Portland Harbor Remedial Investigation

Presentation to the
CSTAG/NRRB
November 18, 2015

Kristine Koch, U.S. EPA Region 10

Portland Harbor

Site Background

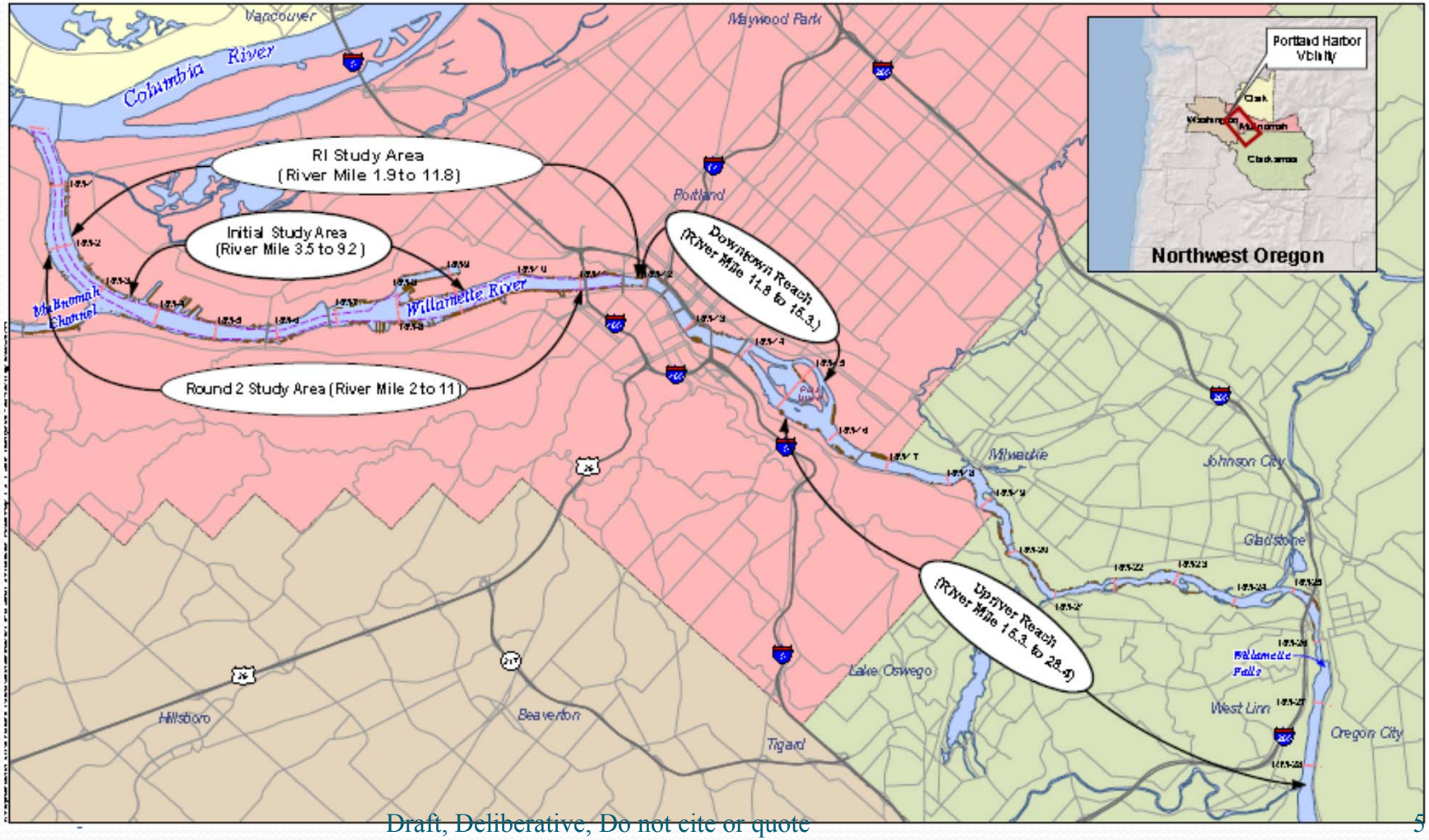
Site Background

- Listed December 2000
- AOC
  - October 2001
  - LWG performing party (10 entities)
- MOU
  - February 2001
  - 6 Tribes
  - 2 Federal agencies
  - 2 State agencies

Site Setting

- Willamette River
  - Cascade Mountain Range to Columbia River
  - 187 Miles long
  - Drainage Area 11,478 mi^2
  - Discharge 8,200 (Aug) – 79,000 (Dec) ft^3/s
  - 19th largest river
  - 1 of 14 American Heritage Rivers
  - Lower Reach RM 0 to RM 26.4

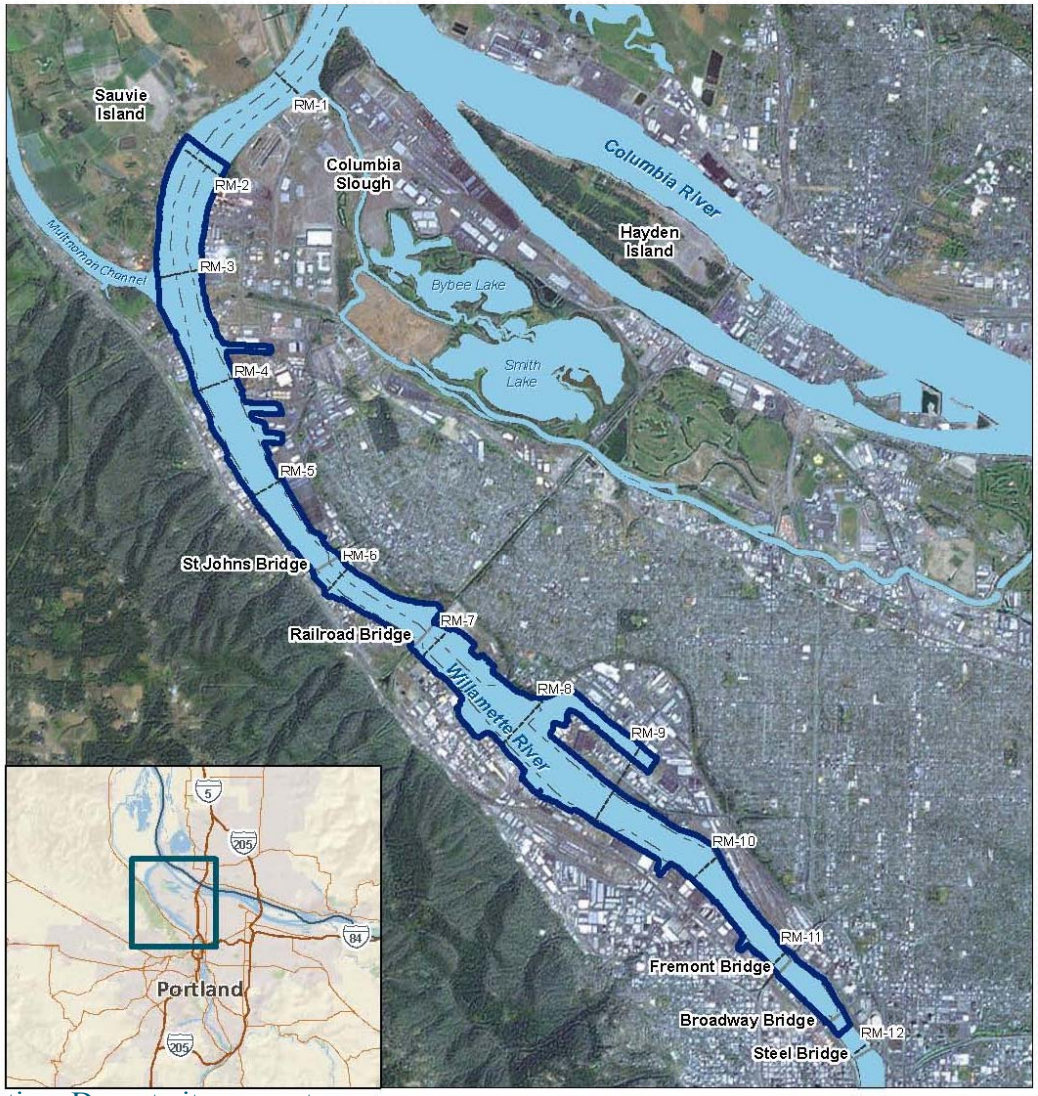
Lower Willamette River



Study Area

- Approx. 10 Mile site
- 40-foot deep navigation channel
- Width varies 600-1,900 ft.
- Armoring ~1/2 shoreline
- Dams moderate flow
- City of Bridges – 5 bridges in study Area

Study Area


Sauvie Island
RM-1
Columbia Slough
RM-2
Columbia River
Hayden Island
Multnomah Channel
RM-3
Bybee Lake
Smith Lake
RM-4
RM-5
St Johns Bridge
RM-6
Railroad Bridge
RM-7
Willamette River
RM-8
RM-9
RM-10
RM-11
Fremont Bridge
Broadway Bridge
RM-12
Steel Bridge
5
205
84
Portland
205

Prior Investigations

- Since 1920s
- Most 1970s to 1980s
- Nearly 700 data sets
  - Large Scale – Federal & State
  - Small Scale – Private
  - Only data collected under the AOC was used for risk assessments

Portland Harbor

Study Area Investigation

Study Area Investigation

- Multi-year study
  - Four rounds
  - 2001 through 2008
  - Timed around
    - varying river stages, river flows, and storm events
  - Four consultants

Preliminary (2001-2002)

- Multibeam Bathymetric Survey
- Juvenile Salmonid Residence Time Survey
- Sediment Trend Analysis Survey
- Sediment Profile Image Survey
- Acoustic Doppler Current Profiler Survey

Round 1 (2002 – 2004)

- Juvenile Salmonid Mark/Recapture Pilot Study
- Collection of Fish Tissue for Chemical Analysis
- Hard-bottom Benthos Sampling Using Multiplates
- Aquatic Plant and Amphibian/Reptile Reconnaissance Survey
- Adult Lamprey Harvest Reconnaissance Survey
- Nearshore Sediment Stakes

Round 1 (cont.)

- 4 Multibeam Acoustic Bathymetry Survey
- Seep Reconnaissance Survey
- Juvenile Lamprey and Benthic Infaunal Biomass Reconnaissance Surveys
- Composite Beach Sediment and Co-located Surface Sediment Sampling
- Soft-bottom Benthos Reconnaissance Survey
- Acoustic Doppler Current Profiler Survey

Round 2 (2004 – 2006)

- Shorebird Area and Beach Sediment Sampling
- Surface Sediment Sampling
- Subsurface Sediment Sampling
- Surface Water Sampling
- Benthic Sediment Toxicity (Bioassays)
- Physical System Information
- Natural Attenuation (radioisotope cores)
- Groundwater Pilot Study – Mapping Tools and Sampling Methods

Round 2 (cont.)

- Groundwater Pathway Assessment
- Subyearling Chinook Salmon Tissue
- Multiplate Epibenthic Invertebrate Tissue
- Reconnaissance for Benthic Invertebrates and Clam Tissue
- Mussel and Lamprey Ammocoete Tissue
- Cultural Resources Analysis

Round 3 (2006 – 2008)

- Surface Water
- Groundwater -Gunderson Site
- Storm Water
- Lamprey Ammocoete Tissue
- Sturgeon Tissue
- Fish and Invertebrate Tissue with Co-located Surface Sediment
- Sediment (Willamette Cove)

Round 3 (cont.)

- Sediment and Sediment Toxicity Bioassay Testing
- Sediment Trap
- Upstream/Downstream Surface and Subsurface Sediment Samples
- Natural Attenuation (Radioisotope Subsurface Sediment Cores)
- Sediment Chemical Mobility Testing

Portland Harbor

Environmental Setting

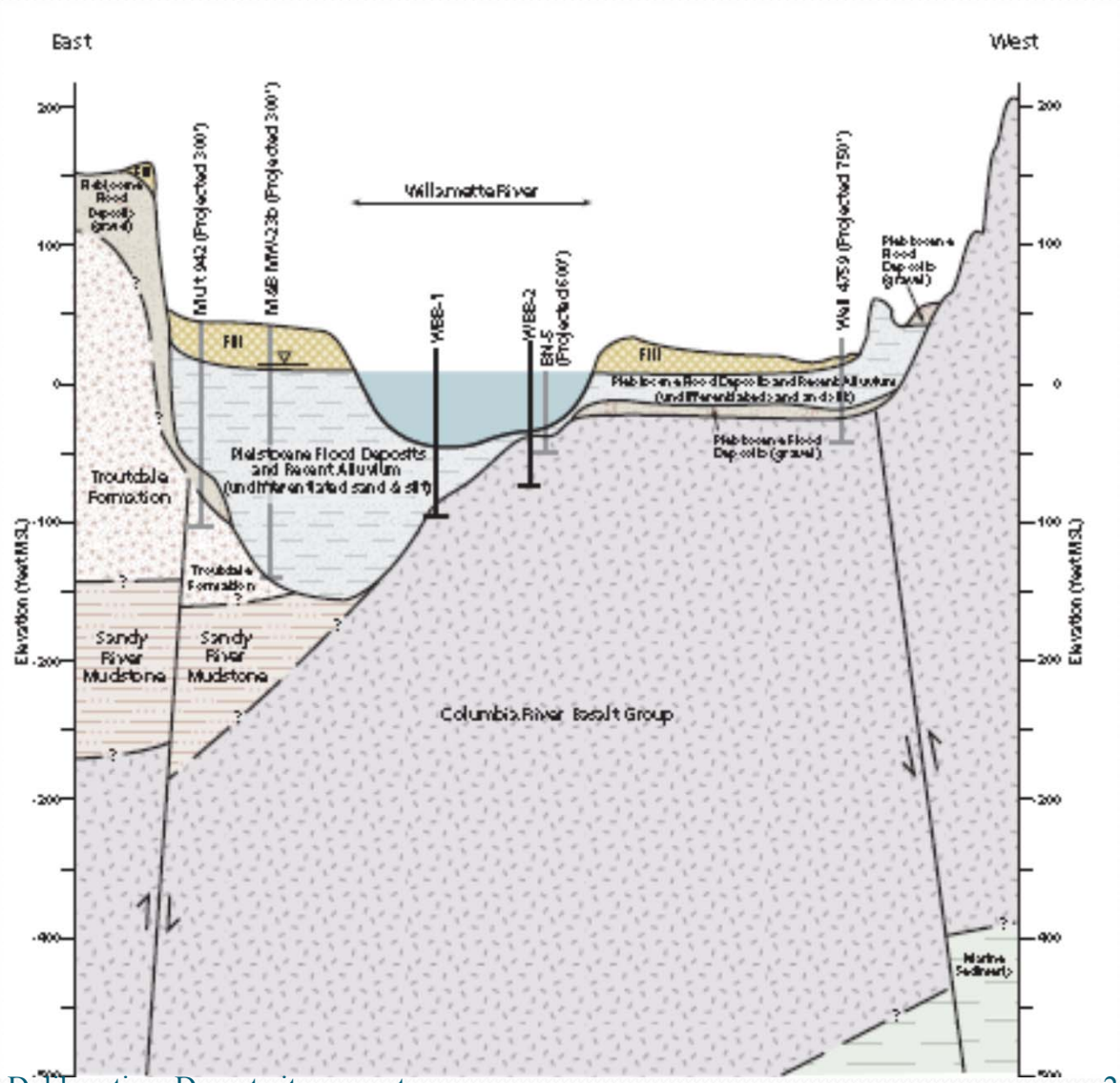
Physical Environment

- 65 miles inland from the Pacific Ocean
- 20 ft above sea level
- Precipitation primarily rain
  - 90% mid-October to mid-May
  - ~42 inches per year
  - Snow rarely >2 in.

