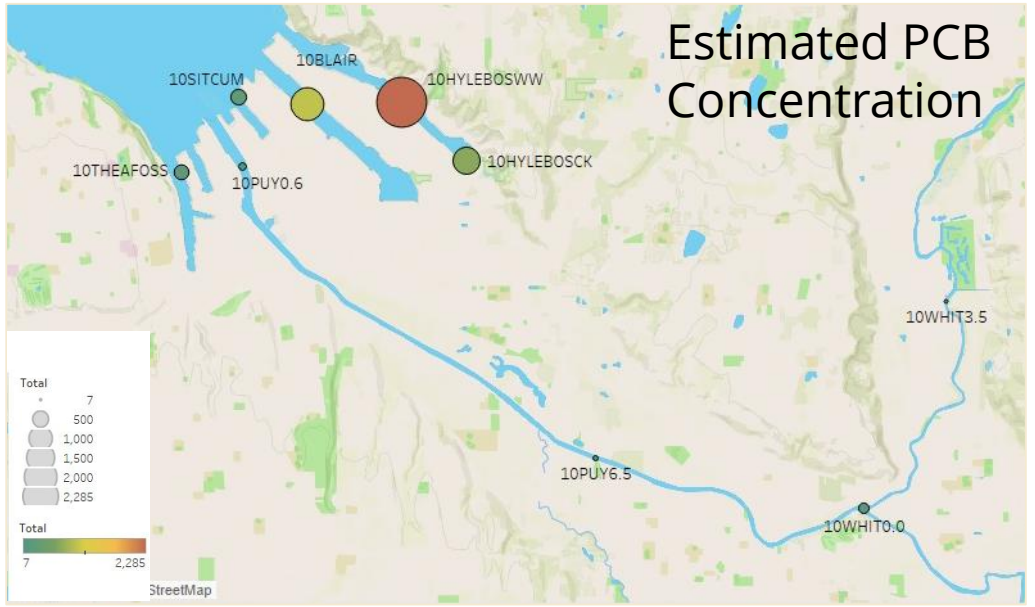
GENERAL APPROACH

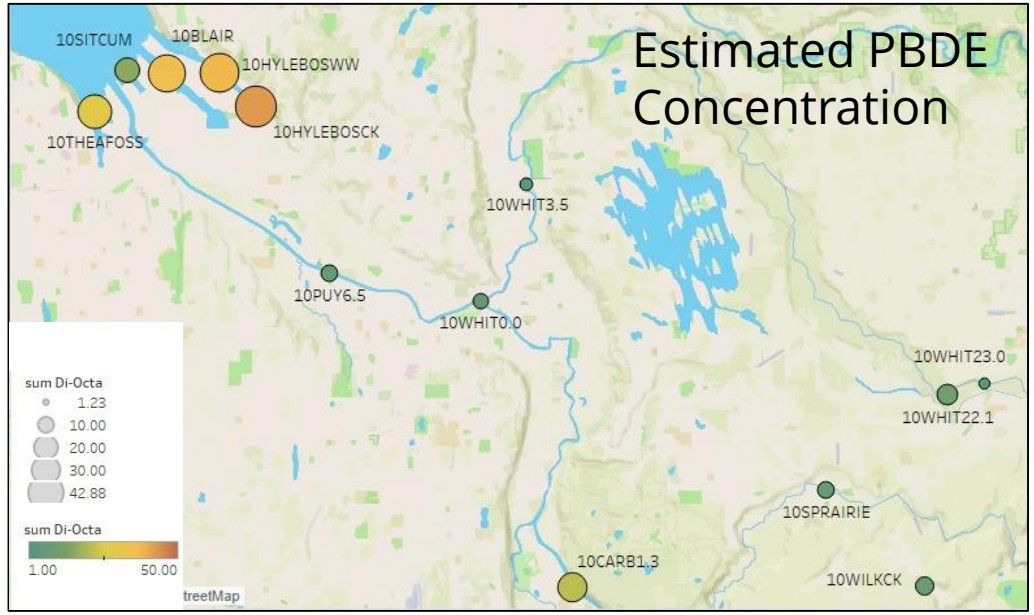
- Monitoring to be performed based on conceptual model of potential loading
  - Focus on potential pathways (e.g., air deposition), sites, and mobilization events

- Use existing information to guide first deployments
  - Surface water monitoring (Gipe, 2024)
  - Sediment monitoring (Port of Tacoma and others)
  - Land use assessment and watershed characterization (Anchor QEA)

- Update locations based on new results

- Locations finalized with input from Technical Advisory Committee





Data from Gipe, 2024

Preliminary Results
Do Not Cite

GENERAL APPROACH

University of Washington Tacoma and Ecology

- Air deposition sampling
- Surface water monitoring – within waterways and working up selected watersheds
- Sediment flux monitoring

Port of Tacoma

- Land use assessment
- Surface water monitoring – selected watersheds
- Sediment deposition

SYMPOSIUM

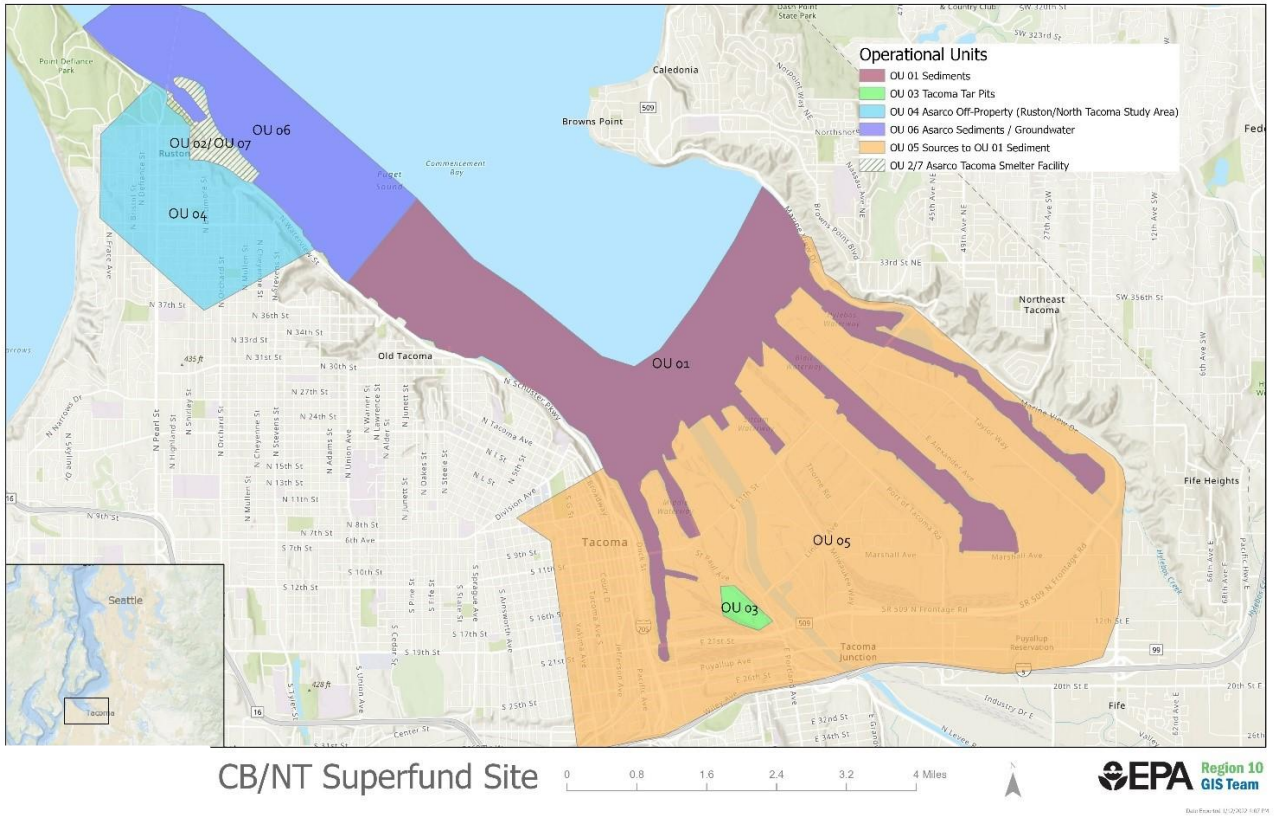
- Establish a common understanding of remediation and monitoring activities in Commencement Bay.

- Establish a common understanding of condition.

- Based on this:
  - Refine the conceptual model of contaminant loading
  - Refine the potential location of sources (and monitoring)
  - Develop and implement a better monitoring program

Commencement Bay Remedy Overview

- 7 Operable Units
- OU1 Sediments/OU5 Sources
  - 8 Problem areas – Tideflats area
  - First Superfund sediment “megasite” (1983)
  - 800 acres
  - Over 100 responsible parties



Objectives of Remediation

- Control sources early
- Achieve specified sediment concentrations
- Reduce fish tissue => reference area
- Maintain functional habitat and enhance fisheries

Refinements to Remedy

- 5 Explanations of Significant Differences (ESDs)
- Specified:
  - Dredging areas and volumes
  - Disposal locations
  - Capping areas
  - Natural recovery areas
- Added enhanced natural recovery
- Changed PCB cleanup goal

Cleanup Remedy Components

Fish advisory

DEPARTMENT OF ECOLOGY State of Washington

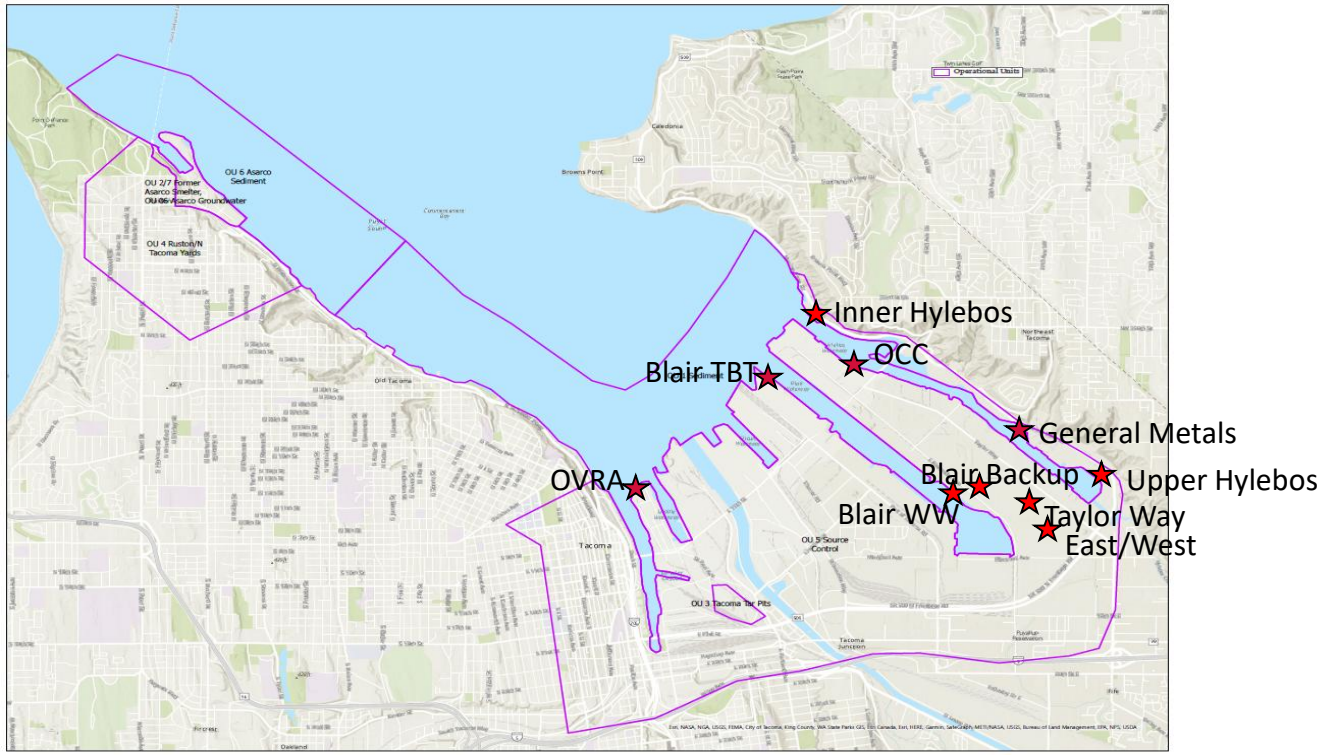
Source control

Dredge and cap above remedial action levels

Monitored natural recovery 10 years post-construction

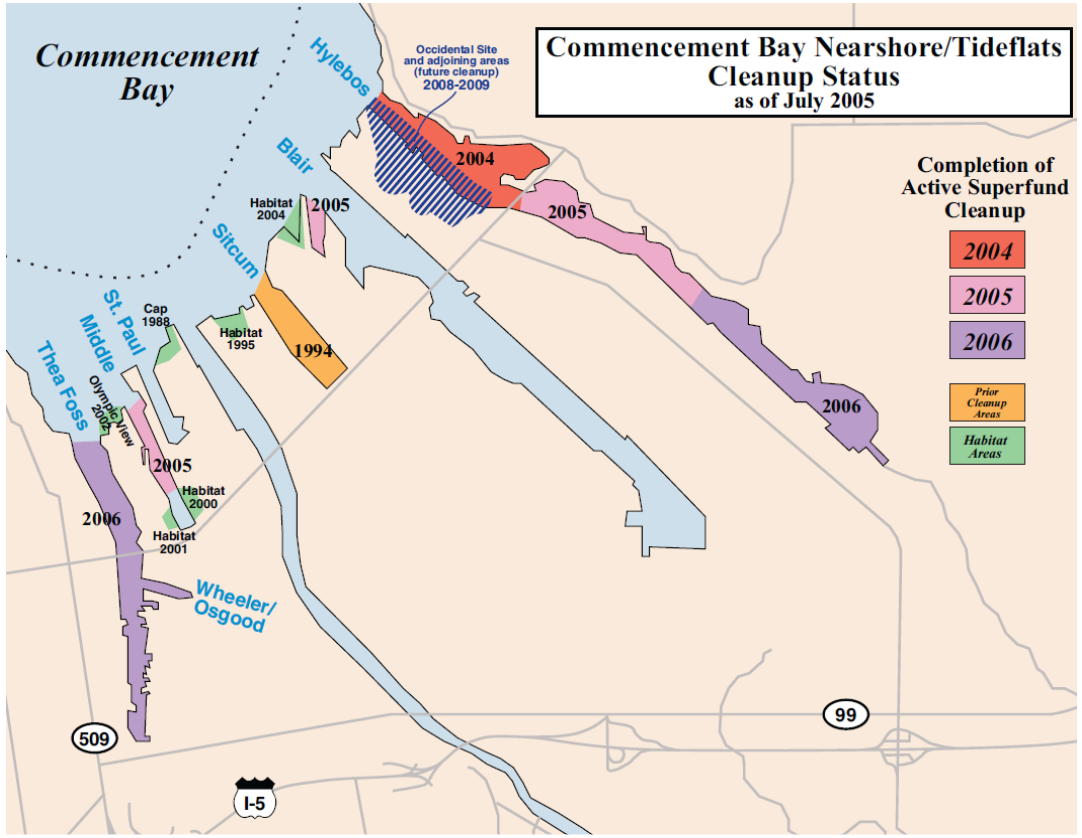
Additional Removal Actions

- Puyallup Land Claim
- General Metals
- Olympic View Resource Area (OVRA)
- Blair TBT
- Occidental (OCC)



Timeline of Remedial Actions

- 1985: Fish and shellfish advisory
- 1988: St. Paul cap and habitat
- 1989: ROD
- 1990 – 2001: Source controls
- 1994 – 2006: Dredging and capping
- 1996: Partial Superfund deletions
- 1997 – 2004: 5 ESDs
- Ongoing: Long-term monitoring and maintenance

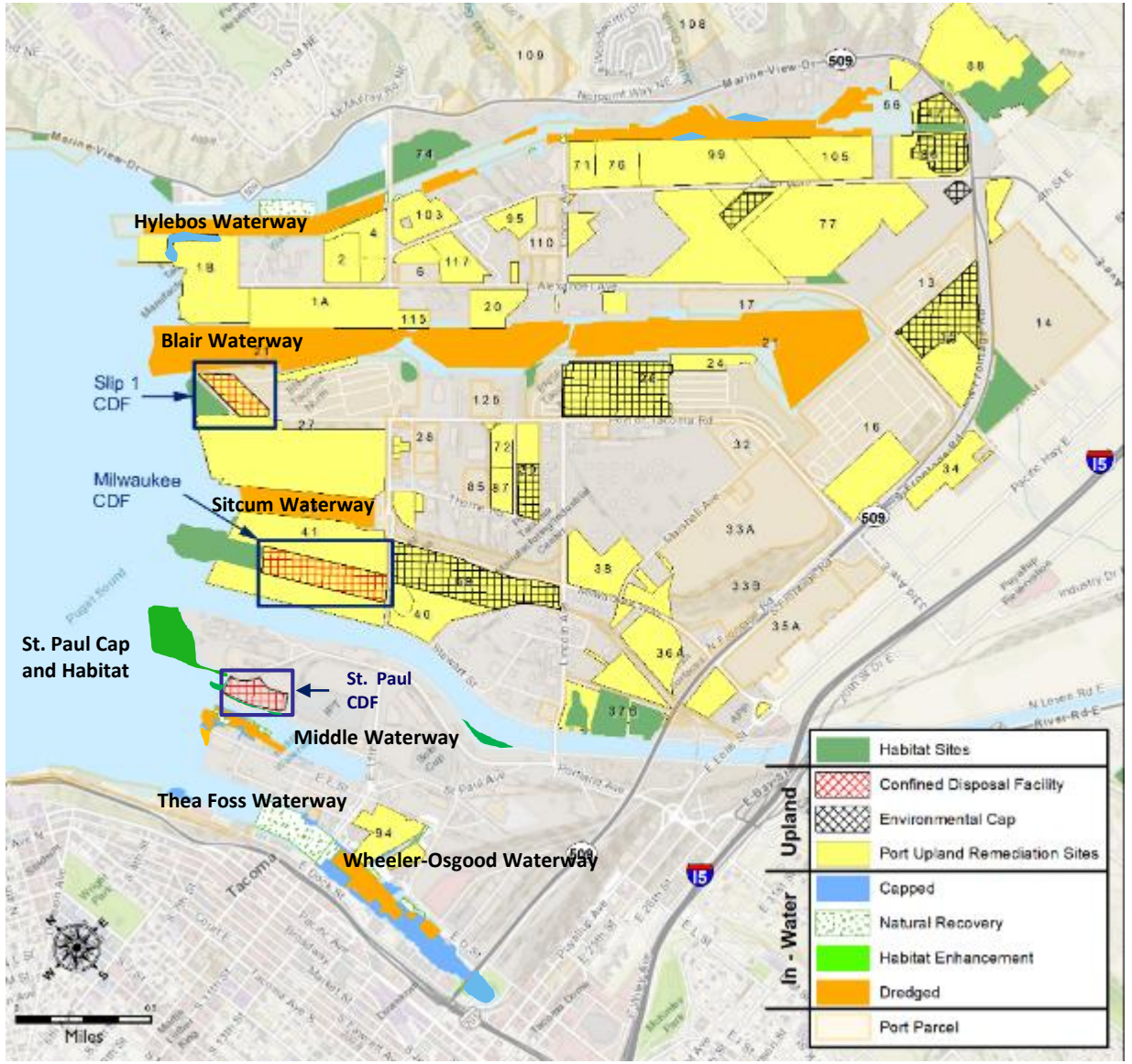


Upland and Nearshore Source Controls

- More work than anticipated
- Started pre-ROD
- Milestone reports – completed in 2001
- 2 major sources still not controlled
- Post-construction recontamination
  - Additional source/response actions
  - Anticipated localized recontamination - phthalates
  - Superfund cannot deal with widespread contamination (no identified source)

Summary of Remedy

- Greater than $600 million
- 500 acres dredged
  - 2,400,000 cubic yards (cy) to three confined disposal facilities (CDFs)
  - 400,000 cy to off-site landfills
  - 200,000 cy to open-water disposal
- 40 acres capped
- 60 acres monitored or enhanced natural recovery
- Coordinated with restoration, navigation, and urban renewal



Source: Port of Tacoma 2019

Significant Remedy Schedule and Scope Deviations

- Source control took longer – delayed construction
- PCB cancer slope changed
- Problem areas increased to entire waterways
- Dredge prism expansion (area & depth)
- Habitat mitigation requirements changed
- Cost (3x greater than pre-design estimates)
- Additional removal actions

COMMENCEMENT BAY PCB, PBDE, & DIOXIN/FURAN MONITORING SYMPOSIUM

Commencement Bay Sediment Cleanup Remedy Effectiveness Monitoring

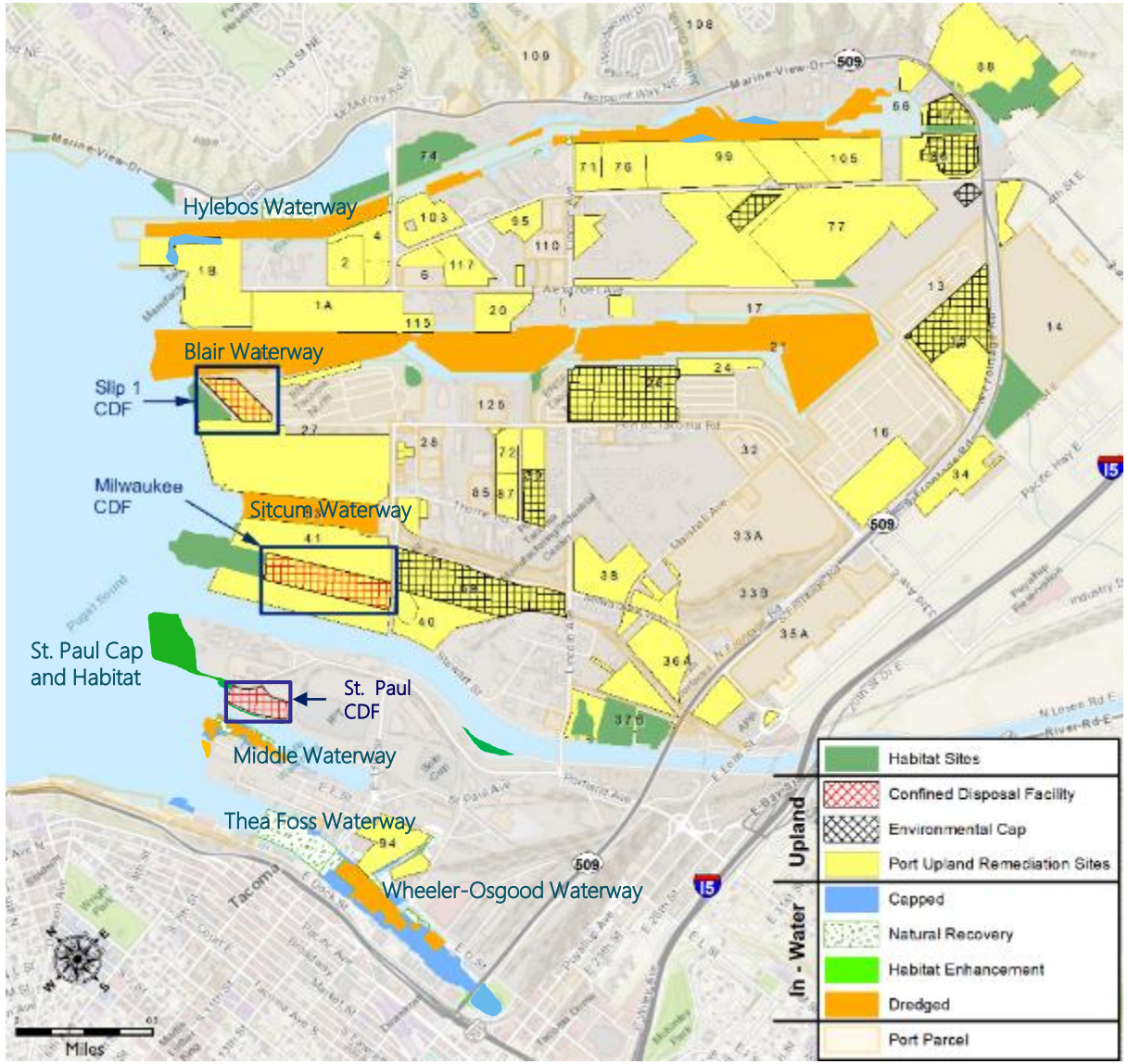
Presented by: Clay Patmont, Anchor QEA

Collaborator: Rob Healy, Port of Tacoma

ANCHOR QEA

Cleanup Remedy Summary

- > $700 million
- Early source controls
- 500 acres dredged
  - 2,400,000 cubic yards (cy) to three confined disposal facilities (CDFs)
  - 400,000 cy to off-site landfills
  - 200,000 cy to open-water disposal
- 100 acres capped or 10-year natural recovery
- Coordinated with restoration, navigation, and urban renewal

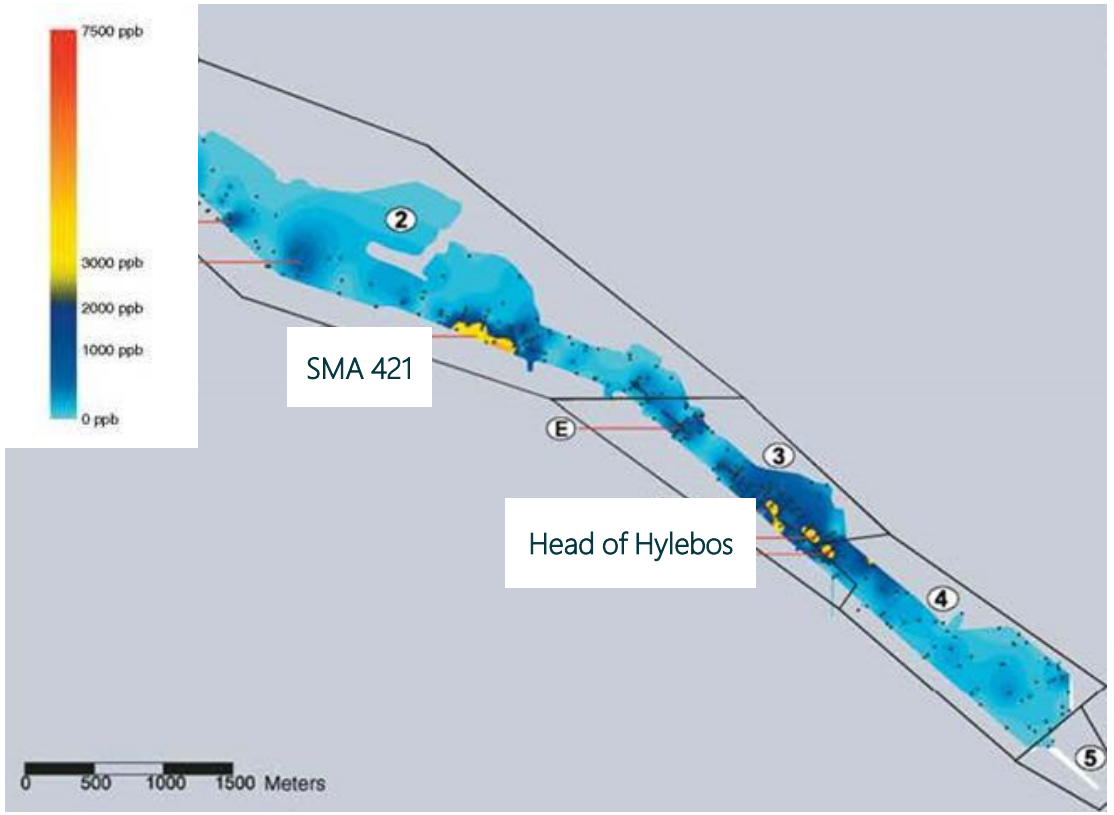


Source: Port of Tacoma (2019)

Hylebos Waterway Remedy

- 1990 - 1999 source controls
  - Wastewater/stormwater controls and upland remediation
  - Sediment Management Area (SMA) 421
    - PCB “hot-spot”
    - 1999 shoreline PCB source control
- 2004 - 2006 remediation
  - 1.2 million cubic yards sediment dredged (24 acres)
  - 11 acres capped or 10-year natural recovery

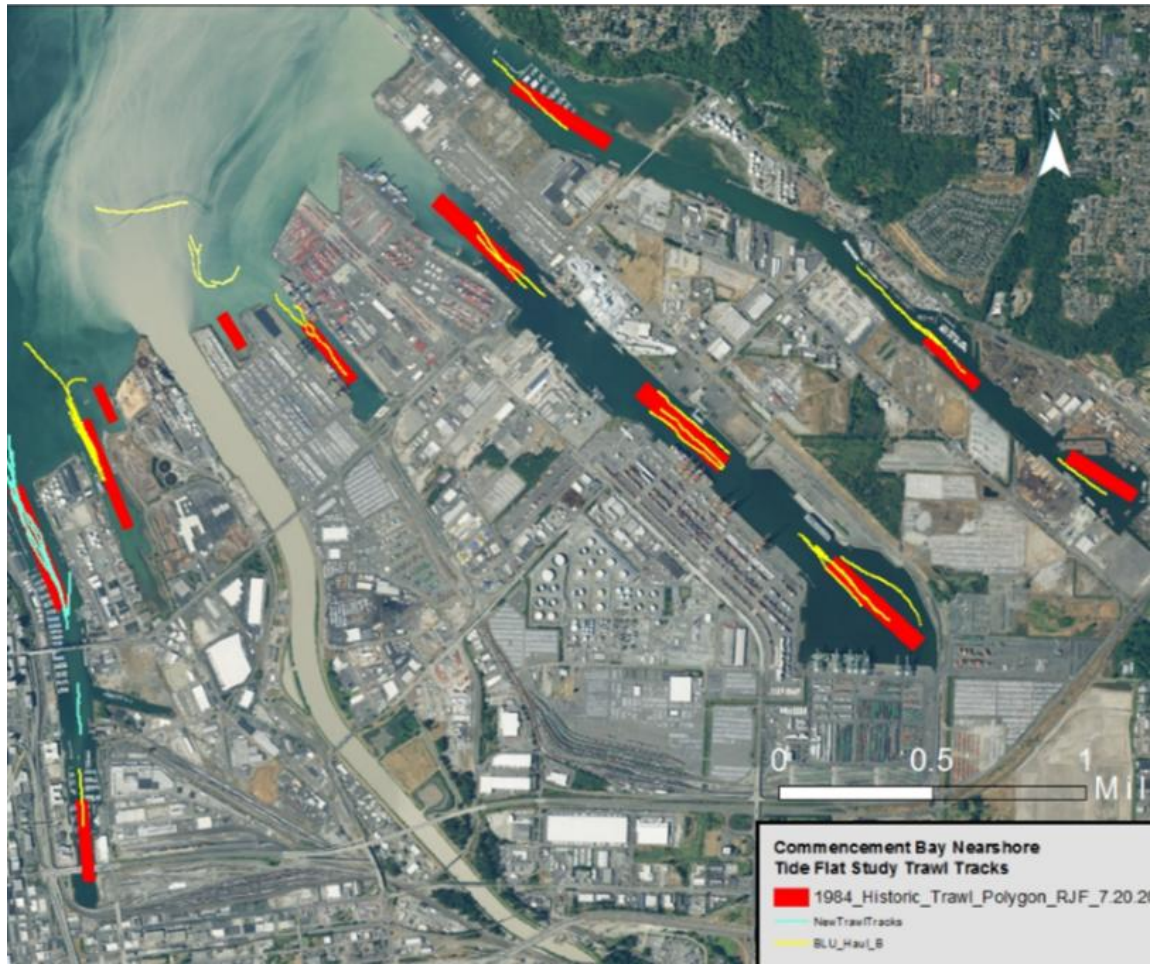
1994 - 1998 Surface Sediment Total PCB Concentrations in Hylebos Waterway



Source: McLaren and Beveridge (2006)

Remedy Effectiveness Monitoring

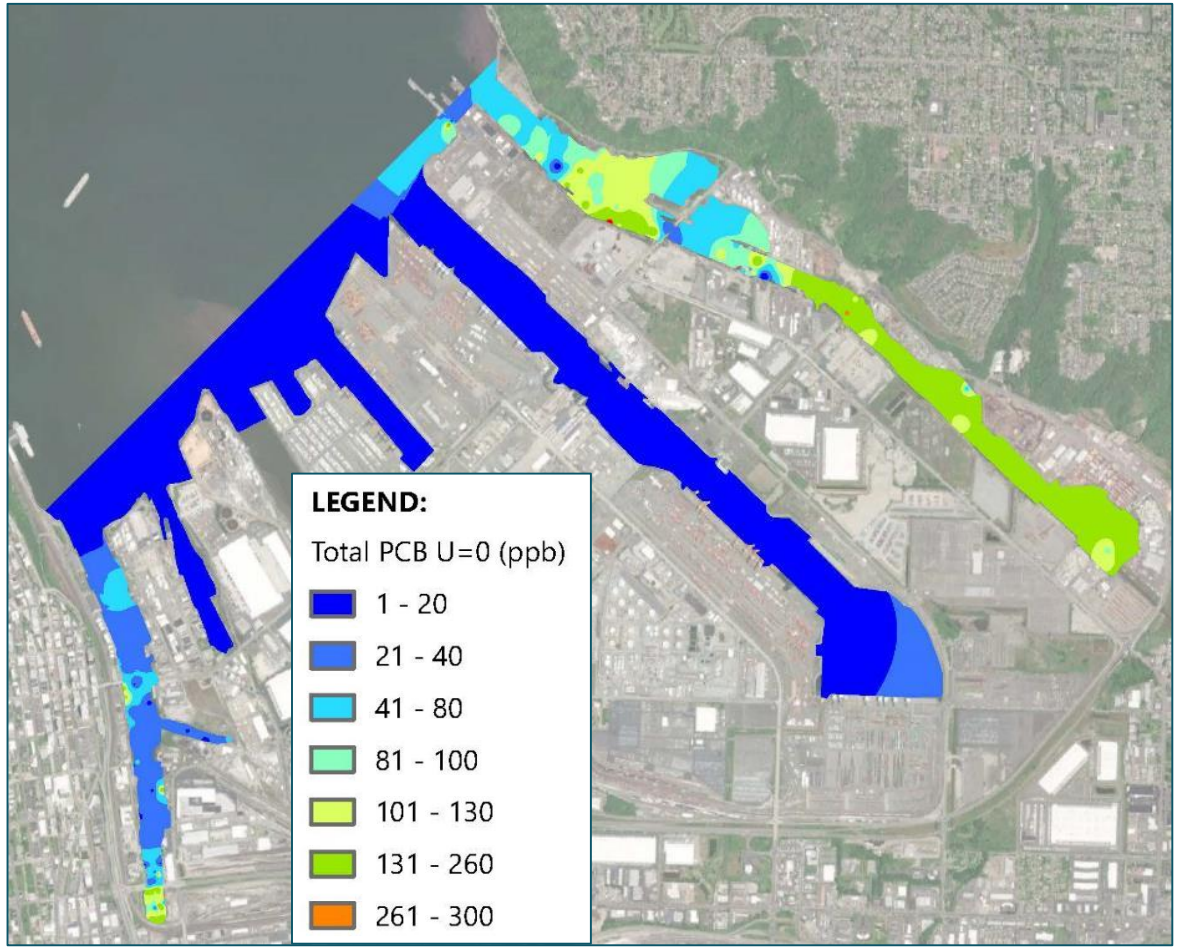
- Surface sediment
  - Chemical concentrations
  - Confirmatory toxicity bioassays
- Fish tissue
  - English sole muscle tissue PCB levels
  - Reference area comparison (Carr Inlet)



Source: Washington State Department of Fish and Wildlife (2019)