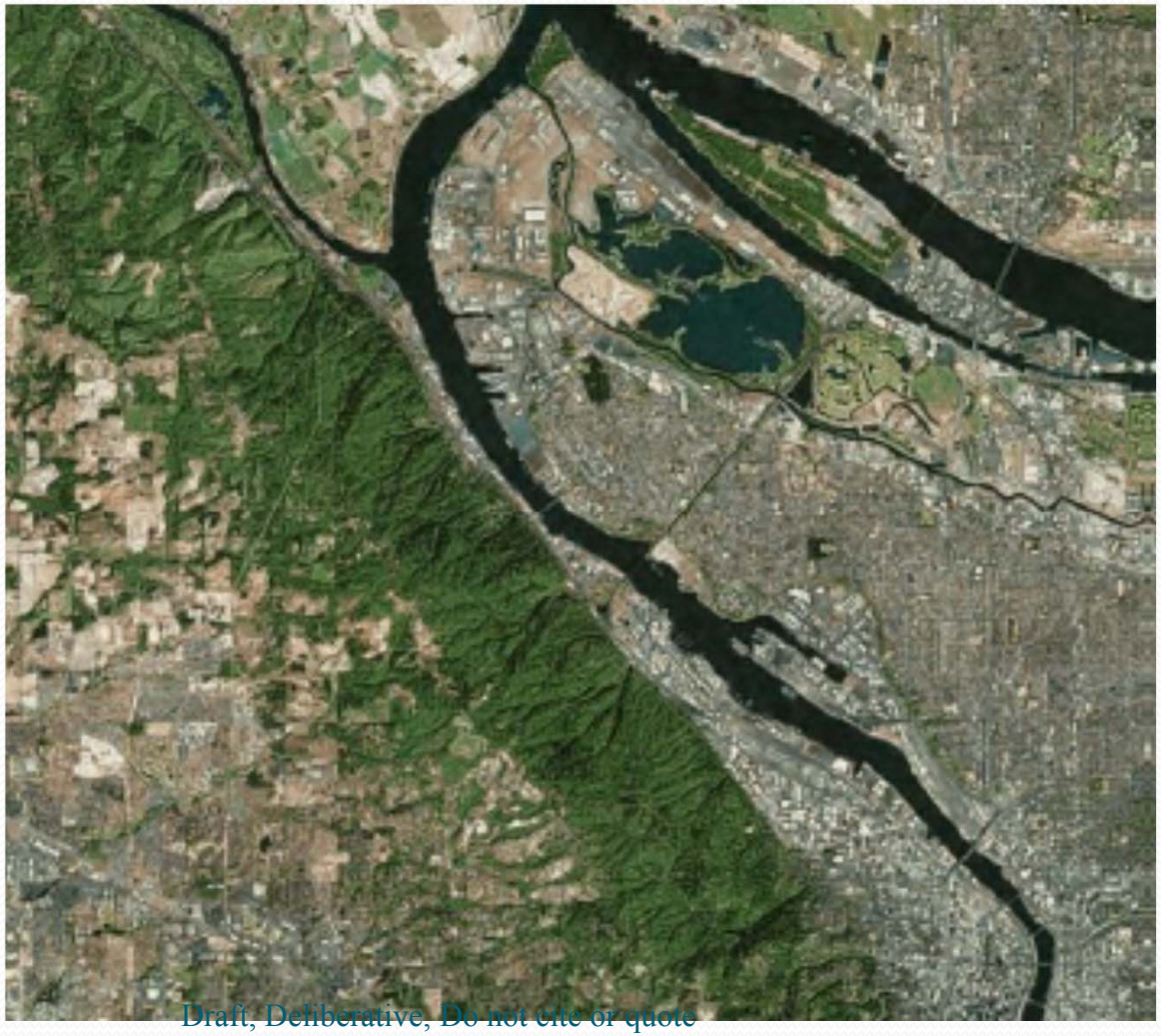
Geology

- Portland Basin
- Tualatin Mountains (Portland West Hills)
- 3 Tectonic Fault Mechanisms

Geology


East
West
Willamette River
Fill
Fill
Pleistocene Flood Deposits and Recent Alluvium (undifferentiated sand & silt)
Troutdale Formation
Sandy River Mudstone
Sandy River Mudstone
Columbia River Basalt Group
Elevation (feet MSL)
200
100
0
-100
-200
-400

Groundwater Flow



Groundwater Flow

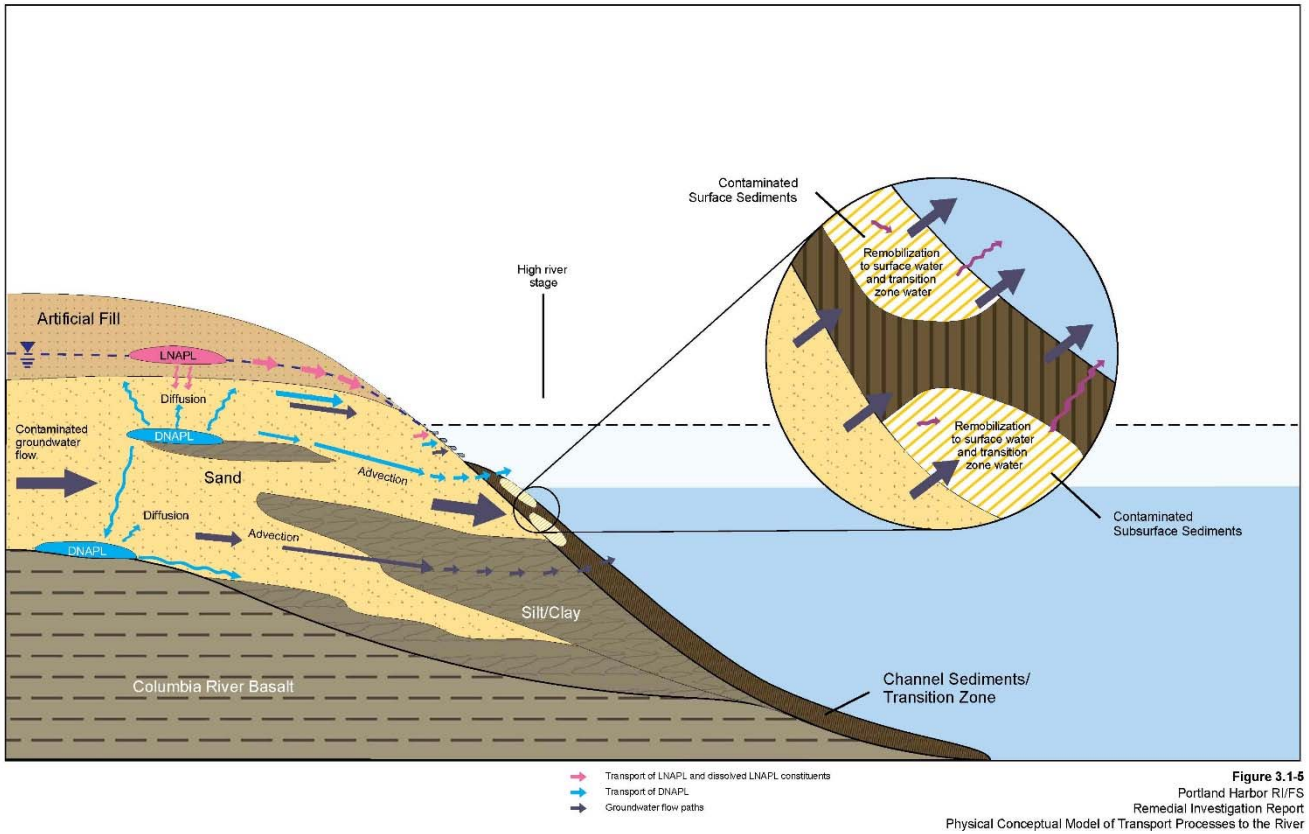
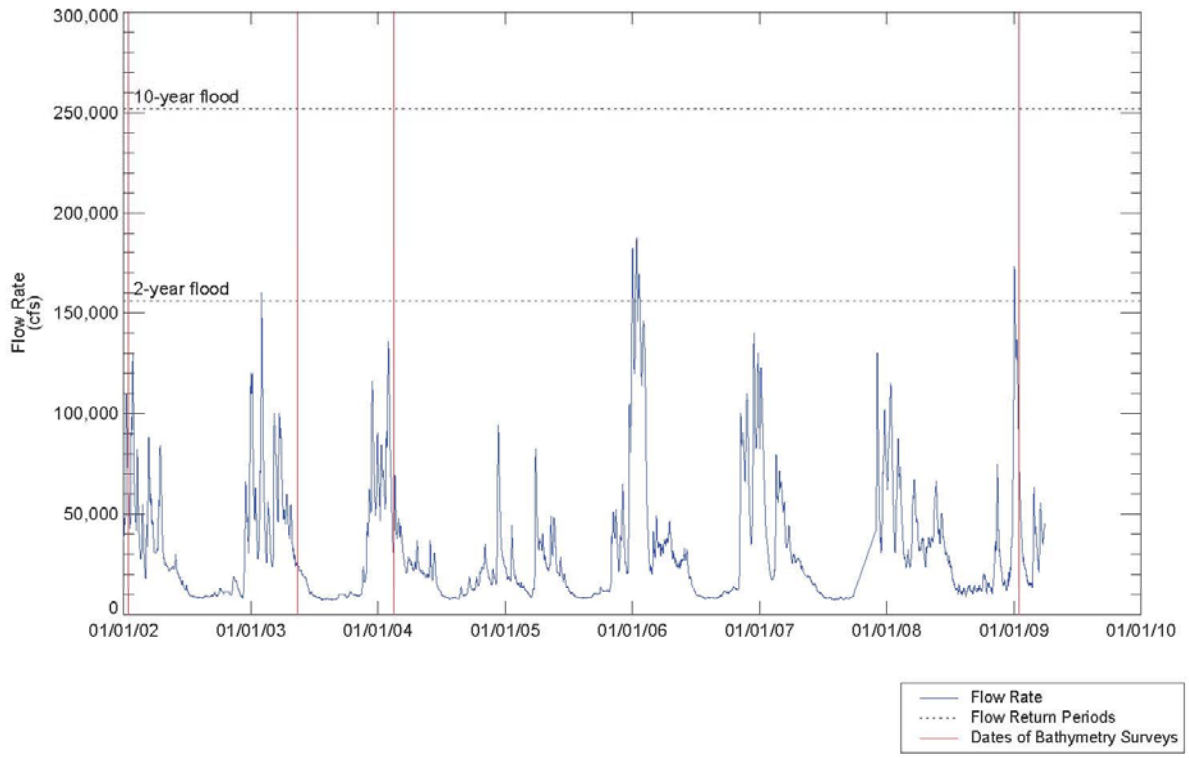


Figure 3.1-5
Portland Harbor RI/FS
Remedial Investigation Report
Physical Conceptual Model of Transport Processes to the River

Regional Hydrology

- Average daily mean discharge
  - Willamette River 33,000 cfs
  - Columbia River 177,000 cfs
- Peak Flows
  - Willamette River 420,000 cfs
  - Columbia River 675,000 cfs
- Columbia River & Multnomah Channel
  - Low flow Columbia & Willamette
  - Low flow Columbia/High flow Willamette
  - High flow Columbia/Low flow Willamette**
- Tidal action
- Dams
- Velocities

Hydrograph



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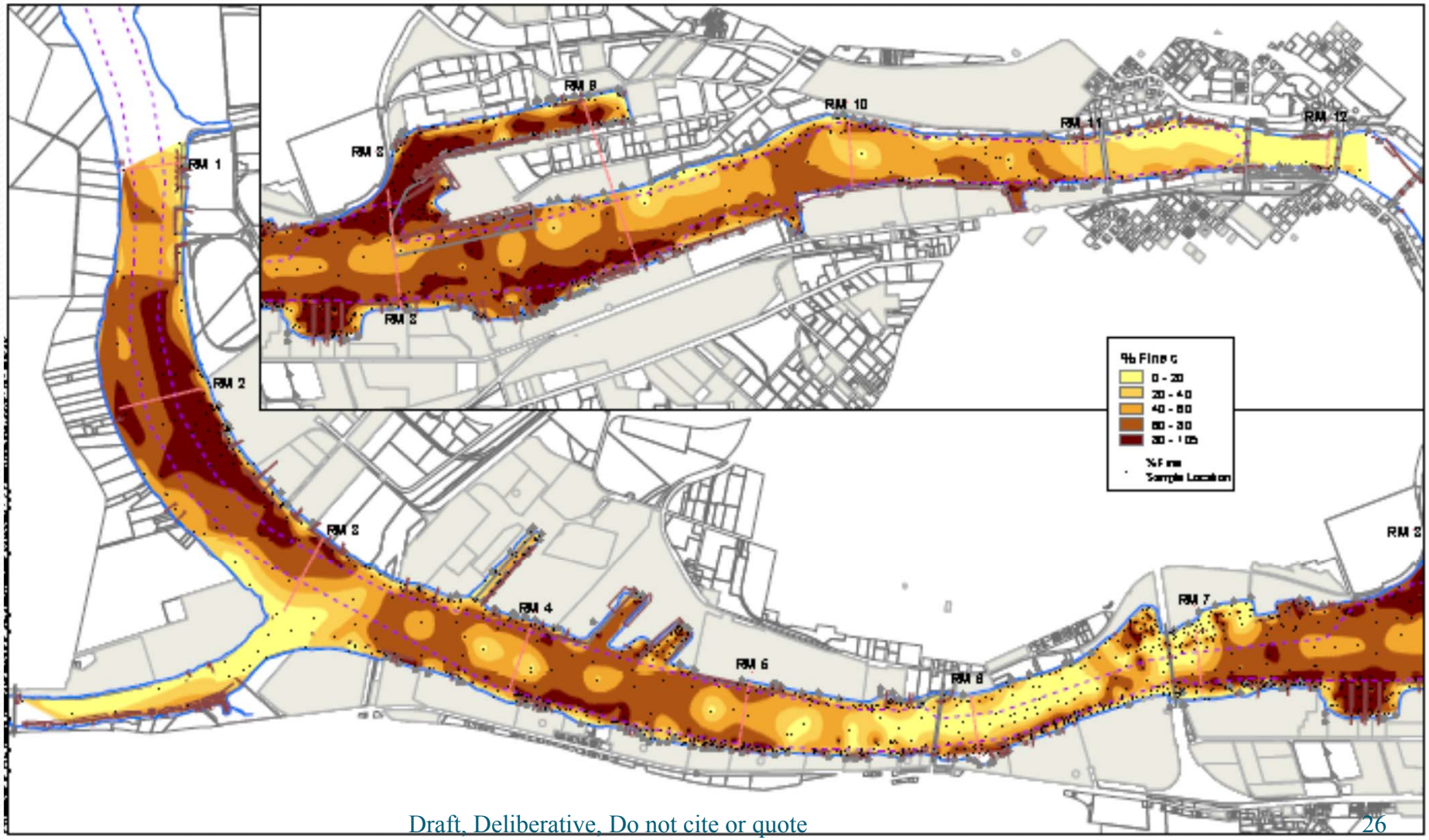
DO NOT QUOTE OR CITE
This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part

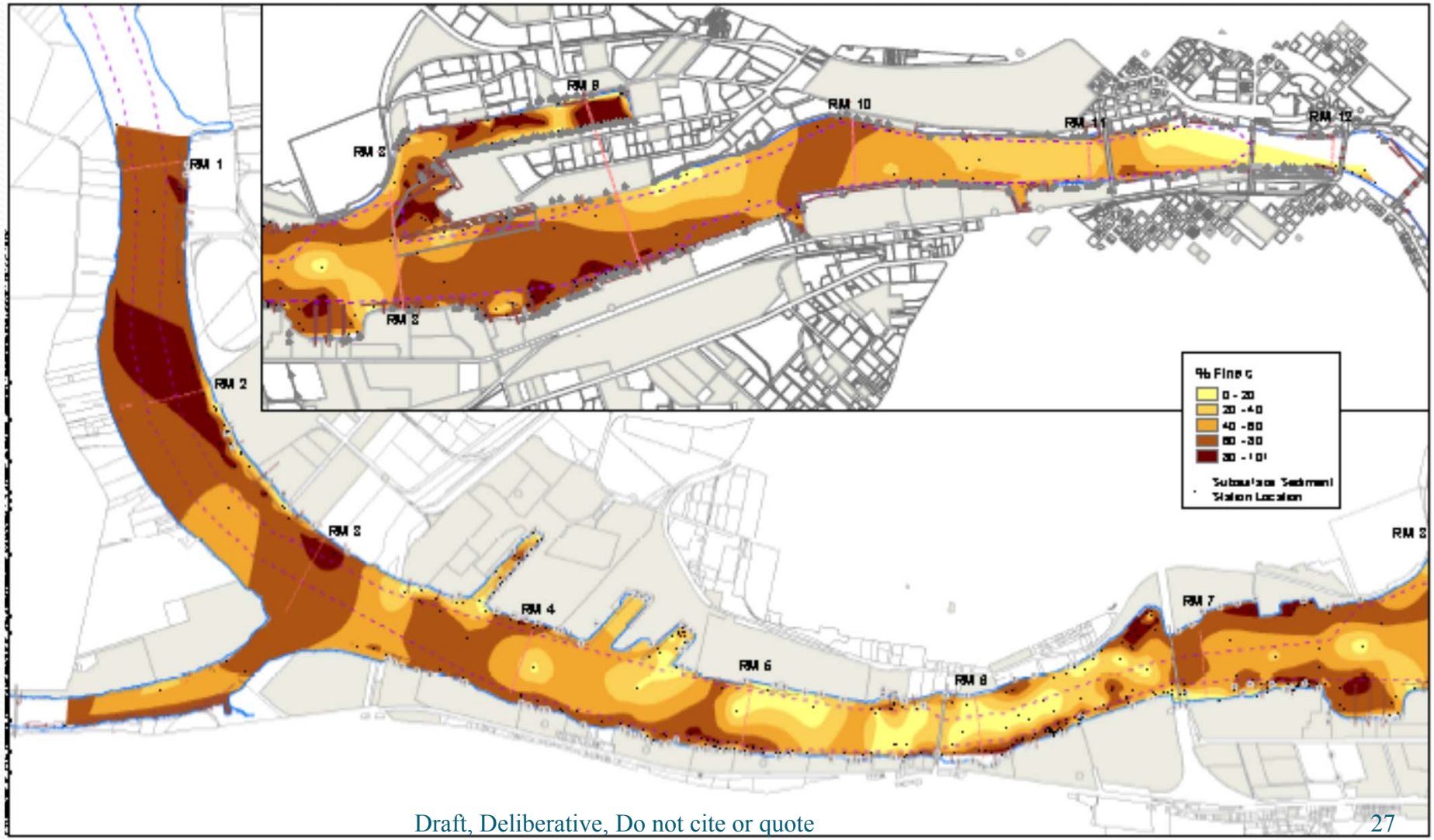
LWG LOWER WILLAMETTE GROUP

Figure 2-66
Portland Harbor RI/FS
Draft Feasibility Study
Flow Rate in Lower Willamette River
Flow rate measured at USGS Gage # 14211720 (Willamette River at Portland, OR).

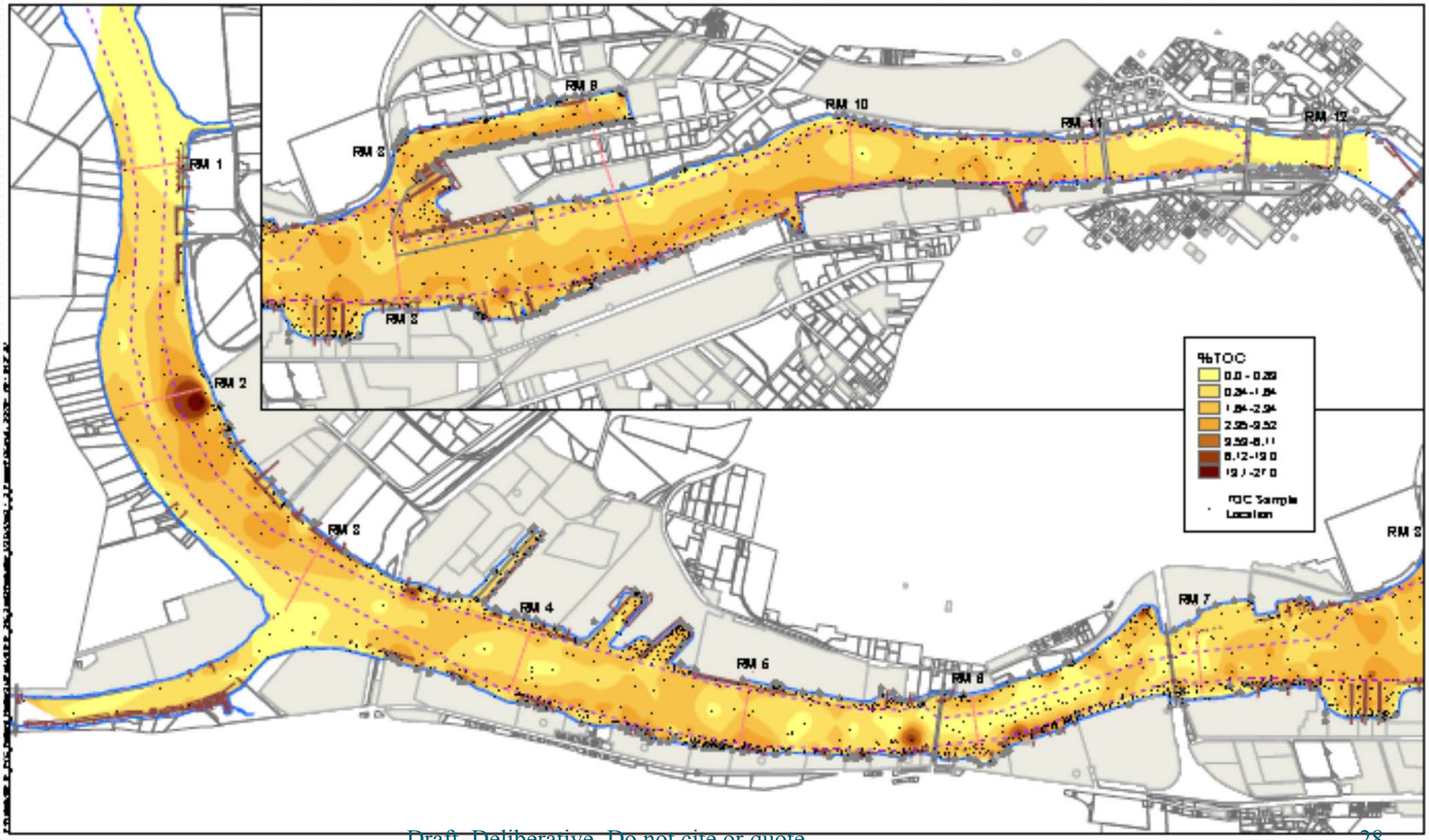
Percent Fines – Surface Sediment



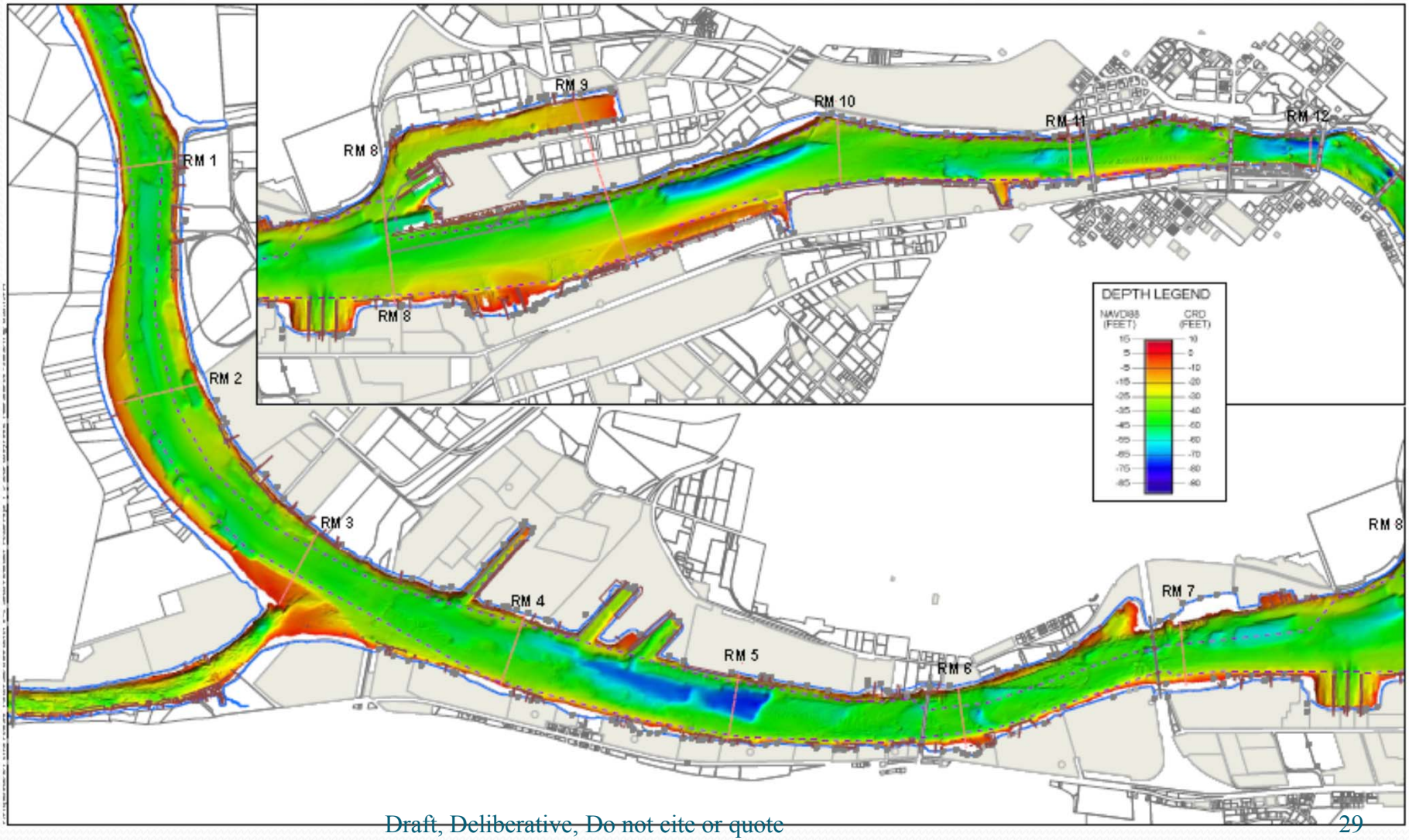
Percent Fines – Subsurface Sediment



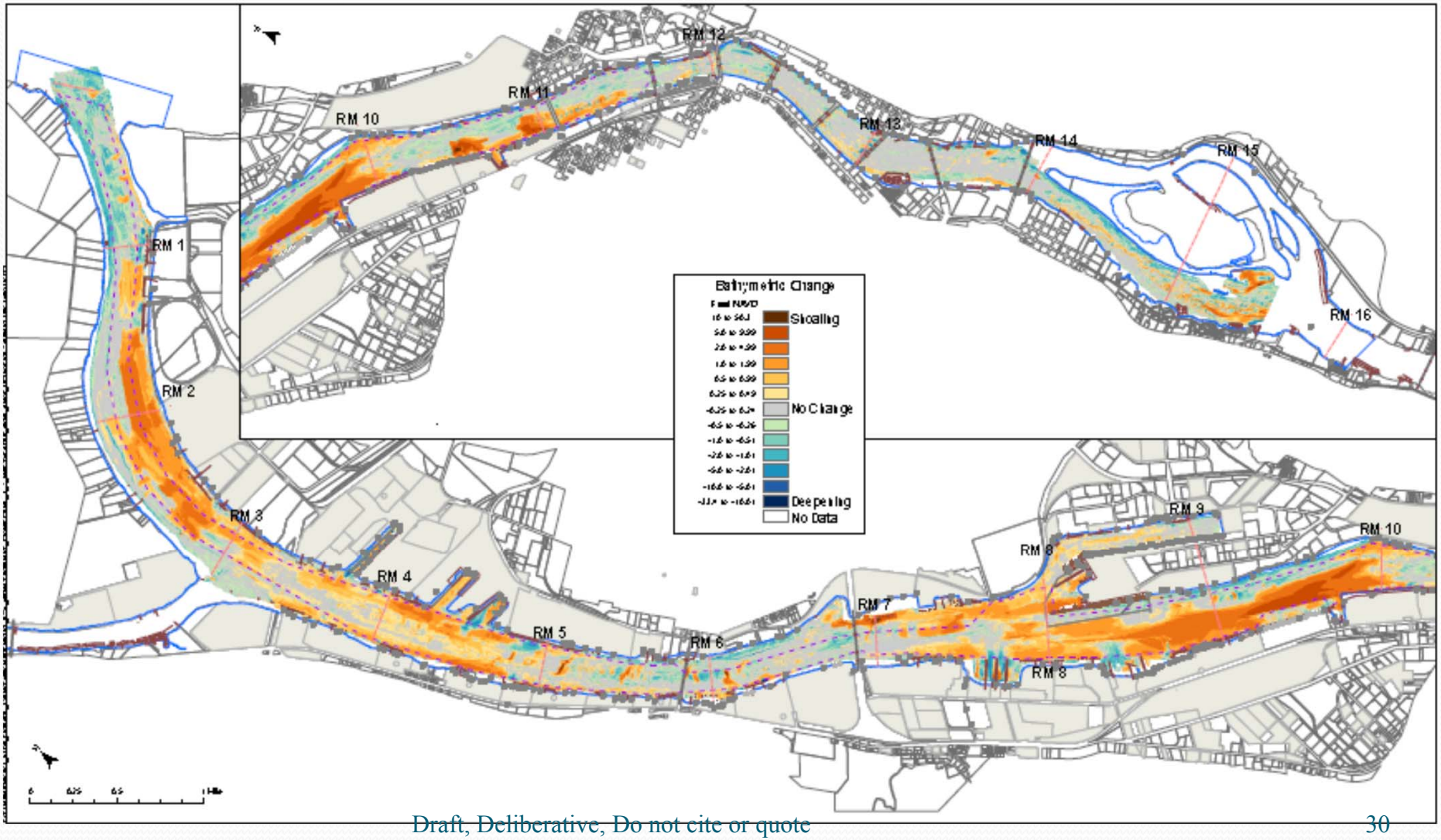
Percent TOC – Surface Sediment



Bathymetry


RM 1
RM 2
RM 3
RM 4
RM 5
RM 6
RM 7
RM 8
RM 8
RM 8
RM 9
RM 10
RM 11
RM 12
DEPTH LEGEND
NAVD88 (FEET)
CRD (FEET)

Bathymetric Change (2002 – 2009)



Sheer Stress

- Sedflume System
- 17 sediment cores – 25 cm
- Range of sheer: 0.1 - 10 N/m^2
- Measured every 5 cm