Surface Sediment Cleanup Levels Achieved

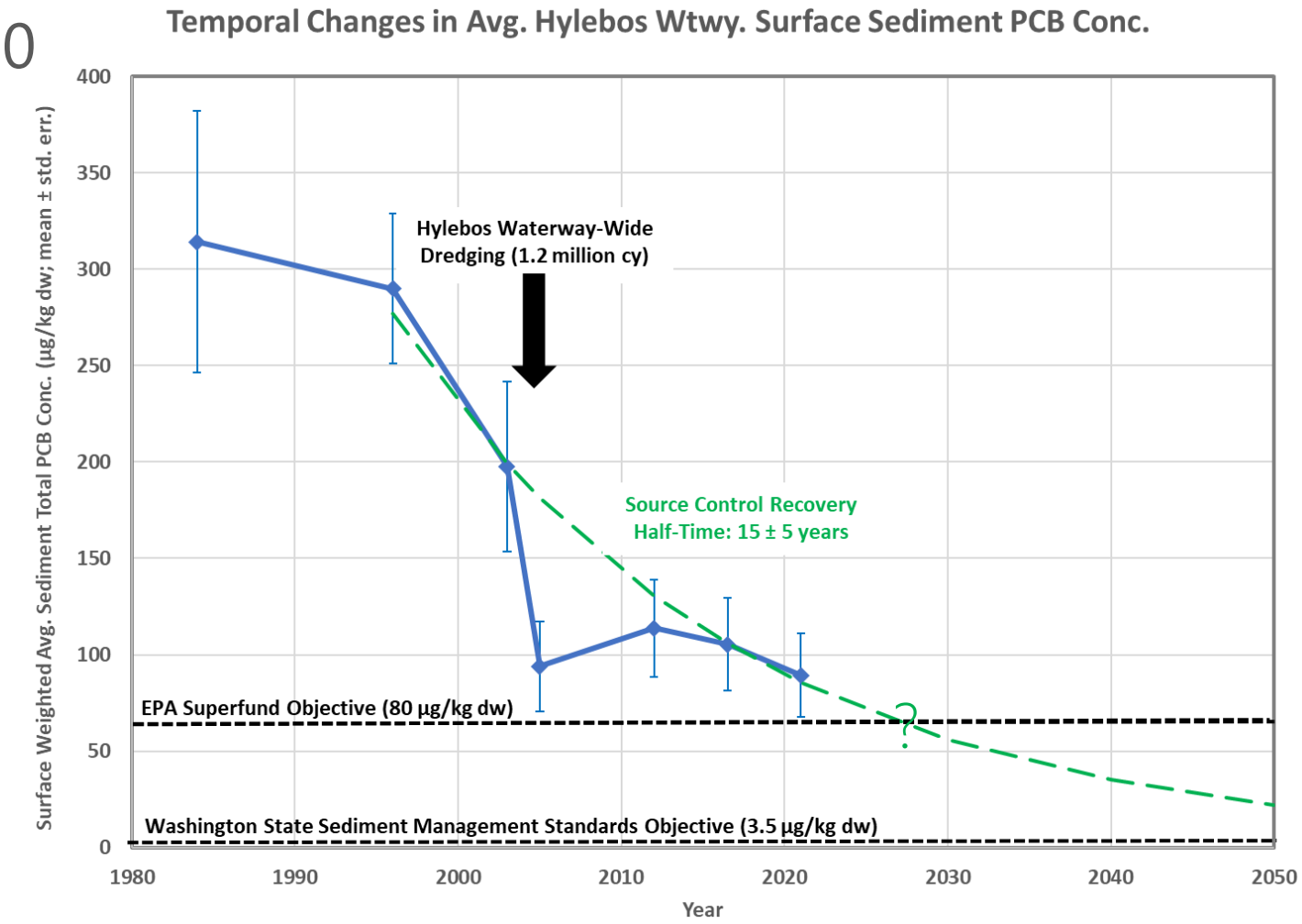
- Concentrations reduced below Superfund sediment cleanup levels
  - Benthic toxicity < cleanup level
    - Bioassay confirmation
  - Total PCBs < 300 ppb cleanup level
  - Localized exceedances:
    - Stormwater outfalls
    - Under-pier embankments



Source: Anchor QEA (2022)

Hylebos Waterway Surface Sediment PCB Trends

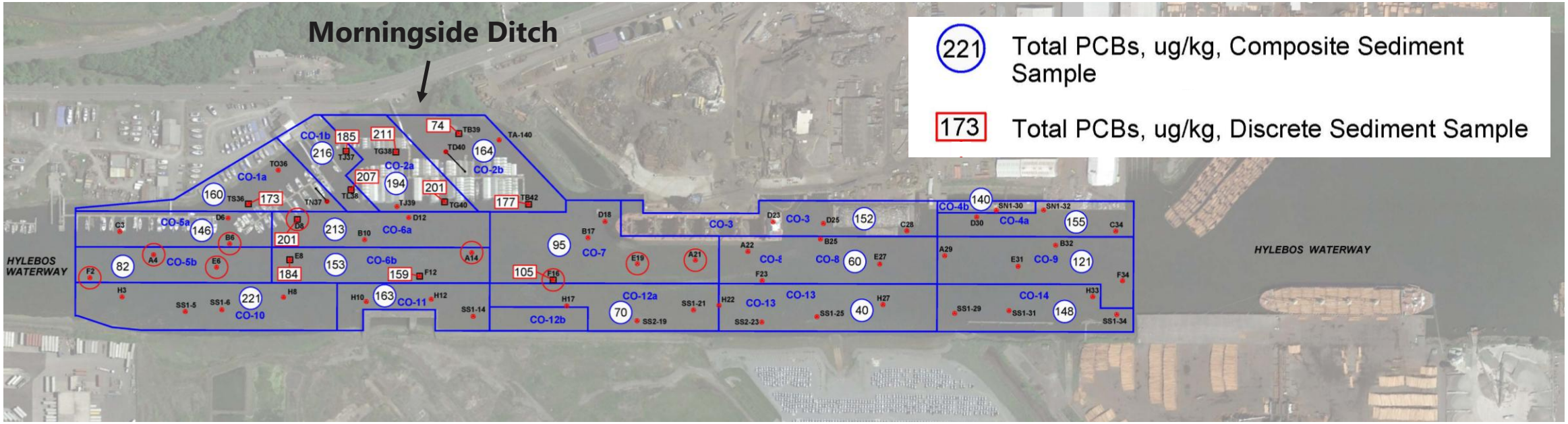
- PCB source controls since 1990
  - Recovery half-time: 15 ± 5 yrs
  - Source controls continuing
- Sediment equilibrium after source controls and dredging
  - Rapid SMA 421 recovery after 1999 source control of eroding shoreline PCB "hot-spot"
  - Recontamination from ongoing lower-level PCB sources after 2006 Head of Hylebos dredging



Source: Anchor QEA (2022)

Head of Hylebos 2021 Surface Sediment PCB Levels

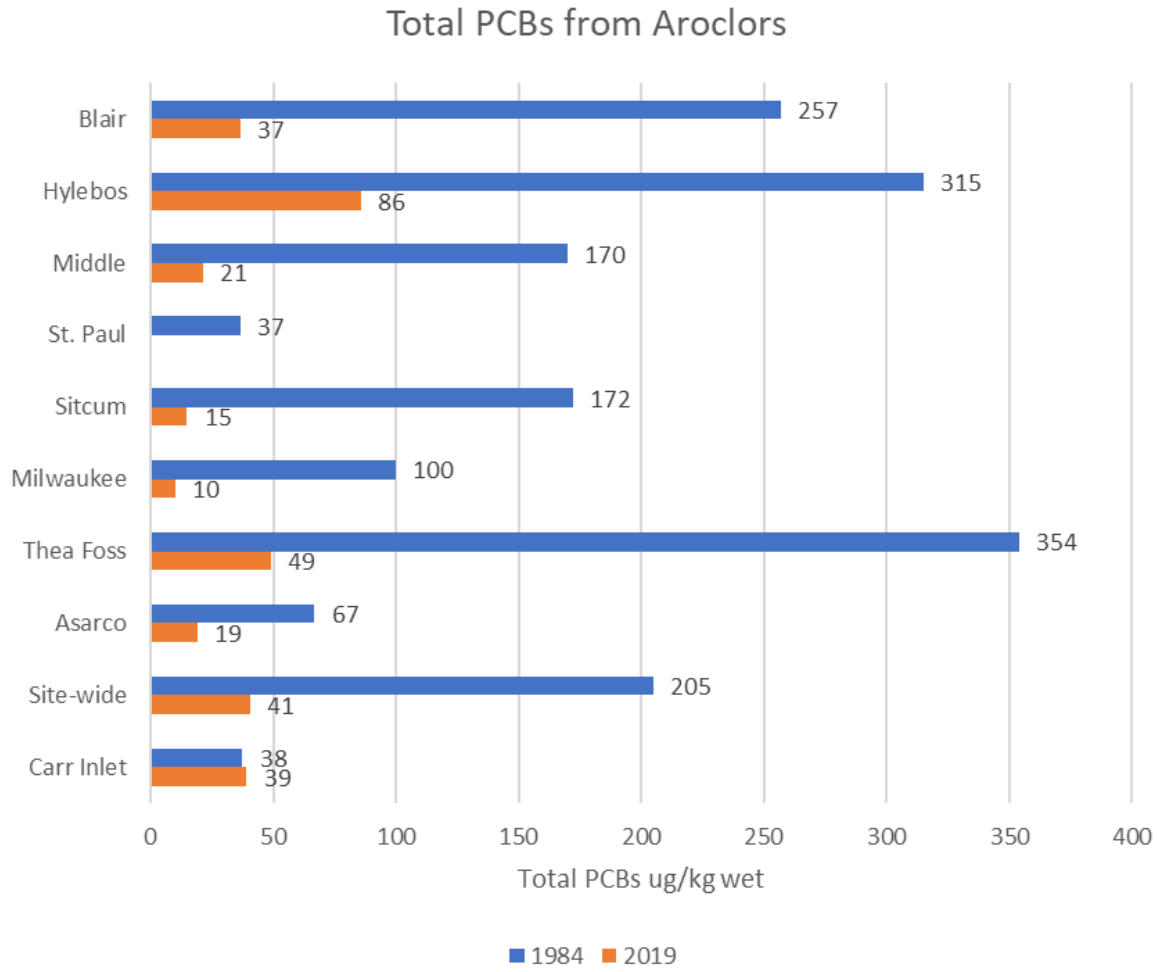
- All concentrations < Superfund sediment cleanup level (300 µg/kg)
- Concentration distributions consistent with lower-level ongoing PCB source within Morningside Ditch watershed



Source: DOF (2021)

PCB Bioaccumulation Objectives Achieved

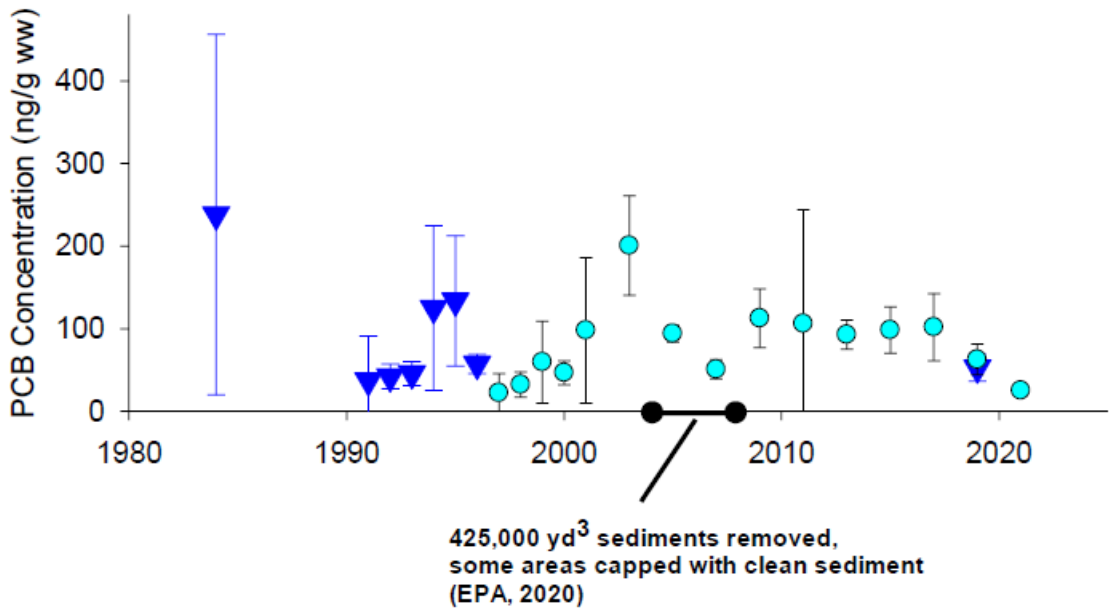
- Pre-remedy sampling - 1984
- Post-remedy sampling - 2019
- 2019 site-wide English sole muscle tissue Total PCB concentration no different than Carr Inlet
  - 80% lower than 1984 levels



Source: Washington State Department of Fish and Wildlife (2019)

Tissue PCB Trends: Thea Foss Waterway Mouth

- Changes in analytical methods
- No long-term trends over last 30 yrs
  - Initial source control reduction
  - Peaks during dredging
  - Uncertain sediment contribution to PCB bioaccumulation



Source: Washington State Department of Fish and Wildlife (2022)

Hylebos Waterway Dioxin/Furan Evaluation

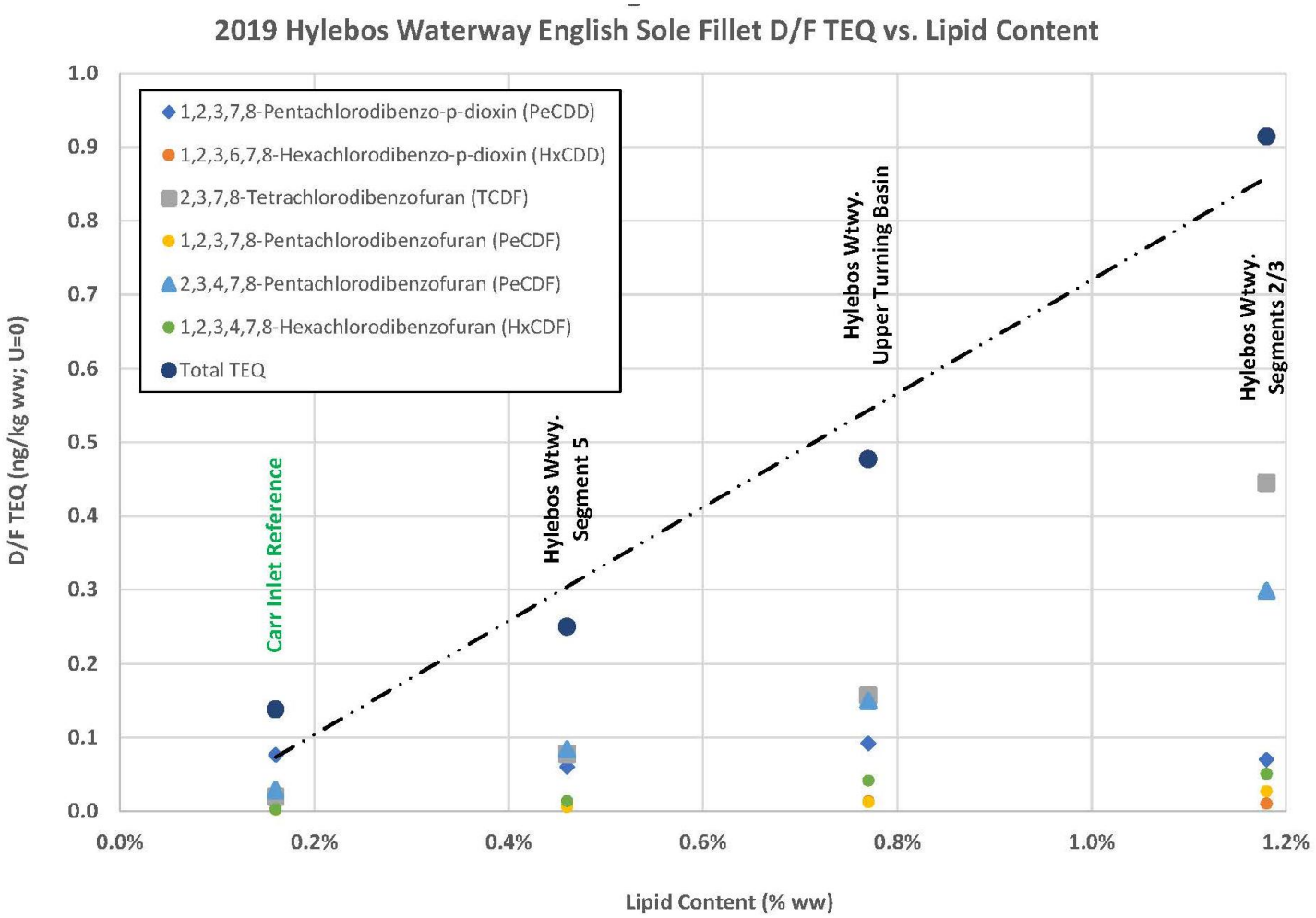
- Composite sampling (2019 - 2021)

Sampling Area	Surface Sediment Dioxin/Furan TEQ (ng/kg)	Sediment Porewater Dioxin/Furan TEQ (pg/L)	English Sole Muscle Tissue Dioxin/Furan TEQ (ng/kg)
Carr Inlet Reference	1	--	0.14
Upper Turning Basin	176	0.43	0.48
Segments 2/3 (Hylebos Head)	124	0.31	0.91
Segment 4	65	0.33	--
Segment 5 (Hylebos Mouth)	69	0.08	0.25

Source: Anchor QEA (2024)

Hylebos Waterway Dioxin/Furan Evaluation

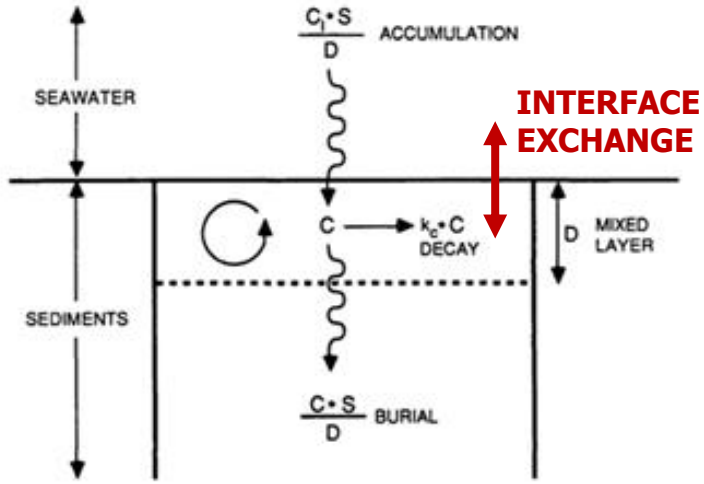
- English sole muscle tissue dioxin/furan concentrations correlated with lipid levels
  - No difference between lipid-normalized concentrations in Carr Inlet and Hylebos Wtwy.
- Dioxins/furans sequestered in Hylebos Wtwy. sediment
  - Black (soot) carbon matrix
  - Biota-sediment accumulation factor 100 times lower than other areas (e.g., Budd Inlet)

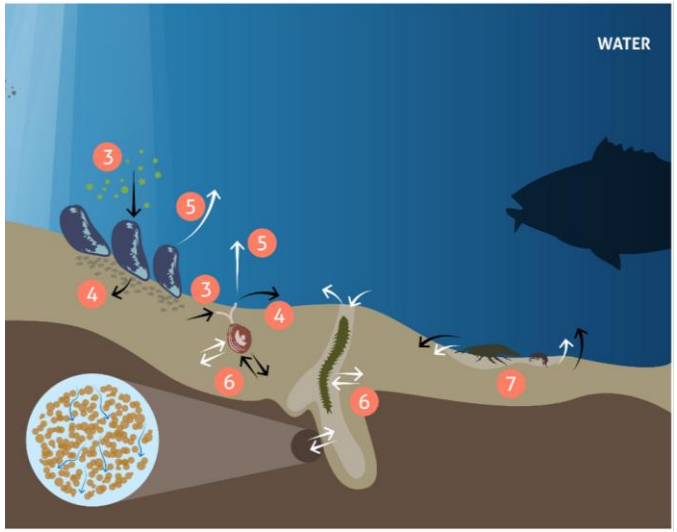


Source: Anchor QEA (2024)

Two Surface Sediment Recovery/Equilibrium Processes

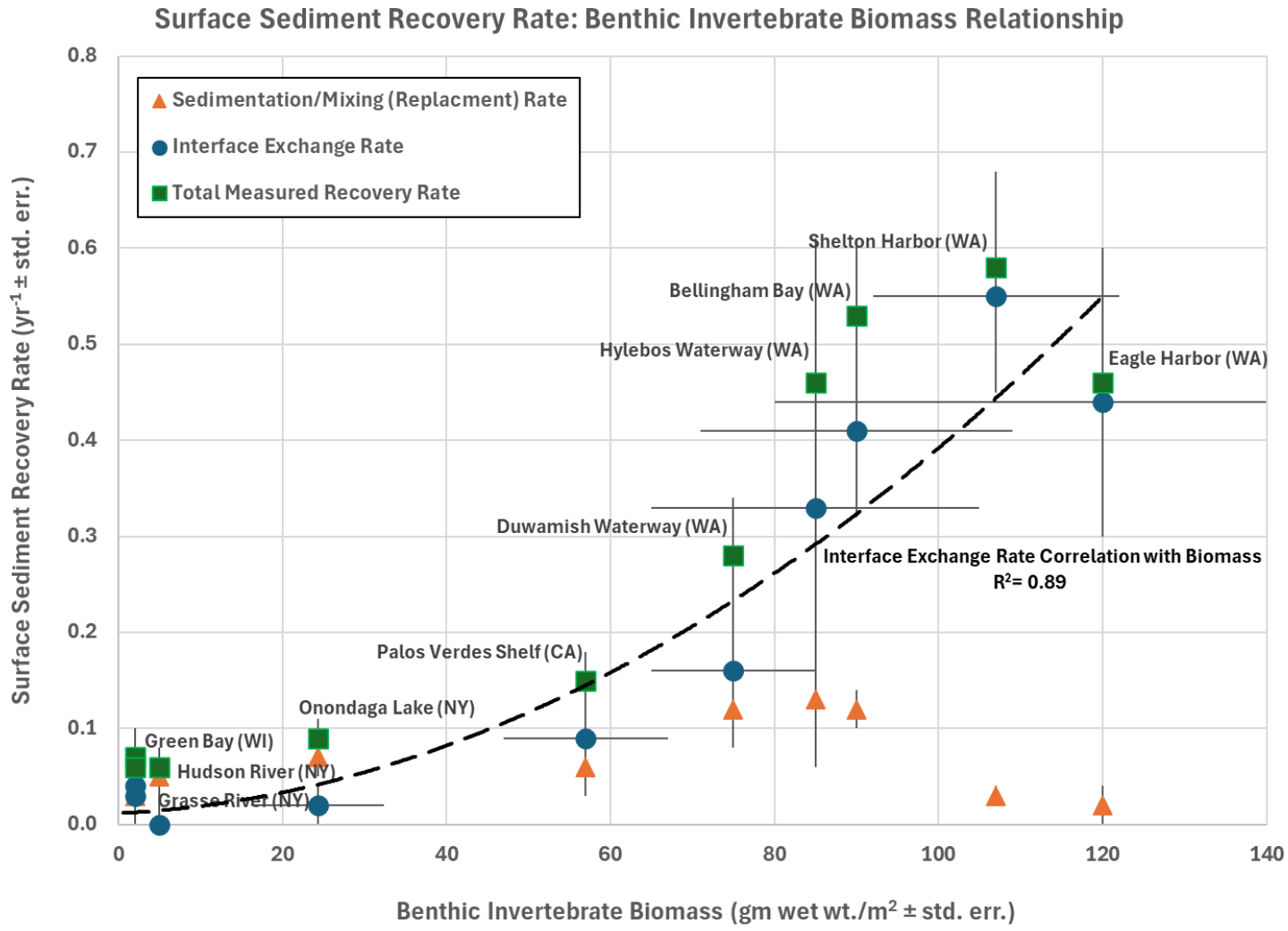
1. Sedimentation/mixing (replacement)
   - Net sediment accumulation
   - Surface sediment mixed layer
   - Measured with ^{210}Lead and ^{137}Cesium radioisotopes
   - Typical replacement rates of 5 - 10%/year
2. Interface exchange
   - Porewater and sediment transfer across interface
   - Driven by benthic biological processes (e.g., feeding)
   - Measured with ^{222}Radon radioisotope and full-scale source control/sediment remedy monitoring





Full Scale Sediment Monitoring Case Study Data

- Measured Puget Sound surface sediment recovery rates of 30 - 60%/year
  - Faster than sedimentation/ mixing (replacement) rates
- Interface exchange rate correlated with benthic invertebrate biomass
  - Feeding, bioirrigation, and bioresuspension processes
  - Corroborated with ^{222}Radon radioisotope measurements



Source: Patmont et al. (2025)

Summary

- Rapid equilibration (30 - 60%/year) of Puget Sound surface sediments
  - Revealed by timely/robust monitoring of full-scale source control/cleanup actions
  - Equilibration rates average 5 - 6 times faster than sedimentation/mixing rates
  - Attributable to benthos interface exchange (e.g., bioirrigation, bioresuspension)
- Source controls in an adaptive management framework can effectively reduce bioaccumulation exposures
  - Paradigm shift needed from broad-scale sediment cleanup?

Q&A

Break

PCBs and PBDEs in Biota from Commencement Bay and the Waterways

Andrea Carey, **Mariko Langness**, Louisa Harding, Molly Shuman-Goodier, Wes Flynn, Dwight Causey, Natasha Winnacott, Robert Fisk, Danielle Nordstrom, Andrew Beckman and Sandra O'Neill

Toxics Biological Observation System (TBiOS)

Washington Department of FISH and WILDLIFE

Talk Outline

- TBiOS Overview
- Juvenile Chinook
- Caged Mussels
- Other Species

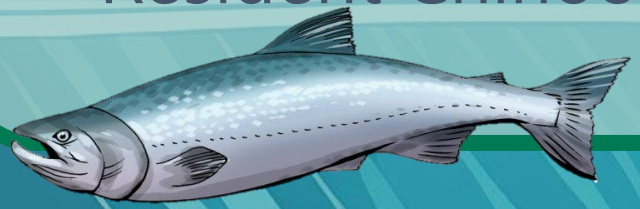
WDFW Toxics Biological Observation System

TBiOS works to understand:

- ***Where*** are fish and shellfish at greatest risk?
- ***What species and life stages*** are at most risk?
- ***Which chemicals*** are causing harm?
- What are the ***health impacts?***
- ***What is the trend***… are conditions improving or worsening?

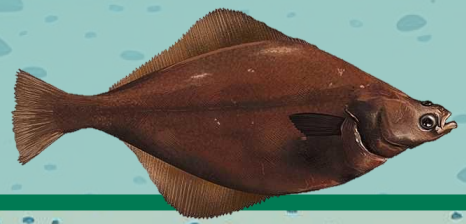
TBiOS Indicator Species

Pelagic (open water) habitat
- Pacific herring
- Resident Chinook salmon

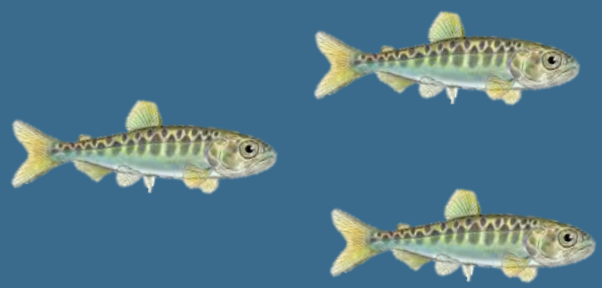


Nearshore habitat
- Transplanted caged mussels
- Juvenile Chinook salmon

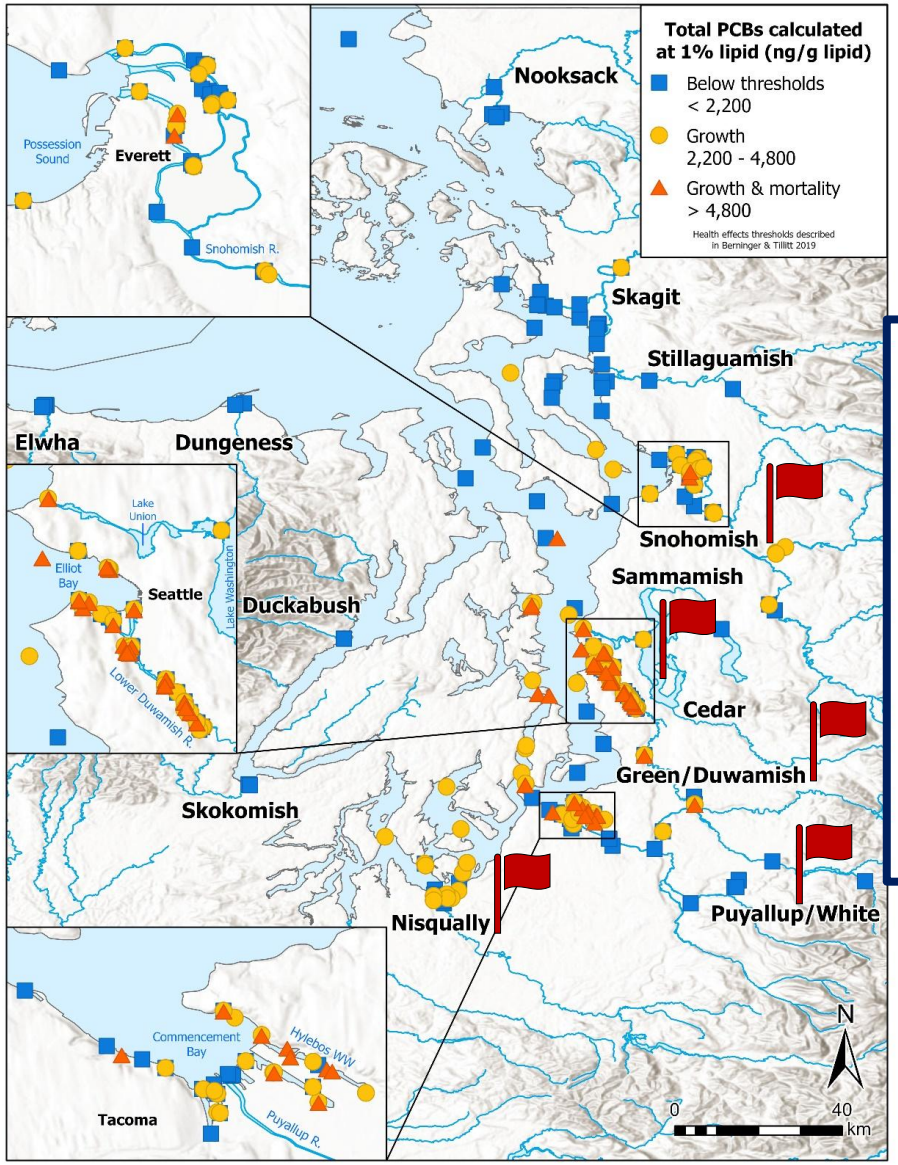
Benthic (seafloor) habitat
- English sole



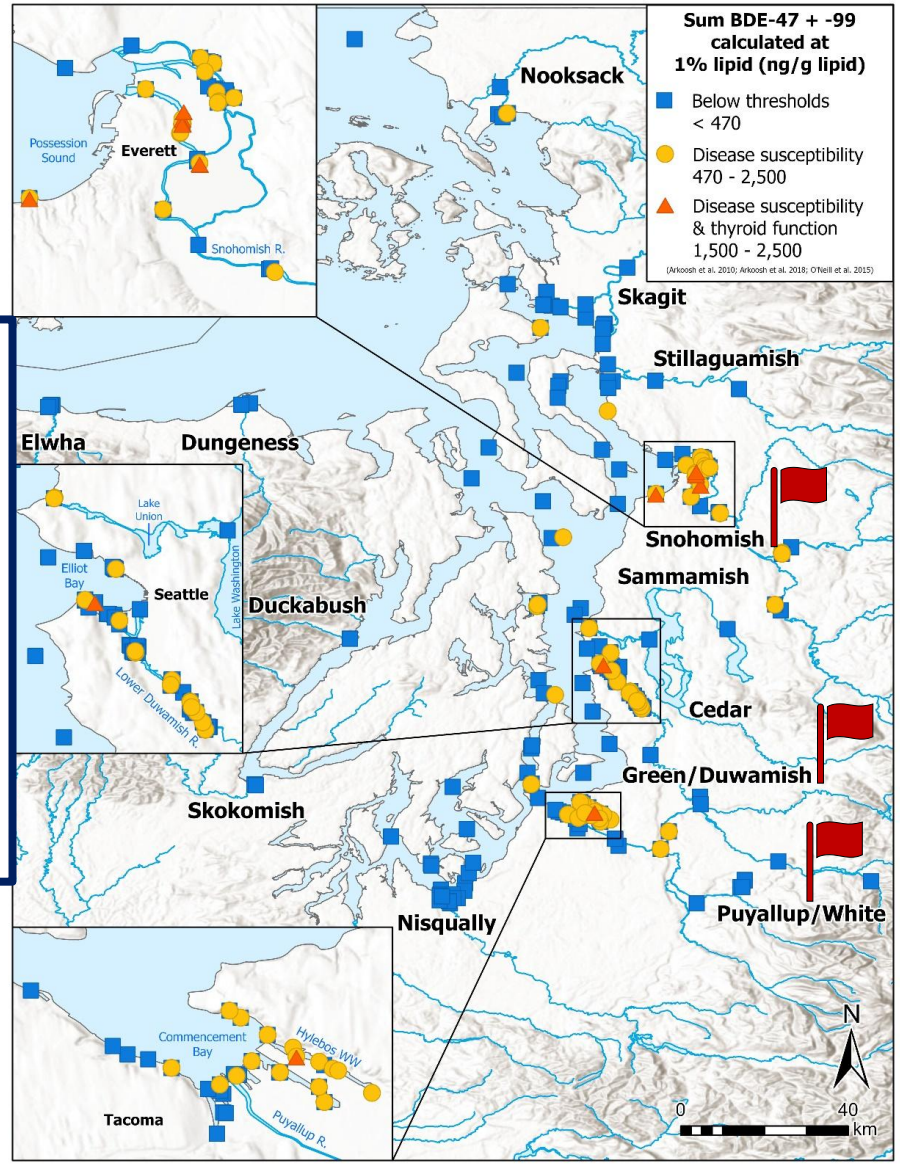
Juvenile Chinook salmon



Why we're here…

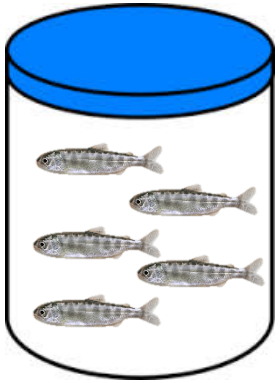


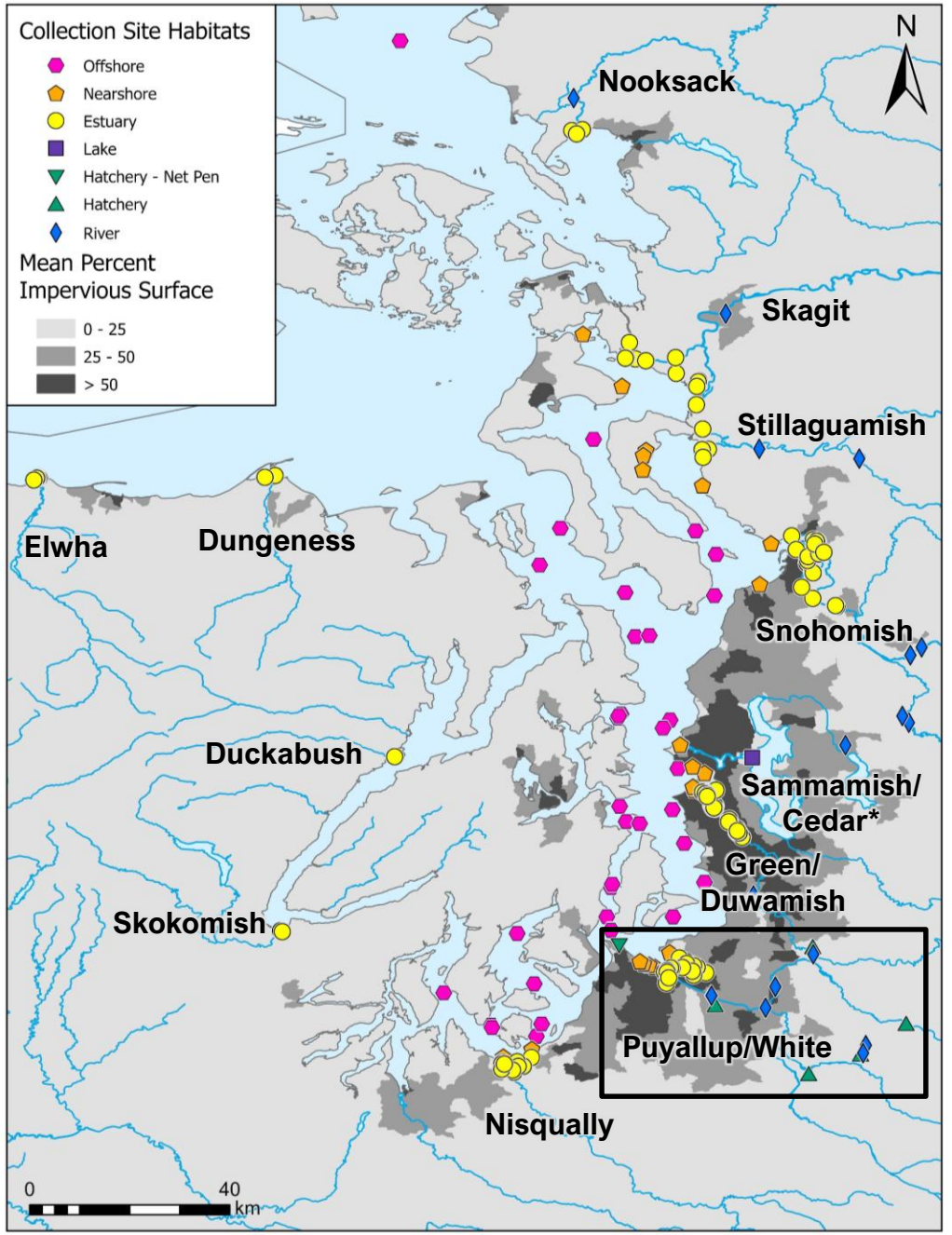
PCBs and PBDEs are impacting the health of juvenile Chinook salmon