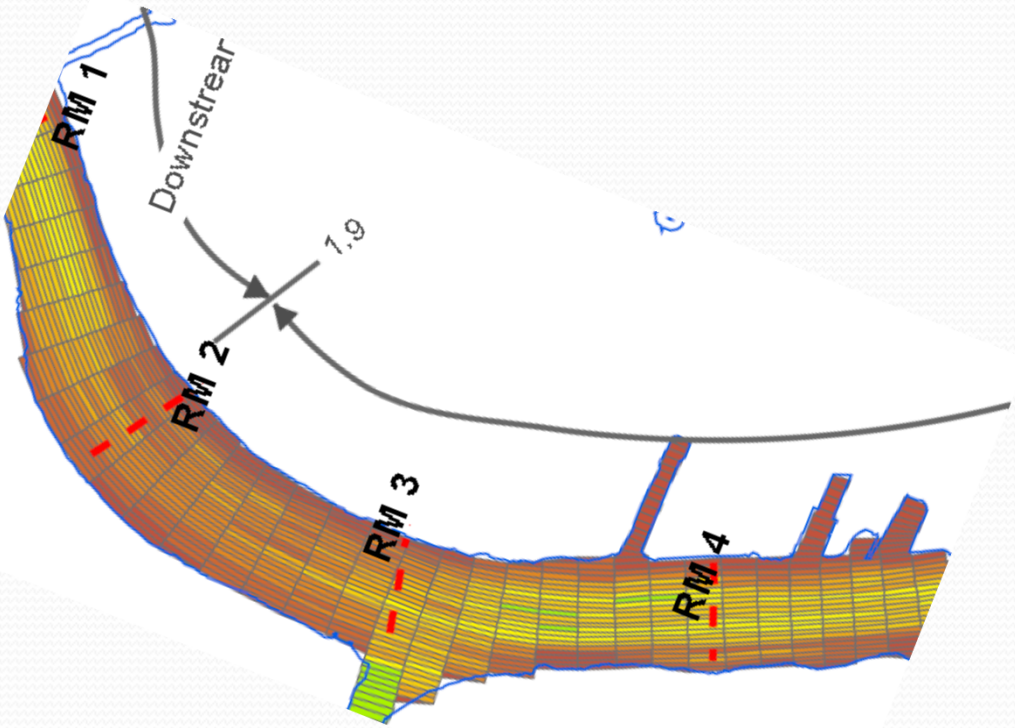
Sheer Stress and Erosion

Shear Stress	Measurements	Erosion Rate (cm/s)	
(N/m^2)	Count	Min	Max
0.1	16	0	0.0003
0.2	23	0	0.0003
0.4	55	0	0.001
0.8	74	0	0.04
1.6	76	0.0002	0.1
3.2	76	0.0003	0.3
6.4	60	0.007	0.4
10	2	0.02	0.04

Sheer Stress and Grain Size

Sample Depth Category	d50 (μm)			T_{cr} (N/m²)	
	Min	Max		Min	Max
0–5 cm	9.7	401		0.06	0.64
5–10 cm	12	367		0.32	1.28
10–15 cm	10	378		0.22	1.28
15–20 cm	7.8	384		0.26	1.28
20–25 cm	10.9	357		0.24	1.28

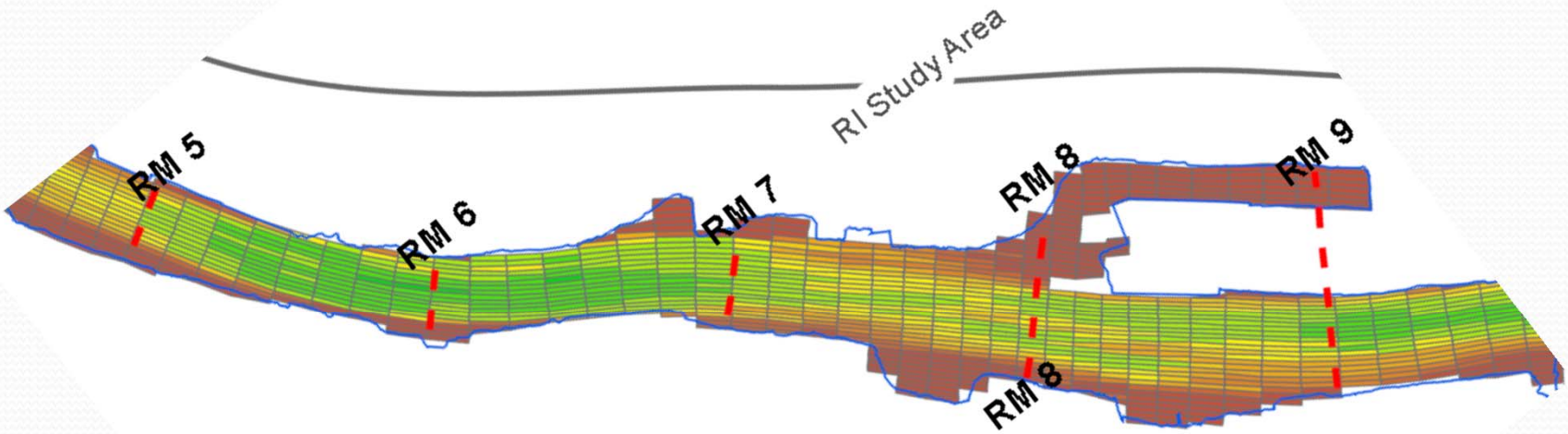
Hydrodynamic and Sediment Transport (HST) Model



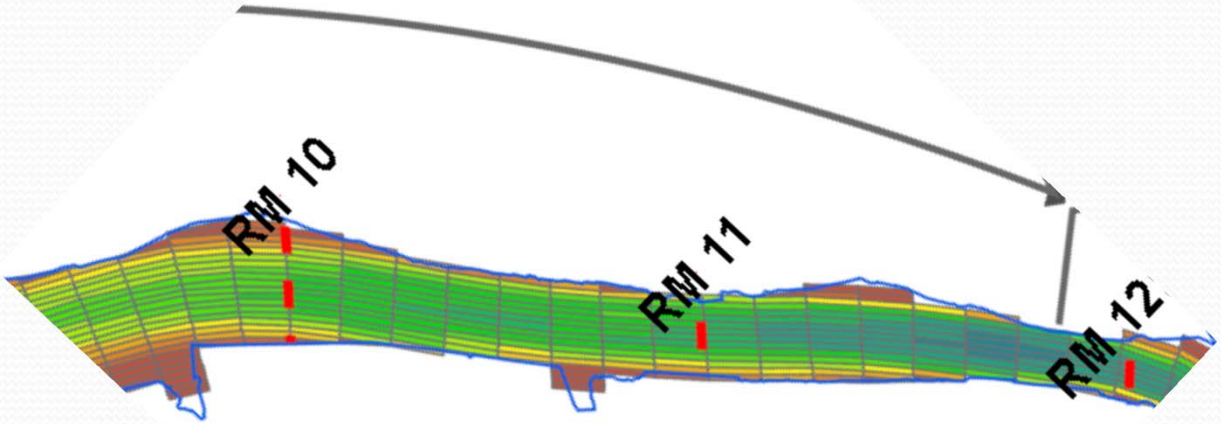
Bed Shear at 160,000 cfs (N/m^2)

- 0.00 - 0.10
- 0.11 - 0.40
- 0.41 - 0.70
- 0.71 - 1.00
- 1.01 - 1.50
- 1.51 - 2.00
- 2.01 - 3.00
- 3.01 - 4.00
- 4.01 - 5.00
- 5.01 - 6.00
- 6.01 - 8.00
- 8.01 - 20.00
- 20.01 - 40.00
- 40.01 - 64.63

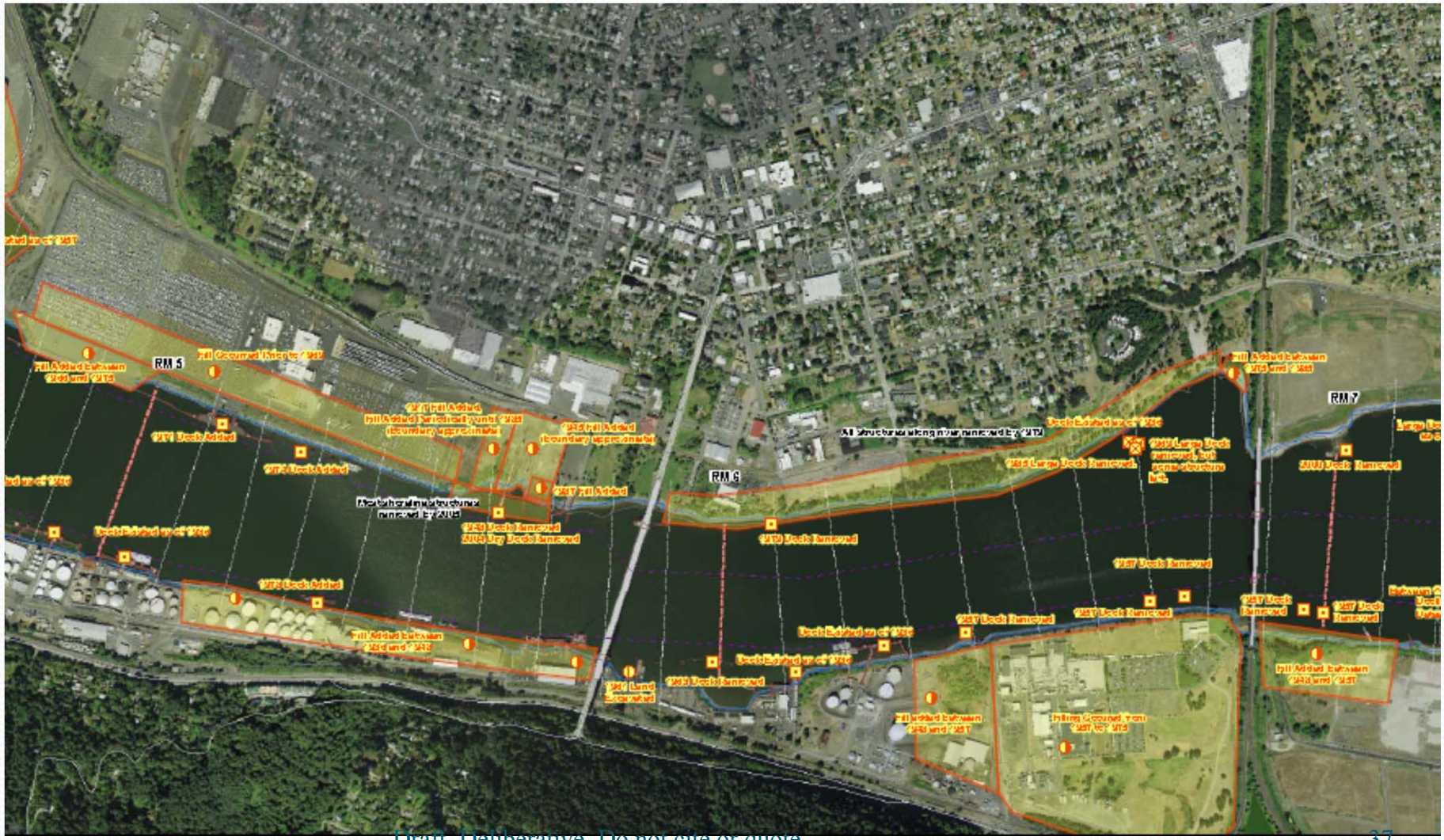
HST Model (cont.)



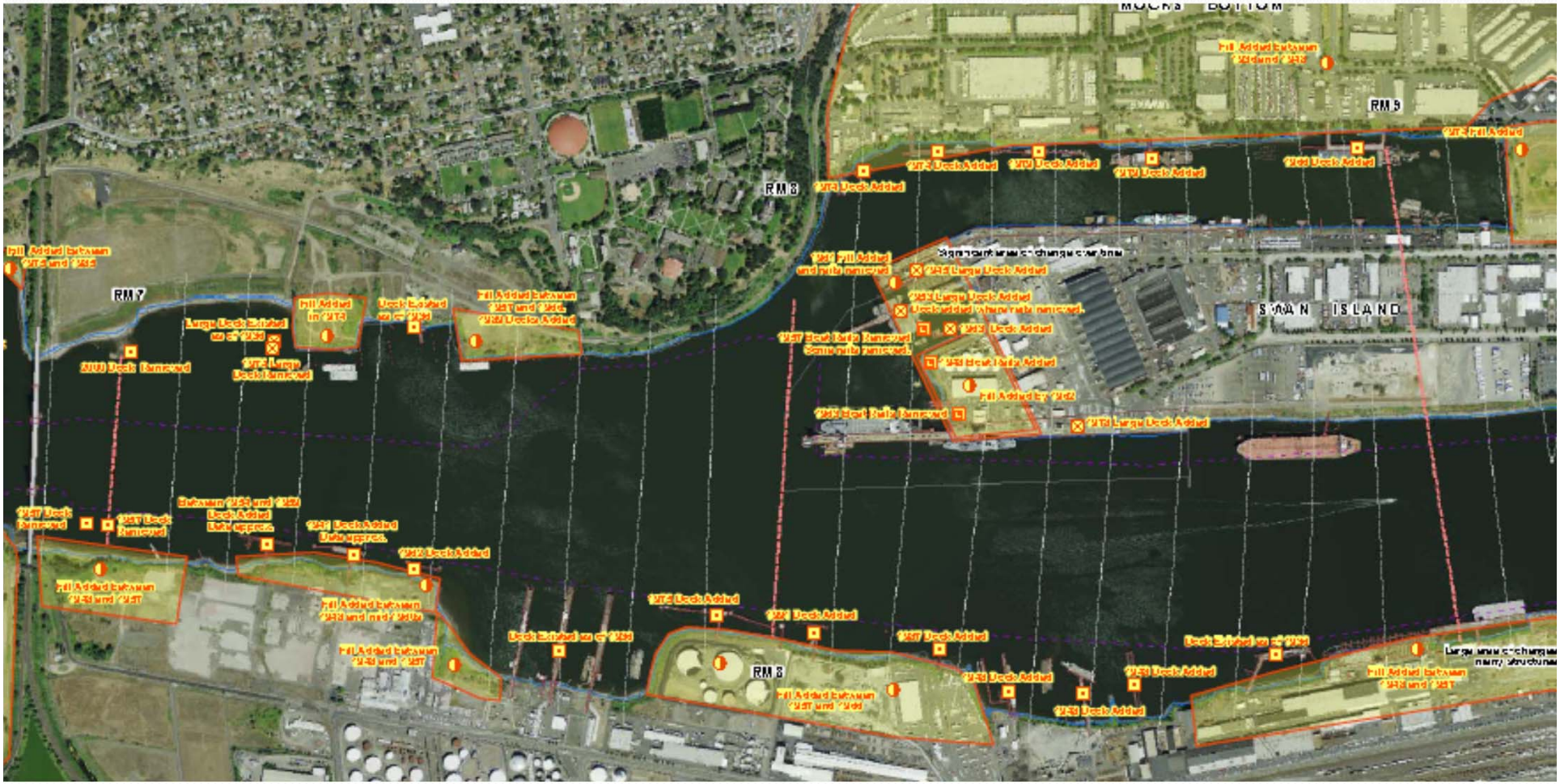
HST Model (cont.)



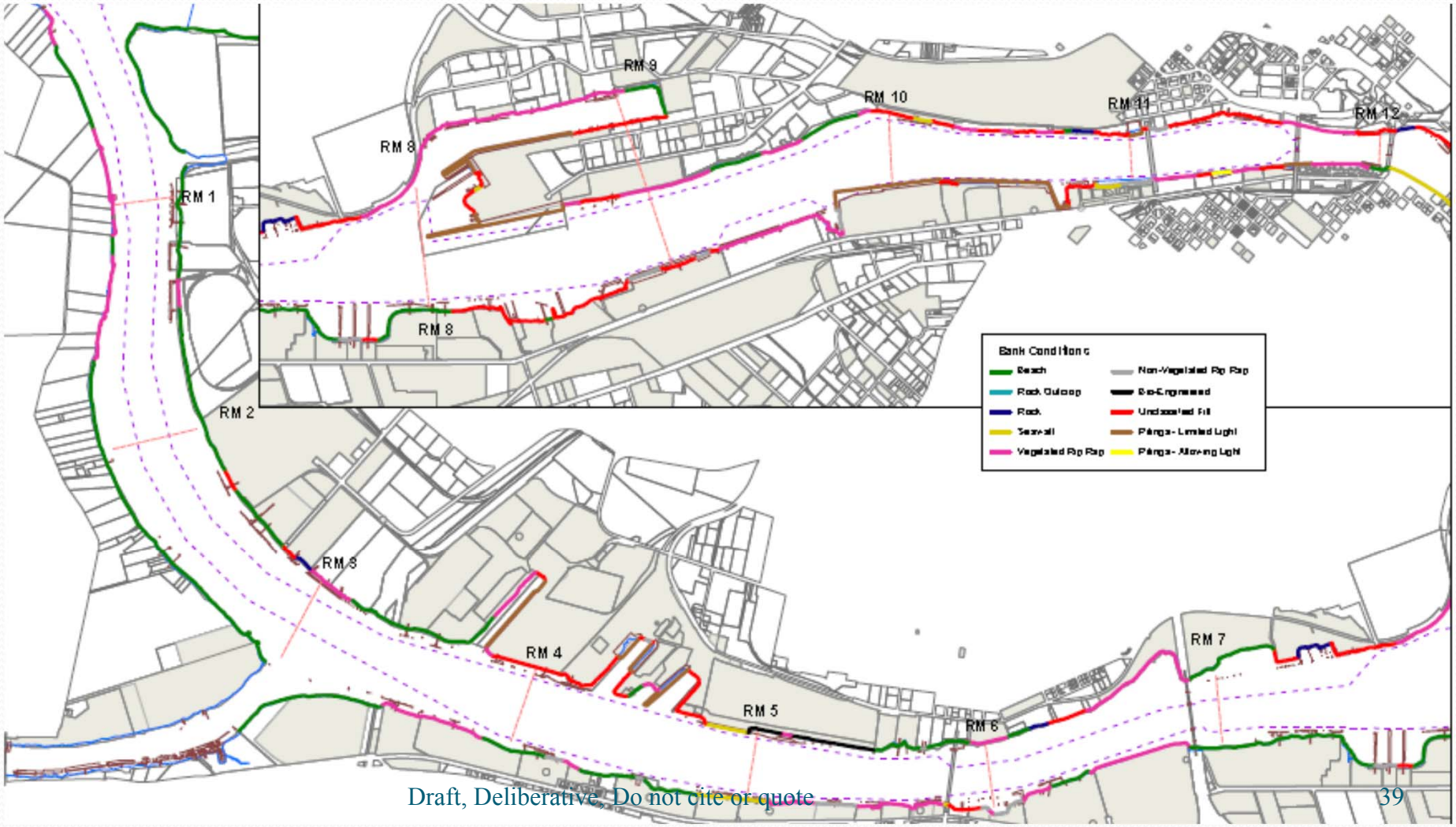
In-Water Structures (RM 5 – 7)



In-Water Structures (RM 7 – 9)



River Banks


RM 1
RM 2
RM 3
RM 4
RM 5
RM 6
RM 7
RM 8
RM 8
RM 9
RM 10
RM 11
RM 12
Bank Conditions
Beach
Rock Outcrop
Rock
Seawall
Vegetated Rip Rap
Non-Vegetated Rip Rap
Bio-Engineered
Undocumented Fill
Pilings - Limited Light
Pilings - Allowing Light

Land Use

- Marine terminals
- Manufacturing
- Commercial operations
- Public facilities
- Parks
- Open spaces

Site Use

- Industry
- Recreation (boating, swimming, camping)
- Fishing
- Navigation
- Ceremonial practices
- Ecological habitat
- Tribal treaty rights to fish and ceremonial practices
- Migratory corridor for ESA listed species (salmon)

Portland Harbor

Nature and Extent

Industrial Sources

- Ship building, dismantling & repair
- Wood products & wood treating
- Chemical manufacturing and distribution
- Metal recycling, production & fabrication
- Manufactured gas production
- Electrical production & distribution
- Bulk fuel distribution & storage
- Asphalt manufacturing
- Steel mills, smelters & foundries
- Commodities shipping terminals
- Rail yards

Contaminant Pathways

- Storm water & CSO discharges
- Industrial waste discharges
- Ground water transport
- Soil & bank erosion
- Air deposition
- Overwater releases
- Upriver sources

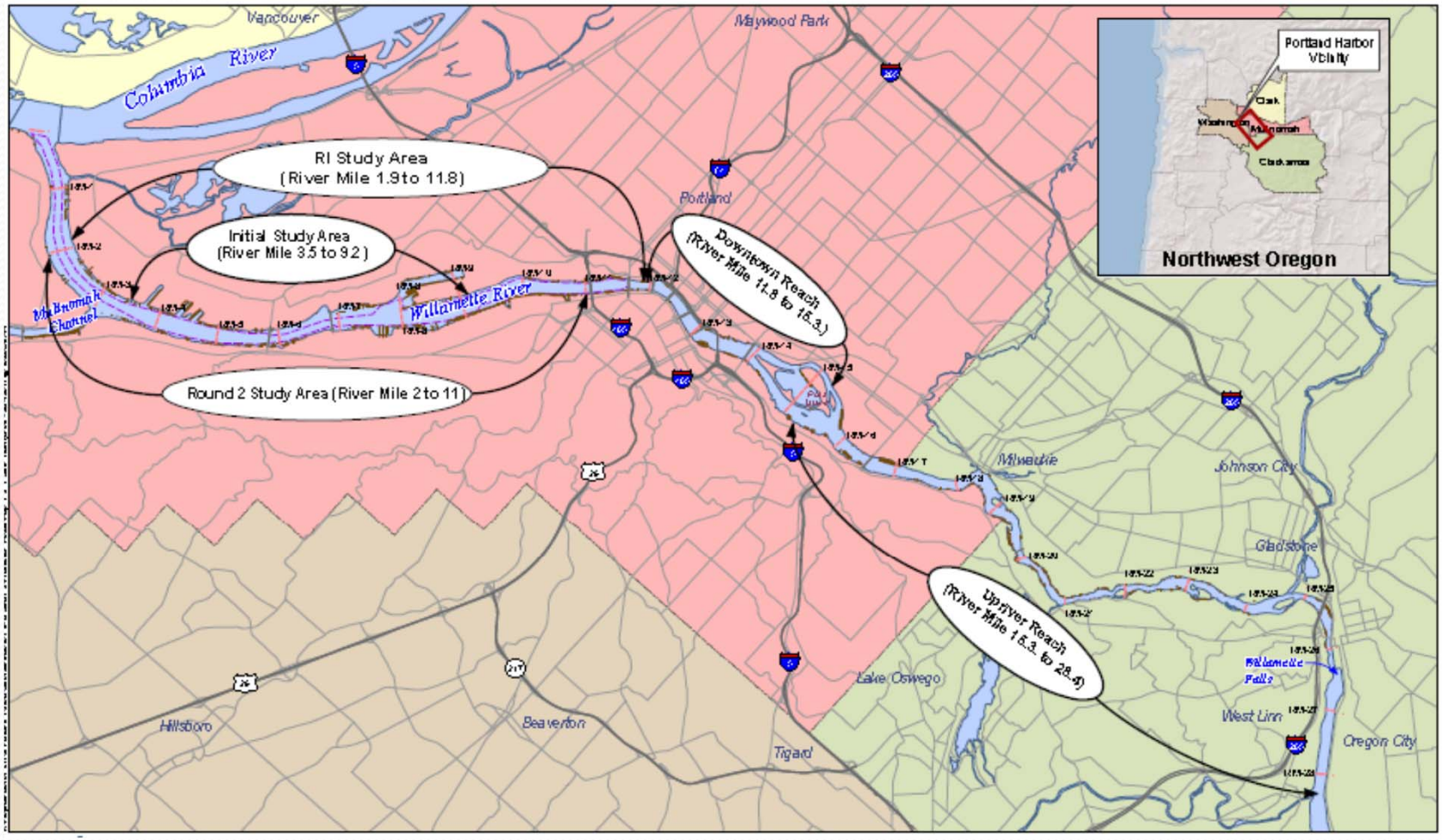
Contaminants

- 185 detected
- 12 indicator contaminants
  - Frequency of detection
  - Cross-media detection
  - Wide-spread sources
  - Risk exceedance
- 21 others – Appendices
- Example with 4 COCs

12 Indicator Contaminants

- Aldrin/Dieldrin
- Arsenic
- BEHP
- Chlordanes
- Chromium
- Copper
- Dioxins/Furans
- DDT & metabolites
- PAHs
- PCBs
- TBT
- Zinc

River Segments



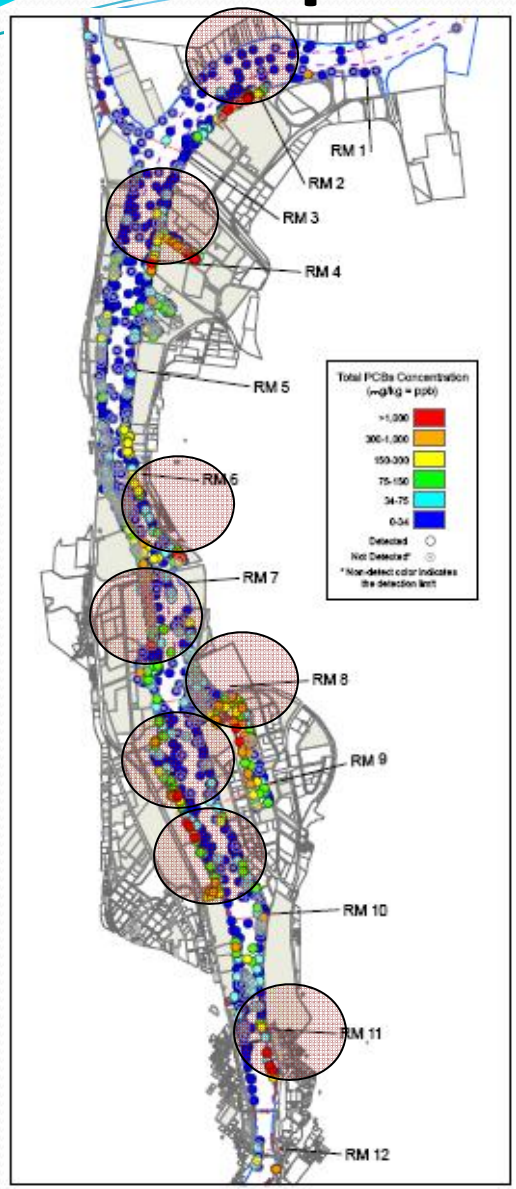
PCBs – Media

- ✓ Sediment
- ✓ Sediment traps
- ✓ Surface water
- ✗ Pore water
- ✓ Biota

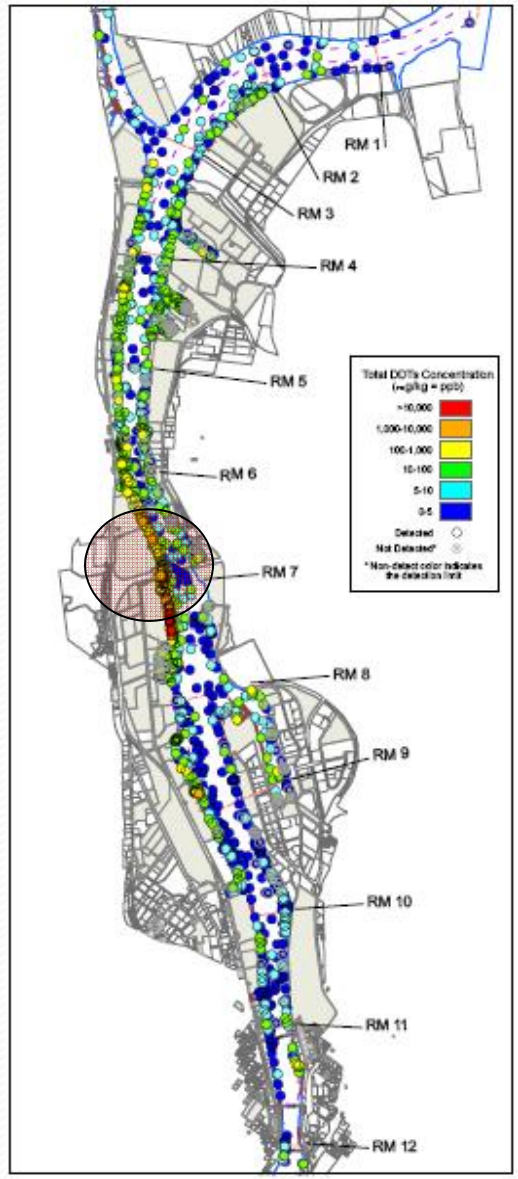
PCB Summary

	Sediment	Sediment Traps	Surface Water	Biota
RM 2E	X		X	X
International Slip (RM 4E)	X	NA	X	X
Willamette Cove (RM 7E)	X	X	X	X
Swan Island Lagoon (RM 8E)	X	X	X	X
RM 11E	X	X	X	X
RM 9W	X	X	X	X

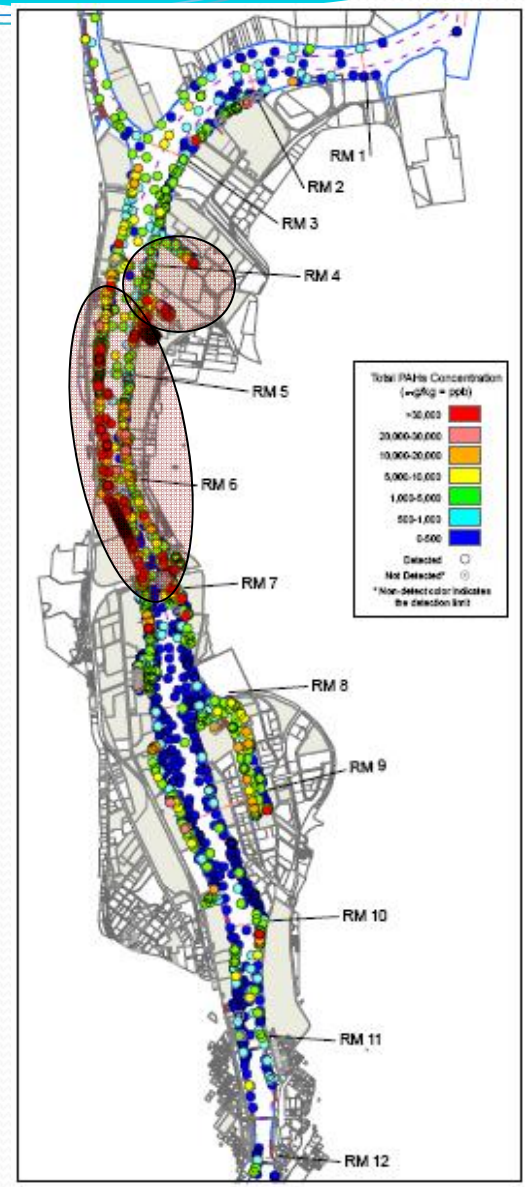
Examples of Contaminant Distribution



Total PCBs



Total DDx



Total PAHs

Dioxin/Furan – Media

- ✓ Sediment
- ✓ Sediment traps
- ✓ Surface water
- ✓ Pore water
- ✓ Biota

Dioxin/Furan Summary

	Sediment	Sediment Traps	Surface Water	Pore Water	Biota
International Slip (RM 4E)	X	X	X	NA	X
Willamette Cove (RM 7E)	X		X	NA	X
Swan Island Lagoon (RM 8E)	X	X	X	NA	X
RM 7W	X	X	X	X	X
RM 9W	X	X	X	NA	X