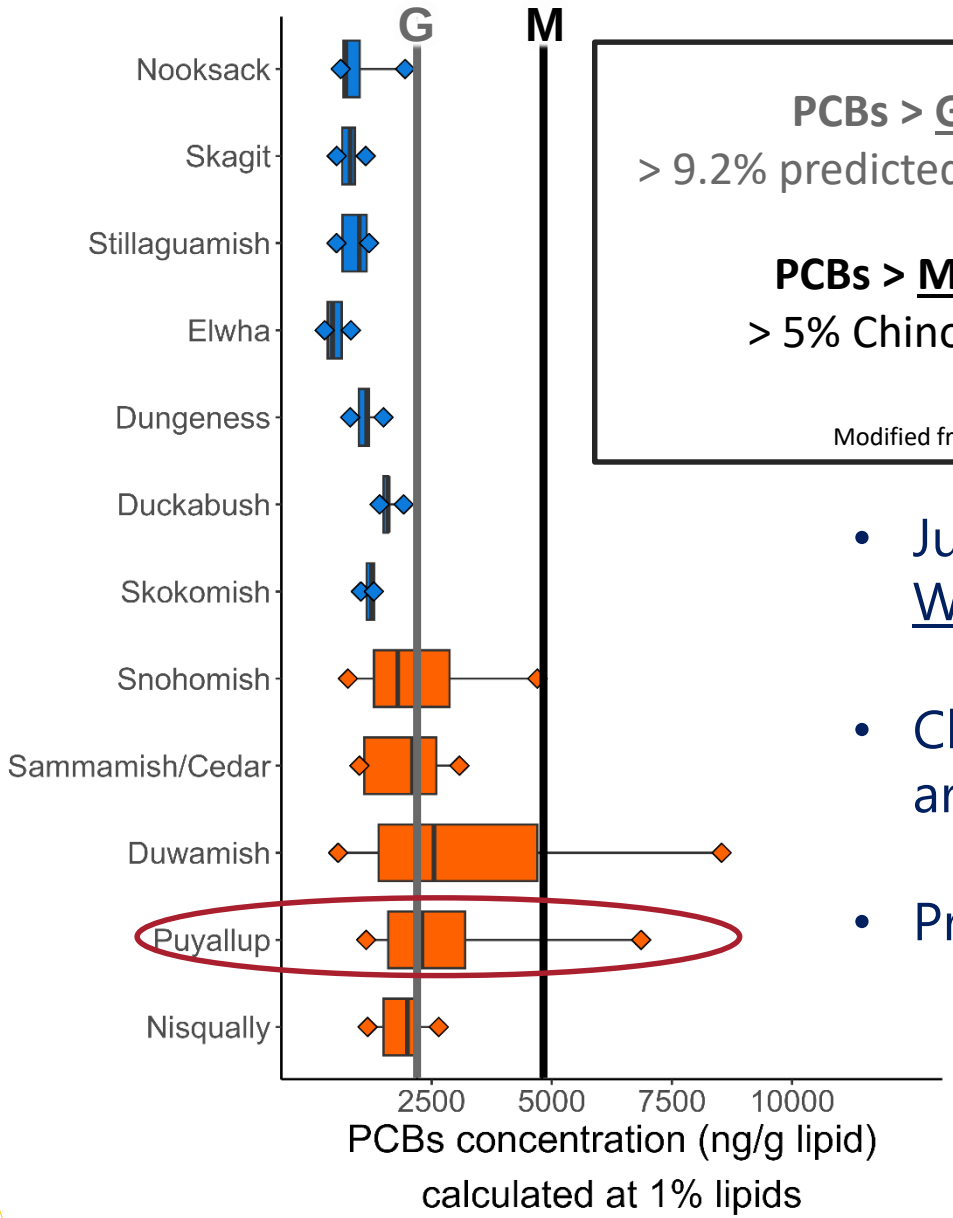
Juvenile Chinook Surveys

- Studies to date
  - 2013, 2016, 2018, 2021, 2023 & *2024*
- Puyallup/White River Watershed
  - Status - **2013, 2016, 2021** and 2024
  - Detailed study 2021
- Fish collected from multiple habitats
- Whole-body composite samples





PCBs



PCBs > Growth threshold
> 9.2% predicted to have reduced growth

PCBs > Mortality threshold
> 5% Chinook predicted to die

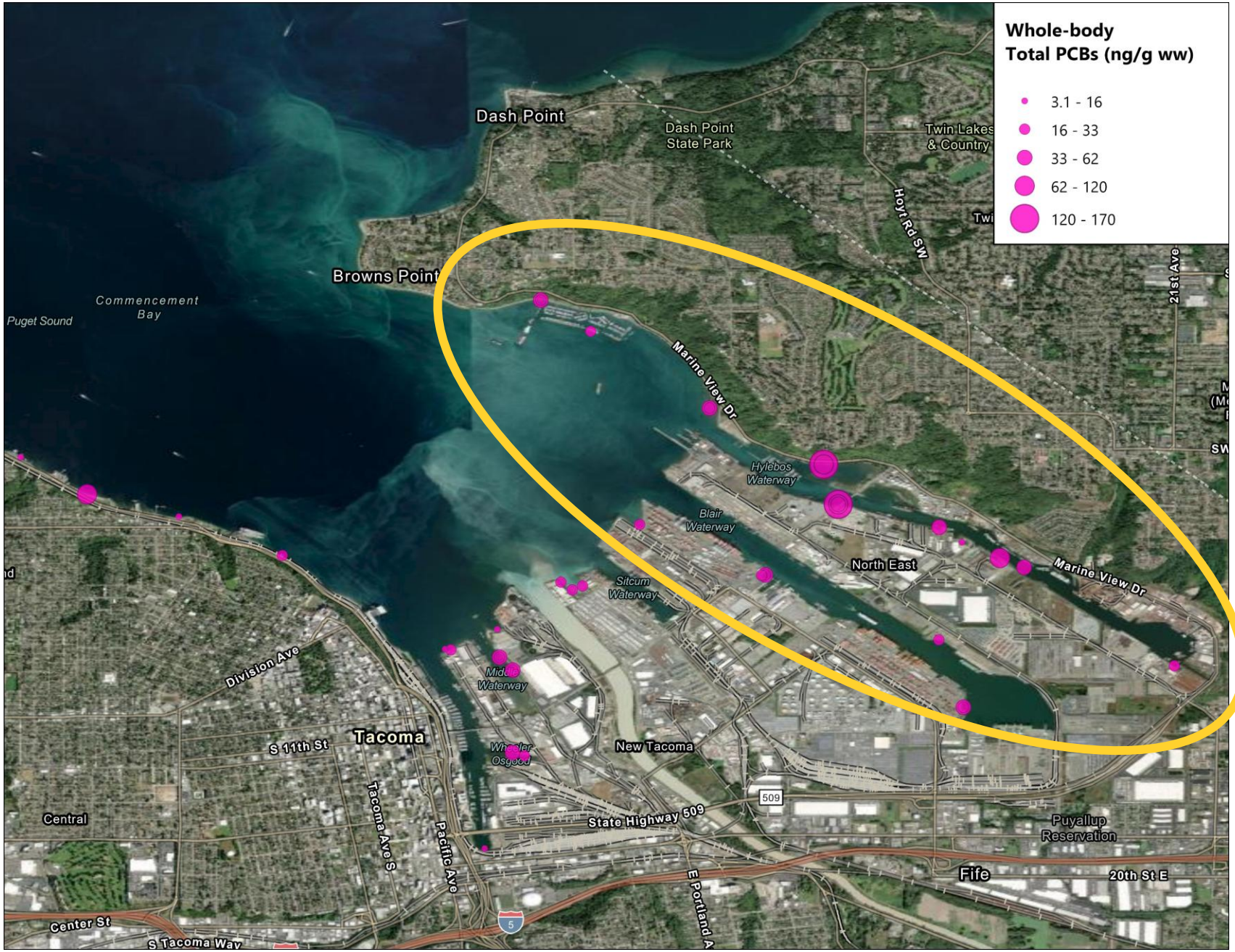
Modified from Berninger & Tillitt 2019

- Juvenile Chinook rearing in urban estuaries and Lake Washington are exposed to harmful PCB levels
- Chinook from the Puyallup/White river estuary (waterways) are exposed to the second highest PCB levels
- Predicted growth and mortality impacts to juvenile Chinook

PCBs in whole-body Chinook salmon

- Composites samples
  - Individual fish have a wider range of PCB levels
- Lowest levels
  - Pt Defiance net pens (not pictured)
- Higher levels
  - Hylebos Waterway
  - Blair Waterway
  - Cliff House/Tyee Marina
  - Ruston Way (1 natural-origin from Harbor Lights)

PCBs are higher in natural (wild) origin Chinook

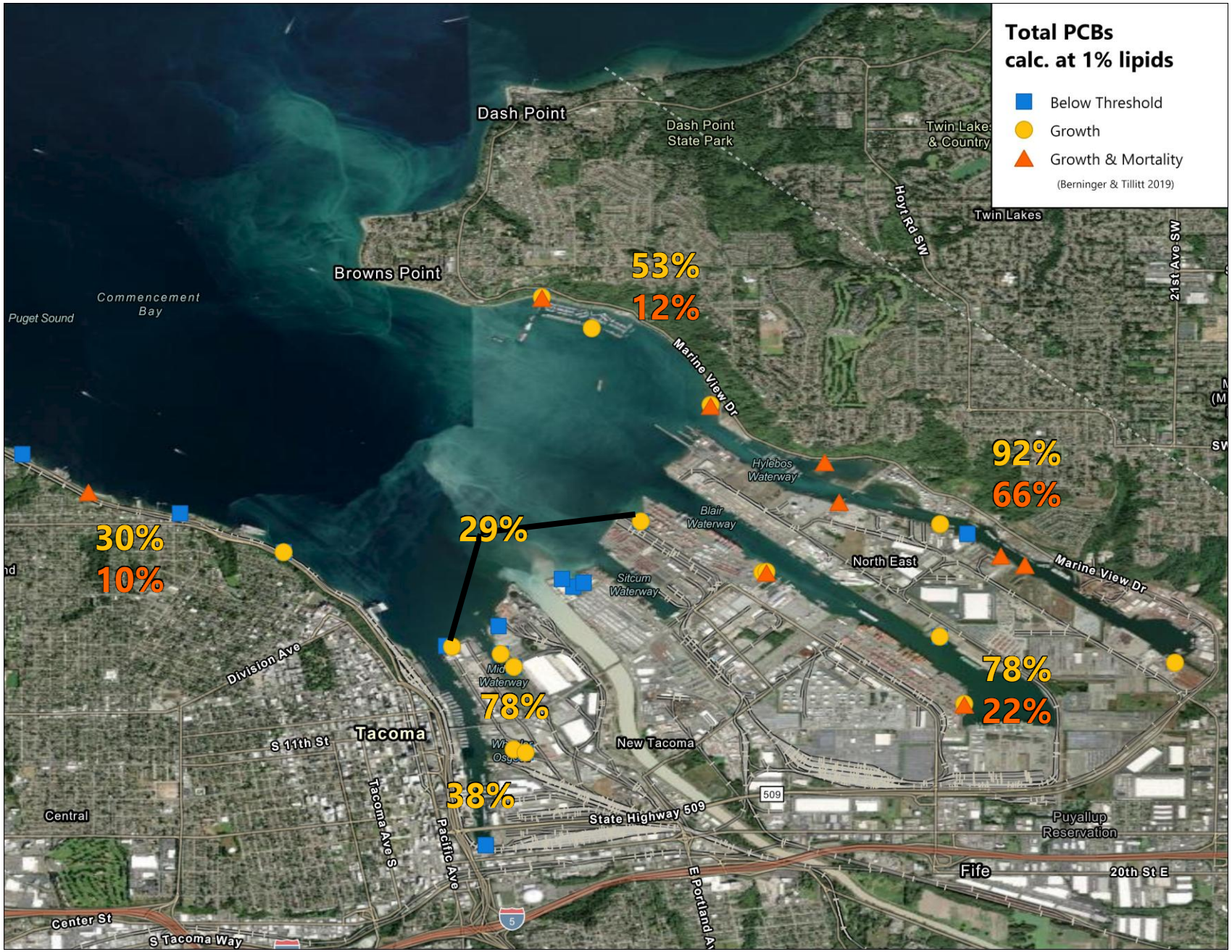


PCBs Fish Health Impacts

Using 1% lipid normalized PCBs is protective, but may overestimate effects

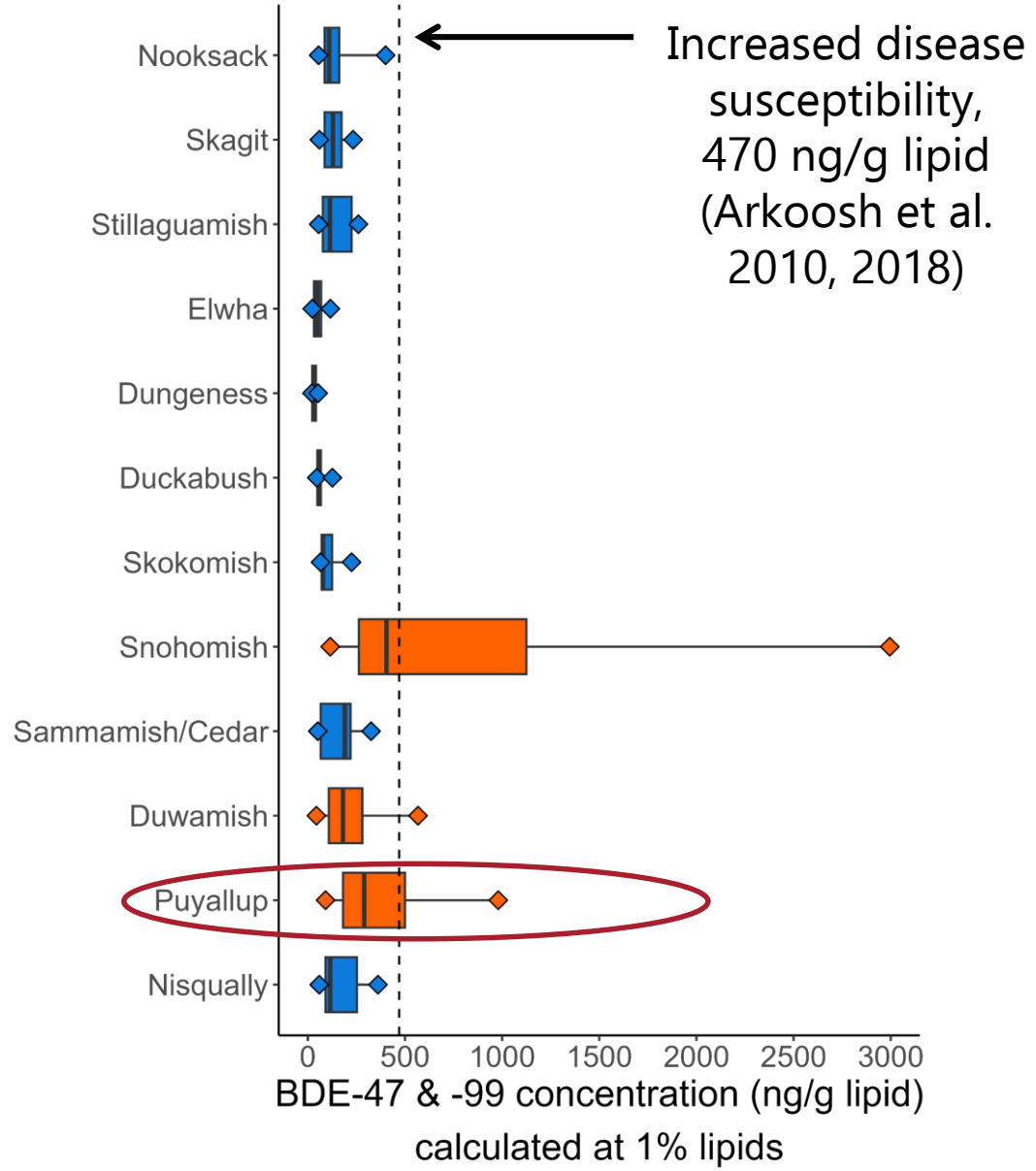
Predict Chinook health is most impacted:

- Hylebos Waterway
- Blair Waterway
- NE Comm Bay
- Lesser extent – Middle and Thea Foss Waterways, SW Comm Bay shoreline



PBDEs

- PBDEs are a more localized issue (linked to wastewater sources)
- Chinook salmon from the Puyallup/White river estuary (waterways) are exposed to the second highest levels of PBDEs
- Predicted to have health impacts



PBDEs in whole-body Chinook salmon

Overall, PBDE levels are lower than PCBs

- Lowest levels
  - Pt Defiance Net Pen & SW shoreline
  - Thea Foss Waterway
  - Middle Waterway
- Higher levels
  - Hylebos Waterway
  - Blair Waterway
  - NE shoreline

PBDEs are higher in natural (wild) origin Chinook

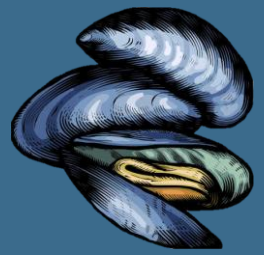
PBDEs Fish Health Impacts

Using 1% lipid normalized PBDEs is protective, and may be overestimating effects

Predict Chinook health is most impacted:

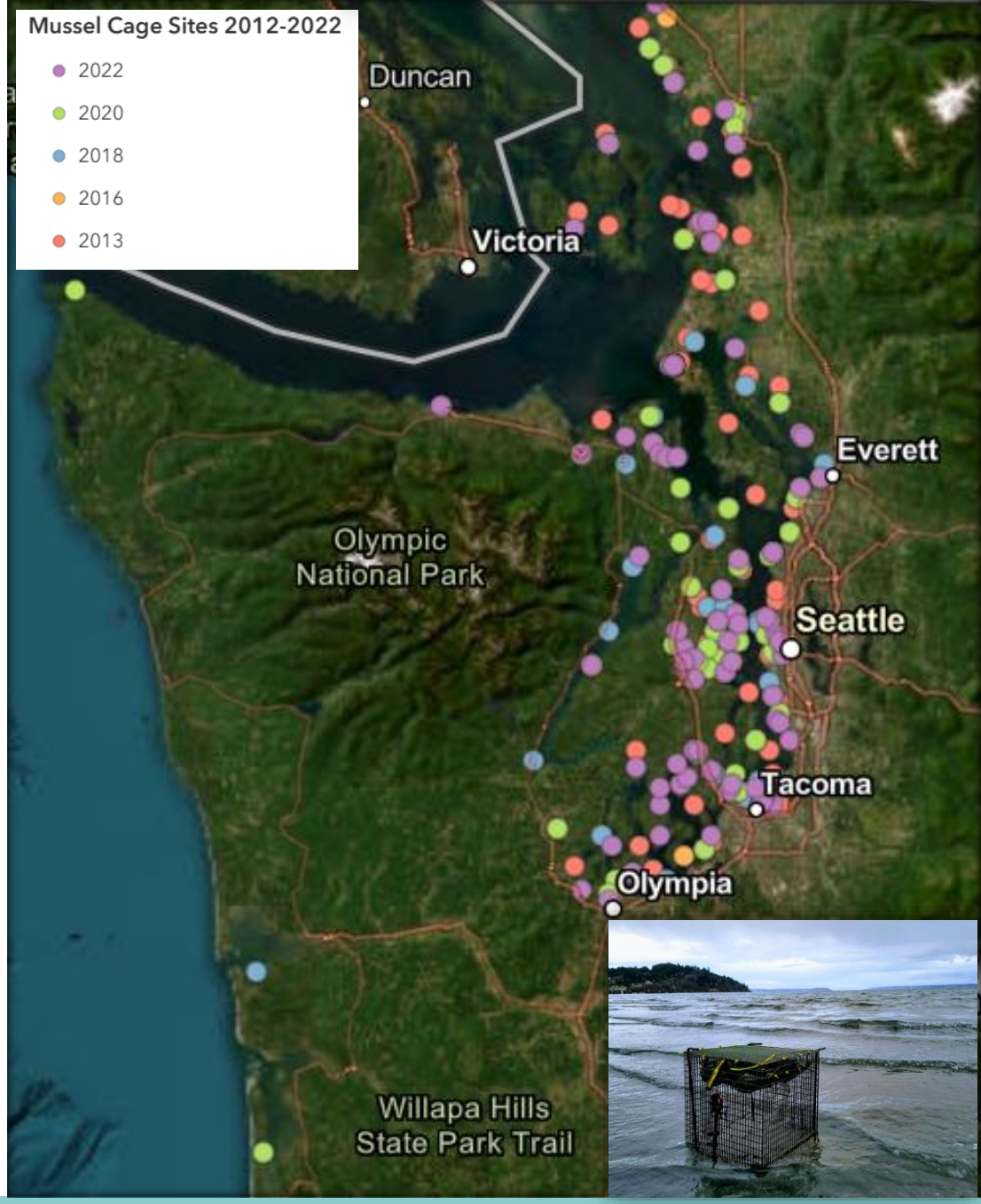
- Hylebos Waterway
- Blair Waterway
- NE Comm Bay

Caged Mussels



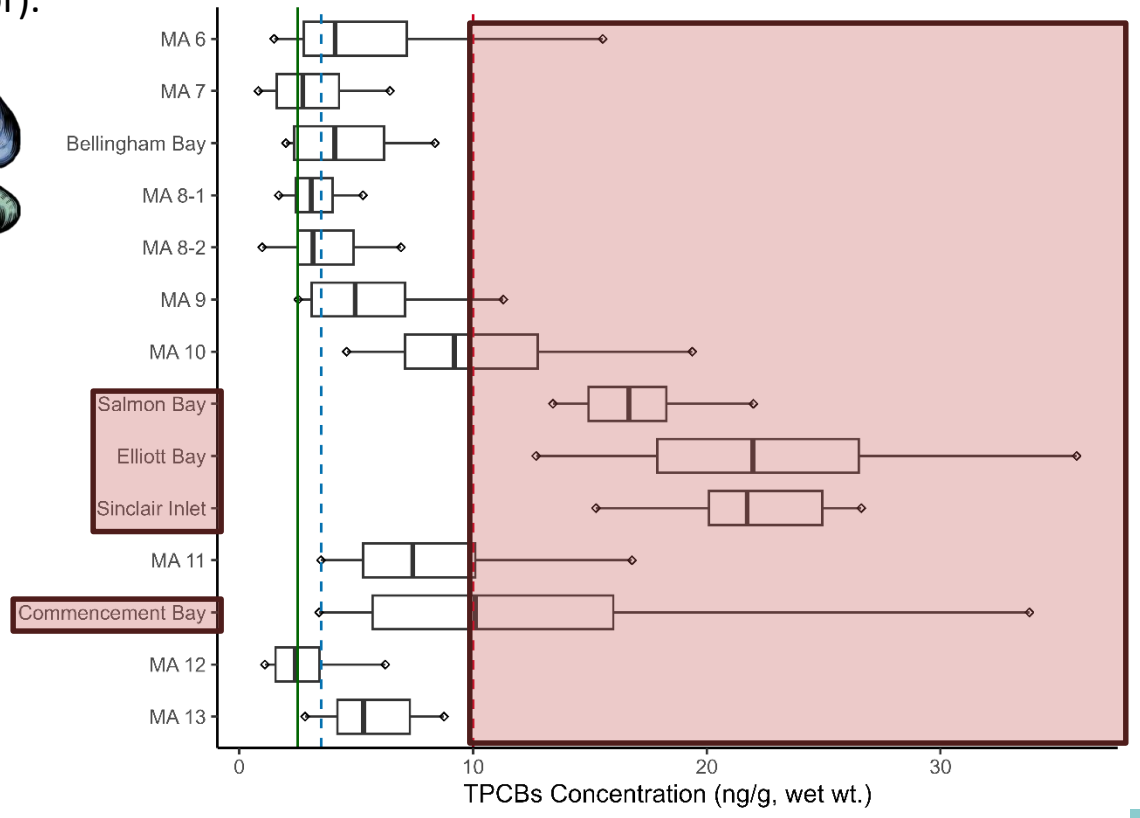
Mussel Surveys

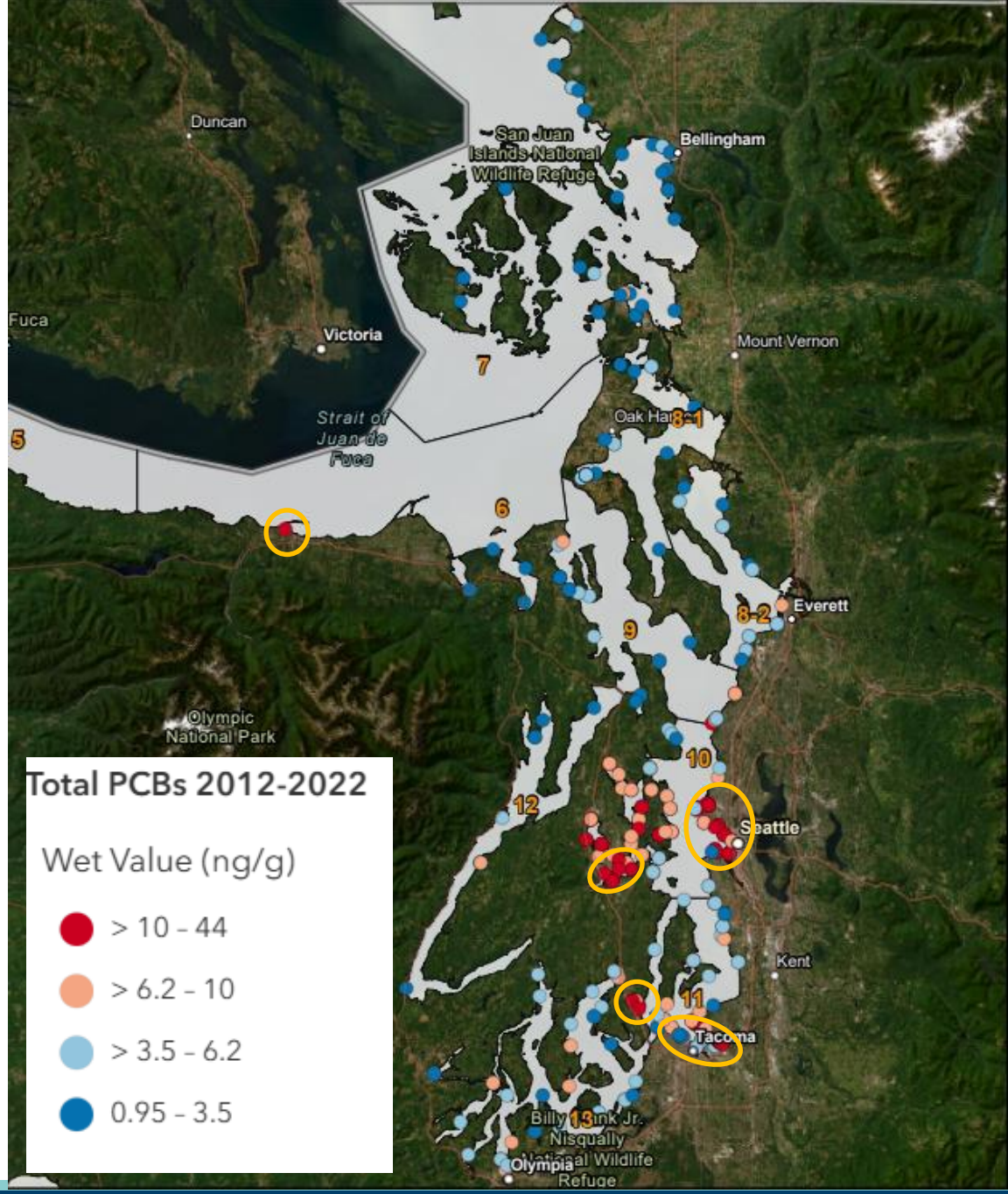
- Native bay mussels (*Mytilus trossulus*) transplanted in anti-predator cages to nearshore monitoring sites.
- Winter exposure for 3 months (Nov – Jan), when stormwater runoff peaks
- Whole body (soft tissue) composite sample
- Advantages: sessile, site selection flexibility, uniform starting population, known exposure period and contaminant accumulation
- Six biennial surveys conducted between 2012 and 2024
- Monitored over 200 unique sites, 28 in Commencement Bay
- Each site represents 800m of shoreline



Mussel PCBs: Puget Sound Status

- Status of PCBs across 14 Puget Sound reporting strata using project specific threshold categories: Lower concentration (25th percentile) ≤ 3.5 ng/g, wet wt.; Higher Concentration (75th percentile) ≥ 10 ng/g wet wt.
- Greatest PCB exposure in mussels occur in the central Puget Sound basin and its urban embayments: Elliott Bay, Salmon Bay, Sinclair Inlet, and Commencement Bay.
- Local hotspots exist within other reporting areas (e.g., Port Angeles, Gig Harbor).

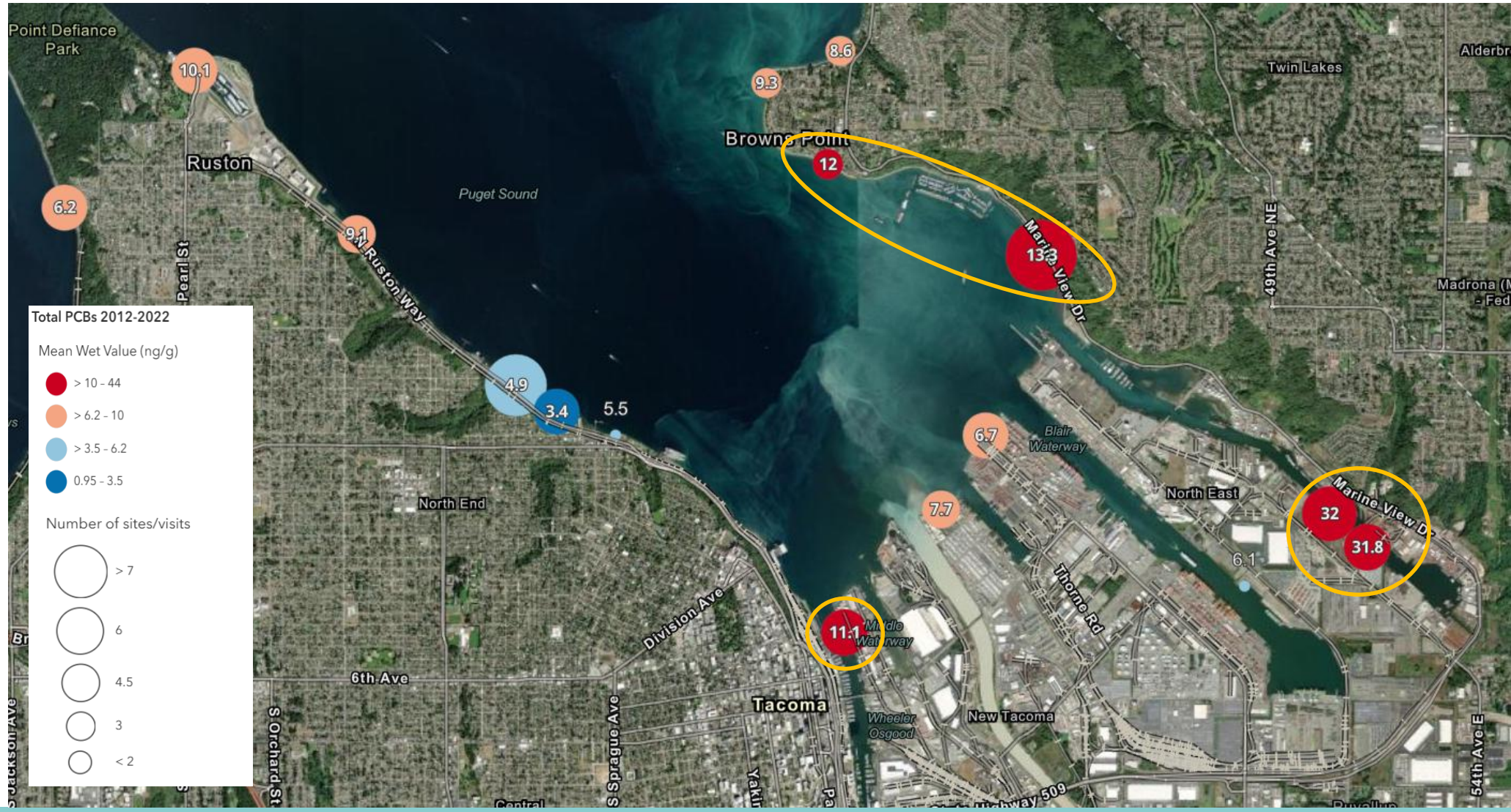




Mussel PCBs: Commencement Bay

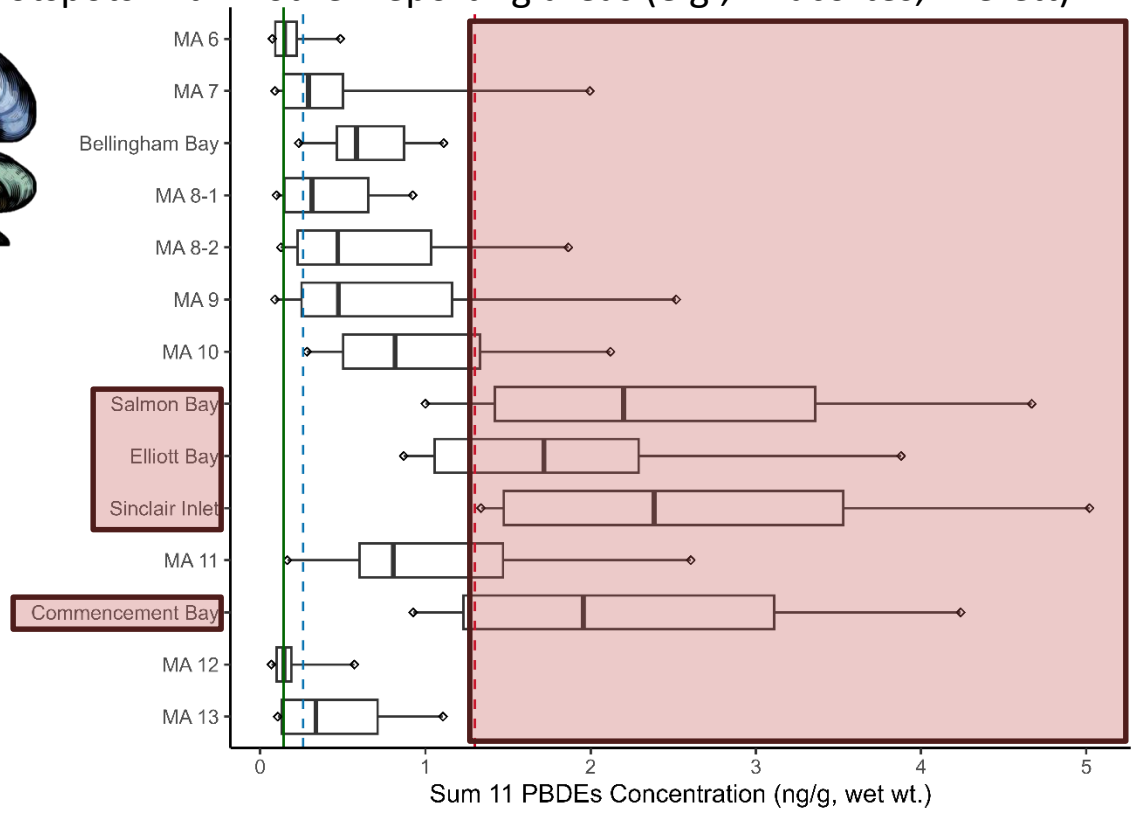
- Greatest PCB exposure in Commencement Bay caged mussels occurs in the Hylebos Waterway.
- Elevated concentrations along the NE shoreline and Thea Foss Waterway.