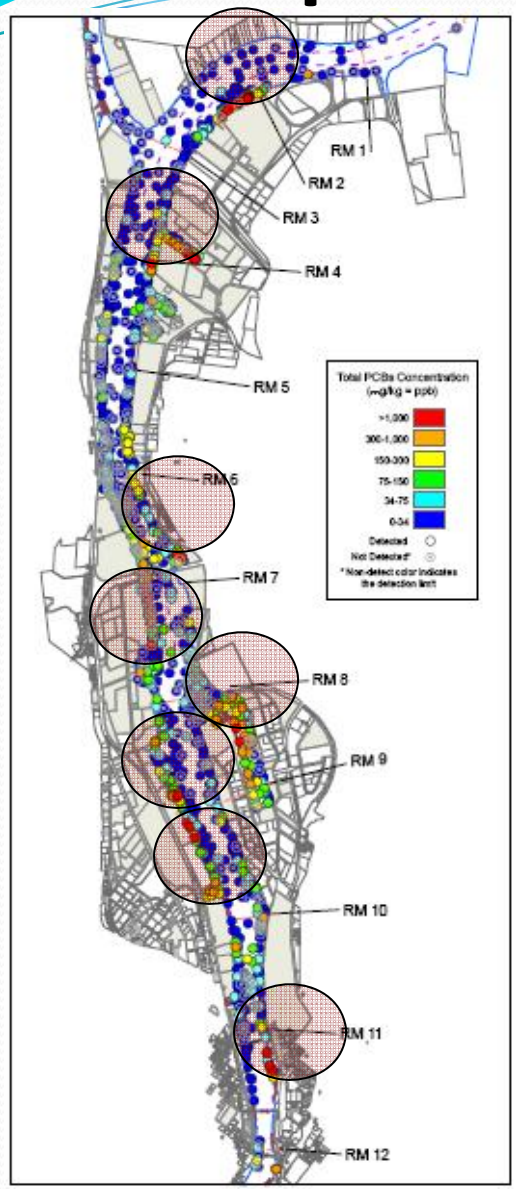
DDx – Media

- ✓ Sediment
- ✓ Sediment traps
- ✓ Surface water
- ✓ Pore water
- ✓ Biota

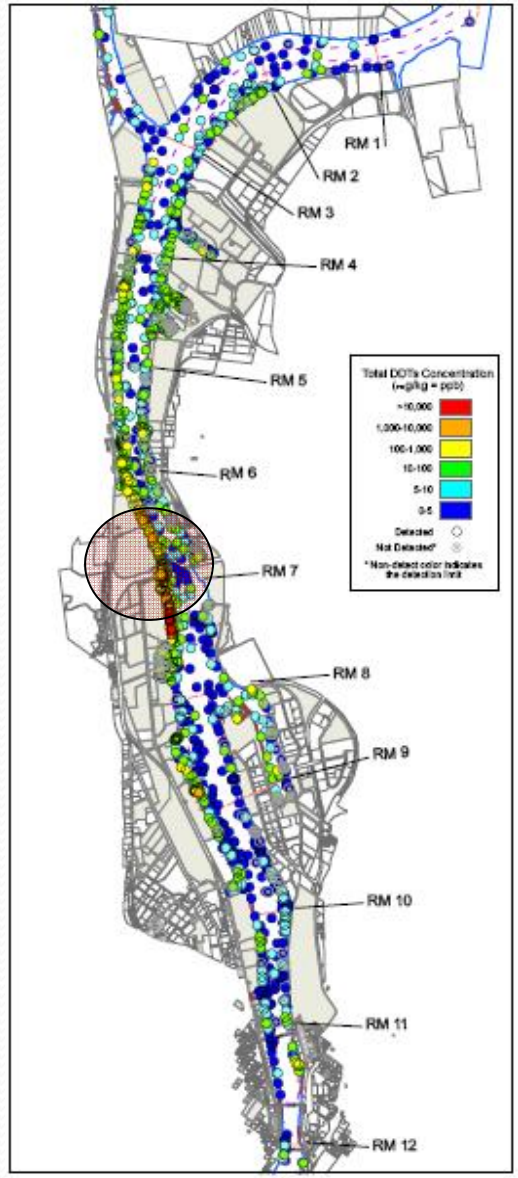
DDx Summary

	Sediment	Sediment Traps	Surface Water	Pore Water	Biota
RM 11E	X	X		NA	
RM 7W	X	X	X	X	X
RM 9W	X	X	X	NA	X

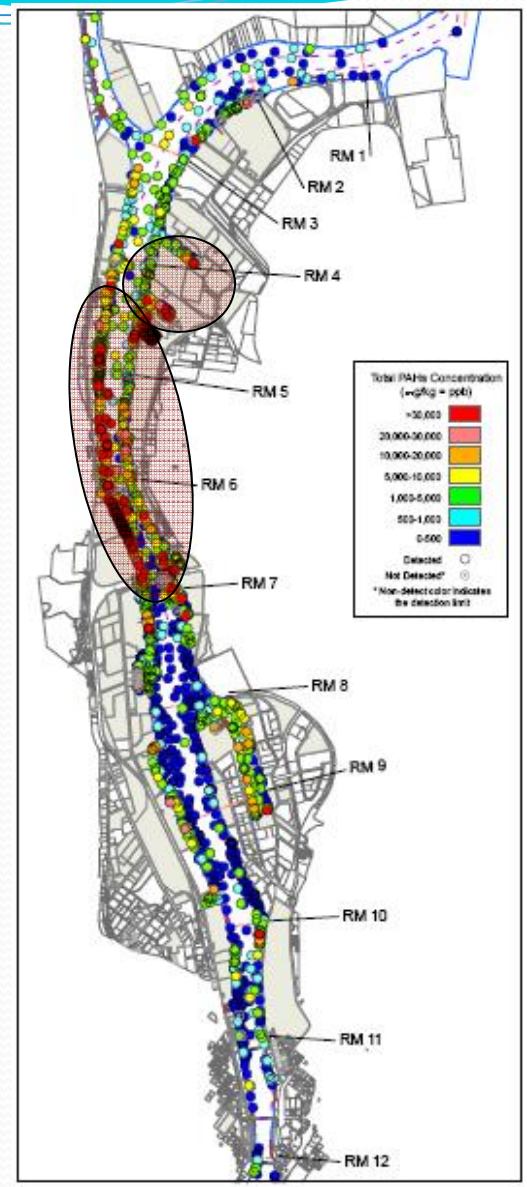
Examples of Contaminant Distribution



Total PCBs



Total DDx



Total PAHs

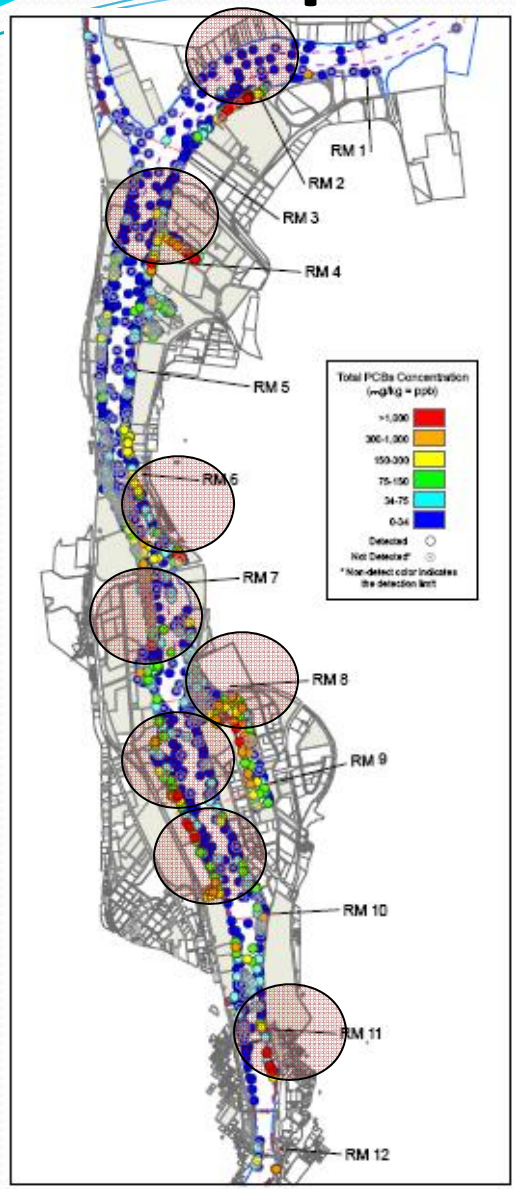
PAHs – Media

- ✓ Sediment
- ✓ Sediment traps
- ✓ Surface water
- ✓ Pore water
- ✓ Biota

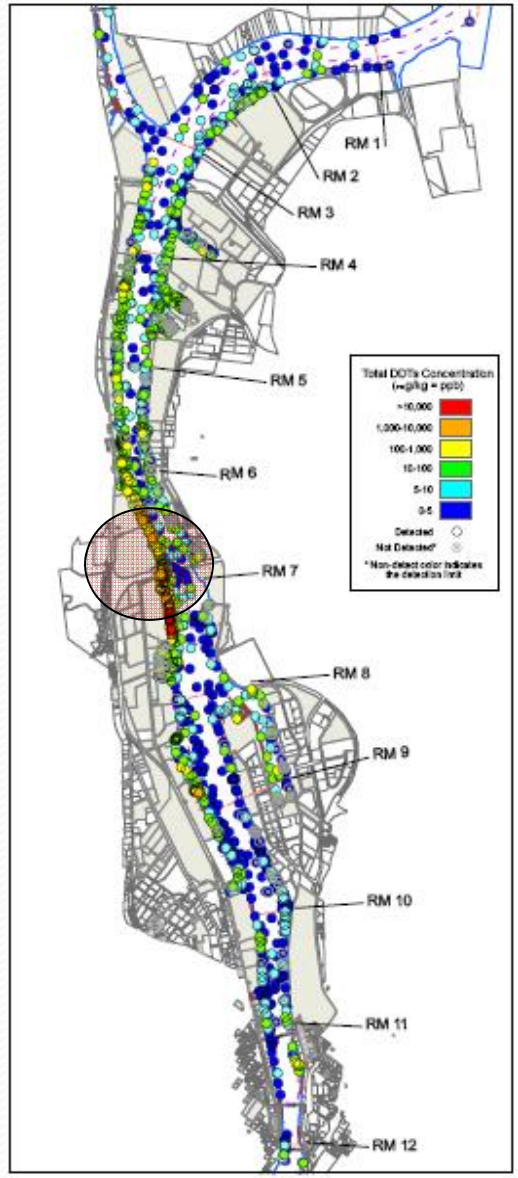
PAH Summary

	Sediment	Sediment Traps	Surface Water	Pore Water	Biota
International Slip (RM 4E)	X	X		NA	X
Swan Island Lagoon (RM 8E)	X	X	X	NA	NA
RM 3W-6W	X			X	X
RM 6W	X	X	X	X	X
RM 9W	X		X	NA	X

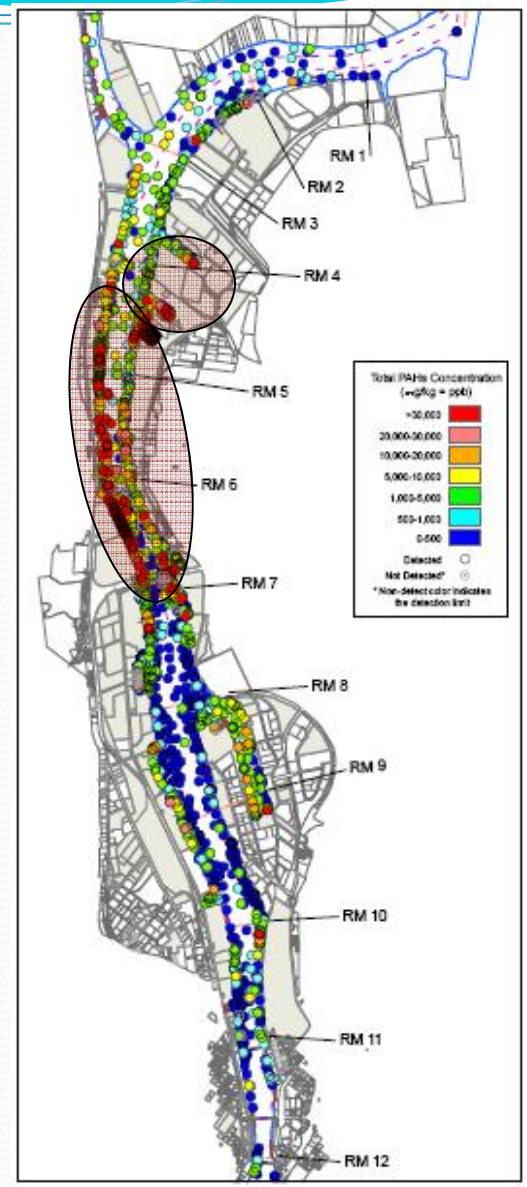
Examples of Contaminant Distribution



Total PCBs



Total DDx



Total PAHs

Portland Harbor

Fate & Transport

Loading, Fate, and Transport

- External Loading – Mass loading to the site from external sources
- Internal Loading – Movement within the site from one medium to another

External Loading Pathways

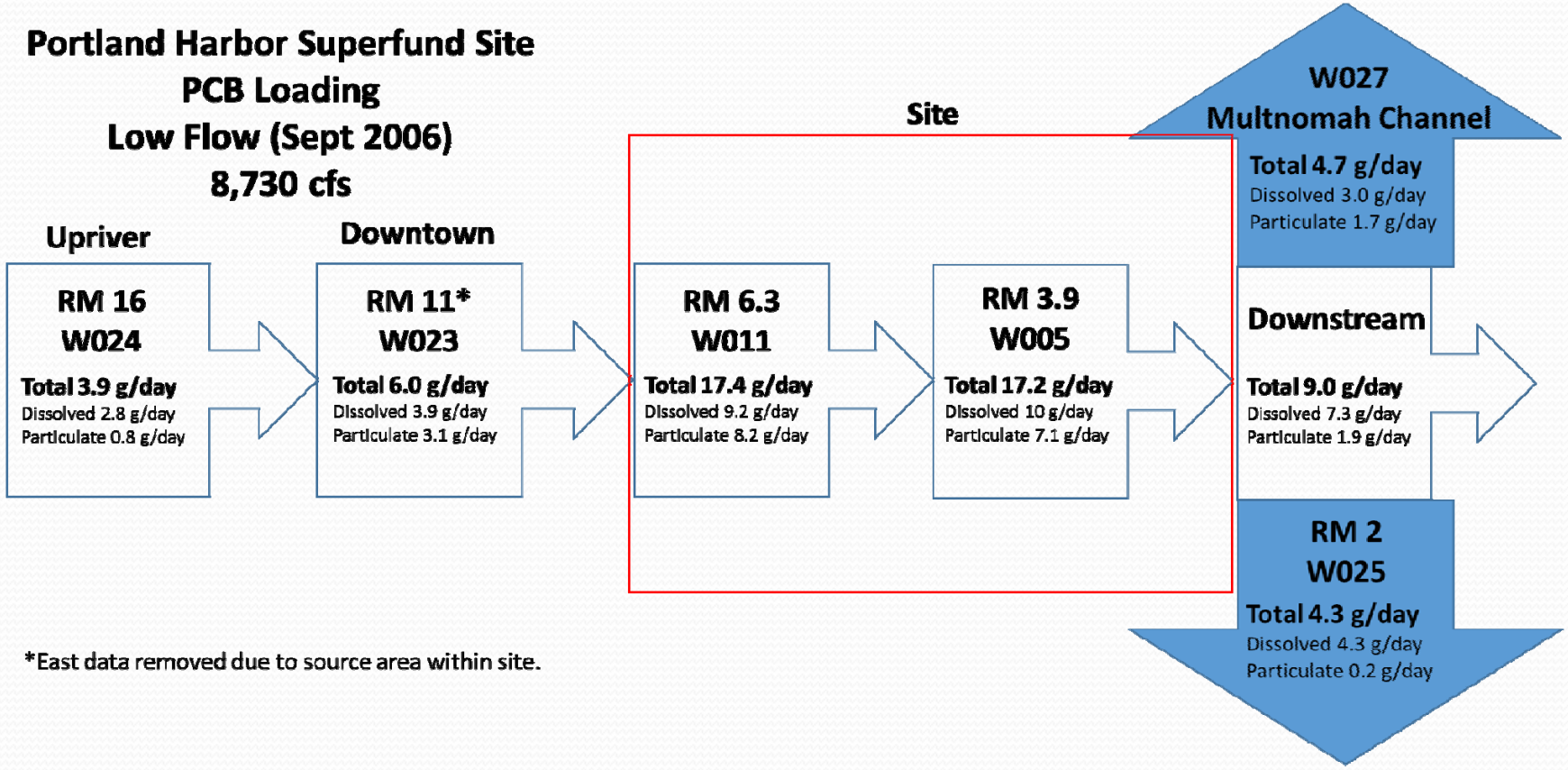
- Upstream loading via surface water, including suspended sediment load and sediment bedload*
- Stormwater runoff
- Permitted non-stormwater point source discharges
- Upland groundwater plume transport to the river
- Atmospheric deposition to the river surface
- Upland riverbank erosion*
- Groundwater advection through sediments
- Overwater releases*