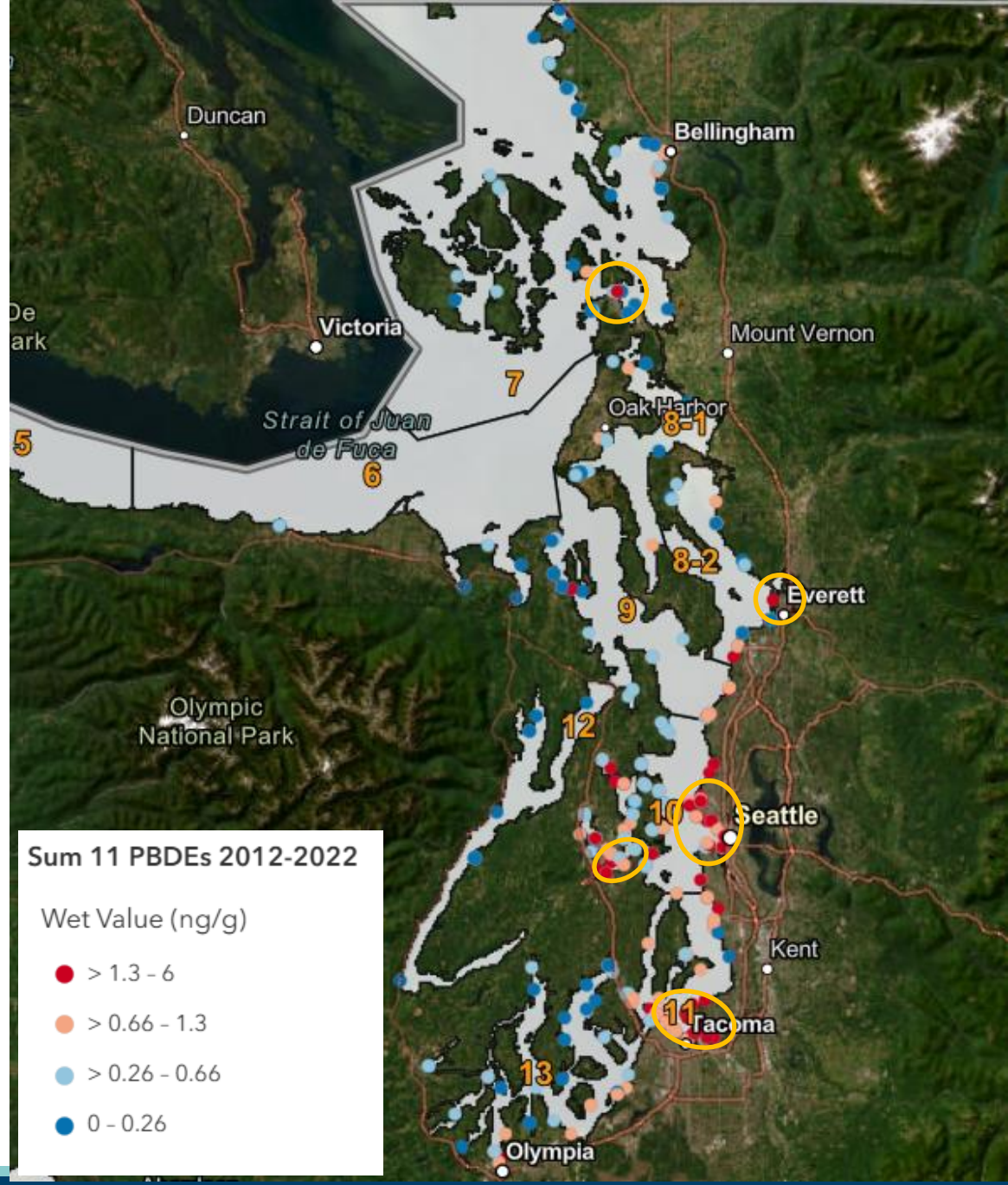
Story Map Link:
https://arcg.is/CqqPO



Mussel PBDEs: Puget Sound Status

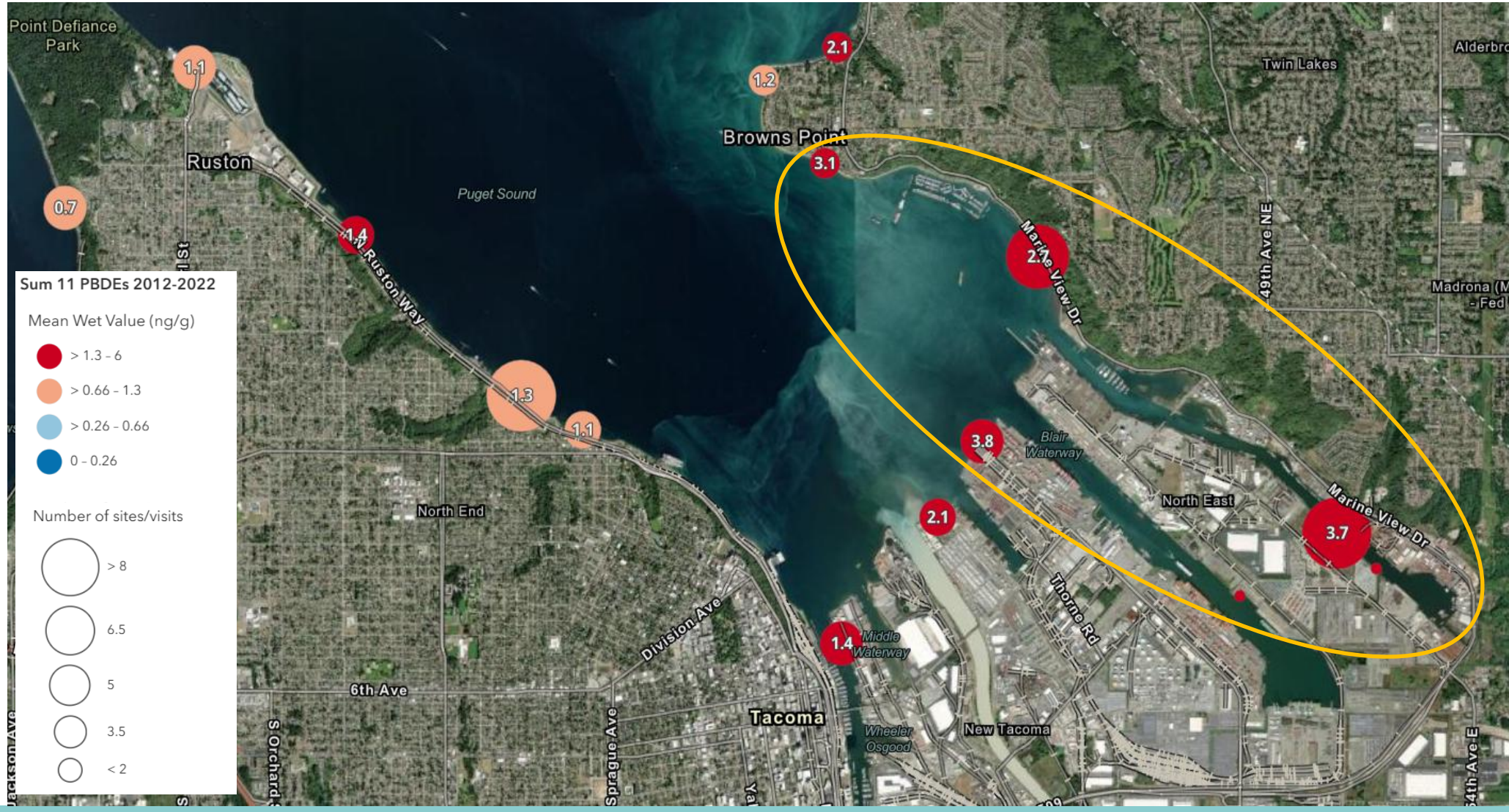
- Status of PBDEs across 14 Puget Sound reporting strata using project specific threshold categories: Lower concentration (25th percentile) ≤ 0.26 ng/g, wet wt.; Higher Concentration (75th percentile) ≥ 1.3 ng/g wet wt.
- Greatest PBDE exposure in mussels occur in the central Puget Sound basin and its urban embayments: Elliott Bay, Salmon Bay, Sinclair Inlet, and Commencement Bay.
- Local hotspots within other reporting areas (e.g., Anacortes, Everett).





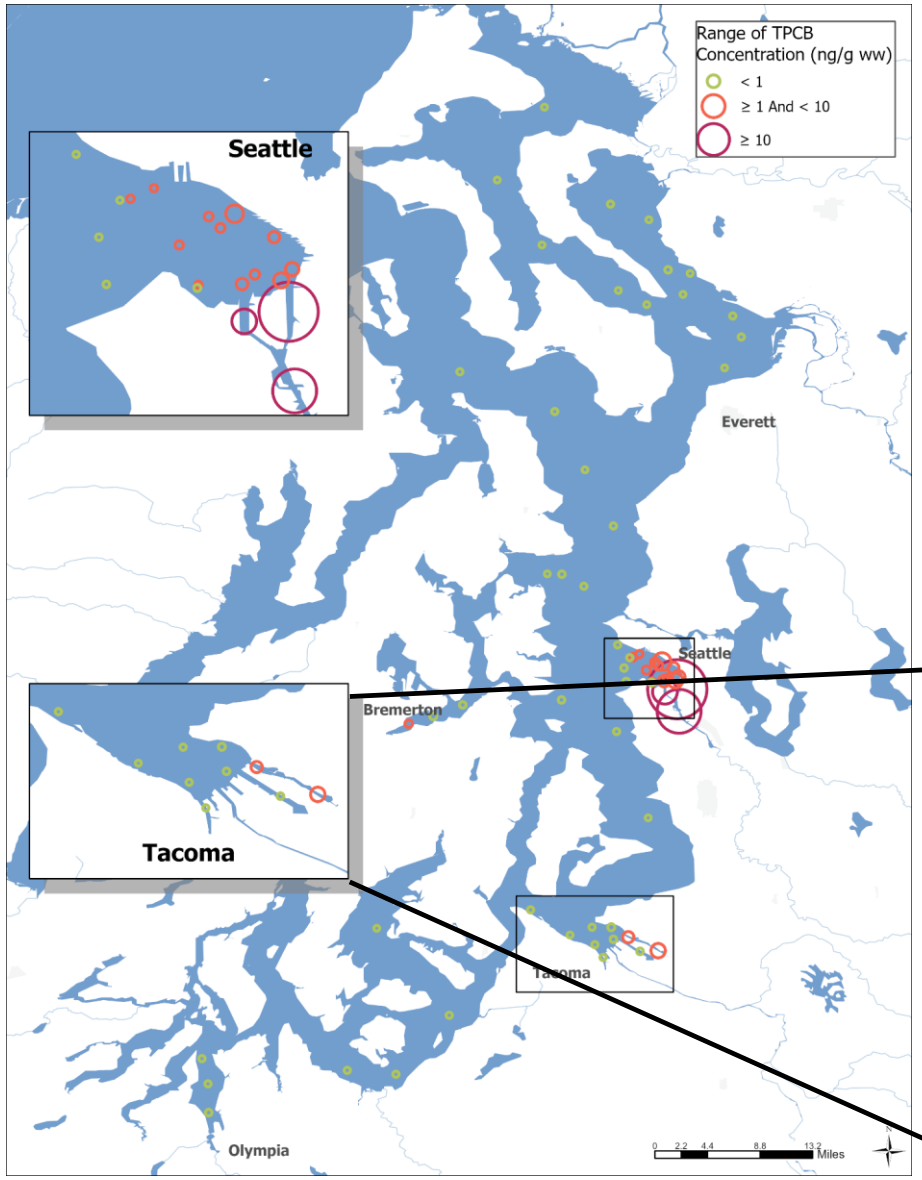
Mussel PBDEs: Commencement Bay

- Elevated PBDE exposure in caged mussels occurs across all Commencement Bay sites.
- Greatest PBDE exposure occurs in the Blair and Hylebos Waterways, and along the NE shoreline.

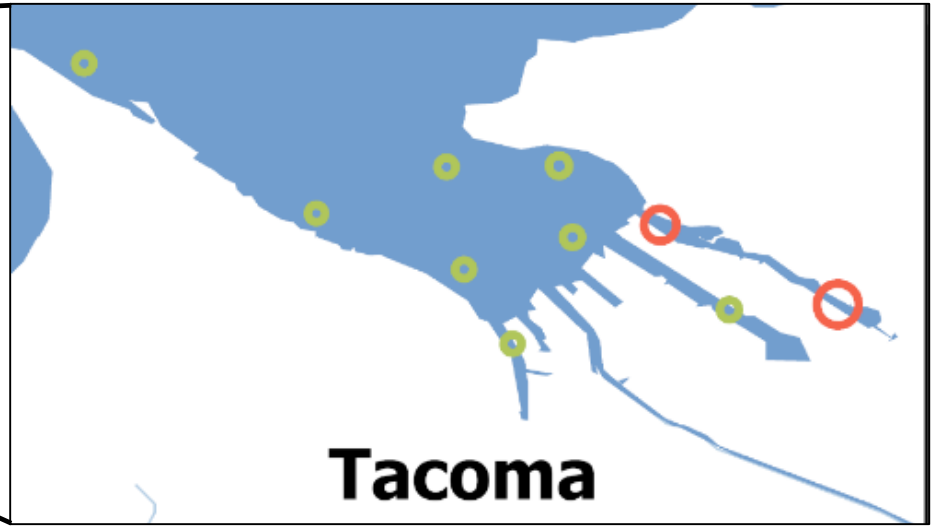


Other Species

2022 Particulate Organic Matter (POM)

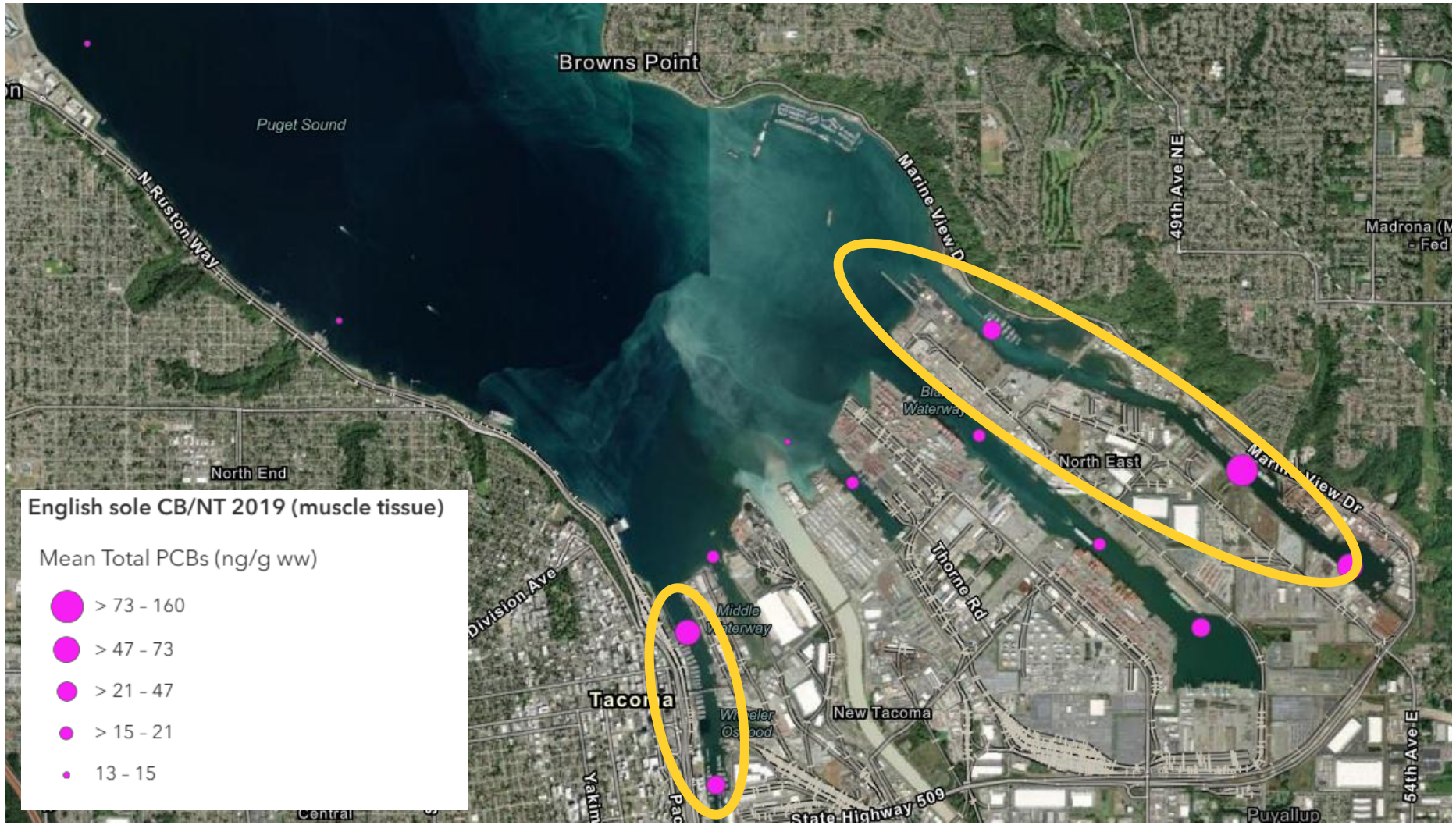


- Water column – POM samples
- Puget Sound wide - 9 sites in Comm Bay and Waterways
- PCBs in POM were highest in Duwamish River (>10 ng/g ww) & elevated throughout Elliott Bay (1-10 ng/g ww)
- PCBS also elevated in POM from two sites in Hylebos Waterway (1-10 ng/g ww)



2019 English Sole Comm Bay & Nearshore Tideflats

- English sole from Commencement Bay had among some of the highest PCB levels in English sole collected from all of Puget Sound.
- Greatest PCB exposure in Commencement Bay English sole occurs in the Hylebos and Thea Foss waterways
- Minimal PCBs along south –west side of Commencement Bay.



Other Impacted Species

Dungeness crab – 2012

- Benthic habitat, 3 sites sampled
- Elevated PCBs in crab muscle (mean 24.1 ng/g ww) triggered a DOH consumption advisory – limit of 4 meals/month
- PBDEs – highest levels in PS crabs (mean 2.8 ng/g ww)

Cutthroat trout (n = 5) – 2013

- Caught at Chinook Landing Marina – high site fidelity
- PCB levels (190-860 ng/g ww) high enough to cause mortality
- Elevated PBDEs (20-83 ng/g ww) – health impact unknown

Conclusions

- Multiple species from the same areas are being exposed to PCBs and PBDEs
  - Hylebos, Blair, & NE shoreline
- PCB and PBDEs levels in juvenile Chinook salmon are high enough to impair fish health and survival
- Contaminant effects on juvenile Chinook salmon heath are likely greater than those predicted by PCBs and PBDEs alone because salmon in Commencement Bay are also exposed to CECs, PFAS, DDTs, metals, etc.

Hylebos Waterway, WDFW 2022

Next steps

Juvenile Chinook

- Contaminant Fingerprint Analyses
- Time Trends (add 2021 and 2024 results)
- Otolith microchemistry (2021) – estuarine residence time/ growth assessment

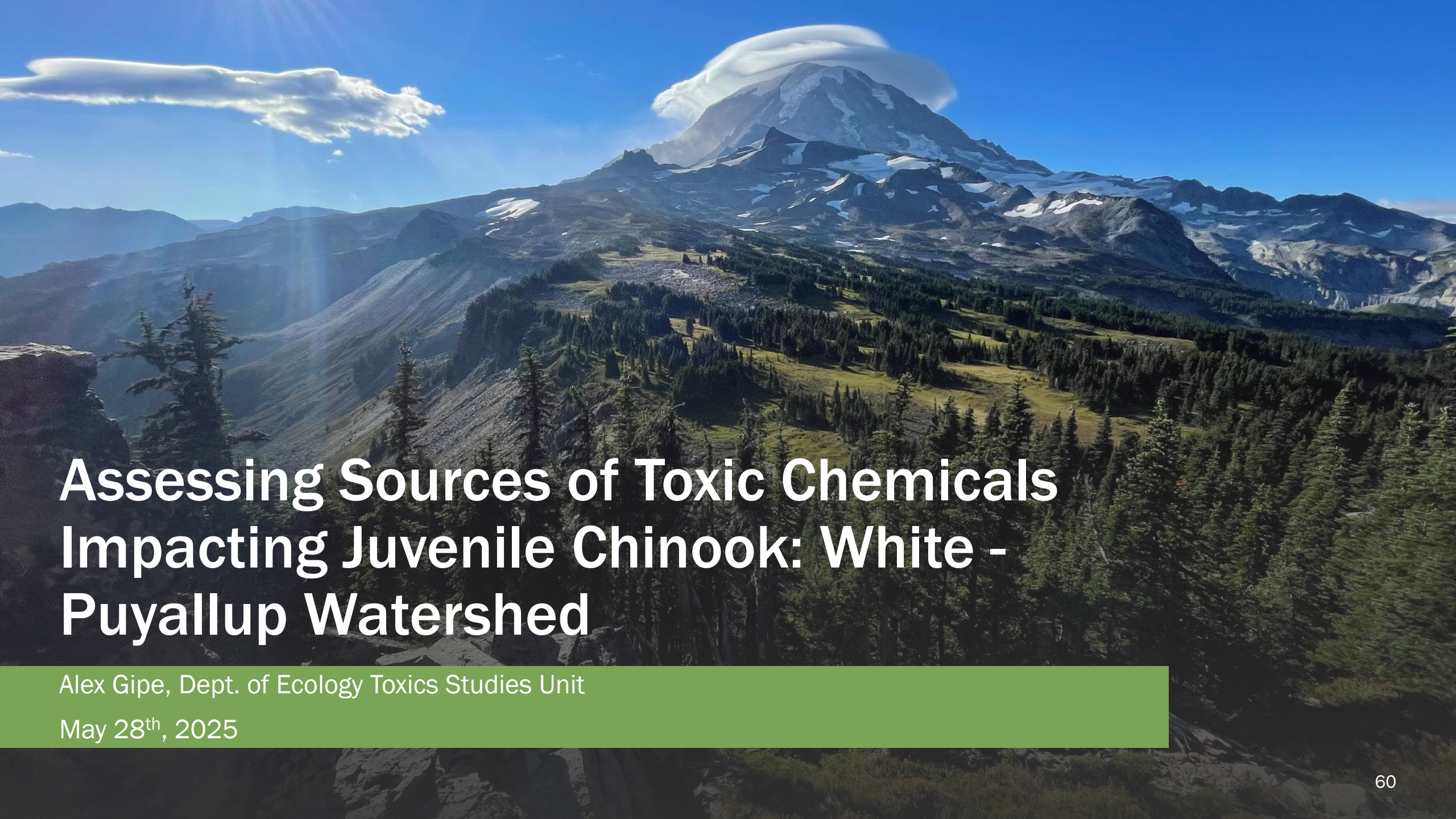
Mussels

- Mussel Survey 2025/2026
- Contaminant Fingerprints Analyses
- Additional evaluation of contaminant patterns in co-located mussel and juvenile Chinook salmon samples

Hylebos Waterway, WDFW 2022

Questions?

https://wdfw.wa.gov/species-habitats/science/marine-toxics



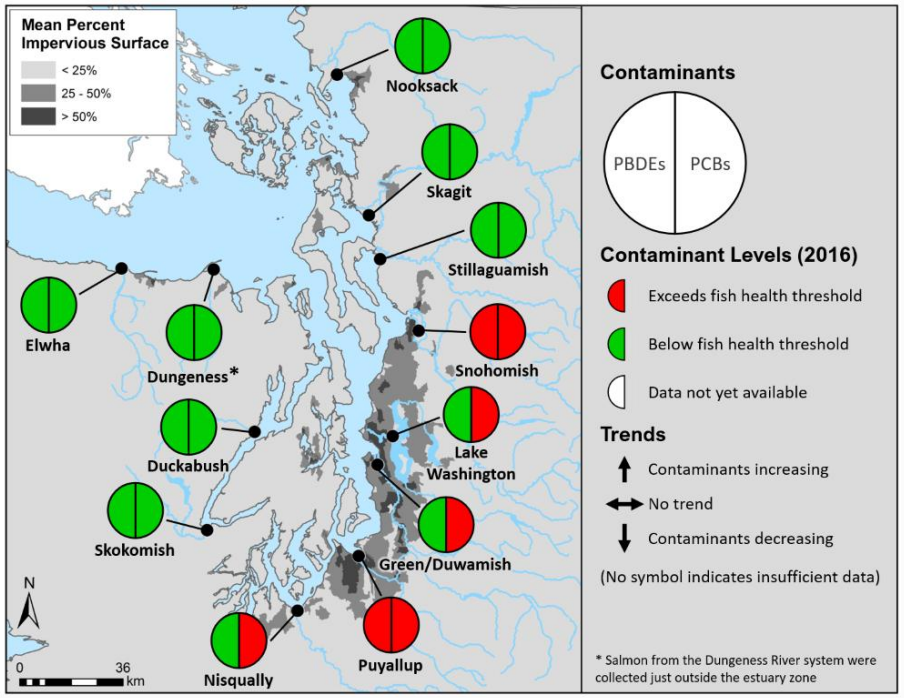
Assessing Sources of Toxic Chemicals Impacting Juvenile Chinook: White - Puyallup Watershed

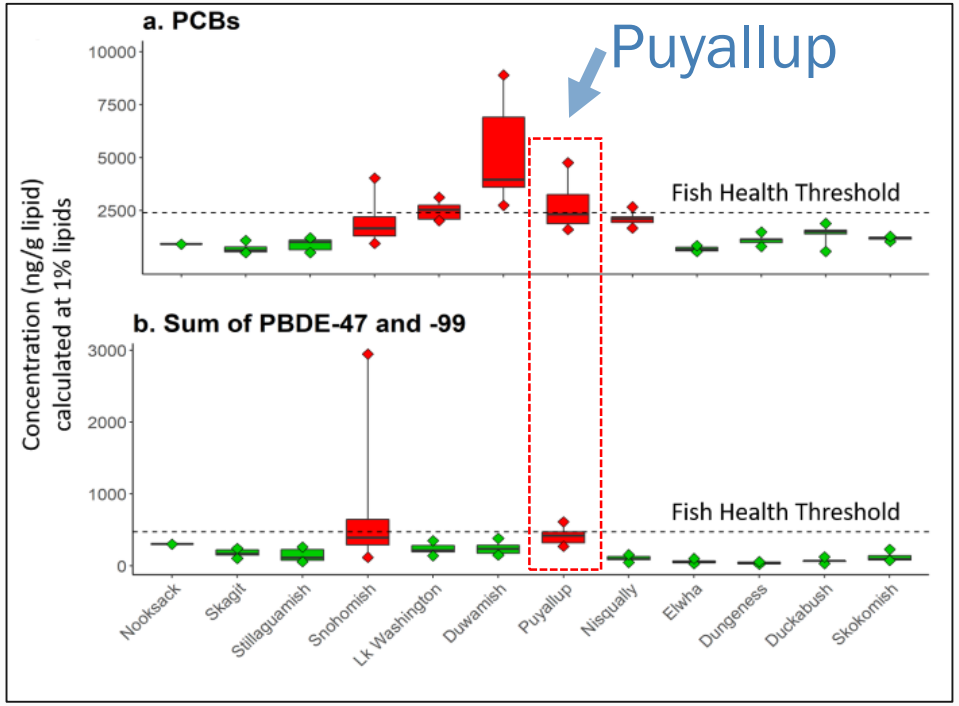
Alex Gipe, Dept. of Ecology Toxics Studies Unit

May 28th, 2025

Toxics in Juvenile Chinook Program

- Partnership Between Ecology and WDFW TBiOS group
- Addresses Toxics in Aquatic Life vital sign recovery goal for juvenile Chinook
- Program Goal: Assess and prioritize potential sources of toxics that may be impacting the health of outmigrating juvenile Chinook

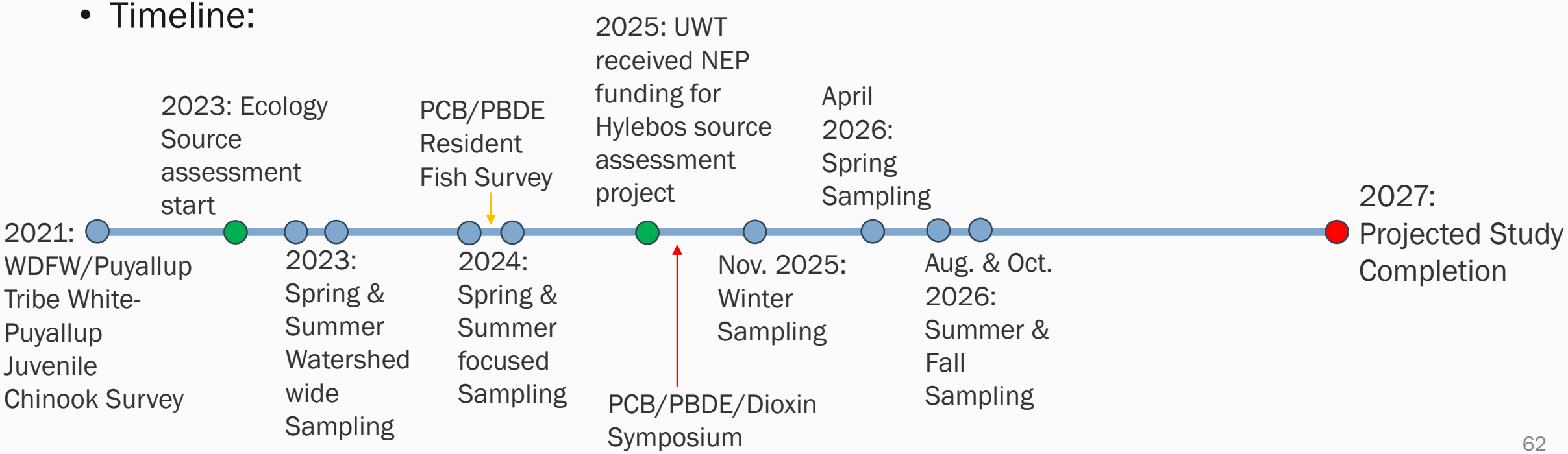




Source: Puget Sound Vital Signs; 2016 WDFW survey of 11 river estuaries and lake Washington

White-Puyallup Source Assessment

- Target Chemicals: PCBs and PBDEs
- Geographical Scope: White-Puyallup watershed including, Commencement Bay, Puyallup R., White R., & Carbon R.
- Sample Media: Passive Samplers (SPMDs), Suspended Sediments, Invertebrate Tissue
- Analytical Methods: EPA 1668C (PCBs) & 1614A (PBDEs); Congener level results
- Timeline:

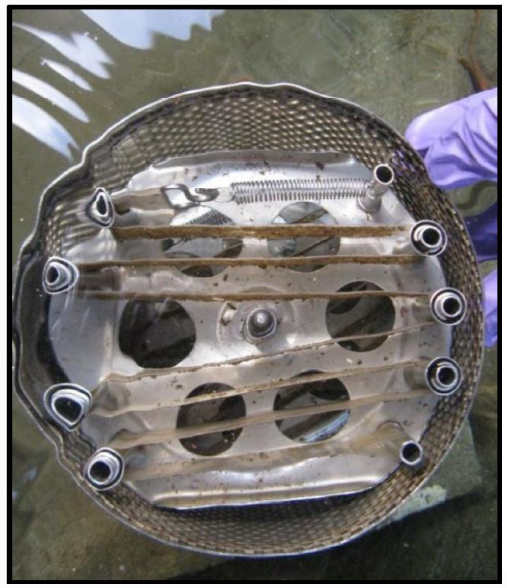


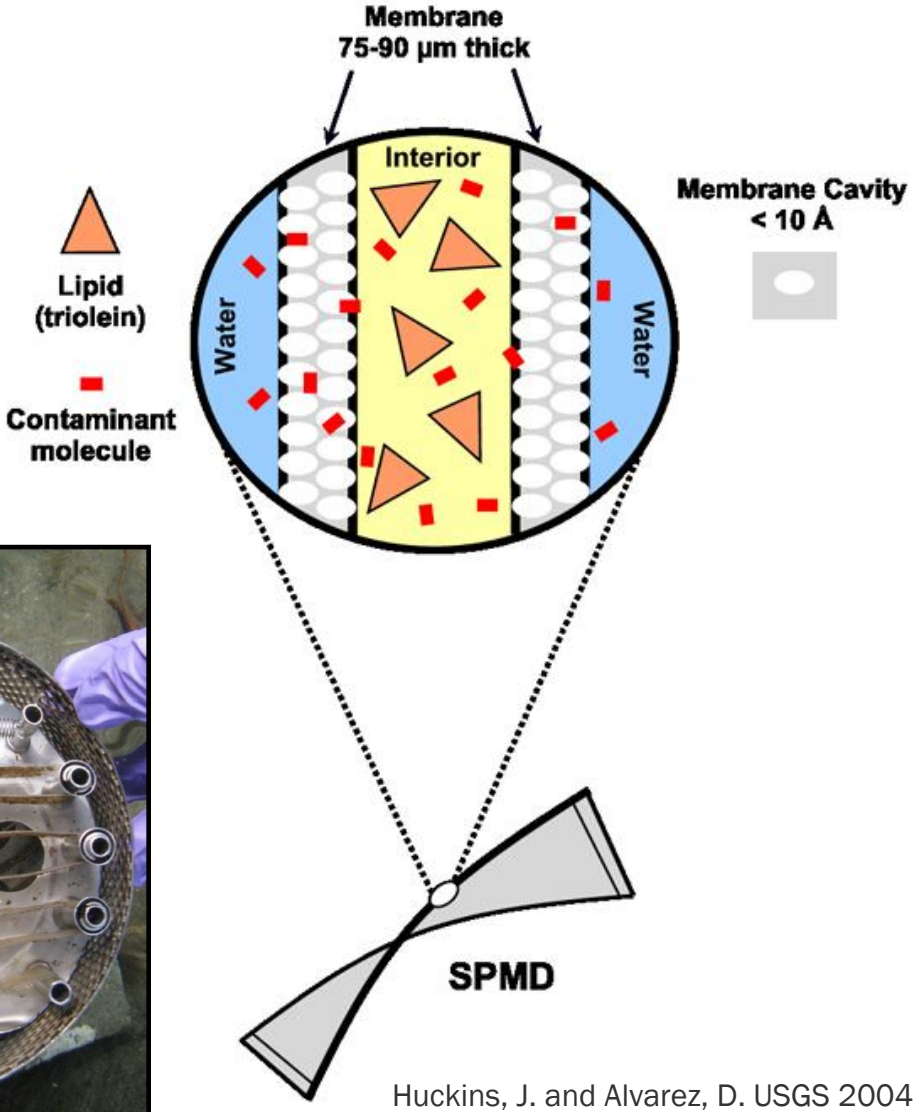
Source Assessment Progress Report

- 4 rounds of sampling (2 Spring/2 Summer) completed
  - 2023 & 2024
  - Passive samplers deployed ~ 30 days
  - Results from 3 of 4 rounds will be reported today
- Resident Fish Survey (Summer 2024)
  - 35 composite tissue samples of resident fish species collected
  - 7 sites across Puyallup, White, Carbon rivers
  - PCBs (congeners) and PBDEs analyzed; awaiting results
  - Used to inform consumption advisories and water impairment listings
- Hylebos waterway focused source assessment (NEP Funded)
  - Initial contracting and planning phase
  - Sampling to begin late 2025
  - Atmospheric deposition, surface waters, sediment flux

Sampling Methods: Passive Samplers (SPMDs)

- Low density polyethylene tube containing high molecular weight lipid (triolein)
- Passively accumulate lipophilic toxics during deployment (~30-day period)
- Measures bioavailable fraction of toxics
- Spiked with performance reference compounds, used to model uptake
- USGS SPMD uptake models can provide estimated environmental concentrations