*qualitative evaluation only

Sediment Bedload Transport

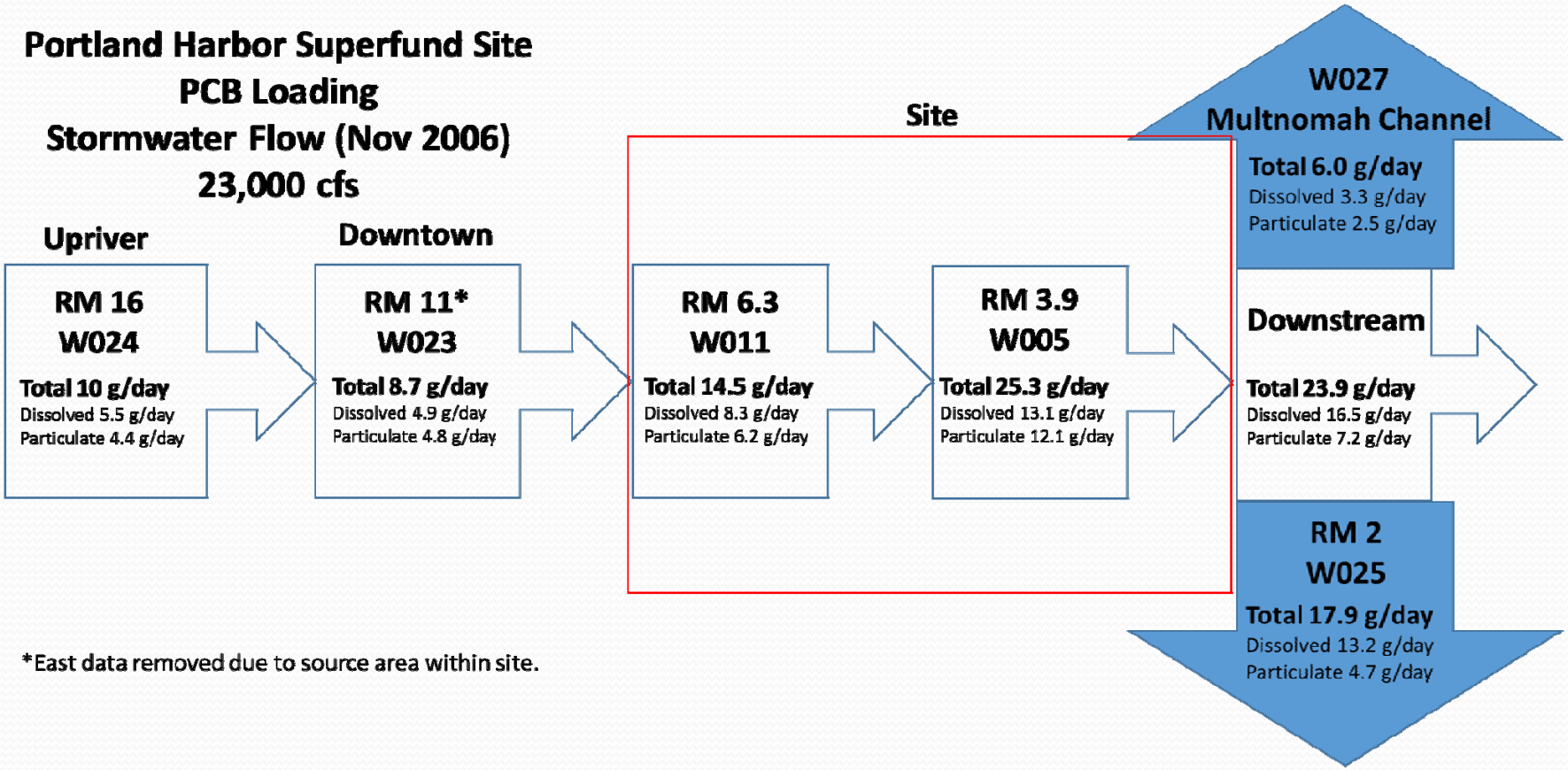
"Quantification of sediment bedload into the Study Area and associated contaminant transport was deemed unnecessary because the sediment bed of the lower Willamette River is mainly cohesive … bedload transport processes are not significant components of upstream loading."

Example Loads in Low Flow



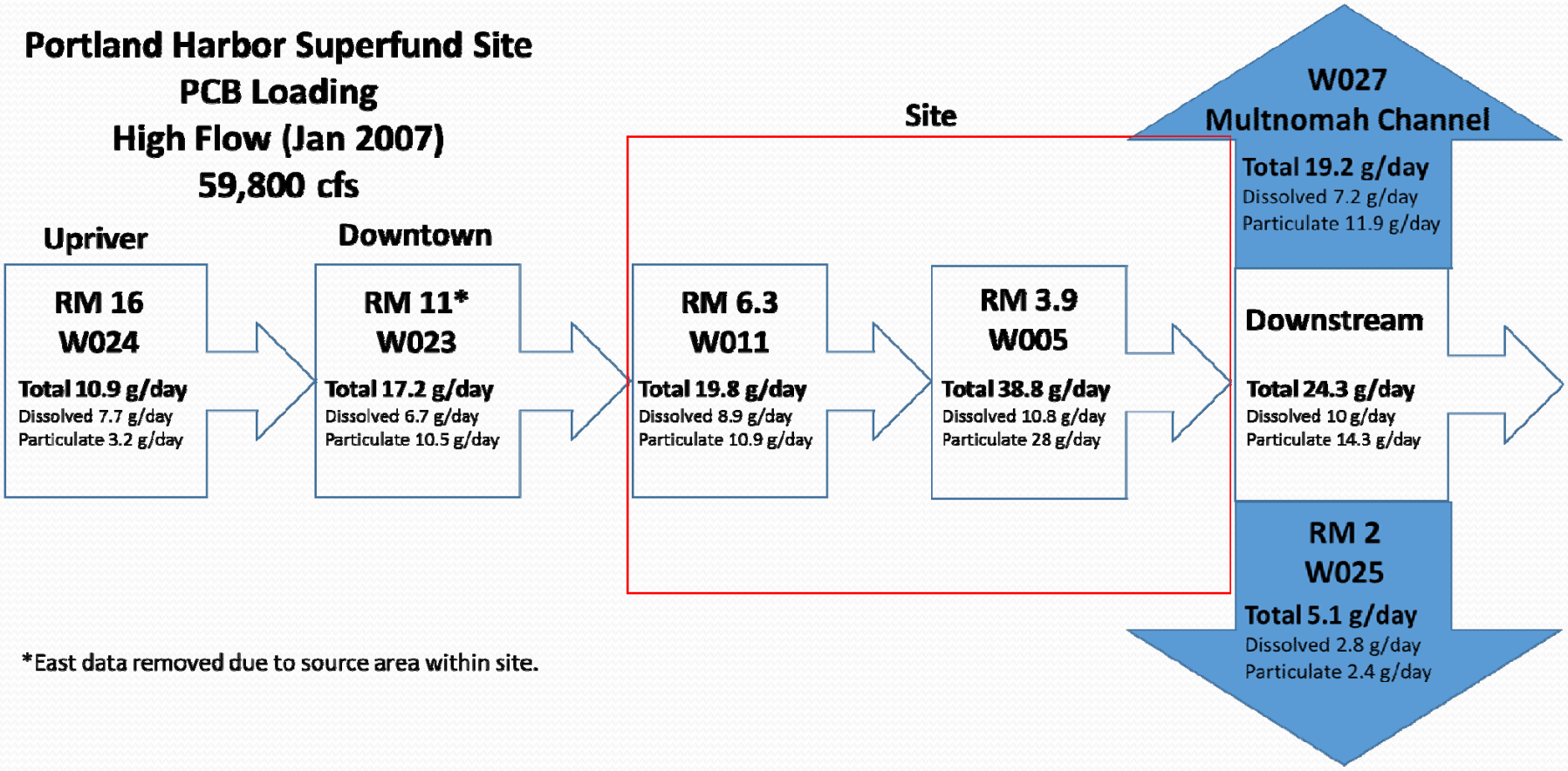
*East data removed due to source area within site.

Example Loads in Stormwater Flow



*East data removed due to source area within site.

Example Loads in High Flow



*East data removed due to source area within site.

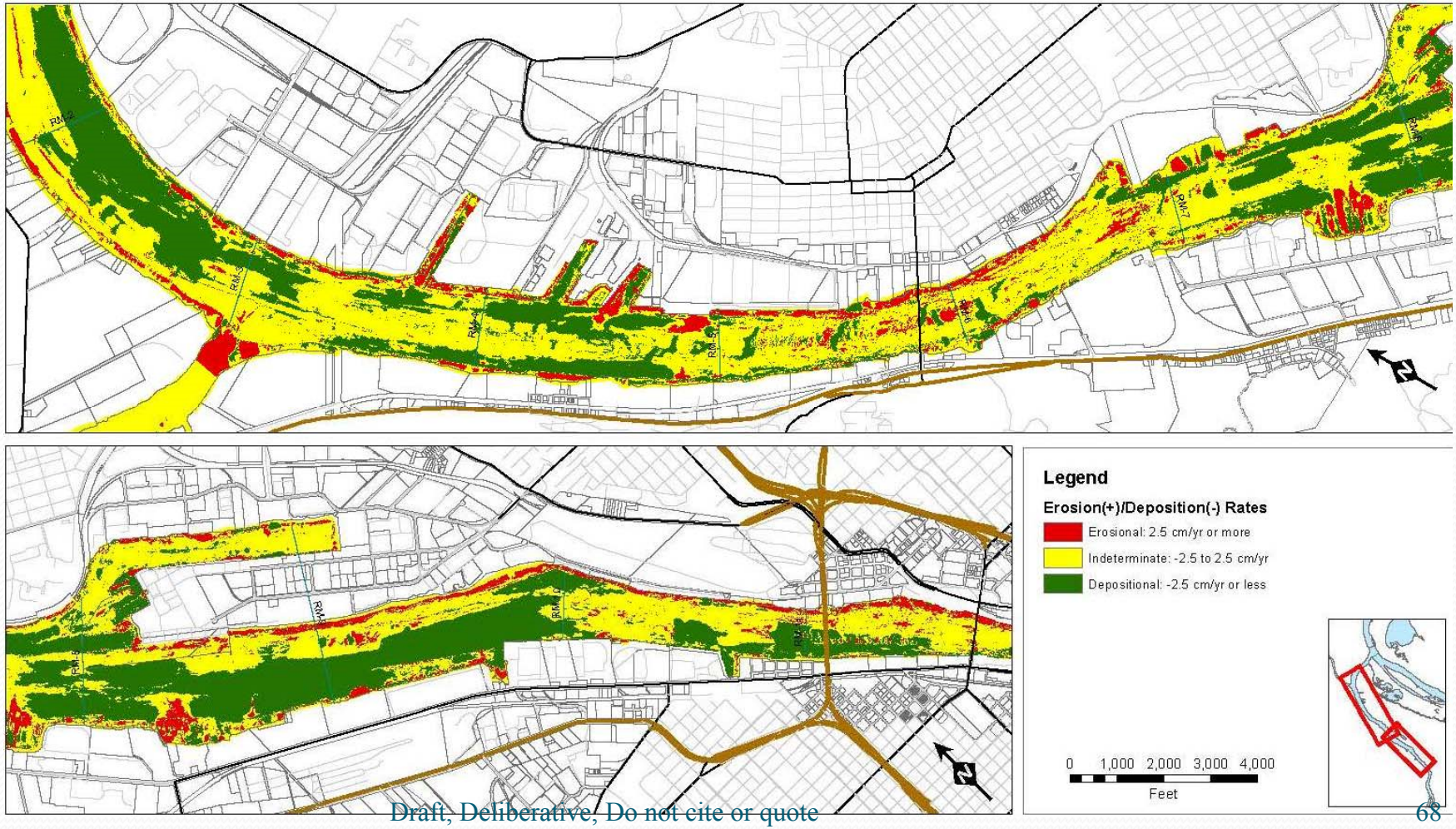
Internal Fate and Transport Processes

- Sediment re-suspension/transport/ deposition
- Solid/aqueous-phase portioning
- Abiotic/biotic transformation and degradation
- Biological uptake
- Groundwater advection through surface sediments

Modeling Results

- 82 percent passes through site
- 18 percent retained
  - 277 million kg/year

Sediment Deposition Rates



Portland Harbor

Background

Sediment Background

OC-corrected BTV and CT Background Concentrations

Contaminant	Units	BTV (95% UPL)	CT (95% UCL)
Arsenic	mg/kg	4	3
BEHP	µg/kg	155	60
Chlordanes	µg/kg	1.1	0.6
Chromium	mg/kg	32.2	23.8
Copper	mg/kg	37.4	25.8
DDx	µg/kg	5	3
Mercury	mg/kg	0.052	0.034
PAHs	µg/kg	222	110
PCB, total Aroclor	µg/kg	23	9
PCB, total congener	µg/kg	12	6
PCDD/F, total	µg/kg	0.29	0.12
Zinc	mg/kg	104	77

Portland Harbor

Baseline Risk Assessment

Baseline Human Health Risk Assessment

Approach developed with input from:

- LWG
- ODEQ
- OHA
- Six Tribes
  - Yakama
  - Nez Perce
  - Grande Ronde
  - Umatilla
  - Warm Springs
  - Siletz

Receptors Evaluated

- Dockside workers
- “In-water” workers
- Recreational
- Transients
- Recreational & subsistence fishers
- Tribal fishers
- Divers
- Domestic water use
- Infants via consumption of breast milk

Exposures Evaluated

	Dockside workers	In-water workers	Recreational	Transients	Recreational/ Subsistence/ Tribal Fishers	Divers	Domestic Water Use
Beach Sediment	●		●	●	●		
River Sediment		●			●	●	
Surface Water			●	●		●	●
Groundwater Seeps			●	●			
Fish/Shellfish Tissue					●		

Fish Consumption Rates

175 g/day – Tribal Fishers

- Based on CRITFC Study

142 g/day – Subsistence Fishers RME

- Based on national consumption data

49 g/day – Recreational Fishers RME

- Based on Columbia Slough Creel Survey

17.5 g/day – Recreational Fishers CT

- Based on national consumption data

Fish Consumption Practices

- Tribal Fishers – Combined diet of migratory and resident fish, whole body consumption
- Subsistence and Recreational Fishers – Resident fish only, fillet only consumption.
- Site-wide – mixed diet, four species
- River mile – SMB only as surrogate for mixed species diet

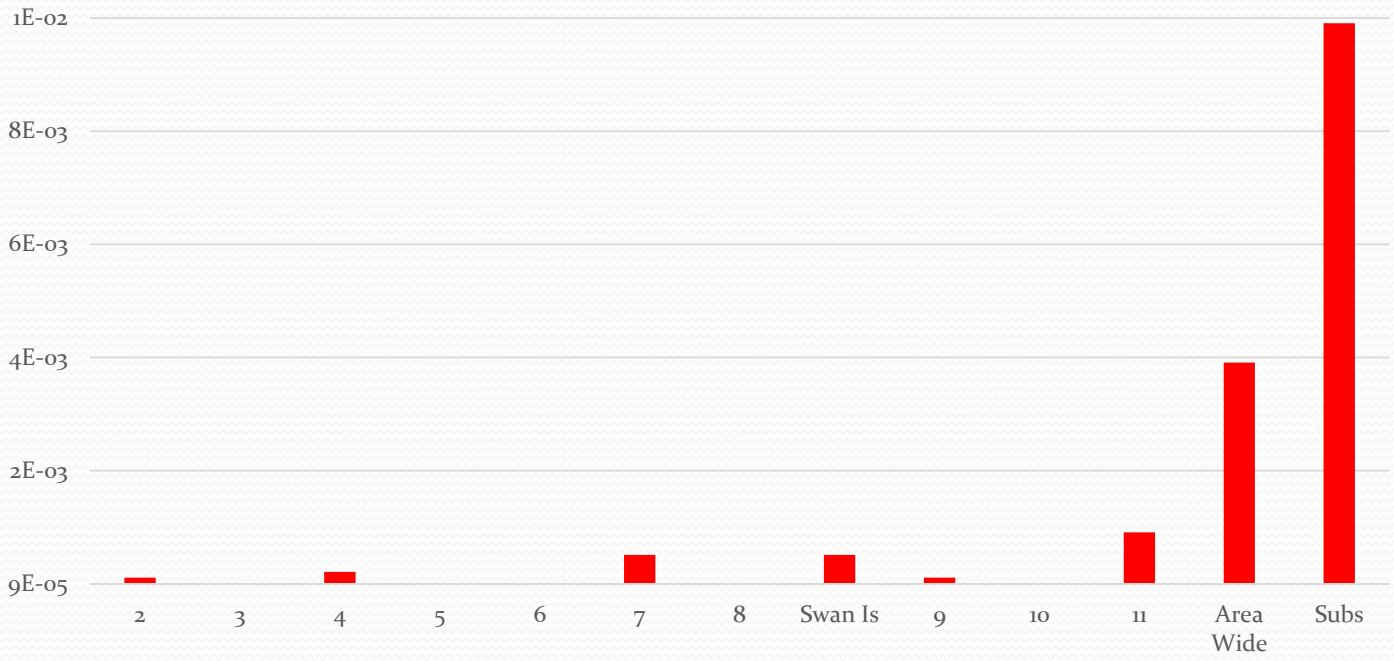
Infant Exposures to POPs

- Children of nursing mothers exposed via pathways evaluated in the risk assessment
- Inclusion of this pathway a collaborative effort between Region 10, ODEQ, and OHA
- Evaluated for PCBs, dioxins/furans, DDx, and PDBEs
- ODEQ incorporated the methodology into its risk assessment guidance