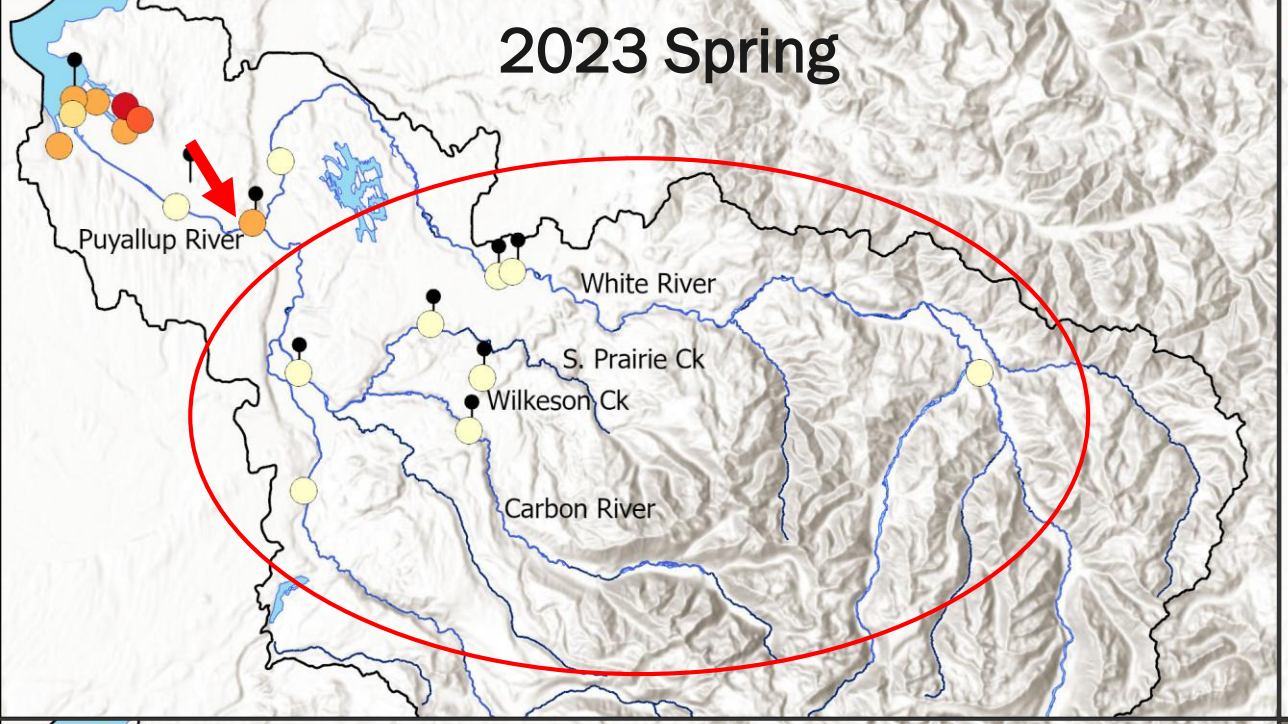


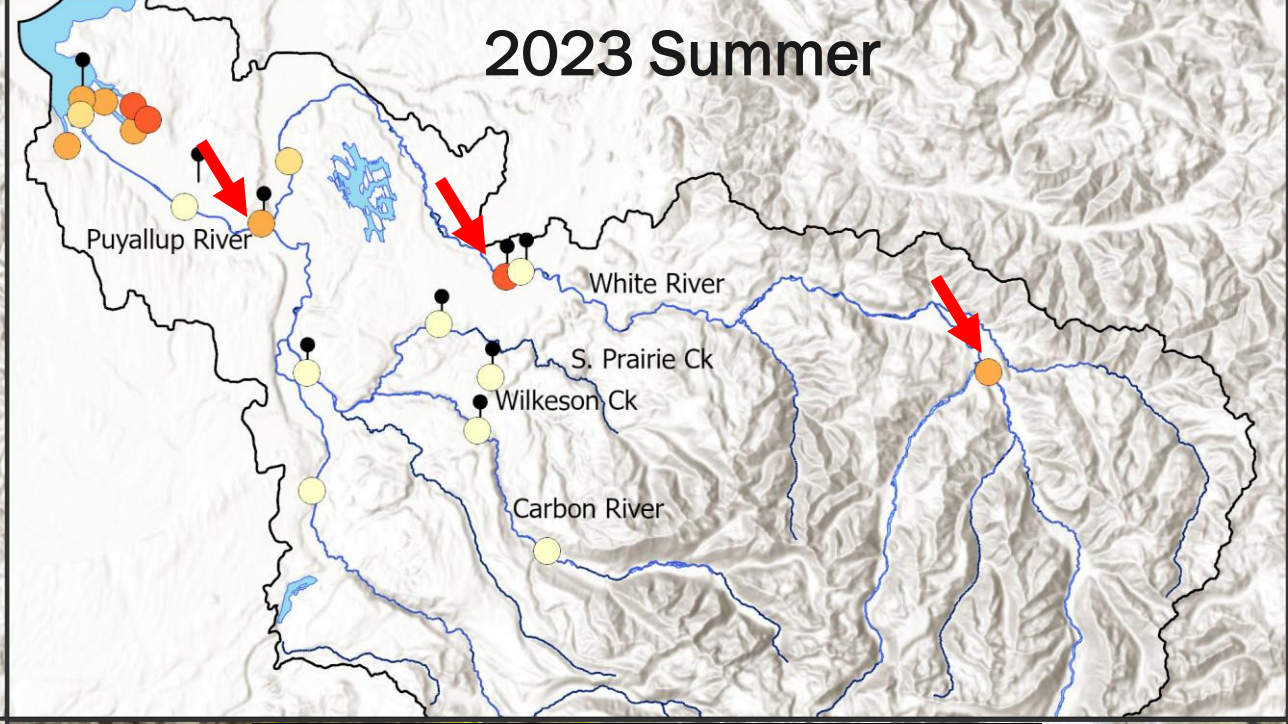
Huckins, J. and Alvarez, D. USGS 2004

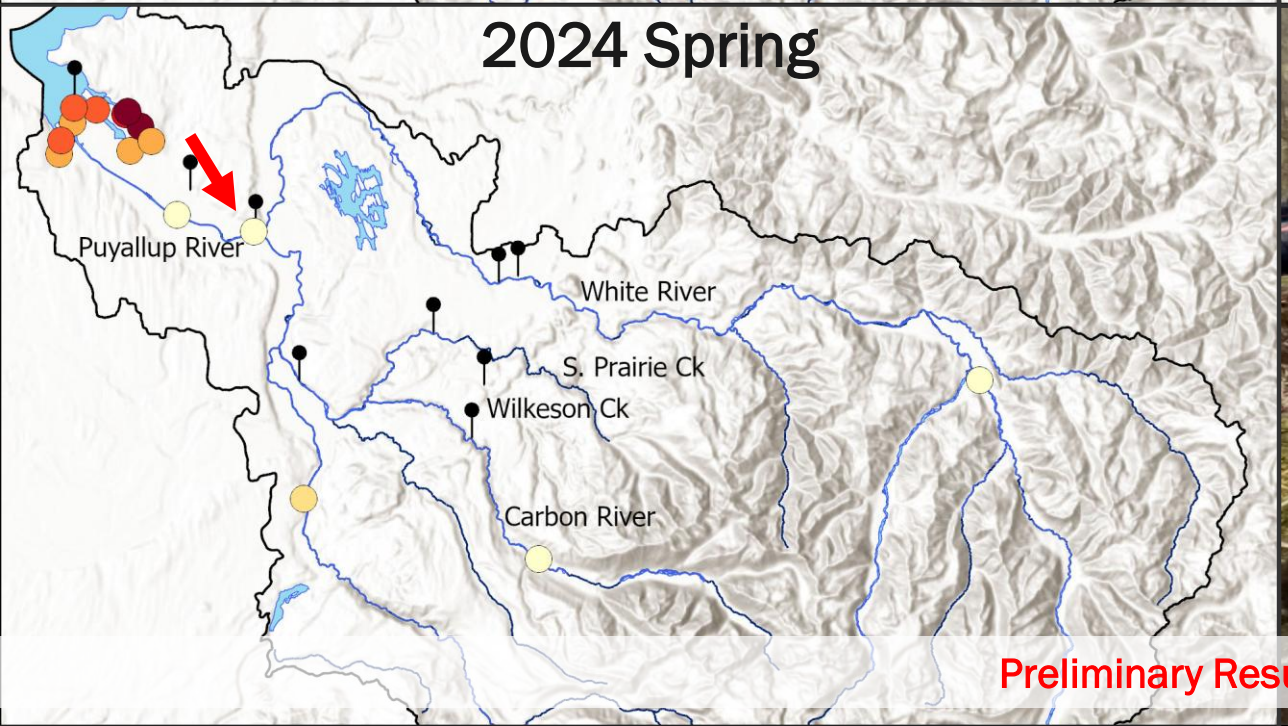
Analytical Methods

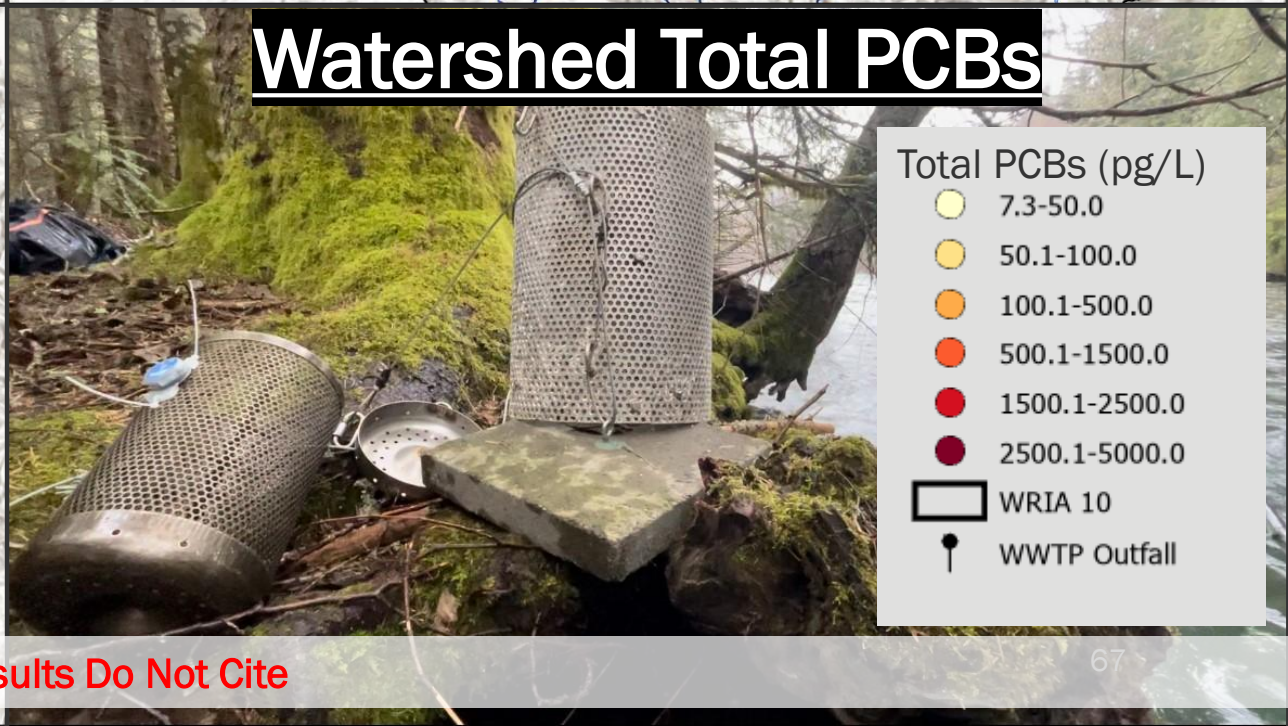
- HRGC/HRMS methods
  - EPA 1668C (PCBs) & 1614A (PBDEs)
  - Congener level results: 209 PCBs, 36 PBDEs, some coelutions
  - ppt detection limits
- Benefits
  - Sensitivity (pg/L and pg/g)
  - Differentiate sources (fingerprint analysis)
  - Robust methods

2023 & 2024 Water column Results

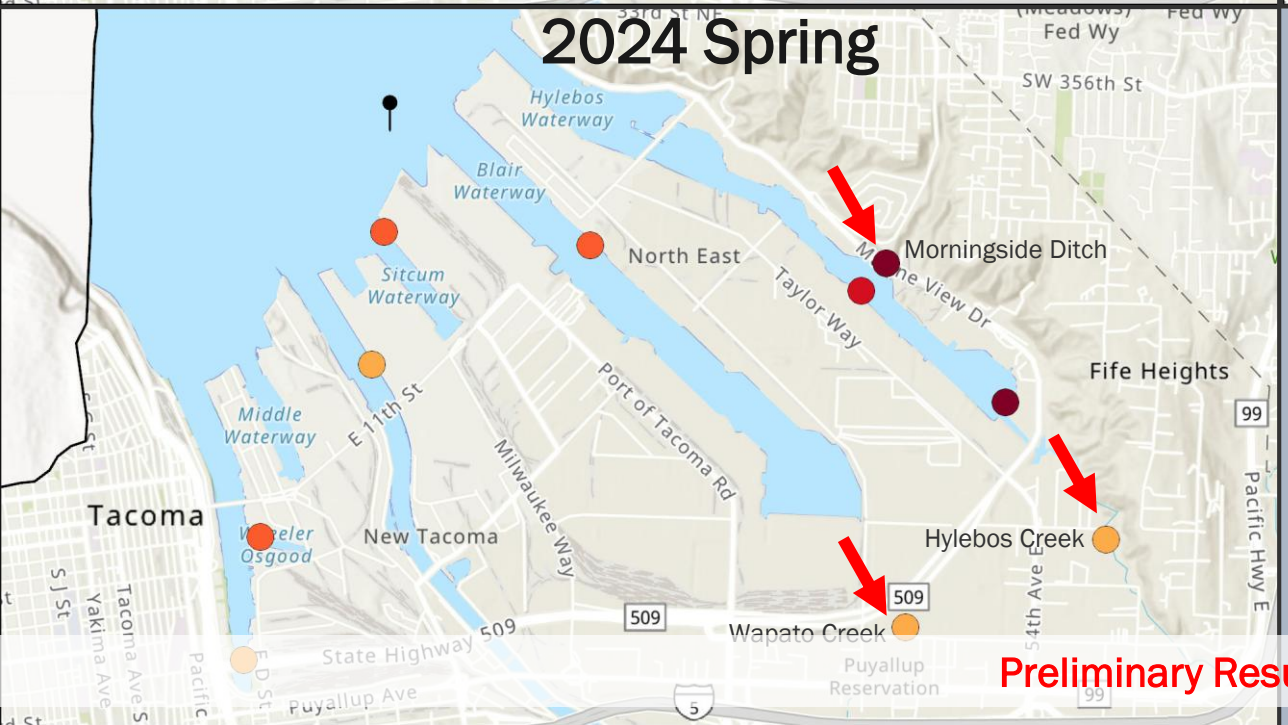






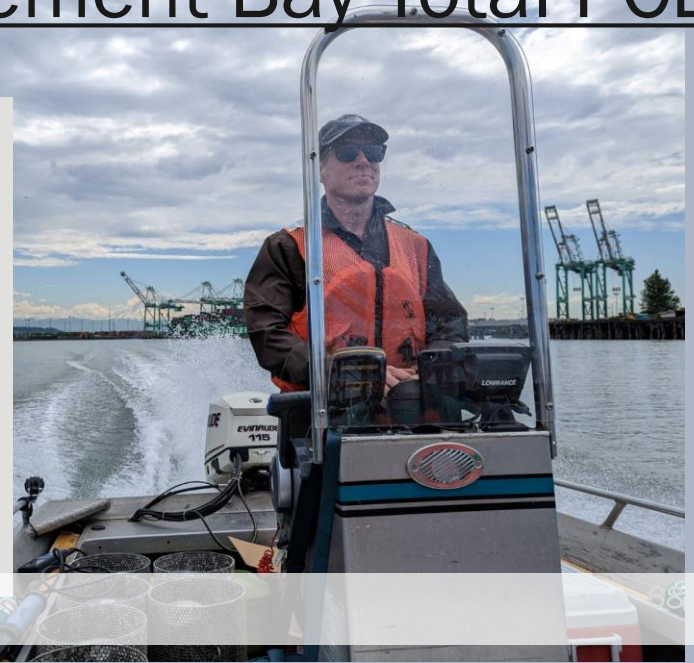


Preliminary Results Do Not Cite

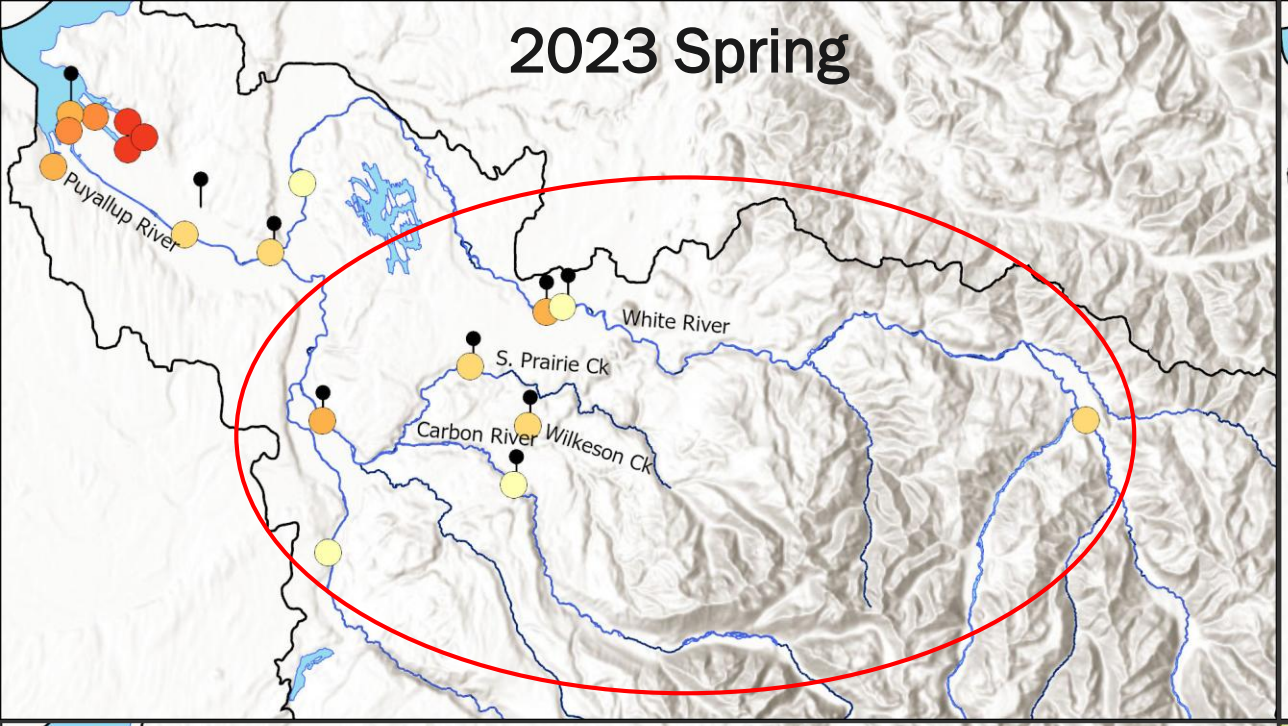


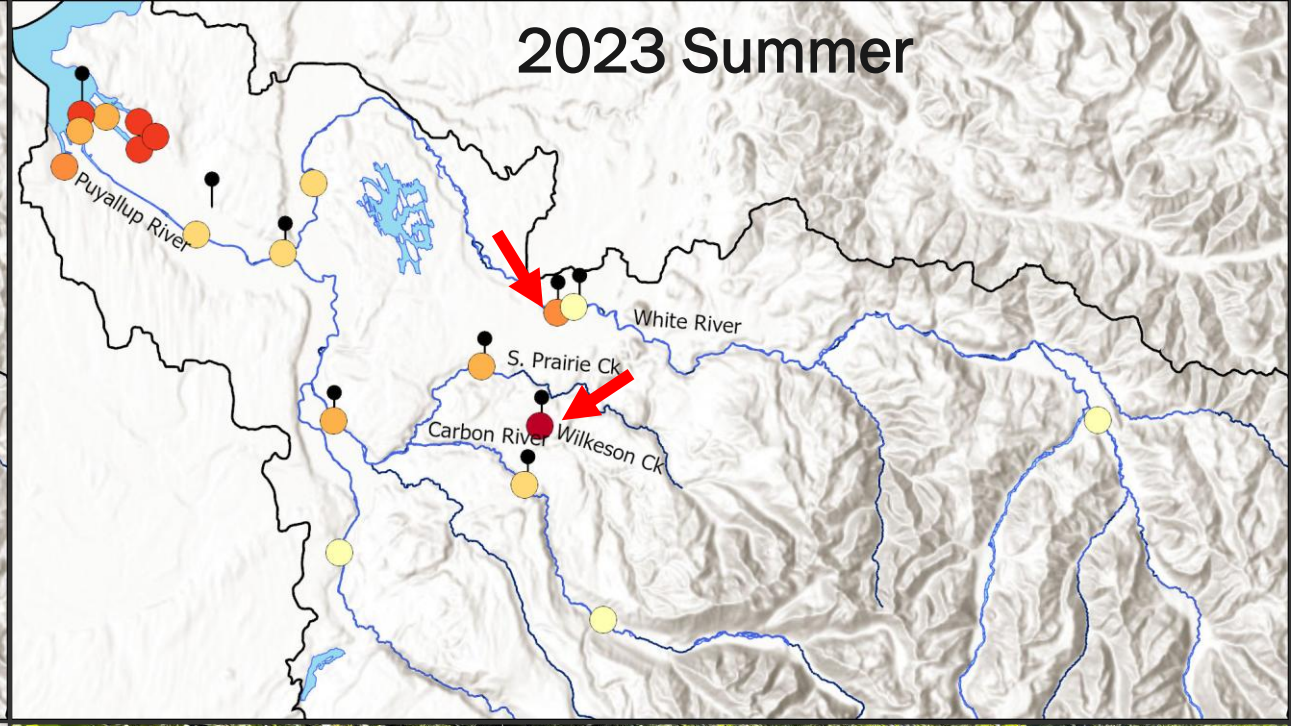
Commencement Bay Total PCBs

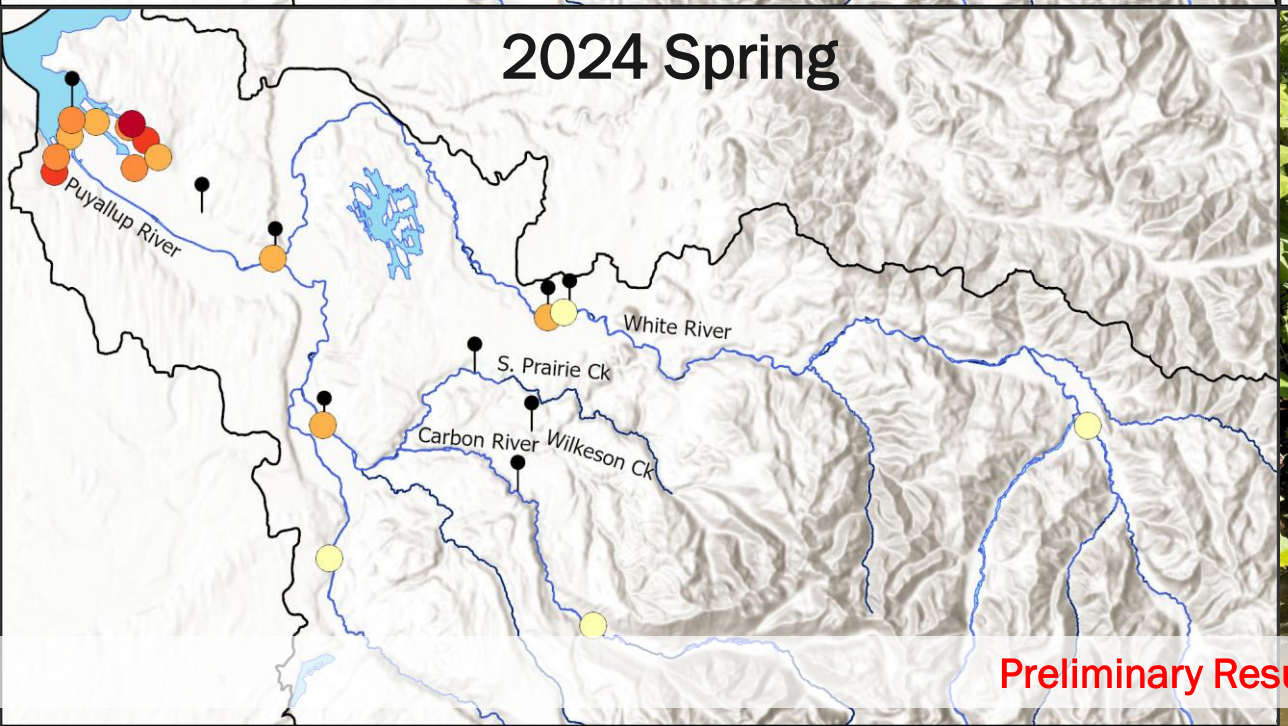
Total PCBs (pg/L)
- 7.3-50.0
- 50.1-100.0
- 100.1-500.0
- 500.1-1500.0
- 1500.1-2500.0
- 2500.1-5000.0
- WRIA 10
- WWTP Outfall

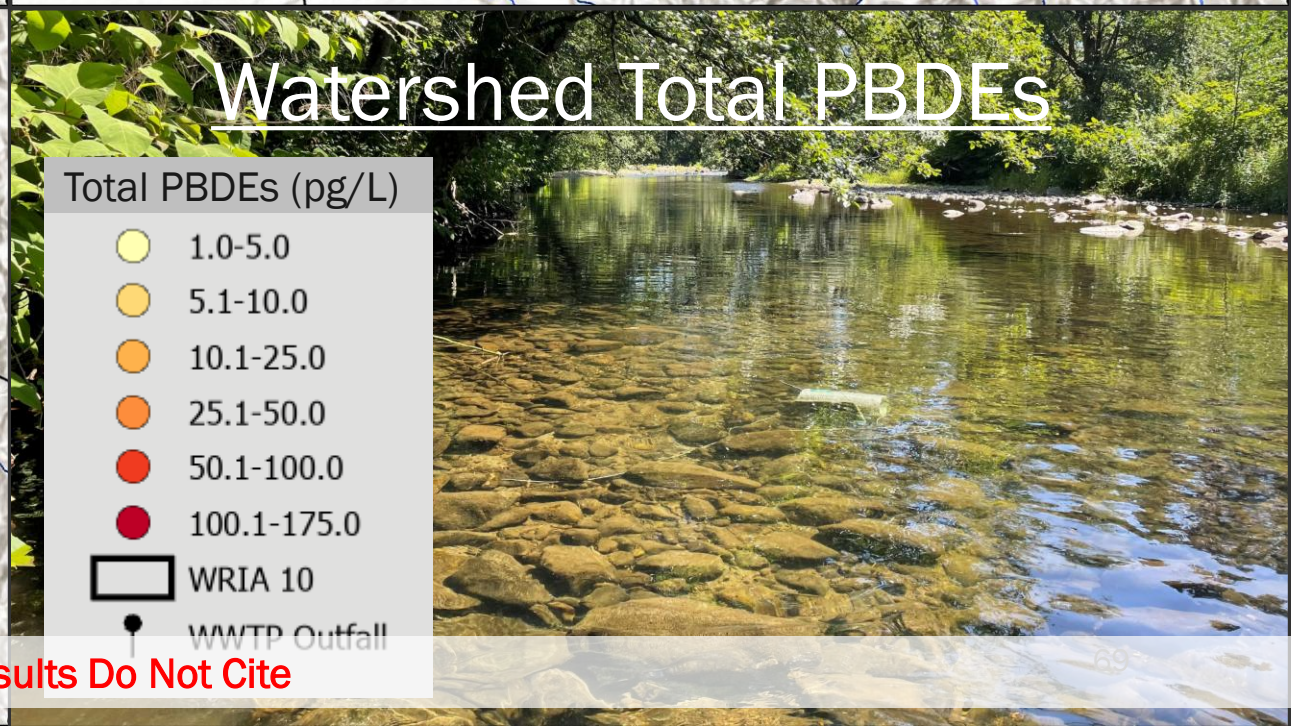


Preliminary Results Do Not Cite







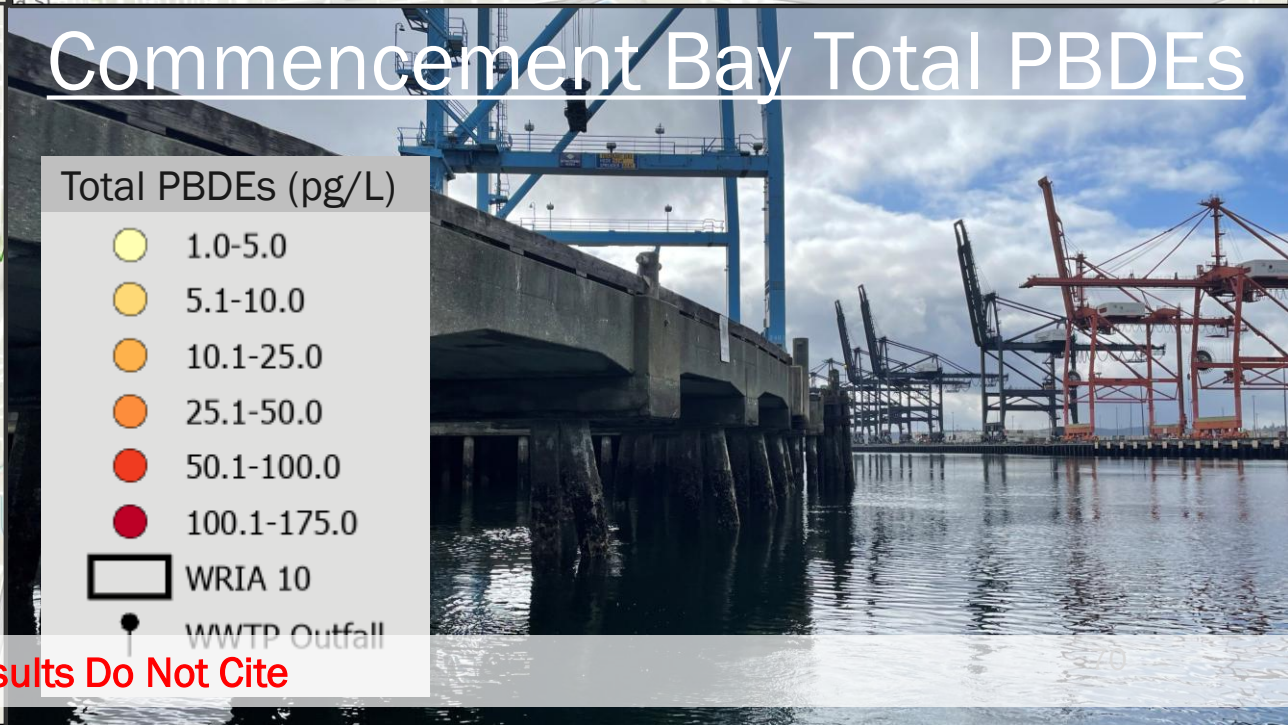


Preliminary Results Do Not Cite


2023 Spring
Hylebos Waterway
Blair Waterway
Sitcum Waterway
Middle Waterway
Wheeler Osgood
North East
Taylor Way
Marine View Dr
Fife Heights
Port of Tacoma Rd
Milwaukee Way
E 11th St
Tacoma
New Tacoma
State Highway 509
Puyallup Ave
Puyallup Reservation
54th Ave E
Pacific Hwy E
SW 356th St
33rd St NE
Fed Wy
509
99
5


2023 Summer
Hylebos Waterway
Blair Waterway
Sitcum Waterway
Middle Waterway
Wheeler Osgood
North East
Taylor Way
Marine View Dr
Fife Heights
Port of Tacoma Rd
Milwaukee Way
E 11th St
Tacoma
New Tacoma
State Highway 509
Puyallup Ave
Puyallup Reservation
54th Ave E
Pacific Hwy E
SW 356th St
33rd St NE
Fed Wy
509
99
5


2024 Spring
Hylebos Waterway
Blair Waterway
Sitcum Waterway
Middle Waterway
Wheeler Osgood
North East
Morningside Ditch
Taylor Way
Marine View Dr
Fife Heights
Port of Tacoma Rd
Milwaukee Way
E 11th St
Tacoma
New Tacoma
Hylebos Creek
Wapato Creek
State Highway 509
Puyallup Ave
Puyallup Reservation
54th Ave E
Pacific Hwy E
SW 356th St
33rd St NE
Fed Wy
509
99
5


Commencement Bay Total PBDEs
Total PBDEs (pg/L)
1.0-5.0
5.1-10.0
10.1-25.0
25.1-50.0
50.1-100.0
100.1-175.0
WRIA 10
WWTP Outfall
Preliminary Results Do Not Cite

Results Summary

- Upper Watershed
  - Spring: PCBs <100 pg/L, PBDEs <25 pg/L
  - Summer: PCBs >100 pg/L & PBDEs >25 pg/L at select sites below WWTP outfalls (Wilkeson & Buckley)
- Commencement Bay
  - Hylebos waterway: Highest concentrations of waterways, PCBs 750 - 4600 pg/L, PBDEs 40-90 pg/L
    - potential sources: Morningside ditch, Hylebos Creek
  - Blair: PCBs 200–1000 pg/L, PBDEs 16-35 pg/L
  - Thea Foss: PCBs 200 - 400 pg/L, PBDEs 22 - 87 pg/L
  - Sitcum: PCBs 150 - 640 pg/L, PBDEs 17 - 52 pg/L
- Puget Sound River Comparisons
  - Spring 2023 PCBs in the Stillaguamish River: 16-80 pg/L
  - 2019-2022 PBDEs in the Snohomish estuary: 20-55 pg/L (Gipe, 2024)

Take aways so far…

- Highest concentrations found in Commencement Bay waterways
  - Similar to juvenile Chinook data
- A few regions in the upper watershed of concern during low flows (summer)
  - Buckley & Wilkeson
  - Tied to WWTP outfalls
- Focused source assessments needed for Hylebos, Blair, and Thea Foss to resolve PCB/PBDE sources

Next Steps

- 2024 data analysis
  - Summer passive sampler deployment
  - Hylebos, Blair, Puyallup R. mouth suspended sediments
  - Resident fish PCB/PBDE survey
- Hylebos focused source assessment (NEP project)
  - Surface water, atmospheric deposition, sediment flux
- Blair and Thea Foss investigations
  - Further surface water sampling to id potential sources
- Upper watershed confirmation sampling
  - Bracketed sampling around hot spots

Thank you

Contact email:
alex.gipe@ECY.WA.GOV

Q&A

Lunch

Commencement Bay Monitoring Symposium
Thea Foss Waterway Project

Dana deLeon, Assistant Division Manager
Laura Nokes, Engineering Project Manager
Environmental Services Department
City of Tacoma

Commencement Bay Monitoring Symposium
Thea Foss Waterway Project

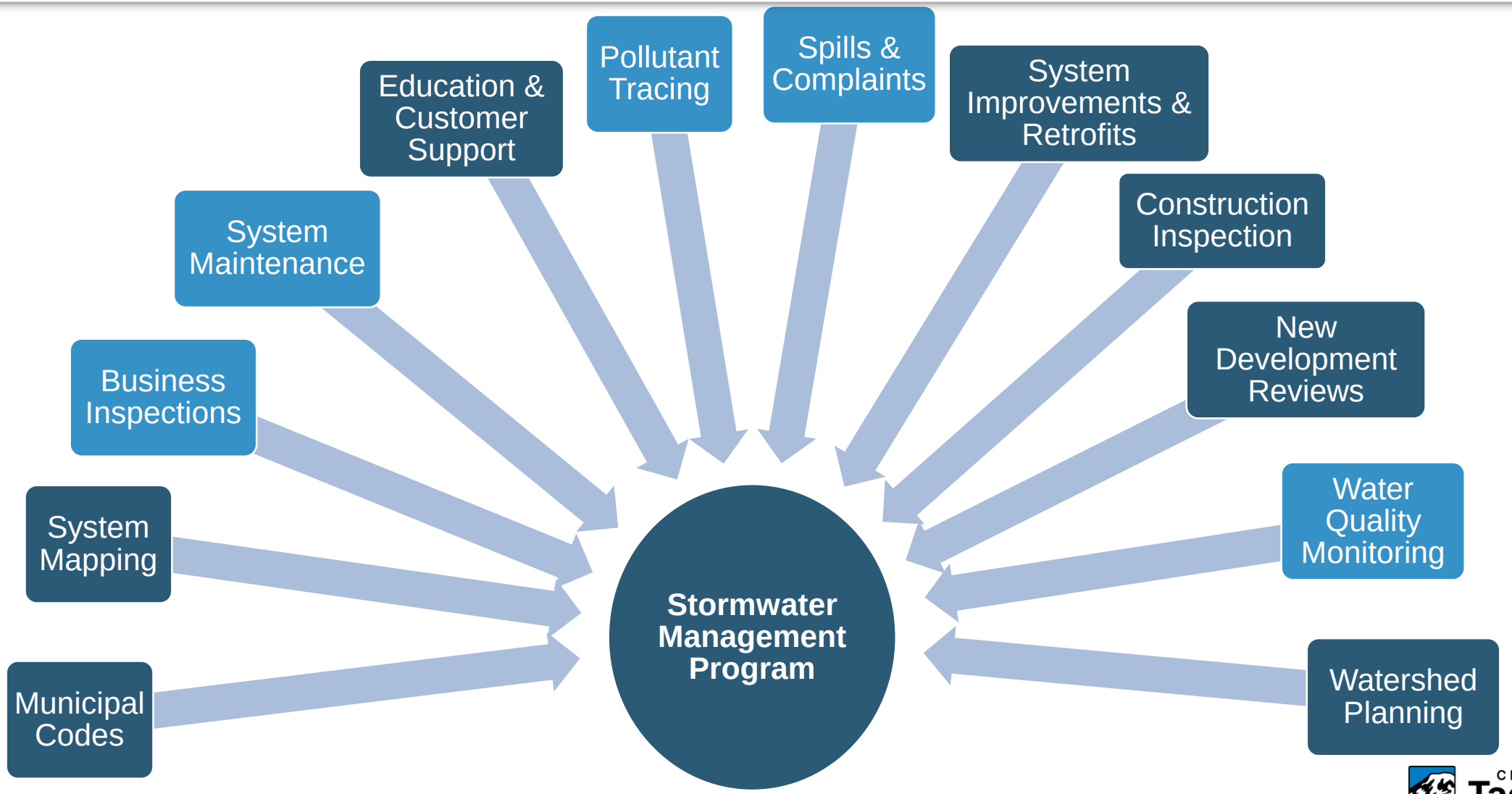
- Tacoma's stormwater management program
- History of the Foss Waterway Superfund Clean-up
- Source control, and
- Source tracing investigations with a focus on PCBs.

Stormwater Management Goals

Primary goal: Implementing strategic stormwater management to ***protect people, property, and habitats*** from stormwater flooding and pollution.

S&E – Stormwater Management Program

Recognizing efforts citywide on Municipal Stormwater



CITY OF Tacoma

Industrialization, Densification & Stormwater

- Industrialization in Tacoma happened for 100+ years before runoff regulations started in 1987 (CWA-MS4).
- Many ubiquitous toxic pollutants
  - Copper, Lead, Arsenic, Mercury
  - Coal Tar, PAHs, **PCBs**, phthalates
  - Solvents, Pesticides
- Population pressures dramatically changed Tacoma's landscape and urban growth has a 'car habitat' focus
- Urban landscapes generally have a low levels of contamination from legacy and current human activity.
- Tacoma got first MS4 permit in 1995 (30yrs ago).
- MS4 permits require programs to manage ubiquitous pollutants in urban areas to prevent contamination of rainfall and manage stormwater runoff.

Tacoma Smelter - Ecology

CITY OF Tacoma

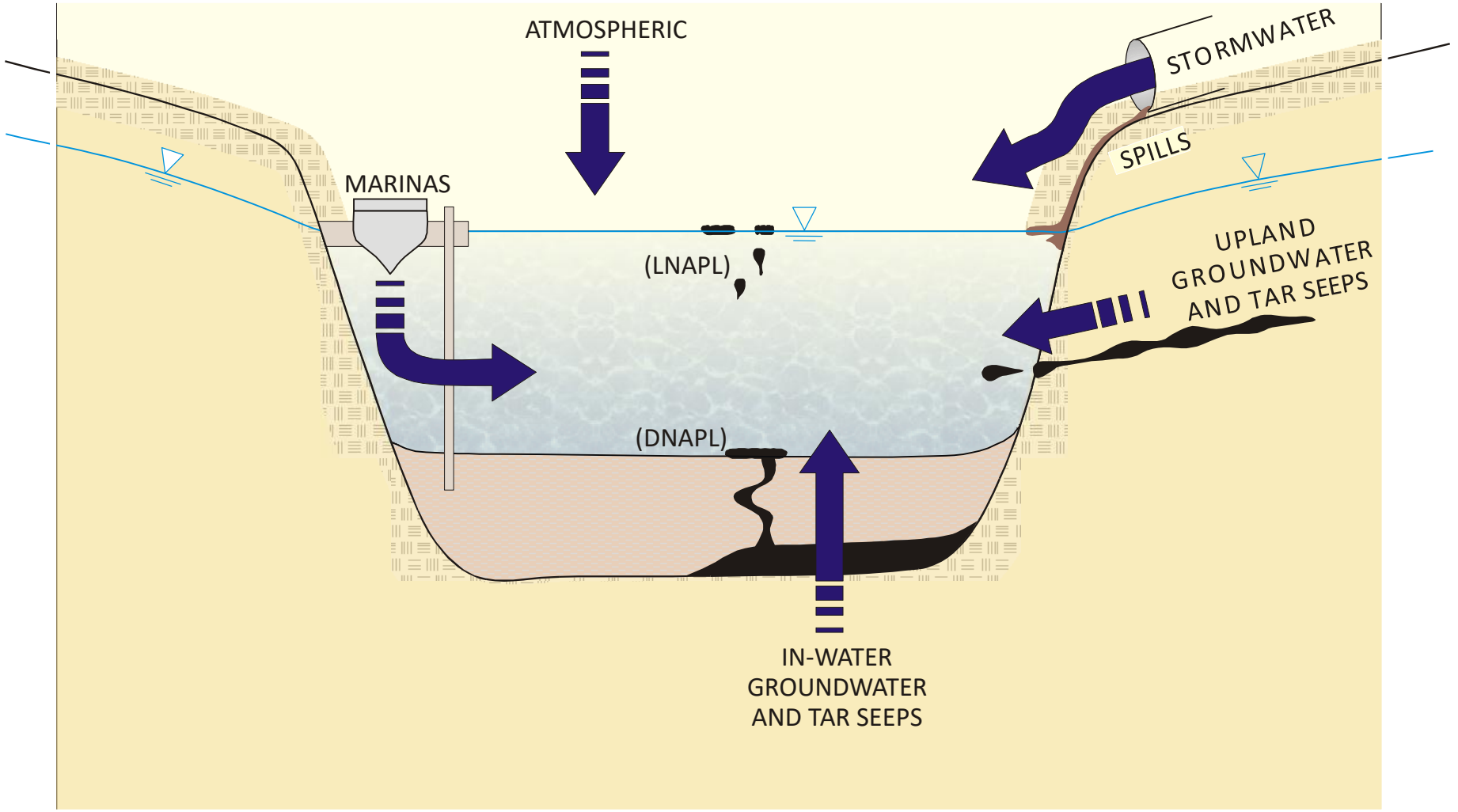
Thea Foss Watershed- successes with stormwater-carried toxic contaminants

CERCLA + NPDES

- This photo is of the Thea Foss Waterway in Tacoma. Put on the Superfund List in mid 1980s, at least 10 years before Tacoma's first MS4 permit.
- The CERCLA clean up actions in the waterway were completed in 2001 and EPA considers the site cleaned up.
- In tandem, Tacoma built a skilled workforce to examine sources of contaminants to the Foss stormwater system. 20+ years of stormwater actions (source tracing, source controls, maintenance, system repairs, and system housekeeping) have eliminated many of the upland sources carried by stormwater to the waterway. Stormwater monitoring results show that stormwater quality goals are met.
- Tacoma has used **ALL** stormwater management tools reduce conventional and legacy pollutants.

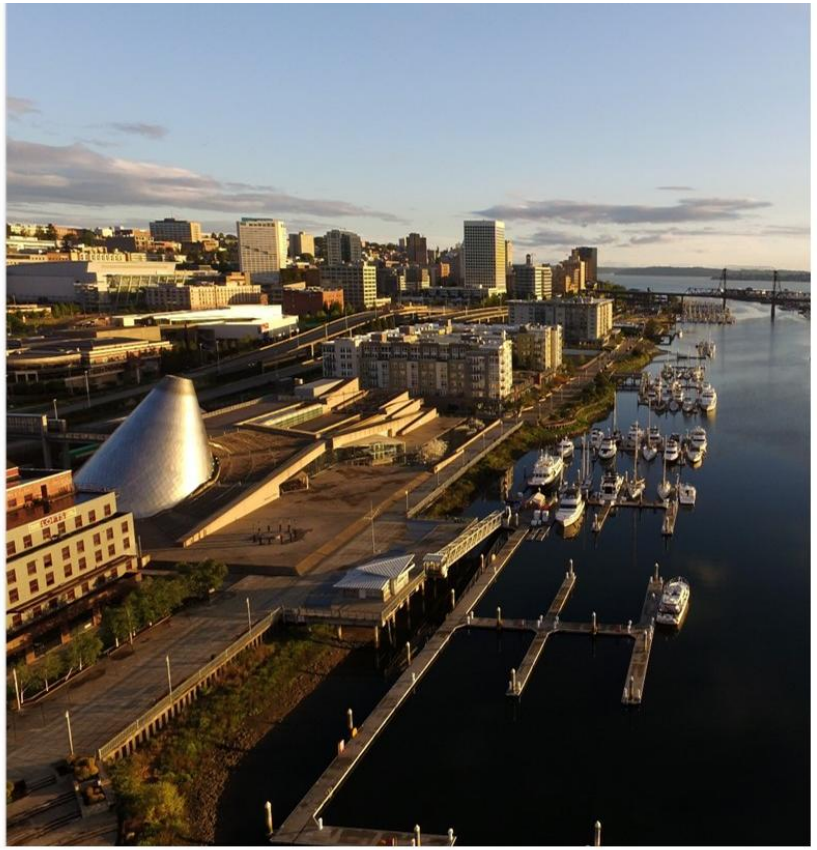
CITY OF Tacoma

Keeping the Waterway Clean
Ongoing Pollutant Sources



Keeping the Waterway Clean

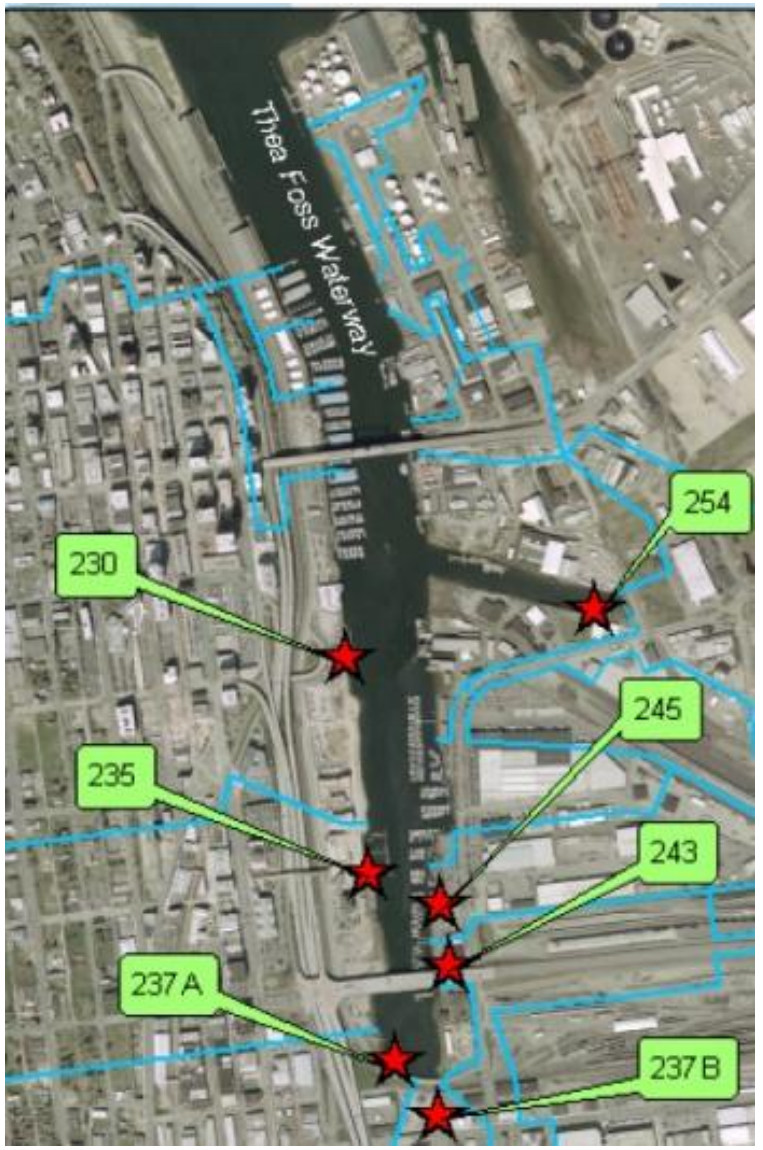
- Our Stormwater Management Program reduces the contaminants discharging to our waterways
- Our Thea Foss Work Plan:
  - evaluates effectiveness of the SWMP and
  - provides early warning of any new problems which arise in the drainage basins.
- An Overview of the Thea Foss Superfund Cleanup can be viewed here: Turning the Tide - City of Tacoma.
- Annual Foss Report for WY2024 and can be found here: 2024 Source Control and Water Year 2024 Stormwater Monitoring Report-compressed.pdf (cityoftacoma.org)



The Foss Work Plan is designed to protect the Waterway from impacts of contaminants in stormwater

Twenty-four years of work and ongoing

- Monitor stormwater and sediment ,
- Analyze data,
- Take field actions, and
- Repeat.

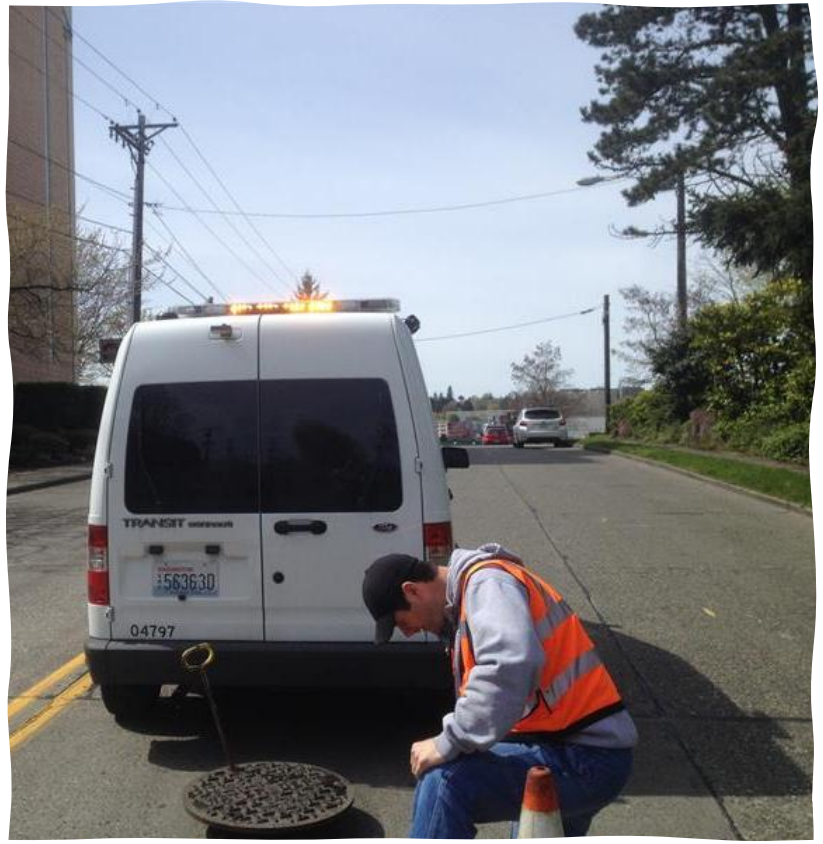


Field Actions of the Foss Work Plan

- Spill Response
- Source Control/Business Inspections
- Source Tracing Investigations
- Non-structural BMPs
- Regional Treatment Devices

CITY OF Tacoma

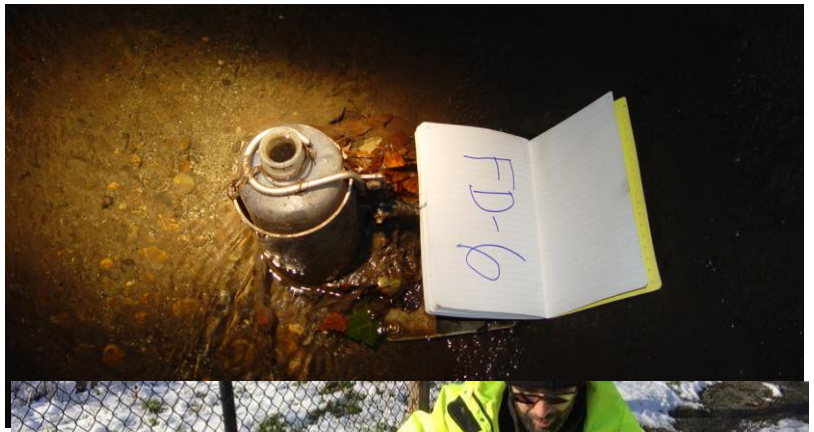
Environmental Compliance



Provide the first line of defense through business inspections, education and spill response.

In 2024, within the Foss Waterway Watershed, Staff:

- Responded to 217 spills/complaints including conducting investigations
- Conducted 177 business inspections and follow-ups
- Provided technical assistance on source control and best management practices (BMPs)

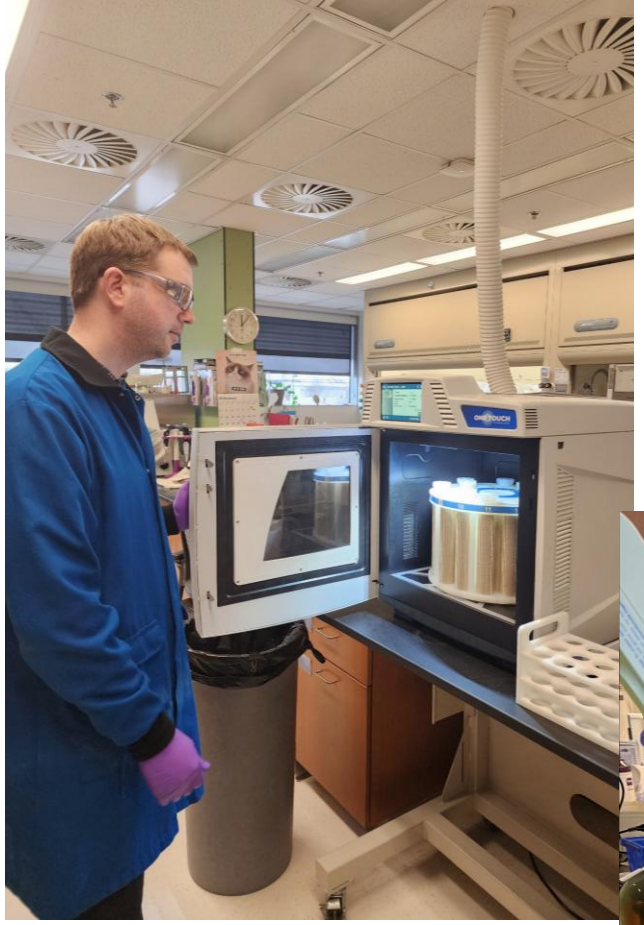


Stormwater monitoring staff collects Foss stormwater, stormwater sediment & in-waterway (as needed) samples; and monitors 7 outfalls' flow & rainfall.

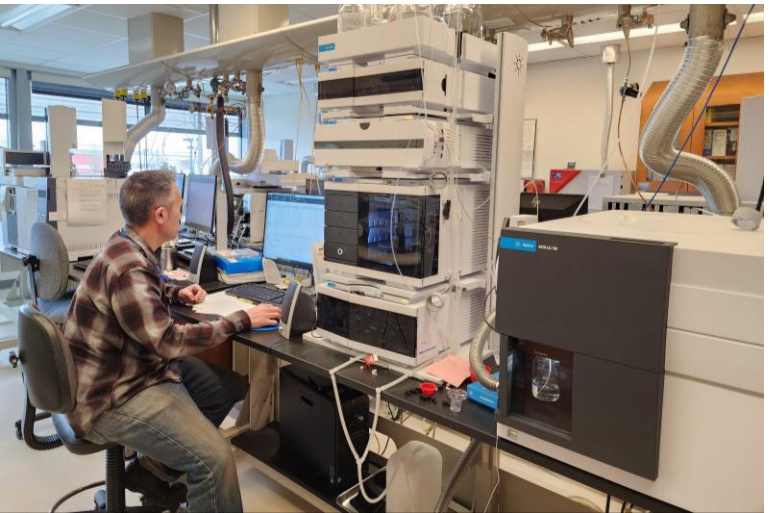
Over 23 years, 2,483 samples have been collected;

- 370 baseflow samples,
- 1,588 stormwater samples, and
- 525 sediment trap samples collected in pipeline

Environmental Services Laboratory



ES Laboratory staff analyze stormwater & sediment samples, providing quality assurance, & data management.



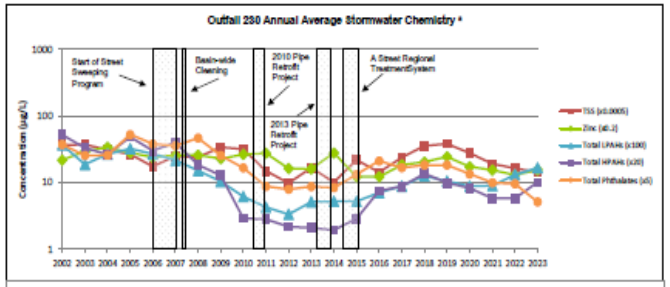
analyzed 79 water & 14 SSPM samples;& all assoc. performance, laboratory and field blanks, and many other QC samples.

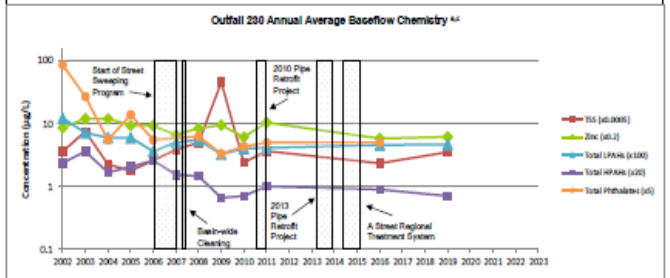
Overall, 12,684 sample and QA/QC results were analyzed last year.

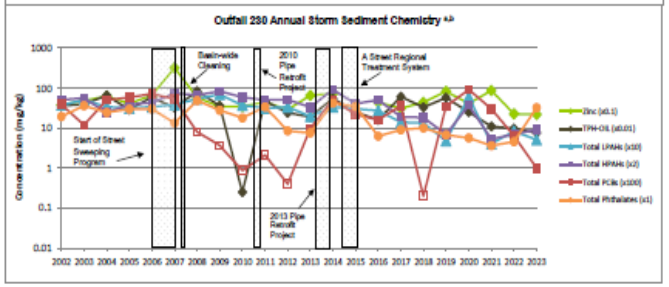
Data Driven Decisions Improving Water Quality

The time trends were modeled with best-fit regression equations to estimate percent reductions over the 23-year monitoring period for these constituents and outfalls:

- **Total Suspended Solids (TSS)**: Approximately 40-75 percent reduction all seven outfalls
- **Copper:** Approximately 33-47 percent reduction in OF235, OF237B, and OF245
- **Lead**: Approximately 69-83 percent reduction in all seven outfalls
- **Zinc**: Approximately 51-71 percent reduction in all seven outfalls
- **PAHs**: Approximately 62-89 percent in all seven outfalls
- **Bis(2-ethylhexyl)phthalate (DEHP)**: Approximately 42-80 percent reduction in all seven outfalls.







Data Driven Decisions

Annual monitoring data used to develop enhanced maintenance approaches. Pilot study in East Side Outfalls looking at increased street sweeping frequencies. Also used to direct line-cleaning.

Data Driven Decisions

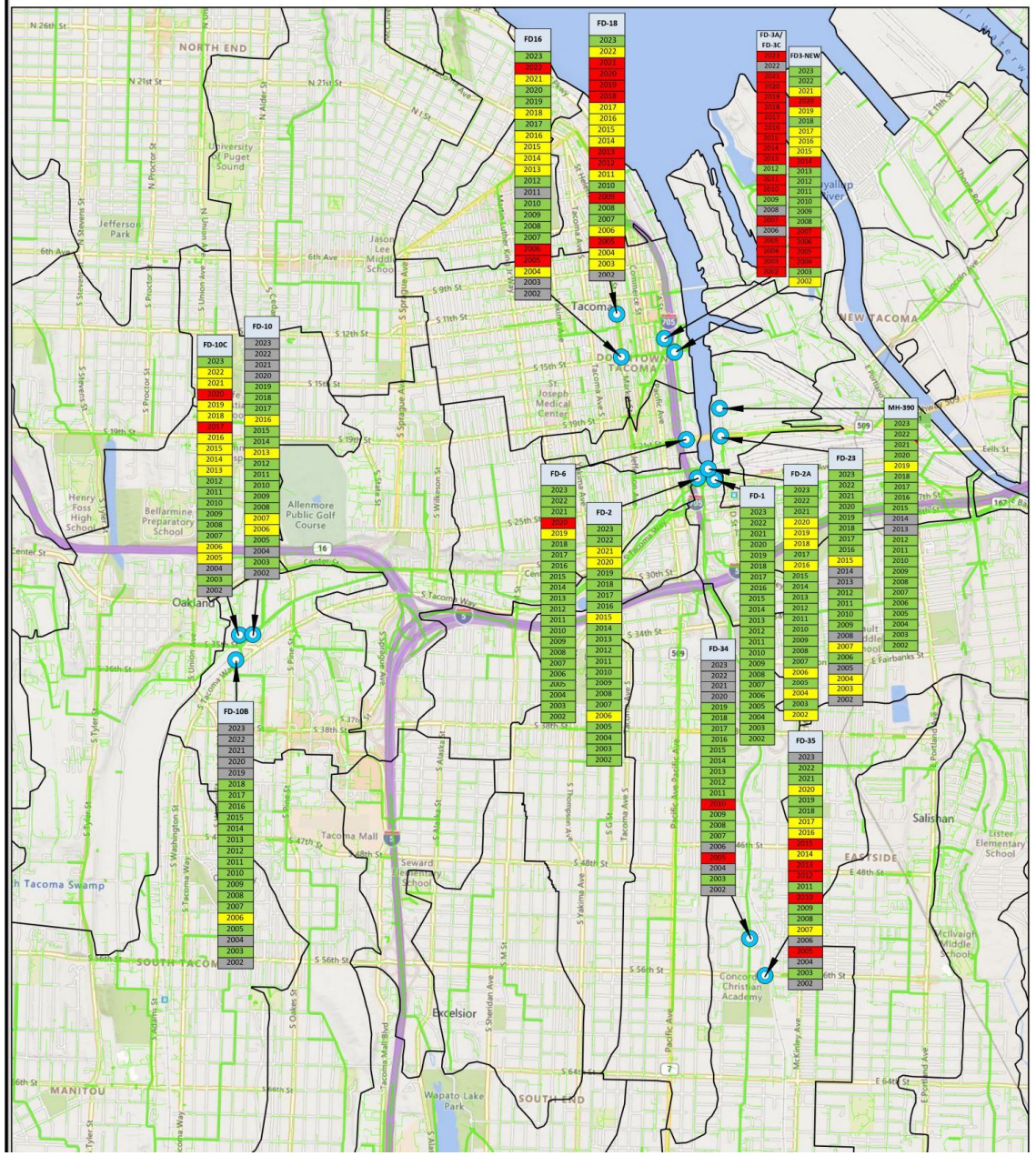
Annual Sediment trap data used to develop a workplan for source tracing

Developing a work plan

Continuing to see **diminished differences** between stormwater sediments and waterway concentrations.

- News Tribune basin (PAHs) – Source Found & Removed
- Nalley basin (PCBs) - Source Found & Removed
- Downtown PCBs, PAHs, and metals.
    - CenturyLink (PCB) – Source Found & Removed
    - Arletta Parking (S 14th & A) (PAH)– Source Found & Removed
    - Wells Fargo/Pacific Partners (PCB) – Ongoing investigation
    - Park Plaza Parking (PCB) – Working with EPA on solution
    - South downtown (Cu) – Waiting for CB cleaning results
    - South downtown (Pb) – Waiting for construction on Jefferson street

Figure 2-1.4
Sediment Trap Results - PCBs



Source Tracing Investigations

Planning an Investigation

Review Historic Investigations (Sampling, cleaning, contaminated sites, construction activities)

Research Pollutants of concern – How do they get into the environment.

Develop sampling analysis plan

Coordinate with lab and sampling team

Schedule business inspections if needed for private properties.

Develop maps, sample IDs, Documentation process.

Conducting an Investigation

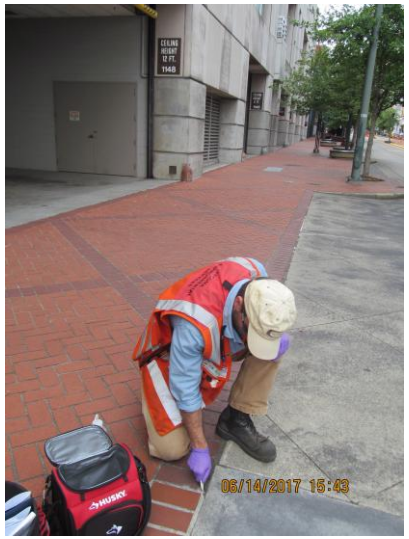
CONDUCT SAFETY MEETING

COLLECT SAMPLES ACCORDING TO PLAN

DOCUMENTATION – FIELD NOTES, PHOTOS, LOCATION NOTES.

CHECK-IN SAMPLES TO LAB, CHAIN OF CUSTODY PROCEDURES

EVALUATE RESULTS & NEXT STEPS



Methods for stormwater sediment collection

Long-term SSPM Trap (Norton)

Short-term SSPM trap (Hamlin)

Catch Basin Sampling

You found something…Now what?

FINAL REPORTING & DOCUMENTATION

CREATE MATERIALS FOR COMMUNICATION (MAPS, LETTERS, PRESENTATIONS)

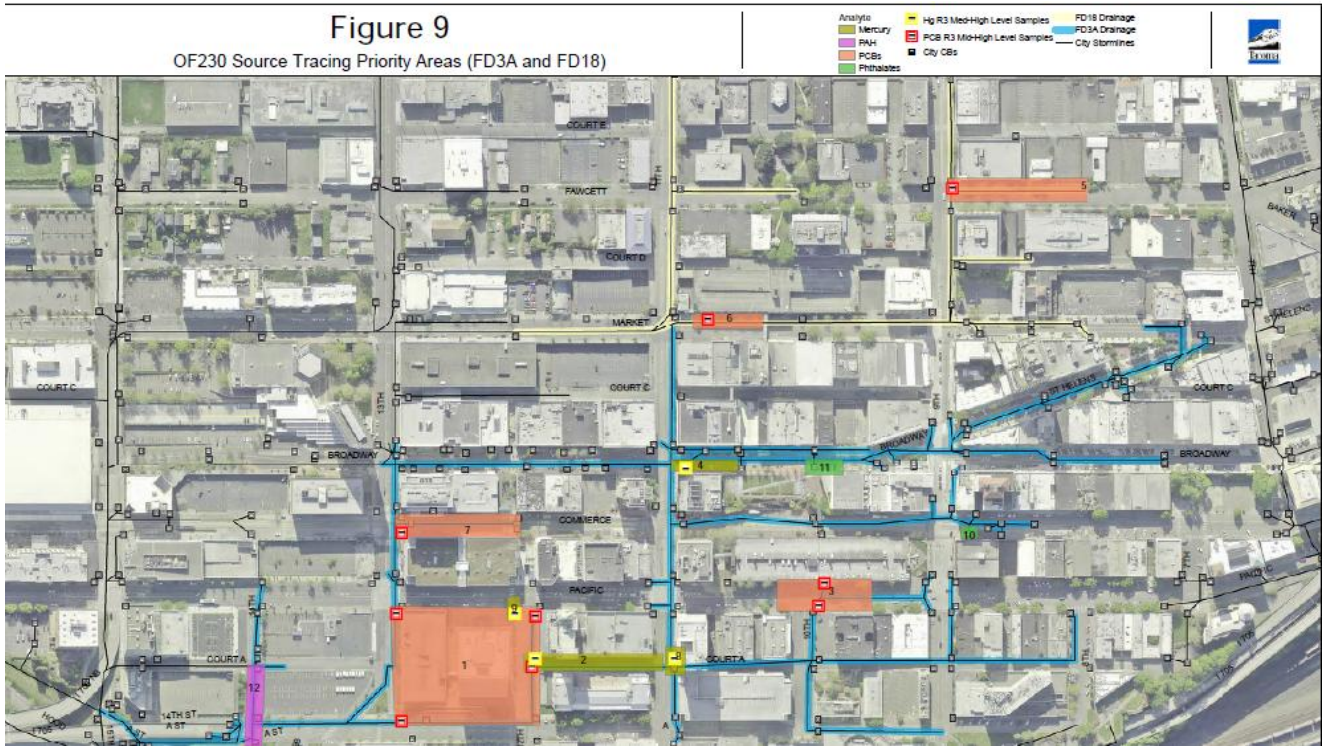
NOTIFY PROPERTY OWNERS AND REGULATORS

ENFORCEMENT & REMEDIATION

FOLLOW-UP SAMPLING

Figure 9

OF230 Source Tracing Priority Areas (FD3A and FD18)



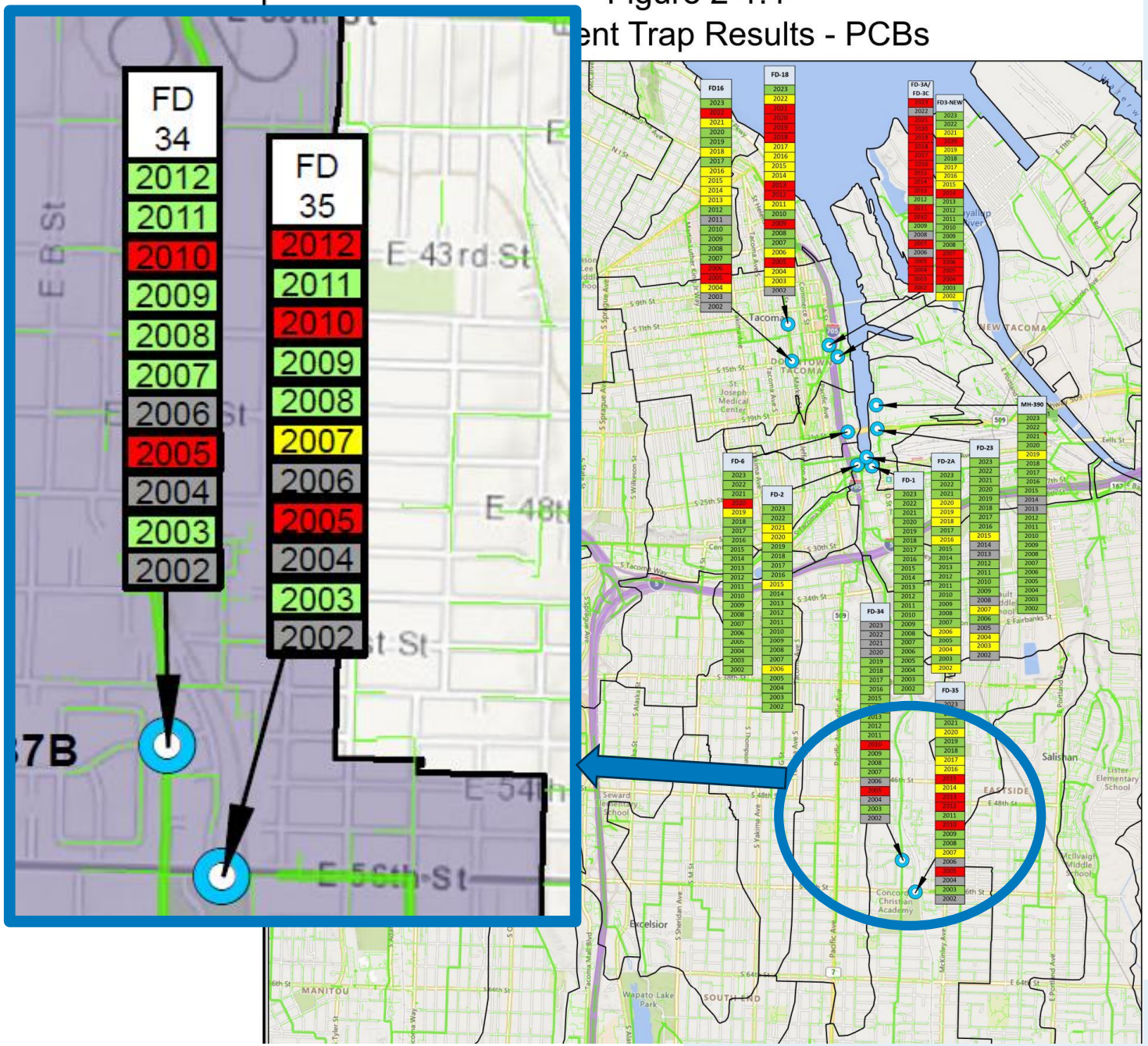
OF230 Source Tracing Investigation - 2012 Priority Results		
Segment	**Location**	**Result (ppm)**
	Total PCBs [a]	
FD3A-E	Commerce Street Segment	0.55
FD3A-E	Pacific Avenue and South 13th	3.1
FD3A-F	Pacific Avenue and South 9th	1.28
FD3A-G	Pacific Avenue (west side) and South 11th	0.44
FD3A-G	Court A and South 12th	0.77
FD3A-G	A Street and South 13th	2.1
FD18-B	Market and South 11th	0.48
FD18-B	Fawcett Avenue and South 9th	2.7
	Mercury	
FD3A-C	11th Avenue Segment – East and Broadway Avenue	0.957
FD3A-G	Court A and South 12th	6.83
	Phthalates	
FD3A-C	Broadway Avenue	64
FD3A-D	Commerce Street and South 9th	231
	PAHs	
FD3A-H	South 14th and A Street	496

[a] – While total PCBs are reported in this table, only Aroclor 1254 was detected.