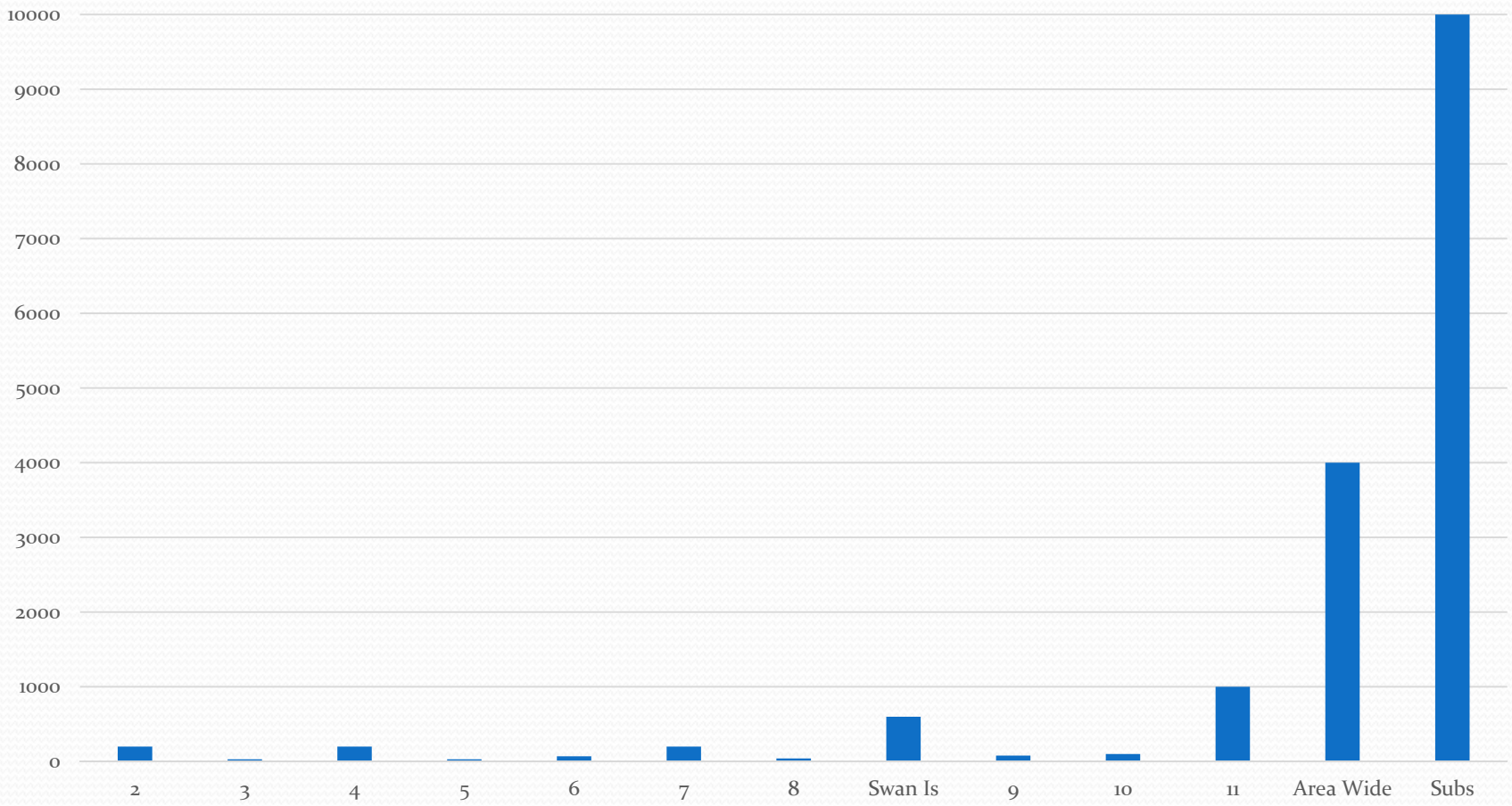
Major Conclusions

- Direct contact >10^{-4} at RM6W and RM7W
- Drinking surface water no significant risks
- Fish consumption risk orders of magnitude higher
  - PCBs primary contributor
  - Dioxins/furans secondary contributors
  - DDx and PAHs on localized scale
- Infants
  - PCBs primary contributors

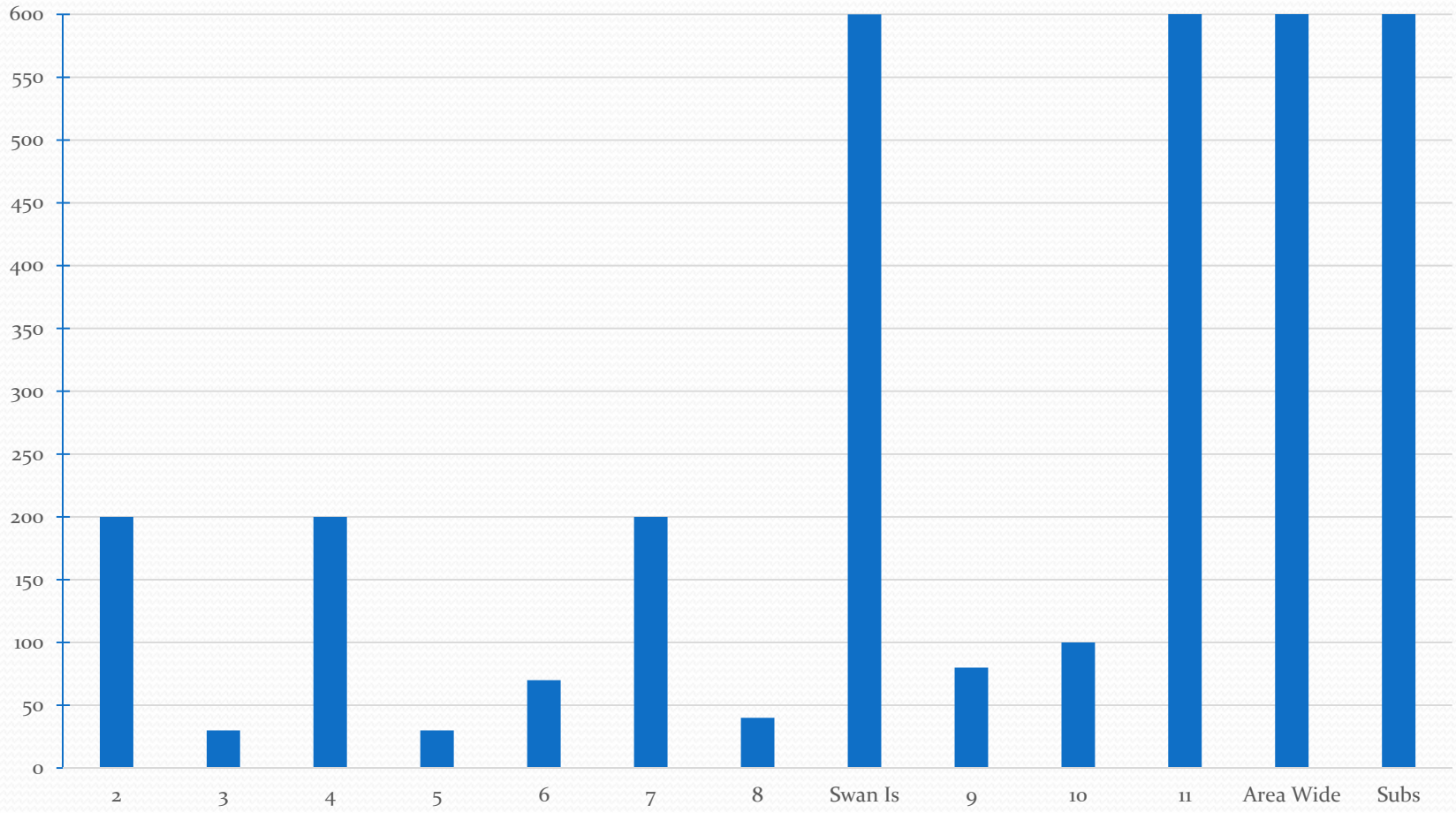
Estimated Cancer Risk by RM



Estimated Hazard Index by RM



Estimated Hazard Index by RM



Baseline Ecological Risk Assessment

- Baseline risk assessment problem formulation
- Study design and Data Quality Objectives
- Field verification of sampling design
- Site investigation and analysis of exposure & effects
- Risk characterization

Contaminants Evaluated in BERA

Number of COPCs Evaluated in the BERA		
Medium or Diet	No. of COPCs	No. of Chemicals without Screening-Level TRVs
Sediment	67	106
Invertebrate tissue	18	23
Fish tissue	16	8
Fish dietary dose	9	11
Bird dietary dose	23	19
Mammal dietary dose	12	11
Bird egg tissue	5	0
Surface water	14	19
TZW	58	14

Evaluated 13 Assessment Endpoints

Survival, growth, and reproduction of:

- Aquatic plants
- Benthic macroinvertebrates
- Bivalves
- Decapods
- Invertivorous fish
- Omnivorous fish
- Piscivorous fish
- Amphibians
- Invertivorous birds
- Omnivorous birds
- Piscivorous birds
- Aquatic dependent mammals
- Survival & growth – detrivorous fish (Pacific Lamprey)

Exposure Routes Evaluated

Aquatic plants – Root uptake; direct contact with sediment, surface water, and TZW

Benthic invertebrates – Direct contact with sediment, surface water, and TZW; ingestion of sediment and food

Fish – Direct contact with sediment, surface water, and TZW; ingestion of sediment and food

Birds and mammals – Ingestion of soil, sediment, and food

Amphibians – Direct contact with surface water and TZW; ingestion of sediment and food

Ecological Effects Assessment

- Compare contaminant concentrations in with TRVs or site-specific SQVs.
- Benthic risks used sediment bioassays and 2 models to develop sediment SQVs

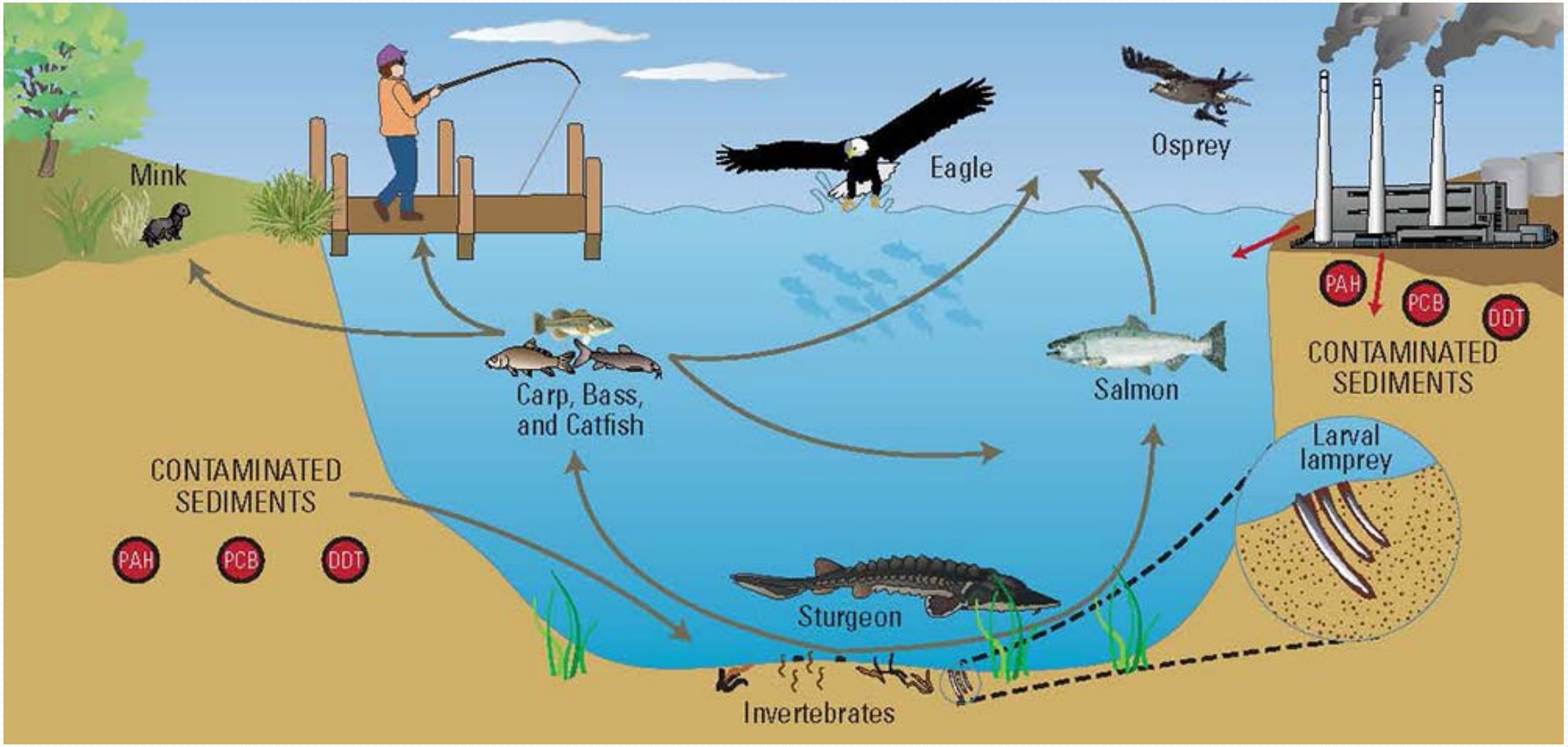
Determination of Ecological Significance

- Relatively high HQs in one or more environmental media
- Unacceptable ecological risks over extensive areas
- Spatial extent of unacceptable risk not generally encompassed by other contaminants
- Unacceptable risks to multiple ecological receptors
- Multiple LOEs indicated unacceptable risks
- Known or has potential to biomagnify in food webs

Contaminants Posing Ecologically Significant Risk

PCBs	Dioxins/furans
PAHs	DDT and metabolites
Total chlordanes	Mercury
Lead	Cadmium
Copper	Bis(2-ethylhexyl)phthalate
Zinc	Dieldrin
Lindane (γ-HCH)	Cyanide
Tributyltin	Ethylbenzene
Perchlorate	C_{10} – C_{12} TPH
Manganese	Vanadium

Baseline Risk Assessment



COCs in Sediment

- PCBs
- Dioxins/Furans
- Total cPAH
- Total PAH
- Aldrin
- Dieldrin
- Total DDE
- DDx
- Lindane
- Total Chlordanes
- Arsenic
- Cadmium
- Chromium
- Copper
- Lead
- Mercury
- Zinc
- BEHP
- Tributyltin
- Hexachlorobenzene
- PBDE