Case Study 1

East Tacoma PCB Investigation

Figure 2-1.4
ent Trap Results - PCBs



Foss Work Plan: PCBs Results in East Tacoma

- Intermittent elevated concentrations in sediment trap between 2005-2012
- Source control investigations performed, source not found
- Storm line cleaning in summer 2011
- Elevated PCBs in WY2012 sediment trap results
- Intensive investigation initiated in fall 2012

Phase 1

- Split up upstream drainage into segments
- Collected sediment from catch basins in each segment and composited
- Could use short-term sediment traps.
- Results indicated that Segment G was elevated for PCBs

Phase 2

- Sampled individual catch basins in Segment G
- 12 catch basins had concentrations greater than 1 ppm PCBs
- Results didn’t indicate a single point source

Phase 3

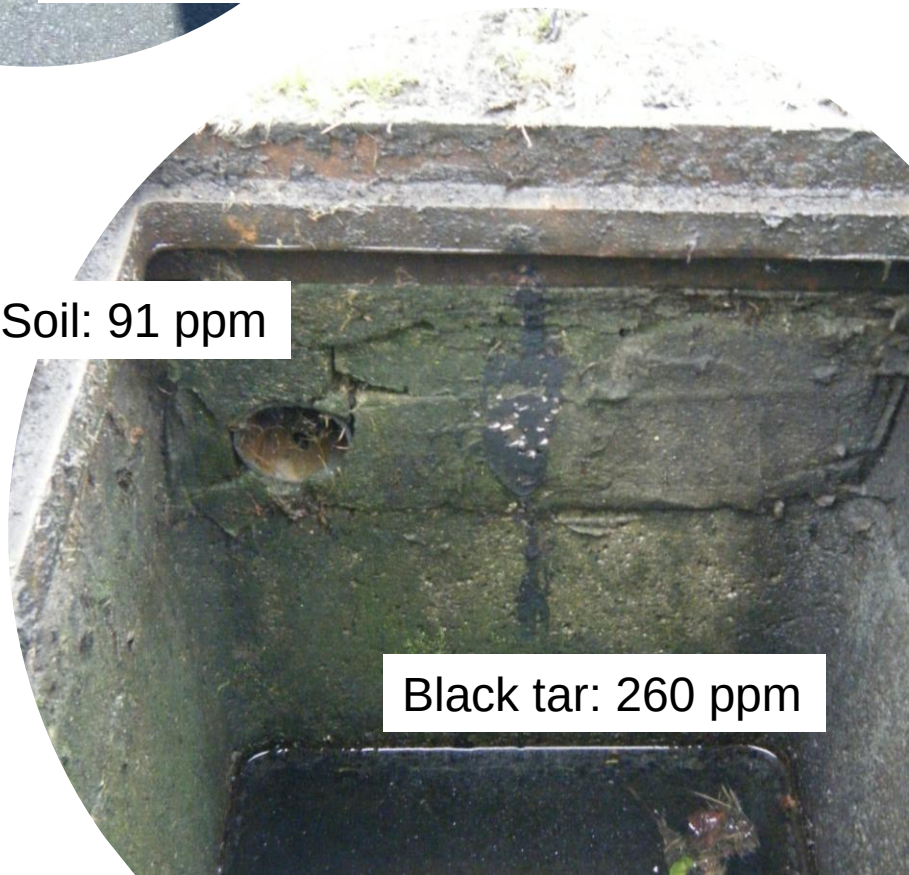
- Additional sampling and investigation (One day – 20 staff;
- Sampled:
  - Catch basins beyond Segment G boundaries
  - Manholes
  - Alley dirt, especially under transformers
  - Soil in planting strips
  - Undeveloped right-of-way
  - Asphalt
  - Gravel under road
  - Black tar present in catch basin
  - Dirt in 2-inch side pipes in catch basins
  - Sealant curb & gutter

Investigation Summary

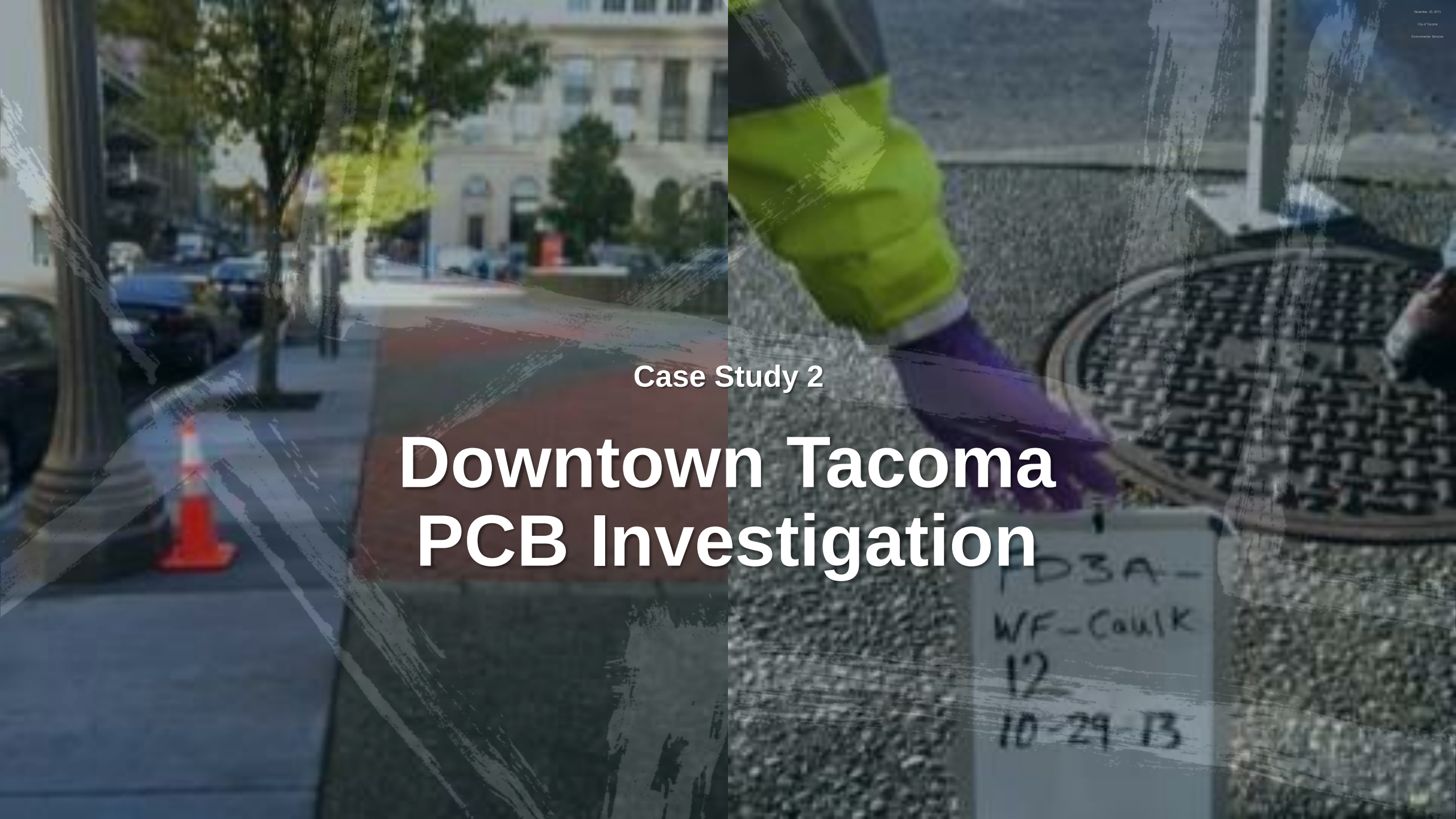
- Desk top research found a 1975 road construction project
- High groundwater table: Project installed 2-inch side pipes to provide drainage during construction of the road – discharged to storm catchbasin.
- Sealant between the asphalt and concrete (curb and gutter), side pipe dirt and tar in CB had PCBs
- PCB material leached into soil underneath road, into the perforated side pipe and during years of high groundwater - discharged to the catchbasin.
- Worked with Ecology/EPA to finalize a cleanup plan
- After additional sampling including asphalt and roadbed cores, roadways were removed and replaced.
- After clean-up and cleaning of system, PCBS were no longer seen in sediment trap.

Sealant: 96 ppm

Side Pipe Soil: 91 ppm



Black tar: 260 ppm

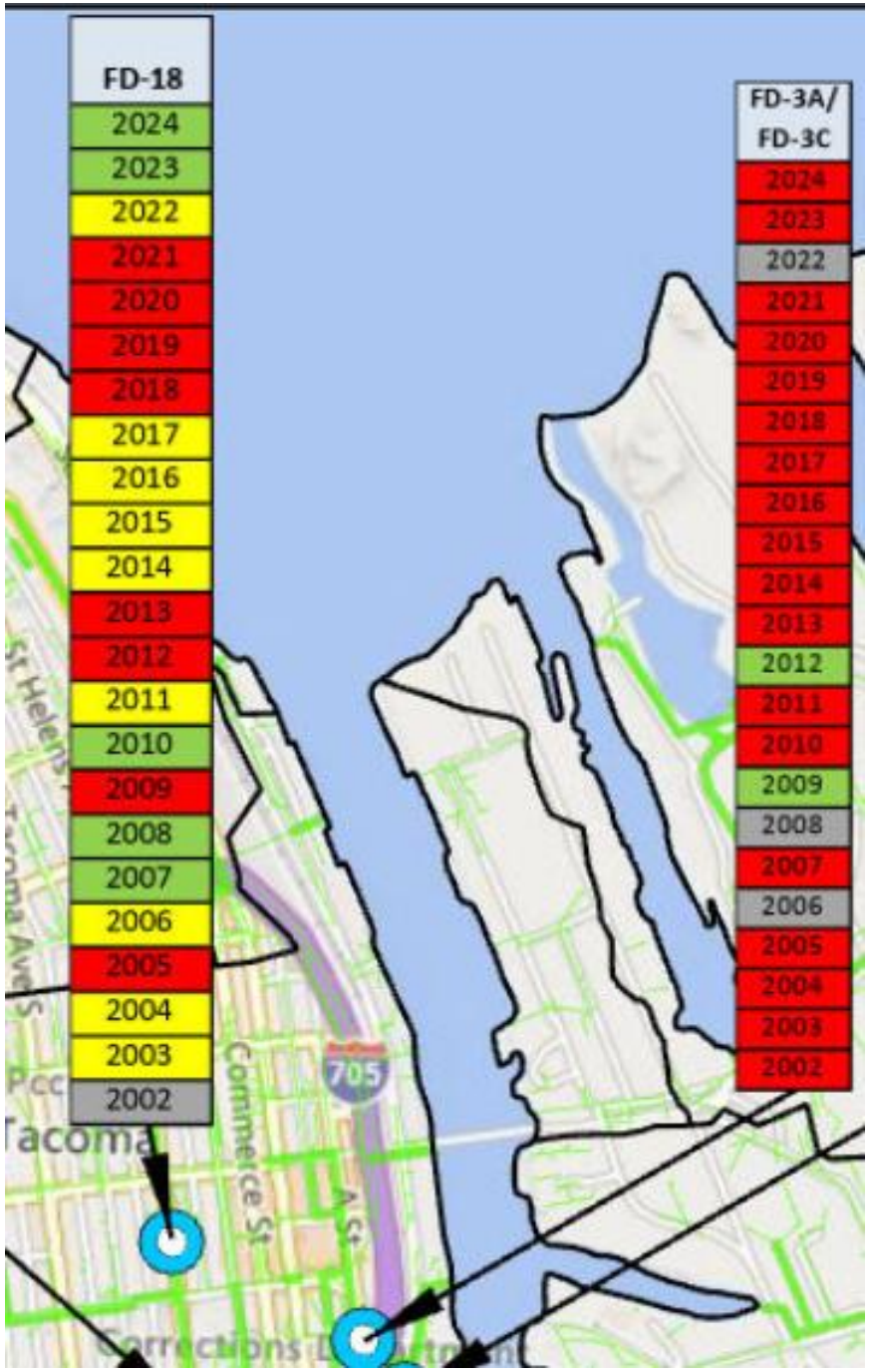


Case Study 2

Downtown Tacoma PCB Investigation

Foss Work Plan: PCBs Results in Downtown Tacoma

- Elevated concentrations in FD-18 and FD3A sediment traps.
- Previous source control investigations performed; source not found
- OF230 Basin-wide stormline cleaning in 2007
- Intensive investigation initiated in fall 2012 for mercury and PCBs in the FD18 and FD3A drainage basins.



Phase 1 2012

- Approximately 250 catch basins
- Short-term traps wouldn’t work here steep slopes & intense flow.
- Split up upstream drainage into 12 segments (FD18 - 4 segments; FD3A - 8 segments)
- Composited sediment from catch basins in each segment
- 2-3 weeks sampling
- 5 segments: PCBs elevated (2 - FD18; 3 - FD3A)

Phase 2 2013

- Sampled and analyzed 34 catch basins in the targeted segments
- 9 catch basins had elevated PCB concentrations
- 5 areas were identified and prioritized for further PCB investigation
- Results indicated several sources

Phase 3 2013 – General Approach

- Targeted 2 drainage areas with the highest PCB concentrations.
  - Highest priority area, CBs w/PCBs @ 2 -16 ppm: around Wells Fargo Building on Pacific
  - 2nd priority area, CBs w/PCBs @ 3 ppm: on S 9th and Pacific
- Other areas targeted for higher priority COCs to start.
- Remaining Areas were targeted subsequent years.
- Conducted additional sampling, investigation and business inspections

Phase 3 2013 ROW Sampling

In the 2 targeted drainage areas:

- Collected samples of roadway sealant and curb line soil to analyze for PCBs.
- Highest concentrations found in curbline soil – 10 ppm.

Phase 3 2013 – Business Inspections & Sampling

PCB Sampling Results

Map ID	Sample Type	PCB's (ppm)	Map ID	Sample Type	PCB's (ppm)
SP1	Paint	ND	WF6	Caulk	87
SP2	Paint	ND	WF7	Paint	ND
SP3	Soil	1.5	WF8	Caulk	190
SP4	Soil	0.79	WF9	Caulk	38,000
SP5	Paint Chips	ND	WF10	Caulk	44
SP6	Roof Tar	ND	WF11	Paint	ND
SP7	Caulk	4.6	WF12	Caulk	2.6
SP8	Caulk	4.1	WF13	Paint	ND
SP9	Caulk	4.1	WF14	Soil	9.6
SP10	Caulk	28	WF15	Caulk	62
SP11	Caulk	6.5	WF16	Caulk	24,000
SP12	Caulk	13,000	WF17	Caulk	1,200
SP13	Caulk	3.0	WF18	Caulk	220
SP14	Caulk	17,000	WF19	Soil	0.49
WF1	Soil	7.5	WF19b	Caulk	4.3
WF2	Paint Chips	6.2	WF20	Caulk	25,000
WF3	Paint	ND	WF21	Caulk	16,000
WF4	Paint	ND	WF22	Caulk	24,000
WF5	Caulk	1,000	WF23	Caulk	53,000

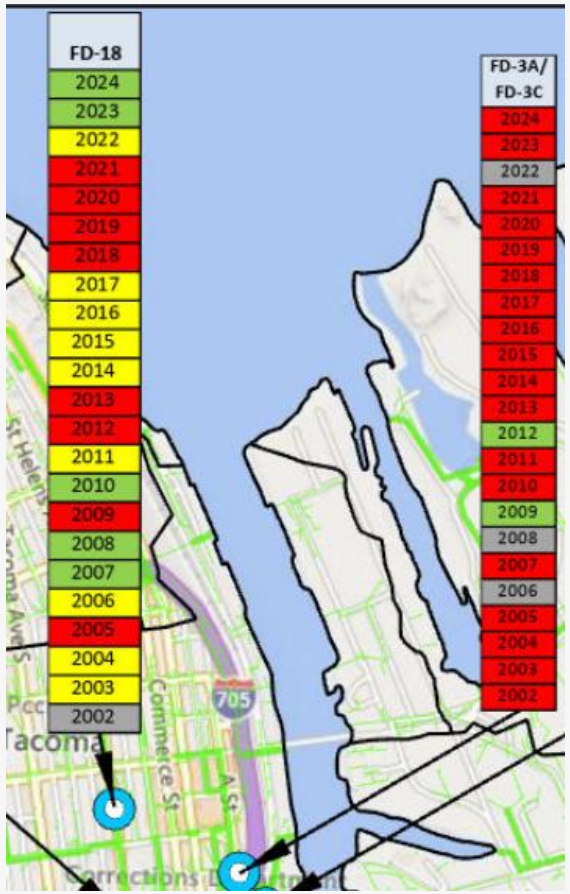
Investigation Summary

- Two properties had caulking with PCBs.
  - 1201 Pacific Ave property sidewalk caulking with 2.6- 53,000 ppm
  - S 12th Building caulking samples 13,000-17,000 ppm
- Notified regulators & Property owners of PCB discovery
- Met with property owners about remediation of PCB containing caulking - removing from both the sidewalk & buildings.
- Cleaned & resampled catchbasins in this area. Potentially found another source. Investigations are on-going.
- Successfully found & facilitated clean-up of other PCB sources in FD18 and FD3A basins

- **FD18 sediment trap has two years of ND for PCBs.**
- **FD3A – Investigations continue.**

Lessons learned

- Need Patience: 13-year investigation in FD3A. Despite multiple successes we are still seeing PCBs in sediment trap.
- Once you find a source the work is not done.
  - Notify property owners, regulators & potentially conduct public meetings.
  - Storm system needs to be cleaned
  - Resample to ensure source is gone.
- Source of PCBs found on buildings/sidewalks were from remodeling not new-construction during the 60s-70s.
- Needle in a haystack! Opportunistic Samples are important.
- Projects are time consuming and expensive.
- Ways to save time & money
  - Short-term traps are a better approach if feasible. Sampling individual catch basins & compositing is labor intensive.
  - Research: Drainage area, looking for possible sources on buildings, mapping data, construction permits, historic land use, spills database, etc.
  - Laboratory savings– Breaking drainage area up and compositing samples. Fewer samples.

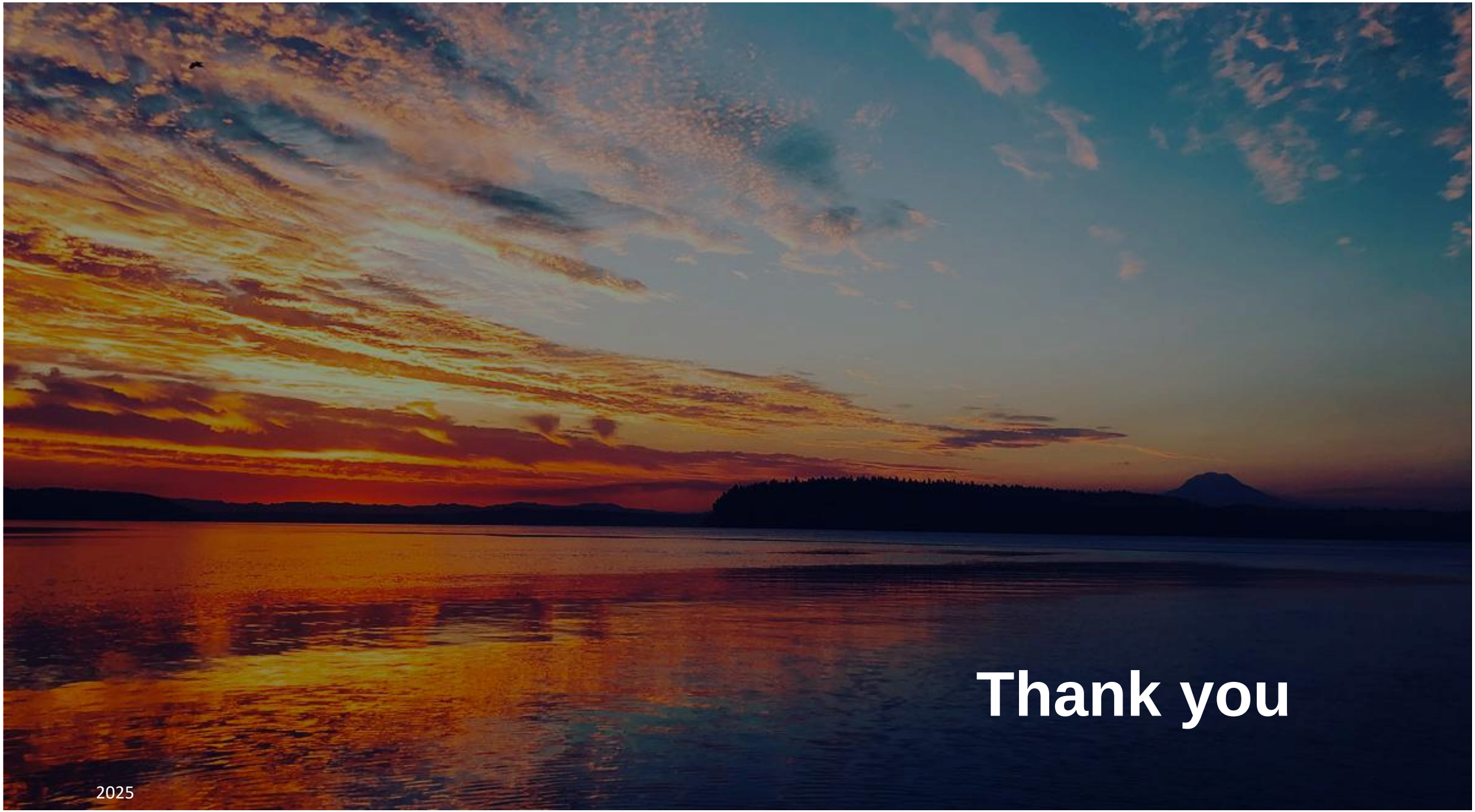


CITY OF Tacoma

Conclusions

- Foss stormwater monitoring data demonstrates a source tracing/control, maintenance, and limited treatment facilities can keep the waterbody's sediment concentrations stable.
- Through monitoring and source tracing efforts the city continues to see diminished concentrations of pollutants in stormwater and stormwater sediment.
- Investigation takes a lot of time, money and effort.
- Current Workplan found in the WY2024 Report on our website. FD3A – continue to look for PCBs.

CITY OF Tacoma


Thank you

Q&A

Break

AFTERNOON SESSION

Commencement Bay Source Tracking Programs

COMMENCEMENT BAY SOURCE TRACKING PROGRAMS – CONSIDERATIONS

What is your conceptual model of what is driving continued levels of PCBs etc. in Commencement Bay?

- Mixing/remobilization/flux of “in place” (*i.e.*, within a OU/study area) historical contaminants
- Chronic but steady releases from “upstream” sources
- Episodic pulses from “upstream” sources (including dredging)

COMMENCEMENT BAY SOURCE TRACKING PROGRAMS – CONSIDERATIONS

Why are you making these measurements?

- Levels of exposure relative to a risk level
- Concentrations in sediments/soils relative to a clean-up goal
- Determining contaminant sources

- *Each program has their specific needs and requirements*
- *How can we harmonize the results across programs to understand the watershed?*

COMMENCEMENT BAY SOURCE TRACKING PROGRAMS – CONSIDERATIONS

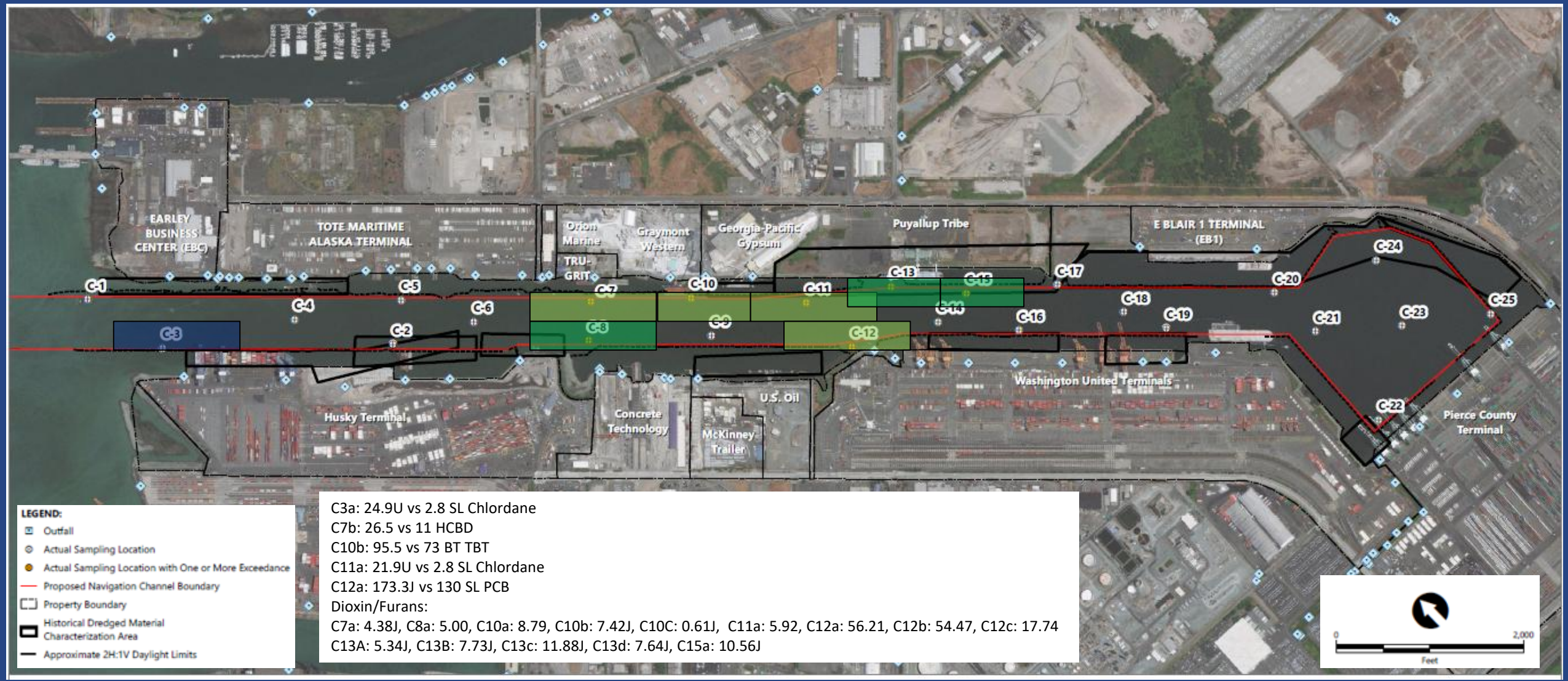
Characteristics of Contaminant Source Identification Programs

- Use multiple sources of information to identify potential sources and pathways
- Map and monitor along suspected gradients
- Determine fingerprints of most-likely source types
- Rapid analytical turn-around to allow focusing/confirmation

Blair Waterway Program Details

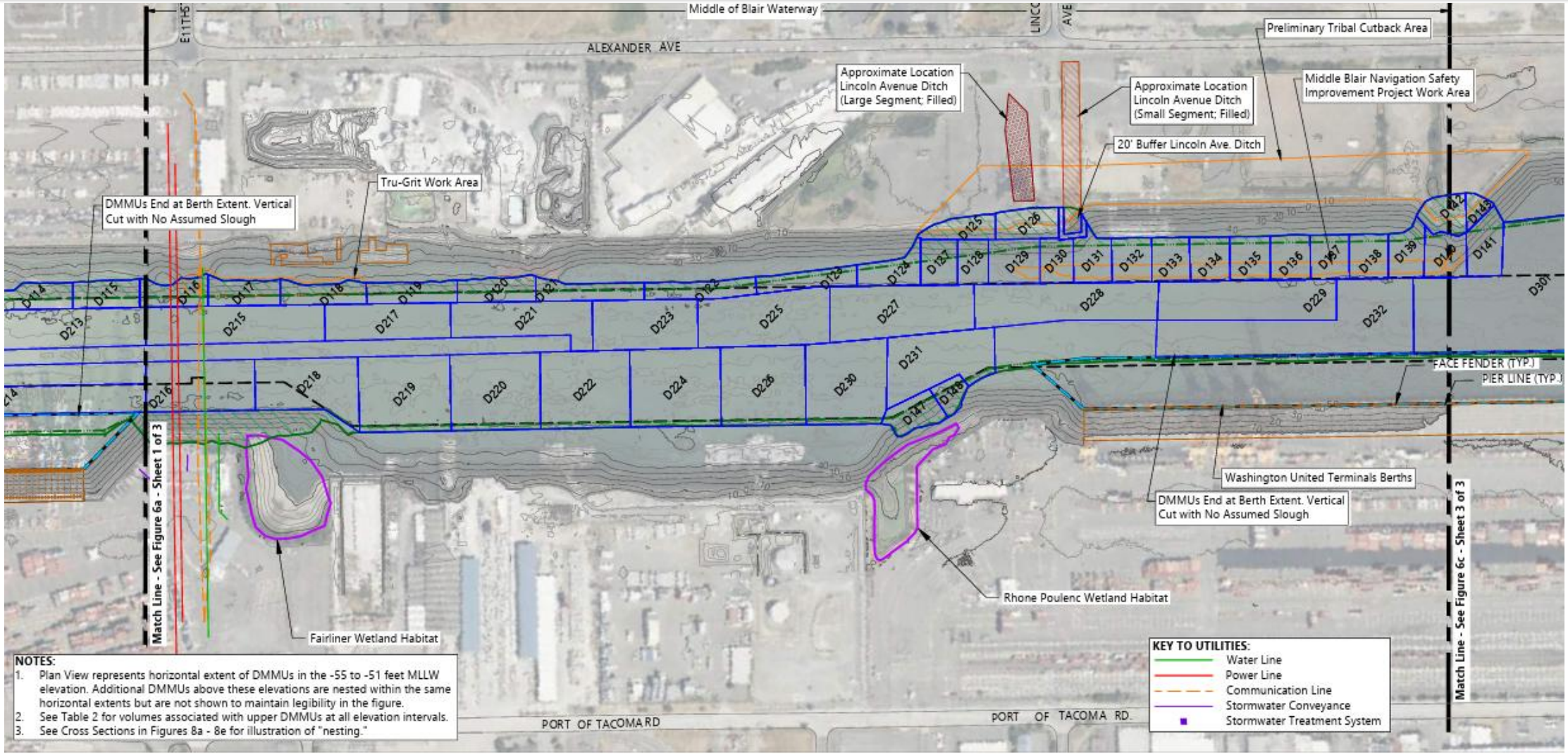
- >$200M program
- ~2.5M cubic yds of sediment requires disposal
- >$50M+ to address contaminated sediment

Blair Deepening 20% Feasibility Study Testing Results



Blair Waterway Sediment Characterization

Port of Tacoma



NOTES:

1. Plan View represents horizontal extent of DMMUs in the -55 to -51 feet MLLW elevation. Additional DMMUs above these elevations are nested within the same horizontal extents but are not shown to maintain legibility in the figure.
2. See Table 2 for volumes associated with upper DMMUs at all elevation intervals.
3. See Cross Sections in Figures 8a - 8e for illustration of "nesting."

SOURCE: Bathymetric survey is a composite of multiple sources (NOAA, USACE, DEA and Tru-Grit) the most recent survey is dated December 6, 2023. Current Federal Navigation Channel line work provided by Port of Tacoma and USACE, dated 2023.
HORIZONTAL DATUM: Washington State Plane South Zone, NAD83, U.S. Survey Feet
VERTICAL DATUM: MLLW

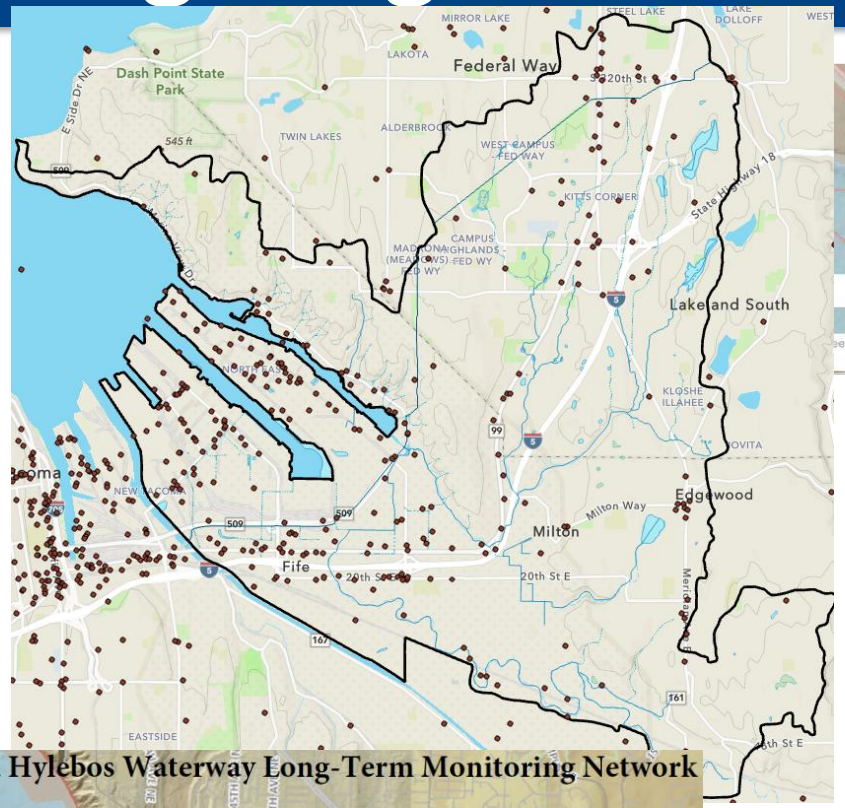
LEGEND:

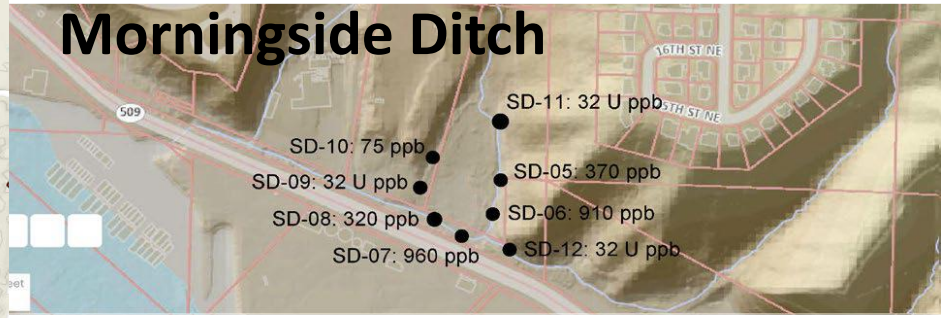
- D203 — Upper DMMU Boundary and Designation
- Berth DMMU Extents
- Updated USACE Feasibility Channel Footprint and Slopes Boundary Line
- Existing Contours (2' and 10' Interval)
- Existing Structure
- Current Federal Navigation Channel
- Updated USACE Feasibility Federal Navigation Channel

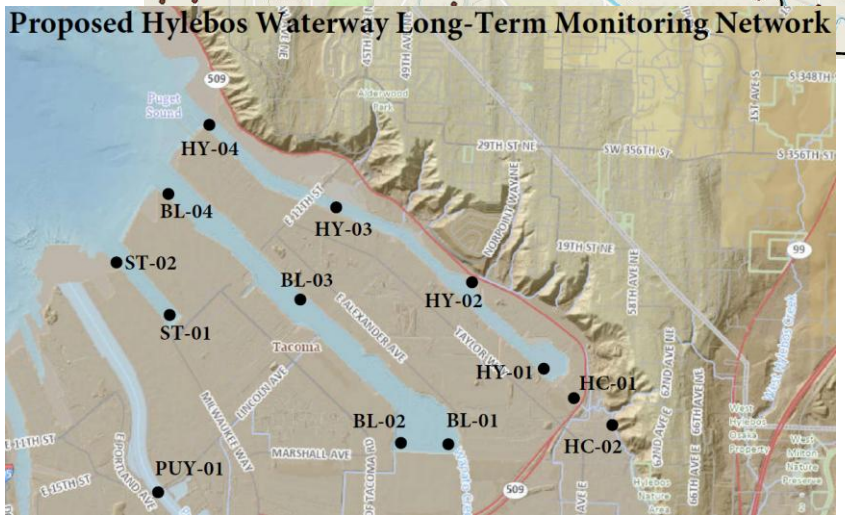
0 400 Feet

Port Source Tracing Program

- Community Engagement
- GIS mapping
- Source Inventory
- Field Surveys
- Select Sample Station Locations
- Sampling and Analysis
- Data validation
- Data Analysis
- Reporting



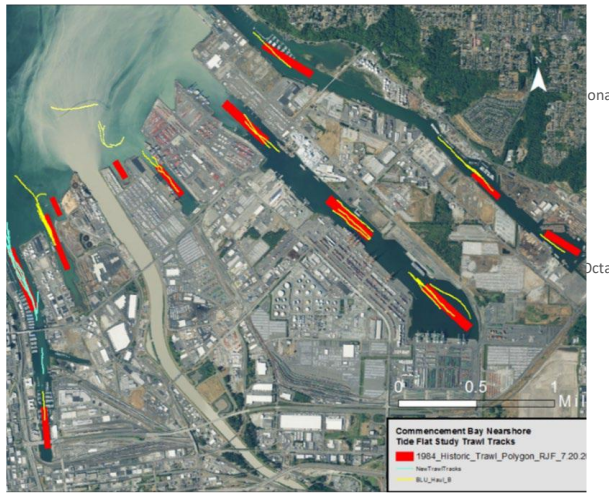


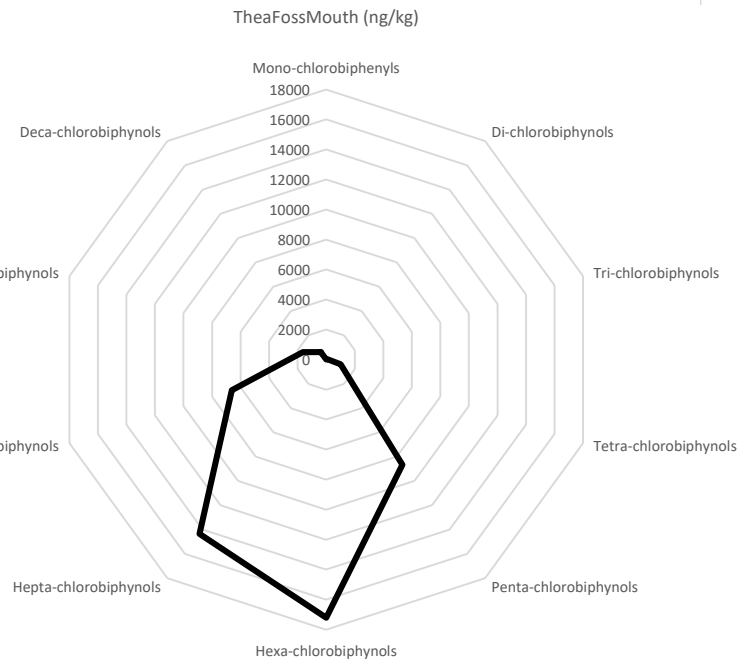


Fingerprinting Methods

CB 2019 English Sole samples indicate two separate PCB sources; the Hylebos (Aroclor 1254) at a higher concentration than the Thea Foss (Aroclor 1260).

	CarrInletMid	HylebosHead	HylebosMiddle	HylebosMouth	BlairHead	BlairMiddle	BlairMouth	Sitcum	Middle	TheaFossHead	TheaFossMouth
A1221	-0.4339	-0.3776	-0.4088	-0.4735	-0.4570	-0.4521	-0.4124	-0.4623	-0.4570	-0.4286	-0.4145
A1232	-0.3334	-0.3291	-0.4037	-0.5752	-0.5007	-0.5405	-0.5427	-0.6202	-0.5007	-0.5850	-0.5738
A1016*	-0.1451	-0.2164	-0.2853	-0.4093	-0.3063	-0.3549	-0.3871	-0.4281	-0.3063	-0.4100	-0.4220
A1242*	0.0883	0.0005	-0.0780	-0.2731	-0.1761	-0.2497	-0.3100	-0.3686	-0.1761	-0.3586	-0.3585
A1248	0.6604	0.5001	0.4232	0.1557	0.2466	0.1250	0.0001	-0.0617	0.2466	-0.0809	-0.0716
A1254*	0.9283	0.9226	0.8942	0.7024	0.7048	0.6319	0.5509	0.4716	0.7048	0.4059	0.4657
A1260*	0.4235	0.5879	0.6452	0.8360	0.8387	0.8947	0.9355	0.9495	0.8387	0.9660	0.9599
A1262	0.1286	0.2994	0.3775	0.6299	0.6136	0.6894	0.7403	0.8139	0.6136	0.8974	0.8472
A1268	-0.3806	-0.2268	-0.1452	0.0321	-0.0932	-0.0316	0.0011	0.1154	-0.0932	0.0916	0.0844





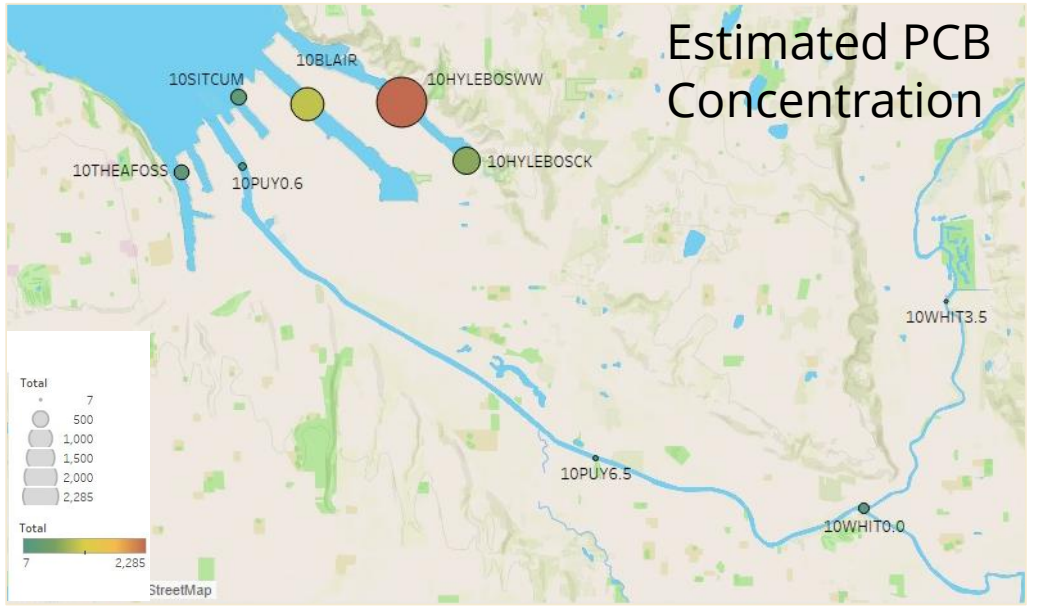
COMMENCEMENT BAY SOURCE TRACKING PROGRAMS

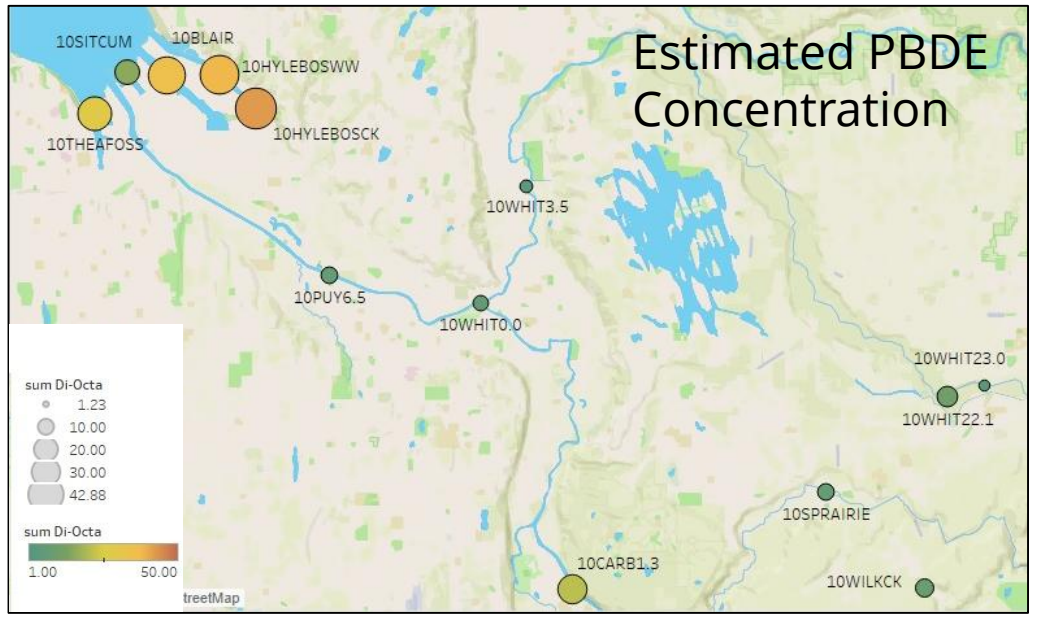
- University of Washington Tacoma and Ecology

GENERAL APPROACH

- Monitoring to be performed based on conceptual model of potential loading
  - Focus on potential pathways (e.g., air deposition), sites, and mobilization events

- Use existing information to guide first deployments
  - Surface water monitoring (Gipe, 2024)
  - Sediment monitoring (Port of Tacoma and others)
  - Land use assessment and watershed characterization (Anchor QEA)

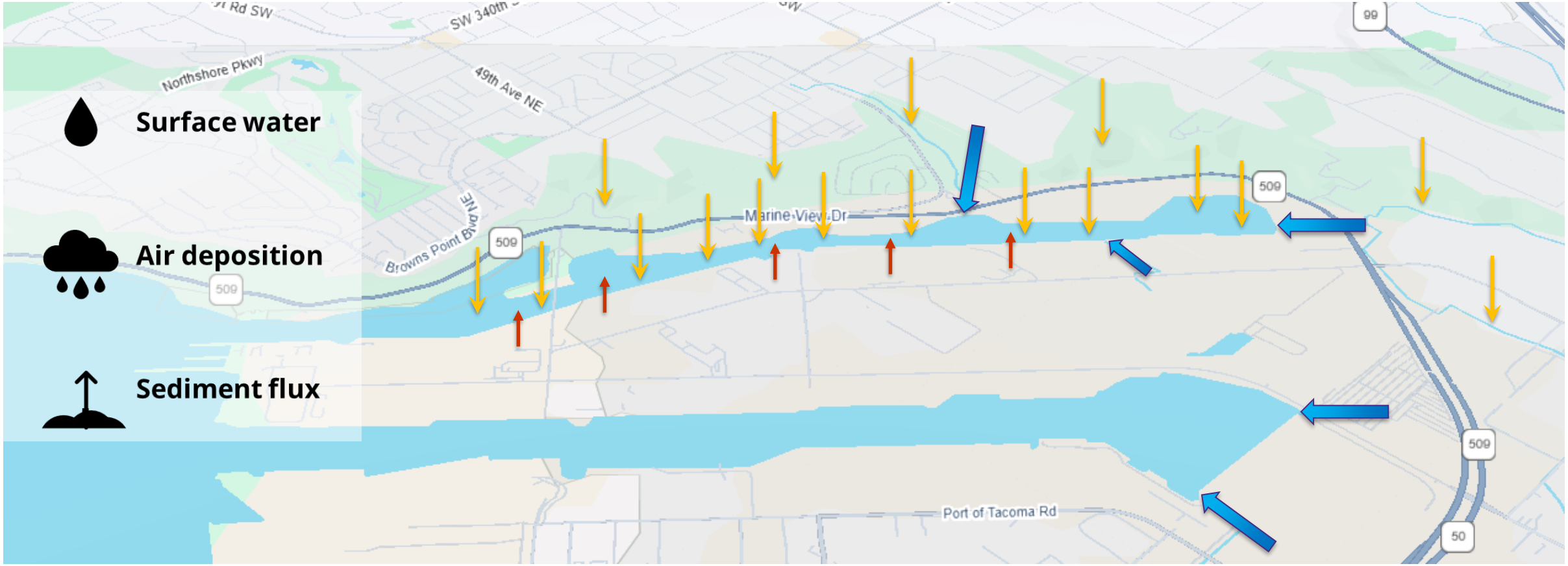




Data from Gipe, 2024

POTENTIAL LOADING PATHWAYS

e.g., surface water inputs, air deposition, and sediment flux



MONITORING APPROACH

Surface water inputs, air deposition, and sediment flux

SURFACE WATER

15-25 locations per event

SPMD and/or

PE passive sampler

Coordinate deployments

AIR DEPOSITION

6-8 locations per event

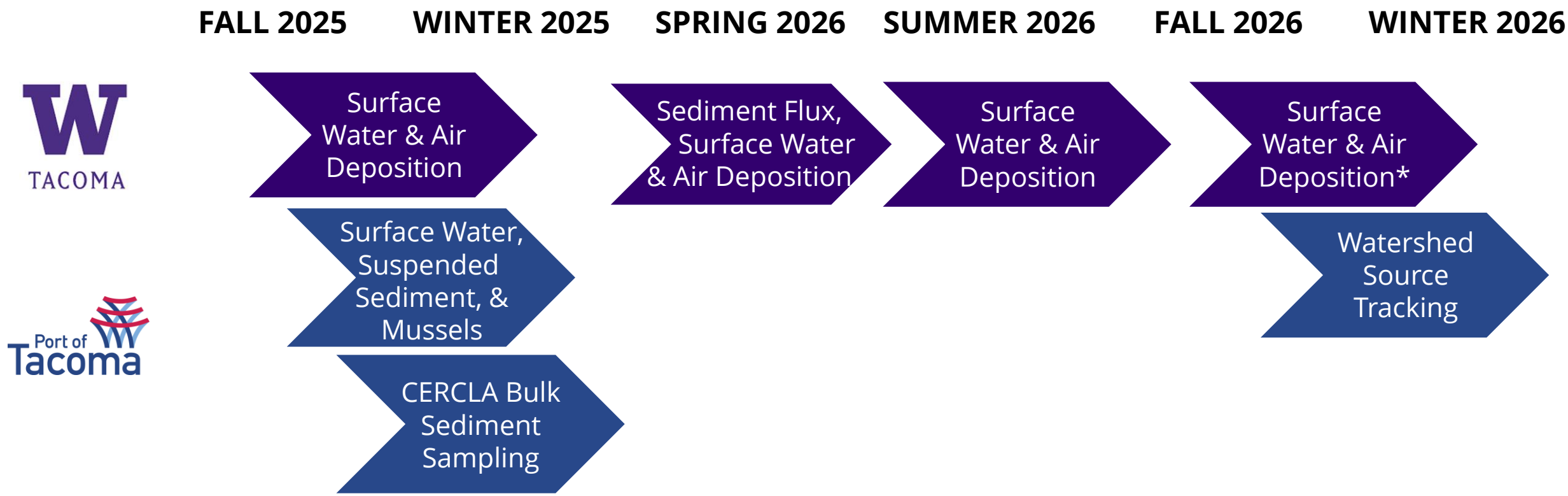
SEDIMENT FLUX

12-16 locations

Polyethylene passive sampler

PRELIMINARY MONITORING TIMELINE

PCB & PBDES Congeners, and Dioxin/Furans

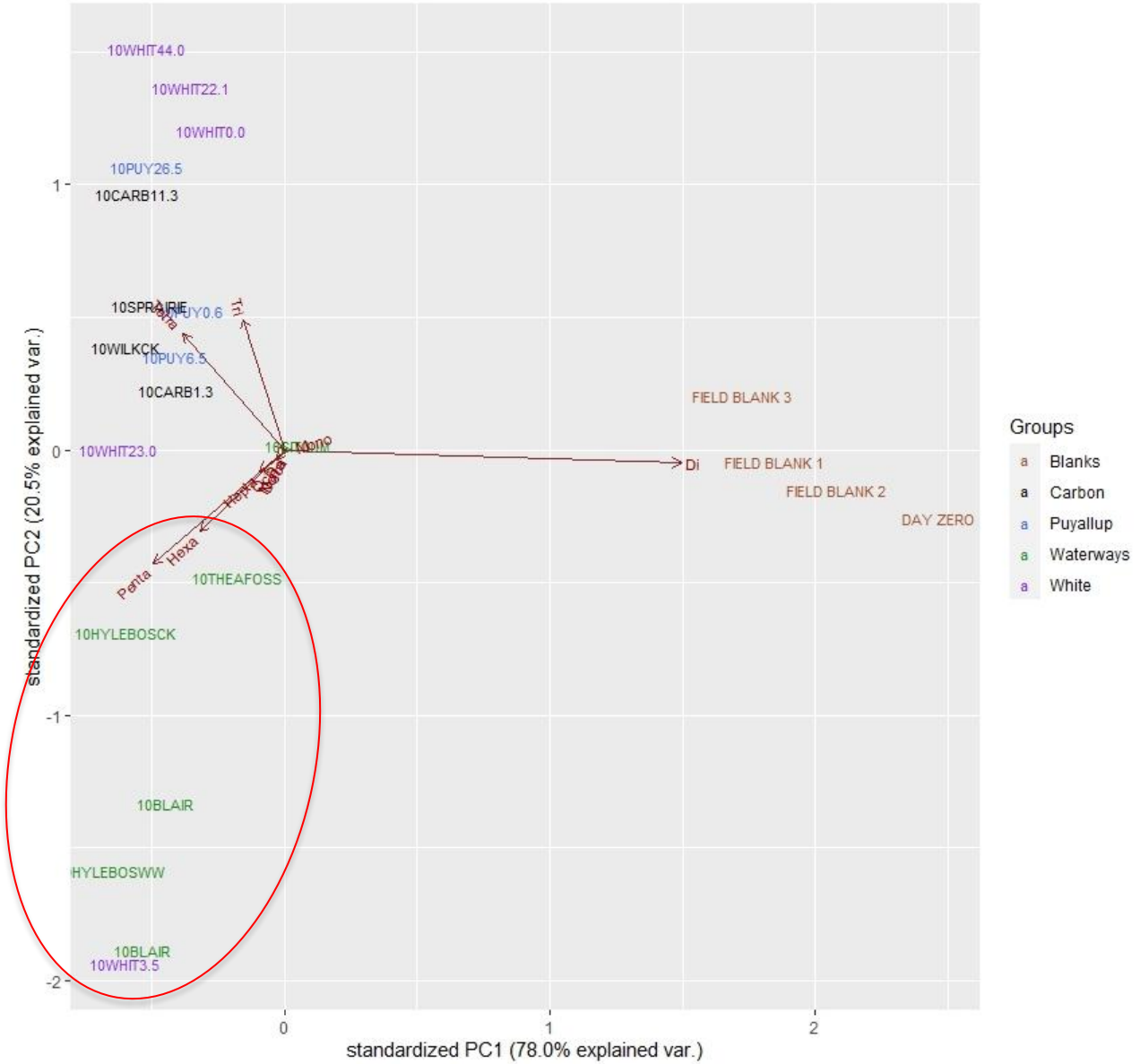


DATA ANALYSIS

- All samples will be analyzed via EPA 1668 and 1614a which provides sensitivity (i.e., low detection limits) and concentrations of congeners.
- Valuable for differentiating samples and identifying sources
- Principal Component Analysis – measure of similarity of samples based on congener patters
- Positive Matrix Factorization – breaks down samples by contributing sources

PRINCIPAL COMPONENT ANALYSIS *(Measure of similarity)*

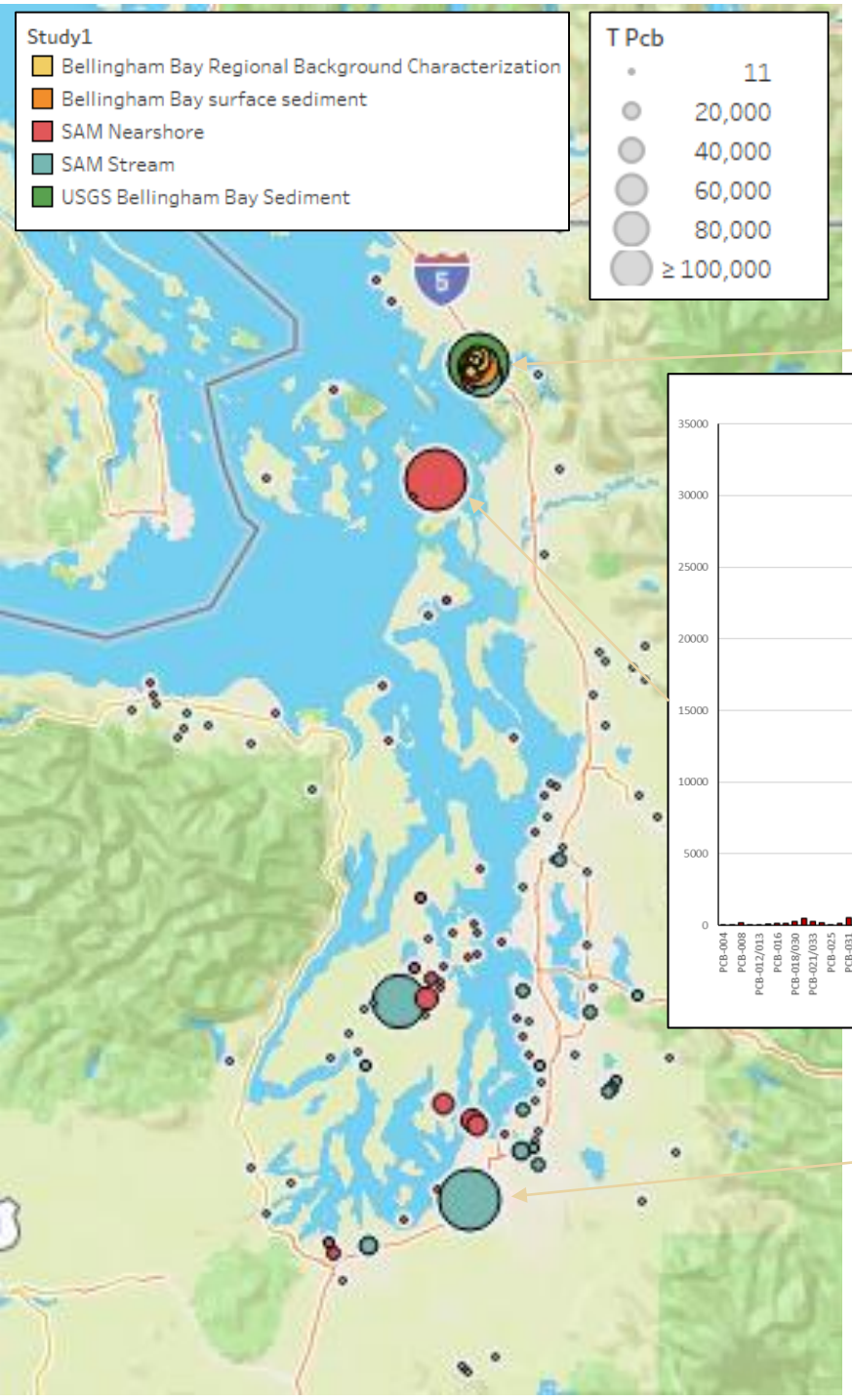
Data from Gipe, 2024

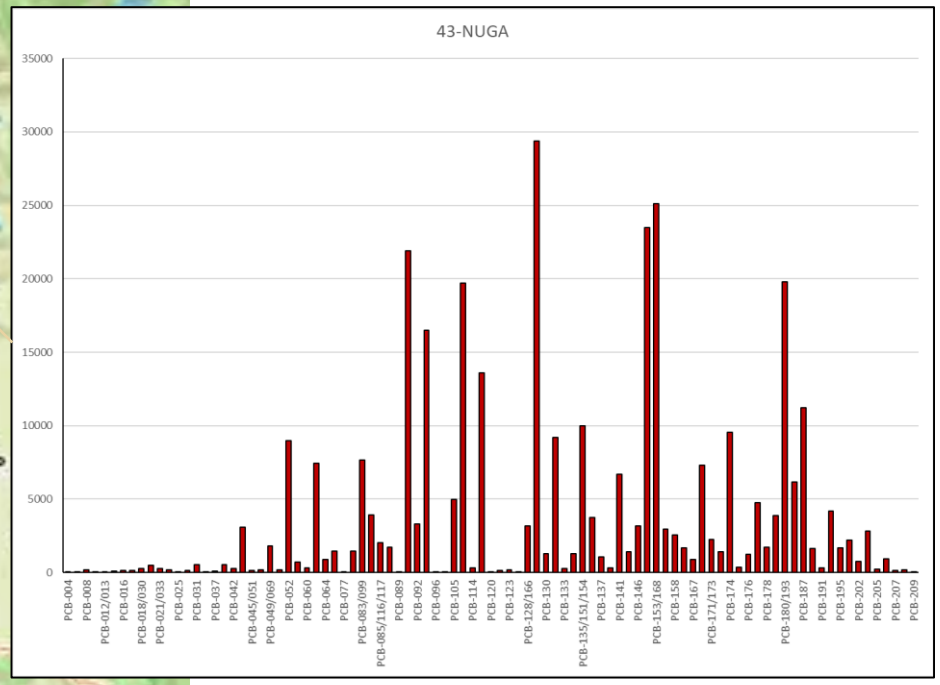


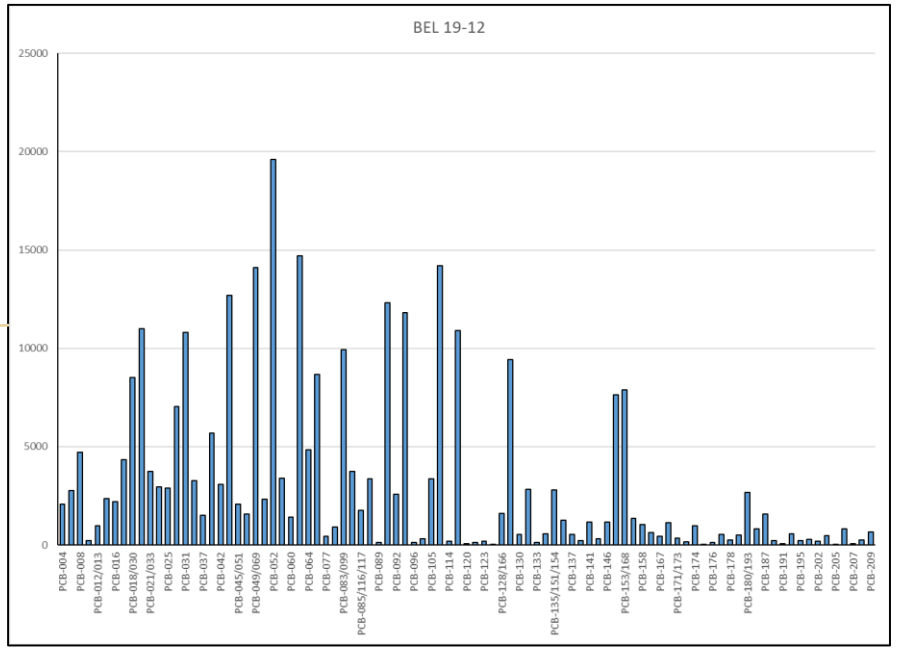
Preliminary Results
Do Not Cite

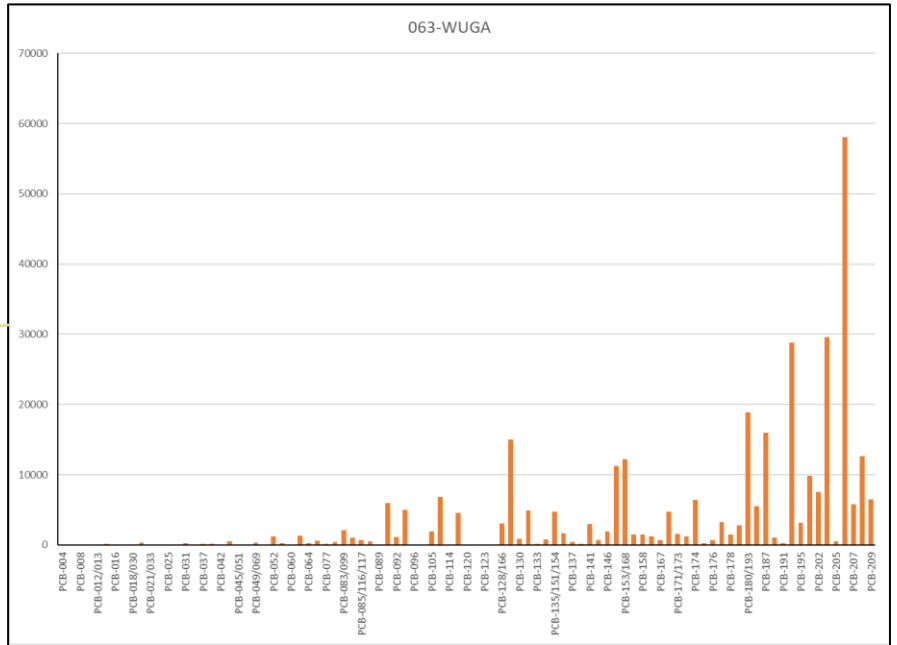
POSITIVE MATRIX FACTORIZATION

(source contributions)





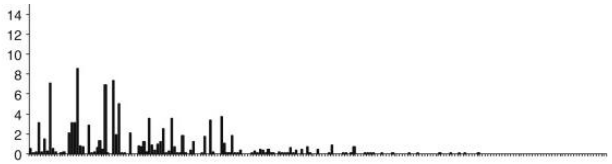




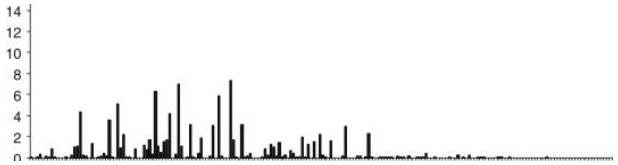
POSITIVE MATRIX FACTORIZATION MODEL
(EPA PMF 5.0)

PMF Algorithm Identifies Best Fit Factor x Contributions

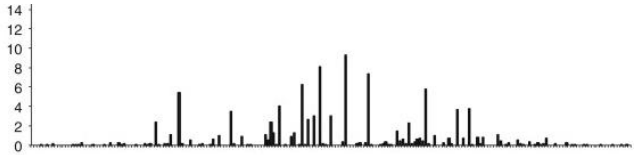
FACTOR 1



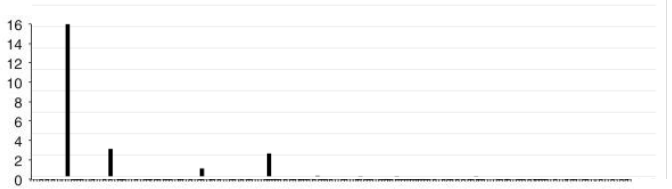
FACTOR 2



FACTOR 3



FACTOR 4



X

CONTRIBUTION OF FACTOR 1

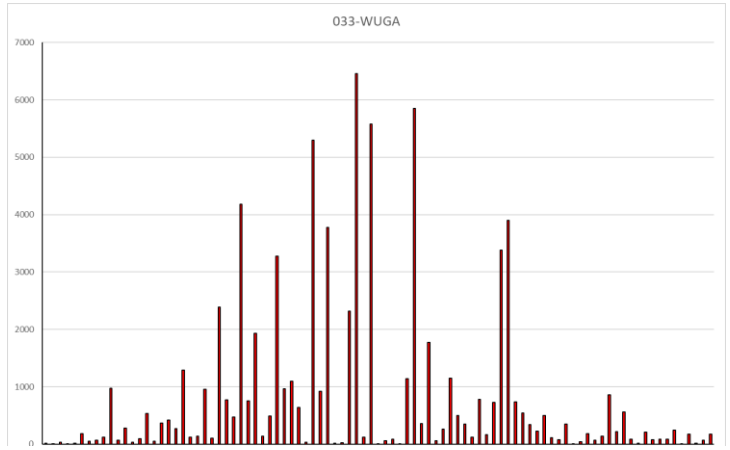
CONTRIBUTION OF FACTOR 2

CONTRIBUTION OF FACTOR 3

CONTRIBUTION OF FACTOR 4

=

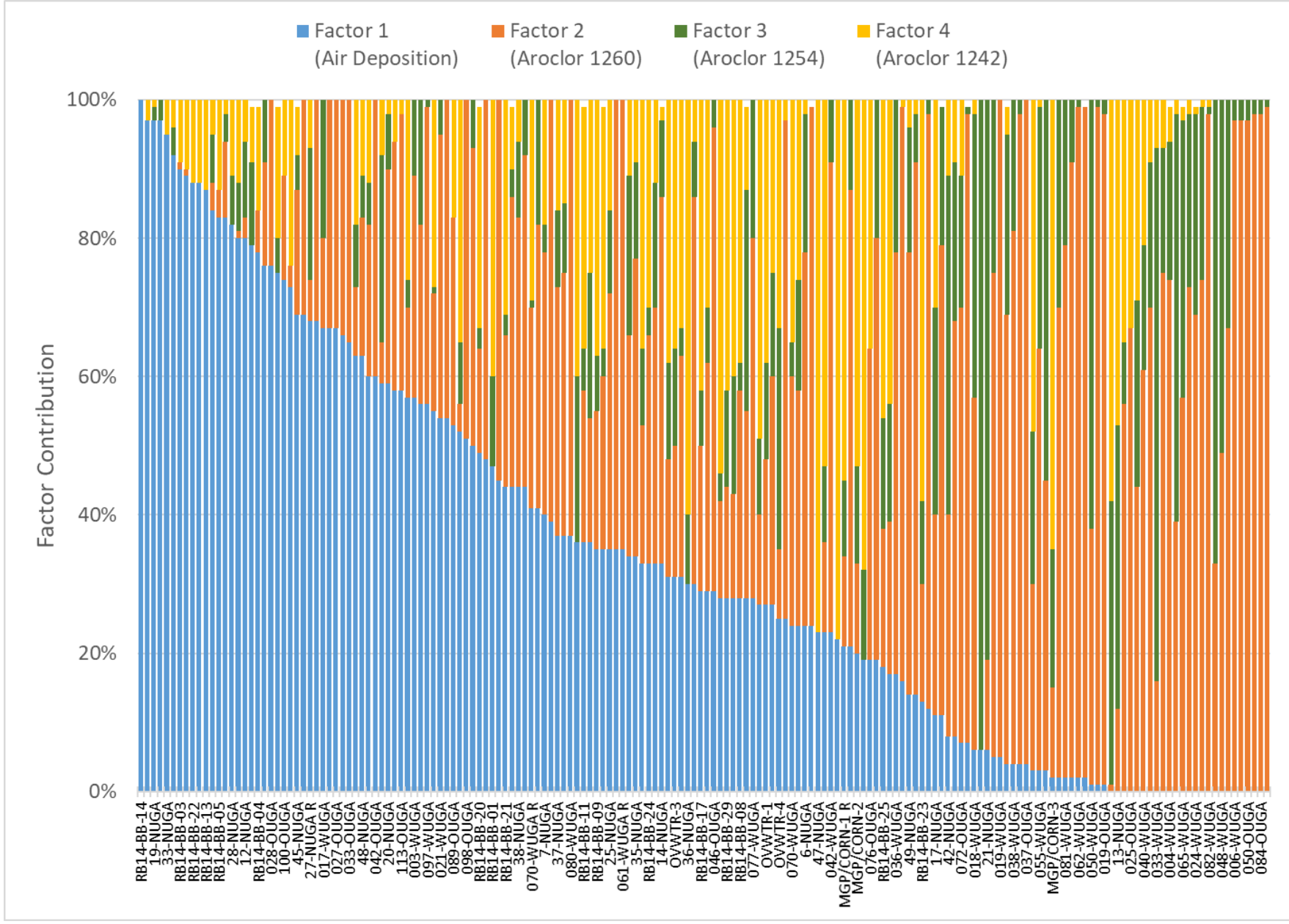
Input Data



PMF FACTOR CONTRIBUTIONS

At Each Sample Location

What sources are important at each site?



DISCUSSION

1. Initial thoughts on the loadings?
   - > Pathways?
   - > Source locations?
   - > Timing?
2. Is there planned or potential monitoring that would strengthen the source tracking (e.g., stable isotopes, PM 2.5 monitoring, etc.)?
3. Other opportunities for collaboration?

SHARE MONITORING DATA

Email Maya (faberma@uw.edu)

- PCB, PBDE, and Dioxin Furan monitoring data
  - > Metadata with methods
  - > Latitude & longitude for each sample
  - > Bonus: QA data
- Suggestions in terms of potential sources. Please include:
  - > Relevant contaminants
  - > Latitude & longitude or address
  - > Context on why

JOIN THE TECHNICAL ADVISORY COMMITTEE

Email Marielle (marlars@uw.edu) by **Friday, June 6**

- Meet for 2 hours, quarterly at the Center for Urban Waters to
  - > Refine the monitoring plans
  - > Adapt monitoring based on preliminary results
- Final symposium
  - > Share the preliminary results
  - > Shape recommendations

Who else should we proactively engage?